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Non-stationarities in land-atmosphere-climate interactions in Europe and the Mediterranean region

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Interactions between the land surface and the atmosphere are of major importance for the regional and global climate. Soil moisture thereby plays a key role: availability of water in the soils is one of the drivers of evaporation and thus impacts on temperature and precipitation. Regions of strong soil moisture-atmosphere coupling include the Mediterranean area while in other regions of Europe non-local effects such as the advection of dry (moist) air are more important. However, previous studies have also shown that climate is fundamentally non-stationary and that such non-stationarities occur on various spatial and temporal scales. These studies have mainly focused on sea-surface-atmosphere interactions or circulation-climate interactions. Thus, the question arises whether soil-moisture-atmosphere-climate interactions also show a non-stationary behavior.
As a first step, Varimax-rotated s-mode principal component analysis (PCA) is used to reduce dimensions of soil moisture fields, circulation variables as well as of 2m temperature fields. The resulting PC loadings represent the spatial patterns while the PC scores are the corresponding time coefficients. For the analysis of non-stationarities, the time coefficients of soil moisture and temperature are further used in 30-year running correlation and feedback parameter analyses. Furthermore, correlation analyses are carried out for the circulation variables and soil moisture or temperature, as changes of the atmospheric circulation are a potential source of non-stationarities. All analyses focus on the boreal summer season 1950-2009.
Results show substantial non-stationaries in the relationship between soil moisture and temperature in several regions in the European and Mediterranean domain. Depending on the region considered, these changes are accompanied by modifications in different large-scale circulation patterns such as the North Atlantic Oscillation, the Scandinavia pattern or a high pressure system centered over parts of Europe.