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Observationally Based Analysis of Land–Atmosphere Coupling

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The temporal variance of soil moisture, vegetation and evapotranspiration over land has been recognized to be strongly connected to the temporal variance of precipitation. However, the feedbacks and couplings between these variables are still not well understood and quantified. Furthermore, soil moisture and vegetation processes are associated with a memory and therefore they may have important implications for predictability.
In this study we apply a generalized linear method, specifically designed to assess the reciprocal forcing between connected fields, to the latest available observational data sets of global precipitation, evapotranspiration, vegetation and soil moisture content. For the first time a long global observational data set is used to investigate the spatial and temporal land variability and to characterize the relationships and feedbacks between land and precipitation.
The variables considered show a significant coupling among each other. The analysis of the response of precipitation to soil moisture evidences a robust coupling between these two variables. In particular, the first two modes of variability in the precipitation forced by soil moisture appear to have a strong link with volcanic eruptions and El Niño–Southern Oscillation (ENSO) cycles, respectively, and these links are modulated by the effects of evapotranspiration and vegetation. It is suggested that vegetation state and soil moisture provide a biophysical memory of ENSO and major volcanic eruptions, revealed through delayed feedbacks on rainfall patterns. The third mode of variability reveals a trend very similar to the trend of the inter-hemispheric contrast in sea surface temperature (SST) and appears to be connected to greening/browning trends of vegetation over the last three decades.