Associate Editor

Please implement the requested changes of referee #1 in your manuscript.

Response:

We have implemented the changes requested by referee #1. We have also revised the English, especially in the Introduction, and made editorial changes in the Abstract.

Reviewer 1

Comment 1.1:

Overall, the authors have addressed all comments, but some points could still be improved. The explanation on the rescaling is appreciated, but answers like 'remaining problems would be solved after the final BG copy editing phase' and the fact that the Fluxcom website is running, but the authors did not update their results, are somewhat disappointing. Therefore, I strongly encourage the authors to update the results for the extended GPP data; a revision is an ideal chance for it to make the paper more wholesome.

Response 1.1:

Many thanks for your suggestions aiming at further improving the manuscript.

In our response we wrote 'Changes have been made to correct the noted problems. Remaining problems would be solved after the final BG copy editing phase.' and we acknowledge that this is not clear. It should read: "We did our best to correct typos and the English. The final copy editing phase will help finalize this process." We have revised the English, especially in the Introduction, and made editorial changes in the Abstract.

In our response we wrote 'Regarding the data access for FLUXCOM, when conducting the analysis, the data was not accessible, and only the data that had been already downloaded was used. However, it looks like the FTP is now running without any access issues.' Unfortunately, the first author has changed position and we do not have resources to integrate more FLUXCOM years into the analysis right now. It must be noticed that there was a word of caution that interannual variability patterns of FLUXCOM data may not be completely realistic (Jung et al. 2020).

We propose to replace on L. 285 of the revised manuscript

"FLUXCOM GPP is available globally at 0.5° x 0.5° resolution, and from 1980 to present, however this study only uses data up to 2013 due to lack of data access."

by

"When this study was performed, the global FLUXCOM GPP data at 0.5° x 0.5° resolution were available from 1980 to 2013. It must be noticed that there was a word of caution that

interannual variability patterns of FLUXCOM data may not be completely realistic (Jung et al. 2020).”

For Figures 4 to 10, the periods of time that are considered are now indicated.

Reference:

Jung, M., Schwalm, C., Migliavacca, M., Walther, S., Camps-Valls, G., Koirala, S., Anthoni, P., Besnard, S., Bodesheim, P., Carvalhais, N., Chevallier, F., Gans, F., Goll, D. S., Haverd, V., Köhler, P., Ichii, K., Jain, A. K., Liu, J., Lombardozzi, D., Nabel, J. E. M. S., Nelson, J. A., O'Sullivan, M., Pallandt, M., Papale, D., Peters, W., Pongratz, J., Rödenbeck, C., Sitch, S., Tramontana, G., Walker, A., Weber, U., and Reichstein, M.: Scaling carbon fluxes from eddy covariance sites to globe: synthesis and evaluation of the FLUXCOM approach, Biogeosciences, 17, 1343–1365, https://doi.org/10.5194/bg-17-1343-2020, 2020.

Comment 1.2:

It would also be good to have a more nuanced view on the impact of soil moisture data assimilation. There are many studies that have shown benefits of assimilating SMOS, SMAP or ASCAT SSM retrievals (or even brightness temperature) to improve soil moisture in state-of-the-art land surface models (often over the US, Canada, Australia). It is not trivial why this study shows comparatively so little impact and it would be great for future researchers to frame this result a little more, i.e. to clarify an apparent contradiction. Perhaps it is just that there are less good reference data in Europe, or less variability in climate, or is the vertical coupling strength of the ISBA model just less than other models?

Response 1.2:

The detrimental effect on the assimilation of decoupling of surface soil moisture was described in past studies and is not specific to the ISBA LSM. For example, Capehart and Carlson (1997) shows that decoupling is caused by strong evaporation rates, with or without a vegetation cover. However, a limitation of the standard version of ISBA used in this study is that a single composite soil-vegetation energy budget is used and the effect of plant residues on evaporation and on surface temperature is not represented. A new version of the ISBA model includes a multiple energy budget together with a representation of litter in forests (Napoly et al. 2017), that will be generalized to low vegetation in the next version of SURFEX. Using this new capability could improve the benefit of assimilating SMOS (Soil Moisture and Ocean Salinity), SMAP (Soil Moisture Active Passive) or ASCAT (Advanced Scatterometer) SSM retrievals or level 1 observations.

This was indicated in Section 4.3:

“The small impact of assimilating SSM can be explained by the fact that we use a state-of-the-art land surface model able to represent diffusion processes into the soil. In dry conditions, the simulated SSM is decoupled from soil moisture of deeper soil layers. As a

result, assimilating SSM has a limited impact on the model state variables (Parrens et al., 2014). On the other hand, directly assimilating LAI impacts deep soil layers and a more efficient analysis of root-zone soil moisture can be done than assimilating SSM alone (see also Fig. 4 in Albergel et al. (2017)).”

was replaced by

“The small impact of assimilating SSM can be explained by the fact that we use a state-of-the-art land surface model able to represent diffusion processes into the soil with many layers. In dry conditions, the simulated SSM is decoupled from soil moisture of deeper soil layers. As a result, assimilating SSM has a limited impact on the model state variables (Parrens et al., 2014). On the other hand, directly assimilating LAI impacts deep soil layers and a more efficient analysis of root-zone soil moisture can be done than assimilating SSM alone (see also Fig. 4 in Albergel et al. (2017)). The detrimental effect on the assimilation of decoupling of surface soil moisture was described in past studies and is not specific to the ISBA LSM. For example, Capehart and Carlson (1997) showed that decoupling is caused by strong evaporation rates, with or without a vegetation cover. However, a limitation of the standard version of ISBA used in this study is that a single composite soil-vegetation energy budget is used and the effect of plant residues on evaporation and on surface temperature is not represented. A new version of the ISBA model includes a multiple energy budget together with a representation of litter in forests (Napoly et al. 2017), that will be generalized to low vegetation in the next version of SURFEX. Using this new capability could improve the benefit of assimilating SMOS (Soil Moisture and Ocean Salinity), SMAP (Soil Moisture Active Passive) or ASCAT (Advanced Scatterometer) SSM retrievals or level 1 observations.”

References:

Capehart, W., and Carlson, T.: Decoupling of surface and near-surface soil water content: A remote sensing perspective, Water Resources Research, 33, 1383-1395, https://doi.org/10.1029/97WR00617, 1997.

Napoly, A., Boone, A., Samuelsson, P., Gollvik, S., Martin, E., Seferian, R., Carrer, D., Decharme, B., and Jarlan, L.: The Interactions between Soil-Biosphere-Atmosphere (ISBA) land surface model Multi-Energy Balance (MEB) option in SURFEX - Part 2: Model evaluation for local scale forest sites, Geoscientific Model Development, 10, 1621-1644, https://doi.org/10.5194/gmd-10-1621-2017, 2017.

Comment 1.3:

Finally, the text change about updating vegetation in dynamic vegetation models is now a bit confusing (L.58). The provided references (Vreugdehil, Lievens, …) do not perform vegetation updating in a dynamic vegetation model – that type of research might be ongoing. Perhaps rewrite without the references as “LAI, for example, could be constrained…” (and leave the references out, or feature references that actually do this).

Response 1.3:

We agree.

"LAI, for example, can be constrained indirectly in LSMs capable of dynamically simulating vegetation, through the assimilation of LSVs such as brightness temperature (Vreugdenhil et al., 2016; Sawada et al., 2020) and radar backscatter 60 (Lievens et al., 2017; Shamambo et al., 2019)."

was replaced by

"LAI, for example, could be constrained indirectly in LSMs capable of dynamically simulating vegetation, through the assimilation of microwave observations (Lievens et al., 2017; Shamambo et al., 2019)."