Intercomparison of Aerosol optical Depth from four reanalysis and their multi-reanalysis consensus by J. Peng et al.

Strengths

The consensus is a useful product to study regional AOD trends over the last decades
Insightful presentation of host model biases in data assimilations
map presentations to illustrate global distributions of component AOD

Weaknesses

The component separation depends on host model input and process assumptions
A model's component skill may suffer from total AOD bias corrections in assimilations
Assimilated satellite AOD has built/in uncertainties (absorption, albedo, cloud-clearing)
The (coarse) monthly temporal scale of the consensus model limits it application.

General

The paper investigates monthly average (mid-visible) AOD maps of MODIS retrieval assimilations of 4 different models and of their average (the consensus) over the last two decades. In addition, the total AOD values are stratified both into maps for sub-micrometer (fine-mode) and super-micrometer (coarse-mode) particles and into maps of contributing aerosol components (SU, OC, BC, DU, SS). Hereby the component separation, if components are spectrally defined (not only by size but also absorption) opens the door for aerosol associated climate impact assessments.

Even though all models rely primarily on the same near real time MODIS AOD retrievals in their assimilations, resulting AOD maps differ, despite overall similar locations of AOD maxima. AOD stratifications into aerosol size modes and even in more detailed aerosol component AOD maps illustrate that these differences are driven by much larger diversity in forecast (emission input, aerosol processing) models. In howfar any component separation skill of modeling though is compromised by AOD bias corrections in the assimilation process remains unclear, To offer a more stable data product for AOD trend investigations over the last two decades and at the same time also to illustrate tendencies of individual models, the concept of an average mode (the consensus, MRC – a reduced ICAP version?) was developed. The consensus AOD values appear realistic (also compared to an alternate top-down approach). Only fine-mode AOD and organic contributions (if absorbing in the mid-visible) are stronger.

Thus, the consensus (with its more moderate behavior) is realistic and with its monthly resolution quite interesting for AOD trend analysis (and apparently there is such companion paper), Considering though that assimilations of satellite data add spatial context, the development of a consensus with daily temporal could be very useful to assist aerosol IOPs or even calculations of radiative surface energy budgets.

For climate impacts (at TOA) however, aside from size also aerosol absorption increasingly matters, so that for such an application aerosol components needs to be associated with characteristic spectral absorption behavior.

Overall the paper is quite informative.

Details

general The NRL group (of the main authors) had offered an ICAP model in the past based on seven models and it would be interesting how different the new MRC consensus is for common years.

general The split in components via maps is a nice illustration over which regions and which seasons particular components are important. But to go the next step (to address aerosol radiative effects) each of these components need to be associated with information of size (distribution) and composition (spectral refractive indices – also addressing absorption), so that needed single scattering properties for radiative transfer can be offered.

general Consensus ??? would not be a '4-model average' be more precise? (An alternate method would be to exclude the largest and smallest model … but then components would not be additive anymore … so … not a good choice here)

Line 64 Why is the consensus better than ICAP? Because each of the 4 data-set addresses all (5 aerosol) components (to add up totals)? In the end (when presenting data) it also would be interesting how total, FM and CM AOD would differ between ICAP and MRC.

Line 83 The use of additional satellite remote sensing data beyond MODIS has probably only a small impact, as this additional volume is small compared to MODIS

Line 117/231 These are nice model descriptions (very useful) but they could be a bit extended. However, since aerosol components are a major element of the model inter-comparison, the model comparisons could be more insightful with a comparison of aerosol microphysical assumptions for each component (possibly in a table), as size and absorption (of each component) are needed for the transition from aerosol (dry-) mass into aerosol optical depth (e.g. reff of log/normal size/distributions or bin/schemes, mid-visible imaginary part of the refractive index) and mass-extinction efficiency (component AOD/ component_dry_mass) also informs on the assumed aerosol water uptake.

Line 253/257 The SDA method assumes 0.5um radius split, while the split using the 22 size bins of the AERONET inversion is at a radius at 0.528um. This is very close. And since a bi-modal distribution has usually a minimum for these sizes the differences in the AOD splits (into FM and CM) are likely small. The small high bias by the SDA may also be possibly associated with its smaller 500nm (compared to the 550nm) reference wavelength.

Line 260 I would have removed high mountain sites for evaluation (e.g. Mona Loa, Izana, …) to begin with - as it will introduce biases in regional (100km2) evaluations

Line 272 What about the AOD overestimates at low AOD by MODIS? Just compare to other retrievals over oceans (e.g. MISR, SeaWifs…)

Line 288 Why not using the few MAN data at least for polar summers and why not including MAN data in general (giving also a FM/CM split reference over oceans)?

Line 319 Figure 1: nicely chosen color-scale to document differences in the most frequent 0.04 to 0.2 AOD range. I wonder though about the MODIS data, which seem to be rather low. If this is the NRL cleaned version, I would also show the standard MODIS version with higher oceanic AOD, because those data are used in non-NAAPS assimilations. This also would explain higher oceanic AODs for those other assimilations.

Line 336 At higher latitudes the lack of sun-light is contributing factor but the main reason for no data over continents then is the (bright) snow cover.

Line 346 It is not always so obvious that clear-sky AOD is always smaller than all-sky AOD - as stated. In some models it is just the opposite, when wet-removal effects exceed potential aerosol swelling effects at higher ambient relative humidity.

Line 347 Figure 2 … I suggest to use the same color scale for absolute MRC data in column 1 as in Figure 1. And the color scale for differences should also be changed to indicated larger and smaller values (right now only larger values are well indicated … e.g. a green color if values are similar, blue scaling for negative and red scaling for positive …?) The NAAPS ABF might be better split into scattering and carbon components … maybe with a scaling from participating other models. Otherwise the consensus SU component is biased high and OC is biased low. Also, the JRA dust is very low and it likely biases the dust consensus low. Otherwise (if you do not care that components add up to total thus not really recommended) you could also remove unfavorable versions for specific components of the consensus.

Line 369 Emissions are the more likely reason, because removal/transport would also show a similar behavior for sulfate, which is not observed.

Line 430 Figure 3: ratios are nice (possibly also DU/CM and SU/FM) the JRA SU is very large and even larger than the NAAPS SU/ABF.

Line 437 The components of the MACv3 climatology (own work) derived from absorption associated FM AOD and CM AOD (along with assumed component properties) yields similar global component mid-visible AOD averages (for annual distributions see the maps below): CM 0.060, FM 0.059, DU 0.025, SS 0.035, SU 0.037, OC 0.017, BC 0.006. The consensus has a larger fine-mode contribution and here a larger OC fraction of about 0.020 globally. I would be interested to look at map differences between the consensus and MACv3. MACv3 monthly 1x1 are mid-visible AOD data (same wavelength, same resolution) are accessible (in netcdf) on anonymous ftp in directory

ftp-projects.mpimet.mpg.de/aerocom/climatology/MACv3_2022/550nm_bands20
in file … MACv3_550nm.nc

Line 457 This is an important point and also a reason why component detail has larger uncertainties than AOD combined totals.

Line 511 I suggest to remove (AERONET) mountain sites and do not go fishing for unlikely (at best secondary) explanations

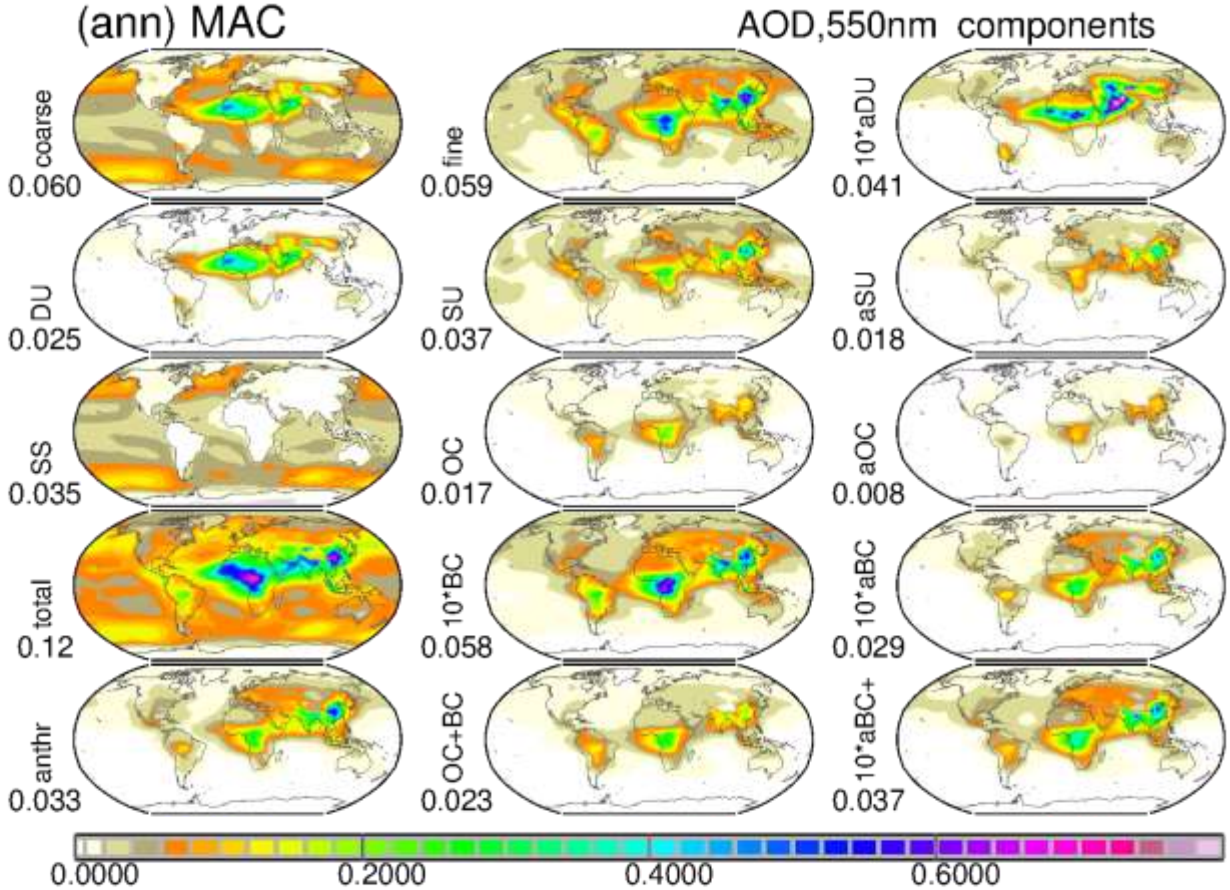
Line 543 Figure 5: it is different to see the coarse-mode biases. If you single out a different shade (here lighter color for CM) then use to for total and give FM and CM the same shade.

Figures 6/7: I need more help with the RMS definition. They probably involve data from the same model for all 20 years and also 12 months? It would be more meaningful to have the average seasonality removed, at least for regions with stronger seasonality … Anyway, I would move figure 6 and 7 in the supplement.

Line 631 It might be nice to show regional component mixtures not annually but for all four seasons

Line 661 This point certainty important. A total bias correction can worsen a (more) skillful component distribution of the forecast model. Even though the maps are illustrative and instructive, these component distributions are not free of error. This is also the reason, why skill I best tested for total AOD.

Line 719 It is nice to offer data access to the four assimilations, but why is a web-location of MRC data missing?


(ann) MAC
AOD,550nm components
coarse
0.060
fine
0.059
10*aDU
0.041
DU
0.025
SU
0.037
aSU
0.018
SS
0.035
OC
0.017
aOC
0.008
total
0.12
10*BC
0.058
10*aBC
0.029
anthr
0.033
OC+BC
0.023
10*aBC+
0.037
0.0000
0.2000
0.4000
0.6000