Global and regional trends of aerosols in the boundary layer and free troposphere using CALIOP satellite observations from 2007 to 2015

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Aerosols alter the radiative budget of the Earth through absorbing or scattering solar radiation and by changing microphysical properties of clouds. Overall, aerosols are short-lived (about a week) species due to the efficient removal by dry and wet deposition in the boundary layer (BL) where a majority of the emission sources are located. As a consequence, most of aerosols are found in the BL indicating that the climate is also affected most by these aerosols. However, aerosols advected in the free troposphere (FT) have a much longer residence time (few weeks) than in the BL, potentially inducing a more long-term effect on climate. Absorbing aerosols may in addition have an enhanced climate effect if they are located above reflective clouds [*Zarzycki and Bond*, 2010]. The short residence time of aerosols implies that they are inhomogeneously distributed over continents and throughout the atmospheric column. Their regional distribution and nature may change rapidly with emission regulation advocated by individual countries, inducing a rapid change in magnitude and distribution of the aerosol climate effects. In this study, we use satellite-retrieved trends in aerosol extinction to understand the current regional and vertical distribution of aerosols as well as temporal trends.

Although atmospheric aerosols have been the subject of intense research for the last decades, aerosol observations in the FT are still relatively sparse. To fill this gap in knowledge and data availability, the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) satellite instrument, dedicated to the measurement of vertically resolved attenuated backscatter, was launched in space in June 2006 [*Winker et al*., 2009]. In this study, we use CALIOP observations (L2 V3 Aerosol Profile product) from 2007 to 2015.

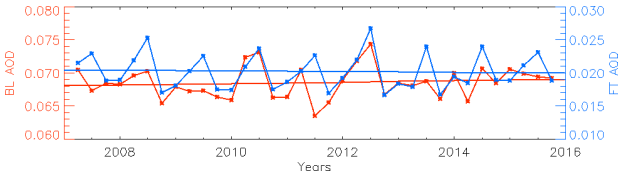

Figure 1: Global and seasonal AOD in the BL and FT observed during daytime in CALIOP from 2007 to 2015.

Our results show that as a global average, 77% and 23% of the AOD is found in the BL and the FT, respectively, during daytime. Although the amount of aerosols in both the BL and FT remains similar (Figure 1), the variability between different regions is large (Table 1). In particular, large decreases of aerosols are observed in America, Europe and East Asia, while large increases of aerosols are observed in India and Indonesia. These observations are in agreement with several studies showing that anthropogenic aerosol emissions in North America, Europe and East Asia are decreasing, inducing a decrease, especially of sulfate aerosols in these regions [*Lu et al*., 2011]. In contrast, aerosol emissions are generally increasing in India [*Lu et al*., 2011]. In terms of biomass burning emissions, the GFED inventory [*Giglio et al*., 2013] indicates that emissions of smoke decrease in South America but increase in Indonesia. Overall, this indicates that aerosols are redistributed over the globe and in particular, a new population of aerosols is emerging over Asia. This might significantly impact the effect of aerosols on climate, especially if the ratio between scattering and absorbing aerosols changes.

	North Am.	South Am.	Euro	India	East Asia	Indo-nesia
BL	-1.5	-0.9	-1.4	1.9	-0.6	6.4
FT	-0.8	-1.8	-1.9	1.5	0.4	8.3

Table 1: Annual relative AOD trends (%/year) observed during daytime in CALIOP from 2007 to 2015 for different regions (Am. is for America).

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Giglio, L., J. T. Randerson, and G. van der Werf (2013) *J. Geophys. Res.*, **118**, 317-328.

Lu, Z., Q. Zhang, and D. G. Streets (2011) *Atmos. Chem. Phys*., **11**, 9839-9864.

Winker, D. M., et al. (2009), *J. Atmos. Oceanic Technol.*, **26**, 2310-2323.

Zarzycki, C. M., and T. C. Bond (2010) *Geophys. Res. Lett.* ***37***, L20807.