Biogeosciences Discuss., 8, C6259–C6268, 2012
www.biogeosciences-discuss.net/8/C6259/2012/

Biogeosciences Discussions

Interactive comment on "Role of land surface processes and diffuse/direct radiation partitioning in simulating the European climate" *by* E. L. Davin and S. I. Seneviratne

E. L. Davin and S. I. Seneviratne

edouard.davin@env.ethz.ch

Received and published: 2 April 2012

We thank reviewer #1 for the helpful comments, which are reproduced below. Our responses are provided after each comment and the modified/new figures are shown at the end of the document.

Major comments:

1. The authors need to address the internal variability of the COSMO-CLM. What is the internal variability of these simulations and is the inclusion of the diffuse fraction within the scope of the internal variability of the model? This does not necessarily require additional simulations; the authors could cite other literature for this specific model.

Response: We added a new figure (now figure 9) to address the question of the internal variability in the model. This figure shows the standard deviation and correlation in reference to E-OBS (Taylor diagram) and its aim is to put into perspective the impact on temperature variability due to the diffuse/direct modification versus the impact of the full replacement of the LSM. It appears that the impact on temperature variability arising from the diffuse/direct modification is modest compared to the impact arising from the replacement of the LSM. The following new paragraph has been included in section 3.2.4: "To put these results in a more general context, we compare the impact of diffuse/direct partitioning alone versus the overall impact of changing the LSM on temperature variability. The model performance in terms of standard deviation (normalized) and correlation is shown for experiments v4.8-TERRA_ML, v4.8-CLM3.5 and v4.8-CLM3.5-dif in the form of a Taylor diagram (Figure 9). Over most regions and at both monthly and daily time scales, temperature variability is reduced (and often closer to observations) when using CLM3.5 instead of TERRA_ML. Accounting for variations in diffuse/direct ratio at the surface (v4.8-CLM3.5 compared to v4.8-CLM3.5-dif) tends to improve the model performance in terms of correlation with observations. It also slightly increases temperature variability for the majority of regions, which is in line with incorporating an additional source of variability. But the overall influence on temperature variability remains quantitatively modest in view of the bigger impact brought about by the full replacement of the LSM."

2. The model evaluation of the diffuse light fraction is too brief and requires more detailed explanation. A few points of discussion needed in Section 3.2.1: (a) The sites presented for model evaluation are located at high latitudes, where one might expect the amount of diffuse radiation to be higher and its impact more important – e.g., a total incoming radiation amount of 300 W m-2 as in Figure 7 is exceptionally low. Can any sites in the southern part of the domain be located for evaluation? (b) The Carpentras site is often biased high – is this correlated with cloud cover discrepancies? (c) In contrast, the Peyerne site shows improved agreement, and an explanation for these higher values is needed.

Response: a) At the scale of Europe, the sites used to evaluate the diffuse light fraction cover a relatively broad range of climates from Carpentras (Mediterranean climate) to Toravere (boreal). Concerning the evaluation of the evapotranspiration sensitivity to diffuse/direct light, the Hyytiala site is the only one offering a relatively long time series (2002-2005) of diffuse fraction and evapotranspiration simultaneously. We added however a paragraph in section 3.2.2 to point out the issue of the representativeness of the Hyytiala site as a limitation for this study: "This comparison with observed data gives an indication that canopy processes are realistically represented in CLM3.5 and that the sensitivity of evapotranspiration to light partitioning is relatively well captured in the model. However, this comparison is limited to a single site, due to the limited availability of relatively long time series of both diffuse light and evapotranspiration at other sites. The site considered here (boreal evergreen needleleaf forest) may not be representative of other ecosystems and future work will be needed to expand such model/data comparison to other ecosystem types and climate zones." b) and c) For all 3 sites, the model shows a tendency to overestimate the diffuse fraction (particularly for Carpentras). This behavior may be related to a too high aerosol optical depth prescribed in the model. The inter-site differences in the bias are likely due to differences in the simulated cloud cover. We added the following paragraph in section 3.2.1: "We note however a tendency of experiment v4.8-CLM3.5-dif to overestimate diffuse fraction (particularly at Carpentras), which might be caused by a too high aerosol optical depth in the model. The aerosol climatology prescribed in the model is indeed known to overestimate aerosol optical depth over Europe (Zubler et al, 2011)."

3. Section 3.2.2: The sensitivity of latent heat to diffuse light is presented for spring and summer data. The authors should discuss the seasonal cycle of latent heat and its components (ground, canopy, transpiration) to understand if this effect is merely a function of ground evaporation or if they can attribute it to transpiration. Also, the representativeness of the Hyttiala site for the full model domain should be discussed (e.g., ecosystem type, canopy type, etc.).

Response: We agree that more explanations of the mechanism behind the evapotranspiration sensitivity to diffuse light will strengthen our point. The ET partitioning can not be examined from the observations, but we can use the model as a framework to interpret the ET response (especially since the model captures well the overall ET sensitivity). We added a new figure (now figure 6b) showing the evapotranspiration partitioning in the model and how the ET components are affected by diffuse light. This shows very clearly that transpiration (and canopy evaporation from intercepted water) and not ground evaporation is responsible for the observed behavior. Section 3.2.2 has been expanded as follows: "For a given amount of incoming radiation, the measured latent heat flux tends to be larger under diffuse conditions. This behaviour is qualitatively and quantitatively well reproduced by the model (experiment v4.8-CLM3.5-dif in Figure 6a). To help understand the underlying mechanism, we examine the sensitivity of the individual evapotranspiration components in the model (Figure 6b). Both transpiration and canopy evaporation (from intercepted water) are increased under diffuse light conditions, due to the more homogeneous distribution of radiation within the canopy with higher diffuse light. This shows that the overall evapotranspiration sensitivity to light partitioning comes from these two components and not from ground evaporation." The representativeness of the Hyytiala site is now discussed (see response above).

4. The model discussion section on the mean climate state (Section 3.2.3) is also too brief and filled with gaps. Suggestions to improve this section: (a) Figure 8 is a confusing mix of absolute values (Figure 8b) and percent changes (Figure 8c), which make it difficult to tell how much of the latent heat change is due to transpiration; (b) the impact on surface temperature (Figure 9) is very difficult to identify as presented in side-by-side figures; these differences should be clear in the figures and potential mechanistic explanations should be provided in the text; (c) the surface temperature changes in Figure 9 should be clearly identified and discussed with respect to earlier conclusions. For example, Scandinavia (where the model evaluation is occurring in Figure 7) shows a broad increase in transpiration, yet shows a marked difference in surface temperatures with cool biases up to 2K over Norway and warm biases up to 2K

BGD

8, C6259–C6268, 2012

Interactive Comment

over Finland; (d) warm biases in the Mediterranean are very large, yet this represents another region where evapotranspiration increases in the model.

Response: Overall section 3.2.3 has been expanded: a) photosynthesis, transpiration and evapotranspiration are now all plotted in terms of relative change (now figure 7). This way one can better appreciate that 1) photosynthesis is more sensitive to diffuse light than transpiration (i.e., increase in water use efficiency with more diffuse light) and 2) transpiration is more sensitive than total ET (due to compensating effect from ground evaporation). b) and c) We added a new sub-figure in Figure 7 showing the temperature difference between the 2 experiments (while keeping the figure showing the temperature bias with respect to CRU; now figure 8). We furthermore added a map of the change in evaporative fraction which provides a mechanistic explanation of the temperature change and also highlights the good spatial correlation between change in evaporative fraction and temperature. d) the increased evapotranspiration (and increased evaporative fraction) does reduce the warm bias in the South, which is now better seen in the figure showing the temperature difference between the 2 experiments.

5. Conclusions, lines 13-15: The authors state that the diffuse inclusion can affect the level of partitioning between sensible and latent heat, yet they do not actually show this in the paper. They show that there is a slight increase in the evapotranspiration and do not show or discuss the partitioning in any detail. Either this should be added to the analysis in Section 3.2.2 or be removed from the conclusions.

Response: As mentioned in the previous response we added a new figure showing the evaporative fraction (figure 7e), which helps interpret the impact on surface temperature.

Minor comments:

1. Model description: The authors mention the convection scheme used (Tiedtke) but I'm assuming that at the resolutions simulated (50km) that some type of representation

of large-scale precipitation is needed.

Response: We added in the model description that: "large-scale precipitation is parametrized with a four-category 1-moment cloud-ice scheme including cloud and rain water, snow and ice."

2. Page 11610, lines 13-17: At the end of this section, the authors state that the bias corrected by the LSM is the same amount as the change in atmospheric components – can this be quantified in the text to support the figures with domain averages? The authors focus on the improved biases north of 50 degrees, and that biases of the opposite sign often increase southern part of the domain (below 35N).

Response: We moved this statement to section 3.1.2 because this point can be made more quantitatively by looking at figure 4 showing the RMSE-scores for temperature and precipitation. From this figure, one can see that the score-improvement brought about by the LSM is typically of the same order of magnitude as the improvement brought about by the atmospheric component. Moreover, looking at the scores for the Mediterranean area there is no indication that biases are increased in this region.

3. Page 11615, line 9-10: does the use of the word "significant" refer to "statistically significant"? If not, then the authors should change their wording. I would disagree with the use of this term here, because the changes are barely outside of the standard deviation and are at exceptionally low light levels.

Response: We didn't want to refer to "statistical significance" therefore we removed this term.

4. Figure 4 seems redundant and unnecessary, or perhaps should be included as supplementary material.

Response: We have removed this figure and rephrased the corresponding paragraph in section 3.1.1

5. Page 11614, line 6: change "evidences" to "evidence"

Response: done

Interactive comment on Biogeosciences Discuss., 8, 11601, 2011.

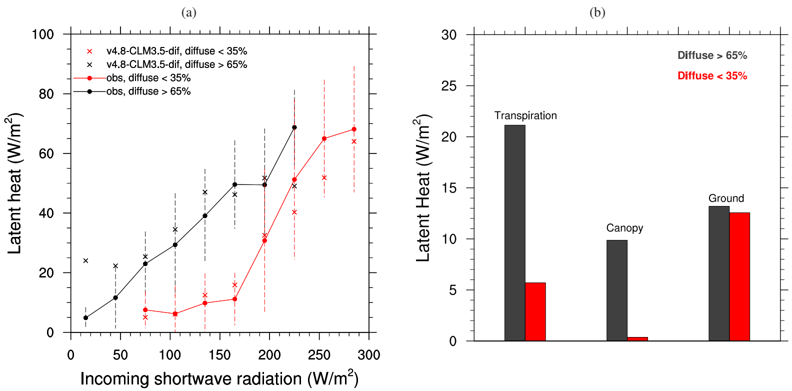

Fig. 6. Latent heat response (observed and simulated) to diffuse/direct light conditions at the Hyytiälä site. a) Latent heat evolution as a function of incoming shortwave radiation for predominantly diffuse light conditions (black) and predominantly direct light conditions (red). The points represent the mean latent heat for specific radiation bins based daily means over the period 2002-2005 restricted to spring and summer (growing season). The standard deviation of the observation is also shown. Diffuse and direct conditions are defined as diffuse light fraction above 65% and below 35%, respectivelly. b) Individual evapotranspiration components in the model and their sensitivity to light conditions. The plotted values are averaged over the 100-200 shortwave radiation range using the same underlying data as for a).

20

Fig. 1. New Figure 6

BGD

8, C6259–C6268, 2012

Interactive Comment

BGD

8, C6259–C6268, 2012

Interactive Comment

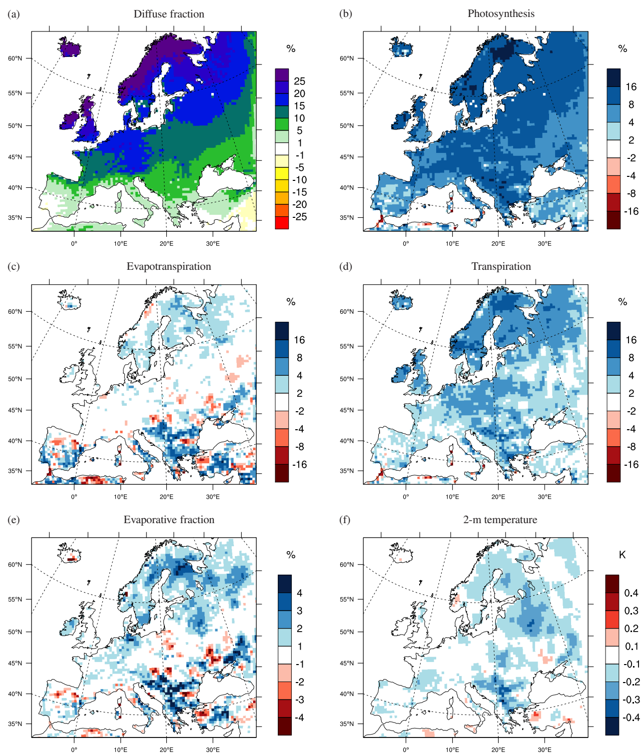

Fig. 7. Summer (JJA) mean change (v4.8-CLM3.5-dif minus v4.8-CLM3.5) for a) diffuse fraction (%), b) photosynthesis (relative change), c) evapotranspiration (relative change), d) transpiration (relative change), e) evaporative fraction (%) and f) 2-meter temperature (K). The considered time period is 1986-2006.

21

Fig. 2. New Figure 7

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

BGD

8, C6259–C6268, 2012

Interactive Comment

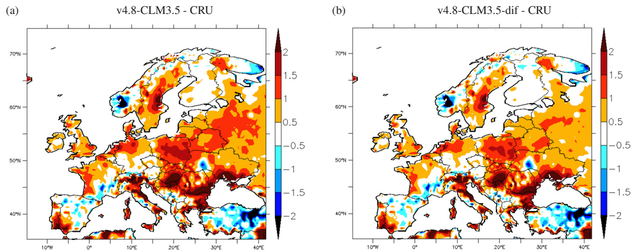

Fig. 8. Summer (JJA) mean 2-meter temperature bias (model minus CRU) for experiments v4.8-CLM3.5 and v4.8-CLM3.5-dif. The considered time period is 1986-2006.

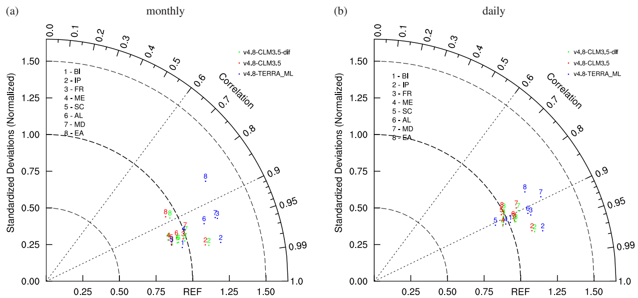

Fig. 9. Taylor diagram for 2-meter temperature displaying the correlation and ratio of variance (normalized standard deviation) in reference to E-OBS. The statistics are shown for different regions and are based on a) monthly and b) daily means for the summer period (JJA).

22

Fig. 3. New Figure 9

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper