Influence of Solar Activity Cycles on Earth's Climate

ESA ITT AO/1-4618/NL/AR

Task 2 – Identification of Relevant Data

WP 200

Technical Note

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September 15, 2005

Document status sheet

ISSUE	REVISION	DATE	REASON FOR CHANGE
0	0	15, 2005	First draft.

Summary

A brief summary of task 2 is given in TN200. For details we refer to the technical notes TN201 (IRF), TN202 (DNSC) and TN203 (DNSC).

The objective of task 2 is to identify relevant data: In TN201 ("Solar Output") relevant solar data are described. In TN202 ("Possible Interactions and Modifications") observations are described of the link between the solar output and observed Earth's climate. In TN203 ("Earth's Climate") observation data are described of climate processes at, or near the Earth's surface.

Links to the relevant data and databases of the data are presented.

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1 Introduction

The objective of task 2, "Identification of Relevant Data" (WP200), is to identify the data to be used in the following tasks. The identified data were collected in a database and lists were produced of links where the data could be retrieved.

An extensive MySQL database of solar data has been produced, which is available at Swedish Institute of Space Physics in Lund.

All the data are also presented in tables 1, 2 and 3.

2 Solar Output (WP 201)

The retrieval of a large number of different measures of solar activity output is presented. The measures are divided into measured Solar Physical Quantities (SPQ) and indicators. SPQ include electromagnetic radiation, solar wind components, particle fluxes, and magnetic fields. Solar indicators include indices such as the sunspot number, flare index, coronal activity, and UV/EUV indices. Solar indicators also include proxies such as ^{14}C and ^{10}Be concentrations, but also solar activity lists of coronal mass ejections, flares, and proton events. The data are given as daily averages, with the exception of the solar wind parameters (hourly averages), the group sunspot number (monthly averages), early readings of the sunspot number (monthly and yearly averages), and ^{14}C and ^{10}Be proxies (resolution from 10 years and above). All data are stored at and electronically retrievable from the Swedish Institute of Space Physics.

The solar data presented in this report are stored in a MySQL database at the Swedish Institute of Space Physics. The database is named `isac` and contains solar data organised in tables according to the data sources described in Table 1 and 2.

3 Possible Interactions and Modifications (WP 202)

The subject of this works package is the link between the direct solar output and the actual observations of the Earth's climate. The following data sets are included.

- External to Earth we have the galactic cosmic rays.
- Closer to Earth, but normally not considered to be part of the climate system, lies the magnetosphere. The magnetosphere is strongly driven by the solar wind and thus very susceptible to solar activity. The dynamics of the magnetosphere is not as easily observable as many of the processes closer to the Earth's surface are.
- On the boundary between the magnetosphere and the denser parts of the atmosphere lies the ionosphere.

- For climate studies the most obvious quantity to investigate is the temperature of the atmosphere.
- Observations of meteorological parameters have been collected from an extensive network of stations for a number of years. These have been integrated into a physical model to give a good indication of the general state of the dense layers of the atmosphere, i.e. troposphere and stratosphere.
- Clouds
- The Earth's radiation budget
- Data sets of ozone measurements and sets of aerosol.
- Water vapour.

4 Earth's Climate (WP 203)

The aim of this report is to identify relevant data sets for exploring a possible response in observed climate parameters to solar variability. This report will focus on indentifying observations relevant for climate processes at, or near, the Earth's surface.

Since the climate response may vary between different geographic zones, high latitude vs. low latitude, oceans vs. land, it is important that data have a reasonable geographic resolution. The data sets presented in this report were sub-divided into three groups, land, ocean and global, depending on their natural geographic distribution, e.g. vegetation, or restrictions in the observing network coverage, e.g. meteorological stations. The data sets are listed in tables after Table 1 and 2.

5 Tables of the relevant data

The database of solar data retrievable from the Swedish Institute of Space Physics is named `isac`. All the data, retrievable from the database, are given in Table 1 and 2. In the table is also given the interval over which the data span, the delay time between the observation and availability, time resolution, and coverage. The short period during which the SPQs have been measured is pronounced. The conversion from the indicators to the SPQs therefore plays a very important role in order to enable long-term interpretations of the solar-climate coupling.

Solar physical quantities	**Interval**	**Delay**	**Res.**	**Cov.**
Total solar irradiance	1978 –	<6 m	daily	92.5%
X-ray flux	1994 –	0 d	daily	97.8%
Radio flux	1947 –	<30 d	daily	96.8%
Solar wind speed	1963 –	0 d	hourly	64.2%
Solar wind proton density	1963 –	0 d	hourly	59.9%
Interplanetary magnetic field	1963 –	0 d	hourly	65.1%
Proton fluxes	1994 –	0 d	daily	96.5%
Electron fluxes	1994 –	0 d	daily	97.6%
Mean magnetic field	1975 –	<40 d	daily	81.8%
Coronal harmonic coefficients	1976–	<60 d	daily	100%
Indicator: Indices	**Interval**	**Delay**	**Res.**	**Cov.**
Sunspot number	1818 –	<30 d	daily	95.3%
	1749 –	<40 d	monthly	100%
	1700 –	<400 d	yearly	100%
Group sunspot number	1610 - 1995	N/A	monthly	89.4%
Sunspot area index	1874 –	0 d	daily	100%
Magnetic plage index	1970 –	<10 d	daily	71.9%
Mt. Wilson sunspot index	1970 –	<10 d	daily	71.9%
Plage area index	1915 - 1984	N/A	daily	72.1%
Solar UV index	1978 –	0 d	daily	86.8%
Solar EUV index	1947 –	∼2 y	daily	100%
Optical flare index	1976 –	1-2 y	daily	100%
Coronal index	1939 –	∼2 y	daily	100%
Indicator: Proxies	**Interval**	**Delay**	**Res.**	**Cov.**
^{14}C, ^{10}Be concentrations	843 – 1982	N/A	5-10 yr	100%
	3 – 40 kyr B.P.	N/A	20-200 yr	100%
$\delta\,^{18}$O composition	0 – 123 kyr B.P.	N/A	50 yr	100%
Indicator: Lists	**Interval**	**Delay**	**Res.**	**Cov.**
Proton events	1976 –	<30 d	N/A	N/A
X-ray flares	1975 –	<30 d	N/A	N/A
Coronal mass ejections	1996 –	<5 m	N/A	N/A

Table 1: A summary of solar physical quantities and indicators electronically stored in the data base at the Swedish Institute of Space Physics. Solar wind parameters are available in real-time but the final values have a delay of 2-14 months. The Indicator/Lists are based on data/images with a temporal resolution of minutes to hours. Coronal harmonic coefficients are given for Carrington rotations but is calculated from daily magnetograms.

Name	Parameter(s)	Data Source
isgi_aa	*aa* index	International Service of Geomagnetic Indices
http://www.cetp.ipsl.fr/∼isgi/source/indices/aa/aa.doc http://www.cetp.ipsl.fr/∼isgi/source/indices/aa/aa1868.ima ⋮ http://www.cetp.ipsl.fr/∼isgi/source/indices/aa/aa2005.ima		
isgi_kp_ap	*Kp* & *ap* indices	International Service of Geomagnetic Indices
http://www.cetp.ipsl.fr/∼isgi/source/indices/Kp/kp-ap.doc http://www.cetp.ipsl.fr/∼isgi/source/indices/Kp/kp1932.wdc ⋮ http://www.cetp.ipsl.fr/∼isgi/source/indices/Kp/kp2005.wdc		
mtwil_mag	Plage & sunspot index	Mt. Wilson Observatory
ftp://howard.astro.ucla.edu/pub/obs/mpsi_data/index.dat		
noaa_coronal	Coronal index	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_CORONA/INDEX/daily_revised.plt ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_CORONA/INDEX/1999 ⋮ ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_CORONA/INDEX/2002		
noaa_dpd	Proton/electron flux	NOAA Space Environment Center
http://www.sec.noaa.gov/ftpdir/indices/old_indices/1994_DPD.txt ⋮ http://www.sec.noaa.gov/ftpdir/indices/old_indices/2004_DPD.txt http://www.sec.noaa.gov/ftpdir/indices/old_indices/2005Q1_DPD.txt http://www.sec.noaa.gov/ftpdir/indices/old_indices/2005Q2_DPD.txt		
noaa_dsd	X-ray flux	NOAA Space Environment Center
http://www.sec.noaa.gov/ftpdir/indices/old_indices/1994_DSD.txt ⋮ http://www.sec.noaa.gov/ftpdir/indices/old_indices/2004_DSD.txt http://www.sec.noaa.gov/ftpdir/indices/old_indices/2005Q1_DSD.txt http://www.sec.noaa.gov/ftpdir/indices/old_indices/2005Q2_DSD.txt		
noaa_dst	*Dst* index	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst.fmt ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst1957 ⋮ ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst2001 ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst2002.final ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst2003 ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst2004 ftp://ftp.ngdc.noaa.gov/STP/GEOMAGNETIC_DATA/INDICES/DST/dst2005.v4		
noaa_euv	Extreme UV index	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_UV/SOLAR2000/Five_cycle_v1_23a.txt		
noaa_flare	Flare index	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/INDEX/daily21.plt ⋮ ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/INDEX/daily23.plt		
noaa_gssn	Group sunspot number	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS/GROUP_SUNSPOT_NUMBERS/monthrg.dat		

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Name	Parameter(s)	Data Source
noaa_iso_bard	^{14}C, ^{10}Be production rates	NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/paleo/climate_forcing/solar_variability/bard_irradiance.txt		
noaa_iso_gisp2	^{10}Be concentration	NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/gisp2/cosmoiso/ber10.txt		
noaa_iso_ngrip	$\delta\,^{18}$O composition	NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/paleo/icecore/greenland/summit/ngrip/isotopes/ngrip-d18o-50yr.txt		
noaa_pevents	Proton event list	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/Satellite_ENVIRONMENT/PARTICLES/p_events.lst		
noaa_plage	Plage area index	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_CALCIUM/DATA/MTWILSON/mtwl1915.cal ⋮ ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_CALCIUM/DATA/MTWILSON/mtwl1984.cal		
noaa_radio	Radio flux	NOAA Space Environment Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_RADIO/FLUX/DAILYPLT.OBS ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_RADIO/FLUX/DAILYPLT.ADJ		
noaa_ssa	Sunspot area	NASA Science Directorate
http://science.nasa.gov/ssl/pad/solar/greenwch/daily_area.txt		
noaa_tsi_comp	Total solar irradiance	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_IRRADIANCE/composite_d25_07_0310a.dat		
noaa_uv	UV index	NOAA Space Environment Center
http://www.sec.noaa.gov/ftpdir/sbuv/NOAAMgII.dat		
noaa_xraylist	X-ray flare list	NOAA National Geophysical Data Center
ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray1975 ⋮ ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray1977 ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray1978.corrected ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray1979 ⋮ ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray2003 ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray2004.REVISED ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SOLAR_FLARES/XRAY_FLARES/xray2005.2		
omni_2	Solar wind parameters	National Space Science Data Center
ftp://nssdcftp.gsfc.nasa.gov/spacecraft_data/omni/omni2_1963.dat ⋮ ftp://nssdcftp.gsfc.nasa.gov/spacecraft_data/omni/omni2_2003.dat		
sdac_cme	Coronal mass ejection list	Center for Solar Physics and Space Weather
http://cdaw.gsfc.nasa.gov/CME_list/UNIVERSAL/text_ver/univ_all.txt		
sidc_ssn	Sunspot number	Solar Influences Data analysis Center
http://sidc.oma.be/DATA/dayssn_import.dat http://sidc.oma.be/DATA/monthssn.dat http://sidc.oma.be/DATA/yearssn.dat		
wso_gfhc	Coronal harmonic coefficients	Wilcox Solar Observatory
http://soi.stanford.edu/∼wso/Harmonic.los/CR1642		

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Name	**Parameter(s)**	**Data Source**
⋮		
http://soi.stanford.edu/∼wso/Harmonic.los/CR2026		
wso_smmf	Mean magnetic field	Wilcox Solar Observatory
http://soi.stanford.edu/∼wso/meanfld/timeseries		
http://soi.stanford.edu/∼wso/meanfld/mf.2001.modif		
http://soi.stanford.edu/∼wso/meanfld/mf.2002.modif		
http://soi.stanford.edu/∼wso/meanfld/mf.2003		
http://soi.stanford.edu/∼wso/meanfld/mf.2004		
http://soi.stanford.edu/∼wso/meanfld/mf.2005		

Table 2: A summary of solar activity data with references to database and data source including a web address.

	Observation	Geographic coverage	Temporal coverage
Cosmic Rays			
	Neutron counts	World wide network 30-60 stations (1953-1956: 2-5 stations)	1953-2004 Hourly data
	Source: www.env.sci.ibaraki.ac.jp/ ftp/pub/WDCCR/ Available at DNSC: none		
	Muon counts	Single station Adelaide	1998-present 15 minute data
	Source: http://www.physics.adelaide.edu.au/astrophysics/index.html Available at DNSC: 1998-2001		
	Cosmic ray-induced ionisation	Global 5x5 degrees grid 16 vertical levels	1951-2000 Monthly data
	Source: I. G. Usoskin, Oulu, Finland Available at DNSC: full data set		

	Observation	Geographic coverage	Temporal coverage
Magneto-/ ionosphere			
	DMSP/SSIES: Ion drift, composition, temperatures	Global (satellites in Sun-synchronous orbit)	(1987)1995-present 4 second data (at satellite position)
	Source: cindispace.utdallas.edu/DMSP/ Available at DNSC: none		
	Total Power Input	Hemispheric average	1983-2001 app. 50 minute
	Source: spidr.ngdc.noaa.gov/spidr/dataset.do Available at DNSC: none		
	Ionograms	World wide network > 200 stations	1942-present 15 minute data
	Source: spidr.ngdc.noaa.gov/spidr/dataset.do Available at DNSC: full data set		

	Observation	Geographic coverage	Temporal coverage
Temperatures			
	Microwave Sounding Units: temperature anomalies	Global Hemispheric, zonal or gridded (2.5 degree) 3 vertical layers	1979-present Daily or monthly data (gridded data only monthly)
	Source: http://www.nsstc.uah.edu/data/msu/ Available at DNSC: monthly hemispheric data 1979-2001		
	Surface stations: temperature anomalies	Global Hemispheric or gridded (5 degree)	1856-present Monthly data (gridded data only from 1960)
	Source: http://www.cru.uea.ac.uk/cru/data/temperature/ Available at DNSC: full data set		
	Radiosonde: temperature anomalies	Global Gridded (5x10 degrees) 9 vertical levels	1958-present Monthly data
	Source: http://badc.nerc.ac.uk/data/hadrt/ Available at DNSC: 1958-1999, updates need to be applied for		

	Observation	Geographic coverage	Temporal coverage
Clouds			
	ISCCP data: type, amount, top temperature, top pressure, optical thickness and many others	Global Gridded (280 km) (Pixel level data at 30 km) 3 vertical levels (cloud types)	1983-2001 3 hour, daily, monthly
	Source: http://isccp.giss.nasa.gov/index.html Available at DNSC: full monthly data set, parts of 3 hr data set		
	Nimbus-7: type, amount, radiance	Global Gridded (4.5 degree) 3 vertical levels (cloud types)	1979-1985 Monthly (twice daily)
	Source: http://www.cgd.ucar.edu/cas/catalog/satellite/cmatrix/ Available at DNSC: total cloud cover data set		
	HIRS: cloudiness	Global Gridded (2x3 degrees) 16 vertical levels	1989-1994 Monthly data (averages over the data period)
	Source: http://www.ssec.wisc.edu/~donw/PAGE/CLIMATE.HTM Also available: 22 year data set Available at DNSC: full 6.5 year data set		

	SSM/I: Cloud liquid water, precipitation, total precipitable water and others	Global Gridded (1 and 2.5 degree)	1987-present Monthly data
	Source: http://www.ncdc.noaa.gov/oa/satellite/ssmi/ssmiproducts Available at DNSC: cloud liquid water data set		

	Observation	Geographic coverage	Temporal coverage
Reanalysis			
	NCEP/NCAR: Meteorological variables	Global Gridded (200 km) 28 vertical layers	1948-present 4 times daily Monthly means
	Source: http://www.cdc.noaa.gov/cdc/reanalysis/ Available at DNSC: air temperatures and geopotential heights – monthly means		
	ECMWF: Meteorological variables	Global Gridded (40 km) 60 vertical levels	1957-2002 4 times daily Monthly means
	Source: http://www.ecmwf.int/research/era/ Available at DNSC: none		

	Observation	Geographic coverage	Temporal coverage
Radiation Budget			
	Albedo, radiation flux, solar incidence	Global, zonal and regional averages (5 or 10 degrees)	1984-present Monthly means of hourly or daily values or actual hourly data
	Source: eosweb.larc.nasa.gov/PRODOCS/erbe/table_erbe.html Available at DNSC: none		

	Observation	Geographic coverage	Temporal coverage
Aerosols			
	Aerosol index	Global Gridded (1.25 x 1 degree)	Nov 1978-present (gap June 1993 – July 1996) Daily
	Source: http://toms.gsfc.nasa.gov/aerosols/aerosols_v8.html Available at DNSC: none		
	Aerosols Optical Thickness	Global (over oceans) Gridded (1 degree)	1998-present Daily

	Source: http://www.osdpd.noaa.gov/PSB/EPS/Aerosol/Aerosol.html Available at DNSC: weekly data

	Observation	Geographic coverage	Temporal coverage
Ozone			
	TOMS Total ozone	Global Gridded (1.25 x 1 degree)	Nov 1978-present (gap June 1993 – July 1996) Daily
	Source: http://toms.gsfc.nasa.gov/ozone/ozone_v8.html Available at DNSC: none		
	GOME Total ozone	Global Gridded (1.25 x 1 degree)	1995-2003 Daily
	Source: http://www-iup.physik.uni-bremen.de/gome/wfdoas/ Available at DNSC: full data set		

	Observation	Geographic coverage	Temporal coverage
Other data			
	NVAP: Water vapor	Global Gridded (1 degree) 4 vertical layers (from 2000 0.5 degree and 5 layers)	1988-2001 Daily (from 2000 twice daily)
	Source: http://www.cira.colostate.edu/climate/NVAP/climate_wvsci.html Available at DNSC: 1988-1997		
	Berlin data: Geopot. height, temperature	Northern hemisphere Gridded (5 degrees) 3 vertical layers	Nov 1964-Jun 2001 Daily data (twice daily in Summer)
	Source: http://strat27.met.fu-berlin.de/products/ Available at DNSC: full data set		