Optical Properties and Chemical composition during AQABA: *A first glance*

Pikridas[1], M., J. Crowley[2], M.Vrekoussis[1,3,4], P. Vouterakos[1], K. Barmpounis[1], R. Evans[5], K. Matjaz[6], N. Mihalopoulos[1,7,8], J. Lelieveld[1,2] and J. Sciare[1]

[1] *Energy Environment and Water Research Center, The Cyprus Institute, Nicosia 1645, Cyprus*
[2] *Max Planck Institute for Chemistry, Mainz, Germany*
[3]University of Bremen, Institute of Environmental Physics and Remote Sensing (IUP), Germany
[4]University of Bremen, Center of Marine Environmental Sciences (MARUM), Germany
[5]Acoem Australasia, 1492 Ferntree Gully Road, Knoxfield, Vic, Australia, 3180
[6]AEROSOL d. o. o., Kamniska 41, SI-1000, Ljubljana, Slovenia
[7]University of Crete, Chemistry department, 71003 Heraklion, Crete, Greece.
[8]National Observatory of Athens, Athens, Greece

THE CYPRUS INSTITUTE
RESEARCH·TECHNOLOGY·INNOVATION

MAX-PLANCK-GESELLSCHAFT

Abstract

In the framework of the AQABA (Air Quality and climate change in the Arabian BAsin) project led by the Max Planck Institute of Chemistry, a two-month long (1st July - 1st September 2017) intensive campaign was performed onboard a research vessel, during which we measured with a high time resolution the physical, optical and chemical properties of the ambient aerosol around the Arabian Peninsula. The campaign consisted of a round trip from south of France (Toulon) to Kuwait crossing the Mediterranean Sea, Red Sea, Indian Ocean and Arabian Gulf, thus exploring for the first time the optical and chemical properties of the atmosphere in the region.
PM_1 and PM_{10} aerosol size fractions were sampled in order to better apportion natural (sea salt and desert dust) against anthropogenic sources and characterize their atmospheric fate. Aerosol absorption (measured with an aethalometer) and light scattering coefficient (measured with a nephelometer) in these two size ranges were monitored along with the water-soluble ions in PM_1/PM_{10} with hourly resolution.
Preliminary results of this characterization suggest 1) high load of dust particles in the Arabian Sea, exceeding those in the Arabian Gulf and Kuwait, and 2) alteration in the optical properties of the dust aerosol in the polluted air of the Arabian Gulf.

1. Introduction

Although the Eastern Mediterranean and the Middle East (EMME) region is a global change hot spot with very high loads of air pollutants and atmospheric dust from the two largest deserts worldwide, it has received only little attention (e.g. in reports of the Intergovernmental Panel on Climate Change; IPCC, 2013). One reason is that observational data (especially in the Middle East) are insufficient, unavailable or of limited quality. How air pollutants, of anthropogenic origin, and dust particles, of natural origin, are combined is unclear because no other areas in the world are subjected to both and in such elevated concentrations.

2. Instrumentation

Aerosol scattering was monitored using a polar nephelometer (Model: Aurora 4000, Acoem Australasia) with an upstream valve that switched sampling between total suspended (TSP) and submicron (PM_1) particles every 10 minutes. Particulate absorption of the same size fractions was simultaneously sampled using an aethalometer, (Model AE33, Magee Scientific) along with the water soluble composition using a Monitor of AeRosol and Gases in ambient Air (MARGA; Model 2S, Metrohm, Applikon). All samples were dried using Nafion or diffusion dryers. Sampling took place 2 m above the roof of the regulated temperature container the instruments were installed in, that was located in the front of Commandor Iona (Fig. 2), the ship used to host the campaign, to minimize contamination.

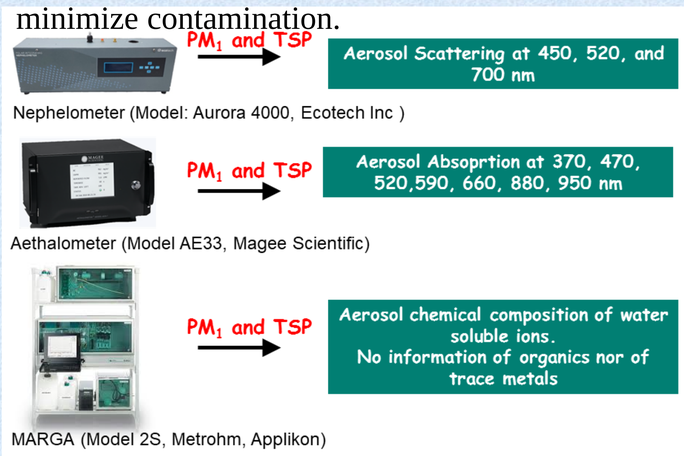


Fig. 1. A fraction of the aerosol instrumentation used in the AQABA campaign

Fig. 2. The Commandor Iona vessel where all the instruments were hosted. Sampling containers were installed in the front of the ship to avoid contamination from the ship's stack emissions.

3. Sampling Strategy and Route

The goal was to travel along the coast of the Arabian Peninsula, starting from Toulon, France, and ending in Kuwait. The same path was followed during both legs (departure and return) shown in Fig. 3. During the return trip several hours were spent near the Stromboli Volcano. The departure and return trips took place during July and August 2017, respectively.

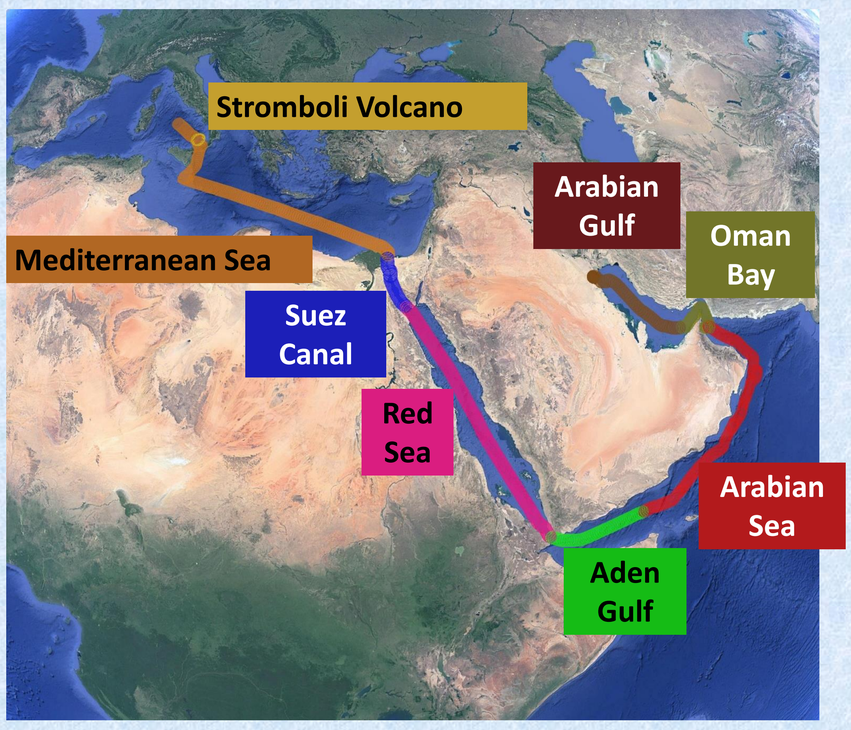
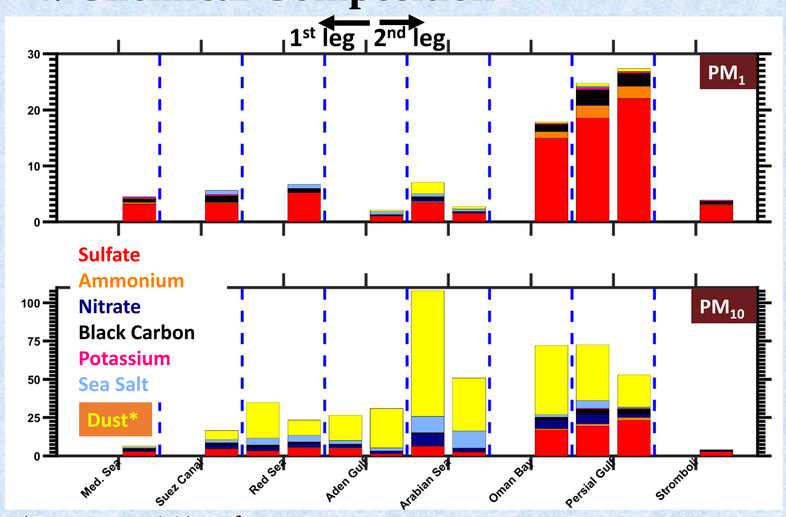


Fig. 3. Ship route during the departure and return trip, divided into sections based geography and particulate chemistry. These sections are the Mediterranean Sea, Suez Canal, Red Sea, Aden Gulf, Arabian Sea, Oman Bay, and Arabian Gulf. During the return trip a good amount of time was spent near the Stromboli Volcano.

4. Chemical Composition

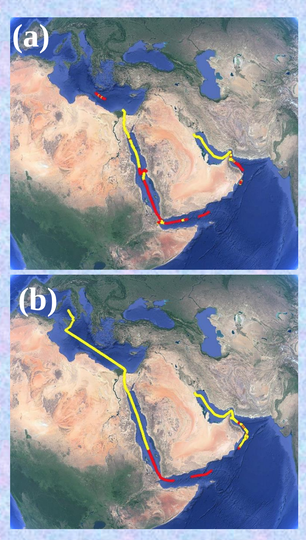


*From water soluble Ca^{+2}

- Dust particles identified in the PM_1 samples at the Arabian Sea. At the same location the highest dust loadings were observed.
- At the Arabian Gulf elevated levels of PM_1 sulfate and black carbon were observed. Sulfate was also identified in the super-micron range.
- The PM_1 chemical fingerprint from the Mediterranean Sea to the Suez Canal is similar

Fig. 4. Chemical composition during both legs corresponding to the trip sections shown in Fig. 3.

5. Wavelength Dependance of Single Scattering Albedo



Single scattering albedo (SSA) is used to identify scattering from absorbing particles. The wavelength dependence of SSA, via its exponent, can be used to qualitatively detect the presence of dust particles (Collaud Cohen et al., 2004). A negative SSA exponent suggesting the presence of dust particles (red dots in Fig. 5) was identified at the lower half of the Red Sea, the Aden Gulf, and the Arabian Sea. However, even though dust particles were identified in the Arabian Golf and the Golf of Oman, the SSA exponent remained positive.

Fig. 5. SSA exponent during both legs of the AQABA campaign. Positive and negative values are shown with yellow and red dots, respectively. Negative values suggest the presence of dust particles.

6. Conclusions

1. Elevated concentrations of sulfate in PM_1 are observed in the Arabian Gulf. Sulfate was also identified in super-micron aerosol particles. Possible source is the sulfur-rich fossil fuel combusted by oil rigs in the area.
2. At the Arabian Sea, dust particles could be identified in the submicron range.
3. The PM_1 chemical fingerprint from the Mediterranean Sea to the upper half of the Suez Canal is similar.
4. SSA exponent is positive in the Arabian Gulf despite the presence of dust particles, suggesting that pollution from fossil fuel combustion (sulfate and BC) altered the aerosol optical properties.