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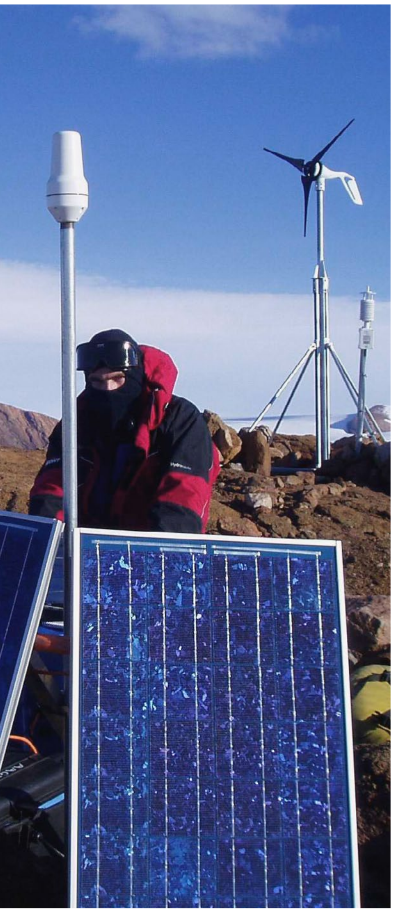

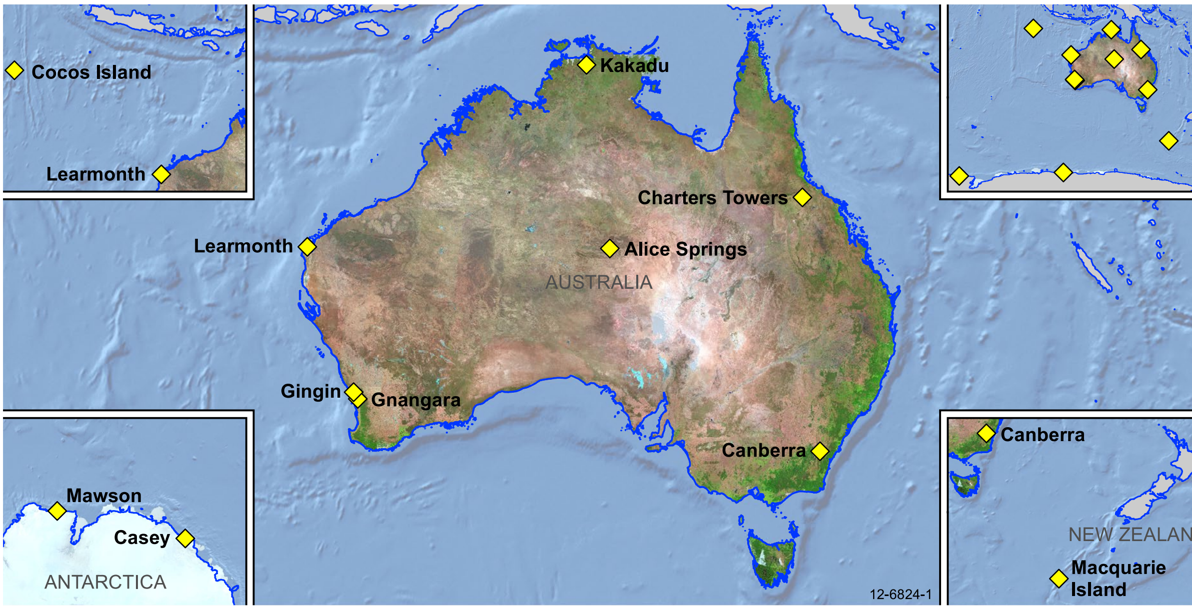

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Volume 59

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Australian Government
Geoscience Australia

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Current as at January 2013

Summary

During 2011, Geoscience Australia operated ten geomagnetic observatories in Australia, the sub-Antarctic, and Australian Antarctic Territory. The observatories were at Kakadu and Alice Springs in the Northern Territory, Charters Towers in Queensland, Learmonth and Gnangara in Western Australia, Canberra in the Australian Capital Territory, Macquarie Island, Tasmania, in the sub-Antarctic, and Casey and Mawson in the Australian Antarctic Territory. In November 2011 a new observatory at Gingin, Western Australia, became operational. After twelve months of operation in parallel with Gnangara, operations at Gnangara will cease and Gingin will become the primary magnetic observatory in southern Western Australia.

At Learmonth observatory, operations were conducted with the assistance of IPS Radio and Space Services, Bureau of Meteorology, Department of Sustainability, Environment, Water, Population and Communities. At Macquarie Island, Casey and Mawson, operational assistance was provided by the Australian Antarctic Division, Department of Sustainability, Environment, Water, Population and Communities.

The absolute magnetometers in routine service at Canberra magnetic observatory also served as the Australian reference magnetometers. The calibration of these instruments can be traced to international standards and reference instruments. Absolute magnetometers at all Australian observatories are referenced against those at Canberra through instrument comparisons.

Geomagnetic time-series data with a range of temporal resolutions were provided to collaborators and data repositories in Australia, Japan, France, Germany, UK, USA and Finland. K indices were scaled with computer assistance for Canberra, Gnangara, Gingin and Mawson observatories. Principal magnetic storms and rapid variations were scaled for Canberra and Gnangara. Magnetic-activity data were provided to agencies in Australia, Japan, France, Germany, Spain, Belgium, UK and USA.

K indices from Canberra contributed to the southern hemisphere Ks index and the global Kp, am and aa indices, and those from Gnangara contributed to the global am index.

This report describes instrumentation and activities, and presents annual mean magnetic values, plots of hourly mean magnetic values and K indices, at the magnetic observatories operated by Geoscience Australia during the 2011 calendar year. No repeat stations were occupied during 2011.

Acronyms and abbreviations

AAD	Australian Antarctic Division
ACT	Australian Capital Territory
A/D	analogue to digital
ADSL	asymmetric digital subscriber line
AGR	Australian Geomagnetism Report
AGRF	Australian Geomagnetic Reference Field
AGSO	Australian Geological Survey Organisation
AIGO	Australian International Gravitational Observatory
AMSL	above mean sea level
ANARE	Australian National Antarctic Research Expedition
ANARESAT	ANARE satellite
ASP	Alice Springs magnetic observatory
BGS	British Geological Survey
BMR	Bureau of Mineral Resources, Geology and Geophysics
BoM	Bureau of Meteorology
CAT	Centre for Appropriate Technology
CKI	Cocos (Keeling) Islands magnetic observatory
CLS	Collecte Localisation Satellites, France
CNB	Canberra magnetic observatory
CNES	Centre National d'Etudes Spatiales, France
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSY	Casey magnetic observatory
CTA	Charters Towers magnetic observatory
D	magnetic declination
DAF	GA Data Acquisition Facility (Alice Springs)
DIM	Declination and Inclination Magnetometer (D, I-fluxgate magnetometer)
DMI	Danish Meteorological Institute
DTU	Danish Technical University
EDA	EDA Instruments Inc., Canada
F	total magnetic intensity
ftp	file transfer protocol
GA	Geoscience Australia
GDAP	Geophysical Data Acquisition Platform
GIN	Geomagnetic Information Node
GNA	Gnangara magnetic observatory
GNG	Gingin magnetic observatory
GPS	Global Positioning System
H	horizontal magnetic intensity
HSPA	high-speed packet access
http	hypertext transfer protocol
I	magnetic inclination
INTER- MAGNET	International Real-time Magnetic observatory Network
IAGA	International Association of Geomagnetism and Aeronomy
IGRF	International Geomagnetic Reference Field
IPGP	Institut de Physique du Globe de Paris, France
IPS	IPS Radio and Space Services
ISGI	International Service of Geomagnetic Indices, France
K	logarithmic index of geomagnetic activity
KDU	Kakadu magnetic observatory
LRM	Learmonth magnetic observatory
LSO	Learmonth Solar Observatory
MAW	Mawson magnetic observatory
MCQ	Macquarie Island magnetic observatory
NGDC	National Geophysical Data Center, USA
NGL	Narod Geophysics Ltd
NOAA	National Oceanic and Atmospheric Administration, USA
nT	nanoTesla
ntpd	Network Time Protocol daemon
OS	operating system
PPM	proton procession magnetometer
QNX	real-time posix operating system
RAAF	Royal Australian Air Force
RCF	ring-core fluxgate
SC	sudden commencement
sfe	solar flare effect
ssc	storm sudden commencement
TCP/IP	transmission control protocol / Internet protocol
UPS	uninterruptible power supply
UT[C]	Universal Time [Coordinated]
VSAT	Very Small Aperture Terminal
WDC	World Data Center
X	north magnetic intensity
Y	east magnetic intensity
Z	vertical magnetic intensity

Contents

Activities and services

Geomagnetic observatories

Geoscience Australia operates eleven permanent geomagnetic observatories in Australia and the Australian Antarctic Territory (Figure 1), located at:

- West Island (CKI), Cocos (Keeling) Islands;
- Kakadu (KDU), Northern Territory;
- Charters Towers (CTA), Queensland;
- Learmonth (LRM), Western Australia;
- Alice Springs (ASP), Northern Territory;
- Gingin (GNG), Western Australia;
- Gnangara (GNA), Western Australia;
- Canberra (CNB), Australian Capital Territory;
- Macquarie Island (MCQ), Tasmania (sub-Antarctic);
- Mawson (MAW), Australian Antarctic Territory, and;
- Casey (CSY), Australian Antarctic Territory.

Figure 1. *The Geoscience Australia geomagnetic observatory network.*

The new Gingin geomagnetic observatory began operations in November 2011. It is about 70 km north of Perth and will eventually replace the Gnangara observatory which is now too close to the outer suburbs of Perth. The two observatories will operate in parallel for about 12 months to obtain an accurate station difference before operations cease at Gnangara. Gingin observatory will permit the continued acquisition of geomagnetic data in southern Western Australia which began in 1919 with the establishment of an observatory at Watheroo by the Carnegie Institution of Washington.

During 2011 work began to establish an observatory on the Cocos (Keeling) Islands. The observatory is a three-way collaboration among Geoscience Australia, IPS Radio and Space Services, and ETH Zurich. The observatory was not yet operational at the end of 2011.

Antarctic operations

Geoscience Australia contributes to the Australian National Antarctic Research Expedition through its magnetic observatories at Macquarie Island, Casey and Mawson. Operations at these observatories are supervised and managed from Geoscience Australia headquarters in Canberra with logistic and operational support provided by the Australian Antarctic Division.

Repeat stations

Geoscience Australia maintains a network of magnetic repeat stations throughout continental Australia and its offshore islands, Papua New Guinea, the Solomon Islands and New Caledonia. Stations are occupied every two to four years to provide secular variation data.

Magnetometer calibration

Canberra magnetic observatory hosts the Geoscience Australia Magnetometer Calibration Facility. Built in 1999, in collaboration with the Department of Defence, it comprises a Finnish/Ukrainian-designed 3-axis coil system used to calibrate observatory variometers and client instrumentation on a cost recovery basis.

Compass calibration

Geoscience Australia provides a service for calibrating and testing direction finding and other instrumentation at cost recovery rates. This service is used by civilian and military agencies requiring the calibration of compasses and compass theodolites as well as the determination of magnetic signatures of other equipment.

Data distribution

Geomagnetic time series recorded by the observatory network are transmitted to Geoscience Australia in near real-time. They are then processed automatically and analysed to derive a range of products distributed to Australian and international clients.

Time series

Preliminary 1-second time series are provided in near real-time by ftp to IPS Radio and Space Services, Sydney, where they are used for space weather forecasting and analysis. One-second data are also provided to the Edinburgh INTERMAGNET geomagnetic information node (GIN) using http.

Preliminary 1-minute time series are available in near real-time on the Geoscience Australia website. One-minute time series are also sent to the Edinburgh INTERMAGNET GIN using http. These data are made available on the INTERMAGNET website. Alice Springs 1-minute time series are sent to the World Data Center for Geomagnetism in Kyoto, Japan.

Definitive 1-minute mean values in X, Y, Z and F, and hourly mean values in all geomagnetic elements for all Geoscience Australia observatories, except the newly established Gingin and Cocos (Keeling) Islands observatories, are submitted annually to the Paris INTERMAGNET GIN. Under agreement with the National Oceanic and Atmospheric Administration (NOAA), USA, these data are then obtained directly from INTERMAGNET by the National Geophysical Data Center (NGDC), Boulder, and ingested into the World Data Center for Solar-Terrestrial Physics.

Australian magnetic observatory data have been contributed to INTERMAGNET since the first CD of definitive data was produced (St-Louis, 2008). Table 1 summarises Australian data that have been distributed on INTERMAGNET CDs. The commencement of regular transmission of preliminary near real-time 1 minute data to the Edinburgh INTERMAGNET GIN and the frequency of data transmission are also shown in the table.

Data are also provided in response to direct requests from government, educational institutions, industry and individuals.

Table 1. *Data distribution from Australian geomagnetic observatories to INTERMAGNET.*

Observatory	Data first on CD	Data first transmitted	Data transmission frequency
KDU	2000	August 2001	real-time
CTA	2000	August 2001	real-time
LRM	2005	23 August 2005	real-time
ASP	1999	December 1999	real-time
GNA	1994	early 1995	real-time
CNB	1991	October 1994	real-time
MCQ	2001	June 2002	real-time
MAW	2005	24 November 2005	real-time
CSY		15 July 2011	real-time

Magnetic activity indices

K indices for Canberra, Gnangara, Gingin and Mawson, are derived using a computer-assisted method developed at Geoscience Australia. The method uses the linear-phase, robust, non-linear smoothing (LRNS) algorithm (Hattingh *et al*., 1989) to estimate the quiet or 'non-K' daily variation. This initial estimate can be adjusted on-screen using a spline fitting technique. The estimated non-K variation for the day is then automatically subtracted from the magnetic variations and the residual scaled for K indices.

Canberra (and its predecessors Toolangi and Melbourne) and Hartland (and its predecessors Abinger and Greenwich) in the UK are the two observatories used to determine the global ‘antipodal’ aa index.

Canberra is also one of thirteen mid latitude observatories used in the derivation of the planetary three hourly Kp range index. Of these observatories, only Canberra and Eyrewell (NZ) are in the southern hemisphere. Gnangara and Canberra are two of the twenty-one observatories in the sub-auroral zones used in the derivation of the ‘mondial’ am index.

K indices from both Canberra and Gnangara are provided to:

- IPS Radio and Space Services, Sydney, from where they are further distributed to recipients of IPS bulletins and reports, and;
- the International Service of Geomagnetic Indices (ISGI), France, for the compilation of the ‘antipodal’ aa index and the world-wide ‘mondial’ am index.

K indices from Canberra observatory are also provided to:

- GeoForschungsZentrum, Potsdam, Germany, for the derivation of global geomagnetic activity indicators such as the ‘planetary’ Kp index;
- University of Newcastle, Australia;
- Geomagnetism Group of the British Geological Survey;
- CLS, CNES (French Space Agency), Toulouse, France, and;
- Royal Observatory of Belgium, Brussels.

All routine K index information is transmitted by email.

Storms and rapid variations

Details of storms and rapid variations at Canberra and Gnangara are provided monthly to:

- World Data Center for Solar-Terrestrial Physics, Boulder, USA;
- World Data Center for Geomagnetism, Kyoto, Japan, and;
- Observatori de l’Ebre, Spain.

Australian Geomagnetism Reports

The Australian Geomagnetism Report was first published as the monthly *Observatory Report* in September 1952. The series was renamed the *Geophysical Observatory Report* in January 1953 (Vol. 1, No. 1) and became the *Australian Geomagnetism Report* in January 1990 (Vol. 38, No. 1). The monthly series was replaced by an annual report in 1993 (Vol. 41). Details of other reports containing Australian geomagnetic data are given in Hopgood (1999 and 2000).

The current annual report series includes data from the magnetic observatories and repeat stations operated by Geoscience Australia. Detailed information about the instrumentation and the observatories is included in McEwin and Hopgood (1994) and Hopgood and McEwin (1997).

From 1999 Australian Geomagnetism Reports have been produced in digital form only. They may be viewed or downloaded at Geoscience Australia's website (http://www.ga.gov.au/earth-monitoring/geomagnetism.html).

World wide web

Australian geomagnetic information, including data and indices from Australian observatories, the current AGRF model, and information about Earth's magnetic field, is available on the Geoscience Australia website.

Instrumentation

Variometers

The basic variometer system used at Australian geomagnetic observatories to monitor magnetic fluctuations comprises a 3-component vector variometer and a total-field scalar variometer. Time-series data are recorded digitally and transmitted to Geoscience Australia in near real-time.

Vector variometer sensors at Australian observatories are orientated so the two horizontal components have similar magnitude. In the typical configuration the horizontal sensors are aligned at 45° to the magnetic meridian (i.e. magnetic NW and NE) and the third sensor is vertical. However, at Macquarie Island each sensor makes an angle of approximately 55° with the magnetic vector so that all 3 components have similar magnitude.

One of the benefits of these alignments is that quality control using the FCheck test, which calculates the difference between F determined using the vector variometer (final data model with drifts applied) and F obtained from the scalar variometer, is optimised. Another is that, should one of the vector channels become unserviceable, vector data may be recovered using the remaining two channels and the scalar variometer data (Crosthwaite, 1992, 1994).

Recording intervals and mean values

The primary recording intervals are 1 second for vector data and 10 seconds for scalar data. Longer-interval time series are derived from these data using the methods described below and summarised in Figure 2 and Table 2.

For vector data, a 1-minute time series is derived from the 1-second data by computing a weighted average of the 1-second value on the minute and the 45 s of data before and 45 s after the minute. The weightings are defined in the INTERMAGNET filter (St-Louis, 2008) and the resulting mean values are centred on the minute. (See Figure 2a.) For example, the minute value labelled 01m is derived from the 1-second values from 00m15s to 01m45s inclusive. Where 1-second data are missing from the average window, gaps of up to 12 data points are filled by linear interpolation. Gaps greater than 12 points are not filled and the associated minute value is not computed.

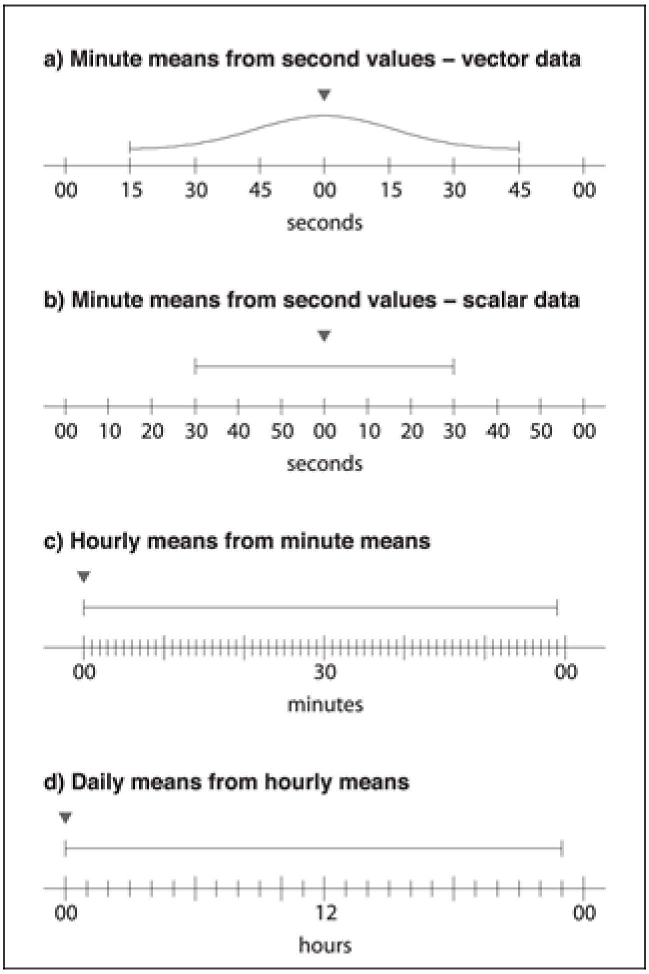


Figure 2. *Derivation of a) minute means from second values for vector data, b) minute means from second values for scalar data, c) hourly means from minute values, and, d) daily means from hourly values.*

For scalar data, 1-minute means are derived from the 10-second time series by using a box filter to average the 10-second value on the minute and the three 10-second values before and after the minute. The resulting mean minute values are also centred on the minute. (See Figure 2b.) At least three 10-second readings must be present in the average window for the 1-minute mean value to be computed.

Hourly mean values are computed from minutes 00m to 59m, using the IAGA-recommended method. (See Figure 2c.) For example, the hourly mean value labelled 01h is the mean of the 1-minute values from 01:00 to 01:59 inclusive. At least twelve 1-minute values must be present in the average window for the hourly mean to be computed.

Table 2. Summary of the derivation of mean value time series.

Time series		Average filter	Data points	
Derived	From		Max	Min
1-minute - vector	1-second	INTERMAGNET	91	7
1-minute - scalar	10-second	Box	7	3
hourly	1-minute	Box	60	12
daily	hourly	Box	24	24
monthly	daily	Box	28-31	1
annual - quiet	minutes	Box	86400	1
annual - disturbed	minutes	Box	86400	1
annual - all-day	minutes	Box	525600-527040	1

Daily means are the average of twenty-four hourly mean values, from hours 00^h to 23^h. (See Figure 2d.) All twenty-four hourly values must be present in the average window for the daily mean to be computed.

Monthly means are computed from daily means. At least one daily value must exist in the month for the monthly mean to be calculated.

Quiet Day, Disturbed Day and All Day annual means are computed by averaging all available minute values for the five International Quiet Days and five International Disturbed Days each month, and for All Days in the year. No minimum number of data points is specified for the annual mean calculations.

Data reduction

Using regular absolute observations, parameters are obtained that enable the calculation of the X, Y and Z (and so H, D, I and F) components of the magnetic field using an equation of the form:

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} S_{XA} & S_{XB} & S_{XC} \\ S_{YA} & S_{YB} & S_{YC} \\ S_{ZA} & S_{ZB} & S_{ZC} \end{pmatrix} \begin{pmatrix} A \\ B \\ C \end{pmatrix} + \begin{pmatrix} B_X \\ B_Y \\ B_Z \end{pmatrix}$$
$$+ \begin{pmatrix} Q_X \\ Q_Y \\ Q_Z \end{pmatrix} (T - T_S) + \begin{pmatrix} q_X \\ q_Y \\ q_Z \end{pmatrix} (t - t_S) + \begin{pmatrix} D_X \\ D_Y \\ D_Z \end{pmatrix} (\tau - \tau_0)$$

where:

- A, B and C are the near orthogonal, arbitrarily orientated variometer ordinates;
- matrix [S] combines scale values and orientation parameters;
- vector [B] contains baseline values;
- vectors [Q] and [q] contain temperature coefficients for sensors and electronics;
- T and t are the temperatures of the sensors and electronics;
- T_s and t_s are their standard temperatures;
- vector [D] contains drift-rates with a time origin at τ_0, where τ is the time.

The parameters in [S], [Q] and [q] are determined using the calibration coils at the Geoscience Australia Magnetometer Calibration Facility while those in [B] and [D] that best fit the absolute observations are determined by visual observation.

Absolute magnetometers

The principal absolute magnetometers used to calibrate variometers at Australian magnetic observatories are DI fluxgate magnetometers (or Declination and Inclination Magnetometers – DIMs) to measure the magnetic field direction, and proton-precession or Overhauser-effect magnetometers to measure its total intensity.

DIMs at Australian observatories use Bartington MAG 01H and DMI Model G fluxgate sensors and electronics mounted on Zeiss Jena 020B and 010B non-magnetic theodolites.

DIM observations at most observatories are performed using the *offset* method. In this method, the theodolite is set to the whole number of minutes nearest a null fluxgate output, resulting in a small non-zero output. The theodolite circle reading and a series of eight fluxgate–time readings are then recorded in each position. At some observatories the *null* method continues to be used. In this method, the theodolite is set to achieve a null fluxgate output and a single theodolite–time reading is recorded in each position.

Reference magnetometers

Geoscience Australia maintains reference magnetometers for declination, inclination and total intensity at Canberra magnetic observatory where they are in routine use to calibrate the variometers. A DIM is used as both the declination and inclination reference and an Overhauser-effect magnetometer is used as the total-field reference.

Regular inter-comparisons performed at IAGA workshops on *Geomagnetic Observatory Instruments, Data Acquisition and Processing* relate the Australian reference magnetometers to international standards. Absolute instruments used at Australian observatories are periodically compared with the reference magnetometers, sometimes through subsidiary travelling reference instruments.

Results identified as *final* in this report indicate that absolute magnetometers used to determine baselines have been corrected to international standards.

Data acquisition

Data-acquisition computers at Australian observatories use software built around the QNX operating system. Timing is governed by the operating system clock which is maintained to within 1 ms of UTC using an external GPS clock. The Network Time Protocol daemon (ntpd), which can maintain the system clock to within 10 ms of UTC, is also available as a backup. All observatories used an external GPS clock to maintain timing accuracy throughout 2011.

ADAM A/D converters are used to convert analogue outputs from the DMI FGE and EDA 3 component variometers to digital data for recording on data-acquisition computers. The Narod ring-core fluxgate magnetometers have built-in A/D converters that provide digital data direct to the acquisition computers.

Observatory data are retrieved to Geoscience Australia in near real-time via the NextG mobile phone network, satellite, ADSL, radio, network links and telephone-line modems within Australia and via the ANARESAT satellite link from Antarctica.

Uninterruptible Power Supplies (UPS) or DC-battery power supplies are installed at all observatories. Lightning surge filters are installed where required.

1. Kakadu

Kakadu Geophysical Observatory is located in the Northern Territory, 210 km east of Darwin and 40 km west of Jabiru on the Arnhem Highway, near the South Alligator Ranger Station, Kakadu National Park. It comprises magnetic and seismological observatories and a gravity station. Kakadu magnetic observatory is situated on unconsolidated ferruginous and clayey sand. Continuous magnetic-field recording began there in March 1995.

The magnetic observatory comprises:

- a 3×3 m air-conditioned concrete-brick Control House, with concrete ceiling and aluminium cladding and roof, where recording instrumentation and control equipment are housed;
- a 3×3 m roofed Absolute Shelter, 50 m NW of the Control House, that houses a 380 mm square fibre-mesh-concrete observation pier (Pier A), the top of which is 1200 mm from its concrete floor;
- two 300 mm diameter azimuth pillars, both about 100 m from Pier A and with approximate true bearings of 27° and 238°;
- two 600 mm square underground vaults that house the variometer sensors, both located 50-60 m from the Control House, one to its SSW and one to its WSW (cables between the sensor vaults and the Control House are routed via underground conduits), and;
- a concrete slab, with tripod foot placements and a marker plate, used as an external reference site E (at a standard height of 1.6 m above the marker plate). The marker plate is 60 m, at a bearing of 331°, from the principal observation pier A.

Key data for the observatory are given in Table 1.1.

Variometers

The variometers used during 2011 are described in Table 1.2.

Analogue outputs from the three fluxgate sensors, and the sensor and electronics temperatures, were converted to digital data using an ADAM 4017 analogue-to-digital converter mounted inside the fluxgate electronics unit. These data and the digital PPM data were recorded on the data acquisition computer located in the Control House.

The magnetic sensors were located in the concrete underground vaults: the fluxgate sensor in the northern vault (the one nearer the Absolute Shelter); and the PPM sensor in the southern vault. Both vaults were completely buried in soil to minimise temperature fluctuations.

The GSM-90 variometer electronics was located in the covered vault with its sensor. DC power and data cables ran between the GSM-90 vault and the Control House.

The fluxgate electronics console was placed in its own partially insulated plastic box, resting on the concrete floor in the Control Hut, with some bricks for heat-sinks to minimise temperature fluctuations.

This proved to be effective in reducing the amplitude of temperature fluctuations with periods of the order of hours.

The equipment was protected from power blackouts, surges and lightning strikes by a mains filter, an uninterruptible power supply and a surge absorber. The data connections between the acquisition computer and both the ADAM A/D and the PPM variometer prior to 2008 were via fibre-optic modems and several metres of fibre-optic cable to isolate any damage from lightning entering the system through any one piece of equipment. The fibre-cables were rearranged during 2007, and during and after 2008 there was no fibre in the PPM data-link.

Table 1.1 *Key observatory data.*

IAGA code:	KDU
Commenced operation:	05 March 1995
Geographic latitude:	12° 41' 10.9" S
Geographic longitude:	132° 28' 20.5" E
Geomagnetic latitude:	-21.49°
Geomagnetic longitude:	206.11°
K 9 index lower limit:	300 nT
Principal pier:	Pier A
Pier elevation (top):	14.6 m AMSL
Principal reference mark:	Pillar AW
Reference mark azimuth:	237° 52.8'
Reference mark distance:	99.6 m
Observer:	A. Ralph

Table 1.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	DMI FGE
Serial number:	E0198 / S0183
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.032 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	4071413 / 42185
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	9600b VSAT satellite link

Table 1.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	Bartington MAG-01H
Serial number:	B0622H
Theodolite:	Zeiss 020B
Serial number:	359142
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081421 / 42186
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Although some lightning protection measures were incorporated in its original construction, Kakadu Observatory has suffered frequent lightning damage since its installation in 1995. Additional protection measures were taken in December 1998 and October 1999, including the installation of an ERICO system. Since then, although power and communications have frequently been interrupted, the observatory has survived serious damage from electrical storms. Still, on 18 November 2010, between 06:30 and 09:30 UT, it appears that a lightning strike damaged nearby electrical infrastructure supporting the observatory and caused 5 days of GSM-90 PPM data loss. In 2011, no data loss occurred due to lightning strike.

The ERICO System 3000 (Advanced Integrated Lightning Protection), comprising a Dynasphere Air Termination unit, mast, and copper-coated-steel earthing rod, was designed to protect an area of 80 m radius. Lengths of copper ribbon and aluminium power cables buried in shallow trenches towards the Absolute Shelter, in the opposite direction, and from the Control House to and around both variometer sensor vaults, and a conducting loop around the Control House, were connected to the ERICO system.

The DMI FGE variometer scale-value, alignment, and temperature sensitivity parameters were measured at the magnetometer calibration facility at Canberra observatory before installation at Kakadu. The sensor assembly was aligned with the two horizontal fluxgate sensors at 45° to the declination at the time of installation and the Z fluxgate sensor vertical. This alignment was achieved by setting the X and Y offsets equal and rotating the instrument until the X and Y ordinates were equal. This method has been found to be accurate using tests performed at the calibration facility.

The Control House, which houses the DMI electronics, had its temperature maintained by an air conditioning unit. The current unit was installed in November 2008 and replaced the previous unit which had become unserviceable. During 2011 the temperature of the DMI electronics ranged from 25.7°C (in the winter months) to 30°C (in the summer months). The annual temperature variation of 4.3°C converted to variations 0.2 nT, 0.7 nT and 0.0 nT in the X, Y and Z channels. The DMI electronics temperature coefficients in the baseline file were: qX 0.04 nT/°C, qY -0.17 nT/°C, and qZ 0.00 nT/°C.

The DMI sensor temperature ranged from 18°C to 26°C during the year. Although buried underground, it varied during the year in accordance with the seasons at long periods and probably with barometric pressure systems at short periods. Temperature variations converted to variations 0.2 nT, 0.5 nT and 0.6 nT in the X, Y and Z channels. DMI sensor coefficients in the baseline file were: QX 0.03 nT/°C, QY -0.06 nT/°C and QZ -0.07 nT/°C.

Variometer data timing was controlled by the QNX data-acquisition computer clock which was maintained using both the 1 PPS and data stream output of a GPS clock. A small error occasionally occurred just after computer resets which was corrected within a few minutes. Time corrections were logged automatically.

Absolute instruments

The principal absolute magnetometers used at Kakadu and their adopted corrections for 2011 are described in Table 1.3.

The best way to use the Kakadu DIM is to take all readings on the x10 scale and to switch to the x1 scale while rotating the theodolite. Additionally, the theodolite should be rotated so that the objective lens passes exclusively through positive field values (or alternatively exclusively through negative field values). These measures reduce the effects of hysteresis in the fluxgate sensor. The observer was trained to use this method throughout the year at Kakadu.

DIM observations at Kakadu were performed using the offset method. All DIM and PPM measurements were made on the principal pier at the standard height.

Table 1.3 describes the corrections applied to the absolute magnetometers to align them with the Australian reference instruments held in Canberra.

At the 2011 mean magnetic field values at Kakadu the D, I and F corrections translate to corrections of:

$\Delta X = 0.0$ nT $\Delta Y = 0.0$ nT $\Delta Z = 0.0$ nT

These instrument corrections have been applied to the data described in this report and to other published definitive data.

Baselines

There were 29 pairs of absolute measurements during 2011. The vector variometer baseline variations were reasonably well controlled though the baseline observations were more scattered and less frequent than would be preferred. Therefore the vector variometer baselines were determined as usual from both the absolute measurements and the scalar F data, but weighting the F data relatively higher than at other observatories with better quality and more frequent absolute observations.

The scalar F baseline was adjusted to make the average (absolute F - scalar F) close to zero. The F difference time series Fv-Fs was then plotted to check variometer baseline variations throughout 2011. This F difference had an average of -4 nT and a range of 1 nT, suggesting the DMI variometer baselines through 2011 were stable. However, an adjustment was needed to force the average Fv-Fs close to zero and so agree with the difference of (absolute F - scalar F).

Two options were explored to achieve this outcome. The first was to apply drifts to the variometer baselines across the 2010-2011 year boundary. A trial was made, and the Fv-Fs difference had a steep slope at the beginning of 2011 with a range of 4 nT. This range was difficult to justify as there were no absolute observations between 2010-11-16 and 2011-01-18.

The second option was to put steps in the variometer baselines across the 2010-2011 year boundary. The step was 2 nT for X, and -2 nT for Z determined by the majority of absolute observation data throughout 2011 to June 2012. The F difference range remained 1 nT with an average of -0.75 nT throughout 2011. This second option was adopted for the 2011 baselines.

There were five baseline jumps in the vector variometer due mainly to the instability of the power supply.

2011-09-14, power supply swapped from Piccolo to UPS:
X 6.8 nT
Z -5.6 nT

2011-11-19, power supply swapped from UPS to Piccolo:
X -1.0 nT

2011-12-14, Piccolo overloaded:
X -1.0 nT
Z 0.5 nT

2011-12-17, Piccolo overloaded:
X 1.0 nT
Z -0.5 nT

2011-12-21, UPS disconnected from Piccolo:
X 5.0 nT
Z -4.0 nT

There was one baseline jump in the scalar variometer.

2011-06-16, electronics position changed in variometer sensor vault:
F -3.5 nT

The means and standard deviations of the weekly absolute observations from the final adopted variometer model and data were:

	mean	stdev
X	0.2 nT	2.9 nT
Y	0.8 nT	4.6 nT
Z	0.2 nT	3.2 nT
D	4.3"	27"
I	1.2"	14"
F	0.1 nT	2.9 nT

Observed and adopted baseline values in X, Y and Z are shown in Figure 1.1.

Operations

When possible, local observer, Andy Ralph, performed absolute observations weekly. Due to weather conditions such as floods and heavy rains during monsoons, and other commitments particularly during the tourist season between monsoons, Andy was unable to make as many observations as is customary at geomagnetic observatories. The lack of frequent quality observations is problematic, but FCheck indicates the DMI FGE magnetometer baselines have been stable since 2010.

The local observer was trained at Kakadu Observatory in September 2006 with refresher training in October 2009. In general, absolute observations were of good quality. Occasionally some observations were unacceptable, the most likely reason being magnetic contamination. Completed absolute observation forms were posted to Geoscience Australia where they were reduced and used to calibrate the variometer data.

On weekly visits, Andy checked the operation of the observatory and maintained the observatory in good condition, such as building pest control, mowing grass and changing batteries.

L. Wang and T. Bolton from GA visited the observatory on 17 June 2011 to fix the problem in GSM-90 PPM which gave multiple spikes sometimes. The problem was the DB9 plug out of the GSM-90 had a ground connected to pin 1 rather than pin 5. The work caused baseline shifts in the PPM data.

Data were retrieved from the data-acquisition system at least every 10 minutes using rsync over ssh in near real-time using the network connection.

The distribution of Kakadu 2011 data is described in Table 1.4. Data losses are identified in Table A.1.

Table 1.4. *Distribution of Kakadu 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
WDC for Geomagnetism	preliminary	real time

Significant events

2011-01-06 DIM electronics box (b0622H) was tested ok and posted back to KDU.

2011-02-01 AR mowed the areas around obs buldings.

2011-02-04 AR reported the phone line is faulty. Reorted the problem to IT helpdeck.

2011-02-08 Chris advised that Telstra will investigate the line problem around 11 Feb

2011-02-09 Telstra advised us that phone line problem has been fixed. - cable was damaged. checked analogue modem connection - no success.

2011-02-24 No Obs collected for previous week as road was flooded. Phone is out in the whole ranger station.

2011-03-18	Andy will be in Sydney from 18 - 28 March. No obs for this period.
2011-04-04	Andy commented that obs difficult with heavy rain and sky very dark,theodolite hard to read.
2011-04-07	Multiple PPM spikes, appears to be instrumental in origin rather than lightning. Spike values are 66240 nT and 0 nT
2011-04-08	00:05 (approx) slay GdapGSM90 and qtalk to GSM90 to re-tune and check parameters "Gem Systems GSM-90 7 IX 1999 ?-menu !-tests Cyymmddwhhmmss-set-time d-date(mm-dd-yy) t-time(hh:mm:ss) Txx-tuning F-field O-magnetic-observatory x-auto-tuning y-no-auto-tuning B-base-5s ok " T46ok +12.5ok N006 ok S076 1723 ok bok (set to RF 3.5s) F46263.11 a 00:13 restart GdapGSM90 00:36 check analogue modem connection - no response
2011-04-11	Multiple PPM spikes have continued since 2011-04-11
2011-05-19	03:15 PPM stops suddenly, 05_53 PPM running O.K. after a brief period of spikes - reason unknown
2011-05-22	Andy reported phone line is faulty.
2011-06-08	Data telemetry fails due to cabling problems on VSAT dish. Due for repair on 2011-06-16
2011-06-17	LJW and Tim Bolton on site. Telemetry re-instated. Found that DB9 out of variometer GSM90 had ground connected to pin 1 rather than pin 5. Both RS232-485 converters also swapped with spares. Not getting readings every 10s. 07:00 change from a to b polarise time.
2011-06-17	around 22:40 16 June UT, PPM vault lid was put back on, then covered with soil. Did absolute obs before the PPM vault was opened and after re-buried. see obs on day 166 and 167
2011-07-15	Next week Andy will be in Arnhem Land then Darwin all week and can’t do obs.
2011-08-30	07UT Mag 6.9 earthquake
2011-09-06	A lid which covered a small vault near Satellite Dish was broken. The size of the hole is 73cm long x 30cm wide
2011-09-13	Since yesterday, the DMI has been regularly stopping (with odd F-Check behaviour when it starts up again).
2011-09-14	AR checked the yellow Piccolo inverter at around UT 00:30, it was hot and a red light flashing on it. Unplugged the DMI power cord from the inverter, and then plugged it into Powerware UPS. AR did obs afterwards.
2011-09-19	Telstra technician on site to repair phone line. 04:08 to 04:17
2011-09-20	Telstra technician on site to repair phone line. 06:04 to 06:33
2011-09-21	Telstra technician on site to repair phone line. 03:12 to 03:25
2011-10-03	AR checked the phone line, it works now.
2011-10-07	Wasps were found in a orange conduit pipe out of the control house wall. Andy sprayed the nests
2011-10-11	A new battery for the Bartington electronics (6V/1.2A) was posted to KDU. AR reported the voltage of the battery in the electronics box dropped from 6v to 4v after two sets of obs. It has happened a few times.
2011-11-03	Andy's arm was badly burned and there will be no obs for next 2-3 weeks.
2011-11-19	Andy met Steve (ATWS) at lunch time 19 Nov Saturday at the Aurora resort. Andy took Steve to the observatory. Steve installed a Piccolo inverter to replace failed unit. The inverter connected to a 2 way power board. One connected to a D-link (not switched on) and the other one connected to a 4 way white power board. DMI, ADAM (through AC/DC converter and TC1000 fibre to serial conver (AC/DC converter).

2011-11-24	Andy Ralph cannot login - ~00:50 remote reboot computer and he can then log in O.K. data loss between 00:55:30 - 00:56:17. 00:57:30 one second missed. 00:57:31 to 00:57:31, spike in z: 25nT 00:57:31 to 00:58:29, X shifted 34nT and Y shifted 16nT.
2011-12-02	received obs for 24 Nov and 29 Nov. Bothe Ef and EP changed 7 nT between two obs.
2011-12-06	Two sets of obs today. first set was done when a spray can was close to absolute hut. EP was -2.1. second set was done after the spray can was relocated 10m away from the hut. EP = -0.65. It appeared that spray cans might be the source for data contamination.
2011-12-18	DMI regularly stopped for about 9 minutes. This has lasted for a few days.
2011-12-21	Andy re-arranged the power for DMI. Piccolo inverter supplied power to DMI, ADAM and TC1000 directly. UPS is plugged into mains, as a spare one for DMI, ADAM and TC1000 if Piccolo failed.

Annual mean values

The annual mean values for Kakadu are set out in Table 1.5 and displayed with the secular variation in Figure 1.2.

Hourly mean values

Plots of the hourly mean values for Kakadu 2011 data are shown in Figure 1.3.

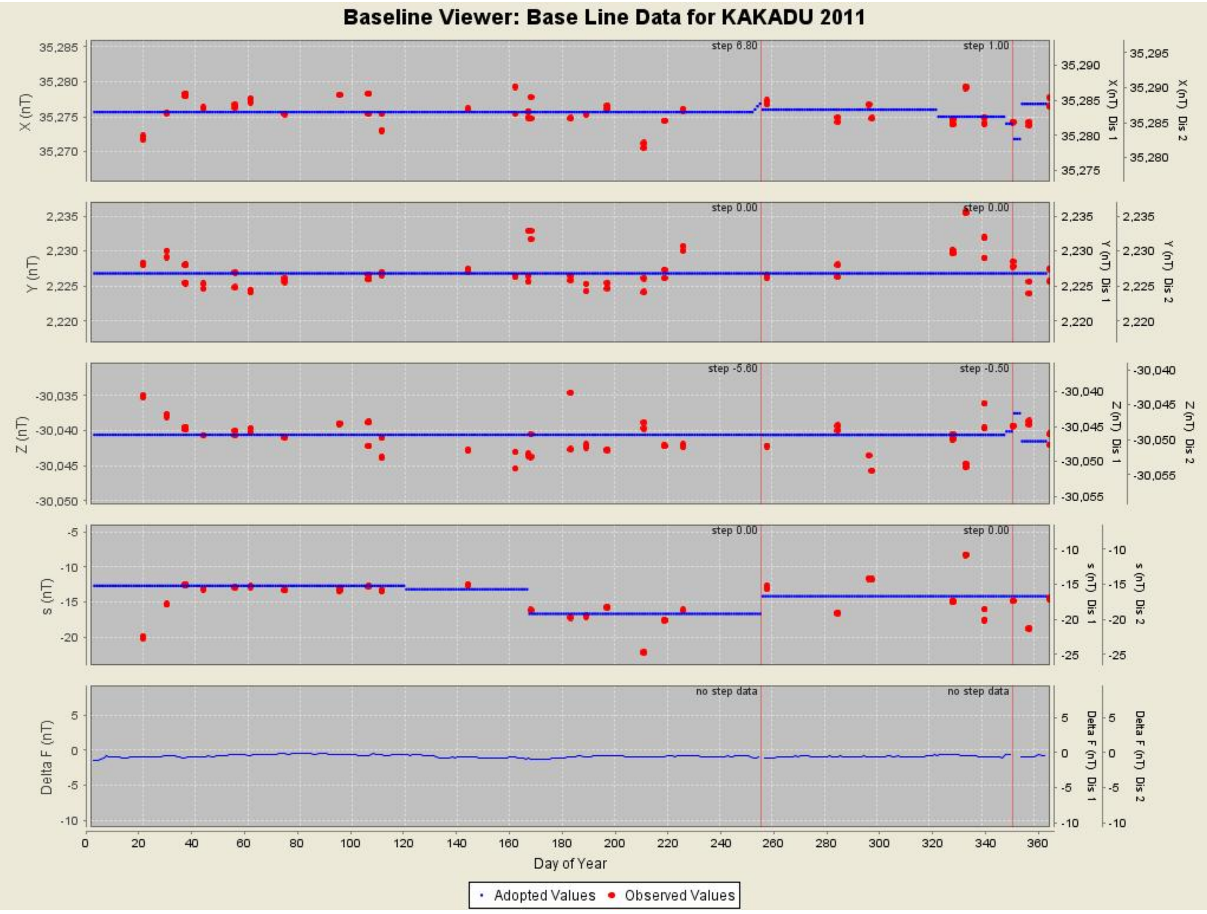


Figure 1.1. *Kakadu 2011 baseline plots.*

Table 1.5. *Kakadu annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 1.2.*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1995.583	A	3	42.6	-40	42.4	35364	35290	2288	-30424	46650	ABZ
1996.728	A	3	42.7	-40	37.9	35397	35323	2292	-30373	46642	ABZ
1997.455	A	3	42.9	-40	35.3	35409	35334	2294	-30336	46626	ABZ
1998.5	A	3	43.7	-40	31.2	35416	35341	2303	-30269	46589	ABZ
1999.5	A	3	44.2	-40	27.4	35432	35357	2309	-30216	46566	ABZ
2000.5	A	3	44.3	-40	24.5	35431	35356	2310	-30163	46531	ABZ
2001.5	A	3	44.3	-40	21.7	35437	35362	2310	-30118	46507	ABZ
2002.5	A	3	44.5	-40	19.1	35439	35364	2312	-30075	46480	ABZ
2003.5	A	3	44.1	-40	18.3	35422	35347	2308	-30046	46449	ABZ
2004.5	A	3	43.3	-40	15.7	35429	35354	2299	-30005	46428	ABZ
2005.5	A	3	42.2	-40	13.4	35424	35350	2288	-29960	46395	ABZ
2006.5	A	3	40.7	-40	10.1	35433	35360	2273	-29910	46370	ABZ
2007.5	A	3	38.6	-40	07.6	35432	35361	2252	-29864	46339	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
2008.5	A	3	36.4	-40	05.2	35434	35364	2229	-29823	46314	ABZ
2009.5	A	3	33.8	-40	02.0	35445	35377	2203	-29777	46293	ABZ
2010.5	A	3	30.4	-39	59.5	35445	35378	2168	-29732	46263	ABZ
2011.5	A	3	27.1	-39	57.0	35447	35382	2134	-29690	46238	ABZ
1995.583	Q	3	42.7	-40	41.8	35376	35302	2290	-30425	46660	ABZ
1996.728	Q	3	42.8	-40	37.6	35403	35328	2292	-30372	46646	ABZ
1997.455	Q	3	42.9	-40	34.7	35419	35345	2295	-30335	46634	ABZ
1998.5	Q	3	43.6	-40	30.7	35426	35351	2303	-30269	46596	ABZ
1999.5	Q	3	44.2	-40	26.9	35442	35367	2310	-30215	46573	ABZ
2000.5	Q	3	44.3	-40	23.7	35446	35370	2312	-30161	46541	ABZ
2001.5	Q	3	44.4	-40	20.9	35452	35376	2312	-30116	46517	ABZ
2002.5	Q	3	44.5	-40	18.4	35454	35378	2313	-30074	46491	ABZ
2003.5	Q	3	44.2	-40	17.4	35439	35363	2309	-30043	46459	ABZ
2004.5	Q	3	43.3	-40	15.0	35441	35366	2301	-30003	46435	ABZ
2005.5	Q	3	42.3	-40	12.7	35436	35362	2290	-29959	46403	ABZ
2006.5	Q	3	40.7	-40	09.6	35442	35369	2274	-29909	46376	ABZ
2007.5	Q	3	38.7	-40	07.3	35438	35367	2253	-29864	46344	ABZ
2008.5	Q	3	36.4	-40	04.8	35440	35370	2230	-29823	46318	ABZ
2009.5	Q	3	33.8	-40	01.8	35448	35380	2203	-29776	46295	ABZ
2010.5	Q	3	30.4	-39	59.1	35450	35384	2168	-29731	46267	ABZ
2011.5	Q	3	27.0	-39	56.5	35454	35390	2134	-29689	46243	ABZ
1995.583	D	3	42.4	-40	43.1	35350	35276	2286	-30426	46641	ABZ
1996.728	D	3	42.7	-40	38.3	35389	35315	2291	-30373	46636	ABZ
1997.455	D	3	42.8	-40	36.1	35393	35319	2292	-30337	46615	ABZ
1998.5	D	3	43.6	-40	32.8	35385	35310	2300	-30273	46568	ABZ
1999.5	D	3	44.2	-40	28.5	35411	35336	2308	-30218	46552	ABZ
2000.5	D	3	44.2	-40	26.0	35403	35328	2307	-30166	46512	ABZ
2001.5	D	3	44.2	-40	23.1	35410	35335	2307	-30121	46488	ABZ
2002.5	D	3	44.5	-40	20.4	35416	35341	2311	-30077	46464	ABZ
2003.5	D	3	44.0	-40	19.8	35396	35321	2305	-30050	46431	ABZ
2004.5	D	3	43.2	-40	16.9	35407	35332	2297	-30008	46412	ABZ
2005.5	D	3	42.2	-40	14.5	35404	35330	2286	-29963	46381	ABZ
2006.5	D	3	40.8	-40	10.9	35419	35346	2273	-29911	46359	ABZ
2007.5	D	3	38.6	-40	08.0	35423	35351	2251	-29865	46332	ABZ
2008.5	D	3	36.4	-40	05.6	35426	35356	2228	-29824	46308	ABZ
2009.5	D	3	33.8	-40	02.3	35439	35371	2202	-29777	46288	ABZ
2010.5	D	3	30.4	-40	00.0	35434	35368	2167	-29733	46256	ABZ
2011.5	D	3	27.1	-39	57.7	35435	35370	2133	-29692	46230	ABZ

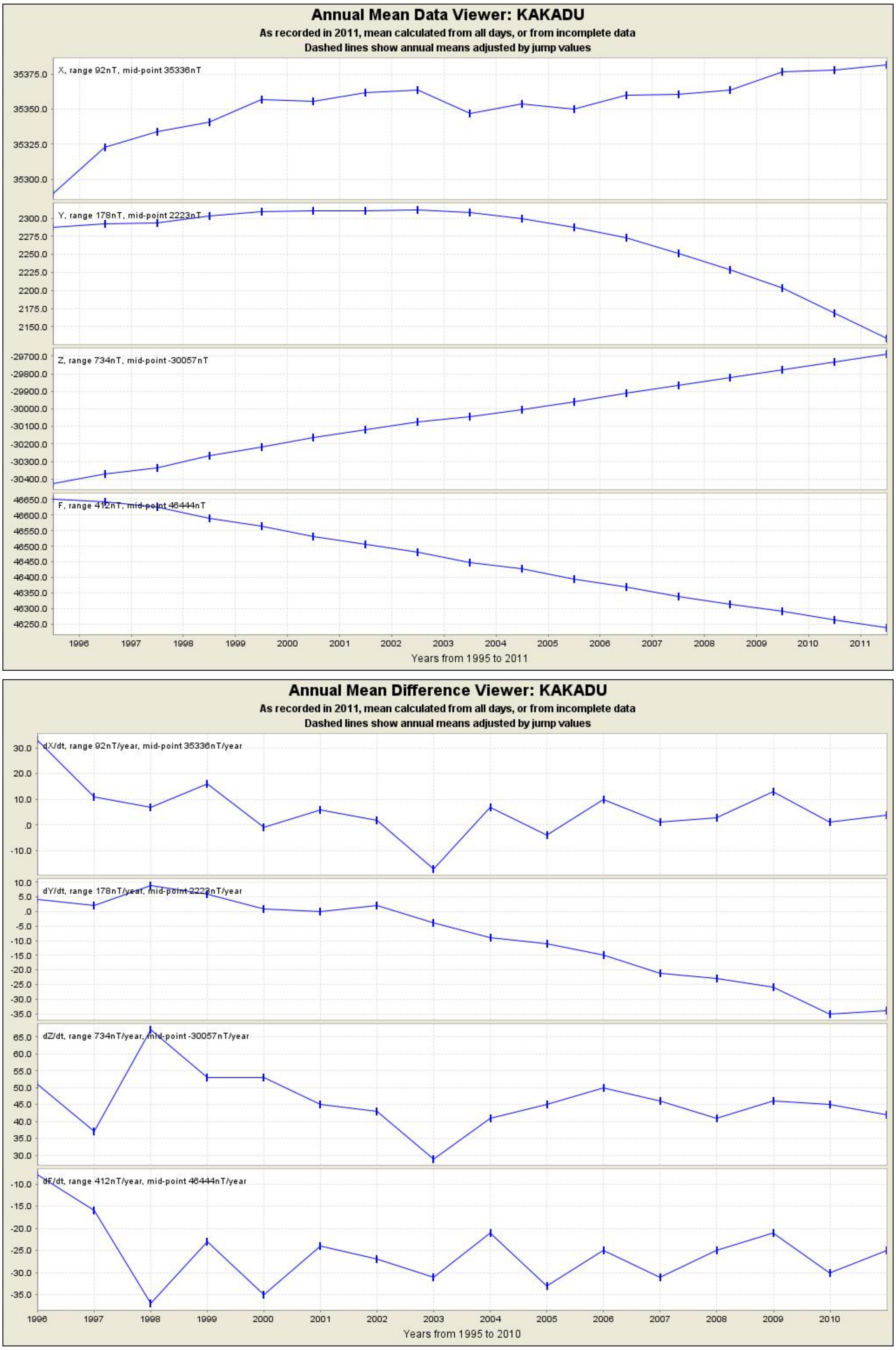
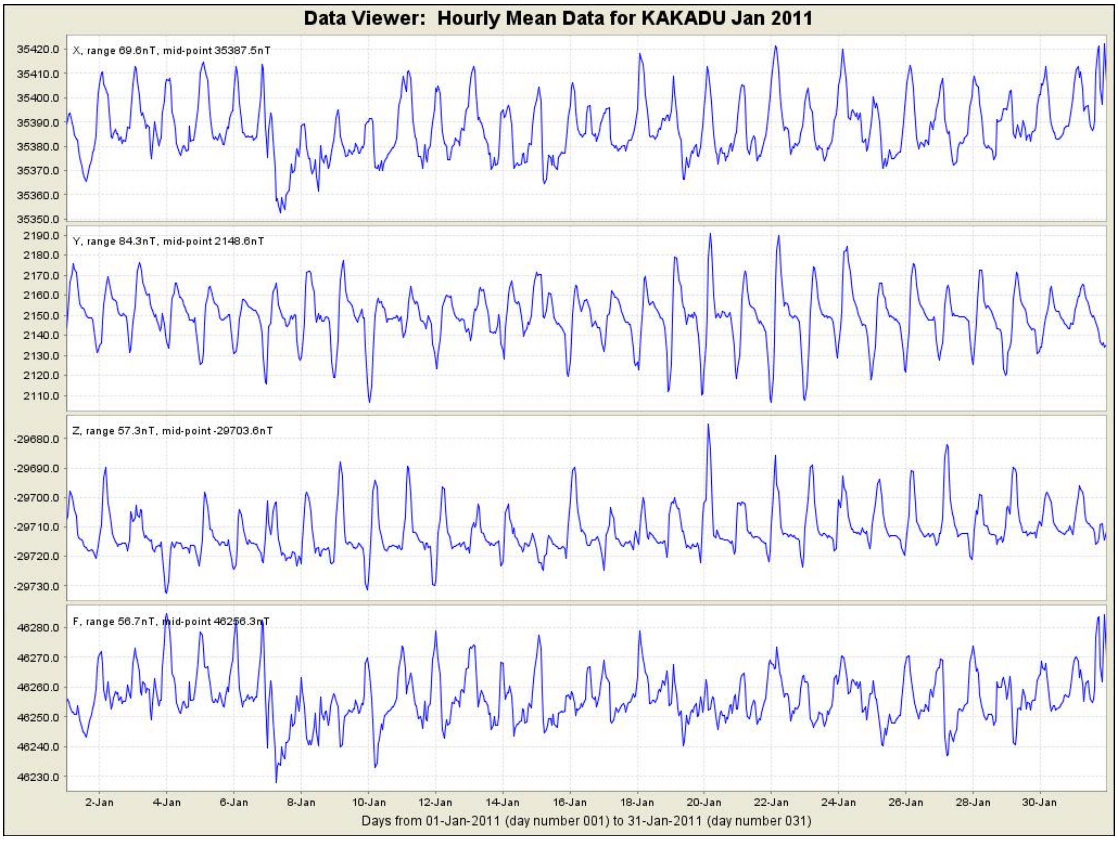
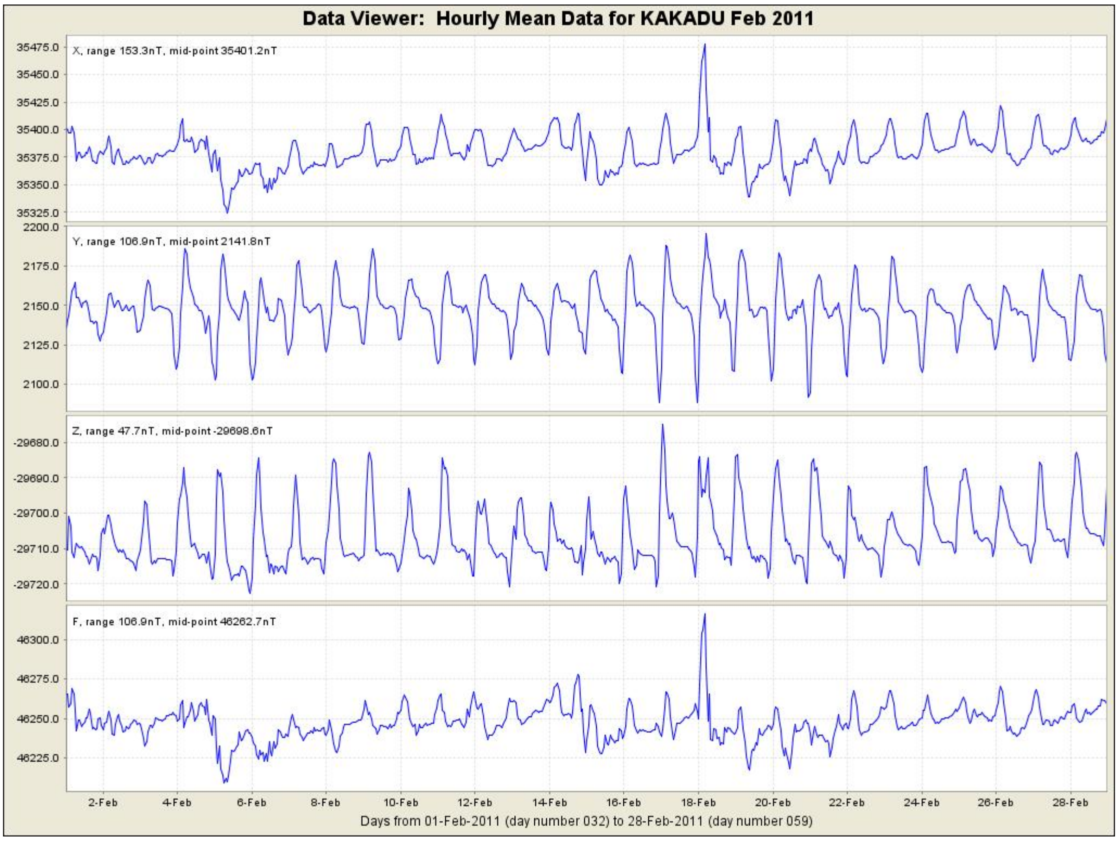
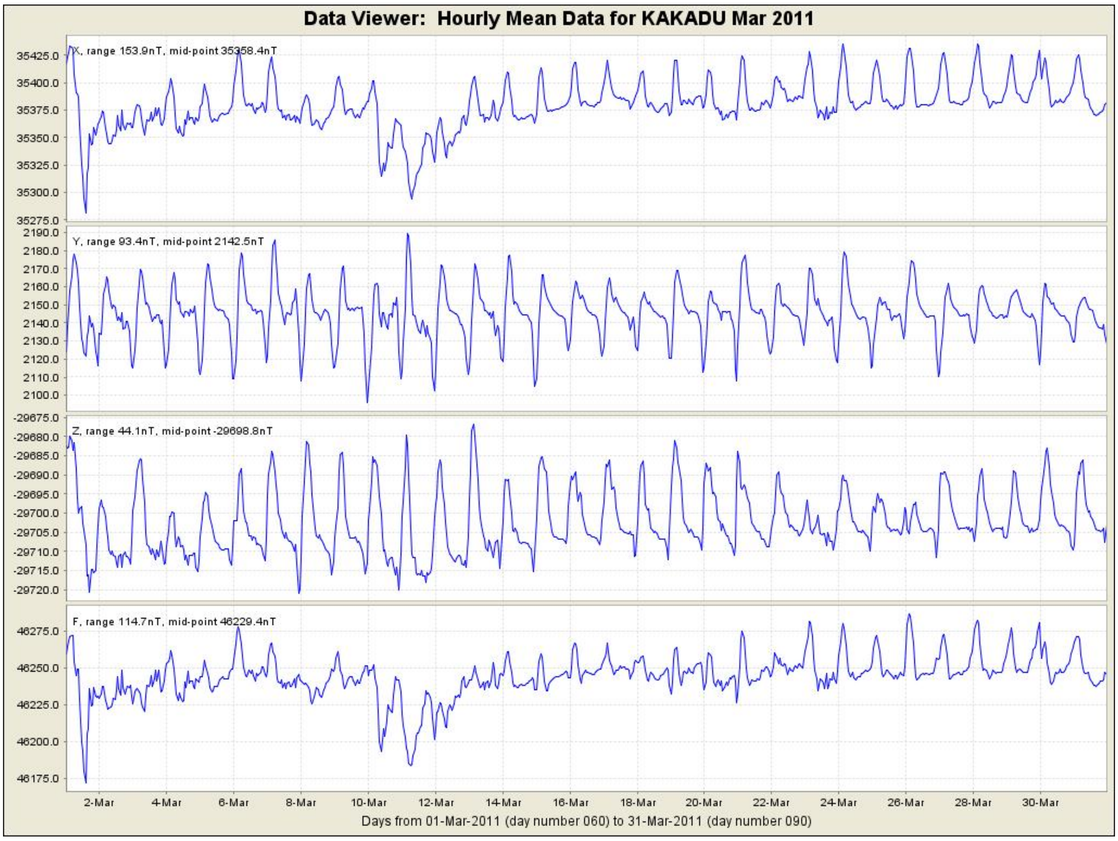
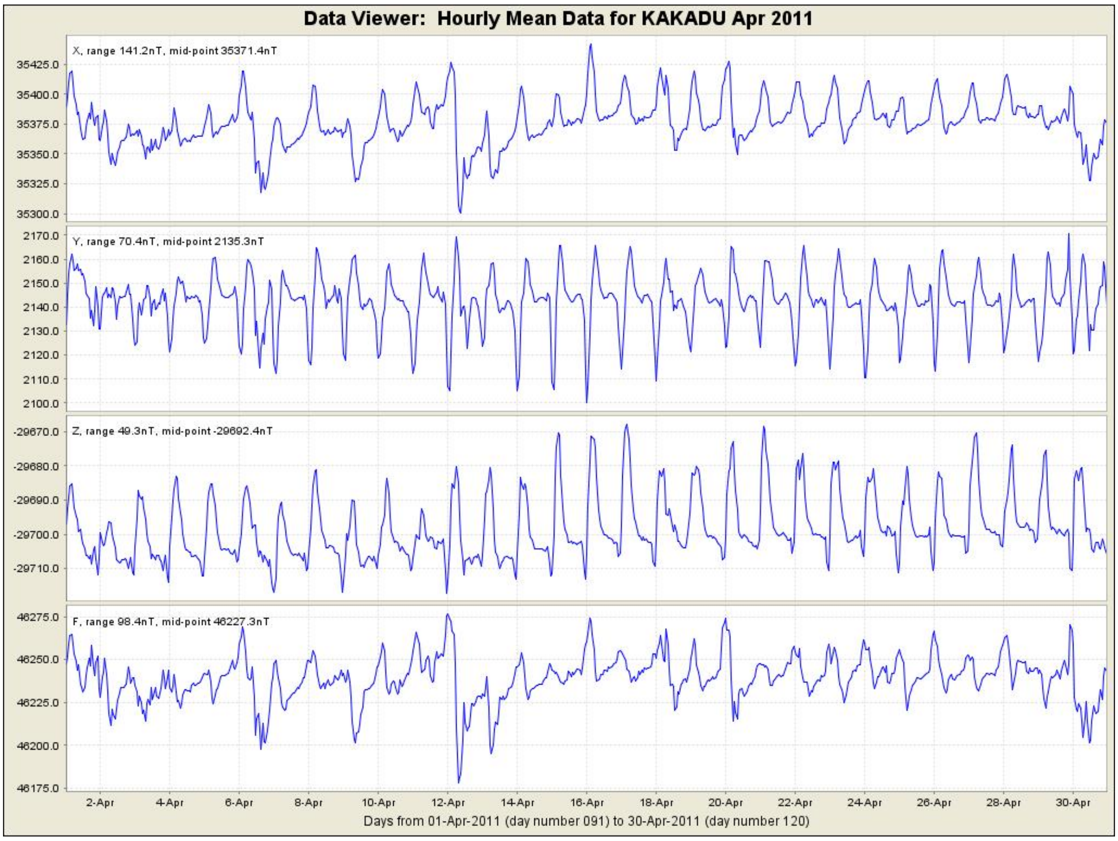


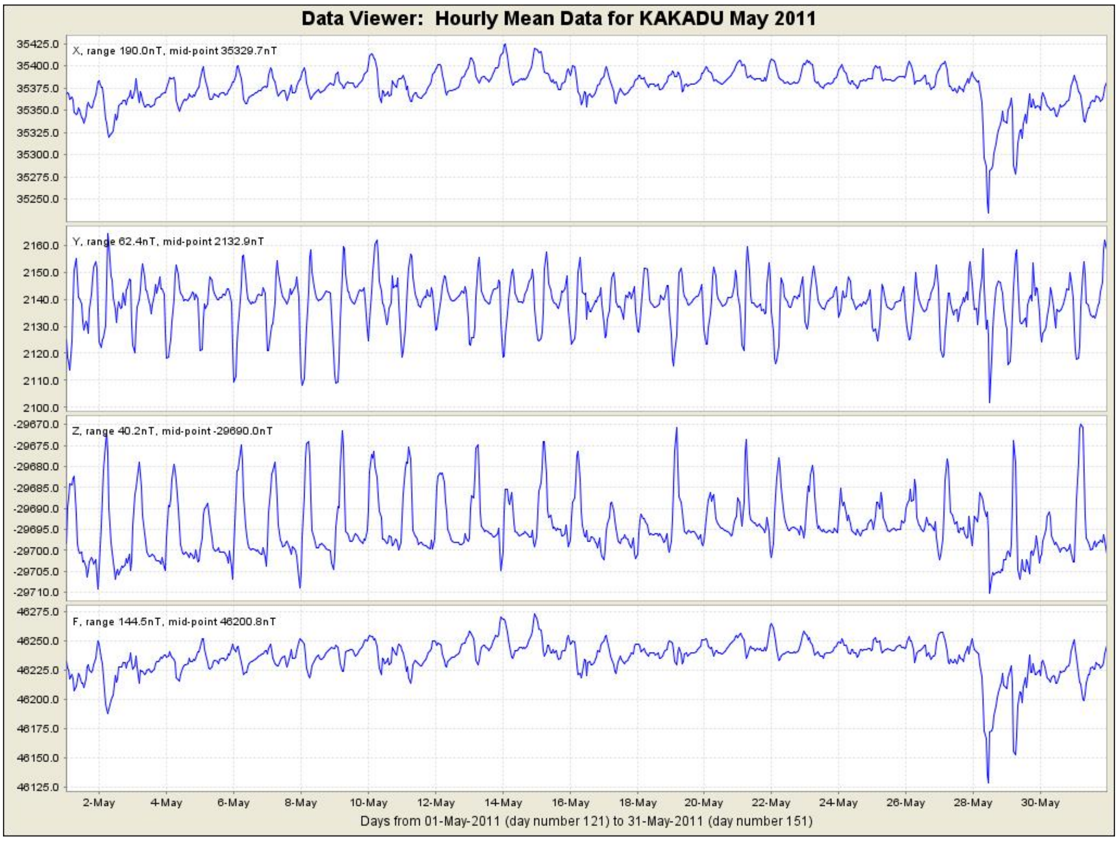
Figure 1.2. *Kakadu annual mean values and secular variation (all days) for X, Y, Z and F.*

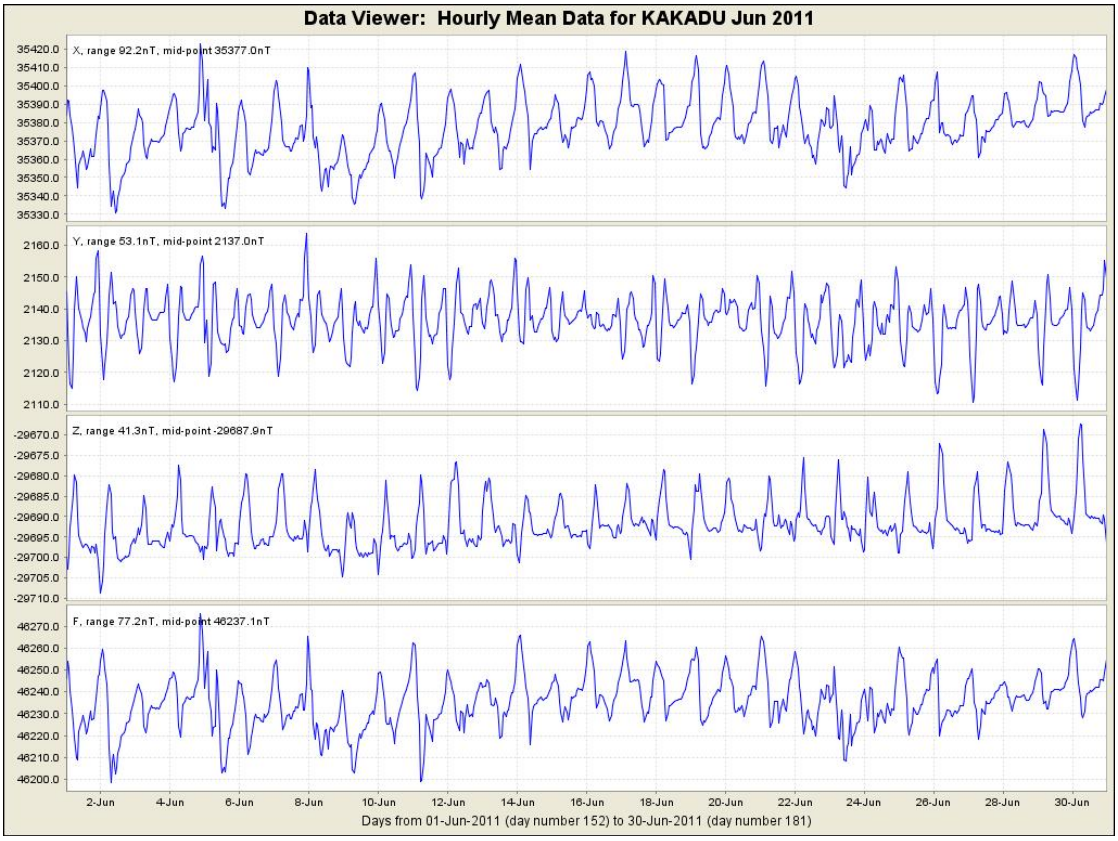

Data Viewer: Hourly Mean Data for KAKADU Jan 2011
X, range 69.6nT, mid-point 35387.5nT
Y, range 84.3nT, mid-point 2148.6nT
Z, range 57.3nT, mid-point -29703.6nT
F, range 56.7nT, mid-point 46256.3nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

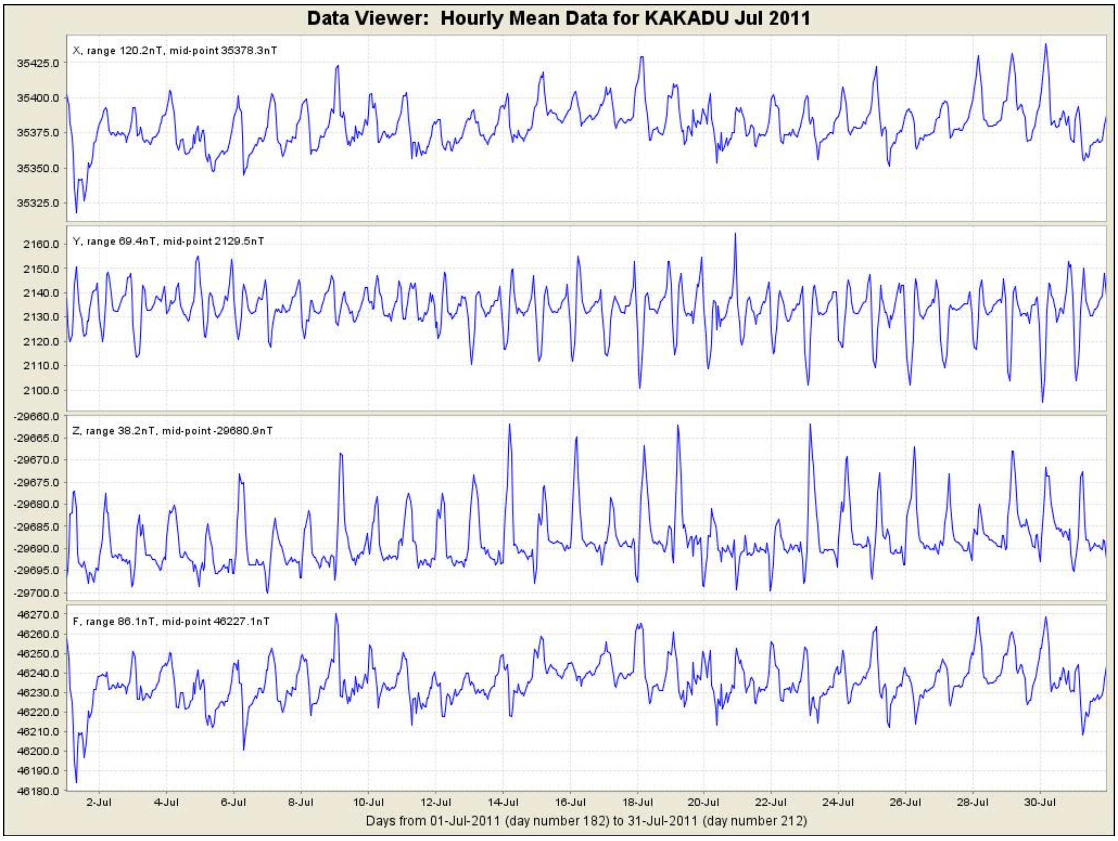

Data Viewer: Hourly Mean Data for KAKADU Feb 2011
X, range 153.3nT, mid-point 35401.2nT
Y, range 106.9nT, mid-point 2141.8nT
Z, range 47.7nT, mid-point -29698.6nT
F, range 106.9nT, mid-point 46262.7nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

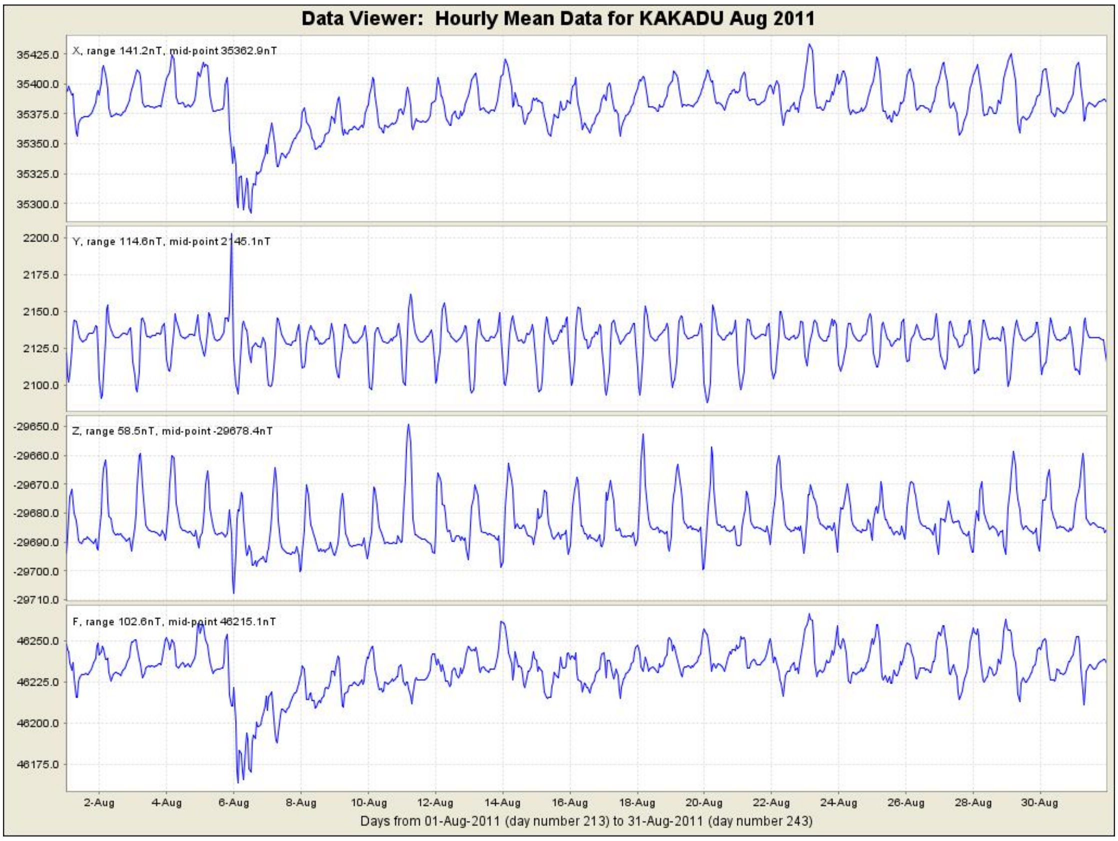

Data Viewer: Hourly Mean Data for KAKADU Mar 2011
X, range 153.9nT, mid-point 35358.4nT
Y, range 93.4nT, mid-point 2142.5nT
Z, range 44.1nT, mid-point -29698.8nT
F, range 114.7nT, mid-point 46229.4nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

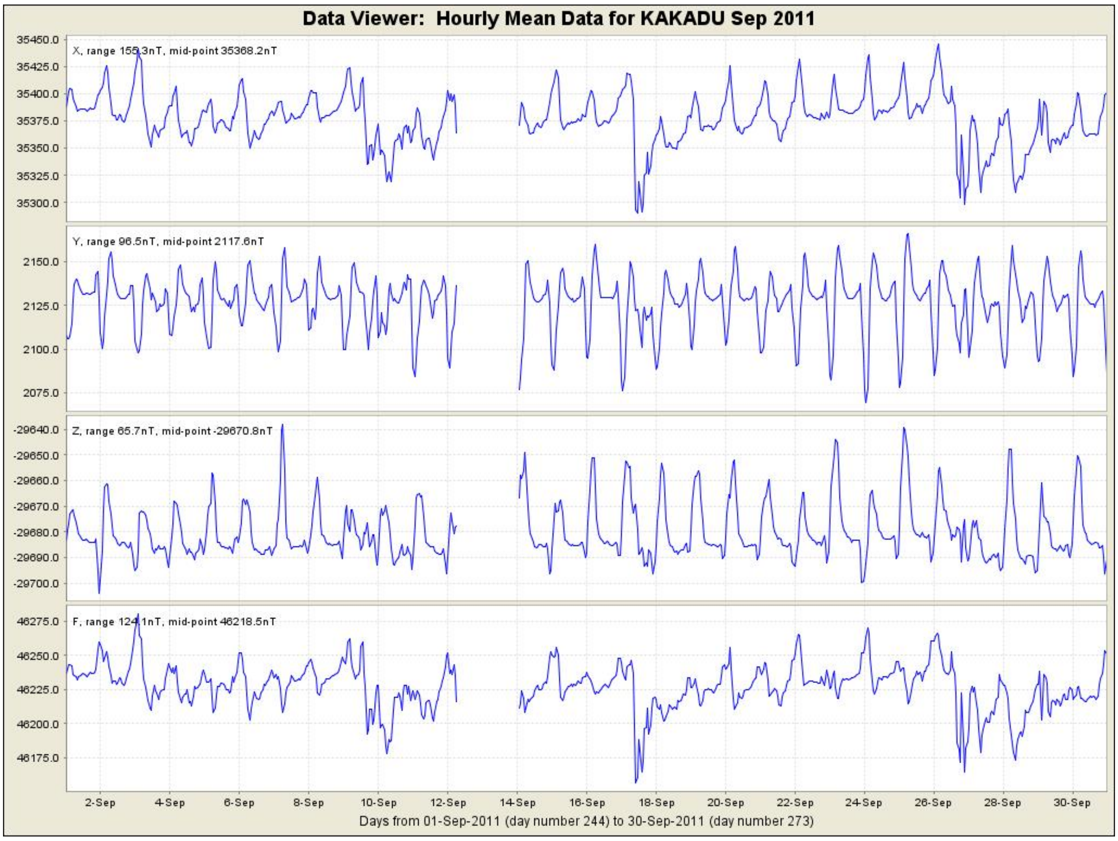

Data Viewer: Hourly Mean Data for KAKADU Apr 2011
X, range 141.2nT, mid-point 35371.4nT
Y, range 70.4nT, mid-point 2135.3nT
Z, range 49.3nT, mid-point -29692.4nT
F, range 98.4nT, mid-point 46227.3nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

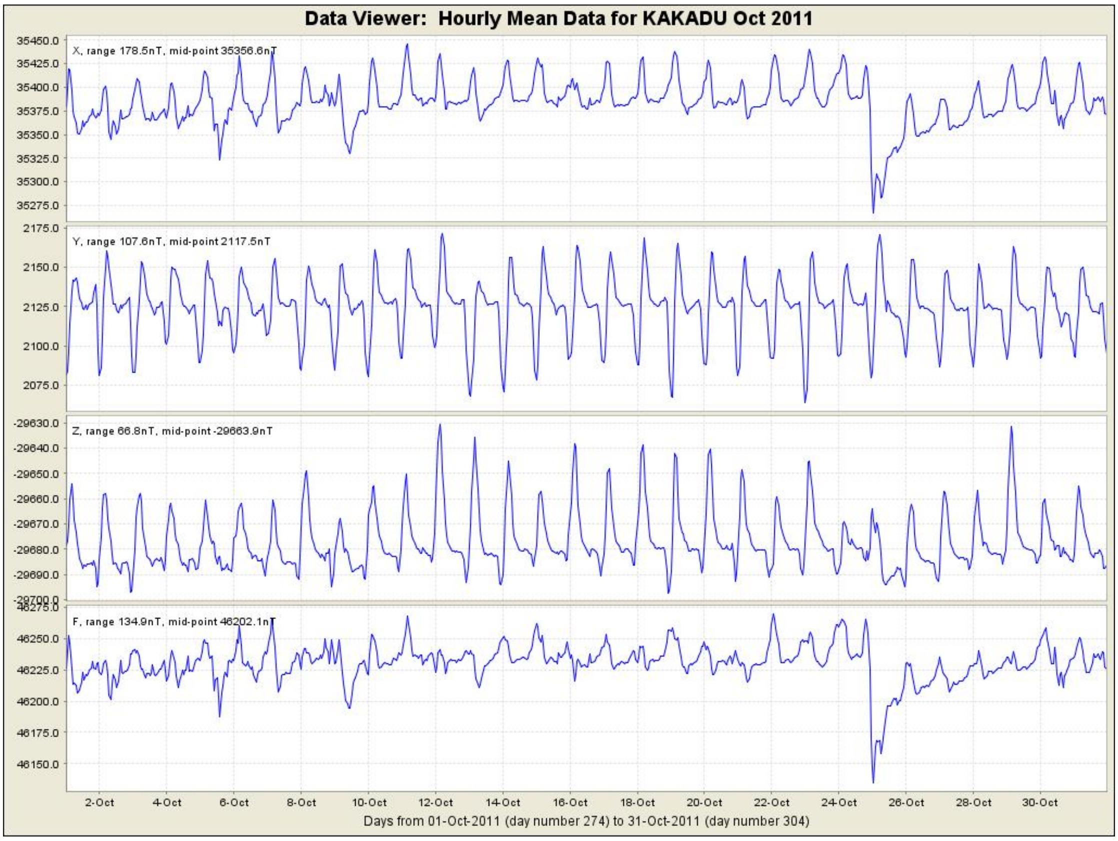

Data Viewer: Hourly Mean Data for KAKADU May 2011
X, range 190.0nT, mid-point 35329.7nT
Y, range 62.4nT, mid-point 2132.9nT
Z, range 40.2nT, mid-point -29690.0nT
F, range 144.5nT, mid-point 46200.8nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)


Data Viewer: Hourly Mean Data for KAKADU Jun 2011
X, range 92.2nT, mid-point 35377.0nT
Y, range 53.1nT, mid-point 2137.0nT
Z, range 41.3nT, mid-point -29687.9nT
F, range 77.2nT, mid-point 46237.1nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for KAKADU Jul 2011
X, range 120.2nT, mid-point 35378.3nT
Y, range 69.4nT, mid-point 2129.5nT
Z, range 38.2nT, mid-point -29680.9nT
F, range 86.1nT, mid-point 46227.1nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for KAKADU Aug 2011
X, range 141.2nT, mid-point 35362.9nT
Y, range 114.6nT, mid-point 2145.1nT
Z, range 58.5nT, mid-point -29678.4nT
F, range 102.6nT, mid-point 46215.1nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for KAKADU Sep 2011
X, range 159.3nT, mid-point 35368.2nT
Y, range 96.5nT, mid-point 2117.6nT
Z, range 65.7nT, mid-point -29670.8nT
F, range 124.1nT, mid-point 46218.5nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for KAKADU Oct 2011
X, range 178.5nT, mid-point 35356.6nT
Y, range 107.6nT, mid-point 2117.5nT
Z, range 66.8nT, mid-point -29663.9nT
F, range 134.9nT, mid-point 46202.1nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)

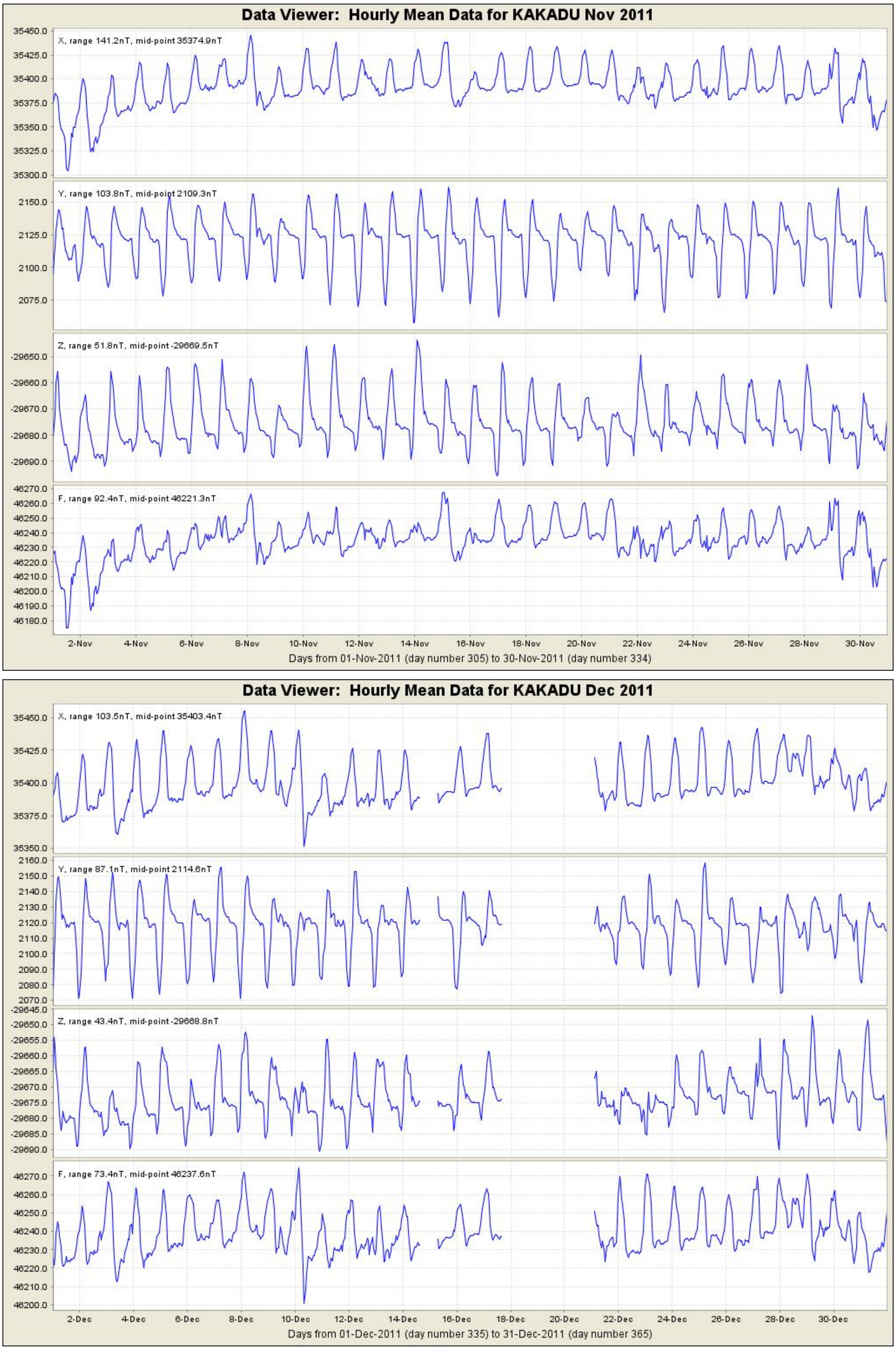


Figure 1.3. *Kakadu 2011 hourly mean values in X, Y, Z and F.*

2. Charters Towers

Charters Towers is 120 km southwest of Townsville in north Queensland. The Charters Towers magnetic observatory is located at Towers Hill, 1.7 km southwest of the town centre, in an area leased to Geoscience Australia by the Charters Towers Regional Council.

The observatory comprises:

- a disused gold mine adit ("the tunnel") approximately 100 m into the northern side of Towers Hill, which houses the variometers;
- a VSAT communications dish outside the tunnel, and;
- an Absolute Shelter on a hillside approximately 250 m to the south-west of the tunnel.

Continuous magnetic-field recording commenced at the observatory in June 1983 (Hopgood and McEwin, 1997).

Key data for the observatory are given in Table 2.1.

Variometers

The variometers used during 2011 are described in Table 2.2.

The vector variometer at the Charters Towers observatory was a DMI FGE non-suspended 3-component fluxgate magnetometer with the sensor mounted on a concrete pillar and orientated magnetic-NW, magnetic-NE, and vertical. Throughout most of 2011 an Overhauser total-field magnetometer monitored variations of the magnetic total intensity, F. The total-field sensor was mounted on a concrete pillar. Acquisition system timing was derived from a Garmin GPS 16 clock and is discussed further below.

Although not temperature controlled, the temperature within the tunnel where the variometer sensors and electronics were located varied over a range of 2.7°C throughout the year, from about 26°C in winter to about 29°C in summer. There was no discernible diurnal temperature variation. The external temperature, as monitored at the nearby Charters Towers airport, varied between 3.5°C (on 2011-07-23) and 40.2°C (on 2011-10-11). The data acquisition system (except the DMI fluxgate magnetometer and GSM-90 total-field magnetometer electronics) was housed in an air-conditioned room in an adjacent arm of the tunnel.

From 2011-09-12 to 2011-10-25 there were no total-field data as the GSM-90 total-field magnetometer was undergoing repair. Sub-nanoTesla interference between the total-field and fluxgate data during the polarisation cycles of the Overhauser magnetometer (6 times per minute) continues to be a problem at the observatory.

There were several periods of disturbance to the variometer data during 2011 probably caused by engineering maintenance and repair work to the tunnel structure. Periods of contaminated data were removed from the one-second fluxgate and ten-second PPM data. These data were also spike filtered using an automatic de-spiking algorithm and some manual spike removal during definitive data processing. There was at least one second of data loss on 317 days throughout 2011 due to removal of contaminated data or spikes, or data transmission problems. The definitive one-minute data were calculated from these de-spiked data. Data loss from the one-minute data set is detailed below.

Table 2.1. *Key observatory data.*

IAGA code:	CTA
Commenced operation:	June 1983
Geographic latitude:	20° 05' 25" S
Geographic longitude:	146° 15' 51" E
Geomagnetic latitude:	-27.51°
Geomagnetic longitude:	221.39°
K 9 index lower limit:	300 nT
Principal pier:	Pier C
Pier elevation (top):	370 m AMSL
Principal reference mark:	Post Office spire
Reference mark azimuth:	34° 40' 45"
Reference mark distance:	1.75 km
Observer:	B.M. Stevenson

Table 2.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	DMI FGE (Version G)
Serial number:	E0227 / S0210
Type:	non-suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.032 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081420 / 42178
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	VSAT satellite link

Table 2.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0036
Theodolite:	Zeiss 020B
Serial number:	394050
Resolution:	0.1’
D correction:	0.0’
I correction:	-0.2’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091318 / 91472
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Absolute instruments

The variometers at CTA were calibrated nominally weekly with a pair of absolute observations. Both absolute PPM and DIM observations were performed on Pier C in the Absolute Shelter. The principal absolute magnetometers used and their adopted corrections for 2011 are described in Table 2.3. The D and I corrections applied in 2011 were determined through instrument comparisons performed during maintenance and calibration visits, most recently on 2010-11-14 Instrument corrections are to the international reference.

At the 2011 mean magnetic-field values at Charters Towers the D, I and F corrections in Table 2.3 translate to corrections of:

ΔX = -2.2 nT ΔY =-0.3 nT ΔZ = -1.9 nT ΔH = -2.2 nT

These instrument corrections have been applied to the data described in this report.

Baselines

Derivation of final baseline parameters for the fluxgate variometer was done by manually fitting a piece-wise linear function, including steps as required, to fit the weekly absolute observations baseline residuals.

The DMI E0227/S0210 variometer performed adequately well in 2011. Throughout 2011 the overall baseline drifts had a range of about 7 nT in the X, Y and Z components. The standard deviations in the difference between the weekly absolute observations and the final adopted vector variometer model and data were:

	σ
X	0.6 nT
Y	0.9 nT
Z	0.6 nT
D	06"
I	04"
F	0.2 nT

Throughout the year the difference between F measured with the CTA vector variometer and the CTA scalar variometer varied over a range of about 1 nT.

Observed and adopted baseline values in X, Y and Z are shown in Figure 2.1.

Operations

The on-site observer-in-charge at CTA observatory, Mr Brad Stevenson performed weekly absolute observations and checks.

Analogue outputs from the DMI FGE 3-channel fluxgate, as well as the fluxgate sensor and electronics temperature channels, were digitized with an ADAM 4017 A/D converter mounted inside the DMI electronics console. Data were recorded at 1-second intervals in the components A (NW), B (NE), C (Z), as well as the DMI variometer sensor and electronics temperatures. These digital data were recorded on an acquisition computer running the Gdap data acquisition system in a QNX operating system. The digital readings from the PPM variometer, cycling once every 10 seconds, were also recorded on the acquisition computer. Data files were telemetered from CTA to Geoscience Australia in Canberra through a VSAT TCP/IP network. Data transfer delay time was 2 to 15 minutes.

The system was powered by a 12 V DC battery-backed supply which also powers the Charters Towers seismic observatory. The 240V AC DMI fluxgate electronics was powered with a dedicated inverter running from the 12 V DC seismic system. Acquisition system timing control was provided by a Garmin GPS 16 GPS clock. The GPS clock failed on 2011-11-02 and was replaced on 2011-11-11. After the GPS clock was replaced there was a significant increase in the number of system timing corrections with a magnitude greater than 1 ms, including numerous corrections with a magnitude of 1 s. These may have degraded the timing accuracy of the data. Timing corrections greater than 1 ms which have been applied to the system are listed in units of seconds and nanoseconds in the *Significant events* section below.

The distribution of Charters Towers 2011 data is described in Table 2.4. Data losses are identified in Table A.2.

Table 2.4. *Distribution of Charters Towers 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
WDC for Geomagnetism	preliminary	real time

Significant events

2011-01-26	Rock fall near control room door occurred sometime before 01UT today
2011-02-04	22:22:49 - CLK **I** 0 C 0 s -3889137 ns
2011-02-08	Tunnel exhaust fan has stopped functioning
2011-02-09	00:02:07 2 bad records, data recorded as 0
2011-03-12	FCheck jump 03:00 - reason unknown, possibly associated with tunnel inspection
2011-03-14	Tunnel repair workers inspecting back end of tunnel
2011-03-16	Tunnel repair work now completed - exact time and dates of works not known.
2011-03-17	03:34 BLV jump in fluxgate and PPM data, possibly caused by movement of steel bulkhead door at end of tunnel during maintenance inspection. No significant FCheck anomaly.
2011-03-24	01:39 BLV jump in fluxgate and PPM as Brad closes the steel bulkhead door. No significant FCheck anomaly
2011-03-28	GA technical officers scheduled at CTA for seismic upgrade 20:23:54 - CLK **I** 0 C 0 s 11026714 ns
2011-04-01	23UT Spikes on data - probably due to seismic system upgrades
2011-04-02	05:16:35 - CLK **I** 0 C 0 s -3230375 ns
2011-05-07	Replace cladding on absolute hut roof.
2011-06-10	Absolute GSM90 will not work - arrange to have it sent back to GA
2011-06-13	09:51:02 - CLK **I** 0 C 0 s -1038196 ns
2011-06-20	GSM90_3091318 arrives with PDA 29739, GSM-90 power/data null modem, and PDA USB/serial and GSM-90 sensor cable. Problem lies with the PDA unit
2011-06-21	Send replacement PDA (barcode 29738) and all other equipment back to CTA
2011-06-24	Replacement equipment arrive in CTA
2011-06-30	New seismometer being installed - some interference on magnetic data
2011-07-12	06:40 sun-geomag reboot and upgrade
2011-08-25	Attempt PPP modem connection - no success
2011-09-12	01:20 (approx) variometer GSM90 failed
2011-09-13	02:13 system shutdown to attempt recovery of GSM-90 variometer. The GSM-90 responds as if it has the wrong baud setting. Shutdown did not fix problem 02:15:24 - CLK **I** 0 C 0 s 933287770 ns 08:43 GSM-90 powered off and on, no improvement
2011-09-14	05:30 try variometer PPM on ser6, same nonsense response
2011-09-15	03:00 try absolute PPM electronics as variometer, all O.K. Brad sends back the variometer PPM electronics
2011-10	Variometer GSM-90 PPM repaired at GA

2011-10-25	Variometer GSM-90 PPM re-installed 08:55 22:00 test GSM-90 PPM and re-start Gdap GSM-90
2011-11-02	06:30 Lost contact with GPS clock
2011-11-03	01:47 slay and restart GdapClock 01:52 reboot Clock did not respond after reboot qtalk/p232 did not work, GdapClockTest2 did not indicate any pulses.
2011-11-04	Send replacement Garmin GPS16x-HVS S/N 1A4075563 via Express Post
2011-11-11	05:00 Brad replaced the GPS clock 04:59:59 - CLK I 0 C 1 s 618551332 ns 17:48:46 - CLK I 0 C -1 s -51903 ns 22:03:51 - CLK I 0 C 0 s -999964557 ns 23:30:10 - CLK I 0 C -1 s -39350 ns
2011-11-12	02:14:33 - CLK I 0 C -1 s -151792 ns 03:23:55 - CLK I 0 C 0 s 999990223 ns 03:34:39 - CLK I 0 C -1 s -10069 ns 07:18:45 - CLK I 0 C -1 s -174 ns 07:36:39 - CLK I 0 C -1 s -52168 ns 11:42:25 - CLK I 0 C 0 s -999989954 ns 11:58:32 - CLK I 0 C 0 s 999996578 ns 14:32:27 - CLK I 0 C -1 s -49597 ns 17:12:25 - CLK I 0 C 0 s -999944496 ns
2011-11-13	04:11:26 - CLK I 0 C 0 s 999991803 ns 05:57:22 - CLK I 0 C 0 s -999951773 ns 07:12:27 - CLK I 0 C 0 s -999927999 ns 09:42:38 - CLK I 0 C -1 s -74800 ns 09:56:16 - CLK I 0 C 0 s 999982305 ns 10:00:27 - CLK I 0 C -1 s -53539 ns 10:31:05 - CLK I 0 C 0 s 999926248 ns 10:41:47 - CLK I 0 C -1 s -27947 ns 13:44:06 - CLK I 0 C 0 s -999986311 ns
2011-11-20	02:11:04 - CLK I 0 C 0 s -1558428 ns 17:11:49 - CLK I 0 C 0 s -1662592 ns 17:21:47 - CLK I 0 C 0 s -1350422 ns 19:01:05 - CLK I 0 C 0 s -1717601 ns 21:31:49 - CLK I 0 C 0 s -1533330 ns
2011-11-21	00:51:06 - CLK I 0 C 0 s -1524188 ns 01:11:48 - CLK I 0 C 0 s -1479792 ns 01:31:49 - CLK I 0 C 0 s -1162565 ns 01:51:06 - CLK I 0 C 0 s -1540712 ns 19:51:48 - CLK I 0 C 0 s -1021516 ns 20:53:18 - CLK I 0 C 0 s -1151907 ns
2011-11-22	03:51:47 - CLK I 0 C 0 s -1234681 ns 05:13:15 - CLK I 0 C 0 s -1751200 ns 05:31:05 - CLK I 0 C 0 s -1120055 ns 07:33:16 - CLK I 0 C 0 s -1341378 ns 11:02:33 - CLK I 0 C 0 s -1014573 ns 11:21:48 - CLK I 0 C 0 s -1182779 ns 12:51:05 - CLK I 0 C 0 s -2636466 ns 15:31:04 - CLK I 0 C 0 s -1313420 ns 15:51:04 - CLK I 0 C 0 s -1762093 ns 16:21:48 - CLK I 0 C 0 s -1150544 ns 16:51:05 - CLK I 0 C 0 s -2986987 ns 18:32:30 - CLK I 0 C 0 s -2589249 ns 18:51:04 - CLK I 0 C 0 s -1300767 ns 21:21:04 - CLK I 0 C 0 s -1394211 ns 22:46:51 - CLK I 0 C 0 s -1329084 ns

2011-11-23	00:51:47 - CLK I 0 C 0 s -1712668 ns
	01:52:31 - CLK I 0 C 0 s -1083037 ns
	02:51:49 - CLK I 0 C 0 s -1883287 ns
	06:41:47 - CLK I 0 C 0 s -1799728 ns
	07:31:04 - CLK I 0 C 0 s -2266335 ns
	08:04:42 - CLK I 0 C 0 s -1032308 ns
	09:22:31 - CLK I 0 C 0 s -1582269 ns
	14:22:31 - CLK I 0 C 0 s -1649349 ns
	15:31:47 - CLK I 0 C 0 s -1410477 ns
	16:01:08 - CLK I 0 C 0 s -1158308 ns
	20:11:04 - CLK I 0 C 0 s -1016464 ns
	20:21:47 - CLK I 0 C 0 s -1288802 ns
2011-11-24	03:01:05 - CLK I 0 C 0 s -2465936 ns
	03:31:48 - CLK I 0 C 0 s -1037818 ns
	05:15:29 - CLK I 0 C 0 s -1084521 ns
	05:52:31 - CLK I 0 C 0 s -1797399 ns
	07:21:47 - CLK I 0 C 0 s -1366172 ns
	08:51:04 - CLK I 0 C 0 s -1100932 ns
	11:41:05 - CLK I 0 C 0 s -1068092 ns
	12:21:05 - CLK I 0 C 0 s -1345322 ns
	15:31:48 - CLK I 0 C 0 s -1386146 ns
	15:41:04 - CLK I 0 C 0 s -1476201 ns
2011-11-26	21:21:46 - CLK I 0 C -1 s -4174 ns
2011-11-27	16:32:57 - CLK I 0 C 0 s -999981907 ns
	20:35:49 - CLK I 0 C -1 s -26794 ns
	23:46:59 - CLK I 0 C 0 s -999997891 ns
	23:46:59 - CLK I 0 C 0 s -999997891 ns
2011-11-28	00:51:45 - CLK I 0 C 0 s -999906968 ns
	06:21:30 - CLK I 0 C 0 s -999985142 ns
	10:42:27 - CLK I 0 C 0 s -999942658 ns
	13:20:10 - CLK I 0 C 0 s -999947835 ns
	15:30:13 - CLK I 0 C 0 s -999721249 ns
	15:46:23 - CLK I 0 C 0 s 999975744 ns
	16:05:57 - CLK I 0 C 0 s -999925748 ns
2011-11-29	03:36:47 - CLK I 0 C 0 s 999991055 ns
	03:53:37 - CLK I 0 C -1 s -47911 ns
	05:59:48 - CLK I 0 C -1 s -42536 ns
	07:22:23 - CLK I 0 C 0 s -999978061 ns
	08:32:27 - CLK I 0 C -1 s -12056 ns
	09:25:15 - CLK I 0 C 0 s 999909844 ns
	09:32:27 - CLK I 0 C 0 s -999972262 ns
	12:02:17 - CLK I 0 C -1 s -102476 ns
2011-12-06	15:51:04 - CLK I 0 C 0 s -1425792 ns
	16:31:06 - CLK I 0 C 0 s -1323039 ns
	19:51:05 - CLK I 0 C 0 s -1091222 ns
	21:21:48 - CLK I 0 C 0 s -1072424 ns
	21:52:32 - CLK I 0 C 0 s -1731288 ns
	23:01:49 - CLK I 0 C 0 s -1433280 ns
2011-12-07	00:15:26 - CLK I 0 C 0 s -1217162 ns
	02:03:59 - CLK I 0 C 0 s -1031827 ns
	05:41:05 - CLK I 0 C 0 s -1886468 ns
	05:51:05 - CLK I 0 C 0 s -1040679 ns
	15:01:05 - CLK I 0 C 0 s -1173537 ns
	15:41:47 - CLK I 0 C 0 s -1884436 ns
	15:51:05 - CLK I 0 C 0 s -1297711 ns
	19:01:47 - CLK I 0 C 0 s -1427595 ns

	20:21:49 - CLK I 0 C 0 s -1209642 ns
	20:51:04 - CLK I 0 C 0 s -1648166 ns
	23:02:31 - CLK I 0 C 0 s -1196141 ns
2011-12-08	00:31:04 - CLK I 0 C 0 s -1395383 ns
	01:13:13 - CLK I 0 C 0 s -2580620 ns
	02:12:37 - CLK I 0 C 0 s -1216513 ns
	04:16:09 - CLK I 0 C 0 s -1516004 ns
	05:21:04 - CLK I 0 C 0 s -1719490 ns
	07:51:49 - CLK I 0 C 0 s -1010299 ns
	10:21:04 - CLK I 0 C 0 s -1617457 ns
	12:51:05 - CLK I 0 C 0 s -1085197 ns
	15:04:02 - CLK I 0 C 0 s -1334944 ns
	15:31:05 - CLK I 0 C 0 s -1390528 ns
	16:01:06 - CLK I 0 C 0 s -1137843 ns
	16:51:05 - CLK I 0 C 0 s -1147386 ns
	18:31:04 - CLK I 0 C 0 s -1562138 ns
	19:41:04 - CLK I 0 C 0 s -1774573 ns
	22:01:52 - CLK I 0 C 0 s -1030217 ns
	23:21:48 - CLK I 0 C 0 s -1471728 ns
	23:21:48 - CLK I 0 C 0 s -1471728 ns
2011-12-09	01:31:05 - CLK I 0 C 0 s -1095426 ns
	01:51:52 - CLK I 0 C 0 s -1217698 ns
	02:23:14 - CLK I 0 C 0 s -1435382 ns
	05:01:04 - CLK I 0 C 0 s -1047560 ns
	06:21:04 - CLK I 0 C 0 s -1162869 ns
	07:01:06 - CLK I 0 C 0 s -1169530 ns
	08:02:31 - CLK I 0 C 0 s -1213626 ns
	08:22:31 - CLK I 0 C 0 s -2087773 ns
	08:31:06 - CLK I 0 C 0 s -1385406 ns
	08:51:50 - CLK I 0 C 0 s -2006864 ns
	12:26:07 - CLK I 0 C 0 s -1081085 ns
	14:48:24 - CLK I 0 C 0 s -2333497 ns
	16:51:04 - CLK I 0 C 0 s -1967922 ns
2011-12-10	05:21:05 - CLK I 0 C 0 s -1104514 ns
	07:11:48 - CLK I 0 C 0 s -1394197 ns
	07:21:07 - CLK I 0 C 0 s -1024474 ns
	10:51:04 - CLK I 0 C 0 s -1799214 ns
	13:51:04 - CLK I 0 C 0 s -1071691 ns
	21:15:26 - CLK I 0 C 0 s -1327955 ns
2011-12-13	00:28:03 - CLK I 0 C -1 s -46792 ns
	00:30:52 - CLK I 0 C 0 s 999958137 ns
	19:54:17 - CLK I 0 C 0 s -999969887 ns
	22:25:57 - CLK I 0 C 0 s -999943314 ns
	23:45:53 - CLK I 0 C -1 s -103266 ns
	23:45:53 - CLK I 0 C -1 s -103266 ns
2011-12-14	01:31:09 - CLK I 0 C 0 s 999923608 ns
	05:12:27 - CLK I 0 C 0 s -999978441 ns
	05:16:40 - CLK I 0 C 0 s 999961425 ns
	09:26:39 - CLK I 0 C -1 s -7890 ns
	12:04:28 - CLK I 0 C -1 s -175263 ns
	12:31:07 - CLK I 0 C 0 s 999974108 ns
	12:37:24 - CLK I 0 C -1 s -35373 ns
	12:59:08 - CLK I 0 C 0 s 999968450 ns
	14:22:44 - CLK I 0 C 0 s -999996626 ns
	14:31:04 - CLK I 0 C 0 s 999985747 ns
	14:51:36 - CLK I 0 C -1 s -11580 ns

2011-12-15	05:53:11 - CLK I 0 C 0 s 999978711 ns
	06:21:04 - CLK I 0 C 0 s -999953569 ns
	07:31:46 - CLK I 0 C 0 s -999598146 ns
	10:54:54 - CLK I 0 C 0 s -999767235 ns
2011-12-21	19:51:04 - CLK I 0 C 0 s -1301463 ns
	20:01:05 - CLK I 0 C 0 s -1798139 ns
	21:31:47 - CLK I 0 C 0 s -1091925 ns
2011-12-22	11:41:06 - CLK I 0 C 0 s -1203218 ns
	15:21:05 - CLK I 0 C 0 s -1239686 ns
	16:21:04 - CLK I 0 C 0 s -1821316 ns
	16:41:05 - CLK I 0 C 0 s -1630795 ns
	18:41:50 - CLK I 0 C 0 s -1258312 ns
	19:52:31 - CLK I 0 C 0 s -1500647 ns
	20:43:15 - CLK I 0 C 0 s -1403786 ns
	21:31:05 - CLK I 0 C 0 s -1250377 ns
	22:41:04 - CLK I 0 C 0 s -2199429 ns
2011-12-23	02:31:49 - CLK I 0 C 0 s -1143375 ns
	02:51:48 - CLK I 0 C 0 s -1477827 ns
	03:21:48 - CLK I 0 C 0 s -1426463 ns
	03:42:33 - CLK I 0 C 0 s -1020563 ns
	06:01:11 - CLK I 0 C 0 s -1725041 ns
	06:41:48 - CLK I 0 C 0 s -1191404 ns
	08:41:05 - CLK I 0 C 0 s -1158246 ns
	09:31:49 - CLK I 0 C 0 s -1304852 ns
	10:33:14 - CLK I 0 C 0 s -1325994 ns
	12:51:49 - CLK I 0 C 0 s -1782446 ns
	14:13:16 - CLK I 0 C 0 s -1035460 ns
	14:32:31 - CLK I 0 C 0 s -1131678 ns
	14:51:49 - CLK I 0 C 0 s -2953040 ns
	15:04:41 - CLK I 0 C 0 s -1223925 ns
	17:21:47 - CLK I 0 C 0 s -1022731 ns
	19:02:33 - CLK I 0 C 0 s -1113231 ns
	22:21:04 - CLK I 0 C 0 s -1332821 ns
	22:41:10 - CLK I 0 C 0 s -1057090 ns
	22:51:04 - CLK I 0 C 0 s -2667192 ns
2011-12-24	01:12:33 - CLK I 0 C 0 s -1356354 ns
	01:31:05 - CLK I 0 C 0 s -1343893 ns
	02:31:48 - CLK I 0 C 0 s -1193499 ns
	03:11:47 - CLK I 0 C 0 s -1160700 ns
	05:25:24 - CLK I 0 C 0 s -1154550 ns
	09:03:59 - CLK I 0 C 0 s -1101371 ns
	12:16:21 - CLK I 0 C 0 s -1691735 ns
	12:51:06 - CLK I 0 C 0 s -1479752 ns
	17:41:04 - CLK I 0 C 0 s -1142024 ns
2011-12-25	00:41:05 - CLK I 0 C 0 s -1955470 ns
	01:01:48 - CLK I 0 C 0 s -1344089 ns
	01:11:50 - CLK I 0 C 0 s -1250081 ns
	01:32:32 - CLK I 0 C 0 s -1002436 ns
	03:01:48 - CLK I 0 C 0 s -1063574 ns
	03:26:52 - CLK I 0 C 0 s -1591844 ns
	04:31:47 - CLK I 0 C 0 s -1464710 ns
	05:01:04 - CLK I 0 C 0 s -1481015 ns
	05:21:47 - CLK I 0 C 0 s -1017488 ns
	05:32:31 - CLK I 0 C 0 s -1358109 ns
	06:52:32 - CLK I 0 C 0 s -1180384 ns
	07:53:14 - CLK I 0 C 0 s -1047630 ns

2011-12-26	01:41:48 - CLK I 0 C 0 s -1508081 ns
	23:03:06 - CLK I 0 C 0 s -2773951 ns
2011-12-28	01:20:27 - CLK I 0 C 0 s -7699729 ns
	11:01:27 - CLK I 0 C 1 s 20843561 ns
2011-12-29	14:20:40 - CLK I 0 C 0 s -999941548 ns
	15:52:27 - CLK I 0 C 0 s -999935624 ns
	18:32:27 - CLK I 0 C 0 s -999875007 ns
	21:26:17 - CLK I 0 C 0 s 999952435 ns
	22:05:42 - CLK I 0 C 0 s -999920850 ns
2011-12-30	00:11:57 - CLK I 0 C 0 s -999983869 ns
	00:23:53 - CLK I 0 C 0 s 999964267 ns
	01:37:22 - CLK I 0 C 0 s -999999298 ns
	01:40:11 - CLK I 0 C 0 s 999965975 ns
	02:56:27 - CLK I 0 C 0 s -999976248 ns
	04:05:58 - CLK I 0 C 0 s -999977308 ns
	09:53:41 - CLK I 0 C 0 s -999985975 ns

Annual mean values

The annual mean values for Charters Towers are set out in Table 2.5 and displayed with the secular variation in Figure 2.2.

Hourly mean values

Plots of the hourly mean values for Charters Towers 2011 data are shown in Figure 2.3.

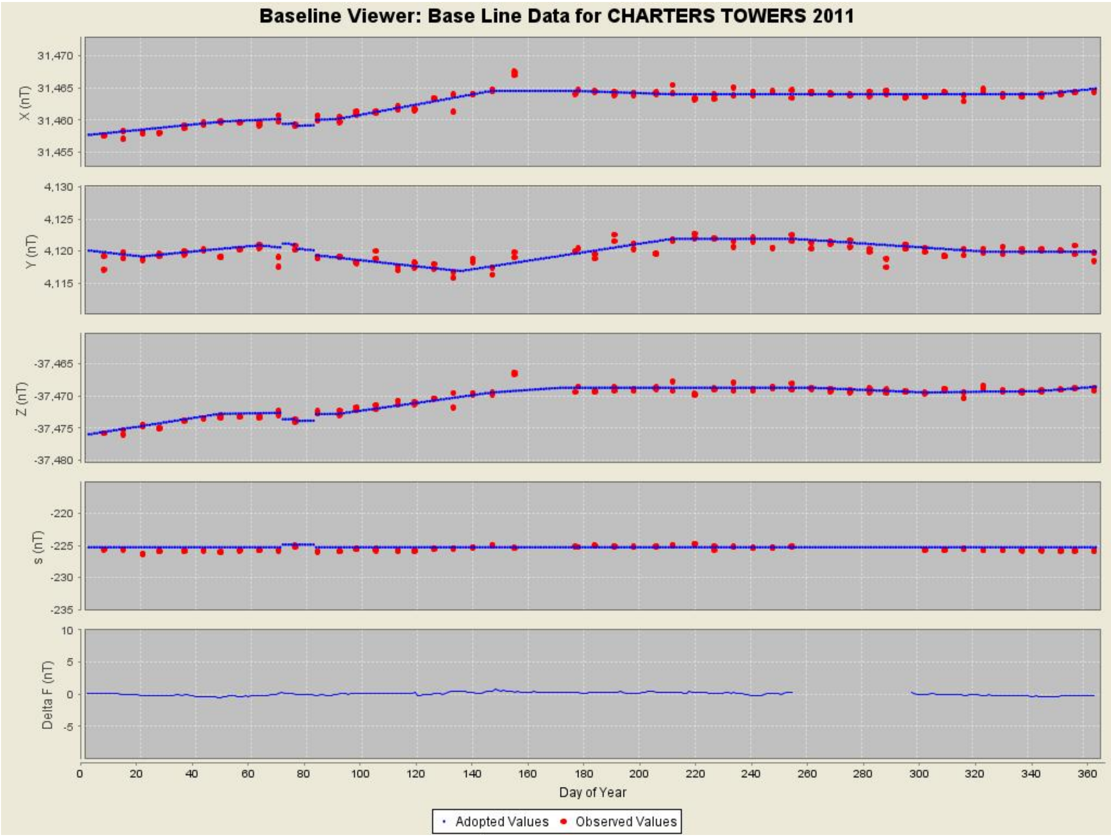


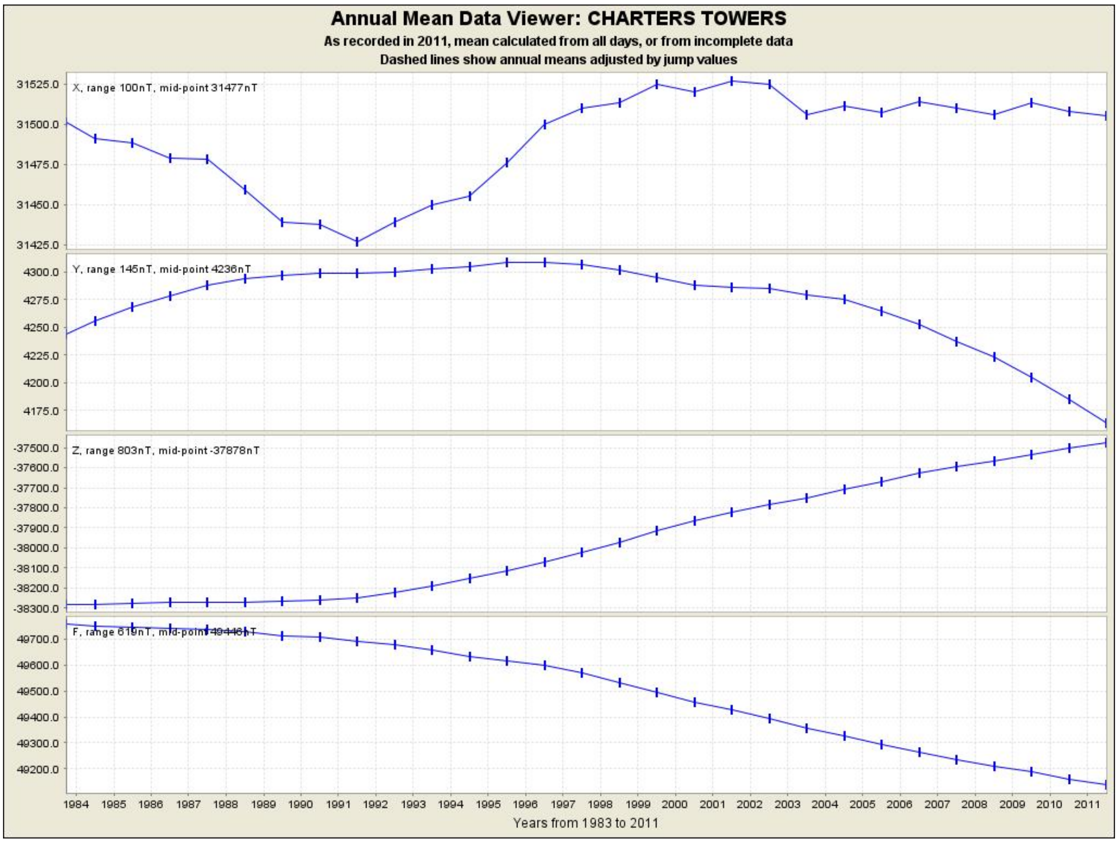
Figure 2.1. *Charters Towers 2011 baseline plots.*

Table 2.5. *Charters Towers annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 2.2. Note that before 31 December 2006 the Charters Towers absolute instruments were corrected to the Canberra reference instruments using corrections of zero for D, I and F. From 00:00 on 1 January 2007, the absolute instruments were corrected to international reference instruments using corrections of D: 0.0', I: -0.2', F: 0.0 nT, H: -2.19 nT, X: -2.17 nT, Y: -0.29 nT and Z: -1.85 nT, as described in Hitchman et al. (2009).*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1983.729	A	7	40.4	-50	17.7	31786	31501	4244	-38280	49756	XYZ
1984.5	A	7	41.9	-50	18.2	31777	31491	4256	-38280	49751	XYZ
1985.5	A	7	43.2	-50	18.0	31776	31488	4268	-38276	49747	XYZ
1986.5	A	7	44.4	-50	18.4	31768	31479	4278	-38274	49740	XYZ
1987.5	A	7	45.5	-50	18.2	31769	31478	4288	-38271	49738	XYZ
1988.5	A	7	46.3	-50	19.2	31751	31459	4294	-38270	49727	XYZ
1989.5	A	7	47.0	-50	20.1	31731	31439	4297	-38267	49711	XYZ
1990.5	A	7	47.2	-50	19.8	31731	31438	4299	-38260	49706	XYZ
1991.5	A	7	47.4	-50	19.8	31719	31427	4299	-38248	49689	XYZ
1992.5	A	7	47.3	-50	18.0	31732	31439	4300	-38221	49676	XYZ
1993.5	A	7	47.4	-50	15.9	31743	31450	4303	-38188	49658	XYZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1994.5	A	7	47.6	-50	14.1	31748	31455	4305	-38151	49633	XYZ
1995.5	A	7	47.7	-50	11.1	31770	31476	4309	-38112	49617	XYZ
1996.5	A	7	47.4	-50	8.1	31793	31500	4309	-38071	49600	XYZ
1997.5	A	7	47.0	-50	5.5	31803	31510	4307	-38024	49571	XYZ
1998.5	A	7	46.5	-50	3.0	31805	31513	4302	-37972	49532	XYZ
1999.5	A	7	45.5	-49	59.8	31816	31525	4295	-37913	49494	XYZ
2000.5	A	7	44.8	-49	58.0	31810	31520	4288	-37866	49455	ABZ
2001.5	A	7	44.5	-49	55.8	31817	31527	4286	-37823	49426	ABZ
2002.5	A	7	44.5	-49	54.0	31815	31525	4285	-37781	49392	ABZ
2003.5	A	7	44.1	-49	53.7	31796	31506	4279	-37751	49357	ABZ
2004.5	A	7	43.6	-49	51.6	31800	31511	4275	-37710	49328	ABZ
2005.5	A	7	42.5	-49	50.1	31795	31507	4265	-37670	49294	ABZ
2006.5	A	7	41.2	-49	47.9	31800	31514	4253	-37627	49265	ABZ
2007.5	A	7	39.5	-49	46.8	31793	31510	4237	-37596	49237	ABZ
2008.5	A	7	38.0	-49	45.7	31788	31506	4223	-37565	49210	ABZ
2009.5	A	7	36.1	-49	44.0	31792	31513	4205	-37532	49187	ABZ
2010.5	A	7	33.9	-49	43.1	31784	31508	4185	-37503	49160	ABZ
2011.5	A	7	31.7	-49	42.2	31779	31505	4164	-37477	49137	ABZ
1983.729	Q	7	40.7	-50	17.0	31797	31512	4249	-38278	49761	XYZ
1985.5	Q	7	43.2	-50	17.4	31787	31499	4270	-38274	49752	XYZ
1986.5	Q	7	44.4	-50	17.8	31778	31489	4280	-38272	49745	XYZ
1987.5	Q	7	45.5	-50	17.7	31776	31486	4289	-38269	49742	XYZ
1988.5	Q	7	46.4	-50	18.3	31764	31472	4296	-38268	49733	XYZ
1989.5	Q	7	47.0	-50	19.1	31746	31454	4299	-38265	49719	XYZ
1990.5	Q	7	47.3	-50	18.8	31746	31454	4302	-38257	49714	XYZ
1991.5	Q	7	47.3	-50	18.6	31739	31446	4301	-38244	49698	XYZ
1992.5	Q	7	47.4	-50	17.1	31746	31453	4303	-38218	49683	XYZ
1993.5	Q	7	47.4	-50	15.3	31754	31461	4304	-38185	49663	XYZ
1994.5	Q	7	47.6	-50	13.2	31762	31469	4307	-38148	49640	XYZ
1995.5	Q	7	47.7	-50	10.4	31781	31488	4310	-38109	49622	XYZ
1996.5	Q	7	47.4	-50	7.7	31799	31506	4310	-38070	49603	XYZ
1997.5	Q	7	46.9	-50	4.9	31812	31519	4308	-38023	49576	XYZ
1998.5	Q	7	46.4	-50	2.5	31815	31522	4303	-37971	49537	XYZ
1999.5	Q	7	45.5	-49	59.3	31825	31534	4296	-37911	49499	XYZ
2000.5	Q	7	44.8	-49	57.2	31823	31533	4290	-37864	49461	ABZ
2001.5	Q	7	44.6	-49	54.9	31831	31540	4289	-37821	49433	ABZ
2002.5	Q	7	44.5	-49	53.2	31828	31538	4287	-37780	49400	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
2003.5	Q	7	44.2	-49	52.7	31811	31521	4282	-37749	49365	ABZ
2004.5	Q	7	43.6	-49	50.9	31810	31522	4277	-37708	49334	ABZ
2005.5	Q	7	42.6	-49	49.4	31806	31519	4267	-37668	49300	ABZ
2006.5	Q	7	41.2	-49	47.4	31808	31522	4255	-37625	49269	ABZ
2007.5	Q	7	39.6	-49	46.5	31799	31515	4238	-37595	49240	ABZ
2008.5	Q	7	38.1	-49	45.4	31794	31512	4224	-37565	49214	ABZ
2009.5	Q	7	36.1	-49	43.8	31795	31515	4206	-37532	49189	ABZ
2010.5	Q	7	33.9	-49	42.8	31790	31513	4185	-37502	49163	ABZ
2011.5	Q	7	31.8	-49	41.8	31786	31512	4165	-37476	49140	ABZ
1983.729	D	7	39.9	-50	18.7	31769	31485	4237	-38281	49746	XYZ
1984.5	D	7	41.8	-50	19.4	31756	31470	4253	-38283	49740	XYZ
1985.5	D	7	43.1	-50	18.9	31761	31474	4266	-38277	49739	XYZ
1986.5	D	7	44.4	-50	19.3	31752	31463	4276	-38276	49732	XYZ
1987.5	D	7	45.4	-50	18.9	31757	31467	4286	-38272	49732	XYZ
1988.5	D	7	46.3	-50	20.4	31731	31439	4291	-38274	49716	XYZ
1989.5	D	7	46.9	-50	22.2	31696	31404	4292	-38272	49693	XYZ
1990.5	D	7	47.1	-50	21.1	31707	31415	4295	-38263	49693	XYZ
1991.5	D	7	47.4	-50	21.8	31687	31394	4295	-38253	49672	XYZ
1992.5	D	7	47.3	-50	19.5	31706	31414	4297	-38225	49663	XYZ
1993.5	D	7	47.4	-50	17.2	31723	31430	4299	-38191	49648	XYZ
1994.5	D	7	47.6	-50	15.1	31730	31437	4302	-38154	49624	XYZ
1995.5	D	7	47.7	-50	12.0	31755	31462	4307	-38114	49609	XYZ
1996.5	D	7	47.4	-50	8.6	31784	31491	4308	-38072	49595	XYZ
1997.5	D	7	47.0	-50	6.4	31788	31495	4305	-38026	49563	XYZ
1998.5	D	7	46.5	-50	4.4	31782	31490	4299	-37976	49520	XYZ
1999.5	D	7	45.5	-50	1.0	31797	31506	4293	-37916	49484	XYZ
2000.5	D	7	44.8	-49	59.7	31783	31493	4284	-37870	49440	ABZ
2001.5	D	7	44.3	-49	57.2	31792	31502	4281	-37826	49412	ABZ
2002.5	D	7	44.5	-49	55.3	31793	31503	4283	-37784	49380	ABZ
2003.5	D	7	43.9	-49	55.1	31772	31483	4275	-37755	49345	ABZ
2004.5	D	7	43.4	-49	52.8	31780	31491	4271	-37713	49318	ABZ
2005.5	D	7	42.4	-49	51.3	31774	31487	4261	-37673	49283	ABZ
2006.5	D	7	41.2	-49	48.6	31787	31501	4252	-37629	49258	ABZ
2007.5	D	7	39.5	-49	47.3	31785	31502	4236	-37597	49233	ABZ
2008.5	D	7	38.1	-49	46.2	31780	31499	4222	-37567	49206	ABZ
2009.5	D	7	36.1	-49	44.3	31787	31508	4205	-37532	49184	ABZ
2010.5	D	7	33.9	-49	43.7	31775	31498	4183	-37504	49155	ABZ
2011.5	D	7	31.7	-49	42.9	31768	31494	4162	-37479	49131	ABZ



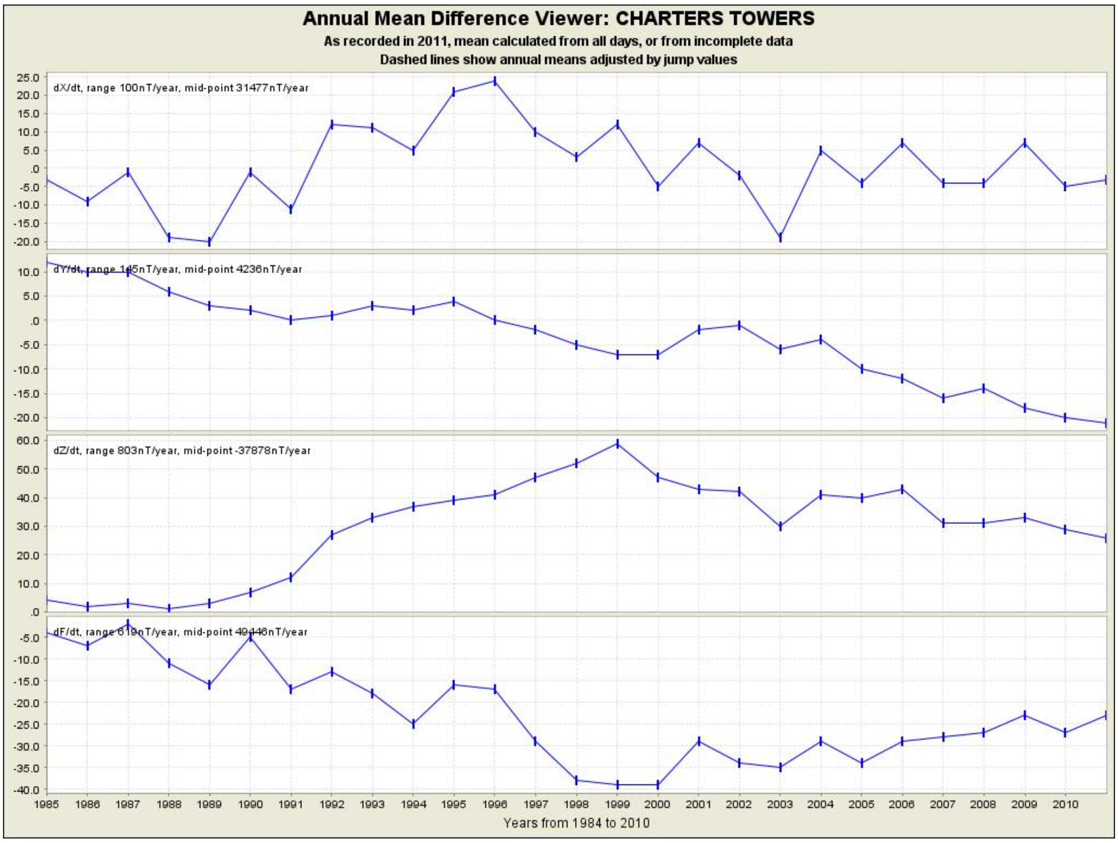
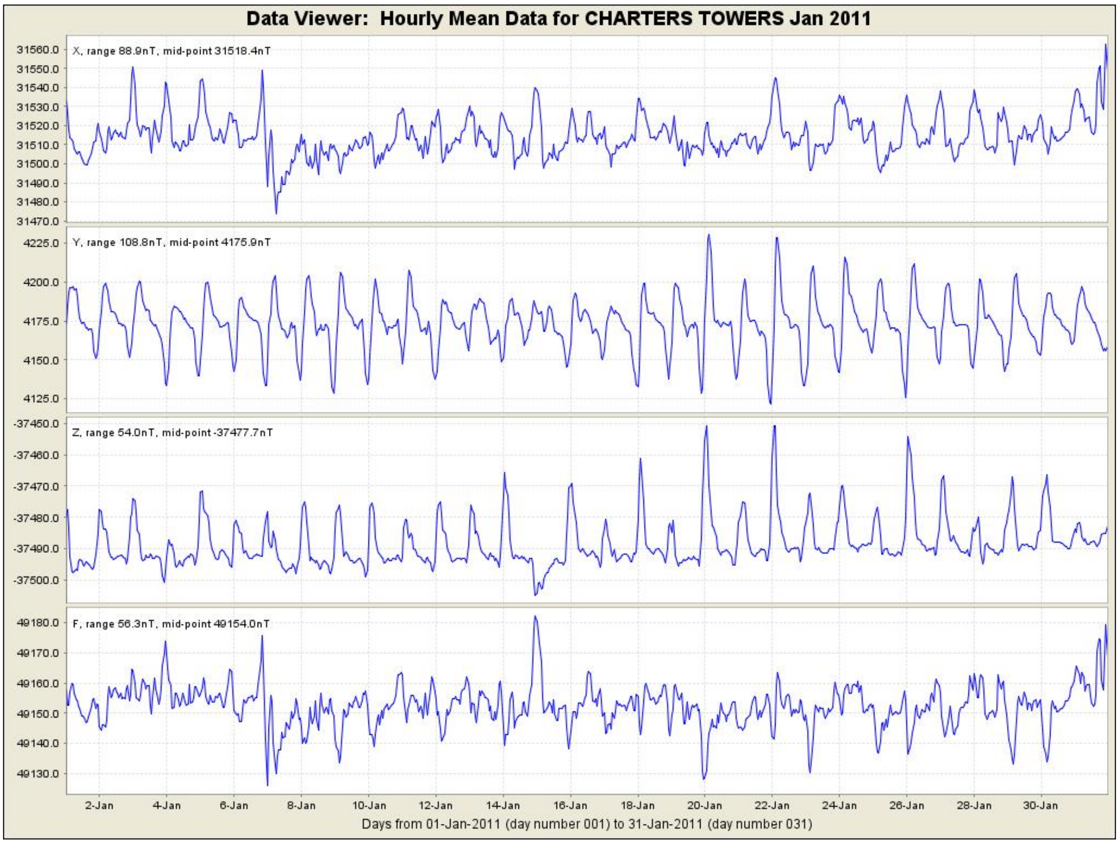
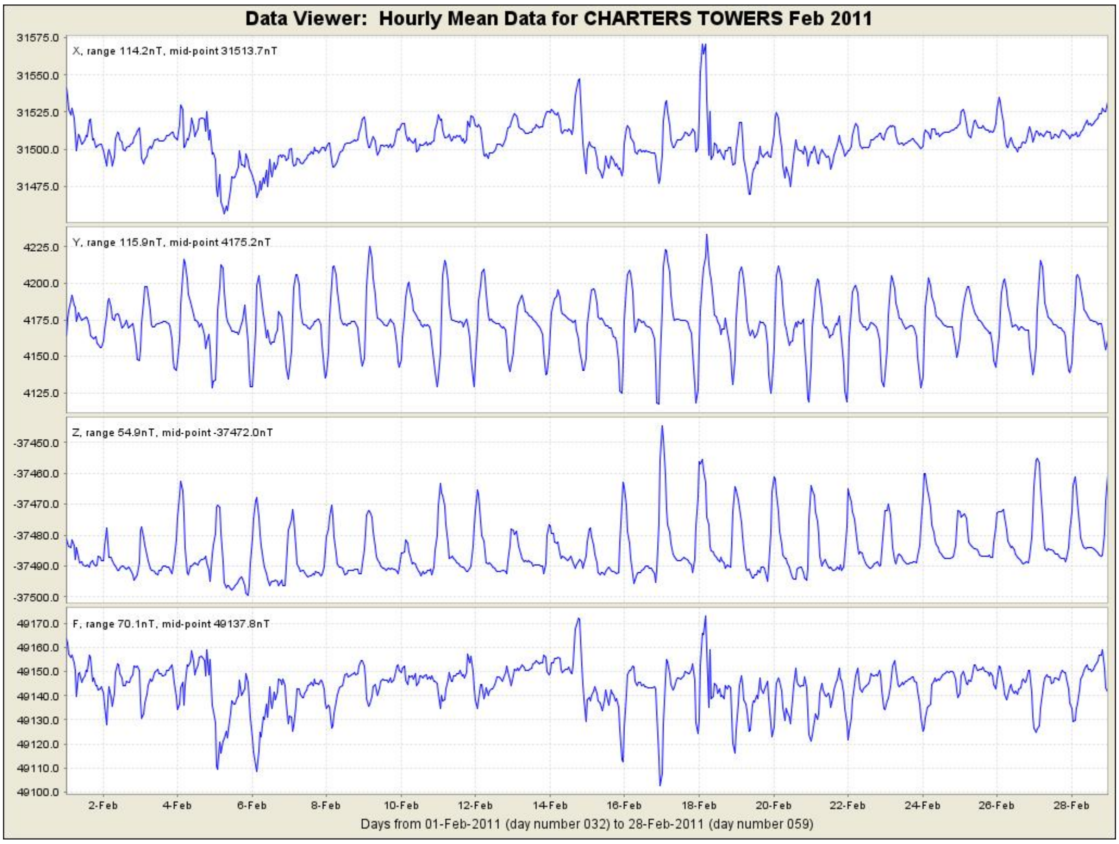
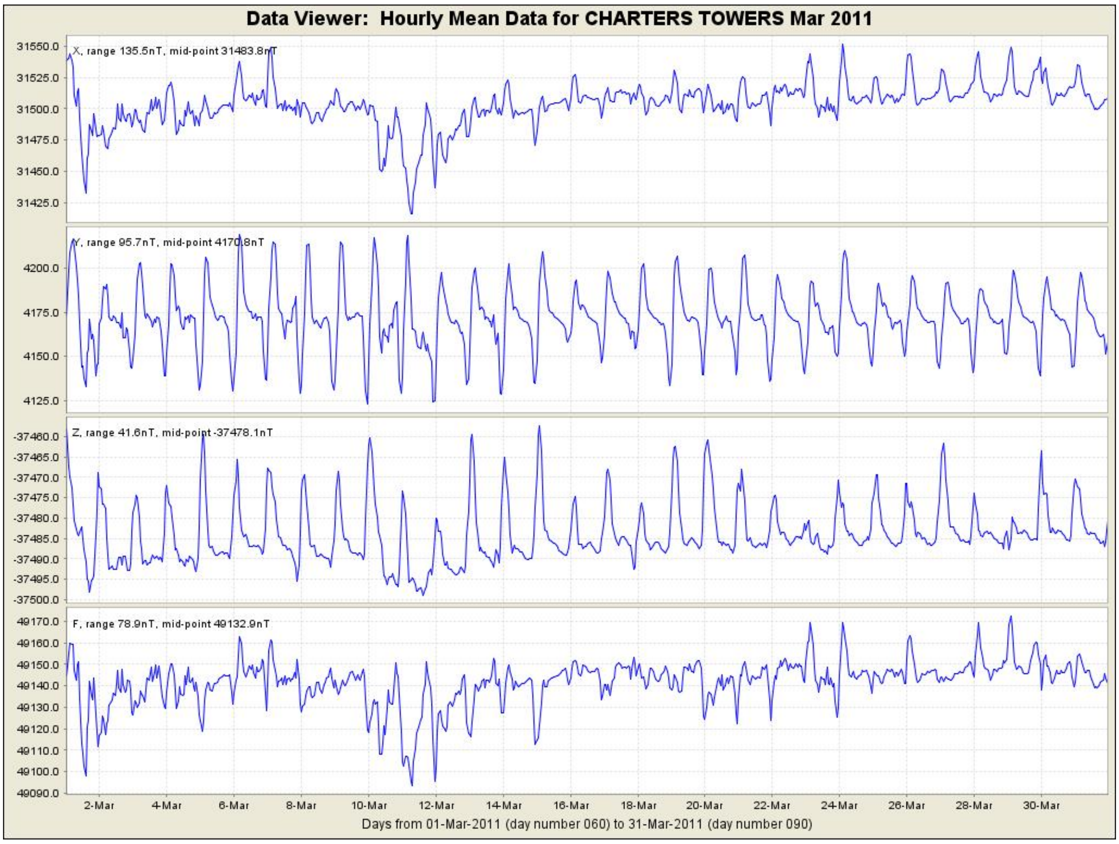
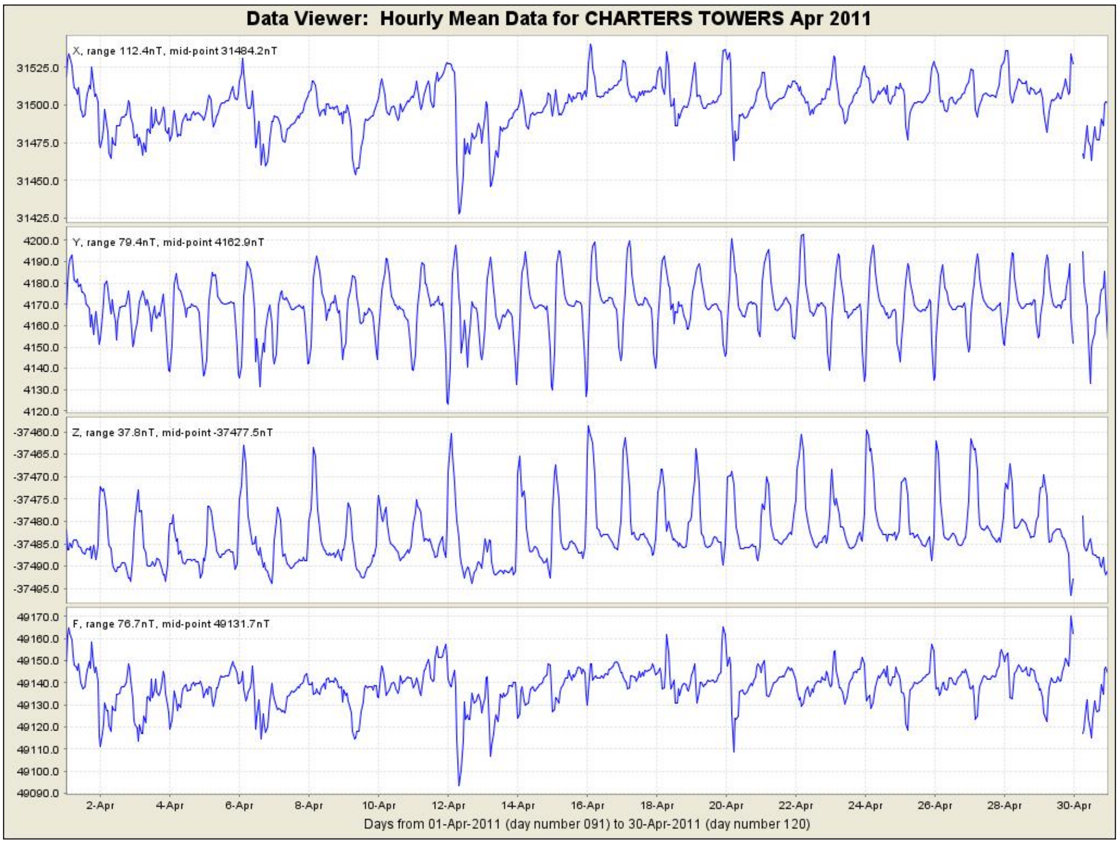


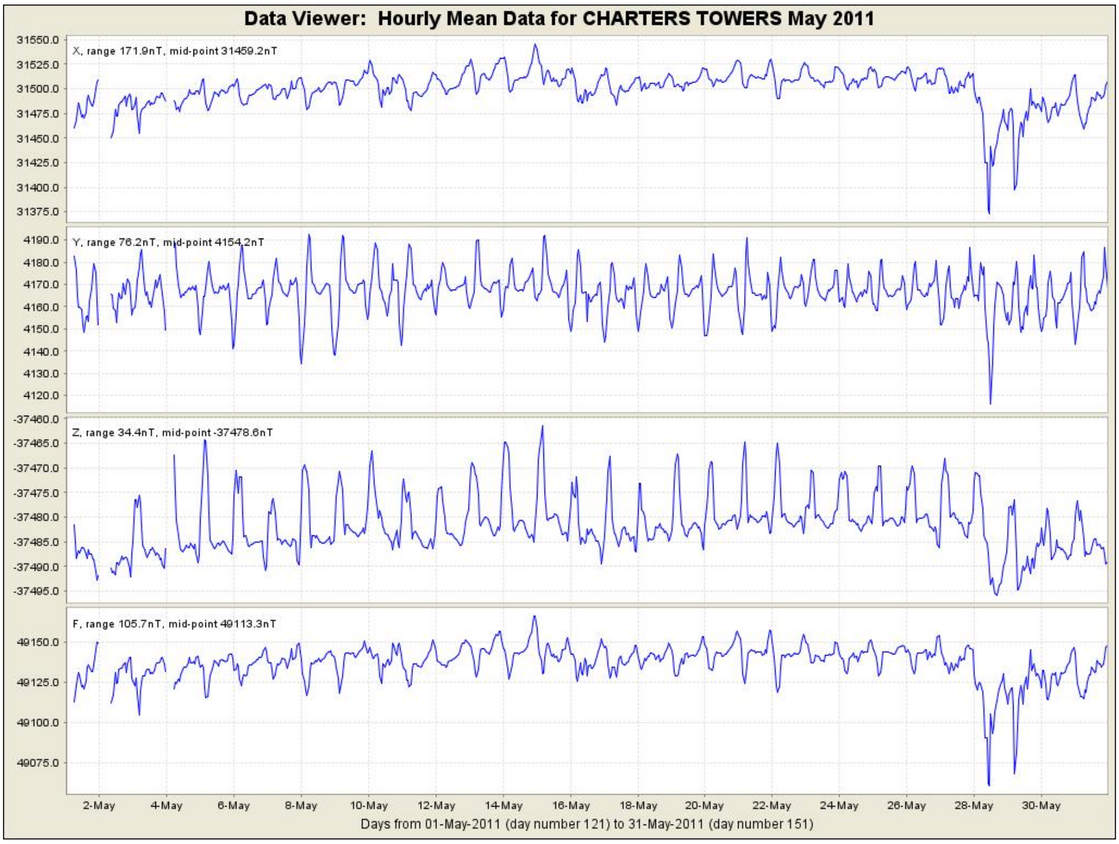
Figure 2.2. *Charters Towers annual mean values and secular variation (all days) for X, Y, Z and F.*

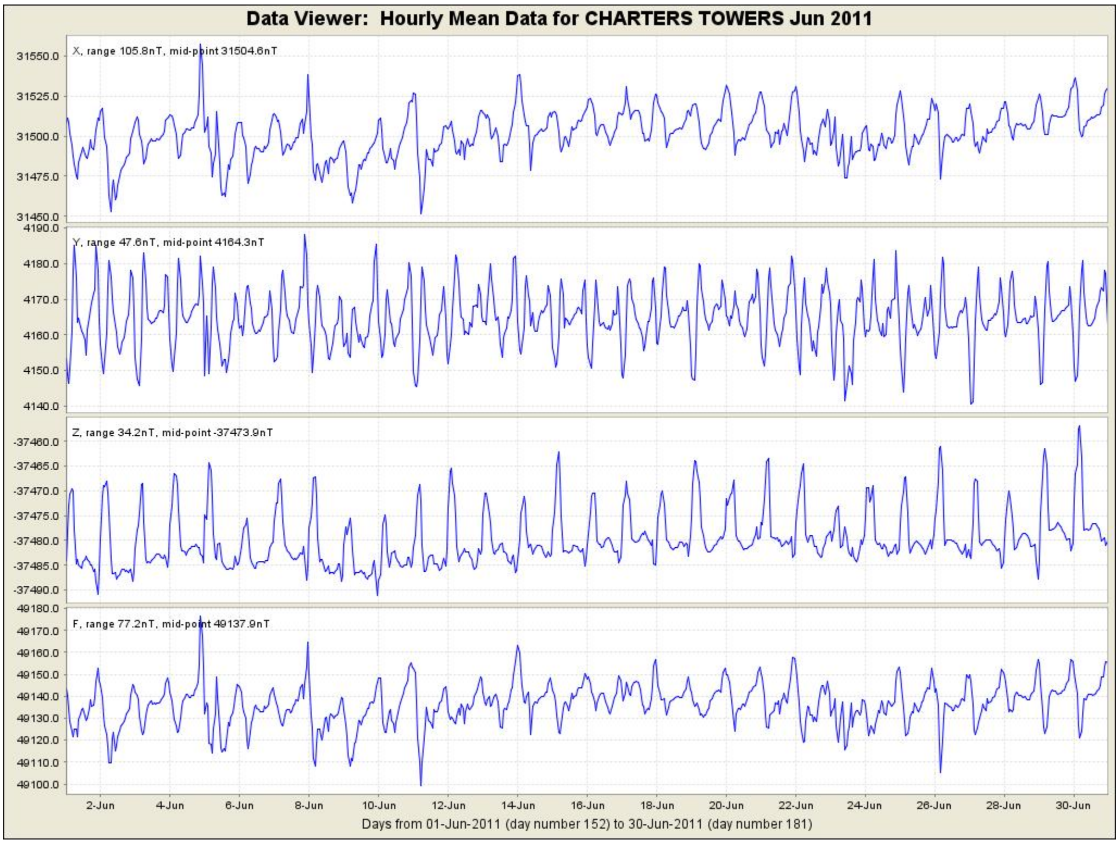

Data Viewer: Hourly Mean Data for CHARTERS TOWERS Jan 2011
X, range 88.9nT, mid-point 31518.4nT
Y, range 108.8nT, mid-point 4175.9nT
Z, range 54.0nT, mid-point -37477.7nT
F, range 56.3nT, mid-point 49154.0nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

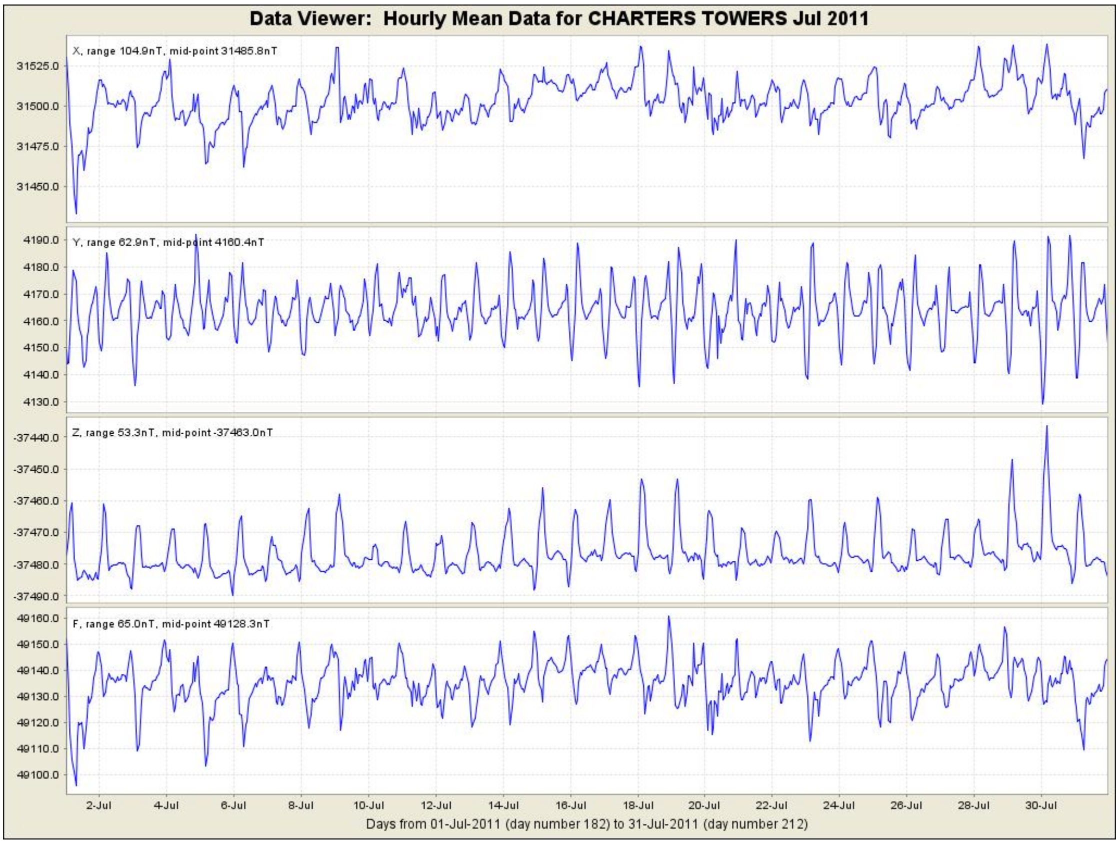

Data Viewer: Hourly Mean Data for CHARTERS TOWERS Feb 2011
X, range 114.2nT, mid-point 31513.7nT
Y, range 115.9nT, mid-point 4175.2nT
Z, range 54.9nT, mid-point -37472.0nT
F, range 70.1nT, mid-point 49137.8nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

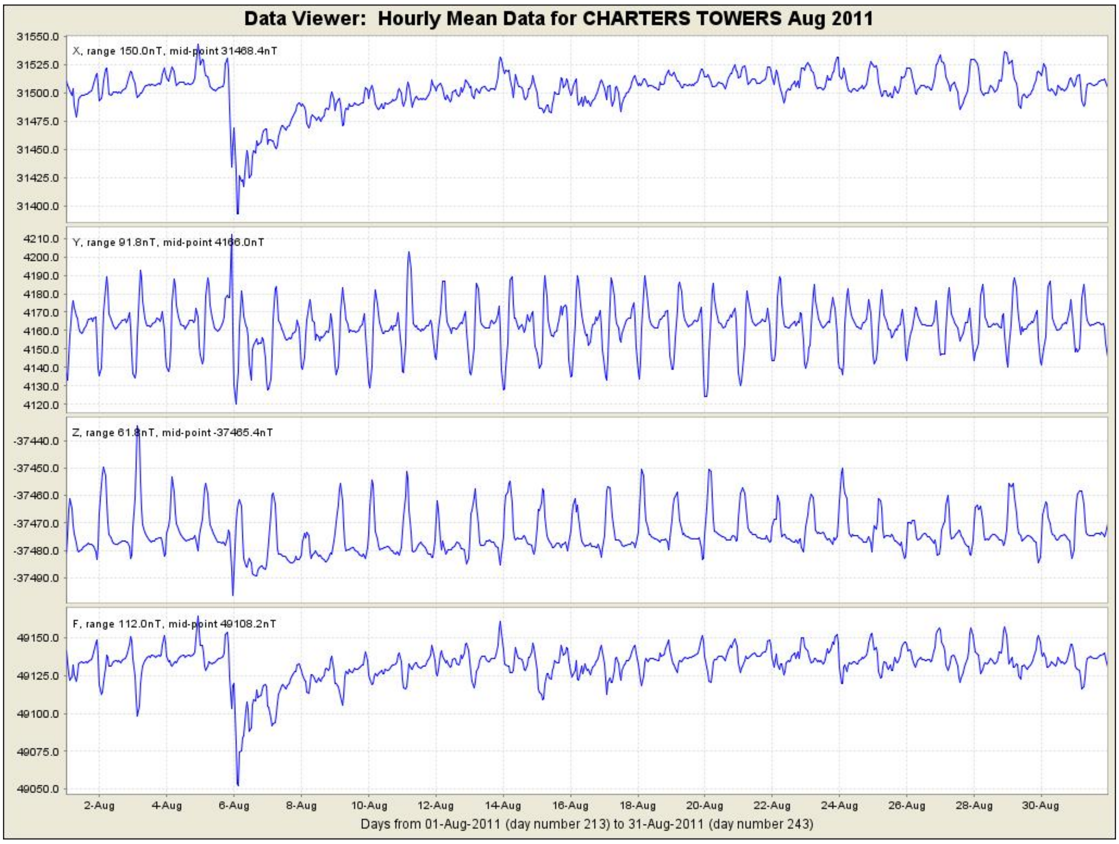

Data Viewer: Hourly Mean Data for CHARTERS TOWERS Mar 2011
X, range 135.5nT, mid-point 31483.8nT
Y, range 95.7nT, mid-point 4170.8nT
Z, range 41.6nT, mid-point -37478.1nT
F, range 78.9nT, mid-point 49132.9nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

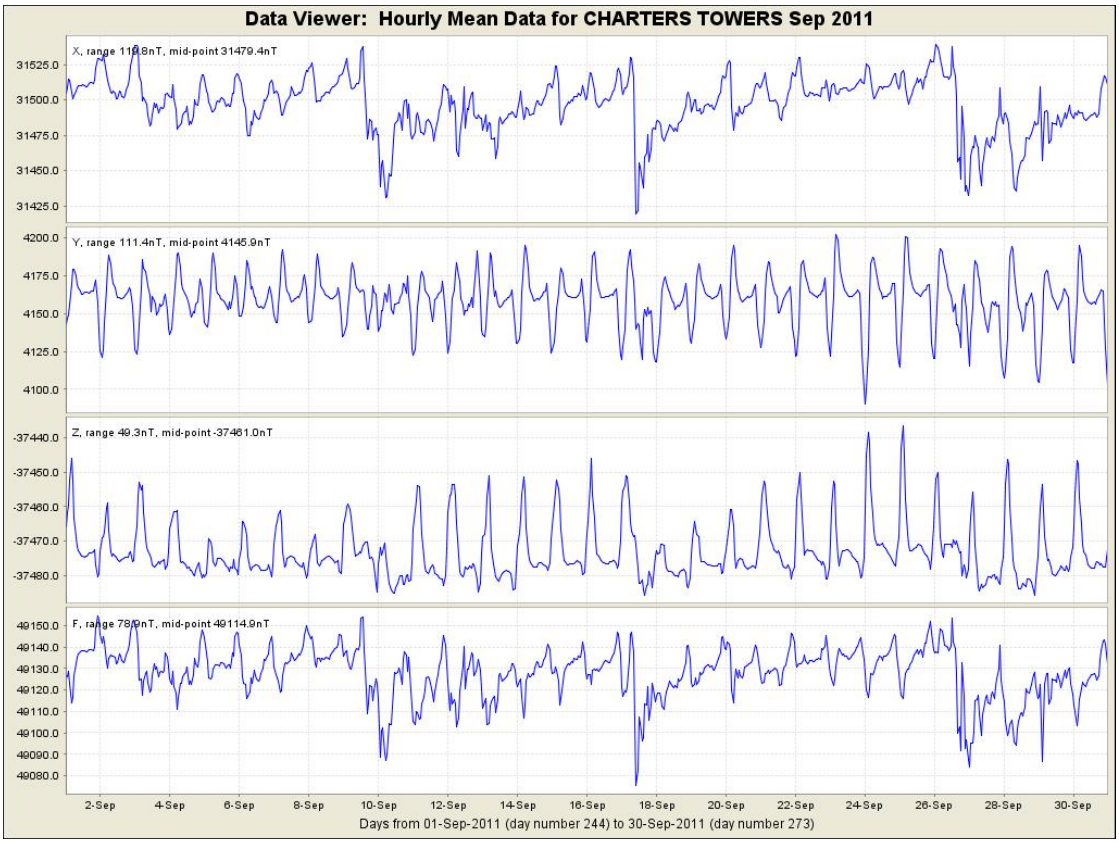

Data Viewer: Hourly Mean Data for CHARTERS TOWERS Apr 2011
X, range 112.4nT, mid-point 31484.2nT
Y, range 79.4nT, mid-point 4162.9nT
Z, range 37.8nT, mid-point -37477.5nT
F, range 76.7nT, mid-point 49131.7nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)


Data Viewer: Hourly Mean Data for CHARTERS TOWERS May 2011
X, range 171.9nT, mid-point 31459.2nT
Y, range 76.2nT, mid-point 4154.2nT
Z, range 34.4nT, mid-point -37478.6nT
F, range 105.7nT, mid-point 49113.3nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)

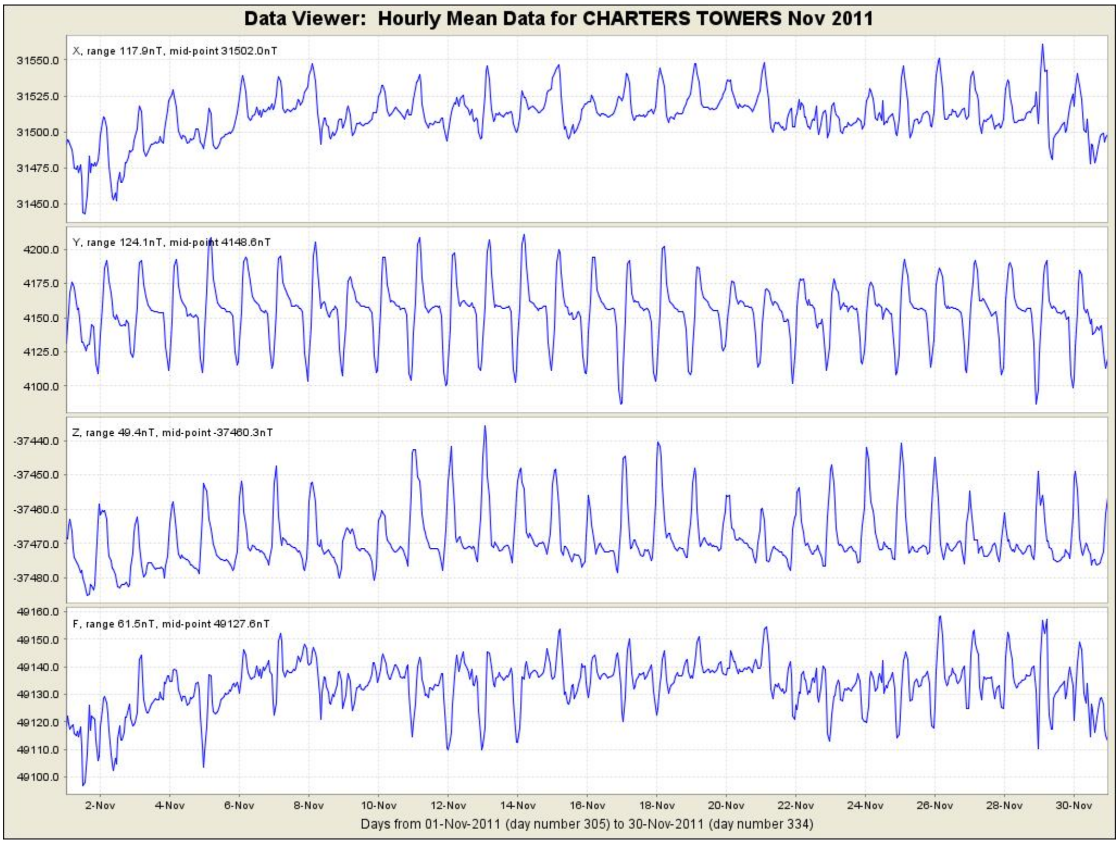

Data Viewer: Hourly Mean Data for CHARTERS TOWERS Jun 2011
X, range 105.8nT, mid-point 31504.6nT
Y, range 47.6nT, mid-point 4164.3nT
Z, range 34.2nT, mid-point -37473.9nT
F, range 77.2nT, mid-point 49137.9nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for CHARTERS TOWERS Jul 2011
X, range 104.9nT, mid-point 31485.8nT
Y, range 62.9nT, mid-point 4160.4nT
Z, range 53.3nT, mid-point -37463.0nT
F, range 65.0nT, mid-point 49128.3nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for CHARTERS TOWERS Aug 2011
X, range 150.0nT, mid-point 31468.4nT
Y, range 91.8nT, mid-point 4166.0nT
Z, range 61.8nT, mid-point -37465.4nT
F, range 112.0nT, mid-point 49108.2nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for CHARTERS TOWERS Sep 2011
X, range 119.8nT, mid-point 31479.4nT
Y, range 111.4nT, mid-point 4145.9nT
Z, range 49.3nT, mid-point -37461.0nT
F, range 78.9nT, mid-point 49114.9nT
2-Sep 4-Sep 6-Sep 8-Sep 10-Sep 12-Sep 14-Sep 16-Sep 18-Sep 20-Sep 22-Sep 24-Sep 26-Sep 28-Sep 30-Sep
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for CHARTERS TOWERS Oct 2011
X, range 156.3nT, mid-point 31472.2nT
Y, range 126.5nT, mid-point 4157.0nT
Z, range 63.9nT, mid-point -37459.2nT
F, range 112.0nT, mid-point 49109.2nT
2-Oct 4-Oct 6-Oct 8-Oct 10-Oct 12-Oct 14-Oct 16-Oct 18-Oct 20-Oct 22-Oct 24-Oct 26-Oct 28-Oct 30-Oct
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)



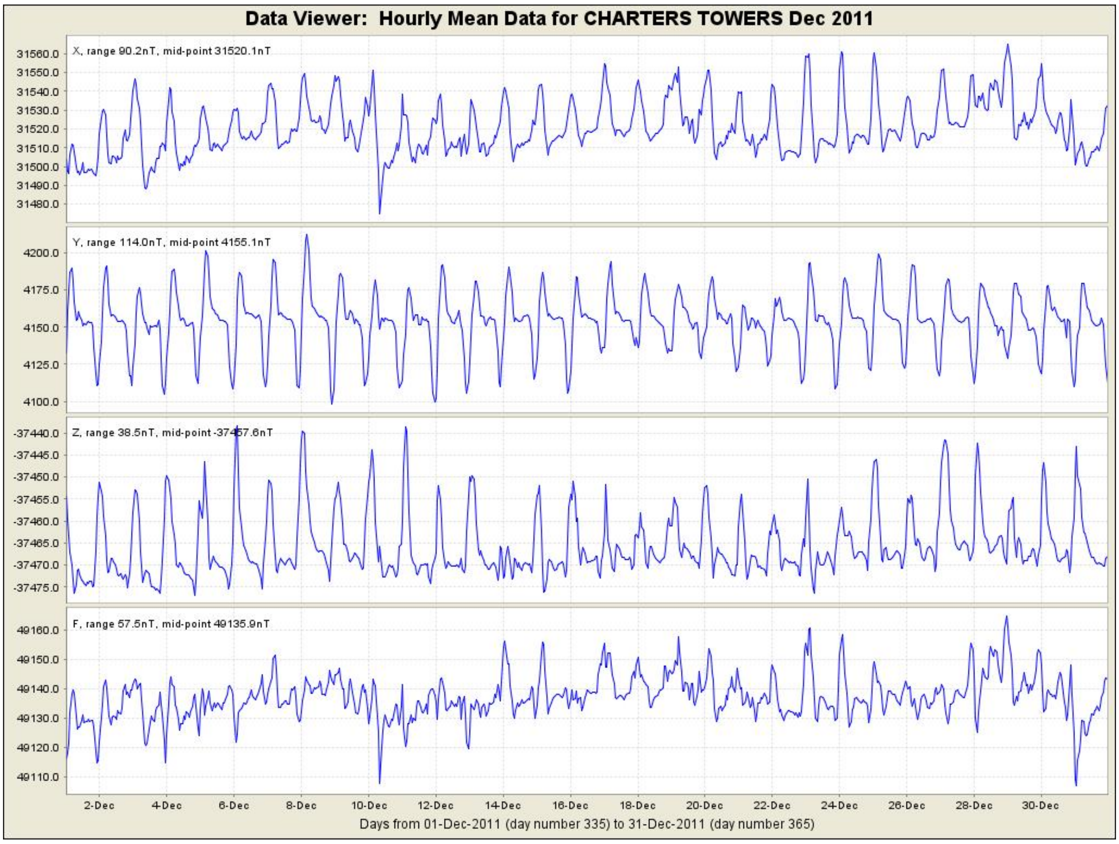


Figure 2.3. *Charters Towers 2011 hourly mean values in X, Y, Z and F.*

3. Learmonth

The Learmonth magnetic observatory is located on North West Cape about 1100 km north of Perth and 35 km from Exmouth in Western Australia. The magnetic observatory is co-located with the Learmonth Solar Observatory, which is jointly staffed by IPS Radio and Space Services and the Unites States of America Air Force. The observatory complex is situated on coastal sand dunes bordering the Exmouth Gulf.

The magnetic observatory consists of:

- three underground vaults located on IPS land, housing variometer sensors and control equipment;
- an Absolute Shelter, located on land belonging to the Royal Australian Air Force (RAAF) 200 m from the solar observatory, enclosing a concrete observation pier (Pier A), the top of which is 1200 mm above the concrete floor, and;
- an external station on RAAF land.

Variometers

The variometers used during 2011 are described in Table 3.2.

The recording equipment, some of the variometer electronic control equipment, and back-up power were housed in the Radio Solar Telescope Network (RSTN) building of the Solar Observatory. The magnetometers and control electronics were housed in three semi-underground concrete vaults, each 800×800×800 mm, lying in a north-south line about 110 m from the RSTN building. The vaults are about 7 m apart and covered in local sand. The fluxgate sensor was in the northernmost vault with the control electronics in the central vault. A GSM-90 total-field sensor was in the southernmost vault with its electronics in the central vault.

Underground conduits containing sensor cables connected the central vault to the two sensor vaults. An underground conduit between the RSTN building and the central vault contained 12 V DC power and digital data cables. The variometer and recording system were powered by a 12 V DC battery box charged from 240 V AC mains power. The recording computer and 12 V DC battery box were housed in the RSTN building. System timing was provided by a GPS clock with time corrections applied automatically and logged. Timing corrections greater than 1 ms are listed in *Significant events* below.

The scalar variometer was unavailable from 01 January. A replacement GSM-90 was installed at the end of July but did not resolve the problem. During a maintenance visit in early November the data protocol converters were replaced in the RSTN building and the control vault which restored the connection to the scalar magnetometer.

The vector variometer performed well throughout the year. The DMI sensor temperature ranged from 23°C to 36°C and the electronics from 21°C to 35°C during the year. Although the sensor and electronics were both buried in instrument vaults, the temperature varied during the year in accordance with the seasons. The temperature extremes recorded at Learmonth Airport during 2011 were 7.3°C on 2011-06-22 and 48.9°C on 2011-01-23. The standard temperature of the variometer system was set to 25°C. Temperature fluctuations in the PPM sensor vault were not recorded but it is expected they would be similar to those experienced by the fluxgate sensor. Temperature corrections have been made in the final data. The maximum daily rainfall was 50.4 mm on 2011-02-23 with a total of 344.4 mm for the year.

Absolute instruments

The principal absolute magnetometers used at Learmonth and their adopted corrections for 2011 are described in Table 3.3.

Table 3.1. *Key observatory data.*

IAGA code:	LRM
Commenced operation:	November 1986
Geographic latitude:	22° 13' 19" S
Geographic longitude:	114° 06' 03" E
Geomagnetic latitude:	-31.85°
Geomagnetic longitude:	187.03°
K 9 index lower limit:	300 nT
Principal pier:	Pier A
Pier elevation (top):	4 m AMSL
Principal reference mark:	West windsock
Reference mark azimuth:	283° 02' 18"
Reference mark distance:	1 km approx.
Observer:	E. Lindsay

The absolute DIM fluxgate instrument, DI0051/313888, was compared to the Canberra geomagnetic observatory reference instrument DI0086/353756 on 21, 28 July, 17, 25 August and 1, 22 September 2009 at the Canberra geomagnetic observatory before being deployed to Learmonth. Instrument differences were measured as -0.05’, -0.10’ in D and I respectively. During an observatory maintenance visit in November 2011 a comparison was made between the travelling reference (DIM 160459/B0610H) and the Learmonth absolute instrument. The results of the comparison showed that no change was required to the previously applied instrument corrections for the Learmonth absolute instruments.

The adopted differences between the LRM instruments and the international average (as defined by observations at IAGA instrument workshops) are given in Table 3.3.

At the 2011 mean magnetic-field values at Learmonth (X=29952 nT, Y=227 nT, Z= 43675 nT) the D, I and F corrections translate to corrections of:

DIM DI0051/313888, GSM-90 2101216/83387

ΔX = -1.3 nT ΔY = -0.4 nT ΔZ = -0.9 nT

These corrections have been applied to all LRM 2011 final data.

Table 3.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	DMI FGE
Serial number:	E0271 / S0237
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.032 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	3091315 / 73103
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	2011-01-01
Total-field variometer:	GEM Systems GSM-90
Serial number:	8092903 / 83385
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	2011-07-30 – 2011-12-31
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	Communications were swapped several times throughout the year. The two telemetry paths available are via radio modem to Giralia seismic station and then VSAT to Canberra or via IPS dedicated data line to Sydney and then via Internet to Canberra.

Baselines

The standard deviations of the differences between the weekly absolute observations and the final adopted variometer model and data were:

	σ
X	0.5 nT
Y	1.1 nT
Z	0.6 nT
D	07"
I	02"
F	0.6 nT

Throughout the year adopted baselines drifted within a range of 5 nT. During November – December, when scalar variometer data were available, there was a range of about 2 nT in the total-field difference between the scalar variometer and the vector variometer.

Observed and adopted baseline values in X, Y and Z are shown in Figure 3.1.

Operations

Absolute observations were performed weekly by Emily Lindsay from IPS Radio and Space Services.

Variometer data were downloaded about every 3-10 minutes through a TCP/IP network connection. One-minute data were then automatically processed to reported status, made available on the Geoscience Australia website, and sent to the Edinburgh INTERMAGNET GIN via e-mail/HTTP. Raw data were also provided to IPS Radio and Space Services via a direct serial link from the acquisition computer in the RSTN building. IPS applied nominal scale values and rotation parameters.

On 30 July, the malfunctioning PPM variometer was replaced during a visit by Jim Whatman. The replacement of the instrument did not correct the problem. In a further attempt to rectify the problem, the data protocol converters were replaced during a maintenance visit in November. Absolute instrument comparisons, tests and checks of reference azimuth marks and piers were also carried out at that time (Lewis and Jones, 2011).

The distribution of Learmonth 2011 data is described in Table 3.4. Data losses are identified in Table A.3.

Table 3.4. *Distribution of Learmonth 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
WDC for Geomagnetism	preliminary	real time

Table 3.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0051
Theodolite:	Zeiss 020B
Serial number:	313888
Resolution:	0.1’
D correction:	-0.05’
I correction:	-0.10’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	2101216 / 83387
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Significant events

2011-01-01	06:11 PC stopped.
2011-01-03	John K recycled the power on the PC, but it still could not start. The input voltage was measured 13.6 V.
2011-01-06	No voltage output on the DC output terminals. John opened the PC box and checked the fuse. and the fuse is ok. Connected power back to the power supply while the PC cover is off, and found that PC is working without connecting to any instruments. Put everything back together again and connected all the plugs back to the PC, and it booted with lights and video signal output. The PPM variometer is not working.
2011-01-12	"route add 192.55.112.0 192.168.33.233" when connected "slrm" and then "slrmg" worked OK Same problem as 2010-06-08, same solution. TO BE RECTIFIED.
2011-01-14	John K recycled the power for both DMI magnetometer and GSM90 variometer. data loss: 3 minutes between 01:34 to 01:37. GSM90 still does not work.
2011-02-04	non-magnetic sheep fence completed around the absolute hut. Today's obs is the first with the completed fence.
2011-02-18	Cyclone Dianne was just off of coast so observations were not able to be completed for this week.
2011-02-25	Another cyclone (Carlos) in area during week but observations completed on Friday as usual.
2011-03-04	System stopped 01:48:30, restarted 01:49:05. Reason unknown. Network routing problem after the reboot caused data telemetry to stop
2011-03-07	PGC changes routing table in boot-up files, - see above
2011-03-11	No obs this week as Emily is away from observatory.
2011-05-06	WVJ adjusted the initial baseline figures.
2011-06-15	EL was only person at station last week so no obs for week.
2011-07-30	06:18 large baseline jump. System reboot. 08:17 data telemetry stops. Jim replacing variometer PPM 14:00 - 16:30 local time
2011-08-02	Jim reports that variometer PPM sensor, cable and electronics replaced. Central and PPM vault opened. Still no PPM data. Jim suspects RS-232/422 converters are not working. 02:12 reboot system. Still no telemetry through GIRL. Lost contact with GPS clock. 03:10 "route add 192.55.112.0 192.168.33.233"- this gets telemetry running again through GIRL
2011-08-03	03:48 slay and restart GdapClock - no improvement 04:11 reboot system 04:12:46 - CLK I 0 Correction 1312344766 765274154 C 0 s 251934305 R 0 s-46333 "route add 192.55.112.0 192.168.33.233"
2011-11-11	AML/WVJ maintenance visit Fri Nov 11 - Tue Nov 15, replace Scalar variometer RS422 converters. Install voltage regulator, obs, station difference, azimuths etc.
2011-11-18	EL unable to collect obs for week ending the 18th
2011-12-06	5.1 magnitude earthquake located about 50 km north of Exmouth, clearly seen in data.
2011-12-13	Ezy-Beach trolley received by EL, will be used from now on to transport equipment to hut

Annual mean values

The annual mean values for Learmonth are set out in Table 3.5 and displayed with the secular variation in Figure 3.2.

Hourly mean values

Plots of the hourly mean values for Learmonth 2011 data are shown in Figure 3.3.

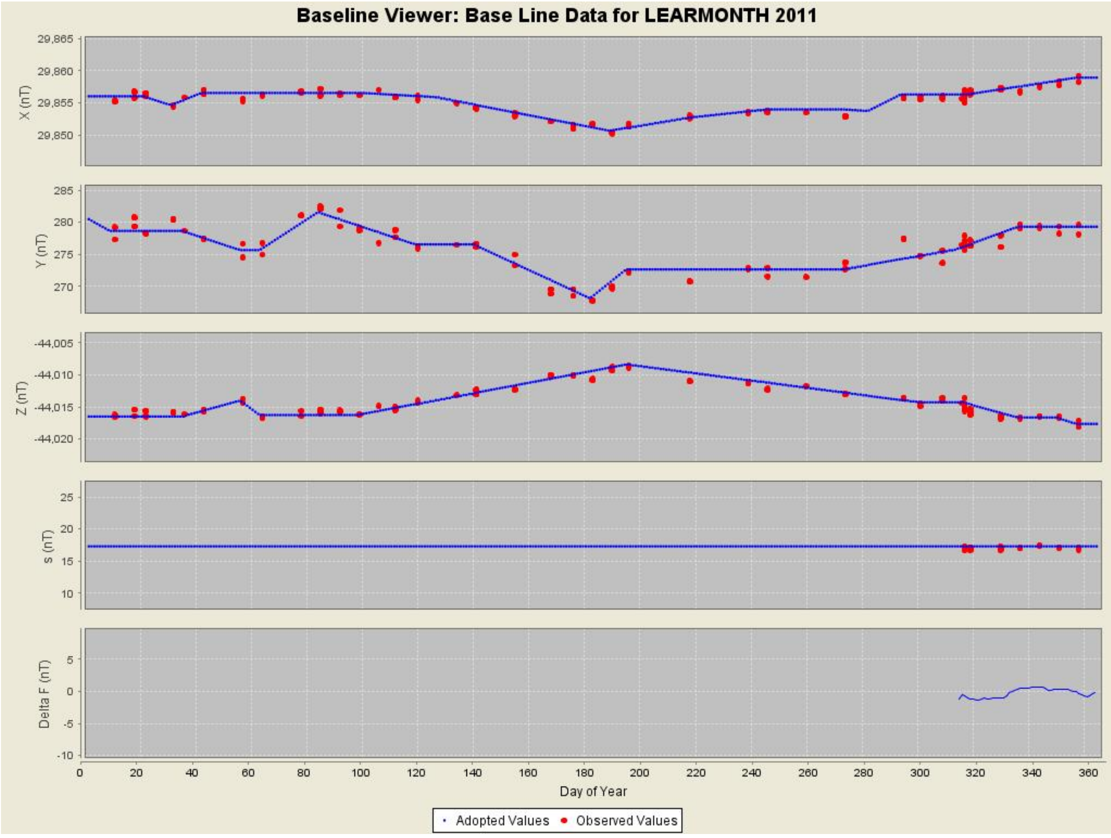


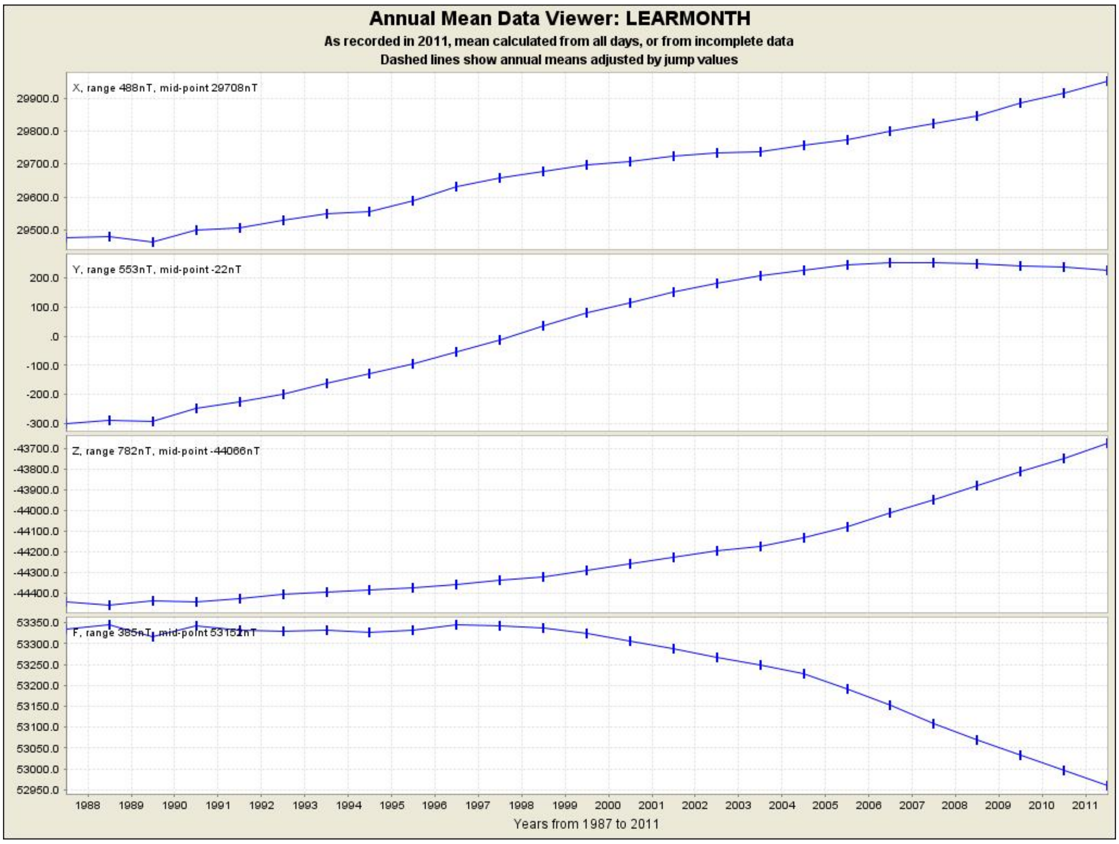
Figure 3.1. *Learmonth 2011 baseline plots.*

Table 3.5. *Learmonth annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 3.2.*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1987.5	A	-0	34.9	-56	26.7	29480	29478	-299	-44446	53334	DHZ
1988.5	A	-0	33.5	-56	27.0	29481	29479	-288	-44457	53344	DHZ
1989.5	A	-0	34.3	-56	27.1	29465	29464	-294	-44436	53317	DHZ
1990.5	A	-0	28.8	-56	25.4	29501	29500	-247	-44441	53342	DHZ
1991.5	A	-0	26.3	-56	24.5	29507	29506	-226	-44426	53333	DHZ
1992.5	A	-0	23.4	-56	22.6	29531	29530	-201	-44407	53330	DHZ
1993.5	A	-0	18.9	-56	21.2	29550	29549	-162	-44396	53331	DHZ
1994.5	A	-0	15.0	-56	20.5	29555	29555	-129	-44386	53326	DHZ
1995.5	A	-0	10.8	-56	18.2	29588	29588	-93	-44373	53333	DHZ
1996.5	A	-0	06.2	-56	15.5	29630	29630	-54	-44358	53344	DHZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1997.5	A	-0	01.3	-56	13.3	29658	29658	-11	-44338	53343	DHZ
1998.5	A	0	04.2	-56	11.6	29676	29676	36	-44320	53338	DHZ
1999.5	A	0	09.2	-56	09.6	29696	29696	80	-44292	53325	ABZ
2000.5	A	0	13.5	-56	07.9	29707	29706	116	-44260	53305	ABZ
2001.5	A	0	17.7	-56	05.7	29724	29724	153	-44227	53287	ABZ
2002.5	A	0	20.8	-56	04.2	29734	29733	180	-44197	53268	ABZ
2003.5	A	0	23.8	-56	03.1	29737	29736	206	-44174	53250	ABZ
2004.5	A	0	26.3	-56	00.4	29759	29758	228	-44132	53229	ABZ
2005.5	A	0	28.3	-55	57.8	29773	29772	245	-44079	53192	ABZ
2006.5	A	0	29.1	-55	53.9	29800	29799	253	-44011	53151	ABZ
2007.5	A	0	29.2	-55	50.3	29823	29822	254	-43946	53109	ABZ
2008.5	A	0	28.5	-55	46.5	29848	29847	247	-43880	53070	ABZ
2009.5	A	0	27.8	-55	42.0	29885	29884	241	-43809	53032	ABZ
2010.5	A	0	27.2	-55	37.9	29916	29915	237	-43744	52996	ABZ
2011.5	A	0	26.1	-55	33.4	29953	29952	227	-43675	52959	ABZ
1987.5	Q	-0	34.8	-56	26.3	29486	29484	-299	-44445	53336	DHZ
1988.5	Q	-0	33.5	-56	26.3	29494	29492	-288	-44455	53349	DHZ
1989.5	Q	-0	34.3	-56	26.2	29481	29479	-294	-44433	53324	DHZ
1990.5	Q	-0	28.7	-56	24.5	29516	29515	-246	-44439	53348	DHZ
1991.5	Q	-0	26.2	-56	23.4	29527	29526	-225	-44423	53341	DHZ
1992.5	Q	-0	23.3	-56	21.7	29545	29544	-200	-44405	53336	DHZ
1993.5	Q	-0	18.8	-56	20.5	29561	29560	-162	-44394	53336	DHZ
1994.5	Q	-0	15.0	-56	19.7	29569	29569	-129	-44384	53332	DHZ
1995.5	Q	-0	10.8	-56	17.5	29600	29600	-93	-44371	53338	DHZ
1996.5	Q	-0	06.3	-56	15.2	29636	29635	-54	-44357	53346	DHZ
1997.5	Q	-0	01.3	-56	12.8	29667	29667	-11	-44338	53348	DHZ
1998.5	Q	0	04.1	-56	11.1	29686	29686	35	-44318	53342	DHZ
1999.5	Q	0	09.2	-56	09.0	29705	29705	80	-44290	53329	ABZ
2000.5	Q	0	13.5	-56	07.1	29719	29719	117	-44258	53311	ABZ
2001.5	Q	0	17.8	-56	05.0	29736	29736	154	-44225	53293	ABZ
2002.5	Q	0	20.8	-56	03.3	29748	29747	180	-44195	53274	ABZ
2003.5	Q	0	23.8	-56	02.2	29752	29751	206	-44171	53256	ABZ
2004.5	Q	0	26.3	-55	59.8	29770	29769	228	-44130	53233	ABZ
2005.5	Q	0	28.3	-55	57.2	29784	29783	245	-44078	53197	ABZ
2006.5	Q	0	29.1	-55	53.4	29808	29807	252	-44010	53154	ABZ
2007.5	Q	0	29.2	-55	50.0	29827	29826	254	-43945	53112	ABZ
2008.5	Q	0	28.4	-55	46.2	29853	29852	247	-43879	53072	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
2009.5	Q	0	27.7	-55	41.8	29888	29887	241	-43809	53033	ABZ
2010.5	Q	0	27.2	-55	37.6	29921	29921	237	-43744	52998	ABZ
2011.5	Q	0	26.0	-55	33.0	29960	29959	227	-43673	52962	ABZ
1987.5	D	-0	34.9	-56	27.3	29469	29467	-299	-44448	53329	DHZ
1988.5	D	-0	33.6	-56	28.2	29461	29459	-288	-44460	53335	DHZ
1989.5	D	-0	34.4	-56	29.0	29433	29431	-295	-44441	53303	DHZ
1990.5	D	-0	29.0	-56	26.7	29478	29477	-249	-44445	53332	DHZ
1991.5	D	-0	26.5	-56	26.5	29473	29472	-227	-44431	53318	DHZ
1992.5	D	-0	23.5	-56	24.1	29506	29505	-201	-44412	53320	DHZ
1993.5	D	-0	18.9	-56	22.3	29530	29529	-163	-44398	53322	DHZ
1994.5	D	-0	14.9	-56	21.6	29537	29537	-128	-44389	53318	DHZ
1995.5	D	-0	10.9	-56	19.1	29574	29574	-94	-44374	53326	DHZ
1996.5	D	-0	06.2	-56	16.0	29622	29622	-53	-44359	53340	DHZ
1997.5	D	-0	01.3	-56	14.2	29643	29643	-11	-44340	53336	DHZ
1998.5	D	0	04.2	-56	13.0	29652	29652	36	-44322	53326	DHZ
1999.5	D	0	09.3	-56	10.7	29677	29677	81	-44295	53317	ABZ
2000.5	D	0	13.4	-56	09.5	29679	29679	116	-44264	53294	ABZ
2001.5	D	0	17.6	-56	07.2	29699	29699	152	-44230	53276	ABZ
2002.5	D	0	20.8	-56	05.4	29712	29712	179	-44200	53259	ABZ
2003.5	D	0	23.8	-56	04.5	29713	29713	206	-44177	53240	ABZ
2004.5	D	0	26.3	-56	01.6	29739	29738	227	-44135	53219	ABZ
2005.5	D	0	28.3	-55	58.9	29754	29753	245	-44082	53184	ABZ
2006.5	D	0	29.3	-55	54.6	29787	29786	253	-44012	53145	ABZ
2007.5	D	0	29.3	-55	50.7	29816	29814	254	-43946	53106	ABZ
2008.5	D	0	28.5	-55	46.9	29841	29840	247	-43881	53066	ABZ
2009.5	D	0	27.8	-55	42.2	29880	29879	242	-43809	53029	ABZ
2010.5	D	0	27.2	-55	38.5	29907	29906	237	-43745	52991	ABZ
2011.5	D	0	26.1	-55	34.1	29941	29940	227	-43677	52955	ABZ



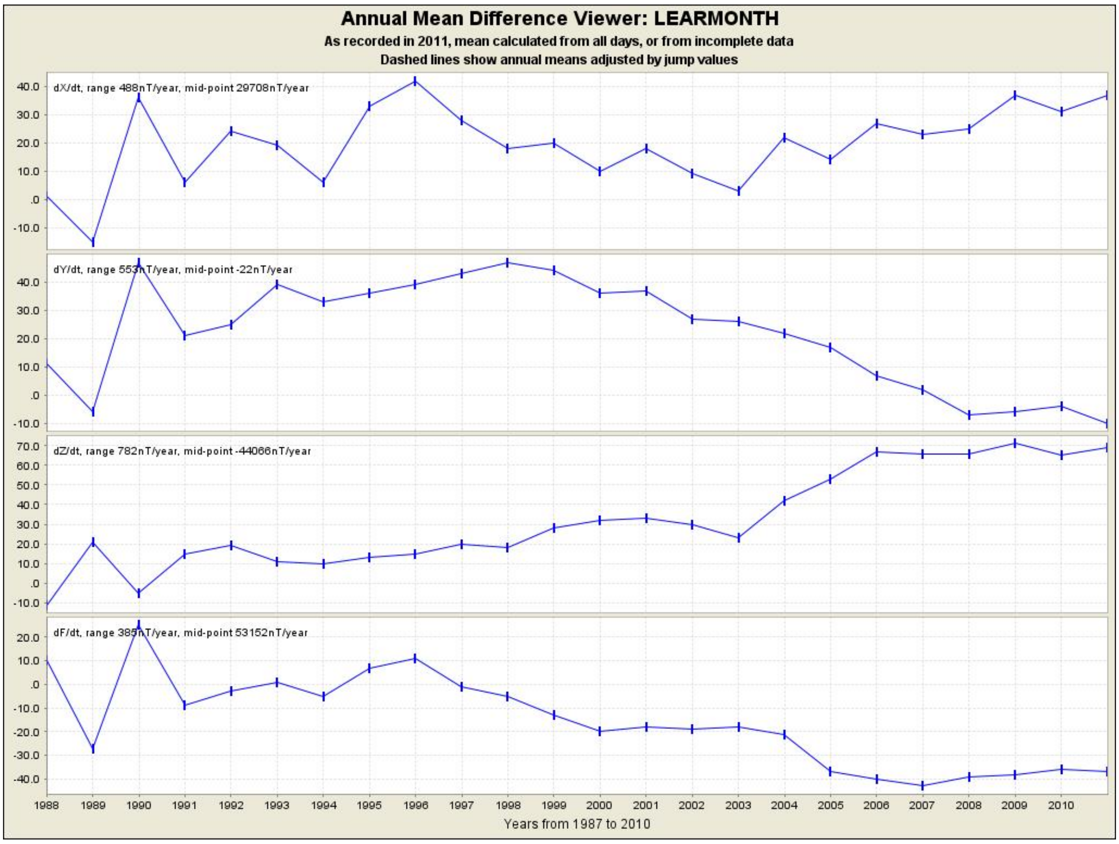
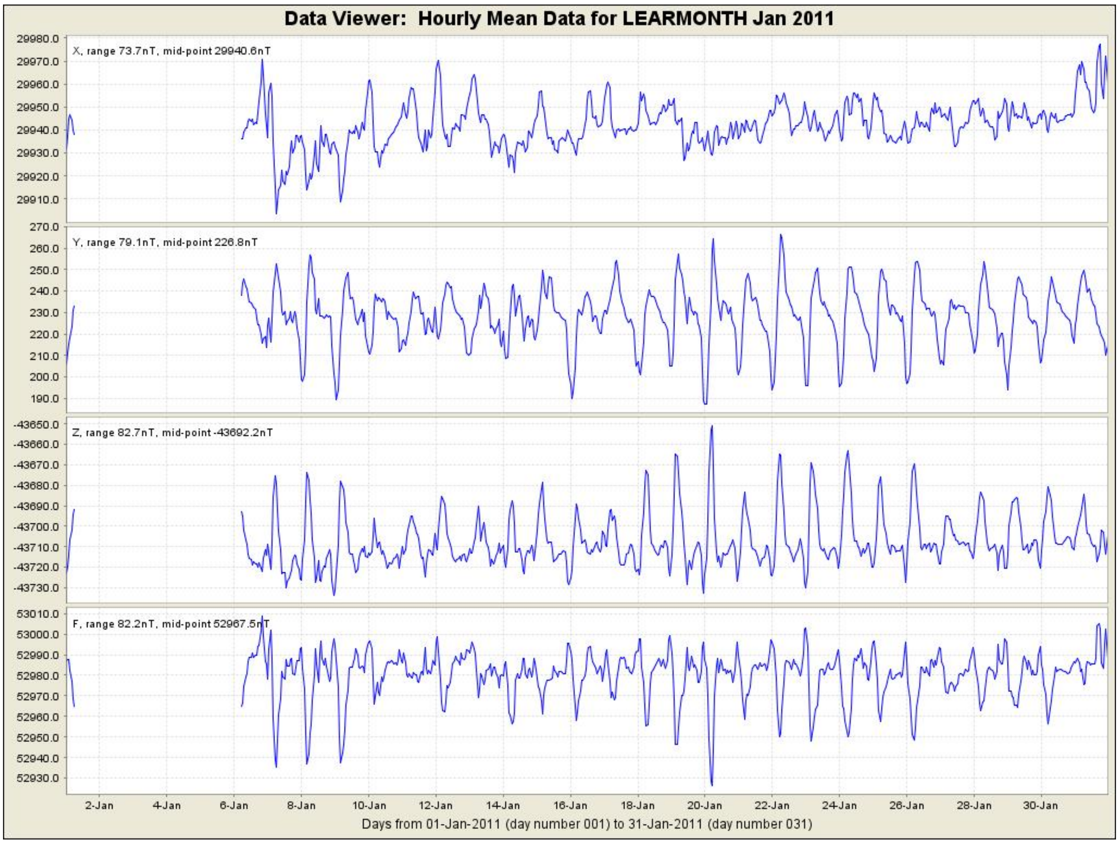
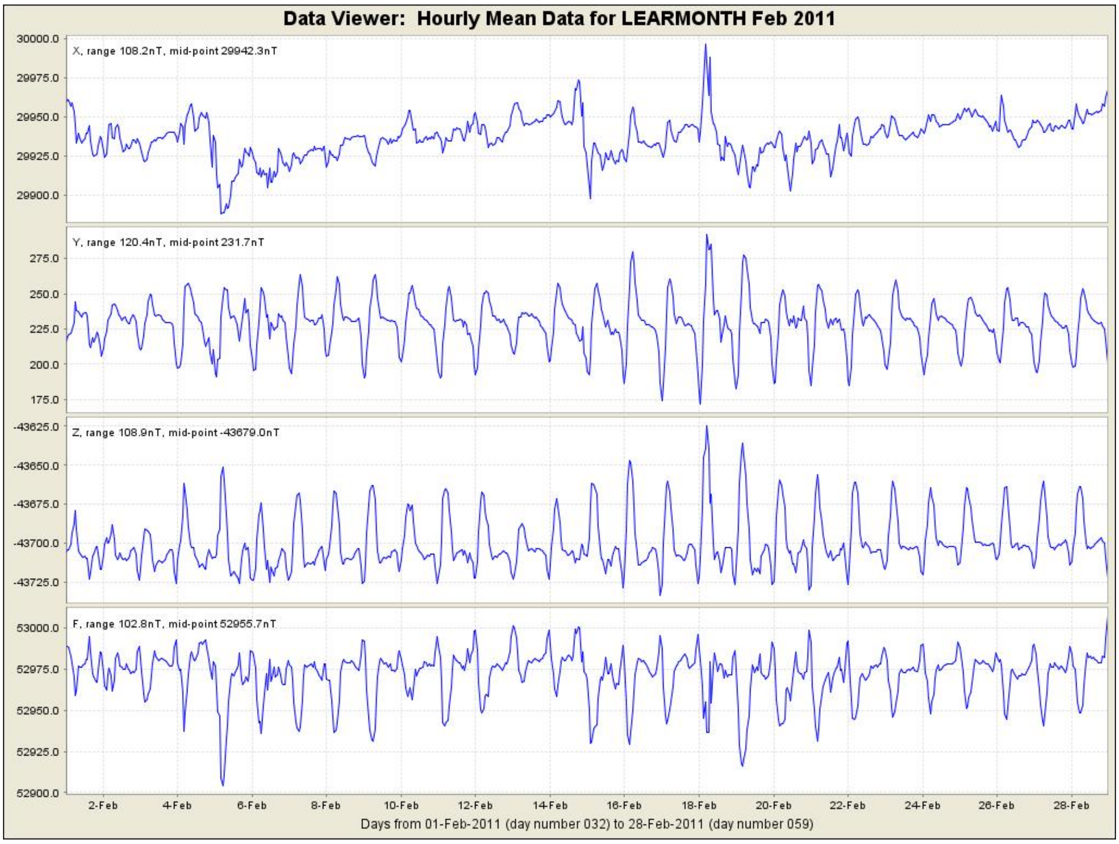
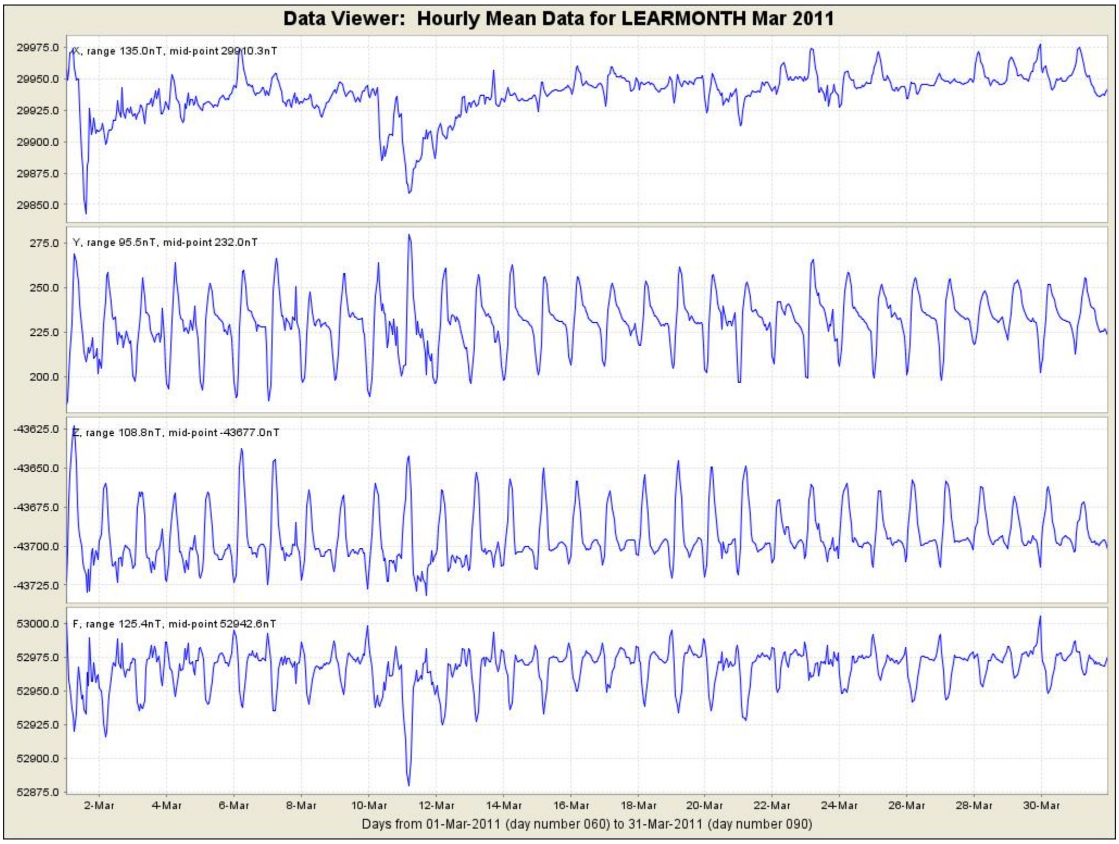


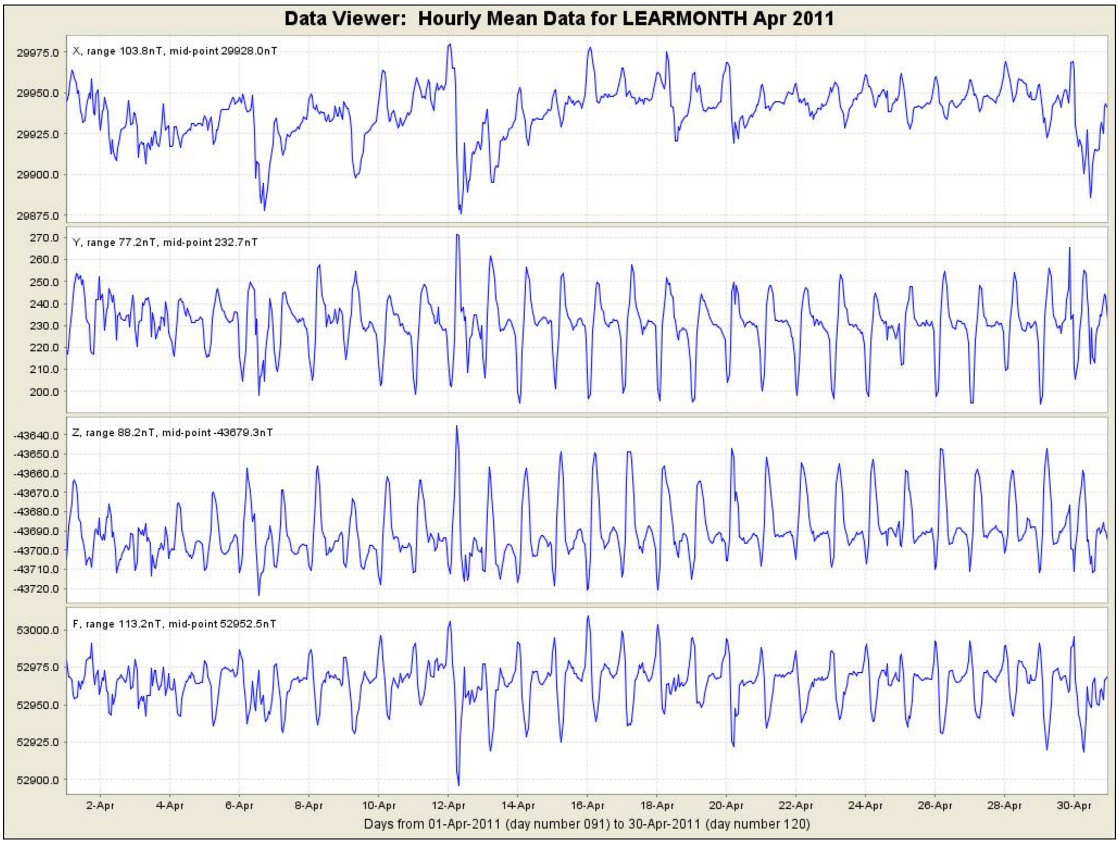
Figure 3.2. *Learmonth annual mean values and secular variation (all days) for X, Y, Z and F.*


Data Viewer: Hourly Mean Data for LEARMONTH Jan 2011
X, range 73.7nT, mid-point 29940.6nT
Y, range 79.1nT, mid-point 226.8nT
Z, range 82.7nT, mid-point -43692.2nT
F, range 82.2nT, mid-point 52967.5nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

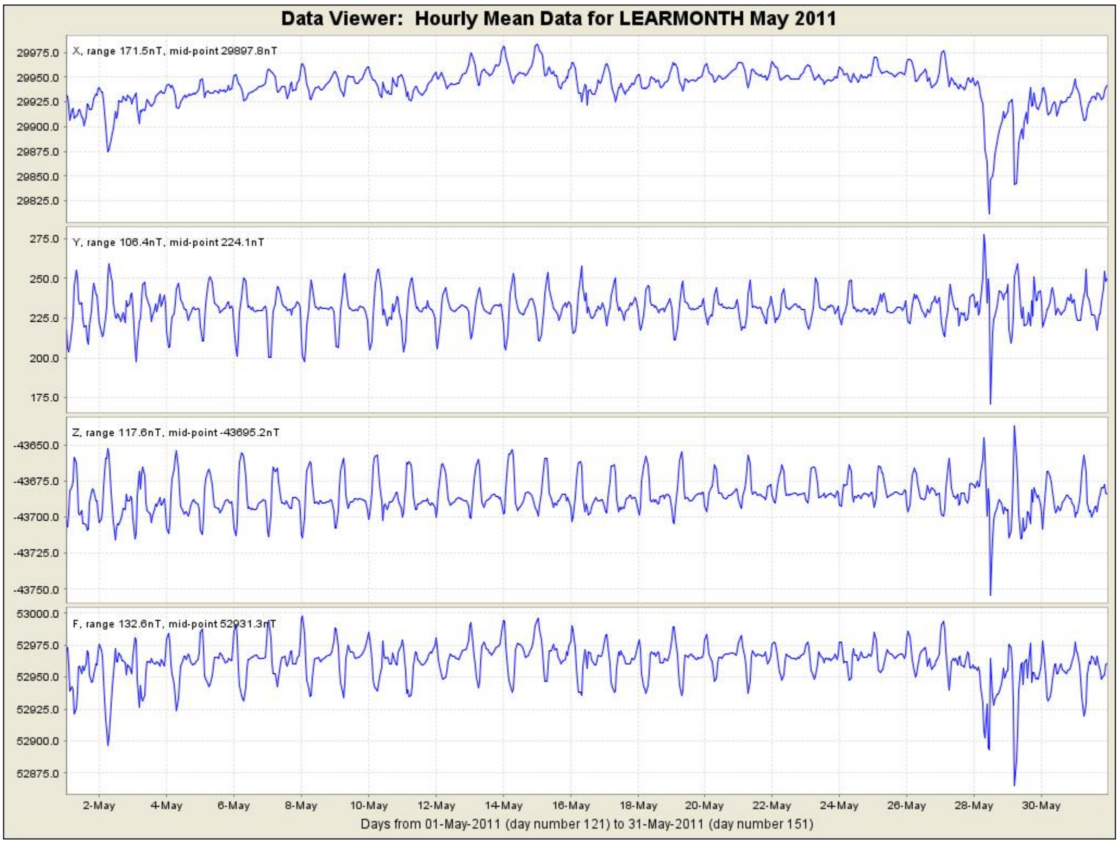

Data Viewer: Hourly Mean Data for LEARMONTH Feb 2011
X, range 108.2nT, mid-point 29942.3nT
Y, range 120.4nT, mid-point 231.7nT
Z, range 108.9nT, mid-point -43679.0nT
F, range 102.8nT, mid-point 52955.7nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

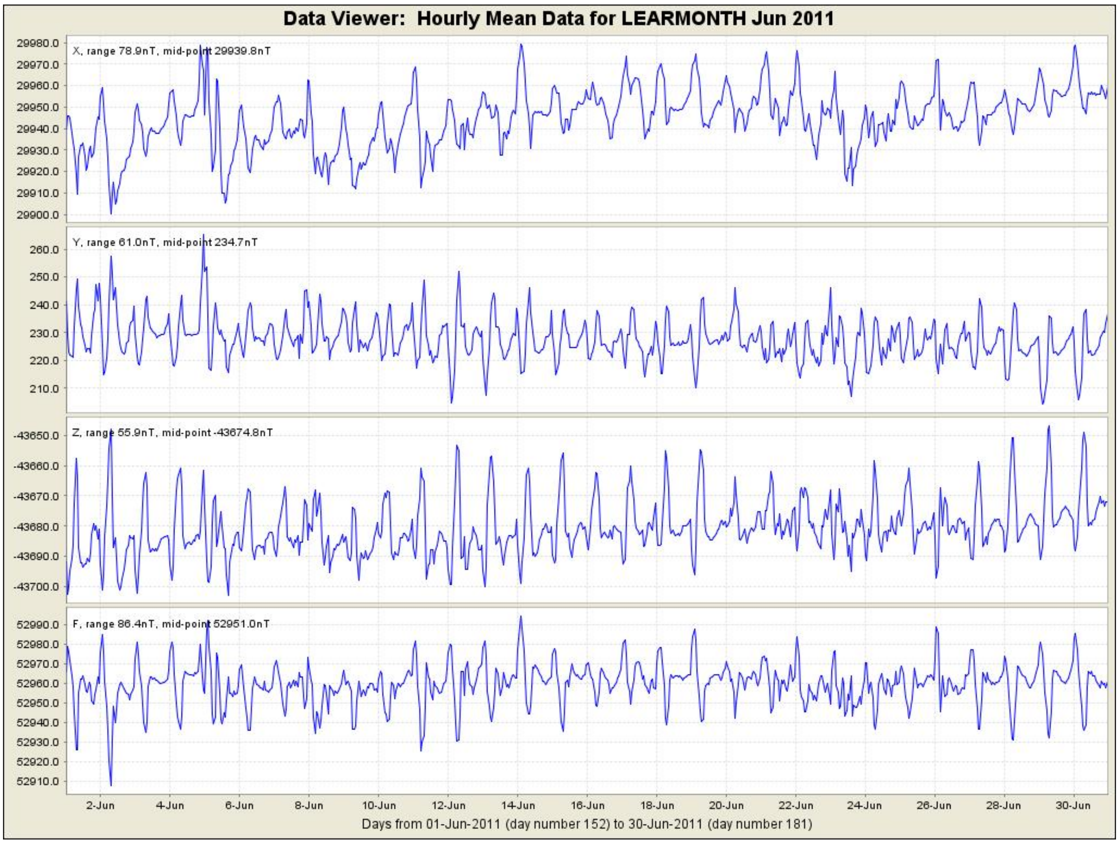


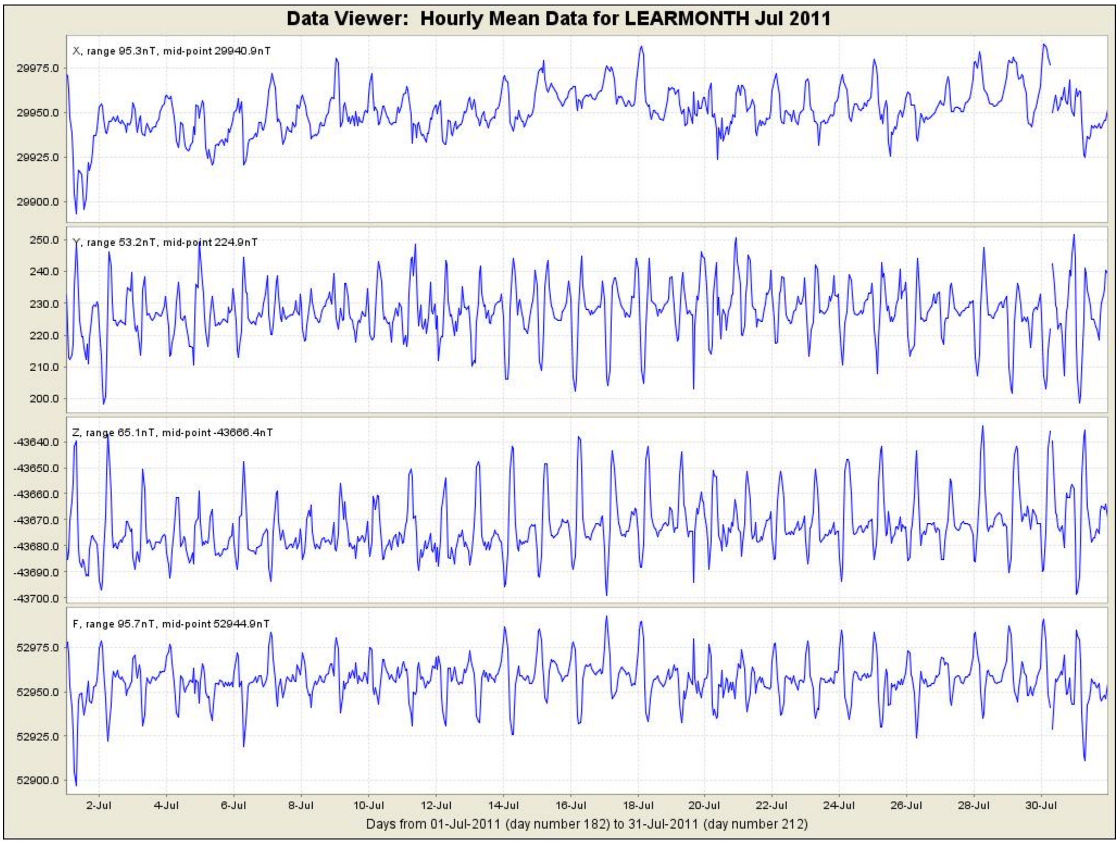
Data Viewer: Hourly Mean Data for LEARMONTH Mar 2011
X, range 135.0nT, mid-point 29910.3nT
Y, range 95.5nT, mid-point 232.0nT
Z, range 108.8nT, mid-point -43677.0nT
F, range 125.4nT, mid-point 52942.6nT
2-Mar 4-Mar 6-Mar 8-Mar 10-Mar 12-Mar 14-Mar 16-Mar 18-Mar 20-Mar 22-Mar 24-Mar 26-Mar 28-Mar 30-Mar
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

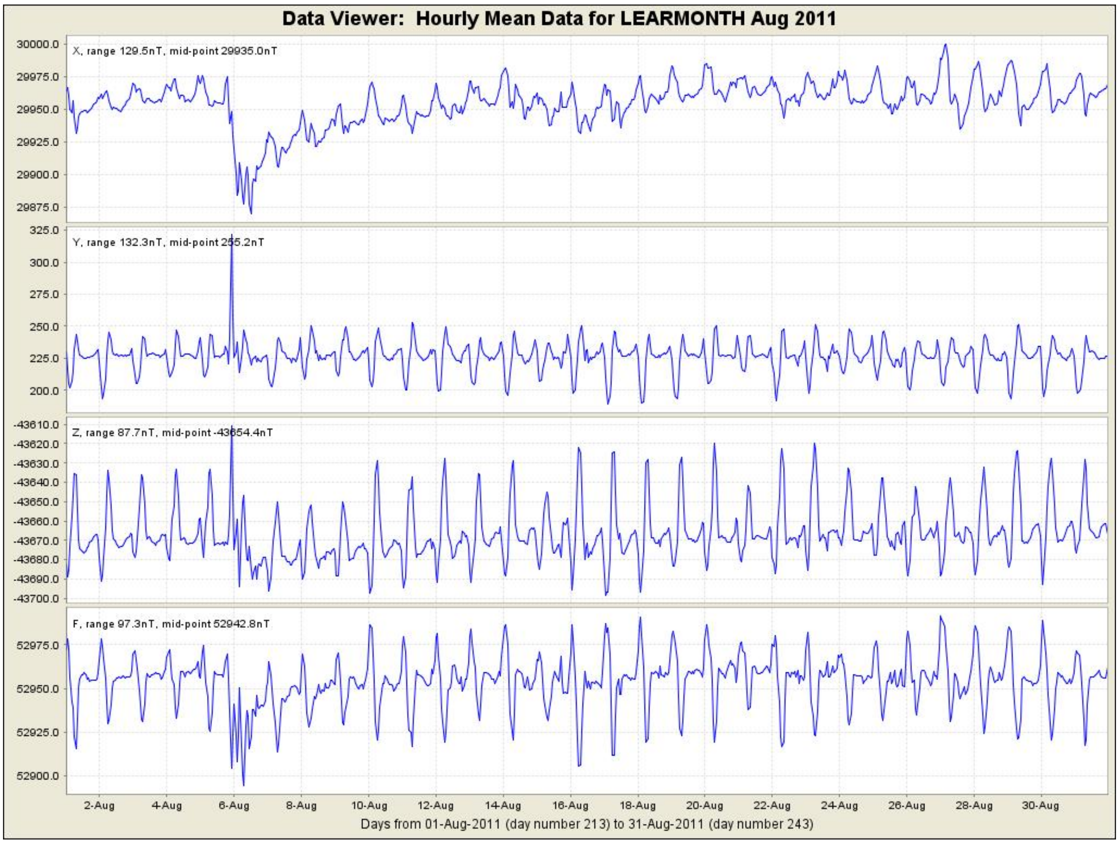


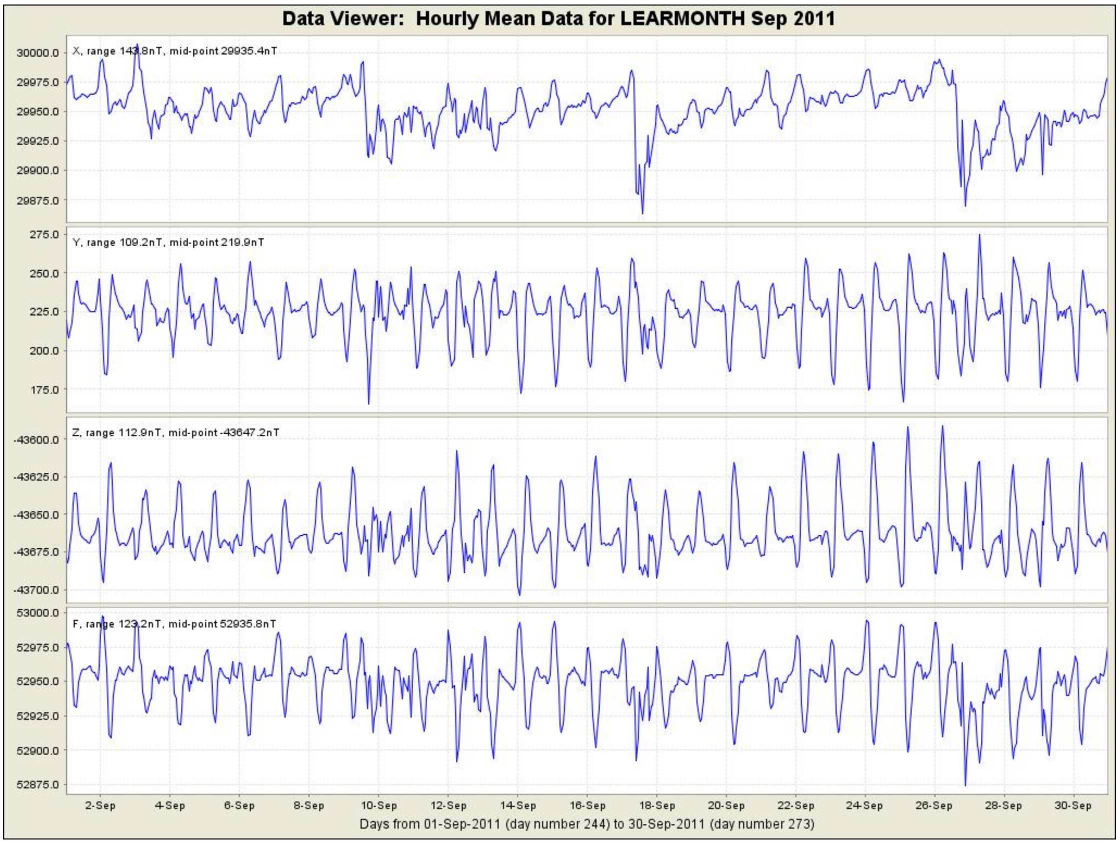
Data Viewer: Hourly Mean Data for LEARMONTH Apr 2011
X, range 103.8nT, mid-point 29928.0nT
Y, range 77.2nT, mid-point 232.7nT
Z, range 88.2nT, mid-point -43679.3nT
F, range 113.2nT, mid-point 52952.5nT
2-Apr 4-Apr 6-Apr 8-Apr 10-Apr 12-Apr 14-Apr 16-Apr 18-Apr 20-Apr 22-Apr 24-Apr 26-Apr 28-Apr 30-Apr
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

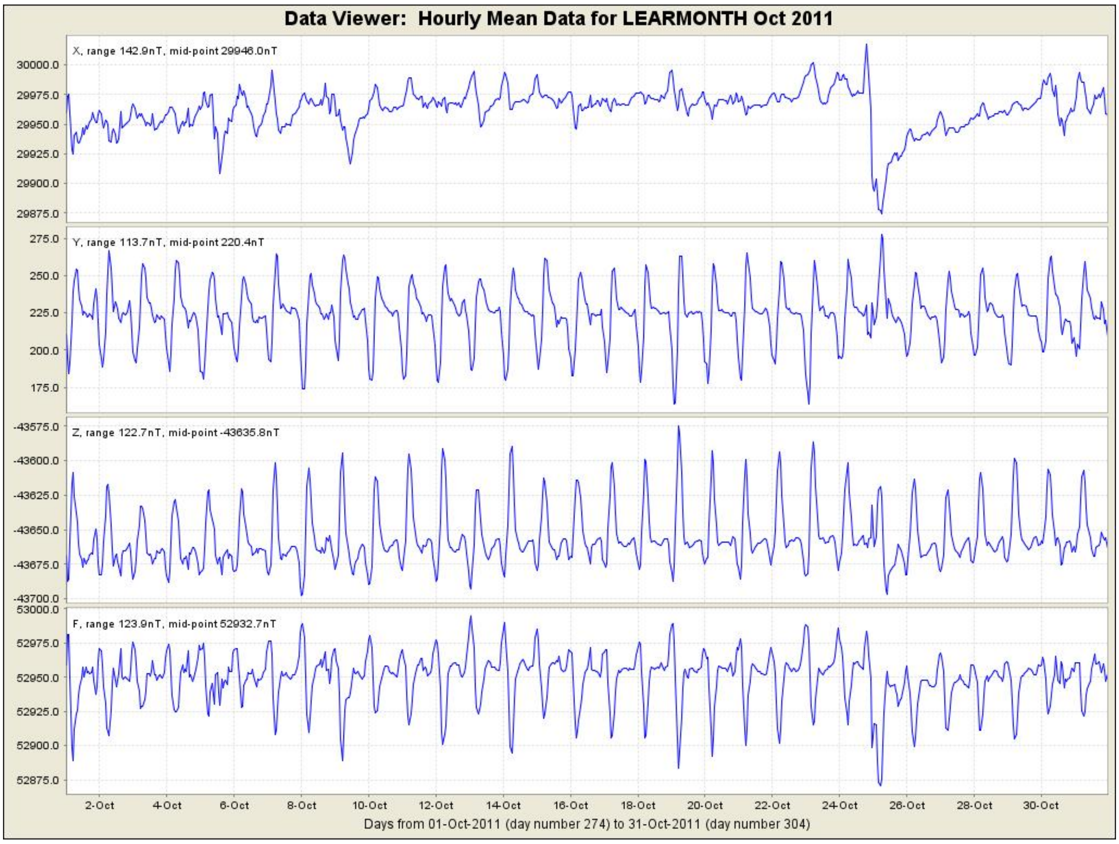

Data Viewer: Hourly Mean Data for LEARMONTH May 2011
X, range 171.5nT, mid-point 29897.8nT
Y, range 106.4nT, mid-point 224.1nT
Z, range 117.6nT, mid-point -43695.2nT
F, range 132.6nT, mid-point 52931.3nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)

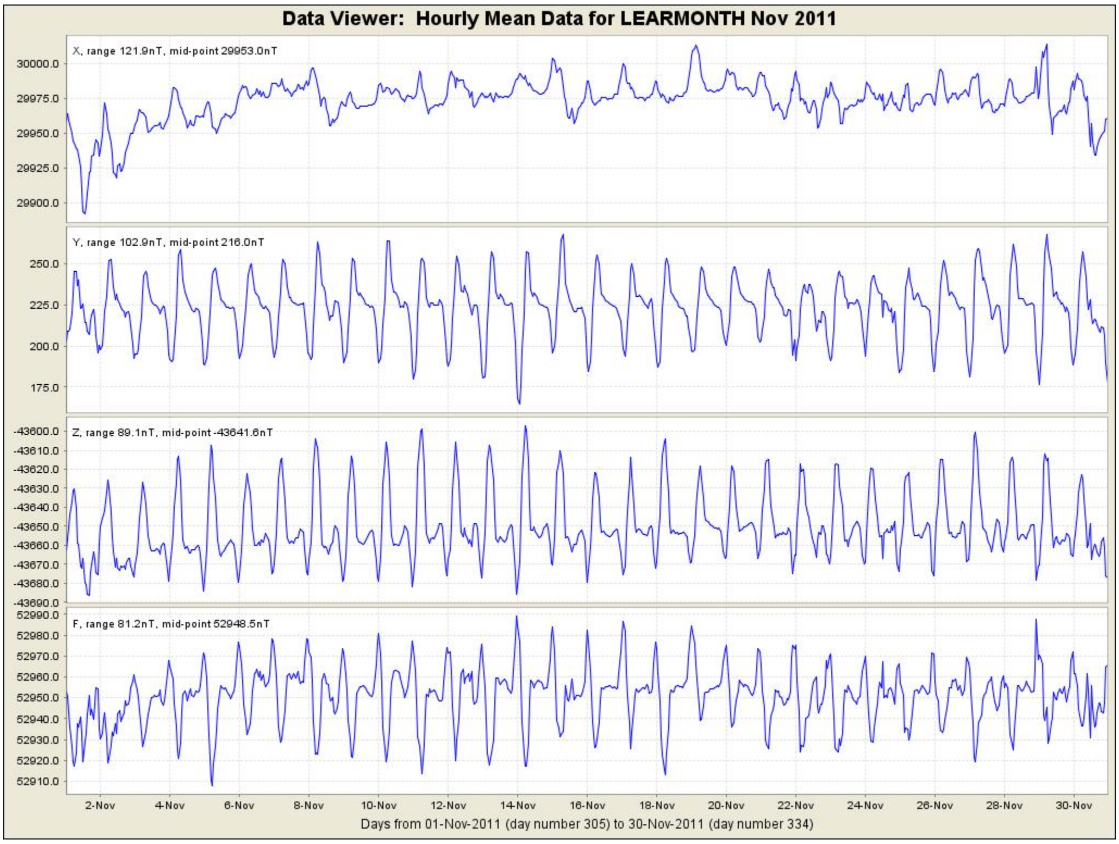

Data Viewer: Hourly Mean Data for LEARMONTH Jun 2011
X, range 78.9nT, mid-point 29939.8nT
Y, range 61.0nT, mid-point 234.7nT
Z, range 55.9nT, mid-point -43674.8nT
F, range 86.4nT, mid-point 52951.0nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for LEARMONTH Jul 2011
X, range 95.3nT, mid-point 29940.9nT
Y, range 53.2nT, mid-point 224.9nT
Z, range 65.1nT, mid-point -43666.4nT
F, range 95.7nT, mid-point 52944.9nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for LEARMONTH Aug 2011
X, range 129.5nT, mid-point 29935.0nT
Y, range 132.3nT, mid-point 255.2nT
Z, range 87.7nT, mid-point -43654.4nT
F, range 97.3nT, mid-point 52942.8nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for LEARMONTH Sep 2011
X, range 143.8nT, mid-point 29935.4nT
Y, range 109.2nT, mid-point 219.9nT
Z, range 112.9nT, mid-point -43647.2nT
F, range 123.2nT, mid-point 52935.8nT
2-Sep 4-Sep 6-Sep 8-Sep 10-Sep 12-Sep 14-Sep 16-Sep 18-Sep 20-Sep 22-Sep 24-Sep 26-Sep 28-Sep 30-Sep
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for LEARMONTH Oct 2011
X, range 142.9nT, mid-point 29946.0nT
Y, range 113.7nT, mid-point 220.4nT
Z, range 122.7nT, mid-point -43635.8nT
F, range 123.9nT, mid-point 52932.7nT
2-Oct 4-Oct 6-Oct 8-Oct 10-Oct 12-Oct 14-Oct 16-Oct 18-Oct 20-Oct 22-Oct 24-Oct 26-Oct 28-Oct 30-Oct
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)



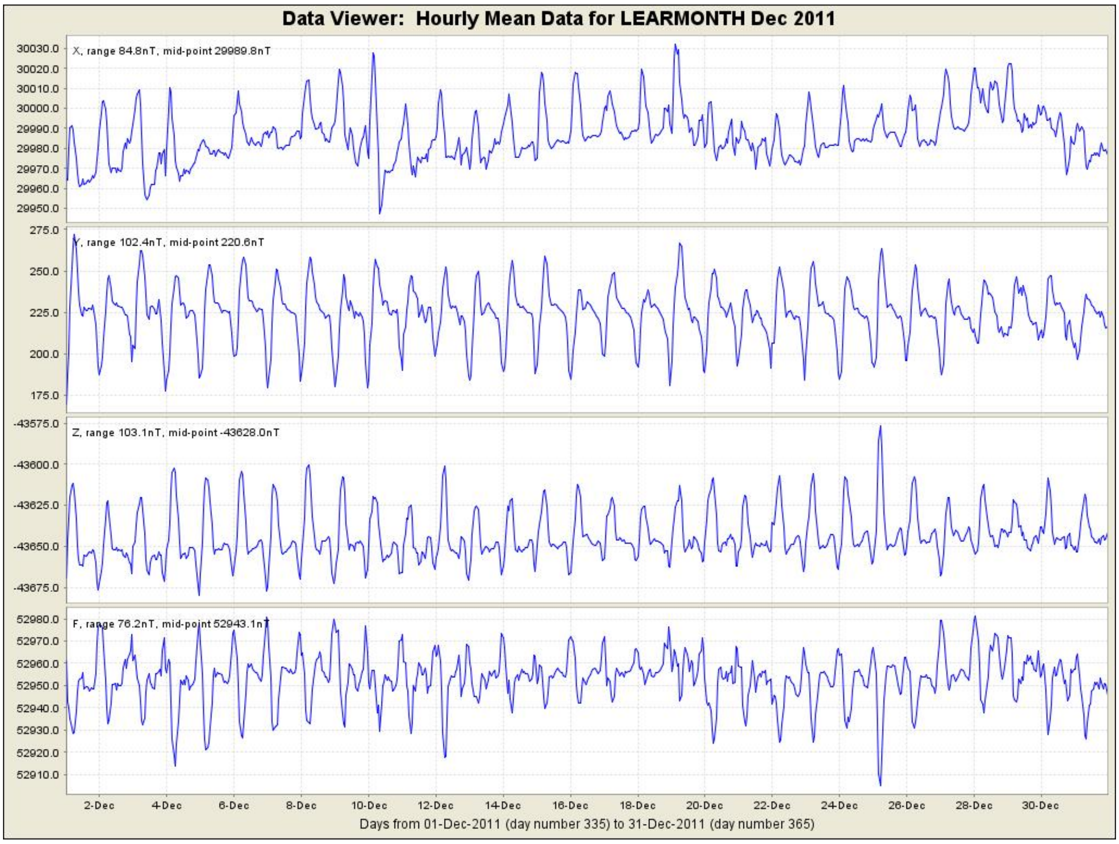


Figure 3.3. *Learmonth 2011 hourly mean values in X, Y, Z and F.*

4. Alice Springs

The Alice Springs magnetic observatory is located approximately 10 km south of Alice Springs in the Northern Territory, on the Centre for Appropriate Technology (CAT), a national indigenous science and technology organisation. The observatory is situated on an alluvial plain over tertiary sediments, overlying late Proterozoic carbonates and quartzites.

The observatory comprises:

- a 3×3 m insulated air-conditioned concrete-brick Control House where recording instrumentation and control equipment are housed;
- a 3×3 m Absolute Shelter, 80 m southeast of the Control House, which encloses a concrete observation pier (Pier G); the top of the pier is 1277 mm above the concrete floor;
- two 300 mm diameter azimuth pillars about 85 m from the absolute shelter at approximate true bearings of 130° and 255°, and;
- two small (1 m^3) underground vaults located approximately 50 m north and 50 m east of the Control House in which the variometer sensors and electronics are housed.

Variometers

The variometers used during 2011 are described in Table 4.2.

The DMI fluxgate sensor and electronics were housed in the eastern underground vault and the PPM sensor and electronics in the northern vault. The fluxgate vault was insulated inside with foam. Both vaults were covered with soil to minimize diurnal temperature fluctuations. The recording equipment was housed in the Control House.

Despite being in buried vaults, the variometers experienced seasonal temperature variations of approximately 20°C. The DMI sensor temperature ranged from 12°C to 32°C during the year and the electronics from 18°C to 35°C. Consequently, the DMI X, Y and Z channels exhibited temperature-related variations of 1.0 nT, 0.2 nT and 1.7 nT, respectively.

Absolute instruments

The principal absolute magnetometers used at Alice Springs and their adopted corrections for 2011 are described in Table 4.3. A Hewlett Packard H4300 hand-held computer was used to communicate via the serial data port of the PPM.

On 2011-06-26, DIM DI0052/313887 was compared at Alice Springs observatory against the travelling reference B0610H/160459. The comparison results confirmed the adopted correction for DIM0052/313887 to the international standard given in Table 3 remains current.

At the 2011 mean magnetic field values at Alice Springs (X=30029 nT, Y=2580 nT, Z= 43837 nT) the D, I and F corrections in Table 4.3 translate to corrections of:

ΔX = -1.4 nT ΔY = 0.8 nT ΔZ = -0.9 nT

These corrections have been applied to all Alice Springs 2011 final data.

Baselines

The fluxgate variometer baselines were controlled by 38 sets of weekly absolute observations through the year. A few jumps in the baselines of the fluxgate and scalar variometers were noted. These occurred on days 033, 039 and 071. Investigation into these baseline changes did not reveal the cause. A planned maintenance visit was undertaken on days 177 to 181 (Wang, 2011). As part of this visit the lid of the scalar variometer vault was removed on day 179 to allow testing of the scalar magnetometer. The magnetometer was switched off at 01:42:00. The testing caused a change in the baseline. The vault lid was fully replaced at the end of the maintenance visit on day 181, causing another baseline shift.

Table 4.1. *Key observatory data.*

IAGA code:	ASP
Commenced operation:	June 1992
Geographic latitude:	23° 45' 39.6" S
Geographic longitude:	133° 53' 00.0" E
Geomagnetic latitude:	-32.35°
Geomagnetic longitude:	208.63°
K 9 index lower limit:	350 nT
Principal pier:	Pier G
Pier elevation (top):	557 m AMSL
Principal reference mark:	Pillar B
Reference mark azimuth:	255° 00' 50"
Reference mark distance:	85 m
Observers:	W. Serone S. Evans

Table 4.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	DMI FGE
Serial number:	E0306 / S0261
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.032 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081419 / 42177
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	NextG modem

Table 4.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0052
Theodolite:	Zeiss 020B
Serial number:	313887
Resolution:	0.1’
D correction:	+0.1’
I correction:	-0.1’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081422 / 01504
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

The final FCheck values for the year varied within a range of about 6 nT. The standard deviations in the 2011 weekly absolute observations from the final adopted variometer model and data were:

	σ
X	0.6 nT
Y	0.9 nT
Z	0.7 nT
D	06"
I	02"
F	0.6 nT

Operations

In 2011, absolute observations were performed weekly by Warren Serone and Shaun Evans, Alice Springs-based officers of Geoscience Australia's Data Acquisition Facility (DAF). During the last two weeks of February the DAF was understaffed due to scheduled holidays. No absolute magnetic observations were made during this period.

The DAF office is approximately 150 m from the observatory site. Magnetic time-series data were transferred to Geoscience Australia in Canberra every 5 minutes via the NextG mobile network.

The QNX acquisition computer used a GPS clock (both pulse-per-second and absolute-time-code) to set the system time. The clock was checked from Geoscience Australia regularly to ensure it was working correctly. If not, it was reset remotely or, if necessary, the computer was re-booted.

The Facilities Manager for the Centre for Appropriate Technology (CAT), from which the observatory site is leased, advised that mowing of fire breaks would occur within the grounds in June. It was expected that mowing would occur in the general area of the magnetometers around 6 June. Contamination was noted during this period and was subsequently removed during processing of the definitive data.

On 6 June the batteries for the absolute instrument failed during the absolute observations. After reviewing these observations they were removed as the accuracy could not be guaranteed. New batteries were bought and installed on 15 June.

A collaborative ant research project between Macquarie University and the CSIRO continued within the observatory grounds. The researchers establish temporary observation sites throughout the grounds each year. These may at times be located within the vicinity of the magnetic observatory buildings. Each site consists of a few shallow trenches with plastic boards on the edges at surface level. The researchers have been made aware of the need to maintain the integrity of the magnetic quiet zone. Careful review of the data shows that some contamination does occur due to the ant research project. This is carefully monitored each year.

A collaborative long-period magnetotelluric (MT) experiment at Hamilton Downs continued in 2011. Two visits where made during the year. The first was to Owen Springs from 19 to 24 February. This visit by Masahiro Ichiki (Tokyo Institute of Technology), Kiyoshi Fujita (Osaka University), Liejun Wang and Jim Whatman (Geoscience Australia) was to complete the installation of equipment that could not completed due to heavy rain in 2010. Another fieldtrip from 29 to 30 June visited both the Hamilton Downs and Owen Springs sites.

Table 4.4. *Distribution of Alice Springs 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
WDC for Geomagnetism	preliminary	real time
WDC for Geomagnetism	preliminary	daily

Significant events

2011-02-08	07:20 baseline jump, mostly in Z channel, reason unknown
2011-02-24	00:55 Jim Whatman and LJW replace NextG modem
2011-02-28	Have not had observations for previous 2 weeks. LJW confirmed today that due to lack of staff at station no observations have been completed for the last 2 weeks. Last obs entered was on 2011-02-11.
2011-03-10	base line jump between 04:36 and 04:42 approximately 1nT.
2011-05-27	Review 2nd set of obs.
2011-06-06	The Centre for Appropriate Technology (CAT) facilities manager advises that they will be preparing fire breaks in the paddock where the sensors are located sometime this week.
2011-06-06	Warren unable to complete a full set of obs as battery went flat at start of 2nd set.
2011-06-15	Warren tested batteries. Found to be faulty and will be replaced. 2 Century PS1270 12V 7Ah batteries purchased from Battery World at $35 each - to be collected by Warren.
2011-06-27	LJW testing PPM. Power turned off to PPM at 01:42:00.
2011-06-29	08:19 - 08:35. LJW put the lid back to PPM vault, and then buried the vault with soil, data contaminated, and baseline changed 3 nT.
2011-07-08	The PPM instrument was picked up today by TollIpec Con note 8372623742 to return to Canberra.
2011-07-22	1st obs not correct.
2011-08-12	No observations for the last 2 weeks.
2011-08-22	observations not useable
2011-08-25	03:30 Test PPP connection via modem - no success
2011-08-29	Baseline file: drift adjustment to Y -0.60 from day 203.
2011-08-30	07UT Mag 6.9 earthquake
2011-09-26	Observations had error in them. Suspected that recording error occured in WD. Changed reading from 304 23.0 to 304 33.0. Made a difference to result.
2011-10-05	2nd Obs error in declination. North and South values of 2nd obs removed.
2011-12-01	Day 334. Error in 2nd Obs ED was recorded as 124 30.3, changed to 235 30.3.
2011-12-21	Small change in data between 21:48 and 22.57. Possible movement of instrument.

Annual mean values

The annual mean values for Alice Springs are set out in Table 4.5 and displayed with the secular variation in Figure 4.2.

Hourly mean values

Plots of the hourly mean values for Alice Springs 2011 data are shown in Figure 4.3.

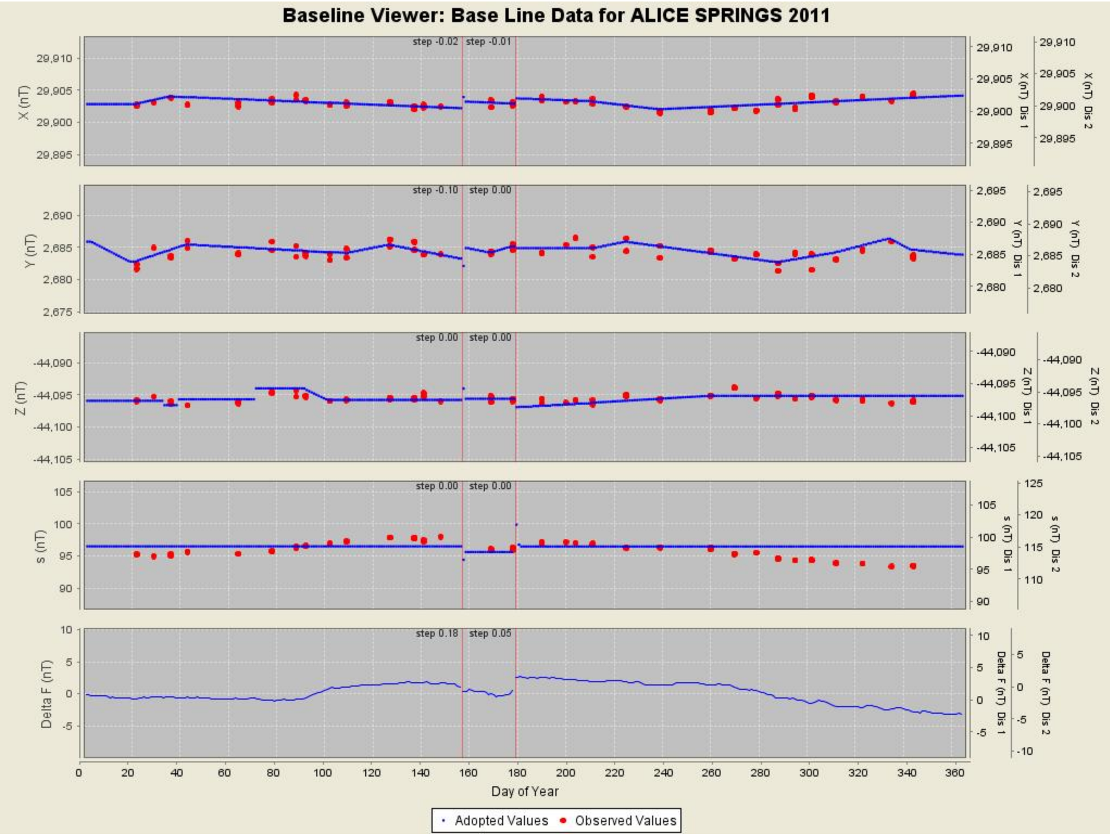


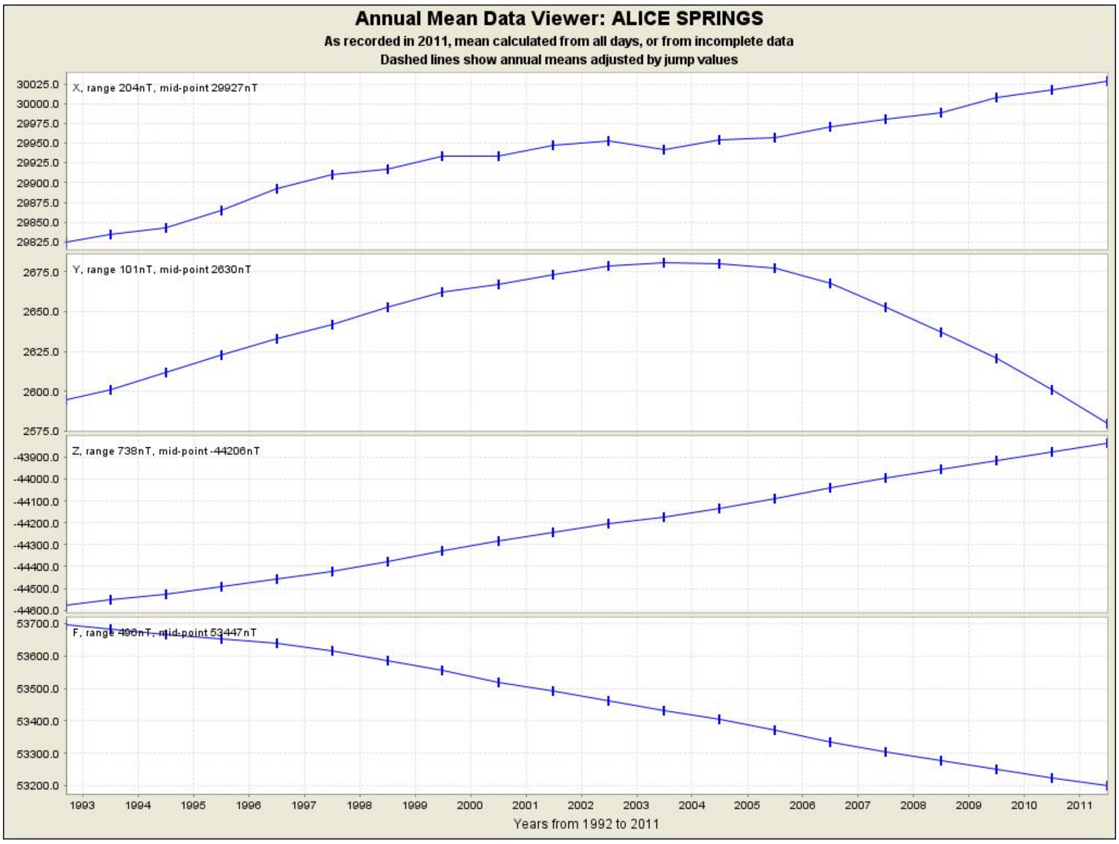
Figure 4.1. *Alice Springs 2011 baseline plots.*

Table 4.5. *Alice Springs annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 4.2.*

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
1992.708	A	4	58.4	-56	06.8	29938	29825	2595	-44575	53695	XYZ
1993.5	A	4	59.0	-56	05.5	29948	29835	2601	-44552	53682	XYZ
1994.5	A	5	00.1	-56	04.1	29957	29843	2612	-44528	53667	XYZ
1995.5	A	5	01.1	-56	01.7	29980	29865	2623	-44494	53652	XYZ
1996.5	A	5	02.0	-55	59.0	30007	29892	2633	-44458	53638	XYZ
1997.5	A	5	02.9	-55	56.6	30026	29910	2642	-44421	53617	XYZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1998.5	A	5	04.1	-55	54.7	30034	29917	2653	-44379	53587	XYZ
1999.5	A	5	04.9	-55	51.9	30052	29934	2662	-44329	53555	XYZ
2000.5	A	5	05.5	-55	50.2	30052	29934	2667	-44282	53517	XYZ
2001.5	A	5	06.0	-55	48.0	30067	29948	2673	-44241	53491	XYZ
2002.5	A	5	06.7	-55	46.3	30072	29953	2679	-44204	53463	XYZ
2003.5	A	5	07.0	-55	45.8	30062	29942	2681	-44175	53433	XYZ
2004.5	A	5	06.6	-55	44.9	30073	29954	2680	-44134	53406	XYZ
2005.5	A	5	06.4	-55	42.0	30076	29957	2677	-44090	53371	ABZ
2006.5	A	5	05.2	-55	39.4	30090	29971	2668	-44038	53336	ABZ
2007.5	A	5	03.5	-55	37.5	30097	29980	2653	-43995	53305	ABZ
2008.5	A	5	01.5	-55	35.6	30104	29989	2637	-43956	53277	ABZ
2009.5	A	4	59.5	-55	33.1	30122	30008	2621	-43913	53251	ABZ
2010.5	A	4	57.1	-55	31.3	30130	30017	2601	-43875	53224	ABZ
2011.5	A	4	54.6	-55	29.4	30140	30029	2580	-43837	53199	ABZ
1992.708	Q	4	58.4	-56	06.0	29950	29838	2596	-44572	53700	XYZ
1993.5	Q	4	59.0	-56	04.8	29959	29845	2603	-44550	53686	XYZ
1994.5	Q	5	00.2	-56	03.3	29971	29857	2614	-44524	53672	XYZ
1995.5	Q	5	01.1	-56	01.0	29991	29876	2623	-44492	53656	XYZ
1996.5	Q	5	02.0	-55	58.6	30013	29897	2633	-44458	53640	XYZ
1997.5	Q	5	02.9	-55	56.0	30035	29919	2643	-44419	53621	XYZ
1998.5	Q	5	04.1	-55	54.1	30043	29926	2654	-44377	53590	XYZ
1999.5	Q	5	04.9	-55	51.3	30061	29943	2663	-44326	53558	XYZ
2000.5	Q	5	05.6	-55	49.5	30065	29946	2669	-44279	53521	XYZ
2001.5	Q	5	06.1	-55	47.3	30078	29959	2675	-44239	53495	XYZ
2002.5	Q	5	06.7	-55	45.5	30086	29966	2680	-44201	53469	XYZ
2003.5	Q	5	07.0	-55	45.0	30076	29956	2682	-44171	53439	XYZ
2004.5	Q	5	06.9	-55	43.1	30084	29964	2682	-44131	53410	XYZ
2005.5	Q	5	06.4	-55	41.4	30087	29967	2678	-44088	53376	ABZ
2006.5	Q	5	05.2	-55	38.9	30097	29979	2668	-44037	53340	ABZ
2007.5	Q	5	03.5	-55	37.2	30102	29985	2654	-43995	53307	ABZ
2008.5	Q	5	01.5	-55	35.3	30110	29994	2638	-43955	53279	ABZ
2009.5	Q	4	59.5	-55	32.9	30125	30011	2621	-43912	53252	ABZ
2010.5	Q	4	57.1	-55	31.0	30135	30022	2601	-43874	53226	ABZ
2011.5	Q	4	54.6	-55	29.0	30146	30035	2580	-43836	53201	ABZ
1992.708	D	4	58.4	-56	08.1	29915	29803	2594	-44579	53686	XYZ
1993.5	D	4	58.9	-56	06.7	29928	29815	2599	-44556	53674	XYZ
1994.5	D	5	00.0	-56	05.1	29940	29826	2609	-44531	53660	XYZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1995.5	D	5	01.1	-56	02.6	29965	29850	2621	-44497	53646	XYZ
1996.5	D	5	02.0	-55	59.5	29998	29883	2632	-44460	53634	XYZ
1997.5	D	5	02.8	-55	57.5	30011	29895	2640	-44423	53611	XYZ
1998.5	D	5	04.0	-55	55.9	30013	29896	2651	-44383	53578	XYZ
1999.5	D	5	04.9	-55	53.0	30034	29916	2660	-44332	53548	XYZ
2000.5	D	5	05.5	-55	51.8	30026	29908	2664	-44287	53506	XYZ
2001.5	D	5	05.8	-55	49.4	30043	29924	2669	-44245	53480	XYZ
2002.5	D	5	06.6	-55	47.6	30051	29931	2677	-44207	53454	XYZ
2003.5	D	5	06.8	-55	47.2	30038	29919	2677	-44178	53423	XYZ
2004.5	D	5	06.6	-55	44.9	30054	29934	2677	-44137	53398	XYZ
2005.5	D	5	06.3	-55	43.1	30058	29939	2674	-44093	53364	ABZ
2006.5	D	5	05.3	-55	40.2	30077	29958	2667	-44040	53331	ABZ
2007.5	D	5	03.5	-55	37.9	30089	29972	2653	-43997	53302	ABZ
2008.5	D	5	01.6	-55	36.1	30097	29981	2637	-43957	53274	ABZ
2009.5	D	4	59.5	-55	33.4	30117	30003	2621	-43913	53249	ABZ
2010.5	D	4	57.1	-55	31.9	30120	30008	2600	-43876	53220	ABZ
2011.5	D	4	54.6	-55	30.1	30129	30018	2578	-43840	53194	ABZ



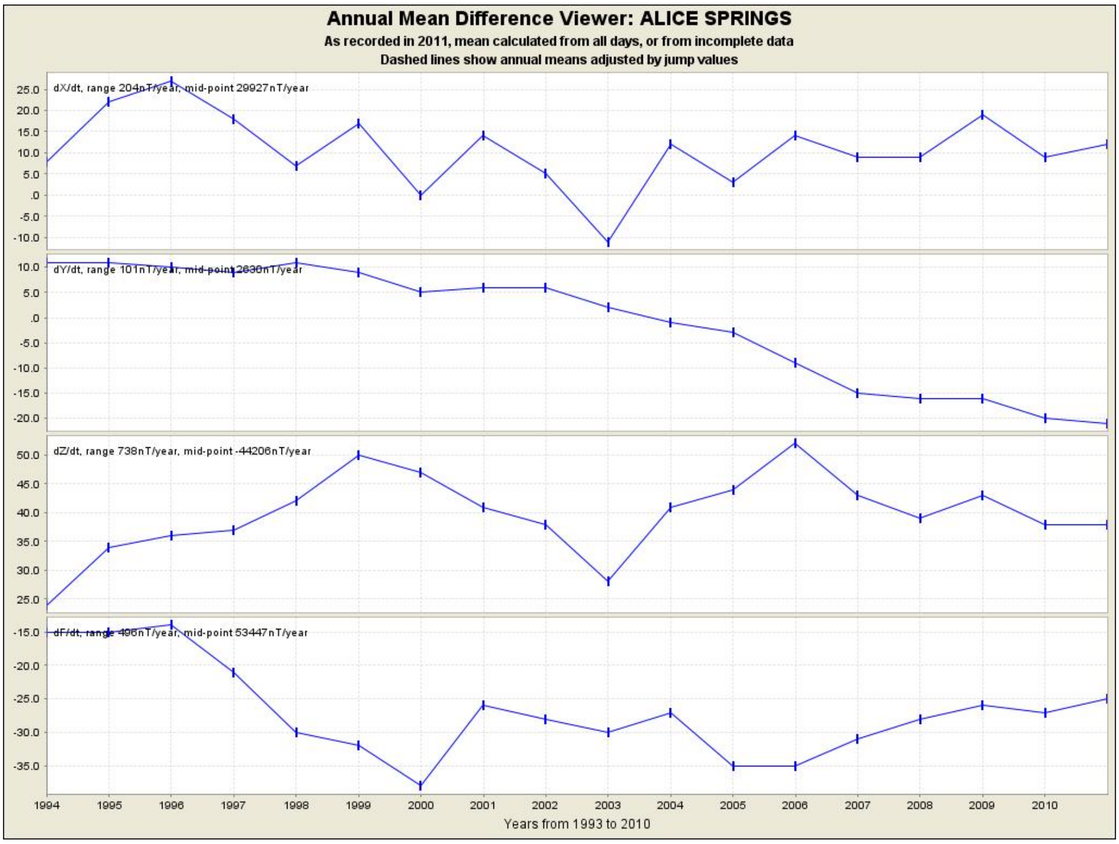
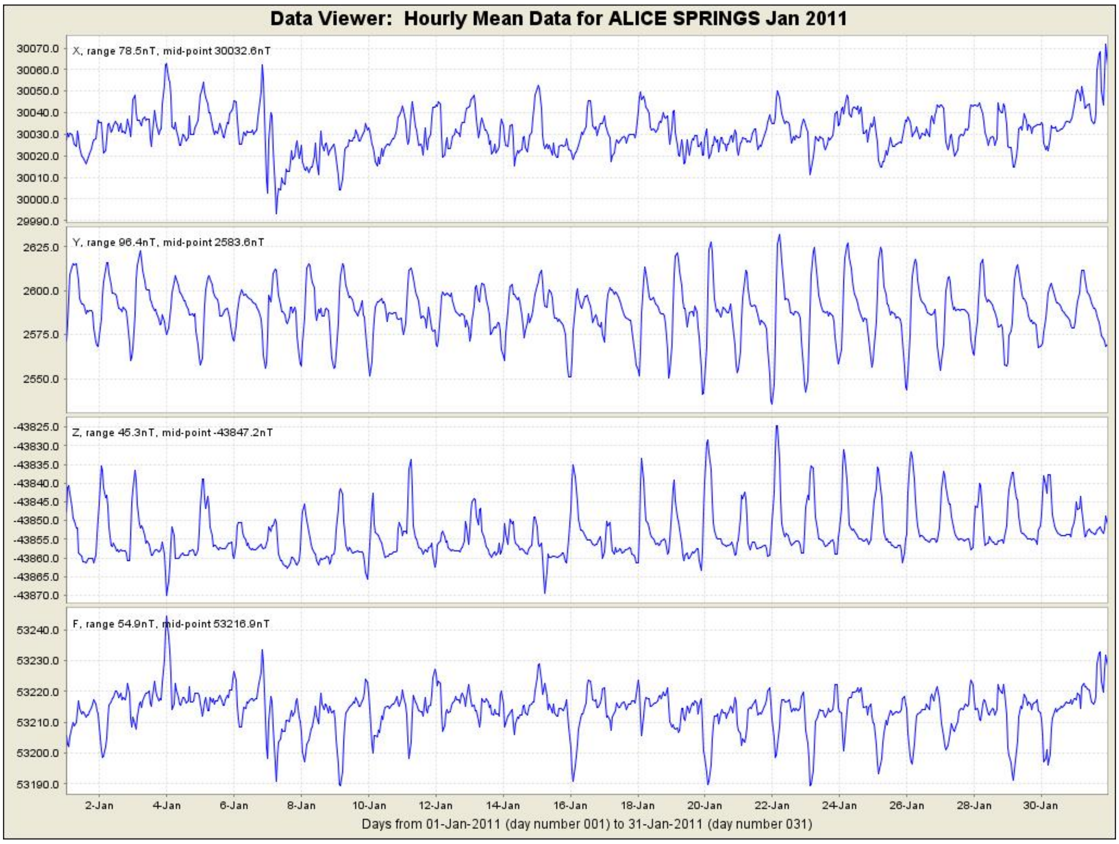
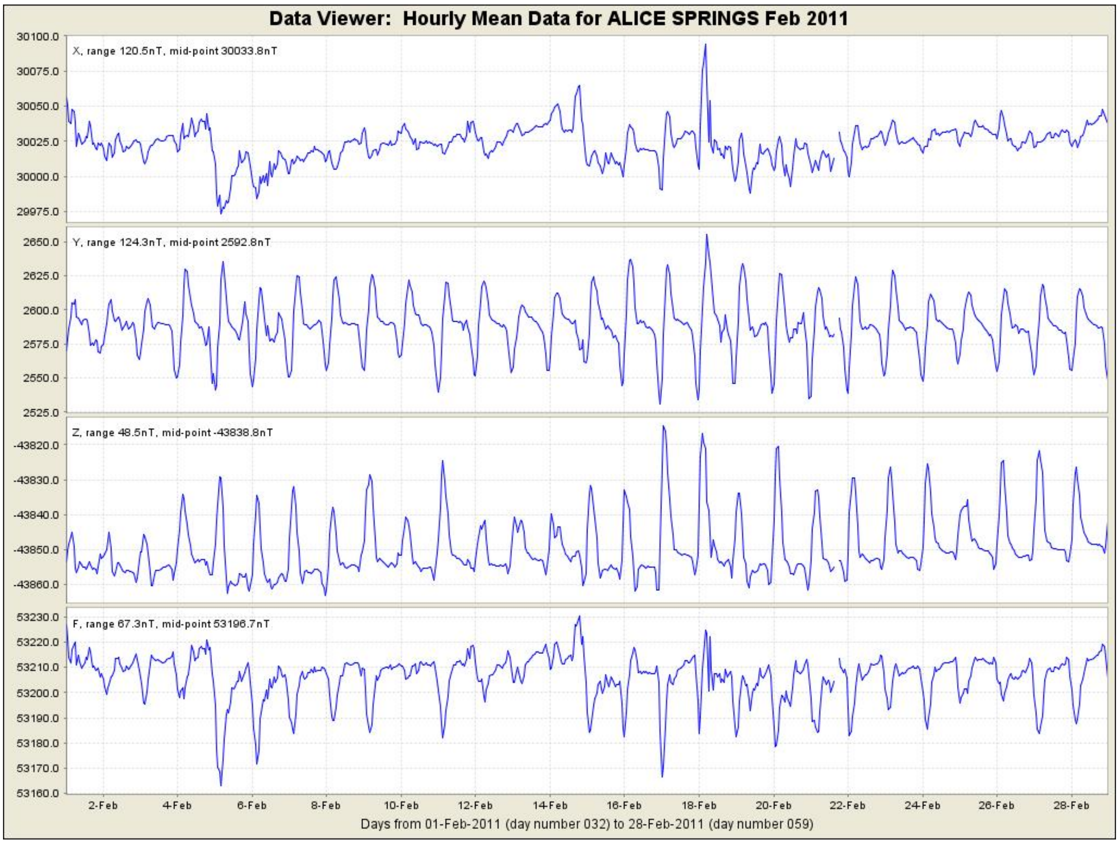


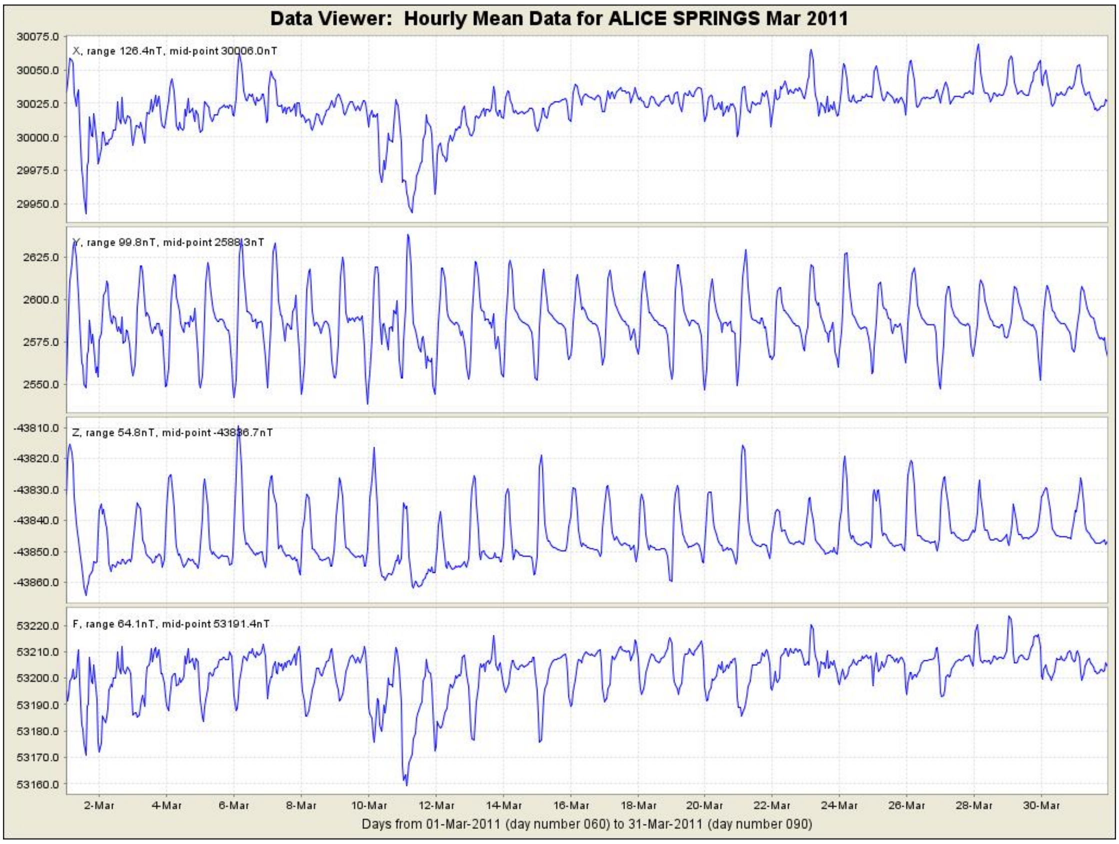
Figure 4.2. *Alice Springs annual mean values and secular variation (all days) for X, Y, Z and F.*

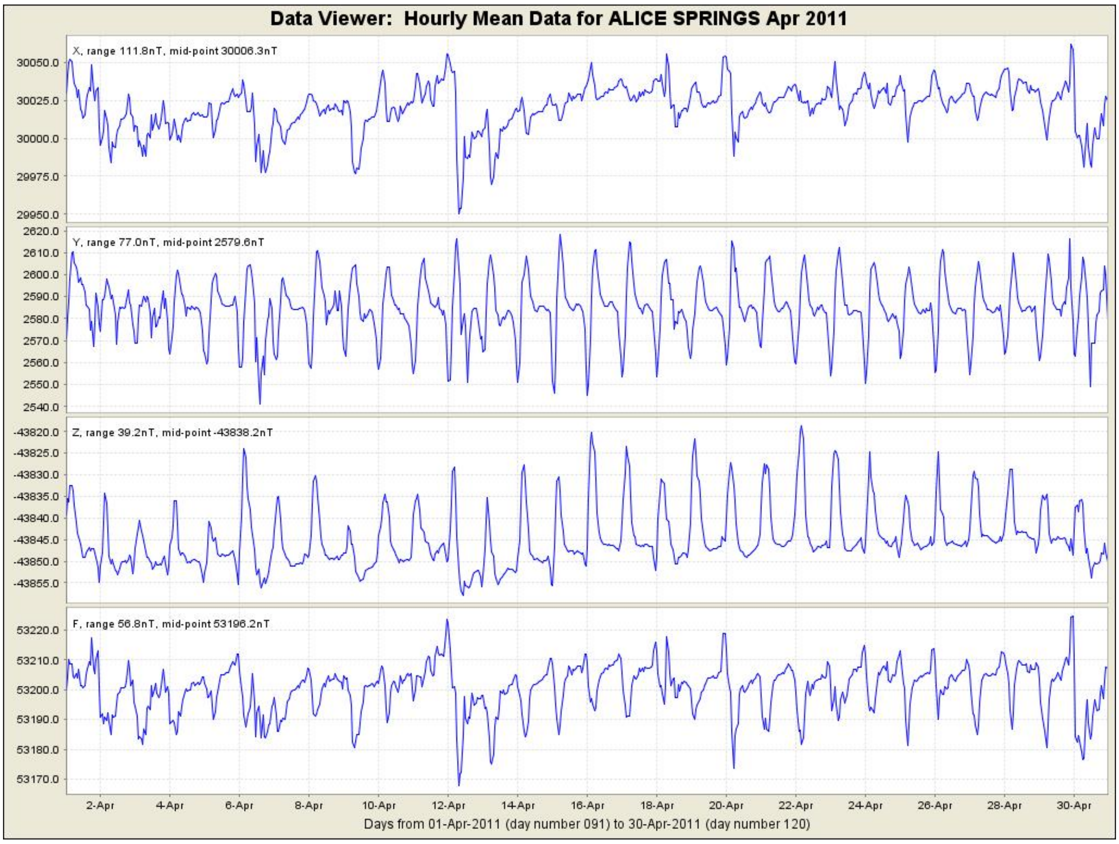


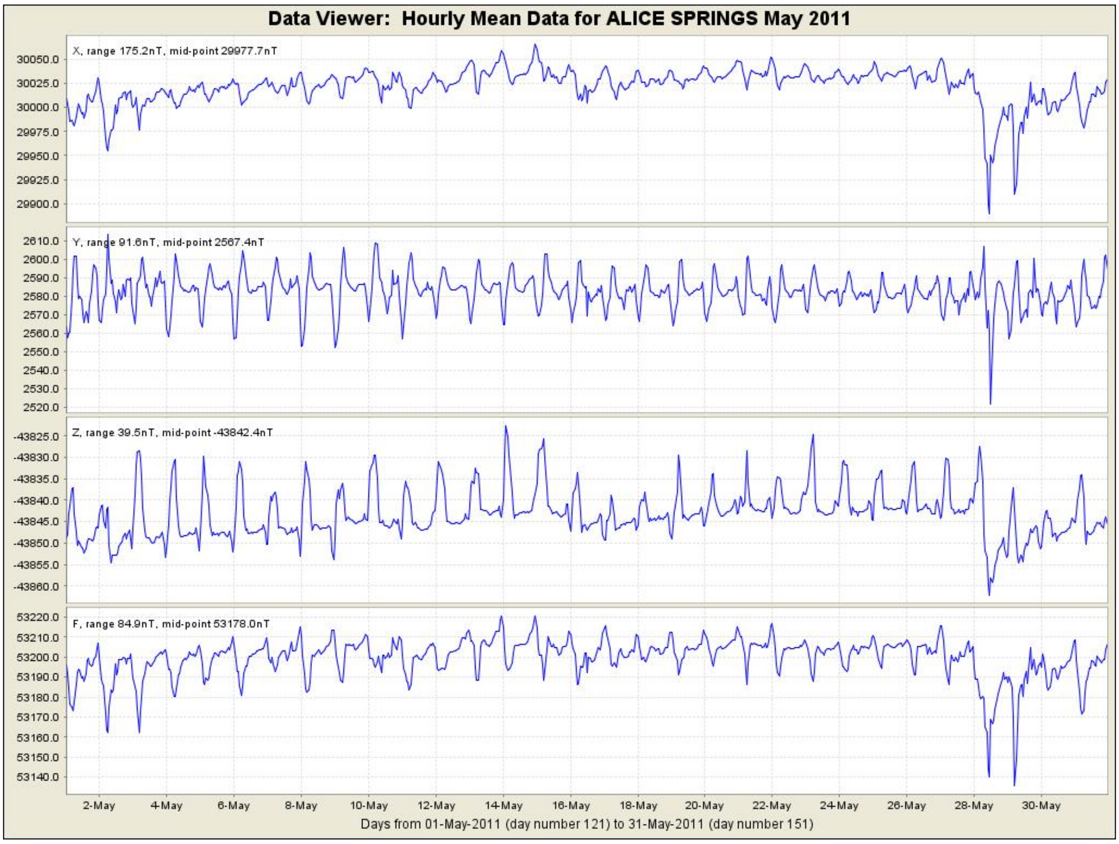
Data Viewer: Hourly Mean Data for ALICE SPRINGS Jan 2011
X, range 78.5nT, mid-point 30032.6nT
Y, range 96.4nT, mid-point 2583.6nT
Z, range 45.3nT, mid-point -43847.2nT
F, range 54.9nT, mid-point 53216.9nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)



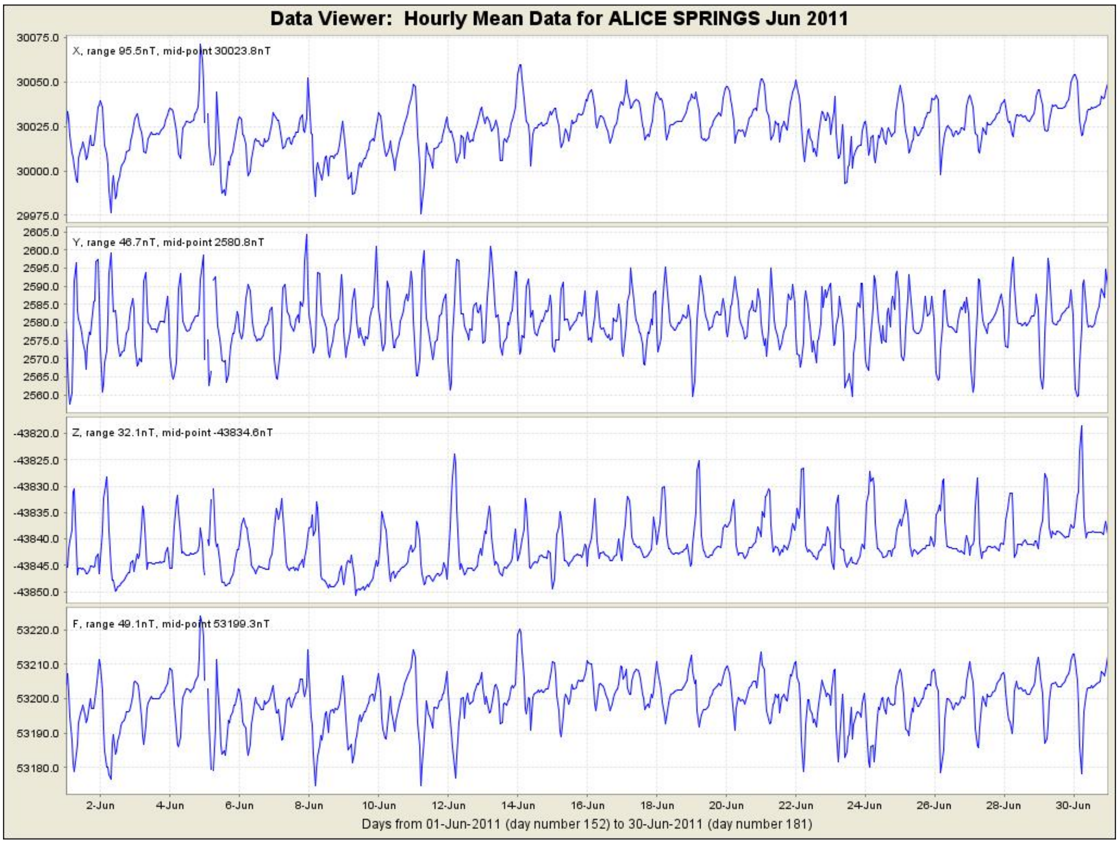
Data Viewer: Hourly Mean Data for ALICE SPRINGS Feb 2011
X, range 120.5nT, mid-point 30033.8nT
Y, range 124.3nT, mid-point 2592.8nT
Z, range 48.5nT, mid-point -43838.8nT
F, range 67.3nT, mid-point 53196.7nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)


Data Viewer: Hourly Mean Data for ALICE SPRINGS Mar 2011
X, range 126.4nT, mid-point 30006.0nT
Y, range 99.8nT, mid-point 2588.3nT
Z, range 54.8nT, mid-point -43836.7nT
F, range 64.1nT, mid-point 53191.4nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

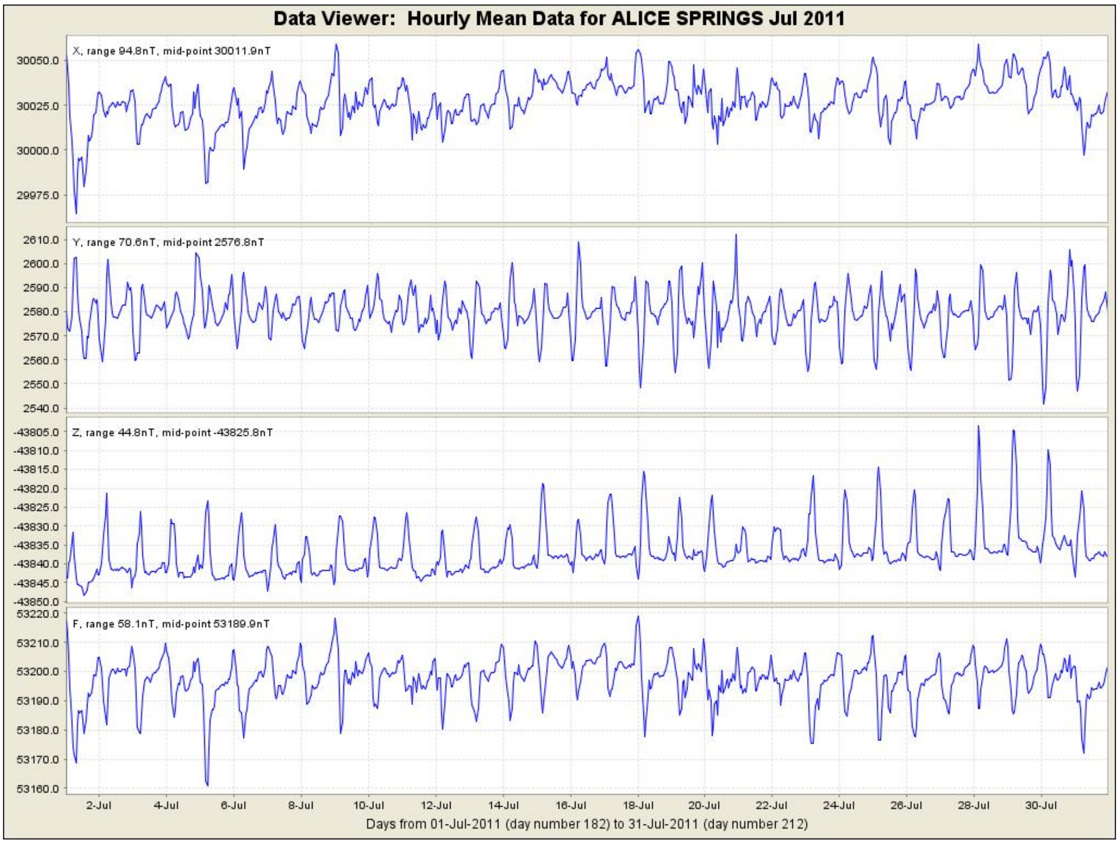

Data Viewer: Hourly Mean Data for ALICE SPRINGS Apr 2011
X, range 111.8nT, mid-point 30006.3nT
Y, range 77.0nT, mid-point 2579.6nT
Z, range 39.2nT, mid-point -43838.2nT
F, range 56.8nT, mid-point 53196.2nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

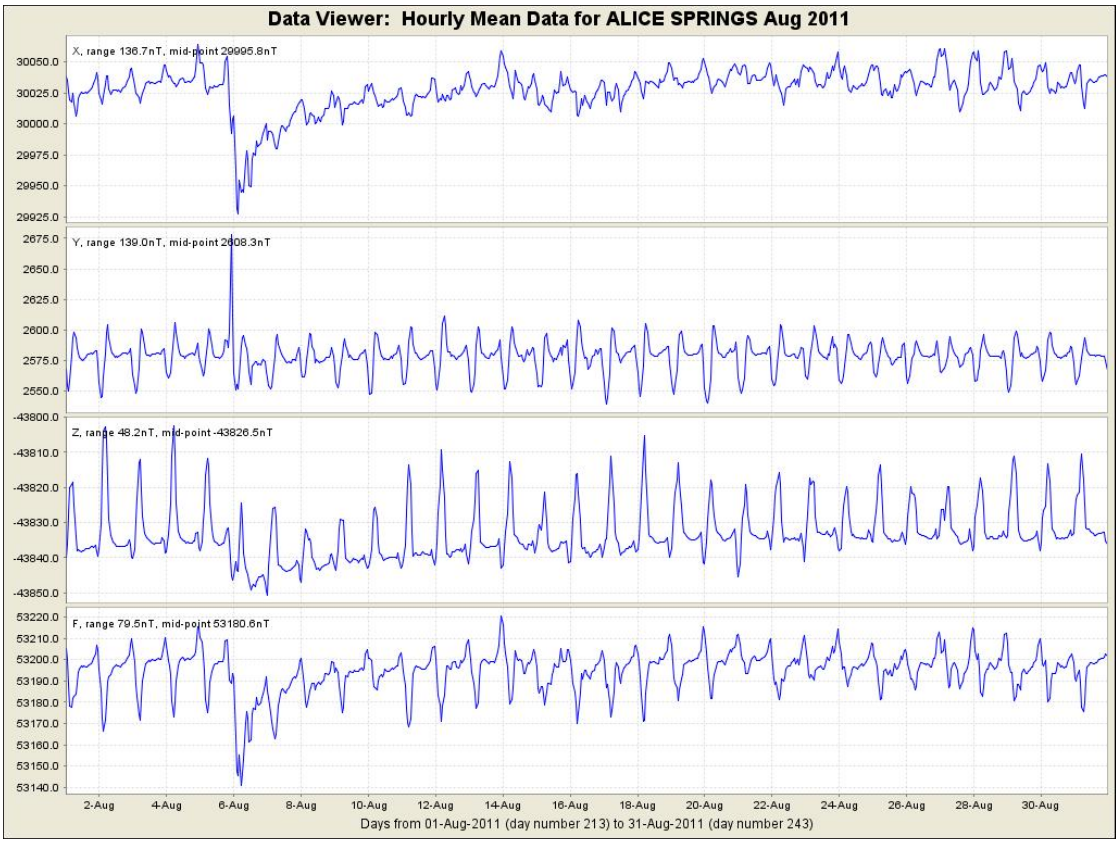


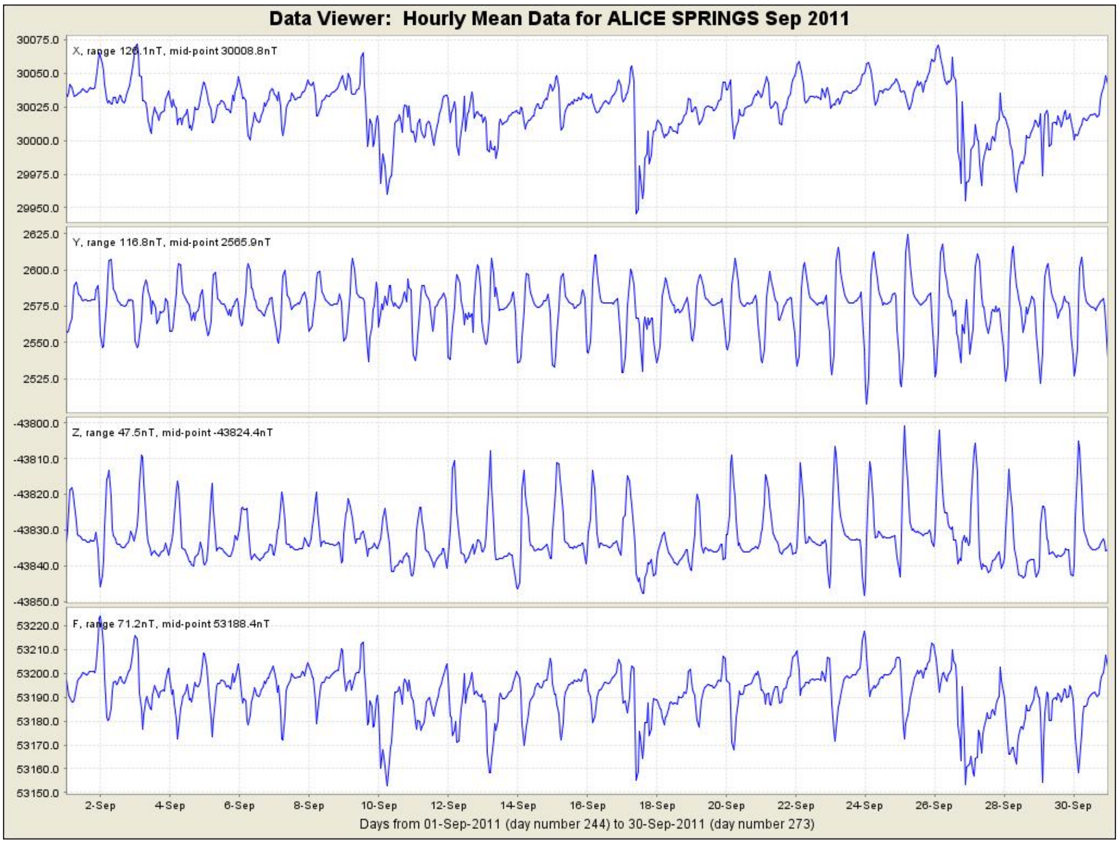
Data Viewer: Hourly Mean Data for ALICE SPRINGS May 2011
X, range 175.2nT, mid-point 29977.7nT
Y, range 91.6nT, mid-point 2567.4nT
Z, range 39.5nT, mid-point -43842.4nT
F, range 84.9nT, mid-point 53178.0nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)

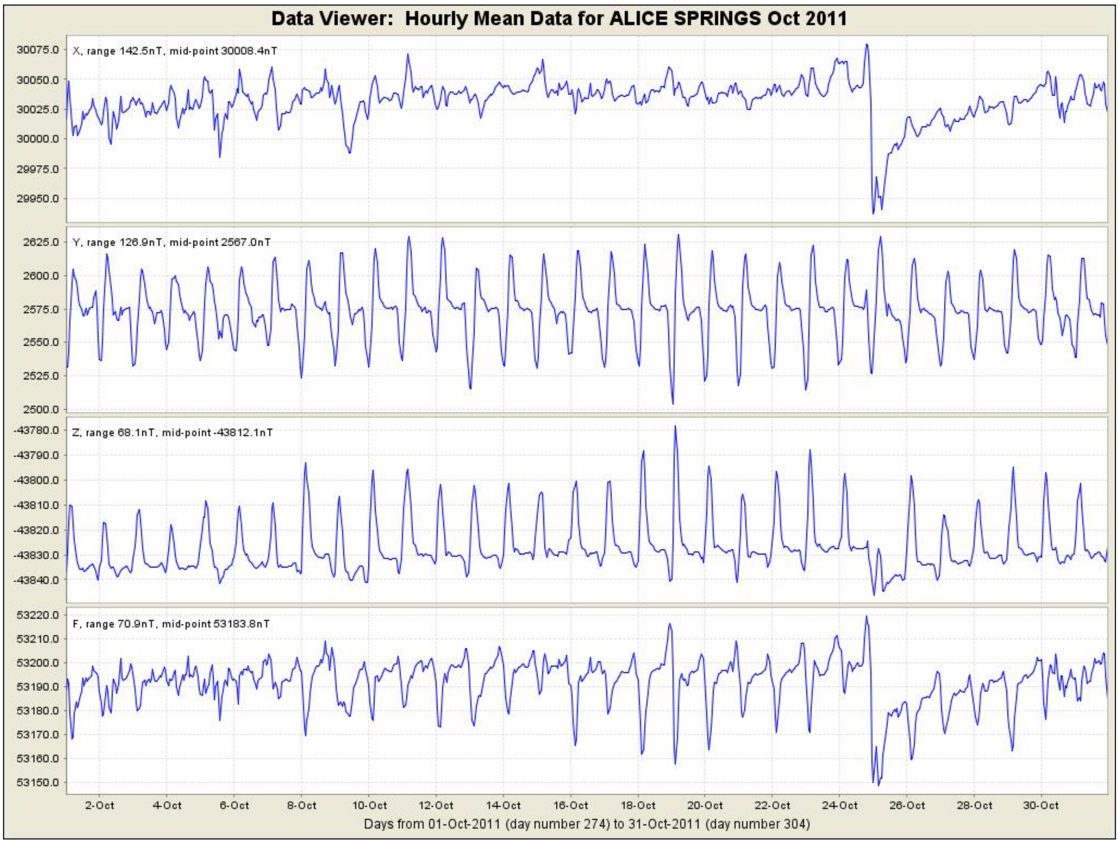


Data Viewer: Hourly Mean Data for ALICE SPRINGS Jun 2011
X, range 95.5nT, mid-point 30023.8nT
Y, range 46.7nT, mid-point 2580.8nT
Z, range 32.1nT, mid-point -43834.6nT
F, range 49.1nT, mid-point 53199.3nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for ALICE SPRINGS Jul 2011
X, range 94.8nT, mid-point 30011.9nT
Y, range 70.6nT, mid-point 2576.8nT
Z, range 44.8nT, mid-point -43825.8nT
F, range 58.1nT, mid-point 53189.9nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for ALICE SPRINGS Aug 2011
X, range 136.7nT, mid-point 29995.8nT
Y, range 139.0nT, mid-point 2608.3nT
Z, range 48.2nT, mid-point -43826.5nT
F, range 79.5nT, mid-point 53180.6nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for ALICE SPRINGS Sep 2011
X, range 126.1nT, mid-point 30008.8nT
Y, range 116.8nT, mid-point 2565.9nT
Z, range 47.5nT, mid-point -43824.4nT
F, range 71.2nT, mid-point 53188.4nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for ALICE SPRINGS Oct 2011
X, range 142.5nT, mid-point 30008.4nT
Y, range 126.9nT, mid-point 2567.0nT
Z, range 68.1nT, mid-point -43812.1nT
F, range 70.9nT, mid-point 53183.8nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)

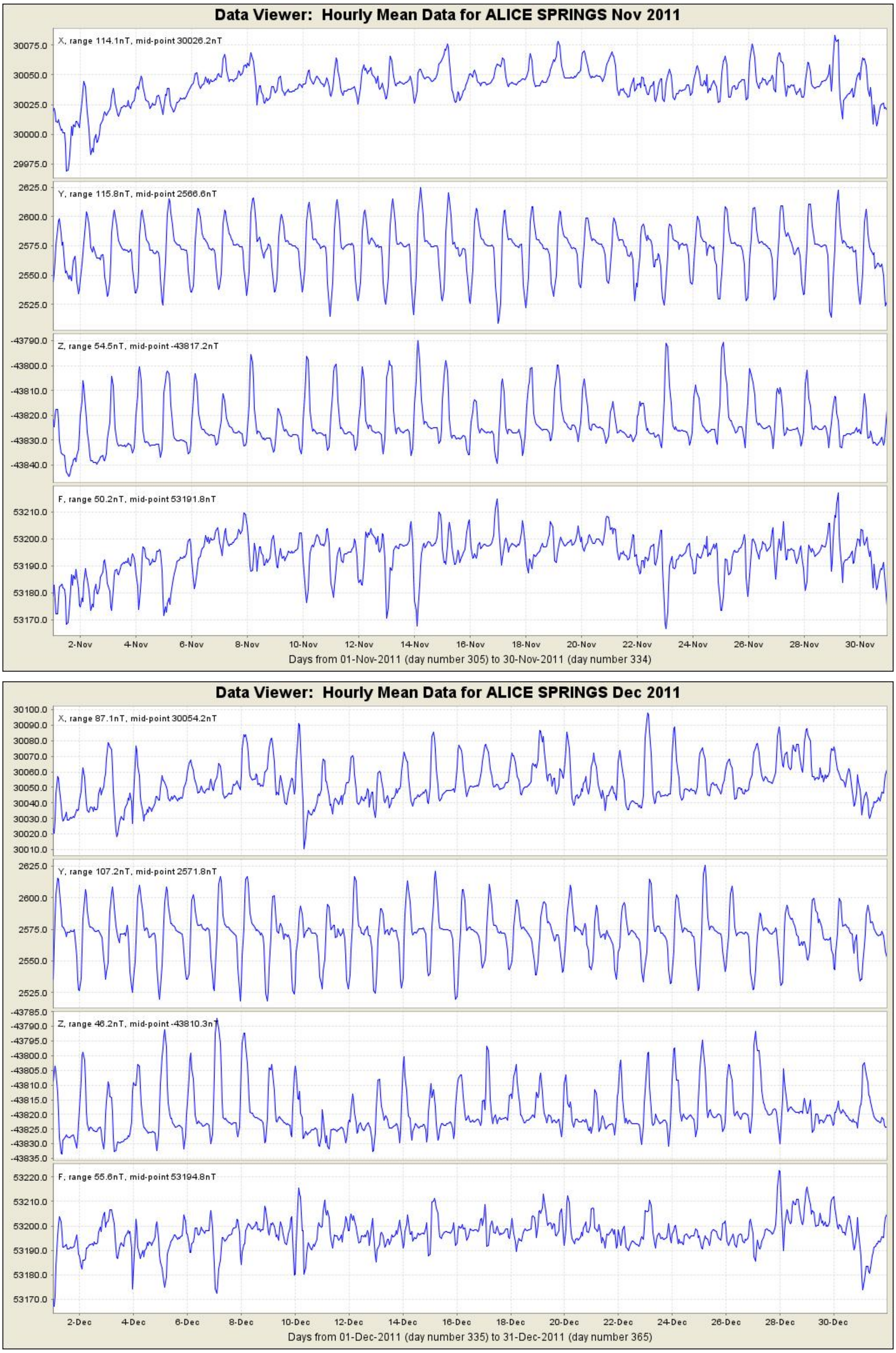


Figure 4.3. *Alice Springs 2011 hourly mean values in X, Y, Z and F.*

5. Gingin

Gingin magnetic observatory is located in southwest Western Australia approximately 100 km north of the city of Perth, 20 km east of the town of Gingin and 50 km north of the Gnangara magnetic observatory site. The Gingin observatory was established to replace Gnangara. After more than 50 years of operation at Gnangara, urban development and sand mining operations have encroached upon the observatory causing problems with security and data continuity. The new Gingin observatory site was chosen after an extensive search of the areas surrounding Perth. Both observatories will run in parallel for at least 12 months before Gnangara is decommissioned in 2013.

The Gingin site is located adjacent to the Australian International Gravitational Observatory (AIGO) and the Gingin Gravity Discovery Centre on well drained sand with magnetic gradients of less than 1 nT/m.

The Gingin observatory consists of:

- a Variometer Vault covered by a mound of sand, that houses the recording equipment, fluxgate variometer sensor and electronics, total-field variometer sensor and electronics, and GPS clock;
- an Absolute House approximately 70 m northwest of the vault;
- an external tripod reference station approximately 70 m north of the Absolute House, and;
- an azimuth reference mark approximately 90 m south of the Absolute House.

Construction of the observatory took place during 2008. The vault and hut are built from re-constituted limestone blocks. The T shaped variometer vault was covered with local sand to enhance thermal stability. The absolute pier was constructed from a fibreglass tube with a marble top.

Variometer instrumentation was installed in October 2009. During installation magnetic contamination was discovered in both the Absolute Hut and Variometer Vault. The contamination was later found to be largely due to magnetic bolts used during construction to fix wooden framework to the masonry. Other sources of contamination existed in security doors, door and window locks, weather strips and light fittings. Over the following two years the Absolute Hut was slowly de-contaminated. Magnetic contamination remains in the Variometer Vault.

Routine weekly absolute observations commenced in the magnetically clean Absolute Hut in November 2011 and fully calibrated observatory data commenced on 2011-11-16.

Variometers

The variometers used during 2011 are described in Table 5.2.

The principal variometer at the Gingin observatory is a DMI FGE suspended 3-component fluxgate magnetometer. The fluxgate sensor was installed in October 2009 on a plinth in the western arm of the T-shaped Variometer Vault. The fluxgate sensors are orientated magnetic-NW, magnetic-NE, and vertical. An Overhauser total-field magnetometer installed in the eastern arm of the vault monitors variations in the magnetic total intensity.

The variometer system is powered with a 12 V battery and mains charger with under/over voltage cut-off and mains power filters. Variometer data are retrieved via a TCP/IP network connection through a NextG mobile telephone modem. The acquisition system timing is synchronised using a GPS clock.

Table 5.1. *Key observatory data.*

IAGA code:	GNG
Commenced operation:	November 2011
Geographic latitude:	31° 21' 23" S
Geographic longitude:	115° 42' 55" E
Geomagnetic latitude:	-40.91°
Geomagnetic longitude:	189.12°
K 9 index lower limit:	430 nT
Principal pier:	Pier A
Pier elevation (top):	50 m AMSL
Principal reference mark:	Pillar S
Reference mark azimuth:	186° 38' 32"
Reference mark distance:	90 m
Observer:	S. Pryde

Table 5.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	DMI FGE (Version G)
Serial number:	E0383 / S0319
Type:	suspended, linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.032 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	708729 / 21889
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.1 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GSP 16 GPS clock
Communications:	HSPA Mobile telephone TCP/IP network

Table 5.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0037
Theodolite:	Zeiss 020B
Serial number:	390444
Resolution:	0.1’
D correction:	-0.05’
I correction:	-0.15’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091317 / 91457
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

There is no active temperature control in the Variometer Vault, but the vault is well insulated with foam inside and local sand outside. This insulation suppressed diurnal temperature variations but an annual temperature change of 16°C was measured inside the vault. The coldest minimum outside temperature, as measured at the Bureau of Meteorology Gingin weather station, was 0°C on 2011-07-04 and the hottest maximum was 41°C on 2011-01-29.

Absolute instruments

The principal absolute magnetometers used at Gingin are the same as those used at Gnangara.

The variometers at GNG were calibrated nominally weekly with a pair of absolute observations. Absolute calibrations commenced on 2011-11-08. Both absolute PPM and DIM observations were performed on Pier A in the absolute hut. Table 5.3 describes the corrections applied to the absolute magnetometers to correct them to the international standard as measured at IAGA workshop through the Australian reference instruments held in Canberra.

The D and I corrections applied in 2011 were determined through instrument comparisons performed during maintenance and calibration visits at Gnangara and Gingin, most recently in November 2011 (Lewis and Jones, 2011). The adopted corrections for 2011 are described in Table 5.3.

At the 2011 mean magnetic field values at Gingin (calculated from November and December only) of X= 23434 nT, Y= 758 nT, Z= -53265 nT, the D, I and F corrections translate to corrections of:

ΔX = -2.3 nT　　ΔY = -0.3 nT　　ΔZ = -1.0 nT

These corrections have been applied to all Gingin 2011 final data.

Baselines

Derivation of final baseline parameters for the fluxgate variometer was done by fitting a piece-wise linear function (including steps where required) to the weekly observed absolute observations baseline residuals. The fluxgate variometer performed adequately well in 2011. There were some short periods of baseline instability, one on 2011-12-17 was of about 1 hour duration and was characterized by a sudden jump and slower recover. Throughout November and December 2011 the overall baseline drifts had a range of about 2 nT in the X, Y and Z components. The standard deviations in the difference between the weekly absolute observations and the final adopted vector variometer model and data were:

	σ
X	0.5 nT
Y	0.9 nT
Z	0.3 nT
D	08"
I	02"
F	0.2 nT

Throughout November and December the difference between the daily average of F measured with the vector variometer with final baseline parameters applied and the scalar variometer varied over a range of about 0.5 nT.

Observed and adopted baseline values in X, Y and Z are shown in Figure 5.1.

Operations

The local observer, Mr Stephen Pryde, performed weekly absolute observations and checks from 2011-11-08. Analog outputs from the DMI FGE 3-channel fluxgate, as well as the fluxgate sensor and electronics temperature channels, were digitized with an ADAM 4017 A/D converter mounted inside the FGE electronics console. Data were recorded at 1 second intervals in the components A (NW), B (NE), C (Z). The FGE variometer sensor and electronics temperatures were also recorded. These digital data were recorded on an acquisition computer running the Geophysical Data Acquisition Platform software on the QNX6.3 operating system. The digital readings from the GSM-90 variometer, cycling once every 10 seconds, were also recorded on the acquisition computer. Data files were telemetered to Geoscience Australia in Canberra through an HSPA mobile telephone TCP/IP network. The data transfer delay time was between 2 and 15 minutes. The variometer system was powered by a 12 V 18Ah battery with trickle charger, under/over voltage cut-off protection and voltage regulators to deliver a constant 12 V to both the vector and scalar magnetometers.

Acquisition system timing control was provided by a Garmin GPS 16 GPS clock. Numerous timing corrections of greater than 1 s were applied to the system between the start of the first absolute calibrations (2011-11-08) and 2011-11-15. Calibrated variometer data collected before 2011-11-16 were discarded because of this timing uncertainty.

During 2011 no data were provided to INTERMAGNET as Gingin is not yet an accredited INTERMAGNET magnetic observatory (IMO).

One-minute data were provided to ISGI via ftp from 2011-12-15 both in real-time and at the end of each UT day. Preliminary 1 minute data were also available on the GA web site (http://www.ga.gov.au).

The distribution of Gingin 2011 data is described in Table 5.4. Data losses are identified in Table A.5.

Table 5.4. *Distribution of Gingin 2011 data.*

Recipient	Status	Sent
1-minute values		
ISGI, France	preliminary	real time
ISGI, France	preliminary	daily
K indices		
ISGI, France		weekly (from 2011-12-16)

Significant events

2011-01-10	Stephen Pryde cycled the power for computer. All instruments working from 05:31 UTC
2011-01-20	17/01/11 10:45:01 - Lost contact GPS
2011-01-21	01:03:35 - CLK I 0 Started Restart GdapClock System shutdown 01:10 drivers started 01:11:03 01:11:03 MachR I 0 Started 01:11:49 Correction 0 s 28515300 ns 01:12:31 Correction 0 s 19198 ns
2011-01-28	19:25:01 Lost contact with GPS
2011-02-02	01:25 restart ser2 driver and GdapClock. few tenths sec difference to 1194 time 01:37 shutdown 01:37:53 mag I 0 Started 01:38:40 Correction 0 s 710403352 ns 01:39:22 Correction 0 s 24657 ns 16:55 Clock fails again
2011-02-07	01:00:58 Reboot system 01:01:45 Correction 1 s 192417194 ns
2011-02-16	12:05 lost contact with GPS clock
2011-02-18	01:09 slay GdapClock; Restart GdapCLock 01:11 01:30 shutdown 01:30:58 Correction 1 s 76435500 ns
2011-02-27	AML and APH visited GNG between 28 Feb to 3 Mar for mag testing.
2011-02-28	Data loss from 16:50 28 Feb to 02:11 01 Mar due to power outage. Both UPS and battery box went flat before power was restored.
2011-03-05	02:35 Lost contact with GPS clock
2011-03-10	03:04 system reboot 03:04:58 Correction 0 s -337748511 ns 03:05:40 Correction 0 s 23360 ns
2011-03-21	04:32 data from GNG stops, cannot connect request SP to visit site and check/reboot
2011-03-22	05:13 SP reboots PC 05:14:38 Correction 6 s 333555100 ns 05:15:20 Correction 0 s 20225 ns
2011-03-31	noise on data

2011-04-05	19:50 lost contact with GPS clock
2011-04-07	04:45 slay and restart GdapClock 04:56 restart system 04:57:01 Correction 0 s 302175977 ns 04:57:43 Correction 0 s 20569 ns
2011-04-11	AML/APH visit observatory 11-14 April Absolute hut testing and rectification of walls. 02:55 Remove UPS from variometer hut approx 4 nT change.
2011-04-12	Rectification of absolute hut system reboot to restart GPS
2011-04-13	absolute hut magnetic testing
2011-04-21	05:13 reboot system to restart GPS
2011-04-27	02:03 noise on data - reason unknown. Baseline jumps and fcheck anomalies originating in fluxgate data. 01:15 (Z jump), 02:05 (noise), 04:15 (jump) 10:04 (jump), 10:10 (noise), 10:15 Lost contact with GPS clock 12:16 (Z jump), 15:22 (PPM spike)
2011-05-02	01:32 Reboot system 01:33:42 Correction 0 s 271258773 ns 01:34:24 Correction 0 s 18798 ns
2011-05-17	00:00 update FV parameter in blv file from 0 to -38 nT
2011-05-26	10:20 Lost Contact with GPS clock
2011-05-30	04:00 Reboot system 04:01:00 Correction 0 s 585209875 ns 04:01:42 Correction 0 s 8109 ns
2011-06-02	10:10:01 Lost contact with GPS clock
2011-06-03	05:41 Reboot system 05:42:25 Correction 0 s 155450408 ns
2011-06-04	16-17UT variometer PPM develops some spikes
2011-06-05	variometer PPM spikes getting worse
2011-06-06	Variometer PPM gets very bad and stops
2011-06-07	00:00 Check performance of PPM - it is running, but will only give "C" quality readings. Signal, Noise, voltage looks good S234 0035 ok
2011-06-15	03:00 (approx) data problems, FCheck jump
2011-06-28	23:45:01 Lost contact with GPS clock
2011-06-29	03:17:30 reboot system 03:18:22 Correction 0 s 67134564 ns
2011-07-11	13:25:01 lost contact with GPS clock
2011-07-20	23:34:30 reboot the system 23:35:33 Correction 0 s -15996217 ns
2011-07-23	11:55 lost contact with GPS clock
2011-07-26	Tried to restart GdapClock, then devc-ser8250 -u2 and Gdapclock no success 06:24 shutdown 06:25:43 Correction 0 s 505095451 ns 06:26:25 Correction 0 s 743 ns
2011-07-29	Clock stops again sometime before 00:00
2011-08-02	Jim Whatman visits observatory - variometer vault door opened
2011-08-03	03:45 reboot system. no improvement 04:07 reboot again; PGC tries talking directly to clock - no success 04:35 reboot again - no success.

2011-08-11	GPS clock still not working - attempt to set time manually, get it within 1 s of UTC
2011-08-15	Fcheck baseline changes of unknown origin. 14:07, 14:20, 19:37 UTC. Noise in Variometer.
2011-08-25	03:00 reboot system in attempt to get GPS clock working - no improvement
2011-11-08	AML/WVJ maintenance visit Tue Nov 8 - Thu Nov 10. Replace acquisition computer and GPS clock. Commence absolute observation. Measure pier difference to station B. 00:21:47 Clock Correction 4s 745650906 ns after replacing the GPS clock
2011-12-02	04:30(approx) update baselines
2011-12-06	Thunderstorms in Perth
2011-12-16	Commence delivery of GNG time series and K indices to ISGI
2011-12-22	Stephen Pryde reports that a University of WA experiment has been set up within 10 m of the absolute hut. Stephen removed the experiment to complete obs and talked with UWA contact about the need for its removal.

Annual mean values

The annual mean values for Gingin are set out in Table 5.5. Secular variation is not presented as this is the first year of observatory operations.

Hourly mean values

Plots of the hourly mean values for Gingin 2011 data are shown in Figure 5.2.

K indices

K indices for Gingin have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. K indices were scaled from preliminary time-series data. K indices have been scaled since 2010-08-01 and provided to the International Service of Geomagnetic Indices (ISGI) since 2011-12-13, in preparation to swap from Gnangara to Gingin as a source of K indices for the derivation of the global “am” index and its derivatives.

K indices measured in 2011 are listed in Table 5.6. The frequency distribution of the K indices and the annual mean daily K sum are given in Table 5.7.

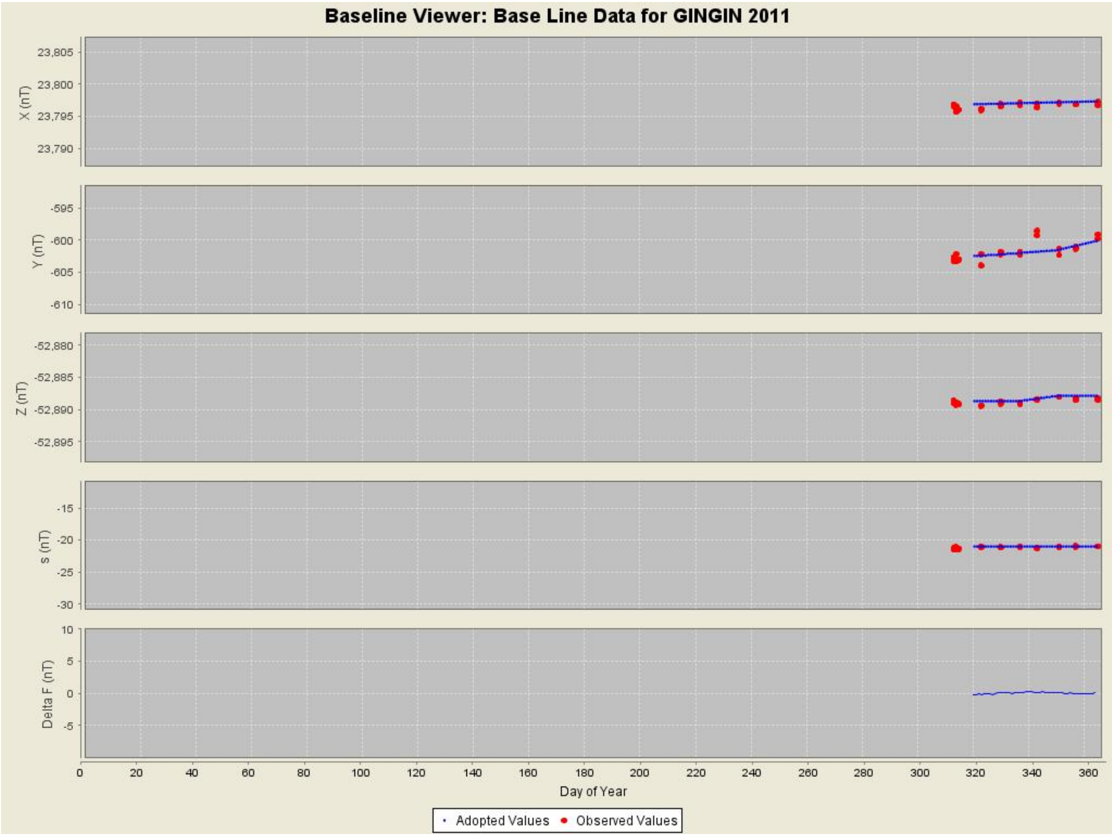


Figure 5.1. *Gingin 2011 baseline plots.*

Table 5.5. *Gingin annual mean values calculated using monthly mean values over All days, the 5 International Quiet days and the 5 International Disturbed days in each month.*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
2011.937	A	-1	38.8	-65	43.0	23816	23807	-684	-52789	57913	ABZ
2011.937	Q	-1	38.7	-65	42.7	23822	23812	-683	-52786	57912	ABZ
2011.937	D	-1	38.8	-65	43.1	23815	23805	-684	-52791	57914	ABZ

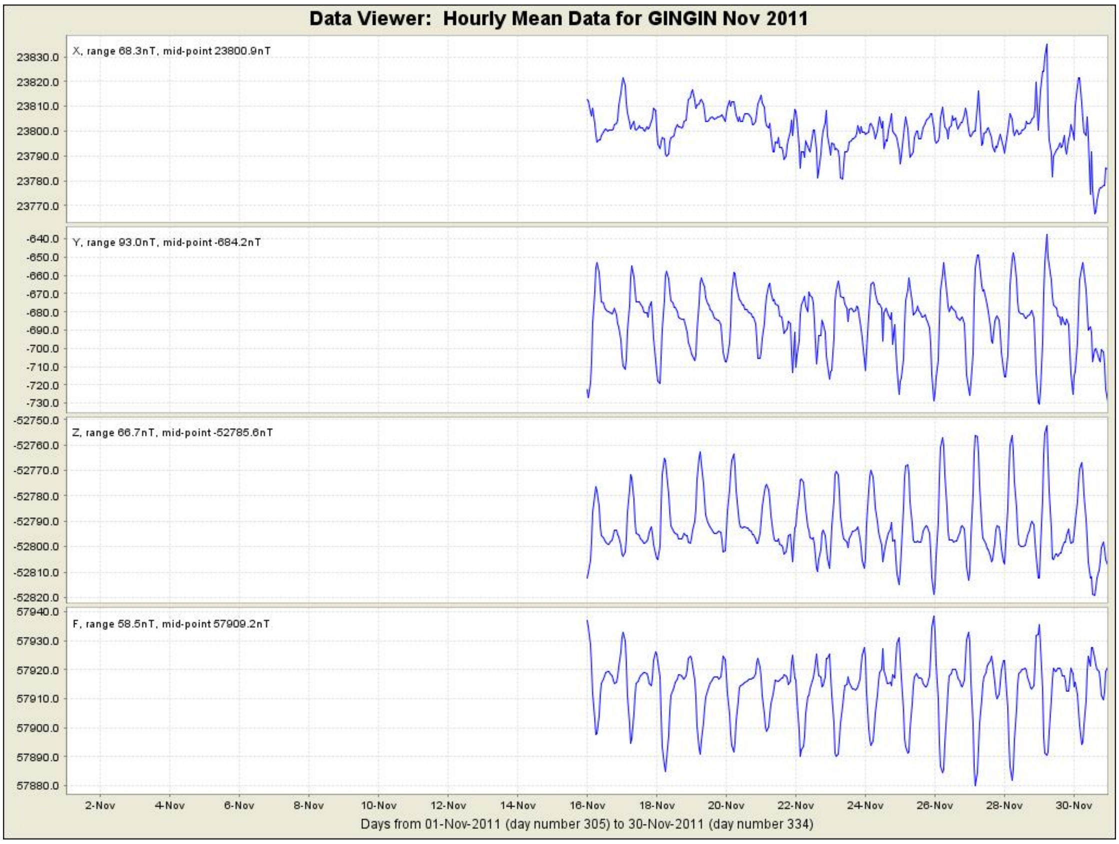
Table 5.6. Gingin 2011 K indices and daily K sums.

Day	January			February			March			April			May			June		
01				3232	1432	20	-235	4654	-	2122	2343	19	3334	4523	27	2121	2434	19
02				3112	2231	15	4232	4433	25	4234	3035	24	3243	3442	25	2233	2221	17
03				1000	0011	3	3132	3433	22	4314	3343	25	3323	3333	23	1010	0100	3
04				2222	2356	24	1223	3344	22	3212	1201	12	2121	1321	13	0110	0034	9
05				4322	2343	23	2211	2222	14	2111	0032	10	1121	2131	12	5443	2422	26
06				2123	3432	20	1111	2222	12	3314	5543	28	0011	0001	3	2111	1121	10
07				1000	1222	8	2222	3243	20	2100	0120	6	1000	2322	10	1001	1344	14
08				1100	0011	4	2120	2211	11	1012	3343	17	0000	1011	3	3121	3213	16
09				1000	0200	3	2021	1132	12	2122	2210	12	0000	1100	2	2122	3222	16
10	--12	2021	-	0122	2121	11	3144	4354	28	1000	2221	8	1123	3333	19	2023	2122	14
11	1112	2343	17	1100	1232	10	4324	3444	28	1111	2322	13	1211	1220	10	2222	3111	14
12	2122	2222	15	2220	1220	11	3222	2133	18	3355	4323	28	0000	0000	0	1223	3221	16
13	1211	2333	16	1000	1011	4	1122	2432	17	2233	2110	14	1011	1111	7	1112	3222	14
14	3232	3432	22	0000	1346	14	2211	0001	7	1110	0002	5	0000	0101	2	2223	0012	12
15	2121	2212	13	3213	3222	18	0000	0000	0	1111	1111	8	2112	1322	14	2211	3111	12
16	2101	3321	13	2221	1100	9	0010	0002	3	1111	0101	6	2233	3232	20	1011	1300	7
17	2121	1112	11	1000	1112	6	1211	0121	9	0002	2211	8	1133	3312	17	3211	3331	17
18	2111	1122	11	4554	4422	30	2011	0101	6	1032	3312	15	2210	1221	11	1110	0000	3
19	2123	2331	17	1122	2211	12	1111	3111	10	1110	1102	7	0001	1100	3	1101	1012	7
20	2112	2231	14	2123	3342	20	1111	3333	16	3332	2111	16	0000	0000	0	1221	2021	11
21	1110	2211	9	2112	2232	15	1---	----	-	1110	0111	6	0011	0122	7	1221	3232	16
22	2010	1121	8	2100	1100	5	--12	2002	-	2211	1211	11	1110	0100	4	2113	3442	20
23	2100	1101	6	0010	2010	4	3233	2442	23	1012	0100	5	0110	2112	8	3333	4433	26
24	1122	1232	14	1111	0000	4	2112	1111	10	1101	1323	12	1111	2210	9	3223	3433	23
25	2011	2122	11	0001	1012	5	1011	3111	9	2100	0110	5	1110	0001	4	1213	2221	14
26	1000	1231	8	1010	2111	7	1000	0000	1	1010	0011	4	1110	1322	11	2311	2331	16
27	1010	1010	4	1000	1101	4	1000	0101	3	0010	0110	3	1111	4343	18	1101	2012	8
28	2101	1322	12	0000	0---	-	1000	2011	5	0000	0121	4	3245	6223	27	1100	0000	2
29	3111	2211	12				0000	0213	6	1110	1236	15	4555	4452	34	0100	0000	1
30	1110	0002	5				5111	1000	9	4235	4344	29	2224	2133	19	1100	0031	6
31	1121	1333	15				0012	1111	7				2223	3343	22			

Day	July			August			September			October			November			December		
01	1232	3431	19	2220	0011	8	1000	0001	2	4322	3233	22	3225	4422	24	3213	3112	16
02	0010	0132	7	2101	1010	6	1001	1122	8	2233	3413	21	2113	3222	16	2011	1233	13
03	2211	1110	9	1100	0011	4	2323	3322	20	1121	3312	14	2100	0110	5	3133	1333	20
04	1112	2244	17	0210	1113	9	2111	3421	15	2122	3321	16	0001	2112	7	2111	2101	9
05	2222	1032	14	2110	0257	18	1000	1342	11	2233	4433	24	1110	0010	4	2000	0112	6
06	1222	0322	14	5434	4312	26	2121	2211	12	1312	3313	17	1001	1202	7	1100	2110	6
07	2012	1133	13	2110	1132	11	1111	3121	11	2222	0311	13	1110	0313	10	0000	0012	3
08	1111	1222	11	1213	4111	14	1100	0000	2	2100	1333	13	3221	3211	15	2000	2110	6
09	2212	2322	16	2241	1011	12	1111	5555	24	3122	2222	16	1011	0000	3	2122	2112	13
10	2221	1312	14	1122	2111	11	5333	2444	28	1210	0210	7	1010	1121	7	3233	1222	18
11	1134	3232	19	1212	1022	11	3210	3223	16	0000	2221	7	1111	0011	6	3121	3322	17
12	3202	4331	18	0112	1120	8	3234	4454	29	1221	1222	13	0022	1200	7	3111	1322	14
13	1212	2111	11	0100	2021	6	3343	2122	20	2100	1110	6	0002	1002	5	2222	2222	16
14	1113	2221	13	1111	1422	13	1101	2022	9	0000	0011	2	0100	0002	3	1110	1112	8
15	1210	1111	8	3222	2332	19	2201	1221	11	3201	3312	15	1122	3203	14	2110	0002	6
16	0111	0111	6	1224	3121	16	2010	0212	8	2212	3113	15	2111	0021	8	1000	0000	1
17	1101	0111	6	1112	2011	9	1245	5543	29	2100	0002	5	1020	1121	8	0000	1001	2
18	1212	2121	12	0000	1210	4	3111	2212	13	2110	0212	9	2100	1112	8	1011	1022	8
19	0123	2443	19	0000	0000	0	0010	0100	2	2112	2112	12	1000	0002	3	3222	3333	21
20	3324	3333	24	1100	1122	8	1112	1021	9	2111	0222	11	1001	0112	6	3211	1331	15
21	3222	2232	18	1000	0011	3	0012	2212	10	1110	0011	5	1011	1214	11	1101	2224	13
22	2231	2222	16	3121	0232	14	1000	1131	7	1000	0001	2	3223	3213	19	3111	1111	10
23	1222	1222	14	2021	2343	17	1100	0001	3	0011	1112	7	3211	2122	14	1100	1001	4
24	1000	0221	6	3200	2203	12	0001	1022	6	2121	0155	17	2112	3232	16	1111	1022	9
25	2223	3231	18	2011	2232	13	2112	1212	12	6333	2212	22	3110	1112	10	2210	0000	5
26	2221	1031	12	1210	0122	9	2213	4565	28	1111	0112	8	2011	1113	10	0000	0111	3
27	1000	0000	1	1111	2221	11	4342	3234	25	2111	2011	9	1222	2311	14	1110	0001	4
28	1000	0001	2	2111	0131	10	3343	4422	25	1000	0001	2	1010	0013	6	1102	3332	15
29	0000	2300	5	3122	1111	12	5443	3323	27	1000	1101	4	3443	1343	25	2133	1223	17
30	2121	3344	20	1001	1020	5	3101	0134	13	1103	3413	16	3213	4223	20	1111	2333	15
31	3222	1322	17	1000	0100	2				4122	3234	21				2123	0122	13

Table 5.7. *Frequency distribution of Gingin 2011 K indices and the annual mean daily K sum.*

K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	623	936	714	387	128	37	7	1	0	0	15
Mean sum	12.0										



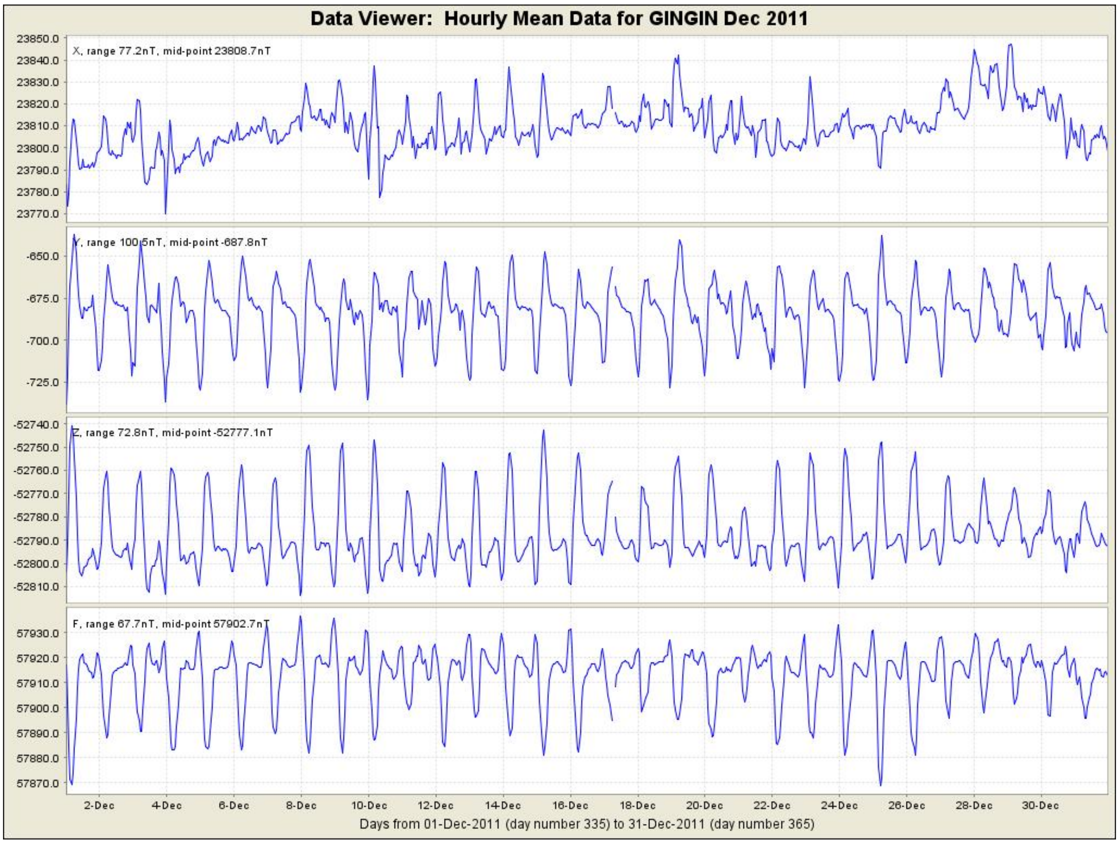


Figure 5.2. *Gingin 2011 hourly mean values in X, Y, Z and F.*

6. Gnangara

The Gnangara magnetic observatory is located within the Gnangara pine plantation approximately 27 km northeast of Perth in Western Australia. This places it only a few kilometres from the limits of urban development. It succeeds the observatory at Watheroo (1919–1959) which was located 180 km north of Perth. Magnetic recording began at Gnangara in 1957.

The observatory is built on the northeastern part of an approximately 260×140 m (3.6 hectare) site. It comprises:

- a 10×5 m Variometer/Recorder Vault, partially underground and partially buried beneath a mound of sand, that houses the recording equipment, fluxgate variometer sensor and electronics, total-field variometer electronics, GPS clock, backup power supply, telephone, and alarm system;
- an Absolute House approximately 70 m northeast of the vault;
- a small sensor vault approximately 20 m northwest of the Variometer Vault that houses the total-field variometer sensor, and;
- four azimuth reference marks.

The site is on well drained sand with magnetic gradients of less than 1 nT/m, although in places some artificial features have introduced higher gradients.

As the Gnangara site is now within a few kilometres of urban development and sand mining operations a replacement observatory has been built about 50 km further north, near the town of Gingin. The new Gingin (GNG) observatory is adjacent to the University of Western Australia's Australian International Gravitational Observatory (AIGO). The Gingin observatory commenced operations in November 2011. Both Gnangara and Gingin observatories will be run in parallel for at least 12 months before operations at Gnangara are discontinued in early 2013.

Variometers

The variometers used during 2011 are described in Table 6.2.

The fluxgate sensor was located at the eastern end of the vault, while the electronic equipment and acquisition PC were at the western end. The acquisition PC was networked via an ADSL modem for remote control and data retrieval. The acquisition equipment were powered with a 12 V battery box and trickle charger. All the equipment was protected with power and telephone line filters. The acquisition PC clock was synchronised using a GPS clock.

The fluxgate variometer sensor and electronics temperatures were monitored. As the variometers were below the ground, the diurnal temperature changes were small but there was a significant annual temperature variation. In 2011 the fluxgate sensor and electronics temperatures varied from about 15°C in August to about 31°C in March. The temperature extremes recorded at Perth Airport during 2011 were 0.2°C on 2011-07-04 and 43.2°C on 2011-01-29. The standard temperature of the variometer system was set to 20°C. Temperature fluctuations in the PPM sensor vault were not recorded but would have exceeded those in the vault housing the fluxgate variometer.

Absolute instruments

The principal absolute magnetometers used at Gnangara and their adopted corrections for 2011 are described in Table 6.3.

An instrument comparison was made between the Gnangara DIM (DI0037/390444) and the travelling reference DIM (B0610H/160459) at Gingin Observatory in November 2011. The instrument corrections for DI0037 were found to be consistent with previous results.

At the 2011 mean magnetic field values at Gnangara (X= 23475 nT, Y= -760 nT, Z= -53224 nT) the D, I, and F corrections translate to corrections of:

ΔX = -2.3 nT ΔY = -0.3 nT ΔZ = -1.0 nT

These corrections have been applied to Gnangara 2011 final data.

Table 6.1. *Key observatory data.*

IAGA code:	GNA
Commenced operation:	June 1957
Geographic latitude:	31° 46' 48" S
Geographic longitude:	115° 56' 48" E
Geomagnetic latitude:	-41.33°
Geomagnetic longitude:	189.40°
K 9 index lower limit:	450 nT
Principal pier:	Pier B
Pier elevation (top):	60 m AMSL
Principal reference mark:	Pillar N
Reference mark azimuth:	315° 21' 42"
Reference mark distance:	70 m
Observer:	S. Pryde

Table 6.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	EDA FM105B
Serial number:	2877 / 2887
Type:	linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.01 nT / count
Total-field variometer:	Geometrics 856
Serial number:	50706
Type:	Proton precession
Acquisition interval:	10 s
Resolution:	0.1 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Trimble Acutime GPS clock
Communications:	ADSL

Table 6.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0037
Theodolite:	Zeiss 020B
Serial number:	390444
Resolution:	0.1'
D correction:	-0.05'
I correction:	-0.15'
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	3091317 / 91457
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

Baselines

As in previous years, there was a significant seasonal variation in the X and Z baselines. However, because it appeared to lag the seasonal temperature variation there did not seem to be a direct correlation with temperature. Consequently no temperature coefficients were applied to the vector variometer data. There were also two baseline jumps, the first caused by removal of equipment from the variometer vault (5 nT), and the second caused by adjustment of the variometer baseline switches (15 nT). Throughout the year baselines varied by about 15 nT in X and Z and 7 nT in Y (excluding the jumps).

The standard deviations in the difference between the 2011 absolute observations from the final adopted variometer model and data were:

	σ
X	0.6 nT
Y	0.8 nT
Z	0.5 nT
D	07"
I	03"
F	0.4 nT

The daily average of the difference between F derived from the vector variometer and F measured by the scalar variometer varied between 1.0 nT and 1.5 nT over the year.

Observed and adopted baseline values in X, Y and Z are shown in Figure 6.1.

Operations

Stephen Pryde was the local observer at Gnangara throughout 2011 with technical assistance from O. McConnel, a Perth-based Geoscience Australia staff member.

Variometer data were recorded on an acquisition PC running the QNX operating system and Geophysical Data Acquisition Platform (GDAP) software. The vector variometer data were sampled once per second, the scalar data were sampled once every 10 seconds. System timing was controlled by a GPS clock. Timing corrections greater than 1 ms are listed in *Significant events* below.

Data communications were over a TCP/IP network using an ADSL link. Data were transmitted to Geoscience Australia every 3-10 minutes where they were processed, stored in a database and distributed to data repositories.

Throughout 2011, K indices for Gnangara were scaled and distributed weekly.

Absolute observations were performed weekly. The stainless steel security door on the Absolute Hut was left open in the same position during observations.

The distribution of Gnangara 2011 data is described in Table 6.4. Data losses are identified in Table A.5.

Significant events

2011-03-02	AML/APH visit observatory, observations with standard GNA instruments 05:30 (approx) remove old UPS and PC from variometer vault. Removing this equipment caused a 5 nT baseline jump (mostly in Z)
2011-04-03	Problems with telemetry throughout the day
2011-04-04	check analogue modem connection - all o.k.

Table 6.4. *Distribution of Gnangara 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
ISGI, France	preliminary	real-time (from 2011-12-16)
WDC for Geomagnetism	preliminary	real time
University of Oulu, Finland	preliminary	hourly
K indices		
IPS Radio and Space Services		weekly
ISGI, France		weekly
Principal magnetic storms and rapid variations		
WDC for Solar-Terrestrial Physics		monthly
WDC for Geomagnetism		monthly
Observatori de l'Ebre, Spain		monthly

2011-04-11 AML/APH visit the observatory, 05:21 attempt to adjust Z baseline on EDA variometer but the adjusting pot has frozen (even when unlocked) no significant change to baseline but enough to cause a small baseline disturbance requiring re-calibration. Reboot ADSL modem in attempt to fix telemetry problems.

2011-04-12 AML/APH visit the observatory. Alter ADSL modem to allow remote access to modem

2011-06-14 00:00 update X and Z drifts from day 113

2011-06-16 01:06:25 - CLK Correction C 0 s -1544926 ns

2011-07-20 Send replacement ABUS "rock" padlock for vault

2011-08-15 22:27 Security monitoring reported a power failure

2011-08-25 03:16 test analogue modem connection - O.K.

2011-10-21 Bees in absolute hut - arrange for removal. Absolute hut PIR alarm sensor switched off as bees in the hut were setting it off.
07:30-08:45 Pest removal personnel on site.

2011-11-10 AML/WVJ visit observatory, do obs, inspection.

2011-12-06 Thunderstorms in Perth - spikes on data.

2011-12-14 Security monitoring report no response from security system since 6 Dec. Investigations reveal telephone line is malfunctioning.
Bees nesting on absolute hut again!

2011-12-16 Commence delivery of GNA time series to ISGI

2011-12-20 Telephone line repaired by Telstra

Annual mean values

The annual mean values for Gnangara are set out in Table 6.5 and displayed with the secular variation in Figure 6.2.

Hourly mean values

Plots of the hourly mean values for Gnangara 2011 data are shown in Figure 6.3.

K indices

K indices for Gnangara have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. K indices were scaled from preliminary time-series data. K indices from Gnangara contribute to the global am index and its derivatives.

K indices measured in 2011 are listed in Table 6.6. The frequency distribution of the K indices and the annual mean daily K sum are given in Table 6.7. Principal magnetic storms observed at Gnangara are listed in Table 6.8, storm sudden commencements in Table 6.9 and solar flare effects Table 6.10.

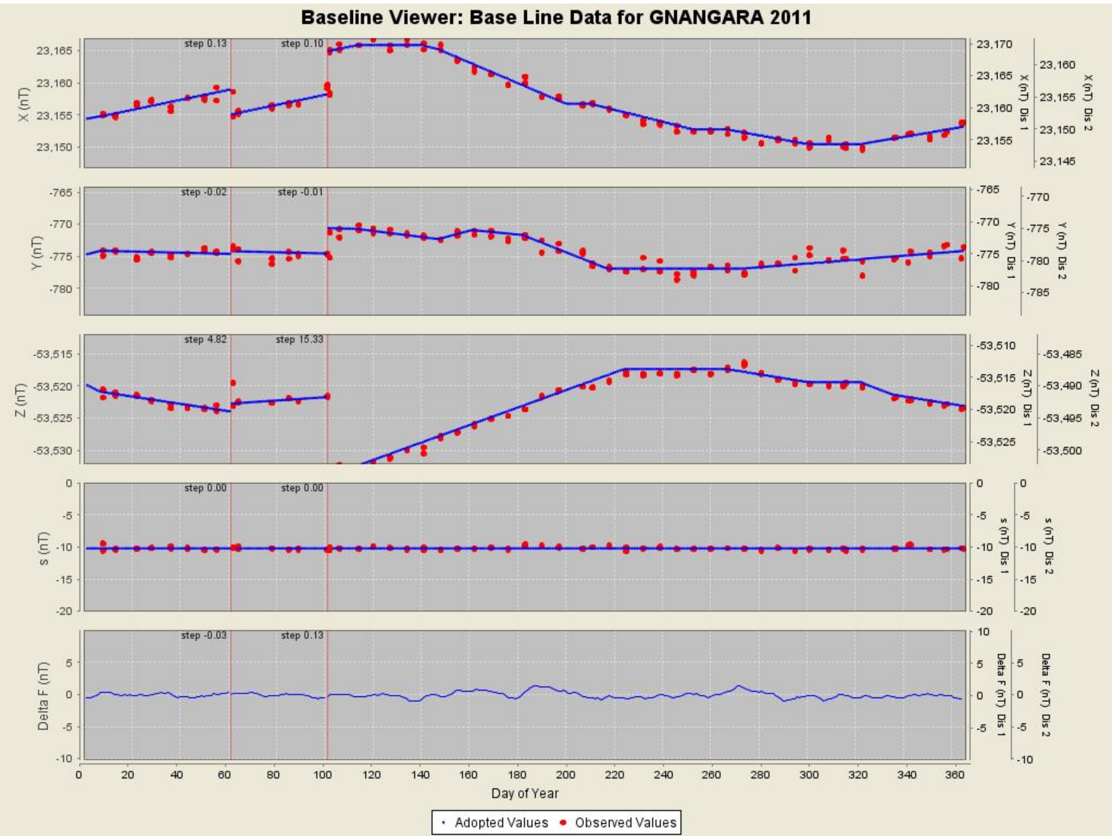


Figure 6.1. *Gnangara 2011 baseline plots.*

Table 6.5. *Gnangara annual mean values calculated using monthly mean values over* ***All*** *days, the 5 International* ***Quiet*** *days and the 5 International* ***Disturbed*** *days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 6.2. In the table, J identifies a jump due to a change of observation site (jump value = old site value - new site value).*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1993.5	A	-2	54.1	-66	40.3	23184	23155	-1174	-53759	58546	ABZ
1994.0	J		-1.6		1.1	8	7	-11	27	-22	ABZ
1994.5	A	-2	48.5	-66	41.2	23176	23148	-1136	-53777	58558	ABZ
1995.5	A	-2	43.0	-66	40.4	23184	23158	-1098	-53765	58550	ABZ
1996.5	A	-2	37.0	-66	38.8	23208	23184	-1060	-53753	58549	ABZ
1997.5	A	-2	30.8	-66	38.2	23216	23193	-1018	-53743	58543	ABZ
1998.5	A	-2	24.8	-66	38.0	23214	23194	-978	-53731	58531	ABZ
1999.5	A	-2	18.5	-66	36.8	23226	23207	-936	-53707	58514	ABZ
2000.5	A	-2	13.6	-66	36.0	23230	23212	-903	-53682	58493	ABZ
2001.5	A	-2	09.0	-66	34.7	23241	23225	-872	-53651	58468	ABZ
2002.5	A	-2	04.7	-66	33.8	23245	23230	-843	-53622	58444	ABZ
2003.5	A	-2	01.1	-66	33.4	23243	23229	-819	-53601	58424	ABZ
2004.5	A	-1	57.3	-66	31.6	23260	23247	-794	-53562	58395	ABZ
2005.5	A	-1	54.6	-66	29.7	23274	23262	-776	-53516	58358	ABZ
2006.5	A	-1	53.0	-66	26.7	23306	23293	-766	-53457	58317	ABZ
2007.5	A	-1	52.1	-66	23.8	23335	23323	-761	-53405	58280	ABZ
2008.5	A	-1	51.8	-66	20.9	23368	23355	-760	-53357	58249	ABZ
2009.5	A	-1	51.5	-66	17.5	23410	23398	-759	-53307	58220	ABZ
2010.5	A	-1	51.2	-66	14.5	23446	23434	-758	-53265	58197	ABZ
2011.5	A	-1	51.2	-66	11.3	23487	23475	-760	-53224	58176	ABZ
1980.5	Q	-3	17.8	-66	25.7	23409	23370	-1345	-53652	58536	DHZ
1981.5	Q	-3	19.1	-66	28.9	23364	23325	-1352	-53685	58549	DHZ
1982.5	Q	-3	20.3	-66	31.9	23321	23281	-1358	-53714	58559	DHZ
1983.5	Q	-3	19.2	-66	33.7	23294	23255	-1349	-53730	58562	DHZ
1984.5	Q	-3	18.9	-66	35.3	23273	23234	-1346	-53752	58574	DHZ
1985.5	Q	-3	17.6	-66	36.5	23259	23221	-1336	-53769	58585	DHZ
1986.5	Q	-3	15.5	-66	38.1	23239	23201	-1321	-53792	58598	DHZ
1987.5	Q	-3	13.5	-66	39.0	23228	23191	-1307	-53806	58606	DHZ
1988.5	Q	-3	11.7	-66	39.9	23214	23178	-1294	-53811	58604	DHZ
1989.5	Q	-3	08.6	-66	40.8	23197	23162	-1272	-53813	58600	DHZ
1990.5	Q	-3	06.1	-66	40.7	23195	23161	-1255	-53802	58588	DHZ
1991.5	Q	-3	02.0	-66	40.4	23194	23162	-1227	-53787	58575	DFI
1992.5	Q	-2	58.0	-66	40.0	23193	23162	-1200	-53770	58559	DFI
1993.5	Q	-2	53.9	-66	39.7	23194	23164	-1173	-53757	58547	ABZ
1994.0	J		-1.6		1.1	8	7	-11	27	-22	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1994.5	Q	-2	48.2	-66	40.5	23187	23159	-1134	-53774	58560	ABZ
1995.5	Q	-2	42.8	-66	39.8	23194	23168	-1098	-53762	58552	ABZ
1996.5	Q	-2	36.9	-66	38.5	23213	23189	-1059	-53752	58550	ABZ
1997.5	Q	-2	30.7	-66	37.7	23224	23202	-1018	-53741	58545	ABZ
1998.5	Q	-2	24.7	-66	37.5	23223	23202	-977	-53728	58532	ABZ
1999.5	Q	-2	18.4	-66	36.3	23234	23215	-935	-53705	58515	ABZ
2000.5	Q	-2	13.5	-66	35.4	23240	23223	-902	-53679	58494	ABZ
2001.5	Q	-2	08.8	-66	34.1	23252	23235	-871	-53648	58470	ABZ
2002.5	Q	-2	04.5	-66	33.1	23257	23242	-842	-53619	58446	ABZ
2003.5	Q	-2	01.1	-66	32.7	23255	23241	-819	-53599	58426	ABZ
2004.5	Q	-1	57.2	-66	31.0	23269	23256	-793	-53559	58396	ABZ
2005.5	Q	-1	54.5	-66	29.1	23284	23271	-775	-53513	58360	ABZ
2006.5	Q	-1	53.0	-66	26.2	23313	23300	-766	-53455	58318	ABZ
2007.5	Q	-1	52.1	-66	23.6	23339	23327	-761	-53404	58281	ABZ
2008.5	Q	-1	51.8	-66	20.7	23372	23360	-760	-53356	58250	ABZ
2009.5	Q	-1	51.5	-66	17.8	23406	23393	-759	-53312	58224	ABZ
2010.5	Q	-1	51.2	-66	14.3	23451	23438	-758	-53264	58198	ABZ
2011.5	Q	-1	51.2	-66	10.9	23493	23481	-760	-53222	58176	ABZ
1993.5	D	-2	54.4	-66	41.3	23167	23138	-1175	-53763	58542	ABZ
1994.0	J		-1.6		1.1	8	7	-11	27	-22	ABZ
1994.5	D	-2	48.9	-66	42.0	23162	23134	-1137	-53780	58556	ABZ
1995.5	D	-2	43.3	-66	41.2	23171	23144	-1100	-53768	58548	ABZ
1996.5	D	-2	37.1	-66	39.3	23200	23176	-1060	-53754	58547	ABZ
1997.5	D	-2	31.1	-66	39.0	23202	23180	-1019	-53746	58541	ABZ
1998.5	D	-2	25.2	-66	39.2	23194	23173	-979	-53736	58528	ABZ
1999.5	D	-2	18.6	-66	37.8	23210	23191	-936	-53711	58512	ABZ
2000.5	D	-2	13.9	-66	37.3	23208	23190	-904	-53688	58490	ABZ
2001.5	D	-2	09.6	-66	36.0	23219	23203	-875	-53656	58465	ABZ
2002.5	D	-2	04.9	-66	34.9	23227	23211	-844	-53627	58441	ABZ
2003.5	D	-2	01.3	-66	34.5	23224	23210	-819	-53605	58420	ABZ
2004.5	D	-1	57.6	-66	32.7	23242	23228	-795	-53566	58391	ABZ
2005.5	D	-1	54.7	-66	30.7	23259	23246	-776	-53520	58355	ABZ
2006.5	D	-1	53.0	-66	27.4	23294	23281	-765	-53459	58314	ABZ
2007.5	D	-1	52.1	-66	24.2	23329	23317	-761	-53405	58278	ABZ
2008.5	D	-1	51.9	-66	21.3	23362	23349	-760	-53358	58248	ABZ
2009.5	D	-1	51.6	-66	18.3	23398	23386	-759	-53314	58222	ABZ
2010.5	D	-1	51.3	-66	15.1	23437	23424	-759	-53267	58194	ABZ
2011.5	D	-1	51.4	-66	11.9	23477	23465	-760	-53227	58174	ABZ

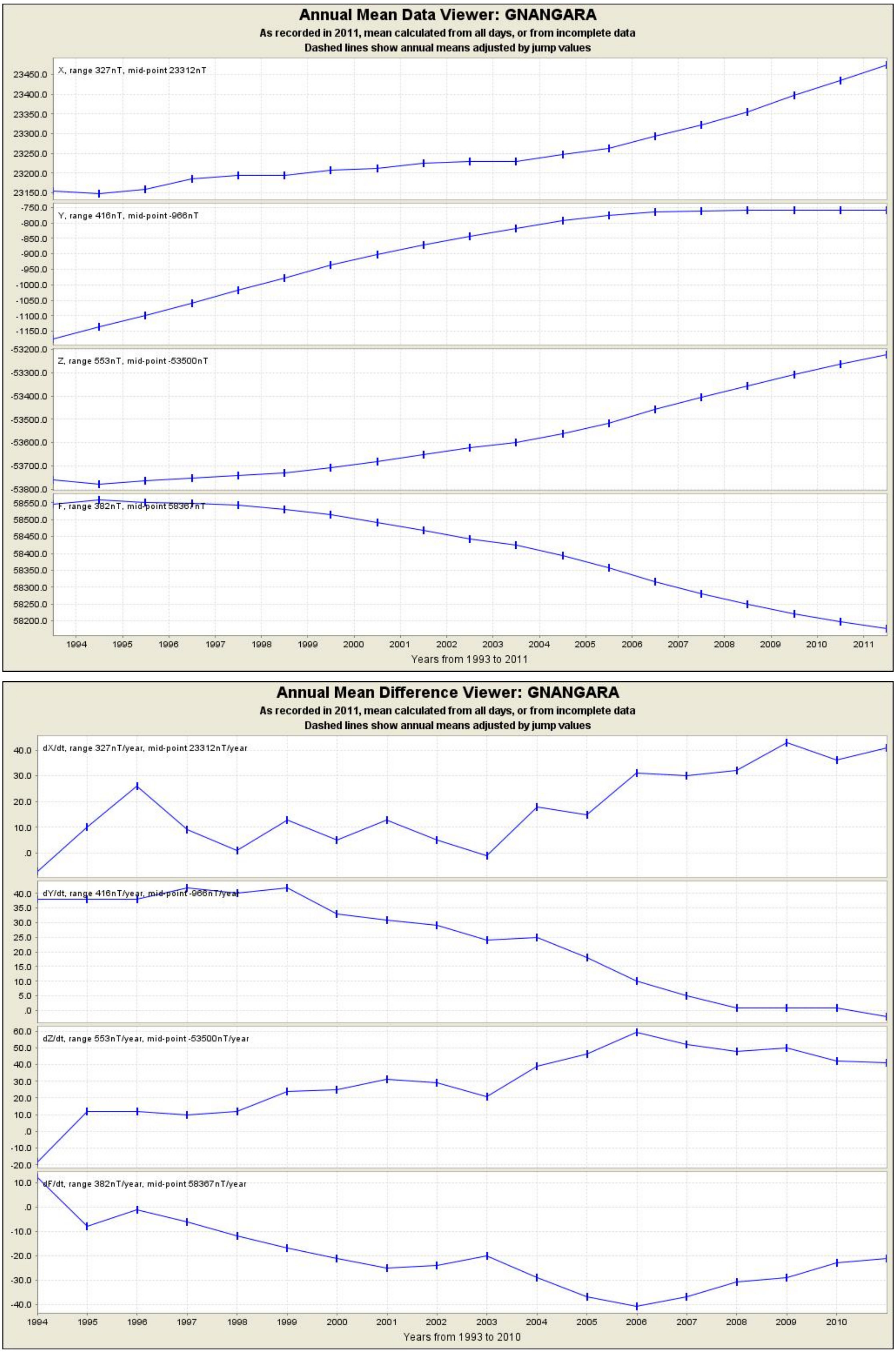


Figure 6.2. *Gnangara annual mean values and secular variation (all days) for X, Y, Z and F.*

Table 6.6. *Gnangara 2011 K indices and daily K sums.*

Day	January			February			March			April			May			June		
01	1101	2111	8	3231	0432	18	3235	4554	31	2122	2343	19	3334	4533	28	2121	2433	18
02	2222	1211	13	3112	2221	14	4232	3433	24	4333	3145	26	3243	3442	25	2233	2221	17
03	1102	2233	14	1000	0011	3	3232	3433	23	3224	3343	24	3323	3332	22	1010	0100	3
04	1112	1221	11	2122	2355	22	1223	3344	22	3212	1201	12	2021	1321	12	0010	0034	8
05	0001	2121	7	4322	2342	22	2211	2222	14	2110	0032	9	1121	2131	12	5443	2422	26
06	1010	0124	9	2123	3432	20	1100	2222	10	2214	5543	26	0011	0001	3	2111	1121	10
07	4222	3333	22	1000	1212	7	2222	3243	20	2100	0120	6	1000	2322	10	1000	1343	12
08	2123	3332	19	1100	0011	4	2121	2211	12	1012	3343	17	0000	1011	3	3212	3213	17
09	2211	2233	16	1000	0200	3	2021	1132	12	2122	2110	11	0000	0100	1	2122	3222	16
10	3112	2021	12	1122	2122	13	3234	4354	28	1000	2221	8	1123	3333	19	2023	2122	14
11	1112	2343	17	1101	1232	11	4324	3444	28	1011	2322	12	1211	1220	10	2122	3111	13
12	2121	1122	12	2110	1220	9	3222	2132	17	2235	4323	24	0000	0000	0	1223	3221	16
13	1211	2333	16	1000	1011	4	2012	2332	15	2133	2110	13	1010	1110	5	1112	3222	14
14	3222	3432	21	0000	1336	13	2211	0001	7	1110	0002	5	1000	0101	3	1223	0012	11
15	2121	2212	13	3113	3222	17	0000	0000	0	1111	1110	7	2111	1322	13	2211	3111	12
16	2101	3321	13	2110	1000	5	1010	0002	4	0111	0101	5	2233	3232	20	1010	1300	6
17	2121	1112	11	1000	1101	4	1211	1120	9	0002	2101	6	1223	3212	16	3111	3331	16
18	2111	1122	11	4553	4421	28	1010	0101	4	0132	3302	14	2210	1211	10	1110	0000	3
19	3123	2331	18	1111	2211	10	1001	2101	6	2120	1102	9	0001	1100	3	1101	1012	7
20	2112	2231	14	2123	3342	20	1101	3333	15	3332	2111	16	0000	0000	0	1221	1021	10
21	1000	2211	7	2112	2232	15	1100	0223	9	1110	0111	6	0011	0122	7	1221	3232	16
22	1010	1110	5	2100	1100	5	2221	2002	11	2211	1111	10	1110	0000	3	2113	2442	19
23	2100	1100	5	0010	2010	4	3233	1442	22	1112	0100	6	0110	2112	8	3333	4433	26
24	0122	1232	13	1110	0000	3	2011	1111	8	1101	1323	12	1111	2210	9	2223	3433	22
25	2011	2121	10	0001	1012	5	1011	3111	9	1100	0110	4	1110	0001	4	1212	2321	14
26	1000	1131	7	1000	2111	6	1000	0000	1	1000	0010	2	1110	1321	10	2201	2221	12
27	1010	1010	4	1000	1101	4	1000	0001	2	0000	0110	2	1111	4333	17	1101	2012	8
28	2001	1222	10	0000	0022	4	1000	2011	5	0000	0121	4	2245	6223	26	0100	0000	1
29	3110	2210	10				0000	0213	6	1110	1236	15	4554	4452	33	0000	0000	0
30	1110	0002	5				4111	1000	8	4235	4344	29	2224	2133	19	1100	0031	6
31	1111	0333	13				0012	1111	7				2233	3333	22			

Day	July			August			September			October			November			December		
01	1232	3431	19	2220	0011	8	1000	0001	2	4222	3233	21	3124	4322	21	3213	2122	16
02	0000	0132	6	2100	1010	5	1001	1122	8	2233	3413	21	2113	2222	15	2011	1233	13
03	2210	1010	7	1100	0001	3	2323	3322	20	1121	3322	15	2000	0110	4	3133	1233	19
04	1111	2244	16	0210	1113	9	2111	3421	15	1012	3311	12	0000	1112	5	2111	2101	9
05	2221	1032	13	2110	0257	18	1000	1342	11	2133	4433	23	1110	0010	4	1000	0112	5
06	1222	0222	13	5434	4312	26	2121	2211	12	1312	3313	17	1000	1202	6	1000	1110	4
07	2012	1133	13	2110	1132	11	1111	2121	10	2121	0311	11	1110	0213	9	0000	0012	3
08	1111	1222	11	1113	4111	13	1100	0000	2	2101	1333	14	3222	3211	16	2000	2110	6
09	2312	2222	16	2241	1011	12	0111	4554	21	3112	2222	15	1001	0000	2	2121	2112	12
10	2221	1312	14	1122	2111	11	5333	2444	28	1200	0211	7	1010	1121	7	3233	1222	18
11	1133	3232	18	1212	1022	11	3211	3223	17	0000	2221	7	1111	0011	6	3121	3322	17
12	3212	4331	19	0112	1120	8	3234	3454	28	1120	0231	10	0012	1200	6	2111	1322	13
13	1212	2110	10	0000	1011	3	3343	2122	20	1100	1110	5	0001	1002	4	2222	2222	16
14	1113	2221	13	1111	1422	13	1111	2022	10	0000	0011	2	0101	1001	4	2110	0112	8
15	1210	1111	8	3112	2332	17	2101	0221	9	3201	3312	15	1111	3202	11	2000	0001	3
16	0111	0111	6	1223	3121	15	2000	0212	7	2202	3113	14	2111	0021	8	1000	0000	1
17	1101	0111	6	1112	2011	9	1245	5542	28	2100	0002	5	1020	1121	8	0000	1101	3
18	1212	2111	11	0000	1220	5	3111	2212	13	2110	0212	9	2100	1112	8	1011	1022	8
19	0123	2443	19	0000	0000	0	0010	0000	1	2102	2112	11	1000	0002	3	3222	3333	21
20	3224	3333	23	1100	1122	8	1111	1021	8	3111	0222	12	1001	0112	6	3111	1331	14
21	3221	2232	17	1000	0011	3	0012	2111	8	1100	0011	4	1011	1214	11	1111	2224	14
22	2231	2222	16	2121	0232	13	1000	1121	6	1000	0001	2	3222	3203	17	3111	1111	10
23	1122	1222	13	2021	2343	17	1100	0001	3	0011	1112	7	3111	2122	13	1100	1001	4
24	0000	0221	5	3101	2203	12	0001	1021	5	2021	0155	16	2112	3232	16	1111	0022	8
25	2123	3231	17	2111	2231	13	2112	1212	12	6333	2212	22	2110	1112	9	2200	0000	4
26	2221	1031	12	1210	0122	9	2212	4565	27	1111	0112	8	1011	1113	9	0000	0011	2
27	1000	0000	1	2110	2211	10	4342	3234	25	2111	1011	8	1122	2211	12	1110	0001	4
28	1000	0001	2	1111	1131	10	3342	4422	24	1000	0001	2	1000	0013	5	1002	3322	13
29	1010	2310	8	3122	1111	12	5442	3323	26	1000	1101	4	3433	1343	24	2133	1223	17
30	2121	3344	20	1001	1020	5	2001	0134	11	1103	3303	14	3103	4222	17	2211	2333	17
31	3222	1222	16	1000	0100	2				4122	3134	20				2022	0122	11

Table 6.7. Frequency distribution of Gnangara 2011 K indices and the annual mean daily K sum.

K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	697	968	716	381	119	33	5	1	0	0	0
Mean sum	11.6										

Table 6.8. Principal magnetic storms observed at Gnangara in 2011.

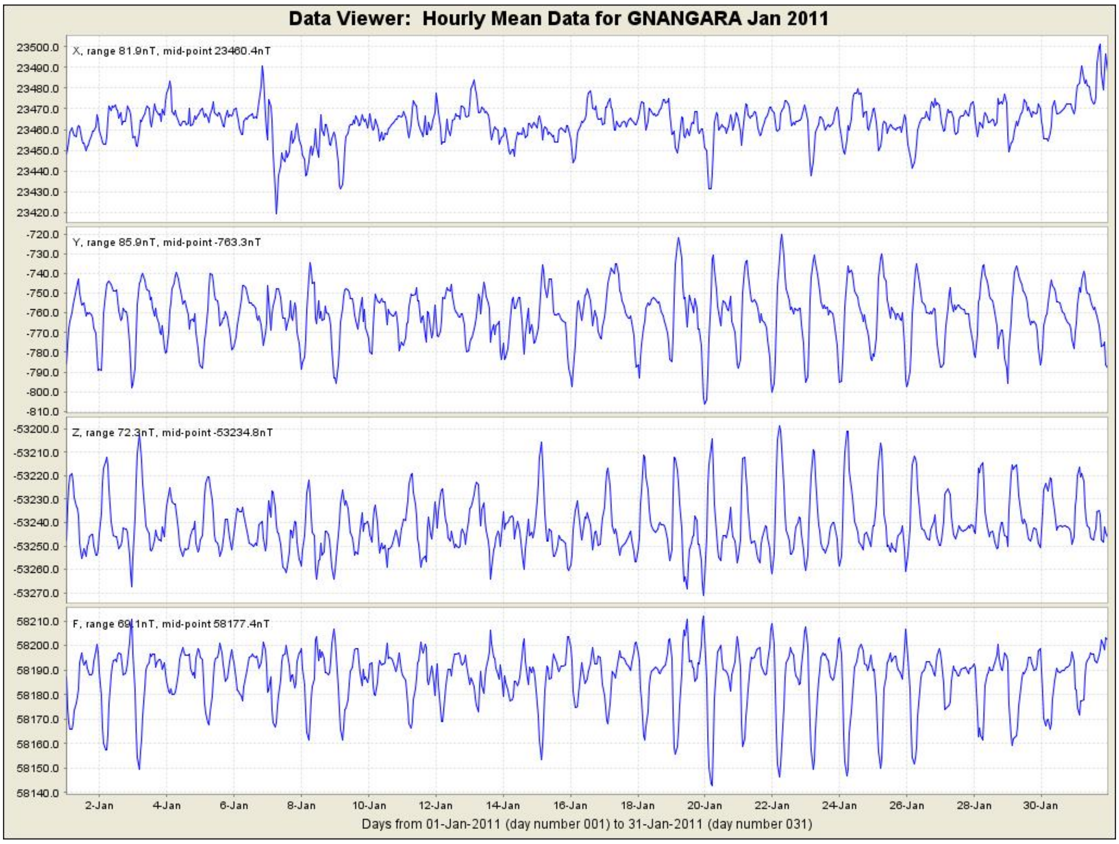
UT Start		Type	SSC amplitudes			Maximum 3hr K indices		Storm Ranges			UT End	
Date	Time		D(')	H(nT)	Z(nT)	Day (3hr periods)	K	D(')	H(nT)	Z(nT)	Date	Time
2011-02-04	02:39	ssc*	-0.48*	2.93	3.18	4(7,8)	5	17.2	112.0	95.2	2011-02-05	07:00
2011-02-14	15:56	ssc	1.5	27.47	14.92	14(8)	6	23.3	91.8	94.8	2011-02-15	04:00
2011-02-18	01:30	ssc*	-4.62	17.93	25.81*	18(2,3)	5	24.4	90.0	133.7	2011-02-18	22:00
2011-03-01	06:18	...				1(4,6,7)	5	15.4	138.3	136.0	2011-03-02	10:00
2011-04-06	09:33	ssc	1.14	21.86	6.5	6(5,6)	5	13.2	88.3	89.4	2011-04-07	05:00
2011-04-29	17:00	...				29(8)	6	26.0	99.4	136.9	2011-05-01	17:00
2011-05-27	11:00	...				28(5)	6	25.2	160.1	141.7	2011-05-28	17:00
2011-05-29	00:03	...				29(2,3,7)	5	15.0	146.4	95.5	2011-05-29	23:00
2011-08-05	17:07	...				5(8)	7	37.1	131.8	186.6	2011-08-06	17:01
2011-09-09	12:43	ssc	2.7	35.0	20.96	9(6,7), 10(1)	5	22.4	127.6	128.9	2011-09-10	11:09
2011-09-17	03:45	...				17(4,5,6)	5	22.5	150.8	144.4	2011-09-18	02:00
2011-09-26	12:35	ssc	2.1	38.62	15.38	26(7)	6	21.7	153.7	124.3	2011-09-27	08:22
2011-10-24	18:31	ssc*	8.88*	50.16	48.56*	25(1)	6	20.6	170.5	107.3	2011-10-25	18:00

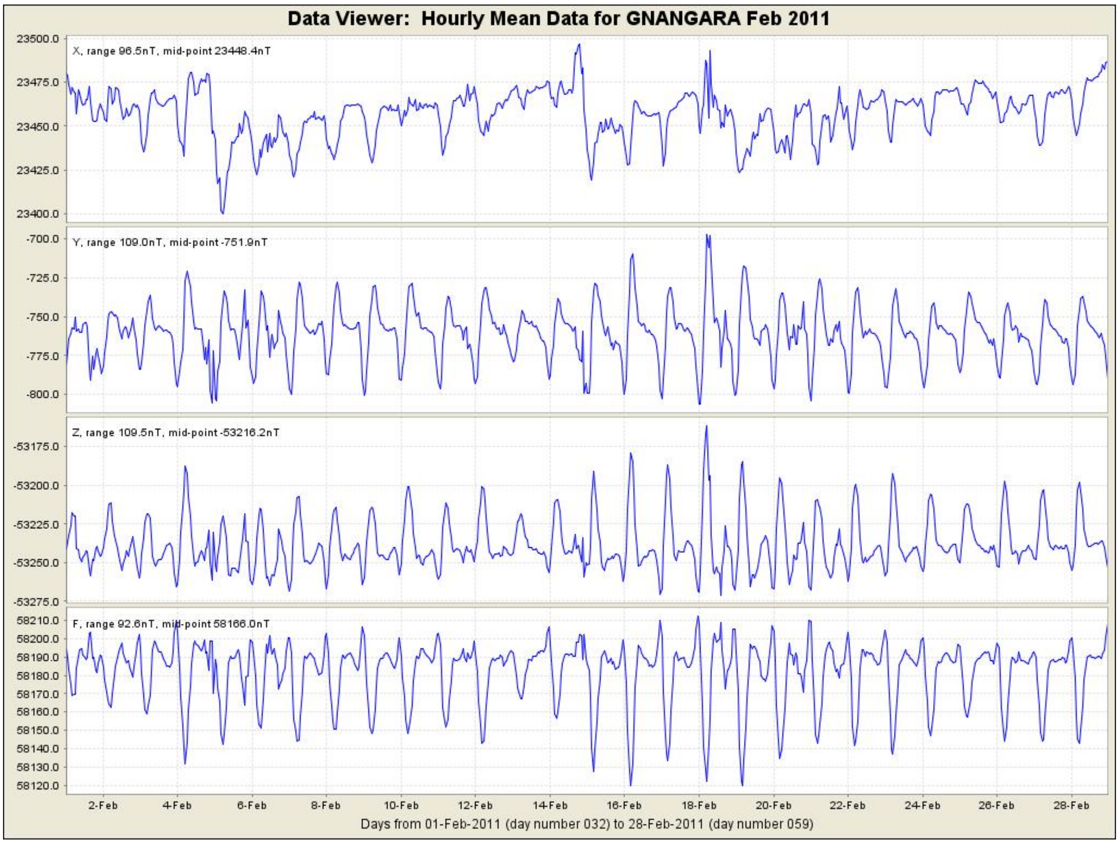
Table 6.9. *Storm sudden commencements observed at Gnangara in 2011.*

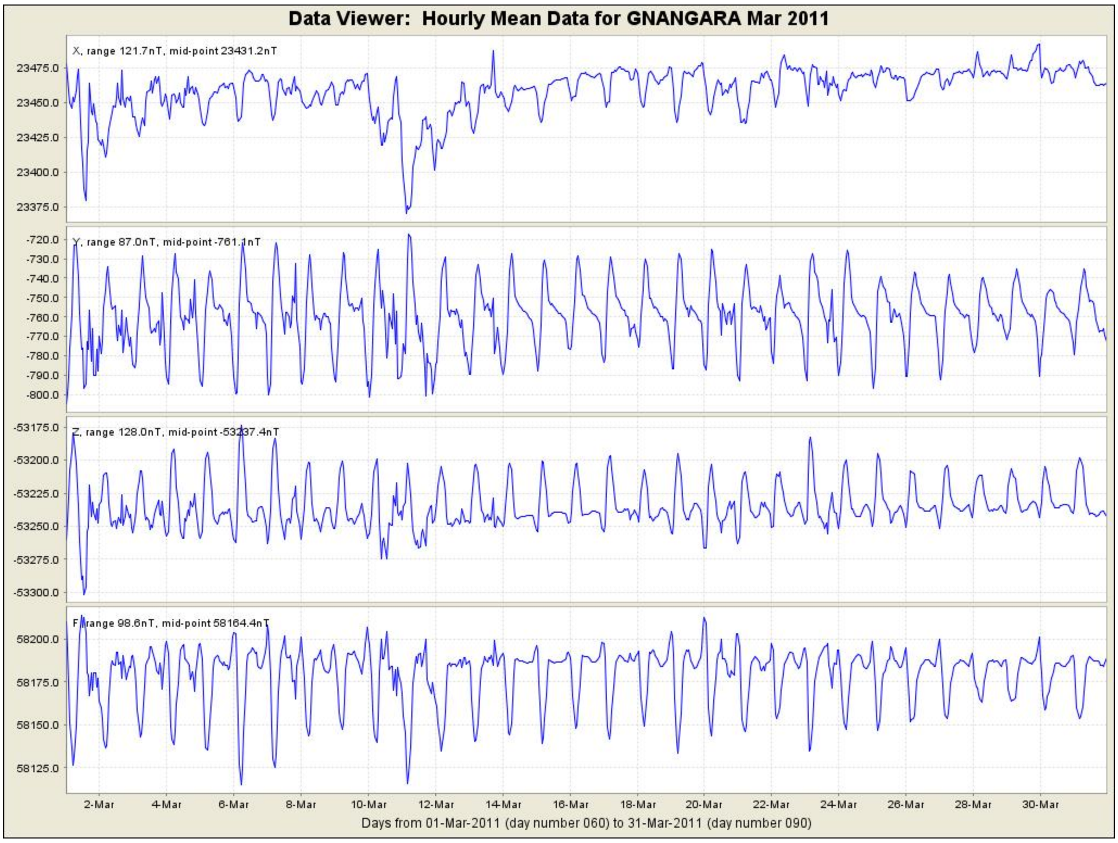
UT		Type ssc/ssc*	Quality A,B,C	Chief movement (nT)		
Date	Time			H(X)	D(Y)	Z
2011-01-06	17:15	ssc	C	7.31	3.67	4.97
2011-02-04	02:39	ssc*	C	2.93	-3.29*	3.18
2011-02-14	15:56	ssc	A	27.47	10.41	14.92
2011-02-18	01:30	ssc*	B	17.93	31.72	25.81*
2011-03-22	14:11	ssc*	B	-9.65*	3.37	-4.47*
2011-03-29	16:02	ssc	A	11.91	7.38	7.54
2011-04-06	09:33	ssc	B	21.86	7.97	6.5
2011-04-18	06:54	ssc	A	14.56	25.35	21.26
2011-04-19	21:09	ssc*	B	4.8	11.44*	7.55
2011-06-04	20:45	ssc	A	24.87	35.29	28.48
2011-06-10	08:48	ssc*	B	5.25	-9.24	-4.27*
2011-06-17	02:39	ssc*	A	5.75	-13.39*	-4.96*
2011-07-01	06:28	ssc	C	5.91	18.99	12.59
2011-08-04	21:55	ssc	A	5.78	16.88	13.36
2011-09-09	12:43	ssc	A	35.0	18.55	20.96
2011-09-26	12:35	ssc	A	38.62	14.53	15.38
2011-10-05	07:37	ssc	B	15.36	13.47	11.14
2011-10-24	18:31	ssc*	A	50.16	60.98*	48.56*
2011-10-30	10:01	ssc	B	15.69	6.89	7.97
2011-11-12	05:58	ssc	B	7.87	6.45	4.85
2011-11-28	21:50	ssc*	A	10.08	-27.63*	-15.28*
2011-12-02	17:15	ssc*	B	9.54	10.33*	9.29*
2011-12-18	19:02	ssc	A	11.7	9.15	8.91
2011-12-28	11:12	ssc	A	12.17	10.92	6.73

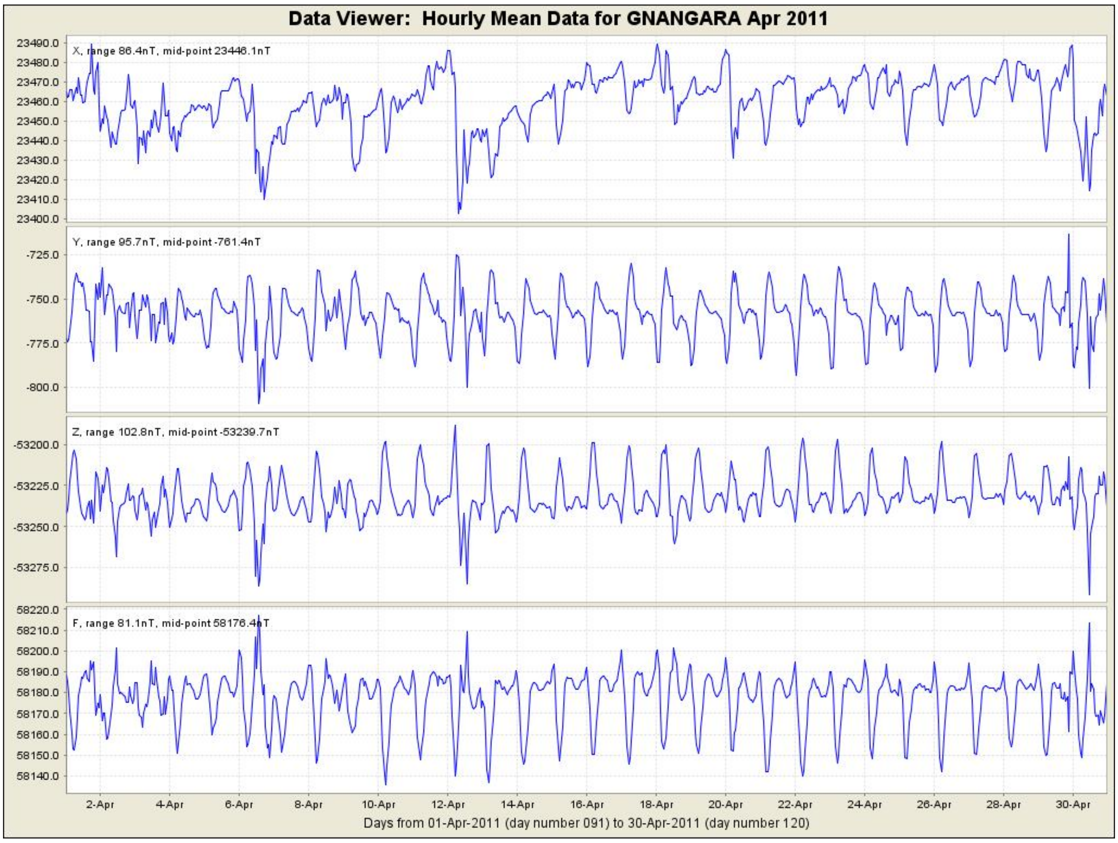
Table 6.10. *Solar flare effects observed at Gnangara in 2011.*

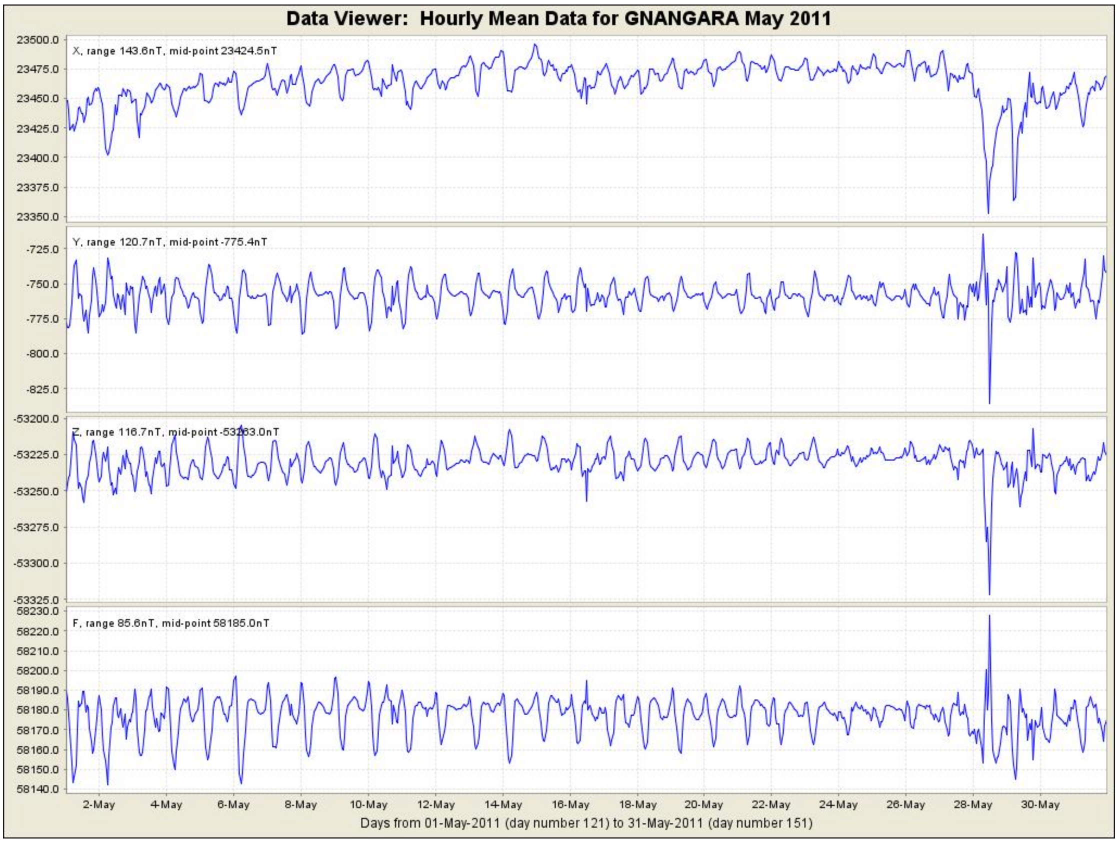
UT Date	Movement			Amplitude (nT)			Confirmation
	Start	Max	End	H(X)	D(Y)	Z	
2011-02-09	01:28	01:32	01:39	0.87	1.02	5.42	solar
2011-02-15	01:48	01:57	02:20	12.26	3.24	13.42	solar
2011-07-30	02:07	02:10	02:17	10.35	0.6	2.86	solar
2011-08-03	04:31	04:32	04:36	1.96	0.48	2.11	solar
2011-08-04	03:49	03:59	04:18	2.57	2.16	11.21	solar
2011-09-07	22:36	22:39	22:52	2.25	0.96	4.66	solar
2011-09-25	02:30	02:34	02:41	1.84	1.02	5.29	solar

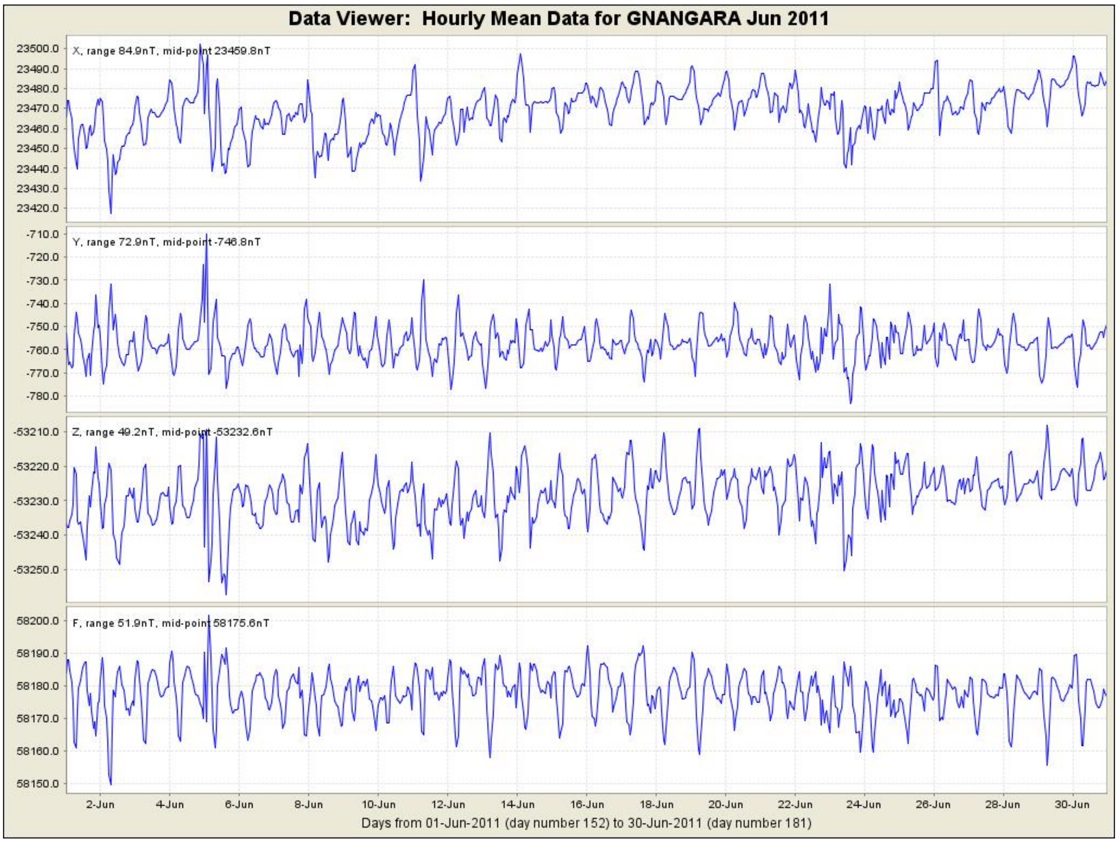

Data Viewer: Hourly Mean Data for GNANGARA Jan 2011
X, range 81.9nT, mid-point 23460.4nT
Y, range 85.9nT, mid-point -763.3nT
Z, range 72.3nT, mid-point -53234.8nT
F, range 69.1nT, mid-point 58177.4nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

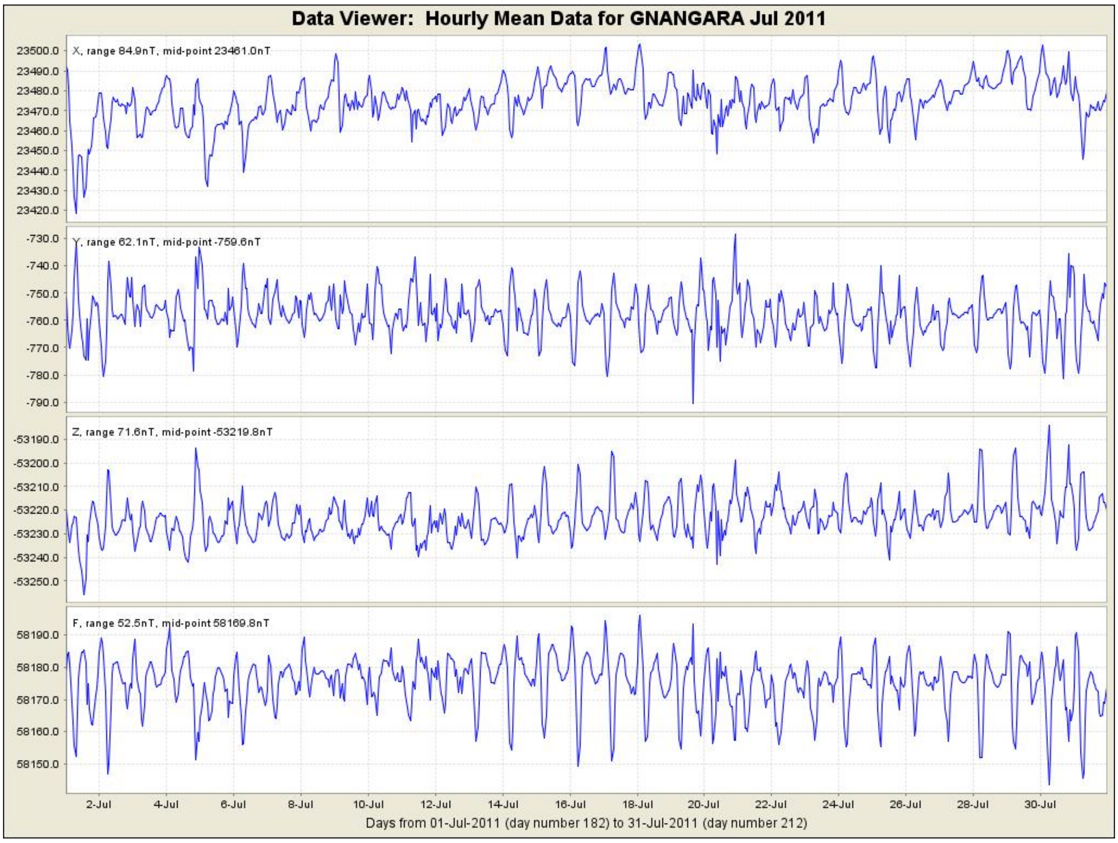

Data Viewer: Hourly Mean Data for GNANGARA Feb 2011
X, range 96.5nT, mid-point 23448.4nT
Y, range 109.0nT, mid-point -751.9nT
Z, range 109.5nT, mid-point -53216.2nT
F, range 92.6nT, mid-point 58166.0nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

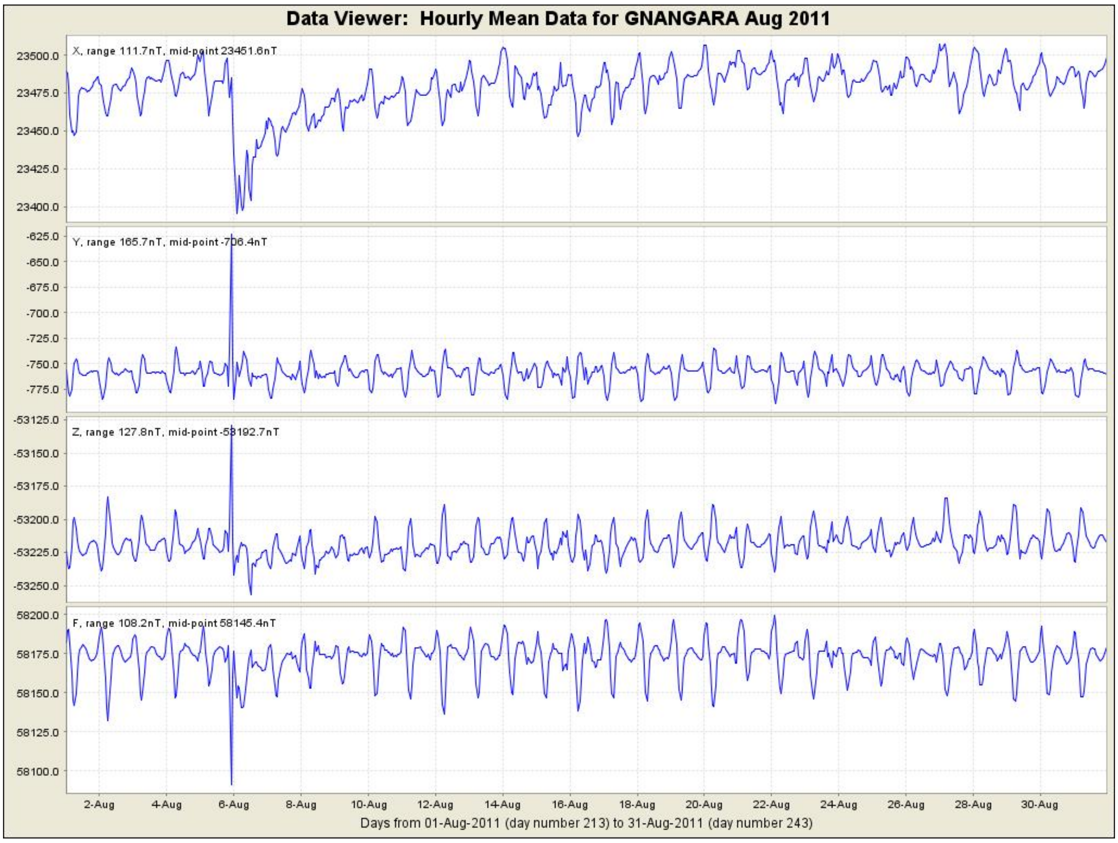

Data Viewer: Hourly Mean Data for GNANGARA Mar 2011
X, range 121.7nT, mid-point 23431.2nT
Y, range 87.0nT, mid-point -761.1nT
Z, range 128.0nT, mid-point -53237.4nT
F, range 98.6nT, mid-point 58164.4nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

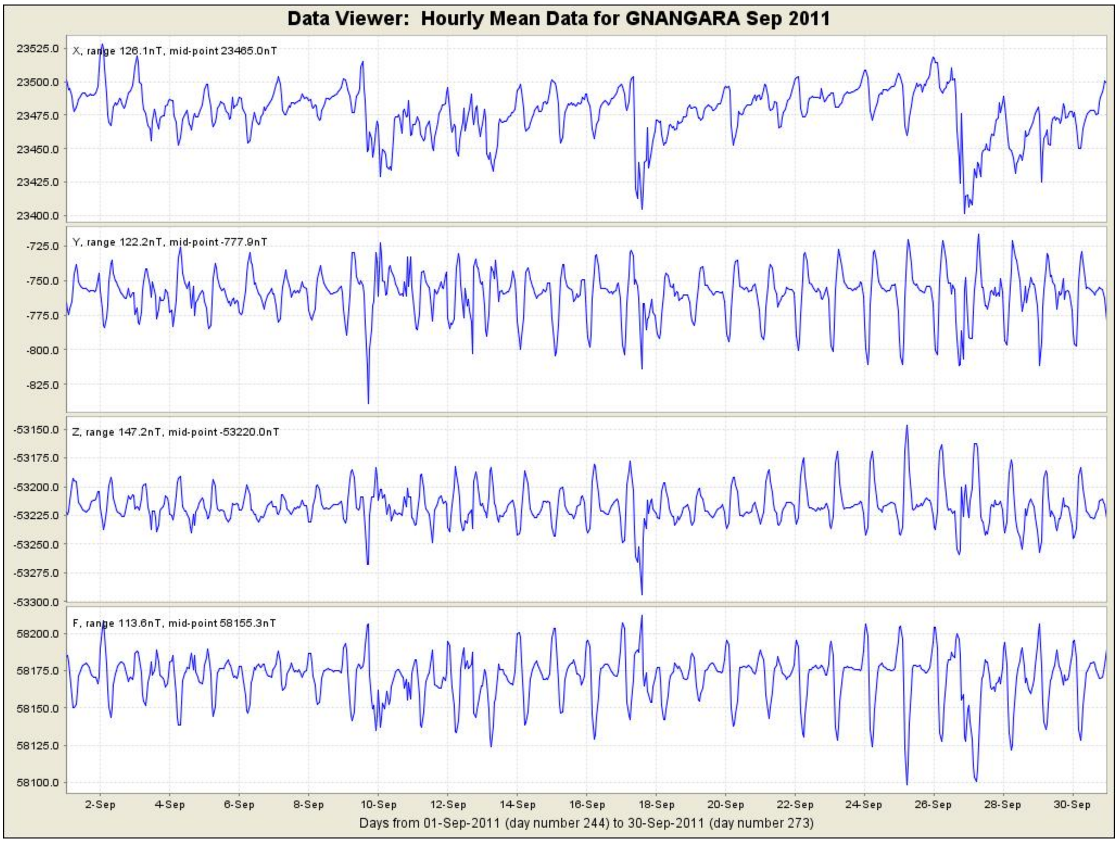

Data Viewer: Hourly Mean Data for GNANGARA Apr 2011
X, range 86.4nT, mid-point 23446.1nT
Y, range 95.7nT, mid-point -761.4nT
Z, range 102.8nT, mid-point -53239.7nT
F, range 81.1nT, mid-point 58176.4nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

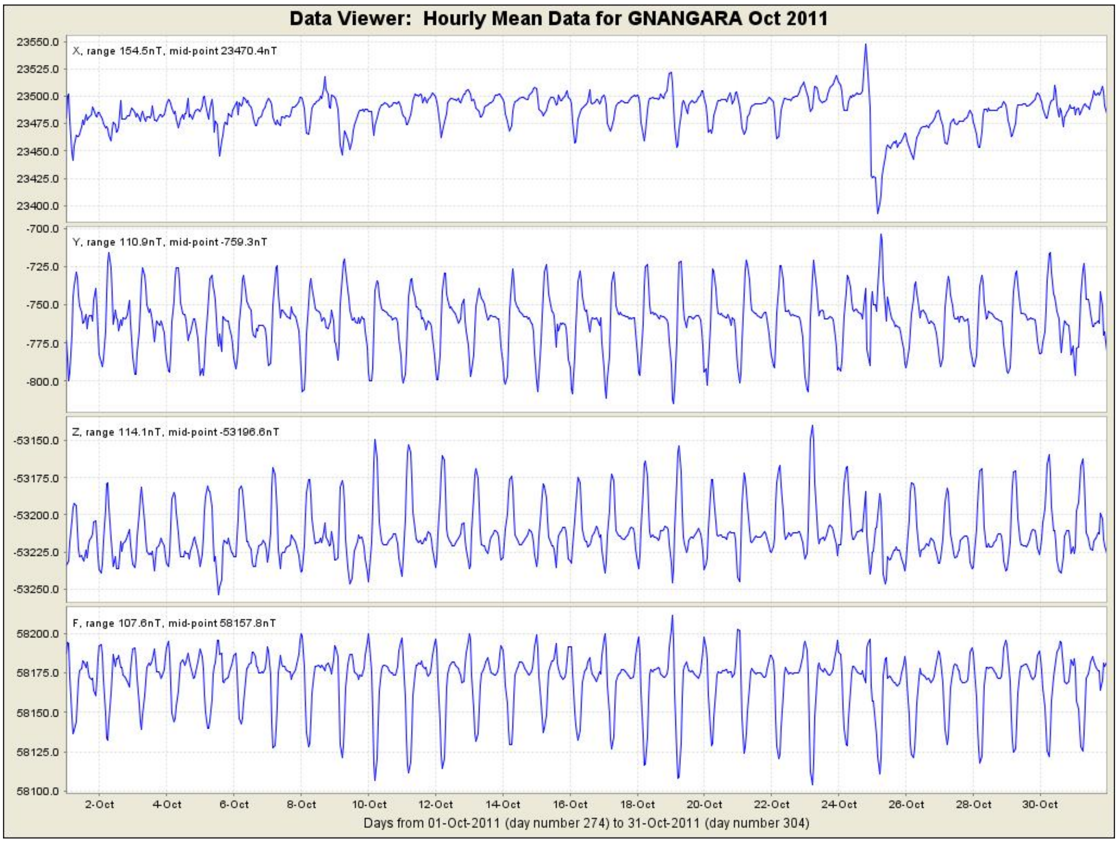

Data Viewer: Hourly Mean Data for GNANGARA May 2011
X, range 143.6nT, mid-point 23424.5nT
Y, range 120.7nT, mid-point -775.4nT
Z, range 116.7nT, mid-point -53263.0nT
F, range 85.6nT, mid-point 58185.0nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)


Data Viewer: Hourly Mean Data for GNANGARA Jun 2011
X, range 84.9nT, mid-point 23459.8nT
Y, range 72.9nT, mid-point -746.8nT
Z, range 49.2nT, mid-point -53232.6nT
F, range 51.9nT, mid-point 58175.6nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for GNANGARA Jul 2011
X, range 84.9nT, mid-point 23461.0nT
Y, range 62.1nT, mid-point -759.6nT
Z, range 71.6nT, mid-point -53219.8nT
F, range 52.5nT, mid-point 58169.8nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for GNANGARA Aug 2011
X, range 111.7nT, mid-point 23451.6nT
Y, range 165.7nT, mid-point -706.4nT
Z, range 127.8nT, mid-point -53192.7nT
F, range 108.2nT, mid-point 58145.4nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for GNANGARA Sep 2011
X, range 126.1nT, mid-point 23465.0nT
Y, range 122.2nT, mid-point -777.9nT
Z, range 147.2nT, mid-point -53220.0nT
F, range 113.6nT, mid-point 58155.3nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for GNANGARA Oct 2011
X, range 154.5nT, mid-point 23470.4nT
Y, range 110.9nT, mid-point -759.3nT
Z, range 114.1nT, mid-point -53196.6nT
F, range 107.6nT, mid-point 58157.8nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)

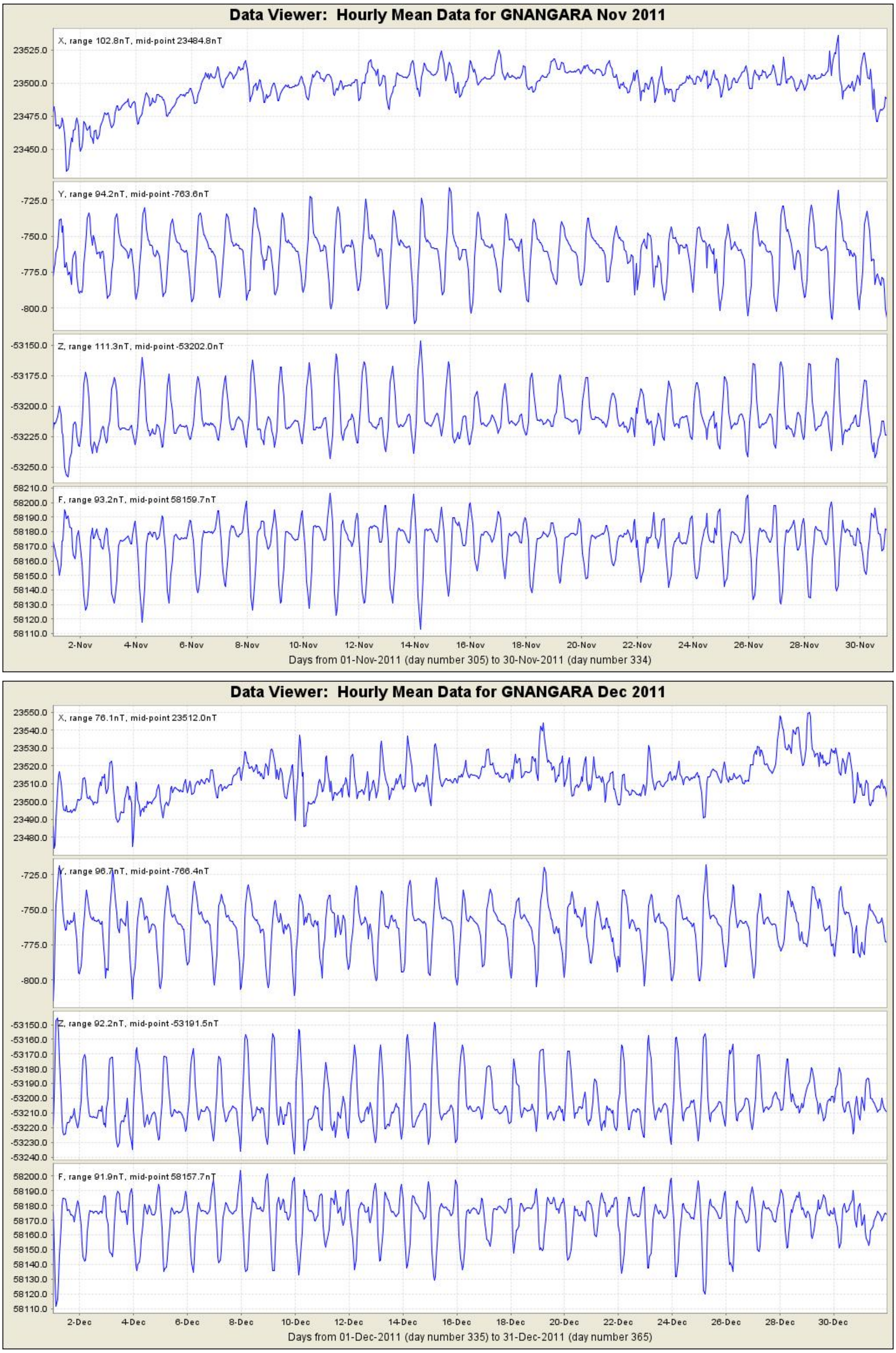


Figure 6.3. *Gnangara 2011 hourly mean values in X, Y, Z and F.*

7. Canberra

The Canberra magnetic observatory is the principal observatory in the Australian geomagnetic observatory network. It is located in the Australian Capital Territory, approximately 30 km to the east of the city of Canberra.

The observatory is on an 8 hectare site and comprises:

- an office building for historical reasons called the “Recorder House”;
- a Variometer House 85 m NW of the Recorder House;
- a Secondary Variometer House some 80 m west of the Recorder House;
- an Absolute House 65 m NE of the Recorder House;
- a Comparison House 12 m west of the Absolute House;
- a sheltered external observation site near the Absolute House;
- four azimuth pillars;
- two tripod stations for azimuth control and external magnetic reference;
- the Geoscience Australia Magnetometer Calibration Facility 120 m SE of the Recorder House;
- a Test House 220 m north of the Recorder House (which now houses Australian Tsunami Warning System (ATWS) equipment);
- an ATWS vault, and;
- a seismic vault.

Variometers

The variometers used during 2011 are described in Table 7.2.

Two 3-component variometer systems operated at the Canberra observatory in 2011.

A Narod ring-core fluxgate operated on a pier in the eastern room of the Variometer House. The room was temperature-stabilised with a globe heater. An Overhauser-effect GSM-90 scalar variometer was housed in the western room of the same building. An acquisition computer in the western room recorded both vector and scalar data; timing was controlled by a Trimble Acutime GPS clock.

A LEMI fluxgate variometer operated on a pier in the Secondary Variometer House. The room was temperature-stabilised with a globe heater. An acquisition computer was located in the same room; timing was controlled by a Garmin GPS clock. The GSM-90 scalar data (accessed across the local area network) from the Narod variometer system were also recorded with LEMI data.

An additional temporary variometer (Narod 200907-2) was installed in the Magnetometer Calibration Facility coils (2011-10-20 to 2011-12-06) during forestry operations (2011-10-18 to 2011-11-01) that corrupted both of the standard variometers.

During 2011, preliminary real-time 3-component variations were supplied to users and data repositories using the time series recorded by the Narod magnetometer. The 2011 definitive

3-component data set for the observatory was also derived from the Narod time series, with gaps in-filled with LEMI data when such data were available, except during the period 2011-10-18 to 2011-11-01. Data corrupted by forestry operations during that period were filled with data from the temporary Narod variometer mentioned above. Weekly, semi-monthly, and monthly K indices and storm reports were scaled from the Narod data.

Table 7.1. *Key observatory data.*

IAGA code:	CNB
Commenced operation:	1978
Geographic latitude:	35° 18' 52.6" S
Geographic longitude:	149° 21' 45.4" E
Geomagnetic latitude:	-42.17°
Geomagnetic longitude:	227.23°
K 9 index lower limit:	450 nT
Principal pier:	Pier AW
Pier elevation (top):	859 m AMSL
Principal reference mark:	NW pillar
Reference mark azimuth:	328° 37' 03"
Reference mark distance:	137.3 m
Observer in charge:	P. Crosthwaite

Table 7.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	Narod (CNB)
Serial number:	9004-2
Type:	ring-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Scale value:	0.025 nT / count
3-component variometer:	LEMI (CN1)
Serial number:	004_A
Type:	linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±5V)
Scale value:	0.05 nT /count
Total-field variometer:	GEM Systems GSM-90
Serial number:	803810 / 81225
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin / Trimble GPS clocks
Communications:	radio link

Table 7.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0086
Theodolite:	Zeiss 020B
Serial number:	353756
Resolution:	0.1’
D correction:	-0.05’
I correction:	-0.15’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	905926 / 21867
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

The weather conditions (as measured at the nearby Canberra Airport weather station) in Canberra were mild. An average day at the peak of summer varied from 16°C to 28°C; an average day at the peak of winter varied from -1°C to 13°C. The average daily range was 14.0°C ±5.0°C (varying from 2.0°C to 25.1°C). The coldest minimum was -8°C and the hottest maximum was 37°C.

The variometer environments were controlled only by a heater, which was generally adequate on cold to mild days. However, on hot days the variometer temperatures were not well controlled. Further, the Narod sensor temperature has not functioned for some years, although it is in the same room as the temperature-monitored electronics, which appeared to vary from 24°C to 25.5°C during the year, except for an excursion up to 27°C for 4 days in late January/early February. The most erratic temperatures were in January/February; the most stable temperatures were from May to October. The LEMI variometer temperatures were less well controlled, the electronics varying by 11°C, with particularly large variations during January and February, and reasonable stability during May to October.

The periods of greatest temperature stability seem to coincide with the periods of greatest baseline stability, as in previous years. Inadequate temperature control is one of the major influences on data quality.

Data from the Narod magnetometer during the periods 2011-03-30T01:36 to 2011-03-30T05:50 and 2011-05-12T23:05 to 2011-05-13T05:40 were either lost or corrupted by large temperature related effects after scheduled power outages to the observatory. Data from the LEMI variometer were used during this period. The two data sets were matched at the start of the periods.

Forestry operations during the period 2011-10-18 to 2011-11-01 at times corrupted the magnetic environment on the western side of the observatory grounds where both Narod and LEMI variometers are located. A temporary Narod variometer was installed and calibrated in the Australian Magnetometer Calibration Facility coils from 2011-10-20 to 2011-12-06. Corrupted Narod data during the period of forestry operations were deleted and filled with data from this temporary variometer.

Maintenance inspections by ATIVO corrupted data on both variometers 2011-06-29T23:35 to 2011-06-29T23:38.

Narod 1-second data required de-spiking. The de-spiking parameters required a spike to exceed 0.25 nT and 7 times the average “spike-factor” of the following minute of data. Typically 40 to 80 seconds of data per day were rejected (average rejection rate was 60 seconds/day). However, up to 446 seconds per day were rejected on days when there were thunderstorms.

LEMI data required little de-spiking except on days when there were thunderstorms. The same de-spiking was applied to LEMI data as for Narod data. On 211 days, no data were rejected. On average only 10 seconds per day were rejected, mostly on the same (thunderstorm) days when there were high rejection rates on the Narod data.

De-spiking provided no visible benefit to GSM-90 data and no de-spiking was applied to it.

Variometer data timing

Time stamps applied to the primary (Narod) variometer data were obtained from the acquisition computer system clock. That clock was synchronised to a GPS clock. During 2011, adjustments to the system clock were less than 1 ms except on the following occasions:

2011-02-20 16:04:33 -0.002

2011-03-30 04:45:36 +1.050
Soon after system restart following prolonged power failure

2011-05-13 04:19:25 +0.935
Soon after system restart following scheduled power outage for electricity authority maintenance

2011-10-10 13:17:13 -0.001

2011-12-16 18:27:17 +0.001

Time stamps were applied in the same manner to the backup (LEMI) variometer data from an independent acquisition computer system clock. That clock was synchronised to a GPS clock. During 2011, adjustments to that system clock were less than 1 ms except on the following occasions:

2011-02-02 01:21:06 +0.736
Shutdown to system to correct GPS clock problem

2011-02-08 22:22:42 +0.034
Shutdown to system to correct GPS clock problem

2011-10-10 23:32:00 +0.436
Shutdown to system to correct GPS clock problem

Absolute instruments

The principal absolute magnetometers used at Canberra and their adopted corrections for 2011 are described in Table 7.3. The absolute instruments used at Canberra also served as the Australian observatory reference instruments.

The instrument corrections given in Table 7.3 for DIM DI0086/353756 were obtained from comparisons against the travelling reference, B0610H/160459, at Canberra observatory on 30 July 2008. International comparison via a travelling reference PPM to other nations' PPMs and frequency standards results in the correction adopted for GSM-90 905926/21867.

At the 2011 mean magnetic field values at Canberra (X=23181 nT, Y=5147 nT, Z= 53015 nT) these D, I and F corrections translate to corrections of:

ΔX = -2.2 nT ΔY = -0.8 nT ΔZ = -1.0 nT

These corrections have been applied to Canberra 2011 final data.

The absolute instrument parameters (e.g. fluxgate sensor alignment) showed no unusual pattern during 2011.

Baselines

An automated procedure that fits a piecewise linear spline curve to the baseline residuals was used to derive final baseline parameters for the variometers. The adopted baselines had a range of 10 nT, 7 nT and 3 nT in X, Y and Z during 2011.

With drift corrections applied, the standard deviations in the difference of absolute observations from the final variometer model were:

	σ
X	0.3 nT
Y	0.9 nT
Z	1.0 nT
D	9"
I	3"
F	0.4 nT

These data are based on 111 observations, comprising mostly weekly pairs of observations.

With drift corrections applied, there was a 0.8 nT range and 0.2 nT standard deviation in the daily-average FCheck throughout the year and a 1.3 nT range and 0.2nT standard deviation in the hourly-average FCheck throughout the year.

Observed and adopted baseline values in X, Y and Z for 2011 are shown in Figure 7.1.

For comparison, the corresponding standard deviations for the LEMI variometer were:

	σ
X	0.3 nT
Y	0.9 nT
Z	1.1 nT
D	9"
I	3"
F	0.5 nT

Variometer comparison

The definitive Canberra data (99.62% primary Narod variometer, 0.25% temporary Narod variometer, and 0.12% LEMI variometer) were compared to the LEMI variometer data. Both Narod and LEMI data sets were aligned using the same methodology using the one set of absolute observations and used to create INTERMAGNET Archive Format binary files which were compared.

The annual statistics of the 525546 available minute-differences of the two data sets (Narod – LEMI) were:

	X	Y	Z
Average	-0.3	+0.5	+0.1
Std.dev	+0.8	+0.9	+0.3
Min	-6.1	-3.5	-19.5
Max	+25.8	+16.4	+60.5

The annual statistics of the 365 daily averages of the difference between the two 1-minute data sets (Narod – LEMI) were:

	X	Y	Z
Average	-0.3	+0.5	+0.1
Std.dev	+0.7	+0.8	+0.3
Min	-4.1	-1.7	-1.3
Max	+1.5	+3.9	+0.7

The annual statistics of the 12 monthly averages of the difference between the two 1-minute data sets (Narod – LEMI) were:

	X	Y	Z
Average	-0.3	+0.5	+0.1
Std.dev	+0.3	+0.3	+0.1
Min	-0.7	-0.1	-0.1
Max	+0.2	+1.2	+0.2

Real-time data comparison

The annual statistics of the 12 monthly averages of the difference between the CNB definitive data and real time reported 1-minute data sets (CNB definitive – CNB real time) were:

	X	Y	Z
Average	-0.2	-0.0	+0.0
Std.dev	+5.6	+1.4	+0.9
Min	-8.9	-2.9	-1.3
Max	+7.5	+2.6	+1.6

The CNB 2011 reported real time data is not within the specification for INTERMAGNET Quasi-definitive data. (The X monthly averages differ by more than 5 nT from the definitive data.)

Operations

Weekly absolute observations were performed by staff of the Geomagnetism Project. Other duties included computer assisted hand scaling of K indices and monitoring database and data-delivery programs.

Data from the Narod, LEMI and GSM-90 variometers were acquired on a computer at the observatory and were automatically retrieved to Geoscience Australia via a radio link every 3 to 6 minutes.

Habits varied between the 5 team members who carried out the weekly calibrations. Some left the equipment transportation boxes (somewhat magnetic) at the Recorder House (65 m from the absolute pier), some in the Comparison House, and some half way between.

The distribution of Canberra 2011 data is described in Table 7.4. Data losses are identified in Table A.6.

Table 7.4. *Distribution of Canberra 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
WDC for Geomagnetism	preliminary	real time
ISGI, France	preliminary	real time
ISGI, France	preliminary	daily
GeoForschungsZentrum, Germany	preliminary	3-hourly
University of Oulu, Finland	preliminary	hourly
K indices		
IPS Radio and Space Services		weekly
University of Newcastle		weekly
British Geological Survey		weekly
CLS, CNES, France		weekly
ISGI, France		weekly
Royal Observatory of Belgium		weekly
GeoForschungsZentrum, Germany		semi-monthly
Principal magnetic storms and rapid variations		
WDC for Solar-Terrestrial Physics		monthly
WDC for Geomagnetism		monthly
Observatori de l'Ebre, Spain		monthly

Significant events

2011-01-06 CN1 data: PPM data time jump 10:05: Fluxgate data jumps 10:06:30 - 10:07:00

2011-01-22 CN1 data: PPM data time jump 05:03: Fluxgate data jumps 05:06:00 - 05:06:30
CN1 data: PPM data time jump 05:33: Fluxgate data jumps 05:36:00 - 05:36:30

2011-01-26 CN1 data: 08:26 FCheck jump, mostly Z channel. Reason unknown

2011-01-27 CNB data file 23:38 AML and WVJ entered CNB variometer hut-training session.

2011-01-27 CN1 data file 23:34 to 23:35.30 AML and WVJ entered CN1 variometer hut-training session.

2011-02-01 08:25 electronics temperature over-ranged >32000. Appears as a baseline jump in XYZ. Can be fixed with a temperature BL change, but will revert if CN1 Adam driver restarts after the temperature cools down again.
01/02/11 22:15:01 - CLK W 0 Lost contact with Gm16 RESET

2011-02-02 No noticeable difference to 1194 time and pips slay and restart GdapClock 02/02/11 01:11:34 - CLK I 0 Started, no fix shutdown at 01:19+
02/02/11 01:20:06 - mag I 0 Started
02/02/11 01:21:06 - CLK I 0 Correction 1296609666 774608809 C 0 s 735638871 R 0 s 3454
02/02/11 01:21:48 - CLK I 0 Correction 1296609708 774305919 C 0 s 61865 R 0 s 3324

2011-02-06 19:45 lost contact with GPS clock on CN1 system

2011-02-08 22:02 stop and restart GdapClock on CN1 system, no improvement
22:21 shutdown and restart CN1 system ** caused temperature channel range jump!
08/02/11 22:21:42 - mag I 0 Started
08/02/11 22:21:42 - MachR I 0 Started08/02/11 22:22:42 - CLK I 0 Correction 1297203762 72221331 C 0 s 34394361 R 0 s 1811

2011-02-15 Approx UT 00:15 Forestry dual cab Hilux passed along track to west of Observatory.

2011-03-06 Corrupted data on CN1 - may correspond to planned power disruption (see PDF file). Although this might account for duplicated F readings, the step jump in X and Z (with NO jump in Y it seems, or auxiliary channels) is perplexing.

2011-03-03,08 Hole cut in top gate sometime during this week.

2011-03-19 Mountain bike event scheduled to go past observatory

2011-04-09,10 24 hour mountain bike race goes past SE corner of observatory

2011-03-17 Day 076 Comparison of 3 GSM_90 to CNB standard added to yearly data.

2011-03-29 Day 087 check first set NU, SD readings. There is 4 minutes difference between the 2 sets and so 1 set has high X2 measurement.

2011-03-29 22:06 (approx) Mains power off. This is a scheduled Country Energy outage 9-3LT. No data telemetry
22:06 CN1 baseline jump
2011-03-30 04:32 system restarted.
CNB Backup power (UPS) lasted 3.5 hours
CNB data loss 01:37 - 04:32 (in the one minute database, the gap was filled with the CN1 data)
CN1 backup power (battery box) did not fail
CN1 no data loss
04:32 CN1 baseline jump

2011-04-05 1st set of obs large difference in X, smaller in Y, Z is good. Review this obs with view to removing. WVJ

2011-04-27 02:49 reboot MAGCALD as no PPM data and no GPS. GPS restarted but PPM did not.

2011-04-27 Second DIM reading is suspect. I changed the SU from 102 34.0' to 102 37.0' to make the X2 better. It may be better to remove this reading altogether.

2011-05-12 Maintenance to power lines into observatory. power probably off at 23:03, telemetry also stops.

2011-05-13	Power back on at 04:05:17, No CN1 data loss, but there is a baseline jump when power re-started. There was data loss from CNB system.
2011-05-17	WVJ using wipper-snipper along paths and around buildings at the observatory.
2011-05-19	04:10:32 road building blast on new section of Kings Highway, no signal on LEMI
2011-06-21	ATIVO possibly visit observatory for maintenance (without any prior arrangements) not sure if this occurred.
2011-06-28	Unable to acquire 2nd set of PPM readings. Cause to be tracked down. WVJ
2011-06-29	23:34 ATIVO visit observatory and cause data corruption on both CNB and CN1 system
2011-07-10	04:52 WVJ + 2 guest in cn1 for 4 minutes.
2011-07-11	05:00 - 07:00 **INTERMAGNET visit**, (approx 28 people)
2011-07-12	06:40 sun-geomag reboot and upgrade
2011-07-26	2nd CNB DIM obs commented out. Travel DIM commented out of obs as well, WVJ 1st attempt at using this DIM.
2011-08-02	LW discovered the army had set up camp at CNB. Captain (see info file) said they set up last Saturday, intend to stay to next Saturday. Clearance had been obtained.! RMC Duntroon contact (see info file). They will move camp no later than this afternoon and will investigate the approval procedure.
2011-08-16	Baseline shift in cn1 by approx 40nT.
2011-08-30	2 vehicles passing by on eastern side of boundary at approx 01:30 UT Comparison of DIM B0702H was not very good so commented out. For std instrument 1st reading SU and SD swapped around at start of lines to fix input error. X2 now is very low. Review this obs as it is questionable.
2011-09-19	17:24 CN1 backward time jump
2011-10-09	02:35:01 Lost Contact with clock CN1
2011-10-10	23:19:34 restarted GdapClock, again at 23:26 along with devc-ser8250 for ser2 only Confirmed no significant time error using 1194 and pips at GA. shutdown CN1 at 23:30:30 10/10/11 23:32:00 - CLK I 0 Correction 1318289520 478792286 C 0 s 436214683 R 0 s 675 10/10/11 23:32:42 - CLK I 0 Correction 1318289562 479375423 C 0 s 9462 R 0 s 619
2011-10-18	04:20:25 cnb, 04:20:42 cn1, spike in all channels, suspect forestry vehicle moving to the west of the observatory travelling north to south.
2011-10-20	NGL variometer installed in MAGCAL as temporary backup variometer during forestry operations (h11*.ngl)
2011-10-25	X in 2nd obs suspect, possibly remove from data. 1 sec DIM commented out, not quiet right. Forestry vehicle working on western fenceline 23:30-00:00 approximately. heater in electronics box in MagCal swithched on at 23:50 and turned off at 00:15.
2011-11-01	00:57 Forestry landcruiser travels south to north along western perimeter road,
2011-12-06	~03 onwards Telstra truck, ute and digger working near front gate to repair telephone cable. Appears to be FCheck shift during those several hours on CN1

Annual mean values

The annual mean values for Canberra are set out in Table 7.5 and displayed with the secular variation in Figure 7.2.

Hourly mean values

Plots of the hourly mean values for Canberra 2011 data are shown in Figure 7.3.

K indices

K indices for Canberra have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. Canberra K indices contribute to the global Kp and aa indices, the southern hemisphere Ks index, and all their derivatives. K indices measured in 2011 are listed in Table 7.6. The frequency distribution of the K indices and the annual mean daily K sum are given in Table 7.7. Principal magnetic storms observed at Canberra are listed in Table 7.8, storm sudden commencements in Table 7.9 and solar flare effects Table 7.10.

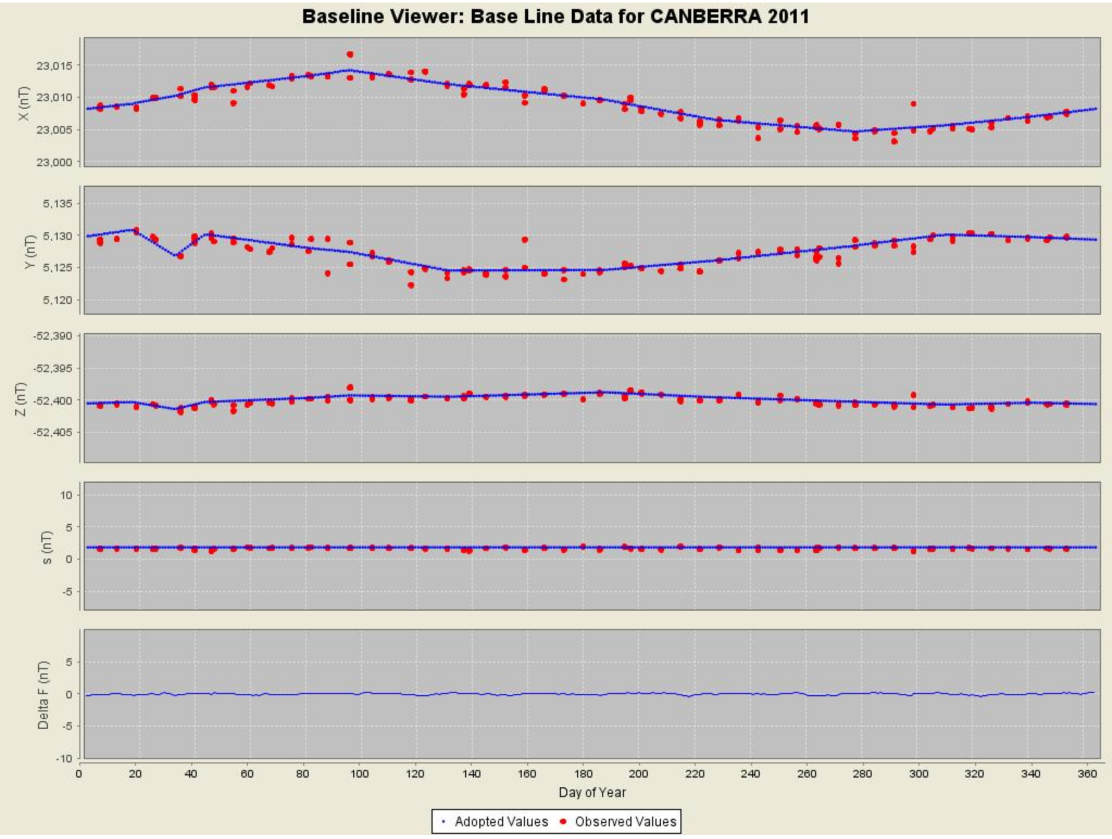


Figure 7.1. *Canberra 2011 baseline plots.*

Table 7.5. *Canberra annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 7.2.*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1979.5	A	12	05.6	-66	05.9	23833	23305	4993	-53778	58822	DFI
1980.5	A	12	08.6	-66	06.9	23808	23275	5009	-53767	58801	DFI
1981.5	A	12	11.2	-66	09.1	23770	23234	5018	-53771	58791	DFI

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1982.5	A	12	14.0	-66	10.8	23736	23197	5030	-53769	58775	DFI
1983.5	A	12	16.6	-66	11.3	23723	23180	5044	-53756	58758	DFI
1984.5	A	12	18.4	-66	11.7	23709	23164	5054	-53741	58739	DFI
1985.5	A	12	20.7	-66	11.6	23703	23155	5067	-53726	58723	DFI
1986.5	A	12	23.2	-66	12.1	23689	23137	5081	-53716	58707	DFI
1987.5	A	12	25.5	-66	12.0	23684	23129	5096	-53699	58690	DFI
1988.5	A	12	27.6	-66	12.8	23665	23107	5106	-53690	58674	DFI
1989.5	A	12	29.0	-66	13.8	23644	23085	5111	-53683	58659	DFI
1990.5	A	12	30.7	-66	13.6	23641	23079	5121	-53667	58643	DFI
1991.5	A	12	31.8	-66	13.9	23628	23066	5126	-53652	58624	DFI
1992.5	A	12	32.4	-66	12.8	23637	23073	5132	-53625	58603	DFI
1993.5	A	12	33.0	-66	11.6	23646	23081	5138	-53597	58581	DFI
1994.5	A	12	33.5	-66	10.8	23649	23083	5142	-53571	58559	DFI
1995.5	A	12	33.8	-66	09.2	23665	23098	5148	-53540	58537	DFI
1996.5	A	12	34.2	-66	07.4	23684	23116	5154	-53507	58514	ABZ
1997.5	A	12	34.2	-66	06.1	23695	23127	5157	-53476	58491	ABZ
1998.5	A	12	34.2	-66	05.2	23698	23130	5157	-53444	58463	ABZ
1999.5	A	12	34.1	-66	03.7	23709	23140	5159	-53403	58429	ABZ
2000.5	A	12	34.2	-66	02.9	23708	23139	5160	-53367	58396	ABZ
2001.5	A	12	34.7	-66	01.5	23716	23146	5164	-53327	58362	ABZ
2002.5	A	12	35.1	-66	00.5	23718	23148	5168	-53291	58331	ABZ
2003.5	A	12	35.5	-66	00.3	23710	23139	5169	-53264	58303	ABZ
2004.5	A	12	35.5	-65	58.8	23719	23149	5171	-53225	58271	ABZ
2005.5	A	12	35.2	-65	57.9	23720	23150	5169	-53190	58240	ABZ
2006.5	A	12	34.5	-65	56.5	23729	23160	5166	-53151	58207	ABZ
2007.5	A	12	34.0	-65	55.5	23732	23164	5164	-53118	58179	ABZ
2008.5	A	12	33.5	-65	54.7	23735	23167	5161	-53088	58152	ABZ
2009.5	A	12	32.8	-65	53.4	23744	23177	5158	-53057	58128	ABZ
2010.5	A	12	32.1	-65	52.9	23744	23178	5153	-53035	58107	ABZ
2011.5	A	12	31.2	-65	52.3	23745	23181	5147	-53015	58089	ABZ
1979.5	Q	12	05.5	-66	05.3	23844	23315	4995	-53775	58824	DFI
1980.5	Q	12	08.6	-66	06.8	23813	23280	5010	-53769	58806	DFI
1981.5	Q	12	11.4	-66	08.3	23783	23246	5022	-53767	58792	DFI
1982.5	Q	12	14.1	-66	10.1	23749	23210	5033	-53766	58778	DFI
1983.5	Q	12	16.5	-66	10.7	23734	23191	5046	-53753	58760	DFI
1984.5	Q	12	18.5	-66	11.1	23719	23174	5056	-53739	58741	DFI
1985.5	Q	12	20.7	-66	11.1	23713	23164	5070	-53724	58724	DFI

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1986.5	Q	12	23.2	-66	11.6	23697	23146	5083	-53714	58709	DFI
1987.5	Q	12	25.5	-66	11.6	23690	23136	5097	-53698	58691	DFI
1988.5	Q	12	27.7	-66	12.2	23675	23118	5109	-53687	58676	DFI
1989.5	Q	12	29.1	-66	13.0	23657	23098	5114	-53680	58662	DFI
1990.5	Q	12	30.8	-66	12.8	23653	23092	5125	-53663	58645	DFI
1991.5	Q	12	31.8	-66	12.9	23645	23082	5130	-53647	58627	DFI
1992.5	Q	12	32.5	-66	12.1	23649	23085	5135	-53622	58605	DFI
1993.5	Q	12	33.0	-66	11.1	23655	23090	5140	-53594	58583	DFI
1994.5	Q	12	33.6	-66	10.2	23661	23095	5145	-53568	58561	DFI
1995.5	Q	12	33.9	-66	08.7	23675	23108	5150	-53537	58538	DFI
1996.5	Q	12	34.2	-66	07.2	23689	23121	5155	-53506	58515	ABZ
1997.5	Q	12	34.2	-66	05.6	23703	23135	5159	-53474	58492	ABZ
1998.5	Q	12	34.3	-66	04.8	23706	23137	5159	-53443	58464	ABZ
1999.5	Q	12	34.1	-66	03.2	23716	23148	5161	-53400	58430	ABZ
2000.5	Q	12	34.3	-66	02.2	23718	23149	5162	-53365	58398	ABZ
2001.5	Q	12	34.7	-66	00.9	23726	23156	5167	-53324	58364	ABZ
2002.5	Q	12	35.1	-65	59.8	23730	23159	5171	-53289	58334	ABZ
2003.5	Q	12	35.6	-65	59.5	23723	23152	5172	-53261	58306	ABZ
2004.5	Q	12	35.5	-65	58.3	23728	23157	5173	-53223	58273	ABZ
2005.5	Q	12	35.2	-65	57.4	23730	23159	5171	-53188	58242	ABZ
2006.5	Q	12	34.5	-65	56.1	23736	23166	5167	-53149	58208	ABZ
2007.5	Q	12	34.0	-65	55.3	23737	23168	5165	-53117	58180	ABZ
2008.5	Q	12	33.5	-65	54.4	23739	23171	5162	-53087	58153	ABZ
2009.5	Q	12	32.8	-65	53.3	23746	23179	5159	-53056	58128	ABZ
2010.5	Q	12	32.1	-65	52.6	23749	23183	5154	-53034	58108	ABZ
2011.5	Q	12	31.2	-65	52.0	23751	23186	5148	-53013	58090	ABZ
1979.5	D	12	05.6	-66	06.9	23816	23287	4990	-53782	58819	DFI
1980.5	D	12	08.4	-66	07.8	23792	23260	5004	-53770	58798	DFI
1981.5	D	12	11.1	-66	10.3	23750	23215	5013	-53776	58787	DFI
1982.5	D	12	13.7	-66	12.4	23710	23172	5022	-53773	58769	DFI
1983.5	D	12	16.6	-66	12.3	23706	23163	5040	-53760	58754	DFI
1984.5	D	12	18.4	-66	12.7	23691	23146	5049	-53745	58735	DFI
1985.5	D	12	20.5	-66	12.4	23690	23142	5064	-53729	58719	DFI
1986.5	D	12	23.3	-66	12.9	23675	23123	5079	-53717	58703	DFI
1987.5	D	12	25.5	-66	12.6	23674	23120	5094	-53701	58688	DFI
1988.5	D	12	27.5	-66	13.8	23647	23091	5102	-53693	58670	DFI
1989.5	D	12	29.0	-66	15.5	23615	23057	5105	-53690	58654	DFI

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1990.5	D	12	30.5	-66	14.8	23619	23059	5116	-53671	58639	DFI
1991.5	D	12	31.6	-66	15.5	23600	23038	5119	-53658	58618	DFI
1992.5	D	12	32.3	-66	14.1	23615	23052	5127	-53630	58600	DFI
1993.5	D	12	33.0	-66	12.7	23628	23064	5134	-53601	58578	DFI
1994.5	D	12	33.4	-66	11.8	23633	23068	5138	-53574	58555	DFI
1995.5	D	12	33.8	-66	10.0	23652	23086	5145	-53542	58533	DFI
1996.5	D	12	34.2	-66	07.9	23676	23108	5152	-53508	58512	ABZ
1997.5	D	12	34.1	-66	06.9	23683	23115	5154	-53479	58488	ABZ
1998.5	D	12	34.2	-66	06.4	23678	23110	5153	-53450	58459	ABZ
1999.5	D	12	34.1	-66	04.6	23692	23124	5156	-53407	58427	ABZ
2000.5	D	12	34.2	-66	04.2	23685	23117	5155	-53372	58392	ABZ
2001.5	D	12	34.6	-66	02.7	23695	23126	5159	-53331	58358	ABZ
2002.5	D	12	35.2	-66	01.6	23700	23130	5165	-53296	58328	ABZ
2003.5	D	12	35.4	-66	01.5	23688	23118	5163	-53266	58295	ABZ
2004.5	D	12	35.3	-65	59.8	23702	23132	5166	-53229	58267	ABZ
2005.5	D	12	35.2	-65	58.9	23704	23135	5165	-53194	58236	ABZ
2006.5	D	12	34.6	-65	57.2	23717	23148	5164	-53153	58204	ABZ
2007.5	D	12	34.1	-65	55.9	23725	23157	5162	-53119	58177	ABZ
2008.5	D	12	33.6	-65	55.1	23728	23160	5160	-53089	58151	ABZ
2009.5	D	12	32.8	-65	53.7	23740	23173	5157	-53058	58127	ABZ
2010.5	D	12	32.1	-65	53.4	23736	23170	5151	-53036	58105	ABZ
2011.5	D	12	31.1	-65	52.9	23735	23171	5145	-53017	58087	ABZ

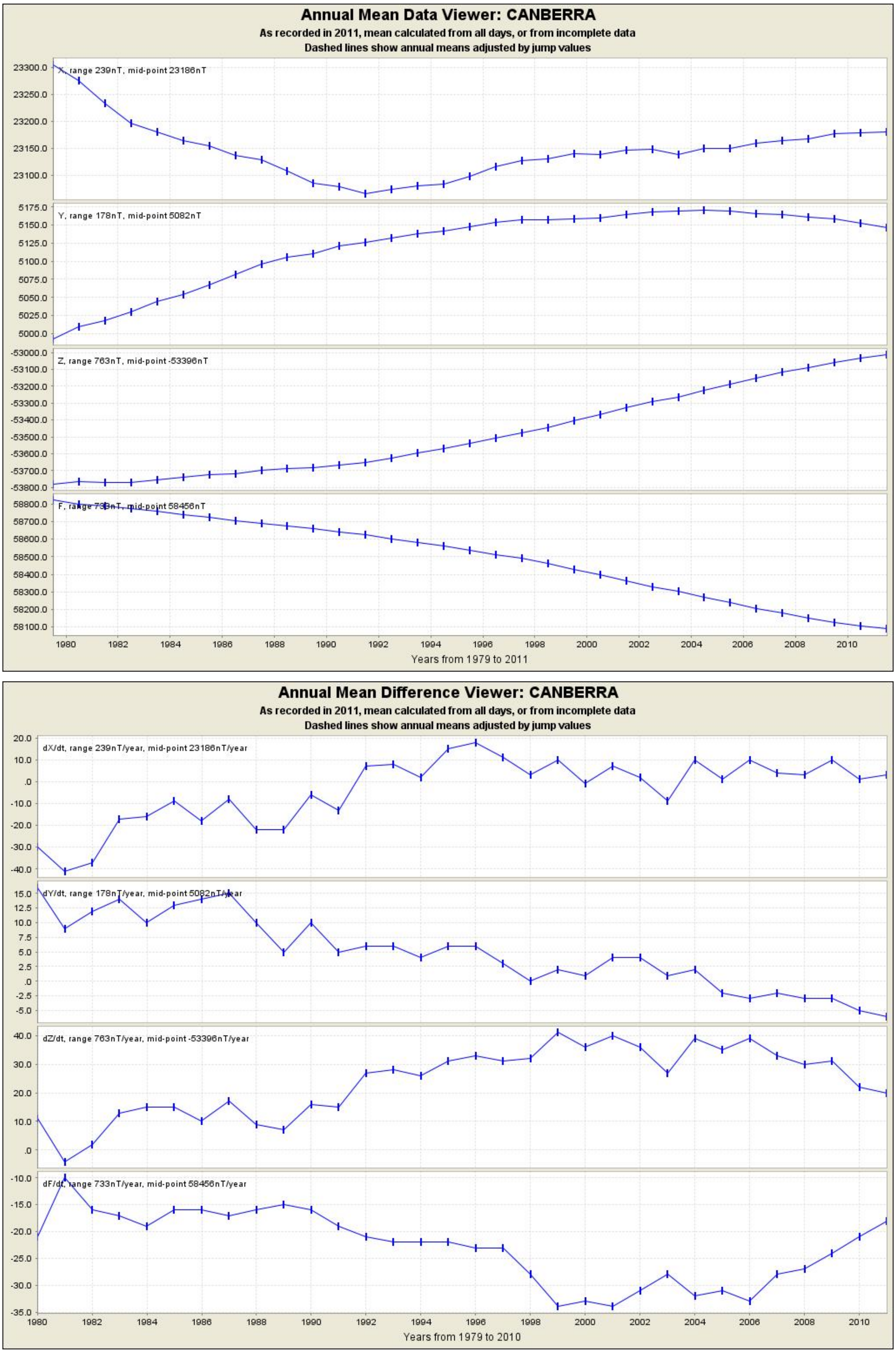


Figure 7.2. *Canberra annual mean values and secular variation (all days) for X, Y, Z and F.*

Table 7.6. *Canberra 2011 K indices and daily K sums.*

Day	January			February			March			April			May			June		
01	1212	2111	11	3342	1332	21	2334	4543	28	0123	2333	17	4334	4322	25	2131	2313	16
02	1222	1222	14	2112	2210	11	3332	3432	23	3234	3123	21	3344	3332	25	2233	2110	14
03	0202	2222	12	0010	0000	1	2242	3323	21	3334	3232	23	2323	3321	19	1111	0000	4
04	2322	2211	15	2233	2245	23	1323	3333	21	1222	1200	10	1122	1310	11	0000	0034	7
05	0011	2111	7	3333	2322	21	1201	2111	9	2212	0012	10	1111	2120	9	5443	2321	24
06	1110	0214	10	1233	3311	17	1211	3322	15	3214	4432	23	0002	0001	3	1122	1110	9
07	4232	3222	20	0100	1201	5	1223	3232	18	2110	0000	4	0000	2311	7	0001	1233	10
08	2223	3221	17	1201	0001	5	1221	2211	12	1112	3233	16	0000	1000	1	2322	3212	17
09	1211	1213	12	0101	1100	4	1021	1123	11	1222	1100	9	0000	1100	2	2222	3221	16
10	2122	2111	12	0222	2011	10	1155	4333	25	0000	2200	4	1033	3321	16	2023	2112	13
11	0111	2331	12	1111	0132	10	3233	3444	26	1011	2221	10	1211	1110	8	1233	3110	14
12	1222	2122	14	1221	1110	9	3222	2122	16	2244	4312	22	0000	0000	0	0113	3210	11
13	1211	2323	15	1010	1001	4	0112	2331	13	1233	3101	14	0000	1100	2	0112	2211	10
14	2232	2312	17	0110	1344	14	1221	0001	7	1210	0000	4	0000	0101	2	1123	1001	9
15	1221	2211	12	2224	3212	18	1100	0000	2	0101	1100	4	1122	1211	11	1122	3101	11
16	1211	3311	13	1111	0000	4	0010	0000	1	0211	0100	5	2133	4122	18	0000	1300	4
17	1221	1102	10	1100	1121	7	1210	1122	10	0002	2200	6	1133	2211	14	3211	2210	12
18	2121	1112	11	3654	2321	26	1010	0000	2	0133	3301	14	1010	2110	6	0110	0000	2
19	2223	2212	16	1011	2211	9	1112	3100	9	0111	0101	5	0022	1100	6	0001	1000	2
20	1113	2110	10	1133	3332	19	1201	3222	13	3432	2100	15	0000	0000	0	1221	1011	9
21	0110	2201	7	2213	3221	16	1110	0212	8	0111	0101	5	0000	0122	5	1221	3221	14
22	1110	2110	7	1101	1100	5	2212	2101	11	1222	2100	10	1110	1100	5	2223	2331	18
23	1101	1100	5	0021	1000	4	2232	2332	19	2112	1100	8	0101	2000	4	2324	4332	23
24	0132	1221	12	0210	0000	3	0002	1100	4	1101	1312	10	0101	2210	7	2123	3322	18
25	2112	2101	10	0101	1000	3	0011	3101	7	1100	0100	3	1000	0000	1	1113	1221	12
26	1110	1120	7	0111	1111	7	0000	0000	0	0011	0000	2	1000	1311	7	2401	2111	12
27	0021	1011	6	1001	1100	4	0000	0012	3	0000	0100	1	0222	3342	18	0002	1001	4
28	1101	1322	11	1211	0011	7	0001	2010	4	0000	0120	3	3166	6312	28	1100	0000	2
29	1111	2200	8				0000	0202	4	0211	1224	13	3555	3442	31	0000	0000	0
30	0221	0001	6				3211	1001	9	4235	4233	26	2114	3111	14	0100	0020	3
31	1222	1332	16				0102	1000	4				2133	3322	19			

Day	July			August			September			October			November			December		
01	2143	3310	17	2221	1001	9	0100	0000	1	3323	3132	20	2235	2432	23	2113	2111	12
02	0001	1121	6	1111	0000	4	0002	2001	5	2233	2412	19	1214	3211	15	2011	1223	12
03	2110	1010	6	0100	0000	1	2323	2301	16	0122	2211	11	1100	0111	5	2143	1222	17
04	0122	2243	16	0200	1002	5	2320	3311	15	0023	2311	12	0001	2001	4	1222	2100	10
05	1222	0121	11	2100	0246	15	1001	2231	10	0234	5423	23	0110	1000	3	0000	1101	3
06	1331	1111	12	5434	4312	26	1132	2211	13	2312	3322	18	0101	2212	9	0000	1100	2
07	1012	1221	10	2110	1120	8	1002	2001	6	2222	0111	11	0121	1312	11	0000	0001	1
08	0122	1211	10	0213	4111	13	0100	0000	1	0111	1322	11	2231	3200	13	1001	2100	5
09	1312	1322	15	2332	1011	13	0101	5454	20	3223	3212	18	0011	0000	2	0122	2112	11
10	1222	1211	12	1132	2110	11	4344	2333	26	1210	0100	5	1000	0111	4	2343	1132	19
11	1144	3222	19	0111	1001	5	2211	4213	16	0011	2210	7	0211	0000	4	2111	3322	15
12	2202	3221	14	0112	0120	7	3244	3443	27	1231	1211	12	0022	0200	6	1111	1322	12
13	2102	2110	9	0100	1001	3	3434	2011	18	1111	2110	8	0011	0011	4	2222	2121	14
14	1223	2210	13	2112	1322	14	1111	1111	8	0000	0010	1	0100	0001	2	1211	0011	7
15	1210	1000	5	3212	2332	18	0211	1211	9	2201	3312	14	1122	3112	13	1010	0001	3
16	0002	1100	4	1323	3111	15	0001	0100	2	2211	3211	13	1111	0010	5	0000	0000	0
17	1101	0100	4	2122	3000	10	0345	4532	26	1000	0101	3	1120	1110	7	0000	1100	2
18	1213	2101	11	0000	1200	3	1202	2102	10	1120	0211	8	1110	1001	5	0011	1012	6
19	1023	2432	17	0000	0001	1	0010	0010	2	1202	2101	9	0000	0001	1	1332	3232	19
20	2334	3323	23	1200	1012	7	2322	2010	12	2210	0121	9	1111	0111	7	2221	1122	13
21	3231	2221	16	0000	1000	1	0012	3102	9	2120	0011	7	1111	1112	9	0102	2123	11
22	2332	2212	17	2132	0132	14	0000	1121	5	0000	0000	0	2222	3312	17	2210	1012	9
23	1212	0110	8	1122	1332	15	0100	0002	3	0111	1102	7	2221	2111	12	1010	0000	2
24	0101	0220	6	2111	2202	11	2002	2011	8	1131	1145	17	1112	3122	13	1021	0011	6
25	1333	3122	18	1111	2320	11	0202	1201	8	5432	2211	20	2120	1112	10	1210	0010	5
26	1121	1021	9	1100	0112	6	2112	5564	26	1111	1102	8	1011	1122	9	1000	0111	4
27	1000	0000	1	2100	2211	9	4443	3234	27	1111	1100	6	2222	2311	15	0110	0000	2
28	1110	0000	3	1112	1121	10	3442	4312	23	0000	0000	0	0010	0014	6	1112	3322	15
29	0000	2200	4	1132	1101	10	6642	3222	27	0000	0001	1	4543	1222	23	1244	2212	18
30	2112	3343	19	0102	1000	4	2100	0123	9	0103	3312	13	3113	4233	20	1121	2222	13
31	3232	1212	16	1010	0000	2				2132	2222	16				1133	0111	11

Table 7.7. *Frequency distribution of Canberra 2011 K indices and the annual mean daily K sum.*

K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	825	947	693	330	95	22	8	0	0	0	0
Mean sum	10.6										

Table 7.8. *Principal magnetic storms observed at Canberra in 2011.*

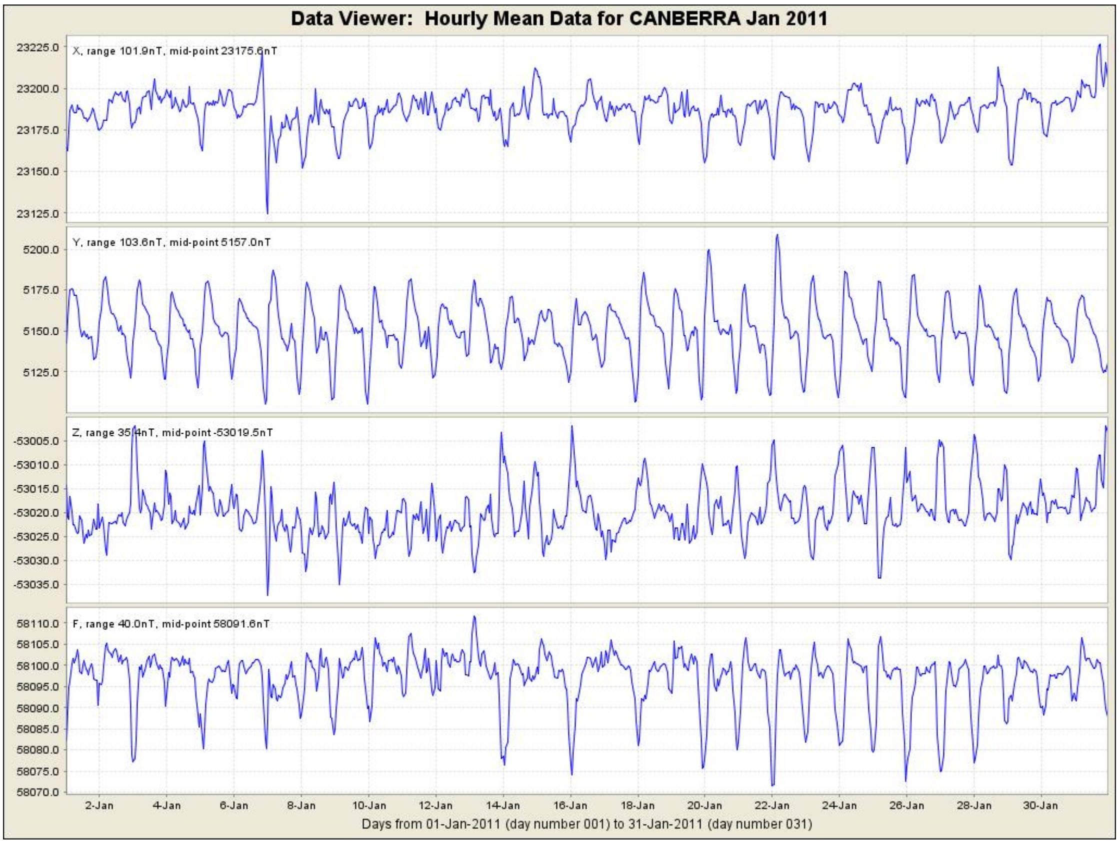
UT Start		Type	SSC amplitudes			Maximum 3hr K indices		Storm Ranges			UT End	
Date	Time		D(')	H(nT)	Z(nT)	Day (3hr periods)	K	D(')	H(nT)	Z(nT)	Date	Time
2011-02-18	01:31	ssc	-1.5	23.59	11.98	18(2)	6	12.8	140.5	43.8	2011-02-18	13:00
2011-03-10	06:37	...				10(3,4)	5	18.5	128.7	46.5	2011-03-12	04:08
2011-05-27	11:00	...				28(3,4,5)	6	18.5	167.0	64.5	2011-05-28	20:00
2011-05-29	02:00	...				29(2,3,4)	5	11.6	144.9	44.6	2011-05-30	02:00
2011-08-05	19:02	...				5(8)	6	29.6	180.5	95.7	2011-08-06	17:03
2011-09-26	12:35	ssc	2.22	59.52	15.12	26(7)	6	16.7	186.7	57.9	2011-09-27	08:04
2011-09-29	01:03	...				29(1,2)	6	11.3	165.9	39.0	2011-09-29	11:04
2011-10-24	18:31	ssc*	6.0*	37.7	4.85	24(8), 25(1)	5	23.0	206.9	62.4	2011-10-25	18:00

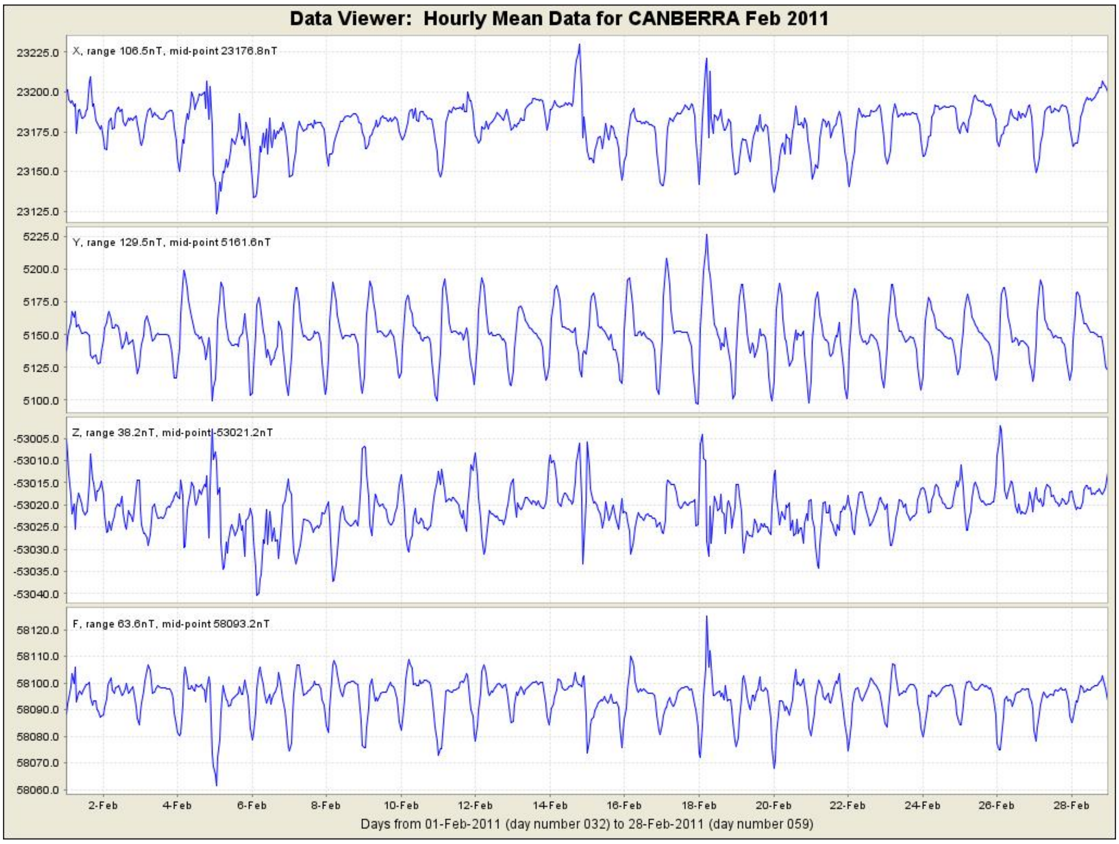
Table 7.9. *Storm sudden commencements observed at Canberra in 2011.*

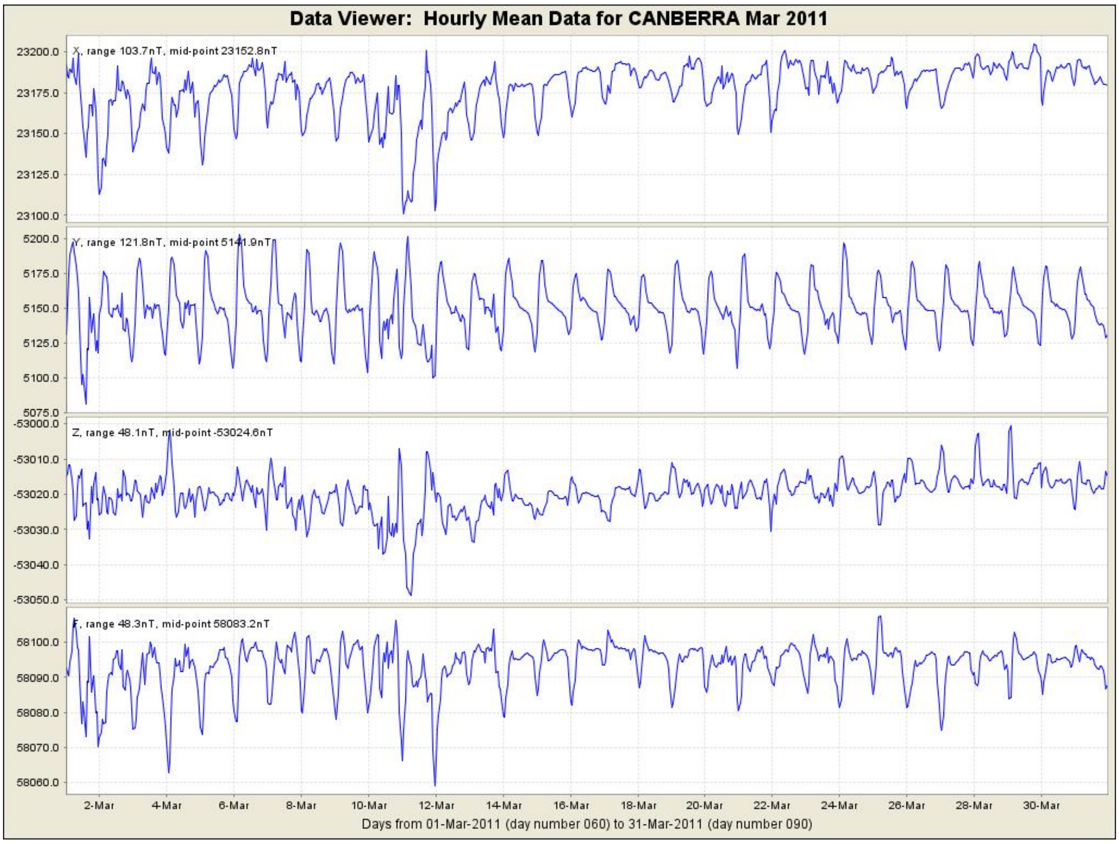
UT		Type ssc/ssc*	Quality A,B,C	Chief movement (nT)		
Date	Time			H(X)	D(Y)	Z
2011-01-06	17:15	ssc	C	8.71	2.8	1.48
2011-02-14	15:56	ssc	A	31.81	2.69	5.97
2011-02-18	01:31	ssc	A	23.59	-10.51	11.98
2011-03-22	14:11	ssc*	B	-14.04*	1.78	-3.16*
2011-03-29	16:02	ssc	A	11.94	2.2	2.19
2011-04-06	09:33	ssc	B	30.6	2.65	5.15
2011-04-18	06:52	ssc	A	24.66	3.7	4.06
2011-04-19	21:09	ssc	C	2.88	-6.96	2.14
2011-06-04	20:44	ssc*	A	24.86	15.16*	3.19
2011-06-10	08:49	ssc	B	6.57	-6.21	3.31
2011-06-17	02:39	ssc	A	17.22	-6.29	4.33
2011-08-04	21:53	ssc	B	11.05	5.76	1.27
2011-09-09	12:43	ssc	A	37.83	9.07	4.67
2011-09-17	03:44	ssc	B	24.92	9.34	2.92
2011-09-26	12:35	ssc	A	59.52	15.2	15.12
2011-10-05	07:37	ssc	B	20.75	2.67	3.57
2011-10-24	18:31	ssc*	A	37.7	41.45*	4.85
2011-10-30	10:01	ssc	C	20.35	0.77	4.03
2011-11-12	05:58	ssc	B	13.03	1.84	2.29
2011-11-28	21:50	ssc*	A	10.89	-48.43*	14.83*
2011-12-02	17:15	ssc	C	7.61	3.98	0.89
2011-12-18	19:02	ssc	B	8.88	2.91	2.49
2011-12-28	11:14	ssc*	A	11.74	5.98*	3.91

Table 7.10. *Solar flare effects observed at Canberra in 2011.*

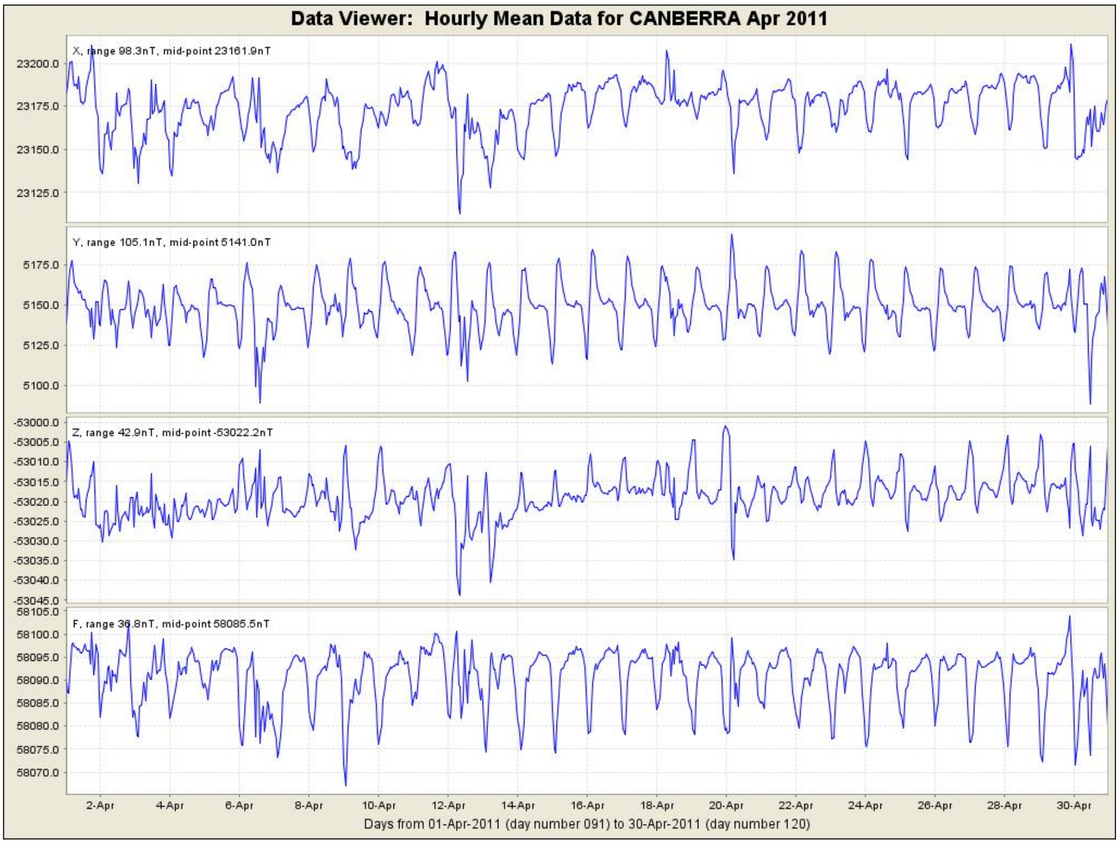
UT Date	Movement			Amplitude (nT)			Confirmation
	Start	Max	End	H(X)	D(Y)	Z	
2011-02-09	01:28	01:32	01:37	2.78	0.78	1.36	solar
2011-03-09	23:18	23:30	23:58	13.04	2.34	2.74	solar
2011-07-30	02:07	02:10	02:16	8.6	1.2	1.07	solar
2011-08-03	04:30	04:32	04:36	4.2	0.72	0.97	solar
2011-08-04	03:51	03:59	04:30	9.39	1.56	4.14	solar
2011-09-07	22:35	22:39	23:04	9.54	0.48	3.87	solar
2011-09-25	04:39	04:59	05:28	8.24	1.98	3.57	solar


Data Viewer: Hourly Mean Data for CANBERRA Jan 2011
X, range 101.9nT, mid-point 23175.6nT
Y, range 103.6nT, mid-point 5157.0nT
Z, range 35.4nT, mid-point -53019.5nT
F, range 40.0nT, mid-point 58091.6nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

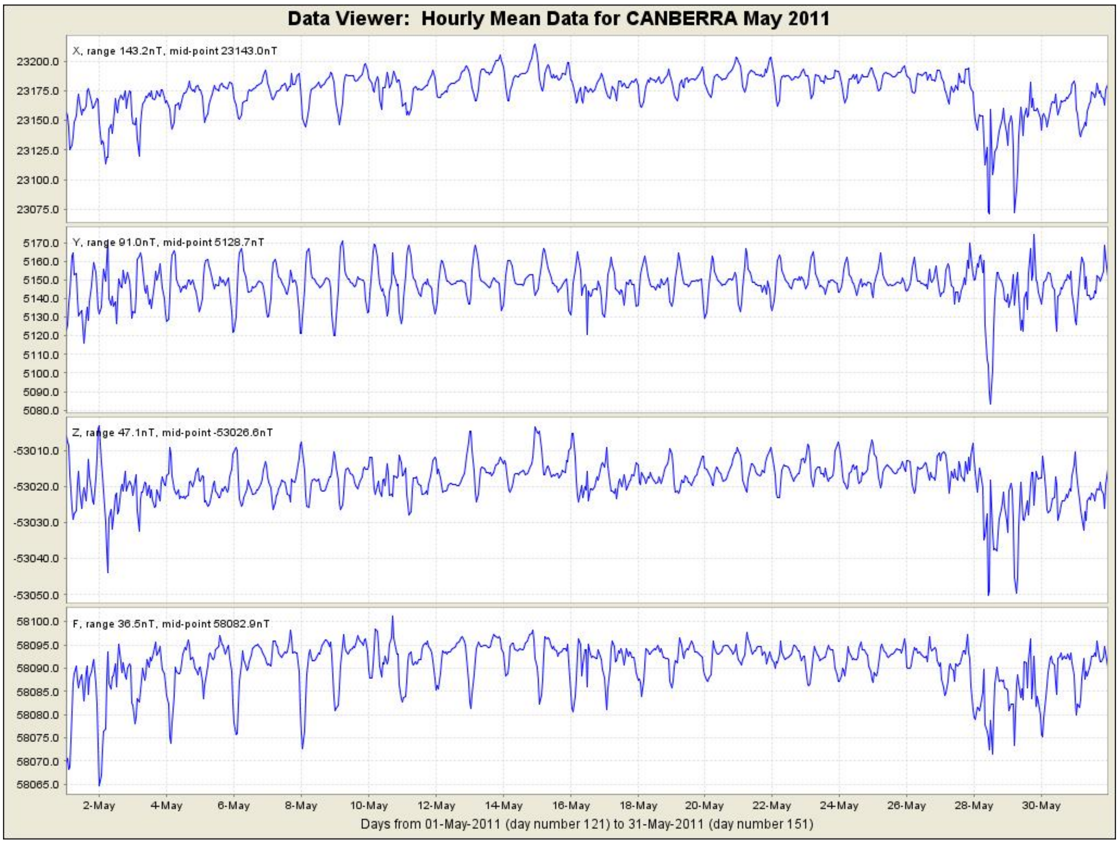

Data Viewer: Hourly Mean Data for CANBERRA Feb 2011
X, range 106.5nT, mid-point 23176.8nT
Y, range 129.5nT, mid-point 5161.6nT
Z, range 38.2nT, mid-point -53021.2nT
F, range 63.6nT, mid-point 58093.2nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

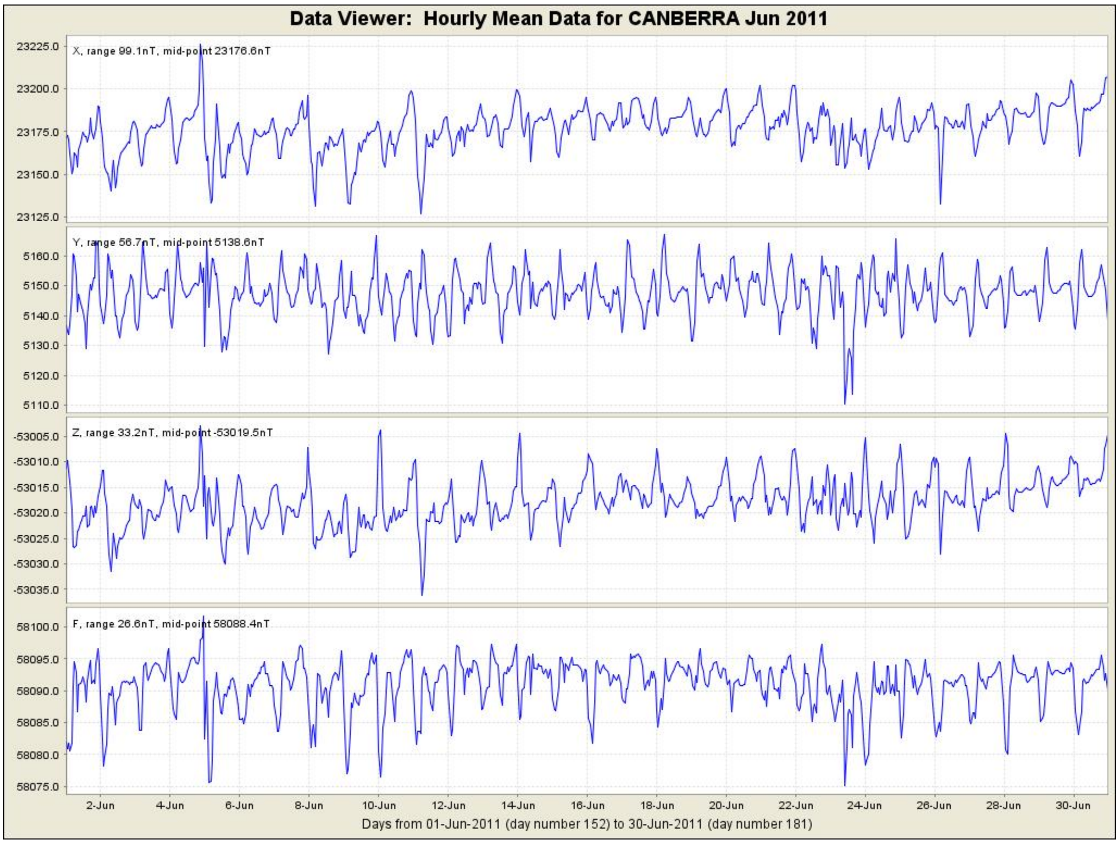


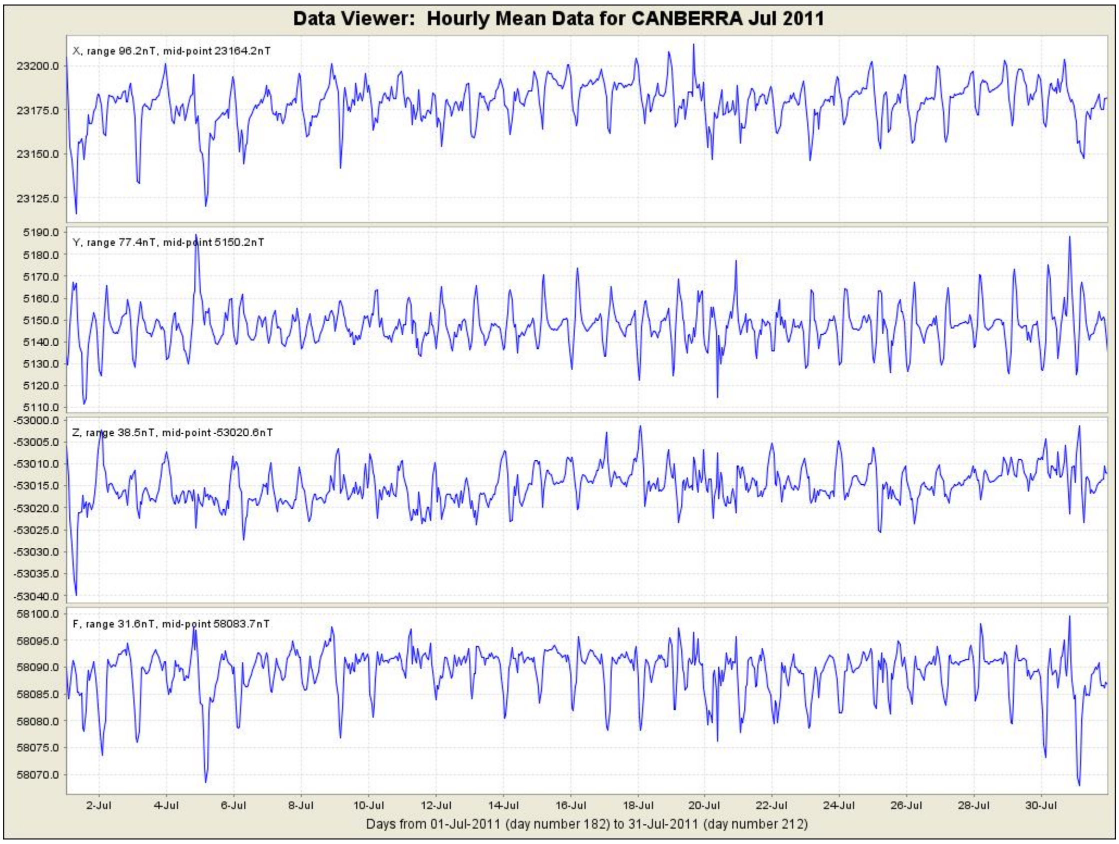
Data Viewer: Hourly Mean Data for CANBERRA Mar 2011
X, range 103.7nT, mid-point 23152.8nT
Y, range 121.8nT, mid-point 5141.9nT
Z, range 48.1nT, mid-point -53024.6nT
F, range 48.3nT, mid-point 58083.2nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

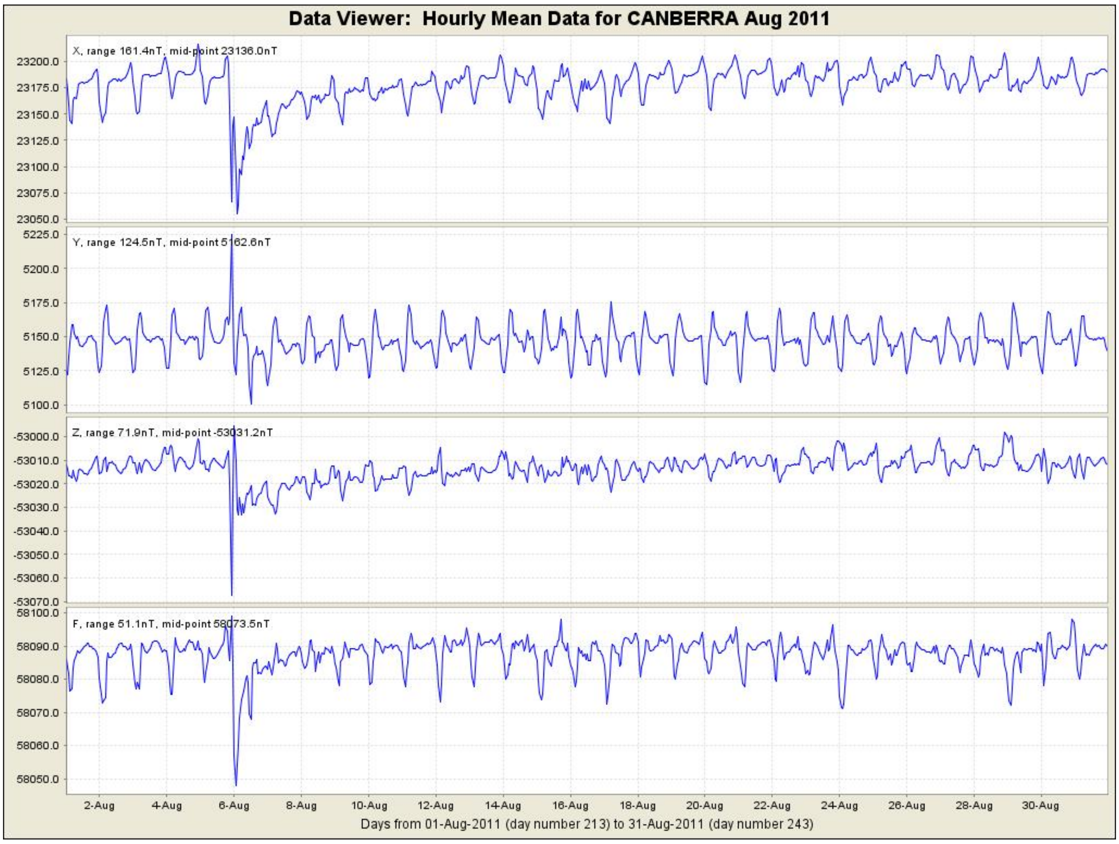


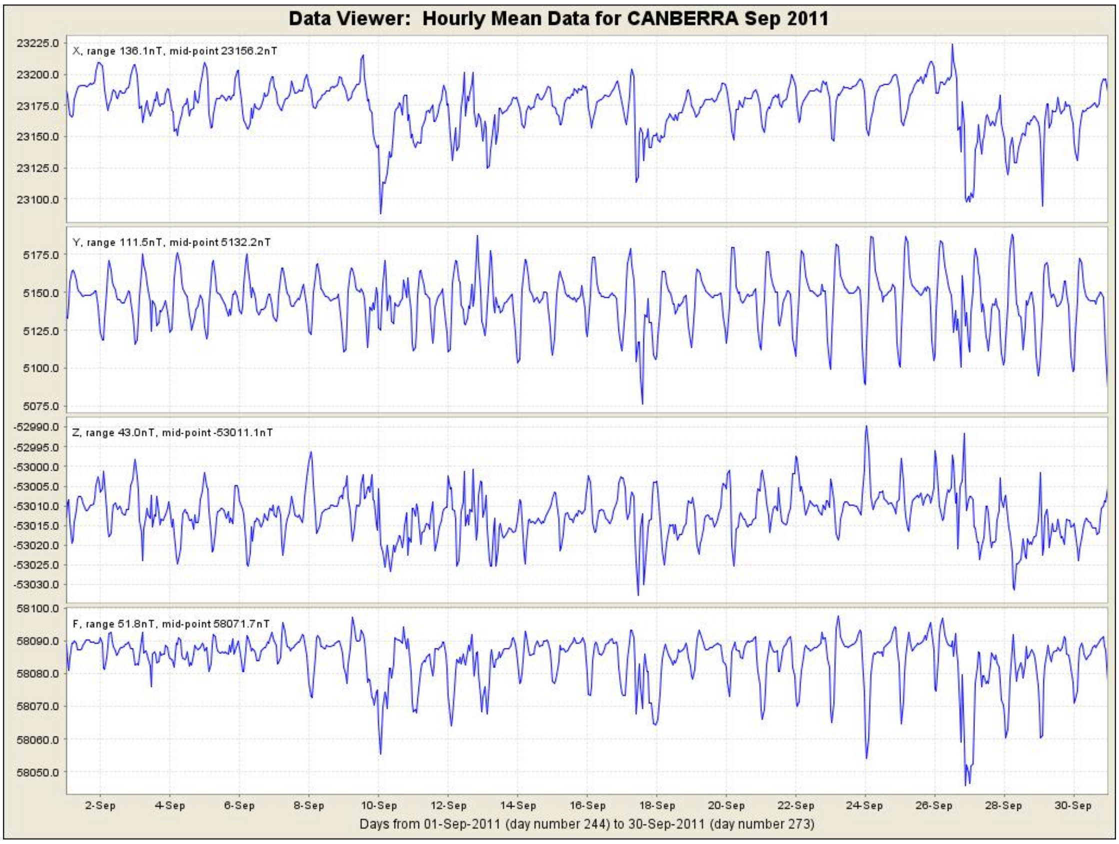
Data Viewer: Hourly Mean Data for CANBERRA Apr 2011
X, range 98.3nT, mid-point 23161.9nT
Y, range 105.1nT, mid-point 5141.0nT
Z, range 42.9nT, mid-point -53022.2nT
F, range 36.8nT, mid-point 58085.5nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

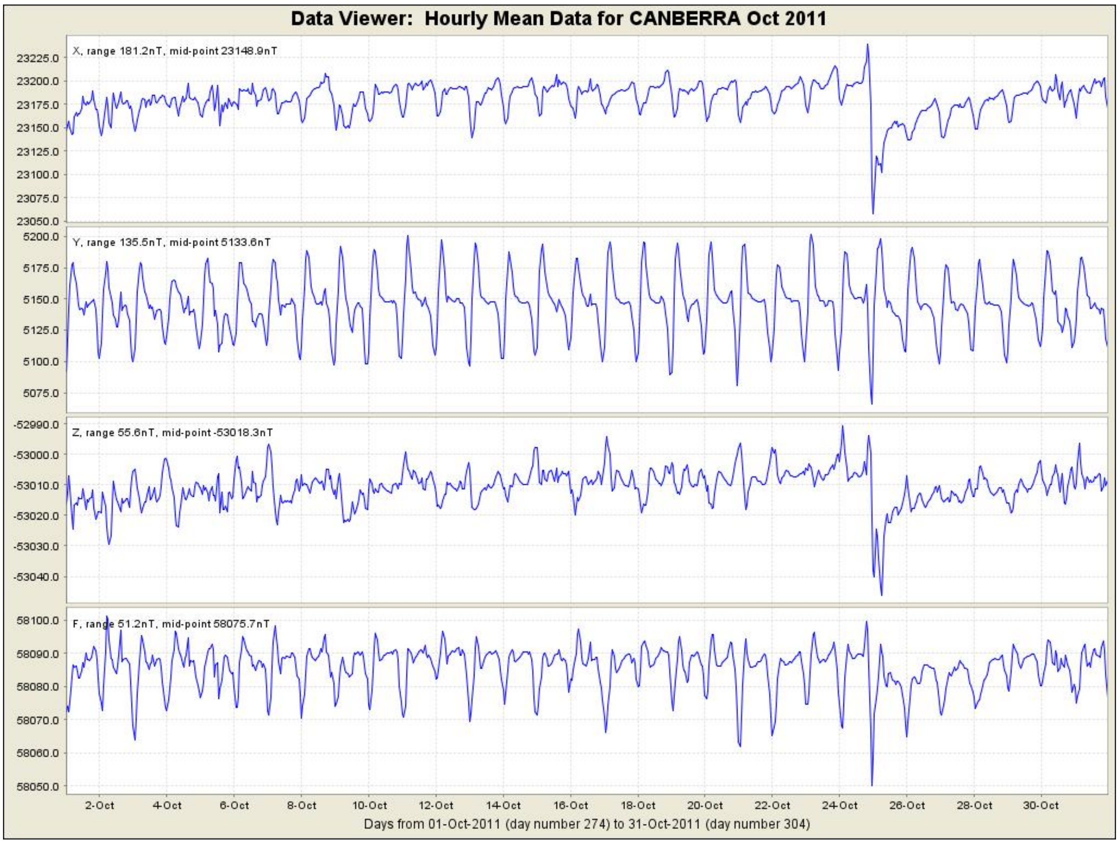

Data Viewer: Hourly Mean Data for CANBERRA May 2011
X, range 143.2nT, mid-point 23143.0nT
Y, range 91.0nT, mid-point 5128.7nT
Z, range 47.1nT, mid-point -53026.6nT
F, range 36.5nT, mid-point 58082.9nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)


Data Viewer: Hourly Mean Data for CANBERRA Jun 2011
X, range 99.1nT, mid-point 23176.6nT
Y, range 56.7nT, mid-point 5138.6nT
Z, range 33.2nT, mid-point -53019.5nT
F, range 26.6nT, mid-point 58088.4nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for CANBERRA Jul 2011
X, range 96.2nT, mid-point 23164.2nT
Y, range 77.4nT, mid-point 5150.2nT
Z, range 38.5nT, mid-point -53020.6nT
F, range 31.6nT, mid-point 58083.7nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for CANBERRA Aug 2011
X, range 161.4nT, mid-point 23136.0nT
Y, range 124.5nT, mid-point 5162.6nT
Z, range 71.9nT, mid-point -53031.2nT
F, range 51.1nT, mid-point 58073.5nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for CANBERRA Sep 2011
X, range 136.1nT, mid-point 23156.2nT
Y, range 111.5nT, mid-point 5132.2nT
Z, range 43.0nT, mid-point -53011.1nT
F, range 51.8nT, mid-point 58071.7nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for CANBERRA Oct 2011
X, range 181.2nT, mid-point 23148.9nT
Y, range 135.5nT, mid-point 5133.6nT
Z, range 55.6nT, mid-point -53018.3nT
F, range 51.2nT, mid-point 58075.7nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)

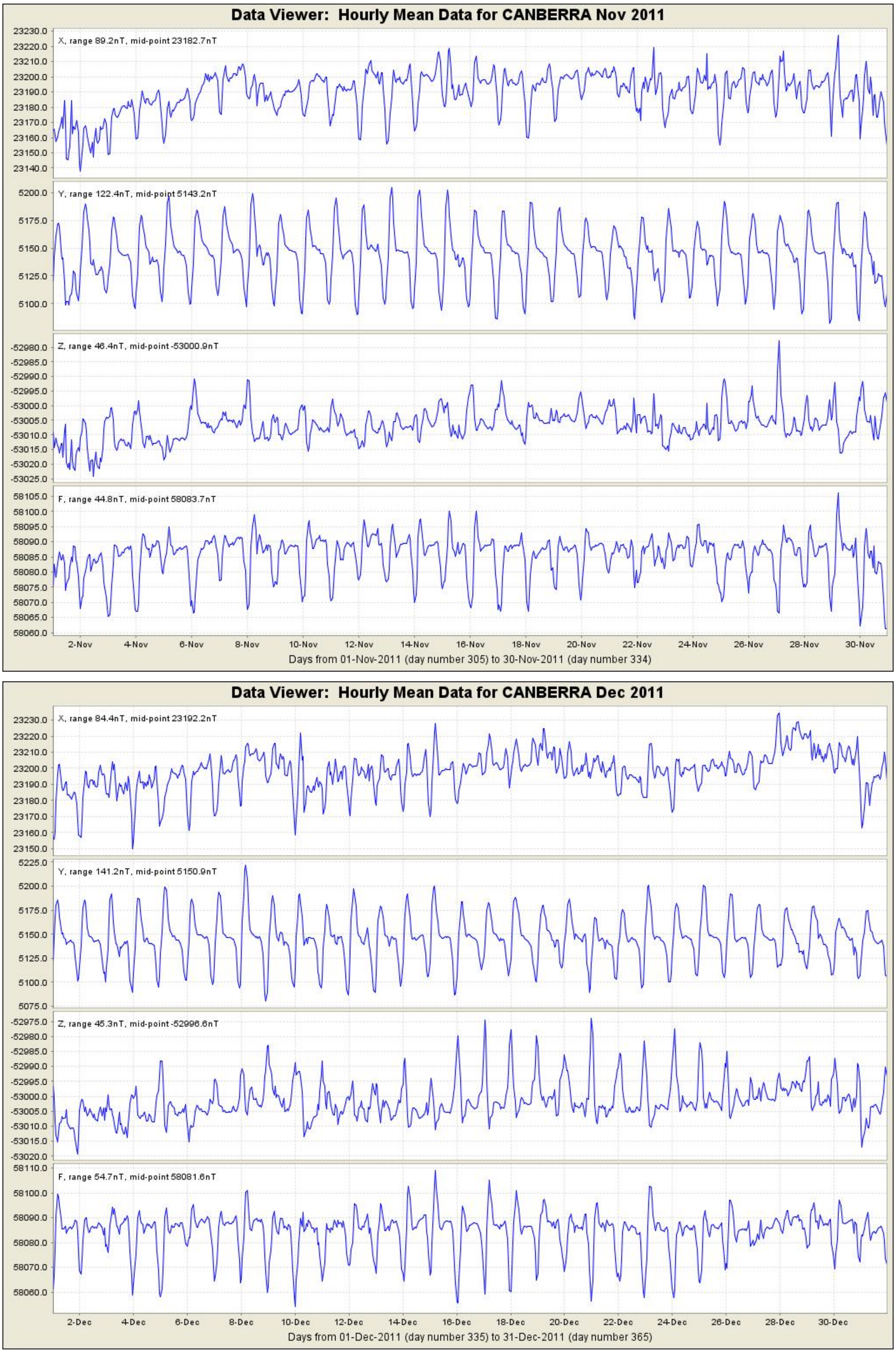


Figure 7.3. *Canberra 2011 hourly mean values in X, Y, Z and F.*

8. Macquarie Island

Macquarie Island is approximately 1500 km southeast of Tasmania and 1300 km north of the Antarctic coast. The magnetic observatory is part of the Australian Antarctic Division research station located on the isthmus at the northern end of the island.

The observatory comprises:

- an office in the station's Science Building;
- a Variometer House 100 m south of the office;
- an Absolute House about 30 m further south, and;
- a PPM House between the Variometer and Absolute Houses.

Power to the huts is routed underground. Data telemetry was via a wireless link to the station local area network until September 2011. After this date the wireless link was replaced by a wired network. The area around the observatory is used by elephant seals and other native wildlife. The Absolute and Variometer Houses are enclosed within non-magnetic protective fences.

Variometers

Two variometer systems operated at Macquarie Island throughout 2011, one referred to as MCQ the other as MQ2. The MCQ system consisted of a Narod Geophysics Limited 3-component ring-core fluxgate and an Elsec 820 proton precession magnetometer. The MQ2 system comprised a Danish Meteorological Institute suspended 3 axis linear-core fluxgate and a GEM Systems GSM-90 total-field instrument. The details of the variometers are described in Table 8.2.

The MCQ fluxgate variometer electronics was situated in the ante-room of the Variometer House and the sensor was mounted on a marble base on the SE pillar of the sensor room of the Variometer House. It was oriented so that the three mutually orthogonal components recorded were of approximately equal magnitudes. At Macquarie Island the magnetic field is approximately 11° off vertical and each of the three orthogonal sensors makes an angle of approximately 55° with the magnetic vector (this orientation is referred to as ABC).

The Elsec 820 total-field variometer was located on the pillar in the PPM House with the electronics console on the floor of the PPM House. The PPM House had no temperature control.

The MQ2 fluxgate variometer sensor was mounted on the NE pillar of the sensor room of the Variometer House and aligned magnetic NW, NE and vertical (this orientation is referred to as ABZ). The MQ2 fluxgate electronics was mounted in an insulated box situated on the floor in the SW corner of the sensor room.

The GSM-90 total-field variometer sensor was mounted on a 22 cm high stand located on the floor of the sensor room, mid-way between the NE and SE pillar. The GSM-90 electronics was located in an insulated box on the floor in the SW corner of the sensor room of the Variometer House.

The temperature of the sensor room of the Variometer House was controlled with a heating system. Temperature variations recorded in DMI electronics were 17°C to 27°C and 11°C to 20°C in the DMI head through the year. There were annual variations of 10°C degrees.

The data acquisition system was situated in the ante-room of the Variometer House. A single data-acquisition computer acquired data from both the MCQ and MQ2 variometer systems. Backup power was provided by two separate systems. An Uninterruptible Power Supply located in the office powered the MCQ fluxgate variometer and the Elsec total-field variometer. A 12 V battery box situated in the ante-room of the Variometer House powered the acquisition computer, the GPS clock, the MQ2 fluxgate variometer and the GSM-90 total-field variometer.

Table 8.1. *Key observatory data.*

IAGA code:	MCQ
Commenced operation:	1952
Geographic latitude:	54° 30' S
Geographic longitude:	158° 57' E
Geomagnetic latitude:	-59.61°
Geomagnetic longitude:	244.13°
K 9 index lower limit:	1500 nT
Principal pier:	Pier AE
Pier elevation (top):	8 m AMSL
Principal reference mark:	NMI
Reference mark azimuth:	353° 44' 13"
Reference mark distance:	200 m
Observers:	A. Gibbs (to 2011-04-13) I. McLean (2011-05-06 to 2011-08-03) T. Hopps (from 2011-08-08)

Table 8.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	Narod (MCQ)
Serial number:	9305-1
Type:	ring-core fluxgate
Orientation:	A, B, C
Acquisition interval:	1 s
Scale value:	0.025 nT / count
3-component variometer:	DMI FGE (MQ2)
Serial number:	E0307 / S0262
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±10V)
Scale value:	0.32 nT / count
Total-field variometer:	Elsec 820 M3 (MCQ)
Serial number:	140
Type:	Proton precession
Acquisition interval:	10 s
Resolution:	0.1 nT
Total-field variometer:	GEM Systems GSM-90 (MQ2)
Serial number:	4081418 / 42176
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	ANARESAT

Definitive 1-minute data for 2011 were derived from the DMI 3 axis linear-core fluxgate variometer and GSM-90 total-field variometer (MQ2 system). Reported data provided to INTERMAGNET in real-time during 2011 were derived from the Narod Geophysics Limited 3 component ring-core fluxgate and Elsec 820 proton magnetometer (MCQ system). The reasons for adopting the DMI and GSM-90 variometers for the definitive data will be explained in *Baselines* below.

Table 8.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI (Primary)
Serial number:	DI0045
Theodolite:	Zeiss 020B
Serial number:	393911
Resolution:	0.1’
D correction:	0.15’
I correction:	-0.10’
DI fluxgate:	DMI (Secondary)
Serial number:	DI0040
Theodolite:	Zeiss 020B
Serial number:	394742
Resolution:	0.1’
D correction:	0.0’
I correction:	-0.10’
Total-field magnetometer:	GEM Systems GSM-90 (Primary)
Serial number:	5091720 / 52453
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Total-field magnetometer:	Austral (Secondary)
Serial number:	525
Type:	Proton precession
Resolution:	1 nT

Absolute instruments

The principal absolute magnetometers used at Macquarie Island and their adopted corrections for 2011 are described in Table 8.3.

The absolute instruments at Macquarie Island were compared against travelling reference instruments on 20 March 2009 (see Hitchman et al., 2010). There was no instrument comparison in 2011, so the adopted instrument corrections from the 2009 comparisons have been applied to all Macquarie Island 2011 final data.

Magnetic absolute measurements were performed nominally weekly in the Absolute House. DIM observations were made on the principal pier AE with a DMI Declination-Inclination magnetometer (DI0045) mounted on a Ziess 020B (393911) theodolite.

PPM observations were performed on pier AW with a GEM Systems GSM-90 Overhauser magnetometer (5091720) with sensor 52453. A Hewlett-Packard H4300 personal digital assistant computer was used to communicate with the GSM-90 magnetometer.

Pier differences of

$\Delta X = -2.6$ nT $\Delta Y = +5.1$ nT $\Delta Z = +4.2$ nT $\Delta F = -4.1$ nT

were applied to adjust observations performed on pier AW to be equivalent to observations on the principal pier AE.

A Declination-Inclination magnetometer (DMI DI0040 on Zeiss 020B 394742) and an Austral PPM (Aust525) were available as back-up absolute instruments. On 27 January, 2 February and 9 February the back-up DIM and primary PPM were used in the weekly routine.

At 2011 mean magnetic field values (X= 10801 nT, Y= 6598 nT, Z= -62932 nT), the D, I and F corrections in Table 8.3 translate to the following corrections in X, Y and Z.

For DIM DI0045 / 393911 and GSM-90 5091720 / 52453:

$\Delta X = -1.8$ nT $\Delta Y = -0.5$ nT $\Delta Z = -0.4$ nT

For DIM DI0040 / 394742 and GSM-90 5091720 / 52453:

$\Delta X = -1.6$ nT $\Delta Y = -1.0$ nT $\Delta Z = -0.4$ nT

Baselines

There were 50 pairs of weekly absolute observations during 2011. The MCQ and MQ2 variometer baselines were well controlled and cross-checked throughout 2011.

The MQ2 (DMI) baselines were quite stable during 2011 with drifts within 2 nT in most cases, except a few points within 4 nT range. The daily mean of the total-field difference between the DMI and GSM-90 (noted as Ef) in the Variometer House varied within 0.6 nT. A filter was used to detect sharp spikes in the variometer data. The filter parameters required a spike have a "spike level" of at least 2 nT and 10 times the average of the following minute. A few (mostly 1 or 2) seconds of data were rejected in 46 days, with a maximum of 10 s data being rejected on 31 March.

The MCQ (Narod) baselines drifted about 8, 10 and 4 nT in Z in X, Y and Z respectively from January to March. There were several baseline jumps over the year. The same filter as above was used to detect sharp spikes in the variometer data. A few seconds to a few minutes data were rejected every day throughout 2011, with the maximum rejected data being 126 s on 12 June.

The Elsec 820 PPM became unstable between 24 February and 28 April, and from 7 October to the end of the year. The problem is mainly due to the aging of the instrument.

The GSM-90 PPM performed satisfactorily throughout 2011. There was 4 minutes data loss due to a system reboot. The F-difference (absolute F measured in the Absolute House minus F recorded in the Variometer House) in 2011 showed a "valley" shape in variations between February and April, with a lowest point of 3 nT. Checking the 2009 F-difference revealed a similar pattern between February and March. While there is no clear reason for the change, it is suspected that seasonal variations affected the Variometer House and Absolute House differently because the F-difference between the DMI and GSM-90 in the same Variometer House varied within only 0.6 nT throughout 2011.

Final MQ2 (DMI) baselines were adopted by applying piecewise linear drifts to observed baseline residuals from the weekly absolute observations. The standard deviations of the differences between the weekly absolute observations and the final adopted variometer model and data using the DMI vector variometer were:

	σ
X	1.0 nT
Y	0.8 nT
Z	0.4 nT
D	12"
I	03"
F	0.3 nT

FCheck, the difference between F measured with the DMI vector variometer and F measured with the scalar GSM-90 variometer, agreed with FP well (i.e. the definitive data followed the absolute measurements).

Observed and adopted baseline values in X, Y and Z are shown in Figure 8.1.

Operations

The magnetic observers at Macquarie Island were members of the Australian National Antarctic Research Expedition and were employed by the Australian Antarctic Division with funding support by Geoscience Australia. Their duties included maintaining the equipment, performing absolute observations to calibrate the variometers, transcribing the observations and emailing them to Geoscience Australia, maintaining the integrity of the observatory and reporting any changes to Geoscience Australia. During 2011, the role of magnetic observer was filled by the ANARE communications technical officers Adrian Gibbs until 2011-04-13, Ian McLean from 2011-05-06 to 2011-08-03 and then by Trevor Hopps from 2011-08-08.

The MCQ (Narod) vector variometer produced 8 samples per second which were filtered and output as 1-second data. The MQ2 (DMI) vector variometer was sampled once per second. Both the GSM-90 and Elsec 820 scalar variometers produced 10-second samples. All variometer data were recorded on an acquisition PC running QNX and the Geophysical Data Acquisition Platform (GDAP) software. Acquisition timing control was provided by a Garmin GPS clock mounted on the roof of the Variometer House.

Data were transmitted every 5 to 12 minutes to Geoscience Australia. "Reported" quality real-time 1-minute data were provided to INTERMAGNET throughout 2011 from the MCQ variometer system. Definitive 2011 1-minute data (and derived data products such as hourly and annual mean values) were subsequently sourced from the MQ2 system. All preliminary and final data preparation was done at Geoscience Australia.

The distribution of Macquarie Island 2011 data is described in Table 8.4.

Table 8.4. *Distribution of Macquarie Island 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012
WDC for Geomagnetism	preliminary	daily

Significant events

2011-02-07	04:11 data recording stops on MCQ system (vector and scalar). 05:37 data recording recommences, electronics temp increases rapidly after re-commencement problems possibly caused by a power failure. E820 PPM does not re-start
2011-02-08	03:35 slay GdapE820 and check ser6, E820 is responding03:38 re-start GdapE820 - PPM data starts flowing
2011-02-11	22:57 E820 data stops
2011-02-13	22:45 slay GdapE820, test with Qtalk, restart GdapE820 at 22:48
2011-02-15	23:05 (approx) slay and restart GdapE820 - gets PPM going but requires tuning. slay, retune, restart - all O.K.
2011-02-18	01:02:52 Slay GdapE820; qtalk, retune; start Gdap E820 01:05:00 (approx)
2011-02-21	~21:00 power house switchover - UPS stopped, Narod and E820 stopped. comms lost temporarily until ping from MAW. Adrian reset UPS. Restart Gdap E820 required.
2011-02-23	22:45 (approx) stop GdapE820, qtalk, restart.
2011-02-24	Narod and E820 data stops - power house change over caused problems with UPS
2011-02-25	UPS reset and Narod restarts 01:20 stop and restart GdapE820
2011-03-10	Telemetry delays, but system is running O.K. Getting Duplicate packets when ping from MCQ to galah 64 bytes from 192.55.112.1: icmp_seq=7 ttl=235 time=612 ms 64 bytes from 192.55.112.1: icmp_seq=7 DUP! ttl=235 time=614 ms 64 bytes from 192.55.112.1: icmp_seq=7 DUP! ttl=235 time=616 ms 64 bytes from 192.55.112.1: icmp_seq=7 DUP! ttl=235 time=619 ms 64 bytes from 192.55.112.1: icmp_seq=8 ttl=235 time=616 ms 64 bytes from 192.55.112.1: icmp_seq=8 DUP! ttl=235 time=619 ms 02:50 slay GdapE820; qtalk to ser6; restart GdapE820 02:52
2011-03-11	02:55 reboot system in attempt to fix network problems. 03:43 possible system reboot during network troubleshooting. Posted a heater and 6 ceramic infrared heat emitters to AAD and ordered one Power PC Sonic Model PS-12180NB 12V 18AH 16 Century PS1270 batteries (for the Linx800 UPS) from Battery World Hobart for V5 to MCQ in April. AAD E-con # 75004A and 75018A
2011-03-15	WaveRiders network radios and switched rebooted to fix duplicate packet problem
2011-03-16	Network performance much improved but still getting occasional duplicated packets
2011-03-18	00:00 (approx) memory card changed in Japanese MAGDAS magnetometer
2011-03-18	01:26:03 - E820 I 0 Started
2011-03-19	Drove the Parks buggy to the Clean Air Lab 13:50-14:00 local time.

2011-03-31	00:02 reboot in effort to fix duplicate packets. Will also reboot the switch and the network radios. 02:52-03:23 ladder in variometer hut to access radios - data contamination
2011-04-06	7 nT baseline jump in Y and smaller jump in X between today's obs and last week.
2011-04-13	Both Narod variometer and PPM Elsec 820 stopped at 06:58. Narod retarted at 07:24, but Elsec 820 did not. multiple power outages here at just before 7 am UTC (6 pm Macca time 1 hour ahead of ASDT), reset the UPS after things settled down. it was off, had to hit the ON button. Final Obs from Adrian Gibbs. No obs until Ian McLean arrives next week.
2011-04-14	message from Adrian Gibbs. Times for intrusions into magzone. Had to drive through the Magnetic Quiet Zone to the Clean Air Lab yesterday. Times below (and another one today) 13-4-2011 00:55-01:00 UTC 12-4-2011 04:20-04:25 UTC 12-4-2011 05:00-05:10 UTC
2011-04-16	slayed GdapE820, retuned E820 by hand (qtalk) the restarted GdapE820. (There were a few bad F values when GdapE820 was restarted without tuning the E820 by hand first.
2011-04-23	21:05:00 MCQ system stops delivering data. Probably a UPS problem Narod and Elsec820 stopped from 24 - 26 due to the UPS problem. Backup variometer mq2 was still running. One minutes data of MCQ was filled with MQ2 in the database.
2011-05-05	first absolute observation by Ian received.
2011-05-15	00:30-00:40 noise/interference on MQ2 fluxgate, reason unknown
2011-05-19	00:02 MCQ system stops producing data Duplicate network packets are still problematic. Ian restarts UPS, E820 requires qtalk restart 22:34 restart E820 again
2011-05-23	15:45 FCheck drift on MCQ system commences, 1 nT over 10 hours
2011-05-24	Simultaneous spikes in A and C channels, occasional spikes in B channel on Narod (MCQ).
2011-06-01	03:57 stopped and restarted GdapE820 - seemed to get E820 data flowing again.04:00 stopped and restarted GdapE820 - seemed to get E820 data flowing again. Seems to have been a power outage 03:00 - 03:40 or so, possibly another power outage at approx 22:00 - 22:15
2011-07-06	22:18 6 July UT MPH died and UPS stopped. reset UPS around 04:30 7 July. there is another power outage scheduled for tomorrow circa 2200 UTC - will take the opportunity to have a look at UPS and hopefully fix the batteries.
2011-08-02	Trevor Hopps is now at Macca, so we ran through a set of obs yesterday - Trevor mentioned that he wasn't exactly sure as to the correct minutes in the last PPM measurements. will be replacing GA UPS batteries today between 0230 to 0330 MBT (0130 until 0230 UTC) - now that we have an extra hand on deck we ought to be able to clear some of the work backlog. Narod and Elsec 820 data loss between 03:17 to 05:37 UT as recorded.
2011-08-03	Ian wrote "I would estimate with the new batteries you should get around 45 minutes or so backup time assuming 50% inverter efficiency and 50% inverter load (400W). Those batteries should be serviceable for about the next 3 years. My recommendation would be to replace the unit with a modern version (ideally the same type as the AAD useto simplify maintenance) before the batteries are next due for replacement". AAD used Linx 800 at Macca.
2011-09-02	02:30 - 04:00 Waverider radio network connection between variometer and Science building replaced with pre-existing copper cable between variometer and Science Building 10Mb/Sec WaveRider radio left in place - to be removed later.
2011-09-20	MCQ 00:44 to 01:12, change in F check as Trevor was near hut with a ladder and tools removing waverider. Not yet completed due to increasing wind and the need to get a cold chisel as pole that the waverider was bolted to has badly oxidized nuts and bolts.
2011-09-21	03:12 to 03:25 Trevor at hut to remove pole.
2011-09-30	Possible noise between 0230-0500 UTC workers within the quiet zone and near the variometer hut.

2011-10-12	01:57 stopped and restarted GdapGSM90 to fix errant F readings. 02:15 restarted GdapAdam as well - noise for past two days in various instruments. 02:25 restarted GdapNGL as well. 02:30 restarted GdapE820 as well.
2011-10-12	Trevor replied that they have been doing some work right on the edge of the Mag Zone with the IPS riometer. It's possible the noise is us. The work finished at 01:30 12-Oct UT, the noise disappeared.
2011-10-13	Elsec820 is getting noisy.
2011-11-18	03:37 slay, tune and restart GdapE820
2011-11-23	there was a step signal appeared on DMI vector data from 01:25 to 02:11 22 Nov (yesterday), and again from 00:34-00:49 UT 23 Nov today. Amplitude of the step signals is about 2 - 4 nT picked by the DMI instrument, but not in Narod instrument. emailed Trevor to inquire.
2011-11-23	Trevor replied that tourist boat was operating during above time and but not sure if the step signals related to the tourist boat. Tourists were walking through outside of the mag-quiet zone.
2011-11-24	Trevor tested cause of the step signals on the magnetic fields. he switched off HF transmitter between 04:05 to 05:00, to investigate if steps were caused by the HF transmitter. Steps disappeared on the DMI data after the transmitter is switched off from 04:05. - still can not confirm it is the cause. Moved the transmitter to another location. The antenna was well outside the mag zone (200 metres) I will leave it at the other location for a few weeks, let's see if this comes back. If not I will remove the antenna closest to the mag zone and will make a note that transmitters at the comms building (may possibly) interfere with this equipment. The transmitting was using the HF band and power was below 100 watts which is reasonably low, not sure it's the culprit but lets see what happens.

Annual mean values

The annual mean values for Macquarie Island are set out in Table 8.5 and displayed with the secular variation in Figure 8.2.

Hourly mean values

Plots of the hourly mean values for Macquarie Island 2011 data are shown in Figure 8.3.

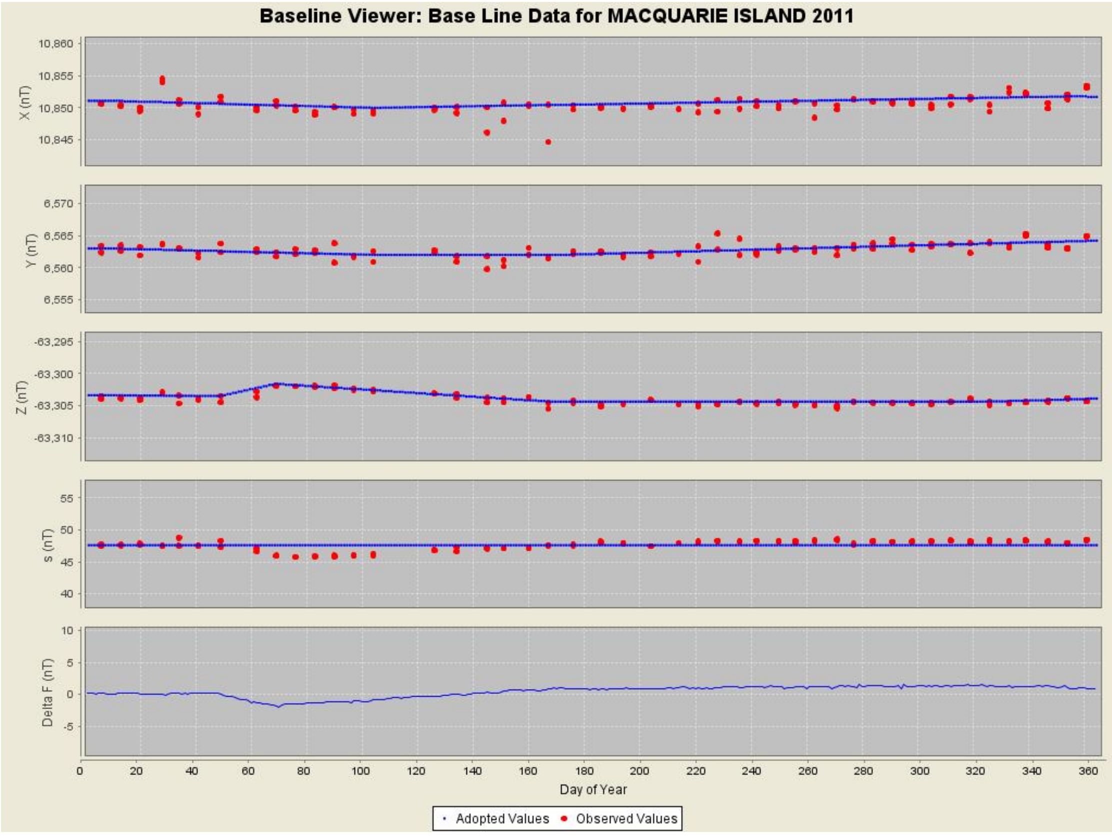


Figure 8.1. *Macquarie Island 2011 baseline plots.*

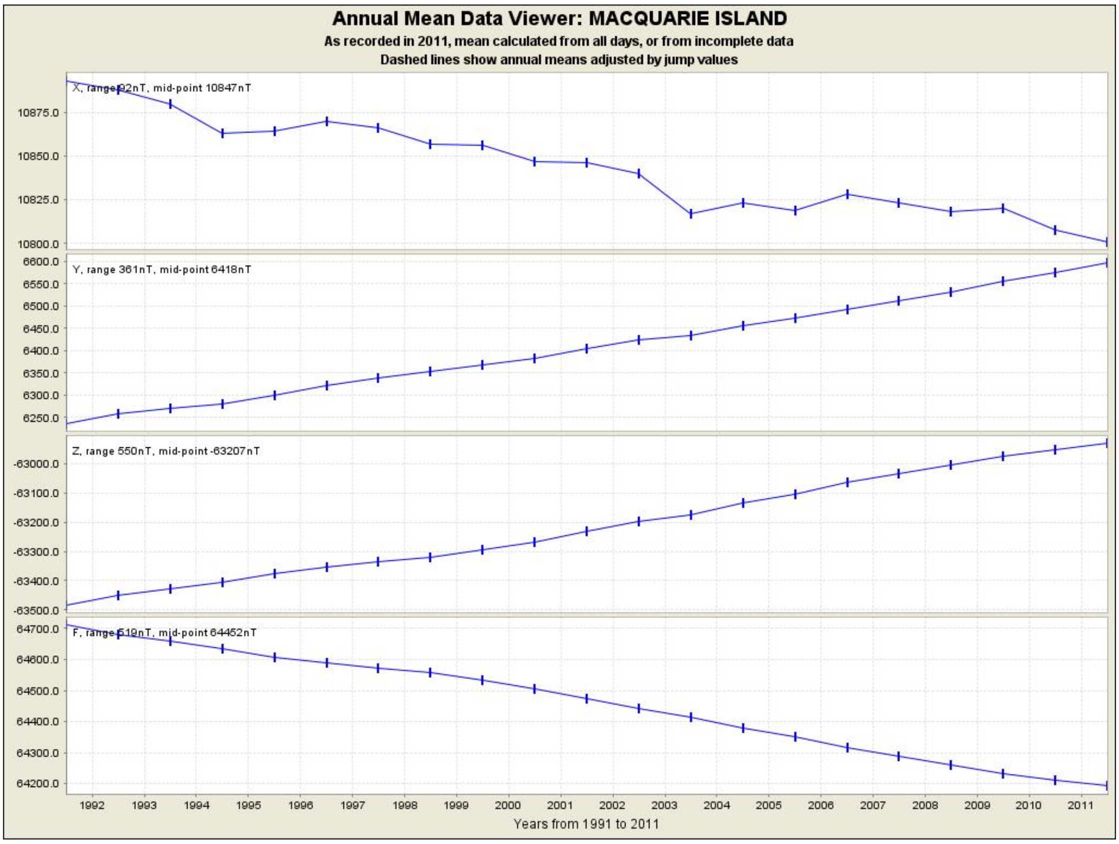
Table 8.5. *Macquarie Island annual mean values calculated using monthly mean values over* ***All*** *days, the 5 International* ***Quiet*** *days and the 5 International* ***Disturbed*** *days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 8.2.*

Year	Days	D		I		H	X	Y	Z	F	Elements
		(°	')	(°	')	(nT)	(nT)	(nT)	(nT)	(nT)	
1991.5	A	29	47.7	-78	48.9	12553	10893	6237	-63482	64711	XYZ
1992.5	A	29	53.1	-78	48.3	12557	10888	6257	-63450	64681	XYZ
1993.5	A	29	57.2	-78	48.1	12558	10880	6270	-63428	64659	ABC
1994.5	A	30	02.2	-78	48.3	12549	10863	6281	-63404	64634	ABC
1995.5	A	30	06.6	-78	47.5	12559	10864	6300	-63376	64608	ABC
1996.5	A	30	11.0	-78	46.4	12574	10870	6322	-63353	64589	ABC
1997.5	A	30	15.4	-78	45.9	12580	10866	6339	-63336	64573	ABC
1998.5	A	30	20.0	-78	45.8	12579	10857	6353	-63320	64557	ABC
1999.5	A	30	23.6	-78	45.2	12586	10856	6367	-63294	64534	ABC
2000.5	A	30	28.4	-78	45.0	12585	10847	6382	-63268	64507	ABC
2001.5	A	30	33.5	-78	44.1	12595	10846	6404	-63231	64473	ABC
2002.5	A	30	39.1	-78	43.5	12600	10840	6424	-63198	64442	ABC
2003.5	A	30	44.6	-78	44.0	12585	10817	6433	-63174	64416	ABC
2004.5	A	30	49.0	-78	42.7	12602	10823	6456	-63134	64380	ABC

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
2005.5	A	30	53.3	-78	42.1	12607	10819	6472	-63104	64352	ABC
2006.5	A	30	57.0	-78	40.8	12625	10828	6493	-63063	64315	ABC
2007.5	A	31	01.9	-78	40.2	12631	10823	6511	-63035	64288	ABZ
2008.5	A	31	07.3	-78	39.5	12637	10818	6532	-63005	64260	ABZ
2009.5	A	31	12.9	-78	38.4	12651	10820	6556	-62973	64231	ABZ
2010.5	A	31	19.0	-78	38.2	12651	10808	6576	-62951	64210	ABZ
2011.5	A	31	25.2	-78	37.7	12657	10801	6598	-62932	64192	ABZ
1951.5		23	50.8	-78	17.6	13383	12241	5411	-64589	65961	HDZ
1952.5		24	04.2	-78	17.8	13371	12208	5453	-64550	65920	HDZ
1953.5		24	14.6	-78	18.2	13360	12182	5486	-64533	65901	HDZ
1954.5		24	28.4	-78	18.4	13356	12156	5533	-64535	65903	HDZ
1955.5		24	42.0	-78	18.6	13350	12129	5579	-64520	65887	HDZ
1956.5		24	53.2	-78	19.3	13333	12095	5611	-64506	65870	HDZ
1957.5		25	05.7	-78	19.8	13319	12062	5649	-64482	65843	HDZ
1958.5		25	16.6	-78	20.1	13307	12033	5682	-64456	65815	HDZ
1959.5		25	26.3	-78	20.9	13288	12000	5708	-64436	65792	HDZ
1960.5		25	32.0	-78	22.0	13262	11967	5716	-64414	65765	HDZ
1961.5		25	50.0	-78	22.5	13240	11917	5769	-64359	65707	HDZ
1962.5		26	05.8	-78	23.3	13216	11869	5814	-64321	65665	HDZ
1963.5		26	08.5	-78	24.2	13193	11843	5813	-64294	65634	HDZ
1964.5		26	17.0	-78	24.7	13174	11812	5834	-64249	65586	HDZ
1965.5		26	28.6	-78	25.5	13152	11773	5864	-64214	65547	HDZ
1966.5		26	37.6	-78	26.7	13121	11729	5881	-64175	65503	HDZ
1967.5		26	46.5	-78	28.5	13084	11681	5894	-64166	65486	HDZ
1968.5		26	54.7	-78	29.7	13053	11639	5908	-64132	65447	HDZ
1969.5		27	02.3	-78	30.8	13026	11602	5921	-64099	65409	HDZ
1970.5		27	09.6	-78	32.1	12996	11563	5932	-64078	65383	HDZ
1971.5		27	13.3	-78	33.3	12963	11527	5930	-64032	65331	HDZ
1972.5		27	22.1	-78	34.4	12937	11489	5947	-64008	65302	HDZ
1973.5		27	27.6	-78	35.8	12905	11451	5951	-63985	65273	HDZ
1974.5		27	34.3	-78	37.6	12865	11404	5955	-63956	65237	HDZ
1975.5		27	43.2	-78	38.2	12847	11373	5976	-63926	65204	HDZ
1976.5		27	51.6	-78	39.1	12822	11336	5992	-63891	65165	HDZ
1977.5		27	59.8	-78	39.9	12802	11304	6010	-63861	65132	HDZ
1978.5		28	11.3	-78	41.1	12773	11258	6034	-63838	65103	HDZ
1979.5		28	19.6	-78	42.3	12745	11219	6047	-63807	65067	HDZ
1980.5		28	28.8	-78	43.0	12723	11183	6067	-63768	65025	HDZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1981.5		28	37.5	-78	44.5	12687	11136	6078	-63735	64985	HDZ
1982.5		28	49.5	-78	45.4	12666	11097	6107	-63711	64958	HDZ
1983.5		28	54.9	-78	45.7	12652	11075	6117	-63674	64919	HDZ
1984.5		29	03.7	-78	46.1	12640	11049	6140	-63650	64893	HDZ
1985.5		29	12.0	-78	47.4	12608	11006	6151	-63619	64856	XYZ
1986.5		29	19.0	-78	47.5	12600	10986	6169	-63590	64826	XYZ
1987.5		29	26.8	-78	47.8	12593	10966	6191	-63584	64819	XYZ
1988.5		29	32.2	-78	47.8	12590	10954	6207	-63560	64795	XYZ
1989.5		29	37.8	-78	47.8	12587	10941	6223	-63552	64786	XYZ
1990.5		29	42.8	-78	48.0	12577	10923	6234	-63519	64752	XYZ
1991.5		29	47.6	-78	47.6	12578	10915	6250	-63487	64721	XYZ
1992.5		29	53.0	-78	47.5	12573	10901	6264	-63447	64681	XYZ
1993.5	Q	29	56.9	-78	47.2	12575	10896	6277	-63427	64661	ABC
1994.5	Q	30	01.5	-78	47.0	12574	10887	6292	-63403	64637	ABC
1995.5	Q	30	06.2	-78	46.5	12577	10881	6308	-63377	64613	ABC
1996.5	Q	30	10.5	-78	45.9	12585	10879	6326	-63356	64594	ABC
1997.5	Q	30	15.2	-78	45.4	12591	10876	6344	-63336	64576	ABC
1998.5	Q	30	19.7	-78	45.1	12593	10870	6359	-63321	64562	ABC
1999.5	Q	30	23.5	-78	44.6	12598	10867	6373	-63293	64535	ABC
2000.5	Q	30	28.3	-78	44.3	12598	10858	6389	-63266	64509	ABC
2001.5	Q	30	33.3	-78	43.4	12608	10857	6409	-63229	64474	ABC
2002.5	Q	30	38.9	-78	42.8	12613	10851	6429	-63196	64442	ABC
2003.5	Q	30	43.7	-78	42.6	12611	10841	6444	-63170	64417	ABC
2004.5	Q	30	48.5	-78	41.8	12619	10838	6463	-63134	64383	ABC
2005.5	Q	30	52.7	-78	41.3	12624	10835	6479	-63106	64356	ABC
2006.5	Q	30	56.6	-78	40.3	12634	10836	6496	-63064	64317	ABC
2007.5	Q	31	01.8	-78	39.8	12639	10830	6515	-63038	64293	ABZ
2008.5	Q	31	07.1	-78	39.1	12645	10826	6535	-63008	64265	ABZ
2009.5	Q	31	12.8	-78	38.3	12654	10822	6558	-62974	64233	ABZ
2010.5	Q	31	18.7	-78	37.8	12658	10815	6579	-62952	64212	ABZ
2011.5	Q	31	25.1	-78	37.3	12664	10808	6602	-62932	64194	ABZ
1993.5	D	29	58.5	-78	50.0	12521	10846	6256	-63429	64654	ABC
1994.5	D	30	03.3	-78	50.2	12514	10831	6267	-63408	64632	ABC
1995.5	D	30	07.8	-78	49.4	12522	10830	6285	-63376	64601	ABC
1996.5	D	30	11.9	-78	47.4	12556	10852	6316	-63350	64583	ABC
1997.5	D	30	16.0	-78	47.3	12555	10843	6328	-63334	64566	ABC
1998.5	D	30	21.0	-78	47.7	12543	10824	6338	-63320	64550	ABC

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1999.5	D	30	24.3	-78	46.4	12564	10836	6358	-63297	64532	ABC
2000.5	D	30	29.0	-78	46.7	12554	10819	6368	-63273	64507	ABC
2001.5	D	30	34.6	-78	46.0	12560	10813	6389	-63238	64473	ABC
2002.5	D	30	40.0	-78	44.8	12574	10816	6413	-63198	64437	ABC
2003.5	D	30	46.6	-78	46.8	12534	10769	6413	-63186	64418	ABC
2004.5	D	30	50.2	-78	45.0	12559	10783	6437	-63136	64374	ABC
2005.5	D	30	55.2	-78	44.3	12565	10779	6456	-63102	64341	ABC
2006.5	D	30	58.1	-78	42.0	12601	10805	6484	-63059	64305	ABC
2007.5	D	31	02.9	-78	41.2	12610	10803	6504	-63031	64280	ABZ
2008.5	D	31	07.9	-78	40.3	12622	10804	6525	-62999	64251	ABZ
2009.5	D	31	13.2	-78	38.8	12643	10813	6553	-62970	64226	ABZ
2010.5	D	31	19.8	-78	39.4	12628	10787	6566	-62947	64201	ABZ
2011.5	D	31	26.0	-78	38.8	12635	10781	6589	-62928	64184	ABZ



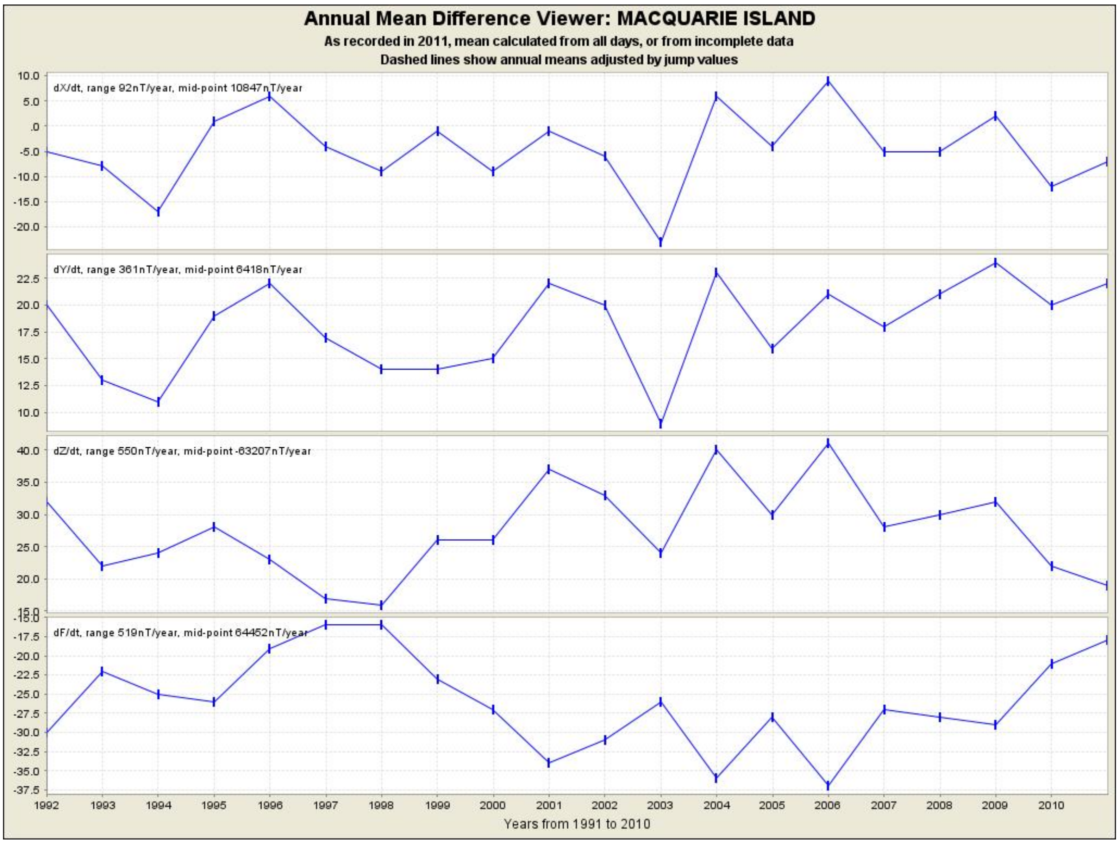
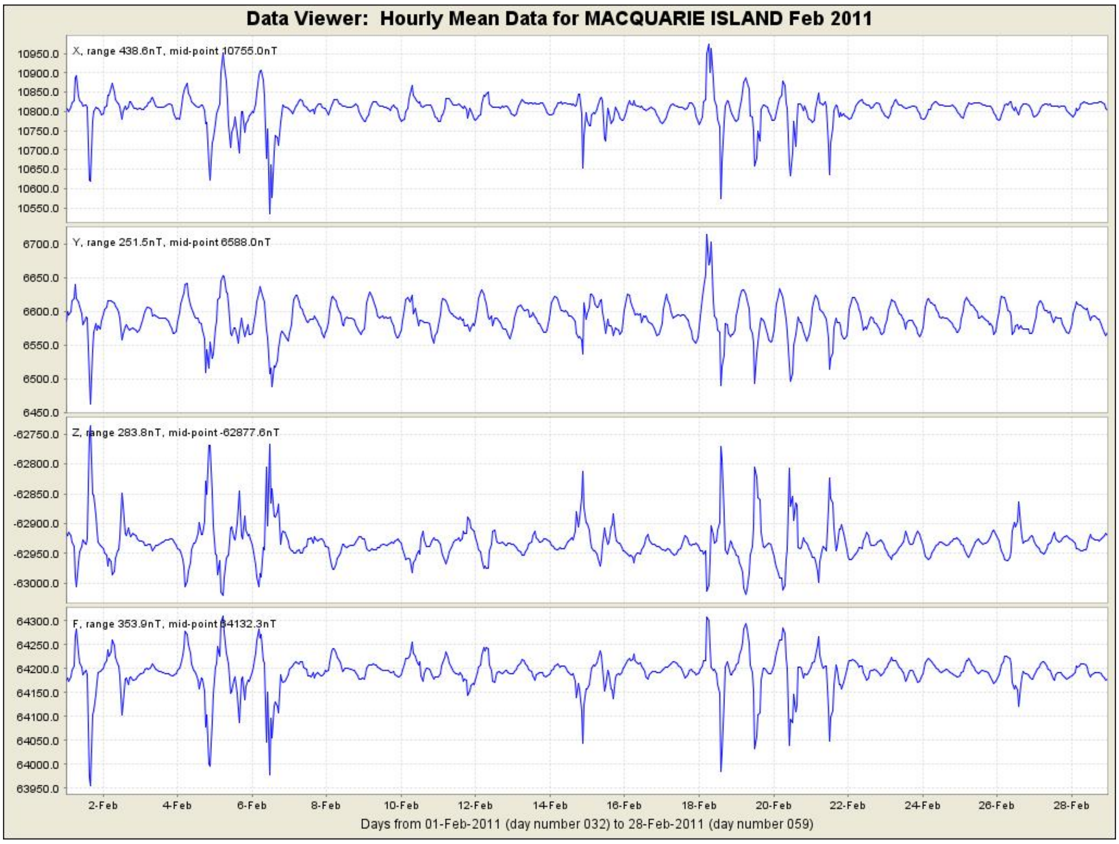
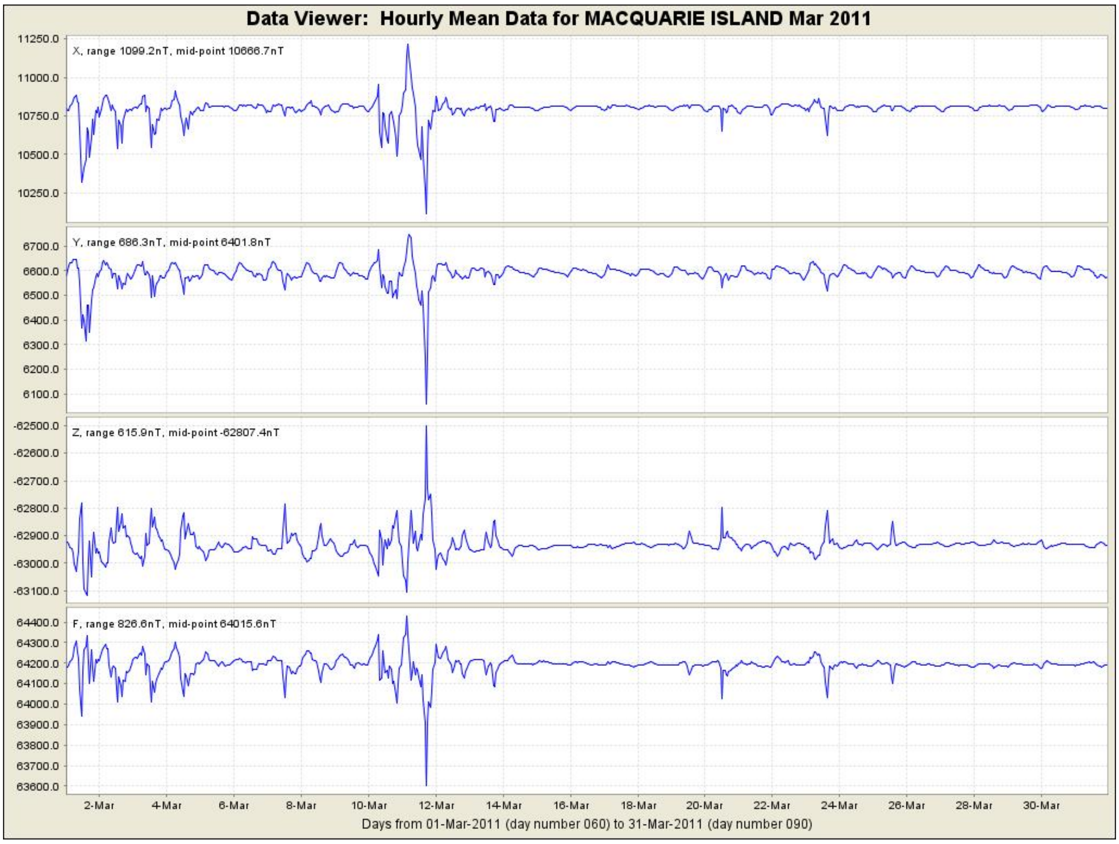


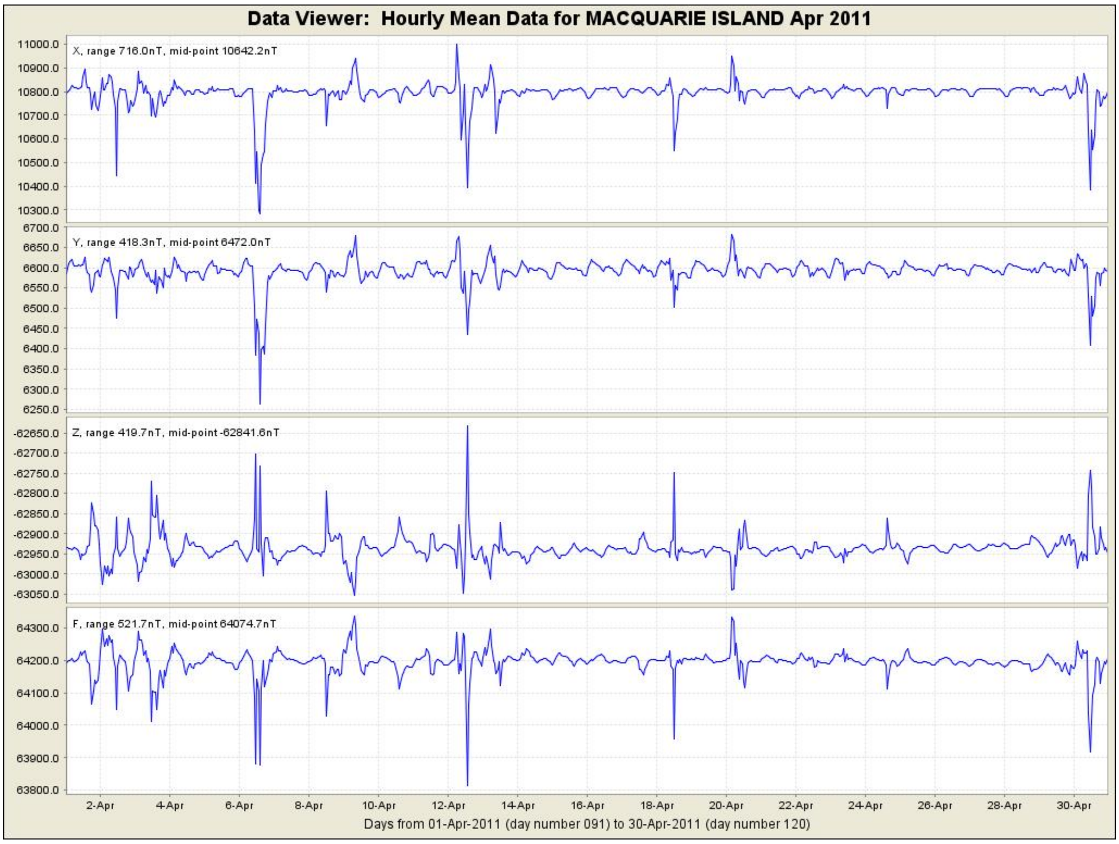
Figure 8.2. *Macquarie Island annual mean values and secular variation (all days) for X, Y, Z and F.*


Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Jan 2011
X, range 413.0nT, mid-point 10696.5nT
Y, range 174.6nT, mid-point 6565.7nT
Z, range 281.8nT, mid-point -62886.6nT
F, range 325.8nT, mid-point 64143.7nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

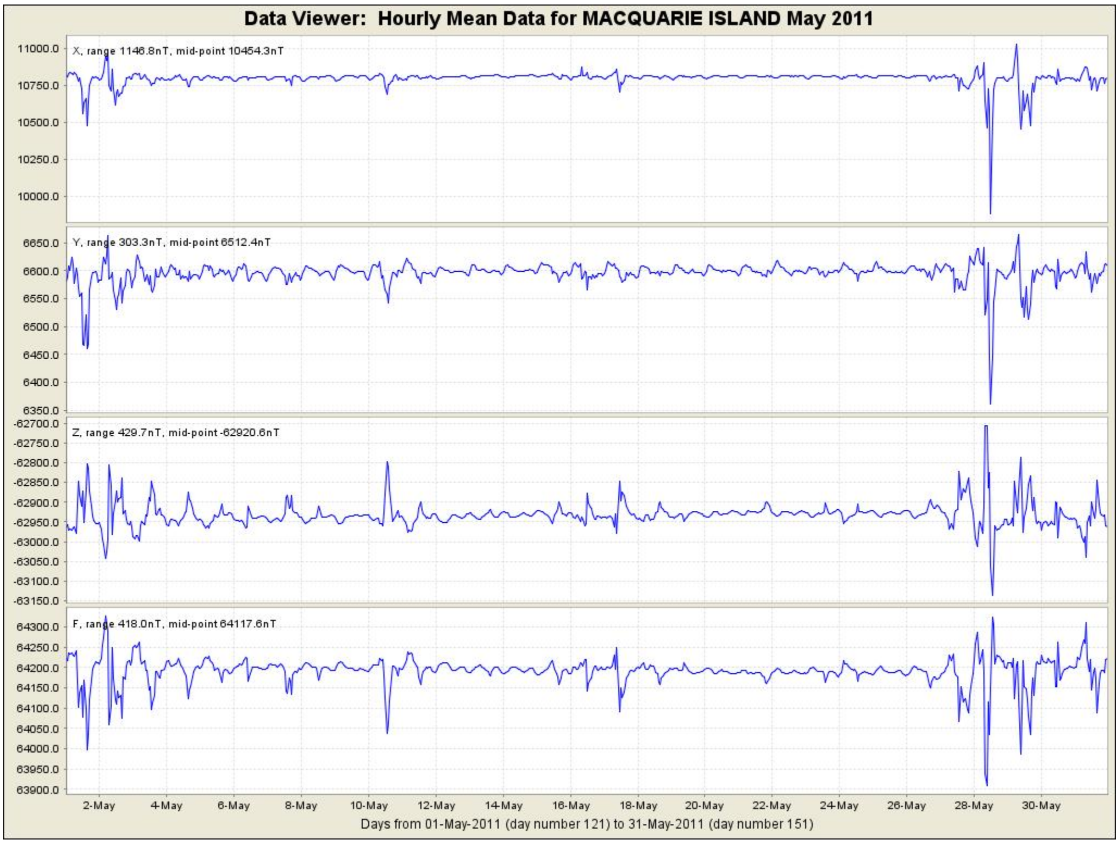

Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Feb 2011
X, range 438.6nT, mid-point 10755.0nT
Y, range 251.5nT, mid-point 6588.0nT
Z, range 283.8nT, mid-point -62877.6nT
F, range 353.9nT, mid-point 64132.3nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)



Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Mar 2011
X, range 1099.2nT, mid-point 10666.7nT
Y, range 686.3nT, mid-point 6401.8nT
Z, range 615.9nT, mid-point -62807.4nT
F, range 826.6nT, mid-point 64015.6nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

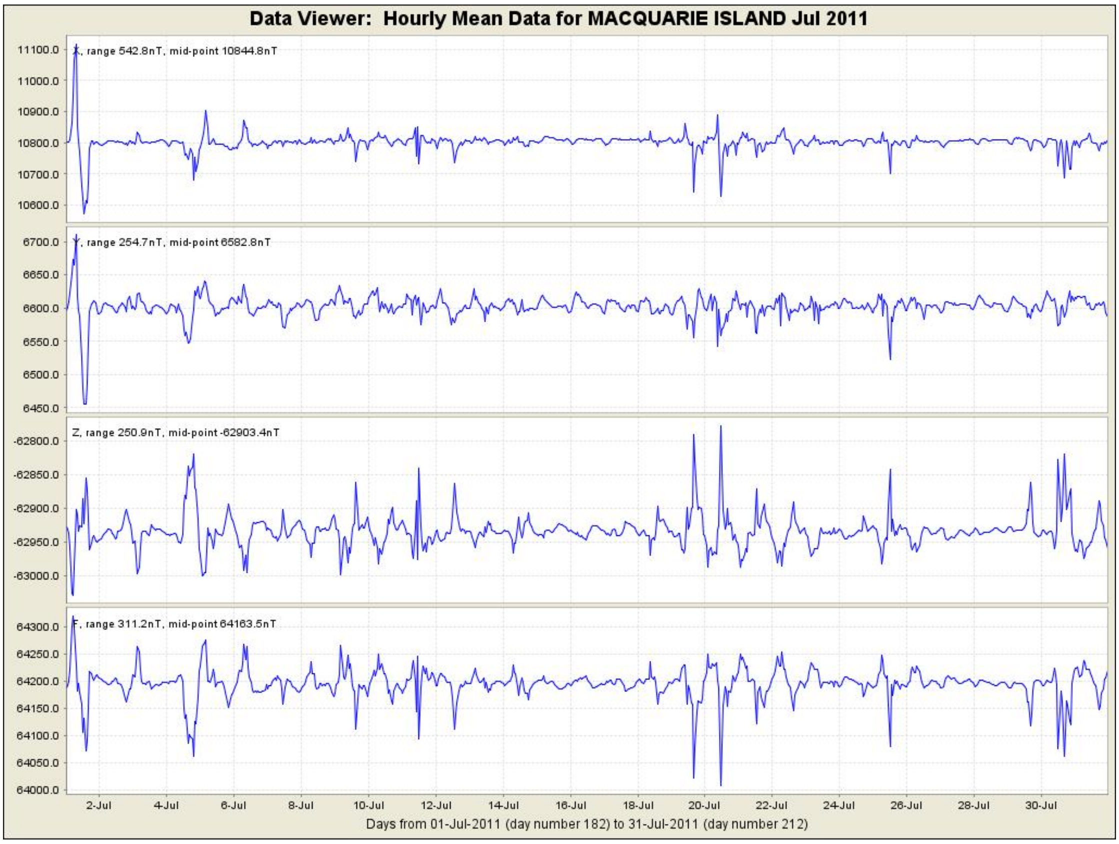


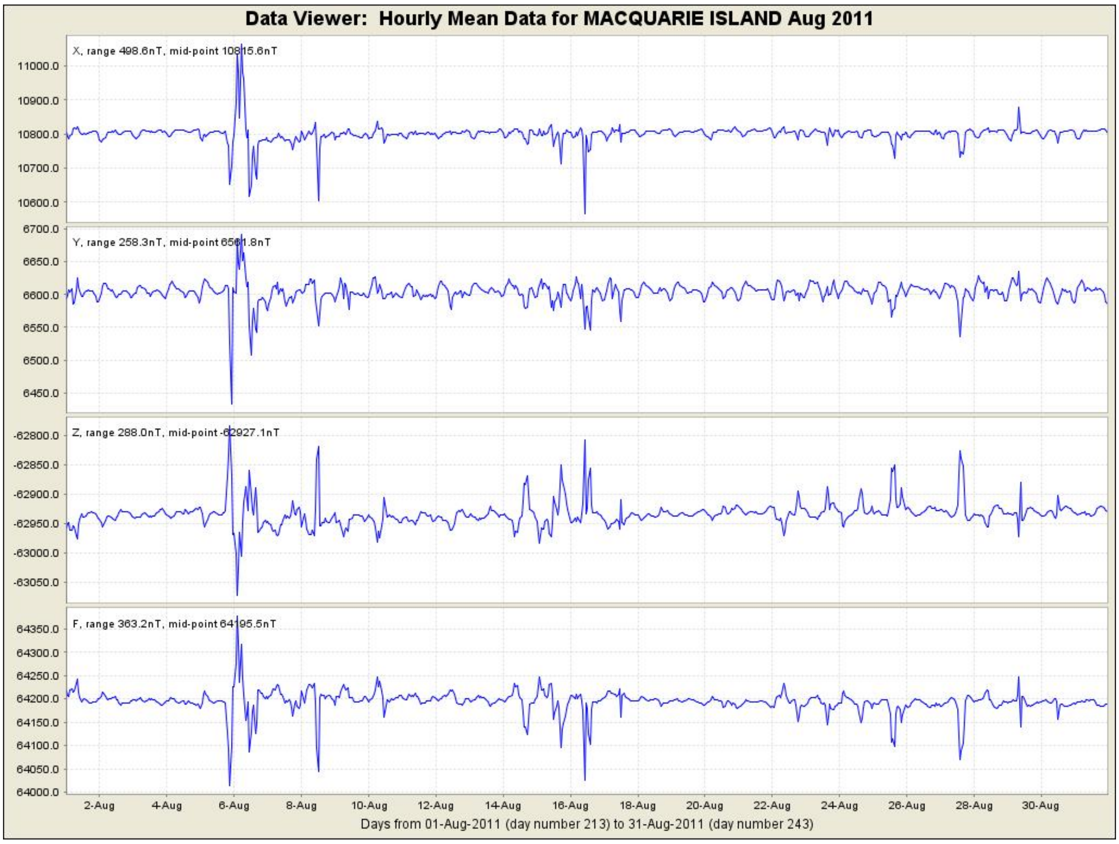
Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Apr 2011
X, range 716.0nT, mid-point 10642.2nT
Y, range 418.3nT, mid-point 6472.0nT
Z, range 419.7nT, mid-point -62841.6nT
F, range 521.7nT, mid-point 64074.7nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

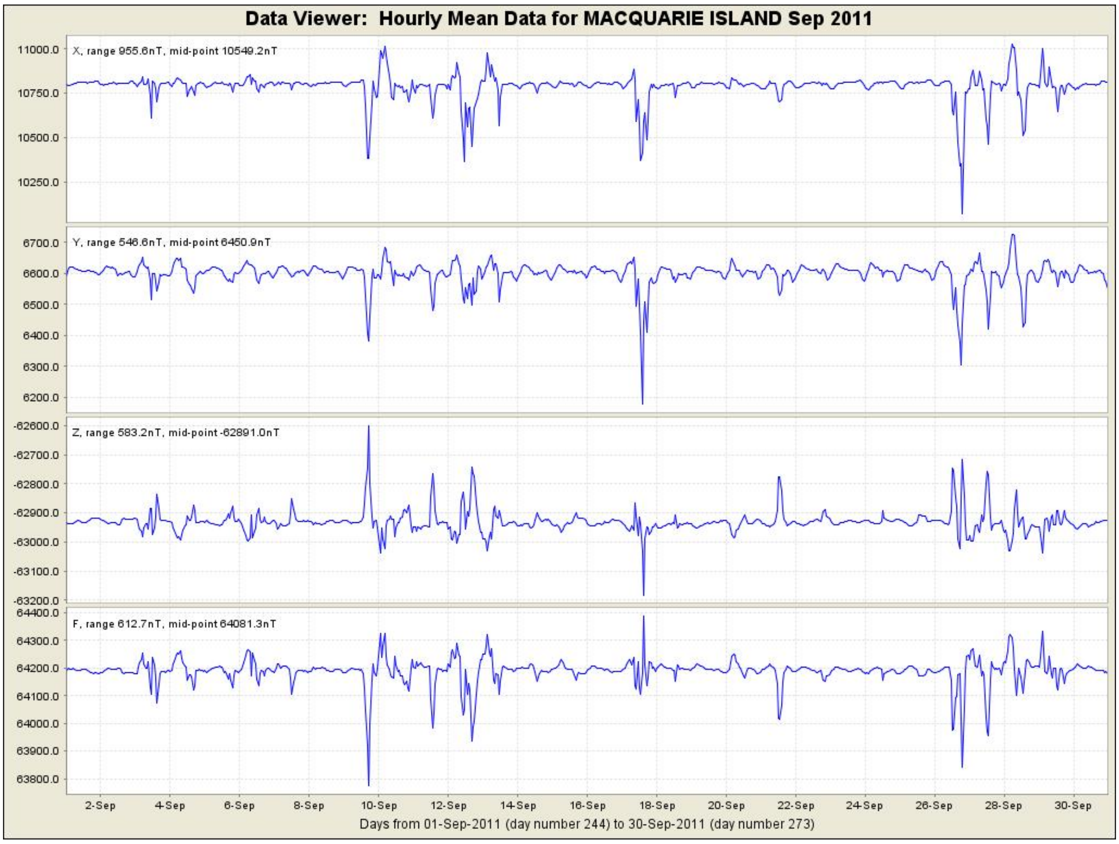


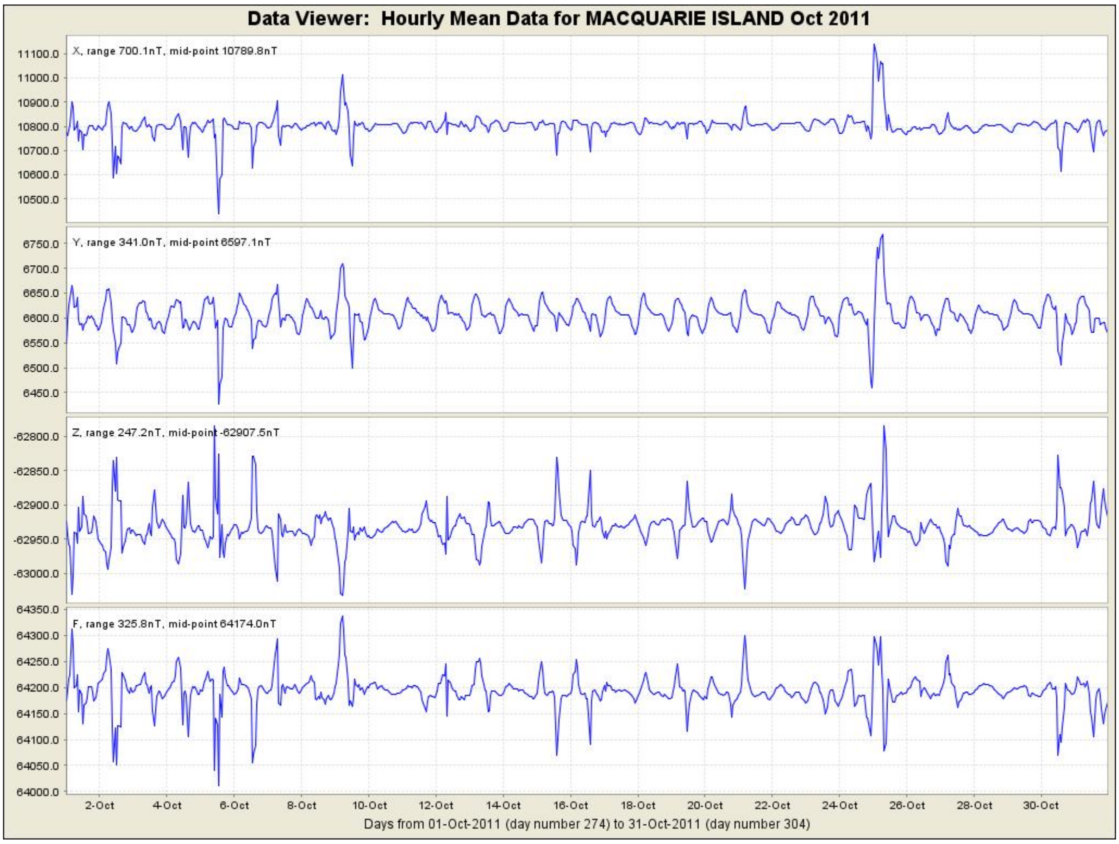
Data Viewer: Hourly Mean Data for MACQUARIE ISLAND May 2011
X, range 1146.8nT, mid-point 10454.3nT
Y, range 303.3nT, mid-point 6512.4nT
Z, range 429.7nT, mid-point -62920.6nT
F, range 418.0nT, mid-point 64117.6nT
2-May
4-May
6-May
8-May
10-May
12-May
14-May
16-May
18-May
20-May
22-May
24-May
26-May
28-May
30-May
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)

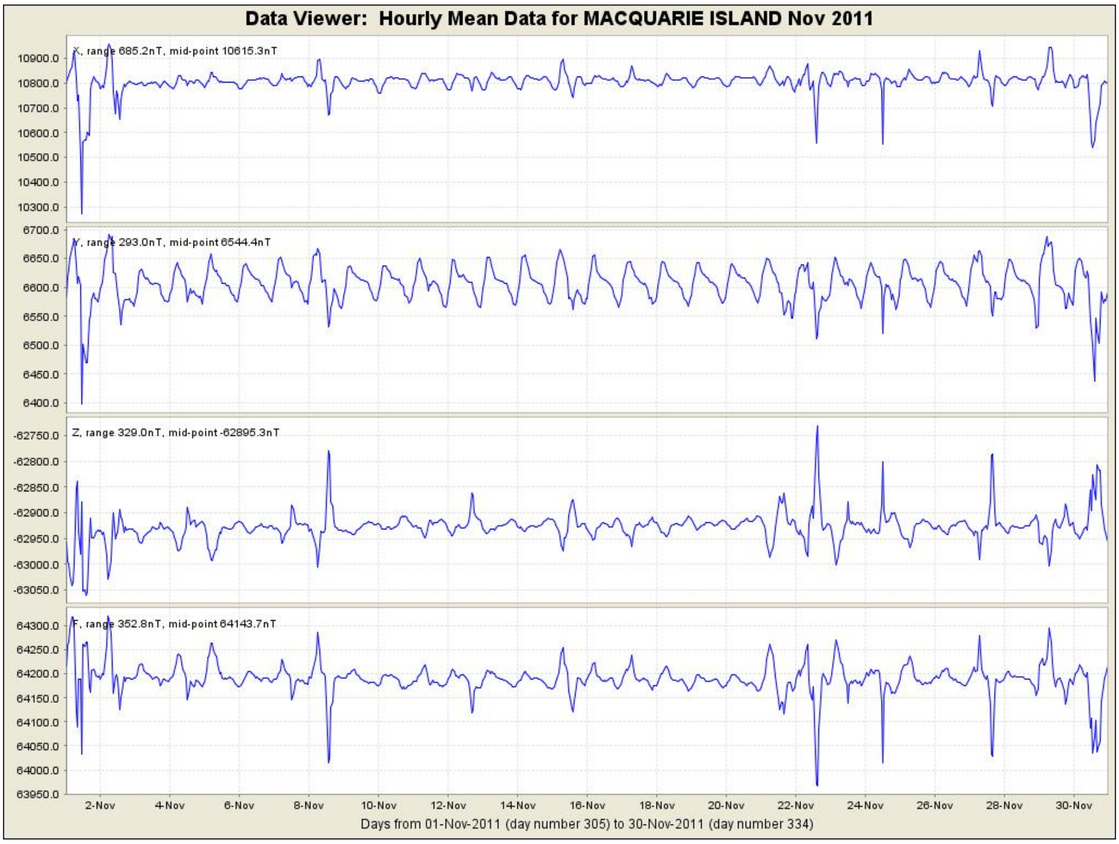
Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Jun 2011
X, range 444.0nT, mid-point 10705.9nT
Y, range 190.0nT, mid-point 6559.5nT
Z, range 250.6nT, mid-point -62922.1nT
F, range 331.6nT, mid-point 64163.4nT
2-Jun
4-Jun
6-Jun
8-Jun
10-Jun
12-Jun
14-Jun
16-Jun
18-Jun
20-Jun
22-Jun
24-Jun
26-Jun
28-Jun
30-Jun
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Jul 2011
X, range 542.8nT, mid-point 10844.8nT
Y, range 254.7nT, mid-point 6582.8nT
Z, range 250.9nT, mid-point -62903.4nT
F, range 311.2nT, mid-point 64163.5nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Aug 2011
X, range 498.6nT, mid-point 10815.6nT
Y, range 258.3nT, mid-point 6561.8nT
Z, range 288.0nT, mid-point -62927.1nT
F, range 363.2nT, mid-point 64195.5nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Sep 2011
X, range 955.6nT, mid-point 10549.2nT
Y, range 546.6nT, mid-point 6450.9nT
Z, range 583.2nT, mid-point -62891.0nT
F, range 612.7nT, mid-point 64081.3nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for MACQUARIE ISLAND Oct 2011
X, range 700.1nT, mid-point 10789.8nT
Y, range 341.0nT, mid-point 6597.1nT
Z, range 247.2nT, mid-point -62907.5nT
F, range 325.8nT, mid-point 64174.0nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)



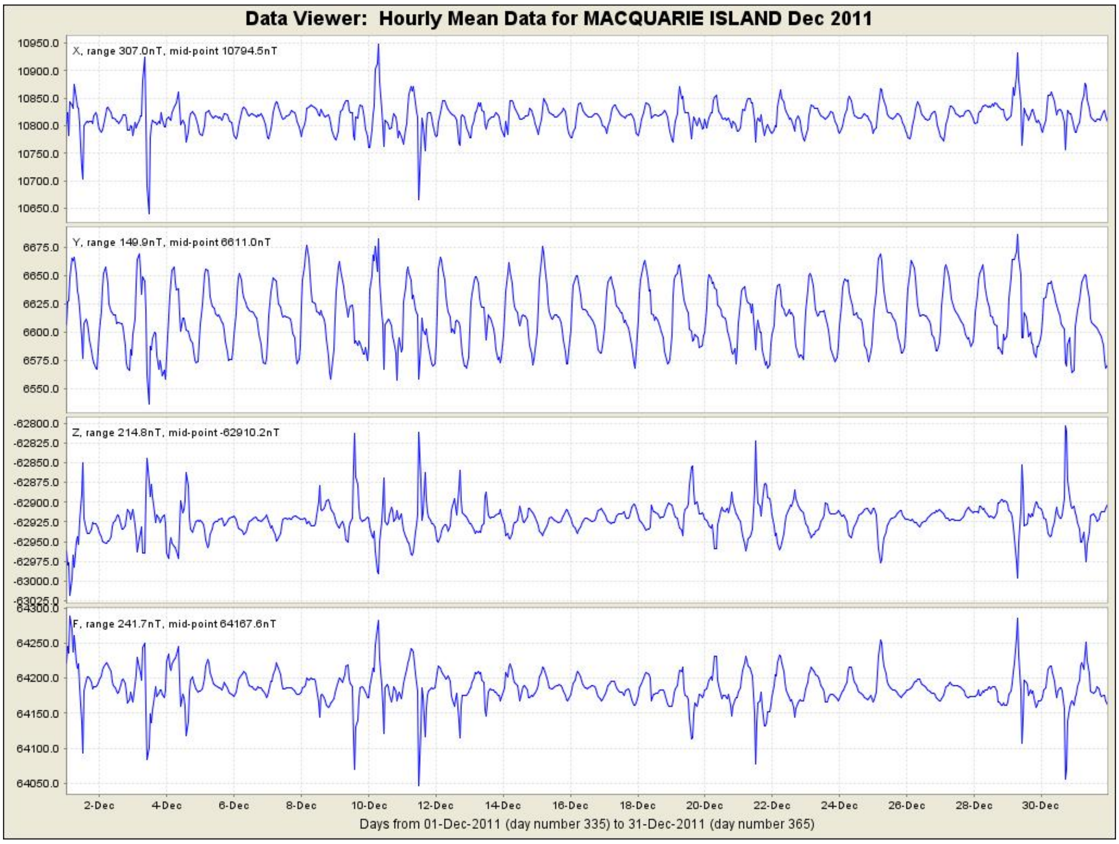


Figure 8.3. *Macquarie Island 2011 hourly mean values in X, Y, Z and F.*

9. Mawson

The magnetic observatory is part of the Mawson scientific research station in Mac Robertson Land, Antarctica. The station is on the edge of Horseshoe Harbour and built on bare charnockite basement rock – there is no ice or soil cover. The magnetic observatory comprises:

- the Variometer House, and;
- the Absolute House;

and is situated in a magnetic quiet zone at East Bay on the southeast extremity of the station.

In 1955 the Mawson observatory commenced recording magnetic variations with a 3-component analogue magnetograph. The observatory has continuously recorded the geomagnetic field at Mawson since that time. In December 1985 the magnetic observatory was converted to digital recording. It was accepted as an INTERMAGNET observatory at the start of 2006. It is operated by Geoscience Australia as part of the Australian National Antarctic Research Expeditions.

Variometers

The variometers used during 2011 are described in Table 9.2. The DMI sensor was located in the recording (eastern) room of the Variometer House. Two of the orthogonal sensors were horizontal and oriented so that they were each at an angle of 45° to the direction of the horizontal component of the magnetic field at the time of installation. The third sensor was aligned vertically. The Narod and total-field sensors were located within the sensor (western) room. Two of the Narod orthogonal sensors were horizontal and oriented so that they were each at an angle of 45° to the direction of the horizontal component of the magnetic field at the time of installation. The third sensor was aligned vertically. The Narod magnetometer produced eight samples per second that were Gaussian filtered and output as 1 second data on the second.

The NGL magnetometer was installed during a maintenance visit to Mawson in late February 2011 (2011-02-25 to 2011-02-28). The previous electronics 9004-1, used at MAW from 1991-2010, failed on 2010-06-23. The 9004-1 electronics and sensor were returned to GA. Sensor 9004-1 arrived at GA in March 2011. Electronics 9004-1 arrived at GA in May 2011. A pulse inverter was installed between the Garmin GPS clock and the new NGL magnetometer, as the GPS produces the opposite polarity pulse to that required by the NGL.

The Overhauser magnetometer was configured for 10 second sampling. During a maintenance visit in February 2011, the 2010 Overhauser variometer magnetometer was replaced and returned to GA. The returned parts were GSM-90 electronics 3091319 and sensor 42175. This indicates that the sensors for the variometer and absolute GSM-90 magnetometers (42175 and 42187) have been incorrectly reported prior to 2010, probably from December 2006.

During the February 2011 maintenance visit, the DMI and NGL magnetometers were connected to independent QNX computers ga-maw-mag1 and ga-maw-mag2 respectively, each with its own battery box power and GPS clock, and sharing a screen and keyboard using a KVM switch. The GSM-90 variometer was connected to ga-maw-mag2 with the NGL magnetometer. GSM-90 data were recorded on both computers by linking it over the QNX *qnet* network from ga-maw-mag1 to ga-maw-mag2. Most vector data during the maintenance visit were excluded from the definitive data set.

Sensor and the electronics temperatures of both fluxgate magnetometers were monitored by in-built dual temperature systems.

Table 9.1. *Key observatory data.*

IAGA code:	MAW
Commenced operation:	1955
Geographic latitude:	67° 36' 14" S
Geographic longitude:	62° 52' 45" E
Geomagnetic latitude:	-73.05°
Geomagnetic longitude:	112.21°
K 9 index lower limit:	1500 nT
Principal pier:	Pier A
Pier elevation (top):	12 m AMSL
Principal reference mark:	BMR89/1
Reference mark azimuth:	350° 36.9'
Reference mark distance:	112 m
Observers:	E. Curtis (to 2011-02-22) I. Phillips (from 2011-03-11)

Temperature regulation during 2011, as in previous years, was not ideal. The heating system (a regulated heater in each sensor room) was inefficient and inadequate. Although there have been attempts to build a controlled heater for a small volume around each magnetometer sensor and each magnetometer electronics within a coarsely controlled low-temperature room environment for many of GA’s observatories, there has been little progress.

Weekly readings of the temperature in the Narod sensor room were not taken after 2011-02-22. The Narod sensor was more temperature stable than the Narod electronics, the DMI sensor and DMI electronics. There were monthly temperature variations of up to 5°C and annual variations of 15-20°C.

None of the equipment is well temperature-stabilised and this is probably a major factor in data quality. Temperature control of the variometers remains a priority in order to improve data quality.

The DMI variometer was used as the primary source of definitive data for Mawson during 2011 (with data gaps filled using Narod data where possible). Real-time data during the year were distributed using the DMI magnetometer data.

Table 9.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	Narod (MAW)
Serial number:	NGL-200907-1 with BMR 9004-3
Type:	ring-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
Scale value:	0.01 nT / count
Period of use:	from 2011-02-26
3-component variometer:	DMI FGE (MW2)
Serial number:	E0291 / S0244
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±10V)
Scale value:	0.32 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	3091319 / 42175
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	to 2011-03-11
Total-field variometer:	GEM Systems GSM-90
Serial number:	8092902 / 83384
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Period of use:	from 2011-03-11
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS16 clock (2)
Communications:	ANARESAT

Spike filters were used to detect sharp spikes in the variometer data. The spike parameters required a spike to have a “spike level” at least 2 nT and 10 times the average of the following minute. Most spike detections on the DMI data were either false detections or indicated periods of generally corrupted data. No spike filtering was applied to the definitive DMI data. Most spike detections on the NGL data were either false detections or indicated range jumps in the variometer. It became apparent that the acquisition system was incorrectly filtering data around range jumps and inserting the spikes. This was not a significant problem but will require correcting in future. The NGL data were therefore spike filtered to remove the artificially generated spikes. A spike filter was not useful for the scalar data as it eliminated apparently valid data during daily auroral zone activity.

As there were two variometers in use at Mawson, it was possible to compare them to gain some estimate of the limitations of the observatory data. Both variometers were calibrated using the same set of absolute measurements. The 440629 minute-value-differences between the two variometers (during the period March-December when both variometers were functioning) had a mean and standard deviation of

ΔX +0.2±0.9 nT ΔY -0.2±1.1 nT ΔZ -0.4±0.6 nT

The scalar GSM-90 variometer(s) performed satisfactorily throughout 2011.

Local meteorological conditions

The meteorological temperature at Mawson during 2011 varied from a minimum -28ºC (2011-05-25) to a maximum +7ºC (2010-12-20). Daily minimum temperatures varied from 28ºC to +1ºC (average 14±7ºC); daily maximum temperatures varied from 22ºC to +7ºC (average 8±7ºC); daily temperature ranges varied from 0ºC to 22ºC (average 6±3ºC).

The daily maximum wind gust varied from 17 to 193 km/h (average 84±29 km/h). The maximum daily maximum wind gust was 193 km/h in October. The minimum daily maximum wind gust was 17 km/h in August. Almost every day was windy due to either blizzard or katabatic conditions. There was from 0 to 17.7 (average 5.5±5.7) hours of sunshine according to the meteorological definition.

Absolute instruments

The principal absolute magnetometers used at Mawson and their adopted corrections for 2011 are described in Table 9.3. DIM D26035/311542 was used until 2011-01-27 and from 2011-03-25 to 2011-04-14. DI0022/353758 was used otherwise during 2011.

(D26035/311542 was returned to GA by Ian Phillips during the 2011/12 summer, arriving at GA 2012-06-04.

DI0132 (PIL7356)/313792 was sent to MAW 2011-12-14 and Darren Henderson confirmed on 2012-03-27 that it had arrived at MAW.)

Table 9.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI (Primary until January 2011)
Serial number:	D26035
Theodolite:	Zeiss 020B
Serial number:	311542
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
DI fluxgate:	DMI (Primary from mid-April 2011)
Serial number:	DI0022
Theodolite:	Zeiss 020B
Serial number:	353758
Resolution:	0.1’
D correction:	0.0’
I correction:	0.0’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	4081417 / 42187
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT

The DI0022/353758-derived sensor-orientation angles δ and ε and the electronics offset T0 were stable throughout the year. D26035/311542 parameters were less stable.

The absolute GSM-90 appeared to perform well, however it appears that there is some small mobile contamination in the Absolute Hut and it is not possible to determine the exact performance of the instrument.

All absolute observations were performed on Pier A while the azimuth mark BMR89/1 was used as the declination reference.

Instrument corrections of zero have been adopted for all Mawson absolute instruments for 2011 as no new evidence about corrections was gathered. At the 2011 mean magnetic field values at Mawson these D, I and F corrections translate to corrections of:

$\Delta X = 0.0$ nT $\qquad$ $\Delta Y = 0.0$ nT $\qquad$ $\Delta Z = 0.0$ nT

Instrument corrections were applied while reducing absolute observations to determine baselines and, accordingly, these corrections have been applied to all Mawson 2011 final data.

Baselines

An automated procedure which fits a linear spline curve to the baseline residuals was used to derive final baseline parameters for the Narod and DMI variometers.

The standard deviations of the differences between the adopted variometer model and data using DMI variometer (used for definitive data) and the absolute observations were:

	σ
X	0.6 nT
Y	0.8 nT
Z	0.5 nT
D	9"
I	2"
F	0.7 nT

(Using 106 observations on 53 days and excluding a pair of observations on 2011-03-11.)

Observed and adopted baseline values in X, Y and Z are shown in Figure 9.1.

For comparison, the standard deviations between the adopted variometer model and data using Narod variometer, and the absolute observations, were:

	σ
X	0.6 nT
Y	0.7 nT
Z	1.0 nT
D	9"
I	4"
F	0.7 nT

(Using 44 observations on 22 days.)

There were some differences between the absolute and variometer GSM-90s throughout the year. During definitive data processing in 2012, it was noticed that there was a change in the difference between the variometer and absolute GSM-90s during absolute observations on 2011-01-01, 2011-09-14 and 2011-11-25. Further investigations indicated that something similar happened between observations on 2010-12-16 and 2010-12-23. It seems likely that there is magnetic contamination in the Absolute Hut or in the vicinity of the Absolute Hut which occasionally moves or changes and causes at least 2 nT errors in absolute measurements. Ian Phillips investigated this issue on occasions during 2011 and could not find the cause. There is a wind generator in the general area which may have the potential to cause interference, although the nature of the interference does not appear consistent with that proposition. The definitive data followed the absolute measurements even though it is likely that at least some of them are contaminated as it is unknown which observations are contaminated.

Operations

The Mawson observer was a member of the Australian National Antarctic Research Expedition and was employed by the Australian Antarctic Division with funding support by Geoscience Australia. Mawson personnel change over each summer with varying periods of overlap. Ian Phillips took over responsibility for the observatory from Ewan Curtis in late February/early March (nominally 1st March) 2011.

The observer was responsible for the continuous operation of the observatory and performed equipment maintenance and installation as required. In 2011 the observers performed absolute observations weekly and forwarded them by email to Geoscience Australia. During the observations the variometer system was also checked. All data processing was performed at Geoscience Australia.

During 2011 data were recorded on two QNX acquisition computers which were connected to the station's radio network hub. Data were retrieved to Geoscience Australia using *rsync* over *ssh* at least every 12 minutes, but normally every 6 minutes. (Data from the alternate variometer system were also retrieved every 6 minutes, interleaved with the primary variometer.)

Real-time data were processed automatically at Geoscience Australia then distributed, usually within a 2 to 15 minute delay.

Variometer data timing

Time stamps applied to variometer data were obtained from the acquisition computer system clock. That clock was synchronised to a GPS clock using both pulse-per-second and absolute-time-code. The clock was checked from Geoscience Australia regularly to ensure it was working. If not, it was reset remotely or, if necessary, the computer was re-booted.

During 2011, on the following 10 occasions, there were corrections in excess of 10 ms on ga-maw-mag1 (DMI variometer) computer:

2011-01-10 01:20:45 -0.143s System restart
2011-01-21 00:57:35 -0.054s Unknown
2011-02-25 14:47:50 +0.230s Maintenance activity
2011-02-25 15:08:06 +0.149s Maintenance activity
2011-02-26 08:02:24 +0.746s Maintenance activity
2011-02-26 22:54:05 +1.061s Maintenance activity
2011-02-28 07:12:48 +0.864s Maintenance activity
2011-04-13 04:55:28 -0.194s Unknown
2011-06-22 06:10:24 -0.014s System reboot as Clock program failed
2011-08-22 03:58:03 +0.488s System reboot as Clock program failed

There were 27 corrections between 1and 2 ms on:

- February 06, 21
- March 04, 17, 18, 20, 28, 30, 31
- April 16
- May 02, 04, 25, 29
- June 06

- July 30
- August 06, 22
- September 24
- October 22, 24, 30
- November 01, 04, 26
- December 18 (2)

The rate of the system clock was 15-20ppm.

There were no time corrections in excess of 1 ms on ga-maw-mag2 (NGL variometer) computer after the completion of the new NGL installation 2011-03-01 throughout the rest of 2011. The rate of the system clock was adjusted to <1ppm.

Daily data plots were examined at Geoscience Australia for possible problems which were usually rectified quickly by the local observer. The final data for the year were reduced and analysed by Geoscience Australia staff.

During 2011, the INTERMAGNET filter was applied to convert 1 second vector real-time and final data to 1 minute data. A box filter (±30seconds from the minute mark) was applied to scalar data.

The distribution of Mawson 2011 data is described in Table 9.4. Data losses are identified in Table A.8.

Table 9.4. *Distribution of Mawson 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily
INTERMAGNET	definitive	July 2012

Significant events

2011-01-06	Interference 05:42:00 – 05:58:00 noted on DMI variometer (No NGL variometer available). No cause reported from MAW.
2011-02-07	Interference 08:48:00 – 11:07:15 noted on DMI variometer (NO NGL variometer available). No cause reported from MAW.
2011-02-25	Terry Smith arrives at MAW for maintenance visit
2011-02-28	Terry Smith departs MAW. Data 2011-02-25T10:55 to 2011-02-28T07:17 will be removed from definitive data set. Raw data exists for DMI through most of this period; raw data exists for NGL from 2011-02-26.
2011-03-22	Received at GA the MAW 1991-2010 NGL BMR 9004-1 sensor
2011-??-??	Received at GA the MAW GSM90 3091319 + sensor 42175 (post Terry's visit, ex variometer)

2011-05-09	Received at GA box from AAD containing MAW NGL electronics BMR 9004-1 (BMR0002494), with serial and power cables, sensor cable, EDA sensor BMR0003138 and sensor cable
2011-05-11	06:57 - 07:03 Ian in variometer hut 09:00 plumber in variometer hut checking for fire extinguishers - none in hut
2011-06-22	Fixing Clock at MAW ga-maw-mag1 RESET began 2011-06-19 12:00:01 22/06/11 06:10:24 - CLK I 0 Correction 1308723024 845389914 C 0 s -13938677 R 0 s 15467 22/06/11 06:11:06 - CLK I 0 Correction 1308723066 846210156 C 0 s 17159 R 0 s 15460
2011-06-29	Interference 10:04:30-10:06:30 noted in both variometers. No cause reported from MAW.
2011-07-19	Electronics temperature behaving strangely. Rising and falling over short periods.
2011-07-25	Narod lost data between 01:37:54 to 01:38:47 (less tha 1m). slay GdapNGL2 and re-started GdapNGL2. DMI lost data from 2011-07-23T10:04:57 to 2011-07-25T02:24:18. slay and re-start GdapAdam.
2011-08-08	Chippie intruded into the quiet zone for inspections. Ian's report Time period for inspections was: Entered MQZ @ 0545Z, Departed MQZ @ 0605Z Noticed brief contamination 05:46
2011-08-17	23:40 lost contact with GPS clock on DMI system (ga-maw-mag1)
2011-08-18	(Also, you may note a disturbance in the variometer data between 07:16 and 07:18Z (2011-08-18) I went into the rooms and had a quick look to make sure everything looked normal as it had been a while since I last checked. All good. Ian P.)
2011-08-22	03:40 Stop and restart GdapClock on DMI system (ga-maw-mag1) 03:54 reboot system 03:58:03 - CLK I 0 Correction 1313985483 509595668 C 0 s 488210114 R 0 s 15453 Multiple backward time jumps in MAW data
2011-10-22	03:58 DMI (MAW) variometer stops delivering data
2011-10-23	22:00 stop and restart GdapAdam to get variometer data flowing again

Annual mean values

The annual mean values for Mawson are set out in Table 9.5 and displayed with the secular variation in Figure 9.2.

Hourly mean values

Plots of the hourly mean values for Mawson 2011 data are shown in Figure 9.3.

K indices

Table 9.6 shows Mawson K indices for 2011. They have been derived using a computer-assisted method developed at Geoscience Australia and based on the IAGA-accepted LRNS algorithm. K indices were scaled from preliminary data from the DMI variometer during 2011 (with gaps filled in with Narod preliminary data). The frequency distribution of the K indices and the annual mean daily K sum are given in Table 9.7.

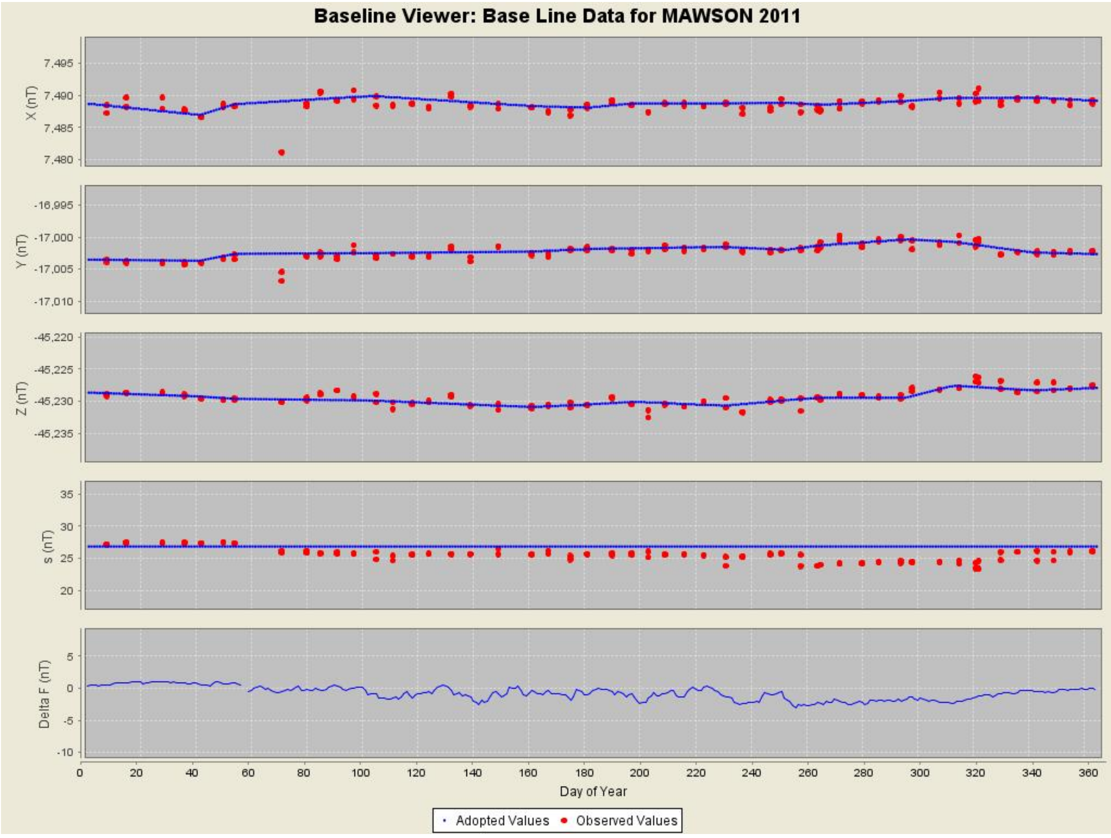


Figure 9.1. *Mawson 2011 baseline plots.*

Table 9.5. *Mawson annual mean values calculated using monthly mean values over **All** days, the 5 International **Quiet** days and the 5 International **Disturbed** days in each month. Plots of these data with secular variation in X, Y, Z and F are shown in Figure 9.2.*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
1955.5		-58	38.1	-69	33.3	18272	9510	-15602	-49012	52307	DHZ
1956.5		-58	53.2	-69	32.5	18282	9447	-15652	-49006	52305	DHZ
1957.5		-59	08.7	-69	31.1	18292	9381	-15703	-48974	52279	DHZ
1958.5		-59	25.6	-69	30.3	18293	9305	-15750	-48940	52247	DHZ
1959.5		-59	42.6	-69	28.5	18293	9227	-15796	-48860	52172	DHZ
1960.5		-59	59.6	-69	25.2	18323	9163	-15867	-48800	52127	DHZ
1961.5		-60	14.6	-69	23.1	18322	9094	-15906	-48707	52039	DHZ
1962.5		-60	30.1	-69	21.1	18333	9027	-15956	-48650	51990	DHZ
1963.5		-60	45.2	-69	17.6	18356	8968	-16016	-48562	51915	DHZ
1964.5		-60	59.2	-69	15.4	18353	8901	-16050	-48460	51819	DHZ
1965.5		-61	12.6	-69	13.1	18356	8840	-16087	-48368	51734	DHZ
1966.5		-61	24.0	-69	09.6	18362	8790	-16122	-48235	51612	DHZ
1967.5		-61	34.4	-69	07.2	18374	8747	-16159	-48168	51553	DHZ
1968.5		-61	43.8	-69	05.2	18365	8698	-16175	-48060	51449	DHZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1969.5		-61	53.0	-69	03.4	18353	8649	-16187	-47954	51346	DHZ
1970.5		-62	00.5	-69	00.4	18358	8616	-16210	-47840	51241	DHZ
1971.5		-62	05.3	-68	56.4	18375	8602	-16237	-47719	51135	DHZ
1972.5		-62	11.4	-68	53.1	18381	8575	-16258	-47600	51026	DHZ
1973.5		-62	17.6	-68	49.7	18391	8551	-16282	-47486	50923	DHZ
1974.5		-62	24.8	-68	47.2	18390	8516	-16299	-47380	50824	DHZ
1975.5		-62	31.4	-68	44.0	18397	8488	-16322	-47269	50723	DHZ
1976.5		-62	37.3	-68	40.0	18418	8470	-16355	-47157	50626	DHZ
1977.5		-62	43.9	-68	36.9	18425	8442	-16377	-47051	50530	DHZ
1978.5		-62	51.9	-68	35.5	18421	8402	-16393	-46986	50468	DHZ
1979.5		-62	57.9	-68	32.9	18425	8375	-16412	-46890	50380	DHZ
1980.5		-63	05.8	-68	29.8	18432	8340	-16437	-46784	50284	DHZ
1981.5		-63	14.6	-68	27.1	18443	8303	-16468	-46705	50215	DHZ
1982.5		-63	21.2	-68	25.5	18433	8267	-16475	-46616	50128	DHZ
1983.5		-63	26.6	-68	22.3	18439	8244	-16494	-46503	50025	DHZ
1984.5		-63	33.1	-68	19.3	18446	8216	-16515	-46404	49936	DHZ
1985.5		-63	40.2	-68	17.0	18457	8186	-16542	-46342	49882	DHZ
1986.5		-63	48.7	-68	15.1	18460	8147	-16565	-46276	49822	XYZ
1987.5		-63	56.6	-68	12.5	18470	8113	-16593	-46198	49753	XYZ
1988.5		-64	04.4	-68	10.7	18475	8078	-16616	-46142	49703	XYZ
1989.5		-64	12.8	-68	09.7	18474	8037	-16634	-46099	49663	XYZ
1990.5		-64	21.1	-68	06.4	18492	8004	-16670	-46015	49592	XYZ
1991.5		-64	28.8	-68	04.2	18502	7971	-16697	-45957	49542	XYZ
1992.5	A	-64	36.9	-68	02.8	18499	7930	-16712	-45894	49482	XYZ
1993.5	A	-64	44.2	-68	00.7	18506	7898	-16736	-45830	49426	XYZ
1994.5	A	-64	52.9	-67	59.4	18511	7858	-16760	-45794	49394	XYZ
1995.5	A	-65	00.9	-67	56.7	18532	7828	-16798	-45741	49352	XYZ
1996.5	A	-65	09.8	-67	54.5	18548	7791	-16833	-45698	49319	XYZ
1997.5	A	-65	19.4	-67	53.0	18560	7749	-16865	-45670	49297	XYZ
1998.5	A	-65	29.1	-67	52.4	18561	7702	-16887	-45648	49278	XYZ
1999.5	A	-65	39.0	-67	51.5	18561	7653	-16910	-45618	49250	XYZ
2000.5	A	-65	48.2	-67	50.6	18566	7610	-16935	-45594	49230	XYZ
2001.5	A	-65	56.2	-67	49.8	18567	7571	-16953	-45565	49203	XYZ
2002.5	A	-66	05.8	-67	49.3	18568	7524	-16975	-45546	49185	ABZ
2003.5	A	-66	15.6	-67	50.7	18546	7466	-16976	-45546	49177	ABZ
2004.5	A	-66	24.1	-67	49.6	18549	7426	-16998	-45514	49149	ABZ
2005.5	A	-66	33.0	-67	50.1	18535	7376	-17004	-45499	49129	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
2006.5	A	-66	40.8	-67	49.3	18536	7338	-17022	-45472	49105	ABZ
2007.5	A	-66	49.2	-67	49.2	18533	7295	-17037	-45460	49093	ABZ
2008.5	A	-66	58.1	-67	49.4	18528	7249	-17051	-45454	49085	ABZ
2009.5	A	-67	06.6	-67	48.9	18533	7209	-17073	-45448	49082	ABZ
2010.5	A	-67	16.8	-67	49.5	18531	7157	-17093	-45466	49097	ABZ
2011.5	A	-67	27.5	-67	49.9	18534	7105	-17118	-45487	49118	ABZ
1992.5	Q	-64	36.5	-68	01.7	18513	7938	-16724	-45885	49479	XYZ
1993.5	Q	-64	43.6	-67	59.4	18522	7908	-16749	-45819	49422	XYZ
1994.5	Q	-64	51.8	-67	57.4	18537	7874	-16781	-45779	49389	XYZ
1995.5	Q	-65	00.4	-67	55.3	18550	7838	-16813	-45731	49350	XYZ
1996.5	Q	-65	09.2	-67	53.5	18561	7799	-16843	-45692	49318	XYZ
1997.5	Q	-65	18.9	-67	52.0	18572	7757	-16875	-45663	49295	XYZ
1998.5	Q	-65	28.6	-67	51.3	18575	7710	-16900	-45642	49277	XYZ
1999.5	Q	-65	38.5	-67	50.2	18579	7663	-16925	-45611	49250	XYZ
2000.5	Q	-65	48.0	-67	49.6	18579	7616	-16946	-45585	49225	XYZ
2001.5	Q	-65	56.3	-67	48.9	18577	7574	-16963	-45555	49198	XYZ
2002.5	Q	-66	05.2	-67	48.2	18581	7532	-16986	-45540	49185	ABZ
2003.5	Q	-66	14.7	-67	48.7	18570	7480	-16997	-45532	49174	ABZ
2004.5	Q	-66	23.5	-67	48.1	18568	7436	-17014	-45503	49146	ABZ
2005.5	Q	-66	32.1	-67	48.4	18557	7389	-17022	-45488	49127	ABZ
2006.5	Q	-66	39.9	-67	48.1	18552	7349	-17035	-45465	49105	ABZ
2007.5	Q	-66	48.7	-67	48.4	18544	7302	-17046	-45455	49092	ABZ
2008.5	Q	-66	57.6	-67	48.6	18539	7256	-17060	-45450	49085	ABZ
2009.5	Q	-67	06.3	-67	48.4	18540	7213	-17080	-45447	49083	ABZ
2010.5	Q	-67	16.2	-67	48.5	18544	7165	-17104	-45460	49097	ABZ
2011.5	Q	-67	27.3	-67	48.9	18546	7111	-17128	-45480	49115	ABZ
1992.5	D	-64	39.6	-68	05.2	18466	7904	-16689	-45907	49482	XYZ
1993.5	D	-64	45.9	-68	03.0	18476	7877	-16713	-45847	49430	XYZ
1994.5	D	-64	55.3	-68	01.9	18476	7831	-16734	-45804	49390	XYZ
1995.5	D	-65	01.7	-67	58.8	18504	7812	-16774	-45752	49353	XYZ
1996.5	D	-65	11.1	-67	56.2	18525	7775	-16814	-45707	49318	XYZ
1997.5	D	-65	20.4	-67	55.0	18534	7733	-16844	-45682	49299	XYZ
1998.5	D	-65	30.9	-67	54.8	18530	7680	-16864	-45665	49282	XYZ
1999.5	D	-65	41.0	-67	53.9	18528	7630	-16884	-45626	49245	XYZ
2000.5	D	-65	49.7	-67	52.6	18543	7593	-16917	-45614	49239	XYZ
2001.5	D	-65	56.4	-67	51.6	18547	7561	-16935	-45583	49212	XYZ
2002.5	D	-66	07.6	-67	51.2	18540	7504	-16953	-45552	49180	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
2003.5	D	-66	17.4	-67	53.2	18510	7443	-16947	-45556	49173	ABZ
2004.5	D	-66	26.0	-67	52.1	18517	7403	-16972	-45530	49152	ABZ
2005.5	D	-66	35.4	-67	53.4	18492	7347	-16970	-45516	49129	ABZ
2006.5	D	-66	42.6	-67	51.6	18504	7316	-16997	-45482	49102	ABZ
2007.5	D	-66	50.0	-67	50.7	18512	7282	-17019	-45463	49087	ABZ
2008.5	D	-66	59.2	-67	51.0	18506	7235	-17034	-45461	49084	ABZ
2009.5	D	-67	07.3	-67	49.9	18520	7200	-17063	-45454	49082	ABZ
2010.5	D	-67	17.8	-67	51.2	18508	7143	-17074	-45475	49097	ABZ
2011.5	D	-67	28.2	-67	51.3	18516	7094	-17103	-45495	49119	ABZ

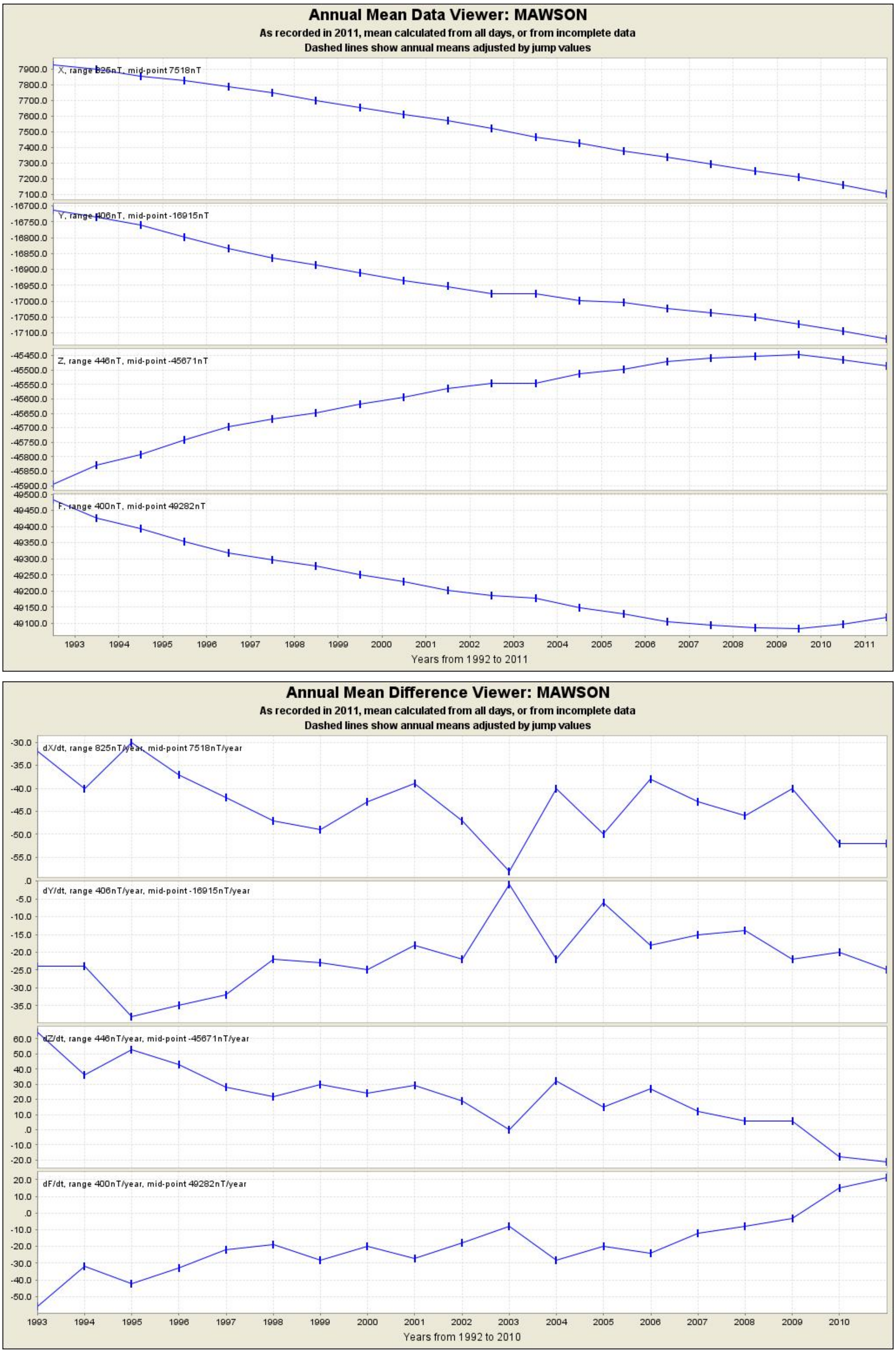


Figure 9.2. *Mawson annual mean values and secular variation (all days) for X, Y, Z and F.*

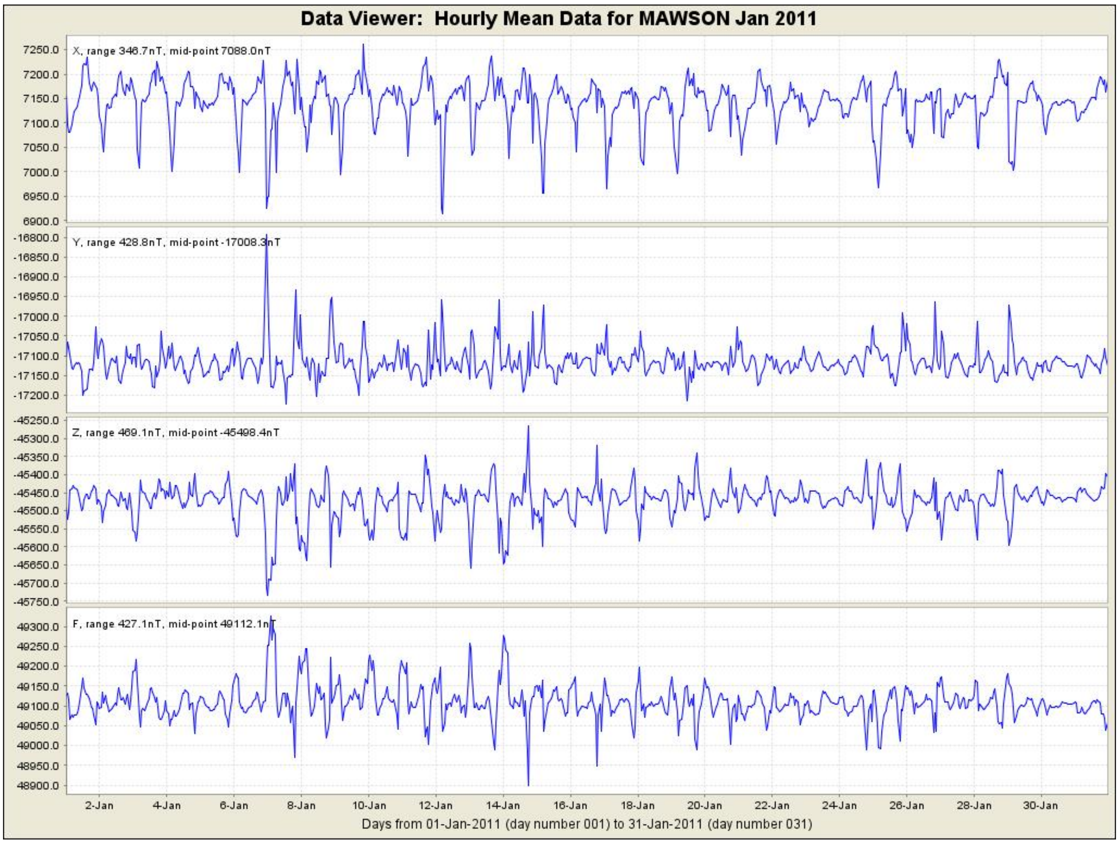
Table 9.6. *Mawson 2011 K indices and daily K sums.*

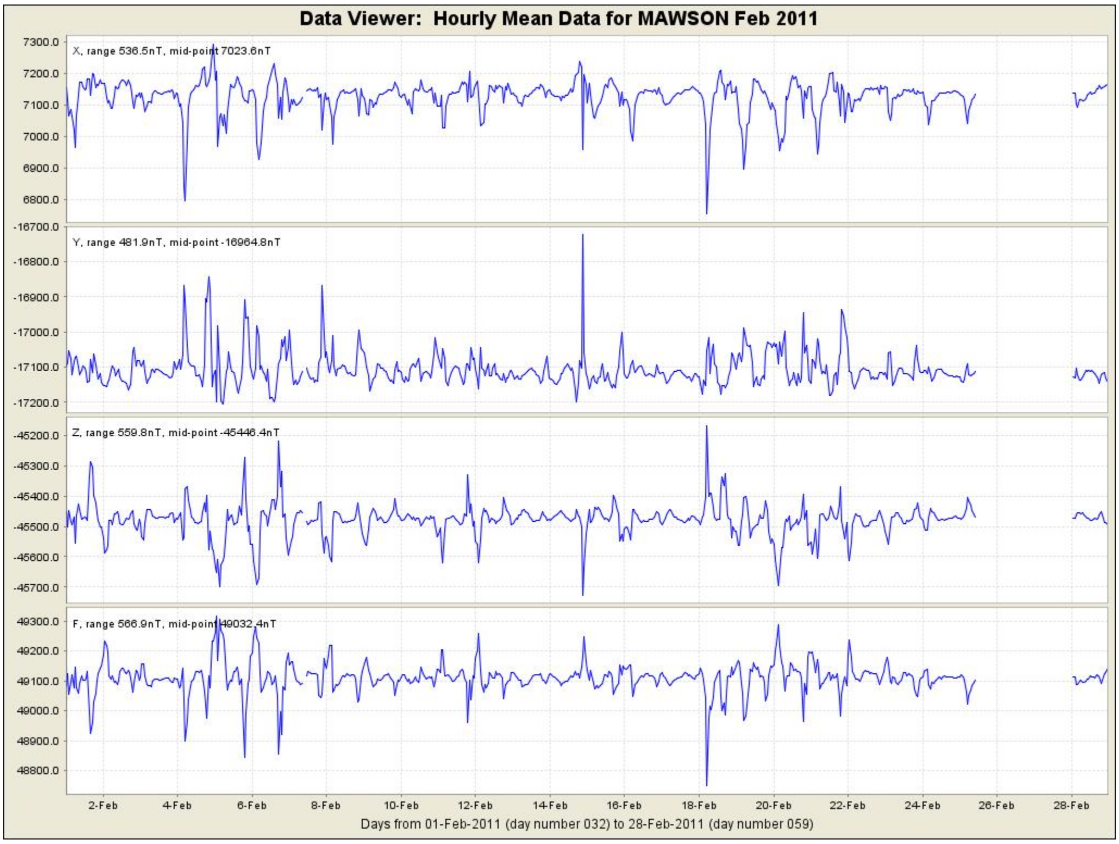
Day	January			February			March			April			May			June		
01	3222	3315	21	4443	3542	29	4554	4574	38	3122	2456	25	4544	4665	38	4343	3437	31
02	3421	3243	22	3333	2353	25	6554	5576	43	6444	3267	36	6564	2666	41	4363	2355	31
03	3412	2343	22	3212	0113	13	3544	4657	38	6644	3467	40	6644	3366	38	3222	1002	12
04	3421	2233	20	3642	2377	34	3553	3576	37	5532	2254	28	3333	3324	24	4231	0137	21
05	1011	2134	13	6544	3365	36	3332	2265	26	5432	0036	23	2431	3263	24	7443	2343	30
06	4421	1236	23	4544	3555	35	1210	2226	16	4433	5566	36	3222	2115	18	2343	2265	27
07	6443	4365	35	4211	2246	22	4421	2465	28	3431	1233	20	4112	2365	24	3222	2357	26
08	4344	4355	32	3522	1156	25	5432	2356	30	3112	2456	24	4110	0025	13	6533	3356	34
09	3432	3354	27	3312	1134	18	4321	2154	22	5543	3224	28	4300	0100	8	6632	3255	32
10	3233	3234	23	2233	3125	21	4664	3466	39	4230	2354	23	2234	3477	32	3144	3135	24
11	3432	3365	29	3421	2254	23	6553	3666	40	4212	2342	20	3431	1134	20	4463	2233	27
12	3643	2233	26	3423	2242	22	6443	2245	30	2454	4416	30	4320	0004	13	5333	3325	27
13	5432	3657	35	2111	1124	13	3223	2443	23	6554	3223	30	2122	0110	9	4323	2325	24
14	4444	4556	36	1110	1447	19	3332	0001	12	2432	0115	18	4400	0133	15	4434	2246	29
15	3532	3333	25	4343	3225	26	2200	0000	4	5322	2124	21	2323	2435	24	4342	4305	25
16	2322	2254	22	2331	1013	14	1121	0001	6	1232	1125	17	4344	3353	29	3211	2421	16
17	4422	3234	24	2221	1022	12	1310	1162	15	3101	0124	12	4335	3265	31	3521	3454	27
18	4332	2224	22	3654	4434	33	2210	0122	10	1133	3313	18	3432	2233	22	5333	2113	21
19	3334	4441	26	4434	3254	29	3113	2114	16	2220	1113	12	3211	2113	14	3223	3134	21
20	2222	3254	22	4453	4365	34	3310	2446	23	4753	3125	30	3110	0100	6	5543	3145	30
21	3311	3343	21	4433	2356	30	5310	0235	19	1211	0114	11	0122	0152	13	4543	3363	31
22	2311	2233	17	4311	2132	17	4521	2004	18	5422	2224	23	2420	1110	11	5443	3446	33
23	2211	1100	8	4421	1244	22	3343	2466	31	4212	2211	15	1100	1245	14	7544	4446	38
24	1121	1245	17	2311	1000	8	2121	2011	10	1111	1436	18	5432	2324	25	5653	4466	39
25	4322	3235	24	1312	1145	18	2021	2214	14	3430	1122	16	4210	0015	13	3434	3335	28
26	4220	1364	22	1321	1345	20	3200	0000	5	1212	1134	15	3221	3354	23	5633	2254	30
27	4212	3120	15	2102	1122	11	1000	0014	6	3020	0110	7	4343	3665	34	3222	2135	20
28	5401	2333	21	1210	0112	8	3111	0233	14	0120	0154	13	6463	6327	37	4300	1000	8
29	5421	2222	20				3000	0224	11	3331	1357	26	7874	3576	47	0111	0001	4
30	3210	0100	7				3300	1000	7	4455	4366	37	6453	3335	32	3410	0123	14
31	2112	1124	14				0111	1344	15				5654	3276	38			

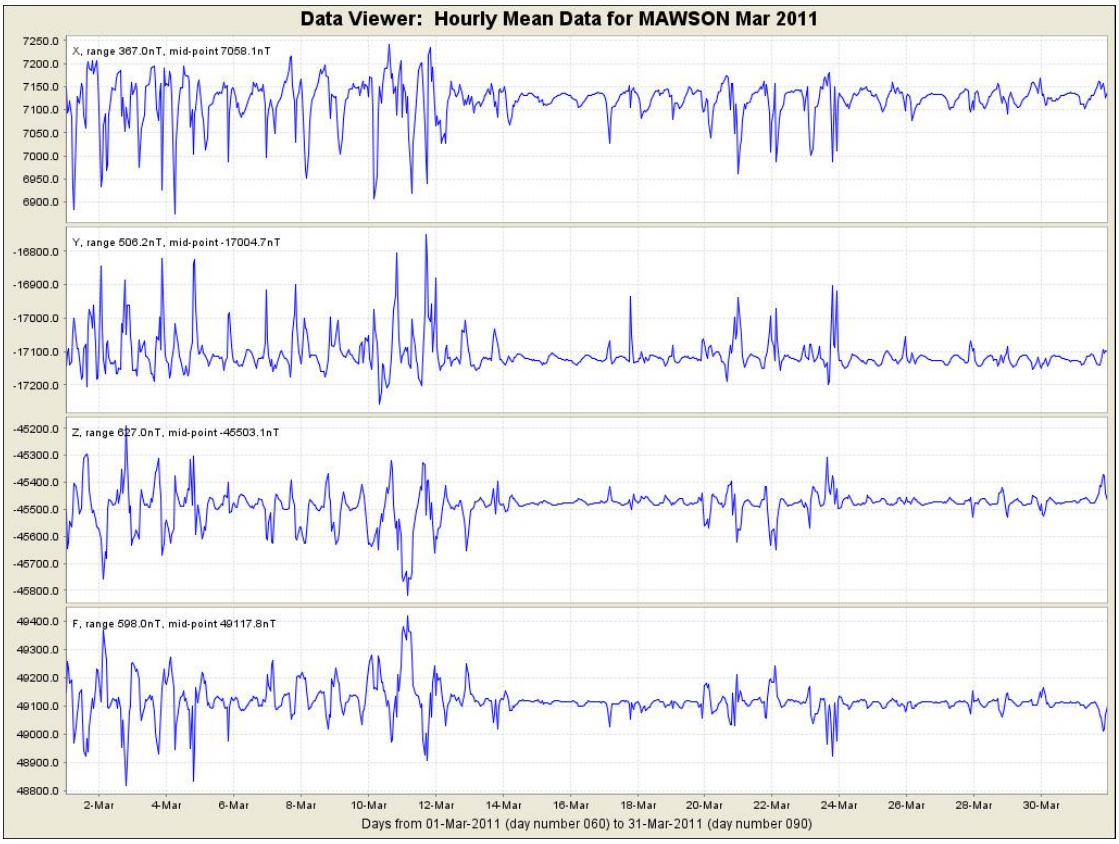
Day	July			August			September			October			November			December		
01	4653	3544	34	3653	2125	27	3300	0024	12	7633	4366	38	4446	4435	34	5533	3143	27
02	1122	1256	20	5322	1131	18	3310	0232	14	3443	3366	32	5443	4433	30	2222	2234	19
03	5732	1001	19	3010	0145	14	4443	2445	30	1122	3355	22	3321	1133	17	3345	3566	35
04	4324	3467	33	0000	0115	7	5542	3534	31	3233	3233	22	2321	2255	22	5323	3213	22
05	6743	4155	35	6521	2369	34	3112	2464	23	5334	5622	30	4432	1233	22	3321	1144	19
06	4453	2246	30	7755	4313	35	3553	3343	29	2432	3233	22	2111	1302	11	2000	1112	7
07	5222	3255	26	5432	2356	30	5432	3154	27	3443	1224	23	1321	2223	16	1210	0113	9
08	3232	2255	24	3433	3115	23	3211	1001	9	3321	2336	23	4532	3321	23	2001	1242	12
09	4622	2336	28	6553	2255	33	2321	3657	29	5453	2225	28	2211	0111	9	3322	4413	22
10	4443	2334	27	5443	3254	30	8765	3466	45	3320	0020	10	2221	2254	20	5553	2355	33
11	5455	4355	36	2322	1265	23	5442	4266	33	1121	1333	15	2332	2030	15	4342	4454	30
12	6433	4363	32	2422	3253	23	7753	5575	44	2432	1163	22	0022	2221	11	4332	3335	26
13	5423	3211	21	3311	2034	17	6764	3255	38	3432	1001	14	3221	0001	9	3323	3224	22
14	4543	3235	29	4332	2555	29	2222	1334	19	2210	1103	10	2210	0001	6	4421	1222	18
15	4421	1233	20	5443	3346	32	2331	1265	23	6322	2312	21	1233	3434	23	2220	1111	10
16	1232	1032	14	3332	3234	23	2211	1114	13	3522	3035	23	4321	1123	17	2200	1001	6
17	3321	1134	18	4322	3223	21	2545	5665	38	3321	1115	17	3431	2243	22	1000	2124	10
18	2343	2233	22	2100	1133	11	2212	1334	18	4320	1111	13	2321	2113	15	3011	1022	10
19	2243	4367	31	1000	0004	5	2220	0000	6	4522	2012	18	3100	1000	5	4331	3353	25
20	5554	3366	37	3220	0126	16	2543	2154	26	4421	1251	20	1010	1133	10	5332	2354	27
21	6553	4356	37	3110	0014	10	0121	2222	12	5331	1134	21	3422	3326	25	3422	4345	27
22	5553	3366	36	5222	1235	22	4111	1455	22	3310	1000	8	3333	4432	25	4422	2244	24
23	4533	2264	29	5121	2262	21	3210	0014	11	0121	2223	13	4533	2245	28	2432	2000	13
24	4112	2234	19	5420	1205	19	1021	1143	13	3341	0267	26	4433	4346	31	1331	2223	17
25	2543	4255	30	5321	2255	25	2202	1222	13	6763	3222	31	5532	1125	24	4431	0010	13
26	5443	3134	27	1120	0145	14	3224	4786	36	3331	0224	18	3222	2334	21	1210	0112	8
27	3311	0003	11	3210	1433	17	5553	4337	35	3422	3044	22	2433	4433	26	2220	0000	6
28	3210	0004	10	3333	1134	21	6564	4564	40	2200	0003	7	2110	1134	13	1111	2333	15
29	1000	0331	8	4333	3235	26	8743	2444	36	2000	0111	5	5553	2363	32	3443	3335	28
30	1122	2475	24	4101	2254	19	5311	1122	16	4311	2315	20	4323	5556	33	4421	2343	23
31	5454	3256	34	1010	0000	2				6232	4164	28				4333	3335	27

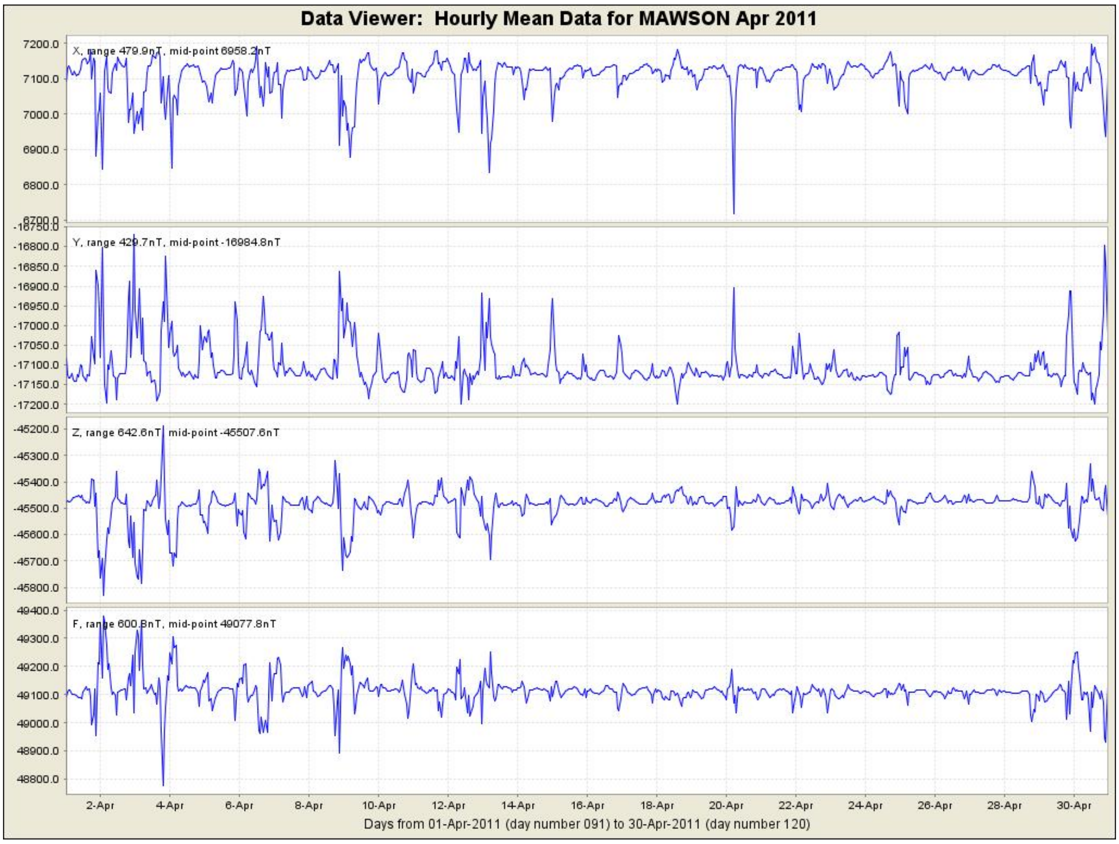
Table 9.7. *Frequency distribution of Mawson 2011 K indices and the annual mean daily K sum.*

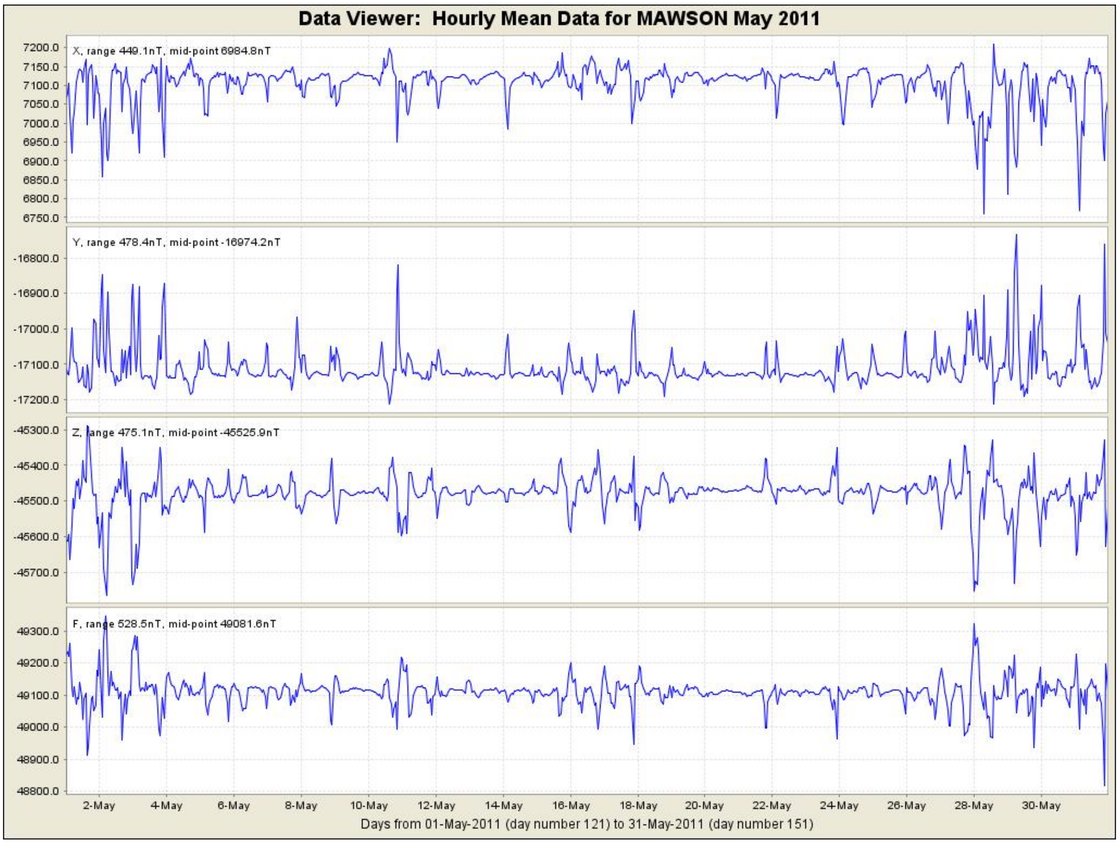
K index	0	1	2	3	4	5	6	7	8	9	-
Frequency	272	453	601	663	443	286	154	43	4	1	0
Mean sum	22.2										

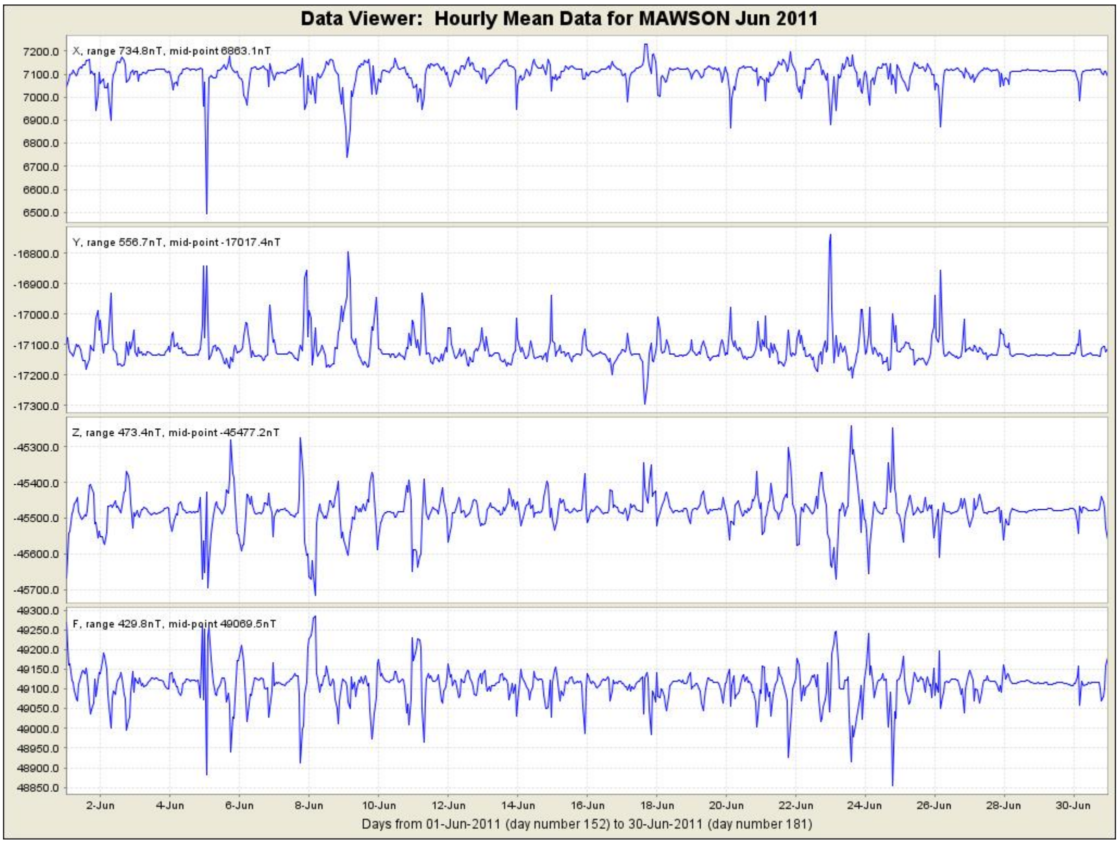

Data Viewer: Hourly Mean Data for MAWSON Jan 2011
X, range 346.7nT, mid-point 7088.0nT
Y, range 428.8nT, mid-point -17008.3nT
Z, range 469.1nT, mid-point -45498.4nT
F, range 427.1nT, mid-point 49112.1nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

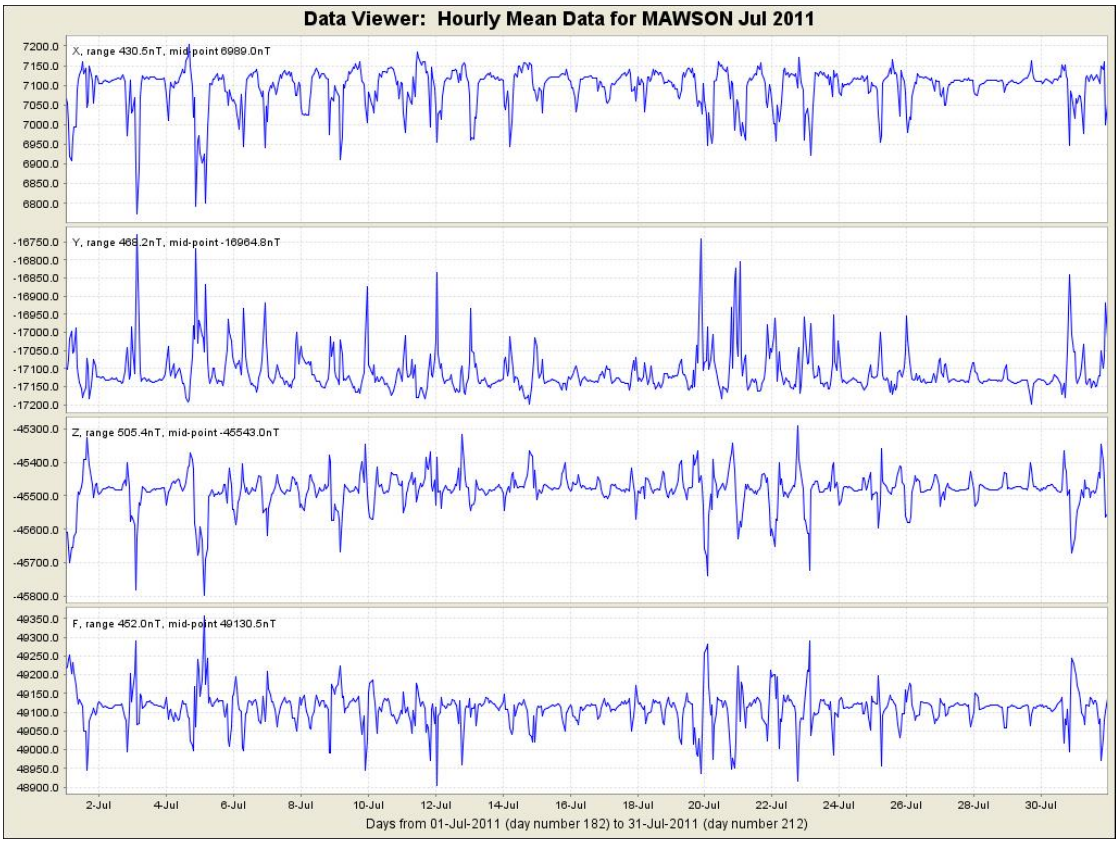

Data Viewer: Hourly Mean Data for MAWSON Feb 2011
X, range 536.5nT, mid-point 7023.6nT
Y, range 481.9nT, mid-point -16964.8nT
Z, range 559.8nT, mid-point -45446.4nT
F, range 566.9nT, mid-point 49032.4nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

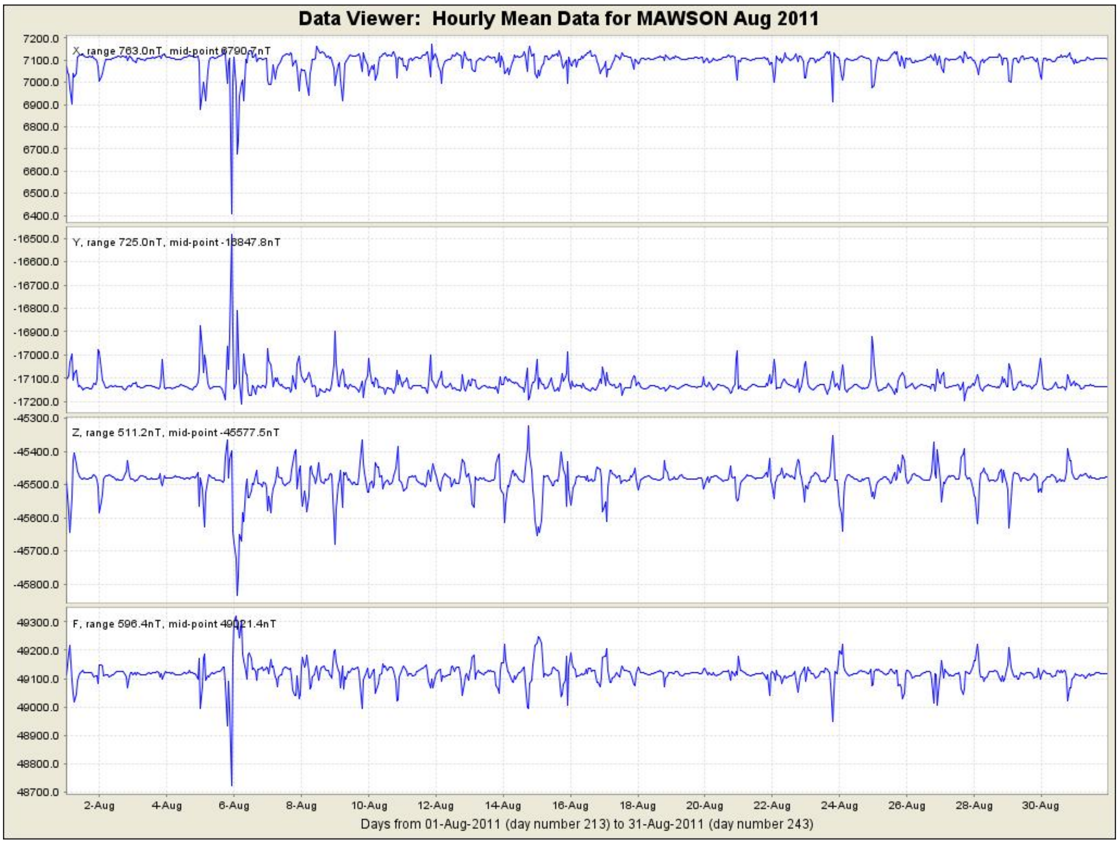

Data Viewer: Hourly Mean Data for MAWSON Mar 2011
X, range 367.0nT, mid-point 7058.1nT
Y, range 506.2nT, mid-point -17004.7nT
Z, range 627.0nT, mid-point -45503.1nT
F, range 598.0nT, mid-point 49117.8nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

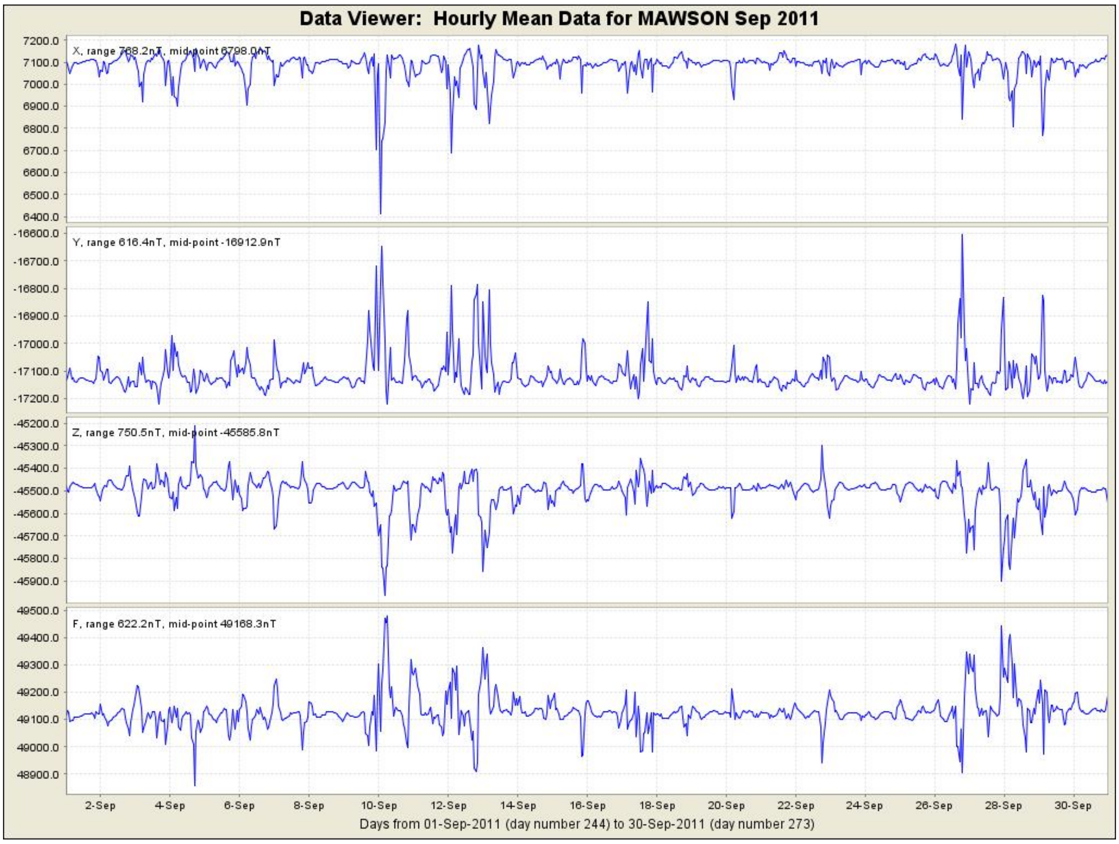

Data Viewer: Hourly Mean Data for MAWSON Apr 2011
X, range 479.9nT, mid-point 6958.2nT
Y, range 429.7nT, mid-point -16984.8nT
Z, range 642.6nT, mid-point -45507.6nT
F, range 600.8nT, mid-point 49077.8nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

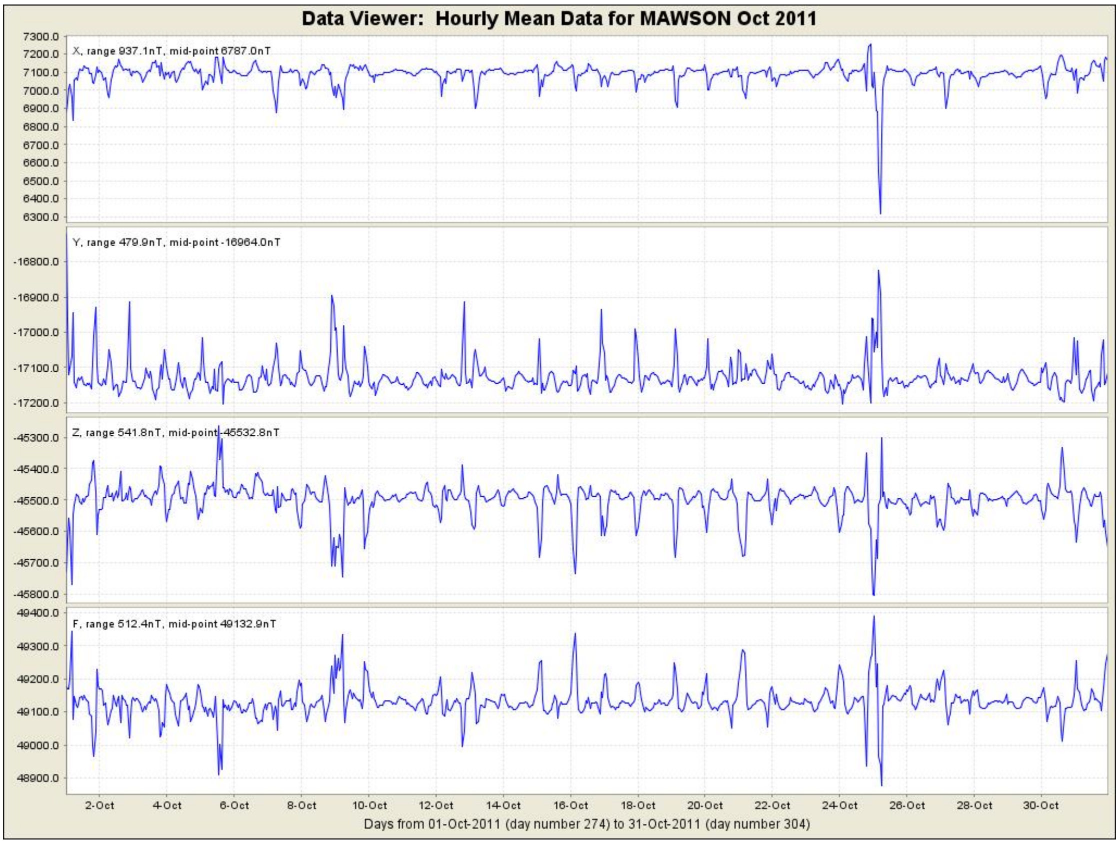

Data Viewer: Hourly Mean Data for MAWSON May 2011
X, range 449.1nT, mid-point 6984.8nT
Y, range 478.4nT, mid-point -16974.2nT
Z, range 475.1nT, mid-point -45525.9nT
F, range 528.5nT, mid-point 49081.6nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)


Data Viewer: Hourly Mean Data for MAWSON Jun 2011
X, range 734.8nT, mid-point 6863.1nT
Y, range 556.7nT, mid-point -17017.4nT
Z, range 473.4nT, mid-point -45477.2nT
F, range 429.8nT, mid-point 49069.5nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for MAWSON Jul 2011
X, range 430.5nT, mid-point 6989.0nT
Y, range 468.2nT, mid-point -16964.8nT
Z, range 505.4nT, mid-point -45543.0nT
F, range 452.0nT, mid-point 49130.5nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for MAWSON Aug 2011
X, range 763.0nT, mid-point 6790.7nT
Y, range 725.0nT, mid-point -16847.8nT
Z, range 511.2nT, mid-point -45577.5nT
F, range 596.4nT, mid-point 49021.4nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for MAWSON Sep 2011
X, range 768.2nT, mid-point 6798.0nT
Y, range 616.4nT, mid-point -16912.9nT
Z, range 750.5nT, mid-point -45585.8nT
F, range 622.2nT, mid-point 49168.3nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for MAWSON Oct 2011
X, range 937.1nT, mid-point 6787.0nT
Y, range 479.9nT, mid-point -16964.0nT
Z, range 541.8nT, mid-point -45532.8nT
F, range 512.4nT, mid-point 49132.9nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)

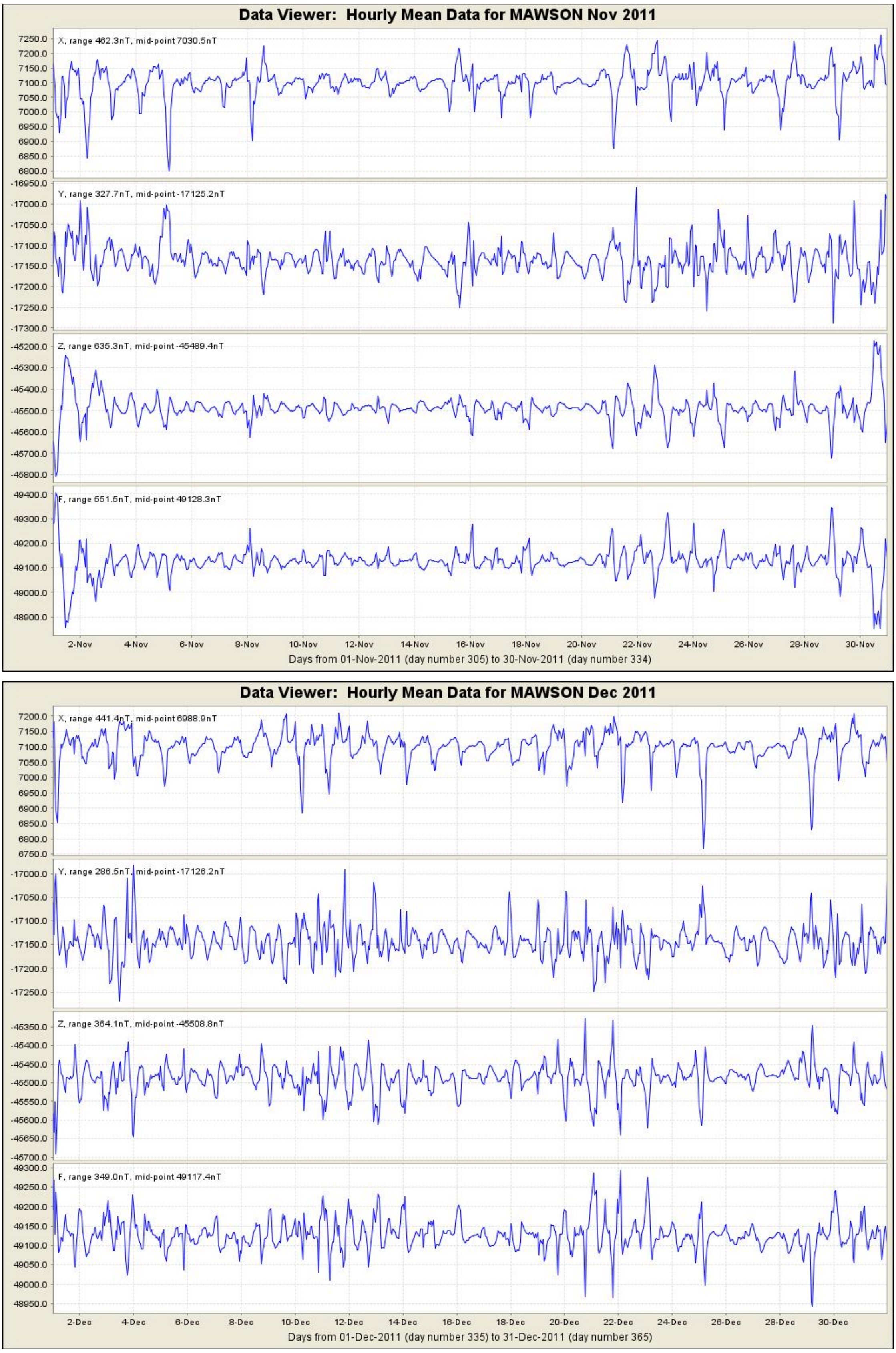


Figure 9.3. *Mawson 2011 hourly mean values in X, Y, Z and F.*

10. Casey

Casey is situated on the Antarctic coast in Wilkes Land 3880 km south of Perth. It is the nearest Australian Antarctic research station to Australia. The magnetic Absolute Hut is about 120 m south of the tank house, the nearest structure of the modern Casey station. The old Casey station, in use until the late 1980s, lies about 1 km northeast of the present Casey.

The geology in the vicinity of Casey includes crystalline rocks with high concentrations of magnetic minerals. As a result there are high magnetic gradients in and around the station, including near the Variometer and Absolute Huts.

Regular magnetic observations began at Casey in 1975. From 1988 a variation station operated there. From 1991 to 1998 it operated as a magnetic observatory, although not to a high standard. Observatory-standard absolute control commenced in 1999. A more detailed history of the Casey (and Wilkes) observatory is given in Hopgood (2001, 2002, 2004a, 2004b).

The magnetic observatory is part of the Casey scientific research station in Antarctica. The magnetic observatory comprises:

- the Variometer Hut, and;
- the Absolute Hut.

The crystalline rocks of Casey have high concentrations of magnetic minerals that cause high magnetic gradients in the area. The observatory is located in one of the places of least gradient in the area but still with a higher gradient than is ideal for a magnetic observatory.

Variometers

The variometers used during 2011 are described in Table 10.2.

The variometers at Casey station are housed within the Variometer Hut. The DMI variometer sensor is located in the southern corner of the hut. The GSM-90 total-field magnetometer sensor is located in the northern corner. Both sensors are mounted on marble plinths. This configuration allows for the maximum separation between the two instruments. The Variometer Hut also contains the variometer electronics mounted within non-magnetic shelves. The instrument power supply, consisting of a 12 V battery box and charger, is also positioned within the shelves.

System timing was provided by a Garmin GPS16-HVS clock mounted on the shelves. Timing corrections were applied automatically and logged. Timing corrections greater than 10 ms are listed in the *Significant events* section. There were some interruptions to data collection throughout the year in both the vector and scalar data sets.

The recording equipment, a QNX acquisition computer, was connected to the station's radio network hub for most of the year and was located within the Variometer Hut. In early October the radio hub was replaced with a fibre optic link as part of an upgrade of the system by the Australian Antarctic

Division. Power is supplied to the computer and variometer equipment through a 12 V battery box with a mains charger.

During the year there were three periods during which data contamination occurred. The first was when a faulty thermostat in the Variometer Hut was replaced between days 136 and 138. The new thermostat was not a comparable model and when set to 10°C automatically switched off, resulting in a rapid plunge in the temperature from approximately 21°C prior to the replacement of the faulty thermostat to -8°C. Trevor Crews was alerted to the temperature change and adjusted the thermostat to just above 10°C. The hut temperature stabilised over the next day but rapid drifts in the data were noted. Data quality cannot be guaranteed for this period and so the data have been removed.

Table 10.1. *Key observatory data.*

IAGA code:	CSY
Commenced operation:	1999
Geographic latitude:	66° 17' S
Geographic longitude:	110° 32' E
Geomagnetic latitude:	-75.95°
Geomagnetic longitude:	184.79°
K 9 index lower limit:	N/A
Principal pier:	Pier B
Pier elevation (top):	41 m AMSL
Principal reference mark:	Trig station G11
Reference mark azimuth:	308° 06' 00"
Reference mark distance:	464 m
Observer:	T. Crews

Table 10.2. *Magnetic variometers used in 2011. See Appendix C for a schematic of their configuration.*

3-component variometer:	DMI FGE
Serial number:	E0199 / S0160
Type:	suspended; linear-core fluxgate
Orientation:	NW, NE, Z
Acquisition interval:	1 s
A/D converter:	ADAM 4017 module (±10V)
Scale value:	0.32 nT / count
Total-field variometer:	GEM Systems GSM-90
Serial number:	4081423 / 42189
Type:	Overhauser effect
Acquisition interval:	10 s
Resolution:	0.01 nT
Data acquisition system:	GDAP: PC-104 computer, QNX OS
Timing:	Garmin GPS 16 clock
Communications:	ANARESAT

The second period of contamination occurred between days 277 and 280 when the radio link was replaced with a new fibre optic link. This upgrade required personnel to enter the Variometer Hut several times over this period resulting in contamination of the data.

The final period of contamination occurred on day 325 when an intrusion into the geomagnetic quiet zone occurred. Personnel from Casey station where undertaking Antarctic survival training and on return to the station passed near the Variometer Hut.

Local meteorological conditions

The meteorological temperature at Casey during 2011 varied from a minimum -32.0°C (2011-07-28) to a maximum of +8.7°C (2011-01-22). Daily minimum temperatures varied from -32.0°C to +1.1°C (average -12.7°C). Daily maximum temperatures varied from -23.9°C to +8.7°C (average -6.1°C).

The daily maximum wind gust varied from 17 km/h to 174 km/h with a daily average wind speed of 59 km/h. The maximum daily maximum wind gust was 174 km/h in April. The minimum daily maximum wind gust was 17 km/h in February. Windy conditions were the norm throughout the year with the higher wind gusts being attributed to blizzards.

Table 10.3. *Absolute magnetometers and their adopted corrections for 2011. Corrections are applied in the sense Standard = Instrument + correction.*

DI fluxgate:	DMI
Serial number:	DI0047
Theodolite:	Zeiss 020B
Serial number:	352229
Resolution:	0.1’
D correction:	0.15’
I correction:	-0.20’
Total-field magnetometer:	GEM Systems GSM-90
Serial number:	810881 / 31960
Type:	Overhauser effect
Resolution:	0.01 nT
Correction:	0.0 nT
Total-field magnetometer:	Geometrics G816 (backup)
Serial number:	766
Type:	Proton precession
Resolution:	1 nT
Correction:	1.5 nT

Absolute instruments

The principal absolute magnetometers used at Casey in 2011, and their adopted instrument corrections, are described in Table 10.3.

At the 2011 mean magnetic field values at Casey (X=-841 nT, Y=-9208 nT, Z=-63284 nT) these D, I and F corrections translate to corrections of:

$\Delta X = 0.7$ nT $\Delta Y = 3.6$ nT $\Delta Z = -0.5$ nT

Instrument corrections were applied while reducing absolute observations to determine baselines and accordingly have been applied to all Casey 2011 final data.

Baselines

During processing, a temperature-related trend became evident in the data. Temperature coefficients were checked and modified and temperature data from 2007 to 2010 were compared. The sensor and electronics temperatures formed a dish shaped trend over the course of a year. Further investigation revealed that the Variometer Hut thermostat had been stuck on 21°C since late 2007. The thermostat was replaced in May 2011 and the temperature set to around 10°C. This adjustment resulted in baseline changes in X of 2.82 nT, Y of 56.9 nT and Z of 7.3 nT.

The sensor and electronics were located in the Variometer Hut and were subject to the same thermal conditions. As such, independent temperature effects were unable to be determined. For 2011 the two temperature coefficients were combined into one value and used as the coefficient for the sensor. The coefficient for the electronics was set to zero.

The final baseline parameters for the variometer were completed by manually fitting a piece-wise linear function to the absolute observations. This function included drifts or jumps, when required, to obtain a good fit to the weekly observed absolute observations baseline residuals.

Observed and adopted baseline values in X, Y and Z are shown in Figure 10.1.

Operations

The Casey observer was a member of the Australian National Antarctic Research Expedition and was employed by the Australian Antarctic Division with funding support by Geoscience Australia.

The observer was responsible for the continuous operation of the observatory and performed equipment maintenance and installation as required. The observer performed weekly absolute observations and forwarded them by e-mail to Geoscience Australia. During the observations the variometer system was also checked. All data processing was performed at Geoscience Australia.

Data were recorded on a QNX acquisition computer which was directly connected to the Casey network via a radio link until early October when the radio link was replaced by a fibre optic link. Data were retrieved to Geoscience Australia using rsync over ssh at least every 10 minutes. Real-time data were processed automatically at Geoscience Australia then distributed, usually with a 2 to 15 minute delay.

The QNX acquisition computer used a GPS clock (both pulse-per-second and absolute-time-code) to set the system time. The clock was checked from Geoscience Australia regularly to ensure it was working. If not, it was reset remotely or, if necessary, the computer was re-booted.

The distribution of Casey 2011 data is described in Table 10.4. Data losses are identified in Table A.10.

Table 10.4. *Distribution of Casey 2011 data.*

Recipient	Status	Sent
1-second values		
IPS Radio and Space Services	preliminary	real time
INTERMAGNET	preliminary	real time
1-minute values		
INTERMAGNET	preliminary	real time
INTERMAGNET	preliminary	daily

Significant events

2011-03-23	00:43 telemetry stops, cannot connect from GA - ping from MAW and then connect O.K.from GA. Changed file name from day 081 to day 082.
2011-05-04	06:08 - 06:14 check variometer thermostat - it was set to 18, reset to 10. No significant temperature changed noted in data. Thermostat is probably faulty. A request was sent to Trevor Crews to check on the temperature of the thermostat in the variometer hut. He entered at 06:08 to 06:14.He checked and found that it was set to 18 degrees so he has changed it back to 10 degrees.
2011-05-13	06:25 - 06:30 check variometer thermostat and confirm it is not working, it is always on.
2011-05-16	00:30 - 01:00 replace faulty thermostat in variometer hut - set thermostat temperature to 5C. Still requires some tidying to finish the installation job, The hut temperature was measured to be 20C before thermostat replacement.
2011-05-17	Variometer hut temperature dropping
2011-05-18	03:00 - 03:22 Trevor and electrician finishing mounting of new thermostat in variometer hut. temperature -8.6C. Increase thermostat setting to +10 Data contamination 04:22 - 04:30 in variometer hut to check temperature again
2011-05-19	07:00 - 07:05 Trevor in variometer. Temperature was 13.5C adjusted thermostat down slightly
2011-06-01	07UT approx adjust X and Y baselines
2011-06-23	first obs X is out, remove from data.
2011-08-21	15:25:01 Lost contact with GPS clock
2011-08-23	06:04 slay and restart GdapClock - no improvement 06:20 reboot system 06:22:12 - CLK I 0 Correction 1314080532 685814114 C 0 s 477845747 R 0 s -39155 Fluxgate variometer data fails to restart GdapAdam not running, but this was not noticed until the following morning. 23:03 Attempt to restart GdapAdam - it will not start. Reboot system - no improvement /usr/local/bin/GdapAdam. Bad file descriptor Copy alternative version of GdapAdam from CNB system to ga-mag-csy:/home/acq and start it from there seems to work O.K. timing correction 06:22:12 0 s 477845747 ns timing correction 23:06:03 0 s 92170909 ns
2011-09-21	22:26 Large changes in X (110nT), Y(40nT) and Z(50nT) and the ppm. Cause of change unknown.
2011-09-30	Possible contamination 2230-2255 UTC.
2011-10-04	Installation of new fibre optic cable to variometer hut. 07:16 - 08:23 UTC.
2011-10-05	Installation of new fibre optic cable to variometer hut. 00:40 - 01:40 UTC. Installation of new fibre optic cable to variometer hut. 06:40 - 08:40 UTC.
2011-10-06	Installation of new fibre optic cable to variometer hut. 00:53 - 01:56 UTC. Fluxgate variometer stops producing data; no response to manual interrogation. Request TC to

check system.
22:55 - still no data - reboot system and data starts flowing.
timing correction 22:59:30 0 s 835394222 ns

2011-10-07 Stops again - reboot at 03:22 forces restart
timing correction 03:24:18 0 s 722582370 ns
Installation of new fibre optic cable to variometer hut. 00:00 - 02:15 UTC.

2011-11-21 Disturbance in data 00:37 to 01:55 (possibly people on survival training walking through mag quiet zone).

2011-12-12 Hagglund vehicle parked inside the magnetic quiet zone 22:00 to 23:00 UTC approximately.

Annual mean values

The annual mean values for Casey are set out in Table 10.5 and displayed with the secular variation in Figure 10.2.

Hourly mean values

Plots of the hourly mean values for Casey 2011 data are shown in Figure 10.3.

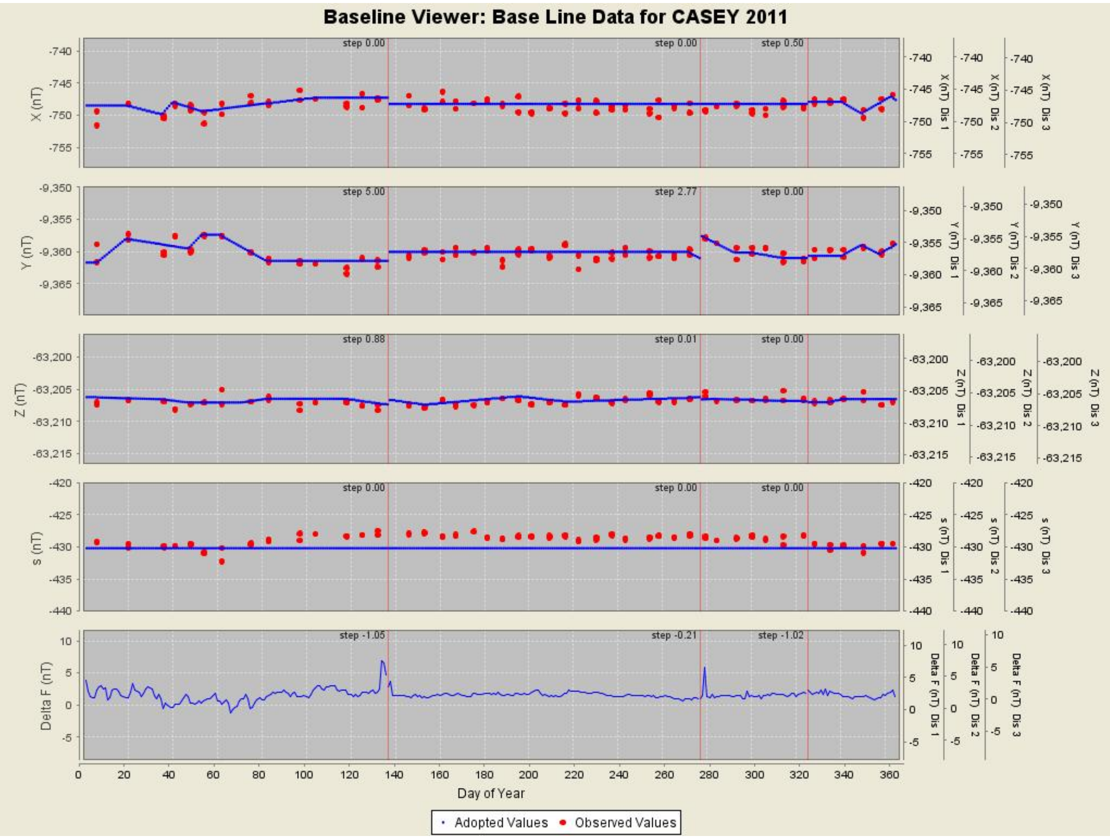


Figure 10.1. *Casey 2011 baseline plots.*

Table 10.5. *Casey annual mean values. Until 1990 these were calculated using the monthly average values of regular absolute observations, denoted by AB. From 1991 they were gained using data from the Australian Antarctic Division fluxgate variometer that was calibrated through regular absolute observations. Until 1997 the means were calculated over the five quietest days at Mawson station, denoted QM. From 1998 monthly means were calculated over* ***All*** *days, the 5 International* ***Quiet*** *days and the 5 International* ***Disturbed*** *days in each month, denoted A, Q and D respectively. In March 2006, absolute observations were moved from Pier A to Pier B. The resulting baseline jump is indicated by the J in 2006 (jump value = old site value - new site value). Plots of these data with secular variation in X, Y, Z and F are shown in Figure 10.2.*

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	’)	(°	’)						
1977.96	AB	-88	29.6	-81	38.7	9495	250	-9492	-64650	65344	DHZ
1978.5	AB	-89	4.3	-81	36.2	9518	154	-9516	-64488	65187	DHZ
1979.5	AB	-89	21.6	-81	35.7	9525	106	-9524	-64469	65169	DHZ
1980.5	AB	-89	31.5	-81	33.9	9568	79	-9568	-64528	65233	DHZ
1981.5	AB	-88	2.1	-81	32.0	9540	327	-9534	-64083	64789	DHZ
1982.5	AB	-90	10.0	-81	28.4	9650	-28	-9650	-64400	65120	DHZ
1983.5	AB	-90	32.0	-81	31.5	9585	-89	-9585	-64326	65037	DHZ
1984.5	AB	-90	50.0			9640	-140	-9639			DHZ
1985.5	AB	-90	50.0	-81	25.9	9650	-140	-9649	-64067	64790	DHZ
1986.5	AB	-90	52.9	-81	27.2	9634	-148	-9633	-64101	64821	DHZ
1987.5	AB	-91	18.6	-81	29.1	9596	-219	-9593	-64097	64811	DHZ
1988.5	AB	-91	28.4	-81	27.2	9630	-248	-9627	-64086	64805	DHZ
1989.5	AB	-90	45.5	-81	23.5	9672	-128	-9671	-63887	64615	DHZ
1990.5	AB	-91	55.0	-81	27.4	9601	-321	-9596	-63920	64637	DHZ
1991.5	QM	-92	1.2	-81	25.0	9642	-340	-9636	-63881	64605	XYZ
1992.5	QM	-92	10.0	-81	25.0	9637	-364	-9630	-63848	64571	XYZ
1993.5	QM	-92	7.3	-81	25.0	9638	-357	-9631	-63852	64576	XYZ
1994.5	QM	-92	17.1	-81	25.3	9629	-384	-9621	-63824	64547	XYZ
1995.5	QM	-92	27.5	-81	25.6	9620	-413	-9611	-63807	64528	XYZ
1996.5	QM	-92	35.4	-81	25.3	9625	-435	-9615	-63804	64526	XYZ
1997.5	QM	-92	42.1	-81	25.2	9623	-454	-9612	-63774	64496	XYZ
1998.5	Q	-92	55.4	-81	25.7	9614	-490	-9601	-63777	64497	XYZ
1999.5	Q	-93	4.9	-81	26.5	9595	-516	-9581	-63762	64480	XYZ
2000.5	Q	-93	12.9	-81	27.0	9584	-537	-9568	-63749	64465	XYZ
2001.5	Q	-93	21.6	-81	27.9	9564	-561	-9548	-63729	64443	XYZ
2002.5	Q	-93	26.1	-81	28.3	9553	-572	-9536	-63708	64421	XYZ
2003.5	Q	-93	37.5	-81	29.4	9534	-603	-9514	-63713	64422	XYZ
2004.5	Q	-93	46.5	-81	30.5	9510	-626	-9489	-63691	64397	XYZ
2005.5	Q	-93	55.7	-81	31.3	9492	-650	-9469	-63682	64385	XYZ
2006.5	J		26.9		3.1	124.2	64.6	-129.3	-446.6	460.0	
2007.75	Q	-94	40.2	-81	35.8	9338	-760	-9307	-63216	63902	ABZ

Year	Days	D		I		H (nT)	X (nT)	Y (nT)	Z (nT)	F (nT)	Elements
		(°	')	(°	')						
2008.5	Q	-94	46.1	-81	36.9	9319	-775	-9287	-63219	63902	ABZ
2009.5	Q	-94	55.7	-81	38.3	9293	-798	-9259	-63226	63906	ABZ
2010.5	Q	-95	04.3	-81	39.8	9269	-819	-9232	-63249	63925	ABZ
2011.5	Q	-95	13.7	-81	41.4	9243	-842	-9205	-63280	63952	ABZ
1998.5	A	-92	55.4	-81	25.7	9615	-490	-9602	-63785	64505	XYZ
1999.5	A	-93	4.8	-81	26.4	9599	-516	-9585	-63772	64490	XYZ
2000.5	A	-93	13.2	-81	27.0	9587	-538	-9571	-63759	64476	XYZ
2001.5	A	-93	21.6	-81	27.9	9566	-561	-9549	-63733	64447	XYZ
2002.5	A	-93	29.4	-81	28.4	9553	-582	-9535	-63719	64432	XYZ
2003.5	A	-93	39.5	-81	29.5	9535	-608	-9515	-63730	64440	XYZ
2004.5	A	-93	47.0	-81	30.4	9512	-628	-9491	-63701	64408	XYZ
2005.5	A	-93	56.5	-81	31.4	9492	-652	-9470	-63694	64397	XYZ
2006.5	J		26.9		3.1	124.2	64.6	-129.3	-446.6	460.0	
2007.75	A	-94	39.2	-81	35.8	9339	-758	-9308	-63221	63907	ABZ
2008.5	A	-94	47.0	-81	37.0	9318	-777	-9286	-63228	63911	ABZ
2009.5	A	-94	55.8	-81	38.3	9294	-799	-9259	-63227	63907	ABZ
2010.5	A	-95	4.8	-81	39.8	9269	-821	-9233	-63254	63930	ABZ
2011.5	A	-95	13.3	-81	41.2	9246	-841	-9208	-63284	63956	ABZ
1998.5	D	-92	58.2	-81	25.8	9615	-498	-9601	-63805	64526	XYZ
1999.5	D	-93	10.7	-81	26.6	9599	-532	-9583	-63796	64514	XYZ
2000.5	D	-93	13.6	-81	27.0	9588	-539	-9572	-63771	64487	XYZ
2001.5	D	-93	19.4	-81	27.8	9570	-555	-9553	-63746	64460	XYZ
2002.5	D	-93	37.4	-81	28.8	9549	-603	-9529	-63747	64458	XYZ
2003.5	D	-93	47.4	-81	30.2	9525	-629	-9503	-63764	64472	XYZ
2004.5	D	-93	47.8	-81	30.5	9513	-630	-9491	-63719	64425	XYZ
2005.5	D	-93	57.2	-81	31.5	9494	-654	-9471	-63715	64419	XYZ
2006.5	J		26.9		3.1	124.2	64.6	-129.3	-446.6	460.0	
2007.75	D	-94	41.0	-81	36.1	9335	-762	-9304	-63234	63919	ABZ
2008.5	D	-94	47.0	-81	37.0	9319	-777	-9286	-63239	63922	ABZ
2009.5	D	-94	57.1	-81	38.3	9294	-802	-9259	-63230	63910	ABZ
2010.5	D	-95	4.6	-81	39.8	9270	-820	-9234	-63262	63938	ABZ
2011.5	D	-95	13.2	-81	41.3	9246	-841	-9208	-63291	63962	ABZ

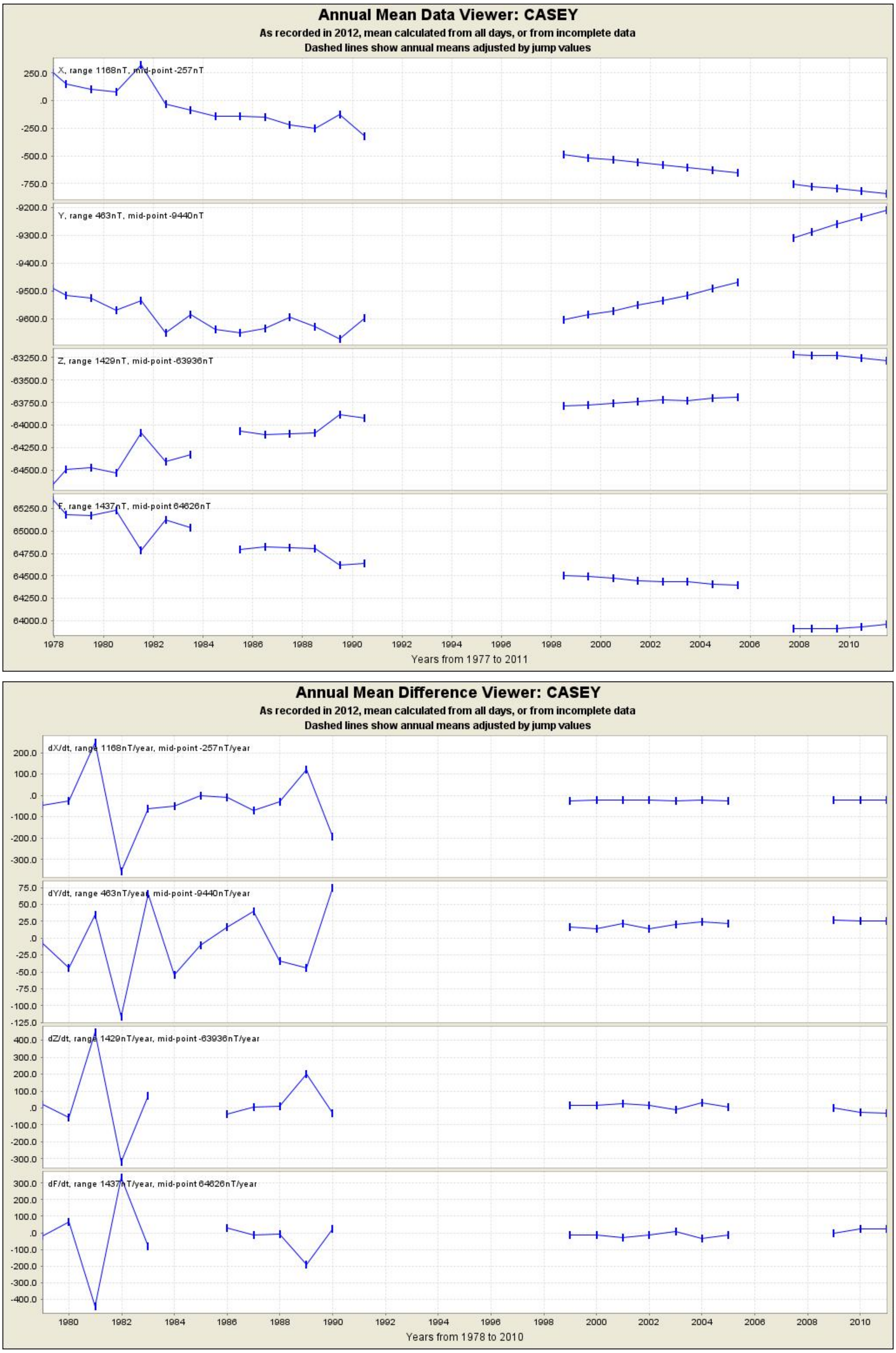
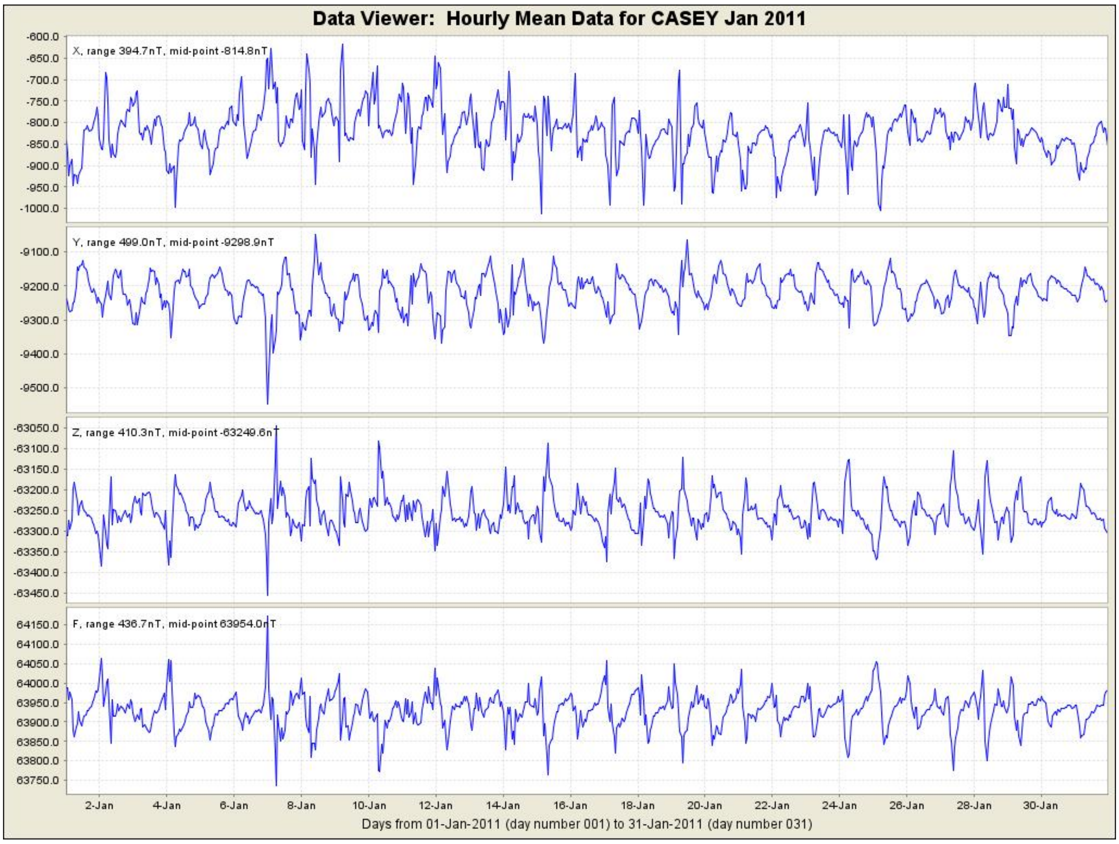
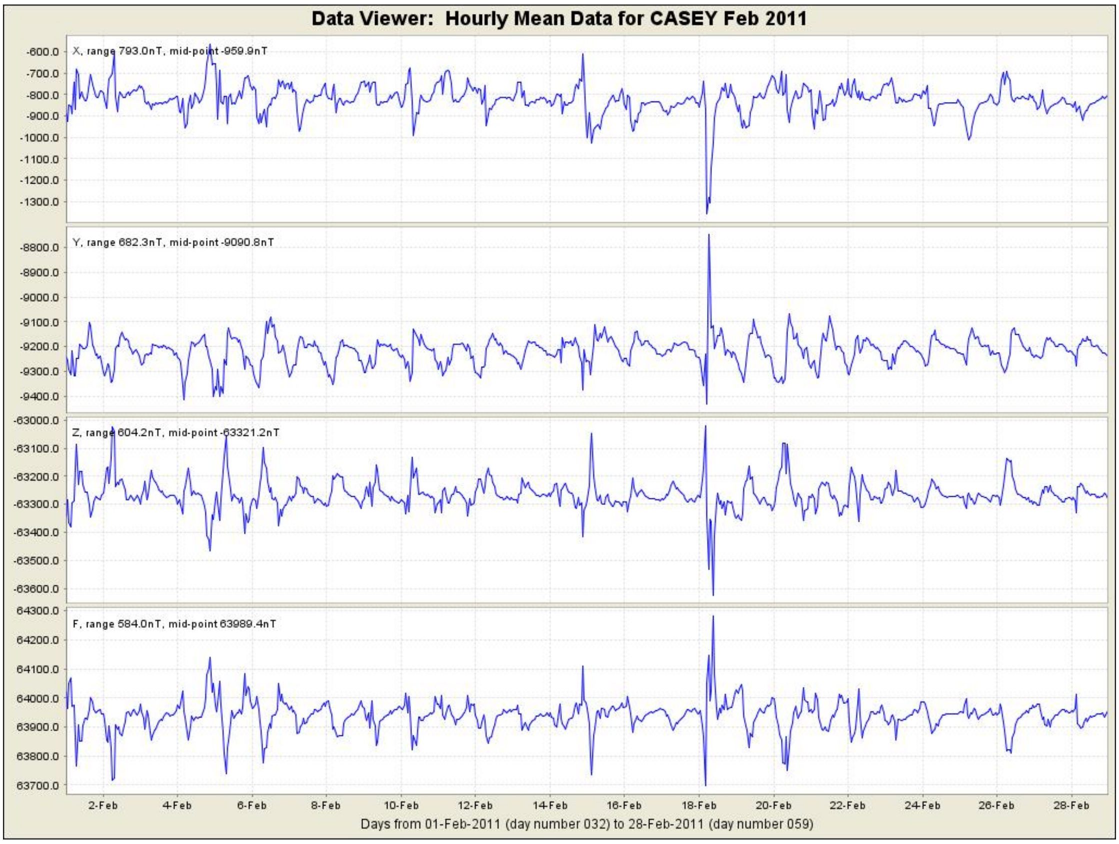


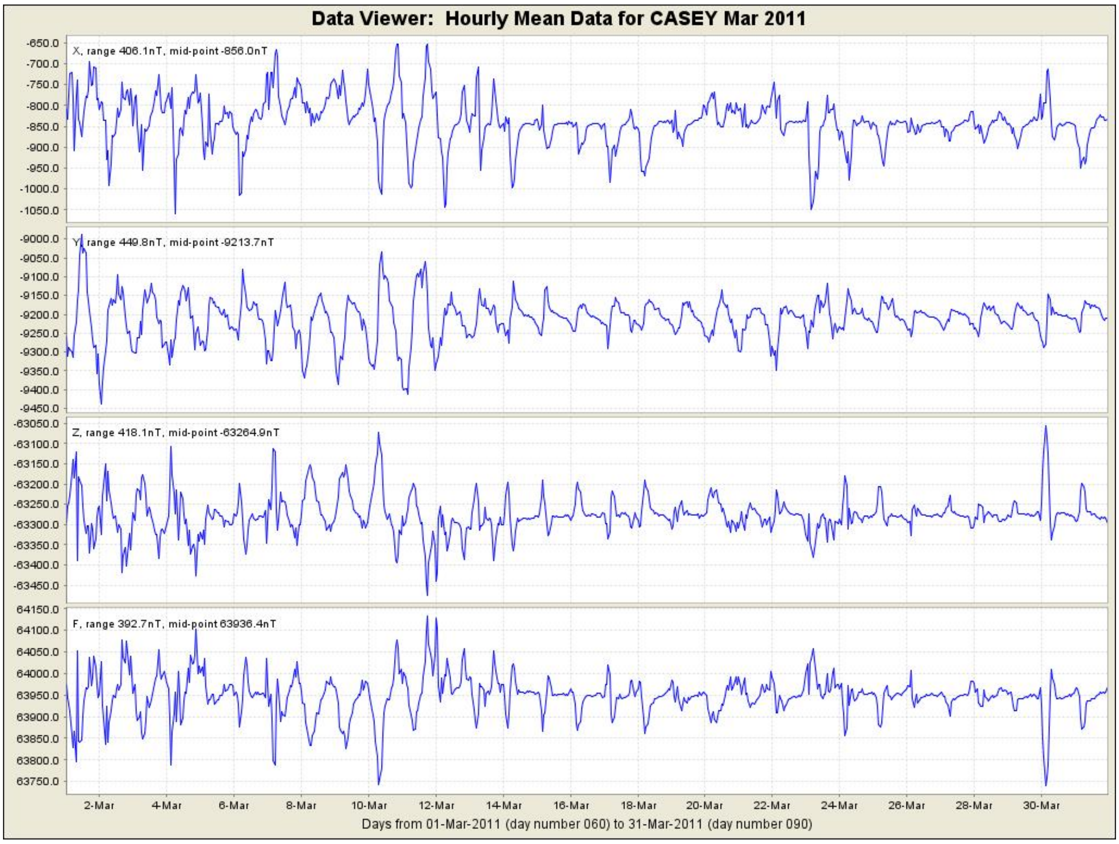
Figure 10.2. *Casey annual mean values and secular variation for X, Y, Z and F (using all days).*

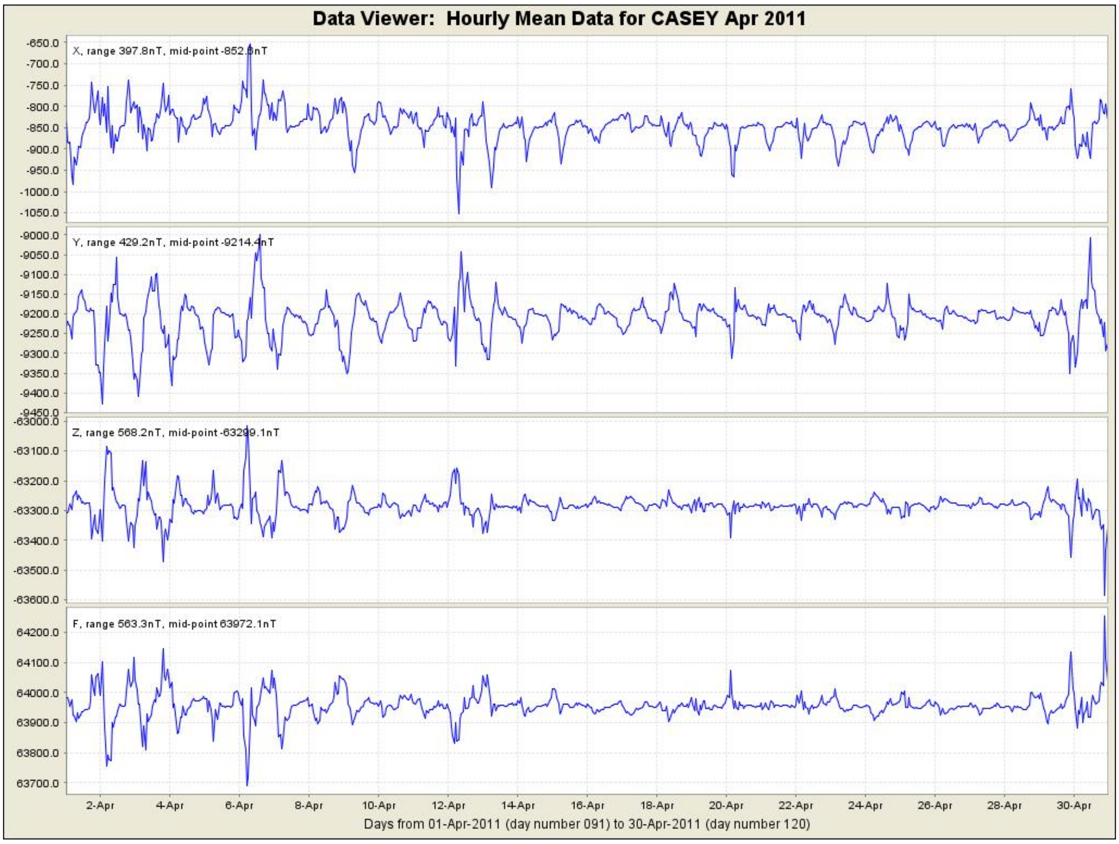


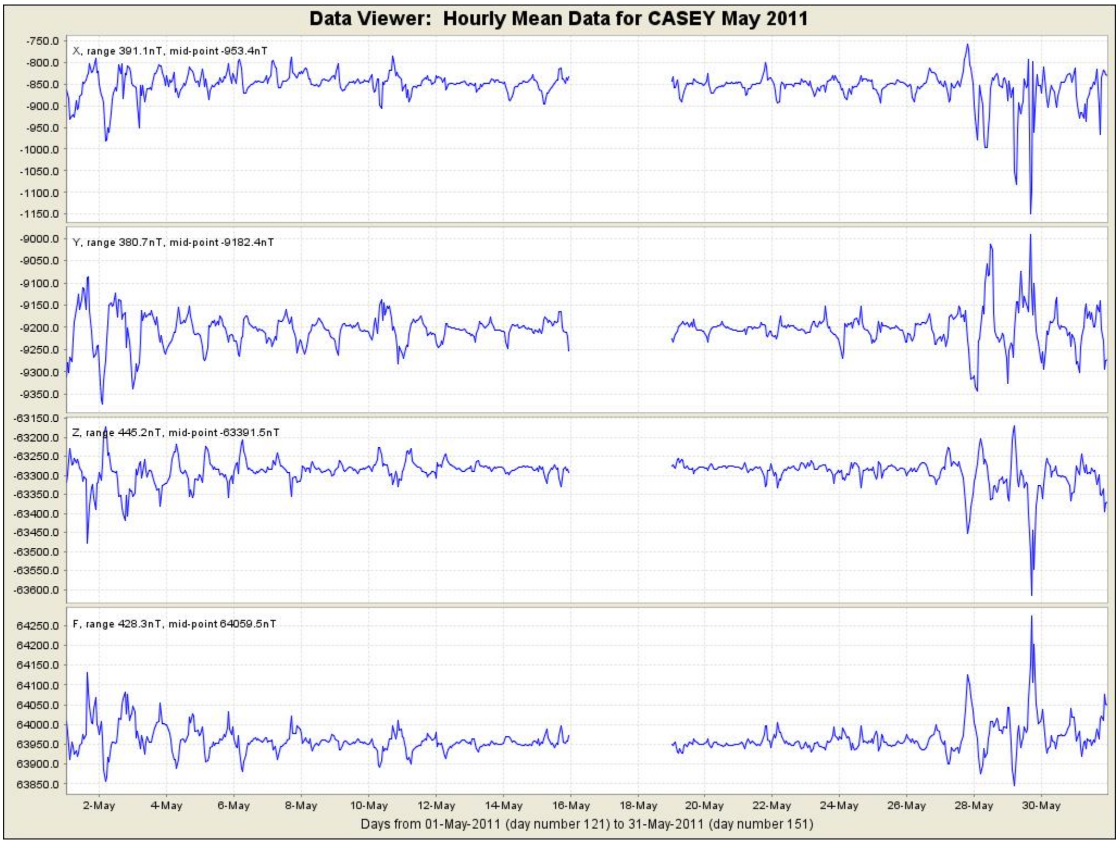
Data Viewer: Hourly Mean Data for CASEY Jan 2011
X, range 394.7nT, mid-point -814.8nT
Y, range 499.0nT, mid-point -9298.9nT
Z, range 410.3nT, mid-point -63249.6nT
F, range 436.7nT, mid-point 63954.0nT
Days from 01-Jan-2011 (day number 001) to 31-Jan-2011 (day number 031)

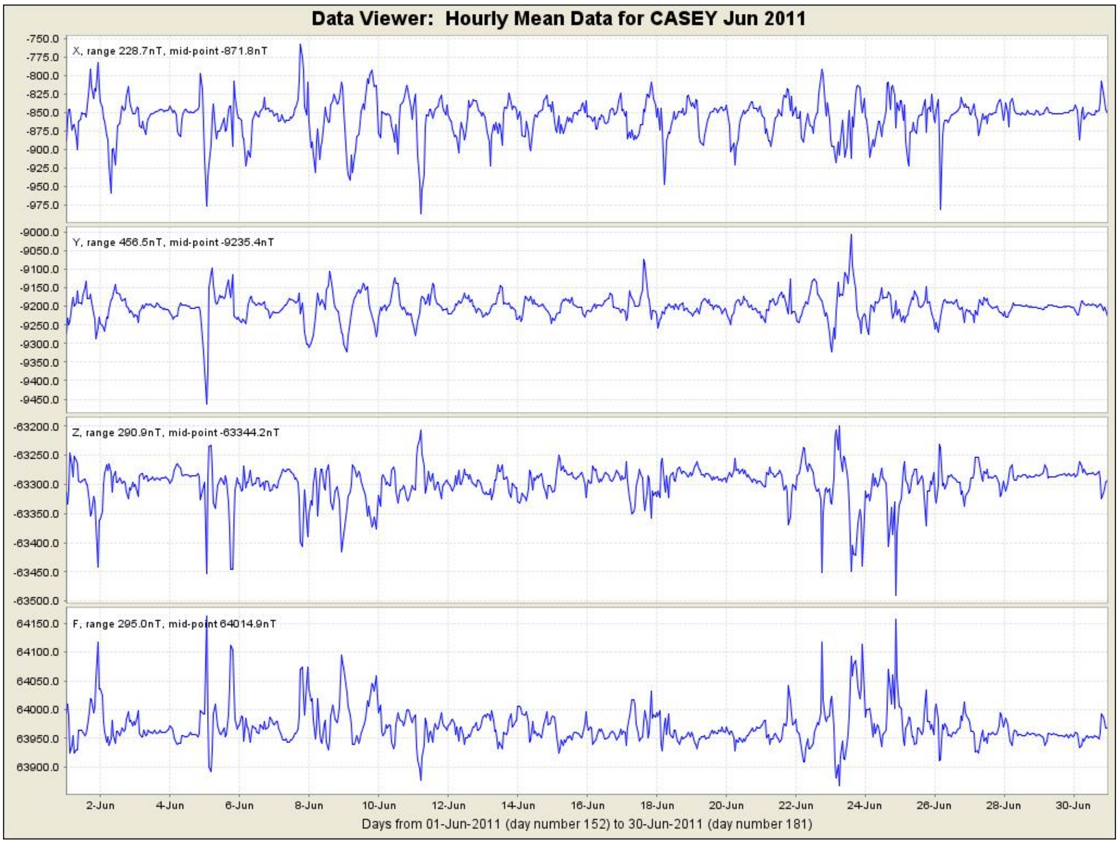


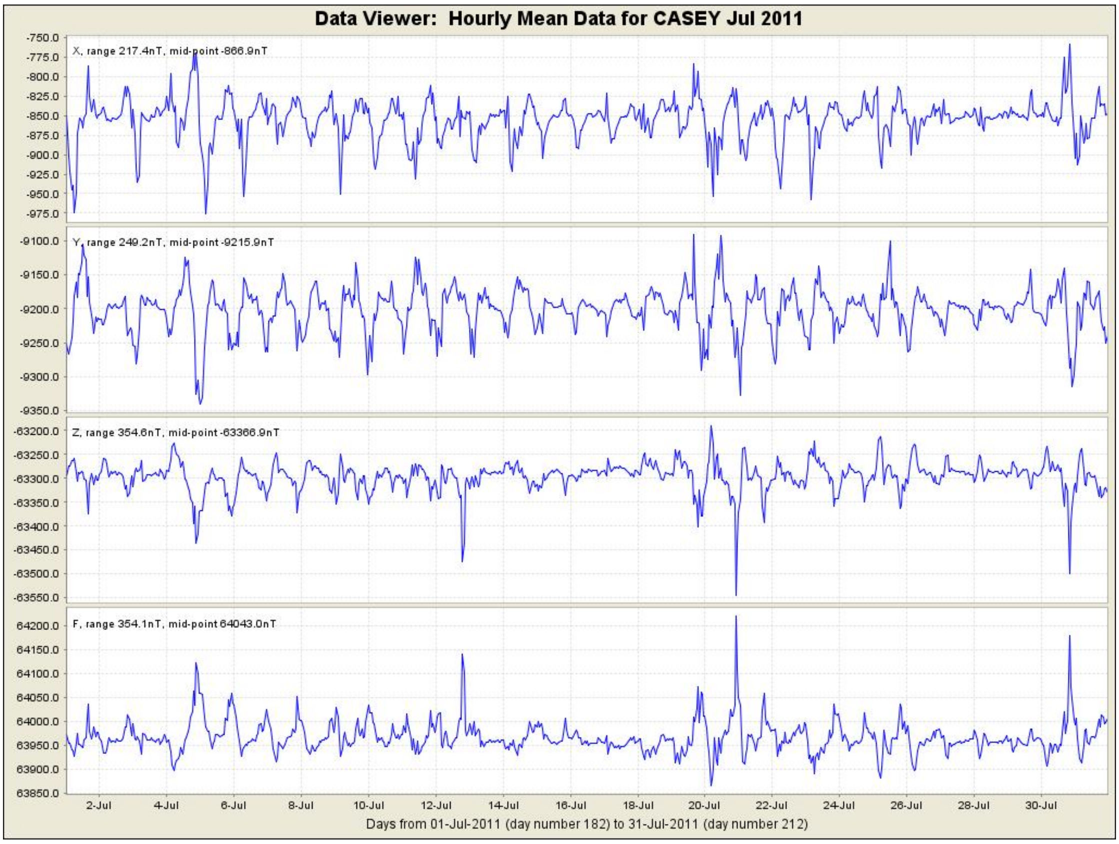
Data Viewer: Hourly Mean Data for CASEY Feb 2011
X, range 793.0nT, mid-point -959.9nT
Y, range 682.3nT, mid-point -9090.8nT
Z, range 604.2nT, mid-point -63321.2nT
F, range 584.0nT, mid-point 63989.4nT
Days from 01-Feb-2011 (day number 032) to 28-Feb-2011 (day number 059)

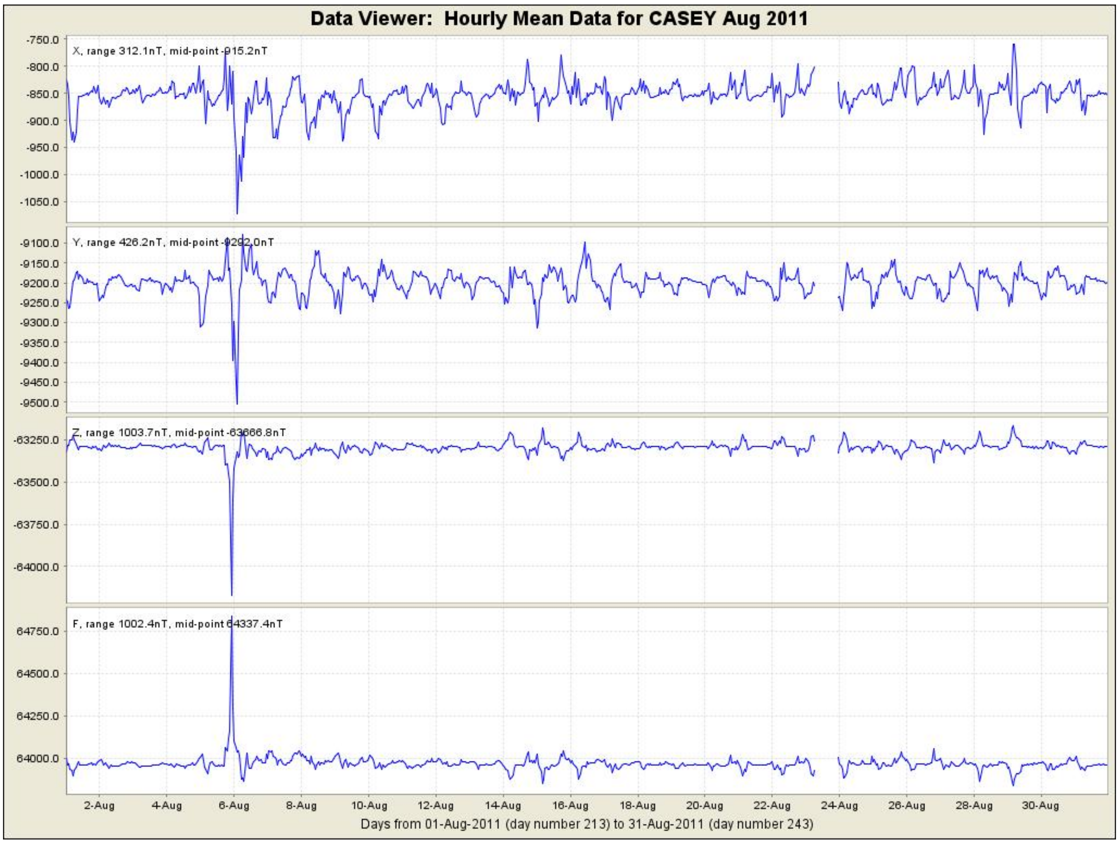

Data Viewer: Hourly Mean Data for CASEY Mar 2011
X, range 406.1nT, mid-point -856.0nT
Y, range 449.8nT, mid-point -9213.7nT
Z, range 418.1nT, mid-point -63264.9nT
F, range 392.7nT, mid-point 63936.4nT
Days from 01-Mar-2011 (day number 060) to 31-Mar-2011 (day number 090)

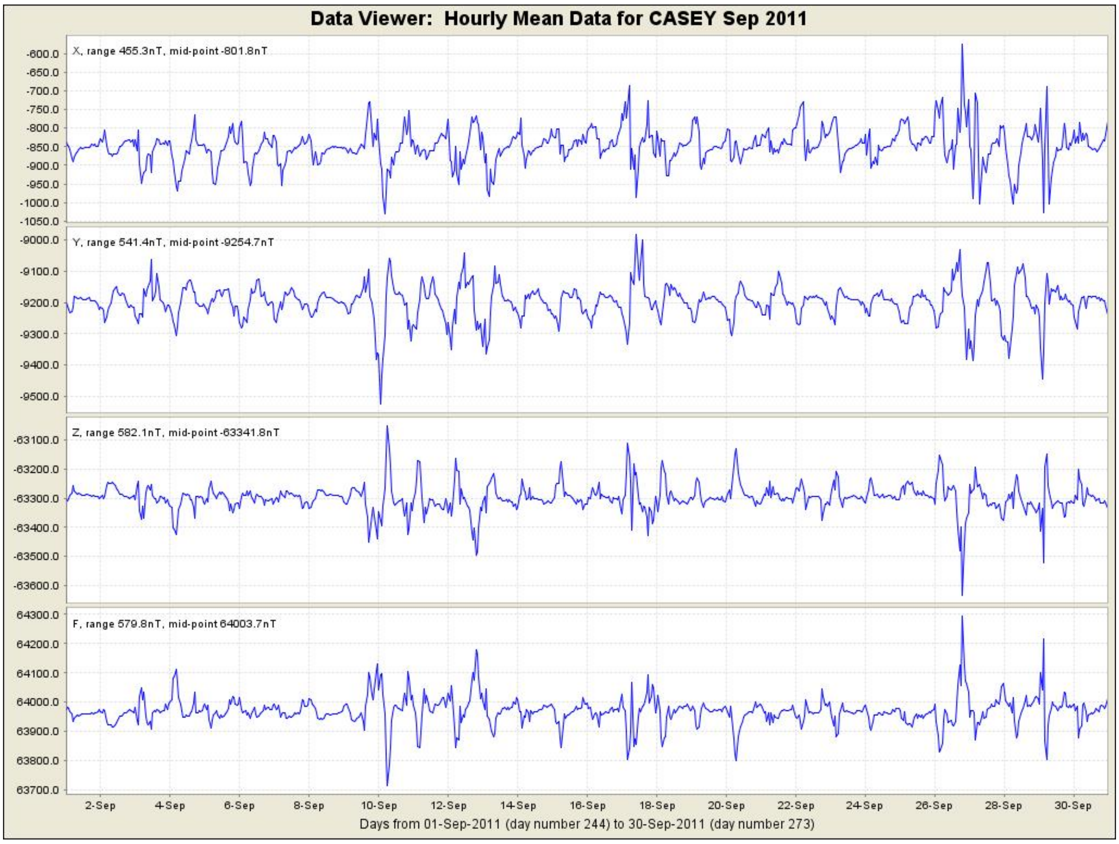

Data Viewer: Hourly Mean Data for CASEY Apr 2011
X, range 397.8nT, mid-point -852.8nT
Y, range 429.2nT, mid-point -9214.4nT
Z, range 568.2nT, mid-point -63299.1nT
F, range 563.3nT, mid-point 63972.1nT
Days from 01-Apr-2011 (day number 091) to 30-Apr-2011 (day number 120)

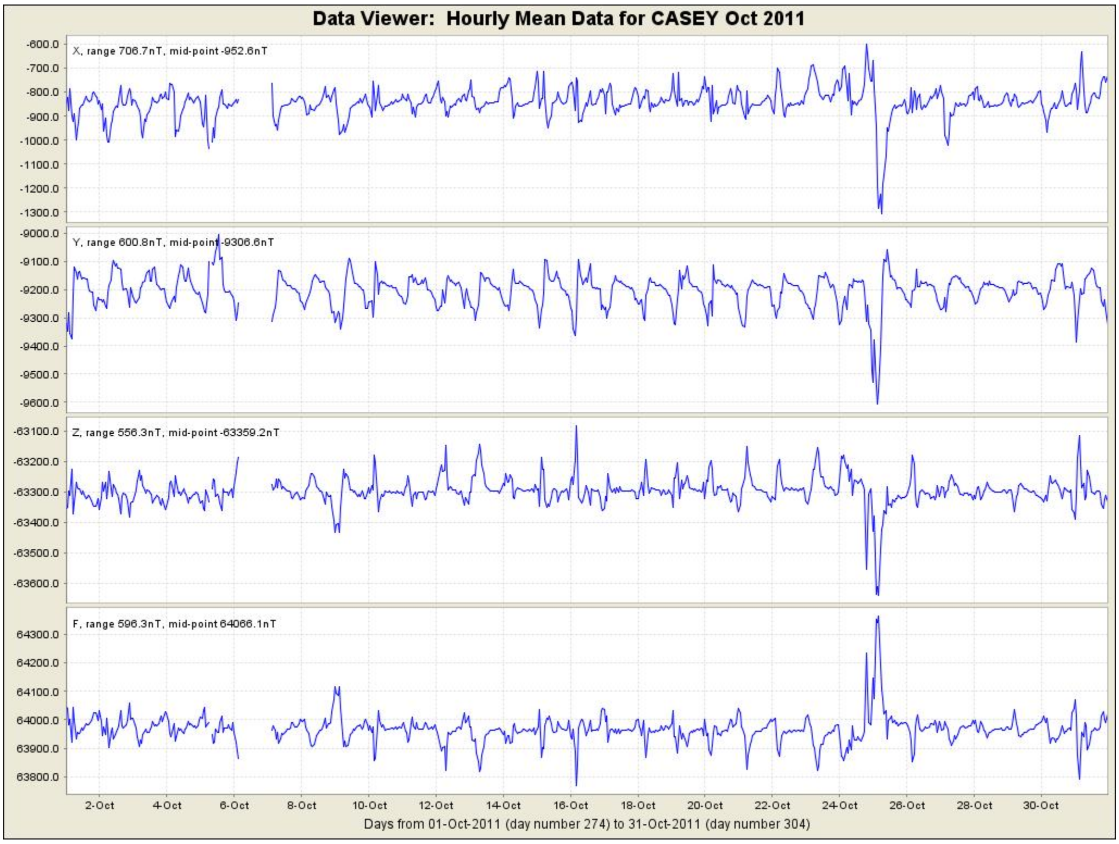

Data Viewer: Hourly Mean Data for CASEY May 2011
X, range 391.1nT, mid-point -953.4nT
Y, range 380.7nT, mid-point -9182.4nT
Z, range 445.2nT, mid-point -63391.5nT
F, range 428.3nT, mid-point 64059.5nT
Days from 01-May-2011 (day number 121) to 31-May-2011 (day number 151)

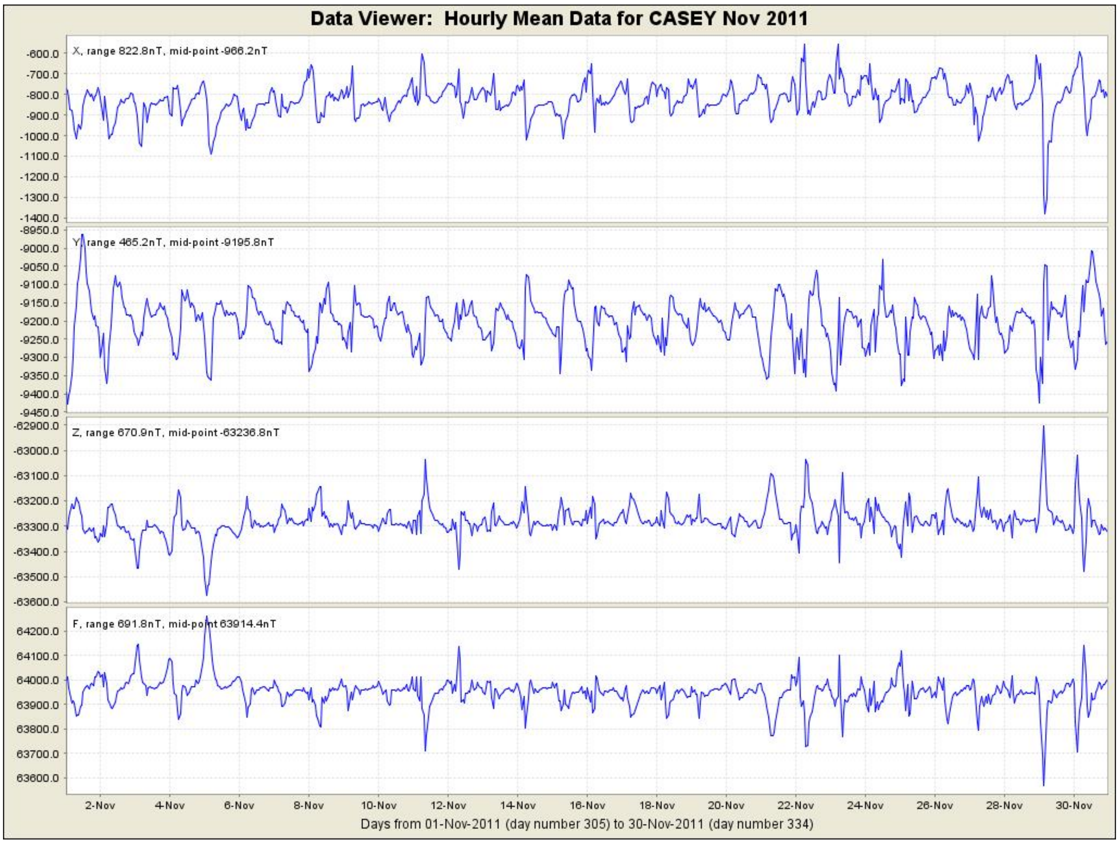

Data Viewer: Hourly Mean Data for CASEY Jun 2011
X, range 228.7nT, mid-point -871.8nT
Y, range 456.5nT, mid-point -9235.4nT
Z, range 290.9nT, mid-point -63344.2nT
F, range 295.0nT, mid-point 64014.9nT
Days from 01-Jun-2011 (day number 152) to 30-Jun-2011 (day number 181)


Data Viewer: Hourly Mean Data for CASEY Jul 2011
X, range 217.4nT, mid-point -866.9nT
Y, range 249.2nT, mid-point -9215.9nT
Z, range 354.6nT, mid-point -63366.9nT
F, range 354.1nT, mid-point 64043.0nT
Days from 01-Jul-2011 (day number 182) to 31-Jul-2011 (day number 212)


Data Viewer: Hourly Mean Data for CASEY Aug 2011
X, range 312.1nT, mid-point -915.2nT
Y, range 426.2nT, mid-point -9292.0nT
Z, range 1003.7nT, mid-point -63666.8nT
F, range 1002.4nT, mid-point 64337.4nT
Days from 01-Aug-2011 (day number 213) to 31-Aug-2011 (day number 243)


Data Viewer: Hourly Mean Data for CASEY Sep 2011
X, range 455.3nT, mid-point -801.8nT
Y, range 541.4nT, mid-point -9254.7nT
Z, range 582.1nT, mid-point -63341.8nT
F, range 579.8nT, mid-point 64003.7nT
Days from 01-Sep-2011 (day number 244) to 30-Sep-2011 (day number 273)


Data Viewer: Hourly Mean Data for CASEY Oct 2011
X, range 706.7nT, mid-point -952.6nT
Y, range 600.8nT, mid-point -9306.6nT
Z, range 556.3nT, mid-point -63359.2nT
F, range 596.3nT, mid-point 64066.1nT
Days from 01-Oct-2011 (day number 274) to 31-Oct-2011 (day number 304)



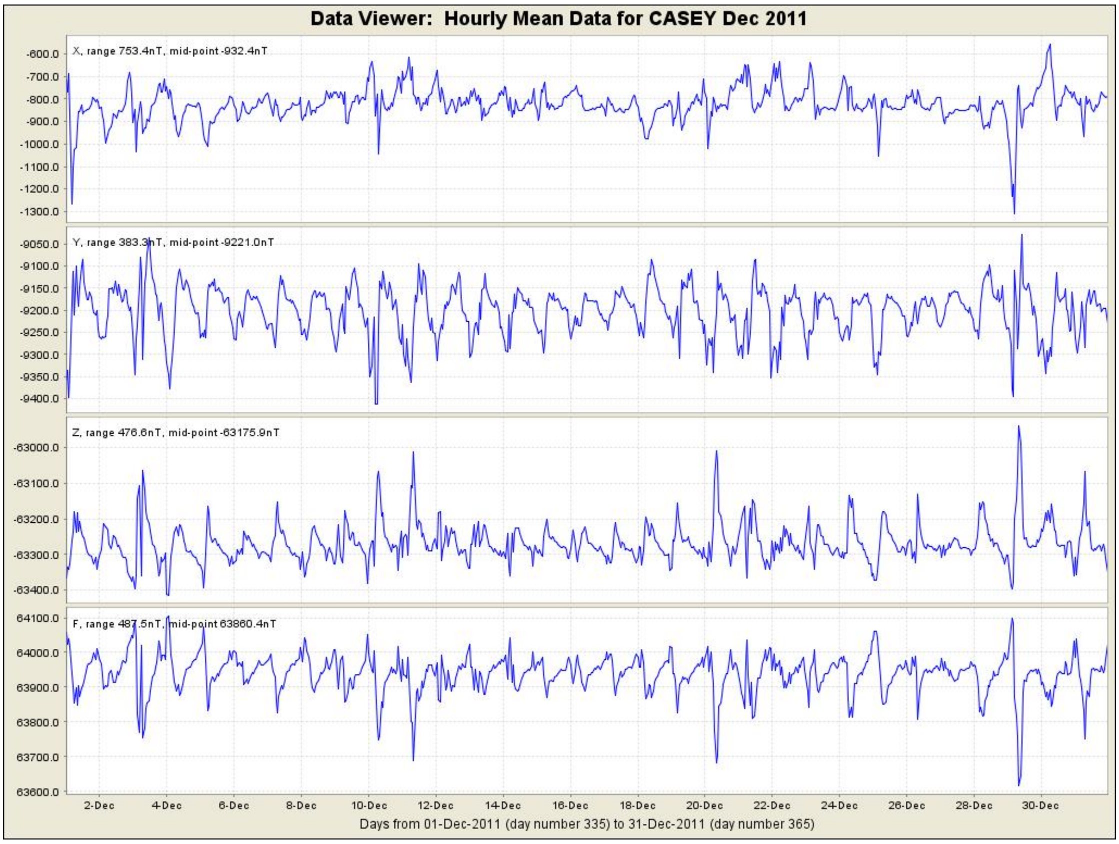


Figure 10.3. *Casey 2011 hourly mean values in X, Y, Z and F.*

Appendix A. Data losses

Table A.1. *Kakadu data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-01-05	16:13	–	16:16	4
2011-06-16	04:47	–	04:48	2
2011-09-12	06:40	–		
2011-09-14			01:00	2541
2011-11-15	07:56	–	08:02	7
2011-11-19	04:27	–	04:27	1
2011-11-24	00:55	–	00:59	5
2011-12-14	15:24	–		
2011-12-15			06:59	936
2011-12-17	16:23	–		
2011-12-21			03:00	4958
Scalar data				
2011-04-08	00:07	–	00:15	9
2011-04-22	17:26	–	17:49	24
2011-04-22	17:51	–	17:55	5
2011-04-22	20:38	–	23:22	165
2011-04-22	23:25	–	23:27	3
2011-04-22	23:36	–	23:36	1
2011-04-22	23:59	–		
2011-04-23			00:08	10
2011-04-23	00:11	–	00:33	23
2011-04-23	00:37	–	00:39	3
2011-04-23	02:06	–	02:09	4
2011-04-23	02:14	–	02:25	12
2011-04-23	03:51	–	03:51	1
2011-04-23	03:53	–	04:30	38
2011-04-23	04:32	–	04:33	2
2011-04-23	04:37	–	04:37	1
2011-04-29	04:24	–	05:00	37
2011-04-29	05:05	–	05:05	1
2011-05-19	03:16	–	05:34	139
2011-05-19	05:38	–	05:38	1
2011-05-19	05:40	–	05:40	1
2011-05-19	05:43	–	05:43	1
2011-05-19	05:45	–	05:45	1
2011-05-20	02:27	–	03:55	89
2011-05-20	03:58	–	03:58	1
2011-05-20	07:05	–	07:17	13
2011-05-31	23:38	–	23:38	1
2011-06-01	00:03	–	00:03	1
2011-06-01	01:40	–	01:40	1
2011-06-01	01:46	–	01:46	1
2011-06-01	03:41	–	03:41	1
2011-06-01	04:41	–	04:41	1
2011-06-01	14:33	–	14:33	1
2011-06-01	21:08	–	21:08	1
2011-06-01	21:24	–	21:24	1
2011-06-01	22:34	–	22:34	1
2011-06-01	22:38	–	22:38	1
2011-06-01	22:47	–	22:47	1
2011-06-01	23:17	–	23:17	1
2011-06-01	23:43	–	23:43	1
2011-06-02	00:15	–	00:15	1
2011-06-02	00:18	–	00:18	1
2011-06-02	00:23	–	00:23	1
2011-06-02	00:55	–	00:55	1
2011-06-02	01:33	–	01:33	1
2011-06-02	02:03	–	02:03	1
2011-06-02	02:43	–	02:43	1
2011-06-02	02:51	–	02:51	1
2011-06-02	03:26	–	03:26	1
2011-06-02	03:32	–	03:32	1
2011-06-02	03:57	–	03:57	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-02	04:15	–	04:15	1
2011-06-02	04:36	–	04:36	1
2011-06-02	05:12	–	05:12	1
2011-06-02	05:27	–	05:27	1
2011-06-02	17:06	–	17:06	1
2011-06-02	17:21	–	17:21	1
2011-06-02	17:39	–	17:39	1
2011-06-02	17:47	–	17:47	1
2011-06-02	17:51	–	17:51	1
2011-06-02	18:15	–	18:15	1
2011-06-02	18:40	–	18:40	1
2011-06-02	21:10	–	21:10	1
2011-06-02	22:00	–	22:00	1
2011-06-02	22:17	–	22:17	1
2011-06-02	22:43	–	22:43	1
2011-06-02	22:57	–	22:57	1
2011-06-02	23:09	–	23:09	1
2011-06-02	23:14	–	23:14	1
2011-06-02	23:16	–	23:16	1
2011-06-02	23:25	–	23:25	1
2011-06-02	23:29	–	23:29	1
2011-06-02	23:45	–	23:45	1
2011-06-02	23:55	–	23:55	1
2011-06-03	00:05	–	00:05	1
2011-06-03	00:12	–	00:12	1
2011-06-03	00:39	–	00:39	1
2011-06-03	00:50	–	00:50	1
2011-06-03	00:59	–	00:59	1
2011-06-03	01:11	–	01:11	1
2011-06-03	01:30	–	01:30	1
2011-06-03	01:36	–	01:36	1
2011-06-03	01:39	–	01:39	1
2011-06-03	01:41	–	01:41	1
2011-06-03	01:56	–	01:56	1
2011-06-03	02:00	–	02:01	2
2011-06-03	02:57	–	02:57	1
2011-06-03	03:12	–	03:12	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-03	03:20	–	03:21	2
2011-06-03	03:25	–	03:25	1
2011-06-03	03:30	–	03:30	1
2011-06-03	04:13	–	04:13	1
2011-06-03	17:10	–	17:10	1
2011-06-03	19:37	–	19:37	1
2011-06-03	19:50	–	19:50	1
2011-06-03	20:24	–	20:24	1
2011-06-03	21:28	–	21:28	1
2011-06-03	21:40	–	21:40	1
2011-06-03	21:49	–	21:49	1
2011-06-03	22:31	–	22:31	1
2011-06-03	22:36	–	22:36	1
2011-06-03	22:40	–	22:40	1
2011-06-03	22:44	–	22:44	1
2011-06-03	23:32	–	23:32	1
2011-06-03	23:55	–	23:55	1
2011-06-04	00:12	–	00:12	1
2011-06-04	00:23	–	00:23	1
2011-06-04	00:36	–	00:36	1
2011-06-04	00:41	–	00:41	1
2011-06-04	00:48	–	00:48	1
2011-06-04	00:52	–	00:52	1
2011-06-04	00:55	–	00:55	1
2011-06-04	01:03	–	01:03	1
2011-06-04	01:09	–	01:09	1
2011-06-04	01:18	–	01:18	1
2011-06-04	01:20	–	01:21	2
2011-06-04	01:23	–	01:23	1
2011-06-04	01:27	–	01:27	1
2011-06-04	01:36	–	01:36	1
2011-06-04	01:58	–	01:58	1
2011-06-04	02:03	–	02:03	1
2011-06-04	02:26	–	02:26	1
2011-06-04	02:53	–	02:53	1
2011-06-04	02:58	–	02:58	1
2011-06-04	03:13	–	03:13	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-04	03:15	–	03:15	1
2011-06-04	05:31	–	05:31	1
2011-06-04	17:30	–	17:30	1
2011-06-04	18:08	–	18:08	1
2011-06-04	18:32	–	18:32	1
2011-06-04	18:38	–	18:38	1
2011-06-04	18:57	–	18:57	1
2011-06-04	19:35	–	19:35	1
2011-06-04	20:04	–	20:04	1
2011-06-04	20:09	–	20:09	1
2011-06-04	20:35	–	20:35	1
2011-06-04	20:39	–	20:39	1
2011-06-04	20:56	–	20:56	1
2011-06-04	20:58	–	20:58	1
2011-06-04	21:02	–	21:02	1
2011-06-04	21:10	–	21:10	1
2011-06-04	21:17	–	21:17	1
2011-06-04	21:36	–	21:36	1
2011-06-04	21:53	–	21:53	1
2011-06-04	22:02	–	22:02	1
2011-06-04	22:09	–	22:10	2
2011-06-04	22:14	–	22:14	1
2011-06-04	22:26	–	22:26	1
2011-06-04	22:30	–	22:31	2
2011-06-04	22:35	–	22:35	1
2011-06-04	22:53	–	22:53	1
2011-06-04	23:00	–	23:00	1
2011-06-04	23:08	–	23:08	1
2011-06-04	23:10	–	23:10	1
2011-06-04	23:24	–	23:25	2
2011-06-04	23:38	–	23:38	1
2011-06-04	23:44	–	23:44	1
2011-06-05	00:01	–	00:01	1
2011-06-05	00:09	–	00:09	1
2011-06-05	00:16	–	00:17	2
2011-06-05	00:27	–	00:27	1
2011-06-05	00:40	–	00:40	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-05	01:05	–	01:05	1
2011-06-05	01:42	–	01:42	1
2011-06-05	01:51	–	01:51	1
2011-06-05	01:59	–	02:00	2
2011-06-05	02:07	–	02:08	2
2011-06-05	02:32	–	02:32	1
2011-06-05	03:29	–	03:29	1
2011-06-05	03:38	–	03:38	1
2011-06-05	03:44	–	03:44	1
2011-06-05	03:47	–	03:47	1
2011-06-05	04:09	–	04:09	1
2011-06-05	04:39	–	04:39	1
2011-06-05	06:04	–	06:04	1
2011-06-05	20:27	–	20:27	1
2011-06-05	21:08	–	21:08	1
2011-06-05	21:39	–	21:39	1
2011-06-05	22:14	–	22:14	1
2011-06-05	23:02	–	23:02	1
2011-06-05	23:25	–	23:25	1
2011-06-05	23:46	–	23:46	1
2011-06-05	23:57	–	23:57	1
2011-06-06	00:28	–	00:28	1
2011-06-06	00:55	–	00:55	1
2011-06-06	01:00	–	01:00	1
2011-06-06	01:25	–	01:25	1
2011-06-06	01:41	–	01:41	1
2011-06-06	01:51	–	01:51	1
2011-06-06	02:02	–	02:02	1
2011-06-06	02:40	–	02:40	1
2011-06-06	22:35	–	22:35	1
2011-06-06	23:13	–	23:13	1
2011-06-06	23:21	–	23:21	1
2011-06-06	23:49	–	23:49	1
2011-06-06	23:54	–	23:54	1
2011-06-07	00:25	–	00:25	1
2011-06-07	00:57	–	00:57	1
2011-06-07	01:59	–	01:59	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-07	16:35	–	16:35	1
2011-06-07	21:13	–	21:13	1
2011-06-07	22:05	–	22:05	1
2011-06-07	23:02	–	23:02	1
2011-06-08	00:13	–	00:13	1
2011-06-08	00:19	–	00:19	1
2011-06-08	00:30	–	00:30	1
2011-06-08	02:16	–	02:16	1
2011-06-08	22:39	–	22:39	1
2011-06-10	18:30	–	18:30	1
2011-06-10	19:46	–	19:46	1
2011-06-10	21:48	–	21:48	1
2011-06-10	23:16	–	23:16	1
2011-06-11	01:33	–	01:35	3
2011-06-11	01:55	–	01:55	1
2011-06-11	02:05	–	02:05	1
2011-06-11	02:20	–	02:20	1
2011-06-11	02:53	–	02:54	2
2011-06-11	04:00	–	04:00	1
2011-06-11	04:17	–	04:17	1
2011-06-11	04:19	–	04:20	2
2011-06-11	04:37	–	04:37	1
2011-06-11	04:48	–	04:48	1
2011-06-11	16:15	–	16:15	1
2011-06-11	17:38	–	17:38	1
2011-06-11	17:50	–	17:50	1
2011-06-11	18:02	–	18:02	1
2011-06-11	18:11	–	18:11	1
2011-06-11	18:43	–	18:43	1
2011-06-11	19:01	–	19:01	1
2011-06-11	19:22	–	19:22	1
2011-06-11	19:43	–	19:43	1
2011-06-11	19:56	–	19:56	1
2011-06-11	20:01	–	20:01	1
2011-06-11	20:24	–	20:24	1
2011-06-11	21:10	–	21:10	1
2011-06-11	21:19	–	21:19	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-11	21:24	–	21:24	1
2011-06-11	21:26	–	21:26	1
2011-06-11	21:51	–	21:51	1
2011-06-11	21:55	–	21:55	1
2011-06-11	22:20	–	22:20	1
2011-06-11	22:29	–	22:29	1
2011-06-11	22:41	–	22:41	1
2011-06-11	22:44	–	22:44	1
2011-06-11	22:57	–	22:57	1
2011-06-11	23:02	–	23:02	1
2011-06-11	23:11	–	23:11	1
2011-06-11	23:15	–	23:15	1
2011-06-11	23:19	–	23:19	1
2011-06-11	23:40	–	23:40	1
2011-06-11	23:46	–	23:47	2
2011-06-11	23:53	–	23:53	1
2011-06-11	23:59	–	23:59	1
2011-06-12	00:29	–	00:29	1
2011-06-12	00:33	–	00:33	1
2011-06-12	00:46	–	00:46	1
2011-06-12	00:55	–	00:55	1
2011-06-12	01:01	–	01:01	1
2011-06-12	01:03	–	01:03	1
2011-06-12	01:17	–	01:17	1
2011-06-12	01:23	–	01:23	1
2011-06-12	01:39	–	01:39	1
2011-06-12	01:44	–	01:44	1
2011-06-12	01:51	–	01:51	1
2011-06-12	01:57	–	01:57	1
2011-06-12	02:05	–	02:05	1
2011-06-12	02:11	–	02:11	1
2011-06-12	02:20	–	02:20	1
2011-06-12	02:23	–	02:23	1
2011-06-12	02:27	–	02:27	1
2011-06-12	02:29	–	02:29	1
2011-06-12	02:33	–	02:34	2
2011-06-12	02:36	–	02:37	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-12	02:39	–	02:39	1
2011-06-12	03:04	–	03:04	1
2011-06-12	03:11	–	03:11	1
2011-06-12	03:17	–	03:17	1
2011-06-12	03:20	–	03:20	1
2011-06-12	03:26	–	03:26	1
2011-06-12	03:29	–	03:29	1
2011-06-12	03:31	–	03:31	1
2011-06-12	03:35	–	03:35	1
2011-06-12	03:37	–	03:37	1
2011-06-12	03:49	–	03:49	1
2011-06-12	03:52	–	03:52	1
2011-06-12	03:54	–	03:54	1
2011-06-12	04:02	–	04:02	1
2011-06-12	04:10	–	04:10	1
2011-06-12	04:13	–	04:14	2
2011-06-12	04:20	–	04:20	1
2011-06-12	04:23	–	04:23	1
2011-06-12	04:26	–	04:26	1
2011-06-12	04:31	–	04:31	1
2011-06-12	04:41	–	04:41	1
2011-06-12	04:44	–	04:46	3
2011-06-12	04:58	–	04:58	1
2011-06-12	05:07	–	05:08	2
2011-06-12	05:15	–	05:15	1
2011-06-12	05:17	–	05:17	1
2011-06-12	05:23	–	05:23	1
2011-06-12	05:50	–	05:50	1
2011-06-12	05:56	–	05:56	1
2011-06-12	06:20	–	06:20	1
2011-06-12	06:27	–	06:27	1
2011-06-12	06:29	–	06:29	1
2011-06-12	12:04	–	12:04	1
2011-06-12	12:24	–	12:24	1
2011-06-12	13:07	–	13:07	1
2011-06-12	13:36	–	13:36	1
2011-06-12	14:14	–	14:14	1
2011-06-12	14:24	–	14:24	1
2011-06-12	14:52	–	14:52	1
2011-06-12	14:57	–	14:57	1
2011-06-12	15:15	–	15:15	1
2011-06-12	15:47	–	15:47	1
2011-06-12	15:55	–	15:55	1
2011-06-12	16:04	–	16:04	1
2011-06-12	16:22	–	16:22	1
2011-06-12	16:29	–	16:29	1
2011-06-12	16:42	–	16:42	1
2011-06-12	16:45	–	16:45	1
2011-06-12	16:54	–	16:54	1
2011-06-12	17:05	–	17:05	1
2011-06-12	17:14	–	17:14	1
2011-06-12	17:23	–	17:23	1
2011-06-12	17:25	–	17:25	1
2011-06-12	17:31	–	17:31	1
2011-06-12	17:57	–	17:57	1
2011-06-12	18:10	–	18:10	1
2011-06-12	18:14	–	18:15	2
2011-06-12	18:18	–	18:18	1
2011-06-12	18:21	–	18:21	1
2011-06-12	18:32	–	18:32	1
2011-06-12	18:34	–	18:34	1
2011-06-12	18:36	–	18:36	1
2011-06-12	19:07	–	19:07	1
2011-06-12	19:13	–	19:13	1
2011-06-12	19:25	–	19:25	1
2011-06-12	19:38	–	19:38	1
2011-06-12	19:47	–	19:47	1
2011-06-12	19:53	–	19:53	1
2011-06-12	20:02	–	20:03	2
2011-06-12	20:07	–	20:08	2
2011-06-12	20:11	–	20:12	2
2011-06-12	20:18	–	20:18	1
2011-06-12	20:21	–	20:21	1
2011-06-12	20:23	–	20:23	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-12	20:29	–	20:29	1
2011-06-12	20:31	–	20:31	1
2011-06-12	20:37	–	20:38	2
2011-06-12	20:42	–	20:42	1
2011-06-12	20:44	–	20:44	1
2011-06-12	20:56	–	20:56	1
2011-06-12	21:01	–	21:01	1
2011-06-12	21:04	–	21:04	1
2011-06-12	21:07	–	21:07	1
2011-06-12	21:10	–	21:10	1
2011-06-12	21:15	–	21:15	1
2011-06-12	21:23	–	21:23	1
2011-06-12	21:26	–	21:26	1
2011-06-12	21:28	–	21:28	1
2011-06-12	21:30	–	21:30	1
2011-06-12	21:33	–	21:35	3
2011-06-12	21:48	–	21:48	1
2011-06-12	21:51	–	21:51	1
2011-06-12	22:04	–	22:04	1
2011-06-12	22:08	–	22:08	1
2011-06-12	22:11	–	22:11	1
2011-06-12	22:13	–	22:13	1
2011-06-12	22:15	–	22:15	1
2011-06-12	22:17	–	22:17	1
2011-06-12	22:23	–	22:24	2
2011-06-12	22:28	–	22:28	1
2011-06-12	22:31	–	22:31	1
2011-06-12	22:34	–	22:34	1
2011-06-12	22:37	–	22:37	1
2011-06-12	22:40	–	22:40	1
2011-06-12	22:42	–	22:43	2
2011-06-12	22:45	–	22:45	1
2011-06-12	22:48	–	22:51	4
2011-06-12	22:54	–	22:54	1
2011-06-12	23:00	–	23:00	1
2011-06-12	23:05	–	23:05	1
2011-06-12	23:09	–	23:09	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-12	23:11	–	23:11	1
2011-06-12	23:14	–	23:14	1
2011-06-12	23:18	–	23:19	2
2011-06-12	23:26	–	23:26	1
2011-06-12	23:28	–	23:28	1
2011-06-12	23:31	–	23:31	1
2011-06-12	23:42	–	23:42	1
2011-06-12	23:46	–	23:48	3
2011-06-12	23:54	–	23:54	1
2011-06-12	23:56	–	23:56	1
2011-06-12	23:58	–	23:59	2
2011-06-13	00:01	–	00:03	3
2011-06-13	00:05	–	00:06	2
2011-06-13	00:09	–	00:09	1
2011-06-13	00:13	–	00:13	1
2011-06-13	00:16	–	00:16	1
2011-06-13	00:30	–	00:30	1
2011-06-13	00:34	–	00:34	1
2011-06-13	00:38	–	00:39	2
2011-06-13	00:43	–	00:43	1
2011-06-13	00:45	–	00:46	2
2011-06-13	00:48	–	00:48	1
2011-06-13	00:50	–	00:50	1
2011-06-13	00:54	–	00:55	2
2011-06-13	00:59	–	00:59	1
2011-06-13	01:03	–	01:03	1
2011-06-13	01:06	–	01:07	2
2011-06-13	01:09	–	01:09	1
2011-06-13	01:17	–	01:17	1
2011-06-13	01:20	–	01:20	1
2011-06-13	01:26	–	01:26	1
2011-06-13	01:31	–	01:32	2
2011-06-13	01:34	–	01:34	1
2011-06-13	01:36	–	01:36	1
2011-06-13	01:38	–	01:38	1
2011-06-13	01:40	–	01:40	1
2011-06-13	01:42	–	01:44	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-13	01:49	–	01:49	1
2011-06-13	01:52	–	01:52	1
2011-06-13	01:57	–	01:58	2
2011-06-13	02:01	–	02:03	3
2011-06-13	02:05	–	02:05	1
2011-06-13	02:07	–	02:07	1
2011-06-13	02:09	–	02:10	2
2011-06-13	02:12	–	02:12	1
2011-06-13	02:14	–	02:14	1
2011-06-13	02:17	–	02:17	1
2011-06-13	02:19	–	02:19	1
2011-06-13	02:32	–	02:32	1
2011-06-13	02:36	–	02:37	2
2011-06-13	02:39	–	02:39	1
2011-06-13	02:41	–	02:42	2
2011-06-13	02:44	–	02:44	1
2011-06-13	02:46	–	02:49	4
2011-06-13	02:53	–	02:53	1
2011-06-13	02:55	–	02:55	1
2011-06-13	03:04	–	03:11	8
2011-06-13	03:16	–	03:18	3
2011-06-13	03:21	–	03:21	1
2011-06-13	03:26	–	03:26	1
2011-06-13	03:32	–	03:32	1
2011-06-13	03:41	–	03:41	1
2011-06-13	03:45	–	03:45	1
2011-06-13	03:47	–	03:47	1
2011-06-13	03:56	–	03:56	1
2011-06-13	04:03	–	04:05	3
2011-06-13	04:07	–	04:10	4
2011-06-13	04:12	–	04:12	1
2011-06-13	04:17	–	04:17	1
2011-06-13	04:20	–	04:20	1
2011-06-13	04:23	–	04:23	1
2011-06-13	04:25	–	04:25	1
2011-06-13	04:30	–	04:30	1
2011-06-13	04:33	–	04:34	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-13	04:38	–	04:38	1
2011-06-13	04:40	–	04:40	1
2011-06-13	04:48	–	04:48	1
2011-06-13	04:51	–	04:52	2
2011-06-13	04:54	–	04:55	2
2011-06-13	04:58	–	04:58	1
2011-06-13	05:03	–	05:03	1
2011-06-13	05:09	–	05:09	1
2011-06-13	05:11	–	05:12	2
2011-06-13	05:18	–	05:18	1
2011-06-13	05:23	–	05:24	2
2011-06-13	05:26	–	05:27	2
2011-06-13	05:30	–	05:30	1
2011-06-13	05:35	–	05:35	1
2011-06-13	05:37	–	05:39	3
2011-06-13	05:42	–	05:42	1
2011-06-13	05:45	–	05:46	2
2011-06-13	05:48	–	05:48	1
2011-06-13	05:57	–	05:57	1
2011-06-13	05:59	–	05:59	1
2011-06-13	06:01	–	06:01	1
2011-06-13	06:03	–	06:03	1
2011-06-13	06:05	–	06:05	1
2011-06-13	06:07	–	06:07	1
2011-06-13	06:13	–	06:14	2
2011-06-13	06:18	–	06:18	1
2011-06-13	06:22	–	06:22	1
2011-06-13	06:25	–	06:26	2
2011-06-13	06:38	–	06:38	1
2011-06-13	06:43	–	06:43	1
2011-06-13	06:48	–	06:48	1
2011-06-13	06:50	–	06:50	1
2011-06-13	06:52	–	06:52	1
2011-06-13	06:57	–	06:58	2
2011-06-13	07:01	–	07:01	1
2011-06-13	07:07	–	07:07	1
2011-06-13	07:10	–	07:10	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-13	07:19	–	07:19	1
2011-06-13	07:25	–	07:26	2
2011-06-13	07:32	–	07:32	1
2011-06-13	07:41	–	07:41	1
2011-06-13	07:43	–	07:43	1
2011-06-13	07:49	–	07:49	1
2011-06-13	07:54	–	07:55	2
2011-06-13	08:02	–	08:02	1
2011-06-13	08:07	–	08:07	1
2011-06-13	08:10	–	08:10	1
2011-06-13	08:12	–	08:12	1
2011-06-13	08:16	–	08:16	1
2011-06-13	08:20	–	08:20	1
2011-06-13	08:44	–	08:44	1
2011-06-13	08:58	–	08:58	1
2011-06-13	09:01	–	09:03	3
2011-06-13	09:08	–	09:08	1
2011-06-13	09:11	–	09:12	2
2011-06-13	09:15	–	09:15	1
2011-06-13	09:18	–	09:19	2
2011-06-13	09:27	–	09:27	1
2011-06-13	09:31	–	09:31	1
2011-06-13	09:50	–	09:50	1
2011-06-13	09:54	–	09:54	1
2011-06-13	09:58	–	09:58	1
2011-06-13	10:27	–	10:27	1
2011-06-13	10:30	–	10:30	1
2011-06-13	10:32	–	10:32	1
2011-06-13	11:08	–	11:08	1
2011-06-13	11:10	–	11:10	1
2011-06-13	11:15	–	11:15	1
2011-06-13	11:28	–	11:28	1
2011-06-13	11:59	–	11:59	1
2011-06-13	12:01	–	12:03	3
2011-06-13	12:10	–	12:10	1
2011-06-13	12:17	–	12:17	1
2011-06-13	12:21	–	12:21	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-13	12:27	–	12:27	1
2011-06-13	12:29	–	12:29	1
2011-06-13	12:33	–	12:33	1
2011-06-13	12:45	–	12:45	1
2011-06-13	12:50	–	12:50	1
2011-06-13	12:52	–	12:52	1
2011-06-13	12:56	–	12:56	1
2011-06-13	13:02	–	13:02	1
2011-06-13	13:11	–	13:11	1
2011-06-13	13:13	–	13:13	1
2011-06-13	13:17	–	13:17	1
2011-06-13	13:41	–	13:43	3
2011-06-13	13:45	–	13:45	1
2011-06-13	13:59	–	14:00	2
2011-06-13	14:09	–	14:10	2
2011-06-13	14:16	–	14:16	1
2011-06-13	14:19	–	14:19	1
2011-06-13	14:22	–	14:22	1
2011-06-13	14:32	–	14:32	1
2011-06-13	14:38	–	14:38	1
2011-06-13	14:45	–	14:45	1
2011-06-13	14:55	–	14:55	1
2011-06-13	14:57	–	14:57	1
2011-06-13	15:02	–	15:03	2
2011-06-13	15:08	–	15:09	2
2011-06-13	15:11	–	15:11	1
2011-06-13	15:14	–	15:14	1
2011-06-13	15:18	–	15:19	2
2011-06-13	15:24	–	15:25	2
2011-06-13	15:28	–	15:28	1
2011-06-13	15:31	–	15:31	1
2011-06-13	15:39	–	15:39	1
2011-06-13	15:44	–	15:44	1
2011-06-13	15:50	–	15:50	1
2011-06-13	15:55	–	15:55	1
2011-06-13	15:57	–	15:57	1
2011-06-13	16:03	–	16:03	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-13	16:06	–	16:06	1
2011-06-13	16:10	–	16:11	2
2011-06-13	16:14	–	16:14	1
2011-06-13	16:20	–	16:20	1
2011-06-13	16:25	–	16:25	1
2011-06-13	16:27	–	16:27	1
2011-06-13	16:29	–	16:29	1
2011-06-13	16:31	–	16:31	1
2011-06-13	16:34	–	16:34	1
2011-06-13	16:37	–	16:37	1
2011-06-13	16:39	–	16:39	1
2011-06-13	16:52	–	16:52	1
2011-06-13	16:55	–	16:55	1
2011-06-13	17:01	–	17:02	2
2011-06-13	17:12	–	17:13	2
2011-06-13	17:15	–	17:15	1
2011-06-13	17:17	–	17:17	1
2011-06-13	17:25	–	17:25	1
2011-06-13	17:28	–	17:28	1
2011-06-13	17:35	–	17:36	2
2011-06-13	17:41	–	17:41	1
2011-06-13	17:47	–	17:48	2
2011-06-13	17:56	–	17:58	3
2011-06-13	18:02	–	18:03	2
2011-06-13	18:06	–	18:07	2
2011-06-13	18:13	–	18:13	1
2011-06-13	18:20	–	18:20	1
2011-06-13	18:22	–	18:23	2
2011-06-13	18:27	–	18:27	1
2011-06-13	18:30	–	18:31	2
2011-06-13	18:33	–	18:33	1
2011-06-13	18:35	–	18:35	1
2011-06-13	18:37	–	18:37	1
2011-06-13	18:41	–	18:43	3
2011-06-13	18:45	–	18:45	1
2011-06-13	18:47	–	18:48	2
2011-06-13	18:53	–	18:53	1
2011-06-13	19:02	–	19:03	2
2011-06-13	19:08	–	19:08	1
2011-06-13	19:13	–	19:14	2
2011-06-13	19:17	–	19:18	2
2011-06-13	19:25	–	19:25	1
2011-06-13	19:27	–	19:27	1
2011-06-13	19:30	–	19:31	2
2011-06-13	19:33	–	19:37	5
2011-06-13	19:43	–	19:43	1
2011-06-13	19:47	–	19:47	1
2011-06-13	19:49	–	19:49	1
2011-06-13	19:53	–	19:54	2
2011-06-13	19:58	–	19:58	1
2011-06-13	20:01	–	20:01	1
2011-06-13	20:03	–	20:03	1
2011-06-13	20:08	–	20:09	2
2011-06-13	20:14	–	20:15	2
2011-06-13	20:18	–	20:19	2
2011-06-13	20:21	–	20:21	1
2011-06-13	20:23	–	20:23	1
2011-06-13	20:33	–	20:33	1
2011-06-13	20:35	–	20:35	1
2011-06-13	20:38	–	20:38	1
2011-06-13	20:41	–	20:41	1
2011-06-13	20:46	–	20:46	1
2011-06-13	20:51	–	20:51	1
2011-06-13	20:59	–	20:59	1
2011-06-13	21:01	–	21:01	1
2011-06-13	21:04	–	21:06	3
2011-06-13	21:10	–	21:10	1
2011-06-13	21:12	–	21:12	1
2011-06-13	21:16	–	21:16	1
2011-06-13	21:18	–	21:18	1
2011-06-13	21:26	–	21:26	1
2011-06-13	21:28	–	21:28	1
2011-06-13	21:33	–	21:33	1
2011-06-13	21:35	–	21:35	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-13	21:37	–	21:37	1
2011-06-13	21:39	–	21:41	3
2011-06-13	21:43	–	21:44	2
2011-06-13	21:47	–	21:50	4
2011-06-13	21:53	–	21:54	2
2011-06-13	21:56	–	22:00	5
2011-06-13	22:02	–	22:03	2
2011-06-13	22:05	–	22:05	1
2011-06-13	22:08	–	22:09	2
2011-06-13	22:13	–	22:16	4
2011-06-13	22:19	–	22:19	1
2011-06-13	22:21	–	22:27	7
2011-06-13	22:29	–	22:29	1
2011-06-13	22:31	–	22:32	2
2011-06-13	22:35	–	22:35	1
2011-06-13	22:37	–	22:38	2
2011-06-13	22:40	–	22:40	1
2011-06-13	22:43	–	22:43	1
2011-06-13	22:45	–	22:45	1
2011-06-13	22:48	–	22:51	4
2011-06-13	22:53	–	22:53	1
2011-06-13	22:57	–	22:57	1
2011-06-13	22:59	–	23:00	2
2011-06-13	23:02	–	23:02	1
2011-06-13	23:05	–	23:07	3
2011-06-13	23:11	–	23:11	1
2011-06-13	23:13	–	23:13	1
2011-06-13	23:15	–	23:17	3
2011-06-13	23:20	–	23:21	2
2011-06-13	23:23	–	23:24	2
2011-06-13	23:28	–	23:30	3
2011-06-13	23:32	–	23:45	14
2011-06-13	23:47	–	23:53	7
2011-06-13	23:55	–	23:55	1
2011-06-13	23:58	–	23:58	1
2011-06-14	00:01	–	00:12	12
2011-06-14	00:14	–	00:17	4

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	00:20	–	00:34	15
2011-06-14	00:36	–	00:38	3
2011-06-14	00:41	–	00:43	3
2011-06-14	00:45	–	00:47	3
2011-06-14	00:50	–	00:54	5
2011-06-14	00:57	–	00:57	1
2011-06-14	00:59	–	00:59	1
2011-06-14	01:01	–	01:01	1
2011-06-14	01:03	–	01:05	3
2011-06-14	01:07	–	01:07	1
2011-06-14	01:11	–	01:11	1
2011-06-14	01:13	–	01:13	1
2011-06-14	01:15	–	01:16	2
2011-06-14	01:18	–	01:19	2
2011-06-14	01:22	–	01:31	10
2011-06-14	01:33	–	01:38	6
2011-06-14	01:40	–	01:41	2
2011-06-14	01:45	–	01:48	4
2011-06-14	01:50	–	01:53	4
2011-06-14	01:56	–	01:56	1
2011-06-14	01:58	–	01:58	1
2011-06-14	02:00	–	02:00	1
2011-06-14	02:03	–	02:03	1
2011-06-14	02:05	–	02:06	2
2011-06-14	02:08	–	02:08	1
2011-06-14	02:10	–	02:13	4
2011-06-14	02:15	–	02:16	2
2011-06-14	02:18	–	02:19	2
2011-06-14	02:22	–	02:25	4
2011-06-14	02:27	–	02:31	5
2011-06-14	02:35	–	02:36	2
2011-06-14	02:38	–	02:38	1
2011-06-14	02:40	–	02:45	6
2011-06-14	02:50	–	02:51	2
2011-06-14	02:53	–	02:53	1
2011-06-14	02:55	–	02:56	2
2011-06-14	02:59	–	02:59	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	03:01	–	03:08	8
2011-06-14	03:10	–	03:11	2
2011-06-14	03:14	–	03:16	3
2011-06-14	03:21	–	03:25	5
2011-06-14	03:28	–	03:30	3
2011-06-14	03:33	–	03:34	2
2011-06-14	03:37	–	03:45	9
2011-06-14	03:47	–	03:56	10
2011-06-14	04:00	–	04:01	2
2011-06-14	04:05	–	04:06	2
2011-06-14	04:09	–	04:11	3
2011-06-14	04:13	–	04:14	2
2011-06-14	04:17	–	04:24	8
2011-06-14	04:26	–	04:28	3
2011-06-14	04:30	–	04:30	1
2011-06-14	04:34	–	04:34	1
2011-06-14	04:36	–	04:38	3
2011-06-14	04:40	–	04:49	10
2011-06-14	04:51	–	04:53	3
2011-06-14	04:55	–	04:57	3
2011-06-14	05:00	–	05:00	1
2011-06-14	05:02	–	05:03	2
2011-06-14	05:05	–	05:05	1
2011-06-14	05:07	–	05:08	2
2011-06-14	05:10	–	05:10	1
2011-06-14	05:12	–	05:13	2
2011-06-14	05:17	–	05:17	1
2011-06-14	05:19	–	05:21	3
2011-06-14	05:23	–	05:24	2
2011-06-14	05:29	–	05:29	1
2011-06-14	05:32	–	05:32	1
2011-06-14	05:36	–	05:36	1
2011-06-14	05:38	–	05:41	4
2011-06-14	05:43	–	05:47	5
2011-06-14	05:49	–	05:49	1
2011-06-14	05:51	–	05:54	4
2011-06-14	05:58	–	05:58	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	06:00	–	06:01	2
2011-06-14	06:03	–	06:03	1
2011-06-14	06:07	–	06:07	1
2011-06-14	06:09	–	06:10	2
2011-06-14	06:12	–	06:12	1
2011-06-14	06:14	–	06:14	1
2011-06-14	06:18	–	06:18	1
2011-06-14	06:24	–	06:24	1
2011-06-14	06:29	–	06:33	5
2011-06-14	06:35	–	06:36	2
2011-06-14	06:38	–	06:39	2
2011-06-14	06:41	–	06:42	2
2011-06-14	06:46	–	06:47	2
2011-06-14	06:49	–	06:54	6
2011-06-14	06:56	–	06:56	1
2011-06-14	06:58	–	06:59	2
2011-06-14	07:01	–	07:01	1
2011-06-14	07:09	–	07:11	3
2011-06-14	07:20	–	07:21	2
2011-06-14	07:23	–	07:23	1
2011-06-14	07:26	–	07:26	1
2011-06-14	07:28	–	07:29	2
2011-06-14	07:34	–	07:34	1
2011-06-14	07:36	–	07:36	1
2011-06-14	07:44	–	07:46	3
2011-06-14	07:54	–	07:56	3
2011-06-14	08:03	–	08:03	1
2011-06-14	08:11	–	08:11	1
2011-06-14	08:13	–	08:13	1
2011-06-14	08:17	–	08:18	2
2011-06-14	08:22	–	08:24	3
2011-06-14	08:27	–	08:27	1
2011-06-14	08:34	–	08:34	1
2011-06-14	08:44	–	08:45	2
2011-06-14	08:48	–	08:48	1
2011-06-14	08:54	–	08:54	1
2011-06-14	08:57	–	08:57	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	08:59	–	08:59	1
2011-06-14	09:01	–	09:01	1
2011-06-14	09:11	–	09:12	2
2011-06-14	09:20	–	09:20	1
2011-06-14	09:22	–	09:22	1
2011-06-14	09:29	–	09:29	1
2011-06-14	09:32	–	09:32	1
2011-06-14	09:36	–	09:36	1
2011-06-14	09:40	–	09:40	1
2011-06-14	09:43	–	09:43	1
2011-06-14	09:47	–	09:47	1
2011-06-14	09:51	–	09:51	1
2011-06-14	09:55	–	09:55	1
2011-06-14	10:00	–	10:00	1
2011-06-14	10:13	–	10:13	1
2011-06-14	10:15	–	10:15	1
2011-06-14	10:28	–	10:28	1
2011-06-14	10:43	–	10:43	1
2011-06-14	10:53	–	10:53	1
2011-06-14	10:56	–	10:56	1
2011-06-14	10:58	–	10:58	1
2011-06-14	11:05	–	11:06	2
2011-06-14	11:09	–	11:09	1
2011-06-14	11:13	–	11:14	2
2011-06-14	11:17	–	11:17	1
2011-06-14	11:25	–	11:25	1
2011-06-14	11:32	–	11:32	1
2011-06-14	11:37	–	11:37	1
2011-06-14	11:41	–	11:42	2
2011-06-14	11:45	–	11:45	1
2011-06-14	11:48	–	11:48	1
2011-06-14	12:07	–	12:07	1
2011-06-14	12:15	–	12:15	1
2011-06-14	12:21	–	12:21	1
2011-06-14	12:28	–	12:28	1
2011-06-14	12:36	–	12:36	1
2011-06-14	12:49	–	12:50	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	12:52	–	12:52	1
2011-06-14	12:56	–	12:56	1
2011-06-14	13:00	–	13:00	1
2011-06-14	13:02	–	13:02	1
2011-06-14	13:08	–	13:08	1
2011-06-14	13:11	–	13:12	2
2011-06-14	13:21	–	13:21	1
2011-06-14	13:25	–	13:25	1
2011-06-14	13:27	–	13:27	1
2011-06-14	13:34	–	13:34	1
2011-06-14	13:39	–	13:40	2
2011-06-14	13:54	–	13:54	1
2011-06-14	13:56	–	13:56	1
2011-06-14	14:15	–	14:15	1
2011-06-14	14:17	–	14:18	2
2011-06-14	14:21	–	14:21	1
2011-06-14	14:24	–	14:24	1
2011-06-14	14:27	–	14:27	1
2011-06-14	14:38	–	14:38	1
2011-06-14	14:41	–	14:43	3
2011-06-14	14:46	–	14:46	1
2011-06-14	14:48	–	14:50	3
2011-06-14	14:56	–	14:56	1
2011-06-14	14:58	–	14:58	1
2011-06-14	15:00	–	15:00	1
2011-06-14	15:04	–	15:04	1
2011-06-14	15:07	–	15:07	1
2011-06-14	15:10	–	15:10	1
2011-06-14	15:15	–	15:15	1
2011-06-14	15:19	–	15:19	1
2011-06-14	15:24	–	15:25	2
2011-06-14	15:29	–	15:29	1
2011-06-14	15:34	–	15:34	1
2011-06-14	15:38	–	15:40	3
2011-06-14	15:46	–	15:46	1
2011-06-14	15:48	–	15:48	1
2011-06-14	15:52	–	15:52	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	15:54	–	15:54	1
2011-06-14	15:56	–	15:57	2
2011-06-14	15:59	–	15:59	1
2011-06-14	16:01	–	16:01	1
2011-06-14	16:03	–	16:03	1
2011-06-14	16:07	–	16:07	1
2011-06-14	16:09	–	16:09	1
2011-06-14	16:11	–	16:11	1
2011-06-14	16:16	–	16:16	1
2011-06-14	16:19	–	16:20	2
2011-06-14	16:22	–	16:24	3
2011-06-14	16:26	–	16:27	2
2011-06-14	16:31	–	16:32	2
2011-06-14	16:37	–	16:37	1
2011-06-14	16:39	–	16:41	3
2011-06-14	16:43	–	16:43	1
2011-06-14	16:46	–	16:47	2
2011-06-14	16:51	–	16:53	3
2011-06-14	16:55	–	16:56	2
2011-06-14	16:58	–	16:58	1
2011-06-14	17:01	–	17:03	3
2011-06-14	17:07	–	17:07	1
2011-06-14	17:10	–	17:12	3
2011-06-14	17:16	–	17:18	3
2011-06-14	17:20	–	17:21	2
2011-06-14	17:24	–	17:24	1
2011-06-14	17:26	–	17:26	1
2011-06-14	17:29	–	17:32	4
2011-06-14	17:35	–	17:37	3
2011-06-14	17:40	–	17:41	2
2011-06-14	17:43	–	17:45	3
2011-06-14	17:47	–	17:51	5
2011-06-14	17:57	–	17:57	1
2011-06-14	18:01	–	18:08	8
2011-06-14	18:16	–	18:16	1
2011-06-14	18:18	–	18:19	2
2011-06-14	18:21	–	18:21	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	18:26	–	18:26	1
2011-06-14	18:28	–	18:28	1
2011-06-14	18:30	–	18:30	1
2011-06-14	18:32	–	18:32	1
2011-06-14	18:36	–	18:36	1
2011-06-14	18:40	–	18:40	1
2011-06-14	18:43	–	18:45	3
2011-06-14	18:47	–	18:47	1
2011-06-14	18:52	–	18:52	1
2011-06-14	18:54	–	18:58	5
2011-06-14	19:01	–	19:02	2
2011-06-14	19:04	–	19:05	2
2011-06-14	19:09	–	19:10	2
2011-06-14	19:12	–	19:12	1
2011-06-14	19:15	–	19:16	2
2011-06-14	19:18	–	19:21	4
2011-06-14	19:23	–	19:23	1
2011-06-14	19:25	–	19:25	1
2011-06-14	19:27	–	19:27	1
2011-06-14	19:36	–	19:36	1
2011-06-14	19:39	–	19:39	1
2011-06-14	19:42	–	19:46	5
2011-06-14	19:48	–	19:50	3
2011-06-14	19:53	–	19:53	1
2011-06-14	19:55	–	19:58	4
2011-06-14	20:00	–	20:01	2
2011-06-14	20:03	–	20:07	5
2011-06-14	20:09	–	20:10	2
2011-06-14	20:12	–	20:12	1
2011-06-14	20:14	–	20:17	4
2011-06-14	20:19	–	20:21	3
2011-06-14	20:23	–	20:27	5
2011-06-14	20:30	–	20:30	1
2011-06-14	20:32	–	20:32	1
2011-06-14	20:35	–	20:35	1
2011-06-14	20:38	–	20:38	1
2011-06-14	20:40	–	20:40	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	20:42	–	20:43	2
2011-06-14	20:46	–	20:46	1
2011-06-14	20:49	–	20:59	11
2011-06-14	21:01	–	21:01	1
2011-06-14	21:05	–	21:07	3
2011-06-14	21:09	–	21:09	1
2011-06-14	21:11	–	21:11	1
2011-06-14	21:15	–	21:15	1
2011-06-14	21:17	–	21:19	3
2011-06-14	21:21	–	21:21	1
2011-06-14	21:23	–	21:26	4
2011-06-14	21:30	–	21:31	2
2011-06-14	21:33	–	21:33	1
2011-06-14	21:35	–	21:43	9
2011-06-14	21:45	–	21:46	2
2011-06-14	21:48	–	21:51	4
2011-06-14	21:53	–	21:53	1
2011-06-14	21:55	–	21:56	2
2011-06-14	22:00	–	22:01	2
2011-06-14	22:04	–	22:06	3
2011-06-14	22:10	–	22:10	1
2011-06-14	22:12	–	22:17	6
2011-06-14	22:19	–	22:27	9
2011-06-14	22:31	–	22:32	2
2011-06-14	22:35	–	22:37	3
2011-06-14	22:39	–	22:42	4
2011-06-14	22:44	–	22:45	2
2011-06-14	22:47	–	22:51	5
2011-06-14	22:53	–	22:56	4
2011-06-14	22:58	–	22:58	1
2011-06-14	23:03	–	23:04	2
2011-06-14	23:06	–	23:10	5
2011-06-14	23:12	–	23:25	14
2011-06-14	23:27	–	23:27	1
2011-06-14	23:29	–	23:30	2
2011-06-14	23:32	–	23:36	5
2011-06-14	23:38	–	23:52	15

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-14	23:54	–		
2011-06-15			00:02	9
2011-06-15	00:04	–	00:12	9
2011-06-15	00:14	–	00:17	4
2011-06-15	00:19	–	00:20	2
2011-06-15	00:22	–	00:23	2
2011-06-15	00:25	–	00:39	15
2011-06-15	00:41	–	00:42	2
2011-06-15	00:44	–	00:45	2
2011-06-15	00:47	–	00:58	12
2011-06-15	01:00	–	01:03	4
2011-06-15	01:06	–	01:11	6
2011-06-15	01:13	–	01:32	20
2011-06-15	01:34	–	01:42	9
2011-06-15	01:45	–	01:46	2
2011-06-15	01:48	–	01:49	2
2011-06-15	01:52	–	01:53	2
2011-06-15	01:56	–	01:59	4
2011-06-15	02:01	–	02:02	2
2011-06-15	02:04	–	02:04	1
2011-06-15	02:06	–	02:11	6
2011-06-15	02:13	–	02:15	3
2011-06-15	02:18	–	02:18	1
2011-06-15	02:21	–	02:26	6
2011-06-15	02:28	–	02:54	27
2011-06-15	02:56	–	03:07	12
2011-06-15	03:09	–	03:15	7
2011-06-15	03:17	–	03:18	2
2011-06-15	03:20	–	03:20	1
2011-06-15	03:22	–	03:26	5
2011-06-15	03:28	–	03:40	13
2011-06-15	03:42	–	03:45	4
2011-06-15	03:47	–	03:53	7
2011-06-15	03:55	–	03:55	1
2011-06-15	03:57	–	03:58	2
2011-06-15	04:00	–	04:25	26
2011-06-15	04:28	–	04:29	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	04:32	–	04:32	1
2011-06-15	04:34	–	04:34	1
2011-06-15	04:36	–	04:36	1
2011-06-15	04:40	–	04:55	16
2011-06-15	04:58	–	04:59	2
2011-06-15	05:01	–	05:01	1
2011-06-15	05:06	–	05:11	6
2011-06-15	05:14	–	05:14	1
2011-06-15	05:16	–	05:16	1
2011-06-15	05:18	–	05:19	2
2011-06-15	05:21	–	05:21	1
2011-06-15	05:24	–	05:27	4
2011-06-15	05:29	–	05:30	2
2011-06-15	05:32	–	05:34	3
2011-06-15	05:37	–	05:39	3
2011-06-15	05:41	–	05:46	6
2011-06-15	05:48	–	05:52	5
2011-06-15	05:54	–	05:54	1
2011-06-15	05:56	–	05:59	4
2011-06-15	06:01	–	06:01	1
2011-06-15	06:03	–	06:03	1
2011-06-15	06:06	–	06:06	1
2011-06-15	06:08	–	06:09	2
2011-06-15	06:15	–	06:17	3
2011-06-15	06:19	–	06:19	1
2011-06-15	06:21	–	06:21	1
2011-06-15	06:24	–	06:30	7
2011-06-15	06:32	–	06:34	3
2011-06-15	06:37	–	06:37	1
2011-06-15	06:40	–	06:41	2
2011-06-15	06:46	–	06:48	3
2011-06-15	06:51	–	06:51	1
2011-06-15	06:55	–	06:57	3
2011-06-15	07:01	–	07:02	2
2011-06-15	07:05	–	07:05	1
2011-06-15	07:09	–	07:09	1
2011-06-15	07:13	–	07:13	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	07:16	–	07:18	3
2011-06-15	07:27	–	07:27	1
2011-06-15	07:30	–	07:30	1
2011-06-15	07:34	–	07:34	1
2011-06-15	07:37	–	07:39	3
2011-06-15	07:41	–	07:44	4
2011-06-15	07:53	–	07:53	1
2011-06-15	07:55	–	07:55	1
2011-06-15	08:00	–	08:00	1
2011-06-15	08:03	–	08:03	1
2011-06-15	08:08	–	08:08	1
2011-06-15	08:13	–	08:13	1
2011-06-15	08:24	–	08:24	1
2011-06-15	08:26	–	08:26	1
2011-06-15	08:29	–	08:30	2
2011-06-15	08:34	–	08:34	1
2011-06-15	08:37	–	08:37	1
2011-06-15	08:39	–	08:40	2
2011-06-15	08:42	–	08:42	1
2011-06-15	08:45	–	08:45	1
2011-06-15	08:52	–	08:52	1
2011-06-15	08:58	–	08:58	1
2011-06-15	09:04	–	09:04	1
2011-06-15	09:07	–	09:07	1
2011-06-15	09:09	–	09:09	1
2011-06-15	09:13	–	09:14	2
2011-06-15	09:16	–	09:16	1
2011-06-15	09:19	–	09:19	1
2011-06-15	09:27	–	09:27	1
2011-06-15	09:29	–	09:29	1
2011-06-15	09:42	–	09:42	1
2011-06-15	09:51	–	09:51	1
2011-06-15	09:53	–	09:53	1
2011-06-15	09:59	–	10:01	3
2011-06-15	10:09	–	10:09	1
2011-06-15	10:14	–	10:14	1
2011-06-15	10:16	–	10:16	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	10:33	–	10:33	1
2011-06-15	10:39	–	10:39	1
2011-06-15	10:48	–	10:48	1
2011-06-15	10:59	–	10:59	1
2011-06-15	11:07	–	11:07	1
2011-06-15	11:12	–	11:12	1
2011-06-15	11:15	–	11:15	1
2011-06-15	11:22	–	11:24	3
2011-06-15	11:29	–	11:29	1
2011-06-15	11:32	–	11:32	1
2011-06-15	11:35	–	11:35	1
2011-06-15	11:40	–	11:40	1
2011-06-15	11:52	–	11:52	1
2011-06-15	11:59	–	11:59	1
2011-06-15	12:05	–	12:05	1
2011-06-15	12:10	–	12:10	1
2011-06-15	12:15	–	12:16	2
2011-06-15	12:37	–	12:37	1
2011-06-15	12:50	–	12:50	1
2011-06-15	13:07	–	13:07	1
2011-06-15	13:16	–	13:16	1
2011-06-15	13:30	–	13:30	1
2011-06-15	13:32	–	13:32	1
2011-06-15	13:37	–	13:37	1
2011-06-15	13:47	–	13:47	1
2011-06-15	13:57	–	13:58	2
2011-06-15	14:00	–	14:00	1
2011-06-15	14:05	–	14:05	1
2011-06-15	14:12	–	14:12	1
2011-06-15	14:25	–	14:25	1
2011-06-15	14:29	–	14:29	1
2011-06-15	14:31	–	14:33	3
2011-06-15	14:47	–	14:48	2
2011-06-15	14:54	–	14:54	1
2011-06-15	14:56	–	14:56	1
2011-06-15	14:58	–	14:59	2
2011-06-15	15:04	–	15:05	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	15:11	–	15:13	3
2011-06-15	15:17	–	15:17	1
2011-06-15	15:19	–	15:20	2
2011-06-15	15:22	–	15:22	1
2011-06-15	15:24	–	15:24	1
2011-06-15	15:26	–	15:27	2
2011-06-15	15:29	–	15:29	1
2011-06-15	15:32	–	15:32	1
2011-06-15	15:35	–	15:35	1
2011-06-15	15:37	–	15:38	2
2011-06-15	15:41	–	15:42	2
2011-06-15	15:44	–	15:44	1
2011-06-15	15:46	–	15:46	1
2011-06-15	15:48	–	15:48	1
2011-06-15	15:52	–	15:53	2
2011-06-15	15:55	–	15:56	2
2011-06-15	15:59	–	16:00	2
2011-06-15	16:02	–	16:04	3
2011-06-15	16:06	–	16:08	3
2011-06-15	16:10	–	16:11	2
2011-06-15	16:18	–	16:18	1
2011-06-15	16:22	–	16:22	1
2011-06-15	16:24	–	16:25	2
2011-06-15	16:29	–	16:29	1
2011-06-15	16:31	–	16:31	1
2011-06-15	16:33	–	16:33	1
2011-06-15	16:42	–	16:42	1
2011-06-15	16:47	–	16:48	2
2011-06-15	16:51	–	16:51	1
2011-06-15	16:53	–	16:54	2
2011-06-15	16:56	–	16:56	1
2011-06-15	16:59	–	17:00	2
2011-06-15	17:03	–	17:03	1
2011-06-15	17:10	–	17:10	1
2011-06-15	17:13	–	17:13	1
2011-06-15	17:15	–	17:19	5
2011-06-15	17:21	–	17:24	4

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	17:27	–	17:31	5
2011-06-15	17:34	–	17:35	2
2011-06-15	17:37	–	17:38	2
2011-06-15	17:44	–	17:45	2
2011-06-15	17:48	–	17:48	1
2011-06-15	17:50	–	17:50	1
2011-06-15	17:53	–	17:53	1
2011-06-15	17:55	–	17:56	2
2011-06-15	17:59	–	18:00	2
2011-06-15	18:03	–	18:04	2
2011-06-15	18:07	–	18:09	3
2011-06-15	18:11	–	18:12	2
2011-06-15	18:14	–	18:18	5
2011-06-15	18:22	–	18:22	1
2011-06-15	18:24	–	18:26	3
2011-06-15	18:28	–	18:30	3
2011-06-15	18:32	–	18:34	3
2011-06-15	18:38	–	18:38	1
2011-06-15	18:43	–	18:43	1
2011-06-15	18:47	–	18:48	2
2011-06-15	18:50	–	18:53	4
2011-06-15	18:55	–	18:55	1
2011-06-15	18:57	–	18:57	1
2011-06-15	18:59	–	19:02	4
2011-06-15	19:05	–	19:05	1
2011-06-15	19:07	–	19:08	2
2011-06-15	19:10	–	19:11	2
2011-06-15	19:14	–	19:14	1
2011-06-15	19:17	–	19:18	2
2011-06-15	19:20	–	19:21	2
2011-06-15	19:23	–	19:26	4
2011-06-15	19:28	–	19:28	1
2011-06-15	19:30	–	19:32	3
2011-06-15	19:34	–	19:34	1
2011-06-15	19:36	–	19:36	1
2011-06-15	19:38	–	19:40	3
2011-06-15	19:43	–	19:44	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	19:46	–	19:46	1
2011-06-15	19:48	–	19:48	1
2011-06-15	19:51	–	19:51	1
2011-06-15	19:54	–	19:57	4
2011-06-15	20:02	–	20:04	3
2011-06-15	20:06	–	20:06	1
2011-06-15	20:08	–	20:08	1
2011-06-15	20:10	–	20:12	3
2011-06-15	20:17	–	20:20	4
2011-06-15	20:23	–	20:23	1
2011-06-15	20:25	–	20:27	3
2011-06-15	20:29	–	20:29	1
2011-06-15	20:31	–	20:31	1
2011-06-15	20:34	–	20:37	4
2011-06-15	20:39	–	20:40	2
2011-06-15	20:42	–	20:46	5
2011-06-15	20:52	–	20:56	5
2011-06-15	21:00	–	21:00	1
2011-06-15	21:02	–	21:04	3
2011-06-15	21:07	–	21:07	1
2011-06-15	21:09	–	21:12	4
2011-06-15	21:14	–	21:21	8
2011-06-15	21:25	–	21:25	1
2011-06-15	21:27	–	21:28	2
2011-06-15	21:33	–	21:34	2
2011-06-15	21:36	–	21:37	2
2011-06-15	21:39	–	21:39	1
2011-06-15	21:43	–	21:43	1
2011-06-15	21:45	–	21:45	1
2011-06-15	21:47	–	21:47	1
2011-06-15	21:51	–	21:55	5
2011-06-15	21:57	–	21:59	3
2011-06-15	22:01	–	22:01	1
2011-06-15	22:03	–	22:03	1
2011-06-15	22:05	–	22:05	1
2011-06-15	22:07	–	22:08	2
2011-06-15	22:11	–	22:11	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-15	22:13	–	22:13	1
2011-06-15	22:15	–	22:21	7
2011-06-15	22:23	–	22:26	4
2011-06-15	22:28	–	22:34	7
2011-06-15	22:36	–	22:38	3
2011-06-15	22:40	–	22:41	2
2011-06-15	22:44	–	22:52	9
2011-06-15	22:54	–	22:55	2
2011-06-15	22:59	–	23:07	9
2011-06-15	23:12	–	23:13	2
2011-06-15	23:15	–	23:19	5
2011-06-15	23:21	–	23:23	3
2011-06-15	23:26	–	23:26	1
2011-06-15	23:28	–	23:29	2
2011-06-15	23:32	–	23:32	1
2011-06-15	23:38	–	23:38	1
2011-06-15	23:40	–	23:41	2
2011-06-15	23:47	–	23:48	2
2011-06-15	23:53	–	23:53	1
2011-06-16	00:00	–	07:13	434
2011-06-16	22:32	–	22:42	11
2011-11-06	16:35	–	16:35	1
2011-11-06	16:38	–	16:38	1
2011-11-24	00:56	–	00:56	1
2011-12-20	06:35	–	06:36	2
2011-12-20	17:30	–	17:30	1
2011-12-20	18:38	–	18:38	1

Table A.2. *Charters Towers data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-01-06	21:33	–	21:35	3
2011-03-12	02:58	–	03:01	4
2011-03-24	01:38	–	01:40	3
2011-04-21	00:00	–	00:02	3
2011-04-29	23:35	–		
2011-04-30			06:00	386
2011-04-30	23:59	–		
2011-05-01			06:00	362
2011-05-01	23:20	–		
2011-05-02			08:30	551
2011-05-03	02:17	–	02:18	2
2011-05-03	23:30	–		
2011-05-04			05:00	331
2011-06-05	23:59	–	23:59	1
2011-08-08	13:15	–	13:16	2
2011-09-13	02:13	–	02:15	3
2011-09-19	00:30	–	00:31	2
2011-11-03	01:52	–	01:53	2
2011-11-14	07:01	–	07:02	2
2011-12-30	00:02	–	00:03	2
Scalar data				
2011-04-29	23:36	–		
2011-04-30			05:59	384
2011-05-01	00:00	–	05:59	360
2011-05-01	23:31	–		
2011-05-02			08:29	539
2011-05-03	23:31	–		
2011-05-04			04:59	329
2011-09-12	01:21	–		
2011-10-25			21:59	63159
2011-11-03	01:53	–	01:53	1

Table A.3. *Learmonth data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-01-01	06:14	–		
2011-01-06			05:46	7173
2011-01-14	01:34	–	01:37	4
2011-03-04	01:48	–	01:49	2
2011-07-30	06:18	–	08:03	106
2011-07-30	08:22	–	08:23	2
2011-07-31	03:12	–	03:16	5
2011-07-31	03:54	–	03:56	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-07-31	04:18	–	04:19	2
2011-07-31	04:37	–	05:08	32
2011-08-02	02:12	–	02:13	2
2011-08-03	04:10	–	04:12	3
2011-11-11	06:38	–	06:55	18
2011-11-12	00:09	–	00:11	3
Scalar data				
2011-01-01	06:12	–		
2011-11-12			00:17	453246
2011-11-24	17:52	–	17:52	1
2011-11-24	20:12	–	20:12	1
2011-11-24	20:14	–	20:15	2
2011-11-24	22:05	–	22:05	1
2011-11-29	02:10	–	02:10	1
2011-11-29	02:24	–	02:25	2
2011-11-30	01:52	–	01:52	1
2011-11-30	12:08	–	12:08	1
2011-12-01	11:46	–	11:46	1
2011-12-03	17:59	–	17:59	1
2011-12-03	18:02	–	18:02	1
2011-12-04	00:02	–	00:03	2
2011-12-04	00:08	–	00:08	1
2011-12-08	16:16	–	16:16	1
2011-12-11	16:06	–	16:06	1
2011-12-12	16:06	–	16:06	1
2011-12-12	16:19	–	16:19	1
2011-12-13	01:41	–	01:41	1
2011-12-14	17:43	–	17:43	1
2011-12-29	15:49	–	15:49	1
2011-12-29	16:20	–	16:20	1

Table A.4. *Alice Springs data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-01-04	03:20	–	03:21	2
2011-02-21	15:35	–	18:18	164
2011-03-10	04:42	–	04:43	2
2011-03-12	09:31	–	10:24	54
2011-06-03	03:50	–	03:52	3
2011-06-03	04:02	–	04:04	3
2011-06-03	04:06	–	04:07	2
2011-06-03	04:11	–	04:13	3
2011-06-03	07:16	–	07:28	13
2011-06-05	00:21	–	00:30	10
2011-06-05	00:52	–	02:14	83
2011-06-05	03:53	–	04:10	18
2011-06-05	04:49	–	04:52	4
2011-06-05	04:59	–	05:57	59
2011-06-05	06:50	–	06:55	6
2011-06-05	08:11	–	08:38	28
2011-06-08	05:33	–	05:34	2
2011-06-08	23:58	–		
2011-06-09			00:01	4
2011-06-09	00:03	–	00:05	3
2011-06-09	00:31	–	00:33	3
2011-06-09	02:10	–	02:25	16
2011-06-09	03:16	–	03:31	16
2011-06-09	03:59	–	04:02	4
2011-06-10	04:26	–	04:28	3
Scalar data				
2011-03-12	09:32	–	09:56	25
2011-03-12	10:06	–	10:12	7
2011-03-12	10:15	–	10:23	9
2011-05-10	21:47	–	21:47	1
2011-05-10	21:51	–	21:51	1
2011-05-10	22:00	–	22:00	1
2011-05-10	22:25	–	22:25	1
2011-05-10	23:00	–	23:00	1
2011-05-12	17:52	–	17:52	1
2011-05-12	20:02	–	20:02	1
2011-05-12	20:52	–	20:52	1
2011-05-12	20:57	–	20:57	1
2011-05-12	22:26	–	22:26	1
2011-05-12	23:24	–	23:24	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-05-13	16:01	–	16:01	1
2011-05-13	22:11	–	22:11	1
2011-05-13	22:43	–	22:43	1
2011-05-13	23:09	–	23:10	2
2011-05-13	23:30	–	23:30	1
2011-05-14	03:45	–	03:45	1
2011-05-15	16:59	–	16:59	1
2011-05-15	20:27	–	20:27	1
2011-05-15	20:33	–	20:34	2
2011-05-15	20:45	–	20:46	2
2011-05-15	22:08	–	22:08	1
2011-05-15	22:24	–	22:24	1
2011-05-15	22:40	–	22:40	1
2011-05-23	15:54	–	15:54	1
2011-05-23	20:20	–	20:21	2
2011-05-23	20:24	–	20:24	1
2011-05-23	20:40	–	20:41	2
2011-05-23	21:00	–	21:01	2
2011-05-23	21:09	–	21:09	1
2011-05-23	21:45	–	21:45	1
2011-05-24	04:37	–	04:37	1
2011-05-24	04:51	–	04:51	1
2011-05-24	13:40	–	13:40	1
2011-05-25	18:39	–	18:40	2
2011-05-25	19:15	–	19:15	1
2011-05-25	19:18	–	19:18	1
2011-05-25	19:24	–	19:24	1
2011-05-25	20:06	–	20:06	1
2011-05-25	20:10	–	20:10	1
2011-05-25	20:21	–	20:21	1
2011-05-25	21:31	–	21:32	2
2011-05-25	21:39	–	21:39	1
2011-05-26	14:11	–	14:11	1
2011-05-26	14:44	–	14:44	1
2011-05-26	14:50	–	14:50	1
2011-05-26	15:28	–	15:29	2
2011-05-26	15:31	–	15:33	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-05-26	15:36	–	15:36	1
2011-05-26	18:33	–	18:34	2
2011-05-26	23:27	–	23:27	1
2011-05-26	23:32	–	23:32	1
2011-05-26	23:53	–	23:53	1
2011-05-26	23:57	–	23:57	1
2011-05-26	23:59	–		
2011-05-27			00:02	4
2011-05-27	00:04	–	00:08	5
2011-05-27	00:14	–	00:14	1
2011-05-27	00:24	–	00:24	1
2011-06-02	06:06	–	06:07	2
2011-06-02	06:12	–	06:12	1
2011-06-02	06:29	–	06:29	1
2011-06-02	06:45	–	06:45	1
2011-06-02	07:06	–	07:06	1
2011-06-02	07:09	–	07:11	3
2011-06-02	07:21	–	07:22	2
2011-06-02	07:27	–	07:27	1
2011-06-02	07:35	–	07:43	9
2011-06-02	07:47	–	07:47	1
2011-06-02	07:51	–	07:53	3
2011-06-02	07:56	–	07:56	1
2011-06-02	08:31	–	08:33	3
2011-06-02	08:37	–	08:45	9
2011-06-02	08:57	–	09:02	6
2011-06-02	09:04	–	09:23	20
2011-06-02	09:26	–	09:29	4
2011-06-02	10:42	–	10:42	1
2011-06-02	10:46	–	10:54	9
2011-06-02	11:10	–	11:15	6
2011-06-02	11:18	–	11:18	1
2011-06-02	11:31	–	11:37	7
2011-06-02	13:04	–	13:07	4
2011-06-02	13:12	–	13:17	6
2011-06-02	13:19	–	13:19	1
2011-06-02	13:23	–	13:23	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-02	16:08	–	16:08	1
2011-06-04	18:02	–	18:02	1
2011-06-04	18:53	–	18:53	1
2011-06-04	19:00	–	19:01	2
2011-06-04	19:07	–	19:07	1
2011-06-04	19:23	–	19:23	1
2011-06-04	19:25	–	19:25	1
2011-06-04	19:51	–	19:51	1
2011-06-04	19:57	–	19:58	2
2011-06-04	20:00	–	20:00	1
2011-06-04	20:08	–	20:08	1
2011-06-04	20:13	–	20:17	5
2011-06-04	20:23	–	20:23	1
2011-06-04	20:26	–	20:29	4
2011-06-04	20:32	–	20:35	4
2011-06-04	20:37	–	20:37	1
2011-06-04	20:40	–	20:40	1
2011-06-04	20:42	–	20:44	3
2011-06-04	20:46	–	20:50	5
2011-06-04	20:59	–	21:00	2
2011-06-05	03:05	–	03:05	1
2011-06-05	03:09	–	04:14	66
2011-06-05	04:16	–	05:00	45
2011-06-05	05:02	–	05:04	3
2011-06-05	05:11	–	05:11	1
2011-06-05	05:58	–	05:58	1
2011-06-05	09:56	–	09:56	1
2011-06-05	21:59	–	21:59	1
2011-06-05	22:03	–	22:03	1
2011-06-05	22:20	–	22:20	1
2011-06-06	00:45	–	00:45	1
2011-06-06	02:10	–	02:12	3
2011-06-06	04:58	–	04:58	1
2011-06-06	08:43	–	08:43	1
2011-06-07	16:29	–	16:29	1
2011-06-07	21:38	–		
2011-06-08			01:31	234

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-08	06:52	–	06:52	1
2011-06-08	20:20	–	20:20	1
2011-06-08	21:29	–	21:29	1
2011-06-09	00:00	–	00:06	7
2011-06-16	22:02	–	22:02	1
2011-06-20	02:19	–	02:19	1
2011-06-20	04:34	–	04:34	1
2011-06-20	05:48	–	05:48	1
2011-06-20	06:23	–	06:23	1
2011-06-20	06:27	–	06:27	1
2011-06-20	06:37	–	06:37	1
2011-06-20	07:15	–	07:15	1
2011-06-20	07:21	–	07:21	1
2011-06-20	07:27	–	07:27	1
2011-06-20	07:34	–	07:34	1
2011-06-20	07:47	–	07:48	2
2011-06-20	07:50	–	07:50	1
2011-06-20	07:55	–	07:55	1
2011-06-20	07:59	–	07:59	1
2011-06-20	08:01	–	08:01	1
2011-06-20	08:05	–	08:06	2
2011-06-20	08:44	–	08:44	1
2011-06-20	08:49	–	08:49	1
2011-06-20	09:10	–	09:11	2
2011-06-20	09:17	–	09:17	1
2011-06-20	10:23	–	10:24	2
2011-06-20	10:26	–	10:26	1
2011-06-20	10:28	–	10:28	1
2011-06-20	11:01	–	11:01	1
2011-06-20	11:14	–	11:14	1
2011-06-20	11:44	–	11:45	2
2011-06-20	11:49	–	11:49	1
2011-06-20	11:51	–	11:51	1
2011-06-20	11:58	–	11:58	1
2011-06-20	12:02	–	12:02	1
2011-06-20	12:16	–	12:17	2
2011-06-20	12:30	–	12:30	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-20	12:51	–	12:51	1
2011-06-20	12:53	–	12:55	3
2011-06-20	12:57	–	12:57	1
2011-06-20	13:00	–	13:00	1
2011-06-20	13:10	–	13:10	1
2011-06-20	13:17	–	13:17	1
2011-06-20	13:20	–	13:20	1
2011-06-20	13:35	–	13:35	1
2011-06-20	13:37	–	13:37	1
2011-06-20	13:40	–	13:40	1
2011-06-20	13:47	–	13:47	1
2011-06-20	13:52	–	13:55	4
2011-06-20	13:59	–	13:59	1
2011-06-20	14:02	–	14:02	1
2011-06-20	14:04	–	14:05	2
2011-06-20	14:07	–	14:07	1
2011-06-20	14:26	–	14:26	1
2011-06-20	14:51	–	14:51	1
2011-06-20	14:53	–	14:54	2
2011-06-20	14:56	–	14:57	2
2011-06-20	14:59	–	15:00	2
2011-06-20	15:20	–	15:20	1
2011-06-20	16:12	–	16:12	1
2011-06-20	16:25	–	16:25	1
2011-06-20	16:27	–	16:27	1
2011-06-20	16:31	–	16:31	1
2011-06-20	16:38	–	16:38	1
2011-06-20	17:00	–	17:00	1
2011-06-20	17:36	–	17:36	1
2011-06-20	17:42	–	17:42	1
2011-06-20	18:03	–	18:03	1
2011-06-20	18:08	–	18:08	1
2011-06-20	18:28	–	18:28	1
2011-06-20	18:40	–	18:40	1
2011-06-20	18:57	–	18:57	1
2011-06-20	19:00	–	19:00	1
2011-06-20	19:03	–	19:03	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-20	19:06	–	19:06	1
2011-06-20	19:15	–	19:15	1
2011-06-20	19:24	–	19:24	1
2011-06-20	19:29	–	19:29	1
2011-06-20	19:38	–	19:38	1
2011-06-20	19:51	–	19:52	2
2011-06-20	19:54	–	19:54	1
2011-06-20	20:18	–	20:18	1
2011-06-20	20:26	–	20:28	3
2011-06-20	20:46	–	20:47	2
2011-06-20	20:52	–	20:52	1
2011-06-20	20:56	–	20:56	1
2011-06-20	20:58	–	21:02	5
2011-06-20	21:05	–	21:05	1
2011-06-20	21:11	–	21:13	3
2011-06-20	21:15	–	21:18	4
2011-06-20	21:23	–	21:23	1
2011-06-20	21:25	–	21:27	3
2011-06-20	21:31	–	21:33	3
2011-06-20	21:35	–	21:35	1
2011-06-20	21:38	–	21:41	4
2011-06-20	21:46	–	21:48	3
2011-06-20	21:59	–	21:59	1
2011-06-20	22:11	–	22:12	2
2011-06-20	22:14	–	22:16	3
2011-06-20	22:18	–	22:19	2
2011-06-20	22:23	–	22:26	4
2011-06-20	22:32	–	22:33	2
2011-06-20	22:35	–	22:38	4
2011-06-20	22:43	–	22:43	1
2011-06-20	22:50	–	22:50	1
2011-06-20	22:52	–	22:52	1
2011-06-20	23:11	–	23:12	2
2011-06-20	23:14	–	23:14	1
2011-06-20	23:29	–	23:30	2
2011-06-20	23:32	–	23:32	1
2011-06-20	23:59	–		

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-21			00:00	2
2011-06-21	00:54	–	00:54	1
2011-06-21	00:56	–	00:56	1
2011-06-21	01:04	–	01:04	1
2011-06-21	01:11	–	01:12	2
2011-06-21	01:15	–	01:15	1
2011-06-21	01:21	–	01:40	20
2011-06-21	01:43	–	01:43	1
2011-06-21	01:46	–	01:48	3
2011-06-21	01:51	–	01:51	1
2011-06-21	01:55	–	01:55	1
2011-06-21	02:00	–	02:00	1
2011-06-21	02:04	–	02:08	5
2011-06-21	02:13	–	02:14	2
2011-06-21	09:24	–	09:25	2
2011-06-21	09:31	–	09:32	2
2011-06-21	10:03	–	10:03	1
2011-06-21	10:32	–	10:32	1
2011-06-21	10:34	–	10:34	1
2011-06-21	10:36	–	10:36	1
2011-06-21	10:47	–	10:47	1
2011-06-21	10:52	–	10:52	1
2011-06-21	10:58	–	10:58	1
2011-06-21	11:12	–	11:12	1
2011-06-21	11:22	–	11:22	1
2011-06-21	11:25	–	11:25	1
2011-06-21	11:30	–	11:34	5
2011-06-21	11:39	–	11:43	5
2011-06-21	11:45	–	11:50	6
2011-06-21	11:53	–	11:56	4
2011-06-21	12:02	–	12:02	1
2011-06-21	12:10	–	12:10	1
2011-06-21	12:13	–	12:16	4
2011-06-21	12:21	–	12:21	1
2011-06-21	12:26	–	12:26	1
2011-06-21	12:28	–	12:31	4
2011-06-21	12:33	–	12:36	4

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-21	12:44	–	12:46	3
2011-06-21	12:50	–	12:50	1
2011-06-21	12:52	–	12:52	1
2011-06-21	12:56	–	12:56	1
2011-06-21	12:59	–	12:59	1
2011-06-21	13:06	–	13:10	5
2011-06-21	13:12	–	13:21	10
2011-06-21	13:23	–	13:26	4
2011-06-21	13:29	–	13:31	3
2011-06-21	13:34	–	13:34	1
2011-06-21	13:36	–	13:36	1
2011-06-21	13:38	–	13:40	3
2011-06-21	13:45	–	13:45	1
2011-06-21	13:47	–	13:47	1
2011-06-21	13:53	–	13:55	3
2011-06-21	13:58	–	13:58	1
2011-06-21	14:00	–	14:04	5
2011-06-21	14:07	–	14:17	11
2011-06-21	14:39	–	14:39	1
2011-06-21	19:16	–	19:16	1
2011-06-21	20:50	–	20:50	1
2011-06-21	21:43	–	21:43	1
2011-06-21	21:45	–	21:45	1
2011-06-21	21:52	–	21:52	1
2011-06-21	22:16	–	22:16	1
2011-06-21	22:19	–	22:19	1
2011-06-21	22:22	–	22:22	1
2011-06-21	22:33	–	22:34	2
2011-06-21	23:19	–	23:19	1
2011-06-22	00:11	–	00:11	1
2011-06-22	00:22	–	00:22	1
2011-06-22	00:49	–	00:49	1
2011-06-22	01:18	–	01:18	1
2011-06-22	01:47	–	01:47	1
2011-06-22	01:53	–	01:53	1
2011-06-22	02:23	–	02:23	1
2011-06-22	03:04	–	03:04	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-22	03:27	–	03:27	1
2011-06-22	03:36	–	03:37	2
2011-06-22	03:40	–	03:41	2
2011-06-22	03:43	–	03:47	5
2011-06-22	03:50	–	03:50	1
2011-06-22	03:58	–	03:58	1
2011-06-22	04:00	–	04:00	1
2011-06-22	04:10	–	04:10	1
2011-06-22	04:13	–	04:17	5
2011-06-22	04:19	–	04:19	1
2011-06-22	04:23	–	04:23	1
2011-06-22	04:33	–	04:33	1
2011-06-22	04:42	–	04:42	1
2011-06-22	04:44	–	04:44	1
2011-06-22	05:12	–	05:12	1
2011-06-22	05:30	–	05:30	1
2011-06-22	05:44	–	05:44	1
2011-06-22	06:32	–	06:32	1
2011-06-22	06:39	–	06:39	1
2011-06-22	06:42	–	06:42	1
2011-06-22	06:54	–	06:54	1
2011-06-22	07:21	–	07:21	1
2011-06-22	07:25	–	07:25	1
2011-06-22	07:28	–	07:28	1
2011-06-22	07:32	–	07:32	1
2011-06-22	07:41	–	07:41	1
2011-06-22	07:51	–	07:55	5
2011-06-22	07:57	–	07:57	1
2011-06-22	08:00	–	08:00	1
2011-06-22	08:32	–	08:32	1
2011-06-22	08:39	–	08:39	1
2011-06-22	08:45	–	08:45	1
2011-06-22	08:52	–	08:52	1
2011-06-22	08:57	–	08:57	1
2011-06-22	09:06	–	09:06	1
2011-06-22	10:59	–	10:59	1
2011-06-22	12:16	–	12:16	1
2011-06-22	12:51	–	12:51	1
2011-06-22	13:09	–	13:09	1
2011-06-22	14:23	–	14:23	1
2011-06-22	14:25	–	14:25	1
2011-06-22	14:31	–	14:32	2
2011-06-22	14:52	–	14:52	1
2011-06-22	14:58	–	14:58	1
2011-06-22	15:22	–	15:22	1
2011-06-22	15:35	–	15:35	1
2011-06-22	15:58	–	15:59	2
2011-06-22	16:06	–	16:06	1
2011-06-22	16:25	–	16:25	1
2011-06-22	16:29	–	16:29	1
2011-06-22	16:34	–	16:34	1
2011-06-22	16:44	–	16:46	3
2011-06-22	16:53	–	16:53	1
2011-06-22	17:19	–	17:19	1
2011-06-22	17:21	–	17:23	3
2011-06-22	17:25	–	17:27	3
2011-06-22	17:30	–	17:30	1
2011-06-22	17:47	–	17:47	1
2011-06-22	17:57	–	17:58	2
2011-06-22	18:04	–	18:05	2
2011-06-22	18:15	–	18:15	1
2011-06-22	18:17	–	18:19	3
2011-06-22	18:43	–	18:43	1
2011-06-22	18:45	–	18:45	1
2011-06-22	18:48	–	18:50	3
2011-06-22	18:52	–	18:53	2
2011-06-22	19:10	–	19:10	1
2011-06-22	19:28	–	19:28	1
2011-06-22	19:42	–	19:42	1
2011-06-22	19:46	–	19:46	1
2011-06-22	19:48	–	19:49	2
2011-06-22	19:52	–	19:55	4
2011-06-22	20:00	–	20:00	1
2011-06-22	20:02	–	20:04	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-22	20:16	–	20:16	1
2011-06-22	20:18	–	20:18	1
2011-06-22	20:20	–	20:22	3
2011-06-22	20:24	–	20:24	1
2011-06-22	20:26	–	20:26	1
2011-06-22	20:28	–	20:28	1
2011-06-22	20:30	–	20:34	5
2011-06-22	20:36	–	20:40	5
2011-06-22	20:42	–	20:42	1
2011-06-22	20:45	–	20:45	1
2011-06-22	20:47	–	20:47	1
2011-06-22	20:57	–	20:57	1
2011-06-22	20:59	–	20:59	1
2011-06-22	21:02	–	21:02	1
2011-06-22	21:04	–	21:11	8
2011-06-22	21:15	–	21:19	5
2011-06-22	21:21	–	21:21	1
2011-06-22	21:23	–	21:24	2
2011-06-22	21:26	–	21:33	8
2011-06-22	21:35	–	21:39	5
2011-06-22	21:42	–	21:45	4
2011-06-22	21:47	–	21:47	1
2011-06-22	21:51	–	21:51	1
2011-06-22	21:54	–	21:55	2
2011-06-22	22:21	–	22:22	2
2011-06-22	22:35	–	22:37	3
2011-06-22	22:39	–	22:44	6
2011-06-22	22:46	–	22:48	3
2011-06-22	22:56	–	22:56	1
2011-06-22	23:02	–	23:02	1
2011-06-22	23:07	–	23:07	1
2011-06-22	23:10	–	23:10	1
2011-06-22	23:12	–	23:12	1
2011-06-22	23:14	–	23:14	1
2011-06-22	23:17	–	23:20	4
2011-06-22	23:22	–	23:24	3
2011-06-22	23:27	–	23:27	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-22	23:31	–	23:31	1
2011-06-22	23:34	–	23:34	1
2011-06-22	23:36	–	23:37	2
2011-06-22	23:40	–	23:41	2
2011-06-22	23:43	–	23:43	1
2011-06-22	23:46	–	23:47	2
2011-06-22	23:49	–	23:50	2
2011-06-22	23:54	–	23:55	2
2011-06-22	23:58	–	23:58	1
2011-06-23	00:00	–	00:01	2
2011-06-23	00:03	–	00:03	1
2011-06-23	00:05	–	00:05	1
2011-06-23	00:09	–	00:09	1
2011-06-23	00:11	–	00:11	1
2011-06-23	00:13	–	00:13	1
2011-06-23	00:25	–	00:25	1
2011-06-23	00:36	–	00:37	2
2011-06-23	00:40	–	00:40	1
2011-06-23	00:42	–	00:42	1
2011-06-23	00:46	–	00:46	1
2011-06-23	00:55	–	00:55	1
2011-06-23	01:10	–	01:10	1
2011-06-23	01:12	–	01:12	1
2011-06-23	01:19	–	01:20	2
2011-06-23	01:22	–	01:22	1
2011-06-23	01:26	–	01:26	1
2011-06-23	01:30	–	01:30	1
2011-06-23	01:35	–	01:35	1
2011-06-23	01:44	–	01:45	2
2011-06-23	01:48	–	01:48	1
2011-06-23	01:50	–	01:50	1
2011-06-23	01:52	–	01:52	1
2011-06-23	01:54	–	01:54	1
2011-06-23	01:56	–	01:56	1
2011-06-23	01:59	–	01:59	1
2011-06-23	02:04	–	02:04	1
2011-06-23	02:09	–	02:09	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-23	02:14	–	02:14	1
2011-06-23	02:24	–	02:25	2
2011-06-23	02:43	–	02:43	1
2011-06-23	02:45	–	02:45	1
2011-06-23	02:47	–	02:48	2
2011-06-23	02:53	–	02:53	1
2011-06-23	02:56	–	02:56	1
2011-06-23	03:00	–	03:00	1
2011-06-23	03:05	–	03:05	1
2011-06-23	03:07	–	03:07	1
2011-06-23	03:09	–	03:12	4
2011-06-23	03:14	–	03:15	2
2011-06-23	03:17	–	03:17	1
2011-06-23	03:21	–	03:21	1
2011-06-23	03:23	–	03:25	3
2011-06-23	03:27	–	03:27	1
2011-06-23	03:29	–	03:29	1
2011-06-23	03:31	–	03:31	1
2011-06-23	03:33	–	03:33	1
2011-06-23	03:35	–	03:36	2
2011-06-23	03:45	–	03:47	3
2011-06-23	03:53	–	03:53	1
2011-06-23	03:56	–	03:57	2
2011-06-23	03:59	–	04:02	4
2011-06-23	04:06	–	04:11	6
2011-06-23	04:13	–	04:25	13
2011-06-23	04:27	–	04:29	3
2011-06-23	04:31	–	04:32	2
2011-06-23	04:34	–	04:35	2
2011-06-23	04:37	–	04:37	1
2011-06-23	04:43	–	04:45	3
2011-06-23	04:47	–	04:48	2
2011-06-23	04:50	–	04:51	2
2011-06-23	04:55	–	04:55	1
2011-06-23	04:57	–	04:59	3
2011-06-23	05:01	–	05:01	1
2011-06-23	05:04	–	05:06	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-23	05:11	–	05:33	23
2011-06-23	05:38	–	05:40	3
2011-06-23	05:42	–	05:42	1
2011-06-23	05:44	–	05:45	2
2011-06-23	05:47	–	05:49	3
2011-06-23	05:51	–	05:51	1
2011-06-23	06:00	–	06:00	1
2011-06-23	06:03	–	06:03	1
2011-06-23	06:11	–	06:15	5
2011-06-23	06:17	–	06:26	10
2011-06-23	06:28	–	06:29	2
2011-06-23	06:31	–	06:39	9
2011-06-23	06:41	–	06:45	5
2011-06-23	06:47	–	06:49	3
2011-06-23	06:51	–	06:53	3
2011-06-23	06:55	–	07:01	7
2011-06-23	07:03	–	07:06	4
2011-06-23	07:08	–	07:12	5
2011-06-23	07:14	–	07:14	1
2011-06-23	07:16	–	07:16	1
2011-06-23	07:21	–	07:31	11
2011-06-23	07:33	–	07:41	9
2011-06-23	07:43	–	07:45	3
2011-06-23	07:48	–	07:48	1
2011-06-23	07:52	–	07:53	2
2011-06-23	07:56	–	07:56	1
2011-06-23	07:58	–	07:58	1
2011-06-23	08:00	–	08:13	14
2011-06-23	08:15	–	08:15	1
2011-06-23	08:17	–	08:18	2
2011-06-23	08:22	–	08:22	1
2011-06-23	08:25	–	08:29	5
2011-06-23	08:32	–	08:32	1
2011-06-23	08:37	–	08:38	2
2011-06-23	08:40	–	08:44	5
2011-06-23	08:50	–	08:50	1
2011-06-23	08:52	–	08:52	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-23	08:58	–	09:00	3
2011-06-23	09:02	–	09:04	3
2011-06-23	09:06	–	09:06	1
2011-06-23	09:09	–	09:16	8
2011-06-23	09:18	–	09:18	1
2011-06-23	09:21	–	09:23	3
2011-06-23	09:25	–	09:30	6
2011-06-23	09:32	–	09:35	4
2011-06-23	09:37	–	09:37	1
2011-06-23	09:40	–	09:51	12
2011-06-23	09:54	–	10:13	20
2011-06-23	10:15	–	10:15	1
2011-06-23	10:17	–	10:25	9
2011-06-23	10:27	–	10:28	2
2011-06-23	10:30	–	10:30	1
2011-06-23	10:32	–	10:32	1
2011-06-23	10:34	–	10:34	1
2011-06-23	10:37	–	10:37	1
2011-06-23	10:40	–	10:40	1
2011-06-23	10:43	–	10:43	1
2011-06-23	10:47	–	10:47	1
2011-06-23	10:49	–	10:49	1
2011-06-23	10:51	–	10:51	1
2011-06-23	10:53	–	10:54	2
2011-06-23	10:59	–	11:00	2
2011-06-23	11:03	–	11:05	3
2011-06-23	11:07	–	11:17	11
2011-06-23	11:19	–	11:19	1
2011-06-23	11:21	–	11:27	7
2011-06-23	11:29	–	11:35	7
2011-06-23	11:37	–	11:42	6
2011-06-23	11:44	–	11:46	3
2011-06-23	11:48	–	11:56	9
2011-06-23	12:01	–	12:01	1
2011-06-23	12:03	–	12:03	1
2011-06-23	12:06	–	12:10	5
2011-06-23	12:12	–	12:12	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-23	12:14	–	12:25	12
2011-06-23	12:28	–	13:30	63
2011-06-23	13:32	–	13:33	2
2011-06-23	13:35	–	13:36	2
2011-06-23	13:39	–	13:49	11
2011-06-23	13:51	–	13:54	4
2011-06-23	14:01	–	14:01	1
2011-06-23	14:05	–	14:05	1
2011-06-23	14:09	–	14:10	2
2011-06-23	14:12	–	14:12	1
2011-06-23	14:16	–	14:18	3
2011-06-23	14:21	–	14:21	1
2011-06-23	14:24	–	14:24	1
2011-06-23	14:27	–	14:30	4
2011-06-23	14:32	–	14:37	6
2011-06-23	14:40	–	14:47	8
2011-06-23	14:49	–	14:54	6
2011-06-23	14:58	–	14:59	2
2011-06-23	15:01	–	15:10	10
2011-06-23	15:12	–	15:16	5
2011-06-23	15:18	–	15:18	1
2011-06-23	15:28	–	15:30	3
2011-06-23	15:33	–	15:35	3
2011-06-23	15:37	–	15:40	4
2011-06-23	15:42	–	15:42	1
2011-06-23	15:44	–	15:50	7
2011-06-23	15:52	–	15:54	3
2011-06-23	15:57	–	15:57	1
2011-06-23	15:59	–	16:01	3
2011-06-23	16:03	–	16:06	4
2011-06-23	16:09	–	16:10	2
2011-06-23	16:12	–	16:12	1
2011-06-23	16:14	–	16:20	7
2011-06-23	16:23	–	16:24	2
2011-06-23	16:26	–	16:26	1
2011-06-23	16:31	–	16:40	10
2011-06-23	16:42	–	16:43	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-23	16:45	–	16:49	5
2011-06-23	16:51	–	16:51	1
2011-06-23	16:59	–	17:00	2
2011-06-23	17:03	–	17:03	1
2011-06-23	17:08	–	17:10	3
2011-06-23	17:12	–	17:12	1
2011-06-23	17:17	–	17:17	1
2011-06-23	17:19	–	17:21	3
2011-06-23	17:23	–	17:23	1
2011-06-23	17:28	–	17:31	4
2011-06-23	17:33	–	17:42	10
2011-06-23	17:44	–	17:51	8
2011-06-23	17:53	–	17:57	5
2011-06-23	17:59	–	18:06	8
2011-06-23	18:08	–	18:10	3
2011-06-23	18:12	–	18:12	1
2011-06-23	18:14	–	18:19	6
2011-06-23	18:22	–	18:25	4
2011-06-23	18:27	–	18:33	7
2011-06-23	18:35	–	18:36	2
2011-06-23	18:38	–	18:41	4
2011-06-23	18:43	–	18:43	1
2011-06-23	18:45	–	18:46	2
2011-06-23	18:48	–	18:49	2
2011-06-23	18:51	–	18:51	1
2011-06-23	18:53	–	18:57	5
2011-06-23	19:01	–	19:12	12
2011-06-23	19:15	–	19:16	2
2011-06-23	19:18	–	19:49	32
2011-06-23	19:51	–	19:58	8
2011-06-23	20:00	–	20:46	47
2011-06-23	20:53	–	20:53	1
2011-06-23	20:57	–	20:57	1
2011-06-23	21:00	–	21:01	2
2011-06-23	21:03	–	21:04	2
2011-06-23	21:06	–	21:11	6
2011-06-23	21:13	–	21:20	8

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-23	21:22	–	21:26	5
2011-06-23	21:28	–	21:35	8
2011-06-23	21:42	–	22:09	28
2011-06-23	22:11	–	22:14	4
2011-06-23	22:16	–	22:19	4
2011-06-23	22:22	–	22:27	6
2011-06-23	22:29	–	22:29	1
2011-06-23	22:32	–	22:38	7
2011-06-23	22:40	–	22:40	1
2011-06-23	22:42	–	23:12	31
2011-06-23	23:14	–	23:27	14
2011-06-23	23:29	–	23:38	10
2011-06-23	23:40	–	23:40	1
2011-06-23	23:42	–	23:42	1
2011-06-23	23:44	–		
2011-06-24			00:06	23
2011-06-24	00:09	–	00:09	1
2011-06-24	00:19	–	00:19	1
2011-06-24	00:25	–	00:25	1
2011-06-24	04:37	–	04:37	1
2011-06-24	04:42	–	04:43	2
2011-06-24	04:45	–	04:45	1
2011-06-24	06:05	–	06:08	4
2011-06-24	06:12	–	06:12	1
2011-06-24	06:14	–	06:14	1
2011-06-24	07:22	–	07:22	1
2011-06-24	07:31	–	07:37	7
2011-06-24	07:48	–	07:48	1
2011-06-24	07:53	–	07:53	1
2011-06-24	07:56	–	07:59	4
2011-06-24	08:01	–	08:01	1
2011-06-24	08:22	–	08:22	1
2011-06-24	08:44	–	08:44	1
2011-06-24	08:49	–	08:49	1
2011-06-24	08:51	–	09:01	11
2011-06-24	09:09	–	09:09	1
2011-06-24	09:12	–	09:25	14

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-24	09:27	–	09:28	2
2011-06-24	09:31	–	09:42	12
2011-06-24	09:45	–	09:51	7
2011-06-24	09:54	–	09:57	4
2011-06-24	10:00	–	10:04	5
2011-06-24	10:10	–	10:10	1
2011-06-24	10:12	–	10:12	1
2011-06-24	10:18	–	10:18	1
2011-06-24	10:33	–	10:33	1
2011-06-24	10:35	–	10:35	1
2011-06-24	10:39	–	10:39	1
2011-06-24	10:41	–	10:44	4
2011-06-24	10:47	–	10:48	2
2011-06-24	11:06	–	11:06	1
2011-06-24	11:13	–	11:14	2
2011-06-24	11:59	–	11:59	1
2011-06-24	12:06	–	12:06	1
2011-06-24	12:52	–	12:52	1
2011-06-24	12:54	–	12:54	1
2011-06-24	12:58	–	12:59	2
2011-06-24	13:01	–	13:01	1
2011-06-24	13:03	–	13:06	4
2011-06-24	13:18	–	13:18	1
2011-06-24	15:35	–	15:35	1
2011-06-24	15:46	–	15:46	1
2011-06-24	16:59	–	17:00	2
2011-06-24	17:03	–	17:04	2
2011-06-24	17:08	–	17:08	1
2011-06-24	17:11	–	17:12	2
2011-06-24	17:16	–	17:20	5
2011-06-24	17:22	–	17:28	7
2011-06-24	17:31	–	17:32	2
2011-06-24	17:34	–	17:34	1
2011-06-24	17:36	–	17:36	1
2011-06-24	17:38	–	17:38	1
2011-06-24	17:41	–	17:41	1
2011-06-24	17:43	–	17:47	5
2011-06-24	17:51	–	18:04	14
2011-06-24	18:08	–	18:15	8
2011-06-24	18:23	–	18:23	1
2011-06-24	18:26	–	18:28	3
2011-06-24	18:30	–	18:30	1
2011-06-24	18:35	–	18:38	4
2011-06-24	18:40	–	18:40	1
2011-06-24	18:44	–	18:44	1
2011-06-24	18:48	–	18:49	2
2011-06-24	18:57	–	18:57	1
2011-06-24	18:59	–	19:07	9
2011-06-24	19:09	–	19:14	6
2011-06-24	19:24	–	19:24	1
2011-06-24	19:27	–	19:28	2
2011-06-24	19:30	–	19:30	1
2011-06-24	19:33	–	19:33	1
2011-06-24	19:37	–	19:38	2
2011-06-24	19:43	–	19:45	3
2011-06-24	19:50	–	19:54	5
2011-06-24	19:56	–	19:58	3
2011-06-24	20:00	–	20:00	1
2011-06-24	20:03	–	20:03	1
2011-06-24	20:07	–	20:07	1
2011-06-24	20:11	–	20:11	1
2011-06-24	20:13	–	20:19	7
2011-06-24	20:21	–	20:22	2
2011-06-24	20:27	–	20:27	1
2011-06-24	20:29	–	20:31	3
2011-06-24	20:33	–	20:52	20
2011-06-24	20:54	–	21:08	15
2011-06-24	21:11	–	21:14	4
2011-06-24	21:16	–	21:24	9
2011-06-24	21:32	–	21:37	6
2011-06-24	21:39	–	21:39	1
2011-06-24	21:41	–	21:43	3
2011-06-24	21:45	–	23:42	118
2011-06-24	23:44	–	23:45	2

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-24	23:48	–		
2011-06-25			00:21	34
2011-06-25	00:24	–	00:39	16
2011-06-25	00:43	–	00:50	8
2011-06-25	00:53	–	01:00	8
2011-06-25	01:03	–	01:20	18
2011-06-25	01:22	–	01:23	2
2011-06-25	01:25	–	01:25	1
2011-06-25	01:29	–	01:29	1
2011-06-25	01:32	–	01:33	2
2011-06-25	01:37	–	01:37	1
2011-06-25	01:40	–	01:40	1
2011-06-25	01:43	–	01:45	3
2011-06-25	01:47	–	01:53	7
2011-06-25	01:56	–	01:56	1
2011-06-25	01:59	–	01:59	1
2011-06-25	02:02	–	02:18	17
2011-06-25	02:27	–	02:28	2
2011-06-25	02:58	–	02:59	2
2011-06-25	03:04	–	03:05	2
2011-06-25	03:09	–	03:11	3
2011-06-25	03:16	–	03:32	17
2011-06-25	03:34	–	03:34	1
2011-06-25	03:36	–	03:40	5
2011-06-25	03:42	–	04:50	69
2011-06-25	05:02	–	05:02	1
2011-06-25	05:04	–	05:04	1
2011-06-25	05:09	–	05:09	1
2011-06-25	05:17	–	05:18	2
2011-06-25	05:32	–	05:32	1
2011-06-25	05:36	–	05:36	1
2011-06-25	05:42	–	05:42	1
2011-06-25	05:44	–	05:46	3
2011-06-25	05:49	–	05:49	1
2011-06-25	05:54	–	06:02	9
2011-06-25	06:04	–	06:04	1
2011-06-25	06:06	–	06:27	22

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-25	06:35	–	06:53	19
2011-06-25	06:55	–	06:59	5
2011-06-25	07:01	–	07:47	47
2011-06-25	07:51	–	07:57	7
2011-06-25	07:59	–	08:18	20
2011-06-25	08:20	–	08:58	39
2011-06-25	09:00	–	09:06	7
2011-06-25	09:10	–	09:10	1
2011-06-25	09:12	–	09:16	5
2011-06-25	09:18	–	09:20	3
2011-06-25	09:22	–	10:39	78
2011-06-25	10:41	–	10:53	13
2011-06-25	10:58	–	10:58	1
2011-06-25	11:01	–	11:02	2
2011-06-25	11:07	–	11:09	3
2011-06-25	11:13	–	11:18	6
2011-06-25	11:21	–	11:28	8
2011-06-25	11:36	–	11:36	1
2011-06-25	11:41	–	12:14	34
2011-06-25	12:17	–	13:43	87
2011-06-25	13:45	–	14:20	36
2011-06-25	20:18	–	20:18	1
2011-06-25	20:51	–	20:51	1
2011-06-25	20:53	–	20:53	1
2011-06-25	21:30	–	21:30	1
2011-06-25	22:25	–	22:26	2
2011-06-26	06:54	–	06:54	1
2011-06-26	07:07	–	07:08	2
2011-06-26	07:33	–	07:33	1
2011-06-26	07:36	–	07:36	1
2011-06-26	07:40	–	07:40	1
2011-06-26	07:42	–	07:42	1
2011-06-26	07:44	–	07:46	3
2011-06-26	07:48	–	07:51	4
2011-06-26	07:55	–	08:00	6
2011-06-26	08:02	–	08:03	2
2011-06-26	08:06	–	08:19	14

Date	Interval (hh:mm)			Data loss (minutes)
2011-06-26	08:22	–	08:22	1
2011-06-26	08:29	–	08:29	1
2011-06-26	08:41	–	08:41	1
2011-06-26	08:50	–	08:50	1
2011-06-26	08:55	–	08:55	1
2011-06-26	08:58	–	08:59	2
2011-06-26	09:07	–	09:18	12
2011-06-26	09:20	–	09:21	2
2011-06-26	09:23	–	09:31	9
2011-06-26	09:33	–	09:33	1
2011-06-26	09:35	–	09:36	2
2011-06-26	09:42	–	09:53	12
2011-06-26	09:55	–	12:00	126
2011-06-26	12:02	–	12:03	2
2011-06-26	12:05	–	12:41	37
2011-06-26	12:43	–	12:43	1
2011-06-26	12:50	–	12:50	1
2011-06-26	12:54	–	12:54	1
2011-06-26	12:58	–	14:31	94
2011-06-26	14:35	–	14:37	3
2011-06-26	14:40	–	14:42	3
2011-06-26	14:44	–	14:45	2
2011-06-26	14:53	–	14:53	1
2011-06-26	14:56	–	14:56	1
2011-06-26	15:44	–	15:44	1
2011-06-26	17:30	–	17:30	1
2011-06-26	17:36	–	17:36	1
2011-06-26	23:30	–	23:32	3
2011-06-27	01:43	–	06:00	258
2011-06-29	08:20	–	08:35	16
2011-08-14	10:19	–	10:19	1
2011-08-14	11:58	–	11:58	1
2011-08-25	06:55	–	06:55	1
2011-08-25	16:42	–	16:42	1
2011-08-28	04:57	–	04:57	1
2011-09-18	07:54	–	07:54	1
2011-10-13	16:39	–	16:40	2
2011-10-13	16:42	–	16:42	1
2011-10-13	17:12	–	17:14	3
2011-10-13	18:06	–	18:06	1
2011-10-13	23:55	–	23:55	1
2011-10-28	00:17	–	00:19	3

Table A.5. *Gingin data losses following the commencement of operation in November.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-12-17	06:55	–	08:00	66
Scalar data				
Nil				

Table A.6. *Gnangara data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-03-02	05:25	–	05:27	3
2011-04-11	05:20	–	05:21	2
Scalar data				
2011-02-18	04:56	–	04:56	1
2011-03-10	18:17	–	18:17	1
2011-07-21	05:55	–	05:55	1
2011-11-10	04:57	–	05:12	16

Table A.7. *Canberra data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-06-29	23:35	–	23:38	4
2011-10-18	05:16	–	05:18	3
2011-10-18	18:59	–	19:04	6
2011-10-19	00:14	–	00:17	4
2011-10-19	02:23	–	02:28	6
2011-10-19	04:29	–	04:32	4
2011-10-19	05:09	–	05:12	4
2011-10-19	21:53	–	21:55	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-10-19	21:58	–	22:00	3
Scalar data				
2011-03-30	01:37	–	04:32	176
2011-05-13	02:13	–	04:06	114

Table A.8. *Macquarie Island data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-03-11	02:54	–	02:56	3
2011-03-11	03:41	–	03:43	3
2011-03-31	00:01	–	00:03	3
2011-10-12	02:25	–	02:26	2
Scalar data				
2011-03-11	02:55	–	02:55	1
2011-03-11	03:42	–	03:43	2
2011-03-31	00:02	–	00:02	1

Table A.9. *Mawson data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-01-06	05:42	–	05:58	17
2011-01-10	01:18	–	01:19	2
2011-02-07	08:48	–	11:07	140
2011-02-25	10:55	–		
2011-02-28			01:17	3743
2011-02-28	07:04	–	07:06	3
2011-02-28	07:09	–	07:11	3
2011-02-28	07:13	–	07:13	1
2011-03-05	05:53	–	05:53	1
2011-03-05	06:18	–	06:18	1
2011-06-29	10:04	–	10:07	4
2011-07-25	01:38	–	01:39	2
Scalar data				
2011-01-10	01:19	–	01:19	1
2011-02-03	09:22	–	09:22	1
2011-02-25	14:30	–	14:46	17
2011-02-25	15:06	–	15:06	1

Date	Interval (hh:mm)			Data loss (minutes)
2011-02-26	06:04	–	22:45	1002
2011-02-27	10:19	–	10:19	1
2011-02-28	04:05	–	04:45	41
2011-02-28	05:14	–	05:15	2
2011-02-28	06:08	–	06:26	19
2011-02-28	07:05	–	07:06	2
2011-03-05	05:53	–	05:53	1
2011-03-05	06:18	–	06:18	1
2011-03-16	05:56	–	05:56	1
2011-03-16	07:00	–	07:00	1
2011-05-27	05:22	–	05:22	1
2011-05-27	05:29	–	05:29	1
2011-06-03	11:53	–	11:53	1
2011-06-03	12:23	–	12:23	1
2011-06-03	12:26	–	12:27	2
2011-10-22	01:12	–	01:12	1
2011-10-22	03:02	–	03:02	1
2011-10-22	03:38	–	03:38	1
2011-10-22	03:54	–	03:54	1
2011-10-22	04:08	–	04:09	2
2011-10-22	04:14	–	04:14	1
2011-10-22	04:22	–	04:22	1
2011-10-22	04:24	–	04:26	3
2011-10-22	04:28	–	04:28	1
2011-10-22	04:42	–	04:42	1
2011-10-22	04:44	–	04:44	1
2011-10-22	04:46	–	04:46	1
2011-10-22	04:48	–	04:48	1
2011-10-22	04:50	–	04:50	1
2011-10-22	04:52	–	04:54	3
2011-10-22	04:56	–	04:56	1
2011-10-22	04:58	–	05:01	4
2011-10-22	05:05	–	05:10	6
2011-10-22	05:14	–	05:16	3
2011-10-22	05:18	–	05:21	4
2011-10-22	05:23	–	05:24	2
2011-10-22	05:26	–	05:26	1
2011-10-22	05:28	–	05:35	8
2011-10-22	05:37	–	05:39	3

Date	Interval (hh:mm)			Data loss (minutes)
2011-10-22	05:41	–	05:46	6
2011-10-22	05:48	–	05:49	2
2011-10-22	05:52	–	05:52	1
2011-10-22	05:54	–	06:12	19
2011-10-22	06:15	–	06:15	1
2011-10-22	06:17	–	06:19	3
2011-10-22	06:21	–	06:25	5
2011-10-22	06:27	–	06:29	3
2011-10-22	06:31	–	06:37	7
2011-10-22	06:39	–	06:40	2
2011-10-22	06:43	–	06:47	5
2011-10-22	06:51	–	06:53	3
2011-10-22	06:56	–	06:59	4
2011-10-22	07:01	–	07:02	2
2011-10-22	07:05	–	07:07	3
2011-10-22	07:11	–	07:14	4
2011-10-22	07:18	–	07:20	3
2011-10-22	07:23	–	07:32	10
2011-10-22	07:34	–	07:42	9
2011-10-22	07:46	–	07:48	3
2011-10-22	07:50	–	07:54	5
2011-10-22	07:56	–	08:03	8
2011-10-22	08:05	–	08:08	4
2011-10-22	08:10	–	08:14	5
2011-10-22	08:16	–	08:24	9
2011-10-22	08:26	–	08:45	20
2011-10-22	08:47	–	08:48	2
2011-10-22	08:50	–	08:50	1
2011-10-22	08:53	–	08:55	3
2011-10-22	08:57	–	08:59	3
2011-10-22	09:17	–	09:17	1
2011-10-22	09:38	–	09:39	2
2011-10-22	09:43	–	09:43	1
2011-10-22	09:49	–	09:49	1
2011-10-22	11:14	–	11:14	1

Table A.10. *Casey data losses.*

Date	Interval (hh:mm)			Data loss (minutes)
Vector data				
2011-05-15	23:59	–		
2011-05-18			23:59	4321
2011-08-23	06:20	–	23:32	1033
2011-10-04	08:09	–	08:21	13
2011-10-05	00:43	–	01:40	58
2011-10-05	06:40	–	08:40	121
2011-10-06	03:43	–	22:59	1157
2011-10-07	00:11	–	03:26	196
Scalar data				
2011-01-25	04:39	–	04:42	4
2011-05-16	00:00	–		
2011-05-18			23:59	4320
2011-08-23	06:21	–	06:21	1
2011-08-23	23:04	–	23:05	2
2011-10-04	07:31	–	08:22	52
2011-10-05	00:41	–	01:40	60
2011-10-05	06:41	–	08:39	119
2011-10-06	00:52	–	01:55	64
2011-10-06	03:41	–	04:08	28
2011-10-06	04:36	–	04:36	1
2011-10-06	04:44	–	04:44	1
2011-10-06	04:52	–	04:52	1
2011-10-06	05:07	–	05:07	1
2011-10-06	05:16	–	05:17	2
2011-10-06	06:41	–	09:08	148
2011-10-06	22:58	–	22:58	1
2011-10-07	00:15	–	02:07	113
2011-10-07	03:23	–	03:23	1
2011-11-18	03:55	–	04:09	15
2011-11-21	00:38	–	01:54	77

Table A.11. *Summary of 2011 data losses from Australian observatories.*

Observatory	Vector		Scalar	
	(minutes)	(%)	(minutes)	(%)
Kakadu	8454	1.61	3261	0.62
Charters Towers	1659	0.32	64772	12.32
Learmonth	7344	1.40	453270	86.24
Alice Springs	505	0.10	3885	0.74
Gingin	66	0.10	0	0.00
Gnangara	5	0.00	19	0.00
Canberra	37	0.01	290	0.06
Macquarie Island	11	0.00	4	0.00
Mawson	3917	0.75	1310	0.25
Casey	6899	1.31	5011	0.95
Total	**28897**	**0.60**	**531822**	**11.09**

Appendix B. Backup data

Table B.1. *Canberra CN1 or temporary variometer data used for infill of CNB variometer during 2011.*

Date	Interval (hh:mm)	Data infilled (minutes)
2011-03-30	01:36 – 05:50	255
2011-05-12	23:05 – 23:59	55
2011-05-13	00:00 – 05:40	341
2011-10-20	04:54 – 05:01	8
2011-10-20	14:14 – 14:26	13
2011-10-20	19:29 – 23:59	271
2011-10-21	01:04 – 01:16	13
2011-10-22	20:49 – 21:01	13
2011-10-23	00:04 – 00:16	13
2011-10-23	18:09 – 18:21	13
2011-10-24	05:44 – 06:26	43
2011-10-25	00:00 – 00:21	22
2011-10-25	02:49 – 03:11	23
2011-10-25	18:00 – 23:59	360
2011-10-26	00:00 – 01:01	62
2011-10-26	03:00 – 06:01	182
2011-10-26	19:24 – 19:31	8
2011-10-27	00:00 – 01:31	92
2011-10-27	15:00 – 16:01	62
2011-10-27	21:19 – 23:01	103
2011-10-30	22:55 – 22:59	5
2011-10-30	23:42 – 23:46	5
2011-11-01	01:19 – 01:25	7
2011-11-01	22:24 – 22:29	6

Table B.2. *Macquarie Island MCQ vector variometer data used for infill of MQ2 vector variometer during 2011.*

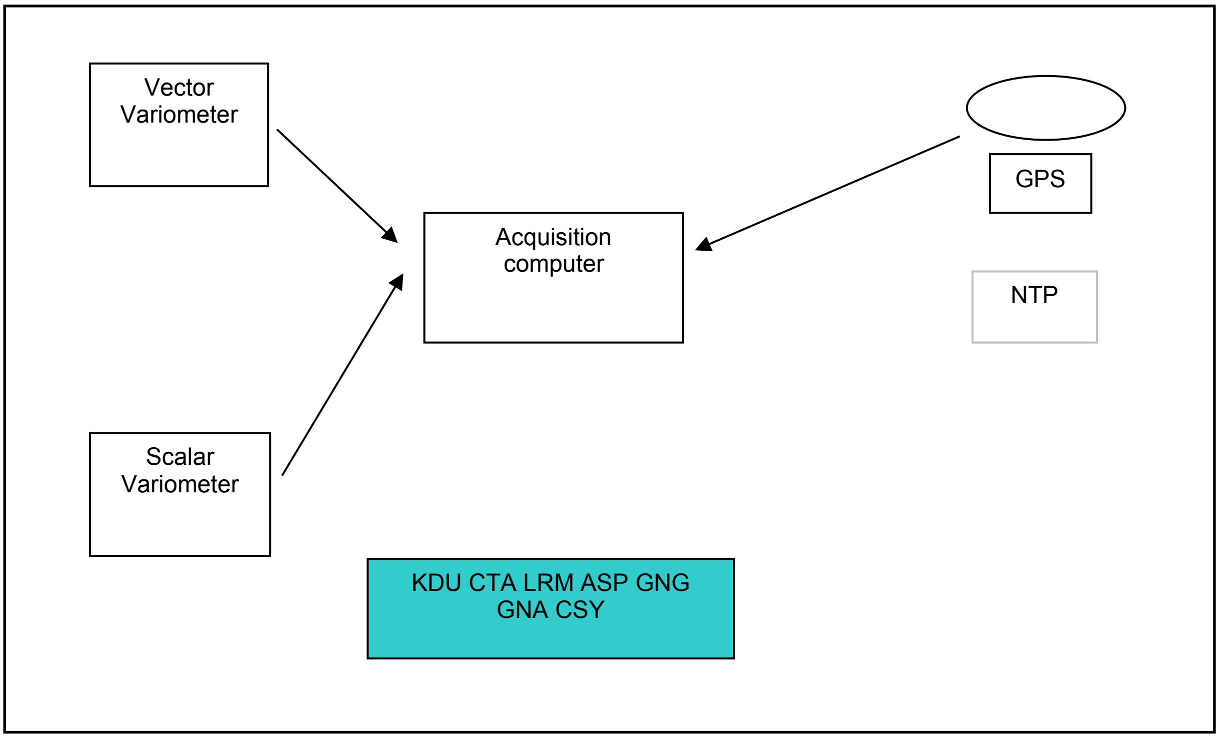
Date	Interval (hh:mm)	Data infilled (minutes)
2011-03-19	02:00 – 06:00	241
2011-03-19	22:00 – 24:00	121
2011-03-20	00:00 – 05:00	301
2011-03-21	00:30 – 01:30	61
2011-03-24	00:30 – 03:00	151
2011-03-24	08:00 – 09:00	61
2011-03-26	00:30 – 04:00	211
2011-05-14	22:00 – 24:00	121
2011-05-15	00:00 – 03:00	181
2011-09-24	02:00 – 04:00	121
2011-09-24	21:00 – 24:00	181
2011-09-25	00:00 – 05:00	301
2011-09-25	21:00 – 23:00	121
2011-09-30	00:00 – 01:00	61
2011-09-30	04:00 – 05:00	61
2011-09-30	22:10 – 22:40	31
2011-10-02	00:00 – 08:00	481
2011-10-03	21:00 – 24:00	181
2011-10-04	00:00 – 23:00	1381
2011-10-06	08:00 – 21:00	781
2011-10-07	23:00 – 24:00	61
2011-10-08	00:00 – 06:00	361
2011-10-10	09:00 – 23:00	841
2011-10-11	20:00 – 24:00	241
2011-10-12	00:00 – 05:00	301
2011-10-13	06:30 – 07:00	31
2011-10-17	05:00 – 06:00	61
2011-10-17	08:00 – 09:00	61
2011-10-19	02:30 – 03:30	61
2011-10-19	07:30 – 08:30	61
2011-10-20	07:00 – 10:00	181
2011-10-21	01:00 – 23:30	1351
2011-10-22	23:00 – 24:00	61
2011-10-23	00:00 – 22:00	1321
2011-10-27	01:00 – 02:00	61

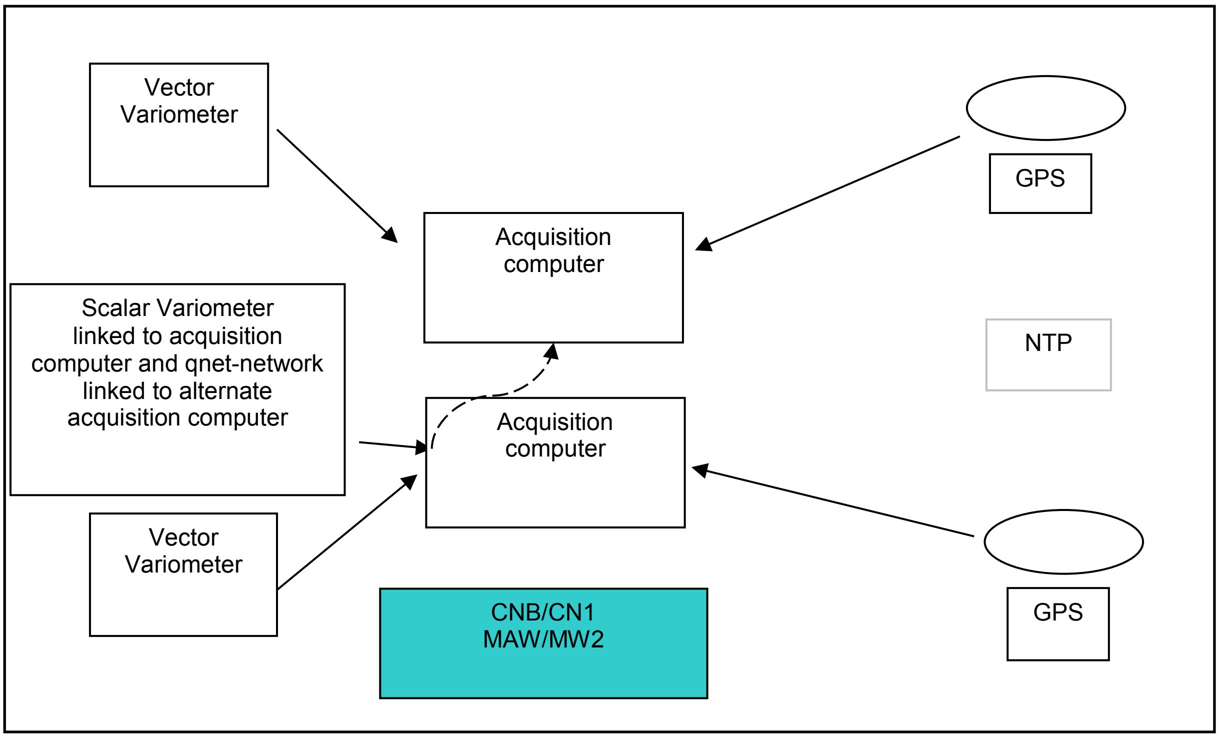
Date	Interval (hh:mm)			Data infilled (minutes)
2011-10-27	14:00	–	15:00	61
2011-11-05	08:00	–	10:00	121
2011-11-18	21:00	–	23:00	121
2011-11-21	00:30	–	01:30	61
2011-11-22	01:00	–	04:00	181
2011-11-23	00:20	–	05:00	281
2011-11-24	02:30	–	04:30	121
2011-11-26	01:00	–	02:00	61
2011-12-13	08:30	–	10:00	91
2011-12-14	08:30	–	11:30	181
2011-12-14	23:20	–	23:59	40
2011-12-15	04:00	–	07:20	201
2011-12-17	02:25	–	03:25	61
2011-12-17	06:40	–	07:00	21
2011-12-18	03:30	–	05:10	101
2011-12-18	09:15	–	09:50	36
2011-12-19	10:54	–	23:00	727
2011-12-20	00:00	–	02:00	121
2011-12-21	05:35	–	06:50	76
2011-12-23	08:55	–	09:50	56
2011-12-23	18:55	–	19:25	31
2011-12-26	03:50	–	04:15	26
2011-12-26	04:54	–	04:58	5
2011-12-27	01:20	–	03:20	121
2011-12-27	04:20	–	07:10	171

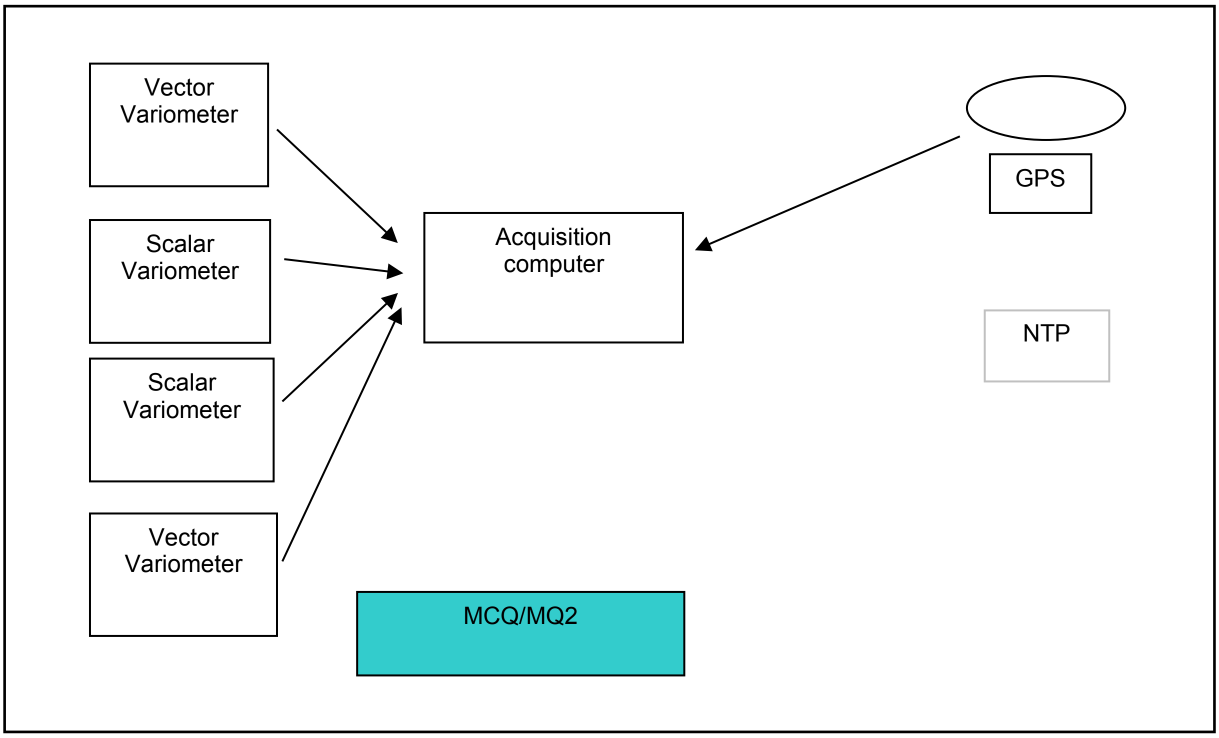
Table B.3. *Mawson MAW (Narod) vector variometer data used for infill of MW2 (DMI) vector variometer during 2011.*

Date	Interval (hh:mm)			Data infilled (minutes)
2011-03-16	21:55	–	21:59	5
2011-07-23	10:05	–	23:59	835
2011-07-24	00:00	–	23:59	1440
2011-07-25	00:00	–	02:25	146
2011-08-22	03:53	–	03:55	3
2011-10-22	03:58	–	23:59	1202
2011-10-23	00:00	–	22:00	1321

Appendix C. Variometer configurations






Vector Variometer
Scalar Variometer
Scalar Variometer
Vector Variometer
Acquisition computer
GPS
NTP
MCQ/MQ2

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Staff

Table 3. Canberra-based staff.

Name	Classification	Responsibility
Peter Crosthwaite	EL1	Digital acquisition, system and software development and maintenance; Canberra and Mawson observatories
Adrian Hitchman	EL2	Section Leader
Bill Jones	APS6	Observatory and system scientific and technical support; Alice Springs, Learmonth and Casey observatories
Andrew Lewis	EL1	Operations Manager; Australian Geomagnetic Reference Field model; Charters Towers, Learmonth, Gnangara and Gingin observatories
Liejun Wang	EL1	Information management; compass calibrations; Kakadu and Macquarie Island observatories
Jim Whatman	APS6	Technical support

Table 4. Observatory-based staff.

Name	Organisation/Company	Observatory	Period
Trevor Crews	AAD	Casey	
Ewan Curtis	AAD	Mawson	to 2011-03-01
Shaun Evans	GA Data Acquisition Facility	Alice Springs	
Adrian Gibbs	AAD	Macquarie Island	to 2011-04-13
Trevor Hopps	AAD	Macquarie Island	from 2011-08-08
Emily Lindsay	IPS	Learmonth	
Owen McConnel	GA	Gnangara, technical support	to 2011-06-30
Ian McLean	AAD	Macquarie Island	from 2011-05-06 to 2011-08-03
Ian Phillips	AAD	Mawson	from 2011-03-01
Stephen Pryde	Pryde Electronic Repairs	Gnangara, Gingin	Gingin from 2011-11-18
Andy Ralph	Kakadu Culture Camp	Kakadu	
Warren Serone	GA Data Acquisition Facility	Alice Springs	
Brad Stevenson	Bradley Stevenson Sales and Service	Charters Towers	