



User Needs: Ionospheric Model

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Acknowledgement to:

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Context

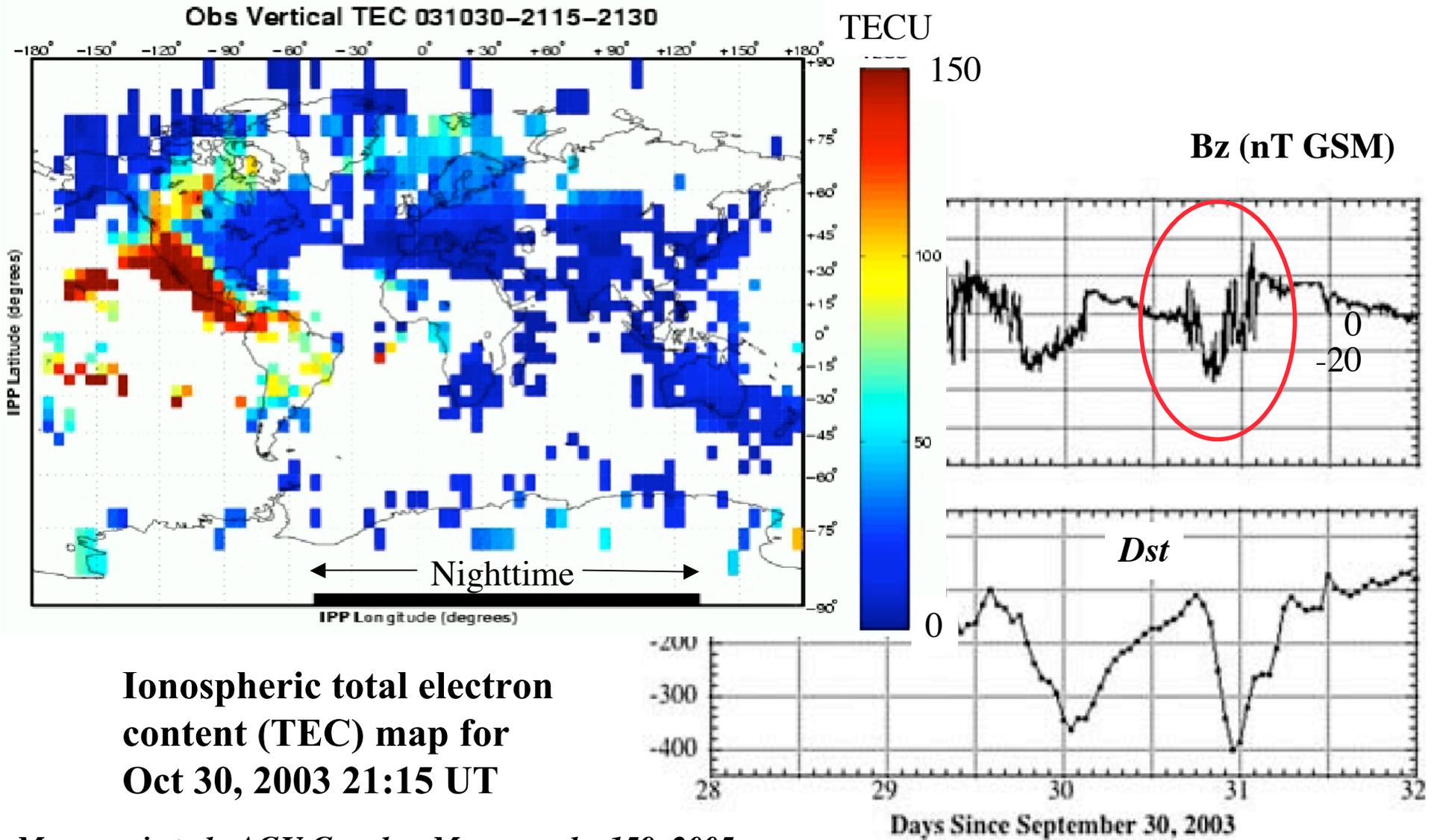


- **Recent “user”**
 - Proposed CCMC model runs for science, w/ PI support
- **Modeler and User**
 - USC/JPL GAIM considered for adoption by CCMC
 - *Data assimilation* model
- **Operational involvement**
 - An early theme in our group: using GPS data for space environment prediction

- **CCMC is impressive**
 - Modeling powerhouse
 - Community involvement
 - Exciting future possibilities



Science Drivers



Ionospheric total electron content (TEC) map for Oct 30, 2003 21:15 UT

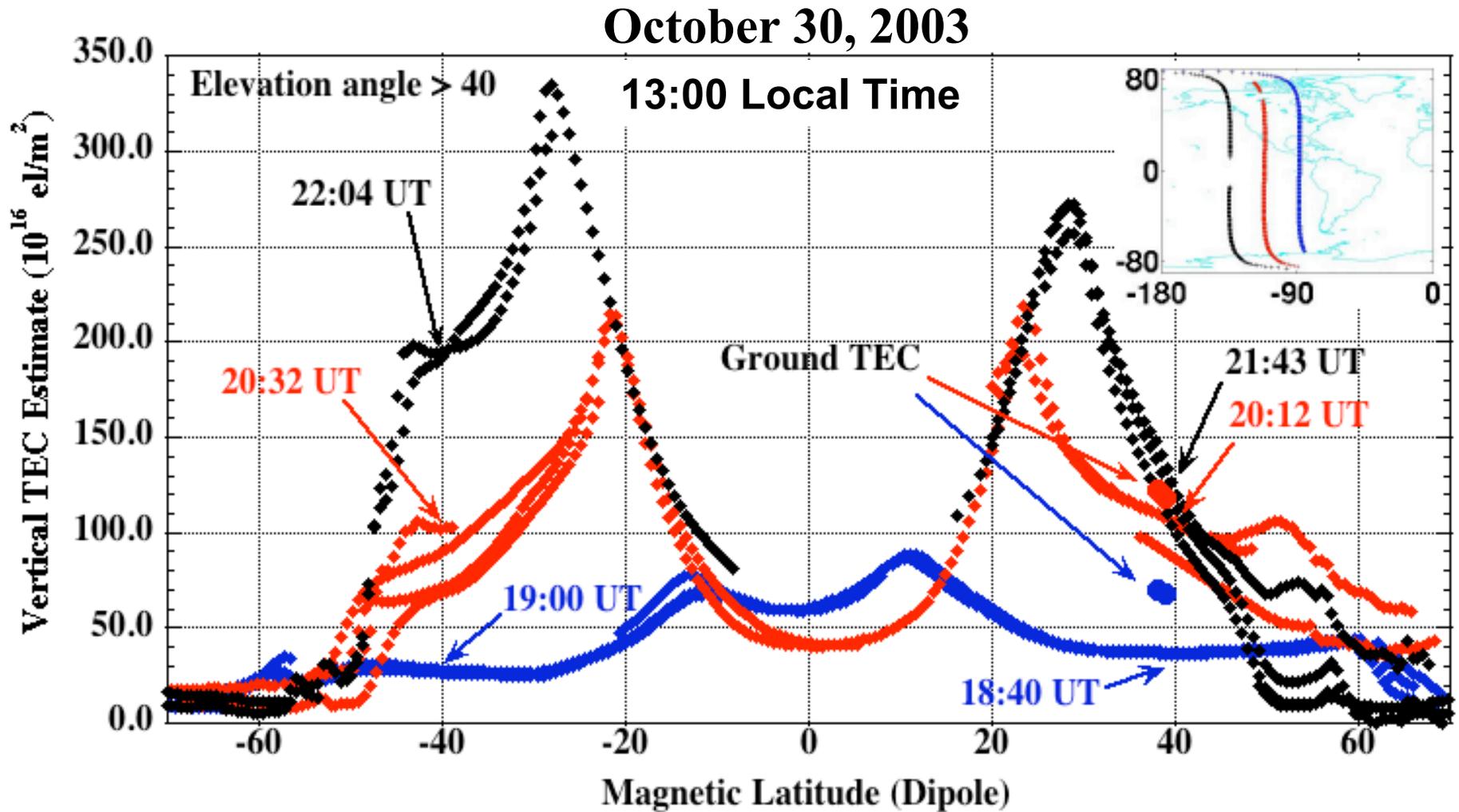
Mannucci et al., AGU Geophys Monograph v159, 2005

CCMC Workshop October 13, 2005

AJM/JPL



Structural Details



Mannucci et al, GRL 2005

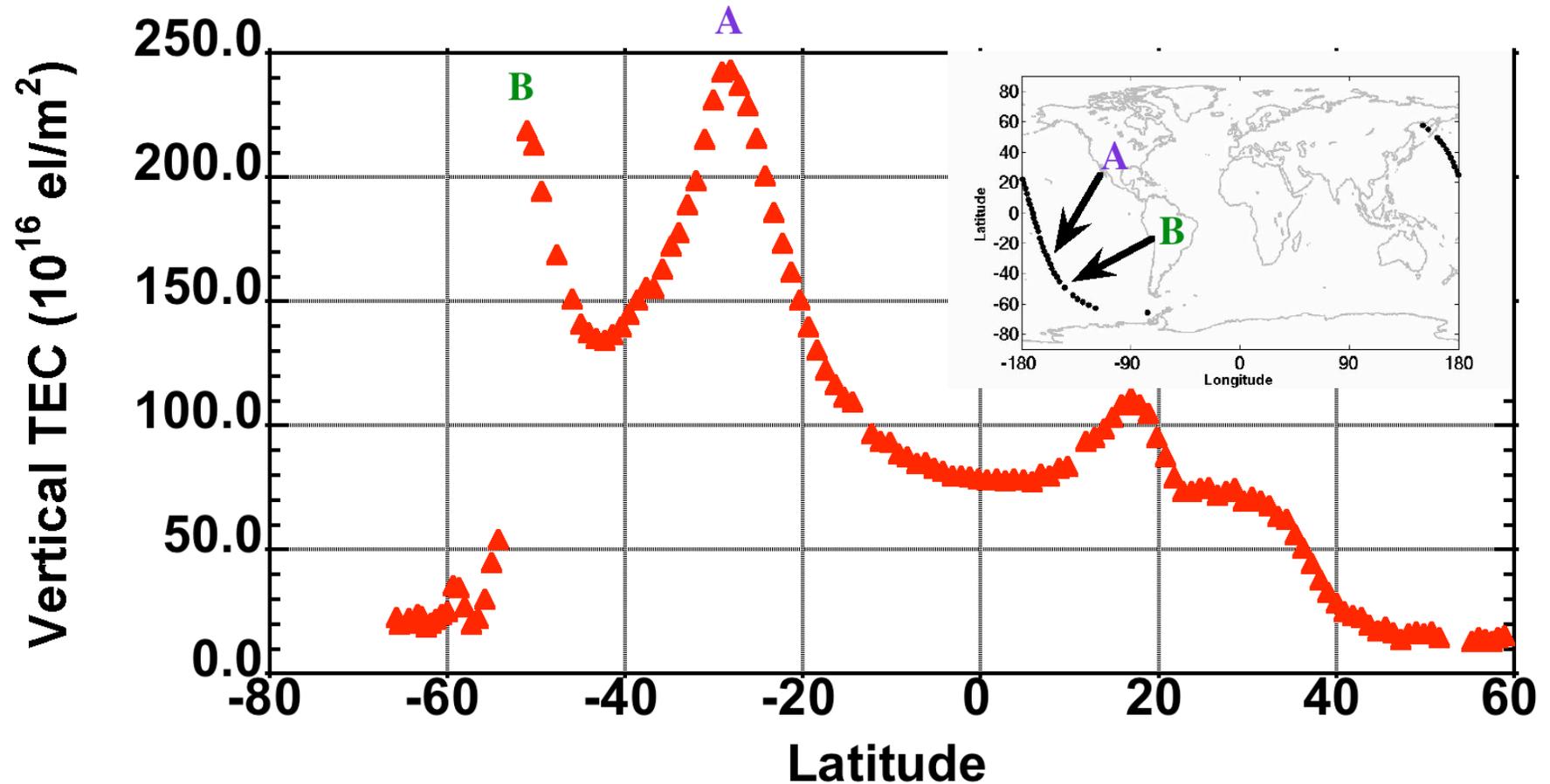
Topside Ionosphere Content (CHAMP ~ 400km altitude)



Altimeter TEC



October 30 ~22:20 UT



*Mannucci et al., Eos Trans. AGU, 84(46),
Fall Meet. Suppl., Abstract SM51F-0620, 2003*

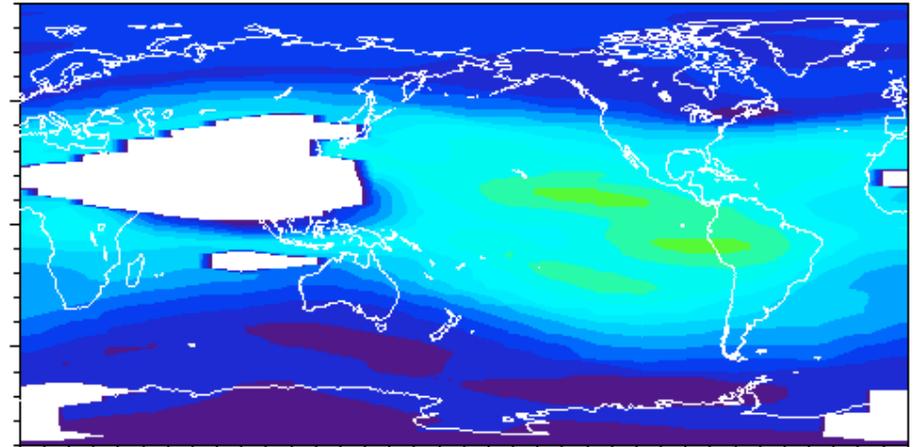
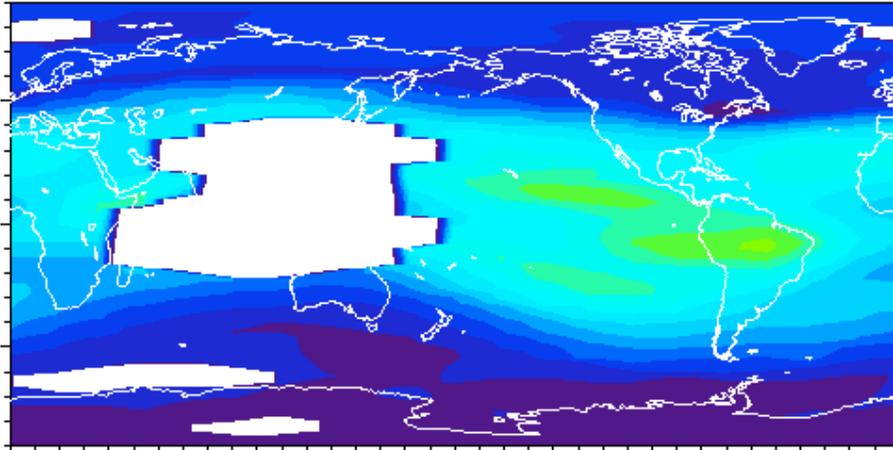


October 30 run at CCMC



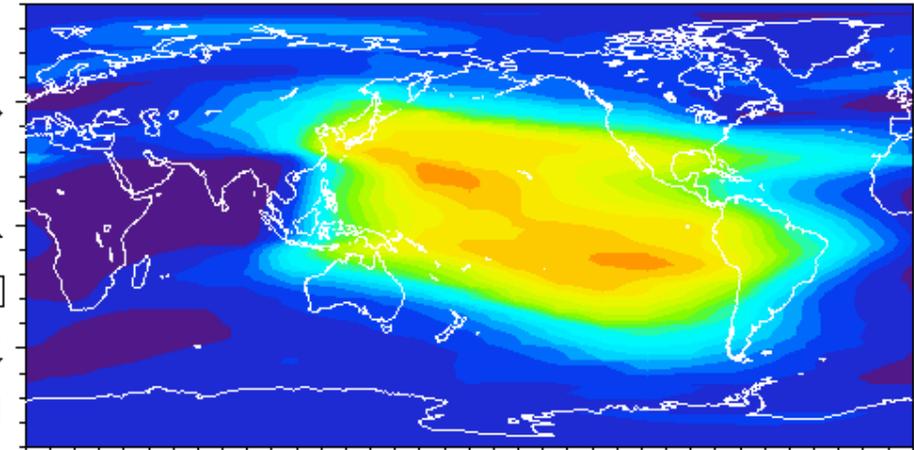
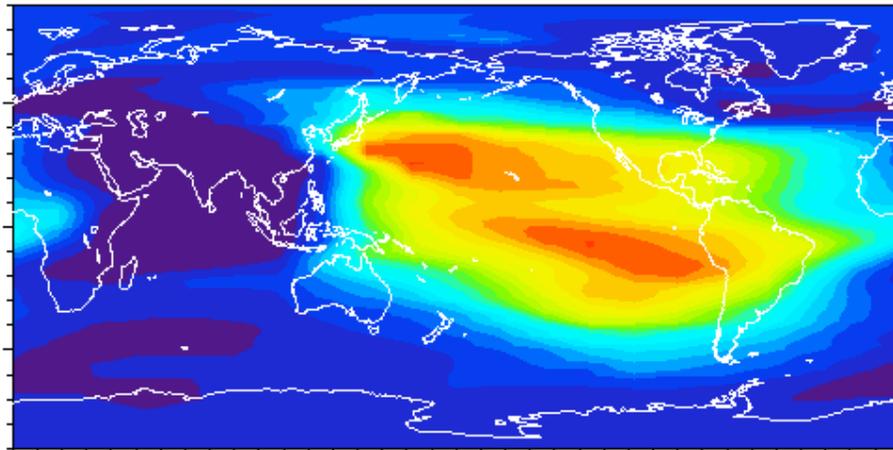
10/30/2003 Time = 21:36:00 H= 750.km

10/30/2003 Time = 22:48:00 H= 750.km



10/30/2003 Time = 21:36:00 H= 450.km

10/30/2003 Time = 22:48:00 H= 450.km



0. 100. 200. 300.

Lon [°]

Region: ionosphere/thermosphere

0. 100. 200. 300.

Lon [°]

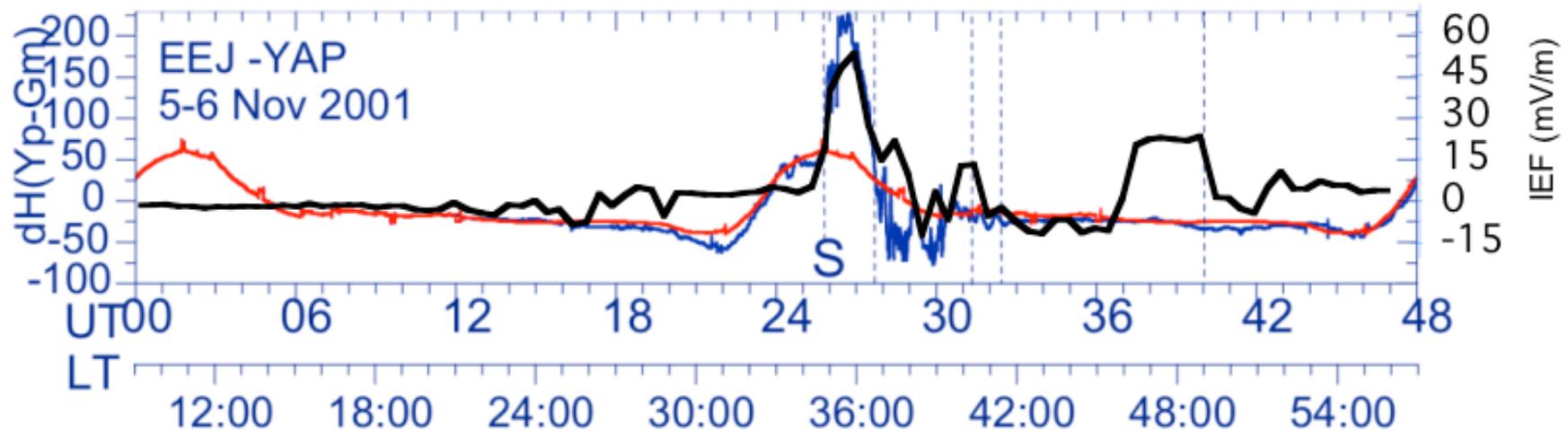
Region: ionosphere/thermosphere



Importance of Coupling?



Equatorial electrojet estimate: Yap and Guam magnetometers



Ionospheric data has motivated renewed interest in penetration electric fields and shielding

Tsurutani et al., JGR 2004



What CCMC Provides



- **Understand how well models describe data**
 - Clues as to where there is new physics
- **Implications of coupling**
 - Compare coupled to un-coupled runs
- **Increased computational resources**
 - Run models that user cannot
- **Forecasting studies**
 - CCMC real-time models and predictions might lead what is available operationally
 - Useful for models that require those forecasted inputs



Suggestions



- **Easily accessible full model output**
- **Modification of designated inputs**
 - **Evolve interfaces for new inputs, e.g. electric fields or winds**
 - **Coordination with PI is critical and compatible with CCMC rules**
- **User groups guide new interfaces**
 - **Tie-in to GEM/CEDAR campaigns and events**
 - **Strengthen advisory group interaction**
- **More flexible inputs/outputs**
 - **Connect forecast products to other model inputs**
- **Citation issue is critical**



Modeler – USC/JPL GAIM Model



- **USC Global Assimilative Ionosphere Model**
 - Developed under ONR/AFOSR MURI – Bob McCoy
 - Prof Chunming Wang, Applied Math at USC
- **Initial development: single-ion assimilative ionosphere model – physics-based Kalman filter**
 - Runs on a dual-CPU workstation
 - Low to middle latitudes (closed field lines)
- **Includes the adjoint model for 4DVAR assimilation**
 - Permits more accurate forecast by adjusting drivers
 - Possible strong science role
- **gaim++ multi-ion code under development**
- **Under consideration: model running at CCMC**
 - Requires funding at this time (proposed)
 - Real-time version



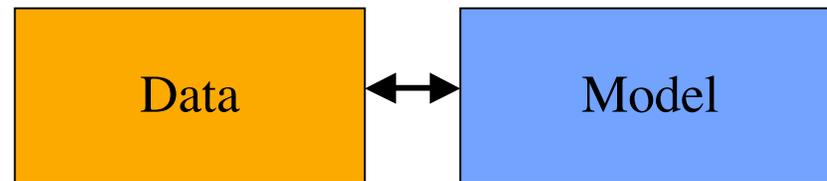
USC/JPL GAIM Applications



- **Real-time demonstration with C/NOFS data (AFRL)**
 - Ground GPS data
 - C/NOFS in-situ electron density
 - C/NOFS CORISS occultations
 - C/NOFS Launch February 2006
- **3D-Ionospheric current model (NASA)**
 - Assimilate COSMIC and C/NOFS data (Ne, conductivity) into GAIM
 - Use C/NOFS electric fields to compute currents
- **Improve deep space tracking (NASA)**
 - GPS ground data surrounding NASA tracking sites
- **Demo with COSMIC constellation**
- **Thorn in Bob Schunk's side**



- **Data assimilation models designed to ingest data**



- **Operational users are adopting these models**
- **GAIM at CCMC \Rightarrow new data sets at CCMC**
- **Implications for CCMC need careful consideration**
 - Increased complexity related to data validation and acquisition
- **Real-time and/or continuous runs**
 - High value for continuous assessment
 - Requires automated validation scripts



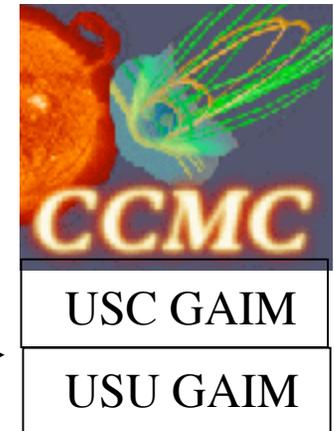
Ionosphere In-A-Box v1.0



- Demo at Space Weather Week 2004
- USC/JPL GAIM forward model and Kalman filter
- Hardware: one dual-CPU Linux workstation
- **Data feeds! -**
 - Geophysical indices from NOAA SEC
 - TEC data every 5 minutes from 77+ GPS sites
 - Ionosonde data every 15 minutes from SEC
 - JASON validation TEC every 3 hours
 - Post-processing GPS TEC from 200-900 sites
- **Outputs:**
 - Updated 3D density grid every 5 minutes
- **Automated validation**
 - (JASON, GPS)

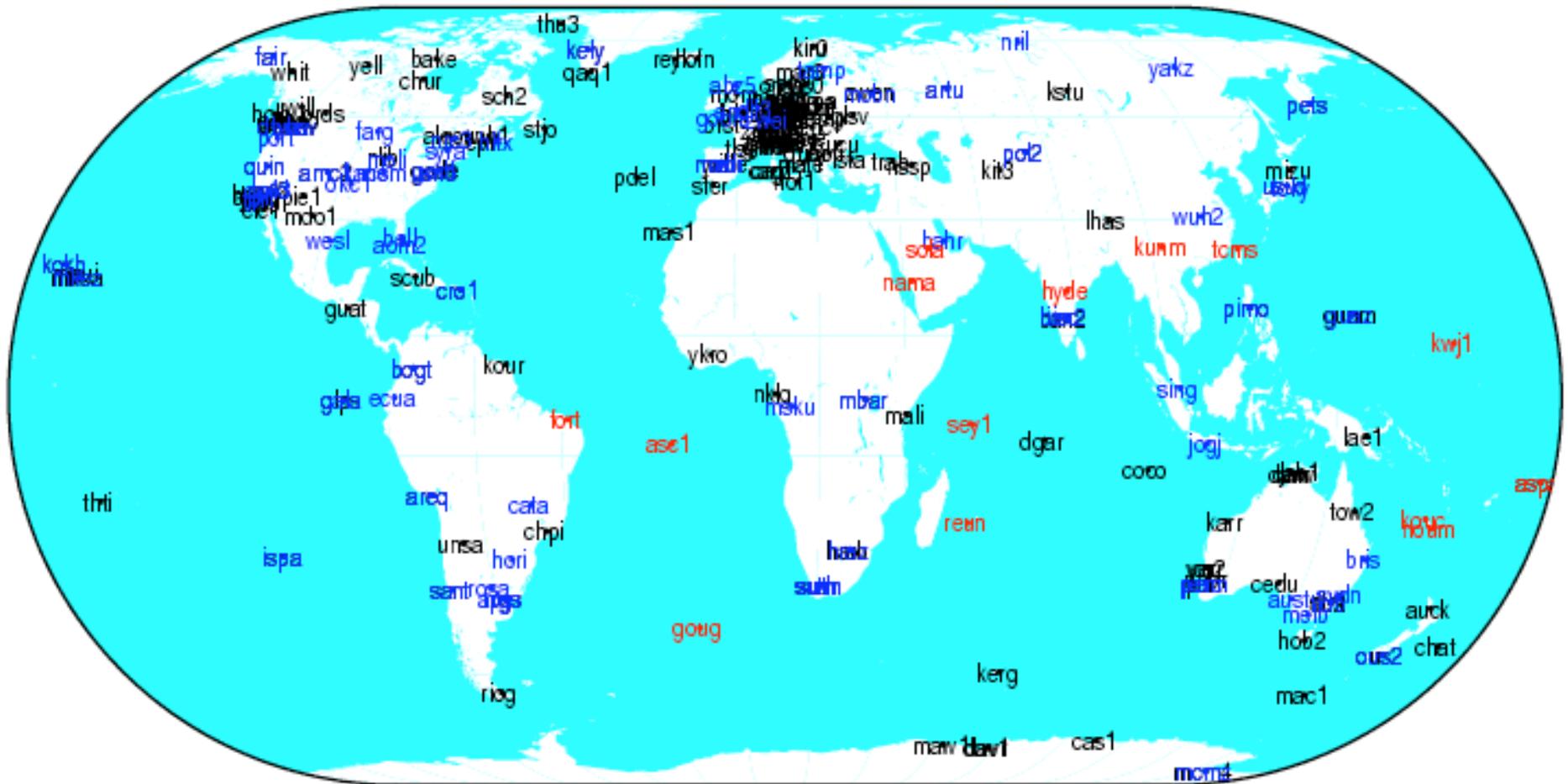


Data Feed





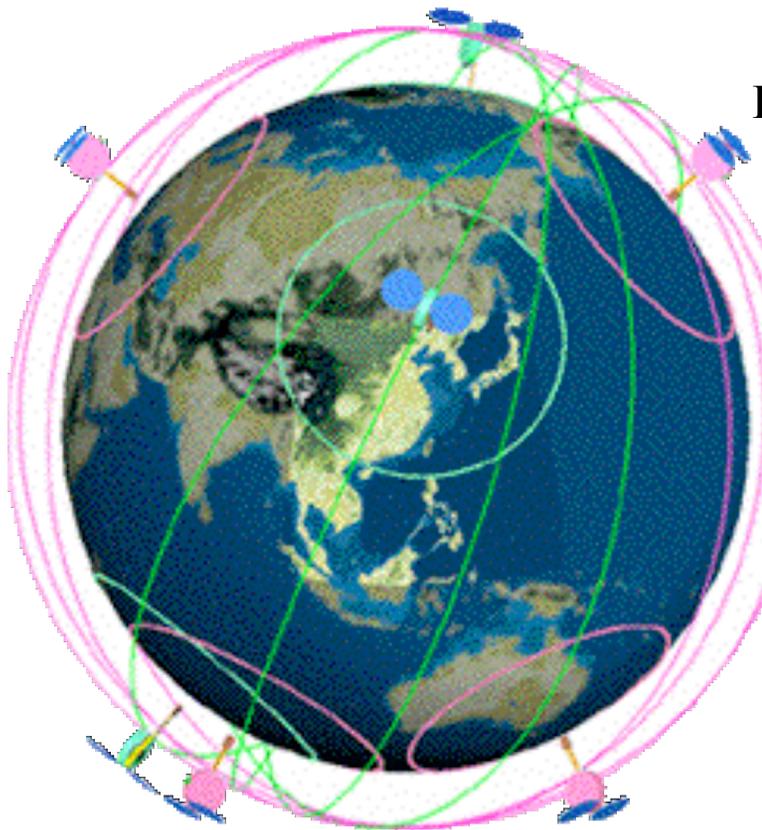
Combined Hourly and Streaming Sites



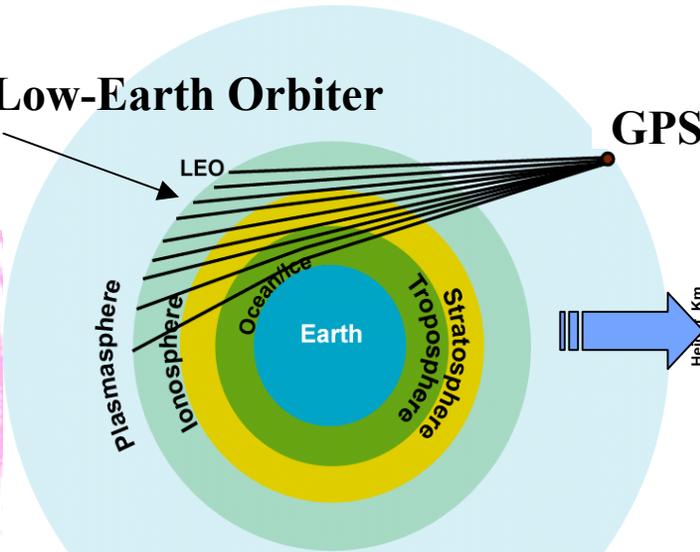
Black = current all hourly, Blue = 77+ streaming, Red = potential add-ons



COSMIC: New Source Of Data

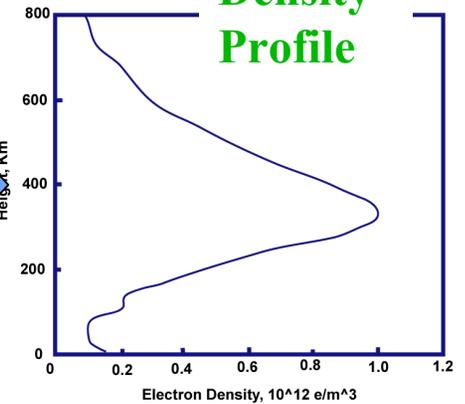


Low-Earth Orbiter



GPS

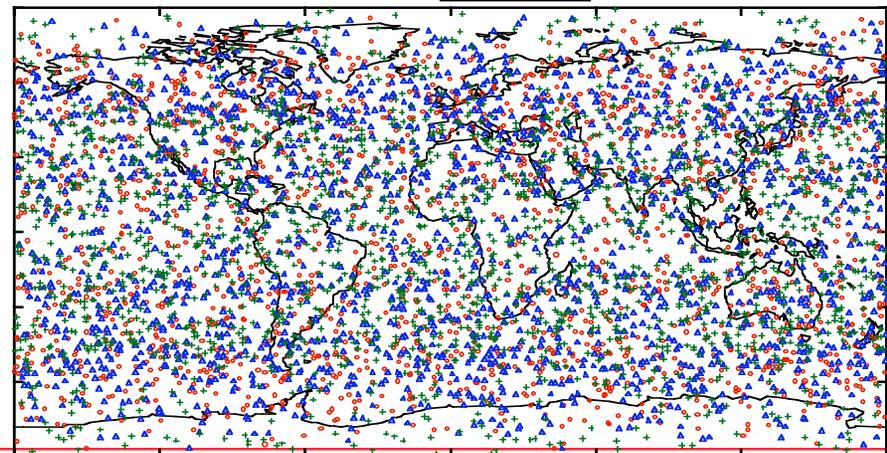
Electron Density Profile



COSMIC coverage

- Rising
- ▲ Setting
- + Grazing

3000 profiles/day



Six-satellite COSMIC constellation
Launch March 2006



NSF NASA USAF NOAA NSPO ONR



Summary



- **CCMC is revolutionizing space science**
- **User-led evolution path**
 - **Listen to *all* your stake-holders!**
 - Users, developers, agencies
- **CCMC is entering data assimilation era**
- **JPL can contribute USC/JPL GAIM**
- **Radical suggestion**
 - **Can ionosphere data be considered as an input for solar wind and magnetospheric models?**
 - **“Non-unique inverse problem” versus “data starved”**