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Sensitivity Experiments on the Impact of Vb-Cyclones to Ocean Temperature and Soil Moisture Changes

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Cyclones developing over the western Mediterranean and move northeastward are a major source of extreme weather and responsible for heavy precipitation over Central Europe. Gaining insight into these processes is crucial to improve the projection of changes in frequency and severity of these so-called Vb-cyclones under future climate change scenarios. This study explores the impact of climate change on Vb-events through a number of idealized sensitivity experiments that assess the role of the sea surface temperature (SST) and soil moisture and their contribution to the moisture content in the atmosphere in recent Vb-events.

To achieve this task, we use the Weather Research and Forecasting model (WRF) to dynamically downscale the ERA Interim reanalysis, simulating five prominent Vb-events that led to extreme precipitation in Central Europe. WRF allows simulating a physical consistent response of Vb-cyclones to different SSTs and soil water volumes. The changes in SSTs are designed to follow the expected temperature changes in a future climate scenario. Additionally the corresponding uncertainty in such projections is considered.

Results indicate that although an increase of the Mediterranean SSTs leads to increased precipitation over Central Europe, e.g. 136% greater precipitation in the +5 K experiment compared to the control simulation, a change in the high-impact region of Vb-events at the northern side of the Alps is not found. This counter-intuitive behavior seems to be related to the increase of atmospheric instability over the artificially heated SSTs. Thereby, precipitation notably increases over the east Adriatic coast in response to warmer SSTs, which corresponds to the first location where the air is lifted. However, Vb-events become less destructive in their high-impact region, due to high loss of atmospheric water. Further experiments demonstrate that changing the SSTs of the Atlantic invokes almost no reaction (around 1% change) with respect to precipitation amounts, neither over Central Europe in general nor in the high-impact region of Vb-events, pointing to the secondary role of the Atlantic in the impact of Vb-events.

Further experiments explore the role of water content in the soil previous to the Vb-events. Introducing a full saturation of the soil leads to a minimal increase of 6% on average in precipitation amounts over Central Europe, indicating that soil moisture in the control simulation is already high. However, a complete desaturation of soil water leads to a reduction in precipitation amounts by 21% on average over Central Europe and over the area of the northern side of the Alps.

Overall, the precipitation changes found in these sensitivity experiments are generally small (1-6%) compared to the ones triggered by the Mediterranean SSTs (increase of 36%). The rather unrealistic sensitivity experiment of a complete desaturation of the soil leads to a precipitation decrease of 21%, so that soil moisture has an effect on precipitation of Vb-cyclones in Central Europe. Hence, the results indicate that the sensitivity of Vb-events to climate change emerges through the Mediterranean Sea, since it is its most important moisture source.