PMEL Organic aerosol sampling methods for NEAQS 2002
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1. Inlet

Aerosol particles were sampled 18m above the sea surface through a heated mast that extended 5 m above the aerosol measurement container. The mast was capped with a cone-shaped inlet nozzle that was rotated into the relative wind to maintain nominally isokinetic flow and minimize the loss of supermicron particles. Air was drawn through the 5 cm diameter inlet nozzle at 1 m^3 min^{-1} and down the 20 cm diameter mast. The lower 1.5 m of the mast were heated to dry the aerosol to a relative humidity (RH) of 55 ± 5%. This allowed for constant instrumental size cuts through variations in ambient RH. Twenty three 1.9 cm diameter electrically conductive polyethylene or stainless-steel tubes extend into this heated zone to direct the air stream at flows of 30 l min^{-1} to the various aerosol sizing/counting instruments and impactors. The efficiency of the mast inlet is discussed in Bates et al. (JGR 2002).

2. Sample collection

Several different combinations of impactors, filters and a denuder were used to sample organic carbon (OC) and elemental carbon (EC) on the ship. Our goal was to obtain size resolved concentrations with minimal positive (caused by the absorption of gas phase organic carbon on the filters) and negative (loss of volatile organic carbon from the particles) artifacts.

Five stainless-steel tubes extending from the base of the sampling mast supplied air at 30 l min^{-1} to each of the 5 impactors used for organic aerosol sampling. All 5 impactors contained two filters in series at the end of the sample stream. The stage 1 filter collected particles with diameters less than the 50% aerodynamic cutoff diameters, $D_{50,aero}$, of the first impactor stage. The backup filter downstream of the stage 1 filter was used to assess sampling artifacts. The two filters are referred to here as the stage 1 filter and backup filter.

Two-stage and one-stage multi-jet cascade impactors (Berner et al., 1979) sampling air at 55% RH were used to determine the submicron and sub 10 micron concentrations of organic carbon (OC) and elemental carbon (EC). The 50% aerodynamic cutoff diameters, $D_{50,aero}$, were 1.1 and 10 μm. For the data reported here, submicron refers to particles with $D_{aero} < 1.1$ μm at 55% RH and supermicron, the difference between the concentrations measured with the two impactors, refers to particles with 1.1 μm < D_{aero} < 10 μm at 55% RH. A 47mm quartz filter (Pall Gelman Sciences, #7202, 9.62 cm^2 effective sample area) was used as the stage 1 filter in these impactors. An additional quartz filter was used as the backup filter to assess sampling artifacts.

An identical submicron (two-stage) impactor was deployed with a Teflo filter (Pall Gelman Sciences, #R2PL047 PTFE membrane filter) as the stage 1 filter and a quartz filter as the backup filter. These data were not used in the calculations reported in the NEAQS data archive.

A third submicron impactor with two quartz filters was deployed downstream of a 30 cm long diffusion denuder that contained 18 parallel strips (34 faces) of 20.3 cm x 2.8

cm carbon-impregnated glass fiber (CIG) filters separated by ~1.8 mm. The denuder cross-sectional area was 9.6 cm^2.

A 7-stage multi-jet cascade impactor ($D_{50,aero}$ of 0.18, 0.31, 0.55, 1.1, 2.0, 4.1, and 10 μm) was used to determine OC and EC mass size distributions. Aluminum foils were used for the impaction substrates and 47mm quartz filters were used as the stage 1 and backup filters.

The quartz filters and Al substrates were cleaned on board ship by baking at 550˚C for 12 hours. The cleaned filters and substrates were stored in Al foil lined (press-fitted) petri dishes, sealed with Teflon tape, in a freezer dedicated solely to these filters. After sample collection the filters and substrates were returned to their petri dishes and stored in the freezer until analysis. All samples were analyzed on board ship.

3. Sample analysis

The analysis of samples was done using a Sunset Labs thermal/optical analyzer. It heated the sample to specified temperatures for specified times, converting evolved carbon to CO_2 and then CH_4 for analysis by FID. The thermal program was the same as that used during ACE-Asia (Schauer et al.2003, Mader et al., 2003). It involved heating in 4 temperature steps to a final temperature of 870˚C in a He environment to drive off OC. After cooling the sample down to 550˚C, a He/O_2 mixture was introduced and the sample was heated further in 4 temperature steps to 910˚C to drive off elemental carbon (EC). The instrument measures the transmission of laser light through the filter to enable the separation of EC from OC that charred during the first stages of heating. The optical OC/EC split works only on the backup filters in the impactors, not on the impactor foils.

No correction has been made for carbonate carbon in these samples so OC includes both organic carbon and carbonate carbon if it was present.

4. Data reported in archive

The following OC/EC data sets are reported in the data archive:

1. Sub-micron OC – data are from the denuder/impactor sampler. The back up quartz filter behind the stage 1 quartz filter was used as the blank.
2. Sub-micron EC – data are the average of the two sub-micron impactor samplers (with and without denuders).
3. Super-micron OC – data are the difference between the sub-10 um impactor and the sub-1 um impactor. Both impactors were run without denuders. Both impactors were corrected for blanks/artifacts using the backup quartz filter behind the stage 1 quartz filter.
4. Super-micron EC – data are the difference between the sub-10 um impactor and the average of the two sub-micron impactor samplers (with and without denuders).
5. 7-Stage OC mass size distribution – The stage 1 quartz filter was corrected for blanks/artifacts using the backup quartz filter. With short sampling periods this might tend to overestimate the stage 1 OC concentration.
6. 7-Stage EC mass size distribution – an optically detected split point between OC and EC can not be used with the Al impactor foils. The split between OC and EC in the 7-stage impactors was based on a split time for the stage 1 quartz filter.

Bates, T.S., D.J. Coffman, D.S. Covert, and P.K. Quinn (2002). 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), 10.1029/2001JD001174.

Mader, B.T., J.J. Schauer, J.H. Seinfeld, R.C. Flagan, J.Z.Yu, H. Yang, Ho-Jin Lim, B.J. Turpin, J. T. Deminter, G. Heidemann, M. S. Bae, P. Quinn, T. Bates, D.J. Eatough, B.J. Huebert, T. Bertram, and S. Howell (2003). Sampling methods used for the collection of particle-phase organic and elemental carbon during ACE-Asia, *Atmos. Environ*., in press.

Schauer, J.J., B.T. Mader, J. T. DeMinter, G. Heidemann, M. S. Bae, J.H. Seinfeld, R.C. Flagan, R.A. Cary, D. Smith, B.J. Huebert, T. Bertram, S. Howell, J. T. Kline, P. Quinn, T. Bates, B. Turpin, H. J. Lim, J. Z. Yu, H. Yang, and M. D. Keywood (2003). ACE-Asia intercomparison of a thermal-optical method for the determination of particle-phase organic and elemental carbon, *Environ. Sci. Technol.,* 37, 993-1001, 10.1021/es020622f.