Optical Properties and Chemical composition during AQABA: A first glance
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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. PM10 and PM2.5 aerosol size fractions were sampled in order to better apportion natural (sea salt and desert dust) against anthropogenic sources and characteristic 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 PM10/PM2.5 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, Ecotech Inc.) with an upstream valve that switched sampling between total suspended (TSP) and submicron (PM1) 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 the Commandor Iona (Fig. 2), the ship used to host the campaign, to minimize contamination.

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.

4. Chemical Composition

5. Wavelength Dependence of Single Scattering Albedo

6. Conclusions
1. Elevated concentrations of sulfate in PM10 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 PM10 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.

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.

Fig. 3. Ship route during the departure and return trip, divided into sections based on 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.

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

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.