Instrumental Methods
Particle number size distributions
Aeroosls99 - INDOEX, 1999

Inlet

Aerosol sampling and analysis methods were similar to those used in ACE-1 (Bates et al., 1998a, 1998b; Quinn et al., 1998) and ACE-2 (Bates et al., 2000; Quinn et al., 2000). 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. Fifteen 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. Comparisons of the total particle count (Dp > 3 nm) during intercomparisons with the NCAR C-130 airplane and ACE-1 ground stations agreed to within 20% suggesting minimal loss of particle number in the inlet system (Weber et al., 1999). A similar comparison with the NCAR C-130 during the Indian Ocean Experiment (INDOEX) showed agreement to within 5%. Assessing the inlet efficiency for larger particles is more difficult. Comparisons of marine boundary layer particle extinction based on in situ measurements and total column measurements (NASA Ames suntracking sunphotometer, Livingston et al., 2000) during ACE-2 agreed to within the uncertainties of the measurements and calculations, however those uncertainties are quite high.

Aerosol number distributions and concentrations

Total particle number concentrations were measured with TSI 3010 and TSI 3025 particle counters (CPC) operated directly off one of the 1.9 cm sampling tubes and a TSI 3010 particle counter connected to an independent 0.6 cm sampling line running to the top of the sampling mast. The 30 minute averaged data over the length of the cruise from the two TSI 3010 counters agreed to within 3.6 ± 9.5% (mean ± one standard deviation of the ratio). The 30 minute average data from the TSI 3025 particle counter was on average 16 ± 6.8% higher than the data from the TSI 3010 counters.

One of the fifteen 1.9 cm diameter tubes was used to supply ambient air to a differential mobility particle sizer (DMPS) located inside the humidity-controlled box at the base of the mast. The DMPS was a University of Vienna (Reischle) medium column, operating with a negative particle charge, connected to a TSI 3010 particle counter. Data were collected in 27 size bins between 22 and 900 nm diameter. The DMPS operated with an aerosol flow rate of 0.5 L/min and a sheath air flow rate of 5 L/min. The sheath air was humidified to 55% RH. Another one of the 1.9 cm diameter tubes was used to supply ambient air to an ultrafine differential mobility particle sizer (UDMPS) and DMPS located just outside the humidity-controlled box at the base of the mast. The UDMPS was a University of Vienna (Reischle) short column instrument, operating with a negative particle charge, connected to a TSI 3025 particle counter. Data were collected in 14 size bins between 3 and 22 nm diameter. The UDMPS operated with an aerosol flow rate of 1 L/min and a sheath air flow rate of 10 L/min. The DMPS on this inlet was identical to the one in the humidity-controlled box. However, the relative humidity of the sheath air was dry resulting in a measurement RH in the UDMPS/DMPS of approximately 10%. Mobility distributions from the three systems were collected every 15-minutes.

The UDMPS/DMPS data were filtered to eliminate periods of calibration and instrument malfunction and periods of ship contamination (based on relative wind and high and rapid changes in CN counts). The filtered mobility distributions were then converted to number-size distributions using the inversion routine of Stratman and Wiedensohler (1997). The data were corrected for diffusional losses (Covert et al., 1997) and size dependent counting efficiencies (Wiedensohler et al., 1997) based on pre-ACE-1 and ACE-2 intercalibration exercises. The accuracy of both the particle sizing and the number of particles in each size bin depends on the stability of the flow rates. Three of the four DMPS flows (CPC, Sheath and Excess) were controlled independently in these three systems. The DMPS inlet flow was the difference of these flows, nominally 10% of the sheath flow. The flow calibration involved setting the CPC flow and DMA sheath flow with an electronic bubble flow meter. The excess flow was balanced with the sheath air flow such that the DMPS inlet flow was equal to the CPC flow. The inversion and evaluation of the DMPS data assumed the sheath and excess flows were equal and that the inlet flow equaled the CPC flow. The drift in the CPC, sheath, and excess flows was generally less than one percent during the cruise (mean $0.63 \pm 0.55\%$). This translates into a similar error in particle sizing of plus or minus a percent. However, a relative drift of 1% in the sheath to excess flow translates into a 10% change in the DMPS inlet flow and thus a 10% change in the number concentration. A change in the inlet flow also results in a change in the transfer function of the DMA which compounds this error, eg., for this case the combined error is on the order of 15%. During Aerosols99, the integrated number concentration from the DMPS operated at 55%RH averaged $18 \pm 10\%$ lower than the total number measured by the TSI 3010. The integrated number concentration from the DMPS system operated at 10% RH averaged $21 \pm 6\%$ lower than the total number measured by the TSI 3010. To correct for the number concentration error, the DMPS data reported have been normalized using the 30 minute average ratio of the total number concentration to the integrated DMPS number concentration. An interactive routine was then used to fit lognormal curves to the different modes of the DMPS number size distributions.

Another one of the 1.9 cm tubes was connected to an Aerodynamic Particle Sizer (APS – TSI 3320) located in the humidity-controlled box at the base of the mast. The APS measured the number size distribution between 0.6 and 9.6 μm aerodynamic diameter. Data at diameters larger than 5 μm were discarded due to potential interferences from phantom counts and uncertainties in large particle collection efficiencies. Although the intent was to measure this distribution at 55% RH, the heat from the instrument effectively dried the sea salt aerosol to below its efflorescence point.

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