CCMC Research and Education Resources for the CEDAR Community

J. Shim, M. Kuznetsova, L. Rastätter, M. Hesse and A. Chulaki

http://ccmc.gsfc.nasa.gov

NASA Goddard Space Flight Center
Overview

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

- 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

Heliospheric Tomography

Solar/SW Monitors

ENLIL

SWMF-IH

SWMF-SC

PFSS

WSA

MAS

Corona

Heliosphere

Magnetosphere

Ionosphere

LFM

GUMICS

SWMF / GM+IM+IE

OpenGGCM

CTIPe

USU-GAIM

TIE-GCM

SAMI2

Weimer

AbbyNormal

IRI
Global Ionosphere/Thermosphere Models

**Electron density**

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

**Neutral density**

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

**TEC**

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

**Height integrated Pederson conductance**

**CTIPe**: Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics, T. Fuller-Rowell et al., NOAA SEC
Access to the Models at CCMC

- 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)

NmF2

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

Electron density along the CHAMP trajectory : CTIPe

Millstone Hill ISR measurements
**ISWA** (Integrated Space Weather Analysis) system is 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

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

**CTIPe** (T. Fuller-Rowell et al., NOAA SEC) is running in real time in test mode.
Soon to be hosted Models at CCMC

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

2. GITM: Global Ionosphere–Thermosphere Model, part of 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
CEDAR ETI Challenge

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

**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)
Challenge Setup : Physical Parameters

- Vertical and horizontal drifts at Jicamarca (VperpN and VperpE)
- Neutral density at CHAMP orbit (Nden)
- Electron density at CHAMP orbit (Eden)
- NmF2 from LEO satellites (CHAMP and COSMIC) and ISRs
- HmF2 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

How to compare model results?
Metrics Examples

• 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:

\[
\frac{(x_{mod})_{\text{max}} - (x_{mod})_{\text{min}}}{(x_{obs})_{\text{max}} - (x_{obs})_{\text{min}}}
\]

> 1: over estimate,
< 1: under estimate
Dependence on Geomagnetic Activity and Metrics

RMS Metrics

Ratio of maximum change

HmF2

Ranking depends on metrics selection
Ne : Dependence on Latitude

Ranking varies with latitude
Outlook

• 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.
Thank you!