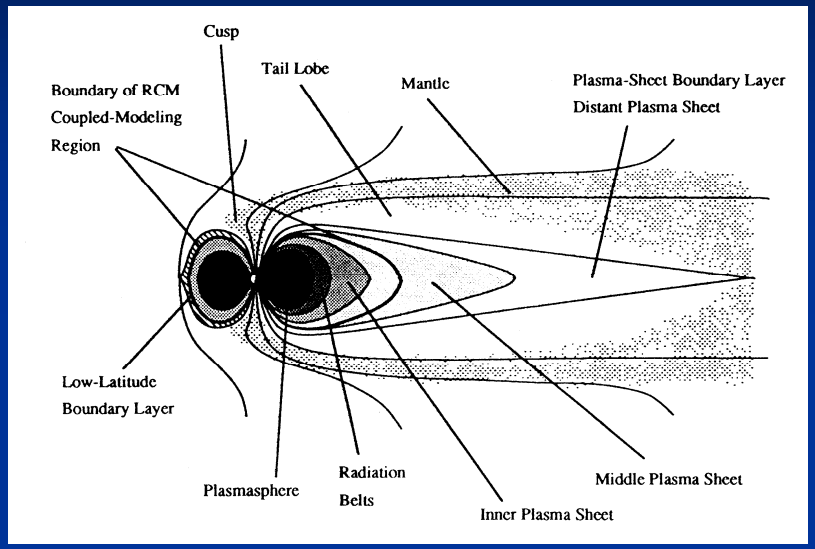
# Rice Convection Model

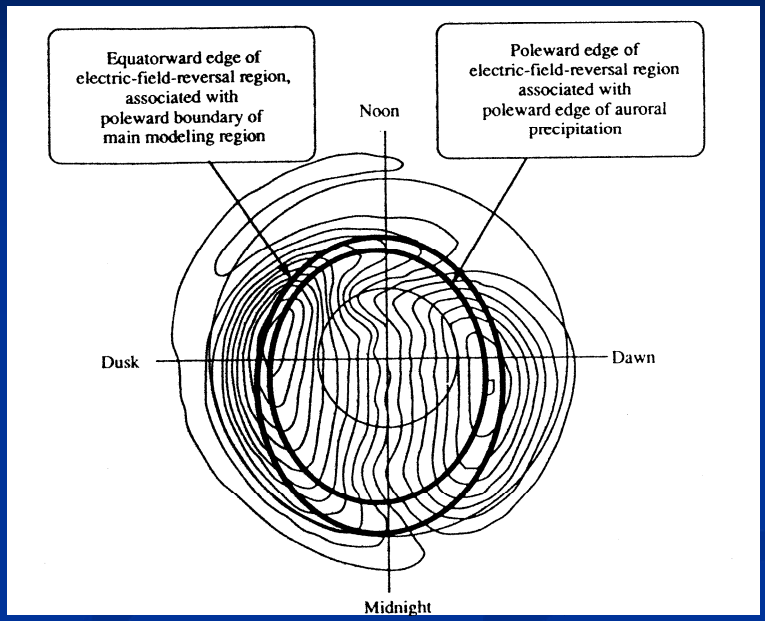
Stanislav Sazykin

Physics and Astronomy Dept.
Rice University, Houston TX

2010 CCMC Workshop, Key Largo

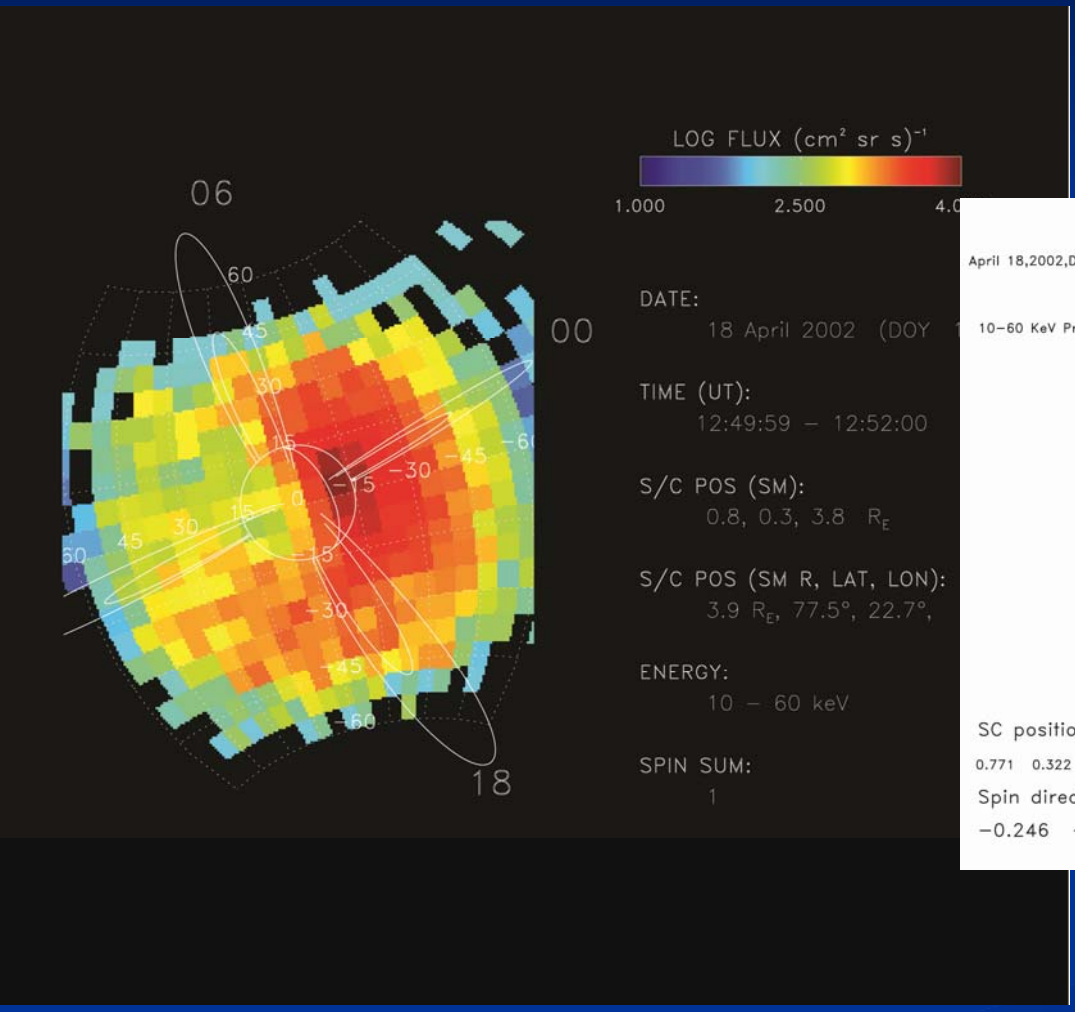
# What the RCM Computes

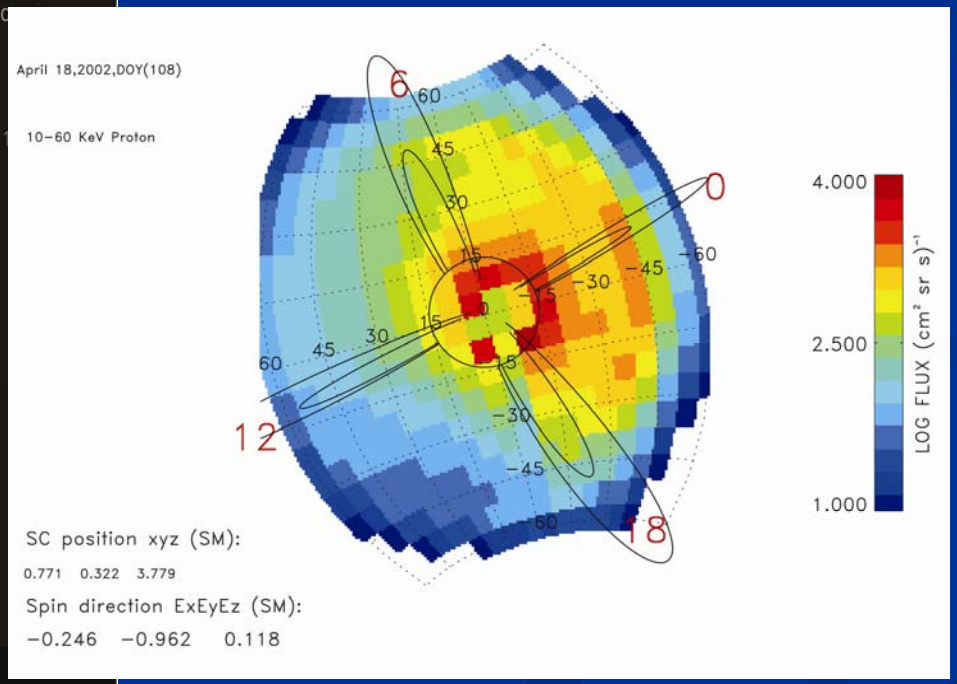



- Ionospheric potential distribution, height-integrated conduction currents
- Field-aligned currents
- Auroral electron precipitation (flux versus energy and moments)
- Phase space density of magnetospheric particles
- Magnetospheric electric field

# HENA images of Storm-Time Ring Current

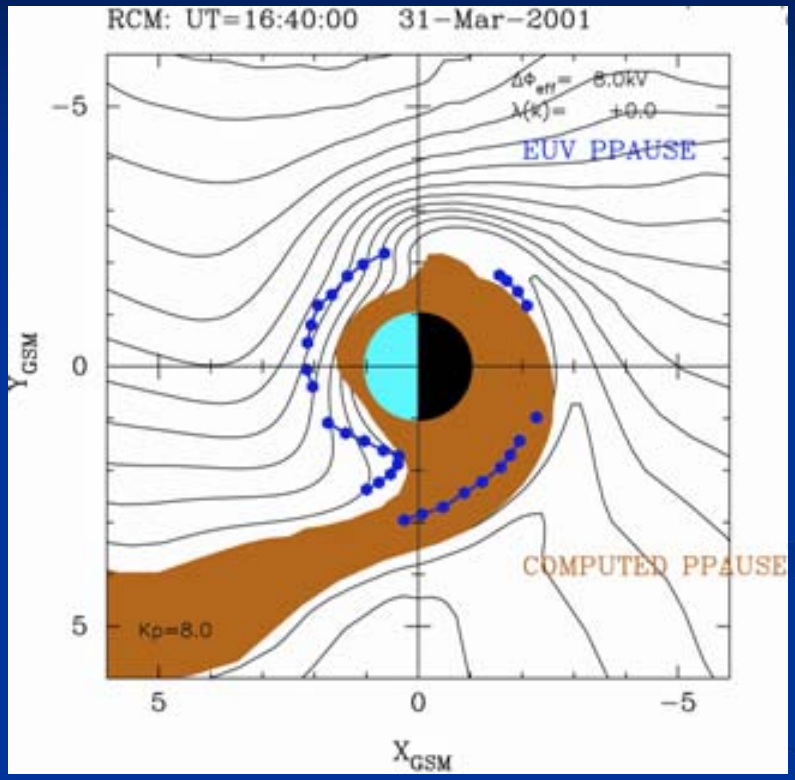



Data

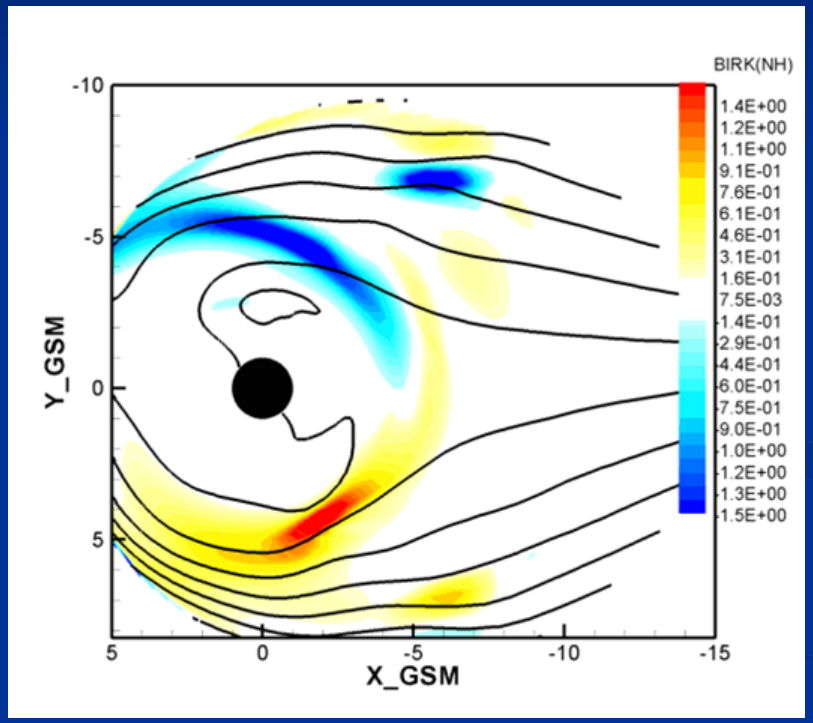
Model

# Storm-time Plasmapause




RCM-computed plasmapause calculated with T03S. The location of the boundary is shown by filling the entire plasmasphere with orange color. Location of the plasmapause derived from EUV image data (blue symbols).

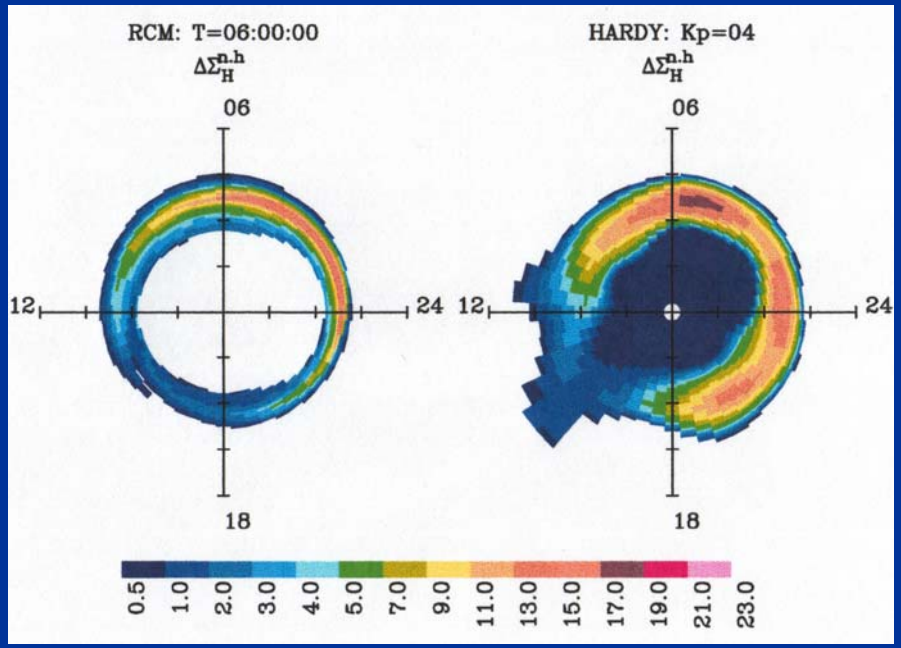
# Field-aligned currents provide large-scale electromagnetic coupling to the ionosphere.

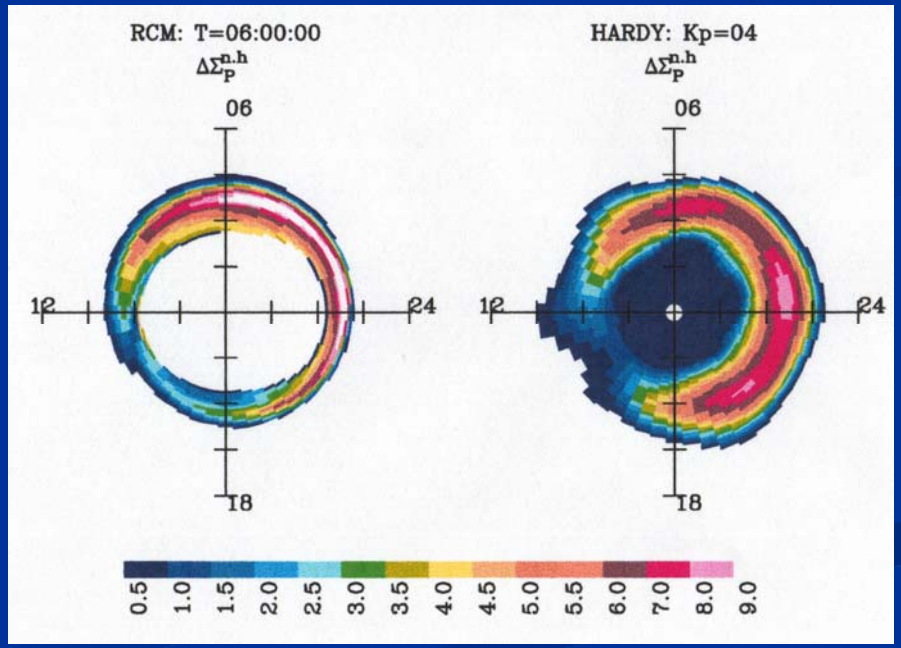



Φ contour spacing is 4 kV. Same time period. Currents are downward (red) and upward (blue).

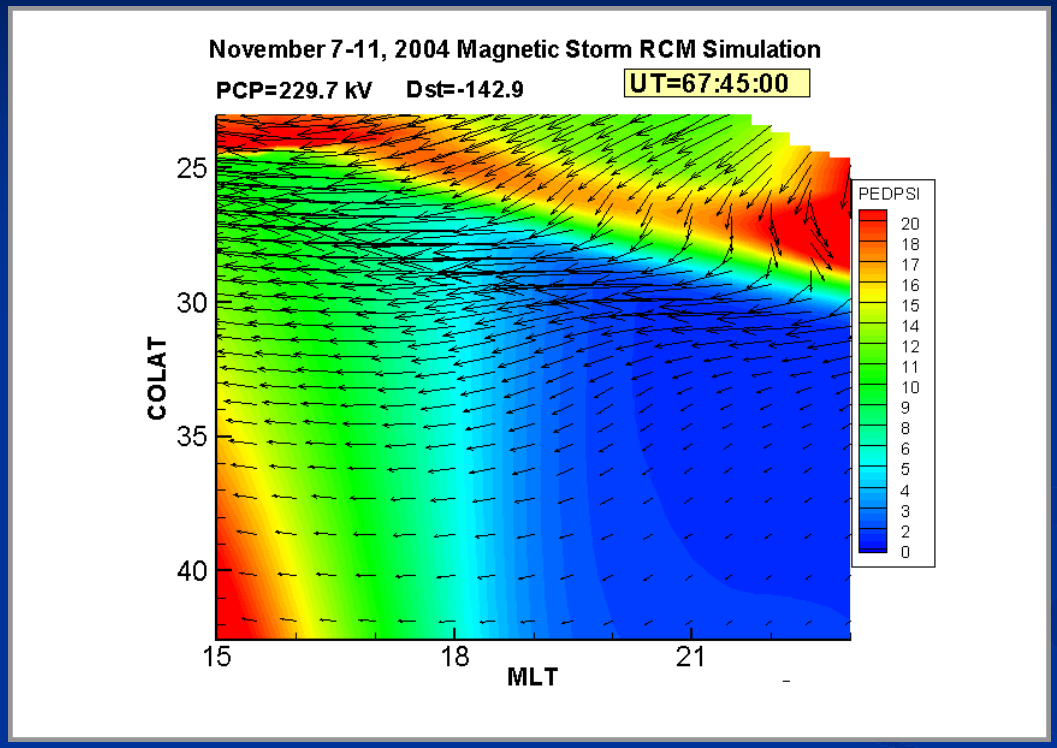
# Auroral Precipitation

- Contribution from auroral electron precipitation (diffuse aurora): evaluated from the electron population assuming a fixed fraction of the strong pitch-angle scattering rate and applying *Robinson et al.* formulas:



# Ionospheric ExB flows

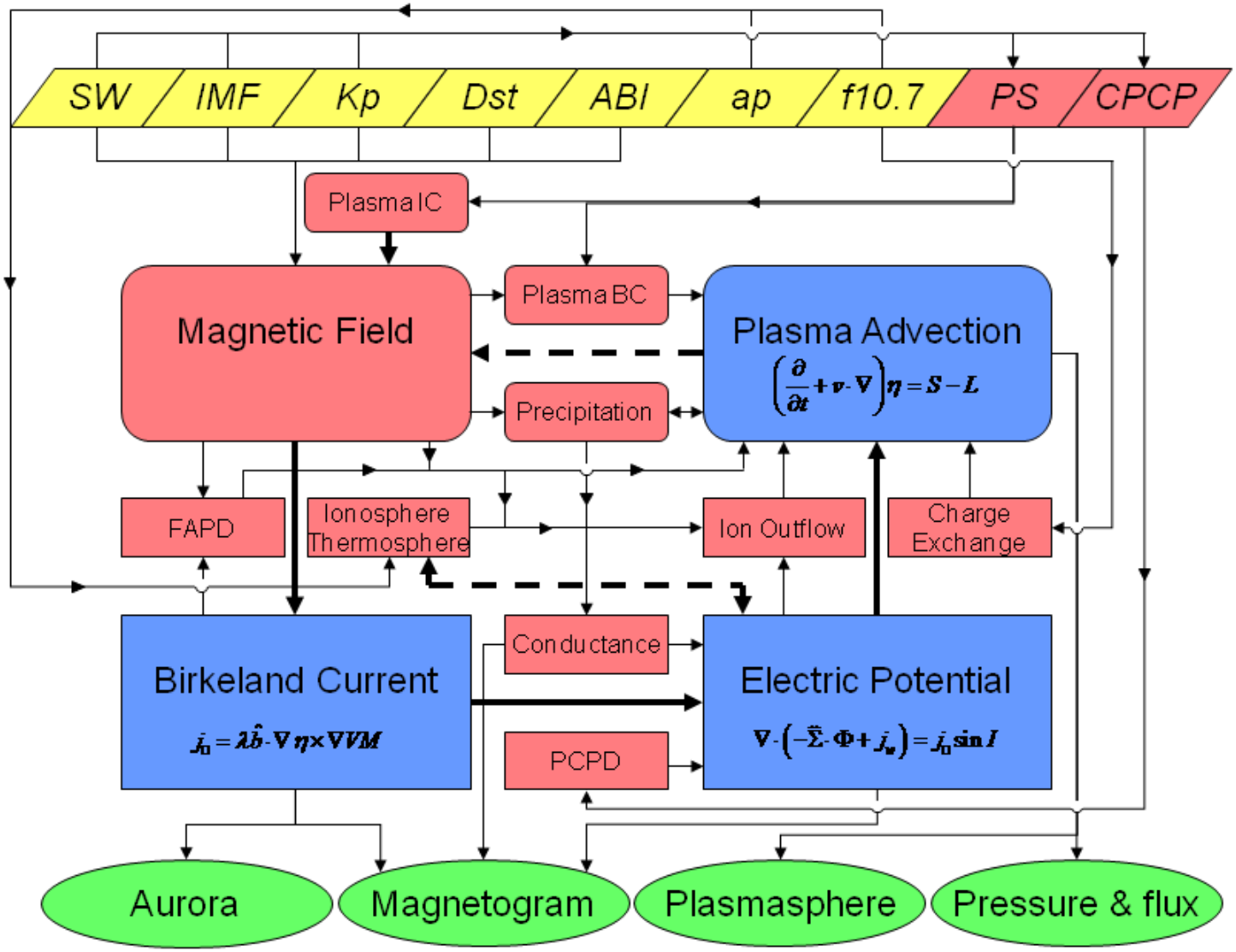



Subauroral Polarization Stream Structures in the evening ionosphere

ExB flows and associated ionospheric horizontal currents are computed to 10° latitude or magnetic equator

- RCM has been effective as a scientific tool
  - Explaining observed phenomena
  - Illuminating physical processes
  - Investigating cause-and-effect relationships.

# Rice Convection Model



# (Some) RCM Inputs

| | |
|---|---|
| *Magnetic field* | *Tsyganenko* B-field models driven by solar wind data as background. Fit measured **B** for modeled event using Grad-Shafranov corrections |
| *Particle initial condition* | *Spence and Kivelson* [1993] empirical pressure distribution |
| *Particle DF at high-L boundary* | Basic *P* and *n* from *Tsyganenko and Mukai* [2003], $T_e/T_i \sim 1/7$ [*Baumjohann et al*., 1989], ion composition estimated from [*Young et al*., [1982]. |
| *Potential at high-L boundary* | PCP estimated from DMSP ion-drift meter observations or from solar wind data and *Boyle et al*. [1997]. Weimer (2005) potential pattern |
| *Ionospheric conductance* | IRI-90 for quiet-time conductance + auroral enhancement based on *Robinson et al*. [1987] formula and RCM-computed precipitation. |

# RCM Predicted Parameters

| **RCM Predicted Parameter** | **Possible Data Sources** |
|---|---|
| Ionospheric E field or ExB drift | Polar orbiters, incoherent- or coherent-scatter radars |
| Field-aligned currents ($\Delta\mathbf{B}$) | Polar orbiters |
| Magnetospheric **E** or flow | Inner-magnetospheric spacecraft |
| Kilovolt particle fluxes in magnetosphere | Geosynchronous or ring-current spacecraft, ENA imagers |
| Auroral precipitation | Polar orbiters, space-borne or ground imaging |
| Plasmasphere | EUV images |
| Ground magnetic fluctuations, magnetic indices | Ground magnetometers |

# RCM Code Details

- Standard Fortran-90 (~25,000 lines with plenty of comments)
- Available to anybody interested.
- Portable
- Runs reasonably fast with typical settings
- Post-processing utilities (Fortran code) to convert binary files to either IDL or Tecplot readable files.
- Code is kept and maintained in a Subversion (prev. CVS) repository since 2005.
- Actively developed by our group.

# RCM and Related Models

Magnetospheric Specification Model (MSM)

- Developed by Rice group in late 1980's—early 1990's for the U.S. Air Force.
- Based on RCM at that time but employed computational shortcuts:
  - Dictated by speed of computers at the space forecasting centers.
  - Electric fields and field-aligned currents were not computed consistently with plasma dist.
- MSFM was designed for specification and short-term forecast of fluxes of the kilovolt electrons that cause surface charging of geosynchronous spacecraft, (but calculated other quantities as well).
- Part of AF-GEOSpace Space Environment Software Program, also in NASCAP-2k.

Comprehensive Ring Current Model (CRCM)

- Developed in late 1990s in collaboration with Mei-Ching Fok
  - Electrodynamics part is the RCM code
  - Particle drift physics is the Fok ring current model (has pitch-angle dependence)
  - Auroral conductance is purely empirical (Hardy et al.) model—no self-consistent auroral boundaries

# Summary

- A version of RCM may be suitable for CCMC
- Advantages:
  - more science can be done that just by model developers
  - extensive comparison with multiple data sets
  - inclusion of recent science
  - flexibility with inputs
  - suitable for limited studies (e.g., geo fluxes, plasmasphere)
- Disadvantages
  - Requires work
  - Size of I/O for d.f.
- Good to have in addition to global coupled codes at CCMC