The relation between aerosol optical depth and lightning from the tropics to the mid-latitudes

Beata Kucienska[1], Graciela B. Raga[1], Orit Altaratz[2], Ilan Koren[2], Arturo Quintanar[1]

1. Centro de Ciencias de la Atmósfera, Universidad Nacional Autónoma de México
2. Department of Environmental Sciences, Weizmann Institute of Science, Israel

Corresponding author email: beata@atmosfera.unam.mx

OBJECTIVE

To study a possible influence of aerosol particles on lightning from the tropics to the mid-latitudes

METHODOLOGY

The relationship between daily data of aerosol optical depth (AOD), derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua satellite at 1:30 pm of local time, and lightning density, recorded by the World Wide Lightning Location Network (WWLLN) between 12:00 pm and 3 pm of local time in 2007, is examined.

RESULTS

Figure1. Lightning density [flashes /deg^2 /hour] for 3 AOD cathegories

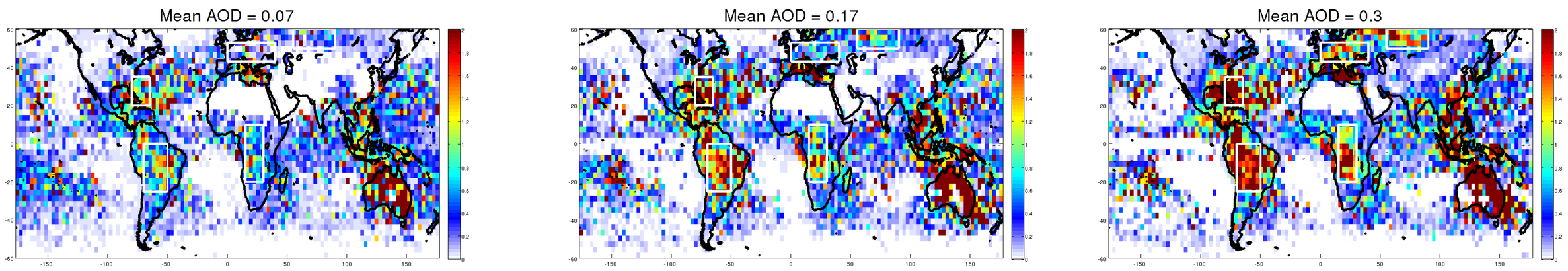


Figure 2. Relation between lightning density and AOD for 5 selected regions

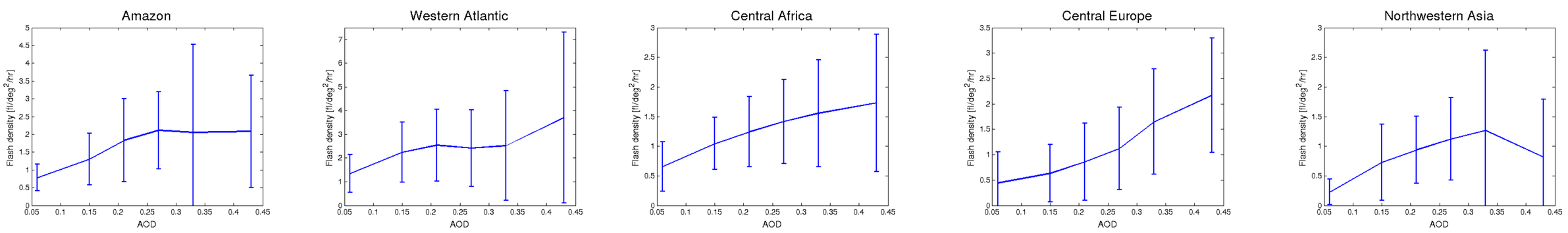
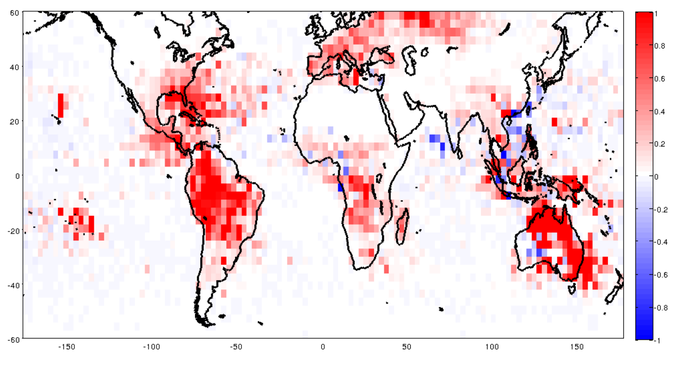


Figure 3. Differences between mean flash densities [fl /deg^2/hr] registered on days with mean AOD=0.3 and mean AOD=0.07.

a) Including days with flash density = 0



b) Only days with flash density > 0

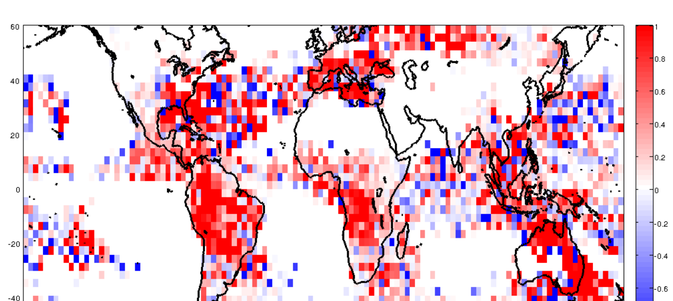
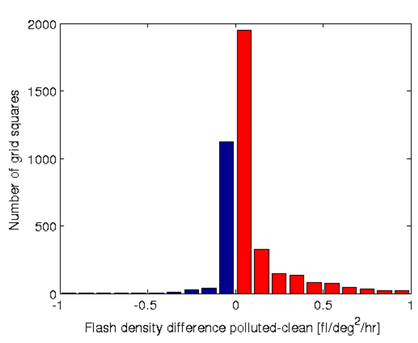
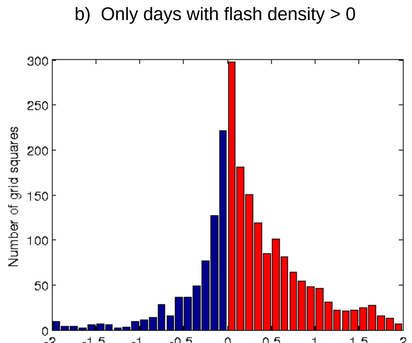


Figure 4. Histograms of the differences between mean flash densities registered on days with mean AOD=0.3 and mean AOD=0.07.

a) Including days with flash density = 0



b) Only days with flash density > 0



DISCUSSION

For several large regions of the world, the increase in AOD implies increase in lightning density, as shown in Fig. 1. The correlation between both variables is stronger for continental regions than for maritime ones, although some coastal oceanic regions also show a significant correlation.
The increase in flash density as a function of AOD is especially pronounced for Amazon, Western Atlantic, Central Africa, Central Europe and Northwestern Asia (Fig. 2). Over the latest region, the lightning density increases with AOD for AOD < 0.33, and decreases for higher AOD values.
Fig. 3 shows differences between flash density recorded on days with moderate and low AOD. In case *a)* days with and without lightning were taken into account, while in case *b)* only days with lightning were included in the averages. Over the continental regions the differences are clearly positive, however over most of the maritime regions, an increase in AOD can imply an increase or a decrease in flash density, as shown in Fig. 3b.
About 70% of all grid squares show positive differences between lightning density recorded on days with moderate and low AOD (Fig. 4a and 4b).
This study includes whole year 2007, however the results are similar when each season is studied separately. Positive correlations between AOD and lightning may be due to meteorological conditions, which can influence both variables, or due to aerosol impact on lightning.
This study is complementary to that of Koren et al. (2012) who found similar relationships between AOD and rainfall from the tropics to the mid-latitudes.

CONCLUSIONS

Lightning density is positively correlated with AOD for very large continental regions and some maritime regions of the Earth, which implies a possible influence of aerosol particles on lightning. This hypothesis has a strong physical basis, since aerosol particles that serve as ice and condensation nuclei participate in the formation of ice crystals, graupel particles and cloud droplets which have an essential role in cloud electrification processes.

REFERENCES: Kucienska, B., Raga, G. B., and Romero-Centeno, R.: High lightning activity in maritime clouds near Mexico, Atmos. Chem. Phys., 12, 8055-8072, doi:10.5194/acp-12-8055-2012, 2012
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