Changes in atmospheric aerosol loading retrieved from space based measurements during the past decade

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Dear N.A.J. Schutgens,

We thank you for the constructive and valuable comments, which replies are listed on the supplement.

This is an interesting paper but the authors seem rather optimistic concerning the accuracy of space-borne aerosol retrievals. E.g., about MODIS they write:

p 26005, line 13: "Their data yield aerosol products having high accuracy (±0.05 or ±15 % over land and ±5 % over ocean for AOT) (Kaufman et al., 1997; Remer et al., 2005, 2008; Levy et al., 2010) suitable for trend analysis."

First, over ocean the official MODIS error estimate is 0.03 or ±5%, not 5% so there is considerable uncertainty regarding low values.

Second, several papers have shown that MODIS accuracy for AOT>0.1 over ocean is worse than 5%, e.g. Zhang & Reid JGR 2006, Shi et al 2011, Schutgens et al.

2013 (see our Fig 20 for a comparison of error estimates). For land, see Hyer et al ACP 2011.

-> The misleading sentence about the retrieval accuracy of MODIS AOT will be modified and the references (Zhang and Reid, 2006; Shi et al., 2011; Schutgens et al., 2013; Hyer et al., 2011) be additionally cited as your suggestion.

The same papers have shown that MODIS AOT over ocean has biases due to e.g. windspeed or cloud fraction. In a changing climate, such biases could potentially cause artificial AOT trends.

-> We agree with your comment that the windspeed and cloud fraction over ocean are potential factors being able to cause artificial trends in cloud-free AOT. Especially to consider the impact of sub scene cloud in this study, we have used a new trend model (i.e. weighted least squares regression). It has been shown that the new model can provide improved results over the region where high variation of cloud fraction is located (see Fig. 3 (c)). However, the method is expected to be less robust over regions, where frequent cloud occurrence persists throughout the year (e.g., most of the marine areas and tropical rain/cloud forests in the equatorial zone). Therefore, to draw a reasonable conclusion in this study, before selecting the regions for regional analysis we have firstly checked where the significant results are located using three criteria as follows:

> **1. To avoid the retrieval uncertainty larger than 50%, the trends with total mean of AOT < 0.1 are removed.**
>
> **2. To minimize the uncertainty effect of large and persistent cloud all year round, the trends with total means of CF (cloud fraction) > 0.8 and standard deviation (σ_{CF}) < 0.06 are discarded.**
>
> **3. To get more significant result at 95% confidence level, the trends with significance ($|B_g/\sigma_{Bg}|$) < 2 are ignored.**

Based on these criteria, we carefully selected the regions as shown in Fig. 1.

This is not to say MODIS data is bad. A comparative study, Breon et al, Rem Sens Environ 2011, showed that MODIS AOT was on par or outperformed other sensors (MISR, POLDER).

-> It can be happened because of instrumental (e.g. different platform characteristics, sensor calibration etc.), or retrieval (AOT retrieval accuracy), or sampling or atmospheric (changes resulting from human activity or natural phenomena) issues. Since different and limited temporal sampling of polar-orbiting satellites is also a significant uncertainty factor in the trend estimates as shown in Fig. 2 and http://www.atmos-chem-phys-discuss.net/13/C8205/2013/acpd-13-C8205-2013-supplement.pdf, we have used multiple polar orbiting satellites observations: Terra (MODIS and MISR), OrbView-2 (SeaWiFS), and Aqua (MODIS) in the manuscript.

Do the authors think these larger random errors and biases will impact their trend analyses?

-> Yes, we do. Therefore, to estimate the errors or biases in trend estimates from satellite observations, the trend validations with ground observations are needed and we have compared the satellite-derived trends with AERONET AOT trends in Fig. 5.