Sensitivity of global direct aerosol radiative forcing to uncertainties in aerosol optical properties by J. Elsay et al.

Strengths

statistical approach (to capture impact uncertainty through multiple simulations)
simplicity (differences from dual/triple calls)
link to observational capabilities (sat AOD retrievals, absorption from Anet inversions)

Weaknesses

implications to climate prediction uncertainty are overdrawn (without indirect effects)
all-sky impacts (clear-sky to all-sky) are based on a simple approximation
pre-industrial aerosol properties are not (but should be) considered in DARF
DARE uncertainties do not include longwave effects (thus likely could be too large)

The paper applies aerosol radiative properties of the MACv2 aerosol climatology as a base-line for uncertainties of aerosol radiative effects and aerosol forcing – but only for solar impacts under cloud-free conditions (at TOA and surface) although with an approximation to estimate all-sky impacts. This study is interesting, but there are also aspects that need to be clarified and possibly corrected during the review process.

While MACv2 aerosol properties are applied to define the solar spectral aerosol properties (AOD, SSA, ASY) and the AOD vertical distribution, questions remain as to why the calculated results are so different from 'official' MACv2 simulations. For clear-sky solar (all) aerosol radiative at the surface the global average -8.6 W/m2 cooling is larger than -7.4 W/m2 in MACv2 (and -7.2 W/m2 in MACv3). This suggests that applied solar AOD values of the implementation in this study are larger. This then could also explain – with a similar absorption potential - why TOA impacts at -4.5W/m2 are more negative (than -3.5W/m2 in MACv2 and -3.7W/m2 in MACv3). It would be very useful to compare global 'input' AOD maps (especially for solar spectral AOD data) to identify the cause for these differences - under the premise that an identical input to aerosol properties was used. Suggested contributions of (environmental) non-aerosol properties are weak, because DARF and DART estimates are based on differences from two simulations, where these properties do not vary (just largely cancel in their impacts).

The estimated aerosol property uncertainty impact on DARE ignored longwave effects, which possibly could reduce uncertainties. For climate relevant DARF (at TOA) the solar impact is sufficient, but other important elements (the pre-industrial uncertainty and more important indirect effect through clouds) are not included, so that climate uncertainty relevance (for me) is more than limited.

Finally the applied observational uncertainties should be reviewed. For AOD I would include an uncertainty that increase also with AOD and for SSA I would ties uncertainty directly to AOD … possibly by using AAOD (AOD*[1-SSA]) uncertainty instead.

Overall, it is an interesting sensitivity study.

Details

(while reading the paper)

Line 33 Aside from TOA and surface impacts also atmospheric impacts and uncertainty could be addressed. Differences between TOA and surface indicate atmospheric impacts and quantify (for solar aerosol radiative effects) the solar heating in the atmosphere.

Line 70 the definition of anthropogenic aerosol requires a pre-industrial state, which cannot be measured and it largely drawn from model simulations (which seem reasonable but involve many assumptions). Given the uncertainty to wildfires at pre-industrial conditions, the anthropogenic AOD is relatively large not only for direct but also for indirect effects.

Line 72/95 I attach a netcdf file with MACv3 AOD/SSA/ASY data at 550nm and I like the authors to check if their implementation reveals similar (especially) AOD values (because I just do not understand why the radiative effects are so more negative – e.g. the DARE values to the net-fluxes at the surface – as the implementation, as described sounds reasonable. If anymore comparison data (e.g. surface albedo, solar insolation) should be compared, please let me know.

Line 129 the explanation attempt via environmental differences seems unlikely as difference in the set-up will cancel when subtracting two simulations.

Line 150 As expected the solar spectral resolution is not an issue, but thanks for checking.

Line 165 The forcing efficiencies agree much better than the forcing … so AOD field difference seem the most likely explanation (I suggest to compare your AOD data to those of an .nc MACv2 or MACv3 data files, which is will send the authors on request).

Line 183 I would associate the AOD not just with a fixed deviation, but also as a function of AOD (as in many satellite retrieval evaluations). Similarly I also would associate the SSA uncertainty with AOD, as suggested by Dubovik. In that sense I would work with AAOD uncertainties rather than SSA uncertainties (and yes satellite data have little skill and mainly reflect a priori assumption). I do no care so much about ASY uncertainties Another way for uncertainties would be to work with local ranges of multi-annual monthly (or in your case seasonal) data at least for AOD, which are provided from ICAP satellite data multi-model assimilations.

Line 272/274 I agree with that assessment

Line 290 For DARF I would distinguish between anthropogenic fraction and other 'host model uncertainties', because the host uncertaintties largely cancel via differences from two simulations, whereas 'anthropogenic' does not.

Page 294 … and for that reason use (for absorption uncertainty) AAOD uncertainties rather than SSA uncertainties. And SSA uncertainties to DARF and DART are less meaningful at low AOD.

Page 315 the dust SSA uncertainty is mainly associated with uncertainties to dust size. But also here I see as AOD association as the larger the dust AOD, the larger the dust size and with that the lower the mid-visible SSA.

Page 385 I agree that anthropogenic uncertainties for DARF should be large. Why was that not included this in your simulations? Pre-industrial AOD and SSA uncertainties are MUCH larger than current satellite or Aeronet uncertainties.

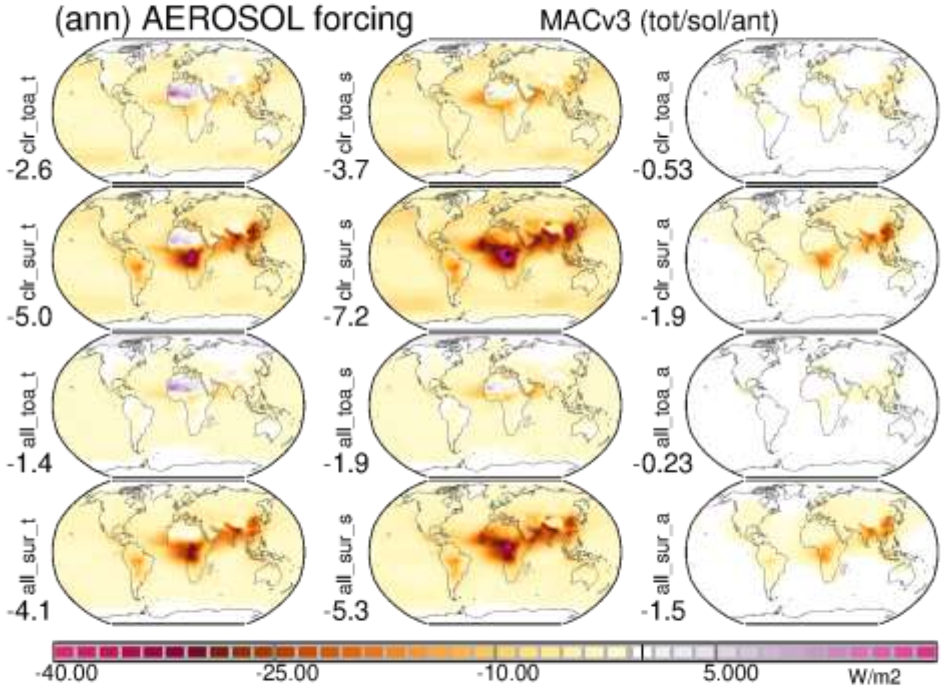
Page 410 MACv3 also uses ISCCP but distinguishes between high, mid and low altitude cloud cover (impacts on forcing and forcing efficiency can be taken from the images). This approach here is simpler but ratios could be compared to MACv3.

Page 430 MACv3 is more absorbing in the fine-mode so that DARF is now reduced from -0.35 to -0.23 W/m2 (just as info). Surface DARF is with -1.9 W/m2 similar.

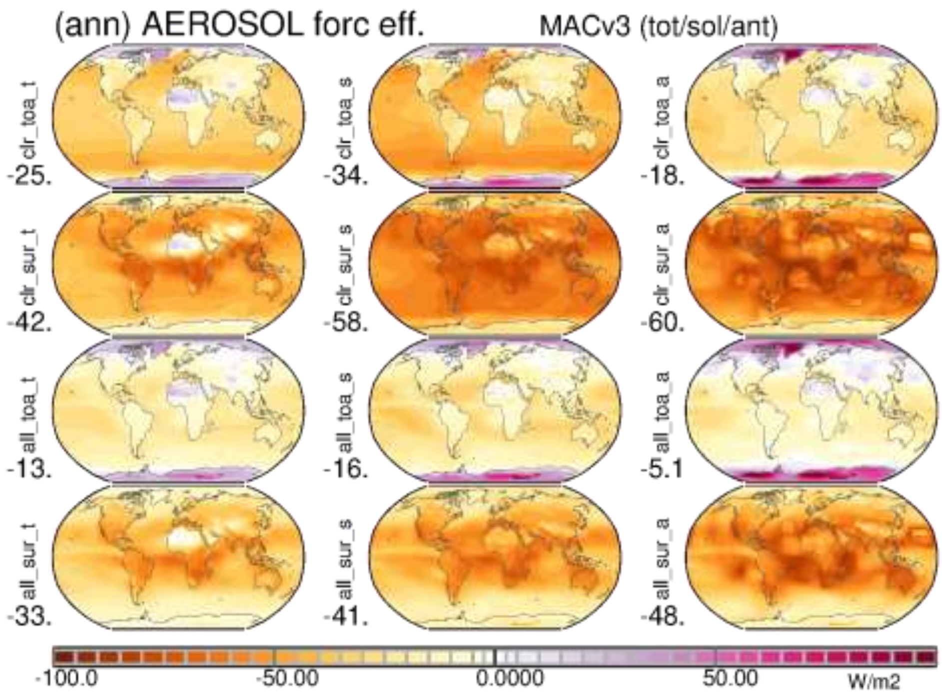
Page 442 Since only solar radiative transfer is addressed here I would focus on DARF (and not so much on DARE).

Page 471 all-sky DARF in MACv3 compared to MACv2 is now shifted to less negative values (based on the same arguments). Still these uncertainties are small compared to uncertainties from indirect effect though water clouds (cover, optical depth, droplet radius). In the conclusions this should be put in perspective … and possibly a follow-up study (to include indirect impacts) on DARF?

MACv3

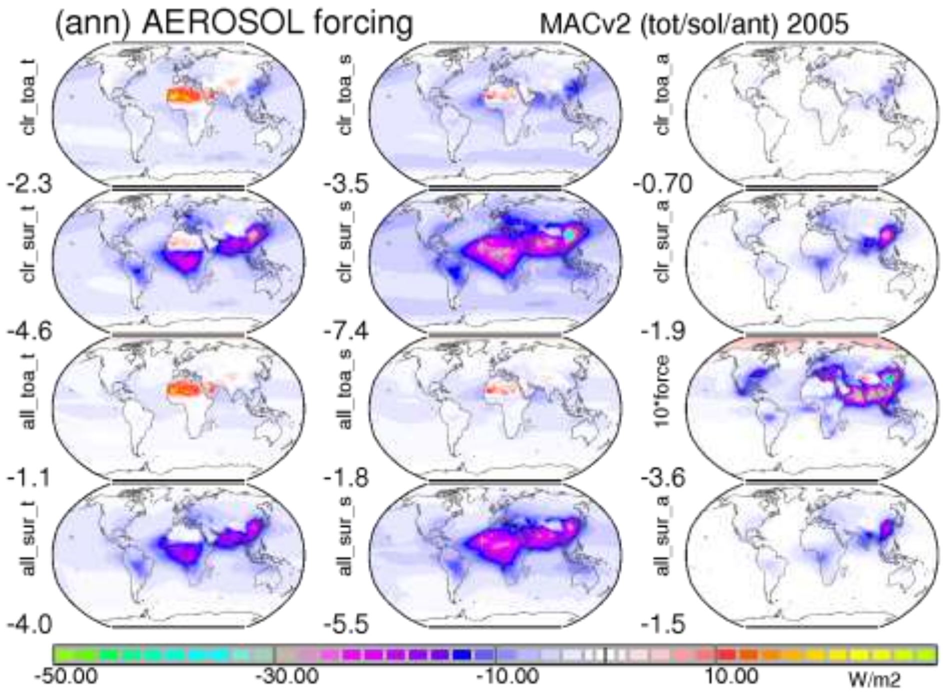


The annual average maps of the radiative effects with MACv3 (similar to MACv2) at TOA (rows 1/3) and surface (rows 2/4), for clear-sky (rows 1/2) and for all-sky (rows 3/4) for solar and IR combined (col1), for solar only (col2) and for anthropogenic solar (col3)

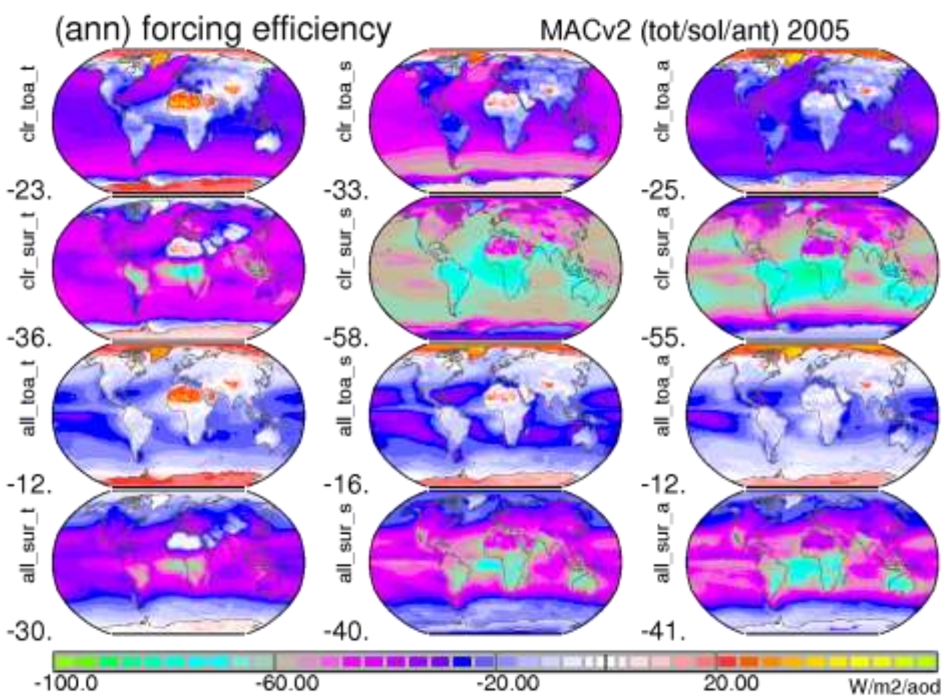


same as above … now for the forcing efficiencies with MACv3

MACv2



The annual average maps of the radiative effects with MACv2 at TOA (rows 1/3) and surface (rows 2/4), for clear-sky (rows 1/2) and for all-sky (rows 3/4) for solar and IR combined (col1), for solar only (col2) and for anthropogenic solar (col3). Hereby anthropogenic values (col3) were multiplied by 10.



same as above … now for the forcing efficiencies with MACv2