Multi-model data assimilation techniques for flood forecasting

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Motivation

The frequency of floods has tripled since 1980 and due to climate change and socio-economic growth it is predicted that by 2080 the annual cost of flooding in Europe alone could be as high as 100 million euros [1]. Early warnings for flood events are vital to allow all the necessary parties enough time to prepare. The European Flood Awareness System (EFAS), part of the European Commission's Copernicus Emergency Management Service, provides ensemble streamflow forecasts for Europe with lead-times up to 15 days.

Objectives

- To improve the skill of the forecast, the EFAS currently applies statistical post-processing locally at river gauge stations where sufficiently long and reliable observations are available.
- In this PhD project, data assimilation techniques will be used, in post-processing, to calculate bias and spread correction parameters by combining the available gauge observations with the forecasts.
- These techniques allow the natural relationships that occur between points up and downstream to be considered and the corrections to be extended along the river channel.

European Flood Awareness System (EFAS)

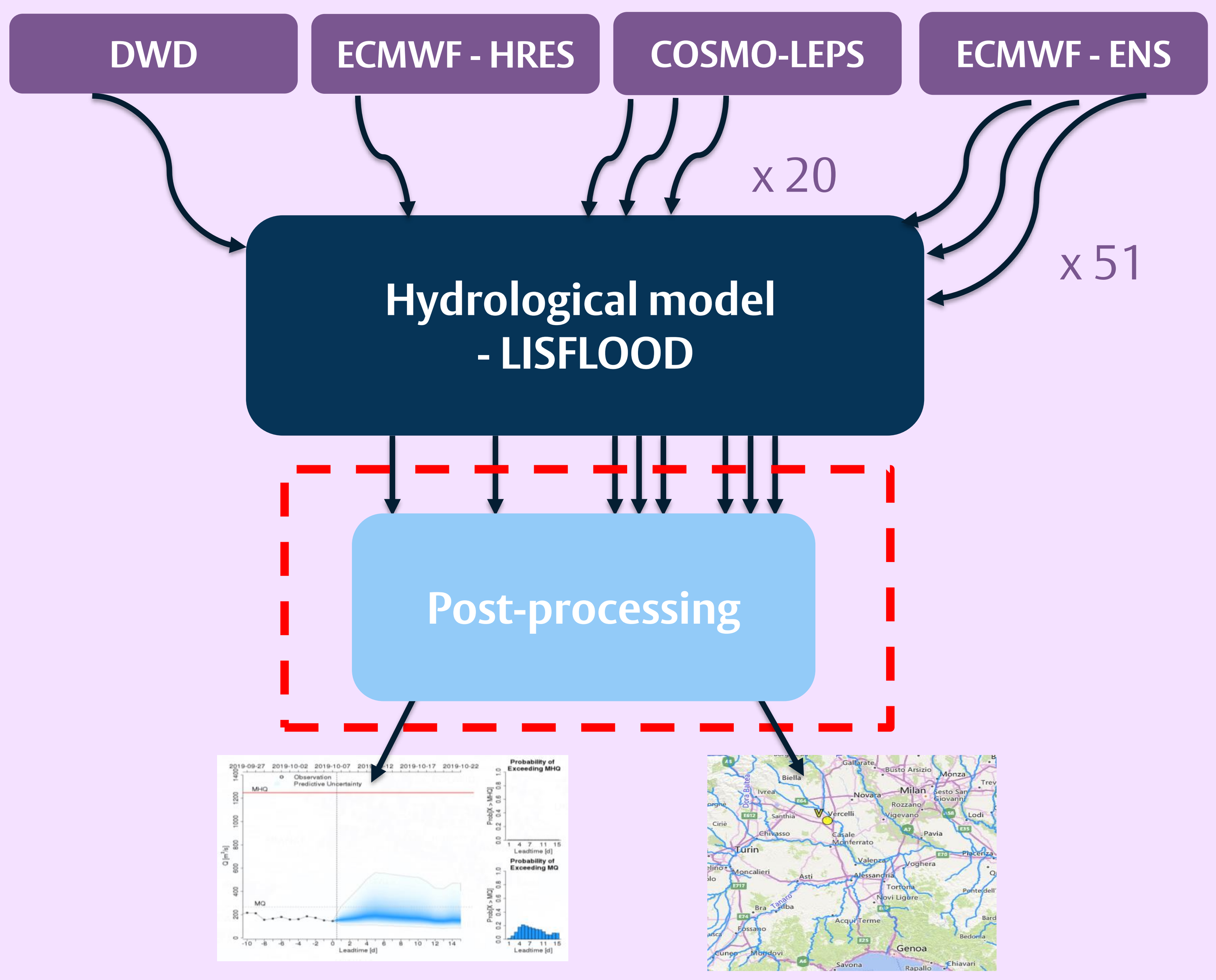

Figure 1: The forecasting chain of the EFAS. The EFAS produces hydrographs at gauge stations, and provides flood alerts for high and severe discharge for all river basins with an upstream area of more than 2000 km^2.

Data Assimilation Techniques

Data assimilation is a mathematical technique that combines model simulations with observations whilst accounting for the uncertainty in both.

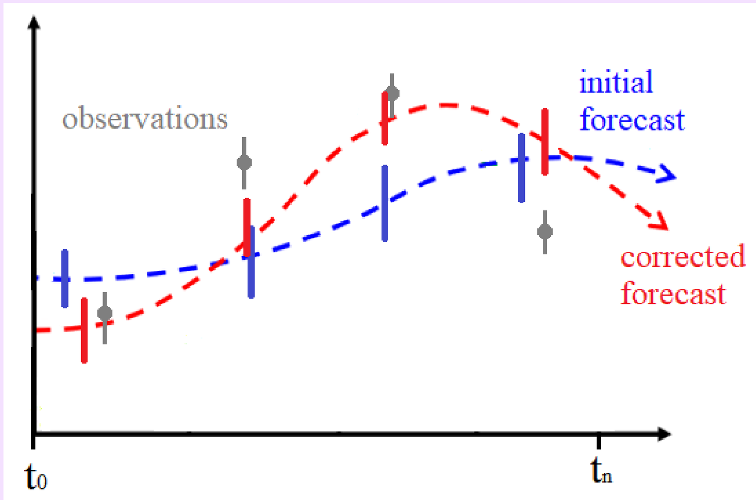

Figure 2: Illustration of data assimilation. Observations are used to modify an initial forecast to create a more accurate forecast.

This post-processing method is based on two techniques:

- Bias correction using state augmentation and the Ensemble Transform Kalman Filter (ETKF, see for example [2]).
- Spread correction using innovation statistics matching (see [3]).

Current work

- Initial work focuses on the ECMWF-ENS driven streamflow forecasts.
- An Ensemble Transform Kalman Filter (ETKF) [3] is used to calculate additive biases, using recent observations and forecast statistics.
- The covariance matrix, one column of which is shown in Fig. 3, will be used to estimate a spread correction parameter by comparing it to the error of the ensemble mean.

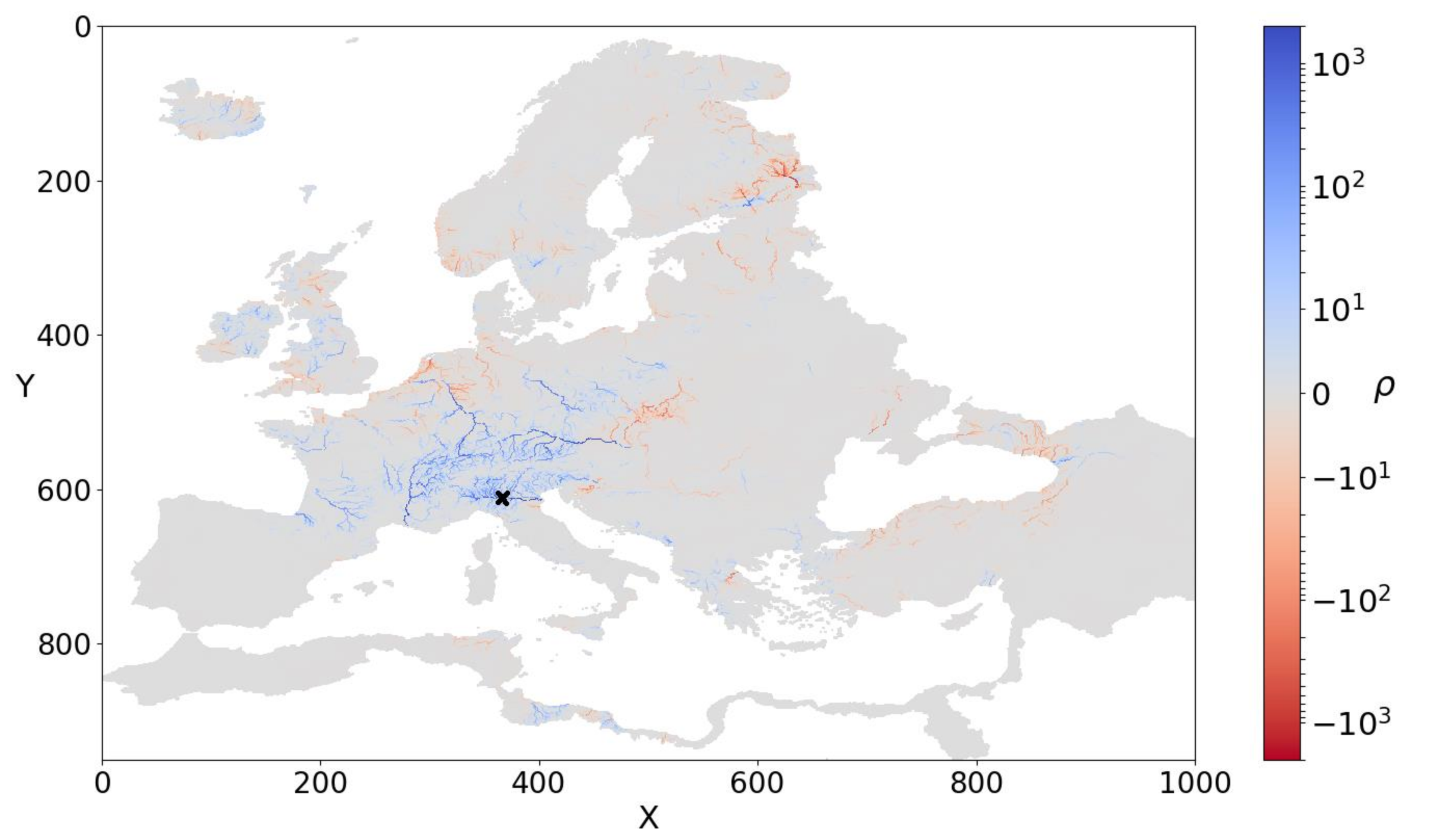

Figure 3: Covariance between the discharge of each land based grid-box and the discharge at a point (black cross) downstream in the Po catchment, Italy. The blue regions indicate a high positive correlation between these locations and the downstream area of the Po catchment, and the red regions indicate a high negative correlation.

Future work

- Inaccuracies in the covariance matrix due to the limited ensemble size, such as the spurious correlations seen in Fig. 3, in for example Iceland, will be treated using regularisation techniques, such as localization [4, 5] and eigenvalue thresholding [6].
- The EFAS provides forecasts on 5km grid across Europe. Due to the spatial scale of the system, the calculation of the covariance matrix is computationally expensive requiring parallel computing techniques.
- Each of the four meteorological forecasts will produce flood forecasts with different statistics so a multi-model approach is necessary to generate a single post-processed flood forecast.
- To evaluate this new post-processing method common skill scores will be calculated and compared to those of the unprocessed forecasts, and forecasts post-processed using the current operational method.

References

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