Geophysical Research Abstracts
Vol. 16, EGU2014-3523, 2014
EGU General Assembly 2014
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Is soil moisture initialization important for seasonal to decadal predictions?

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The state of soil moisture can can have a significant impact on regional climate conditions for short time scales up to several months. However, focusing on seasonal to decadal time scales, it is not clear whether the predictive skill of global a Earth System Model might be enhanced by assimilating soil moisture data or improving the initial soil moisture conditions with respect to observations.

As a first attempt to provide answers to this question, we set up an experiment to investigate the life time (memory) of extreme soil moisture states in the coupled land-atmosphere model ECHAM6-JSBACH, which is part of the Max Planck Institute for Meteorology's Earth System Model (MPI-ESM). This experiment consists of an ensemble of 3 years simulations which are initialized with extreme wet and dry soil moisture states for different seasons and years. Instead of using common thresholds like wilting point or critical soil moisture, the extreme states were extracted from a reference simulation to ensure that they are within the range of simulated climate variability. As a prerequisite for this experiment, the soil hydrology in JSBACH was improved by replacing the bucket-type soil hydrology scheme with a multi-layer scheme. This new scheme is a more realistic representation of the soil, including percolation and diffusion fluxes between up to five separate layers, the limitation of bare soil evaporation to the uppermost soil layer and the addition of a long term water storage below the root zone in regions with deep soil. While the hydrological cycle is not strongly affected by this new scheme, it has some impact on the simulated soil moisture memory which is mostly strengthened due to the additional deep layer water storage.

Ensemble statistics of the initialization experiment indicate perturbation lengths between just a few days up to several seasons for some regions. In general, the strongest effects are seen for wet initialization during northern winter over cold and humid regions, while the shortest memory is found during northern spring. For most regions, the soil moisture memory is either sensitive to wet or to dry perturbations, indicating that soil moisture anomalies interact with the respective weather pattern for a given year and might be able to enhance or dampen extreme conditions. To further investigate this effect, the simulations will be repeated using JSBACH with prescribed meteorological forcing to better disentangle the direct effects of soil moisture initialization and the atmospheric response.