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Observations of the Effect of Dry Soils on Air Temperatures

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A new approach is applied to satellite and in situ observations towards the characterization of regions of intense soil moisture-temperature coupling. We estimate two energy balances – one based on actual evaporation and one based on potential evaporation – and analyze their differential skill in explaining the dynamics of air temperature. The approach is applied to the study of climatological coupling hotspots as well as the anomalous role of soil moisture deficit during specific heatwaves in the past. Results using recently developed satellite-based evaporation (GLEAM) and temperature fields from reanalysis (ERA Interim) are validated using meteorological measurements and atmospheric profiles from sounding archives.

We find strong soil moisture-temperature coupling during the 2003 and 2010 heatwave events in Western Europe and Russia, especially in the regions in which the peak of temperatures occurred. Much lower coupling is found in the 2006 heatwave in California, and soil moisture deficit is suggested to have played an insignificant role in the event. Our observational results of the importance of dry soils in the occurrence of heatwaves are complemented with results obtained from CLASS, a conceptual model that couples the surface properties to the diurnal atmospheric boundary layer dynamics. By combining all these methods, we expect to understand whether soil moisture deficit is a necessary condition for the occurrence of mega-heatwaves or whether similar temperatures can still happen due to large-scale synoptic conditions. Ultimately, our analyses aim to provide independent observational estimates of the effect of soil moisture on air temperature dynamics that can be used to benchmark climate models.