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European drought under climate change and an assessment of the uncertainties in projections

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Extreme weather/climate events have significant environmental and societal impacts, and anthropogenic climate change has and will continue to alter their characteristics (IPCC, 2011). Drought is one of the most damaging natural hazards through its effects on agricultural, hydrological, ecological and socio-economic systems. Climate change is stimulating demand, from public and private sector decision-makers and also other stakeholders, for better understanding of potential future drought patterns which could facilitate disaster risk management.

There remain considerable levels of uncertainty in climate change projections, particularly in relation to extreme events. Our incomplete understanding of the behaviour of the climate system has led to the development of various emission scenarios, carbon cycle models and global climate models (GCMs). Uncertainties arise also from the different types and definitions of drought. This study examines climate change-induced changes in European drought characteristics, and illustrates the robustness of these projections by quantifying the effects of using different emission scenarios, carbon cycle models and GCMs. This is achieved by using the multi-institutional modular "Community Integrated Assessment System (CIAS)" (Warren et al., 2008), a flexible integrated assessment system for modelling climate change. Simulations generated by the simple climate model MAGICC6.0 are assessed. These include ten C4MIP carbon cycle models and eighteen CMIP3 GCMs under five IPCC SRES emission scenarios, four Representative Concentration Pathway (RCP) scenarios, and three mitigation scenarios with CO_2-equivalent levels stabilising at 550 ppm, 500 ppm and 450 ppm. Using an ensemble of 2160 future precipitation scenarios, we present an analysis on both short (3-month) and long (12-month) meteorological droughts based on the Standardised Precipitation Index (SPI) for the baseline period (1951–2000) and two future periods of 2001–2050 and 2051–2100. Results indicate, with the exception of high latitude regions, a marked increase in drought condition across Europe especially in the second half of 21st century. Patterns, however, vary substantially depending on the model, emission scenario, region and season. While the variance introduced by choice of carbon cycle model is of minor importance, contribution of emission scenario becomes more important in the second half of the century; nevertheless, GCM uncertainty remains the dominant source throughout the 21st century and across all regions.

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