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Current and future changes in precipitation and its extremes

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Although there is considerable risk associated with extremes of precipitation, linking climate model projections to impacts remains a challenge. In this work we seek robust responses in precipitation and water vapour fluxes simulated by climate models that are physically understandable and consistent with available observations.

The temperature dependence of precipitation variability for the present day and in the future for CMIP5 model simulations is evaluated. We find that model simulations of the present day (with realistic sea surface temperature (SST), sea ice and radiative forcings) are able to capture interannual variability in land precipitation well. Over the period 1988-2008 the observed global precipitation rises with temperature at the rate 3-4%/K while the response is smaller in the models (around 2%/K). Extreme precipitation is found to become more intense with warming in models and observations. Mid-latitude winter flooding in the UK is also analysed and linked to large-scale "Atmospheric Rivers" or "Warm Conveyor Belts" in which moisture fluxes are substantial and which may be resolved adequately by climate models. The model response in the tropics is dependent on the simulation of tropical cyclones but also small-scale convective processes which cannot be resolved by current climate models. Therefore it is unsurprising that a substantial range in responses of extreme tropical precipitation is simulated by the models.

Observations and models show a tendency for wet regions of the tropics to become wetter and dry regions of drier as temperature increases. This links to increases in moisture transport from the dry source regions to the wet regions as low-level water content increases at around 7%/K, again readily captured by models. However, models struggle to simulate the precipitation climatology in the dry regions. There is evidence that the model simulations underestimate the responses of intense precipitation to warming for the present day; it is not yet clear whether this relates to inhomogeneity in the satellite records, model deficiencies or the influence of radiative forcings which can initiate fast precipitation responses independent of changes in SST.