Hydrological reanalysis through streamflow assimilation in a hydrological model over 662 catchments in France

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The knowledge of historical French weather has recently been improved through the development of the SCOPE (Spatially COherent Probabilistic Extended) Climate reconstruction, a high-resolution ensemble daily reconstruction of precipitation and temperature covering the period 1871–2012, and based on a statistical downscaling of the Twentieth Century Reanalysis (Caillouet et al., 2016, 2017). The SCOPE Climate dataset has been used as an input for hydrological modeling using GR6J, a hydrological lumped conceptual model, over 662 catchments in France, in order to build a 140-year ensemble national-scale streamflow reconstruction (Caillouet et al., 2017). However, historical observations of discharge do exist from at least the 1910's. These observations – even though rather scarce and sparse – do not currently feed the streamflow reconstructions. The goal of this study is therefore to assimilate these historical hydrometric observations for building a 150-year hydrological reanalysis over France.

This study considers ensemble-based data assimilation (Evensen, 2003) over the 662 catchments, and defines a semi-distributed model through the combination of the model states of all individual catchment-specific model parameterizations. This configuration critically allows assimilating streamflow observations from neighbouring catchments if available. Two features are implemented for assimilating streamflow data: (1) an anisotropic localization procedure based on the initial streamflow reconstruction without assimilation, and (2) a Gaussian transformation, on both the streamflow and the two model water stores to be updated. This transformation allows using the Ensemble Kalman filter in an optimal way for the highly non-gaussian variables.

The overall data assimilation is here applied for reconstructing the daily streamflow over France for the 2009-2012 period. The methodology is evaluated on increasing observation density using actual historical density of 1910, 1935 and 1960. A consistent set of independent stations is used for validation in term of both accuracy and reliability. Results show that: (1) the reanalysis show better performance than the initial hydrological reconstructions, (2) the accuracy of the reanalysis increases with the assimilated observation density, and (3) building a semi-distributed model allows a more effective assimilation of streamflow observation by spreading the information both temporally and spatially.

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