EMISSIONS OF VOLATILE ORGANIC COMPOUNDS IN ENERGY CROPPING SYSTEMS

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Gas flux chambers at the research station Dedelow

All plants emit signaling chemicals, called biogenic volatile organic compounds (BVOCs). These protect plants from stress and mediate communication within the ecosystem, attracting insects for pollination or sending warning signs to pests or neighboring plants. BVOCs also contribute to air chemistry and have a considerable indirect effect on the climate. The emissions from agriculture depend on the crop, environmental conditions, phenology, and field management. In order to quantify BVOC emissions for energy crops under current and future climatic conditions, the VOCE project measured BVOC fluxes from maize, rapeseed and ryegrass and extended available computer models to simulate these emissions in regional applications.

The emission dynamics of biogenic volatile organic carbon compounds (BVOCs) from crops are rarely studied, despite their key role in regulating ozone concentration, methane lifetime and the formation of secondary aerosols in the atmosphere. BVOC emissions are likely to change in the future, in association with temperature, atmospheric CO_2 and land-use change. In order to assess the impact of bioenergy crops on air chemistry, the project VOCE measured the BVOC emissions of maize, winter rapeseed and ryegrass during the cropping seasons 2015, 2016 and 2017. This work was carried out by scientists of the KIT/IMK-IFU Garmisch-Partenkirchen and the Helmholtz Zentrum München at the ZALF Research Station in Dedelow, Brandenburg. For these measurements, special gas flux chambers (see picture) were used, which regularly and automatically recorded gas fluxes in a 10-minute time window covering an area of 1 m^2. Proton transfer reaction mass spectrometry (PTR-MS) was then used to identify and quantify the BVOCs emitted by the plants. These data were the primary source of information to calibrate and validate the BVOC emission modules, which were added to the agroecosystem model MONICA by ZALF scientists. Two distinct emission modules were tested, differing in structure and mechanisms. The simpler approach »Guenther« was able to reproduce the measured experimental data well, but unable to react to future changes of the atmospheric CO_2 concentration. This aspect is taken into account by the second integrated approach »JJV«, which requires further validation beyond the project lifetime.

With the model MONICA and the integrated modules developed during this project, ZALF makes available a generic agroecosystem model which allows calculating the BVOC emissions of maize and winter rapeseed at the regional and national level. The open source nature of the project fosters the collaboration within the scientific community, which can benefit from the work carried out during the VOCE project and contribute to its extension. In this regard, ZALF encourages experimental work to study the BVOC emission patterns of other crops and hopes to bridge the gap between ecosystem and air chemistry models. Such integrated solutions help to disentangle some of the feedback mechanisms between crops and the atmosphere and could therefore become an essential tool for the design of climate-smart cropping systems.

Project: Emissions of Volatile Organic Compounds in Energy Cropping Systems (VOCE) **Term:** 2015–2018
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Partner: KIT/IMK-IFU, HMGU