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Testing drought vulnerability in a multi-model environment

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The availability of freshwater resources is pivotal in daily life, as it is used to feed populations, to drive local and global economies, and to sustain terrestrial and aquatic habitats. Although water is abundant globally, much of it is not directly available for human use nor environmental needs. Freshwater resources are not evenly distributed across the globe, and the supply of freshwater can vary highly over time. Often, those areas that have a large number of economic activities or dense populations do not coincide geographically with those that are rich in freshwater resources.

Water scarcity is usually referred to as the mismatch between the demand for and supply of freshwater resources, given a predetermined time horizon and spatial scale. Although the terms water scarcity and drought are often used interchangeably, they refer to quite different phenomena. Whereas drought is a natural phenomenon that indicates a temporary negative deviation from average hydrological values in space and time, water scarcity is often seen as a human construct, referring to the imbalance in freshwater resources due to the overuse of water relative to the amount of water available. Although (hydrological) droughts can act as water scarcity trigger, they are not per se a prerequisite. Systematic overuse of available freshwater resources can result in water scarcity, even without the occurrence of a drought. The opposite is also true, as the occurrence of a drought might not per se result in water scarcity; for example in areas where there is no or limited water demand. Hence, operational use of standardized drought indicators or fixed critical drought thresholds in water management, as is currently wide-spread, may give locally wrong incentives for the minimization of water scarcity conditions and impacts.

By linking drought (here: Q1-Q99 water availability conditions) and water scarcity indicators (WSI) we define in this study drought vulnerability. In doing so, we first assess with a monthly resolution over the period 1971-2010 which drought conditions lead to water scarcity in various regions at the globe. Both physical and social conditions determine whether an area qualifies as water scarce, hence the first results of this study show a wide variety of critical drought threshold at which water scarcity conditions are identified with best accuracy. The multi-model, multi-forcing nature of this study allows us, secondly, to evaluate the robustness of our results to model settings and uncertainties. The use of a false-alarm/missed-hit ratio enables us, finally, to inform policy makers on usage of upper- and lower-boundary drought thresholds in their operational water management, either minimizing the missed hits or the false alarms in identifying water scarce situations.

The results of this study may be useful in operational water management, as drought indicators are an often-used tool here. Moreover, long-term adaptation planning targeting water scarcity benefits from a better insight in the relation between drought and water scarcity. As drought indicators are often used in a forecasting mode as well, our results may be of added value in this discipline too.