Author's Response to review comments of Referee #2

by Friederike Höpner on behalf of the authors
December 7, 2015

We thank referee#2 for her/his constructive comments which we will account for in the revised manuscript. Below is a point-by-point response to the comments. A marked-up manuscript is provided as well.

1. *Page 3909, line 5: Please specify the start and end of the campaign period.*

   We have added the specific time in the revised version in the abstract and introduction as follows:
   'The Cloud Aerosol Radiative Forcing Experiment (CARDEX), conducted from 16 February to 30 March 2012...'

2. *Page 3909, line 20: 'more frequently': Please quantify the number of elevated layers observed using the backscatter signal*

   Since we do not have detailed lidar or in-situ data for INDOEX, we can not quantify the frequency difference of elevated aerosol layers. The comparison is based on mean particle number concentration profiles and their standard deviation.
   We have reformulated the sentence.
   'This feature is different compared to what was observed during the Indian Ocean Experiment (INDOEX) conducted in winter 1999, where aerosol number concentrations generally decreased with height.'

3. *Page 3909, line 23-26: Please rephrase the sentence.*

   We have rephrased the sentence as follows:
   'By combining vertical in-situ measured particle absorption with scattering calculated with Mie-theory, layers with single-scattering albedo (SSA) values of specific source regions were derived and utilized to calculate vertical particle absorption profiles from MiniMPL profiles.' → 'Layers with source region specific single-scattering albedo (SSA) values were derived by combining vertical in-situ particle absorption coefficients and scattering coefficients calculated with Mie-theory. Those SSA layers were utilized to calculate vertical particle absorption profiles from MiniMPL profiles'

4. *Page 3910, line 9-11: Lower MAE for 880 nm...what about 520 nm?*

   We have calculated the MAE as well for 520 nm. The information is included in the abstract and section 3.3 in the revised manuscript.

5. *Page 3910, line 26: Delete the word very*

   'very' has been deleted.
   'A very recent study by Samset et al. (2014)...' → 'A recent study....'

6. *Page 3912, line 17: Please provide a reference if possible.*

   We have provided the reference Bosch et al., 2014 and Ramana and Ramanathan, 2006 in the revised manuscript.

7. *Page 3914, section 2.2 state if the klett method is used*

   We added the information in section 2.2 and even a bit more specific information in 2.6
   in section 2.6: 'First, the extinction profile from the MiniMPL was calculated from the measured elastic backscatter signal and an assumed lidar ratio with the solution of the lidar equation presented by Fernald (1984) according to the method described in Klett (1981).'

8. *Page 3916, line 12 typo error*

   We cannot find any typo error here. It may appear as an error as the reference is Ramana and Ramanathan (2006). To be more clear we will change to the following:
   '....can be found in Corrigan et al. (2006) as well as Ramana and Ramanathan (2006)'

9. *Page 3916, line 28-29: The authors assume that arrival heights of 400 and 2000 m give a good indication for the air mass origin within the MBL and FT. Could you explain how you have selected the specific heights? Isn't it possible to perform trajectory analysis for the center of each elevated layer observed*

   We have chosen only two heights throughout the period for consistency. The altitudes have been determined using the MPL estimates of the boundary layer top height, which was found to be between 600 and 1400m.
   An extended explanation has been added to the revised version.

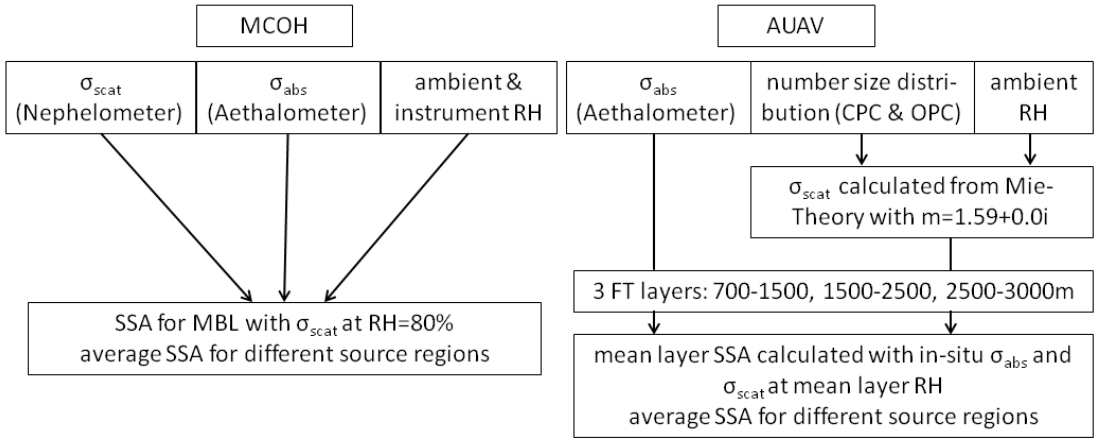

Figure 1: Flow chart describing the determination of SSA profiles from surface and AUAV measurements.

10. *Page 3917, section 2.5: In addition to Figure 1, please provide a flow chart for the methodology used to estimate the vertical distribution of SSA.*

    We thank the referee for the idea, which adds more clarification to section 2.5
    A flow chart similar to figure 1 has been added to the supplements.

11. *Page 3918, line 12-16: The authors should also present the SSA from AERONET even if AERONET provide only total columnar values.*

    AERONET SSA is now presented in the results part in section 3.1.4.

12. *Page 3918, line 26,27: Please add sr after the lidar ratio values*

    The revised manuscript has been modified accordingly.

13. *Page 3920, line 14-18: please rephrase. It is not clear to me what you want to state*

    The sentence has been reformulated.
    'A CARDEX-specific MAE was calculated relating σ_{abs} at 880 nm linearly to the EC mass concentration from filter measurements (equivalent to EBC in Eq. (4)). An inversely proportional relation between σ_{abs}(800 nm) and the EC mass concentration as in Eq. (4) is valid since the particle absorption σ_{abs} at 880 nm is considered to be dominated by BC absorption which can be approximately quantified by the filter derived EC mass concentration (e.g. Yang et al., 2009). At lower wavelengths, other

absorbing species as dust or organic carbon become more relevant for the particle absorption.

14. *Page 3921, line 5-8: Same as comment 9. Also, the information on the vertical scale is important for the three groups of clusters. Did the author check the height information during the air mass transportation?*

    Please see answer to comment 9. We checked also the trajectory height information during the air mass transport. Complementary information regarding the height information has been included in section 2.4, 3.1 and within the discussion of the example cases in section 3.2.

15. *Page 3922, line 5: Are you sure that on 10 of February you have the lower values?*

    The concentration is decreasing rapidly on February 10 due to changing wind direction. We have specified the time of day in the revised manuscript version as follows:
    'The lowest values were found during the short period with pure marine air mass origin (10 Feb. p.m. – 12 Feb. a.m.).

16. *Figure 3: Could you explain the relatively large values of PM10 before 11 February with air masses coming from Arabian Sea comparing with lower values after 2nd of March? Could it maybe that trajectory height information would give a clear indication if and when the air masses are really affected from local pollution or marine aerosols?*

    High values of particle number concentration for AS air masses before Feb. 11th are most likely due to transport close to the urban Indian west coast. Emissions from India will influence the air mass during those days. In order to account for differences in AS airmass characteristics due to slightly different transport paths, we have reformulated the text as follows::
    'Air masses from AS are likely influenced by dust from desert regions in South Asia or the Arabian Peninsula. AS air masses may also be transported along the urban Indian west coast which can result in higher particle number concentration as seen e.g. on 9 and 10 February or 12 to 14 March.'

17. *Page 3923, line 10 (Figure 4): Please provide the mean AOD also for the period 1-15 February since no information on AOD is given from AERONET sunphotometer (Figure 3 a)) for this time period*

    The mean AOD field from MODIS has been added (see Fig.2) and described in

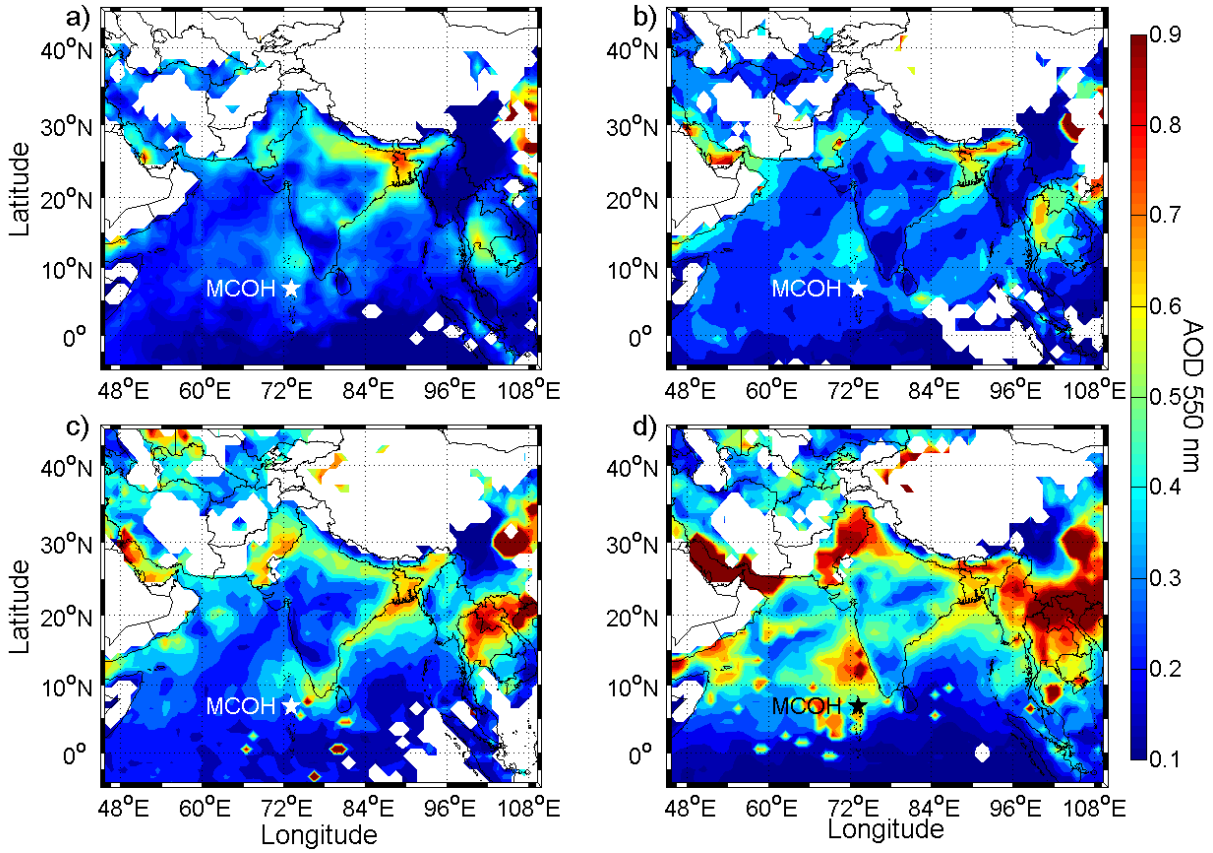

Figure 2: Mean AOD at 550 nm derived from measurements by the MODIS instrument onboard the Terra satellite. **(a)** 1 till 14 February 2012, **(b)** 15 till 29 February 2012, **(c)** 1 till 15 March 2012. **(d)** 16 till 31 March 2012.

the text.

18. *Page 3923, line 17-21: Is this confirmed by lidar measurements? A plot with the number of layers for 5 days period, or a plot showing the vertical distribution of the layers would be helpful for the reader.*

    Lidar measurements show high backscatter signals in the boundary layer and lofted aerosol layers in some occasion. A timeseries of the vertical extinction from the MPL shown in figure 3 has been added to the supplements.

19. *Page 3926, line 22-26: Please compare the common SSA dataset (16 days period)*

    A comparison with the common SSA dataset has been done and included in table 3.

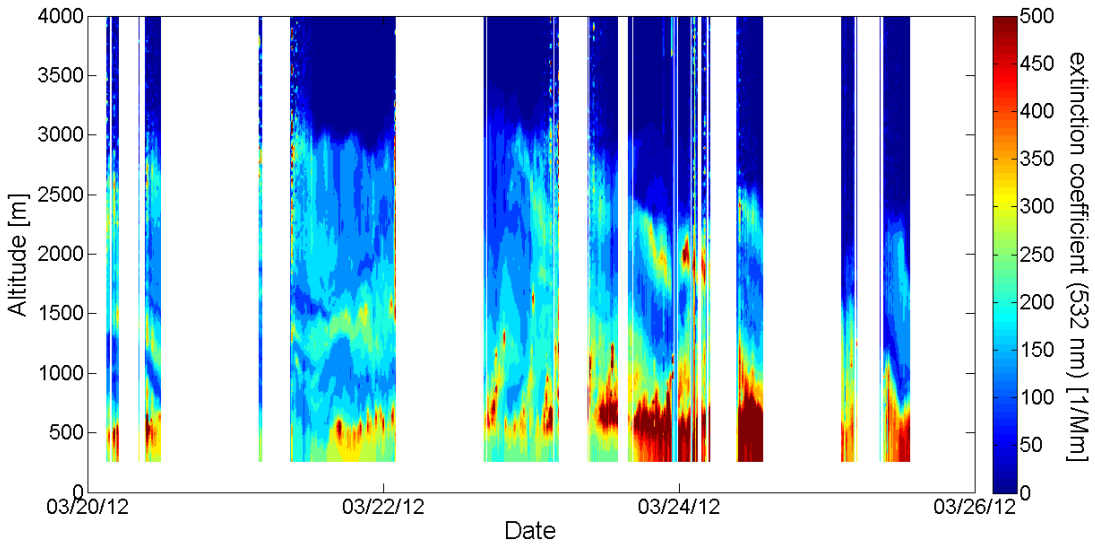

Figure 3: Timeseries of vertical MPL extinction profiles from 20 – 26 March 2012.

20. *Page 3931, line 16-18: For the two last flight days, where does the air masses coming from? Do you have any idea of the aerosol type and therefore the ssa values for these cases?*

    We apologize for the confusion. The outliers are from March 23.
    The air masses in the free troposphere are classified as air masses from the Indo-Gangetic Plain. Compared to other days within the same classification, those air masses have been transported more over central India and the western IGP. There was less influence from the polluted eastern outflow of the IGP but maybe more influence from dust regions. Hence, the real SSA could be higher for this day compared to the mean SSA.
    The issue has been described in more detail in the revised version.

Yang, M., Howell, S. G., Zhuang, J., and Huebert, B. J.: Attribution of aerosol light absorption to black carbon, brown carbon, and dust in China – interpretations of atmospheric measurements during EAST-AIRE, Atmos. Chem. Phys., 9, 2035–2050, doi:http://dx.doi.org/10.5194/acp-9-2035-200910.5194/acp-9-2035-2009, 2009.