

Analysis of Satellite Data to Study Continental CO₂ Fluxes and Their Drivers

MSc Thesis

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Project Overview:

The annual variation in atmospheric CO₂ levels is primarily driven by the terrestrial carbon cycle and is influenced by climatic factors such as temperature and precipitation. These fluctuations are further shaped by climate modes like El Niño and by long-term climate change. Understanding these inter-annual variations (IAV) in CO₂ is crucial for assessing the biosphere's carbon uptake and release in response to shifting climatic conditions.

This MSc project will leverage long-term XCO₂ satellite data (2009–2023), which have been integrated into an atmospheric inversion system to determine CO₂ fluxes at the continental scale. The research will also use Dynamic Global Vegetation Models (DGVMs) to identify the climatic drivers behind these variations. The project aims to provide valuable insights into the contributions of different regions to CO₂ flux variability and global uncertainty and improve predictions of the carbon cycle in future (Bastos et al., 2020; Metz et al., 2023; Metz et al., 2025).

Skills and Requirements:

- Programming skills in Python
- Background in environmental physics
- Interest in understanding the carbon cycle's response to climate variability

References:

- Bastos, A., O'Sullivan, M., Ciais, P., Makowski, D., Sitch, S., Friedlingstein, P., Chevallier, F., Rödenbeck, C., Pongratz, J., Lujikx, I. T., Patra, P. K., Peylin, P., Canadell, J. G., Lauerwald, R., Li, W., Smith, N. E., Peters, W., Goll, D. S., Jain, A., Kato, E., Lienert, S., Lombardozzi, D. L., Haverd, V., Nabel, J. E. M. S., Poulter, B., Tian, H., Walker, A. P., and Zaehle, S.: Sources of Uncertainty in Regional and Global Terrestrial CO₂ Exchange Estimates, *Global Biogeochem. Cycles*, 34, e2019GB006393, <https://doi.org/10.1029/2019GB006393>, 2020.
- Metz, E.-M., et al. (2023). Soil respiration-driven CO₂ pulses dominate Australia's flux variability. *Science*, 379, 1332-1335.
- Metz, E.-M., et al. (2025). Seasonal and interannual variability in CO₂ fluxes in southern Africa as observed by GOSAT. *Biogeosciences*, 22, 555–584. [DOI Link](#)