# Model Coupling Working Group

The working group on model coupling met on Tuesday night, October 30, 2001 from 6:00pm to 10:00pm. The first part of the session was devoted to presentations showing examples of model coupling in different components of the solar-terrestrial system. We heard the following presentations:

George Fisher – Coupling of ANMHD, a subphotospheric flux emergence model, with a model of a solar active region based on ZEUS-3D. At present this is "driving" since there is no feedback. However, feedback may be important because the corona can affect deeper layers.

Jon Linker – Coupling of the SAIC coronal model with Dusan Odstrcil's heliospheric model.

Chuck Goodrich – Computational Frameworks for model coupling. Several existing frameworks are discussed (Overture, AMR++, META-CHAOS, Cactus, Globus, Common Component Architecture, etc.). The Boston University STC consortium is considering using these.

Aaron Ridley – Coupling of the University of Michigan's BATS-R-US magnetospheric model with TIME-GCM. Some of the feedbacks (dynamo currents) produce only small effects in the magnetosphere.

Darren DeZeeuw – Coupling of the BATS-R-US magnetospheric model with the Rice Convection Model. This is hot off the press and there are no direct comparisons with data yet.

Jan Sojka – Coupling of the TDIM ionospheric model with the Lyon-Fedder-Mobarry (LFM) magnetospheric model. There was no feedback in these simulations, i.e., the LFM model was used as a driver for the TDIM. Comparisons with observations and the effects of different drivers (statistical, empirical, LFM) are discussed in the literature and presented here. Using the LFM yields details in the TDIM output that are not present when using the other drivers.

Jimmy Raeder – Coupling of Raeder's magnetospheric model with Tim Fuller-Rowell's CTIM thermosphere-ionosphere model. The coupled model yields much improved ionospheric conductances and consequently a more realistic

ionospheric response. Coupling the models took >1y and was only possible with close collaboration of the original model developers. Scientific issues and consequences of the coupling have so far only been marginally addressed; full exploration will take years.

Bob Strangeway – An experimentalist's perspective. Testing magnetosphere-ionosphere coupling hypotheses, for example regarding the relationship between various ionospheric inputs from the magnetosphere and ionospheric ion outflows requires sophisticated models that treat these processes from first principles.

Ken Nishikawa – An outlook on ionospheric outflows in global particle simulations.

These presentations illustrated the wide range of parameter regimes encountered in solar terrestrial physics, and the specialized nature of coupling physics-based models. The discussion following these talks centered on the topic of what role should the CCMC play in model coupling.

In Michael Hesse's presentation Tuesday morning, he introduced the idea of a suite of models in each discipline. Each of these models would be designed to interact through a standard set of interfaces. A user of the CCMC would then be able to select different models from each category and couple them automatically. During the discussion we referred to this idea as the "patch-panel" approach.

While the attractiveness of the patch-panel approach for users of the CCMC is obvious, its feasibility is not. Although a number of model-coupling efforts are now underway in the community, model coupling in solar-terrestrial physics would still have to be described as in its infancy. The presentations demonstrated that many subtleties arise in these efforts, and successful model coupling is the result of intense collaborations between the scientists who have developed the original codes.

Given the difficulty in coupling models, Terry Onsager raised the question "Should the CCMC get involved in model coupling?" One of the chief arguments for CCMC involvement was summarized by Michael Hesse: "We should strive to develop standard interfaces for the models now. Otherwise there is a lot duplication of effort as individual groups tackle similar coupling

problems." However, there were a number of arguments against CCMC getting involved in coupling models (at least initially): (1) The CCMC has finite resources and probably doesn't have the manpower and expertise to do this effectively. (2) Running and validating individual models is difficult enough and should be the main priority of the CCMC. (3) The duplication of efforts may be beneficial. Since there are no established and proven methods of model coupling some degree of experimentation and competition between groups will in the end produce better results. (4) Coupling of models may not be the best course for codes destined for operations.

Summary Consensus:

1) The "patch panel" approach might be a long-term goal for the CCMC, but it is not feasible at the present time.

2) Coupling of models is in its infancy. In most cases it goes well beyond the technical aspect of feeding data from one model to another. The feedback loops between coupled models often entail new physics, for example coupled oscillations or instabilities. Exploring these processes are basic science issues that are beyond the purview of the CCMC.

3) There are many ongoing model coupling activities in the solar-terrestrial physics community, but these typically require intensive work by (and the expertise of) the respective model developers.

4) The CCMC at present does not have the manpower to tackle these projects.

5) However, the CCMC could and should ingest already coupled models.

6) Some interfaces are not really coupling points but rather driving interfaces, such that there is data flow in only one direction. Such "interface points" in the solar-terrestrial system might be amenable to swapping of modules in the future (e.g., the corona-heliosphere interface or the solar wind – magnetosphere interface) while others are more distant.