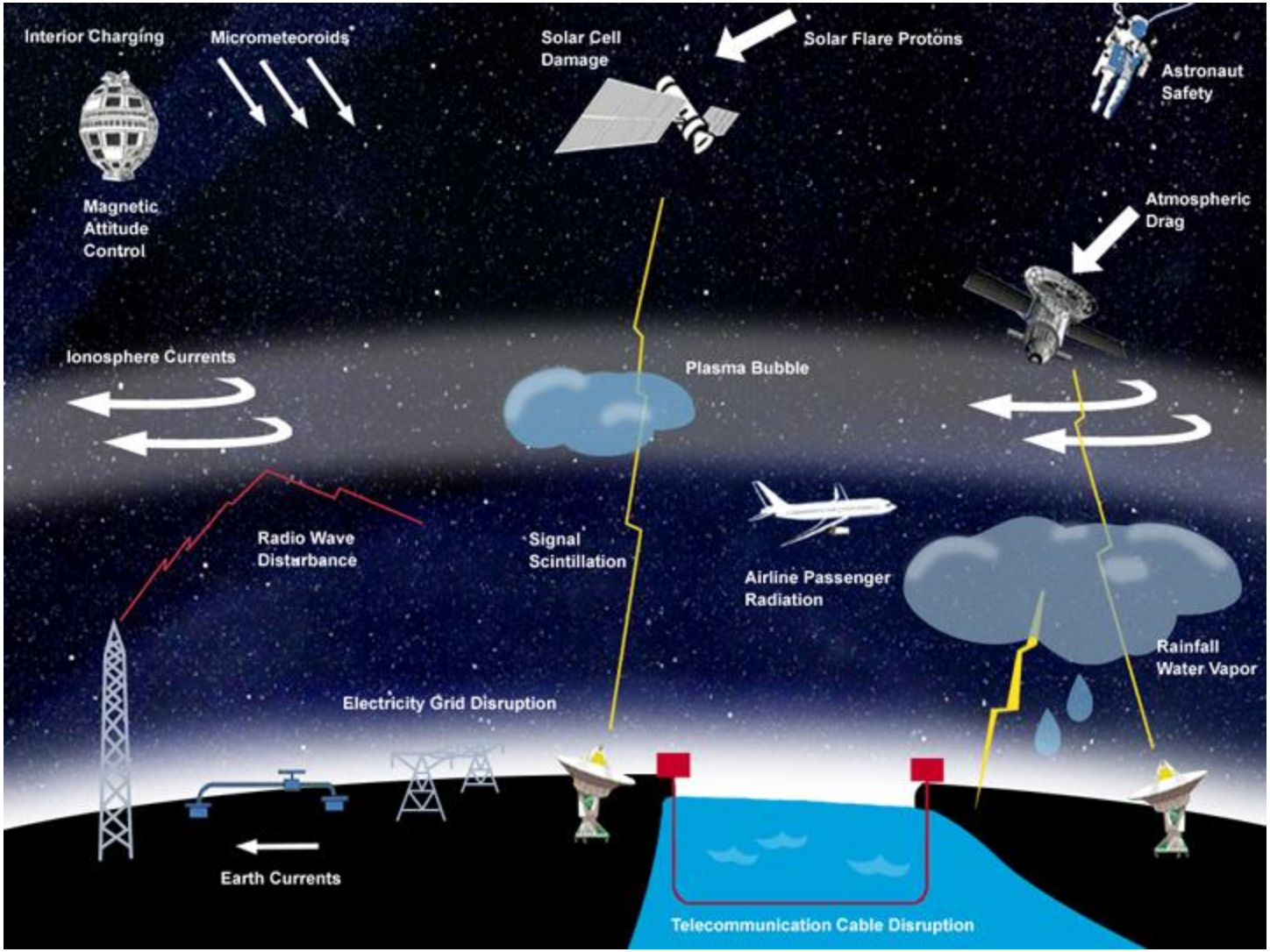
Space Weather

and the

Ionospheric Storm on 24/25 Oct. 2011

Volker Wilken

DLR


Interior Charging
Micrometeoroids
Solar Cell Damage
Solar Flare Protons
Astronaut Safety
Magnetic Attitude Control
Atmospheric Drag
Ionosphere Currents
Plasma Bubble
Radio Wave Disturbance
Signal Scintillation
Airline Passenger Radiation
Rainfall Water Vapor
Electricity Grid Disruption
Earth Currents
Telecommunication Cable Disruption

DLR

Ionospheric Storm on 24/25 Oct. 2011

The space weather event started on October 22, 2011 when a solar flare of class M1.3 was observed. The eruption started at 10:00 and ended at 13:09 UT. Remarkable is the long duration of the flare of 3 hours showing a maximum at 11:10 UT.

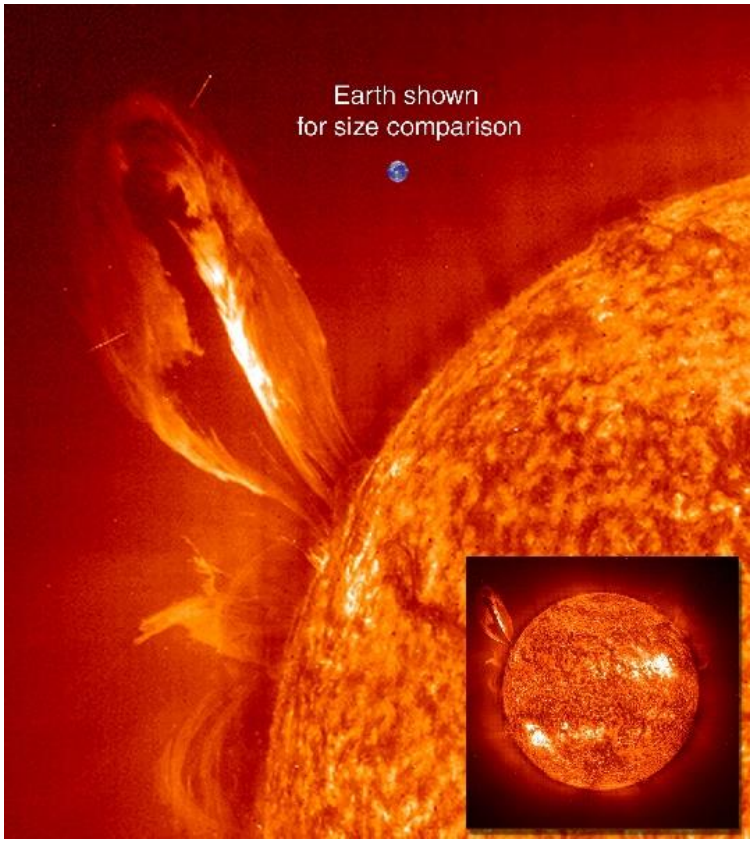
The solar flare was associated with a coronal mass ejection which arrived in the evening hours of 24 October 2011 at the ACE Satellite just before entering the Earth's magnetosphere.

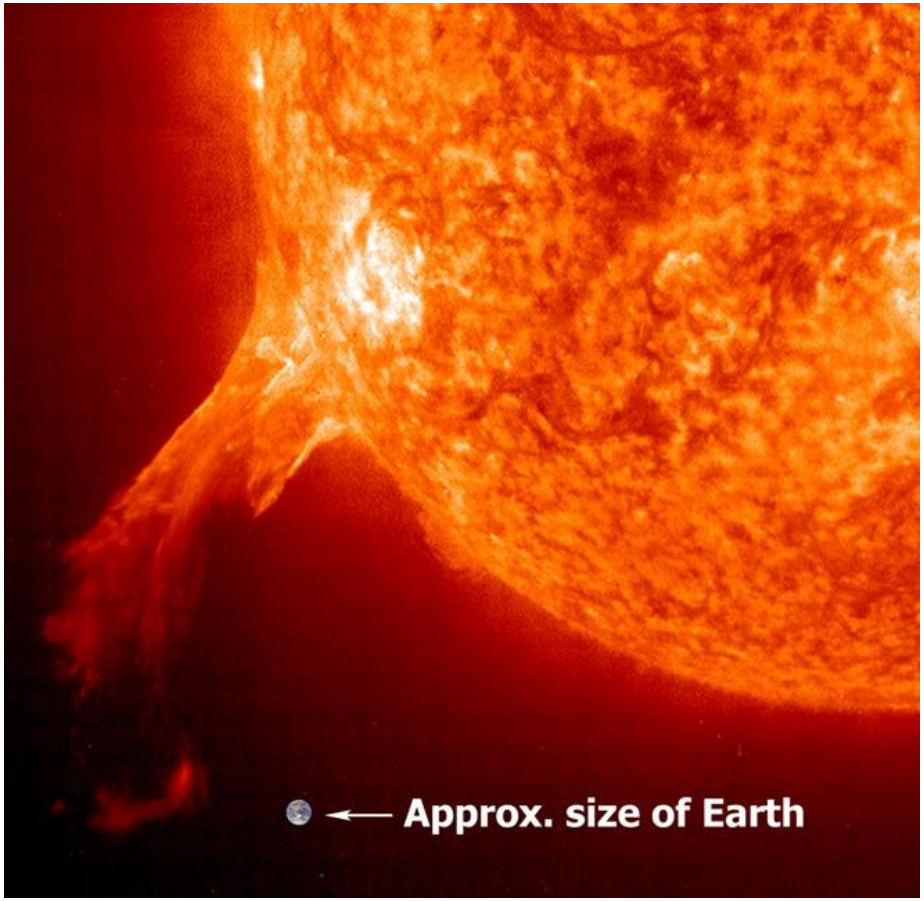
M_{sun}= 1.99*10^{30}kg

R_{sun}= 696000km

M_{earth}= 5.974*10^{24}kg

R_{earth}= 6371km



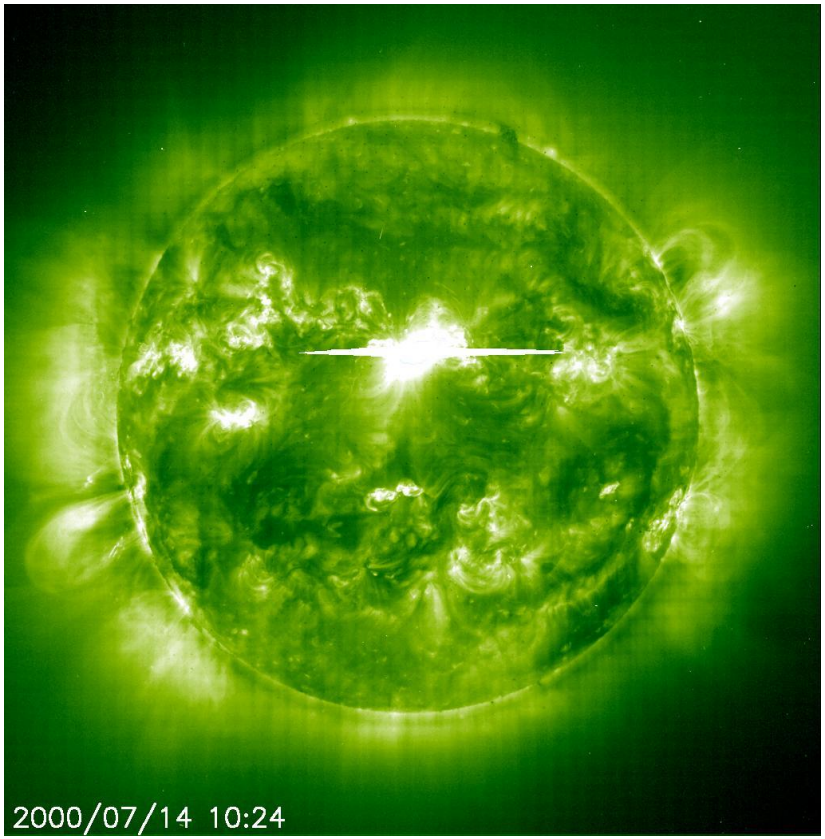


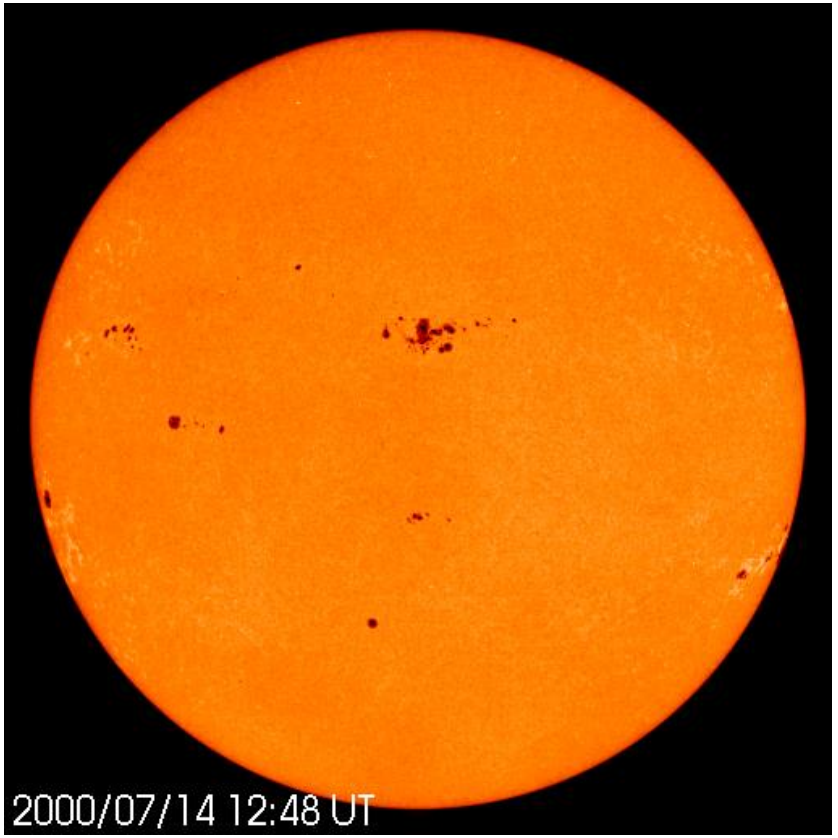
$M_{sun} \approx 333000\ M_{earth}$

$R_{sun} \approx 109\ R_{earth}$

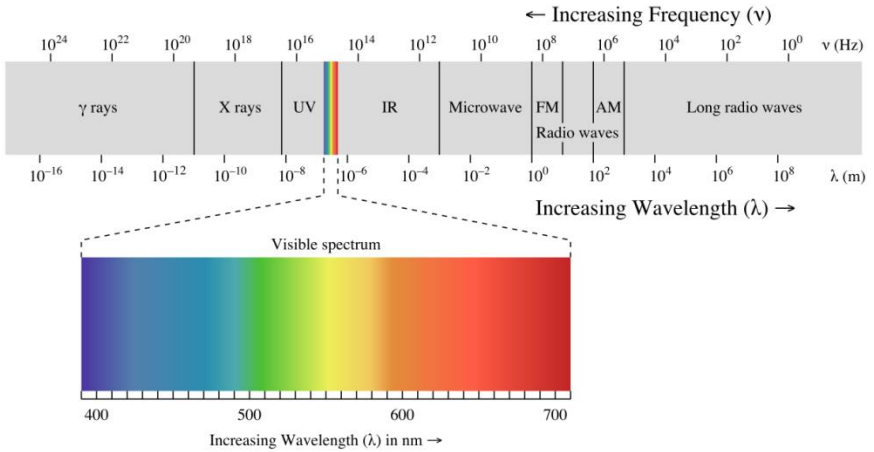
DLR

Extreme ultraviolet **I**maging **T**elescope /
Solar and **H**eliospheric **O**bservatory





EIT/Soho
Fe XII 195Å
(19.5nm)

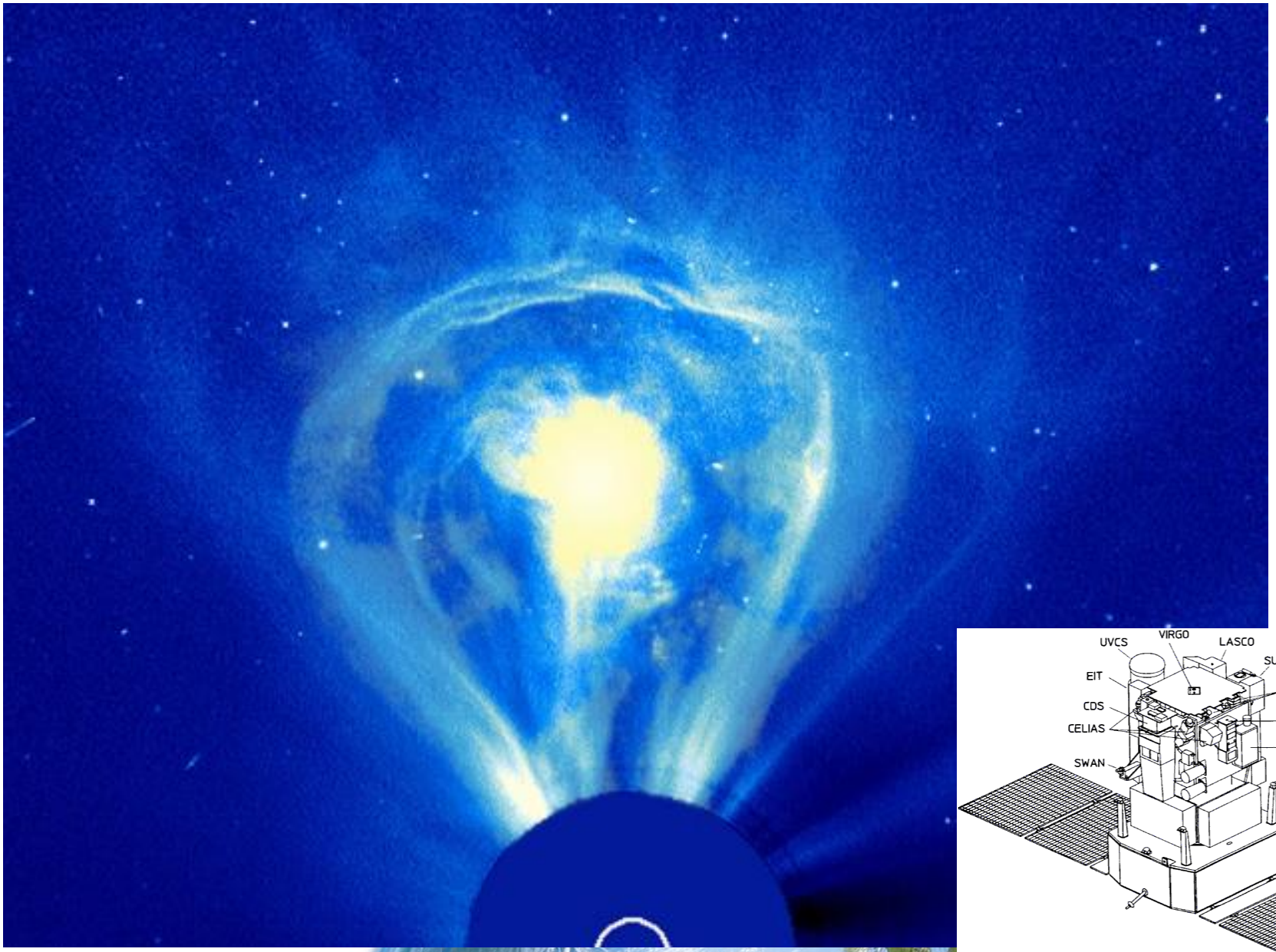


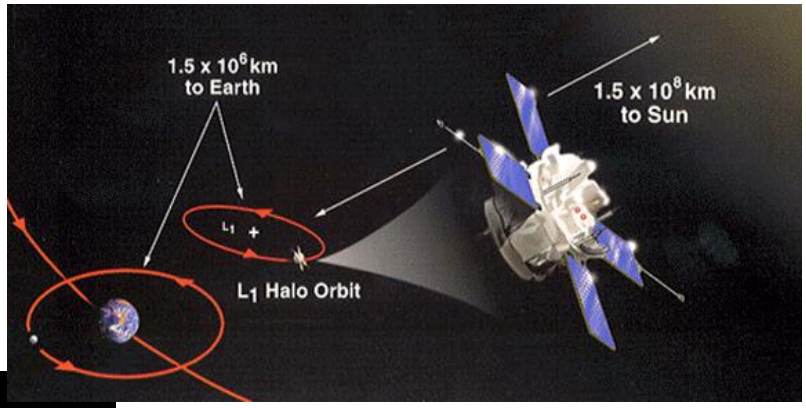
DLR

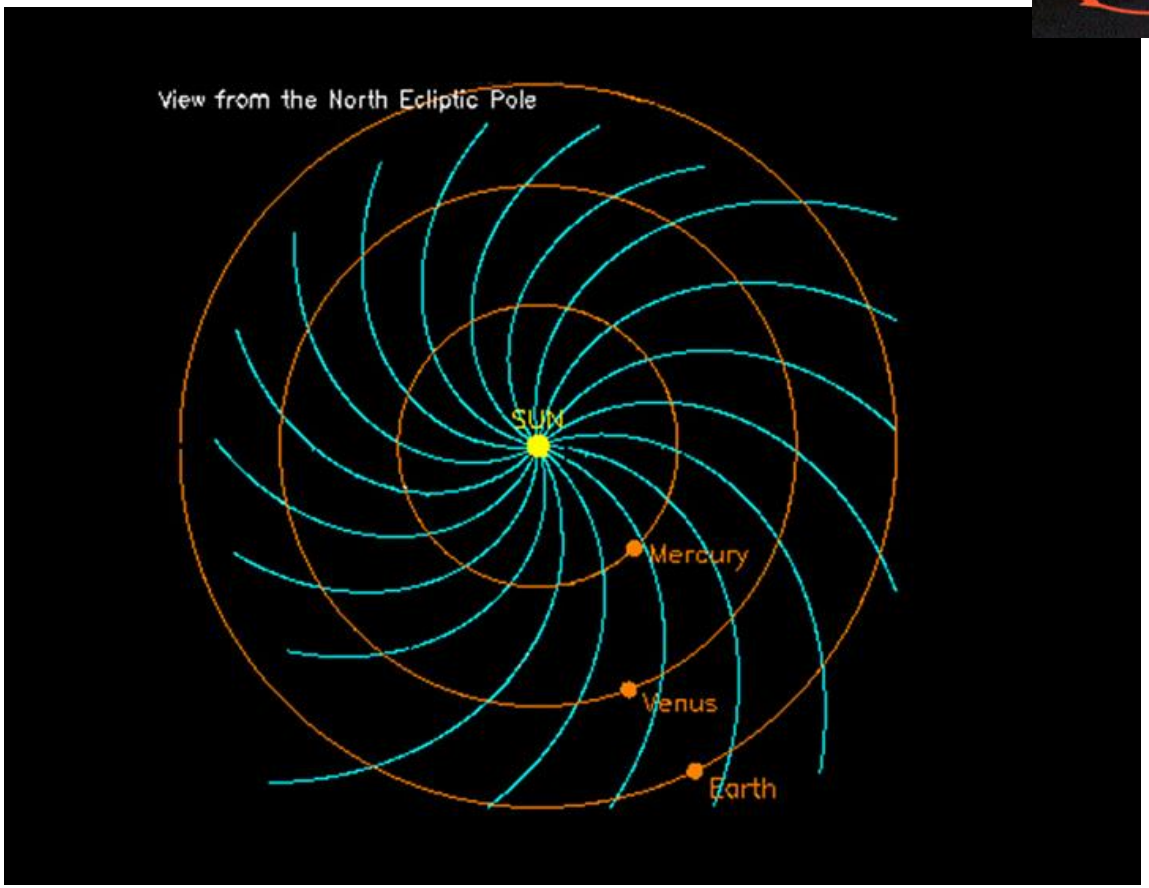
solar flare class	scale	x-ray brightness in the wavelength range 1 to 8 Angstroms in W/m^2
A	1 - 9	$< 10^{-7}$
B	1 - 9	$10^{-7} <= I < 10^{-6}$
C	1 - 9	$10^{-6} < = I < 10^{-5}$
M	1 - 9	$10^{-5} < = I < 10^{-4}$
X	1 - …	$I > = 10^{-4}$

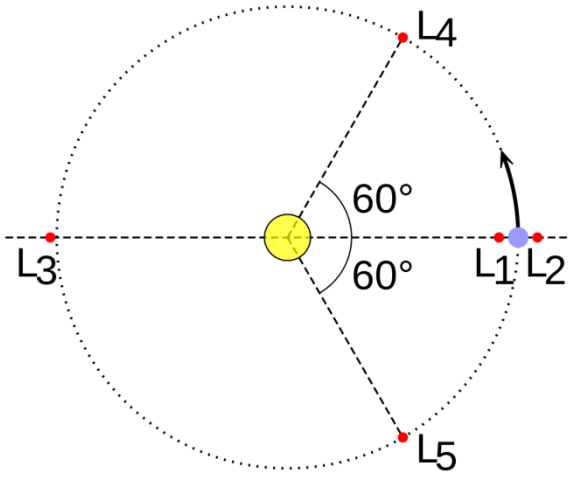
DLR

LASCO / Large Angle and Spectrometric Coronagraph



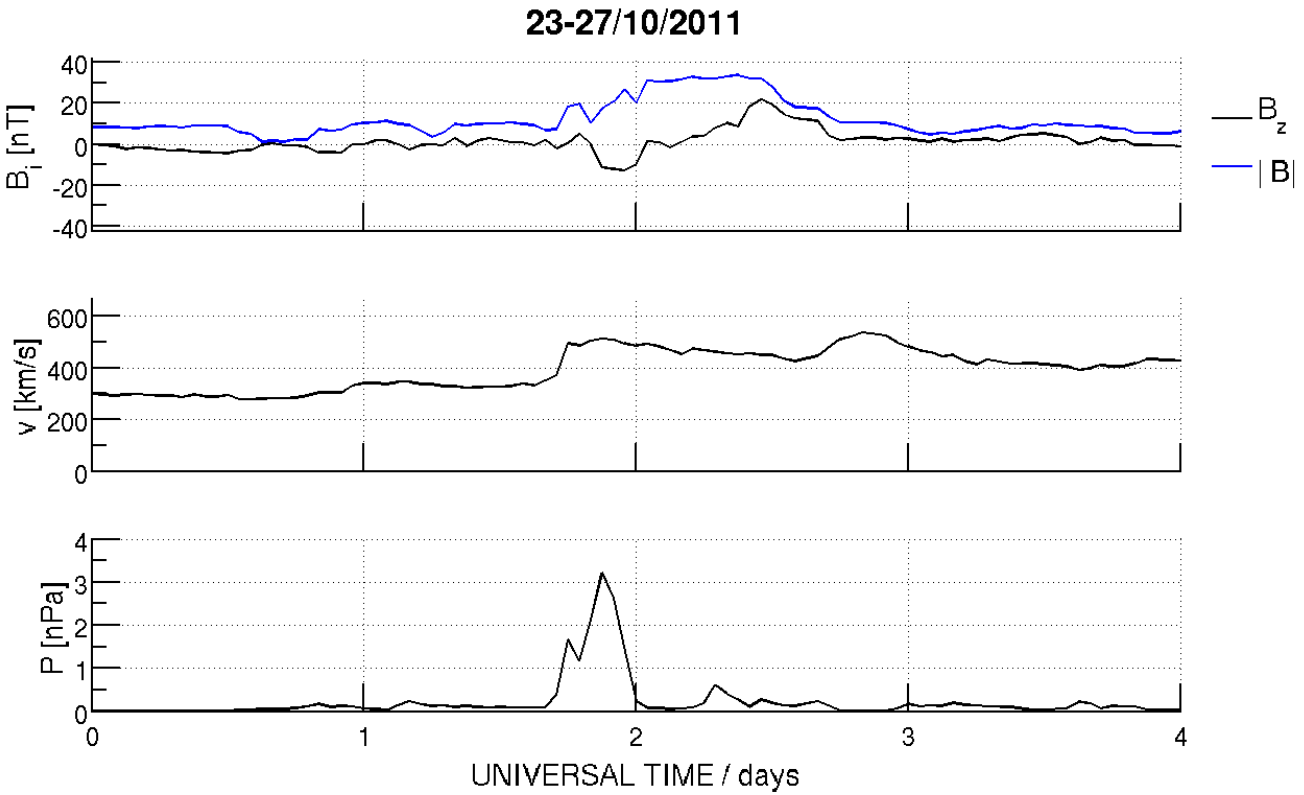

1.5 x 10^6 km
to Earth
1.5 x 10^8 km
to Sun
L1
L1 Halo Orbit


View from the North Ecliptic Pole
SUN
Mercury
Venus
Earth

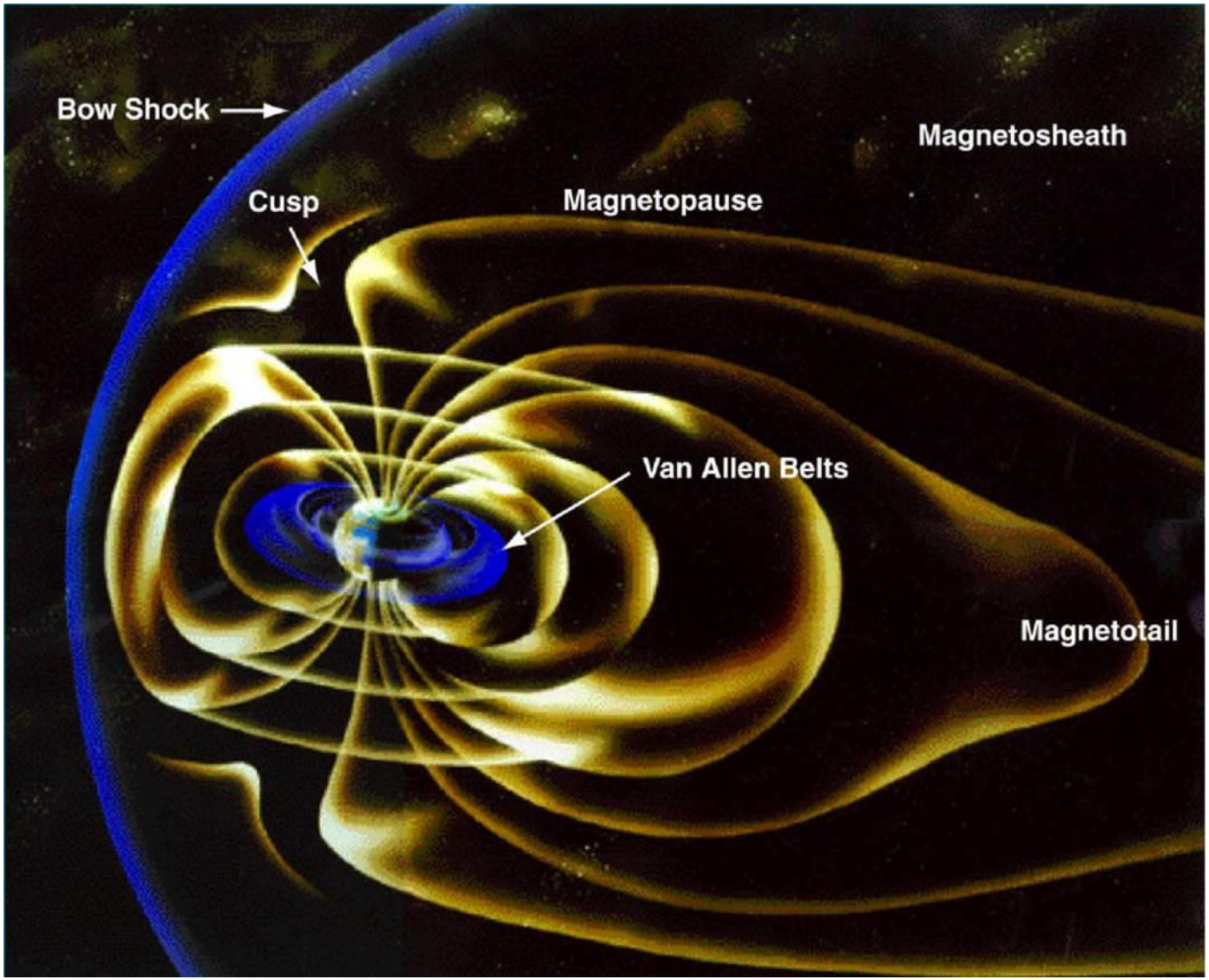

L4
60°
60°
L3
L1
L2
L5

DLR

Ionospheric Storm on 24/25 Oct. 2011

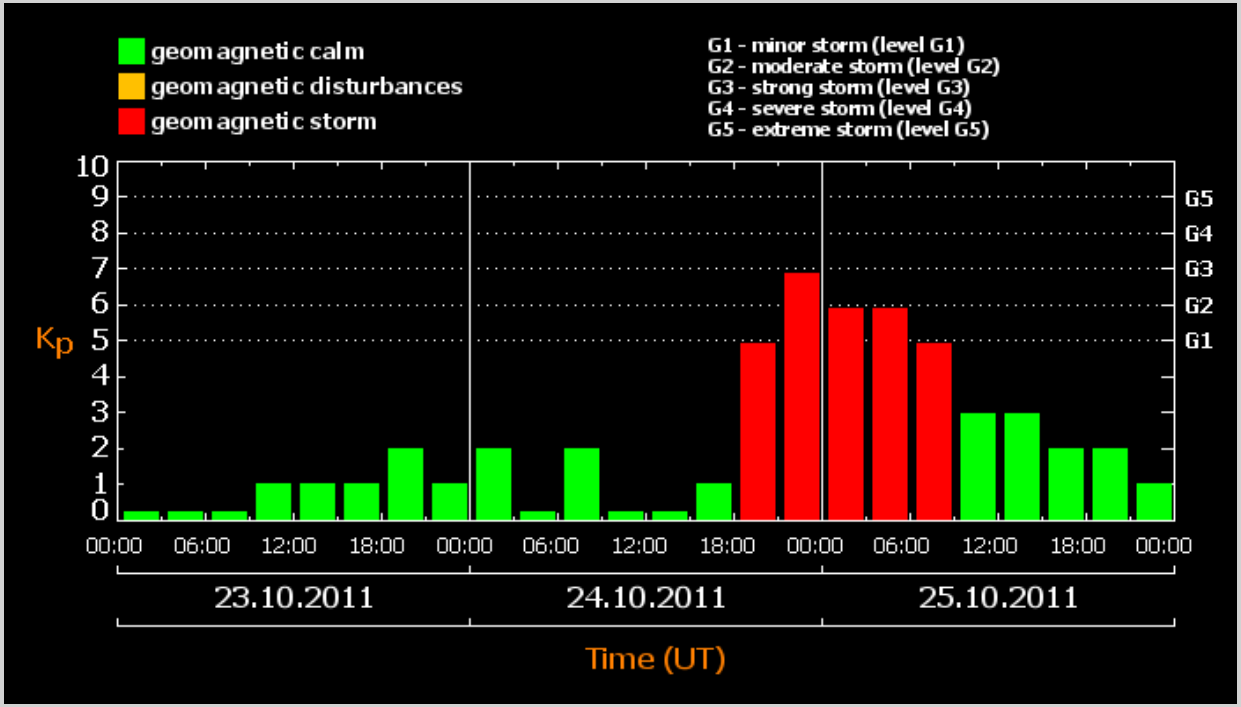


Solar wind measurements at the ACE satellite. Shown are the interplanetary magnetic field, the velocity of the solar wind and the solar wind pressure during the period 23 till 27 October 2011. The enhancement of the plasma pressure was guided by a negative Bz component indicating good coupling conditions with the geomagnetic field.


Bow Shock
Magnetosheath
Cusp
Magnetopause
Van Allen Belts
Magnetotail

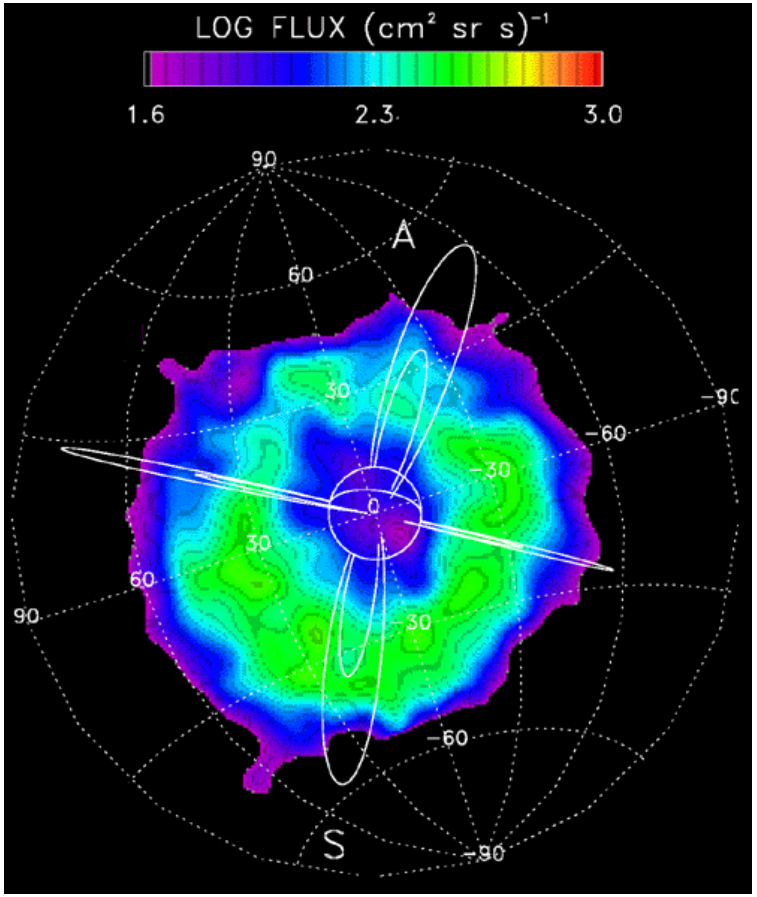
DLR

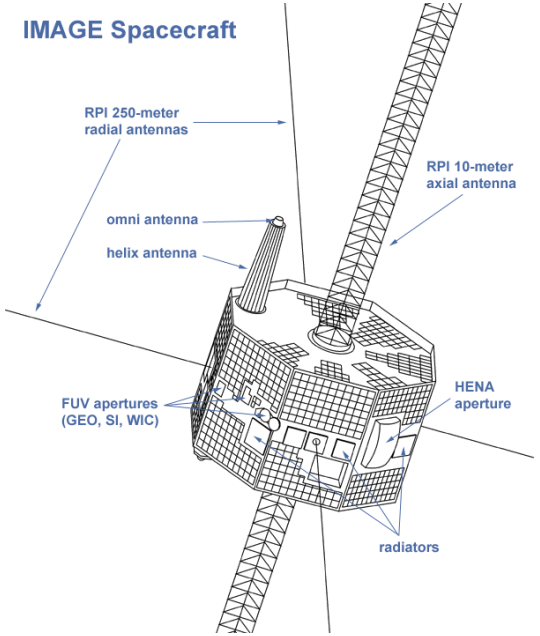
Ionospheric Storm on 24/25 Oct. 2011



Planetary Kp-Index for the geomagnetic storm on October 24 and 25, 2011.

DLR

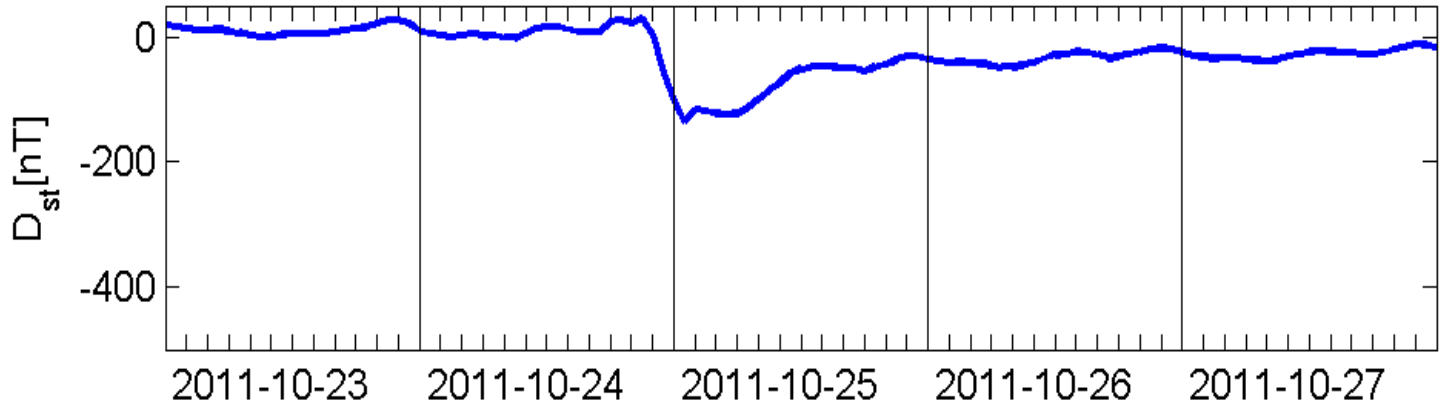




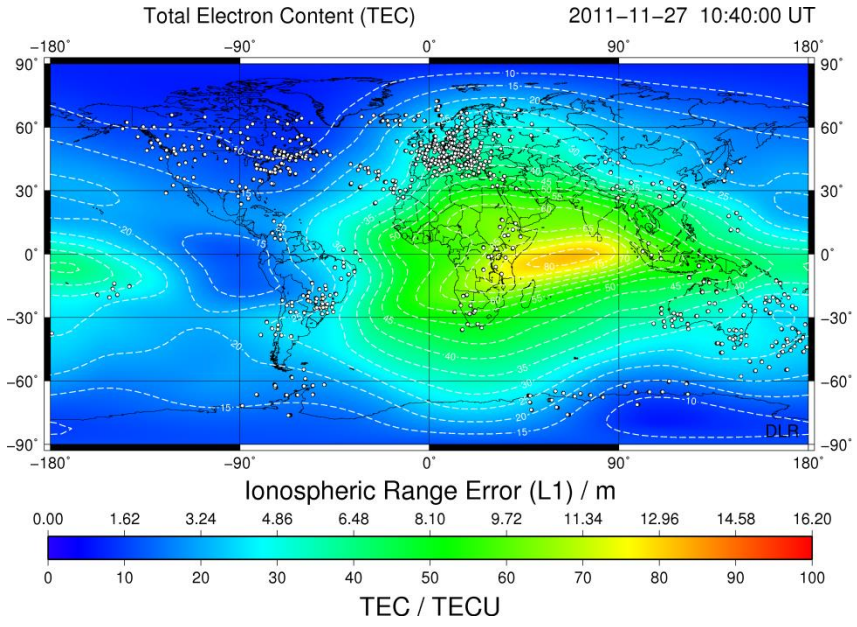
The ring current is one of the major current systems in the Earth's magnetosphere. It circles the Earth in the equatorial plane.

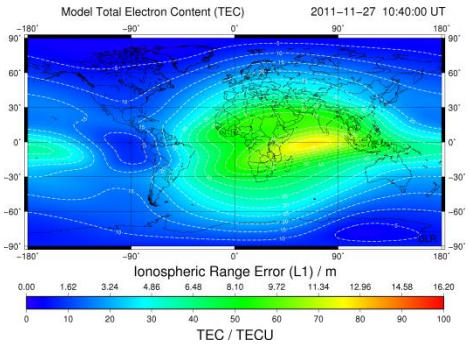
DLR

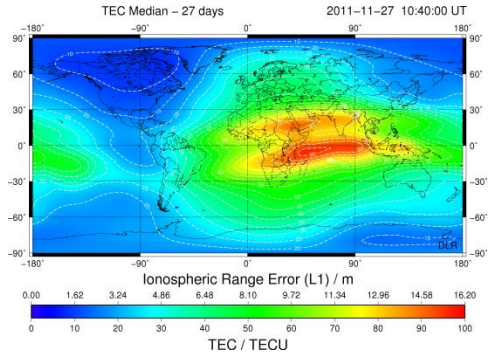
Ionospheric Storm on 24/25 Oct. 2011

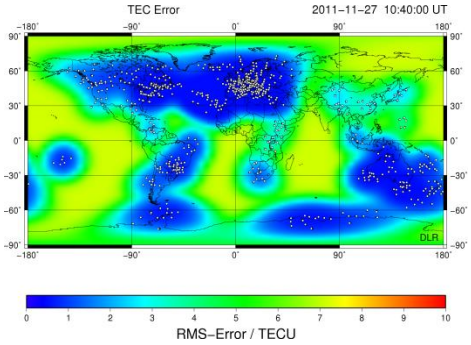


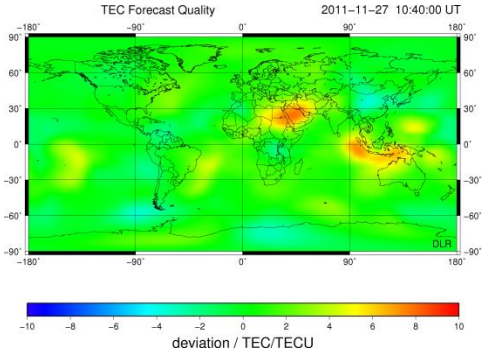
Dst index during from 23-27 October 2011

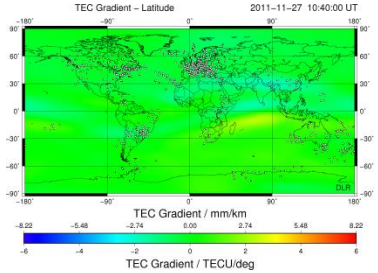

Total Electron Content (TEC)
2011–11–27 10:40:00 UT
Ionospheric Range Error (L1) / m
0.00 1.62 3.24 4.86 6.48 8.10 9.72 11.34 12.96 14.58 16.20
0 10 20 30 40 50 60 70 80 90 100
TEC / TECU
DLR

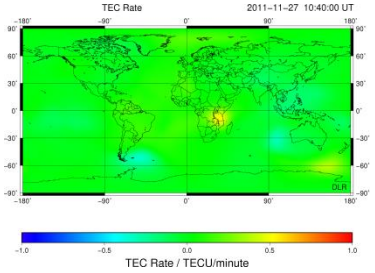

Model Total Electron Content (TEC)
2011–11–27 10:40:00 UT
Ionospheric Range Error (L1) / m
0.00 1.62 3.24 4.86 6.48 8.10 9.72 11.34 12.96 14.58 16.20
0 10 20 30 40 50 60 70 80 90 100
TEC / TECU
DLR

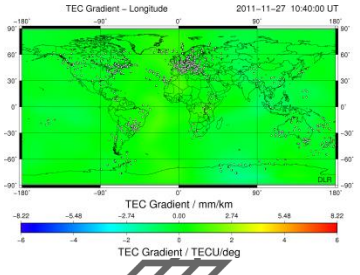

TEC Median – 27 days
2011–11–27 10:40:00 UT
Ionospheric Range Error (L1) / m
0.00 1.62 3.24 4.86 6.48 8.10 9.72 11.34 12.96 14.58 16.20
0 10 20 30 40 50 60 70 80 90 100
TEC / TECU
DLR

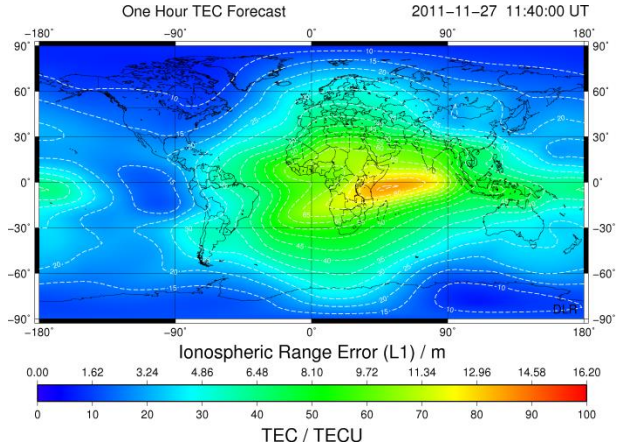

TEC Error
2011–11–27 10:40:00 UT
0 1 2 3 4 5 6 7 8 9 10
RMS–Error / TECU
DLR


TEC Forecast Quality
2011–11–27 10:40:00 UT
–10 –8 –6 –4 –2 0 2 4 6 8 10
deviation / TEC/TECU
DLR


TEC Gradient – Latitude
2011–11–27 10:40:00 UT
TEC Gradient / mm/km
–8.22 –5.48 –2.74 0.00 2.74 5.48 8.22
–6 –4 –2 0 2 4 6
TEC Gradient / TECU/deg
DLR

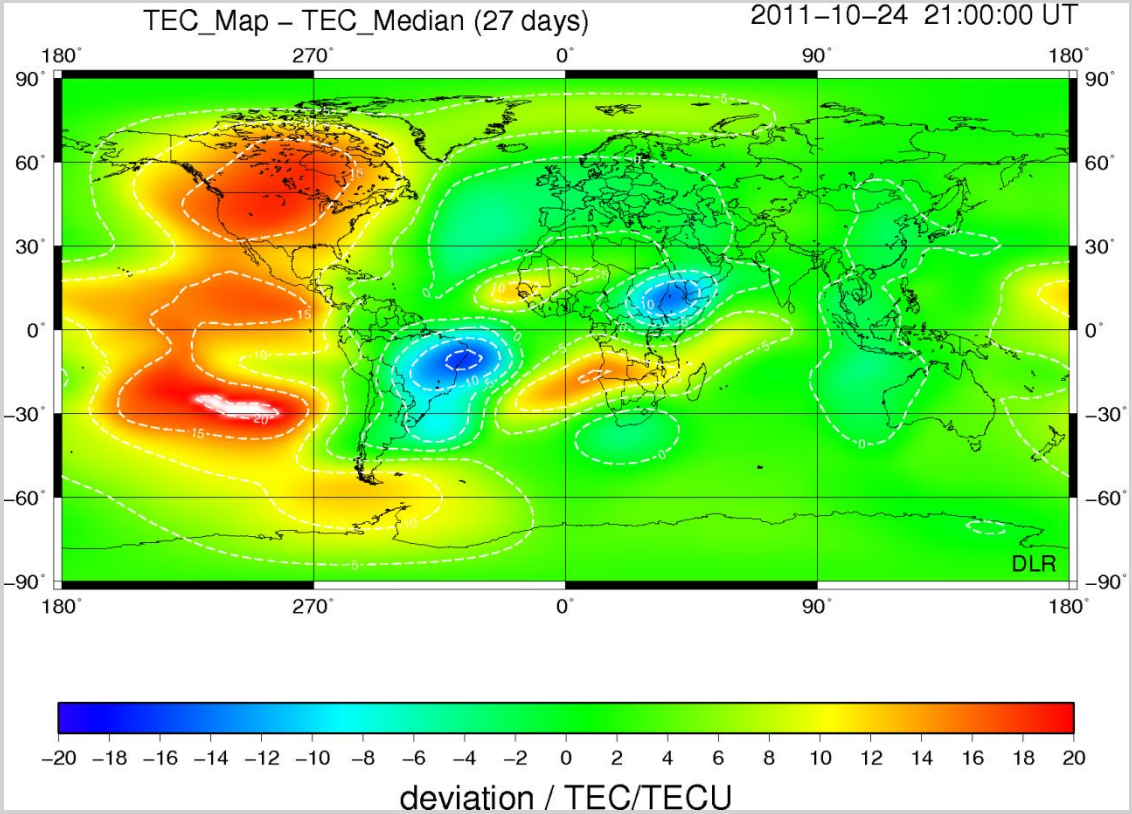

TEC Rate
2011–11–27 10:40:00 UT
–1.0 –0.5 0.0 0.5 1.0
TEC Rate / TECU/minute
DLR


TEC Gradient – Longitude
2011–11–27 10:40:00 UT
TEC Gradient / mm/km
–8.22 –5.48 –2.74 0.00 2.74 5.48 8.22
–6 –4 –2 0 2 4 6
TEC Gradient / TECU/deg
DLR


One Hour TEC Forecast
2011–11–27 11:40:00 UT
Ionospheric Range Error (L1) / m
0.00 1.62 3.24 4.86 6.48 8.10 9.72 11.34 12.96 14.58 16.20
0 10 20 30 40 50 60 70 80 90 100
TEC / TECU
DLR

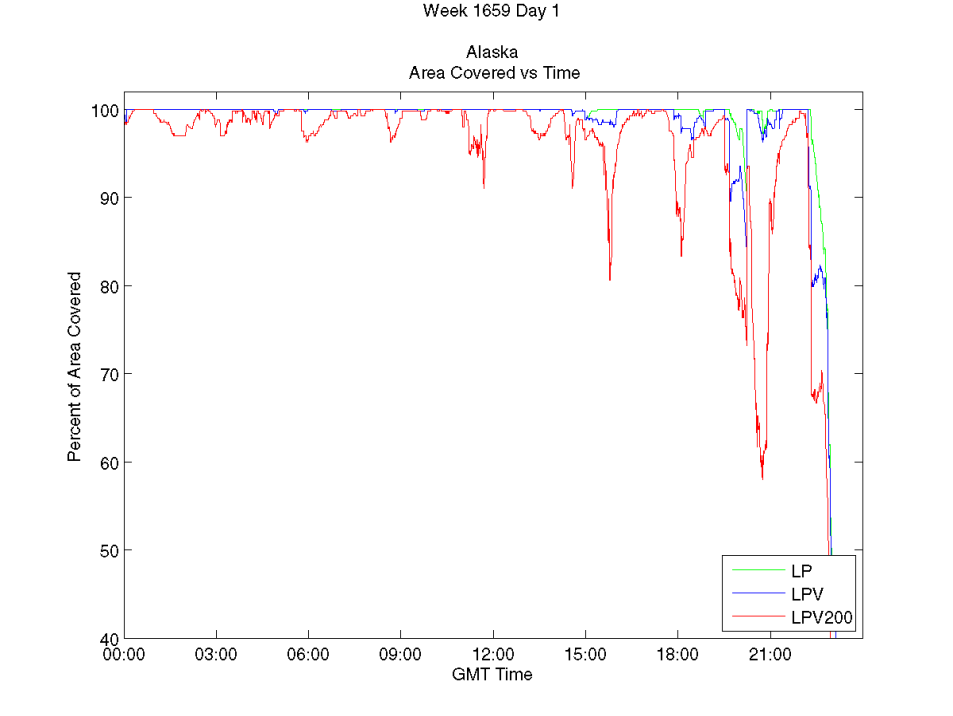
TEC Global

Ionospheric Storm on 24/25 Oct. 2011



Deviations of global TEC from previous 27 day medians on 24 October 2011 at 21:00 UT.

Ionospheric Storm on 24/25 Oct. 2011



LPV availability of WAAS over Alaska on 24th October 2011.

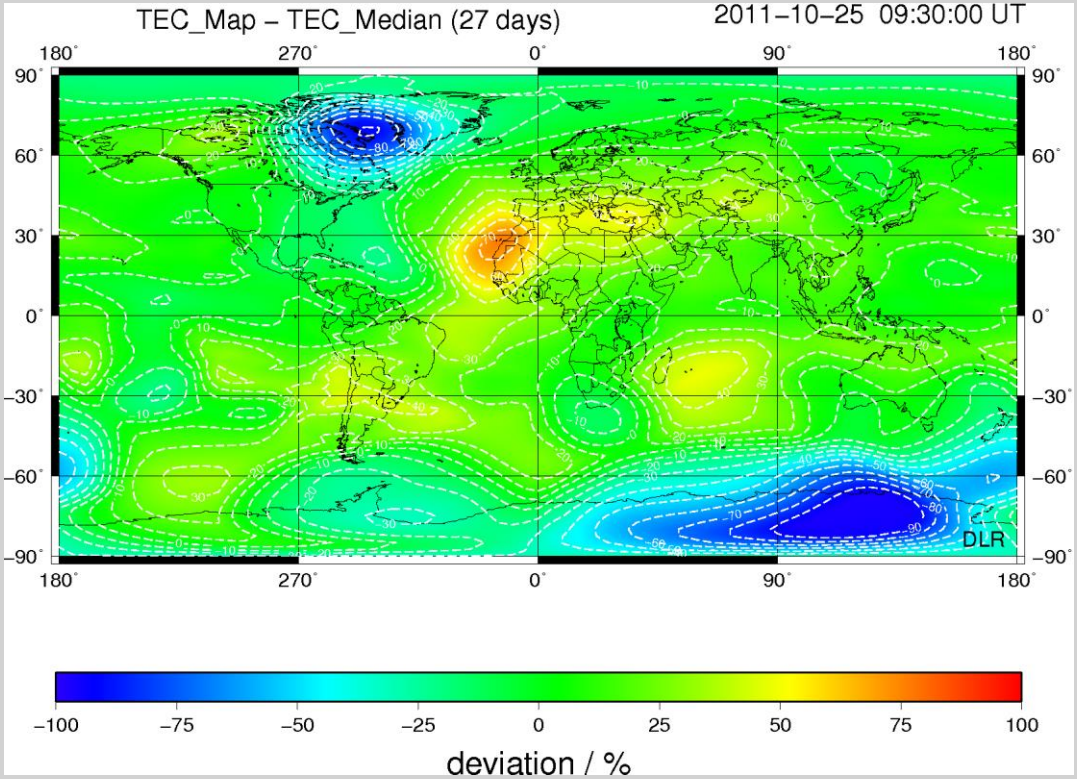
WAAS (http://www.nstb.tc.faa.gov/RT_VerticalProtectionLevel.htm)

(**L**ocalizer **P**erformance with **V**ertical Guidance)

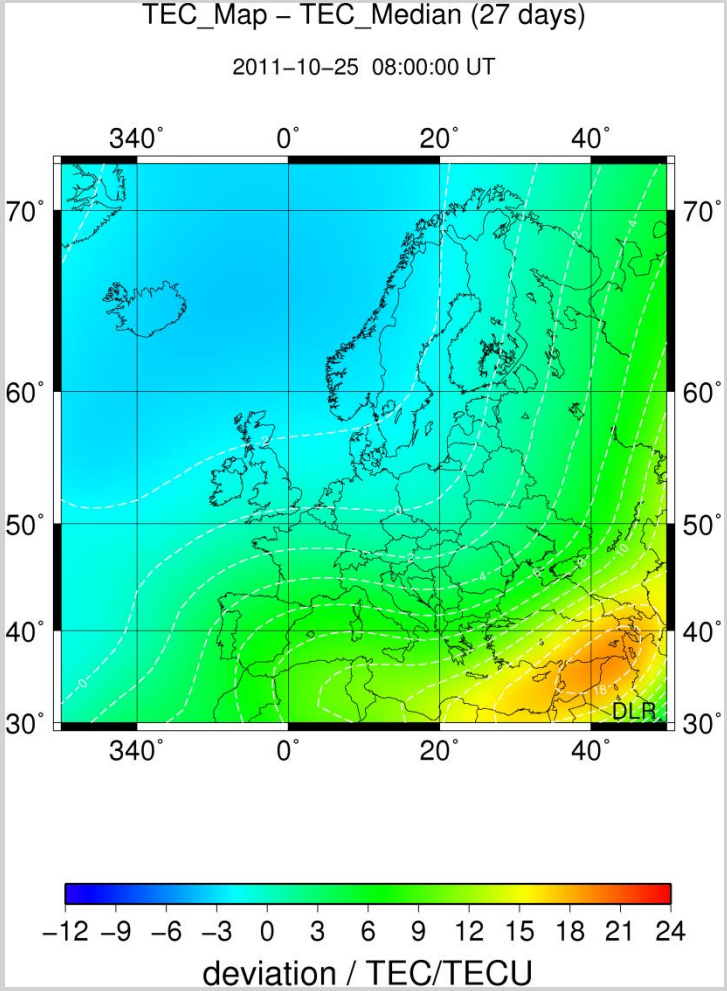
Heavily reduced availability of the **E**uropean **G**eostationary **N**avigation **O**verlay **S**ervice (EGNOS)

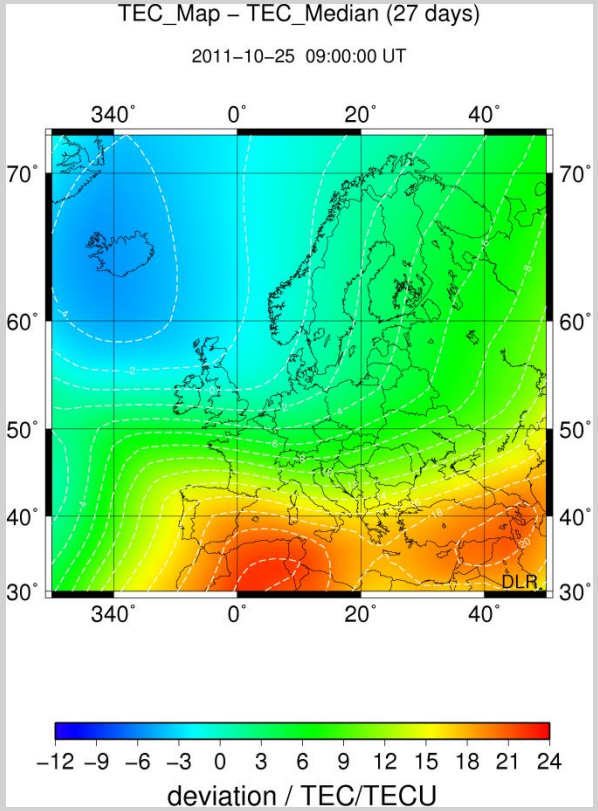
DLR

Ionospheric Storm on 24/25 Oct. 2011

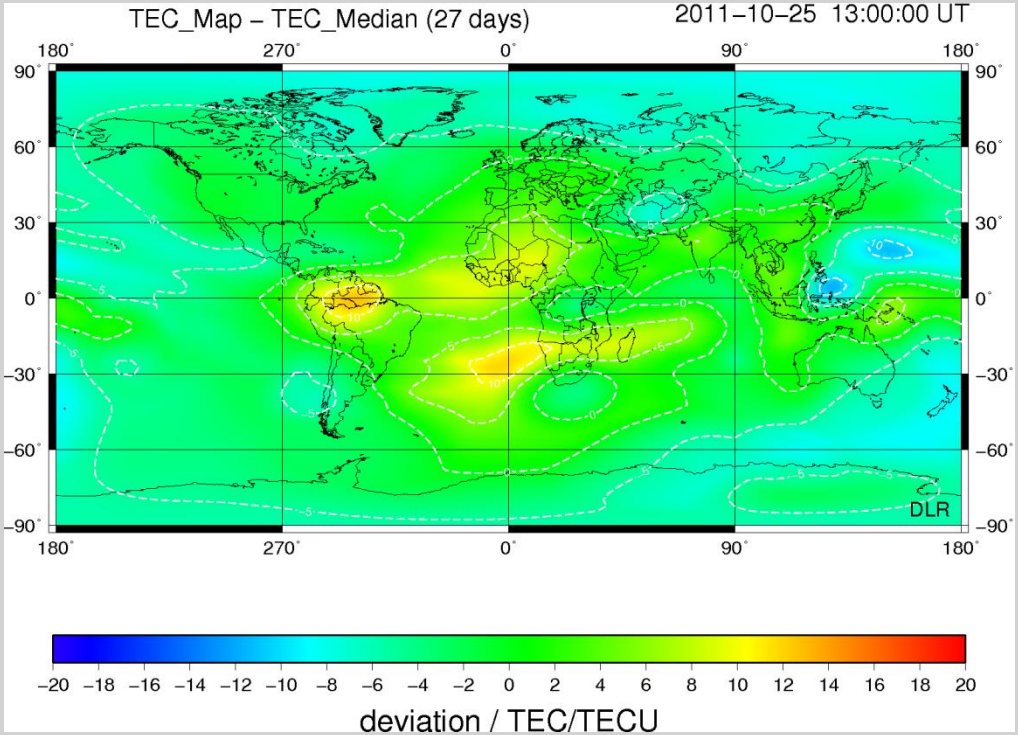


Ionospheric Storm on 24/25 Oct. 2011

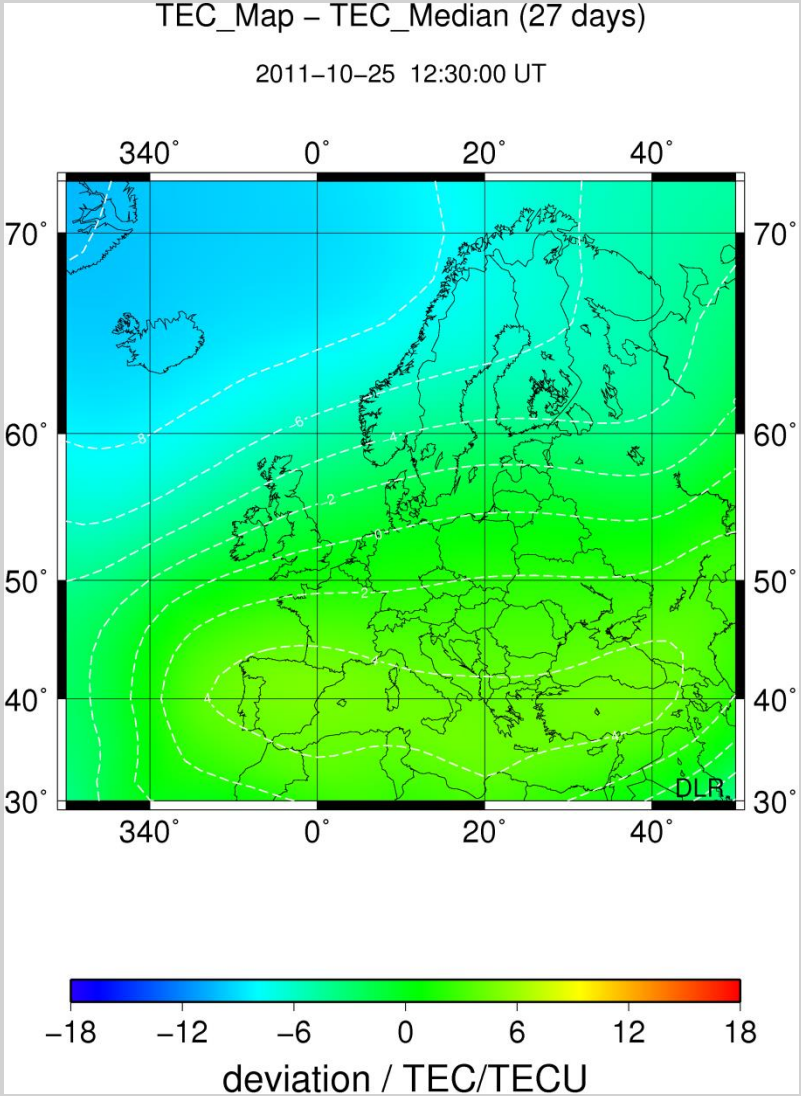


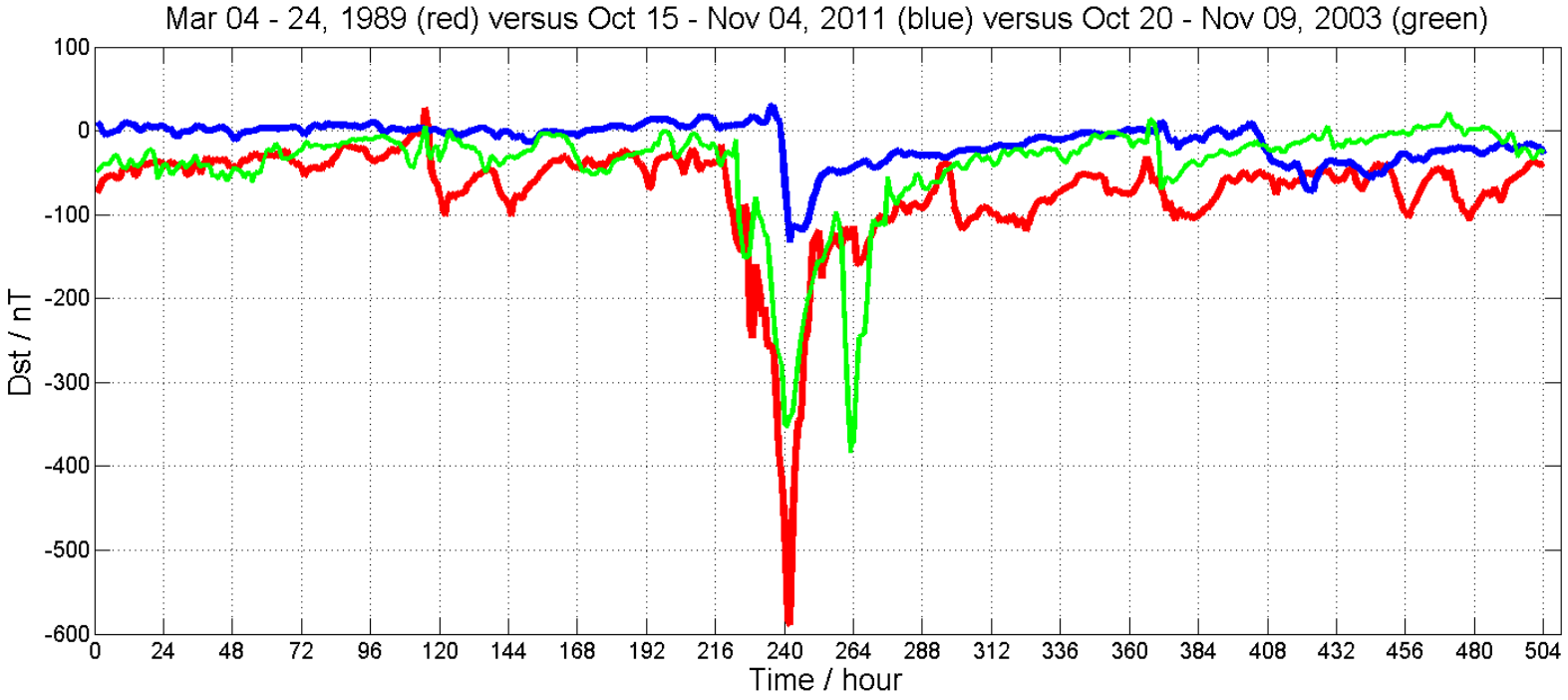


Ionospheric Storm on 24/25 Oct. 2011



Ionospheric Storm on 24/25 Oct. 2011

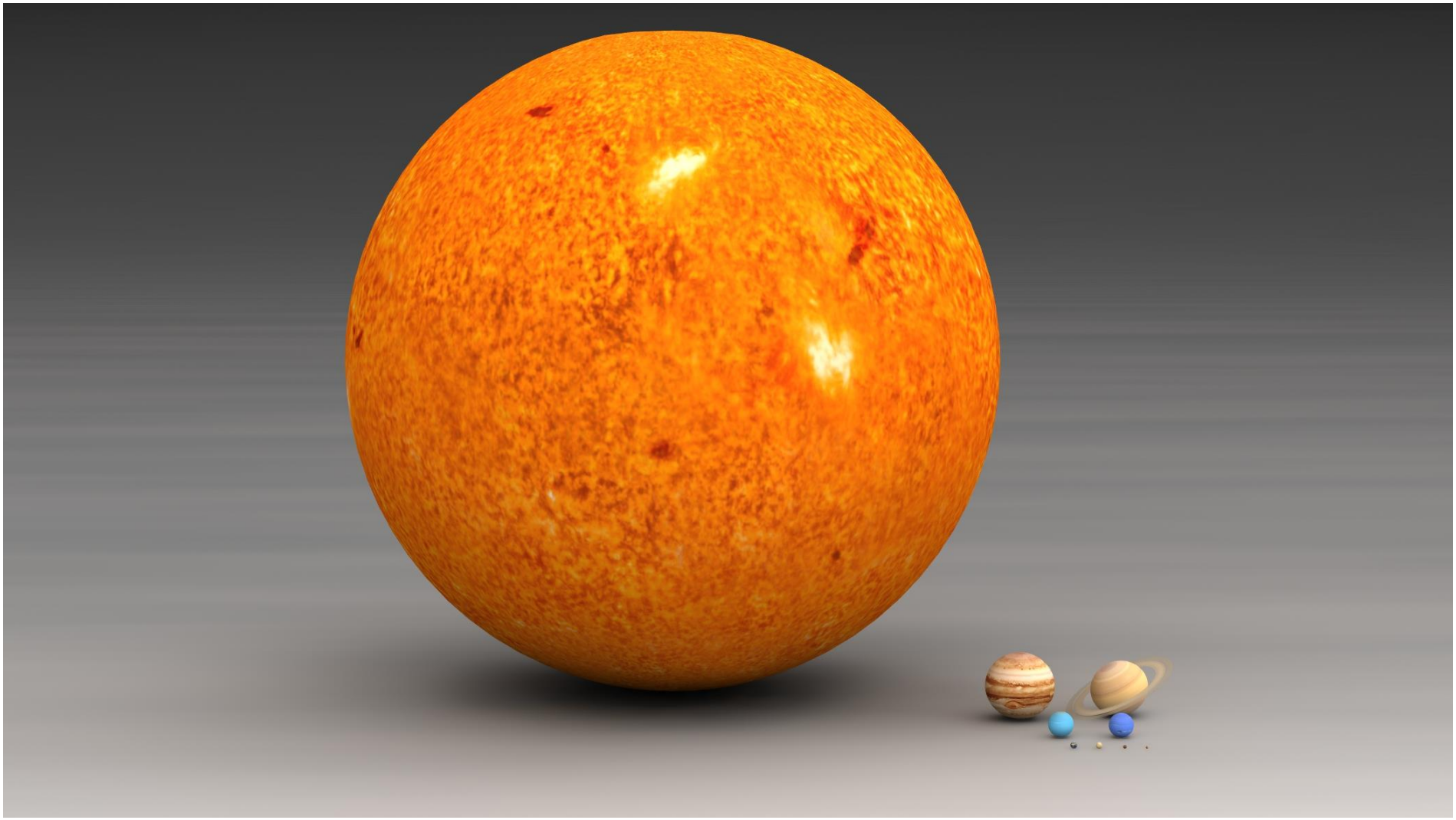



Mar 04 - 24, 1989 (red) versus Oct 15 - Nov 04, 2011 (blue) versus Oct 20 - Nov 09, 2003 (green)
Dst / nT
100
0
-100
-200
-300
-400
-500
-600
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
384
408
432
456
480
504
Time / hour

DLR

DLR

Thank you!



DLR