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Observed and simulated changes in water vapour, precipitation and the clear-sky longwave radiation budget of the surface and atmosphere

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Recent warming and moistening of the lower troposphere imply a response of the surface and atmospheric longwave radiative energy budget and hydrological cycle. Satellite observations, reanalyses and climate models are utilised to monitor fluctuations in column integrated water vapour (CWV), surface net downward clear-sky longwave radiation (SNLc) and precipitation over the period 1979-2006. Observed and simulated CWV increases in accordance with the Clausius Clapeyron equation and all datasets demonstrate a consistent increase in the longwave radiative cooling of the clear-sky atmosphere with surface warming (3-5 Wm-2K-1) partly relating to the robust increase in SNLc with CWV at the rate of 1-1.5 Wkg-1. Enhanced atmospheric longwave radiative cooling implies precipitation increases smaller than the Clausius Clapeyron rate, as reproduced by the models. However, when considering the ascending branch of the tropical circulation, using vertical motion fields from reanalyses, the satellite observations indicate a much larger precipitation response. Conversely, a rapid decline in observed precipitation over the subsiding branches of the tropical circulation since 1979, approaching 10%/decade, is larger than the corresponding decline simulated by models over the much longer time period 2000-2100. The possible reasons for this discrepancy and its relation to the surface and atmospheric energy budget are discussed.