Geophysical Research Abstracts
Vol. 18, EGU2016-1484, 2016
EGU General Assembly 2016

Assimilation of groundwater levels to improve predictions of soil moisture with TerrSysMP

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Remote sensing techniques can monitor surface soil moisture spatially and temporally for areas with sparse vegetation, but these measurements are limited to the top few centimeters of the soil. Groundwater level (GWL) data are available in many places at regional and national scales, at low cost and with high accuracy and could provide valuable additional information on root zone soil moisture. For example, shallow groundwater level results more likely in surface runoff because of excess saturation while deep groundwater levels generally are related to limited evapotranspiration and lower soil moisture contents. Data Assimilation (DA) allows to optimally combine model predictions and GWL data to improve root zone soil moisture characterization in integrated models. In our work, a highly modular and scale-consistent Terrestrial System Modeling Platform (TerrSysMP) is used. It includes models for three terrestrial compartments: the atmospheric model COSMO for the atmosphere, the Community Land Model (CLM version 3.5) for the land surface and the groundwater flow model ParFlow for the subsurface. In our 1D synthetic experiments, three soil types, five climate datasets and five plant types are used to simulate groundwater level. The relation between groundwater dynamics and the root zone soil moisture and evapotranspiration are studied. These relations show that the sensitivity of root zone soil moisture content is a function of groundwater level with no sensitivity for groundwater levels below 10m and high sensitivity for groundwater levels above 2.5m. Therefore, assimilation of groundwater level can improve root zone soil moisture under some conditions only. Data assimilation experiments were carried out and demonstrated that assimilation of groundwater level can improve estimation of root zone soil moisture and evapotranspiration, especially in combination with surface soil moisture observations.