Grazing-induced BVOC fluxes from a managed grassland

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Introduction

- Grassland ecosystems cover one fourth of the Earth's land surface and are both sources and sinks of Biogenic Volatile Organic Compounds (BVOCs) which play an important role in atmospheric chemistry and and thereby on climate and air quality.
- The use of grassland for cattle breeding is a common practice in many parts of the world.
- As it has been widely demonstrated that plants emit large bursts of BVOCs when they are mechanically damaged, grass tearing and trampling during grazing are expected to induce large BVOC emissions as well.
- In the present study we followed BVOC emissions from grazed and intact grassland simultaneously.

Method and materials

- The investigations were performed using automated dynamic flow-through enclosures in a managed grassland in Belgium over the 2015 and 2016 growing season. The enclosures (Fig. 1) used in the investigation were constructed according to Pape et al. (2009). Three of enclosures were put on the grazed and three on the undisturbed grassland patch.
- BVOC fluxes, together with carbon dioxide (CO_2) and water vapor (H_2O) fluxes from grazed and undisturbed grassland were followed simultaneously using PTR-MS (Proton Transfer Reaction-Mass Spectrometry) and a LI-840 non-dispersive IR gas analyzer.
- Vegetation in the grassland was (mainly) composed of four species: *Lolium perenne* L., *Trifolium repens* L., *Taraxacum* sp., and *Ranunculus repens* L..

Fig. 1: Automated dynamic flow-through enclosures on the grassland

Results

Table 1: The main emitted/deposited BVOC of the grazed and undisturbed grassland. Compounds identification was done with the help of literature on grassland by Brilli et al.(2012), Ruuskanen et al. (2011), and Davison et al. (2007).

	Main emitted/deposited BVOC of the grazed and undisturbed grassland							
m/z	33	45	59	61	71	73	81	83
(tentative) Identification	methanol	acetaldehyde	acetone	acetic acid	methyl vinyl ketone/ methacrolein	butanone/ butanal	hexenals/ monoterpenes	hexenols/ hexanal/ hexenyl acetates

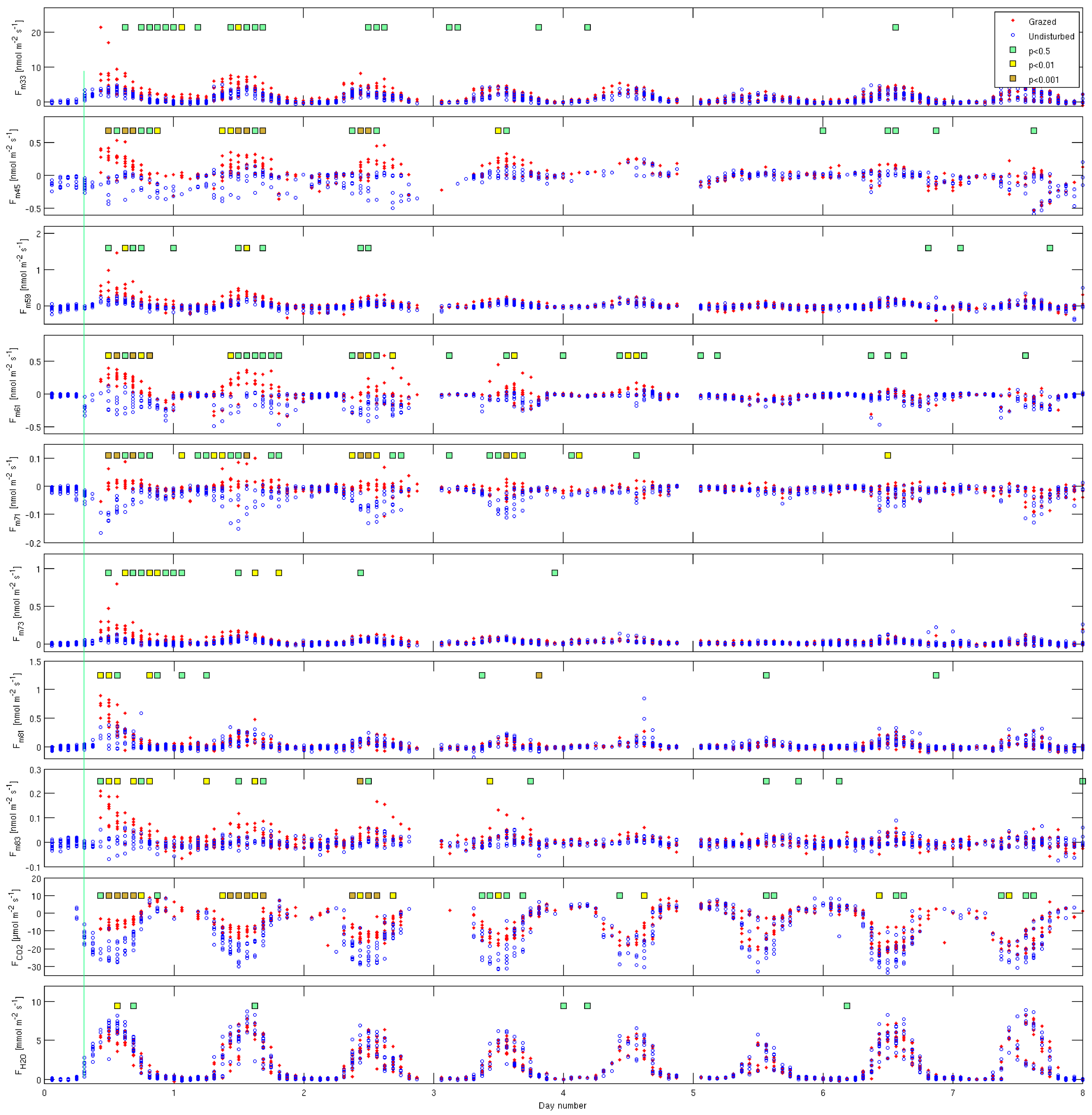

Fig. 2: Fluxes of BVOC , H_2O and CO_2 from grazed and undisturbed grassland. The lime, yellow and gold squares above the flux values indicate the level of significance of the differences between the fluxes from the grazed and undisturbed grassland using ANOVA statistics. The lime vertical line indicates the end of grazing event.

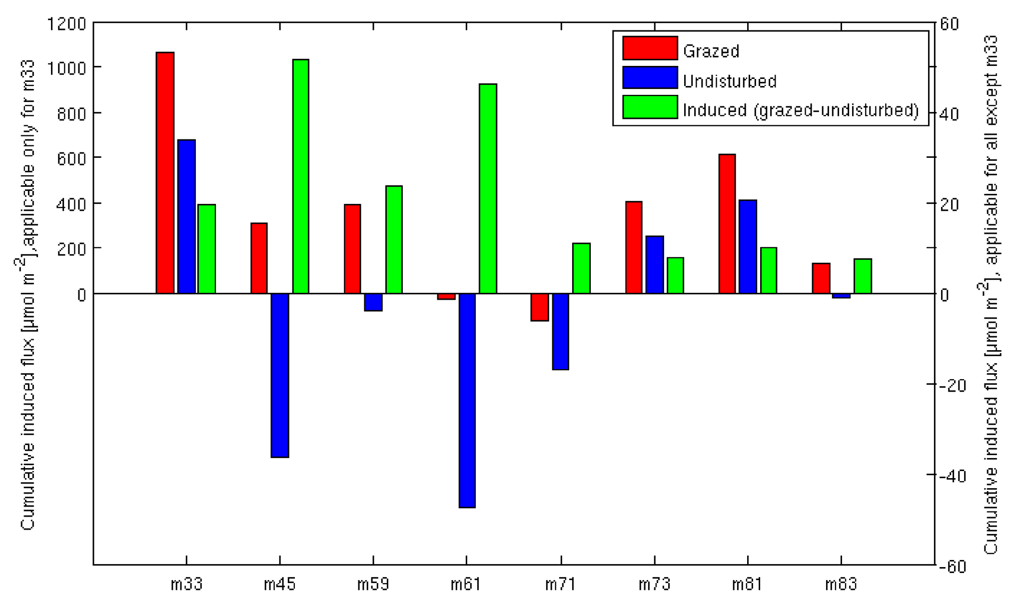

Fig. 3: Cumulative BVOC fluxes from the grazed and undisturbed grassland measured over 7.5 days and their differences (induced emissions) .

Table 2:Spearman's correlation coefficient (rho) values obtained between BVOC fluxes from undisturbed grassland and different environmental and plant physiological parameters. (*:p<0.05; **:p<0.01; ***:p<0.001 and ns:not significant.)

Compounds	Light	Temperature	Transpiration	CO_2	Ambient concentration	Relative humidity
	Spearman's correlation coefficient (rho)					
m33	0.67 (***)	0.56 (***)	0.60 (***)	-0.52 (***)	0.36 (***)	-0.16 (***)
m45	-0.07 (ns)	-0.30 (***)	-0.15 (**)	-0.01 (ns)	-0.79 (***)	-0.01 (ns)
m59	0.71 (***)	0.66 (***)	0.76 (***)	-0.52 (***)	0.03 (ns)	-0.47 (***)
m61	0.16 (**)	-0.11 (ns)	0.02 (ns)	-0.08 (ns)	-0.69 (***)	-0.11 (*)
m71	-0.39 (***)	-0.66 (***)	-0.55 (***)	0.28 (***)	-0.93 (***)	0.25 (***)
m73	0.66 (***)	0.63 (***)	0.65 (***)	-0.43 (***)	0.21 (***)	-0.22 (***)
m81	0.55 (***)	0.59 (***)	0.65 (***)	-0.44 (***)	-0.28 (***)	-0.44 (***)
m83	-0.08 (ns)	-0.11 (*)	-0.06 (ns)	-0.03 (ns)	-0.39 (***)	-0.14 (**)

Discussion

Grazing-induced BVOC fluxes

- Grazing induced high emissions of BVOC compounds which lasted for 2-5 days including the grazing day.
- While daytime depositions of m45, m61 and m71 compounds were noticed from the undisturbed grassland, emissions were observed from the grazed grassland
- m33, m59, m73, and m81 compounds were found to be emitted from both the undisturbed and grazed grassland during daytime.
- The compounds at m81 from the undisturbed and grazed grassland could be monoterpenes and hexenals, respectively.
- The grazing-induced BVOC with the highest 7.5-day-accumulated fluxes (Fig. 3) are the m33, m45, m61 and m59 compounds. Remark that these accumulative fluxes are lower limits as measurements started 3 hours after the grazing event.

Discussion (continued)

- Emission of the m33, m73 and m81 compounds after the grazing increased by 57, 62 and 49%, respectively, compared to the undisturbed grassland patch over the accumulation period.
- While 36, 4, and 1 µmol m^{-2} of m45, m59 and m83 compounds, respectively, were deposited on the undisturbed patch, 15, 20, 6 µmol m^{-2} emissions were observed from the grazed patch over the accumulation period.
- Deposition of m61 and m71 compounds decreased by 97 and 64% on the grazed patch compared to the undisturbed patch over the accumulation period.

BVOC flux drivers of undisturbed grassland

- Fluxes of m45, m61 and m71 compounds, for which daytime depositions were observed, show a relatively good negative correlation with ambient concentration compared to the rest of the compounds (Table 2). High ambient concentrations of these compounds resulted in high deposition rates.
- A good positive correlation between fluxes of m33, m59, m73, and m81 compounds, and light intensity, temperature, and transpiration rates was observed. On the contrary, fluxes of m45, m61 and m83 were poorly correlated with these parameters.
- Among the deposited compounds, m71 fluxes showed relatively better correlation with the transpiration rates, temperature and light intensity.
- A better correlation between fluxes and CO_2 uptake rates were found for m33, m59, m73, and m81 compared to the other compounds.
- Relative to the other parameters, relative humidity showed poor correlation with the fluxes except for m59 and m81.

Conclusions and prospectives

- Grazing can induce high BVOC fluxes from grassland.
- Flux intensity, pattern and composition is different from the grazed and undisturbed grassland.
- Light intensity, temperature and transpiration rates were the main controlling parameters for the emitted compounds. On the other hand, it was the ambient concentration for the deposited compounds.
- This kind of investigations has to be performed in different parts of the world to find out how vegetation composition and weather conditions affect the grazing-induced emissions.

References

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