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Atmospheric Chemistry and Physics Discussions

Interactive comment on "AOD trends during 2001–2010 from observations and model simulations" *by* A. Pozzer et al.

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We thank the referee #1 for the positive review. We will add the reference of the Lyapustin et al. (2014), which is appropriate for this study.

As we discussed on the reply to Dr. Sayer, we agree that the newer MODIS dataset could be better for this study, but, at the time being this is not possible as collection 6 has not been released yet. Additionally the DeepBlue algorithm in Collection 5.1 contains missing data that could severely change our trends due to their distribution imbalance during the 2001-2010 period. For the same reason the trends calculated using SeaWIFS version 4 do not change with respect to the ones calculated from version 3 of the same dataset. Details are in the reply to Dr. Sayer.

Fig.1, axis labels too small. We agree that the figures can be improved. The main point here is to show the overall good agreement between AERONET observations and model results. We will replace them with a linear plot (rather log-log).

Fig.2, improve figure. We will try to improve the figure. Nevertheless we would like to mention that "not enough retrievals" are shaded grey, missing data are shaded white and the trends are shaded blue or red, depending on their sign. The "+" overimposed to significant trends are forming a sort of grid in the figures.

Fig.3, too many figures of trends from model results. The referee is correct, but we added the figures for the sake of completeness.

Fig.5, legend and caption insufficient. The figures depict the trends estimated by observations (X-axis) and simulation (Y-axis) for different regions (letters). The observations datasets are organized in row (Top: MODIS, Middle: MISR, Bottom: SeaWIFS), while the simulations are organized in column (Left: RCP00, Right : RCP85). All the units are in %(AOD)/yr and the diamonds are only to localize clearly the points in the figure. We will add this information in the label of the revised version.

Table 1, units As written in the table label, the unit are in 10^{-3}(AOD)/yr

Other comments:

1. **Why RCP8.5 only and not other scenarios?** RCP85 was chosen as a "reasonable" dataset for anthropogenic emissions after the year 2000, as mentioned in the manuscript (Page 26626, line 6). In practice, RCP85 is the emissions projection which best reproduces the 2000-2010 decade. Indeed, differences in regional emissions can be very high, and we refer to the work of Granier et al. (2011), who performed an accurate study on the regional and global emissions.

They showed that RCP6 and RCP4.5 have significantly larger emissions of CO than any other dataset, while RCP6 have significantly larger emissions of any tracer over USA and significantly lower over China.

2. **What about seasonal trends?** de Meij et al. (2012a) studied the trends of high/low episodes, analyzing the trends of the yearly variability of the observations (de Meij et al., 2012a, see Supplementary figure S1a,b). They showed that the yearly variability presents "a small positive trend over West, Central and southern Africa and a more profound variability over the Arabian Peninsula, the Arabian Gulf and East China". A detailed analysis is presented in the study. Mishchenko and Geogdzhayev (2007), instead, analyzed the seasonal trends and found a strong seasonal increase along the west coast of Africa due to biomass burning, followed by a decrease in the AOD trend during autumn. They also found decreasing AOD trends during summer over South-East Asia. Further studies on seasonal trends are from Papadimas et al. (2008), over the Mediterranean basin, and from Zhao et al. (2008), who found a decreasing tendency in the AOD trend (with high confidence) during winter, spring and summer in both hemispheres.

3. **In section 3, you need more description of the observation datasets.** To improve the section we will add the following information. These will also be referred in the text to explain differences in the satellite retrievals.

   - MODIS has one NADIR looking camera which retrieves data in 36 spectral bands, from 0.4μm - 14.5μm with spatial resolutions of 250m (bands 1 - 2), 500m (bands 3 - 7) and 1000m (bands 8 - 36). Daily level 2 (MOD04) aerosol optical thickness data are produced at the spatial resolution of 10x10km over land, aggregated from the original 1km x 1km pixel size. As the swath width is about 2330km, the instrument has almost a daily global coverage.
   - MISR data are acquired at 0.275x0.275 km^2 and 1.1x1.1 km^2 and aerosol

products are derived at 17.6x17.6 km^2 resolution. MISR has four forward looking cameras, one nadir and four backward looking cameras (at viewing angles of $70.5°$, $60.0°$, $45.6°$, $26.1°$, and $0°$), and each camera measures in four different wavelengths centred at: 446 nm (blue), 558 nm (green), 671 nm (red) and 866 nm (near infrared). There is a time difference of 7.5 minutes between the first and the last camera to view the exact geographic position as the satellite flies over. Each path has a swath width of 360 km with a 16-day repeat cycle.

   There is no difference in the overpass time between MODIS and MISR Terra as they are on the same platform (10.30 am/pm in a heliosynchronous orbit).

4. **WASO component and embedded liquid water: more detail are needed. Are there trends in water vapor and/or humidity from meteorological datasets that must be studied?** The WASO-H_2O AOD relationship was analyzed already by de Meij et al. (2012b), both for the model and the observations for different regions. They showed that, in Europe, the WASO aerosol contributes about 0.04 (37%) to the yearly mean and the associated aerosol water 45%, respectively. In North America the inorganic part contributes 30 to 40% to the total AOD and the associated aerosol water 40%. Interestingly, this high associated water to the total AOD present in the Eastern US produces higher AOD in the East than over the West, which is confirmed by the observations (AERONET). Over other region water AOD is minor with respect to other aerosol components such as Organic Carbon and/or Dust.

   Following also the comments from referee #2, trends of relative humidity (RH) and water vapour have been estimated (see Fig.1), together with other meteorological variables. From the model results a clear positive trend over India can be observed (see Fig.1). Despite such trend, as reply to referee #2, this does not influence our conclusions in the manuscript.

5. **Are there any other differences in the model outputs, other than AOD ?** As the referee correctly suggested, not only the aerosols (and therefore AOD) are influenced by changing emissions but also trace gases. One example is given by Yoon and Pozzer (2014), who study the trend of CO exactly with the same dataset used here. It must be however stressed that the simulations RCP00 and RCP85 do present exactly the same binary identical meteorology. This special set-up was decided so to analyze in detail the effect of trends in the emissions on the atmospheric chemistry, removing any possible feedback of the chemistry on the dynamics. Therefore any dynamical variable (such as wind, precipitation and so on) does not present any difference between the two simulations.

6. **I believe that model outputs, even if not necessarily accurate or precise, should still be able to decipher trends.** We fully agree with the referee, and we will rephrase the sentence. Although the model presents biases in the AOD estimations, these are not important for the trends calculations as only long term changes are calculated.

7. **There is a huge discrepancy [of observations] over the Amazon with RCP85.** As the referee correctly pointed out, most of the AOD trends estimated from satellite retrivals are not statistically significant. This is the case of the region over the Amazon: the negative AOD trends calculated from the MODIS observations are not statistically significant. Therefore it can be expected that the model will not be able to reproduce such observations, as the variability/noise of the AOD is very large over this region. Therefore, when comparing Fig.2 and 3 of the manuscript, one should be aware that the model should be able to reproduce regions of significant trends, i.e. clear trends signal than can be detected despite noise and variability. Therefore we confirm that model results from simulation RCP85 represents better the observations, although with some discrepancies.

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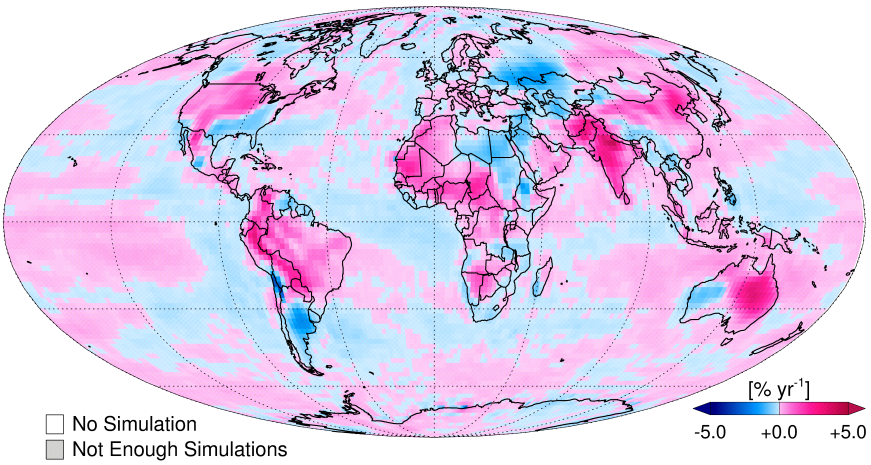

Fig. 1. Linear trend in %/year for Relative Humidity (RH) in simulations RCP85 and RCP00.