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A bottom-up perspective of the net land methanol flux: synthesis of global eddy covariance flux measurements

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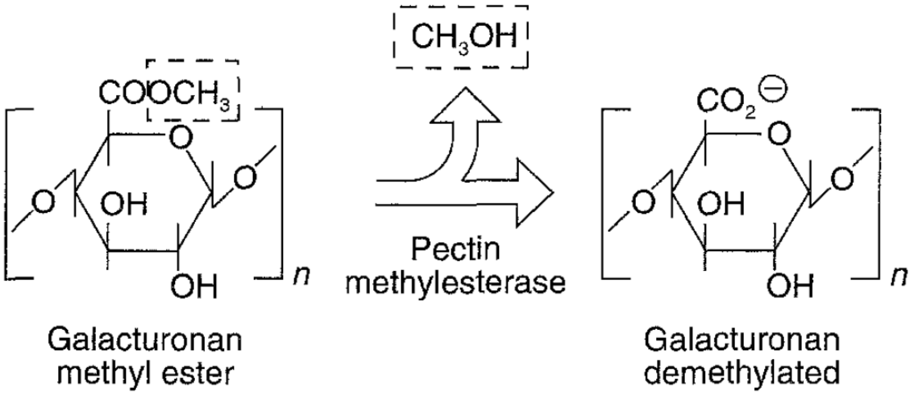
Motivation

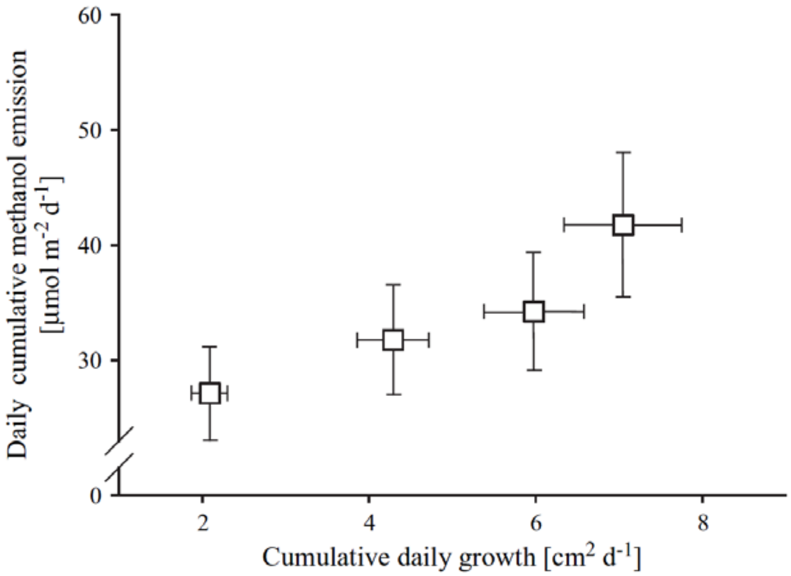
- Methanol (CH_3OH) is the second most abundant volatile organic compound (VOC) in the troposphere after methane.
- Plays a significant role in controlling tropospheric oxidants.
- Methanol emission comprise 10% of total global VOC emissions, being thus the second most important single contributor after isoprene.

Motivation

- Methanol is produced as a by-product of pectin metabolism during cell wall synthesis and methanol production thus generally scales with plant growth.



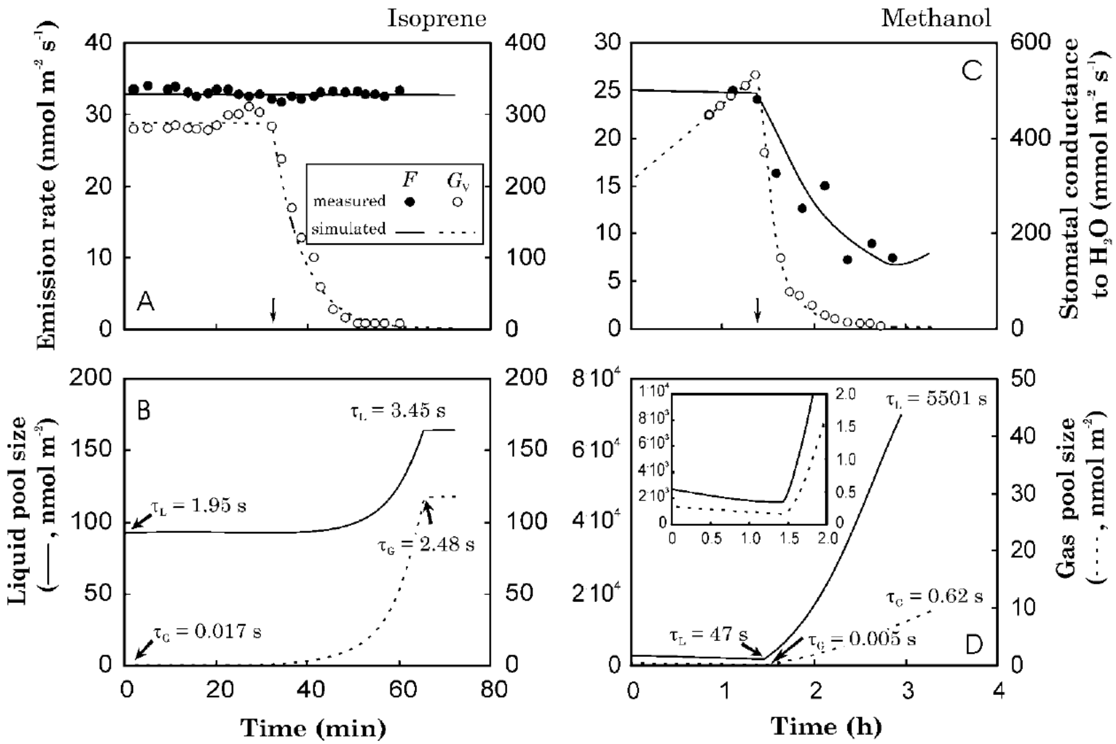
Fall & Benson (1996)



Hüve et al. (2007)

Motivation

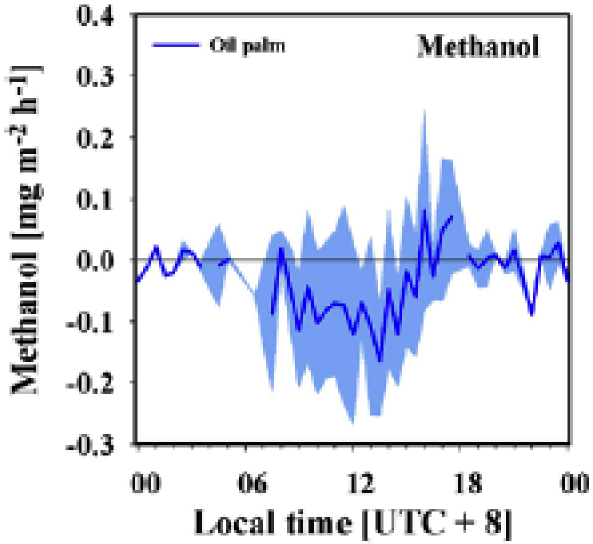
- Due to the low Henry constant of methanol, methanol emissions are under strong stomatal control.



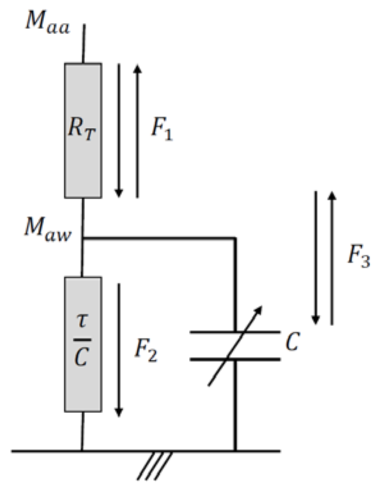
Niinemets & Reichstein (2003)

Motivation

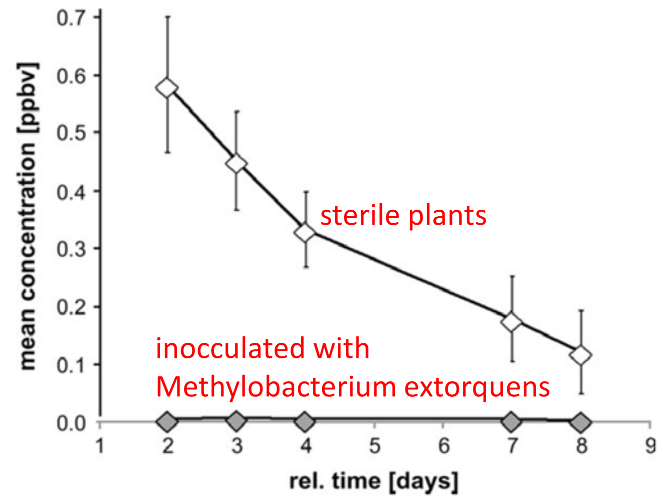
- At ecosystem scale, deposition of methanol is increasingly reported and has been linked to the presence of surface water, methylotrophic bacteria and chemical transformations.



Misztal et al. (2011)



Laffineur et al. (2012)



Abanda-Nkpwatt et al. (2006)

Motivation

- Methanol (CH_3OH) is the second most abundant volatile organic compound (VOC) in the troposphere after methane.
- Plays a significant role in controlling tropospheric oxidants.
- Methanol emission comprise 10% of total global VOC emissions, being thus the second most important contributor after isoprene.
- Consensus that methanol is primarily of biogenic origin, but terrestrial source estimates vary widely (75-245 Tg y^{-1}).
- The data underlying these budget calculations largely stem from small-scale leaf gas exchange measurements.
- **The main objective of this study is to use ecosystem-scale methanol flux measurements that have increasingly become available during the past decade to look at the exchange of methanol from a new perspective.**

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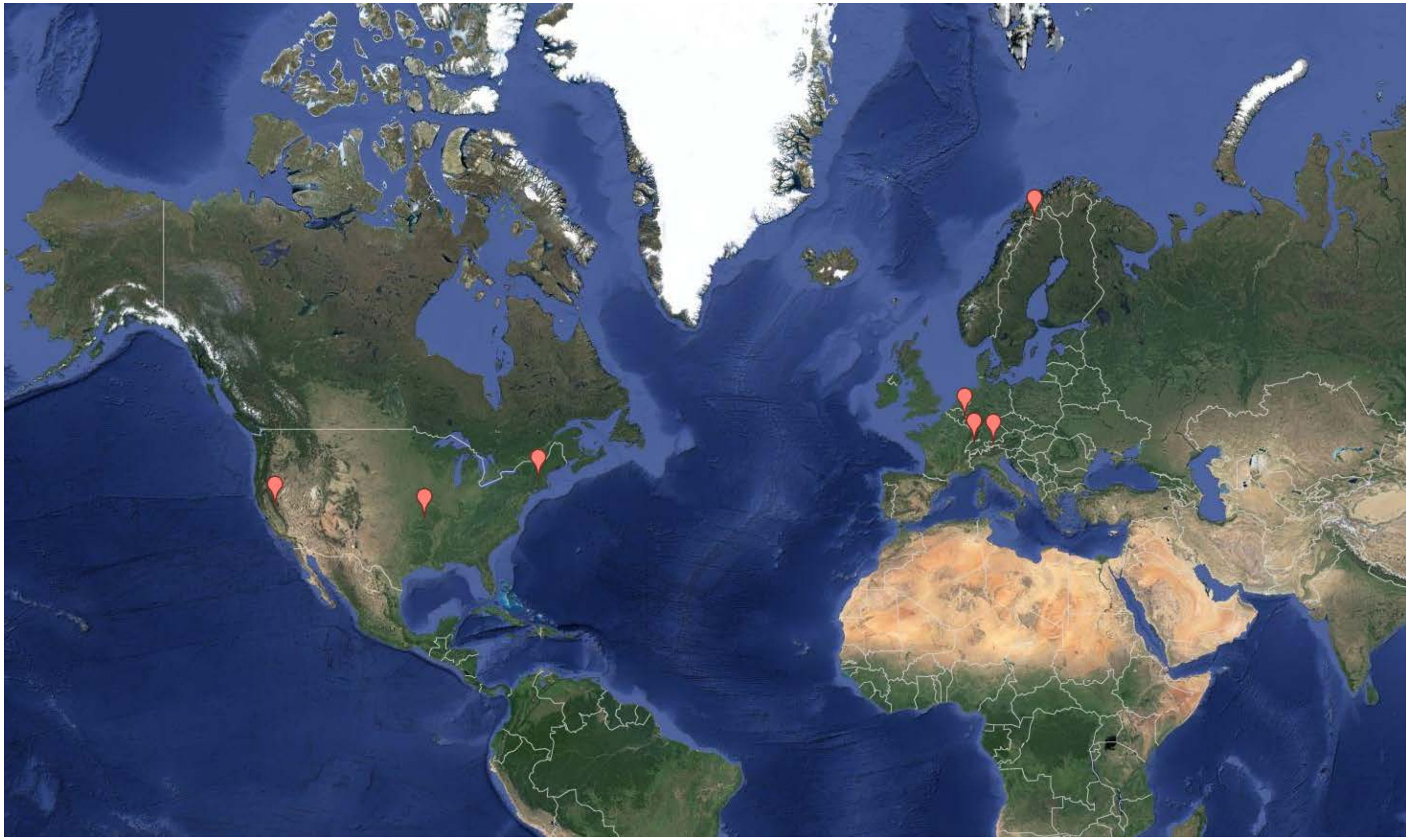
Study sites





Study site

	Blodgett forest	Stordalen	Vielsalm	Neustift	Oensingen-INT	Oensingen-EXT	Harvard forest	Missouri Ozark
Country	USA	Sweden	Belgium	Austria	Switzerland	Switzerland	USA	USA
Latitude	38.89 N	68.33 N	50.30 N	47.12 N	47.28 N	47.28 N	42.54 N	38.76 N
Longitude	120.63 W	19.05 E	5.98 E	11.32 E	7.73 E	7.73 E	72.17 W	92.16 W
Elevation	1315	351	450	970	450	450	340	219
MAP (mm)	1290	304	1000	852	1100	1100	1066	1110
MAT (degC)	9.0	-0.7	7.5	6.5	9.0	9.0	7.8	13.6
Climate	Mediterranean	Boreal	Temperate maritime	Temperate alpine	Temperate continental	Temperate continental	Temperate	Temperate continental
Biome	Coniferous evergreen forest	Wetland	Mixed forest	Grassland	Grassland	Grassland	Mixed forest	Deciduous broadleaf forest
Flux method	REA	EC	EC	EC	EC	EC	EC	EC

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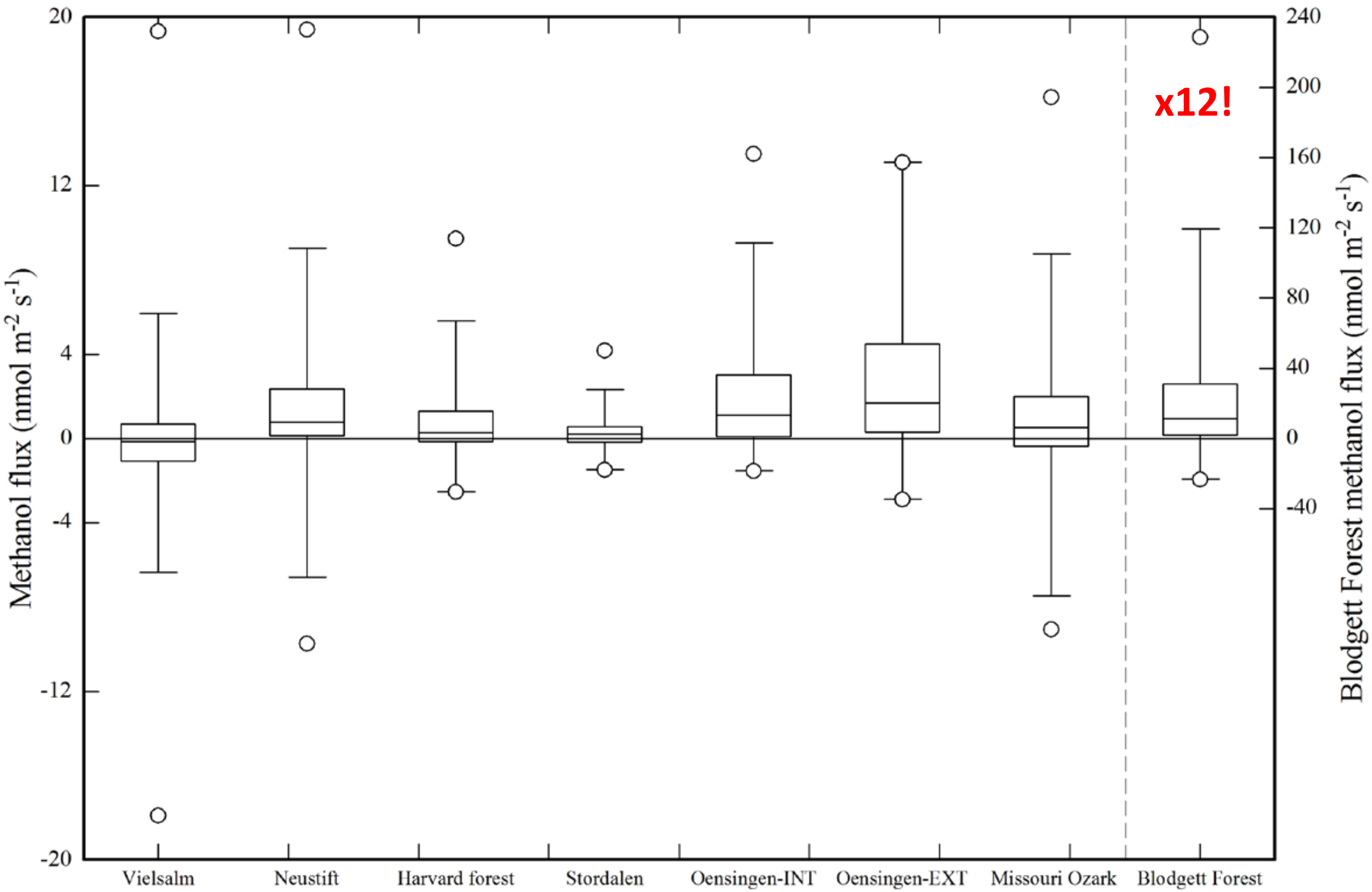
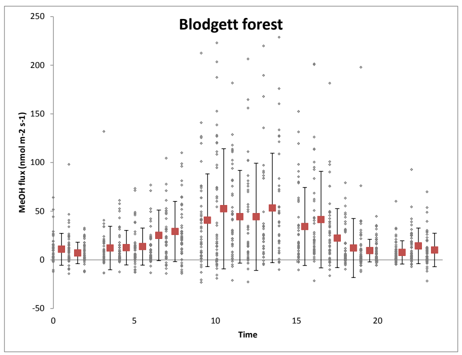
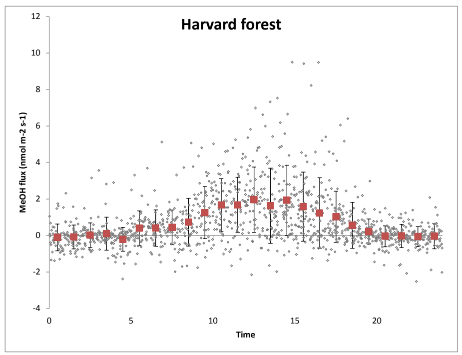
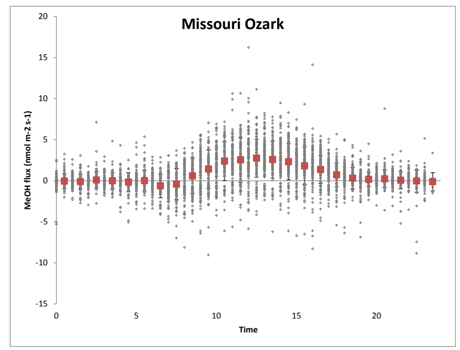
Exploratory analysis

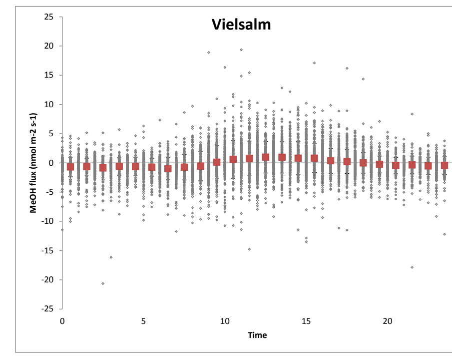


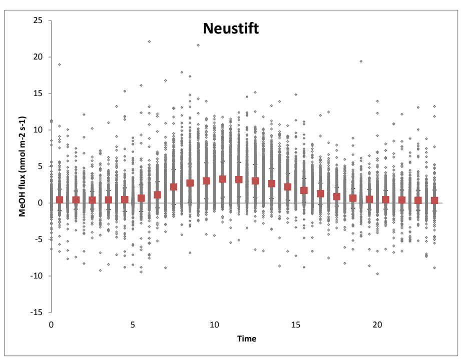
Exploratory analysis

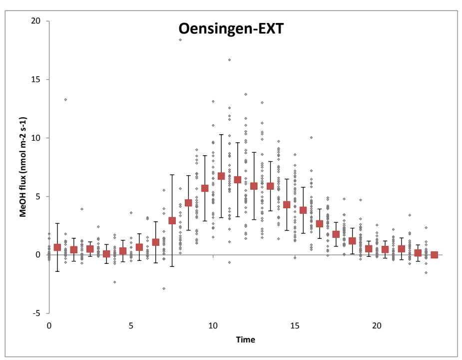


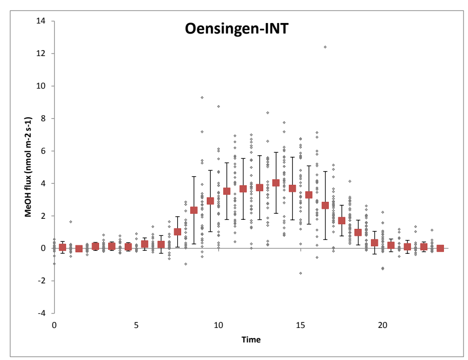


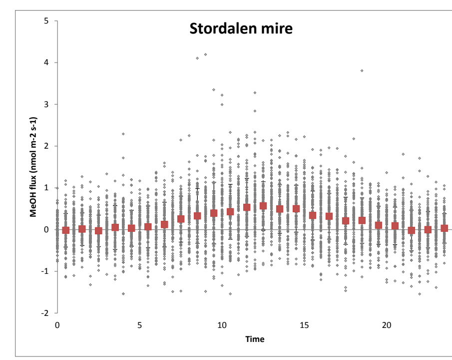








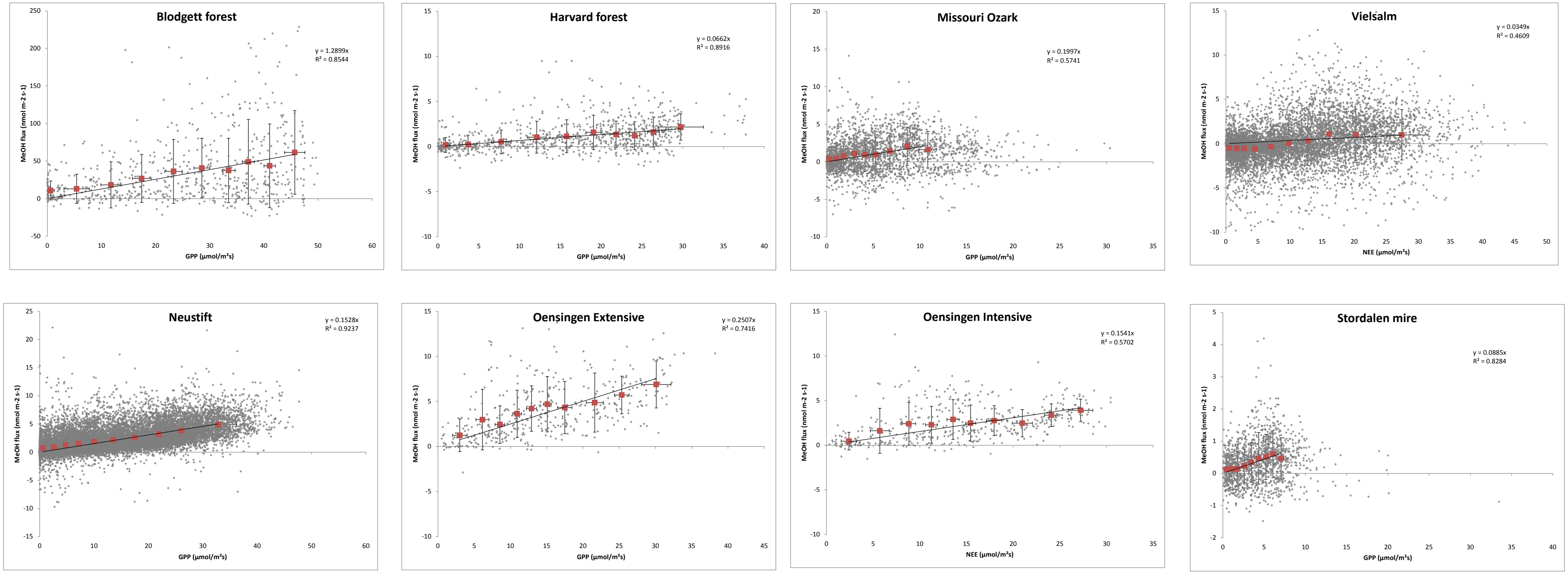




Exploratory analysis

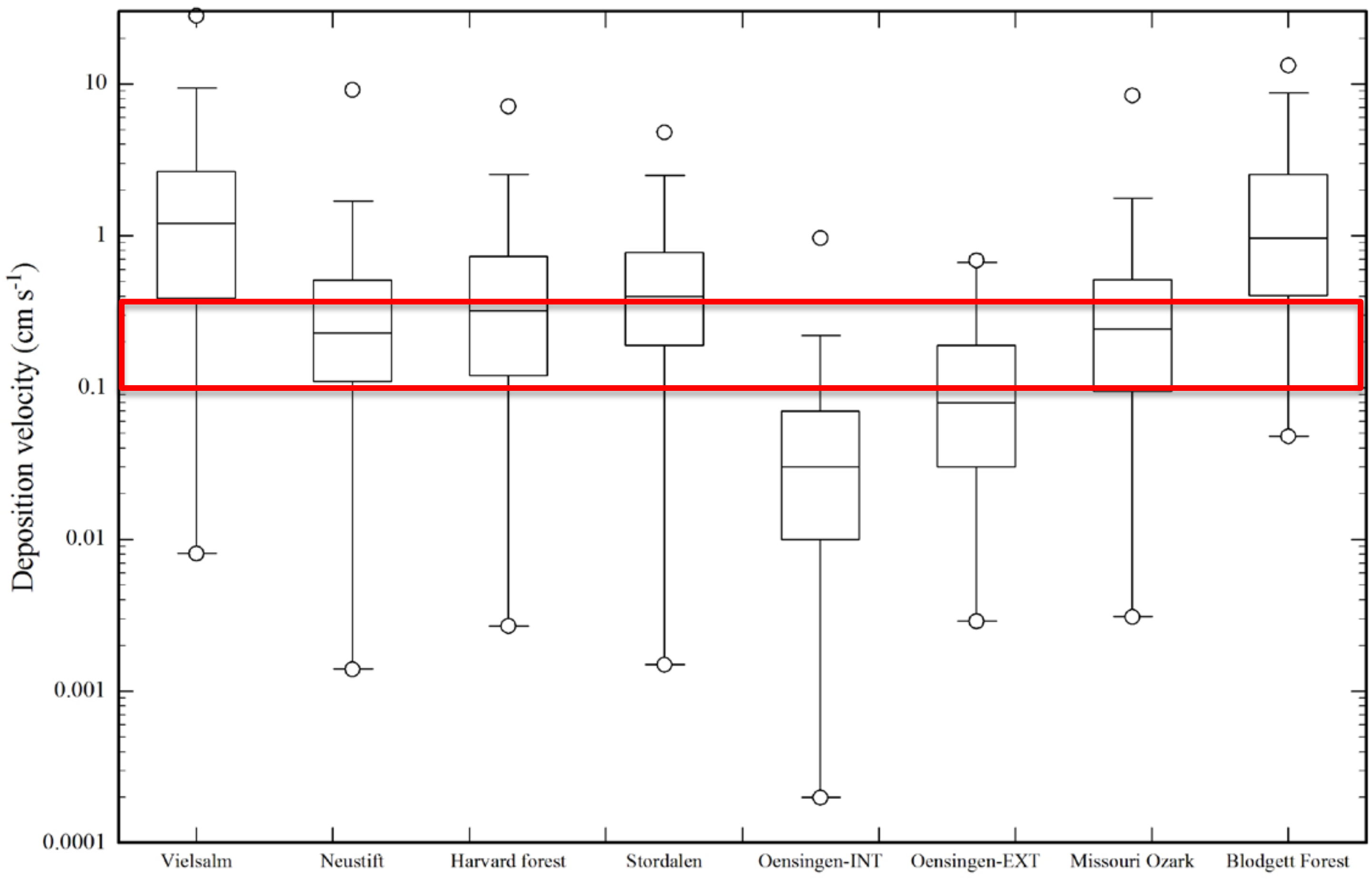
	partial η^2	p-value
Corrected model	.564	.000
Constant term	.000	.039
PAR	.029	.000
TA	.000	.002
u*	.001	.000
GPP	.001	.000
RH	.002	.000
[MeOH]	.001	.000
Site	.053	.000
Site x PAR	.011	.000
Site x TA	.008	.000
Site x u*	.013	.000
Site x GPP	.008	.000
Site x RH	.063	.000
Site x [MeOH]	.010	.000

Relation to productivity

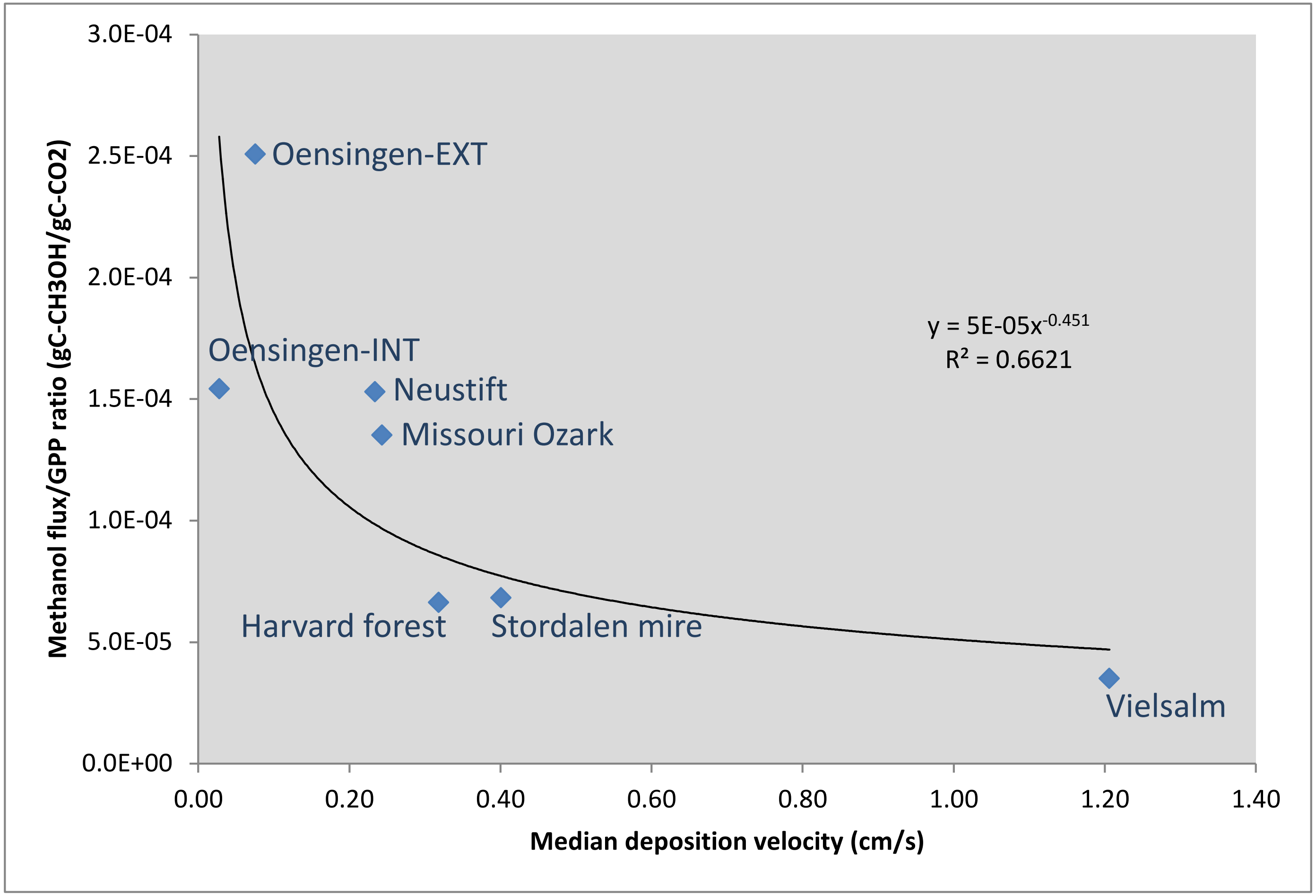


- slope ranges between 3.5 10^{-5} – 2.5 10^{-4} gC-CH_3OH/gC-CO_2
- average slope 1.24 10^{-4} gC-CH_3OH/gC-CO_2
- taking Beer et al. (2010) global GPP (123 PgC y^{-1}) => 40 Tg y^{-1}

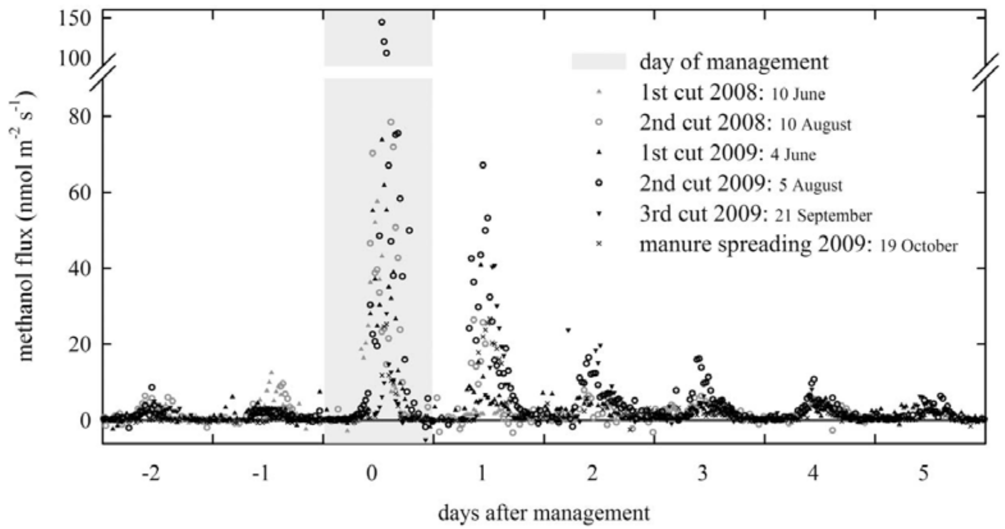
Deposition


10
1
0.1
0.01
0.001
0.0001
Deposition velocity (cm s-1)
Vielsalm
Neustift
Harvard forest
Stordalen
Oensingen-INT
Oensingen-EXT
Missouri Ozark
Blodgett Forest

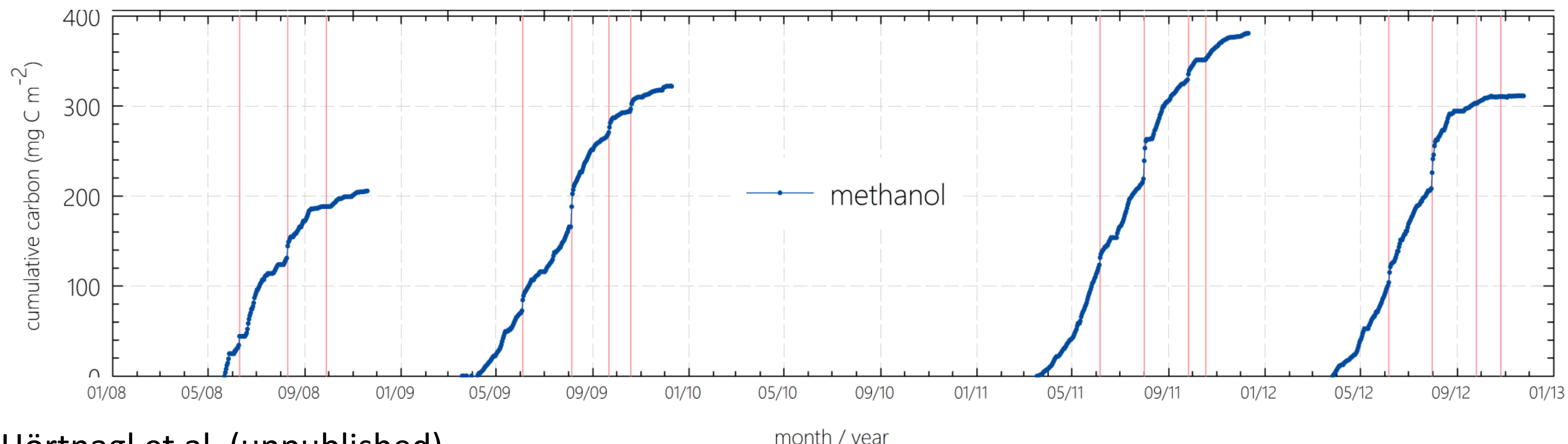
Deposition


Methanol flux/GPP ratio (gC-CH3OH/gC-CO2)
3.0E-04
2.5E-04
2.0E-04
1.5E-04
1.0E-04
5.0E-05
0.0E+00
Oensingen-EXT
Oensingen-INT
Neustift
Missouri Ozark
Harvard forest
Stordalen mire
Vielsalm
y = 5E-05x-0.451
R² = 0.6621
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
Median deposition velocity (cm/s)

Effects of disturbance



Hörtnagl et al. (2011)



Hörtnagl et al. (unpublished)

Conclusions

- At ecosystem scale, the methanol flux is bi-directional, emission and deposition occurring concurrently.
- Models generally treat emission and deposition separately, which makes it difficult to get the net flux right and makes it close to impossible to make use of ecosystem flux measurements for calibration/validation.
- Sign of methanol exchange driven by productivity, modulated by stomatal conductance and surface wetness.
- Methanol emissions following disturbance need to be accounted for.