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Modelling global water stress at the monthly time-scale

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It is estimated that currently over one billion people have problems obtaining access to sufficient freshwater resources, while due to population growth and climate change the number of people affected by water scarcity and water stress will rise to four billion by 2050 (UNEP, 1999). To assess current water stress and it development under different socio-ecomomic and climate scenario's Global Hydrological Models (GHMs) are important tools. Until now, GHM-analyses calculating water demand and water availability have been performed on yearly totals only. However, it can be expected that availability of water is often out of phase with water demand and that actual water stress may be underestimated using yearly totals. Also, yearly budgets cannot shed light on the persistence and recurrence time of water stress. In this paper we present an analysis of global water stress based on monthly data of water availability and water demand. Here, severe water stress is defined to occur in case local water demand exceeds 40 percent of the local water availability A 40-year time series of water availibility is obtained by the GHM PCR-GLOBWB forced with CRU meteorological data downscaled to daily time steps using the ERA40 reanalysis dataset. Thus, apart from representing a within-year regime, the water availability analyses also consider between-year climate variability. Availability calculations contain both local precipitation surplus (precipitation minus evaporation), but also upstream river discharge, water in reservoirs, groundwater abstraction as well as green water (soil water used by irrigated crops). Water demand is calculated on a monthly basis for the year 2000, while these monthly values are taken constant over the years. It consists of water demand for agriculture (both rainfed as well as irrigated and lifestock), industry and domestic water use. Domestic water demand as well as the recycling fraction of industrial and domestic water demand for each country are related to its development stage. In our calculations, water demand interacts with water availability in two ways. Irrigation water demand depends on the transpiration deficit as calculated with PCR-GLOBWB, while water availability from upstream river discharge is corrected for upstream blue water demand. Results show that calculations of global water stress based on montly analyses result in more regions that experience severe water stress. This indeed suggests that analyses based on yearly average water availability and demand underestimate global water stress. Analyses of water stress persistence and recurrence time reveal areas where prolonged periods of water stress occur (e.g. North India) as well as areas where the average water stress is low, but ocassionaly short periods of severe water stress are possible (e.g. South-East England).