



The Abdus Salam
International Centre for Theoretical Physics



310/1749-39

ICTP-COST-USNSWP-CAWSES-INAF-INFN
International Advanced School
on
Space Weather
2-19 May 2006

*Solar Activity: Predictions and Real-Time
Forecasts*

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SE-223 70 Lund
SWEDEN*

These lecture notes are intended only for distribution to participants

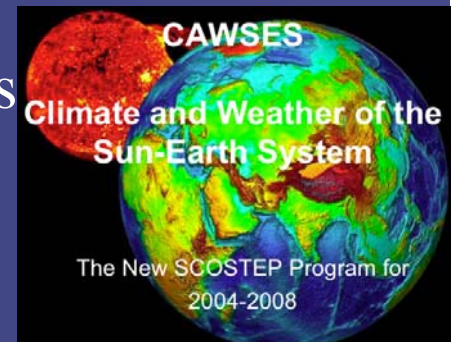
The Sun: Space Weather Applications:

4) Solar Activity: Predictions and real-time forecasts

ICTP-COST-CAWSES-INAF-INFN, Trieste, 2006



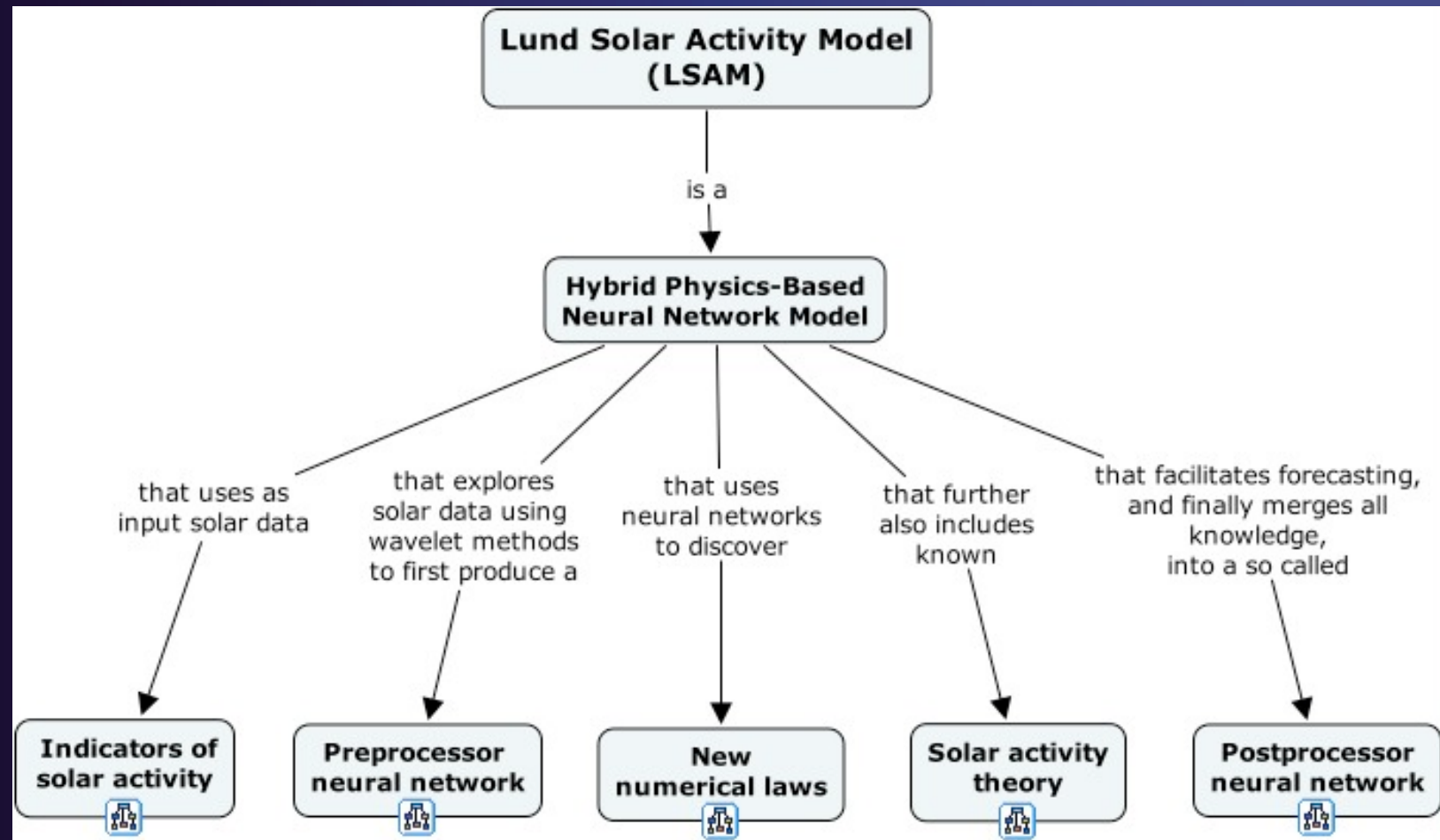
Henrik Lundstedt
Swedish Institute of Space Physics
Lund, Sweden
www.lund.irf.se



Outline of my fourth talk

- AI and neural network methods
- **Forecasting** with NN and **services for users**
- **Real space weather events:** Bastille event 2001, Halloween event 2003, November event 2004 and events in January and September 2005.
- Today's event

Hybrid physics-based neural network



Workshops arranged by us

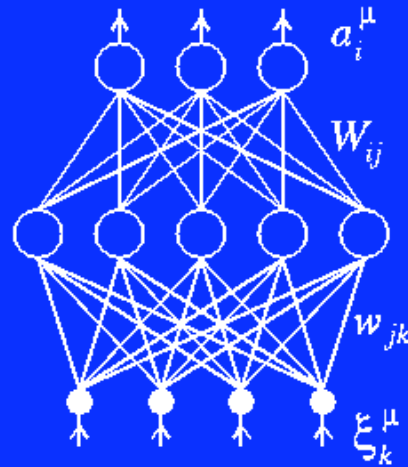


Workshops on "Artificial Intelligence Applications in Solar-Terrestrial Physics" were held in Lund 1993 and 1997. A third workshop was held in September 19-21, 2005

Artificial neural networks

The basic element of every ANN is an artificial neuron or simply a neuron (which is an abstract model of a biological neuron (nerve cell)).

Multi-layer error-back-propagation (MLBP)

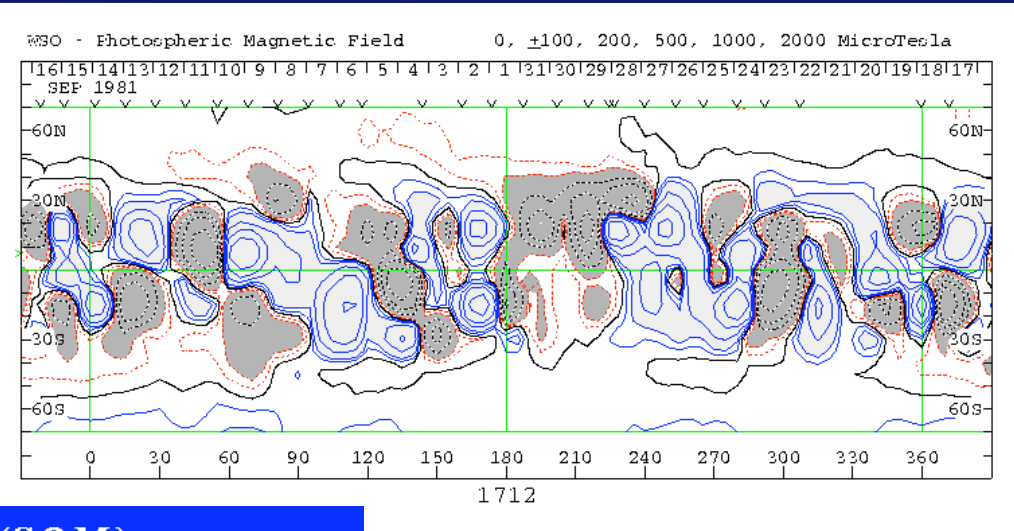


$$a_i^\mu = g_i \left(\sum_j W_{ij} g_j \left(\sum_k w_{jk} \xi_k^\mu \right) \right)$$

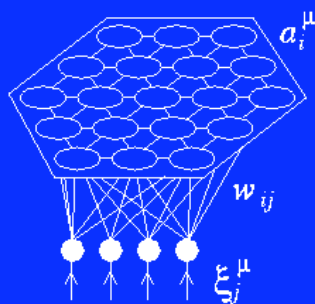
Back-propagation learning : $\Delta W_{ij}(t+1) = -\eta \frac{\partial E}{\partial W_{ij}} + \alpha \Delta W_{ij}(t)$

Error measure : $E = \frac{1}{2} \sum_{i\mu} (d_i^\mu - a_i^\mu)^2$

Synoptic map of WSO



Self Organized Map (SOM)



$$a_i^\mu = \begin{cases} 1 & \text{if } i=i^* \\ 0 & \text{if } i \neq i^* \end{cases}$$

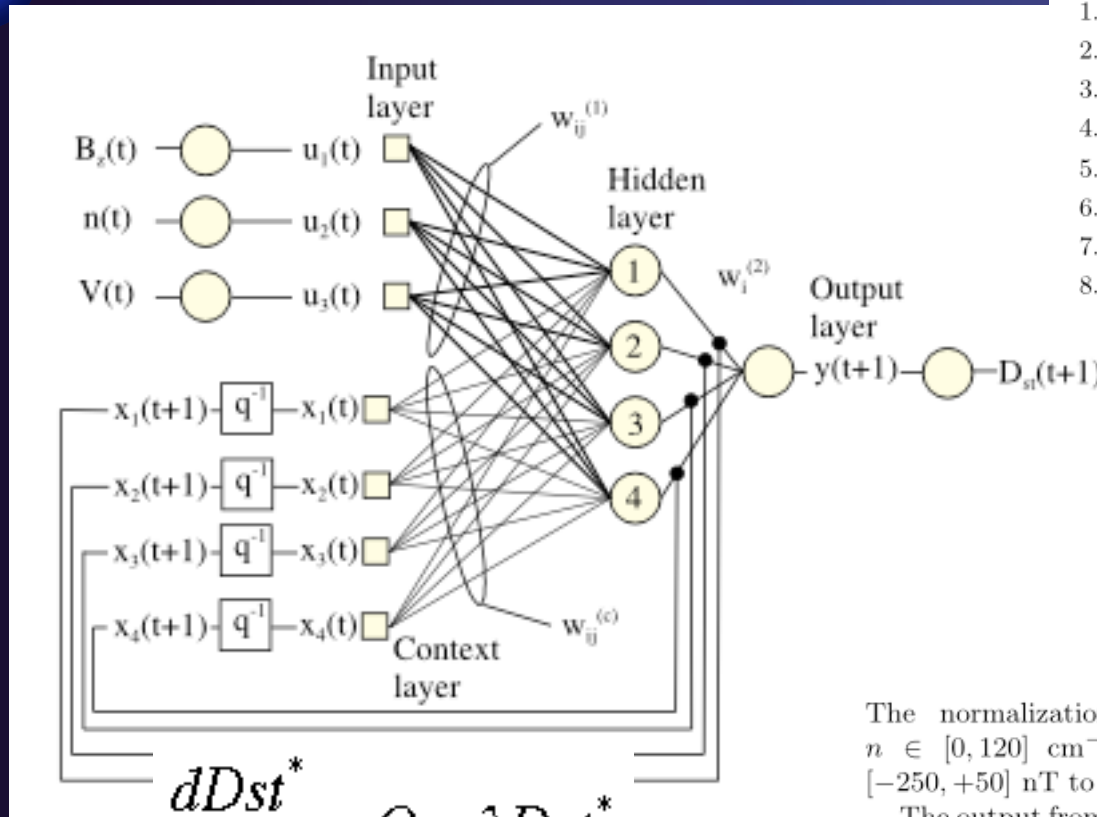
$$h_i^\mu = \sum_j w_{ij} \xi_j^\mu \quad h_{i^*}^\mu > h_i^\mu \text{ for all } i$$

Kohonen learning : $\Delta w_{ij} = \eta \Lambda(i, i^*) (\xi_j^\mu - w_{ij})$

Neighborhood function : $\Lambda(i, i^*) = e^{-\frac{|r_i - r_{i^*}|^2}{2\sigma^2}}$

Download Lund Dst model in Java and Matlab (www.lund.lrf.se/dst/models)

Lundstedt, H., Gleisner, H. and P. Wintoft, Operational forecasts of the geomagnetic Dst Index, Geophys. Res. Lett., 29, 34-1--34-4, 2002.



$$\frac{dDst^*}{dt} = Q - \lambda Dst^*$$

The ARMA filter is obtained by adding auto-regressive terms to a MA filter. The partial recurrent network (Elman) becomes identical to a linear ARMA filter if it is assigned linear activations functions.

1. Set $\mathbf{x} = (0.39, 0.22, -0.83, 0.14)^T$.
2. Get the first observation of B_z , n , and V .
3. Compute $\mathbf{u} = (u_1, u_2, u_3)^T$ from Eq. 7.
4. Compute $\mathbf{x} \leftarrow \tanh(\mathbf{W}^{(1)}\mathbf{u} + \mathbf{W}^{(c)}\mathbf{x} + \mathbf{b}^{(1)})$.
5. Compute $y \leftarrow \mathbf{w}^{(2)}\mathbf{x} + b^{(2)}$.
6. Compute Dst from Eq. 8.
7. Get the next observation of B_z , n , and V .
8. Go back to step 3.

The weights and biases are

$$\mathbf{W}^{(1)} = \begin{pmatrix} -0.5946 & 0.0904 & 0.0428 \\ 0.6215 & 0.4485 & 0.2516 \\ -1.4217 & 0.4988 & 0.1409 \\ 0.3372 & -0.5065 & 0.7190 \end{pmatrix}$$

$$\mathbf{W}^{(c)} = \begin{pmatrix} 0.6099 & 0.2223 & -0.4379 & 0.0053 \\ 0.7935 & 0.5000 & -1.2654 & -0.0428 \\ -0.3496 & 0.1024 & 0.3605 & 0.1790 \\ -0.2067 & 0.2270 & 0.5446 & 0.1019 \end{pmatrix}$$

$$\mathbf{b}^{(1)} = \begin{pmatrix} -0.1081 \\ -0.7252 \\ -0.2307 \\ 0.5406 \end{pmatrix}$$

$$\mathbf{w}^{(2)} = (0.2535 \quad 0.3172 \quad -0.4860 \quad -0.2346)$$

$$b^{(2)} = 0.0712$$

$$Dst = 150y - 100. \quad (8)$$

The normalization transforms $B_z \in [-30, +30]$ nT, $n \in [0, 120]$ cm⁻³, $V \in [200, 1000]$ km/s, and $Dst \in [-250, +50]$ nT to the $[-1, +1]$ interval.

The output from the network is described by the following equations

$$x_i(t+1) = \tanh \left(\sum_{j=1}^{n_1} w_{ij}^{(1)} u_j(t) + \sum_{j=1}^{n_c} w_{ij}^{(c)} x_j(t) + b_i^{(1)} \right) \quad (9)$$

$$y(t+1) = \sum_{i=1}^{n_2} w_i^{(2)} x_i(t+1) + b^{(2)}. \quad (10)$$

Applications

Input parameters	Output	KBNM method	Reference
Daily sunspot number	Daily sunspot number	SOM and MLP	Liszka 93;97
Monthly sunspot number	Date of solar cycle max and amplitude	MLP and Elman	Macpherson et al., 95, Conway et al, 98
Monthly sunspot number and aa	Date of solar cycle max and amplitude	Elman	Ashmall and Moore, 98
Yearly sunspot number	Date of solar cycle max and amplitude	MLP	Calvo et al., 95
McIntosh sunspot class & MW magn complex.	X class solar flare	MLP expert system	Bradshaw et al., 89
Flare location, duration X-ray and radio flux	Proton events	MLP	Xue et al., 97
X-ray flux	Proton events	Neuro- fuzzy system	Gabriel et al., 00
Photospheric magnetic field expansion factor	Solar wind velocity 1-3 days ahead	RBF & PF MHD	Wintoft and Lundstedt 97;99

Applications

Input parameters	Output	KBNM method	Reference
Solar wind n, V, Bz	Relativistic electrons in Earth magnetosphere hour ahead	MLP	Wintoft and Lundstedt, 00
Solar wind n, V, Bz, Dst	Relativistic electrons one hour ahead	MLP, MHD, MSFM	Freeman et al., 93
ΣKp	Relativistic electrons day ahead	MLP	Stringer and McPherron, 93
Solar wind V from photospheric B	Daily geomagnetic Ap index	MLP	Detman et al., 00
Ap index	Ap index	MLP	Thompson, 93
Solar wind n, V, Bz	Kp index 3 hours ahead	MLP	Boberg et al., 00
Solar wind n, V, B, Bz	Dst 1-8 hours ahead	MLP, Elman	Lundstedt, 91; Wu and Lundstedt, 97
Solar wind n, V, B, Bz	AE 1 hour ahead	Elman, MLP	Gleisner and Lundstedt, 00, Gavrishchaka et al., 00, 01

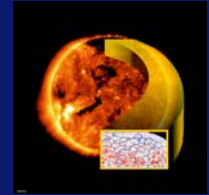
Applications

Input parametrs	Output	KBNM method	References
Solar wind V^2B_s , $(nV^2)^{1/2}$, LT, local geomag $\Delta x^e, \Delta Y^w$	Local geomagnetic field $\Delta X, \Delta Y$	MLP and RBF	Gleisner and Lundstedt 00
Solar wind n, V, B_z	None, weak or strong aurora	MLP	Lundstedt et al., 00
foF2	foF2 1 hour ahead	MLP	Wintoft and Lundstedt, 99
AE, local time, seasonal information	foF2 1-24 hours ahead	MLP	Wintoft and Cander, 00
foF2, A_p , F10.7 cm	24 hours ahead	MLP	Wintoft and Cander, 99
ΣK_p	Satellite anomalies	MLP	Wintoft and Lundstedt 00
Solar wind n, V, B_z	dBx/dt , GIC	Elman, MLP	Kronfeldt et al., 01 and Weigel et al.,02

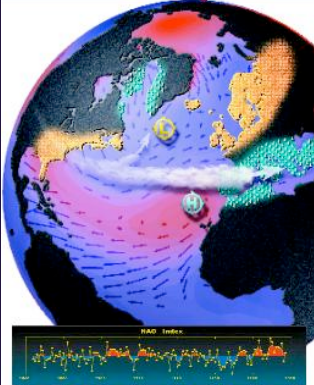
Lundstedt, H., Progress in space weather predictions and applications, Adv. in Space Res., 36, 2516-2523, 2005.



Solar wind E parameter correlated with atmospheric pressure Forecasts of NAO from solar activity and solar wind E

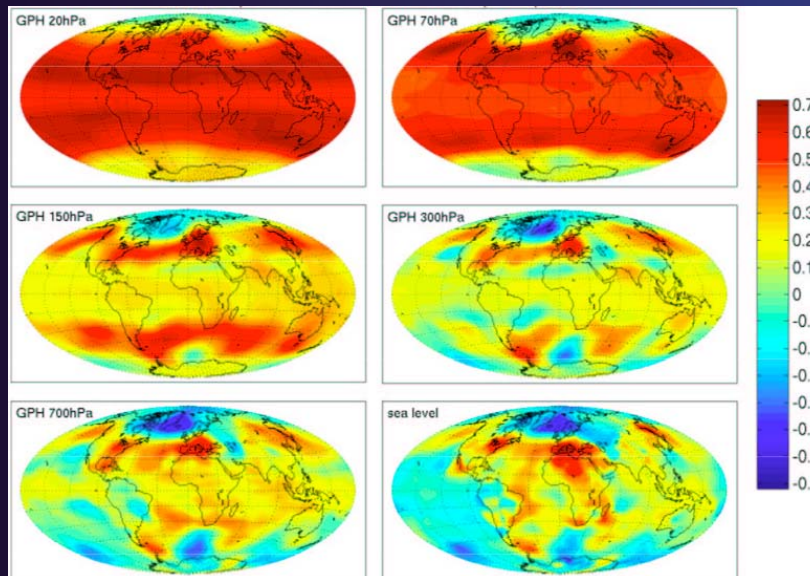
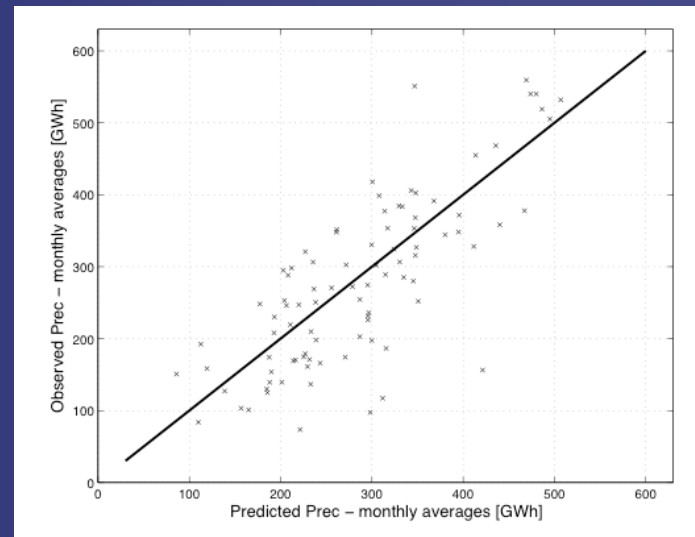
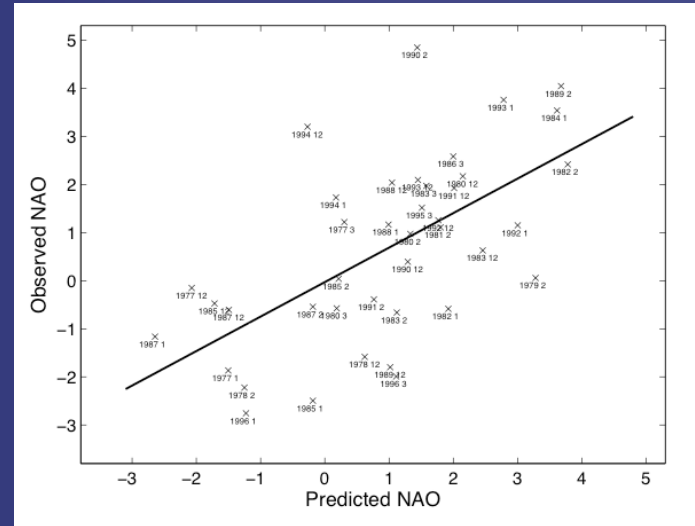


The negative NAO index phase



- The negative NAO index phase shows a weak subtropical high and weak Icelandic low.
- The reduced pressure gradient results in fewer and weaker winter storms crossing on a more west-east pathway.
- They bring moist air into the Mediterranean and cold weather to northern Europe.
- The US east coast experiences more cold air outbreaks and hence snowy winter conditions.
- Greenland, however, will have milder winter temperatures.

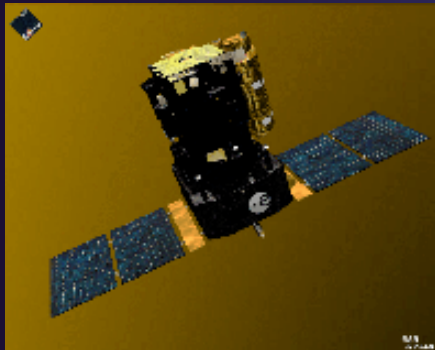
Meteo Webcam Publiq, 2000



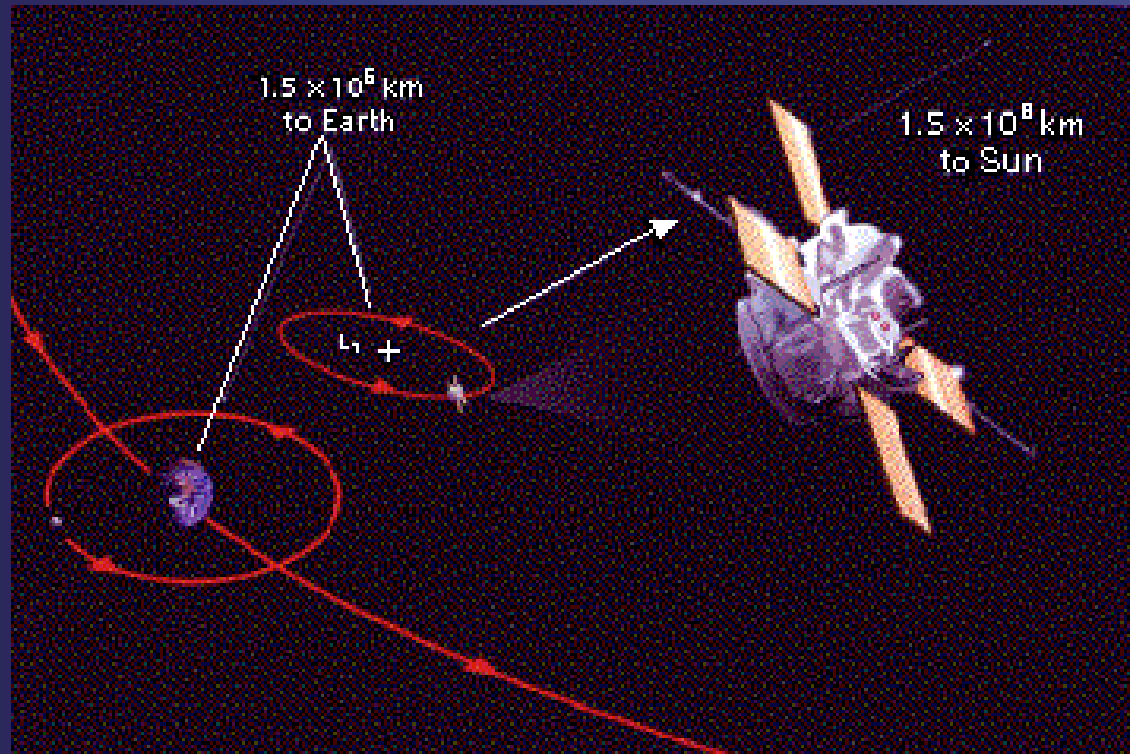
20hPa = 26km
70hPa = 18km
150hPa = 14km
300hPa = 9.2km
700hPa = 3.0km

Real-time forecasts and warnings based on KBN

Solar input data

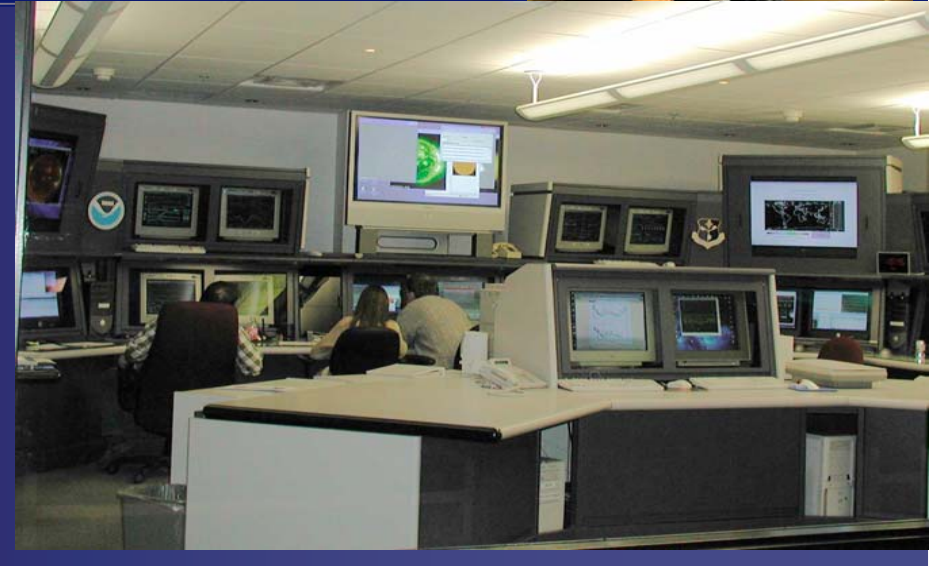
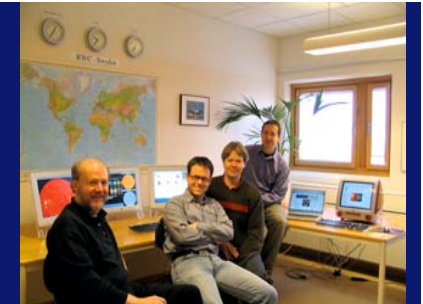


Solar observations with SOHO make warnings 1-3 days ahead possible.

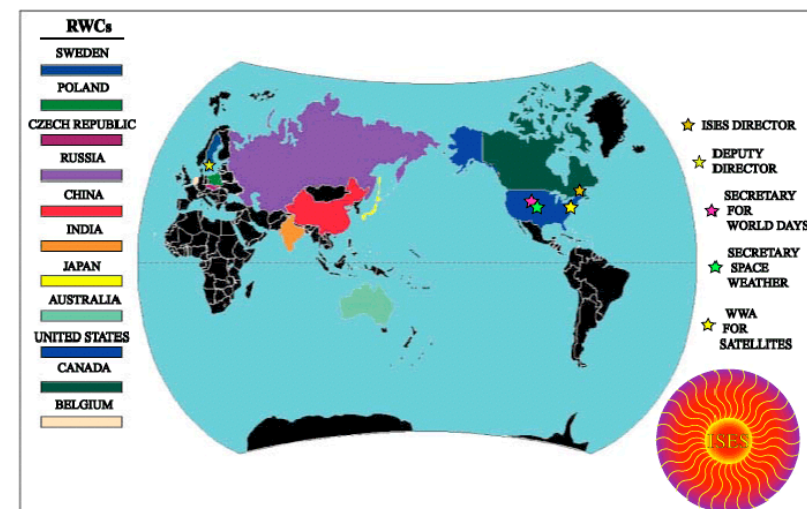


Solar wind observations with ACE make accurate forecasts 1-3 hours ahead possible.

Today general forecast service is given by RWCs within ISES



ISES Director: D. Boteler
Deputy Director: H. Lundstedt
Secr. for World days: H. Coffey
Secr. Space Weather: J. Kunches
WWW for Satellites: J. King



ESA/Lund Space Weather Forecast Service

Welcome to ESA Space Weather Forecast Service

ESA SPACE WEATHER FORECAST SERVICE

USER GUIDE

What is Space Weather?

- [Glossary](#)
- [Visual Dictionary](#)

Specific User Information

- [Scientists](#)
- [Civil Aviation](#)
- [Power System Operators](#)
- [Communication Operators](#)
- [Public and Science Tourists](#)
- [Satellite Launch and Operators](#)
- [Space Agencies \(Man in space\)](#)

Links

- [ESA Forecast Service](#)
- [Dst Prediction Model](#)
- [Extended Forecast Service](#)
- [Lund Space Weather Center](#)



- [ESA Space Weather Programme](#)



Latest information on forecasts of Kp, Dst, AE and GIC

The screenshot displays the 'LUND SPACE WEATHER FORECAST SERVICE' interface. At the top, it says 'Welcome to Lund Space Weather Forecast Service'. The main heading is 'LUND SPACE WEATHER FORECAST SERVICE'. On the left, there is a 'USER GUIDE' section with links for 'What is Space Weather?', 'Glossary', and 'Visual Dictionary', followed by 'Specific User Information'. The central part of the interface features a flowchart with red and yellow boxes. Red boxes include 'IRF', 'HF Comm. Condition', 'ACE', and 'Geo-magnetic Storm', each pointing to a 'Latest Info' box. Yellow boxes include 'Forecast of Kp, Dst, AE and GIC' and 'Forecast of Aurora', also pointing to 'Latest Info' boxes. On the right, three large circular indicators show the status: 'Space Storm NOT Ongoing' (red), 'Warning NO' (yellow), and 'Quiet YES' (green). A central window titled 'Kp + Dst + AE + GIC forecasts' provides the following data:

Kp + Dst + AE + GIC forecasts

Latest Kp-Forecast from: Tue Dec 04 10:00:00 CET 2001
Kp Forecast: 1.7
Kp Forecast Valid to: Tue Dec 04 13:00:00 CET 2001

Latest Dst-Forecast valid for: Tue Dec 04 14:19:31 CET 2001
Forecasted Dst = -5 nT
Dst Forecast is updated every 10 minutes.

Latest AE-Forecast valid for: Tue Dec 04 14:55:01 CET 2001
Forecasted AE = 3,043 nT
AE Forecast is updated every 5 minutes.

Latest GIC-Prediction from: Tue Dec 04 13:52:47 CET 2001
Predicted Current: -2,812 A
GIC Forecast valid to: Tue Dec 04 14:39:25 CET 2001

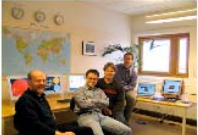
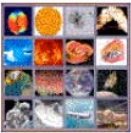
The interface also includes a sidebar with navigation options (Favoriter, Tidigare, Sak, Komplet, Sidhällare) and the ESA logo at the bottom left.

RWC-Sweden

http://www.lund.irf.se/rwc/

IRF

**Regional Warning Center Sweden
of
International Space Environment Service**



SPACE WEATHER
The International Journal
of Research and Applications

Glossary and Dictionary

- [Solar and space weather glossary](#)
- [Visual space weather dictionary](#)
- [NOAA space weather scales](#)



Space Weather Now

The solar activity is increasing (7-day forecast).

Active sunspot region 649 poses the greatest threat for a major solar flare.

The holographic images (SOHO/MDI) reveal a big sunspot on the far side of the Sun.

Earth is not inside a fast solar wind from a coronal hole.

Rymdvädet nu

Solaktiviteten är ökar (7-dagars prognos).

Aktiva solfläcksområdet 649 kan producera en kraftig "solar flare".

De holografiska (SOHO/MDI) bilderna visar en stor solfläcksgrupp på solens baksida.

Jorden ligger inte inuti en snabb solvind från ett koronahål.

Contact Information

[ISES home](#)

Director - [D.Boteler](#)

Deputy - [H.Lundstedt](#)

Secretary Space Weather - [J.Kunches](#)

Secretary for World Days - [H.Coffey](#)


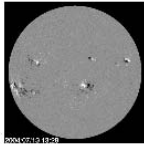
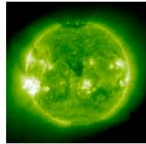
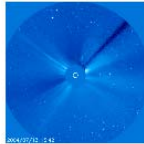
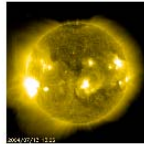
[Regional Warning Center Sweden](#)

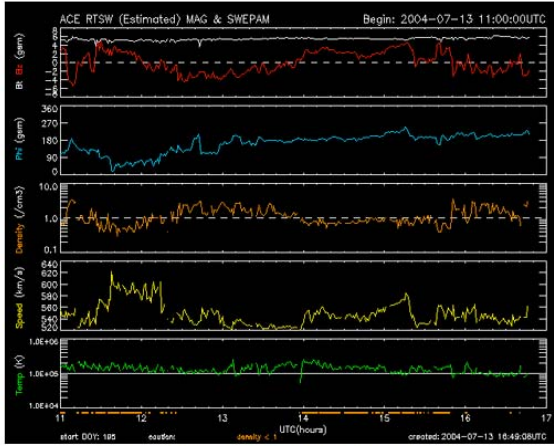
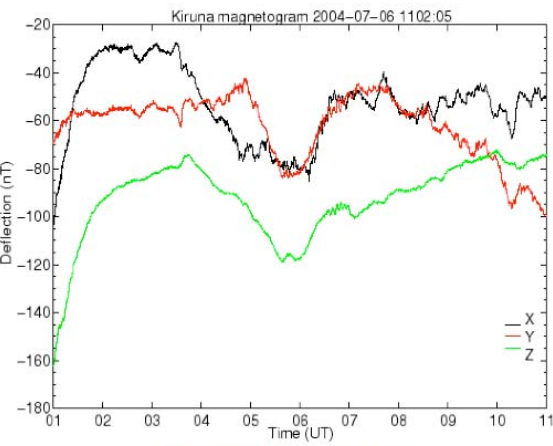


Active region monitor (Big Bear)

RWC-Sweden web

RWC-Sweden
CURRENT SOLAR AND SPACE WEATHER

<p>Sunspots Solfäckor</p>  <p>SOHO/MDI</p> <p>Sunspot number (SEC) Latest active region summary (SEC) Solar cycle progress (SEC/ISES) Solar cycle 24 (Lund)</p>	<p>Solar magnetic field Solens magnetfält</p>  <p>SOHO/MDI</p> <p>MDI/STANFORD</p>	<p>Solar flares Strålningsutbrott</p>  <p>SOHO/EIT</p> <p>Solar X-ray flux (SEC)</p>	<p>Coronal mass ejections Solplasmautbrott</p>  <p>SOHO/LASCO</p> <p>GOES proton flux (SEC)</p>	<p>Coronal holes Koronahål</p>  <p>SOHO/EIT</p>
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<p>Solar wind Solvinden</p>  <p>Shocks and 48 hour of solar wind data (SOHO/CELIAS)</p>	<p>Earth's magnetic field Jordens magnetfält (IRF-Kiruna)</p>  <p>Latest Magnetogram (Brorfelde/DMD)</p>
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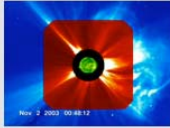

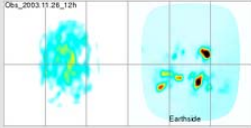

Fast **solar wind** and large negative **Bz** value cause geomagnetic storms.
Snabb **solvind** och stort negativt **Bz** värde orsakar jordmagnetisk storm.

The plot shows the deviation from the expected means of the three components (X, Y and Z) of the geomagnetic field.
Diagrammet visar avvikelser från förväntade medelvärden för jordmagnetiska fältets tre komponenter (X, Y och Z).

RWC-Sweden web

RWC-Sweden
FORECASTS

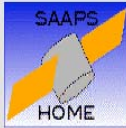
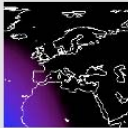

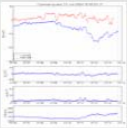
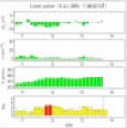
Sun

 Solar activity - Cycle 24 Solaktiviteten - Cykel 24 Lund	 Solar activity 1-5 weeks Solaktiviteten 1-5 veckor LMSAL	 Solar activity 1-2 weeks Solaktiviteten 1-2 veckor SOHO/MDI	 Solar activity 1-3 days Solaktiviteten 1-3 dagar SEC/NOAA Big Bear Solar Observatory
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L1

Solar Wind Speed	Shocks	IMF
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Earth

 Satellite Anomalies Satellitproblem Lund	 Radio Blackouts SEC/NOAA	 Aurora Norrsken Lund	 Geomagnetic activity Jordmagnetisk aktivitet Dst(Lund) and Kp(Lund)	 Geoelectric field/GIC Jordelektriska fältet/GIS Lund
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DATA

Solar-Terrestrial Data 	Data Plotter 
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ISES RWS Centers



ISES REGIONAL WARNING CENTRES

RWC-USA

SEC's Space Weather Now

http://www.sec.noaa.gov/SWN/

Virtual Science Center LWS 1 - SOHO 19 Daily North ...ction Center Komplet.t.se Target Ljud ...eokamera... InFocus® > S... and Africa Lectures.html

National Weather Service
Space Environment Center

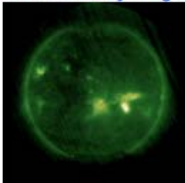
www.weather.gov

Site Map News Organization Search Enter Search Here Go

SEC HOME -> Space Weather Now

Space Weather Now
Updated: 2006 May 01 1650 UTC (May 01 1050 MDT)

SXI Solar X-ray Imager



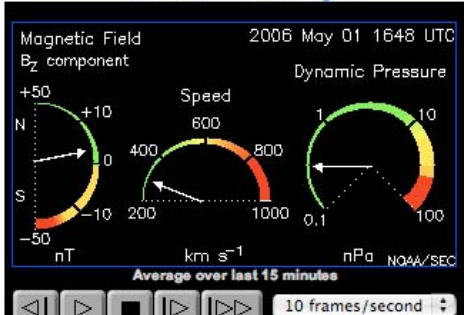
2006 May 01 1647 UT

NOAA Scales Activity
Range 1 (minor) to 5 (extreme)

NOAA Scale	Past 24 hours Max.	Current
Geomagnetic Storms	none	none
Solar Radiation Storms	none	none
Radio Blackouts	none	none

Latest Alert: May 01 0628 UTC ALERT: Type II Radio Emission
Last Advisory Bulletin: None in last 7 days.

Real-Time Solar Wind Pages



Magnetic Field
Bz component

Speed

Dynamic Pressure

Average over last 15 minutes

10 frames/second



photography

ISES RWS Centers China, Japan, Belgium, Canada

Solar Activity Prediction Center
National Astronomical Observatories, CAS

www.bao.ac.cn 今日预报 预报中心 研究工作 成员介绍 中心动态 科普园地 论坛 联系我们 English

中心消息

2004年7月王宇宁研究员赴法...
2006年7月国际空间环境服务...
中国日地观测资料

相关链接
Space Environment Center
空间环境预报中心
Huairou Solar Observing Station
Big Bear Solar Observatory
SCOSTEP
Solar Physics Division
SOHO
ISCS

今日预报 发布时间: 2006年4月30日

<过去24小时太阳活动综述>
太阳活动为低水平。日面上共有2群黑子。最大1群为 NOAA 0875(S09 L115), 面积200, 磁分为B_C, McIntosh分类为Dce。近期尚有2个C级耀斑, 最大1个为C2.3级 (对急区待定), 另1个C1.1级耀斑来自NOAA 0875, 地磁地平静。

<未来48小时太阳X射线耀斑和地磁活动预报>

发布日期	X射线耀斑	地磁活动
2006-4-30	M级	平静

<未来三天太阳F10.7cm射电流量预报>

第一天	第二天	第三天	24hr	48hr	72hr
106	104	102	05	05	05

<过去三天太阳活动状况>

日期	2006-4-29	2006-4-28	2006-4-27
X射线耀斑	C2.3级	C1.9	M7.9级
质子事件	无	无	无
地磁活动	平静	弱	平静
日冕物质抛射	日冕物质抛射	无	无
黑子相对数	36	51	39
新生黑子数	0	0	1
总群数	2	3	3
10厘米射电流量	111	112	109
射电爆发事件数	0	0	0

往日报表查询

NICT National Institute of Information and Communications Technology
Space Environment Information Service

Japanese(EUC) English

Solar-Terrestrial ISES Alert and Forecast
ISES Plain report from RWC's to Tokyo
Solar Activity Chart
Geomagnetic Activity Chart

Solar
Solar Image Data Base
Hiraiso Radio Spectrograph(HIRAS)

Interplanetary
Real Time Solar Wind Plot (1day)
Plot Archive (every 1 day)
Sector & Corotation

SIDC - Solar Influences Data Analysis Center

x: 009 visit us at http://www.sidc.be SIDC/RWC-Belgium forec

Welcome to the homepage of the Solar Influences Data Analysis Center - SIDC.
The SIDC is a research group for solar physics at the Royal Observatory of Belgium. Its operational activities include the World Data Center for the sunspot index and the Regional Warning Center Belgium for space weather forecasting.

Latest News

Apr 12, 2006: Total Solar Eclipse
Mar 28, 2006: The new SIDC website
Feb 23, 2006: The static Sun
Dec 20, 2005: New: the Estimated ISN
Dec 6, 2005: Birthday of SOHO
click here for all SIDC news items

Most recent alerts

2006 Apr 27 16:31 UTC
A class M7.9 solar X-ray flare occurred on 2006/04/27 with peak time 15:52 [more]
2006 Apr 20 08:40 UTC
END OF ALL QUIET ALERT The SIDC - RWC Belgium expects [more]

PRESTO FROM SIDC - RWC BELGIUM Mon May 1 2004, 12:03 UTC
Geomagnetic conditions are expected to be unsettled to active, with potential for isolated periods of minor storming conditions towards the

Government of Canada / Gouvernement du Canada

Canada

Franglais Contact us Help Search Canada Site
Home Current Space Weather Effects on Technology NRCan
Data Geomagnetism CSA

Space Weather Canada
ISES Regional Warning Centre for Canada
Geomagnetic Field - CURRENT STATUS 2006 05 01 17:00 UT

Polar	Unsettled
Auroral	Quiet
Sub-auroral	Quiet

Latest Forecast

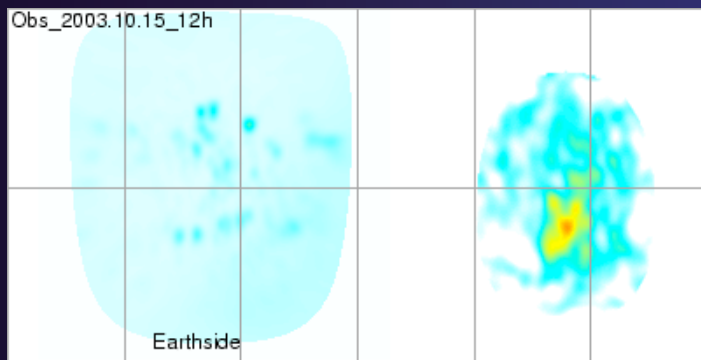
The Canadian Space Weather Forecast Centre in Ottawa is operated by [Natural Resources Canada \(NRCan\)](#), with support from the [Canadian Space Agency \(CSA\)](#). It is a Regional Warning Centre (RWC) of the [International Space Environment Service \(ISES, formerly IUWDS\)](#). The ISES global network monitors a variety of parameters that help to characterize the conditions on the Sun, in space between the Sun and Earth, and on the Earth. The data are used by Regional Warning Centres and others to develop Space Weather warnings and alerts.

This activity contributes to the [priorities](#) of the [Earth Sciences Sector](#):

- Natural hazards and emergency response

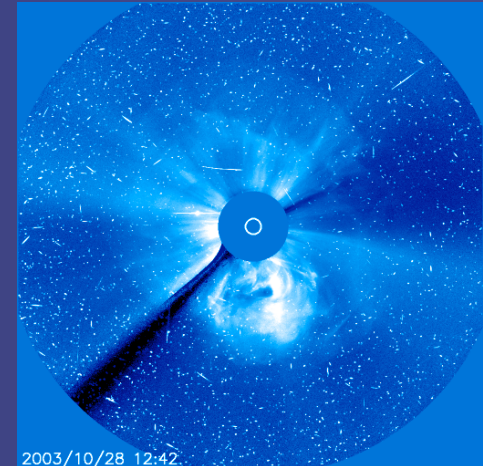
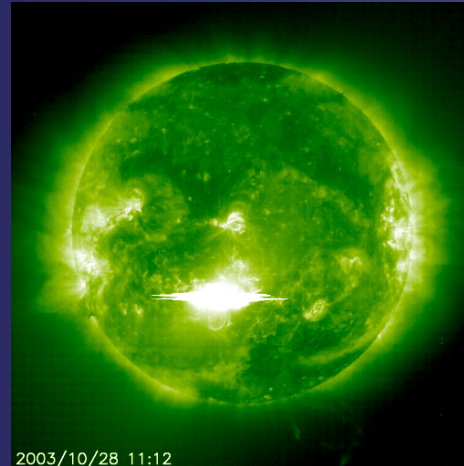
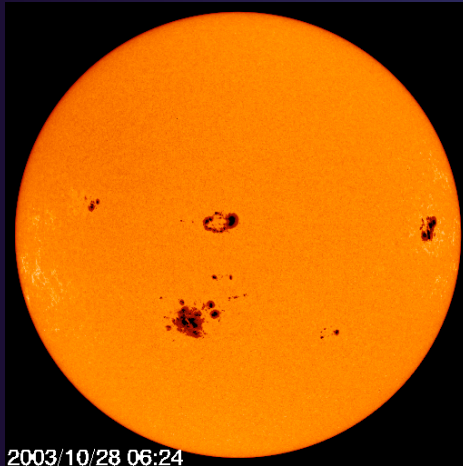
Latest modified: 2006-04-4 [important notices](#)

The October 14 -November 6 events: It all started with no sunspots



- No sunspots (R=24)
- Aurora observed in Southern Sweden (Gothenburg, Lund)
- Media got interested
- SOHO/MDI far side images had told me Large ARs were to come

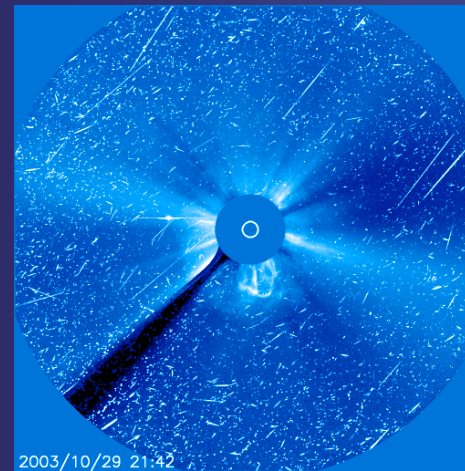
Then came the AR 486, October 28 event



- Even more interviews
- Warnings and reports were sent to power industry
- Discussions with power operators

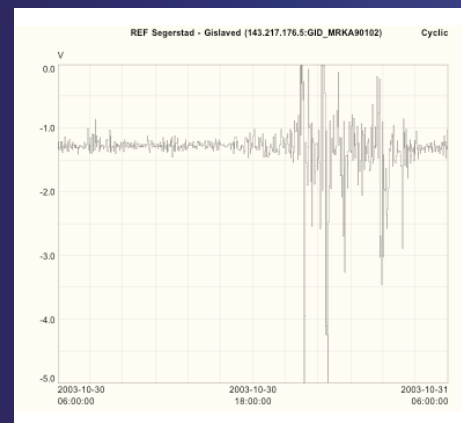
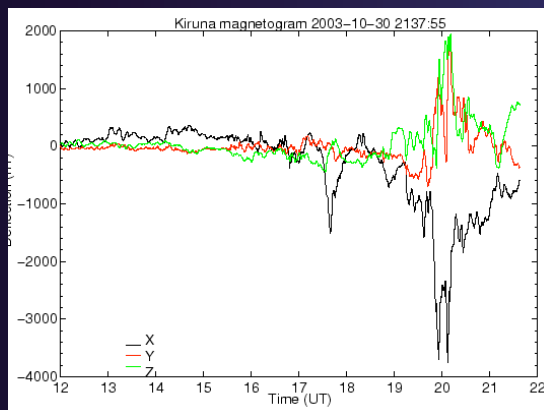
Power outage in Malmö

2003-10-30 at 21:07:15 (20:07:15 UT) The tripping of a 130-kV power line in the Malmö caused an outage of 50 000 customers. The outage time ranged from 20 to 50 minutes.
(Sture Lindahl, ELFORSK report 2004)



The halo CME
arrived ~16.20-30UT
October 30, 2003:
Dst = - 342nT

Power Outage in Southern Sweden, October 30, 2003



Courtesy Sydsvenskan Bild.

The power failure got enormous media attention in Sweden and around the world

The screenshot shows the svt.se website with a blue header. The main headline is "Våldsamma utbrott på Solen" (Violent outbreaks on the Sun) dated 2003-10-29 17:16. The article describes a solar storm with a magnitude of 4, which caused a geomagnetic storm. It mentions that the storm was observed by the Swedish Space Agency and that it caused a power outage in Malmö. The article also notes that the storm was caused by a collision between two solar wind streams.

Våldsamma utbrott på Solen
2003-10-29 17:16
Gigantiska utbrott, enorma gasmoln och magnetstormar. Solen är just nu inne i en mycket våldsamt fas. Satelliter, elnät och telefonsystem kan i värsta fall skadas.

Forskarna påpekar dock att detta är helt normalt. Solens aktivitet pendlar ständigt mellan lugna och våldsamma perioder i en elvaårig cykel. Just nu befinner vi oss vid maximum av en sådan cykel. Det märks främst genom att det bildas ovanligt många fläckar på solens yta. Solfläckarna leder till våldsamma utbrott eller solfacklor då miljontals ton gas kastas ut i rymden.

Kan orsaka störningar
Redan under gårdagen observerades ett enormt utbrott - ett av de största som noterats sedan mätningarna började för 25 år sedan. Idag nåddes jorden av gasmolnet.
Vid kollisionen uppstod en häftig storm som kraftigt påverkade jordens magnetfält innan det hastigt upplöstes. Fler liknande utbrott med magnetstormar väntas inträffa den närmaste tiden.

Stormarna ger upphov till magnifika norrsken. Men de kan också orsaka störningar som slår ut elförsörjningen. Ett utbrott 1989 slog t.ex. ut strömmen över en stor del av Kanada och delar av Europa.
Fast egentligen är detta fenomen enligt forskarna inte särskilt dramatiskt. Solfläckar observerades redan under romartiden och har studerats ända sedan de första teleskopen konstruerades på

Every TV, radio station and newspaper had something

The screenshot shows a web browser window displaying a news article from tv4.se. The article is titled "Solmagnetisk störning bakom strömavbrott?" (Solar magnetic disturbance behind power outage?). The article discusses a solar storm that caused a power outage in Malmö on October 29, 2003. It mentions that the storm was caused by a collision between two solar wind streams and that it was observed by the Swedish Space Agency. The article also notes that the storm was caused by a collision between two solar wind streams.

Solmagnetisk störning bakom strömavbrott?
Malmö Sydskraft misstänker att det var solmagnetisk störning som orsakade ett tims långt strömavbrott i Malmö på torsdagskvällen.

Stora delar av centrala Malmö drabbades och som mest var 50 000 hushåll utan el. Det var en 130-kilovoltsledning som slogs ut, men trots felsökning har Sydskraft Nät inte lyckats hitta något fel på de egna ledningarna som kan förklara strömavbrottet. I stället arbetar man med hypotesen att det var jordmagnetiska strömmar, orsakade av solstormar, som slog ut systemet. Strömavbrottet inträffade strax efter klockan 21 på torsdagskvällen och efter en timme hade alla hade fått strömmen tillbaka.

-i Det finns en rad liknande händelser som inträffade samtidigt under torsdagskvällen som indikerar att jordmagnetiska strömmar kan vara orsaken till strömavbrottet i Malmö, säger Peter Sigenstam, analysansvarig på Sydskraft Nät.

Våldsamt fas
Solen är för närvarande är inne i en våldsamt fas där det bildas ovanligt många fläckar på dess yta. Solfläckarna leder till våldsamma utbrott då miljontals ton med magnetisk gas kastas ut i rymden. Både på tisdagen och onsdagen observerades enorma utbrott.
På onsdagen nåddes jorden av det första gasmolnet. Vid kollisionen uppstod en häftig magnetstorm som kraftigt påverkade jordens magnetfält. Stormarna kan skapa störningar som bland annat slår ut elförsörjningen. Vid ett utbrott 1989 slogs strömmen ut över en stor del av östra Kanada och delar av Europa. Sverige har hittills inte drabbats av några större liknande incidenter.

Jämtland och Närke
Samtidigt som Malmö drabbades av strömavbrottet kopplades två av Svenska Kraftnätets transformatorer i Jämtland och Närke ifrån. Precis som i Malmö kunde dessa sedan kopplas in igen utan några bestående fel.
-i Vi tror att detta orsakades av jordmagnetiska strömmar. För vår del klarade vi oss utan strömavbrott, säger Sture Larsson, teknisk direktör på Svenska Kraftnät, till TT.
-i Mätningar från Institutet för rymdfysik i Kiruna visar också att det var kraftiga magnetiska störningar vid den aktuella tidpunkten. Dessutom uppmättes det starka strömmar i jorden vid kärnkraftverket i Oskarshamn som indikerar att det var något onormalt som hände, säger Jan-Erik Olsson, informationschef på Sydskraft Nät.
Sydkrafts hypotes får stöd från forskaren Peter Stauning vid Danmarks meteorologiska institut, som vid tidpunkten för strömavbrottet uppmätte en mycket kraftig magnetisk impuls.
-i Klockan 21 börjar en kraftig impuls, som kulminerar klockan 21.06 och 21.07, så det finns helt klart ett samband, säger Stauning till den danska nyhetsbyrå Ritzau.

Magnus Stattin

Grid impacts in Sweden Halloween 2003

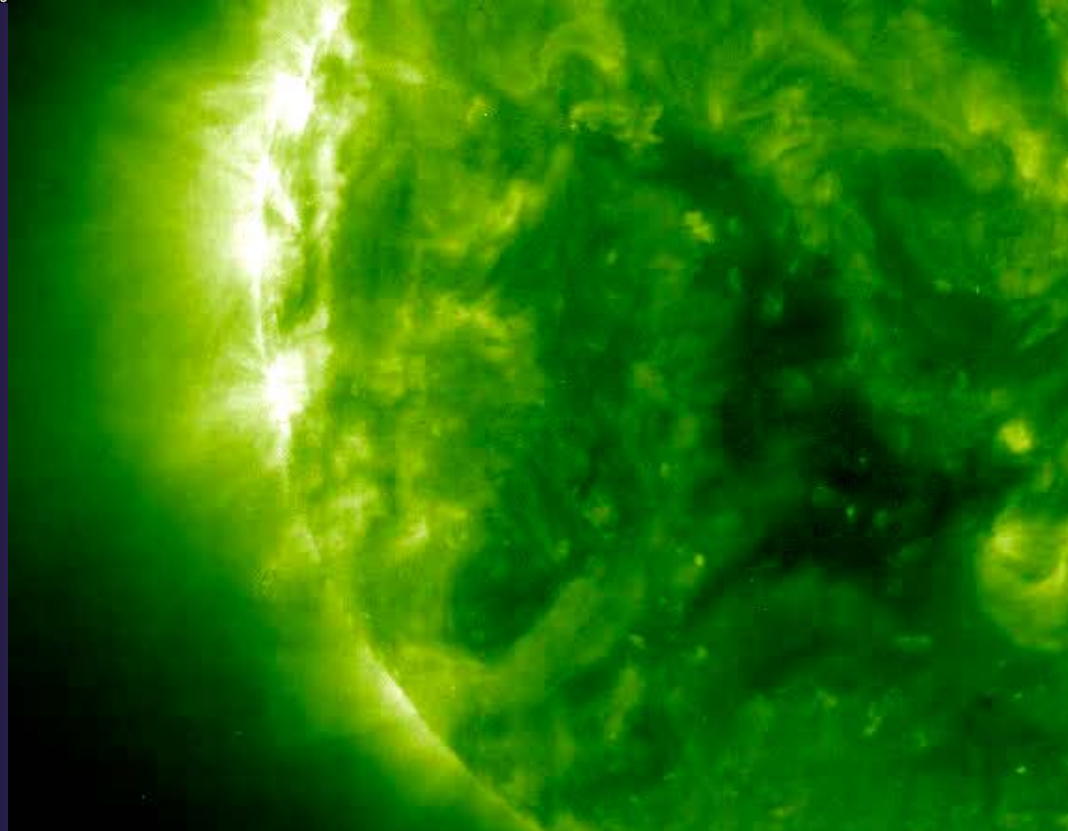
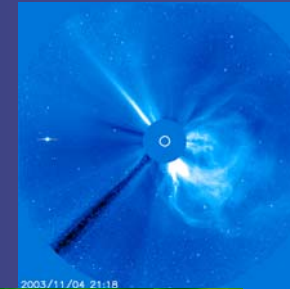
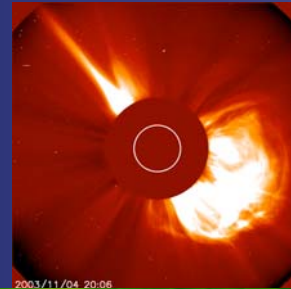
"Circuit breakers for several power lines and transformers were tripped from the most sensitive non-directional residual overcurrent relays. More than 50% of the disconnected objects were energized within 1 to 5 minutes, either by automatic switching equipment or by manual switching operations. In the other case, it took some 25 to 90 minutes to inspect the disconnected objects before they were re-energized.

Following disconnections were reported:

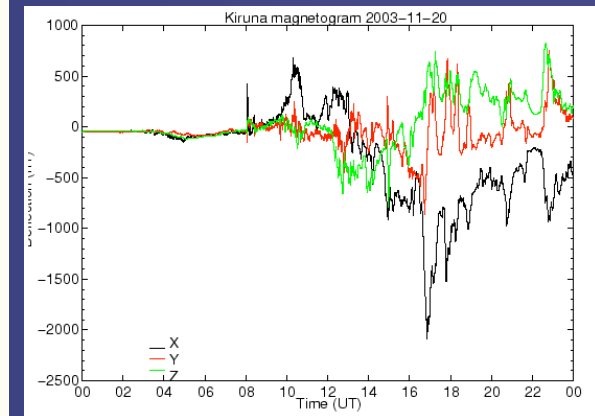
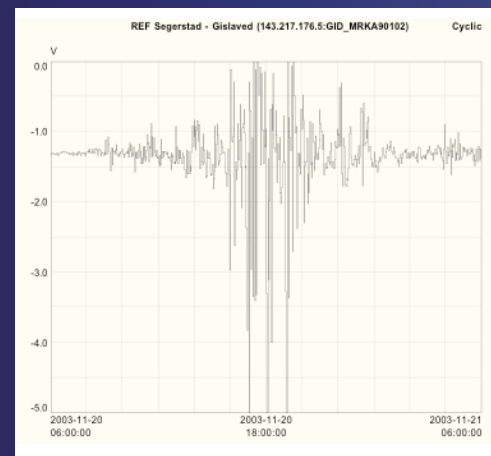
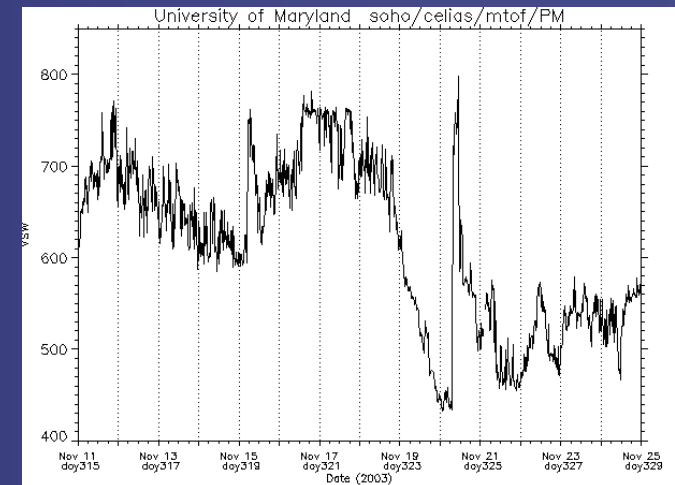
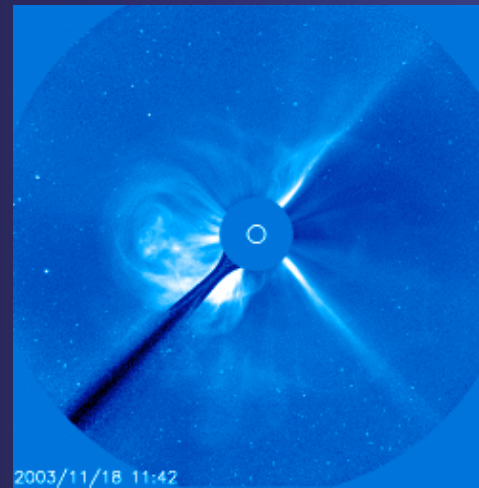
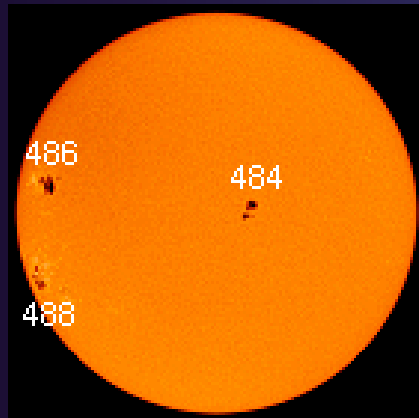
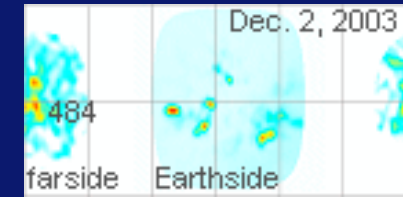
- 2003-10-29 at 07:11:42: A 220-kV power line from a power station in Härjedalen was disconnected and 140-MW generation was disconnected.
 - 2003-10-29 at 07:12:29: A 130-kV power line in Östergötland was disconnected. the same line was disconnected a second time at 08:04:10
 - 2003-10-29 at 07:46:04: The 400-kV power line from Hemsjö to Karlshamnsverket caused the interruption of 300 MW power import from Poland via the HVDC-link SwePol link.
 - 2003-10-30 at 20:55:28. A 400/220-kV transformer near Östersund.
 - 2003-10-30 at 21:03:43: A 400/130-kV transformer near Örebro caused overload in the 130-kV network.
 - 2003-10-30 at 21:03:44: A 130/10kV transformer near Norrköping was tripped.
 - 2003-10-30 at 21:07:15: The tripping of a 130-kV power line in the Malmö caused an outage of 50 000 customers. The outage time ranged from 20 to 50 minutes.
 - 2003-10-30 at 21:08:00: A 130-kV power line from Örebro.
 - 2003-10-30 at 21:08:32: A 130 kV power line near Boden.
- Increased temperature:**
- 2003-10-29 at 08:00:00: High temperatures in the step-up transformer of Oskarshamn 2 nuclear power unit, which was repeated several times."

(Lindahl, S.X., Effect of Geomagnetically Induced Currents on Protection Systems, pp.132-133, Elforsk report 03:34, 2003)

And thenX28 (45) !!!! solar flare on November 4, 2003 (ESA Space Weather Meeting)



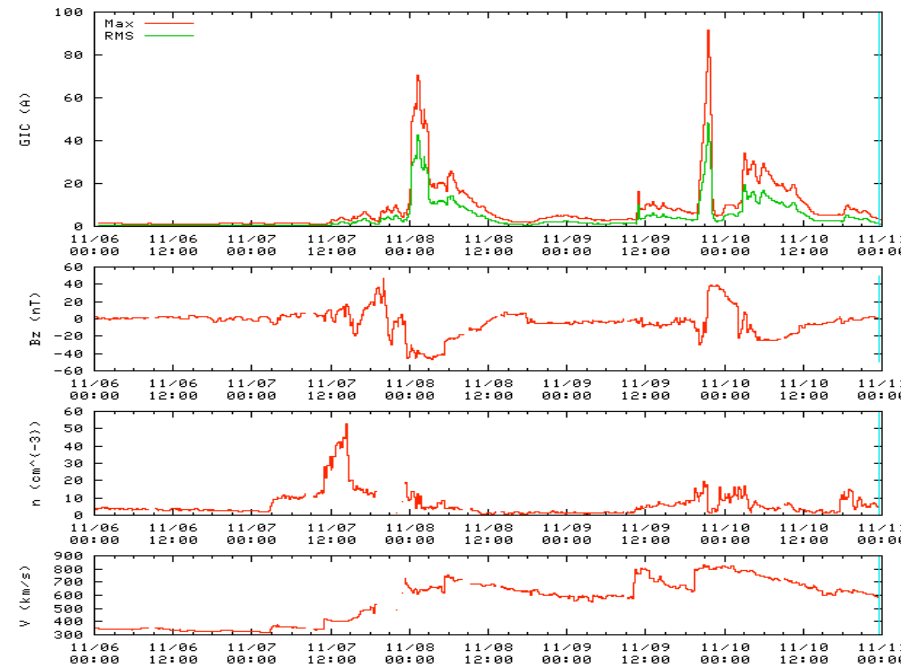
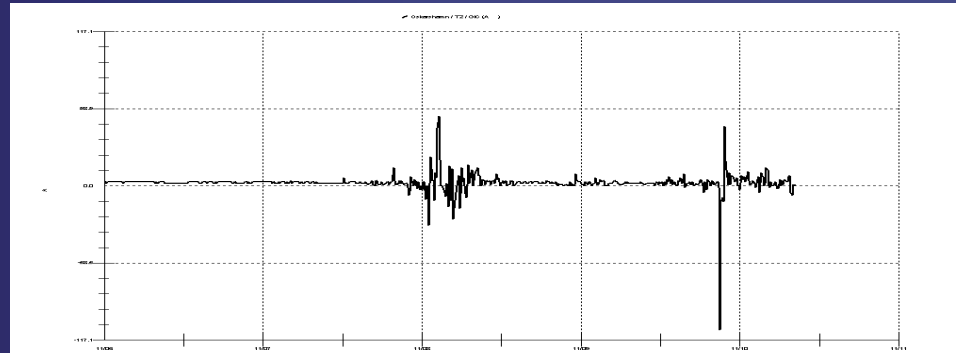
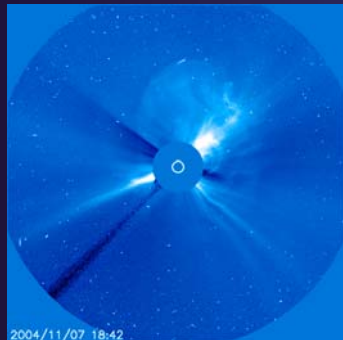
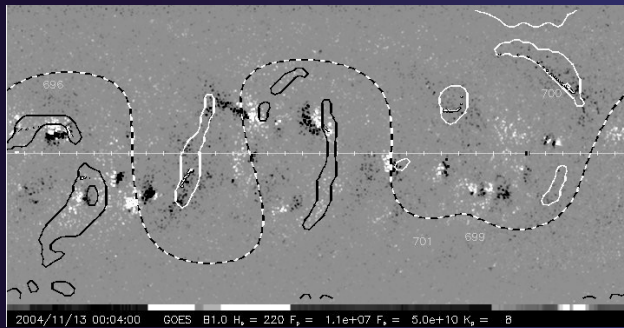
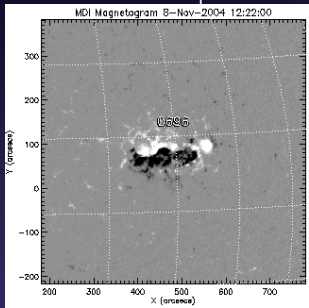
Active Regions 484/486/488 one rotation later



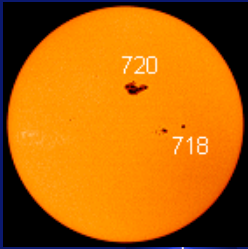
The Sun

GIC measurements vs GIC forecasts

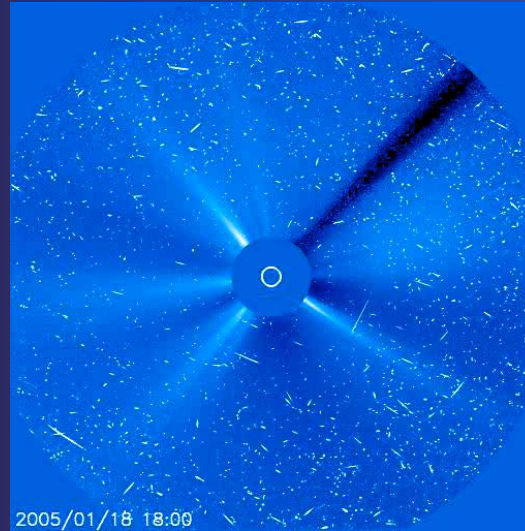
November 6-11, 2004



Events in January 2005

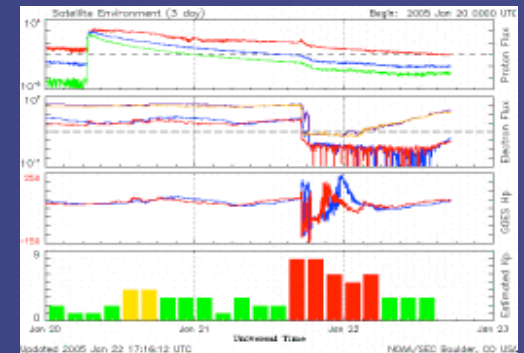
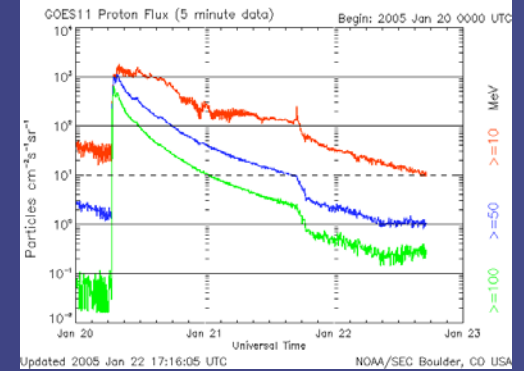
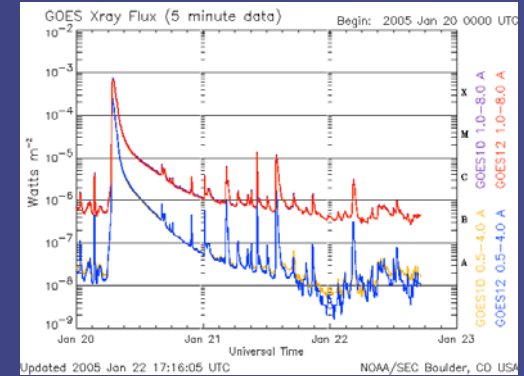


2004/12/14 03:18



2005/01/18 18:09

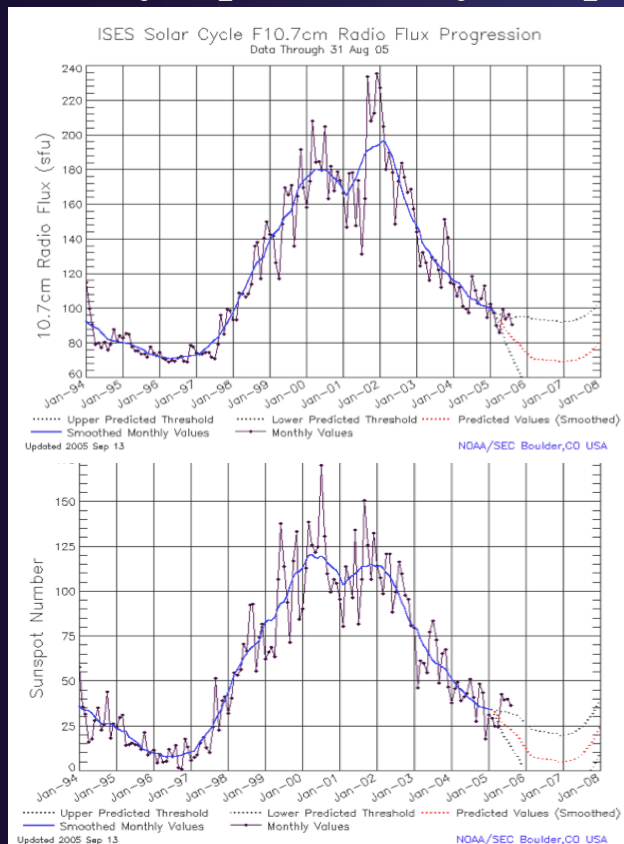
Proton events
Severe geomagnetic storms
Aurora seen in Arizona
Satellites failure



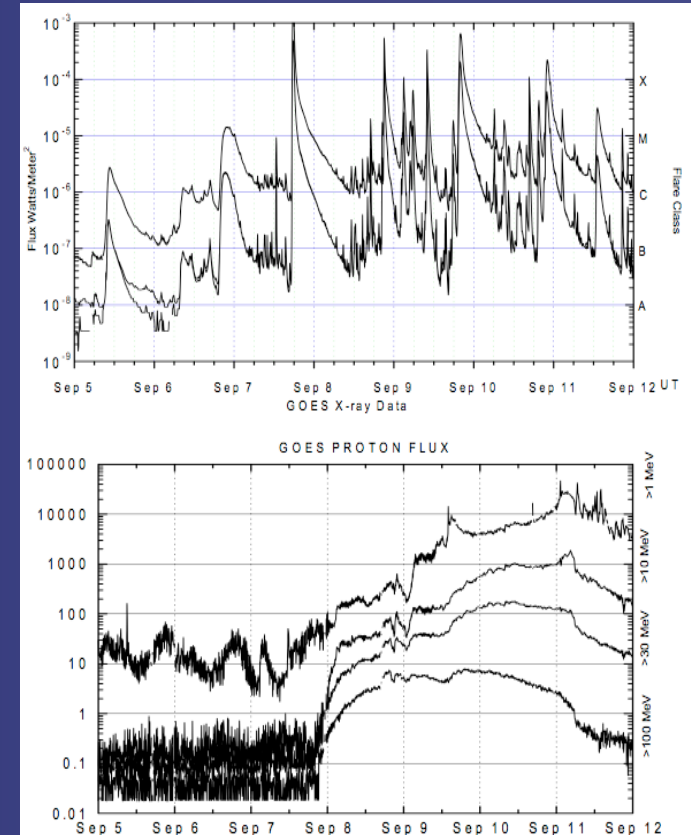
Rz and F10.7 are no good indicators of coronal activity (1D): The activity in September 2005 might not be unusual!

On September 7, 2005 an X17 solar flare occurred(!) and we have had as many severe geomagnetic storms and X flares in 2005 (i.e. close to sunspot min) as during Solar Max (2000)!

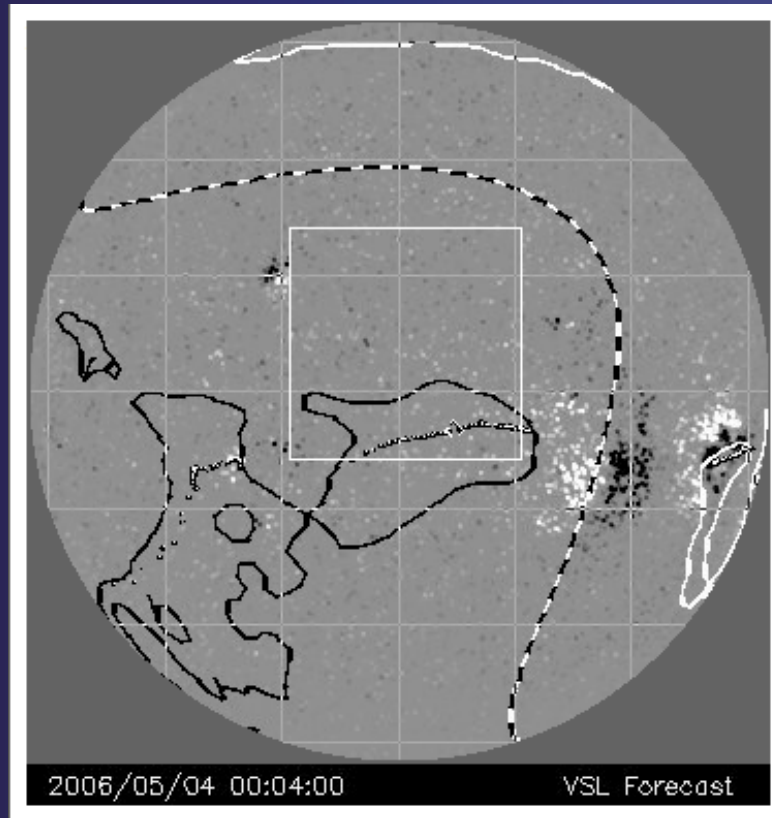
Strong solar surface magnetic field activity represented by sunspots



Coronal flare, CME/proton activity and coronal hole/fast solar wind



Today's space weather





THE END

Thanks!