# Coupled Magnetosphere Ionosphere Thermosphere Model

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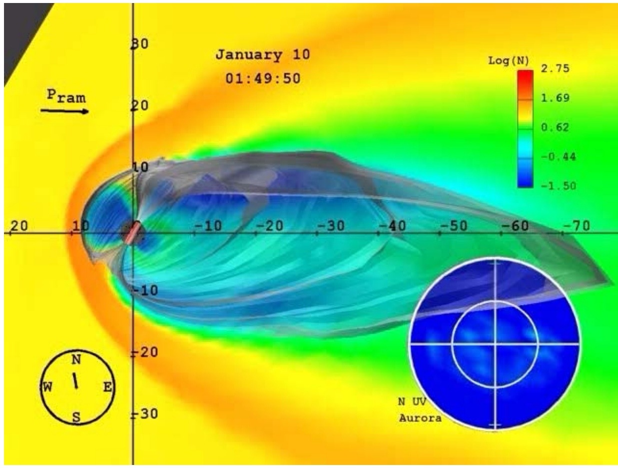
# LFM Magnetospheric Model

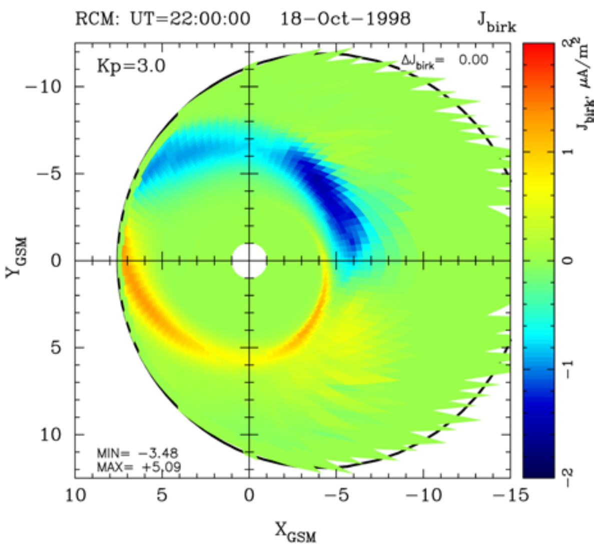
- Uses the ideal MHD equations to model the interaction between the solar wind, magnetosphere, and ionosphere,

  now multifluid
  - Computational domain
    - 30 $R_E < x < -300 R_E$ & $\pm 100 R_E$ for YZ
    - Inner radius at 2 $R_E$
  - Calculates
    - full MHD state vector everywhere within computational domain Fraction of s timestep
  - Requires
    - Solar wind MHD state vector along outer boundary
    - Empirical model for determining energy flux of precipitating electrons
    - Cross polar cap potential pattern in high latitude region which is used to determine boundary condition on flow

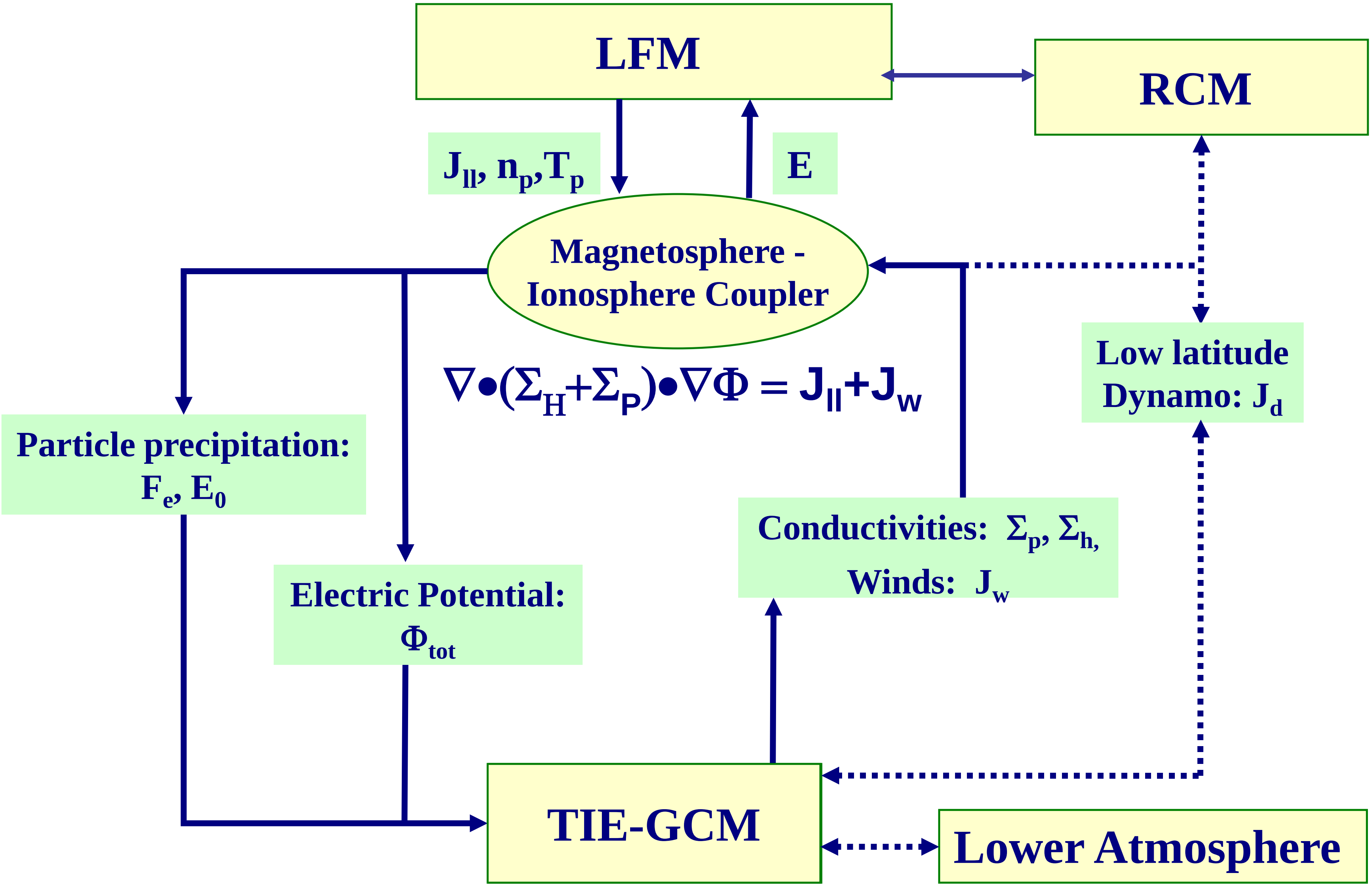


# Rice Convection Model

- Uses drift and current conservation equations to determine the plasma motion, currents, and electric fields in the inner magnetosphere
  - Computational domain
    - Closed slow flow field region of the magnetosphere
  - Calculates
    - Distribution functions of electrons and ion species on flux tubes ~2s timestep
  - Requires
    - Magnetic field model
    - Electric field along high latitude boundary
    - Initial and boundary values for plasma
    - Ionospheric conductance



# Geospace Modeling



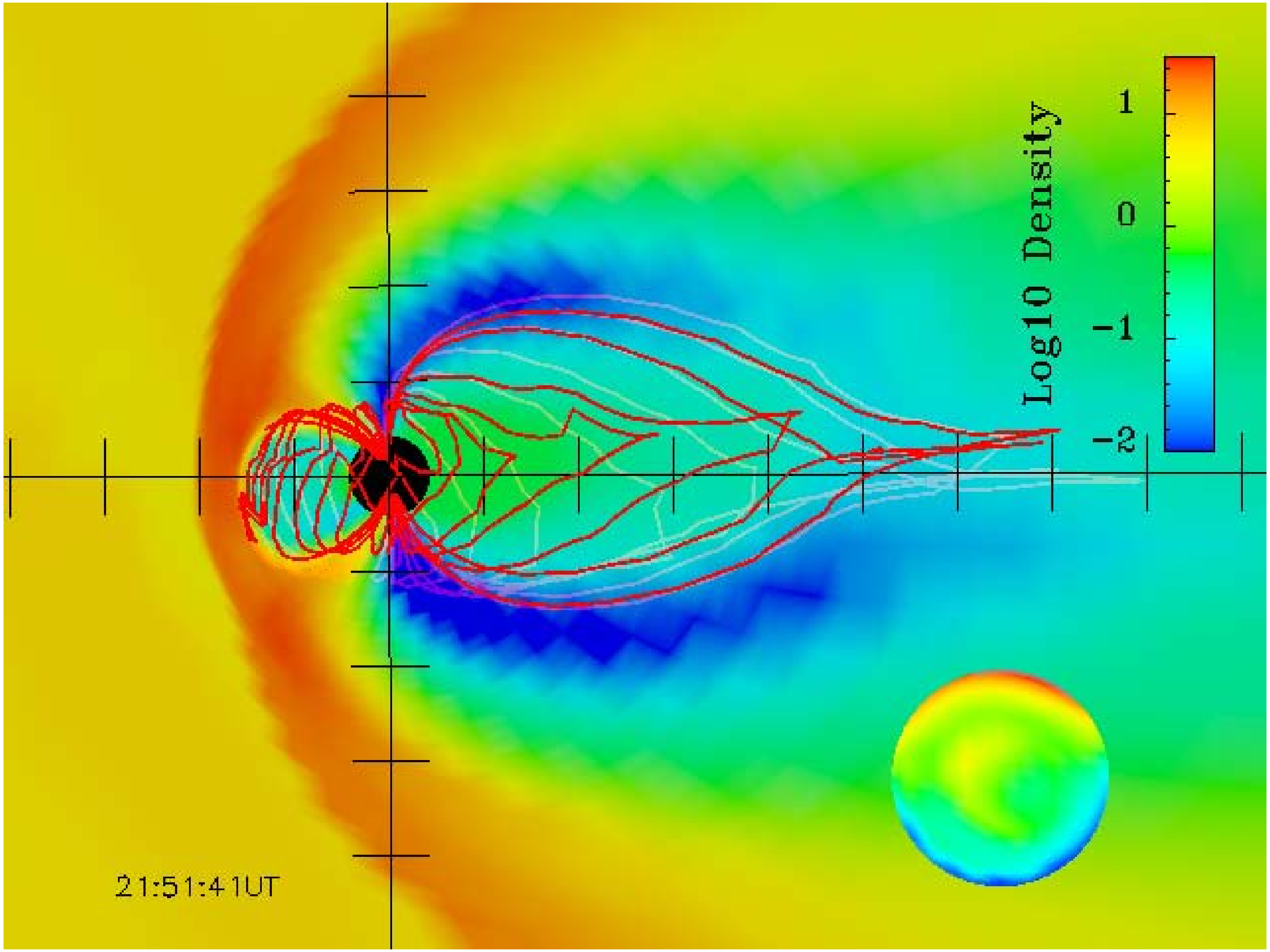
# Code Coupling Technology

- **Programming paradigm that enables efficient coupling of models and is flexible, modular, and extensible**
  - **Efficient transmission of information among codes**
  - **Interpolation of data between grids**
  - **Control mechanisms to synchronize execution and interaction**
  - **Minimal modifications to existing code base**

- ***Intercomm***
  - **A. Sussman (University of Maryland)**
  - **Solution to the “MxN” problem in coupling parallel codes**
  - **Addresses multiple executable control issues**

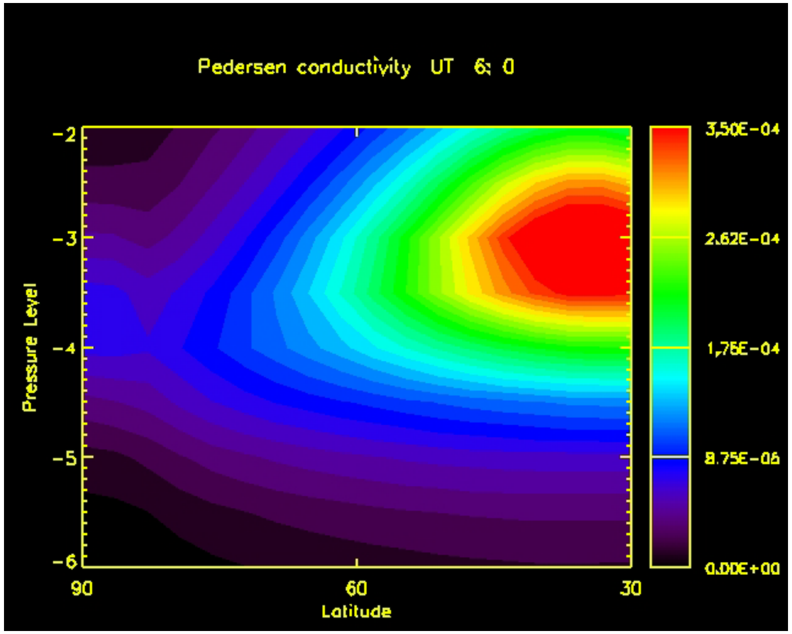
- ***Overture***
  - **B. Henshaw & D. Quinlan (LLNL)**
  - **C++ framework for solving differential equations on overset grids**
  - **Used to handle interpolation between model grids**

# Magnetosphere-Ionosphere-Thermosphere Coupling

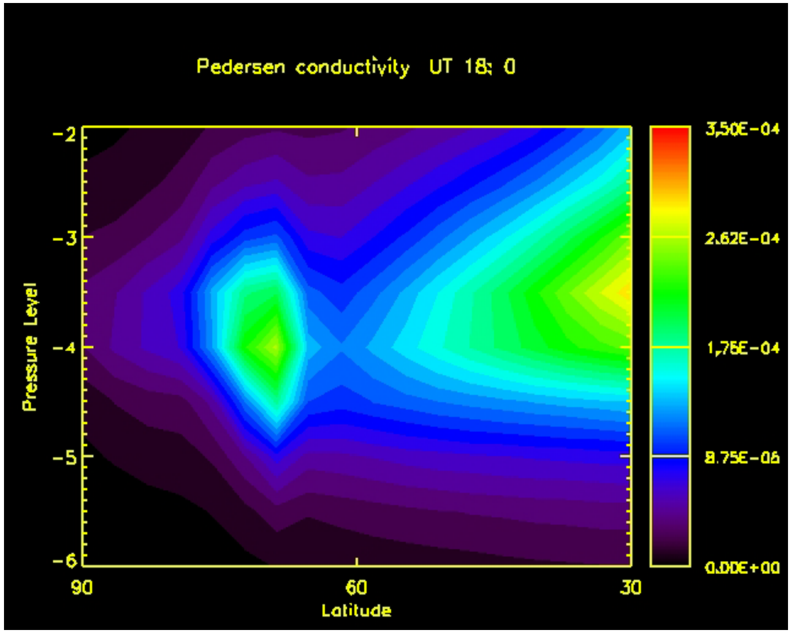


# Pedersen conductivity changes in response to changes in field-aligned currents

## Before a storm



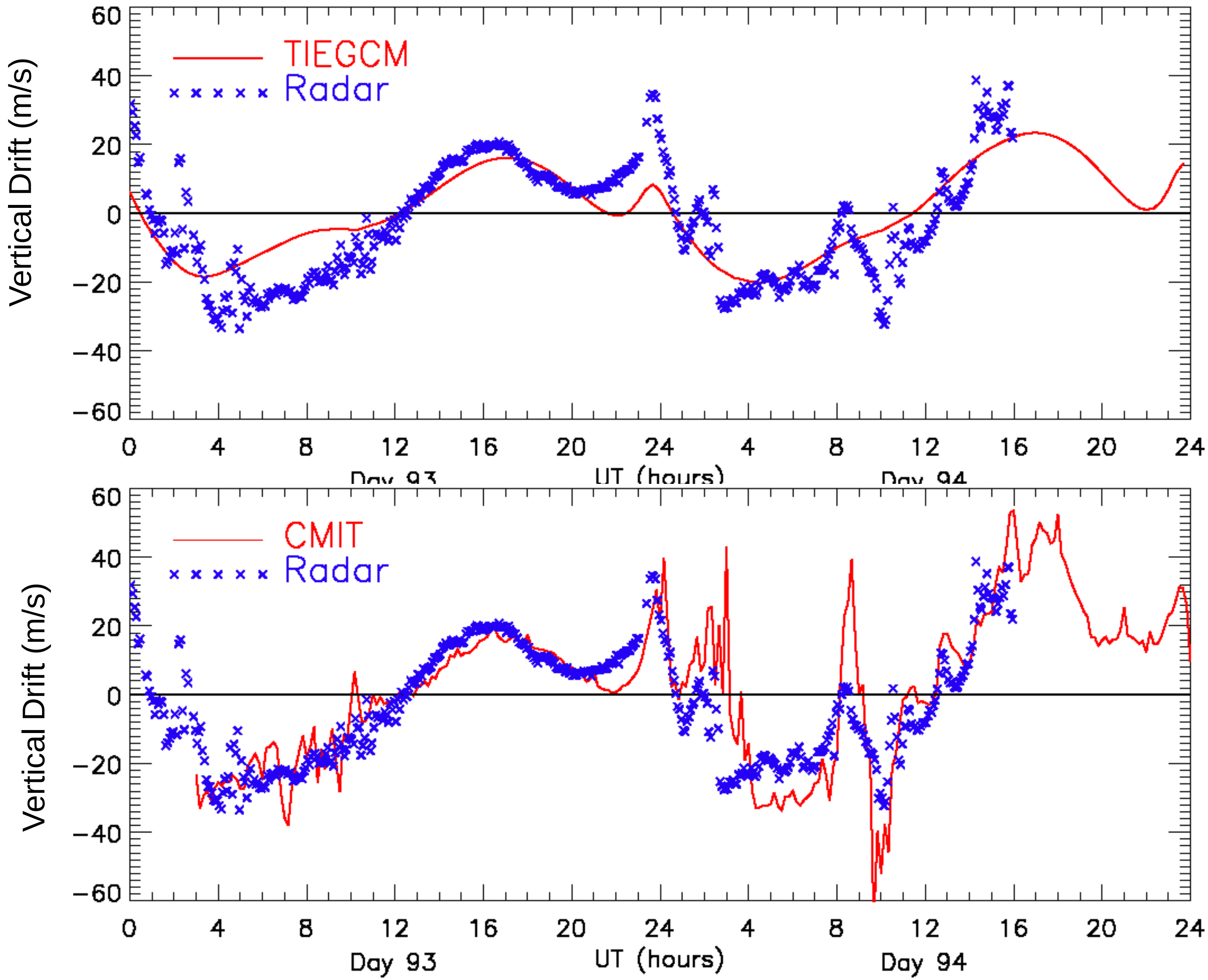

## During a storm



# Equatorial Vertical Drift — Comparison with Jicamarca Data

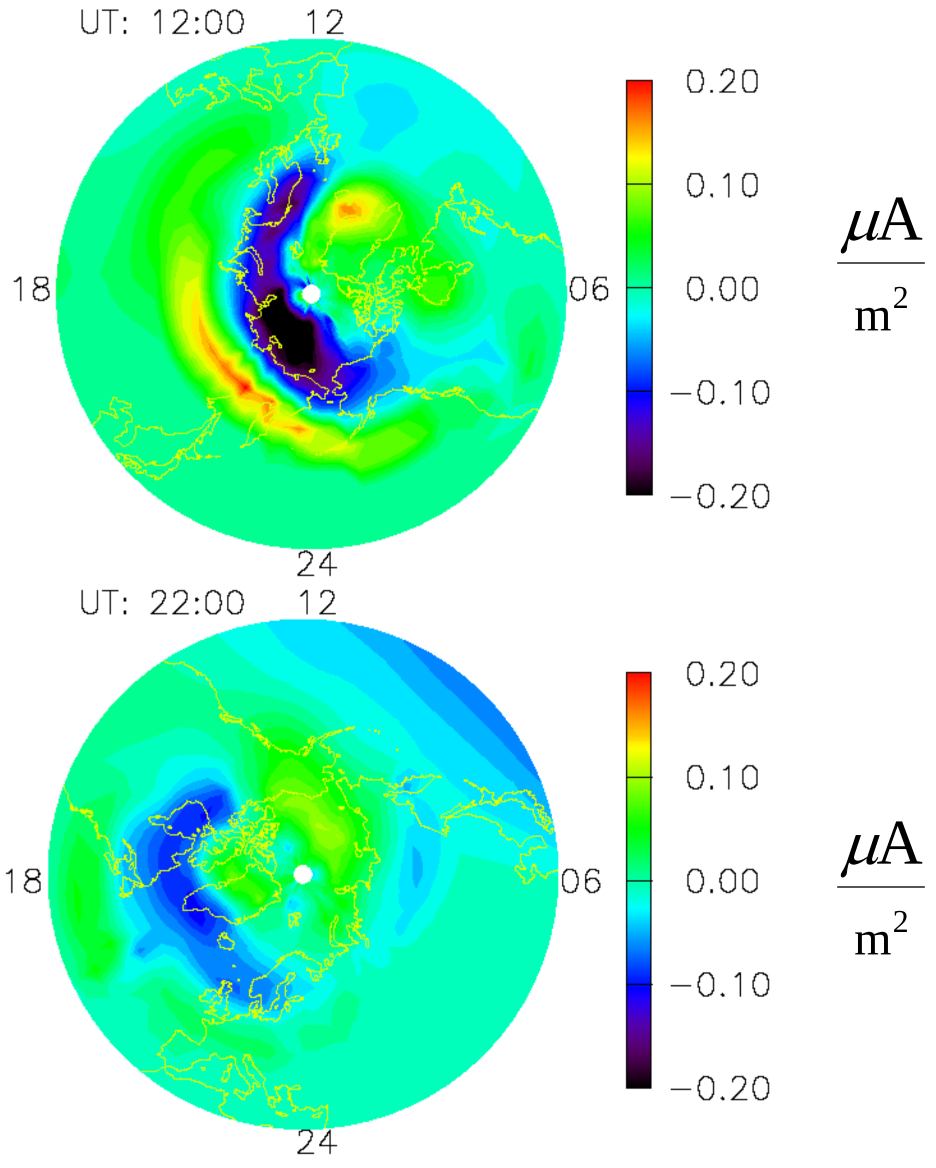
TIEGCM alone

Coupled LFM/TIEGCM CMIT 2.0




Wang et al. 2008

# Flywheel Effect




**Max 27% of magnetospheric current**

Wang et al. 2007

# Why do we need RCM?
# Region 2 Currents

214 T. A. POTEMRA

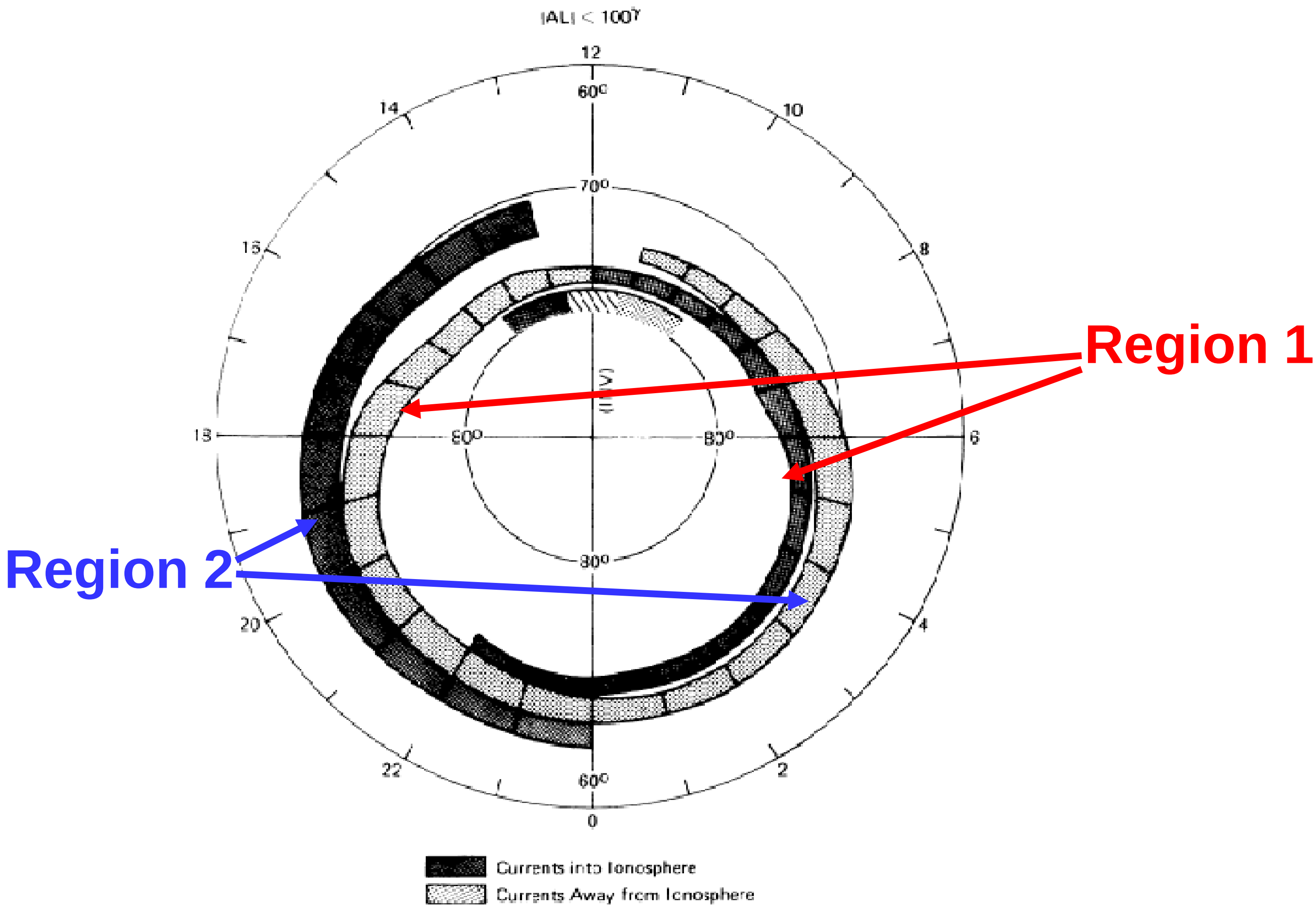
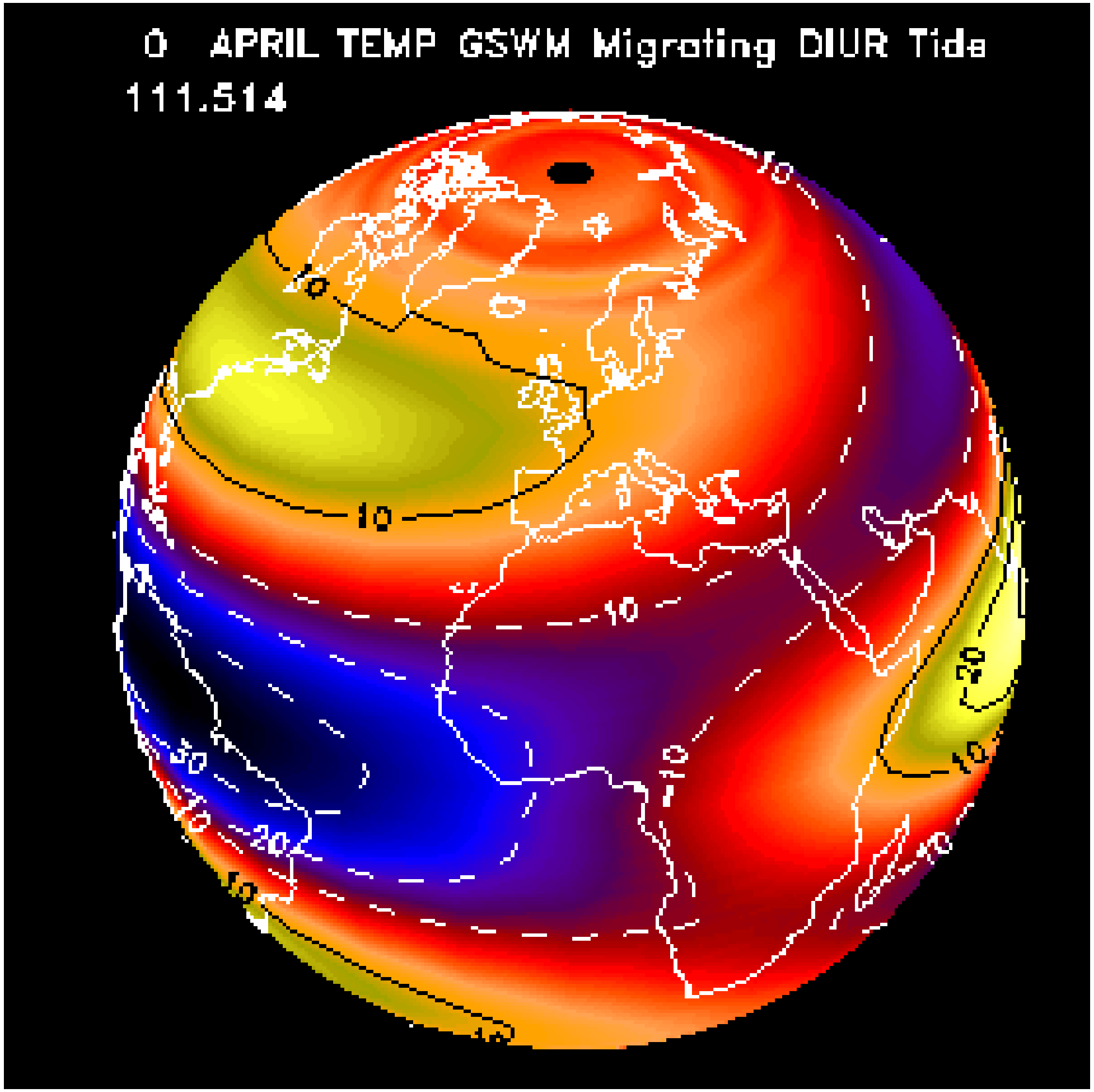
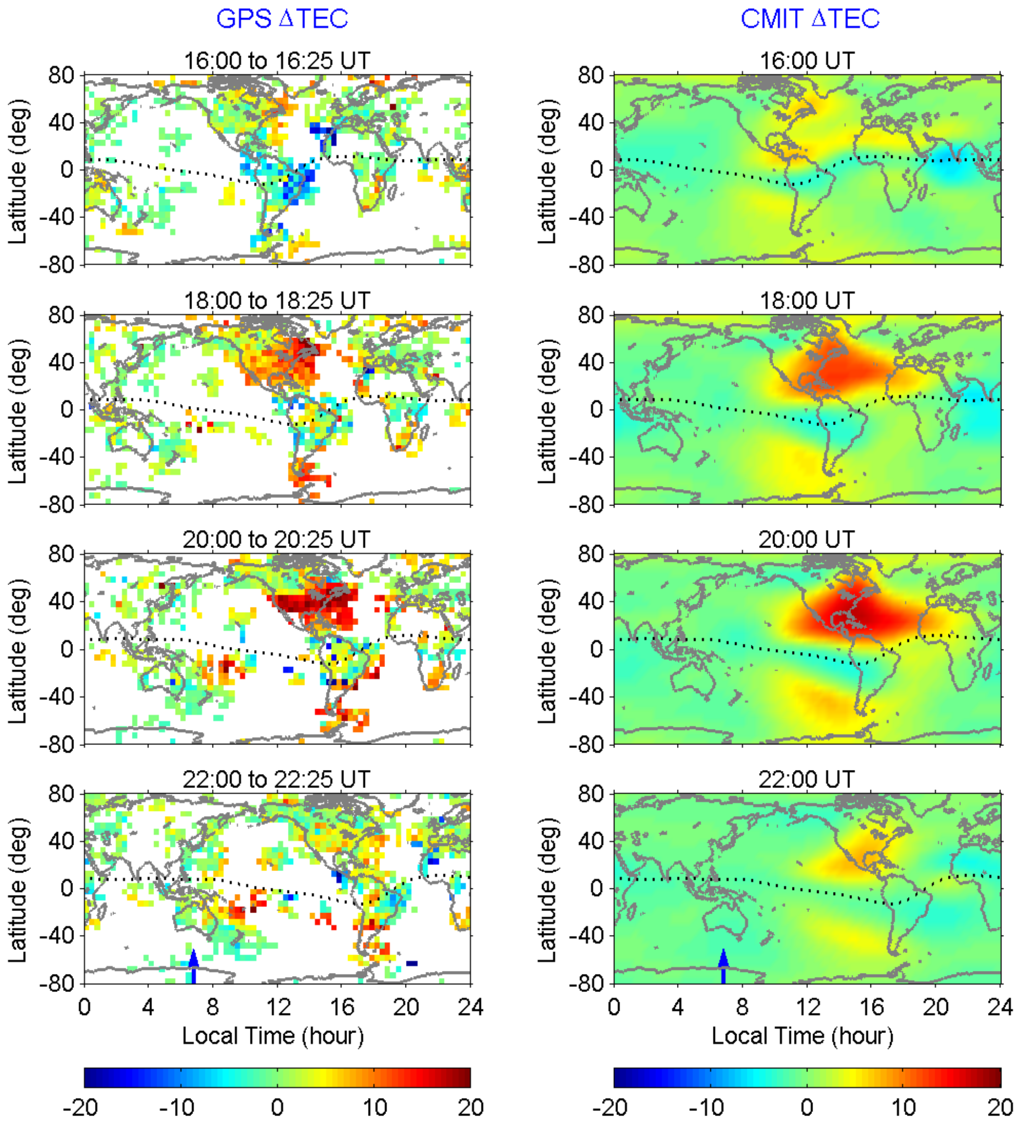



Fig. 5. The spatial distribution and flow directions of large-scale field-aligned currents determined from data obtained on 493 passes of TRIAD during weakly disturbed conditions (|AL| < 100γ) from Iijima and Potemra (1976b). The hatched area shown between 1130 and 1230 MLT in the polar cusp region indicates that the current flow directions are often confused.

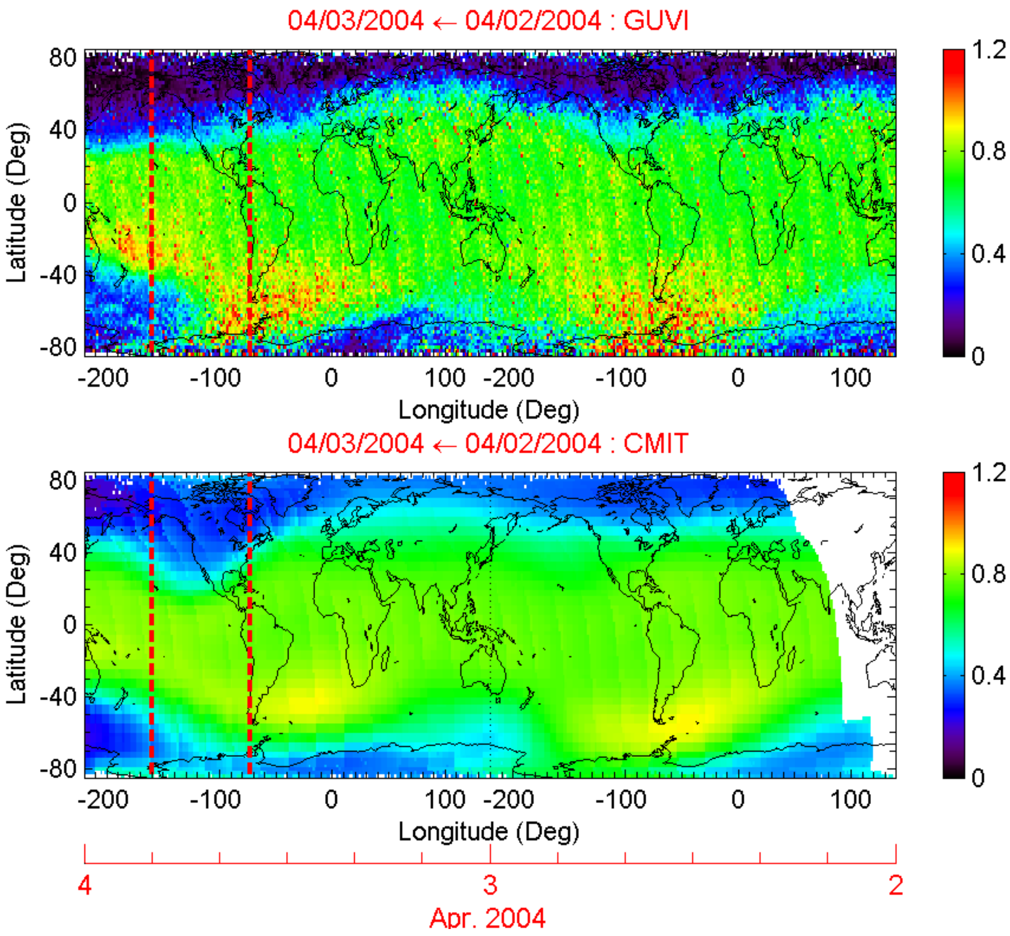
# CMIT Lower Boundary GSWM



# How does LFM help our solution? 1. Electron Density



# How does LFM help our solution? 1. Neutral Composition



# Conclusions

**Using a first-principles model of the magnetosphere is necessary:**

**-To self-consistently account for feedback to the magnetosphere**
**-To capture dynamic and non-linear variations of the thermosphere and ionosphere**

**Coupling is preferable because**

**- Different mathematical base**
**- Few fields exchanged**
**- Large differences in necessary time steps**
**- Philosophy of minimal intrusion in existing codes**

# Why do we need RCM?
# 2 – Shielding

- The inner edge of the plasma sheet tends to shield the inner magnetosphere from the main Electric convection field.
- This is accomplished by the inner edge of the plasma sheet coming closer to Earth on the night side than on the day side.
  - Causes region-2 currents, which generate a dusk-to-dawn E field in the inner magnetosphere.
- When convection changes suddenly, there is a temporary imbalance.
  - For a southward turning, part of the convection field penetrates to the inner magnetosphere, until the nightside inner edge moves earthward enough to re-establish shielding.