Review of the revised 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.*

Comments to the author's responses

All my comments were addressed – although those involving extra analyses were unfortunately denied - so if not in this paper … then hopefully in a future contribution. When the authors state as the goal "to evaluate aerosol optical depths for irradiance computations", then also the clear-sky LW fluxes need to addressed, especially near dust sources. Typical mineral dust aerosol radii near sources are 3-6um and even transported dust has effective radii of about 1.5um. Their given justification to ignore LW effects assumes too small (ca 0.5um) radii for mineral dust. In that context also the last sentence of the abstract ('… are unknown.') is very unsatisfying. For the dust inconsistency problem also possibly poor choices of AERONET references contribute, as (1) column properties (like AOD) of regions should not be compared to mountain site data (as Izana) and (2) months when other aerosol types dominate should be excluded (as for DJF in western Africa). And if AERONET is applied to reveal biases for AOD, then also the offered AOD split between fine-mode/coarse-mode AOD should be applied. I reject the notion that MATCH does not contain (approximately) this size information with its component processing, where dust and seasalt basically define the coarse mode AOD and (organic and black) carbon and sulfate define the fine-mode AOD. And for cases, where/when relevant AERONET sites are missing (as for northern Africa, central Africa or ocean regions), comparisons at coarser temporal (e.g. monthly, seasonal) resolutions (as offered by top down climatologies or other approaches such CERES, SRB 4, ICAP) are (as in my initial review) encouraged for insights on MATCH tendencies.

The strength of MATCH AOD data are high temporal resolution AOD maps (as needed in modeling) to include short-term regional anomalies, but that does not mean that global multi-annual (average) maps are correct. The most important section is chapter 4. So there should be more weight (and analysis) and less weight on the first 25 pages. In particular, the detailed comparisons to MERRA distract, as it is only a different model interpretation with quite different results and MERRA results are even left out in the comparisons at TOA fluxes (CERES) and surface fluxes (BRSN) of chapter 4.

On responses to my minor points of the initial review …

- The demonstrated smaller AERONET AOD at cloud-free conditions at the CART/Bondville sites may be meteorology (air-mass) related. These statistics will not necessarily apply to many other AERONET sites, for instance at dust dominated sites where higher AOD will likely be associated with less clouds.
- The assumed 1um mineral dust size (0.5um eff radius) is very small, even for transported dust. Thus, the associated reasoning for LW impacts are not important (to the surface irradiance) is not convincing at all. Also with larger (up to 10um) dust sizes the effective solar absorption potential (e.g. 1-SSA) quickly increases so that for the same AOD the solar surface irradiances will be lower (dust size in MATCH could be possibly included via a proportional link between dust AOD and dust effective size, as sizes near dust sources are usually larger).
- in Figure 1 there are not the promised maps for SSA and g ….?
- I agree with the authors and retract from my initial conclusion of a "likely stronger fine-mode absorption in MATCH compared to MERRA", because Figure 4 compares model simulated AOD maps. Still, the larger MATCH AOD values in regions, where fine-mode aerosol (SU, OC, BC) types dominate are concerning – possibly helped by the fact that MATCH assimilations only constrains the total AOD and not local component mixtures.
- I still suggest in AOD assessments to separate fine and coarse mode AOD contributions when

comparing to MERRA and AERONET. For AERONET inversions detailed (ambient) 22 bin size classes a separation at the 0.528um size-bin boundary is recommended and in modeling the separation by components with combining BC/OC/SU (fine) and SS/DU (coarse). AERONET also offers simple fine-mode fractions via the AOD spectral dependence (and the SDA method) from direct attenuation data. The fine-mode effective radius can certainly vary (as demonstrated in a figure by the authors) but there are always a minimum at aerosol radii of about 0.5um (unless there is a major volcanic eruption with effective sulfate aerosol radii near 0.5um).
- if you use high altitude mountain AERONET sites (e.g. Izana) then you get underestimates in comparisons to regional averages (bad choice!). Also West-African sites (e.g. Ilorin) are biomass dominated in NH winter and dust dominated in NH summer, which complicates a type association unless a seasonal separation is done. You also present fine-mode and coarse mode distributions but I suspect that fine-mode is not dust (as fine-mode dust is secondary to coarse mode dust).

Comments to the responses

36 these maybe convective regions … but a much more important element is that these are regions with fine-mode aerosol maxima (by wildfires and pollution).

45 make sure to pick regionally presentative AERONET dust site (exclude mountain sites)

47 if AOD is correct, but the dust size (and solar absorption) is underestimated, then a model yields too high solar irradiances at the surface

152 OPAC is parts in outdated (e.g. too much dust absorption, too little BC absorption) … but more importantly, how is OPAC applied? I assume (if so state that) that MODIS AOD are compared to simulated AOD and differences are expressed via component mass corrections by applying OPAC aerosol type based Mass Extinction Efficiencies – assuming locally/monthly fixed aerosol component mixtures.

158 Sinyuk (2003) dust RFI-imag values are much better than those in OPAC … also you may note that in his paper the coarse mode dust effective radius (in Table 1) is ca 1.5um (number mode radius of 0.63um and stddev of 1.72).

182 as from AOD differences aerosol component mass is adjusted … this of course requires mass extinction coefficients for aerosol type (which also include water uptake). Are these coefficients based on OPAC and if so have they been checked for realism?

205 errors in the captions: “thickens” and “left)” and “right)”

222 … and eastern EU / west Asia

230 I do not see that “Match-Modis differences are smaller than Merra-Modis differences”. And there is no plausible explanation by MERRA is so much smaller than MODIS and by MATCH over many land regions is even larger than MODIS (based on Figure 2 differences I am surprised to see in Figure 3 that the global averages of MATCH is smaller than MODIS? Also in Figure 4 clear and all-sky MATCH-MODIS differences are positive, which is inconsistent with Figure 3 means).

265 I suggest to replace ‘convective’ with ‘fine-mode AOD maxima’

283 Anomalous high AOD by MATCH at near overcast conditions (as shown in Figure 5) will not matter much for solar irradiances at the surface, when clouds reflect most of the solar energy… or? So for solar irradiance all-sky AODs (and ‘averages’) are less meaningful that clear-sky AODs.

340 Many aerosol types have if not monthly so at least seasonal maxima, so an evaluation to AERONET (in Table 2) on a seasonal basis would be much more insightful … even better with a separation into fine-mode and coarse-mode AOD.

387 … so what is the conclusion? Spell it out. MODIS AOD are likely overestimated without QAC so that MATCH is relatively high compared to MERRA. But this does not answer the question why MATCH is significant larger than MODIS over many continental regions as shown in Figure 2.

393 If MATCH (via MODIS) misses large aerosol events, why are AOD values over continents (incl. wildfire regions) so large?

422 the AOD data presented in Figure 9 are maxima (if I read the captions correctly). Why are not median and interquartile-range values are presented instead? And is there a direct sample link between AOD and PV of just max statistics?

426 explain 100% post and neg error in the captions. If the guess is 0.2 … then at 100% the lower bound is 0.1 and the upper bound 0.4, which would give an asymmetry not shown in Figure 10. Also it would be nice to show results for a more absorbing (dust or wildfire) aerosol, because the error max at sza near 0.5 will vanish and will more simply decrease with insolation. Still I do not see the value of this figure as not even an AOD value is given in the captions (as usually AOD uncertainty wants to be translated into W/m2 irradiance error). Why do I have to read the text to get the info and with those definitions even negative AOD are possible..? Figures and captions should be self-explanatory! But do we need section 3.1 other than stating AOD error as function of aerosol type and SZA… all of which could be placed in a table.

486 CERES detects SW (and LW) upward radiation (and not solar 'irradiances' as at the surface).

493 Aside from AOD and precipitable water there are other knobs for tuning such as (aerosol absorption, aerosol (dust) size and aerosol elevation, surface albedo). Just tuning with global averages may provide globally the correct result for the wrong regional/seasonal regions. Thus a regional evaluation is strongly encouraged. Later surface albedo changes are included … so are these not elements in the global adjustments, as they seem to be higher everywhere in Table 4

500 to increase the shortwave reflection in terms of aerosol properties also less aerosol absorption and a smaller aerosol type (relative more fine-mode AOD) helps

508 MATCH AOD is already high at mid-latitudes … even to MODIS, so an additional 0.02 AOD seems to go the wrong way.

510 there is no 'top right' in Figure 10

519 MODIS AOD over oceans are already likely too high, so that further increase can not be justified.

534 I miss in Table 4 the clear-sky upward MATCH based SW (and LW) uncorrected upward fluxes (to compare to CERES based TOA obs) and the clear-sky downward MATCH based SW (and LW) uncorrected downward fluxes (to compare to BSRN/buoy data).