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Interactive comment on "Comparison of Different Sequential Assimilation Algorithms for Satellite-derived Leaf Area Index Using the Data Assimilation Research Testbed (lanai)" *by* Xiao-Lu Ling et al.

Xiao-Lu Ling et al.

lingxl@nju.edu.cn

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Anonymous Referee #1

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Discussion paper

Major comments

The submitted paper uses four assimilation methods(KF, EnKF, EAKF and PF) and CLM4CN to assimilate LAI, and chooses a best assimilation method by comparing with MODIS LAI. MODIS satellite remote sensing data can obtain LAI products with long time series. However, due to the impacts of cloud cover, aerosols, snow cover, and sensor failure, MODIS LAI products are characterized by high noise, low accuracy, and large fluctuations in the time series. Therefore, MODIS LAI data with better quality should be selected as observations based on quality control (QC) information. The research objective is reasonable and the review portion and figures need to be improved.

Response: We appreciate your comments, which are helpful for us to further improve this paper. In the revised manuscript, we have focused on the following issues.

1. Proofreading has been done to improve the readability and quality of this manuscript. The quality of all the figures has also been improved.

2. The description for the experimental design and spin-up process has been added to Section 2. The ensemble simulation during the time period of 1998 2001 is treated as spin-up, which explains why the result is shown for the year 2002.

3. The datasets for assimilation and estimation are introduced in Section 2.4.2. The Global Land Surface Satellite (GLASS) LAI dataset is used as observations for assimilation. To evaluate the assimilation result, an improved LAI dataset developed from the MODerate Resolution Imaging Spectroradiometer (MODIS) is utilized, which can reduce the spatial and temporal inconsistencies by considering the characteristics of the MODIS LAI data and quality control (QC) information.

Specific comments

1. What does the letter represent in formula (2)? It is not clear.

Response: If there are enough observations, the posterior density at k can be approximated by

$$p(X_k^a|Y_{1:k}) \approx \sum_{n=1}^{N} w_{i,k}\delta(X_k^a - X_{i,k}^a)$$

in which $\delta(*)$ is the Dirac Function and $\sum_{n=1}^{N} w_{i,k} = 1$. $p(X_k^a|Y_{1:k})$ is the posterior probability distribution,$X_{i,k}^a$ is the particle element, $w_{i,k}$ is the weight of each particle, N is the number of particles.

2. Line 13-15 in page 6, What method is used to solve the particle degradation problem in PF?

   Response: We didn't do anything to solve the particle degradation problem in this study. We will address this issue in our future studies.

3. In section 2.4, time period of the atmospheric datasets is 1998-2010 in DA, why the time of LAI in the result is 2002?

   Response: 80 atmospheric forcing datasets at 6-hour intervals over the period of 1998-2010 are used in this study. Considering computational cost and filter performance, only 40 members are randomly selected. The reasons why the time of LAI in the result is 2002 are given below. First, the ensemble simulation during the time period of 1998 2001 was treated as spin-up. The description of the spin-up process has been added to Section 2.4.1. Second, the purpose of this study is to find out the optimal algorithm, which needs many experiments to be conducted. Aiming at global scale and considering the computational cost, only one-year assimilation and ensemble simulation are conducted. We try to first find out the best experiment, and then conduct long-term simulation or assimilation in the future.

4. What does "Observation Proportion" mean in Table 1?

   Response: We apologize for the confusion. The phrase"Observation Proportion" has been changed to"Algorithms without observation rejection". We also add some details related to this type of experiments to Section 2.5.

5. Which version of MODIS LAI collection did you use?

   Response: Global Land Surface Satellite (GLASS) LAI dataset is used in this study as observations for assimilation (Zhao et al., 2013). Since the ensemble simulation or assimilation is run at the resolution of 0.9° latitude by 1.25° longitude, the original spatial resolution of 0.05° of GLASS LAI is upscaled to the same resolution. To evaluate the assimilation result, an improved LAI dataset developed from the MODerate Resolution Imaging Spectroradiometer (MODIS) (Yuan et al., 2011) is utilized, which can reduce the spatial and temporal inconsistencies by considering the characteristics of the MODIS LAI data and quality control (QC) information (Baret et al., 2013). The resolution of MODIS LAI is 1-km, which is upscaled to grid level to evaluate the analysis of LAI and assimilation effect. Section 2.4.2 is newly added to the revised manuscript.

6. There is no legend in Figure 1. Please add.

   Response: Figure 1 is improved and legend is added to the revised manuscript.

7. Due to the impacts of cloud cover, aerosols, snow cover, and sensor failure, MODIS LAI products are characterized by high noise, low accuracy, and large fluctuations in the time series. By calculating the RMSE of assimilation/simulation LAI and MODIS LAI, can this paper really choose a better assimilation algorithm?

   Response: To evaluate the assimilation result, an improved LAI dataset developed from the MODerate Resolution Imaging Spectroradiometer (MODIS) (Yuan et al., 2011) is utilized, which can reduce the spatial and temporal inconsistencies by considering the characteristics of the MODIS LAI data and quality control (QC) information (Baret et al., 2013). The resolution is 1-km, which is upscaled to the grid level to evaluate the analysis of LAI and assimilation effect. It is better evaluating the LAI estimation by using in-situ observations, but it is not possible to do so on global scale

8. Lines 2-3 in page 11, “assimilated observation” is mean “assimilated LAI”?

   Response: You are right. The sentence has been changed as suggested.

9. The legend and coordinate axis numbers are blurred in Figure 6.

Response: Figure 6 is corrected in the revised manuscript.

10. "the distribution characteristics of both innovations and residuals are identical for the algorithms of KF and PF, which means that these two algorithms are not very efficient for LAI assimilation." Why innovations and residuals are identical, KF and PF are invalid. However, both innovations and residuals are not exactly the same for the algorithms of KF and PF ((g) and (h), (o) and (p) in Figure 6).

    Response: The word "identical" is changed to "similar"; furthermore, Figure 6 has been improved in the revised manuscript.

11. How to calculate the proportion of accepted LAI observations?

    Response: During assimilation, the DART can calculate the number of non-assimilated observations when the difference of the prior mean and observations is larger than three times of the expected value. The proportion of accepted LAI observations is defined as the number of accepted observations divided by the number of total observations.

12. lines 3-4 in page 13, what are the conditions that observations are rejected during data assimilation.

    Response: The "Algorithms" experiments would reject some observations under certain conditions using the KF, EnKF, EAKF, and PF algorithms. The expected value of the difference between the prior mean and observations is $\sqrt{\sigma_{prior}^2 + \sigma_{obs}^2}$, in which σ_{prior} and σ_{obs} are standard deviations of prior PDF and observation PDF respectively. DART will reject the observation if the bias of the prior mean and observation is larger than three times of the expected value.

13. lines 13-14 in page13, is RMSE calculated by EAKF_noreject (EAKF_reject and MODIS LAI?

    Response: Correct. The sentence has been changed as suggested.