CCMC Role in GEM: Support of GEM Focus Groups

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2012 CCMC Workshop, Key Largo

Geospace Environment Modeling

- Geospace Environment Modeling (GEM) is a broad-based, community-initiated research program on the physics of the Earth's magnetosphere and the coupling of the magnetosphere to the atmosphere and to the solar wind. The purpose of the GEM program is to support basic research into the dynamical and structural properties of geospace, leading to the construction of a global Geospace General Circulation Model (GGCM) with predictive capability. This GGCM model will be modularized and will complement parallel developments of magnetohydrodynamic models. The strategy for achieving GEM goals is to undertake a series of campaigns and focus groups, in both theory and observational modes, each focusing on particular aspects of the geospace environment.

- The GEM program is sponsored by National Science Foundation (NSF) Division of Atmospheric and Geospace Sciences

- http://aten.igpp.ucla.edu/gemwiki/index.php/Main_Page

GEM Structure

GEM is organized into 5 research areas:

- Dayside magnetosphere
- Inner magnetosphere and storms
- Tail, including plasma sheet and substorms
- Magnetosphere - ionosphere coupling, aurora
- GGCM

Definition of GGCM

GGCM (Global General Circulation Modeling) Research Area is one of the five GEM areas. Its general purpose is to include focus groups that fall into the scope of the GEM program but cross more than one of the other four main areas (tail, dayside, M-I coupling, and inner magnetosphere), including developing, validating, and comparing analytic, first-principles numerical, and data-based models of geospace environment that span more than one region and that lead to development of a global description of the geospace. Activities appropriate for GGCM include, but are not limited to, use and development of multiple and/or coupled models or standalone models describing more than one region, designing and implementing "metrics" studies, support and extension of modeling "challenges" from focus groups in this and other research areas, and providing formal partnership with other organizations or institutions that support GGCM-relevant research in collaboration with GEM.

Adopted by Steering Committee in late 2010.

GEM Focus Groups

Real work is done in Focus Groups that fall under one of the research areas:

- **Near Earth Magnetosphere: plasma, fields, and coupling (2007 - 2012, RA: IMS, Tail)**
- Plasmasphere-Magnetosphere Interactions (2008 - 2013, RA: IMS)
- Substorm Expansion Onset: The First 10 Minutes (2008 - 2013, RA: Tail)
- Modes of Solar WInd-Magnetosphere Energy Transfer (2008 - 2013, RA: Tail)
- **Dayside FACs and Energy Deposition (2010 - 2012, RA: Dayside, MIC)**
- Radiation Belts and Wave Modeling (2010 - 2014, RA: IMS)
- The Magnetosheath (2010 - 2014, RA: Dayside)
- **Metrics and Validation (2011 - 2015; M. Kuznetsova, A. Ridley, T. Guild, L. Rastaetter, H. Singer; RA:GGCM)**
- The Ionospheric Source of Magnetospheric Plasma--Measuring, Modeling and Merging into the GEM GGCM (2011 - 2015; RA: MIC, GGCM)
- Scientific Magnetic Mapping & Techniques (2011 - 2015; RA: MIC)
- Tail-Inner Magnetosphere Interactions (2012 - 2016; RA: Tail)
- Transient Phenomena at the Magnetopause and Bow Shock and Their Ground Signatures (2012 - 2016; RA: Dayside)

GEM Focus Groups Supported by CCMC

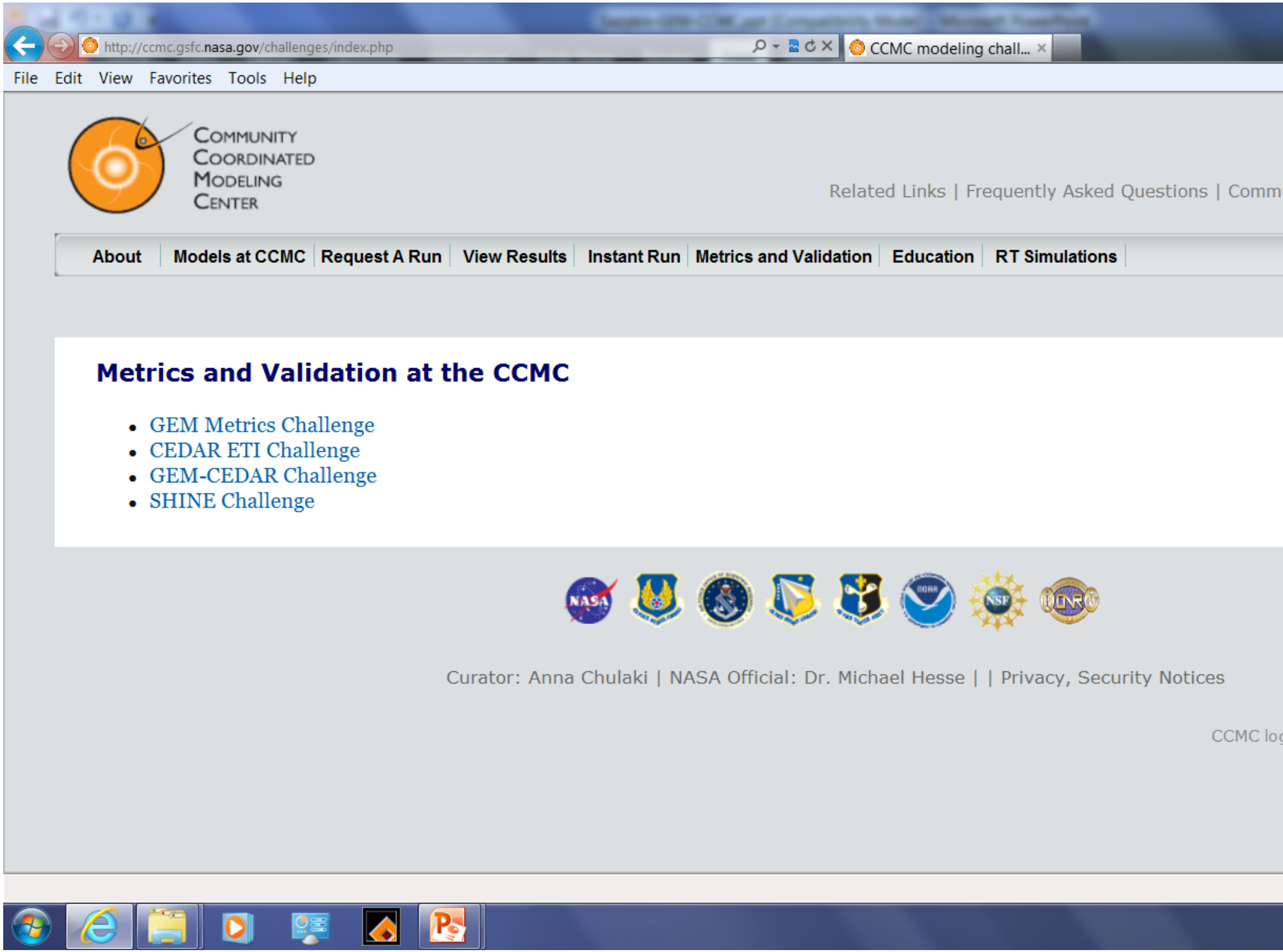
- **Metrics and Validation (2011 - 2015; M. Kuznetsova, A. Ridley, T. Guild, L. Rastaetter, H. Singer; RA:GGCM)**
  - From it inception, has been very successful.
  - In December 2009, GEM steering committee decided to renew this focus group.
  - Within this focus group, CCMC facilitates different modeling "challenges".
  - Other focus groups bring their challenges to this group. CCMC-developed tools and hosting capabilities will be of great value.
- **Near Earth Magnetosphere: plasma, fields, and coupling (2007 - 2012, RA: IMS, Tail)**
- **Dayside FACs and Energy Deposition (2010 - 2012, RA: Dayside, MIC)**

CCMC and GEM

- Some of the CCMC goals (evaluation of the state of the art of geospace models and improvement of them) resonate with GEM goals.
- CCMC is a valuable partner of GEM
  - Participation in Metrics and Validation focus group
  - Initiation and support of a sequence of modeling challenges
  - CCMC hosts the challenge, keeping track of both the data and model results and providing a forum for model developers to collaborate.
  - Support for other GEM focus groups

History of Modeling Challenges

- Started in 2008 in GEM Metrics and Validation focus group (M. Kuznetsova and A. Ridley) and fully supported by CCMC.
- Progress:
  - GEM challenge (summer 2008 GEM workshop)
  - CEDAR Electrodynamics Ionosphere Thermosphere (ETI) challenge (summer 2009 CEDAR workshop)
  - CEDAR-GEM challenge (currently built upon first two)
- CCMC goal is to evaluate the current state of the space physics modeling capability and to address the differences between various modeling approaches.
- CCMC hosts challenges, keeping track of both the data and model results.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CEDAR ETI Challenge
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CCMC log

GEM Modeling Challenge

- Started in summer 2008 by M&V Focus Group
- M. Kuznetsova, Lutz Rastaetter, A. Ridley
  - ground-based perturbations
  - inner magnetospheric dynamics
- Reported first results at summer 2009 Workshop
- CCMC provided place to run models, archive results
- CCMC developed tools for analysis (Metrics Tools Suite)
- Modelers were allowed to enter more than one model result, so they can show what can be done in near-real-time and in a more science-grade production.
- It was not required to participate in all aspects of the comparisons.

Update on GEM Challenge

- **Event 1:** Oct 29, 2003 06:00 UT - Oct 30, 06:00 UT
  Event 2: Dec 14, 2006 12:00 UT - Dec 16, 00:00 UT
  Event 3: Aug 31, 2001 00:00 UT - Sep 01, 00:00 UT
  Event 4: Aug 31, 2005 10:00 UT - Sep 01, 12:00 UT
- **Metric Study 1:** Magnetic field at geosynchronous orbit (GOES)
  Metric Study 2: Magnetopause crossings by geosynchronous satellite (GOES and LANL)
  Metric Study 3: Plasma density/temperature at geosynchronous orbit (LANL)
  Metric Study 4: Ground magnetic field perturbations (ground based magnetometers)
  Metric Study 5: Dst index (*added at the GEM 2009 summer workshop, real progress made in 2011*)—connection to NEM f/g.

Models in Dst metric study

Magnetosphere:

- SWMF
  - DST as wri)en by model
- OpenGGCM
  - DST computed from 3D magnetosphere outputs
- CMIT-LFM (new)
  - DST computed from 3D magnetosphere outputs
- WINDMI DST written by model

Ring Current (all new):

- RAM-SCB:
  - LANL ring current, stand alone or with SWMF, D. Welling
- RCM: muliple drivers and boundary conditons, S. Sasykin
- FRC: Fok ring current, run with outputs from SWMF, CCMC

Models in Dst metric study

- IRF-96: Impulse Response FuncWon with 96 lags, R. Weigel, GMU
- BFM92: empirical relaWon by Burton et al. (1975), modified by Feldstein (1992) and Murayama (1982)
- NARMAX: polynomial derivaWon, R. Boynton et al. (new)
- RiceDst: Rice Univ. neural network Spec., R. Bala (new)
- RDST: Real-Wme Dst Spec., Space Env. Corp, V. Eccles (new)

CEDAR-GEM Challenge

- **Event 1:** Oct 29, 2003 06:00 UT - Oct 30, 06:00 UT
  Event 2: Dec 14, 2006 12:00 UT - Dec 16, 00:00 UT
  Event 3: Aug 31, 2001 00:00 UT - Sep 01, 00:00 UT
  Event 4: Aug 31, 2005 10:00 UT - Sep 01, 12:00 UT
  Event 5: May 15, 2005 00:00 UT - May 16, 00:00 UT
  Event 6: July 9, 2005 00:00 UT - July 11, 00:00 UT
- **Added more physical parameters:**
  - Auroral oval position (high latitude boundary)
  - Auroral oval position (low latitude boundary)
  - Poynting flux (Joule heating) into ionosphere along DMSP tracks
  - Plasma Velocity (Vx - along track, Vy cross track, Vz - vertical)
  - Cross polar cap potential (northern and southern hemisphere)
  - Joule heating (or Poynting flux) integrated over each hemisphere in GW.

CCMC Metrics Tools

- Web interface to submit simulation results
- Online time series plotting tool
- Database of model settings
- Customizable table of archived results for metrics study

GGCM Baseline Model Comparison and Model Capabilities

- Evaluate current state of GGCM models
- To track model improvements over time, especially as researchers couple various models together, and improve various aspects of their models (such as numerical techniques, grid resolutions, etc.)
- Regular journal paper documenting model results over time for the same simulation(s).

Publications

- Pulkkinen, A., L. Rastätter, M. Kuznetsova, M. Hesse, A. Ridley, J. Raeder, H. J. Singer, and A. Chulaki (2010), Systematic evaluation of ground and geostationary magnetic field predictions generated by global magnetohydrodynamic models, J. Geophys. Res., 115, A03206, doi:10.1029/2009JA014537.[
- Pulkkinen, A., et al. (2011), Geospace Environment Modeling 2008–2009 Challenge: Ground magnetic field perturbations, Space Weather, 9, S02004, doi: 10.1029/2010SW000600.
- Rastätter, L., M. M. Kuznetsova, A. Vapirev, A. Ridley, M. Wiltberger, A. Pulkkinen, M. Hesse, and H. J. Singer (2011), Geospace Environment Modeling 2008–2009 Challenge: Geosynchronous magnetic field, *Space Weather*, 9, S04005, doi: 10.1029/2010SW000617.
- Shim, J. S., et al. (2011), CEDAR Electrodynamics Thermosphere Ionosphere (ETI) Challenge for systematic assessment of ionosphere/thermosphere models: NmF2, hmF2, and vertical drift using ground-based observations, *Space Weather*, 9, S12003, doi:10.1029/2011SW000727.

Conclusions

- CCMC provides invaluable contribution to GEM.
- Results are collected for models not at CCMC to facilitate science. "Place" for challenges organized by other focus groups in GEM.
  - Archival services for simulation runs
  - Analysis tools
  - Interaction between CCMC and GEM participants regarding metrics
- Publications to record state of geospace models at CCMC.
- Possible improvements:
  - Better interaction between model developers and CCMC (developer's-requested analysis tools in addition to user-driven interfaces).
  - Better support for focus groups (advanced planning for focus group proposals?)
  - Incentives for model developers to benchmark their codes?