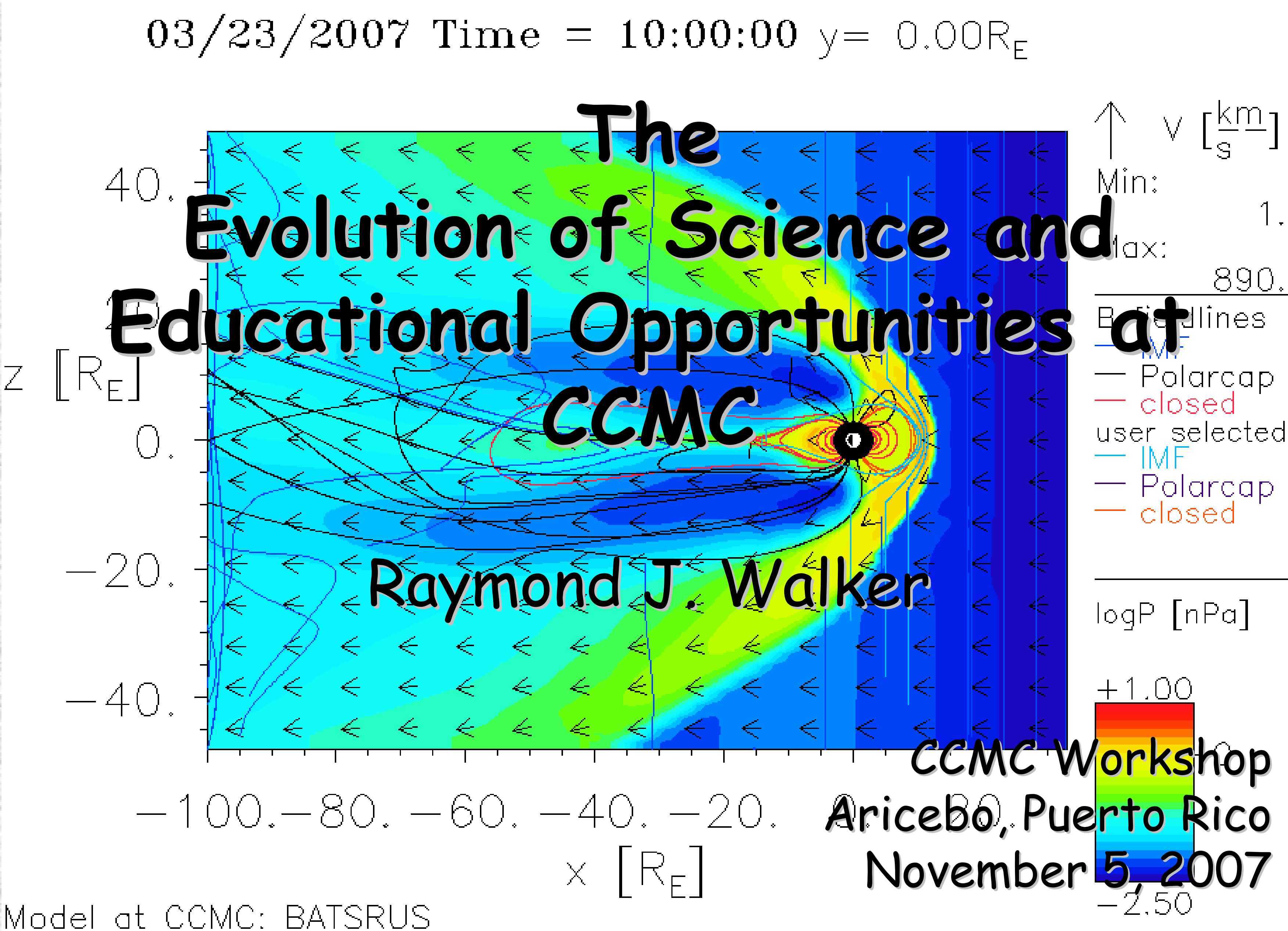
The Evolution of Science and Educational Opportunities at CCMC

Raymond J. Walker

CCMC Workshop
Aricebo, Puerto Rico
November 5, 2007



CCMC's Tasks - Operations

- Performs science-based validation and metrics-based evaluations of models for operations customers and decision makers.
- Tests models, e.g. through real-time runs.
- Develops model installation kits for operational use and supports model installation at operational facilities providing space weather forecasts.

CCMC's Tasks- Science

- Adopts state of the art space weather models that are developed by outside researchers into the CCMC. Model treatment at the CCMC is governed by the Rules of the Road document.
- Executes simulation runs with these models at no cost to scientists interested in event or case studies.
- Dedicated model runs can be requested online. Results will become publicly available on the CCMC website.
- Offers a variety of visualization and output analysis tools to aid the user in interpretation of simulation results.
- Provides access to coupled models and existing model frameworks.
- Invites members of the community to provide feedback on models and services offered by the CCMC, both through online comment submission and during biennial community workshops.

Services for Science

- Runs on request
  - Requests can either be made through the web site or by personal contact with CCMC staff.
  - Results will be made publicly available.

- Visualization
  - Tools for plotting model and simulation results.
  - Access to results is through a web page which produces plots.
  - CCMC staff will make tools available to users.
  - Visualization routines are implemented in IDL or OpenDX.

Our Experiences with CCMC in Education

- ESS 265: Techniques in Space Physics – Spring 2005
  - Mostly data analysis students
  - Instrumentation
  - Time series data analysis
  - Three lectures on simulations
- Homework assignment to run two codes (BATSRUS and OpenGGCM) for the same solar wind and IMF conditions.
  - Students found this taste of simulation interesting
  - Wanted more analysis capability
  - Wanted more depth in explanation of the techniques and codes

ESS 261 – Topics in Magnetospheric Physics "Simulation for Data Analysts"

- Ten week course at the discretion of the instructor.
- Tried to provide a deeper discussion of simulations.
- Allow students to carry out a more extensive evaluation of codes.
- Allow students to use the codes as tools for the analysis of data.

Syllabus

- April 3 – **Organization**
- April 5 – **Lecture** MHD Theory
- April 10 – **Lecture -** Introduction to simulation codes – (Solving hyperbolic equations, explicit and implicit codes, solving elliptical equations.)
- April 17 – **Lecture** –- Introduction to CCMC – Hands on sessions looking at southward IMF results.
- April 19 – **Lecture** – Actual MHD codes – (Open GGCM and BATSRUS)- Fok ring current model
- May 1 – *Student report* – Transport for southward IMF using the OpenGGCM and BATSRUS simulations.
- May 8– **Lecture** – Aurora and kinetic simulations –Dave Schriver
- May 15- **Lecture** – Ordinary Differential Equations and hands on session – particle calculations.

Syllabus Continued

- May 17- *Student report* - Effect of resolution on MHD results – use BATSRUS with differing resolutions.
- May 22 – **Lecture** – Using particle trajectory calculations to study the structure and dynamics of the magnetotail. – Maha Ashour-Abdalla
- May 24 – **Lecture** – Particle in cell codes
- May 29 – *Student report* – Magnetospheric transport for northward IMF.
- May 31.– **Lecture** – Modeling the inner magnetosphere – (Rice Convection Model)
- June 5 – *Student report* – Transport under realistic conditions.

Exercise 1: Transport for B_{ZIMF}<0 – Shasha Zhu lead

Solar Wind Input:

Northward turning: 00:30

Southward turning: 03:00

Simulation Box:

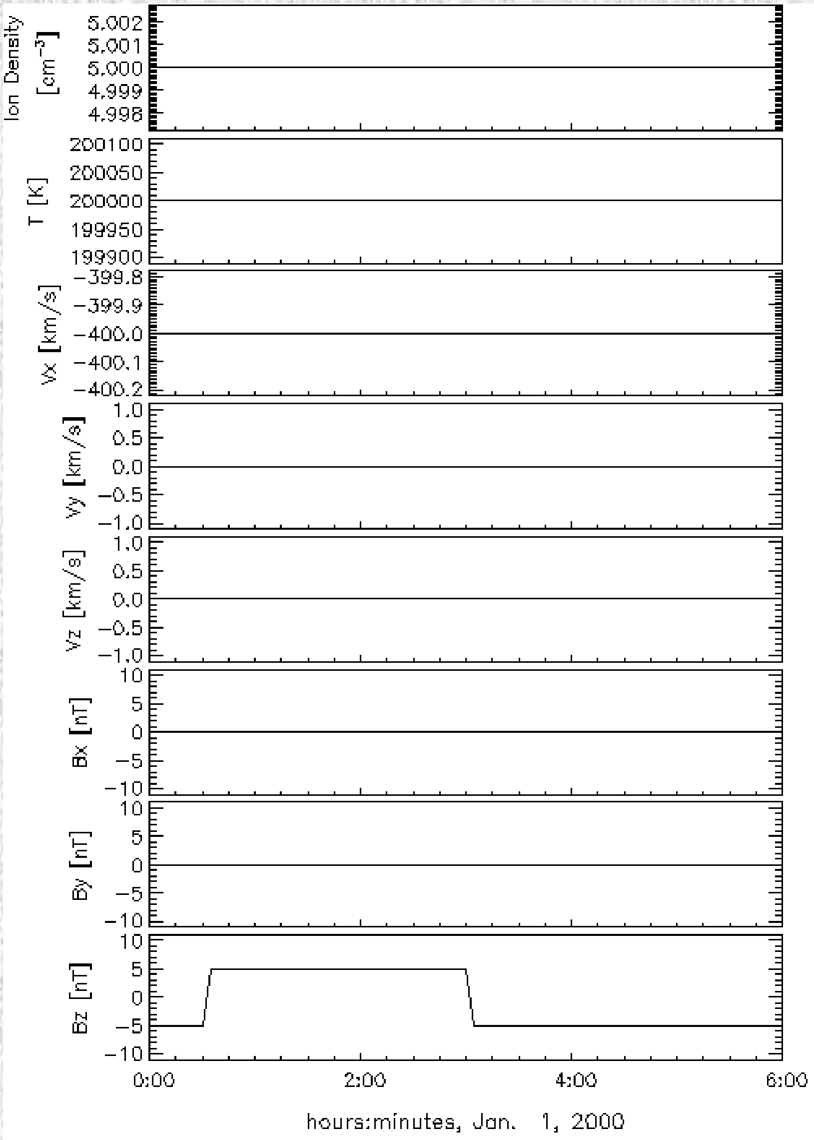
BATSRUS: (33…-255 Re)

Need 8 min to propagate to ionosphere

Open GGCM: (24…-350 Re)

Need 6 min to propagate to ionosphere

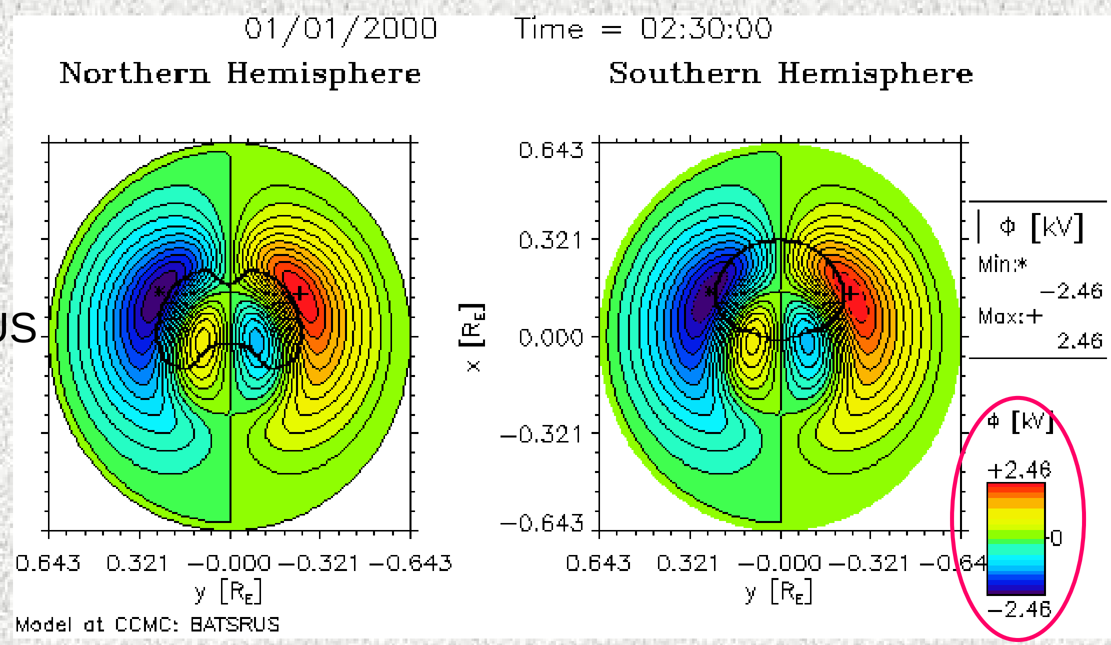
Ionosphere: Uniform Pedersen Conductance



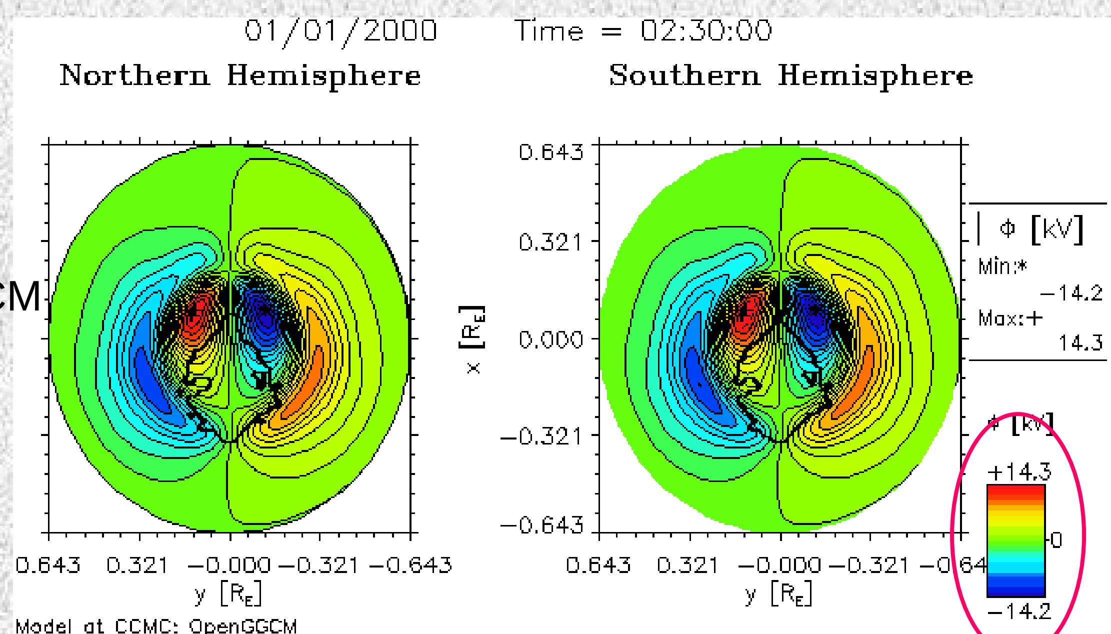
Comparison of the Ionospheric Potentials

- By 02:30 both reached a quasi-steady configuration
- Polar cap potential is small for both.
- Details of the convection pattern and polar cap boundary are different.

BATSRUS



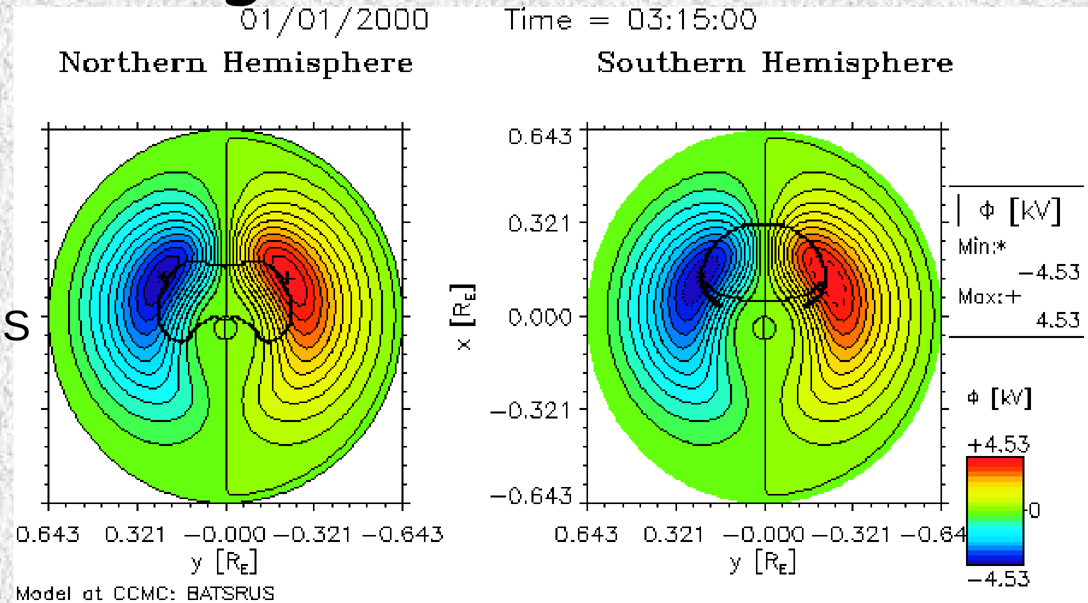
OpenGGCM



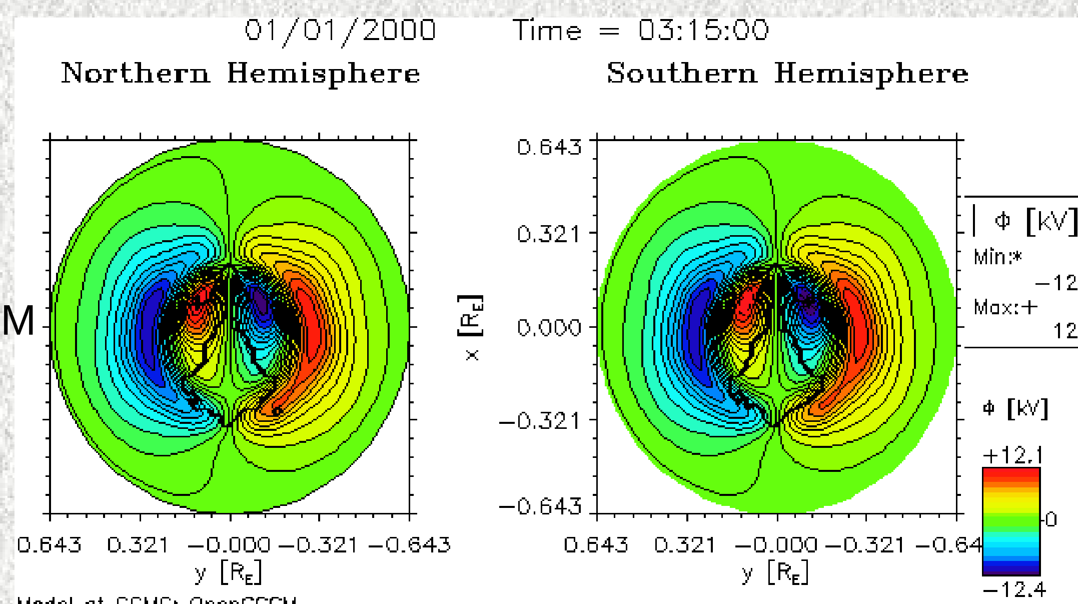
Fifteen Minutes After the Southward Turning

- BATSRUS: two (three?)-cell convection pattern; Φ starts to increase
- Open GGCM: still show four-cell convection pattern; Φ continues decreasing?

BATSRUS



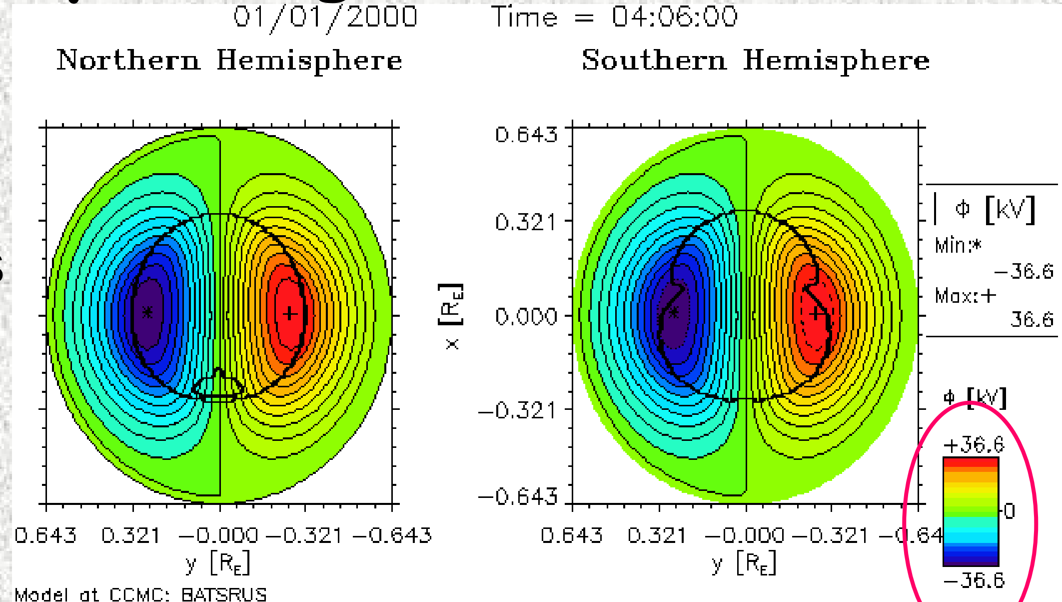
OpenGGCM



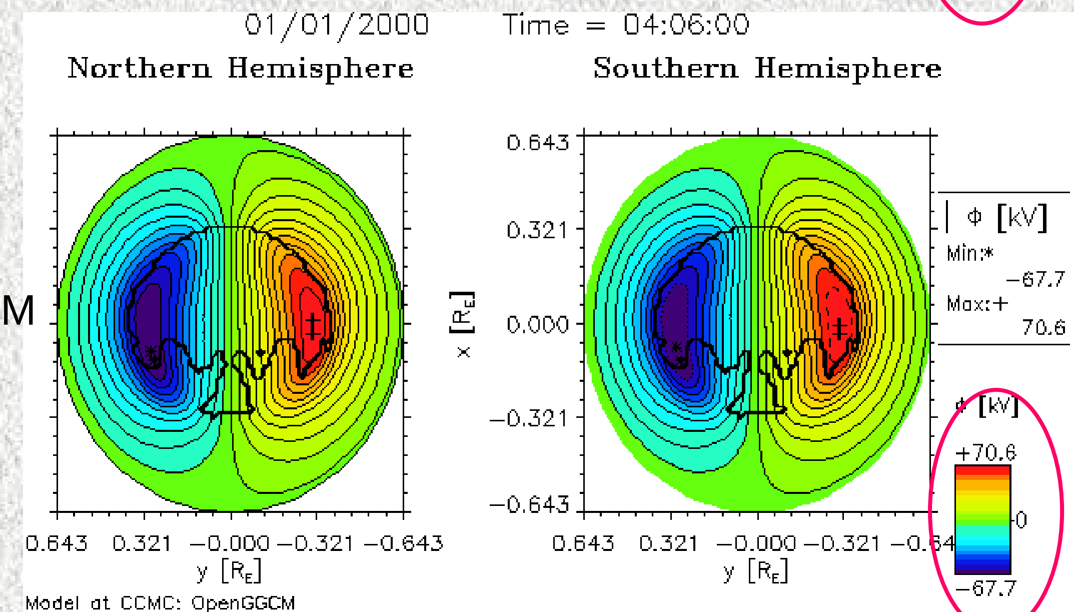
Both Models Reached a Quasi-steady Configuration

- Similar two celled convection patterns
- Potential difference was larger on GGCM than on BATSRUS.

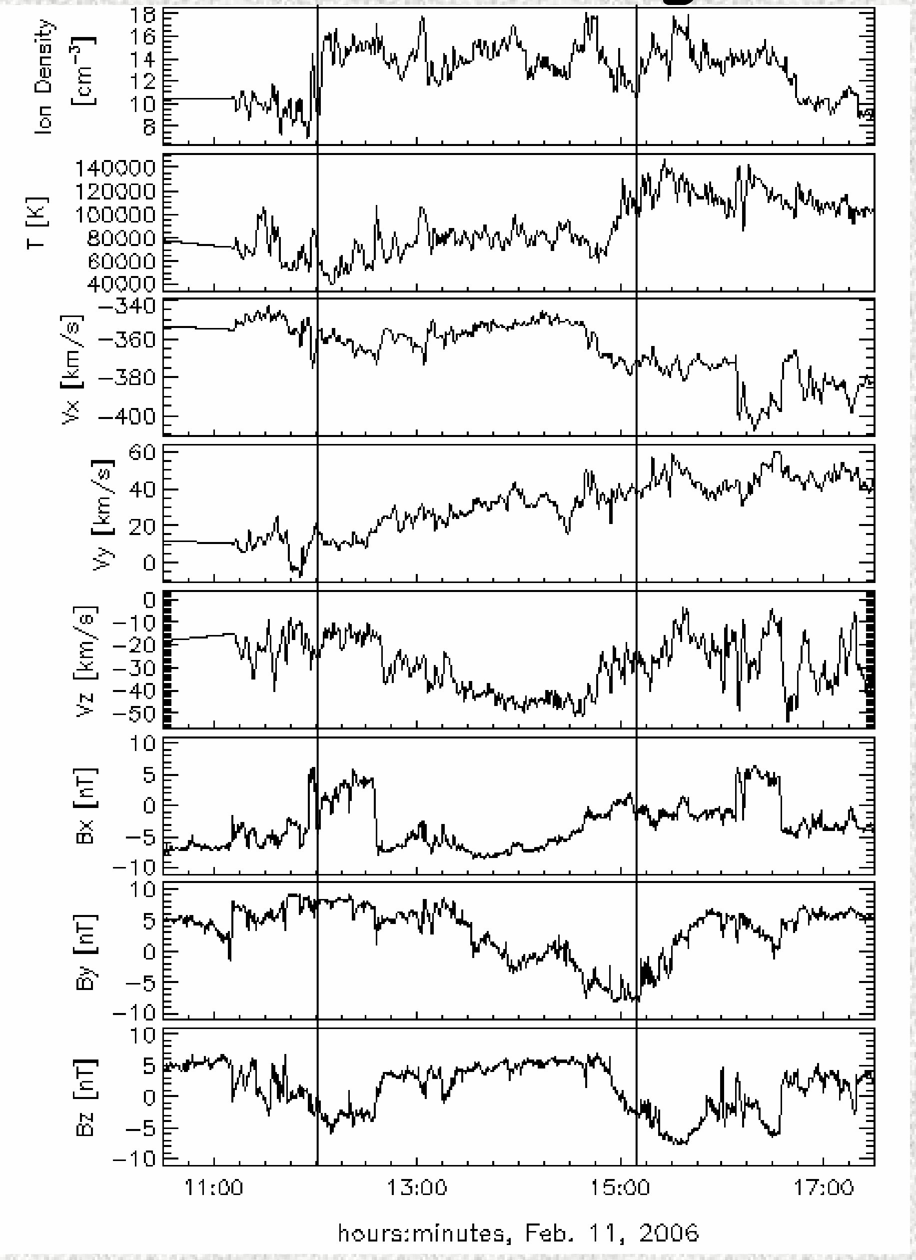
BATSRUS



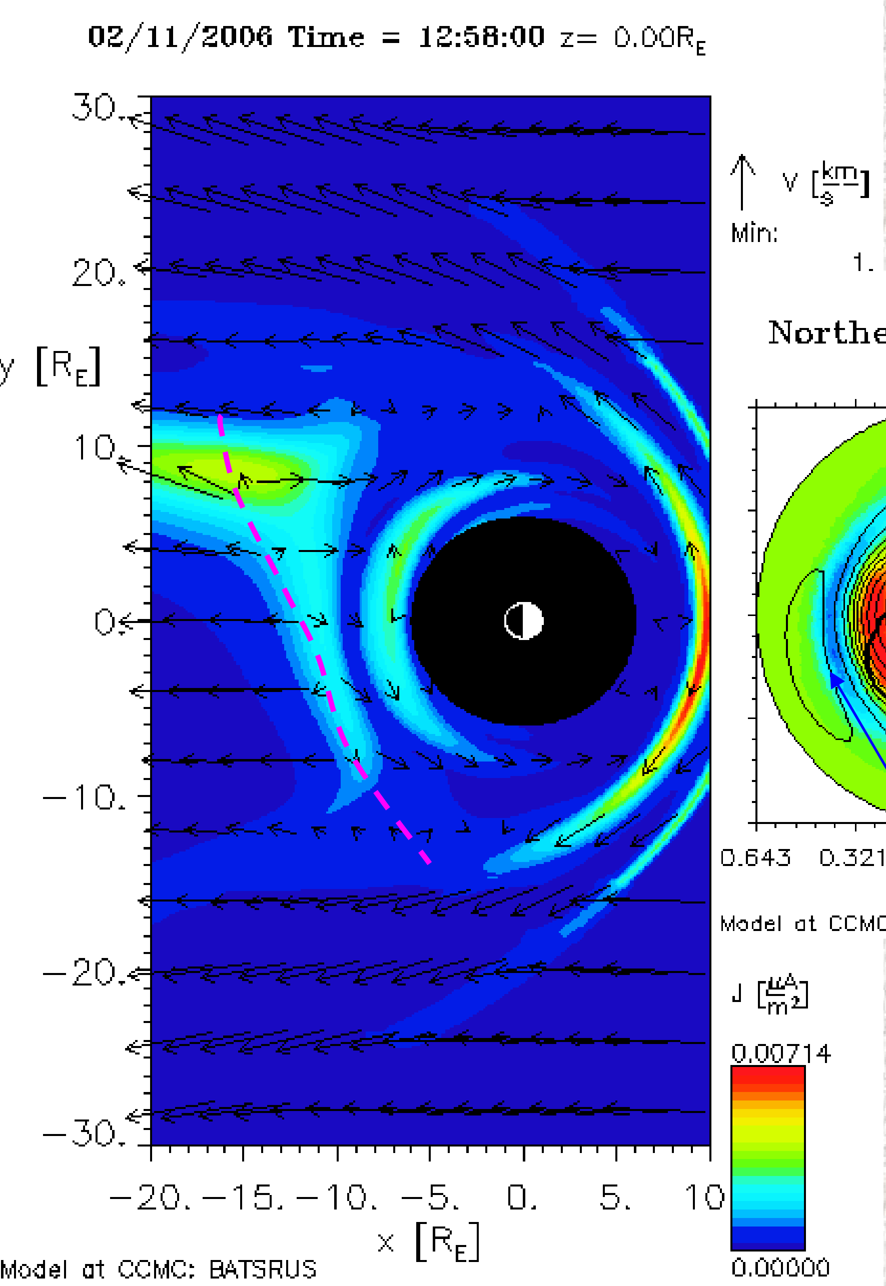
OpenGGCM

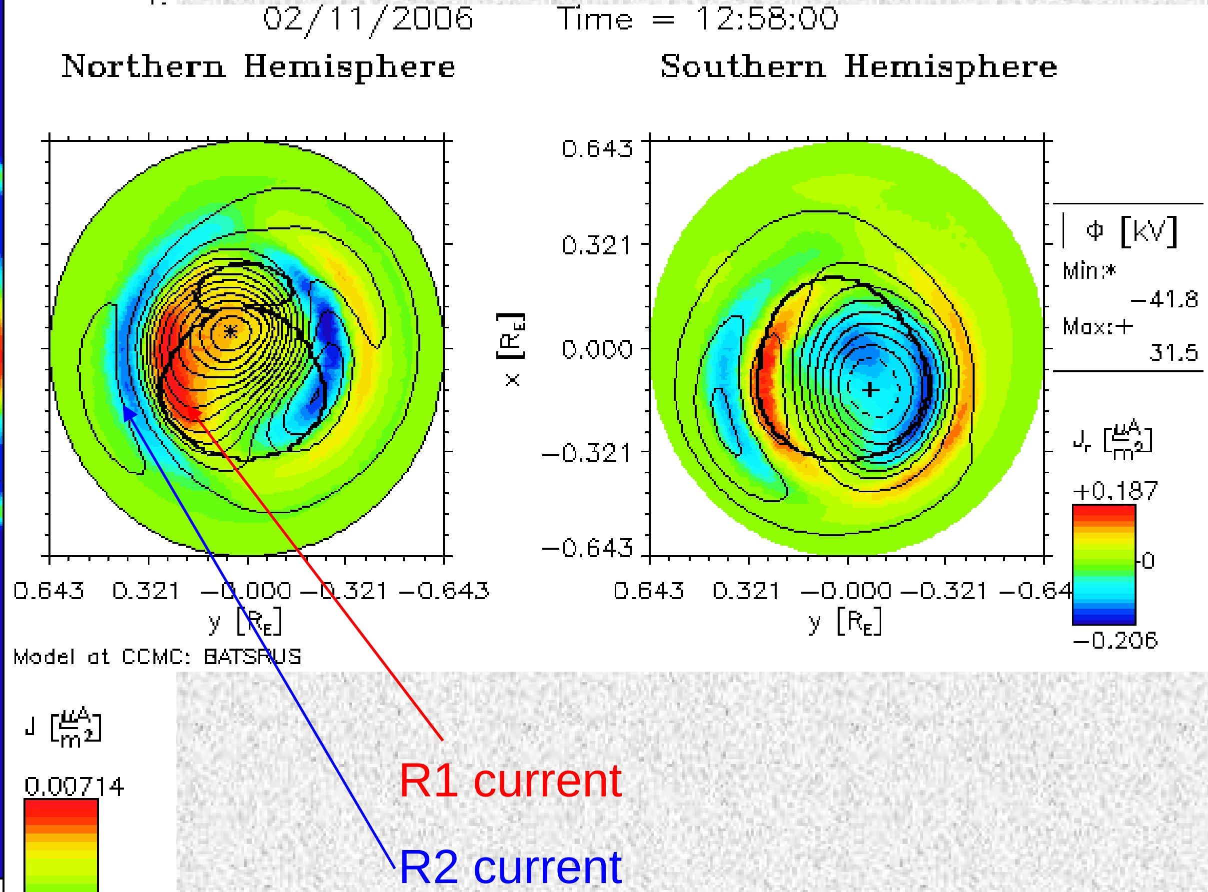


ACE Solar Wind Observations: February 11, 2006 – Marisa Vogt Lead

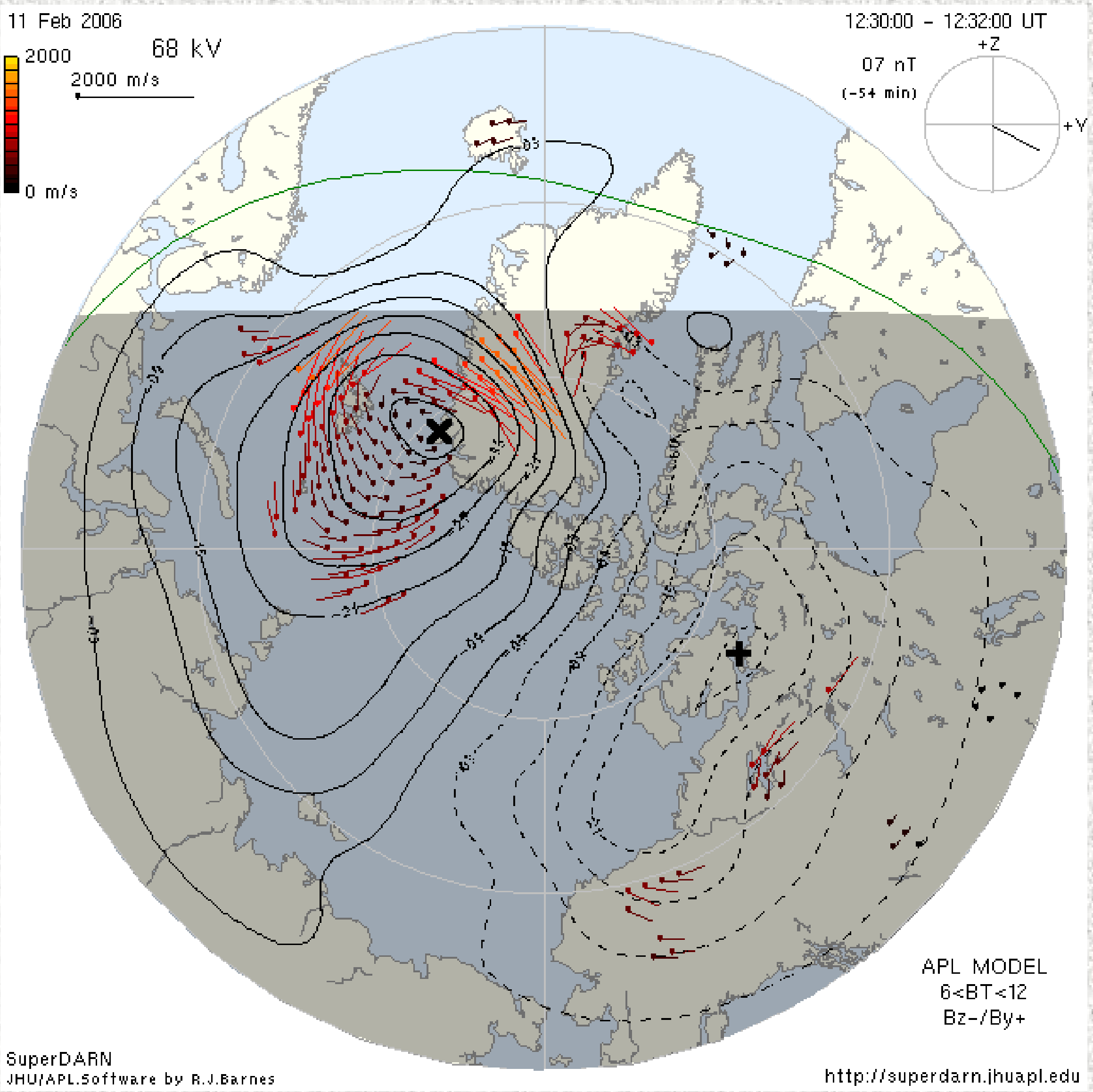


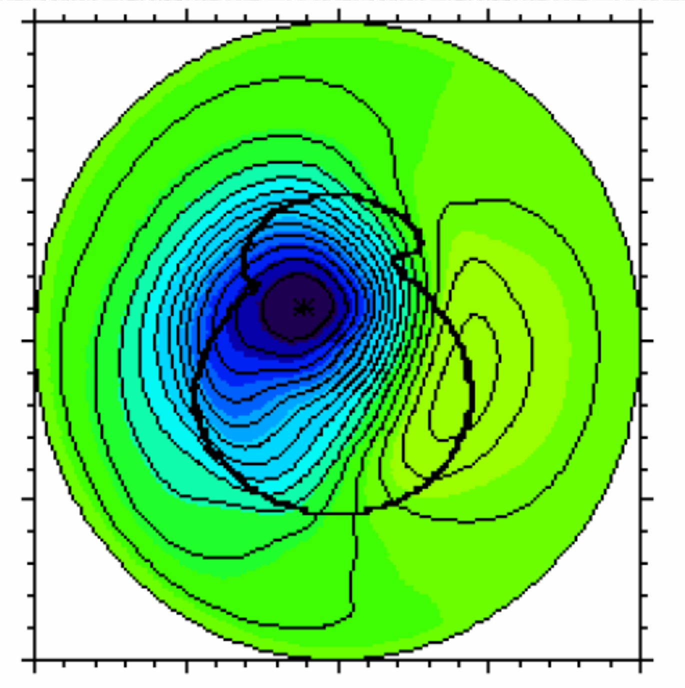
BATSRUS and the Rice Convection Model



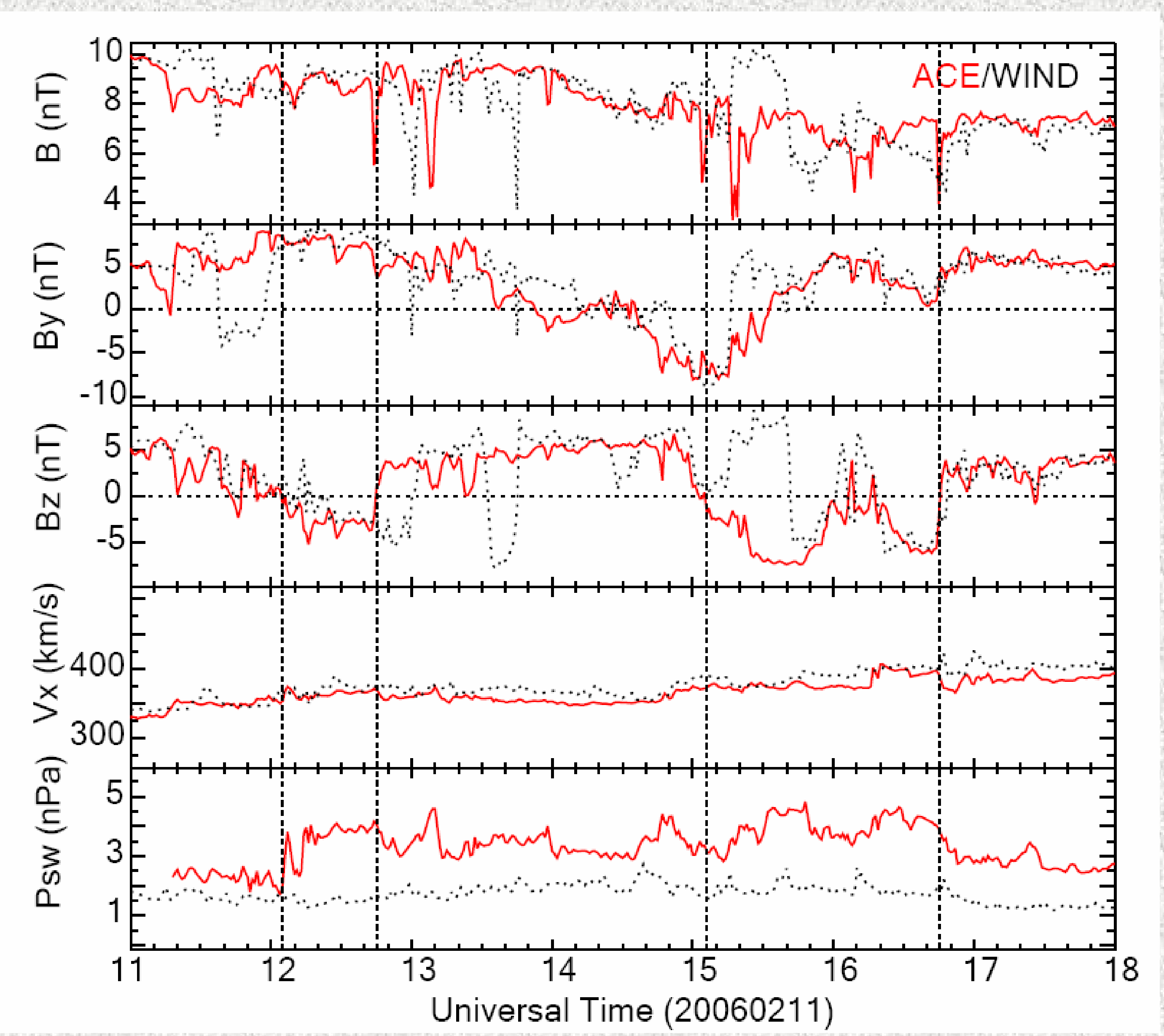


Comparison After the Southward Turning: Agreement is Good





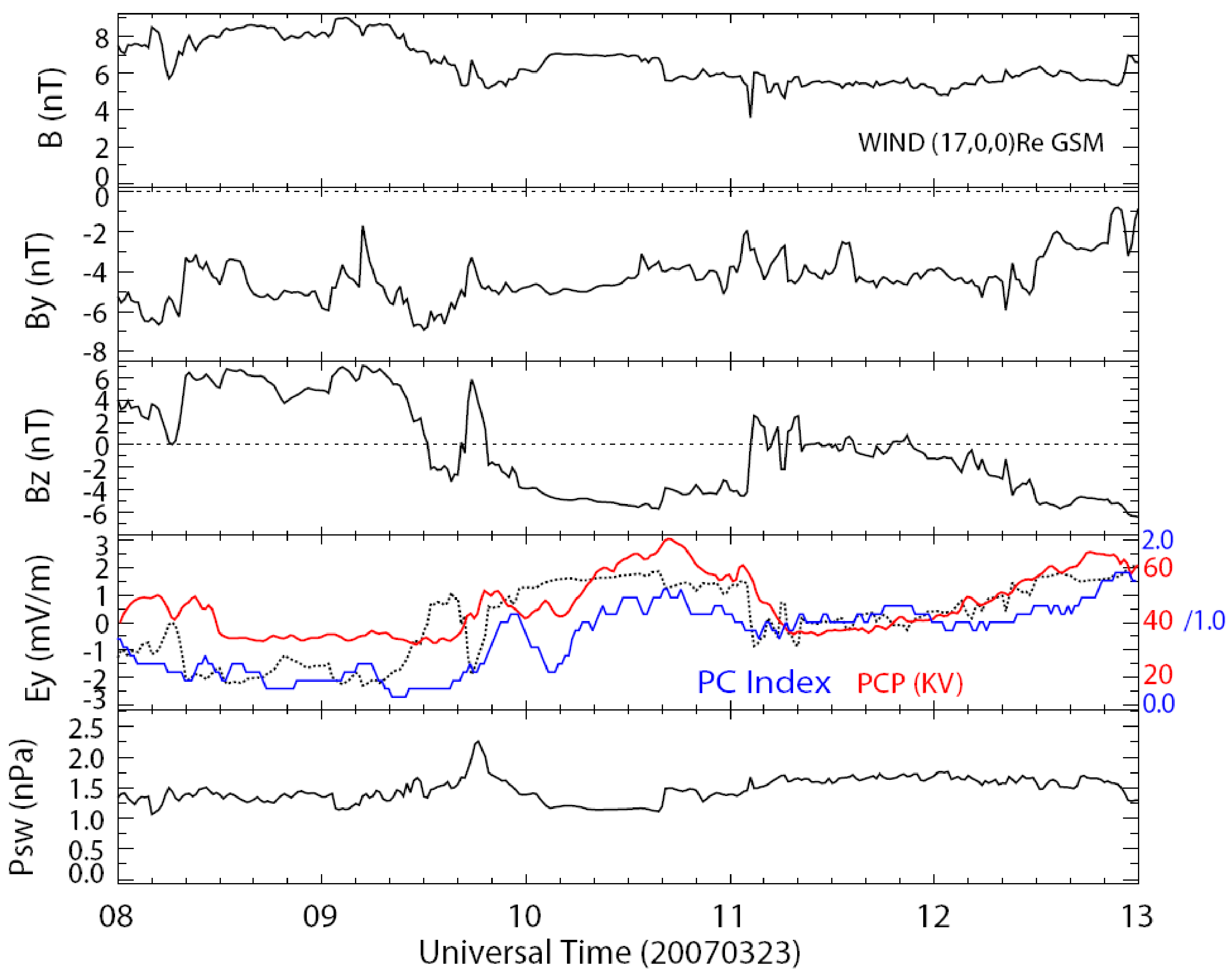
Comparison between Propagated Wind and ACE Solar Wind Observations



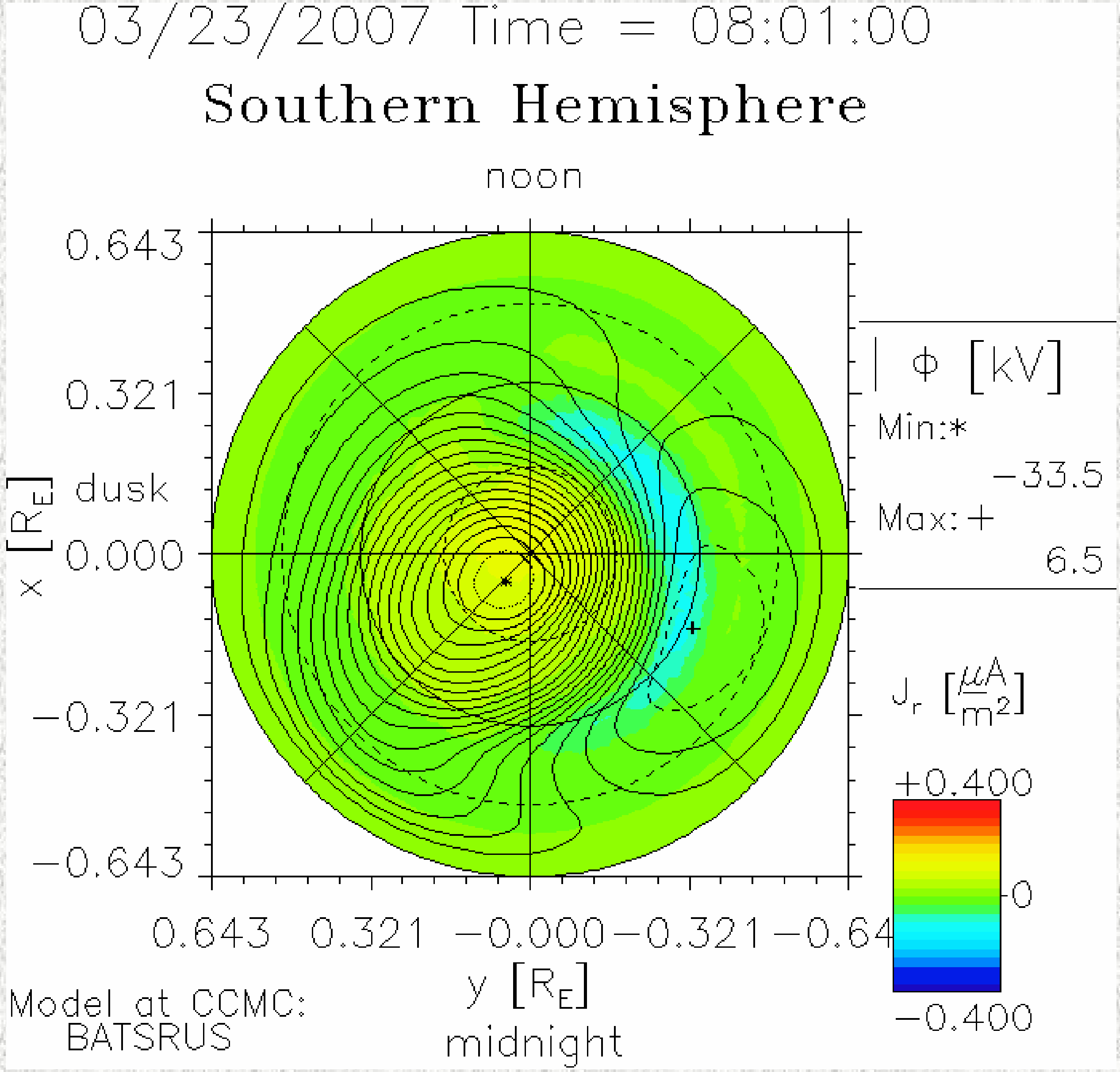
EPILOGUE

- Overall the students liked the class (I got very good grades).
- The one criticism was that they wanted to get actual hands on experience running codes and modifying them.
- Vassilis Angelopoulos saw the students working on the simulations and asked them to model an event for THEMIS.
- Two to the students (Shasha Zhu and Xianzhe Jia) wanted to work on the THEMIS event and asked if I would continued the class into the summer.
- They currently are working on a substorm event that Vassilis selected.

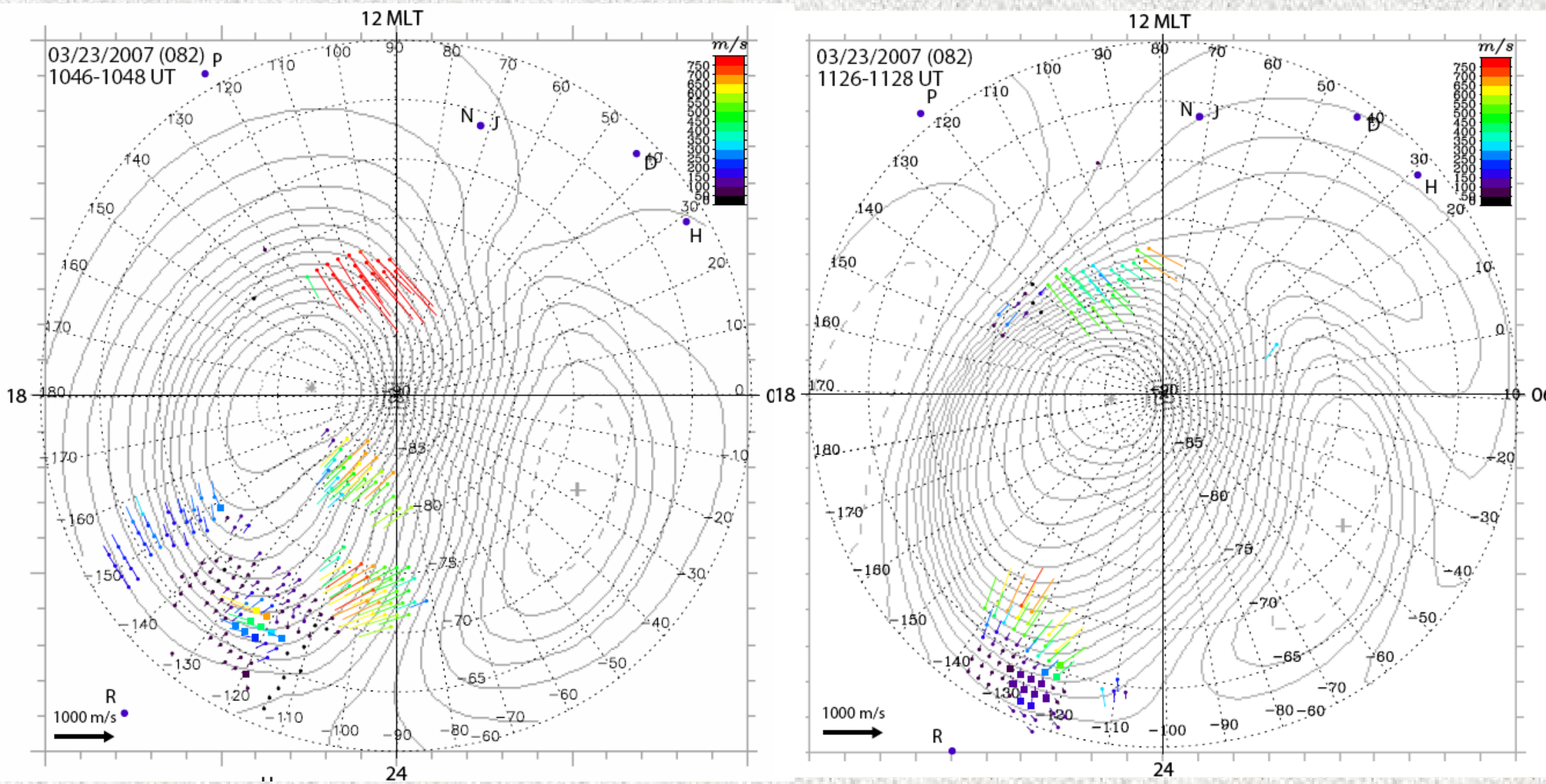
Solar Wind Parameters for March 23, 2007



Ionospheric Convection and Field Aligned Currents



Comparison of Radar Observations and Simulation Results



Heliophysics Summer School
Organized by George Siscoe
Plasma physics of the local cosmos

1	Introduction to common processes in our local cosmic laboratory: Magnetic processes and couplings, and Generation of structures and transients				Cosmic reality: common processes in action	Couplings in action	Transients in action	IHY school day
	Day 1 Monday, July 30	Day 2 Tuesday,July 31	□Day 3 Wed., Aug. 1	Day 4 Thurs., Aug. 2	Day 5 Friday, Aug. 3	Day 6 Sat., Aug. 4	Day 7 Monday Aug. 6	Day 8 Tues., Aug. 7
8:30-10:00 (incl. 15 min break)	Introduction to Heliophysics Tom Bogdan	Magnetic reconnection Terry Forbes	Magnetic field structures: Cavities and ropes Mark Moldwin	Turbulence: macro- and micro-scale Chuck Smith	Comparative planetary environments Fran Bagenal	Solar/stellar winds & magnetic fields Viggo Hansteen	CMEs & flares Terry Forbes	Explosive energy conversion Craig DeForest
10:30-12:00 (incl. 15 min break)	Creation and destruction of magnetic fields Matthias Rempel	Magnetic field topology and electrical currents Dana Longcope	Field-plasma-neutral interactions Fran Bagenal	Comparative magnetospheres Vytenis Vasyliunas	Solar/stellar environments Viggo Hansteen	Solar wind-magneto-sphere-ionosphere coupling Frank Toffoletto	Magneto-spheric storms & substorms Frank Toffoletto	Energetic particles from solar eruptions Mihir Desai
1:00- 3:00	On-line data from Space Physics Data Facility, etc. Aaron Roberts	Basic magnetic topologies George Siscoe	Photosphere -heliosphere connections Karel Schrijver	Viewing Tsyganenko models with CISM DX Michael Gehmeyer	Tour of m'sphere with CCMC models George Siscoe	Tour of heliosphere with CCMC models George Siscoe	End to end data analysis Ilia Roussev	Long-term trends in Sun-climate Caspar Ammann
3:30- 5:30	On-line models from CCMC Masha Kuznetsova	Using heliophysics data Barbara Thompson	Tour of local facilities (SEC, LASP, NCAR)	Student 1-on-1 discussions with mentors	Ionosphere/ Thermosphere Tim Fuller-Rowell	Modeling CMEs with CCMC models George Siscoe	Q/A discussions with teachers	Discussions, presentation, expectations, and evaluation

Combined formal presentations with hands on examples using CCMC

Tour of the Magnetosphere with CCMC

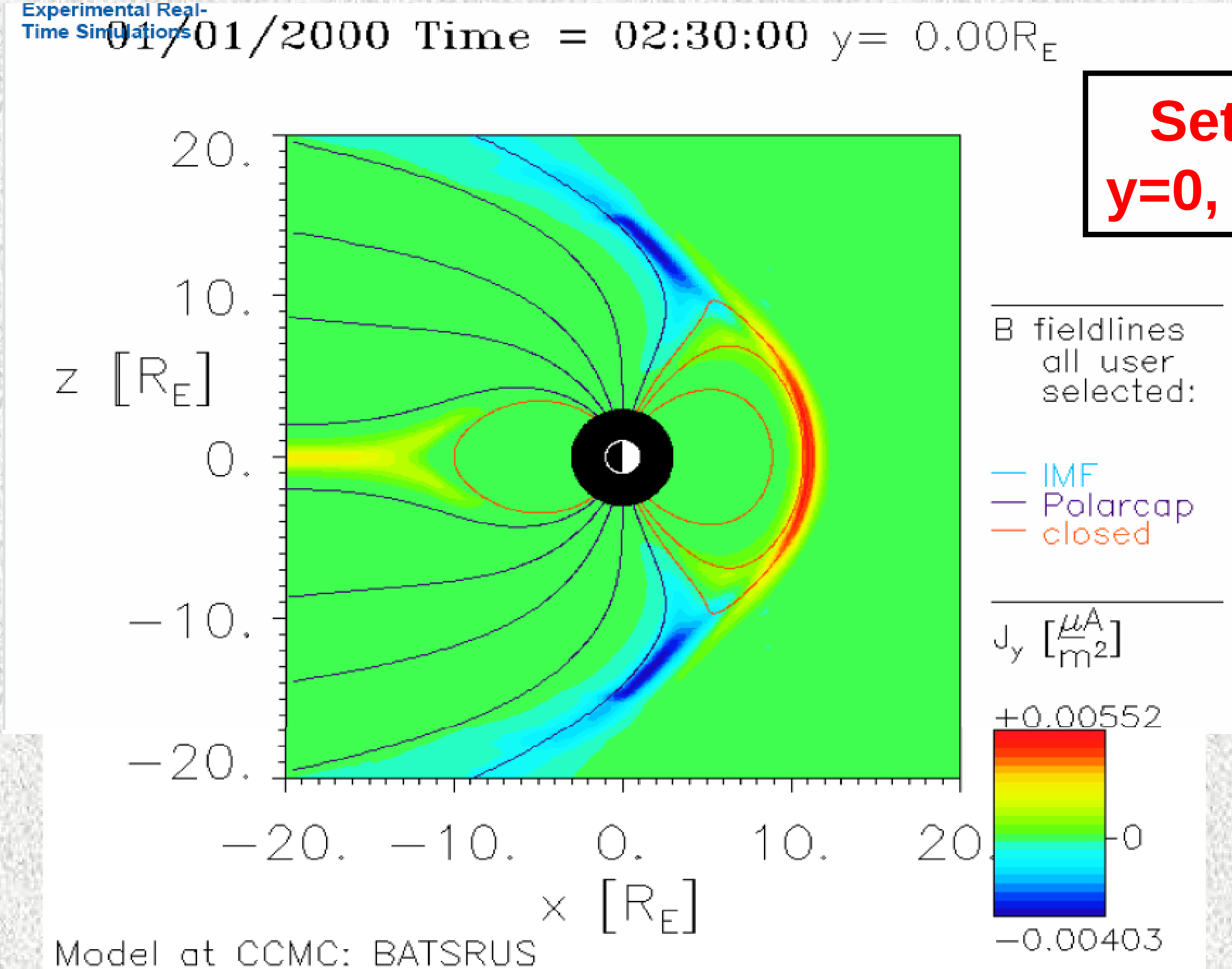
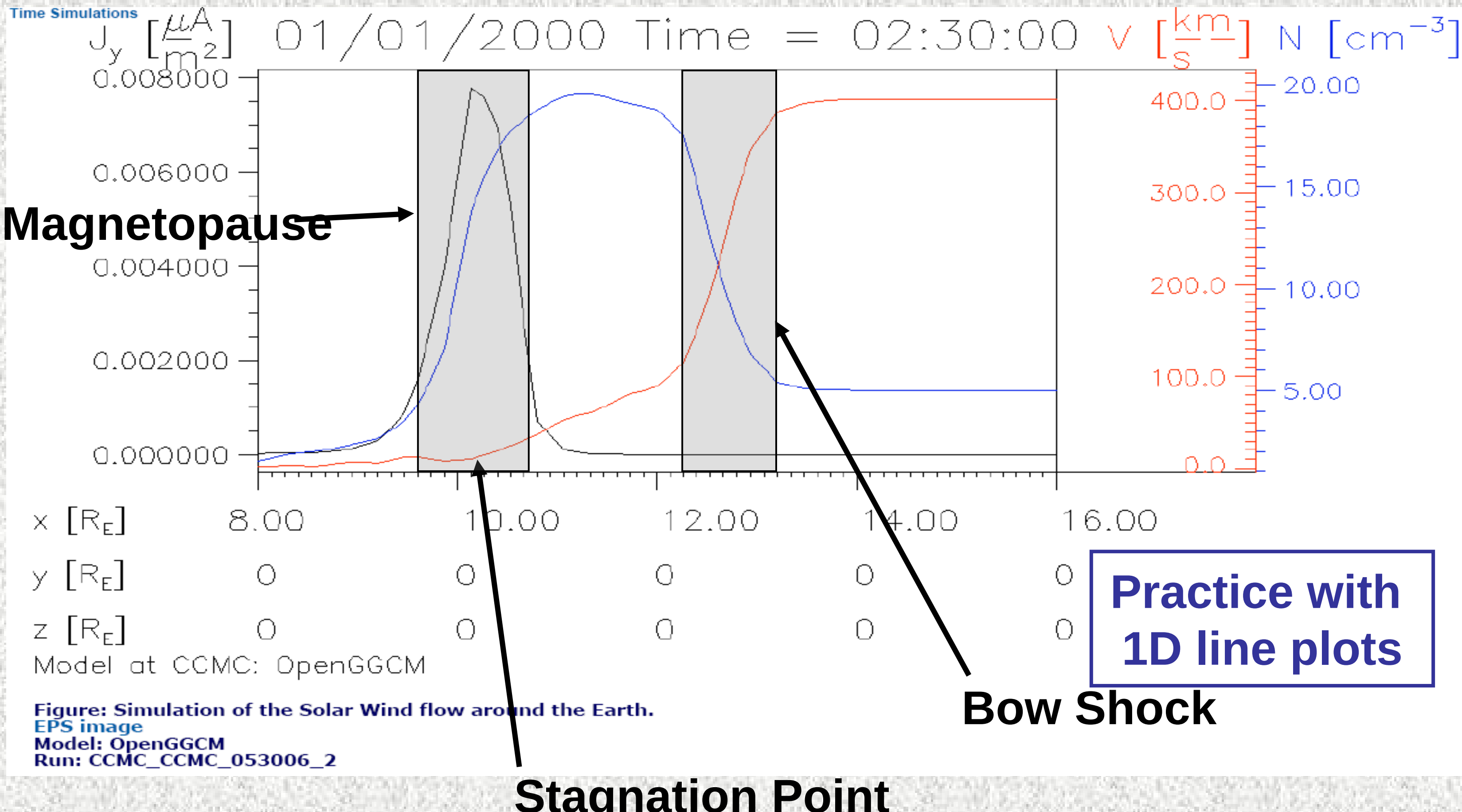


Figure: Simulation of the Solar Wind flow around the Earth.
EPS image
Model: BATSRUS
Run: CCMC_CCMC_053006_1

Setup for Z IMF, y=0, J_y, & field lines

Practice with 2D color contour plots

Flying through the bow shock and magnetopause



1. Make similar plots of (N, T, P) and (P, P_{ram})
2. Find ratio of $P_{stagnation}$ to P_{ram}

A Personal Evaluation of CCMC

- As an outsider I cannot evaluate CCMC's operations task.
- It is an integral part of space physics research. This is recognized world wide.
- It has proven to be extremely valuable for education.
  - Demonstrating basic space physics concepts.
  - Teaching graduate students how to make simulations a part of their data analysis effort.
- The next challenge is to help with educating students in simulating.