Geophysical Research Abstracts
Vol. 18, EGU2016-12792, 2016
EGU General Assembly 2016

Variational assimilation of land surface temperature observations for enhanced river flow predictions

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Data assimilation (DA) has the potential of improving hydrologic forecasts. However, many issues arise in case it is employed for spatially distributed hydrologic models that describes processes in various compartments: large dimensionality of the inverse problem, layers governed by different equations, non-linear and discontinuous model structure, complex topology of domains such as surface drainage and river network.On the other hand, integrated models offer the possibility of improving prediction of specific states by exploiting observations of quantities belonging to other compartments. In terms of forecasting river discharges, and hence for their enhancement, soil moisture is a key variable, since it determines the partitioning of rainfall into infiltration and surface runoff. However, soil moisture measurements are affected by issues that could prevent a successful DA and an actual improvement of discharge predictions.In-situ measurements suffer a dramatic spatial scarcity, while observations from satellite are barely accurate and provide spatial information only at a very coarse scale (around 40 km).Hydrologic models that explicitly represent land surface processes of coupled water and energy balance provide a valid alternative to direct DA of soil moisture.They gives the possibility of inferring soil moisture states through DA of remotely sensed Land Surface Temperature (LST), whose measurements are more accurate and with a higher spatial resolution in respect to those of soil moisture.
In this work we present the assimilation of LST data in a hydrologic model (Mobidic) that is part of the operational forecasting chain for the Arno river, central Italy, with the aim of improving flood predictions. Mobidic is a raster based, continuous in time and distributed in space hydrologic model, with coupled mass and energy balance at the surface and coupled groundwater and surface hydrology. The variational approach is adopted for DA, since it requires less restrictive hypothesis than Kalman and Monte Carlo filters and smoothers, although it needs the not straightforward derivation of an adjoint model. The developed assimilation system is tested through hindcast experiments on selected events in the period 2010-2014 that actually resulted into false alarms in the Arno river basin (about 8230 km2). The hydrologic model is run with the spatial and temporal resolutions that are employed operationally, i.e. 500 m and 15 minutes. The improvement in discharge forecasts is evaluated through classical performance indexes as error on peak flow and Nash-Sutcliffe efficiency. In addition, performances of LST assimilation are compared with those obtained with the assimilation of discharge data at multiple punctual locations for the same events.