Community-Wide Project: GEM-CEDAR Modeling Challenge

For Space Environment modeling, confidence assessment of model predictions is an essential element

- **Quantitative assessment** of models’ capabilities to model storm impact on geo-space system.

- Define **physical parameters** and **metrics formats** relevant to specific space weather applications.

- Address **uncertainties** and **challenges** in model-data comparisons.

- CCMC provides support by archiving results and developing on-line interactive model validation systems, coordinate community tools development.

- Joint publications (> 20 participating models, 10 papers)

- FOCUS SO FAR: Comparison of time series from model and observation at specific locations/trajectories; extending to 2D comparison.
Status of Community-wide Project
GEM-CEDAR Modeling Challenge

• Model Validation Projects:
  o Poynting flux/Joule heating
  o Auroral oval boundaries
  o Global TEC
  o Neutral density/Satellite drag

• Role of magnetospheric drivers on IT system

• Climatology Assessment of Ionosphere/Thermosphere Models:
  (background support study)
Poynting Flux/Joule Heating

- Poynting Flux along the DMSP-15 satellite track from E (derived from measured plasma velocities) and B measurements.

- Modeled PF and Joule Heating from
  - empirical PF models
  - physics-based 3-D ionosphere models
  - ionospheric electrodynamics solvers of magnetosphere models

- Selected six storm events

Auroral Oval Boundary

• Started with equatorward boundary using DMSP energy flux data

• Trying to find consistent way to define boundary (e.g., threshold-based)

• Participating models: old Hardy, New Hardy, Ovation Prime, Weimer, coupled global MHD model with Fok ring current model, AMIE

• Correlation between auroral boundaries with
  o Poynting flux,
  o Joule heating,
  o Field-aligned currents,
  o Total electron content,
  o Auroral charging

Global TEC Study

- Started with 8 longitude sectors for 2006 Dec. event:
  - RMSE, NRMSE, and ratio of max.
  - dTEC_q = TEC – TEC_q(pre-storm)
  - Using 15 simulations from 8 IT models

- Addressed TEC modeling challenges:
  - TEC data preparation for validation study
  - Biases in TEC data
Neutral Density/Satellite Drag

- Neutral density measurement along the CHAMP orbit
- Model-data comparison using
  - Point value
  - Orbit averaged value
- Baseline removal to remove difference in quiet time reference levels among models, and to quantify variations due to storms.
- Satellite Drag at high altitude (> 600 km)
Role of Drivers

**Driver-Swapping (MI Coupling) Patch-Panel Tool**

- **High-Latitude Electric Potential Models**
  - empirical
  - data assimilation
  - global MHD
  - • Weimer
  - • Foster
  - • Heppner & Maynard
  - • Heelis
  - • AMIE
  - • SAM
  - • SWMF
  - • Open-GGCM
  - • LFM-MIX

- **Particle Precipitation Models**
  - empirical/analytical
  - • Fuller-Rowell & Evans
  - • Hardy et al.
  - • Ovation Prime
  - • Roble & Ridley

- **Penetration Electric Field Models**
  - global MHD
  - • SWMF
  - • Open-GGCM
  - • LFM-MIX

- **inner magnetosphere model**
  - • RCM
  - • CRCM

All drivers are converted to a common format.
The tool is called as a KAMELEON subroutine to provide values on the grid:
call kameleon (model, time, mlts, mlats, variables, values_output)

IT Models (CTIPe/TIE-GCM/GITM)
CTIPe runs with different high-latitude electric potential models

(for 2006 Dec. event: Orbit averaged density along the CHAMP orbit)

• All three CTIPe runs use the same model for auroral particle precipitation (Fuller-Rowell & Evans)
Regional TEC Study

TEC Changes during 2013 Mar. Storm
foF2 for 35 days including 2013 Mar. Storm (doy 076) at Millstone Hill

Millstone Hill (blue)

Change

Percentage change

red: foF2 – foF2_quiet(doy 075)
blue: foF2 – foF2_quiet(30-day median)
Outlook

• Focus on **Auroral Region**: a hub for GEM-CEDAR joint projects
  - boundaries
  - conductance

• New observations beyond DMSP data
  - new data comparison:
    - e.g., FUV Auroral Images (Yongliang Zhang)

• Boundaries based on different impact
  - auroral charging