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Robustness and uncertainties in global water scarcity projections

Martina Floerke (1), Stephanie Eisner (1), Naota Hanasaki (2), and Yoshihide Wada (3)

(1) Center for Environmental Systems Research, University of Kassel, Kassel, Germany (floerke@usf.uni-kassel.de), (2) National Institute for Environmental Studies, Tsukuba, Japan, (3) Department of Physical Geography, Utrecht University, Utrecht, Netherlands

Water scarcity is both a natural and human-made phenomenon and defined as the condition where there are insufficient water resources to satisfy long-term average requirements. Many regions of the world are affected by this chronic imbalance between renewable water resources and water demand leading to depletion of surface water and groundwater stocks. Total freshwater abstraction today amounts to 3856 km^3 of which 70% are withdrawn by the agricultural sector, followed by the industry (19%) and domestic sectors (11%) (FAO 2010). Population growth and consumption change have led to threefold increase in total water withdrawals in the last 60 years through a rising demand for electricity, industrial and agricultural products, and thus for water (Flörke et al. 2013). The newly developed "Shared Socio-Economic Pathways" (SSPs) project global population to increase up to 7.2 or even 14 billion people by 2100 (O'Neill et al. 2012); and meeting future water demand in sufficient quantity and quality is seen as one of the key challenges of the 21st century.

So far, the assessment of regional and global water-scarcity patterns mostly focused on climate change impacts by driving global hydrological models with climate projections from different GCMs while little emphasis has been put on the water demand side. Changes in future water scarcity, however, are found to be mainly driven by changes in water withdrawals (Alcamo et al. 2007, Hanasaki et al. 2012), i.e. sensitivity to climate change outweighs exposure. Likewise, uncertainties have mainly been assessed in relation to the spread among climate scenarios and from global hydrological models (GHMs) (Haddeland et al. 2011, 2013; Schewe et al. 2013, Wada et al. 2013) while the contribution of water use modelling related to total uncertainty remains largely unstudied.

The main objective of this study is to address the main uncertainties related to both climate and socio-economic impacts on global and regional water scarcity, and to provide robust and consistent conclusions to be used for decision making. The analysis is based on an ensemble of hydrological and water demand projections for the 21st century as simulated by three state-of-the-art global hydrological and water use models forced by climate projections of five global circulation models and socio-economic drivers corresponding to SSP2.

The GHM-ensemble shows reasonable agreement in projected domestic and irrigation water withdrawals whilst there is a large discrepancy between the projections of industrial water withdrawals which translates into considerable uncertainty in temporal and spatial water-scarcity patterns. Consequently, impact assessments need to consider water demand as an additional dimension of uncertainty to assess both exposure and sensitivity to climate change.