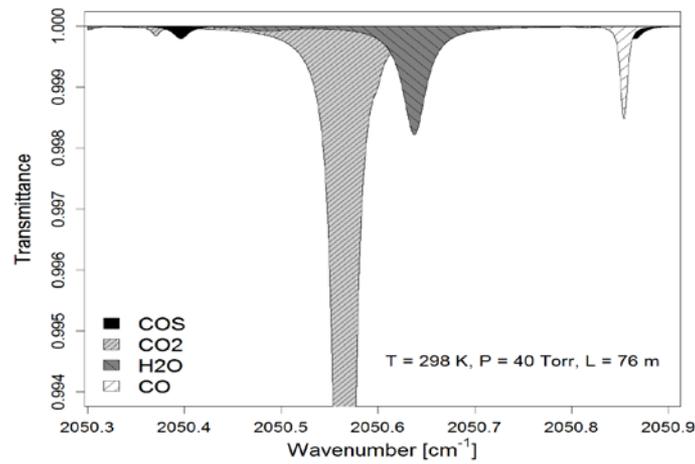
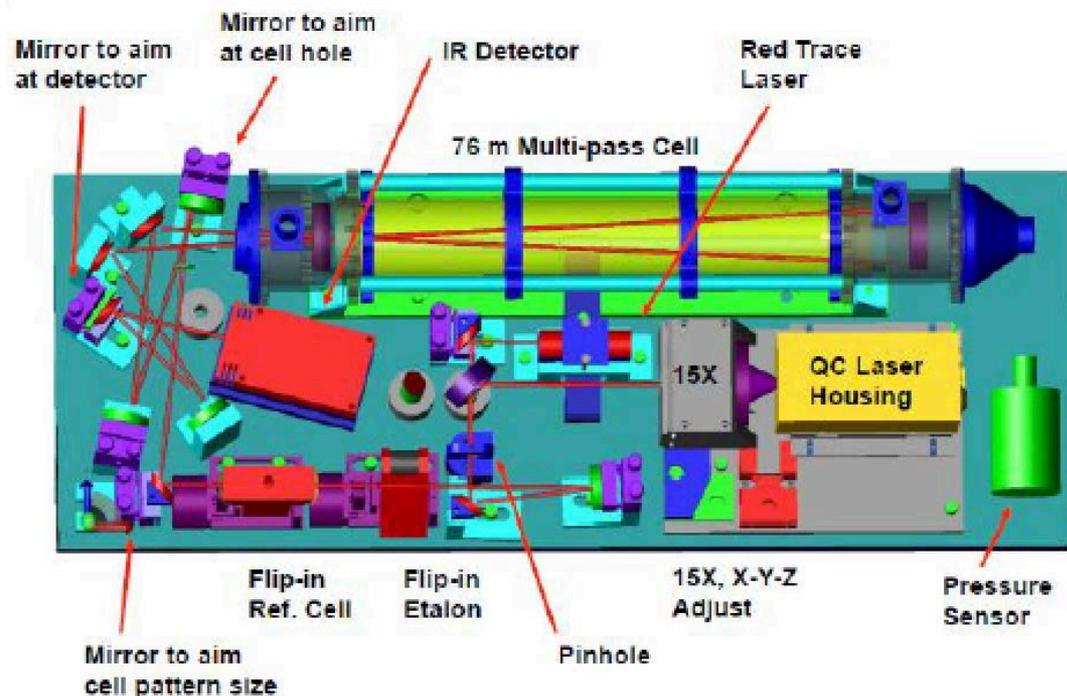


Quantum cascade laser spectrometer (QCLS)

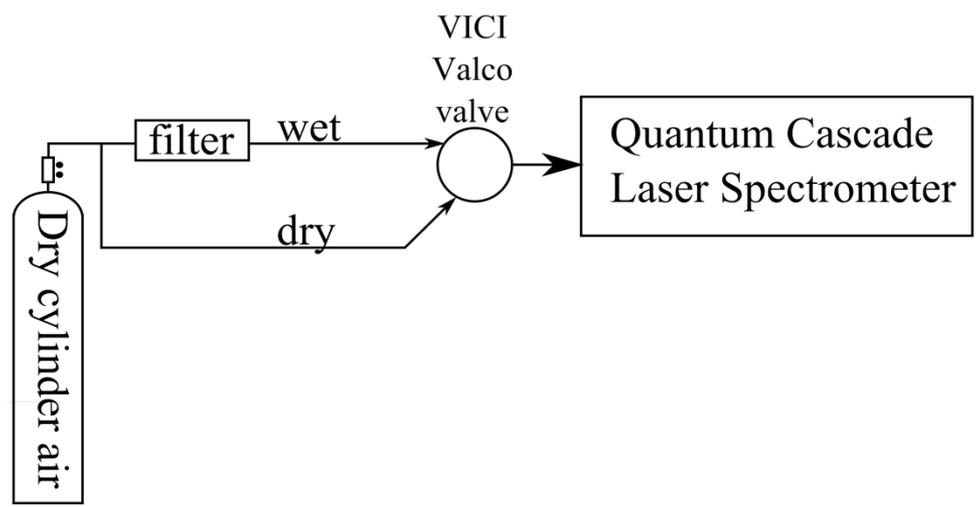
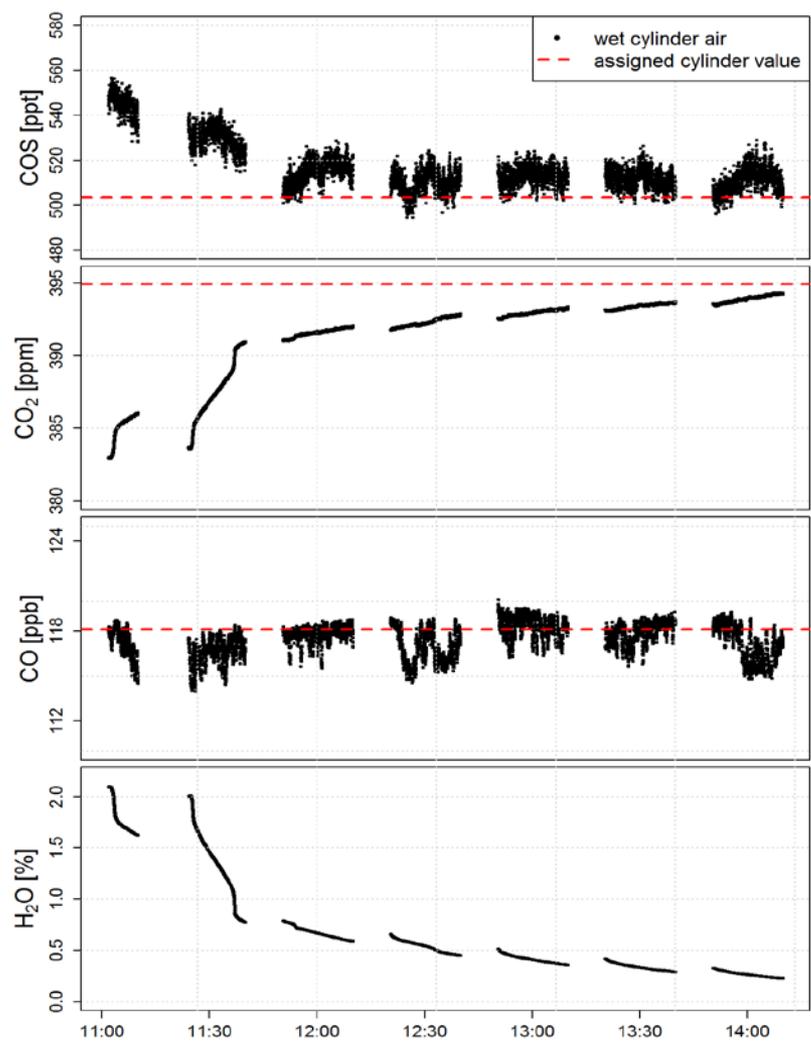


Aerodyne Research Inc.

Cell volume	0.5 L
Path length cell	76 m
Pressure	40 Torr
Cell temperature	~22 degr. C
Laser temperature	~-19.8 degr. C

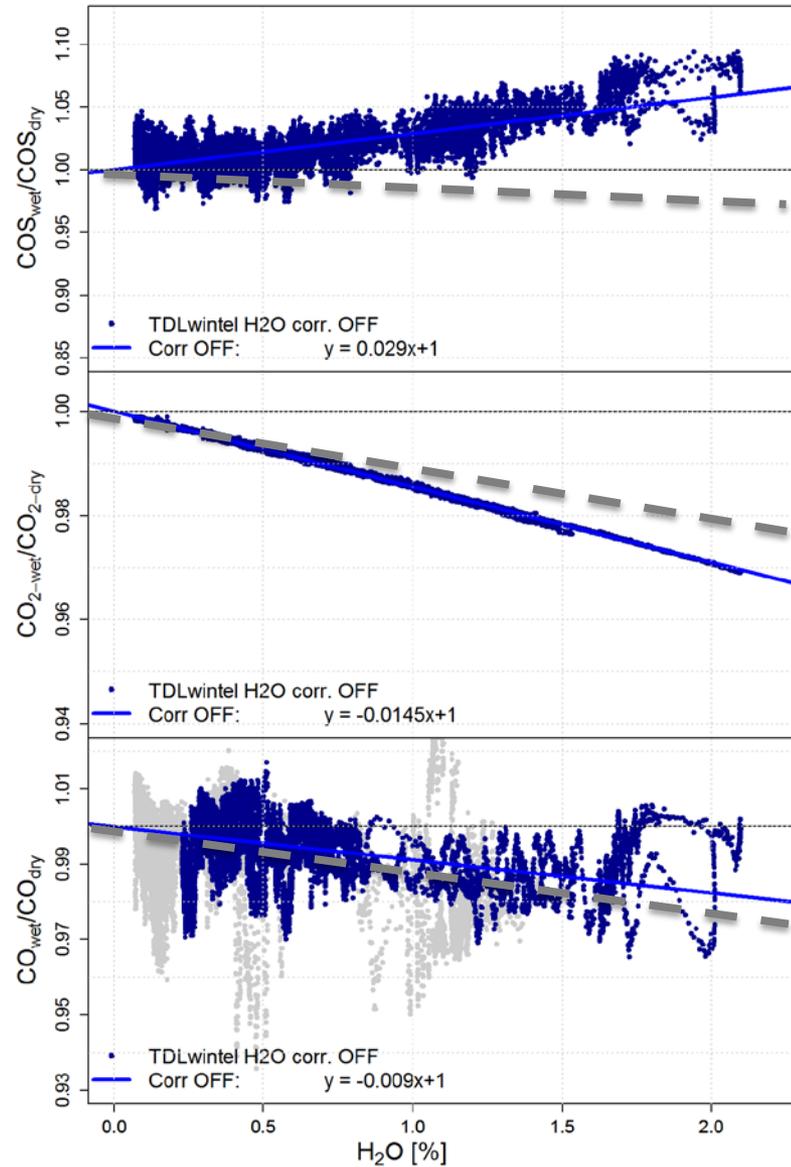


COS dry mole fractions: Water vapor corrections

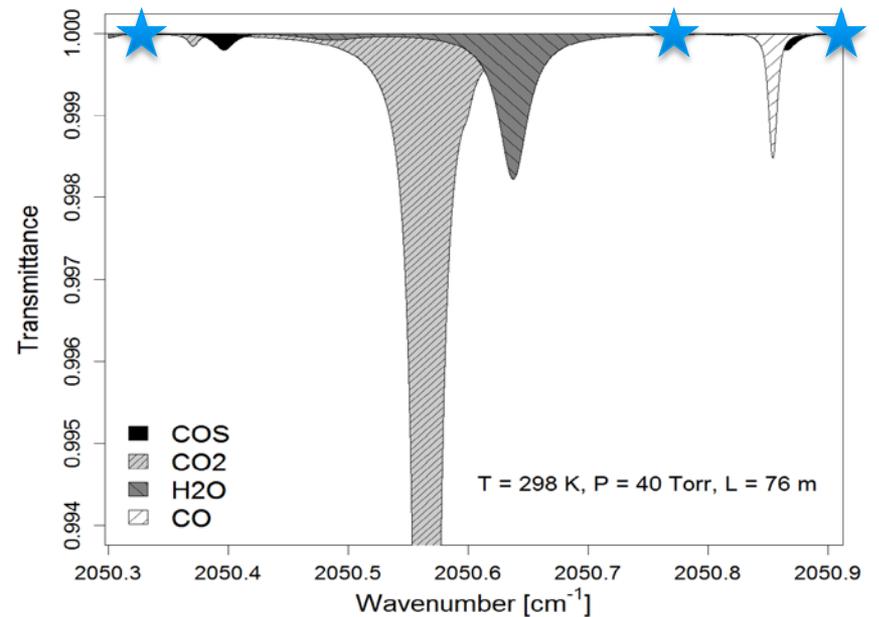


Water vapor experiment with humidified cylinder air to characterize the H₂O dependence.

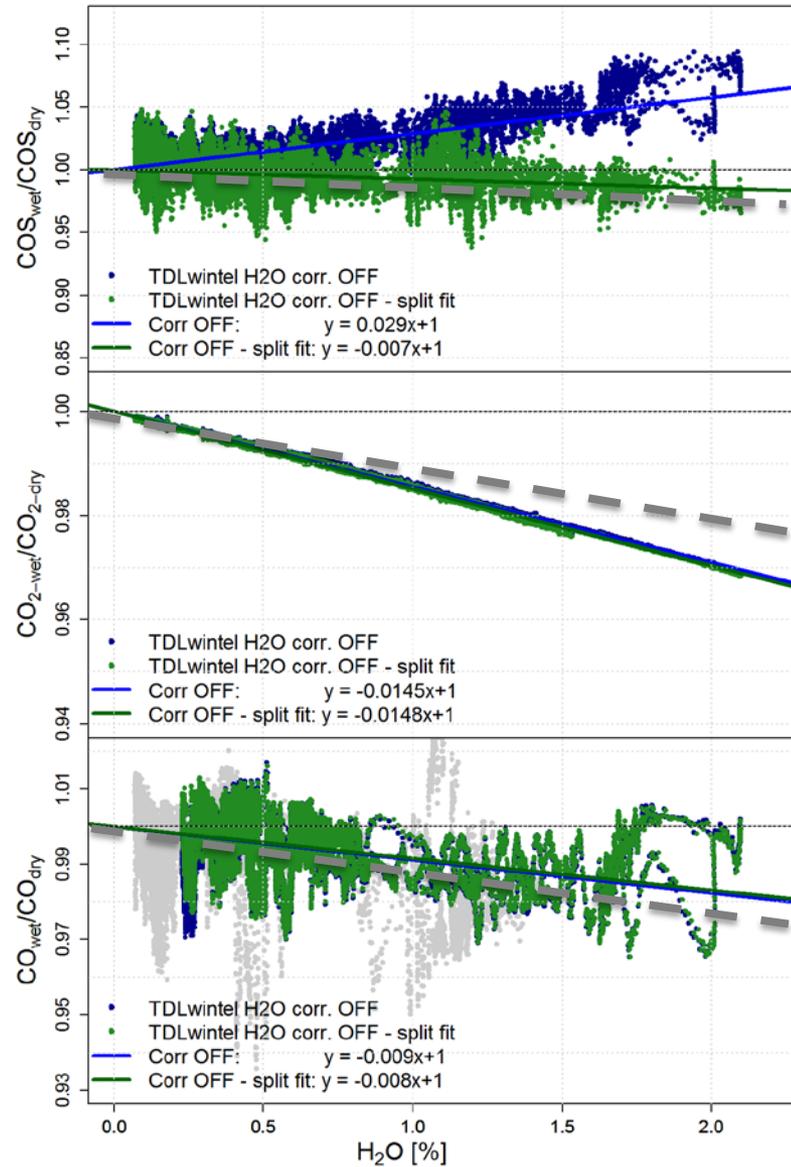
Water vapor corrections



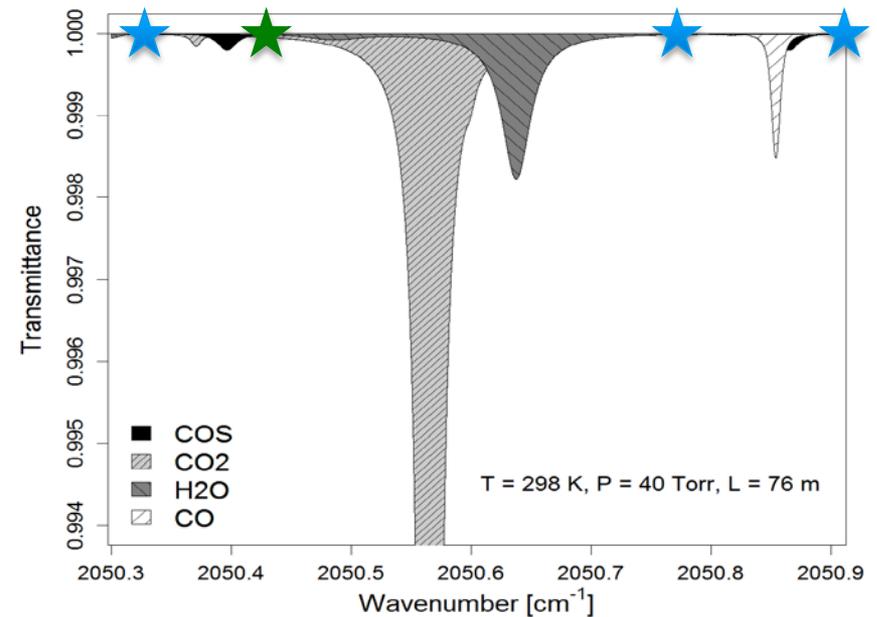
Water correction can be applied based on linear H_2O dependence.



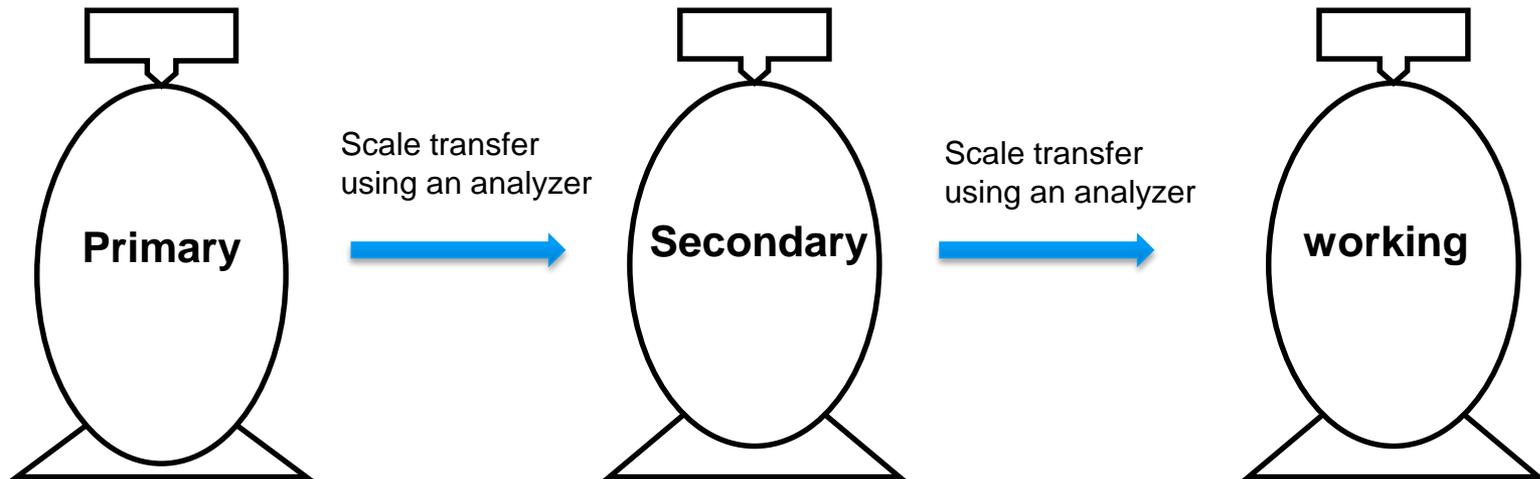
Water vapor corrections



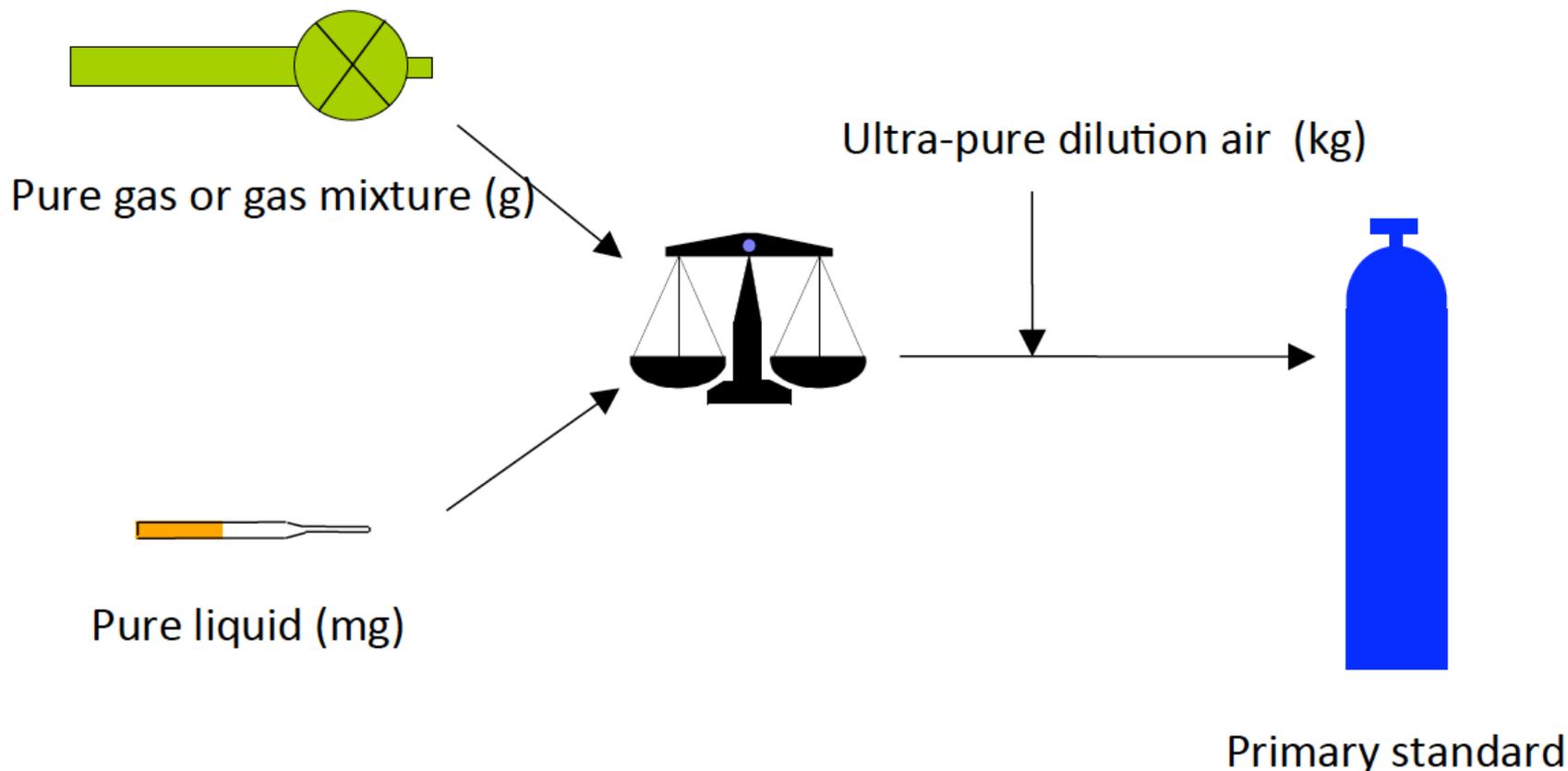
Updated water corrections



COS Scale transfer



NOAA Primary COS standard: gravimetric method



- COS pure gas: 99.9% purity
- Uncertainty ~ 0.1-0.5%

Uncertainty of QCLS COS, CO₂, CO measurements

Uncertainty contributions	COS [ppt]	CO ₂ [ppm]	CO [ppb]
Repeatability of the NOAA or WMO scale ^a	2.1	0.07	2.0
Transfer scale to working standards (1 σ) ^b	2.8	0.12	1.7
Measurement calibration ^c	2.8	0.12	1.7
Water vapor correction (1 σ)	2.9	0.10	1.1
Measurement precision (1 min) ^d	5.3	0.09	0.3
Overall uncertainty	7.5	0.23	3.3

^a For COS: defined as the standard deviation of the measurements associated with the cylinder calibration. For CO₂ and CO: certified by the WMO central calibration laboratory (NOAA/ESRL).

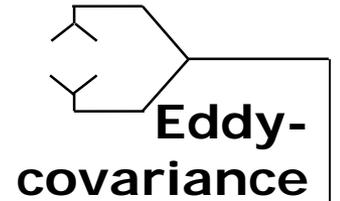
^b Average uncertainty over four cylinders in Table 2 (method 3).

^c Using the single bias correction (see Sect. 2.2.2) it is the same as transferring the scale to the working standards.

^d The standard deviation over minute-averaged cylinder measurements after drift correction with reference measurements every 30 min (Table 3).



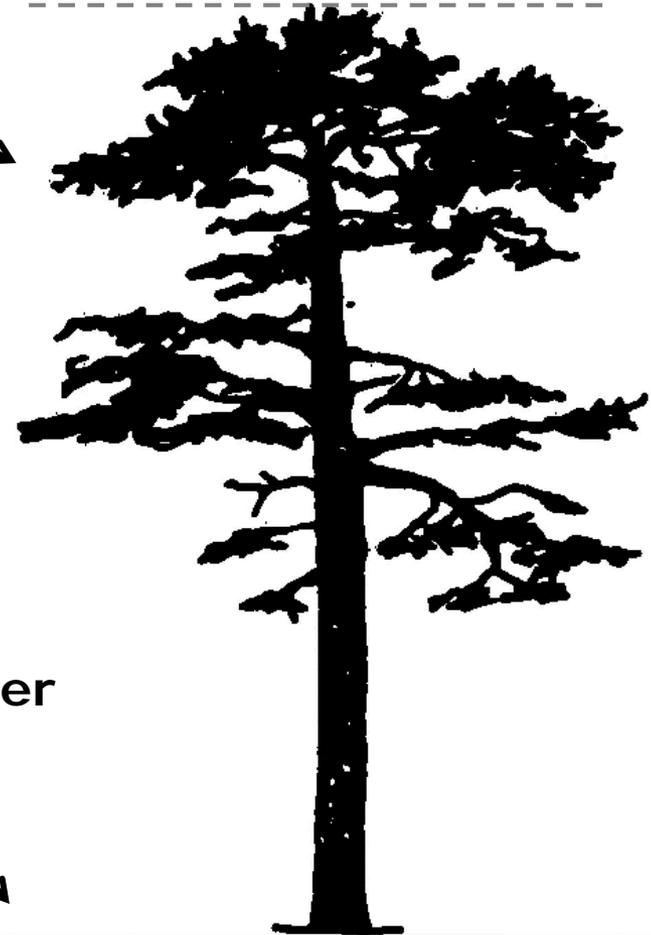
Measurement setup



**Branch
chamber
fluxes**

17 m

2016-2017

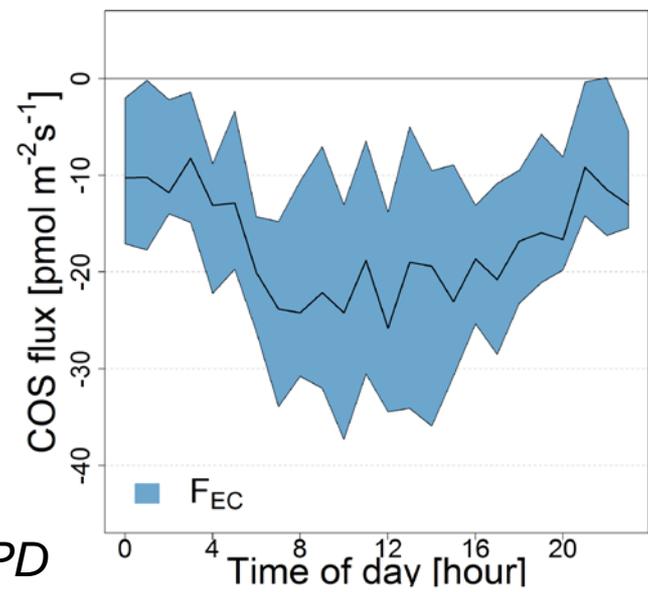
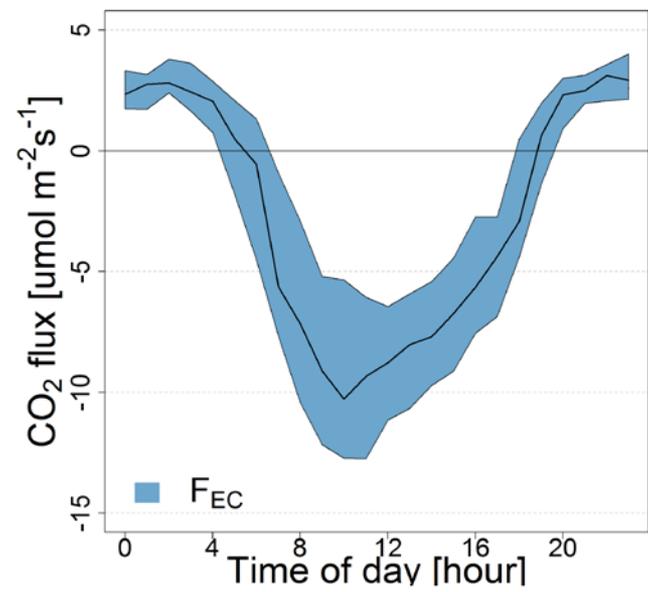
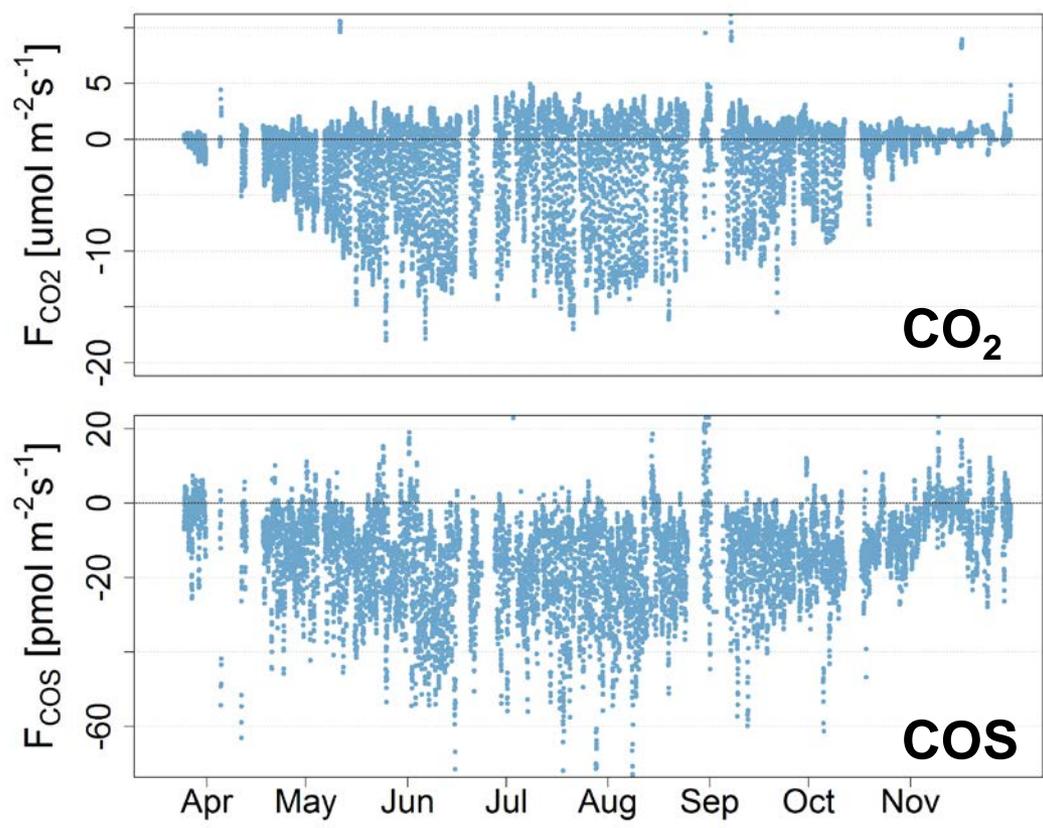


2015-2016

**Soil chamber
fluxes**

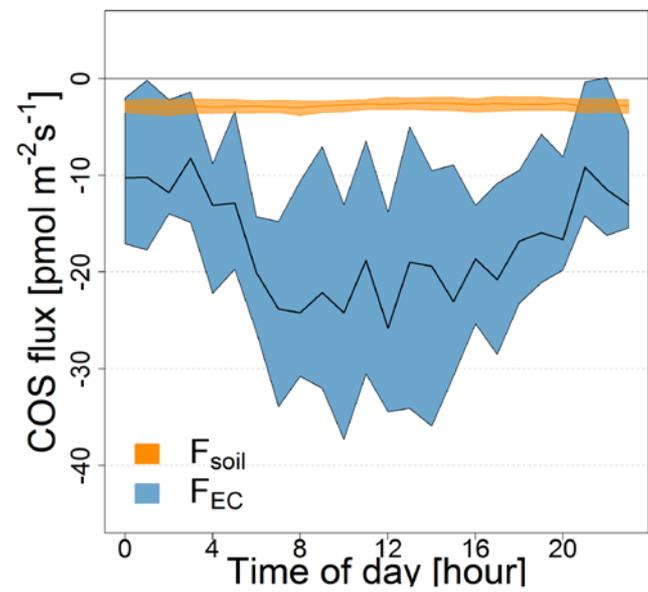
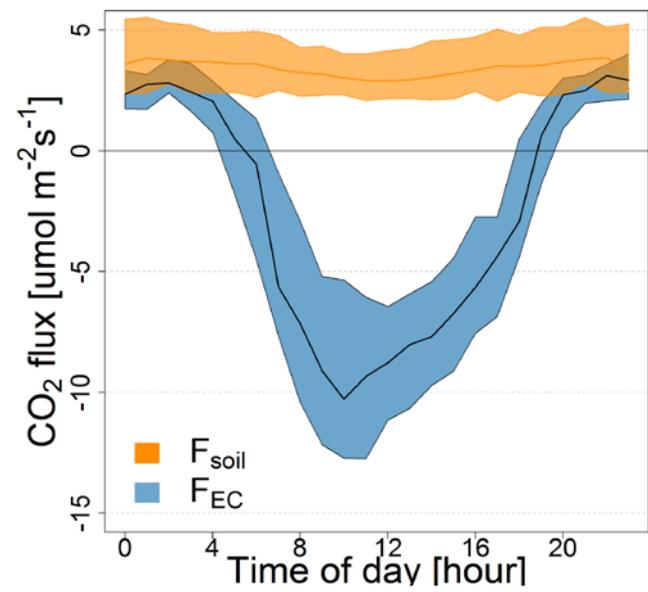
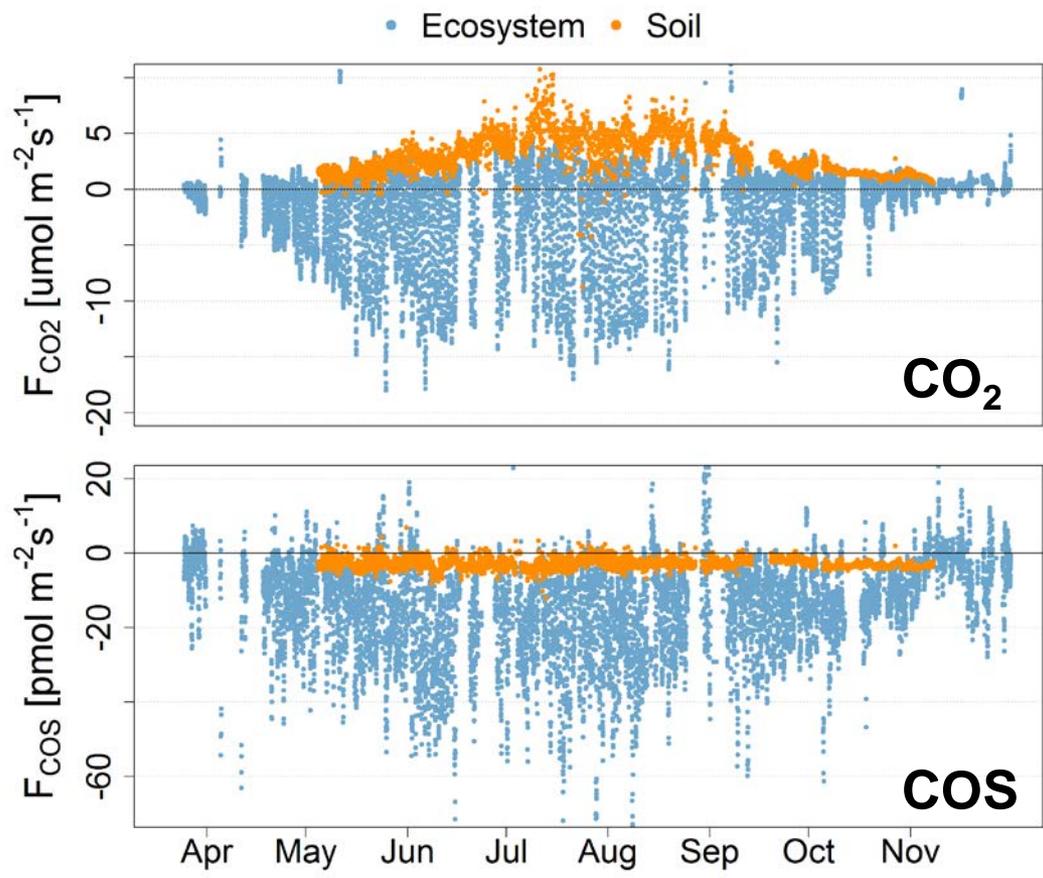


Ecosystem COS and CO₂ flux



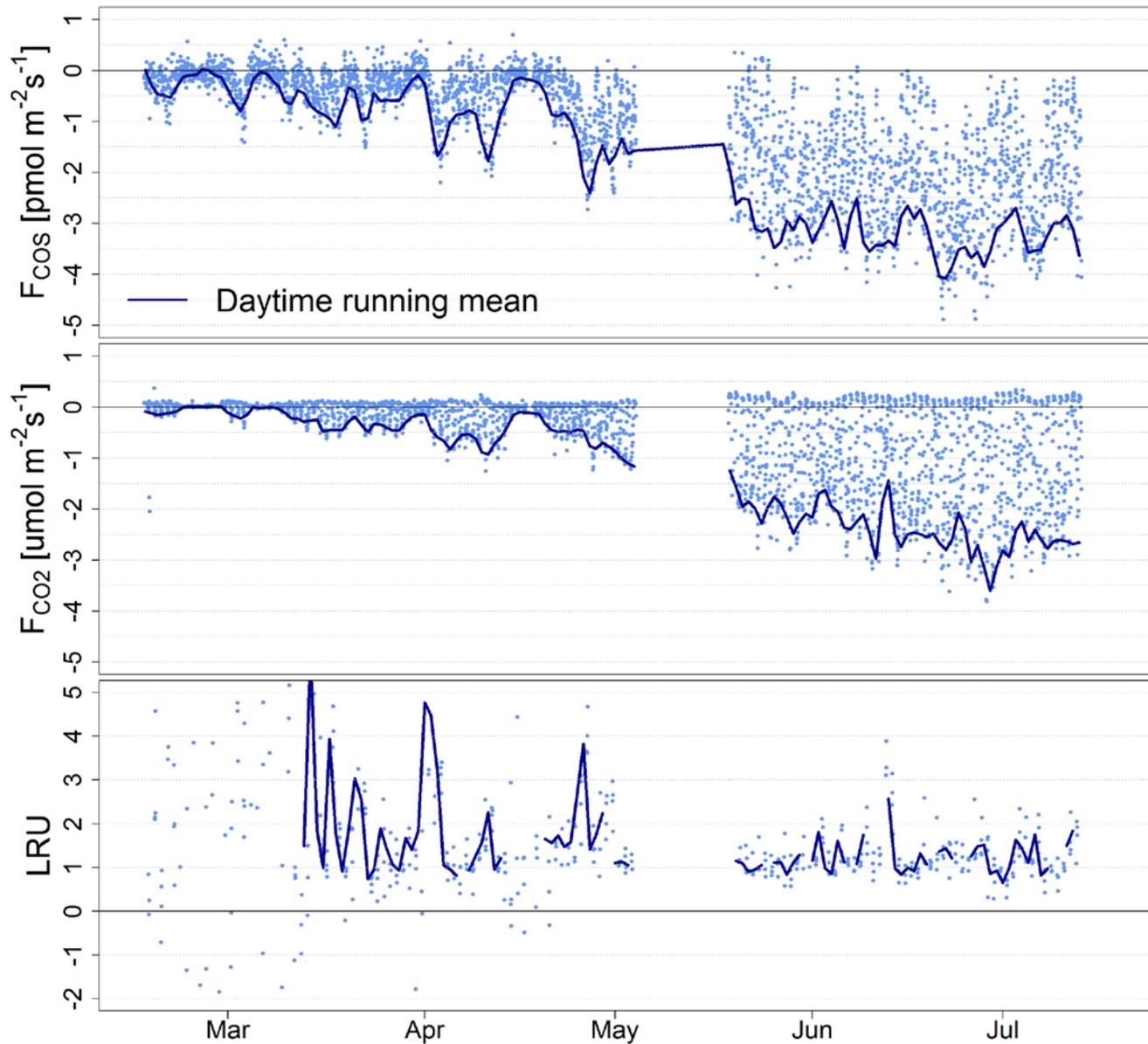
Night-time COS uptake contributes to 13 % of total daily uptake.

Ecosystem and soil COS and CO₂ flux



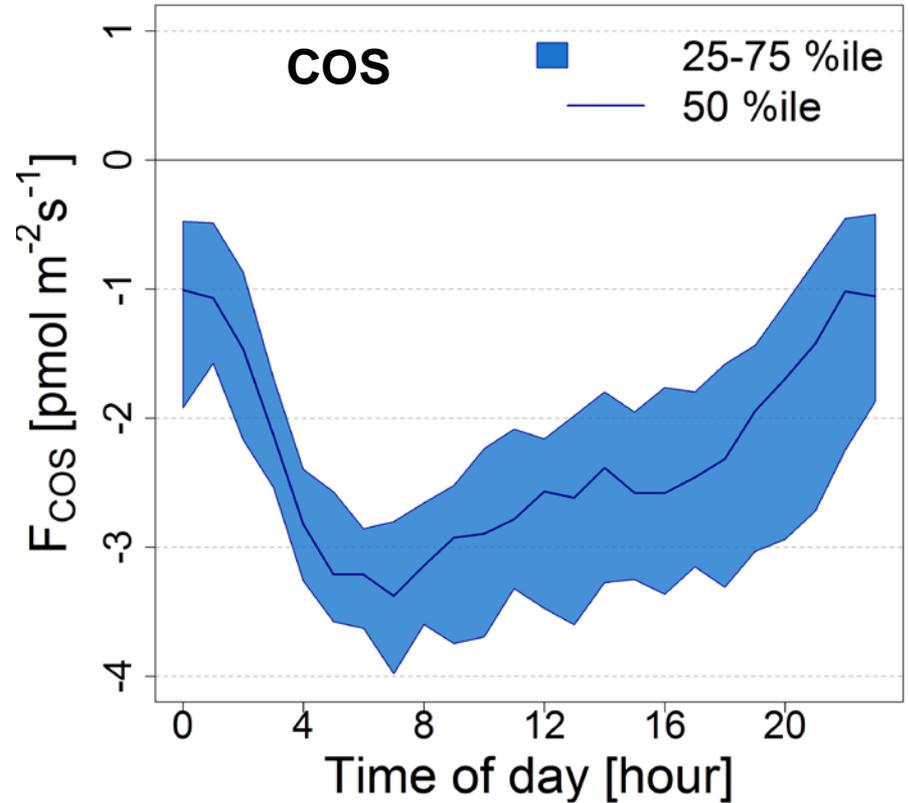
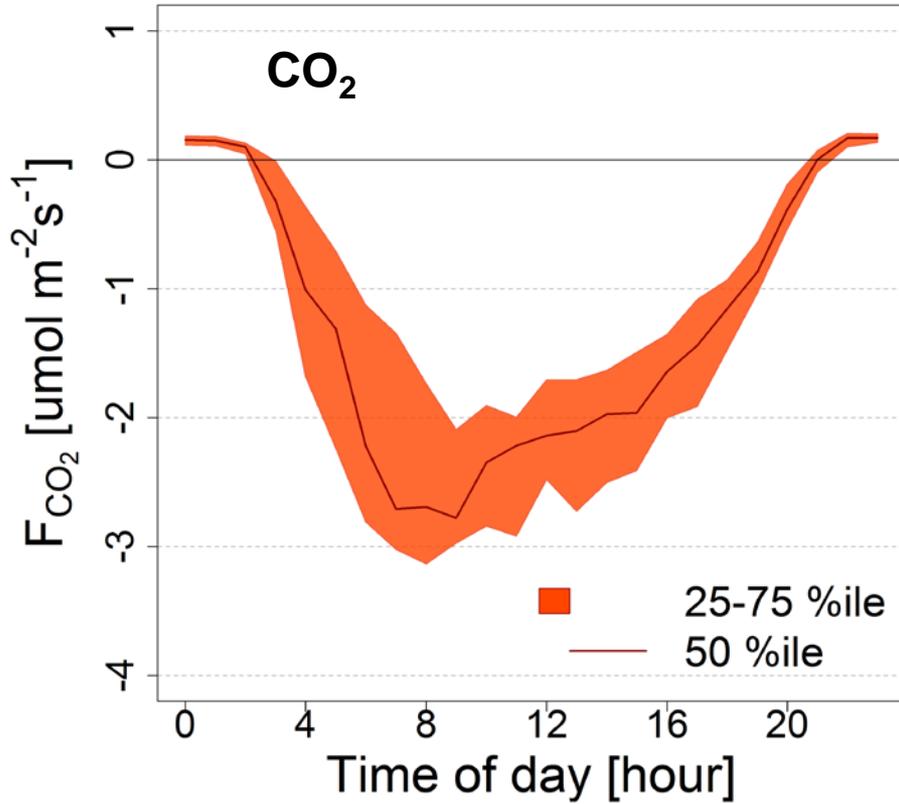
Magnitude of soil flux compared to
 total ecosystem COS flux:
 Night-time: 34-40 %
 Day-time: 13 %

Branch COS and CO₂ flux

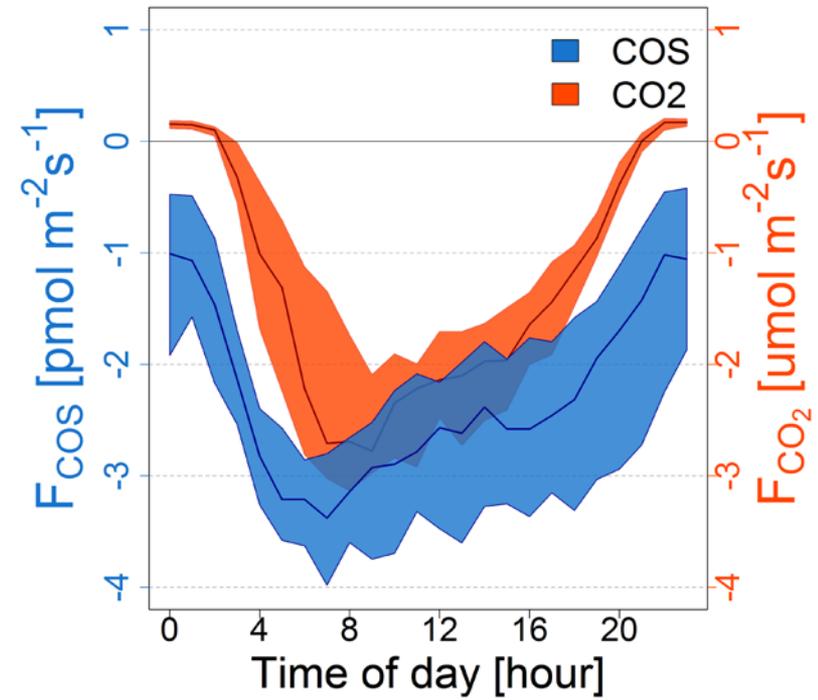
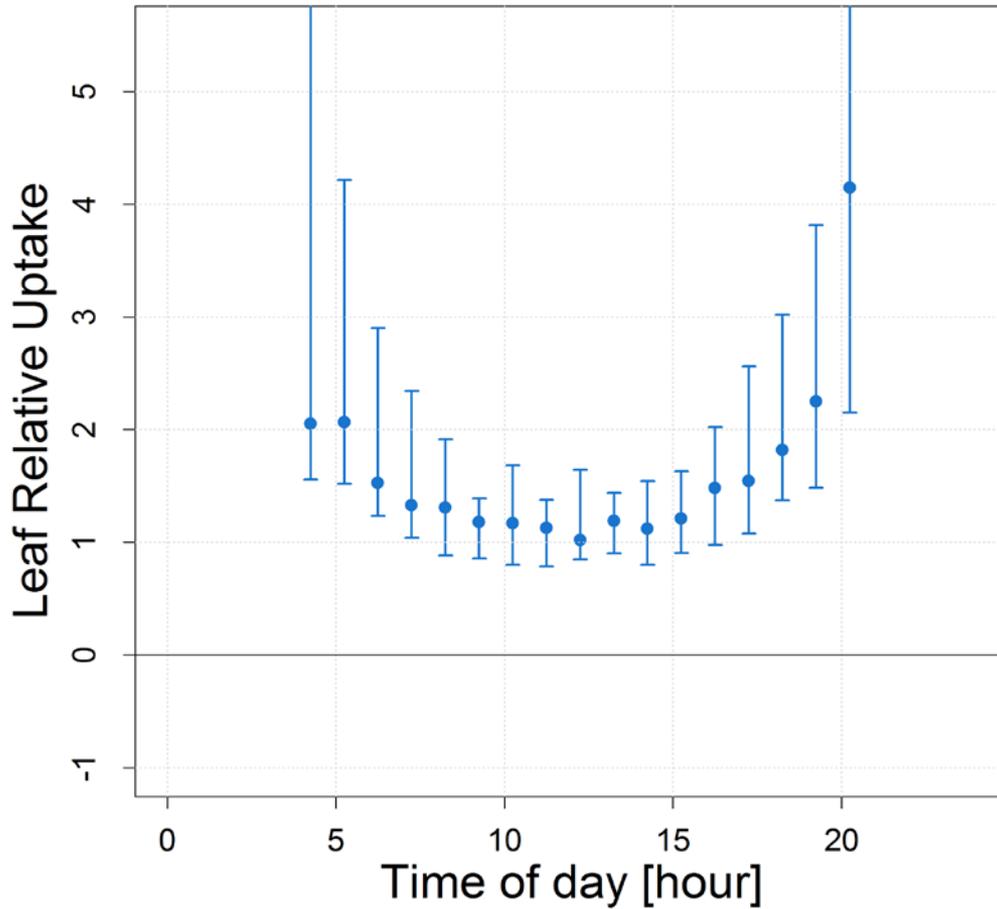


$$LRU = F_{CO_2} / F_{CO_2} * CO_2 / COS$$

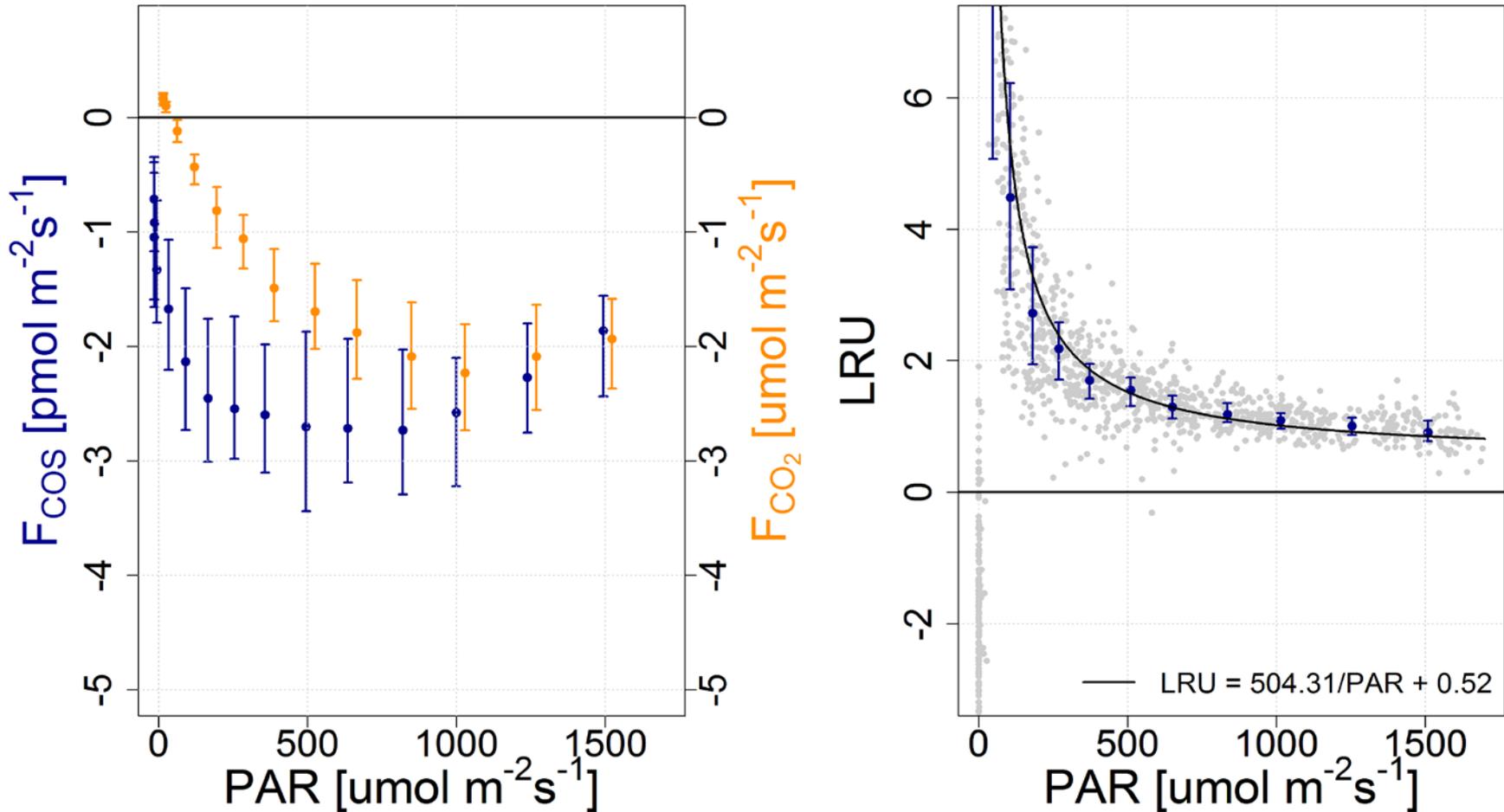
Branch COS and CO₂ flux



Leaf Relative Uptake (LRU)

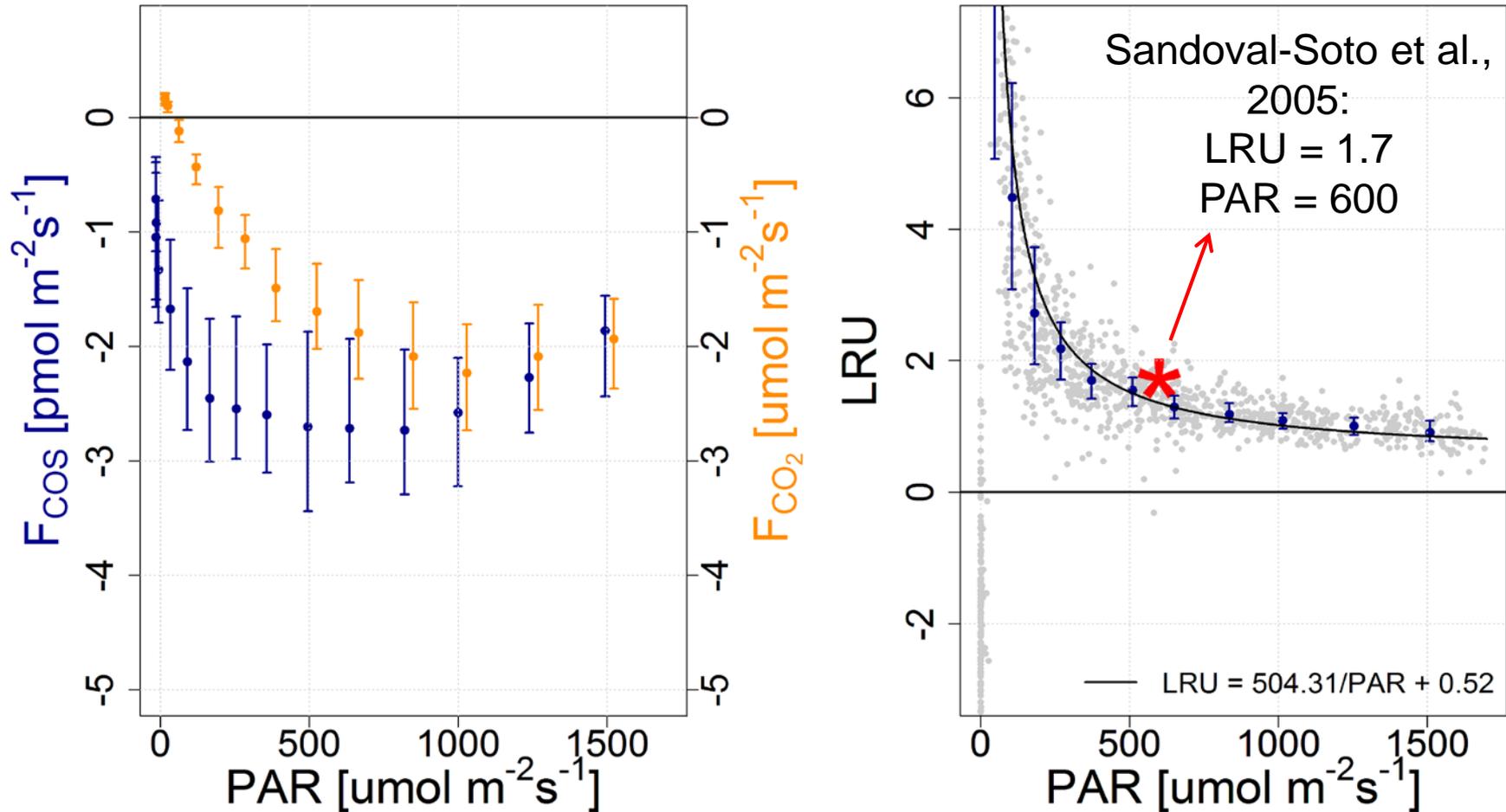


Different response of COS and CO₂ fluxes to PAR



Earlier studies: $\text{LRU} = 1.5 - 2.5$

Different response of COS and CO₂ fluxes to PAR



Earlier studies: LRU = 1.5 – 2.5

Summary

Atmospheric measurement: dry mole fraction, pay attention to the scale

Nighttime COS uptake $\sim 13\%$ of total daily uptake. Daytime COS uptake by soil $\sim 13\%$ of the ecosystem COS flux.

The non-constant LRU should be taken into account in COS-based GPP estimates

