

## **Metrics and Validation Focus Group Proposal**

GGCM Research area

Term: 5 years, including 2 years of leadership transition

Current Co-Chairs (during the transition period): Masha Kuznetsova (NASA GSFC/CCMC), Aaron Ridley (University of Michigan).

New Co-Chairs (after the transition period): Tim Guild (Aerospace Corporation), Lutz Rastaetter (NASA GSFC/CCMC), Howard Singer (NOAA/SWPC)

*Abstract:* We propose a five-year plan for the Metrics and Validation Focus Group (M&V FG) to support GEM needs for systematic and quantitative evaluation of general geospace circulation models (GGCM) with a goal of testing current model capabilities and identifying areas in need of future scientific development. In 2008-2010, a series of metrics studies, the GGCM Modeling Challenge, provided new model results (published or in preparation) that also provides guidance to GEM model developers and scientists. Ongoing and new GGCM baseline model comparisons are needed to understand the differences between various modeling approaches and the role of different model settings in model performance, as well as collaborations with all GEM focus groups that have models ready for evaluation. In addition, we will establish collaborations with the CEDAR community by initiating a joint GEM-CEDAR modeling challenge focused on magnetosphere/ionosphere coupling. At the end of the two-year transition period we plan to finish a first round of challenges for six on-going metrics studies and to present a report on the current state of GGCM modeling. Also, at the end of the transition period, we will have built the base for further model validation projects that will make it possible to utilize the results of the first round of metrics studies as benchmarks. The Community Coordinated Modeling Center (CCMC) will continue to support the focus group activities and will work with the research community to develop a suite of interactive on-line metrics tools.

### **Description, Timeliness and Relationship within GEM of Metrics and Validation**

*Description:* The GEM community has recognized that due to the maturity and increasing complexity of state-of-the-art global space weather models, there is a great need for a *systematic* and *quantitative* evaluation of different GGCM modeling approaches. We address this need by organizing and implementing a comprehensive, community-wide effort to measure and track model predictions (metrics) and provide a community venue devoted to comprehensively testing models against observations to understand model shortcomings (validation). This dual role provides the GEM community with both performance tracking tools as well as the detailed feedback necessary to improve models. It is this unique combination of models and modelers, data and data providers, and objective measures of model performance that provides cohesion to the entire GEM program, which has the ultimate goal of developing an accurate general geospace circulation model.

*Timeliness:* The functions performed by the Metrics and Validation Focus Group are in some ways timely, and in others timeless. They are timely as we enter the era of the NASA Radiation Belt Storm Probes (RBSP) mission, with its goal of gaining an understanding of the radiation belts to the point of predictability. Comprehensively testing models against observations,

understanding their shortcomings, and improving them are necessary steps along the way to successfully predicting the space environment. The functions performed by this FG are timeless, however, because they represent the iterative cycle of model test and improvement that a GGCM goes through on its way to successfully predicting the space environment.

*Relationship within GEM:* We feel that the role of the Metrics and Validation FG within GEM is to facilitate modeling challenges with all of the GEM focus groups. We aim to co-sponsor modeling challenges with all Focus Groups, ensuring that both scientific advancement and reproducible metrics result from these challenges. This is true for many of the metric studies presently underway (see below). It is by this process that the Metrics and Validation FG provides cohesion across the GEM community– it connects models and observations in a routine, testable way, that leads to improved understanding of the geospace system.

### **Status of GGCM Challenges (including deliverables) and future plans:**

We accomplish our overarching goal through a multi-pronged GGCM Challenge. In the summer of 2008, the GGCM Metrics and Validation Focus Group initiated the Challenge, with general goals to: 1) Evaluate the current state of space science models and track model performance over time, 2) facilitate the interaction between research and operation communities, 3) facilitate collaboration among modelers, data providers and research communities, and 4) ultimately to facilitate further model improvement.

The present list of active “Metric Studies” undertaken by the Metrics and Validation Focus Group are listed in the Table below, including the date of initiation, deliverables, expected date of completion, and relevant Focus Group Co-Sponsor. For details on the status of each Metric Study, please see the GEM Modeling Challenge webpage at the CCMC ([http://ccmc.gsfc.nasa.gov/support/GEM\\_metrics\\_08/](http://ccmc.gsfc.nasa.gov/support/GEM_metrics_08/)).

All of these “Metrics Studies” are ongoing with broad participation from the GEM community and significant involvement of the Community Coordinated Modeling Center (CCMC). In order to maintain continuity in all modeling and planning activities we propose to transition the Focus Group leadership gradually, ramping up the involvement of new Co-Chairs over a two year period while the ongoing metrics studies are brought closer to closure, yielding deliverables.

### *Joint GEM-CEDAR Challenge plans.*

To analyze the effects of the geospace environment on the ionosphere, we have worked on plans to involve the CEDAR Community in the Modeling Challenge. This activity is especially relevant due to the upcoming joint GEM-CEDAR Workshop in 2011. GEM M&V FG co-chairs were involved in the organizing of the CEDAR Electrodynamics-Thermosphere-Ionosphere Challenge. CEDAR modelers included GEM challenge events for the series of planned comparative studies. Many of the magnetospheric models are coupled to ionosphere-thermosphere models; therefore, the metrics evaluations can be conducted for both coupled and uncoupled simulations in both domains, with the ultimate goal of understanding the joint

coupled Magnetosphere / Ionosphere / Thermosphere system.

Phys. Parameter/ Metrics Study	When Initiated	Deliverables /Expected completion			Relevant GEM research topics/ GEM FG co-sponsors
		Observ. data time series preparation	Database of model results	Paper upon 1st round (*) completion.	
<i>1. Magnetic field at geosyn. orbit.</i>	summer 2008	completed	completed	Rastaetter et al., 2010; Pulkkinen et al., 2010,a	Inner Magneto- sphere FG, RBSP
<i>2. Magnetopause crossing by geosyn. satellites</i>	summer 2008	completed	expected: 2011	expected: 2012	Dayside RA, Reconnection
<i>3. Plasma parameters at geosyn.. orbit</i>	summer 2008	expected: 2011	completed	expected: 2012	Inner Magneto- sphere FG
<i>4. Ground magnetic perturbations</i>	summer 2008	available	completed	Pulkkinen et al., 2010,a,b	(**)(***)
<i>5. Dst Index</i>	summer 2009	available	expected: 2011	expected: 2011	Inner Magneto- sphere FG,
<i>6. Heat flux into ionosphere</i>	summer 2010	expected: 2011	expected: 2011	expected: 2012	Dayside FACs and Energy Deposition FG (***)
<i>7. Auroral oval</i>	fall 2010	new			Inner Magneto- sphere FG (**)(***)

(\*) 2nd round is planned approximately in 2 years after the 1<sup>st</sup> round completion.

(\*\*) Metric studies of primary interest to operational community (NOAA/SWPC, AFWA)

(\*\*\*) Potential topic for joint GEM-CEDAR Challenge

#### *Baseline-model comparisons.*

To understand significant differences in model outputs demonstrated by some of metrics studies we initiated a series of baseline model comparisons. The researchers agreed to run different MHD codes for various solar wind and IMF conditions and compare the results. Initial simulation results were presented at 2009 and 2010 summer workshops and additional investigations were defined. Further investigations will include (1) examining the reconnection rate in the different codes to determine how each handles reconnection for the different IMF orientations; (2) examining the magnetopause location, the amount of open flux in the polar cap; (3) the cross polar cap potential; and (4) the Dst index as a function of time. With these

types of comparisons, the M&V FG can collaborate with other FGs within the GEM community. It is expected that the FG will arrange a special issue of a journal to capture the results of these comparisons.

### **Future metrics and validation plans.**

Consistent with our goal of being the glue that binds GEM together, we plan to engage *all* of the GEM focus groups about facilitating a relevant modeling challenge for the state of the art models in their groups. The existing collaborations which are presently leading to Metrics Studies discussed above will continue, and the new Co-Chairs of the M&V FG will engage additional Focus Groups starting with those ending first (Plasma Entry and Transport, Space Radiation Climatology, and Diffuse Auroral Precipitation). Ultimately we plan to build collaborations throughout the GEM community, yielding a systematic and quantitative measuring stick by which to measure modeling progress.

### **The role of the CCMC in support of the Metrics and Validation Focus Group**

The CCMC has a unique and continued role in supporting the Metrics and Validation Focus Group. Not only have CCMC personnel provided past FG leadership, but they have also developed much of the infrastructure required to perform the metrics studies summarized above. CCMC personnel will continue to provide FG leadership in this proposed 5 year plan. The CCMC will continue working with the community to develop an automated system that will allow repeating the metrics studies on regular basis, to archive challenge results and to monitor progress over time. The availability of these tools will allow further extension of GGCM metrics and validation activities. The CCMC is supporting CEDAR and SHINE modeling Challenges and will facilitate collaboration between communities on model validation projects.

### **Conclusion**

Throughout this proposal we have identified the value of utilizing “metrics and validation” to advance our GEM science, to demonstrate model capabilities, and to lead the way for new model improvements. We have described current work with other focus groups and plans for remaining flexible and cognizant of GEM community needs and working with models from additional focus groups. We have outlined a plan for including new leadership in the Metrics and Validation Focus group with a plan for a smooth and orderly transition. We have described past accomplishments and completed activities, as well as outline new, community generated, activities, challenges, and science questions that seek to involve all GEM focus groups and advance GEM science.