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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global precipitation response to changing external forcings since 1870" *by* A. Bichet et al.

Anonymous Referee #1

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This paper assesses variability in global land precipitation and temperature during 1870-2005 using a series of experiments with the ECHAM5-HAM atmospheric GCM. The experiments include: CTRL (control, with time varying SSTs, GHG concentrations, aerosol emissions, solar irradiance), AEC (constant aerosol emissions), SSTC (climatological SSTs), and AESSTC (constant aerosol emissions and climatological SSTs). The paper concludes that i) SSTs are a dominant forcing driving trends and decadal variability in global land temperature and precipitation since 1870; ii) the atmosphere-only response to increasing aerosol emissions after 1930 amounts to a decrease in global land temperature and precipitation; iii) the atmosphere-only response to increasing GHG concentrations results in an increase in global land temperature and precipitation after about 1950; and iv) between about 1950 and 1970, the aerosols impact on global land temperature and precipitation is larger than the GHG impact, whereas the

opposite is true after 1970. The following comments need to be addressed before the paper can be published in ACPD.

Major comment:

In contrast to the authors' assertion (p. 9391, lines 22-23), I am left somewhat dissatisfied with the ability of the ECHAM5 model to reproduce the observed global land temperature and precipitation anomalies. This is particularly the case with regard to precipitation (e.g., Fig. 4), which is the primary focus of the study. While modeled and observed annual precipitation anomalies share some common features, as noted by the authors, (e.g., the overall precipitation increase from 1901 to the 1950s, decline until the early 1990s, and recovery thereafter) other features evident in the observations are not reproduced by the model (e.g., the sign of the centennial precipitation trend, the magnitude and in some cases the sign of the decadal precipitation variations). If the observed features not reproduced by the model are a result of either errors in the observations or unforced variability in the real world, then this is not a serious problem. However, if the discrepancies between model and observations arise due to an unrealistic response of the simulated land precipitation to variations in SST and/or external forcing, then the remainder of the paper essentially amounts to an evaluation of the sensitivity of MODELED PRECIPITATION, with unclear relevance for the real world. So, I would like some further assurance that the ECHAM5 model does indeed produce a reasonable response of land precipitation to changes in SST and external forcing. Are there other studies that have examined this that could be cited? If not, one way to address this issue without the need for additional experiments would be to compare the modeled and observed land precipitation response to SST variations associated with El Nino, and to volcanic forcing. In both cases, the observed land precipitation has been shown to decrease (Gu et al., 2007; Trenberth and Dai, 2007). If it can be shown more convincingly that model simulated land precipitation responds realistically to forcing, then this would suggest (possible measurement and forcing uncertainties aside) that a significant portion of the observed variability in land precipitation during

the past $\sim$ 100 years has been unforced, which would be an important result.

Minor comments:

1. p. 9379, line 29 – p. 9380, line 2: "Note that in AESSTC, the only remaining forcings expected to affect the climate at decadal scale are the greenhouse gases. Therefore, AESSTC can be used to evaluate the greenhouse gases effects." – What about solar irradiance variations? Aren't these included in the AESSTC experiment?

2. p. 9380, lines 20-22: "This section describes the evolution of the climate forcings applied in our study since 1870: Namely, these are the aerosol emissions, the greenhouse gas concentrations, and the SSTs." – Again, what about solar irradiance?

3. p. 9382, line 8: "consists of monthly observed air temperatures from 1850 to present" – 2-m air temperatures?

4. p. 9382, lines 15-16: "Note that when comparing observed against simulated temperature, we change the grid of the simulated temperatures each year according to the data coverage." – Is this also done when comparing observed and simulated precipitation?

5. p. 9384, lines 15-16: "Thus the bias in the second period might actually be somewhat larger than indicated in Fig. 3." – Shouldn't it say "than indicated in Fig. 2"?

6. p. 9386, lines 17-18: "smaller by about 20 mm/year between 1930 and 1970" – suggest instead "decrease by about 20 mm/year"

7. p. 9386, lines 20-22: "the anomalies simulated in AEC (red curve) show decadal variations similar to the one simulated in CTRL (black curve), but exhibit a larger trend after about 1930" – Actually, the trend in annual land precipitation looks to be almost flat in AEC after 1930, while it is larger (and negative) in CTRL.

8. p. 9386, lines 24-27: "Note that even though the representation of aerosol variations with HAM overall improves the agreement with observations, it appears that aerosol

effects might have been overestimated in our simulations, leading to a too large effect on the climate (Figs. 4 and 7)." – I'm not sure I see how Figs. 4 and 7 would suggest that the simulated aerosol effect is too large. . .can you elaborate on this?

9. p. 9387, lines 13-15: "our results suggest that the global land precipitation trend and variability, since 1870, primarily respond to the trend and variability of the global land evaporation" – probably better to say "global land precipitation trend and variability are more highly correlated with the trend and variability of the global land evaporation", since it's unclear to what extent the precipitation decrease is a response to decreased land evaporation or vice versa.

10. p. 9389, line 17: "associated increase in air capacity" – suggest "air moisture holding capacity"

11. p. 9391, line 24: "SSTs (encapsulating other forcings)" – should note here that the SSTs encapsulate not only changing external forcings, but also the unforced (internal) variability that occurred in the real world.

References:

Gu, G., et al., 2007: Tropical rainfall variability on interannual-to-interdecadal and longer time scales derived from the GPCP monthly product. J. Clim., 20, 4033-4046.

Trenberth, K. E., and A. Dai, 2007: Effects of Mount Pinatubo volcanic eruption on the hydrological cycle as an analog of geoengineering. Geophys. Res. Lett., 34, L15702, doi:10.1029/2007GL030524.

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