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

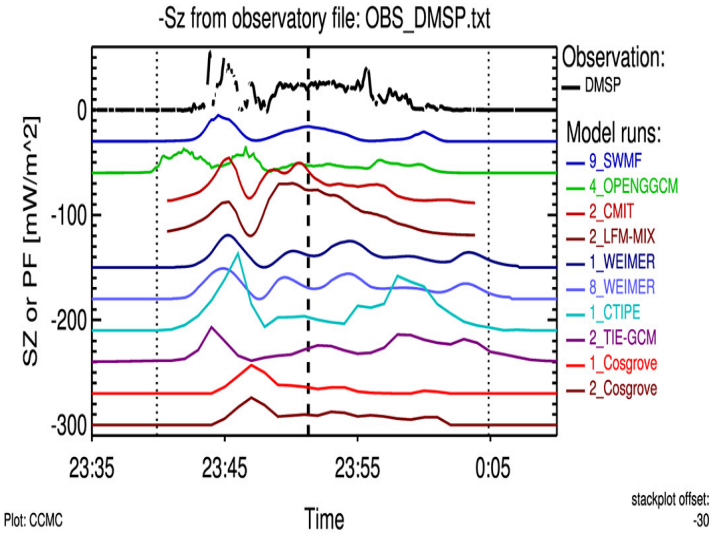
- Model Validation Projects:
  - Poynting flux/Joule heating
  - Auroral oval boundaries
  - Global TEC
  - Neutral density/Satellite drag
- Role of magnetospheric drivers on IT system
- Climatology Assessment of Ionosphere/Thermosphere Models: (background support study)

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

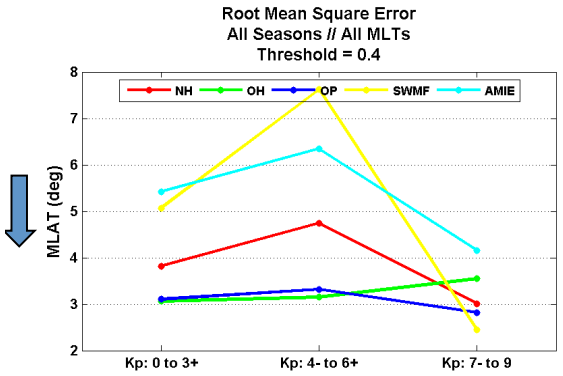
- Selected six storm events



- Rastätter L., et al. (2016), GEM-CEDAR challenge: Poynting flux at DMSP and modeled Joule heat, Space Weather, 14, 113–135, doi: 10.1002/2015SW001238.

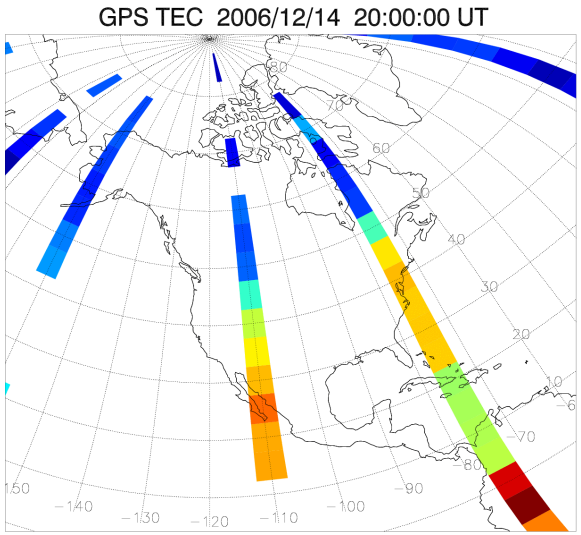
Auroral Oval Boundary

- 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
  - Poynting flux,
  - Joule heating,
  - Field-aligned currents,
  - Total electron content,
  - Auroral charging



- Lane, C., A. Acebal, and Y. Zheng (2015), Assessing predictive ability of three auroral precipitation models using DMSP energy flux, Space Weather, 13, 61–71, doi:10.1002/2014SW001085.

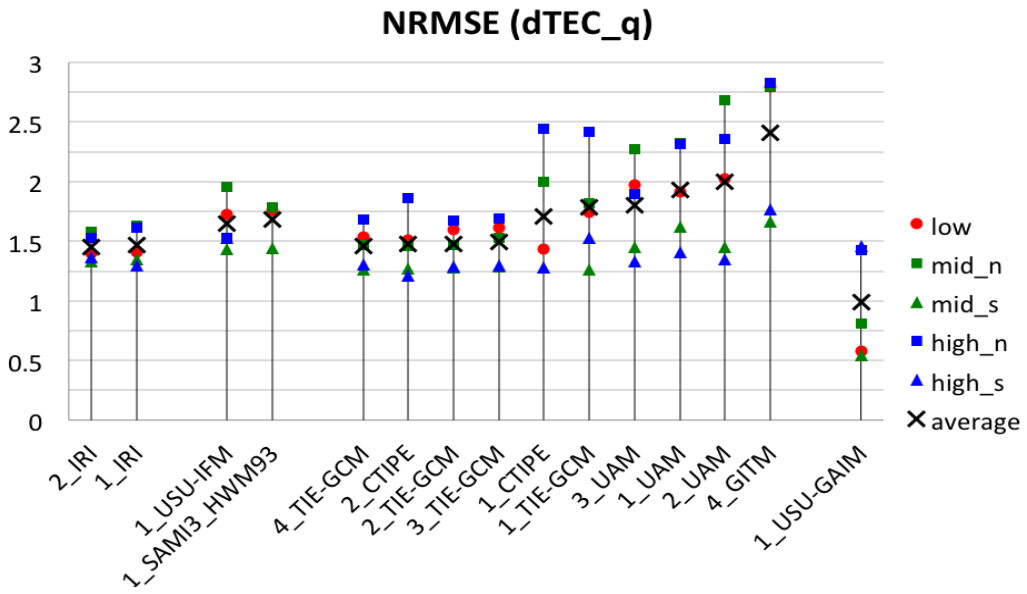
Global TEC Study



5° lat × 5° lon × 15 min

- Addressed TEC modeling challenges:
  - TEC data preparation for validation study
  - biases in TEC data

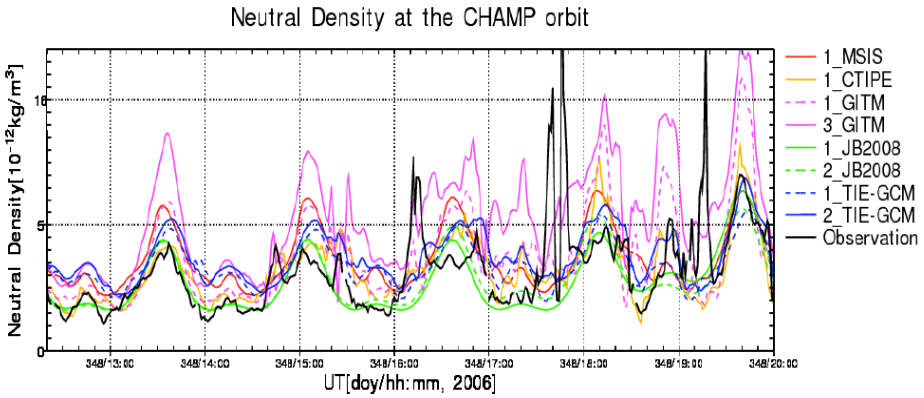
- Started with 8 longitude sectors for 2006 Dec. event:
  - RMSE, NRMSE, and ratio of max.
  - dTEC_q = TEC – TEC_q(pre-storm)
  - Using 15 simulations from 8 IT models

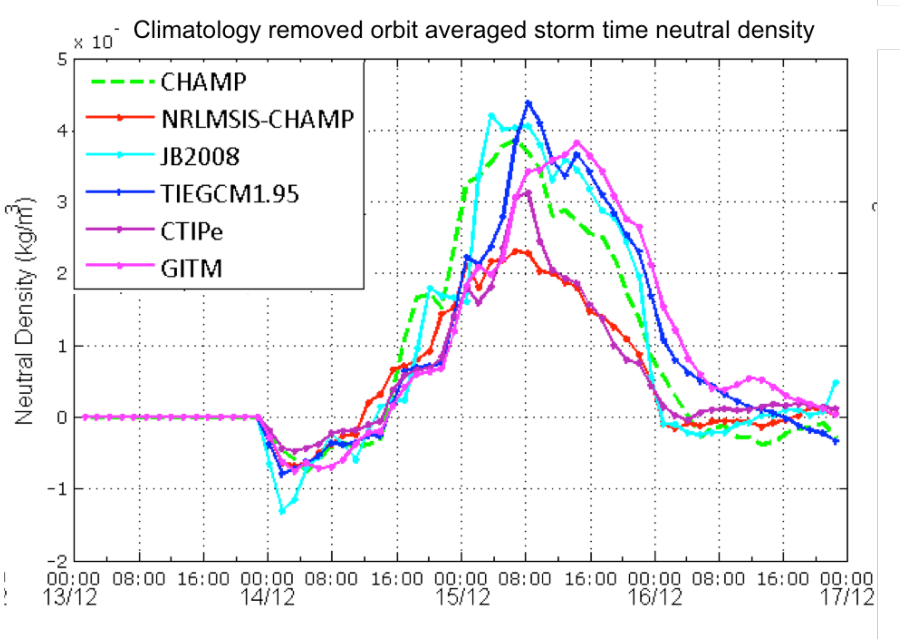


Neutral Density/Satellite Drag

- 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)

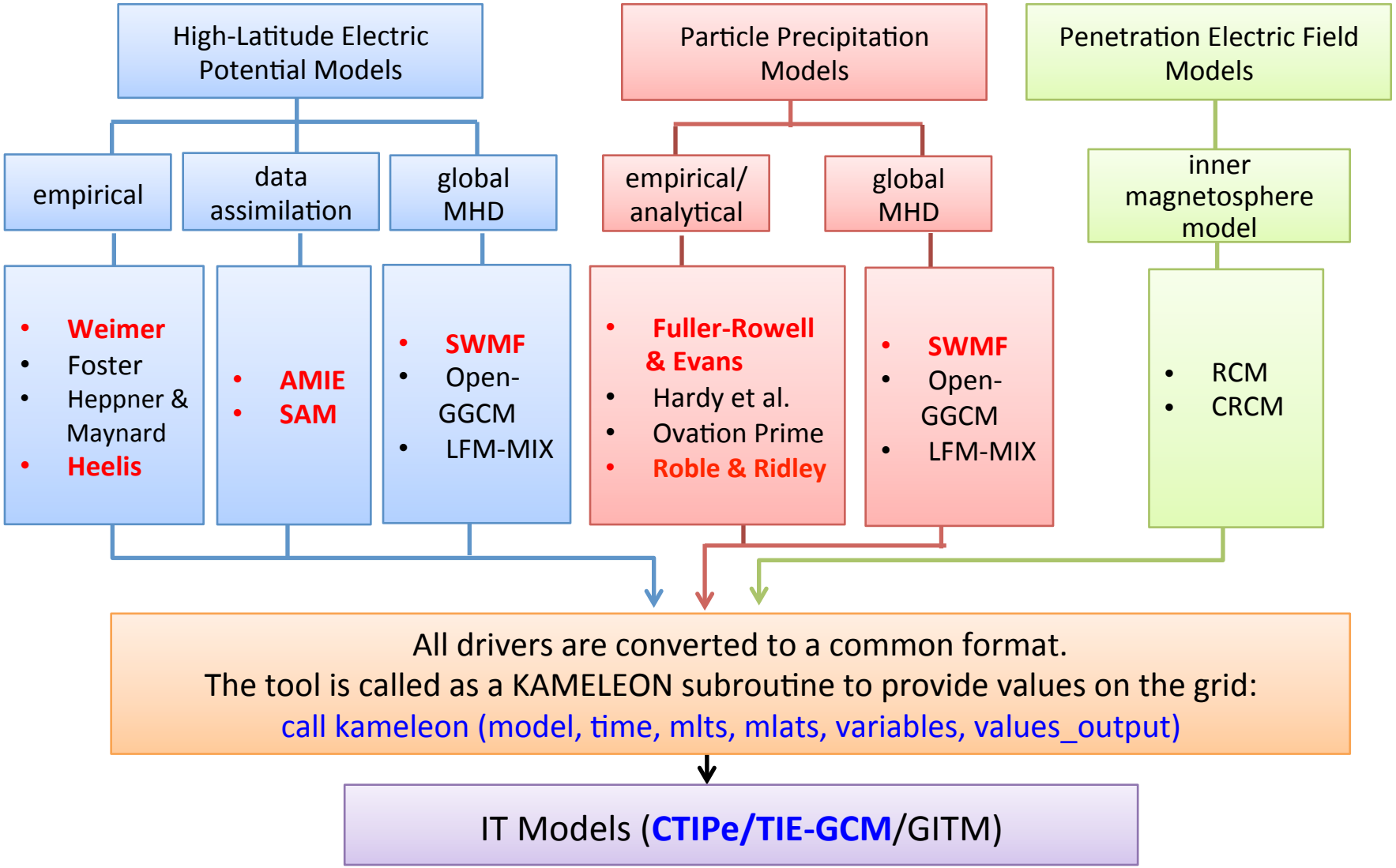
Modeled and observed neutral density along the CHAMP orbit





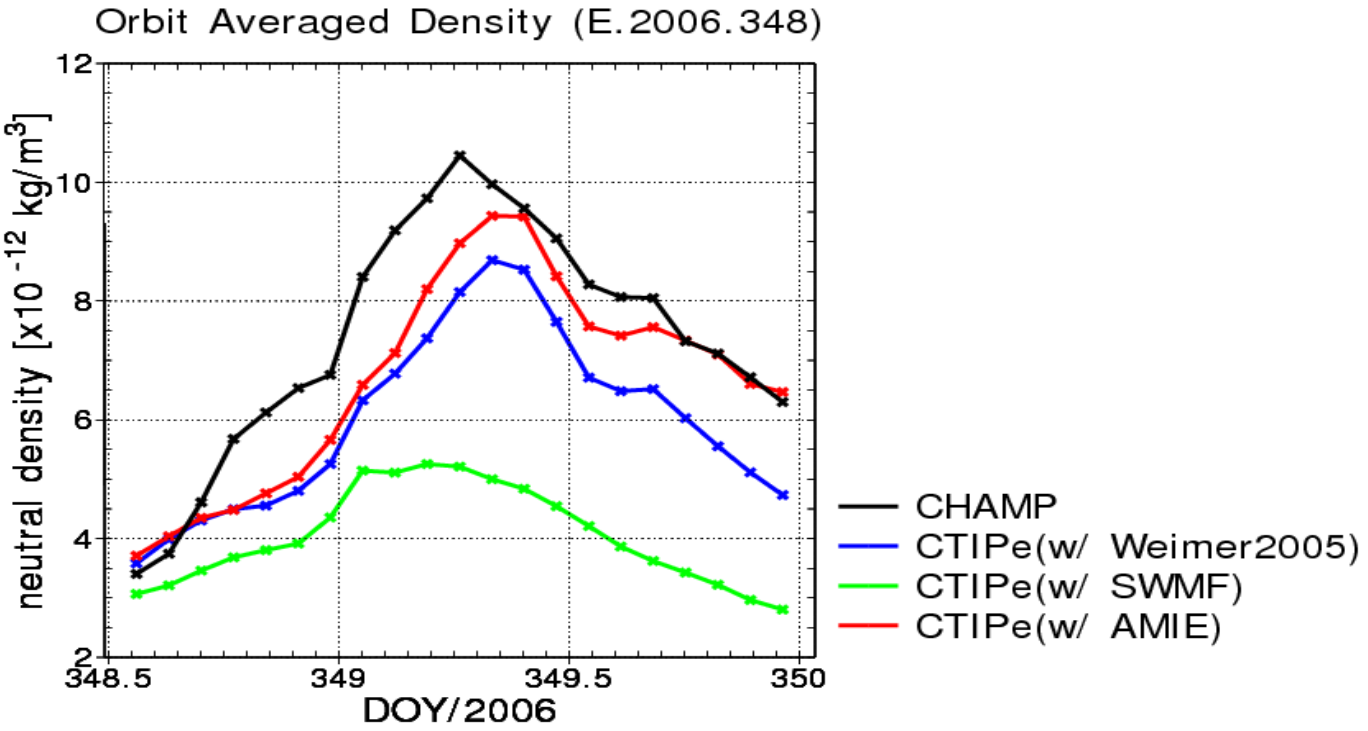
Role of Drivers

Driver-Swapping (MI Coupling) Patch-Panel Tool



CTIPe runs with different high-latitude electric potential models

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

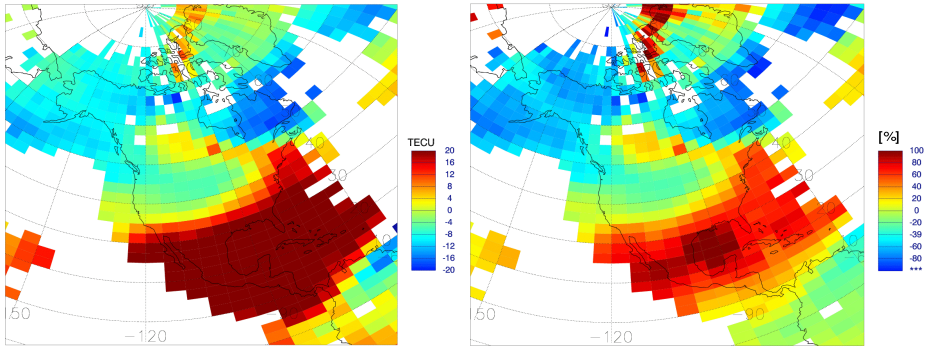


- All three CTIPe runs use the same model for auroral particle precipitation (Fuller-Rowell & Evans)

Regional TEC Study

TEC Changes during 2013 Mar. Storm

MIT_0002 d_TEC 2013/03/17 20:00:00 UT



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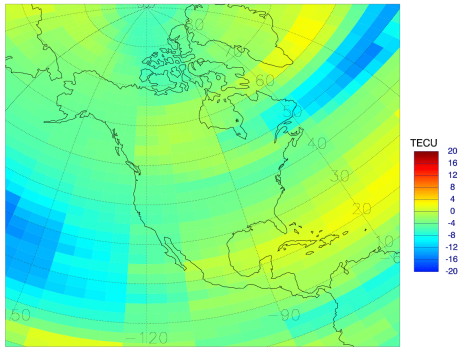
CTIPE_0001 d_TEC 2013/03/17 20:00:00 UT



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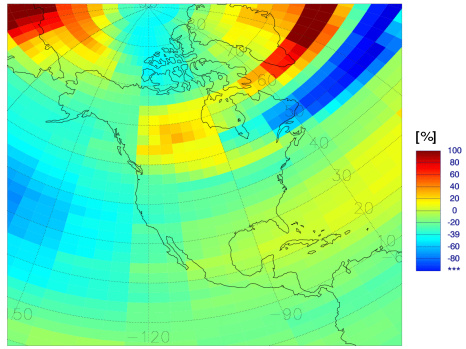

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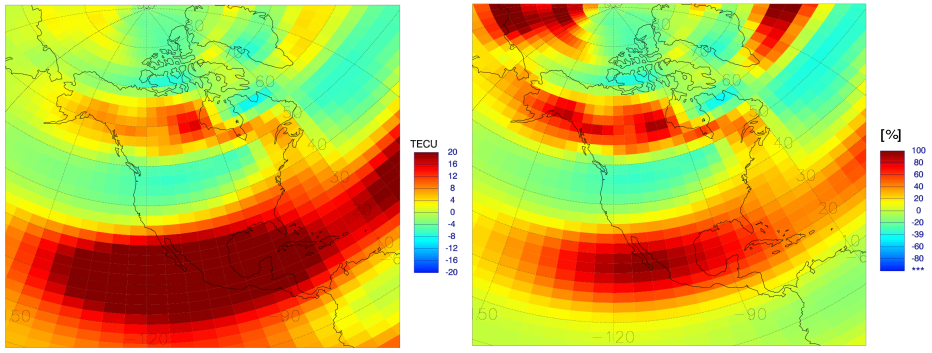

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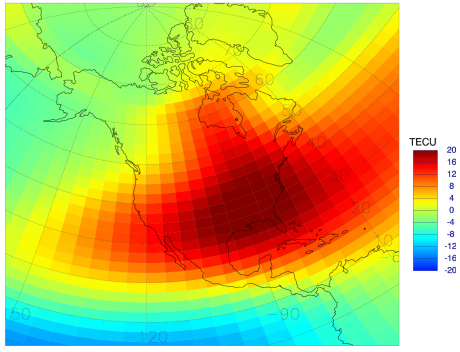
TIEGCM_0004 d_TEC 2013/03/17 20:00:00 UT



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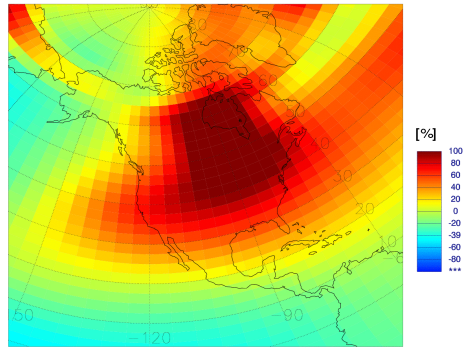
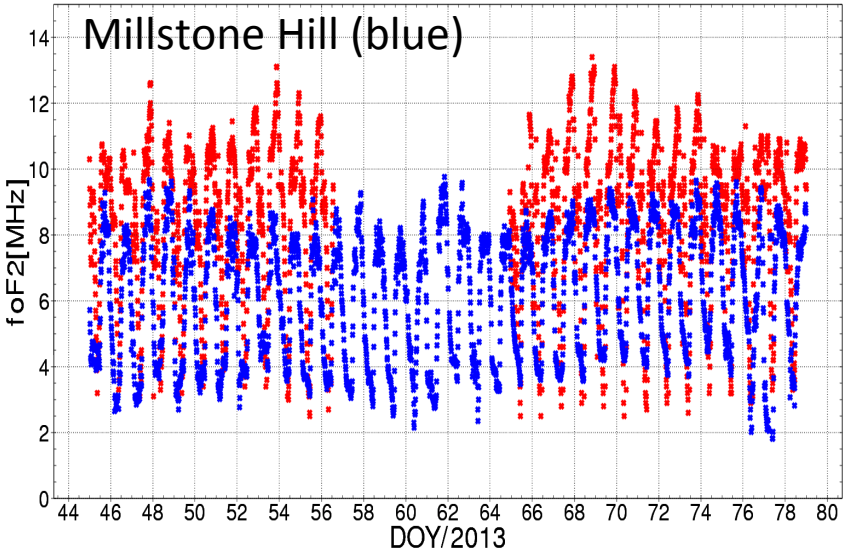
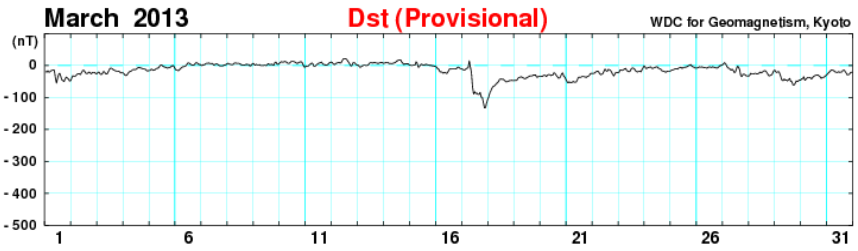
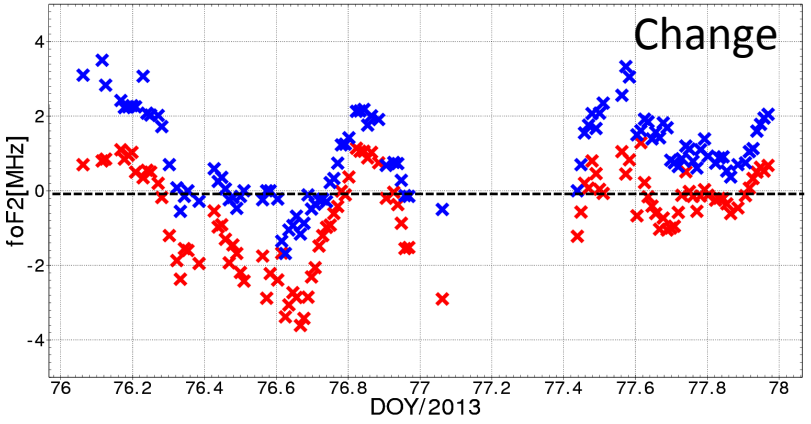
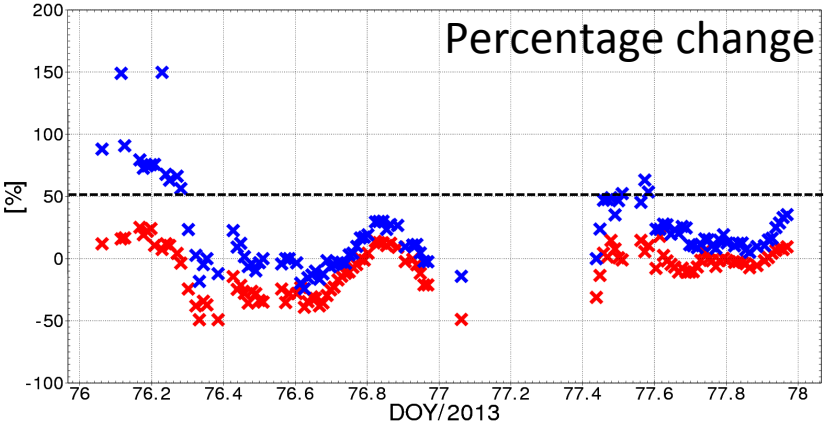


foF2 for 35 days
including 2013 Mar. Storm (doy 076)
at Millstone Hill









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