Deliverable 2.4

Online provision of L1 solar wind and geomagnetic indices data base

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Collaborations beyond AFFECTS and Acknowledgements

The L1 solar wind data for this deliverable are exclusively from the ACE spacecraft. ACE is a NASA mission with international Co-I involvement. Data from ACE are courtesy of the MAG and SWEPAM instrument teams. ACE data are received by the Real Time Solar Wind (RTSW) network around the globe to ensure continuous availability of ACE data. German Aerospace Center Neustrelitz is part of this network and receives ACE data during daytime hours at the European sector. ACE Real Time Solar Wind (RTSW) data are collected and processed by NOAA-SWPC Boulder.

The global (planetary) geomagnetic indices comprising this deliverable are the result of contributions from selected observatories; the list of contributors may be variable and is specified at any given time in the description of the index in question. The chosen providers for the index data are GFZ Potsdam Helmholtz Centre, Potsdam and within AFFECTS, NOAA-SWPC.

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1 Introduction and scope of the document

The work packages of the FP7 AFFECTS project are systematically structured by function. The fundamental work is the provision of relevant space weather data which is part of WP2 "Data, Calibration, Maintenance, Instrumentation". This report describes the development of the online provision of an L1 solar wind data base and a geomagnetic indices data base (deliverable 2.4).

These two data bases are essential for the scientific work performed in the work packages WP3 and WP4 and for the processing and dissemination in WP5 and WP6.

The solar wind and geomagnetic indices data bases are part of a list of data bases (described in tasks 2.5-2.8 in [REF1]) which are to be established within the AFFECTS project. These two data bases are collected at the SWACI server at DLR for subsequent processing and delivery of space weather products within the AFFECTS project (cf. [REF1]). To enable easy access to users and an effective data exchange between consortium partners, DLR Neustrelitz has established a specific SWACI AFFECTS Web portal (http://swaciweb.dlr.de/affects/).

This document summarizes all information on the layout and implementation of the online solar wind and geomagnetic indices data bases and describes their potential usage.

2 Online provision of data bases on the SWACI – AFFECTS Website

The AFFECTS Description of Work (DoW, [REF1]) promotes the online provision of a list of data bases for the AFFECTS consortium members and the online dissemination of a variety of space weather products and services. Therefore the establishment of dedicated online platform(s) for the dissemination is necessary.

Responsible for the dissemination of AFFECTS data and products are the two AFFECTS consortium members ROB and DLR who share the corresponding tasks of the DoW. For the purpose of dissemination DLR established an appropriate website under the umbrella of its currently running system "Space Weather Application Center – Ionosphere" (SWACI). This special dissemination website will be entitled in the following as "SWACI-AFFECTS website". The SWACI-AFFECTS website is in operation since spring 2011 and is constantly updated. Data bases and space weather products and services are disseminated on this website by the time the corresponding deliverable is completed. A screen shot of the SWACI-AFFECTS website homepage is shown in Figure 1.

The establishment of the SWACI-AFFECTS website is part of the work done for this deliverable. This work included

- to layout the website,
- to install and establish a content management system,
- to establish a user data base and user accounts with specific user access rights,
- to insert written content onto each part of the website and
- to build a connection to the SWACI data base for online data dissemination.

Each consortium member received a dedicated user account with unlimited access to the data bases and services that are and will be disseminated on the SWACI-AFFECTS website. The system also provides the opportunity for non AFFECTS consortium members to register on the website for using specific services e.g. the Early Warning for GNSS users which will be implemented in 2012.

Using the online data base access, data and products processed in the SWACI environment can be automatically uploaded onto the website. Therefore the work done for this deliverable is fundamental work done for all the dissemination activity of the AFFECTS project.

When layouting the SWACI-AFFECTS website, all dissemination activities described in the DoW have been considered. Blank pages (having only headlines) have been inserted as templates to be filled with content by the time the concerning task/ deliverable is completed and the data base or space weather product is ready to be disseminated. Currently the SWACI-AFFECTS website provides web space for the following items:

- Geomagnetic observations
  - Local geomagnetic activity indices
  - Dst index
  - Global geomagnetic activity index Kp
  - AE index
- Vertical sounding

- Solar data
- GNSS based TEC
  - TEC Europe
  - TEC Global
- Early Warning GNSS

The L1 solar wind data base will be available on the SWACI-AFFECTS website under the menu item "Solar data" and the geomagnetic indices data base under the menu item "Geomagnetic observations/ Global geomagnetic activity index Kp" by the time deliverable 2.4 is completed.

An introduction and description of the FP7 Project AFFECTS and its consortium members is given on the SWACI-AFFECTS website homepage as presented in Figure 1.

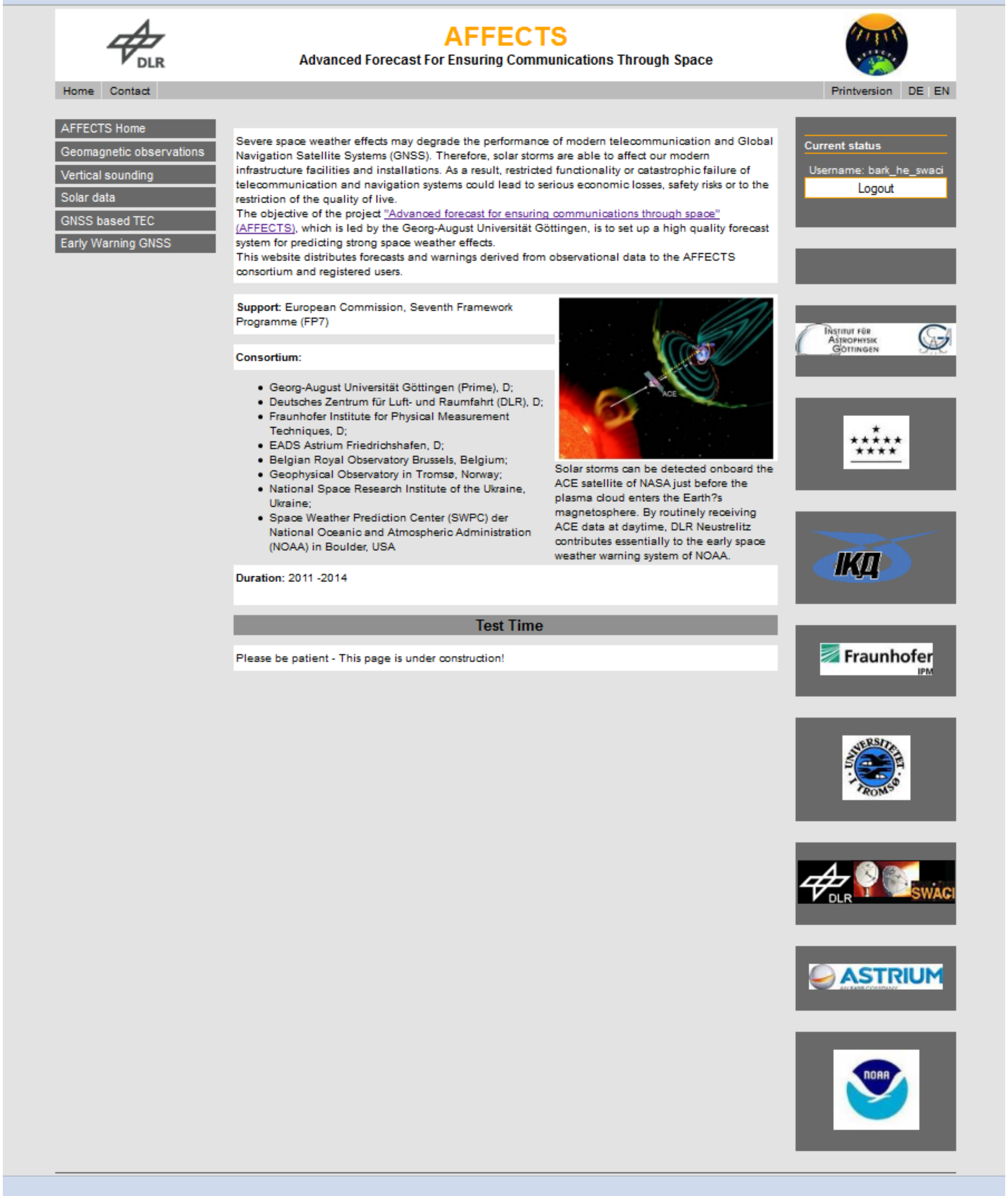


Figure 1 SWACI-AFFECTS website: http://swaciweb.dlr.de/affects/

3 L1 solar wind data base

3.1 Importance of ACE level 2 data

The stream of charged particles ejected from the Sun's corona give rise to a permanent plasma flow referred to as "solar wind". Due to the highly electrical conductance, magnetic field lines are carried along the solar wind. Both the interplanetary magnetic field (IMF) and streaming charged particles have a deep impact on the dynamics of the atmosphere. Sudden changes in solar wind parameters or magnetic field strength often result in strong perturbations of terrestrial conditions.

In particular, negative values of the z-component of IMF lead to a perturbations and reconnections of field lines. Under certain conditions, terrestrial magnetic field loses its protective function against solar wind particles and as a result charged particles are injected into the upper atmosphere.

On the other hand sudden changes of solar wind pressure give rise to distortions of terrestrial magnetic field lines that initiate a cascade of dynamic processes starting in the upper atmosphere.

The satellite ACE is located at the Lagrange point about 1.5 Mio. km away the Earth towards the Sun. On board are 9 instruments that measure significant physical values characterizing IMF and solar wind. Useful parameters to build up a forecast system within AFFECTS are IMF-components, solar wind speed and solar wind density that are provided by ACE (MAG and SWEPAM instruments) in near real time. ACE corrected data are provided by NOAA and Caltech as "level 2 data".

3.2 Data description

A dedicated data description of the ACE data is provided by NOAA-SWPC and Caltech on the website of the ACE Science Center (http://www.srl.caltech.edu/ACE/ASC/). Excerpts of this original description are presented in the following.

There are 9 instruments on board ACE, i.e.:

1. **MAG** (**MAG**netometer Instrument, *measure IMF*)
2. **SWEPAM** (Solar Wind Electron, Proton, and Alpha Monitor, *measures solar wind speed and density*)
3. **SIS** (**S**olar **I**sotope **S**pectrometer)
4. **EPAM** (**E**lectron, **P**roton, and **A**lpha **M**onitor)
5. **CRIS** (**C**osmic **R**ay **I**sotope **S**pectrometer)
6. **ULEIS** (**U**ltra **L**ow **E**nergy **I**sotope **S**pectrometer)
7. **SEPICA** (**S**olar **E**nergetic **P**article **I**onic **C**harge **A**nalyzer)
8. **SWIMS** (**S**olar **W**ind **I**on **M**ass **S**pectrometer)
9. **SWICS** (**S**olar **W**ind **I**onic **C**omposition **S**pectrometer)

Real time data is provided by (1-4):

ACE Instrument Data	1-minute average	5-minute average	1-hour average
EPAM		X	X
MAG	X		X
SIS		X	X
SWEPAM	X		X

3.2.1 Time Data

The timing data indicate the start of the integration period for the data record, in Universal Time (UTC), are formatted as follows:

year	int32	year
day	int32	day of year (first day of year is day 1)
hr	int32	hour of day
min	int32	minute of hour
sec	float32	seconds (accurate to millisec)
fp_year	float64	floating point (fractional) year
fp_doy	float64	floating point day of year (starting at 1.0)
ACEepoch	float64	ACE epoch time in seconds since Jan 1, 1996 at 0hr UT

3.2.2 MAG

MAG level 2 data is organized into 27 day time periods. For each Bartels Rotation, the level 2 data contains time averages of the magnetic field data over the following time periods:

1 second, 16 second, hourly, daily, 27 days

A data value of -999.9 indicates bad or missing data for the given time period. Magnetic field vectors are given in the RTN, GSE, and GSM coordinate systems. All data are given in nT where the error is less than 0.1 nT.

The averaged Mag data, which are all float32, are:

Br	The r component of the magnetic field vector in the RTN coordinate system
Bt	The t component of the magnetic field vector in the RTN coordinate system
Bn	The n component of the magnetic field vector in the RTN coordinate system
Bmag	The <|B|> magnetic field magnitude
Delta	The angle in degrees with 0 at Br/Bt plane + toward Bn (90 to +90 degrees), i.e. the RTN latitude
Lambda	The angle in degrees with 0 at Br and + toward Bt (0 to 360 degrees), i.e. the RTN longitude

Bgse_x	The x component of the magnetic field vector in the GSE coordinate system
Bgse_y	The y component of the magnetic field vector in the GSE coordinate system
Bgse_z	The z component of the magnetic field vector in the GSE coordinate system
Bgsm_x	The x component of the magnetic field vector in the GSM coordinate system
Bgsm_y	The y component of the magnetic field vector in the GSM coordinate system
Bgsm_z	The z component of the magnetic field vector in the GSM coordinate system
dBrms	RMS values of underlying high-resolution measurements. This is the rms variation of the vector over the time interval, calculated as follows 1) calculate the average magnitude of each of the three components of the vector, over the time interval. 2) for each component, average the square of the difference between the measurement and the average 3) add the averages from the three components 4) take the square-root of the result, i.e. dBrms = sqrt(sum_i <(B_i -)^2>)

For the 16-second averages, dBrms is calculated using the highest resolution data (3 vectors/second, from one of the two sensors). For the 4-minute and hourly averages, the 16-second averages are used as input to the calculations.

sigma_B -- The variance of |B| over the time interval, i.e. sigma_B = sqrt(<(|B|-<|B|>)^2>).

If sigma_B/<|B|> is small, there was little variation during the time period.

If sigma_B/<|B|> is large, there was much variation during the time period.

sigma_B is only calculated for the 4-minute and hourly averages. It is calculated using the 16-second averages as input.

MAG real time

Description	*Format*	*Units*	*min/max*
IMF X-component in GSM coordinates	Float	nT	-200.0 / 200.0
IMF Y-component in GSM coordinates	Float	nT	-200.0 / 200.0
IMF Z-component in GSM coordinates	Float	nT	-200.0 / 200.0
IMF component magnitude	Float	nT	0.0 / 200.0
IMF latitude in GSM coordinates	Float	degrees	-90.0 / 90.0
IMF longitude in GSM coordinates	Float	degrees	0.0 / 360.0

3.2.3 SWEPAM

SWEPAM level 2 data is organized into 27-day time periods. For each Bartels Rotation, the level 2 data contains time averages of solar wind parameters over the following time periods:

64 seconds (ion data only), 128 seconds (electron data only), hourly (all data), daily (all data), 27 days (1 Bartels rotation) (all data)

Sensor	Measured Species	Measured Quantities	Typical Energy (KeV)	Measurement Technique

SWEPAM	H, He, e^-	E/Q distributions	0.26 - 36 (ions) 0.001 - 1.35 (e^-)	E/Q

SWEPAM data consists of the following data items:

- proton_density -- proton density (np in cm -3)
- proton_temp -- radial component of the proton temperature (TP,rr in o Kelvin)
- Proton_speed -- proton speed (VP in km/s)
- Ratio of Alpha Density to proton Density (nHe/nP)
- Proton Velocity Vector in GSE coordinates (in km/s)
- Proton Velocity Vector in RTN coordinates (in km/s) Proton Velocity Vector in GSM coordinates (in km/s)

SWEPAM real time

Description	*Format*	*Units*	*min/max*
Solar wind proton density	Float	p/cc	0.0 / 200.0
Solar wind bulk speed	Float	km/s	200.0 / 2000.0
Solar wind ion temperature	Float	degrees K	1.00E4 / 1.00E7

3.2.4 EPAM

The Electron, Proton, and Alpha Monitor (EPAM) is composed of five telescope apertures of three different types. Two Low Energy Foil Spectrometers (LEFS) measure the flux and direction of electrons above 30 keV (geometry factor = 0.397 cm2*sr), two Low Energy Magnetic Spectrometers (LEMS) measure the flux and direction of ions greater than 50 keV (geometry factor = 0.48 cm2*sr), and the Composition Aperture (CA) measures the elemental composition of the ions (geometry factor = 0.24 cm2*sr). The telescopes use the spin of the spacecraft to sweep the full sky. Solid-state detectors are used to measure the energy and composition of the incoming particles.

Sensor	Measured Species	Measured Quantities	Energy Range (MeV/nuc.)	Measurement Technique
EPAM	Ions, e^-, H, He, CNO, Fe Group	Z, M, E	0.05 - 5.0 (ions) 0.04 - 0.31 (e^-) 0.2 - 93 (atomic species)	dE/dx - E

Flux Uncertainties

Flux data uncertainties are derived from statistical (counting) errors only. The uncertainties are fractional uncertainties, and are given as 1/sqrt(N), where N is the number of events in the averaging period. For no events, an uncertainty value of -999.9 is given.

Flux Averaging Method

The averaging procedure, used to create the flux for 1 day and Bartels rotation (27 day periods) from the 1 hour data, calculates the total counts and divides by the actual time in the period. This time is calculated from the sum of the livetimes (see below) in the period. The equation used is as follows:

Flux = cnt/(deltaT*deltaE*geometrical_factor), where cnt = total number of counts in time period, deltaT= actual collection time in sec , (3600 * sum of livetimes in the period), deltaE=energy range in MeV, geometrical_factor in units of cm2 * Sr

LEMS30 Data

The LEMS30 telescope, (Low-Energy Magnetic Spectrometer), measures ions. The LEMS30 sensor is oriented at 30 degrees from the spin axis.

A rare-earth magnet in front of the LEMS30 detector sweeps out any electrons with energy below about 500 keV. These electrons are measured in the B detector which is located at the back of the CA60 telescope assembly and are referred to as DE30 electrons. The LEMS30 detector is a 200 micron, totally depleted, solid-state, silicon surface barrier detector. The geometrical factor for the LEMS30 ions is 0.428 (cm^2*sr). The eight channels from the LEMS30 detector and their energy passbands are given in the following table.

Channel	Energy Passband (MeV)	Species
P1	0.047-0.065	ions
P2	0.065-0.112	ions
P3	0.112-0.187	ions
P4	0.187-0.310	ions
P5	0.310-0.580	ions
P6	0.580-1.06	ions
P7	1.06-1.91	ions
P8	1.91-4.75	ions

DE30 Data

The DE30 detector, (Deflected Electrons), measures electrons at 30 degrees from the spacecraft spin axis. Electrons entering the LEMS30 detector are swept out by a rare-earth magnet and are deflected into the B detector. The 4 DE channels are pure electron channels. The geometrical factor for the DE30 channels is 0.14 (cm^2*sr). The DE channels, energy passbands, and species are given in the following table.

Channel	Energy Passband (MeV)	Species
DE1	0.038-0.053	electrons
DE2	0.053-0.103	electrons
DE3	0.103-0.175	electrons
DE4	0.175-0.315	electrons

CA60 Data

The CA60 telescope, (Composition Aperture) measures ion composition. It's look-direction is oriented 60 degrees from the spacecraft spin-axis.

The CA telescope is capable of determining ion composition using a dE X E detection scheme. Although the principal responsibility of EPAM is to monitor electrons, protons, and alphas, the CA provides an unambiguous determination of ion composition, unlike the LEMS detectors. The CA60 telescope is comprised of three solid state detectors, a thin, ~5 micron epitaxial silicon detector referred to as the D detector, and two thick (200 micron) totally depleted surface barrier silicon detectors known as C and B. The B detector, as measures deflected electrons from the LEMS30 head, but also acts as the anti-coincidence detector for the CA.

The CA system uses log amplifiers to extend the dynamic range of the detector. These amplifiers are extremely temperature sensitive, and therefore are thermally regulated with heaters to maintain calibration. The logic used in the CA depends on slanted discriminators to define each species group. The eight Ca rate channels, denoted by the symbols W1 - W8, count all particles in a given energy/nucleon range. Multiple species may therefore be associated with a single Ca rate channel. As a result, a species group is identified by the dominant species in that group.

Energy Channel	Passband (MeV/nuc)	Species Group	
W1	0.480-0.966	H	
W2	0.968-1.20	H	
W3	0.389-1.28	He	
W4	1.28-6.98	He	
W5	0.465-1.71	O	-9
W6	1.71-19.1	O	-9
W7	0.239-0.840	Fe	0-28
W8	0.840-92.7	Fe	0-28

Note: ACE Level 2 EPAM data only includes channels W3 - W8 at this time.

The above table lists the detailed information for each group. Defined for each energy channel W are the energy passbands, the dominant species, and the atomic number response were appropriate. An example of the multiplicity of species for a given species group is given by the O-species group. This group is defined by the rate channels denoted W5 and W6 and is dominated by oxygen; however, there is also a significant contribution from Carbon and Nitrogen. This group is therefore also identified as the CNO group. Similarly, the Fe-group is made up of all species with ($9 < Z < 29$), but again iron is the dominant species.

LEFS60 Data

The LEFS60 detector, (Low Energy Foil Spectrometer), measures ions and electrons with a look angle of 60 degrees to the spin axis. An aluminized Parylene foil is used to absorb ions with energies below approximately 350 keV, while allowing electrons with energies above about 35 keV to pass through to the solid-state detector. The geometrical factor for the LEFS60 telescope is 0.397 (cm^2*sr). The following table shows the LEFS60 channels, passbands, and species.

Energy Channel	Passband (MeV)	Species
E1'	0.045-0.062	electrons
E2'	0.062-0.103	electrons
E3'	0.103-0.175	electrons
E4'	0.175-0.312	electrons
FP5'	0.546-0.761	ions
FP6'	0.761-1.22	ions
FP7'	1.22-4.97	ions

WARTD60 Data

The WARTD60 is a special part of the CA60, (Composition Aperture) and measures ions above certain energy thresholds. These 4 channels measure integral flux, not differential flux as the other EPAM detectors. The following table shows the WARTD60 channels and species/energies available.

Energy Channel	Species
Z2	Z > 1, E > 0.7 MeV
Z2A	Z > 7, E > 7.5 MeV
Z3	Z > 5, E > 2.5 MeV
Z4	Z > 10, E > 9.0 MeV

LEMS120 Data

The LEMS120 detector, (Low-Energy Magnetic Spectrometer), measures ions at 120 degrees from the spacecraft spin axis. A rare-earth magnet in front of the detector sweeps out any electrons with energy below about 500 keV. The geometrical factor for the LEMS120 telescope is 0.428 (cm^2*sr) and the channel names, passbands, and species are given in the following table.

Energy Channel	Passband (MeV)	Species
P1'	0.047-0.066	ions
P2'	0.066-0.114	ions
P3'	0.114-0.190	ions
P4'	0.190-0.310	ions
P5'	0.310-0.580	ions
P6'	0.580-1.05	ions
P7'	1.05-1.89	ions
P8'	1.89-4.75	ions

EFS150 Data

The LEFS150 detector, (Low Energy Foil Spectrometer), measures electrons with energies less than about 350 keV and ions with a look direction of 150 degrees from the spin axis. An aluminized Parylene foil is used to absorb ions with energies below approximately 350 keV, while allowing electrons with energies above about 35 keV to pass through to the solid-state detector. The geometrical factor for the LEFS150 telescope is 0.397 (cm^2*sr). The following table shows the LEFS150 channels, energy passbands, and species.

Note: After DOY 78, 1998, the E1, E2 and E3 channels contain fill data (-999.9). This is due to a sudden noise increase in the detector, which makes the output from these channels unreliable.

Energy Channel	Passband (MeV)	Species
E1	0.045-0.062	electrons
E2	0.062-0.102	electrons
E3	0.102-0.175	electrons
E4	0.175-0.312	electrons
FP5	0.540-0.765	ions
FP6	0.765-1.22	ions

FP7 1.22-4.94 ions

EPAM real time

Description	Format	Units	min/max
Differential electron flux 38-53 keV	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E8
Differential electron flux 175-315 keV	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E7
Differential proton flux 47-68 keV	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E8
Differential proton flux 115-195 keV	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E7
Differential proton flux 310-580 keV	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E7
Differential proton flux 1060-1900 keV	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E6
FP6p (761-1220 keV proton flux)	Float	p/(cm2-sec-ster-MeV)	0.00/1.0E7
Anisotropy Index	Float	Dimensionless	0.0/2.0

3.2.5 SIS

SIS level 2 data is organized into 27-day time periods. For each Bartels Rotation, the level 2 data contains time averages of energetic charged particle fluxes over the following time periods:

256 seconds, hourly, daily, 27 days (1 Bartels rotation)

Sensor	Measured Species	Measured Quantities	Energy Range (MeV/nuc.)	Measurement Technique
SIS	2 <= Z <= 28	Z, M, E	5 - 150	dE/dx - E

Species and Energy Ranges

Currently, flux data are available for 14 elements, in units of particles/(cm^2 Sr sec MeV/nucleon), in eight energy ranges. The energy ranges are different for each element.

The elements for which data are available are:

He, C, N, O, Ne, Na, Mg, Al, Si, S, Ar, Ca, Fe, and Ni.

The following notes also apply:

- The SIS team currently recommends that a systematic uncertainty of 5% be added to the statistical uncertainties derived from the counts data.
- A flux value of -999.9 indicates bad or missing data.

For the 27-day Bartels Rotation averages, two kinds of averages are provided:

- Quiet-time flux averages, where data from Solar Energetic Particle Event time periods have been excluded.
- Flux averages computed using all the data.

Element Counts

These are the actual event counts used to calculate the flux data. The statistical uncertainty of the flux data can be derived from these counts (N). The flux uncertainties can be calculated as flux/sqrt(N), where N is the number of events in the averaging period.
Caution: Counts for He may be low during periods of high solar activity. SIS livetimes for He can be low during these periods.

Flux averaging method

Average flux = Sum(flux)/(Number of samples), for all the good 256-second samples in the time period.

Lifetime

Uptime_fraction is based on the number of 256-second averaging periods contained in the given averaging period. This may later be upgraded to a true livetime.

Solar Activity Flag

This variable is set to 1 if either the SIS helium or oxygen flux is higher than a certain threshold, for a given averaging period. The variable is intended to indicate periods of high solar activity. If this variable is zero, low solar activity for the period is indicated.
Note: the flag is set to 1 (non-quiet) if there is no Helium data available for a given time period. The thresholds are defined as follows:

threshold_He: (flux_He[0]+flux_He[1]+flux_He[2])/3. > 1.e-4

(Note: Prior to Jan. 28, 1998, the second term for He is not used, i.e.

threshold_He = (flux_He[0]+flux_He[2])/2. > 1.e-4)

threshold_O: (flux_O[0]+flux_O[1]+flux_O[2])/3. > 2.e-5

For the Bartels rotation data, there is no solar_activity_flag. However, there are two sums. The first sum is over all the data during the period regardless of solar_activity. The second sum is over only the quiet days, i.e. those days where the solar_activity_flag is zero.

SIS real time

SIS - Solar Isotope Spectrometer Integral Flux of High-energy Solar Protons

Description	Format	Units	min/max
Integral proton flux at >10 MeV	Float	p/(cm2-sec-ster)	0.00 / 1.00E5
Integral proton flux at >30 MeV	Float	p/(cm2-sec-ster)	>0.00 / 1.00E5

3.2.6 Spacecraft location

Description	Format	Units	min/max
X position in GSE coordinate	Float	Re	0.0 / 300.0
Y position in GSE coordinate	Float	Re	-200.0 / 200.0
Z position in GSE coordinate (Earth radii)	Float	Re	-200.0 / 200.0

3.3 Retrieval of ACE data

To an observer looking up from the Earth ACE appears to slowly circle the Sun as it follows its orbit around the L1 libration point, about 1.5 million kilometers out from the Earth on the Earth-Sun line. To obtain continuous data from ACE, SWPC relies on a network of ground tracking stations located at various sites around the world (the Real Time Solar Wind network, RTSW). All stations, except for Boulder, use at least a 10 meter diameter parabolic antenna to receive the extremely weak S band radio telemetry signals from the 5 watt transmitter on the ACE spacecraft.

The German Aerospace Center Neustrelitz is part of this network and receives ACE data during daytime hours at the European sector (http://www.swpc.noaa.gov/ace/acetrack_48h.html).

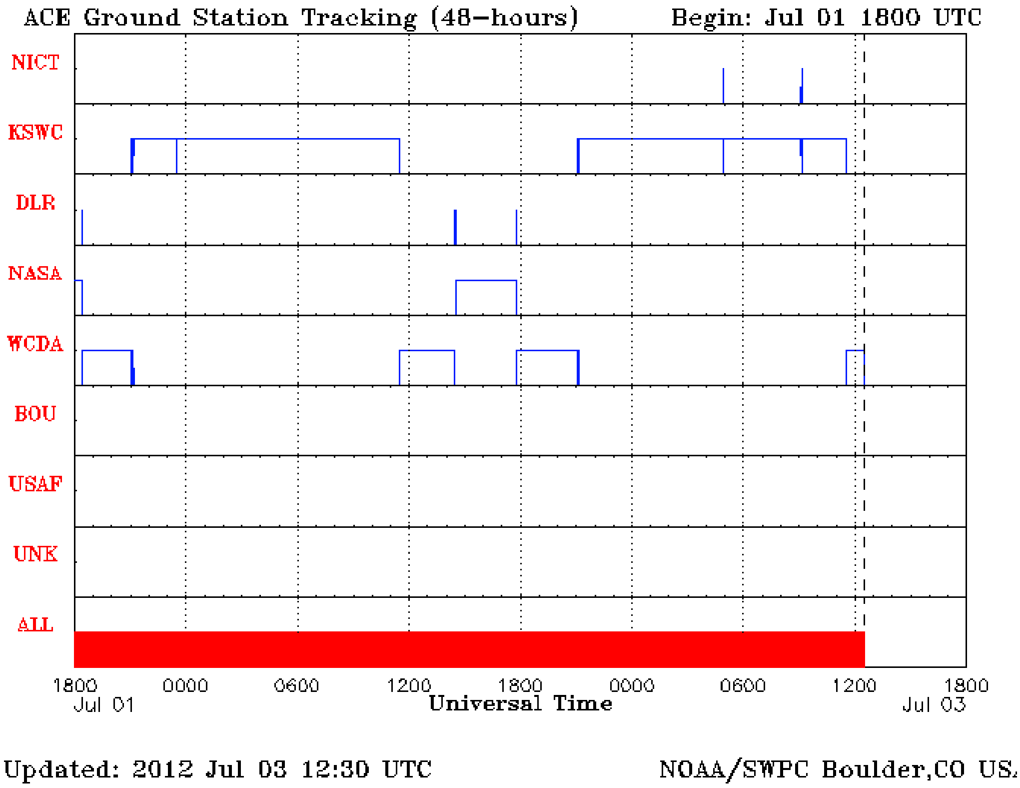


Figure 2 ACE ground station tracking

Figure 2 shows the ACE RTSW data received and processed by NOAA-SWPC as a function of time. It indicates the currency of the ACE RTSW data and the total temporal coverage achieved by the network. Data received from each ground system in the RTSW tracking partnership are displayed in their respective panels with the total tracking coverage shown at the bottom.

The RTSW ground system partnership consists of:

- National Institute of Information and Communications Technology (NICT) in Tokyo, Japan
- Korean Space Weather Center (KSWC) in Jeju, Korea
- German Aerospace Center (DLR) from Neustrelitz, Germany
- NASA's Deep Space Network (NASA)
- NOAA's Wallop Command and Data Acquisition (WCDA) station at Wallop's Island, VA
- NOAA's Space Weather Prediction Center (BOU) in Boulder, CO
- United States Air Force (USAF) stations within the Air Force Satellite Control Network
- UNK (unknown) indicates a new, unassociated tracking station identifier. New identifiers are usually assigned within a few days.

3.4 Storage and access of the ACE data

3.4.1 Storage in E-SWDS

ACE data are stored after retrieval and processing at NOAA-SWPC in the External Space Weather Database Store (E-SWDS). The E-SWDS is a near real-time, relational data base method of electronic communication between the NOAA-SWPC operational database and external users. It consists of hardware and software maintained by NOAA-SWPC. This method of data retrieval is in addition to services previously provided by NOAA-SWPC for FTP and Web access [REF2].

3.4.2 Restricted Access

Using E-SWDS, information is exchanged from NOAA-SWPC automated systems and personnel to external parties via an Open Database Connectivity (ODBC) interface or similar technology such as Java Database Connectivity (JDBC™). E-SWDS allows for the establishment of connections based on individual user ID's and passwords for the access of database information via predefined views or stored procedures. The database is open only for read access to a previously identified subset of operational space weather data [REF2].

The access and use of the E-SWDS ("Service") subject is bound to specific Terms of Use defined by SWPC.

Being a privileged partner of NOAA-SWPC and registered user of the E-SWDS, DLR is able to access ACE data directly from E-SWDS. Therefore the ACE data can be directly used in real time for forecasting modules of the Forecast System Ionosphere (FSI) being established in AFFECTS.

3.4.3 Free Access

Free user access is available on the following websites and ftp servers listed in Table 1.

Instrument	Mode	File path	Naming convention
MAG	Historical	ftp://mussel.srl.caltech.edu/pub/ace/level2/mag/	mag_data_16sec_2240.hdf
	Real time	http://www.swpc.noaa.gov/ftpmenu/lists/ace.html http://www.swpc.noaa.gov/ftpmenu/lists/ace2.html	YYYYMMDD_ace_mag_tt.txt
SWEPAM	Historical	ftp://mussel.srl.caltech.edu/pub/ace/level2/swepam/	swepam_data_1day_2246.hdf
	Real time	http://www.swpc.noaa.gov/ftpmenu/lists/ace.html http://www.swpc.noaa.gov/ftpmenu/lists/ace2.html	YYYYMMDD_ace_swepam_tt.txt
EPAM	Historical	ftp://mussel.srl.caltech.edu/pub/ace/level2/epam/	epam_data_1day_2240.hdf
	Real time	http://www.swpc.noaa.gov/ftpmenu/lists/ace.html http://www.swpc.noaa.gov/ftpmenu/lists/ace2.html	YYYYMMDD_ace_epam_tt.txt
SIS	Historical	ftp://mussel.srl.caltech.edu/pub/ace/level2/sis/	sis_data_1day_2240.hdf
	Real time	http://www.swpc.noaa.gov/ftpmenu/lists/ace.html http://www.swpc.noaa.gov/ftpmenu/lists/	YYYYMMDD_ace_sis_tt.txt

		ace2.html	
Spacecraft location		http://www.swpc.noaa.gov/ftpmenu/lists/ace2.html	YYYYMMDD_ace_loc_1h.txt

Table 1 List of ACE real time data access

3.5 Provision and use of ACE data in AFFECTS

Real time ACE data will be retrieved from E-SWDC and provided internally in the FSI by a special ACE processing module. This module establishes a connection via JDBC to the E-SWDC, downloads the real time ACE data and writes it into ASCII files. These ASCII files are provided to other processing modules of the FSI.

Next to the FSI internal ACE data provision, an online data base is published on the SWACI-AFFECTS website, containing the respective hyperlinks for the download of near real time (NRT) ACE data. All necessary hyperlinks being specified in Table 1 are listed under the menu item “Solar data” on the SWACI-AFFECTS website. A screen shot is shown in Figure 3.

Figure 3 Content of SWACI-AFFECTS website showing L1 solar wind data base

Solar wind information is an important element in the arsenal of solar-terrestrial measurable quantities available to AFFECTS. The ACE data is required for many tasks which are to be solved within AFFECTS. An overview is given in Table 2.

Description of ACE data use	*Lead beneficiary*	*Data access*
Development of the geomagnetic activity forecast module	SRI-NASU-NSAU	online
Implementation of the geomagnetic activity forecast module	SRI-NASU-NSAU	FSI

Preliminary studies for provision of early warning messages for GNSS users	DLR	online
Analyses of solar-terrestrial relationships for the development and improvement of the TEC perturbation model	DLR	online
Driving the TEC perturbation model for forecasting TEC as part of the FSI	DLR	FSI
Implementation of Kp near real-time warnings	UGOE	online
Parameterization of geomagnetic and TEC disturbances for quantification of early warnings	UGOE	online
Prediction of ICME magnetic field structure, calibration of ENLIL, improve forecast	UGOE	online
Improve forecast of CME arrival times, ENLIL calibration	UGOE	online
ACE alert when CME arrives	UGOE	online
Quantitative comparison of solar wind data with forecasted solar wind conditions in geo-space based on solar observations and modeling results (ENLIL code)	UGOE	online
Determination of magnetospheric - and subsequent driven ionospheric dTEC variations – disturbances levels on solar wind and CME input parameters for severe events	UGOE	online
Analysis of storm magnitudes during present and past events and ionospheric response	UGOE	online
Near Real-Time analysis for space weather beacon system to allow 15-30 min. forecasts of geo-space storms and validation of their onsets with respect to early warnings and for inclusion into mobile phone space weather application	UGOE	online
Provision of momentary severe geo-space weather conditions	UGOE	online
Comparison with polar electro jet and dTEC variations	UGOE	online

Table 2 Use of ACE data

4 Geomagnetic indices data base

4.1 Importance of geomagnetic activity data

Geomagnetic indices and lists of remarkable geomagnetic events constitute data series aiming at describing at a planetary scale the magnetic activity, or some of its components. The data series are homogeneous since 1868 for aa and the list of ssc, 1932 for Kp, 1953 for the list of Sfe, 1957 for Dst and 1959 for am.

Commonly used geomagnetic indices that are critical in defining the magnitude of geomagnetic storms are the official planetary K value (Kp), the corresponding a value (ap) and Dst. Some indices are as well available as estimated and predicted values to be used in real time specifications and forecasts of space weather.

Kp and its related indices (ap, Ap, Cp) are widely used in ionospheric and magnetospheric studies and are generally recognized as indices measuring worldwide geomagnetic activity. The IAGA-97 Resolutions #5 and #6 recognize the value of preserving the uniqueness of the official IAGA indices and the importance of geomagnetic activity indices for characterization and prediction of a wide range of geomagnetic phenomena.

In AFFECTS these indices will be required for regression modelling and forecasting geomagnetic activity in WP4.

4.2 Data description

4.2.1 Kp and related geomagnetic indices

Geomagnetic disturbances can be monitored by ground-based magnetic observatories recording the three magnetic field components. The global *Kp* index is obtained as the mean value of the disturbance levels in the two horizontal field components, observed at 13 selected, subauroral stations. The name *Kp* originates from "*p*lanetarische *K*ennziffer" (= planetary index).

The following definition of *K* variations has been given by [REF3]:

K variations are all irregular disturbances of the geomagnetic field caused by solar particle radiation within the 3-h interval concerned. All other regular and irregular disturbances are non *K* variations. Geomagnetic activity is the occurrence of *K* variations.

Local disturbance levels are determined by measuring the range (difference between the highest and lowest values) during three-hourly time intervals for the most disturbed horizontal magnetic field component. First, however, the quiet-day variation pattern has to be removed from the magnetogram, a somewhat subjective procedure. The range is then converted into a local *K* index (first introduced 1938 for the magnetic observatory Niemegk near Potsdam) taking the values 0 to 9 according to a quasi-logarithmic scale, which is station specific; this is done in an attempt to normalize the frequency of occurrence of the different sizes of disturbances. But *K* still remains a local index, describing disturbances in the vicinity of each observatory. According to the geographic and geomagnetic coordinates of the observatories, each observatory still has an annual cycle of daily variations. Using statistical methods, J. Bartels generated conversion tables to eliminate these effects. By applying the conversion tables, a standardized index *Ks* for each of the 13 selected observatories is determined. In contrast to the *K* values, the *Ks* index is expressed in a scale of thirds (28 values):

0o, 0+, 1-, 1o, 1+, 2-, 2o, 2+, ... , 8o, 8+, 9-, 9o

The main purpose of the standardized index *Ks* is to provide a basis for the global geomagnetic index *Kp* which is the average of a number of "*Kp* stations", originally 11. The *Ks* data for the two stations Brorfelde and Lovö, as well as for Eyrewell and Canberra, are combined so that their average enters into the final calculation, the divisor thus remaining 11.

The geomagnetic ap, Ap, Cp and C9 indices and the classification of international Q-days and D-days are derived from the *Kp* index.

4.2.2 Dst index

The Dst index is an index of magnetic activity derived from a network of near-equatorial geomagnetic observatories that measures the intensity of the globally symmetrical equatorial electro jet (the "ring current").

More in detail, Dst is the average of the disturbance variation D(T) at UT *T* measured at four geomagnetic observatories normalized to the dipole equator.

$$Dst(T) = D(T) / \cos\phi \quad (1)$$

The disturbance variation *D(T)* is defined for each observatory as product of the deviations *ΔH(T)* and the solar quiet variations *Sq(T)*

$$D(T) = \Delta H(T) S_q(T) \quad (2)$$

The deviation *ΔH(T)* is the difference between the baseline value for H $H_{base}(T)$ and the observed H value $H_{obs}(T)$. The $H_{base}(T)$ is defined for each observatory in a manner that takes into account the secular variation. For each observatory, the annual mean values of H, calculated from the "five quietest day" for each month, form the data base for the baseline.

The average *Sq* for each month is determined for each observatory from the values of *H(T)* for the internationally selected five quietest days of the month. The 12 sets of the monthly average *Sq* so determined for the year are expanded in a double Fourier series with local time *t* and month number *s*

$$S_q(t,s) = \sum_n \sum_m A_{m,n} \cos(mt + \alpha_m) \cos(ns + \beta_n) \quad (3)$$

This representation allows to calculate *Sq(T)* at any UT hour *T* of the year. This procedure is applied to each observatory.

4.3 Retrieval of geomagnetic indices

4.3.1 Kp and related geomagnetic indices

The sites listed here are those used in the creation of the *Kp* index, and hence also in the derived ap index. The observatories listed in Table 3 are mentioned in the order of their geomagnetic latitude (beginning with the highest one). The location of these observatories is shown on a map in Figure 4.

Observatory					Geographic		Geomagnetic		K=9 (nT)
#	Code	Name	Location	Active	Lat.	Long.	Lat.*	Long.*	
1	LER	Lerwick	Scotland	1932-actual	60°08'	358°49'	62.0°	89.2°	1000
2	MEA	Meanook	Canada	1932-actual	54°37'	246°40'	61.7°	305.7°	1500
3	SIT	Sitka	Alaska (US)	1932-actual	57°03'	224°40'	60.4°	279.8°	1000
4	ESK	Eskdalemuir	Scotland	1932-actual	55°19'	356°48'	57.9°	83.9°	750
5	LOV	Lovö	Sweden	1954-2004	59°21'	17°50'	57.9°	106.5°	600
	UPS	Uppsala	Sweden	2004-actual	59°54'	17°21'	58.5°	106.4°	600
6	AGN	Agincourt	Canada	1932-1969	43°47'	280°44'	54.1°	350.5°	600
	OTT	Ottawa	Canada	1969-actual	45°24'	284°27'	55.8°	355.0°	750
7	RSV	Rude Skov	Denmark	1932-1984	55°51'	12°27'	55.5°	99.4°	600
	BFE	Brorfelde	Denmark	1984-actual	55°37'	11°40'	55.4°	98.6°	600
8	ABN	Abinger	England	1932-1957	51°11'	359°37'	53.4°	84.5°	500
	HAD	Hartland	England	1957-actual	50°58'	355°31'	54.0°	80.2°	500
9	WNG	Wingst	Germany	1938-actual	53°45'	9°04'	54.1°	95.1°	500
10	WIT	Witteveen	Netherland	1932-1988	52°49'	6°40'	53.7°	92.3°	500
	NGK	Niemegk	Germany	1988-actual	52°04'	12°41'	51.9°	97.7°	500
11	CLH	Cheltenham	USA	1932-1957	38°42'	283°12'	49.1°	353.8°	500
	FRD	Fredericksburg	USA	1957-actual	38°12'	282°38'	48.6°	353.1°	500
12	TOO	Toolangi	Australia	1972-1981	-37°32'	145°28'	-45.6°	223.0°	500
	CNB	Canberra	Australia	1981-actual	-35°18'	149°00'	-42.9°	226.8°	450
13	AML	Amberley	New Zealand	1932-1978	-43°09'	172°43'	-46.9°	254.1°	500
	EYR	Eyrewell	New Zealand	1978-actual	-43°25'	172°21'	-47.2°	253.8°	500

Table 3 List of geomagnetic observatories used for the derivation of Kp index.

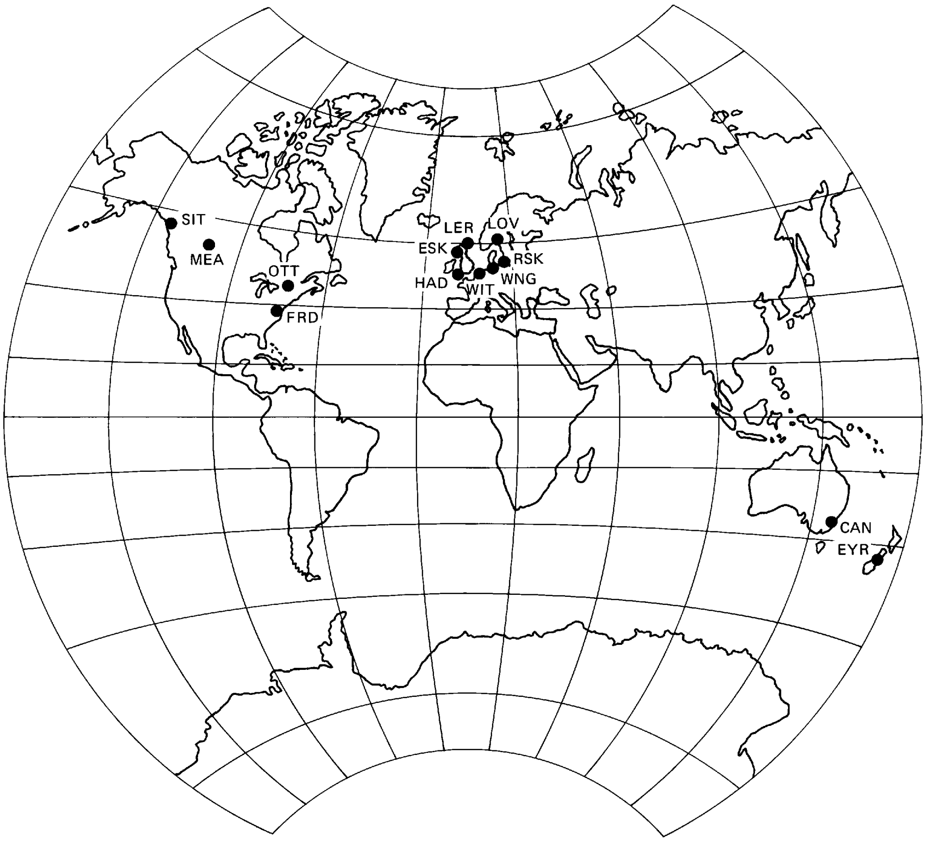


Figure 4 Distribution of Kp observatories (courtesy of ISGI, [REF6])

During 1949-1996 *Kp* has been derived at the Institut für Geophysik of Göttingen University, Germany. Since 1997 the *Kp* and related indices are derived at the Adolf Schmidt Geomagnetic Observatory Niemegk of the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences.

4.3.2 Dst index

The Dst index is derived using the data from the four geomagnetic observatories listed in Table 4. Their geographic location is shown in Figure 5.

Observatory	*Acronym*	*Dipole Lat.*	*Dipole Long.*
Honolulu	HON	21.0 N	266.4
San Juan	SJG	29.9 N	3.2
Hermanus	HER	33.3 S	80.3
Kakioka	KAK	26.0 N	206.0

Table 4 List of Dst observatories

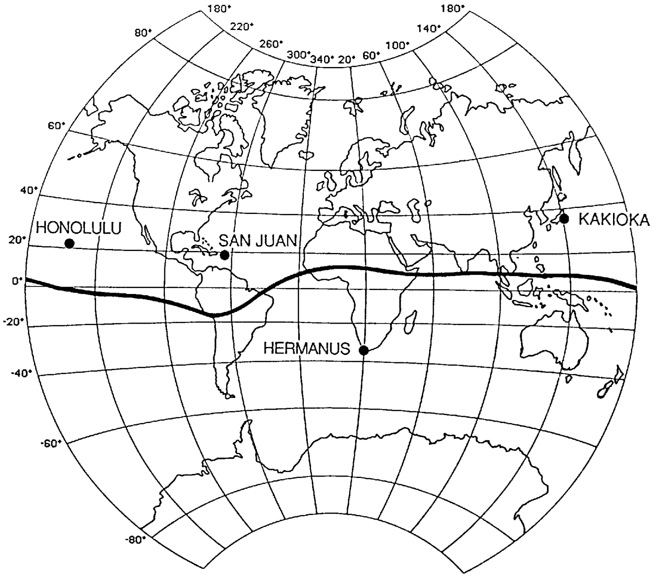


Figure 5 Distribution of Dst observatories (courtesy of ISGI, [REF5])

These observatories were chosen on the basis of the quality of observation and for the reason that their locations are sufficiently distant from the auroral and equatorial electro jets and that they are distributed in longitude as evenly as possible.

4.4 Storage and access of geomagnetic indices data

The International Service of Geomagnetic Indices (ISGI) is in charge of the elaboration and dissemination of geomagnetic indices, and of lists of remarkable magnetic events with data provided by geomagnetic observatories.

ISGI prepares and circulates the geomagnetic indices data with the help of collaborating institutes listed in Table 5.

Institute	*Data*	*Data access*
LATMOS	am, Km, aa, Kpa	http://isgi.cetp.ipsl.fr/source/indices/
WDC-C2 for Geomagnetism	Dst, Ae	http://swdcwww.kugi.kyoto-u.ac.jp/
GFZ	Kp, Ap	ftp://ftp.gfz-potsdam.de/pub/home/obs/kp-ap/
Observatori de l'Ebre	rapid variations	http://www.obsebre.es
Danish National Space Institute	Kp, Ap PC	ftp://ftp.space.dtu.dk/WDC/indices/kp-ap/ ftp://ftp.space.dtu.dk/WDC/indices/pcn/
Arctic and Antarctic Research Institute	PC;	http://www.aari.nw.ru/

Table 5 List of ISGI collaborating institutes providing historical geomagnetic indices data

The data access given in Table 5 describes the data archive of historical data. The provision of near real time (NRT) data, which is requested for the forecasting tools to be developed in WP4, is described in Table 6.

Data	*Institute*	*Data access*
Kp	GFZ	http://www-app3.gfz-potsdam.de/kp_index/qlyymm.tab http://www-app3.gfz-potsdam.de/kp_index/qlyymm.wdc
Dst	WDC-C2 for Geomagnetism	http://wdc.kugi.kyoto-u.ac.jp/dst_realtime/presentmonth/index.html http://wdc.kugi.kyoto-u.ac.jp/dst_realtime/yyyymm/dstyymm.for.request replacing yyyymm and yymm by year and month digits, e.g. http://wdc.kugi.kyoto-u.ac.jp/dst_realtime/201207/dst1207.for.request

Table 6 Near real time geomagnetic indices

Please note that the near real time data is only preliminary data. Not all magnetometers may contribute to this data. These preliminary indices are later recalculated when all data is available. The definitive data is then disseminated in the data bases listed in Table 5 and for Dst-index (1957-2008) on the following websites:

http://wdc.kugi.kyoto-u.ac.jp/dst_final/yyyymm/dstyymm.for.request

replacing yyyymm and yymm by the requested year and month, e.g.:

http://wdc.kugi.kyoto-u.ac.jp/dst_final/200812/dst0812.for.request

or on the FTP server of NOAA

ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/

Also requested in the AFFECTS DoW are predicted Kp values. These are estimated by NOAA-SWPC using Wing Kp Model [REF4]. The Wing Kp Predicted Geomagnetic Activity Index model is known to perform well for large geomagnetic storms and includes both a 1 hour and a 4 hour advance prediction of activity. Wing Kp 7-day model output is available via HTTP and FTP using the following hyperlinks:

- http://www.swpc.noaa.gov/wingkp/wingkp_list.txt
- ftp://ftp.swpc.noaa.gov/pub/lists/wingkp

4.5 Provision and use of geomagnetic indices for AFFECTS

NRT data and data of the last month required for different FSI processing modules are internally provided in the FSI. Automatic processes are established, downloading the corresponding files (c.f. Table 5 and Table 6) from the website and ftp servers and storing them on the FSI Pickup Point. The Pickup Point inhabits the input data for the FSI. All data stored there is then provided to the FSI processing modules.

For the processor development and scientific purpose, the geomagnetic indices can be directly downloaded from the given data bases (Table 5 and Table 6). Therefore hyperlinks to all data sources are provided on the respective SWACI-AFFECTS web pages operated DLR. Screen shots of the SWACI-AFFECTS website content are shown in Figure 6 to Figure 8.

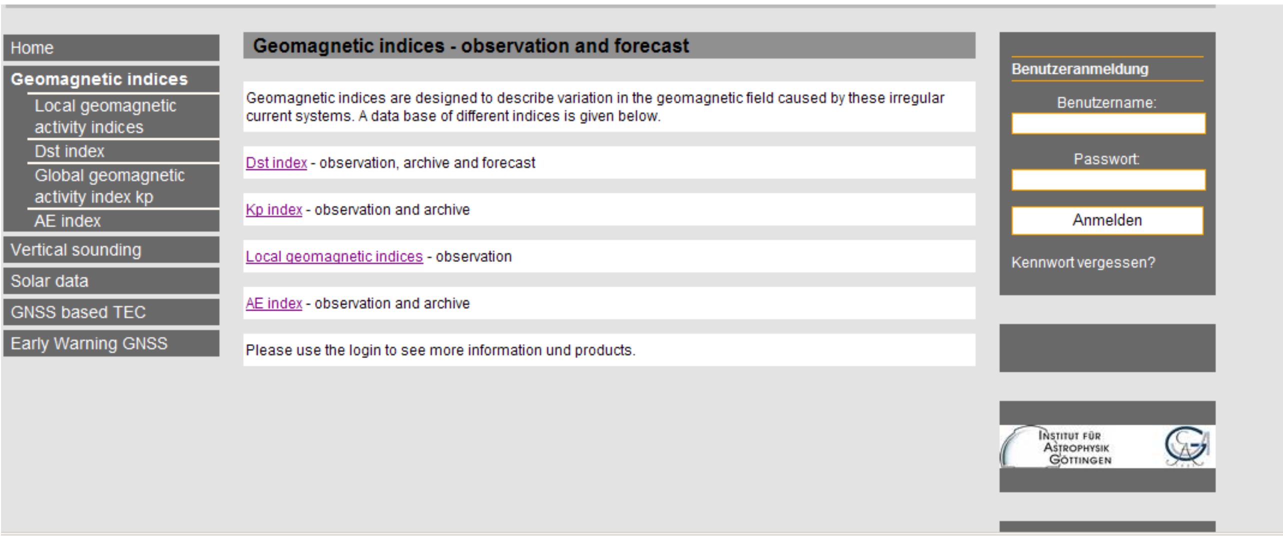


Figure 6 Content of SWACI-AFFECTS website showing geomagnetic indices data base overview

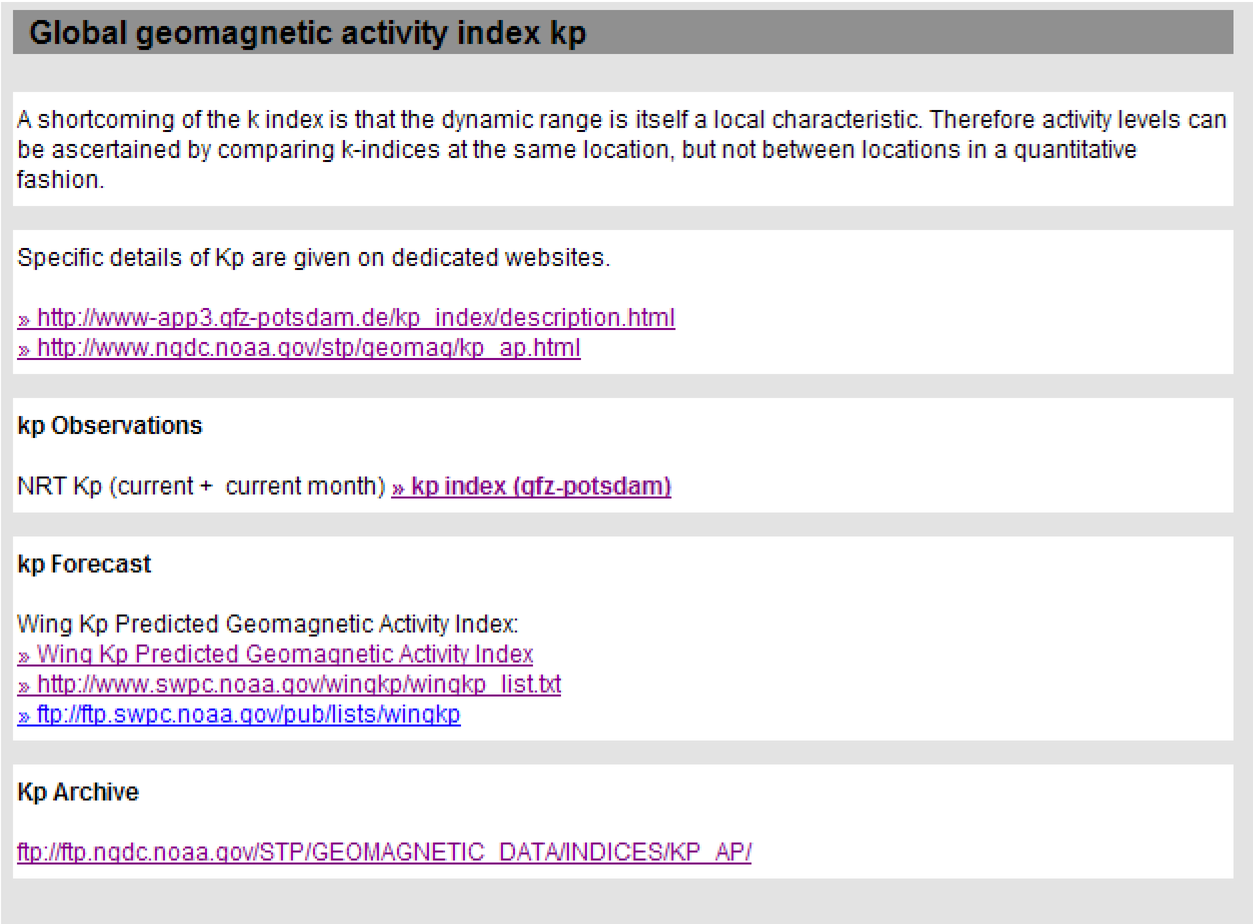
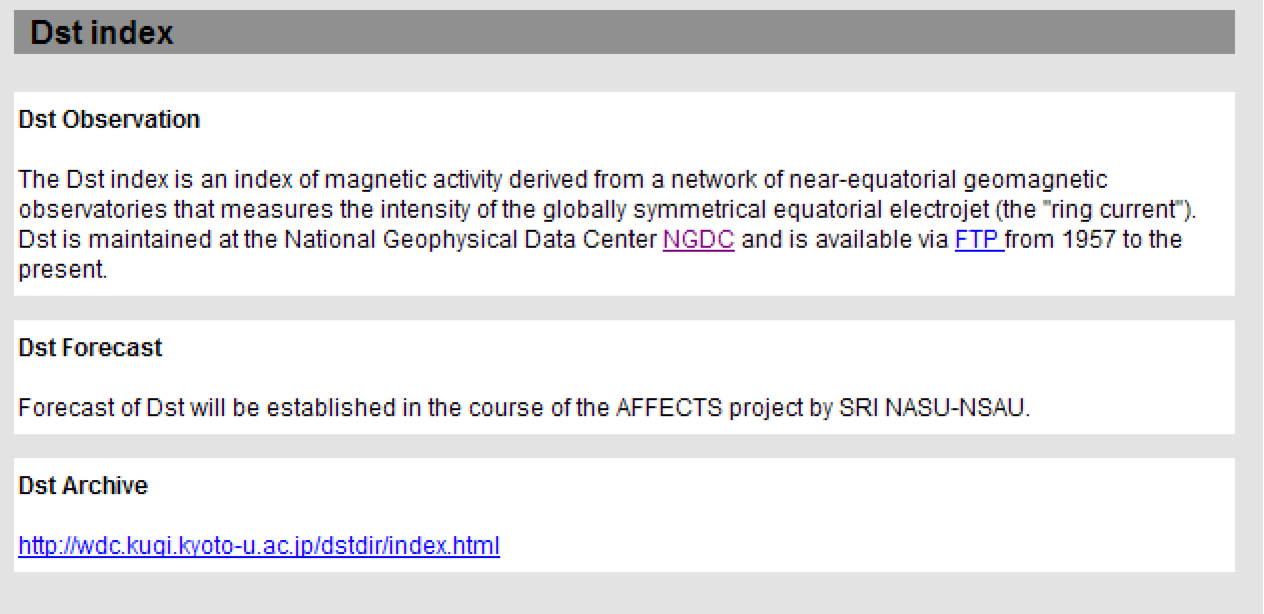


Figure 7 Content of SWACI-AFFECTS website showing geomagnetic indices data base of Kp



Dst index

Dst Observation

The Dst index is an index of magnetic activity derived from a network of near-equatorial geomagnetic observatories that measures the intensity of the globally symmetrical equatorial electrojet (the "ring current"). Dst is maintained at the National Geophysical Data Center NGDC and is available via FTP from 1957 to the present.

Dst Forecast

Forecast of Dst will be established in the course of the AFFECTS project by SRI NASU-NSAU.

Dst Archive

http://wdc.kugi.kyoto-u.ac.jp/dstdir/index.html

Figure 8 Content of SWACI-AFFECTS website showing geomagnetic indices data base of Dst

Sustentative, many links to geomagnetic data bases will be available at http://affects.uit.no.

The data will be primarily used to develop and validate the forecasts proposed in WP4 and WP5. The use of the geomagnetic indices data by the AFFECTS users/beneficiaries is described in Table 7.

Description of application	*Beneficiary*	*Data access*
Development of forecast for geomagnetic indices	SRI-NASU-NSAU	online
Implementation of operational forecast tool for forecasting geomagnetic indices	SRI-NASU-NSAU	FSI
Development of perturbation TEC model	DLR	online
Implementation of forecast tool for forecasting perturbed TEC	DLR	FSI
Implementation of Kp near real-time warnings for severe (Kp ge. 8- or potential candidates) space weather events based on ACE data, CIR and high speed stream impacts	UGOE	online
Parameterization of geomagnetic and TEC disturbances for quantification of early warnings	UGOE	online
Comparison of Dst, Kp, ap, Ap and UoT magnetometer data (also for items below) with forecasted activity levels based on solar observations, validation of solar wind and CME forecasts in testbed analysis	UGOE	online
Determination of resulting geomagnetic disturbance levels in response to solar wind parameters measured by ACE, validation of solar wind – magnetosphere coupling functions	UGOE	online
Analysis of magnetospheric ionospheric coupling during geomagnetic storms	UGOE	online

Analysis of polar electro jet and ring current distributions during geomagnetic storms, with special emphasis on polar electro jet movements to lower latitudes, including dTEC variations	UGOE	online
Comparisons of magnetospheric and ionospheric disturbance levels of present and past storms with focus on events since launch of ACE	UGOE	online
Integration into space weather mobile phone application (later)	UGOE	online
Usage of Kp in ROB's geomagnetic forecast (presto and ursigram products)	ROB	online
Use of Kp for quality control of ROB's Kp forecasts (comparison of forecasts to observations)	ROB	online
Inclusion of near real time and archive Kp data into the Solar Timelines viewer for AFFECTS (D2.2, February 2013)	ROB	online

Table 7 Description of applications of geomagnetic indices

5 Summary

For the purpose of online dissemination of data bases and space weather products developed during the AFFECTS project, a new website, the so-called SWACI-AFFECTS website, has been established under the umbrella of the currently running system for SWACI at DLR in Neustrelitz.

http://swaciweb.dlr.de/affects/

An L1 solar wind data base and a geomagnetic indices data base have been established and provided on the SWACI-AFFECTS website. Real time as well as historical data is provided by these online data bases. Additionally, real time data provision is prepared for the use in the FSI using special processing modules for the direct access to the data bases.

Some basic links to data descriptions and online data archive access are collected in Table 8.

Information	**URL**
SWACI-AFFECTS website	http://swaciweb.dlr.de/affects/
Kp and Ap explanatory homepage	http://www.ngdc.noaa.gov/stp/geomag/kp_ap.html
Dst explanatory homepage	http://www.ngdc.noaa.gov/stp/geomag/dst.html
NRT Kp (current + current month)	http://www-app3.gfz-potsdam.de/kp_index/qlyymm.tab
NRT Ap (current + current month) in penultimate column	http://www-app3.gfz-potsdam.de/kp_index/qlyymm.tab http://www-app3.gfz-potsdam.de/kp_index/qlyymm.html
NRT Dst	http://wdc.kugi.kyoto-u.ac.jp/dst_realtime/presentmonth/index.html
Dst archive	http://wdc.kugi.kyoto-u.ac.jp/dstdir/index.html
Suggested download tool "wget"	http://gnuwin32.sourceforge.net/packages/wget.htm
ACE homepage	http://www.srl.caltech.edu/ACE/
ACE data description	http://www.srl.caltech.edu/ACE/ASC/level2/
ACE data	http://www.swpc.noaa.gov/ace/index.html

NRT solar wind (current + 2-hour history)	http://www.swpc.noaa.gov/ftpdir/lists/ace/ace_swepam_1m.txt ftp.swpc.noaa.gov/pub/lists/ace/ace_swepam_1m.txt http://www.swpc.noaa.gov/ftpmenu/lists/ace.html/ ace_swepam_1m.txt
NRT interplanetary magnetic field (current + 2-hour history)	http://www.swpc.noaa.gov/ftpdir/lists/ace/ace_mag_1m.txt ftp.swpc.noaa.gov/pub/lists/ace/ace_mag_1m.txt http://www.swpc.noaa.gov/ftpmenu/lists/ace.html/ ace_mag_1m.txt
NRT electron and proton fluxes (current + 2-hour history)	http://www.swpc.noaa.gov/ftpdir/lists/ace/ace_epam_5m.txt ftp.swpc.noaa.gov/pub/lists/ace/ace_epam_5m.txt http://www.swpc.noaa.gov/ftpmenu/lists/ace.html/ ace_epam_5m.txt
NRT high energy proton flux (current + 2-hour history)	http://www.swpc.noaa.gov/ftpdir/lists/ace/ace_sis_5m.txt ftp.swpc.noaa.gov/pub/lists/ace/ace_sis_5m.txt http://www.swpc.noaa.gov/ftpmenu/lists/ace.html/ ace_sis_5m.txt
History / Archive	ftp://mussel.srl.caltech.edu/pub/ace/level2/

Table 8 List of information locations and references

6 References

[REF1] AFFECTS Grant Agreement, Annex I (Description of Work), Part A

[REF2] External Space Weather Data Store (E-SWDS) Program, DOC/NOAA/NWS

[REF3] M. Siebert, Maßzahlen der erdmagnetischen Aktivität, in Handbuch der Physik, vol. 49/3, 206-275, Springer, Berlin Heidelberg, 1971;

[REF4] Wing, S., J. R. Johnson, J. Jen, C.-I. Meng, D. G. Sibeck, K. Bechtold, J. Freeman, K. Costello, M. Balikhin, and K. Takahashi (2005), Kp forecast models, *J. Geophys. Res.*, 110, A04203, doi:10.1029/2004JA010500

[REF5] http://isgi.cetp.ipsl.fr/des_dst_ind.html (2012-07-18)

[REF6] http://isgi.cetp.ipsl.fr/des_kp_ind.html (2012-07-18)

7 Appendix

7.1 List of Acronyms

ACE	**A**dvanced **C**omposition **E**xplorer
AFFECTS	**A**dvance **F**orecast **F**or **E**nsuring **C**ommunications **T**hrough **S**pace
CME	**C**oronal **M**ass **E**jection
CRIS	**C**osmic **R**ay **I**sotope **S**pectrometer
DLR	**D**eutsches Zentrum für **L**uft- und **R**aumfahrt
DoW	**D**escription **o**f **W**ork
EPAM	**E**lectron, **P**roton, and **A**lpha **M**onitor
E-SWDS	**E**xternal **S**pace **W**eather **D**ata **S**tore
GSE	**G**eocentric **S**olar **E**cliptic
GSM	**G**eocentric **S**olar **M**agnetospheric
IMF	**I**nterplanetary **M**agnetic **F**ield
ISGI	**I**nternational **S**ervice of **G**eomagnetic **I**ndices
LEFS	**L**ow **E**nergy **F**oil **S**pectrometer
NOAA	**N**ational **O**ceanic and **A**tmospheric **A**dministration
MAG	**MAG**netometer Instrument
NRT	**N**ear **R**eal **T**ime
ROB	**R**oyal **O**bservatory of **B**elgium
RTN	**R**adial **T**angential **N**ormal
RTSW	**R**eal **T**ime **S**olar **W**ind network
SEPICA	**S**olar **E**nergetic **P**article **I**onic **C**harge **A**nalyzer
SIDC	**S**olar **I**nfluence **D**ata **C**enter
SIS	**S**olar **I**sotope **S**pectrometer
SWACI	**S**pace **W**eather **A**pplication **C**enter – **I**onosphere
SWEPAM	**S**olar **W**ind **E**lectron, **P**roton, and **A**lpha **M**onitor
SWICS	**S**olar **W**ind **I**onic **C**omposition **S**pectrometer
SWIMS	**S**olar **W**ind **I**on **M**ass **S**pectrometer
SWPC	**S**pace **W**eather **P**rediction **C**enter Boulder
UGOE	Georg-August-**U**niversity **Gö**ttingen
ULEIS	**U**ltra **L**ow **E**nergy **I**sotope **S**pectrometer
UoT	**U**niversity **o**f **T**romsø
UT	**U**niversal **T**ime
WP	**W**ork **P**ackage