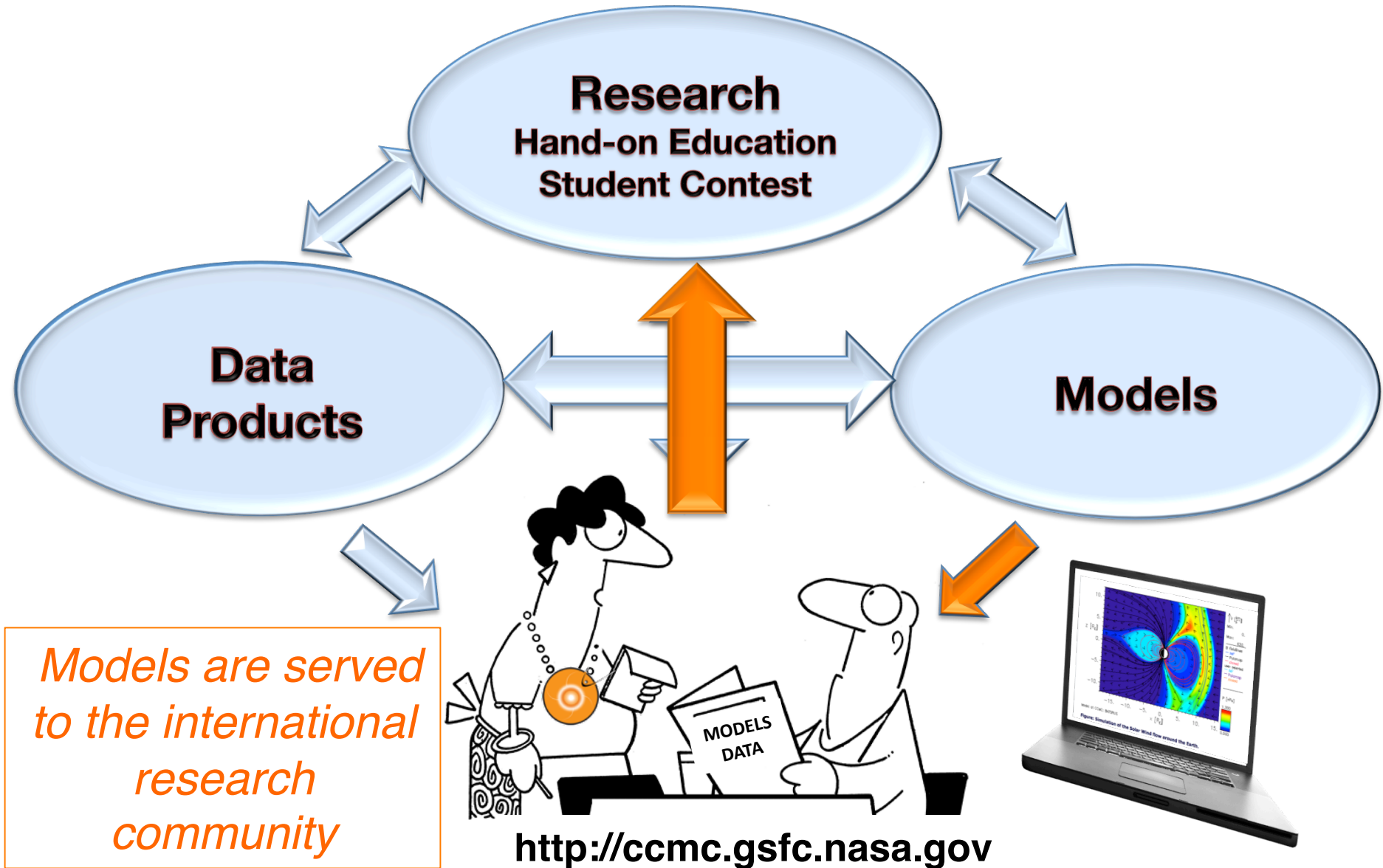


**Tour of CCMC Models.
Runs-on-Request:
Global Magnetosphere Models**

Masha Kuznetsova & CCMC Team



Dissemination of Space Weather Resources: CCMC Runs-on-Request (RoR) System



Models are served to the international research community

<http://ccmc.gsfc.nasa.gov>

Expanding Collection of Models at CCMC: > 80



Corona Heliosphere Magnetosphere Inner Magnetosphere Ionosphere/Thermosphere

Space Weather Without Borders

Environment Spatial Scales

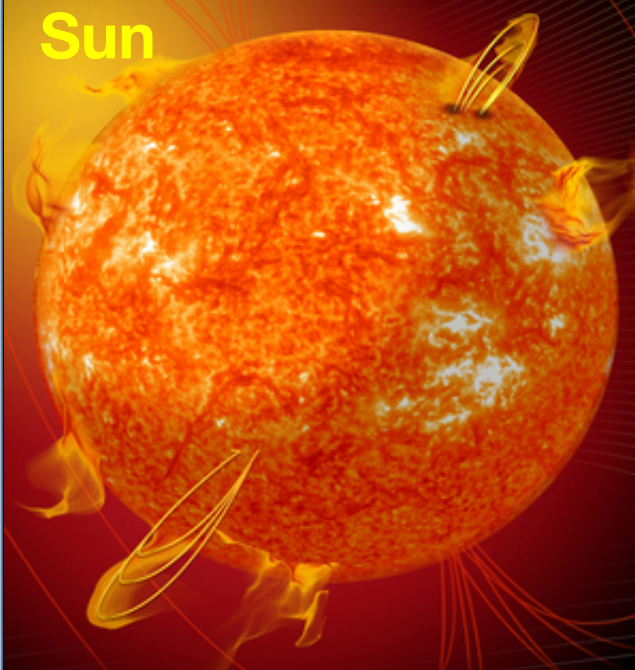
Heliosphere ~ 100 au

From Sun to Saturn: ~ 10 au

From Sun to Earth: 1 au ~ 150,000,000 km

1 a.u ~ 200 Solar radii (R_s)

Sun



1 Solar radius

~ 110 Earth radii (R_e)

1 Earth's radius (R_e)

= 6370 km

Geosynchronous orbit 6.6 R_e

Kinetic scales: ~100 m – 0.1 R_e

Plasma structures

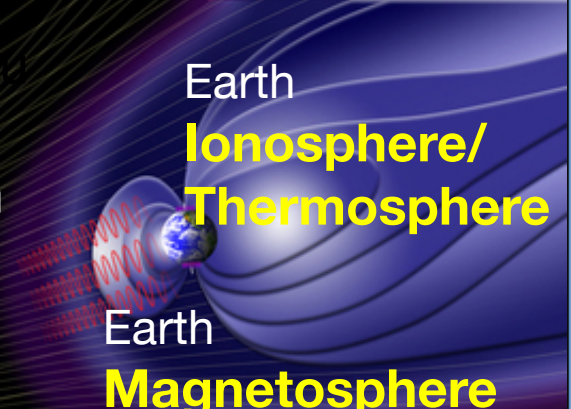
in ionosphere: ~ 1 m – 100 m

Earth

**Ionosphere/
Thermosphere**

Earth

Magnetosphere



Diversity of spatial scales : $> 10^{10}$
There is a strong coupling between the scales

Type of Models

Empirical Models

Physics-based (first principle models with different approximations). Examples:

- Magnetohydrodynamics (MHD) – single species fluid
- Multi-fluid, Hall MHD
- Kinetic (particles)

Data assimilative

Modeling Sub-Domains

Solar Corona [Rs]: 1-2.5 Rs, 1-20 Rs

Heliosphere [au]: 1-2 au, 1-10 au +

Global Magnetosphere [Re]:

2 -3 Re – inner boundary

20 – 40 Re – inflow boundary

(- 1000) – (-300 Re) – tailward boundary

Ionosphere Electrodynamics: on the sphere (120 km)

Inner Magnetosphere [Re]: 1-8 Re

- ring current (1- 8 Re)

- radiation belts

Ionosphere [km]: 80 – 1000 km

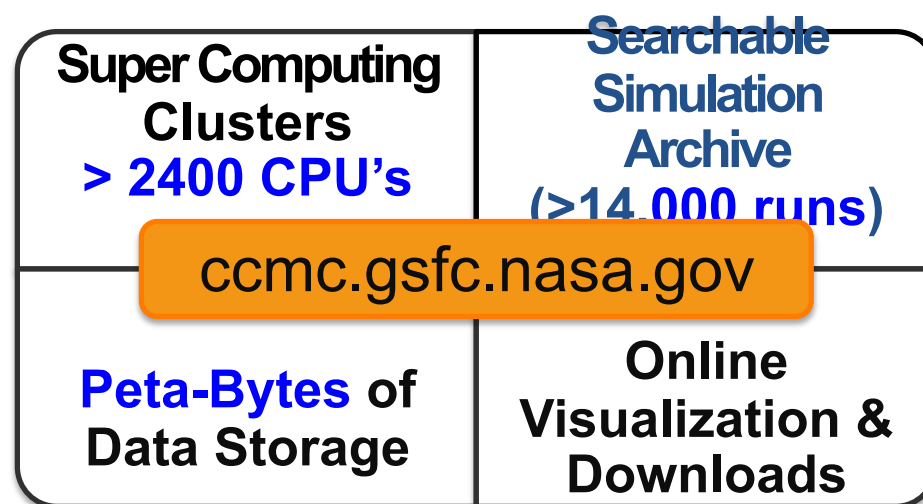
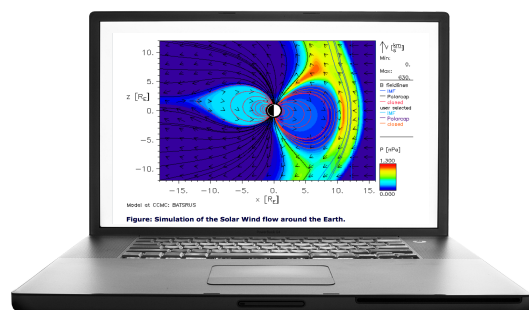
Multi-scale models, coupled model chains and adaptive simulation grids are required to model impacts from the Sun

Example: Space Weather Modeling Framework (SWMF),
Gombosi et al, U. Mich.



Runs-on-Request

Models are served to the international research community through **web-based interactive Runs-on-Request service**

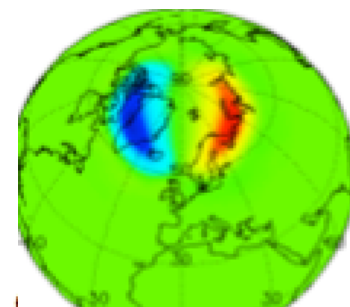
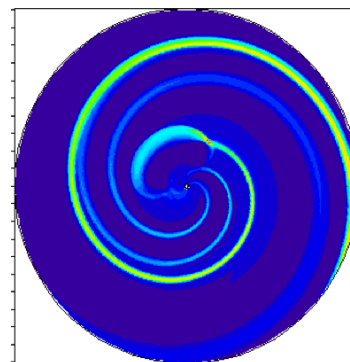


- ✓ User-configurable input parameters and model settings.
- ✓ Users advising and custom simulations.
- ✓ **Create synergy between analysis of observational data and scientific modeling.**
- ✓ **Maximize return on investments into model development.**



Interactive On-line Visualization & Analysis

- ✓ Basic model output and derived quantities.
- ✓ User-ordered custom variables (*email the formula to Lutz and it will be tested & added*).
- ✓ Automated movie & time series generation.
- ✓ Time series plotter & analyzer.
- ✓ 2D slices, Line plots, 3D flow lines, ASCII lists
- ✓ Magnetic mapping.
- ✓ Interfaces with Virtual Observatories.
- ✓ Change-Log on CCMC web page.



Choose Quantities:

Choose Plot Mode:

ColorContour (2D)

3D-Surface

Line (1D)

Contour (2D)

Vector (2D)

ColorContour (2D)

Color+Vector

Contour+Vector

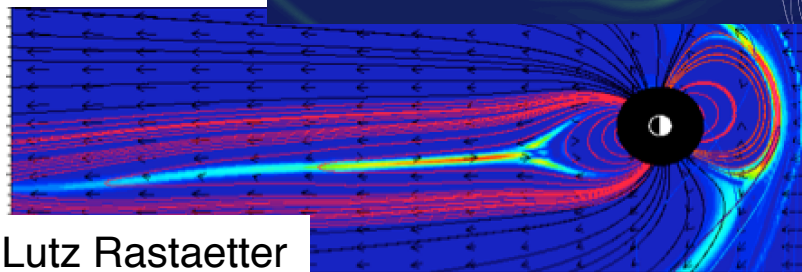
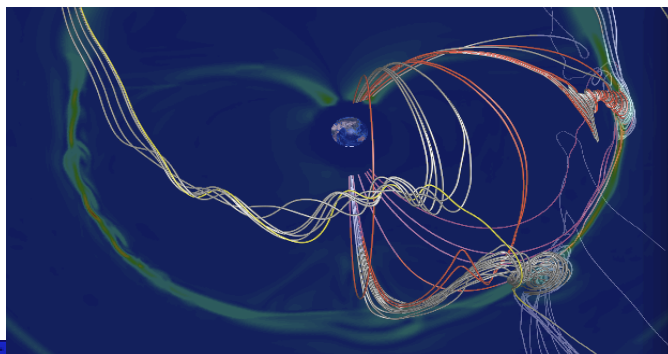
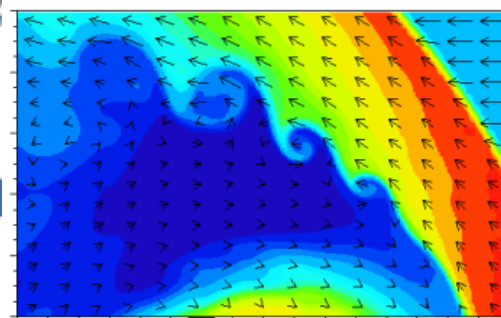
Color+Contour

Color+Vector+Contour

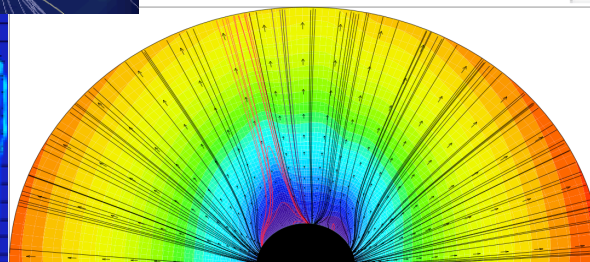
Color+Vector+Flowlines

3D Flowlines

Q 1: J



Lutz Rastaetter

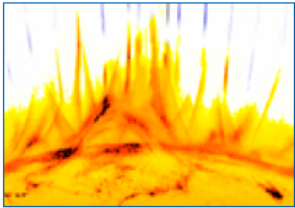


Vertical) Li

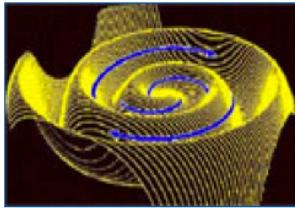
ble

32

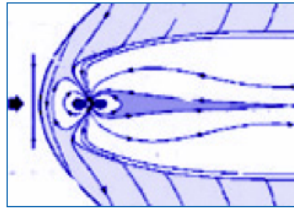
B1_y
B1_z
En.
J_x
J_y
J_z
B
beta
V
J
B1



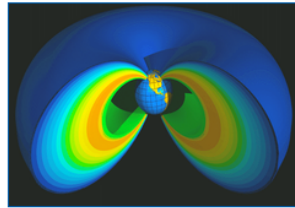
Solar Models Results



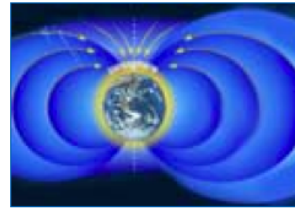
Heliosphere Models Results



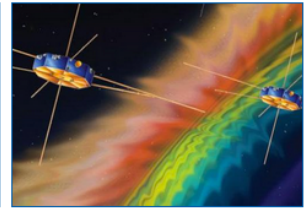
Global Magnetosphere Models Results



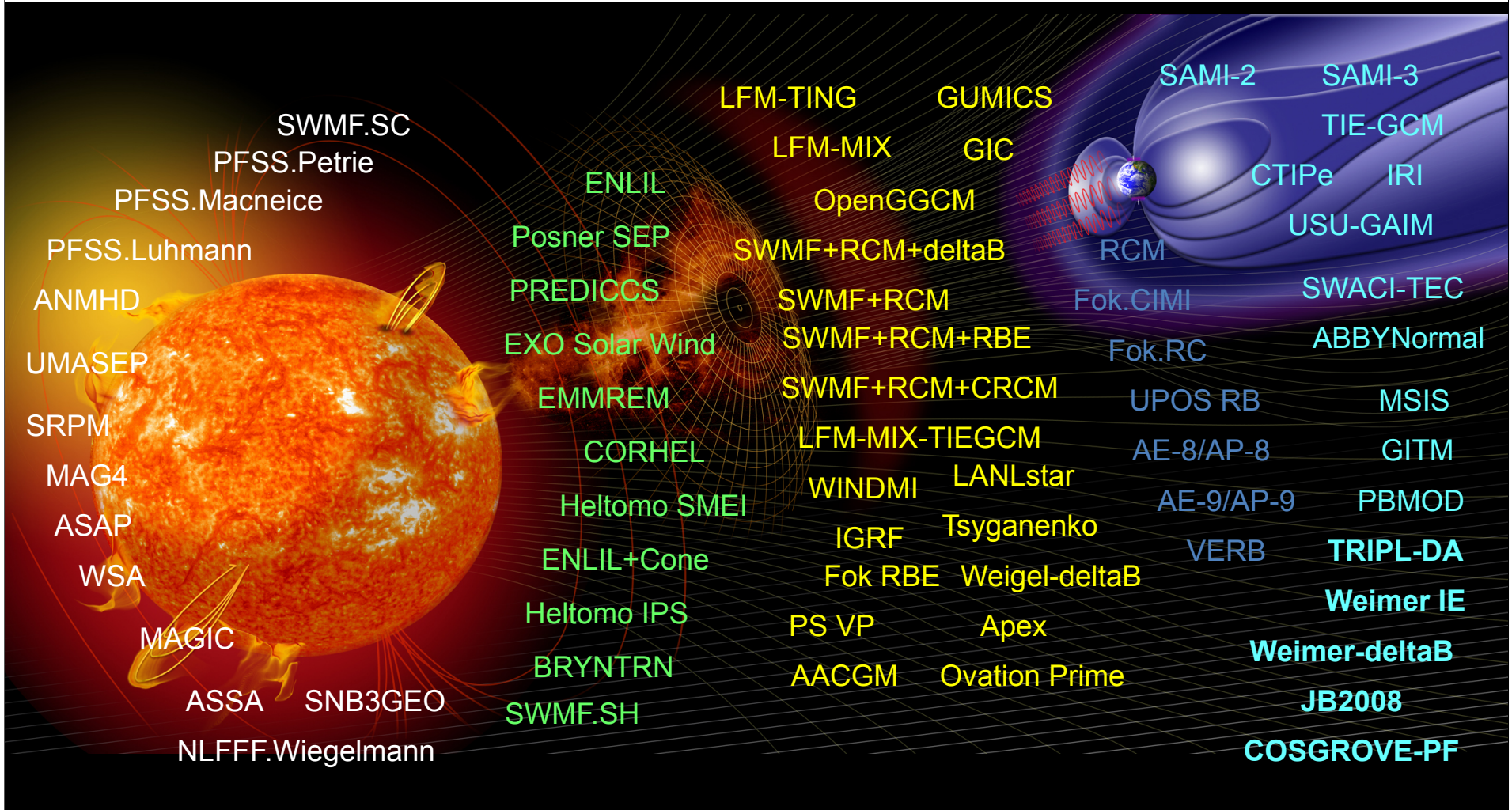
Inner Magnetosphere Models Results



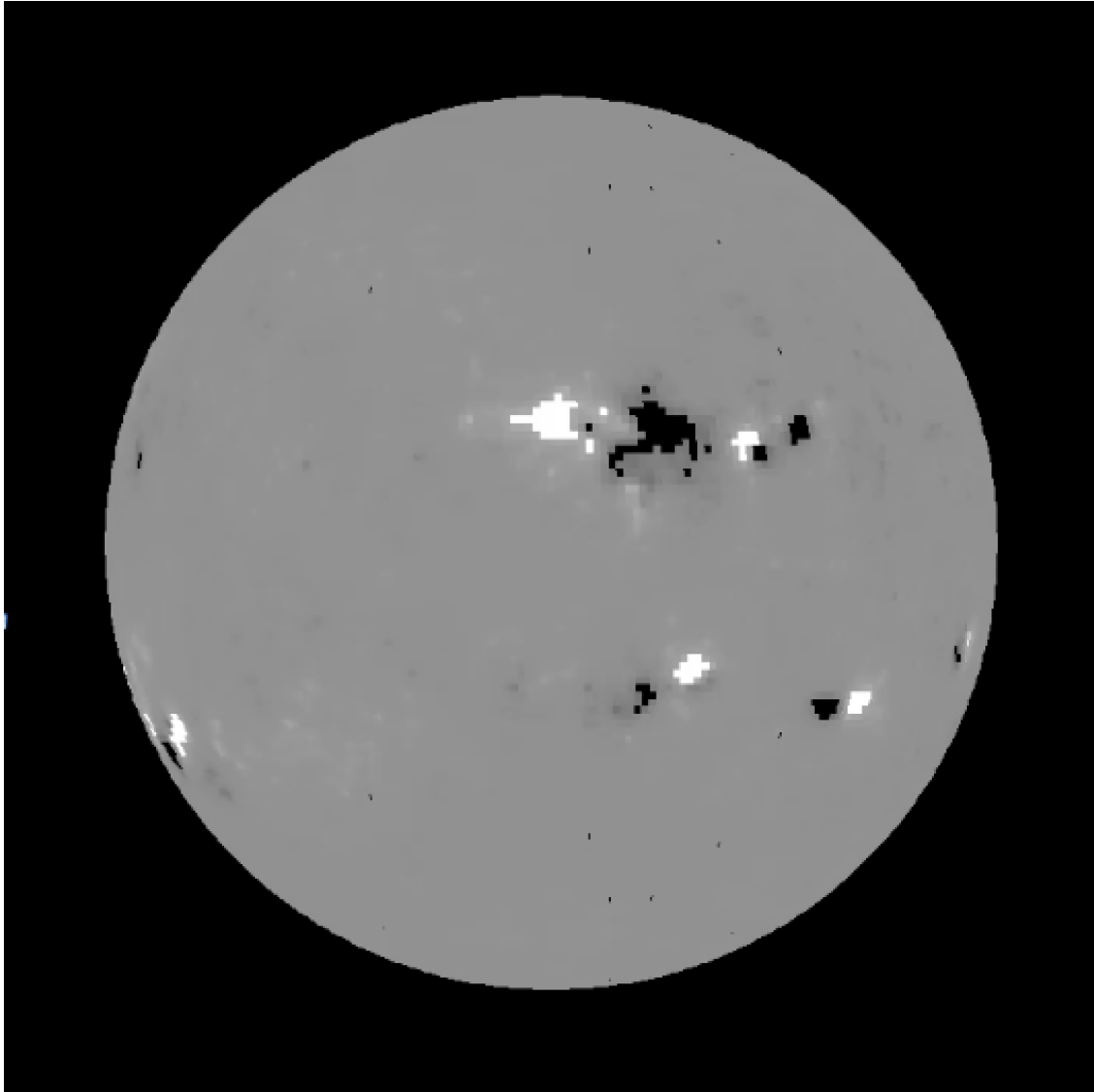
Ionosphere / Thermosphere Models Results



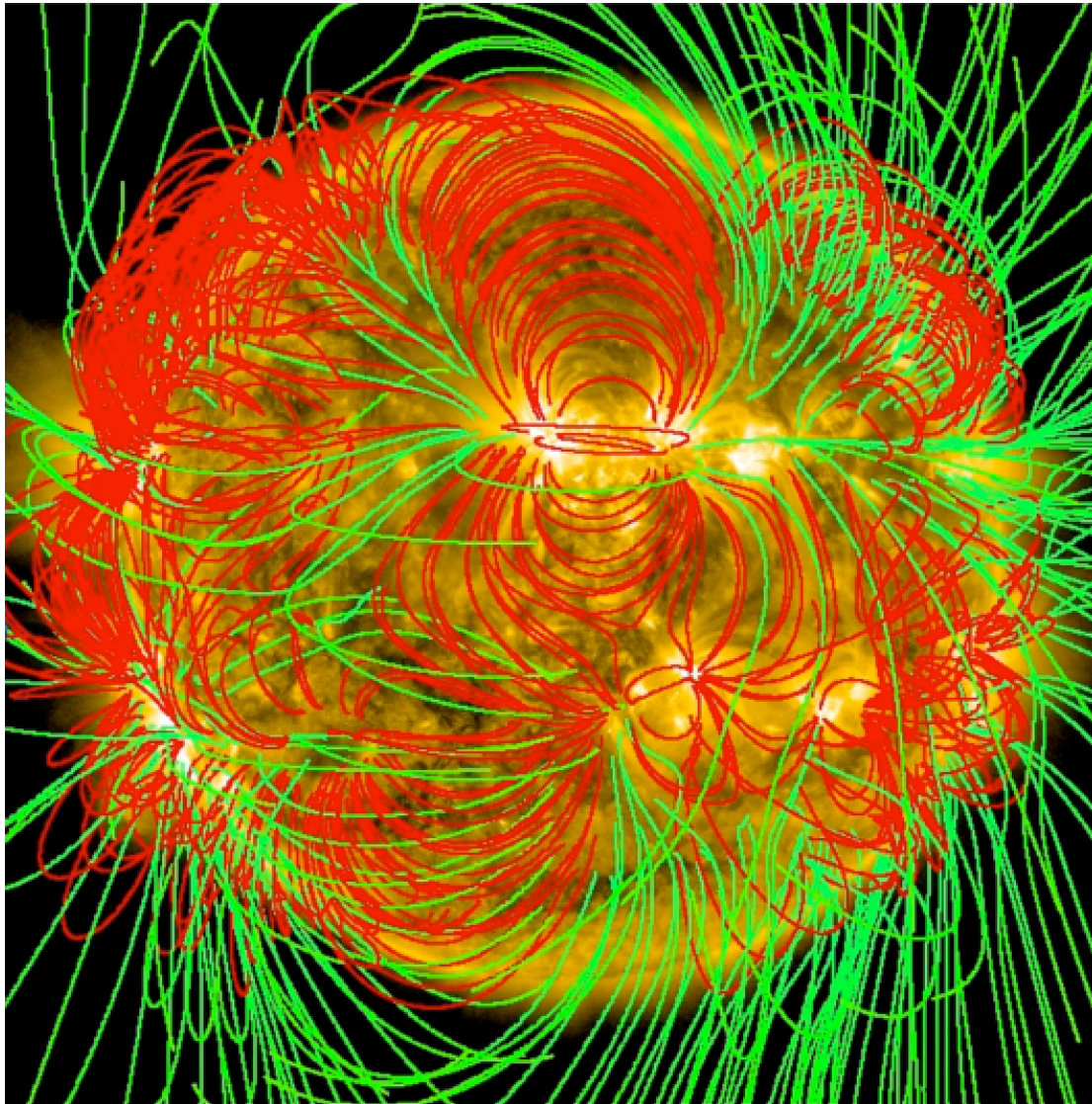
Local Physics Models Results



Solar Magnetograms: Input for Models of Solar Corona



Nonlinear Force-Free 3-D Coronal Magnetic Field Reconstruction



Solar Corona:
1-2.5 R_s , 1-20 R_s

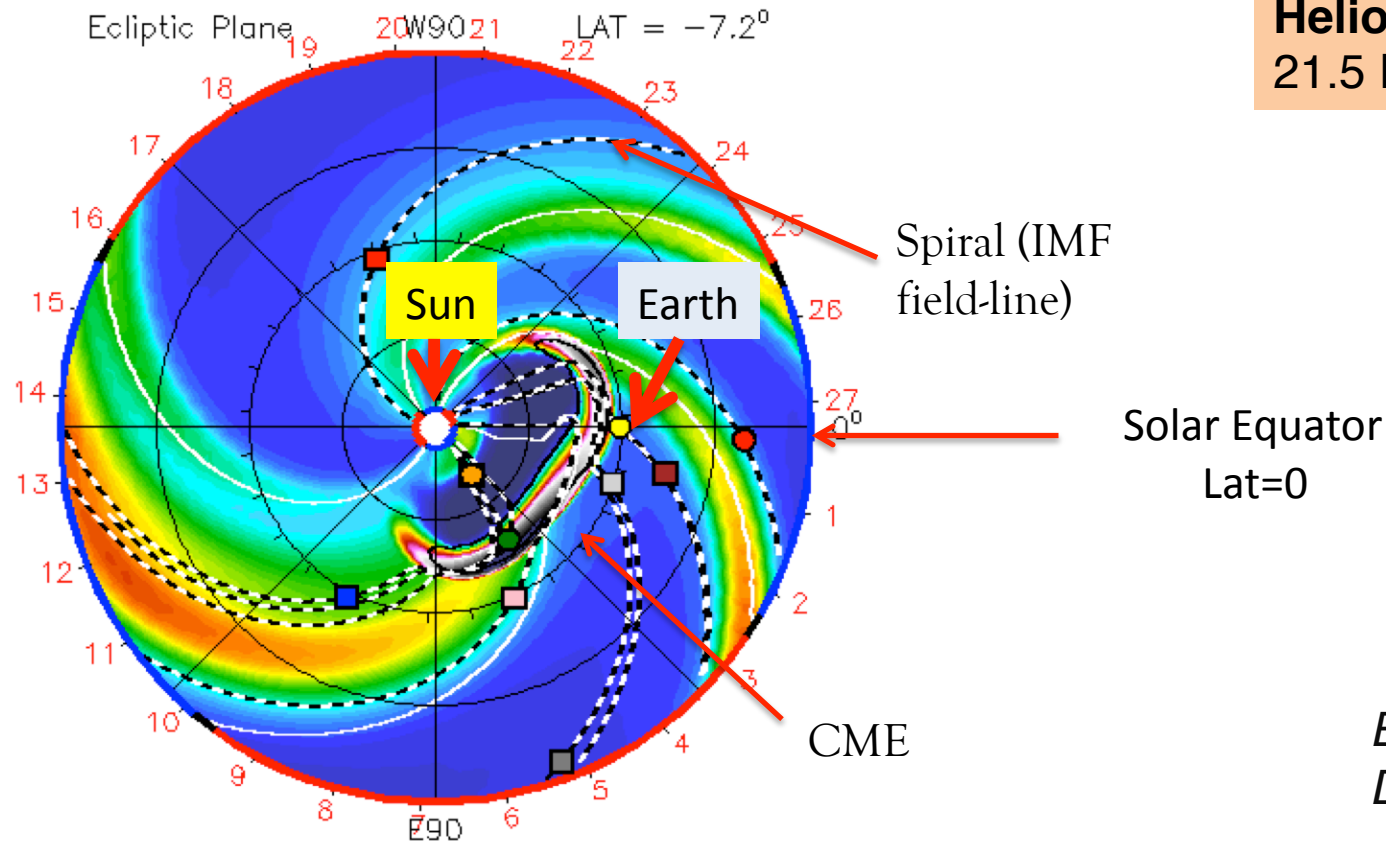
NLFFF
Wiegmann
Model

Heliospheric Model Enlil

2012-03-08T06:00

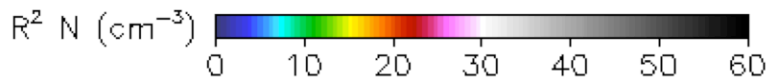
- Earth ● Mars ● Mercury ● Venus ■
- Spitzer ■ Stereo_A ■ Stereo_B

Inner Heliosphere:
21.5 Rs – 2 a.u.



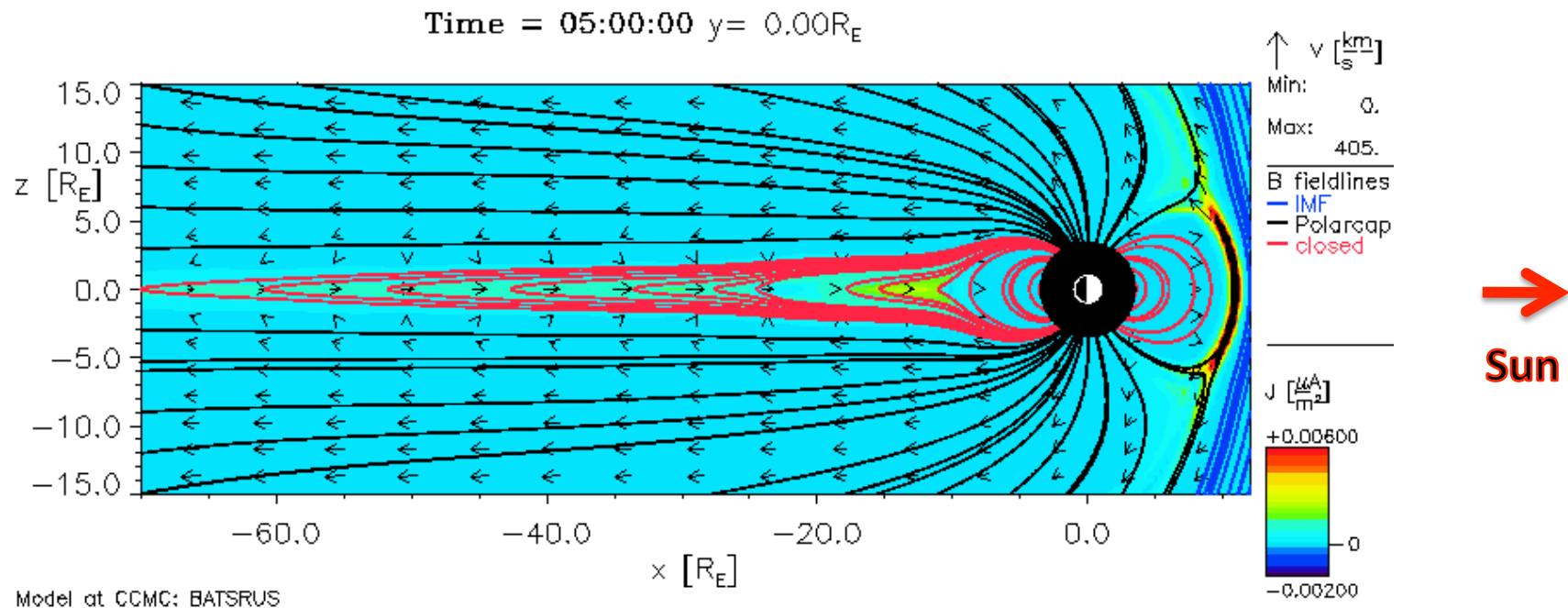
*Enlil Cone Model,
D. Odstrcil*

MHD



Magnetosphere Model SWMF/BATSRUS (MHD)

Magnetosphere:
2 Re – 1000 Re



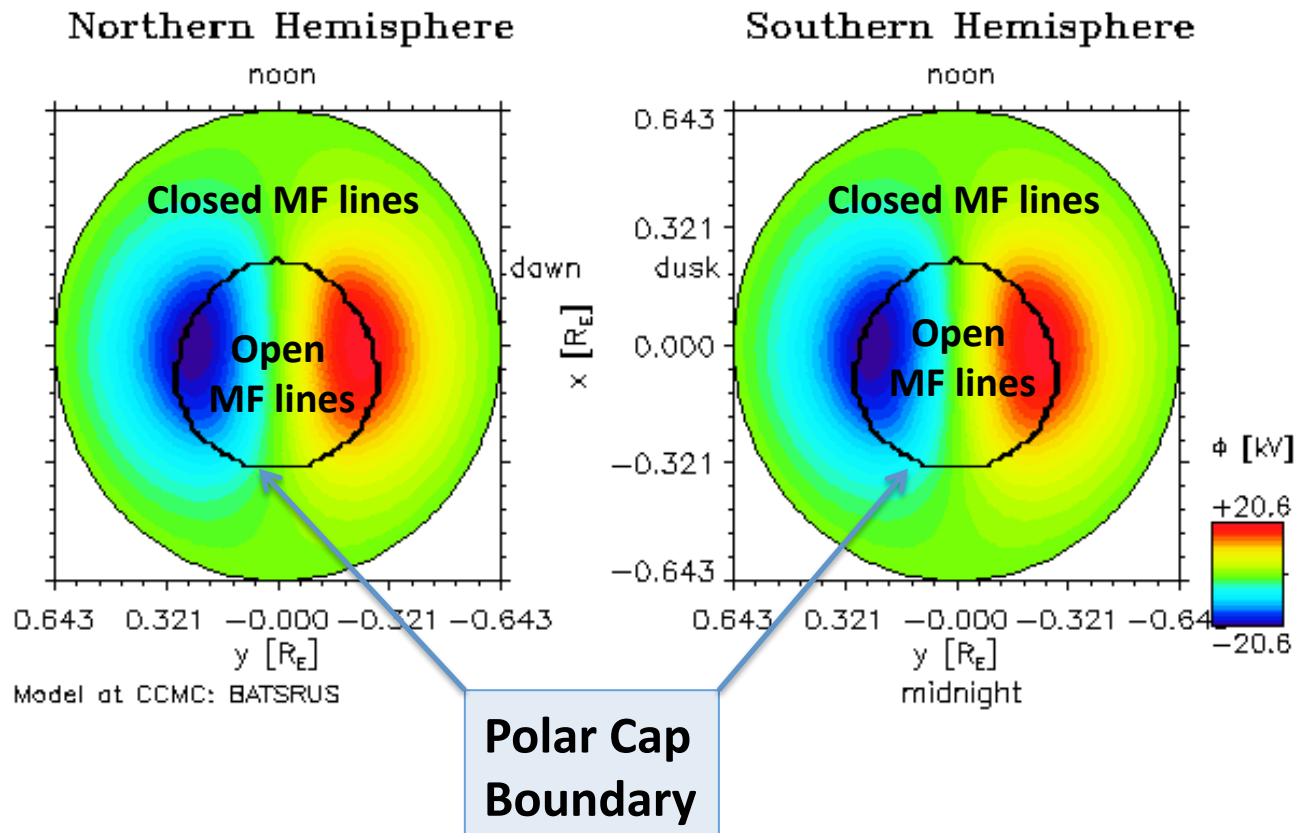
Space Weather Modeling Framework (SWMF), *Gombosi et al, U. Michigan*

Red lines (closed): Magnetic field (MF) lines with both ends connected to the Earth

Black lines (open): MF lines with only one end at the Earth

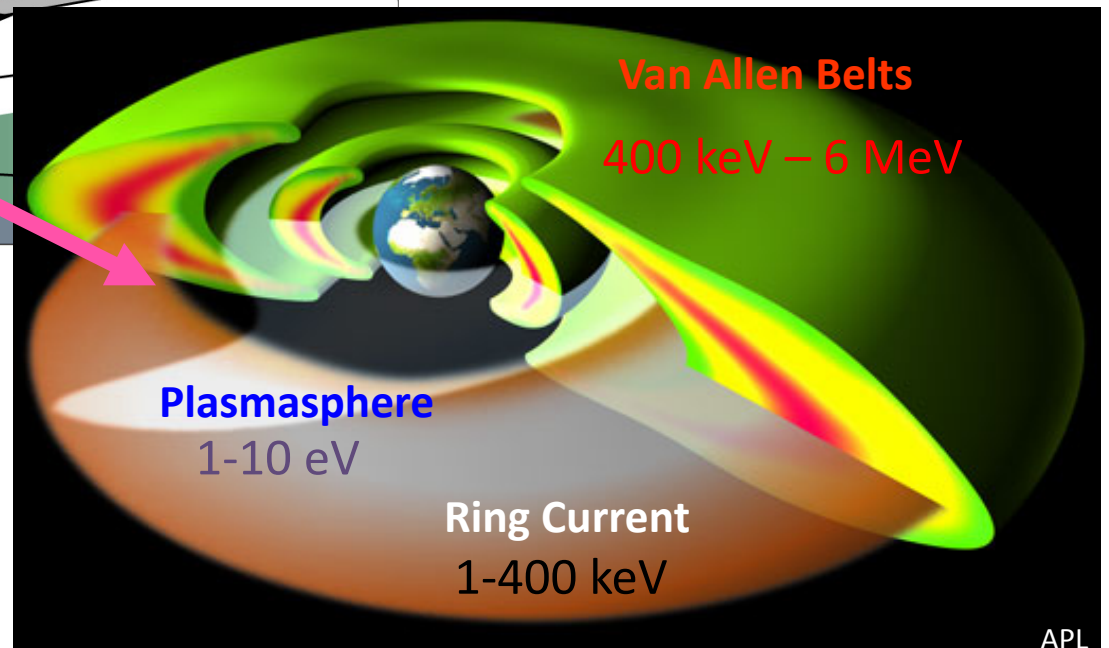
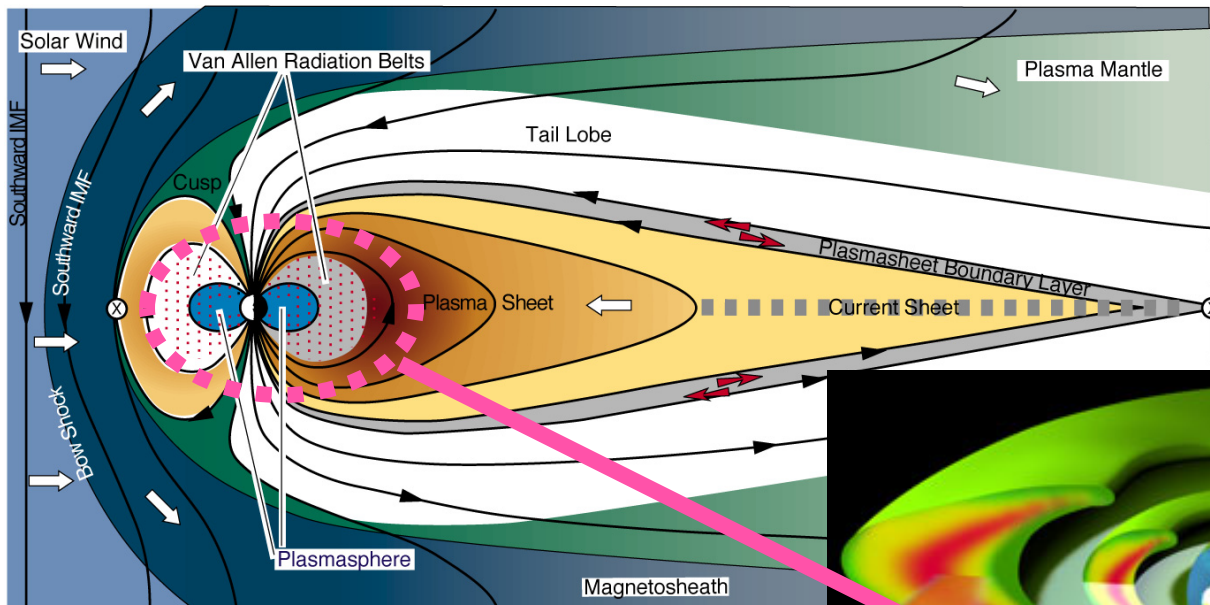
Blue lines (interplanetary): MF lines with both ends in the interplanetary space

Ionosphere Electrodynamics

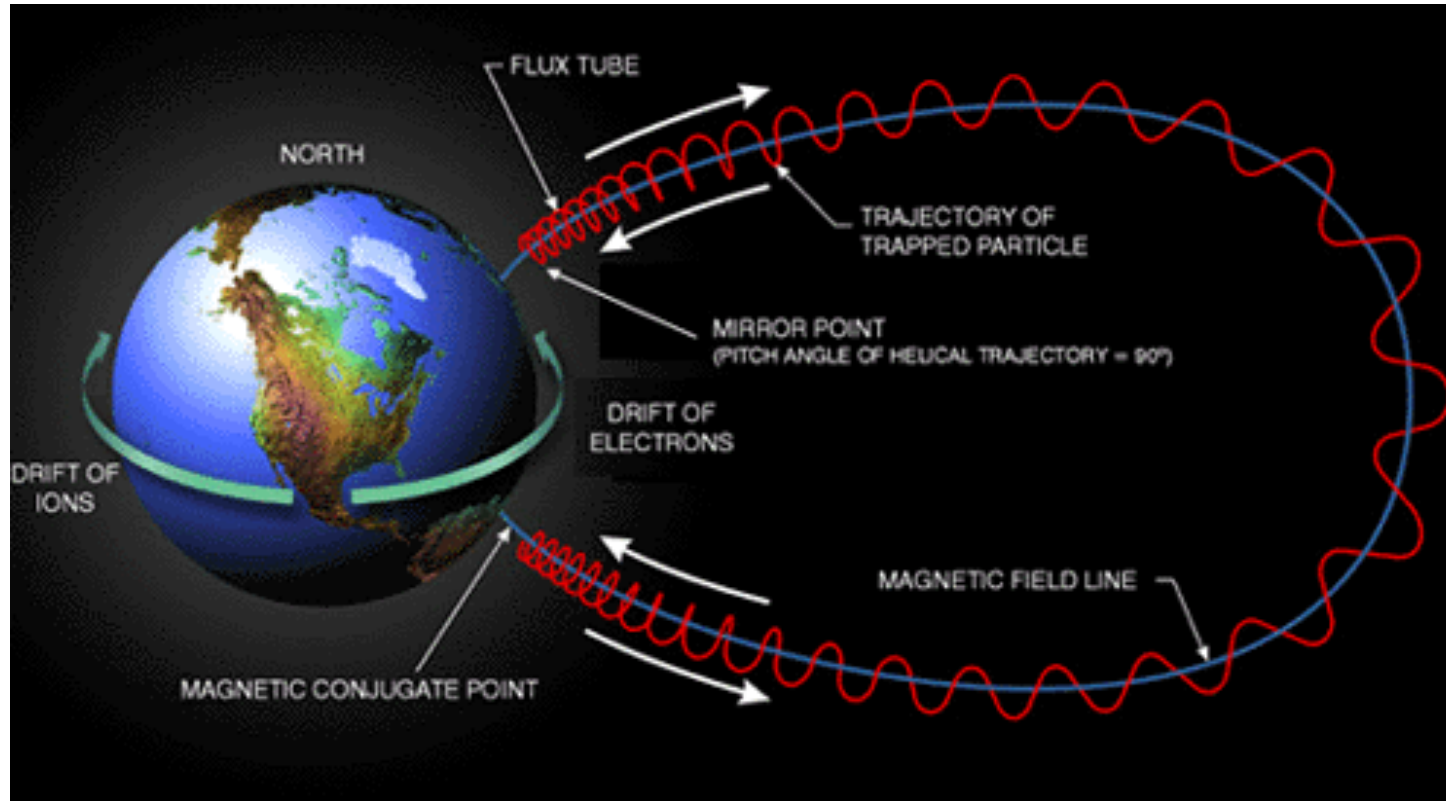


Closed: Magnetic field (MF) lines with both ends connected to the ionosphere
Open: MF lines with one end connected to the ionosphere and another end to the interplanetary space

Inner Magnetosphere (up to ~ 10 RE)



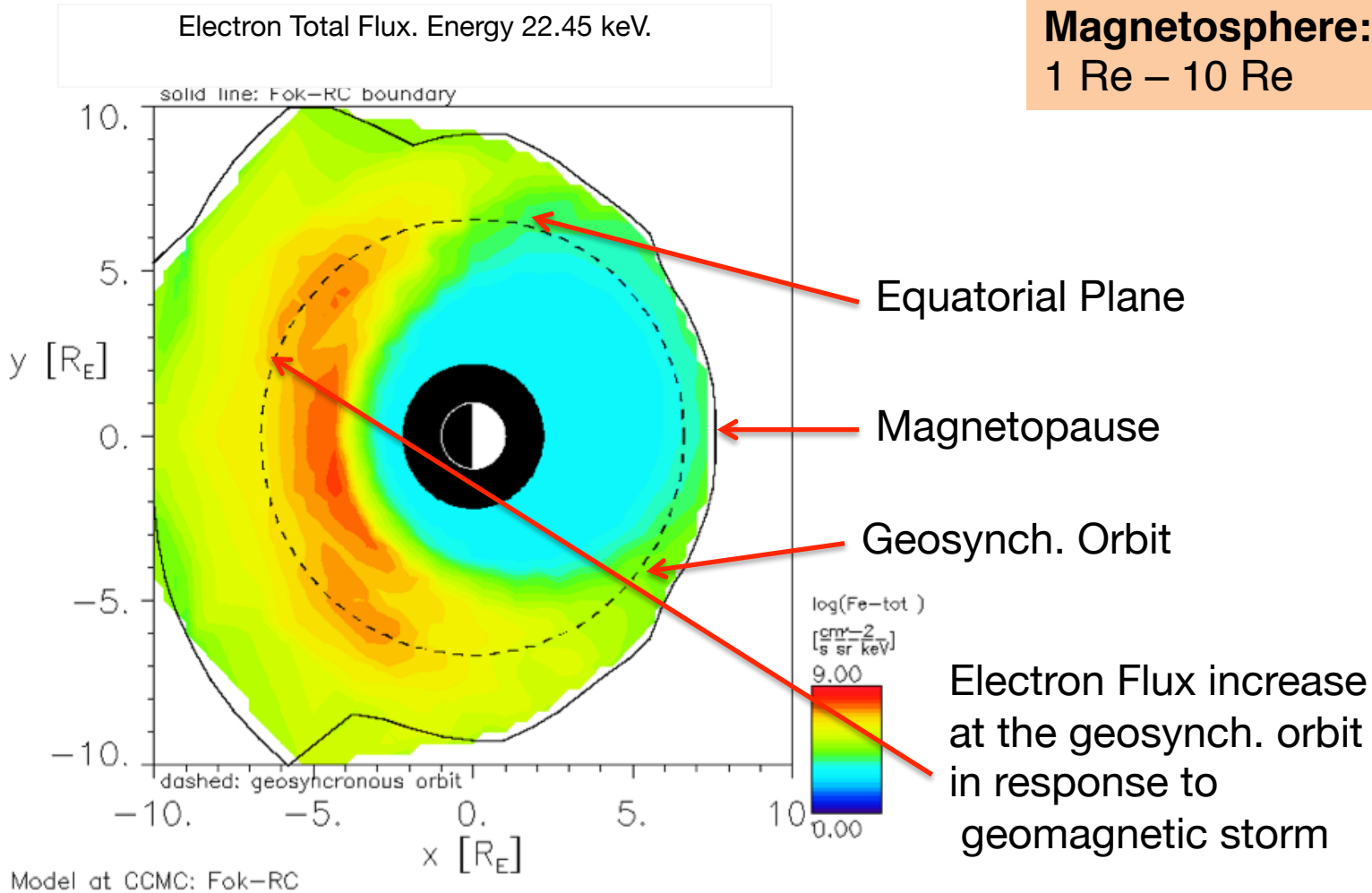
The charged particles that make up the **inner magnetosphere current system** are trapped in the Earth's magnetic field, *bouncing back and forth along the magnetic field lines between "mirror points" in the northern and southern hemispheres.*



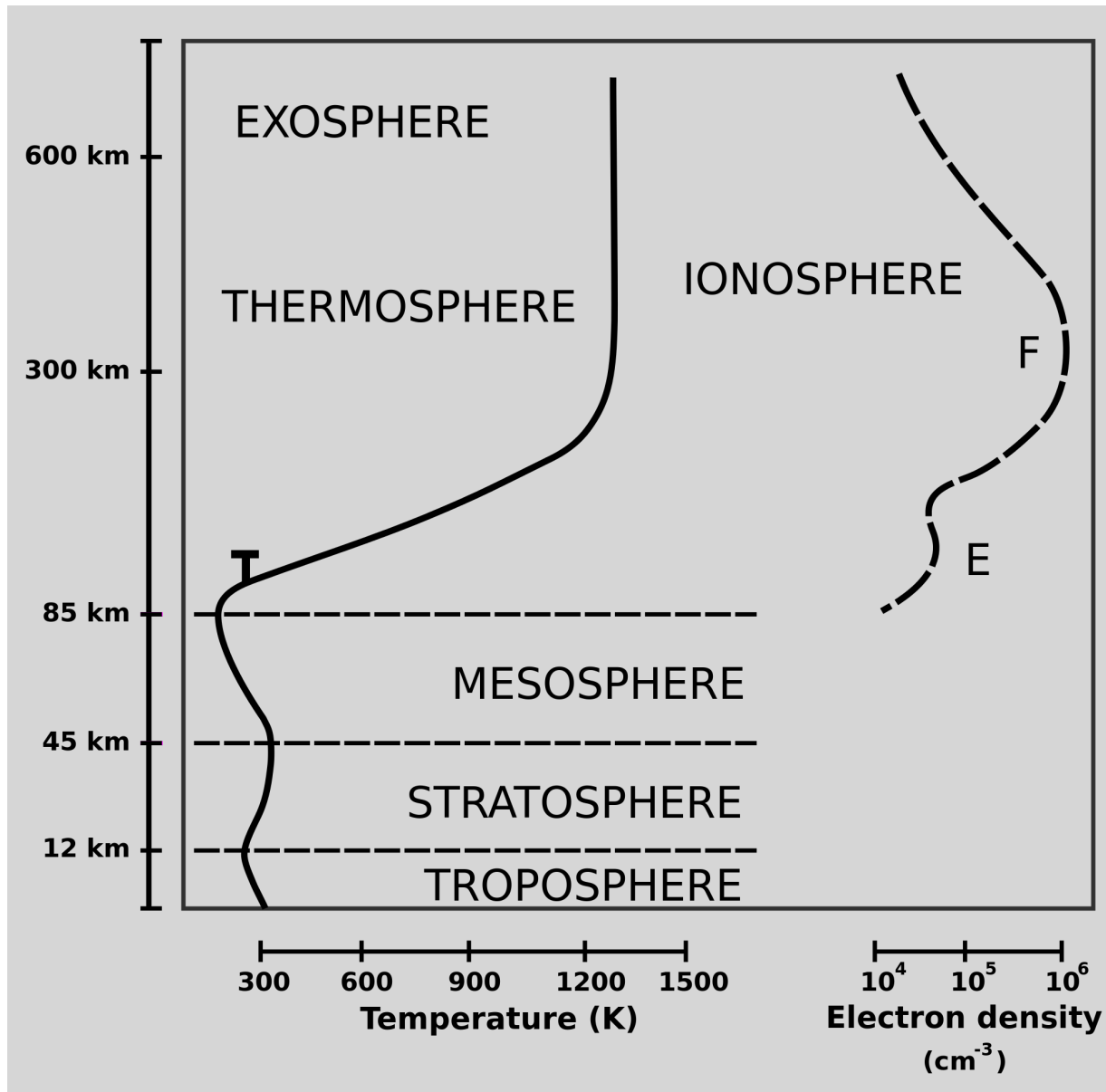
Ring current circles the Earth in the equatorial plane and is generated by the **longitudinal drift** of energetic (10 to 200 keV) **charged particles** trapped on field lines.

Inner Magnetosphere Model Fok Ring Current

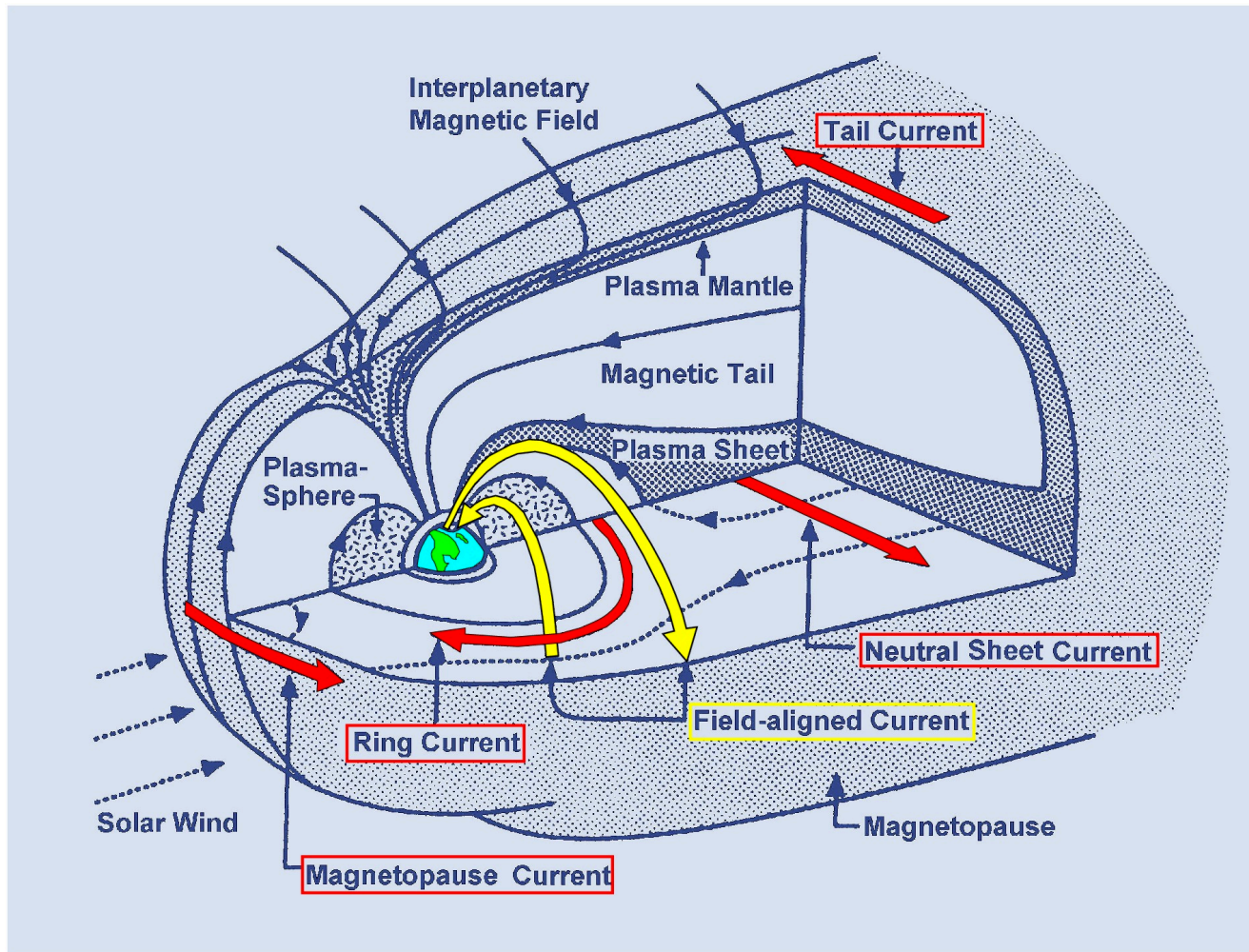
**Inner
Magnetosphere:
1 Re – 10 Re**



Global Ionosphere/Thermosphere Models



Anatomy of Magnetosphere



Runs with artificial Conditions

[http://ccmc.gsfc.nasa.gov/
support/SWREDI/bootcamp/
results_mag_model.php](http://ccmc.gsfc.nasa.gov/support/SWREDI/bootcamp/results_mag_model.php)

Runs with artificial Conditions

[https://ccmc.gsfc.nasa.gov/support/HSS_2011/
results21.php](https://ccmc.gsfc.nasa.gov/support/HSS_2011/results21.php)