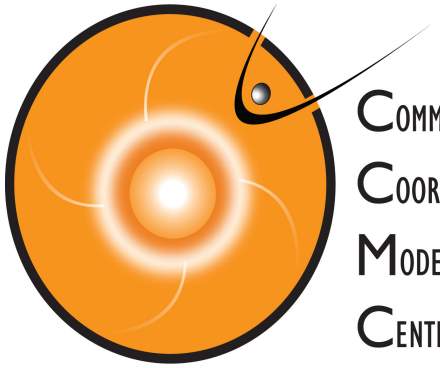


Sun-Earth Connection;

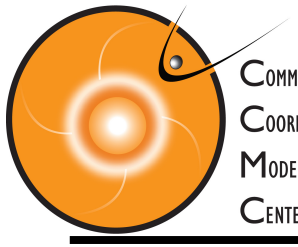
The Earth's Magnetosphere and the Importance of Space Weather

Presented by:
Dr. Yaireska (Yari) Collado-Vega

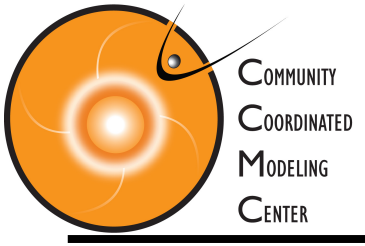
CCMC/SWRC

NASA Goddard Space Flight Center

Thanks to the CCMC/SWRC team



The Sun



The Sun's Rainbow

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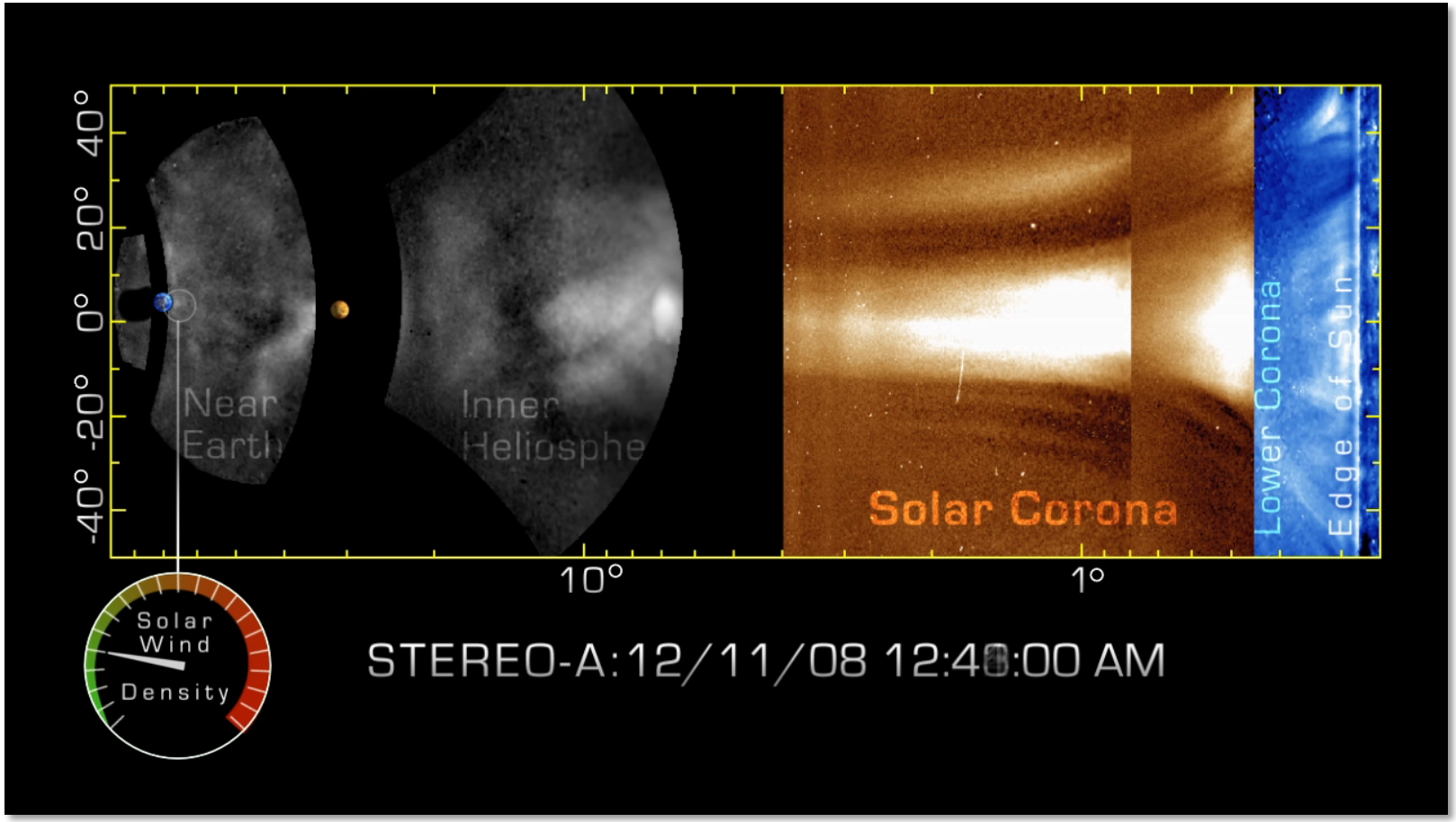
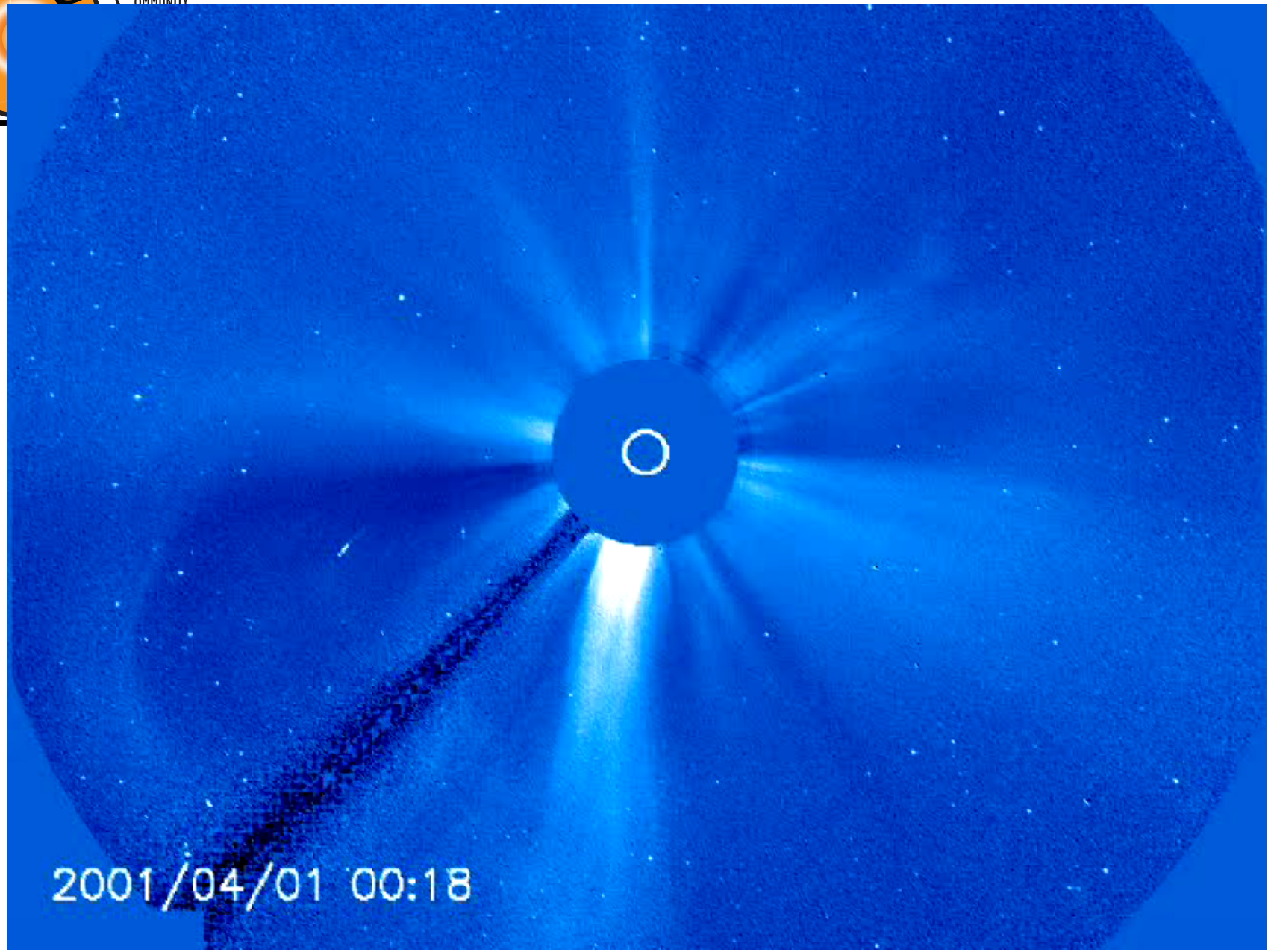
CME propagation



CME propagation to the Earth takes typically 1-3 days.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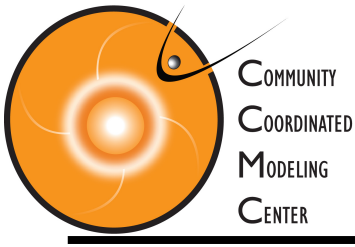
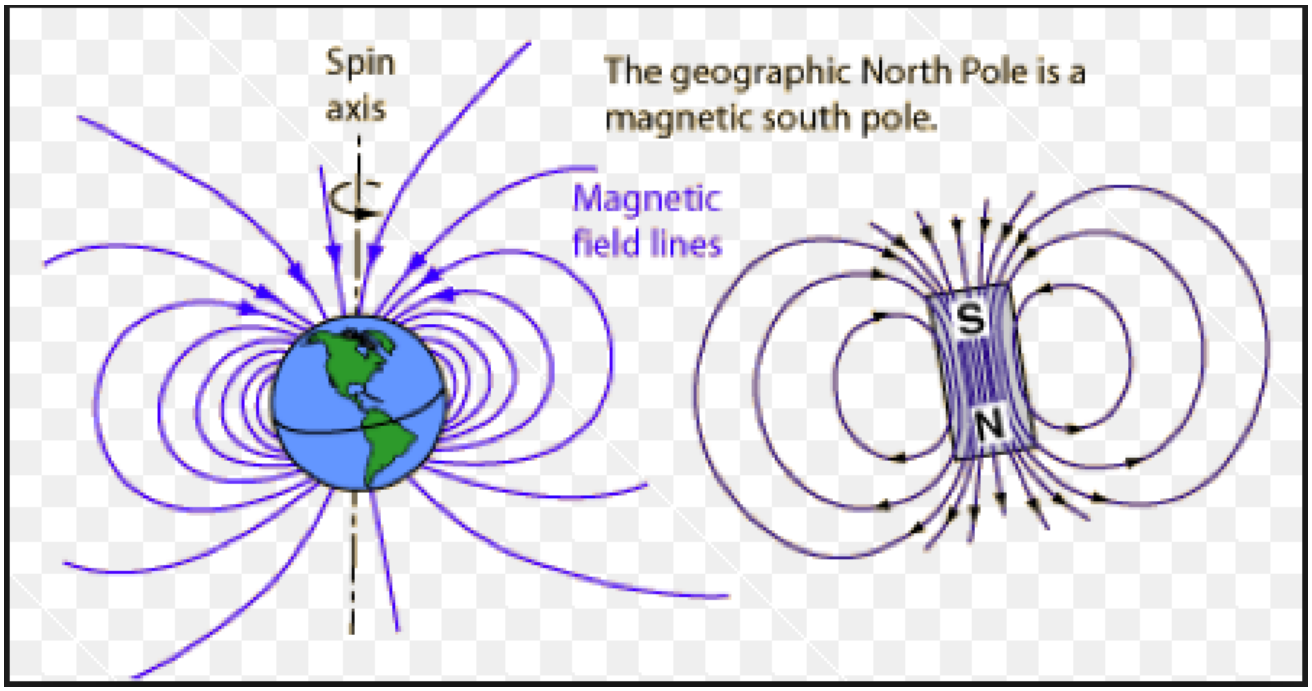


Magnetic Field of the Earth



The Earth's magnetic field is similar to that of a bar magnet. The magnitude varies over the surface of the Earth in the range 0.3 to 0.6 Gauss.

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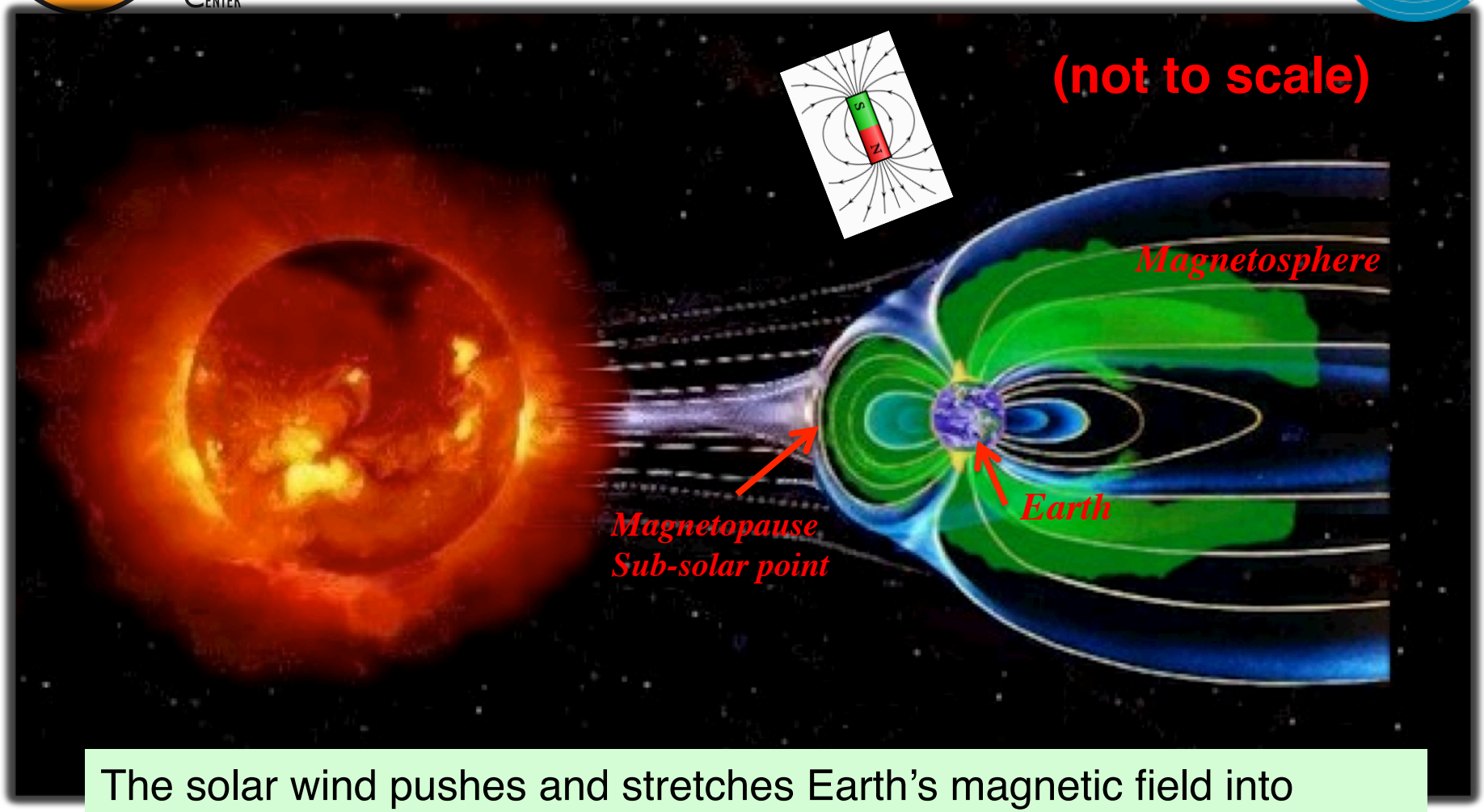
Earth's Magnetic Field



The solar wind pushes and stretches Earth's magnetic field into comet-shaped region called the magnetosphere. The magnetosphere and Earth's atmosphere protect us from the solar wind and other kinds of solar and cosmic radiation.

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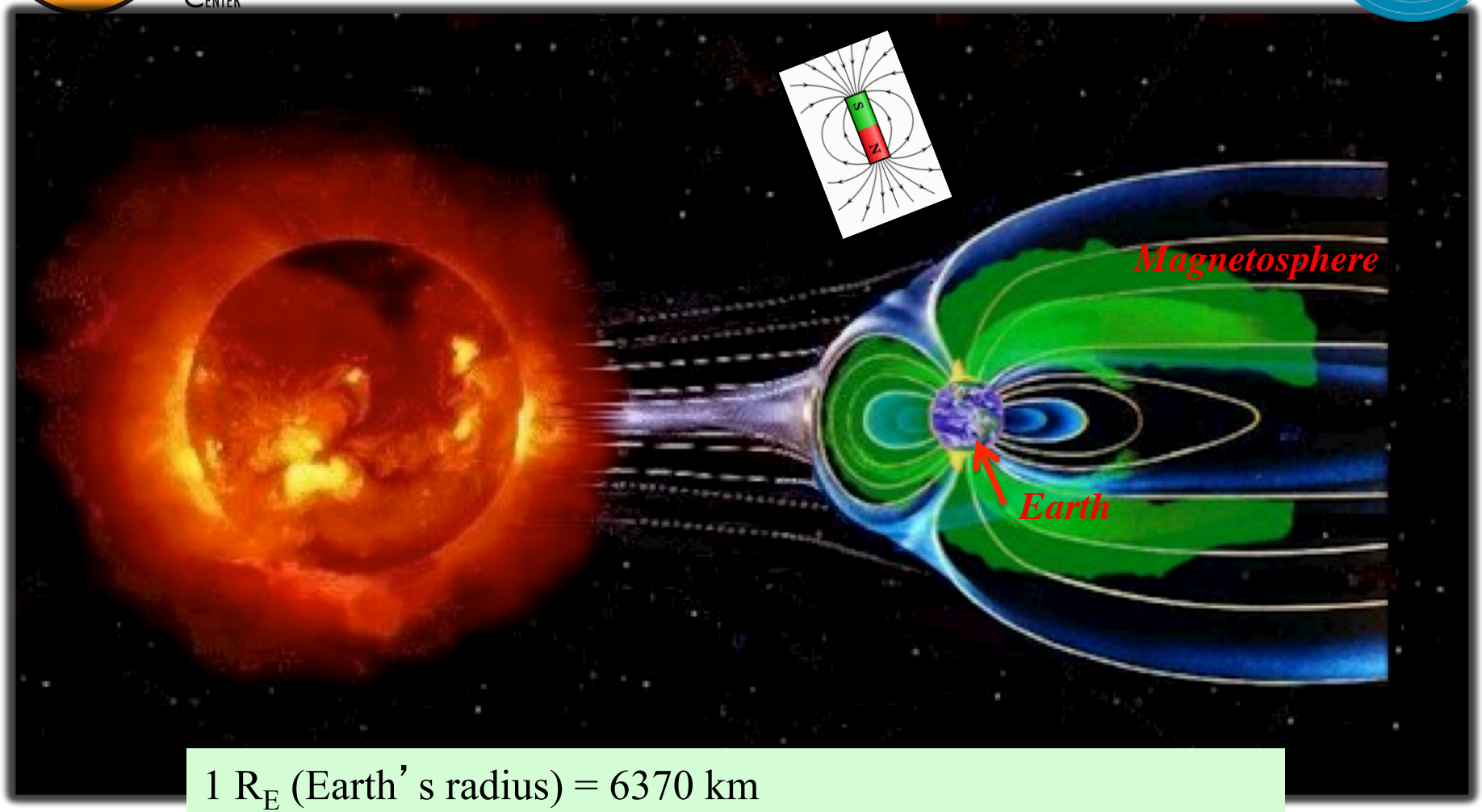
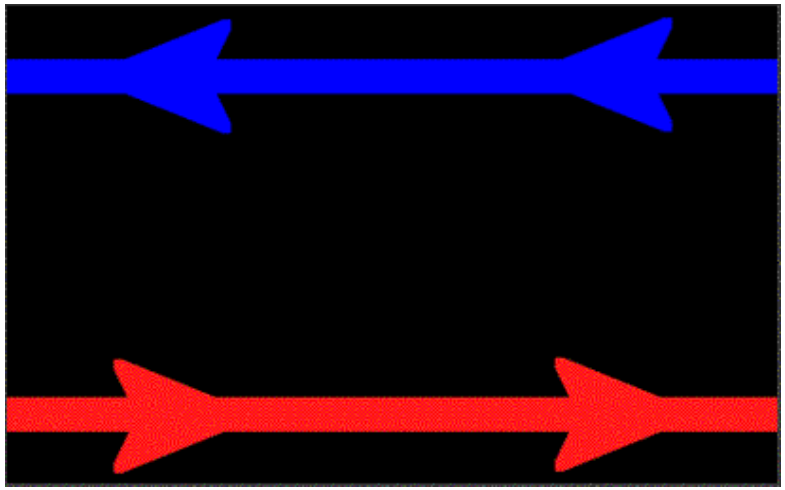
Spatial Scales

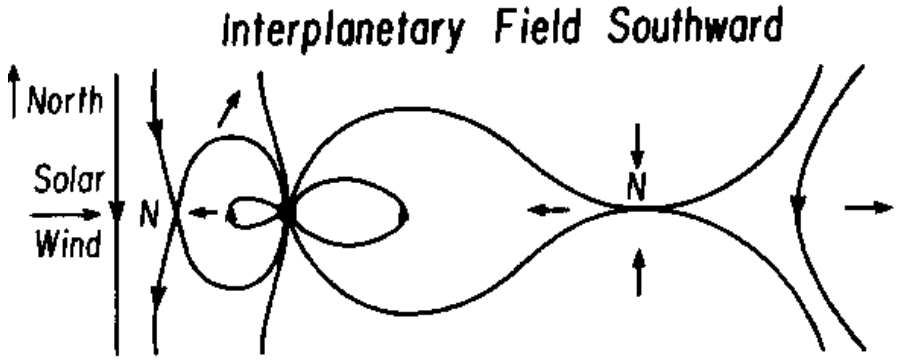


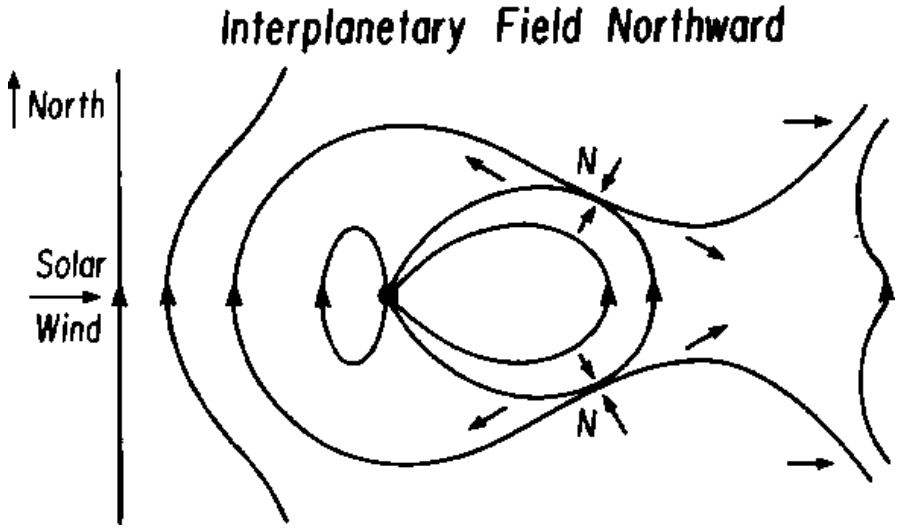
1 R_E (Earth's radius) = 6370 km
1 R_S (Solar radius) ~ 110 R_E
1 AU (Distance between the Sun and the Earth) ~ 215 R_S

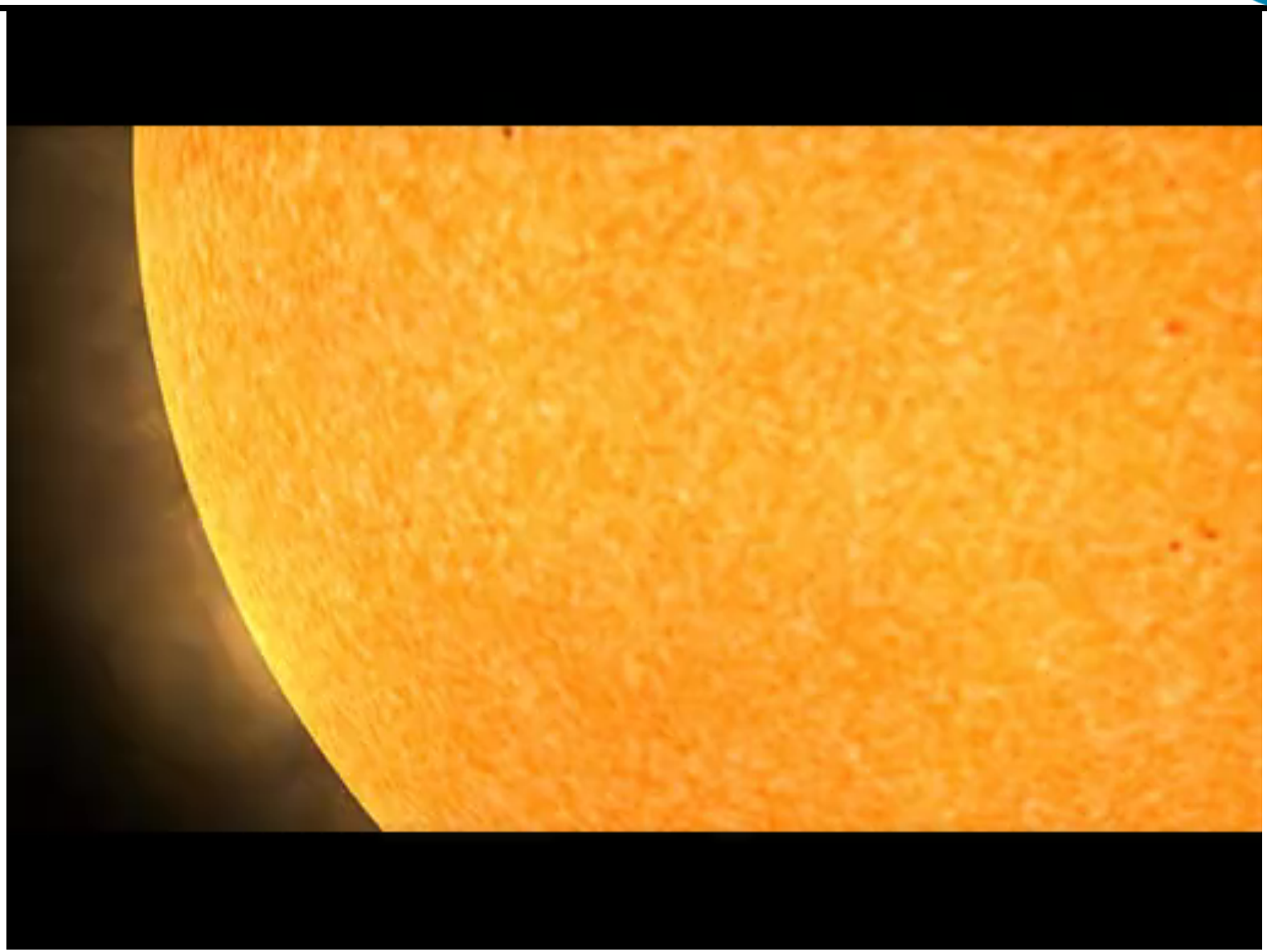
Magnetosphere for Southward and Northward IMF Orientation

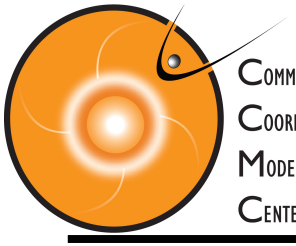


Magnetic Reconnection



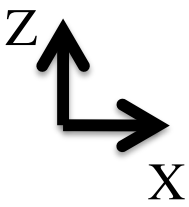


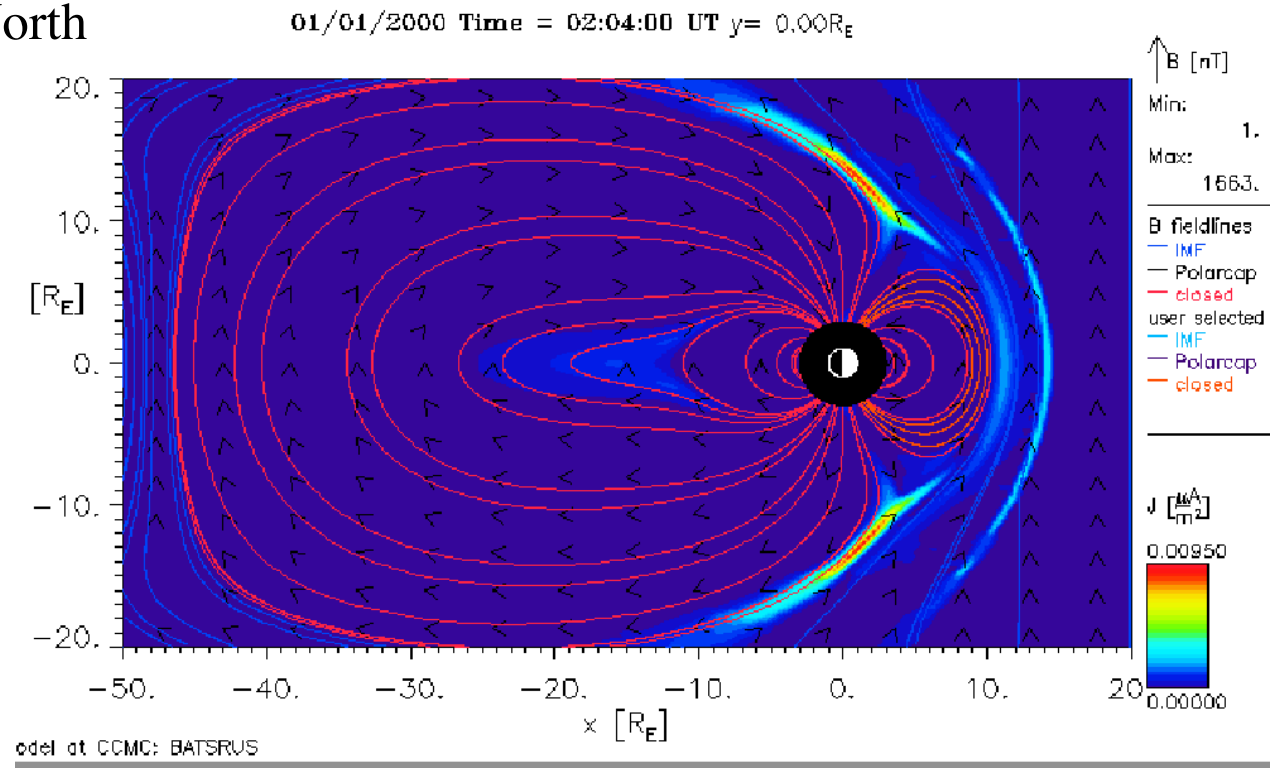




Magnetosphere:
Northward IMF

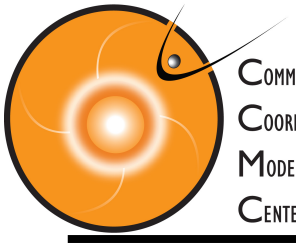
X: Earth to Sun
Z: South to North



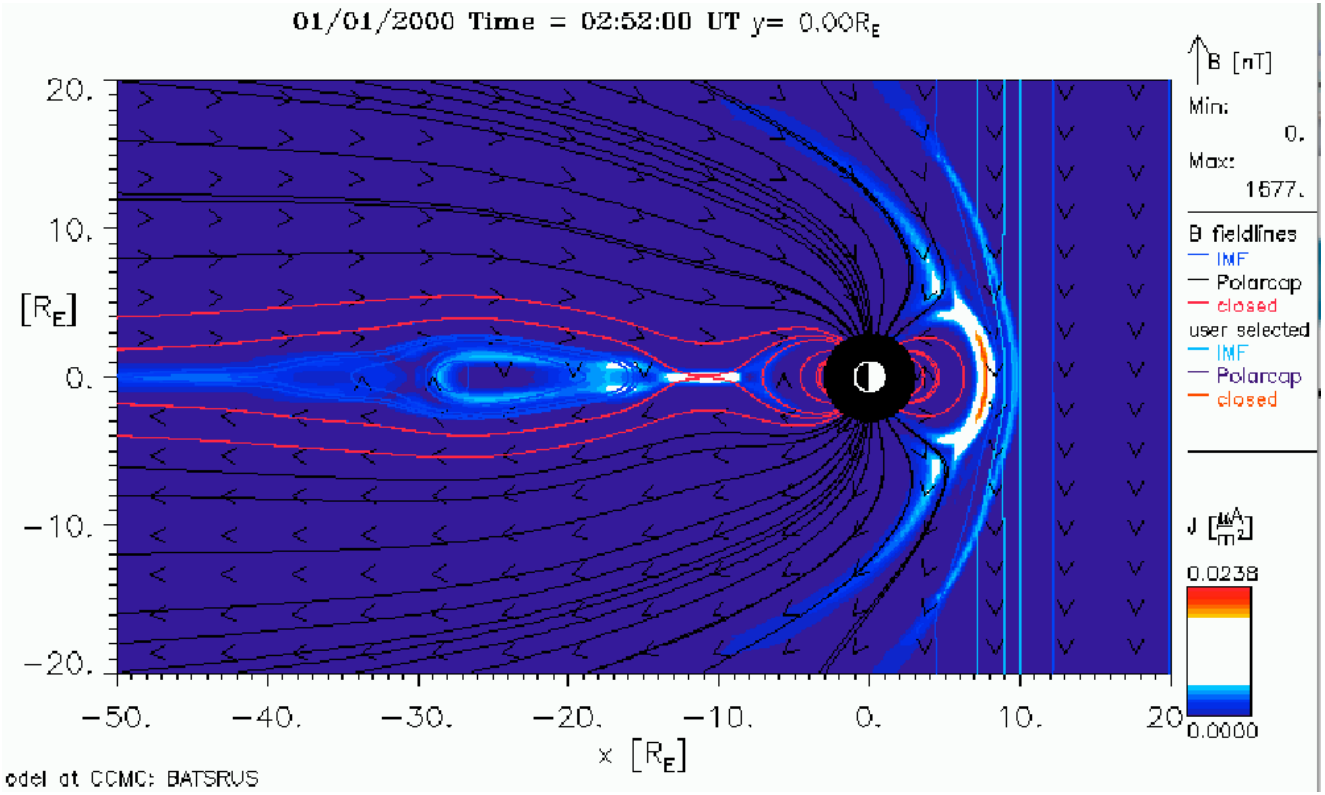


Sun

Red lines (closed): Magnetic field (MF) lines with both ends connected to the Earth
Black lines (open): MF lines with only one end a the Earth
Blue lines (interplanetary): MF lines with both ends in the interplanetary space



Magnetosphere:
Southward IMF



Red lines (closed): Magnetic field (MF) lines with both ends connected to the Earth
Black lines (open): MF lines with only one end a the Earth
Blue lines (interplanetary): MF lines with both ends in the interplanetary space

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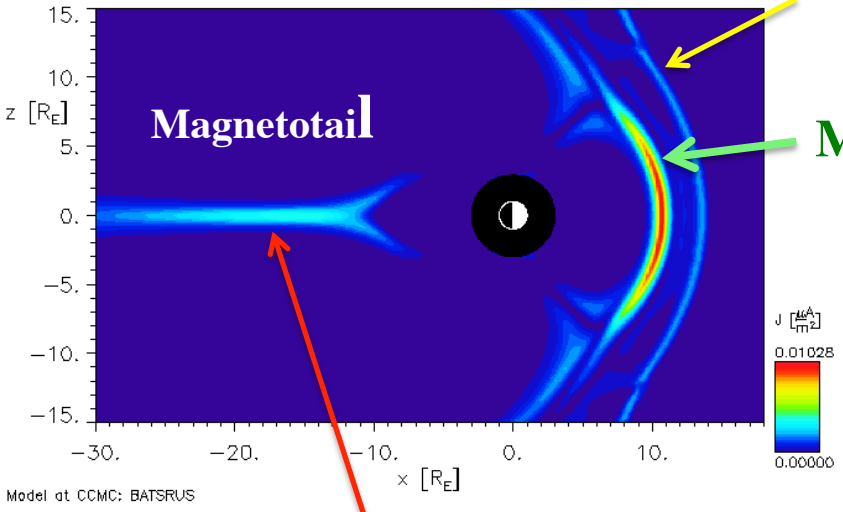
Magnetosphere in Different Cut Planes

meridional cut Y=0

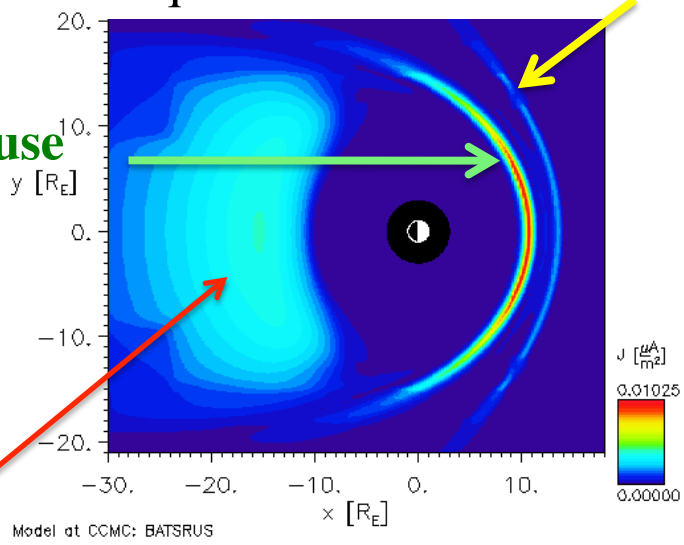
Bow shock



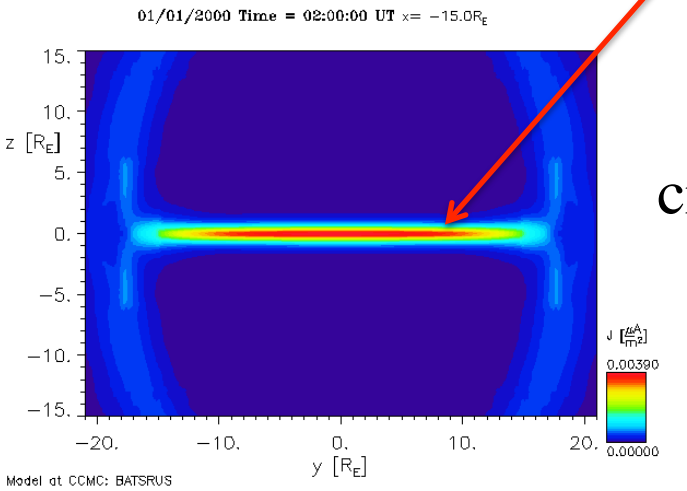
Magnetopause

equatorial cut Z=0

Bow shock

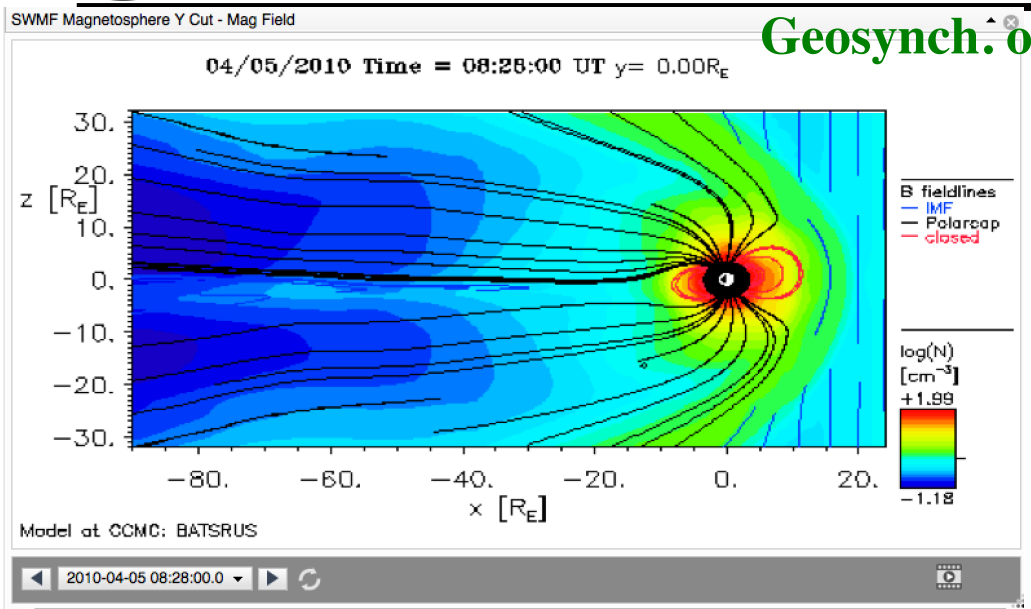


Magnetotail current sheet

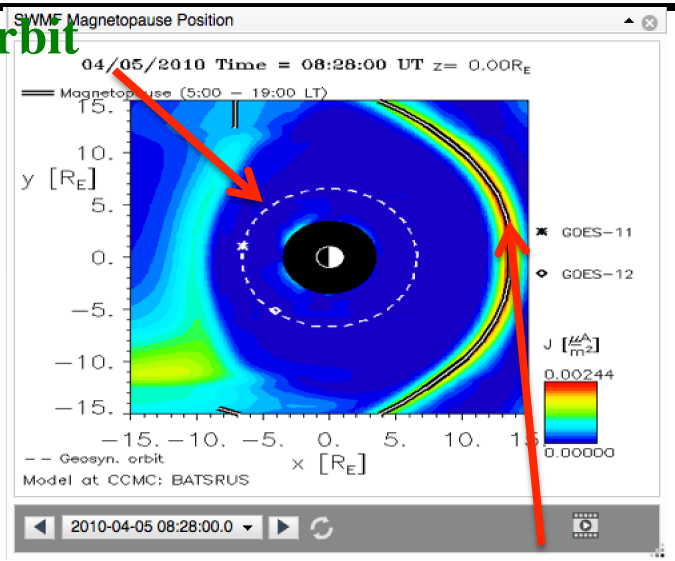


cross-tail cut X= -15 R_E

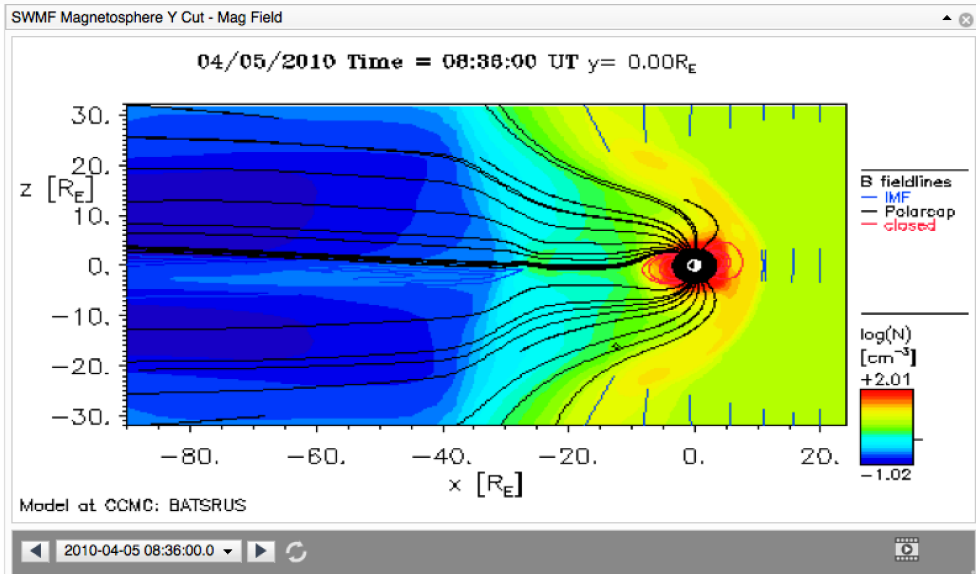
Magnetosphere:
Quiet vs. Compressed

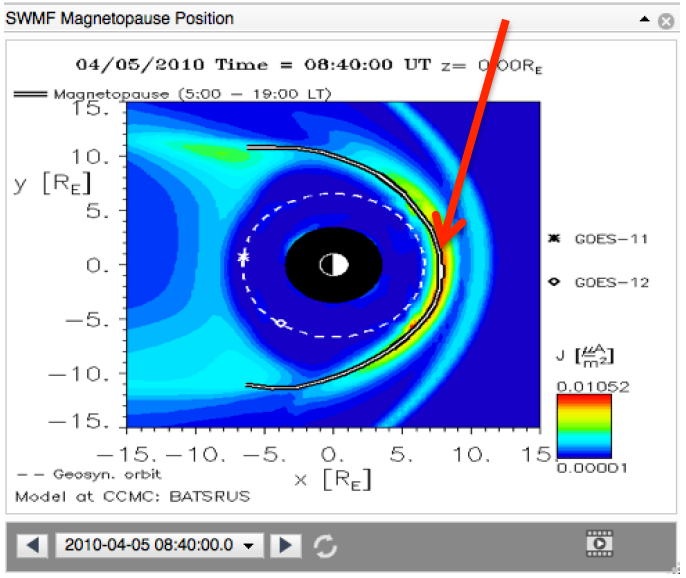


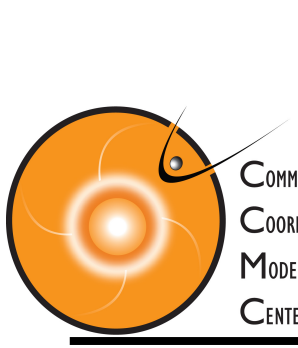
Geosynch. orbit



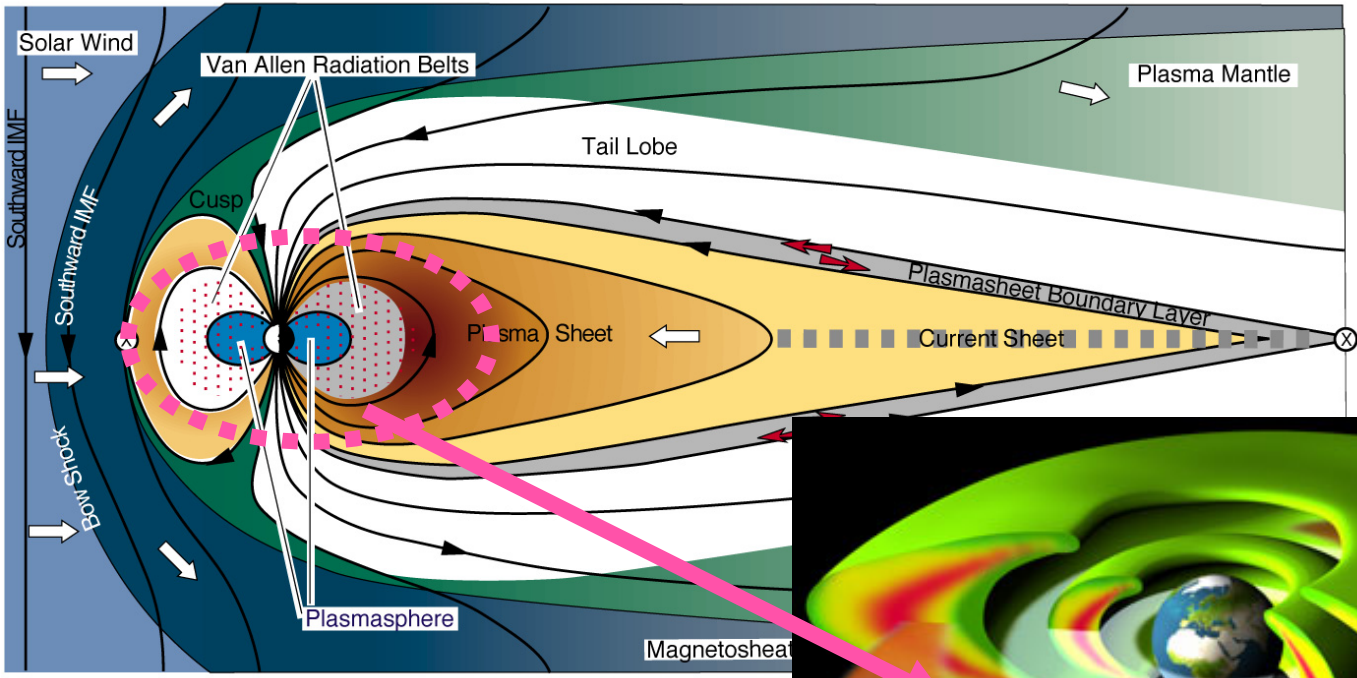
Magnetopause

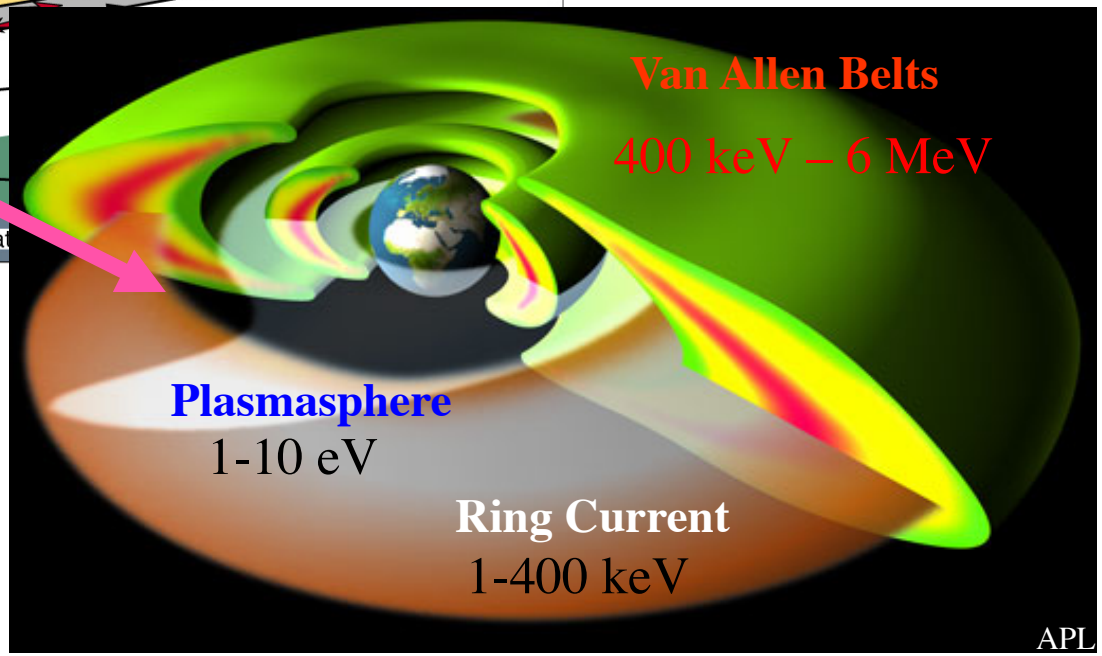






Inner Magnetosphere (up to ~ 10 RE)





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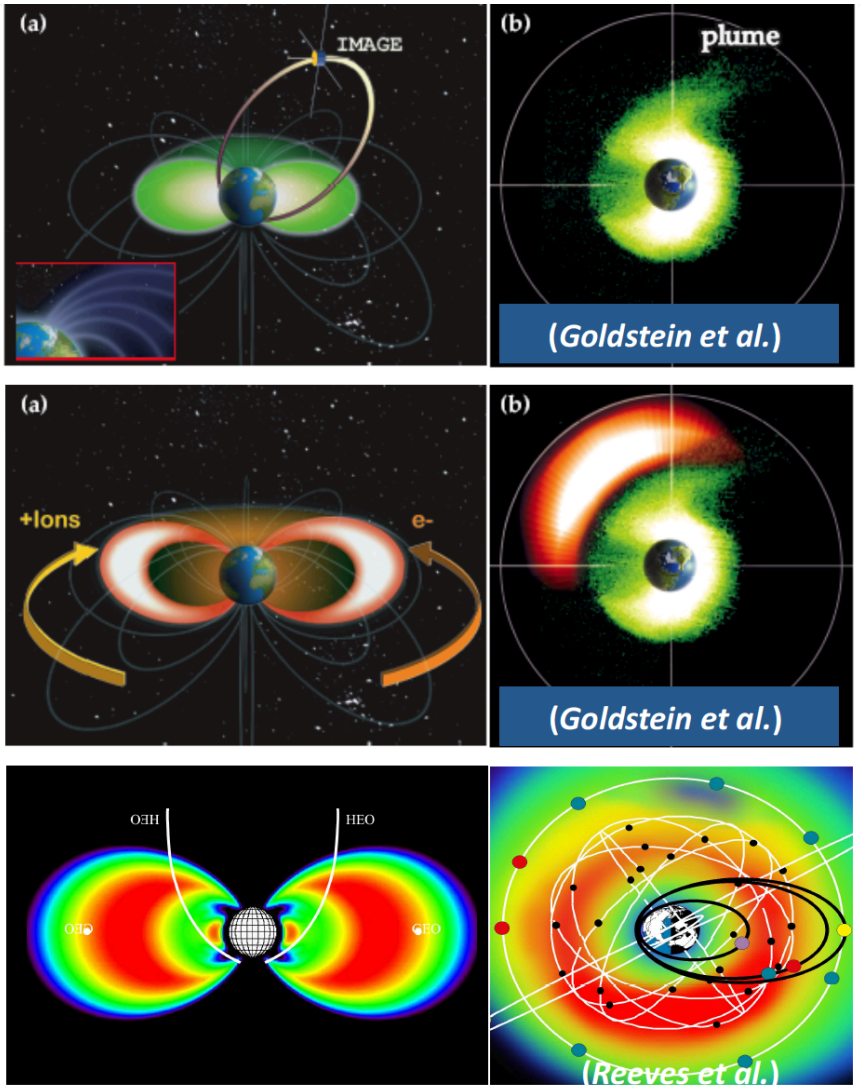
Inner Magnetosphere Plasmas

- Plasmasphere
  - 1-10 eV ions
  - ionospheric origin
- Ring current
  - 1-400 keV ions
  - both ionospheric and solar wind origin
- Outer radiation belt
  - 0.4-10 MeV electrons
  - magnetospheric origin

Inner magnetosphere: Gigantic Particle accelerator



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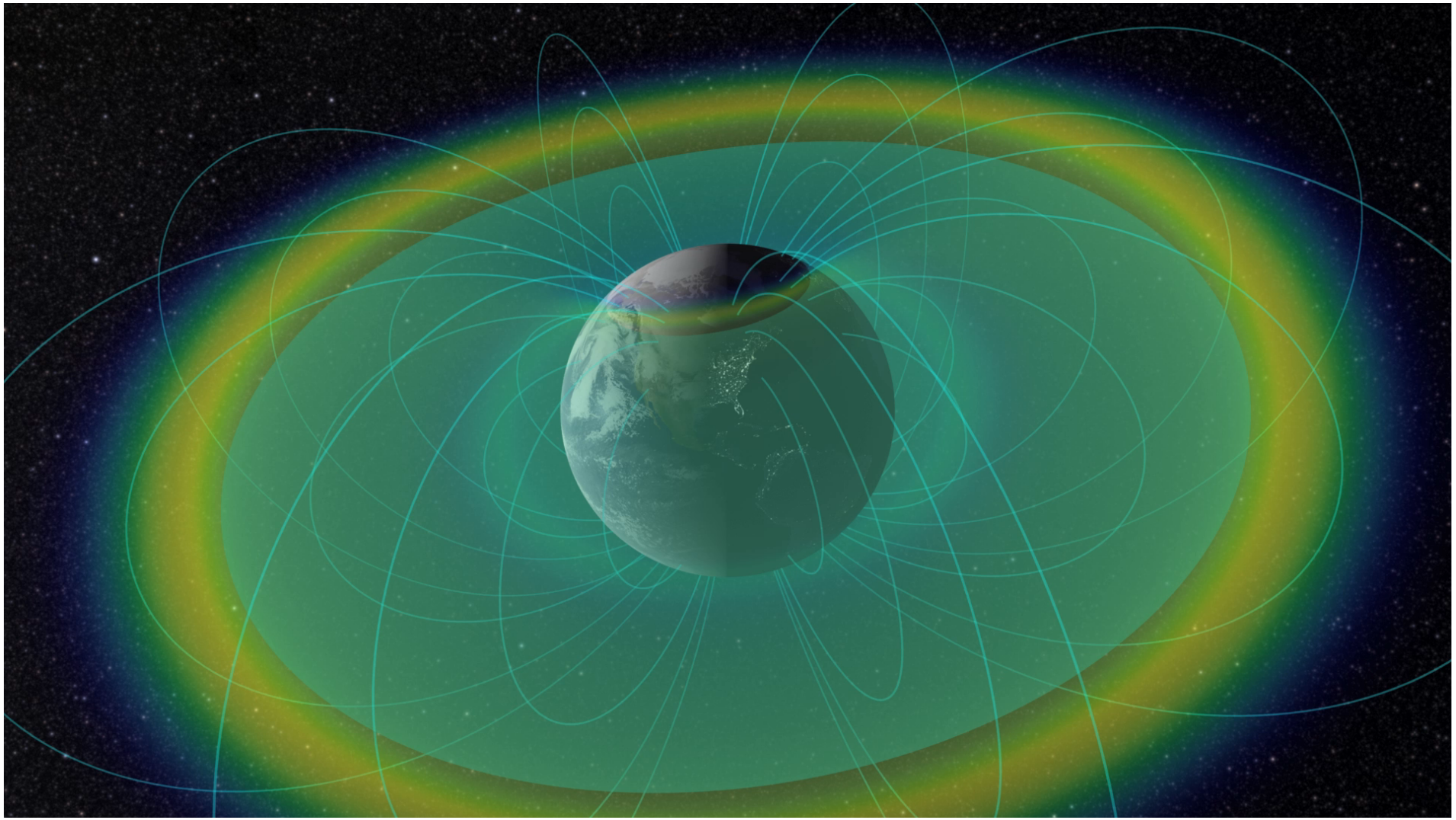

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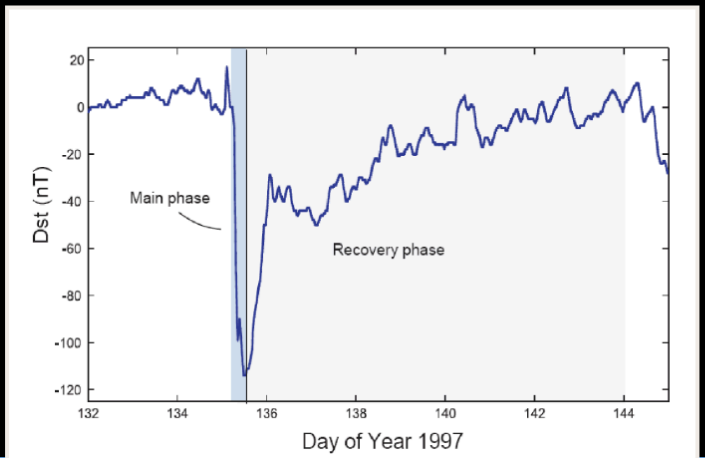
Magnetic Storms

- Most intense solar wind-magnetosphere coupling
- Associated with solar coronal mass ejections (CME), coronal holes HSS
- IMF Bz southward, strong electric field in the tail
- Formation of ring current and other global effects

- Dst measures ring current development
  - Storm sudden commencement (SSC), main phase, and recovery phase
  - Duration: days



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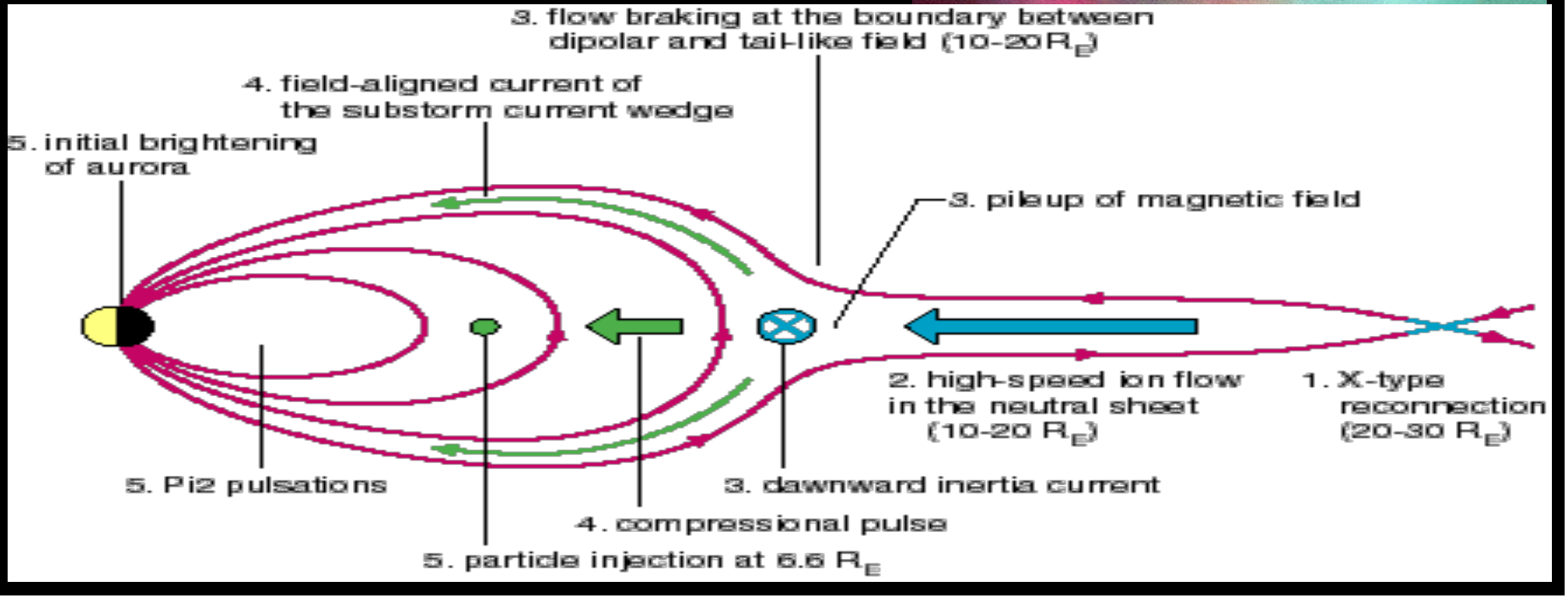
Substorms

- Instabilities that abruptly and explosively release solar wind energy stored within the Earth's magnetotail.
- manifested most visually by a characteristic global development of auroras
- Last ~ hours



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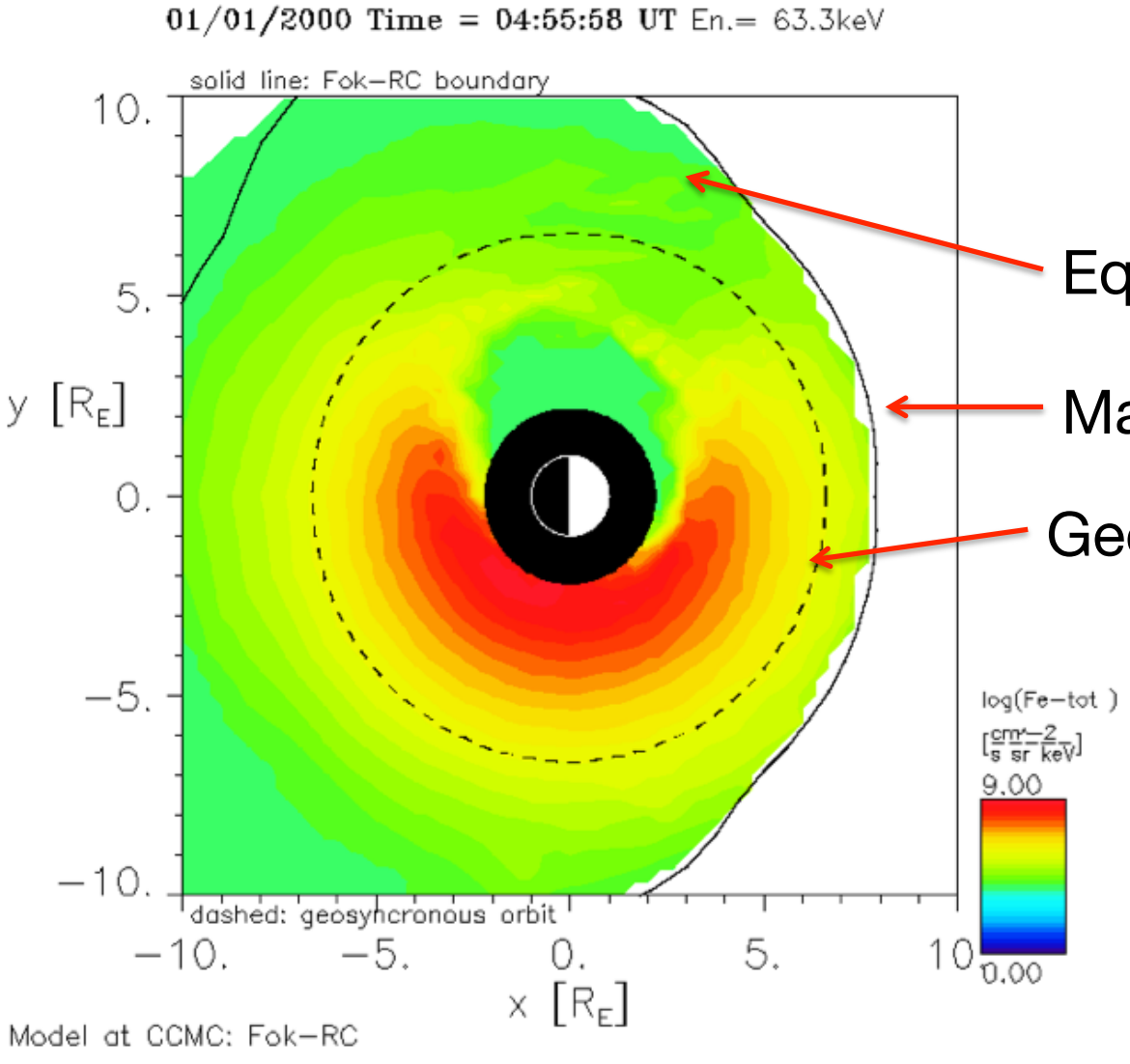
Electron Total Flux. Energy 63.3 keV. Color Contour



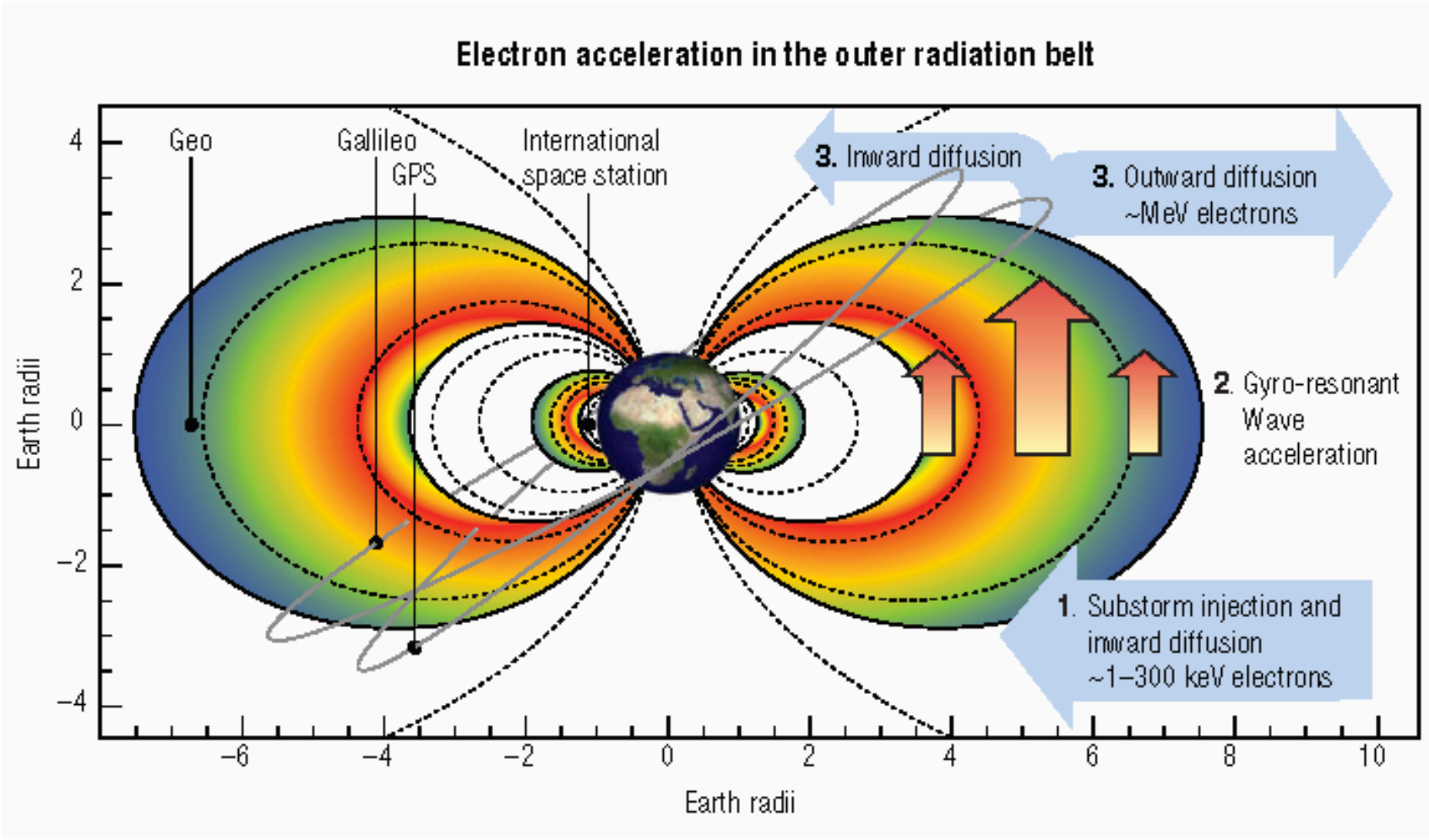
Equatorial Plane

Magnetopause

Geosynch. Orbit

Sun

Earth radius



Horne et al., 2007, Nature Physics

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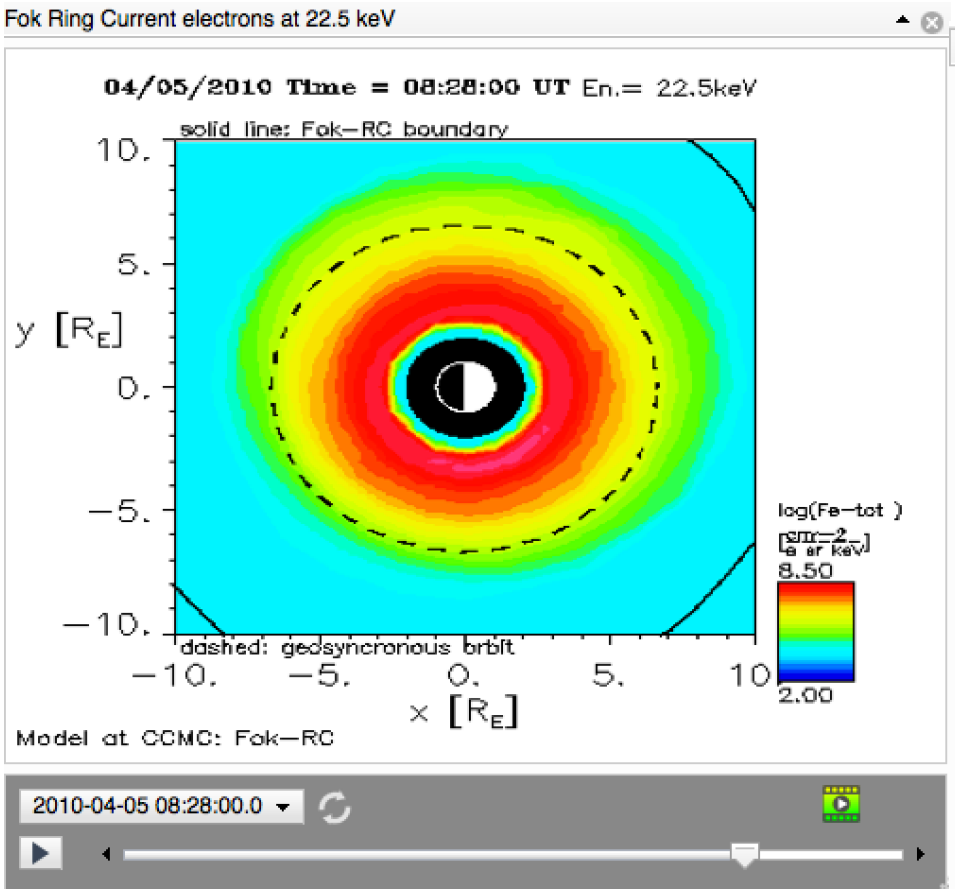
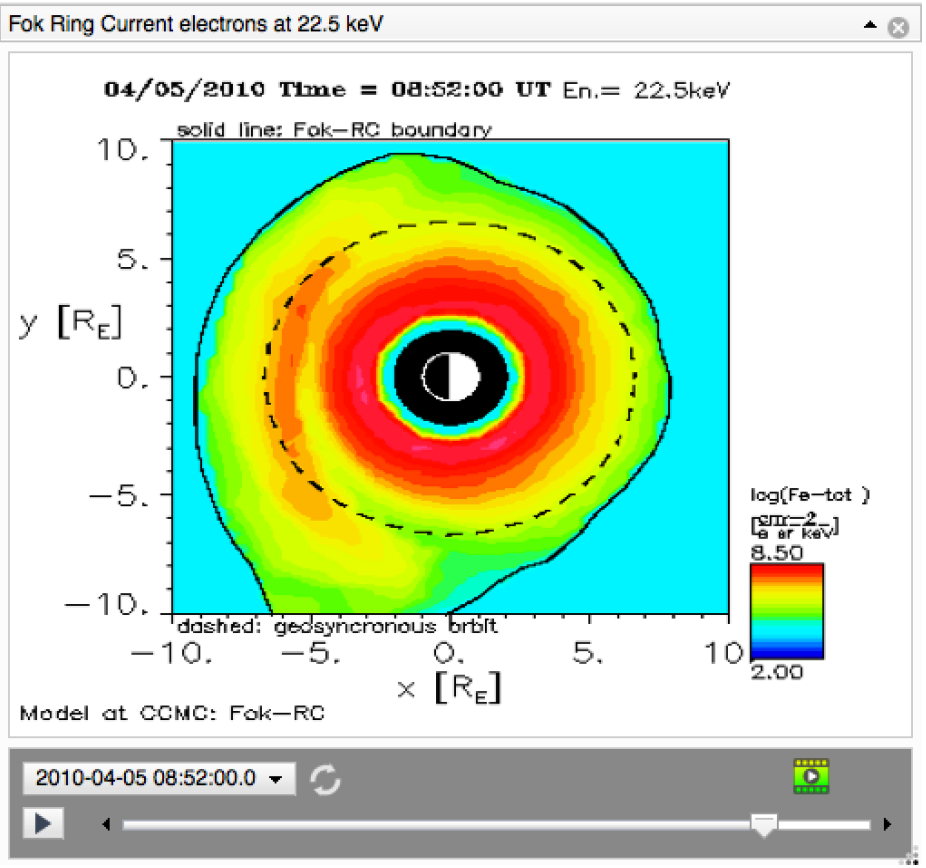
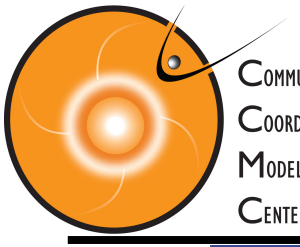
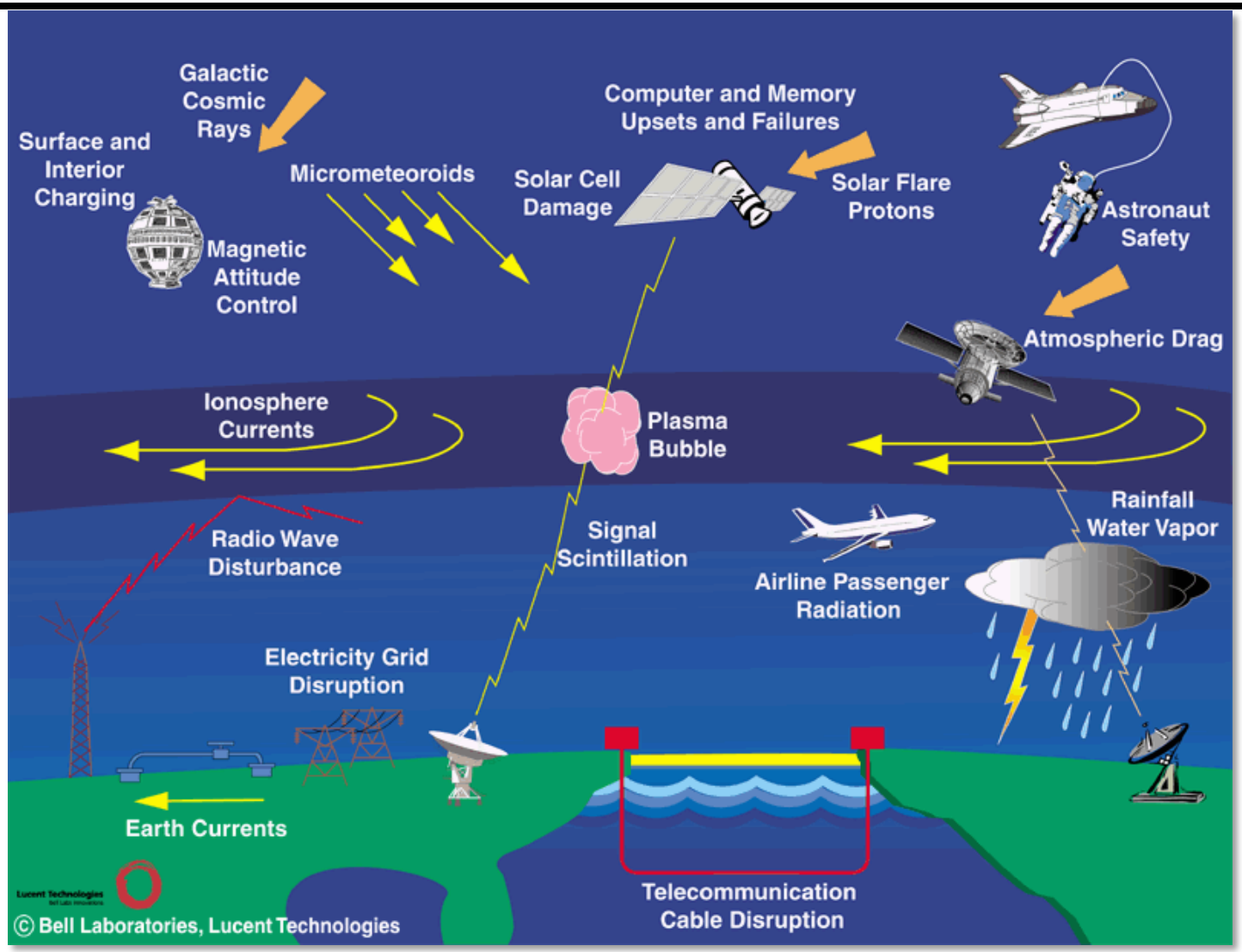
Ring Current:
Quiet vs. Active







Space Weather Impacts



Space weather impacts (credit: L. Lanzerotti/Bell Labs)

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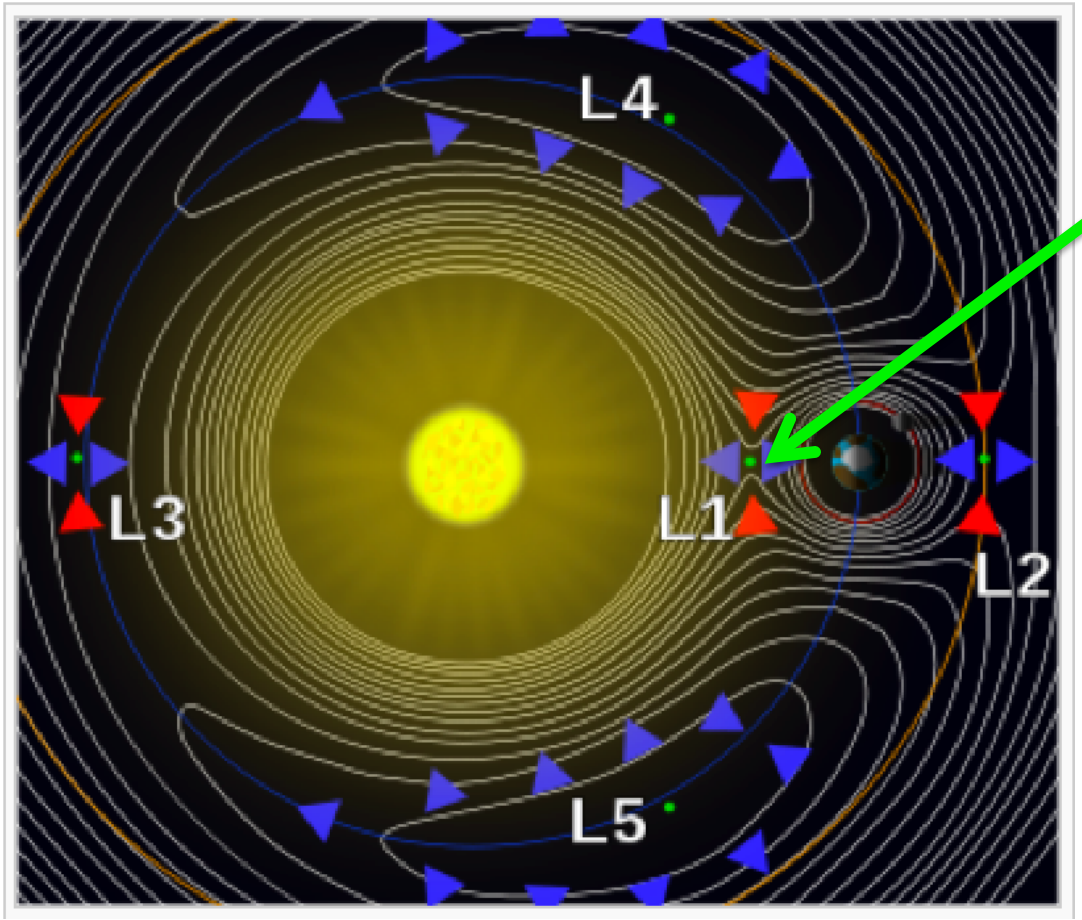
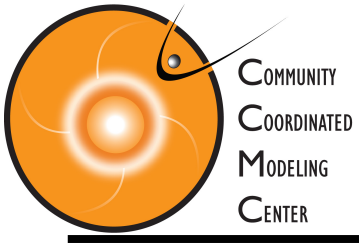
Lagrange Point – L1



Advanced
Composition
Explorer

L1 (Solar Wind Monitor ACE location): ~ 200 R_E sunward
You can fit 1 Sun between the Earth and L1.
2 R_S (Solar diameter) ~ 220 R_E



Solar Wind Speed at ACE

Bulk Speed **Zoom:** In Out full **Pan:** left right

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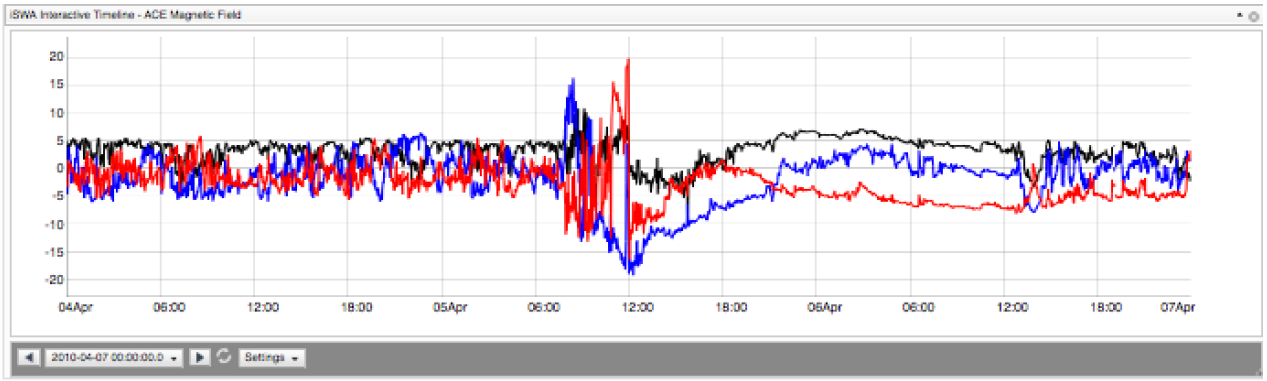
Solar Wind Parameters at ACE

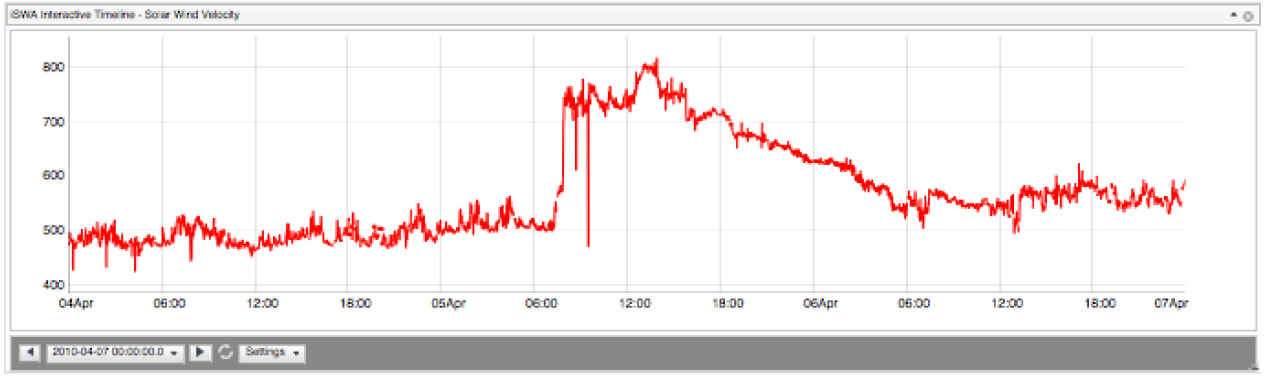
on 04/05/2010



nT

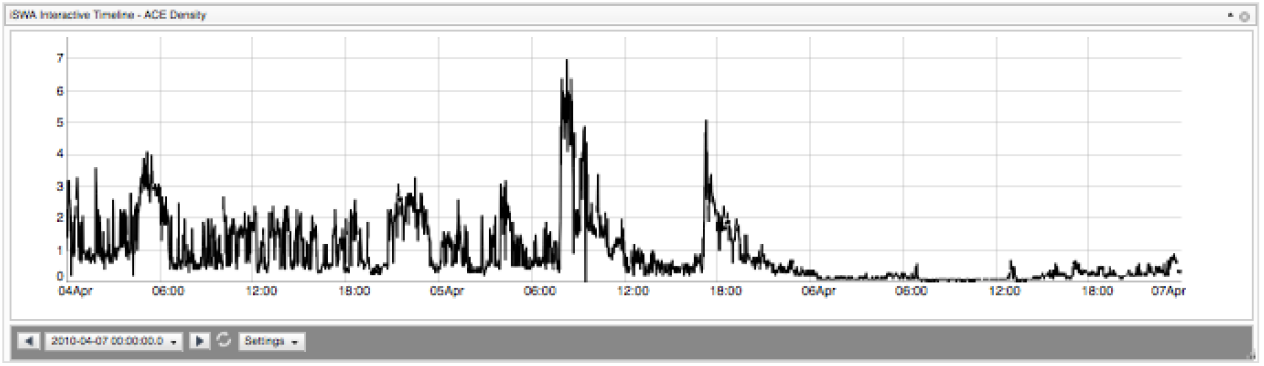
Magnetic field
B_x, B_y, B_z

X: Earth to Sun
Z: North to South



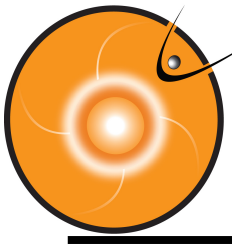
km/s

Velocity



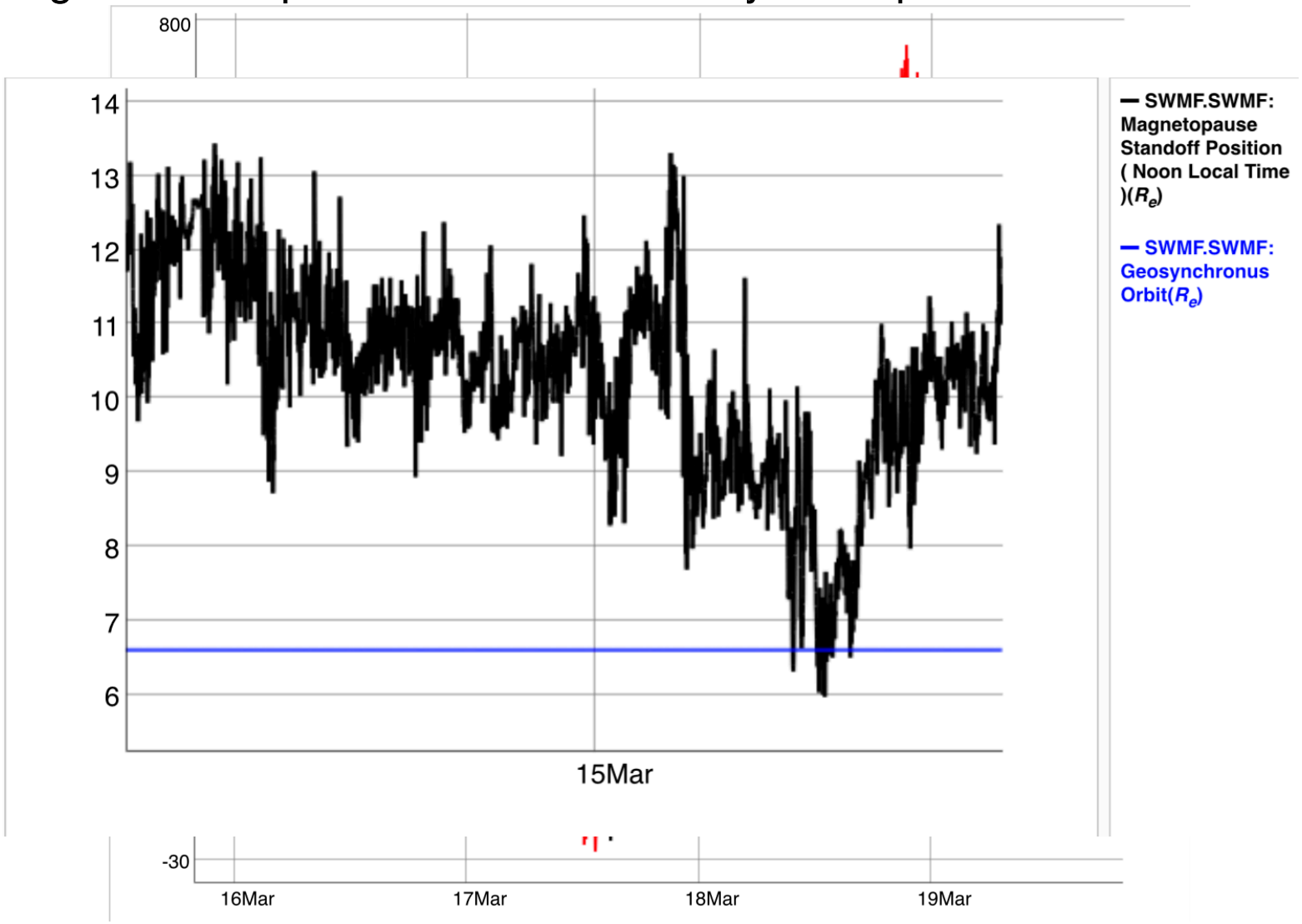
part/cm^3

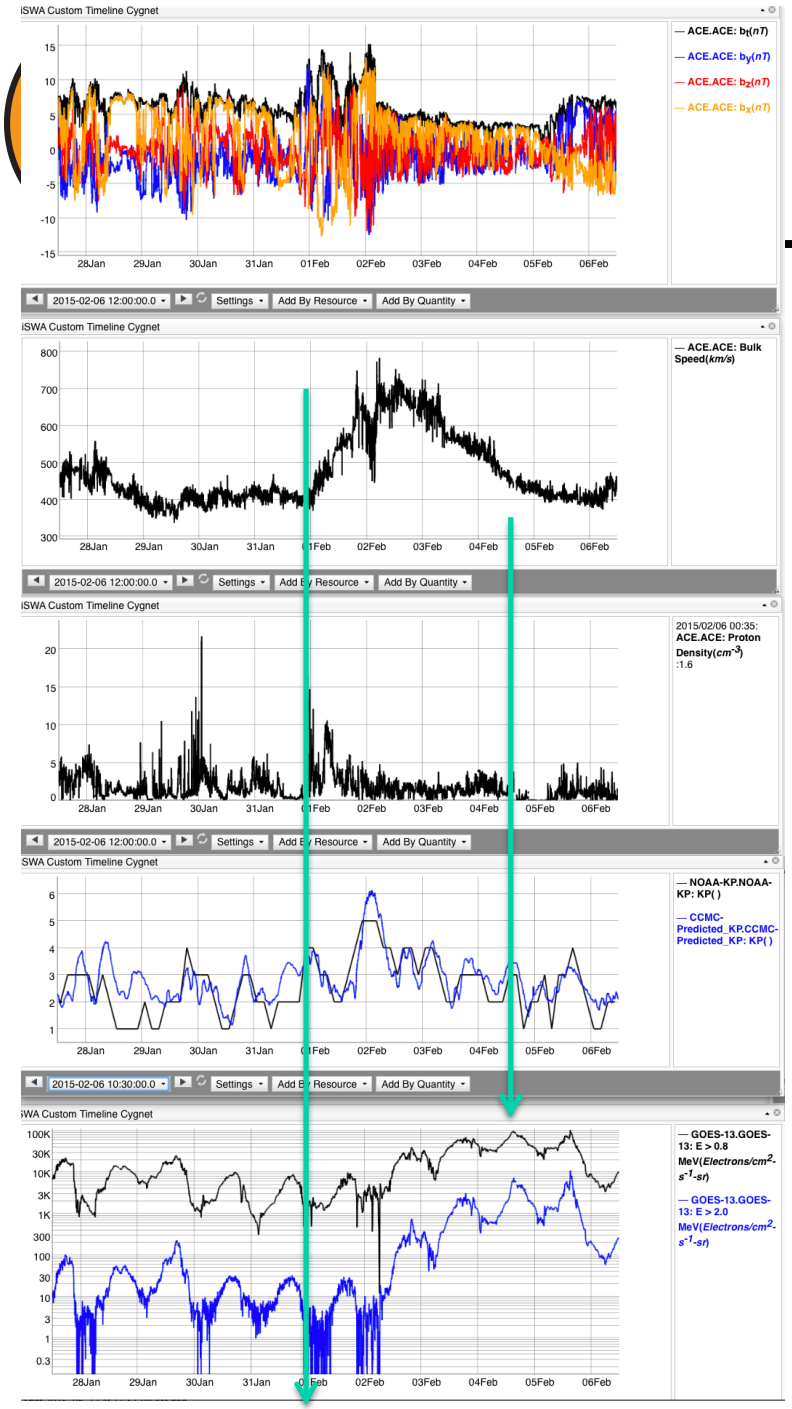
Density

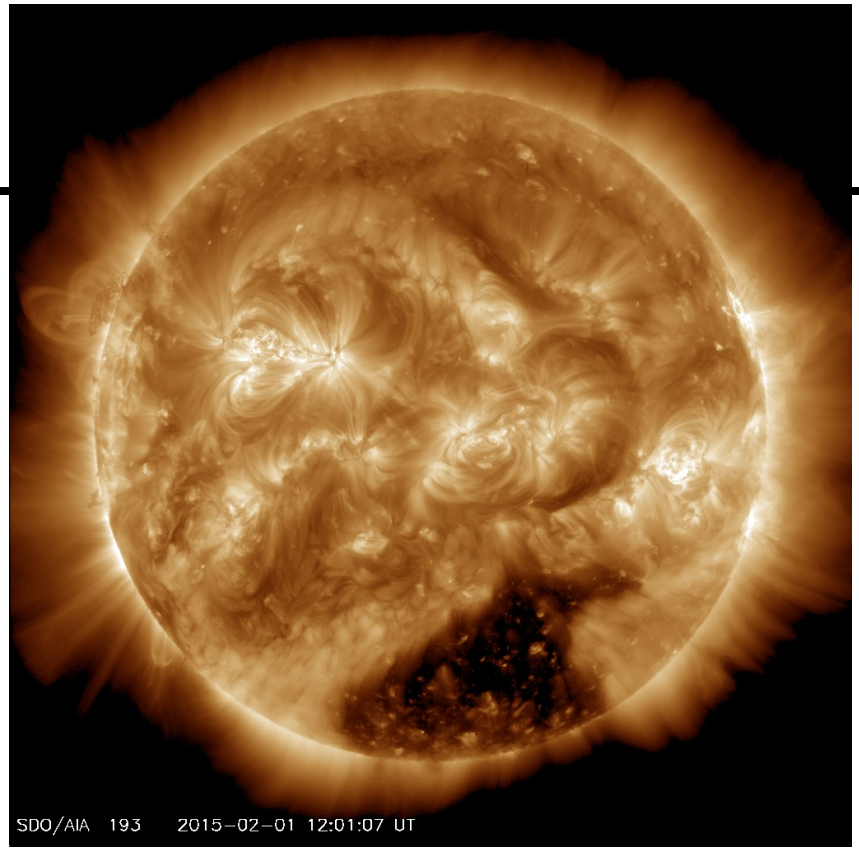


Magnetopause Stand-off Distance

Degree of compression of MP due to dynamic pressure of solar wind







HSS and radiation belt electron flux enhancement

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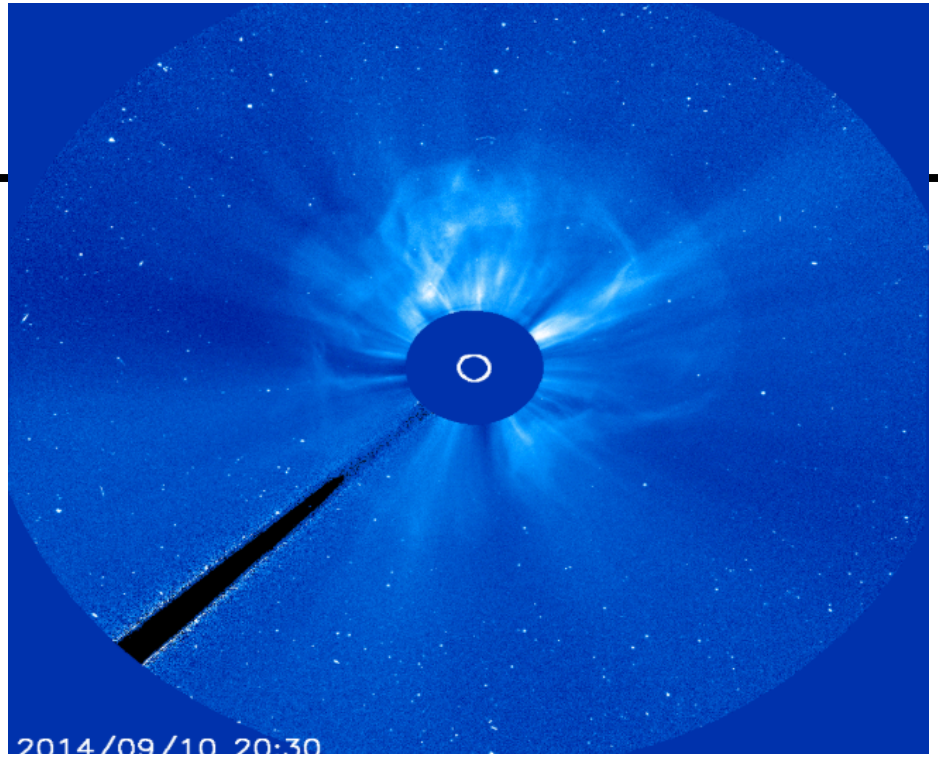
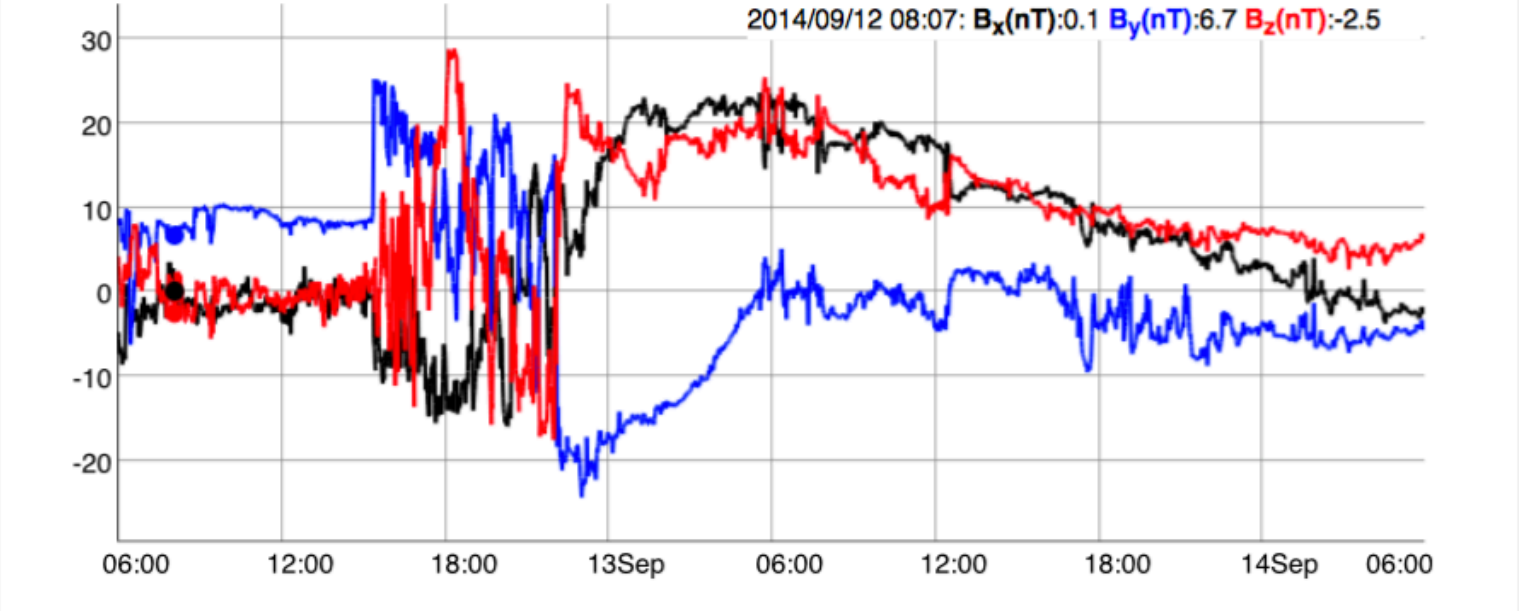
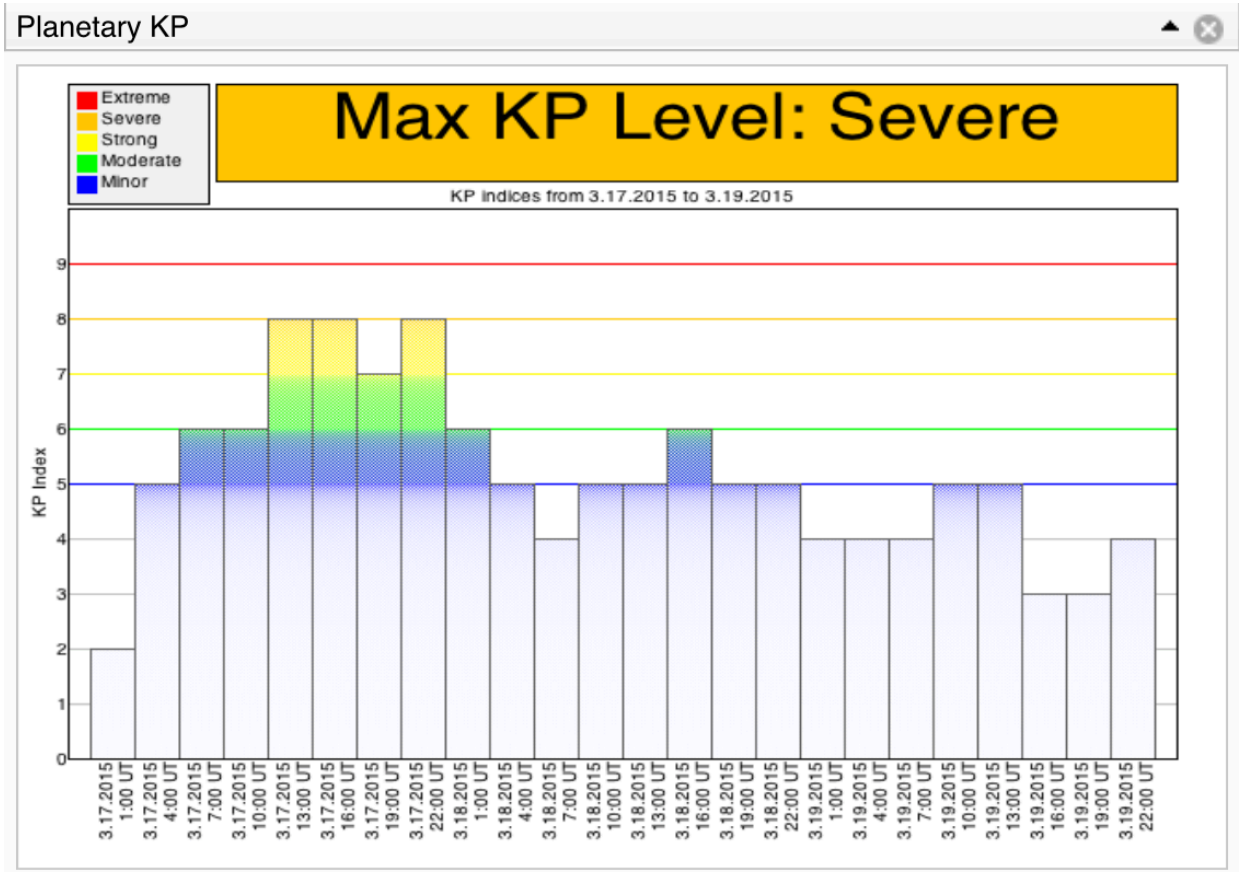




Kp index

"*p*lanetarische *K*ennziffer" (= planetary index).

- Geomagnetic activity index - range from 0-9
  disturbance levels of magnetic field on the ground – currents



Threshold
Kp>=6

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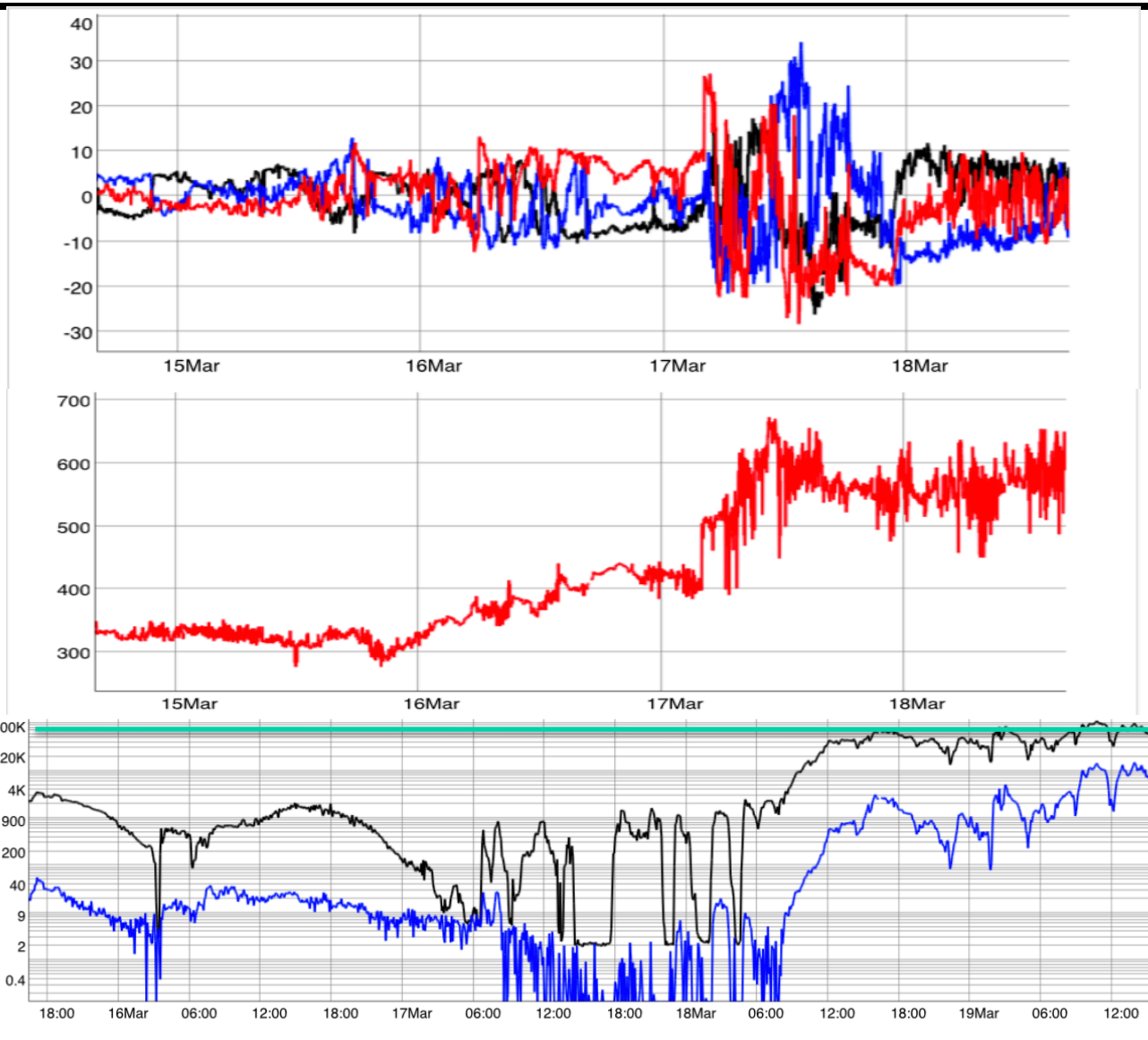
HSS and Radiation Belt Electron Flux Enhancement



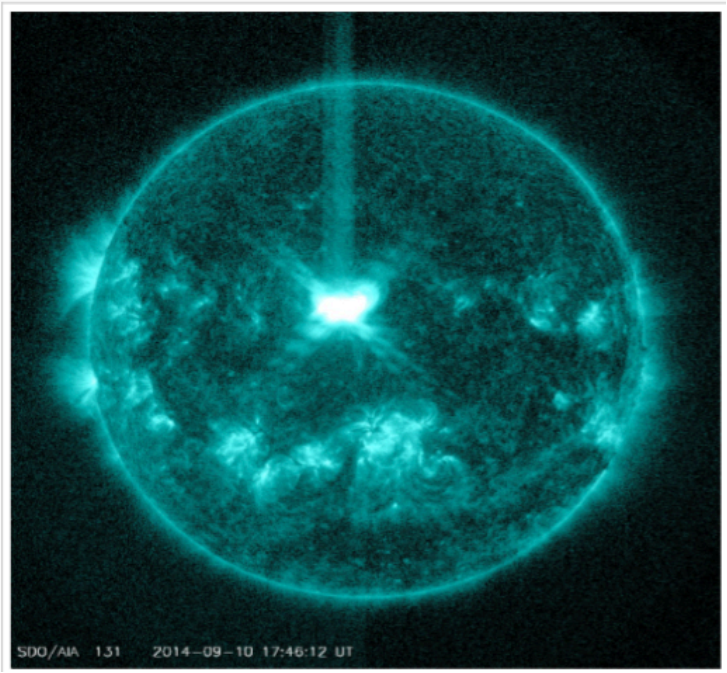
Energetic Proton Flux

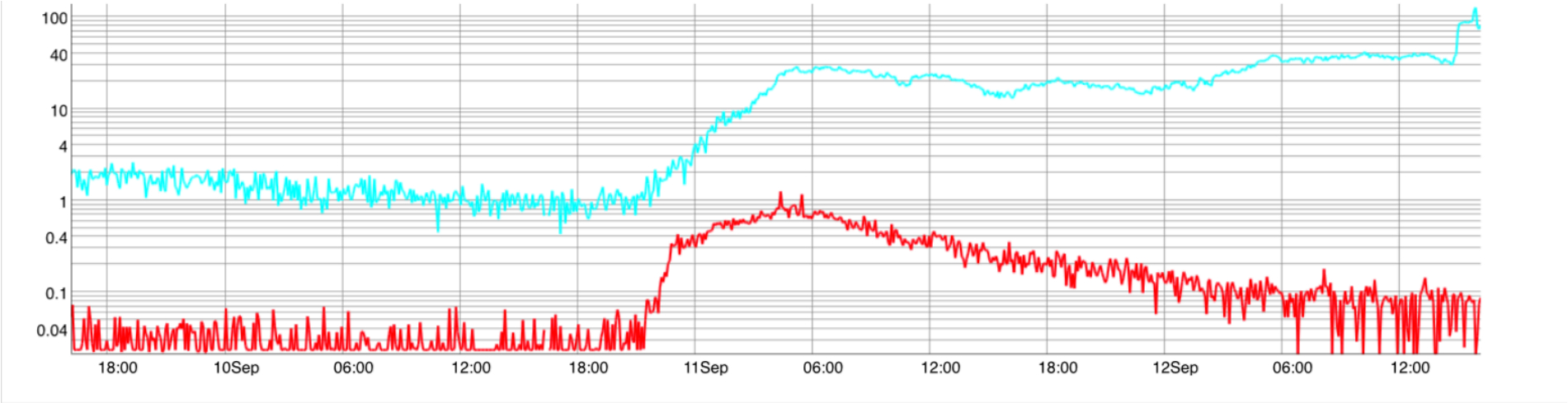
- >10 MeV flux by GOES spacecraft

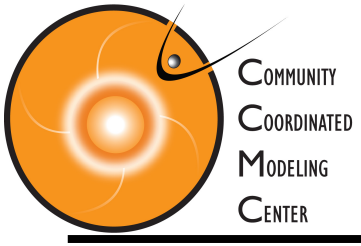
Threshold: 10 pfu

- >100 MeV flux by GOES spacecraft

Threshold: 1 pfu

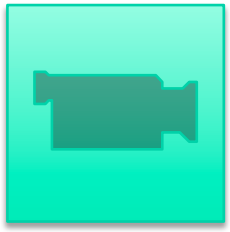


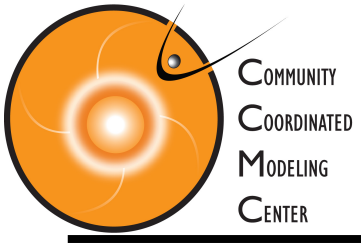




Watch the video

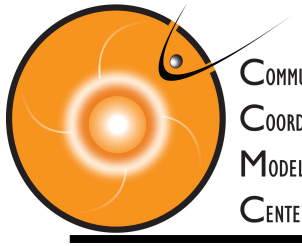
http://missionscience.nasa.gov/sun/sunVideo_04magnetosphere.html





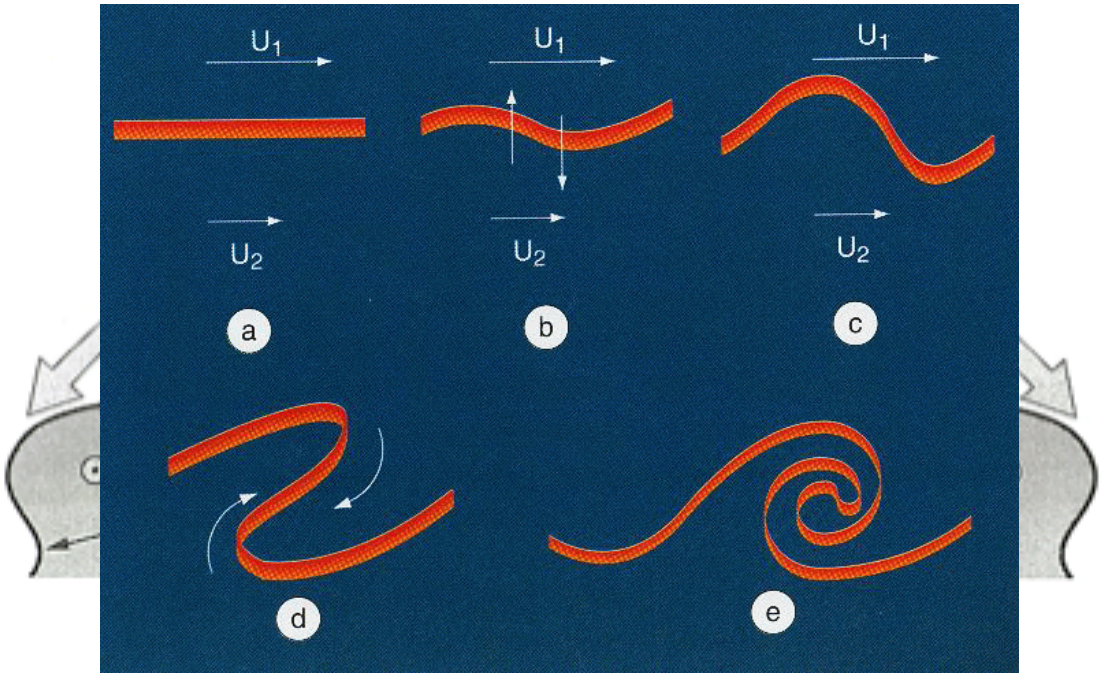
iSWA Layout:
07/12/2012

http://goo.gl/V0JjxV



Magnetosphere Physics Research

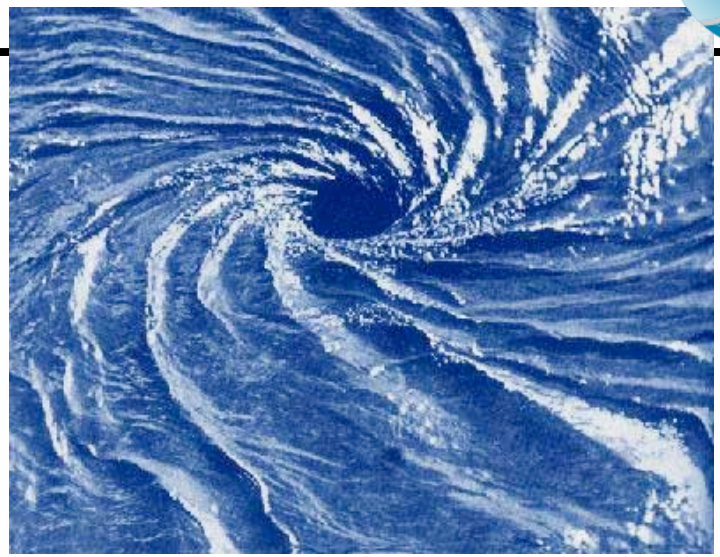
Kelvin-Helmholtz Instability



- Waves that occur between the velocity shear of two fluids.
- It creates vortices on the magnetopause, specially on the flanks.
- Predominantely at high solar wind velocities and northward IMF (positive Bz) component.
- Many scientific models have been created to study these two parameters: the flow velocity and the magnetic field.

Community Coordinated Modeling

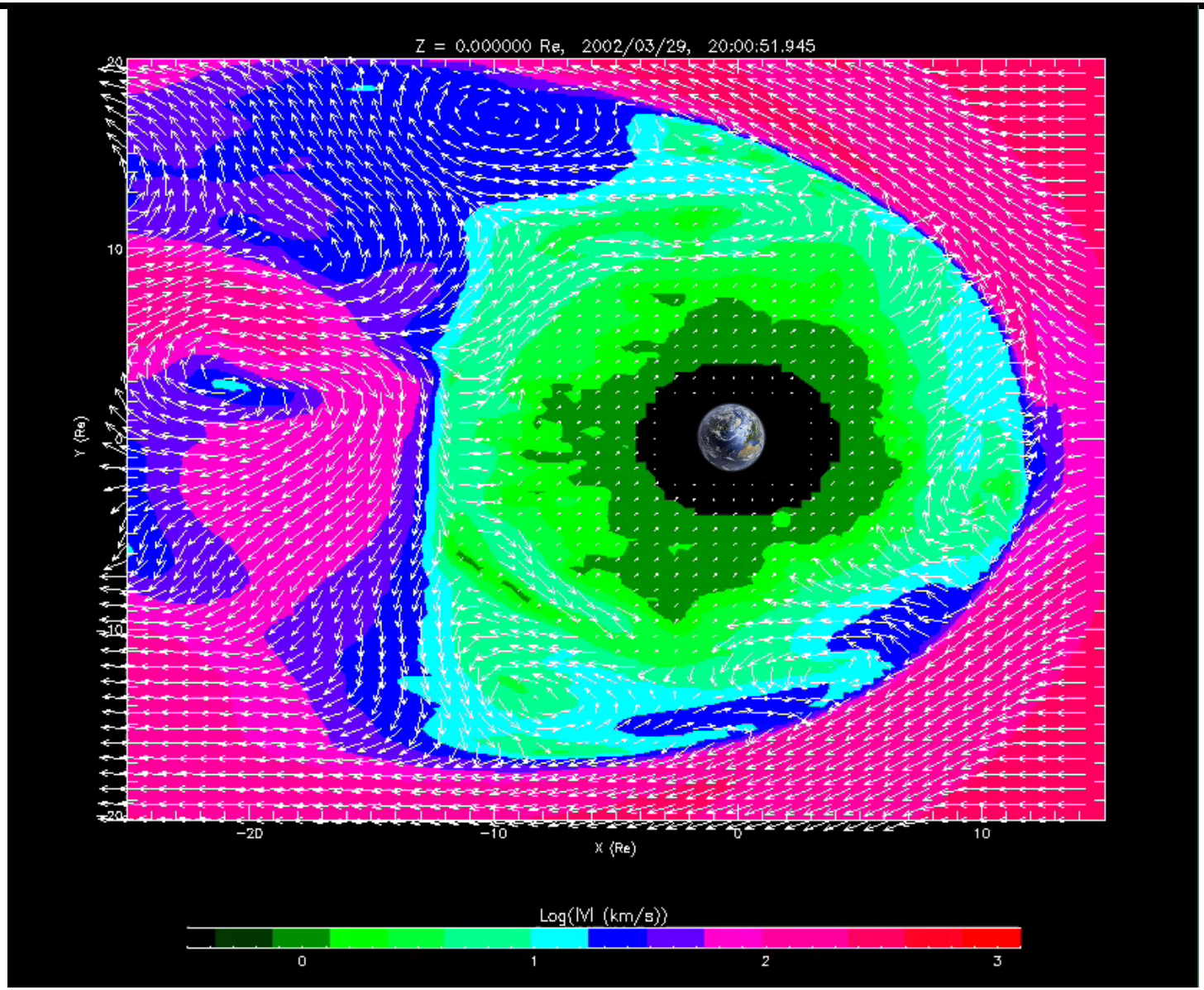
Examples of Kelvin-Helmholtz Instability



Community Coordinated Modeling Center

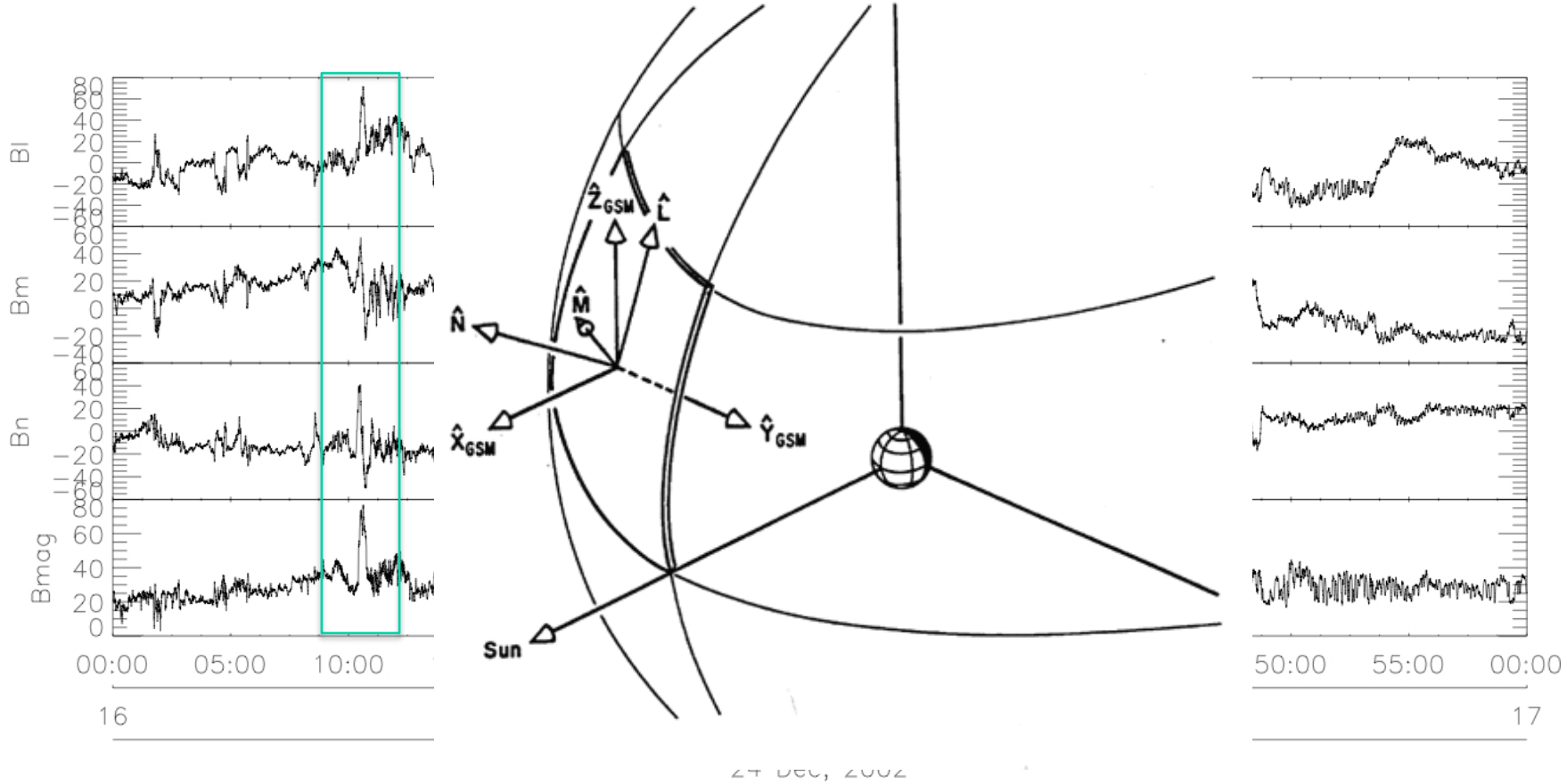
Magnetosphere Physics Research

Collado-Vega, Y. M., et al., JGR, 2007



Flux Transfer Events (FTEs)

Flux Transfer Events (FTE's) are magnetopause signatures that result from the passage of flux ropes produced by reconnection.



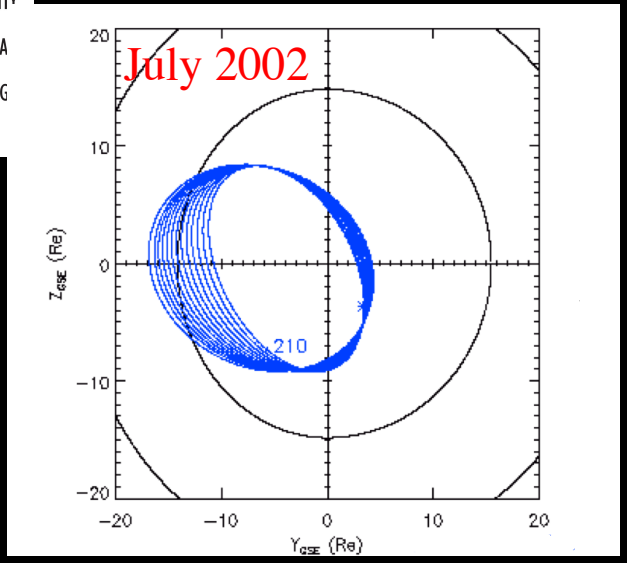
From Collado-Vega, Y. M., Ph.D. Thesis, 2013

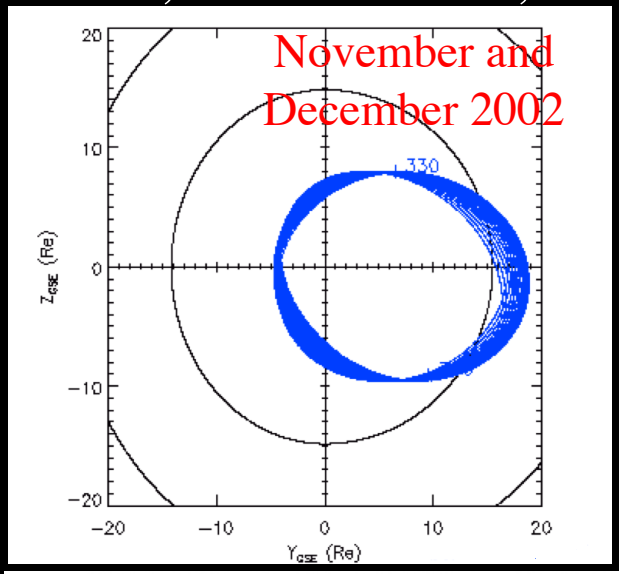
2nd Part

Community Coordinated Modeling Center

Largest – 386 km/s

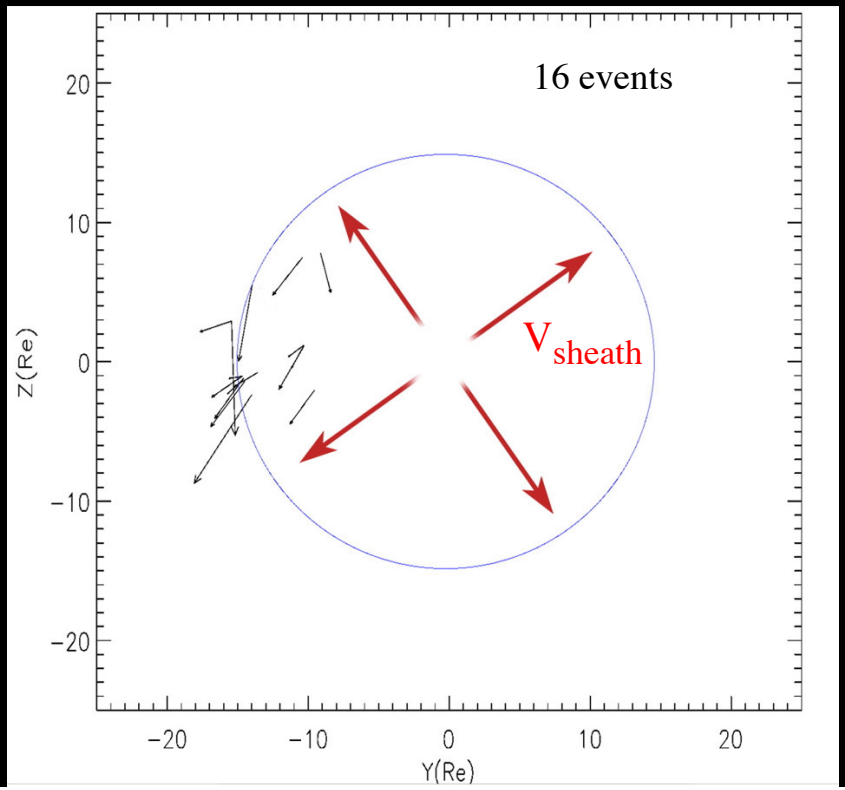
Smallest – 90 km/s

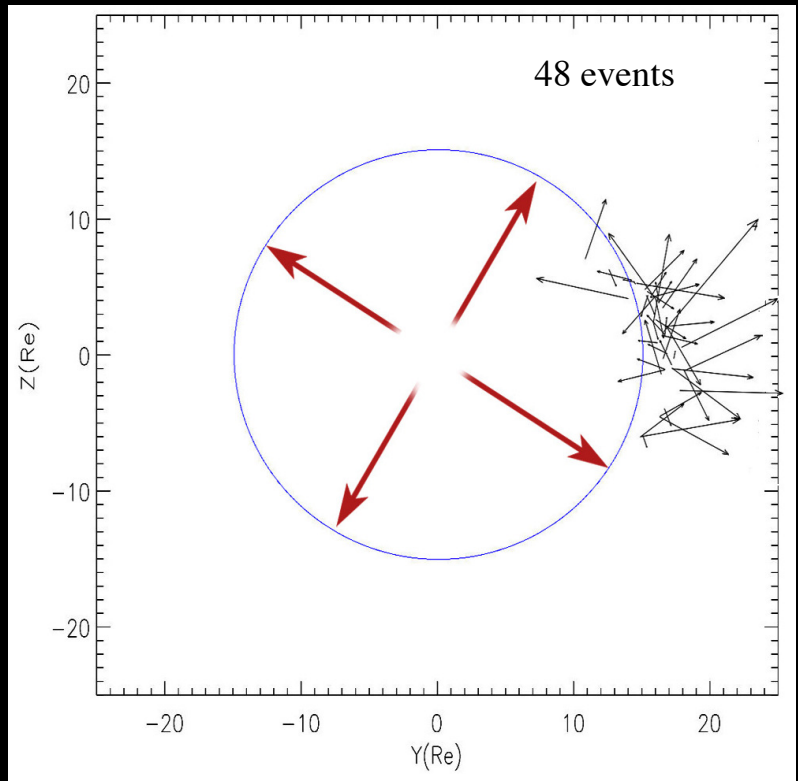




Largest – 412 km/s

Smallest – 92 km/s

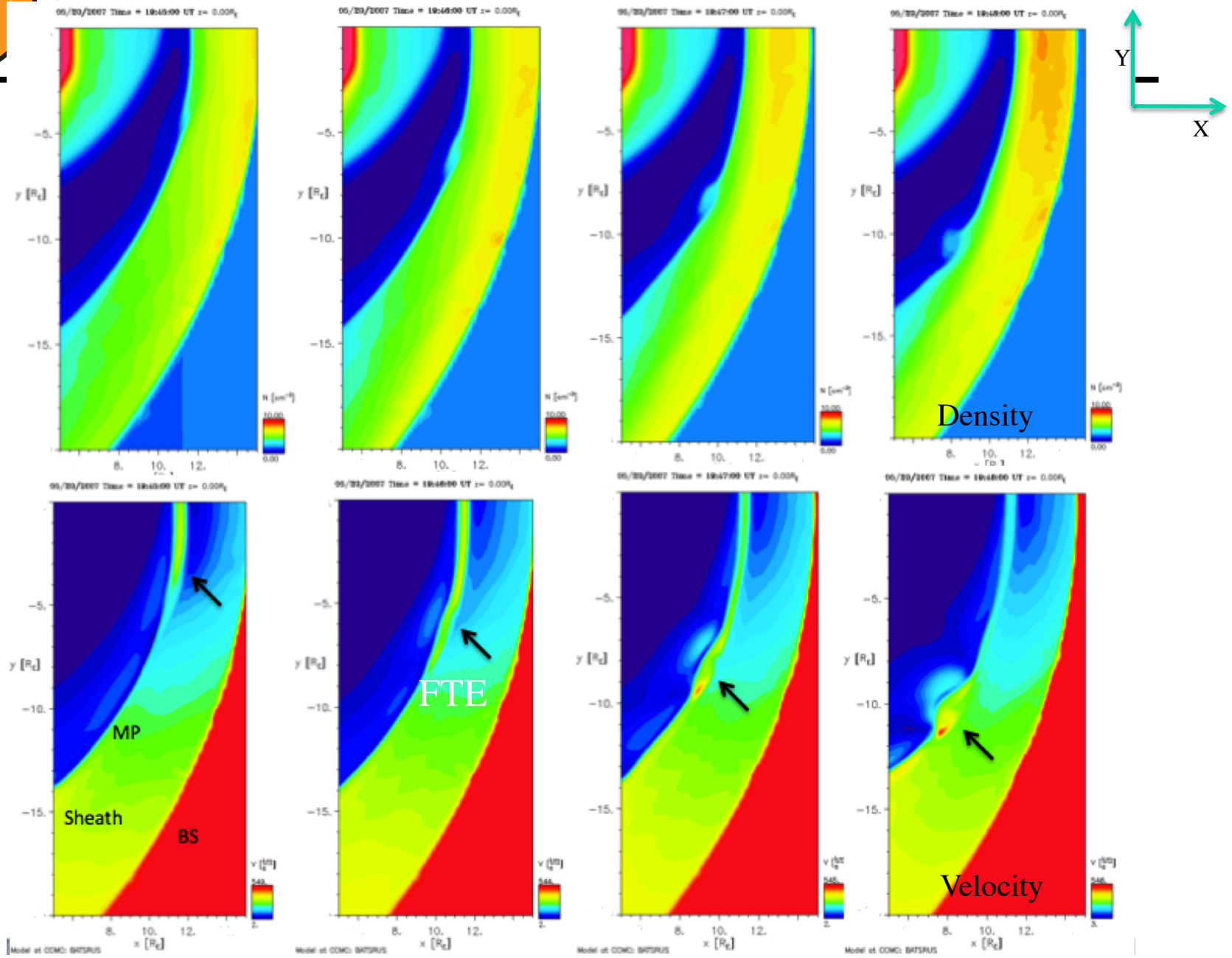


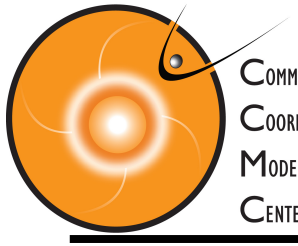


2nd Part

COMMUNITY COORDINATED

MHD Simulations (19:45-19:48 UT)





Magnetopause Stand-off Position

From Collado-Vega, Y. M., et al., In progress