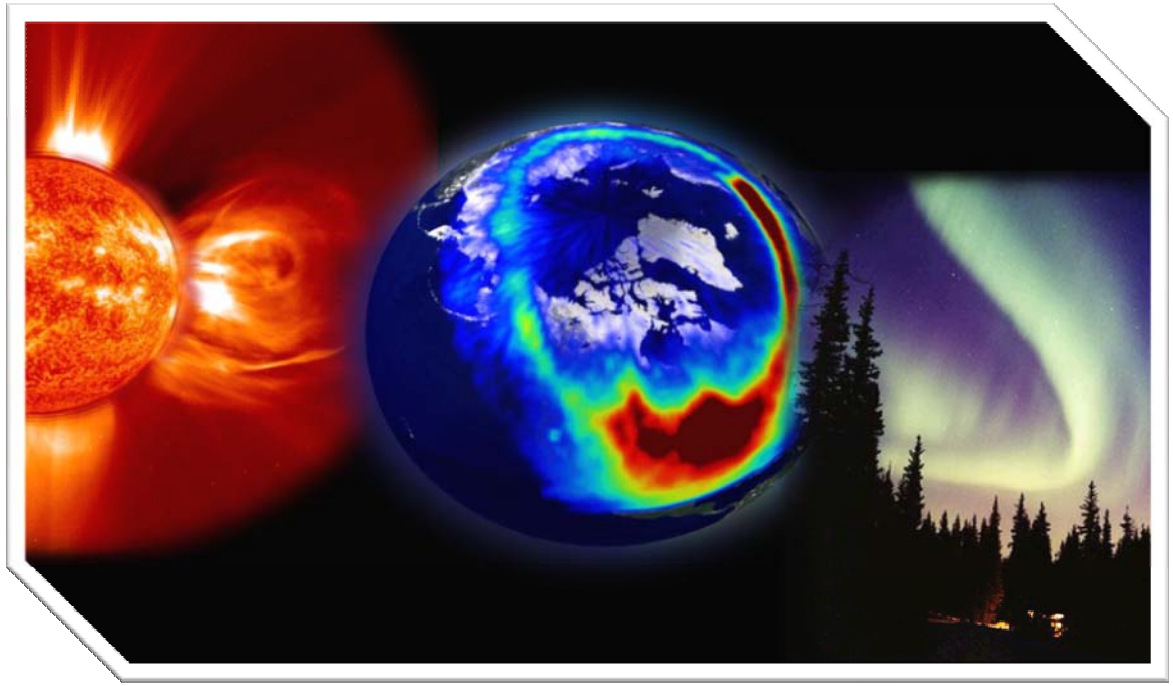
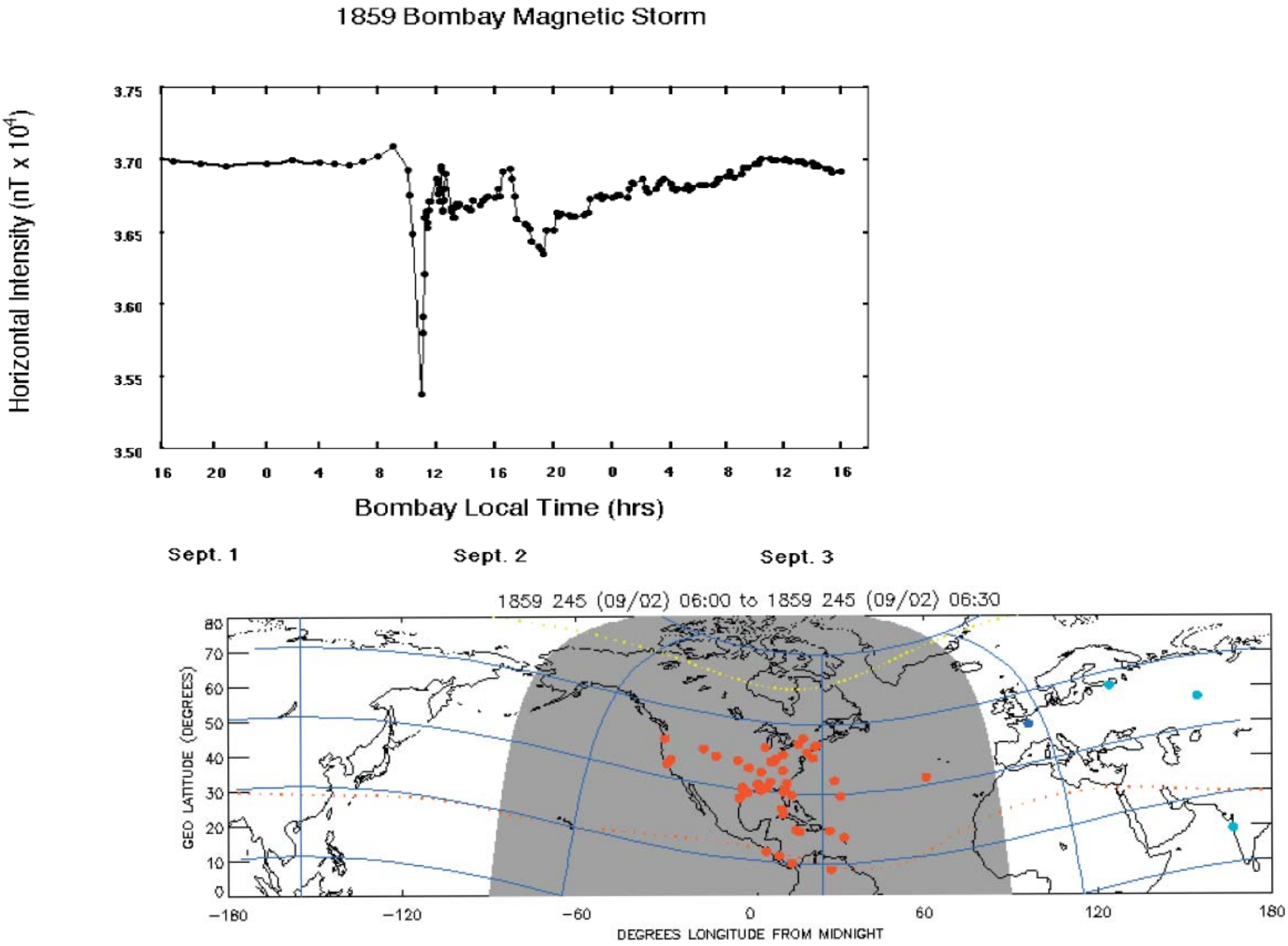


# Meteorología Espacial: Sistemas de predicción y aviso

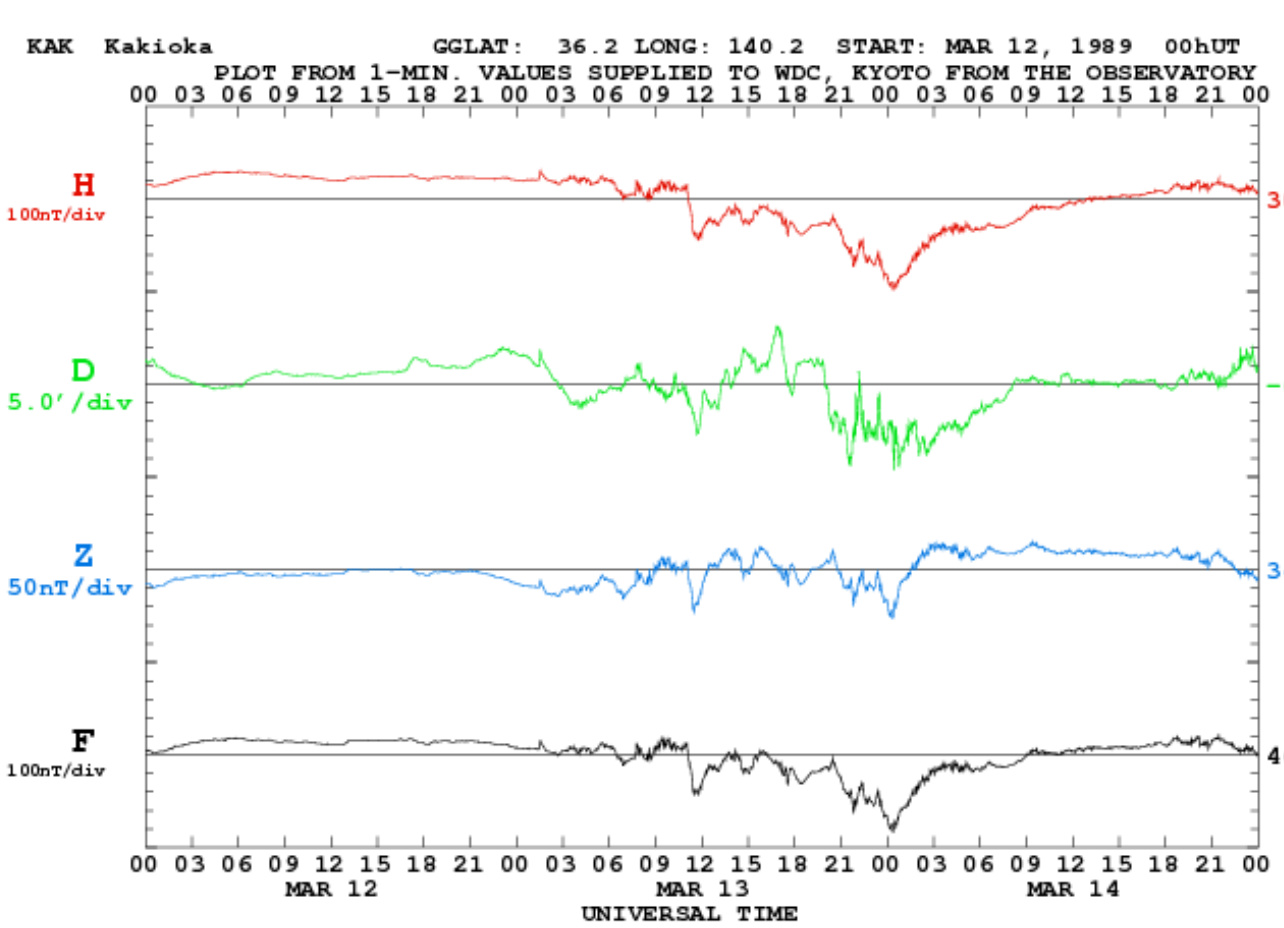
Consuelo Cid
SRG - Space Weather, Departamento de Física, Universidad de Alcalá
consuelo.cid@uah.es




Locations of reported auroral observations during the first ~1.5 hours of the September 2, 1859, magnetic storm . Courtesy J.L. Green, NASA

- Problemas en el telégrafo ( ~8 horas)
- “Luces nocturnas” en todo el globo
- Carrington lo relaciona con dos emisiones brillantes en luz blanca seguidas procedentes de un grupo de manchas grande y complejo cerca del centro del disco (“One swallow does not make a summer”)


Thomas Alva Edison
(1847 -1931)



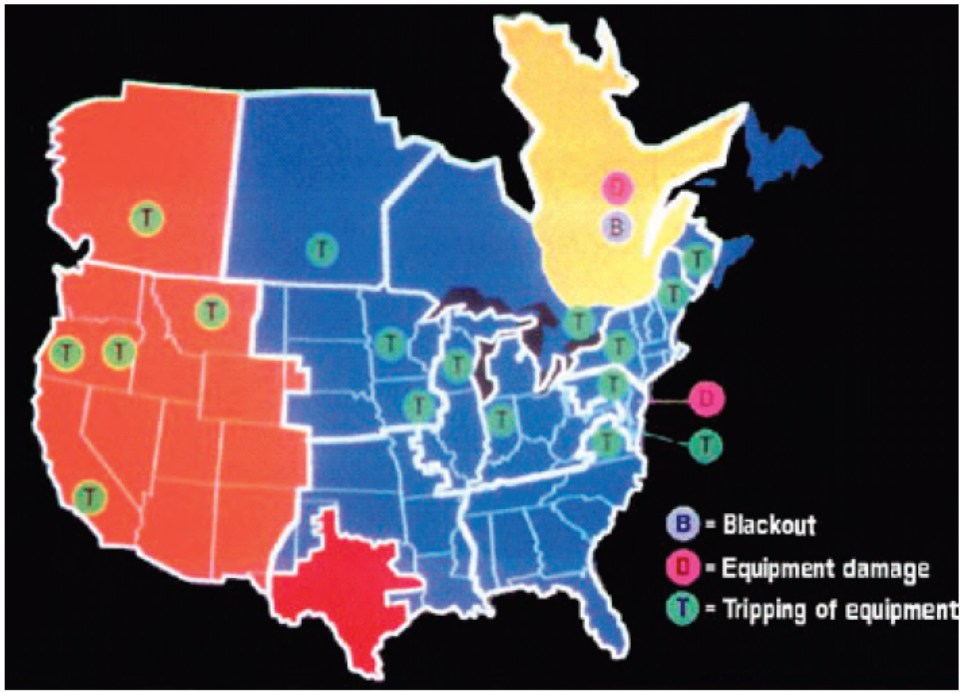


~ 1/3 menos intensa en la variación de campo magnético que el suceso de 1859

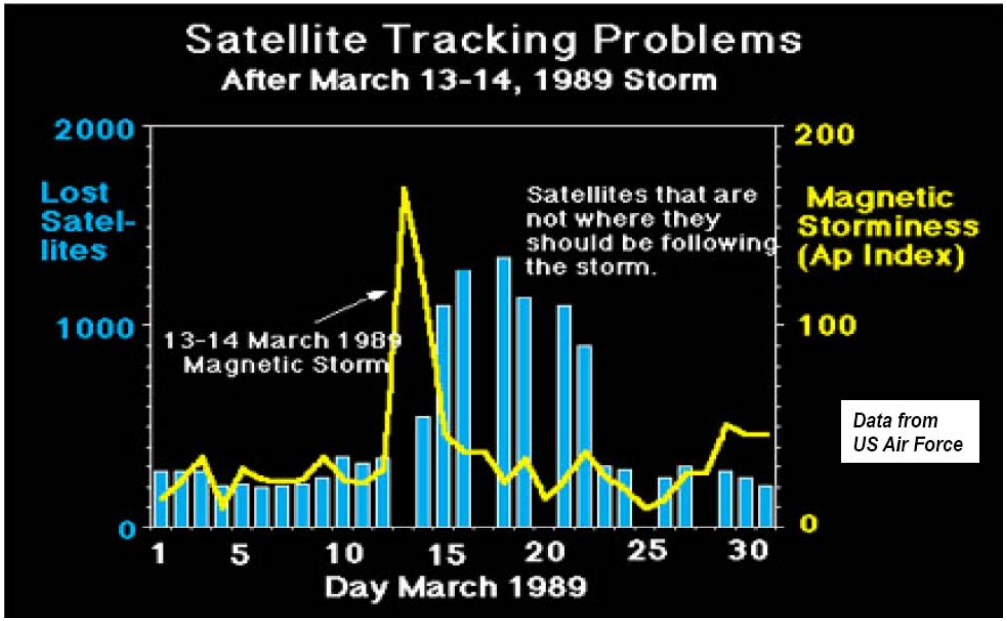
- El sistema eléctrico de Quebec sufrió un apagón de 9 horas
- Hubo problemas con numerosos satélites

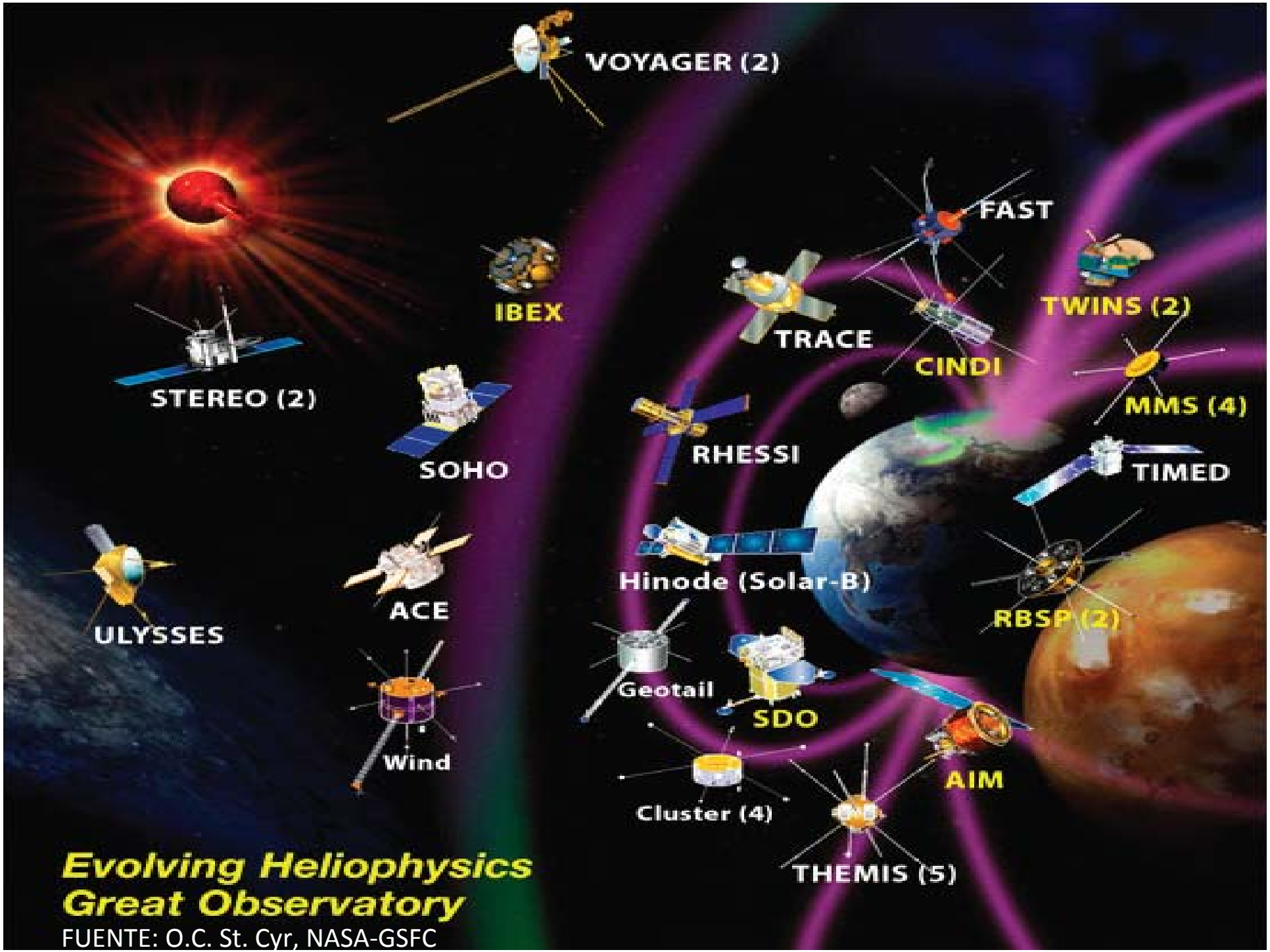
**Daño en el transformador**

**Sobrecalentamiento**




Power system events due to the March 13, 1989, geomagnetic storm.
SOURCE: Electric Power Research Institute, Inc.

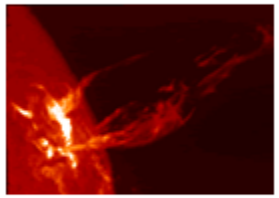





FUENTE: O.C. St. Cyr, NASA-GSFC

*http://www.swpc.noaa.gov/forecast.html*

## NOAA / Space Weather Prediction Center



### 3-day Report of Solar and Geophysical Activity

Last 75 Reports | Today's Space Weather | Space Weather Now

**Prepared jointly by the U.S. Dept. of Commerce, NOAA, Space Weather Prediction Center and the U.S. Air Force.**
**Updated 2011 Mar 21 2200 UTC**

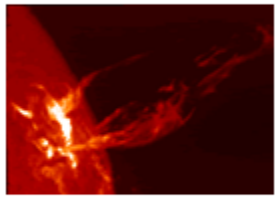
```
Joint USAF/NOAA Report of Solar and Geophysical Activity
SDF Number 080 Issued at 2200Z on 21 Mar 2011
```

IA. Analysis of Solar Active Regions and Activity from 20/2100Z to 21/2100Z: Solar activity increased to low levels. Isolated C-class flares were observed, the largest of which was a long-duration C4 at 21/1719Z from newly-numbered Region 1176 (S13E81). Region 1176 was the return of old Region 1165, which produced M-class flares during its previous rotation. SOHO/LASCO images showed a halo-CME, first visible in C2 images at 21/0236Z. The halo-CME was determined to be a backside event associated with a flare from old Region 1169 (N20, L=061).

IB. Solar Activity Forecast: Solar activity is expected to be low during days 1 - 3 (22 - 24 March) with a chance for an M-class flare from Region 1176.

*http://www.swpc.noaa.gov/forecast.html*

## NOAA / Space Weather Prediction Center



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SDF Number 080 Issued at 2200Z on 21 Mar 2011

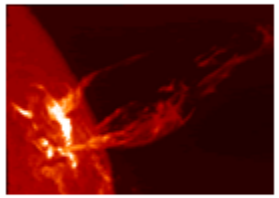
IA.  Analysis of Solar Active Regions and Activity from  20/2100Z
to 21/2100Z:  Solar activity increased to low levels. Isolated
C-class flares were observed, the largest of which was a
```

IIA. Geophysical Activity Summary 20/2100Z to 21/2100Z: Geomagnetic field activity was at quiet levels. A greater than 10 MeV proton event at geosynchronous orbit began at 21/1950Z and was in progress at the time of this report. Stereo-A EUVI 195 images indicated the source for the proton event was likely a flare from old Region 1169 which also spawned the back sided halo-CME mentioned above.

IIB. Geophysical Activity Forecast: Geomagnetic activity is expected to be at quiet levels during days 1 - 2 (22 - 23 March). Geomagnetic activity is expected to increase to quiet to unsettled levels on day 3 (24 March) as a coronal hole high-speed stream begins to disturb the field. The greater than 10 MeV event at geosynchronous orbit is expected to end on day 1 (March 22).

*http://www.swpc.noaa.gov/forecast.html*

## NOAA / Space Weather Prediction Center



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IA.  Analysis of Solar Active Regions and Activity from
to 21/2100Z:  Solar ac
C-class flares were ob
long-duration C4 at 21
```

```
/0236Z.
```

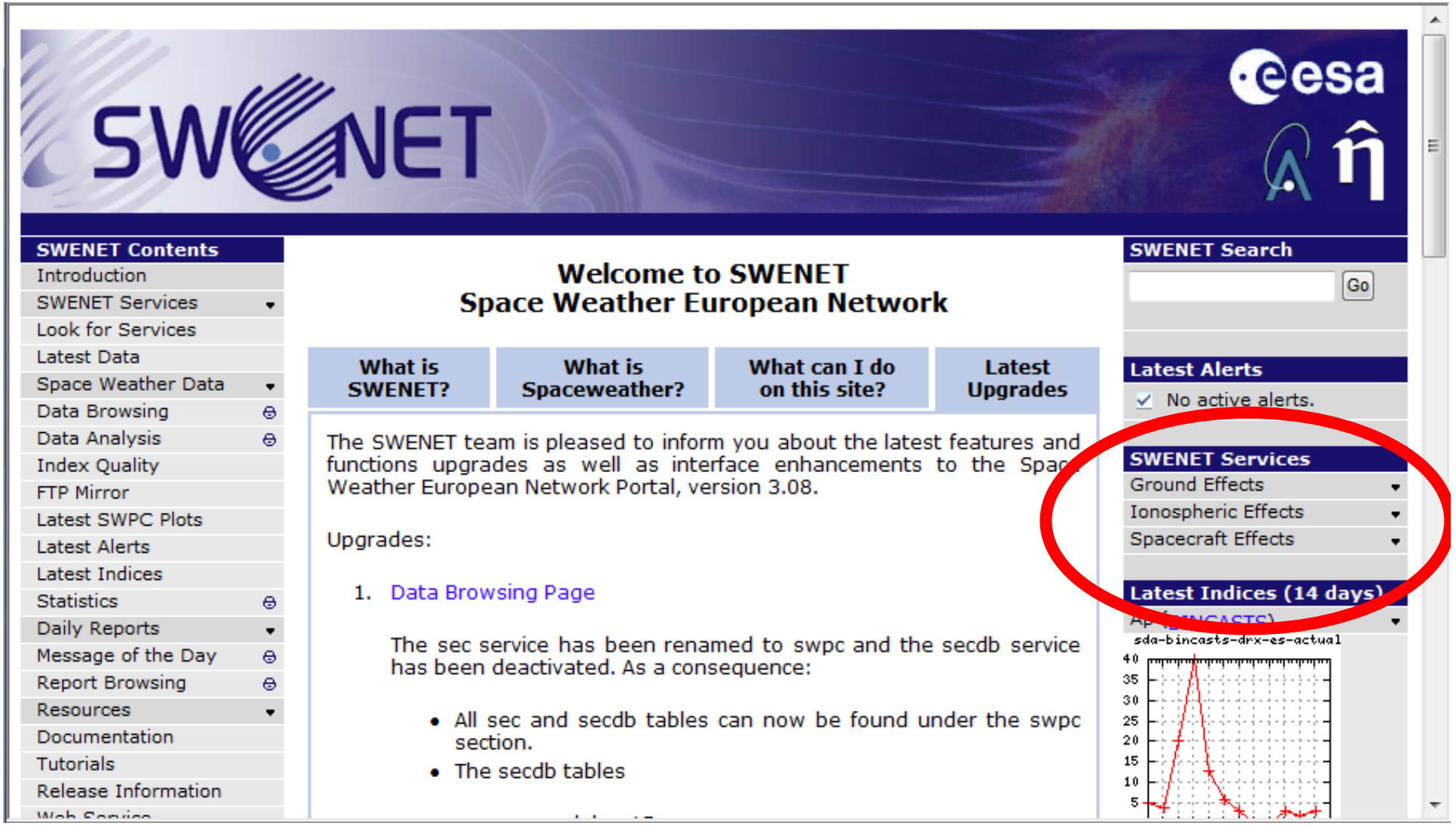
III. Event Probabilities
22 Mar-24 Mar
Class M 30/30/30
Class X 05/05/05
Proton 10/01/01
PCAF green

IV. Penticton 10.7 cm Flux
Observed 21 Mar 101
Predicted 22 Mar-24 Mar
115/125/135 90 Day Mea
21 Mar 094

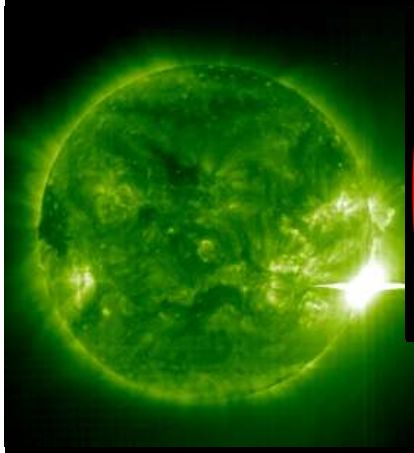
V. Geomagnetic A Indices Observed
Afr/Ap 20 Mar 004/004
Estimated Afr/Ap 21 Mar 002/004
Predicted Afr/Ap 22 Mar-24 Mar
005/005-005/005-008/008

VI. Geomagnetic Activity Probabilities
22 Mar-24 Mar A.
Middle Latitudes Active 10/10/15 Minor storm 01/01/05 Major-severe storm 01/01/01 B.
High Latitudes Active 15/15/20 Minor storm 01/01/10 Major-severe storm 01/01/01

http://www.esa-spaceweather.net/swenet/

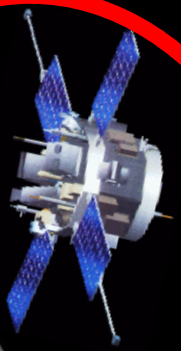


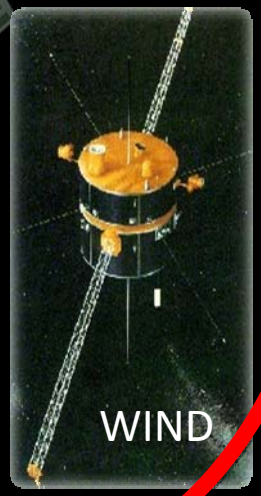
# Los “centinelas”



ACE

SOHO





WIND

L1

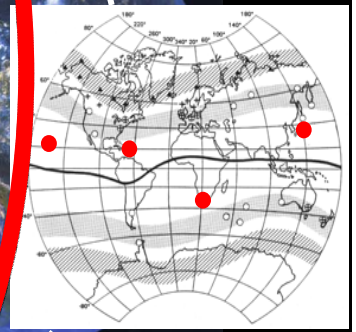
Proba -2

GOES

SDO

geoestacionarios

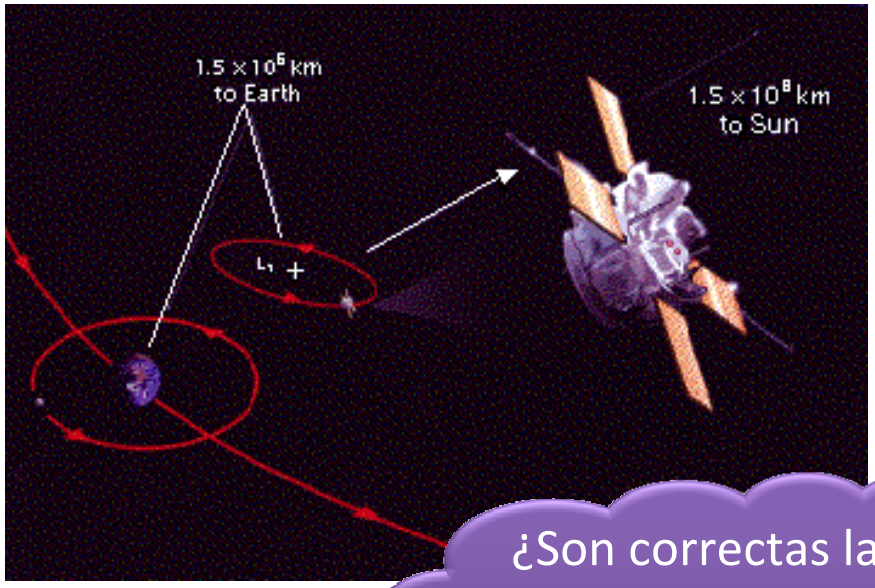
AE



Dst

en superficie

# El tiempo de antelación




Observaciones solares (ej. SOHO) permiten predecir las tormentas con una antelación de 1 a 3 días

Observaciones del viento solar (ej. ACE) permiten predicciones más fiables, pero con una antelación entre 1 y 3 horas

¿Son correctas las afirmaciones anteriores?

¡Depende a qué fenómeno se refieran!

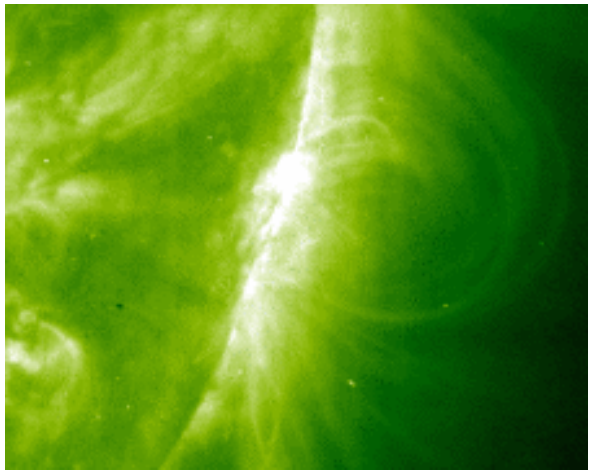
# ¿Qué fenómenos predecir o avisar?

*www.sec.noaa.gov*

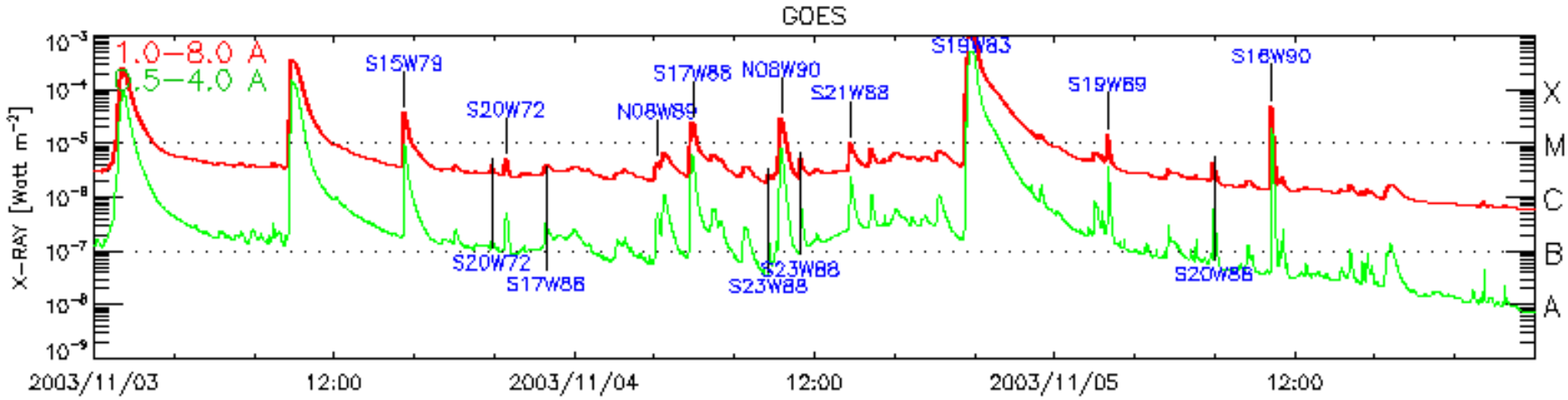
- **Tormentas geomagnéticas**
  - Redes de potencia eléctrica, conducciones de gas, …
- **Tormentas de radiación solar**
  - Astronautas, naves espaciales, líneas aéreas
- **“Bloqueos” de radio**
  - Comunicaciones radio, navegadores

Cada fenómeno puede producirse de forma aislada o acompañado de

# “Bloqueos” radio



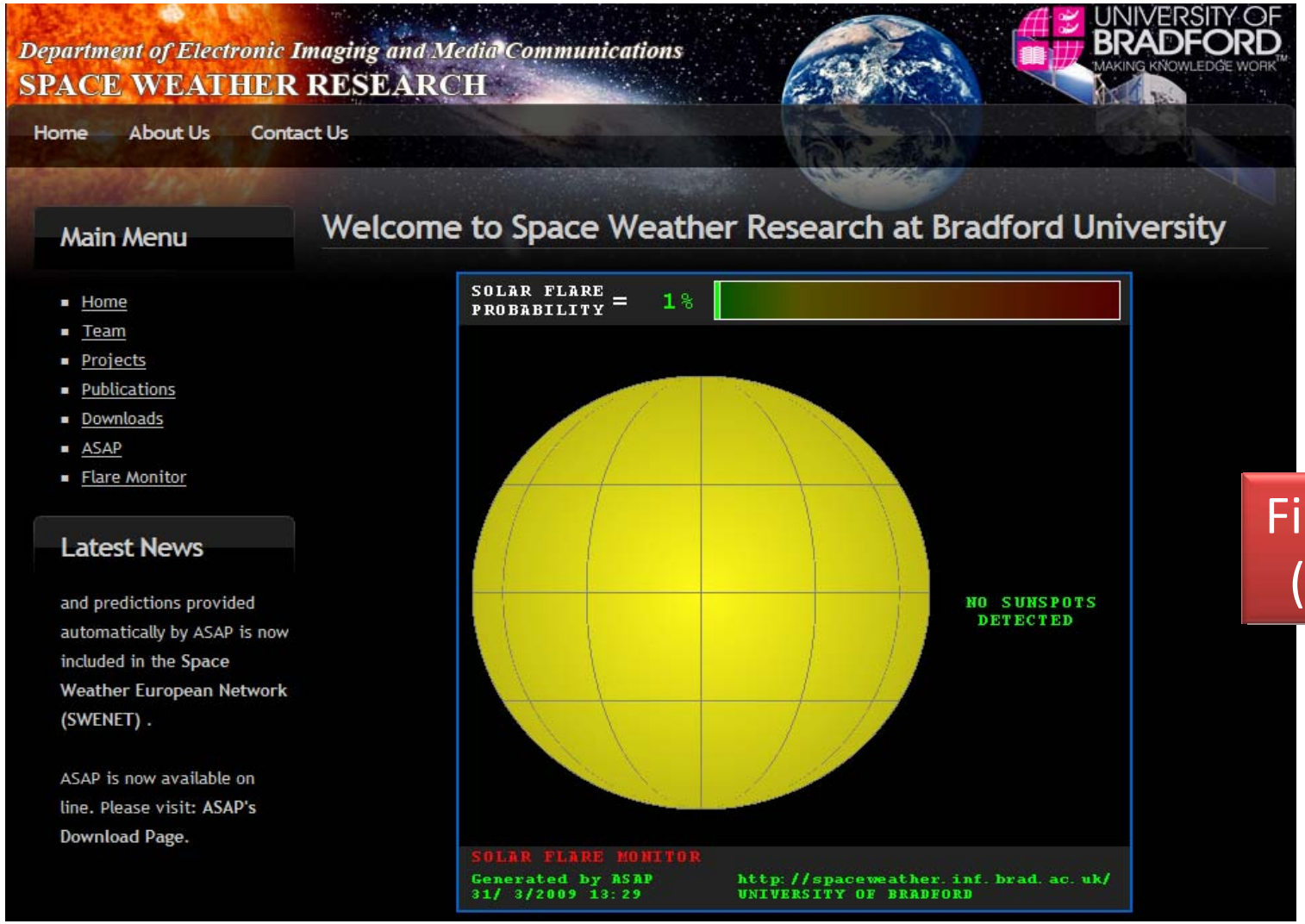
Los problemas se producen en el lado diurno por emisión solar en rayos X o EUV (*luz: 8 minutos*)



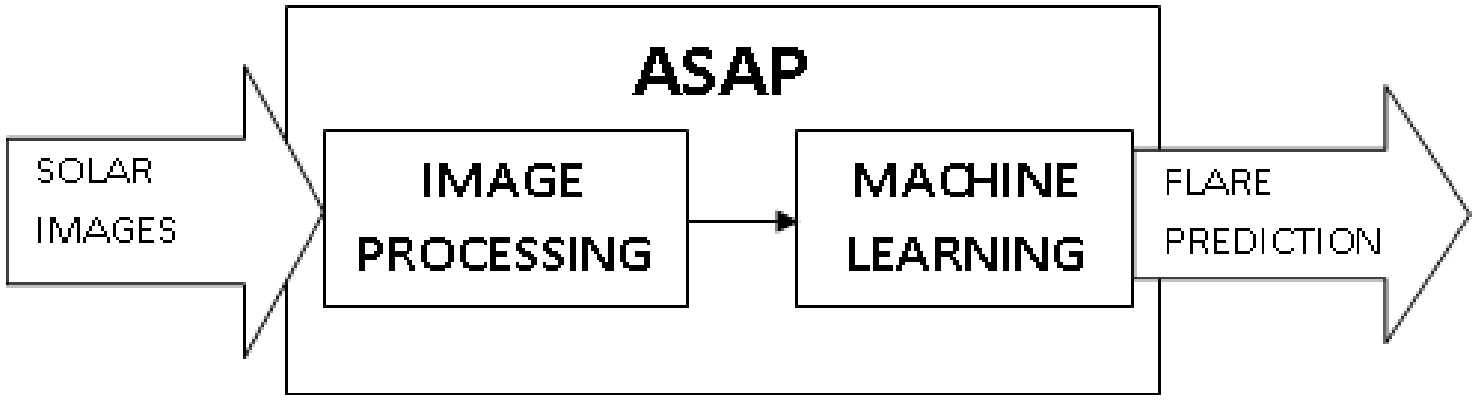
# ASAP (As soon as possible)

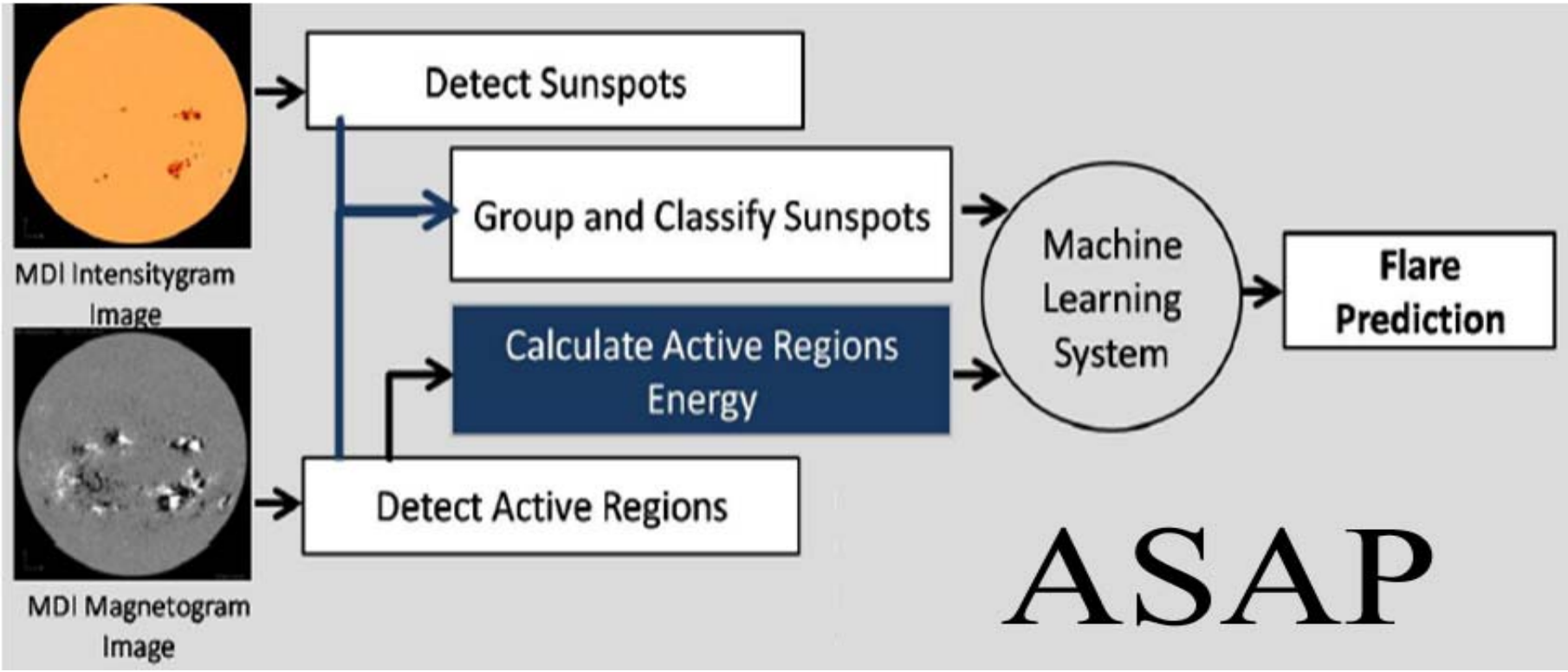
Predicciones automáticas de fulguraciones solares en la web

**http://spaceweather.inf.brad.ac.uk/**




Fiabilidad 70% (según web)

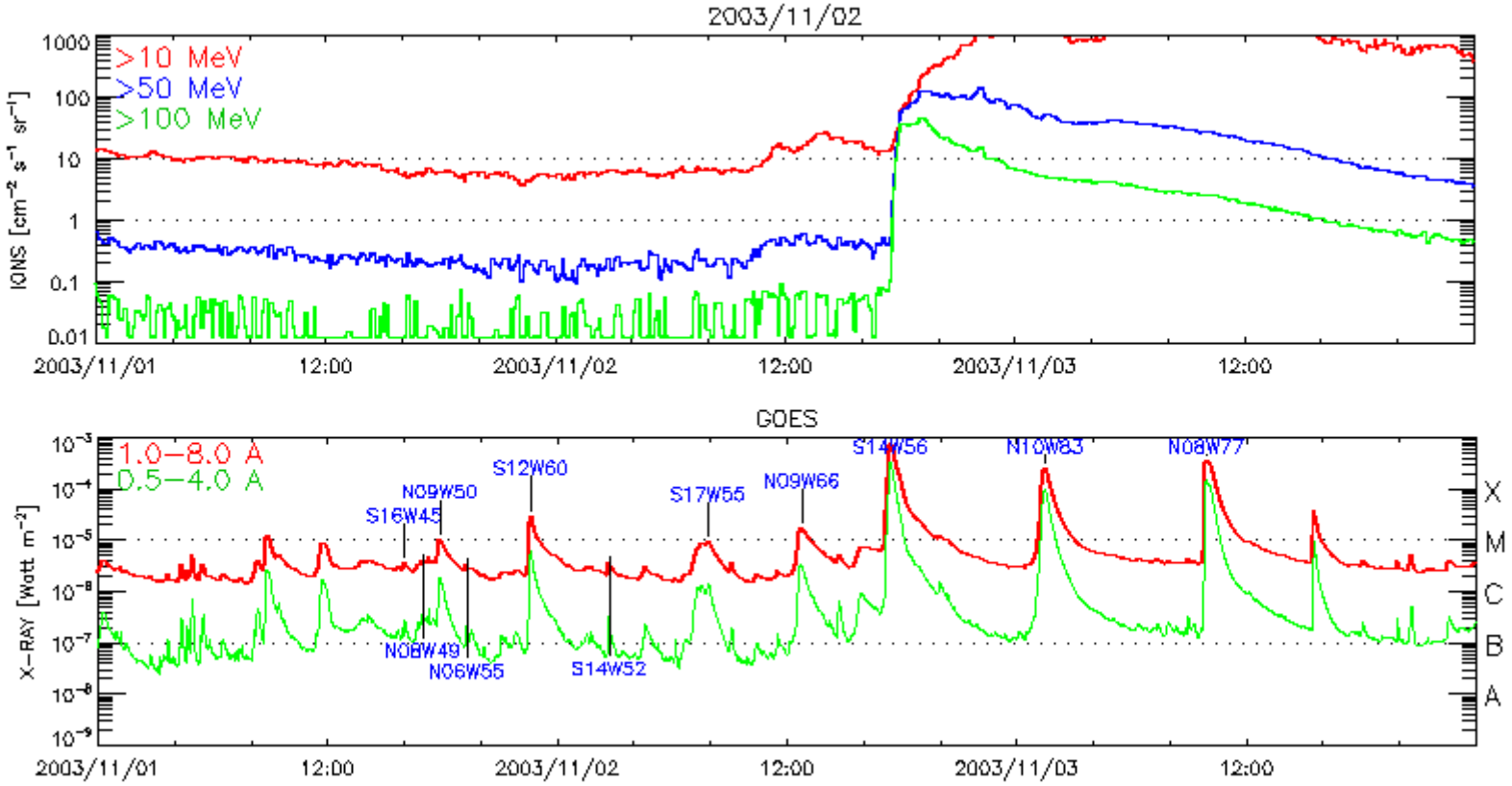



FUENTE: R. Qahwaji, Univ. Bradford, UK

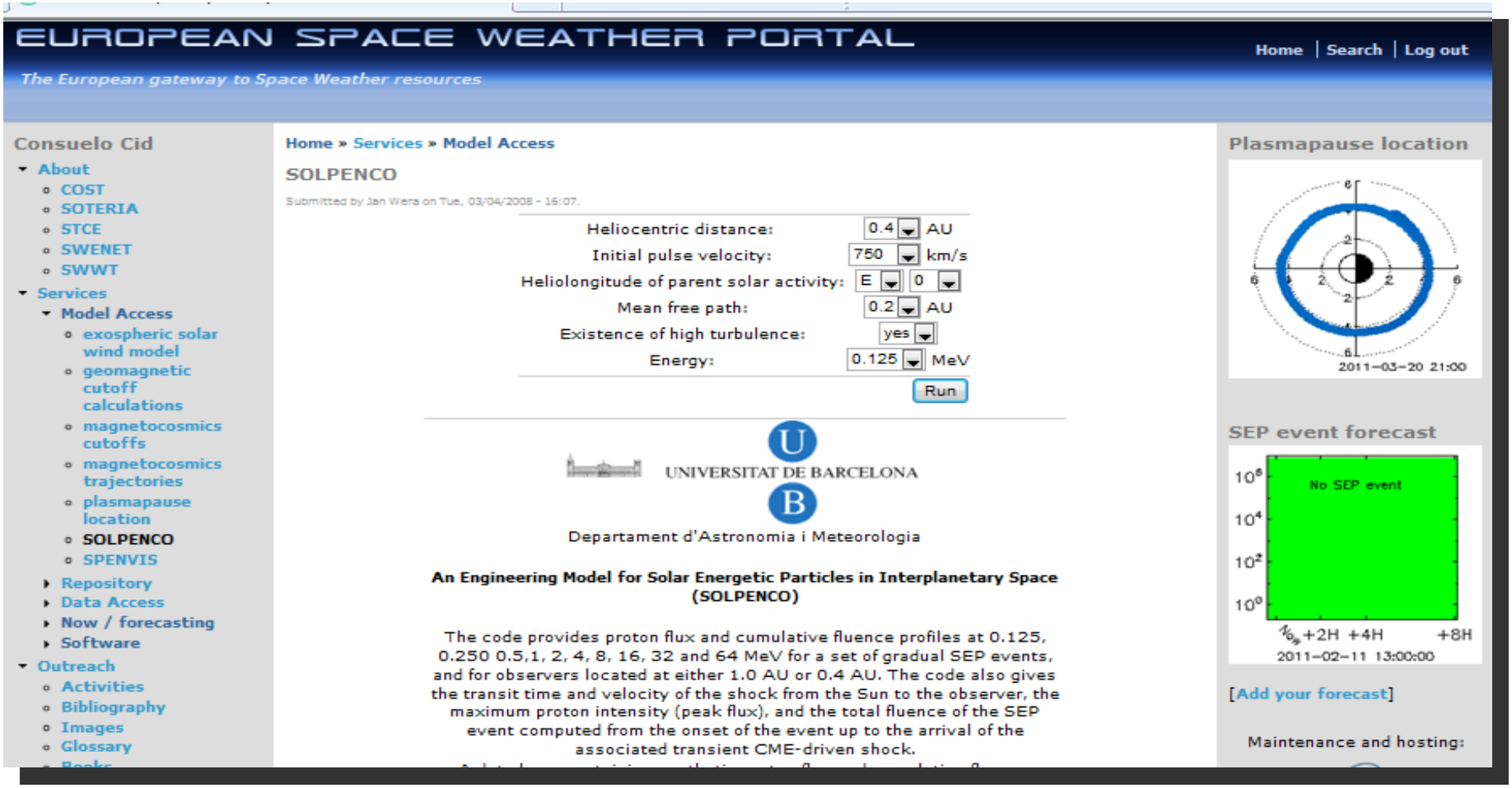
# Tormentas de radiación solar

Los problemas se producen fundamentalmente en las zonas polares y zona de noche (*partículas: 30 min-24 h*)



# SOLPENCO

Predicciones flujo máximo y fluencia de sucesos de partículas energéticas **a partir de leyes físicas**




*www.spaceweather.eu/es/solpenco*

# EUROPEAN SPACE WEATHER PORTAL

*The European gateway to Space Weather resources*



Consuelo Cid

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  - SOTERIA
  - STCE
  - SWENET
  - SWWT
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    - geomagnetic cutoff calculations
    - magnetocosmics cutoffs
    - magnetocosmics trajectories
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## SOLPENCO

Submitted by Jan Wera on Tue, 03/04/2008 - 16:07.

**Input parameters:**

| | |
|---|---|
| Radial distance (AU): | 0.4 |
| Angular position of the observer: | W00 |
| Initial pulse velocity (km s$^{-1}$): | 750.0 |
| Turbulent foreshock region: | Yes |
| Proton mean free path (AU): | 0.2 |
| Proton energy (MeV): | 0.125 |

**Shock arrival at spacecraft:**

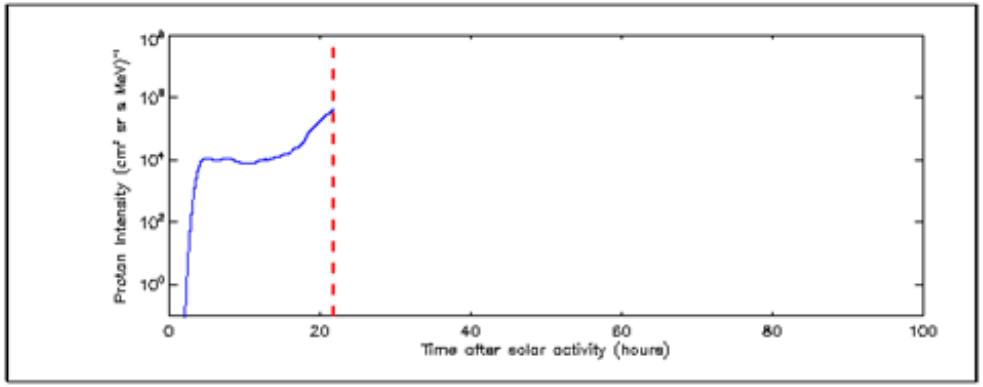
**Transit time** = 21.89 hours

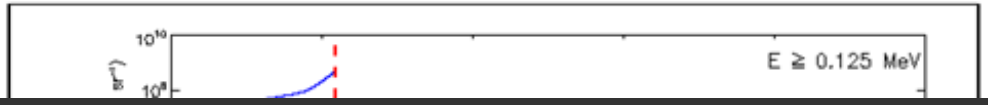
**Transit velocity** = 760.7 km s$^{-1}$

**Total fluence** = 5.3e+08 cm$^{-2}$ sr$^{-1}$

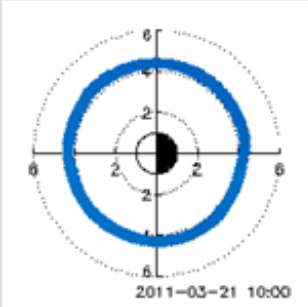
**Peak Intensity:**

4.4e+05 cm$^{-2}$ sr$^{-1}$ s$^{-1}$ MeV$^{-1}$ at 21.89 hours

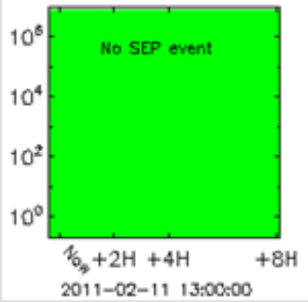



## Plasmapause location

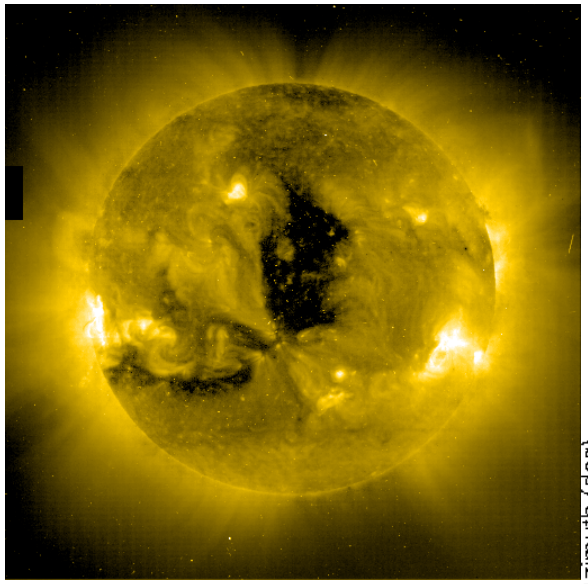



## SEP event forecast

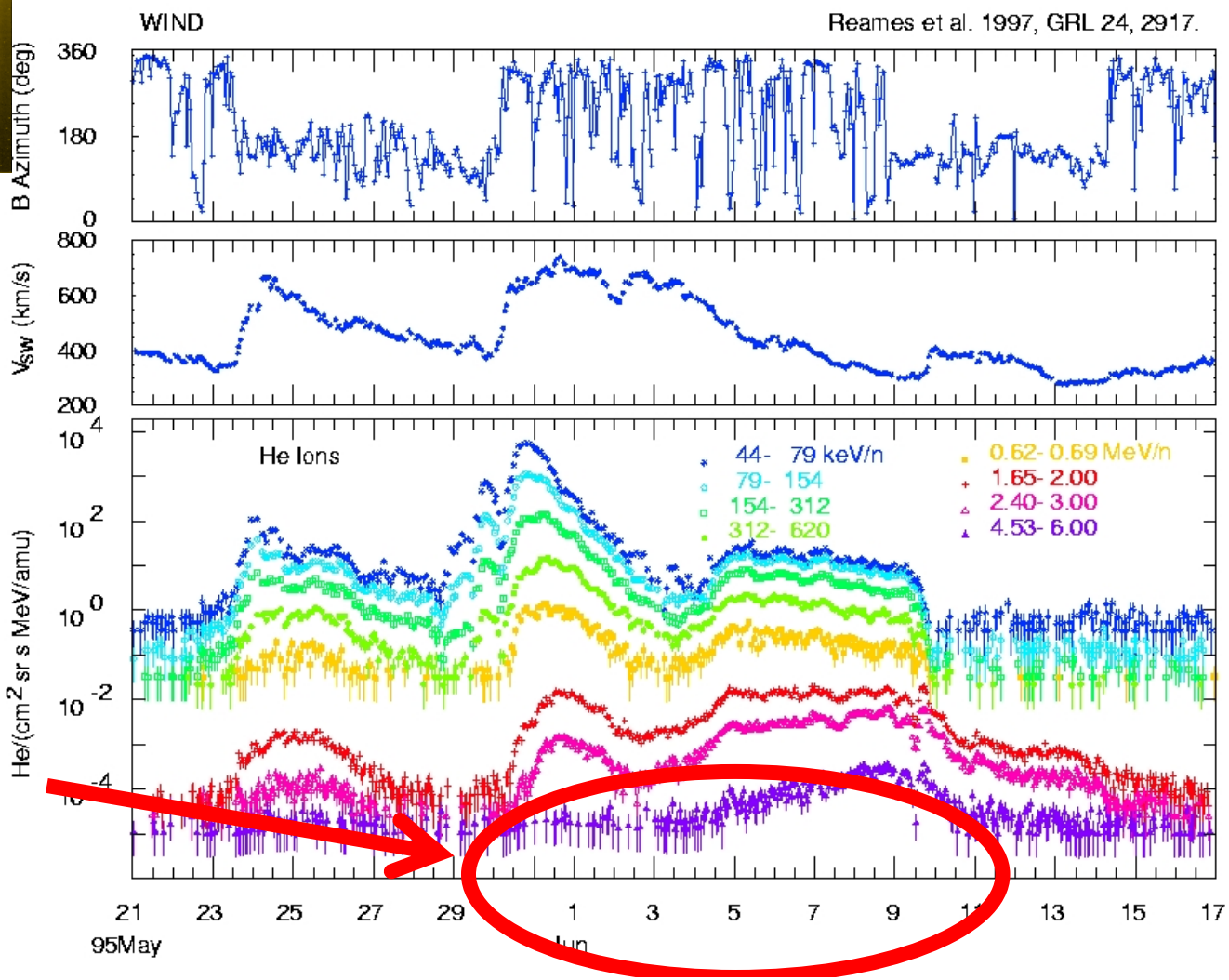



[Add your forecast]

Maintenance and hosting:



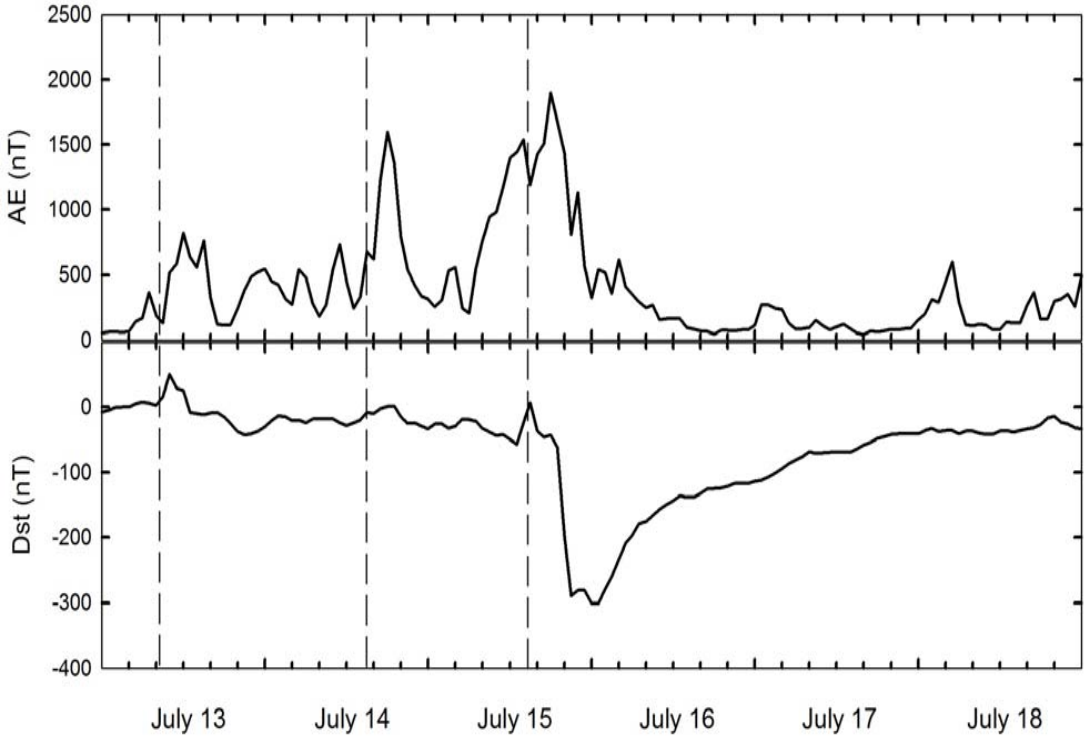
# Los agujeros coronales también generan partículas relativistas

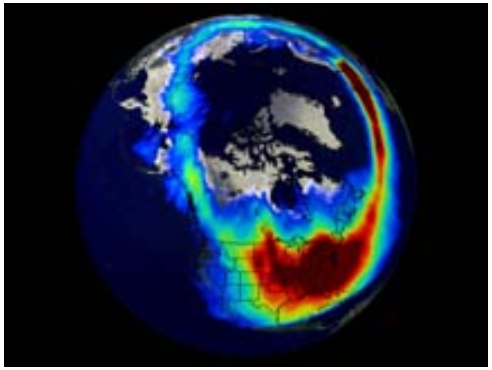



¡varios **días**!

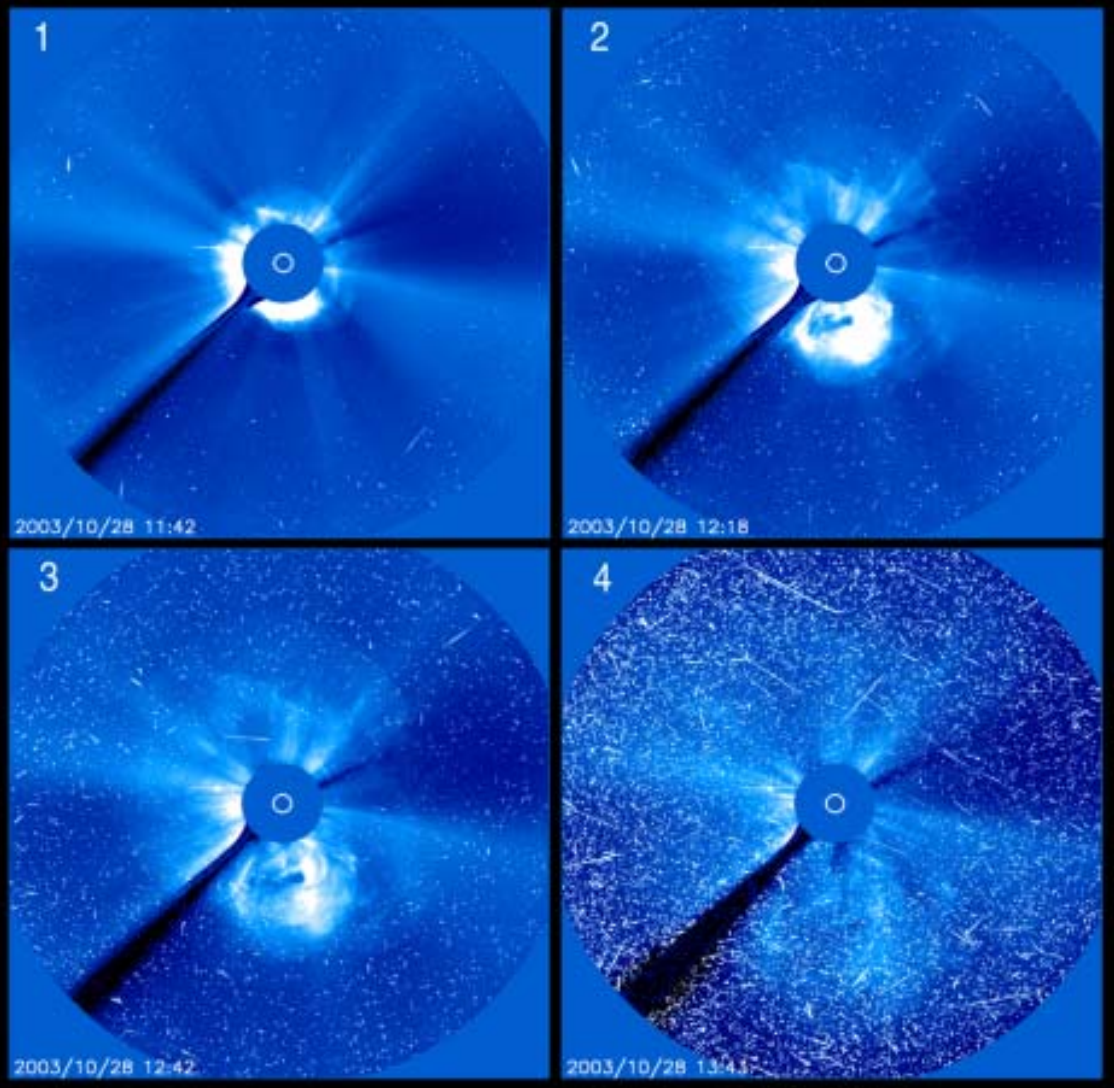
# Tormentas geomagnéticas

Implican un aumento en las corrientes de la magnetosfera, fundamentalmente en el anillo de corriente (*plasma 1-4 días*)

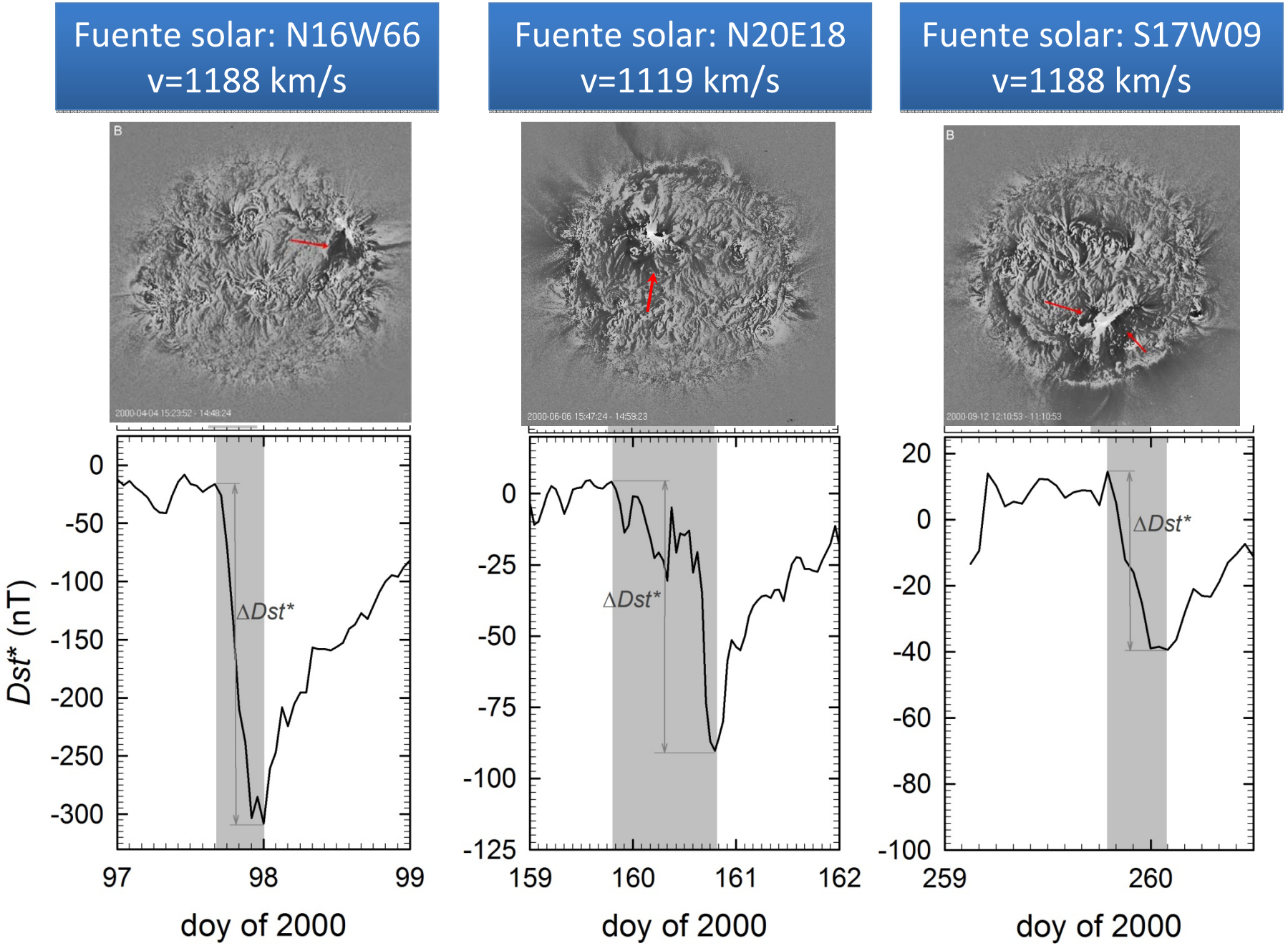


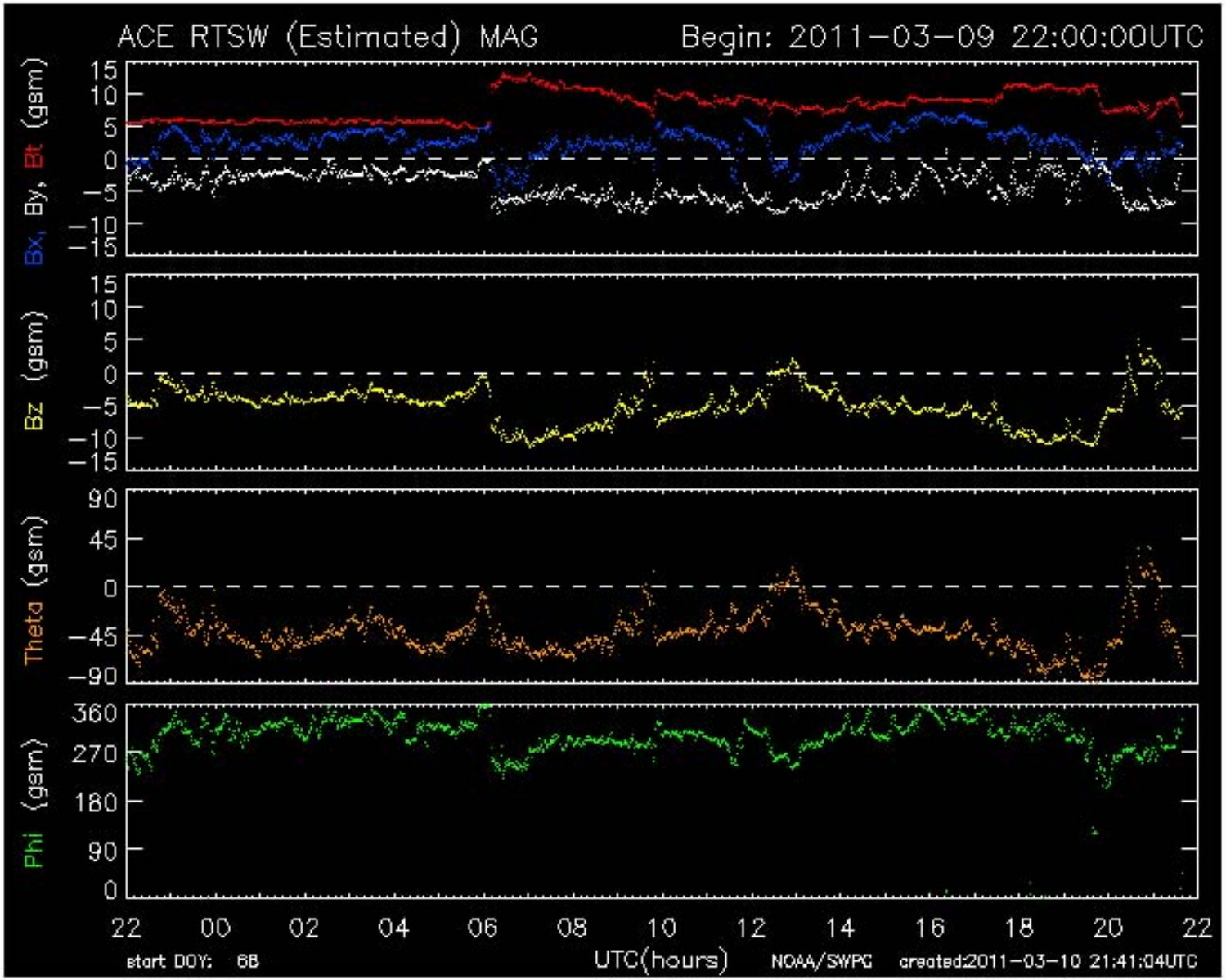



¿Es posible saber si el plasma de una CME llegará a la Tierra?



*Rodriguez et al., Space Weather, 2009*




ACE RTSW (Estimated) MAG
Begin: 2011-03-09 22:00:00UTC
Bx, By, Bt (gsm)
Bz (gsm)
Theta (gsm)
Phi (gsm)
22 00 02 04 06 08 10 12 14 16 18 20 22
start DOY: 68
UTC(hours)
NOAA/SWPC
created:2011-03-10 21:41:04UTC

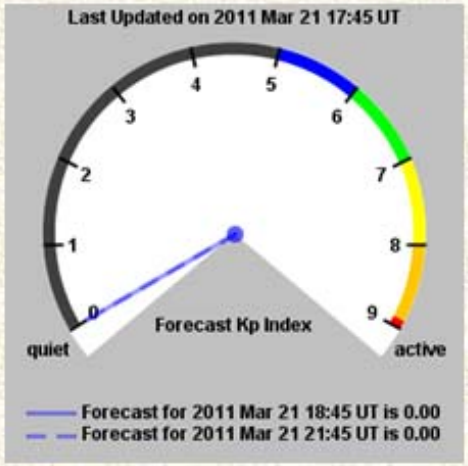
http://sd-www.jhuapl.edu/UPOS/kp_dst/kp_dst.html

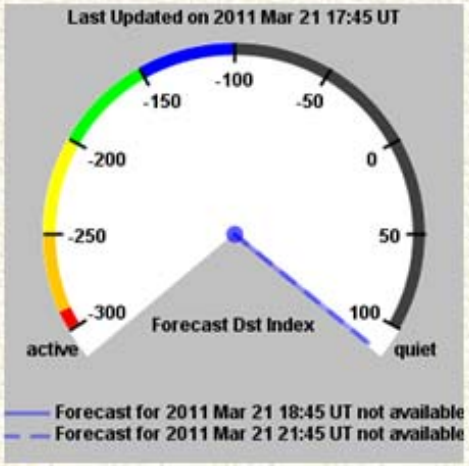
**University Partnering for Operational Support**

**JHU/APL - University of Alaska)**

## Predicting Geomagnetic Activity and Storms

As technology advances, space weather prediction has become increasingly important to many human activities, e.g., communications, navigation systems, satellites, power grid, space travel, etc. Kp and Dst are two of the most common indices used to indicate the severity of disturbances in near-Earth space. For the past few years, the ACE spacecraft, located at the L1 point, has been reliably providing solar wind measurements up to approximately 45-60 minutes in advance of its arrival at Earth. Kp and Dst models based on solar wind input can use ACE observations to make short-term forecasts of these two indices.



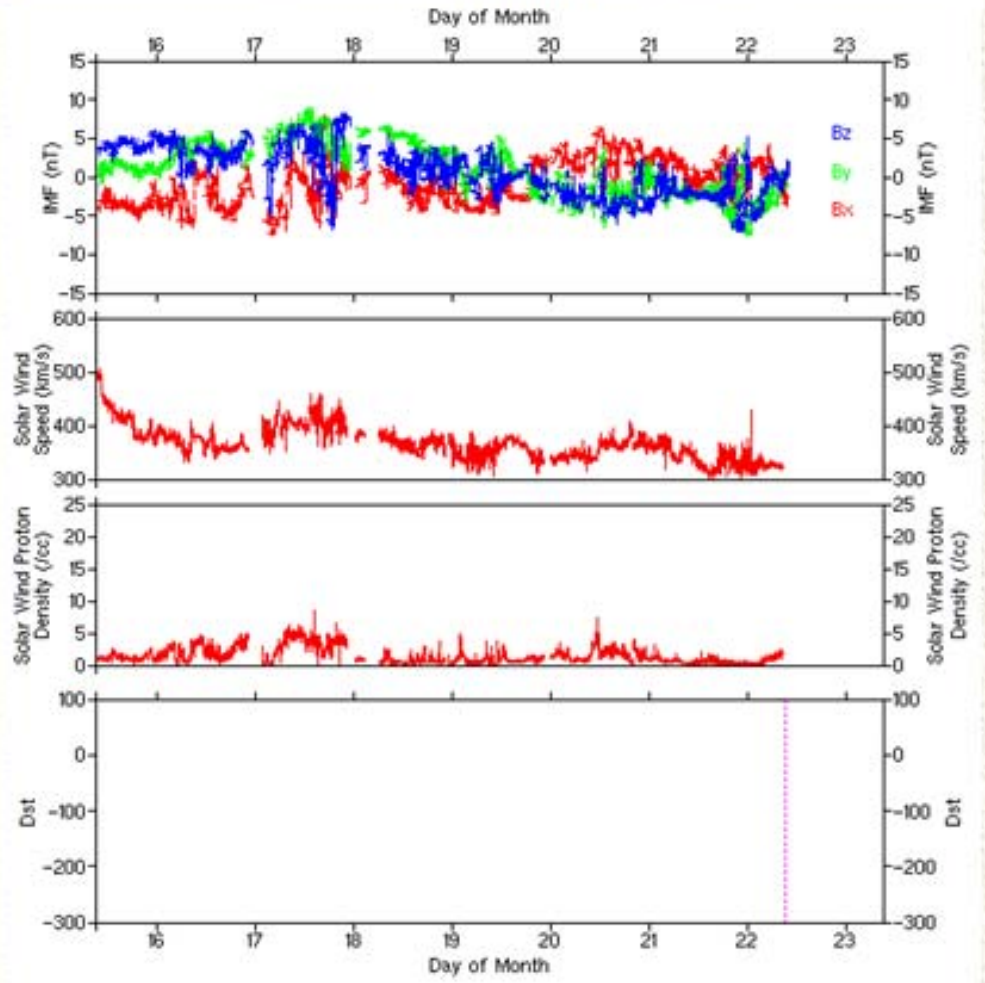




Utilizando redes neuronales y datos de viento solar

Forecasting Dst Home | UPOS home

# Dst 1-Hour Forecast

## 7 Day Display

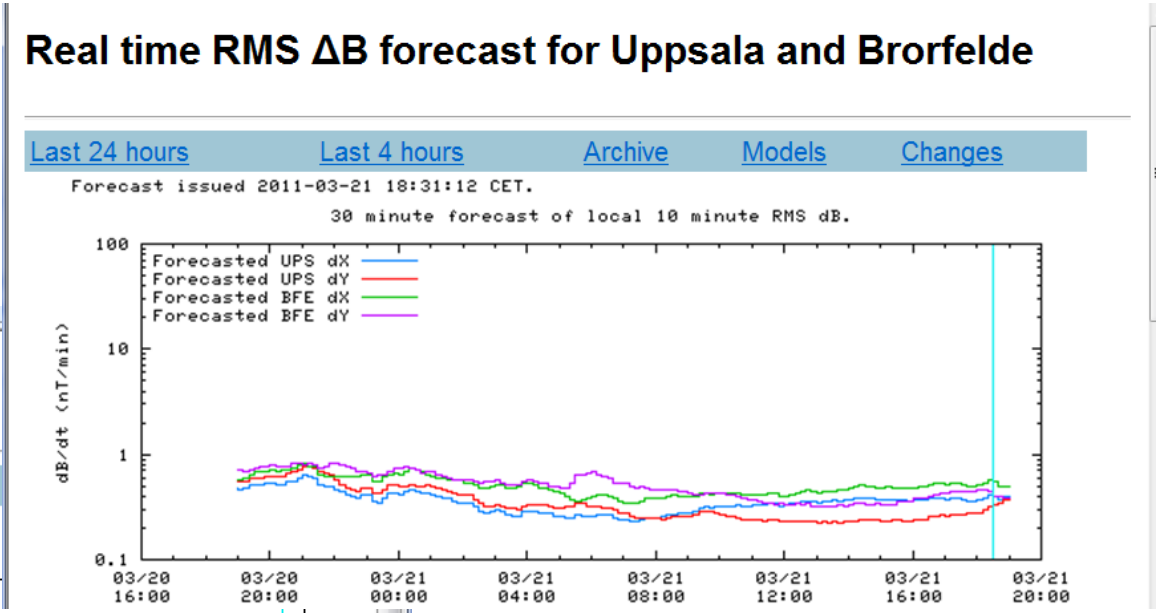


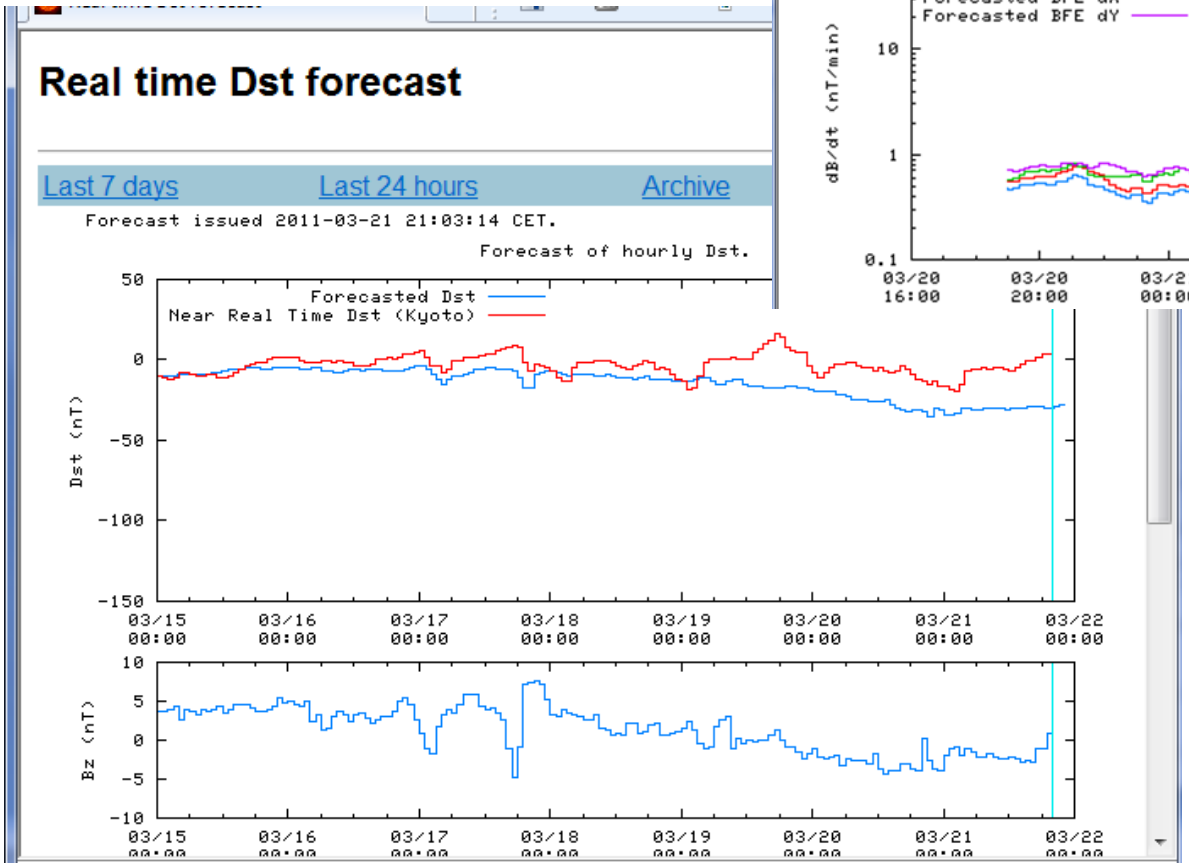

Plots most recently generated on Tue Mar 22 09:00:17 UT 2011

http://sd-www.jhuapl.edu/UPOS/ForecastingDST/index.html

http://rwc.lund.irf.se/rwc/dst/models/dstdoc/index.html

# Swedish Institute of Space Physics




- Datos de viento solar
- Basado en redes neuronales

Home | Team | Space Weather Monitor | Some recent publications | Our activities at ISSI | COST Action ES0803 | SRG Main page

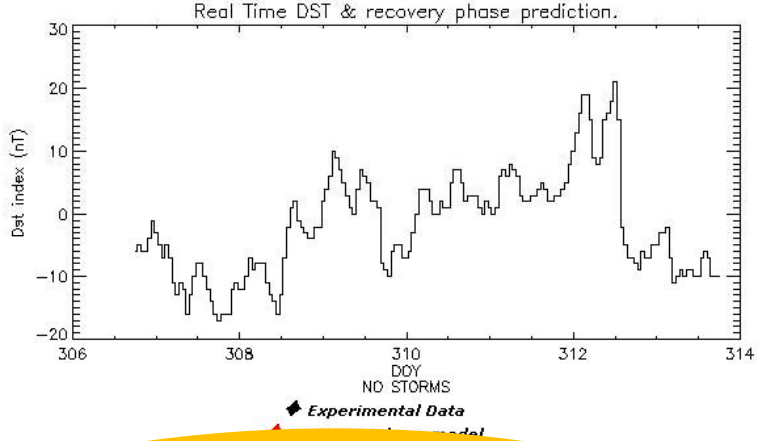
# UAH Space Weather Monitor

Using high resolution real-time magnetic field data from MAG on board ACE spacecraft, the UAH monitor produces an alert when a significant magnetic perturbation is going to take place at the terrestrial surface at low-mid latitudes, as measured by Dst index.

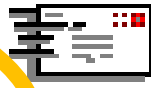
LAST DATA FROM MAG/ACE: 09 Nov 2010 at 18:26 (UT)


The picture displays a red flag for a hazard warning. Green flags indicate no warning

**Using real-time data of the DST index from SWENET, the system produces the expected recovery phase if a hazard warning take place.**




**Información por e-mail**



***TO RECEIVE REAL-TIME ALERTS FILL IN THE INFORMATION BELLOW .***

**Name:**

**Institution Name:**

**Mail:**

Submit

**www.spaceweather.es**

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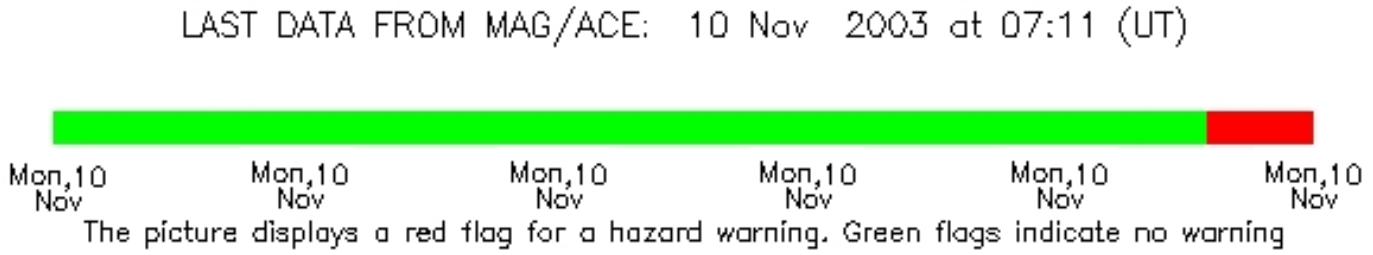
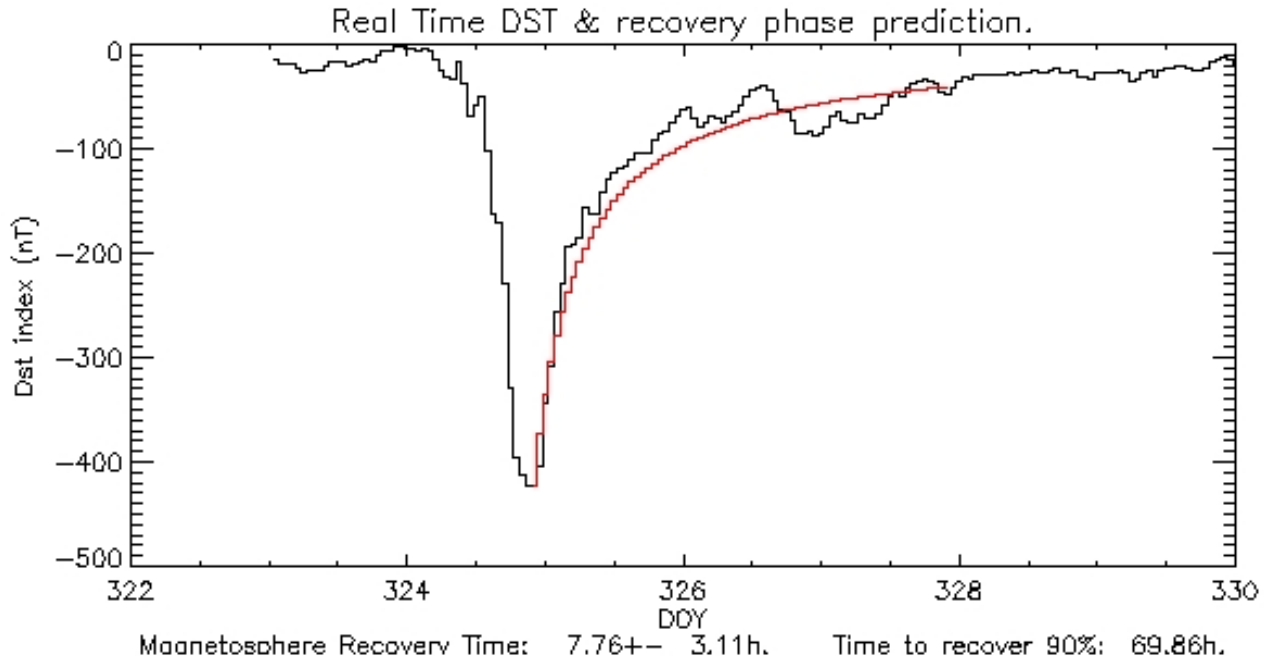



## Sólo datos de $B_z$ y basado en leyes físicas



# CONCLUSIONES

- Es necesario avanzar en el conocimiento de la Ciencia que hay en la interacción entre el Sol y la Tierra para mejorar los sistemas de predicción

- Debe existir un programa de seguridad en el ámbito de la Meteorología Espacial a nivel global para el planeta, tanto a nivel de modelos de predicción, como a nivel de suministro de datos. La colaboración internacional es imprescindible



Gracias por
su atención