Manuscript "Speeding up the AOT retrieval procedure using RTT analytical solutions: FAR code" by Katsev et al. MS No: amt-2010-33

Answer to Reviewer 2

We appreciate the detailed and useful comments of our reviewers. Below, please, find our answers. All needed additions and corrections have been made in the revised version of the manuscript. In the cases when comments of the Reviewer 2 are close or the same as in Review 1, we refer to our answer to Reviewer 1.

1. "Authors achieve acceleration of radiative transfer by modeling the atmosphere as a two-layer system, and by applying Sobolev's approximation to find the contribution from the lower layer where most of aerosol is contained. It seems to me that the accuracy of proposed solution is by far not good enough for the remote sensing applications. From the data presented, one can see the error of up to 10-15% for a limited set of used geometries. It may be larger at other geometries, especially when closer to the principle plane. This error is not systematic. It depends on the view geometry, which will result in angular dependence of the retrieved AOT/surface reflectance. "

Please, see our answer to general comment of Reviewer 1.

2. The radiative transfer model seems to be incomplete. "For example, the surface bidirectional reflectance is not taken into account."

In our manuscript we use the equation obtained assuming a Lambertian underlying surface. Nevertheless, the surface bidirectional reflectance is partially taken into account (see answer #9 to the specific comment of Reviewer 1).

The correspondent note is included in the manuscript.

3. "Contrary to the statement on page 1651, there is a water vapor absorption in the red and near-infrared spectral regions. There is also a non negligible NO2 absorption at wavelengths shorter than about 500 nm."

The FAR algorithm includes absorption of ozone, water vapor, and oxygen. The optical thickness of absorption of NO_2 at 442.5 nm is less than 0.003 and can be neglected. (See also Fig.2 in the answer to Reviewer 1).

4. “The authors mention that the developed radiative transfer model has polarization components, but I am not sure what accuracy the Sobolev’s approximation would give in case with polarization.”

The reflection and transmission functions of the layer «2» are computed accurately with the RAY code taking into account the atmosphere stratification and light polarization effects, the reflectance $R_1(\mu, \mu_0, \varphi)$ from the layer “1” is determined within the MSA by Eqs.(16)-(20) without accounting for polarization. As it was shown in (Katsev et al., 2009), the errors due to neglecting polarization effects for the layer “1” in the most typical situations do not exceed 1%.
Correspondent note is included in the text of the revised manuscript.

5. “The aerosol retrieval algorithm should handle all conditions, including rather asymmetric scattering by aerosols, and higher optical thickness where the accuracy of Sobolev’s approximation is even lower. “

Aerosol phase function with any asymmetry is allowed in the layer “1”. In the manuscript, we presented Modified Sobolev’s Approximation (MSA) developed particularly to provide accuracy for elongated phase function as well. It is why the transport optical characteristics arrive in the MSA equations. The MSA accuracy was checked and given in the manuscript for elongated phase function (the phase function of the continental aerosol) and AOT $\tau \leq 1$.

6. “Several times the authors mention the developed and earlier described code RAY, which is used as a benchmark to establish the accuracy of the developed algorithm. I didn’t find, however, any accuracy statement for the code RAY in this manuscript. I would presume that the accuracy of code RAY was established earlier against community-recognized RT codes, such as DISORT (in scalar case). If that is the case, I recommend authors to provide a simple accuracy statement for the code RAY, which will allow to better understand the results presented here. “

In the manuscript there is the reference (Kokhanovsky et al, 2010) to the paper where accuracy of the RAY code considered along with accuracy of the most accurate codes used for the LUT computations and RAY is considered as a code for the benchmark results. For instance, the relative error of RAY for the first Stokes vector component is estimated to be about 0.003% for Rayleigh scattering and about 0.2% for aerosol scattering at AOT=0.3 (Kokhanovsky et al, 2010). So, RAY

shows not worse accuracy of RT calculations for an aerosol atmosphere than the other best codes, but is much faster that allows one to use RAY in iterative aerosol inversion technique.
The correspondent note is included in manuscript.

7. "Modeling spectral dependence of surface reflectance using prescribed database albedo may work for aerosol retrievals locally, especially over deserted surfaces which don't change over time. However, this approach doesn't work at larger scale. The vegetated surfaces have a seasonal cycle and rapid changes. How does this algorithm account for the surface change (and for changes in the view geometry which call for the BRDF effect)? In general, treatment of surface reflectance in the aerosol retrieval algorithm should be discussed in more detail, as this is the main error source in the aerosol retrievals."

We agree with this statement. It is a weak point of our approach as of many known approaches. Moreover, we are working to improve modeling spectral dependence of surface reflectance. As for the regard to BRDF, see, please, answer #9 to the specific comment of Reviewer 1.

8. "Presented results on validation of AOT with AERONET measurements look promising, but it is not possible to have a reliable accuracy assessment from just several points, without representative statistics. Can you provide comparison with AERONET, for example, for one year of data? "

We have included in the revised version of the manuscript comparison with AERONET for two years for the period March- September 2008 and 2009 years.

9. "As a summary, presented idea is very promising for developing physically-based retrieval algorithms, especially in cases with high dimensionality of measurements (e.g., multi-angle, multi-spectral, polarization). The described approach moves in this direction, but it seems that some further work is needed to achieve the accuracy of better than 1-2% which is required for a reliable inversion of the remote sensing data."

We completely agree that use of the fast RT codes is the step in developing procedures for processing data of high dimensionality satellite measurements. Actually, we have been working in this direction.
Frankly speaking, the accuracy better than 1-2% practically has not been achieved in the existing codes (see for instance Kokhanovsky et al., 2007 and our answer to Reviewer 1). But keeping this two issues in view (potentiality of using RT codes rather than LUT and required AOT retrieval

accuracy) we developed ART code (Katsev et al., 2009). The FAR technique is much faster but less accurate version of ART that may be used in situations when just time of data processing is crucial (for instance, monitoring the trans-boundary transfer of impurities, particularly in the cases of the emergencies as volcano eruptions, various industrial disasters).

10. “The work would also strongly benefit if some representative statistics of AERONET comparison were obtained expanding validation presented in this paper. “

We included much more representative comparison FAR with AERONET at 440 nm and provided statistical parameters of this comparison in the revised manuscript (see Fig.4 in the answer to Reviewer 1).

11. “It needs to be mentioned that the language of the manuscript needs extensive corrections, mainly in the first half of the manuscript”.

Corrections will be done.