Observed and simulated precipitation responses in wet and dry regions

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Introduction

Using satellite and ground-based observations and CMIP5 simulations we demonstrate atmospheric moistening leading to contrasting precipitation responses in wet and dry regions and the amplification of precipitation extremes

Changes in the global water cycle

- Column integrated water vapour from SMMR and SSM/I satellite microwave instruments over ice-free oceans, ERA Interim reanalysis over remaining regions
- Surface specific humidity from HadCRUH
- Precipitation from GPCP combined satellite and gauge product
- Comparison with AMIP5 simulations (prescribed observed sea surface temperature and sea ice & realistic radiative forcings)

Wet regions become wetter, dry drier

- Contrasting wet and dry region responses to current and future tropical warming as anticipated from thermodynamic scaling
- Variability over land influenced by El Niño Southern Oscillation

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\begin{align*}
\text{Trends in global water vapour (W) consistent with thermodynamics} \\
\text{Co-variation: } \frac{dW}{dT} \approx 7\%\text{/}K \\
\text{Moisture bal.: } (P - E) \approx - \nabla \cdot (u q) \\
\frac{\Delta (P - E)}{\Delta T} = - \nabla \cdot (u q) \Rightarrow - \nabla \cdot (u q) \approx - a P - \frac{\Delta q}{\Delta T} \Rightarrow \Delta q = \alpha (P - E) \\
\Delta P = \alpha (P - E) + \Delta E \approx \alpha (P - E) + k E = \alpha (P - \beta E)
\end{align*}
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Decadal ENSO variability important for changes in land precipitation

- During warm El Niño years changes in atmospheric circulation cause reduction in land precipitation (anti-correlated with ocean precipitation)
- Decadal changes in ENSO may explain discrepancy between coupled model precipitation anomalies and GPCC observations 1950-70
- AMIP5 simulations able to capture interannual variability in precipitation over land due to prescribed ocean temperature

Future changes in precipitation extremes

- 5-day average precipitation is split into intensity bins
- Sensitivity to tropical mean temperature changes for interannual variability and climate change are calculated in each bin

References


This work was funded by the UK Natural Environment Research Council PAGODA and PREPARE projects

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