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Azores 2017 Field Campaign Report

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ARM
CLIMATE RESEARCH FACILITY

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Acronyms and Abbreviations

ACTOS	Airborne Cloud and Turbulence Observation System
ARM	Atmospheric Radiation Measurement
APS	aerodynamic particle sizer
ASL	above sea level
CCN	cloud condensation nuclei
CDNC	cloud droplet number concentration
DFG	German Research Foundation
DOE	U.S. Department of Energy
ENA	Eastern North Atlantic
FT	free troposphere
IAC	International Aerosol Conference
MBL	marine boundary layer
MPSS	mobility particle sizer system
TROPOS	Leibniz Institute for Tropospheric Research

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1.0 Summary

Aerosol particles play an important role for the regional and global climate. Therefore, a network of measurement sites has been established worldwide, but only a small fraction of them is capturing the marine boundary layer (MBL) while approximately 70% of the Earth's surface is covered with water. The main focus of this project is to improve the knowledge of sources and exchange processes of aerosol particles in general (German Research Foundation [DFG] project WE 2757/2-1) and of cloud condensation nuclei in particular (DFG project HE 6770/2-1) in the MBL in the northeastern Atlantic Ocean where the influence of local anthropogenic sources is negligible.

The main hypothesis of the project is that long-range transport of aerosols from North America as well as new particle formation in the free troposphere (FT) and at cloud edges followed by vertical transport contribute significantly to the aerosol budget in the MBL. The knowledge of sources and sinks of aerosol particles in combination with vertical exchange between FT and MBL is a prerequisite to predict aerosol particle number concentrations in the lowest regions of the MBL and its influence on the formation of clouds. These processes are not sufficiently quantified over the ocean up to now.

To verify the hypothesis stated above, vertical exchange processes and particle sources over the Azores will be quantified using data of 17 measurement flights with high spatial resolution using a helicopter-borne platform developed at the Leibniz Institute for Tropospheric Research (TROPOS). Here, aerosol particle number concentration and vertical wind speed have been measured with a temporal resolution allowing the direct estimate of the vertical turbulent flux of aerosol particles in different heights for the first time. In addition, aerosol particle number size distributions, number concentrations of cloud condensation nuclei (CCN), cloud droplet number concentration (CDNC), and particle absorption at three different wavelengths have been determined. The data analysis is ongoing and final results are not available yet. The detailed analysis of these data will be used to conclude sources and origin of the investigated aerosol particles.

Measurement flights performed by the helicopter are limited in time and therefore provide a 'snapshot' of the atmosphere. Thus, additional continuous measurements of aerosol particle number size distributions were installed at two ground-based sites. One of them is located a few meters above sea level at the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility's Eastern North Atlantic (ENA) observatory on Graciosa Island, Azores, and the second one at 2200 m above sea level (ASL) in the FT (Pico Mountain Observatory, Pico Island, Azores). Here, number size distributions with identical instrumentation were measured in the size range from 10 nm to 10 μm. These continuous measurements will be used in the next months to study connections and exchange processes between MBL and FT over the whole measurement period of one month.

First results indicate significant differences in the shape of particle number size distributions between MBL (ENA) and FT (Pico Mountain): in some cases more aerosol particles in the Aitken mode range (< 100 nm) are present in the free troposphere compared to sea level as frequently stated in the literature. However, the opposite behavior has been observed, i.e., Aitken mode was detected in the FT while it was present in the MBL at the same time. The data will be analyzed in more detail during the next month in connection with data sampled by ARM, such as ground-based optical measurements and some profiling data.

2.0 Results

This report is mainly about the number size distribution measurements at ENA. There were performed with two instruments: one Mobility Particle Sizer System (MPSS, TROPOS) and an Aerodynamic Particle Sizer (APS, TSI Inc.).The main purpose of these data is to be analyzed within the scope of the whole project, i.e., in combination with measurements from the helicopter-borne platform, Airborne Cloud and Turbulence Observation System (ACTOS). The ground-based measurements from ENA are in good agreement with airborne measurements in the lowest 200 m above the ocean. Thus, the ENA site is representative of the MBL, excluding the local emission sources such as vehicular and air traffic. The MBL is frequently characterized by a bimodal aerosol number size distribution.

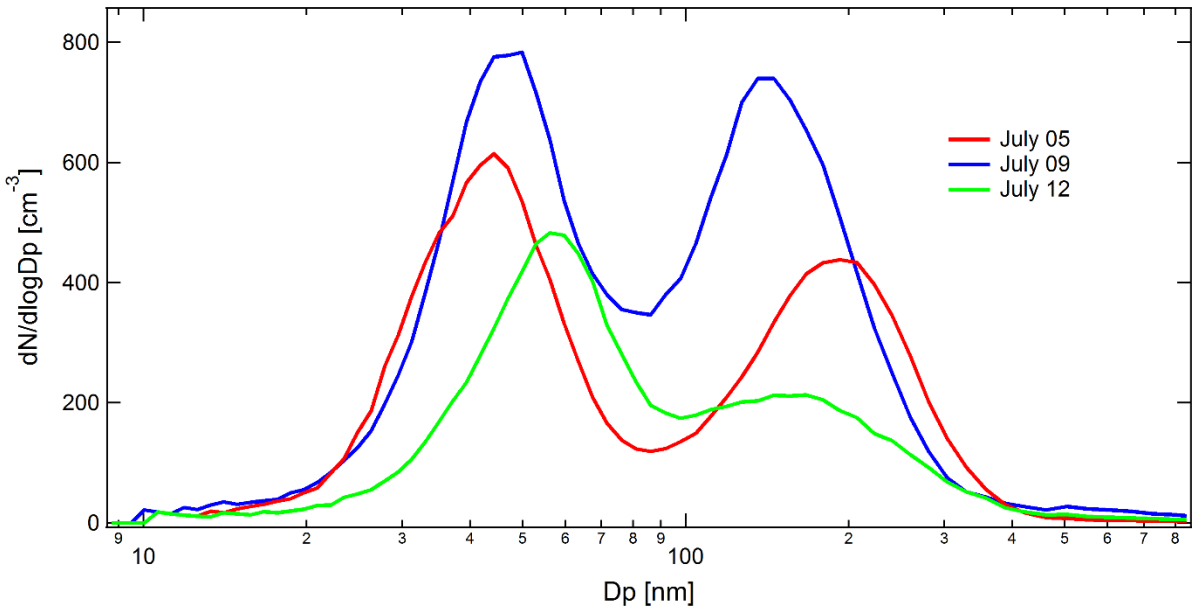

Figure 1. Median number size distributions of three selected days during the campaign. The bimodal structure was the dominant feature, but the ratio between the modes and the total number concentrations was variable.

Figure 1 shows median number size distributions of three selected days during the first half of the campaign. The bimodal shape is clearly visible in all curves, which is in good agreement with former studies. This is not surprising due to the location of the measurements size and shows that marine aerosols dominate. During extremely clean cases, as observed on July 12, the accumulation mode is very weak compared to the Aitken mode. On that day, the air masses originated from the Caribbean, a region with probably a lot of rain and cloud processing leading to a removal of potential cloud condensation nuclei. Air masses on the other two days originate from northern/ northwesterly directions, also clean marine areas with probably less precipitation. A more detailed analysis of air mass origin and aerosol properties will be the subject of further studies.

The detailed analysis of the data will follow in combination with airborne data. Results will be also used for publications and two abstracts containing these data will be submitted for the International Aerosol Conference (IAC) in St. Louis, Missouri, USA, in 2018.

3.0 Publications and References

Wehner, B, K Chevalier, S Henning, K Weinhold, O Welz, C Mazzoleni, and P Fialho, Aerosol Measurements in the Marine Boundary Layer and Free Troposphere in the North Eastern Atlantic Ocean, abstract to be submitted to the International Aerosol Conference St. Louis, 2018.

Wehner, B, K Chevalier, S Henning, K Weinhold, O Welz, C Mazzoleni, and P Fialho, Investigation of the Vertical Layering and Transport Processes of Aerosol Particles in the Marine Boundary Layer and the Free Troposphere over the Atlantic Ocean, abstract to be submitted to the International Aerosol Conference St. Louis, 2018.


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