Changes in atmospheric circulation with global warming

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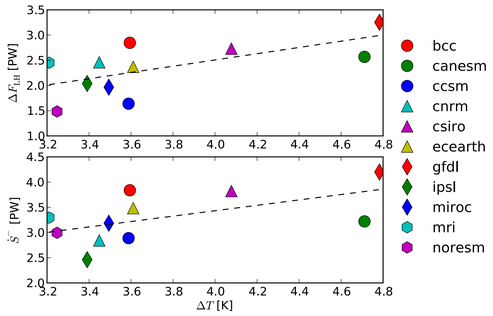
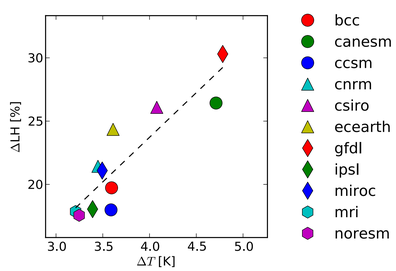
Radiative cooling

The increase in latent heat flux is of similar magnitude as the increase in radiative cooling above 315 kJ/kg. Both increase by 0.5-0.6 PW per degree of warming.



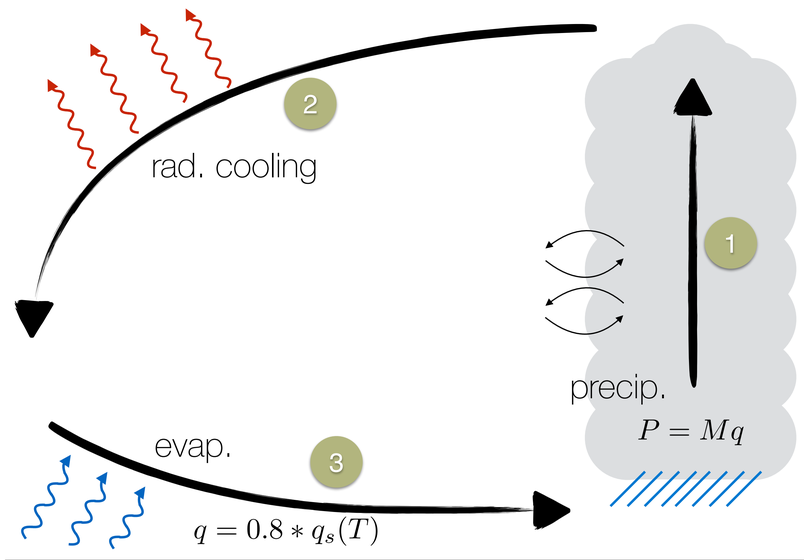
Latent heat / evaporation

The atmospheric circulation widens in heat—moisture space with global warming. We find a widening of 7% per degree of warming consistent with Clausius-Clapeyron scaling. This leads to increased LH fluxes that must be balanced by radiative cooling.



Summary

- We study how the global atmospheric circulation changes from late 20th century to late 21st century in climate-model simulations using a thermodynamic stream function.
- All models show a slowdown of the circulation as well a warming and moistening. This is quantified by regressing the warming, moistening and slowdown onto surface warming.
- Lower tropospheric specific humidity increases more rapidly than latent heat transport which results in a slower atmospheric circulation.



Implications for the ocean: A more moist lower troposphere implies more evaporation, and increased latent heating implies more precipitation. A slowdown of the atmospheric circulation could thus lead to more pronounced E-P patterns (Held & Soden, 2006; Durack et al., 2012) and a widening of the thermohaline circulation in T—S space (Zika et al., 2012; Döös et al., 2012).

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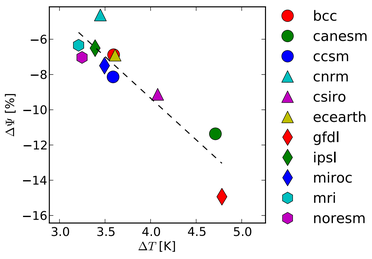
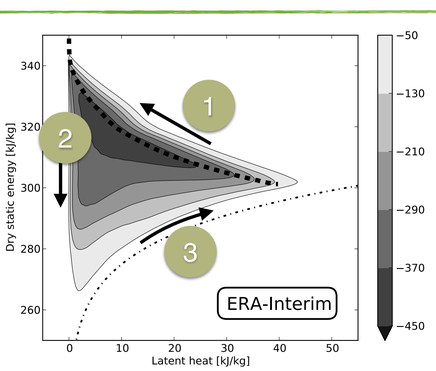
Durack et al., 2012, Science 336, pp 455-458
Held & Soden, 2006, J. Clim. 19, pp 5686-5699
Kjellsson et al., 2014, J. Atmos. Sci., in press.

Mass transport & precipitation

The maximum mass transport decreases, i.e. the atmospheric circulation slows down by ~5 % per degree of warming. This result is robust across all models studied.





Method

The hydrothermal stream function (Kjellsson et al., 2014) combines the Walker and Hadley cells and midlatitude eddies into a single circulation. The circulation has three branches associated with precipitation, radiative cooling, and moistening/ diabatic heating respectively.