



Soil-moisture-atmosphere coupling hotspots and their representation in seasonal forecasts of boreal summer

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This study examines the spatial distribution and characteristics of soil-moisture-atmosphere coupling "hotspots" across the Northern Hemisphere during the boreal summer months, and evaluates how well these features are represented in dynamical seasonal forecasting systems. Specifically, the study utilizes hindcasts from the Copernicus Climate Change Service (C3S) multi-model seasonal forecast ensemble to investigate the role of soil moisture anomalies in modulating atmospheric conditions, with a focus on their impact on temperature and precipitation predictability.

The analysis reveals that regions with strong soil-moisture atmosphere coupling such as parts of the western United States, southern Europe, and Eurasia exhibit substantial potential for improving seasonal climate predictions, particularly for surface temperature and rainfall. These regions act as "memory reservoirs," where soil moisture anomalies can influence atmospheric conditions weeks to months ahead, offering a window of opportunity for enhancing forecast skill.

However, the study also identifies key limitations that currently hamper forecast reliability. Notably, there is considerable uncertainty in the initialization of soil moisture states due to limitations in observational data and inconsistencies across land surface models. In addition, estimates of soil moisture persistence timescales vary significantly between models, impacting the realism of the simulated land-atmosphere interactions.

Furthermore, while some regions demonstrate realistic coupling, others including large areas of North America, Eastern Europe, and Northern India, show evidence of excessive coupling strength, which lead to systematic biases in seasonal temperature forecasts as well as errors in the sign of atmospheric anomaly forecasts. The findings highlight the importance of improving soil moisture initialization and coupling parameterizations to enhance the reliability of seasonal climate forecasts.