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Interactive comment on "A method for retrieving clouds with satellite infrared radiances using the particle filter" *by* Dongmei Xu et al.

Anonymous Referee #1

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Ensemble forecasts are produced as the routine products in many NWP operational centers. Using these products to estimate uncertainties is convenient and becomes popular.

This paper employed PF method, where the ensemble data is used to estimate cloud fraction, to retrieve cloud. The PF method provided improvements on the accuracies of cloud retrieval, i.e. cloud profile, cloud mask and cloud top, and also made the cost cheaper. This action is meaningful. Glad to see the study when satellite data is increasing in volume and plays the important role in providing extra information in NWP and data assimilation systems.

The extension of PF method to the cloud data retrieval is, I think, a good contribution to

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Discussion paper

the application of cloud products and a good addition to the literature. However, I see some deficiencies or ambiguous sentences in the paper that lead me to suggest major revisions before it is published. I see three major points that need to be corrected or explained.

1) The probabilities of the cloud distribution are presented by the initial particles. Thus, a particle initialization scheme is needed. Authors firstly generated the perturbations of cloud fractions by inflating, deflating and moving the clouds. My question is: (a) why did authors generate perturbations of cloud fractions when the cloud fractions were actually available among the ensemble members? Or say, why not use cloud fraction in ensemble members directly to generate the particles? If authors argue that the ensemble spread of cloud fractions in ensemble dataset is not large enough, it is reasonable but some statements should be stated here. (b) Did authors use any method and rule in this study to inflate, deflate and move the cloud? Some random perturbations might be deficient, and accounting for different perturbation methods could very well change some of the results in the basic PF experiment. I get the conclusion partly from Fig. 4, where the cloud fraction is obviously different between PF and APF and thus the different cloud retrievals are produced.

2) L174-175. “Generally, for each FOV, the retrieved cloud fractions are extrapolated to its four neighboring model grid points”. What method is employed by authors to do the extrapolation from one cloud fraction to its neighboring grid points? Compared with the interpolation from background to FOV, which is a routine way to calculate the residual, is there any chance to make accuracy loss of radiance observations by the extrapolation? If so, how the loss of accuracy affects the weight in Eq. 3? I think authors need to tell the reader in more detail about this.

3) It is not a real question here. It is fine to use 150 hPa as the highest extent in this study. However, in reality, the tropopause could be higher than 150 hPa, e.g. an anvil cloud in a mature thunderstorm around tropopause at low latitude region. The fact can be also found out in Fig.4, where the cloud fraction around 150 hPa is not zero in

the experiment 'PF'. I do not ask authors to run extra experiments to estimate cloud fraction on all model levels because the cloud fraction is too small above 150 hPa and I consider this less important in this study. I just would like to say that we should not omit any extreme weather when we have the ability to resolve it.

That is a summary of my major concerns. The following are minor specific concerns generally relevant to specific portions of the text.

Line 13-16: If authors use the qualitative comments (L13-14) as the beginning, I suggest to add, say ' by using ensemble forecasts/products', behind PF in L15 to keep consistent to the L13-14. I don't think that all of readers are familiar with Particle Filter in which the ensemble concept is implicit when they read the abstract firstly, although the PF is introduced in section 2.

L48-50: Check parenthesis and comma, which do not match.

L98-101: Is c0 constant, if it is not the control variable ?

L101-102: Might state how Rvk is calculated briefly, e.g by forward CRTM operator with the inputs of temperature and humidity profiles in background.

L107: Suggest to note that the 'particles' correspond with 'ensemble members', i.e. one cloud profile as one of particles is derived from an ensemble member.

L131: If the observation error in Eq. 3 is specified in GSI, please state it.

L152: Only GOES-13 and -15 used in this study ? Does not match with Fig. 4.

L175: See major concern 2.

L189-196: Do authors implement bias correction for these satellite cloud products as reference ?

L202: Should be Eq. 3.

L216: Title of x-axis missed. Also check Fig. 2(c)(d).

L221 and L236: From Fig. 2a, I think the results are produced by using PF, because authors use these words “specified value of cloud fractions”. However, the “normalized J0” is showed in Fig. 2c. It is confusing because MMR employs the cost function. If J0 is the residual in Eq. 3, please state it clearly.

L249: Fig. 2 could be separated into two figures, cloud fraction Fig. 2(a)(b) and normalized J0 Fig. 2(c)(d).

L293: I guess authors use AIRS as Robs to calculate residual, but need to re-write the word “from AIRS”.

L372: Keep the units consistent. Check Fig. 9 and Fig. 10. Use (hour) or (hr), not (hh).

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