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Physical Properties of Fine Aerosol Particles in the South Eastern Mediterranean and around the Arabian Peninsula During The AQABA Campaign: Hygroscopicity, Mixing State and Potential Cloud Droplet Numbers

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Fine aerosol particles in the atmosphere affect the global climate directly by absorbing and scattering radiation. In addition, by acting as Cloud Condensation Nuclei (CCN) they affect the structure of clouds, change their albedo and precipitation patterns, thus indirectly modulating the planetary energy balance. Due to the high variability of the physical and chemical properties of aerosol particles, however, quantifying their contributions on the climate is a challenging task. Particle properties may change depending on the activity of their sources and the meteorological conditions. In addition their mixing state can vary with time and location. Having information about the variation of the properties and the mixing state is therefore very important for understanding the contribution of atmospheric particles on climate.

Here we report measurements of hygroscopicity and mixing state of fine aerosol particles, conducted with a custom made hygroscopic tandem differential mobility analyzer (HTDMA) during the Air Quality and climate change in the Arabian Basin (AQABA) ship based campaign that was conducted from early July to end of August 2017. The ship crossed the southeastern Mediterranean Sea (SEMED), the Red Sea (RS) and circulated the Arabian peninsula. All these areas pose an increased climate and health related scientific interest as they are affected by multiple sources, distributed in intrinsically different regions, of physical aerosols and pollutants, depending on the meteorology conditions and patterns. In addition, measurements reporting the physicochemical properties of aerosol particles, and more specifically their hygroscopicity, are scarce in the Eastern Mediterranean and the Middle East (EMME) regions.

Apart from the hygroscopicity and the mixing state of the sampled fine aerosol particles, directly derived from the HTDMA measurements, we also estimated their hygroscopic properties based on their chemical composition measurements. Our results show that the apparent hygroscopic parameter κ of the fine aerosol fraction had a maximum value of approx. 0.4 throughout the campaign, excluding times when the measurements were affected by our ship plumes. Larger (e.g., accumulation mode) particles exhibited values close to this maximum in the Persian Gulf, due to their significant sulfate content. Furthermore, we estimate the potential cloud droplet number and its dependence on particle hygroscopicity, number concentration and wind updraft velocity across the ship's path.