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Emissions and ambient air concentrations of isoprene, monoterpenes and sesquiterpenes at a Northern wetland

Hellén H., Schallhart S., Praplan A.P., Tykkä T., Aurela M., Lohila A., Hakola H.

Wetlands

- about 2% of the total land surface area of the world
- more than half of the global wetlands are in the Far North
- important sinks for carbon dioxide and sources of methane
- knowledge on their VOC emissions is very limited

Background

Measurement site:

- Lompolojänkkä fen
- North-western Finland
- Part of Pallas-Sodankylä Global Atmospheric Watch (GAW) station

Methods:

- Emission measurements with flow through Teflon chambers and an in situ TD-GC-MSs
- Ambient air measurements with an in situ TD-GC-MS

See ‘Hellén, H., Schallhart, S., Praplan, A. P., Tykkä, T., Aurela, M., Lohila, A., and Hakola, H.: Terpenoid measurements at a Northern wetland revealed a strong source of sesquiterpenes, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-1154, in review, 2020.’ for more details.

Vegetation

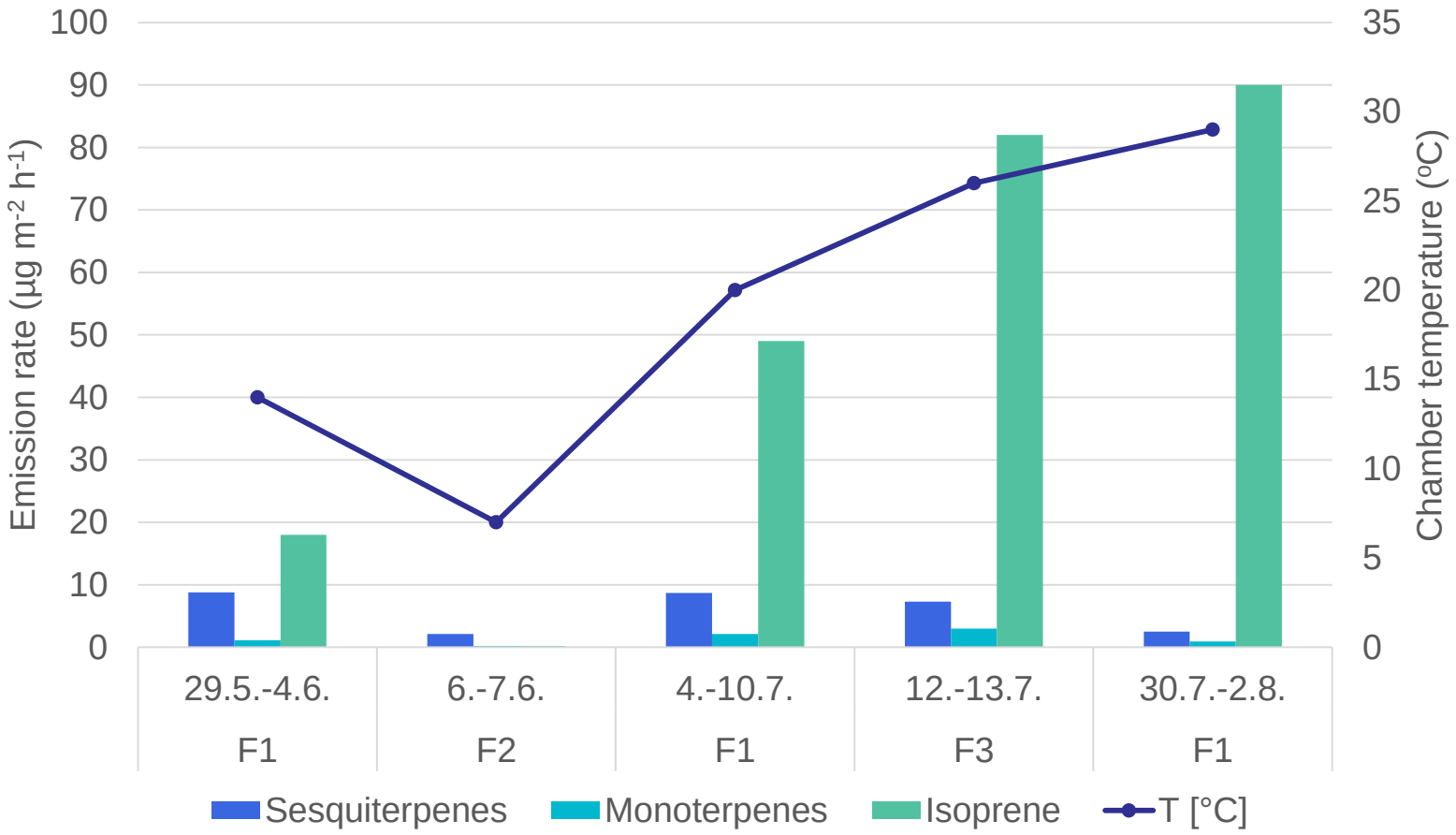
Frame1

Frame2

Frame3

- Sedges
- Sphagnum moss species
- Willows
- Horsetail…

Mean emission rates in 2018



- As in earlier wetland studies, isoprene had the highest emissions
- Emissions of sesquiterpenes were exceeding monoterpene emissions all the time.
- Concomitant with temperature, monoterpene and isoprene emissions were higher in July than in early summer
- Highest sesquiterpenes emissions were measured in early summer.
  - Possible reason: compounds produced in soil and trapped in frozen soil and snow cover during winter.

Sesquiterpenes are highly reactive and have very high SOA formation potentials → even small emissions can have huge impact on local atmospheric chemistry.

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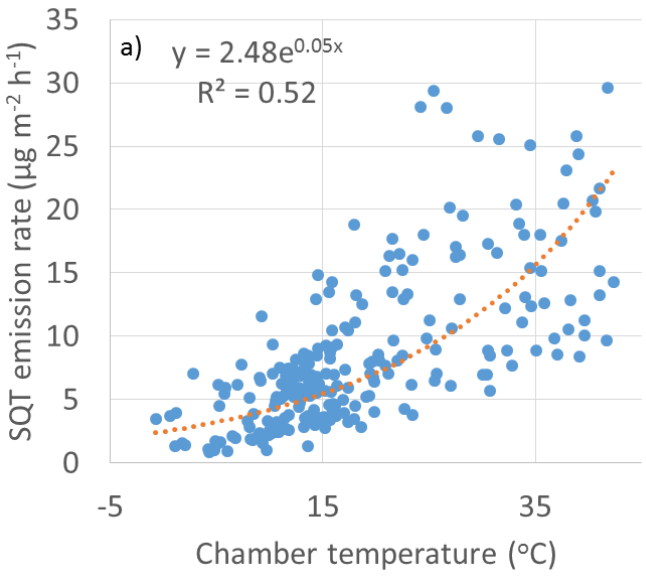
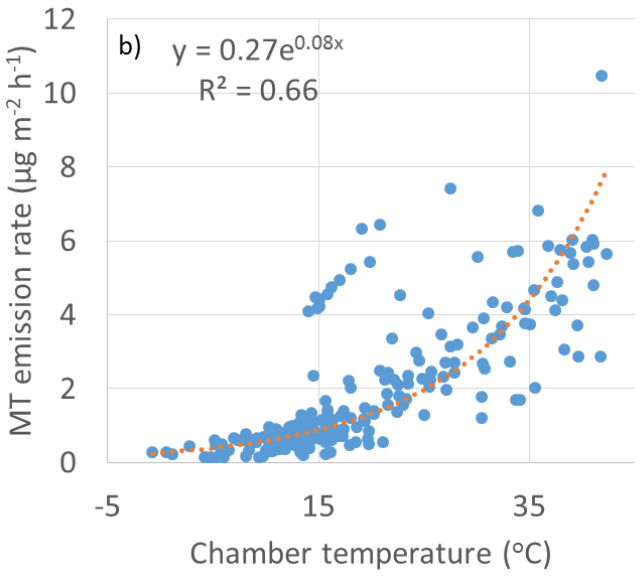
Temperature denpendence of the emission rates in May-August 2018

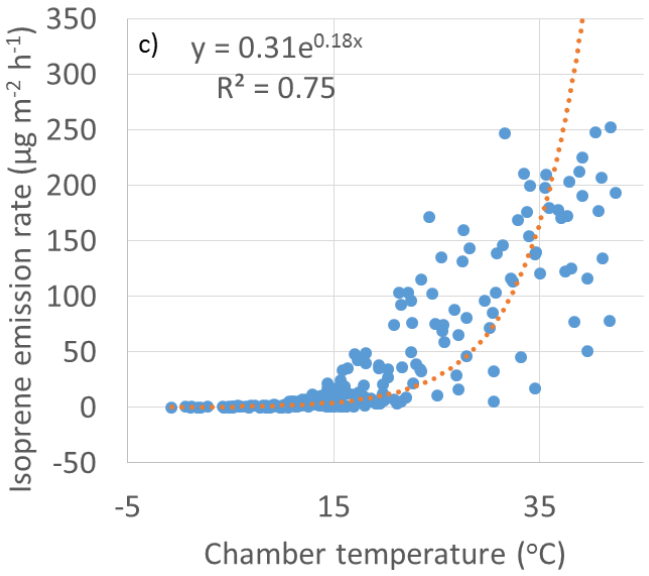
Sesquiterpenes



Monoterpenes



Isoprene



Wetland emissions showed clear exponential correlation with the temperature.

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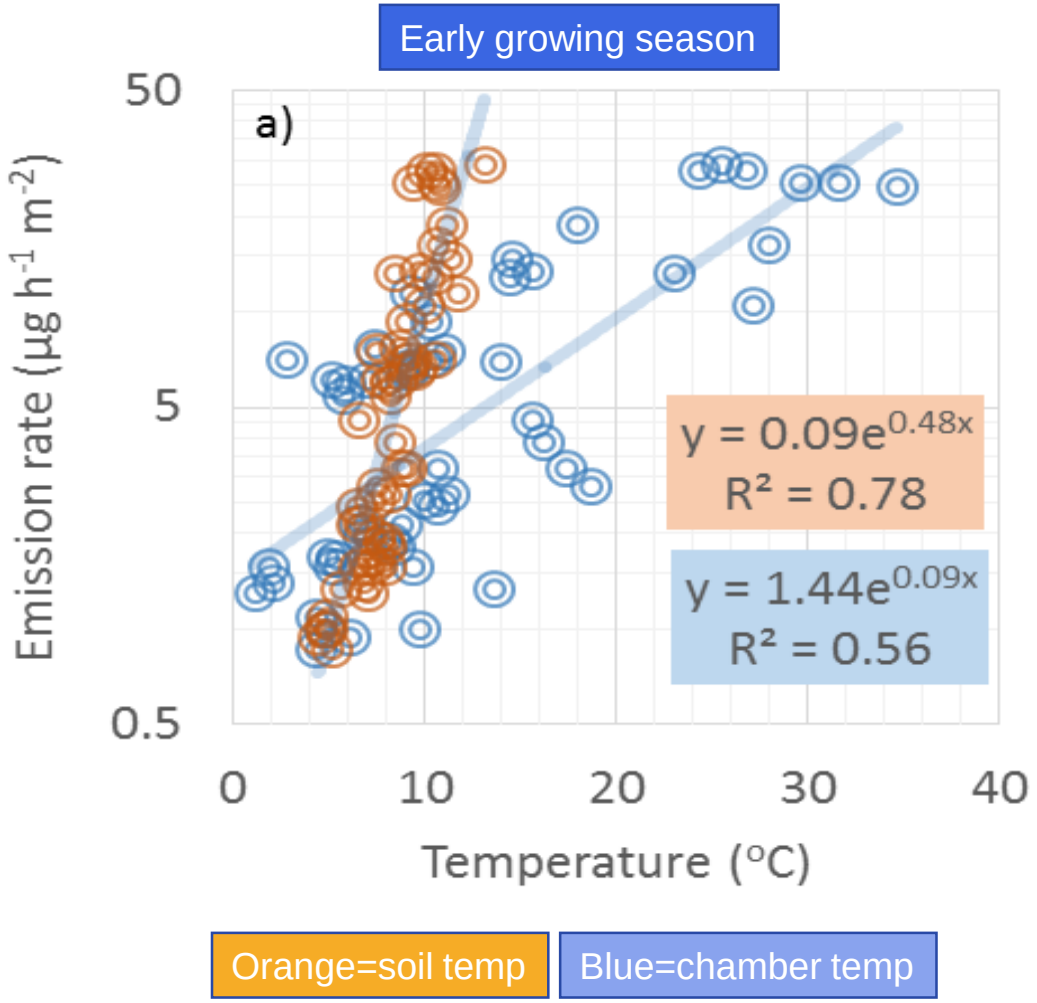
During early growing season sesquiterpenes emissions correlated with soil temperature



- Sesquiterpene emissions were better correlated with soil temperature than chamber temperature in early summer (soil temp < 15°C, not much vegetation).
  - produced under the snow due to microbiological activity and released when snow is melting and soil thawing?
- Later new growth affects the emissions

  → correlation with soil temperature weakens and correlation with chamber temperature increases.

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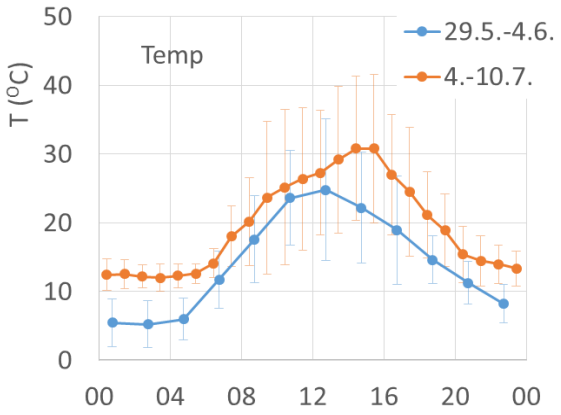
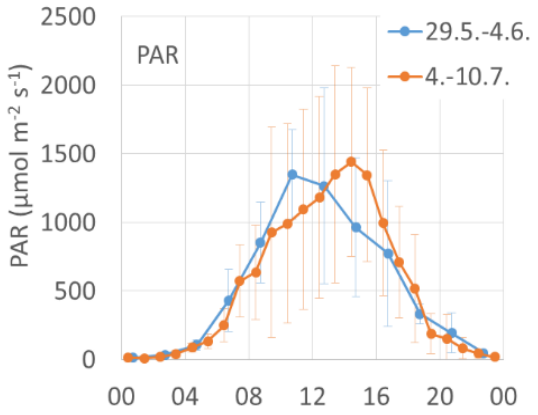
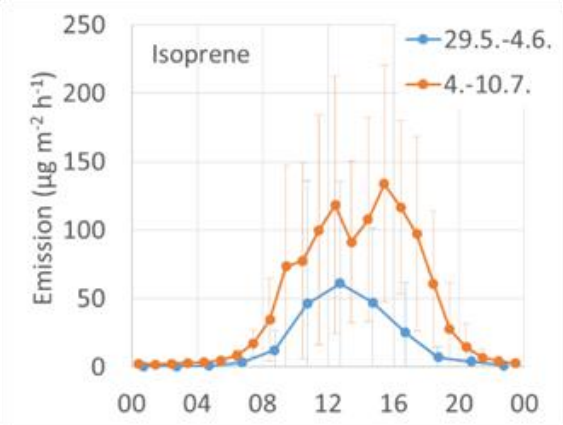
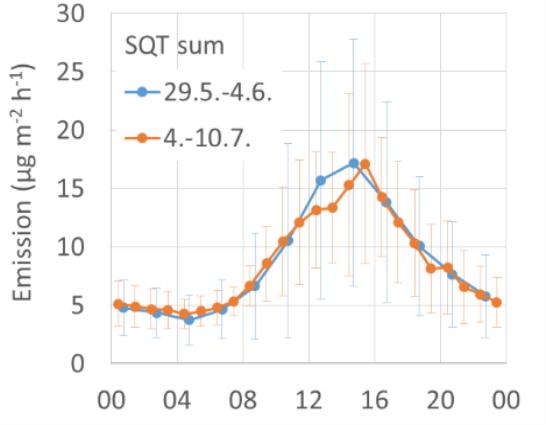
Diurnal variation of the emission rates

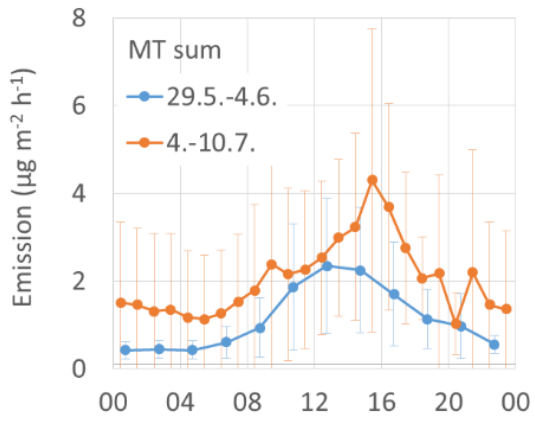




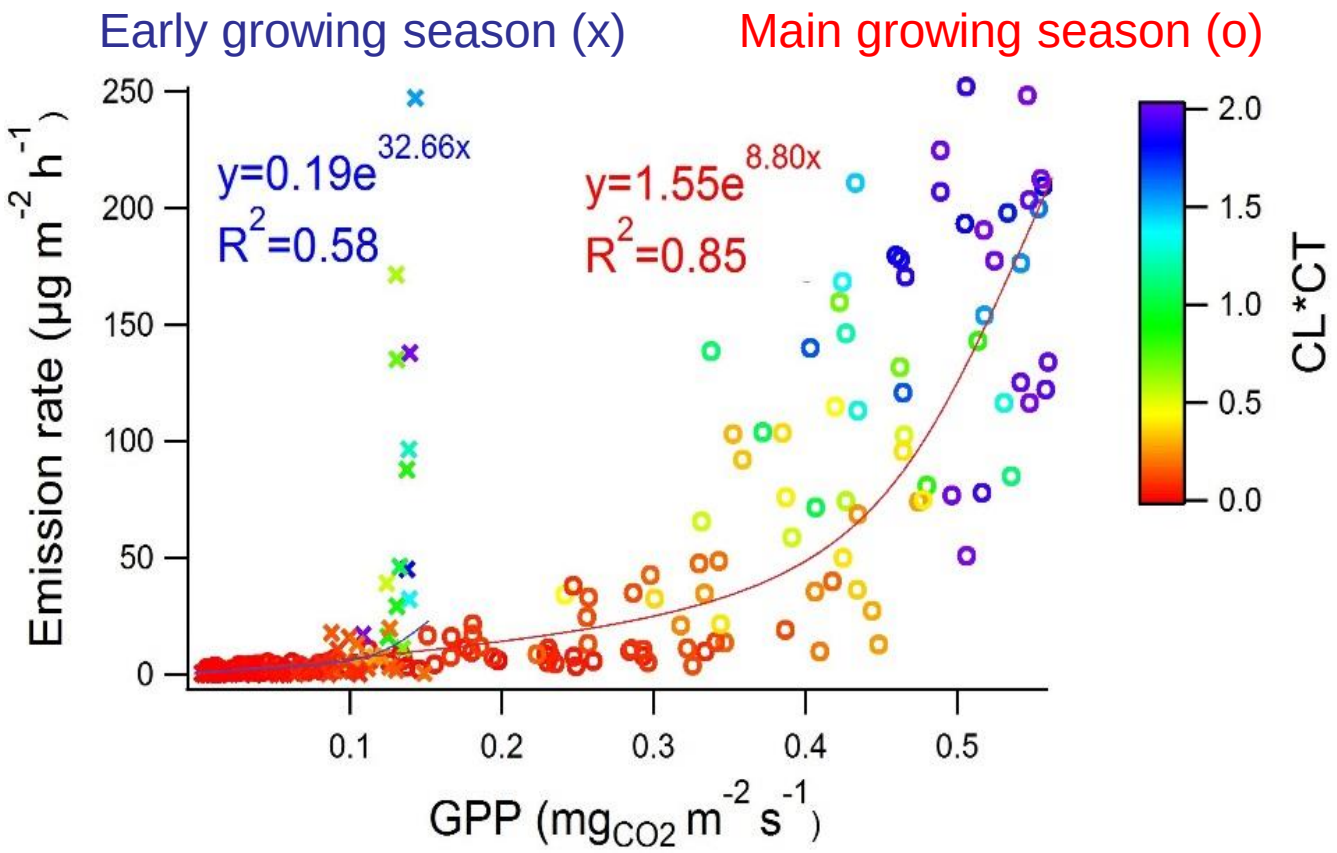
- Mean diurnal variation of all terpenes followed the variations of temperature and PAR.
- Isoprene emission is light dependent → the emissions were not detected during nights
- Monoterpenes and sesquiterpenes were emitted also during night.
- During night time sesquiterpenes were clearly the most significant compounds group emitted.







Isoprene emissions correlated with gross primary production of CO_2



Isoprene emission rate vs. CO_2 gross primary production (GPP) in the beginning of summer (29.5.-7.6., crosses and blue fitting) and in July (4.7.-13.7., dots and red fitting) measured at Lompolojänkkä fen in summer 2018. Color corresponds to the strength of the light and temperature activation coefficient (CL*CT) in the range 0.0-2.0. R^2 values are from the corresponding transformed straight lines (ln(y), ln(x)).

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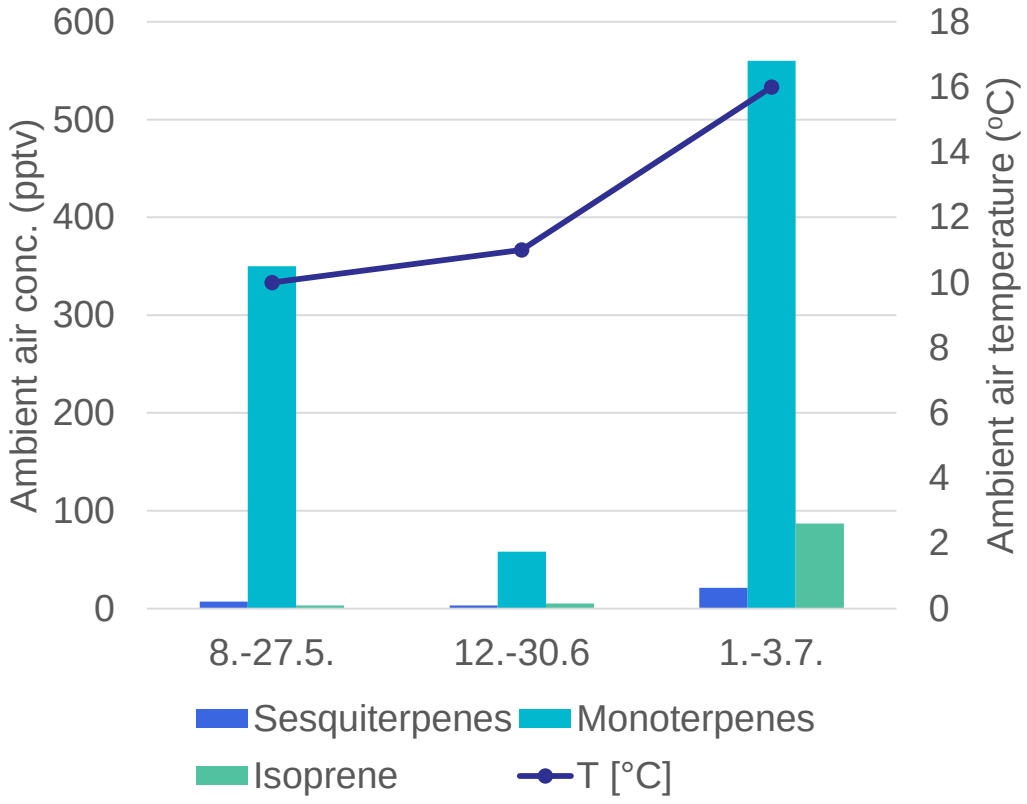
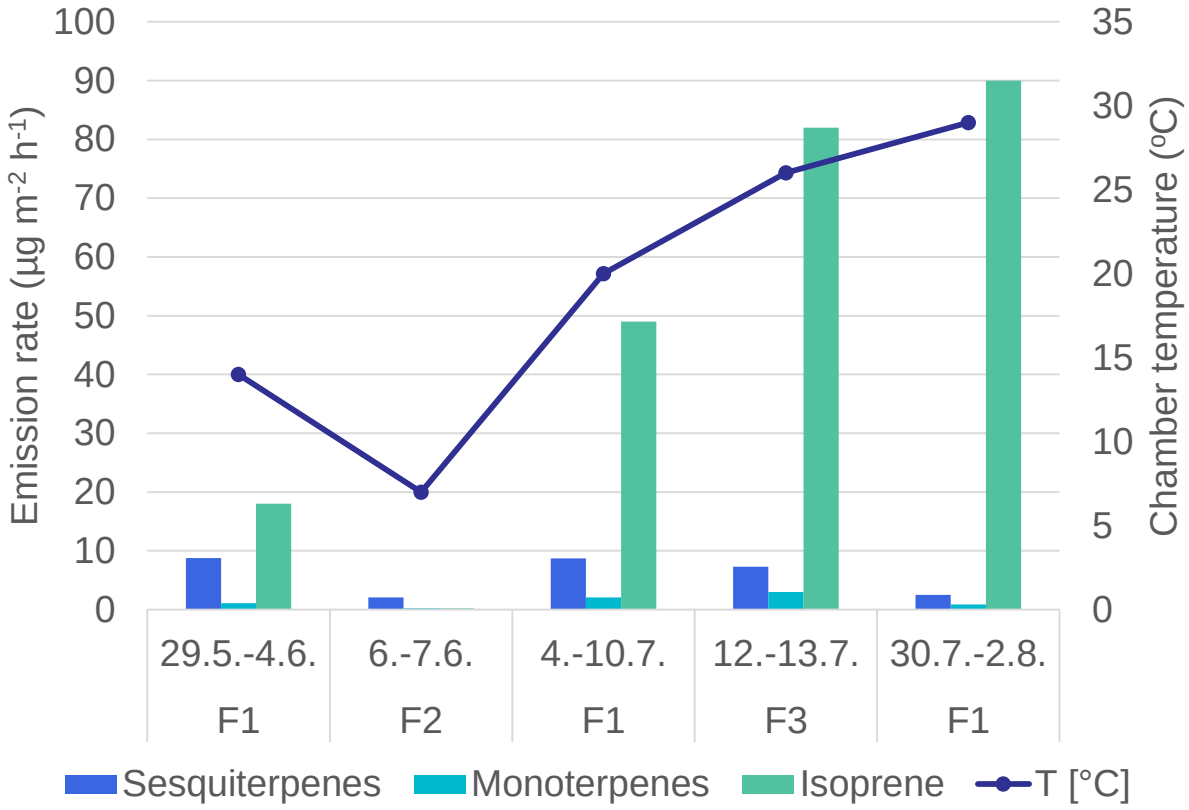
Ambient air concentrations

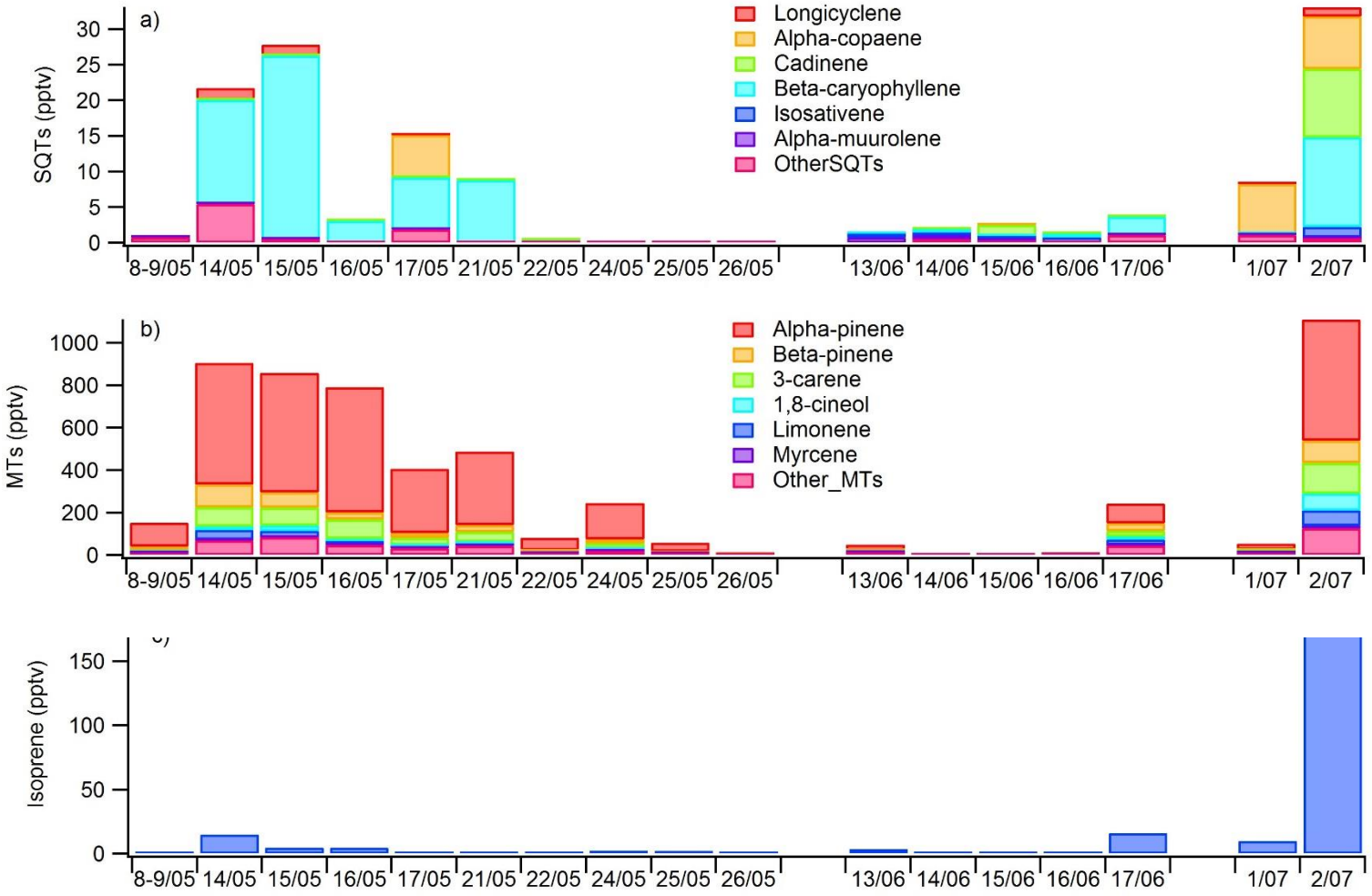


Emission rates



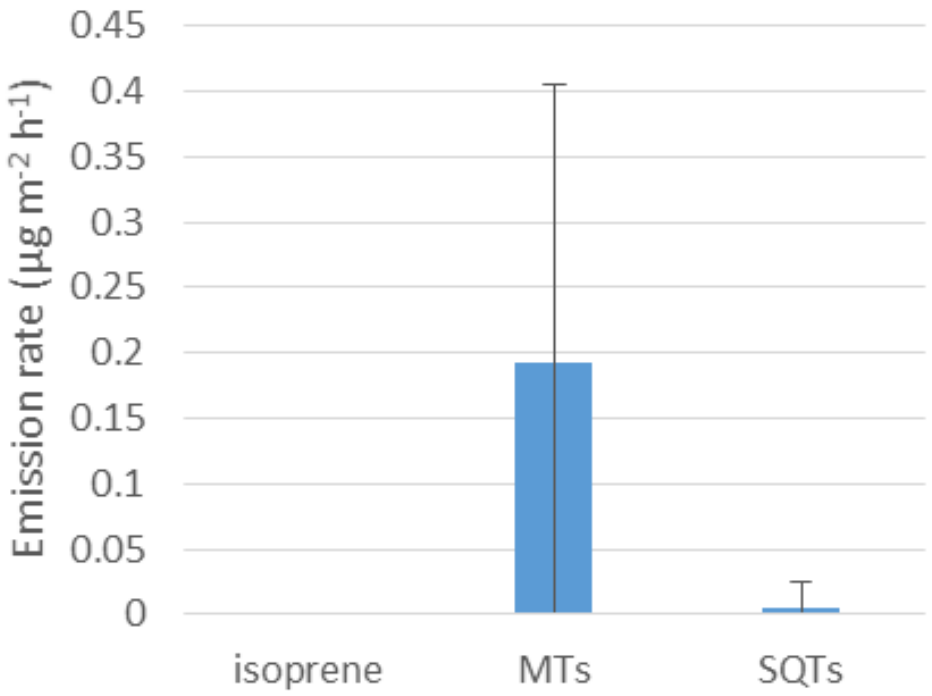
Although terpene emissions from the fen were quite considerable, it is clear when we compare these ambient concentrations to the emission rates that they were not the only emissions affecting atmospheric concentrations, but most probably surrounding forest contributed as well. (Remark: simultaneous emission and ambient air measurements were not possible since the same instrument was used for both).

Daily mean ambient air concentrations at Lompolojänkkä fen in 2018



Highest daily mean concentrations for both monoterpenes and sesquiterpenes were measured during the snow melting period in May.

Emissions from the melting snow



Snow emission measurements above the snow cover in the end of April and beginning of May, when snow was melting, show low but clear emissions of mono- and sesquiterpenes.

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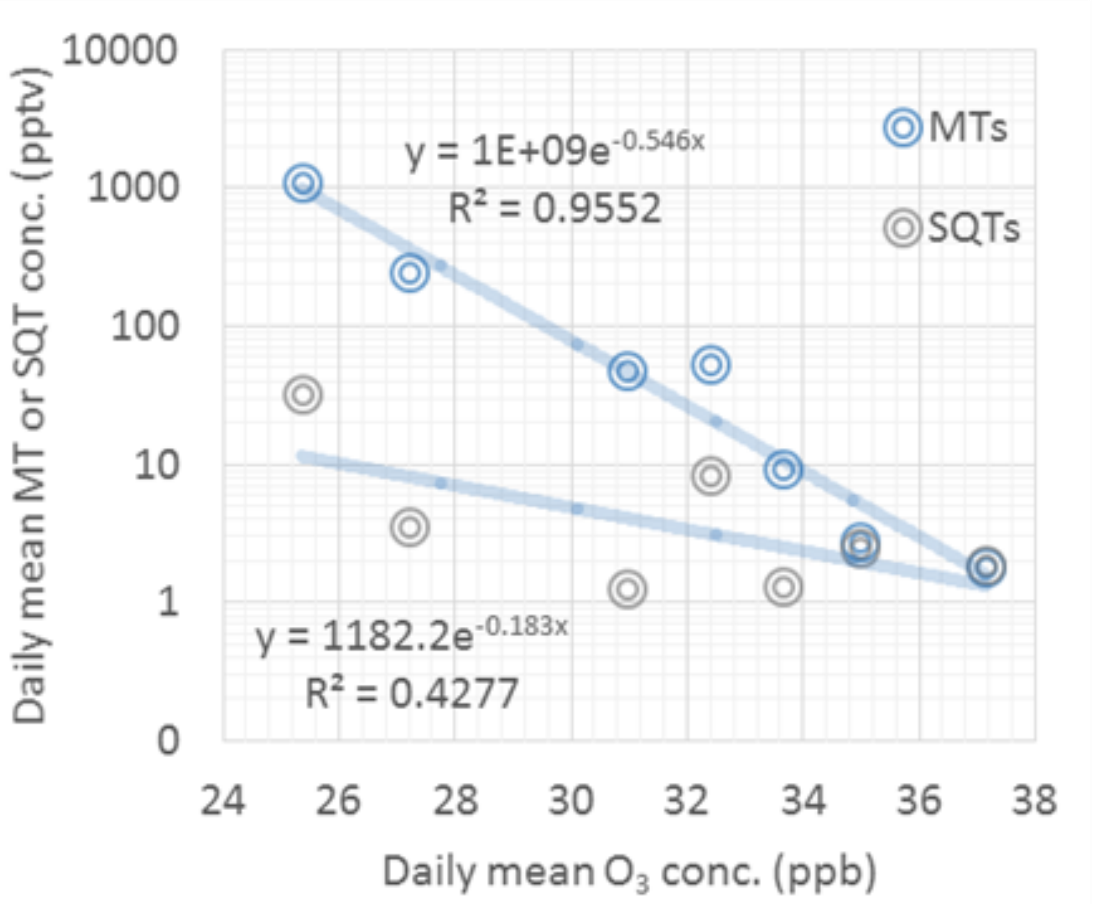
Dependence of ozone concentrations on terpene concentrations



- Daily mean mono- and sesquiterpene concentrations had a negative exponential correlation with ozone concentrations

  → vegetation emissions can be a significant chemical sink of ozone at this sub-Arctic area.

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Summary

- Isoprene was the main terpenoid emitted (monoterpenes 10% of isoprene)
- Sesquiterpene emissions were several times higher than monoterpene emissions, especially in early summer.
  - compounds trapped in frozen soil and snow cover during winter could be an important source of sesquiterpenes?
- Emissions showed clear exponential correlation with the temperature
- Isoprene emission rates correlated with the gross primary production of CO_2
- BVOC concentrations observed at the fen were not only affected by the fen emissions, but also by emissions from surrounding forests
- Strong correlation of daily mean ambient air concentrations of mono- and sesquiterpenes with ozone indicated that BVOC emissions from these ecosystems have strong impact on the local ozone levels