Improving European flood forecasts: deriving reservoir management rules with satellite data and machine learning

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In the Summer of 2021 severe flooding struck across Europe leading to hundreds dead, thousands traumatized and billions of Euros worth of damage. Flooding continues to a major threat to humanity across the world, and in many places we know that our changing climate is making floods worse. One of the most important ways that we can save lives in the face of such natural hazards is to prepare for the upcoming floods through the development of early warning systems.

This studentship provides a unique opportunity for cutting-edge research that addresses real world forecasting challenges working with the European Flood Awareness System (EFAS), part of the European Commission's Copernicus Emergency Management Service for Floods (efas.eu). This system provides early information on upcoming floods days and even weeks ahead to national authorities and to the European Commission's Emergency Response Coordination Centre. This studentship includes highly sought-after placements with the European Centre for Medium-Range Weather Forecasts (who are co-funding the studentship) and the Red Cross Red Crescent Climate Centre.

One of the most challenging parts of predicting floods in Europe is understanding river management. Reservoirs, in particular can be very challenging to model because they are operated by a diverse set of agencies and private industries and the operational rules for reservoir management are rarely shared openly. It can be therefore difficult to represent these influences on the river flows within the flood forecasting modelling systems. This means that forecasts of upcoming floods have the potential to be improved substantially if some additional information on how and when reservoir releases are made into the river channel is identified.

One of the most exciting advances in satellite technology for early warning systems is the ability to monitor, in real time, water from space, including reservoir levels. One very recent development is the recent launch of the Sentinel 6 constellation. Sentinel-6 is part of the European Copernicus programme and will complement the largest operational Earth observation programme in the world. It is a radar altimetry mission to monitor sea-level rise, wave height and windspeed but its data can also be used to map rivers and lakes and for hydrological purposes such as water and flood management by providing measurements of the height of water over rivers, . lakes and reservoirs. This supplements existing satellite water level products already available from Sentinel 3A and also the upcoming SWOT mission.

This research will

- Use radar altimeter and optical satellite data together with machine learning techniques to derive reservoir operating rules for major reservoirs on the European river network.
- Test the derived rules within the latest EFAS forecasts and reanalysis datasets held at ECMWF
- Evaluate the improvement in forecasts

- Investigate the real world value of implementing this strategy for saving lives and avoiding economic damage with the Red Cross Red Crescent Climate Centre.

Severe flooding in Germany in July 2021 (*photo credit: Rachael Hicks CC*)

The student will be embedded with the forecasting teams at the European Centre for Medium Range Weather Forecasts – a world-leading forecast centre - to develop the machine learning algorithms and then embed and evaluate them within the operational flood forecasting systems. In addition, working with the Red Cross Red Crescent Climate Centre, the student will be able to evaluate the impact of the forecast improvements on real world forecast user situations.

Training opportunities:

This studentship provides Visiting Scientist status at ECMWF and embedding within the forecasting teams there led by Prof Christel Prudhomme. The student would be able to work part time at ECMWF, including a 3 month full time placement, and have access to supercomputing facilities.

The studentship also includes a 3 month placement with the Red Cross Red Crescent Climate Centre to develop an understanding of the context for humanitarian use of forecasts. This would be undertaken virtually, but would also include funded visits to colleagues in Europe.

Student profile:

This project would be suitable for students with quantitative skills or knowledge from Undergraduate and Masters degrees in Meteorology, Hydrology, Climatology, Mathematics, Environmental Science or a related field. Experience of coding in python, R, MATLAB or similar is desirable.

Funding particulars:

This project is co-funded by the Copernicus Emergency Management Service Computational Centre at ECMWF.