

Satellite based analysis of the direct aerosol effect of absorbing aerosols above clouds

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Tiny, solid or fluid particles suspended in the air are considered as aerosols. They interact with the incoming solar radiation, with the interaction being a function of their size, composition and location in the atmosphere. These interactions may result in either a negative (cooling) or positive (warming) radiative forcing at the top of the atmosphere (TOA). The resulting forcing can be due to the direct or indirect aerosol effect, which are both not very well represented in numerical models and constitute the biggest uncertainties when it comes to quantifying human induced climate change.

It is feasible to investigate these aerosol effects on a global scale by the means of satellite data. Measurements from different instruments mounted on satellites of the “A-Train” satellite constellation are very well suited for this, since these guarantee a very good correlation in time and space.

It is possible to qualitatively identify absorbing aerosols in the presence of clouds by combining the UV Aerosol Index (UV-AI) derived from OMI measurements with cloud parameters derived from MODIS measurements. Nevertheless, determining exactly those situations with absorbing aerosols above clouds on a global scale is difficult, since no information of the vertical profile of a particular situation is used.

Different approaches for appointing a functional dependency between the alteration of the local planetary albedo (LPA) and the presence of absorbing aerosols in cloudy scenes have been followed. Relating changes of LPA directly to the value of the UV-AI is not possible, since there is no quantitative dependency between the UV-AI and aerosol concentration, especially at low values. Another approach is the use of the simple mathematical model of linear regression. Doing this, the cloud optical depth is directly included in the calculations and the UV-AI is just used as an indicator for absorbing aerosols. The results show a decrease of LPA with increasing amount of absorbing aerosols in cloudy scenes, which is exactly the effect derived by numerous numerical calculations of other studies. Deriving the direct aerosol effect of absorbing aerosols in cloudy scenes from measurements is thereby feasible by using the simple approach of a linear regression.

Finally, the direct radiative forcing of anthropogenic absorbing aerosols in cloudy scenes for the year 2005 was calculated with the results of the linear regression. The more the calculations are restricted to high values of the UV-AI, the more positive the global mean radiative forcing gets (up to $+0.1 \frac{W}{m^2}$, depending on the season). Regional and seasonal variations are especially pronounced off the Atlantic coast of southern Africa. During the biomass burning season, the forcing can be more than $+10 \frac{W}{m^2}$ in seasonal mean, whilst it is much lower throughout the rest of the year.

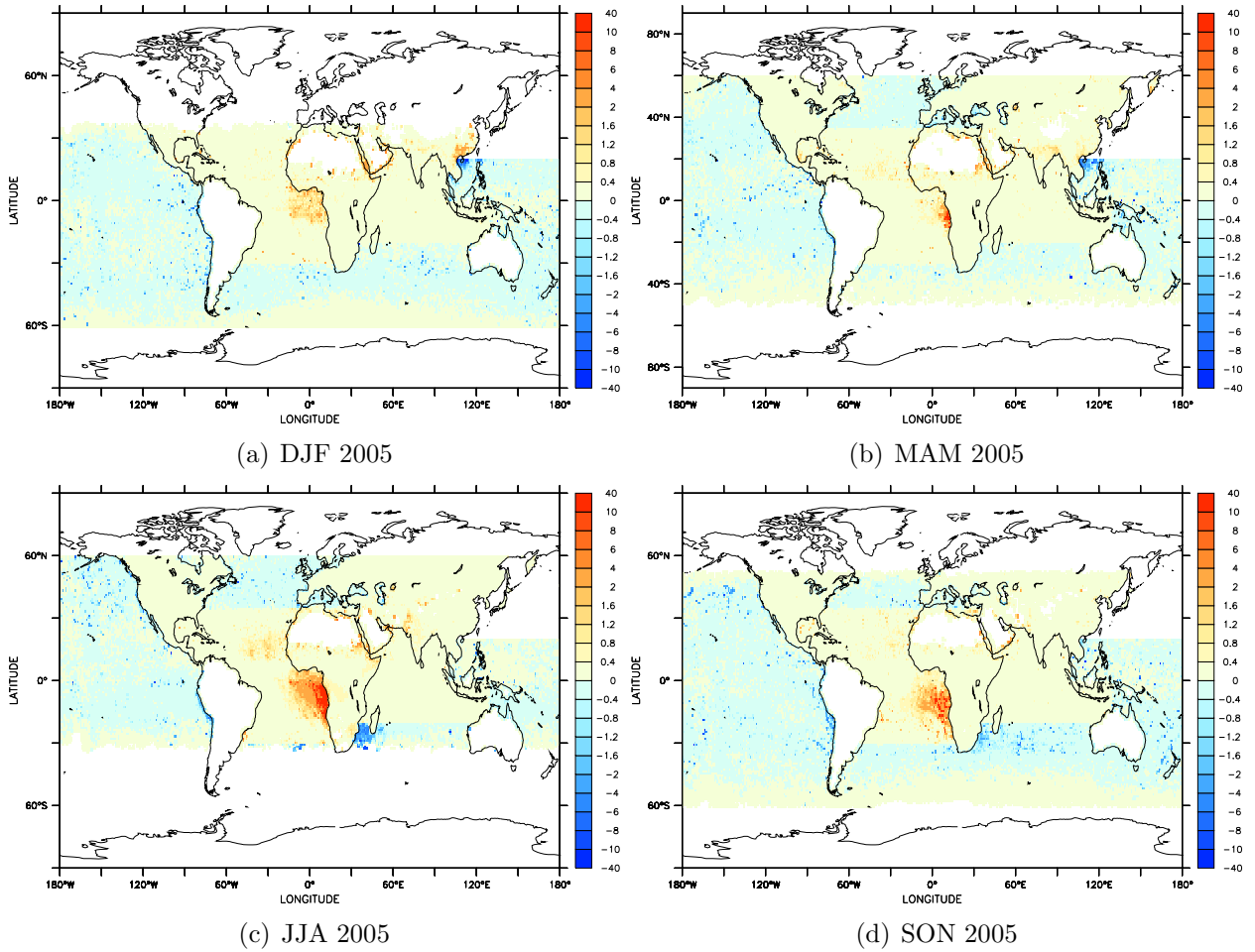


Figure 1: Shortwave direct radiative forcing of anthropogenic absorbing aerosols in cloudy scenes for the year 2005 in $\left[\frac{W}{m^2}\right]$. (a) December, January, February; (b) March, April, May; (c) June, July, August; (d) September, October, November

The results of the calculations of the direct aerosol forcing of anthropogenic aerosols in cloudy situations are shown in Fig. 1. Here, the calculations were restricted to situations with an OMI UV-AI > 0.7 . By this, the presence of absorbing aerosols is assured to a high degree. The seasonal cycle of biomass burning in southern Africa can very well be depicted from the plots, showing a weak positive forcing in winter (DJF), a more regionally restricted signal in spring (MAM) and a pronounced positive forcing during summer (JJA) and autumn (SON) over the Atlantic off the coast of southern Africa. These patterns correspond to the seasonal cycle of biomass burning in southern Africa, starting in summer and lasting on until November. The positive forcing during winter might be due to transport of biomass burning aerosols from northern Africa towards the Atlantic.