Review of paper:

Evaluation of aerosol optical depths and clear-sky radiative fluxes of the CRERES Edition 4.1 SYN1deg data product *by D.Fillmore et al.*

Positives

- Overdue assessment of Match aerosol properties used in the CERES data product
- Comparisons between MATCH and MERRA
- Using AERONET and BSRN references
- Efforts to match scales and conditions in data-comparisons

Concerns

- focus on AOD (also modulated by prescribed water uptake), while rad.flux disagreements are also effected by aerosol absorption (varies regionally/seasonally) and aerosol size.
- focus only on shortwave radiative (clear-sky) closure, while the added use of the longwave radiative (clear-sky) closure would provide extra constraints.
- Limiting AERONET data analysis to AOD, while detailing and complementing data (AODf, AODc, AAOD and even water vapor) are available.
- Ignoring a focus on (wildfire and dust) seasons, where aerosol signals are stronger.

General comments:

The paper investigates the quality of the aerosol representations of the Match model in radiative transfer applications for the surface (and atmospheric) radiation flux product. Considering that the surface (and atmospheric) energy budget are important for surface processes (and atmospheric dynamics) this contributions is overdue. First AOD data are compared to MODIS noon-time (retrievals) and to Merra (assimilations), then spatially limited (sparse, land-based) comparisons to AERONET data are analyzed and finally the calculated clear-sky downward radiative fluxes are compared to (also) spatially limited BRSN data. Finally, also necessary corrections, not just limited to aerosol properties are discussion so that closure with the (stronger to observed tied) TOA fluxes are achieved.

There are apparent limitations, that cannot be changed, such as (1) the climatological emissions (without the ability to cover specific dust or wildfire events … other than general noon-time (total) AOD adjustments with MODIS retrieval data) and (2) assumed aerosol types (refractive indices, size, water uptake).

Many of the offered comparisons are interesting. For instance the separation between less cloudy and cloudy events, the relatively strong (stronger than in Merra) aerosol water uptake is revealed. Also, the separation of the analysis to the reference (AERONET, BSRN) into region for the focus on the representation biases of specific aerosol is commendable but in the end the final conclusions leave more questions than answers.

In order to get closure with TOA CERES clear-sky data, the full potential of aerosol properties is not investigated by rather changes to water vapor and solar surface albedo are ‘invited’. This is disappointing from an aerosol property perspective (AERONET offers a split into fine and coarse mode AOD contributions, AAOD absorption data for high aerosol load cases on which I would focus first, and even water vapor column data, for LW closure) and from a radiative flux (closure) perspective (as SW data are also accompanied by LW data).

I know that the paper has already some volume but the last sentence of the conclusion is not satisfying at all.

On another note, I would also look to compare the (clear-sky) surface (and also TOA) radiation budgets of CERES (with the Match data) to those in Langley SRB product. Maybe in this context even aerosol optical and radiative (also component) properties of MACv2 (derived from optics) could be compared.

The MACv2 (1x1, mon) aerosol climatology is available via anonymous ftp … and even single scattering properties for your 31 (17 +14) band spectral resolution are available
ftp-projects.zmaw.de/aerocom/climatology/MACv2_2018
all subdirectories are useful … but those 4 most useful for you
/documents - documentation in papers
/550nm – 550nm properties for the reference year
/spectral/ssp_31bands - your spectral resolution for the 2010 reference year
/spectral/ssp_31bands - aeback … are pre-sel aero components with assumed opt properties)
/spectral/ssp_31bands/by_years - your spectral res. for indiv.years (only anthro. AODf changes)

(for access: use filezilla [FIREFOX does not work anymore] or use lftp from a linux machine)

Minor comments:

Line 33 "AOD are greater at all-sky conditions" not necessarily in modeling … "supported by AERONET" how? as AERONET only samples at cloud-free view.

Line 35 Merra like Match are also using MODIS data … so we compare to model applications of satellite retrievals (which could be incorrect and biased) but not against the truth.

Line 46 Differences can be attributed not just to amount (AOD) but also to aerosol absorption and aerosol size (SSA). For larger differences in case of dust aerosol it would be also great to look for consistency with broadband longwave fluxes. (This however requires not only good data on dust size and dust IR absorption but also accurate data for water vapor profiles and dust altitude).

Line 140 are the needed ancillary data (10m winds, climatology oxidants fields and emission inventories .. what databases?) for each specific year (since 2000) applied … or are these based only a general climatology?

Line 149-158 the assumptions for the aerosol component optical properties are essential, thus at least component reff and RFimag at 550nm (and for dust components also the RFI at 10um) and resulting SSA values at 550nm for all components should be listed. I also assume a component external mixing … correct?

Line 183 By assuming that AOD differences drive the changes in aerosol mass, it is likely postulated that the model assumed mixtures and mass extinctions apply, which may not be the case especially if AOD changes are associated with a singular aerosol component. In that sense it would be better to assimilate at least fine-mode and coarse mode properties separately as their properties are quite different. Another limitation is that the fine and coarse mode assumption for absorption and size in MODIS retrievals likely differ from those assumed in the Match model, so that the AOD comparison are biased.

Line 197 it is interesting that Merra considers more input than just MODIS AOD … but I wonder in what way other day will and can override MODIS AOD data… thus I think the Merra data cannot really serve as reference. (In that context also the aerosol component treatment is likely different).
Figure 2 line 205 the multi-annual differences between Merra and Match are large and even often with different signs in some regions (and more than 0.3 is very large!)

Line 215 could not the daily MODIS data be subsampled for improved Match model comparisons (although MODIS may be still biased). Then it also would be interesting to compare fine-mode AOD and coarse mode AOD. On the other hand more than 15 years of data twice a data averaged (via monthly) into multi-annual global averages should provide sufficient statistics.

Line 220 the number of MODIS AOD –compared to other AOD data- will dominate so differences in AOD input between Merra and Match should not matter that much

Line 224 AOD are generally smaller over ocean than over land (expect for outflow regions) so that AOD differences should be smaller. Generally, oceanic assimilated oceanic AOD differences are smaller although Merra has significantly larger (MODIS-like) AOD over the southern oceans.

Line 225 the sharp land/sea contrast off northern Africa in differences (likely a model feature) are concerning, as well Merra's much lower values over SE and E Asia and Match's larger values over E Asia, E. Europe/N.Asia and over the Andes mountains stand out. I would investigate in what way a too strong absorbing aerosol type in the model would cause an AOD overestimate (e.g. in Match) or a too waekly absorbing aerosol type in the model would cause an AOD underestimate (e.g. in Merra) – assuming that the retrieval absorption assumption are correct. (It also would not hurt to compare SSA maps between Merra and Match to better understand the large AOD differences in the models in some regions).

Line 233 the log/log plot choice hides the (MODIS high) bias at lower AOD values. Nonetheless the scatter (consider that these are assimilation) are considerable. Overall, the assimilated global annual AOD values are lower at 0.142 in Merra and 0.160 in Match. It is known that MODIS is biased high (mainly at lower AOD values) so the relatively large global average in Match surprises. It would be nice to compare by AOD-bin and by region/seasons at least for ideas on how to find clues for better comparisons … so Figure 4 offers some insights but many regional differences are so large that they need some explanation.

Figure 4 Line 261 why just 1 month (jan 2020) and not 15+years? It is interesting that AOD increase from clear-sky to all-sky in Match apparently only happens pollution regions over E. Asia US and Europe, which begs the question if assumed ambient rel. humidity aerosol water uptake in Match at higher rel.hum is too strong (also clouds with 100% hum. only occupy specific layers). And with clouds in the neighborhood there is not only the issue with aerosol size swelling but also the issue with wet removal. Thus, global models are highly diverse if AOD under all-sky are actually larger or smaller with respect to the clear-sky value. The large difference over biomass regions suggest that aerosol (fine-mode) absorption is much stronger in Match. Thus I would compare fine-mode SSA and water uptake between both models.

Line 268 … and aerosol absorption (and dust size)

Figure 5 line 291, Bejing is an urban difficult site with a lot of near surface pollution during winter. Both models suggest larger AOD with clouds, whereby the increase is much stronger in Match than Merra. Otherwise the AERONET values are larger, most likely due to nitrate aerosol, which is missing in Match and possibly also Merra.

Line 304 the cases with less than 1% (in 1deg regions) are probably too few for useful statistics. (I would split all cases in ca equal counts with more and less clouds). I am bit surprised than with the 1% threshold relative many cases are found … so do I misinterpret here? Also not that in the comparisons many AERONET sites are more local (urban) and not regionally representative.

Line 325 … would this make you want to reduce the water uptake in Match?

Table 2 Line 341 I wonder about the many matches for Australia, the small AOD values over Brazil with the biomass burning, the relatively large AOD values over central Africa (although the sites are spread. and the small values for N.Africa associated with dust.
I strongly recommend to use AERONET as reference not just for AOD, but also for the split in AODf and AODc and also for AAOD data (at larger AERONET AOD cases AOD550 > 0.25).
Given the large differences between the models in some regions (in Fig 4) the bias differences among the models are relatively small … why?

Line 440 Figure 10 (not 8)

Line 469 also dust size is an issue (as larger dust for the same mid-vis AOD has lower SSA and also larger spectral near-IR AOD)

Line 511 I do not follow the argument of a likely lower dust AOD … as such a tendency seems to go the right direction … given the 0.07 bias in Table 2…??

Line 560 I wonder about the surface albedo treatment (at 14% solar broadband values are mentioned and now a significant 3% increase was mentioned). I hope the Kato model uses the spectral dependency for local soil conditions from MODIS. I would tinker not just with AOD but also with size and absorption before starting to change the surface albedo.

Line 571 … exactly … and NO it should be part of this study.