Geophysical Research Abstracts
Vol. 13, EGU2011-1635, 2011
EGU General Assembly 2011

Modelling global water stress of the recent past: on the relative importance of trends in water demand and climate variability

Yoshihide Wada (1), L.P.H. (Rens) Van Beek (1), Marc F.P. Bierkens (1,2)

(1) Utrecht University, Physical Geography, Utrecht, Netherlands (m.bierkens@geo.uu.nl), (2) Deltares, Unit Soil and Groundwater Systems, Utrecht, Netherlands

Water scarcity, caused by an existing regional imbalance of water availability and water demand, poses a serious environmental issue to the global society. Since the late 1990s, several studies have quantified blue water stress at the global scale by confronting water demand with blue water availability (i.e. surface freshwater in rivers, lakes and reservoirs) simulated with a global hydrological model. While these assessments have identified regions suffering from current water stress and vulnerable to future water scarcity due to the effects of the climate change and prone to frequent droughts (e.g., Australia, Central and West USA, India, North-East China, Pakistan), the development of past water stress as a result of population and economic growth and expanding irrigated area has not yet been quantified. Yet insight into the most important causes of past water stress may provide important clues for the correct projection of future water stress. Here, we develop a method to reconstruct past water demand from the agricultural (i.e. irrigation and livestock), industrial and domestic (i.e. households and municipalities) sectors over the period 1960 to 2001. Trends in past water demand and their effect on trends in water stress are subsequently contrasted against variations in water stress due to climate variability.

Agricultural water demand is estimated based on past extents of irrigated area and livestock densities. We develop a simple algorithm to approximate past economic development based on GDP, energy and household consumption and electricity production, which is subsequently used together with population numbers to estimate industrial and domestic water demand. Desalinated water use and groundwater abstraction are additionally calculated over the same period, the latter being proportional to water demand in excess of blue water availability. We use mostly annual country statistics but results are spatially disaggregated to a spatial resolution of 0.5° and a temporal resolution of one month as 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. Climate variability is expressed by monthly blue water availability simulated by the global hydrological model PCR-GLOBWB coupled with a prospective reservoir operation scheme at a spatial resolution of 0.5°.

Comparisons of estimates of irrigation, industrial and domestic water demand with reported consumptive water use (e.g., FAO AQUASTAT) show generally good agreements from 1960 to 2000 ($R2>0.95$ and $0.9<\alpha<1.1$). We estimate that during this period the amount of global (gross/net) water demand has more than doubled from 1708/818 to 3708/1832 km3/yr while the number of people exposed to severe water stress (i.e. water scarcity index>0.4) tripled from 0.5 to 1.8 billion (17 to 30%) of the global population. Time series of country averaged water stress reveal that growing water demand enhanced the intensity of water stress up to 200% while climate variability is often a main determinant for extreme events (i.e. droughts). However, our results also suggest that in several countries (e.g., India, China, Mexico) some of the past observed droughts were mostly anthropogenically driven due to increased water demand