

# **Carbonyl sulfide – a new window into the carbon cycle**

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# Outline



- Carbonyl sulfide – what is it?
- COS and photosynthesis
- The atmospheric imprint of global photosynthesis
- Carbon cycle terminology
- The gross primary productivity dilemma
- Using COS to infer gross primary productivity



## Carbonyl sulfide

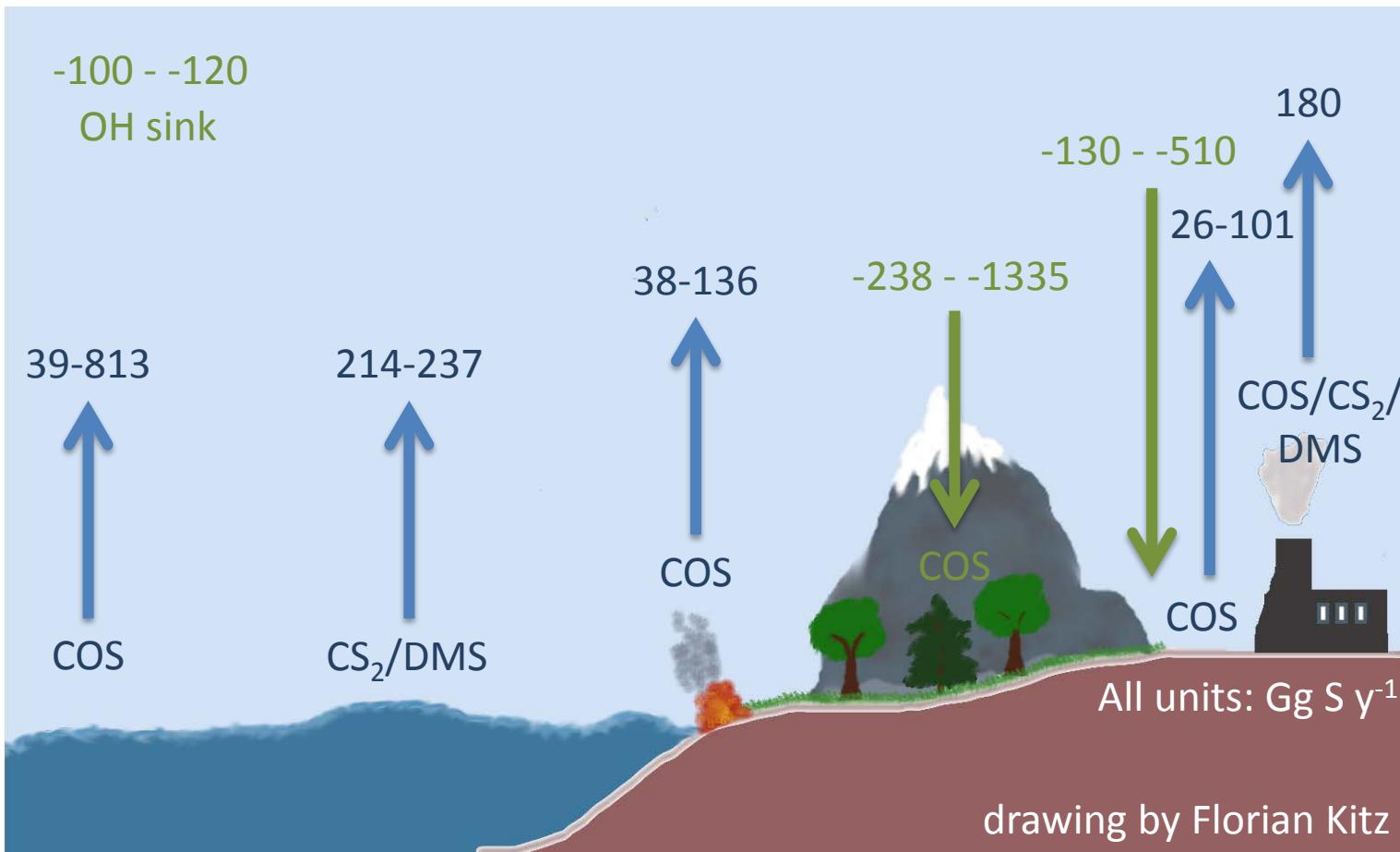


- Abbreviation: COS or OCS
- Most abundant sulfur-containing gas in atmosphere
- Present global annual average mixing ratio: 500 ppt
- Atmospheric lifetime: ca. 1-3 years



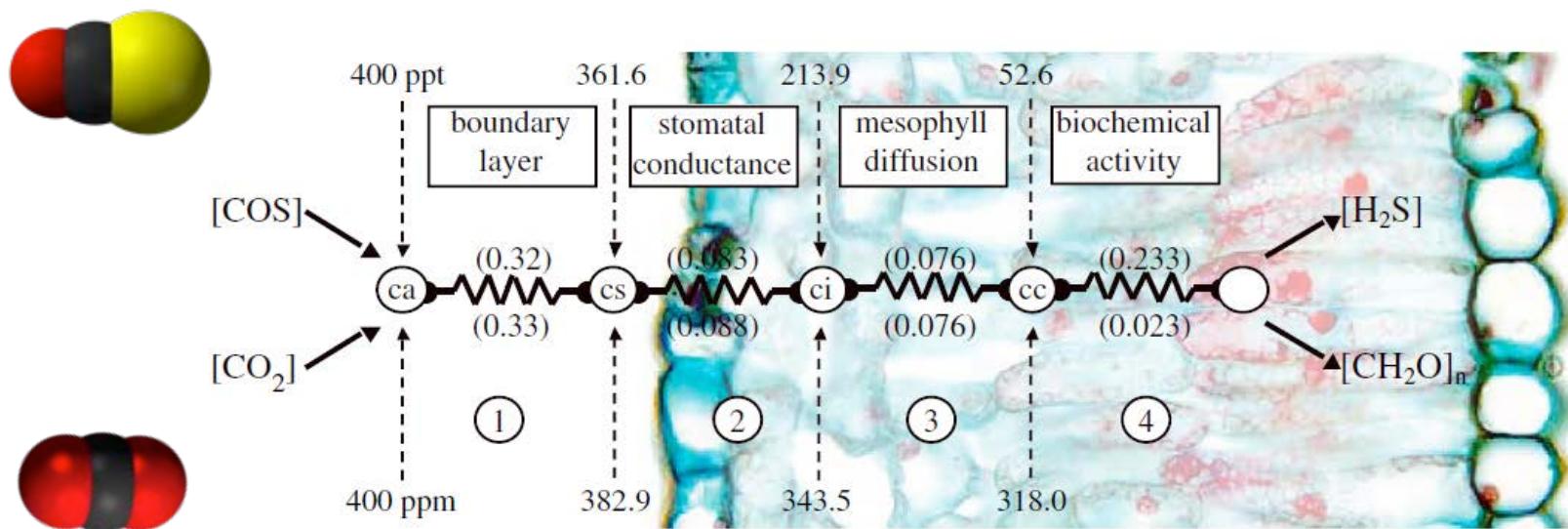


# Global COS cycle



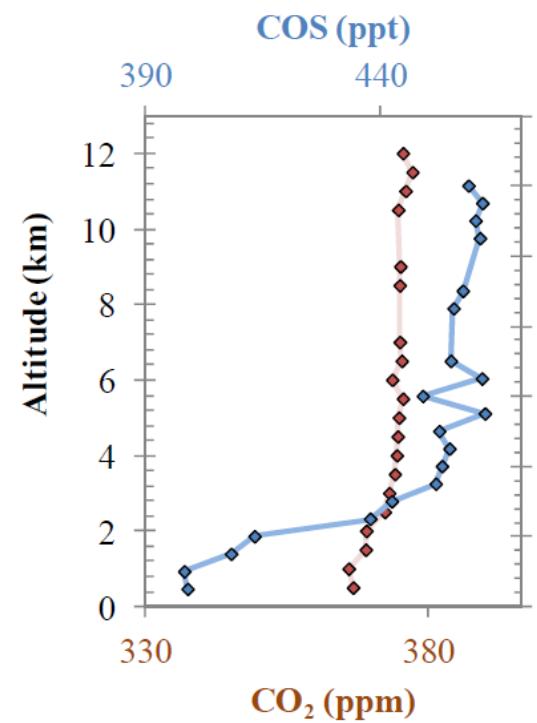
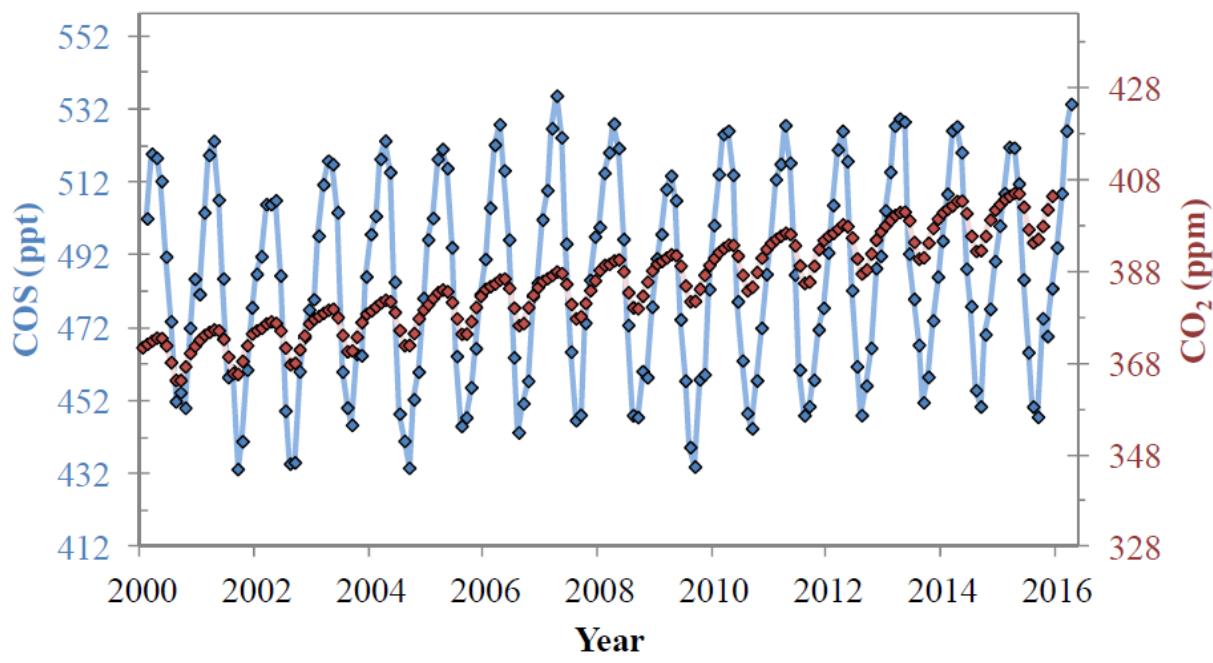


# COS and photosynthesis



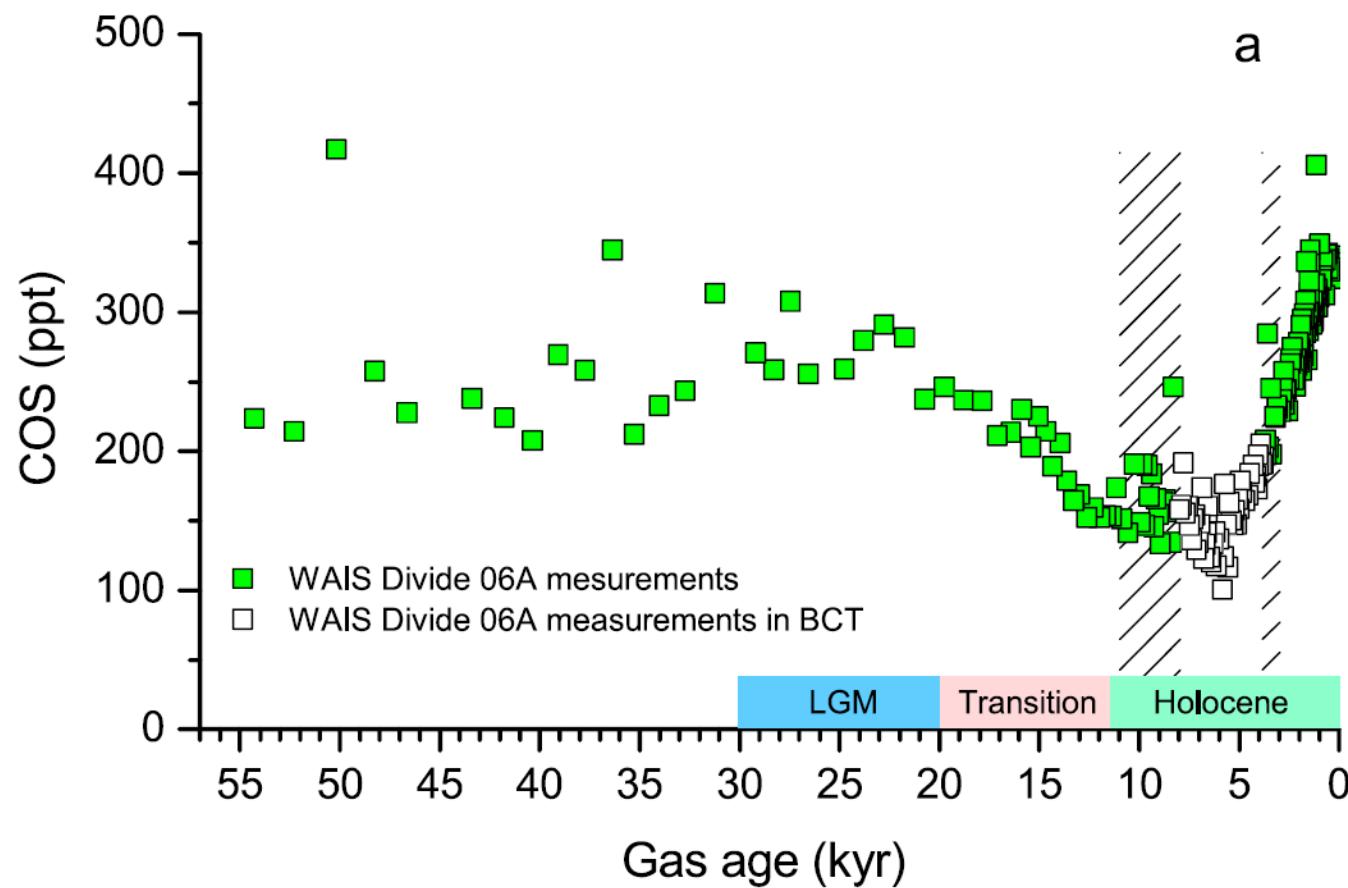


# COS and CO<sub>2</sub>



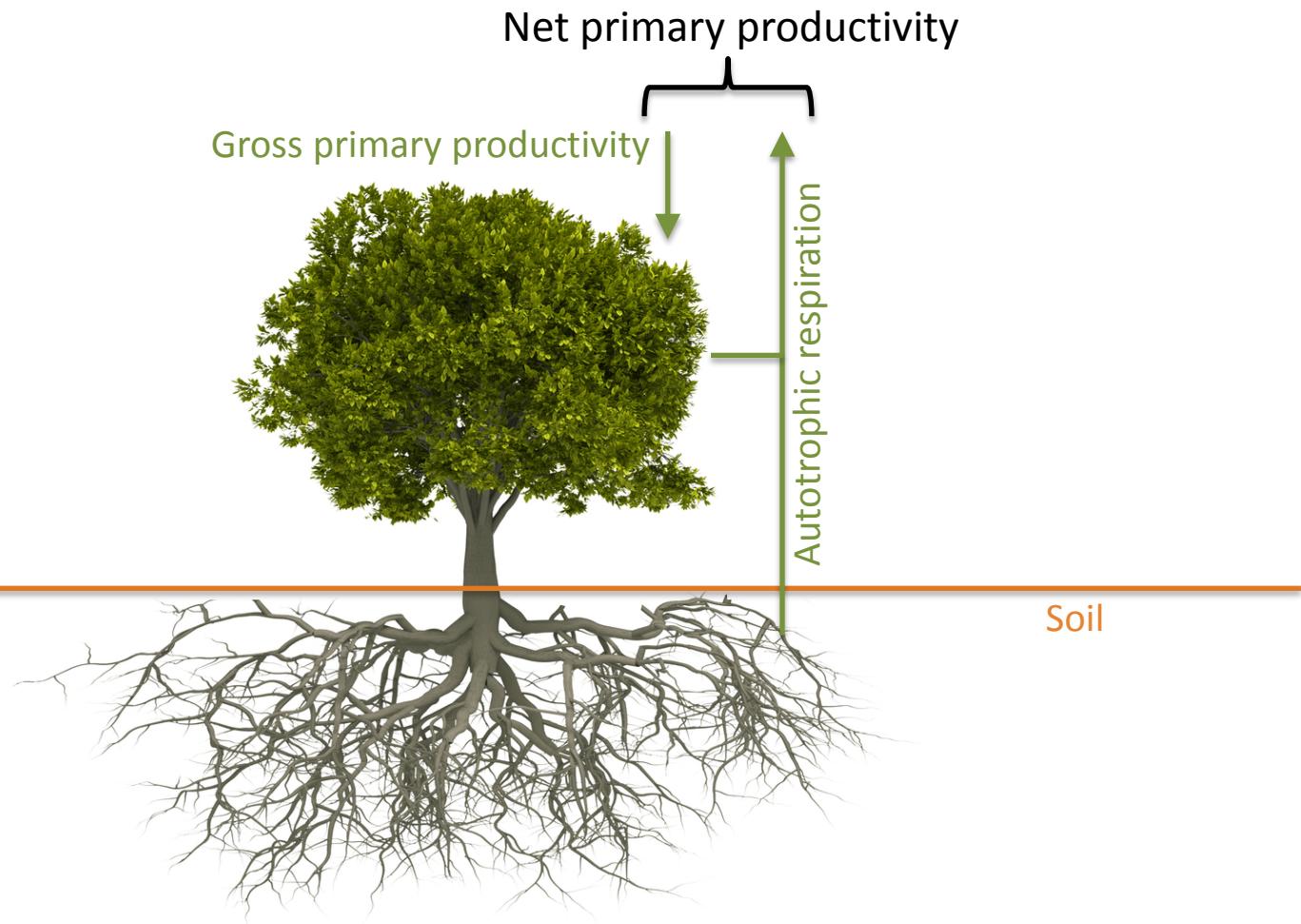


# COS in ice cores



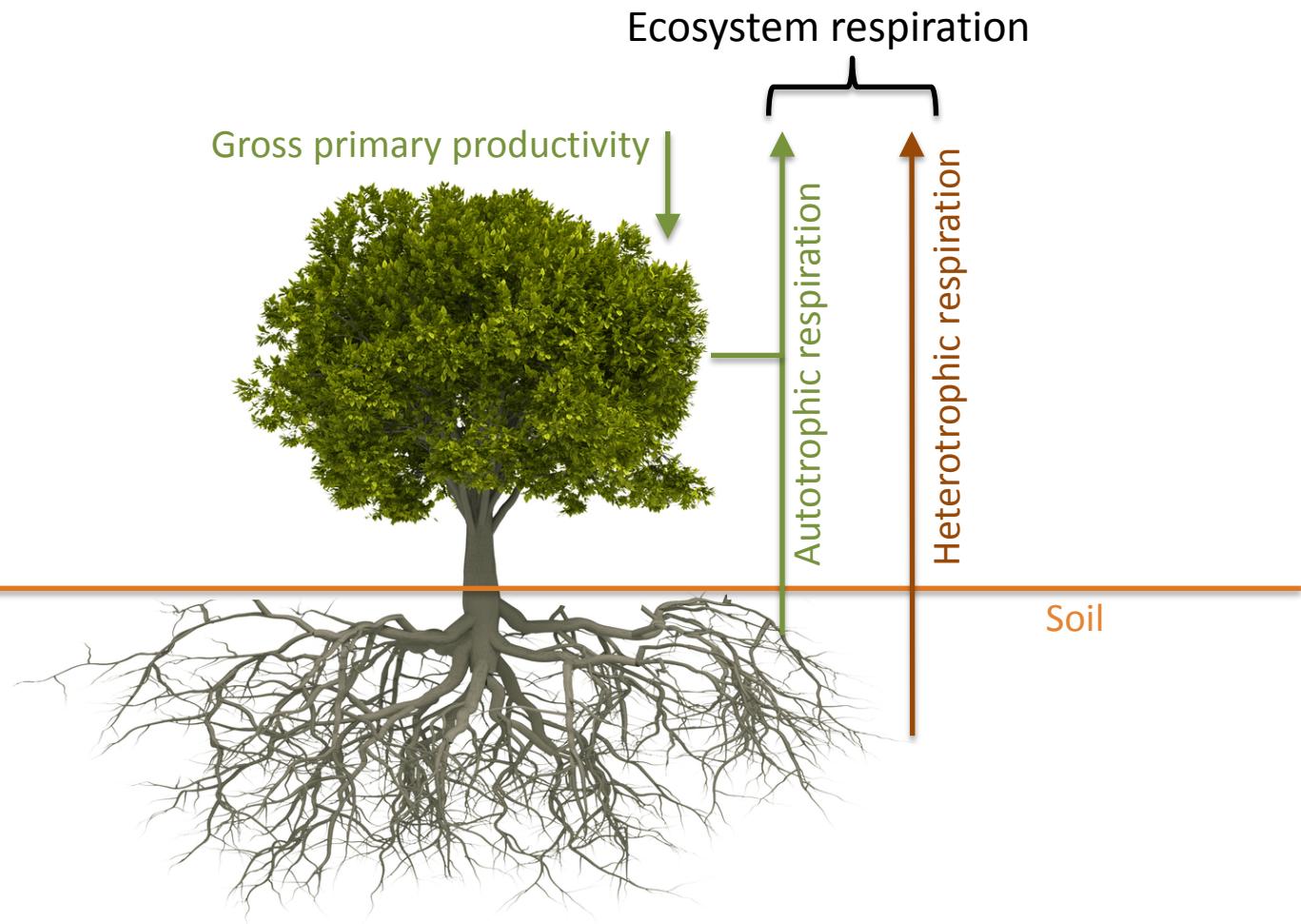


# Terrestrial carbon cycle





# Terrestrial carbon cycle





# Terrestrial carbon cycle

Net ecosystem productivity

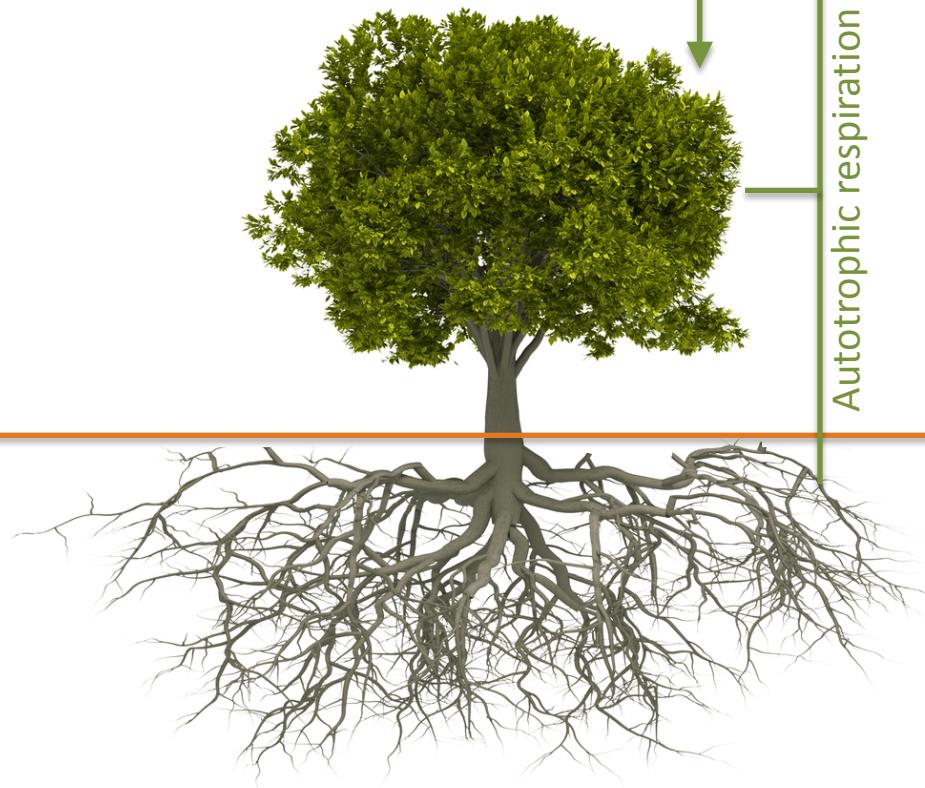
Gross primary productivity



Autotrophic respiration

Heterotrophic respiration

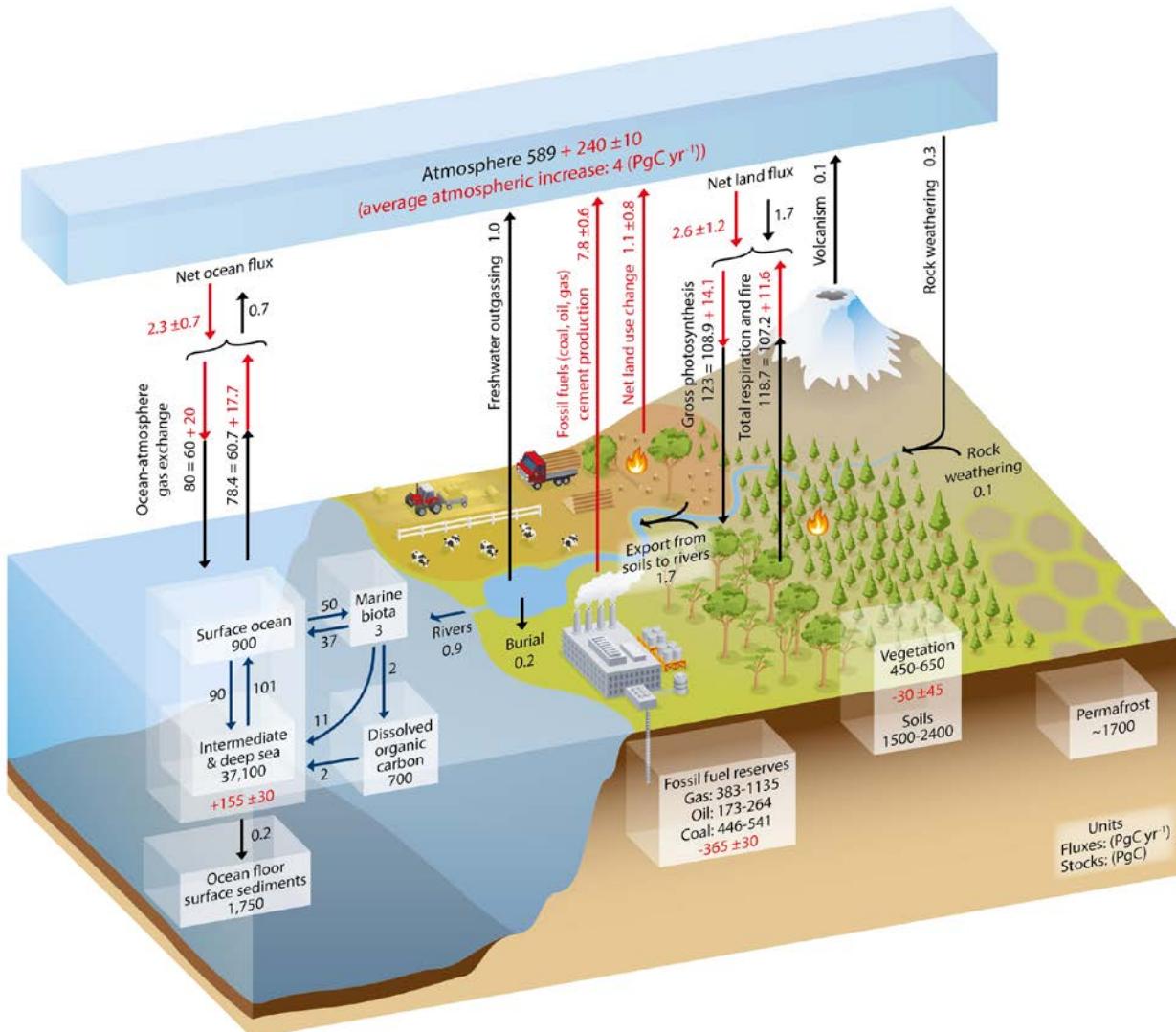
Soil





# Global carbon cycle

1 ppm  $\approx 2.12 \text{ PgC}$





# Terrestrial carbon cycle

Net ecosystem productivity

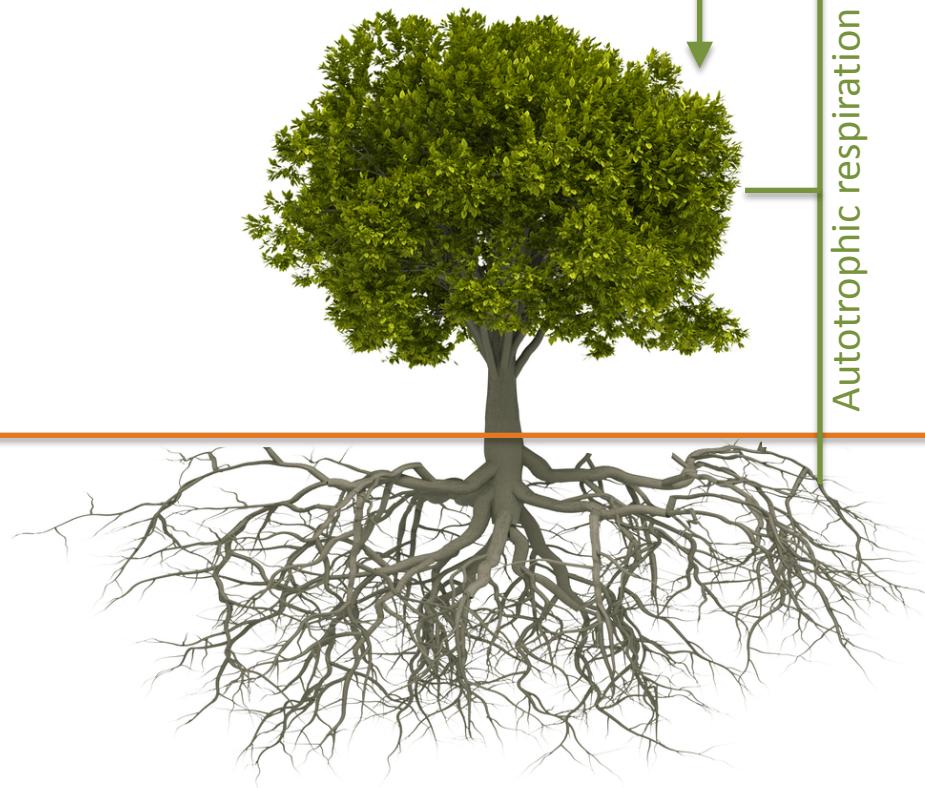
Gross primary productivity



Autotrophic respiration

Heterotrophic respiration

Soil





# The GPP dilemma

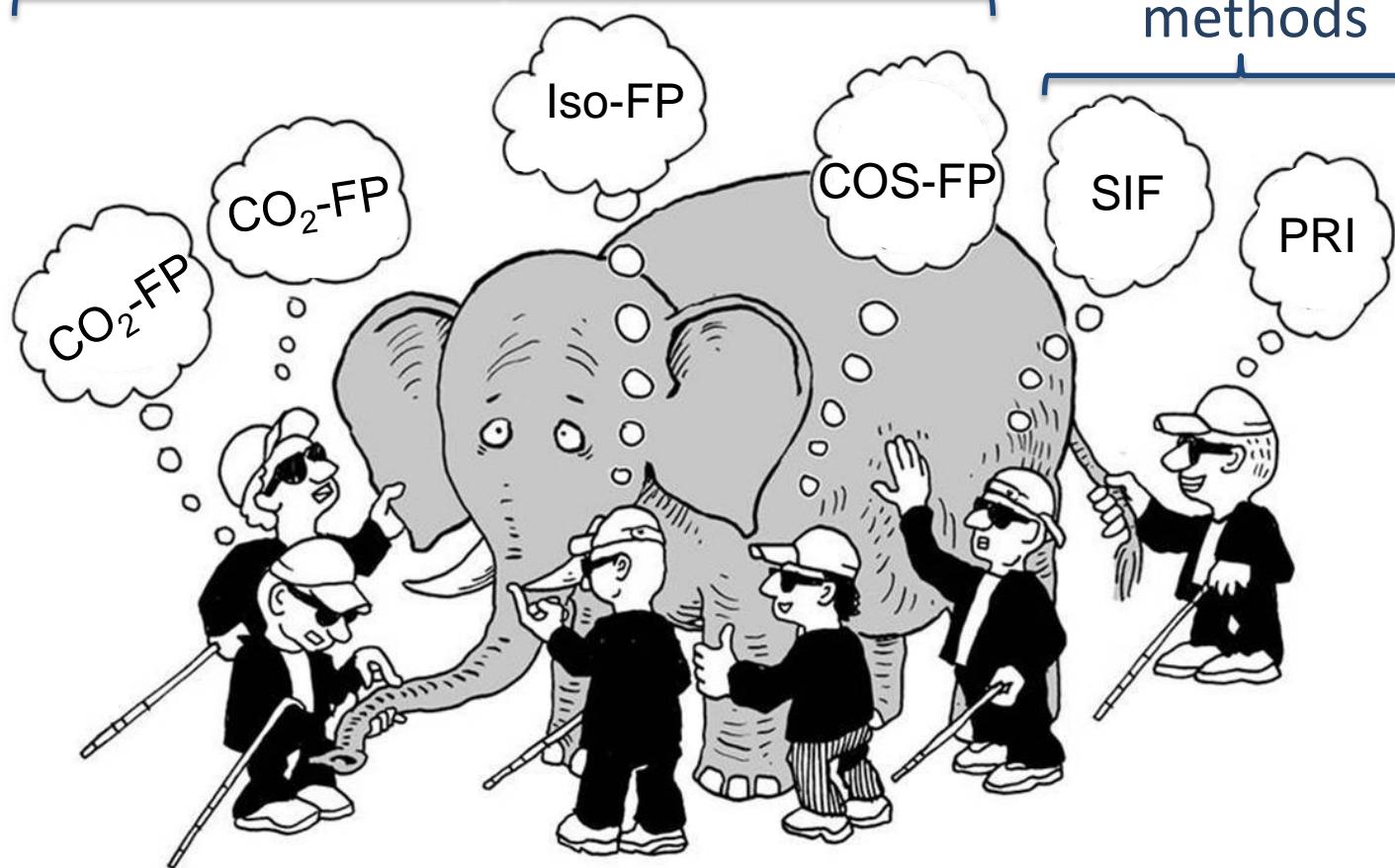
Measurements → Model → GPP



# Multiple constraints on GPP

Flux partitioning (FP) methods

Light use  
efficiency (LUE)  
methods

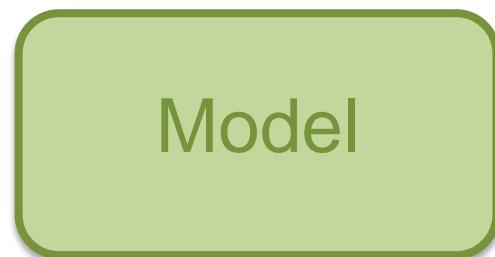




# COS flux partitioning



Measurements →



→ GPP

$F_{\text{cos}}$ ,  $\chi_{\text{cos}}$ ,  $\chi_{\text{CO}_2}$

$$\lambda = (F_{\text{cos}} / \chi_{\text{cos}}) /$$

$$(GPP / \chi_{\text{CO}_2}) \approx \text{const.}$$

no other COS sources or sinks

$$GPP = (\chi_{\text{CO}_2} / \chi_{\text{cos}}) \cdot (F_{\text{cos}} / \lambda)$$



# COS flux partitioning

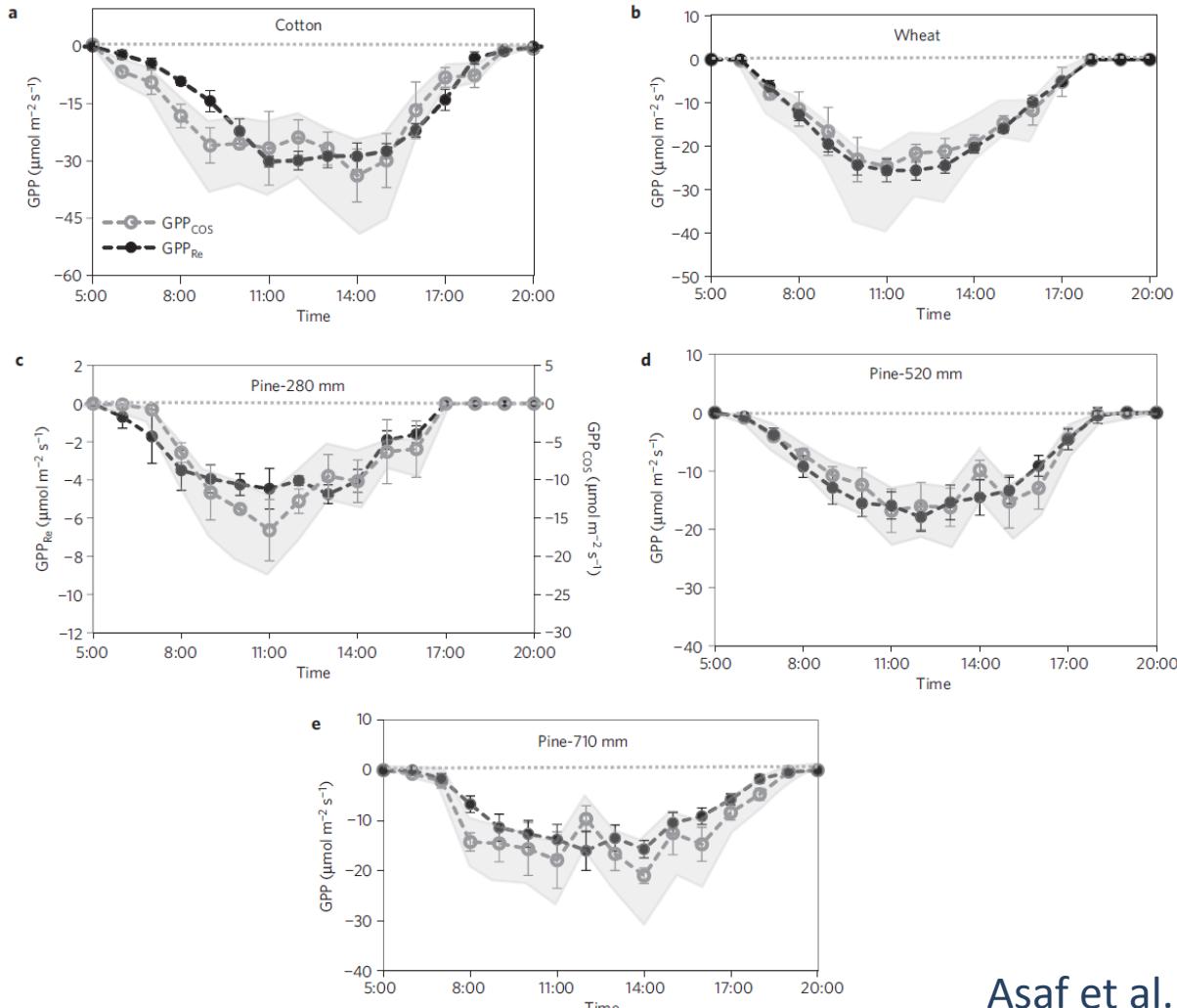
**Table 1.** Normalized Leaf Relative Uptake Values Across the Campaign

Genus (Species)	Mean	Median	n	Hour of Day	Temperature (C)	Site
<i>Malus</i> sp.	2.1	2.1	2	12.2	37.9	GH
<i>Fraxinus</i> sp.	1.6	1.5	4	14.7	38.0	GH
<i>Acer</i> sp.	2.3	2.3	2	10.6	33.0	GH
<i>Catalpa</i> sp.	1.7	1.7	5	13.5	39.4	GH
<i>Betula</i> sp.	1.6	1.5	3	15.2	38.8	GH
<i>Populus fremontii</i>	<b>4.9</b>	4.9	3	15.8	40.9	GH
<i>Ulmus</i> sp.	1.9	1.8	3	11.2	34.3	GH
<i>Gleditsia</i> sp.	1.4	1.4	2	11.8	35.1	GH
<i>Pinus ponderosa</i>	1.3	1.4	3	12.7	NaN	GH
<i>Quercus</i> sp.	1.5	1.6	4	10.8	NaN	GH
<i>Populus tremuloides</i>	1.6	1.6	19	13.5	32.5	NWR
<i>Pinus flexillis</i>	1.5	1.4	15	12.1	29.9	NWR
<b>All Samples<sup>a</sup></b>	<b>1.7</b>	<b>1.6</b>	65	-	-	-

<sup>a</sup>Daytime (9:00-17:00 local time) LRU (unitless) for all measured tree genera. Excluding *Populus fremontii*. Bold numbers denote the outlying value of *Populus fremontii* and the average (mean and median) LRU that emerges from all measurements.

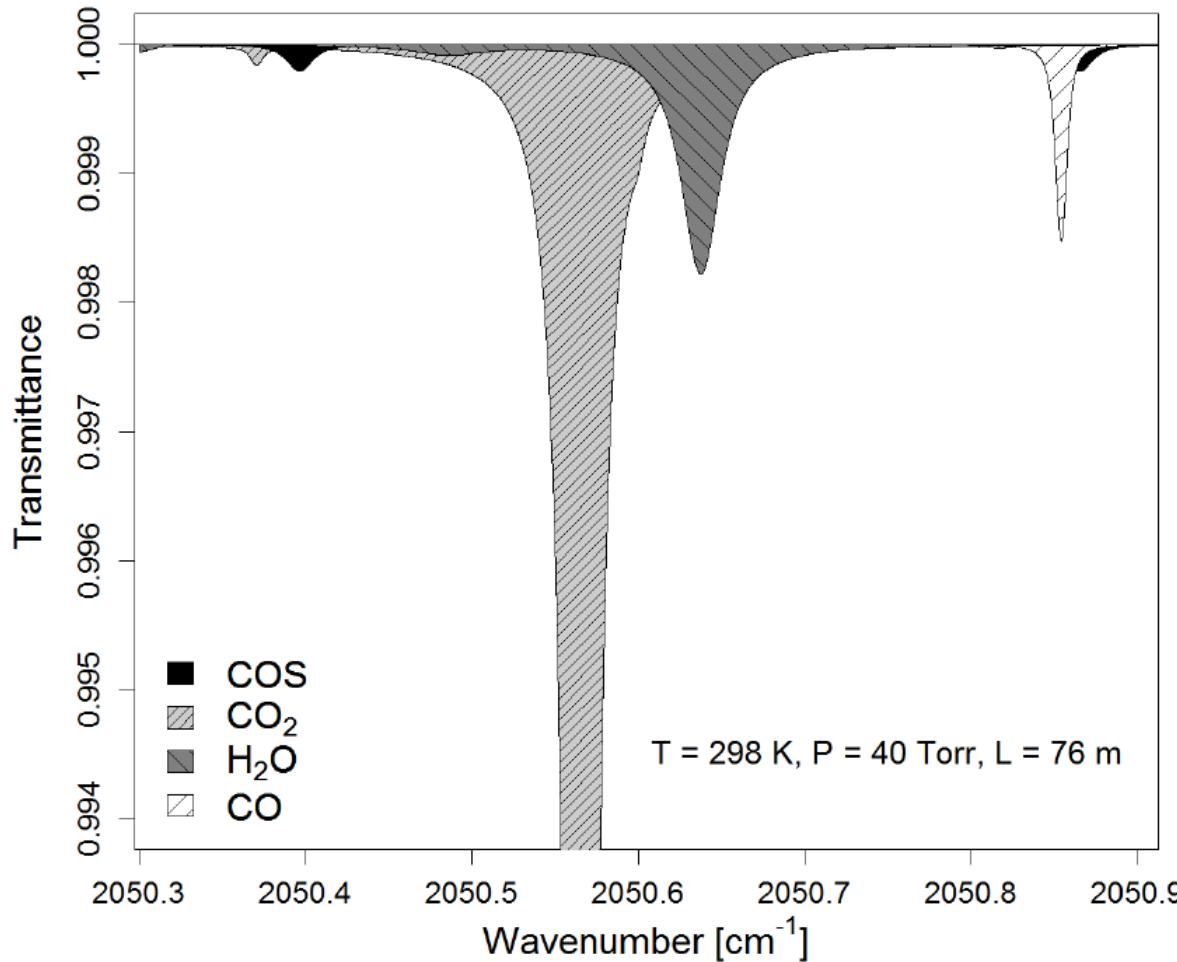


# COS flux partitioning





# Laser spectroscopy



[www.aerodyne.com](http://www.aerodyne.com)



# Activities 2015-2016

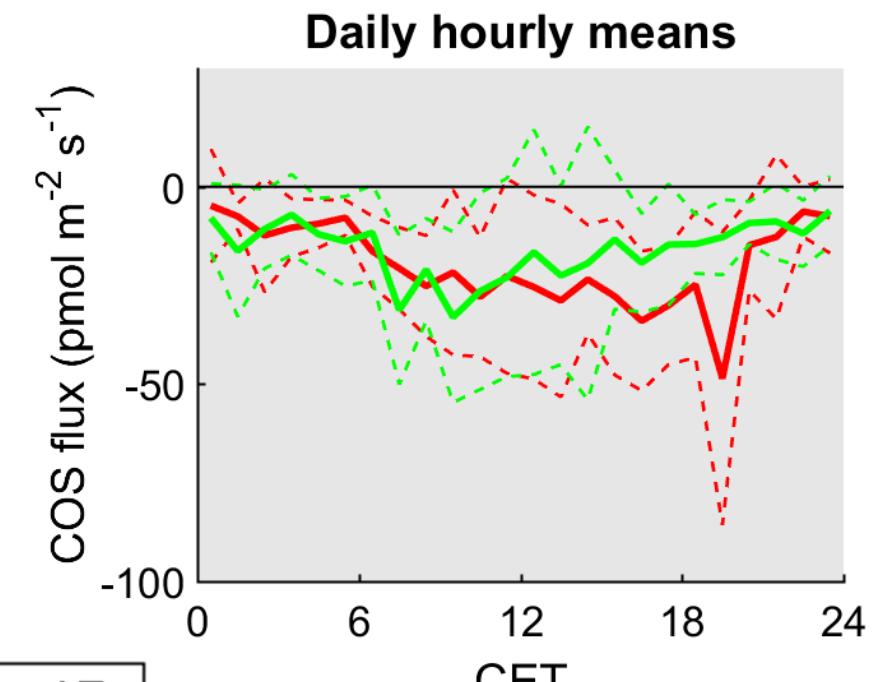
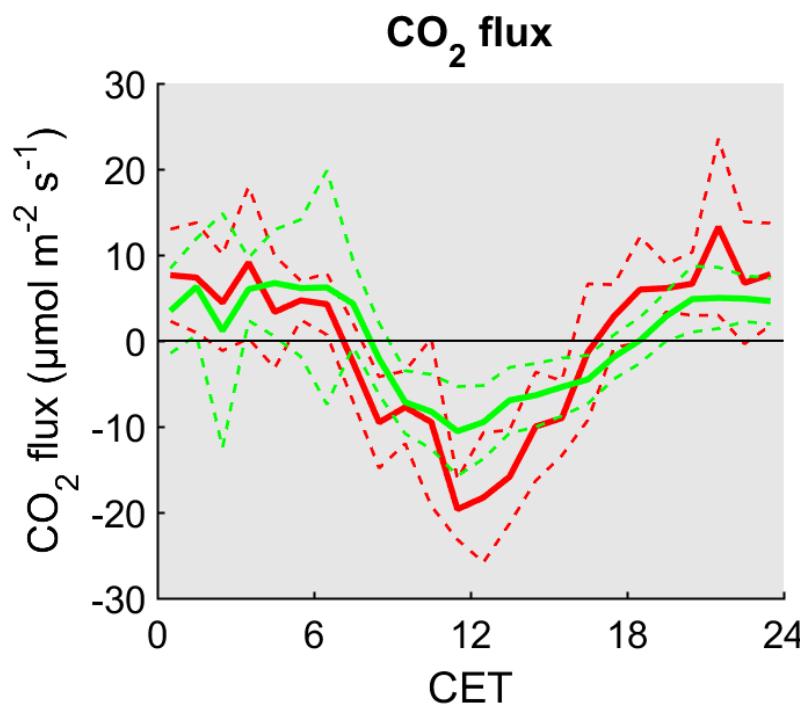
**FWF**

Der Wissenschaftsfonds.





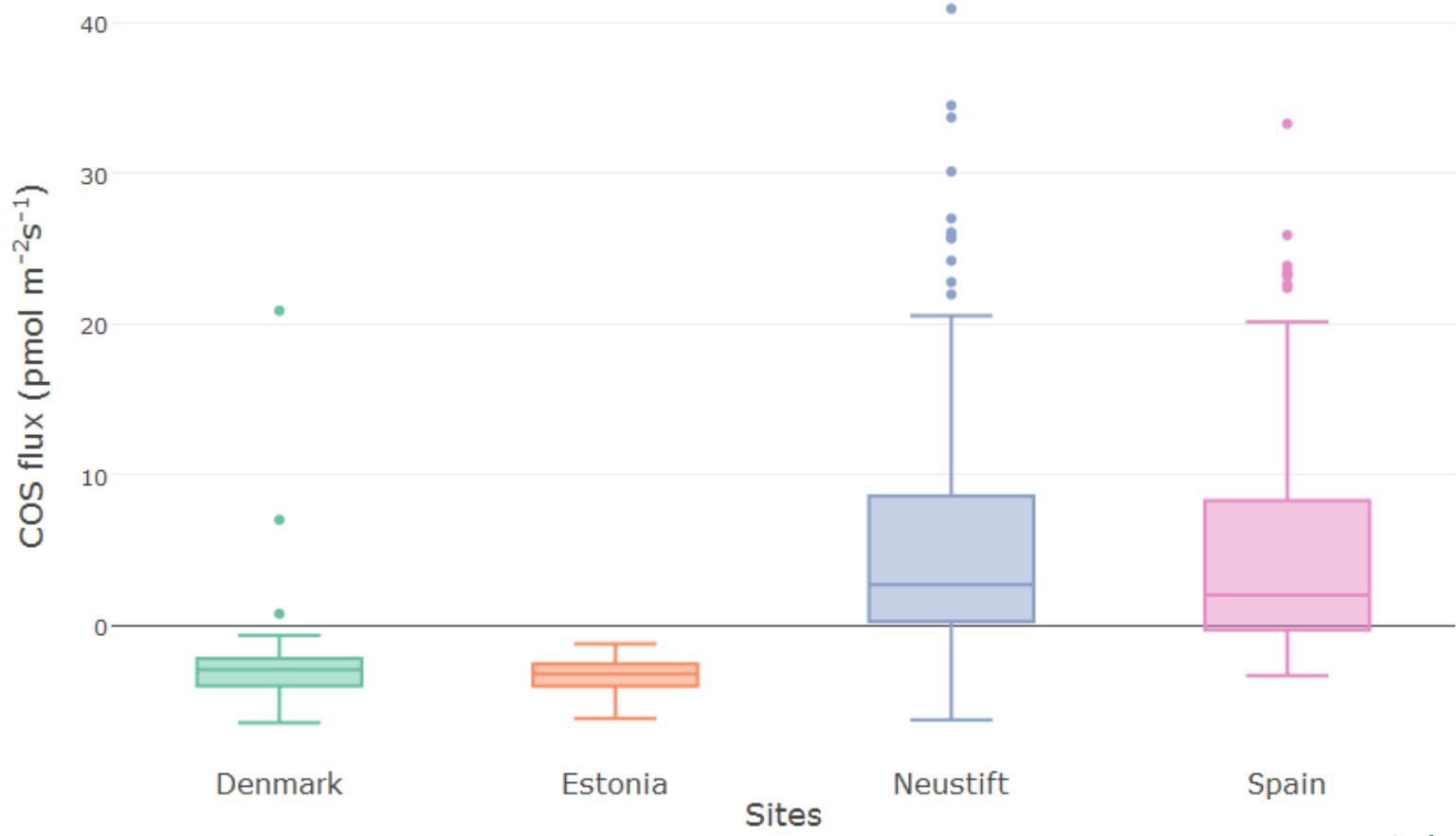
# Ecosystem-scale



— AT  
— ESP



# Soil complications



Kitz et al. (in prep.)



## Take-home message



- Carbonyl sulfide – a key component in the multiple constraints approach for narrowing down uncertainty of GPP
- Huge potential for global scale analyses combining satellite measurements and transport modelling
- COS and stomatal conductance – even more promising?!



# Anthropogenic COS

