Responses to Reviewer #2

- “The study is well structured with a clear presentation of results. However, the accuracy of the LAI product used in the paper needs to be examined over the study area and especially in the Landes forest region. On L362-363: “Before the storm, the LAI of the pine forest presents a marked annual cycle and ranges from 1.2 m²m⁻² at wintertime to 4.5 m²m⁻² at summertime”. This is in contrast to small seasonal variations of LAI based on field measurements in evergreen needleleaf forests in other studies, such as in Heiskanen et al [2012] (Heiskanen, J., M. Rautiainen, P. Stenberg, M. Mõttus, V-H Vesanto, L. Korpela, T. Majasalmi, Seasonal variation in MODIS LAI for a boreal forest area in Finland, Remote Sensing of Environment, 2012, https://doi.org/10.1016/j.rse.2012.08.001). I wonder whether this is due to the use of the coarse resolution LAI data (0.25x0.25deg) in the study? So that the LAI is from mixed land cover types instead of pure pine forest. I suggest the authors examine the LAI data at its original 1km resolution over the Landes forest area, and see if the seasonality of the LAI for pine forest is reasonable relative to field measurements. If it does, then they can focus their analyses on relatively pure pixels of pine forest at 0.25deg resolution.”

RESPONSE 2.1:

In this study, the Copernicus Global Land Service (CGLS) LAI is used. This product has many advantages. It does not present the unrealistic large variations observed in MODIS products (e.g. Heiskanen et al. (https://doi.org/10.1016/j.rse.2012.08.001), Brut et al. (https://doi.org/10.5194/bg-6-1389-2009), Li et al. (https://doi.org/10.3390/s150306196)). Also, this product is less prone to saturation effects than MODIS and compares much better to reference LAI maps containing ground observations (Li et al. (https://doi.org/10.3390/s150306196)).

The satellite-derived LAI values for the unperturbed forest are consistent with typical values observed over the Landes forest. Using in situ observations over a mature (30 years) forest stand of the Landes forest, Rivalland et al. (https://doi.org/10.5194/angeo-23-291-2005) showed that total LAI can vary from 1.8 m²m⁻² in February to 4.2 m²m⁻² at the end of July (Figure 2.1). They also showed that a key driver of the LAI seasonal cycle is the understory vegetation which has no green leaves at wintertime and has a LAI of about 1.5 m²m⁻² in July. This large contribution of the understory to the total LAI is not always observed in coniferous forests.

For example Heiskanen et al. showed that the maximum LAI of the understory vegetation of a coniferous forest in southern Finland ranges from 0.2 to 0.8 m²m⁻². This could explain why they observed small seasonal variations of LAI based on field measurements.

Figure 2.1 – In situ observations of tree and understory vegetation over a mature stand of the Landes forest. Reproduced from Figure 1 in Rivalland et al. 2005.
Figure 2.2 shows that the CGLS LAI observed in 2007 is consistent with the in situ observations of total LAI showed in Figure 2.1. The smaller wintertime values observed in the satellite-derived LAI before the storm (1.2 m$^2$m$^{-2}$ against 1.8 m$^2$m$^{-2}$ in Rivalland et al.) could be explained by the fact that not all forest stands are mature. After the storm, LAI values are much reduced. The annual maximum LAI value is reduced by 1 m$^2$m$^{-2}$.

These elements were included into the Discussion section.

Figure 2.2 – CGLS LAI before (2007) and after (2009) the Klaus storm over the Landes forest area most affected by the storm.

- “The writing of the paper can be improved. For example, in several places the paper describes that the observed $\sigma^*$ values are compared to simulated (in the abstract), and the observed are lower than the simulated (e.g. L379). Given the observations are used as the reference, I suggest the authors re-write such sentences.”

  **RESPONSE 2.2:**
  Thanks for noting this. It was corrected. The Abstract was completely rewritten.

- “L305, change “that” to “than” ”

  **RESPONSE 2.3:**
  Thanks for noting this. It was corrected.

- “L322-323, note the observed $\sigma^*$ is used as reference, I suggest change the sentence to something like the simulated $\sigma^*$ values at springtime are systematically higher than the observed...”

  **RESPONSE 2.4:**
  Thanks for noting this. It was corrected.

- “L334-344, I wonder if it would be more informative and/or straightforward to simply plot time series of $\sigma^*$ and LAI for the Landes forest to show the changes before and after the storm? I understand this is to follow Teuling et al [13], however, that study was to present the evidence of cloud cover enhancement over the forested region relative to non-forested agriculture areas. What are the advantages of using the difference here?”

  **RESPONSE 2.5:**
  Plotting the time series of $\sigma^*$ for the Storm area was done (see Figure 2.3) but this figure was not shown because the impact of the storm was not clearly visible on the forest $\sigma^*$ alone. The $\sigma^*$ time series are sensitive to rainfall events and the storm impact on the signal is...
masked by the weather factor. Using the difference with neighboring areas tends to eliminate the weather factor. We do not focus on the same subject as addressed by Teuling et al. but we follow the same protocol to highlight differences in geophysical variables.

This was indicated in the revised version of the manuscript (end of Section 2.8).

Figure 2.3 – Time series of observed $\sigma^o$ for the Storm area (after screening out soil freezing episodes).

• “In addition, can you provide some explanation/causes to the observed $\sigma^o$ change before and after the storm? Is it due to changes in land cover? Are there field evidence/pictures?”

RESPONSE 2.6:
We think that the impact of the Klaus storm cannot be defined as land cover change. This area mostly remained a forested area but with much fewer standing trees after the storm. Details (including pictures) are given on this official web site (in French): http://www.georisques.gouv.fr/articles/retour-sur-la-tempete-klaus-du-24-janvier-2009

This was indicated at the start of Section 4.1 (formerly 5.1).

• “L349, change “on” to “one””

RESPONSE 2.7:
Thanks for noting this. It was corrected.

• “L362, according to ESA CCI Land Cover map (https://maps.elie.ucl.ac.be/CCI/viewer/) and field measurements in Heiskanen et al [2012], evergreen coniferous forest dominates the Landes forest region, which has small seasonal variations in LAI. Are there field measurements of LAI in Landes forest area? Winter LAI of 1.2 appears to be too small for evergreen coniferous trees. Is this due to the use of coarse resolution LAI data? See above.”

RESPONSE 2.8:
Field measurements in Heiskanen et al [2012] are for a forest in southern Finland, not for the Landes forest. See also RESPONSE 2.1. A detailed analysis of LAI observations over the Landes forest is out of the scope of this study. This could be done in another study. We mentioned this in an enhanced prospect part of the Conclusion section.
“L349-370, it would be helpful and perhaps makes the paper more interesting to link the changes in LAI, Sigma0, and WCM parameters to changes in land cover available from the annual CCI land cover maps (see link above).”

RESPONSE 2.9:
Thanks for this suggestion. This could be done in another study focusing on higher spatial resolution products. For example, part of this study could be repeated using Sentinel-1 σ° data aggregated to the spatial resolution of LC-CCI (300 m x 300 m), together with Copernicus Global Land Service satellite-derived LAI at the same spatial resolution. We have mentioned this in an enhanced prospect part of the Conclusion section.

“L371, Discussion. The same WCM has been used in previous studies to assimilate ASCAT σ° into land surface models (i.e. [7]). Please provide some comparisons in terms of methods/results between this study and previous studies. For example, what are the ranges of the four WCM parameters in previous studies? Do they encounter similar issues over karstic areas and wheat croplands at springtime?”

RESPONSE 2.10:
Differences and similarities between our work and Lievens et al. are summarized in Table 2.1.

Table 2.1 – Comparison of WCM implementation in this study and in Lievens et al. (2017)

<table>
<thead>
<tr>
<th>Present study</th>
<th>Lievens et al. 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>A,B,C,D prior values &amp; boundaries setting</td>
<td>Same as in Lievens et al. 2017</td>
</tr>
<tr>
<td>Optimization method</td>
<td>SCE-UA</td>
</tr>
<tr>
<td>Averaged correlations</td>
<td>Presented for the period 2010-2016. The R score falls between 0.17 and 0.82 (Table 2).</td>
</tr>
<tr>
<td>Seasonal scores (e.g. MAM, JJA)</td>
<td>R and RMSE are presented in Table 2 for MAM and JJA. R and mean bias maps are presented in Fig. 4 for MAM and JJA. Shortcomings of the WCM are found over karstic areas and wheat croplands thanks to a seasonal analysis of the model scores.</td>
</tr>
<tr>
<td>WCM version</td>
<td>with V1 = 1 and V2 = LAI</td>
</tr>
<tr>
<td>A,B,C,D parameter values</td>
<td>Statistical distribution is presented in Table 1 and Fig. 2. Maps are showed in Fig. 3.</td>
</tr>
</tbody>
</table>

Figure 2.4 shows that considering mean correlation value, i.e. ignoring seasonal changes in this score, karstic areas and wheat croplands are much less visible.
• “L379, suggest change the sentence to the simulated values are higher than the observed”  
  **RESPONSE 2.11:**  
  Thanks for noting this. It was corrected.

• “L403-409, can you provide the basis for the relation between observed σ° and LAI/SSM? I believe that it can be found in the literatures, which would be helpful to better understand the impact of LAI/SSM on the simulated/observed σ°.”  
  **RESPONSE 2.12:**  
  Picard et al. (2003) (Figure 11) have shown that VV σ° observations at an incidence angle of 40° (close to the configuration of the ASCAT observations used in this study) are affected by large changes in the ratio of vegetation to soil contribution to backscatter. At the beginning of spring, soil backscatter is the dominant mechanism. The stem-ground interaction gradually becomes the dominant mechanism and soil moisture has no longer an impact on the signal.  
  *This was indicated in the Discussion section.*

• “Please make sure the links to the references work, I can’t open some of them, such as 19-21.”  
  **RESPONSE 2.13:**  
  We checked that all links are working on our version of the manuscript.

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**Figure 2.4** – Mean temporal correlation between simulated and observed σ° values for the 2010-2016 time period.