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Observed and simulated precipitation responses in wet and dry regions

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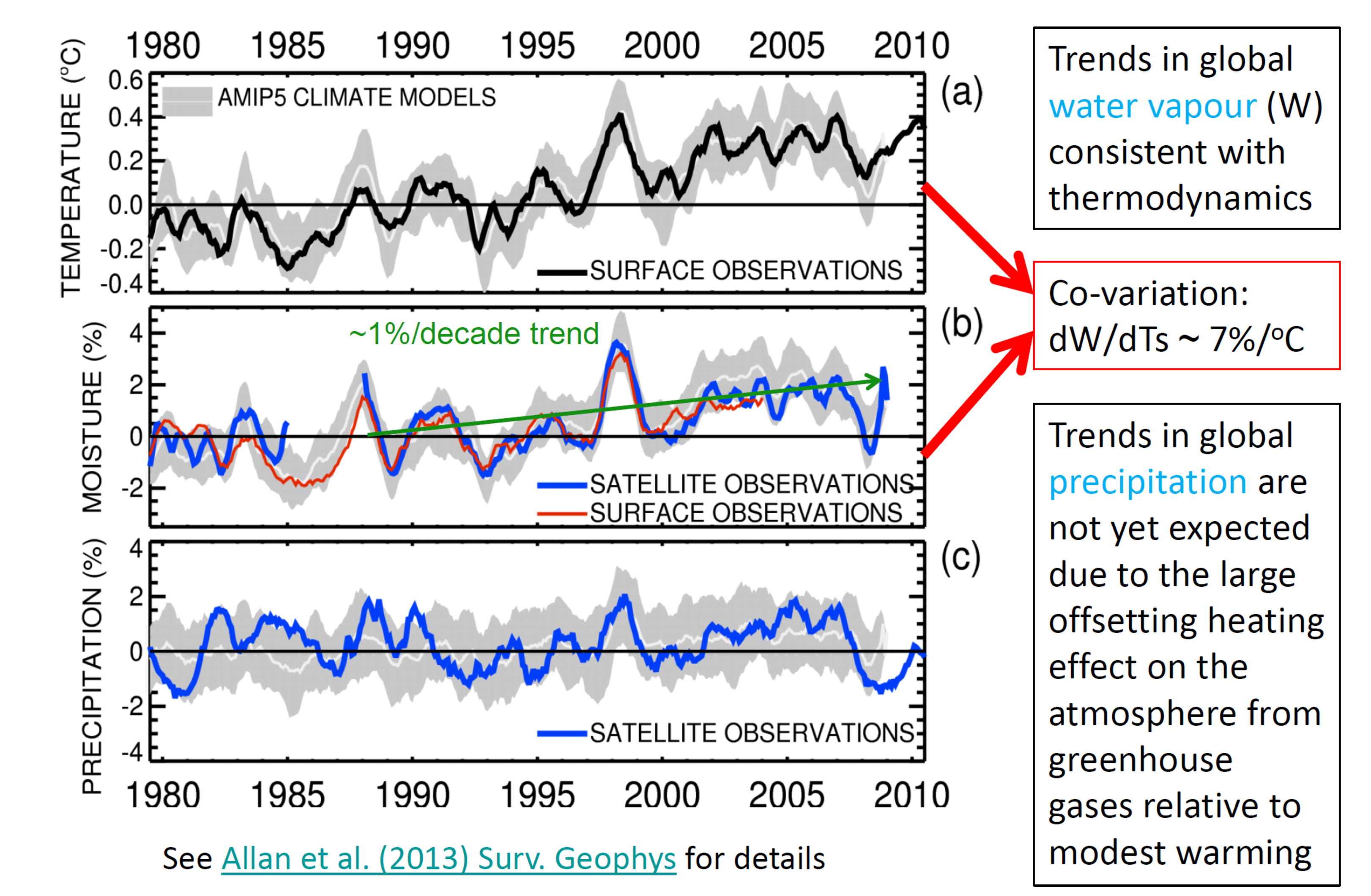
Introduction

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 guage product
- Comparison with AMIP5 simulations (prescribed observed sea surface temperature and sea ice & realistic radiative forcings)



See Allan et al. (2013) Surv. Geophys for details

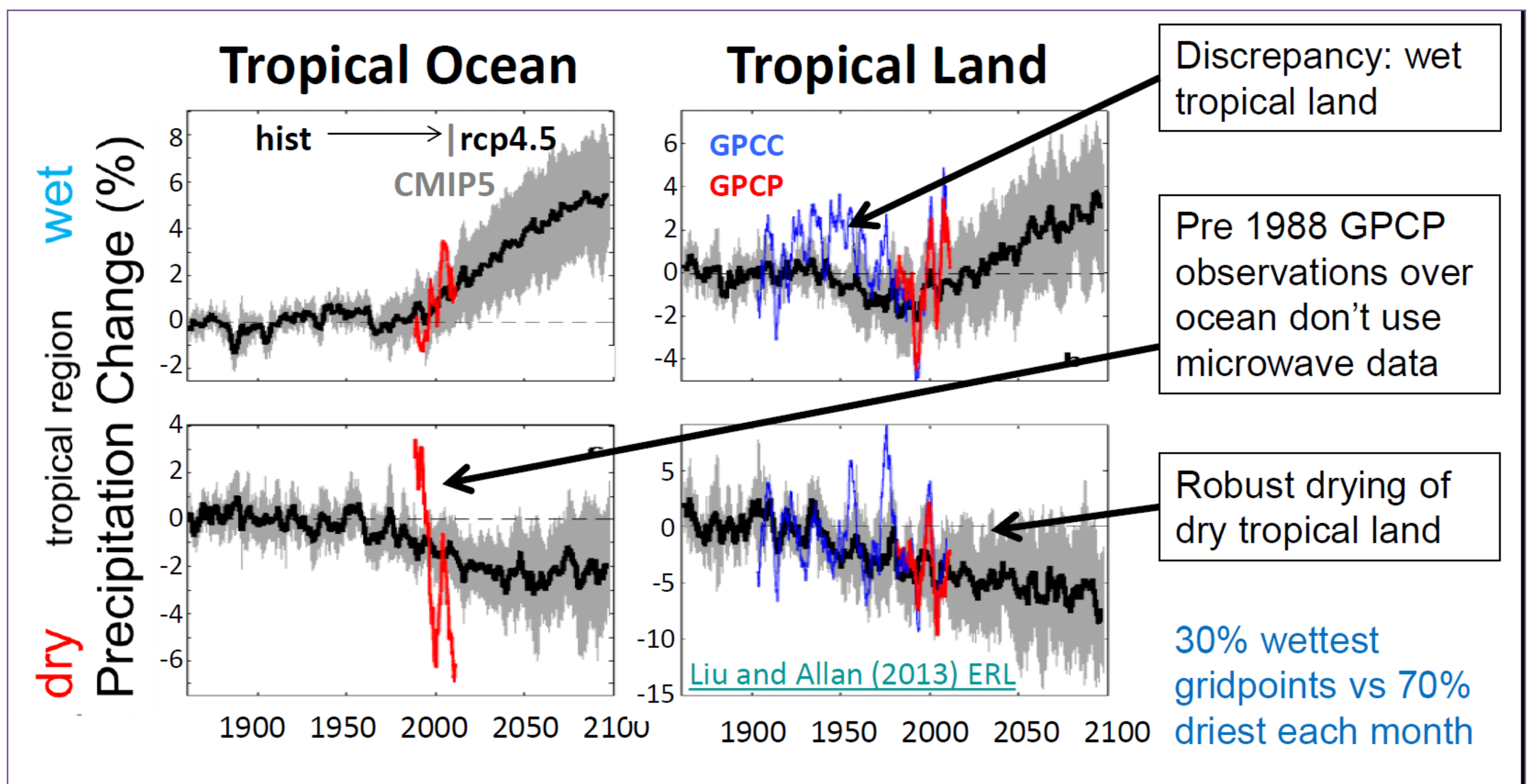
Wet regions become wetter, dry drier

- 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

$$Thermodyn.: \frac{1}{q_s}\frac{dq_s}{dT} = \alpha \sim 7\%/K \quad Moisture\ bal.: (P-E) \approx -\nabla.(u\,q)$$

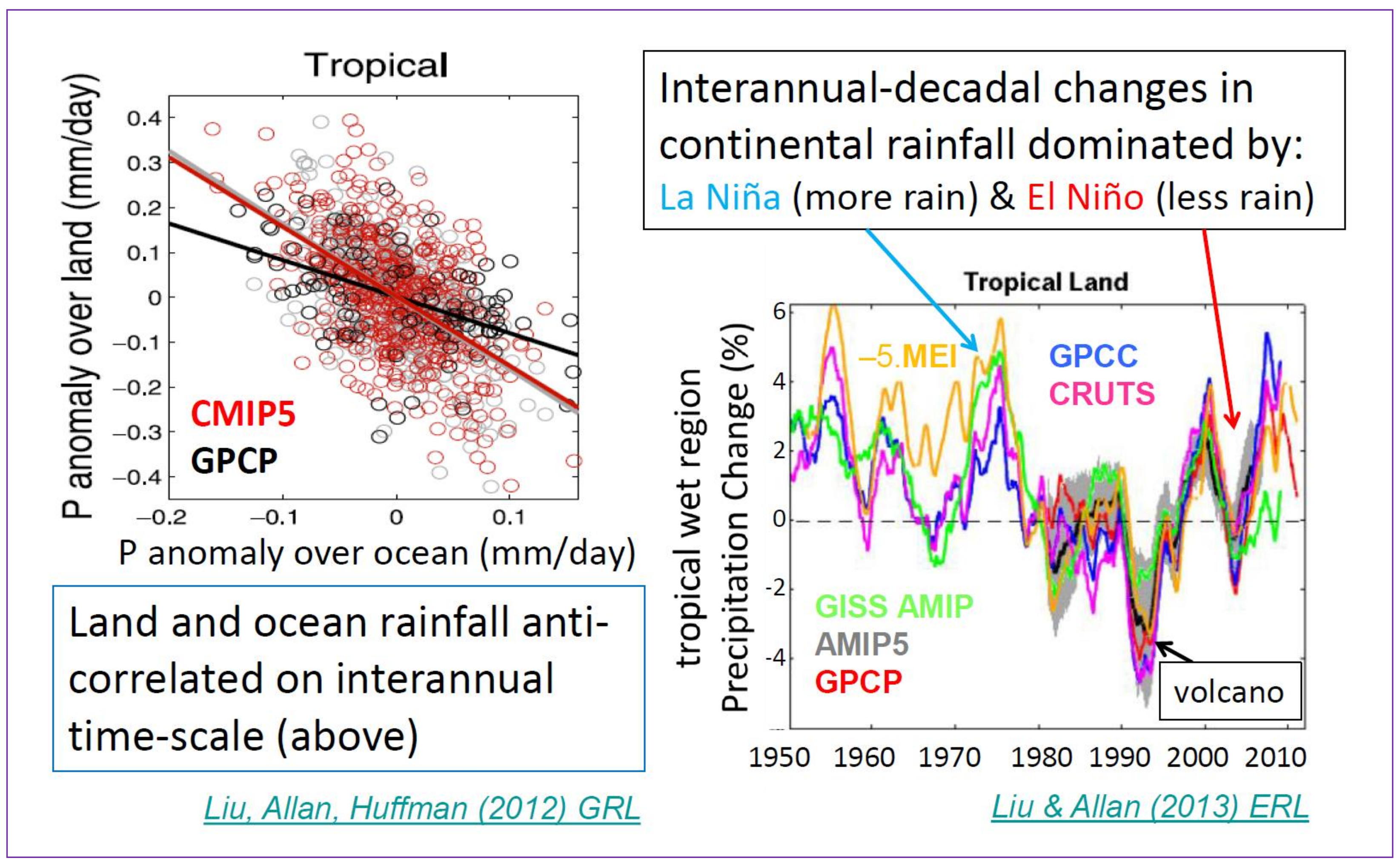
$$\frac{\Delta(P-E)}{\Delta T} = -\nabla.\frac{\Delta(u\,q)}{\Delta T} \approx -\nabla.u\frac{\Delta q}{\Delta T} \approx -\alpha\nabla.(u\,q) = \alpha(P-E)$$

$$\Delta P/\Delta T \approx \alpha(P-E) + \Delta E \approx \alpha(P-E) + kE = \alpha(P-\beta E)$$



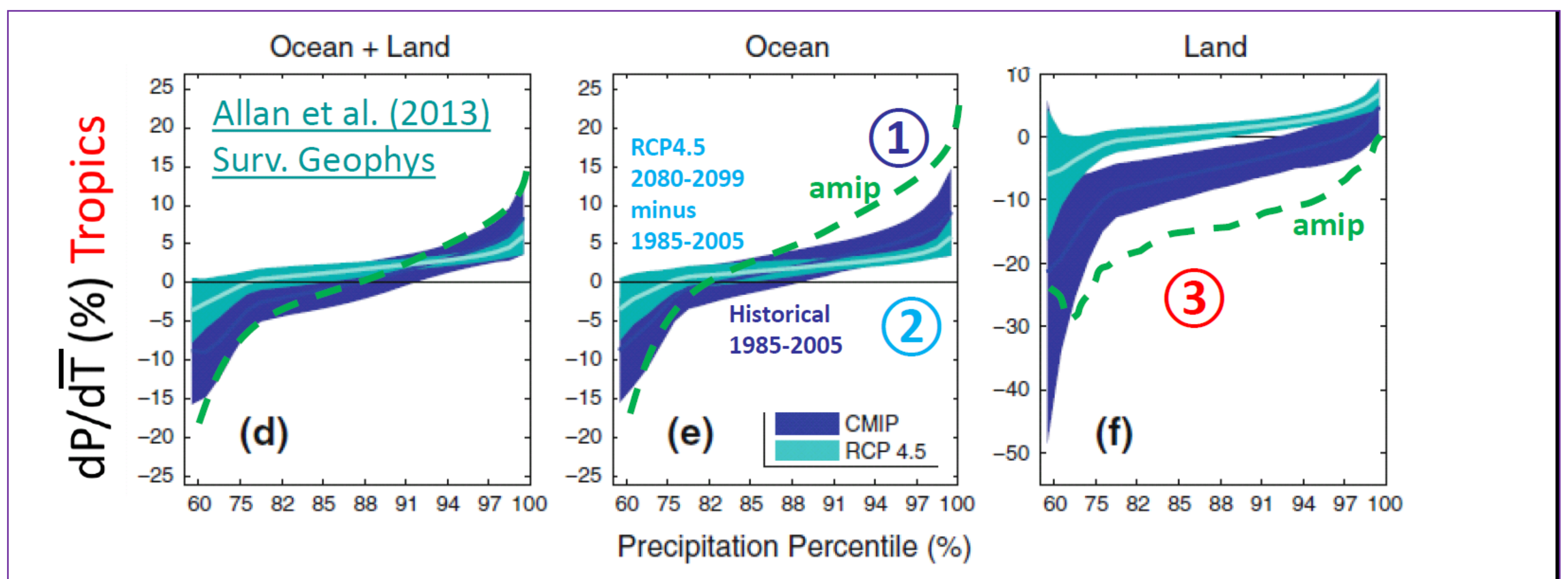
Decadal ENSO variability important for changes in land precipitation

- 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



1. Smaller dP/dT sensitivity for coupled simulations (historical vs amip)
2. Smaller dP/dT sensitivity under climate change (historical vs rcp4.5) as dP/dT supressed by direct atmospheric heating from rising greenhouse gases
3. More positive dP/dT over land under climate change (rcp4.5 vs historical) as Temperature rises un-related to ENSO for climate change response

- Amplification of precipitation extremes with climate warming
- Interannual variability is not a good proxy for climate change over land

References

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2. Liu, C. and R.P. Allan (2013) Observed and simulated precipitation responses in wet and dry regions 1850-2100, Environ. Res. Lett., 8, 034002, doi:10.1088/1748-9326/8/3/034002
3. Liu, C., R. P. Allan, and G. J. Huffman (2012) Co-variation of temperature and precipitation in CMIP5 models and satellite observations, Geophys. Res. Lett., 39, L13803, doi:10.1029/2012GL052093

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