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Interactive Comment

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

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Reply to interactive review comment by Anonymous Referee 1

We thank Referee 1 for the positive evaluation of our manuscript. The referee's main concern is the lack of discussion around potential external forcings that are not represented in the model, but might have an influence on Sahelian rainfall and that we seem to imply that natural variability is the main (only) cause for the Sahelian drought during the 1980ies.

In the paper we concentrate on the effect of natural albedo variability on Sahelian rainfall and in this sense it is true that we do not focus on the influence of potential anthropogenic forcings, such as land use change, greenhouse gas (GHG) emissions and anthropogenic aerosols, all of which could possibly be controlled by future policies.

As we state in the introduction, it is now generally accepted that the main driver for Sahelian rainfall variability is the variability in sea surface temperatures (SSTs). However, it seems that there are some additional processes that are not properly represented in models, which leads to a slightly too low response of the precipitation signal, when models are just forced by observed SSTs. One possible such process it natural variability of land surface albedo and we show that this process, when properly represented, does indeed make it possible to explain "the missing part" of the signal. Two further hypotheses that have been considered is the impact of human land-use change and of dust aerosols. Dust aerosols are not taken into account in any of our simulations, however studies considering this hypothesis did not arrive at an unanimous conclusion in terms of the impact of dust aerosols on the rainfall, whether an increase in dust increases rainfall or vice versa (for a review, see Nicholson, 2013), which is why we have not discussed it further here. Man-made desertification has been shown to have a potential impact. However, the scenarios used to investigate this hypothesis have been deemed too unrealistic in terms of their magnitude (for a review, see Nicholson, 2013). Our conclusion is thus, that natural variability would suffice to explain the missing part of the precipitation signal.

We do, however, not mean to say, that natural variability is the sole driver for the Sahelian precipitation, since SSTs are responsible for the main part of the signal and it is not clear which SST patterns play the largest role in forcing Sahelian rainfall and if these patterns are purely due to natural variability. There are some studies that suggest that these patterns are also caused by external forcings such as anthropogenic greenhouse gas emissions and/or anthropogenic aerosol emissions

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(e.g., Held et al., 2005; Ackerley et al., 2011; Booth et al., 2012). In our introduction we wrote (p. 597,l. 27) "These factors either enhance the natural SST signal. . .". We have now deleted the word "natural", since this was clearly misleading.

By using the reconstructed SST dataset, we thus assume that we indirectly capture these forcings, as their signal should be present in the SSTs. In the paper we already argued along those lines for GHGs emissions, though the main reason we discuss the GHGs is that they also have a potential direct effect on vegetation, which would not necessarily be the case for anthropogenic aerosols.

In terms of potential policies, the main challenge would be to find out, are there, and if so which, anthropogenic drivers of the sea surface temperatures patterns that influence Sahelian precipitation. This question is beyond the scope of our study, due to the fact that these forcings are not explicitly modelled in our set-up. From a policy perspective this study is more relevant in terms of what can be done in order to improve predictions for Sahel, rather than policies potentially directly affecting Sahelian rainfall variability. We now try to further highlight this point at the end of our conclusions.

Specific comments:

1. *Suggestion to include an influence diagram.* In Vamborg et al. (2011) there is a diagram depicting the different parts of the two albedo schemes. We have added a modified version of this diagram, which includes the different time-scales, to the paper.

2. We have added the following sentence on page 598, line 10. "Natural albedo variability on these time-scales is mainly modulated by changes in the vegetation cover. This includes changes in plant composition, changes in foliage cover during the growth period, changes to the extent of soil coverage by dead and living vegetation and changes to the soil composition due to biodegradation. All these variations lead to

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changed spectral properties of the land surface and thus to a changed albedo."

3. By just giving two examples we wanted to highlight the wide range of hypotheses, i.e. hypotheses related to very different sub-compartments of the climate system, rather than give a list of examples.

4. We agree that this sentence was unclear. What Delire et al. (2004) showed was that the representation of vegetation dynamics in a coupled vegetation-atmosphere model setup, can lead to an internal generation of persistence in precipitation anomalies. They attribute this effect to a coupling of various slow processes in the vegetation dynamics that enhance the response of precipitation. We have changed the sentence accordingly.

5. We have added this information to the sentence on page 604. We decided to use both, since though related, they allow us to visualise two slightly different aspects of variability.

Typos have now been corrected and a spell-checker used.

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