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Contribution of developing foliage to canopy emissions of volatile organic compounds

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Biogenic sources play a key role in volatile organic compounds (VOC) budget especially in rural areas. The evergreen coniferous forests are the main source of VOCs in many boreal regions. Significant seasonality in emission strength from coniferous trees has been reported, which mostly has been related to prevailing temperatures. Emission modeling is based on parameterizations obtained from short term field campaigns or intermittent measurements from mature foliage during the maximun emission period in mid-summer. However, the developing foliage may significantly differ in emission patterns (both quality and quantity) from the mature foliage, and this variability has not been accounted for in regional modeling approaches. Therefore long-term online emission measurements from developing biomass are necessary.

We set up an automated system consisting of several dynamic shoot enclosures and a PTR-MS (Proton Transfer Reaction Mass Spectrometer) at the SMEAR II station (Station for Measuring forest Ecosystem-Atmosphere Relationships) in southern Finland. Emissions from both mature and developing Scots pine shoots were measured for three years over the whole spring and growing season, and the shoot and needle growth were measured simultaneously. Emission rates were calculated based on needle mass in the end of growing season, and compared with those of mature shoot.

The developing shoots emitted significantly more methanol (M33), acetone (M59), isoprene + MBO (M69) and monoterpenes (M137) than the mature ones. Needle elongation rate correlated with the ratio between the emissions from developing and mature shoot. After the needle elongation period in late July, emissions from the current year shoots were equal or less than those from the previous year's shoot.

The conditions during the growing season affect needle biomass growth and thus also the emission capacity of the mature foliage in the following year. During springs 2009 and 2010 the monoterpene emission rates from the developing shoots were several orders of magnitude higher than those of the mature shoots. During spring 2011 the monoterpene emissions from the developing shoot were lower than those from the mature shoot. The temperature dependency of emissions varies from year to year, and seems to be related with the growth rate of the shoot.

Our results clearly demonstrate that actively growing new biomass is a strong source for VOCs in the Scots pine canopy, and indicate that the cumulative seasonal canopy emission estimates based on upscaling from mature foliage may be significantly biased. The seasonal patterns of the factors regulating emissions need to be more carefully analyzed, and the emission rate parameterisations revised for the foliage growth period.