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FACULTY OF FOREST SCIENCES AND FOREST ECOLOGY
BIOCLIMATOLOGY
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Analysis of a 23-years Long Eddy-covariance Fluxes Dataset from a Mixed Deciduous Forest in Germany

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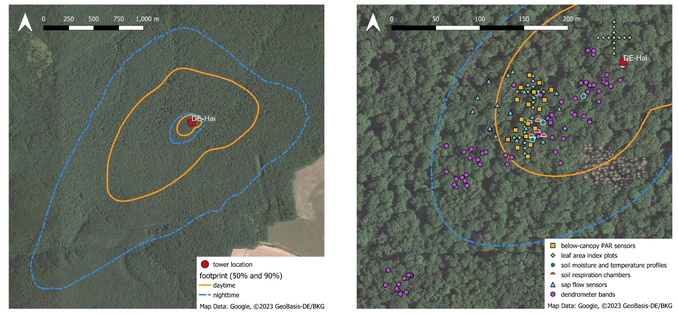


Left: Footprint climatology (50% and 90% contour line) for day- and nighttime individually in 2020, estimated with the FFP model after Kljun et al. (2015). *Right:* Installations within main footprint in the South-West of the tower.

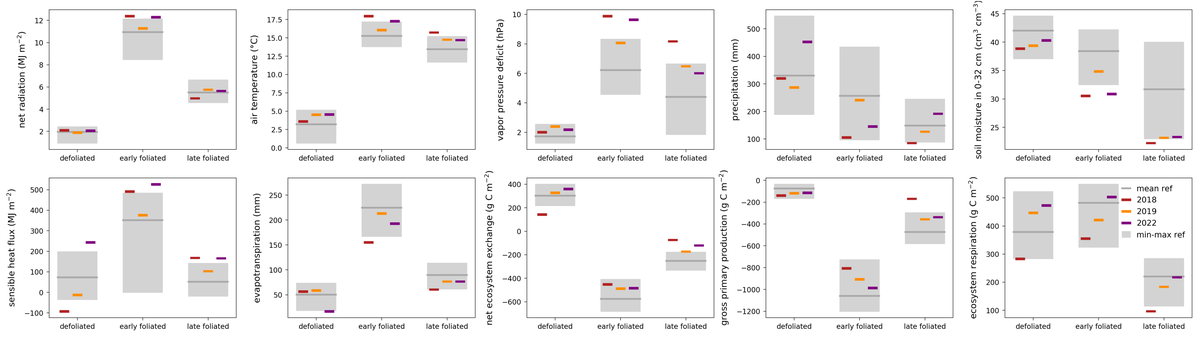
Introduction - Hainich Study Site

The Hainich site (DE-Hai) is an unmanaged and protected forest with a heterogeneous structure, located in the central part of the Hainich National Park (established in 1997). Because of its history and current heterogeneous stand structure, the forest can be characterized as an old-growth, uneven-aged (1-250 years) mixed beech forest, which also exhibits large amounts of dead wood. The eddy-covariance flux tower was established in 2000.

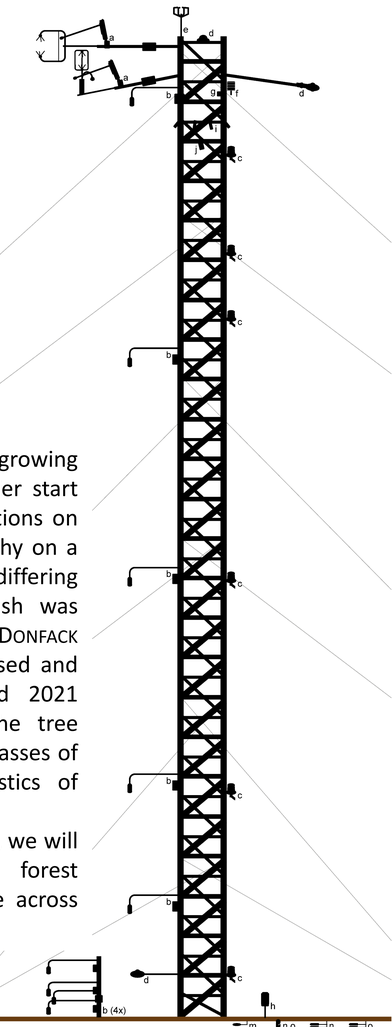
The suboceanic-submontane climate of the site in combination with fertile soil conditions provide nearly optimal growing conditions for a beech forest. However, the forest was impacted by the general climate trend and extreme conditions during the last five years.

The deciduous forest was a large and persistent net carbon sink, with an annual net ecosystem exchange between -393 and -670 g C m^{-2} during reference years (2000-2017, 2021, 2022). This net carbon sink declined by up to 54% during the drought years 2018, 2019 and 2022. Further, evapotranspiration was reduced by up to 25 %.

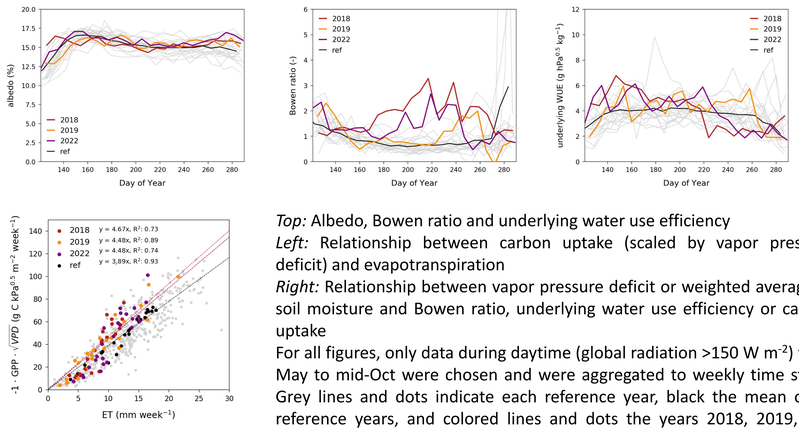
Meteorological Conditions and Flux Measurements

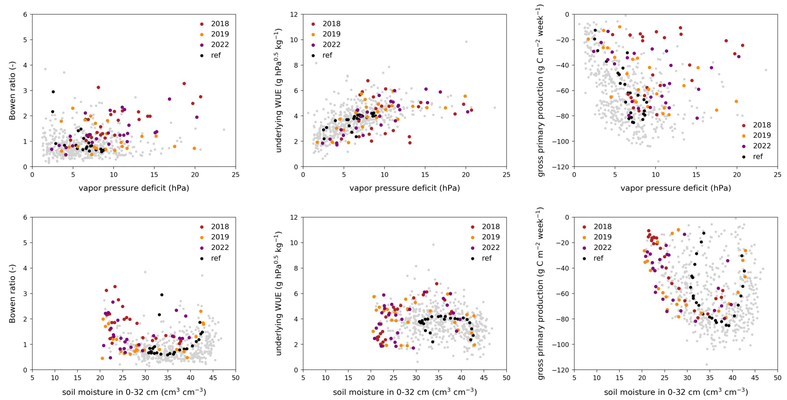


Meteorological conditions and flux measurements during defoliated (mid-Oct - Apr), early (May - Jul) and late foliated (Aug - mid-Oct) period from 2000-2022. The grey areas show the range of averages or sums for each period for all reference years, the grey horizontal line indicates the mean. The colored horizontal bars show the averages or sums for the years 2018, 2019, and 2022.



Biophysical and Ecophysiological Effects





Top: Albedo, Bowen ratio and underlying water use efficiency
Left: Relationship between carbon uptake (scaled by vapor pressure deficit) and evapotranspiration
Right: Relationship between vapor pressure deficit or weighted average of soil moisture and Bowen ratio, underlying water use efficiency or carbon uptake
For all figures, only data during daytime (global radiation >150 W m^{-2}) from May to mid-Oct were chosen and were aggregated to weekly time steps. Grey lines and dots indicate each reference year, black the mean of all reference years, and colored lines and dots the years 2018, 2019, and 2022.

Further Effects

At the Hainich site, the duration of the growing season has been increasing due to an earlier start (Kloos et al.). The impact by drought conditions on green fraction were dependent on topography on a large spatial scale. On the tree scale, a differing stomatal response between beech and ash was observed based on sap flow measurements (Donfack et al.). Overall structural complexity decreased and tree vitality declined between 2013 and 2021 (Heidenreich & Seidel 2022). Moreover, the tree growth response differed between various classes of vitality, species, and structural characteristics of individual trees (Koebsch et al.).

In the Horizon Europe project CLIMB-FOREST, we will further analyze the interplay between forest structure, biophysical effects, and resilience across multiple forest sites.

CLIMB-FOREST

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Acknowledgements

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