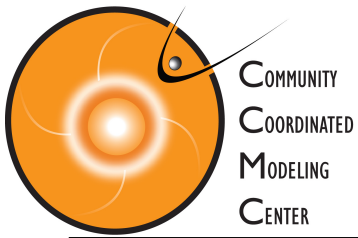# Earth's Magnetosphere

CCMC/SWRC SW REDI

NASA Goddard Space Flight Center
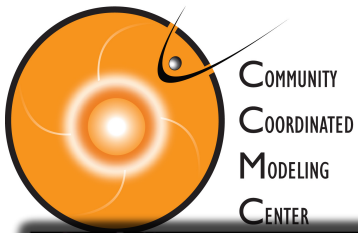
Magnetic Field of the Earth

Spin axis

The geographic North Pole is a magnetic south pole.

Magnetic field lines

S

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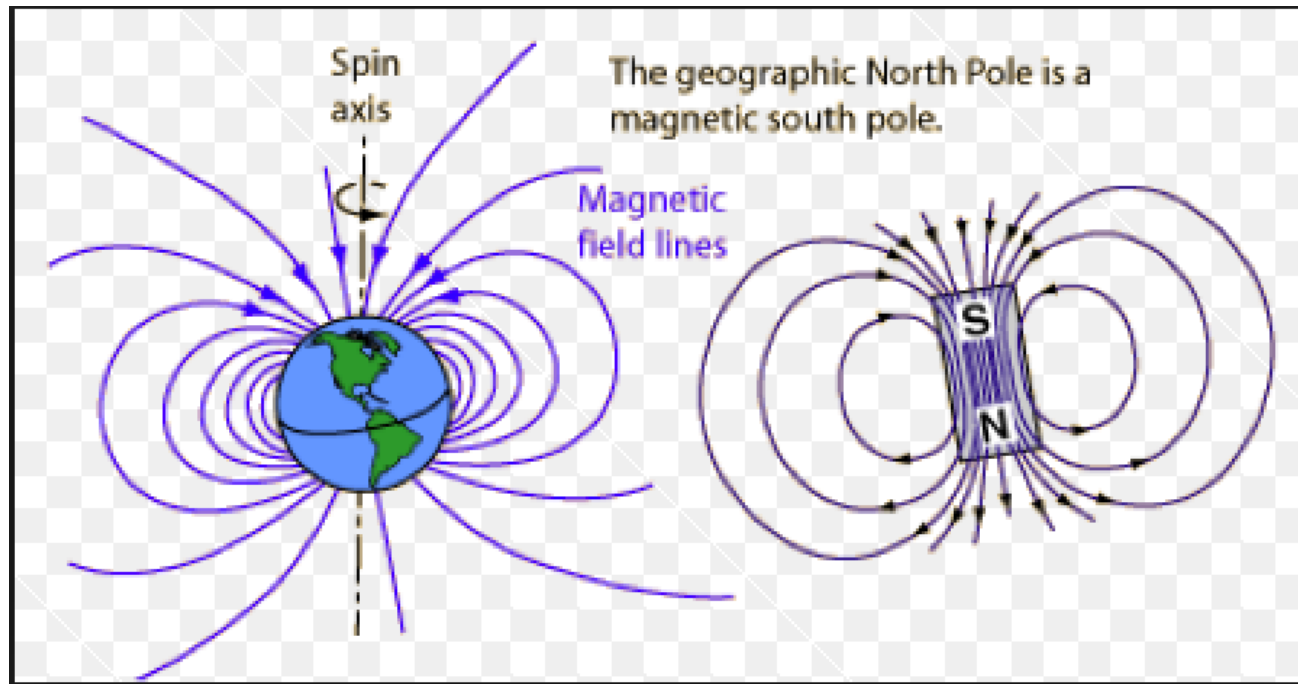
The Earth's magnetic field is similar to that of a bar magnet. The magnitude varies over the surface of the Earth in the range 0.3 to 0.6 Gauss.

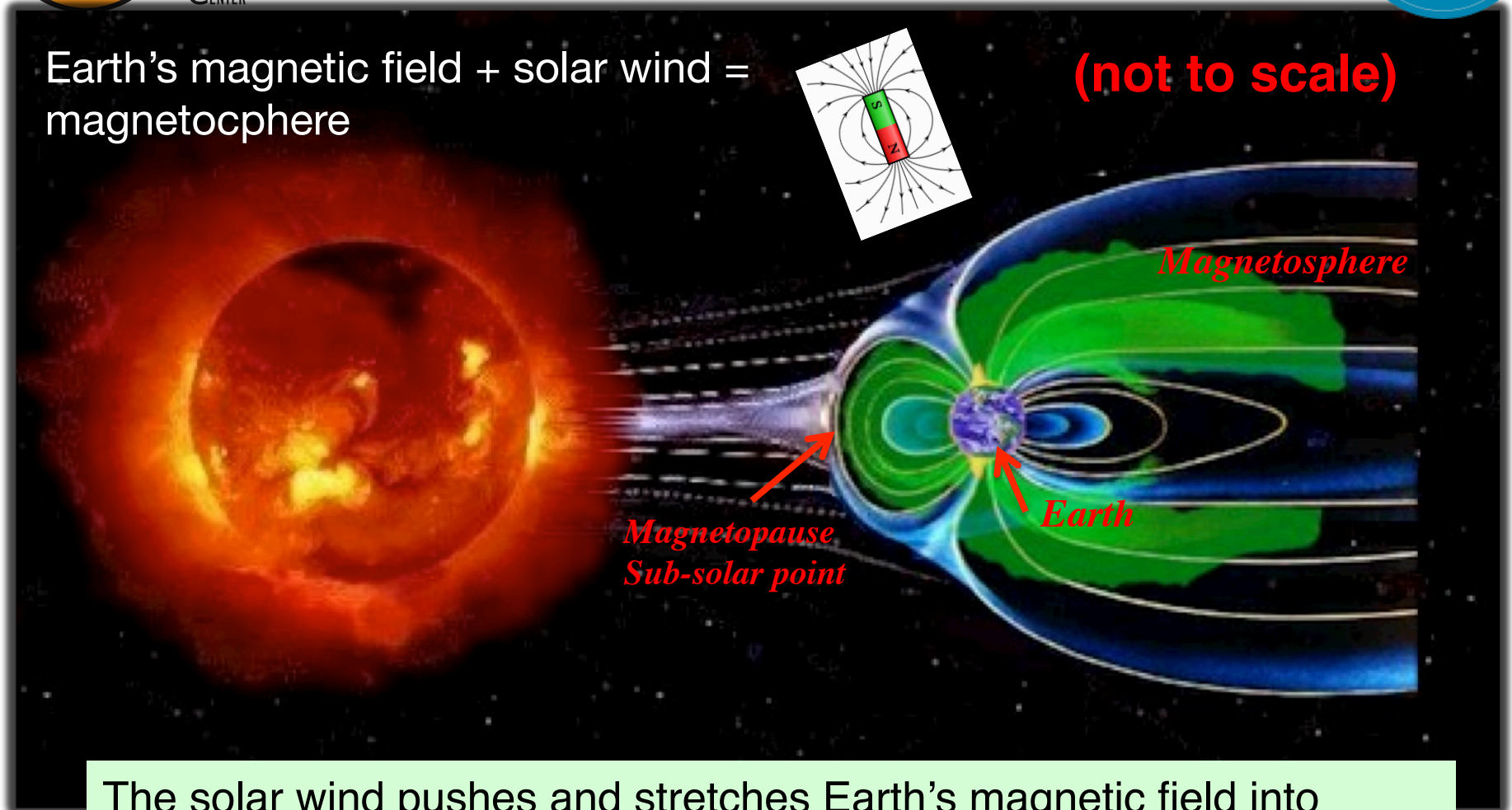# Earth's Magnetic Field – Our Shield

Earth's magnetic field + solar wind = magnetocphere

(not to scale)

Magnetosphere
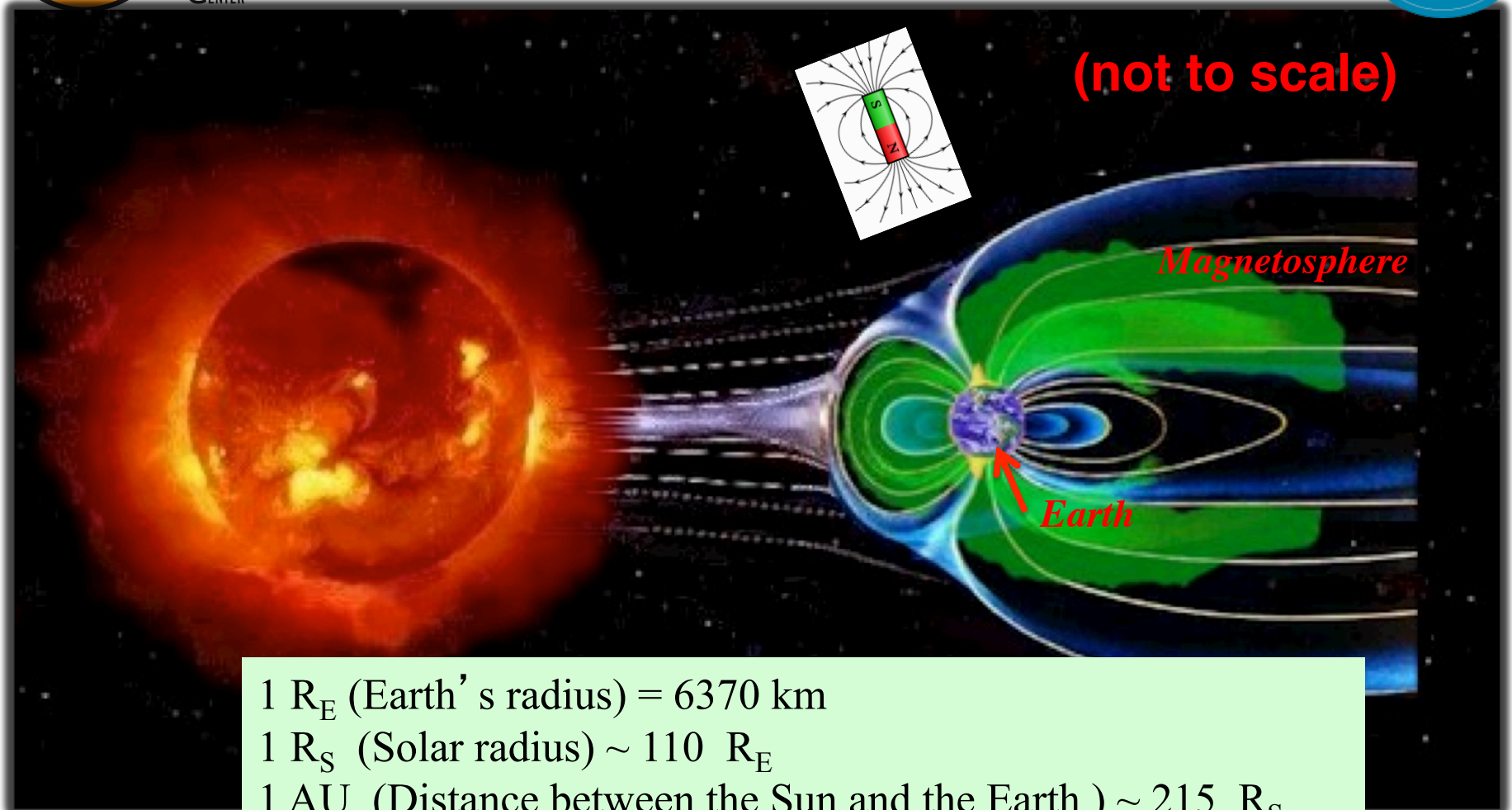
Magnetopause Sub-solar point

Earth

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.
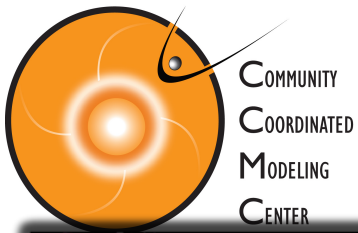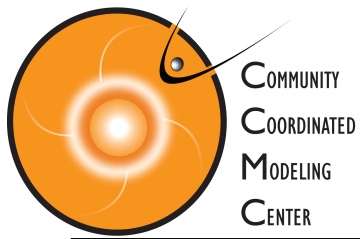
Spatial Scales

(not to scale)

Magnetosphere

Earth

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

Watch the video
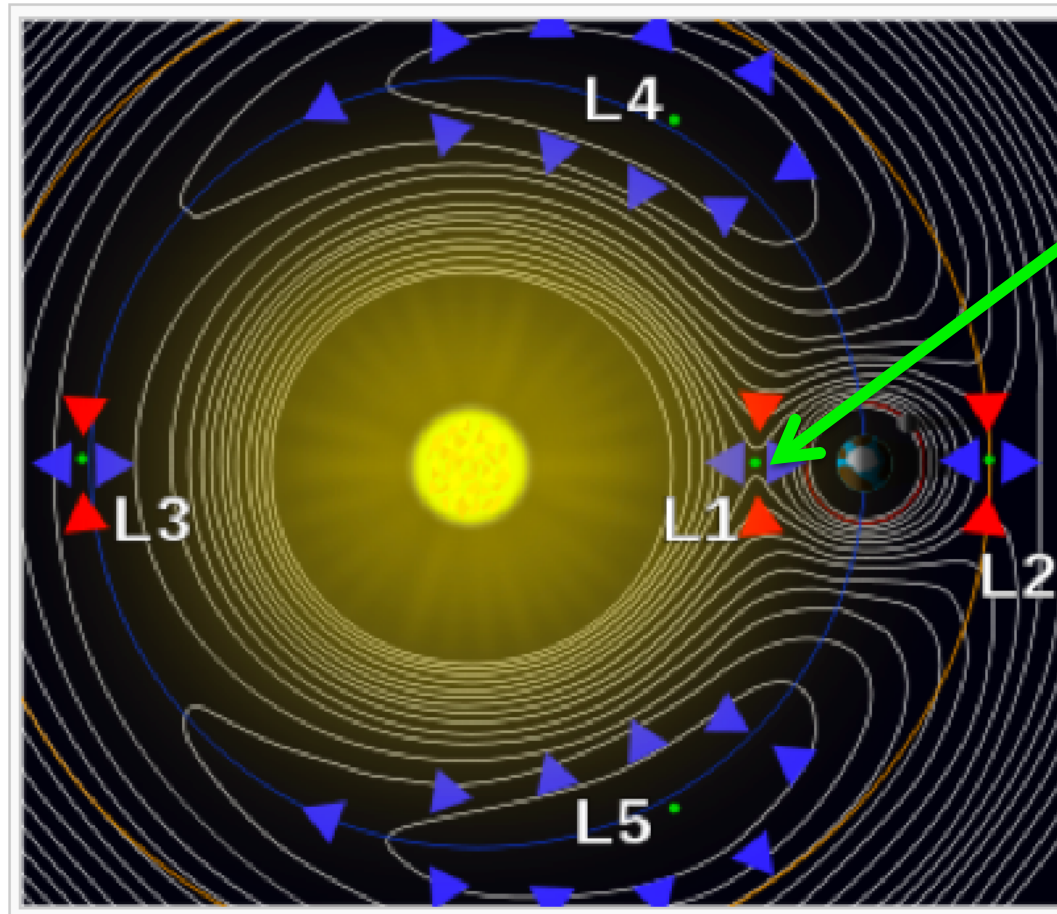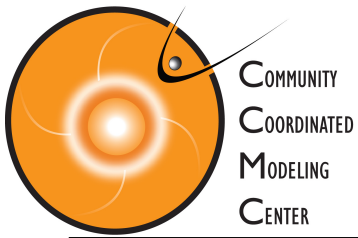
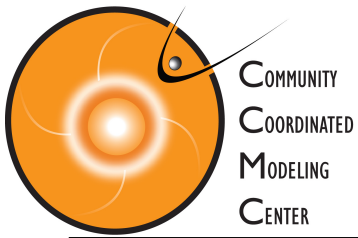Mysteries of the Sun

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

Advanced
Composition
Explorer
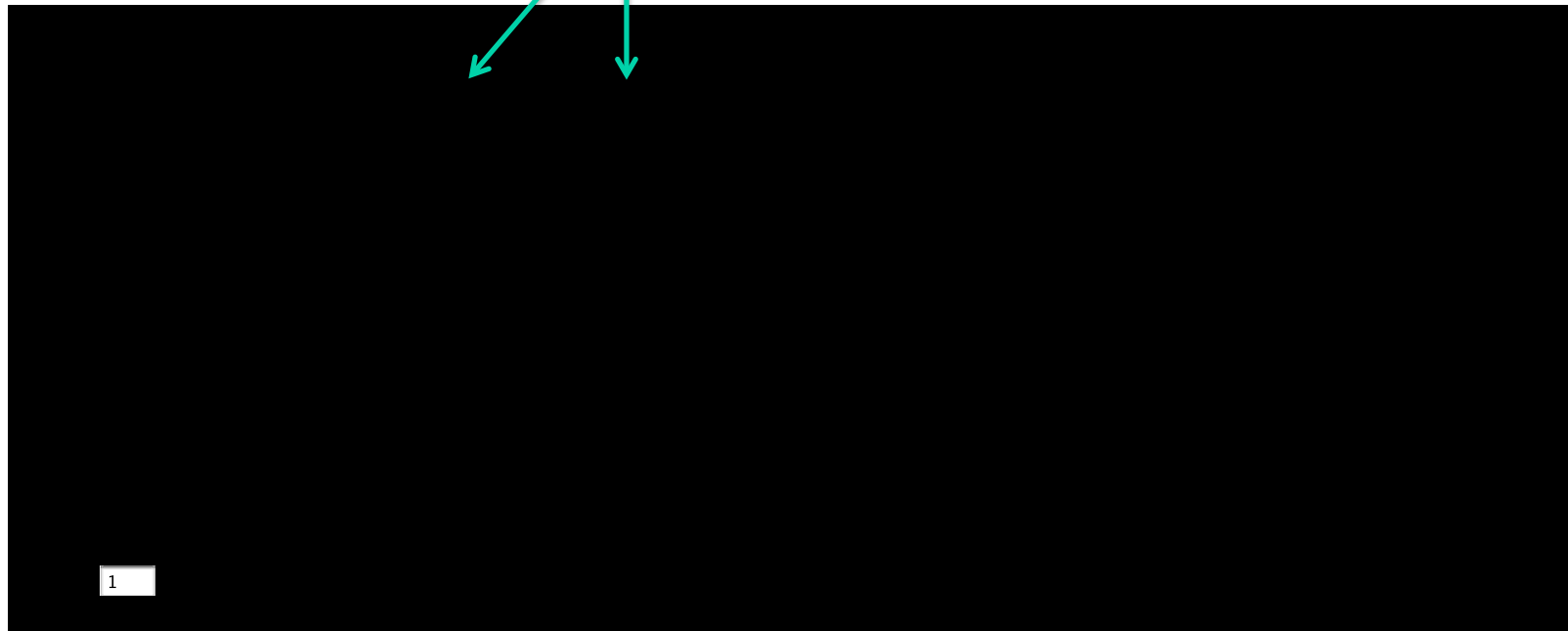
L1 (Solar Wind Monitor ACE location): ~ 200 R_E sunward
You can (almost) fit 1 Sun between the Earth and L1.
2 R_S (Solar diameter) ~ 220 R_E
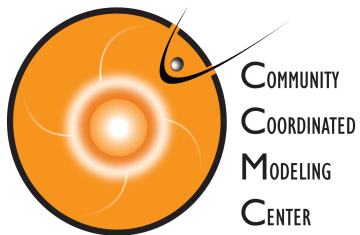
Solar Wind Speed Variations
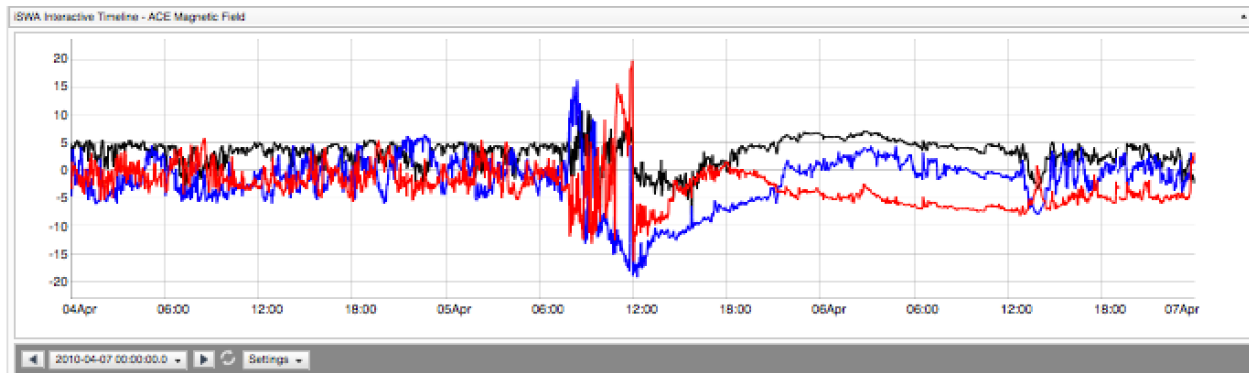# (ACE observations)

High Speed Streams (HSS)

1

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

May 2010 – Feb 2011 (9 months)

Solar Wind Parameters at ACE
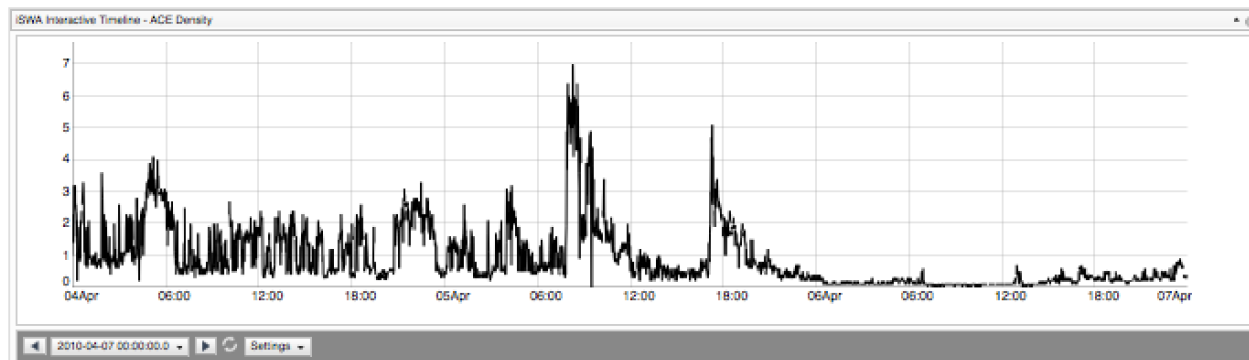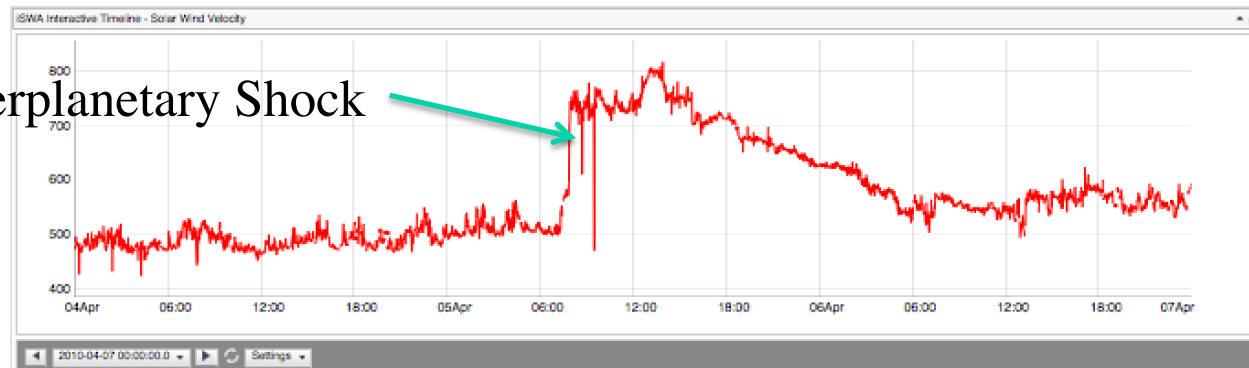## Apr 5 – 7, 2010

[units]

Magnetic field   [nT]
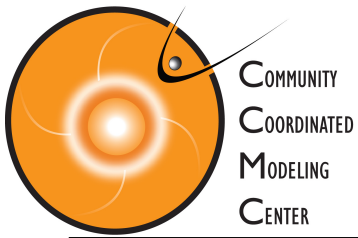
B_x, B_y, B_z

[nT = nanotesla]

1 nT = 10^{-5} Gauss

Interplanetary Shock

Velocity   [km/s]

Density [part/cm^3]
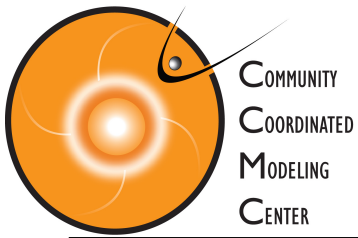
Geocentric Solar Ecliptic (GSE):

X axis: Earth to Sun

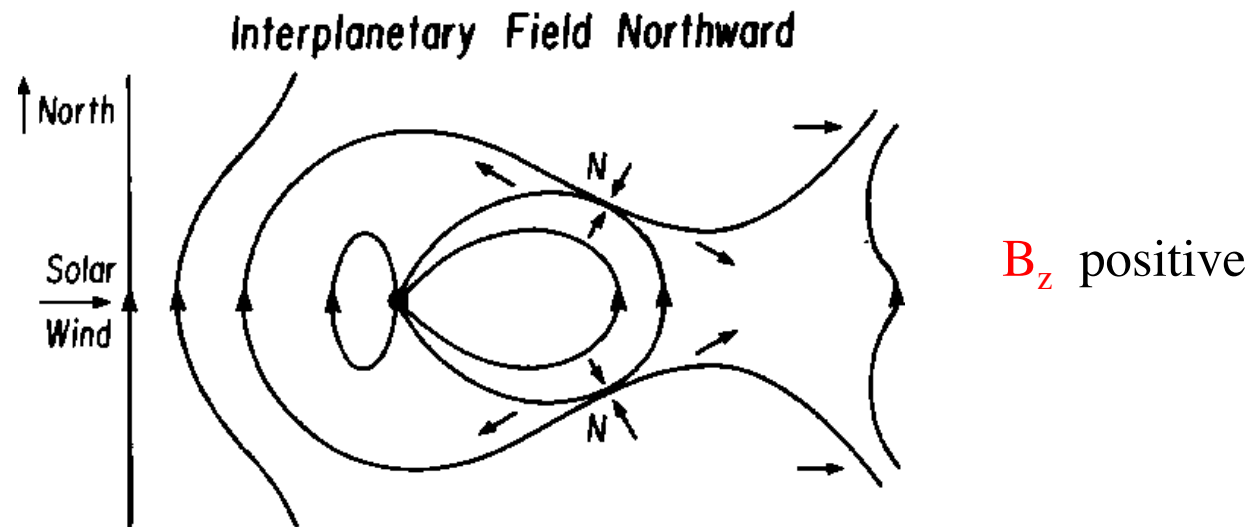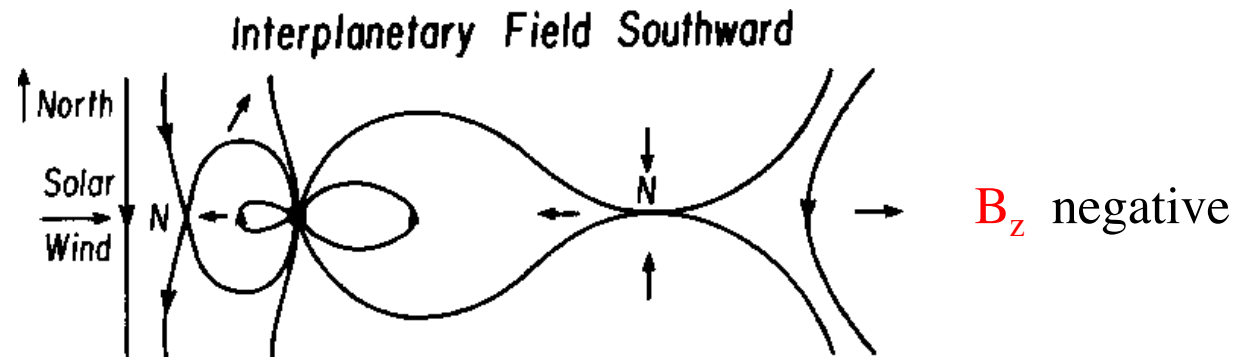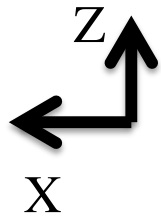Z-axis: Perpendicular to Ecliptic (toward Ecliptic North Pole)
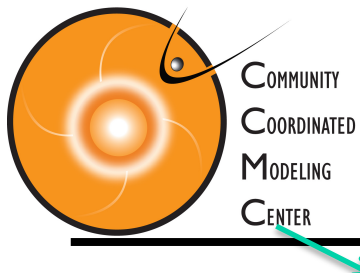
Geocentric Solar Magnetospheric (GSM):

X axis: Earth to Sun

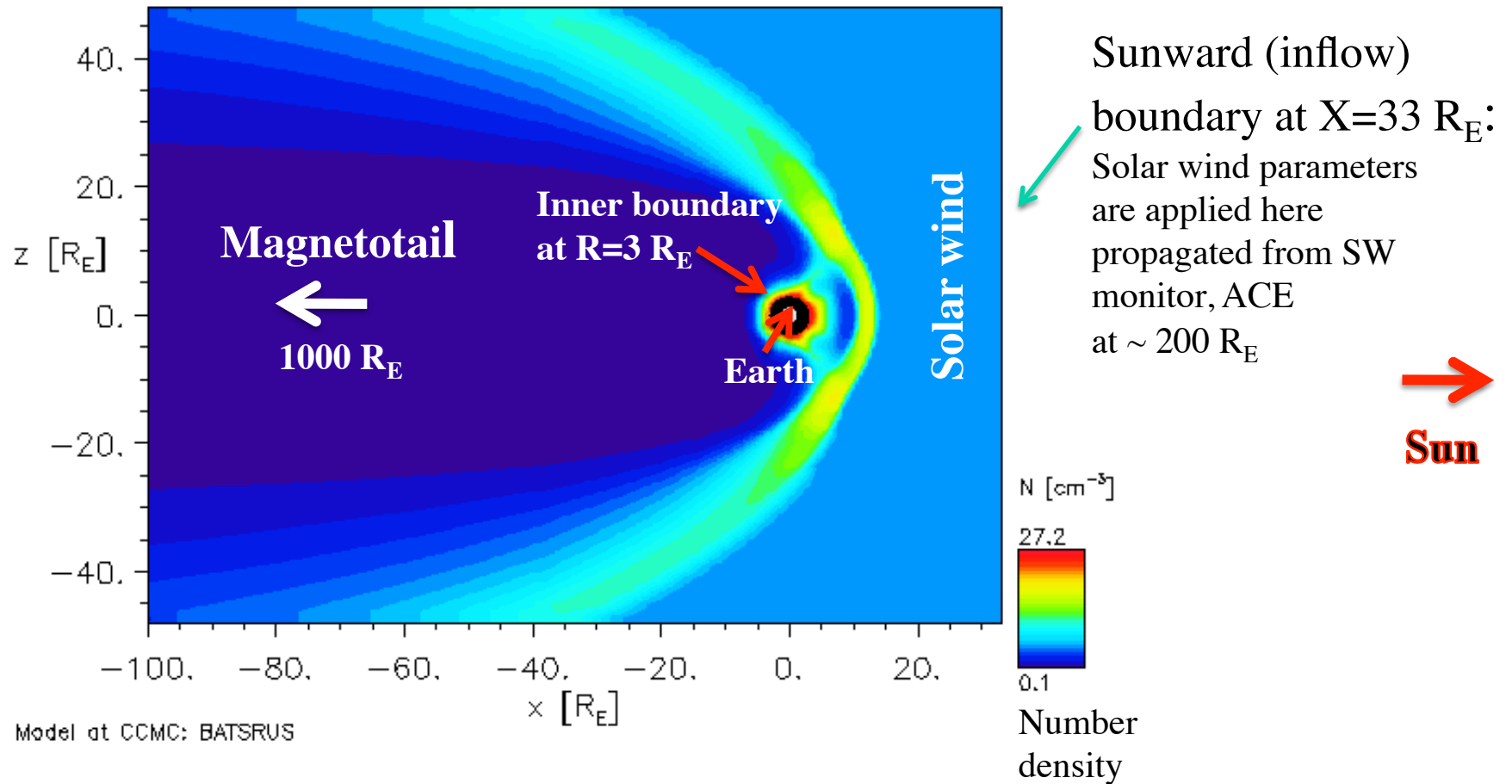Z-axis: Projection Earth's magnetic dipole axis on GSE Y-Z plane

Interplanetary Field Southward
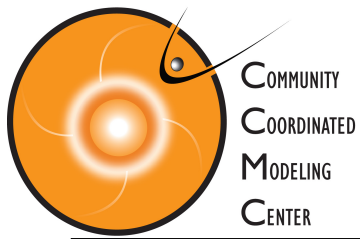
B_z negative

Interplanetary Field Northward

B_z positive

Magnetosphere in Global MHD Simulations:

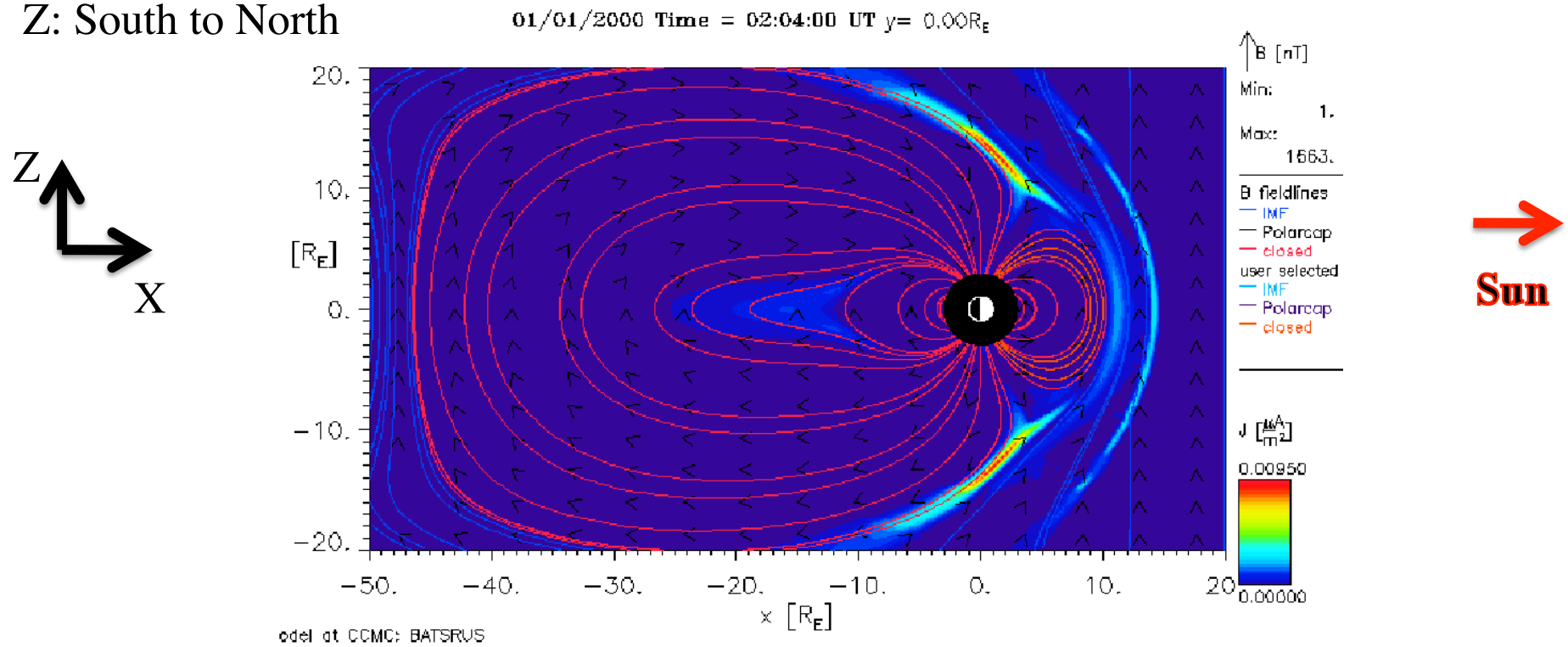**Global MHD Models:** Gombosi et al), OpenGGCM (Raeder), LFM (Lyon et al)

Sunward (inflow) boundary at X=33 R_E:
Solar wind parameters are applied here propagated from SW monitor, ACE at ~ 200 R_E

Magnetotail

Inner boundary at R=3 R_E

1000 R_E

Earth

Solar wind

Sun

N [cm^{-3}]

27.2

0.1

Number density

Model at CCMC: BATSRUS

z [R_E]

x [R_E]

Magnetosphere:
Northward IMF

X: Earth to Sun
Z: South to North

01/01/2000 Time = 02:04:00 UT y= 0.00 R_E
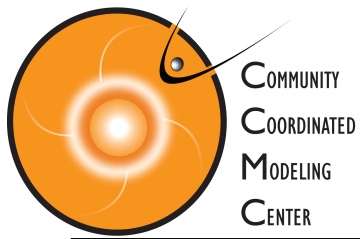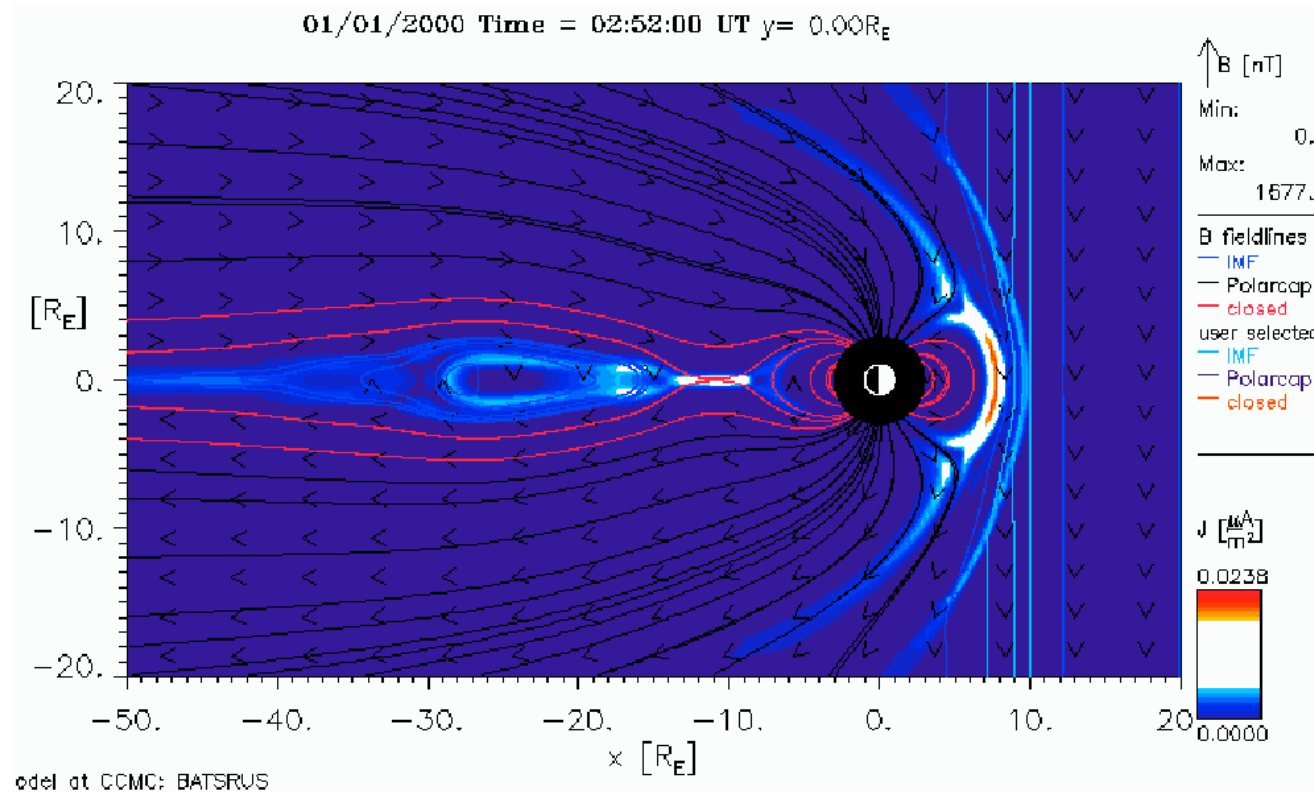
Sun

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
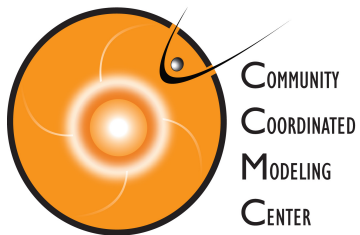
01/01/2000 Time = 02:52:00 UT y= 0.00R_E

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
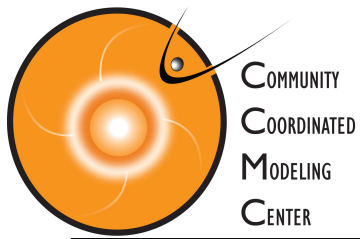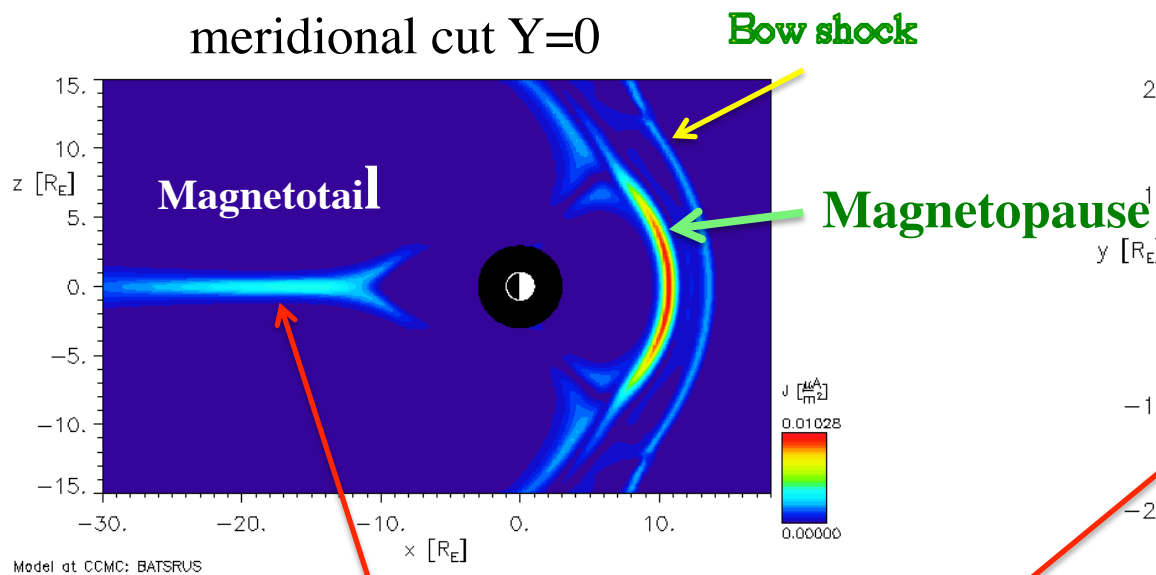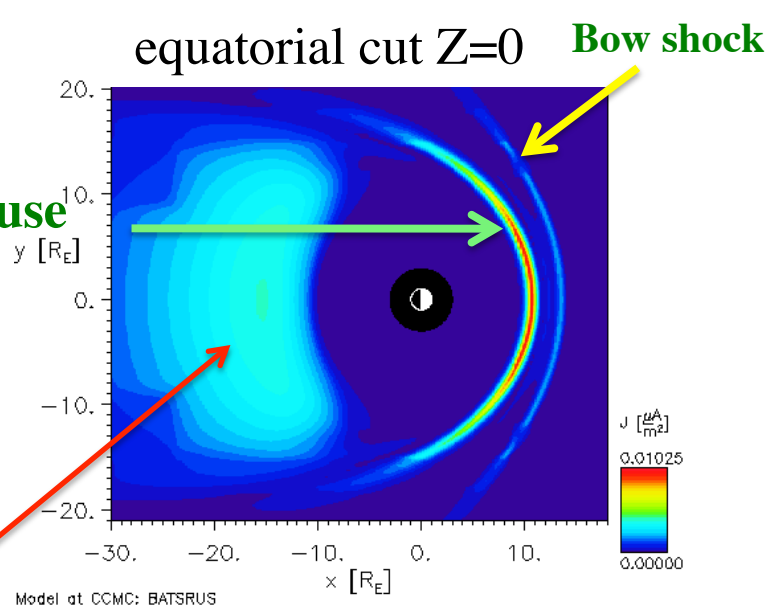
Magnetosphere:
North to South Turning

01/01/2000 Time = 02:00:00 UT y= 0.00R_E

Model at CCMC: BATSRUS
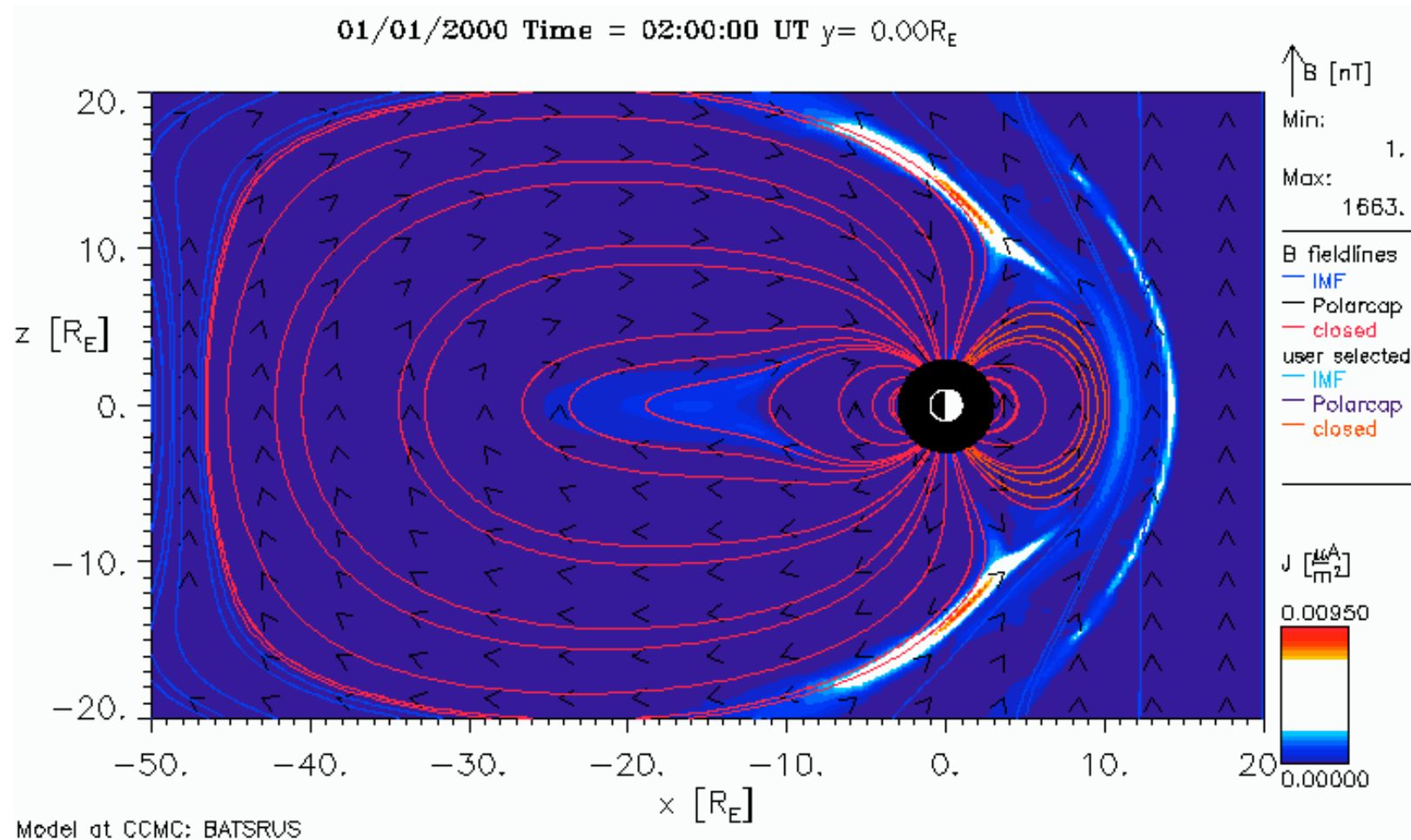
Magnetosphere
in Different Cut Planes

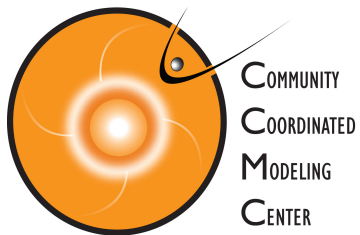meridional cut Y=0

Bow shock

equatorial cut Z=0   Bow shock

Magnetotail

Magnetopause

Magnetotail current sheet

cross-tail cut X= -15 R_E

01/01/2000 Time = 02:00:00 UT x= -15.0 R_E

Model at CCMC: BATSRUS
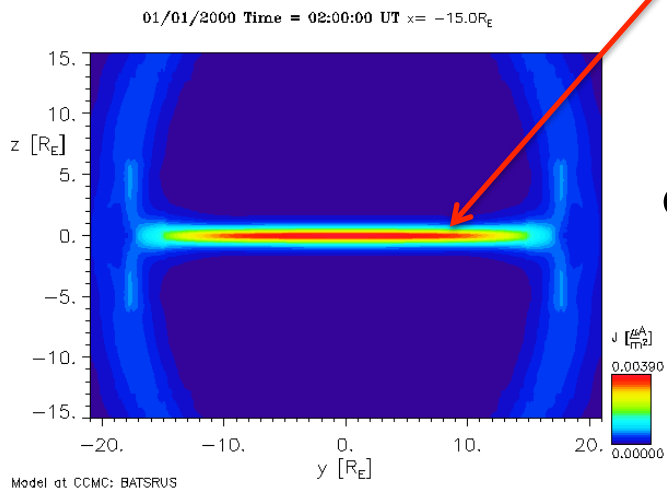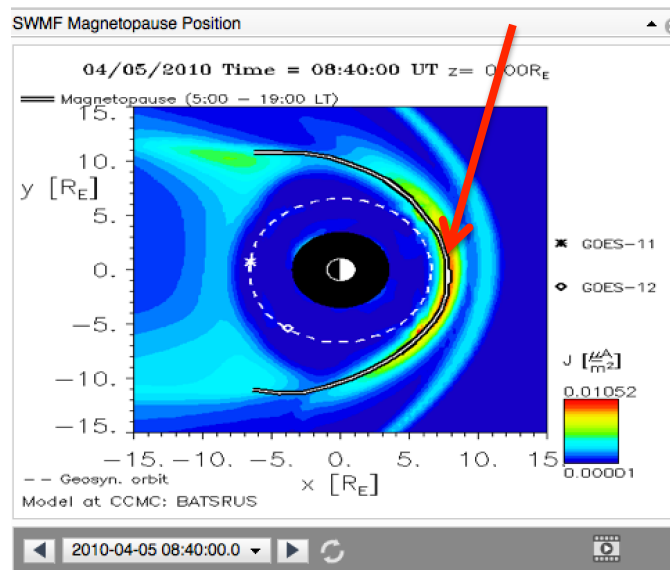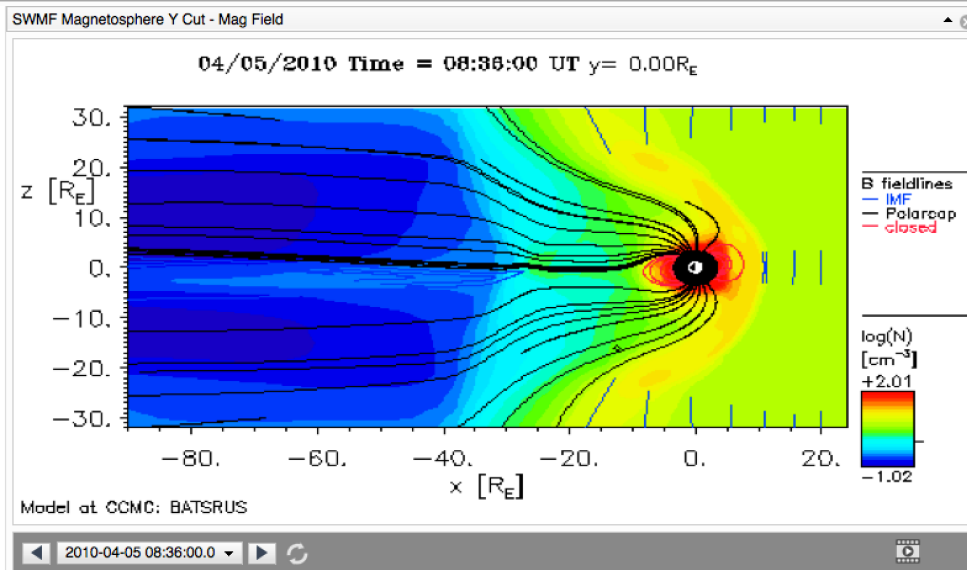
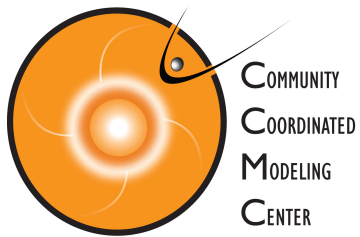# Magnetosphere:
Quiet vs. Compressed

Geosynch. orbit
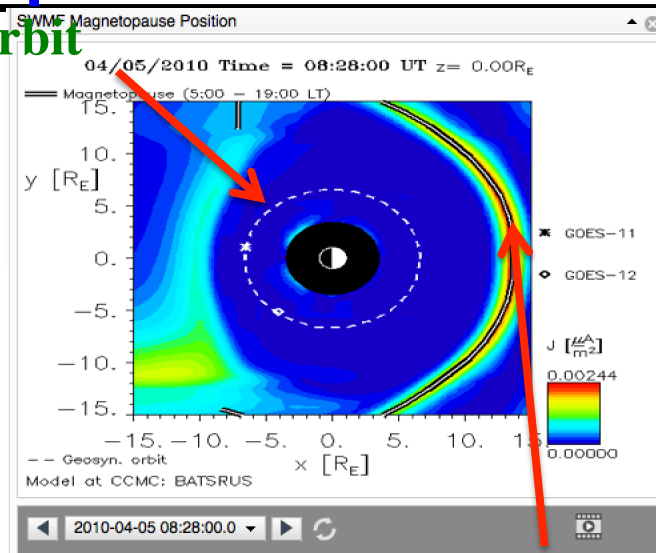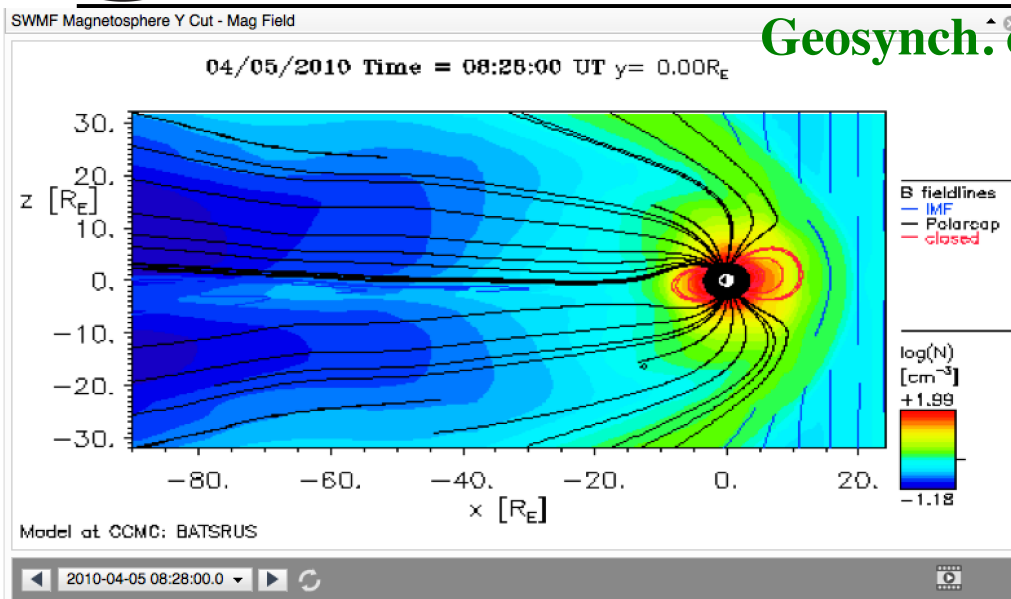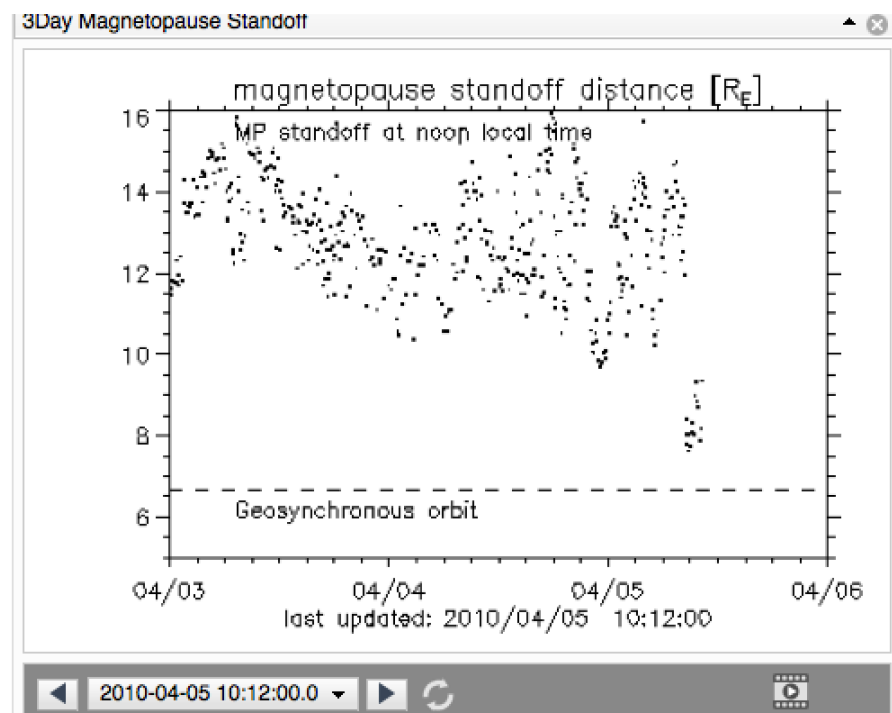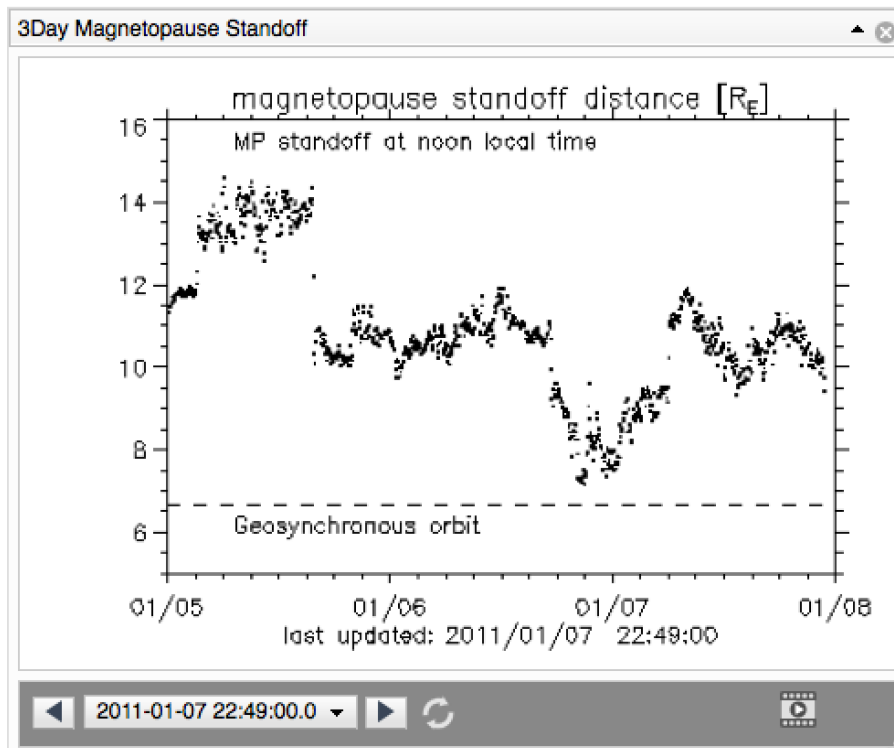

Magnetopause

Magnetopause Stand-off Distance

Degree of compression of
Magnetosphere due to dynamic
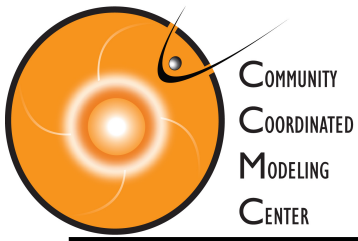pressure of solar wind
(interplanetary shock or HSS)

r0 <=6.6 Re – model product

Events: Apr 5, 2010,

Dec 28, 2010

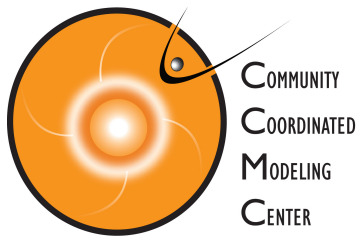Jan 6, 2011, 22:30 UT

Non-event: Dec 1 – 7, 2010

Kp

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

- Geomagnetic activity index

  range from 0-9   disturbance levels of magnetic field on the ground - currents

1. Non-event   - period of 12/01/2010 – 12/7/2010

2. Moderate event – April 5, 2010

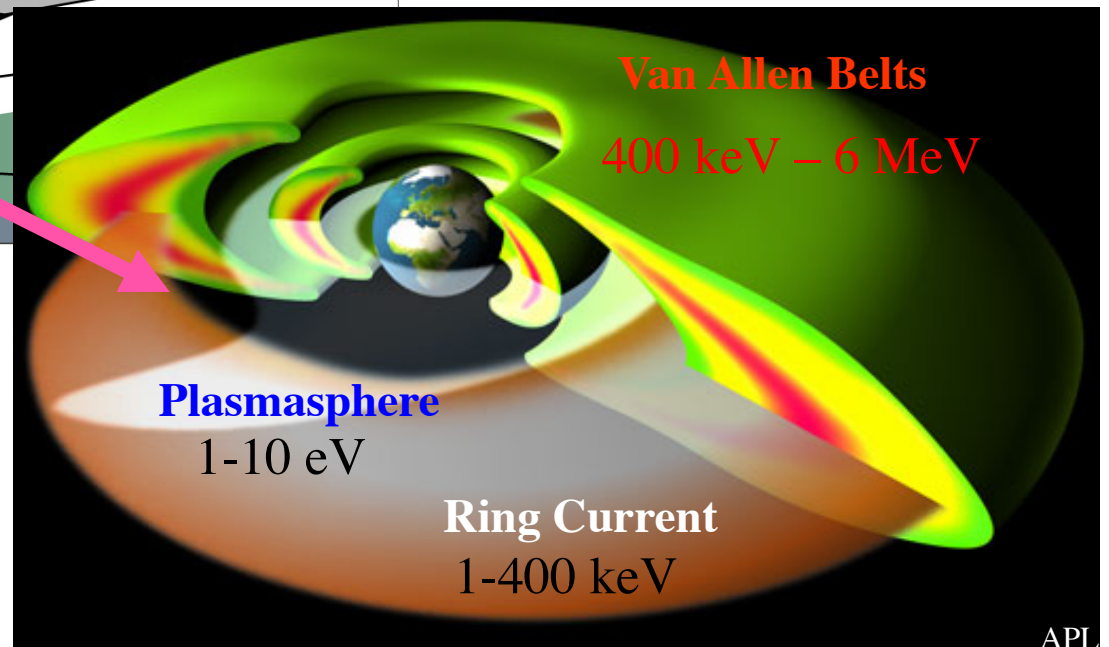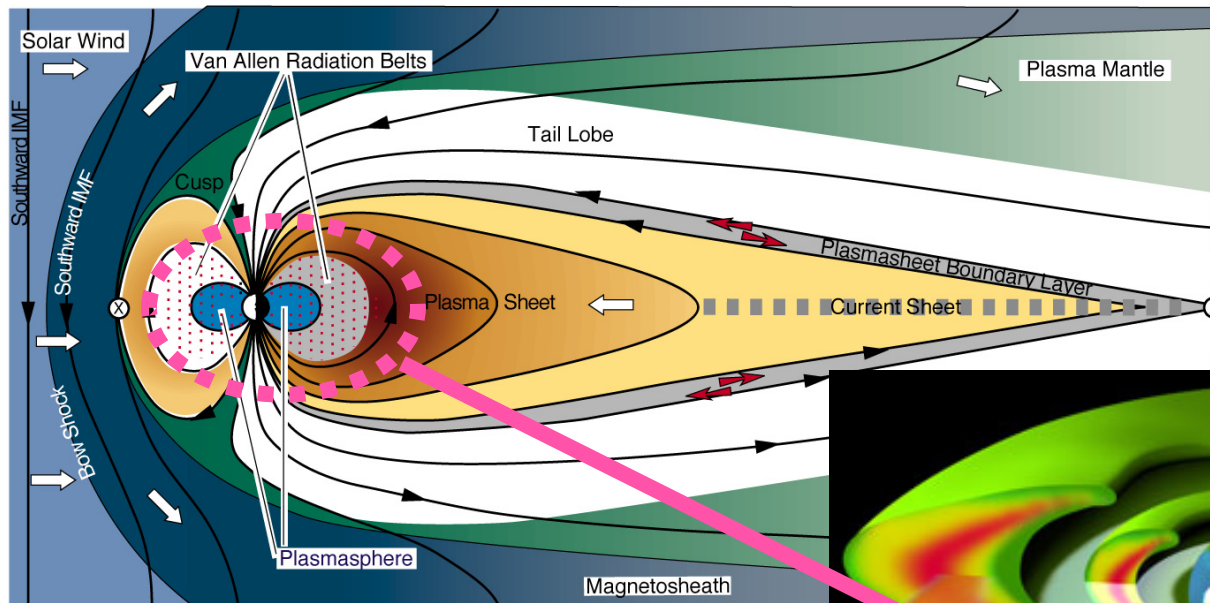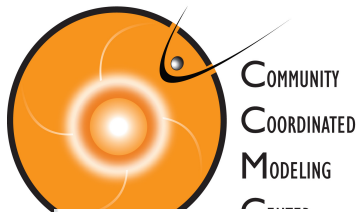3. Extreme event - Oct 29 – Oct 31, 2003

http://bit.ly/Kp_layout

Threshold Kp>=6

Solar Wind

Van Allen Radiation Belts

Plasma Mantle

Southward IMF

Southward IMF

Tail Lobe

Cusp

Plasmasheet Boundary Layer

X

Plasma Sheet

Current Sheet

X

Bow Shock

Plasmasphere

Magnetosheath

Van Allen Belts

400 keV – 6 MeV

Plasmasphere
1-10 eV

Ring Current
1-400 keV

APL
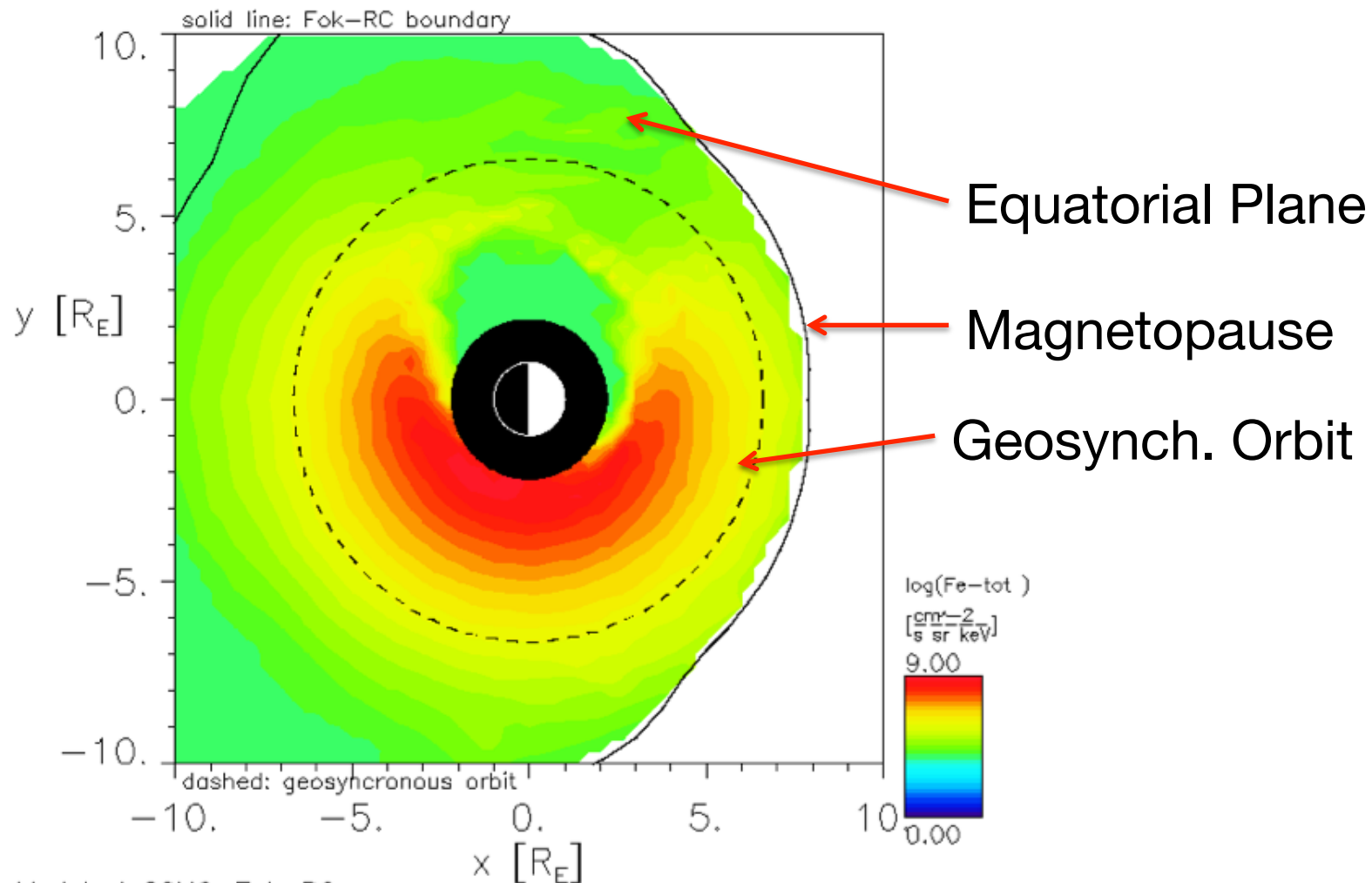
Electron Total Flux.
Energy 63.3 keV. Color Contour

01/01/2000 Time = 04:55:58 UT En.= 63.3keV

solid line: Fok-RC boundary

Equatorial Plane

Magnetopause

Geosynch. Orbit

Sun

log(Fe-tot)
$[\frac{cm^{-2}}{s\ sr\ keV}]$
9.00

0.00

dashed: geosynchronous orbit

Model at CCMC: Fok-RC

y [R_E]

x [R_E]

Earth radius
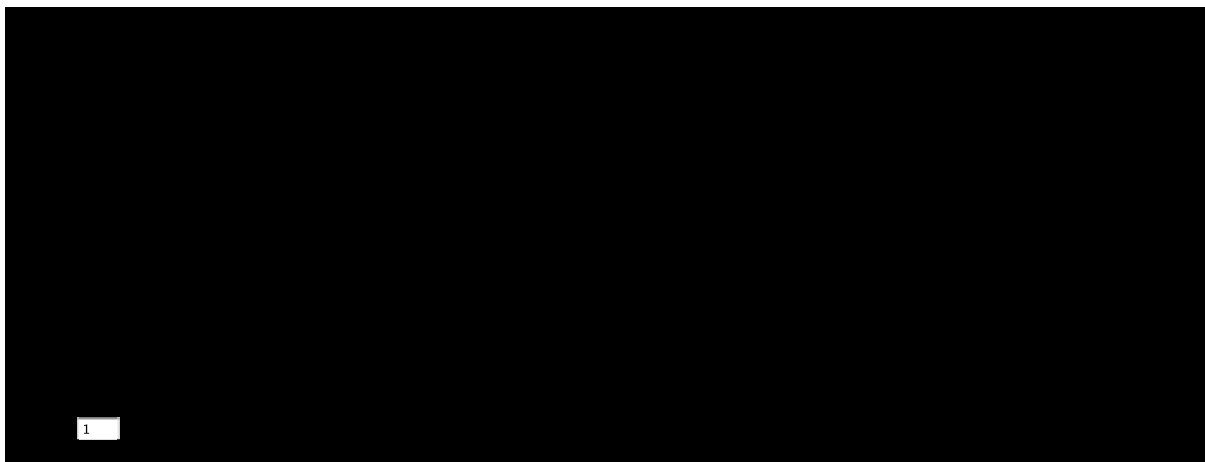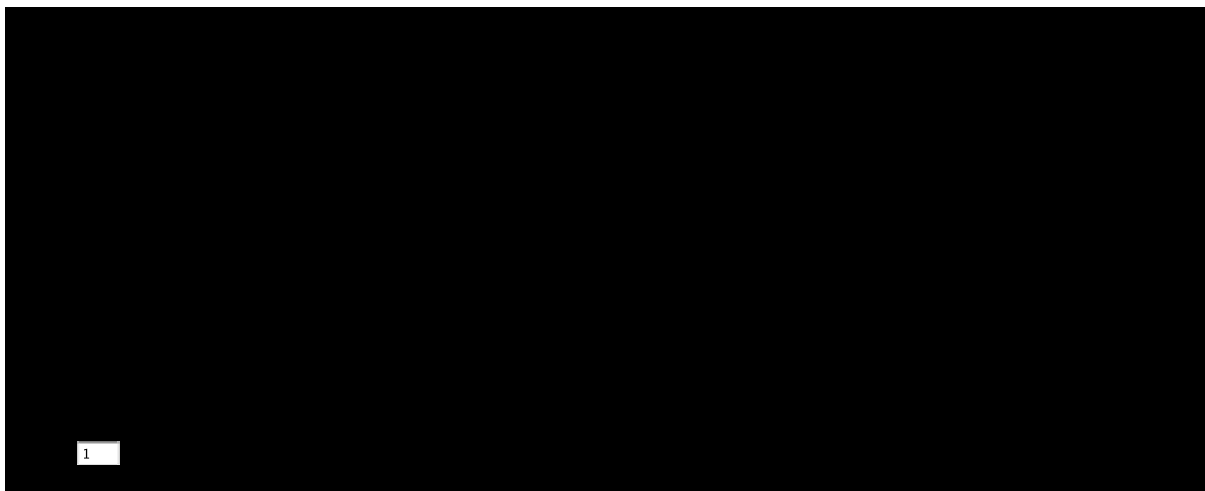
Ring Current:
Quiet vs. Active
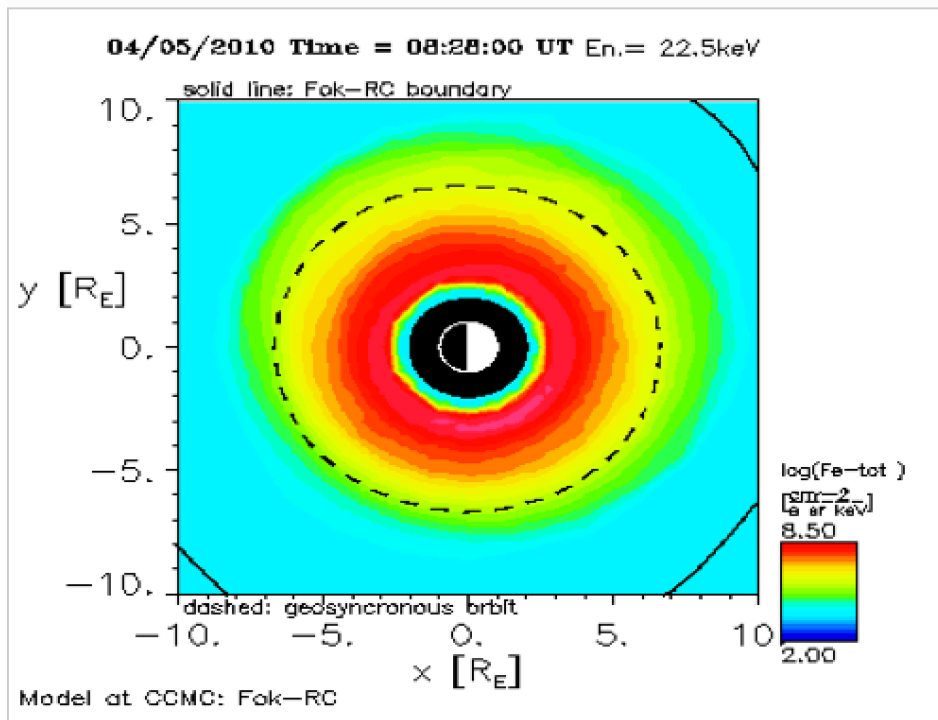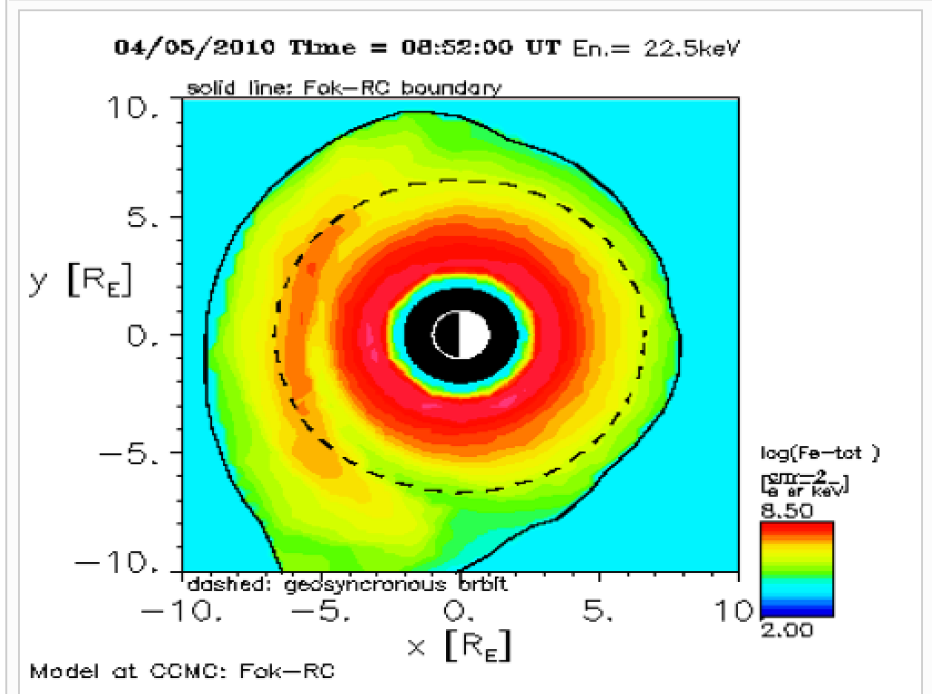
HSS and Radiation Belt Electron Flux Enhancement

Click the check boxes to toggle series visibility


```
1
```

☑ E > 0.8 MeV ☑ E > 2.0 MeV **Zoom:** In Out full **Pan:** left right
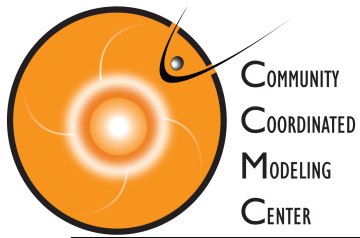


```
1
```

☑ Bulk Speed **Zoom:** In Out full **Pan:** left right
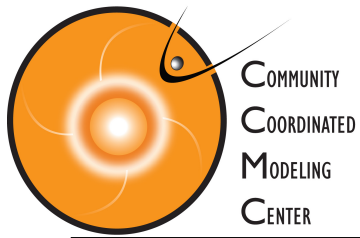
iSWA Layout:
04/05/2010

http://iswa.gsfc.nasa.gov/IswaSystemWebApp/index.jsp?
i_1=327&l_1=9&t_1=2130&w_1=1372&h_1=403&s_1=2010-04-07%2000:00:00.0!3!
&i_2=335&l_2=32&t_2=300&w_2=800&h_2=400&s_2=2010-04-06%2022:30:00.0!3!
&i_3=41&l_3=878&t_3=734&w_3=495&h_3=416&s_3=2010-04-05%2010:00:00.0_0_
10_3&i_4=51&l_4=858&t_4=1209&w_4=509&h_4=477&s_4=2010-04-05%2010:00:00
.0_1_80_3&i_5=337&l_5=836&t_5=300&w_5=800&h_5=400&s_5=2010-04-07%2000:
00:00.0!3!
&i_6=323&l_6=8&t_6=2552&w_6=1370&h_6=390&s_6=2010-04-07%2000:00:00.0!3!
&i_7=325&l_7=6&t_7=1700&w_7=1380&h_7=408&s_7=2010-04-07%2000:00:00.0!3!
&i_8=125&l_8=390&t_8=2965&w_8=646&h_8=418&s_8=2010-04-06%2023:56:00.0_
0_10_3&i_9=39&l_9=175&t_9=1226&w_9=493&h_9=409&s_9=2010-04-05%2010:00:
00.0_0_10_3&i_10=43&l_10=33&t_10=722&w_10=792&h_10=468&s_10=2010-04-05
%2010:00:00.0_0_10_3

http://1.usa.gov/14w5DoF