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Mass concentration and ion composition of coarse and fine particles in an urban area in Beirut: effect of calcium carbonate on the absorption of nitric and sulfuric acids and the depletion of chloride

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Abstract. Levels of coarse (PM10-2.5) and fine (PM2.5) particles were determined between February 2004 and January 2005 in the city of Beirut, Lebanon. While low PM mass concentrations were measured in the rainy season, elevated levels were detected during sand storms originating from Arabian desert and/or Africa. Using ATR-FTIR and IC, it was shown that nitrate, sulfate, carbonate and chloride were the main anionic constituents of the coarse particles, whereas sulfate was mostly predominant in the fine particles in the form of $(NH_4)_2SO_4$. Ammonium nitrate was not expected to be important because the medium was defined as ammonium poor. In parallel, the cations Ca^{2+} and Na^+ dominated in the coarse, and NH_4^+, Ca^{2+} and Na^+ in the fine particles. Coarse nitrate and sulfate ions resulted from the respective reactions of nitric and sulfuric acid with a relatively high amount of calcium carbonate. Both $CaCO_3$ and $Ca(NO_3)_2$ crystals identified by ATR-FTIR in the coarse particles were found to be resistant to soaking in water for 24 h but became water soluble when they were formed in the fine particles suggesting, thereby, different growth and adsorption phenomena. The seasonal variational study showed that nitrate and sulfate ion concentrations increased in the summer due to the enhancement of photochemical reactions which facilitated the conversion of NO_2 and SO_2 gases into NO_3^- and SO_4^{2-}, respectively. While nitrate was mainly due to local heavy traffic, sulfates were due to local and long-range transport phenomena. Using the air mass trajectory HYSPLIT model, it was found that the increase in the sulfate concentration correlated with wind vectors coming from Eastern and Central Europe. Chloride levels, on the other hand, were high when wind originated from the sea and low during sand storms. In addition to sea salt, elevated levels of chloride were also attributed to waste mass burning in proximity to the site. In comparison to other neighboring Mediterranean countries, relatively higher concentrations of calcium in Beirut were good indication of calcitic crustal abundance. Considering the importance of the health and climate impacts of aerosols locally and regionally, this study constitutes a point of reference for eastern Mediterranean transport modeling studies and local regulatory and policy makers.

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