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Ensemble Kalman Filter applied to a distributed model for hydrological balance and flood forecasting in the Arno river basin (Italy)

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Modern distributed hydrological models reach an high degree of complexity in describing physical processes that affects the hydrological cycle, such as channel routing, turbulent heat and moisture fluxes that defines the energy budget and groundwater modelling. Such complexity must deal with the difficulty in calibrating physical models, whose parameters cannot be often related to easily measurable physical variables. In this work an approach based on the Ensemble Kalman Filter (EnKF) is proposed in order to develop a calibration scheme that uses information on real time flow measurements to continuously revise parameter and state estimates. The choice of the EnKF requires a much greater computational effort but allows the use of highly nonlinear dynamics both in the state evolution equation of the model and in the observation equation. The optimization algorithm has been first tested on a simple lumped parameters model based on water mass balance of a surface soil layer, considered as a non linear reservoir with threshold behaviour. In a second stage, the EnKF has been implemented in MOBIDIC-2, a distributed hydrological model for flood forecasting and water mass balance characterized by the coupling of mass and energy balance, explicit groundwater modelling and diffusive approximation for channel flow simulation (Muskingum-Cunge). The case study refers to the Arno basin, with outlet at Subbiano station (750 sq km) while the integration is performed on a period of 10 months, from January to October 2005. The model coupled with the EnKF seems to be able to reproduce measured flows by optimizing the basin parameter estimates. Both lumped parameters, such as base flow delay constant, and distributed parameters, such as soil hydraulic conductivity and wave celerity of the river network, converge. Also, a good estimate of distributed states that are difficult to measure, such as soil moisture or soil temperature maps, is produced and can be used in other hydrological analysis.