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A comprehensive study of the extreme heat and drought of the 2018 European summer

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The summer of 2018 was an extraordinary extreme season in Europe bringing simultaneous, widespread and coherent extremes of heat and drought in large parts of the continent with extensive impacts on agriculture, forests, water supply, and large financial losses. Joining different areas of expertise available within the German ClimXtreme project (https://www.climxtreme.net/index.php/en/), we present a comprehensive analysis of the 2018 extreme European summer in terms of heat and drought.

First, we define the events using different traditional, as well as, novel metrics. Then, we present a comprehensive dynamical analysis of the background atmospheric state, in order to better understand the events by bringing together different approaches. First results indicate that the summer of 2018 was characterized by persistent NAO+ conditions, which favored the occurrence and persistence of a Eurasian double jet stream structure. Both of those features contribute to the occurrence of heat extremes in western and central Europe. Additionally, positive blocking frequency anomalies were present over Scandinavia, which favored the intense heatwave in the region. An analysis of Rossby wave activity during the 2018 summer shows an eastward propagation of Rossby wave packets from the Pacific towards the Atlantic and the European continent already at the end of June and before the initiation of the heatwave over Scandinavia. When the peak over the Iberia occurs, there is no pronounced Rossby wave activity, which highlights the different mechanisms involved, i.e., subtropical ridges and Saharan air intrusions.

Low-frequency precursors, such as SSTs and soil moisture in spring, and their role in shaping those extreme events are also analyzed. A conspicuous tripolar SST anomaly pattern over the N. Atlantic, consisting of a cold blob south of Greenland and Iceland, was prominent starting in early spring. At the same time, a severe soil moisture depletion over Germany between April and July reflects the persistently warm and dry conditions in spring 2018 that caused anomalously dry soils in summer.

Last but not least, a tailored attribution study is presented, comparing the 2018 central European heatwave with similar events in the MPI Grande Ensemble and in CMIP6 models. To provide

tailored information for this study, the event was defined as the maximum daily temperature in Germany averaged over different lengths of periods of consecutive days to account for the prolonged heat that characterized the summer of 2018. According to the MPI-GE almost every summer will be more extreme than 2018 under a 2˚C warmer world.

As heat and drought conditions are likely to become more frequent and intense under anthropogenic climate change, we argue that the scientific community can benefit from such comprehensive and transdisciplinary studies.

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