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Interactive comment on "Background albedo dynamics improve simulated precipitation variability in the Sahel region" *by* F. S. E. Vamborg et al.

F. S. E. Vamborg et al.

freja.vamborg@mpimet.mpg.de

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Reply to interactive review comment by Referee 2 - M. Crucifix.

We thank the second referee, M. Crucifix, for his insightful and detailed comments. Below we discuss the suggested changes and comments point-by-point.

Summary

The experiments are not only forced by the same reconstruction of sea-surface

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temperatures, but also starting from the same initial conditions. However, the stratospheric horizontal diffusion is varied in the first year in order to generate the three ensemble members for each set-up. We have added one further sentence to make this clearer.

General appreciation

"The existence or not of a pause in the wet anomaly around 1945 probably largely conditions the autocorrelation and the power spectra".

We agree that it is difficult to say whether or not the wet anomaly "pauses" around 1945, as the observed time-series seem to indicate. We do not see how it would be possible to analyse this with the current setup, though we are open for suggestions. We also do not think that it would affect our results to a large extent whether this pause is present or not, since visual inspection of the simulated time-series suggests that this "pause" is also captured by the model.

"Perhaps the most surprising result is the large difference in the standard deviation of albedo anomalies"

The standard deviations (SD) given on page 610, line 1-2 are only for the period 1989-2005, since this is the period for which observational data exists. This is pointed out in the text, but we agree that these values might thus be slightly misleading for the rest of the discussion. When we calculate the SD for the period 1901-2006 the differences are not quite as large, which is what visual inspection of the whole plot would indicate. We have lengthened this part of the text, by giving the SD for the whole studied period as well as for the wet and the dry periods. For all these periods the SD of the dynamic albedo is lower than for the static scheme in combination with dynamic vegetation, however not by as much as for the period 1989-2005. This further

ESDD
4, C603–C608, 2013

highlights the different behaviour of the two schemes in terms of temporal variability, with the dynamic albedo scheme having, as expected, much slower variations than the static scheme.

As for the conclusions in that part of the text, which, as pointed out by the reviewer, are not very clearly written, we wanted to convey the following. Previously it has been suggested that a large change in mean albedo is necessary to capture the persistence of Sahelian rainfall, but that observations of albedo do not support such a hypothesis (for a review, see Nicholson, 2013). Here the mean does not change by a large amount between the wet and the dry periods in either of the set-ups and still we see that one set-up (with the dynamic background albedo scheme) captures the persistence better than the others and thus closely matches the observed precipitation persistence. The difference in rainfall persistence must thus be related to the difference in albedo variability between the three set-ups, rather than a difference in the mean albedo change. Due to the interaction of several processes at many time-scales we find it difficult to pin-point the exact reason for the persistence effect due to the dynamic scheme. We have extended this section to make these points clearer.

A further, related, concern of the reviewer is the lack of a clear message of what leads to the apparent non-linear behaviour, caused by the introduction of the dynamic albedo scheme. He proposes that it might be due to the SSTs themselves.

We agree that it is not as clearly discussed as it should be and to some extent this is because it is not possible to disentangle all interactions with this relatively limited set of experiments. We try to stress in the paper, that it is clear that a large portion of the signal seen in the precipitation is a result of the SST forcing. We have not discussed whether or not the response of the precipitation to albedo changes is dependent on the underlying SST signal or not, as the reviewer suggested as a possible explanation. Our assumption is also that this might very well be the case,

ESDD
4, C603–C608, 2013

meaning that we need the pre-conditioning of the precipitation from the SSTs in order for the slow dynamics in the albedo to play a significant role for the precipitation variability, i.e. to entrain the albedo-precipitation feedback.

We derive this assumption from a comparison of the variability of precipitation in a coupled ocean-atmosphere set-up (ECHAM5-JSBACH/MPIOM), using the three different land-surface set-ups used in the present study, but for pre-industrial control runs. As in this study, we find a lower standard deviation of the albedo with the dynamic scheme, concurrent with a stronger auto-correlation. However, we cannot find a significant difference in the precipitation variability as a result of these differences in the albedo variability. Additionally, there are no periods of persistent above or below mean anomalies in the precipitation time-series of theses simulations. This thus indicates that a persistent signal needs to be present in the SSTs for the albedo scheme to have a significant impact on precipitation variability. These results should, however, be taken with some caution. The precipitation spectra of the coupled model show a far too strong dependence on the ENSO signal, which is a known "variability bias" all across the equatorial belt of the coupled model used. This means that any other signals in the spectra are too small to be seen, making any firm statements impossible. This "variability bias" is the reason for which we have not discussed these results in the present study.

We agree that this question is highly relevant and thus need to be revisited. This could be done either by forcing the model with a constant set of SSTs or run in a coupled model where the "variability bias" has been solved. Such experiments are beyond the scope of this study, as our aim here was too investigate whether natural albedo variability would be a sufficient explanation for the part of the precipitation signal that is missing, when only forcing the model with SSTs and not to discuss the signal due to the SSTs themselves.

ESDD
4, C603–C608, 2013

To rectify these shortcomings in the manuscript, we have extended the section on the standard deviations, as well as included a more detailed discussion of the albedo variability and its possible connection to the SSTs.

Model specification

As requested, we have added a table listing the parameters used for the two schemes.

Other minor comments

Argument p. 612, ll. 15-20.

We agree that the argumentation is not clear. Comparing models and their differing results is extremely difficult, since it is not always possible to really pin-point the most important differences between them. What e.g. Wang et al. (2004) showed is that in their model precipitation persistence is increased, when the dynamic vegetation scheme is switched on. This is however not the case in our study. We assume that the difference arises from the formulation of the dynamic vegetation schemes. The main differences we could find, were the differently parameterised time-scales, though there are of course other differences, both in the schemes and in the coupling with the atmosphere. Our assumption is that the longer time scale in JSBACH, is too long to have a memory effect relevant for the precipitation persistence here, whereas the parameterisation in Wang et al. (2004) leads to a shorter-term memory effect on the relevant time-scale. The model used by Wang et al. (2004) is the same model that was used by Delire et al. (2004), where they find increased persistence in precipitation, even without a strong SST signal. This is why we conclude that the inter-annual memory in vegetation, which in their studies lead to precipitation persistence, is either artificially enhanced in their studies, or it is underes-

ESDD
4, C603–C608, 2013

timated in our setup. We have changed the text in order to make this statement clearer.

We have moved the reference to Crucifix (2005) to the introduction.

Misprints

Misprints have been changed.

References

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Interactive comment on Earth Syst. Dynam. Discuss., 4, 595, 2013.