Physical / Chemical Characterization of Airborne Saharan Dust during the Aerosol and Ocean Science Expeditions (AEROSE)

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Introduction

- The Aerosol and Ocean Science Expeditions (AEROSE) are a series of trans-Atlantic intensive atmospheric field campaigns conducted aboard the NOAA research vessel Ronald H. Brown (RHB).
- AEROSE was designed to obtain a suite of complementary measurements and Oceanographic observations of Saharan dust from the African continent across the Atlantic Ocean.
- These observations are being used to characterize aerosols microphysical evolution, climate impacts, heterogeneous chemistry, and marine meteorology along the cruise path.
- This study examines the trend of dust outbreaks between two observational periods namely: July 2006 and July 2009.
- The AEROSE ship tracks based on satellite aerosol climatology are shown in figure 1a, 1b, and 1c.

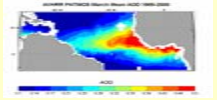

Figure 1

Figure 2: AEROSE cruise tracks

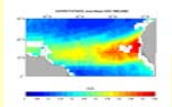

Figure 3

Figure 1 and 3: AVHRR PATMOS mean AOD 1985-2000 climatology for March and June

Methodology

- Quartz Crystal Microbalance cascade impactor was used to perform in-situ real time measurement of the AEROSE samples in various portions of dust plume that occurred over the tropical Atlantic Ocean.
- Case studies were selected among major dust outbreaks that occurred during the month of July 2006 and 2009.
- The morphology and chemical composition of the AEROSE samples were obtained using the Oxford JSM 6360 – LV Scanning Electron Microscope (SEM) attached to an Energy Dispersive X-ray microanalysis (EDX) system.
- Statistical analyses were performed to determine the trend of dust outbreaks between the two observational periods
- The air mass history were computed with NOAA ARL HYSPLIT model to determine the dust source region

Figure 4: SEM/EDX microanalysis system

Figure 5: QCM electrode

Figure 6: QCM cascade impactor

Objective

A major goal of our research has been to characterize Saharan dust aerosols to gain a predictive understanding of the physical and chemical processes governing the size, dynamics, and chemical composition of dust as it crossed the Atlantic Ocean.

Results

- Figures 7 and 8 show the mean atomic percentage composition of the AEROSE 2006 and 2009 samples. These data represent the averages over all six stages of the QCM.

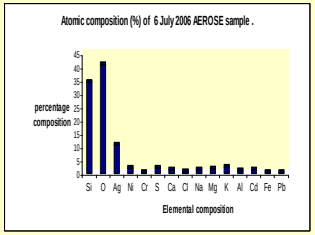

Figure 7: Mean atomic % composition of 6 July 2006 AEROSE samples

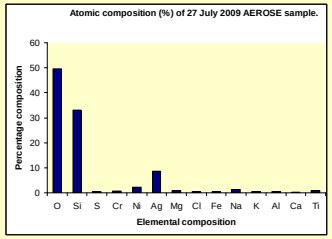

Figure 8: Mean atomic % composition of 27 July 2009 AEROSE samples

- The SEM analyses showed evidence of hygroscopic growth on the QCM substrate due to high relative humidity in the sampling area, changes in the surface mixing state of the mineral dust during long distant transport, and different source region characteristics of dust particles.

size cut (μm)	5	2.5	1.2	0.6	0.3	0.15
July 2006						
July 2009						

Figure 9: SEM images for the AEROSE 2006 and 2009 samples.

- Back trajectory analysis consistent with the Ozone Monitoring Instrument (OMI) reveal an outflow of air masses from Mauritania, Senegal, and a weak outflow from the Algeria-Mali border. These were intercepted during July 2006. However, in July 2009, the source regions are Mauritania and northwest Angola.

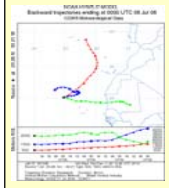

Figure 10: Back trajectory for 6 July 2006

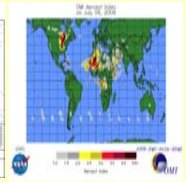

Figure 11: OMI for 6 July 2006

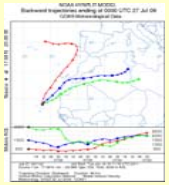

Figure 12: Back trajectory for 27 July 2009

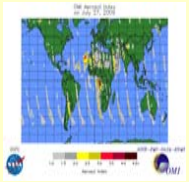

Figure 13: OMI for 27 July 2009

Summary

- Chemical composition of the AEROSE 2006 samples is indicative of a well-mixed dust-urban plume regime. The 2009 samples are predominantly dust aerosols.
- Some of the representative SEM images for the observational period showed evidence of hygroscopic growth on the QCM substrate.
- The Ozone Monitoring instrument (OMI) and the NOAA Hysplit model points to different source regions for air masses arriving at the sampling environment for both years

Future Studies

- microRaman spectroscopy will be utilized to obtain the oxidative state of elements present in the AEROSE sample.
- Auger spectroscopy will provide information on the chemical aging of the dust sample.
- Powder X-ray diffraction will give more comprehensive information on the mineralogy of the particles.
- Statistical analyses using data from previous AEROSE campaigns.

References

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