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Investigating the representation of heatwaves in km-scale simulations

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Interactions between land and atmosphere play an important role in the climate system on a wide range of spatial and time scales. Soil moisture is of particular importance as it constrains evapotranspiration, thereby affecting the surface energy and water balance. This influence then extends to extreme events such as droughts and heatwaves and even manifests as a local source of predictability.

Several studies suggest that high resolution model simulations which explicitly resolve convective processes can present substantially different soil moisture-precipitation feedback compared to simulations where convection is parameterized. In some instances, this feedback even changes sign between the two. The cause is from different soil moisture content (mostly in summer season) in parameterized vs. explicit simulations, which results in a different partitioning between heat fluxes, in turn modulating the amplitude and persistence of heatwave events.

The present study investigates modulation of heatwaves in km-scale convection permitting simulations during the 2000-2009 period. A second research topic is understanding whether km-scale modeling is beneficial for the representation of this phenomenon. Here, we consider a subset of five WRF RCM simulations within the CORDEX Convection Flagship Pilot Study. Further simulations from other modeling consortia are currently being analyzed for a truly multi-model perspective.

The analyses focus on the comparison of heatwaves simulated at convection resolving (~3km grid spacing) and non-convection resolving (~15km grid spacing) scales for each RCM. The five RCMs constitute a small multi-physics ensemble, where each member presents a different setup in terms of combinations of physical schemes. Analyses cover three different subdomains of the greater Alpine region: the Alps, Po valley, and Adriatic region.

Preliminary results show that, at very high resolutions with explicitly resolved convection, heatwave events exhibit lower soil moisture content than coarser resolution simulations. This feature affects the surface energy balance in terms of heat fluxes partition, with a subsequent impact on the maximum temperature, which is higher in the convection permitting simulations

and generally in better agreement with observations. However, the heatwave maximum temperature modulation produced at the convection permitting scale, cannot be fully explained by differences in heat fluxes partition. This aspect suggests that also a different representation of small-scale circulation features is likely to play a role in determining the temperature modulation.

For areas with complex topography (e.g., Alps), results indicate a more consistent topography-driven soil moisture spatial patterns and related temporal evolution during heatwaves. At the same time, over different domains (e.g., Po valley) an excessive drying in the convection permitting RCMs is observed.

Finally, in agreement with other studies, the resulting drier conditions characterizing convection permitting RCMs likely arise from consistently longer (up to double) mean dry spell length compared to those from the simulations with parameterized convection. These findings shed light on how altered soil moisture-precipitation feedback can affect temperature extremes representation leading to ask at what extent heatwaves projected changes are dependent on the resolution considered.