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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.

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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: Thanks very much for your comments to improve this manuscript. In the revised manuscript, we have focused on the following issues. 1. A thorough proofreading for language has been done to this manuscript, also the quality of all the figures has been improved.

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

3. The datasets for assimilation and estimation was also included in Section 2.4.2. The Global Land Surface Satellite (GLASS) LAI datasets was used as the assimilated observation. To evaluate the assimilation result, an improved LAI dataset developed from the MODerate Resolution Imaging Spectroradiometer (MODIS) was utilized, which can reduce the spatial and temporal inconsistencies observed at the local spatial or temporal scales 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

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

   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 in this study, maybe in the future we could focus on this topic.

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: The 80 atmospheric forcing datasets with 6-hour time intervals for the period of 1998-2010 were used in this study. Actually only 40 members was randomly selected by considering computational cost and filter performance. The reason for the time of LAI in the result is 2002 is listed as follows. Firstly, the ensemble simulation during the time period from 1998 to 2001 was treated as spin-up process. We may miss the section of description for the spin-up process, which has been added in Section 2.4.1. Secondly, the purpose of this study is to find out the optimal algorithm, meaning that many experiments will be designed. Aiming at global scale, only one-year assimilation and ensemble simulation were conducted in considering of computational cost. We were trying to firstly find out the best experiment, and then conducting a long-term simulation or assimilation in the future.

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

Response: Sorry for the confusion. We have changed the word from "Observation Proportion" to "Algorithms without observation rejection". We also add some details for this kind of experiments in Section 2.5.

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

   Response: Global Land Surface Satellite (GLASS) LAI datasets was used in this study as assimilated observation (Zhao et al., 2013). As the ensemble simulation or assimilation was run at a 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) was utilized, which can reduce the spatial and temporal inconsistencies observed at the local spatial or temporal scales by considering the characteristics of the MODIS LAI data and quality control (QC) information (Baret et al., 2013). The resolution is 1 kilometer, and was also upscaled to grid levels to evaluate the analysis LAI and assimilation effect. We also added section 2.4.2 during this revision.

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

   Response: Figure 1 is improved in this revision.

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) was utilized, which can reduce the spatial and temporal inconsistencies observed at the local spatial or temporal scales by considering the characteristics of the MODIS LAI data and quality control (QC) information (Baret et al., 2013). The resolution is 1 kilometer, and was also upscaled to grid levels to evaluate the analysis LAI and assimilation effect. It is better to evaluate the LAI

estimation by using in-situ observations, but it is not possible to do the estimation at global scale.

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

   Response: Yes, and it has been changed as suggested.

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

   Response: Figure 6 is corrected in this revision.

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 of identical is changed to similar, and furthermore, Figure 6 was improved during this revision.

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

    Response: During assimilation, DART can calculate the number of non-assimilated observation when the difference of prior mean and observation is larger than 3 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 observation under certain conditions using the KF, EnKF, EAKF, and PF algorithms. The expected value of the difference between prior mean and observation is $\sqrt{\sigma_{prior}^2 + \sigma_{obs}^2}$, in which σ_{prior} and σ_{obs} are the standard deviation of prior PDF and observation PDF respectively. DART will reject the observation if the bias of prior mean and observation is larger than 3 times of the expected value.

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

Response: Yes, and it has been changed as suggested.