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Atmospheric Chemistry and Physics Discussions

Interactive comment on "How can aerosols affect the Asian summer monsoon? Assessment during three consecutive pre-monsoon seasons from CALIPSO satellite data" *by* J. Kuhlmann and J. Quaas

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Firstly, The EHP hypothesis focuses mainly on the heavy pre-monsoon aerosol loading (dust mixed with soot) over the Indo-Gangetic Plains (IGP) that pushes against the southern slopes of the Himalayas. The radiative heating along the southern (aerosols from IGP) and northern slopes (due to dust from Taklamakan) of the TP triggers convective feedback processes resulting in tropospheric temperature anomalies over the TP. Therefore, conceptually, the aerosol-induced heating would occur largely over the southern slopes (I am not too sure about the northern slopes) and not necessarily

over the TP. Heating (or warming) over the TP may be a consequence of other atmospheric feedback processes triggered by aerosol-induced heating over the slopes. Authors should clarify this key aspect in the manuscript and then decide whether the aerosol-induced heating over the TP (or over the slopes) is critical to monsoon via the EHP mechanism. Additionally, Liu et al., 2008 (ACP) show from CALIPSO the presence of dust mixed with soot along the southern slopes and therefore the possibility of enhanced heating over the slopes is a more likely response due to aerosols.

– The precise location of aerosols and aerosol-induced shortwave heating is indeed an important issue when testing the EHP hypothesis. In the paper by Lau et al. (2006), the authors identify "the most pronounced shortwave heating [...] over and around the TP". They state that the "shortwave heating is closely linked to the concentration of black carbon and dust" and that "at the top of the TP, even though AOT [aerosol optical thickness] is small, the shortwave heating is non-negligible because of the stronger effective absorption" above a "high-albedo surface". The authors calculate anomalous shortwave absorption due to aerosols over the TP of 16.8 W/m^2 (Lau et al.'s Table 1) and aerosol-induced heating rates of 0.2 to 0.4 over the TP slopes that extend up to altitudes of 5 to 6 km, also above the TP (Lau et al.'s Fig. 3).

There are three major differences of these results in comparison to ours: a) We see barely any heating above the TP. We locate the strongest heating close to the aerosol sources, i.e. over the TD and the IP/GP, but not over the TP slopes (our Figs. 8, 9, and 10). b) We simulate heating to occur mostly in the lower 4 to 5 km of the atmospheric column, peaking on average at around 2 km (our Fig. 11). The heating is not "elevated". c) We do not see a quantitatively important reinforcement of heating rates over high-albedo surfaces of the TP, but only above the adjacent deserts (our Fig. 12). We acknowledge that, with our RTM, we cannot capture convective feedback processes that might indirectly heat the air above the TP. We believe, however, that convection of this kind should transport larger quantities of aerosols above the TP, which CALIPSO does not seem to measure.

In our interpretations of our results concerning the point you mentioned, we have added some clarifications concerning the precise locations of strong and weak heating and the role of the Himalayan slopes.

Specific comments: Section 2.1 CALIPSO Satellite Data Authors should let readers be aware of the various uncertainties associated with the CALIPSO data. Additionally, the data they use are Level-2 products and many of these products are in beta stage and not validated.

– This is an excellent point. Since the CALIPSO products are relatively new, we should stress the associated uncertainties more. We added a paragraph explaining some issues with CALIPSO aerosol data at the end of Section 2.1. However, other studies were already successful in using CALIPSO Level 2 products. For instance, Mielonen et al. (2009, Geophysical Research Letters, Vol. 36, L18804) showed that in 70% of the cases, CALIPSO aerosol type classification is in agreement with AERONET measurements. We completely agree that CALIPSO data, especially on Level 2, are subject to large uncertainties. Yet, since the data is unique in providing global three-dimensional aerosol distributions, which especially is an asset in remote regions such as the TP where in situ measurements are sparse, and since, to our knowledge, no fundamentally different CALIPSO aerosol products are planned by the NASA team, we make use of the data. It may not be perfect, but it is the best data we have.

I don't think the Arabian Sea should be considered part of their analysis as it is not in close proximity to the TP. Moreover, the dust blowing over the Arabian Sea is eventually transported to the Indo-Gangetic Plains (these regions are already part of the analysis). Section 3: How do the authors explain polluted dust over the Arabian Sea? Are there any references to this observation?

– In fact, the aerosols from the Arabian Sea are likely to be detected again above the Indus Plains, which we also mention in the text. However, the region is of special importance also because of the strong winds of the Somali Jet that may advect aerosols

towards the TP. The (occasional) observation of polluted dust above the Arabian Sea was indeed surprising, yet other authors have reported similar findings. Pease et al. (1998, Journal of Arid Environments, Vol. 39, pp. 477-496) observed remnants of anthropogenic pollution above the Arabian Sea and suspected their origin in India, while Tindale and Pease (1999, Deep-Sea Research II, Vol. 46, pp. 1577-1595) described anthropogenic pollution above the Arabian Sea as originating "from wood stoves, cooking fires, light industry, and urban areas that ring the Sea". We think that the profiles of the AS region might be interesting in order to give a complete account of aerosol distributions in the possible source regions.

When authors show the frequency occurrences of dust (and other aerosol types) and their altitudes, the issue of number of samples is not discussed or clearly explained. Therefore, the analysis carried out over different regions may be biased by the sampling issue especially when CALIPSO transects are sparse and often attenuated by clouds. This is a major issue the authors should address to make the results appear more coherent.

The number of samples was indeed missing in the presentation of our results. We have added these numbers to Figure 2. Although the CALIPSO tracks are sparse, the along-track resolution is extremely high. Therefore, we obtain several thousands of samples for each year and each subregion.

Reviewer 1 raised a similar issue when requesting some metric on the regional variability, which led us to including a measure of the variability as an error bar in Fig. 2.

We completely agree that CALIPSO's incapability of penetrating thick clouds may lead to an undersampling of lower atmospheric layers. In the considered geographical region at the considered time of the year, however, the issue of cloud attenuation turns out not to be too obstructive. Even close to the ground, CALIPSO provides aerosol data in 80 to 90% of the cases. However, in cloudy skies potential direct radiative effects of aerosols, especially in the shortwave, would presumably be small, so neglecting this should only imply a small error.

Section 4: This is where authors describe the methodology of the combined analysis of wind and aerosol data. It needs to be explained in more detail. The first paragraph needs to be more clear.

– We rewrote the first paragraph completely and hopefully made our approach more clear. We interpreted the results in more detail.

Minor Comments – Thank you for the detailed suggestions, we built them all in, which certainly made the text clearer.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 4887, 2010.