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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Direct and disequilibrium effects on precipitation in transient climates" *by* D. McInerney and E. Moyer

Anonymous Referee #1

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The authors present an analysis of the transient response of precipitation to greenhouse gas forcing, framed in terms of two "pathways", one related to the disequilibrium between oceanic and atmospheric heating and the other related to fast and slow responses of the climate to such forcing. Overall, I find this analysis to be well-motivated and interesting and believe it should be of appeal to the readers of *Atmospheric Chemistry and Physics*.

Major Comments:

Since the aim here is to investigate precipitation, the authors may want to consider a diagnostic (vertically-integrated) moisture budget analysis for precipitation perturbations, namely:

$$P' \approx E' - < \nabla \cdot (q' \overline{v}) + \nabla \cdot (\overline{q} v') > - < \partial_t q' > \quad (1)$$

where overbars indicate mean quantities, primes departures from means, and <. . .> mass weighted vertical integration (see, e.g., Seager et al. 2010). Globally averaged, (1) requires precipitation and evaporation perturbations to balance, although on very short timescales, the last term on the RHS, the atmospheric moisture storage term, could be important. On smaller scales–even perhaps the global-scale land/ocean partitioning discussion in Section 3–the circulation–related terms are likely to be important.

A moisture budget analysis could certainly complement the discussion in Section 6 on the surface energy budget. At the same time, I would also suggest broadening the discussion in 6 to include energetic considerations from an atmospheric column perspective. Indeed, both the surface and column energy budgets affect (1), through interactions with evaporation but also through circulation.

The authors may want to consider adding some further discussion of the physical mechanisms for precipitation change under global warming, or at least cite some additional references on the development of such mechanistic understanding, e.g., the work of Chou and Neelin (2004). On a related note, some studies of the El Niño/Southern Oscillation (ENSO) impact on climate have used applied the disequilibrium concept (see, e.g., Chiang and Sobel 2002 and additional references below).

Minor Comments:

Pg19652, Lines 14-16–The authors note "..the direct effect would relate to changes in surface energy fluxes other than ocean heat uptake. . ." Should "ocean heat uptake" be "latent heat flux"?

Pg19656, Line 7–subject/verb agreement: “bulk. . .involve” should be “bulk. . .involves”

Pg19657, Lines 13-15–The authors state “These experiments were however hampered by low signal-to-noise: four used slab-ocean models and the single coupled model run involved only a single realization.” I wouldn’t characterize that the use of slab ocean models as hampering by low signal-to-noise, but perhaps I’m missing something?

Pg19657, Lines 19-20–Given the availability of CMIP5 data, it may be worthwhile to “justify” use of CMIP3. Apart from the continuity with the cited study of Andrews and Forster (2010), is it because of the simplicity of the “1pctto2x” experimental design?

Pg19658, Line 24–subject/verb agreement: “data. . .is” should be “data. . .are”

Pg19664, Lines 17-18–The statement “The latent heat flux is constrained by the fact that surface energy fluxes must balance” is not strictly correct, since ocean heat flux divergence will create regions of positive and negative net surface flux.

Pg19665, Lines 16-17âĂŤsubject/verb agreement: “abrupt forcing increase and imposition . . . drives” should be “abrupt forcing increase and imposition . . . drive”

Additional References:

Chiang, J.C.H., and B.R. Lintner, 2005: Mechanisms of remote tropical surface warming during El Niño. *J. Clim., 18*, 4130-4149, doi:10.1175/JCLI3529.1.

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Kucharski, F., A. Bracco, J.H. Yoo, A.M. Tompkins, L. Feudale, P. Ruti, and A. Dell’Aquila, 2009: A Gill–Matsuno-type mechanism explains the tropical Atlantic influence on African and Indian monsoon rainfall. *Q.J.R. Meteorol. Soc., 135*, 569–579.

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Seager, R., N. Naik, and G.A. Vecchi, 2010: Thermodynamic and dynamic mechanisms for large-scale changes in the hydrological cycle in response to global warming. *J. Clim., 23*, 4651-4668.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 19649, 2012.