A new method for quantifying sodium sulfate, sodium nitrate, and sodium chloride aerosols

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Sea salt aerosols are abundant in the marine boundary layer and have large influences on the Earth's radiative budget. Significant conversion of sodium chloride (NaCl) to sodium sulfate (Na_2SO_4) or sodium nitrate ($NaNO_3$) can take place via the reactions with sulfuric acid (H_2SO_4) or nitric acid (HNO_3) in polluted air exported from urban areas to coastal regions. In situ, continuous measurements of NaCl, Na_2SO_4, and $NaNO_3$ aerosols are needed to understand the chemical transformation of sea salt particles with air mass aging. However, there is no established method for quantifying these aerosol compounds with high time resolution. We have developed a new online particle mass spectrometer (refractory aerosol thermal desorption mass spectrometer; rTDMS) to quantify non-refractory and refractory sulfate aerosols. The combination of a graphite particle collector and a carbon dioxide (CO_2) laser enables high desorption temperature (radiation temperature > 1200 K). The evolved gas molecules are detected by using a quadrupole mass spectrometer. The purpose of this study is to develop a new method for quantifying the mass concentrations of NaCl, Na_2SO_4, and $NaNO_3$ aerosols by optimizing the laser desorption scheme of the rTDMS. Laboratory experiments were performed to test the instrument sensitivities to these aerosol compounds. The temporal evolution of ion signals at m/z 23 (Na^+), 30 (NO^+), 36 (HCl^+), and 48 (SO^+) during the laser desorption were monitored. Preliminary data indicate that ion signals originating from $NaNO_3$, NaCl, and Na_2SO_4 particles were clearly identified by three sequential peaks associated with an increase in the radiation temperature. The limit of detection, linearity of the instrument response, and potential artifacts under real world conditions are discussed.

Keywords: Sea salt aerosols, Online measurement, Quantification of each sodium salts