The Case for a National Space Weather Strategy: Major Space Weather Events and their Impact

Space Weather Users Workshop
Sydney, Australia

16 November 2017

Bill Murtagh
Program Coordinator
National Oceanic and Atmospheric Administration
Space Weather Prediction Center

Space Weather Operations, Research, and Mitigation Subcommittee
National Science and Technology Council

Overview

The Case for action

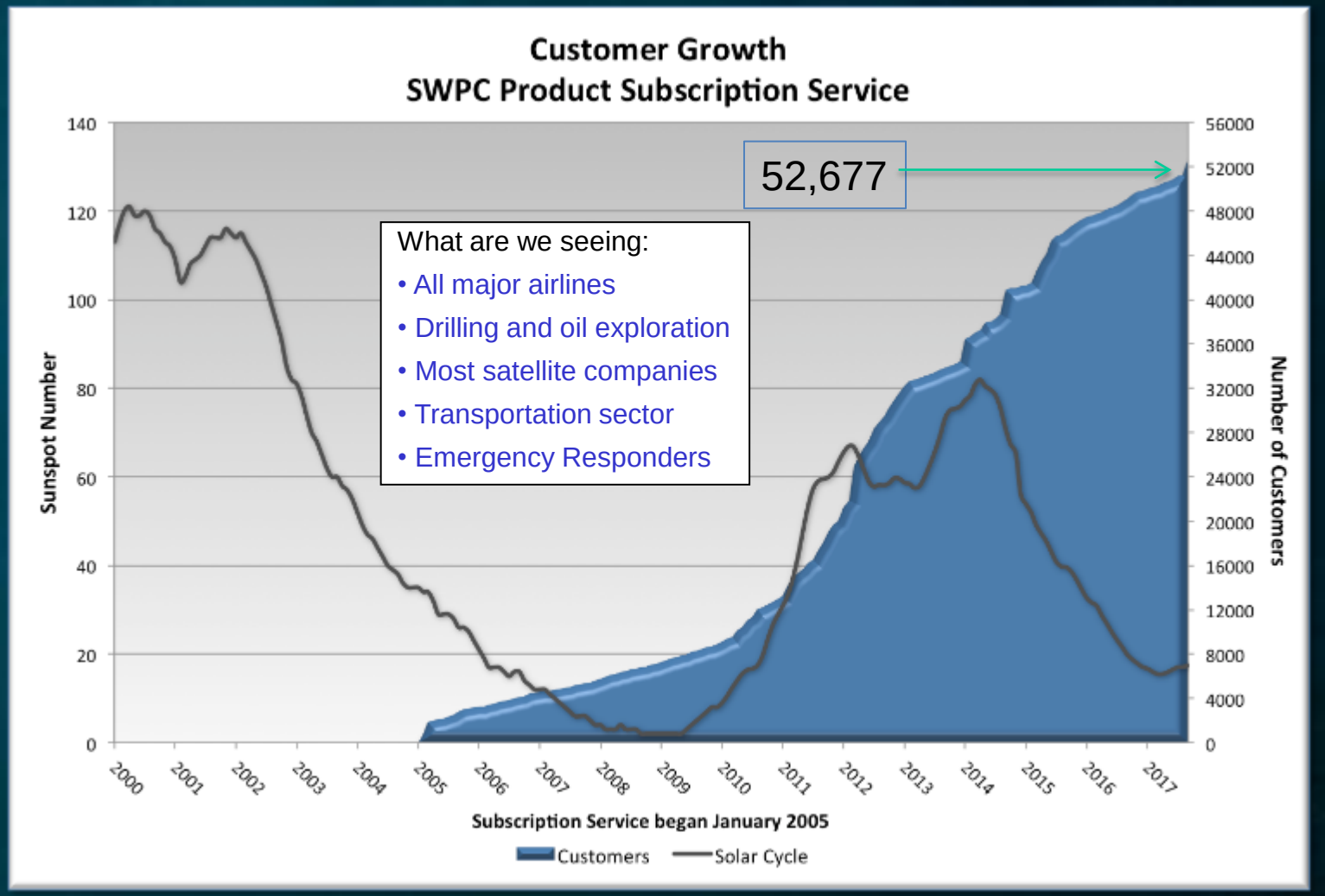
- Societal and economic impacts – reliance on advanced technology
- Space weather types and associated impacts
- Extreme space weather events

Societal and economic impacts

Growing interdependencies across critical infrastructure systems have increased the potential vulnerabilities to space weather

Customer Subscriptions

(through September 2017)



1554 new registrations in September 2017

March 2012

BROADBAND DSLReports.com login · register

Skyterra 1 satellite

Solar Flares Knock Out LightSquared Satellite
As Run of Bad Fortune Continues

by Karl Bode Friday 16-Mar-2012 tags: satellite · business · wireless · alternatives · bandwidth · trouble · wireless

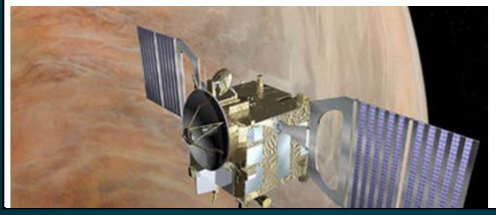
Tipped by viperadamr

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

SPACE.com Follow Us: Follow @spacedotcom

Raging Solar Storm 'Blinds' Venus Spacecraft

by Denise Chow, SPACE.com Staff Writer
Date: 08 March 2012 Time: 12:01 PM ET



Strong radiation from one of the most intense solar storms in the past five years has temporarily "blinded" a European spacecraft in orbit around Venus, and mission controllers are now racing to fix the problem.

STARS AND STRIPES

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General: Recent solar storm interfered with Air Force satellite

By CHRIS CARROLL
Stars and Stripes
Published: March 22, 2012

WASHINGTON — A major solar storm early this month appears to have caused one or more momentary satellite computer failures, but the Air Force's top space official said Thursday the Pentagon's fleet of orbiters is tough enough to withstand an increasingly energetic sun.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

ORDER JO 7110.10V
Effective Date:

Subject: Flight Services

Section 3. Alerting Service

7 March 2012: INCERFA was issued for Air Canada 003 (Vancouver to Tokyo) until communications were established with the flight.

November 2015

SECTIONS HOME SEARCH The New York Times

Solar Storm Knocks Out Flight Control Systems in Sweden

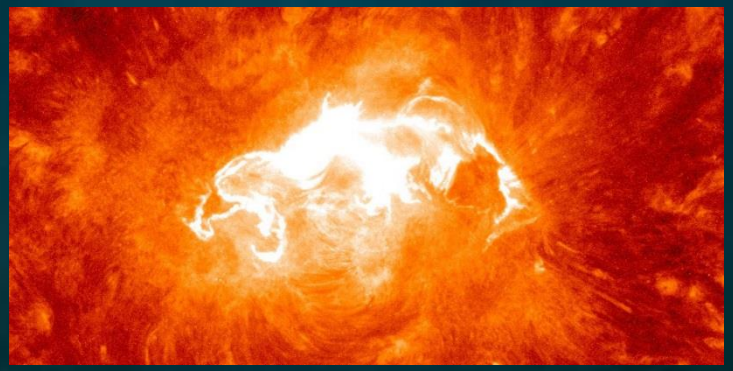
The Weather Channel 29° Anchorag… 1 46° Vilnius, Lit… 84° Patanga,…

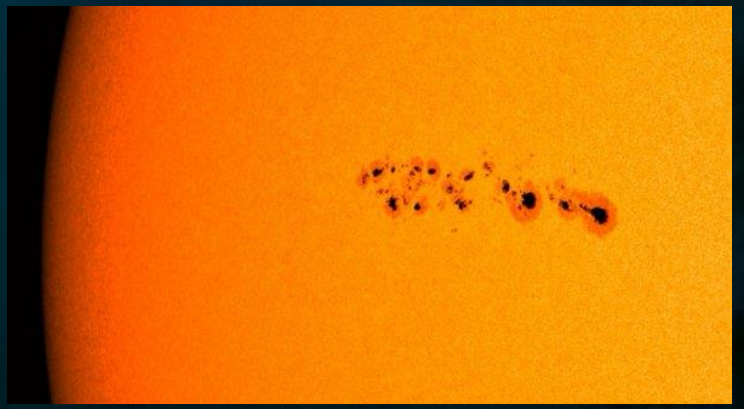
Science

Massive Solar Storm Halts Air Travel in Sweden

Published Nov 5 2015 09:09 AM EST | The Associated Press

"Flights disappeared from radar screens in Swedish air traffic control towers during the blackout, which lasted about an hour"

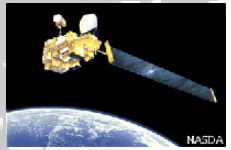




Space Weather – Global Impacts
October 2003

Numerous Polar flights rerouted

Failures of GPS based positioning

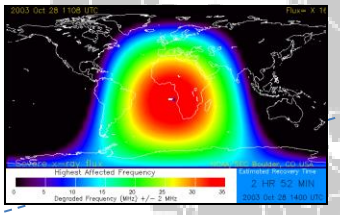


Loss of Japan's ADEOS II satellite

NOTAM
Flight route restrictions due to geomagnetic storm impact on communications

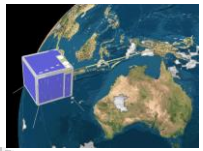
Solar cell damage on ESA's Smart-1 satellite

Nuclear power plants reduced power due to geomagnetic storm



Widespread HF outage over African continent

SatComm and HF outages



Numerous anomalies on FedSat and other Australian satellites

Oilfield services company reported several cases of survey Instrument Interference around world

C.R. Luigs drill ship, loses GPS, resorts to backup systems

Transformer damage

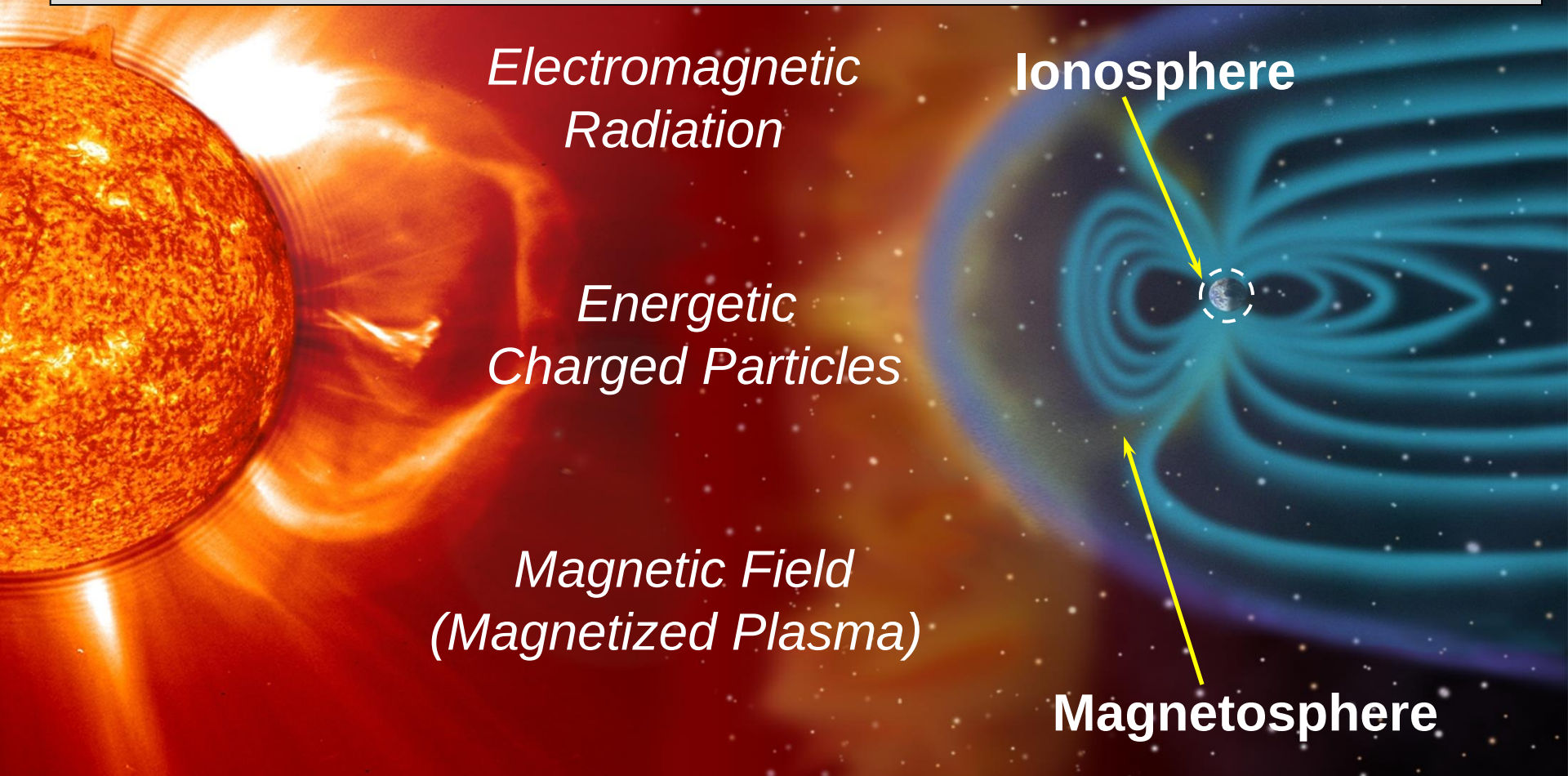
SatComm and HF outages

Over 130 hours of HF communication blackout in Antarctic

- Space weather types and associated impacts

Drivers of space weather?

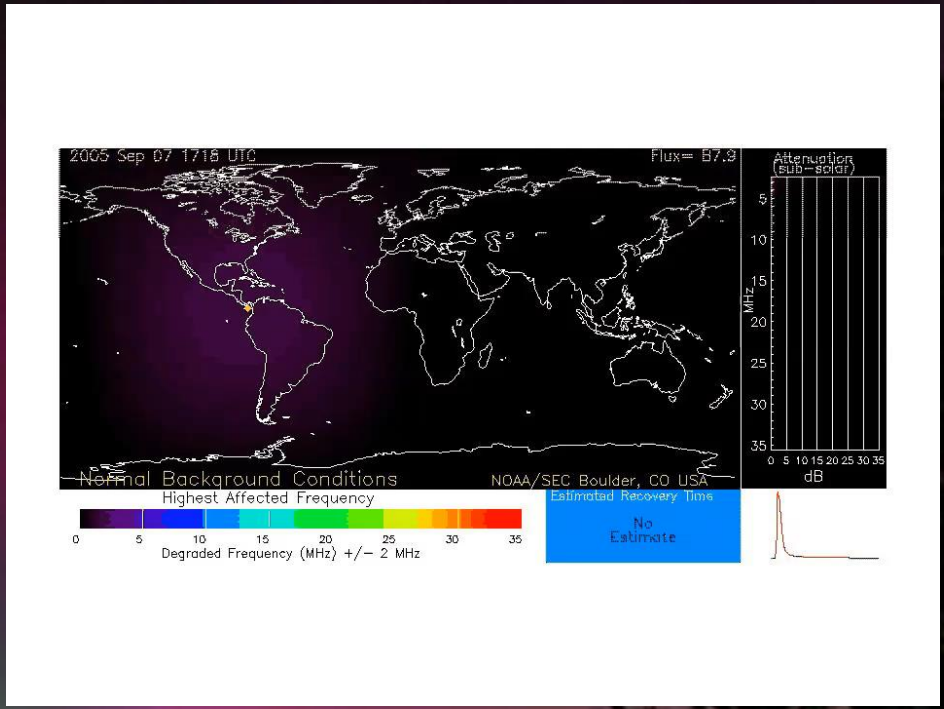
Space weather refers to the variable conditions on the Sun and in space that can influence performance and reliability of space and ground-based technological systems, and endanger life or health



Solar Flares Radio Blackouts *(EM Radiation)*

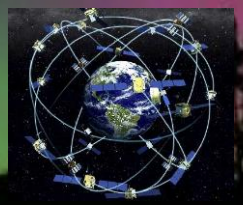
GOES-12 SXI
http://sxi.ngdc.noaa.gov
http://www.sec.noaa.gov/sxi

- *A violent* explosion in the Sun's atmosphere with an energy equivalent of a hundred million hydrogen bombs.

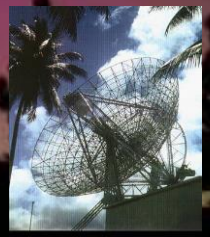


Duration: Minutes to ~3 hours

Impacts



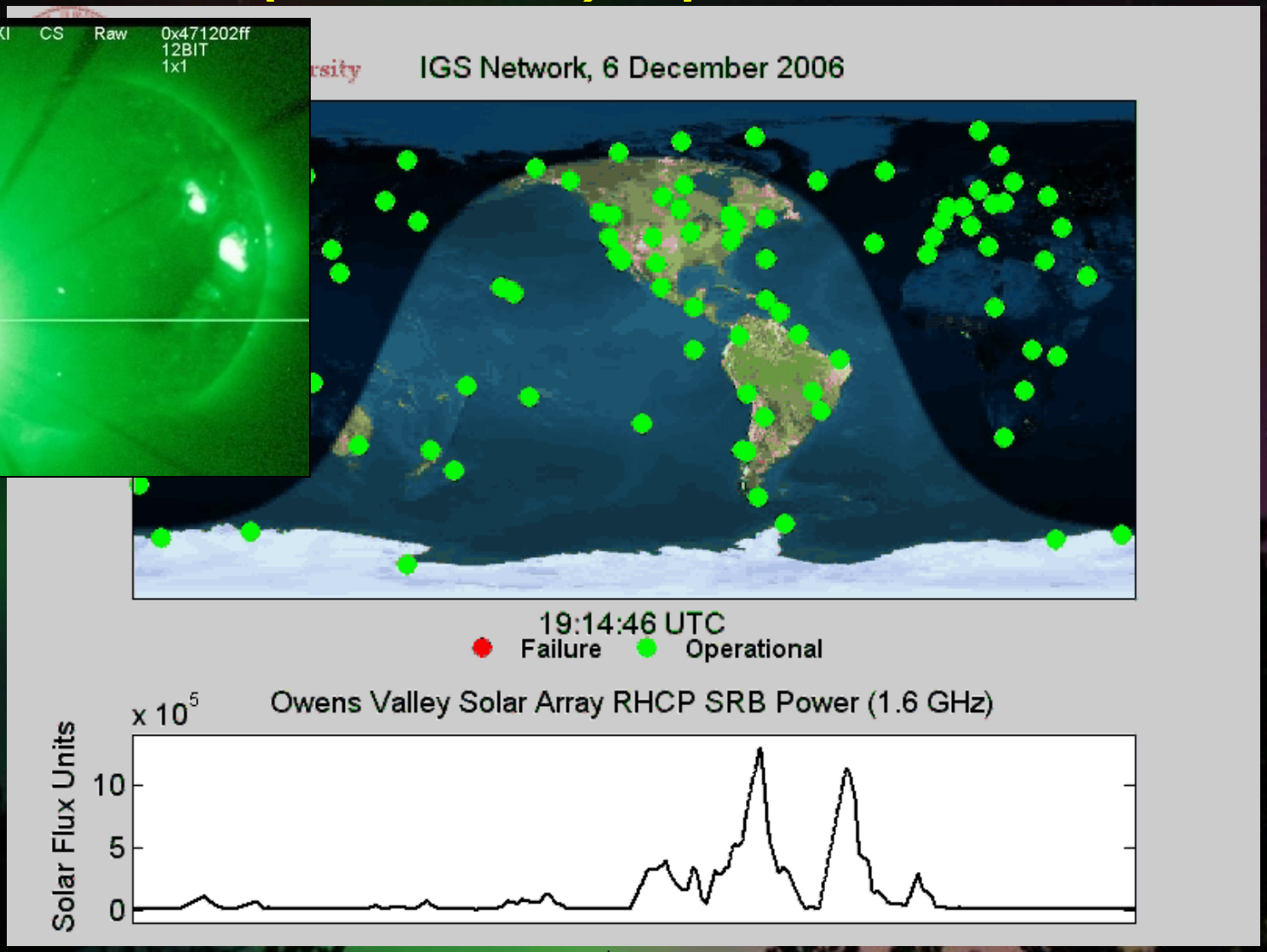
GPS Network



Communications
Ground and Space-based

Radar

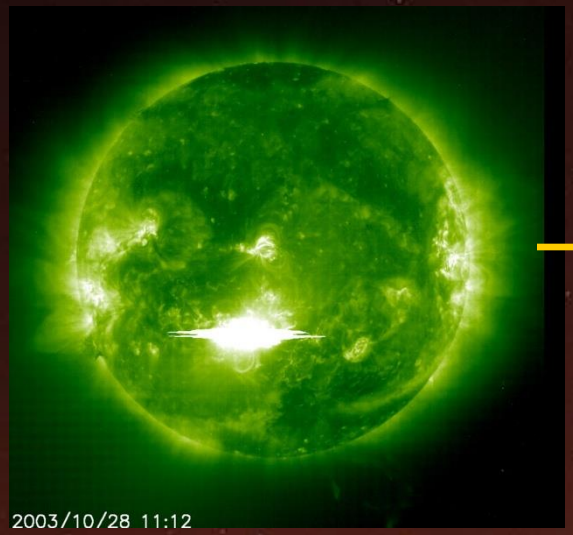
Solar Flare (Radio Burst) Impact on GPS – 6 Dec 2006



GPSOC at Schriever AFB

- "At approximately 6 Dec/1930Z there was a widespread loss of GPS in the Mountain States region, specifically around the 4 corners region of NM/CO. Several aircraft reported losing lock on GPS…were tracking 7-9 satellites, and abruptly lost lock and were tracking 0-1."

Solar Radiation Storms (Charged particles)



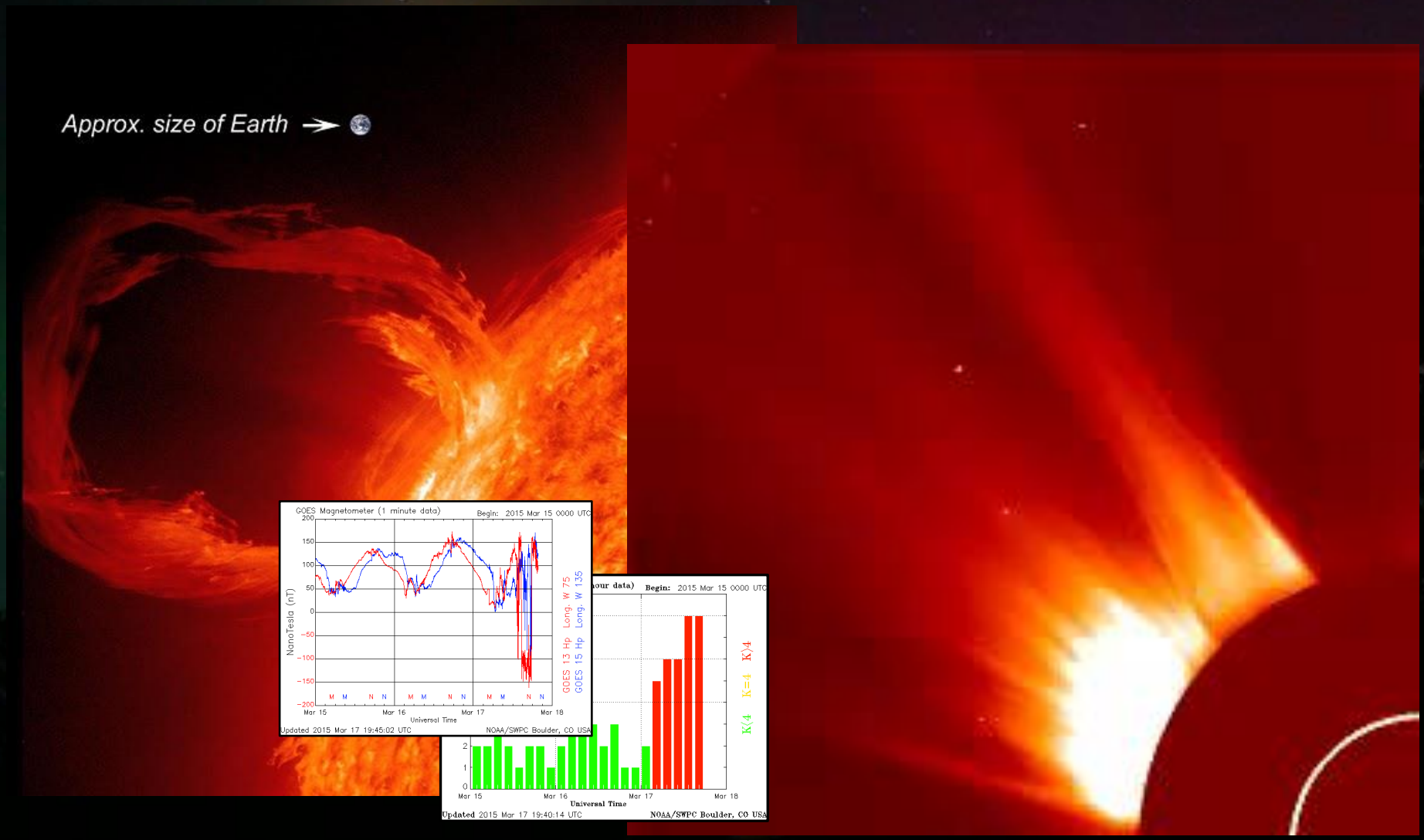
Impacts…

- Satellite Opera
  satellite)
- Aviation (comm
- High latitude H

D

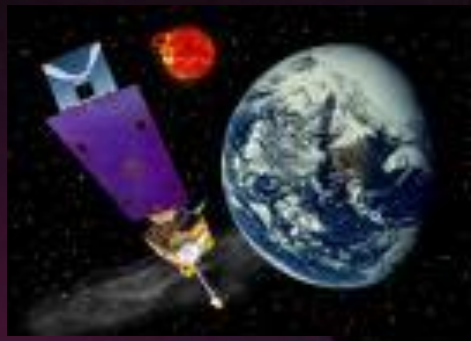
Geomagnetic Storms *(magnetic field)*

Coronal Mass Ejections (CMEs) create geomagnetic storms



Geomagnetic Storm Impacts

Impacts from geomagnetic storms are wide-ranging with potentially significant consequences.



Satellite Operations

Manned Spaceflight

GPS

Power Grid Operations

Aircraft Operations

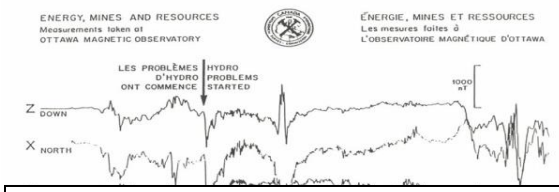
Significant grid problems have occurred…

HYDRO-QUEBEC PRESS RELEASE

Direction Relations Publiques
HYDRO-QUEBEC
MONTREAL, CANADA

MARCH 13 BLACKOUT CAUSED BY AN EXCEPTIONALLY STRONG MAGNETIC STORM

Montreal, March 15, 1989 - Hydro-Quebec confirms that the March 13 blackout was caused by the strongest magnetic storm ever recorded since the 735-kv power system was commissioned. At 2:45 AM the storm, which resulted from a solar flare, tripped five lines from James Bay and caused a generation loss of 9,450 MW. With a load of some 21,350 MW at that moment, the system was unable to withstand this sudden loss and collapsed within seconds, thereby causing the further loss of generation from Churchill Falls and Manio-Outardes.



Information Notice No. 90-42:
FAILURE OF ELECTRICAL POWER EQUIPMENT DUE TO SOLAR MAGNETIC DISTURBANCES

Specific events occurred at the Three Mile Island Unit 1, Hope Creek Unit 1, and Salem Unit 1 nuclear power plants. …inspection of the generator step-up transformer… severe overheating, melted low-voltage service connections in phases A and C, and insulation discoloration in phase B. On September 19, at Salem Unit 2 nuclear power plant, a second solar storm damaged the generator step-up transformer. *Sep 1990*

Department of Homeland Security
Information Analysis and Infrastructure Protection
Daily Open Source Infrastructure Report for 03 November 2003

Current Nationwide Threat Level is
ELEVATED
Significant Risk of Terrorist Attacks
For info click here
www.whitehouse.gov/homeland

Energy Sector

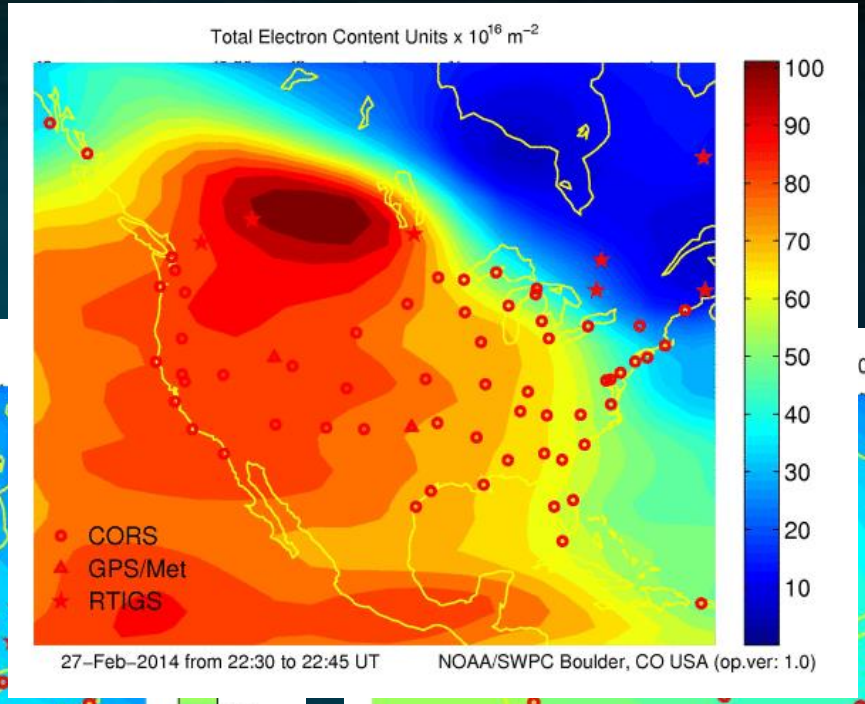
Current Electricity Sector Threat Alert Levels: Physical: Elevated, Cyber: Elevated
Scale: LOW, GUARDED, ELEVATED, HIGH, SEVERE [Source: ISAC for the Electricity Sector (ES-ISAC) – http://esisac.com]

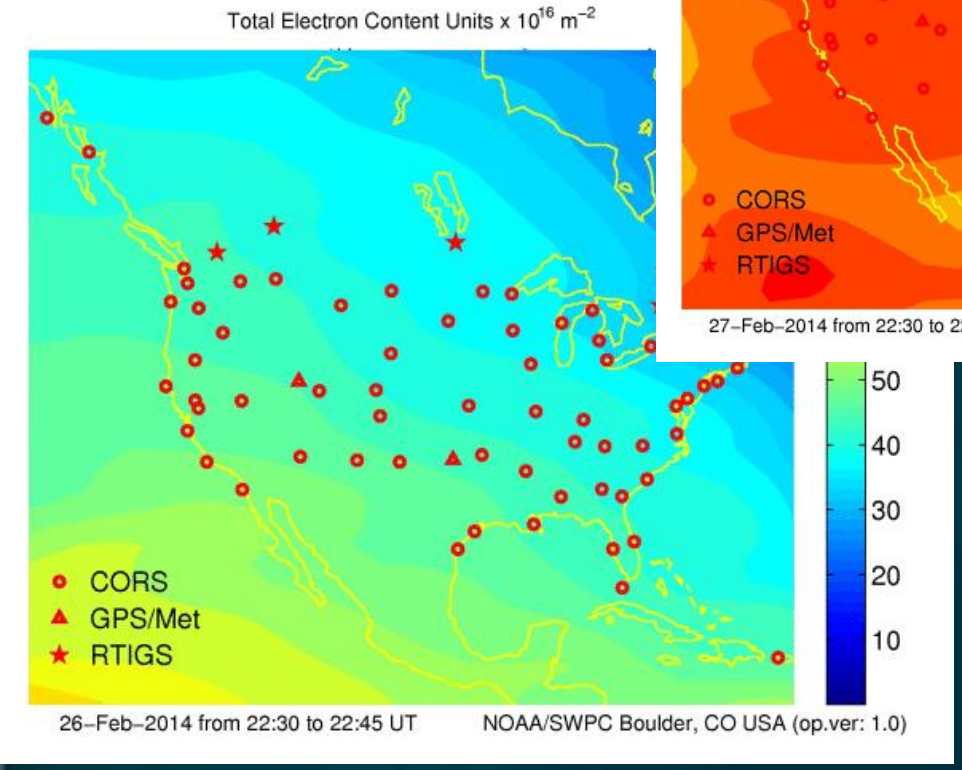
October 31 ***- Sun storm causes problems for Swedish power system. The solar storm has caused technical glitches in Sweden's power system in the past few days and may be to blame for a blackout that affected 50,000 people on Thursday, October 30****.*

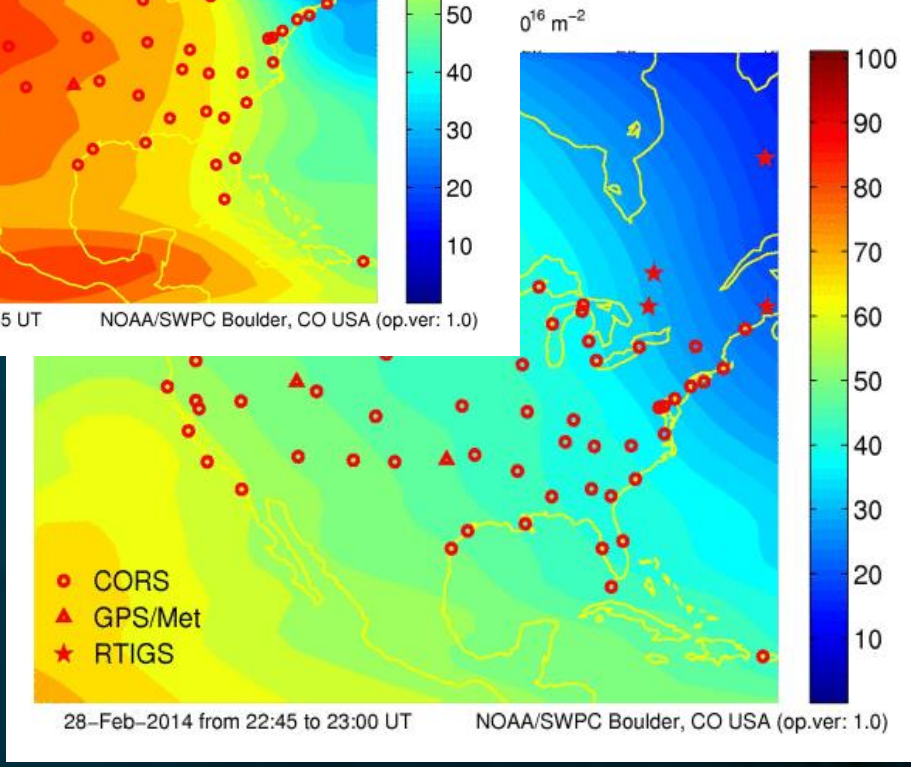
Transformer winding failure

Transformer exit-lead overheating

Ionospheric Storm Feb 2014





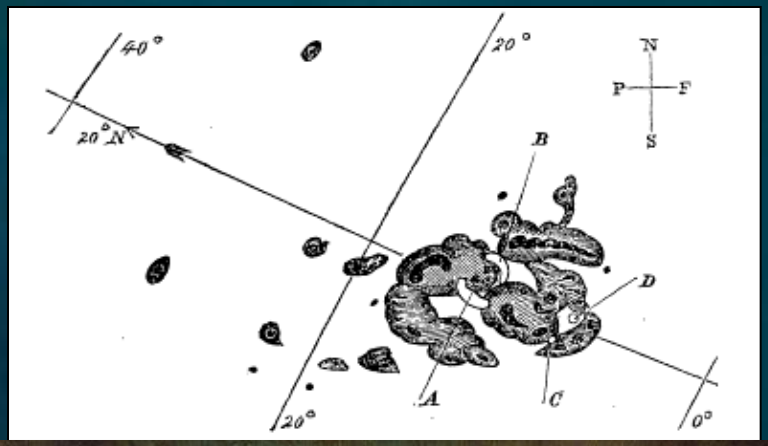


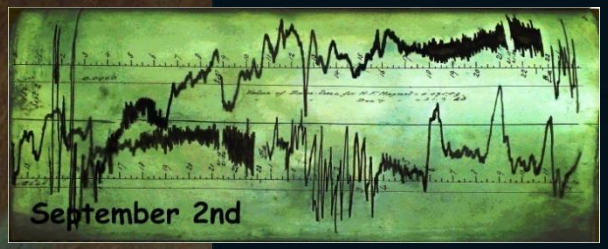
An Ionospheric Storm began on 2/27/14. The WAAS LPV and LPV200 service was not available in Eastern Alaska and Northeastern US. At times, North Central US and all of Alaska lost LPV and LPV200 Service.

(A localizer performance with vertical guidance (LPV) approach is a modern aviation instrument approach procedure using WAAS.)

Extreme Space Weather

Carrington Event – Sep 1-2, 1859





Visible Aurora, Sep 2

May 1921 Geomagnetic Storm

SUNSPOT CREDITED WITH RAIL TIE-UP

New York Central Signal System Put Out of Service by Play of Northern Lights.

The sunspot which caused the brilliant aurora borealis on Saturday night and the worst electrical disturbance in memory on the telegraph systems was credited with an unprecedented thing at 7:04 o'clock yesterday morning, when the entire signal and switching system of the New York Central Railroad below 125th Street was put out of operation, followed by a fire in the control tower at Fifty-seventh Street and Park Avenue.

This is the first time that a sunspot has been blamed for such a piece of mischief. From other accounts it appeared

The New York Times
Published: May 16, 1921

CABLES DAMAGED BY SUNSPOT AURORA

Ships to Be Sent Out to Mend Lines Put Out of Service by Magnetic Display.

ELECTRIC DISTURBANCES AFFECT FRENCH WIRES

Aurora Not Visible, Its Absence Being Attributed to Atmospheric Conditions.

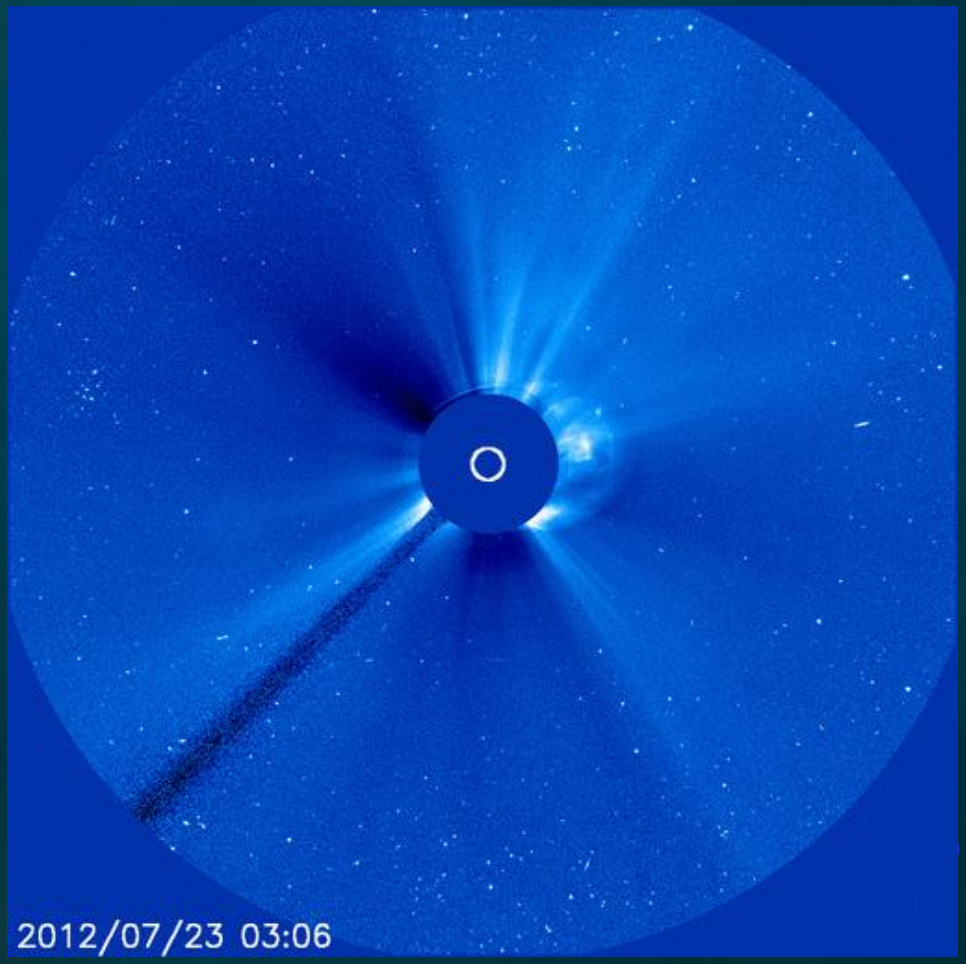
By Wireless to THE NEW YORK TIMES.

PARIS, May 17.—The disturbance which interrupted telegraphic transmission in the United States last week has been making itself felt also in France.

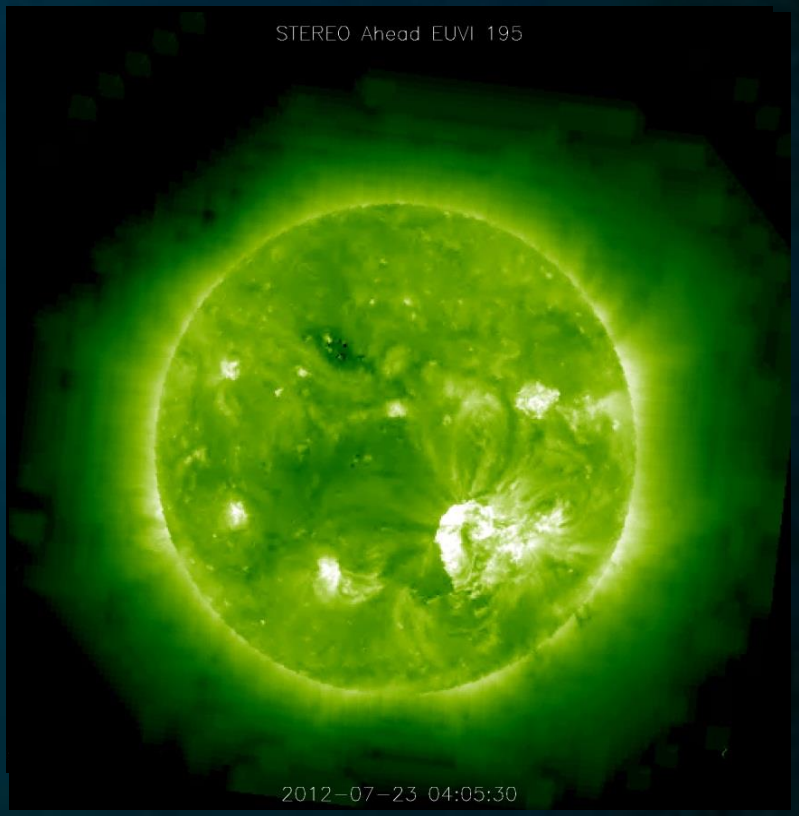
On Saturday night especially the operators at the central transmission stations came to the conclusion that a strange force had got into their instruments, for nothing would go right. Morse instruments, instead of making dots and dashes, recorded one long line,

Extreme Space Weather

23 July 2012 – Close call!



Powerful solar flare on 23 July, 2012…



The coronal mass ejection speed: ~2900 km/s or 10.5 million km/h – Carrington like!

23 July 2012

- **“Using a well-proven geomagnetic storm forecast model, we find the 23-24 July event would have produced a geomagnetic storm that was comparable to the largest events of the 20th Century.”**

A Major Solar Eruptive Event in July 2012: Defining Extreme Space Weather Scenarios; D.N. Baker et al.

ENR
Engineering News-Record

Home » What is the Chance a Solar Storm Could Knock Out The Power Grid?

Power & Industrial | Viewpoint | Risk

Risks Revisited

What is the Chance a Solar Storm Could Knock Out The Power Grid?

Researchers fine-tune estimates of a strong punch that could put out our lights

June 22, 2017

Richard Korman

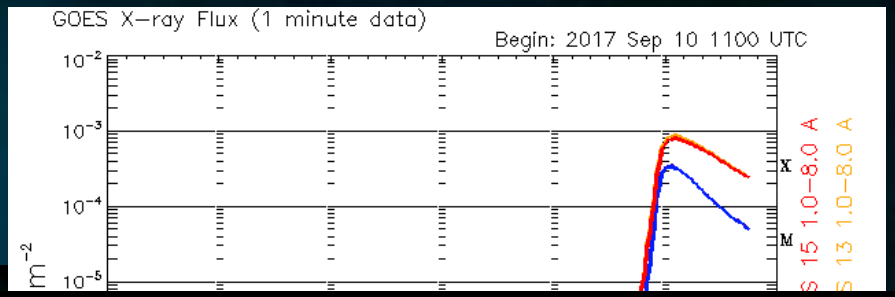
KEYWORDS natural disaster / Risk Management / solar storms / space weather

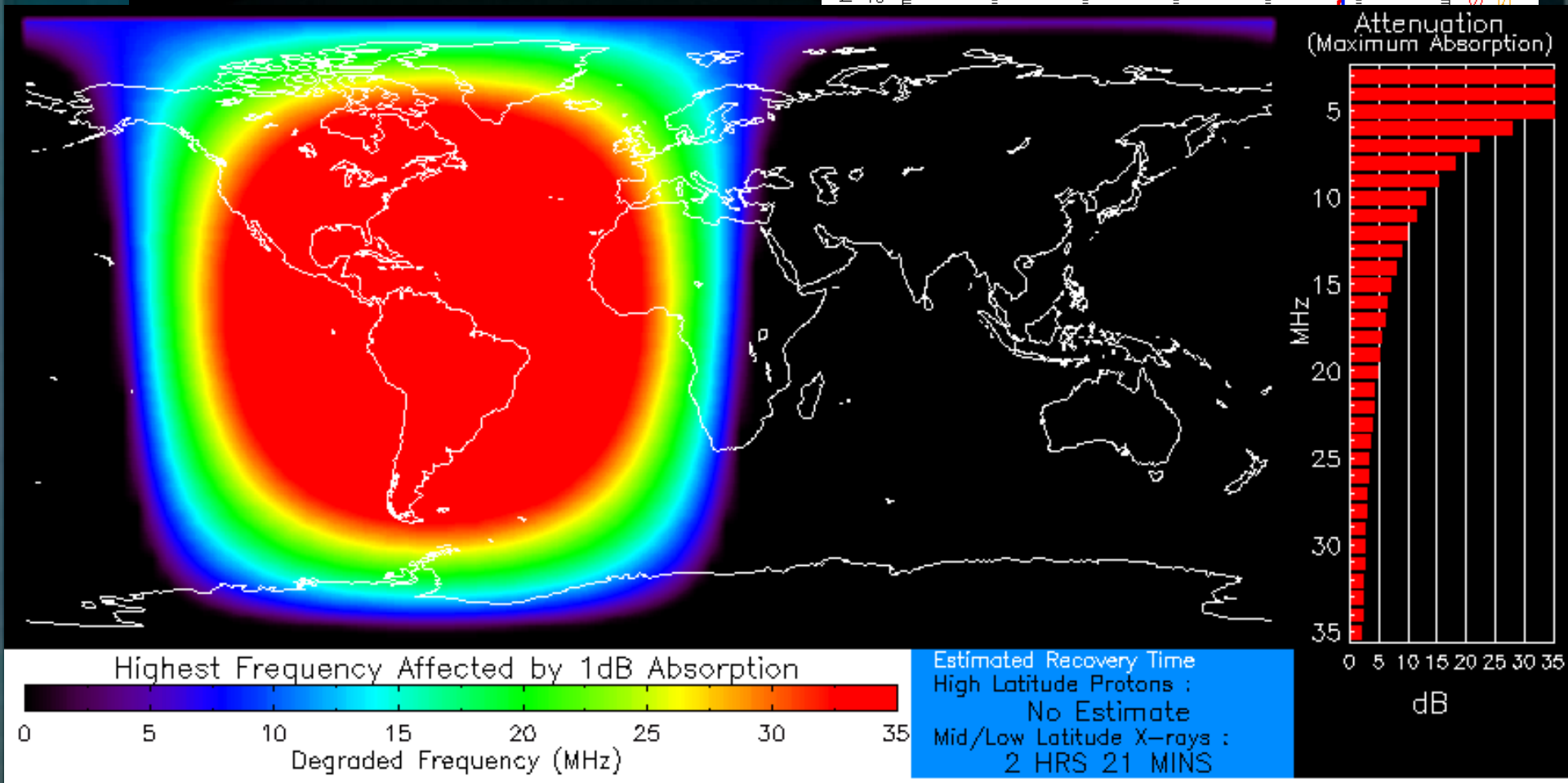
"estimate that there is a 10% chance of a Carrington-level event over the next decade"

Concluding Remarks

- Severe space weather is a hazard that poses significant risks to the economy and security of nations around the world
- We must understand the space environment in the context of its impact on system operations
- Nations should consider including space weather in the identification, assessment, and prioritization of risks
- Nations must work together to enhance the resilience of critical infrastructure to the adverse effects of space weather

September 2017





Strong X-ray flux
Product Valid At : 2017-09-10 16:06 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA

September 2017

Sep 10th: "Solar flare activity with major impact on HF Comms. Between approximately 1610z and 1710z communicated with flights primarily by VHF and SAT Phones due to degraded HF frequencies. Contacted ATC facilities to advise flights if unable on HF, contact NY on SAT phones or air-to-air on VHF guard. Three ATC Clearance message deliveries were delayed during this event."
Aviation Voice Services

NOTE: *The aircraft emergency frequency (also known as GUARD) is a frequency used on the aircraft band reserved for emergency communications for aircraft in distress*