Human water consumption intensifies hydrological drought worldwide

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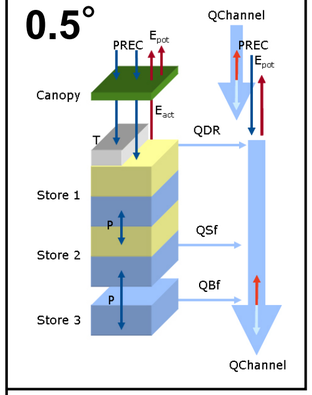
1. INTRODUCTION

Over the past decades, human water consumption has more than doubled, primarily due to a large increase in irrigation water demand, and substantially reduced streamflow or river discharge over various regions of the world.
However, it remains unclear whether human water consumption has caused any intensification of hydrological droughts. The objective of this study is, therefore, to investigates the influence of human water consumption on resulting hydrological droughts worldwide.

2. METHODS – MODEL and DATA

PCR-GLOBWB

0.5°



We simulated streamflow by the global hydrological model PCR-GLOBWB at a half degree spatial resolution, i.e. 50 km by 50 km at the equator, over the period 1960-2010. The model was forced with temperature, reference evapotranspiration, and precipitation, which were taken from CRU and ERA-40 (1960-2000) and ERA-Interim (2001-2010).

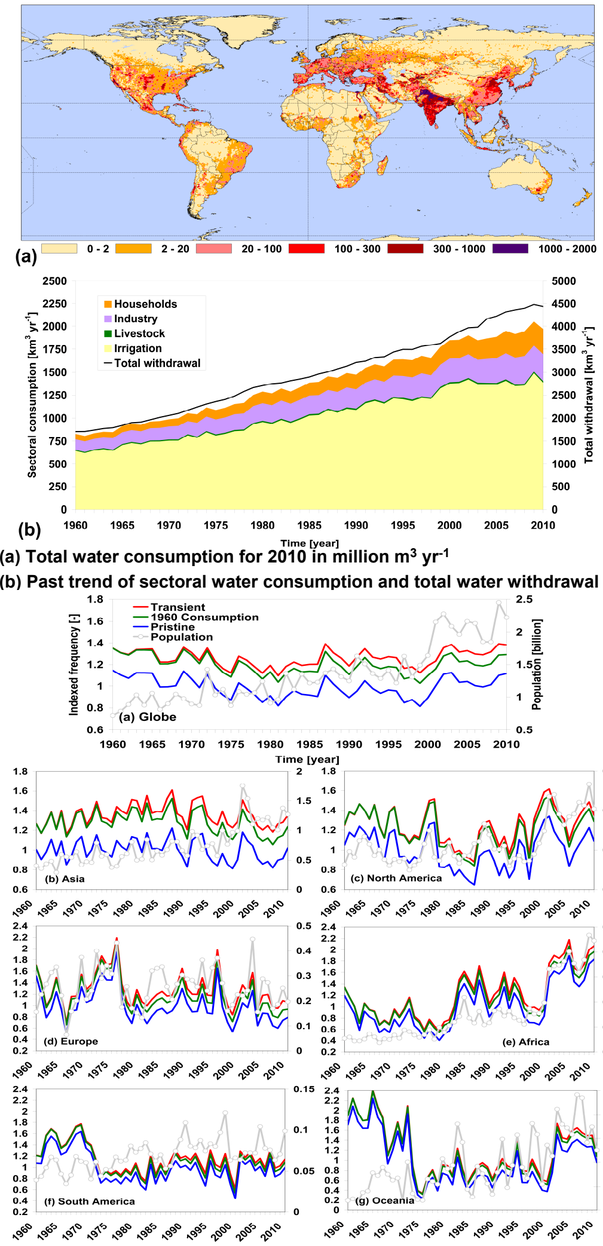
We reduced the amount of streamflow with different levels of estimated human water consumption over the period 1960 -2010:

1. Pristine or no human water consumption
2. 1960 human water consumption
3. Transient human water consumption 1960-2010

We applied the commonly used variable threshold level method with Q_{80} to identify below-normal water availability as the onset of hydrological droughts. We then standardized the deficit volume dividing by the threshold level to express the relative intensity of drought conditions to normal streamflow conditions.

$$SDfv_{i,m} = \frac{\max(0, Q_{80i,m} - RivDis_{i,m})}{Q_{80i,m}}$$

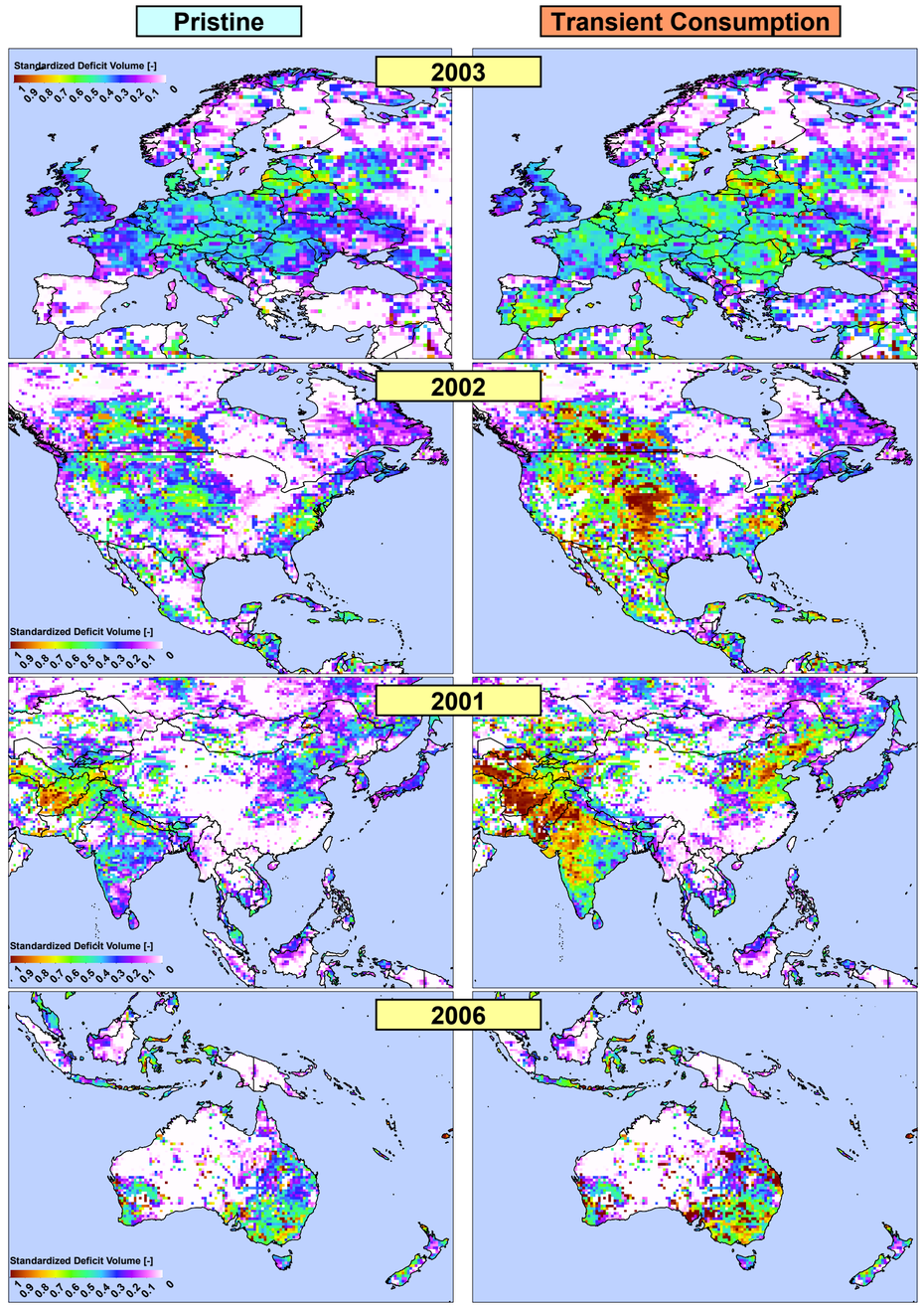
3. RESULTS



(a) Total water consumption for 2010 in million m³ yr⁻¹

(b) Past trend of sectoral water consumption and total water withdrawal

Drought frequency with pristine, 1960 consumption, and transient consumption over the period 1960-2010. Population under 80% of normal streamflow condition, i.e. standardized deficit volume≥0.2, is plotted per year in billion based on transient consumption.



4. CONCLUSIONS

- Human water consumption intensified hydrological droughts substantially by 10-500% depending on regions. Irrigation is mostly responsible for the intensification.
- With human water consumption, global drought frequency increased by more than 27%.
- Global population under severe hydrological droughts increased from 0.7 billion in 1960 to 2.2 billion in 2010 due to rapid population growth and increased population density.

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