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Significant contribution of isoprene oxidation products in summertime organic aerosols at the summit of Mt. Fuji, Japan

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We investigated the organic molecular compositions and size distributions of the summertime aerosols collected at the summit of Mt. Fuji (3776 m, a.s.l.) using gas chromatography/mass spectrometry. More than 120 organic species were detected in the aerosols and grouped into different compound classes such as aliphatic lipids, sugars, phthalate esters, sterols, hydroxy-/polyacids, and biogenic secondary organic aerosol (SOA) tracers for the photooxidation of isoprene (e.g., 2-methyltetrols), alpha/beta-pinene (e.g., pinic acid), and beta-caryophyllene (beta-caryophyllinic acid). Total concentrations of the identified organics were 76.1-325 ng m-3 (average 183 ng m-3) for the whole-day samples, which are more than 10 times higher than those in nighttime samples (9.28-19.2 ng m-3, average 15.6 ng m-3). Higher concentrations of both primary and secondary organic marker compounds were observed in the whole-day samples, indicating that the mountain venting at Mt. Fuji should act as an efficient pump that uplifts the ground-surface aerosols and their precursors to the free troposphere. Interestingly, isoprene SOA tracers (2.87 ng m-3 in nighttime and 69.2 ng m-3 in whole day) were found to be the most abundant compound class. 2-Methylerythritol and 2-methylthreitol, the well-known isoprene SOA tracers, were detected as the dominant single compounds. Using a tracer-based method, we estimated the concentrations of secondary organic carbon (SOC) derived from isoprene, alpha/beta-pinene, and beta-caryophyllene to be 2.16-51.2 ngC m-3 (15.5 ngC m-3) during the nighttime and 183-954 ngC m-3 (465 ngC m-3) during the whole day. These values correspond to 0.80-31.8% (12.5%) and 21.6-48.9% (31.9%) of the organic carbon (OC) concentrations in nighttime and the whole-day samples, in which isoprene-derived SOC accounts for 80% and 72% of total SOC, respectively. This indicates that a large amount of organic aerosols in the free troposphere should be derived from the oxidation of isoprene emitted from the forest areas on the foothills. Size distributions of the identified organics were unimodal in most cases. Biogenic SOA tracers (e.g., 2-methyltetrols and 3-hydroxyglutaric acid), levoglucosan and malic acid were detected in the fine mode, while sucrose and trehalose that are abundant in airborne pollen and dust aerosols peaked in the coarse mode. This study provides useful information to understand the sources and abundances of organic aerosols over high mountains in East Asia.

Keywords: organic aerosols, Mt. Fuji, levoglucosan, 2-methyltetrols, biogenic VOCs, isoprene