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Do Changes in the Hadley Circulation Explain the Mediterranean Amplification?

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Climate change projections show an enhanced summer warming and drying over the Mediterranean, which is commonly referred to as the Mediterranean amplification. This amplified warming can potentially have harmful impacts on society, like more frequent heat waves or water scarcity. The physical mechanisms behind the Mediterranean amplification have been debated. Some studies hypothesize that a poleward expansion of the Hadley cell could explain the increased warming, others point towards an influence of temperature lapse rate changes.
In this study we apply a series of pseudo global warming (PGW) experiments that allow us to separate and quantify multiple drivers of climate change in regional climate model (RCM) simulations. More specifically, 30-year long simulations for current and future conditions are conducted with suitably modified lateral boundary conditions. To assess the robustness of the results, an ensemble of three CMIP5 GCMs is considered. Thus, the ensemble of PGW simulations consists of one RCM driven by three different GCMs.
The amplified summer warming over the Mediterranean is a robust feature in all simulations. Our results suggest that, even though an expansion of the Hadley cell can potentially have important consequences in the Mediterranean, a northward expansion alone cannot explain the amplified warming. Consistent with a previous study, we find that changes in lapse rates are the most robust and important driver of the Mediterranean amplification. The different changes in lapse rates depending on latitude are crucial and will be discussed in detail. We conclude that different changes in lapse rates, which are rooted in relatively straightforward thermodynamics, are decisive for the amplified Mediterranean warming and drying in climate change projections.