Terrestrial Carbon Flux Dynamics in the Southern American Temperate Region: Insights from Dynamic Global Vegetation Models (DGVM) and GOSAT XCO_2 Measurements

Sanam N. Vardag[1,2], Lukas Artelt[1], Eva-Marie Metz[1], Sourish Basu[3,4], Martin Jung[5], André Butz[1,2,6]

Contact: sanam.vardag@uni-heidelberg.de

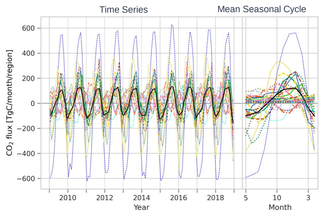
UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

Why SAT?

- Semi-arid regions in the southern hemisphere exhibit large uncertainties as in-situ observations are sparse.
- Satellites can provide new information.
- Proccesses governing semi-arid regions need to be better understood to constrain the global carbon budget.

Dynamic Global Vegetation Models (DGVMs)

DGVMs (TRENDY v9)

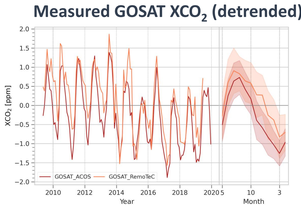


- DGVMs show an **inconsistent picture** on carbon dynamics in the SAT calling for additional independent atmospheric constraints.

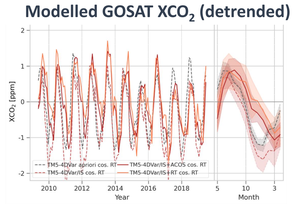
Atmospheric Constraints

- GOSAT XCO_2 measurements have a good **measurement coverage** over remote regions.
- Using GOSAT XCO_2 measurements in an inversion with the transport model TM5, leads to updated CO_2 fluxes.
- We observe a distinct seasonal cycle with **maximum emissions in September.**

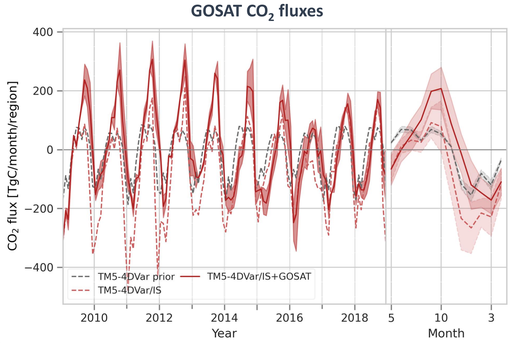
Measured GOSAT XCO_2 (detrended)



Modelled GOSAT XCO_2 (detrended)



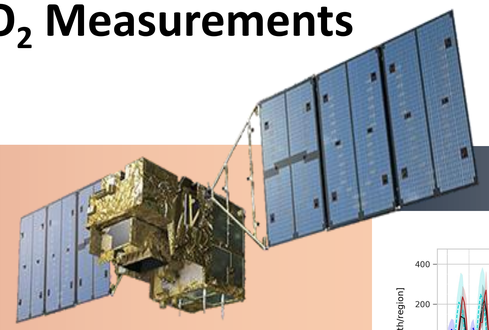
GOSAT CO_2 fluxes

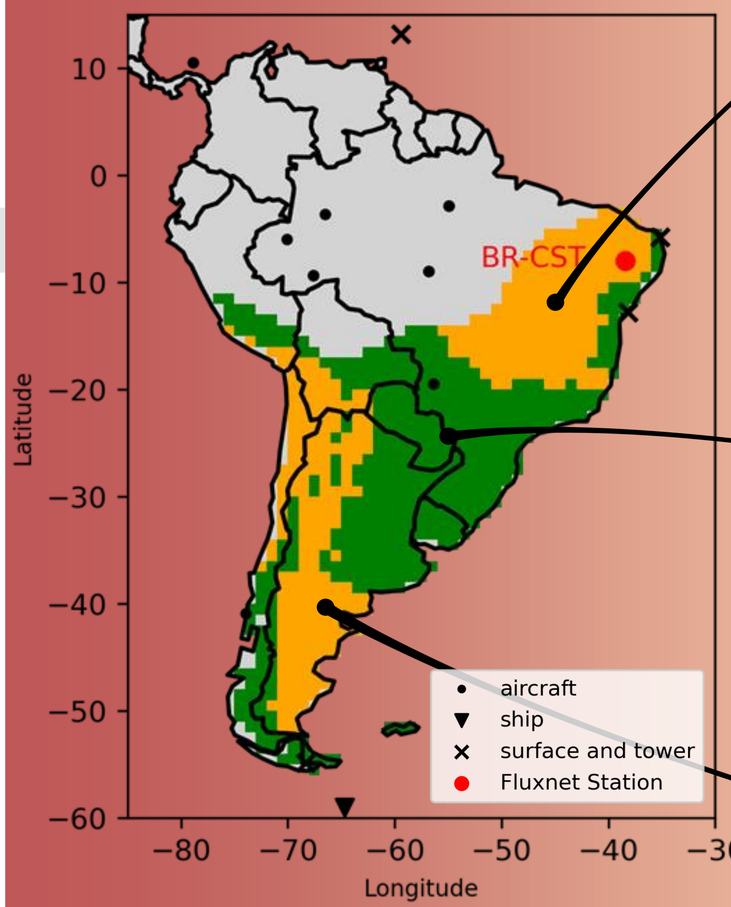


- OCO-2 (not shown) shows same seasonality, but different magnitude.

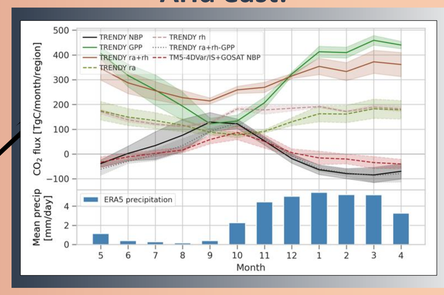
Key Messages

- Seasonal cycle of South American Temperate region originates from **fast response of heterotrophic respiration after rainfall following drought conditions.**
- Combination of process-based ecosystem models with top-down approach enhances understanding of carbon dynamics.

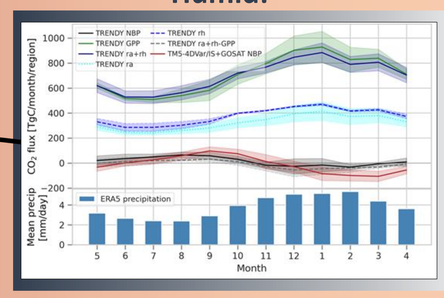




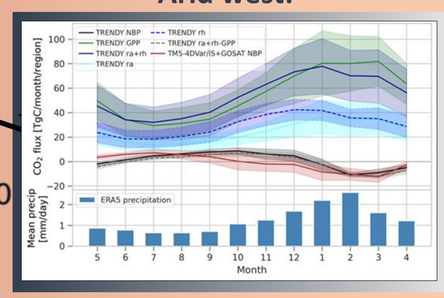
Arid east:



Humid:

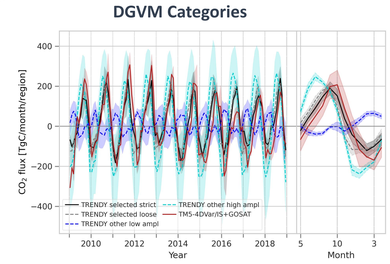


Arid west:



Selection of DGVMs

DGVM Categories



- We select DGVMs, which strictly follow the GOSAT-informed fluxes.
- OCN and CLASSIC exhibit the same seasonal cycle suggested by GOSAT.

Seasonal Cycle of Gross Fluxes

- The selected models show that the net emission peak in September is caused by an **early increase in heterotrophic respiration (rh)** compared to autotrophic respiration (ra) and gross primary production (GPP).

Gross Fluxes of Selected DGVMs

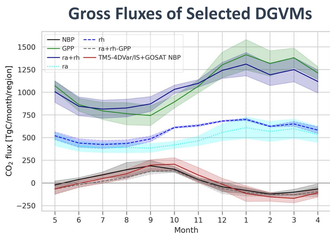
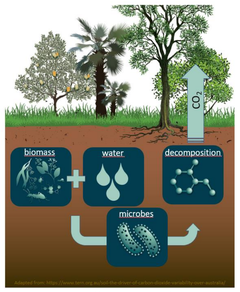


Illustration of Birch Effect

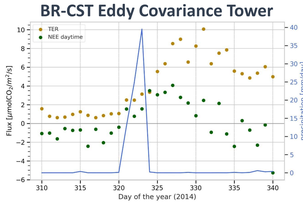


Adapted from: https://www.tern.org.au/soil-the-driver-of-carbon-dioxide-variability-over-australia/

- The seasonal cycle is mostly influenced by **the arid east region** (see central plots).
- Our findings suggest that the **Birch effect** may have a large importance for SAT region in accordance to recent findings for Australia (Metz et al., 2023).

Local Flux Tower BR-CST

BR-CST Eddy Covariance Tower



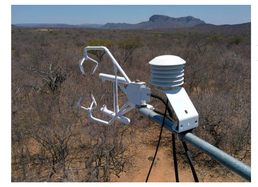


Photo: Rodolfo Souza, 01/20/2016

- BR-CST tower shows an **increase in Terrestrial Ecosystem response (TER) following precipitation after drought conditions** supporting our continental findings on a local scale.

[1] Institut für Umweltphysik, Heidelberg University, Heidelberg, Germany
[2] Heidelberg Center for the Environment, Heidelberg University, Heidelberg, Germany
[3] NASA Goddard Space Flight Center, Greenbelt, Maryland, USA
[4] Earth System Science Interdisciplinary Center, University of Maryland, College Park, USA
[5] Max Planck Institute for Biogeochemistry, Jena, Germany
[6] Interdisciplinary Center for Scientific Computing, Heidelberg University, Heidelberg Germany

References:
Metz, E.-M., Vardag, S.N., Basu, S., Jung, M.,...Butz, A. Soil respiration–driven CO_2 pulses dominate Australia's flux variability. Science, 379, 1332-1335, https://doi.org/10.1126/science.add7833, 2023.

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