

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

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We would like to thank the reviewer for his constructive comments and the in depth reading and understanding of the manuscript. The major comment was particularly interesting and we agree with the reviewer. Therefore, this comment led to the reformulation of an entire paragraph and the revision of a figure. All the points of the minor comments have been considered, and will lead to changes in the revised manuscript, as described below:

Major comment:

p.9391, lines 22-23. The review was not convinced by the ability of the ECHAM5 model to reproduce the observed global land temperature and precipitation, and raises the

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question of whether the modeling study has a relevance for the real world. We agree with the referee, Fig. 4 from the submitted manuscript raises the question of the model ability to correctly capture observed precipitation. Therefore, the entire paragraph (from p.9384, line 17, to p.9385, line17) will be reformulated as follows. Figure 5 from the submitted manuscript will also be changed to the following figure.

“The global land precipitation anomalies, relative to the 1901-2000 mean, are shown as 11-years running mean in Fig. 4. Despite a wet and dry bias in the 1930s and 1970s respectively, simulated (solid curves) and observed (dashed curves) global land precipitation anomalies are in reasonable agreement since 1901 (Fig. 4): Simulated and observed annual anomalies increase from 1901 to the 1950s, decline until the early 1990s, and then recover (New et al., 2001; IPCC, 2007). However, their centennial trends (1901-200) are of opposite sign (-10 mm/year and + 10 mm/year respectively), and the magnitude of their decadal variability differs. Note that the centennial trends are relatively small compared with the decadal variabilities. Finally, we find that in the 1930s, the wet bias is mostly located in China and in northern South America (not shown). As mentioned in New et al. (2001), observations in these areas might not be very accurate during this period. Fig. 5a indicates that ECHAM5-HAM (solid curve) reproduces the observed (CRU, dashed curve) global land precipitation decadal and inter-annual variabilities, albeit different magnitudes in specific time periods, such as during the 1930s and 1970s. Nevertheless, Fig. 5a shows that observed and simulated global land precipitation anomalies decrease after large tropical volcanic eruptions (blue vertical lines), as well as during El NINO events (green vertical lines), and increase during La NINA events (magenta vertical lines). These two atmospheric responses, more pronounced in the tropics (Fig. 5b), are in line with previous studies (Gu et al., 2007; Trenberth and Dai, 2007). This suggests, in agreement with Hagemann et al. (2006), that ECHAM5-HAM produces overall a realistic response of land precipitation to changes in external forcings and SSTs. We conclude that the discrepancies between observed and simulated global land precipitation seen in the 11 years running means (Fig. 4) may not be due to an unrealistic response of land precipita-

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tion to changes in SSTs and external forcings in our model. Consequently, the results discussed in our modelling study are relevant for the real world.”

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? We agree with the referee, the total solar irradiance (TSI) has not been mentioned in the submitted manuscript. It is an external forcing and has indeed an effect on the temperature and precipitation. Therefore, this sentence will be changed as follow: “In AESSTC, the only remaining forcings expected to affect the climate at decadal scale are the greenhouse gases and the total solar irradiance (TSI). Therefore, AESSTC can be used to evaluate these two forcings. Note nevertheless, that according to Solanki and Krivova (2003), the TSI influence on climate is not a dominant factor after 1970. ”
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? Same comments as in point 1. Therefore, TSI will be added to the list of climate forcing listed in this sentence.
3. p. 9382, line 8: “consists of monthly observed air temperatures from 1850 to present” – 2-m air temperatures? The observed surface temperature are 2 meters temperatures. It will be changed in the revised manuscript.
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? No, the observational based precipitation datasets we use (CRU and GHCN) have been spatially infilled by interpolation (Mitchell and Jones, 2005; New et al., 2001).

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Therefore, there is no need to change the grid of the simulated precipitation according to the coverage for the comparison, as it was done for the temperature datasets.

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”? The reviewer is correct, it will be changed in the revised manuscript.
6. p. 9386, lines 17-18: “smaller by about 20 mm/year between 1930 and 1970” – suggest instead “decrease by about 20 mm/year” The reviewer is correct, it will be changed in the revised manuscript.
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. We agree, the sentence will be changed in the revised manuscript with the following: “.....the anomalies simulated in AEC (red curve) show decadal variations similar to the ones simulated in CTRL (black curve), but after about 1930, the trend is almost flat in AEC, whereas it decreases by about 10 mm/year 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? Our results show that modeled surface temperatures and precipitation underestimate the observed surface temperature (Fig. 2) and precipitation (Fig. 4) since about 1970. We think that this might be due to an overestimation of the aerosols effects in our experiments. However, there is no previous study that shows that either 1) ECHAM5-HAM overestimate the impact of aerosols on climate, and/or 2) the aerosols emissions reconstructed in the NIES dataset are too large. Therefore, this sentence will be deleted in the revised

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manuscript.

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. We agree with the referee, the sentence will be changed in the revised manuscript with the following: “...global land precipitation trend (-0.92 mm/decade) and variability are more highly correlated with the trend (-0.77 mm/decade) and variability of the global land evaporation ( $r^2=0.81$ ), as opposed to global oceanic evaporation (trend=-0.15 mm/decade,  $r^2 = 0.36$ ).”

10. p. 9389, line 17: “associated increase in air capacity” – suggest “air moisture holding capacity We agree, it will be changed in the revised manuscript.

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. We agree, the sentence will change in the revised manuscript with the following: “...SSTs (encapsulating other forcings, as well as unforced variability)...”

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 9375, 2011.

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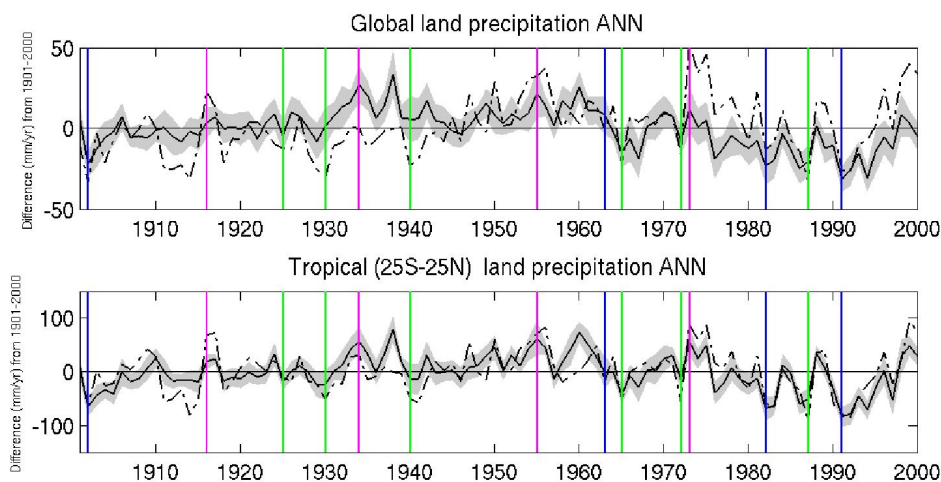


Fig. 1.

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