Exploring the potential of using satellite data assimilation in hydrological forecasts

H-SAF and HEPEX combined workshops on hydrology took place at ECMWF on 3 to 7 November 2014. The event gathered over 90 scientists from around the world, including experts in hydrological product development, satellite data assimilation and hydrological forecasting from both research and operational centres. The H-SAF and HEPEX (Hydrologic *Ensemble Prediction Experiment*) workshops overlapped, with a joint session on 5 and 6 November providing an excellent opportunity to exchange the latest information and scientific results on the use of the EUMETSAT satellites for hydrological applications.

The H-SAF workshop started with overviews of the H-SAF project and the EUMETSAT Satellite Application Facility (SAF) network, which is part of the EUMETSAT application ground segment. The SAFs aim to complement the production of standard meteorological products at the EUMETSAT central facility and to provide products and services to users. The H-SAF (SAF on support to operational hydrology and water management) satellite products focus on soil moisture, precipitation and snow products.

The H-SAF is developing a range of precipitation products from satellite microwave and infrared observations. Several talks looked at the performance of the rainfall products during recent weather events that led to major flooding. Participants also considered the science of retrieving precipitation and the validation of these rainfall products. Although some success is evident in validating against other observations and indirectly through running hydrological models, rainfall is so variable in scale and duration that using and validating the products is extremely challenging. One theme that emerged was the need to harmonise rainfall products across different satellites and sensors and GPM (Global Precipitation Measurement) is an important element to inter-calibrate the microwave products.

Excellent presentations were given on the role of soil moisture in land–atmosphere interactions and on soil moisture remote sensing from space using scatterometer data. Very new research was shown on the potential of using satellite-derived soil moisture (e.g. from ASCAT) to estimate rainfall. The basic idea of this approach is to regard the soil as a natural rain gauge and to invert a land-surface model to estimate rainfall from the observed soil moisture increments. The method tends to detect too many small rainfall events due to the noise in the ASCAT soil moisture data, but does seems able to estimate accumulated rainfall over a few days very well. Several presentations showed the use of H-SAF soil moisture products and rainfall data from ASCAT for improved runoff prediction, with very encouraging results. Interesting feedback from the flood forecast community highlighted the need for anomaly soil moisture products for operational hydrology.

For remotely sensed snow products, using multi-sensor/multi data sources approaches was recommended. Snow is one of the most difficult and complex targets, however, there is a clear need for snow products both for NWP and hydrological applications. Two presentations focused on the use of H-SAF snow products in hydrological models, showing promising results. The UK met Office is currently developing its snow data assimilation system to use in situ observations. There are still large uncertainties in snow water equivalent products; however, H-SAF products can provide relevant information for validation and intercomparison purposes.

The H-SAF workshop was very successful, showing a large range of hydrological applications using the H-SAF products and useful recommendations from the user community.

The assimilation of in situ and remotely sensed information is one of the key frontiers of hydrological ensemble prediction and has received considerable attention from the HEPEX community. This is demonstrated through the interest in these workshops as well as published special issues, several other HEPEX workshops and multiple blog posts on http://www.hepex.org. In particular, remotely sensed information on snow, precipitation and soil moisture as provided by H-SAF can play an important role in international forecasting systems such as the European Flood Awareness System (EFAS) or national forecasting systems such as those of the UK Flood Forecasting Centre and Australian Bureau of Meteorology. International efforts such as monitoring potential famines through droughts heavily rely on H-SAF related

products. The huge potential of such remotely sensed information can be realized only through adequate training and communication, as well as employing international networks such as HEPEX and FRIEND (**Flow Regimes from International Experimental and Network Data)**. Studies focused on end users allow benefits to be established, in terms of both model performance and economic value. This has to be paired with user-friendly access and user-targeted tools such as the H-SAF map room. In addition, open source, generic and modular data assimilation tools such as the OpenDA (openda.org), which allows for collaboration across institutional and scientific boundaries, is key to enable a quick transfer of research into operations.

The HEPEX workshop highlighted that there is no consistent picture of the effectiveness of assimilating remotely sensed information on discharge. Assimilation does not always have a positive impact on discharge simulations or forecasts, in particular when snow or soil moisture is assimilated, although the blending of in situ observations and satellite data shows great potential. All studies that use data assimilation of discharge (also known as 'updating') show an improvement in the modelling of discharge. This also confirms the general findings that assimilating satellite or in situ observations of one hydrological variable can demonstrably improve analysis of that particular variable. Any benefit depends on a large variety of factors from catchment/event characteristics to the properties of the data assimilation itself – so far no assimilation method has clearly emerged as a front-runner in hydrological operational frameworks. Also, the quality of the hydrological model plays an important role, in particular for integrating and assimilating data on various scales.

Hydrological models are highly non-linear in their response to driving data and care has to be taken when the assimilation is aimed at improving the modelling of extreme events. The HEPEX workshop highlighted the importance of including a full uncertainty assessment in ensemble forecasting and data assimilation to avoid overconfidence. Accounting for uncertainty helps the forecaster to make a more informed decision.

The joint workshop has been a great opportunity to explore the connections between H-SAF and HEPEX. It showed the potential of using satellite data assimilation in hydrological forecasts. It also revealed that the operational use of satellite data of soil moisture and snow is not yet fully developed, and the added benefit is not always clear. However, including satellite data will be increasingly important in future systems and there is room for more research into bias correction, validation and uncertainty estimation of satellite products to make the most out of them.

The H-SAF workshop was supported by EUMETSAT. The HEPEX workshop was co-sponsored by FRIEND.

More information

Programme and presentations, including videos, are available at: http://www.ecmwf.int/en/h-saf-and-hepex-workshops-coupled-hydrology

The organisers would like to thank the EUMETSAT H-SAF and HEPEX partners for their support with organising this workshop and all the participants for their contributions.