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Simulation experiments studying the influence of plant VOC emission patterns on the formation of new particles

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Roughly 90 percent of the global volatile organic compounds (VOC) are emitted from land vegetation (Guenther et al, 1995). VOCs influence atmospheric oxidation capacity and serve as precursors for secondary organic aerosol (SOA).

In regions with low primary aerosol concentrations, biogenic SOA production proceeds via nucleation of gas phase species. Investigations of the mechanism underlying the frequently observed nucleation events in the European boreal forest demonstrate a straightforward relation between monoterpene emissions and gas-to-particle formation (Tunved et al, 2006). This is important because nucleation can provide substantial numbers of aerosols.

Number density and size distribution of aerosols are sensitive quantities that determine direct and indirect climate effects of aerosols. Kerminen et al. (2005) estimated a current radiative forcing by new particle formation in Boreal regions of about -0.2 to -0.9 Wm^{-2}. Extrapolating current monoterpene emission rates into the year 2100, Tunved et al. (2008) predict a 40% increase of cloud condensation nuclei (CCN) over Boreal forests caused by a temperature increase of 5.8°C.

Here we present results from simulation experiments conducted under atmospherically relevant conditions using VOC emissions from a variety of tree species. Specific emission patterns and total VOC concentrations were varied and nucleation rates from photochemical degradation of these mixes were determined.

Experiments were conducted in the Jülich Plant Atmosphere Chamber (JPAC, Mentel et. al, 2009). The system consists of two temperature controlled chambers, one housing the plants the second one used for photochemical SOA production. Ambient conditions such as temperature, relative humidity, photosynthetic active radiation (PAR), CO_2, O_3, and NO_x levels can be controlled in the chambers. OH is produced photochemically from O_3 and H_2O and typically reaches values of $1\text{-}5\times10^7$ cm^{-3}.

The emissions of trees (spruce, pine, birch, beech and oak) were taken as gas phase SOA precursors. The formation of new particles was observed to depend on OH and VOC concentration. Nucleation rates observed in this set up are generally larger than found in field measurements (Kulmala et al, 2004). This is due to the very low condensational sink in the JPAC experiments. Growth rates are at the upper end of ambient observations.

Of the tree species investigated oak emissions were observed to lead to the lowest nucleation rates. Dependencies of the nucleation rate on VOC emission patterns will be discussed. Furthermore we will discuss implications of these dependencies for new particle formation in response to climate change.

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