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Direct and indirect effects of climate warming on volatile organic compound emissions from arctic tundra

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Tundra covers vast areas in the Arctic and is characterized by sparse, low-statured vegetation, large carbon stocks in the soil, and a cold climate. These areas are currently experiencing drastic changes due to global warming. The average temperatures are increasing twice as fast as the global temperature increase, and this warming is causing evident alterations, e.g. changes in the vegetation cover as well as thawing of permafrost. During the past decade, we have assessed how climate warming and its consequences affect the emissions of volatile organic compounds (VOCs) from the tundra. The main findings from this work are summarized in this presentation.

We measured VOC emission from tundra vegetation in long-term field manipulation experiments in the Subarctic, Low Arctic and High Arctic. In these experiments, we applied passive warming with open-top chambers (OTCs) alone and in combination with other treatments, such as leaf litter addition, shading or herbivory, in well-replicated experimental designs. VOCs were sampled into adsorbent cartridges from ecosystem and branch enclosures with a push-pull technique. The cartridges were analyzed by thermal desorption and gas chromatography-mass spectrometry.

The OTCs increased daytime air temperature by 1-4 °C, and this resulted in VOC emission increases by a factor of 2-5. These strong VOC emission increases under moderate warming appeared before any vegetation changes took place (Lindwall et al. 2016) or even when plant biomass had decreased in the plots warmed for six years (potentially due to drought stress; Kramshøj et al. 2016). After 13 years of OTC warming in a wet heath tundra, the increased VOC emissions owed also to warming-induced increases in the VOC-emitting plant biomass, changes in vegetation community and the increased amount of leaf litter (Valolahti et al. 2015).

To synthesize the findings from these several independent experiments, we compared direct effects of temperature to effects of air temperature earlier during the same growing season, soil moisture, photosynthetically active radiation (PAR), and vegetation cover. This was accomplished using multivariate models and structural equation modelling. The preliminary results suggest that the temperature in the period preceding sampling can be as important a predictor of VOC emission as the actual temperature, PAR and soil moisture. The direct and lagged effects of temperature also vary for different VOCs and interact with seasonality and vegetation composition. To conclude, VOC emissions from arctic tundra ecosystems are likely to strongly increase with climate change both due to direct effect of warming and due to indirect effects on growing season length, vegetation composition and biomass.

References

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