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Aerosol and Cloud Experiments in the Eastern North Atlantic (ACE-ENA) Winter Intensive Operational Period: Aerodynamic Particle Sizer Field Campaign Report

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Acronyms and Abbreviations

AAF	ARM Aerial Facility
ACE-ENA	Aerosol and Cloud Experiments in the Eastern North Atlantic
ADC	analog-to-digital converter
APS	aerodynamic particle sizer
ARM	Atmospheric Radiation Measurement
ASCII	American Standard Code for Information Interchange
DOE	U.S. Department of Energy
ENA	Eastern North Atlantic
IOP	intensive operational period
UHSAS	ultra-high-sensitivity aerosol spectrometer

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1.0 Summary

An aerodynamic particle sizer spectrometer (APS, model 3321 by TSI Inc., Shoreview, Minnesota) was deployed at the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) user facility Eastern North Atlantic (ENA) observatory during the second (winter) intensive operational period (IOP) of the Aerosol and Cloud Experiments in the Eastern North Atlantic (ACE-ENA) field campaign. Data were collected from January 9 through February 26, 2018, covering the second deployment of the ARM Aerial Facility (AAF) aircraft within ACE-ENA.

The standard ENA instrument suite does not provide measurements of aerosol particle size distribution for diameters greater than one micron. Properties of coarse-mode (super-micron) aerosols are rarely measured, although super-micron particles can play an important role in the aerosol life cycle, affecting aerosol optical properties and cloud nuclei activity (e.g., Clarke et al. 2003). The APS was deployed to fill this gap in particle size measurements: it is capable of measuring size-resolved concentration of the aerosols in the 0.5-20 μm range (aerodynamic diameter).

The APS was installed in the aerosol trailer to sample through the main stack. Special attention was given to selection of the instrument location (just below the main stack) to minimize particle losses in the connecting lines. Most atmospheric aerosols are hygroscopic, so the measurement of the aerosol size distributions should either be performed in a controlled humidity environment or accompanied by concurrent measurement of the temperature and humidity of the sample air. The latter strategy was used during this deployment: a high-precision humidity/temperature transmitter (model EE08 by E+E Elektonik GMBH, Engerwitzdorf, Germany) was mounted in the APS sampling line immediately upstream of the APS inlet.

A dedicated laptop computer was used for data collection and communications. The APS was controlled with vendor-supplied software (Aerosol Instrument Manager, ver. 10.1, TSI); aerosol size distribution data were collected over a period of 55 seconds and converted to one-minute averages. Temperature and humidity analog signals were acquired via analog-to-digital converter (ADC) module (model WTAIN-M by Weeder Technologies, Fort Walton Beach, Florida) using vendor-supplied software (ModCom) with 1- sec resolution. In post-processing, the APS data were exported from TSI proprietary format into "comma-separated value" American Standard Code for Information Interchange (ASCII) files and matched with appropriately averaged temperature and humidity data. Two significant periods of missing data were caused by local power outages. Vendor-supplied software was not designed for unattended operation: it needs to be manually restarted including sensor configuration setup.

2.0 Results

Information on the coarse-aerosol properties are particularly important at a coastal or island site, such as ENA, where marine aerosol is often dominated by large sea-salt particles (Clarke et al. 2003). To illustrate, we compiled a data set of aerosol size distributions that covers a broader range of aerosol sizes collected by a suite of instruments. An ultra-high-sensitivity aerosol spectrometer (UHSAS) is part of standard ENA instrumentation, providing aerosol size distributions in the 0.06--1 μm range; the data are available through the ARM Data Center. To combine UHSAS-measured size distribution (optical size, assumed to be close to the geometric diameter) with APS-measured data (aerodynamic diameter), the

APS sizing was corrected for density of dry sea salt (ρ=2.2 g/cm^3) following Baron and Willeke (2001). Total concentration was calculated as a sum of UHSAS distribution from its smallest bin (60 nm) to 0.75 µm and APS "density-corrected" distribution from 0.75 µm to the APS's largest bin (20.54 µm). A threshold size of 0.75 µm was arbitrarily chosen in the overlapping size range.

Aerosol loadings were generally small during the entire campaign. Total number concentrations were mostly below 250 cm^{-3}: minimum=16, median=138, mean=180, maximum=3700 cm^{-3}. Figure 1 presents an example of combined aerosol size distributions. The red line shows a time series of total aerosol number concentration derived from combined UHSAS-APS size distributions.

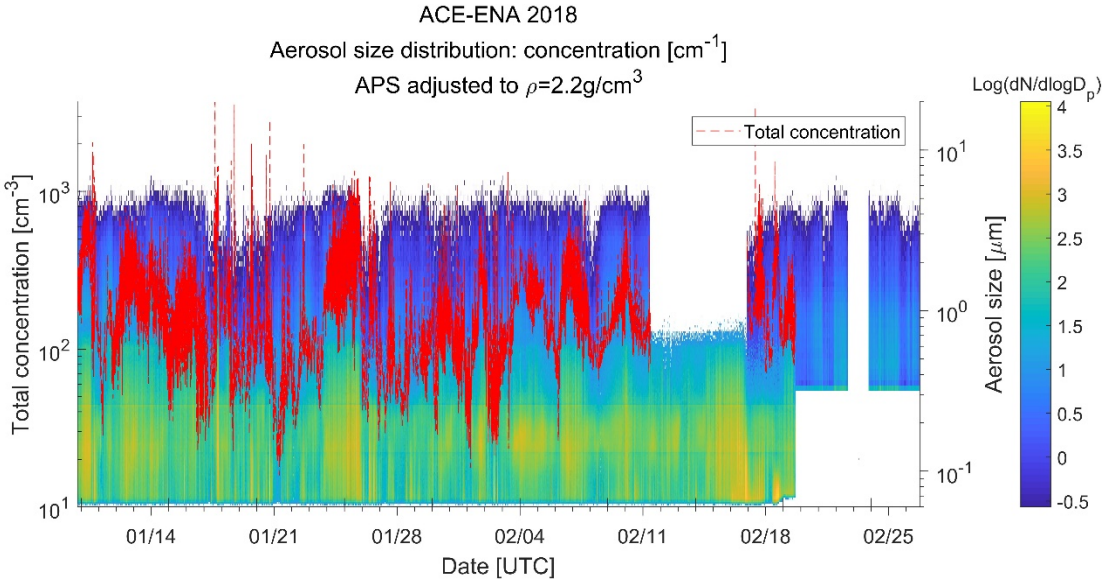

Figure 1. Time series of particle number concentrations as a function of time and geometric diameter measured using the APS (upper "band") and UHSAS (lower "band"). The APS sizing was adjusted to particle density of ρ=2.2 g/cm^3. The red line depicts aerosol total number concentration.

Obviously, number size distributions were dominated by the fine particles all the time, but surface and volume size distributions were mostly dominated by coarse-mode aerosols. Figure 2 presents a time series of coarse-mode fraction (diameter greater than 1 µm) for aerosol number, surface, and volume concentrations expressed as a percentage of totals.

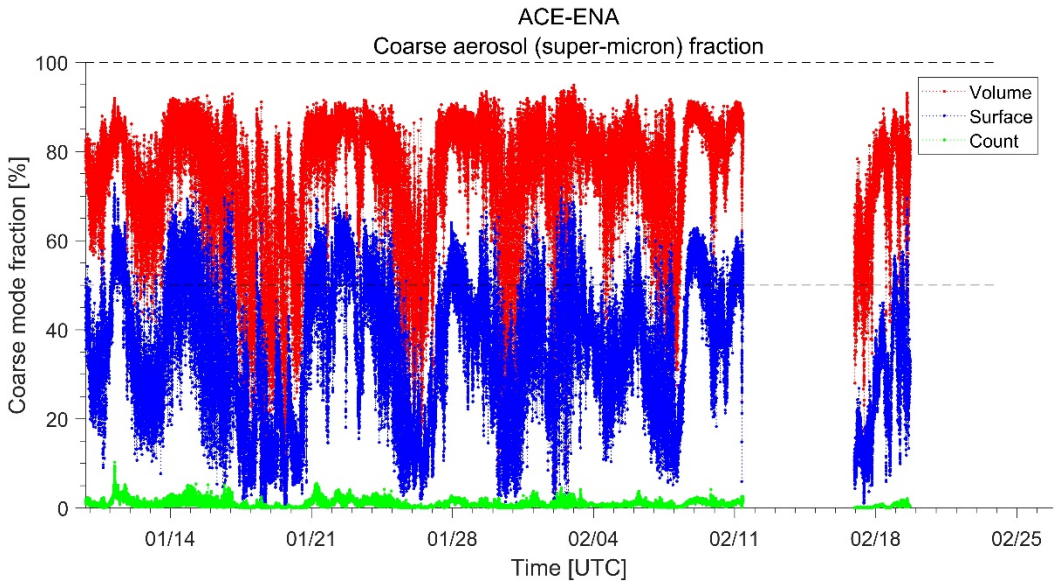

Figure 2. Time series of coarse-mode aerosol fractions (D_p>*1* μm); coarse-mode aerosol contributions to the aerosol total number, surface, and volume are expressed as a percentage of totals.

The deployment of the APS during the ACE-ENA second IOP provided important information on aerosol properties. Combined with the data routinely recorded at the ENA site, the new data set can be used to continue studies of coarse-aerosol impact on aerosol life cycle, cloud condensation nuclei activity, and optical properties, For example, the data can be used for simultaneous retrieval of aerosol effective density and index of refraction following Kassianov et al. (2014).

3.0 Publications

Baron, PA, and K Willeke. 2001. *Aerosol Measurement: Principles, Techniques and Applications*, 2nd ed. Wiley-Interscience, New York, New York, pp. 51 and 66.

Clarke, A, V Kapustin, S Howell, K Moore, B Lienert, S Masonis, T Anderson, and D Covert. 2003. "Sea-salt size distributions from breaking waves: Implications for marine aerosol production and optical extinction measurements during SEAS." *Journal of Atmospheric and Oceanic Technology* 20(10): 1362–1374, https://doi.org/10.1175/1520-0426(2003)020<1362:SSDFBW>2.0.CO;2

Kassianov, E, J Barnard, M Pekour, LK Berg, J Shilling, C Flynn, F Mei, and A Jefferson. 2014. "Simultaneous retrieval of effective refractive index and density from size distribution and light scattering data: Weakly absorbing aerosol." *Atmospheric Measurement Techniques* 7(10): 3247–3261, https://doi:10.5194/amt-7-3247-2014

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