Offline Analyses of the Sources of Organic Aerosol and the Hygroscopicity of Water-Soluble Aerosol in Northern Europe

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Abstract

Understanding the sources and hygroscopicity of atmospheric organic aerosol (OA) over boreal forest regions, where biogenic emissions contribute significantly to aerosol formation, is important for assessing its impact on radiative balance and climate. In this study, the sources of OA and the hygroscopicity of water-soluble aerosol in Hyytiälä Forest Station were investigated for submicron particles collected on filters in the period of July 2021 – June 2022. OA extract solutions were prepared according to their solubility to water as water-soluble organic matter (WSOM) and water-insoluble organic matter (WISOM). WSOM was further fractionated into humic-like substances (HULIS) and high-polarity fraction (HP-WSOM) by solid-phase extraction. The fractions were analyzed by the offline use of a high-resolution aerosol mass spectrometer, and the hygroscopicity of WSOM samples at 85% relative humidity was analyzed using a tandem differential mobility analyzer. Among the fractions, HP-WSOM on average had the highest O/C ratio (0.93±0.54), followed by WSOM (0.73±0.15), HULIS (0.60±0.10), and WISOM (0.28±0.10). By the positive matrix factorization for the OA fractions, their sources were attributed to fossil fuel OA, biomass burning OA (BBOA), biogenic secondary OA (BSOA), and more oxidized oxygenated OA (MO-OOA), where BSOA showed a clear seasonality. Respective OA fractions were dominated by distinctive sources: HP-WSOM was dominated by MO-OOA (78%), HULIS by BSOA (69%), and WISOM by fossil fuel OA (67%). The hygroscopicity parameter of water-soluble matter (κ) was in the range of 0.16 - 0.37, and summer showed generally lower κ values (0.21±0.03) than winter (0.30±0.06). An inverse correlation was found between the measured κ and that estimated from a preliminary calculation of the volume fraction of organics.

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