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Persistence of Heat Waves and its Link to Soil Moisture Memory

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In this study, we assess the role of soil moisture for heat wave persistence using simulations with the regional climate model COSMO-CLM. We perform a control run as well as three different sensitivity experiments with prescribed soil moisture contents (constant at plant wilting point, respectively field capacity, and prescribed to the mean seasonal cycle).

Several studies have investigated changes in the frequency of hot summer days but very few investigated changes in their persistence. We use two different heat wave thresholds for the definition of hot days, either defined by the 90^{th}-percentile of the control run or by the 90^{th}-percentile of the respective sensitivity experiment. When the threshold is set to the 90^{th}-percentile of the respective sensitivity experiment, we can infer from a difference in heat wave statistics between the sensitivity and the control experiments that they are characterized by a different number of threshold exceedances and, hence, a different mean length of threshold exceedances (i.e. hot day persistence). When using the 90^{th}-percentile of the CTL experiment, on the other hand, a difference in heat wave length may also simply be induced by a modified temperature density function in the sensitivity experiment (e.g. change in mean temperature). In this study, we investigate differences in heat wave duration in the experiments using both hot day thresholds. With the joint analysis of the two measures, it is possible to disentangle variations in heat wave duration caused by differences in the intrinsic persistence of daily maximum temperatures, and those due to differences in the corresponding probability density functions.

We identify that simulations with prescribed soil moisture, even for constant dry conditions, present a lower intrinsic heat wave persistence than simulations with interactive soil moisture. Correspondingly, with prescribed soil moisture, the autocorrelation of daily maximum temperature is significantly decreased (by 20% for 5-day lags to more than 50% for 20-day lags), and the number of short exceedances increases while longer exceedances are less frequent. This effect is related to the impact of soil moisture memory in the interactive simulation. Such effects may be overlooked when using the 90^{th}-percentile of the control run for the definitions of hot days. Our results highlight the key role of soil moisture memory for the persistence of heat wave events, beside the known effects of soil moisture on heat wave intensity.

References: Lorenz, R., E.B. Jaeger, and S.I. Seneviratne, 2010: Persistence of heat waves and its link to soil moisture memory. Submitted to Geophys. Res. Lett.