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Discussions

Interactive comment on "Regional co-variability of spatial and temporal soil moisture - precipitation coupling in North Africa: an observational perspective" *by* Irina Y. Petrova et al.

Anonymous Referee #1

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The paper uses observations to explore the impacts of both spatial and temporal soil moisture variability on rainfall in North Africa. The authors use existing methodologies, but by applying them at much higher resolution they are able to explore feedback mechanisms, and their regional variations, in considerably more detail than in past global assessments. The authors find negative spatial and temporal soil moisture – precipitation feedbacks across the region, which are correlated with each other (implying co-dependence). They focus on two particular hotspots of this feedback, and discuss the role of wetlands, the size and propagation of typical convective systems in each region, and the role of rainfall persistence on their results.

Overall the paper is novel, timely and interesting, and the approach could (and should) be applied to other regions in the future as well. Unfortunately the paper is not always presented as clearly as it could be, partly in the structure, and partly the language. This means that I am left a bit unclear about some of the conclusions the authors reach, how they fit together and whether they are all well justified. I would therefore recommend the paper for publication once the following major revisions have been addressed.

Major comments

Presentation:

I found the paper a bit disjointed to read. I think there are lots of interesting ideas, but it jumps a bit from one thing to the other. I wonder if the results could be reorganised to make it easier to read. One suggestion is to first describe the feedbacks, i.e. show both the spatial and temporal soil moisture – precipitation coupling (figures 4, 5, 9, maybe 10), and then have a section talking about processes. The description of processes should then be consistent with both the spatial and temporal feedbacks you observe. The language throughout could be improved a bit as well (I have included some suggestions below, but my comments are not comprehensive). Finally, some figures I think could also be improved (my suggested changes are in the minor comments).

Wetlands (S 4.3):

Of the results, this is the part that I found most confusing, and therefore least convincing. Some points:

- Your definition of extreme is very confusing, it would be easier if it were expressed simply as the values above/below given percentiles (which is more or less what is done here, as far as I can tell, but with a fixed offset as well).

- I agree that features such as wetlands are likely to lead to extreme soil moisture gradients, but you might also expect the temporal variability to be low (at least over the wet part). Given you calculate temporal statistics, why not use this as an additional criterion? i.e. find locations with high spatial and low temporal variability.

- Following on from this, in Fig 6b the dots (where the median and mean are opposite signs) do not really match the extremes (colours). I'm therefore not sure if the statement is justified that "extreme [soil moisture gradients] . . . in some cases appear to predefine its significance".

- The map (fig 6a) is not all that useful, as it is hard to see the exact locations and extent of topographic and wetland regions. It is therefore hard to tell if the conclusions in the last two paragraphs are really substantiated. For example, the region of extremes in the south East is very large, and I can't really tell how much of it falls on actual wetland. Similarly, the Gezira scheme in the map is quite small, and it's quite hard to tell what points on the significance contours you are linking to it.

- More mechanistically, could the wetlands not be partly the cause of the covariability between the spatial and temporal feedbacks? The wetlands are approximately spatially and temporally constant, therefore when the soils surrounding it are drier than normal, this will always represent both a temporal and spatial negative soil moisture anomaly.

Reasons for covariability of spatial and temporal SMPC:

The discussion here is again a bit muddled. In the conclusions you state "the drying of the soil for several days . . . may play a role in the opposite sign of the temporal coupling as compared to the positive relationship in wetter climates". It is worth noting that in G15 the temporal coupling is positive across most of the globe, including in other arid and semiarid regions (northern India, Australia, Saudi Arabia, etc.). The 3-4 day variability of rainfall in West Africa driven by African easterly waves is a factor, as is pointed out. I think, however, that the primary factors is probably that this is a high CIN/high CAPE environment, therefore anything that helps overcome the CIN will enhance rainfall. This is mentioned in the text when comparing the southern and northern part of the domain, but I suspect it can also explain the differences with other areas of the globe.

Minor comments

P2, L8: 'have a direct effect on the resulting sign'. It would be useful to explicitly state what the sign they find is (i.e. positive temporal, negative spatial)

P4, L9-10: 'on the northern flank. . .' In the diagram it looks like the gradients go across the ITCZ, as opposed to just being on the northern side?

P6, L29-30. You say you need at least three values of Lmin – do you take the three lowest? (presumably, unless Lmin is 0, there is only one minimum value). I am also confused by the criterion that 'negative rainfall gradient between Lmax and its adjacent four pixels must be present'. If Lmax is the maximum, then the gradient with the 4 pixels surrounding it will always be negative – I suspect I am misunderstanding this line.

P8, L9: '. . .orography mask applied in this study'. Do you mean the maxima are produced by the fact that you are masking the region around the maxima? This sentence is not very clear.

P8, L31: I wonder if the different datasets agree more also because precipitation retrievals themselves are more consistent over flat terrain, while they are likely to disagree more over complex topography.

P9, L19: might be worth mentioning that the significant correlations lie exactly on the semiarid transition zone between forest (in the south) and the desert. Also, have you considered the impact of vegetation (where, presumably, you do not get soil moisture retrievals) on your results? You do get some significance extending down to 8N, where it is quite vegetated.

P9, L23-28: While the explanation offered here sounds plausible, I would be wary of drawing conclusions from a few 'blue' points – as you say, this is likely not statistically significant. Also, are you sure less than 0.1% of points have a positive delta(e)? In the 5° domain there is less than 100 points (and one 'blue' point).

P12, L23-26: have you looked at the seasonal variability? I wonder if june (or years which are particularly dry) behave differently.

P13, L25: I imagine the point here is that boundary layer moisture in the north is less tied to (local) soil moisture, and depends more on the larger scales (i.e. monsoon intrusions), which is why you don't see a wet advantage even though moister conditions do increase rainfall.

P13, L30: might be worth mentioning that in some cases soil moisture gradients can determine the location of convection, even if the trigger is provided by cold pools or the larger scale (Birch et al 2013) Birch, C. E., D. J. Parker, A. O'Leary, C. M. Taylor, J. H. Marsham, P. Harris, G. Lister, 2013: The impact of soil moisture and atmospheric waves on the development of a mesoscale convective system: A model study of an observed AMMA case, Q. J. R. Meteorol. Soc., 139, 1712-1730, doi:10.1002/qj.2062

P14, L13-24: I find this whole section quite speculative, and as I say in the major comments, doesn't really address the differences in Sahel with the rest of the globe (what about tropical areas? Or other semiarid ones that are different?). Also, I'm not sure I agree with "the above relationship is consistent with the negative spatial but positive temporal SMPC". I can see the link with the positive temporal relationship, but why a negative spatial one?

P15, L1: what's the explanation for this conclusion on predictability?

P15, L3-4: 'supports the relevance' I don't understand this sentence. As far as I can tell all of this could be explained just with the spatial relationship.

P15, L7: wouldn't a positive temporal and negative spatial relationship maximise the moisture flux?

P15, L29-32: I don't understand this point. The reason for filtering water bodies and topography is to isolate the role of soil moisture, because it is very likely that water/mountains are much stronger controls.

Figures

Figure 1: I don't understand how/why you regrid the wind data to a finer grid. In any case, you only plot the streamlines for every $\sim 5^{\circ}$, so this seems redundant. I suggest you delete the last line. L2: change 'indicates' to 'shows'. L3: state the longitudes for the zonal mean. Change 'rectangular' to 'rectangle'.

Figure 3: the 'golden shading' is very hard to see. I suggest you replace it with stippling. Also, is it necessary for panel a for the contours to go up to 3000? A smaller range would highlight more detail.

Figure 4: 'rectangular' to 'rectangle'.

Figure 5: This plot is not very clear, as it's very hard to match specific runs to the symbol (as there are so many, and they are so small). My suggestion would be to move this information into a table. Potentially, you could also include a box and whisker plot, with one box and whisker for T12, one for G15, a dot for your study, and potentially a dot for T12 TRMM/merged and G15 TRMM/GLEAM (as these are the closest set of observations to what you use). I think this would give a better overview of how your results compare with the literature.

Figure 6: see my comments on the wetlands above regarding panel a.

Figure 9: it is not clear from the caption what is the difference between panels a and b?

Figure 11: provide a bit more detail on what you are showing in the caption (e.g. Se). x axis is time, not daily rainfall (as far as I can tell), and you should give some measure of what timescales you are showing. Y axis is both soil moisture and rainfall. 'rainfall sums' over what period? In the bottom panel, are these many short rainfall events, or persistent rainfall (it looks like the former as it is presented)?.

Figure 12: I like the idea of including a conceptual diagram, but at the moment I don't really follow its logic (particularly the drawing on the left). It doesn't really explain the

coexistence of the two mechanisms either; in the second step ('soil dries out in A'), presumably you return back to where you were in step 1 before it rains (it won't get drier than when it is dry), so why do you get 'stronger than usual SM gradient'?

Editorial

P2, L15. Delete 'recognized'.

P2, L18: change 'subtle' to 'less clear'.

P3, L4: 'anomaly' to 'anomalies'

P4, L3: change 'inset rectangular' to 'dashed rectangle'.

P4, L25: 'into' to 'in'

P4, L27: 'few studies HAVE'.

P5, L1: 'still JUST A few centimetres'

P9, footnote: 'statistics' to 'statistic' (or 'is' to 'are')

P9, L1-2: 'does not exclude or even favour higher' to 'is not expected to affect the' (if I understand it correctly).

P9, L9: 'coherence' to 'agreement'.

P11, L23: 'AN additional area'

P11, L30: 'increase in THE amount'

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