

RWC-SWEDEN

OF INTERNATIONAL SPACE ENVIRONMENT SERVICE (ISES)



North Lund: European Spallation Source (ESS)



**Location of RWC-Sweden
at Ideon Science Park**



**Lund downtown,
1000 years old cathedral**



**Lund - Copenhagen
(30 min)**

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Swedish Institute of Space Physics (IRF)
Sweden**

1. IRF-Lund and 2. IRF-Kiruna

OUTLINE

Regional Warning Center (RWC) Sweden of ISES

- **History**
- **Service**

Ongoing and Planned Activities

- **Solar storm research**
- **New local and global geomagnetic activity forecasts**
- **EU and ESA collaborations**
- **Agency collaborations**

RWC-SWEDEN OF ISES 2000 -



Boulder, 2002



ISES, 2000



Boulder, 2005



Ottawa, 2008



ISES, 2012

PREDICTION OF THE SOLAR (SUNSPOT) CYCLE

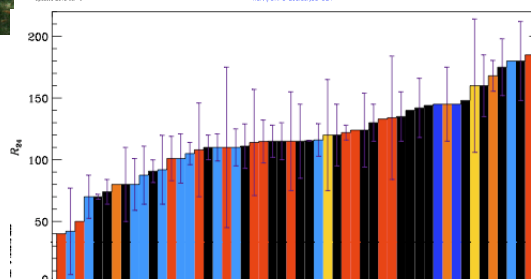
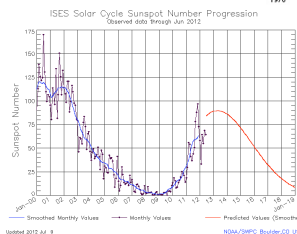
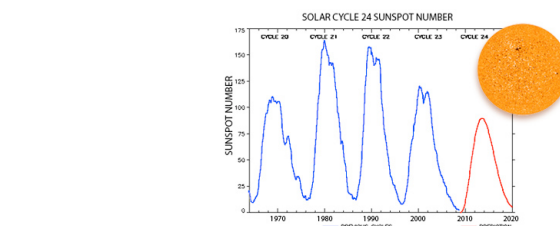


$$R_z = k(10g + f)$$

Solar Cycle 24 Prediction
 Issued April 2007, updated May 2008:

Min Dec. 2008,
Max 2013 May

$R_z=90$, weakest since 1928.



A summary plot (D. Pesnell) of predictions based on "Climatological", "Precursor", "Dynamo model", "Spectral" and "Neural network" methods.

RWC-SWEDEN SERVICE



Regional Warning Center Sweden
of
International Space Environment Service



In Swedish



SUMMARY
EXPLAINED

- [Glossary of space weather terms](#)
- [NOAA space weather scales](#)



SUMMARY (Latest update 2012-07-09 09:30 CET)

Solar Activity Now

- Solar cycle activity level below and on the solar surface is (**increasing**).
- Solar activity regions (no) and a CME (no) on the far-side of the Sun are seen.
- Solar activity regions behind eastern limb are seen: (no).
- Solar surface magnetic activity on Earthside is (**high**).
- Solar activity in the corona, (Earth-directed Coronal Mass Ejections; Major Solar Flares (last 24hr); Equatorial Coronal Holes): (no; no; yes).

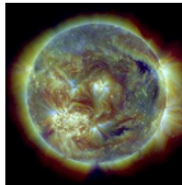
Effects of Solar Activity: (Now; Past 24hrs)

- Proton storms, and herewith radiation hazards to astronauts, satellite problems, and navigation system problems: (no; yes).
- Radio blackouts, and herewith low frequency and HF communication problems: (no; yes).

Forecasts of Effects of Solar Wind and Interplanetary Coronal Mass Ejections

- Geomagnetic storms, (Kp >= 5 or Dst < -50 nT) and herewith problems for electrical systems such as power grid systems and gas pipelines: (Forecasts of 3-hourly [Kp-index](#) and one-hourly [Dst-index](#)).
- Geomagnetically induced currents for one station in Southern Sweden: (30-minute forecasts of [GIC](#)).

Contact Information
[RWC-Sweden in Lund](#)
[ISES home](#)
Director - [T. Östinger](#)
Deputy - [H. Lundstedt](#)



Today's SDO AIA image

RWC-Sweden local service:

Real-time forecasts:

Kp, Dst, dB/dt, GIC

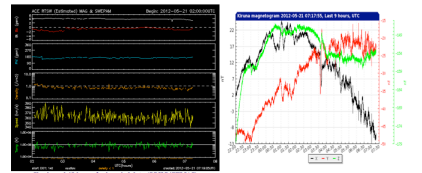
IRF real-time **data:**

Kiruna/Lycksele magnetogram,

Riometer data, All-Sky camera

CURRENT SOLAR AND SPACE WEATHER

<p>Sunspots</p> <p>SDO/HMI</p> <p>Sunspot number (SWPC)</p> <p>Latest active region list (SWPC)</p> <p>Solar cycle progress (SWPC)</p> <p>Solar cycle 24 (Lund)</p>	<p>Solar magnetic field</p> <p>SDO/HMI</p> <p>Magnetogram (HMI/SUNMAG)</p>	<p>Solar flares</p> <p>SOHO/EIT 304</p> <p>GOES solar X-ray flux (SWPC)</p>	<p>Coronal mass ejections</p> <p>SOHO/LASCO</p> <p>GOES coronal flux (SWPC)</p>	<p>Coronal holes</p> <p>GOES-H SXI (SWPC)</p>
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FORECASTS AND WARNINGS

<p>Solar Cycle 24</p> <p>Land</p>	<p>Solar activity 1-2 weeks in advance based on far-side activity</p> <p>SOHO/SDO/GONG</p>	<p>Solar activity days in advance</p> <p>Latest STEREO/NASA images</p>	<p>Solar activity days, hours in advance</p> <p>SWPC/NOAA</p> <p>The Bear Solar Observatory RWC, Australia and Solar Monitor SUNGLATE (IMSAL)</p>
<p>Forecasts of Coronal Mass Ejection impact</p> <p>WSA-Enlil NOAA-NWS-SWPC and WSA-Enlil Cone Model CME</p>			
<p>L1</p> <p>Solar Wind Speed (NOAA/SWPC)</p>	<p>IME (IMSAL)</p>		
<p>Earth</p> <p>Satellite Anomalies</p> <p>Land</p>	<p>Radio Blackouts</p> <p>D-Region (SWPC/NOAA)</p> <p>THC map (DLR)</p> <p>Scintillation index (DLR/IRF-Sweden)</p>	<p>Aurora</p> <p>Land</p>	<p>Geomagnetic activity</p> <p>Dst (Lund) and Kp(Lund)</p> <p>GIC and dB/dt</p>

RWC-SWEDEN - ONGOING AND PLANNED ACTIVITIES

SOLAR STORMS AND SPACE WEATHER, a research project funded by MSB and IRF

- New solar storm models and forecasts will be developed.
- A workshop on “Solar Storms and Topology” is planned for 2014.
- A magnetometer near Lund is planned for 2013.
- New geomagnetic activity forecasts will be developed.

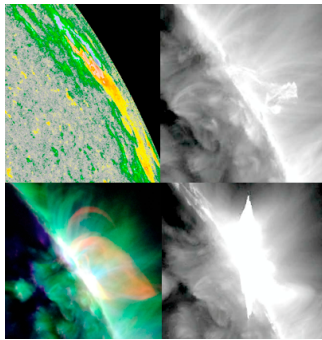
EU FP7 EURISGIC (2011-2014) project

EU COST project “Developing Space Weather Products and Services in Europe” (2008-2012)

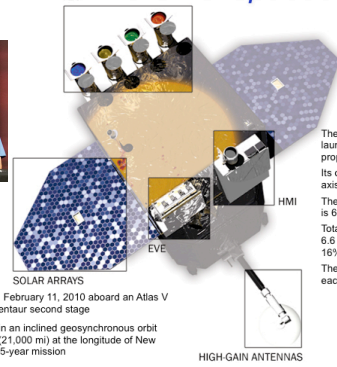
ESA ODI (2009-2012) Database project

SOLAR STORM RESEARCH

- Moderate solar storms are studied topologically based on SDO observations



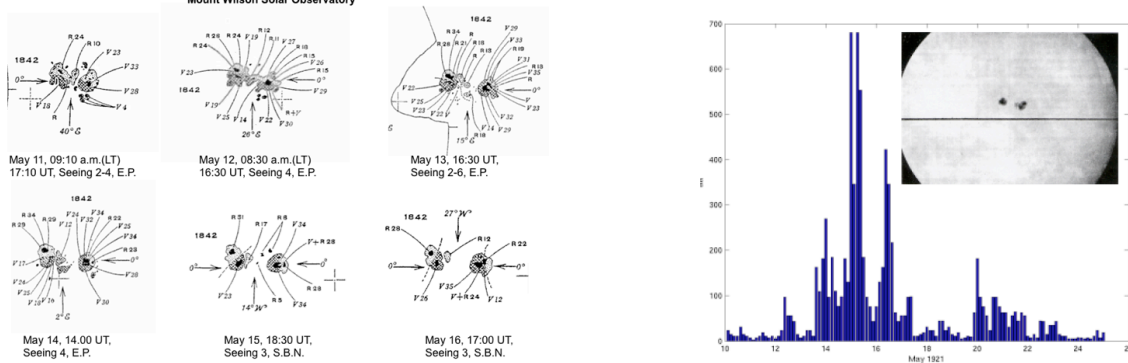
The SDO Spacecraft



The total mass of the spacecraft at launch was 3000 kg (payload 300 kg; propellant 1400 kg). Its overall length along the sun-pointing axis is 4.7 m, and each side is 2.2 m. The span of the extended solar panels is 6.25 m. Total available power is 1500 W from 6.6 m² of solar arrays (efficiency of 16%). The high-gain antennas rotate once each orbit to follow the Earth.

Launched on February 11, 2010 aboard an Atlas V EELV with Centaur second stage SDO is now in an inclined geosynchronous orbit ~36,000 km (21,000 mi) at the longitude of New Mexico for a 5-year mission

- Extreme historical solar storms are compared with SDO data



SOLAR STORMS AND TOPOLOGY

Conjecture: Solar storms occur to reduce magnetic field complexity and herewith preserving topological invariants



Carl Friedrich Gauss
1777-1855

$$\mathcal{L}_{i,j} = \frac{1}{4\pi} \oint \oint \frac{(\bar{x}_i - \bar{x}_j) \cdot (d\bar{x}_i \times d\bar{x}_j)}{|\bar{x}_i - \bar{x}_j|^3}$$

$$H = \int \bar{A} \cdot \bar{B} d^3x, \quad \bar{B} = \nabla \times \bar{A}$$

$$H = -\frac{1}{4\pi} \iint \bar{B}(\bar{x}) \cdot \frac{(\bar{x} - \bar{x}')}{|\bar{x} - \bar{x}'|^3} \times \bar{B}(\bar{x}') d^3x d^3x'$$



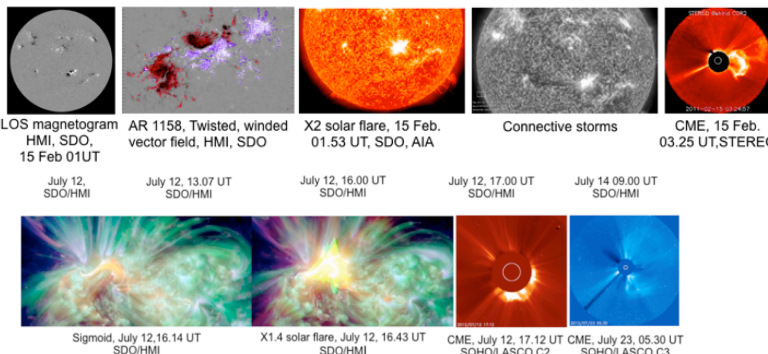
linking number 1

In the case of finite flux tubes, limited to each flux tube i and flux tubes j

$$H_m = \sum_{i=1}^N T_i \Phi_i^2 + \sum_{i=1}^N \sum_{j=1, j \neq i}^N \mathcal{L}_{i,j} \Phi_i \Phi_j$$

Self helicity
(Twist + Writhe)

Mutual helicity



LOS magnetogram
HMI, SDO,
15 Feb 01UT

AR 1158, Twisted, winded
vector field, HMI, SDO
July 12, 13:07 UT

X2 solar flare, 15 Feb.
01.53 UT, SDO, AIA

Connective storms
July 12, 17:00 UT
SDO/HMI

CME, 15 Feb.
03.25 UT, STEREO

July 12,
SDO/HMI

July 12, 13:07 UT
SDO/HMI

July 12, 16:00 UT
SDO/HMI

July 12, 17:00 UT
SDO/HMI

July 14 09:00 UT
SDO/HMI

Sigmoid, July 12, 16:14 UT
SDO/HMI

X1.4 solar flare, July 12, 16:43 UT
SDO/HMI

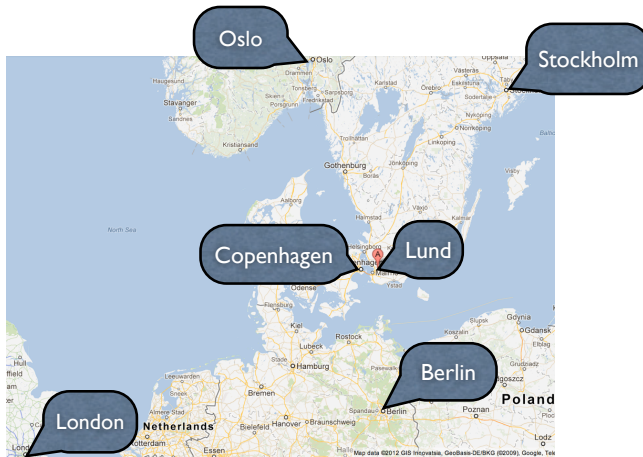
CME, July 12, 17:12 UT
SOHO/LASCO C2

CME, July 23, 05:30 UT
SOHO/LASCO C3

Lundstedt, H., Solar Storms and Topology: Observed with SDO, in Proceedings of TIEMS conference Space Weather and Challenges for Modern Society, 22-24 October 2012.

NEW GEOMAGNETIC ACTIVITY FORECASTS

- Install a magnetometer close to Lund
- Develop new neural network forecasts of dB/dt and GIC



A magnetometer close to Lund

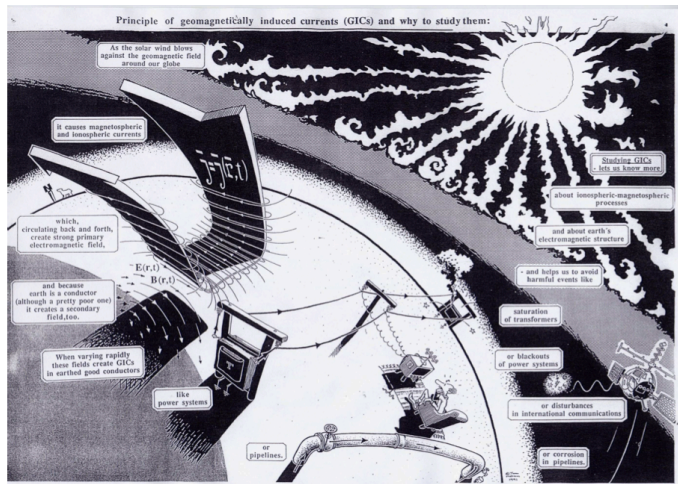
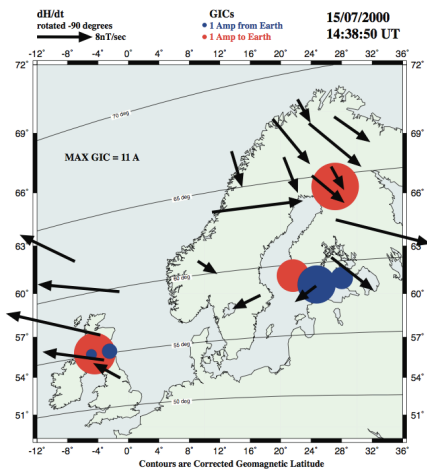


P. Wintoft, H. Lundstedt, M. Wik, and L. Eliasson, Data Driven Models Forecasting Levels of Geomagnetic Disturbance Related to GIC, in Proceedings of TIEMS conference Space Weather and Challenges for Modern Society, 22-24 October 2012.

FORECAST PROTOTYPE OF GIC FOR WHOLE EUROPE

A screenshot of the EURISGIC project website. The header features a banner with the text "EURISGIC EUROPEAN RISK FROM GEOMAGNETICALLY INDUCED CURRENTS an EU/FP7 Space Research Project". Below the banner is a navigation menu with links: Home, About, News, Documents, Multimedia, Links, Contact. The main content area is divided into several sections: "Latest News" with a blue background and white text; "Funded by EU/FP7" with a logo for the Seventh Framework Programme; "Connect to EURISGIC" with social media icons for YouTube, Facebook, and Twitter; "Member Login" with a form for User Name, Password, and Remember Me; "Welcome to the EURISGIC project website" with a detailed introduction to the project; and "Search by Keyword" with a search input field. The "EURISGIC Consortium" section lists member institutions with their respective national flags: Finnish Meteorological Institute, British Geological Survey/Natural Environment Research Council, NeuroSpace, Swedish Institute of Space Physics, Geodetic and Geophysical Research Institute of the Hungarian Academy of Sciences, Polar Geophysical Institute of the Russian Academy of Sciences, and The Catholic University of America at NASA/Goddard Space Flight Center.

FP7: EURISGIC (2011–2014) EUROPEAN RISK FOR GIC



Coordinator: Finnish Meteorological Institute (FMI)

Participants: British Geological Survey (BGS), NeuroSpace, Swedish Institute of Space Physics (IRF), Geodetic and Geophysical Research Institute (GGRI), Polar Geophysical Institute (PGI), Catholic University of America (CUA)

The Lund group work on a GIC forecast prototype for whole Europe

EU COST 0803 and ESA ODI projects



ODI Open Data Interface

SAAPS/SEDAT/SPENVIS

- Spacecraft Anomaly Analysis and Prediction System (SAAPS)
www.lund.irf.se/saaps
- Space Environment Database and Analysis Tool (SEDAT)
www.ukssdc.ac.uk/sedat/
- Space Environment Information System (SPENVIS)
www.spENVIS.oma.be/



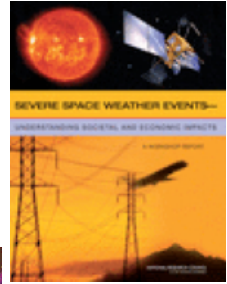
Peter Wintoft, Lars Eliasson, Jan Karlsson
Swedish Institute of Space Physics
Daniel Heynderickx
DH Consultancy
Hugh Evans
Estec

- Create a common database to hold data from:
 - ✦ SAAPS
 - ✦ SEDAT
 - ✦ SPENVIS
- Compliant with CDF/ISTP/PRBEM.
- Update SAAPS/SEDAT/SPENVIS to access data from the common database.
- Shall be possible to ingest data in both text format and CDF format.

SOLAR STORMS/SPACE WEATHER AND SOCIETY

The meeting and report that really changed agencies interest for solar storms and space weather effects -
 “A Workshop on Managing Critical Disasters: The Case of a Geomagnetic Storm”

NAS
report



1. **Helena Lindberg**, Director-General, Swedish Civil Contingencies Agency (MSB)
2. **William Craig Fugate**, Administrator, FEMA
3. **Thomas J. Bogdan**, Director, SWPC, NWS, NOAA

The ISES presentation was given by H. Lundstedt

AGENCIES INFORMATION ABOUT SOLAR STORMS - RISKS AND THREATS AND APPROVED RESEARCH PROJECTS

Welcome to
 Krisinformation.se - the national website for emergency information

The Swedish government has instructed MSB (the Swedish Civil Contingencies Agency) to provide a national website for emergency information, directed at the general public and the media, in collaboration with other emergency management authorities.

Krisinformation.se



Myndigheten för samhällsskydd och beredskap
 Swedish Civil Contingencies Agency

nrpassa

 Sök

STARTSIDA HÄNDELSER OCH KRISER KRISBEREDSKAP **RISKER OCH HOT**

Startsida > Risker och hot > Extremt väder och naturolyckor > Solstormar

Elstörningar
Extremt väder och naturolyckor
Solstormar
Ras och skred
Storm
Vinteroväder
Åska
Oversvämning
Naturolyckor utanför Sverige
Händelser i utlandet
Internetsäkerhet
Kärntekniska olyckor
Smittsamma sjukdomar
Terrorism

Solstormar

De flesta solstormar som drabbar jorden får små eller inga konsekvenser för samhället. Samtidigt ökar vår sårbarhet för den här typen av händelser då vi blir alltmer beroende av elektricitet och elektronik, som i värsta fall kan slås ut av solstormar.

Solen slungar ständigt ut materia. En så kallad solstorm uppstår när aktiviteten på solen blir så kraftig att partiklar bildar elektromagnetiska fält som kastas i hög hastighet mot jorden.

Två typer av solstormar

Solstormar kan antingen vara koronamassutkastningar eller elektromagnetiska strålningutbrott, soleroptioner. Koronamassutkastningarna ger upphov till geomagnetiska stormar, vilket är störningar i jordens eget magnetiska fält. Detta kan skada elförsörjningen. Soleroptionerna kan skapa problem för radiokommunikation och GPS-systemet.

Soleroptionerna är stora explosioner på solens yta som uppkommer nära solfläckar. Partiklar accelererar och sänder ut strålning som kan nå jorden. Koronamassutkastningar är stora plasmamoln med fria elektroner och protoner som kastas ut från solens yttre hölje (korona).

Soleroptionerna kan nå jorden snabbt. Koronamassutkastningar brukar nå jorden inom tre eller fyra dygn. De allra flesta koronamassutkastningarna böjer dock av och passerar vid sidan av jordens skyddande magnetishölje.

Konsekvenser av solstormar

I extrema fall kan solstormar orsaka störningar i elförsörjning, elektroniska kommunikationer och orsaka problem för tåg- och flygtrafik.

När elektriska strömmar, som är orsakade av solstormen, går genom

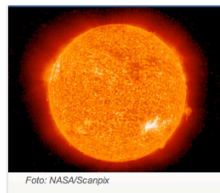


Foto: NASA/Sciapix

Läs mer om solstormar

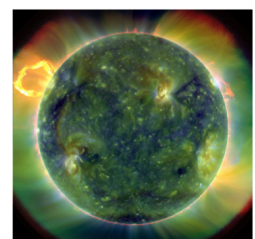
- Institutet för rymdfysik
- Myndigheten för samhällsskydd och beredskap (MSB)
- Svenska kraftnät
- Tema: elstörningar
- SMHI om solstormar

RWC-Sweden gave updated warnings (e.g. downgraded GIC effects) to MSB and Svenska Kraftnät for 2012 January and March solar storms

Solstormar och rymdväder
 Projektbeskrivning

Henrik Lundstedt och Peter Wintoft
 Institutet för rymdfysik (IRF)

14 februari 2011



Approved research project:
 “Solar storms and space weather”