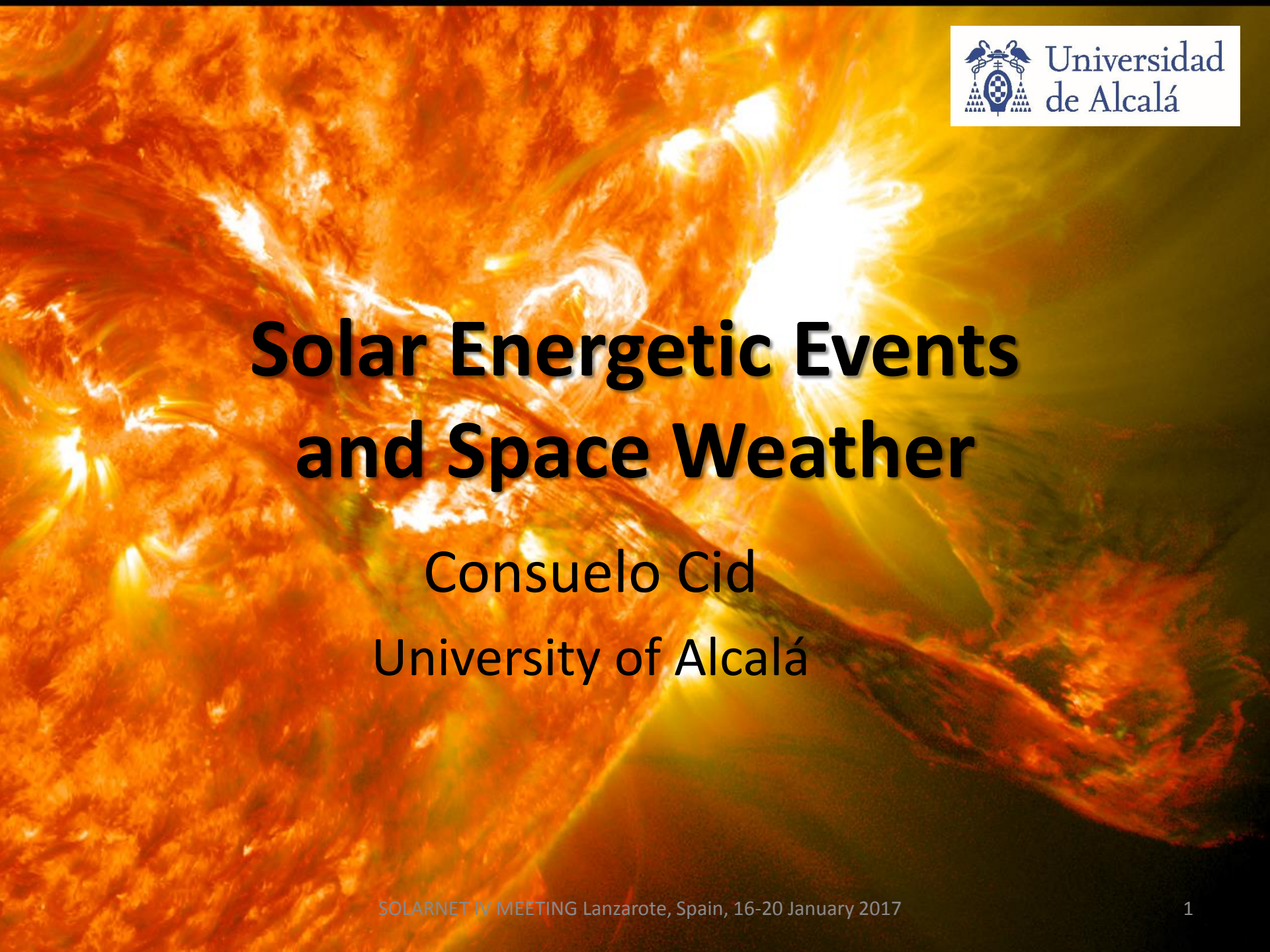
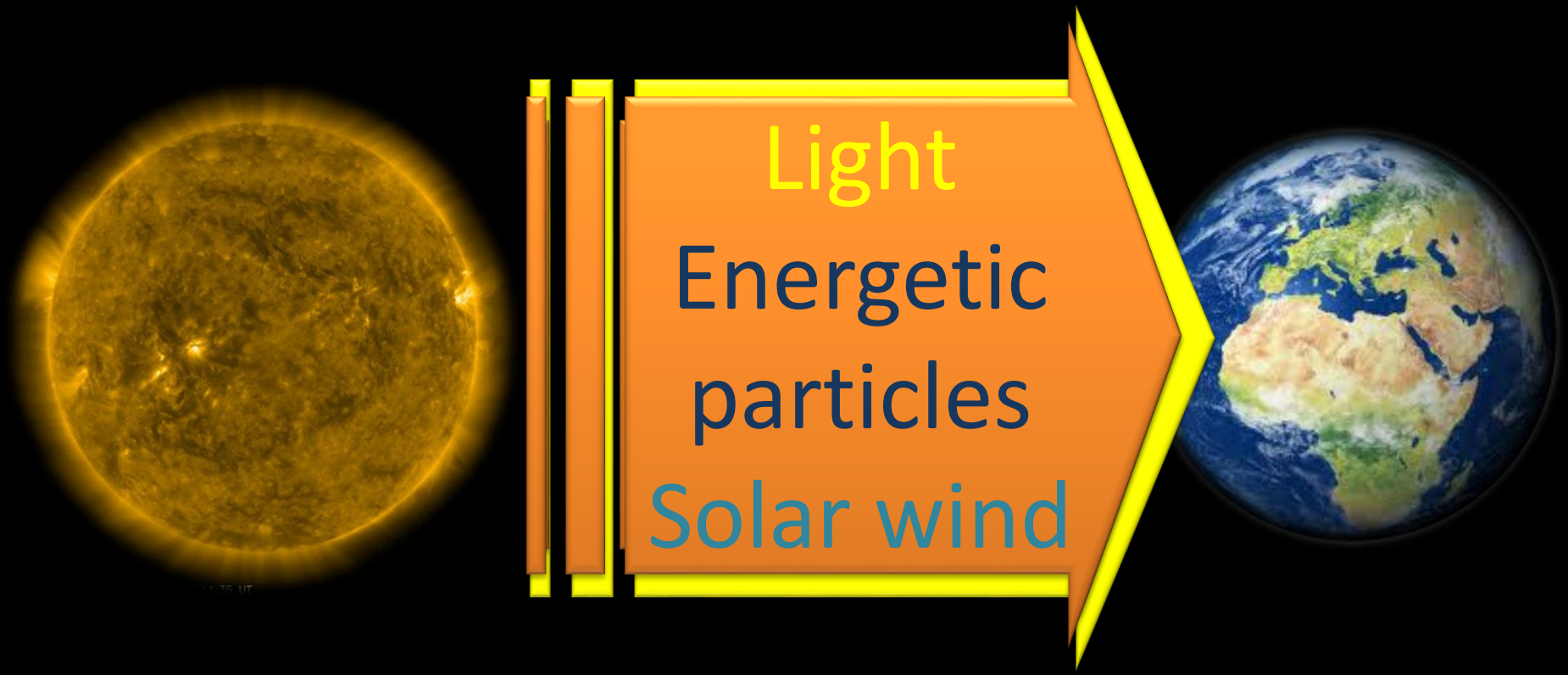


Solar Energetic Events and Space Weather

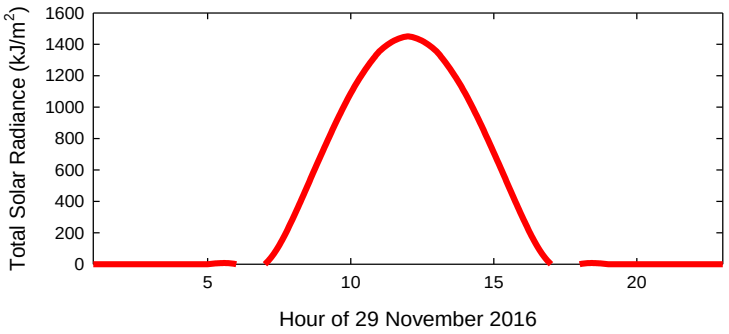
Consuelo Cid

University of Alcalá

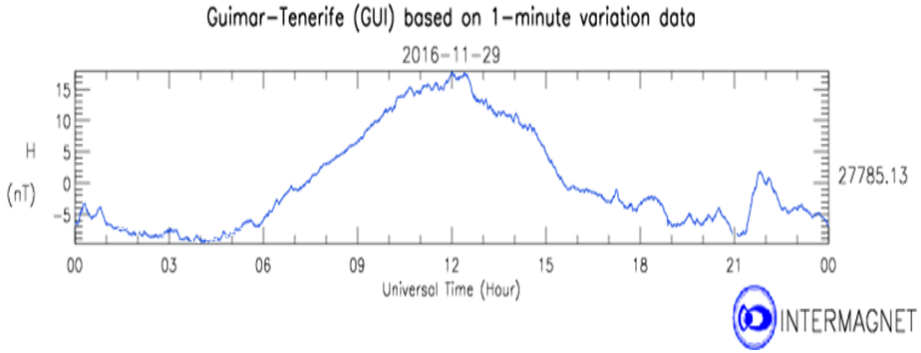
Solar-terrestrial interaction



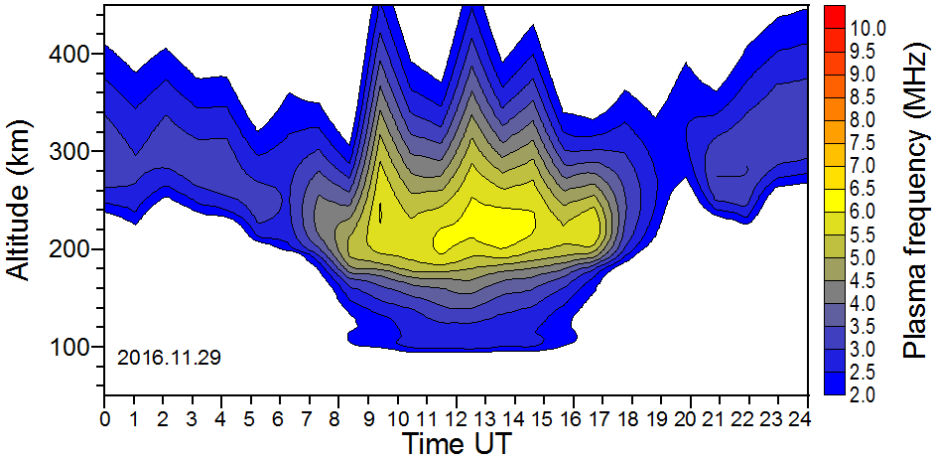
Quiet time



Total solar irradiance at Cordoba (http://www.agenciaandaluzadelaenergia.es/)

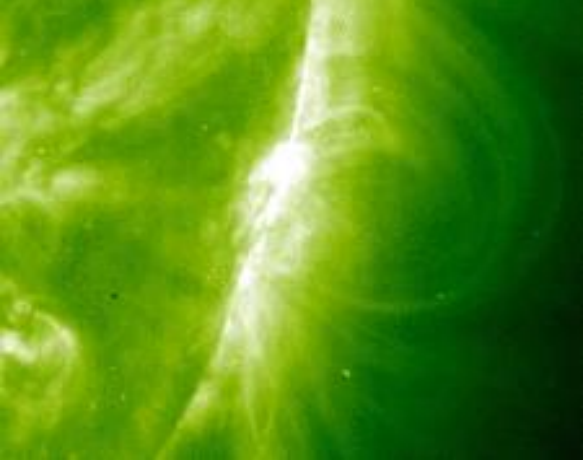


Daily variation of ground magnetic field at Guimar-Tenerife (http://www.intermagnet.org/)



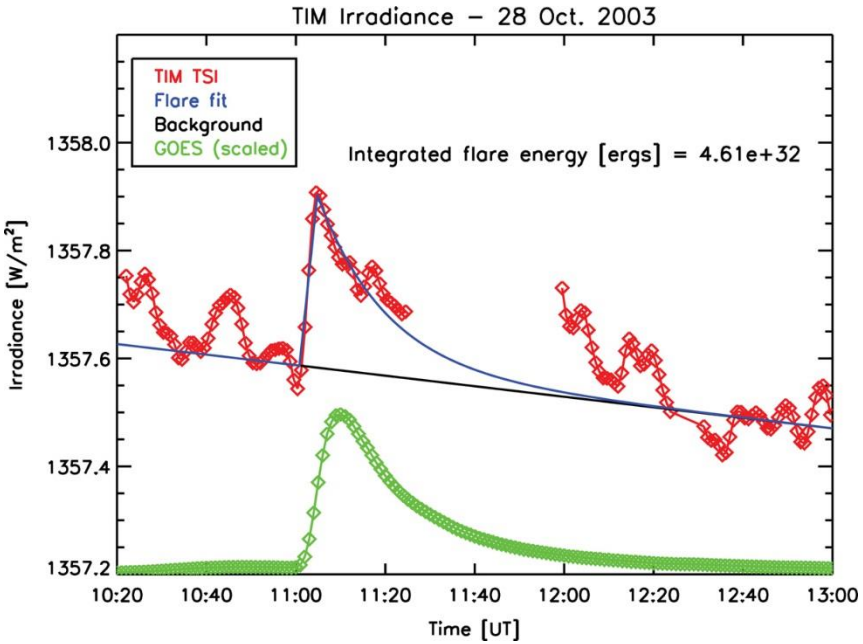
Ionospheric daily variation of electric density at Ebro Observatory (http://www.obsebre.es/)

WHEN THE LIGHT INCREASES: FLARES

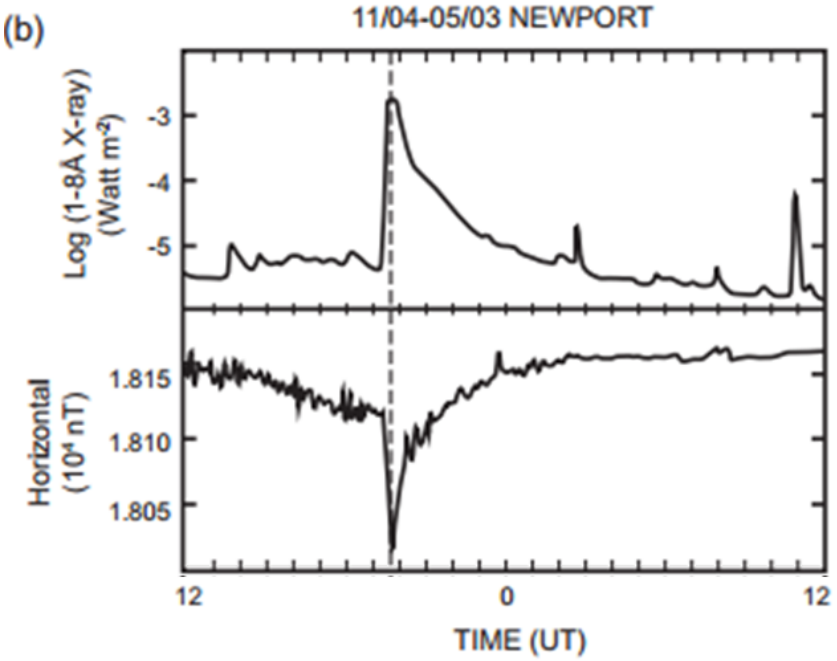


Flares and disturbances

Solar Flare Effect (SFE) is a indirect effect of an ionospheric disturbance due to the increase of light



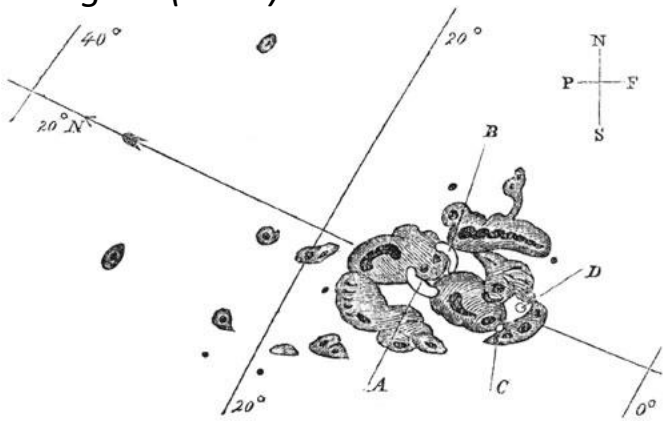
From Kopp (2016)
http://dx.doi.org/10.1051/swsc/2016025



From Cliver and Dietrich (2013)
http://dx.doi.org/10.1051/swsc/2013053

The Carrington event

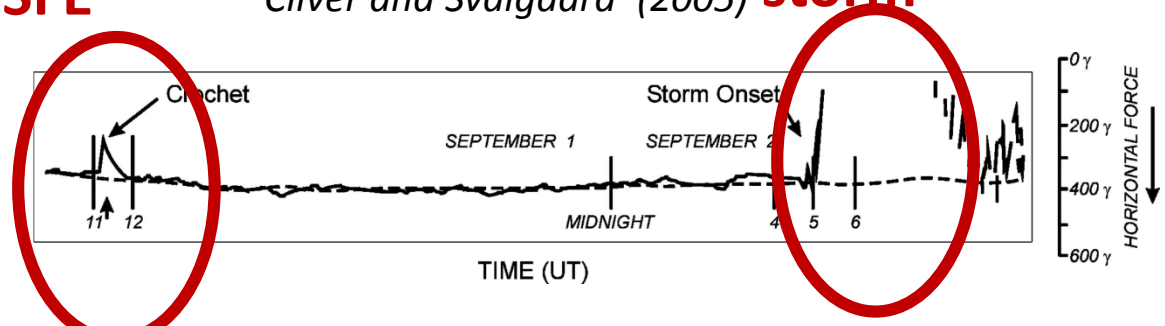
Carrington (1859)



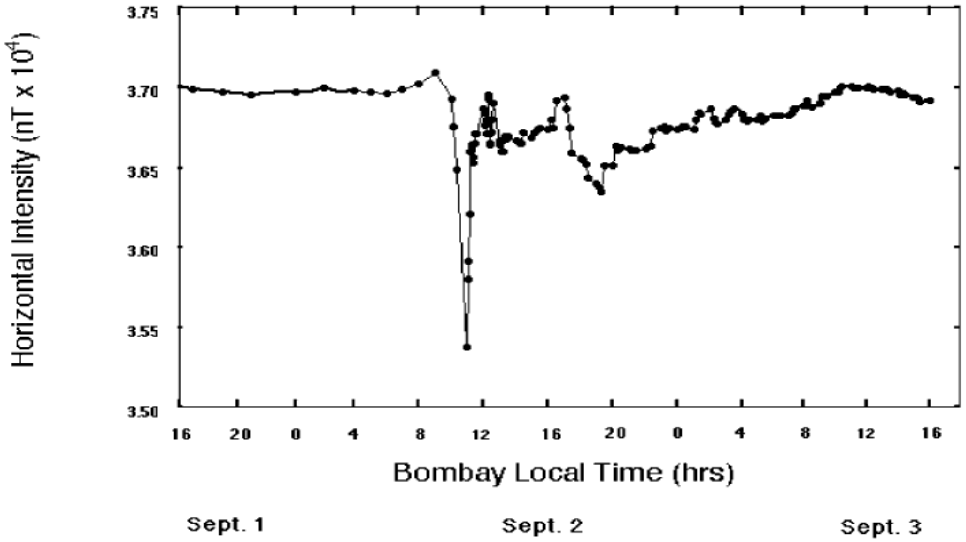
SFE

Cliver and Svalgaard (2005)

Geomagnetic storm



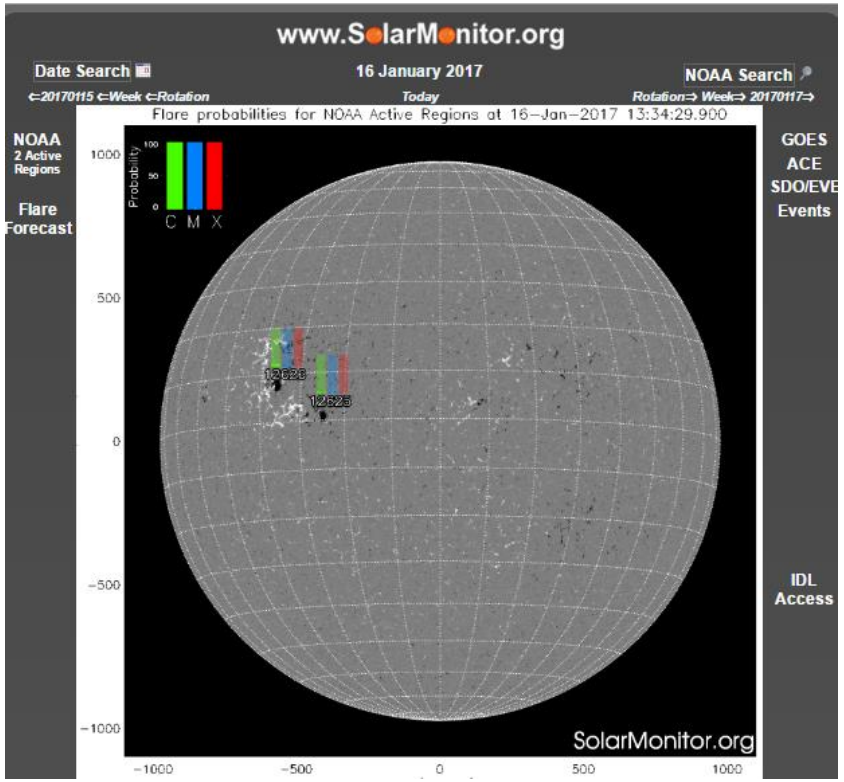
While the contemporary occurrence may deserve nothing…



Tsurutani et al. (2003)

When a flare will happen?

- Nowdays is not possible to accurately forecast when a flare is going to happen
- Forecasting is based on probability
- Bloomfield et al. (ApJ, 2012): McIntosh class and GOES X-flares are considered in the statistics to determine probabilities for different flare magnitudes



Solar Flares Knock HughesNet Satellite Offline

Service Offline Most of Tuesday...

by Karl Bode

Wednesday Mar 14 2012 08:17 EST

Tipped by viperadamr

Several users in our forums note that the recent round of solar flares managed to knock Hughesnet's Spaceway 3 satellite offline for a large chunk of yesterday. The outage primarily impacted the HughesNet SPACEWAY HN9000 service, which is predominately used for enterprise connectivity. Users in our forums note that the service had been offline since around 11 PM (EST) Monday night, but has only returned for most of the company's customers. HughesNet has confirmed that the outage was due to a "[illegible] solar storm.

Solar Flares Knock Out LightSquared Satellite

As Run of Bad Fortune Continues

by Karl Bode

Friday [illegible] 2012 08:41 EST

Tipped by viperadamr

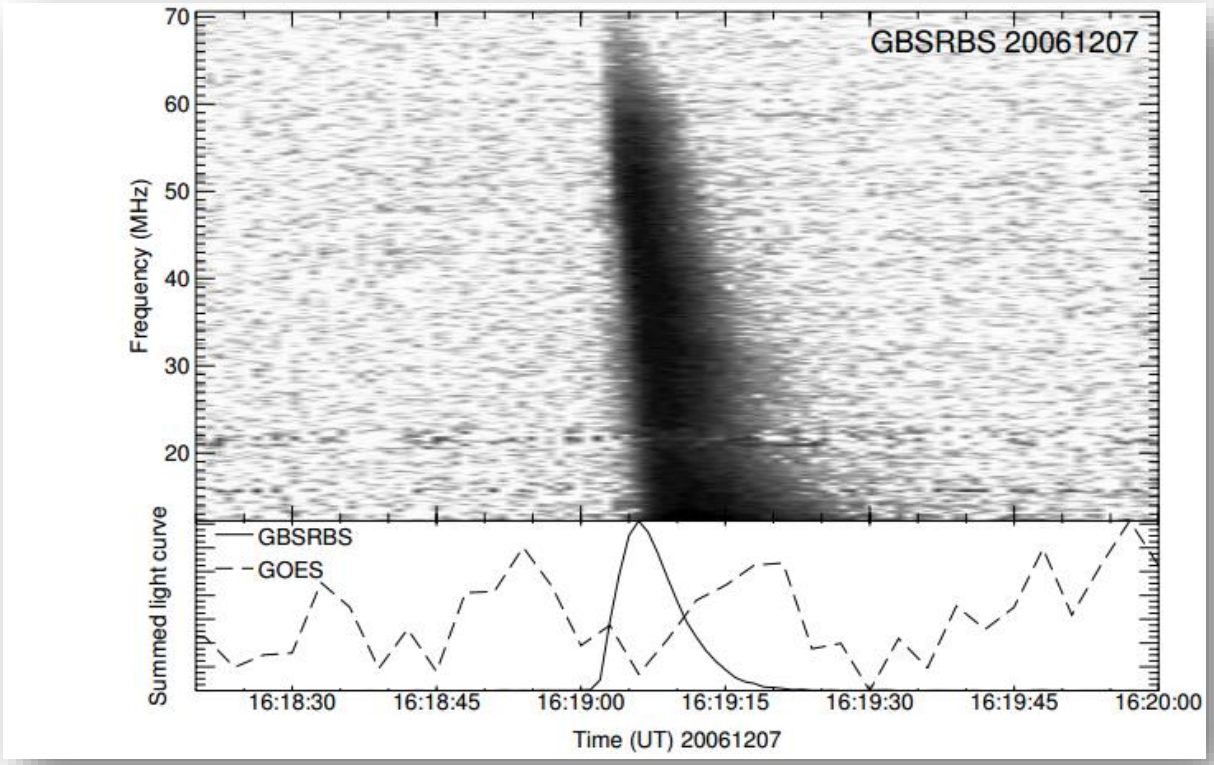
Earlier this week we noted that recent solar flares managed to knock HughesNet's Spaceway 3 satellite offline for a significant part of Tuesday. User viperadamr writes in to note that the flares also took out LightSquared's Skyterra 1 satellite, which has been out of service since the original solar flare on March 7. The last update from the company was on March 9 insisting they'd have the satellite operational again by last Sunday -- something that didn't happen. The outage arrives as LightSquared slowly stumbles toward death after being rejected a necessary waiver to operate their interference-prone hybrid LTE network.

Really?

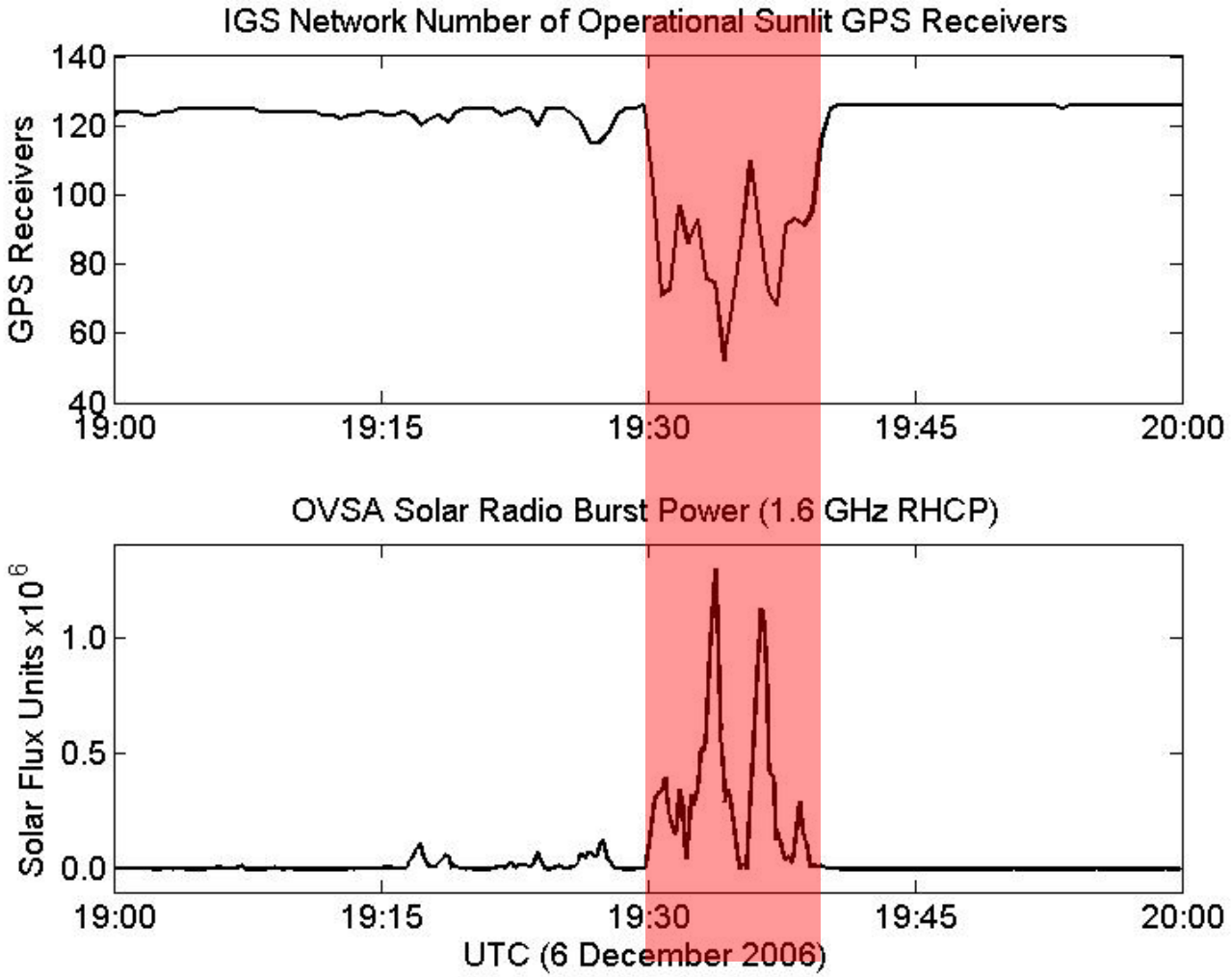
Is a light enhancement able to knock out a spacecraft?

http://www.dslreports.com/

Radio Burst



From White (2007)



credits : Cornell U. GPS Laboratory

10 min

The effect of solar radio bursts on the GNSS radio occultation signals

Xinan Yue,[1,2] William S. Schreiner,[1] Ying-Hwa Kuo,[1] Biqiang Zhao,[3] Weixing Wan,[3] Zhipeng Ren,[3] Libo Liu,[3] Yong Wei,[3] Jiuhou Lei,[4] Stan Solomon,[2] and Christian Rocken[5]

Received 18 March 2013; revised 19 August 2013; accepted 20 August 2013; published 10 September 2013.

[1] Solar radio bu
frequency range, o
specific frequency
(GNSS) signals an
(LEO-) based high
(COSMIC, CHAM
University Corpora
effect of SRB on t
radio flux was used
and statistical anal
signals show frequ
noise ratio (SNR) g
successful retrieval
during SRB occurr
decreased data volu
space weather mon
ionospheric and at
respectively, while
A threshold value
GNSS SNR decrea

Effect of intense December 2006 solar radio bursts on GPS receivers

Alessandro P. Cerruti,[1] Paul M. Kintner Jr.,[1] Dale E. Gary,[2] Anthony J. Mannucci,[3] Robert F. Meyer,[3] Patricia Doherty,[4] and Anthea J. Coster[5]

Received 29 October 2007; revised 15 July 2008; accepted 17 July 2008; published 29 October 2008.

[1] Solar radio bu
receivers. The stron
receivers. This ever
reported event. The
occurred near solar
few tens of minute
and L2 (1227.60 MH
these events sugge
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during the next sol

Citation: Cerruti, A.
intense December 20

The total failures of GPS functioning caused by the powerful solar radio burst on December 13, 2006

E. L. Afraimovich, V. V. Demyanov, and G. Ya. Smolkov

Institute of Solar-Terr

(Received October

We investigated failures
ciated with the intense (X3
December 13, 2006. Accor
tire sunlit side of the Earth
from the wideband solar rad
extreme solar radio burst o
factors in the functioning
factors in their developmen

The May 1967 great storm and radio disruption event: Extreme space weather and extraordinary responses

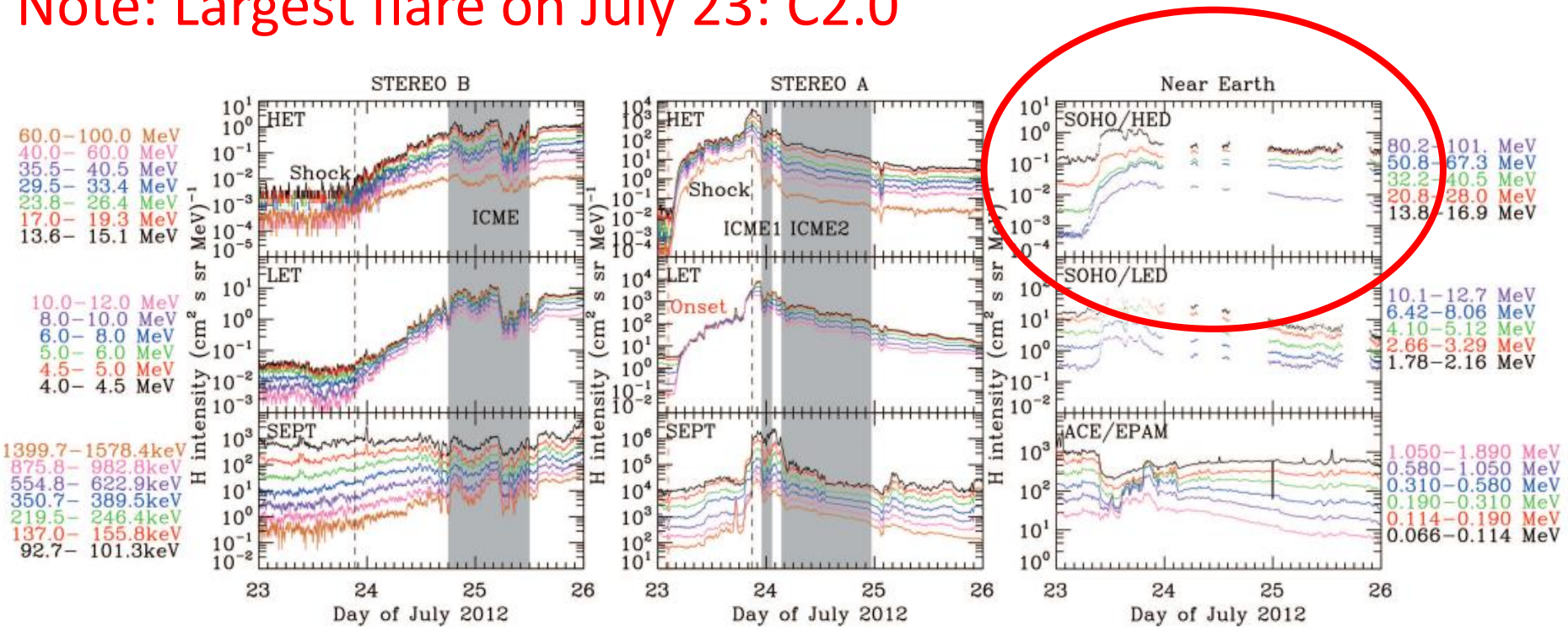
D. J. Knipp[1,2], A. C. Ramsay[3], E. D. Beard[3], A. L. Boright[3], W. B. Cade[4], I. M. Hewins[5], R. H. McFadden[5], W. F. Denig[6], L. M. Kilcommons[1], M. A. Shea[7], and D. F. Smart[7]

[1]Department of Aerospace Engineering Sciences, University of Colorado Boulder, Boulder, Colorado, USA, [2]High Altitude Observatory, National Center for Atmospheric Research, Boulder, Colorado, USA, [3]Retired from U.S. Air Force, Air Weather Service, [4]Baylor Institute for Air Science, Baylor University, Waco, Texas, USA, [5]Institute for Scientific Research, Boston College, Boston, Massachusetts, USA, [6]National Centers for Environmental Information, NOAA, Boulder, Colorado, USA, [7]Retired from U.S. Air Force, Air Force Research Laboratory

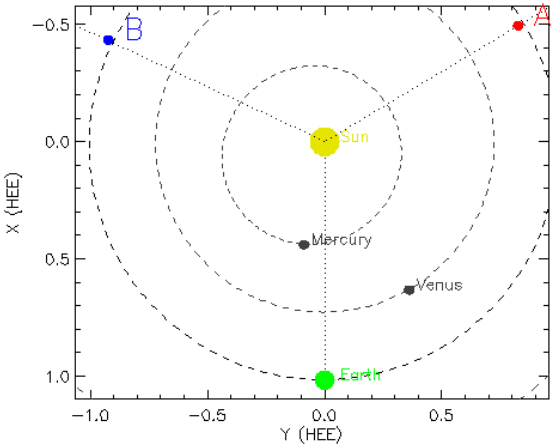
Abstract Although listed as one of the most significant events of the last 80 years, the space weather storm of late May 1967 has been of mostly fading academic interest. The storm made its initial mark with a colossal solar radio burst causing radio interference at frequencies between 0.01 and 9.0 GHz and near-simultaneous disruptions of dayside radio communication by intense fluxes of ionizing solar X-rays. Aspects of military control and communication were immediately challenged. Within hours a solar energetic particle event disrupted high-frequency communication in the polar cap. Subsequently, record-setting geomagnetic and ionospheric storms compounded the disruptions. We explain how the May 1967 storm was nearly one with ultimate societal impact, were it not for the nascent efforts of the United States Air Force in expanding its terrestrial weather monitoring-analysis-warning-prediction efforts into the realm of space weather forecasting. An important and long-lasting outcome of this storm was more formal Department of Defense-support for current-day space weather forecasting. This story develops during the rapid rise of solar cycle 20 and the intense Cold War in the latter half of the

WHEN THE FLUX OF ENERGETIC PARTICLES INCREASES: SEP EVENTS

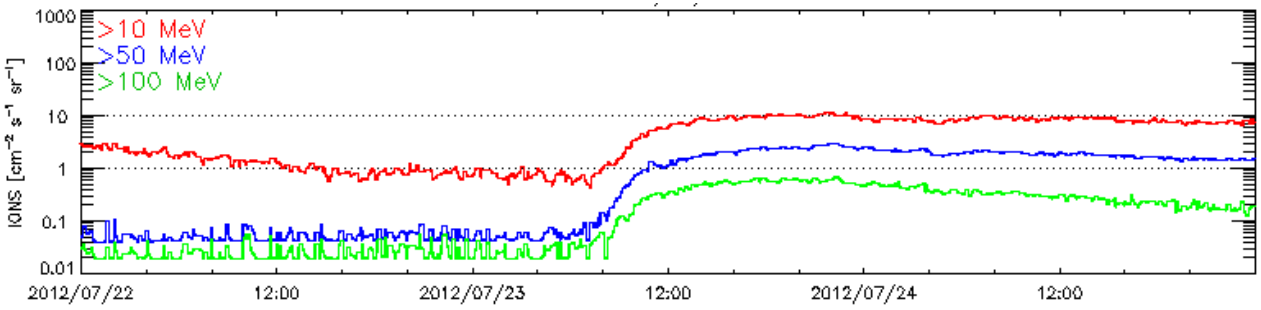
Note: Largest flare on July 23: C2.0



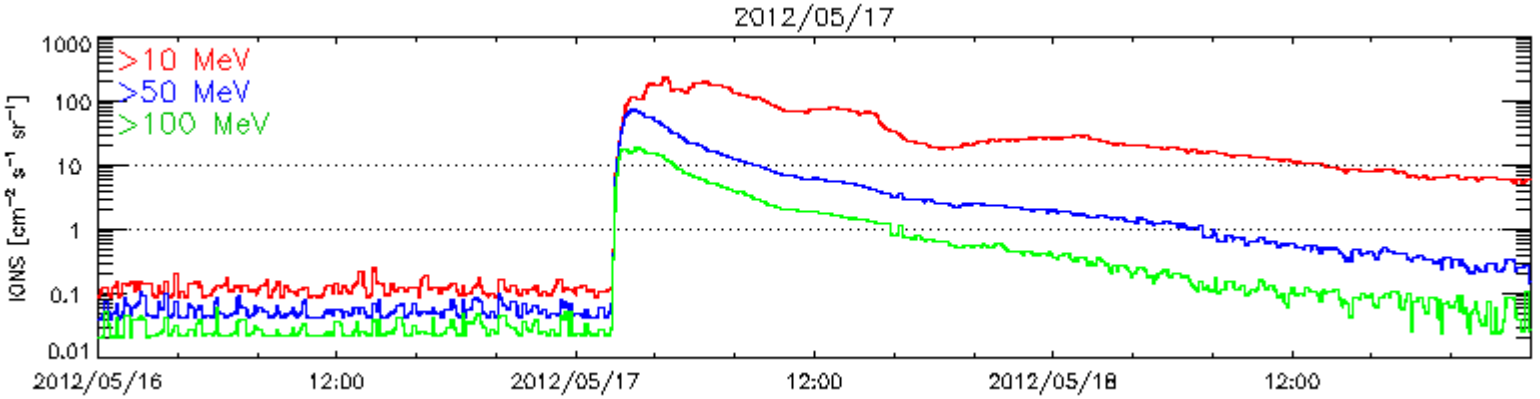
From Zhu et al. (2016)



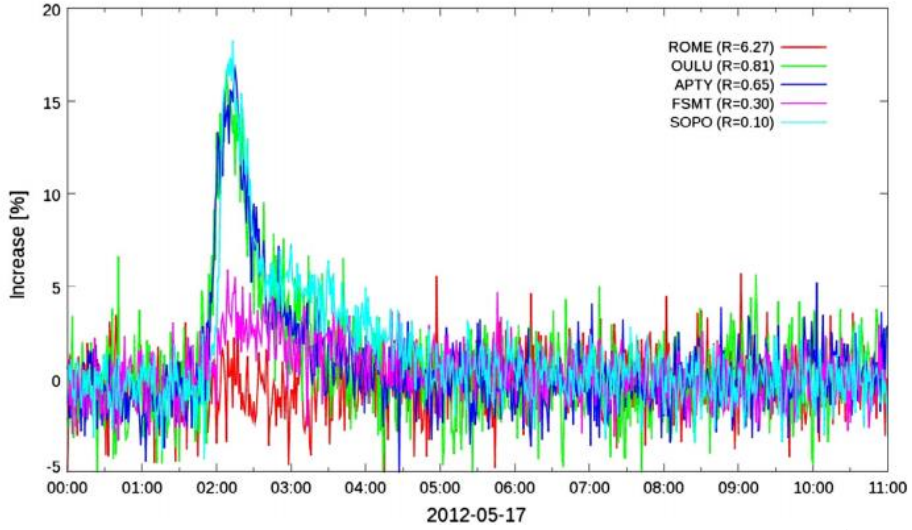
GOES 13



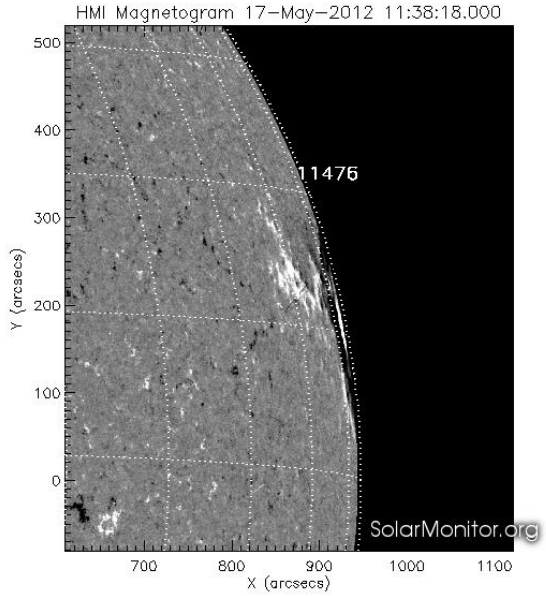
Sometimes SEPs reach the ground



M5.1 flare from AR11476



From Berrilli et al. (2014)



…but that happens only at times

Number	Baseline Start	Onset date	Onset time
71	2012-05-17 00:00:00	2012-05-17	01:53:00
70	2006-12-13 01:00:00	2006-12-13	02:47:00
69	2005-01-20 05:00:00	2005-01-20	06:51:00
68	2005-01-17 06:00:00	2005-01-17	00:00:00
67	2003-11-02 16:00:00	2003-11-02	17:30:00
66	2003-10-29 19:00:00	2003-10-29	21:30:00
65	2003-10-28 10:00:00	2003-10-28	11:22:00

www.nmdb.eu/nest/gle_list.php

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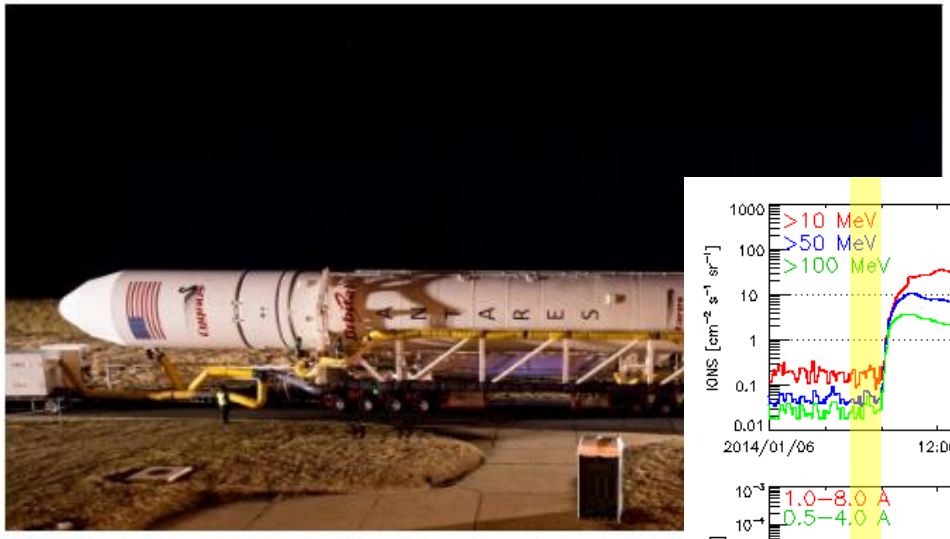
Technology & Science | Quirks & Quarks Blog | Spark | Photo Galleries

Solar flare delays U.S. rocket launch

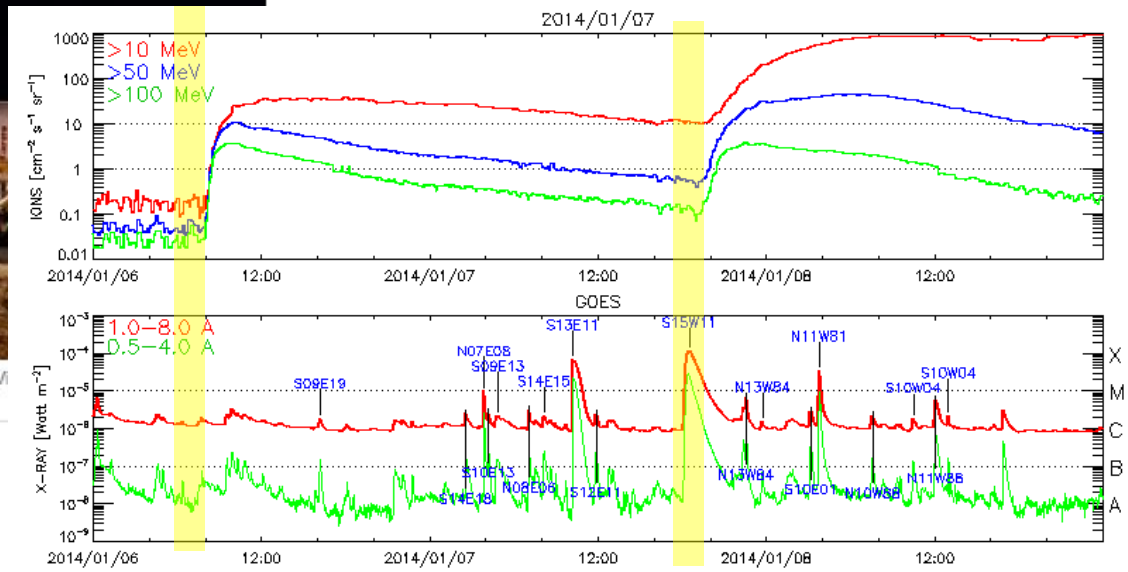
Solar particles could lead to a launch failure, said chief technical officer

The Associated Press Posted: Jan 08, 2014 2:45 PM ET | Last Updated: Jan 08, 2014 2:45 PM ET



Orbital Science Corporation Antares rocket is seen on launch pad at NASA's Wallops Island, Vi
2013 (NASA/Bill Ingalls/Reuters)

Note that not all SEPs are related to flares



No event that day at http://www.nmdb.eu/nest/gle_list.php

WHEN MASS LEAVES THE SUN: CMES


LASCO C2 - 2015/03/15 - 07:48:05Z
AIA 193 - 2015/03/15 - 07:35:42Z

AGU PUBLICATIONS

Space Weather

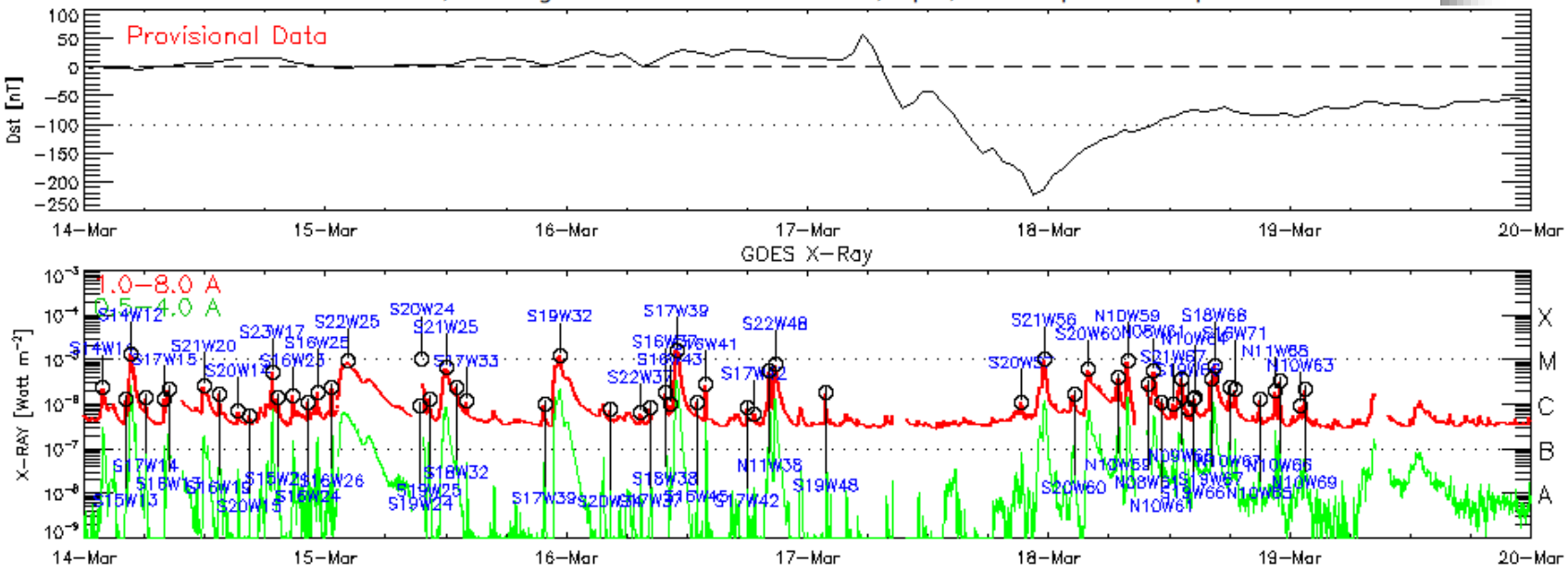
NEWS ARTICLE
10.1002/2015SW001213

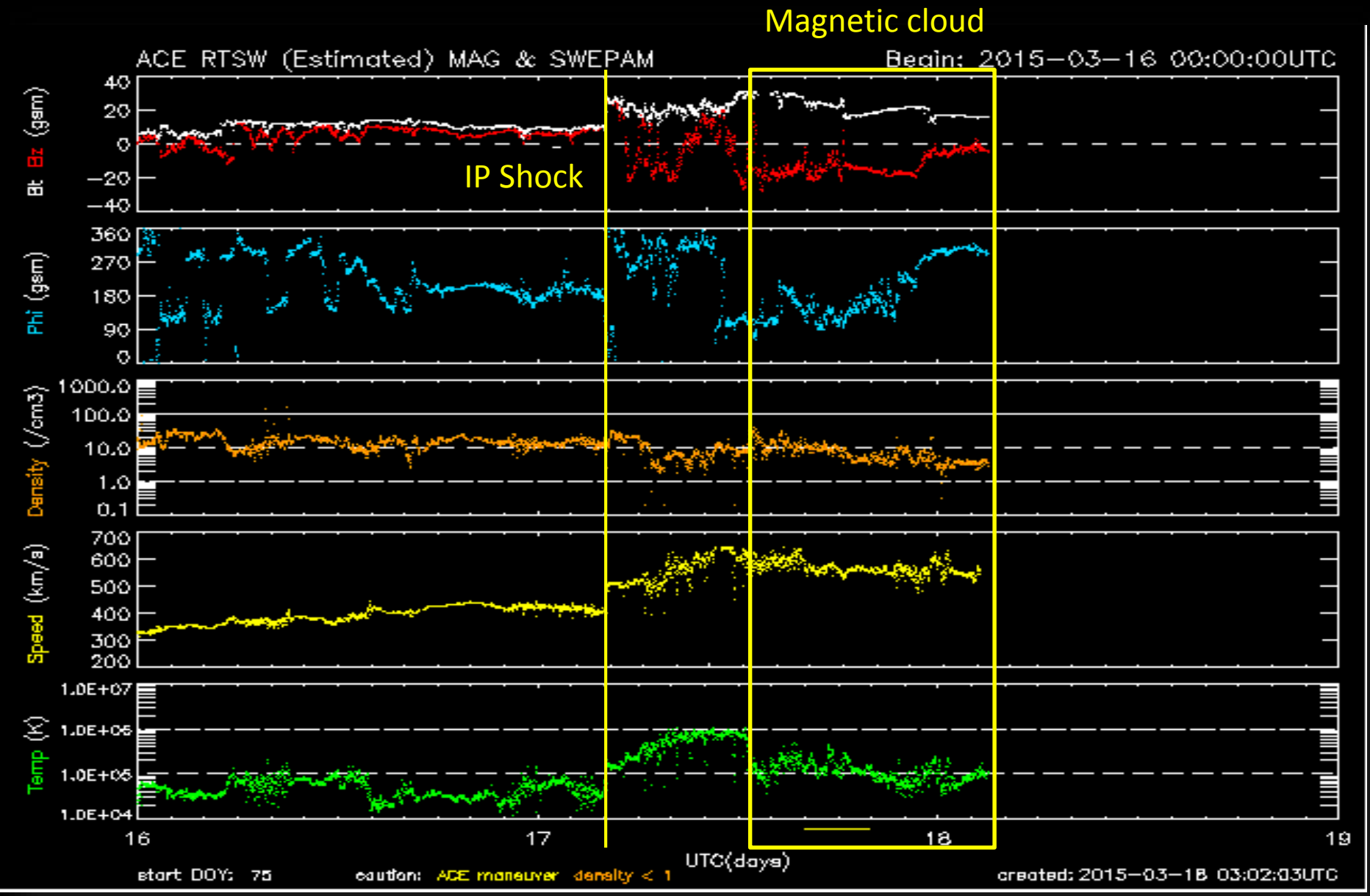
Citation:
Kamide, Y., and K. Kusano (2015), No Major Solar Flares but the Largest Geomagnetic Storm in the Present Solar Cycle, *Space Weather, 13*, doi:10.1002/2015SW001213.

No Major Solar Flares but the Largest Geomagnetic Storm in the Present Solar Cycle

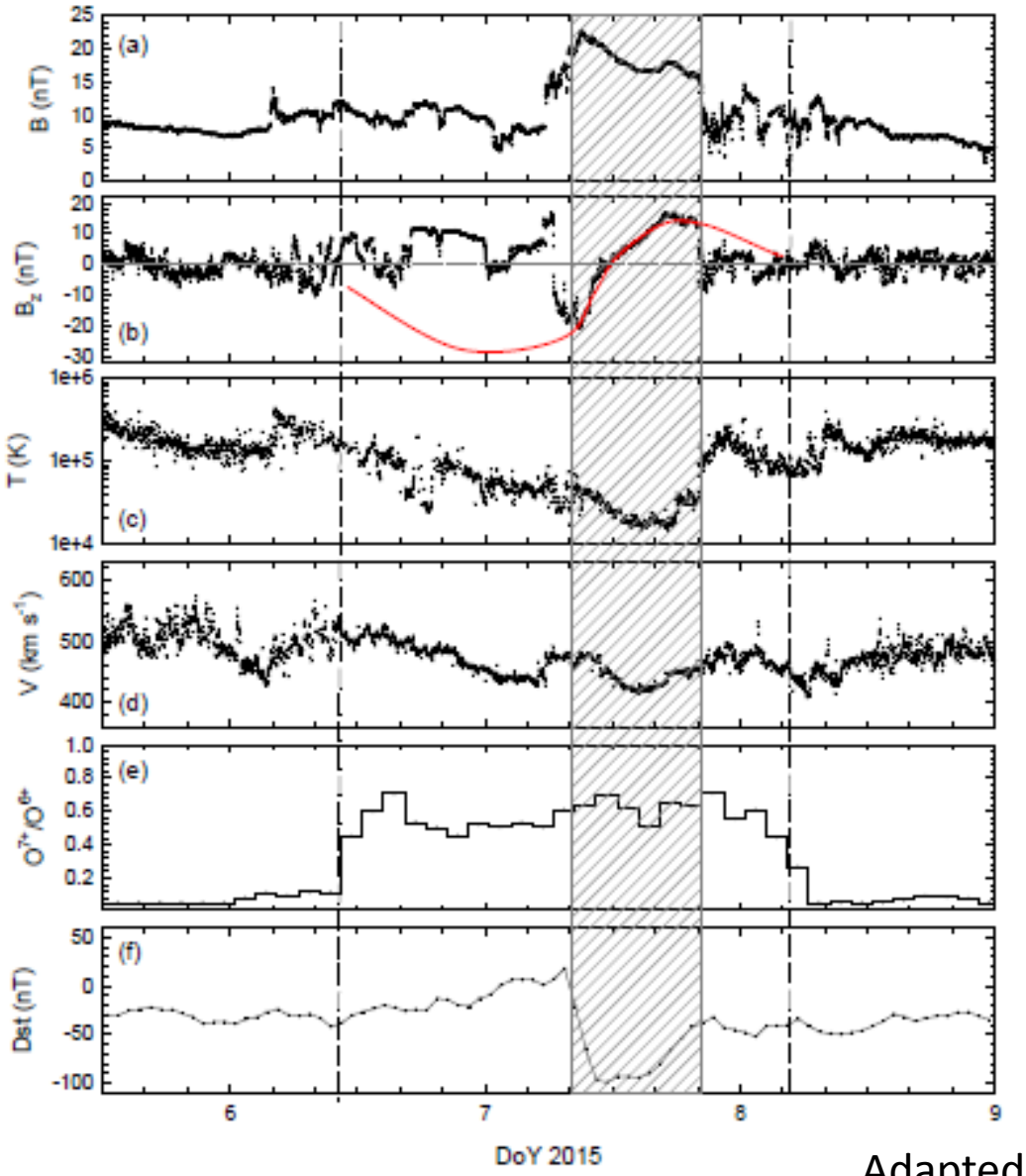
Y. Kamide and K. Kusano

A severe geomagnetic storm, and the largest in solar cycle 24, occurred on 17–18 March 2015 without significant precursor X- or M-type solar flares. Figure 1 shows (first to fourth panels) solar wind variables, auroral electrojets indices, and the Disturbance Storm Time (*Dst*) index associated with the event, which was classified as a G4 (severe) level storm (http://www.swpc.noaa.gov/noaa-scales-explanation). Red auroras were seen even from the northern part of Japan for first time during the present cycle, attracting considerable interest by the media and general public. Some of the headlines in Japan are as follows: Auroras came to northern Japan after 11 years (Asahi newspaper) and space weather prediction came off and low-latitude auroras appeared (Yomiuri newspaper). Unfortunately, space weather agencies worldwide, including the ones in the United States, Japan, and Europe failed to predict that a severe

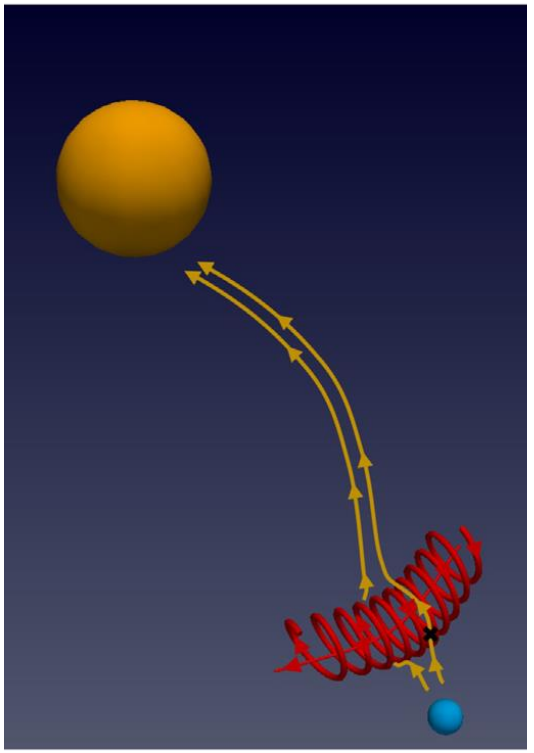



Magnetic cloud
ACE RTSW (Estimated) MAG & SWEPAM
Begin: 2015-03-16 00:00:00UTC
IP Shock
Bt Bz (gsm)
Phi (gsm)
Density (/cm3)
Speed (km/s)
Temp (K)
UTC(days)
start DOY: 75
caution: ACE maneuver density < 1
created: 2015-03-18 03:02:03UTC

The ground response



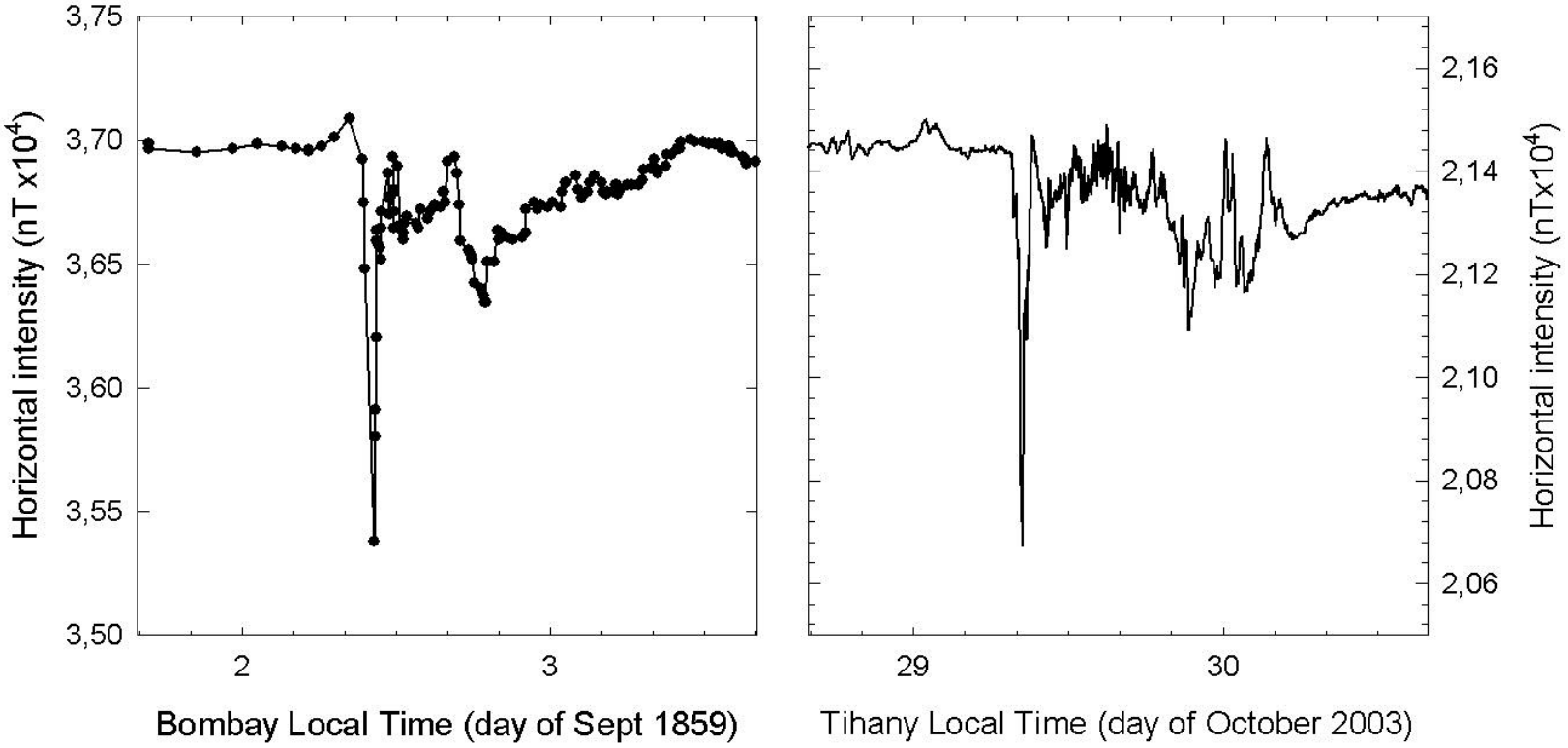
Interaction avoid to accurately forecast from solar observations (…up to date)



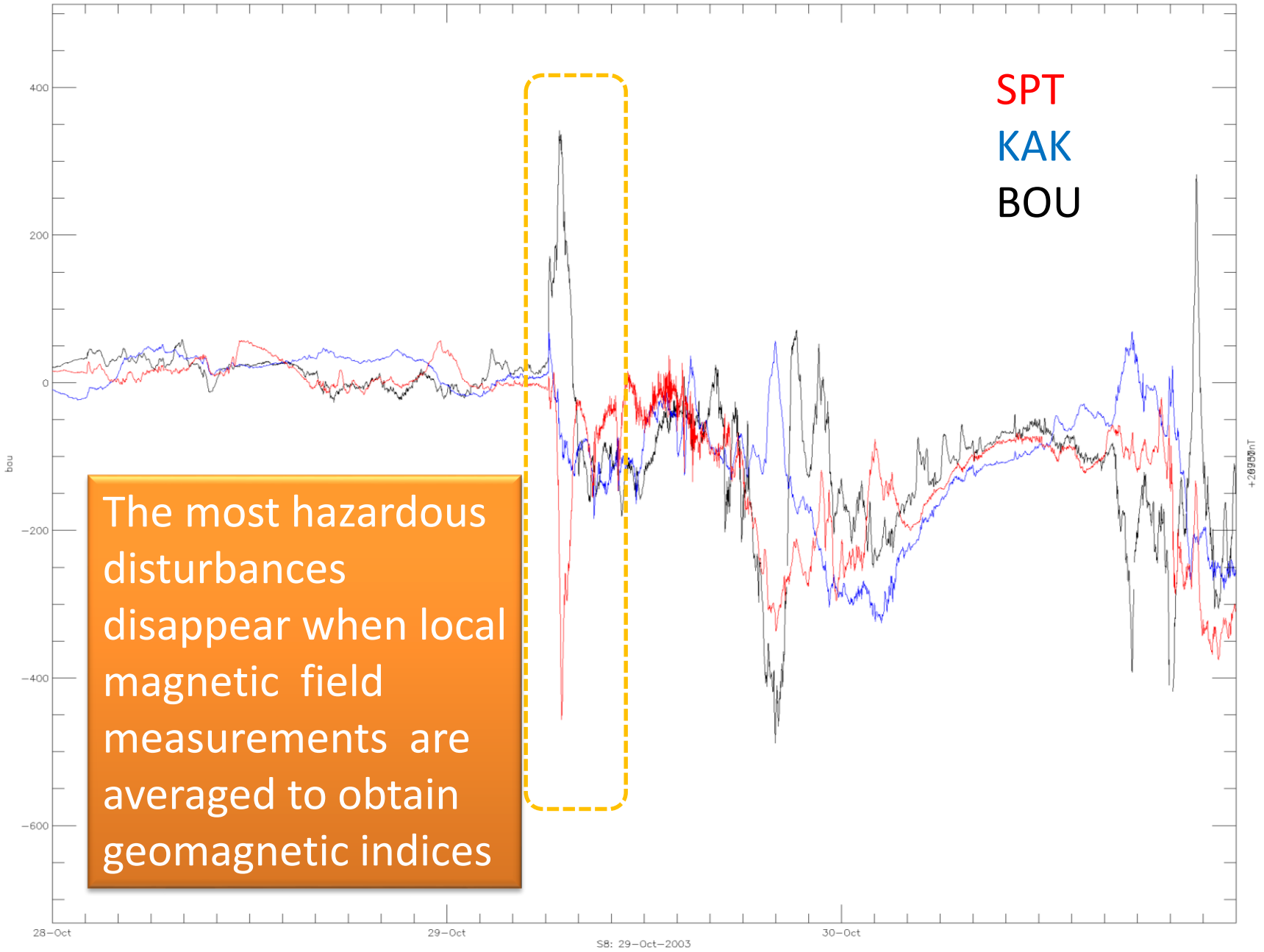
Adapted from Cid et al. (2016)

But the scientific scenario is not always useful for society

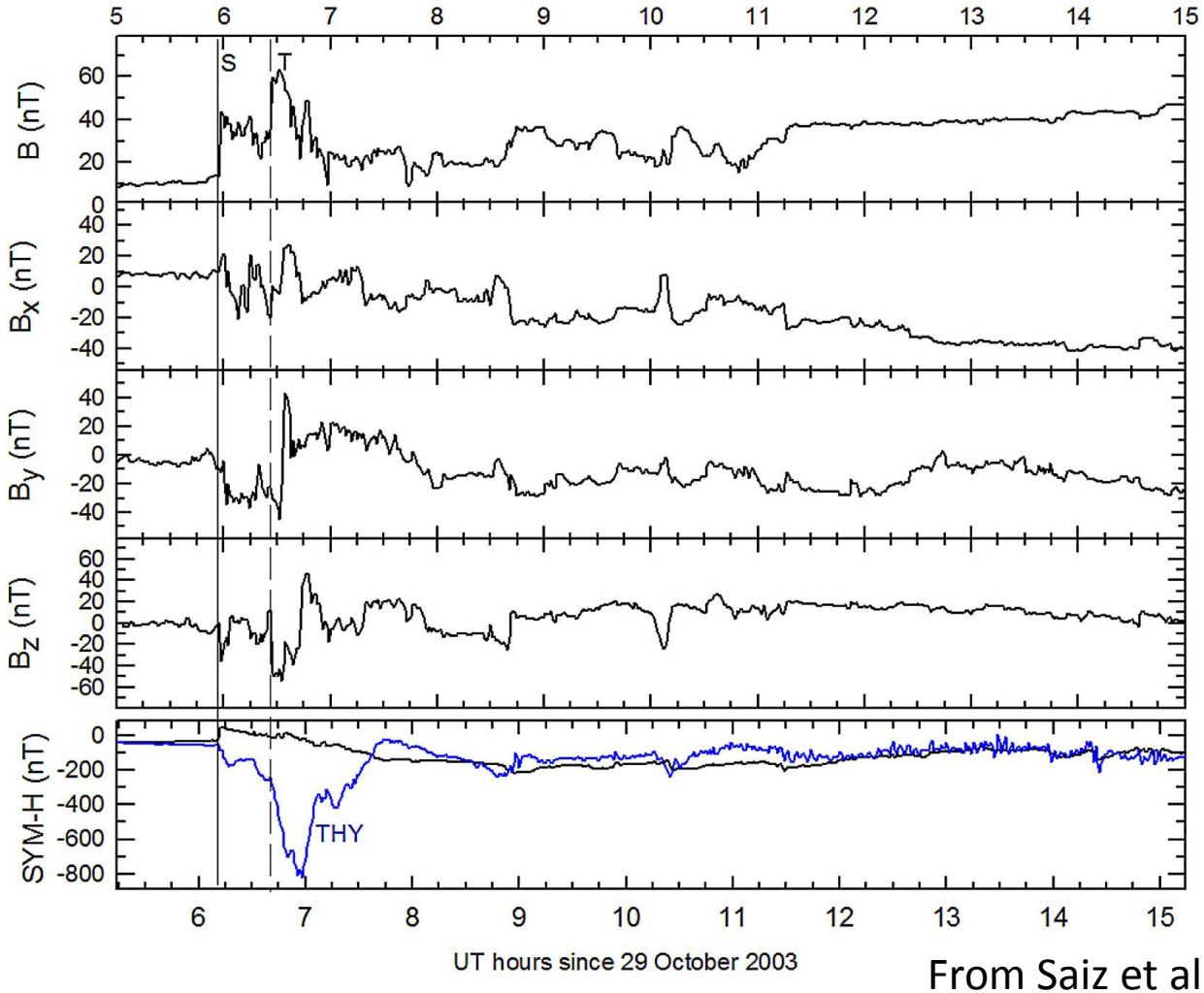
A Carrington-like geomagnetic storm observed in 21st century



From Cid et al. (2015)


SPT
KAK
BOU
400
200
0
−200
−400
−600
bou
28−Oct
29−Oct
30−Oct
S8: 29−Oct−2003
The most hazardous disturbances disappear when local magnetic field measurements are averaged to obtain geomagnetic indices

What triggered the spike?



From Saiz et al. (2016)

What is the SOLAR trigger of ground spikes?

MAY

OUR RESEARCH

BRING THE ANSWER

Thanks for your attention!