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Surface energy budget constraints on future global precipitation revisited

Richard Bintanja and Frank M. Selten
Royal Netherlands Meteorological Institute, Weather and Climate modelling, De Bilt, Netherlands (selten@knmi.nl)

Observations and climate model simulations both show that global mean precipitation (which equals surface evaporation) will increase with climate warming, but at a much lower rate than the atmospheric water content. This muted response has been attributed primarily to the nonlinear dependency of downwelling infrared radiation (which provides the energy for evaporation) on atmospheric water vapour. However, we demonstrate here that this is not a sufficient constraint. Instead, on the basis of fundamental physics we find that the redistribution of energy at the surface crucially limits changes in global evaporation (and hence precipitation). More specifically, the warming surface must re-emit about 70% of the extra energy through infrared radiation, leaving just maximum 30% for evaporation thereby explaining the muted global precipitation response. This fraction will further diminish as climate warms, meaning that precipitation increases will be even more subdued. This finding provides fundamental insights on the mechanisms behind the changing global hydrological cycle, with global and regional implications for issues such as water availability.