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# GNI - A System for the Impaction and Automated Optical Sizing of Giant Aerosol Particles with Emphasis on Sea Salt

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Size distributions of giant aerosol particles (e.g. sea-salt particles, dry radius larger than 0.5 $\mu$m) are not well characterized in the atmosphere, yet they contribute greatly to both direct and indirect aerosol effects. Measurements are problematic for these particles because they (i) occur in low concentrations, (ii) have difficulty in passing through air inlets, (iii) there are problems in discriminating between dry and deliquesced particles, (iv) and impaction sampling requires labor intensive methods. In this study, a simple, high-volume impaction system called the Giant Nuclei Impactor (GNI), based on free-stream exposure of polycarbonate slides from aircraft is described, along with an automated optical microscope-based system for analysis of the impacted particles.

The impaction slides are analyzed in a humidity-controlled box (typically 90% relative humidity) that allows for deliquescence of sea salt particles. A computer controlled optical microscope with two digital cameras is used to acquire and analyze images of the aerosol particles. Salt particles will form near-spherical cap solution drops at high relative humidity. The salt mass in each giant aerosol particle is then calculated using simple geometry and K ¨ohler theory by assuming a NaCl composition.

The system has a sample volume of about 10 L/s at aircraft speeds of 105 m/s. For salt particles, the measurement range is from about 0.7 $\mu$m dry radius to tens of micrometers, with a size-bin resolution of 0.2 $\mu$m dry radius. The sizing accuracy was tested using glass beads of known size.

Characterizing the uncertainties of observational data is critical for applications to atmospheric science studies. A comprehensive uncertainty analysis is performed for the airborne GNI manual impaction and automatic optical microscope system for sizing giant aerosol particles, with particular emphasis on sea-salt particles. The factors included are (i) sizing accuracy, (ii) concentration accuracy, (iii) impaction effects leading to coalescence between particles on the slides, and (iv) impaction effects leading to particle breakup.

The significant factors contributing to uncertainty are identified through classical un- certainty analysis and a novel stochastic Monte-Carlo model for estimating coalescence of particles impacting on a slide. These are then used to determine the combined system uncertainty.

For the giant seasalt size range of 0.7 $\mu$m to 16 $\mu$m dry radius (rd), the combined sizing uncertainty ranges from 9% for small particles to 6% for large particles. For the same size range, the combined concentration uncertainty is less than 8%. Not included in the uncertainty calculation is solution drop aerosol breakup on impact; a detailed analysis using 288 slides and more than 100,000 images finds that the overall effect to be small for analyzed particles with rd $\leq$ 11 $\mu$m. The scarcity of larger particles make the impaction breakup analysis too uncertain for these large sizes.

The GNI instrument has been used to derive average sea-salt size distributions for the 2008 VOCALS project off the coast of northern Chile using the NSF/NCAR C-130 research aircraft. Total giant sea-salt mass loadings at an altitude of 200 m above sea surface points to only about half the aerosol loading commonly found in near-surface observations from ships. It is hypothesized that most ship-based measurements, often optical, are of particles that are not in equilibrium with the ambient humidity, thus leading to overestimates of the sea-salt aerosol loading. This has important implications for verifying the sea-salt values predicted by climate models.