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Towards Understanding Biospheric Gross Carbon Fluxes: sources and sinks of Carbonyl Sulfide

Huilin Chen[1], Linda Kooijmans[1,2], Alessandro Zanchetta[1], Steven van Heuven[1], Maarten Krol[2], Wu Sun[3], Ulli Seibt[3], Juho Aalto[4], Kukka-Maaria Erkkilä[4], Timo Vesala[4], Ivan Mammarella[4], Kadmiel Maseyk[5]

1. University of Groningen, Groningen, The Netherlands;
2. Wageningen University, Wageningen, The Netherlands;
3. University of California Los Angeles, CA, USA;
4. University of Helsinki, Helsinki, Finland;
5. The Open University, Milton Keynes, UK.

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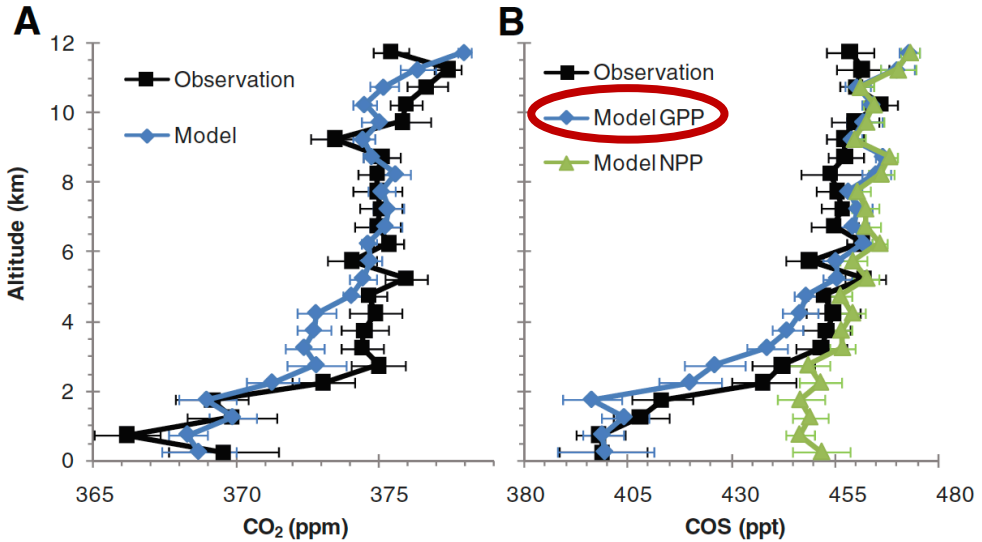
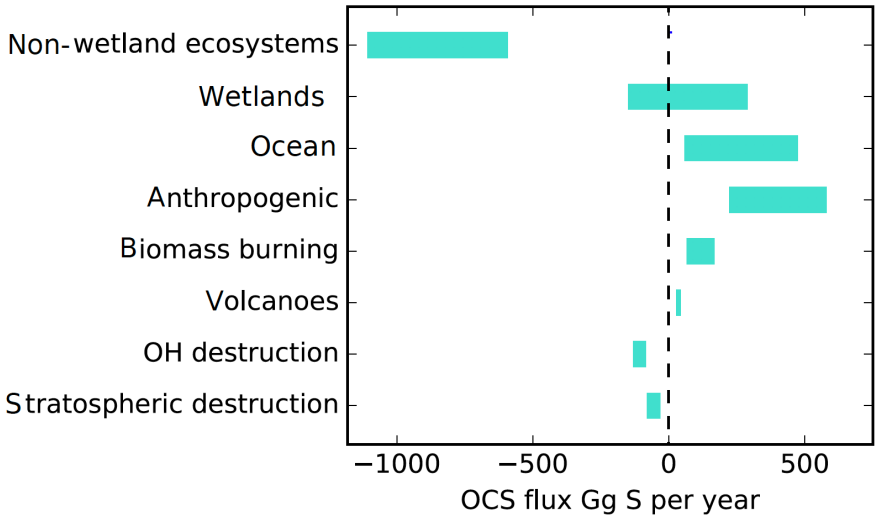
Carbonyl Sulfide (OCS or COS) as a tracer for GPP



Campbell et al., 2008



Whelan et al., 2018

- North America summer drawdown of atmospheric COS related with GPP
- COS Plant uptake $F = GPP \cdot \frac{[COS]}{[CO_2]} \cdot V_{COS/CO_2}$
- Vcos/co_2: Leaf-scale relative uptake

- Bottom-up global budget of COS
- Non-wetland ecosystems mainly plant uptake
- Also significant anthropogenic sources

COS measurement campaigns -2015, 2016, 2017 Hyytiälä -2014, 2018, 2019 Lutjewad

Hyytiälä boreal forest

10 Hz: Eddy-cov.

1 Hz: Profile + chambers

Lutjewad tower

Hyytiälä:

- COS 1 Hz from Groningen: profile + chambers (Kooijmans et al., 2016)
- COS 10 Hz from Helsinki: eddy covariance (Kohonen et al., 2019)
- Groningen COS overall uncertainty (1-s): 7.1 ppt COS, 0.22 ppm CO_2, (calibration, water vapor corrections etc.)

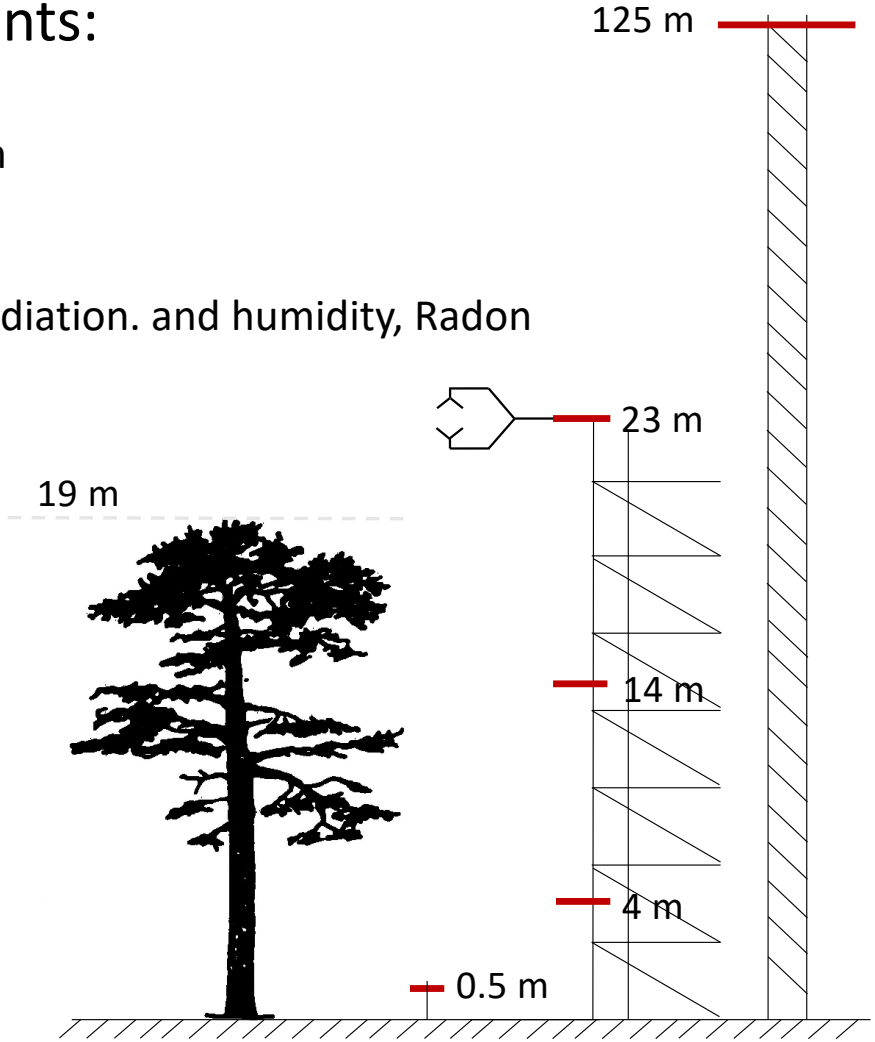
Hyytiälä Measurement campaigns

COS and CO_2 measurements:

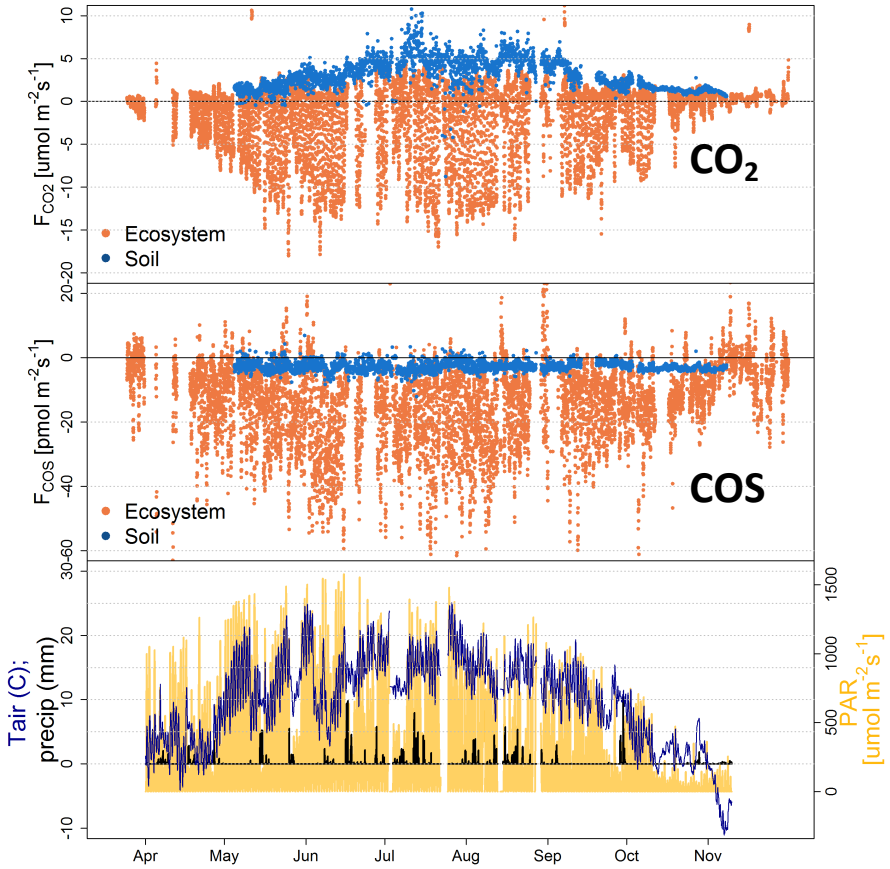
- **Eddy-covariance** (23 m)
- **Profile**: 0.5, 4, 14, 23, 125 m
- **Soil chamber fluxes**
- **Branch chamber fluxes**
- Meteorological variables: radiation. and humidity, Radon

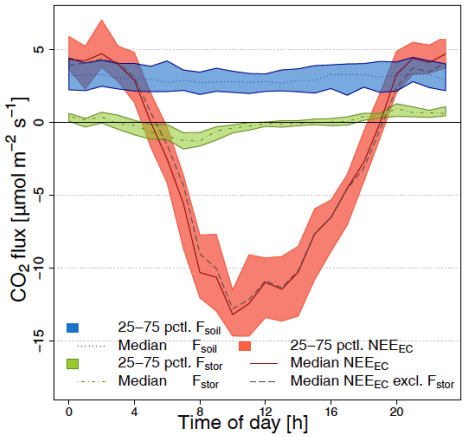
Branch chamber

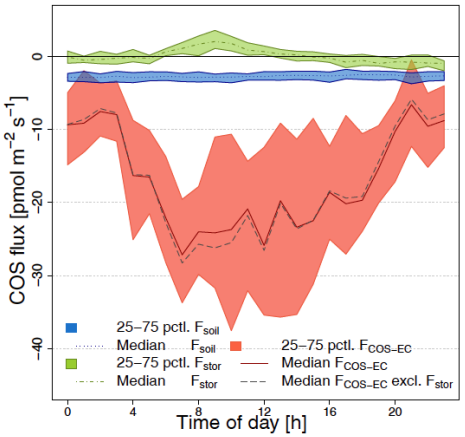
Soil chamber

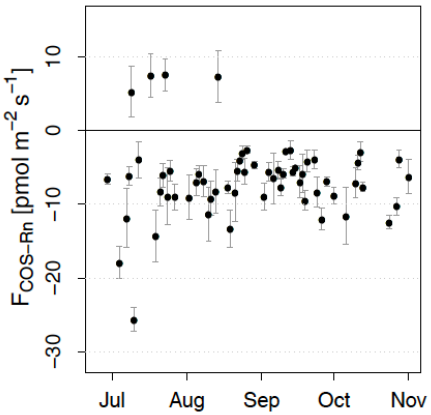


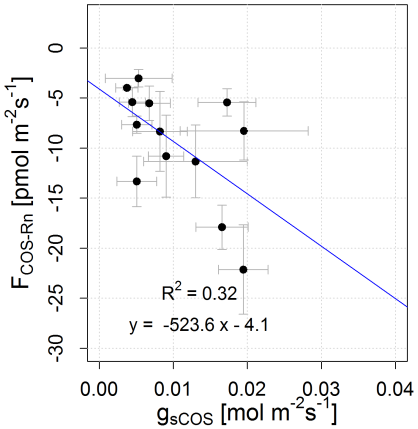
Hyytiälä ecosystem fluxes COS and CO_2 - 2015











Time series of ecosystem CO_2, COS fluxes in 2015

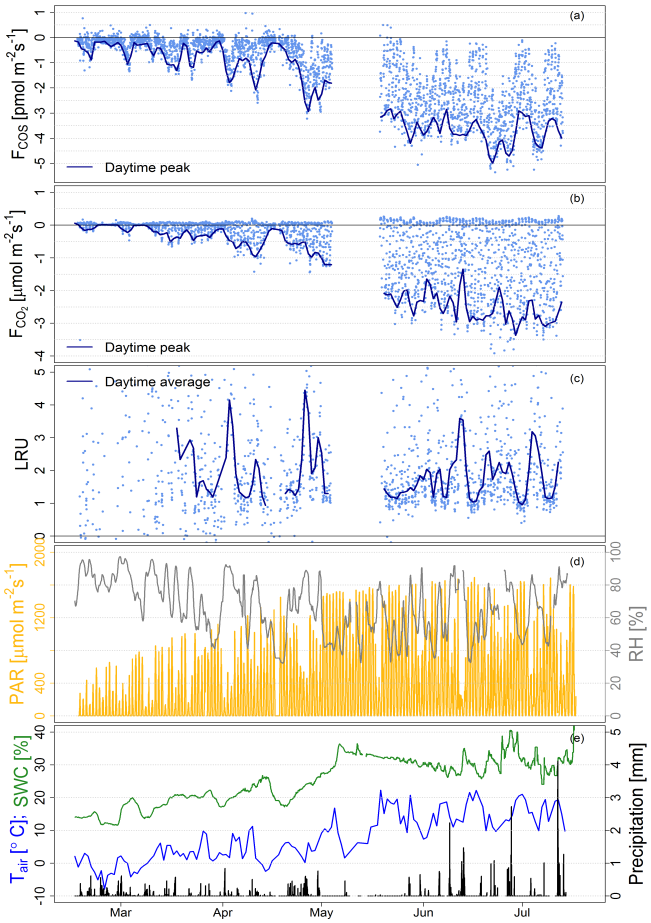
Diurnal cycles of CO_2, COS fluxes Jul&Aug

Nighttime COS fluxes

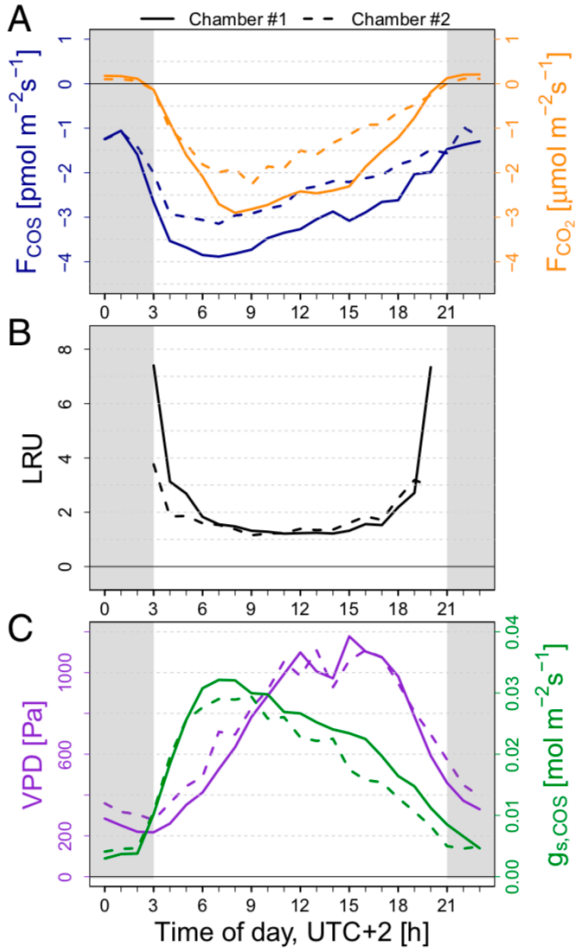
Nighttime COS uptake (Jul - Nov) contributes to 21 % of the total daily uptake *Kooijmans et al., 2017*

Soil/total ecosystem COS flux: Nighttime (Jul - Nov): 34-40 %; Daytime (Jul): 13 %

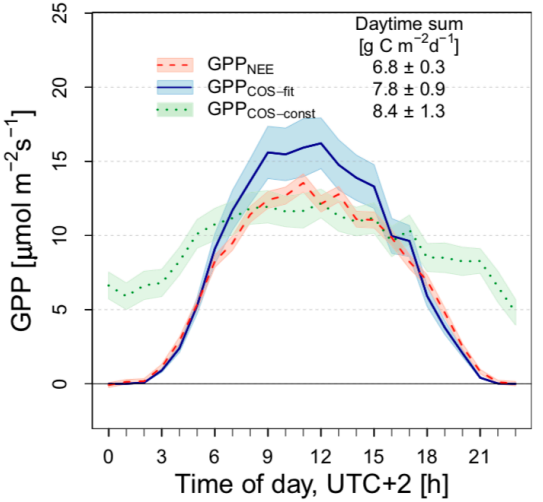
Hyytiälä GPP estimates based on leaf chamber measurements COS and CO_2 - 2017



Time series of hourly fluxes and meteo.



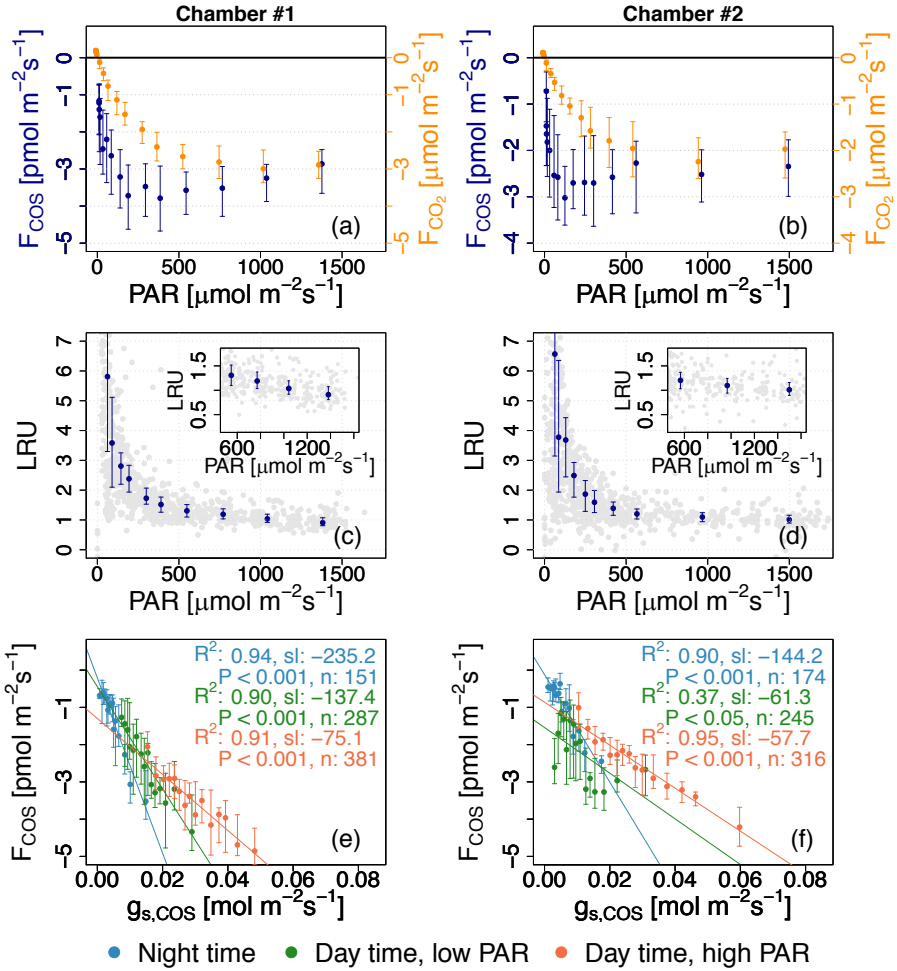
Average diurnal cycles 18 May – 13 July 2017

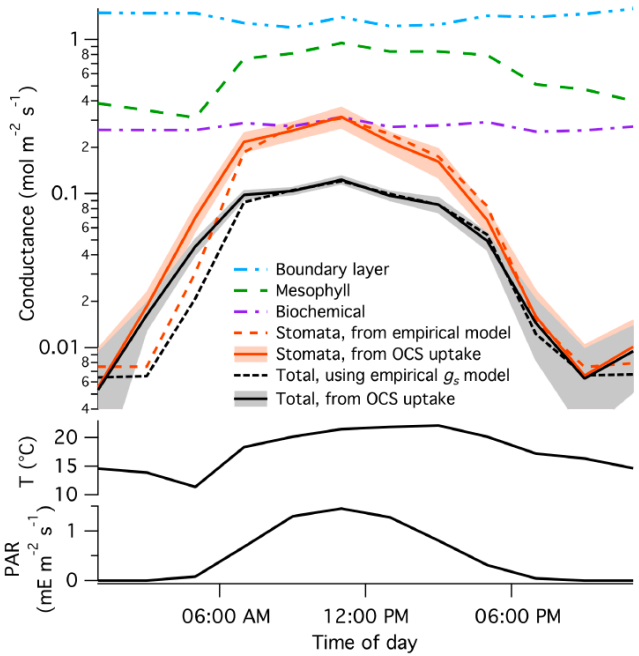


GPP estimates based on COS and standard methods

Kooijmans et al., 2019

Hyytiälä responses of F_{COS}, F_{CO2} and LRU to light and of F_{COS} to $g_{s,COS}$



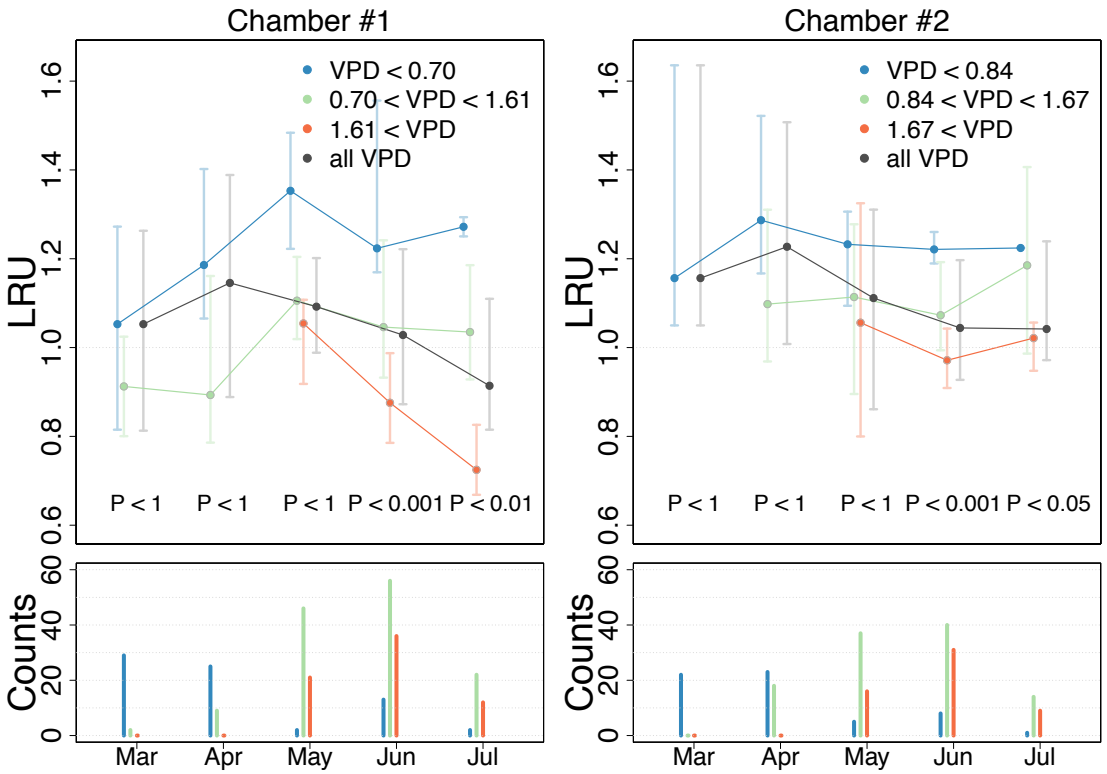


$g_{t,cos}=(g_{s,cos}^{-1} + g_{i,cos}^{-1})^{-1}$

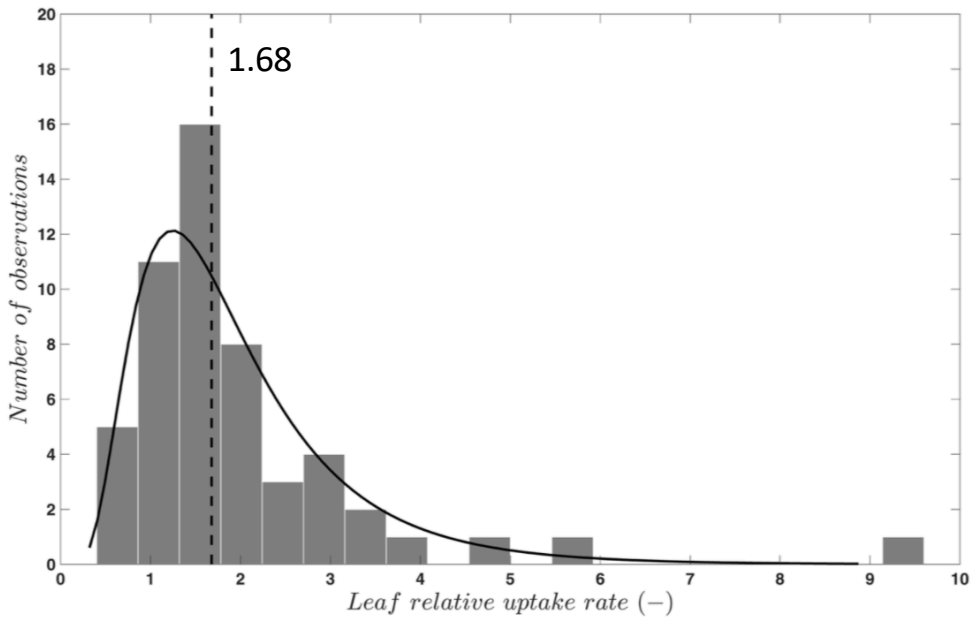
Kooijmans et al. 2019

Wehr et al., 2017

Seasonal variation of light-saturated LRU



Hyytiälä seasonal variation of light-saturated LRU

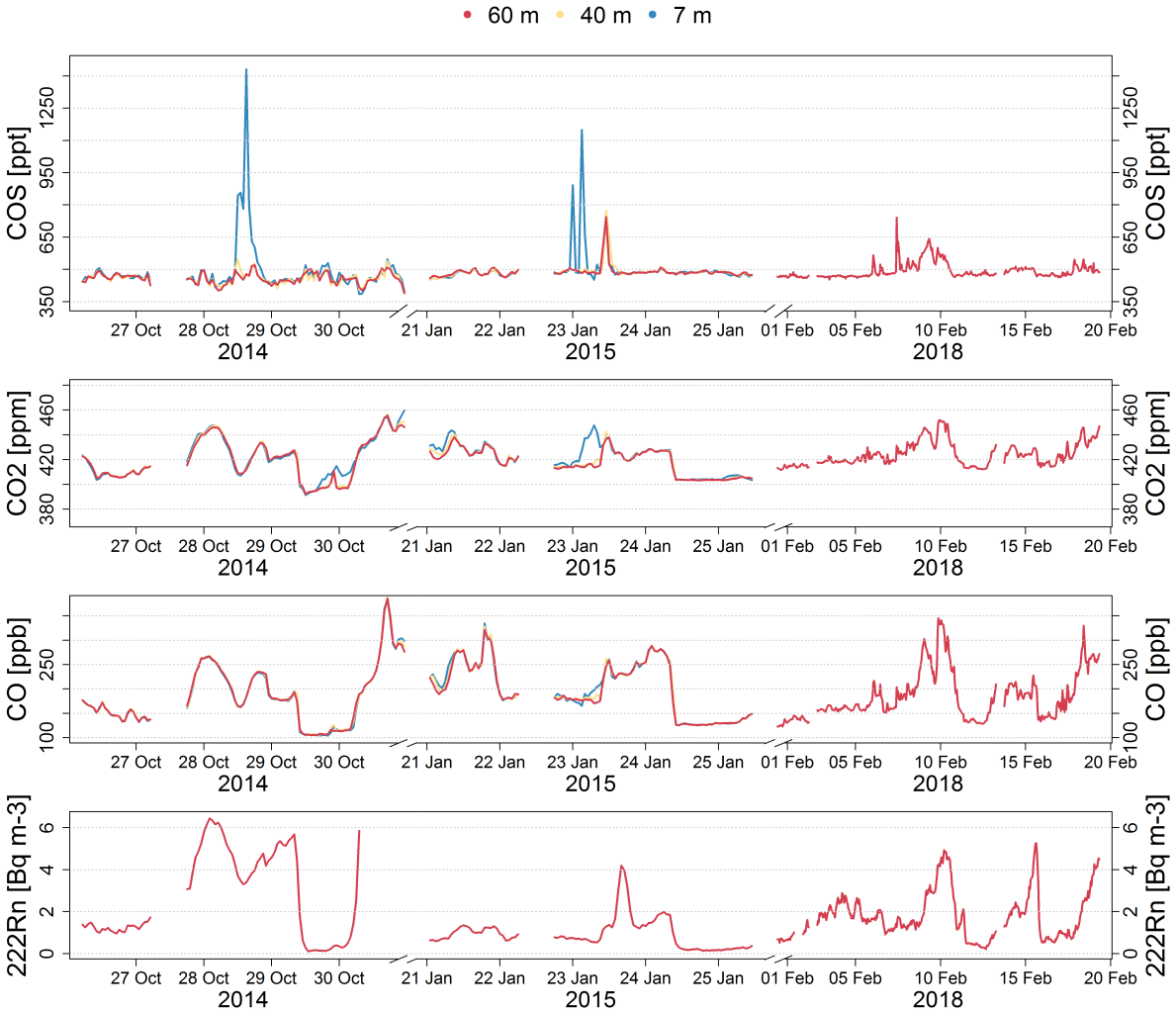


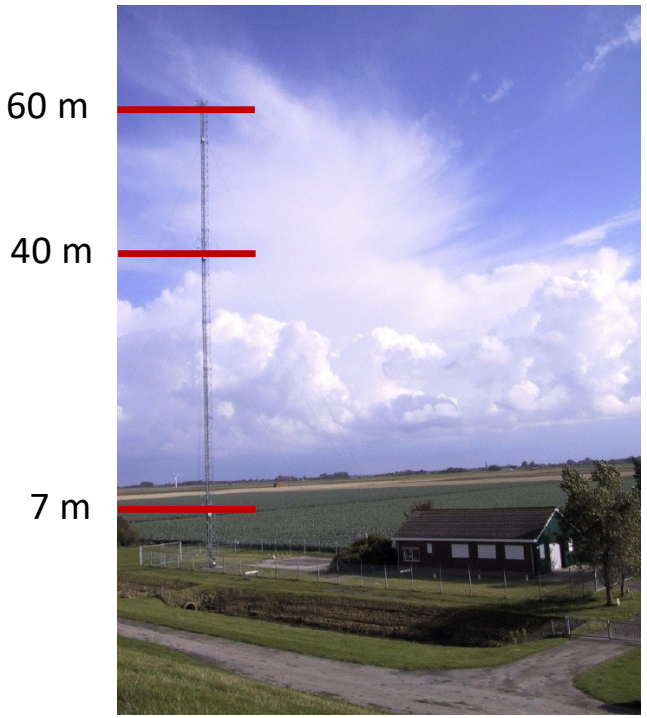
Frequency distribution (bars) and a lognormal fit (solid line) to published values (n = 53) of the leaf relative uptake rate of C3 species.

LRU on average 1.1 *Kooijmans et al. 2019*

Whelan et al., 2018

Lutjewad elevated COS measurements

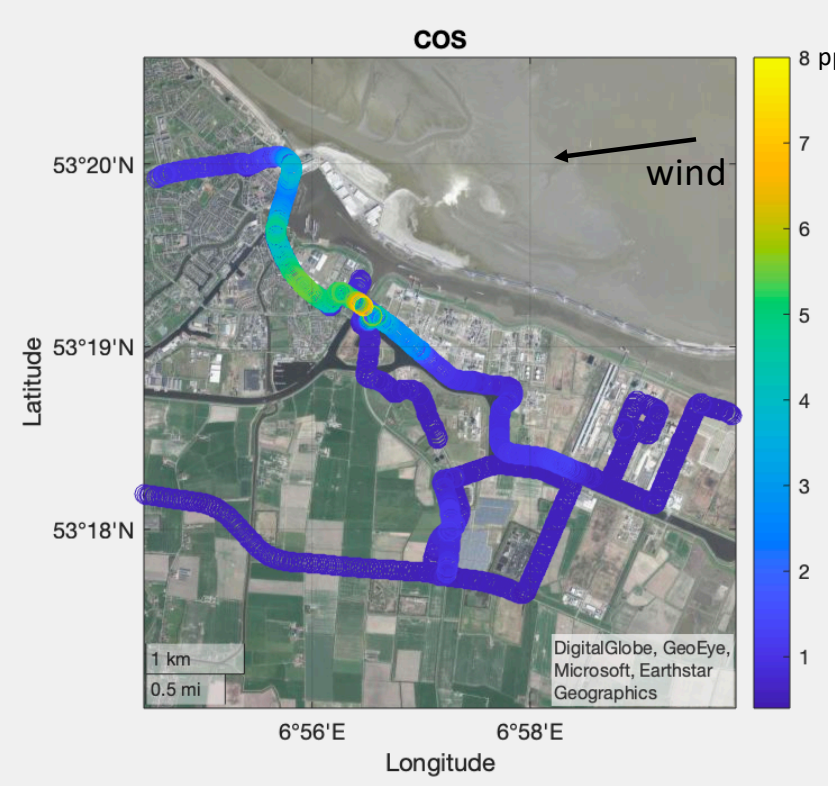


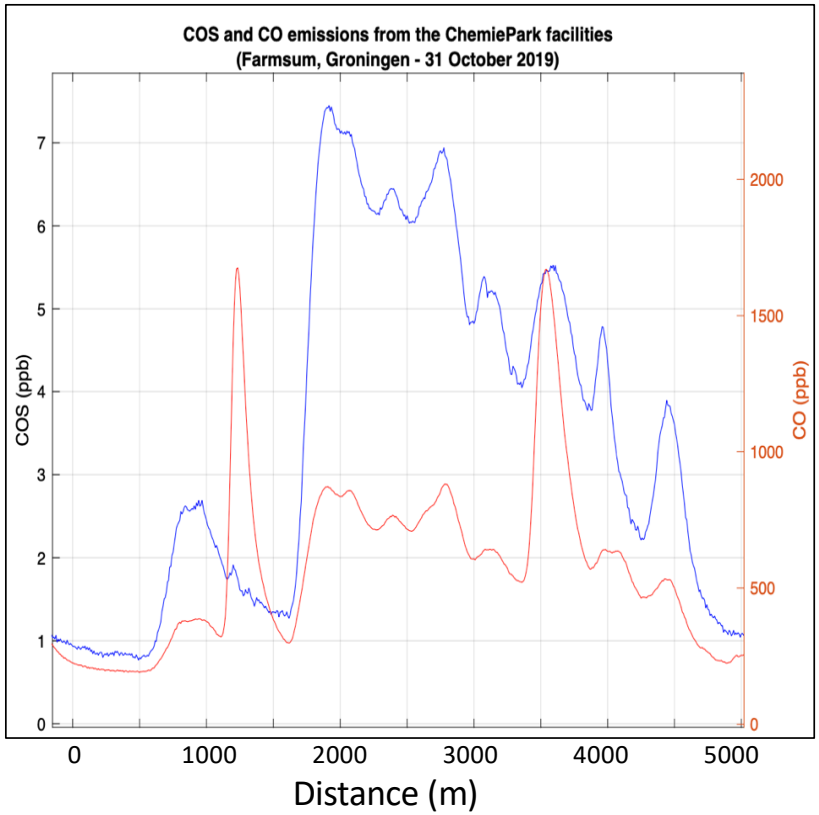


Mobile van COS measurements Groningen province

- Lutjewad
  - Ploughing
- Delfzijl
  - Industrial area
- Suike Unie
  - Sugar factory

Delfzijl Industrial observed COS enhancements

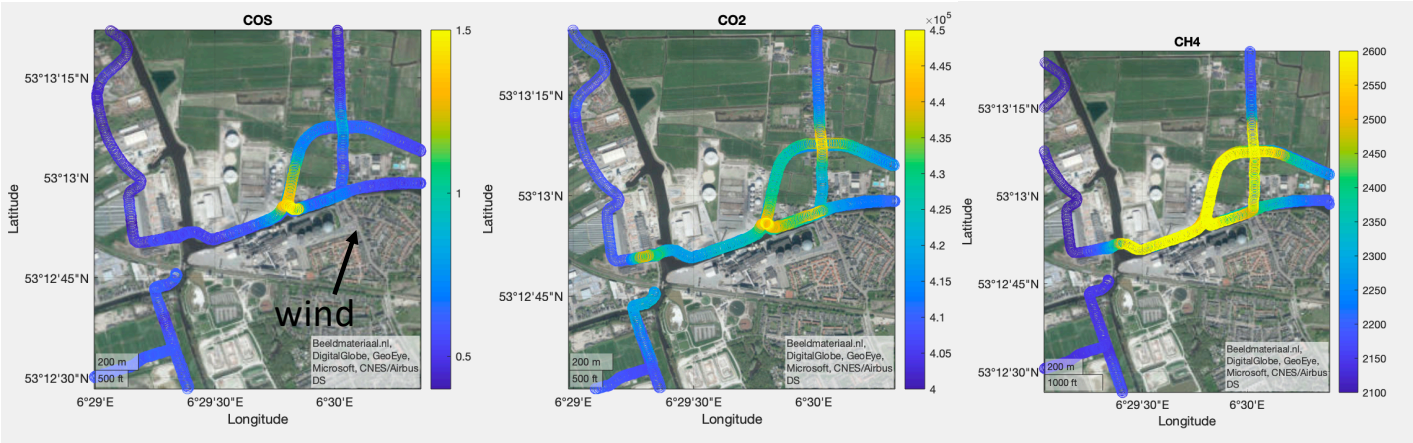




- High correlation with CO, with a ratio of 9.6 ppt(COS)/ppb(CO)

  Sources: Combined heat and power plant; metal smelting; Alloys production, waste and soil treatment; Bio-methanol production

SuikerUnie Sugar factory – COS emissions



- COS enhancements observed, significant CH_4 enhancements, but not collocated

Summary of preliminarily estimated emissions of various sources

Source	COS enhancements	Distance from source	Estimated COS emissions
SuikerUnie	0.71 - 1.27 ppb	~ 300 m	2.35 - 4.21 kg(S)/y
ChemiePark	1.32 - 6.97 ppb	~ 400 m	3.84 - 31.8 kg(S)/y
Silicon carbide (SiC) facility	0.42 - 0.69 ppb	~ 600 m	3.39 - 5.52 kg(S)/y
Ploughing agricultural land	~0 ppb	~ 100 m	~ 0 kg(S)/y

Conclusions

Hyytiälä boreal forest

Significant COS uptake during night

- 21% of daily total fluxes
- Soil /total ecosystem COS flux: Nighttime: 34-40 %; Daytime: 13 %

Leaf chamber measurements

- COS uptake mainly controlled by g_{s_cos}, and also limited by g_{i_cos} under high light
- LRU varies with light and VPD in the peak growing season

Lutjewad amospheric site

- COS spikes observed occasionally at the Lutjewad station
- Anthropogenic emissions observed from chemical facilities and sugar factory
- No ploughing COS emissions detected