Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2017-547-RC1, 2017

Hydrology and Earth System Sciences
Discussions

Interactive comment on "A simplified model of precipitation enhancement over a heterogeneous surface" *by* Guido Cioni and Cathy Hohenegger

Anonymous Referee #1

Received and published: 12 October 2017

General Comments:

This paper uses an idealized simulation with prescribed soil moisture gradients to derive a simplified algorithm that represents the amount of precipitation generated by local evaporation and advection terms. The authors note that previous studies have qualitatively shown how soil moisture gradients and atmospheric profile influence precipitation, and state that their goal is to quantitatively isolate the primary drivers of precipitation. I believe their methods, i.e. using an idealized model with prescribed soil moisture gradients, are sound, and their results are relevant.

Overall, I find that the paper convincingly demonstrates the relative important of soil moisture gradients over the absolute magnitude of soil moisture, which makes sense physically, but it glosses over some other important points that deserve more expla-

nation, such as the importance of the atmospheric profiles. Also, the derivation of the algorithm they use seems fine, but needs some clarification in order for the reader to be able to completely recreate their results.

The second stated goal of the paper is to determine "what is the relative role of the atmosphere, or in other words the efficiency in converting these potential moisture sources into precipitation." Terms that represent the efficiency of advection and evaporation are derived, but there is no discussion of how the actual atmospheric profile impacts those terms, which then detracts from the significance of these findings. Also, while the authors cite publications that use the two atmospheric profiles utilized in the model simulations, they do not display them in a figure or discuss them in any way. This leaves the reader wondering what the difference is between them, what the profiles are like, and how these profiles could affect the results. For example, a profile that is more unstable could increase convection and strengthen the circulation, however there is no context like this provided in the paper. Also, I looked up the two profiles in the cited publications and found it difficult to compare them because they are presented in different formats. Because of these oversights, the reader is left unsure why the authors included two different profiles in the first place, and how the atmospheric profile impacts the authors' findings.

Specific Comments:

1. page 3 line 10-12: "the change of precipitation with soil moisture does not depend on the soil moisture content itself and that the most efficient way to increase precipitation consists in increasing the surface wetness gradient.", but page 1 line 8-9: "these changes surprisingly do not depend on soil moisture itself but instead purely on parameters that describe the atmospheric initial state." — is it the atmospheric state or the soil moisture gradient that is most important? Also, see my other comments about the importance of addressing the atmospheric state more thoroughly in the paper.

2. Page 10, Line 11: "In order to test the validity of the theory proposed in section 2"

is confusing. This is stated in section 2, and I'm not sure what the theory is. Suggest repeating what the theory is or otherwise clarifying here.

3. Page 4: Please clarify why the "dry-soil advantage profile of Findell and Eltahir 2003" is used and why it is appropriate for this investigation.

4. Please include an additional figure with the two atmospheric profiles (from Findell and Eltahir 2003 and Schlemmer et al. 2012).

5. Page 4: Please clarify why the Schlemmer et al. (2012) profile is used over a different one, what question is answered by including it in the study, and how it differs from the profile from Findell and Eltahir 2003.

6. Figure 2: This figure takes some time and effort to interpret. It would be easier for the reader if vectors were used in place of windspeed contours and if the "dry" and "wet" sides are labeled. Also, please add a sentence to the text explicitly stating which side in Figure 2 is warmer (and why) and which direction the front is propagating. This all may seem obvious, and is stated more explicitly later in the text, but to the first-time reader it takes time to put it all together while examining figure 2.

7. Page 8 Line 24: Clarify what "the fact that one efficiency doesn't match well" means. Which efficiency? And it doesn't match well with what?

8. Page 8 Line 29: which sounding is "another sounding?". Also see previous comments about soundings. This would be a good place to spend some time discussing what it is about the two profiles that result in efficiencies that are higher than with the first sounding.

9. Page 9 Line 2: "a weaker sensitivity of that particular atmospheric state" ....see above comments about the atmospheric profiles. This reference is too vague, and needs more explanation.

10. Page 10 Lines 18-19. This is the first point that the soil type is referenced. The data and methods should include a sentence stating the soil type used in the simulation, the

reason why it is used, and its field capacity.

11. Page 12: The derivation of beta needs some more explanation. Was it derived using a best fit method from Figure 3? I'm not sure.

12. As a reader, it was difficult to get through sections 4.2 and 4.3. There were some jumps in the logic between equations that were hard to follow, and not all terms were defined (see above). I think if the authors revisit these sections and provide more explicit explanations even where they think the transitions should be obvious, it will help the reader finish the paper.

13. Page 15, Line 20: "these parameters depend solely on the atmospheric state." See above comments.

14. Figures 9 and 10: These are important figures. More explanation of these figures is needed, particularly the significance of n_a < n_b (and visa versa) and of beta, and what that means physically. As a reader, I found myself quite bogged down by this point and it was difficult to extract what the authors were hoping to convey with these figures.

Technical Corrections:

Page 1 Line 1-2: For clarity, I suggest rewording the first sentence of the abstract to read "Soil moisture heterogeneities influence the onset of convection and subsequent evolution of thunderstorms producing heavy precipitation through the triggering of mesoscale circulations."

Page 1 Line 6: Suggest rewording to read "A key element of the model is the representation of precipitation as a weighted sum"

Page 1 Line 18: Suggest rewording to read "and which can then affect the distribution of precipitation."

Page 2 Line 17: Please clarify what is meant by "a negative spatial coupling coexists

together with a positive temporal coupling."

Page 3 Section 2.1 heading: Is the subheading "2.1 Experimental Design" needed here? There are no other subsections in Section 2.

Page 3 Line 3: "overt" should be "over"

Page 6 Lines 6-8: This sentence is difficult to understand. I suggest rewording it.

Page 7 Line 11: "It is immediate to verify" is awkward. I suggest rewording.

Page 8 Line 5: "firstly" should be "first"

Page 8 Line 23: The text states n_a = 0.15 and n_b = 0.10, but Figure 5 states that they are 0.16 and 0.11, respectively.

Page 10 Line 19: what is "the expected one"? Please clarify.

Equation 6: I couldn't find a definition for L_front anywhere in the text. Please include a definition here.

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