The VOC-Ozone Connection: a grassland case study

Lukas Hörtnagl (1), Ines Bamberger (2), Ralf Schnitzhofer (2), Juergen Dunkl (2), Albin Hammerle (1), Martin Graus (2), Armin Hansel (2), Georg Wohlfahrt (1)
(1) University of Innsbruck, Institute of Ecology, Sternwartestr. 15, 6020 Innsbruck, AUSTRIA, * Email: lukas.hoertnagl@uibk.ac.at
(2) Institute of Ion Physics and Applied Physics, University of Innsbruck, Austria

Conference Marie Curie-iLEAPS
Feedbacks - Land-Climate Dynamics - Key Gaps
Hyères, November 16th – 20th 2008

BACKGROUND

The exchange of biogenic volatile organic compounds (BVOC) between plants and the atmosphere provides an important feedback to the climate system. BVOC are, for example, involved in the generation of tropospheric ozone (O_3), which is known to reduce plant photosynthesis and growth, BVOC affect the life time of the greenhouse gas methane (CH_4) in the atmosphere, and act as nucleation centres for precipitable water and thus have the potential to change the amount and timing of precipitation.

Methanol (CH_3OH, abbreviated MeOH) is a BVOC that is emitted by plants through a large variety of processes – for example during cell wall elongation and thus more generally speaking during growth and in response to stress, such as hypoxia, low temperatures or high O_3 concentrations.

Here we investigate what has been demonstrated in leaf-level laboratory experiments – that plants respond to oxidative stress caused by the stomatal uptake of O_3 by emitting MeOH [1]. To this end we report MeOH and O_3 flux measurements made above a temperate mountain grassland in Tyrol/Austria during the vegetation period 2008.

METHODS

Fluxes of MeOH (and several other BVOC) and O_3 were estimated by means of the eddy covariance method employing a sonic anemometer for the measurement of the vertical wind speed and a proton-transfer-reaction mass spectrometer (PTR-MS) and a O_3-analyser for the quantification of the respective scalar concentrations.

As a measure of plant oxidative stress we use the time-integrated O_3 uptake, calculated either on a daily basis (from sunset) or on a longer-term basis (over the duration of the experiment).

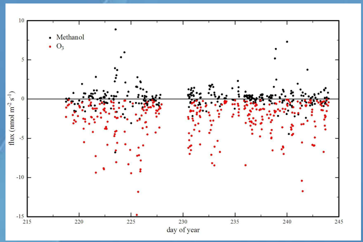

Fig. 1 Half-hourly **MeOH** and **O_3** flux.

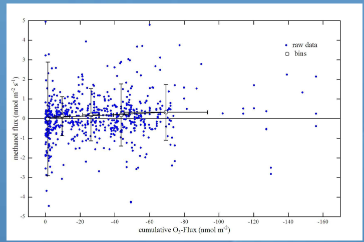

Fig. 2 Half-hourly **MeOH-flux** versus **time-integrated O_3 uptake**. O_3 uptake was integrated on a daily basis from sunset.

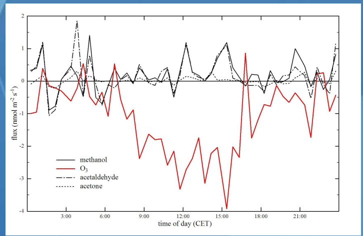

Fig. 3 Bin-average diurnal course of the fluxes of **MeOH**, **Acetaldehyde**, **Acetone** and **O_3**.

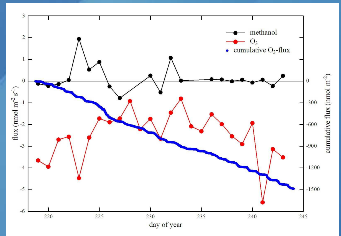

Fig. 4 **Midday average** MeOH and O_3 flux (symbols) and time-integrated O_3 uptake (integration has been performed over the 25 day duration of the experiment)

The field site:
Neustift, Stubai Valley

RESULTS

Figures 1 and 2 show that, on a daily basis, the flux of MeOH increases with the time-integrated uptake of O_3 – MeOH deposition and emission prevailing at low and high time-integrated O_3 uptakes, respectively.

While several other BVOC showed similar diurnal time courses as compared to MeOH (**Fig. 3**) and in fact their fluxes were highly correlated with the flux of MeOH (data not shown), the time-integrated O_3 uptake had little or no effect on their fluxes (data not shown). On longer time scales (25 days), the correlation between oxidative stress and MeOH flux broke down (**Fig. 4**), indicating that MeOH fluxes at these time scales are driven by other factors (such as the cut of the grass occurring on 10th August or growth) and/or that detoxification of O_3 by plants occurs efficiently on a daily basis and that therefore little cumulative effects of O_3 uptake exist beyond one day.

CONCLUSION

MeOH emission by a temperate mountain grassland was correlated with the time-integrated uptake of O_3 by the ecosystem confirming leaf-level laboratory studies indicating that the oxidative stress induced by O_3 uptake through stomata results in the emission of MeOH.

As the reaction with the hydroxyl radical (OH), which is responsible for the destruction of the greenhouse gas CH_4, is the major sink of atmospheric MeOH, this process provides an indirect radiative forcing which should be included by coupled earth-atmosphere models.

References
[1] J. Beauchamp *et al.*, 2005, *Plant Cell Environ.*, 28, 1334-1343.

Visit us: WWW.BIOMET.AT.TT