Decrease in water availability in High Asia not likely in the coming decades

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Background

Rivers originating in the high mountains of Asia are among the most melt water dependent river systems on Earth, yet large human populations depend on their resources downstream. Across High Asia's river basins, there is large variation in the contribution of glacier and snow melt to total runoff, which is poorly quantified. The lack of understanding of the hydrological regimes of High Asia's rivers is one of the main sources of uncertainty in assessing the regional hydrological impacts of climate change.

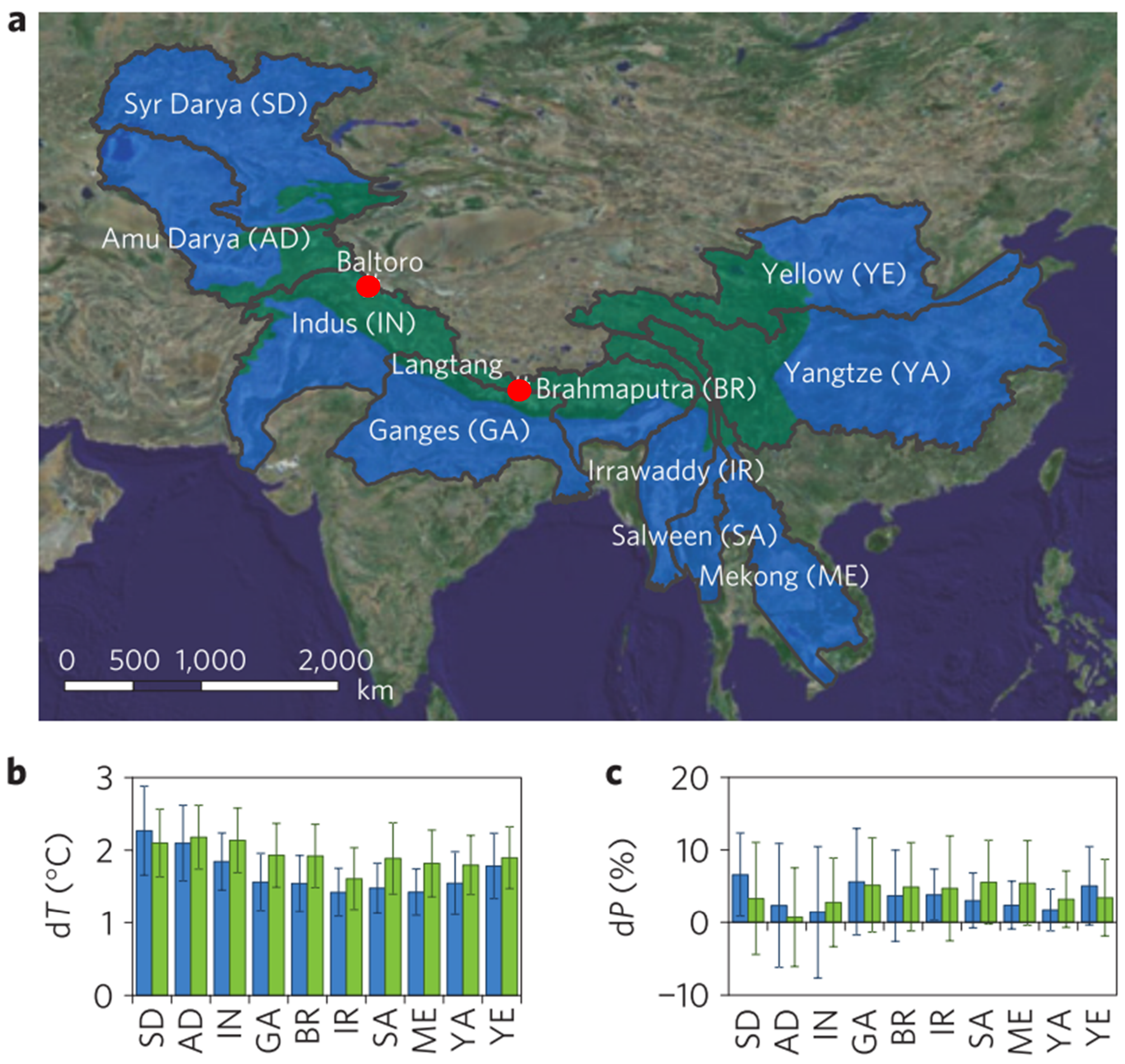

Fig 1: Overview of main Asian river basins (**a**) and their projected changes in temperature (**b**) and precipitation (**c**) for 2021-2050 relative to 1961-1990 for RCP4.5. The red dots show the locations of the glacierized watersheds of the Langtang and the Baltoro.

Streamflow contributions

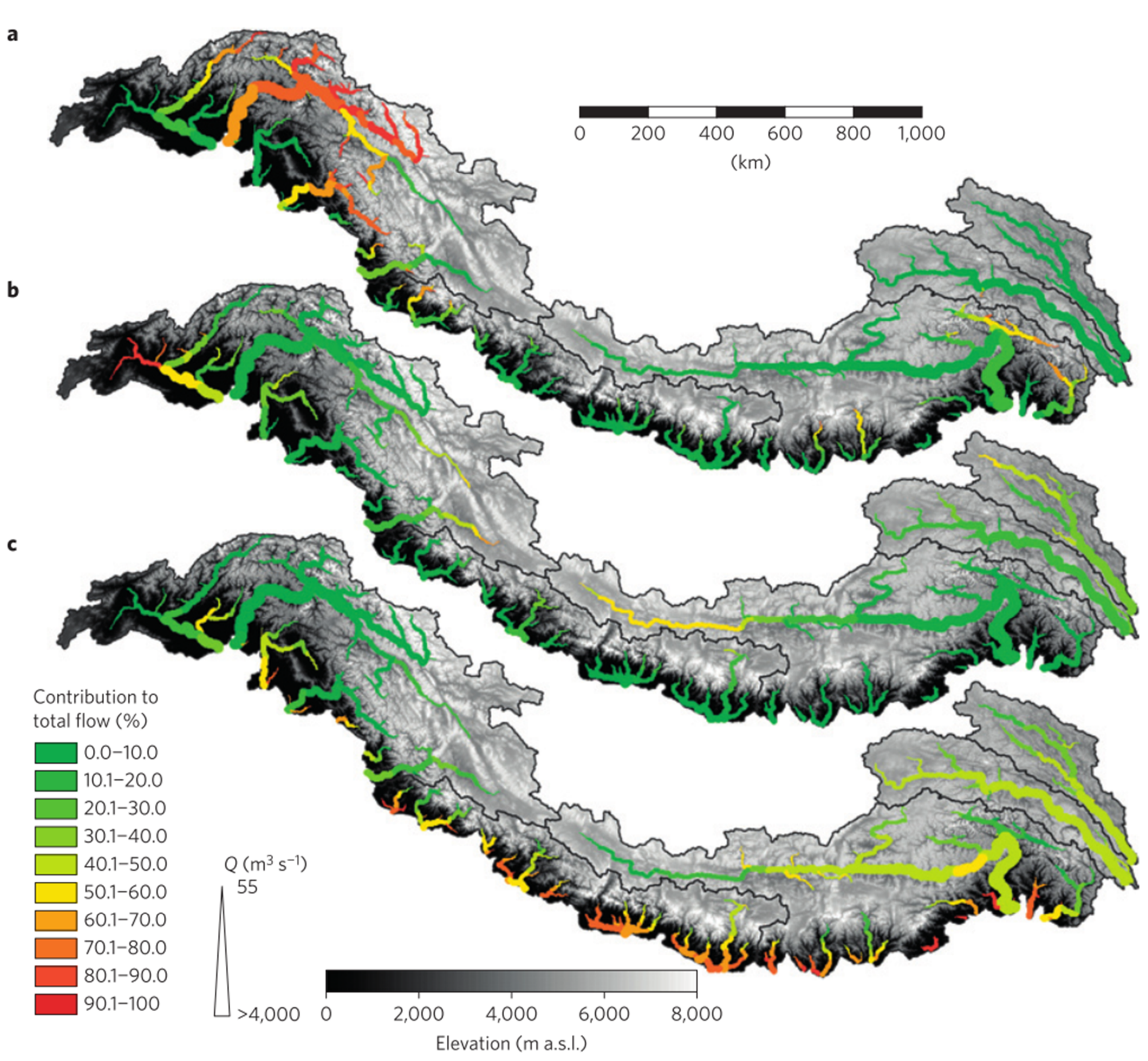

Fig 2. Contribution to total flow by glacier melt (**a**), snow melt (**b**) and rainfall runoff (**c**) for major streams during 1998–2007.

Approach

Contrasting hydrological regimes are quantified at two different scales in contrasting climates in Asia:

- Small scale high altitude glacierized catchments (Baltoro, Langtang)
- Large scale upstream river basins (Indus, Ganges, Brahmaputra, Salween, Mekong)

Subsequently the hydrological impact of climate change is analyzed at both spatial scales using the latest climate model output: ensembles of downscaled CMIP5 GCM runs covering the entire range of temperature and precipitation projections for RCP4.5 and RCP8.5.

Conceptually different glacio-hydrological models are used at catchment and basin scale. At the catchment scale a highly detailed glacio-hydrological model [Immerzeel et al. 2011] is used, whereas at the basin scale the SPHY-model [Terink et al. 2014] is used. The largest difference is the spatial resolution (90 m versus 1 km) and the fact that at the catchment scale glacier dynamics are explicitly included, whereas at the large scale future retreat is parameterized [Lutz et al. 2013].

Future Hydrology

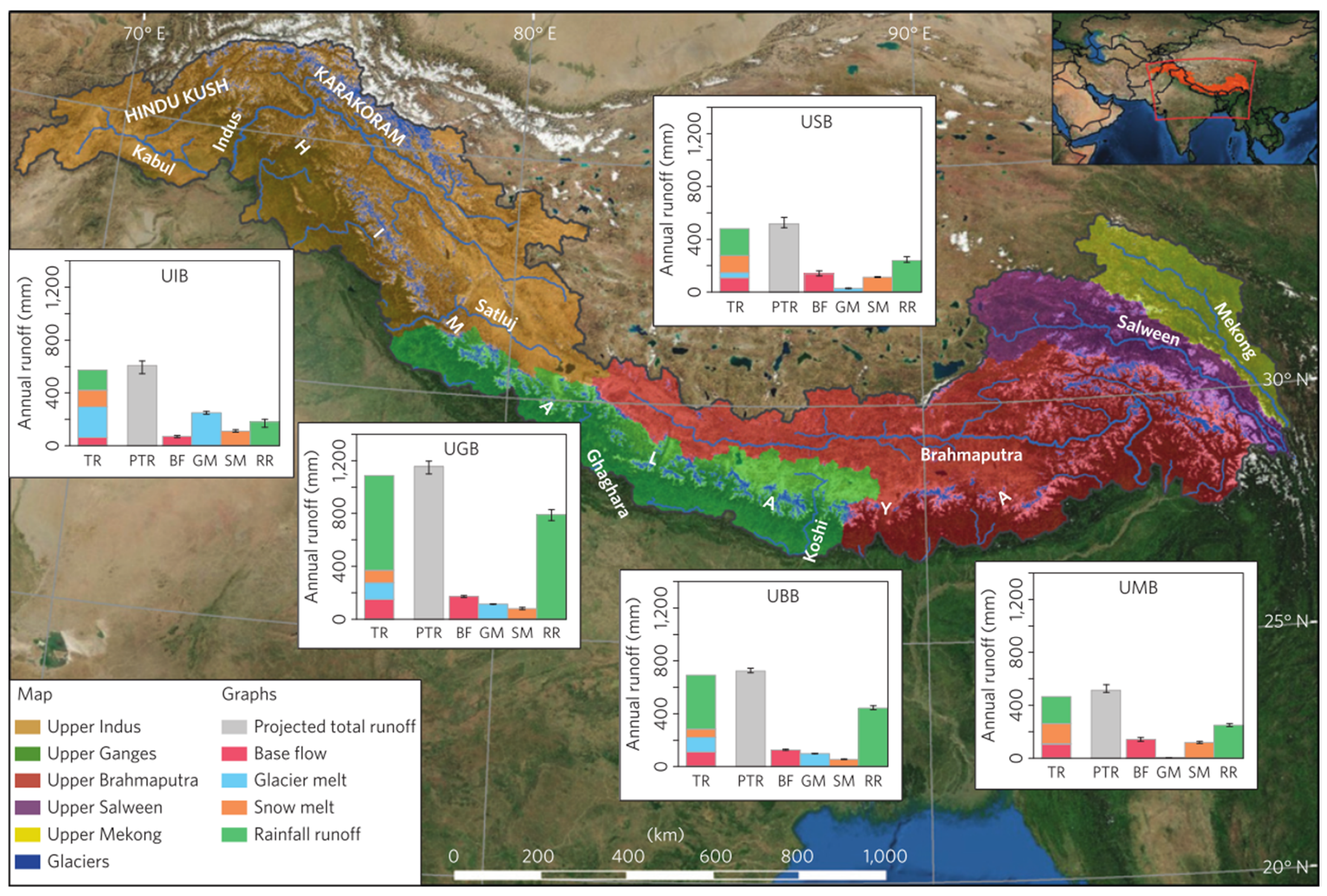

Fig 3: Bar plots show the average annual runoff generation (TR) for the reference period (1998–2007). The second column shows the mean projected annual total runoff (PTR) for the future (2041–2050 RCP4.5). In the subsequent columns, PTR is split into four contributors. Error bars indicate the spread in model outputs for the model forced by an ensemble of 4 GCMs.

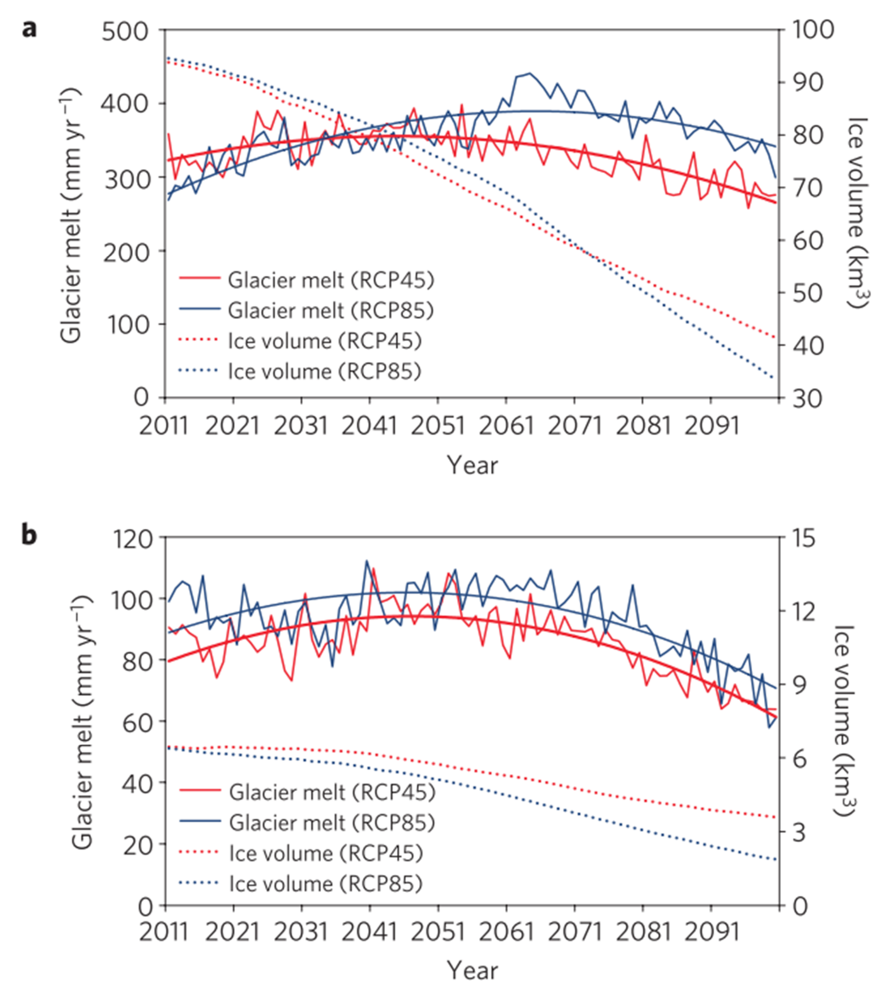

Fig 4: Future melt and ice volumes in the small scale catchments, Baltoro (**a**) and Langtang (**b**) for RCP4.5 (red) and RCP8.5 (blue).

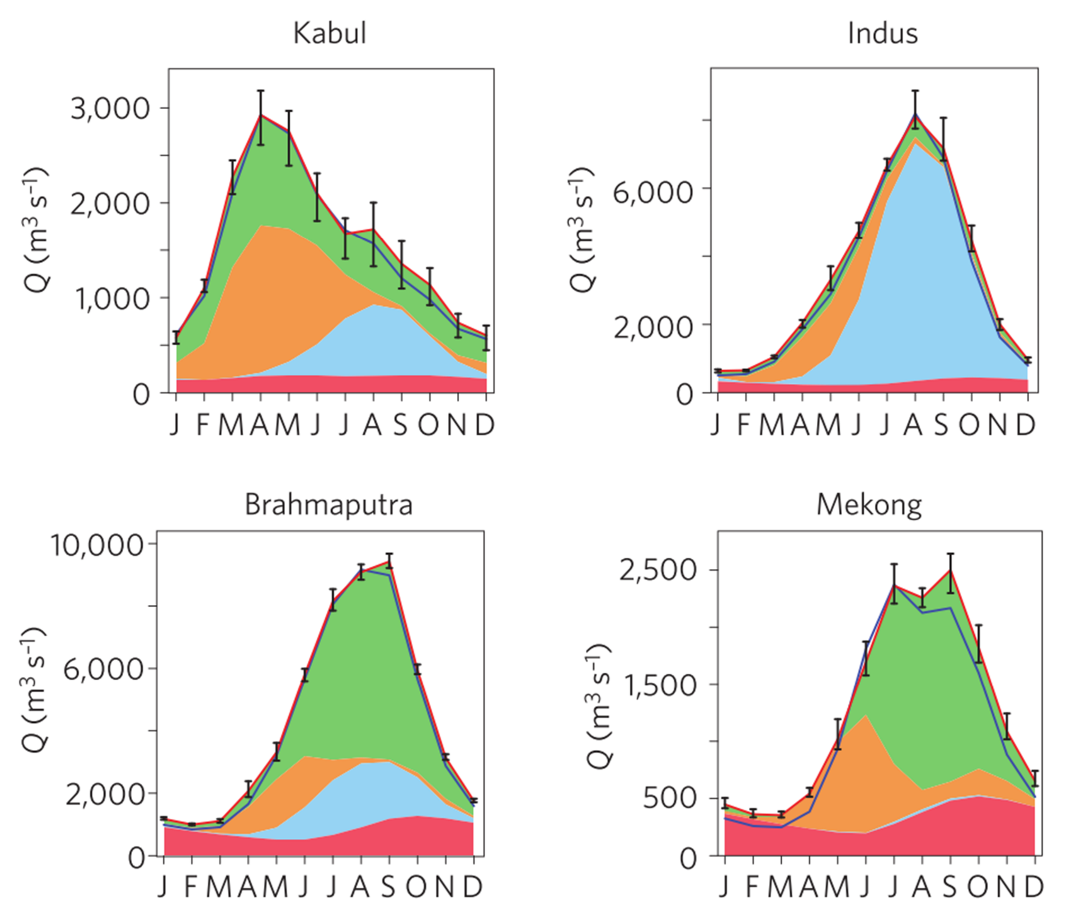

Fig 5: Average annual hydrographs for 2041–2050 (RCP4.5) at major rivers' outlets from the upstream basins. Plots show the mean projected discharge for the future (red line) and the discharge for the reference period (1998–2007, blue line). Colors indicate the stream flow composition. The error bars indicate the spread in projections for the future period when forced with an ensemble of 4 GCMs.

Conclusions

Despite the conceptual differences the conclusions are remarkably similar for both scales:

- The average annual runoff will increase in the coming decades as a result of projected increases in precipitation in combination with sustained higher glacier melt.
- The challenge for the future is coping with intra-annual shifts in the water balance and a possible increase of extreme events.

Publications

- Lutz, A. F. et al., **2014**. Consistent increase in High Asia's runoff due to increasing glacier melt and precipitation. *Nature Climate Change.*
- Immerzeel, W. W. et al., **2013**. Rising river flows throughout the twenty-first century in two Himalayan glacierized watersheds. *Nature Geoscience.*
- Lutz, A. F. et al., **2013**. Comparison of climate change signals in CMIP3 and CMIP5 multi-model ensembles and implications for Central Asian glaciers. *Hydrology and Earth System Sciences.*
- Immerzeel, W. W. et al., **2011**. Hydrological response to climate change in a glacierized catchment in the Himalayas. *Climatic Change.*
- Terink, W. et al., **2014**. SPHY v2.0: Spatial Processes in Hydrology. *Geoscientific Model Development* (in preparation).

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