AGU PUBLICATIONS

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Supporting Information for

Irrigation as a potential driver for anomalous glacier behaviour in High Mountain Asia

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WRF settings

We used the following modules for representing the physics and dynamics in WRF.

Table S1: Physics modules and assumptions used in WRF.

Radiation	RRTMG scheme (Iacono et al., 2008)
Microphysics	Morrison scheme (Morrison et al., 2009)
Cumulus	Kain-Fritsch (new Eta) scheme (Kain, 2004)
Planetary boundary layer	YSU scheme (Hong et al., 2006)
Atmospheric surface layer	MM5 Monin-Obukhov scheme (Beljaars, 1995; Dyer & Hicks, 1970; Paulson, 1970; Webb, 1970; Zhang & Anthes, 1982)
Land surface	Noah-MP (Niu et al., 2011)
Top boundary condition	Rayleigh damping
Diffusion	Calculated in physical space

Text S1. Irrigation patterns

Figures S1 and S2 show the amounts of water applied for the 2000 irrigation scenario for summer and winter, respectively. Furthermore, the increase of irrigated amounts of the 2010 scenario with respect to the 2000 scenario are shown, indicating large increases in Myanmar, North-India, Lower Indus basin, and Tarim basin, but also some decreasing irrigation intensity in some areas, such as parts Upper Indus basin, and Fergana valley (Uzbekistan) in summer. For the ΔHIST case, we ran WRF with the 2010 irrigation and with no irrigation, whereas for the ΔDEC case, we ran WRF with the 2010 irrigation and the 2000 irrigation.

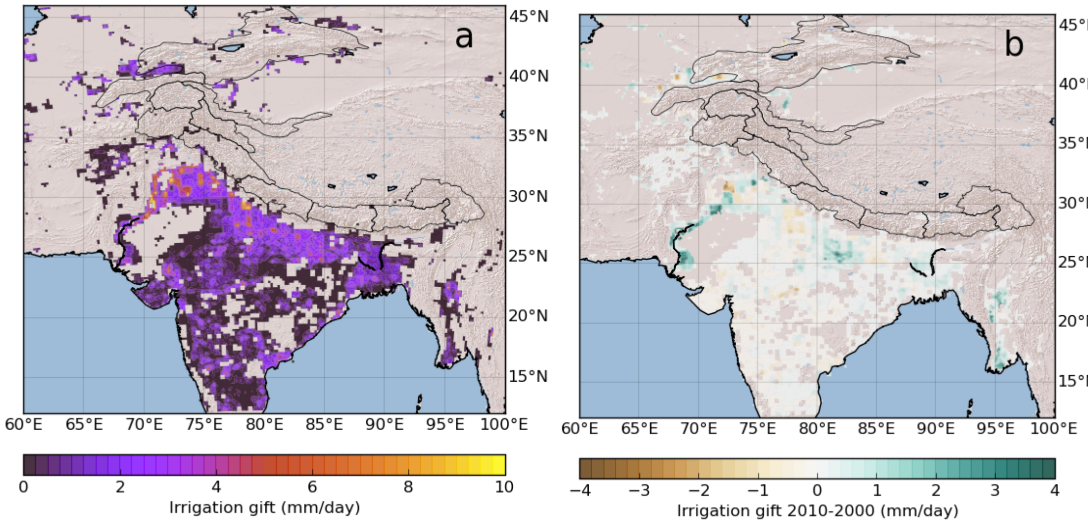


Figure S1. Summer irrigation gifts in the WRF model. The amount of water added to the surface for the summer WRF simulations for the year 2000 (a), and the difference in irrigation between the years 2010 and 2000 (b).

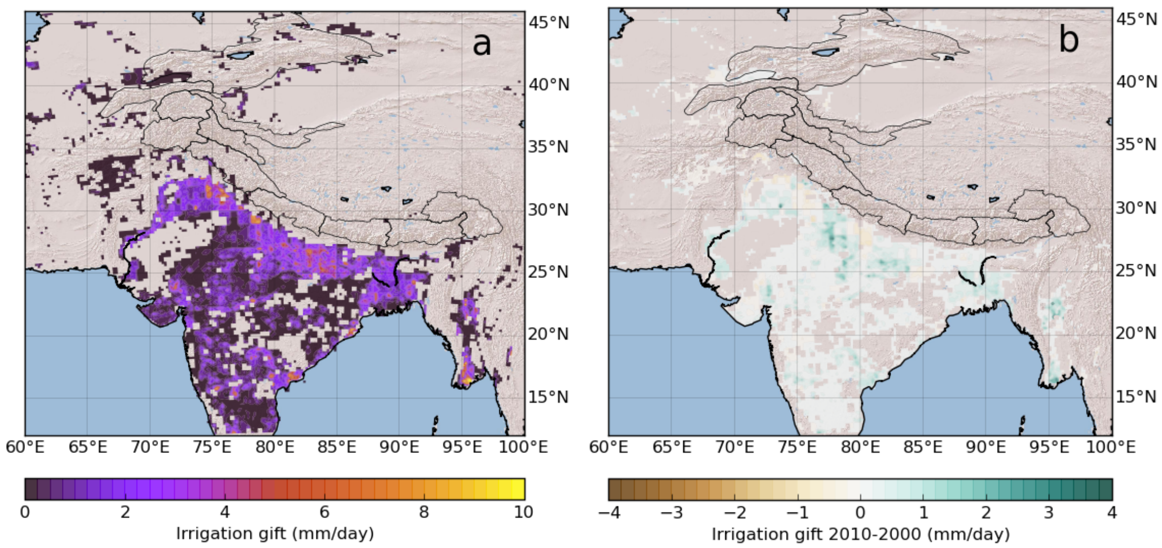


Figure S2. Winter irrigation gifts in the WRF model. The amount of water added to the surface for the winter WRF simulations for the year 2000 (a), and the difference in irrigation between the years 2010 and 2000 (b).

Text S2. Separate effects of irrigation and greenhouse gas concentrations

We have also performed separate tests that only change the irrigation amounts or only the greenhouse concentrations. Fig. S3 shows these results for the changes corresponding to the ΔHIST case. It is clear that the combined results in Fig. 3 is dominated by the irrigation changes, not the greenhouse gas concentration changes.

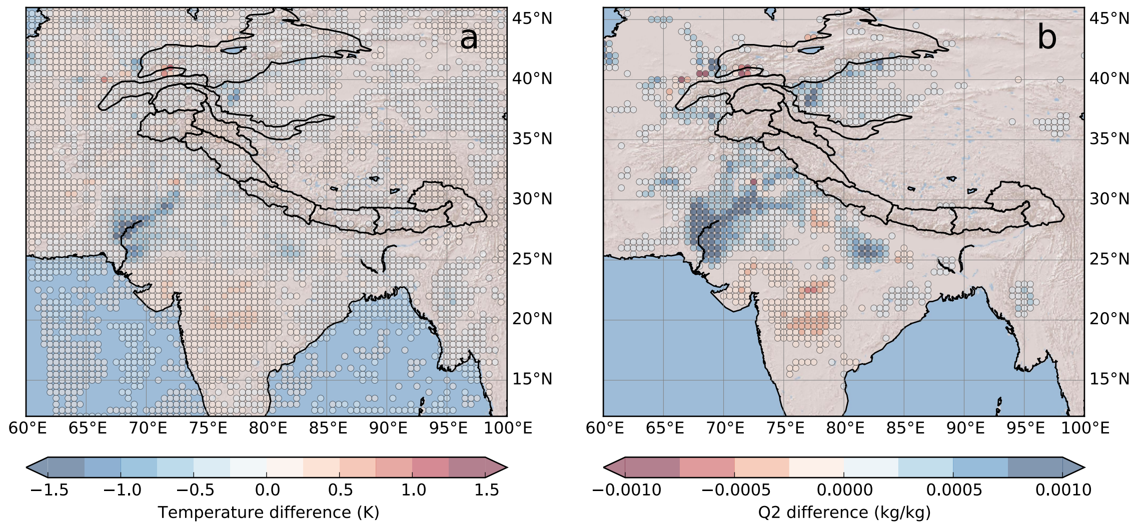


Figure S3. As Fig. 1, but with for the ∆DEC case

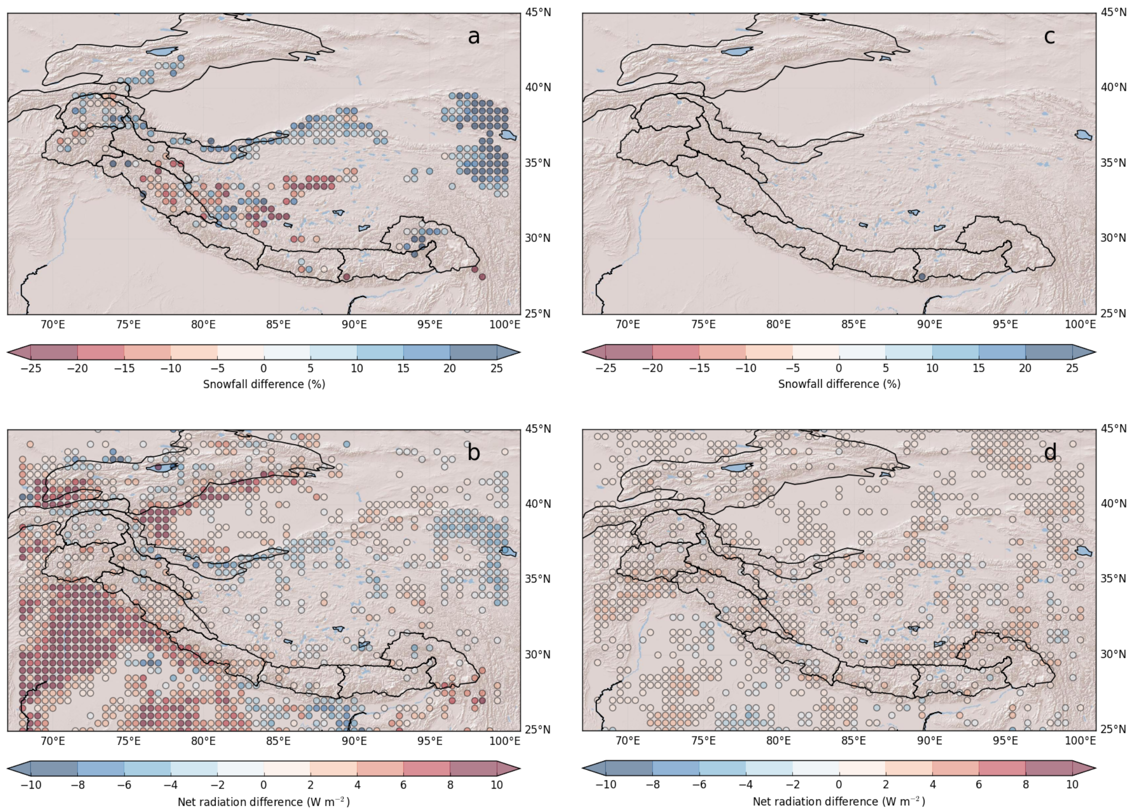


Figure S4. As Fig. 3, but with changing only the irrigation amounts (a and b), and changing only the greenhouse gas concentrations (c and d).

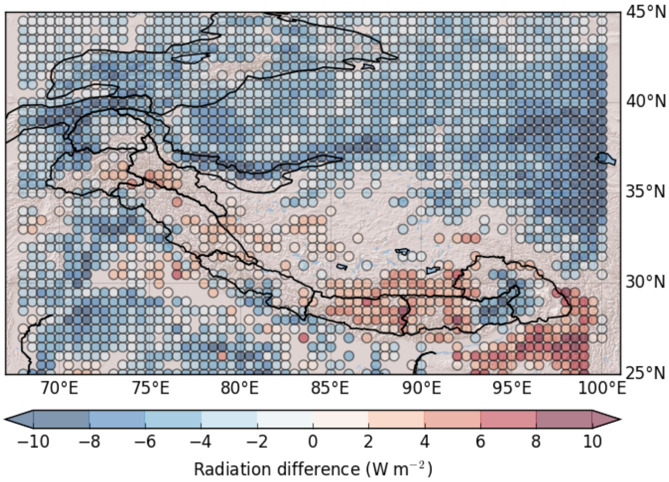
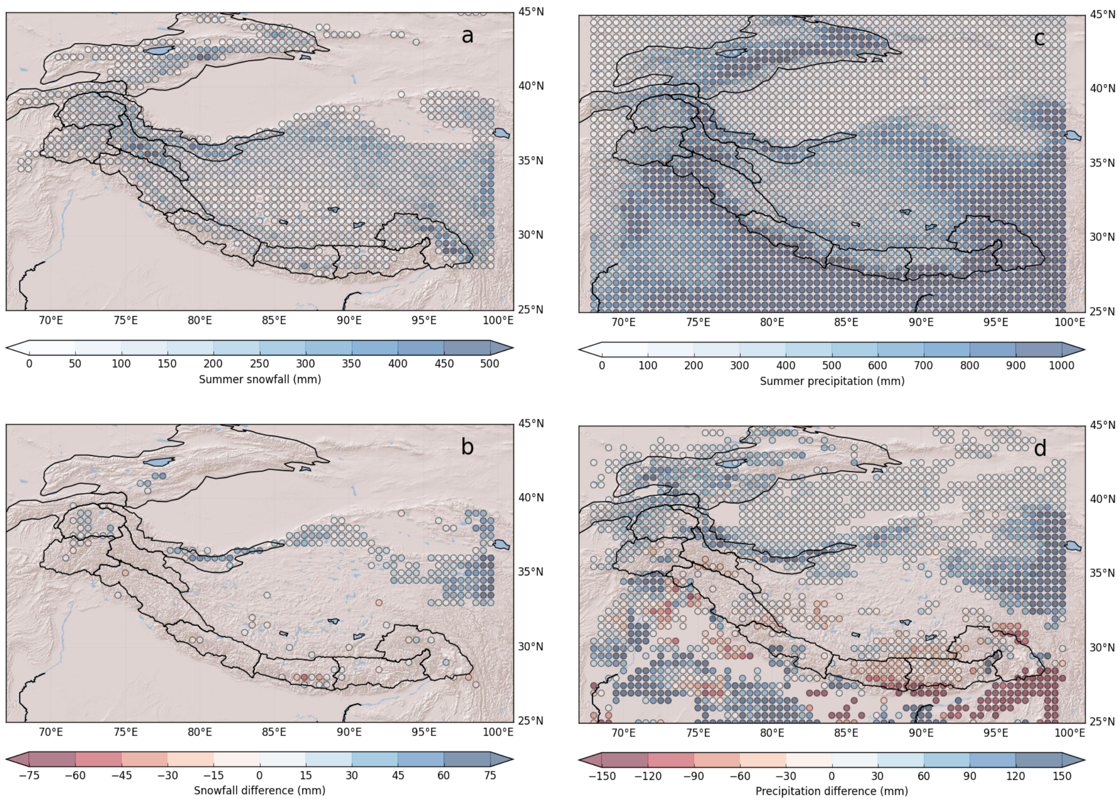


Figure S5. The changes in the downward shortwave radiation component of the surface radiation budget for the ∆HIST case. Only 0.5°x0.5° bins are shown where P<0.01, including field significance.

Snowfall and total precipitation



c

Figure S6. The mean summer snowfall (a) and mean summer precipitation (c), and their changes for the ∆HIST case (b and d). For the total snowfall and precipitation, only 0.5°x0.5° bins are shown where values are larger than 10 mm. For the changes, only 0.5°x0.5° bins are shown where P<0.01, including field significance.

Text S3. Effect of irrigation on middle tropospheric dynamics

Changes in temperature and humidity at the surface can also cause changes in the large-scale circulation at higher altitudes. Indeed, we see differences in the wind fields and geopotential heights in the middle troposphere when irrigation is increased. Fig. S7 show that an increase of irrigation causes a lowering of the geopotential height and associated increase of cyclonic motion over north-west HMA at 400 hPa, just above the mountain tops, in summer. For the ΔHIST case, the scale of this difference is almost as large as the entire model domain, and so interactions with the dynamics outside the domain might shift this structure. However, qualitatively, these results are very similar to previous irrigation simulations (Lee et al., 2011), as well as observations (Forsythe et al., 2017; Yang et al., 2016). Simulations where only the GHG concentrations are increased show a weaker trend over north-west HMA, and in the opposite direction (anticyclonic). Hence, we confirm here that irrigation indirectly affects the large-scale circulation, also at higher altitudes.

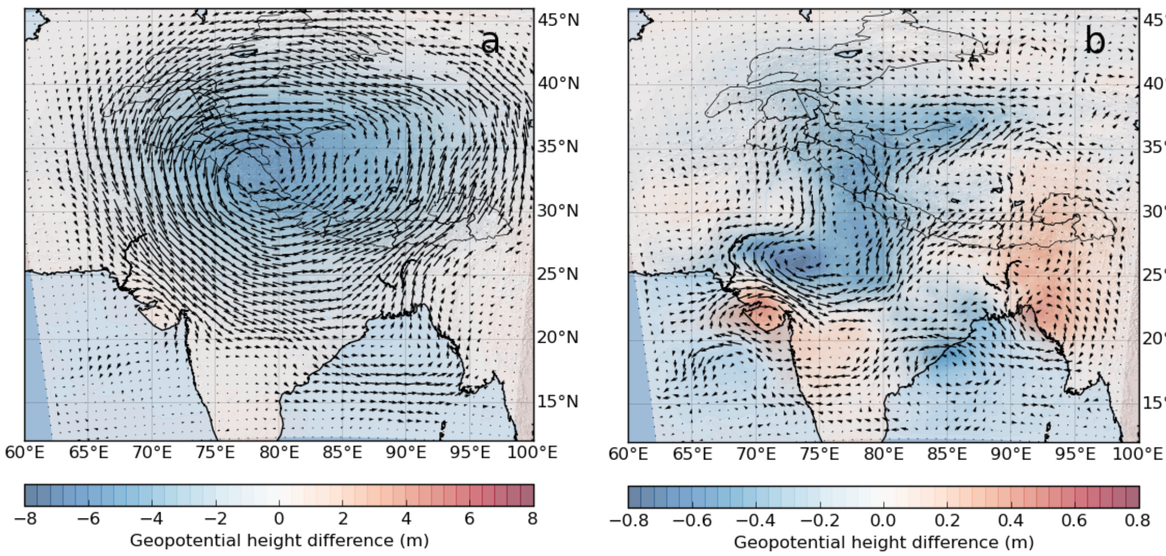


Figure S7. Summer geopotential height and wind differences at 400 hPa for the ΔHIST case (a) and the ΔDEC case (b).