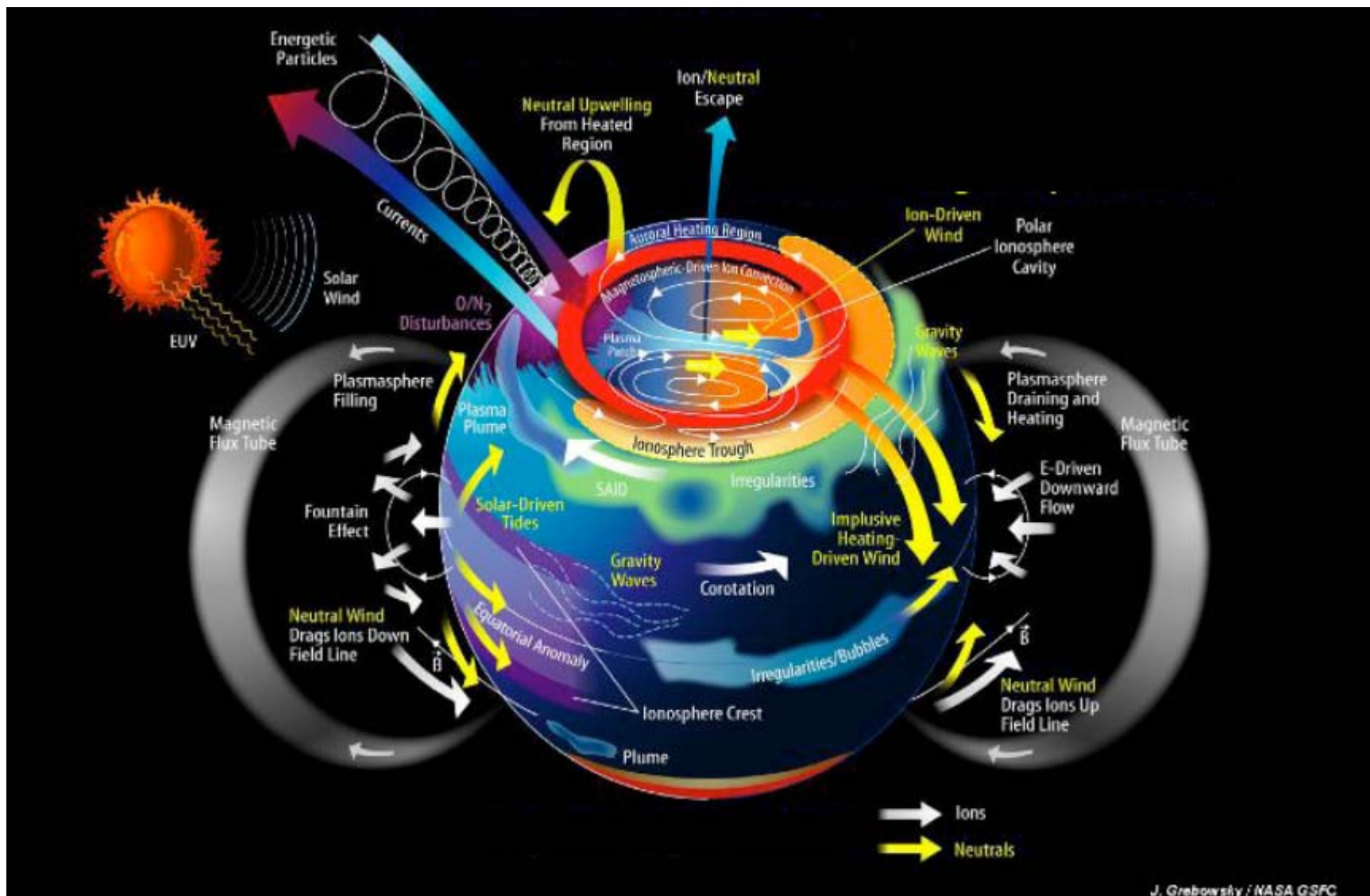
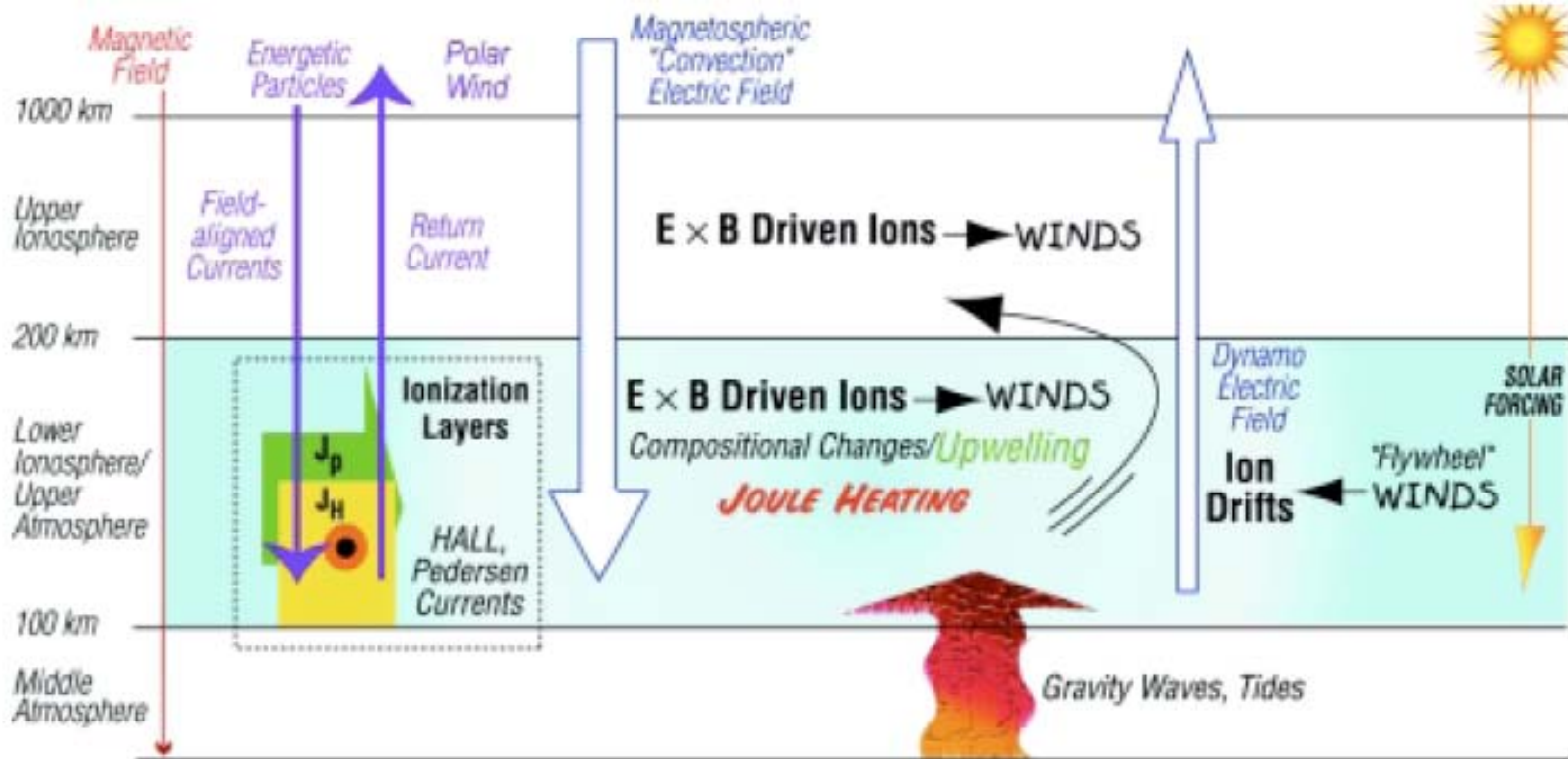


# User needs: ionosphere models (IPY support)

Anthony J. Mannucci  
Jet Propulsion Laboratory  
California Institute Of Technology

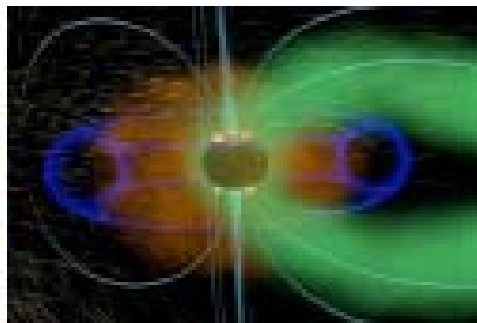
- 
- **The Role Of Modeling**
  - **Modeling In A Scientific Context**
  - **Modeling In An Operational Context**
  - **User Needs**





**Coupling:** changing plasma density changes conductivity which affects the electrodynamics and therefore the plasma state. Changing the neutral distribution function changes the plasma distribution function (via the dynamo) changing the neutral distribution function via ion-neutral coupling (adapted from comments by Heelis, 2007)

GEC Science and Technology Definition Team Report, 2001 (adapted from Volland 1996)



## Mass Exchange



## Electrodynamic Coupling



## Chemical – Dynamical Coupling

After Thayer, Kozyra, Heelis, Robinson  
 “Space-Based Ionosphere-Thermosphere Research:  
 The Next Steps”  
 Manhattan Beach, CA October 2007





- **Sparse data sampling -- ultimate product is physics-based models**
  - observations to feed models
  - large scale linked model development required
- **Require a multi-year period of simultaneous observations of the whole system to understand the linkages**
- **Follow physical processes from start to finish (e.g. sun to upper atmosphere)**
  - ensure that all significant links in the chain are identified
  - enable a global theory & modeling effort to **achieve predictive goals**

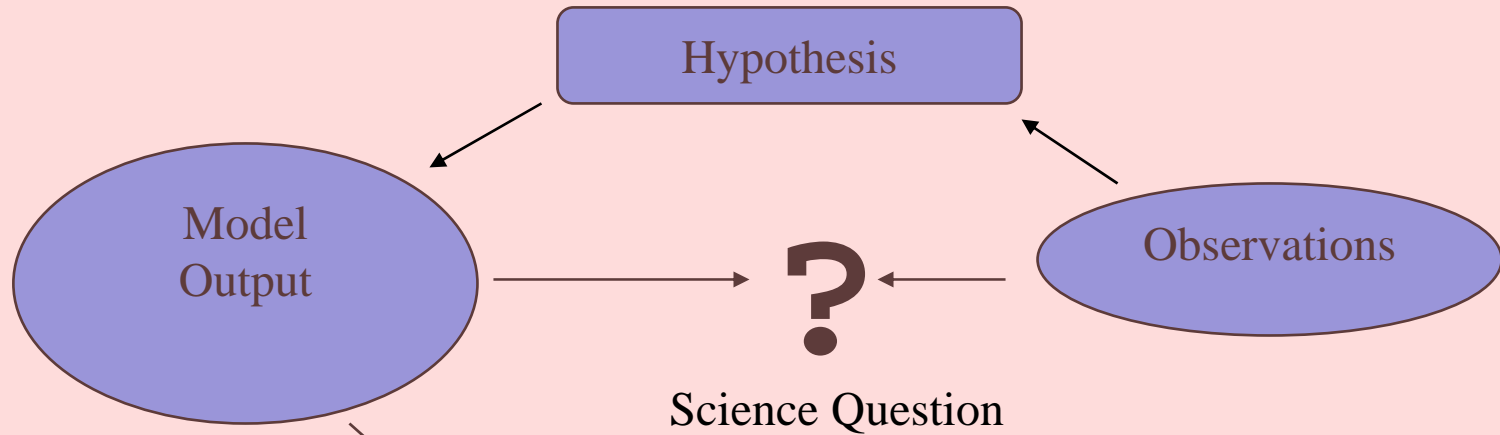


## ***Sample problem area treatment***

*Since observational sampling of the Sun, heliosphere, and geospace is extremely sparse, the SAT adopted the view that the ultimate product of the program would be in physics-based models of the various regions of importance. In this approach, the role of observations is to understand the physical processes so that theory and models can be developed, and, eventually, to drive the models so that nowcasting and predictions can be made. In the words of one attendee at the SAT workshop, “the observations should be made to feed the models.”*



## Scientific Context

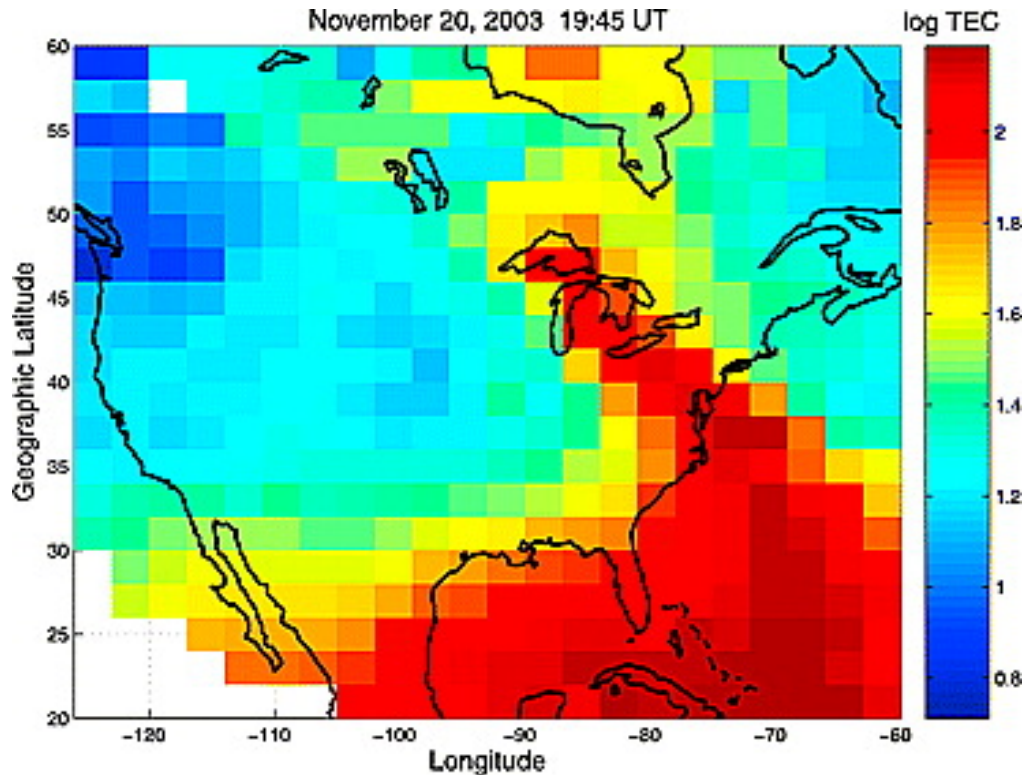


## Operational Context



- **CCMC contains large-scale global models**
- **Spatial and temporal boundary conditions are not fully constrained**
- **The model physics is approximate**
- **Agreement with observations is a challenge**
  
- **Within the physical domain represented by the model, the model output describes what *could* occur**
- **Model output may not represent what did occur**
- **What could occur is very important and *instructive***

Foster et al,  
JGR, 2005



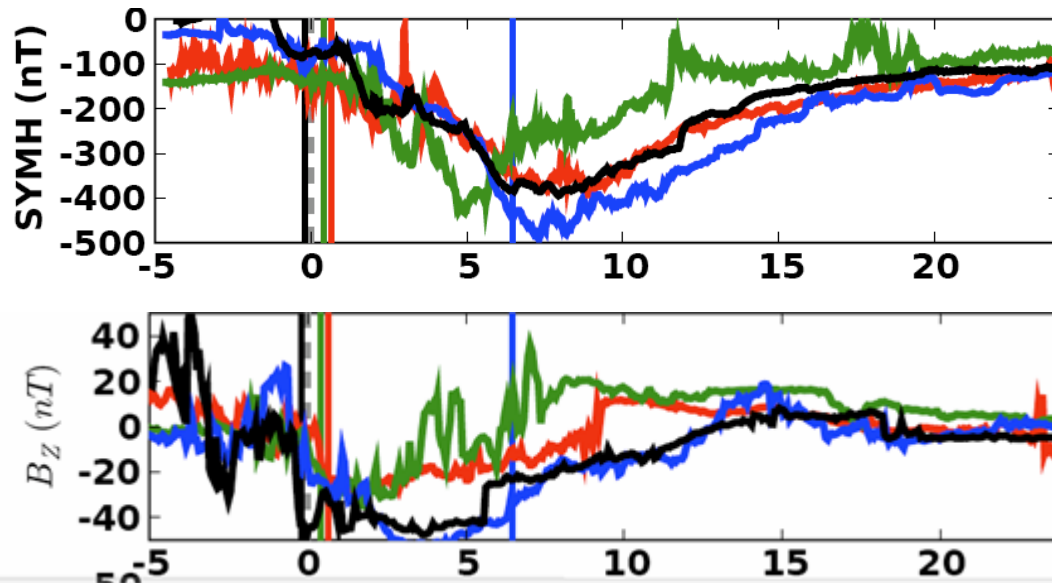
GPS TEC data

Dusk effect

Two possible interpretations:

- **Entrainment in the two-cell convection pattern**
- **“Polarization terminator”**: conductivity changes associated with terminator

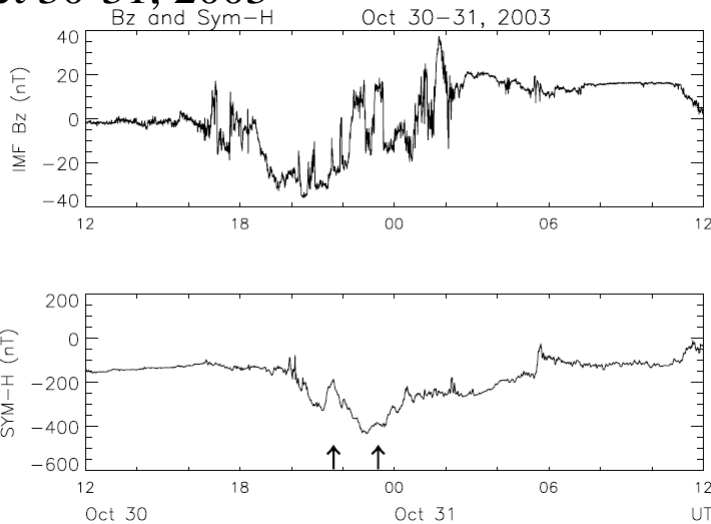
The penetration electric field appears at the equator during a very different phase of the storm for Nov 20 2003



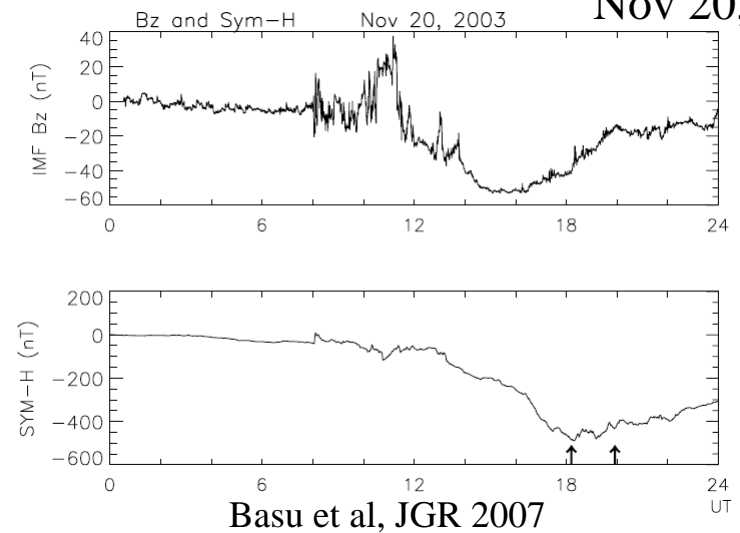
— Oct 29 2003  
— Oct 30 2003  
— Nov 20 2003  
— Nov 7 2004

Mannucci et al.,  
final revisions,  
JGR 2008

Oct 30-31, 2003

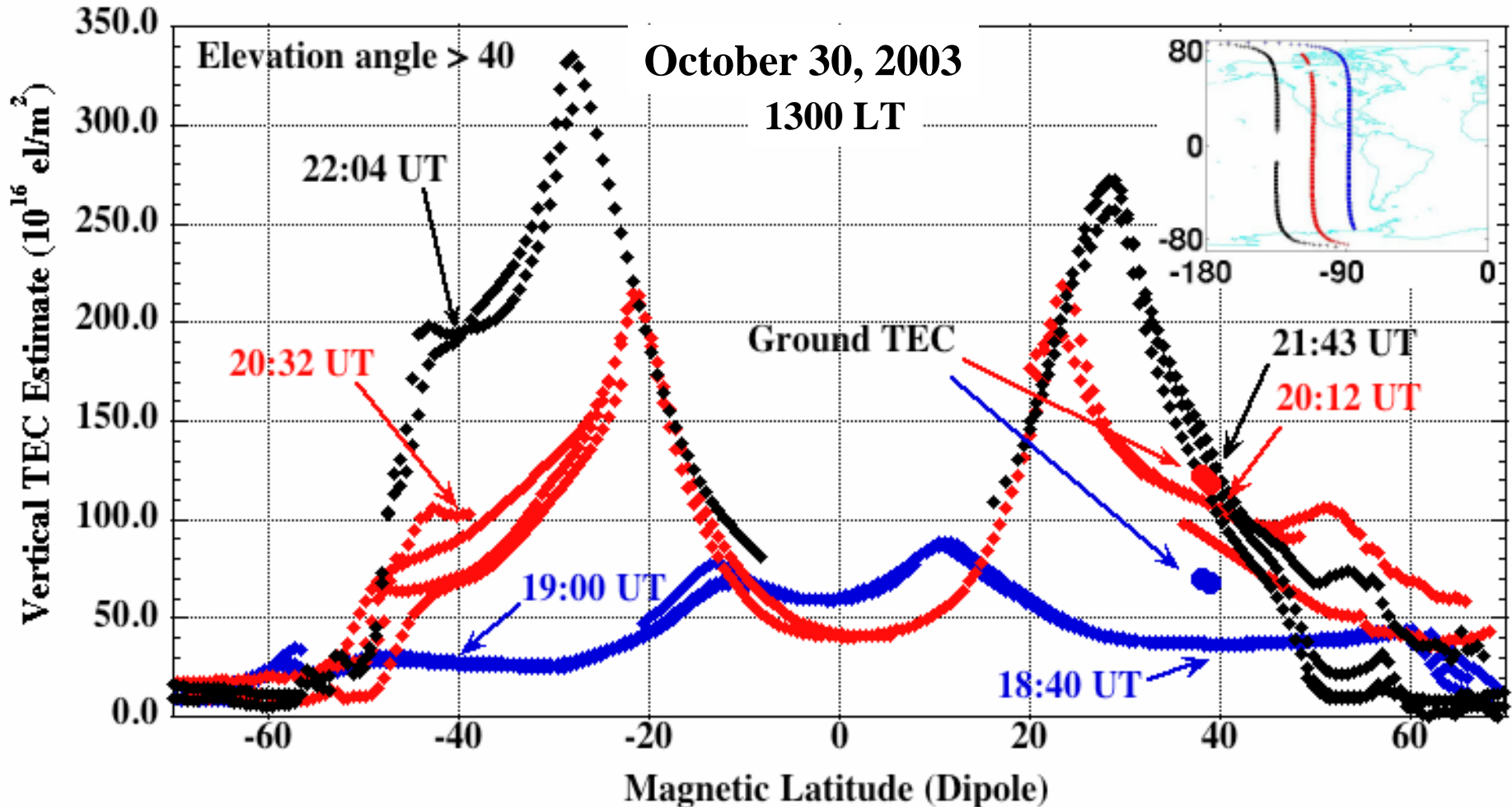


Nov 20, 2003



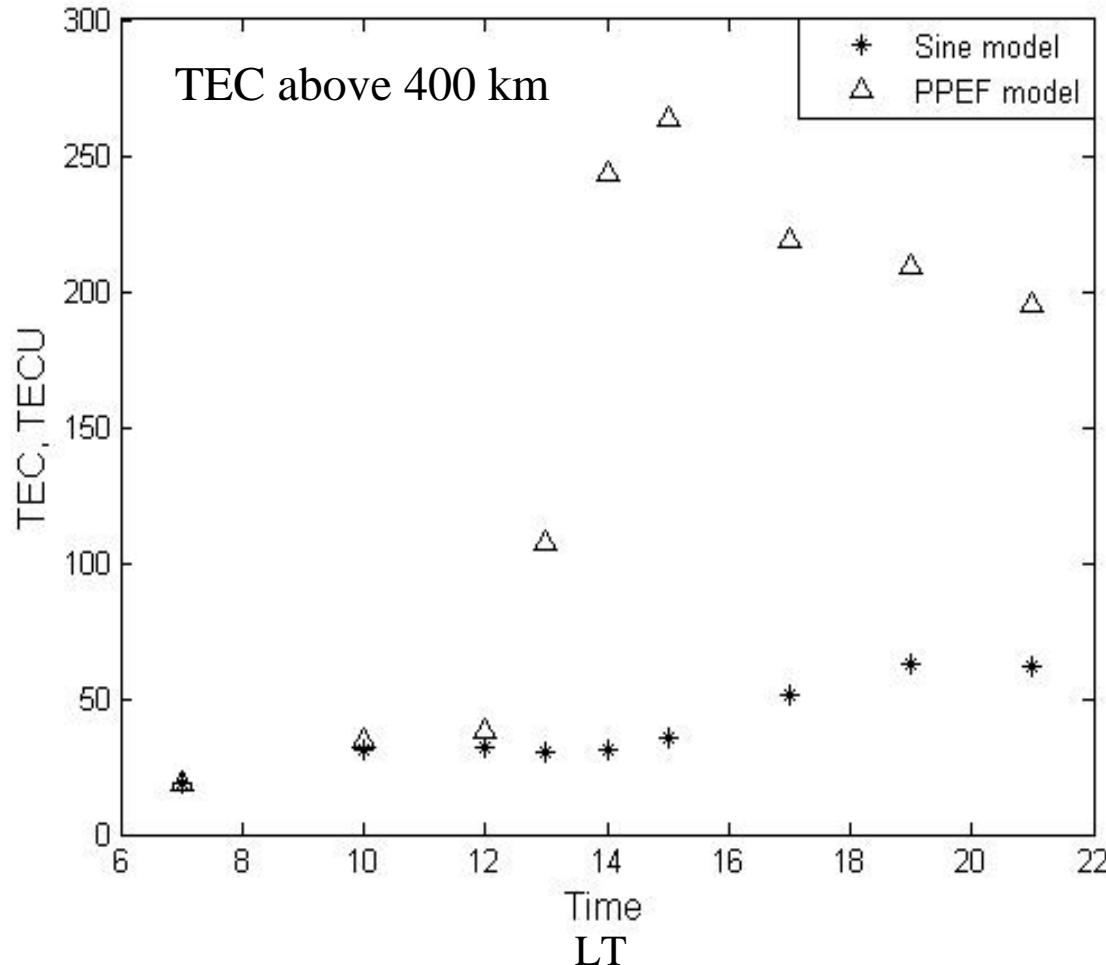
Basu et al, JGR 2007

## CHAMP (TEC above 400 km altitude)



Mannucci et al., GRL 2005

Electric field estimate using CHAMP magnetometer data: **4 mV/m**  
 Ann. Geophys., 25, 569–574, 2007



Background sinusoid 0.5 mV/m

Enhanced electric field  
 12 - 14 LT  
 (single longitude model)

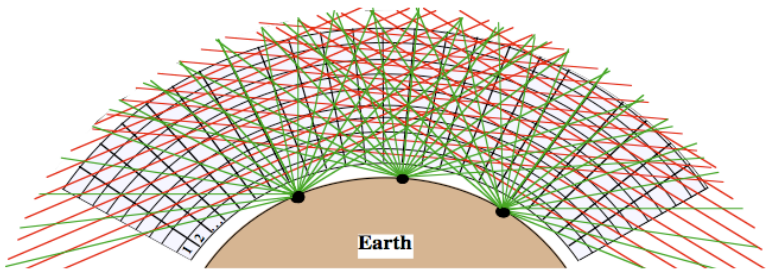
25° Latitude

CHAMP value ~230 TECU

CCMC Version: sinusoidal E  
 with peak value specified

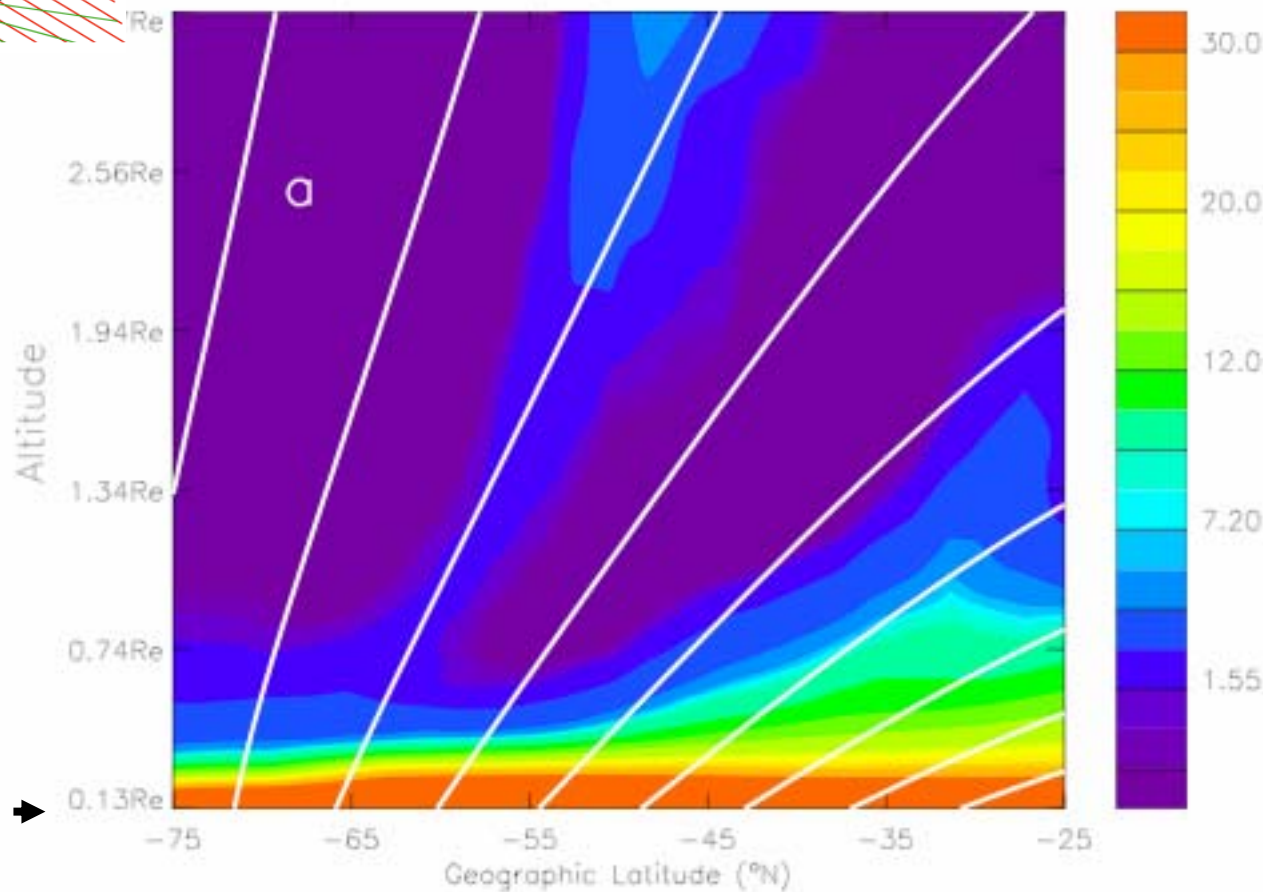
Verkhoglyadova et al., in Coupling  
 Processes in the Equatorial Atmosphere  
 Symposium Proceedings, March 2007





Fedsat Low-Earth Orbiting  
GPS Receiver  
Tomographic  
reconstruction of over-  
satellite TEC

Reconstructed Electron Density ( $\times 10^6$  el/cm<sup>3</sup>)  
FedSat pass on 16/12/03 at 22:19–22:35 UT



800 km →

Yizengaw et al., GRL 2006

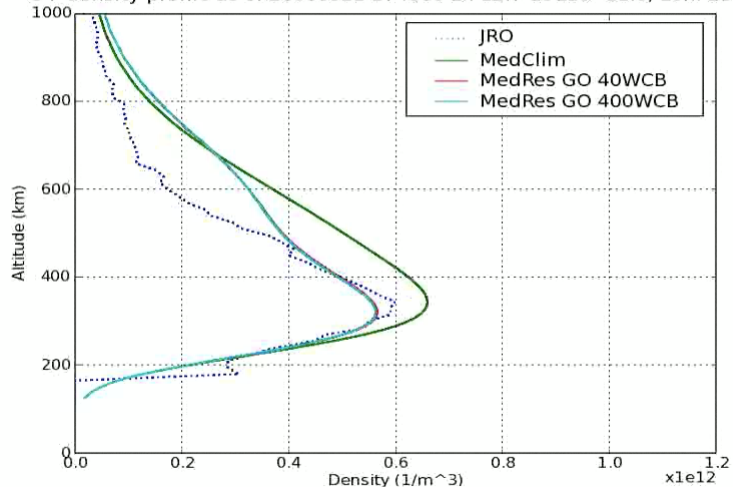


- **Strongly “driven” system**
  - Observed state is a consequence of many factors varying in time
- **Several key inputs are essentially unmeasured**
  - Global winds, global electric fields, thermospheric composition, conductivities, certain high-latitude inputs
  - Complex feedbacks are modifying these “inputs”
- **The system itself is nearly unobserved**
  - The “ionospheric disk” has never been observed
  - Compare, e.g., to the solar disk
- **Models are the bridge between scientific hypotheses and observations**
- **Limited observations and limited model constraints are significant challenges to testing our hypotheses**

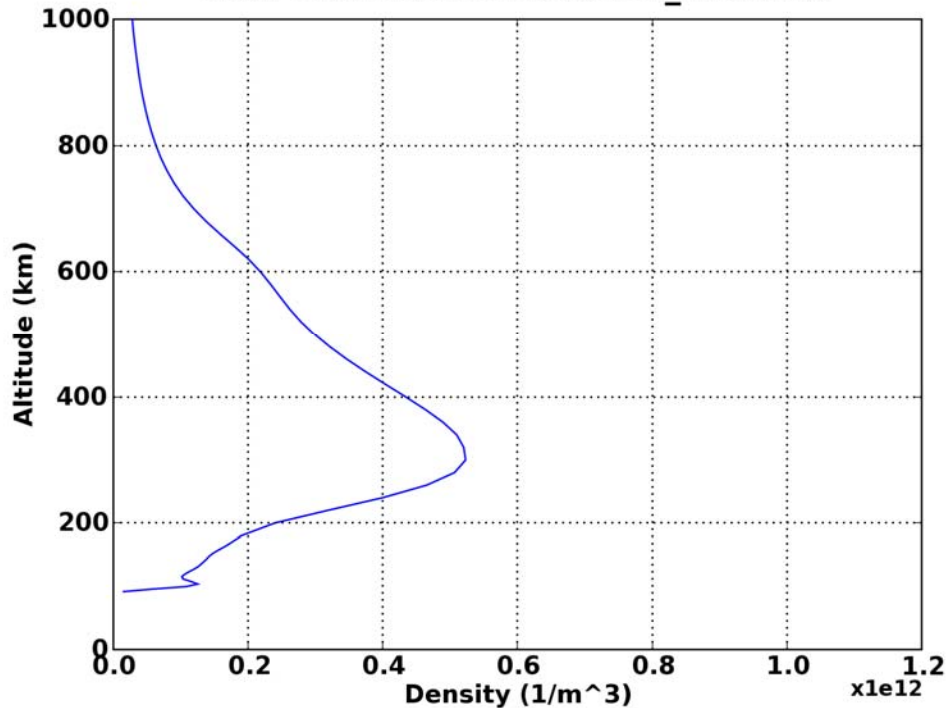
- **Data assimilation is critical**
- **We use a broad definition of “data assimilation”**
  - **Whatever technique works best**
- **Understanding is subordinate to quantitative accuracy**
- **USU-GAIM at CCMC is a major accomplishment**

- **Where are the data?**
- **What type of data are there?**
- **What do we expect to happen when these data are assimilated?**
  - **TEC data**
  - **GPS occultation data**
  - **UV radiances**
  - **Beacon TEC data (CERTO, CITRIS)**
  - **Sounders (ground and space)**
  - **In-situ data**
    - **Less useful in an assimilative context**

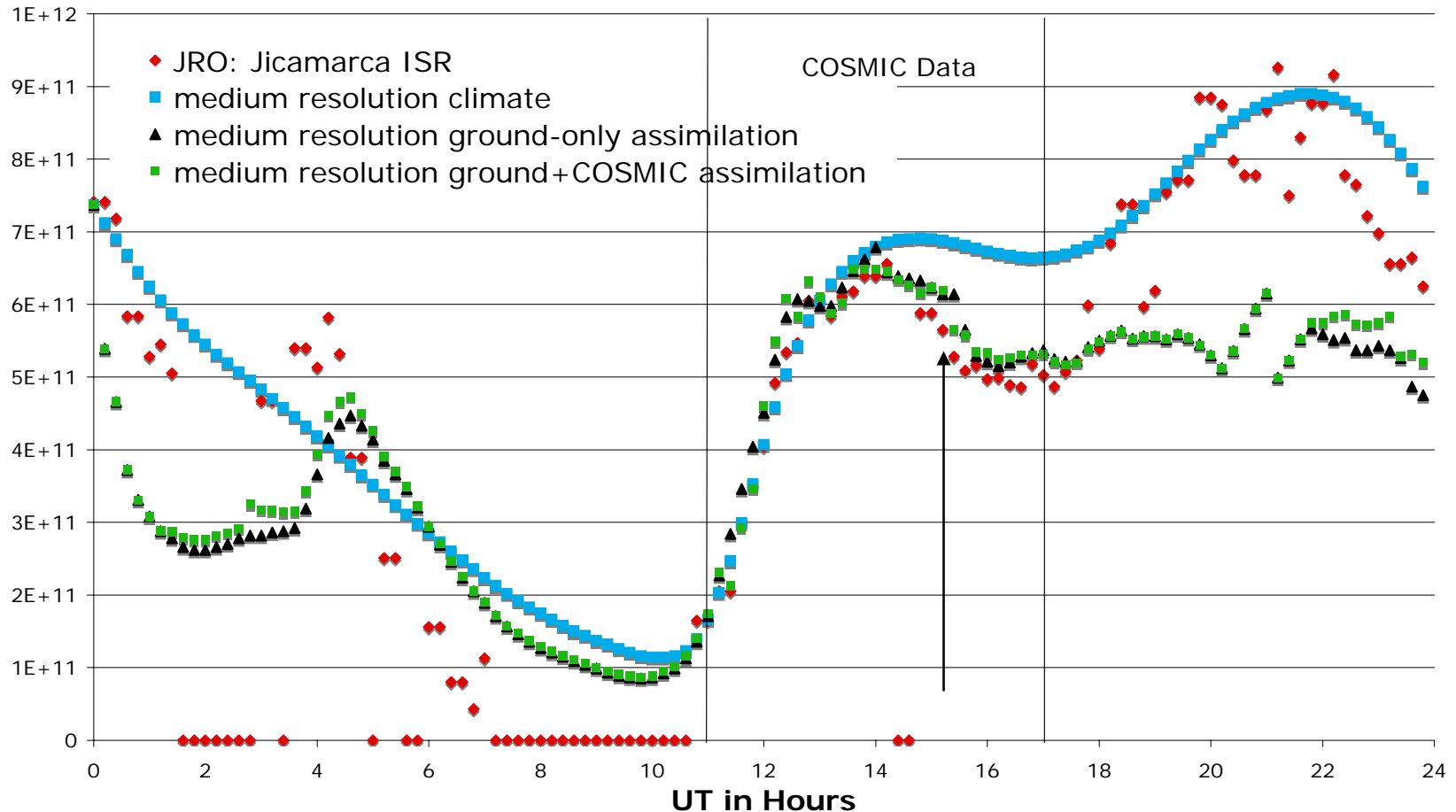
O+ density profile as of 20060921 174800 LT: 12.7 at Lat: -11.0, Lon: 284.0



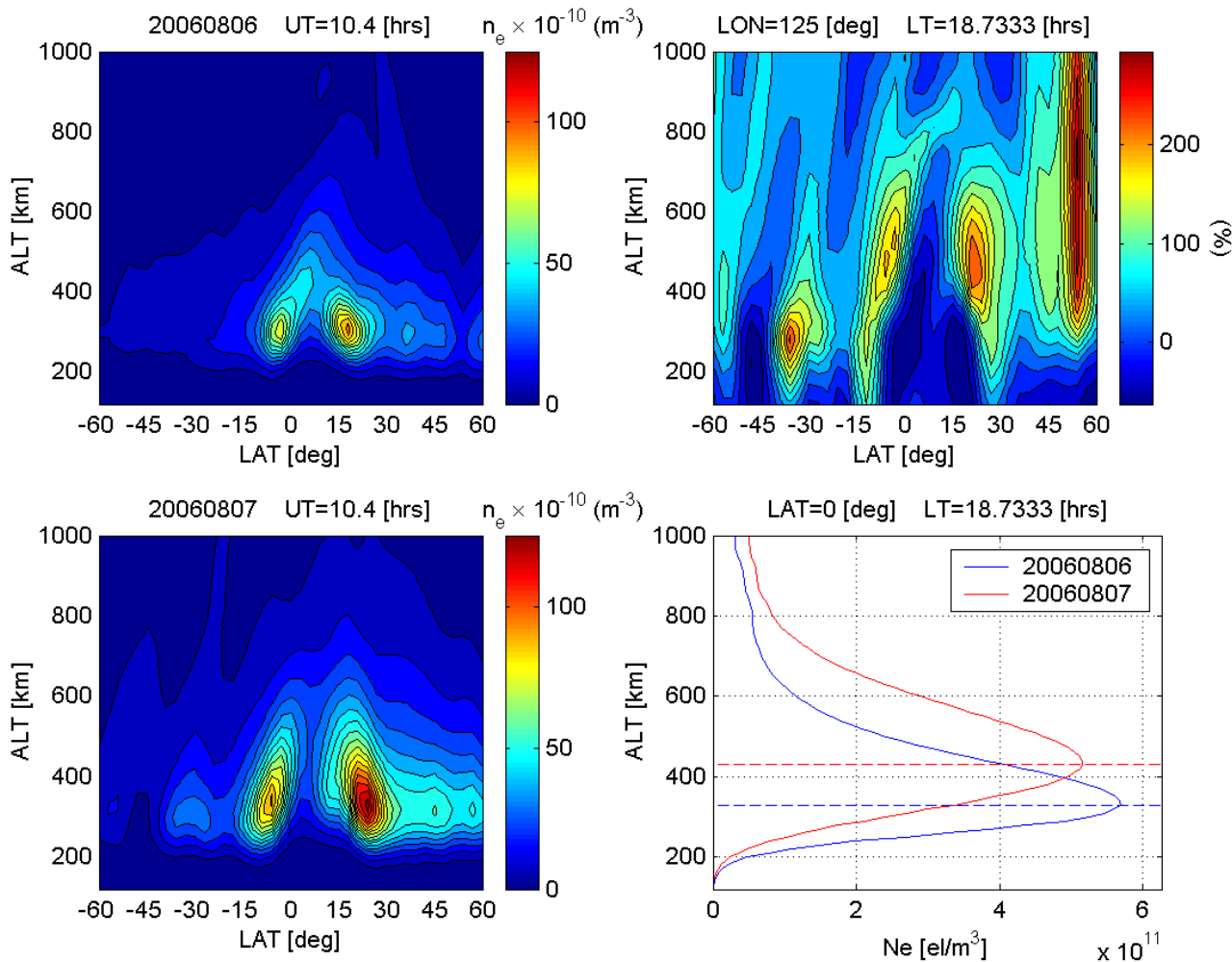
USU-GAIM ccmc20060921\_1800.txt



## GAIM Medium Resolution Assimilation Results for Sept 21, 2006



Medium resolution GAIM NmF2 with COSMIC data matches well during the dense data period 11-17 UT



Inputs: Ground TEC and COSMIC occultation data

- **Data assimilation: need to know the locations and times of the data**
- **Select data on/off by some reasonable criteria**
- **Data assimilation is an extremely useful addition to CCMC**



- **Near-term: provide more diagnostic information on the drivers**
  - Winds, electric fields, etc.
  - Multiple output fields
- **Longer-term: inclusion of carefully tuned case-studies, studies from specific publications, etc.**
  - Pre and post-tuned runs
- **Longest-term: modify the drivers, user-tuning**
  - Difficult in practice
  
- **Specific request: AMIE**
- **Coupling (not sure what to say here)**

- Outreach, think of the possibilities...



## IHY-Africa Space Weather Science and Education Workshop

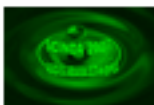
12-16, November 2007, in conjunction with

### 2<sup>nd</sup> Africa SCINDA Workshop

11, November 2007, Addis Ababa, Ethiopia



- Home
- Schedule
- Registration
- Abstracts
- Deadlines
- Lodging
- Travel Information
- Travel Support
- Useful Links



SCINDA2007

Objectives	Announcements	International Committee	Local Committee	Sponsors	About Ethiopia	Addis Ababa
<p>The <b>IHY-Africa Space Weather Science and Education Workshop</b> will be held in Addis Ababa, Ethiopia during Nov 12-16, 2007. The meeting will follow the 2<sup>nd</sup> Africa SCINDA Workshop on Sunday 11<sup>th</sup> November. Both meetings will be held at the Ghion Hotel. The Workshop is under the auspices of the International Heliophysical Year (IHY), in cooperation and collaboration with several international and African national programs, including CAWSES, eGY, AMMA, and AFREF. The workshop is sponsored by many US and International Agencies. The IHY-Africa Workshop is hosted by The Ethiopian Physical Society in conjunction with Addis Ababa University and Bahir Dar University.</p> <p><b>Workshop Objectives:</b> The purpose of the workshop is to facilitate scientific interaction and promote space science in Africa, with a strong educational focus. The space science community is currently exploring ways to increase the observational infrastructure in the African sector, and to encourage scientists in Sub-Saharan Africa to become involved in the science objectives, and to host instrumentation at their institutions. The new observational infrastructure will facilitate the study of space weather, spark interest in space science education and research, and encourage the next generation to become interested in the space sciences.</p> <p>The workshop will provide an ideal opportunity to develop strong interactions with scientists in Africa. A strong educational focus is planned with a break-out group.</p> <p>Sessions will include:</p> <ul style="list-style-type: none"> <li>I. Ionospheric Irregularities and Scintillations</li> <li>II. Total Electron Content</li> <li>III. Electrodynamics and the Plasmasphere</li> <li>IV. Satellite and Ground-based Data</li> <li>V. Panel Discussion</li> </ul>						
<p><b>Instructions</b></p> <p>Please use the side bar to the left to go to main pages. Use the horizontal panel at the top to follow announcements, addresses of committee members, and information about Ethiopia and the city of Addis Ababa.</p>						

- **CCMC contains state-of-the-art models of the ionosphere-thermosphere system**
- **To progress on the scientific side: diagnostics, tuning, AMIE, coupling?**
- **To progress on the assimilation/operational side: data locations and switches**
- **Does CCMC address the “valley of death” problem?**
  - **Transition to operations is past the valley**
- **NOAA 2-day prediction – encouraging**
  - **One has to start somewhere (C/NOFS lesson)**

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# BACKUP SLIDES

- 1. Could what the model is describing happen?**
- 2. What did happen?**
- 3. Is the model describing what did happen**
  - 1. If so, then we have closed the loop**
  - 2. But only if we have no free parameters to “tune”**
  - 3. If we have free parameters, then we have learned something about what is possible, but not what actually did occur**