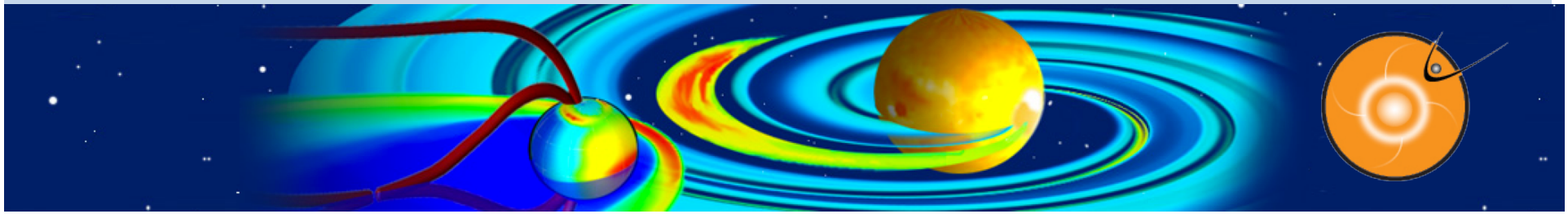
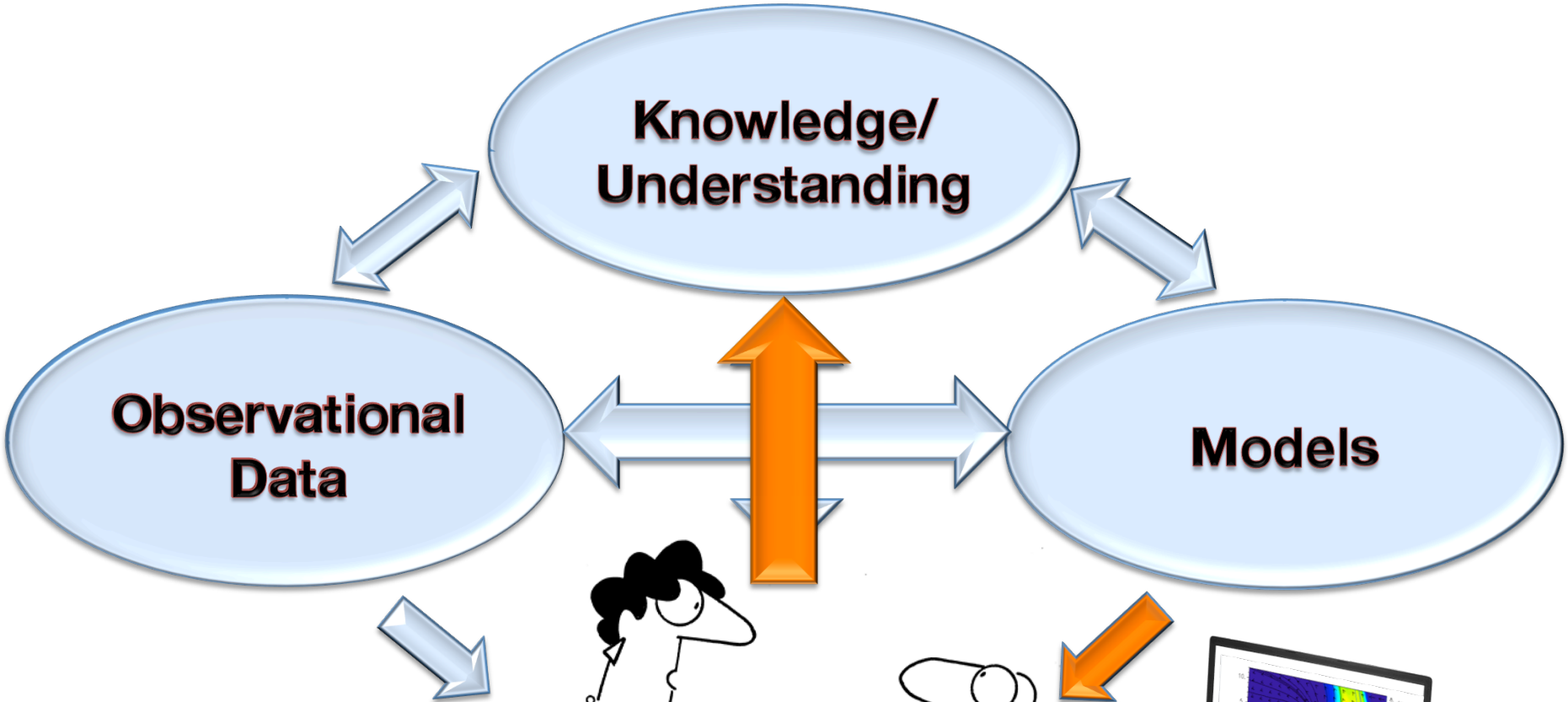
Community Coordinated Modeling Center (CCMC)

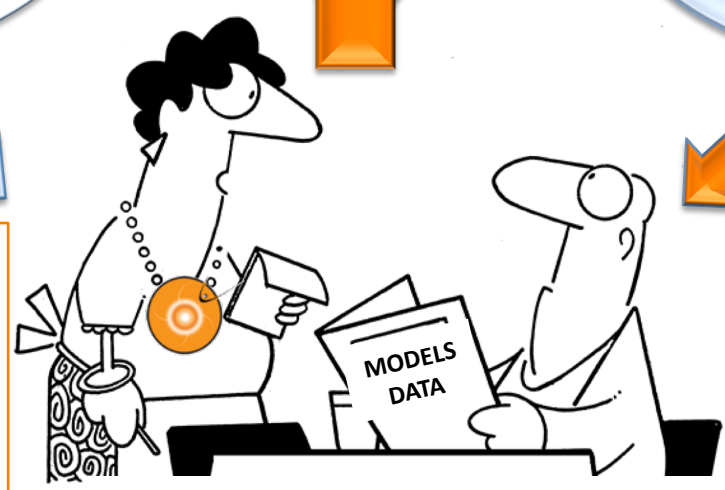


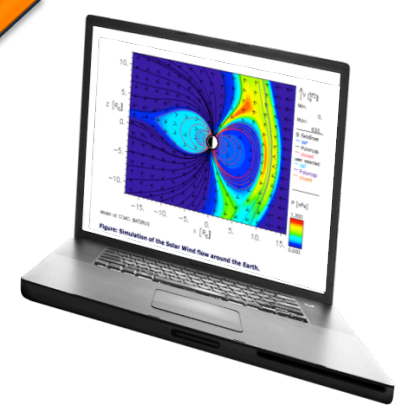
Tour of CCMC Models. Runs-on-Request: Global Magnetosphere Models

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

SWMF.SC
PFSS.Petrie
PFSS.Macneice
PFSS.Luhmann
ANMHD
UMASEP
SRPM
MAG4
ASAP
WSA
MAGIC
ASSA
SNB3GEO
NLFFF.Wiegelmann

ENLIL
Posner SEP
PREDICCS
EXO Solar Wind
EMMREM
CORHEL
Heltomo SMEI
ENLIL+Cone
Heltomo IPS
BRYNTRN
SWMF.SH

LFM-TING
GUMICS
LFM-MIX
GIC
OpenGGCM
SWMF+RCM+deltaB
SWMF+RCM
SWMF+RCM+RBE
SWMF+RCM+CRCM
LFM-MIX-TIEGCM
WINDMI
LANLstar
IGRF
Tsyganenko
Fok RBE
Weigel-deltaB
PS VP
Apex
AACGM
Ovation Prime

SAMI-2
SAMI-3
TIE-GCM
CTIPe
IRI
USU-GAIM
RCM
SWACI-TEC
Fok.CIMI
ABBYNormal
Fok.RC
UPOS RB
MSIS
AE-8/AP-8
GITM
AE-9/AP-9
PBMOD
VERB
TRIPL-DA
Weimer IE
Weimer-deltaB
JB2008
COSGROVE-PF

Corona
Heliosphere
Magnetosphere
Inner Magnetosphere
Ionosphere/ Thermosphere

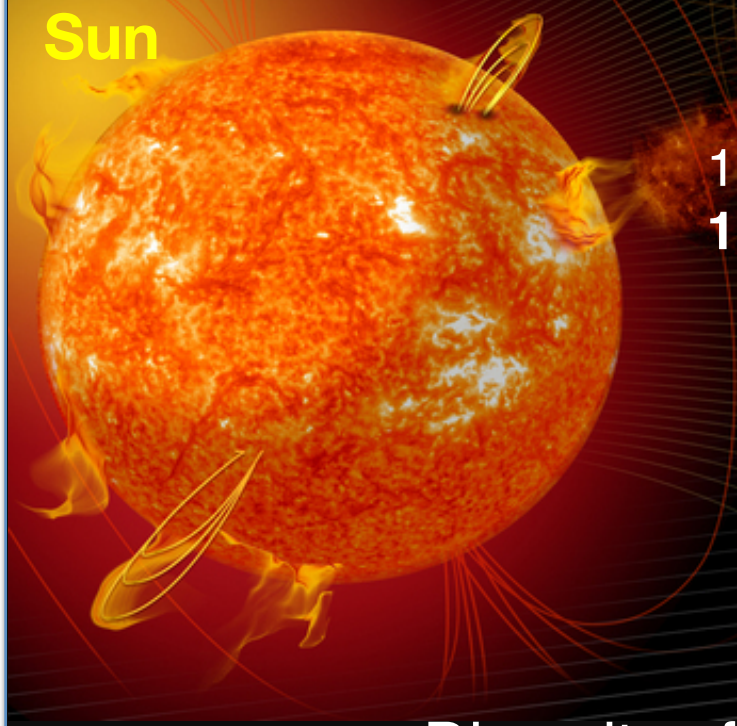
Space Environment Spatial Scales

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 (Rs)

Earth
Ionosphere/
Thermosphere

Earth
Magnetosphere

Sun



1 Solar radius ~ 110 Earth radii (Re)
1 Earth's radius (Re) = 6370 km

Geosynchronous orbit 6.6 Re
Kinetic scales: ~100 m – 0.1 Re
Plasma structures
in ionosphere: ~ 1 m – 100 m

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

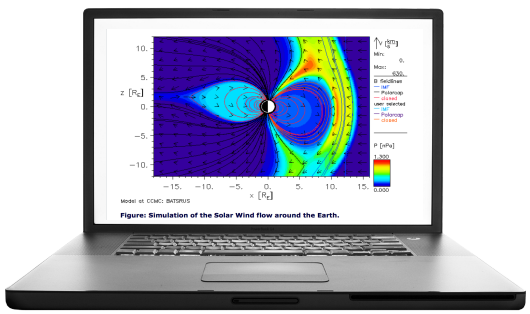
Ionosphere [km]: 80 – 1000 km

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



Requests

Results

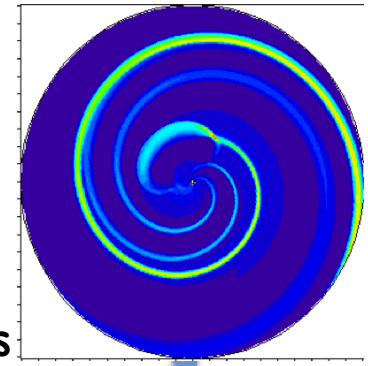
(since 2001)

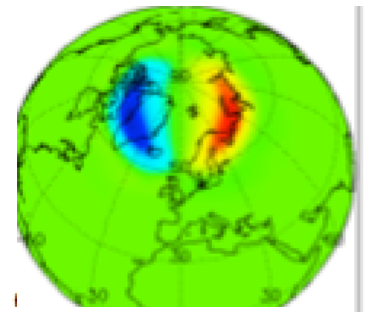
Super Computing Clusters > 2400 CPU's	Searchable Simulation Archive (>14,000 runs)
ccmc.gsfc.nasa.gov	
Peta-Bytes of Data Storage	Online Visualization & Downloads

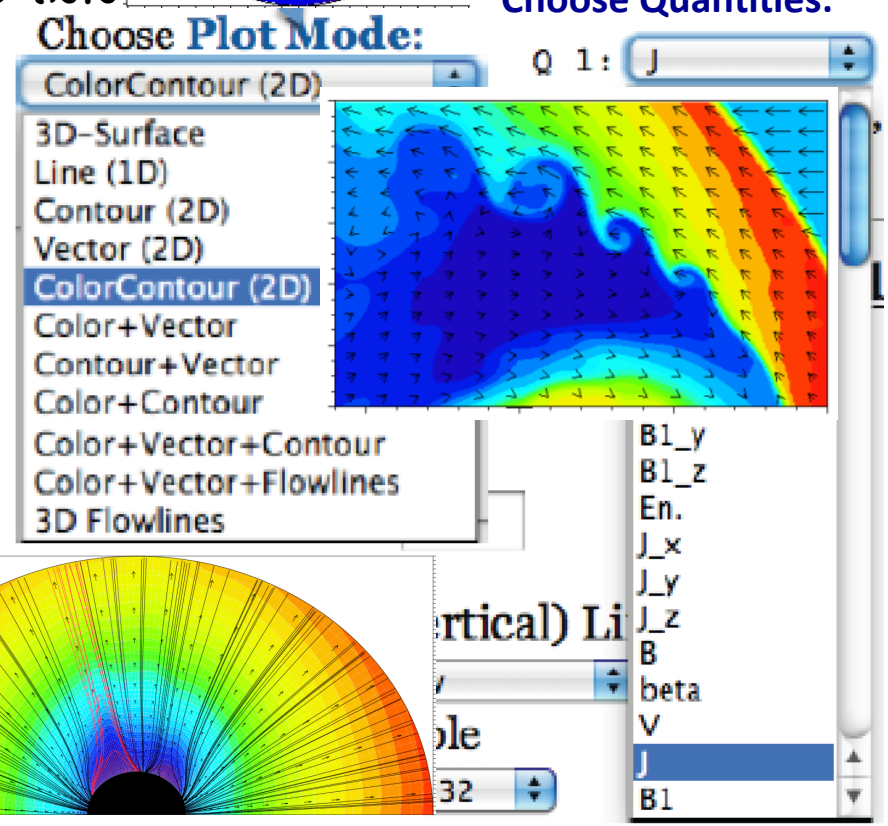
- ✓ User-configurable input parameters and model settings.
- ✓ Users advising and custom simulations.
- ✓ **Create synergy between analysis of observational data and scientific modeling.**
- ✓ Maximize return on investments into model development.

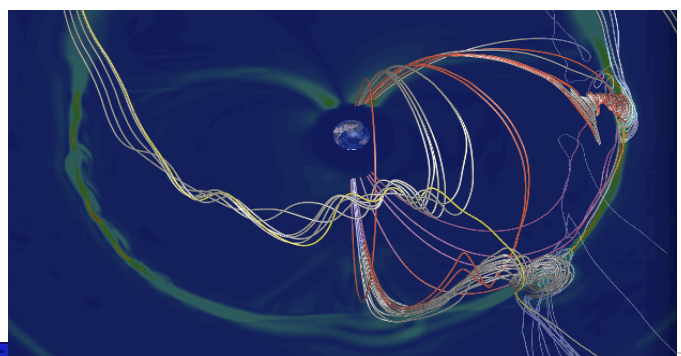
Interactive On-line Visualization & Analysis

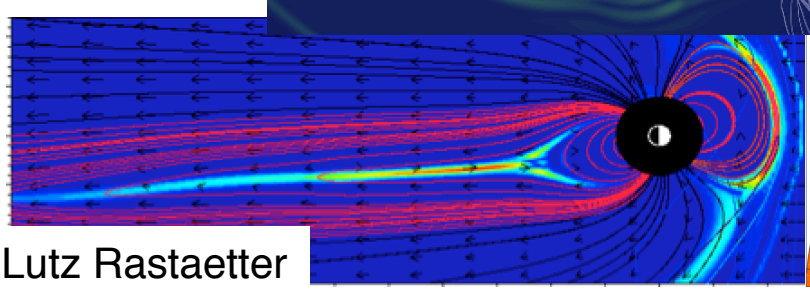
- ✓ Basic model output and derived quantities.
- ✓ User-ordered custom variables (*email the formula to Lutz and it will be tested & added*).
- ✓ Automated movie & time series generation.
- ✓ Time series plotter & analyzer.
- ✓ 2D slices, Line plots, 3D flow lines, ASCII lists
- ✓ Magnetic mapping.
-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

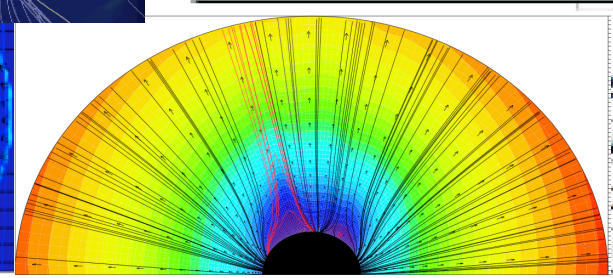




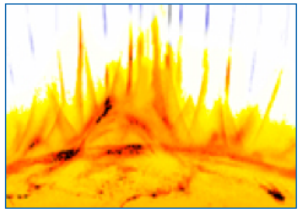




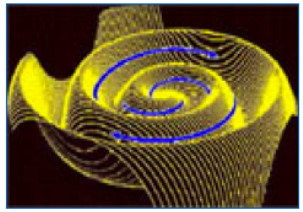




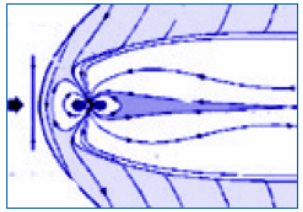
Lutz Rastaetter



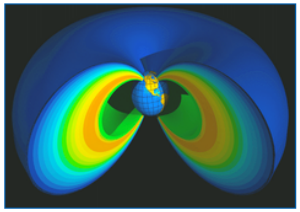
Solar Models Results



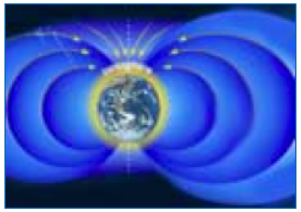
Heliosphere Models Results



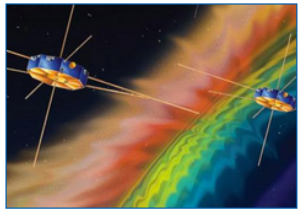
Global Magnetosphere Models Results



Inner Magnetosphere Models Results



Ionosphere / Thermosphere Models Results



Local Physics Models Results

SWMF.SC
PFSS.Petrie
PFSS.Macneice
PFSS.Luhmann
ANMHD
UMASEP
SRPM
MAG4
ASAP
WSA
MAGIC
ASSA
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CORHEL
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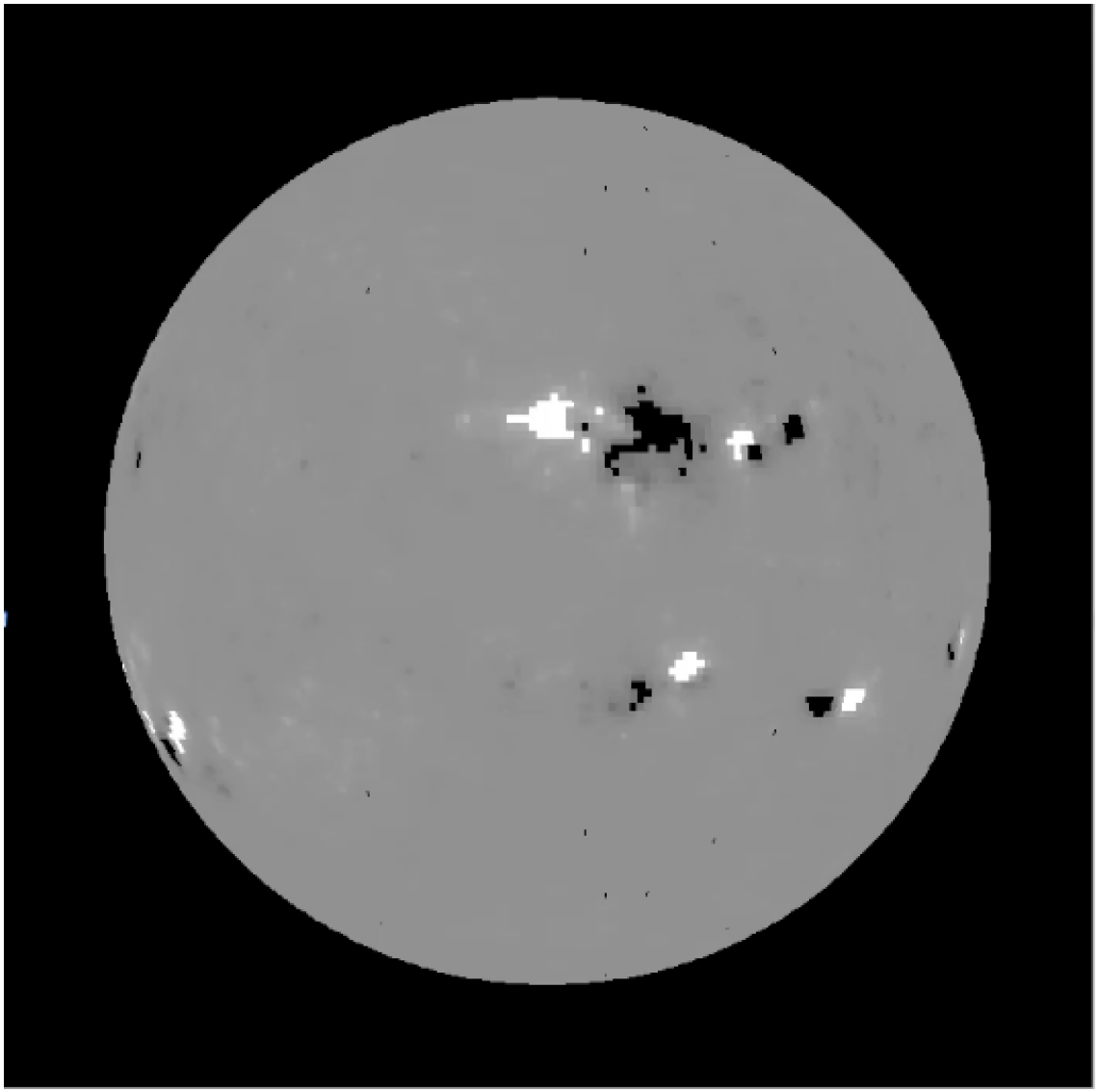
ENLIL+Cone
Heltomo IPS
BRYNTRN
SWMF.SH

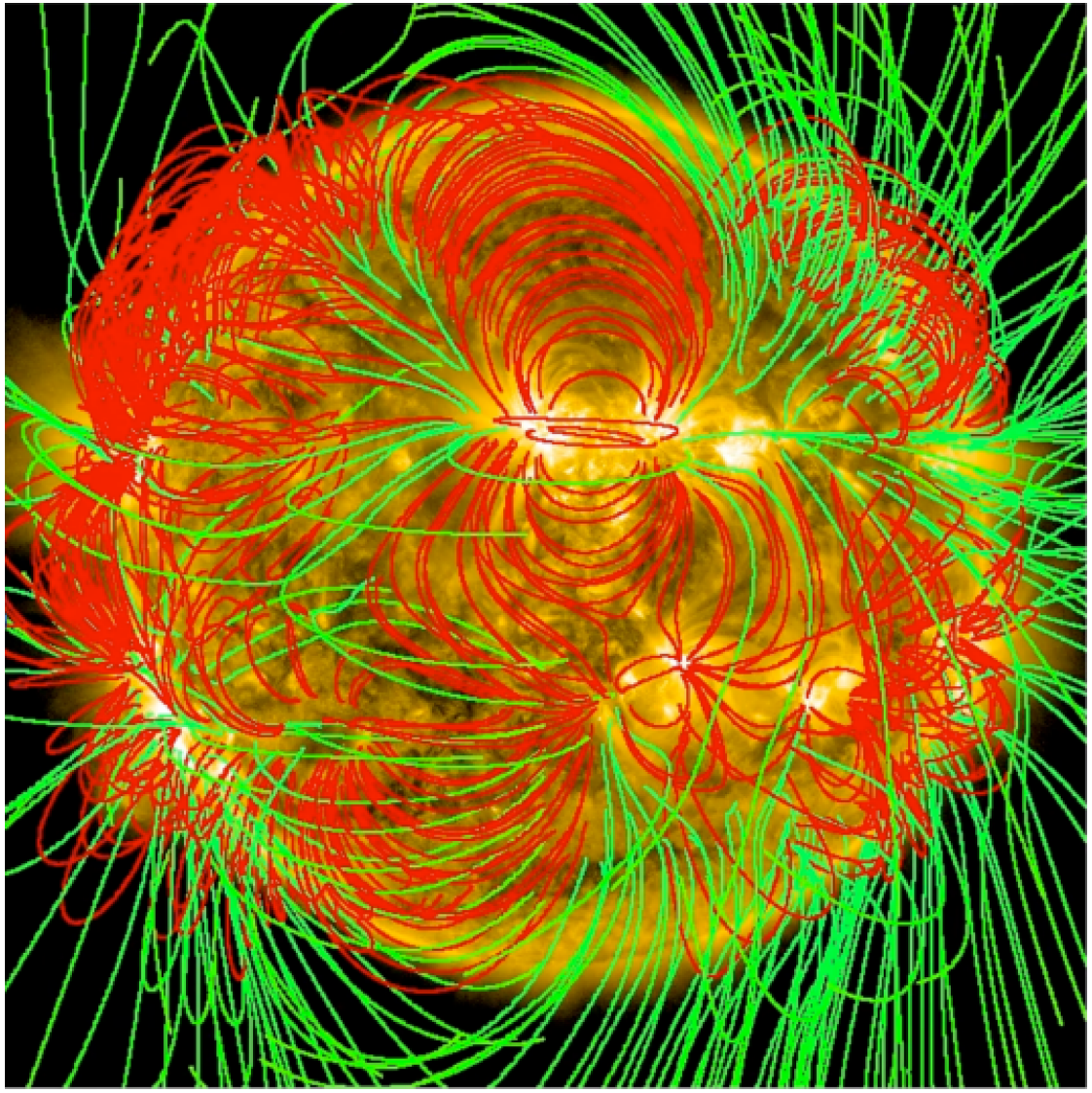
LFM-TING
GUMICS
LFM-MIX
GIC
OpenGGCM
SWMF+RCM+deltaB
SWMF+RCM
SWMF+RCM+RBE
SWMF+RCM+CRCM
LFM-MIX-TIEGCM
WINDMI
LANLstar
IGRF
Tsyganenko
Fok RBE
Weigel-deltaB
PS VP
Apex
AACGM
Ovation Prime

SAMI-2
SAMI-3
TIE-GCM
CTIPe
IRI
USU-GAIM
RCM
SWACI-TEC
Fok.CIMI
ABBYNormal
Fok.RC
UPOS RB
MSIS
AE-8/AP-8
GITM
AE-9/AP-9
PBMOD
VERB
TRIPL-DA
Weimer IE
Weimer-deltaB
JB2008
COSGROVE-PF

Solar Magnetograms: Input for Models of Solar Corona



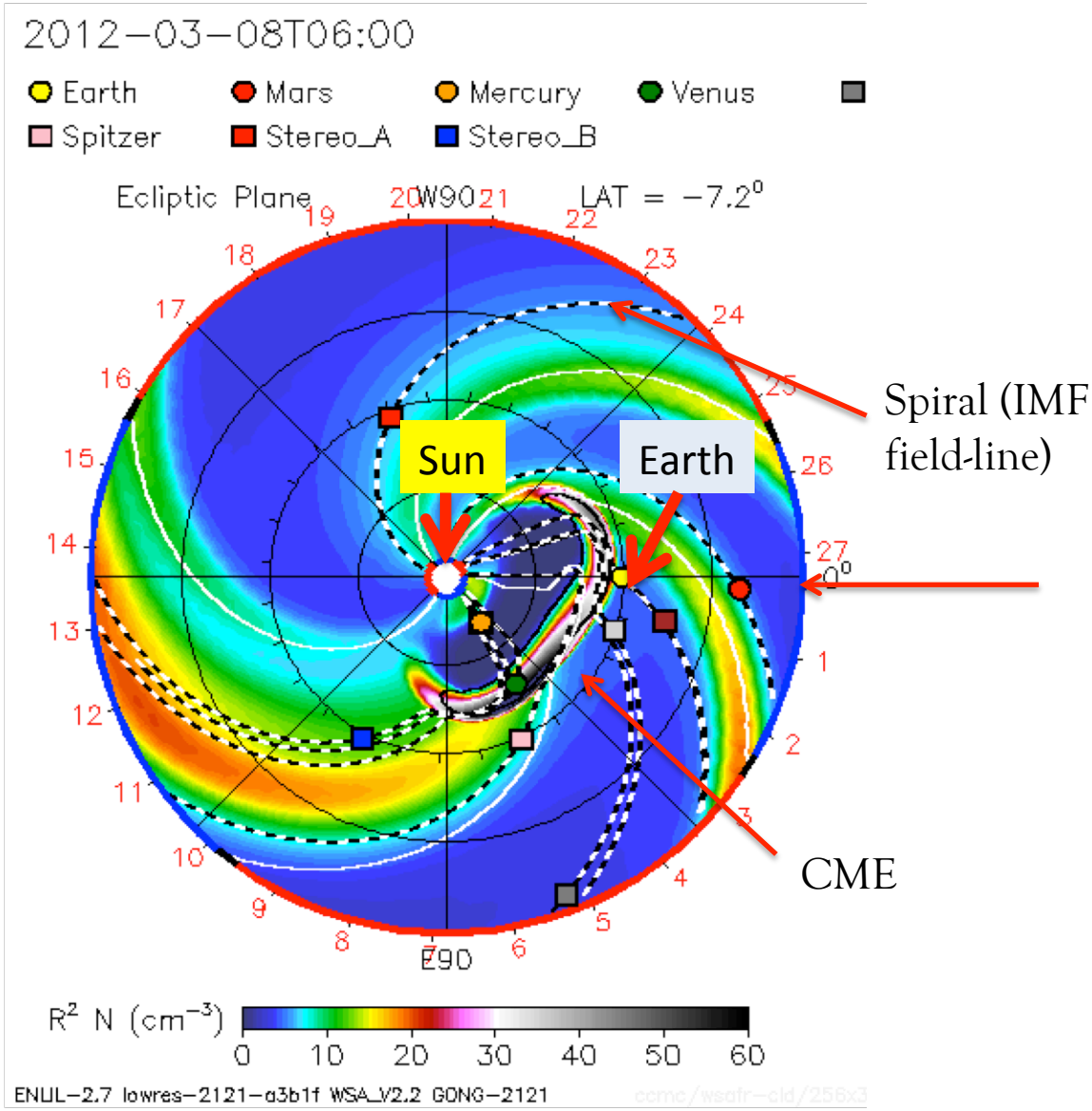
Nonlinear Force-Free 3-D Coronal Magnetic Field Reconstruction



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

NLFFF
Wiegelmann
Model

Heliospheric Model Enlil



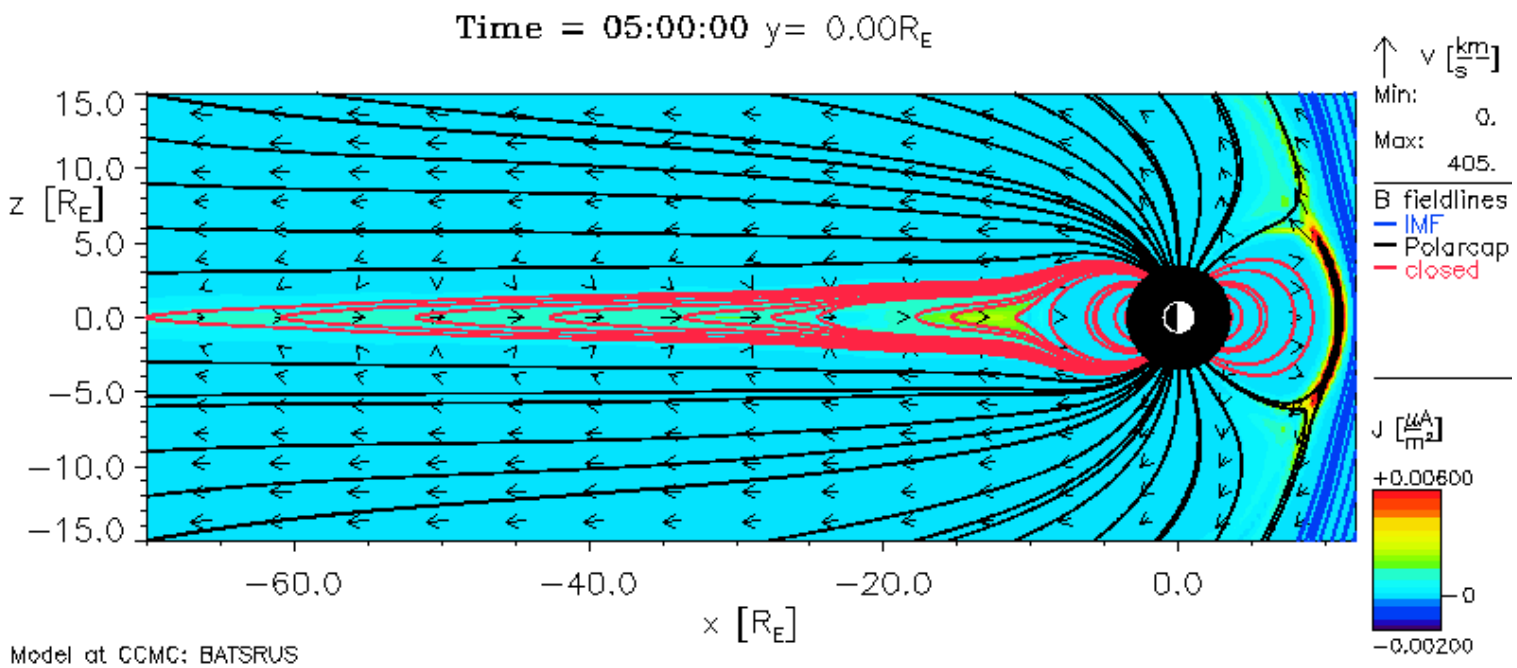
Inner Heliosphere:
21.5 Rs – 2 a.u.

Enlil Cone Model, D. Odstrcil

MHD

Magnetosphere Model SWMF/BATSRUS (MHD)

Magnetosphere:
2 Re – 1000 Re

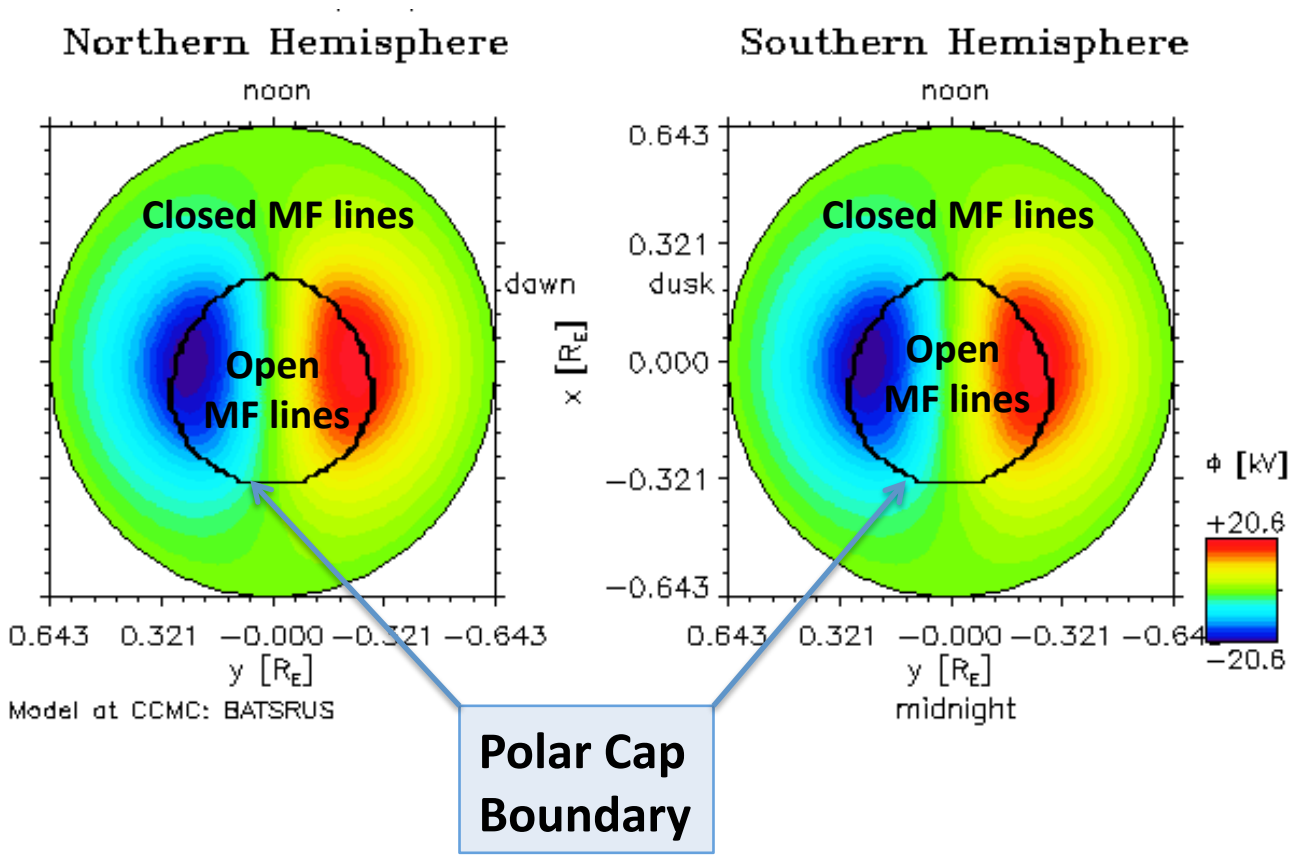


Sun

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

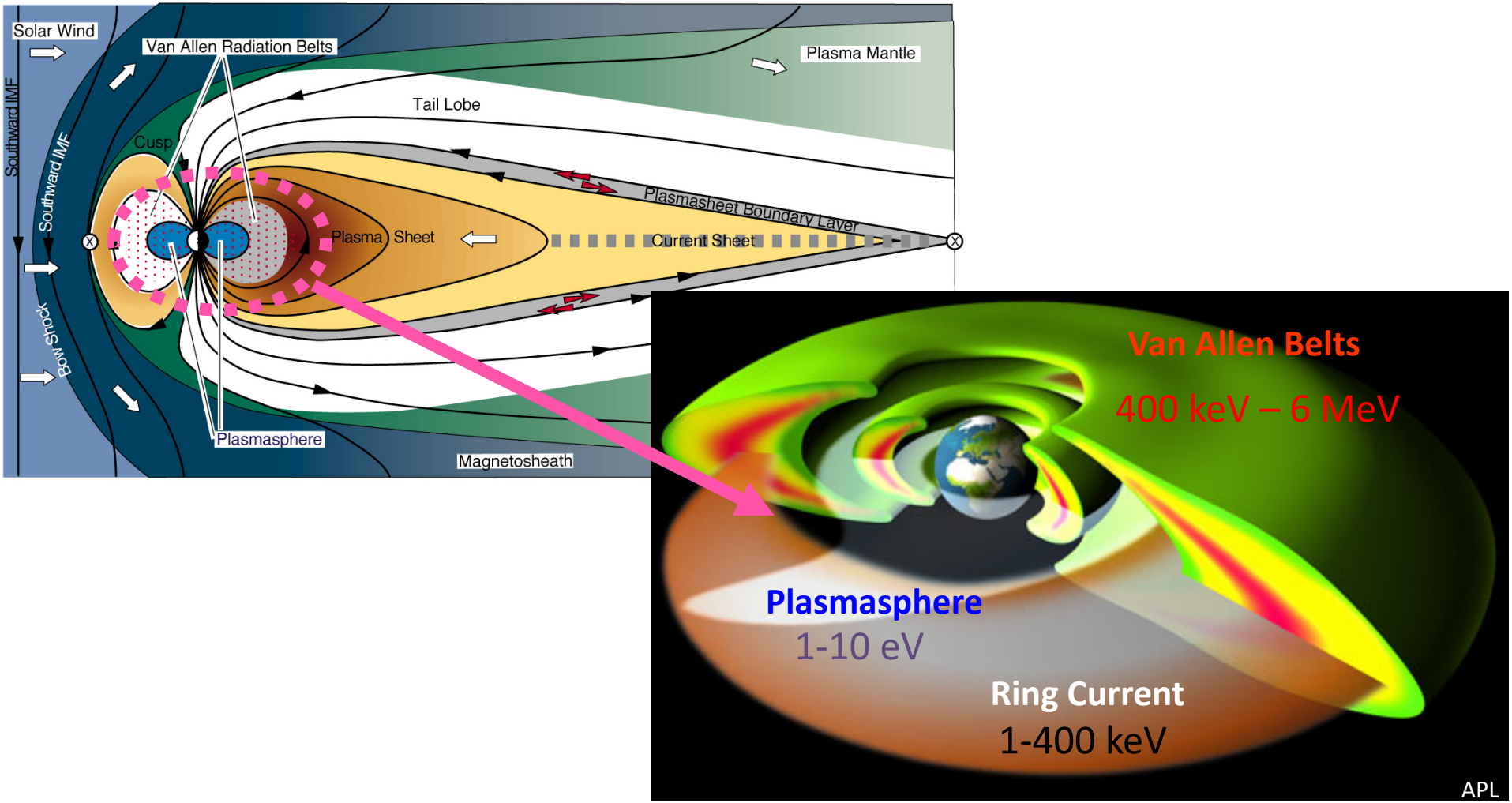
Red lines (closed): Magnetic field (MF) lines with both ends connected to the Earth
Black lines (open): MF lines with only one end a the Earth
Blue lines (interplanetary): MF lines with both ends in the interplanetary space

Ionosphere Electrodynamics

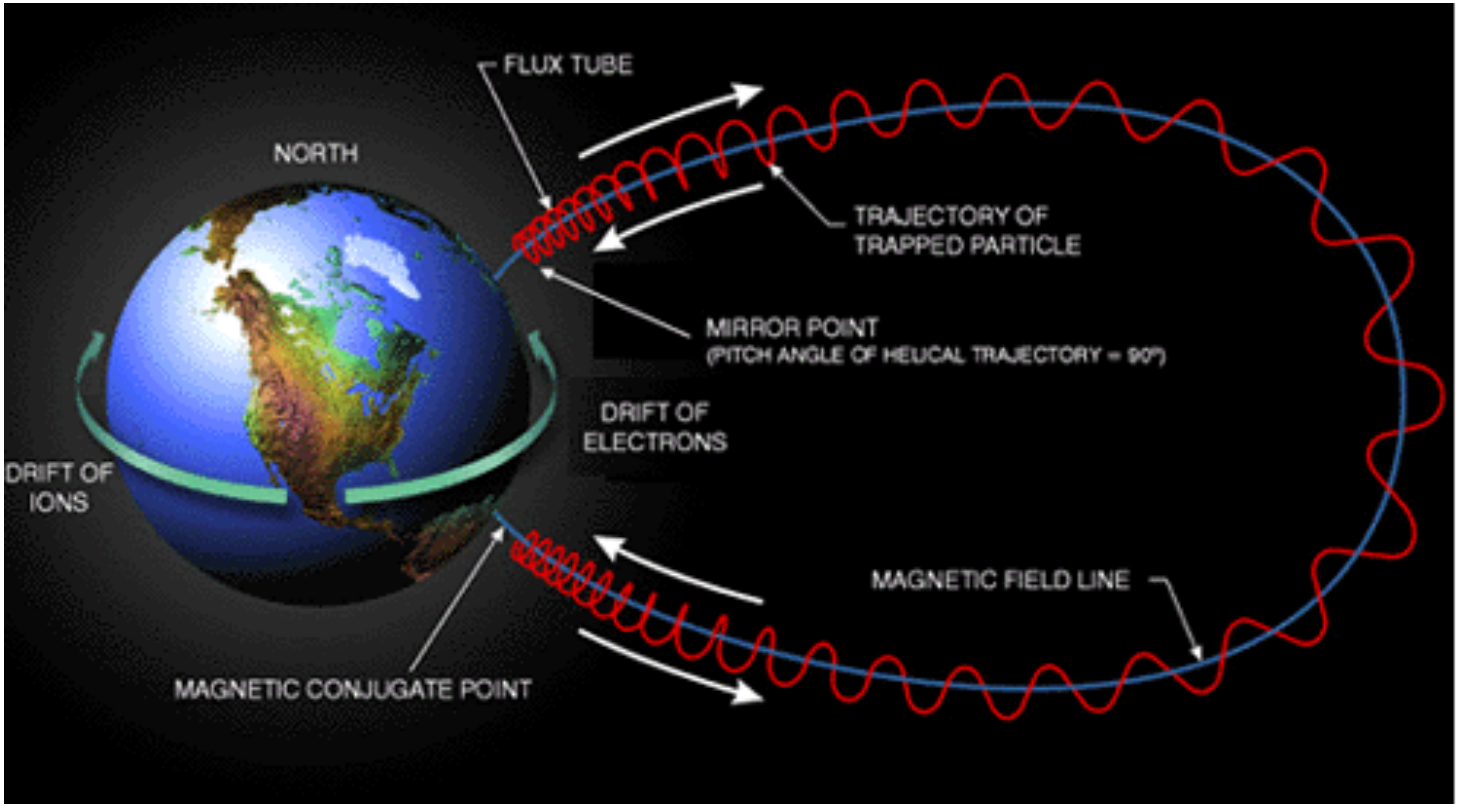


Closed: Magnetic field (MF) lines with both ends connected to the ionosphere
Open: MF lines with one end connected to the ionosphere and another end to the interplanetary space

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.*

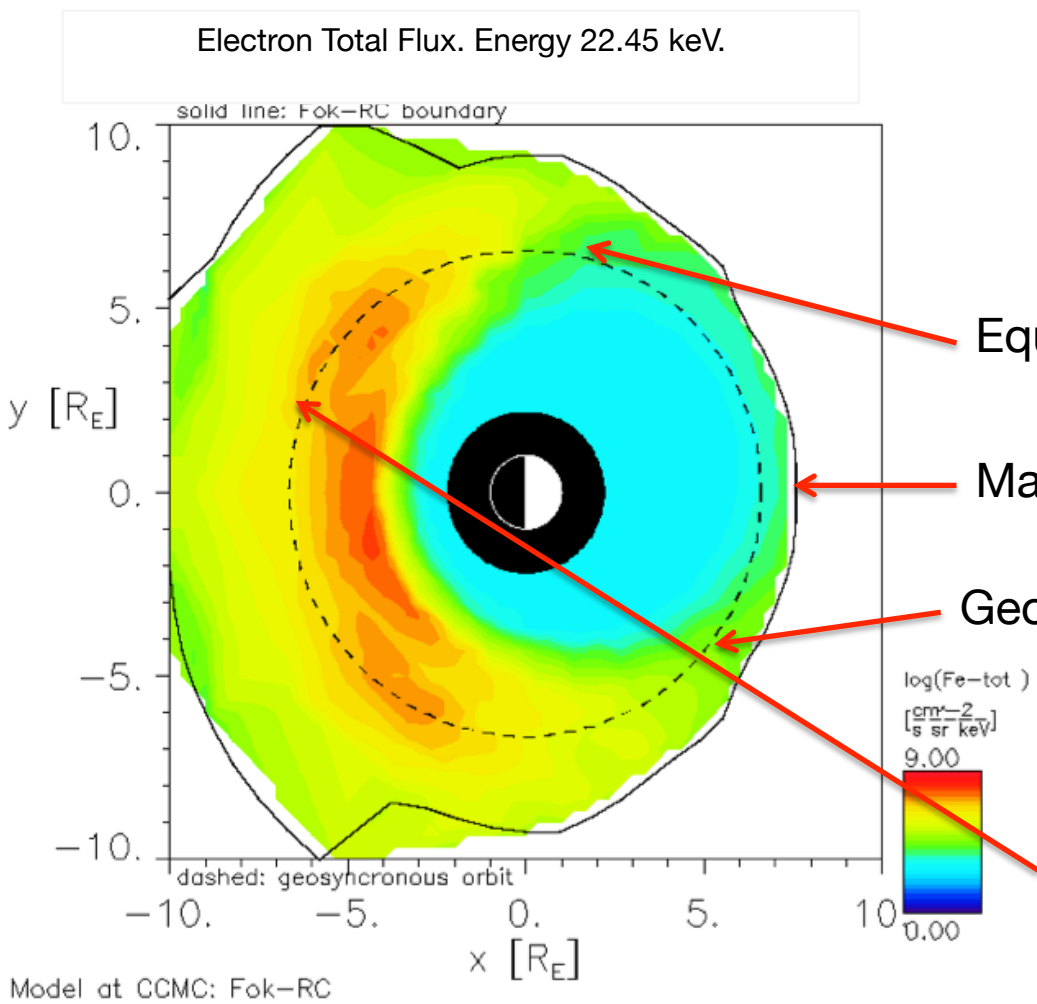


~~MHD~~

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



Equatorial Plane

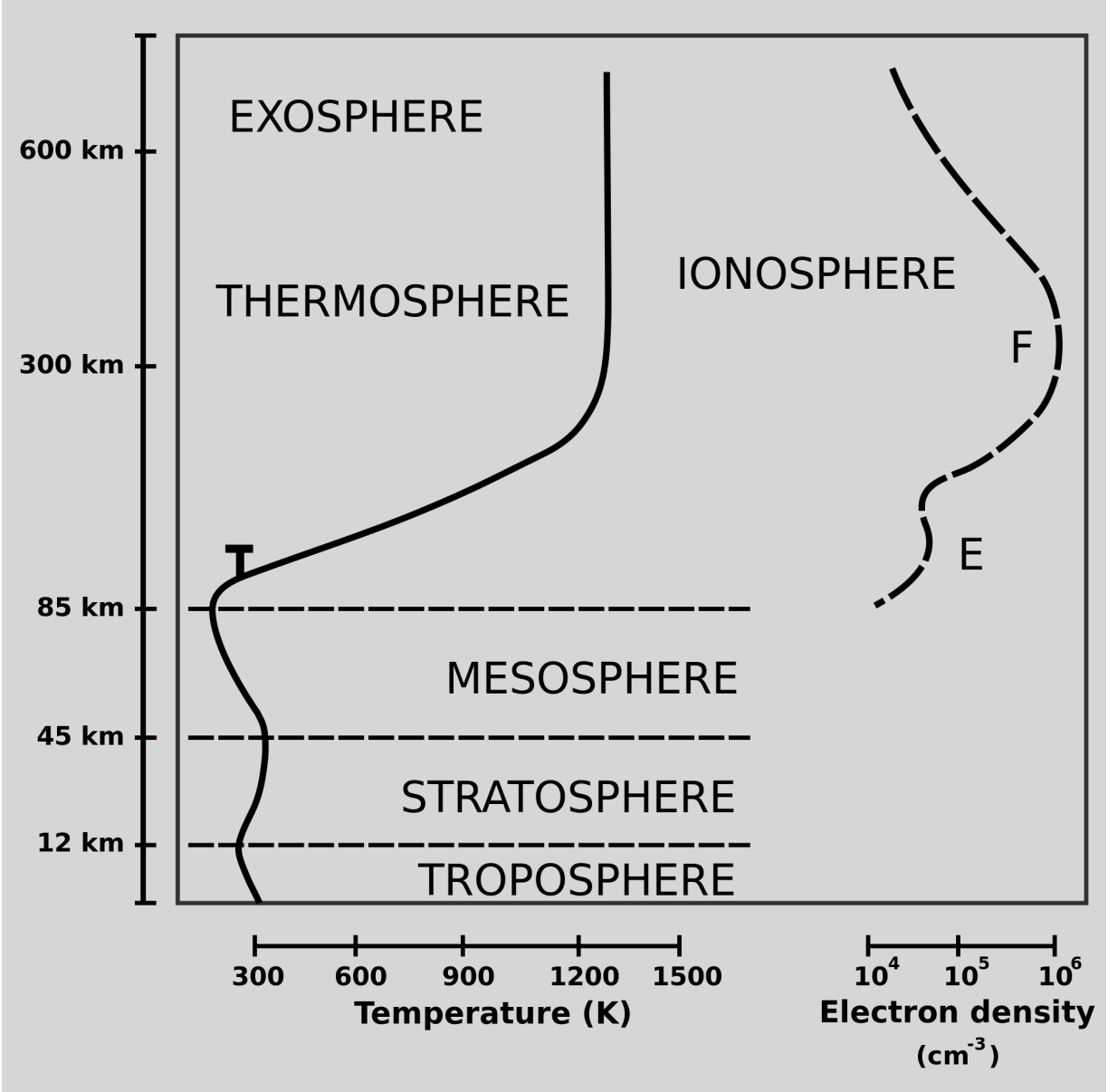
Magnetopause

Geosynch. Orbit

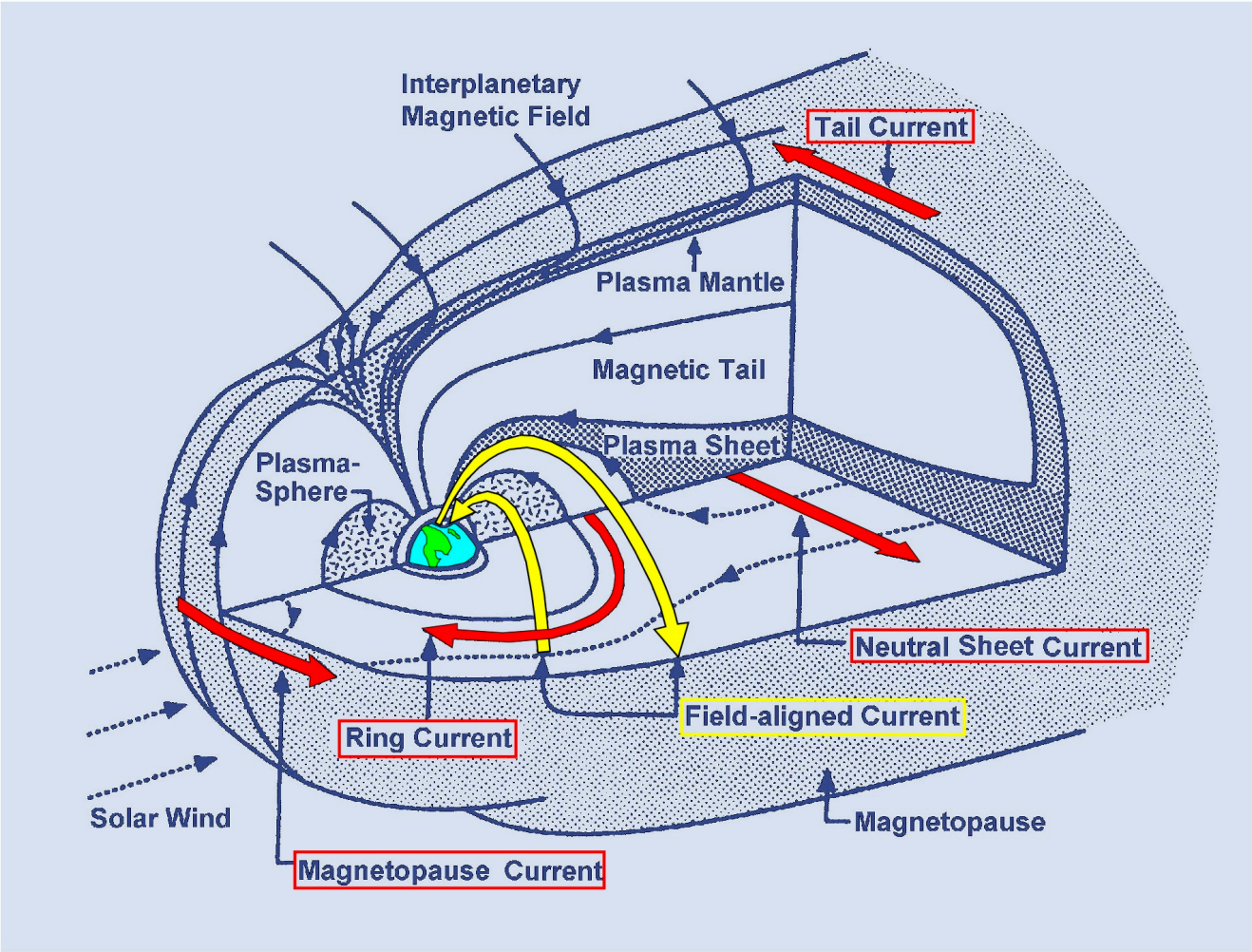
Electron Flux increase at the geosynch. orbit in response to geomagnetic storm

Sun

Global Ionosphere/Thermosphere Models



Anatomy of Magnetosphere



Runs with artificial Conditions

http://ccmc.gsfc.nasa.gov/support/SWREDI/bootcamp/results_mag_model.php

Runs with artificial Conditions

http://ccmc.gsfc.nasa.gov/support/SWREDI/bootcamp/results_mag_event.php