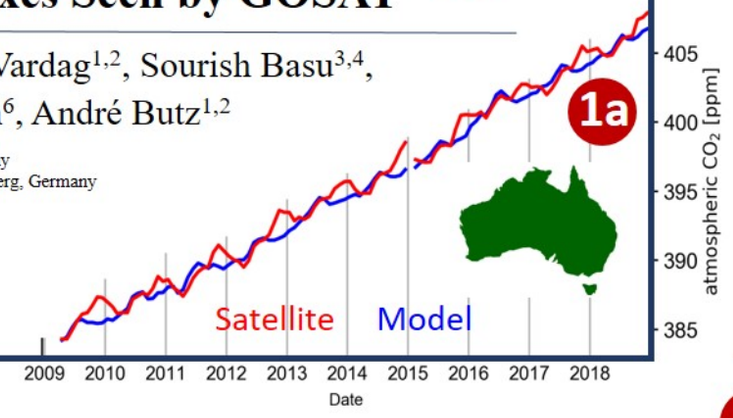
Seasonal and Interannual Variability of Australian Carbon Fluxes Seen by GOSAT

Eva-Marie Schömann[*1], Sanam N. Vardag[1,2], Sourish Basu[3,4], Martin Jung[5], Stephen Sitch[6], André Butz[1,2]

[1] Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany
[2] Heidelberg Center for the Environment (HCE), Heidelberg University, Heidelberg, Germany
[3] Goddard Space Flight Center, NASA, Greenbelt, Maryland, USA
[4] Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA
[5] Department of Biogeochemical Integration, Max Planck Institute for Biogeochemistry, Jena, Germany
[6] College of Life and Environmental Sciences, University of Exeter, Exeter EX4 4RJ, UK



Highlights

- GOSAT reveals CO_2 emission pulses at the end of the dry-season in Australia.
- Emission pulses dominate the seasonal and inter-annual variability of Australian carbon fluxes
- Emissions are caused by a precipitation driven increase of respiration

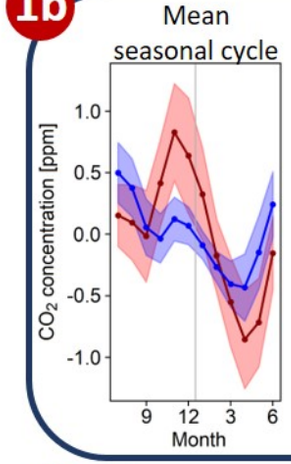
Summary

- Satellites help to better constrain large-scale carbon fluxes in regions with sparse in-situ measurements
- GOSAT reveals enhanced CO_2 concentrations and high CO_2 emissions in Australia at the end of each year from 2009 to 2018, which are not captured by model approaches
- Vegetation models attribute the emissions to an increase of respiration preceding an uptake by vegetation growth
- Soil rewetting seems to be the cause for the increase of respiration on regional scale

Motivation

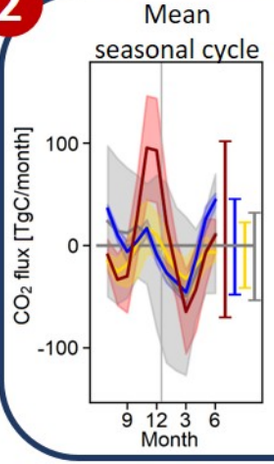
The seasonal and inter-annual variability of the global carbon sink is mainly caused by variations in the carbon cycle of terrestrial ecosystems[1]. However, current approaches to quantify large-scale carbon fluxes like inverse modelling, dynamic global vegetation models and machine learning strategies suffer from sparse in-situ measurement coverage or the complexity of carbon-water cycle interactions in some regions, e.g. Australia[2,3]. Satellite CO_2 measurements can help to fill the gap and better constrain regional carbon fluxes in Australia[4].

1b Australian CO_2 concentrations



GOSAT (mean ACOS and RemoTeC) shows **enhanced CO_2 concentrations** at the end of the year compared to in-situ based inverse models (mean of Carbon Tracker, TM5-4DVar, CAMS) visible in the absolute atmospheric concentrations from 2009 to 2018 (1a) and the detrended mean seasonal cycle (1b).

2 Australian CO_2 fluxes

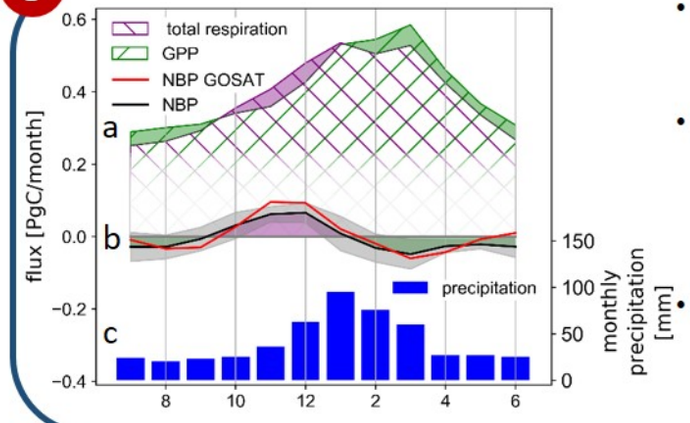


Large CO_2 emissions at the end of the year:

- are shown by:
GOSAT satellite based CO_2 fluxes

- but not captured by:
In-situ based inverse models
Machine learning approach FLUXCOM
the mean TRENDY ensemble of dynamic global vegetation models.

3 What drives the CO_2 fluxes?



- Subset of TRENDY models reproduce satellite based net ecosystem fluxes (NBP, 3b).
- The TRENDY models can split up the net fluxes into vegetation uptake (GPP) and CO_2 release via respiration (3a, NBP = resp. - GPP).
- Increasing respiration at the onset of the rainy season (3c) and a delayed increase of GPP causes CO_2 emission pulses.

Conclusion

The large CO_2 emissions (2) and therefore the enhanced CO_2 concentrations (1) seen by GOSAT at the end of each year over Australia are caused by an increase of ecosystem respiration followed by a delayed carbon uptake by vegetation growth (GPP) (3). The respiration increases with the onset of the rainy season. Together with local flux observations (see preprint) this suggests soil-rewetting to be the driver of the respiration process.

References:
[1] P. Friedlingstein et al., Global Carbon Budget 2020. *Earth Syst. Sci. Data*. **12**, 3269–3340 (2020), doi:10.5194/essd-12-3269-2020.
[2] M. Jung et al., Scaling carbon fluxes from eddy covariance sites to globe: synthesis and evaluation of the FLUXCOM approach. Biogeosciences. 17, 15 1343–1365 (2020).
[3] N. MacBean et al., Dynamic global vegetation models underestimate net CO2 flux mean and inter-annual variability in dryland ecosystems. Environ. Res. Lett. 16, 94023 (2021), doi:10.1088/1748-9326/ac1a38.
[4] R. G. Detmers et al., Anomalous carbon uptake in Australia as seen by GOSAT. Geophys. Res. Lett. 42, 8177–8184 (2015), doi:10.1002/2015GL065161.

I will be present:
July 12&13: 8-9,11-12 CEST (15-16,18-19 JST)
July 14: 8-9 CEST (18-19 JST)

Contact:
eschoema@iup.uni-heidelberg.de

A preprint of the results is available at https://arxiv.org/abs/2207.06869
Title: 'Respiration driven CO_2 pulses dominate Australia's flux variability'