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Model, Field, and Laboratory Studies on Source Apportionment of Anthropogenic and Biogenic Organic Aerosol

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Organic aerosol (OA) represents a large fraction (20–90%) of $PM_{2.5}$; thus, accurate knowledge of the contributions of OA sources is crucial for effective control strategies to reduce ambient $PM_{2.5}$ concentrations. Sources and formation pathways of OA, however, are complicated and not yet well characterized. For accurate source apportionment of OA, we conducted smog-chamber experiments, field measurements and forward and receptor model simulations. Production yields of 28 organic markers for anthropogenic and biogenic secondary organic aerosol (SOA) were determined through smog-chamber experiments. By careful evaluation of these production yields with the vapor pressures and ambient behaviors of these compounds, five markers were identified as suitable for application to source apportionment of anthropogenic and five other markers for biogenic SOA. The $PM_{2.5}$ chemical composition, including the SOA markers, was observed at urban, suburban and forest sites in the Kanto area during winter and summer. Concentrations of primary OA markers were higher in winter and higher at the urban site than at the other two sites. In contrast, SOA markers were higher in summer and at the suburban and forest sites.

We estimated the source contributions of OA by conducting simulations with three receptor models (positive matrix factorization, SOA-tracer and chemical mass balance models) using the ambient concentrations (field measurements) and production yields (chamber experiments) of the OA markers. The receptor model results indicate that motor vehicles, cooking and biomass burning contributed dominantly to ambient OA in winter, whereas in summer biogenic SOA had the largest contributions. These estimates are supported by the general agreement among the results of the three models. The forward model was modified by including condensable particulate matter emissions and SOA formation from intermediate-volatility organic compounds (Fig. 1). Source contributions estimated by the forward model are consistent with those of the receptor models for the major OA sources (Fig. 2). These results show that stationary combustion sources, biomass burning, cooking, biogenic VOC and stationary evaporative sources contribute significantly to ambient OA in the Kanto Area.

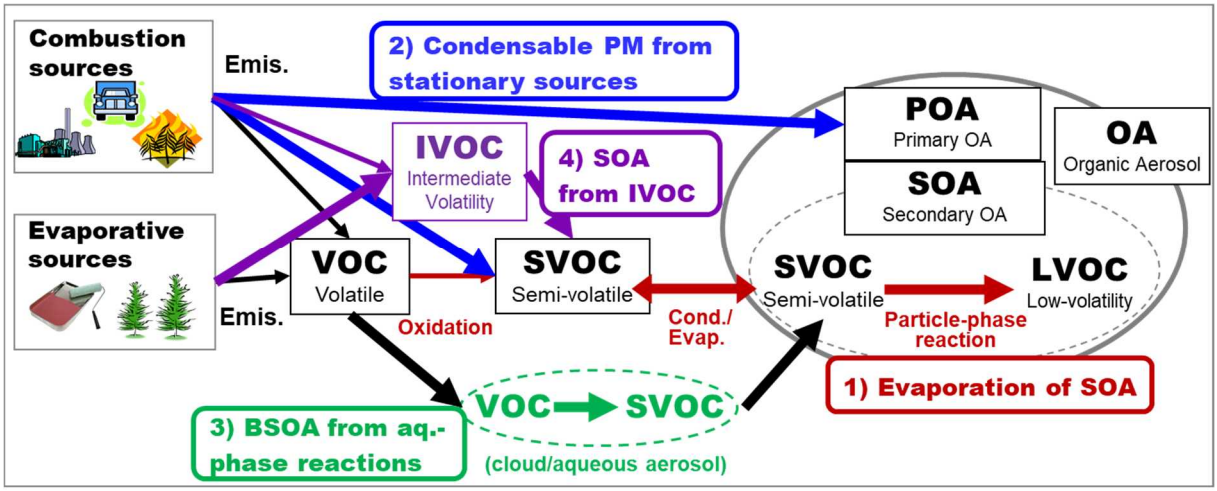

Fig. 1 Improvements to the forward model in this study.

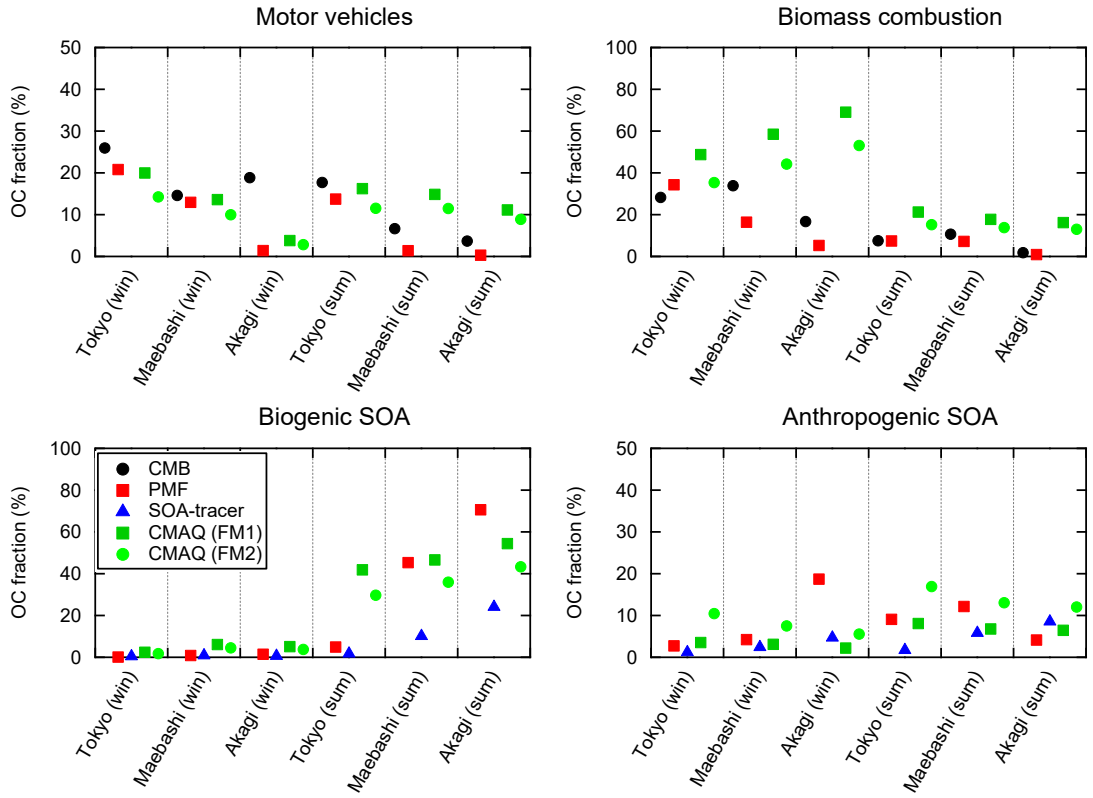

Fig. 2 Organic carbon (OC) source contributions estimated by three receptor models (CMB, PMF and SOA tracer method) and two sensitivity simulations by a forward model (CMAQ).

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