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Deciduous birch canopy as unexpected contributor to stand level atmospheric reactivity in boreal forests

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In boreal forests, deciduous trees such as birches may in future climate become more abundant due to their large biomass production capacity, relatively good resource use ability and large acclimation potential to elevated CO_2 levels and warmer climate. Increase in birch abundance may lead to unpredicted consequences in atmospheric composition. Currently it is acknowledged that conifers such as Scots pine and Norway spruce are important sources for volatile organic compounds (VOCs), especially monoterpenes, throughout the year, although the strong temperature relationships implies that emissions are highest in summertime. However, the dynamics of the deciduous birch foliage VOC emissions and their relationship with environmental drivers during the development, maturation and senescence of foliage has not been well analyzed. Long-term measurements of birch, which are unfortunately very sparse, can provide very useful information for the development of biosphere-atmosphere models that simulate boreal and subarctic forested areas where birch is often a sub-canopy species, occurs as a mixture among conifers or forms even pure stands in the higher latitudes.

We measured the branch level VOC emissions from a mature Silver birch with proton transfer reaction mass spectrometer during 2014 and 2015 at the SMEAR II station (Station for Measuring Ecosystem-Atmosphere Relations), southern Finland. Our results showed that the Silver birch foliage is a huge source for both short-chained volatiles such as methanol, acetaldehyde and acetone, as well as for monoterpenes. The mean emission rates from birch leaves were 5 to 10 times higher than the corresponding emissions from Scots pine shoots. We compared several semi-empirical model approaches for determining the birch foliage monoterpene standardized emission potentials, and utilized the continuous emission measurements from the two growing seasons for development of a novel algorithm which accounts for the leaf development and senescence in addition to prevailing temperature and light conditions. With these improvements and inputs to the 1D biosphere-atmosphere model SOSAA (model to Simulate Organic vapours, Sulphuric Acid and Aerosols), we showed that the contribution of Silver birch to stand scale atmospheric reactivity may exceed the ones from conifers, and therefore specific land use and species distribution patterns should be accounted for in biosphere-atmosphere models describing the surface-atmosphere exchange of reactive gases.