

## **Assessment and Validation of Space Weather Models in the framework of the European COST Action ES0803**

The European community is in possession of a large number of unique space weather models that could drive the development of reliable and fully operational space weather products and services. Some of these models are purely research models while others are more or less adapted to operational requirements. In any case, the successful transition of models from research to operational mode needs to be certified through well designed tests, most notably the systematic evaluation of their prediction capabilities in quantitative terms. The European activity in this matter has lagged behind the work that is performed within the US, as for example the pioneering work that the Community Coordinated Modeling Center (CCMC) performs on the validation of US models (<http://ccmc.gsfc.nasa.gov/>). Therefore it is urgent for the European research community to undertake a parallel assessment of European space weather relevant models. To bridge the gaps, the European COST Action ES0803 “Developing Space Weather Products and Services in Europe” (<http://www.costes0803.noa.gr/>) addresses the assessment and validation of existing space weather research and operational models as one of its key activities. Its aim is to organize the relevant discussion in pan-European level and to establish the basis for future developments in Europe by providing recommendations and roadmaps as well as validation results per group of space weather models.

For this purpose, COST ES0803 coordinates validation efforts undertaken by individual research teams over Europe per group of space weather models while monitoring closely the international developments in the field. In this framework, an investigation of the current practices and the available services regarding the assessment of space weather models for operational use was carried out within the Action, in order to take advantage of the relevant experience obtained within worldwide and European coordinated activities, such as the Community Coordinated Modeling Center – CCMC (<http://ccmc.gsfc.nasa.gov/>), the Center of Integrated Space Weather Modeling – CISM (<http://www.bu.edu/cism/>), and the European Space Weather NETwork – SWENET (<http://www.esa-spaceweather.net/swenet/>). The results of this investigation\* were presented at the SWWT Plenary Meeting that was held on June 18, 2010 in Brussels, in combination with validation results received from the systematic assessment of ionospheric forecasting models that was performed within COST ES0803. The strong interaction with the SWWT community allowed the identification of key issues still open for discussion that may be summarized as follows:

- Assessment of space weather models in terms of users’ needs and requirements
- Clear definition of metrics for the quantitative assessment of the models’ prediction ability (determination of parameters for comparison, cadence, etc)
- Independent validation of European models by a central system - Model availability and data transfer
- Potential exploitation of the experience that the meteorological community has already gained in this exercise

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\* The results are also included in the report “Review study of current practice and available services for the assessment of space weather models for operational use” by Tsagouri I., Glover A. and Belehaki A., available through the COST ES0803 website at <http://www.costes0803.noa.gr/>

As a next step, the COST ES0803 Workshop on Assessment and Validation of Space Weather Models was organized in Alcalá, Spain from 16 to 17 March 2011 (<http://www.spaceweather.es/cost/home.html>). The workshop program was organized into three sessions as follows:

(1) *Interdisciplinary activities and validation approaches*, which was meant as an introduction to validation procedures in use in domains other than space weather, and in particular in operational environments. This part was very instructive as operational models need to fulfill quantified customer requirements, where the need for quantitative validation and confidence measures arises automatically, in contrast to basic space weather research.

(2) *Space weather prediction and validation concepts*, which focused on concepts and procedures for prediction and validation of newly developed or recently updated space weather models in Europe.

(3) *Space weather research – models and model support activities*, which dealt with new models and supporting research activities. The presentations given in this session demonstrated a certain lack of systematic model validation and performance assessment in general although some of the presented models are related to existing space weather services.

The workshop activities included also a technical discussion that was mainly devoted to the discussion on verification and validation plans of the workshop participants, especially where assessment and validation questions remain open. Such questions include:

- Validation of “one time event” models, such as solar cycle prediction models
- Use of real time data by many space weather prediction models and how to record possible effects in their performance
- Acquisition of comparable validation results - use of metrics in the validation of operational models
- Strategy to balance between false alarms and misses
- Treatment of spatial and temporal data gaps

The discussion also made it clear that for the effective validation of space weather models the strong interaction between users and scientists is required. Finally, one may argue that although the assessment and validation of space weather models in Europe has been put into discussion and some advances have been made, there is still much to be done on this in the future. COST ES0803 efforts continue in these activities and are expected to yield useful and constructive results at the end of the project’s lifetime next year.

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