Master Thesis: How Do Droughts Affect the Terrestrial Carbon Cycle?

Terrestrial ecosystems absorb carbon dioxide (CO_2) through photosynthesis and release it through respiration. The balance between these processes, called net ecosystem exchange (NEE), determines whether ecosystems act as carbon sinks or sources. Droughts can strongly reduce carbon uptake, and their effects may persist even after soil moisture conditions have returned to normal. Understanding these responses is essential for predicting how the terrestrial carbon sink will change under future climate conditions.

The aim of this thesis is to investigate how strongly droughts affect terrestrial carbon uptake and how long these effects persist. Using monthly NEE estimates from atmospheric CO_2 inversions, the project will analyse carbon flux anomalies during major drought years across different regions. These estimates will be compared with satellite observations of solar-induced chlorophyll fluorescence (SIF), which provides information on photosynthetic activity, and other vegetation indices.

By analysing correlations between carbon fluxes, vegetation indices, soil moisture, and temperature at different time lags, the project will investigate how quickly ecosystems respond to drought, how much carbon uptake is reduced, and how long recovery takes.

The results will be compared with simulations from terrestrial biosphere models. This will help assess whether models reproduce the magnitude and timing of drought-induced carbon flux anomalies and their persistence after drought conditions have ended.

The thesis is suitable for a student interested in terrestrial ecosystems and data analysis. Python will be used to process and analyse the data.

Further reading:

Vardag, S. N., Basu, S., Butz, A., and Metz, E.-M.: A GOSAT-Based Assessment of Interannual Variability in Terrestrial CO_2 Fluxes and Its Hydroclimatic Drivers, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2026-4054, 2026.

Contact:

Dr. Sanam Vardag (Sanam.vardag@uni-heidelberg.de)