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Leaf ontogeny dominates the seasonal exchange of volatile organic compounds (VOC) in a SRC-poplar plantation during an entire growing season

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The declining cost of many renewable energy technologies and changes in the prices of fossil fuels have recently encouraged governments policies to subsidize the use of biomass as a sustainable source of energy. Deciduous poplars (Populus spp.) trees are often selected for biomass production in short rotation coppiced (SRC) for their high CO_2 photosynthetic assimilation rates and their capacity to develop dense canopies with high values of leaf area index (LAI). So far, observations and projections of seasonal variations of many VOC fluxes has been limited to strong isoprenoids emitting evergreen ecosystems such tropical and Mediterranean forests as well as Citrus and oil palm plantation, all having constant values of LAI.

We run a long-term field campaign where the exchange of VOC, together with CO_2 and water vapor was monitored during an entire growing season (June - November, 2012) above a SRC-based poplar plantation. Our results confirmed that isoprene and methanol were the most abundant fluxes emitted, accounting for more than 90% of the total carbon released in form of VOC. However, Northern climates characterized by fresh summertime temperatures and recurring precipitations favored poplar growth while inhibiting the development of isoprene emission that resulted in only 0.7% of the net ecosystem carbon exchange (NEE).

Besides, measurements of a multitude of VOC fluxes by PTR-TOF-MS showed bi-directional exchange of oxygenated-VOC (OVOC) such as: formaldehyde, acetaldehyde, acetone, isoprene oxidation products (iox, namely MVK, MAC and MEK) as well as ethanol and formic acid.

The application of Self Organizing Maps to visualize the relationship between the full time-series of many VOC fluxes and the observed seasonal variations of environmental, physiological and structural parameters proved the most abundant isoprene ad methanol fluxes to occur mainly on the hottest days under mid-high light intensities when also NEE and evapotraspiration reached the highest rates. However, the seasonal pattern of methanol emission was also highly correlated with high VPD and NEE, whereas the highest isoprene emissions were mostly associated with the highest values of LAI. During the hottest and sunniest days we observed iox production triggered by photochemical reactions and deposition to the canopies. Nevertheless, peaks in formaldehyde deposition did not match with those of iox and isoprene emission. The emission of other OVOC species was mainly related to low values of LAI, most likely as a result of leaf senescence.

We have compared the observed time-series of isoprene and methanol fluxes with the simulated seasonal patterns obtained from the canopy-scale model of emissions of gases and aerosols from nature (MEGAN). The model accuracy increased when a dynamic function to predict seasonal changes in the basal emission factor was applied. However, the simulated cumulative carbon emitted in form of isoprene underestimated the observed amount by 30% on a seasonal basis, whereas good agreement was found between observed and prediceted methanol emissions.

Current research is aimed at improving process-based models that account for the ontogeny of leaves in order to predict the impact of VOC emitted from deciduous SRC-poplar plantations on air chemistry and quality.