Research Project #4

Future plant systems and air quality (ICE-3 & IBG-3)

Plants and air composition are closely coupled. Plants remove carbon dioxide from the air, and in turn emit a multitude of volatile organic compounds. These are not only important for attracting pollinators or defending against herbivores - they are also indicators for plant stress. Moreover, gaseous plant emissions are reactive drivers of atmospheric chemistry and precursors to air pollutants. Climate change and environmental stressors such as heatwaves, drought, pests, and pollution are increasingly affecting all ecosystems, including human-made ones like agricultural vegetation and city trees. Such environmental stressors alter the emission amounts and composition of biogenic volatile organic compounds (BVOCs) from the plant systems. BVOCs contribute to ozone and secondary organic aerosol (SOA) formation, which influence both air quality and climate[1].

However, changes in future BVOC emissions and of resulting changes in their feedback on air quality and climate are not well understood[1]. Existing research suffers from fundamental methodological limitations. Laboratory studies have often examined individual stressors only, or studies on multiple stressors excluded soil and root interactions, thus failing to capture comprehensive ecosystem-scale responses. Field studies provide environmental relevance but cannot isolate mechanistic pathways or control confounding variables. This creates a critical "scaling gap" between controlled mechanistic understanding and real-world predictions. Newer studies show that atmospheric stressors such as tropospheric ozone do not only affect the plant directly but also soil microbial communities and thus the entire terrestrial ecosystem[2]. This PhD project aims to investigate how future climate change and stress scenarios impact plant and soil BVOC emissions from agricultural plants and urban tree species, and how these changes affect atmospheric chemistry and ecosystem function.

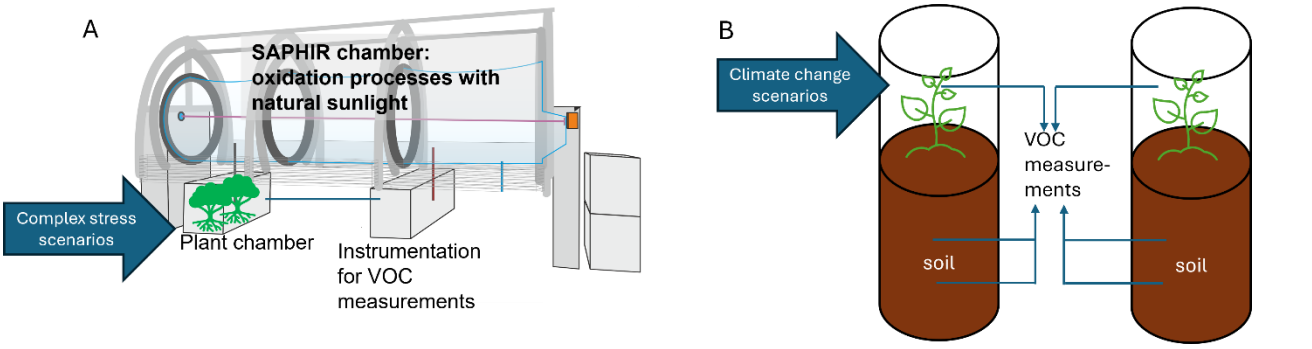

Figure 1. A: SAPHIR-PLUS setup with plant chamber for controlled complex stress experiments with six trees simultaneously and outdoor atmospheric simulation chamber SAPHIR. B: AgraSim setup with six different long-term climate change scenarios that are run in six chambers simultaneously for agricultural crops and their soils.

The candidate will use proton transfer reaction mass spectrometry and gas chromatography to study BVOC emissions in simulation chambers (Agrasim at IBG-3 and the SAPHIR-PLUS chamber at ICE-3) under realistic future climate and stress scenarios. The atmospheric chemistry and aerosol formation impact of the emissions will be investigated using SAPHIR, the atmospheric simulation chamber at ICE-3, and aerosol measurement methods such as aerosol mass spectrometry.

The goal of the project is to establish quantitative relationships between combinations of climate-related and environmental stressors (e.g. temperature, ozone, nutrients) and their impact on biogenic volatile organic compound emissions and atmospheric chemistry to identify biosphere-atmosphere exchange patterns.

Key Tasks in This PhD Project:

- Optimize state-of-the-art mass spectrometry methods (e.g. proton transfer reaction time-of-flight mass spectrometry, aerosol mass spectrometry) and gas chromatography for measuring biogenic volatile organic compounds and their oxidation products
- Conduct experiments to quantify and characterize the emission of volatile organic compounds from relevant plant species and soils under long-term climate change scenarios in the AgraSim facility, and under combined biotic and abiotic stressors in a plant chamber (SAPHIR-PLUS)
- Study photooxidation processes and aerosol formation of characteristic BVOC mixtures under various atmospheric conditions in the large state-of-the-art atmospheric oxidation chamber SAPHIR
- Use advanced data analysis methods including statistical tools on the large multidimensional datasets obtained from the experiments

Location of the HITEC Fellow	Forschungszentrum Jülich, Institute of Climate and Energy Systems – Troposphere (ICE-3), Supervisors: Dr. Thorsten Hohaus, Jun.-Prof. Dr. Eva Pfannerstill, Director: Prof. Dr. Anke Nölscher https://www.fz-juelich.de/en/ice/ice-3
Partners of the HITEC Project	Forschungszentrum Jülich, Institute of Bio- and Geosciences - Agrosphere (IBG-3), Partner: Prof. Nicolas Brüggeman, Directors: Prof. Dr. Jan Vanderborght and Prof. Dr. Wulf Amelung https://www.fz-juelich.de/en/ibg/ibg-3
Specific **requirements**	• M.Sc. in chemistry, physics, meteorology, environmental sciences or a related field • Excellent experimental skills; experience in mass spectrometry or gas-phase measurements is an advantage. • Data analysis experience and/or programming knowledge in Python are an asset • Excellent oral and written communication skills in English • Ability to communicate results clearly in presentations and in writing • Self-motivated, structured working style • Excellent cooperation and teamwork skills
For **project specific** questions please **contact**	Dr. Thorsten Hohaus, ICE-3, t.hohaus@fz-juelich.de Jun.-Prof. Dr. Eva Pfannerstill, ICE-3, e.pfannerstill@fz-juelich.de

[1] Steiner: Role of the Terrestrial Biosphere in Atmospheric Chemistry and Climate, Acc. Chem. Res., 53, 2020.
[2] Agathokleous et al.: Ozone affects plant, insect, and soil microbial communities: A threat to terrestrial ecosystems and biodiversity, Science advances, 6, 2020.