On Extrapolating Nighttime Ecosystem Respiration To Daytime Conditions and Implications for Gross Primary Productivity Estimation

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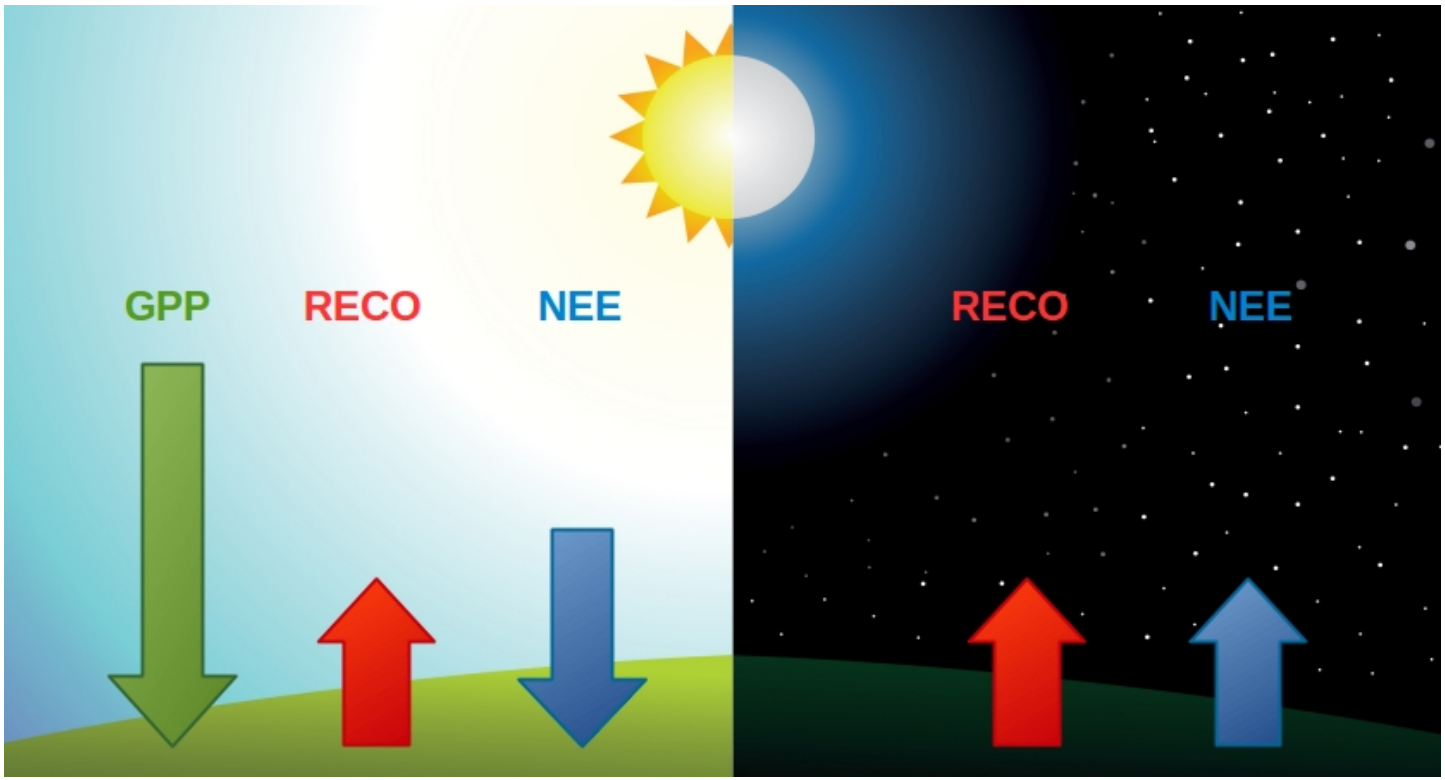
Eddy covariance flux partitioning algorithms

GPP = Reco - NEE



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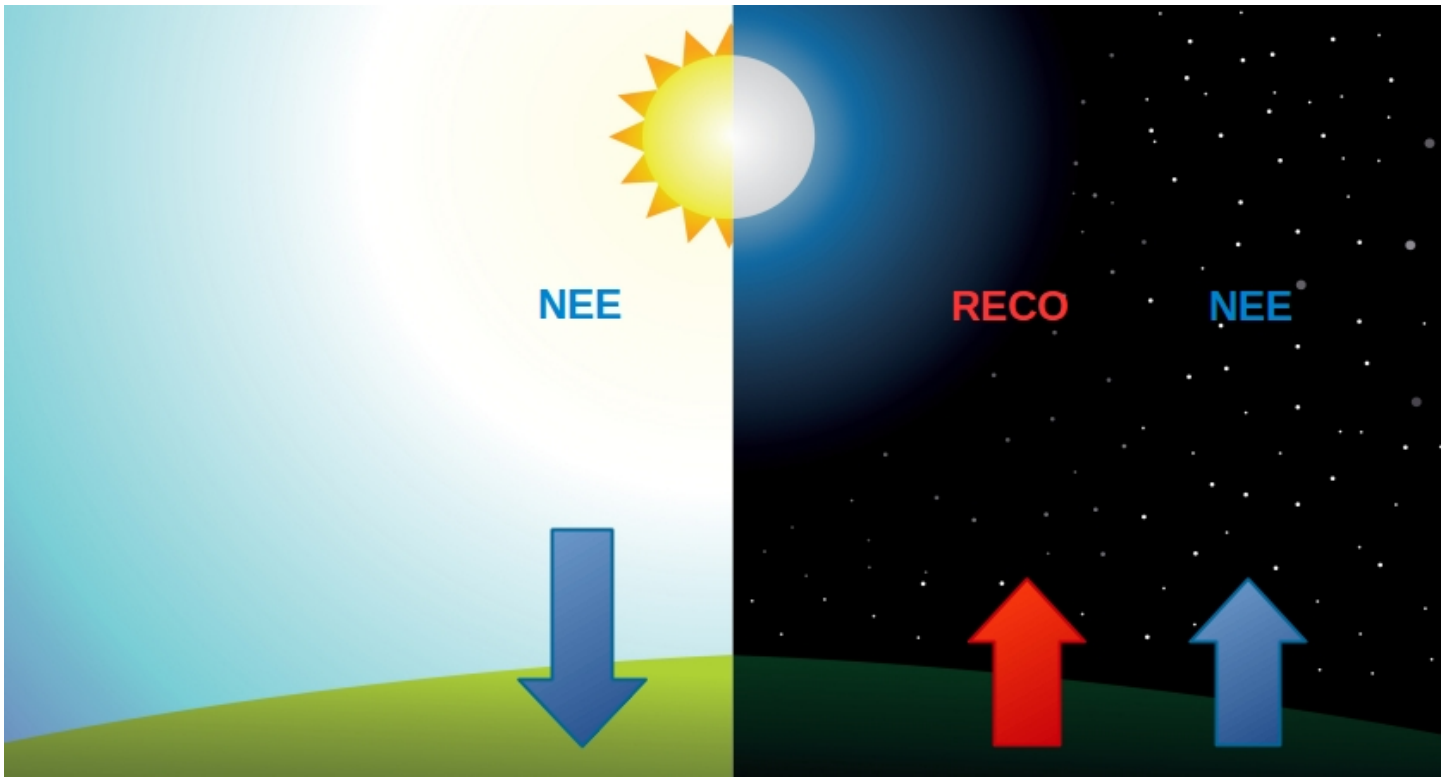

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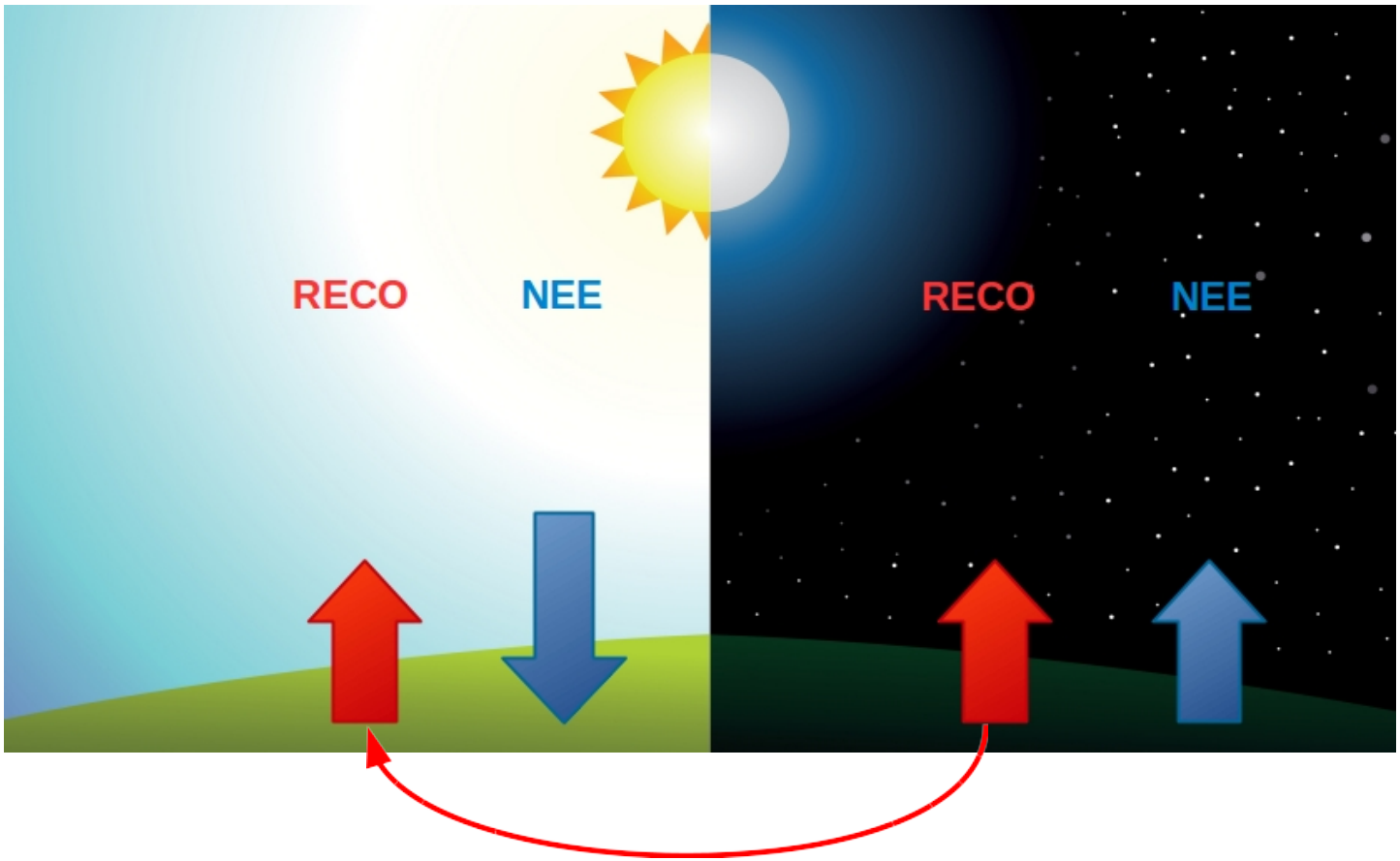

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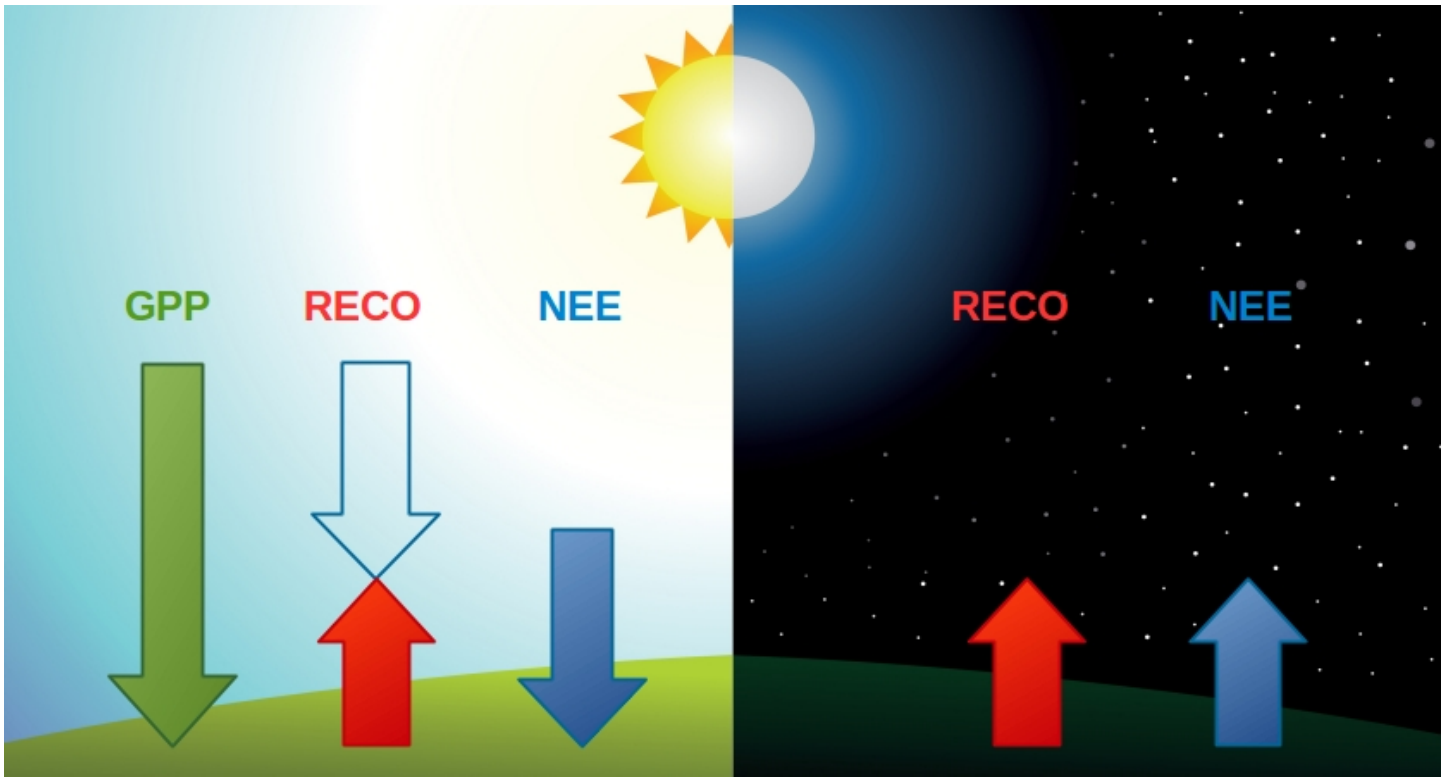

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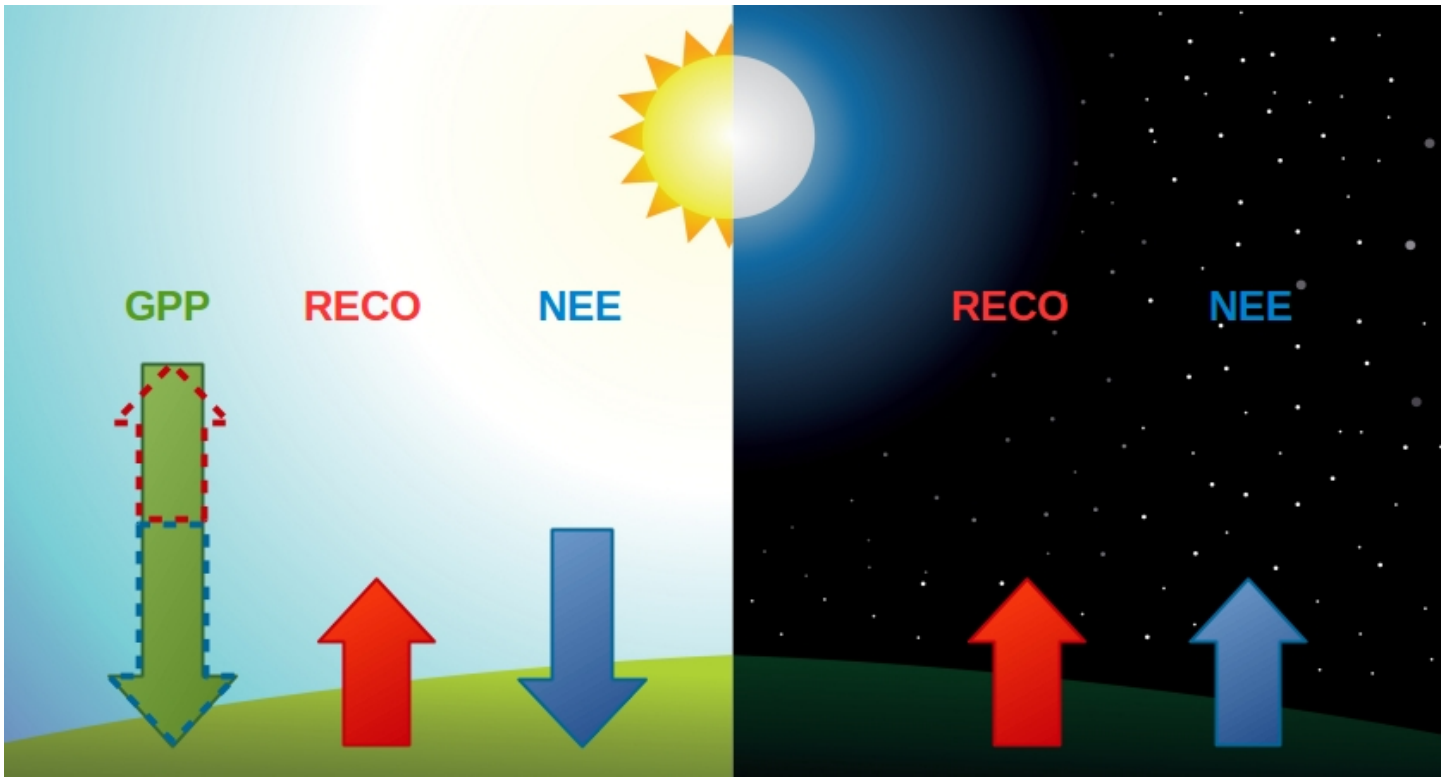

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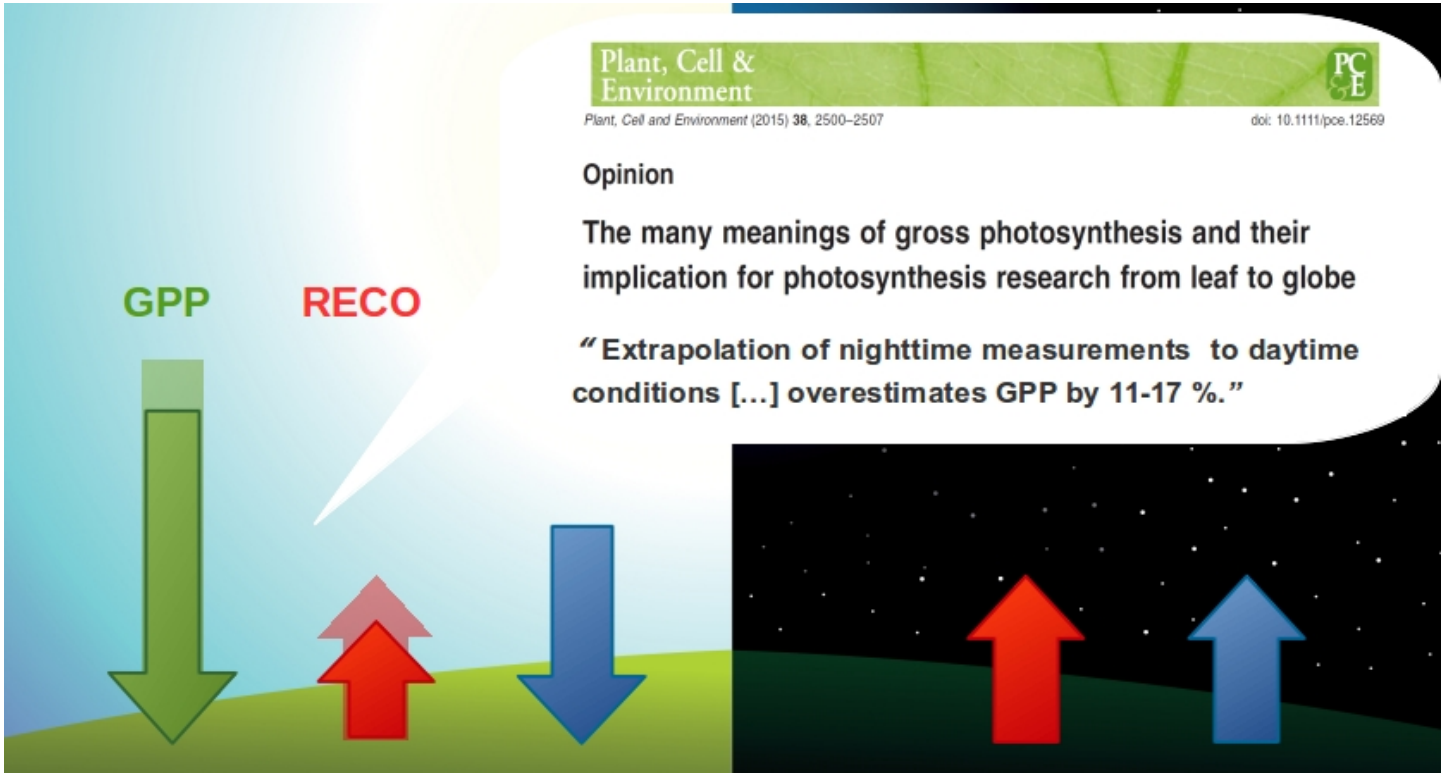
Overestimation of daytime Reco

GPP = Reco - NEE



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Overestimation of daytime Reco

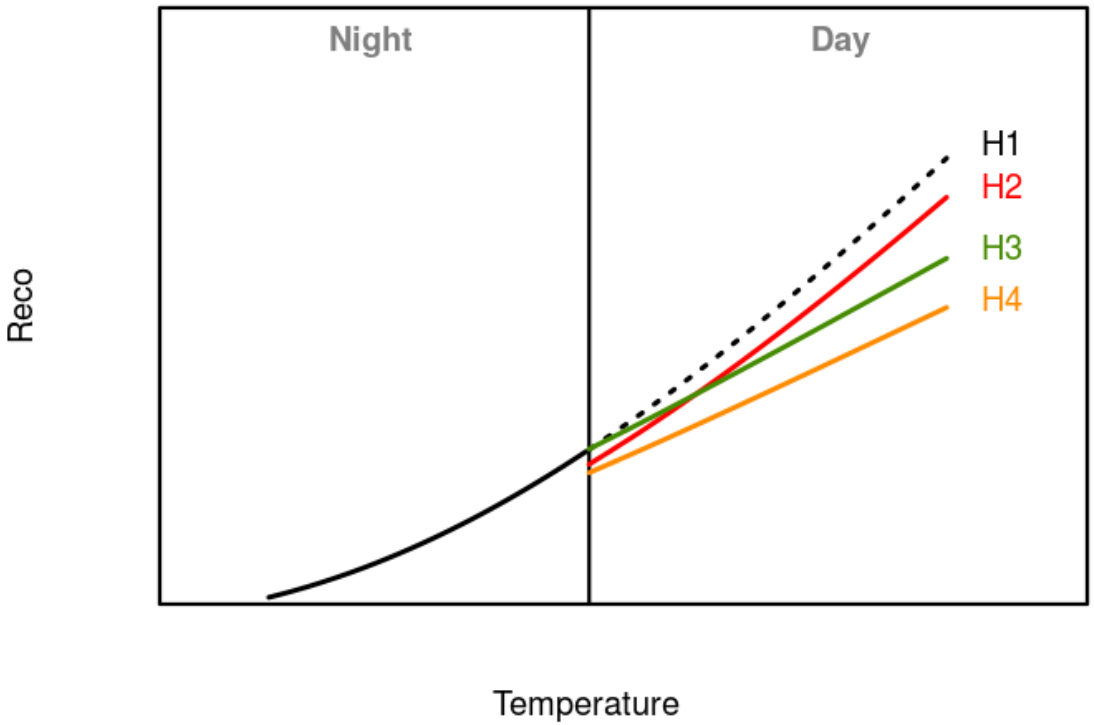
(i) Extrapolation from lower to higher temperature range.

(ii) Different contributions of respiration components such as soil (roots, microorganisms) and aboveground vegetation.

(iii) Differing temperature sensitivities.

(iv) Circadian changes in specific respiration rates,

Hypothesis



H1: Unique relationship during day and night

H2: The temperature response is the same, but Reco in the common temperature range is offset

H3: The temperature response is different

H4: Combination of H2 and H3

Objectives

- ✓ Does **nighttime** NEE provide unbiased estimates of **daytime** Reco?
- ✓ If this is not the case, which is the effect on **daytime Reco** and the resulting **uncertainty of GPP**?

  To this end...

- ✓ ...we quantified **dark Reco** during **nighttime and daytime** conditions using automated **ecosystem-chambers** in a mountain grassland

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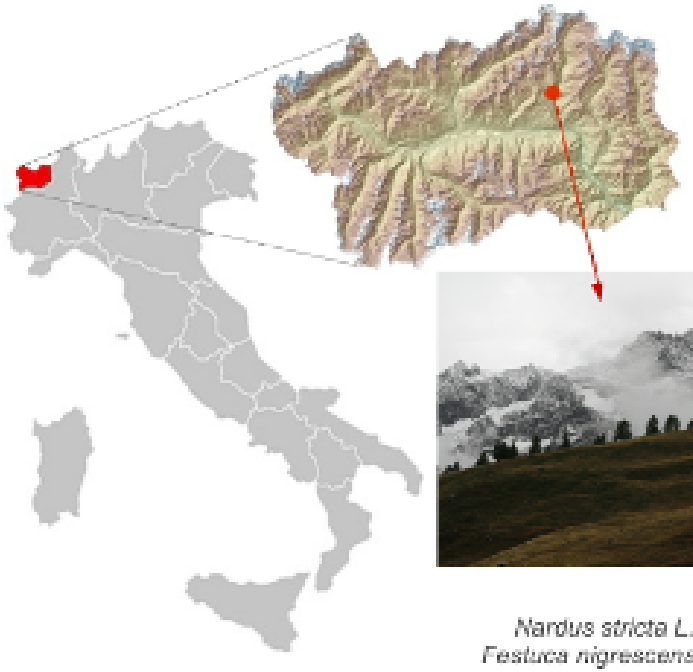
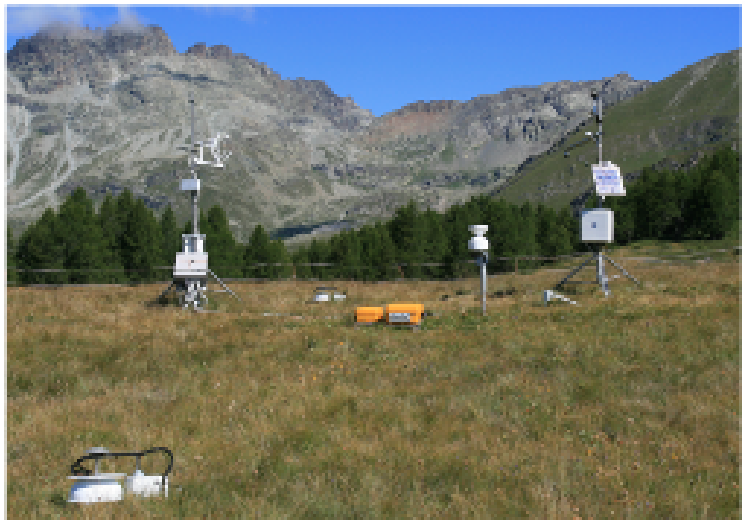
Study site



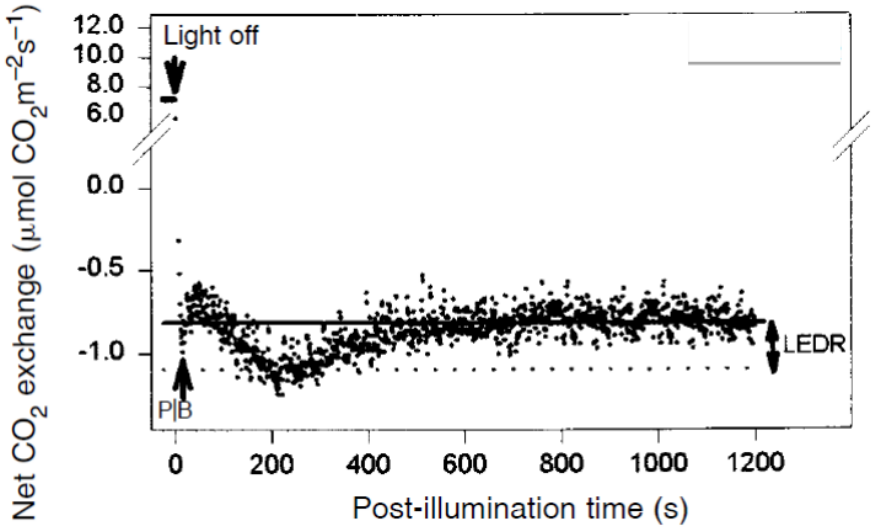
Nardus stricta L., 35%,
Festuca nigrescens All. 11%,
Arnica montana L. 6%,
Carex sempervirens Vill. 5%,
Trifolium alpinum L. 4%

- Short-statured vegetation at a subalpine grassland (2150 m asl, Torgnon, Italy)
- 4 opaque ecosystem chambers (LI8100-104) + multiplexer
- Short closure time ($\sim$ 2 min)
- Continuous measurements (half-hourly) during the entire season (June-October)



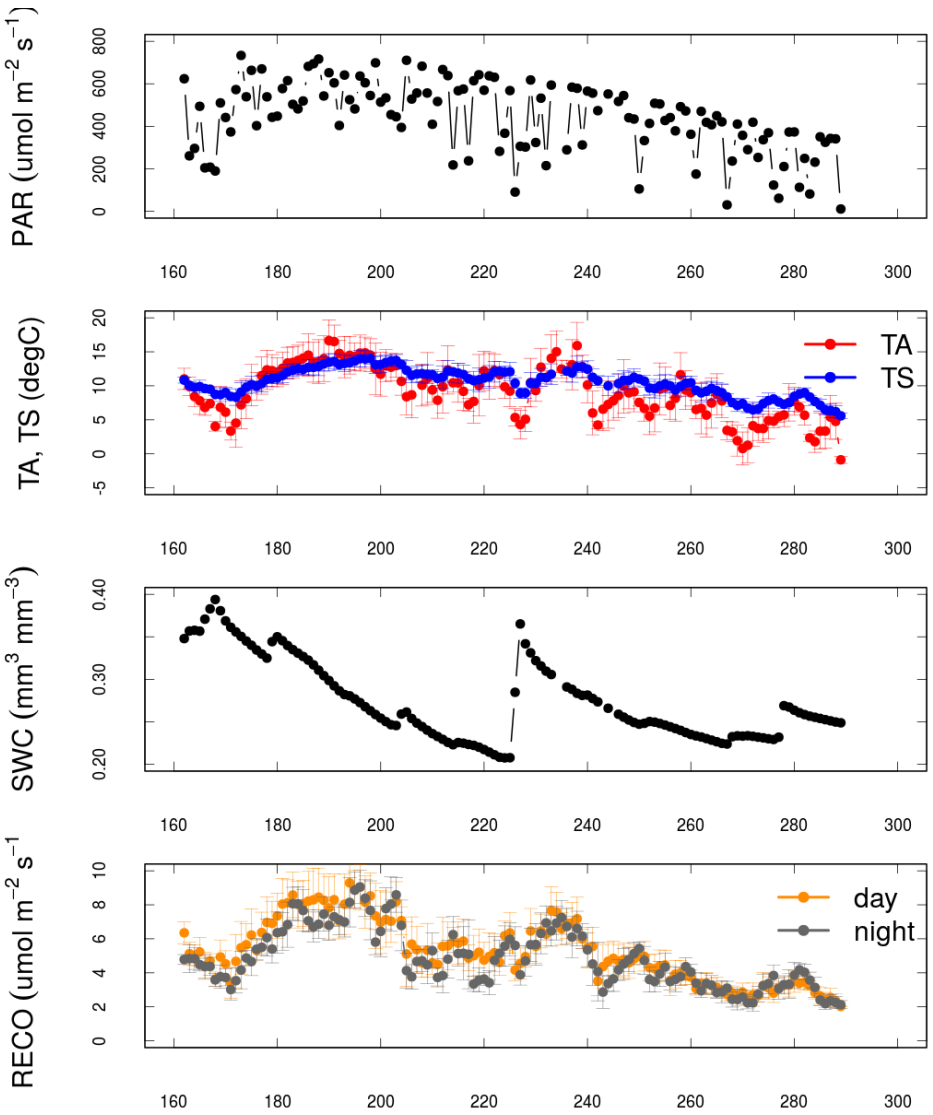
Automated ecosystem chambers method

✓ **Measurements of dark Reco during daytime** ≠ ✗ **Measurements of daytime Reco**



Atkin et al. Aust. J. Plant Physiol. 1998

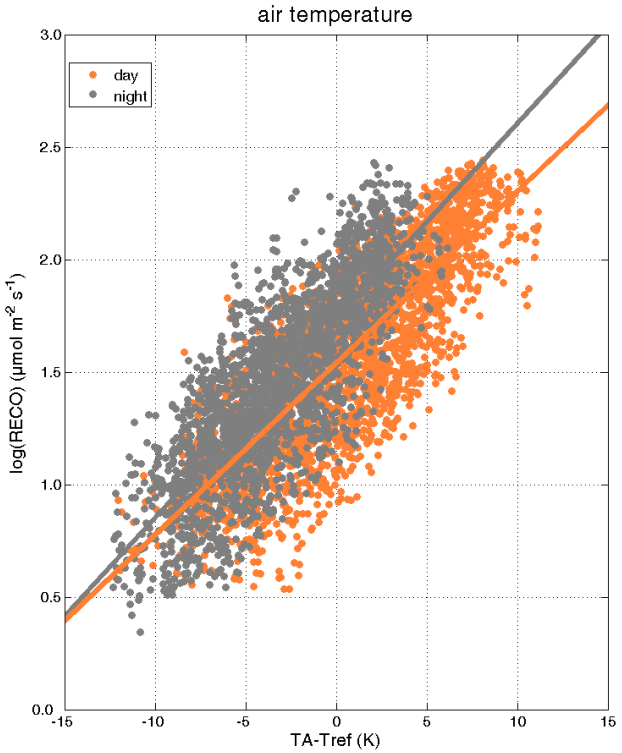
Data overview

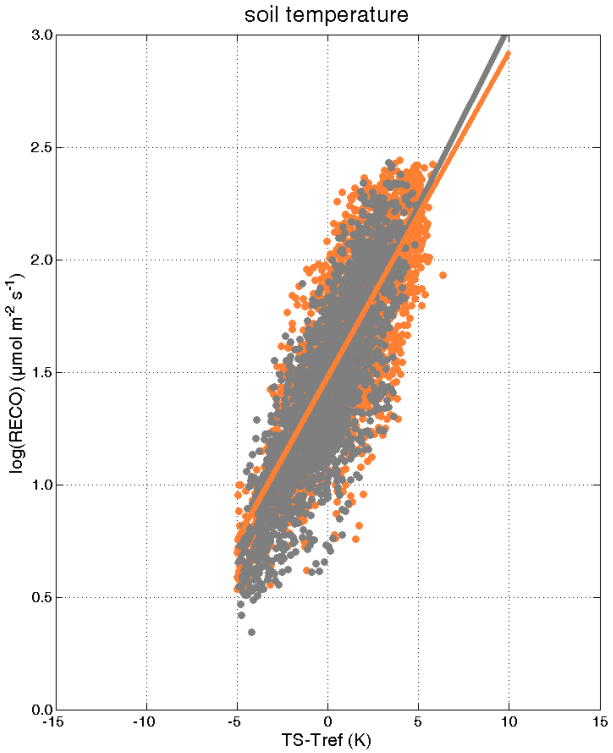


Relationships between Reco and temperature

Reco vs Temperature fitting model

$$Reco = R_{@T_{ref}} e^{E_0(T - T_{ref})}$$





$R_{@T_{ref}}$ = Reco at reference temperature

T_{ref} = reference temperature (283.15 K)

E_0 = temperature sensitivity of Reco

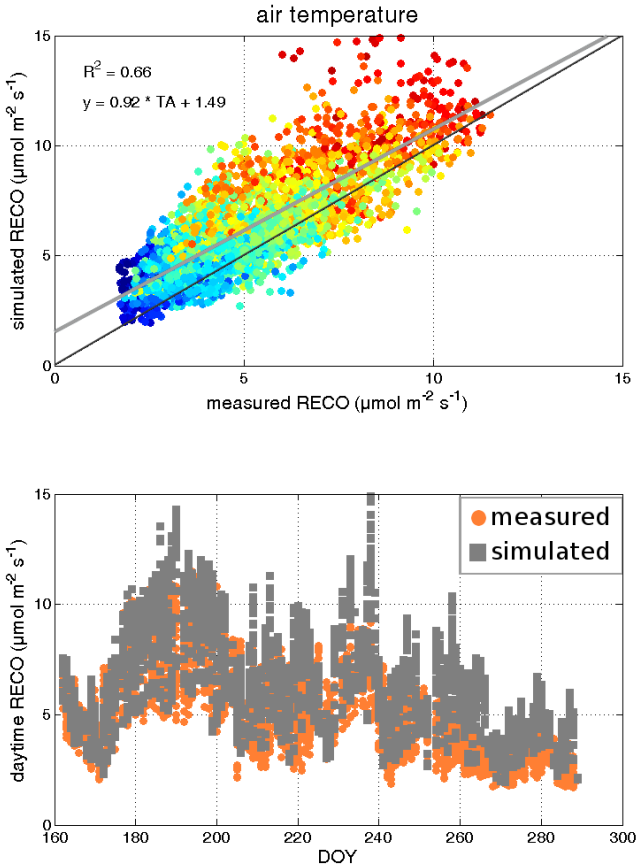
T = air **(TA)** or soil **(TS)** temperature

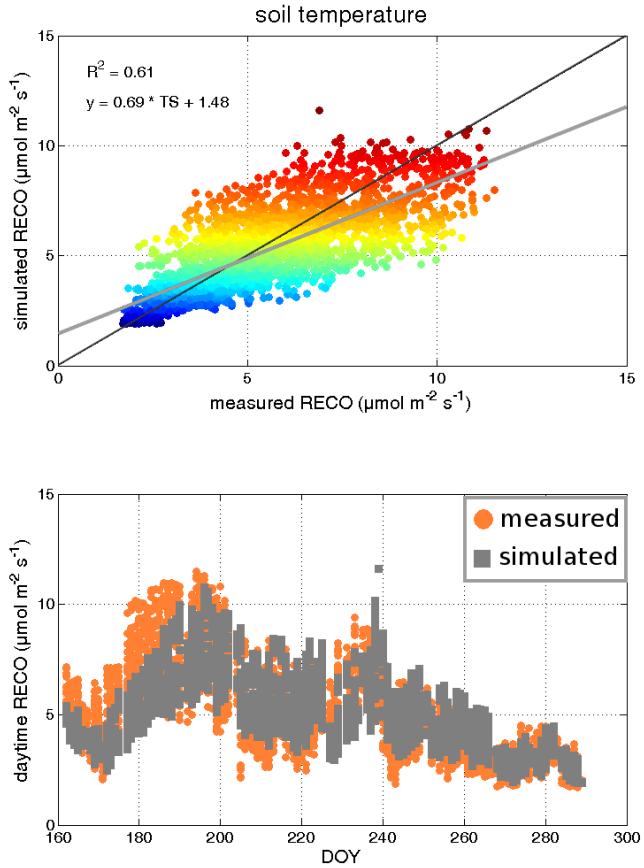
	$R_{@T_{ref}}$ ($\mu molm^{-2}s^{-1}$)	E_0 (K)	r^2
TA Day	4.6	0.07	0.65
TA Night	5.6	0.08	0.65
TS Day	4.3	0.14	0.66
TS Night	4.2	0.15	0.68

Daytime Reco simulated with nighttime parameterisation

Air temperature

overestimation





Under-Overestimation

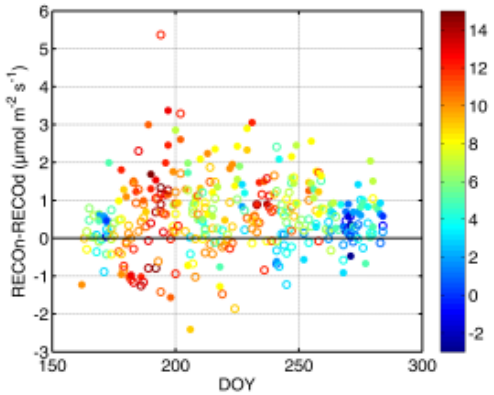
Soil temperature

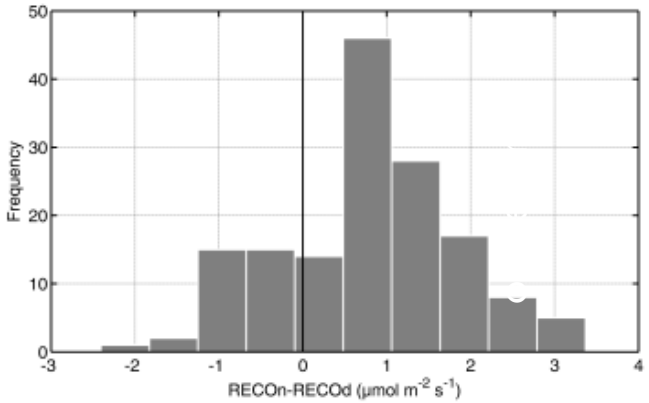
Simulated RECO/measured RECO	Simulated gCm^{-2} vs Measured gCm^{-2}		
TA: 1.20	387	-	322
TS: 0.96	310	-	322

Differences between measured Night and Day RECO

overestimation

air temperature





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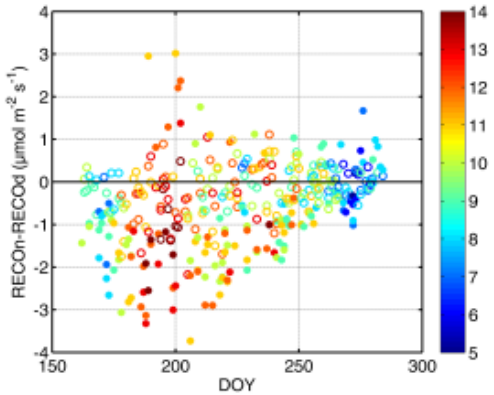
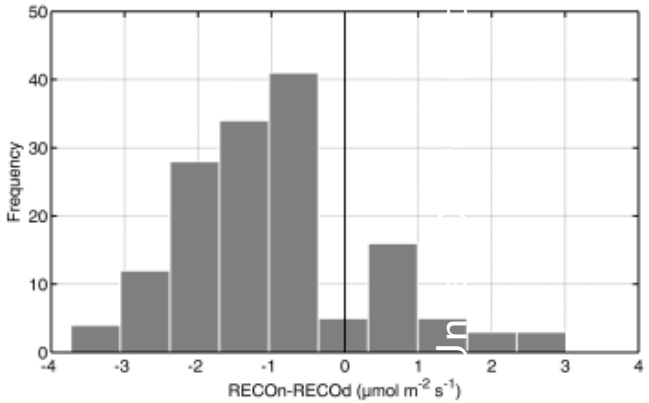
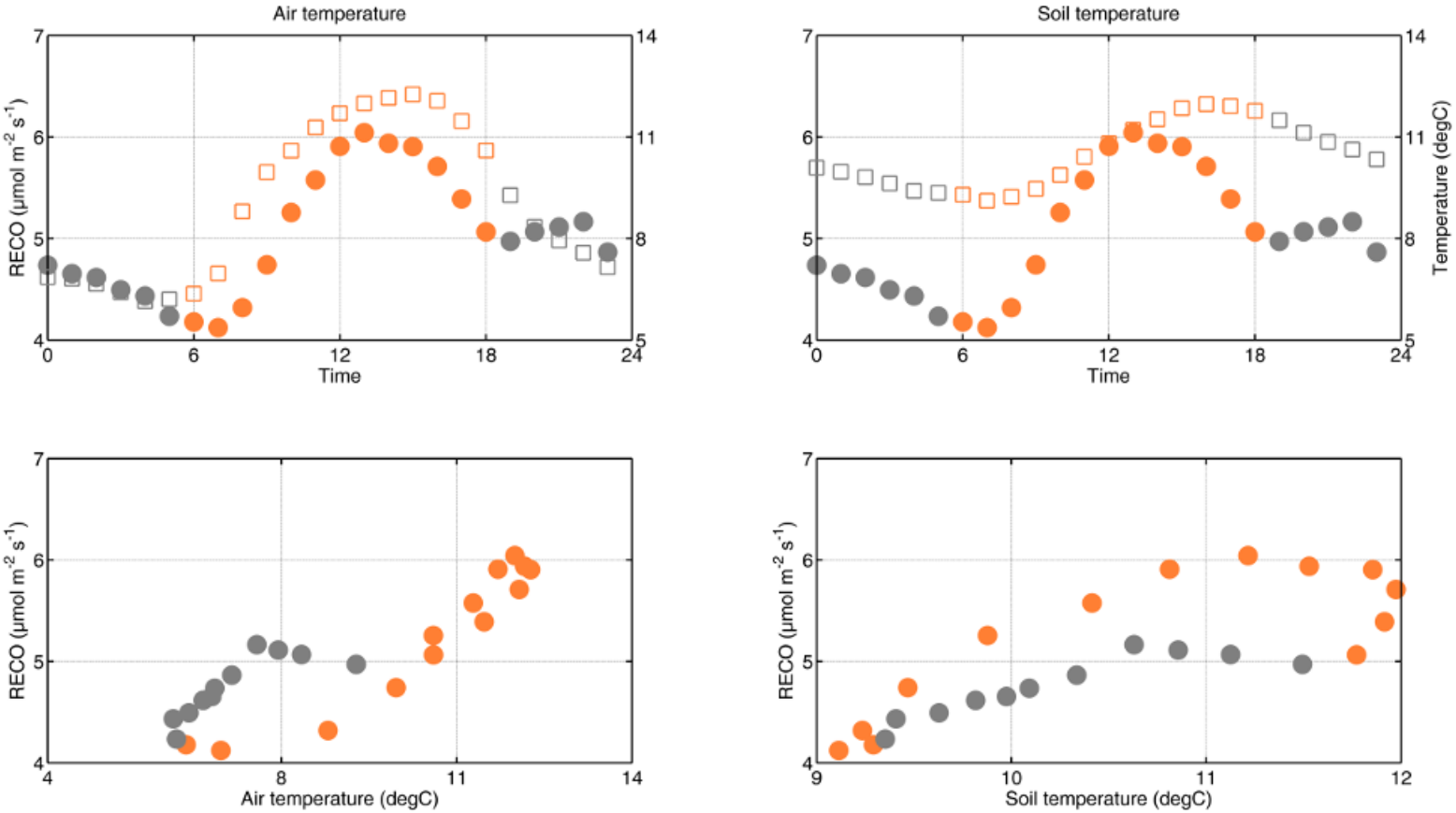




Mean diurnal variation of measured Reco and driving temperatures



Air temperature:

Higher Reco during night at the same temperature range

Soil temperature:

Higher Reco during day at the same temperature range

Simulated daily patterns of temperature, soil respiration and above ground respiration

Simulated daily pattern of Temperature...

$$\text{Ta,s}=T_{avg} + A_o e^{(-z/D)} sin(pi/12(t-8) - z/D)$$

T_{avg} = average daily temperature (degC)

A_o = temperature amplitude (degC)

z = soil depth (m)

D = damping depth (m)

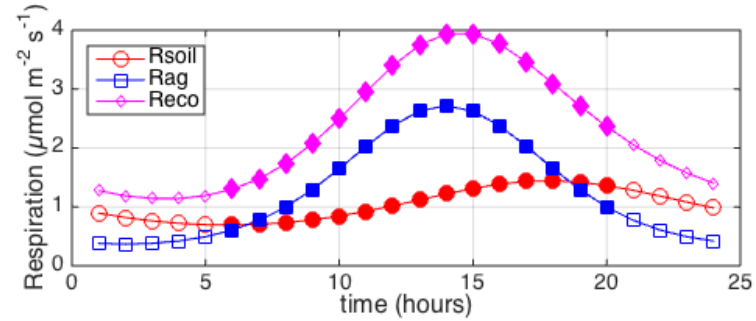
...Rsoil and Rag

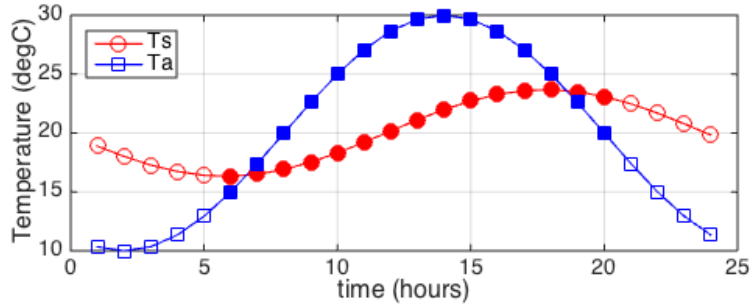
$$\text{Reco} = R_{@T_{ref}} e^{E_0(Ts-T_{ref})} + R_{@T_{ref}} e^{E_0(Ta-T_{ref})}$$

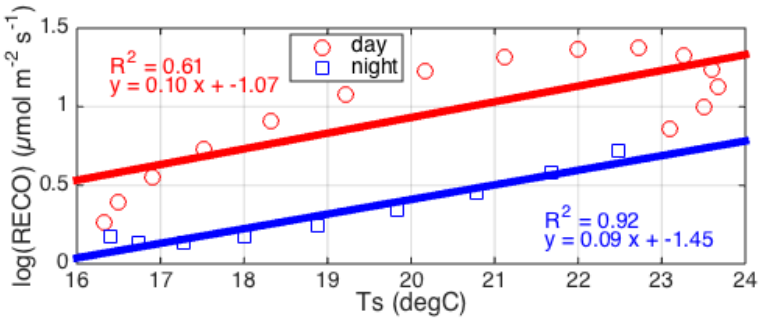
$R_{@T_{ref}} e^{E_0(Ts-T_{ref})}$ = **Rsoil**

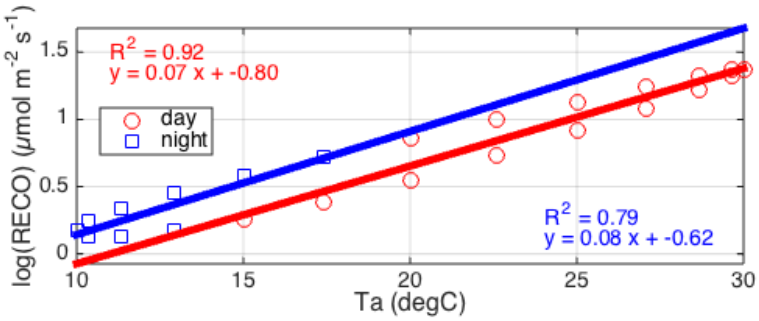
$R_{@T_{ref}} e^{E_0(Tag-T_{ref})}$ = **Rag**

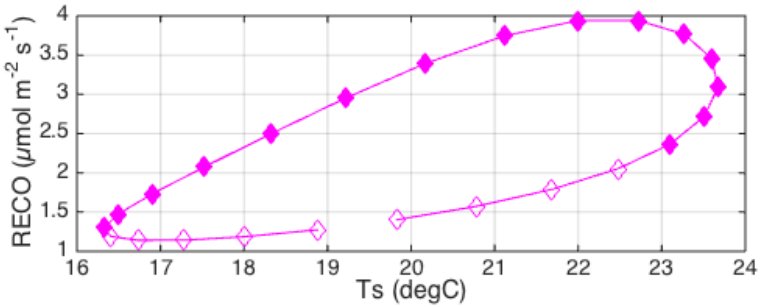
Simulated daily patterns of Reco, Rsoil, Rag

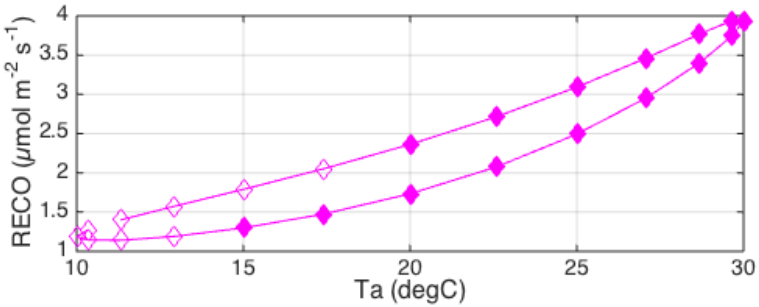












Take home message

- We have to reject hypothesis **H1**: extrapolating nighttime RECO does not yield unbiased estimates of dark daytime RECO. The bias is dependent on **chosen driving temperature**
- TA as main driver of Reco led to an overestimation of $\sim$**12%** of the daily measured Reco, while TS led to an underestimation of $\sim$**2%**
- The differential bias may be explained by be the shift in phase and amplitude of TA and TS and the **Rsoil** vs. **Rag** contributions during nighttime and daytime

Thanks for your attention

http://www.biomet.co.at

http://www.arpa.vda.it/climate-change-impacts

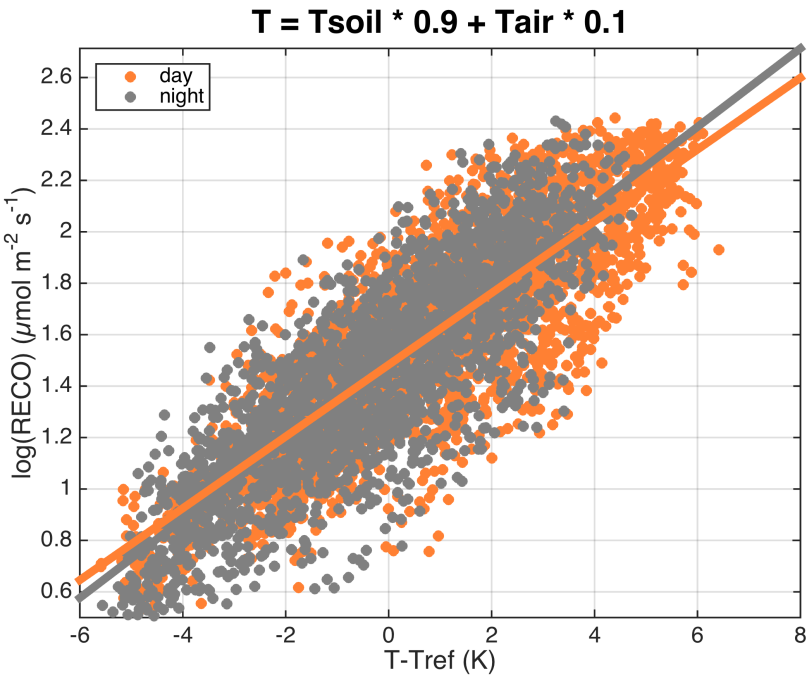
Acknowledgments:

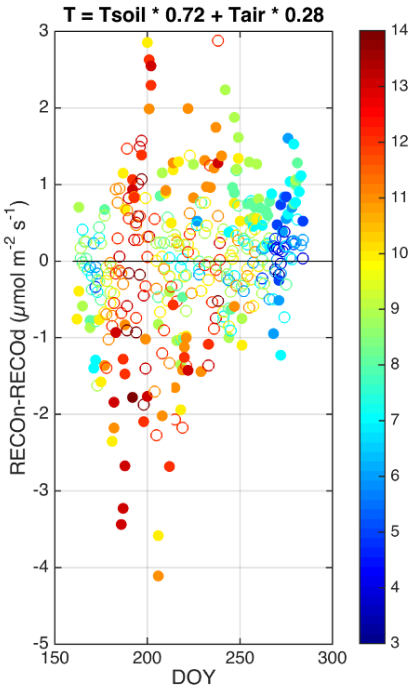
Mirco Migliavacca[1], Edoardo Cremonese[2], Gianluca Filippa[2], Michel Isabellon[2]

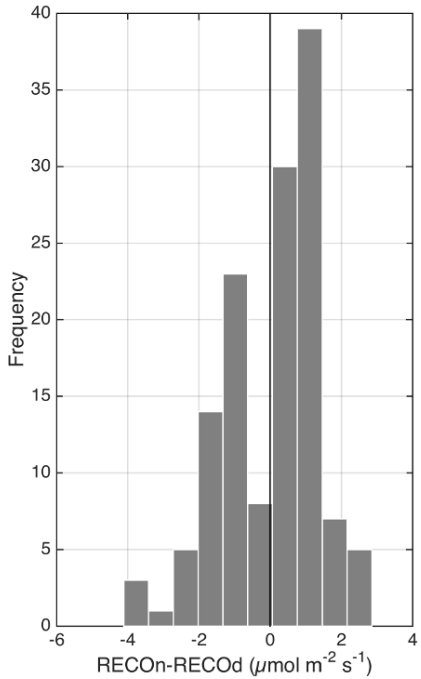
[1] Max Planck Institute for Biogeochemistry, Jena, Germany

[2] Environmental Protection Agency of Aosta Valley - ARPA VdA

Weighted model







dark-adaptation experiment