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Identification of global hotspots of land-surface - precipitation interaction from reanalysis fields

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Identification of areas around the globe where precipitation and the land-surface are strongly coupled is of interest for both meteorological and hydrological applications. Of particular interest are areas with a two-way coupling between the land-surface and precipitation, that is, areas with land-surface – precipitation feedbacks (LSPF). Since it is impossible to prove the existence of feedbacks by analysing observations, LSPF have traditionally been studied within a modelling framework, by comparing output from one or more models for runs with differing levels of land-atmosphere coupling. However, that approach precludes the construction of a real-world climatology of LSPF. The latter requires comprehensive, quasi-continuous and high-quality datasets with sufficient spatial coverage.

In the present study, we attempt to identify hotspots of LSPF at the global scale from the 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 diagnostics.

The first set starts with a diagnosis of the convective triggering potential and moisture conditions in the lower atmospheric layers, up to pressure levels of 700 hPa (CTP-HIlow). This CTP-HIlow framework assesses the potential for the land-surface to influence convective precipitation, but only from an atmospheric point of view. Therefore, CTP and HIlow are combined with an assessment of the surface wetness state, using either soil moisture content or evaporative fraction, and of planetary boundary layer (PBL) development during the day. Finally, convective precipitation is detected in order to determine the possible occurrence of two-way coupling.

The second set assesses the sensitivity of the near-surface equivalent potential temperature to evaporative fraction from a description of the development of the convective PBL during the day. It includes the impact of temperature and humidity gradients in the lower free atmosphere on PBL development. The diagnostic assesses to what extent changes in surface wetness would be able to sustain convective precipitation. Again, convective precipitation is detected in order to determine the possible occurrence of two-way coupling.

Both diagnostics were used to detect LSPF during the summer half-year of 1999-2008. The results were largely consistent among the diagnostics. Moreover, they largely confirm earlier analyses from modelling 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. The results also suggest that regions with positive feedback may be present in wet parts of the globe, like the Amazonian rain forest, which is to some extent consistent with earlier analyses of precipitation recycling ratios. Negative feedback cases are rarely found by the diagnostic sets used here.