Geophysical Research Abstracts
Vol. 20, EGU2018-19708, 2018
EGU General Assembly 2018

Testing soil moisture data assimilation in a 3D subsurface hillslope model

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Data assimilation with 3D subsurface hydrologic models comes along with various challenges. Apart from obvious technical issues regarding the large number of model states and the involved demand of computational resources, there can be as well model and method specific problems. The ratio of available observations to unknown model states and parameters is much smaller compared to models of lower dimensionality and smaller scale. Besides, complex flow patterns might develop that cannot be captured entirely by the data assimilation and will be compensated in a different way instead, for example by assigning wrong parameters in parameter updates. This would allow for decent estimates of current states, but will probably not be useful for making predictions.

In this work, we apply the ensemble Kalman filter to a 3D hillslope model of 50x50x20m extension using Parflow. Synthetic observations are generated with the same model. We focus on the handling of the soil hydraulic parameters, which are spatially variable, temporally constant and assumed to be generally unknown. A changing water table as well as the presence of overland flow and lateral fluxes in the unsaturated zone add to the complexity of the flow pattern. It is investigated whether under such conditions data assimilation soil moisture and run off observations can be used to obtain decent estimates and predictions. The cases are compared to scenarios where flux is only vertical and the groundwater table does hardly change.

Furthermore, a more detailed analysis on how to handle the soil hydraulic parameters is made. In a similar study using a 1D unsaturated flow model, parameter updates were found to be the best way to handle parameter uncertainty, resulting in good predictions of soil moisture. Regarding the limited number of observations and the high spatial variability of the parameters in a 3D model, decreasing the large amount of unknown parameters by assigning homogeneous parameter zones could be more efficient than attempting to resolve the full heterogeneous structure.