Assessing the Sensitivity of the ORAC Optimal Estimation Aerosol Retrieval Scheme for MSG SEVIRI to Input Aerosol Parameters

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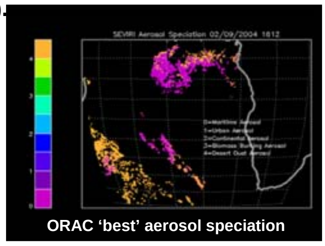
We use the GEOS-Chem chemistry transport model (CTM) to provide information on the speciation of aerosols for the Meteosat Second Generation (MSG) Spinning Enhanced Visible Infrared Imager (SEVIRI) aerosol retrieval algorithm. The optimal estimation retrieval scheme uses aerosol properties including aerosol size distribution, mixing ratio and refractive indices in combination with Mie theory and the DISORT radiative transfer model to derive reflectance and transmission. We use observed aerosol properties from the NERC SOLAS Dust outflow and Deposition to the Ocean (DODO) aircraft campaign to assess the sensitivity of the retrieved aerosol optical depth to the input aerosol parameters. We also test the sensitivity of the retrieval to solar zenith angle.

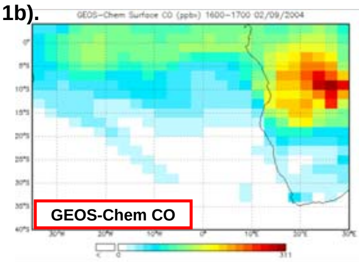
1. Selecting Aerosol Speciation using the GEOS-Chem CTM.

Retrieval of aerosol optical properties is in general an ill-posed problem requiring *a priori* information on aerosol properties. The Oxford-RAL Aerosol and Cloud (ORAC) retrieval scheme selects the 'best' aerosol speciation from one of five possible aerosol models: desert dust, biomass burning, continental, maritime and urban. A typical retrieval is shown in Figure 1a below. This method is unable to unambiguously identify which (if any) of the assumed classes is correct and lacks information about the spatial coherence of the aerosol plume.

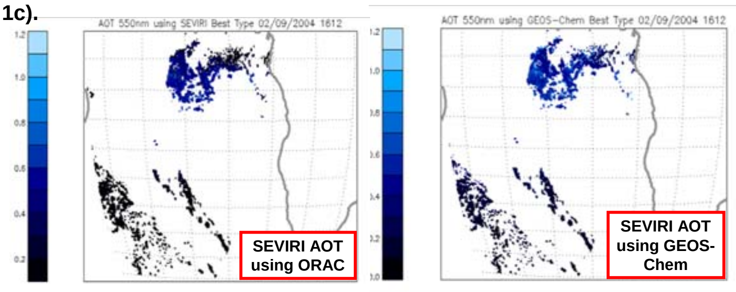
1a).



1b).



1c).

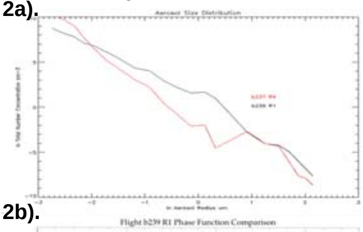


In this example for 2nd Sept 2004, we use GEOS-Chem model concentrations of carbon monoxide (CO), a tracer of incomplete combustion, greater than 115 ppbv (Figure 1b) to identify biomass burning for the retrieval shown in Figure 1a. We select maritime aerosol across the remainder of the study domain. Figure 1c shows that using GEOS-Chem to identify biomass burning aerosol types generally elevates the SEVIRI AOT retrievals over regions of biomass burning outflow.

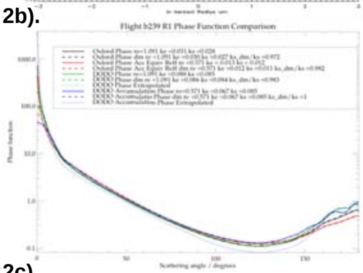
2. Using DODO observations to test the sensitivity of the ORAC phase function to input aerosol size distribution and refractive index.

The ORAC scheme retrieves aerosol optical depth at 0.55 microns and aerosol effective radius, the latter parameter controlling the relative amount of each contributing aerosol component. Optical properties are generated using aerosol components described as size distributions and refractive indices from the Optical Properties of Aerosols and Clouds database. Here, we use observed aerosol properties from the NERC SOLAS Dust Outflow and Deposition to the Ocean (DODO) aircraft campaign in August 2006 off the west coast of Africa to assess the sensitivity of the retrieved aerosol optical depth to the currently assumed model of the desert dust aerosol class. Data is for flights on 22nd, 24th and 25th August 2006.

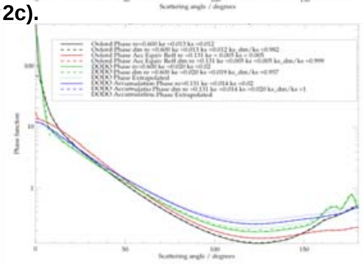
2a).



2b).



2c).

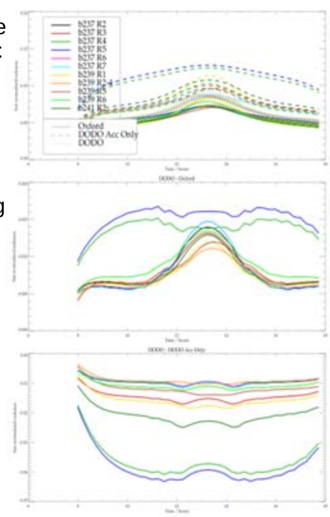


Data from nine of eleven flights describe dust sampled between 2-6km altitude and the modeled phase function (green) at 0.55 µm shows generally good agreement with that assumed in the retrieval scheme (black) although discrepancies are larger for near back-scattering angles (Figure 2b). Flight b327 R4 and R5 (Figure 2c) sampled dust between 0-1km altitude which has a different size distribution (Figure 2a) and chemical composition. These data agree less well with the Oxford phase function and need to be examined in further detail. The difference between the two examples reflects the spatial and temporal variability in dust size distribution that is yet to be propagated through the ORAC system and represented as an error component on the retrieved quantities.

3. Testing the sensitivity of the ORAC retrieval to solar zenith angle.

Data from eleven flights are used to generate aerosol optical properties which are then input into the forward model used in the ORAC retrieval to derive radiances. Figure 3 shows the radiances calculated for all flights comparing input from the Oxford data and the DODO flights using combined measurements from the coarse and accumulation aerosol modes, and just the accumulation mode. These are shown as a function of time of day reflecting changes in solar zenith angle.

3).



Flight b237, runs 4 and 5 give a phase function that differs significantly from the Oxford data currently used in the ORAC retrieval. At an aerosol optical depth of 0.5 the radiances generated for these flights show much less variation with solar zenith angle and are greater than the radiances generated using the Oxford phase function, especially during the early morning and late afternoon. DODO data including both the coarse and accumulation aerosol modes gives similar radiances to the current Oxford optical properties. Using the accumulation mode alone gives a similar variation with respect to solar zenith angle but higher absolute values. This is possibly a function of greater back scattering and a lower forward scattering peak shown in the phase function in Figures 2a and 2b.

4. Future work.

- Aerosol profile data from DODO will be used to further test the consistency of the satellite observations with the field campaign data.
- Sensitivity of the retrieval to the identified difference in optical properties between the assumed Oxford properties and the field campaign data will be quantified.
- Our proposed approach to identify aerosol types based on model CO will be extended to SEVIRI Saharan Dust Index to identify dust plumes and tested using ORAC data during 2006 via the ESA GlobAerosol project.