Hydrol. Earth Syst. Sci. Discuss., 6, C3336–C3341, 2010
www.hydrol-earth-syst-sci-discuss.net/6/C3336/2010/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Contribution of soil moisture feedback to hydroclimatic variability" *by* N. Y. Krakauer et al.

N. Y. Krakauer et al.

nkrakauer@ccny.cuny.edu

Received and published: 13 February 2010

We thank the reviewers for their careful reading, and appreciate the opportunity to submit a revised and improved version of our paper. Our responses to the points raised are as follows:

1 Review 1:

a) *It will be better if the authors choose some regions, e.g., Illinois and Oklahoma, with enough soil moisture and precipitation observation to evaluate the model simulations.*

We have added a fuller description of work comparing GISS GCM output with station measurements of soil moisture and of water fluxes: "The GISS ModelE land surface model has been calibrated against measured evaporation fluxes from several FLUXNET sites representing different biomes, which has yielded regionally reduced biases in temperature, cloud cover, and precipitation fields relative to previous versions (Friend and Kiang 2005). . . . Compared to observational time series of 20th Century soil moisture, the performance of GISS ModelE was comparable to that of other general circulation models that have contributed to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change: the mean seasonal cycle of soil moisture was generally well represented, but the decadal-scale increase in soil moisture seen in sites in Russia and the Ukraine was not captured, perhaps because the model forcing fields underestimate the magnitude of solar dimming due to aerosol pollution, which has regionally reduced evaporation (Li et al. 2007)."

b) *For model–data comparison, a reference is suggested:*
Dirmeyer P. A. et al., 2006: Do global models properly represent the feedback between land and atmosphere? J. Hydrometeorol., 7, 1177–1198, doi:10.1175/JHM532.1.

We added the citation.

c) *In discussion section, the authors mentioned that "the model soil layer can be many meters deep . . . , and trees are found to access water down to 10 m depth . . . ". A little bit more discussion may be added. Suggest a reference:*
Niu, G. Y., et al., 2007: Development of a simple groundwater model for use in climate models and evaluation with Gravity Recovery and Climate Experiment data, J. Geophys. Res., 112, D07103, doi:10.1029/2006JD007522.

We added the citation.

d) *In section 3.1 Mean state, 4th paragraph, first two lines (p6975): "Cloud fraction decreased by 0.2% over land, concentrated during spring and summer, . . . ". However, Table 1 indicates that cloud fraction increases during summer.*

Table 1 shows that cloud cover is reduced in the DYNA integration as compared to the CLIM integration, but that the interannual variability of cloud cover increases in the DYNA integration.

2 Review 2:

a) *since, as the authors agree, soil models can be biased and could not represent non-linear interactions between soil and atmosphere corretly, they should discuss into more extent the performances for the soil model they used*

We now include additional discussion and references on the treatment of soil water and evaporation rates in the GISS land surface model.

b) *plots are presented with different scales depending on the seasons, they should be the same to allow a quicker interpretation*

We now use the same color scale for all seasons in each plot.

c) *there is and issue about how statistical significance of differences is computed. The authors are implicitly assuming that the two variance is the same. This is actually false, in fact it is one of the results of the paper. I suggest a t-test or better a non-parametric test like Mann-Whitney.*

We now discuss this interesting issue in the Methods section: "In this method of estimating the significance level of differences between CLIM and DYNA, the across-run variance was estimated from an ensemble of runs with dynamic soil moisture. Thus,

we in effect assume that the across-run variability for integrations with climatological soil moisture is similar to that for integrations with dynamic soil moisture. Insofar the variance of an ensemble of runs with identical, climatological soil moisture might be expected to be smaller because specifying the soil moisture removes one of the potential drivers of variability between runs, our estimates of the significance of differences seen between CLIM and DYNA runs would be conservative."

d) *fig 9: why are there differences in the antarctic continent?*

These could be real (while there is no significant difference in evaporation from Antarctica between the two runs, soil moisture feedback at lower latitudes could, for example, induce changes in circulation regime that affect temperature patterns) or chance (as per the caption to Figure 1, differences that are significant at the 0.1 level are shown, some of which may be spurious).

3 Review 3:

a) *While you thoroughly address differences between your results and those of other studies in the Discussion section, I would encourage you to elaborate on how your experiments differ from past work and why the inconsistencies/weaknesses of previous findings make this study relevant (which I believe it is) in your Introduction.*

We have tried to discuss the background to this study more fully in the Introduction.

b) *Because a portion of the Results and Discussion hinges on the representation of evapotranspiration in GISS GCM ModelE, it would be nice to have another few sentences in the Methods section describing the relationship between soil moisture and evaporation/transpiration in ModelE.*

We have elaborated our description of this aspect of the model.

c) *Pg. 6968, Ln. 7 - Why is "evaporation" (as opposed to "evapotranspiration") used throughout the paper? I assume you are using the terms interchangeably, but it would be good to note that in the manuscript.*

We are using the terms interchangably, and have added a clarification to this effect.

d) *Pg. 6973 - Do the CLIM runs close the water budget? If so, how? Was excess precipitation run off? And was water added when precipitation was not available to wet soils?*

We now elaborate on this: "The standard GISS ModelE land surface model, as used in the DYNA integration, conserves water mass, in the sense that the change in water stored in the soil, canopy, and snowpack over any time period is equal to precipitation minus evaporation and runoff. The atmospheric model also conserves water, in that the change in atmospheric water vapor content is equal to evaporation minus precipitation. In the CLIM integration, the land surface model does not conserve water, because the soil moisture is kept at climatology regardless of how much water percolates or runs off, although the atmospheric model continues to conserve water."

e) *Pg. 6978, Ln. 20 - I am unclear as to why the correlation length scale of temperature over the ocean should change at all given fixed SSTs. Possibly the difference is surface versus near-surface temperature?*

Yes. We looked at the response of surface air temperature (at 2-m elevation, by meteorological convention) to soil moisture feedback. Surface air temperature is influenced both by local sea surface temperature and by advection, and is therefore not completely determined by the sea surface temperature field.

f) *Pg. 6981, Ln. 2-8 - This statement is interesting, but may need further qualification. If you have a high soil water capacity and a relatively insensitive evapotranspiration response to soil moisture, then this is likely true. But depending on your representation of soil moisture you might also dry out your soils on a soil water fraction basis. One way*

I thought of your experiment was that you were basically assigning a seasonal cycle to the response of evapotranspiration to soil moisture.

A high-enough soil water capacity would mean that typical seasonal-scale interannual fluctuations would only affect soil water content by a small fractional amount. In our experiment, soil water content was set to be constant from year to year (in the CLIM run). Nevertheless. evapotranspiration varied from year to year in response to, for example, variations in humidity and windspeed.

g) *Table 1 - Why is standard deviation normalized by the mean for all variables except temperature?*

Meteorological temperature fluctuations are not commonly reported in normalized terms, probably because the 'baseline' temperature is fairly constant worldwide (ranging from say 230 to 300 K) compared to mean precipitation and evaporation (which range over at least a factor of 100).

h) *Figures 1-10 - Font of titles, axes numbers/labels, and scale numbers needs to be larger.*

Done.

i) *Figure 5 - Break into multiple figures, panels are too small.*

We can split Figure 5 into two to help make it is easier to read, but we expect this to be less of a problem in the final publication because of the bigger page size.

All technical comments have also been addressed.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 6967, 2009.