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Impact of a Geomagnetic Storm on the GNSS-based Positioning Service CPOS

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Credit for pictures and illustrations of space phenomena: NASA, NASA/SDO, ESA



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Solar flares

Extremely powerful explosions on the Sun,
driven by release of magnetic tension



PRE-FLARE



Subsurface flows relaxed

BUILD UP



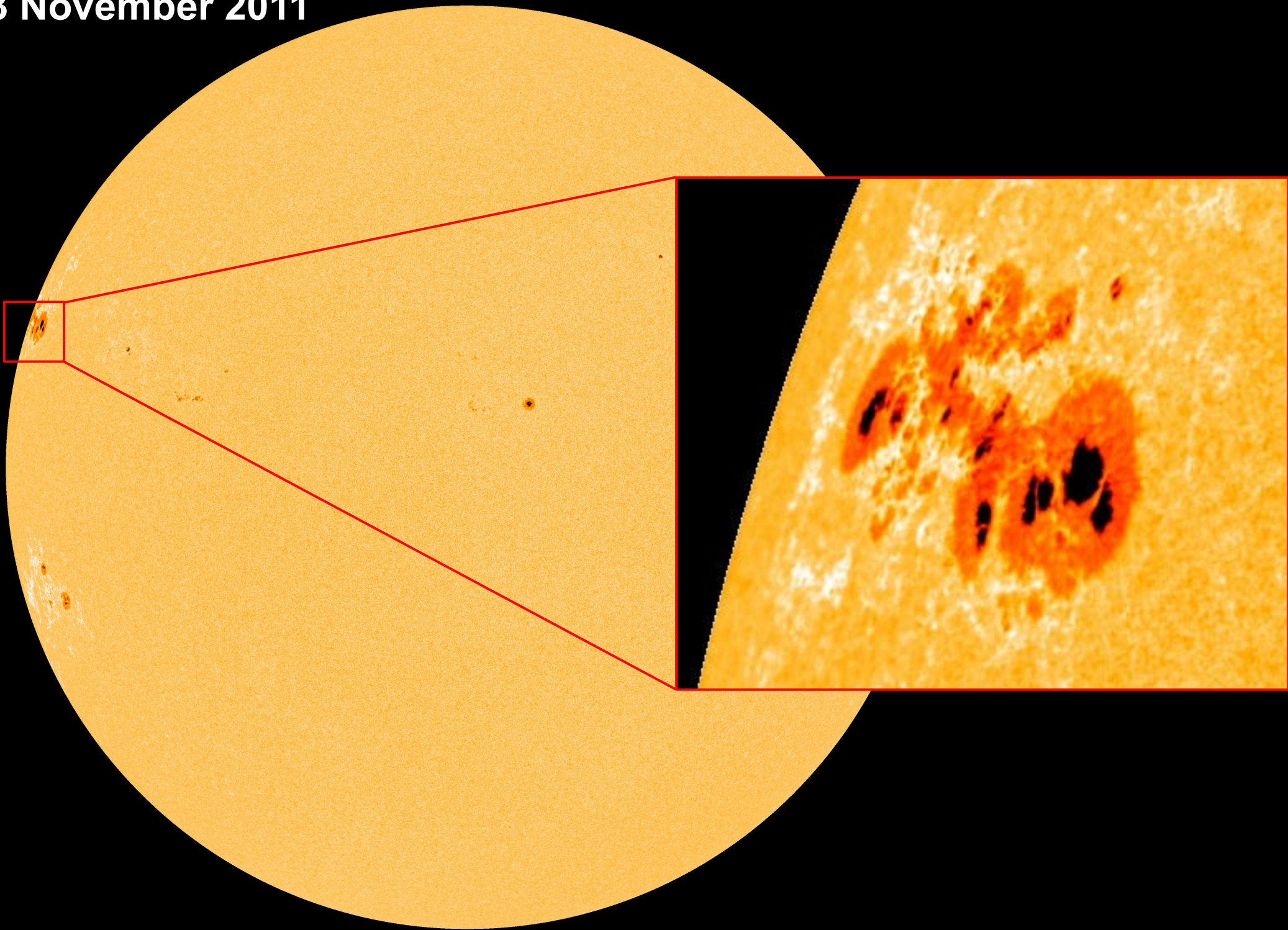
Flux tube twisted by subsurface flows

FLARE



Flare goes off
Plasma ejected

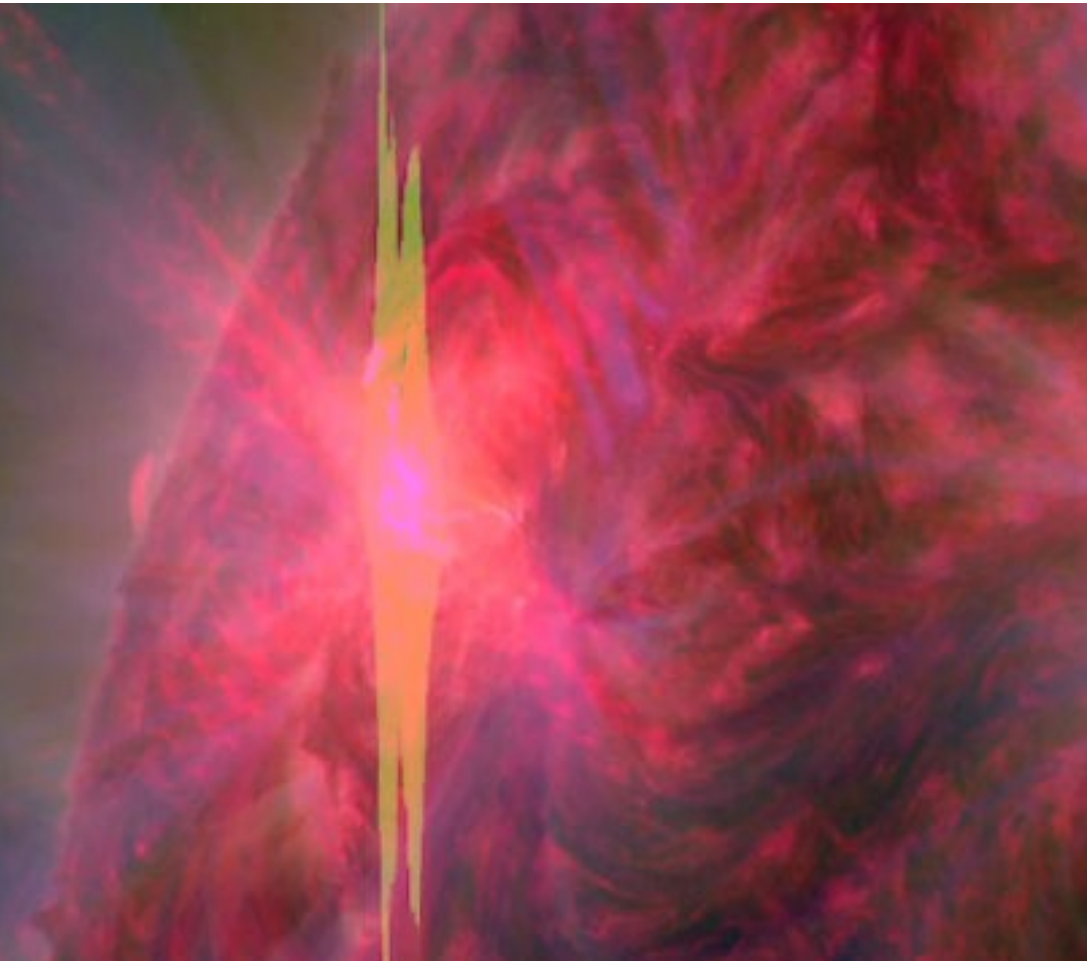
3 November 2011



3 November 2011 – X-class Solar Flare

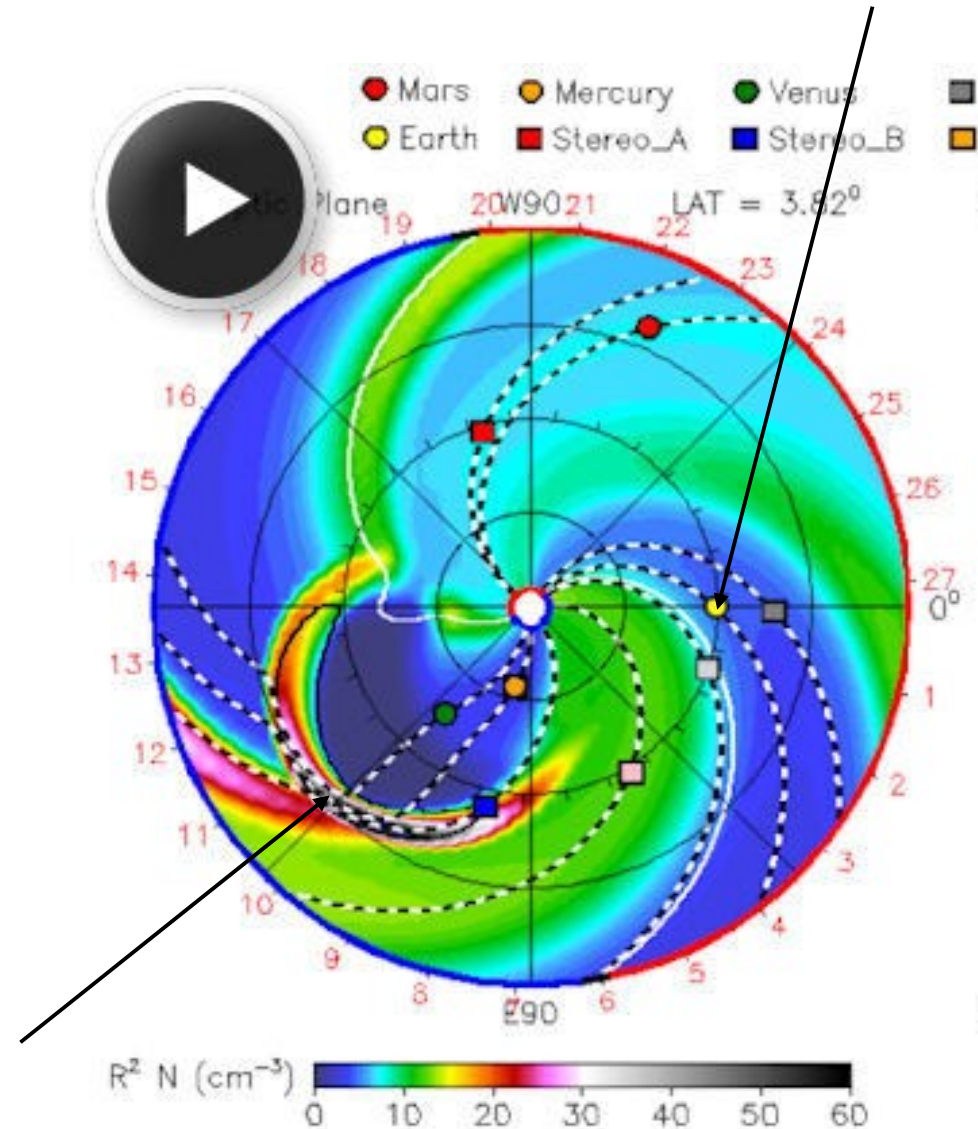
At around 20:27 UT, the sunspot AR1339 releases an X2-flare and launches a CME.

|
(=== an R3 radio blackout)



CME
(modeled)

The CME was not directed towards **Earth**



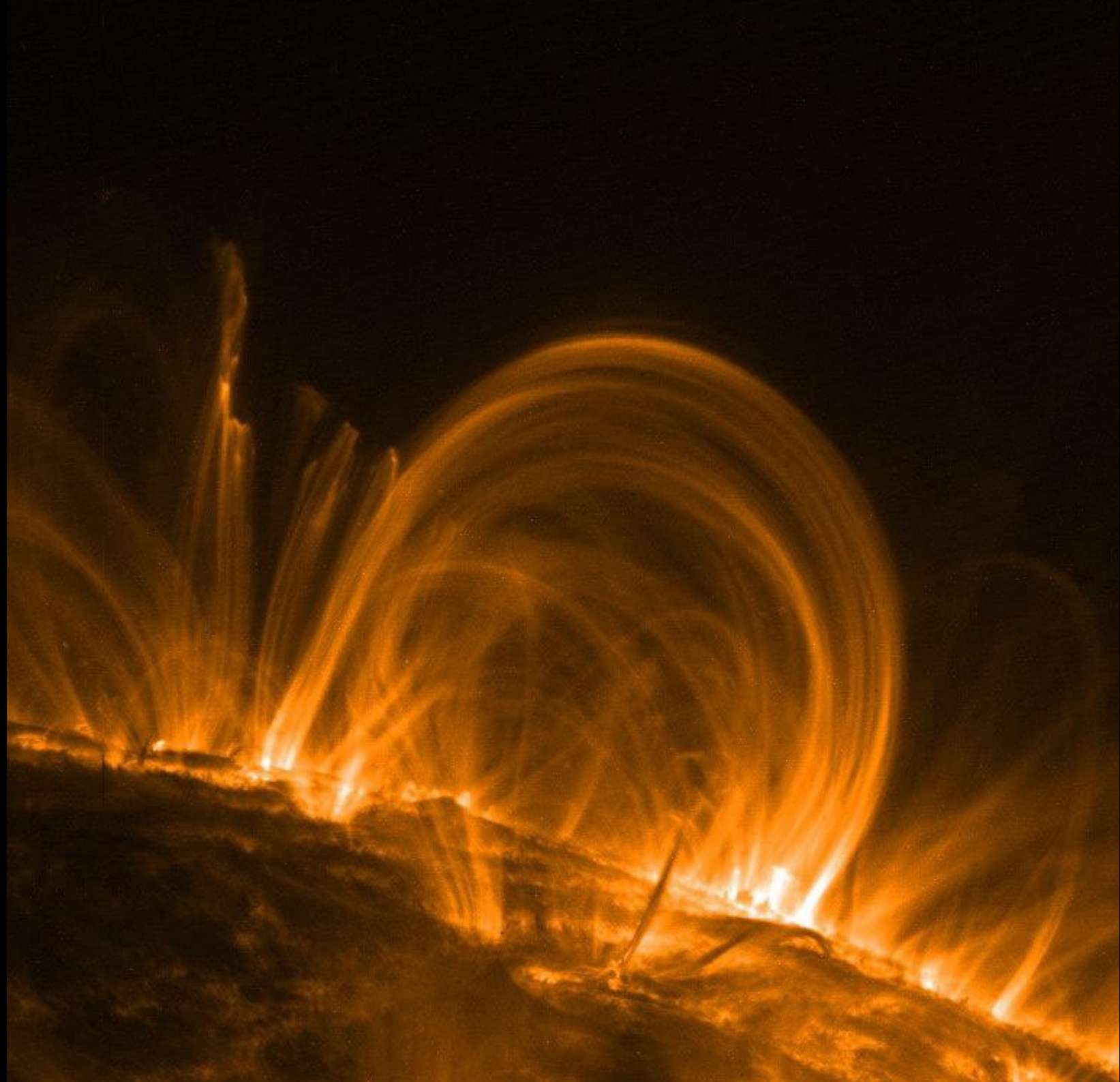
Effects of solar flares

- High-energy electromagnetic radiation (X-rays and gamma rays)
- Energetic particles (Protons at > 100 MeV)
- **Coronal Mass Ejections**

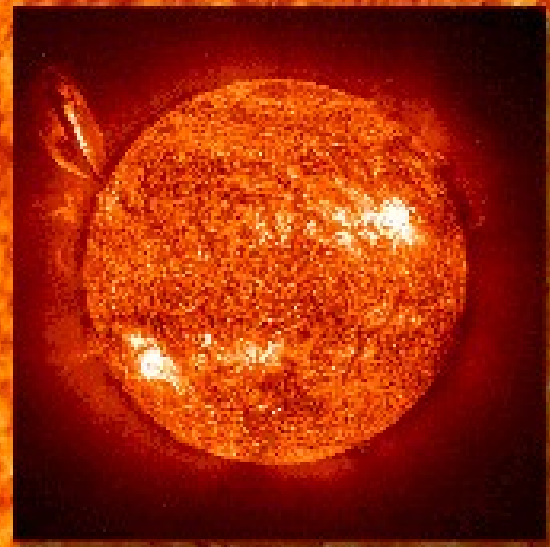


Coronal Mass Ejections (CMEs)

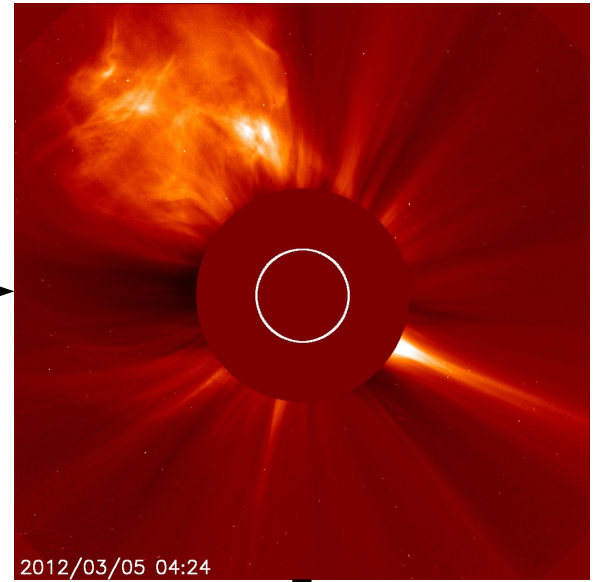
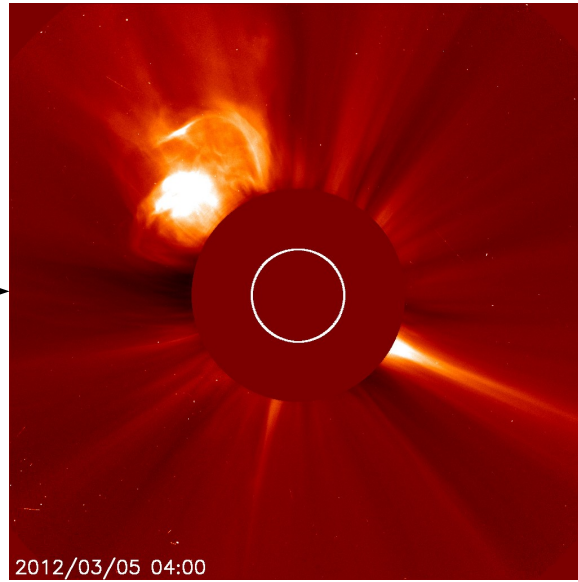
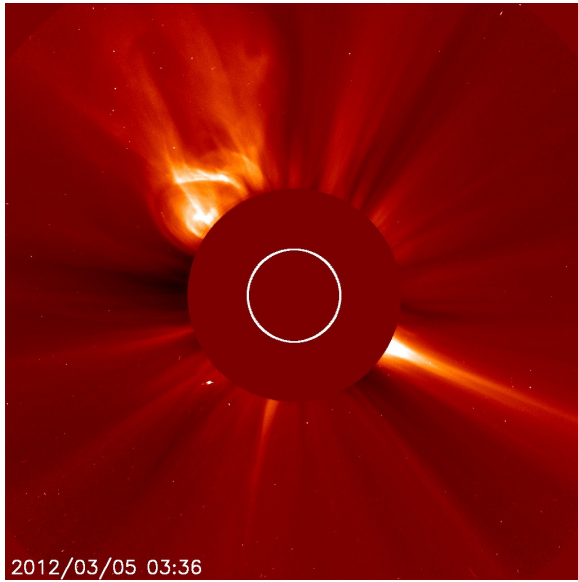
Giant clouds of plasma
escaping from the Sun



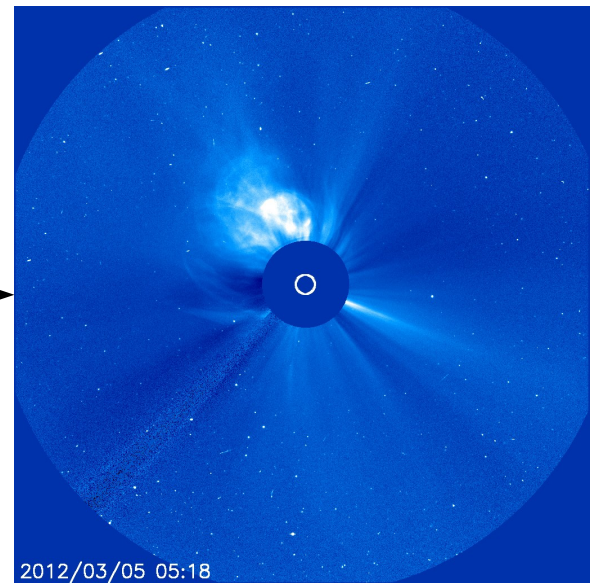
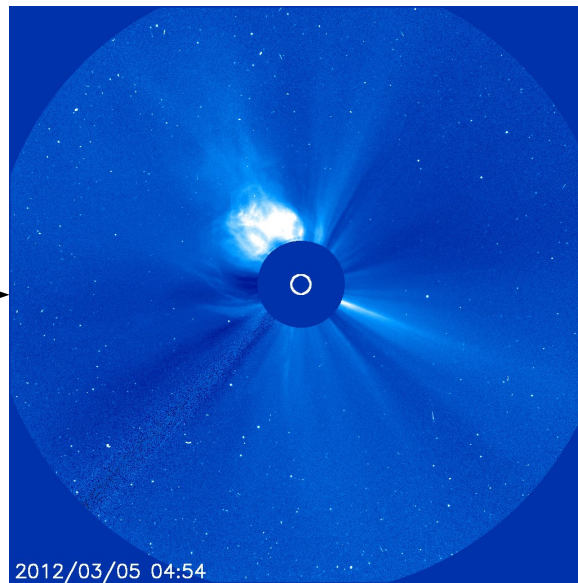
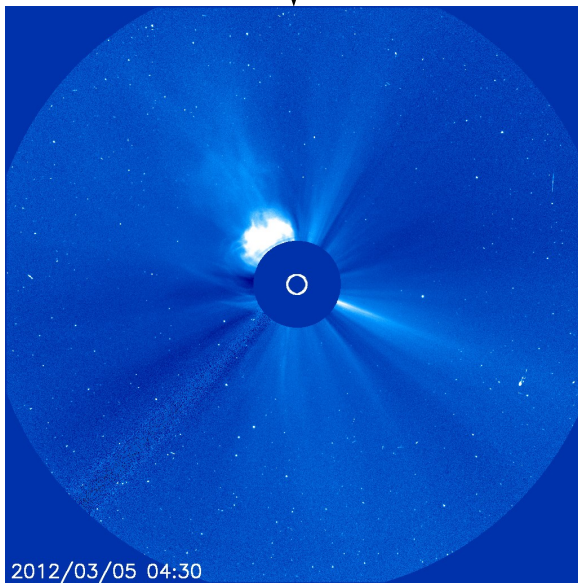
Earth shown
for size comparison

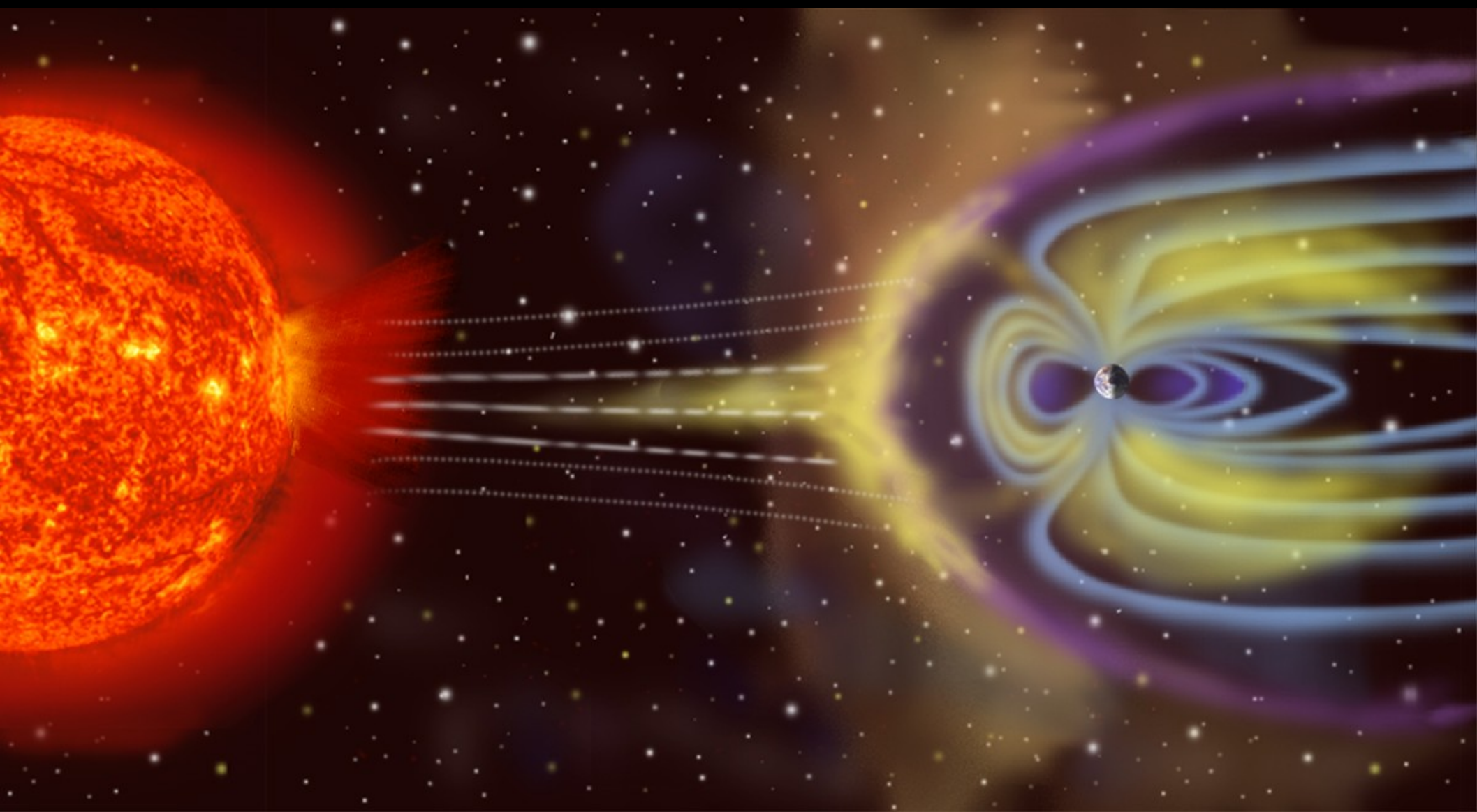


03:36



05:18





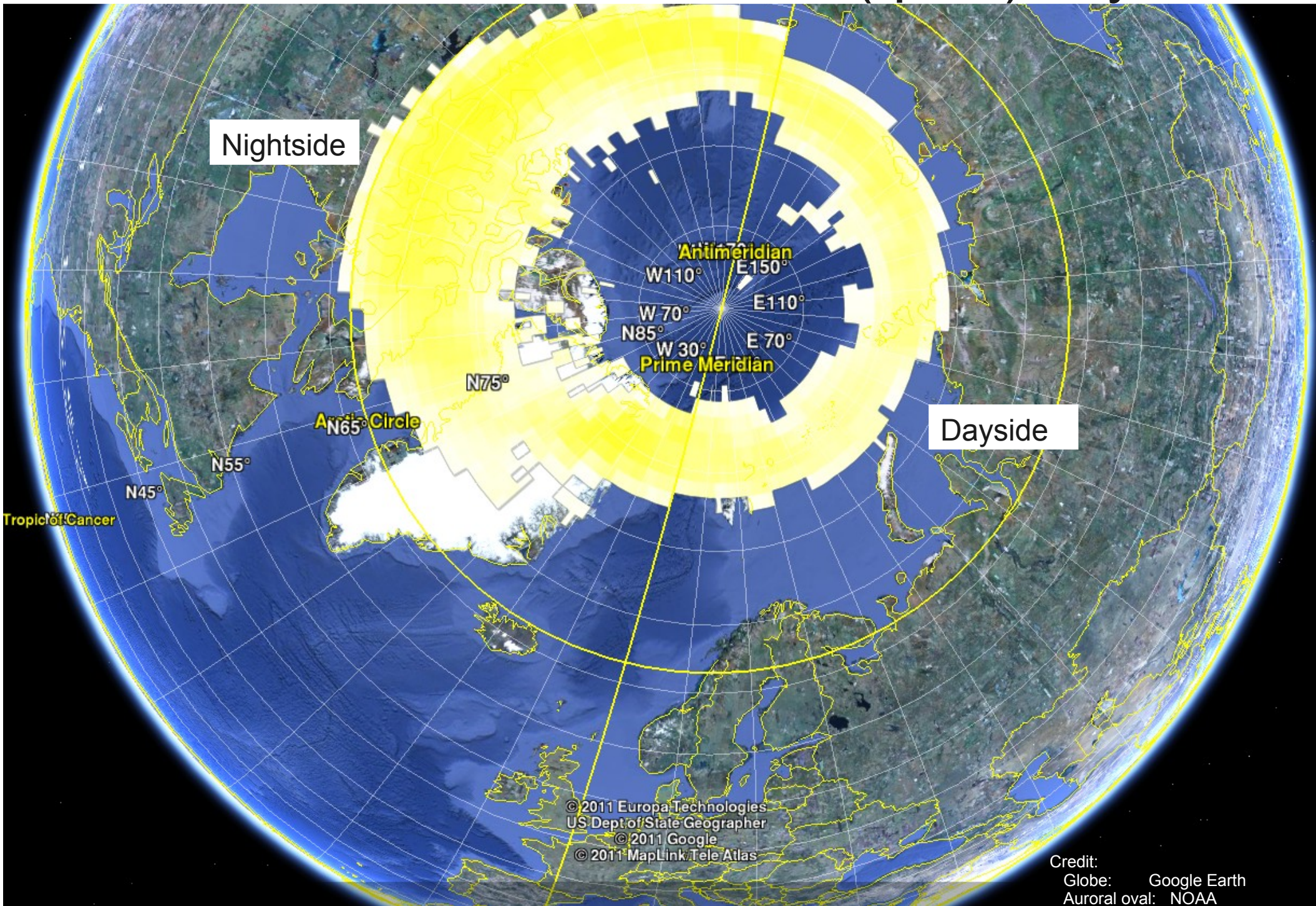


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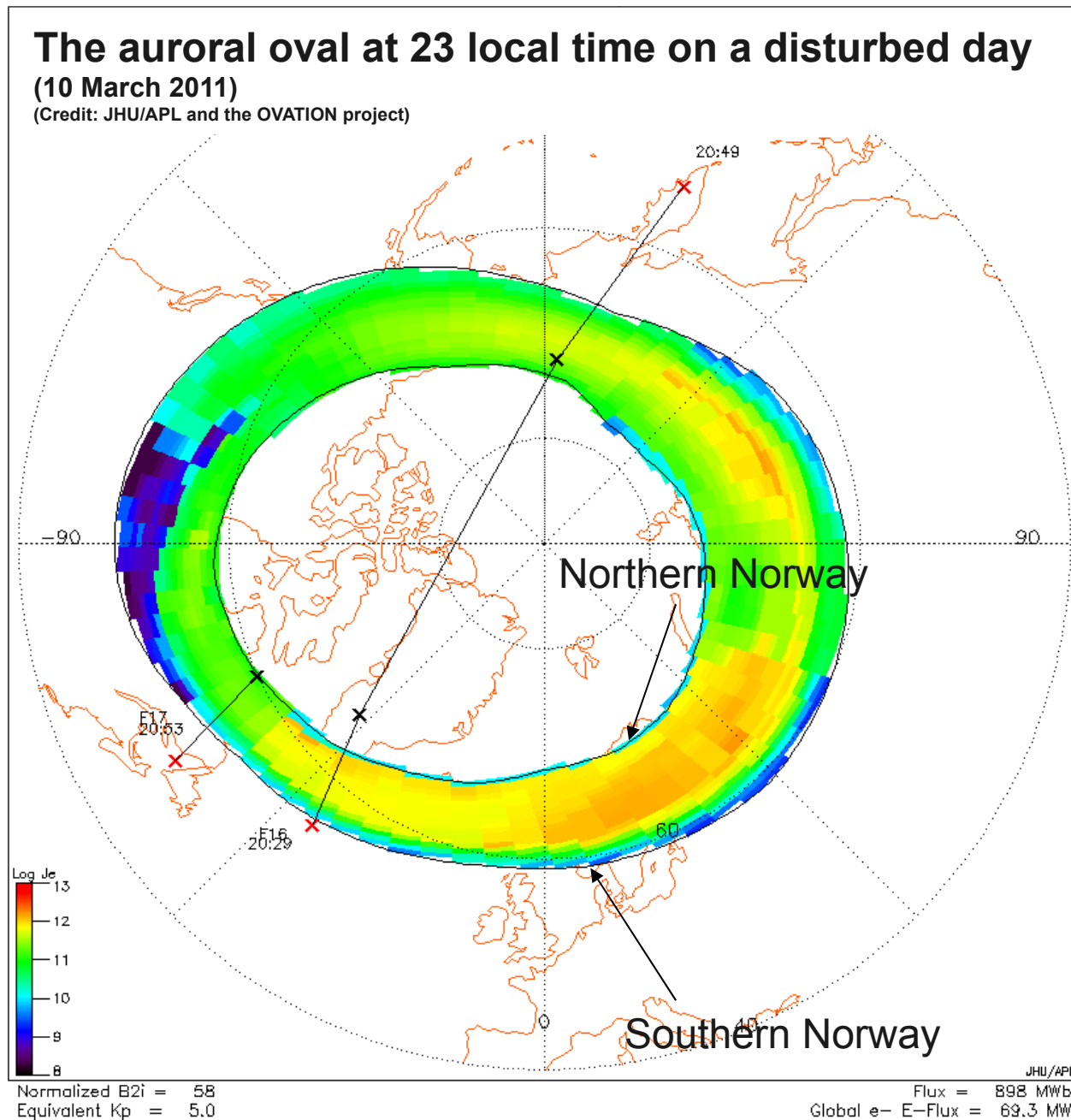
Auroral oval

Pretty lights in the sky

Auroral oval on a normal (quiet) day



During geomagnetic storms, Norway is in a «perfect» position (If you want to see aurora)





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CPOS

The positioning service of the NMA

Centimeter accuracy in real-time

CPOS is based on a nationwide network of GNSS receivers



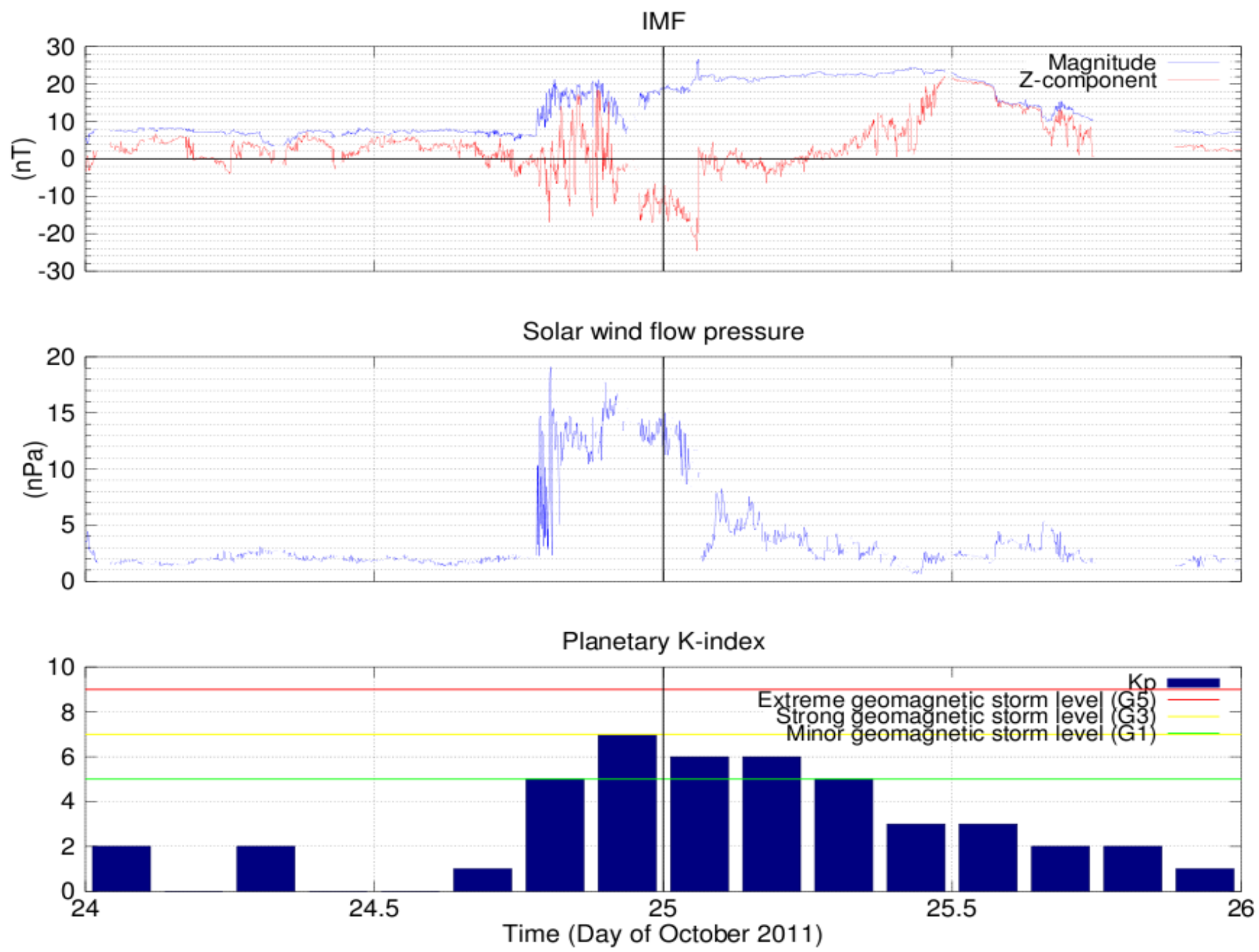


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Geomagnetic storm

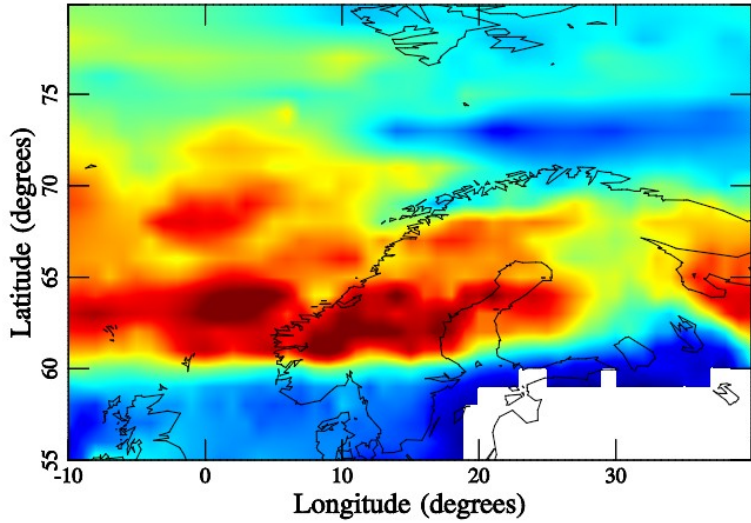
24 October 2011

Overview of the event and its effects on CPOS

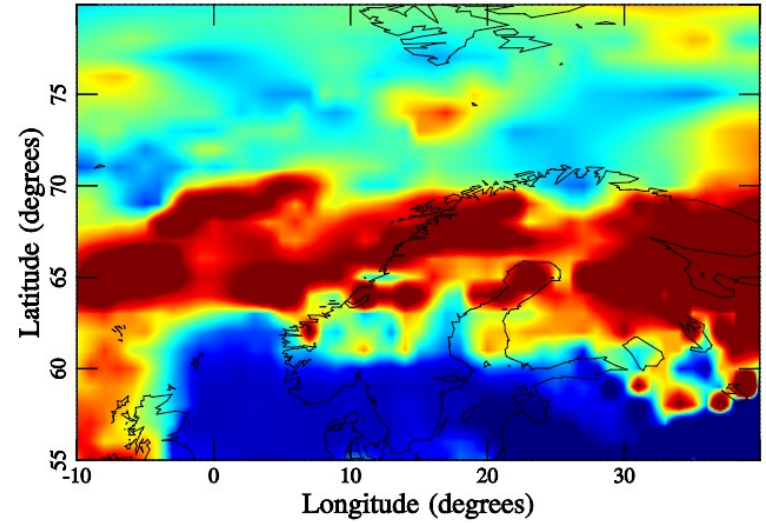


2011-10-24 22:05 UT

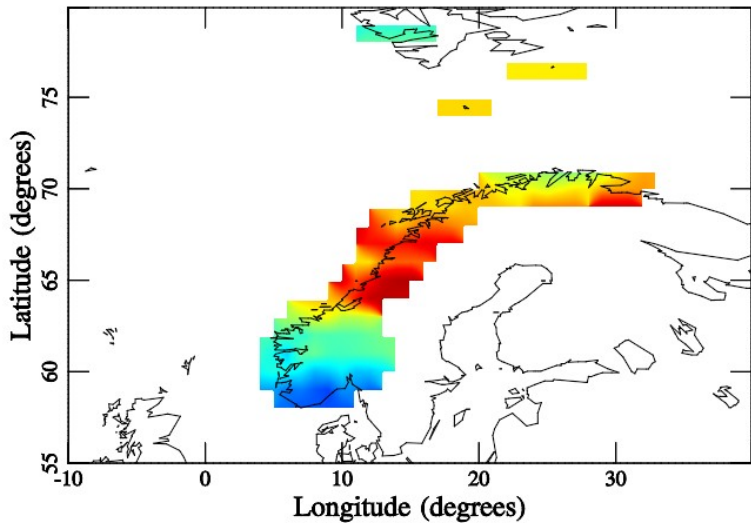
**Amount of plasma in the ionosphere
(TEC)**



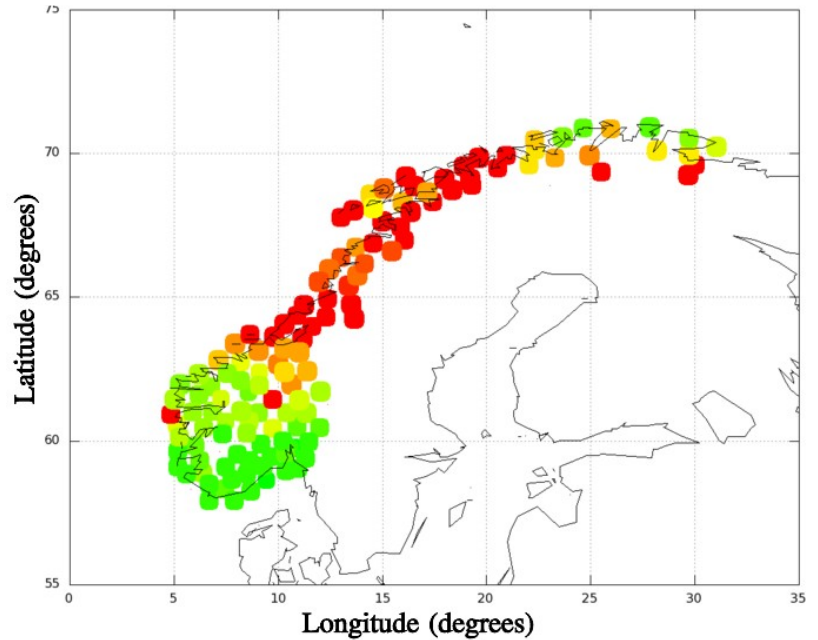
**Ionospheric disturbance level
(ROTI)**



**Effect of disturbances at ground level
(ROTI)**

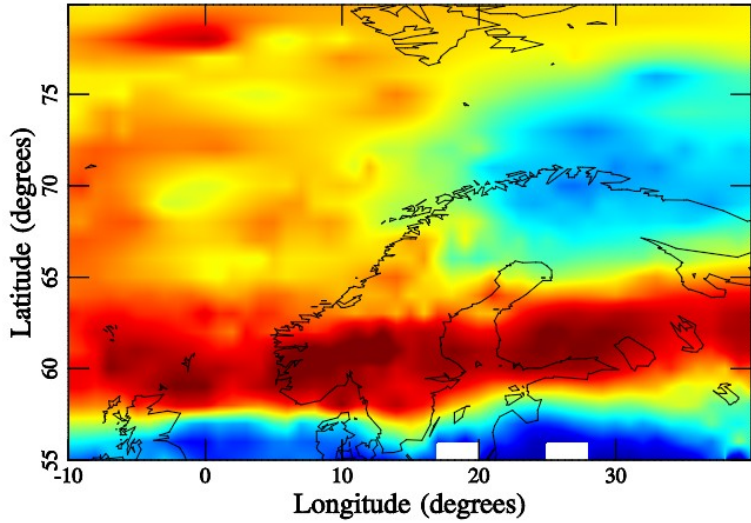


CPOS Processing Status

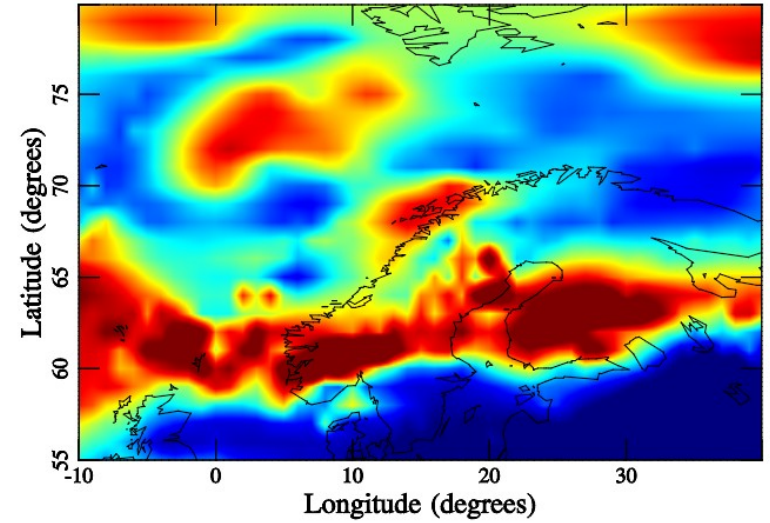


2011-10-24 23:00 UT

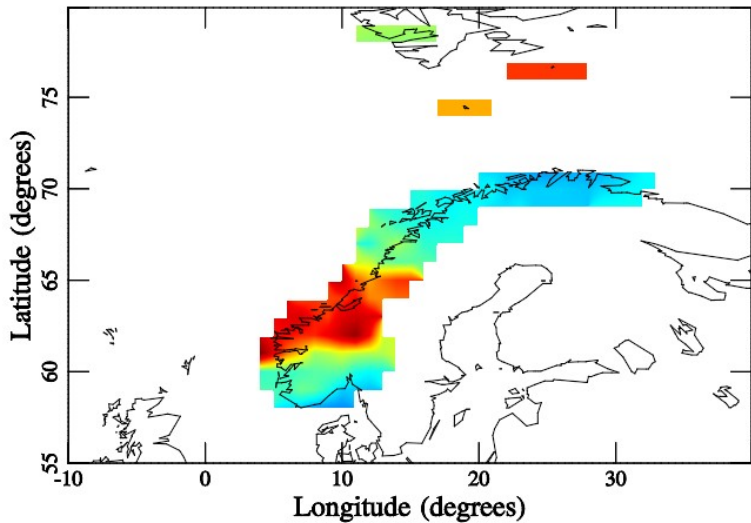
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(TEC)**



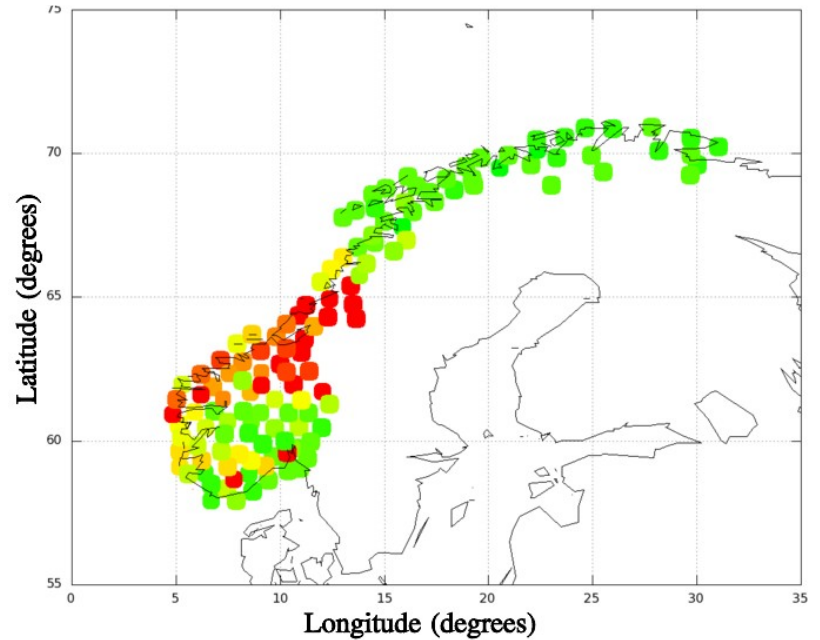
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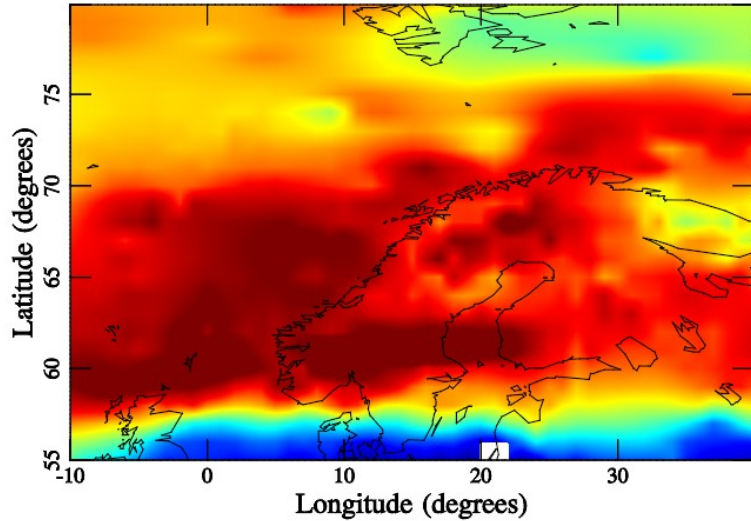


CPOS Processing Status

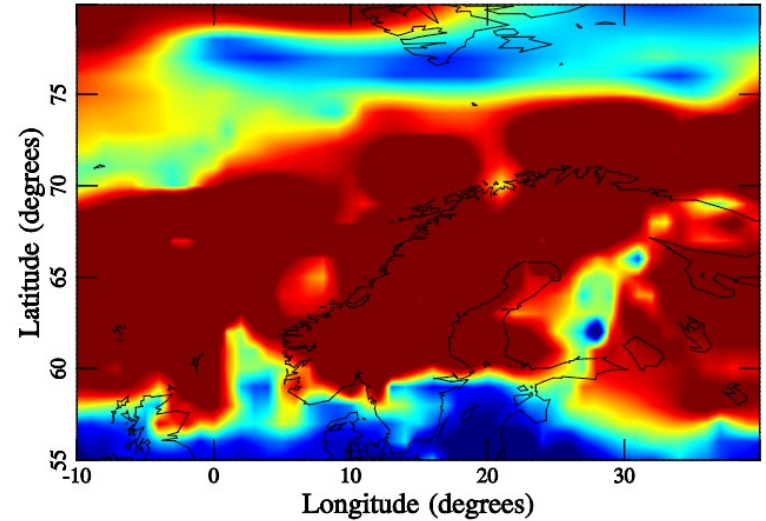


2011-10-24 23:30 UT

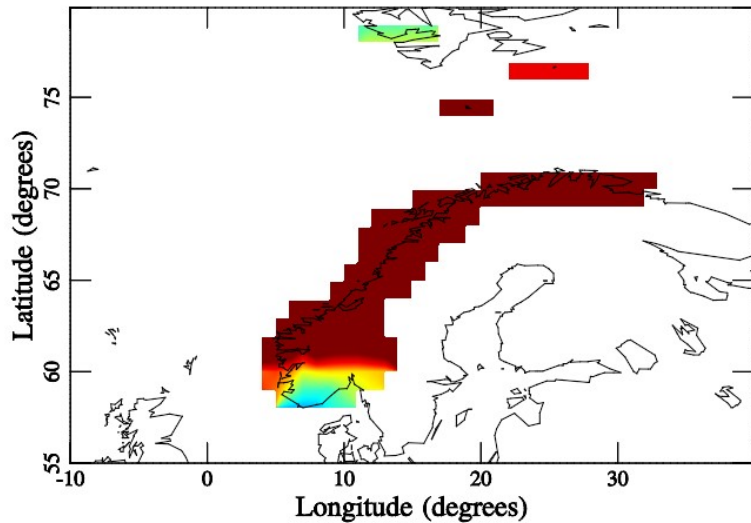
**Amount of plasma in the ionosphere
(TEC)**



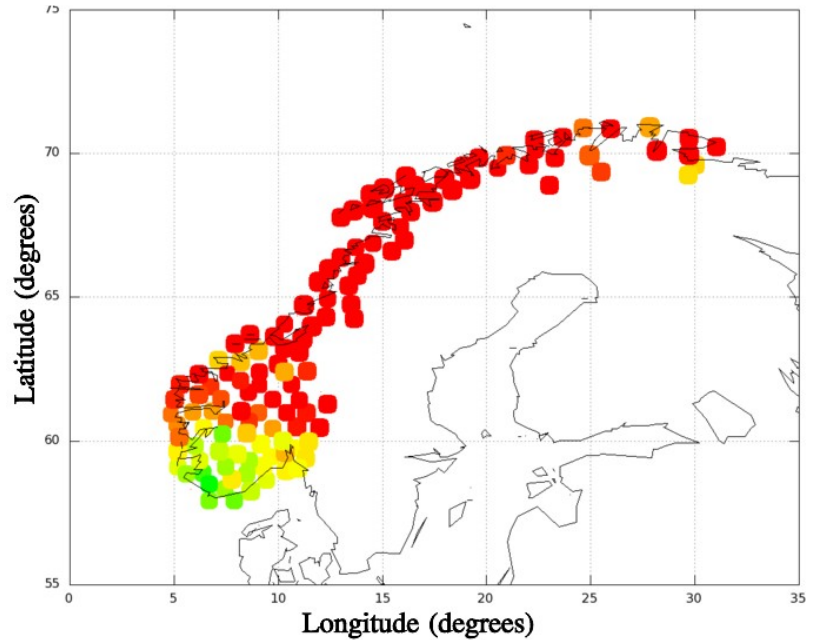
**Ionospheric disturbance level
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**Effect of disturbances at ground level
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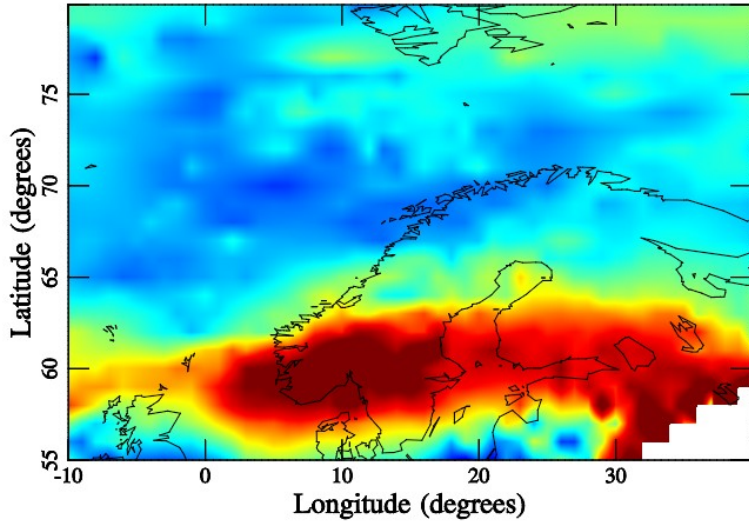


CPOS Processing Status

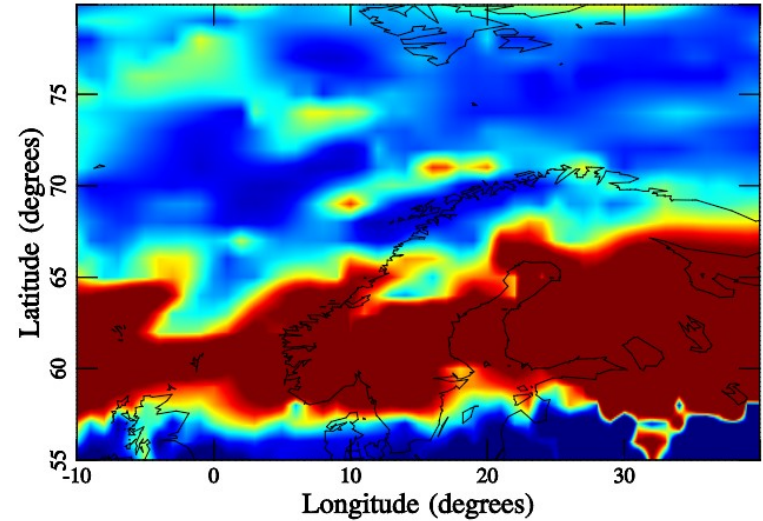


2011-10-25 01:20 UT

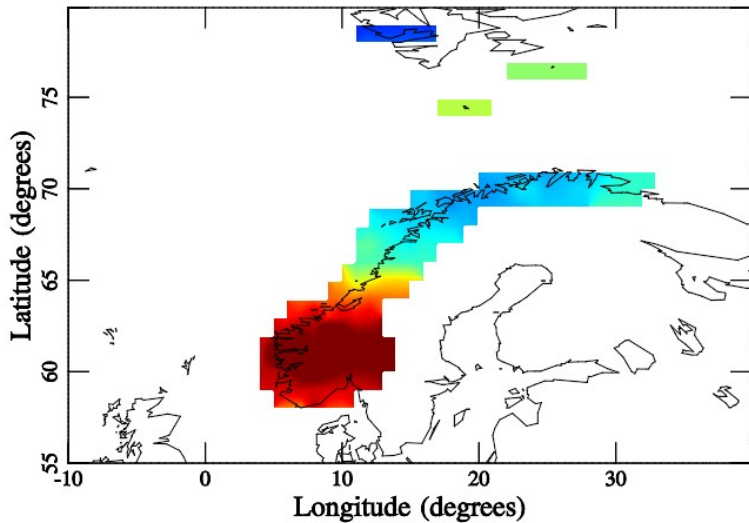
**Amount of plasma in the ionosphere
(TEC)**



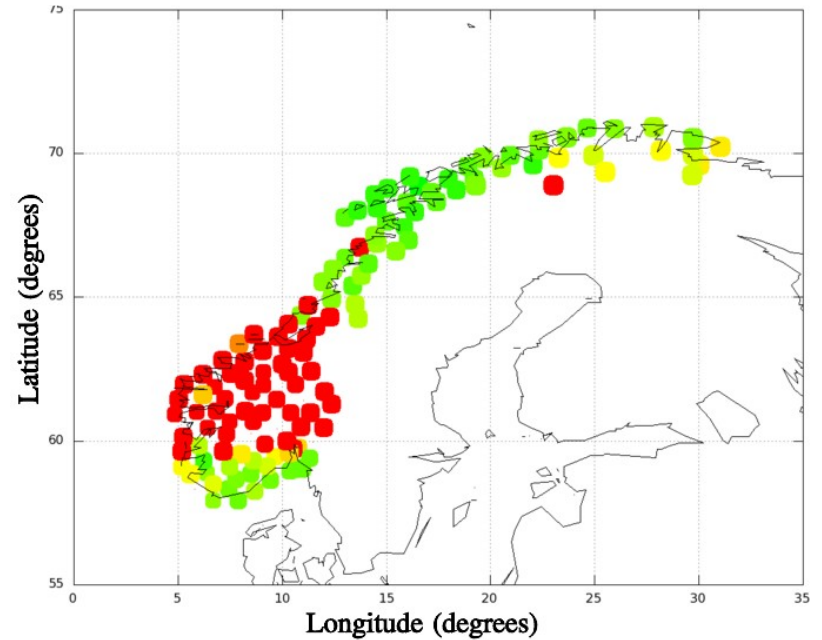
**Ionospheric disturbance level
(ROTI)**



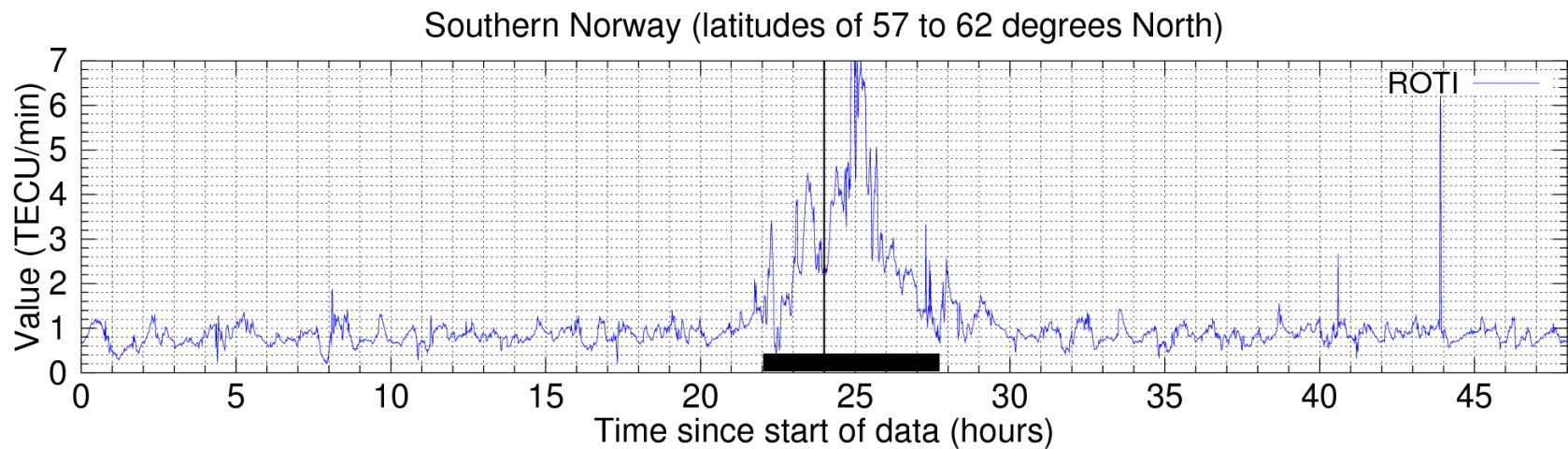
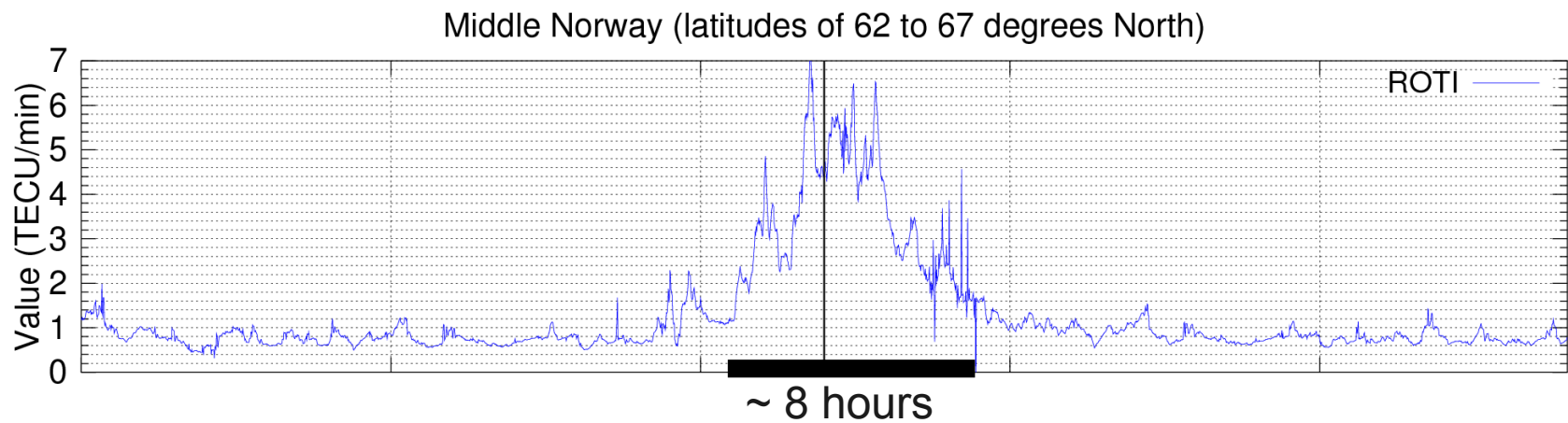
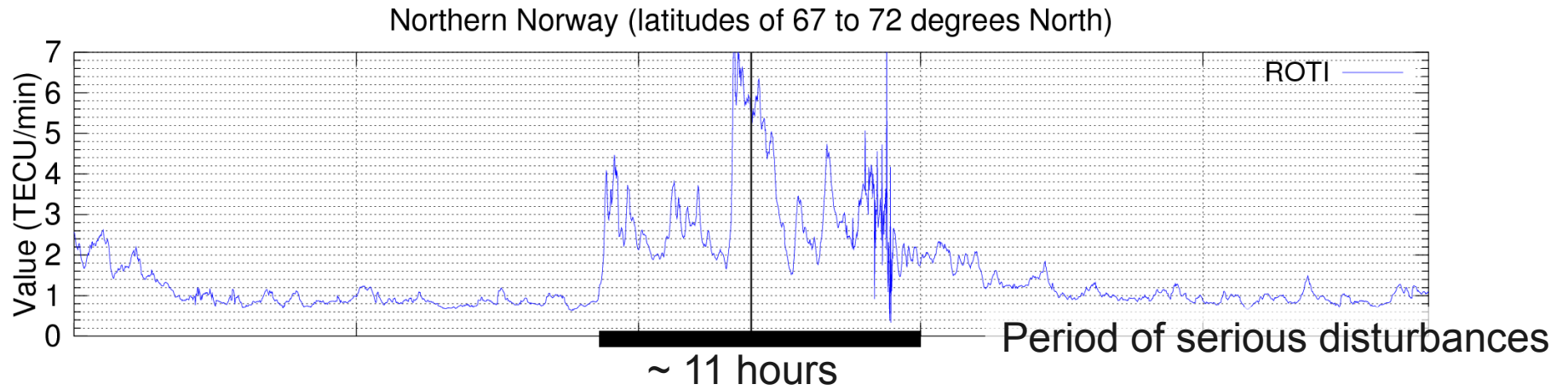
**Effect of disturbances at ground level
(ROTI)**



CPOS Processing Status

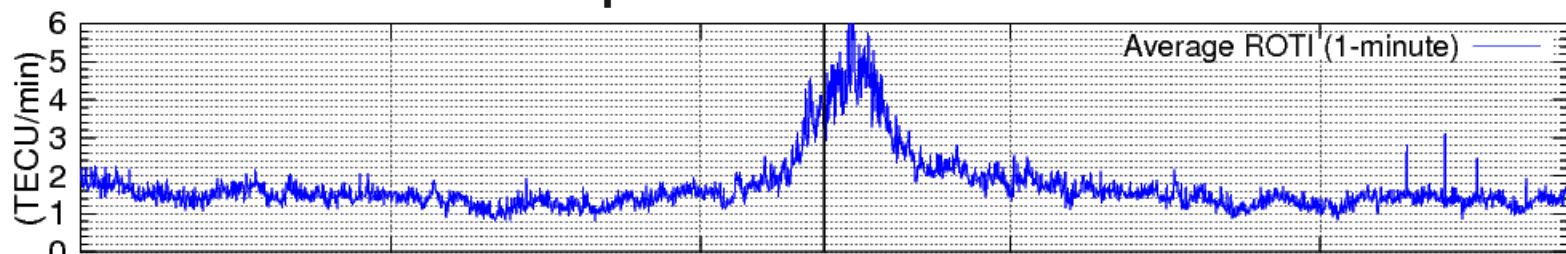


The ionospheric disturbances lasted for hours

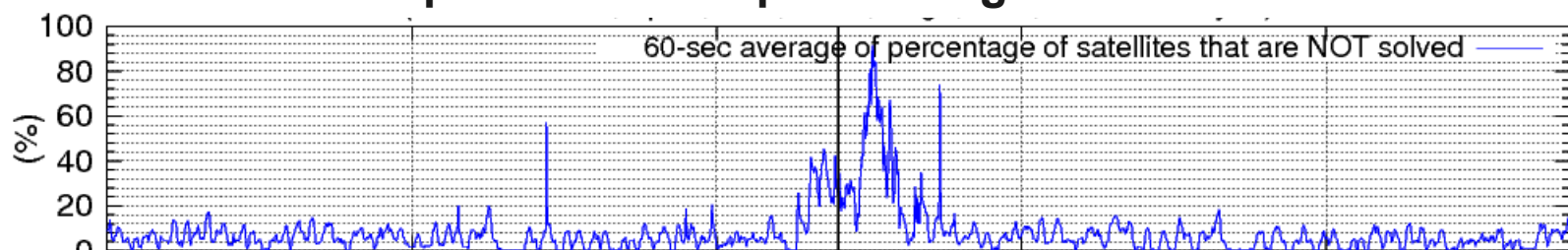


GNSS monitor measures user experience

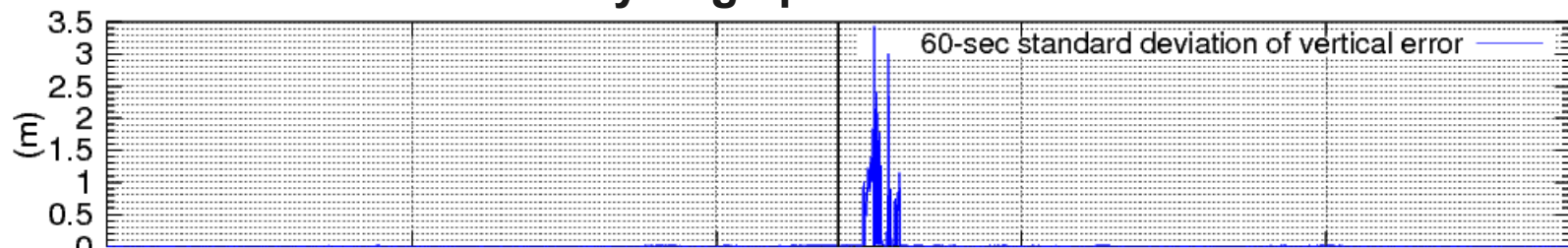
Ionospheric disturbance level



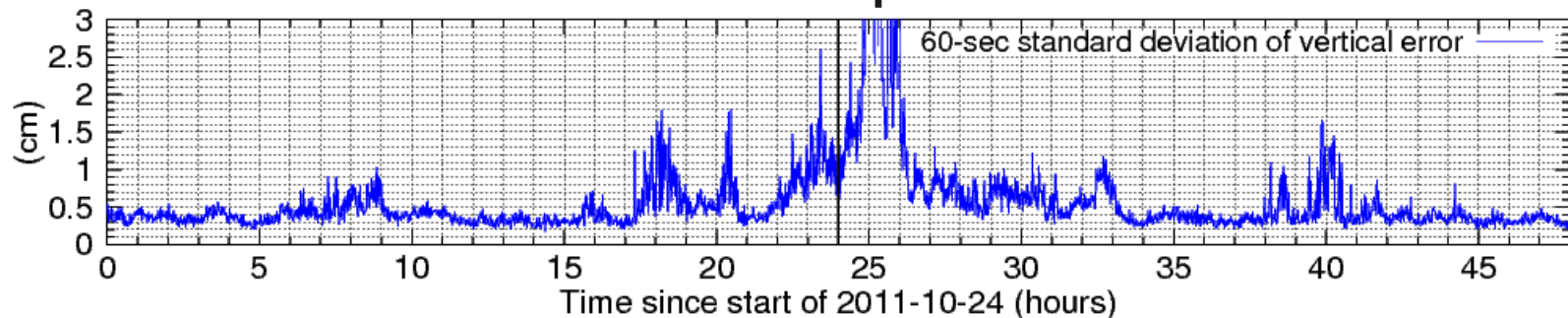
Disruption of CPOS processing near Hønefoss



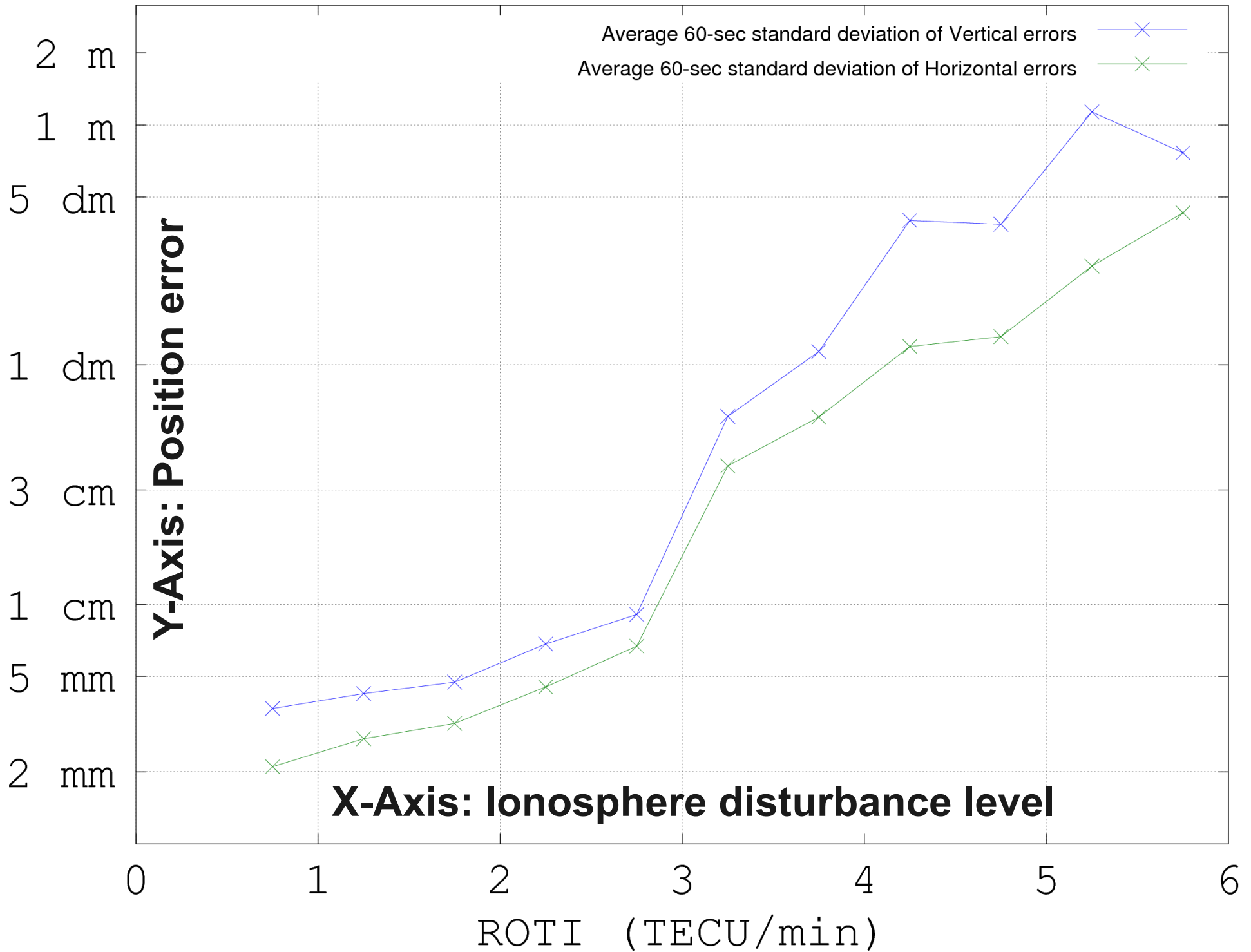
Very large position errors



Small to moderate position errors



Position errors increased by more than 20 000 %



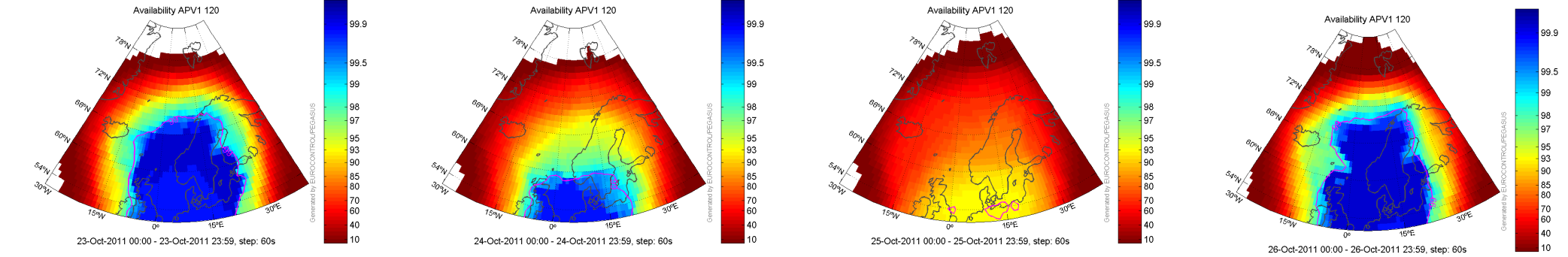
EGNOS performance was also affected

The time period shown in the previous plots

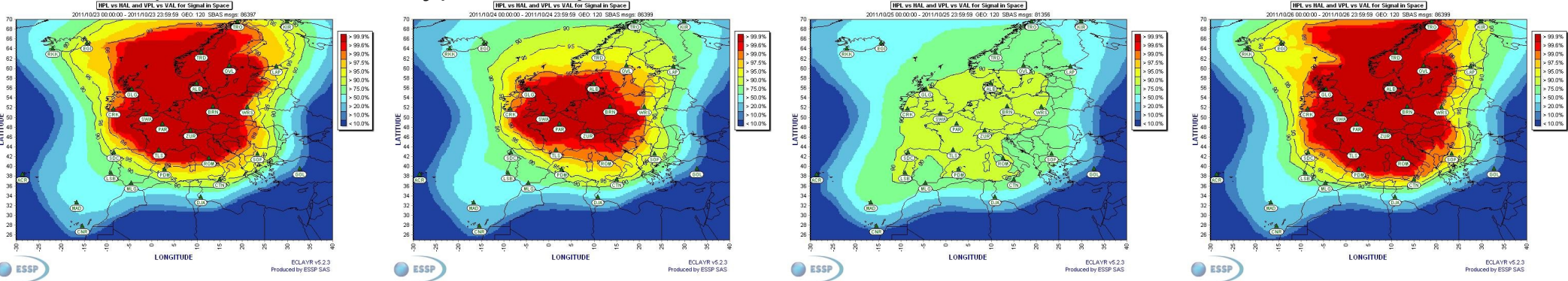
23 October	24 October	25 October	26 October
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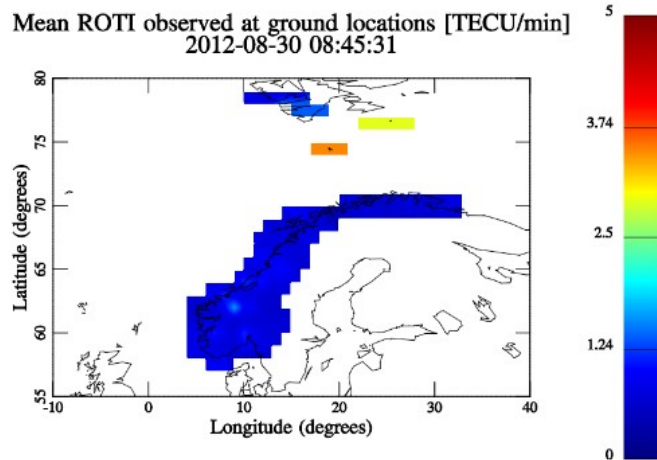
Geomagnetic storm

EGNOS (APV-1 Availability) in Scandinavia



EGNOS (APV-1 Availability) in Europe





Forstyrrelser på bakken

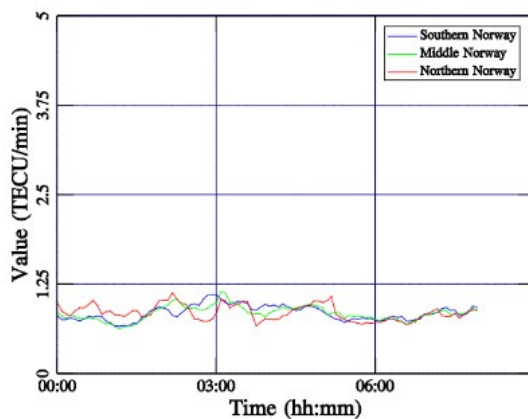
Figuren viser hvilke områder på bakken som er påvirket av ionosfæreforstyrrelser ([ionosfære](#)). I disse områdene kan man forvente problemer med å gjøre GNSS-målinger ([GNSS](#)).

Fargeskalaen går fra blått til rødt, hvor blått er rolige forhold og rødt er store forstyrrelser. En ny figur produseres hvert 5. minutt. I figuren er det brukt UTC tid ([UTC](#)).

Real-time ionosphere monitoring service

An expanded ionosphere monitoring service will be available at ESAs space weather portal at a later date

2012-08-30 00:00:00 to 2012-08-30 08:59:59
Rate of TEC Index at ground



Tidsserie for forstyrrelser på bakken

Figuren viser siste døgns ionosfæreaktivitet for tre regioner. Regionene er :

- Sør-Norge: 57-62 grader nord ([blå linje](#))
- Midt-Norge: 62-67 grader nord ([grønn linje](#))
- Nord-Norge: 67-72 grader nord ([rød linje](#))

En ny figur produseres hver time. I figuren er det brukt UTC tid ([UTC](#))

Skalaen er som følger:

- 0-1 TECU/min - lav aktivitet
- 1-3 TECU/min - moderat aktivitet
- 3-5 TECU/min - høy aktivitet
- 5+ TECU/min - meget høy aktivitet

Siden dette er en nyutviklet nettside, kan det være deler av tjenesten som ikke fungerer optimalt. Vi ønsker derfor tilbakemeldinger på alle aspekter ved tjenesten. Kontakt: satref@kartverket.no



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Questions?