From Space Weather Modeling to Forecasting: Community Recommendations on Transitions to Civilian Operations

1. Context and Document Purpose

In October 2008 the NOAA Space Weather Prediction Center (SWPC) announced an initiative to establish a Development Testbed Center (DTC) to promote the transition of space weather models to operations[1]. SWPC, in partnership with Air Force Weather Agency (AFWA), requested the NCAR Research Applications Laboratory (RAL) and High Altitude Observatory (HAO) to conduct a study exploring DTC implementation.

Because of the immense importance of model transitions for the National Space Weather Program (NSWP) as a whole and for the research and operational communities, the DTC initiative stimulated intense interest, extensive discussion, and several meetings among many interested parties. Since October the research community, NCAR study team, and operational community have discussed key facets of DTC implementation as well as potential concerns in several forums, including open community meetings on January 14, 2009 in conjunction with the Phoenix AMS meeting and on March 5-6 at the University of New Hampshire.

Both the NCAR study team and members of the research community developed documents[2,3,4,5] detailing concepts and issues of model transition. Successive versions of these documents benefited significantly from the community discussions and have converged to consensus in many areas.

The NCAR study has been completed recently and is documented in submitted reports[3,4,5] that outline a DTC concept called the Space Weather Prediction Testbed (SWPT). These reports effectively represent several areas of broadly agreed underlying needs and needed elements of transitions. We do not repeat that here.

The purpose of this document is to capture outcomes of the community discussions that supplement the SWPT study, with the aim of contributing constructively to Agency implementation decisions. In particular, we highlight areas where important consensus exists, where alternative approaches or tradeoffs should be examined, or where particular considerations merit special attention.

In this document we use the name "Space Weather Prediction Testbed" (SWPT) as a generic term for the elements that are needed for transition, without implying a specific implementation structure (central or distributed) or institution (NOAA, FFRDC, commercial entity, university).

2. Guiding Considerations

There is an urgent national need to improve space weather forecast capabilities by facilitating the operational use of sophisticated models that are developed within the research community.

We are at the threshold of a qualitatively different approach to forecasting. Introducing global environment models into operations, from which diverse forecast products are (or may be) derived, is fundamentally different (and more powerful) than, for example, "handing off" a model with a small number of fixed, directly-useable outputs.

Sustaining continued improvements is critical. The real power of introducing sophisticated, physics-based global models lies in starting up the path of steadily improving forecasts through model refinements and forecast-product development over many years. It is essential that the transition process be structured to support sustained improvement and the introduction of new models.

Successful transitions to operations will require funding by operational agencies, including appropriate support for modeler participation. The NOAA-AFWA SWPT initiative appears to provide an important step in this direction.

There are many ways that SWPT functions could be implemented, with relative advantages and disadvantages in several areas. Agency implementation decisions should be made with the benefit of broad inputs to ensure full exploration of the options and tradeoffs.

3. Specific Recommendations and Comments

Intellectual property (IP) issues should be addressed clearly, up-front. Model developers are concerned about threats to their IP and their professional viability that might arise through model transitions. For example, results from SWPT validations could be published without modeler involvement, SWPT personnel could use their knowledge to compete against the contributing model developers, or conflicts of interest could arise if active or future model developers served in a SWPT role. These concerns can be resolved to a large degree by licensing a model to the SWPT in a way that clearly identifies how the model and its results may or may not be used.

The distribution of scientific expertise for transitions should be considered carefully. There is lack of agreement within the community about the degree to which expertise and intellectual leadership should reside within NOAA versus being delegated to a SWPT. A strong research branch within NOAA would provide the most integrated approach; however this must be traded against other demands for resources to support transition activities.

Developer participation is required and must be supported. The transition from global environment models to forecast products is not a simple one-way process. During the transition, and as forecasters gain experience, inevitably there are subtle questions about the model and suggestions for changes. Addressing these requires developer participation. Mechanisms for this two-way interaction must be provided. Funding for the necessary developer participation must be provided by the operational agencies.

The SWPT implementation should be competitively bid. An open competition is the best way to identify a full range of SWPT options and to allow their full consideration.

The management and advisory structure should be designed to encourage scientific advice. The NCAR Concept of Operations report[3] shows an Executive Board directing the Implementation Team, and a separate Science Advisory Panel (representing the model developer community) that apparently provides input to the Executive Board. It would be more effective to integrate the Advisory Panel with the Executive Board. While it's clear that the operational agencies are the ultimate directing authority (the voting members) it would promote clearer advice and more informed decisions if the Advisory Panel was included in Executive Board meetings.

Assessment metrics should be public. Metrics should be established by the forecast community that accurately reflect their needs. Metrics for operational forecasts, and those for forecast products in development, should be made publicly available, as should the data required for model input or to calculate the metrics. This allows developers, CCMC, AFRL, and others to compare against the current state-of-art, and will enable the development community to accurately target model improvements to forecast capabilities of established importance.

There are multiple paths from research to operations. Given the diversity of model types and forecast needs, it is important to allow some flexibility rather than force transitions to follow a single path. For example transitions to a SWPT could come from CCMC, AFRL, a model developer, or a commercial enterprise. In some cases, one of these providers might interact

directly with the operational entity. Partnerships in which several of these players contribute different elements are desirable and will probably be common.

To maintain the perception of fairness, operational agencies should disseminate the basis for selecting models to transition. This will be easier for "2nd generation" models when the forecast metrics are well established and publicly available. Information contributing to the decision might be drawn from CCMC, AFRL, NRL, and studies conducted by the scientific community. It could be beneficial if specifically desired studies were funded by the operational agencies.

Strong commercial sector participation is valuable to the Space Weather enterprise. The transition process should be structured to take advantage of all national capabilities: commercial, academic, national laboratories, civilian government, and military.

Enhanced coordination of the national effort may improve the rate of progress. Many of the elements needed to sustain the desired path of long-term forecast improvement are supported across multiple agencies: e.g., continued development of research models, acquisition of key observational inputs, etc. Increased agency collaboration and coordination could lead to faster progress by more efficiently allocating the limited resources.

A mix of model types will be required. SWPT mechanisms must support transitions for several types of modeling that are, and will be, required for improving forecasts, e.g., physics-based, assimilative, empirical, and hybrid combinations.

An important bottleneck in the research-to-operations chain is understaffing and resource limitations at the government operational forecast centers.

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based on community meetings January 14, 2009 in Phoenix[a] and March 5-6 at UNH[b].

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