Wrap-up report for ESWW11 Session 13 - *Transitioning space weather research to operations: learning from the NWP experience*

There were 12 oral presentations and 5 posters in a diverse and interesting session that covered topics such as transitioning models into operations, model development, space weather services and communications and development of improved space weather indices.

The Process of Transitioning Models into Operations

S. Bingham outlined the process for transitioning space weather research to operations at the Met Office. 'Operational' at the Met Office means an automated end-to-end system with a real-time observations stream, model predictions, product dissemination and quality control monitoring. The process of converting research models to operations starts with running the research model on a desktop PC, then running the revised model on the development environment, and finally running the model on an operational suite. The resultant operational model has thus been rigorously tested, imbedded into a robust infrastructure and is supported 24/7. Examples of models transitioned to operations at the Met Office were given, including WSA Enlil, REFM andD-RAP. This process threw up a whole range of unexpected challenges (such as re-writing code and FTPing input data through firewalls) which had to be successfully overcome. The Met Office public space weather webpage which includes forecasts is:
http://www.metoffice.gov.uk/publicsector/emergencies/space-weather

Operational Model Development and Coupling

S. Poedts outlined Phase 1 of the ESA Virtual Space Weather Modelling Centre, whose goal is to develop a proof of concept prototype Sun to Earth space weather modelling system. Available models include XTRAPOL (NLFF Magnetic Field Reconstruction), AMRVAC (solar wind and superposed CMEs), iPIC-3D and COOLFluiD and GUMICS-4 (magnetosphere). Couplings implemented so far include ACE data – COOLFluiD (magnetosphere), ODI data – Gumics4, AMRVAC – Gumics4 and COOLFluiD – iPIC3D. The next phase of VSWMC will include an extension of the number of these couplings, and better GUIs and visualisation tools. VSWMC differs from the similar CCMC at NASA in that it is distributive and interactive. As it happened, **M. Kuznetsova** discussed CCMC. Compared to VSWMC, CCMC has far more models available (more than 60), and it provides facilities for runs on request, continuous real-time simulations and input parameters (eg CME initialisation). Metrics and validation tools are also well developed, including for example CME and flare forecast scoreboards, to compare forecasts from different centres.

D. Odstrcil discussed the use and development of the WSA Enlil model for real-time forecasting of the heliosphere. In particular he focused on the initialisation of the inner boundary of Enlil using IPS data instead of the WSA model. Another improvement is to continually evolve the solar wind (rather than the model being spin up afresh every time a new forecast is run). Results are encouraging and the upgrades are being made available via CCMC. WSA Enlil has also been run in real-time ensemble mode to provide forecasts of Coronal Mass Ejections, as discussed by **A. Pulkkinen.**

N. Ganushkina talked about FMI's Inner Magnetosphere Particle Transport and Acceleration Model (IMPTAM), which provides the realtime nowcasts of low energy (< 200 keV) electrons. Modelled fluxes for <100 keV electrons are, on average, in very good agreement with observed fluxes, but for

150 keV electrons the modelled flux is constantly smaller than observed (by up 1-1.5 orders of magnitude)

Space Weather Services and Communications with Users

T. Laitinen talked about FMI's 24/7 space weather service being provided as part of their wider natural hazards service (LUOVA). Warnings are disseminated via the LUOVA website, SMS and email to Government and other key users. 24/7 coverage comes from FMI forecasters with space weather scientist support during office hours and (from 2015) on call. Their warnings are based on NOAA scales (focusing on G5, S3-S5 and R4-R5 only) with associated hazard levels (not dangerous to dangerous) and actions. FMI also has its own observations and models (such as IMPTAM 9see above) and GUMICS-5 (see below) which are primarily research tools now being developed for operational use.

C. Burnett discussed the **c**ommunication challenges in providing web-based services at the Met Office. These include a diverse user group with a wide range of space weather knowledge and diverse user requirements. The Met Office have space weather public web pages written for the general public, and sector specific pages which have more technical information for specialist users. Email-based technical forecasts are also available, and users can set their preferences for which alerts and warnings they wish to receive.

Improved Indices

A. Guerrero developed an operational real-time local disturbance index for space weather purposes. By removing the impact of solar variability, the index he produced provides an improved way of assessing geomagnetic variability in Spain. NOAA's S scales are useful for radiation storm impacts on satellites. They are less useful for aviation impacts. Hence **M. Meier** developed a space weather index for the radiation field at aviation altitudes. His new scale is based on the radiation dose an airline passenger or crew member would receive, and hence is focused on health rather than avionic (eg single event upset) impacts. **L. Billingham** is trying to improve operational geomagnetic index forecasting. Due to the limitations of data assimilation for geomagnetic forecasting, he is scoping out new ways of predicting geomagnetic indices (namely 3-hour forecasts of ap) using machine learning. **M. Tshisaphungo** showed initial attempts to develop a new ionospheric storm index for the South African Region.

Other Model and Observation Based Applications

T. Laitinen described using GUMICS-5 in real-time to simulate GOCE Decay**.** GUMICS-5 was driven with ACE observations to simulate the magnetosphere and ionosphere. The solar wind propagation from L1 to the Earth allows around 20 minutes prediction time and so new GUMICS-5 runs were made very 20 minutes. GUMICS can predict Joule Heating and electron precipitation but has no neutral atmosphere model, so, using quiet time atmospheric profiles from NRLMSISE-00, and assuming a globally even heat distribution and a heating profile with maximum at 120 km they were able to calculate neutral density profiles with and without Joule heating. They could then deduce GOCE orbital variations and the modelling variations agreed very well with the actual GOCE decay rate.

S. Benck talked about Space Weather Services Based on the Energetic Particle Telescope (EPT) Data. The EPT flies on PROBA-V, which was launched in 2013 on a LEO sun synchronous orbit. EPT measures proton, electron, and He ion fluxes. The development of flux forecast applications is underway. **D. Koronczay** discussed the real-time acquisition of plasmaspheric electron densities which were assimilated into the PLASMON model for space weather predictions. **P. Coïsson** used magnetometer data from 16 sites in the BCMT network (http://www.bcmt.fr/) to produce prototype Sudden Storm Commencement alerts by email. In addition, the WAMNET network of observations (http://www.bcmt.fr/wamnetnetwork.html) in Mali and Ivory Coast provides data for equatorial electrojet studies. The International Service of Geomagnetic Indices (http://isgi.latmos.ipsl.fr/) prepares and disseminates geomagnetic data and lists of remarkable events. **V. Kalegaev** described real-time forecasts at MSU's Space Monitoring Data Center . Their focus is radiation monitoring for satellites, and they produce forecasts of solar wind velocity and GEO relativistic electron flux using solar observations, solar wind parameters and particle fluxes in the magnetosphere**.**

Outcomes

The session showed that there are many examples where the transition of space weather research to operations was strongly influenced by the experience of NWP. To keep this strand of work going, we are proposing a session for ESWW12 entitled, “Incorporating best practice into the development of operational space weather prediction systems”. In other words, you’ve transitioned your research to operations, but is the daily operation of your system good enough and does it meet international and other guidelines? We have also proposed a European Meteorological Society session in Sept 2015 on “Meteorology, climate and space weather: science, applications and coordination”. This will encourage further discussion on delivery of operational space weather services and products.