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Centennial-scale soil moisture dynamics as a fingerprint of climate variability and change

Pier-Luigi Vidale (1), Marie-Estelle Demory (1,1,1), Malcolm Roberts (2), Anne Verhoef (3), and Leonard Shaffrey (1)

(1) NCAS-Climate, Dept. of Meteorology, University of Reading, Reading, United Kingdom (p.l.vidale@reading.ac.uk, +44-(0)118-3788316), (2) Met Office Hadley Centre, Exeter, UK, (3) Department of Geography and Environmental Science, University of Reading, Reading, United Kingdom

The terrestrial branch of the water cycle has been increasingly under scrutiny in the past two decades. Recent focus has extended from diurnal to multi-annual controls on persistent states of the land surface and soil, as well as multi-scale links with the energy and carbon cycles.
Measurement and long-term monitoring of the within-soil components of the hydrological cycle are technically challenging and limited by high spatial heterogeneity and the high expense of in-situ observations. New techniques exploiting the complementarity of micrometeorological and remote sensing measurements (as well as reanalyses) have emerged and revealed significant long-term temporal variability. Some recent studies (e.g. Jung et al. 2010) have also suggested possible trends in soil moisture amounts, which could/should be interpreted in the framework of fingerprinting climate variability and change. These highly valuable observational time series are, however, still relatively short.
Here we exploit the potential of (coupled) AOGCMs, deployed at high-resolution over centennial time scales, and capable of skilfully representing climate system variability. The AOGCM output can be used for augmenting the observational time series and help attribute the soil moisture fingerprints. Our centennial-scale analysis reveals significant decadal soil moisture variability, affecting all regions in the Jung et al. (2010) study. Inter-annual variability, in particular in the Mississippi and Amazon basins is also evident, partly explained by ENSO, and is superposed on decadal variability. These decadal soil moisture anomalies appear to be well correlated with periods of more active ENSO variability and could easily be confused with trends when considering shorter-term observations.
Analysis of complementary climate change experiments, forced with both transient and stabilised GHG levels, also reveals a strong response of the soil moisture cycle, with a clear centennial-scale trend, as well as enhanced interannual to decadal variability, in agreement with the theoretical predictions of Allan and Soden (2007).