Dear Editor,

Thank you for sending us the reviews of our manuscript AMTD-3-1197–1227, 2010 **“Reducing uncertainties associated with filter-based optical measurements of soot aerosol particles with chemical information”.** In here we address the Reviewers critiques (indicated in blue) on our manuscript.

We are very grateful for the comments given by three reviewers and believe they helped in improving the quality of the manuscript. We have read through the comments very carefully and made the best of the Reviewers suggestions whenever they were constructive. We have made every attempt to provide evidence and explanations to objectively address.

Sincerely Yours,

Erik Engström and Caroline Leck

P. Krecl
earpk@leeds.ac.uk
Received and published: 3 May 2010

The paper introduces a new correction for optical filter-based measurements using aerosol chemical composition to account for the optical effects of non-absorbing particles or low-absorbing particles deposited on the sampled filter. My main questions refer to the validity and suitability of this new correction.

(I) Nomenclature. Since the PSAP instrument is an optical filter-based method that measures the aerosol absorption coefficient, I strongly suggest you use the term "light absorbing carbon" instead of "soot" when referring to PSAP measurements as suggested by Bond and Bergstrom (2005) and Andreae and Gelencsér (2006). The term "soot" is considered vague since it may include any dark-appearing, carbon-containing compound generated in combustion.

<<<<< Yes, we changed the text to "light absorbing carbon" or "black carbon"**. >>>>>**

(II) Discussion on the chemical correction. The present study by Engstrom and Leck proposes the use of chemical information to apply an additional correction to PSAP measurements. The results obtained when applying this new correction need further discussion.
As described in the Introduction section (page 1200, lines 22-24), the optical effects of non-absorbing particles or low-absorbing particles (such as sulphate, nitrate, mineral dust and sea salt) are reduced by

(Ia) monitoring the back-scattered light at 40# due to particles accumulated on the filter with a second sensor (section 2.2) and

(b) quantifying the light scattered by the inorganic fraction of the non-absorbing material present on the filter (sections 2.3.2 and 2.4).

The light scattered by the inorganic mass fraction of the particles deposited on the filter was estimated by multiplying the total ion mass concentration (determined by ion chromatography, IC) by the mass scattering efficiency specific to the source.

(II) From my point of view, you have to discuss on the mixing state of the aerosol when applying the chemical correction. The PSAP is a filter-based optical instrument and measures the attenuation of light transmitted through particles that are continuously collected on a filter (Lin et al., 1973).

If a particle deposited on the filter has a light-scattering core coated with light-absorbing material, the PSAP instrument will "see" that particle as an absorber material. However, the IC will reveal an inorganic fraction, which would be mainly composed of scattering material. According to your chemical correction, that particle might contribute to the light scattering when in fact the particle is an absorber material for the PSAP.

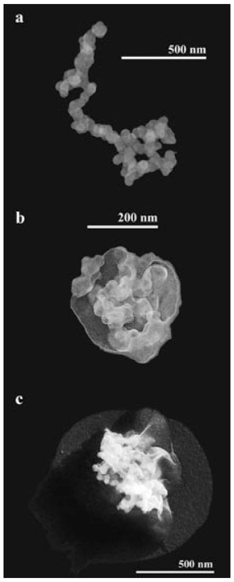

Fig. 3 in Coz and Leck, 2010. Examples of the main types of agglomerates found in the samples: (a) fresh aggregate with very thin layer covering the structure in which the primary spherules are perfectly seen. (b) aged aggregate in an inorganic transparent kernel that frequently presents inclusions of salts in the structure and, (c) aged agglomerate with an organic viscous film that seems to have spread out when impacting in the filter.

<<<<< Coz and Leck (2011), used TEM quantification of the state of mixture and morphology of the "soot"-agglomerates (aggregates) collected in air at the MCOH station during the same collection period (winter) as of this study. Coz and Leck (2010) showed that 11-29 % of the aggregates sampled at Hanimaadhoo were coated with an organic layer and 17-25 % with an inorganic layer, depending on the source region (shown in Fig 3 above). The remaining being closed "soot"-aggregates only. To be concluded is that the very relevant concern brought up by the rev., does not seem to have been met.

Spencer et al. (2008) measured size-resolved chemical composition of individual aerosol particles at the MCOH during October to November 2004 (a period not covered in this study). They reported that as much as 80% of the EC particles collected were mixed with sulfate.

Also mixtures with sea-salt were found. Although the Coz and Leck and Spenser et al., studies differ in the relative occurrence of internally mixed soot particles identified, the result from both studies imply that the majority of the light absorbing carbon particulate matter was coated with scattering components and not the opposite.

If instead the relative contribution of light absorbing carbon mass to total mass was considered: Stone et al. (2007) studied aerosol particles at the Maldivian sites MCOH and Gan during the period 30 August - 21 January 2005. A sub-micrometer aerosol particle mass concentration in the range of 0.2 - 30.8 ug/m^3, was reported, which was dominated by sulfate > organic mass > NH_4^+ > Na^+. In comparison to the inorganic mass very low carbon mass concentrations were measured (1.11 +- 0.09 ug/m^3). Chowdhury et al. (2001) performed measurements at Kaashidhoo in Maldives, 11-26 February 1999. They reported a fine particle mode (<1.8 um) mass concentration of: SO_4^{2-} 37%, EC 6-11%, and NH_4^+ 7%. These relatively low mass contributions of EC/soot/ light absorbing carbon to total inorganic mass was also in accord with the findings in this study with determined soot to total inorganic mass ratios of 4% during winter and 1% during the monsoon period respectively.

So even if we allow for the presence of soot aggregates with a light-scattering core coated with light-absorbing material, 90% or more of the mass analyzed on our substrates would impose systematic errors due to the optical effects of non-absorbing or low absorbing particles in the sample. Additional, empirical corrections, are therefore required to account for this effect, and by that reduce systematic errors, of the deposited particulate matter (PM) on radiative transfer on the surface of, and within, the filter itself. This work was attempted in this study**. >>>>>**

(III) Comparison with other studies (Table 4). I strongly recommend that the authors check other aerosol variables available (e.g. PM10 or PM2.5 concentrations, particle number concentrations) which are common to the three experiments during the winter season. This might provide more information to determine whether the higher absorption coefficients observed by Corrigan et al. (2006) are related to different aerosol characteristics compared to the other two studies.

<<<<<

Observations	Location	Period	Range	SSA
Bates et al., 2002	Outflow from Indian continent	Feb. – March, 1999	1040 - 1940 cm^{-3}	0.85 +- 0.01
Bates et al., 2002	Arabian Sea	Feb. – March, 1999	540 - 1640 cm^{-3}	0.93 +- 0.02
Corrigan et al., 206	MCHO, Maldives	Oct. – Nov., 2004	1540- 2660 cm^{-3}	0.93+- 0.02
This study	MCHO, Maldives	March – April, 2007	600 - 1450 cm^{-3}	No data

The result from these three available studies (Quinn et al., refer to values from Bates et al., 2002) suggests that the significantly higher absorption coefficients observed by Corrigan et al. (2006) are not primarily causally related to differences in aerosol characteristics between these studies.

As already indicated in the manuscript we attribute the deviation in the reported absorption coefficients to differences in applied techniques. Corrigan et al., 2006 used an aethalometer to measure the light absorption coefficient. The ratio between uncorrelated absorption coefficients measured by the aethalometer and PSAP based instrumentation has been shown to ranged from 1.20 (470 nm/467 mm) to 1.29 (520 nm/530 nm) according to Chow (2009). Arnott et al. (2005) confirm and show that the absorption coefficients measured by the aethalometer could over -estimate the absorption coefficients by as much a 50% in comparison.

Corrigan et al., 2006 implemented the correction protocol developed by Arnott et al., 2005. The protocol was optimized for continental conditions only. It applied an empirically derived routine based on laboratory and field absorption measurements performed together with a photoacoustic photometer to acquire corrected light absorption coefficients. The 10 parameters in this method were fixed to certain pre set values and not adjusted continuously to take into account variations in the optical properties of the aerosol particles collected. After applying the correction protocol according to Arnott et al. (2005) for continentally influenced data the results of Corrigan et al., 2006 showed a contribution of scattering to the absorption measurements similar to the low 2% reported by Bond et al., 1999. However it must be stressed that the correction method developed by Arnott et al., 2005 was not valid for clean summer monsoon conditions at the MCOH (air being advected over the ocean for more than 10-days), as negative absorption coefficients were retrieved. To solve this problem the scattering correction in Corrigan et al. was tuned to only generate positive values.

Quinn et al. (2002) on the other hand measured the light absorption coefficient with a PSAP instrument using the correction protocol of Bond et al., 1999, which takes into account the effect of scattering in general, but uses pre set values for the correction parameters which depend on changes on the transmission as more mass being loaded on the filter-matrix. We emphasize that the correction protocol applied by Quinn et al. (2002) does not account for the dependence of aerosol light scattering on the chemical composition of the non-absorbing particulate matter loaded on the filter-matrix. This work was performed in the present study.

To conclude, we attribute deviations in the reported absorption coefficients (Table 4), being most pronounced during the monsoon period with up to two orders of magnitude in difference (Corrigan et al.), to the choice of applied techniques and implemented correction protocols. Corrigan et al. used the most simplified protocol, in which not only the correction of the light scattering was assumed independent on changes in aerosol composition and amount but also tuned to generate positive soot levels during the clean monsoon period. **>>>>>**

IV) How suitable is this chemical correction for optical filter-based measurements conducted at high frequency? Optical filter-based methods (e.g., Aethalometer and PSAP instruments) were developed to provide continuous measurements of the aerosol light absorption coefficient with high sampling frequency (even in the order of minutes). You should comment on the suitability of the chemical correction method when the PSAP is operated on a high sampling frequency on the filed which is a rather different situation compared to the way you operated it in the laboratory.

<<<<< The aerosol particles were collected on individual filters for 24 or 48 hours depending on ambient levels of particulate mass. After collection the filter samples were stored until further determinations of the aerosol light absorption coefficient. The analyses were performed with a soot photometer based on similar principles as of a commercial PSAP. The determinations were performed under stable conditions at the Department of Meteorology clean room laboratory. Subsequently, each filter was chemically determined for inorganic -and low carbon chain organic mass by Ion Chromatography.

The chemical correction method applied in this study is thus not unsuitability as the determinations of both the light absorbing - and the low-non-absorbing particulate matter is made on the very same filter and sample after 24-48 hours of integrated sampling of air. To avoid confusion we will clarify the use of the PSAP- based soot photometer in use. **>>>>>**

Minor comments.

(V) Linear regression analysis (measured bap and calculated #sp;ionmass), section 2.3.2. You should provide more information on the linear regression analysis you performed between the measured bap and calculated #sp;ionmass such as correlation coefficient and number of samples.

<<<<< More statistics are provided and presented in a Table format. **>>>>>**

(VI) Add standard deviations in Tables 1, 2, and 3.

<<<<< The percentiles do provide the best description of the data. This as the data is not normally distributed (Bell curve). **>>>>>**

PhD Baumgardner (Referee) darrel.baumgardner@gmail.com
Received and published: 3 May 2010

Overview

The study that is presented here is focused on improving interpretation of filter-based light absorption measurements. The approach that is taken is somewhat unique in that the corrections that are derived to account for the light scattering "artifact" are based on the link between the chemical composition and the optical properties of the particles on the filter.

<<<<< Correct, this was the intention of this study. **>>>>>**

Whereas I believe that this approach is worth exploring, it is an approach that is fraught with potential uncertainties that may not improve the accuracy of the absorption measurement, but may actually decrease the accuracy.
I don't think that the authors have adequately identified these uncertainties in their analysis and until they are taken into account, I would not recommend this approach to others that wish to apply it to their measurements.

<<<<< The Reviewer statements on the usefulness etc of the correction protocols presented in this study are based on a **mere feeling** without any stated grounds! We thus refrain from discussing the reviewer's personal judgment. **>>>>>**

As a general statement, given the dozens of studies that have been published on instrument comparisons and developments of algorithms to correct for the intrinsic limitations of filter-based techniques, it seems to me that we are approaching asymptotically the limit to which we can continue trying to extract information from these techniques.

<<<<< None of the studies referred to, that have been published on instrument comparisons and developments of algorithms to correct for the limitations of filter-based techniques, uses determined aerosol chemical composition on each filter-sample collected in an attempt to account for the errors caused by the low absorbing matter co-deposited on the filter matrix. The Single Particle Soot Photometer (SP2) by Schwartz et al. (2006) seems to be one of the more promising techniques available. It retrieves *in situ* information on both number and mass size distribution and mixing state simultaneously. In indeed being very promising the Schwartz technique however poses a few thoughts relevant for this study: What is the cost of a SP2 system? Is it affordable for small research groups in developing countries under monitoring conditions, or is it only made possible for event based sampling during field campaigns with financial support from universities in industrialized countries? How much chemical particle information is derived in comparison to our method? **>>>>>**

Page 1202: Second Sentence. Is there a single diffuser plate for each detector.

<<<<< Yes, the diffuser plates for each of the detectors are clearly shown Figure 2. **>>>>>**

How well characterized are these plates and detectors so that reference is true reference, i.e. what is the background response of the two detectors and diffuser plates in the absence of a filter?

<<<<< The characterization of the detectors was performed by the manufactures. The set values were listed before the trials begun. The reference was only used in order to determine if the light source was stable. To achieve an absolute value of the reference was therefore not important. **>>>>>**

What is the filter to filter deviation?

<<<<< Statistics on filter to filter deviation (better than 2%) have been added to the revised version of the manuscript. **>>>>>**

and when looking at a "clean" portion of a filter, how does the light transmission through this filter change across its surface?

<<<<< Blank filters were divided into four 90 degrees sectors. The filters were rotated and each sector was measured with the soot photometer. The relative standard deviation for the internal variation of the filter surface was 3.3%. This result has been added to the revised version of the manuscript. **>>>>>**

How are the diodes calibrated?
Page 1203: Line 15. A photodiode or two photodiodes?

<<<<< The schematic drawing in Figure 2 was unfortunately misleading in that sense that the soot photometer only has one LED as light source. The light beam from the LED is then divided into 3 parts. These three parts goes to the soot spot, the blank filter and the reference. An absolute calibration is not necessary to perform since our determinations are based on relative measurements of the absorption coefficient. This is now clarified in the text and Fig. 2 is redrawn. **>>>>>**

Page 1203: Line 22. I don’t understand these two components, 40;1 and 40;2. Figure needs to be revised. two photodiodes (see above)? Collection angles? How well characterized? Are the components one with a clean filter and one with the sample?

<<<<< To be able to derive an absolute value of the backscattering, one needs a measurement of the total backscattering or a well defined calibrated sector. In the optical correction described we use the signal as a relative measure of the backscattering. As such a measurement of the total backscattering is not needed. **>>>>>**

Page 1204: Line 9. Don’t call it single scattering albedo. Call it something else or it is misleading, even with the explanation that it is not an absolute value. The community knows what SSA is and in this paper it is nothing even close. Not only is only a tiny fraction of the scattering measured but the absorption has not even been yet corrected.

<<<<< We agree. We now realize that the values referred to as SSA in this study are not in use and will therefore be removed from the text. **>>>>>**

Page 1205: Line 1. Even this value for the MAC is highly suspect and uncertain.
An uncertainty of +/- 20% would be generous and at the least needs to be propagated into the final results.

<<<<< Yes, the uncertainty will propagate to the final results. However we don’t agree on the suggested value of uncertainty (+/- 20%). An uncertainty of +/- 10% is more appropriate according to published literature. In general we are indeed hesitant to use any MAC number as it should, if used, be very regionally and seasonally specific. The table below shows published data on established MAC values and the method and wavelength in use. A MAC value of 10 m^2/g at λ = ca 550 nm seems to be a reasonable number to use and is consistent with the MAC number recommended by the commercial PSAP manufacturer. The conversion to units of mass light absorbing particulate matter was only performed to be able to roughly compare with other published studies. Table 4 is one example. All our results are reported as “soot” absorption coefficients throughout the manuscript. We will add a number of uncertainties in the MAC value used in the legend of Table 4. **>>>>>**

Observations	Method	Location	Period	Average MAC (m^2g^{-1})
Mayol-Bracero et al. (2002)	PSAP at λ =550 nm	INDOEX campaign	February, 1999	10.8 +- 1.6
Mayol-Bracero et al. (2002)	PSAP at λ =550 nm	INDOEX campaign	March, 1999	5.6 +- 0.8
Kondo et al. (2009)	PSAP at λ =565 nm	6 sites in east Asia	2004 - 2007	10.5 +- 0.7
Adams et al. (1990)	photoacoustic spectroscopy λ =514 nm	Los Angeles	summer, 1987	10 +- 0.5

Page 1206: Line 12. Define "synthetic soot". This process of fitting the coefficients needs a better description, e.g. is there a unique combination of these three coefficients and don't these values need constraints?
Define "synthetic soot".
I suspect a best fit is possible with quite a few different combinations of these three k values.

<<<<< Our instrument was compared to a MAAP instrument at an intercomparison workshop performed at Leibniz Institute for Tropospheric Research, Leipzig, Germany (Müller et al., 2010). Ammonium sulfate and carbon black (Printex 75, Evonik Degussa GmbH) in a solution were atomized to generate aerosol particles of a defined composition. The particles were dried and fed into a mixing chamber, from where the particles were distributed to the connected instruments. True, different combinations of the three k values were derived, and the combination that resulted in the least deviation from the MAAP instrument was chosen, that is 9.4%. This means that with the selected optical correction algorithm 9% of the values could not be explained. **>>>>>**

Page 1206: Line 24. Why is only the inorganic mass used?
Clearly there is a major contribution of OC to the soot and just as clearly OC has a very strong scattering signal that if not taken into account will lead to corrections that are even larger than those that are being derived with only the inorganics. My guess if the OC correction was added, the resulting, corrected values would end up close to zero or negative.

<<<<< Coz and Leck (2010) used TEM quantification of the state of mixture and morphology of the “soot”-agglomerates (aggregates) collected in air at the MCOH station during the same collection period (winter) as of this study. They showed that 11-29 % of the aggregates sampled at Hanimaadhoo were coated with an organic layer and 17-25 % with an inorganic layer, depending on the source region (shown in Fig 3 above). The remaining being closed “soot”-aggregates only. In the light of these results the statement by the reviewer that “Clearly there is a major contribution of OC to the soot” is not correct.

The Reviewer's guess on that the corrected values would end up close to zero or negative is again based on a **mere feeling** without any stated grounds! We thus refrain from discussing the reviewer's judgment. **>>>>>**

Herein lies the basic problem with this technique. First of all, the value of 3.8m2g−1 has a large uncertainty and depends on specific mixtures of salts AND OC, as well as the uniformity and depth of the loading.

<<<<< A fundamental and serious drawback of the well-established filter-based optical measurements of aerosol absorption coefficients is that the light absorbing particulate matter is co-deposited with non-absorbing or low absorbing particles (inorganic constituents) on a filter matrix prior to the light absorption determination. This most likely changes the combined optical properties of the deposit and filter matrix. Additional, empirical, corrections are therefore required to account for the effect, and reduce systematic errors, of the deposited particulate matter on radiative transfer on the surface of, and within, the filter itself. For the first time this study uses determined aerosol chemical composition on each filter-sample collected. This is done to account for the errors caused by the low absorbing matter co-deposited on the filter matrix. In this view it would surely also been desirable to also correct for the possible scattering effects imposed by co-deposited OC.

In recent years a number of studies have suggested that the presence OC co-deposited on the filter-matrix could have a significant effect on aerosol light absorbing measurements (Schnaiter et al. 2005, Subramanian et al. 2007, Cappa et al. 2008 and Lack et al. 2008). The most polluted case at Hanimaadhoo could probably equal the “Urban-downwind” case in the classification in Lack et al (2008). In such a case, the estimated enhancement factor of the light absorption was 1.27. This larger apparent absorption, called the lense effect, assumes that the OC is internally mixed with the “soot”-aggregate, in being consistent with the Fig (c) above from Coz and Leck (2011). The light beam (at λ = 550 nm) will pass the transparent organic coating, which enables the beam to be focused on the absorbent “soot”-core. The absorbing core will intercept more of the incoming light with a reduction in the transmitted light as a result. Therefore, a larger apparent absorption will be detected.

Without information on the aerosol state of mixture Quinn et al. (2002) reported a mass fraction of <15% for OC and up to 7% for BC in the outflow from the Indian subcontinent. Mayol-Bracero (2002) found a mass fraction of 35% for OC and 14% for BC. So even if we allow for the lens effect by internally mixed OC, more than 65% of the non-absorbing mass is made up by non-absorbing constituents other than OC. Additional, empirical corrections are therefore required to reduce optical effects of inorganic constituents. The goal of this novel study was therefore to directly link the optical determinations of the particulate matter with the inorganic chemistry on the particles co-deposited on the filter-matrix. **>>>>>**

Secondly, why is the chemical correction always larger than the optical correction and what will happen if further correction is applied for the OC contribution?

<<<<< The used optical correction protocol is based on a mixture of ammonium sulfate and carbon black (Printex 75, Evonik Degussa GmbH). The determinations of total inorganic mass on the filters (this study) showed that ammonium sulfate accounted for the 85% (Arabian group) and 60% (South Indian Ocean) respectively. The more complete chemical information used in the chemical correction protocol would explain the larger chemical correction. **>>>>>**
Basic question: is it worse to under-correct or over-correct ? What is the authors’opinion? Are they correcting too much or too little?

<<<<< It is well established that filter-based optical measurements of soot suffer from systematic errors due to the optical effects of non-absorbing or low absorbing particles, such as inorganic constituents, in the sample which relates to the dependence of aerosol light scattering on the chemical composition. The aim of this study was reduce this effect. In a novel attempt to do so we directly linked the optical determinations of the particulate matter with the inorganic chemistry of the particles co-deposited on the filter-matrix. So even if we allow for the lens effect by internally mixed OC, more than 65% of the non-absorbing mass is made up by non-absorbing constituents other than OC. Our correction is “too little” but accounts for the major optical effect of non-absorbing or low absorbing particles **>>>>**

Page 1211: Line 7. "The benefits in using the chemical quantification of the non-absorbing matter collected on the PCMB filters was that a C_ion_mass could be quantified for each of the two groups separately (Sect. 2.3.2)". However, ignoring the scattering properties of OC and BC could introduce major uncertainties.

<<<<< See above **>>>>>**

Anonymous Referee #2
Received and published: 20 August 2010

The manuscript presents a new approach to correcting the well-documented problems with filter-based measurements of black carbon concentrations - namely by using chemical information as an additional proxy measurement for non-BC scattering by the aerosol.
The goal of the manuscript is intriguing, but unfortunately it was poorly developed, There is no clear demonstration that this new approach is in fact of value.

<<<<< We fail to see why the goal of this manuscript is poorly developed.
For global assessments of climate effects of soot global data are required, most importantly in regions where strong economic developments imply substantial increases in atmospheric concentrations, such as India, South-East Asia, and China. From the latter region the first reports on soot-related climate forcings over the past decade emphasize the urgency of better atmospheric data. The presented method uses an instrument of low cost of construction that can be implemented in the field under primitive conditions. This enables researchers with small economical means to perform monitoring at remote locations, especially in the South-East Asia, and China, where it is much needed. **>>>>>**

measurements corrected by this new method and more traditional approaches are compared, but without any information suggesting which result is more accurate.

<<<<< Please see comment (III) by P. Krecl above. **>>>>>**

As only bulk inorganic chemical properties are measured the related assumptions (e.g. MSE, lack of non-detected inorganic materials such as mineral dust etc...) are so significant as to likely overwhelm any value from the additional measurement dimension.

<<<<< Indeed a feature of elevated concentration of Ca^{2+} when transport of crustal material from the large desert areas in the Middle East was observed. As pointed out in the manuscript on page 1210 both recent satellite retrievals (Kaufman et al., 2001) and data from the AERONET network of ground-based radiometers (Dubovik et al., 2002) from the Middle East/Arabian peninsula show low light absorption by dust in the visible to near infrared wavelengths. Therefore we assumed that the main influence of crustal material on optical measurements of soot through light scattering was covered by the chemical corrections performed in this study. The MSE value used in this study was calculated for the inorganic fraction that we analyze, so that effect is accounted for. **>>>>>**

Thus I am not convinced that there is any reason to perform this analysis (for the reasons stated in the manuscript). I do not believe that, with the data set shown, the authors will be able to support their statements about reducing uncertainty in filter-based measurements of BC concentrations.

<<<<< The Reviewer statements on the usefulness etc of the correction protocols presented in this study are based on a **mere feeling** without stated grounds! We thus refrain from discussing the reviewer's judgment. **>>>>>**

References

Andreae, M.O. and Gelencsér, A.: Black carbon or brown carbon? The nature of light-absorbing carbonaceous aerosols, Atmos. Chem. Phys., 6, 3131-3148, 2006.

Adams, K. M., Davis, L. I., Japar, S. M. and Filey, D. R.: Measurement of Atmospheric Elemental Carbon: Real-Time Data for Los Angeles During Summer 1987, Atmos. Env., 24A(3), 597-604, 1990.

Arnott, W. P., Hamasha, K., Moosmuller, H., Sheridan, P. J. and Ogren, J. A.: Towards aerosol light-absorption measurements with a 7-wavelength Aethalometer: Evaluation with a photoacoustic instrument and 3-wavelength nephelometer, Aerosol. Sci. Tech., 39, 17-29, 2005.

Bates, T. S., Coffman, D. J., Covert, D. S. and Quinn, P. K.: Regional marine boundary layer aerosol size distributions in the Indian, Atlantic, and Pacific Oceans: A comparison of INDOEX measurements with ACE-1, ACE-2, and Aerosols99, J. Geophys. Res., 107(D19), 8026, 2002.

Bond, T.C. and Bergstrom, R.W.: Light absorption by carbonaceous particles: an investigative review, Aeros. Sci. Tech., 40, 27-67, 2006.

Cappa, C. D., Lack, D. A., Burkholder, J. B. and Ravishankara, A. R.: Bias in Filter-Based Aerosol Light Absorption Measurements Due to Organic Aerosol Loading: Evidence from Laboratory Measurements, Aerosol. Sci. Tech., 42:12, 1022-1032, 2008.

Chow, J. C., Watson J. G., Doraiswamy, P., Chen, L. A., Sodeman, D. A., Lowenthal, D. H., Park, K., Arnott, W. P. and Motallebi, N.: Aerosol light absorption, black carbon, and elemental carbon at the Fresno Supersite, California, Atmos. Res., 93, 874-887, 2009.

Chowdhury, Z, Hughes, L.S. and Solomon, L. C. G.: Atmospheric particle size and composition measurements to support light extinction calculations over the Indian Ocean, J. Geophys. Res.-Atmos, 106, 28,597-605, 2001.

Corrigan, C. E., Ramanathan, V. and Schauer, J. J.: Impact of monsoon transitions on the physical and optical properties of aerosols, J. Geophys. Res.-Atmos., 111(D18), D18208, 2006.

Coz, E. and Leck, C.: Morphology and state of mixture of atmospheric soot aggregates during the winter season over Southern Asia–a quantitative approach, Tellus B, 63: 107-116, 2011.

Dubovik, O., Holben, B., Eck, T. F., Smirnov, A., Kaufman, Y. J., King, M. D., Tanre, D. and Slutsker, I.: Variability of absorption and optical properties of key aerosol types observed in worldwide locations, J. Atmos. Sci., 59, 590-608, 2002.

Kaufman, Y., Smirnov, A., Holben, B. and Dubovik, O.: Baseline maritime aerosol: methodology to derive the optical thickness and scattering properties, Geophys. Res. Lett., 28, 3251-3254, 2001.

Kondo, Y., Sahu, L., Kuwata, M., Miyazaki, Y., Takegawa, N., Moteki, N., Imaru, J., Han, S., Nakayama, T., Oanh, N. T., Hu, M., Kim, Y. J. and Kita, K.: Stabilization of the Mass Absorption Cross Section of Black Carbon for Filter-Based Absorption Photometry by the use of a Heated Inlet, Aeros. Sci. Tech, 43, 741-756, 2009.

Lack, D. A., Cappa, C. D., Covert, D. S., Baynard, T., Massoli, P., Sierau, B., Bates, T. S., Quinn, P. K., Lovejoy, E. R. and Ravishankara, A. R. ,: Bias in Filter-Based Aerosol Light Absorption Measurements Due to Organic Aerosol Loading: Evidence from Ambient Measurements, Aerosol. Sci. Tech., 42, 1033-1041, 2008.

Lin, C.I., Baker, M.B. and Charlson, R.J.: Absorption coefficient of the atmospheric aerosol: a method for measurement, App. Opt., 12, 1356-1363, 1973.

Mayol-Bracero, O. L., Gabriel, R., Andreae, M. O., Kirchstetter, T. W., Novakov, T., Ogren, J., Sheridan, P. and Streets, D. G.: Carbonaceous aerosols over the Indian Ocean during the Indian Ocean Experiment (INDOEX): Chemical characterization, optical properties, and probable sources, J. Geophys. Res. 107, D19, 2002.

Müller, T., Henzing, J. S., de Leeuw, G., Wiedensohler, A., Alastuey, A., Angelov, H., Bizjak, M., Collaud Coen, M., Engström, J. E., Gruening, C., Hillamo, R., Hoffer, A., Imre, K., Ivanow, P., Jennings, G., Sun, J. Y., Kalivitis, N., Karlsson, H., Komppula, M., Laj, P., Li, S.-M., Lunder, C., Marinoni, A., Martins dos Santos, S., Moerman, M., Nowak, A., Ogren, J. A., Petzold, A., Pichon, J. M., Rodriquez, S., Sharma, S., Sheridan, P. J., Teinilä, K., Tuch, T., Viana, M., Virkkula, A., Weingartner, E., Wilhelm, R. and Wang, Y. Q.: Characterization and intercomparison of aerosol absorption photometers: result of two intercomparison workshops, Atmos. Meas. Tech. Discuss., 3, 1511-1582, 2010.

Schnaiter, M., Gimmler, M., Llamas, I., Linke, C., Jäger, C. and Mutschke, H.: Strong spectral dependence of light absorption by organic carbon particles formed by propane combustion, Atmos. Chem. Phys., 6, 2981–2990, 2005.

Schwarz, J. P., Gao, R. S., Fahey, D. W., Thomson, D. S., Watts, L. A., Wilson, J. C., Reeves, J. M., Darbeheshti, M., Baumgardner, D. G., Kok, G. L., Chung, S. H., Schulz, M., Hendricks, J., Lauer, A., Kärcher, B., Slowik, J. G., Rosenlof, K. H., Thompson, T. L., Langford, A. O., Loewenstein, M. and Aikin, K. C.: Single-particle measurements of midlatitude black carbon and light-scattering aerosols from the boundary layer to the lower stratosphere, J. Geophys. Res., 111, D16207, 2006.

Spencer, M. T., Holecek, J. C., Corrigan, C. E., Ramanathan, V. and Prather, K. A.: Size-resolved chemical composition of aerosol particles during a monsoonal transition period over the Indian Ocean J. Geophys. Res.-Atmos., 113, 2008.

Stone, E. A., Lough, G. C., Schauer, J. J., Praveen, P. S., Corrigan, C. E. and Ramanathan, V.: Understanding the origin of black carbon in the atmospheric brown cloud over the Indian Ocean J. Geophys. Res.-Atmos., 112, 2007.

Subramanian, R., Roden, C. A., Boparai, P. and Bond, T. C.: Yellow beads and missing particles: Trouble ahead for filter-based absorption measurements, Aerosol. Sci. Tech., 41, 630-637, 2007.

Quinn, P., Coffman, D., Bates, T., Miller, T., Johnson, J., Welton, E., Neususs, C., Miller, M. and Sheridan, P.: Aerosol optical properties during INDOEX 1999: Means, variability, and controlling factors, J. Geophys. Res.-Atmos., 107, 2002.