Review of HETEAC – The Hybrid End-To-End Aerosol Classification model for EarthCARE by Wandinger et al.

This is a very nice paper describing the model to be used for tropospheric aerosol classification associated with the ATLID and MSI measurements to be acquired during the EarthCARE mission. The paper provides a good description of how the aerosol components were determined, the aerosol optical and physical characteristics of these components, and how they are combined and used to provide aerosol types from the ATLID measurements. The manuscript provides several Figures and Tables to describe these items and an example applied to simulated data. The model should be a good starting point for the EarthCARE aerosol classification. The authors correctly note that this scheme should preserve the CALIOP aerosol types as much as possible in order to facilitate long-term investigations using data from both missions. Along those lines, as noted in comments below, it would be helpful if additional information were provided to determine how the aerosol optical and microphysical characteristics of aerosol types associated with ATLID classification compare with those associated with the CALIOP aerosol types. I recommend publication of this manuscript after addressing the minor comments listed below.

1. Lines 35-45 and discussion of Figure 8. How much variation or uncertainty in aerosol size, absorption (SSA), asymmetry parameter, Angstrom exponent is associated within the aerosol classification for a particular set of lidar observables (lidar ratio, depolarization)? How does this uncertainty then impact the closure of TOA fluxes to the desired accuracy of 10 W/m^2?
2. Lines 44 and 525 mention aerosol components associated with aerosol transport models (e.g. sulfate, organic carbon, black carbon). Line 525 mentions that these aerosol components in the CAMS model were mapped to the HETEAC components. How was this mapping done? It would be helpful to know this mapping in order to use the EarthCARE measurements to help evaluate the ability of aerosol transport models to apportion aerosol extinction and AOD to the model aerosol components.
3. Line 166. Why were only ground-based observations of the lidar ratio and particle linear depolarization used without any airborne measurements?
4. Figure 2. It seems that the HETEAC fine strongly absorbing component provides an upper bound on the observed lidar ratio, the HETEAC coarse spherical component provides a lower bound on the observed lidar ratio, and both components provide lower bounds on the observed particle linear depolarization. However, there seems to be several observations of particle linear depolarization ratio that exceed the depolarization ratio of the HETEAC coarse non-spherical component. Could/should this component have been chosen such that its depolarization ratio was higher (~30%) to better bound the observed depolarization ratios?
5. Table 2. It would be helpful to know the values of lidar ratio, linear particle depolarization ratio, and Angstrom exponent corresponding to the standard Nd:YAG wavelengths (532, 1064 nm) used by many aerosol lidars including CALIOP.
6. Figure 4. Do the HETEAC component values of refractive index shown in Figure 4 correspond to dry (RH=0%?, RH<40%) conditions?
7. Line 330. How accurate would RH have to be in order to be considered in HETEAC? Are there any plans to use model reanalysis RH fields when producing updated versions of the ATLID data products?

8. Table 5. This table doesn't show dependence of linear particle depolarization on RH. Should we assume that depolarization for these particles is negligible for all RH?
9. Line 400 and lines 705-712. The HETEAC components do not account for nonspherical sea salt. The conclusion mentions the presence of these aerosols in thin layers near the top of the marine BL (Haarig et al., 2017b) and gives the impression that these aerosols are not considered in the HETEAC scheme because: a) they are not observed often and only in thin layers near the BL top, b) the depolarization ratio of these particles is relatively small (~8% at 355 nm), and c) ATLID may have insufficient resolution to detect these aerosols. An article was recently submitted to Frontiers in Remote Sensing that will indicate that items a), b), and perhaps c) are not necessarily true so the suggestion is made to begin considering how the HETEAC model would deal with such aerosols in the future.
10. Lines 445-465. From this discussion, it seems that the HETEAC model for coarse, non-spherical aerosols (dust) can correctly reproduce the lidar observations of lidar ratio and linear depolarization ratio at 355 nm but would be unable to do so at 532 nm? Is this correct? If so, how will this impact the use of the HETEAC scheme when relating ATLID observations of dust to those from CALIOP?
11. Figure 7. How does the HETEAC handle lidar observations of lidar ratio and/or particle depolarization that lie outside the triangles of points formed by the HETEAC components?
12. Figure 9 and Table 6 provide lidar observable values that correspond to the six tropospheric A-TC aerosol types and how these types are comprised of the HETEAC components. Lines 154-155 state that "The EarthCARE aerosol classification scheme shall preserve the aerosol types of CALIPSO as far as possible to allow long-term global investigations over the lifetime of both missions." This is a commendable goal and will be very important as one would expect that researchers will attempt to combine the CALIOP and ATLID measurements for long term records. The six tropospheric A-TC aerosol types seem to coincide with some of the same aerosol types (at least in name) associated with the CALIOP tropospheric aerosol types. For these apparently common types, how do the lidar observables (at 532 nm) associated with the A-TC types coincide with the corresponding CALIOP values observed (particle depolarization) or assumed (lidar ratio) for these associated aerosol types? How do the underlying aerosol properties (e.g. size, SSA, refractive index) for this common aerosol types compare between A-TC and CALIOP aerosol types?
13. Figure 10. This is a nice figure to show an example of the HETEAC aerosol classification and brings to mind a few questions.
    a. I don't recall seeing elsewhere in the paper a discussion of the spatial and vertical resolutions of the ATLID retrievals of lidar ratio and linear particle depolarization; what are these resolutions? Presumably the resolutions associated with the lidar ratio retrievals are coarser than the resolutions associated with the retrievals of particle linear depolarization. If this is true, how does the HETEAC classification deal with these different resolutions?
    b. There are gaps (white areas) in the lidar ratio and depolarization images on the right. Are these gaps because the aerosol loading was too small for trustworthy measurements? If so, what are the minimum aerosol extinction values for which there will be expected retrievals of lidar ratio and linear particle depolarization? Likewise,

what are the minimum aerosol extinction values required for the HETEAC aerosol classification?

c. Looking again at the images on the right, there are more white areas (no retrievals?) associated with linear particle depolarization than for lidar ratio. Why? (I would have expected the opposite). Does the HETEAC algorithm still attempt to perform a classification if there is a retrieval of only one of two lidar observables?

d. The right side of the top right image shows relatively high values (70-80 sr) of the lidar ratio and low values of aerosol depolarization around 5 km. Figure 2a shows that these lidar ratios and depolarization ratios are associated are smoke and/or mixtures that contain smoke. However, the target classification shown in the bottom right seems to show this area is dominated by continental pollution with little, if any, smoke or smoke mixtures. Why?

14. Line 565. Can the column integrated aerosol classification probabilities be illustrated for the example shown in Figure 10?
15. Line 678. Suggest changing to “Ground-based and airborne measurements that measure…”