Future irrigation water demand under climate change: regional variability and uncertainties arising from GHMs and CMIP5 climate projections

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1. INTRODUCTION

The irrigation sector uses by far the largest amount of water and is responsible for 70% of the global water demand. At a country scale, irrigation water demand often exceeds 90% of the total water demand in many of developing countries such as India, China, Pakistan, where irrigation sustains much of food production and the livelihood of millions of people. The global area of irrigated land is not expected to expand dramatically in the coming decades. Future irrigation water demand is, however, subject to large uncertainties due to anticipated climate change, i.e. warming temperature and changing precipitation variability, in various regions of the world.

2. METHODS – MODEL and DATA

We employed a set of seven global hydrological models (GHMs) to quantify the impact of climate change on regional irrigation water demand, and the resulting uncertainties arising from newly available CMIP5 climate projections in the framework of the Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP; http://www.isi-mip.org/).

GHMs used:
H08, LPJmL, MPI-HM, PCR-GLOBWB, VIC, WaterGAP, WBM (all at a 0.5 degree grid or ≈50km by ≈50km at the equator)

RCPs used: RCP2.6, RCP4.5, RCP6.0, RCP8.5

GCMs used:
HadGEM2-ES, IPSL-CM5A-LR, GFDL-ESM2M, MIROC-ESM-CHEM, NorESM1-M

Output used: Potential irrigation water demand
Simulation period: 1971-2099 (Irrigated areas remain constant)

3. RESULTS

The relative contribution of each source (GHMs, GCMs, RCPs) of uncertainty (fractional uncertainty; %) in irrigation water demand projections over the period 2005-2100, relative to the period 1971–2005.

- Global irrigation water demand increased by ~6% by 2050 and ~10% by 2100 respectively primarily due to higher evaporative demand as a result of increased temperature (ensemble mean).
- Regional irrigation water demand decreased over some parts of Europe and Southeast Asia, but increased over South Asia, the U.S., the Middle East and Africa.
- The global and regional projections are highly uncertain over many parts of the world.
- The ensemble projections among the different GHMs, GCMs, and RCPs vary between -30% and +35% for India, between -25% and +28 for the U.S., between -20% and +28% for Mexico, between -22% and +26% for Pakistan, and between -22% and +24% for China.
- The model uncertainty among the different GHMs dominates the uncertainty in the irrigation water demand projections by ~2025. However, afterwards the uncertainty of the climate projections, or specifically in the precipitation projections derived from different RCPs from different GCMs, substantially increases. Thus, the dominant sources of the uncertainty lie both in the GHMs and in the climate projections.

4. CONCLUSIONS

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