

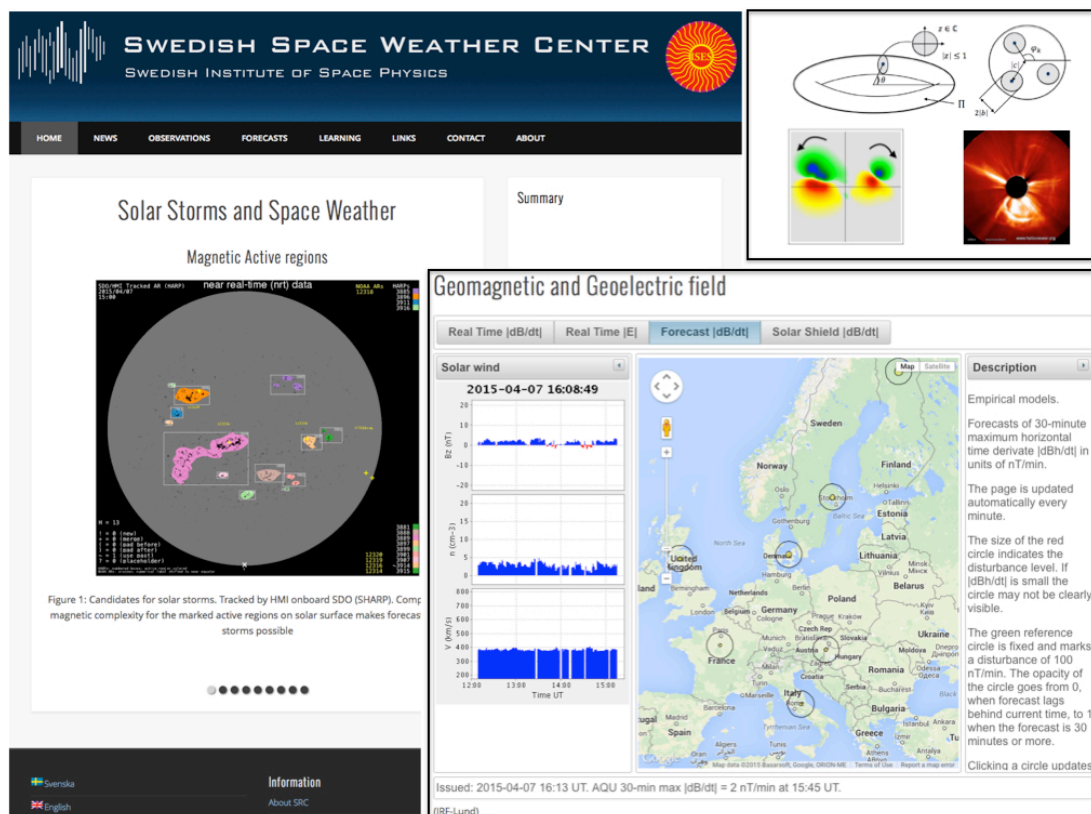
# Annual ISES Report 2015

## Regional Warning Center Sweden

### Swedish Institute of Space Physics in Lund (IRF-Lund)

The research project “Solar storms and space weather” is funded by The Swedish Civil Contingencies Agency (MSB). The continuation 2015 is now focused on daily warnings of severe to extreme solar storms. IRF-Lund participates in the EU H2020 – PROTEC-project PROGRESS that started in January 2015 and is led by University of Sheffield. IRF-Lund also participates in two ESA SSA projects: On new forecasts of parameters related to GIC for whole Europe, led by Tromsø Geofysiska Observatorium (TGO) in Norway and “Tailoring Space weather services in Arctic regions”, led by Danish Technical University (DTU), Denmark.

## 1. Recent accomplishments



**Figure 1.** A new RWC-Sweden web service, SDO SHARP image, a solid torus model with simulated magnetogram of May 1921, the extreme solar storm of 2012, and real-time  $|dB/dt|$  forecasts based on ACE solar wind data.

### 1.1 A complex solid torus as a model of an extreme solar storm

A complex solid torus model (Fig 1.) was developed in order to be able to study an extreme solar storm, the so-called “Great Storm” or “New York Railroad Storm” of May 1921, when detailed observations were unavailable: no high spatial or high time resolution magnetic field observations, no routinely solar flare or coronal mass ejection observations. We suggest that a topological change happened in connection with the occurrence of the extreme solar storm. The solar storm caused one of the

most severe space weather effects ever. The article “The extreme solar storm of May 1921: observation and a complex topological model” in *Ann. Geophys.*, 33, 109-116, 2015, was published 27 January 2015.

We have now continued by studying more recent extreme solar storms; on 4 November 2003 and on 23 July of 2012 (Fig. 1).

## 1.2 dB/dt forecast system for Europe

The EU EURISGIC project has been finished. The goal was to develop a dB/dt forecast system for Europe (Fig. 1).

## 1.3 A new RWC-Sweden web site – “Swedish Space Weather Center”

A new web site “Swedish Space Weather Center” ([src.irf.se](http://src.irf.se)) has been developed (Fig 1). However, improvements are still done.

## 2. Highest priority product goals

### 2.1 Warnings of severe to extreme solar storms.

The Swedish Civil Contingencies Agency (MSB) is prioritizing support to research and development that will lead to early (days ahead) reliable warnings of extreme solar storms. In line with this we are developing daily warnings of severe to extreme solar storms in successive steps. First we have focused on solar flare forecasts based on solar magnetic field complexity. As input we have used SDO magnetic field data and complexity parameters available by the Stanford SHARP system. Next we will integrate what we have learned from earlier topological studies of extreme solar storms.

### 2.2 One day workshop in Lund on extreme solar storms.

As part of the research project “Solar storms and space weather”, funded by MSB, we arrange the one day workshop “Forecasts and Warnings of Extreme Solar Storms” on June 1<sup>st</sup>. The workshop will address the following key questions: How extreme can a solar storm become and how long is the build-up time? What observations are needed? How to define a measure for an extreme solar storm? How to make forecasts and warnings?. Invited speakers are from USA, Japan, Italy, France, Germany and Sweden.

## 3. Highest priority data needs

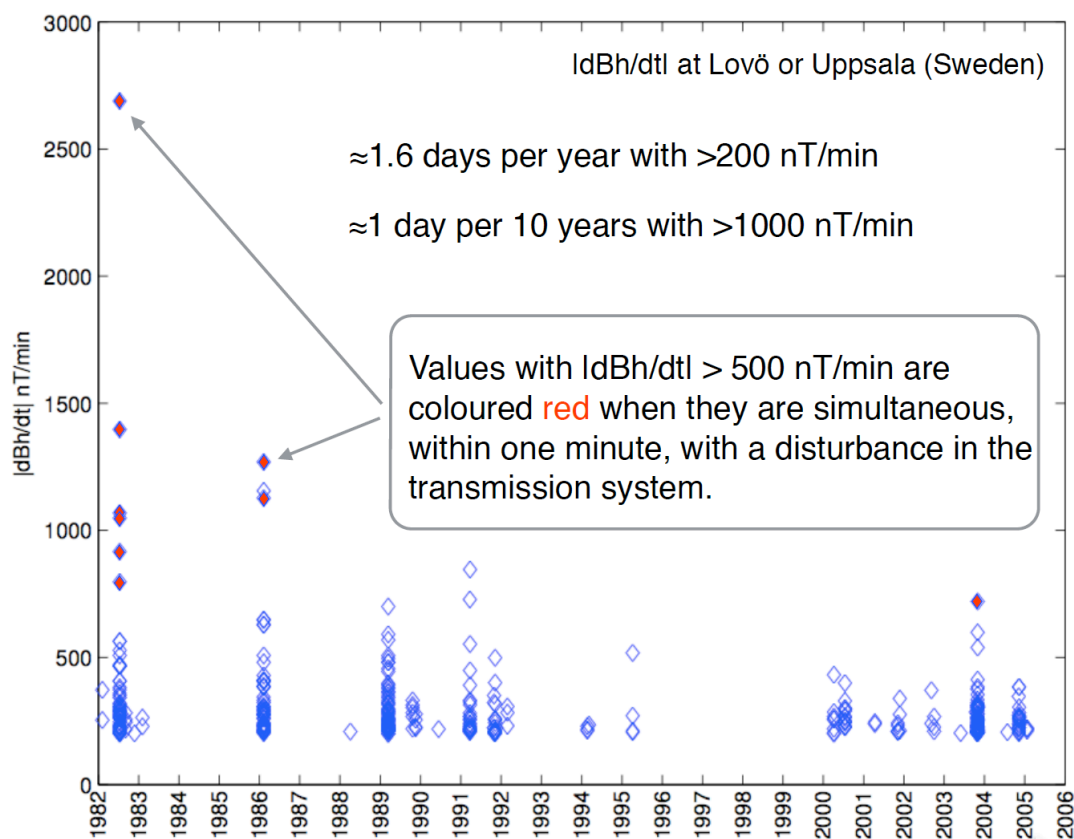
As input to the forecast the most important data are:

- Solar magnetic field and velocity data observed with Solar Dynamics Observatory (SDO) and derived complexity parameters such as given by the SHARP system.
- Solar wind data available by ACE/DSCOVR.
- Geomagnetic magnetic field data.

#### 4. Recent information on user impacts

In a collaboration with the Swedish National Grid (SvK) it was found that at times of the  $|\text{dBh}/\text{dt}| > 500$  nT/min the transmission system was disturbed (Fig. 2).

It was also found that about 1 day per 10 years, a value of  $|\text{dBh}/\text{dt}| > 1000$  nT/min is measured in Lovö or Uppsala.



**Figure 2.** All events at Lovö or Uppsala in Sweden when  $\text{dB}/\text{dt}$  exceeded 200 nT/min between 1982 and 2006.

During the geomagnetic storm of 17 March a  $|\text{dBh}/\text{dt}|$  of 200-400 nT/min was measured at latitude of Uppsala. We informed SvK and MSB during the storm. One transformer in Örnsköldvik was briefly disconnected with no consequences for end users.

#### 5. Forecast verification summary

The verification of the preliminary forecasts of severe solar flares, based on SDO complexity magnetic data, is in progress. The subject will further be discussed during 1 June workshop in Lund.

During the EURISGIC project a study was completed of the verification.