Atmos. Chem. Phys. Discuss., 13, C5775–C5778, 2013
www.atmos-chem-phys-discuss.net/13/C5775/2013/

Atmospheric Chemistry and Physics Discussions

ACPD
13, C5775–C5778, 2013

Interactive Comment

Interactive comment on "Investigation of the "Elevated Heat Pump" hypothesis of the Asian monsoon using satellite observations" *by* M. M. Wonsick et al.

Anonymous Referee #4

Received and published: 11 August 2013

Review of paper titled "Investigation of the "Elevated Heat Pump" hypothesis of the Asian monsoon using satellite observations"

This paper investigates the Elevated Heat Pump (EHP) hypothesis on the effects of absorbing aerosol-induced atmospheric warming on the Asian monsoon. Since the publication of the EHP hypothesis proposed by Lau et al. 2006, and previous papers on aerosol-monsoon (Menon et al. 2002, Ramanathan et al. 2005), several other climate modeling and observational studies have further explored the role of absorbing aerosols in perturbing large-scale Asian monsoon circulation and rainfall patterns.

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Interactive Discussion
Discussion Paper

The topic of the present manuscript by Wonsick et al is aimed at investigating the EHP hypothesis and is therefore of potential interest to the aerosol-monsoon community.

That said, I think there are major issues with the data analysis approach as well as authors' contradictory interpretations and understanding of EHP and their own results. The observational results presented in the manuscript are weakly portrayed, particularly arising due to lack of statistical robustness of the studied aerosol-convection-monsoon relationship. Authors use a very limited dataset and use a highly simplistic approach to investigate the aerosol-monsoon relationship and often use mere superposition of datasets (e.g. aerosol, convection, rainfall) to derive cause and effect. In my opinion, the paper is not suitable for publication in ACP.

Main concerns:

Very limited dataset is used to investigate the EHP mechanism. MISR Aerosol Optical Depth (AOD) data are used as two pairs of contrasting years in terms of the aerosol loading over northern India. Two years of high AOD and two years of low AOD are selected from the MISR time series of AOD for the 6-year period 2000-2005. The entire analysis of convection and rainfall, and their interpretations related to the EHP mechanism, is based on the 4 years of contrasting aerosol loading.

I find the usage of only 4 years of data to investigate the aerosol-monsoon relationship, and the subsequent results, to be seriously lacking in robustness. A longer period is needed for such investigation. Clearly, there are longer records for aerosol, convection and rainfall data before 2000 as well as after 2005. Regarding aerosol data, MISR data itself continues till present, so is MODIS (with TOMS having a longer time series). It should be noted that MISR has a narrow swath and overpasses the same location once in 7-8 days (compared to daily coverage from MODIS), and therefore has a limited sample size in its monthly mean products.

Authors use the upper tropospheric temperature data for April in high and low aerosol loading years to assess the temperature anomaly over the Tibetan Plateau associated

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with aerosol-induced heating. Authors did not include results for May when the EHP hypothesis predicts a subsequent large temperature anomaly over Tibetan Plateau and the Himalayan foothills in May, unlike the authors' emphasis only on April (section 4.1) related to the upper tropospheric temperature anomaly throughout the manuscript and specifically related to the discussions based on Fig. 5. In fact, the maximum aerosol loading over the Himalayan foothills and the Indo-Gangetic Plains is during May and early June (in observations). Therefore, it is essential to investigate the month of May in terms of the temperature anomaly.

Authors' investigation of Convection and Rainfall in the foothills of the Himalaya and northern India, and their assertion that these two parameters should be higher in May only is not consistent with EHP, which rests on the precipitation response in May and June. After all, June is the monsoon onset period over India. Climatologically, northern India receives monsoon rainfall during latter part of June. Majority of the discussions (section 4.2) on differences in the frequency of occurrence of convection (and Fig. 6a and Fig. 6b) are based on May, which should be discussed for May and June (or May-June together), in order to investigate the EHP in a coherent manner. In fact, Fig. 6c shows the difference in frequency of occurrence of convection, in June, to be higher over northeastern India, along the foothills of the Himalaya (and lower over southern continental India), i.e. consistent with the EHP.

Lines 20-25, Page 10136: Concerning convection in July, authors state "This is contrary to the hypothesis, which predicts less precipitation in the low aerosol years".

According to the EHP hypothesis, high aerosol loading years may experience advancement of early monsoon rainfall. I don't think that directly implies low aerosol loading years would experience less precipitation, as the authors are alluding to. Several other factors/parameters such as land-sea gradient, heat fluxes, convective instability, etc, play larger roles than aerosol absorption in affecting the monsoon circulation. I think the Lau et al 2006 paper associates aerosol absorption effects in amplifying the land-sea meridional tropospheric temperature gradient, but at the same time cautions that

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natural forcing agents play larger role than aerosols.

Figure 9 and Table 1: I find this figure and related discussions on page 10137, and Table 1 and related discussions on page 10139 to be extremely weak. In my opinion, this is a mere superposition of aerosol and rainfall data. Using monthly mean data, a high aerosol loading region cannot be simply taken to be a link in causing less rainfall for that region, and therefore should not be attributed to semi-direct effect. I think that is a dangerous thing to do and unfortunately, in the literature, some papers use a direct correlation between monthly mean aerosol and rainfall to derive semi-direct effect. In fact, high aerosol loading could be simply due to less cloudiness or rainfall occurring over the region, and vice versa, in monthly mean column-integrated satellite data. More detailed work is needed to address and establish semi-direct effect of aerosols on cloudiness, and not just by showing direct correlation.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 10125, 2013.