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Mechanisms for Amplified Central European Summer Precipitation Extremes in a Warmer Mediterranean Climate

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Central European climate is influenced by the Mediterranean Sea, where a strong increase in sea surface temperature (SST) has been observed during the last four decades. One example of extreme weather events are cyclones following the “Vb” pathway. These cyclones are generated over the Mediterranean Sea, travel northeastwards around the Alps and then hit central European countries. These cyclones carry large amounts of moisture and cause extreme precipitation, and subsequently flooding, particularly in summer.

To investigate the mechanisms causing increased summer extreme precipitation due to increased Mediterranean SST in Europe, we analyze a series of simulations with the atmospheric general circulation model ECHAM5. In the control run, we forced the model with the 1970-1999 SST climatology. In an additional run, we replaced the Mediterranean and Black Sea SST forcing with the climatology of the warmer 2000-2012 period. ECHAM5 was run at high horizontal resolution (T159) and integrated for 40 years in each experiment. 20-season return levels were derived as a measure of extreme precipitation for daily precipitation in JJA (June - August). These return levels are estimated as quantiles of a stationary generalized Pareto distribution, based on exceedances of the 95th precipitation percentile.

We have shown in a previous contribution that precipitation return levels in JJA increase along the Vb cyclone track although the number of Vb cyclones does not increase. Here we discuss the mechanisms responsible for this increase. Due to the warmer climate in the Mediterranean region, climatological mean evaporation and precipitable water in the atmosphere are increased. On extreme days, composites show an even further increase in precipitable water over the central European region. On these extreme days, a higher sea level pressure gradient between central Europe and the Atlantic causes enhanced cyclonic flow that transports more moisture from the Mediterranean region to central Europe. These results imply that not only the thermodynamic impacts of higher temperature enhance extreme precipitation over central Europe, but, in addition, dynamical changes lead to increased moisture transport into the region when Mediterranean SSTs are increased.