

Interactive comment on “Sensitivity of the West African hydrological cycle in ORCHIDEE to infiltration processes” by T. d’Orgeval et al.

T. d’Orgeval et al.

Received and published: 22 October 2008

The authors would like to thank the referee for his detailed comments that help to improve the quality of the article. Below are the answer to the different questions.

Questions - Why are the 13 different vegetation types with parameters given in Table 1 if they are not used as such but are grouped into three ensembles for use in the simulations. Why not give representative parameter values for the three ensembles?(p.2255, lines 16-22)

ANSWER: Transpiration and interception loss are computed separately for the 13 different vegetation types with the given parameters but the induced throughfall and root uptake are aggregated per vegetation ensembles in order to provide the sources and

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sinks of water for the three different tiles in a grid box. In the corrected version this distinction is explained.

- What is the size of the "gridbox" as used in line 22, p. 2255? Do the three tiles make up one gridbox? What is the difference between grid box and grid point? How does the 0.5o x0.5o base map mentioned in line 17 (p. 2257) correspond with the 1o x 1o scale forcing data mentioned in line 18 (p.2259).

ANSWER: The main distinctions are: 1. Grid box indicates the 1x1 degree scale of the forcing. This is the scale at which the energy balance is computed. 2. 3 tiles effectively make up one grid box. The hydrological balance is computed at this scale. 3. Finally, the routing is computed a scale of 0.5x0.5 degree. The revised paper is corrected to clarify this point. The expression "grid point" is removed from the article as it has no meaning in the context.

- Provide more explanation on "Parameters have been fixed in accordance with validations against Hapex-Sahel observations" (line 25, p. 2255). Calibration of ORCHIDEE is not very well described in this paper.

ANSWER: There was no specific calibration of ORCHIDEE for this article. The version used here is the same as in d'Orgeval and Polcher (2008). The developments that led to this version of ORCHIDEE consist in the introduction of 3 infiltration parameterizations. The rest of ORCHIDEE was not changed or recalibrated for this article. Concerning the infiltration parameterizations, simulations forced by Hapex-Sahel observations were performed for different sets of parameters. It allowed to distinguish the respective roles of the three parameterizations:

1. Surface reinfiltration has a short term impact mainly on bare soil evaporation. s_{max} was therefore fixed in order to obtain reasonable simulations of evaporation for the bare soil site of hapex-sahel.

2. Deep-soil infiltration determines the way transpiration respond at a longer term to

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precipitation. Here, the parameterization was inspired by Decharme et al, and it was validated with a special emphasis on the way evapotranspiration declines at the end of the rainy season.

3. Rootzone infiltration has an important role for the transpiration changes over a few days. The parameterization was inspired by the deep-soil one, but parameters were fixed in order to obtain similar evapotranspiration variability as in Hapex-Sahel observations. This calibration is described in more details in d'Orgeval (2006). In the revised version, each subsection describing the parameterization contains a sentence summarizing the way ORCHIDEE was parameterized.

- What is meant with (line 9, p. 2257) "the fraction of vegetation type v on the tile"?

ANSWER: The "fraction of vegetation type v " refers to the 13 vegetation types, whereas the tile refers to the part of the grid box corresponding to a single hydrological balance (see the answer to the second question).

- Are the sub-basins referred to in line 15 (p. 2257) the same as the basins B, B', B"; of Figure 1?

ANSWER: Yes. A reference to the figure is added in the revised version, and "sub-basins" was replaced by "basins".

- Is ORCHIDEE as used in Section 3.2 in its original form, i.e. without the new infiltration parameterizations?

ANSWER: No. ORCHIDEE. On page 2259, line 23-25, we indicate that "The version of ORCHIDEE used in GSWP2 (de Rosnay and Polcher, 1998) is older than the one described in Sect. 2 and compared to the multi-model mean in the next subsection." This sentence is clarified in the revised version; it means that the version without the new parameterizations only participates to the multi-model mean and is not shown individually in this article.

- I wonder whether the authors can explain what is meant with "structural resistance"

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and how it is due to the vertical structure of leaves. How is this different from the canopy resistance? (p. 2260, line 25).

ANSWER: The structural resistance roughly represents the impact of the 3D structure of the canopy on local turbulence and on the vegetation-atmosphere transfers, whereas "canopy resistance" is used to describe the bulk stomatal resistance. This is explained with more details in de Rosnay and Polcher (1998). In the revised version, the sentence is changed to clarify this point.

- The fact that the catchment size as estimated by the ORCHIDEE procedure can be in error by as much as 20% (see p.2263, line 21) makes me wonder about the accuracy of the location/size of the floodplains and ponds and the appropriate vegetation patterns (see Section 4.3). This clearly also has a bearing on the uncertainty associated with the soil map.

ANSWER: The error may be high for two reasons:

1. the routing map is too coarse. Indeed the routing is computed at a scale of 0.5x0.5 degree. As the border between two basins does not follow the 0.5x0.5degree limits, the partitioning of water at the edge of a catchment may be inaccurate. However, this is negligible for large basins such as the ones used in this study. Moreover, the misplaced areas are generally not areas with ponds or floodplains, but consist in mountainous areas.

2. the border of large catchments in the desert are not well defined. Therefore, the most uncertain catchment sizes are obtained for Dongola (Nile) and Malanville (Niger) for their border in the Sahara. However, this has no impact on the river flows and on the analysis because no water is received from the misplaced area.

- The last four lines of the Conclusions (p. 2273, lines 4-7) refer to the structuration (??) of the AMMA project and the need for improved insight into the link between various scales and the means to validate regional parameterization of small scale processes.

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I did not see much evidence in this paper of linking various scales and any validation was done at very large scale indeed.

ANSWER: The parameterization of ponds for example are inspired by small scale processes that have been documented on the field inside the Niamey grid box. The idea in section 4 is therefore to test the impact of these small scale features (ponds of a few tens of meters) at large scale (the large Malanville catchment). Similarly, the parameterization of rootzone infiltration represents the fact that increased porosity linked to the presence of roots will help water to infiltrate in the presence of vegetation. This was particularly observed in the tiger bush systems in the Sahel, which consist in an alternance of sand bands and bush rows on a low slope. The above-mentioned parameterizations were discussed with small scale hydrologists within the AMMA project before their implementation in the ORCHIDEE Land Surface Model. And even if their effect is not tested at a larger scale than the Dongola, Malanville or Kinshasa catchments, the results suggest that their impact at larger scales should be non-negligible.

Minor comments

ANSWER: To every minor comment below corresponds a correction in the final version of the article. Every suggestion by the reviewer has been accepted. When there is no suggestion, the correction has been made by the authors (see the final version). The questions raised are answered in the revised version of the article.

p.2252 4: "resulting version". Resulting from what? 9, 10: why distinguish here between basins and regions? 14: "could be recalibrated". Replace with "was calibrated" or "has been calibrated"

ANSWER: This sentence was removed as it was not clear. In fact ORCHIDEE was not calibrated specifically.

18,19: "denser monitoring at different scales" What is meant with this? 19: "calibration of the infiltration parameterizations"

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p2253 1: though? 18: replace "corresponding to" with "which relate to" 19: "in the vertical part"? 28: "seems so determinant". Do you mean "appears to be of such significance"? 29: "in the horizontal part"?

p2254 2: "in an original routing scheme"? You mean "a new routing scheme"? 3: the world's 10 largest river basins 8: across the globe 9: At a smaller scale. 15: Should "processes" be replaced with "pathways". (A pond is not a process) 18: large-scale 22: delete "introduced" 24: sub-regions in West Africa 25: in river basins across Africa 26: "and ways to improve"

p2255 9: The vertical diffusion of water. 11: maximum upward hydrological flux 13: Water extraction from roots... 23, 24: New parameterizations have been introduced to represent three infiltration processes (surface infiltration, deep-soil infiltration and rootzone infiltration) that are considered to be important to...

p2256 2: on the slope of the land surface... 5: with the reinfiltreated fraction (θ) given by ... 7: Integration of θ over the grid box gives... 9: with depth (z) 17: where $z_s=0.5\text{m}$ 18: inconsistency 19-21: This is unclear and needs rephrasing.

p2257 8: Carsel and Parrish (1988). Is it Carsel or Carsell? 8: above-mentioned? 9: is tile equivalent to grid box (0.5 x0.50) 16,17: explain "with a different time constant"

p2258 2: swamps 12: mainly? 13: a hypothesis is made about the shape 17: where SB is the ...

p2259 3: first-order 20: spin-up or spin up 20: three consecutive years (not y!) of spin up 23-25: "and compared to"??

p2260 2: surprised to see that W.Africa goes all the way to 30oE! 7: drier than what? 9: "is the beginning of the desert" You mean "on the edge of" or "at the margin of"? 22: is far less than the ET estimated with the other models 27: leaves

p2261 13: significant source of.. 27: resulting? 28: consists of a

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p2262 14: On the opposite? 16: Those two features..

p2263: 7: consists of... 18: errors in 20: error in

p2264 10: Then? You mean "Next"? 11: What is meant with "different sources of sensitivity"? Sensitivity is a measure of the response to changes. Perhaps you mean the "sensitivity to (changes in) forcing, different parameters and parameterizations" 16: Before describing? conducting? the sensitivity tests for the infiltration processes... 21: ...was available for two pairs of years... 26: consists of...

p2265 19: "...improved with currently available data" 24: However, this sensitivity test is somewhat limited because both maps come...

p2266 18: first-order

p2267 3: experiments 17/18: ...for a much smaller catchment size. 22/23: An example of the annual cycle... p2268 2: is the orography of these basins. p2269 4: drainage below the rootzone. 7: bare soil evaporation+runoff represents respectively.. 8/9: (transpiration+drainage represents respectively...

p2270 3/4: ..no analysis..was carried out... 10/11: by a canopy structural resistance that is too high, resulting in a decrease in transpiration... 12: ...by reducing the canopy structural resistance... 13:.. It would also cause ORCHIDEE to yield results which are closer to those obtained with the other LSMs in GSWP2. 23/24: rephrase: "...there is no element that leads to..." Element?

p2271 5: first-order 9: ..major part of the error... In what? 21: One assesses or investigates the sensitivity; or performs a sensitivity analysis. 24: Next, ORCHIDEE simulations of...

p2272 4: .. the uncertainties associated with the vegetation map, the soil map and... 13/14: Indeed, if parameterizations were changed or new parameterizations added, it... 25: may also be addressed...

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p2273 4: what is meant with structuration? 6: by offering a means...

p2275 14: I think that it is likely that V. Charles should be replaced by C. Vorosmarty?

Table 1: How are root coefficient c and structural resistance r_s defined? Figure 1: Line 4: surface area Line 7: water flows out of each reservoir Figure 2: Add Hydrology and Routing to the Figure as in Fig. 1 Line 3: surface areas Line 5: "receive a fraction $\frac{1}{2}$ of the runoff..

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 5, 2251, 2008.

HESSD

5, S1546–S1553, 2008

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