

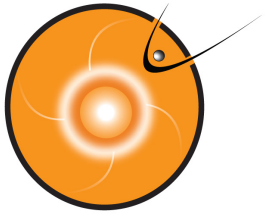
# CCMC Research and Education Resources for the CEDAR Community

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M. Hesse and A. Chulaki

<http://ccmc.gsfc.nasa.gov>

NASA Goddard Space Flight Center

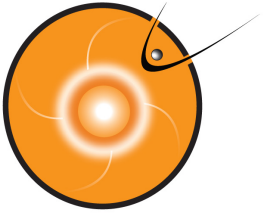




# Overview

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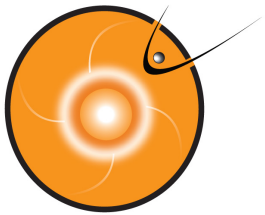
- About CCMC
  - Ionosphere/Thermosphere Models at CCMC
  - CEDAR ETI (Electrodynamics Thermosphere Ionosphere) Challenge
  - Outlook
-



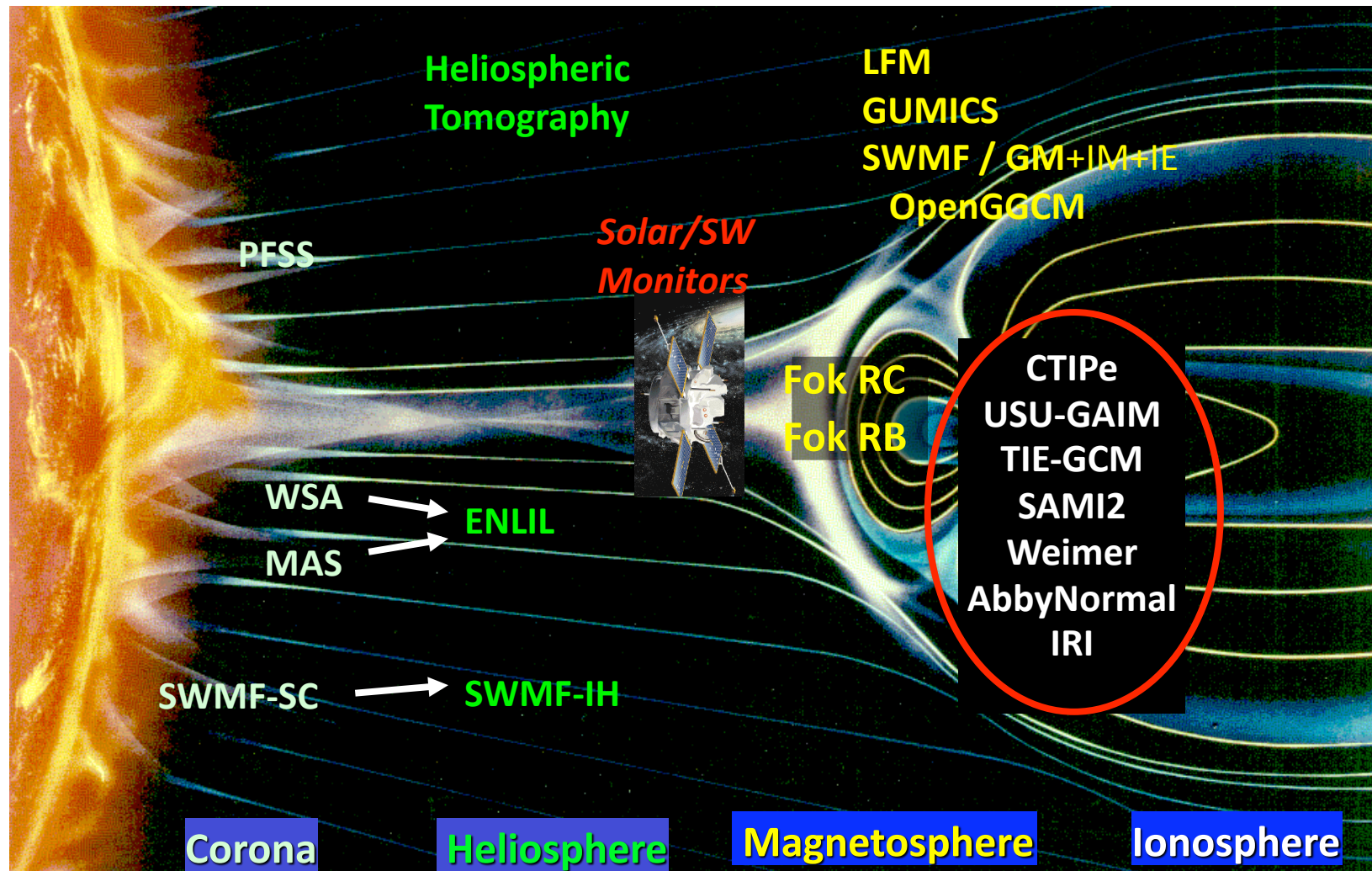
## CCMC Goals

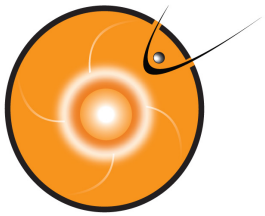
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- Facilitate community research and education
    - provide access to modern space research models
    - on-line visualization & analysis tools
  - Address national space weather needs, and support NASA robotic mission
    - model validation & metric studies
    - real-time runs
    - space weather forecasting tools
-



# CCMC Models Cover Entire Domain

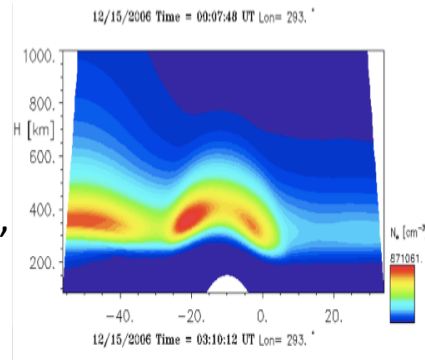




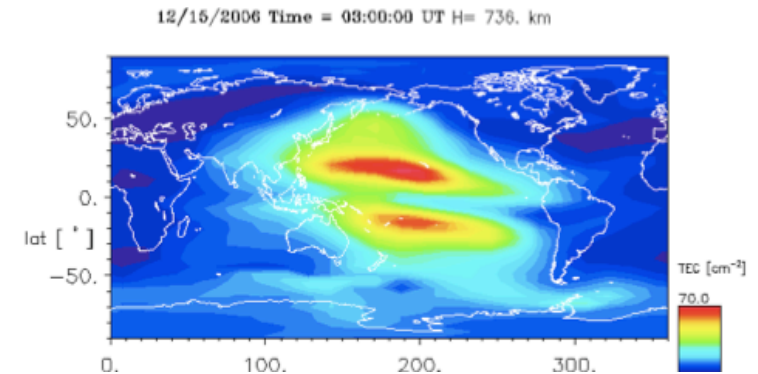
# Global Ionosphere/Thermosphere Models

## Electron density

**SAMI2**: SAMI is Another Model of the Ionosphere, J. Huba et al., NRL

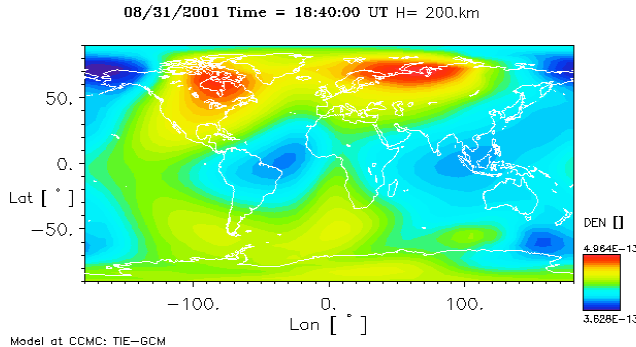


## TEC



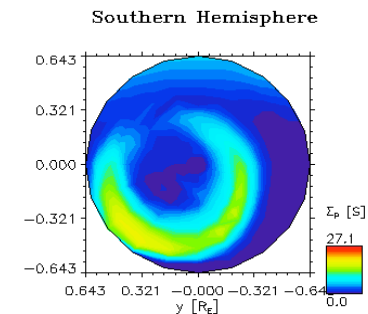
**USU-GAIM** : Global Assimilative Ionosphere Model, R. Schunk et al., Utah State Univ.

## Neutral density

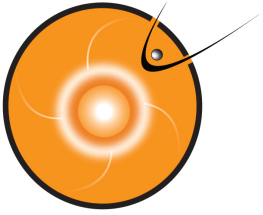


**TIEGCM** : Thermosphere Ionosphere Electrodynamics General Circulation Model, R. G. Roble et al., High Altitude Observatory – NCAR

## Height integrated Pederson conductance



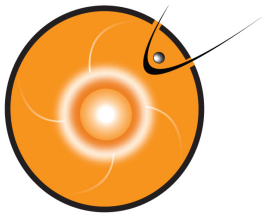
**CTIPE** : Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics, T. Fuller-Rowell et al., NOAA SEC



## Access to the Models at CCMC

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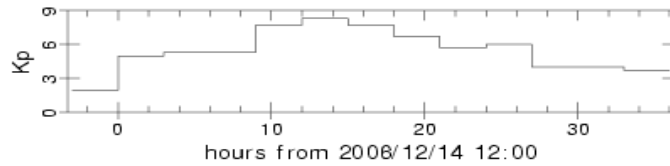
- request model runs
  - visualize the results on the web interface
  - timeseries outputs
  - movies on request
  - extensive database of simulation results
-



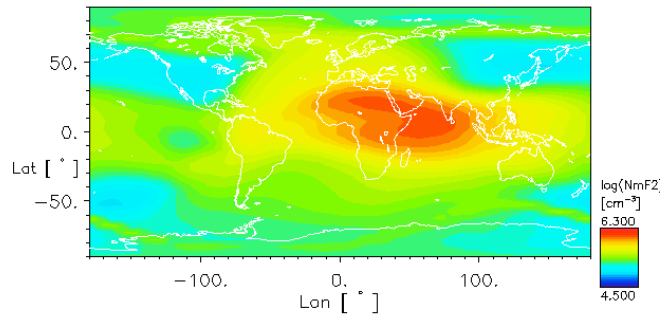
# Online Interactive Visualizations

2006 AGU Storm (12.14.12:00-12.16.00:00) : TIE-GCM

(Run# CCMC\_AGUSTORM\_020810\_IT)

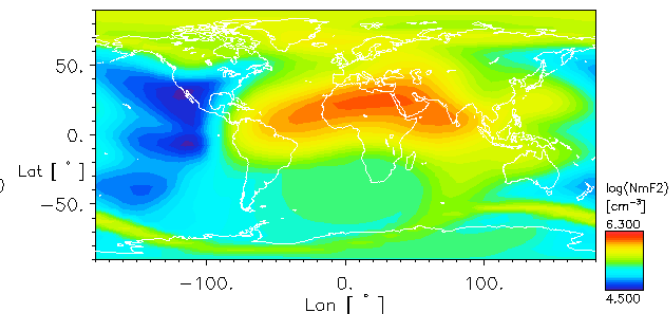


12.14.1200UT

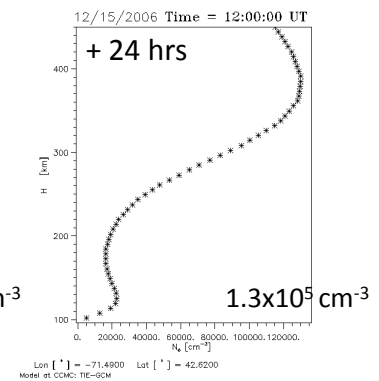
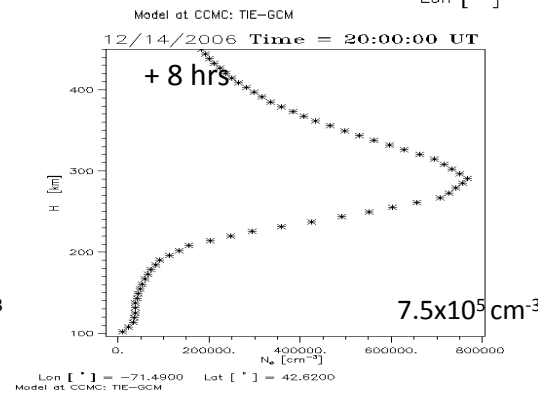
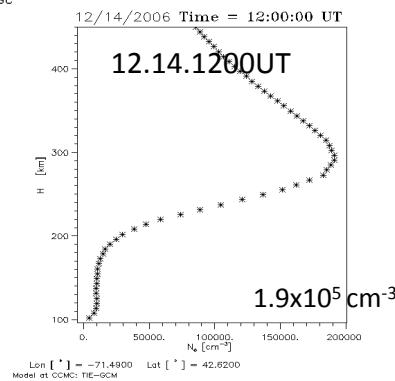


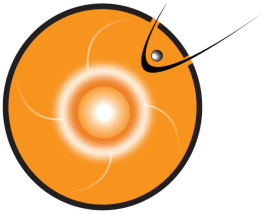
NmF2

12.15.1200UT



Electron density profile over Millstone Hill (42.6N,288.5E)

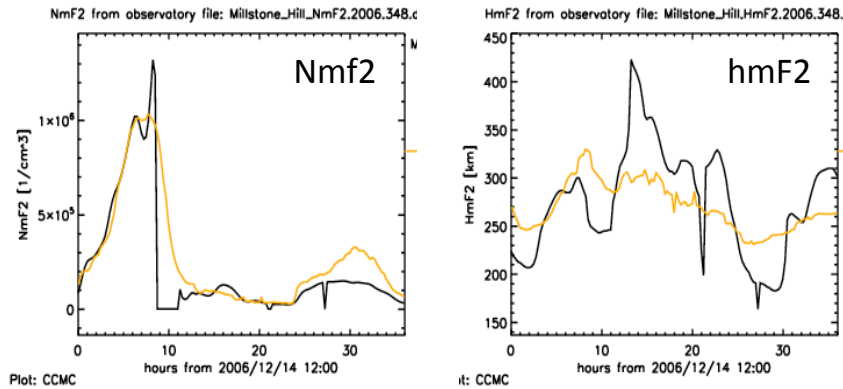




# Model-Observation Comparison

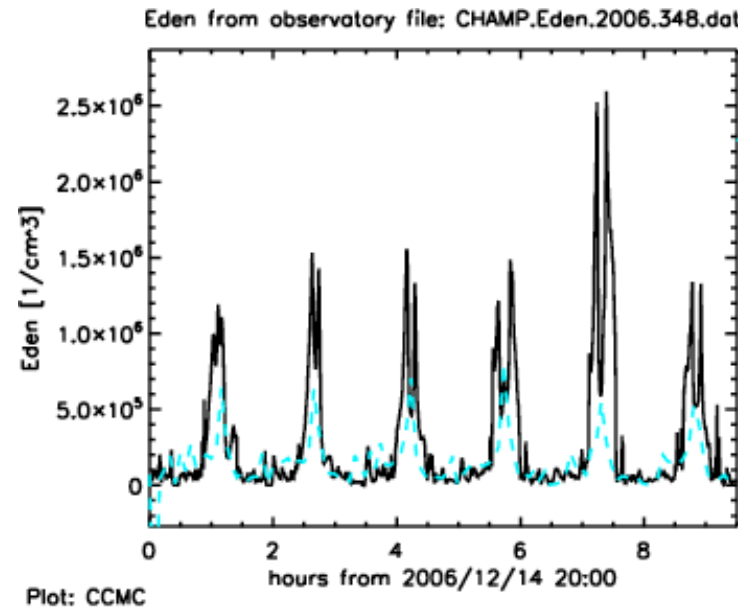
2006 AGU Storm (12.14.12:00-12.16.00:00)

NmF2 and hmF2 : USU-GAIM

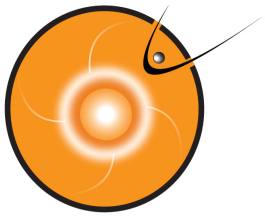


Millstone Hill ISR measurements

Electron density along the  
CHAMP trajectory : CTIPE

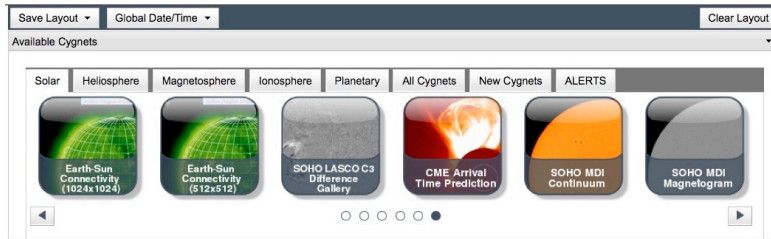




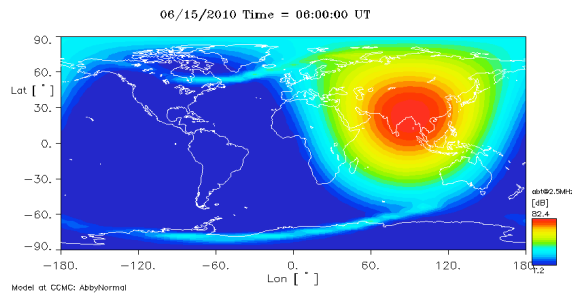


# ISWA (Integrated Space Weather Analysis) system

: a web-based dissemination system (<http://iswa.gsfc.nasa.gov>)

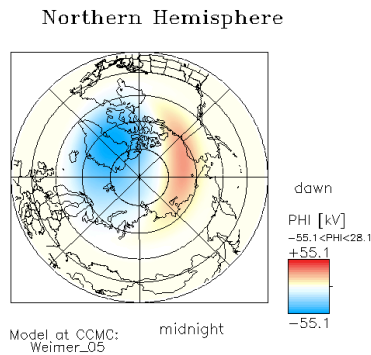


**AbbyNormal** : ABsorption BY the D and E Region of HF Signals with NORMAL Incidence, J. Vincent Eccles et al., Space Environment Corporation



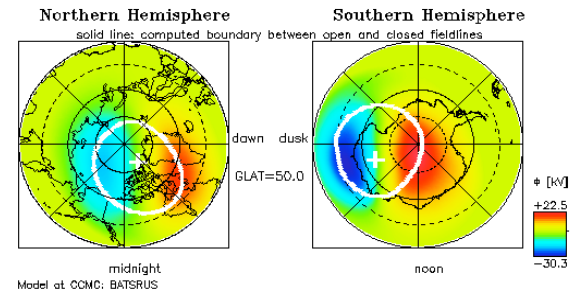
**Weimer** : Weimer-2005 electric potentials, D. Weimer, Virginia Tech

06/16/2010 Time = 18:04:00

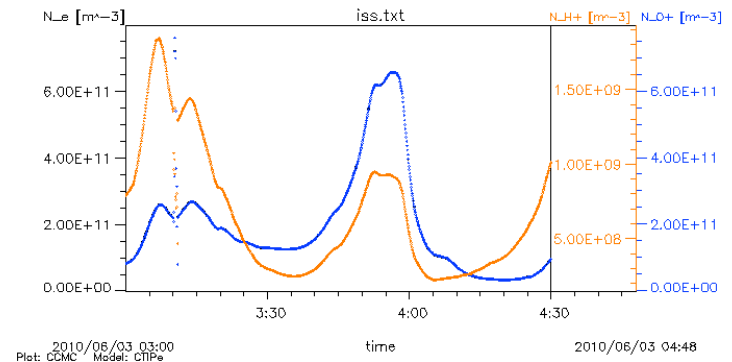


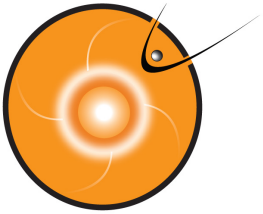
## BATS-R-US: Tamas Gombosi et al.

06/14/2010 Time = 08:20:00



**CTIPE** (T. Fuller-Rowell et al., NOAA SEC) is running in real time in test mode.

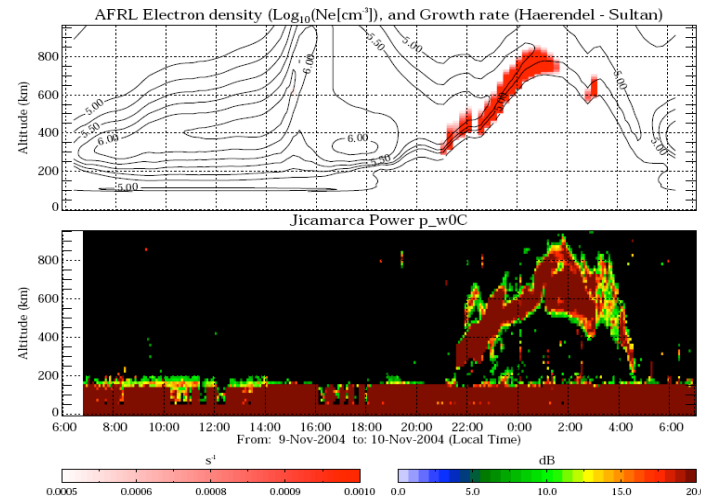




## Soon to be hosted Models at CCMC

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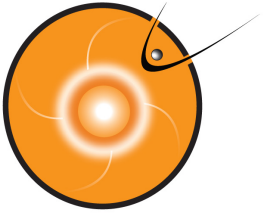
### 1. PBMOD: Ionosphere Scintillation model, J. Retterer, AFRL



### 2. GITM: Global Ionosphere–Thermosphere Model, part of the Space Weather Modeling Framework (SWMF), A. Ridley et al., University of Michigan

### 3. SAMI3: SAMI is Another Model of the Ionosphere, J. Huba et al., NRL

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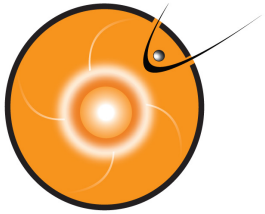


# CEDAR ETI Challenge

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## Goals :

- to help to evaluate the current state of the IT models
  - to track model improvements over time
  - to facilitate interaction between research and operation communities
  - to facilitate collaboration between modelers and between research communities
-



# Challenge Setup : Events

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## **GEM storms**

E.2006.348: 2006/12/14 (doy 348) 12:00 UT - 12/16 (doy 350) 00:00 UT (Kp\_max = 8)

E.2001.243: 2001/08/31 (doy 243) 00:00 UT - 09/01 (doy 244) 00:00 UT (Kp\_max = 4)

E.2005.243: 2005/08/31 (doy 243) 10:00 UT - 09/01 (doy 244) 12:00 UT (Kp\_max = 7)

**Year of incoherent scatter radar (ISR) observations** from 2007/03/01 (doy 060) – 2008/03/31 (doy 091)

## **Moderate storms**

E.2007.091: 2007/04/01 (doy 091) 00:00 UT - 04/02 (doy 092) 12:00 UT (Kp\_max = 5)

E.2007.142: 2007/05/22 (doy 142) 12:00 UT - 05/25 (doy 145) 00:00 UT (Kp\_max = 5.7)

E.2008.059: 2008/02/28 (doy 059) 12:00 UT - 03/01 (doy 061) 12:00 UT (Kp\_max = 5.3)

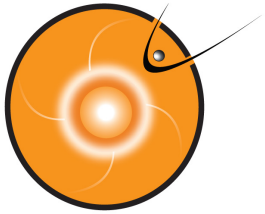
## **Quiet periods**

E.2007.079: 2007/03/20 (doy 079) 00:00 UT - 03/22 (doy 081) 00:00 UT (Kp\_max = 0.7)

E.2007.190: 2007/07/09 (doy 190) 00:00 UT - 07/10 (doy 191) 00:00 UT (Kp\_max = 0.3)

E.2007.341: 2007/12/07 (doy 341) 00:00 UT - 12/09 (doy 343) 00:00 UT (Kp\_max = 1.0)

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# Challenge Setup : Physical Parameters

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- Vertical and horizontal drifts at Jicamarca ( $V_{\text{perpN}}$  and  $V_{\text{perpE}}$ )
- Neutral density at CHAMP orbit ( $N_{\text{den}}$ )
- Electron density at CHAMP orbit ( $E_{\text{den}}$ )
- $N_mF2$  from LEO satellites (CHAMP and COSMIC) and ISRs
- $H_mF2$  from LEO satellites (CHAMP and COSMIC) and ISRs

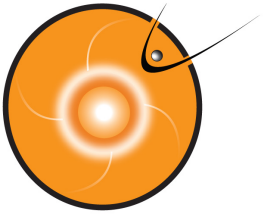
Millstone Hill (42.62 N, 288.51 E)

EISCAT Svalbard (78.09 N, 16.02 E)

Poker Flat (65.13 N, 212.53 E)

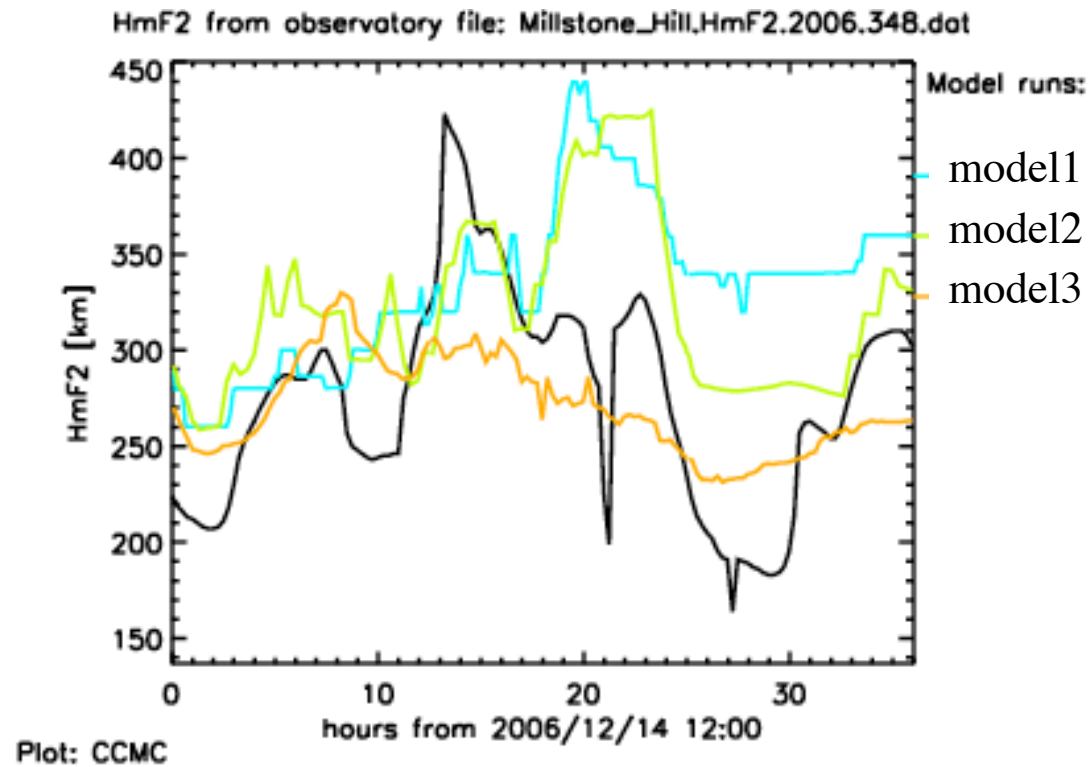
Sondrestrom (66.99 N, 309.05 E)

- Global TEC
-



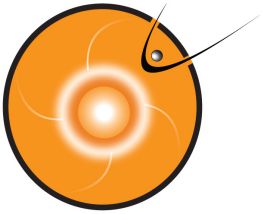
# HmF2 : E.2006.348

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How to compare model results ?

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# Metrics Examples

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- Metrics based on RMS

Model Skill Score :

$$\left(1 - \frac{\text{Model Score}}{\text{Reference Model Score}}\right)$$

Model Score against the observation :

$$\sqrt{\frac{\sum (x_{obs} - x_{mod})^2}{N}}$$

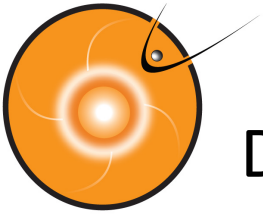
Reference Model : IRI-2007

- > 0 : better than reference model,
- < 0 : worse than reference model

- Metrics based on ratio of the difference between maximum and minimum values during an event:

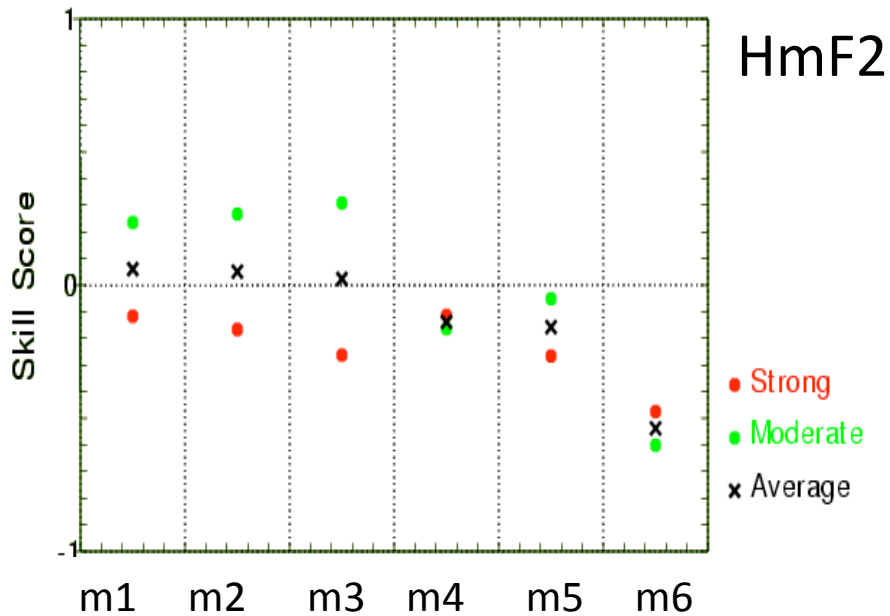
$$\frac{(x_{mod})_{\max} - (x_{mod})_{\min}}{(x_{obs})_{\max} - (x_{obs})_{\min}}$$

- > 1 : over estimate,
  - < 1 : under estimate
-

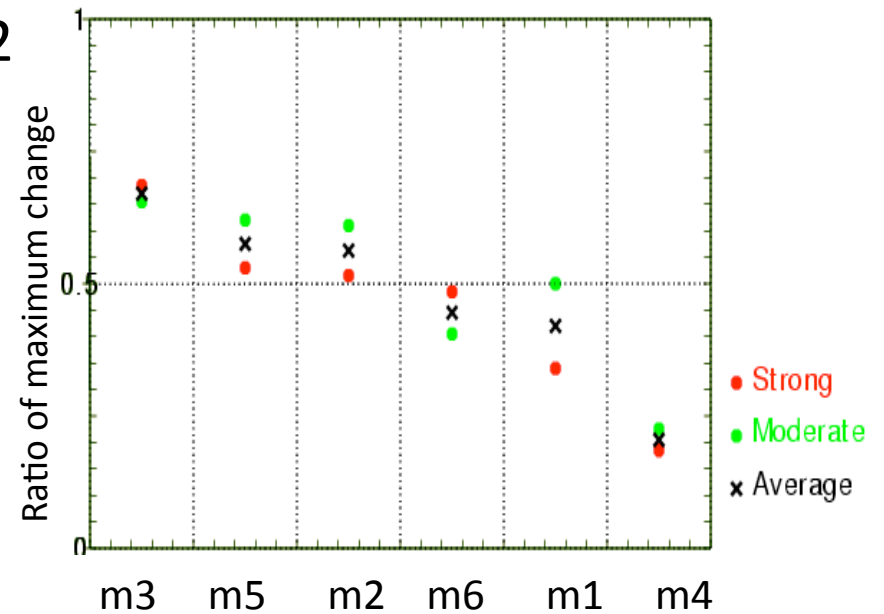


# Dependence on Geomagnetic Activity and Metrics

RMS Metrics

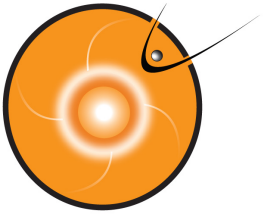


Ratio of maximum change

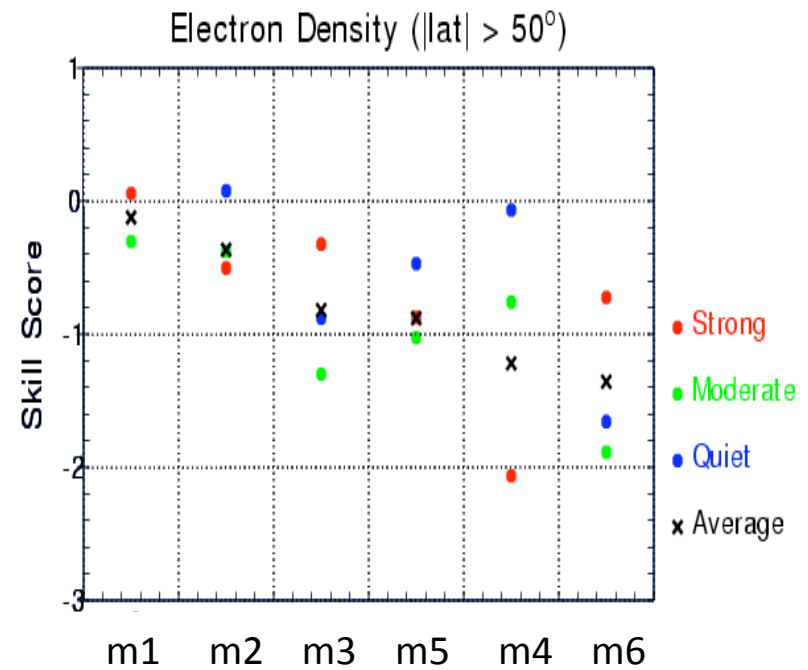
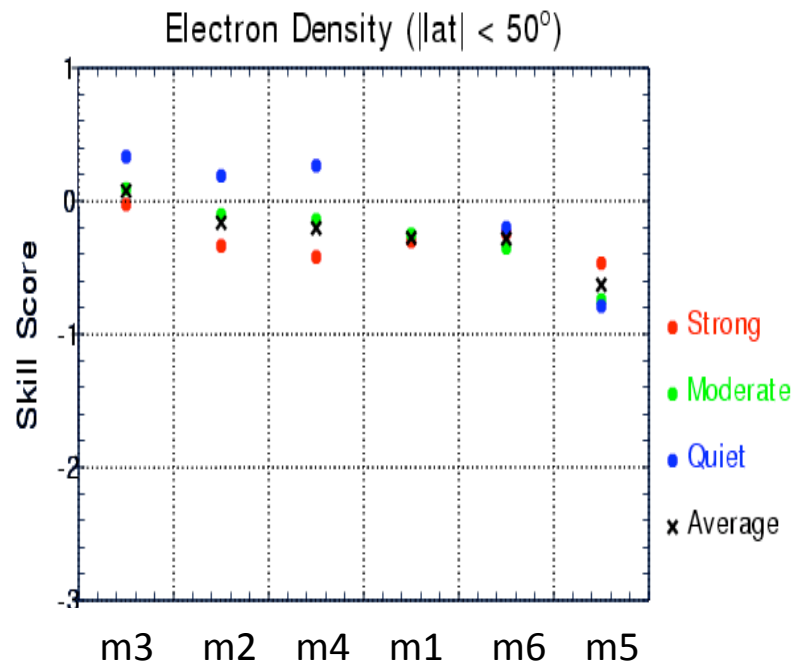


Ranking depends on metrics selection

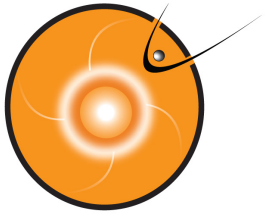




# Ne : Dependence on Latitude



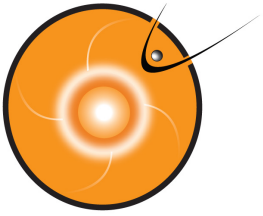
Ranking varies with latitude



# Outlook

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- Broad range of ITM models are available to anyone.  
<http://ccmc.gsfc.nasa.gov>
  - CCMC has unique experience in running models in real time.
  - CCMC space weather tools based on real time runs support NASA robotic missions.  
<http://iswa.gsfc.nasa.gov>
  - CCMC expands V&V activity.
  - CCMC supports GEM & CEDAR modeling challenges and facilitates joint GEM-CEDAR model validation project.
  - You are invited to CETI workshop on Friday 10:30-12:30.
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Thank you !

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