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Improved characterization of root zone soil moisture in land surface models by assimilation of groundwater level data. An example with TerrSysMP.

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Land surface model predictions are affected by uncertainty with respect to parameters, atmospheric forcings and process representation. Therefore, constraining land surface model predictions by assimilation of soil moisture data is of great interest, using techniques like the Ensemble Kalman Filter. Soil moisture is a key variable in land surface models linking the water and energy cycles. However, various studies found that assimilation of remotely sensed soil moisture content improved root zone soil moisture characterization only marginally. In addition, below densely vegetated areas measured remotely sensed soil moisture content is unreliable. In this study, we explored groundwater level data as an additional information source to be used in data assimilation to constrain root zone soil moisture characterization and land surface model predictions. In order to extract as much information as possible from groundwater level data we used the model TerrSysMP, which represents groundwater better than classical land surface models considering lateral subsurface flow, and fully coupled interactions between the vadose zone and groundwater. The assimilation of groundwater level data in integrated hydrological models like TerrSysMP is challenging. If groundwater level data are assimilated in terms of pressure information and used to update pressure in the vadose zone and aquifer, unrealistic updates may be generated in the upper vadose zone during (very) dry conditions as probability density functions of pressure are highly skewed. On the other hand, if groundwater level data are assimilated in terms of soil moisture values (equal to porosity in the aquifer) and used to update soil moisture in the vadose zone, under specific conditions which we will detail in the presentation updating also does not work well. We tested different data assimilation strategies in synthetic experiments and found that assimilating groundwater level data in terms of pressure, but updating model states in terms of pressure or soil moisture, depending on specific conditions, outperformed other methods. We call this approach a mixed state vector approach and tested it also for joint assimilation of surface soil moisture and groundwater level data. Other data assimilation experiments show the feasibility to jointly update distributed fields of saturated hydraulic conductivity and van Genuchten alpha with an iterative Ensemble Kalman Filter, while considering uncertainty of van Genuchten n without updating this parameter.