Master Thesis: Detecting Rainfall-Induced NO2 Emission Pulses from Space

Dry soils can release large amounts of gases into the atmosphere shortly after rainfall. These short-lived emission pulses are caused by the rapid activation of microbial processes when dry soils become wet again. Previous research has shown that such rainfall-induced pulses of CO_2 can be detected from space and contribute substantially to the variability of Australia's carbon balance (Metz et al., 2023). Soil microorganisms also produce nitrogen oxides (NO_2) (Corrochano-Monsalve et al., 2026), but the magnitude and geographical extent of rainfall-induced NO_2 emissions remain poorly understood.

The aim of this master thesis is to investigate whether rainfall-induced NO2 emission pulses can be detected using satellite observations. We will use measurements of NO_2 from the TROPOMI satellite. By combining satellite observations with precipitation, soil moisture, and temperature data, we will investigate whether enhanced NO_2 concentrations occur following rainfall events.

The project will contribute to a better understanding of how soil microbial activity influences atmospheric composition and how these processes respond to changing precipitation patterns.

The thesis is suitable for a student interested in satellite remote sensing, atmospheric chemistry, and interactions between soils and the atmosphere. Good Python programming skills are desirable, as well as an interest in working with large observational datasets.

Contact:
André Butz (andre.butz@uni-heidelberg.de)
Sanam Vardag (Sanam.vardag@uni-heidelberg.de)

References:

Metz, E.-M., et al. (2023): Soil respiration–driven CO_2 pulses dominate Australia's flux variability. *Science*, 379, 1332–1335. https://doi.org/10.1126/science.add7833

Corrochano-Monsalve, M., et al. (2026): Aridity and vegetation cover shape microbial nitrogen-cycling potential across global drylands. *Soil & Environmental Health*. https://doi.org/10.1016/j.seh.2026.100250