1. Research Aims

We aim to improve our understanding of anthropogenic influences on the global hydrological system, specifically river discharge and land surface evapotranspiration. Therefore we investigate two anthropogenic influences on the global hydrological system: land cover change and climate change. Using experiments with the global hydrological model PCR-GLOBWB we assess the separate and combined effects of both land cover and climate change. Furthermore, we compare the effects of land cover change to the effects of water abstraction and irrigation.

Attributing changes in the global hydrological system to land cover change, climate change, and water abstraction and irrigation, will improve projections of future changes in water abundance and scarcity.

2. Model Set-up & Input

PCR-GLOBWB experiments

The PCRaster Global Water Balance model simulates water storage in two vertically stacked soil layers and an underlying soil layer, as well as water exchange between the layers and between the top layer and the atmosphere. Here, we use a resolution of 30 arcmin, roughly 50x50km for more detail, see e.g. van Beek (2011, Wada 2014). Experiments are summarised in Table 1, methods and inputs are further explained below.

The first four experiments are used to compare the effect of climate (FIX 1850-1879 vs 1976-2005) as well as land cover change (TRANS vs FIX). The last three experiments allow us to compare the effect of land cover change (LC2000 vs LC1850) to that of water abstraction and irrigation (HUM2000 vs LC2000).

We use fractional crop and pasture cover from the harmonized land use data, while pasture and natural vegetation derives from GLCC. We place by crops.

3. Results

3.1 Climate (1976-2005 vs 1850-1879)

Precipitation dominates discharge changes for both FIX and TRANS experiments. For climate only (FIX, evapotranspiration [ET]) changes play a minor role and are sometimes of opposite sign than the imposed change in potential reference ET. Differences between the means of 1976-2005 and 1850-1879 are shown. Based on CMIP5 historical forcings.

3.2 Land cover (2000 vs 1850, %)

Changing landcover from 1850 to 2000 (LC2000 vs LC1850) has a bigger impact on discharge and ET than including irrigation and water demand (LC2000 vs HUM2000). The latter mainly causes decreased discharge through abstraction and increased ET through irrigation. Land cover change affects discharge through ET, such as lower ET and higher discharge where forest is replaced by crops.

4. Discussion, conclusions and outlook

Climate vs. land cover (FIX vs. TRANS)

Precipitation dominates discharge changes for both FIX and TRANS experiments. For climate only (FIX, evapotranspiration [ET]) changes play a minor role and are sometimes of opposite sign than the imposed change in potential reference ET. Including land cover change (TRANS) leads to discharge changes of the same sign as in FIX, but the impact of climate is strengthened or weakened through a large impact on ET.

Land cover vs. irrigation and abstraction (LC vs. HUM)

Changing landcover from 1850 to 2000 (LC2000 vs LC1850) has a bigger impact on discharge and ET than including irrigation and water demand (LC2000 vs HUM2000). The latter mainly causes decreased discharge through abstraction and increased ET through irrigation. Land cover change affects discharge through ET, such as lower ET and higher discharge where forest is replaced by crops.

Future we next step is to extend the historical period shown here (for FIX and TRANS) towards future scenarios RCP2 and 8.5, as well as to include anthropogenic impacts (irrigation, water demand etc) in those experiments. Furthermore, besides annual mean changes as shown here, we can investigate seasonal changes, look at separate ET fluxes (transpiration, bare soil or interception evaporation), examine discharge variability, compare discharge to observations (e.g. GRDC), and much more!!

References

De Roo, A. et al. (2014). Hydrology and Earth System Sciences, 18 (12), 5025-5040
Hagem, J. et al. (2013). Earth System Dynamics, 4, 219-236
van Beek, R. et al. (2011). Water Resources Research, 47 (7)
Wada, Y. et al. (2014). Earth System Dynamics, 5, 1-19