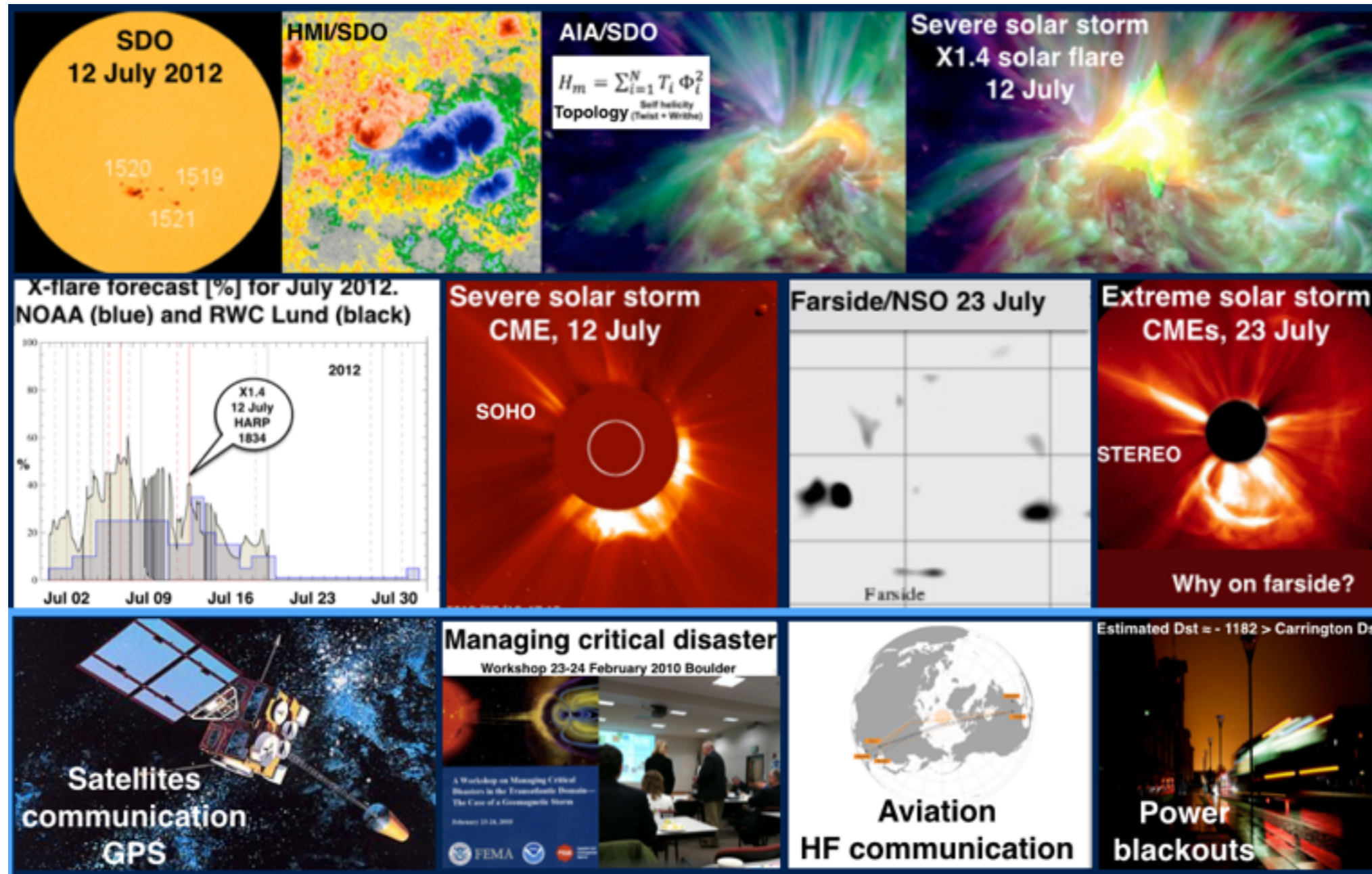


RWC-SWEDEN (Swedish Space Weather Center)



Henrik Lundstedt, Peter Wintoft and Magnus Wik
Swedish Institute of Space Physics
Sweden

Space Weather in Sweden - a short background

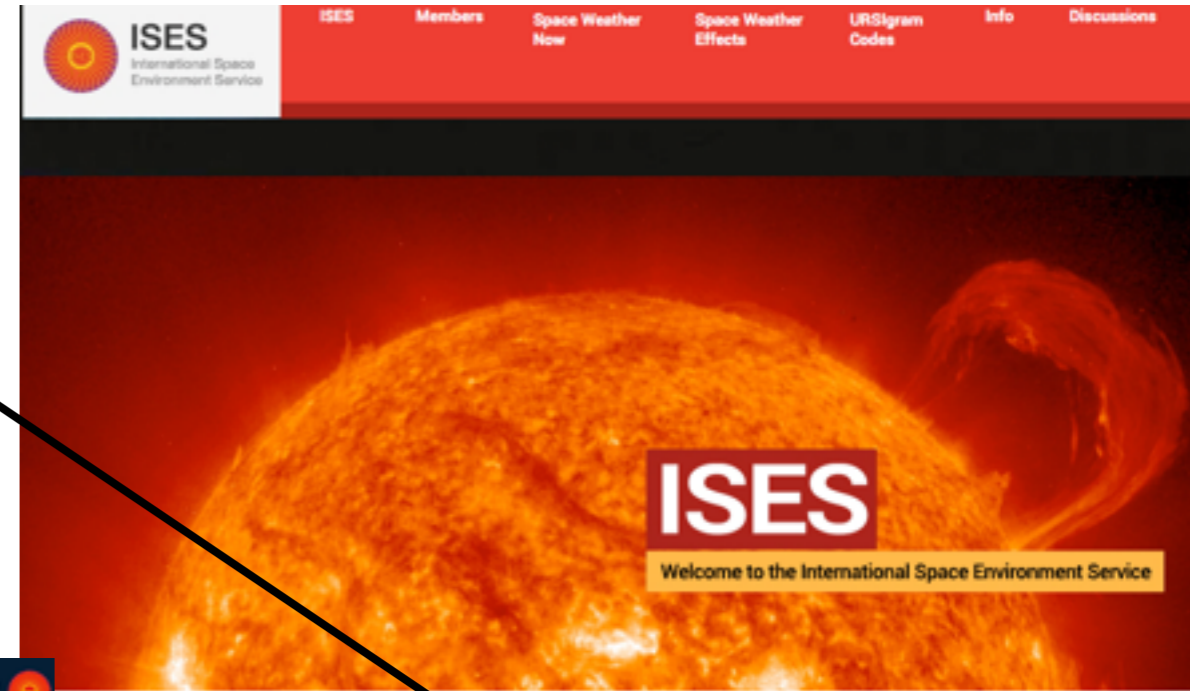
- “Space weather” first mentioned in NASA’s Technical Document 62-206, **1962** (by satellite engineers).
- US Air Force started to use it in **1970**.
- In **1981** the power company Sydkraft contacted H. Lundstedt then at Lund Observatory, Lund University. Since then continued collaborations with electrical companies in Sweden.
- Other collaborations: Swedish Civil Contingencies Agency (MSB), SvK, SydGas, EON, Elforsk, FOI, FM, SMHI, Lantmäteriet, Luftfartsverket, Esrange and so on.
- The word “Rymdväder” (Space weather in Swedish) was first mentioned by Swedish media in the newspaper Sydsvenskan” **1991**.
- The group in Lund becomes RWC-Sweden within ISES **2000**.
- Important steps in USA for Sweden: NSF/NSWP definition **1995**, **2000** LWS, (SDO,2010,..) Heliophysics (“What causes the Sun to vary? How do the Earth and Heliosphere respond? What are the impacts on humanity?”) 2035, CISM..(operational models).
- In 2010 MSB raises interest: FEMA-MSB-NOAA/ISES meeting in Boulder, USA **2010**. H. Lundstedt was invited to participate.
- In EUROPE: Space weather activities started within ESA **1995**. The IRF Lund group have participated in six ESA solar/space weather projects, two EU/COST projects, EU/FP7-project EURISGIC, in EU/HORIZON2020, PROGRESS,two SSA ESA projects.



- Importance of relation to users: Long-term build-up of mutual understanding of science and technology is a key to obtain relevant information.

RWC-Sweden (Swedish Space Weather Center) of ISES, of Swedish Institute of Space Physics (IRF)

Operational Forecasts



Solar Storms and Space Weather

Magnetic Active regions

Figure 1: Candidates for solar storms. Tracked by HMI onboard SDO (SHARP). Computation of n complexity for the marked active regions on solar surface makes forecasts of solar storms possible.

<http://src.irf.se>

Latest Conditions
2013-12-17
The Sun has past 24 hrs produced weak solar flares and herewith caused only weak communication problems.

Solar Magnetic Activity

GONG farside

X-flare Prediction

This plot shows the mean photospheric excess magnetic energy density, from SHARP - Space-Weather HMI Active Region Patches.

ISES

The International Space Environment Service (ISES) is a collaborative network of space weather service-providing organizations around the globe. Our mission is to improve, to coordinate, and to deliver operational space weather services. ISES is organized and operated for the benefit of the international space weather user community.

ISES currently includes 16 Regional Warning Centers, four Associate Warning Centers, and one Collaborative Expert Center. ISES is a Network Member of the International Council for Science World Data System (ICSU-WDS) and collaborates with the World Meteorological Organization (WMO) and other international organizations.

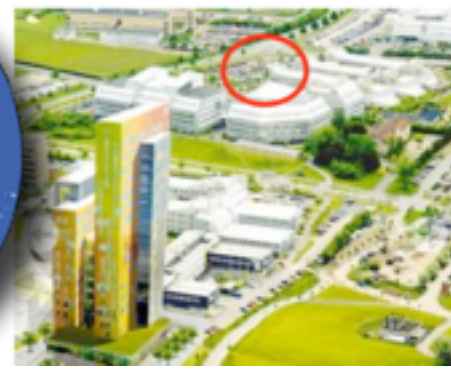
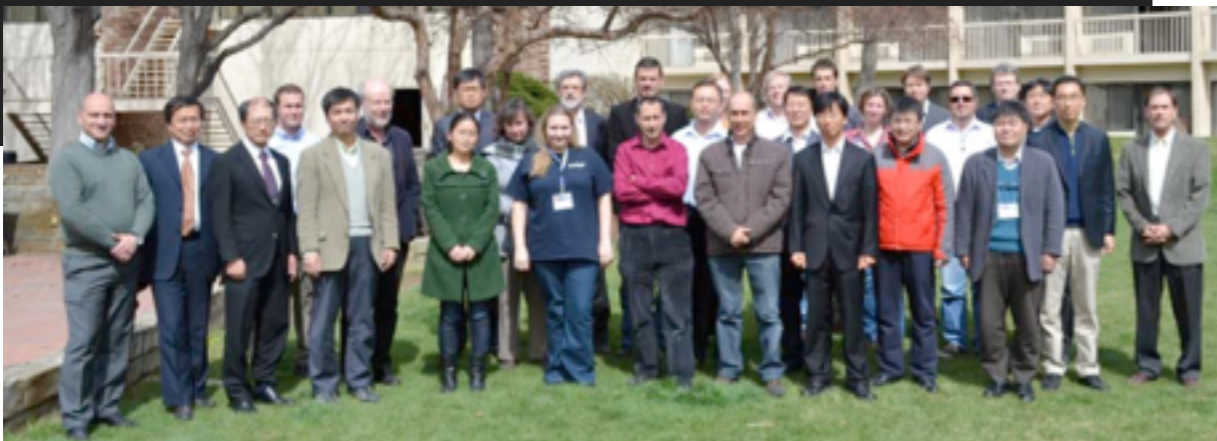
NEWS

see more

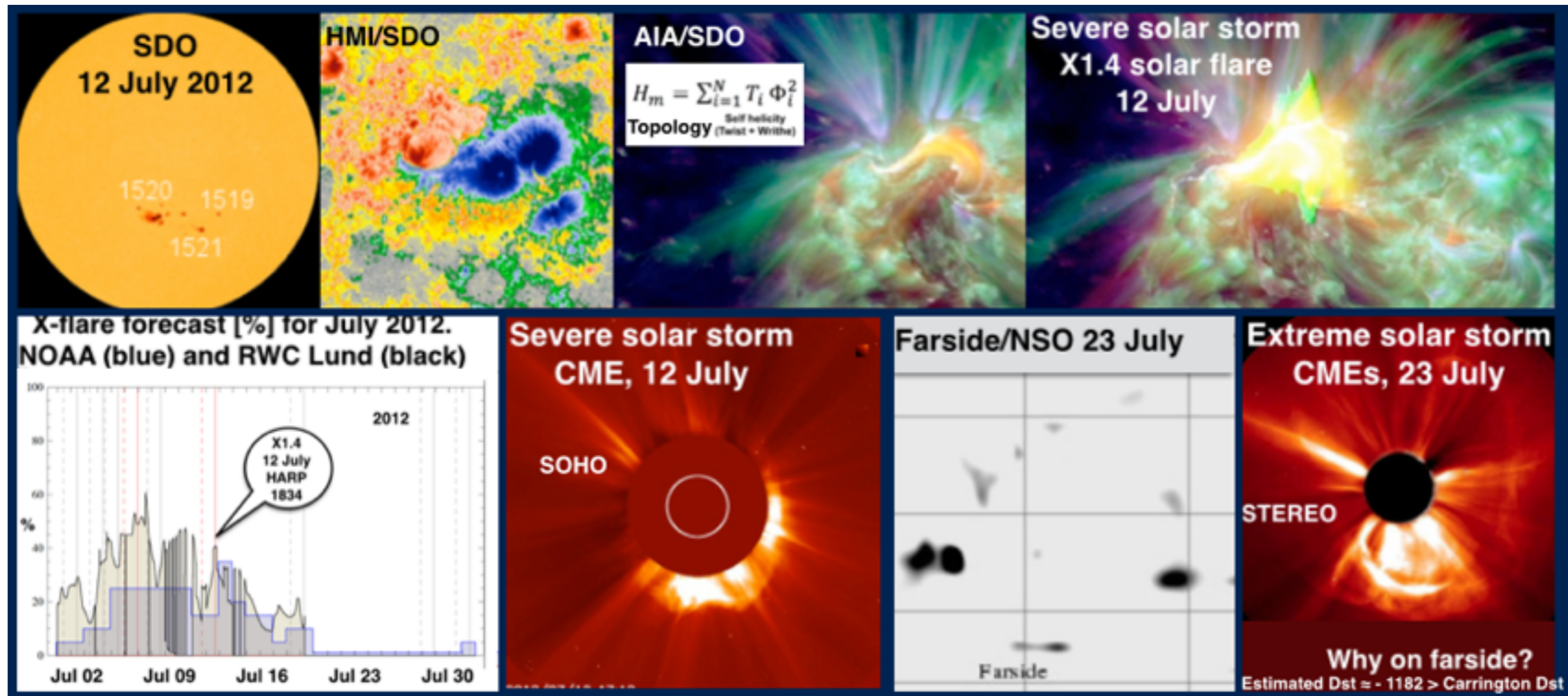
New ISES Deputy Director: Clezio Marcos De Nardin (RWC Brazil)

New ISES Member: Regional Warning Center UK

Members

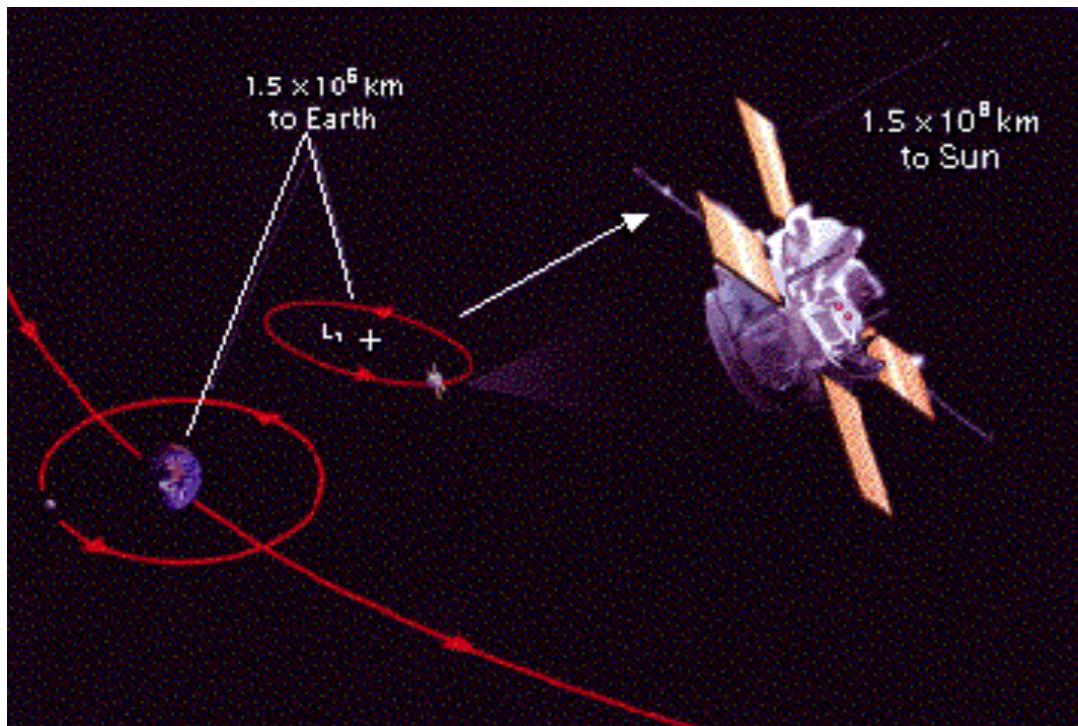


Forecasts and Warnings of Extreme Storms at the Sun



Illustrated by the
12 and 23 July 2012 solar storm events

Forecasts based on real-time measurements at L1

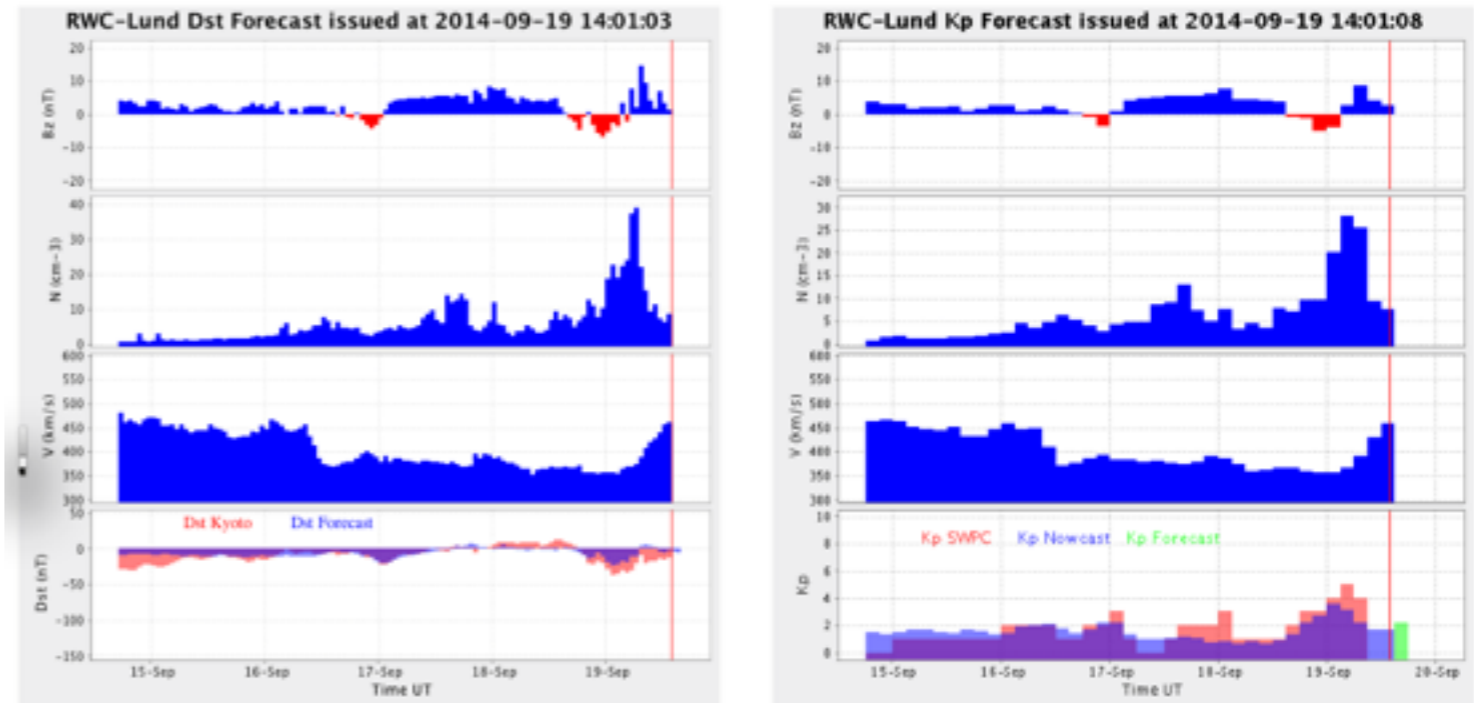


Real-time solar wind data at L1 from ACE.

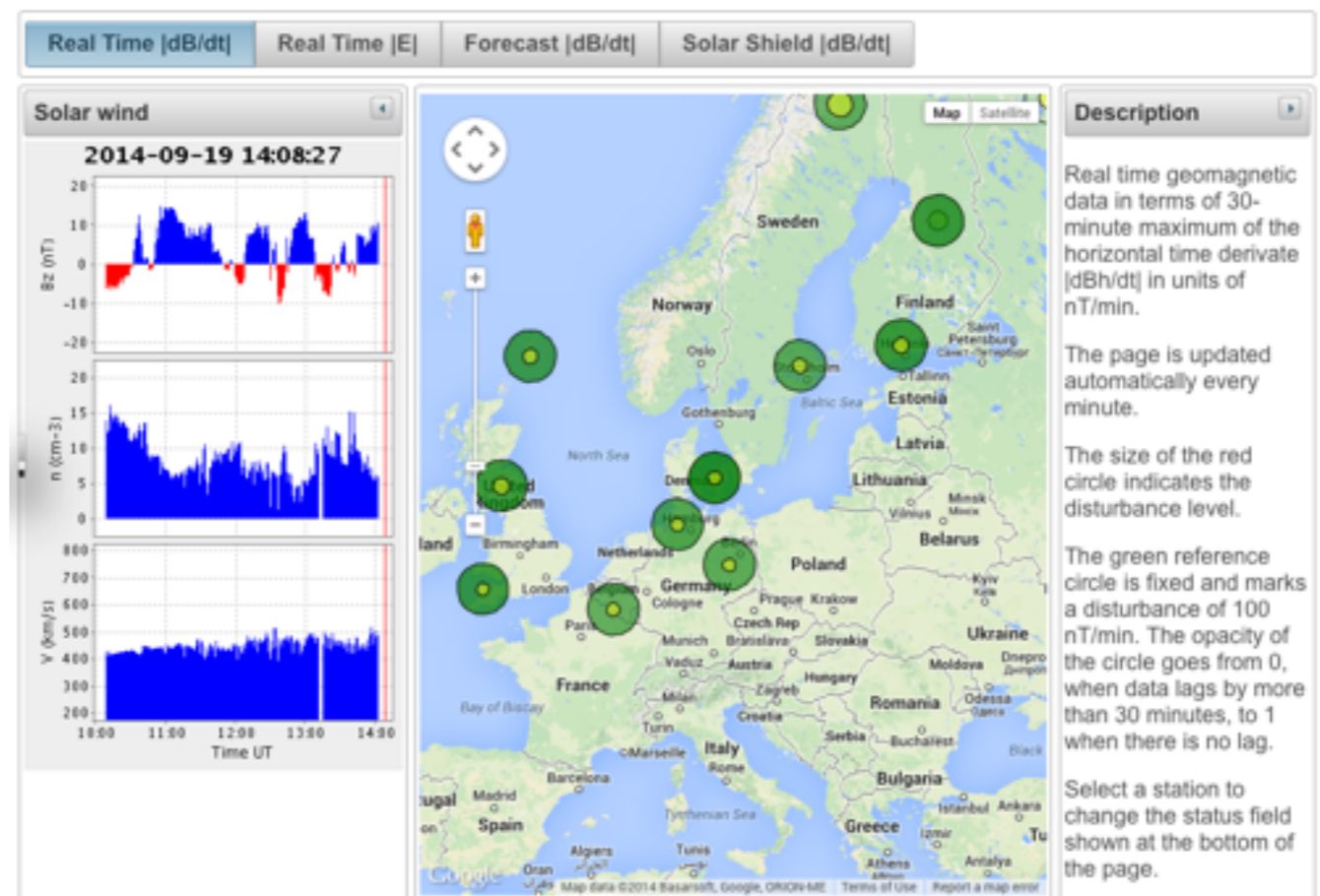
Replaced by DSCOVR 2016



Dst and Kp Indices



Geomagnetic and Geoelectric field



Issued: 2014-09-19 14:12 UT. BFE 30-min max [dB/dt] = 7 nT/min at 14:08 UT.

MSB's interest in "Solar storms and space weather" - How did it start?

Meeting and report that drastically increased the interest:
- Will today's high tech society handle a extreme solar storm?
"A Workshop on Managing Critical Disasters:
The Case of a Geomagnetic Storm" February 23-24, 2010.

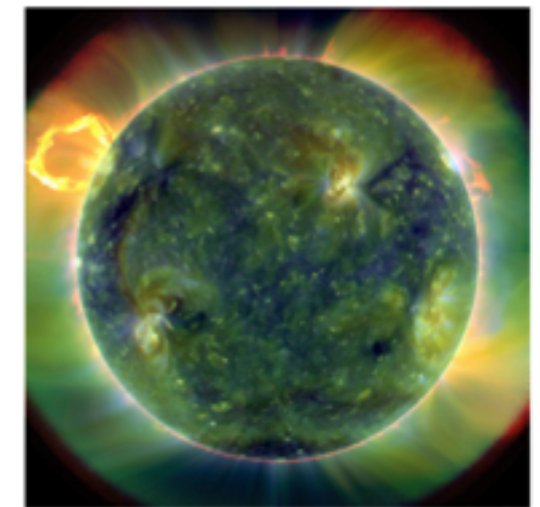


1. **Helena Lindberg, Director-General, Swedish Civil Contingencies Agency (MSB)**
2. **William Craig Fugate, Administrator, FEMA**
3. **Thomas J. Bogdan, Director, SWPC, NWS, NOAA**
4. ISES presentation given by H. Lundstedt

Solstormar och rymdväder
Projektbeskrivning

Henrik Lundstedt och Peter Wintoft
Institutet för rymdfysik (IRF)

14 februari 2011



SOLSTORMAR OCH RYMDVÄDER
Plan för fortsättning av forskningsprojektet

H. Lundstedt, P. Wintoft och M. Wik
Juni 2014

INLEDNING

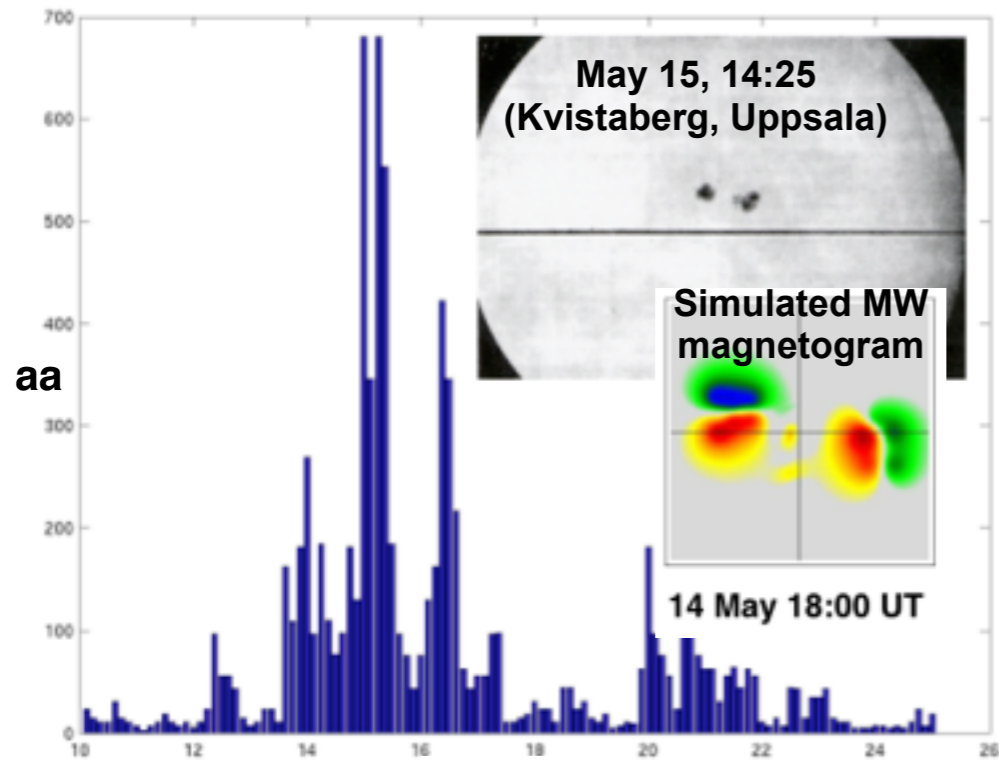
Rymdväder definieras som det plasmatilstånd i solens heliosfär, som jorden med dess atmosfärer och de andra planeterna befinner sig i. Vid tillfällen av solstormar påverkas speciellt de högteknologiska systemen, både på jorden och ute i rymden som samhället idag blivit så beroende av.

Rymdväder

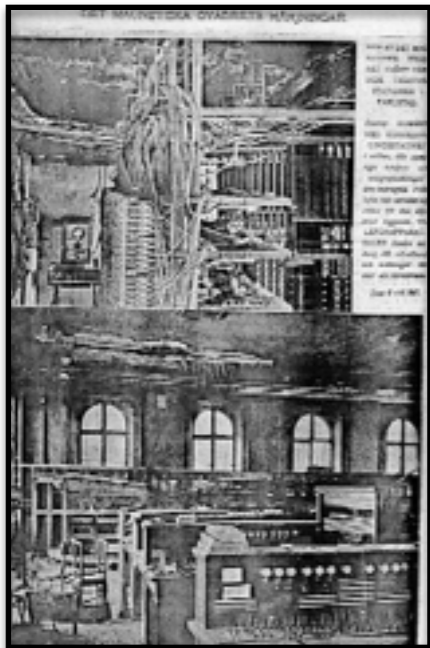


Knowledge and models of extreme solar storms

Weak solar cycle - Four years after max



May 1921

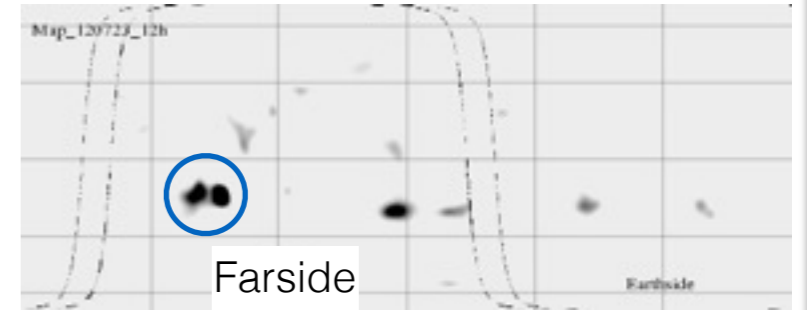
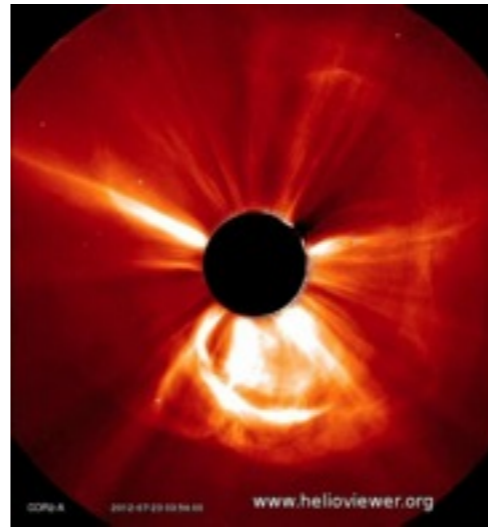


Southern polar lights observed on Apia Samoa

Dst = -900 nT
dB/dt of
~5000nT/min!

First extrem solar storm with available solar magnetic field measurements.

Weak solar cycle at max

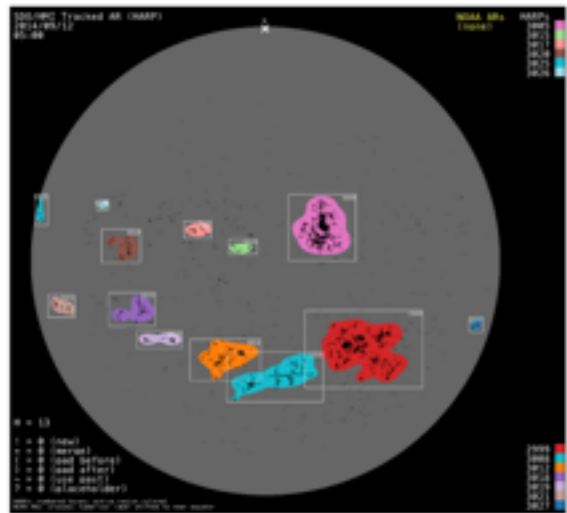
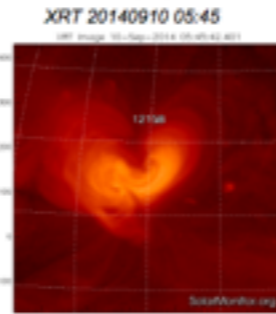
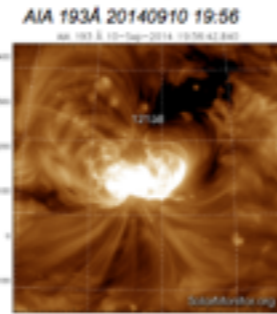
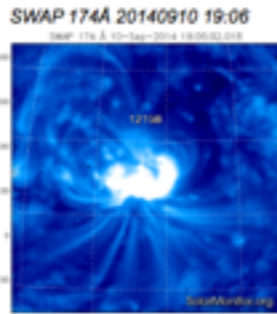
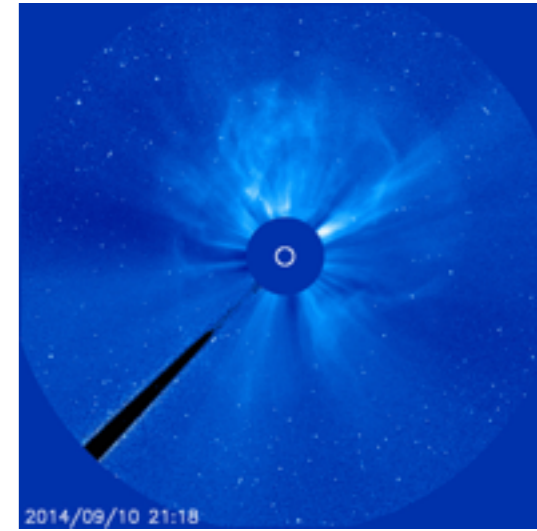
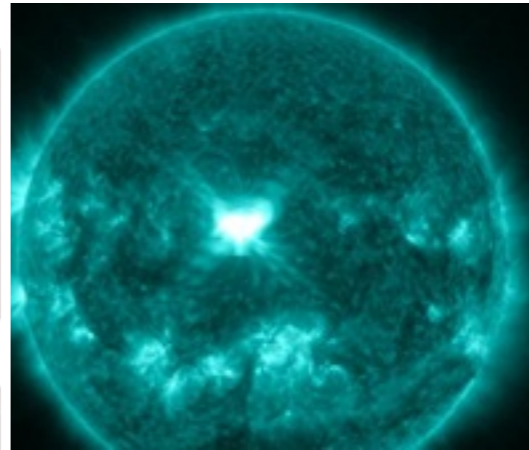
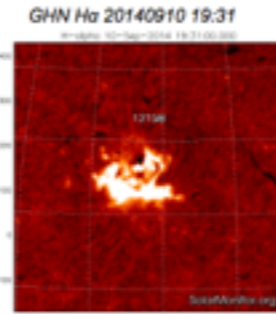
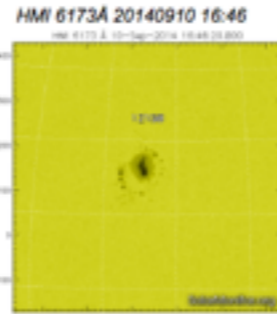
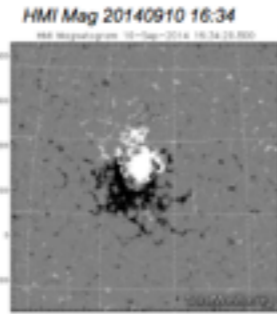
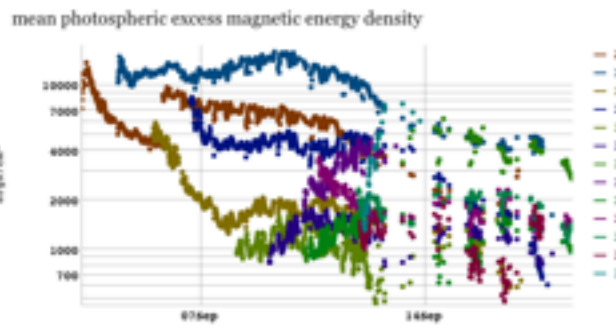


On 23 July 2012 a CME was ejected from solar farside with a velocity of ~3000 km/s ! according to STEREO. Estimated Dst ≈ -1182nT. Larger than 1859 Carrington event!

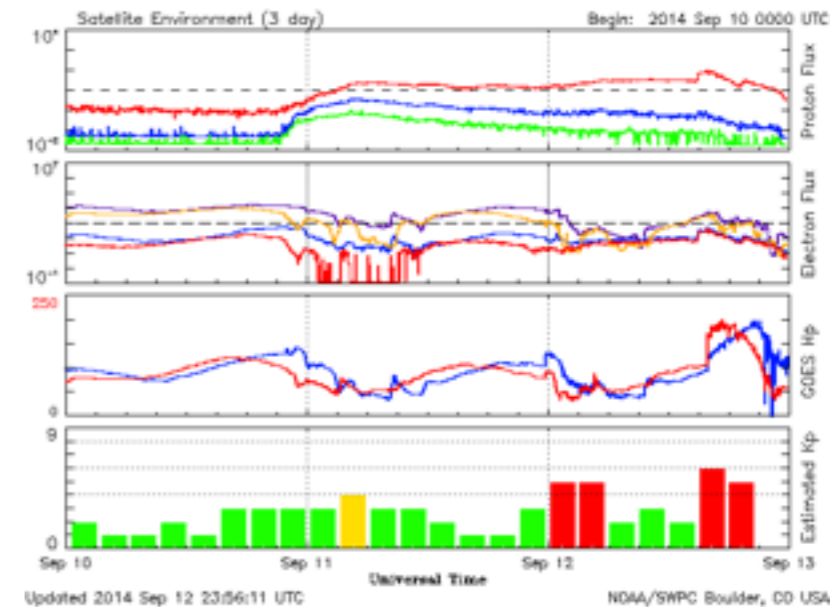
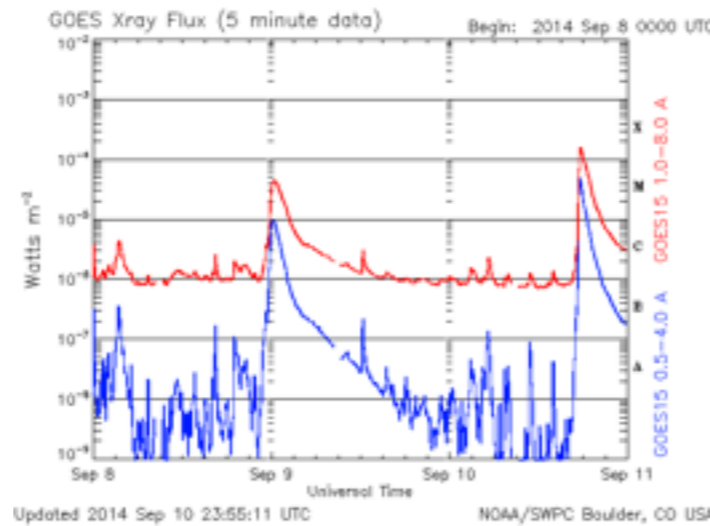
Recent extrem solar storm.

References: Baker, D., et al., 2013; Kappenman, J. G., 2006; Lundstedt, H., 2012; NOAA Mem., 2004.

Severe solar storm 10 September 2014



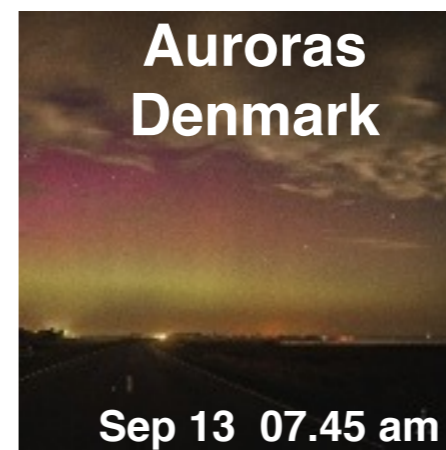
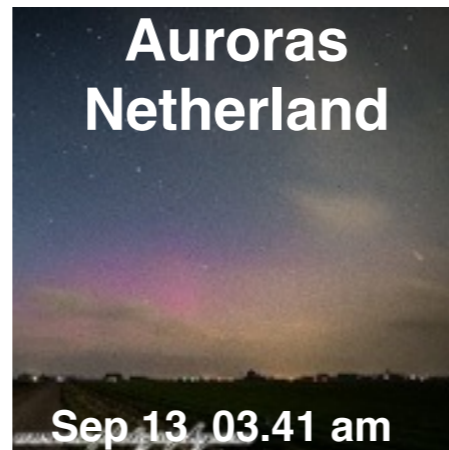
X1.6, 17:45UT Sep. 10 CME $V \approx 800 \text{ km/s}$



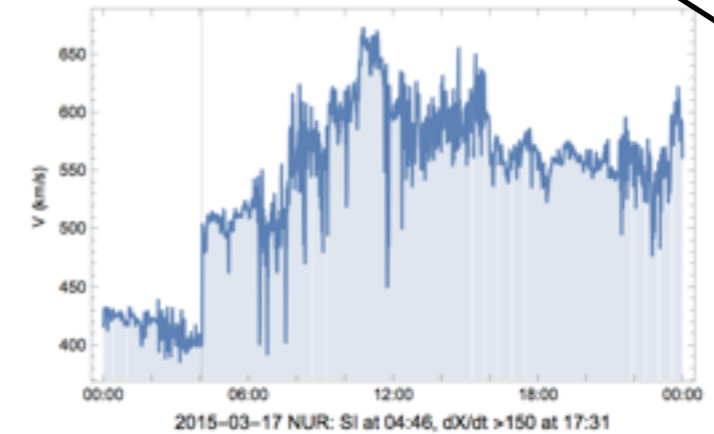
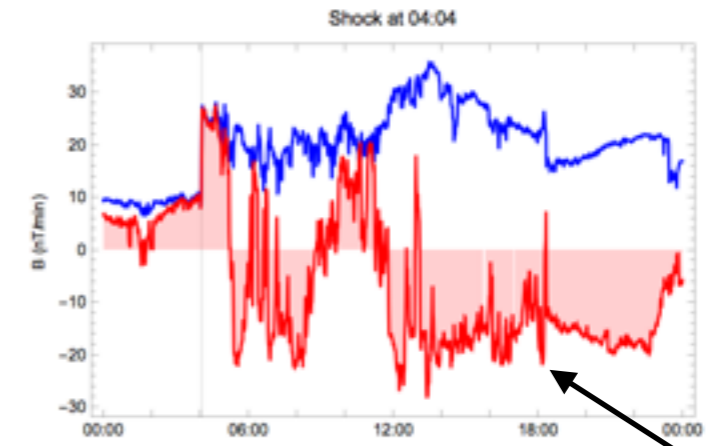
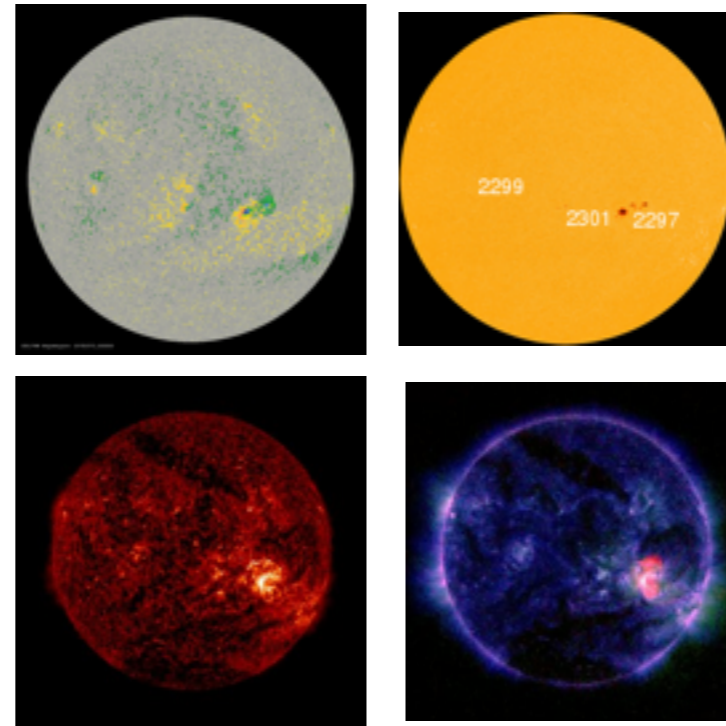
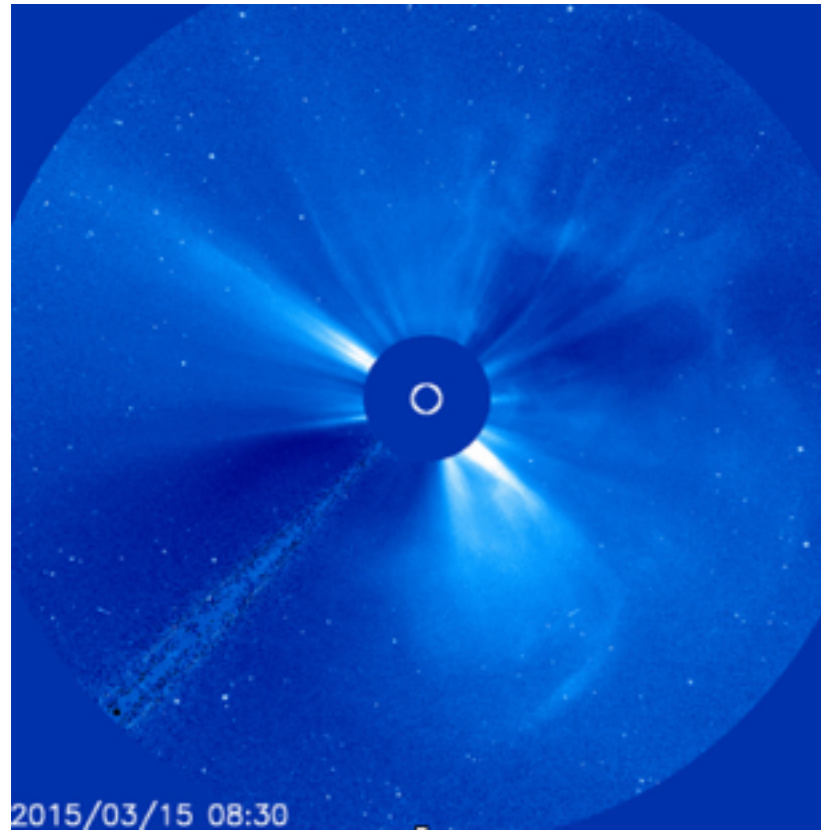
max $\approx 100 \text{ pfu}$

**Kp 7
G3**

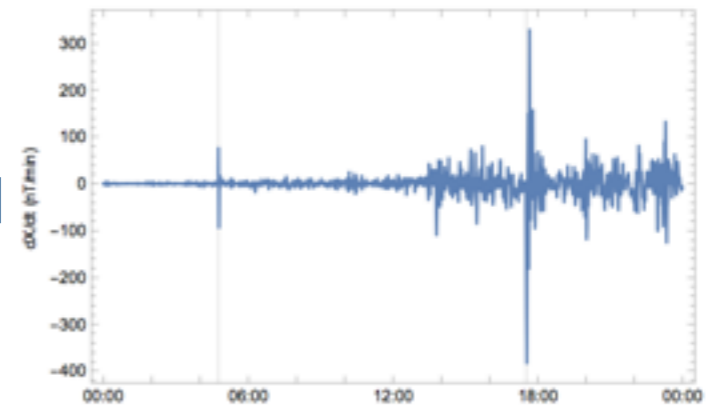
**Message to MSB/SvK -
no or minor effects
Uppsala 30-min max IdB/dtI
= 48nT/min 17.21 UT**



Solar storm of 15 March - Geomagnetic storm 17 March 2015



Stayed long negative!

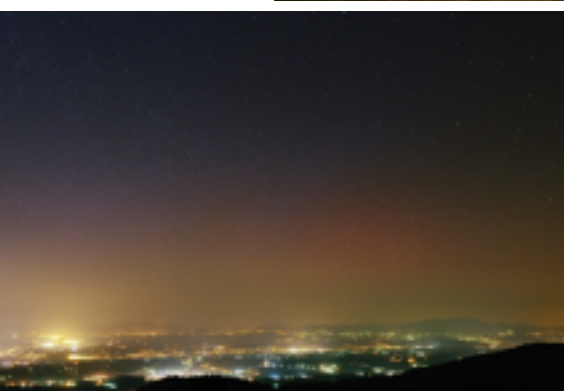


We had continuous contact
The Swedish National Grid SvK
and informed MSB

Öresund

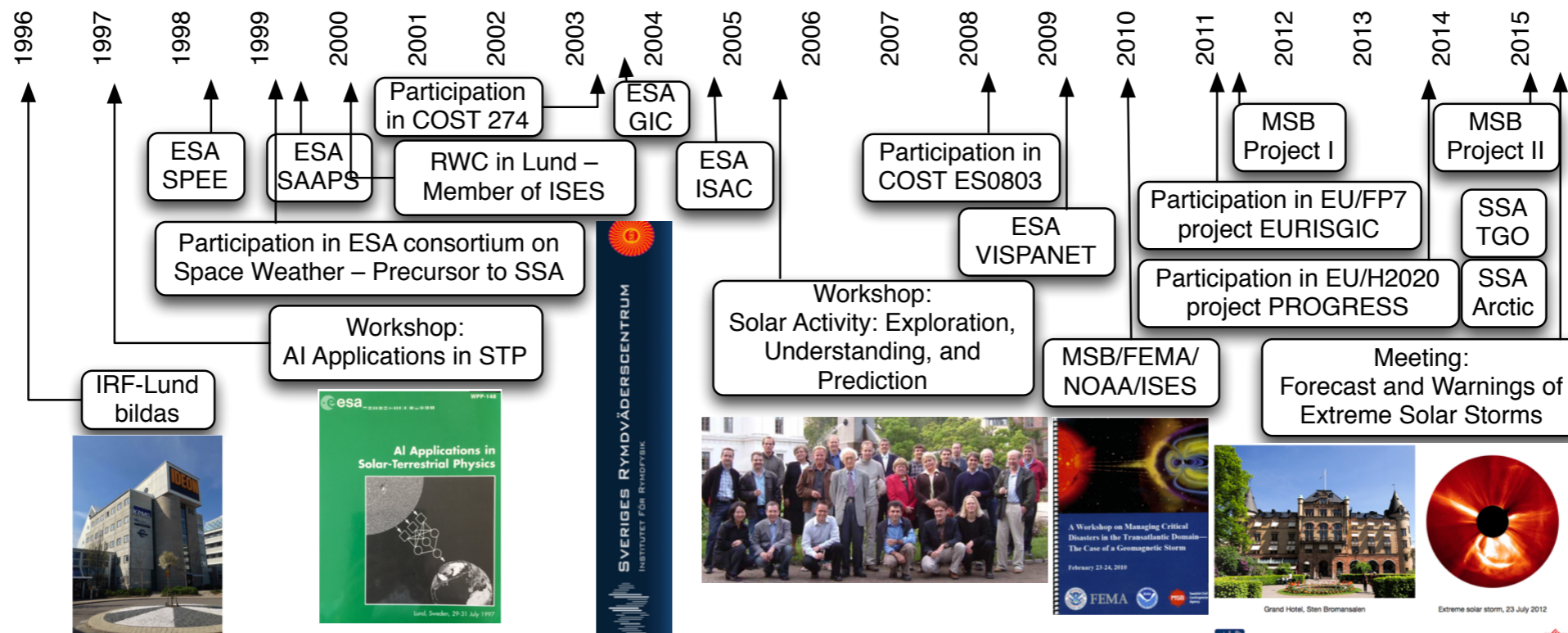
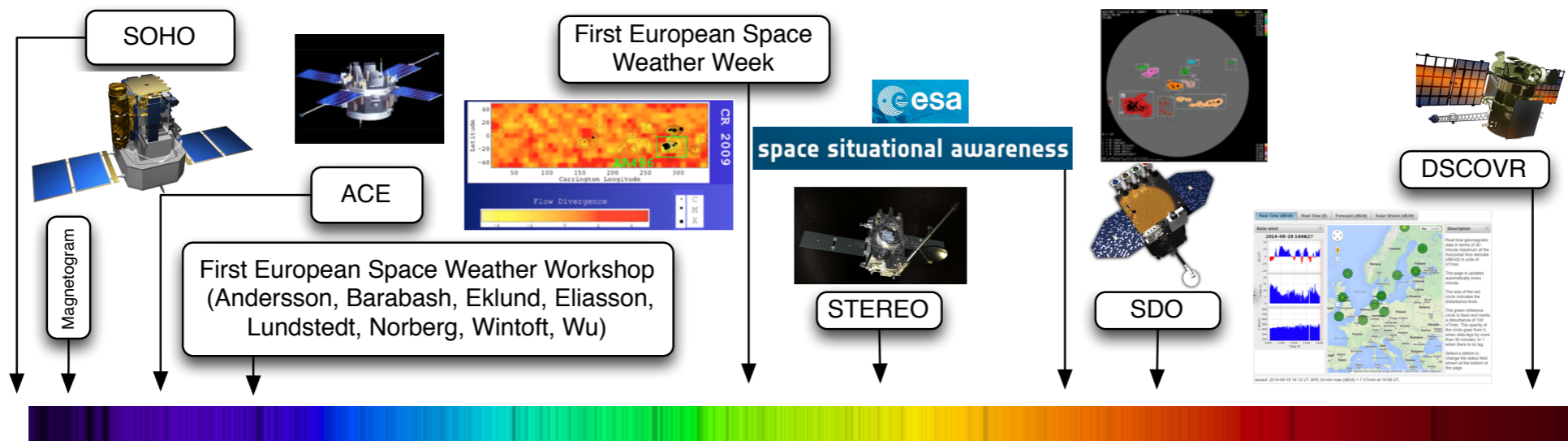


NOAA G4,
Kp 8



19h UT 17, Zagreb, Croatia

Thank you!



Current group: Henrik Lundstedt, Peter Wintoft, Magnus Wik, Juri Katkalov

Comments and questions: henrik@lund.irf.se or peter@lund.irf.se

