Review of paper:

Estimates of direct radiative forcing due to aerosol from the MERRA assimilation over the Amazonas region.

by B.Penna et al.

Positives

- exploring the seasonality and their inter-annual variations of aerosol direct radiative effects over the Amazon region

Concerns

- method-1 results are unlikely to yield reliable aerosol rad.effects other than at the surface
- it is often unclear to what spatial and temporal scales the given variability refers to
- the climate impact relevance is limited

General comments:

Estimates for aerosol direct effects at clear-sky conditions are presented for the Amazonas region on different spatial and temporal scales. The highlight of the paper is the analysis of regional output from dual calls (with and without aerosol) of a multi-year MERRA-2 reanalysis and associated GOCART radiative transfer simulations. The results display the strong inter-annual variability of aerosol loading (and associated aerosol direct radiative effects) during the dry season with maxima usually during September. Hereby the confirmation of the retrieved regional AOD variability with MODIS retrievals could be extended to regional AOD retrieval variations of other satellite sensors, such as MISR, SeaWiFS and ATSR.
With the strong seasonal and inter-annual variability all aerosol direct radiative effects are usually offered via large ranges (for TOA, atmosphere and surface). As the associated spatial and temporal scales are often not mentioned, the usefulness of this presentation is somewhat limited, also as no central a multi-year regional annual and multi-year seasonal averages are offered.
The method 1 has deficiencies. The method is only a function of AOD to determine clear-sky radiative effects. Such an approximation may work possibly at the surface, but is unlikely to provide useful results for aerosol direct radiative effects at TOA and thus also for the atmosphere. Aerosol absorption and surface reflectance bring in additional dependencies to be considered. Moreover, the comparison the method 2 is limited, as method 1 apparently applies a non-zero background and also as likely only clear-sky solar radiative effects are addressed in method 1..
And then there is a limited climate relevance as carbon aerosol has relatively as carbon aerosol (as dominant during the biomass burning dry season) has an almost neutral response at the TOA, especially when considering the presence of clouds (which are ignored in this study).
The paper is a nice analysis of long-term MERRA-2 simulations on variability of aerosol and its associated direct radiative effects. Since there are also other parameters which influence the aerosol direct radiative effects it might also be useful to diagnose from the MERRA-2 simulations data for AAOD, possible even hereby separating AOD and AAOD by accumulation mode and coarse mode for aerosol information (in the reanalysis) on both size and absorption. Another parameter to diagnose would be the solar surface albedo. AS another suggestion I would tone down results for method 1 and at best present its estimates for radiative effects at the surface.

Minor comments:

The title should be more accurate. The term ‘forcing’ implies anthropogenic climate relevant radiative effects at TOA and all-sky conditions (with clouds). But here (1) only total aerosol (and not anthropogenic aerosol) radiative effects and (2) only at clear-sky conditions and (3) in method1 probably only effects on solar radiation are examined. Maybe "**Estimates of aerosol direct radiative effects and their temporal variability over the Amazon region during the last decades based on MERRA-2 reanalysis output**"

1/5 … monthly average **solar** radiative **effects** at the top …

1/6 the very large values (-10 at TOA and -30 at surf) were only reached in the center of biomass burning … It is unclear if you talk about inter-annual variability or spatial variability and then again in your paper you show define two different size Amazonas region (your official definition in the text and Merra-3 plots… so 'averages' cannot be really compared)

1/7 it is unclear how natural aerosols are defined …. certainly not by monthly with relatively little aerosol (as there are even natural contributions – e.g. by lightening – during the dry season)

2/19 by the way the contribution from biomass burning to net-flux changes at the TOA (the climate impact) is relatively small with the relative strong absorption, though radiative effects to atmospheric dynamics (solar heating) and surface processes (reduced insolation) certainly matter

2/7 Ok with this regional definition but then show this region via a frame in Figures 6, 7 and 8.

2/16-18 incorrect formulas (the Angstrom parameter is neg. slope in log-space): in the 2.formula a minus sign is missing: alfa = - ln(AOD1/AOD2) / ln(lambda1/lambda2) and 1.formula should be: AOD,550 = exp (-alfa*ln(550/lambda) +ln(AOD,lamda))

4/16 add 'solar'

4/22 I doubt that method 1 can be applied to the region without significant error. It is not clear to me based on what data these polynomial were derived and how they were validated (just for a specific site/time?). When the aerosol absorption changes over time these relationships will likely break down, even if absorption changes are implicitly included (e.g. larger AOD may correlate in that region with larger absorption). I also question the usefulness of such polynomial fits with sign-changing (positive and negative) pre-factors, which yields partial cancellations and does not seem very useful for conceptual understanding which such simple fit should offer. I would have tried a much simple linear fit first, possibly as a function of AAOD as well.

4/26 using AOD data of the wet season as natural reference is poor, especially if absorption (less) and particle size (larger) differ.

5/13 so the MERRA output was diagnosed and hereby SW and LW aerosol direct clear-sky radiative effects were considered .Is this consistent with method 1 or does method 1 just address solar radiations impacts (which then should be ca 10% stronger)?)

8/8 It is unclear how the forcing is determine with method 1, as there are dependencies on surface albedo and absorption which cannot be consider by the simplicity of method 1

9/1 apparently the forcing variability that was mentioned in the abstract refers to the interannual variability during the dry season .. that should be made clear in the abstract.

10/2 … because higher AOD values in that region are stronger absorbing so, and with stronger absorption the direct aerosol efficiency decreases. (Still, here just clear-sky TOA effects are addressed but all-sky TOA effects are much more interesting). Also the TOA effect depends on variations to the solar surface albedo.

11/8 It also would be great not just to address regional range but actually determine multi-annual averages as typical value, possibly with a seasonal and monthly dependence (which then could be compared to the MACv2 climatology data – see below).

14/9 It was not clear that the method 1 fit only refers to dry-season AOD minus wet season AOD data. This even further reduces potential comparisons. Clearly this difference should be spelled out much clearer before comparing rad. forcing results. Anyway for me such as simple method 1 AOD approach has only (limited merit) for impact on surface (net-) fluxes, and results for TOA and thus also the atmosphere should be marked as highly unreliable – and I would remove those results from the paper.

below are for reference results (and comparisons) of off-line simulations for aerosol direct radiative effects with the MACv2 aerosol (monthly) climatology for the Amazonas region:

1. TOA and surface effects - annual
2. cloud effects and atmospheric effects - annual
3. clear-sky effects – seasonal
4. surface and atmos clear-sky effects - monthly

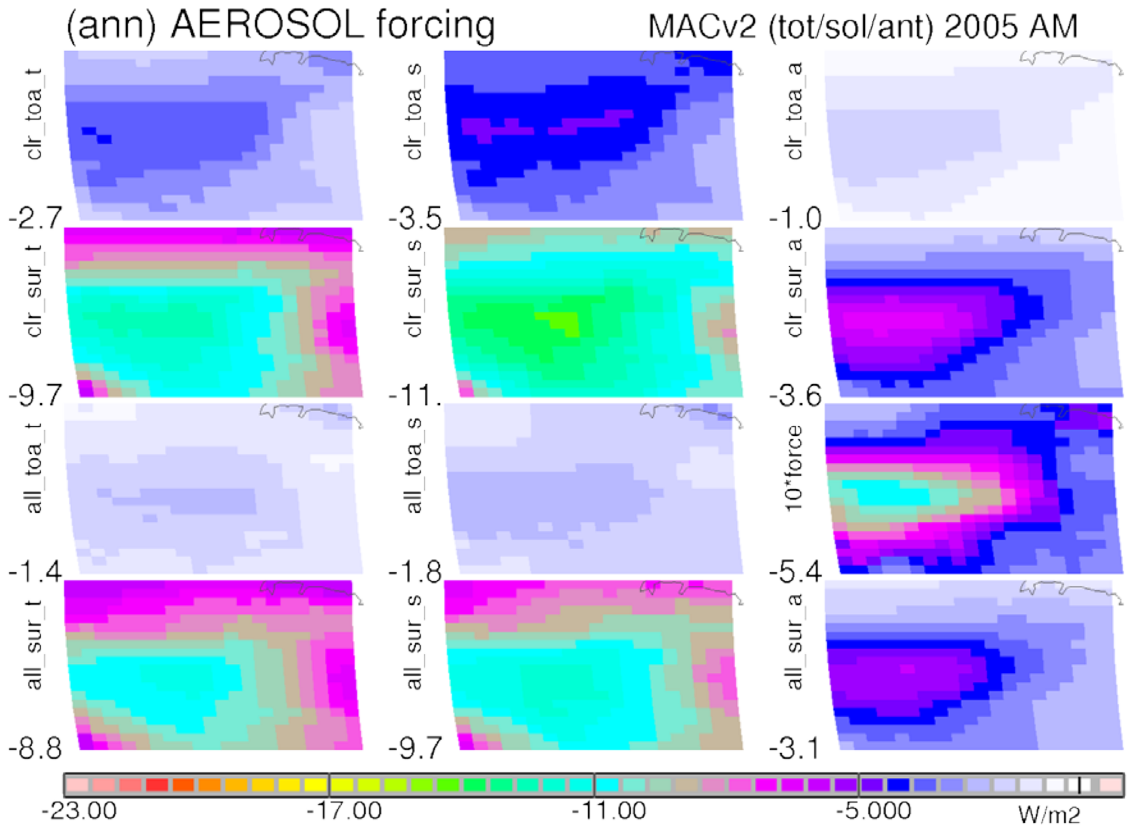

Figure 1 *Annual maps for radiative effects of today's average aerosol (left), its solar effect only (center) and the anthropogenic impact. Clear sky effects are presented in the upper two rows: at the TOA (row 1) and at the surface (row2) and all-sky effects (with ISCCP clouds) are presented in the lower two row: at the TOA (row 3) and at the surface (row 4). Note, data in the annual map for today's anthropogenic aerosol direct forcing (column 3, row3) are multiplied by a factor 10. Blue colors indicate a cooling and red colors a warming. Values below the label indicate regional averages.*

clear-sky TOA (solar +IR)	-2.7W/m2	
clear-sky surface (solar +IR)	-9.7W/m2	
clear-sky TOA (solar)	**-3.5W/m2**	(-1.0W/m2 anthrop)
clear-sky surface (solar)	**-11.0W/m2**	(-3.5W/m2 anthrop)
all-sky TOA (solar +IR)	-1.4 W/m2	
all-sky surface (solar +IR)	-8.8 W/m2	
all-sky TOA (solar)	-1.8 W/m2	(-0.54W/m2 anthrop)
all-sky surface (solar)	-9.7 W/m2	(-3.1 W/m2 anthrop)

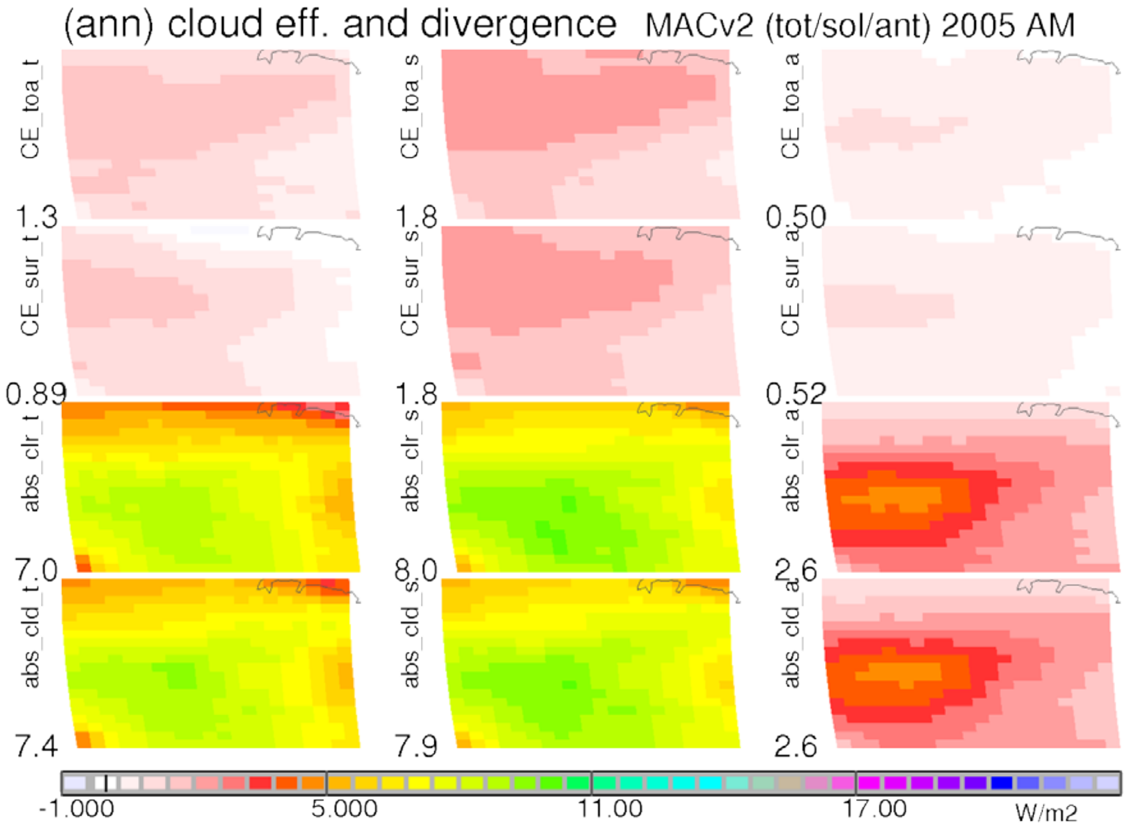

Figure 2 *Annual maps for cloud effects ('all-sky' minus 'clear-sky': top two rows) and of aerosol atmospheric effects ('TOA' minus 'surface': bottom two rows) for today's average aerosol (left), its solar effect only (center) and the anthropogenic impact. Cloud effects are presented at TOA (row1) and at the surface (row2). Note due to the aerosol solar absorption the relative reduction s at the TOA are much larger than at the surface. Aerosol atmospheric effects are presented at clear-sky (row 3) and all-sky (with ISCCP clouds) conditions (row 4). The positive cloud-effect values show that clouds cause the direct forcing to be less negative and the positive (red to green colors) indicate that major contributions are by solar absorption.*

clear-sky absorption (solar+IR)	+7.0 W/m2
all-sky absorption (solar +IR)	+7.4 W/m2
clear-sky absorption (solar):	**+8.0 W/m2**
all-sky absorption (solar):	+7.9 W/m2

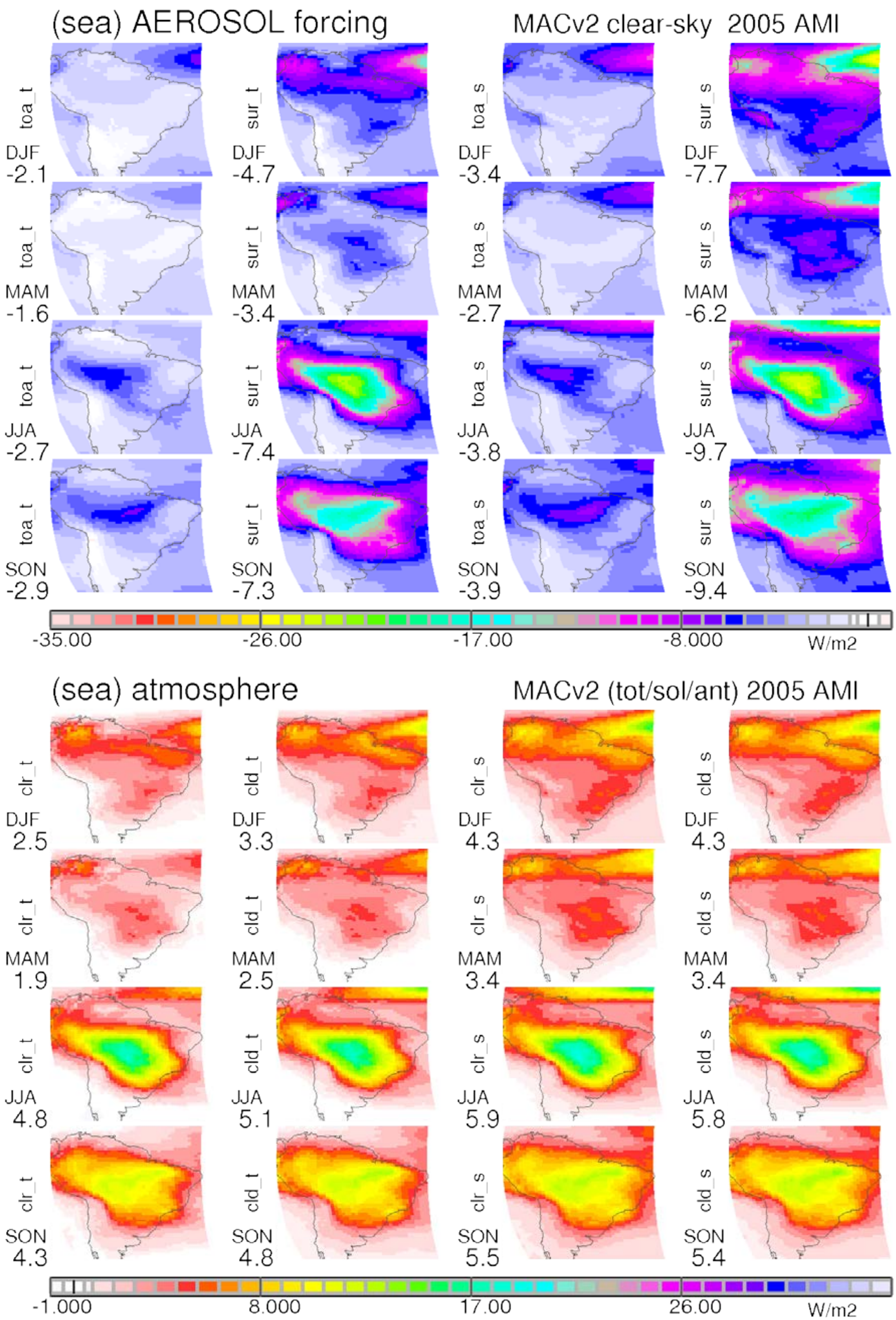

***Figure 3** seasonal clear-sky aerosol radiative effects over the MERRA Amazonas region.*

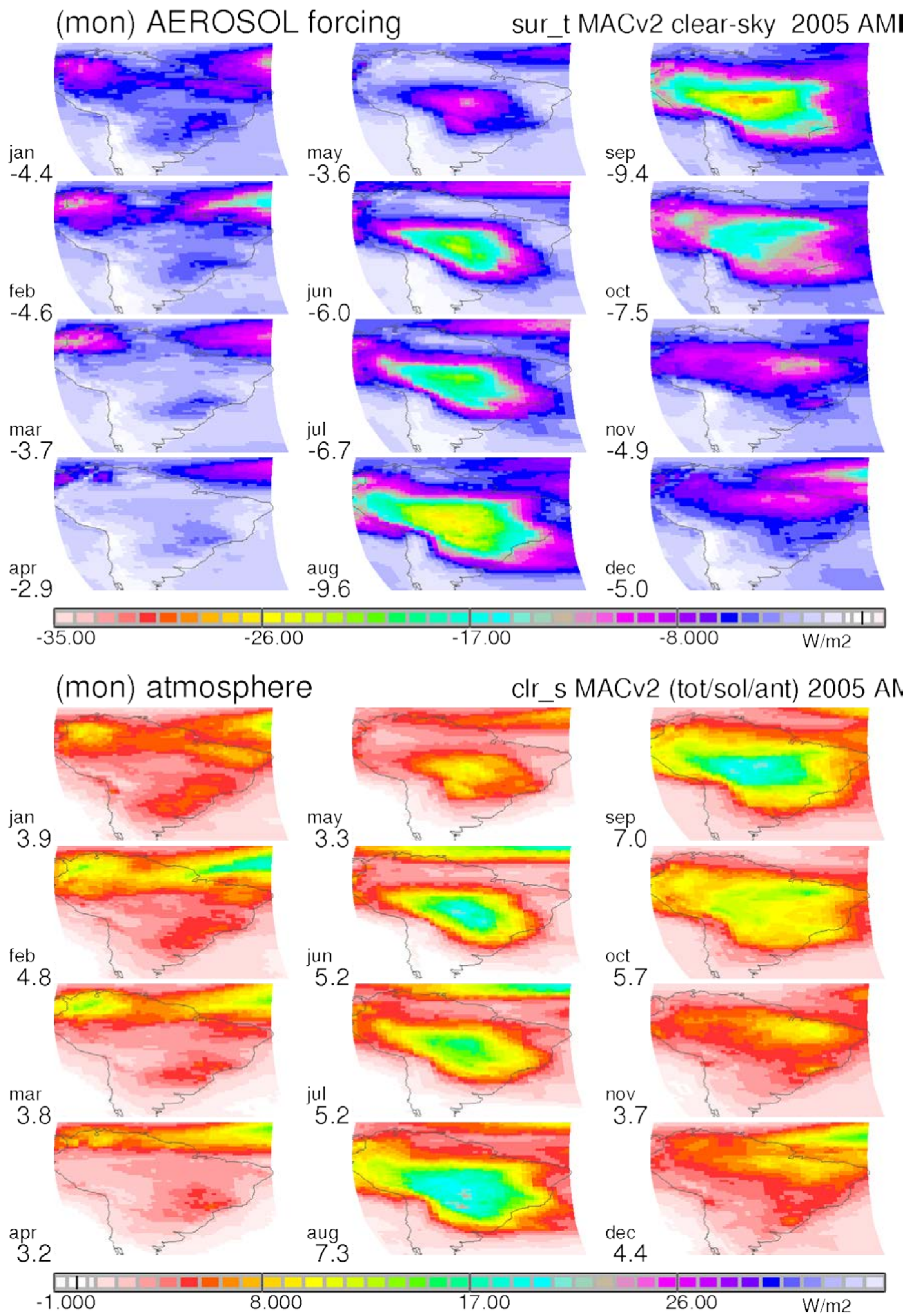

Figure 4 *monthly clear-sky aerosol rad. effects at surf and atm over MERRA Amazonas region.*