Modelling Feedbacks between Biogenic Emissions and Air Chemistry from Site to Globe

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Background

Biogenic volatile organic compounds (BVOCs) are important drivers for tropospheric air chemistry, i.e. ozone levels and aerosol formation - and thus climate change. However, even for the best known compounds, emission estimates are highly uncertain.

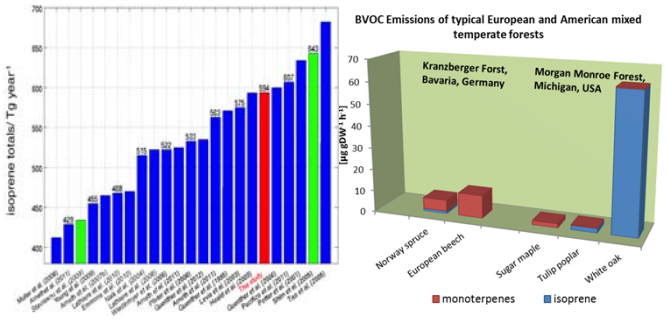

Fig.: Left: Estimates of global isoprene emissions from various publications (Sindelarova et al. 2014 (ACP)); Right: Emissions of typical species of the same plant vegetation type in different regions.

Simulation results

- Emission responses to environmental conditions are sensitive to parameters used in photosynthesis models
- Different emission response patterns can be represented based on photosynthesis processes, without using species-specific BVOC parameterization
- The new emission model produces similar but somewhat higher emission patterns as 'state-of-the-art' approaches when implemented into a coupled global-air chemistry model (CESM)

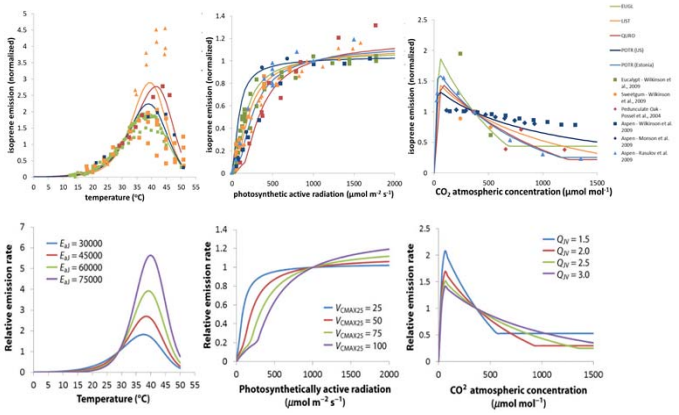

Fig.: Top: Measured (points) and simulated (lines) isoprene emission responses to temperature, radiation, and CO_2 conc. of 5 tree species. Bottom: Impact of the most sensitive photosynthesis parameters to isoprenoid emission rate (from Grote et al. 2014 (PCE)).

Modelling

The new model derives isoprenoid BVOC emission directly from the electron transport potential of photosynthesis. Model requirements are designed to be met by land-surface models that apply the Farquhar assimilation scheme, e.g. JULES or CLM.

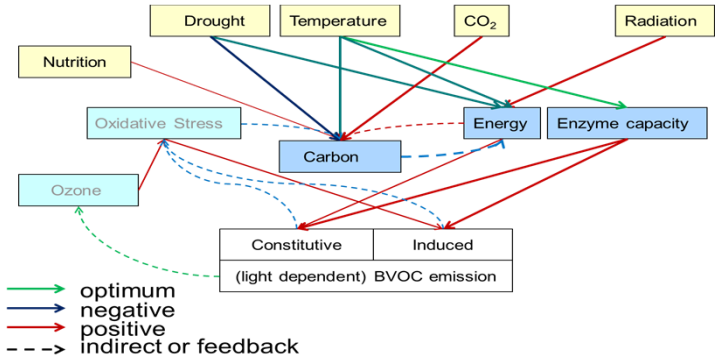

Fig.: Concept of the newly developed JJV model. Light blue sections are in preparation to consider the ozone impact on photosynthesis (negative feedback) and BVOC induction (positive feedback).

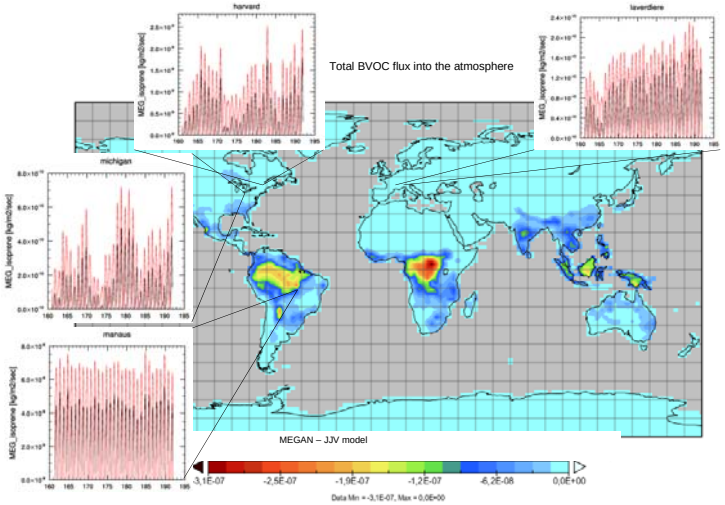

Fig.: Difference between isoprene emissions simulated with JJV and with MEGAN globally and for specific sites during 5 weeks in summer (Red: JJV model, Black: MEGAN model).

Conclusion and Outlook

The new mechanistic approach represents the commonly observed decrease of (isoprene) emission with increasing CO_2 air concentration. Emission responses are tightly coupled with photosynthesis. Further work will consider air pollution impacts and improve the plant-functional type concept.