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Local Land-Atmosphere Coupling (LoCo): hotspots of land-surface - precipitation feedback from reanalysis fields

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Identification of regions with strong coupling between the land-surface state and precipitation is of interest from a climatological and a hydrological point of view. Of particular interest are areas with a two-way coupling between the land-surface and precipitation, that is, with land-surface - precipitation feedback (LSPF). It is impossible to prove occurrence of feedback by analyzing observations. Therefore, LSPF has traditionally been studied by comparing output from one or more models for simulations with differing levels of land-atmosphere coupling. However, that approach precludes the construction of a real-world climatology of LSPF. In the present study, we attempt to identify hotspots of LSPF at the global scale from ERA-Interim and MERRA reanalysis fields. To detect in these datasets combinations of land-surface states and atmospheric conditions that could be indicative of LSPF we use two alternative sets of Local Coupling (LoCo) diagnostics that recognize the crucial role of the state and development of the Atmospheric Boundary Layer (ABL) in triggering convective precipitation. The first set diagnoses the convective triggering potential and moisture conditions in atmospheric layers up to a pressure level of 700 hPa (CTP-HIlow). This CTP-HIlow framework assesses the likelihood of surface-state dependent generation of convection. Therefore, we combine CTP-HIlow with surface wetness state, using either soil moisture content or evaporative fraction, and with ABL development during the day, using ABL height and Lifting Condensation Level (LCL). The second LoCo diagnostic set assesses the sensitivity, Ó, of the near-surface equivalent potential temperature to evaporative fraction, assuming the development of a convective ABL during the day. It takes into account the impact on ABL development of temperature and humidity gradients in the lower free atmosphere. The diagnostic assesses to what extent changes in surface wetness would sustain or suppress convection. In both sets, convective precipitation is detected in order to determine whether a possible feedback loop is actually closed. We analyzed the aforementioned reanalysis fields for the summer half-year of 1999-2008 (ERA-Interim) or 2003-2009 (MERRA). The results from both diagnostic sets were largely consistent, although using Ó suggested slightly larger regions with frequent positive feedback situations, in particular in the wet tropics. Spatial patterns of the fraction of summer days with possible positive feedback conditions derived from the respective reanalysis fields were largely consistent as well. However, in the hotspot regions detected, the maximum frequency of possible feedback situations was much larger in MERRA than in ERA-Interim. Our results using soil moisture as an indicator of surface wetness confirm earlier analyses from modeling studies where hotspots with possible positive feedback were found mainly in regions with large gradients of soil moisture and intermediate to large evapotranspiration rates, such as the Sahel region. Using evaporative fraction as a wetness indicator tends to shift regions of strong coupling towards wetter regions. The results suggest that positive feedback may be frequently present over rain forest, which is to some extent consistent with earlier analyses of precipitation recycling ratios over the Amazon region. Negative feedback cases are rarely found with the LoCo diagnostics used here.