Response to Reviewer # 2

This paper presents a flexible physically based algorithm for the retrieval of aerosol optical properties using multi-wavelength, -pixel information over the ocean. The algorithm is evaluated theoretically for several oceanic conditions based on the synthetic data and experimentally using GOSAT/CAI measurement in comparison to other counter- part satellite products, i.e., MODIS, as well as those from AERONET observations. In general, optimal estimation method combined with the spatial smoothness constraints from adjacent pixels is a promising inversion technique for the aerosol/hydrosol retrieval. The methodology, which retrieves the atmospheric and oceanic variables simultaneously, is also interesting. However, some modifications are needed to make the paper clearer.

Thanks for the reviewer's insightful comments very much, which helped to improve our manuscript greatly. We have revised our paper based on your comments carefully. We also have reworded/rephrased some sentences that may improve or clarify the paper further. Our responses are listed in below after each comment.

Major comments:

1: The multiple pixel method shows an advanced skill in the aerosol retrieval, however, some contaminations might be still introduced for the reflected radiance due to the multiple scattering between each pixels, i.e., adjacent effects in the radiative transfer. How do you process such effects in your retrieval?

Response: Thanks for the comments very much. Adjacent effect is an important aspect for the radiative transfer and remote sensing, particularly for the retrieval from high-resolution imager. We agree with the reviewer's comment that some errors can be still introduced for the derived satellite reflectance from neighbor pixels even though the multi-pixel method is benefit to account for the multiple scattering between each pixels in the forward radiation simulation. Nevertheless, we have to neglect this effects since the spatial resolution of CAI are 500m for band1 through band3 and 1500m for band4, of which the adjacent effect is very small. Using 3D radiative transfer model is convenient for such kind of retrieval, however, the calculation loading will increase dramatically. It is important for us to

investigate the influence of instrument spatial resolution on the performance of multi-pixle retrieval in the next step. We added the clarification of this aspect in the last part of session 4 as "It should be noted that we neglect the multiple scattering influence between neighbor pixels caused by the adjacent effect in the retrieval, since the effect is generally small for the CAI instrument with moderate spatial resolution. Nevertheless, we have to consider the adjacent effect for the extremely high spatial resolution imagers using 3D radiative transfer model. "

2. The land-ocean contrast retrieval is interesting, it looks that the soot above ocean can be potentially estimated by benefiting from the retrieval over land, however, it is not clear that how those values (Line 30 - 31) are determined based on Eq. 6?

Response: Thanks. In general, we derive the Eq. 6 based on the simply single scattering approximation (Kaufman, 1987) for the calculation of neutral reflectance. The following figure shows the relationship between the ground neutral reflectance and aerosol single scattering albedo (SSA) in different conditions of asymmetry factor (g) and phase function (p). Since we fixed the particle size distribution in this study, an empirical equation between volume soot fraction (Sootf) with fine mode proportion (f) and SSA is derived as shown in the following figure. It is demonstrated that the soot fraction is about 2.05% when the asymmetry factor and phase function are 0.7 and 0.0142, respectively, corresponding to the neutral reflectance and SSA are about 0.232 and 0.935.

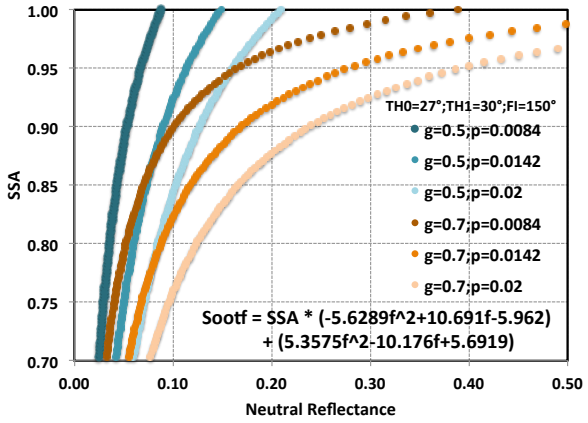

Figure: Relationship between single scattering albedo (SSA) and ground neutral reflectance in different conditions of asymmetry factor (g) and phase function (p) at 674 nm in this study.

3. It is better to discuss the perspective of current algorithm on the application to the global ocean.

Response: Thanks for the comments very much. More descriptions on the application of current scheme to the global ocean are added in the last section of manuscript as "It is demonstrated that the multi-pixel scheme exerts a promising technique in the aerosol and hydrosol retrieval based on the multiple source constraints from satellite observation, apriori and neighbor pixel information in an iteration manner. To apply the scheme used in the global ocean, we have constructed a neural network solver to accelerate the algorithm and related study will be explicated in another work."

Minor comments:

1: L9P1, 'thickness' should be 'properties'.

Response: Thanks. Done.

2: L25P1, it is difficult to say whether the 'overestimation' is unreasonable or not without comparison to other products or validation.

Response: Thanks. "to correct the overestimation of aerosols" modified to "for the aerosol retrieval".

3: L14P2, 'an improved two-channel method' should be 'improved two-channel methods'.

Response: Thanks. Done.

4: L24P4, 'a smoothing constraint' should be 'smoothness constraints'.

Response: Thanks. Done.

5: L6P5, 'vector' -> 'vector in two directions'.

Response: Thanks. Done.

6: L8P7, '443nm' should be '443 nm'.

Response: Thanks. Done.

7: L17P7, 'had' should be 'have'.

Response: Thanks. Done.

8: L26P11, ‘overestimations’ -> ‘higher values’.

Response: Thanks. Done.

9: L29P11, similar to L25P1, sentence of ‘Nevertheless, . . .’ should be reorganized.

Response: Thanks. Sentences from L25P11 to L34P11 were reorganized as follows

“Generally, the derived AOTs without using SWIR measurements (Fig. 7a) demonstrate obvious higher values than those retrieved by adding SWIR information (Fig. 7d) near coastal region. It is caused that the satellite reflectance at SWIR channels are much less sensitive to the suspended sediment than those at visible bands in turbid waters, so that the aerosols can be estimated without significant contamination of sediment (Wang and Shi, 2007) based on the SWIR observation. Although we simultaneously conduct the oceanic sediment retrieval in the algorithm, it is still difficult to use 4 spectral measurements to estimate at least 5 free variables (AOT of fine, sea spray and dust, sediment and CDOM) in the high backscattering surface condition, where the retrieval could be degenerated. Nevertheless, such deficiency can be improved using the multi-pixel scheme even though the SWIR measurements are not used (Fig. 7b), which indicates the potentiality of multi-pixel strategy in the aerosol retrieval over high turbid waters, particularly for those multi-spectral instruments without the SWIR observation.”

References:

Kaufman, Y. J. (1987), Satellite sensing of aerosol absorption, J. Geophys. Res. Atmos., 92(D4), 4307-4317.

Wang, M., and W. Shi (2007), The NIR-SWIR combined atmospheric correction approach for MODIS ocean color data processing, Opt. Express, 15(24), 15722-15733.