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Finding organic vapors – a Monte Carlo approach

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Aerosols have an important role in regulating the climate both directly by absorbing and scattering solar radiation, as well as indirectly by acting as cloud condensation nuclei. While it is known that their net effect on radiative forcing is negative, several key aspects remain mysterious. There exist plenty of known primary sources of particles due to both natural and man-made origin – for example desert dust, volcanic activity and tire debris. On the other hand, it has been shown that the formation of secondary particles, by nucleation from precursor vapors, is a frequent, global phenomenon. However, the very earliest steps in new particle formation – nucleation and early growth by condensation – have many big question marks on them.

While several studies have indicated the importance of a sufficient concentration of sulphuric acid vapor for the process, it has also been noted that this is usually not enough. Heads have therefore turned to organic vapors, which in their multitude could explain various observed characteristics of new particle formation. But alas, the vast number of organic compounds, their complex chemistry and properties that make them difficult to measure, have complicated the quantifying task. Nevertheless, evidence of organic contribution in particles of all size classes has been found. In particular, a significant organic constituent in the very finest particles suggests the presence of a high concentration of very low-volatile organic vapors.

In this study, new particle formation in the boreal forest environment of Hyytiälä, Finland, is investigated in a process model. Our goal is to quantify the concentration, to find the diurnal profile and to get hints of the identity of some organic vapors taking part in new particle formation. Previous studies on the subject have relied on data analysis of the growth rate of the observed particles. However, due to the coarse nature of the methods used to calculate growth rates, this approach has its drawbacks in accuracy, the inability to find diurnal variation and the lack of size resolution. Here, we aim to shed some light onto the problem by applying an ad hoc Monte Carlo algorithm to a well established aerosol dynamical model, the University of Helsinki Multicomponent Aerosol model (UHMA). By performing a side-by-side comparison with measurement data within the algorithm, this approach has the significant advantage of decreasing the amount of manual labor. But more importantly, by basing the comparison on particle number size distribution data – a quantity that can be quite reliably measured – the accuracy of the results is good.