Oslo, Norway, 22 – 24 October 2012

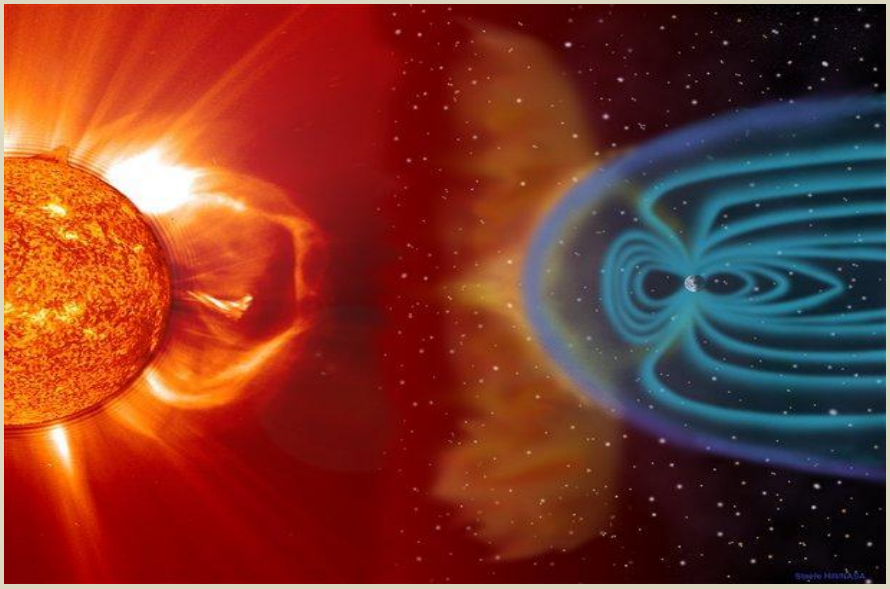

Photo: NASA

Poster Presenters

Abstract

Oslo Conference

"Space Weather and Challenges for Modern Society"

1. *Ari Viljanen, Finland*
2. *Sebastian Schäfer, Norway*
3. *Øyvind August Rui, Norway*
4. *Peter Stauning, Denmark*
5. *Eija Tansaknen, Finland (2)*
6. *Brynjar Hansen, Norway*
7. *Janet C. Green, USA*
8. *Brage Førland, Norway*
9. *Henrik Lundstedt, Sweden*
10. *Jone Peter Reistad, Norway*
11. *Rico Behlke, Norway*
12. *Zahra Bouya, Australia*
13. *Magnar G. Johnsen, Norway*
14. *Dave Neudegg, Australia*
15. *Lars Dyrud, USA*
16. *Jøran Moen, Norway*
17. *Peter Wintoft, Sweden*

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High-voltage Power Grid Disturbances during Geomagnetic Storms

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Abstract

The very strong geomagnetic storm on 13 March 1989 caused extensive disruptions of high-voltage power circuits, particularly in the Province of Quebec, Canada, but also to a lesser degree in Scandinavia. Similar events have occurred earlier, among others, during the great storms of 13-14 July, 1982, and 8-9 February, 1986. Some of the high-voltage power grid disturbances are related to the shock-like magnetic disturbances accompanying the compression of the front of the magnetosphere by sudden enhancements in the solar wind plasma flow. Other cases are related to extraordinarily intense substorm events. The relations between characteristic features of magnetic storms and high-voltage power grid disturbances during these storms are presented and possible precautions against adverse effects are discussed.

Nowcast Server for Geomagnetically Induced Currents

Ari Viljanen (1) (ari.viljanen@fmi.fi), **Eija Tanskanen** (1), **Yaroslav Sakharov** (3), **Yury Katkalov** (3) and **Risto Pirjola** (1,2)

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2) Natural Resources Canada, Ottawa, Canada
3) Polar Geophysical Institute, Apatity, Russia

Abstract

During the latest years, availability of real-time ground magnetometer data has become a well-established routine. This has made it possible to provide up-to-date modelling of geomagnetically induced currents (GIC). Within the FP7/EURISGIC (European Risk from Geomagnetically Induced Currents) project, such a nowcast has been tested for the Finnish and North-West Russian high-voltage power grids and the Finnish natural gas pipeline. The input consists of real-time data from 13 IMAGE magnetometer stations in North Europe, a model of the ground conductivity, and a DC description of the power grids and the pipeline. This exercise has run since spring 2012 without any major problems. The next step will be an

extension to forecasting based on magnetohydrodynamic simulations starting from in-situ solar wind measurements, and allowing for a lead-time of some tens of minutes. Basically, the only difference to nowcasting is to replace past magnetic field data by forecasted values. We will also then extend the power grid model to cover whole Europe. The nowcast server, as well as the forthcoming forecast server, is generic in that it is applicable in any geographic scale. Because the method determines ionospheric (equivalent) current densities, it also serves as a real-time monitor of ionospheric electrojets.

Real Time Scintillation Observation at the NMA During Geomagnetic Activity

Sebastian Schäfer (schseb@statkart.no)

Norwegian Mapping Authority

Abstract

Ionospheric scintillation is the main threat for satellite based navigation and positioning systems. The Norwegian Mapping Authority establishes a real time scintillation monitor system based on data from multi-frequency, multi-constellation receivers located at high latitudes between 65N and 80N. The system provides time series of scintillation indices, such as S4 and SigmaPhi, as well as overview maps showing the spacial distribution of scintillation over northern Europe with an update rate of one minute. Scintillation events detected during increased geomagnetic activity will be presented. The observed spatial and temporal occurrence of scintillation will be compared with the performance of the high precision positioning system CPOS operated by the Norwegian Mapping Authority.

Measurement of GIC in the Norwegian high voltage grid

Øyvind August Rui (Oyvind.Rui@statnett.no) , Evald Sætre, Trond Ohnstad

Statnett SF, Norway

Abstract

The Norwegian TSO Statnett has initiated a R&D project for examining the impact of GIC on the power system. The work will be based on earlier experiences and reported problems in

other power companies. The focus is on transformers and Statnett has had at least one transformer trip due to GIC.

The Norwegian Power Grid consists of 420kV (1645 km) and 300kV (3800 km) solid earthed system and a 132kV (2635 km) of resonant earthed neutral system. Transmission lines run both West – East and North – South and have the length of 90 to 120 km. The paper will present measurements of GIC in transformer neutrals. Statnett has earlier measurements (from 1999-2002) and new measurement equipment is in the process of being installed. The reasons for choosing a specific substation for the measurements will be briefly discussed. What equipment that is used and how it is connected to the transformers will be presented. Currents and voltages in the 420 kV phases are also registered and it is possible to see how the GIC current influence the harmonic generation and the reactive power consumption of the transformer.

Space Weather Analysis and Novel Browser-based Tools

E.I. Tanskanen (1,2) (Eija.Tanskanen@fmi.fi), D. Pitchford (3) and A. Pulkkinen (4)

(1) Finnish Meteorological Institute, Space Weather Group, Helsinki, Finland
(2) University of Bergen, Department of Physics and Technology, Norway
(3) SES Engineering, Luxemburg
(4) NASA, Goddard Space Flight Center, Greenbelt, US

Abstract

We will present time series analysis of solar, solar wind and magnetospheric space weather measurements. Phenomena in time scales from seconds to solar cycles will be covered. We compare occurrence rate and strength of the most geo-effective solar wind structures such as high-speed streams (HSS), interplanetary shocks (IS) and coronal mass ejections (ICME). Detailed analysis of the source region for the geo-effective solar wind structures as well as their magnetospheric effects will be presented. We found out that the occurrence rate of the strongest geomagnetic events (storms and substorms) maximizes during the declining solar cycle phase, which is most strongly driven by high-speed streams originating from the solar coronal holes. A novel browser-based analysis tool called Substorm Zoo (www.substormzoo.org) will be presented and an example space weather event will be shown. On November 6, 2001, two GEO satellites measured high s/c charging values at the time when very high velocity HSS together with ICME hit the Earth. We will use Substorm Zoo (1) to present space weather data in different parts of the heliosphere, (2) to analyze the

space weather event, (3) to compare with the long-term space weather statistics and (4) to discuss about the space weather effects of the disturbance.

Substorms Zoo - a Browser-based Tool for Space Weather Research, Teaching and Public Outreach

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(2) University of Bergen, Department of Physics and Technology, Norway

Abstract

Large amount of high-resolution measurements are nowadays available from different heliospheric locations. It has become an issue how to best handle the ever-increasing amount of information about the near Earth space weather conditions, and how to enable the social data analysis. To resolve the problem, we have developed an interactive web interface, called Substorm Zoo (www.substormzoo.org), which has become a powerful tool for scientists, space weather customers, teaching and public outreach as well. The aim is to (1) provide a combined data repository for different heliospheric measurements including the geomagnetic activity indices with a possibility to customized views, (2) enable the use of pre-identified event lists, creation and sharing of own lists, (3) allows discussion on individual activity events e.g. substorms from the users of the site, and (4) enable the interactive data analysis on-line with a possibility to write and share comments. In this talk, we will present the basic features of Substorm Zoo and give examples of the use for educational, scientific and public outreach purposes.

Reduction of vulnerability for safety-critical GNSS applications

Brynjar Hansen (brynjar.hansen@spacecentre.no)

Norwegian Space Centre, Norway

Abstract

Global satellite navigation systems (GNSS) have become the preferred infrastructure for positioning, navigation and timing (PNT) for a number of safety-critical applications. These

include civil aviation, maritime operations, dynamic positioning of offshore vessels, search and rescue operations, and land-based emergency services to name but a few.
Ionospheric effects of geomagnetic storms and radio noise from powerful solar flares have a potential to impact GNSS signals.

Multiple GNSS will be more robust to the effects of space weather than GPS due to a number of in-built system mitigation features. Operational mitigation measures among users will further increase the robustness of multiple GNSS to space weather effects. A variety of mitigation measures are already implemented in many safety-critical sectors.

Public and private sectors are responsible for assessing the degree of vulnerability associated with their own use of GNSS. Key factors are increased awareness about GNSS dependence and sector specific continuity requirements. Redundant systems and mitigation procedures should be tested and implemented as required.

New NOAA Data, Products, and Research Safeguarding the Satellite Infrastructure from Space Weather

Green, J.C. (janet.green@noaa.gov), W. Denig, J. Rodriguez, T. Onsager, W. Murtagh, R. Rutledge, J. Stankiewicz, J. Kunches, D. Wilkinson

National Geophysical Data Center, USA

Abstract

Satellites operating in near Earth space are subjected to intense electron and proton radiation that can degrade spacecraft performance or cause complete failure. The radiation intensity near Earth fluctuates dramatically depending on the current space weather conditions. In response to this environmental threat to this aspect of the world's technological infrastructure, NOAA is enhancing its support for understanding and resolving satellite anomalies caused by space weather. The NOAA Space Weather Prediction Center provides real time measurements of the space radiation intensity and issues alerts, warnings and watches when warranted by the current threat conditions. Now, the NOAA National Geophysical Data Center is complementing this effort by providing additional data, products, and expertise for post- satellite anomaly assessment, resolution, and improved satellite design. We report on NOAA's plans for providing data, products and services to protect the world's satellite infrastructure from space weather effects.

SuperMAG: The Global Ground Magnetometer Initiative

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Abstract

For decades ground based magnetometers have proven to be the workhorse of magnetosphere-ionosphere physics and their importance is indisputable. The data set provided by the ground magnetometer community is truly unique since it provides continuous and nearly global measurement of a fundamental parameter — the ground level magnetic field perturbations. SuperMAG is a worldwide collaboration of organizations and national agencies that currently operate more than 300 ground based magnetometers. Magnetometer data from different sources are highly heterogenous, with varying levels of noise, different resolution and coordinate systems. The SuperMAG initiative (Gjerloev, 2009, 2012) provides a fully operational solution to these complications. SuperMAG provides easy access to validated ground magnetic field perturbations in the same coordinate system, identical time resolution and with a common baseline removal approach. All data are cleaned using both automatic and manual processes. The purpose of SuperMAG is to help scientists, teachers, students and the general public has easy access to measurements of the Earth's magnetic field, and our web site provides many tools for exploring and downloading data. This includes plotting and downloading of magnetometometer data, magnetic indices derived from SuperMAG data, polar plots (both static and animations) of magnetometer data and auroral images.

Regional Warning Center Sweden of ISES

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2) *Swedish Institute of Space Physics in Kiruna, Sweden*

Abstract

IRF in Lund operates since June 2000 a Regional Warning Center of International Space Environment Service (ISES). Lundstedt was elected Deputy Director of ISES 2002. ISES now consists of 14 RWCs worldwide. Warnings of solar storms, mainly based on Solar Dynamics

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Obsevatory (SDO) and GOES satellite observations, are given. Real-time forecasts are offered of geomagnetic storm indices Kp, Dst, dB/dt and GIC, based on ACE solar wind data. Aurora forecasts are also offered. The Swedish Civil Contingencies Agency (MSB) has granted a research project to further improve forecasts of solar storms and space weather effects. Forecasts and database routines are, and have been developed within ESA and EU projects. Power industry has been a costumer for many years of forecasts for geomagnetic storms, dB/dt and GIC. IRF also operates magneto-meters providing real-time data.

Hemispheric Differences in Solar Wind Dynamo Induced Currents

Jone Peter Reistad (jreistad@gmail.com) **and Nikolai Østgaard**

University of Bergen, Norway

Abstract

Earlier studies using simultaneous imaging from space of the Aurora Borealis (Northern Hemisphere) and Aurora Australis (Southern Hemisphere) have revealed that the aurora can experience a high degree of asymmetry between the two hemispheres. One candidate used to explain the asymmetry is hemispheric differences in the Solar Wind (SW) dynamo efficiency. Using a dataset consisting of 19 hours of global simultaneous imaging from space of the aurora -borealis (IMAGE satellite) and -australis (Polar satellite) we find that the SW dynamo is likely to be the most controlling mechanism for producing bright aurora in the nightside polar part of the oval. This is consistent with enhanced region 1 currents expected to result from the SW dynamo induced magnetopause currents where the relative hemispheric strength is to the first order controlled by the IMF Bx component while IMF Bz is negative.

We perform a statistical analysis of the auroral brightness distribution along the oval from Northern Hemisphere only (entire IMAGE WIC database) during two extreme cases, one favouring only the SW dynamo induced currents while the other one not. From this analysis we find evidence of differences in auroral brightness along the whole night sector auroral oval for the two cases. This result indicates that the IMF Bx component influences the field aligned current strength and give further support to the idea that the SW dynamo effect is related to auroral brightness and associated currents in the ionosphere.

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Maritime Radio Systems Performances in the High North (MARENOR)

R. Behlke (1) (rico.behlke@gmx.net), B. Kvamstad (2), H. C. Juul (3) and the MARENOR consortium

(1) Polar Science and Guiding, Longyearbyen, Norway,
(2) MARINTEK, Trondheim, Norway (project manager),
(3) EMGS, Trondheim, Norway (project owner)

Abstract

As the activity level is increasing in the Arctic, there is also a growing focus on safety and efficiency of maritime and marine operations. Support systems based on Global Navigation Satellite Systems (GNSS) and digital communication are being developed and taken into use. However, the environmental and space conditions in and over the Arctic opposes navigation and communication systems to challenges different from other places on Earth. Ionospheric and atmospheric effects, harsh weather conditions leading to rapid vessel movements, icing on antennas and other outdoor equipment, low elevation angles, poor groundbased communication infrastructure and system architectures are elements that have an effect on the total performance of the navigation and communication systems. MARENOR will develop a tool for total quality of assessment on such systems. This will be achieved through measurement campaigns and analysis.

The main objective of MARENOR is to quantify the system performance of the most common navigation and communication systems being used by maritime users in the High North. This will be achieved through measurement campaings and analyses of:

1. System architecture,
2. Signal propagation (L-, C-, Ku-, Ka-band),
3. Signal degradation factors (ionosphere, atmosphere, ship movements, position, icing on antennas).

The expected result is a model and tool for quality of system assessment on navigation and communication performance at high latitudes.

In this paper, we present an overview of the MARENOR project, summarise the processes that exhibit degrading effects on radio signals traversing the Earth's ionosphere and an outlook on possible correction mechanisms.

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New Space Weather Service for Monitoring and Forecasting Regional Ionospheric Perturbations over Australia based on GNSS Techniques

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Abstract

Ionospheric perturbations can degrade precise positioning services and affect Safety of Life (SoL) applications of Global Navigation Satellite Systems (GNSS). Near real time detection and forecasting of ionospheric perturbations might warn users of a potential degradation of the performance of these systems.

In this paper, a new Australian Regional Ionospheric Disturbance Index (AusRDI) is introduced based on a regional dynamic approach ignoring smooth large scale and slowly developing deviations. The Spherical Cap Harmonic Analysis (SCHA) method was firstly used to estimate TEC at evenly distributed grid points from GPS data collected from the Australian Regional GPS Network (ARGN). The SCHA model is based on longitudinal expansion in Fourier series and fractional Legendre co-latitudinal functions over a spherical cap-like region including the Australian continent. This harmonic expansion requires fewer coefficients to represent the fine structure of regional ionospheric features and may be adapted to take advantage of regions of densely distributed observations in order to observe and model ionospheric dynamics over Australia on a range of spatial scales. Principal Component Analysis (PCA) was then used to decompose the TEC dataset into a series of orthogonal Eigenfunctions (EOF base functions) and associated coefficients. PCA is non parametric and as such does not utilize deviation from a previously described average to determine perturbations. The new disturbance index provides an objective measure of ionospheric perturbation processes reflected in small spatial and rapid temporal variations. Furthermore the index is predictable using early space weather information. Such index can provide reliable information and has great practical value for operational radio systems sensitive to current space weather conditions.

Tromsø Geophysical Observatory: Near Real-time Geomagnetic Data Provider for Space Weather Applications in the European Sector

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Abstract

Tromsø Geophysical Observatory (TGO) is responsible for making and maintaining long time-series of geomagnetic measurements in Norway. TGO is currently operating 14 magnetometer stations from southern Norway to Svalbard. Data from these are acquired, processed and made available for the user community in near real-time. TGO is participating in several European Union (EU) and European Space Agency (ESA) space weather related projects where both near real-time data and derived products are provided. In addition the petroleum industry is benefiting from our real-time data services for directional drilling.

Near real-time data from TGO is freely available for non-commercial purposes. TGO is exchanging data in near real-time with several institutions, enabling the presentation of near real-time geomagnetic data from more than 40 different locations in Fennoscandia and Greenland. The open exchange of non real-time geomagnetic data has been successfully going on for many years through services such as the world data center in Kyoto, SuperMAG, IMAGE and SPIDR. TGO's vision is to take this one step further and make the exchange of near real-time geomagnetic data equally available for the whole community. This presentation contains an overview of TGO, our activities and future aims. Our contribution to the space weather forecasting and nowcasting effort in the EU and ESA will be presented with emphasis on our real-time auroral activity index and brand new auroral activity monitor and electrojet tracker. see http://www.tgo.uit.no/

Active Region AR1429 March 2012 -Case Study of Space Weather Consequences

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Abstract

Solar cycle 24 is living up to predictions as a modest solar maxima. However there have been several active regions that have provided a range of space weather effects. The most prominent of these at the time of abstract submission (August 2012), was AR1429 in March 2012. The region was relatively large, peaking at 1270 millionths of the solar disc and magnetically complex at Macintosh Ekc with up to 28 spots. AR1429 produced two high M-class and 3 low X-class flares in early March when it was

in the eastern hemisphere. Significant shortwave fadeouts resulted from at least one of the flares with a loss of HF radio bandwidth. Each major flare had an associated coronal mass ejection (CME) with some Earthward directed component and the potential for geoeffectiveness. However the CMEs did not perform as expected, with the 3rd not arriving at Earth, perhaps being overtaken by the 4th, and the 5th, arriving substantially earlier than predicted. Geomagnetic Major Storm levels were achieved and significant ionospheric disturbances with large global reductions in F2 electron densities and HF radio frequencies. Two solar proton events, moderate and strong, also occurred with potential for spacecraft hazards.

AMPERE and GEOScan: Utilizing Commercial Space Infrastructure for Disaster Mitigation, Planning and Response.

Lars Dyrud (Lars.Dyrud@jhuapl.edu), **Brian Anderson, Jonathan Fentzke and Gary Bust**

Johns Hopkins Applied Physics Laboratory, USA

Abstract

The past decade has seen a confluence of events that push geoscience into a new era enabling vast advances in space hazard characterization and monitoring. One primary direction for research of our Earth environment consists in taking a view of the Earth-atmosphere-geospace as a complete system. Without the global system perspective we cannot tackle many open questions and policy makers cannot make actionable decisions without real-time global coverage of key space measurements. A fundamental impediment to advance in this area is the paucity of observations, particularly in space. Fortunately, the dramatic increases in the number of commercial space platforms and technological advancements in commercial off the shelf (COTS) components and instrumentation enable the deployment of global arrays of instrumentation at a fraction of the historic cost enabling observational advances required to tackle system-level science questions. The cost reduction results from (a) using commercially developed instruments that are repurposed from their original consumer and industrial uses, such as GPS, inertial measurement, and magnetometers, and (b) new low cost access to space via commercially available hosted payloads, sub-orbital flights, and CubeSats. We will present recent research on this topic in general, and focus specifically on how the AMPERE program and GEOScan initiative can provide affordable breakthrough space weather data for communications, GIC's and the radiation environment. AMPERE is in final development and has already shown the capability to time resolve storm-time dynamics and substorm onset showing great promise for

providing warning for and monitoring of geomagnetic storm hazards including GICs. GEOScan proposes to fly a full constellation of radiation dosimeters and GPS receivers for 3D imaging of the of the ionosphere a plasmasphere to 3 TECU accuracy and 2D imaging of radiation belt ions and electrons.

In-situ Investigations of SATCOM/GNSS Outage Regions

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Abstract

It is well known that diffraction of radio phase fronts produces amplitude and phase fluctuations even at GHz frequencies used for satellite communication and navigation systems. These scintillations are caused by naturally occurring ionospheric plasma density irregularities at scales from hundred of meters to a few kilometers that are generally most severe at high and low latitudes, the so-called SATCOM outage regions. In order to forecast scintillation events it is necessary to obtain a description of the underlying physical processes.

We have developed the Investigation of Cusp Irregularities (ICI) sounding rockets program to investigate plasma instability key processes in connection with polar cap patches and daytime auroral activities above Svalbard. We have developed a light-weight instrument, multi-Needle Langmuir Probe system that is suitable to fly on small satellites. Please visit the poster and you will get research high-lights as well as our vision to demonstrate a new concept space weather satellite, CubeSTAR. CubeSTAR is a 2U cubesat, a student satellite project to map SATCOM outage regions in LEO orbit.

Data Driven Models Forecasting Levels of Geomagnetic Disturbance Related to GIC

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Abstract

The upstream solar wind interacts with Earth's magnetosphere causing geomagnetic storms primary driven by shocks and the turning of the IMF to negative Bz. During these events the local magnetic field, measured at ground stations, show a large degree of fluctuation from the highest measured resolution (seconds) to several minutes. These fluctuations induce electrical currents (GIC) in power grids, where the level of GIC is also determined by the ground conductivity. Currently, empirical models forecasting 10-minute root-mean-square (RMS) dB/dt are operational at Regional Warning Center-Sweden. The models use the ACE real-time solar wind data and provide forecasts for two locations in southern Scandinavia. In on-going work, carried out within the EU/FP7 project EURISGIC, more locations will be added covering Europe. Categorical forecasts representing various levels of disturbances in dB/dt are also explored. The work is partly funded by the EU/FP7 project EURISGIC and the MSB project "Solar storms and space weather".

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