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The extreme future of soil moisture over the Mediterranean region

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Soil moisture is a key hydrologic state variable driving the exchange of water and heat energy between the land surface and the atmosphere through evaporation and plant transpiration, regulating surface temperature, humidity and potentially affect precipitation though recycling processes. Soil moisture is a fundamental element of the surface water budget, determining the health or stress on land surface ecosystems and managed systems such as agriculture and agroforestry. The surface water budget, and therefore soil moisture, depends on precipitation, irrigation (when present), soil infiltration, surface runoff, baseflow, and evapotranspiration. Furthermore, soil moisture-based indices are used as indicators of agricultural droughts, and soil moisture drought is one of the preconditioning effects for the development of extreme temperatures, influenced by atmospheric dynamics.

Climate change poses a major threat to all Mediterranean countries due to the combination of significant reductions in precipitation, increases in temperature, and the higher frequency of climate extremes, especially driving water scarcity and related multi-sectoral impacts. Most Mediterranean countries already endure higher frequencies of droughts and deficits in soil moisture and water storage. In this study, future projections of soil moisture are examined using a multi-model EURO-CORDEX regional climate ensemble, in agreement with three future emission scenarios (RCP2.6, 4.5 and 8.5). The drivers of future soil moisture dynamics are also analysed along with their effects on relative humidity and evaporation rates.

As expected, the projections show a clear reduction of soil moisture throughout the entire annual cycle, in response to a significant decrease in precipitation and an increase in temperature, leading to a substantial rise in potential evapotranspiration. The overall total soil moisture decreases ranges from -5% for the RCP2.6 to -20% (-10%) for the RCP8.5 (RCP4.5), w.r.t. the present climate. Projections reveal that for the RCP4.5 (RCP8.5) for the mid-century soil moisture deficits up to 5x (6x) are projected to occur, and for the end-of-century even 7x for the RCP8.5. The annual cycle of soil moisture, both in the present and future climate, is determined by precipitation and potential evapotranspiration, and deficit is both enhanced and covers a wider monthly window in the future, especially for the RCP8.5.

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