BVOC fluxes
over a temperate mountain grassland

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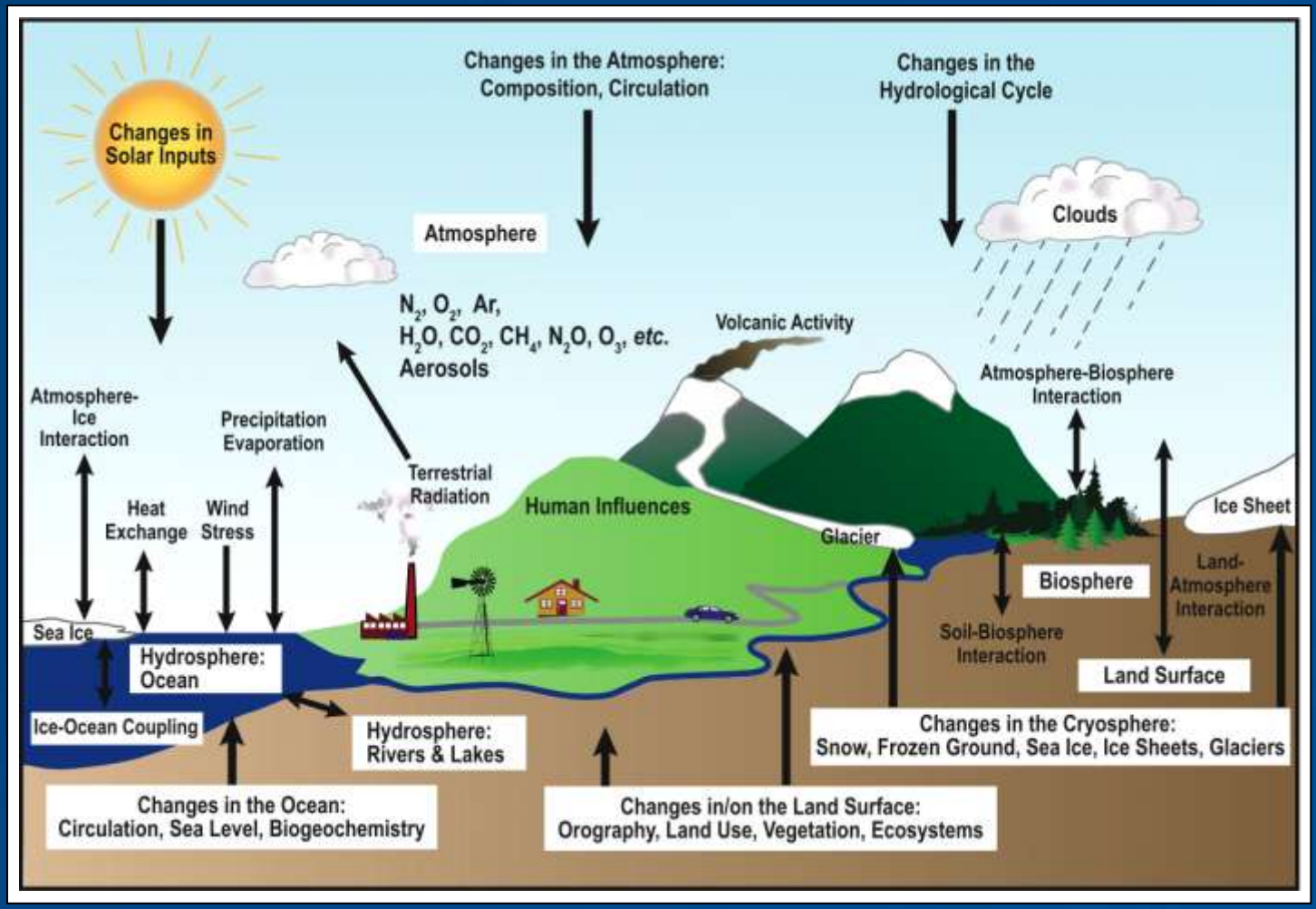
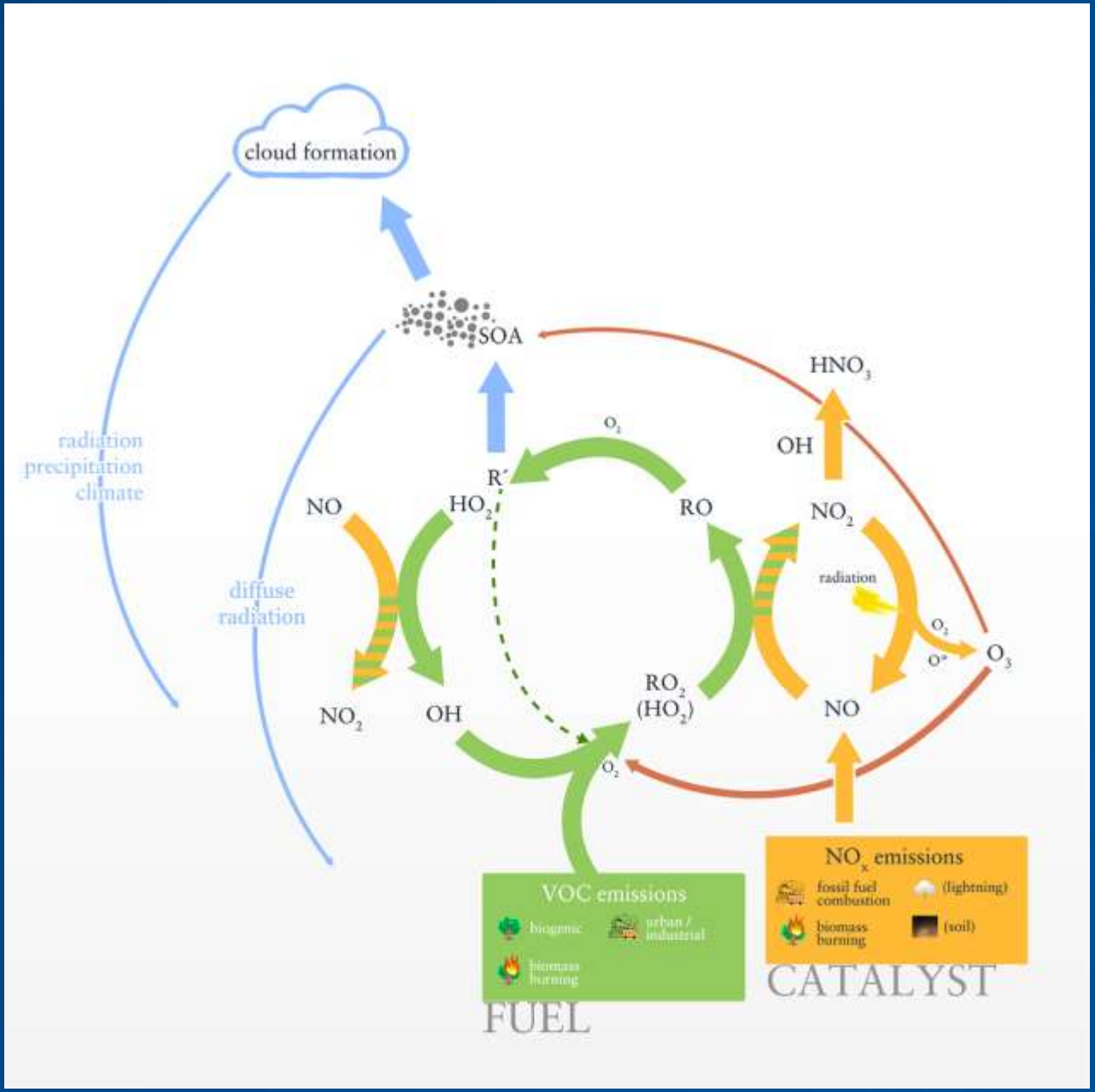
Background



IPCC (2007), FAQ1.2, Fig. 1

Background

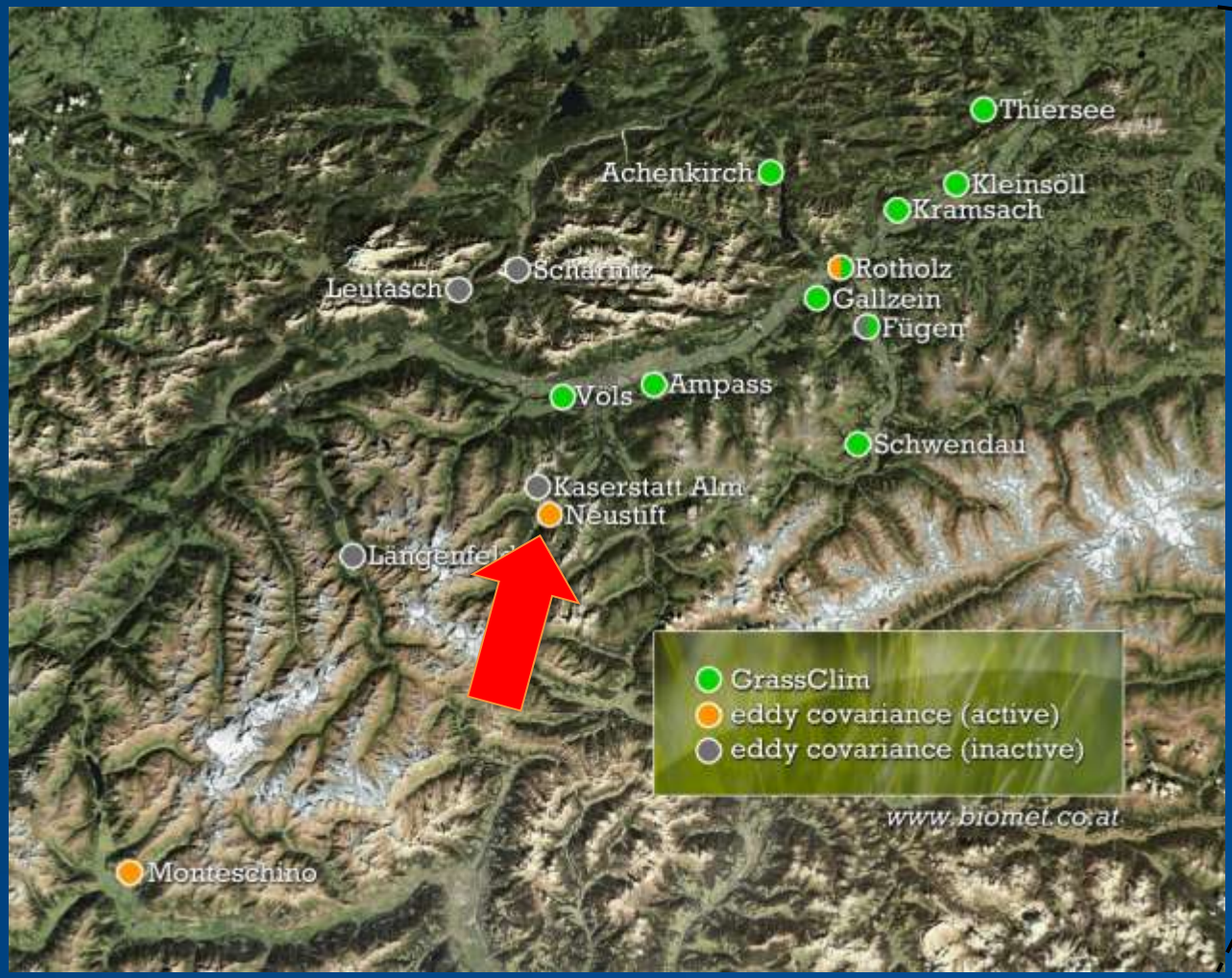


Hörtnagl (2011), PhD thesis

Study Site

Study Site

Neustift, Stubai Valley, Austria



Study Site

Neustift, Stubai Valley, Austria

Study Site

Neustift, Stubai Valley, Austria

intensively managed **meadow**

3 cuts / year | fertilized once / year
also: cows

970 m a.s.l.

humid continental **climate**
w/ alpine influences

6.5 °C | 852 mm

eddy covariance **flux** measurements since 2001

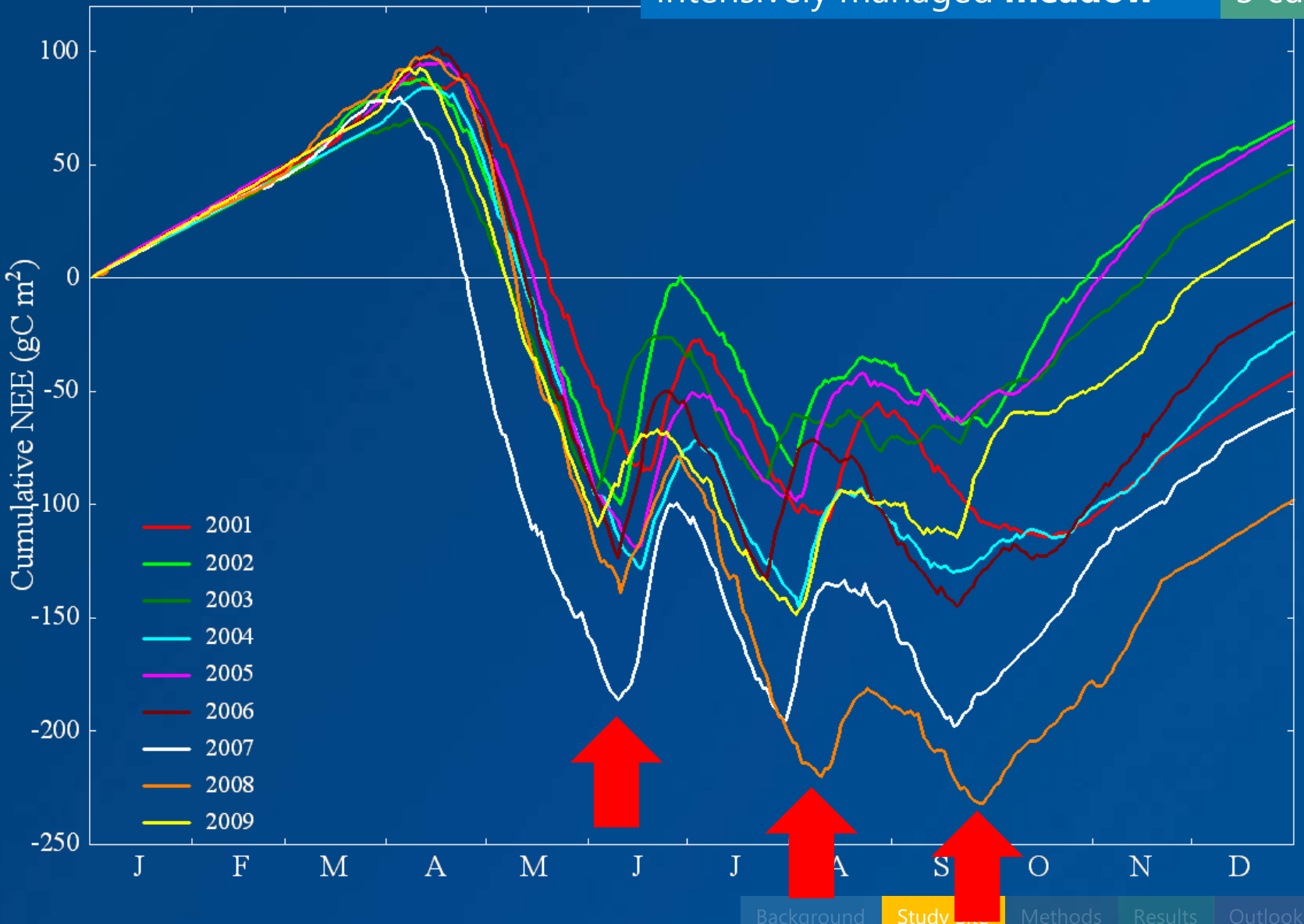
CO_2 | H_2O | Energy |
CH_4 | N_2O | O_3 | NMVOCs

Vegetation: mainly graminoids and forbs

Study Site

Neustift, Stubai Valley, Austria

intensively managed **meadow** | 3 cuts



Methods

Methods

sonic anemometer → wind data

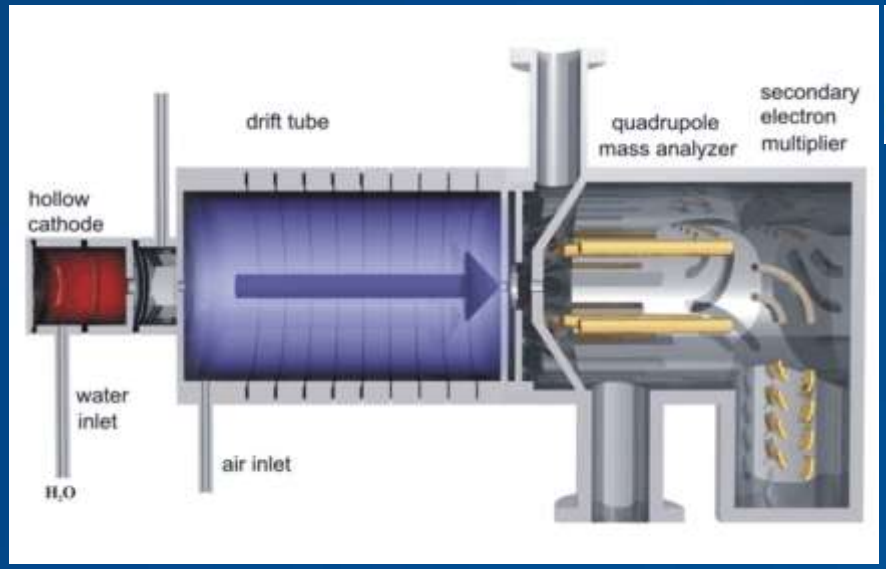
Eddy Covariance

$$F_x = \overline{w' \rho_x'}$$

Methods | PTR-MS → VOC mixing ratios

Eddy Covariance

$$F_x = \overline{w' r_x'}$$

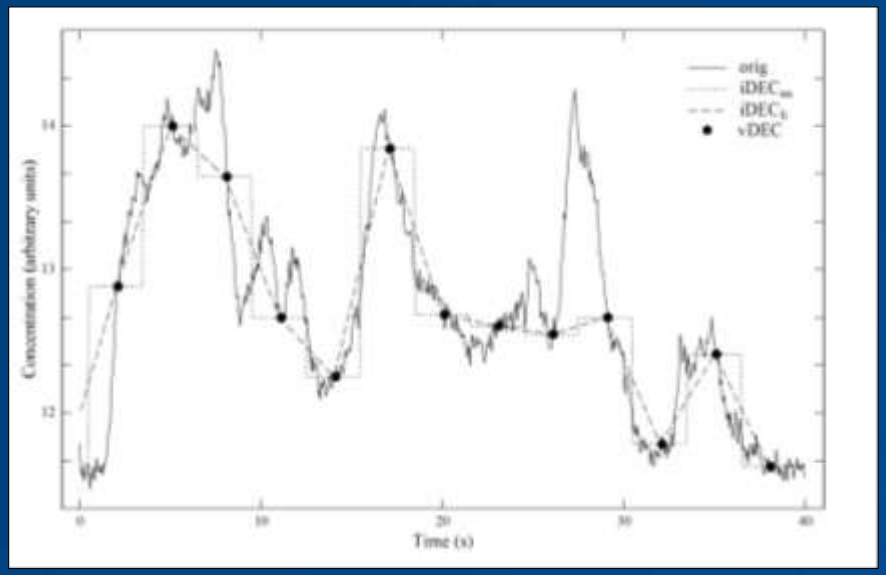


$$H_3O^+ + R \longrightarrow RH^+ + H_2O$$

Proton Transfer Reaction - Mass Spectrometer (PTR-MS)

Methods | two different time series

PTR-MS

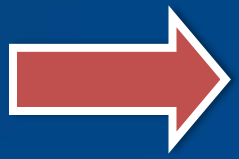


Hörtnagl et al. (2010)

sonic anemometer

VOC concentrations
0.4 Hz

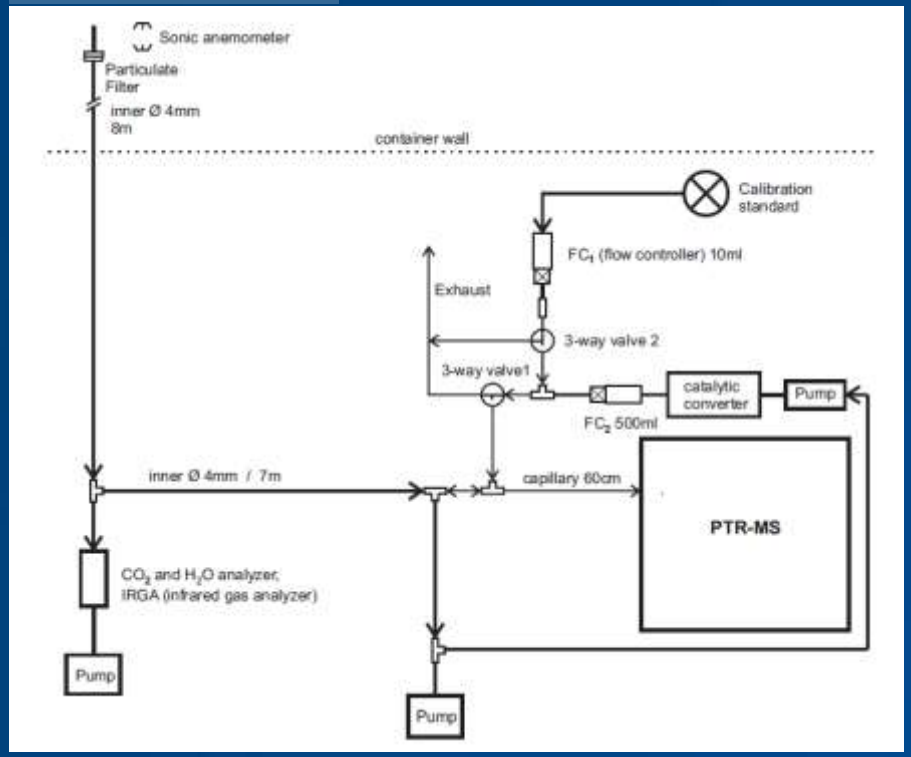
3D wind data
20 Hz



Methods

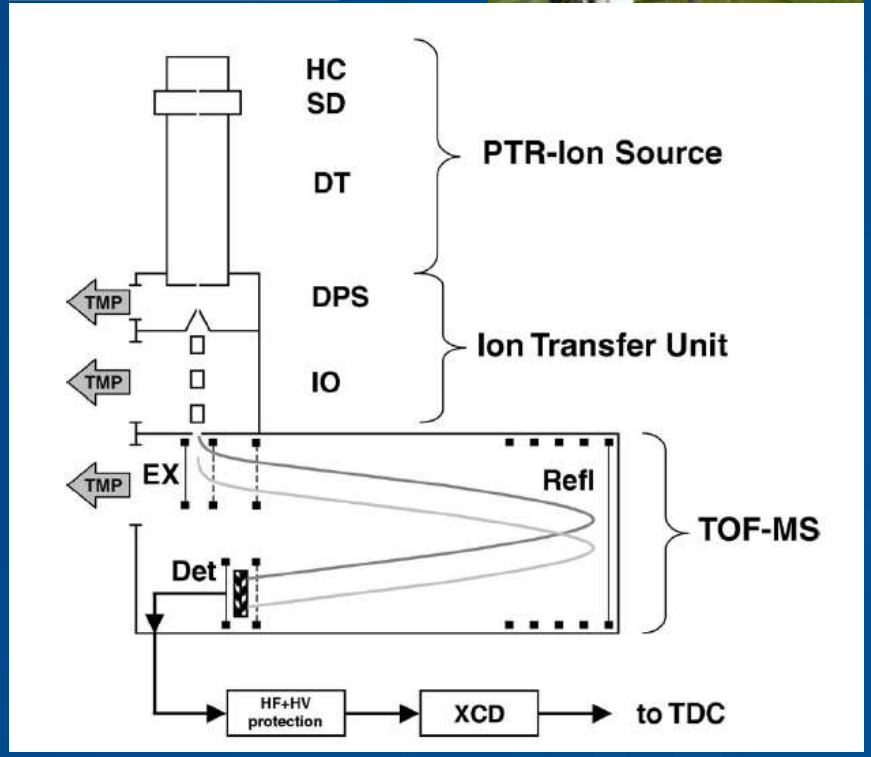
PTR-MS/TOF → VOC mixing ratios

PTR-MS



Bamberger et al. (2010)

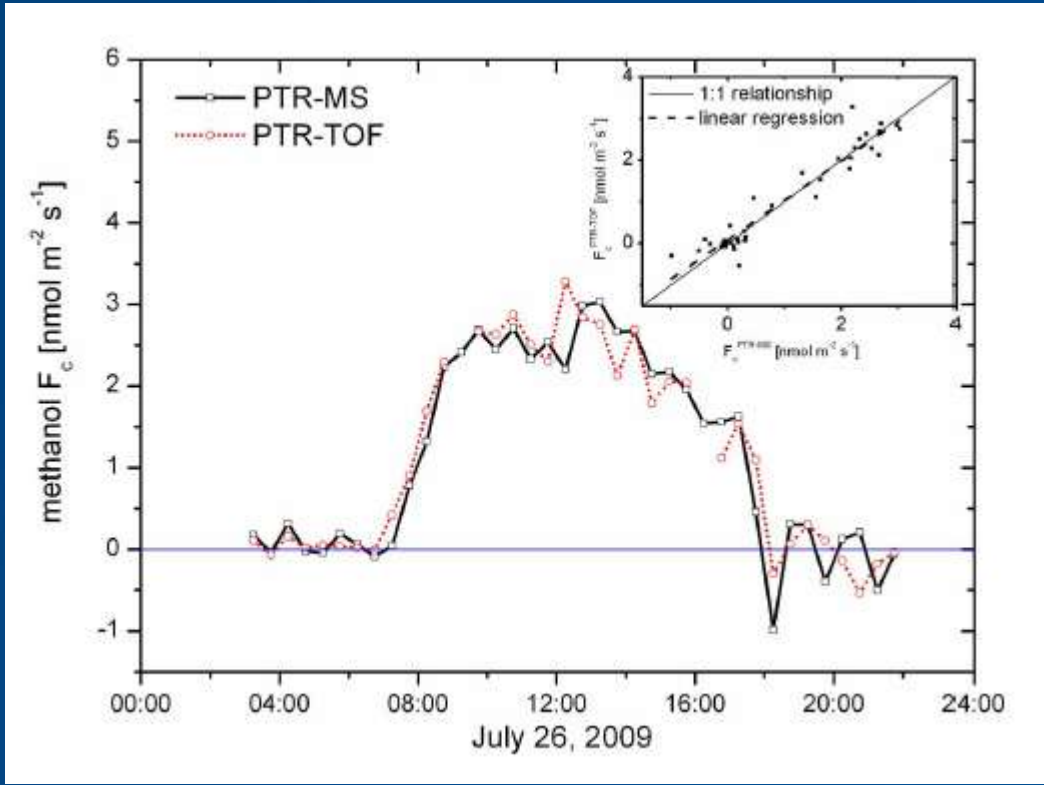
PTR-TOF



Graus et al. (2010)

Methods data series with different time resolutions

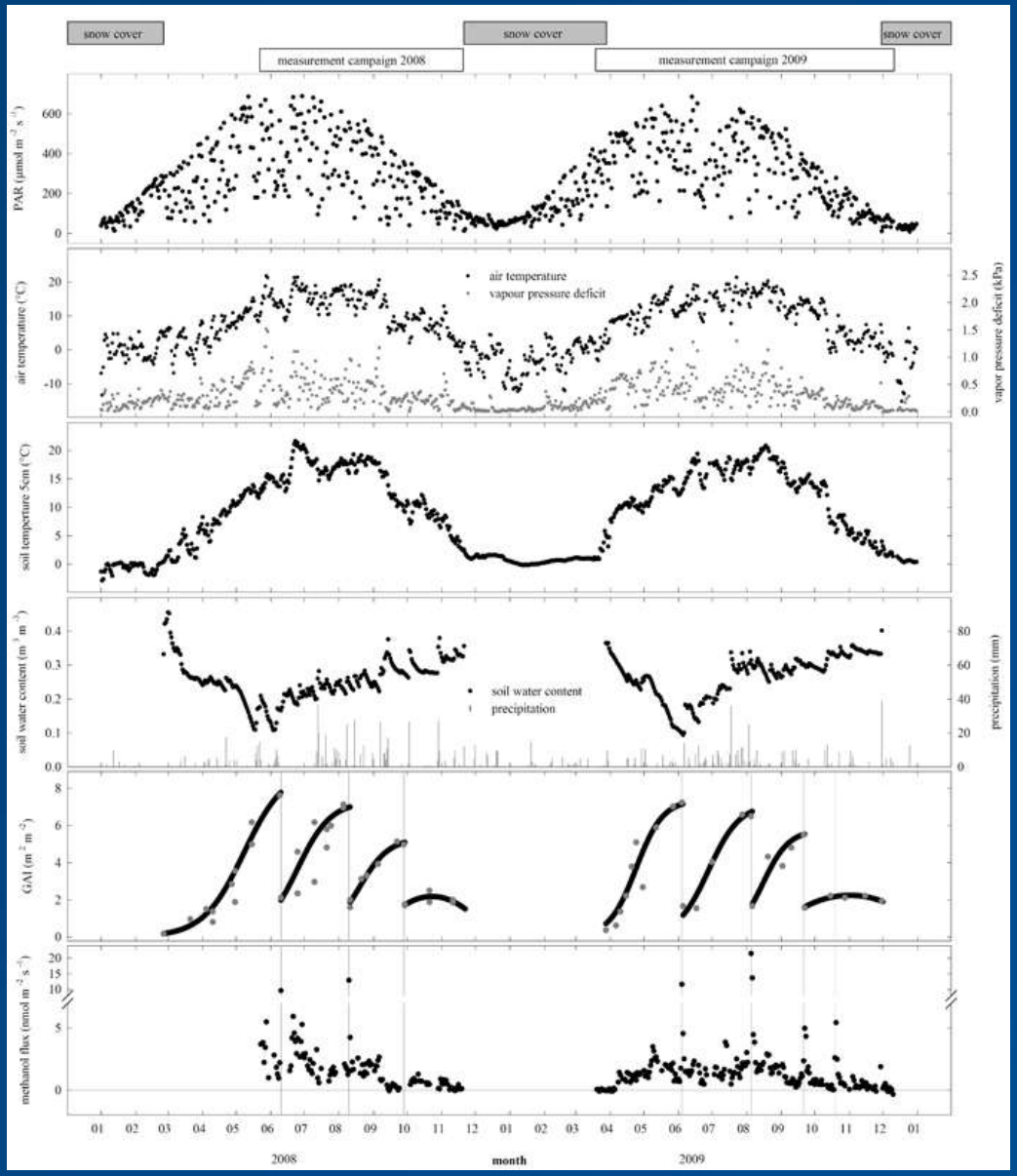
sonic anemometer	wind data	20 Hz	36000 values / half hour
PTR-MS	VOCs	0.4 Hz	720 values
PTR-TOF	VOCs	10 Hz	18000 values



Müller et al. (2010)

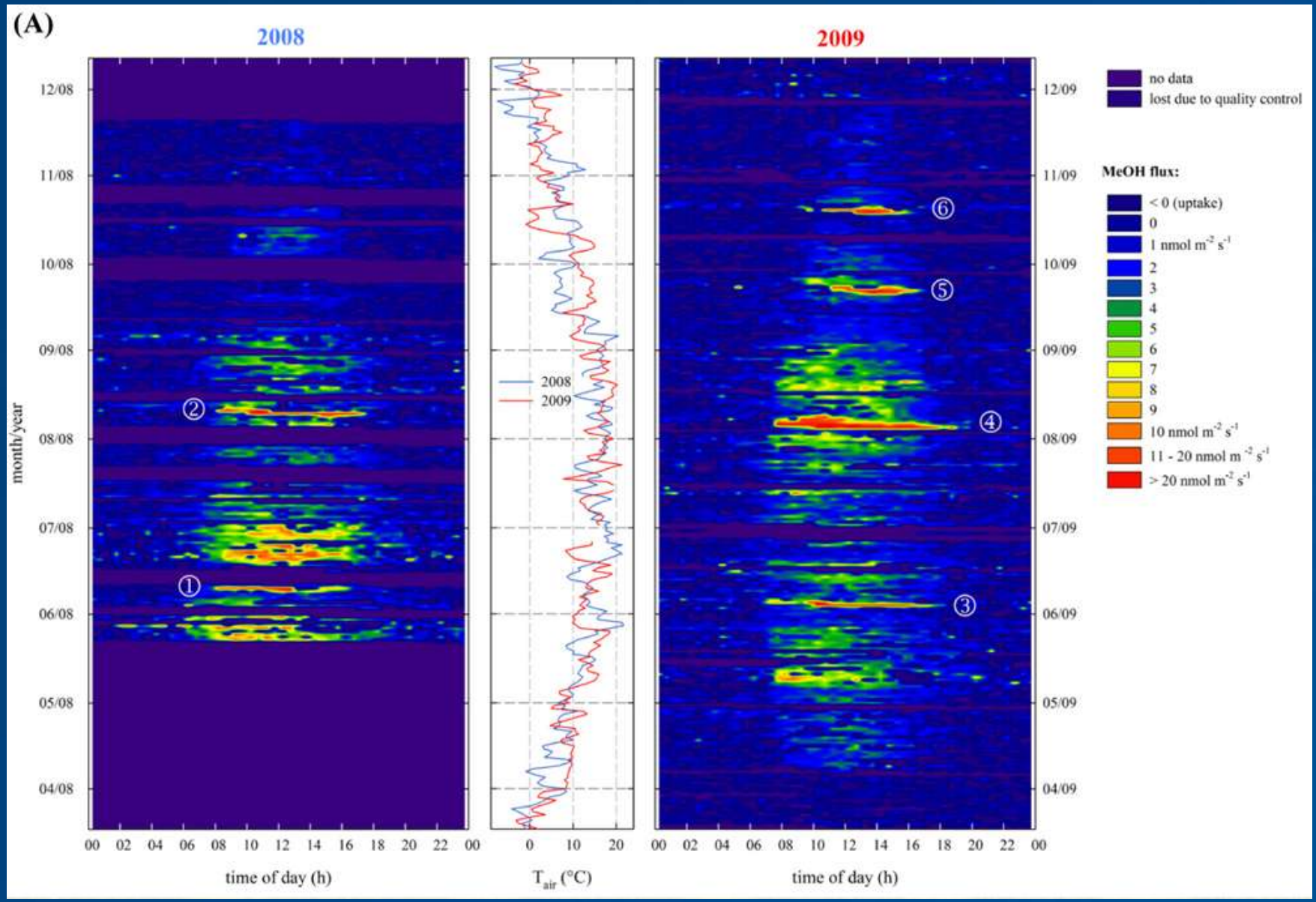
Results

Controls on Methanol Fluxes

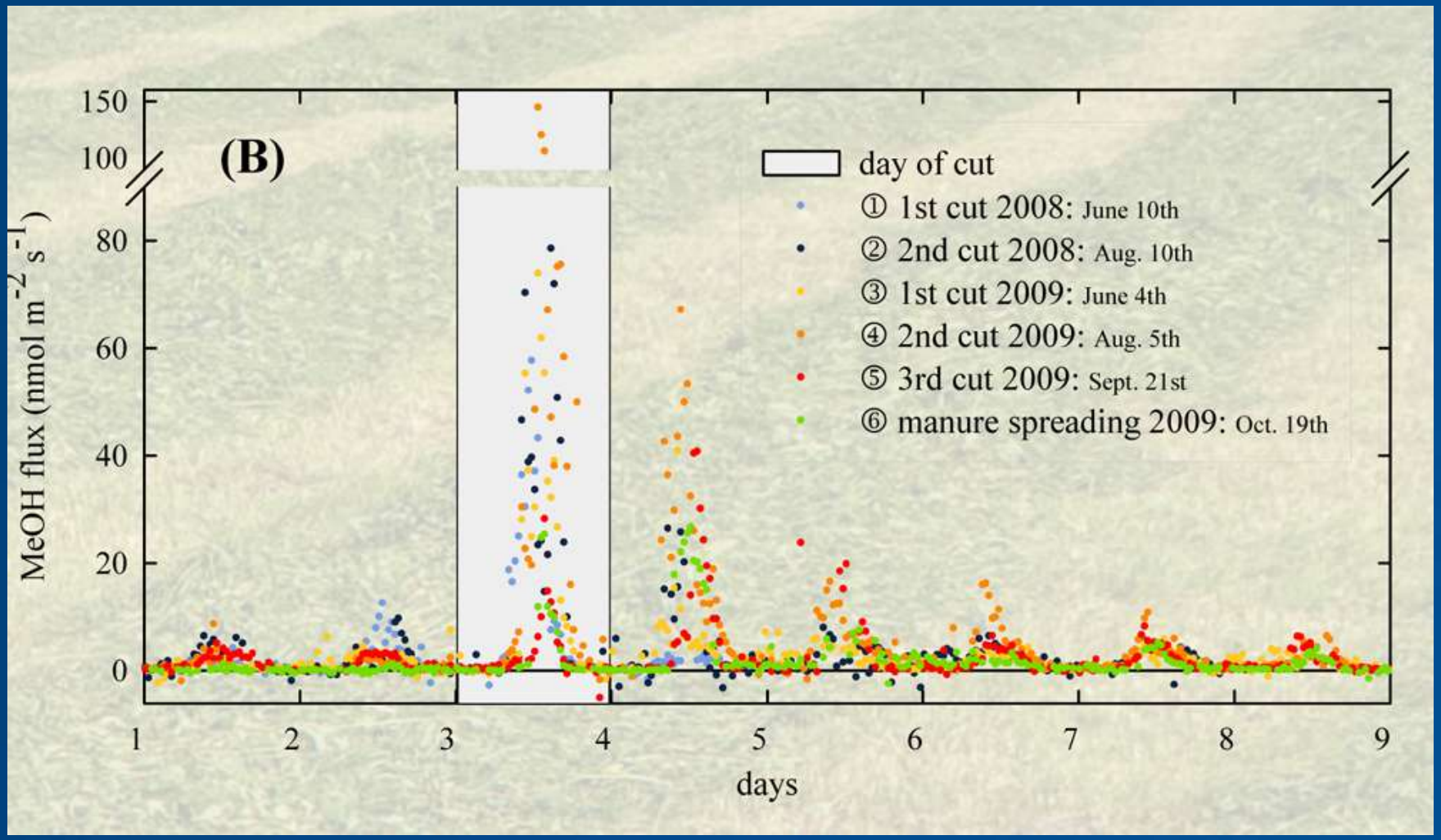


Hörtnagl et al. (2011)

Results Controls on Methanol Fluxes



Results Controls on Methanol Fluxes: **Management**



Hörtnagl et al. (2011)

Results Controls on Methanol Fluxes: **Management**

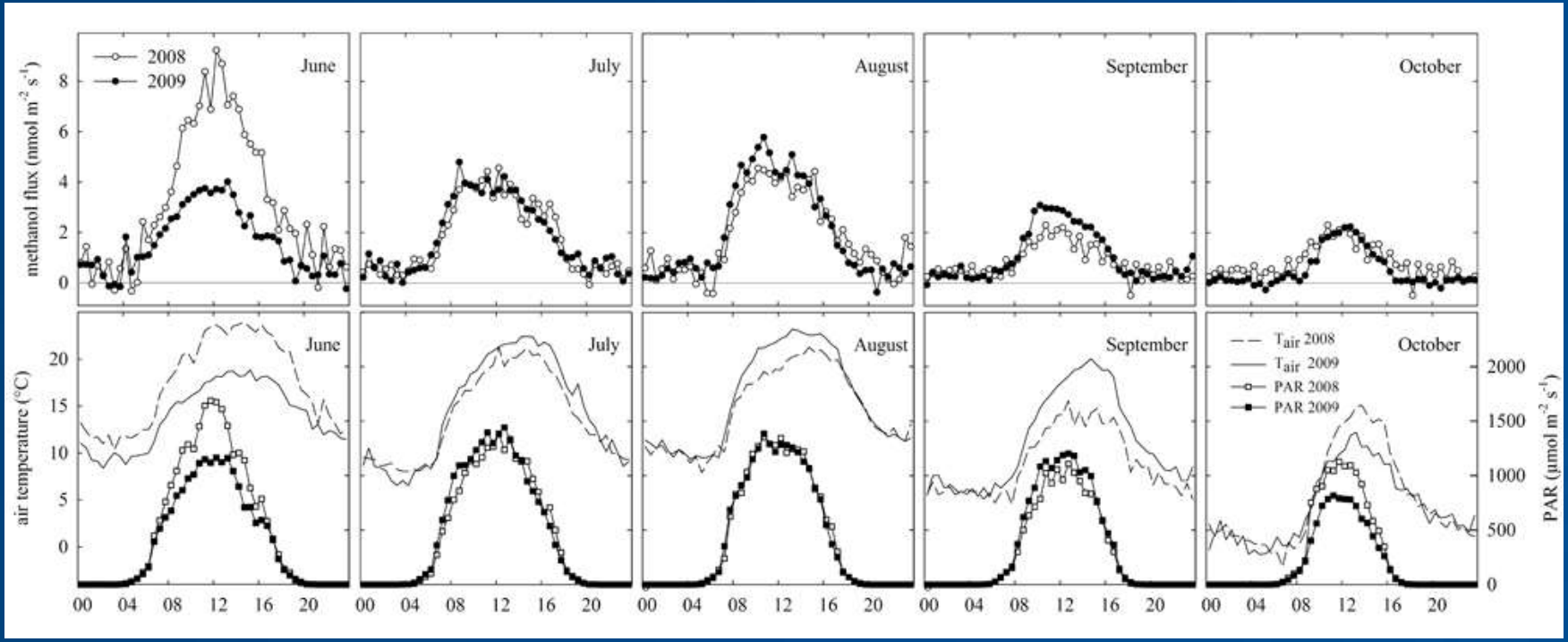
Table 1. Maximum Methanol Fluxes Before, During and After Management Events[a]

Days After Management	First Cut June 2008	Second Cut August 2008	First Cut June 2009	Second Cut August 2009	Third Cut September 2009	Fertilization October 2009
−2	4.1 (17.6)	6.4 (19.4)	3.9 (16.6)	8.6 (17.0)	5.0 (23.7)	1.2 (4.3)
−1	12.5 (23.4)	9.6 (17.4)	7.5 (18.6)	2.4 (14.2)	3.3 (21.5)	1.1 (3.8)
0	57.6 (24.5)	78.4[b] (24.6)	73.8 (18.6)	144.5[b] (22.2)	28.1[b] (21.9)	25.3 (4.9)
1	3.8[c] (18.6)	26.4[b] (26.5)	40.9 (21.3)	67.1[b] (25.4)	40.7[b] (22.0)	26.7 (9.9)
2	–	7.9 (23.9)	6.9 (20.4)	16.5 (26.4)	23.7[b] (21.9)	7.5 (14.1)
3	–	6.4 (16.9)	5.2 (17.5)	16.2 (24.2)	6.4 (20.8)	3.4 (12.9)
4	–	6.6 (23.3)	5.8 (19.9)	10.8 (21.9)	8.2 (19.8)	5.1 (10.6)
5	–		3.9 (19.3)	6.4 (20.9)	6.3 (20.8)	4.1 (9.7)

[a]Flux rates are reported in nmol m^{-2} s^{-1}. Numbers in parentheses give the maximum air temperature in °C for the respective day.
[b]Grass left on field for drying.
[c]Day not fully captured by measurements.

Hörtnagl et al. (2011)

Results Controls on Methanol Fluxes



Hörtnagl et al. (2011)

Controls on Methanol Fluxes: **Analysis**

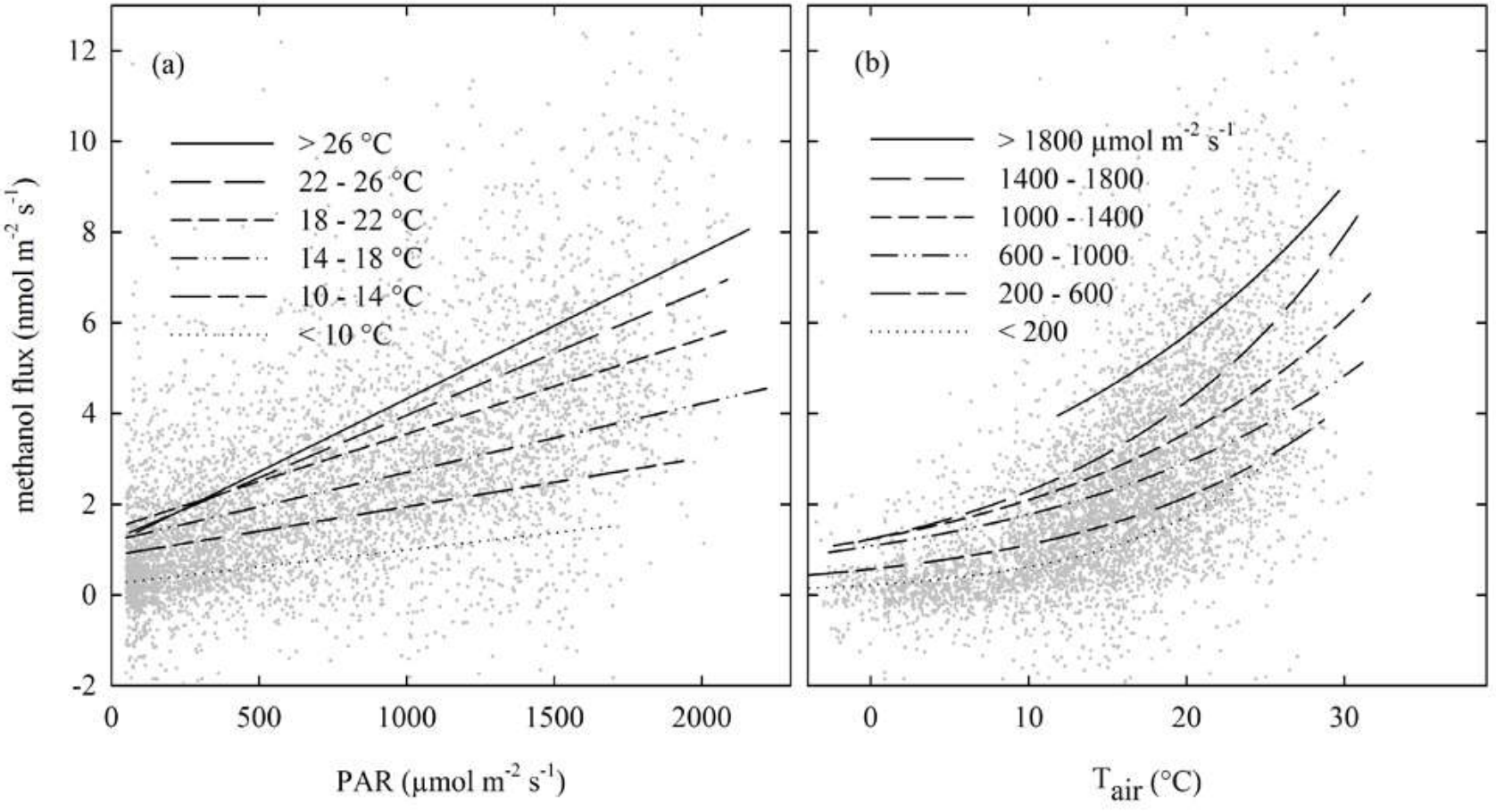
Table 2. Regression Analysis of the Methanol Flux[a]

	Simple Linear Regression						Multiple Linear Regression					
	Half-Hourly			Daily Average			Half-Hourly			Daily Average		
	N	r	p	N	r	p	Partial Correlation	Tolerance	p	Partial Correlation	Tolerance	p
NEE	5503	−0.44	***	228	−0.08	ns	–	–	–	–	–	–
Latent heat flux	5503	0.63	***	219	0.71	***	–	–	–	–	–	–
Sensible heat flux	5503	0.32	***	235	−0.01	ns	–	–	–	–	–	–
GAI	5503	–	–	321	0.39	***	–	–	–	0.10 (0.11)	0.64 (0.64)	ns (ns)
dGAI	5503	–	–	321	0.53	***	–	–	–	0.12 (0.18)	0.51 (0.51)	ns (*)
SWC	5503	−0.36	***	321	−0.60	***	−0.12	0.69 (0.59)	*** (ns)	0.00 (0.18)	0.51 (0.46)	ns (*)
f_{dif}	5503	−0.43	***	321	−0.25	***	0.10	0.32 (0.32)	*** (***)	0.20 (0.14)	0.21 (0.21)	* (ns)
g_{surf}[b]	3954	0.34	***	219	0.35	***	0.08	0.79 (0.75)	*** (***)	0.00 (0.15)	0.79 (0.73)	ns (ns)
VPD	5503	0.50	***	321	0.68	***	−0.25 (−0.17)	0.20 (0.19)	*** (***)	0.04 (0.06)	0.14 (0.14)	ns (ns)
T_{soil}[b]	5503	0.45	***	321	0.72	***	−0.06 (0.00)	0.24 (0.23)	*** (ns)	0.01 (0.11)	0.12 (0.11)	ns (ns)
T_{air}[b]	5503	0.60	***	321	0.82	***	0.32 (0.19)	0.10 (0.08)	*** (***)	0.29 (0.11)	0.07 (0.06)	*** (ns)
PAR[b]	5503	0.60	***	321	0.63	***	0.36 (0.39)	0.29 (0.29)	*** (***)	0.28 (0.16)	0.14 (0.13)	*** (*)
Methanol VMR	5503	0.41	***	321	0.80	***	−(0.30)	−(0.52)	−(***)	−(0.49)	−(0.28)	−(***)

	Half-Hourly	Daily Average
Whole model r^2	0.52 (0.56)	0.74 (0.80)

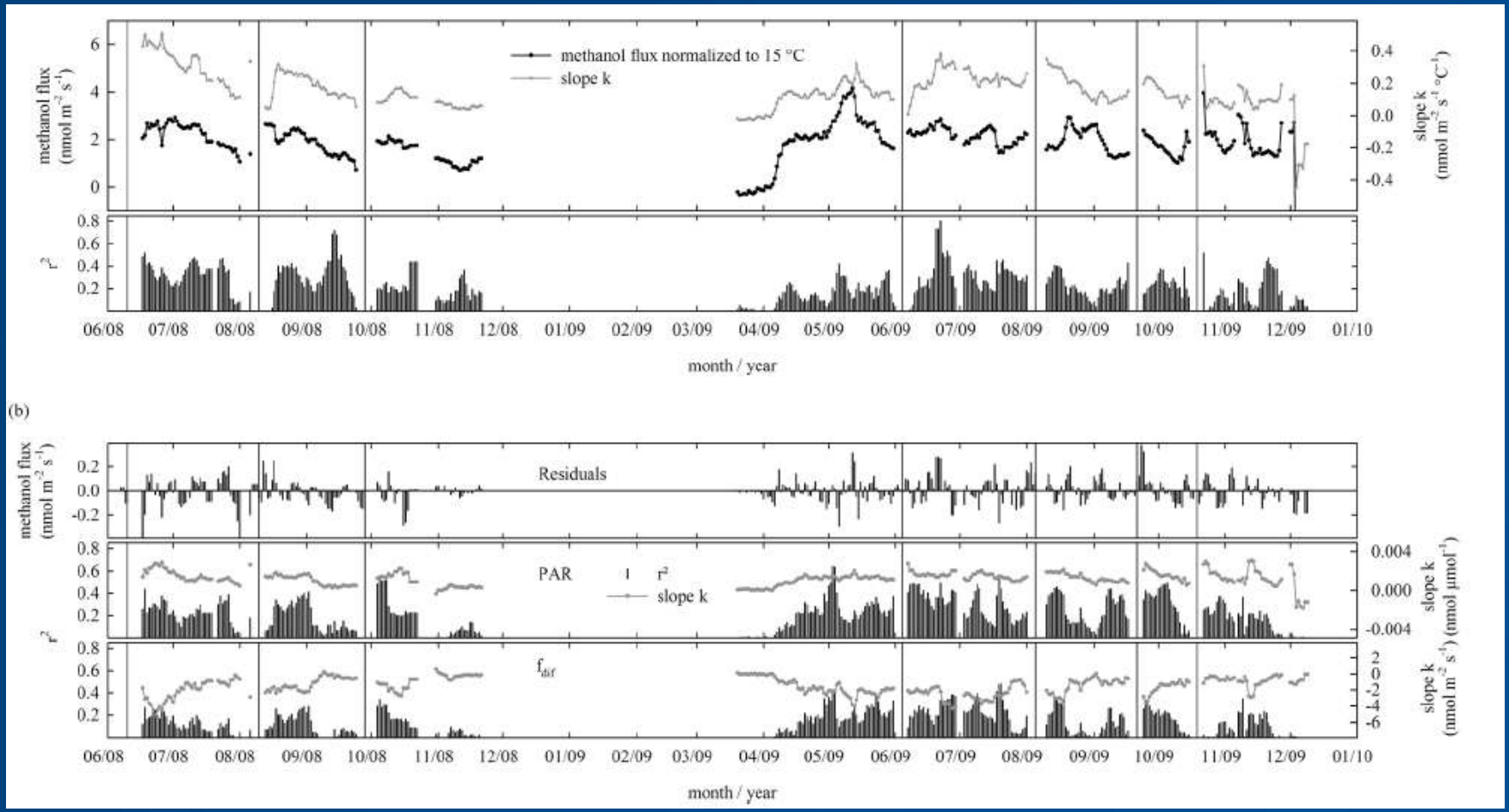
Hörtnagl et al. (2011)

Controls on Methanol Fluxes: T_{air} and PAR



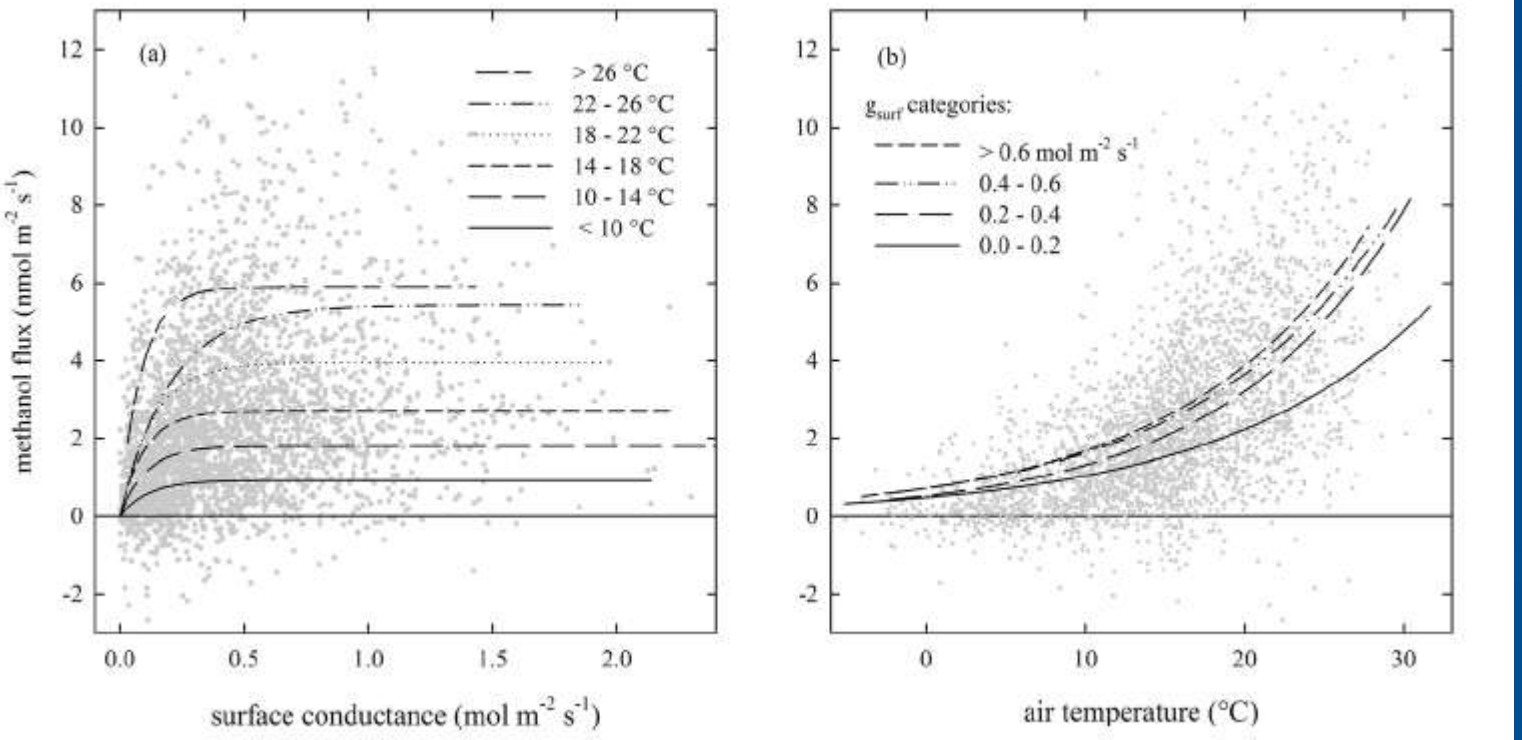
Hörtnagl et al. (2011)

Results Controls on Methanol Fluxes: T_{air} and PAR



Hörtnagl et al. (2011)

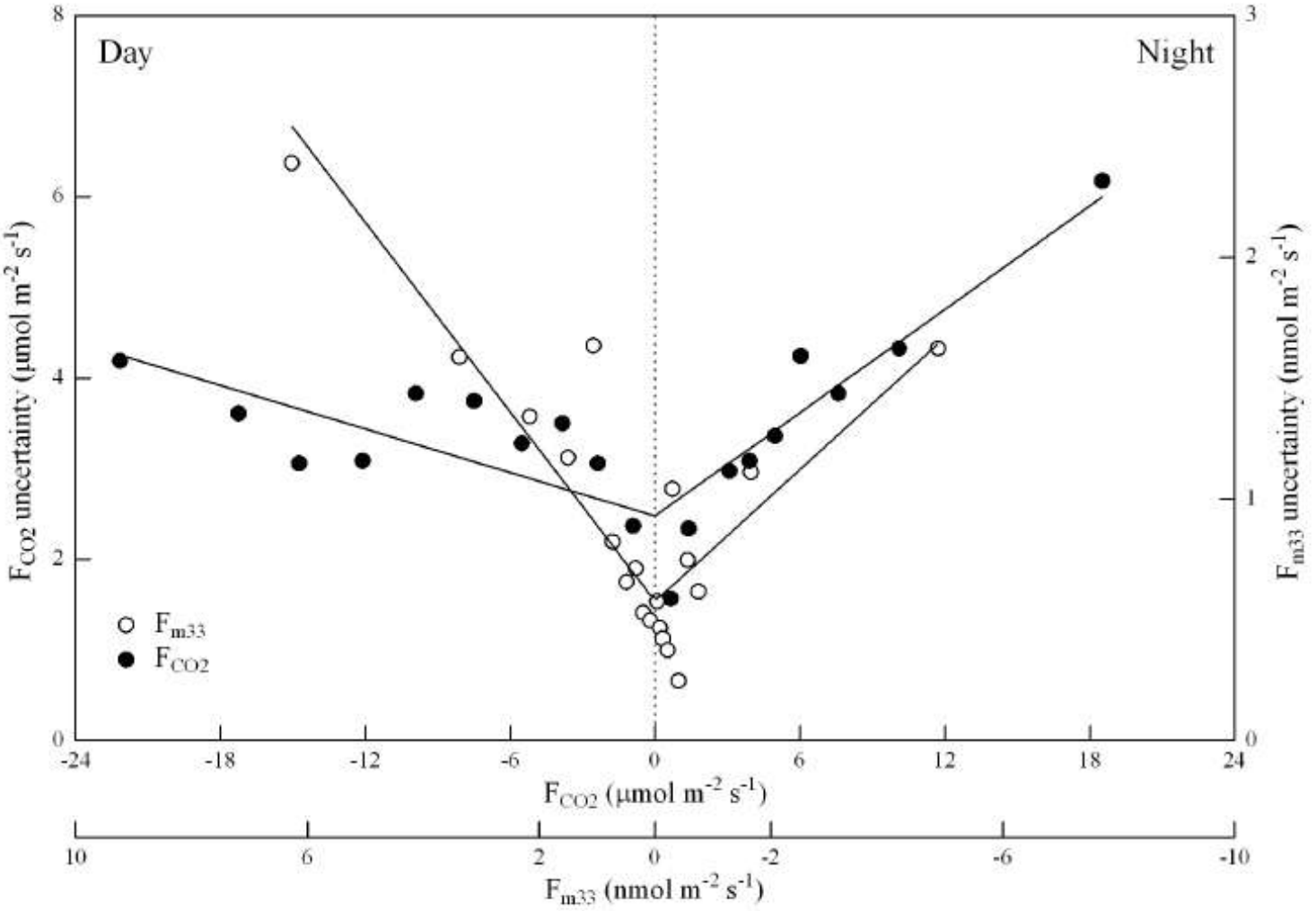
Results Controls on Methanol Fluxes: Surface Conductance?



Hörtnagl et al. (2011)

Methanol Fluxes: Uncertainties

2008



Bamberger et al. (2010)

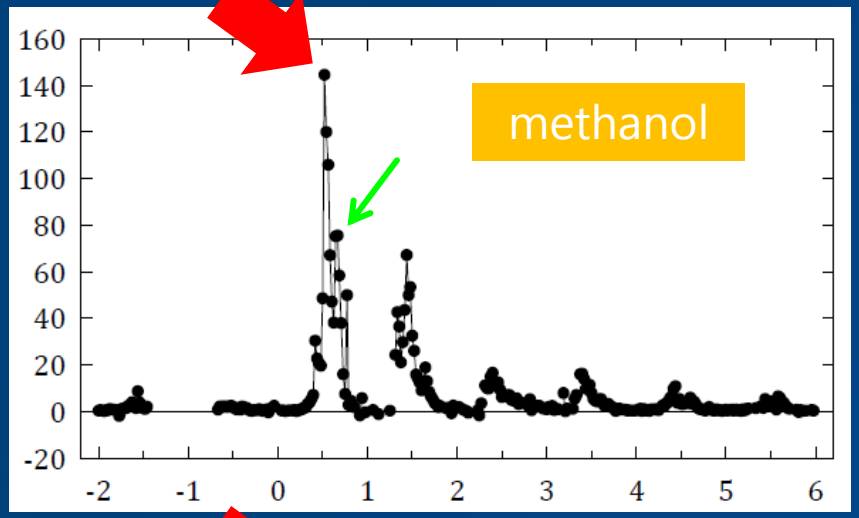
The Effect of Cutting

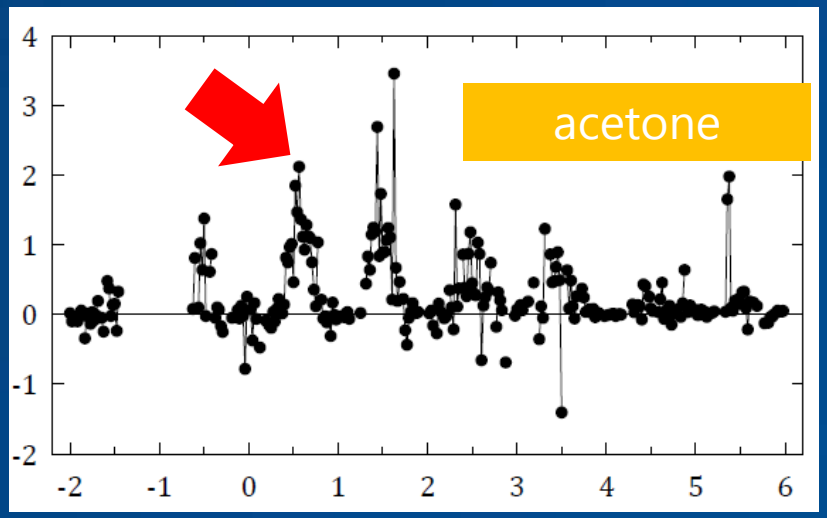
	Study site	Method	Date	Management	Days after cut	methanol	acetaldehyde	acetone	butanone	Methylbutanals, pentenals (and isoprene)	C_6 compounds
this study	agricultural grassland, intensive	EC, PTR-TOF	Aug 2009	undisturbed	−4	9.3	m	m	m	m	m [e,f,g]
				cutting	0	98.1	10.7	2.2	0.7	1.6	20.3 [e,f,g]
				grass removed	2	16.9	m	1.8	m	m	0.2 [e,f,g]
Bamberger et al. (2010)	agricultural grassland, intensive	EC, PTR-MS	Aug 2008	undisturbed	−1	9.6	1.2	m	–	m	1.4 [g]
				cutting	0	78.4	11	m	–	m	8.3 [g]
				drying	1	26.4	9.5	m	–	m	2.0 [g]
Davison et al. (2008)	agricultural grassland, extensive	EC, GC-FID-PTR-MS	Jun 2005	cutting	0	91.5	19.4	12.7	5.6	–	20.6 [h], 8.9 [i]
				drying	1	26.6	10.5	3	1.2	–	1.5 [h], 1.8 [i]
Brunner et al. (2007)	agricultural grassland, intensive	EC, PTR-MS	Jun 2004	undisturbed [a]	–	4	–	–	–	–	–
				cutting	0	30	–	–	–	–	–
				grass removed	1	6.9	–	–	–	–	–
	agricultural grassland, extensive		Jun 2004	undisturbed [a]	–	10	–	–	–	–	–
				cutting	0	110.9	–	–	–	–	–
				drying	1	20	–	–	–	–	–
				grass removed	1	19	–	–	–	–	–
Oloffson et al. (2003)	golf course	REA, GC/MS	Sep 2000	cutting	0	–	–	–	–	–	3.6 [l], 1.4 [k], 0.0 [i]
				hay removed	1	–	–	–	–	–	0.005 [l], 0.0 [k], 0.0 [i]
			Jul 2001	cutting	0	–	–	–	–	–	2.7 [l], 0.2 [k], 4.1 [i]
				hay removed	1	–	–	–	–	–	0.1 [l], 0.0 [k], 0.0 [i]
Warneke et al. (2002)	alfalfa field	EC, PTR-MS	Aug 2000	undisturbed	−1	32.9	0.4	0.2	–	–	m [i,j,k,l]
				cutting	0	69.4	2.9	1.2	–	–	m [i,j,k,l]
				drying [b]	1	44.2	m	m	–	–	m [i,j,k,l]
Karl et al. (2001c)	agricultural grassland	EC, PTR-MS	Aug 1999	drying	1	17.3	9.5	2.4	–	2.9	m [g], 0.7 [h]
		gradient	Aug 1999	cutting	0	72.8	18.9	7.2	m	1.2	m [g], 1 [h]
		gradient		drying	1	17.3	6.3	1.6	0.1	1.6	m [g], 1 [h]
Karl et al. (2001a)	agricultural grassland	EC, PTR-MS	Mai 2000	cutting	0	309	34.1	0.3	0.6	2.9 [c]	m [e,f,g]
				drying	1	106.1	10	m	m	m [c]	m [d,e,f,g]
		gradient	Mai 2000	cutting	0	436.9	20.4	1.2	1.1	5.9 [c]	m [e,f,g]

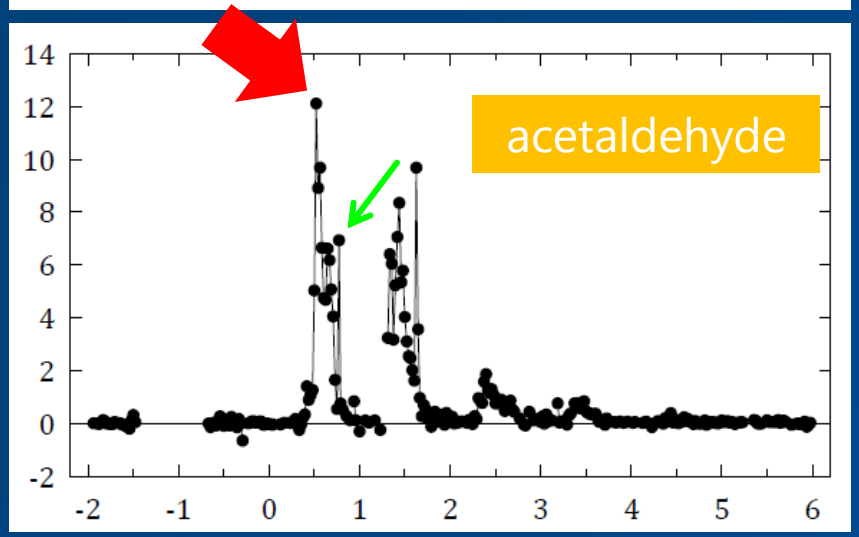
cutting: during the day of cutting with grass drying on the field;
drying: at least one day after cut with grass drying on the field;
– flux not measured;
m flux measured, but not reported;
[a] during mature phase, [b] small patch was cut in the morning, [c] no isoprene, [d] fluxes generally lower by a factor of 3 than on day of cut,
[e] hexanal, [f] hexenols, [g] hexenals, [h] hexenols plus hexanal, [i] (Z)-3-hexenal, [j] (E)-2-hexenal, [k] (Z)-3-hexenol, [l] (Z)-3-hexenyl acetate

Ruuskanen et al. (2011)

Results The Effect of Cutting August 2009







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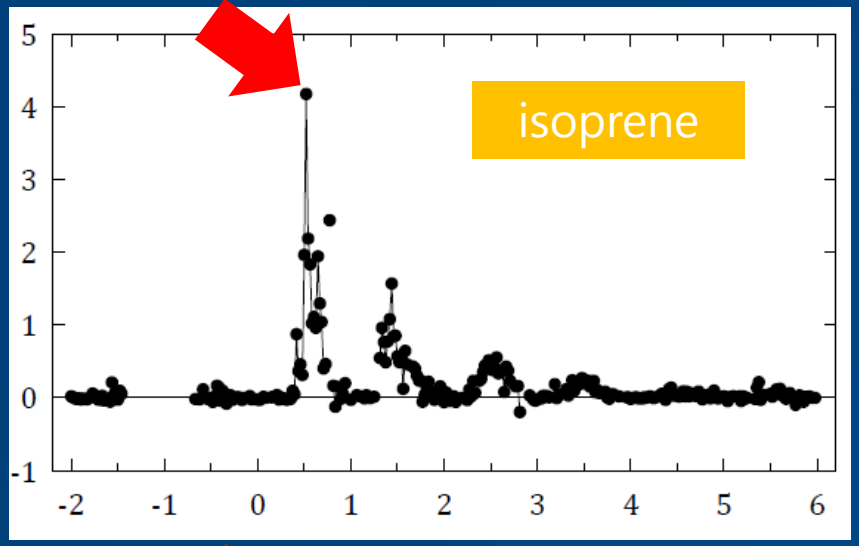
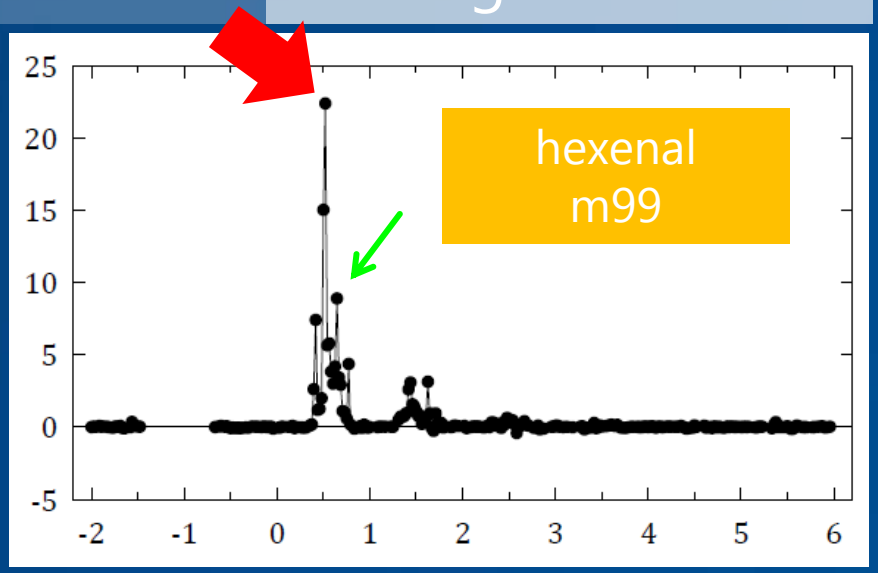
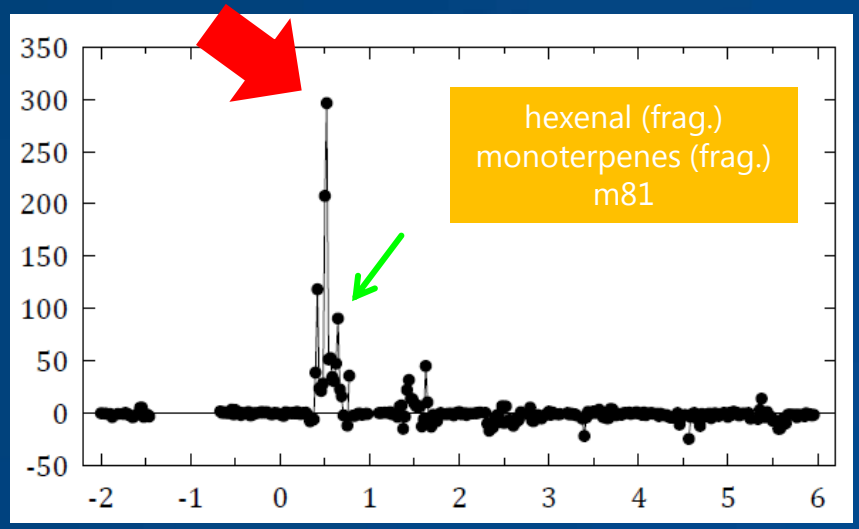
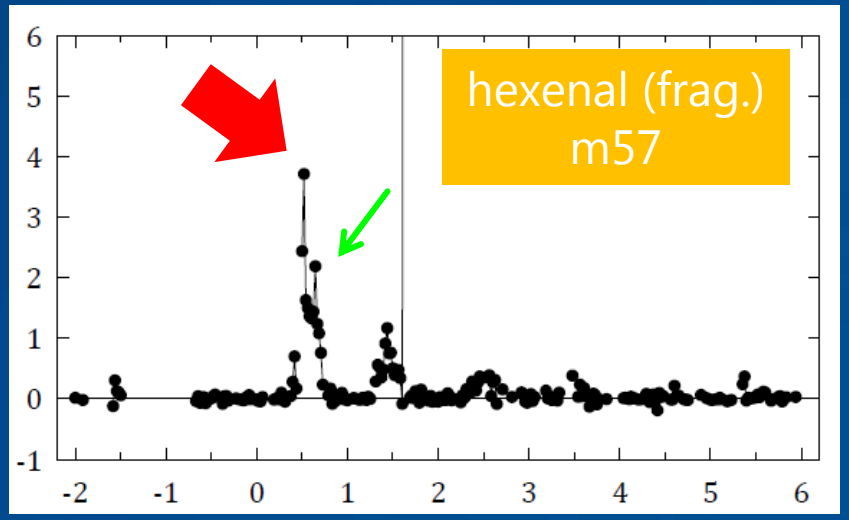
The Effect of Cutting

August 2009



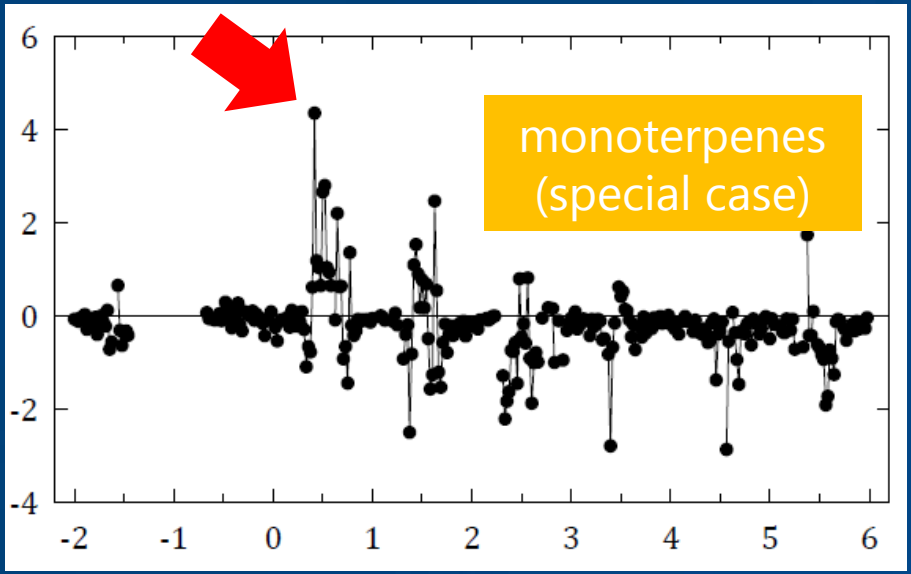






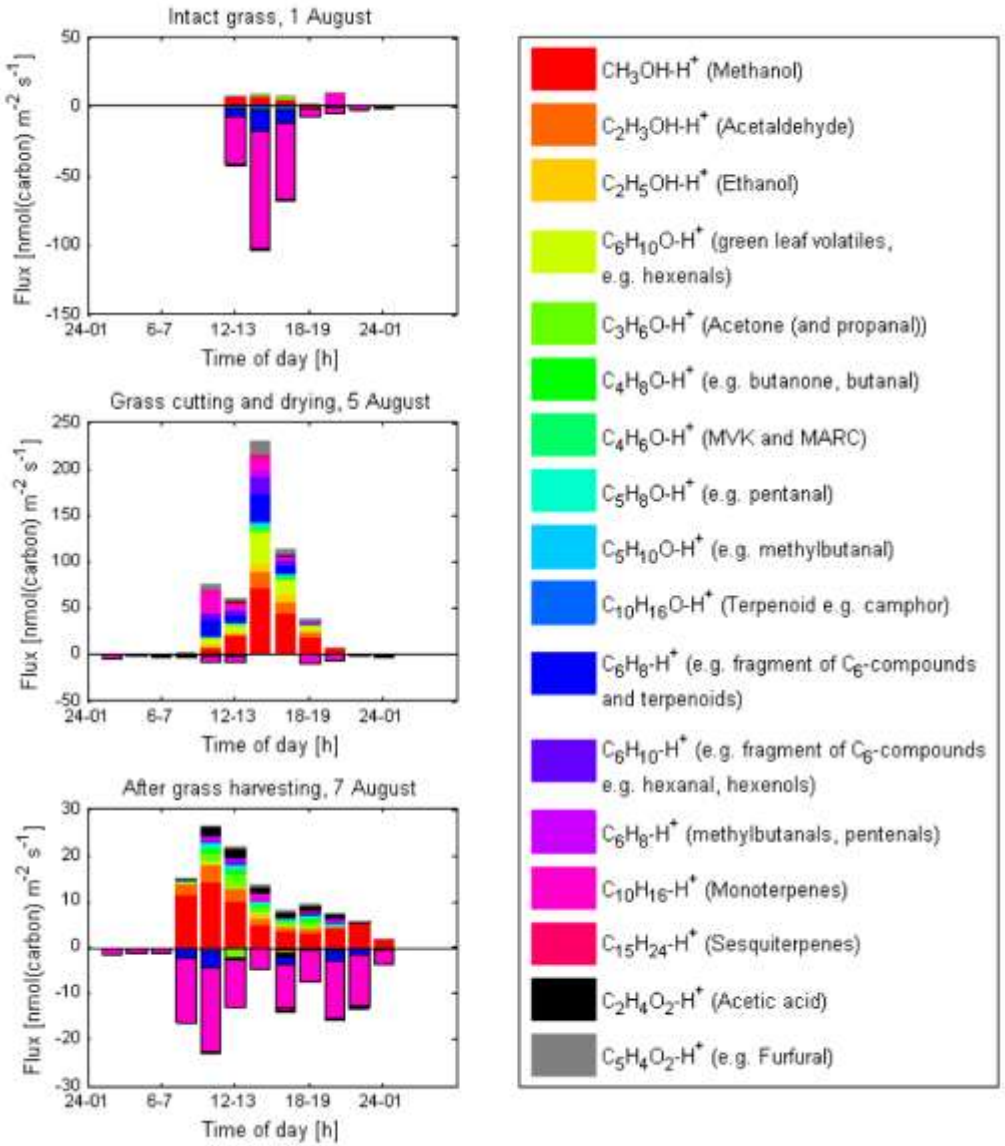
The Effect of Cutting

August 2009



The Effect of Cutting

2009



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The Effect of Cutting

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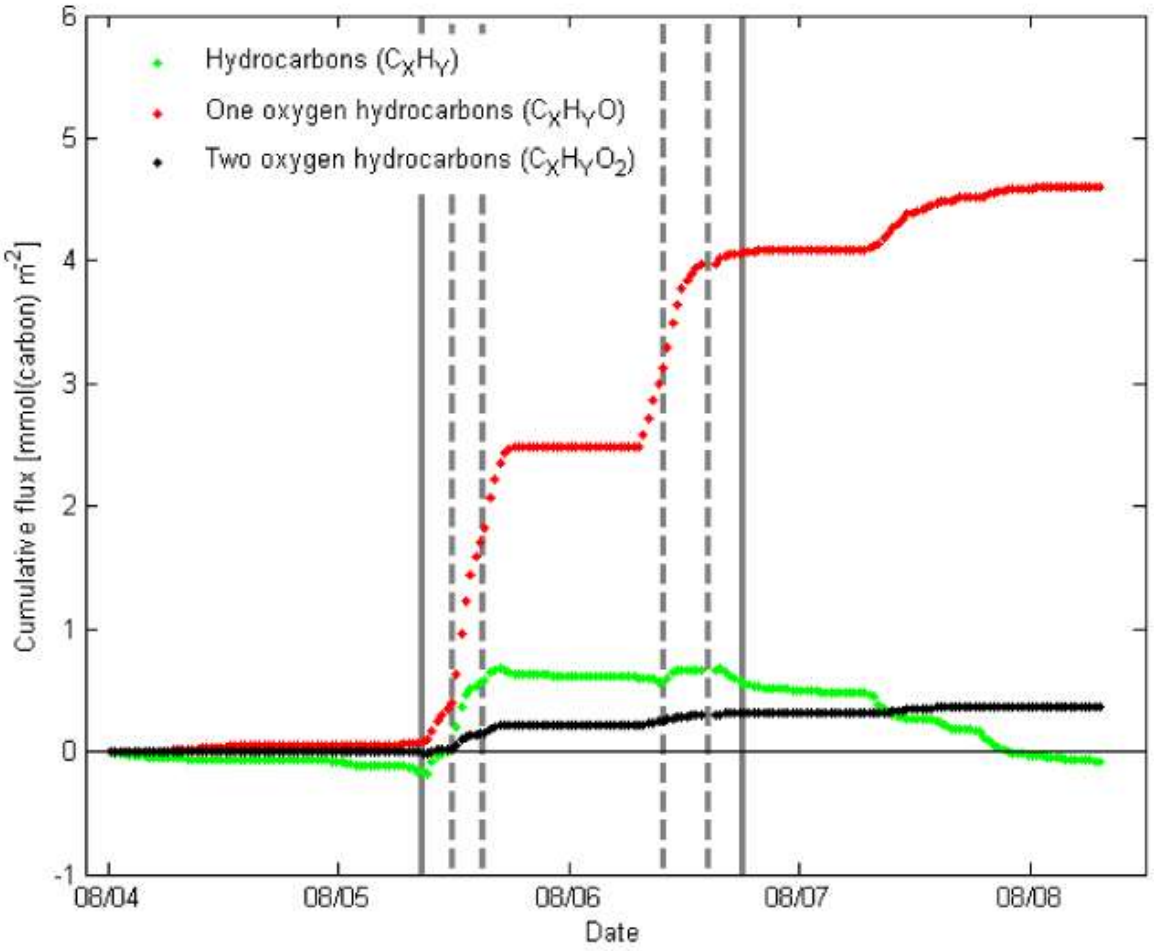

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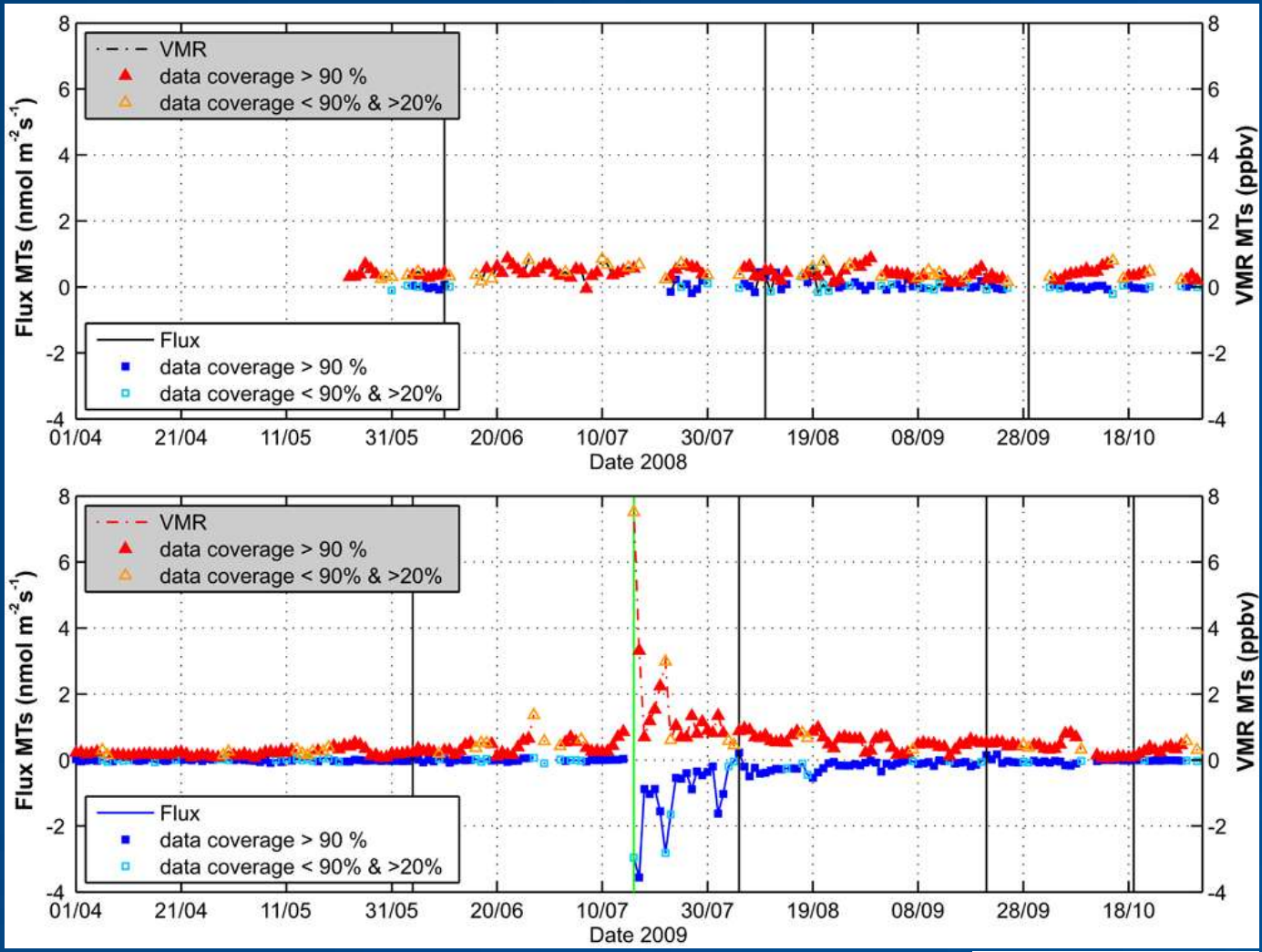
Results

Deposition Fluxes of Terpenes

2009



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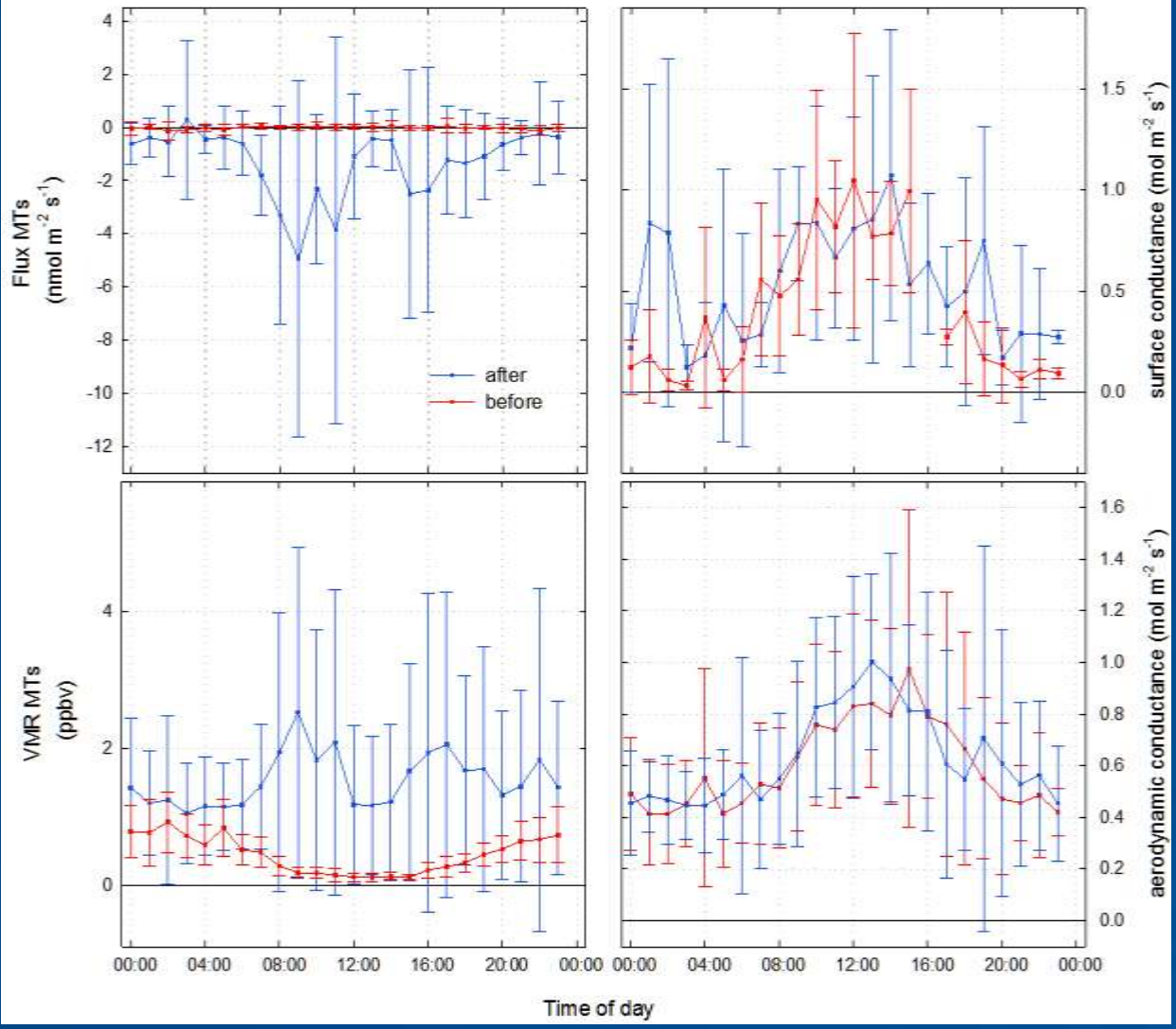
Deposition Fluxes of Terpenes

2009



Bamberger et al. (2011)

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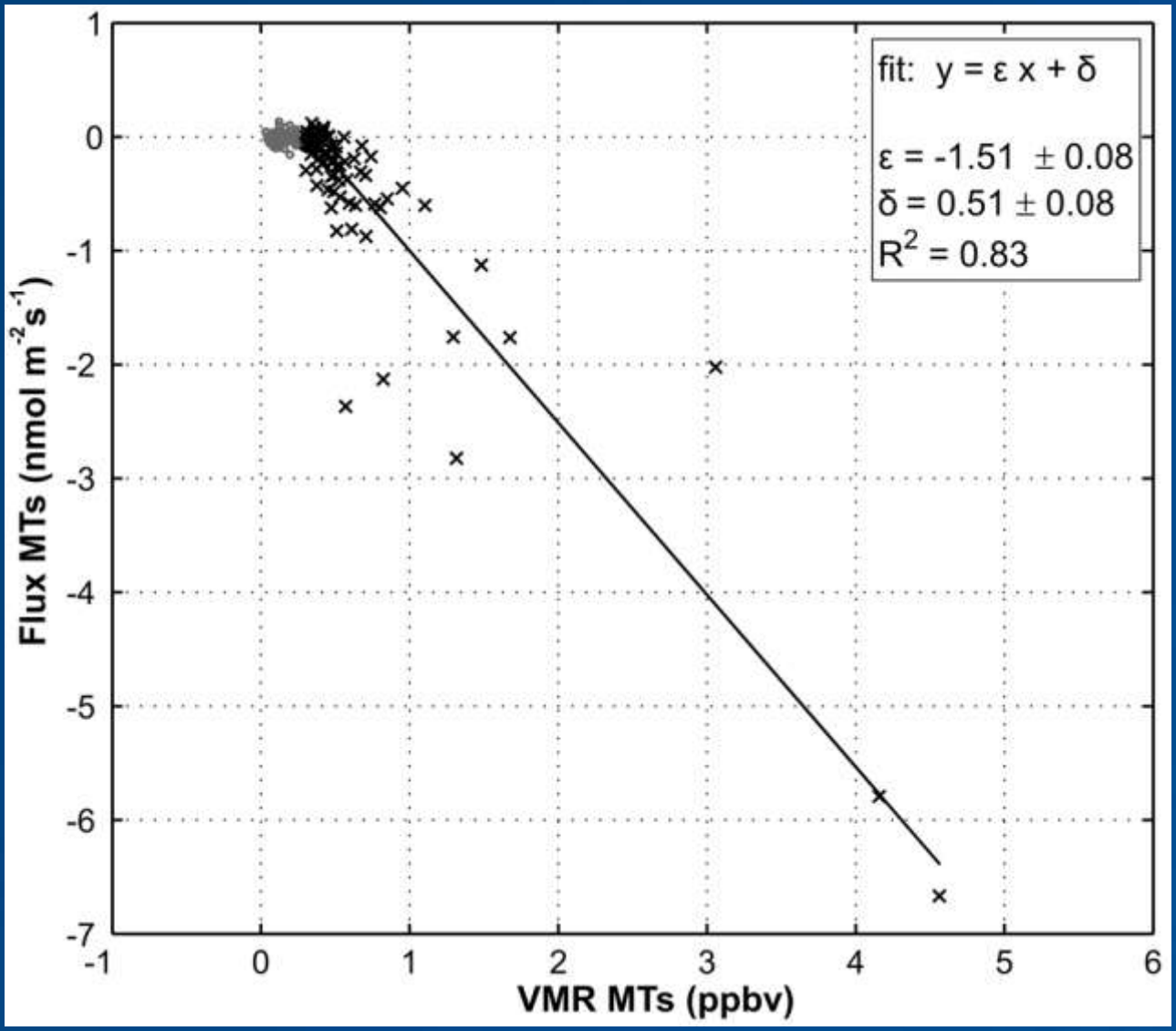

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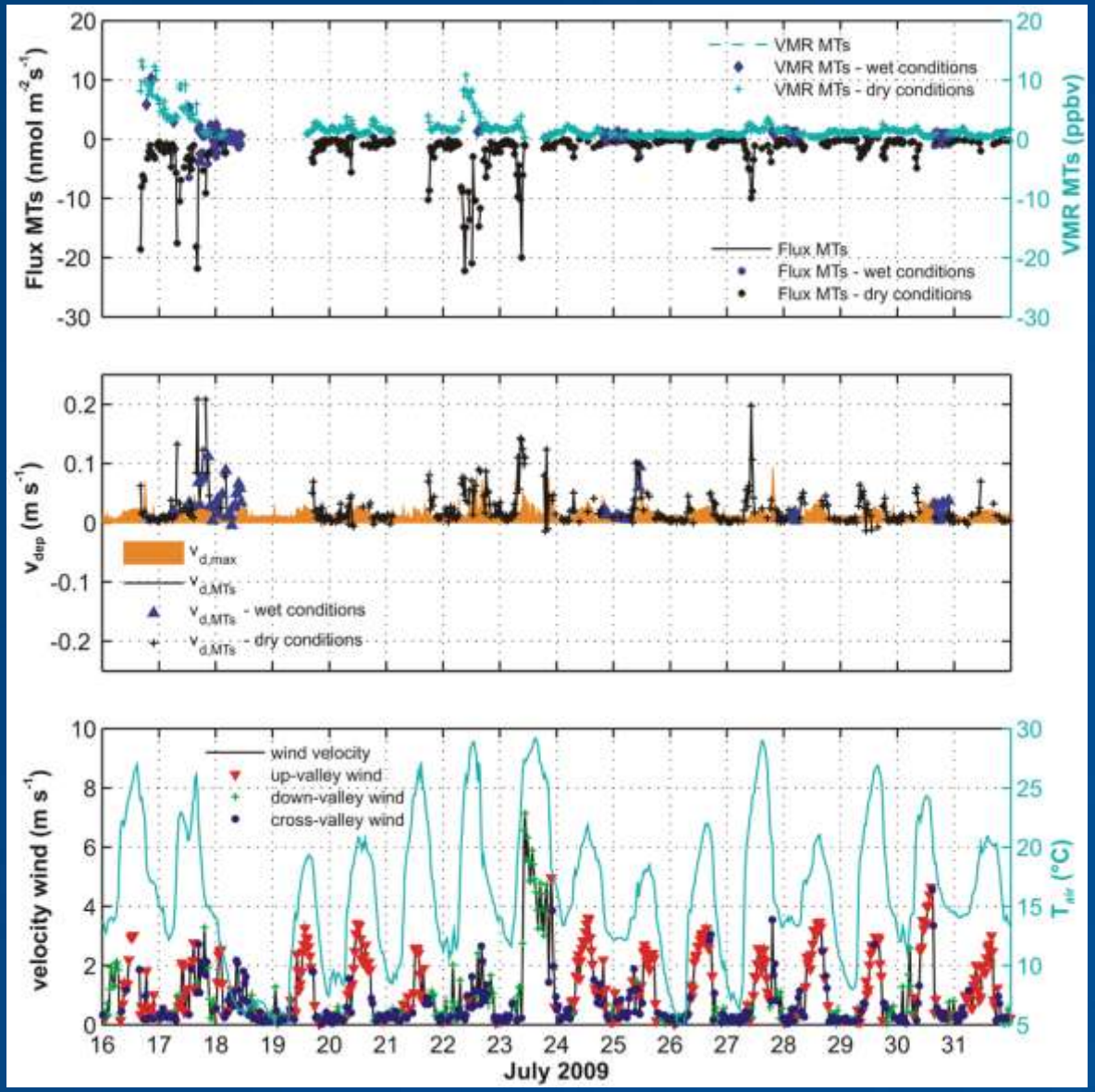
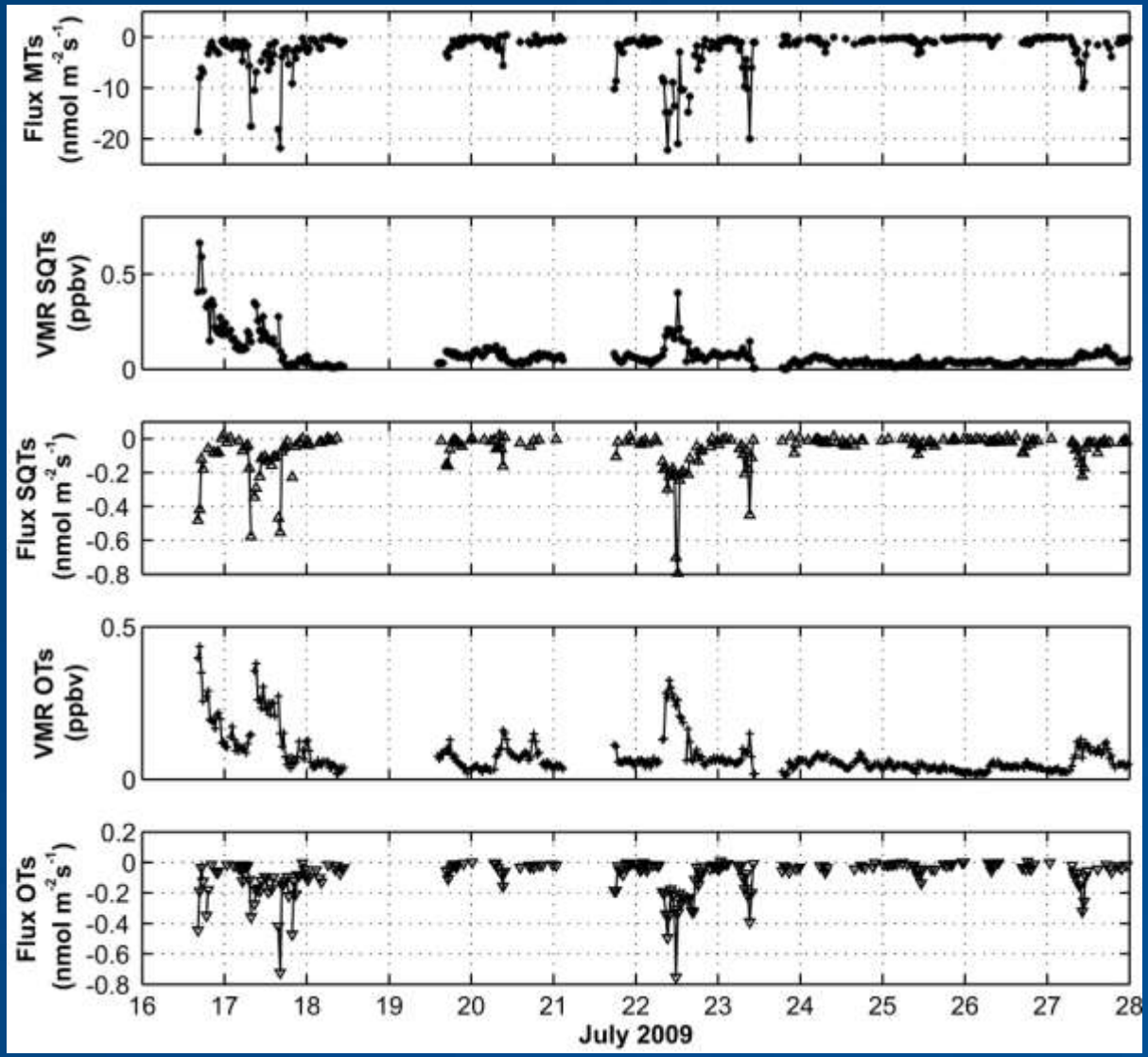


Bamberger et al. (2011)

Results

Deposition Fluxes of Terpenes

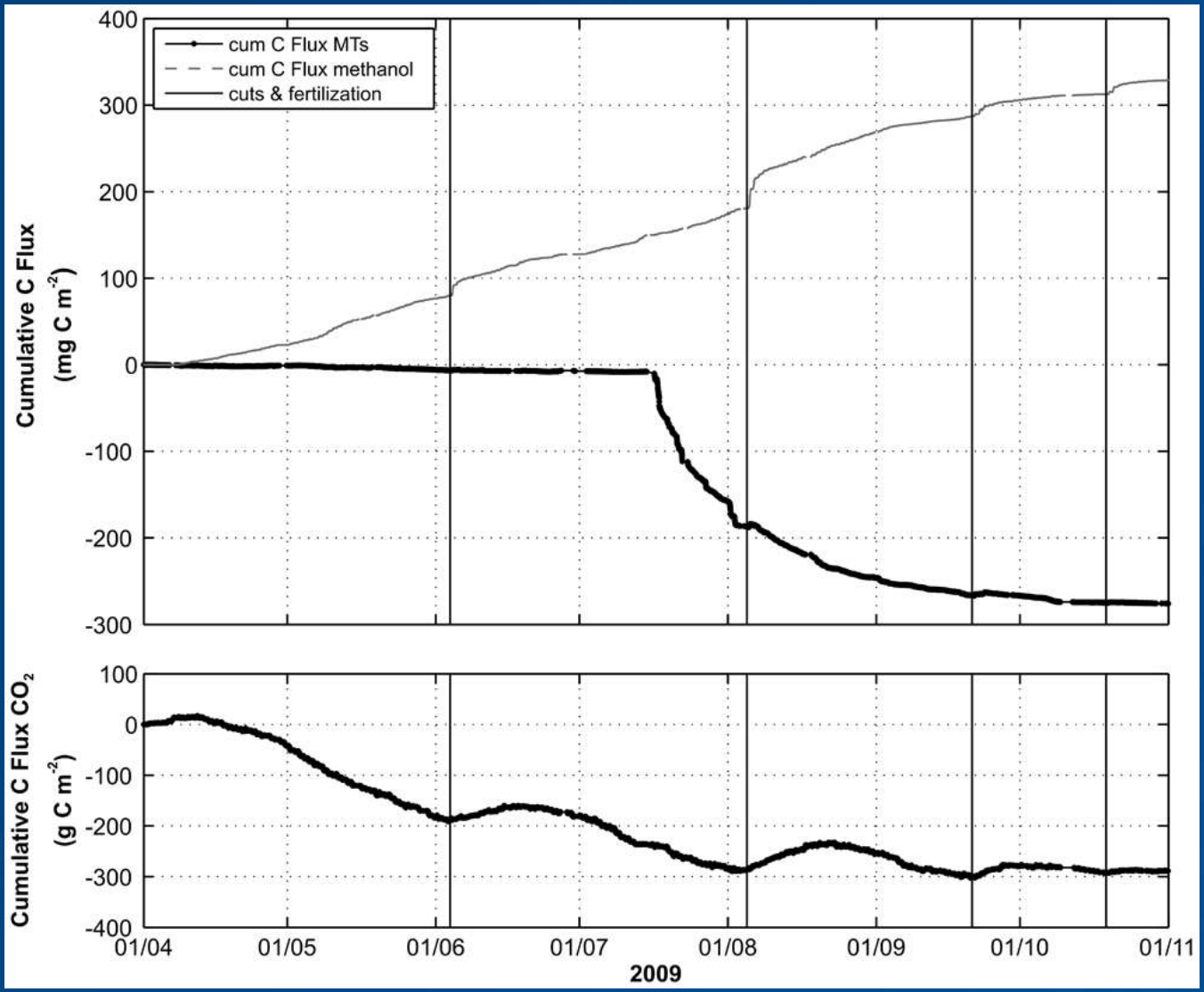
2009



Bamberger et al. (2011)

Deposition Fluxes of Terpenes

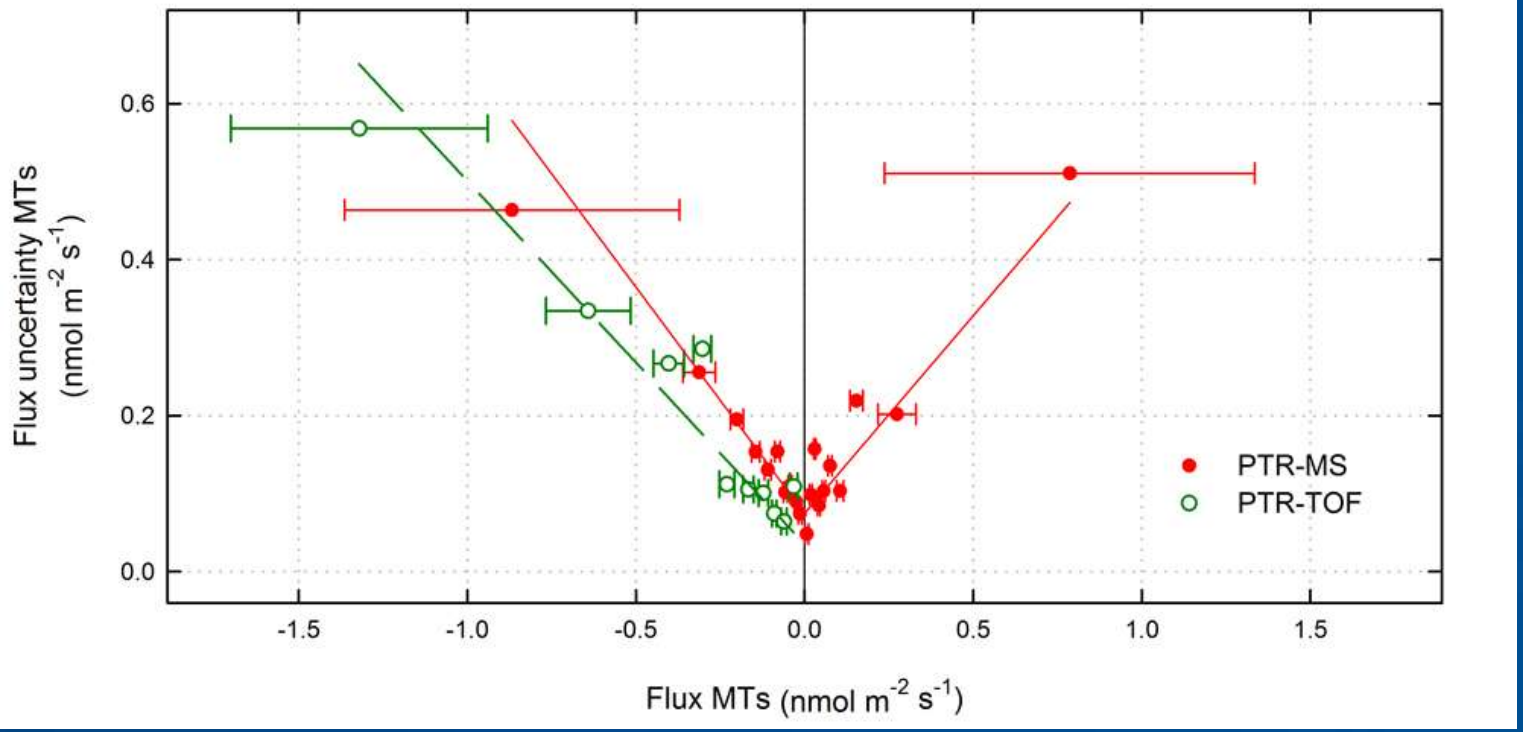
2009



Bamberger et al. (2011)

Deposition Fluxes of Terpenes

2009

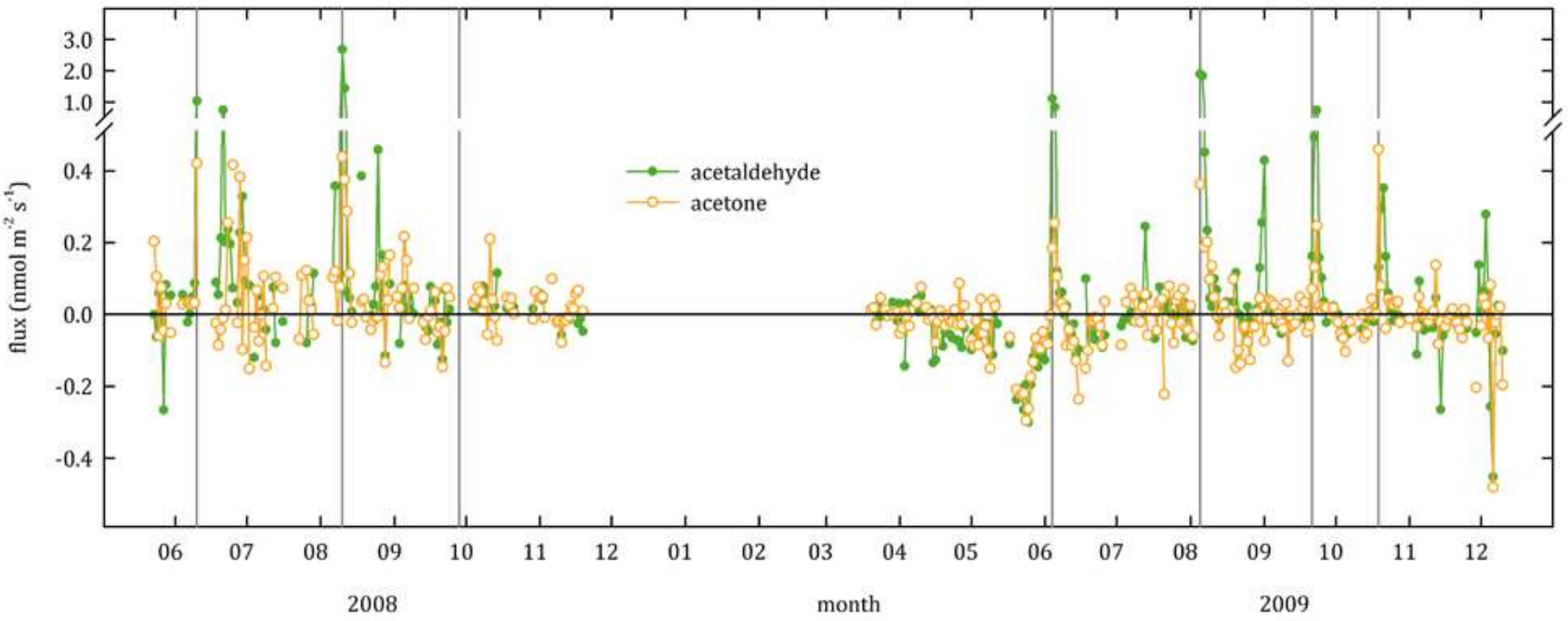


Bamberger et al. (2011)

Results

Acetone and Acetaldehyde Fluxes

2008 / 2009

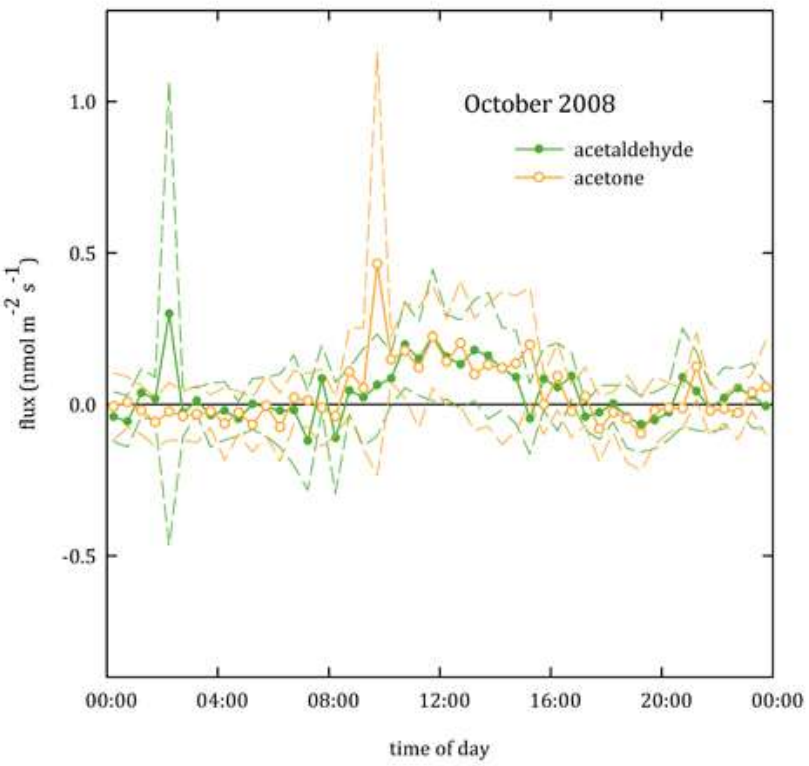


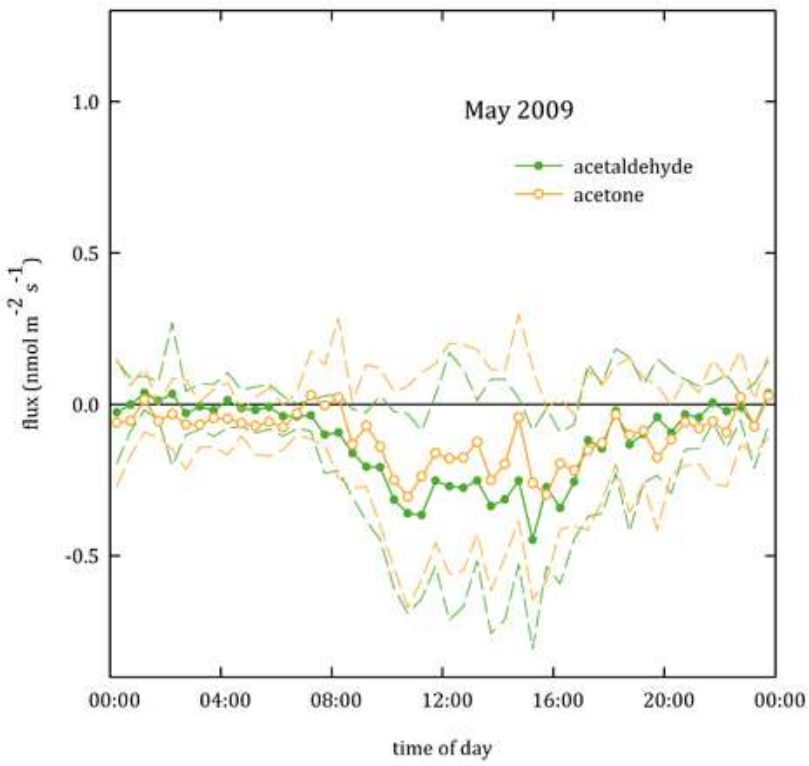
Hörtnagl et al., *in preparation*

Results

Acetone and Acetaldehyde Fluxes

2008 / 2009



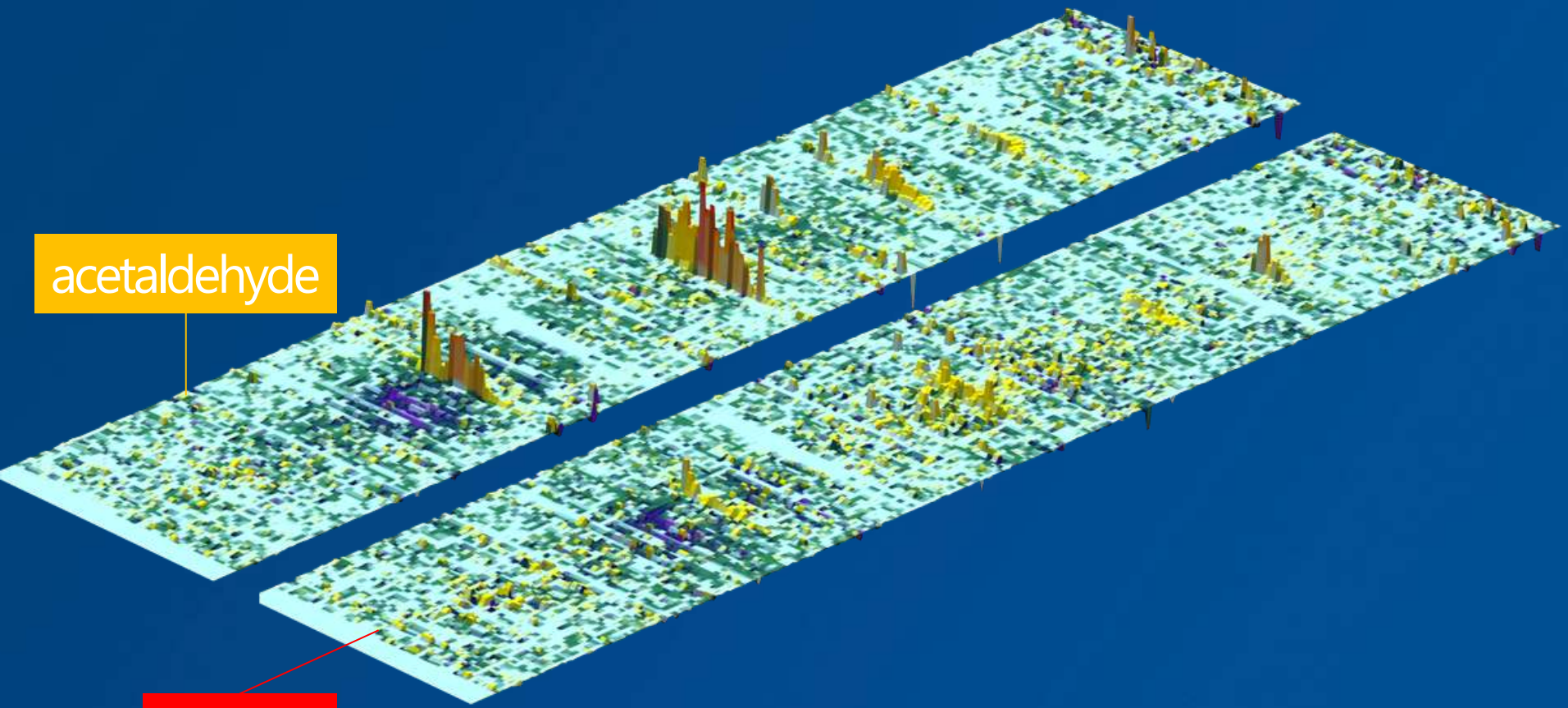


Hörtnagl et al., *in preparation*

Results

Acetone and Acetaldehyde Fluxes

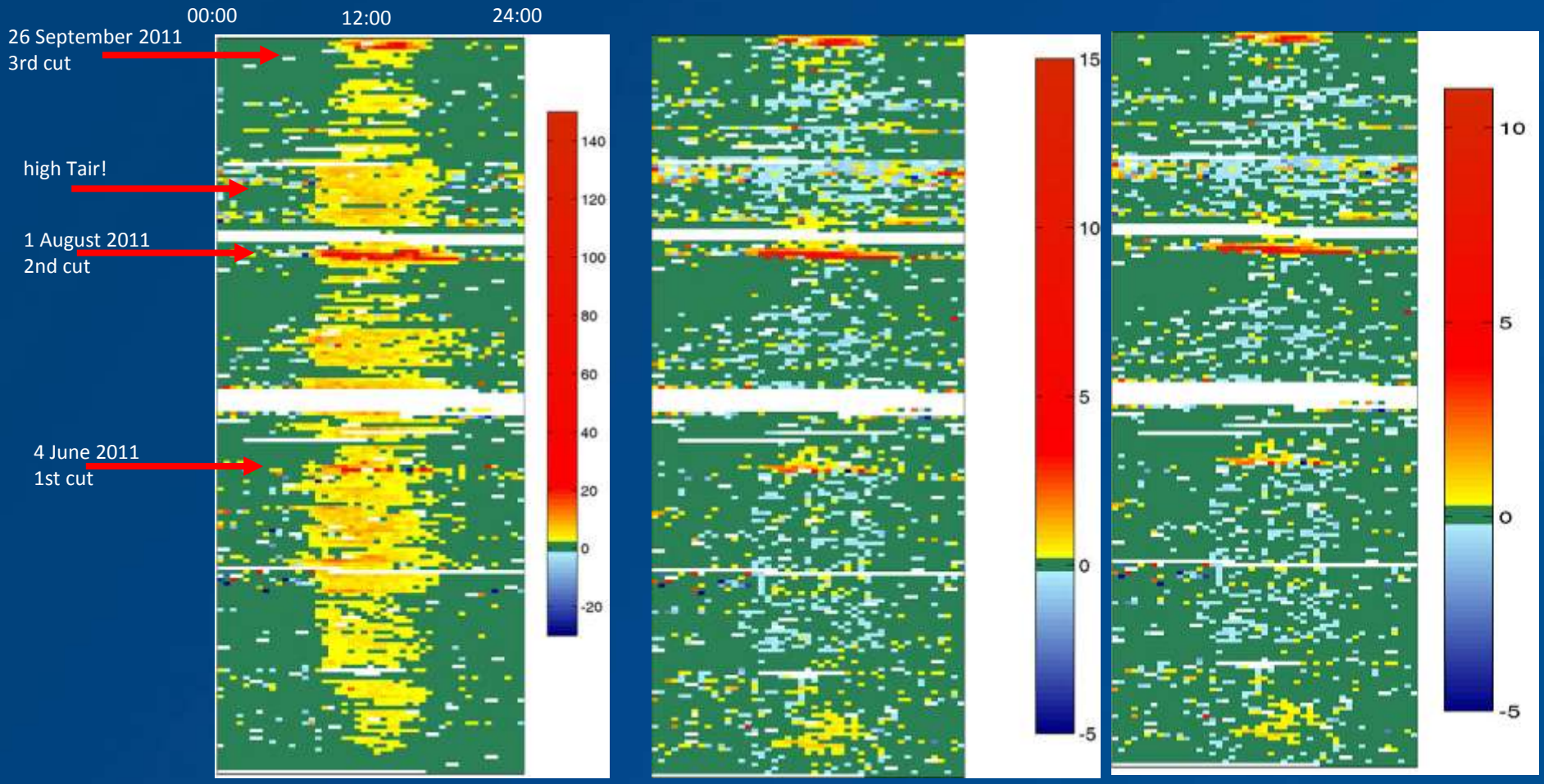
2009



Hörtnagl et al., *in preparation*

Outlook

2011



methanol

acetaldehyde

acetone

Thank you for your time!

Literature

Hörtnagl, L., Bamberger I., Graus M., Ruuskanen T. M., Schnitzhofer R., Müller M., Hansel A., and Wohlfahrt G. (2011), Biotic, abiotic, and management controls on methanol exchange above a temperate mountain grassland, J. Geophys. Res., 116, G03021, doi:10.1029/2011JG001641.

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