

# SAAPS

## Satellite Anomaly Analysis and Prediction System

Technical Note 1

Database and database tools

Version 1.0

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## Document status sheet

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# Chapter 1

## Introduction

This document describes in detail the various data that are relevant to SAAPS. Part of the data shall be included in the SAAPS database as described in the URD for the Database and Database Tools. The sections describing the data are organized according to the sources.

The database should provide long uninterrupted time series of data and real time data. Long time series are needed to develop reliable models and to be able to perform various analysis. Real time data are needed to be able to run the models in real time.

### 1.1 Acronyms

**ACE** Advanced Composition Explorer

**GOES** Geosynchronous Operational Environmental Satellite

**IRF-Lund** Swedish Institute of Space Physics (Institutet för rymdfysik),  
Lund Division

**LANL** Los Alamos National Laboratory

**NGDC** National Geophysical Data Center

**NOAA** National Oceanographic and Atmospheric Administration

**NSSDC** National Space Science Data Center

**SAAPS** Satellite Anomaly Analysis and Prediction System

**SEC** Space Environment Center

**TSO** Time Series Object

**WDC** World Data Center

## Chapter 2

# Data structure

### 2.1 Key parameters

Time of an observation is a key parameter to all the data. Using year, month, day, hour, minute, second representation introduces the problem that one needs to keep track of several fields. Only the year field increases monotonically with time while the other fields are cyclic. The day field also has the problem that its maximum number depends on the month and year. If time instead can be represented as a series of numbers that increases monotonically with time things are simplified. There are several ways to achieve this. The Julian date is the number of days that has elapsed since noon GMT on January 1, 4713 B.C. In Matlab one can use the day number which is the number of decimal days since January 1, 0000. And finally, in Java time is represented as the number of milliseconds since January 1, 1970, UT00. Times before 1970 are negative numbers. For the data that goes into the SAAPS database time will be stored in the Java millisecond format. Routines to convert between the different time formats exist and are easily implemented.

For satellites and spacecraft, the position is another key parameter and it will be stored in the database when available. The coordinate system used can either be a cartesian (x,y,z) system or a spherical system with radius, longitude, and latitude. For geostationary satellites the simplest system is the spherical as all variables will be close to constant. The cartesian systems can be either the geocentric solar-magnetospheric (GSM) or the geocentric solar-ecliptic (GSE). The transformation between the different systems is part of SAAM and is described in the SAAM Technical Note [*Wintoft, 2000a*].

## 2.2 Time series object – TSO

Time series data are a central part in SAAPS. Therefore, a Time Series Object (TSO) is defined. It contains time ordered data together with the meta data describing the contents. The meta data contain the names and physical units of the data fields. The detailed implementation of TSO is described in [*Wintoft, 2000c*].

The tools for reading data from and storing data into the SAAPS database shall operate on TSO. The analysis and prediction tools also use TSO as input and produces TSO as output. The TSO can finally be used by the plotting tools.

## Chapter 3

# Data sources

### 3.1 GOES data

The NOAA Geosynchronous Operational Environmental Satellites (GOES) monitors the space weather with the Space Environment Monitor (SEM) that has instruments for X-ray, energetic particle, and magnetic field measurements. The first observations with the GOES satellites started in July 1974.

Custom CD's for any period from 1974 to present can be ordered from NOAA. Five-minute and 1-minute data are also available on CD's from 1986 to present.

#### 3.1.1 GOES 1986 to 1997 CD-ROM

The GOES data for the years 1986 through 1997 reside on two CD-ROMs. They contain 5 minute averages of the X-ray, energetic particle, and magnetic field data collected by GOES-05, -06, -07, -08, -09 between January 1986 and August 1997.

The data comes in 5 different versions and are indicated with letter G, Z, I, H, A as the first letter in the file names on the CDs. All versions contain the X-ray, magnetic field, and electron data. Then, depending on the version, they contain uncorrected proton channels (G), corrected proton channels (Z), corrected integral proton (I), HEPAD (H), and uncorrected alpha particles (A). The I and Z versions have been partially corrected for secondary responses in the particle data. The data that shall enter into the SAAPS database are the I version to conform it to the real time data. The parameters are summarized in Table 3.1.

The longitude positions of each satellite on each day at 0000UT are also available. The longitude is given in degrees west ( $l_W$ ) of the central meridian. The longitude data stored in SAAPS are in eastern longitude and therefore the longitude is transformed according to  $l = 360 - l_W$ . The longitude positions for the GOES satellites are shown in Figure 3.1. It is

Table 3.1: The GOES data

Name	Description	Units
XL	1-8 X-rays	$\text{Wm}^{-2}$
XS	0.5-4 X-rays	$\text{Wm}^{-2}$
E1	> 2 MeV electrons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P1	> 1 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P2	> 5 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P3	> 10 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P4	> 30 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P5	> 50 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P6	> 60 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
P7	> 100 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$

seen that there are always two satellites present at any one time and the longitude spacing between the satellites ranges from 30 to 60 degrees or 2-4 hours local time.

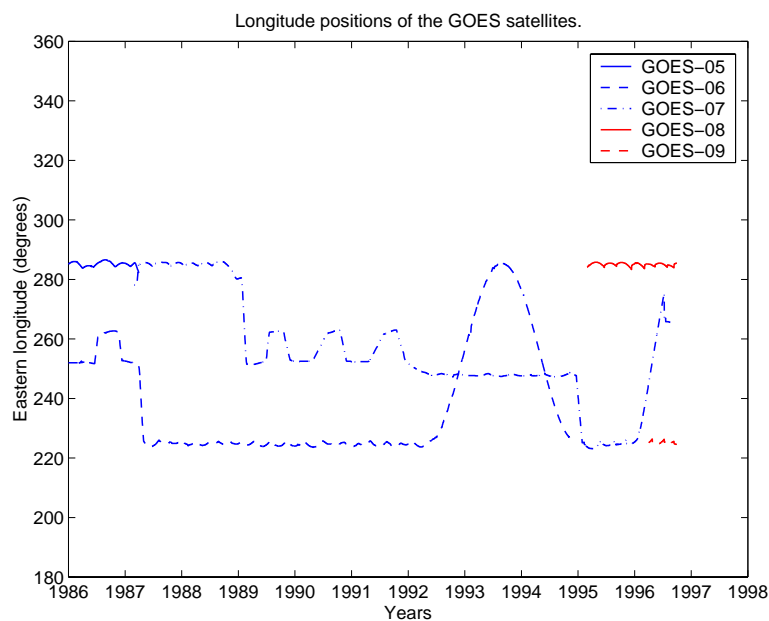


Figure 3.1: The positions of the GOES satellites for the period 1986 through 1996.

### 3.1.2 GOES data: latest data

The latest GOES data are available over the Internet from SEC. The data exist both in 1 minute and 5 minutes resolution. Data are available in



separate files for each day about 1 month back in time. Also the latest two hours of data exist in a separate file. The header information in each file contains the location of the spacecraft in longitude west. The particle data and the X-ray data are kept in separate directories. The contents are given in Table 3.2. The latest 5 minute data are generally 5 to 10 minutes old.

Table 3.2: Internet based GOES data.

Description	Units
1-8 X-rays	$\text{Wm}^{-2}$
0.5-4 X-rays	$\text{Wm}^{-2}$
> 0.6 MeV electrons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 2 MeV electrons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 4 MeV electrons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 1 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 5 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 10 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 30 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 50 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$
> 100 MeV protons	$\text{cm}^{-2}\text{sec}^{-1}\text{sr}^{-1}$

### 3.2 LANL geosynchronous energetic particle data

The LANL geosynchronous energetic particle data comes from 10 different satellites flown over the period 1976 to present. The satellites are named by their international satellite designator number (ISDN) where the first four digits in the name are the year of the launch and the last three digits are the launch number. Typically data are available from 3-4 satellites simultaneously. The satellites operate at a circular  $6.6R_E$  geosynchronous orbit at the geographic equator. Data are acquired in real time at Los Alamos and then processed, formatted and put on line every night. Digital data are typically available within 24 hours.

The energetic particle data from the LANL satellites comes from two different instruments. The CPA instruments was used on satellites launched between 1976 to 1987 and operated until 1995. The instrument measures electrons from 30 keV to 2 MeV in 12 energy channels and protons from 75 keV to 200 MeV in 26 channels. The SOPA instrument is used on satellites launched from the beginning of 1989. It measures electrons from 50 keV to 26 MeV in 16 channels and protons from 50 keV to > 50 MeV in 15 channels. It also measures heavier ions. The 16 electron energy channels of the SOPA instrument are listed in Table 3.3.

Table 3.3: The SOPA electron energy channels

Channel name	Nominal energies
E1	50–75 keV
E2	75–105 keV
E3	105–150 keV
E4	150–225 keV
E5	225–315 keV
E6	315–500 keV
E7	500–750 keV
E8	0.75–1.1 MeV
E9	1.1–1.5 MeV
E10	> 1.5 MeV
ESP1	0.7–1.8 MeV
ESP2+3+4	1.8–3.5 MeV
ESP5+6	3.5–6.0 MeV
ESP7	6.0–7.8 MeV
ESP8	7.8–10.8 MeV
ESP9	10.8–26 MeV

### 3.2.1 The LANL 1996-1998 CDROMs

The LANL CDROMs contain  $1^m20^s$  resolution data for the period 1996 through 1998. Each CD contain half a year of data. The data fields are summarized in Table 3.4. There are data from the three satellites 1990-095, 1991-080, and 1994-084.

Table 3.4: The LANL CDROM data fields

Field	Description
1	UT
2	Geographic latitude
3	Geographic (western) longitude
4	Radius in $R_E$
5	$D_{st}$
6	$K_p$
7–50	Electron for energies 21.6 eV to 25.8 MeV
51–105	Protons for energies 3.2 eV to > 20 MeV
106–117	Various

### 3.3 OMNI solar wind data

From the NSSDC OMNIweb the hourly averages of the solar wind magnetic field and plasma data are available. The data comes from several different satellites flown over the period 1963 to present. The satellites are IMP 1 to 8, AIMP 1 and 2, HEOS 1 and 2, VELA 3, OGO 5, merged LANL VELA Speed Data (July 1964 - March 1971), merged LANL IMP T,N,V (Including all IMP 8 LANL Plasma), ISEE 1 to 3, PROGNOZ 10, and WIND. The data are organized into files holding one year each. There are two types of data files. The first type uses the GSE or GSM coordinate systems for the magnetic field vectors and the solar wind vectors. The second type is a transformation from the GSE system to the RTN system. In addition to the solar wind data the files also contain solar and geomagnetic data. The different parameters are summarized in Table 3.5.

### 3.4 ACE solar wind data

The ACE spacecraft was launched on August 25 1997 and was placed in a halo orbit at the Lagrange L1 point. There are 9 instruments on the spacecraft. The two instruments relevant for SAAPS are the magnetometer instrument (MAG) and the solar wind electron, proton, and alpha monitor (SWEPAM). The on-line data are listed in Table 3.6. Both historic and real time data are available over the Internet. The historic data are available from the CDAWeb where a request can be made for data from specific instruments, time resolution, and time period. The latest month of data in 1 or 5 minute resolution are available from SEC. The real time data are also available at SEC with a one minute time resolution covering two hours back in time. The latest observation of the real time data is generally 4 to 5 minutes old.

The hourly average solar wind data from the ACE spacecraft are one hour lagging averages. This means that for the hourly average data value at time  $t$  the data for the time period  $t - 1$  hours to  $t$  has been used. The difference between the lagging average and the central average is illustrated in Figure 3.2.

Table 3.5: The OMNI data set.

Description	Units
Field Magnitude Average $F = \langle  \mathbf{B}  \rangle = \frac{1}{N} \sum  \mathbf{B} $	nT
Magnitude of Average Field Vector $B =  \langle \mathbf{B} \rangle  =  \frac{1}{N} \sum \mathbf{B} $	nT
Lat. angle of aver field vector	Degrees (GSE coords)
Long. angle of aver. field vector	Degrees (GSE coords)
$B_x$ GSE, GSM	nT
$B_y$ GSE	nT
$B_z$ GSE	nT
$B_y$ GSM	nT
$B_z$ GSM	nT
$\sigma_F$ , RMS Standard Deviation in average	nT
$\sigma_B$ , RMS Standard Deviation in field	nT
$\sigma_{B_x}$ , RMS Standard Deviation in GSE	nT
$\sigma_{B_y}$ , RMS Standard Deviation in GSE	nT
$\sigma_{B_z}$ , RMS Standard Deviation in GSE	nT
$T$ , Plasma temperature	K
$n$ , Ion Density	$\text{cm}^{-3}$
$V$ , Plasma (Bulk) speed	$\text{kms}^{-1}$
$\phi$ , Plasma (Bulk) Flow Long. Angle	Degrees, GSE*
$\theta$ , Plasma (Bulk) Flow Lat. Angle	Degrees, GSE
$\sigma_T$	K
$\sigma_n$	$\text{cm}^{-3}$
$\sigma_V$	$\text{kms}^{-1}$
$\sigma_\phi$	Degrees
$\sigma_\theta$	Degrees
$K_p$ , Planetary Geomagnetic Activity Index	
C9, Geomagnetic activity index (0 to 9)	
$R$ , Sunspot number	
$D_{st}$ , Ring current index	nT
> 1 MeV Proton flux	$\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$
> 2 MeV Proton flux	$\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$
> 4 MeV Proton flux	$\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$
> 10 MeV Proton flux	$\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$
> 30 MeV Proton flux	$\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$
> 60 MeV Proton flux	$\text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}$

Table 3.6: The ACE on-line MAG and SWEPAM data.

Name	Units	Description
$B_x$	nT	Magnetic field x-component in GSM (GSE??)
$B_y$	nT	Magnetic field y-component in GSM
$B_z$	nT	Magnetic field z-component in GSM
$B_t$	nT	Total magnetic field
$n$	$\text{cm}^{-2}$	Protons density
$V$	$\text{kms}^{-1}$	Bulk flow speed
$T$	K	Ion temperature

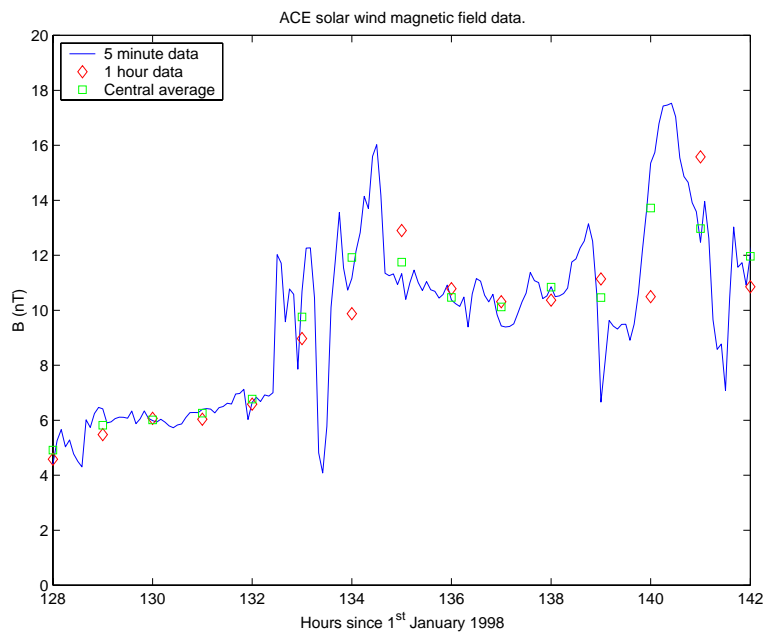


Figure 3.2: The relation between the ACE 5 minute data, hourly data, and central average hourly data.

## 3.5 Geomagnetic indices

### 3.5.1 $AE$

The  $AE$  index is a measure of the global electrojet activity and is related to the substorm activity [Mayaud, 1980]. The  $AE$  index is derived from several (10-14) high latitude ( $\approx 70^\circ$ ) stations.

No real time data of  $AE$  exist. The historic hourly average data exist at the NGDC ftp site and extends over the years 1957 to 1988.

Real time forecasts of the  $AE$  index using ACE solar wind data exist at IRF-Lund.

### 3.5.2 $D_{st}$

The ring current index  $D_{st}$  is derived from four equatorial magnetic stations [Mayaud, 1980]. The unit of  $D_{st}$  is nT or  $\gamma$ , where  $1\gamma = 1\text{nT}$ . The typical range of  $D_{st}$  is from +50nT to -150nT, although these values can be largely exceeded.

Several groups have developed models for the predictions of  $D_{st}$  from solar wind data. Generally, these models produce accurate predictions 1 to 3 hours ahead.

The near real time  $D_{st}$  and provisional  $D_{st}$  are available online from the WDC-C2 in Kyoto, Japan. They also provide a service for downloading the final  $D_{st}$ .

### 3.5.3 $K_p$

The planetary magnetic index  $K_p$  is derived from several midlatitude magnetic stations [Mayaud, 1980]. The possible values of  $K_p$  are 0, 0+, 1-, 1, 1+, 2-, 2, ..., 9-, 9 where 0 means very quiet and 9 very disturbed magnetosphere, respectively. The time resolution is 3 hours.

The final  $K_p$  is available with about one year time lag. There is also a preliminary  $K_p$  available with about one day time lag from SEC. Finally, there are also reliable predictions of  $K_p$  using solar wind data [Boberg *et al.*, 1999]. The predictions range from now-casting to 3 hour predictions.

## 3.6 Satellite anomaly data

A database of satellite anomalies should at least contain the reported times of anomaly events. However, a more detailed description at the anomaly event leads to a better understanding of the situation. Table 3.7 summarizes the data that should go into the database. All the parameters have a certain uncertainty which may also be included, if available.

The type of anomaly should contain a description at which part of the satellite the anomaly occurred. Often different anomaly types are triggered

by different environments. This could be seen on the Meteosat-3 anomalies [Rodgers, 1991].

Table 3.7: Satellite anomaly data.

Name	Unit	Description
Time		The time of the anomaly in UT
Radius	km	Satellites radial position at time of anomaly
Longitude	°E	Satellites longitudinal position at time of anomaly
Latitude	°E	Satellites latitudinal position at time of anomaly
Type		A description of the anomaly type
Diagnostic		A description of the cause of the anomaly

The following sections describe shortly the anomaly data currently available. The anomalies will be further studied in the SAAM and SAPM technical notes [Wintoft, 2000a, Wintoft, 2000b].

### 3.6.1 Marecs-A

Marecs-A was launched on 20 December 1981 into geostationary orbit and was operated until August 1996. During this time a power undervoltage indicator (A108) tripped more than 1800 times. It is believed that the anomalies were mainly due to deep dielectric charging caused by  $> 1$  MeV electrons [Wrenn and Smith, 1996]. Figure 3.3 shows the distribution of anomalies for the complete period. There were at most 12 anomalies in any one day.

### 3.6.2 Meteosat-3

Meteosat-3 was launched on 15 June 1988 into geostationary orbit and operated by Eumetsat. It was one in a series of European meteorological satellites. Meteosat-3 was in use until May 1995 when it was moved to 70W and finally put into junk orbit on 21 November 1995. During this period it experienced 724 anomalies. Figure 3.4 shows the distribution of anomalies for the complete period. This data set is identical to the one used by [Andersson *et al.*, 1998] and [Wu *et al.*, 1999].

### 3.6.3 Tele-X

Tele-X was a broadcasting satellite owned by Nordiska Satellitaktiebolaget (NSAB) and operated by Esrange. The satellite was launched on 2 April 1989 into a geostationary orbit at 5E. It was operated until 1998 when it was put into junk orbit. During the period 2 April 1989 to 26 October 1996 there were reported 192 anomalies. Figure 3.5 shows the distribution of anomalies for the complete period.

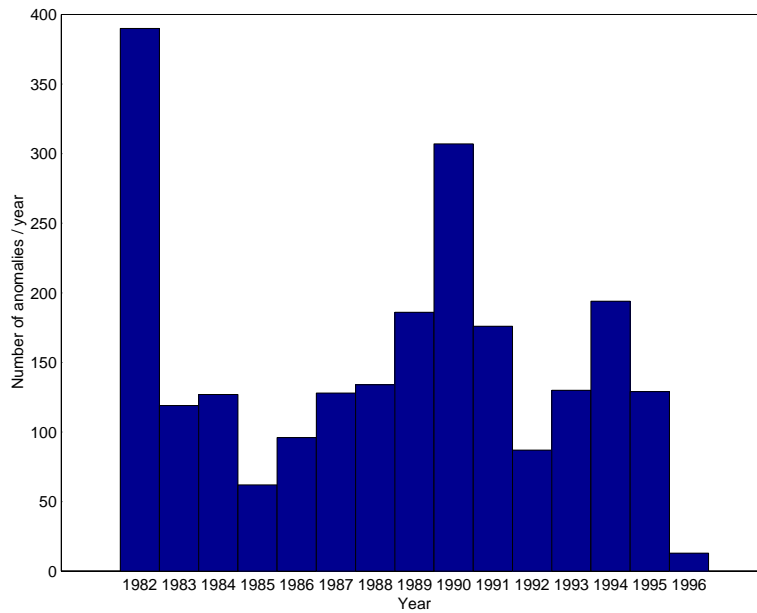


Figure 3.3: The number of Marecs-A anomalies for each year. Note that the first and last bins with data does not include a whole year.

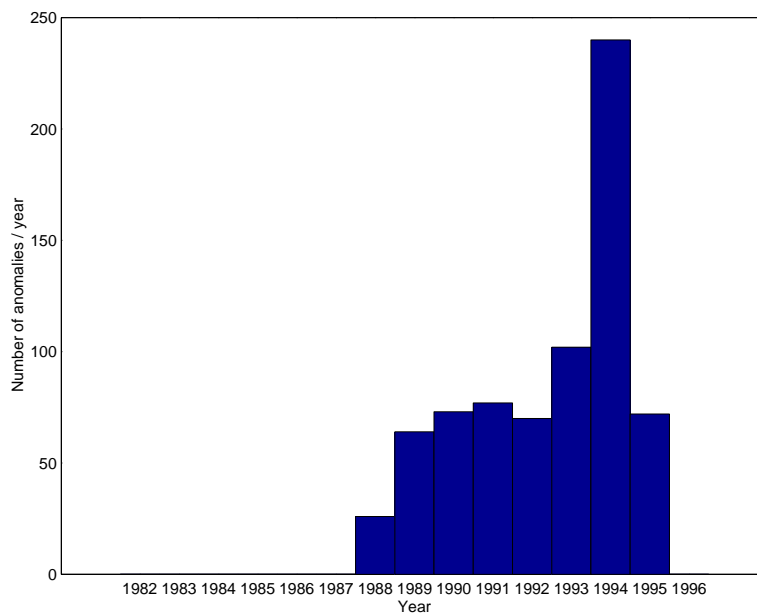


Figure 3.4: The number of Meteosat-3 anomalies for each year. Note that the first and last bins with data does not include a whole year.



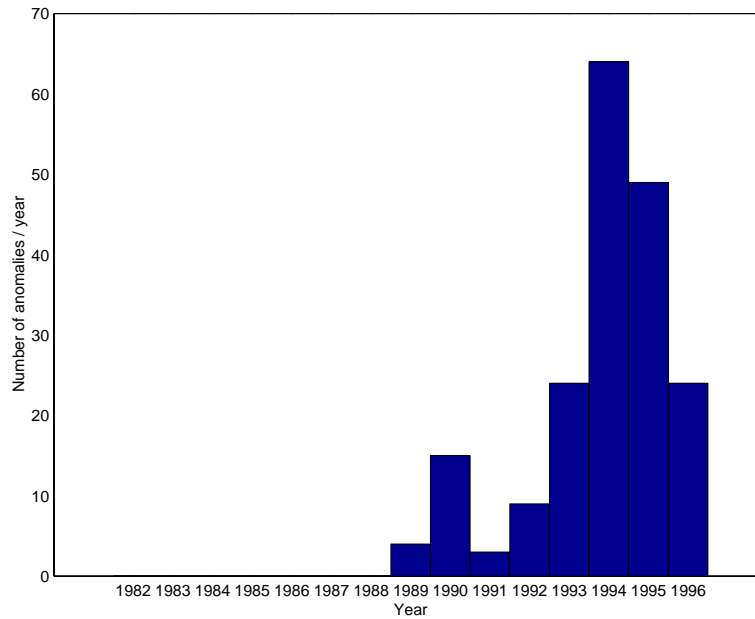


Figure 3.5: The number of Tele-X anomalies for each year. Note that the first and last bins with data does not include a whole year.

### 3.6.4 NSSDC anomaly data set

The NSSDC anomaly data set contain 5034 reported anomalies from a large number of different satellites. The database contain the fields listed in Table 3.9. Tables 3.10 and 3.11 describes the anomaly types and diagnostics, respectively. The data set extends over a period from 1963 to 1994 and the distribution of anomalies are shown in Figure 3.6.

From the NSSDC data set the 19 satellites that have more than 90 reported anomalies have been selected. They are described in Table 3.8. The name of the spacecraft is either a real name or an alias name. Alias names are preceded by the @ symbol.

### 3.6.5 TDRS-1 anomaly data set

At NSSDC there is a second data set, the TDRS-1 anomaly database, which extends over the period 1983 to 1993 and contain 5812 reported anomalies. The data fields are the same as those listed in Tables 3.9 to 3.11. The distribution of the anomalies is shown in Figure 3.7. On seven different occasions the satellite experienced more than 50 anomalies per day with a maximum of 310 anomalies on 19 August 1985. All the events were SEUs.

Table 3.8: The NSSDC data sets. The orbit, type, and diagnostic coding are described in Tables 3.9 and 3.10.

Name	Orbit	No. of events	First event	Last event	Type	Diag.
SCATHA	E	316	1979-03-28	1988-03-07	316 ESDM	150 ECEMP 121 ESD 45 UNK
@GW0101	G	294	1975-01-14	1976-11-26	294 TE	294 ECEMP
IRON-9434	G	182	1987-01-09	1991-08-09	168 UNK 14 SE	182 UNK
MARECS-A	G	180	1982-01-27	1989-03-31	147 PC 26 TE 7 UNK	173 ESD 7 UNK
@PN0303	G	174	1982-11-11	1989-04-12	154 PC 15 PF 5 UNK	142 ESD 26 UNK
GPS-5113	I/C/S	172	1984-10-30	1990-07-12	172 SE	172 UNK
STS-48	C	162	1991-09-13	1991-09-18	162 SE	162 SEU
GPS-6374	I/C/S	145	1986-01-30	1990-06-28	145 SE	145 UNK
GPS-5118	I/C/S	143	1984-10-28	1990-08-07	140 SE 3 UNK	141 UNK 2 ESD
GPS-9521	I/C/S	125	1984-10-06	1990-07-05	125 SE	125 UNK
@GG0505	G	124	1982-09-28	1994-04-15	82 UNK 17 ESDM 11 SE 9 PF	91 UNK 22 ESD 11 SEU
GPS-9794	I/C/S	123	1985-01-13	1990-08-06	123 SE	123 UNK
GPS-9783	I/C/S	113	1984-12-27	1990-07-01	113 SE	113 UNK
@GG0504	G	109	1982-03-04	1994-03-17	94 UNK 7 ESDM 4 PF 3 SE	98 UNK 8 ESD 3 SEU
GPS-5114	I/C	100	1984-10-25	1989-10-13	99 SE 1 UNK	100 UNK
METEOSAT-2	G	99	1981-09-08	1986-10-22	99 PC	98 ESD 1 UNK
@GG0502	G	97	1980-12-06	1993-08-25	55 UNK 18 SE 15 PF 1 PC	70 UNK 18 SEU 9 ESD
STS-39	C	97	1991-04-28	1992-05-03	97 SE	97 SEU
METEOSAT-1	G	94	1977-05-04	1979-01-03	94 PC	94 ESD

Table 3.9: The NSSDC anomaly data fields.

Field	Units	Description
VER		Format version
EDATE		Entry date for the data
BIRD		Spacecraft name, real or alias
ADATE		Date on which the anomaly occurred
STIMEU	UT	Start time of the anomaly
STIMEQ	h	Uncertainty of STIMEU
DUR	h	Duration for a continuous event
ORBIT		C = undefined E = elliptical G = geostationary I = inclined P = polar S = undefined
ALT	km	Altitude above Earth's surface
NS		Hemisphere of the latitude, N or S
LAT	°	Geographic latitude
LATQ	°	Uncertainty in geographic latitude
EW		Hemisphere of the longitude, E or W
LON	°	Geographic longitude
LONQ	°	Uncertainty in geographic longitude
ATYPE		Anomaly type
ADIAG		Cause of anomaly
ACOMMENT		Any further comments

Table 3.10: Anomaly types

PC	Phantom command
PF	Part failure
TE	Telemetry error
SS	System shutdown
ESDM	Electrostatic discharge measured
UNK	Unknown

Table 3.11: Cause of the anomaly

ECEMP	Electron caused electromagnetic pulse
ESD	Electrostatic discharge
SEU	Single event upset
UNK	Unknown

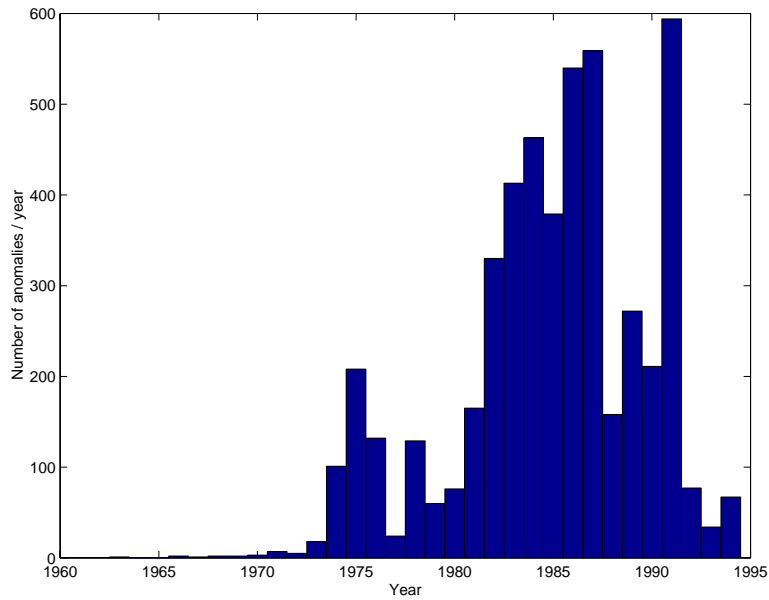


Figure 3.6: The number of NSSDC anomalies for each year.

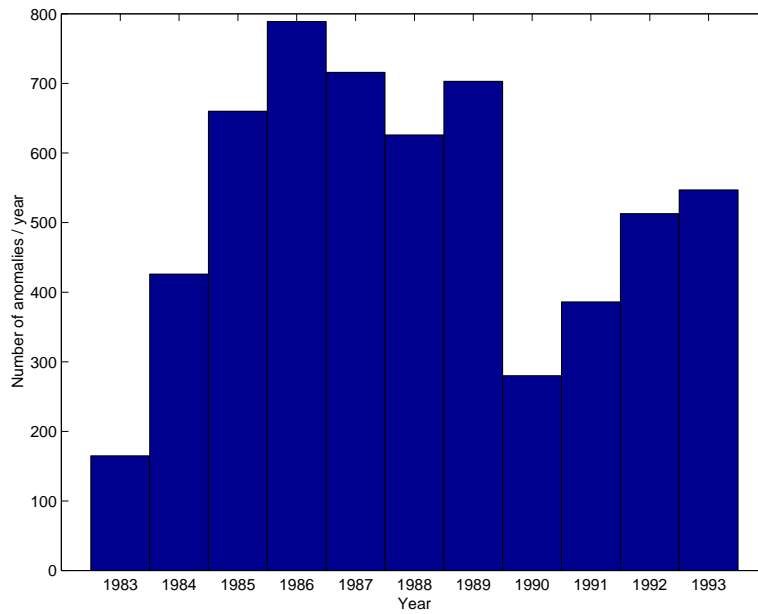


Figure 3.7: The number of TDRS-1 anomalies for each year. Note that the first and last bins with data does not include a whole year.

### 3.6.6 Satellite anomaly set alias

In SAAPS names for different anomaly data sets must be used so that e.g. the user understands which model is related to which anomaly data set. However, the real names of the satellites must not be disclosed. Therefore, satellite alias names shall be used and are summarised in Table 3.12.

Table 3.12: The relation between satellite names and alias names.

Alias name	Real name
S001	ESA: Marecs-A
S002	ESA: Meteosat-3
S003	ESA: Tele-X
S004	NSSDC: SCATHA
S005	NSSDC: @GW0101
S006	NSSDC: IRON-9434
S007	NSSDC: MARECS-A
S008	NSSDC: @PN0303
S009	NSSDC: GPS-5113
S010	NSSDC: STS-48
S011	NSSDC: GPS-6374
S012	NSSDC: GPS-5118
S013	NSSDC: GPS-9521
S014	NSSDC: @GG0505
S015	NSSDC: GPS-9794
S016	NSSDC: GPS-9783
S017	NSSDC: @GG0504
S018	NSSDC: GPS-5114
S019	NSSDC: METEOSAT-2
S020	NSSDC: @GG0502
S021	NSSDC: STS-39
S022	NSSDC: METEOSAT-1

## 3.7 Online data

The online data that are automatically stored in the SAAPS database are summarized below.

$D_{st}$ , **Near real time quick look** The near real time quick look  $D_{st}$  index is available with a time lag of up to 24 hours.

URL: <http://swdcd.db.kugi.kyoto-u.ac.jp/dst/dir/dst1/q/Dstqthism.html>

$K_p$ , **Estimated** The estimated  $K_p$  index is available with about a 3 to 6 hour time lag.

URL: <ftp://ftp.sec.noaa.gov/pub/latest/DGD.txt>

**$K_p$ , Nowcast** The nowcasted  $K_p$  index is available in real time.

URL: <http://sol.irfl.lu.se/KpForecast/latestNowcast.txt>

**$K_p$ , Forecast** The forecasted  $K_p$  index is available with up to a 3 hour forecast.

URL: <http://sol.irfl.lu.se/KpForecast/latestForecast.txt>

**ACE magnetic field data** The 1 minute resolution ACE magnetic field data are available with a time lag of about 2 minutes.

URL: [ftp://ftp.sec.noaa.gov/pub/lists/ace/ace\\_mag\\_1m.txt](ftp://ftp.sec.noaa.gov/pub/lists/ace/ace_mag_1m.txt)

**ACE plasma data** The 1 minute resolution ACE plasma data are available with a time lag of about 2 minutes.

URL: [ftp://ftp.sec.noaa.gov/pub/lists/ace/ace\\_swepam\\_1m.txt](ftp://ftp.sec.noaa.gov/pub/lists/ace/ace_swepam_1m.txt)

**GOES-8 particle data** The 5 minute GOES-8 electron and proton flux data are available with a time lag of about 5 minutes.

URL: [ftp://ftp.sec.noaa.gov/pub/lists/particle/G8part\\_5m.txt](ftp://ftp.sec.noaa.gov/pub/lists/particle/G8part_5m.txt)

**GOES-8 x-ray data** The 5 minute GOES-8 x-ray flux data are available with a time lag of about 5 minutes.

URL: [ftp://ftp.sec.noaa.gov/pub/lists/xray/G8xr\\_5m.txt](ftp://ftp.sec.noaa.gov/pub/lists/xray/G8xr_5m.txt)

**GOES-10 particle data** The 5 minute GOES-10 electron and proton flux data are available with a time lag of about 5 minutes.

URL: [ftp://ftp.sec.noaa.gov/pub/lists/particle/G10part\\_5m.txt](ftp://ftp.sec.noaa.gov/pub/lists/particle/G10part_5m.txt)

**GOES-10 x-ray data** The 5 minute GOES-10 x-ray flux data are available with a time lag of about 5 minutes.

URL: [ftp://ftp.sec.noaa.gov/pub/lists/xray/G10xr\\_5m.txt](ftp://ftp.sec.noaa.gov/pub/lists/xray/G10xr_5m.txt)

## Chapter 4

# Database and database tool

The data that goes into the database will be organized according to the data source. One item in the database could thus be the ACE magnetic field data.

The database tool is the interface to the database by which the different modules can access the data. Basically it should be possible to store and retrieve data.

### 4.1 Storing data

The first time data are stored in the database ancillary information is created. The database can then grow with time either continuously from real time data or occasionally from user input data.

The real time data shall be automatically downloaded from the source and stored in the database. This data are always data that are sampled equidistant in time. This fact dramatically speeds up the algorithms for finding a position in the database where the data should be stored.

There are a few problems that may occur when trying to store real time data into the database. These are:

1. new data contain data gaps,
2. new data with missing times,
3. the server providing the data is not reachable,
4. the SAAPS server is down.

When the data contain data gaps they are generally indicated with a flag for the fields with no values. The data will be stored in the database and the fields with missing data will be indicated as data gaps.

When the down-loaded data contain missing times it will be indicated as a data gap in the SAAPS database. This will ensure that the stored time series are contiguous.

Occasionally the server providing the data will not be reachable. As the down-loading is scheduled on a regular basis SAAPS will connect again and try to down-load data. If the data from the data provider extends further back in time than the connection has been down the new data will be stored as usual and no gaps will exist. If the connection is down for a longer period then there will be data with missing times.

## 4.2 Retrieving data

Retrieving data is straight forward. The basic way to retrieve data is to select the parameter and a time interval. It should also be stated whether it is an open interval, a closed interval, or a semi-open interval. If the interval  $[t_1, t_2]$  is to be retrieved the one of the following may take place:

**open**  $t_a - \Delta t < t_1 \leq t_a$  and  $t_b \leq t_2 < t_b + \Delta t$ ,

**closed**  $t_a \leq t_1 < t_a + \Delta t$  and  $t_b - \Delta t < t_2 \leq t_b$ ,

**open-closed**  $t_a - \Delta t < t_1 \leq t_a$  and  $t_b - \Delta t < t_2 \leq t_b$ ,

**closed-open**  $t_a \leq t_1 < t_a + \Delta t$  and  $t_b \leq t_2 < t_b + \Delta t$ .

Here  $t_a$  and  $t_b$  are times that exist in the database and  $\Delta t$  is the sample interval. Thus the time series retrieved from the database extends over the interval  $[t_a, t_b]$ .



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