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Soil moisture change linking contrasting atmosphere-landscape scales and hydro-climatic changes

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Soil moisture plays a central role for land-climate interactions in the climate system. Soil moisture is also a key landscape component for hydrological and biogeochemical cycling, waterborne solute/pollutant transport, and vegetation, ecosystem and agricultural conditions. The soil moisture definition as a ratio of water volume to bulk soil volume (water content) and/or of water volume to pore volume (degree of saturation) applies across different spatial scales - from centimetres to kilometres - depending on the question of interest and the measurement method used to answer it. This paper presents a quantification framework that links large-scale hydro-climatic conditions at the surface with typically locally accounted for soil and groundwater conditions in the subsurface. The framework enables evaluation and screening of variability and change in long-term soil moisture statistics. Such statistics are here assessed for observed hydro-climatic records extending over the whole 20th century and for different soils in a major Swedish hydrological drainage basin. Frequencies of particularly dry and wet soil moisture events are investigated for different climatic periods within this century. Results show large increase in the frequency of dry events from the beginning to the end of the century, even though precipitation has increased over this time. The increase in dry event frequency implies increased risk for hydrological drought, agricultural drought and groundwater drought under decreasing meteorological drought risk. The risk increase for other types of drought than the meteorological is here caused by increased evapotranspiration along with increased temporal variability in runoff driven by historic agricultural expansion and intensification, rather than by atmospheric climate change. Synthesized hydro-climatic data across different scales and parts of the world shows similar emerging patterns of landscape-driven rather than atmosphere-driven hydro-climatic change.