Differences in high temperature sensitivity between herbaceous and woody plants affect high-latitude isoprene emissions as temperatures rise

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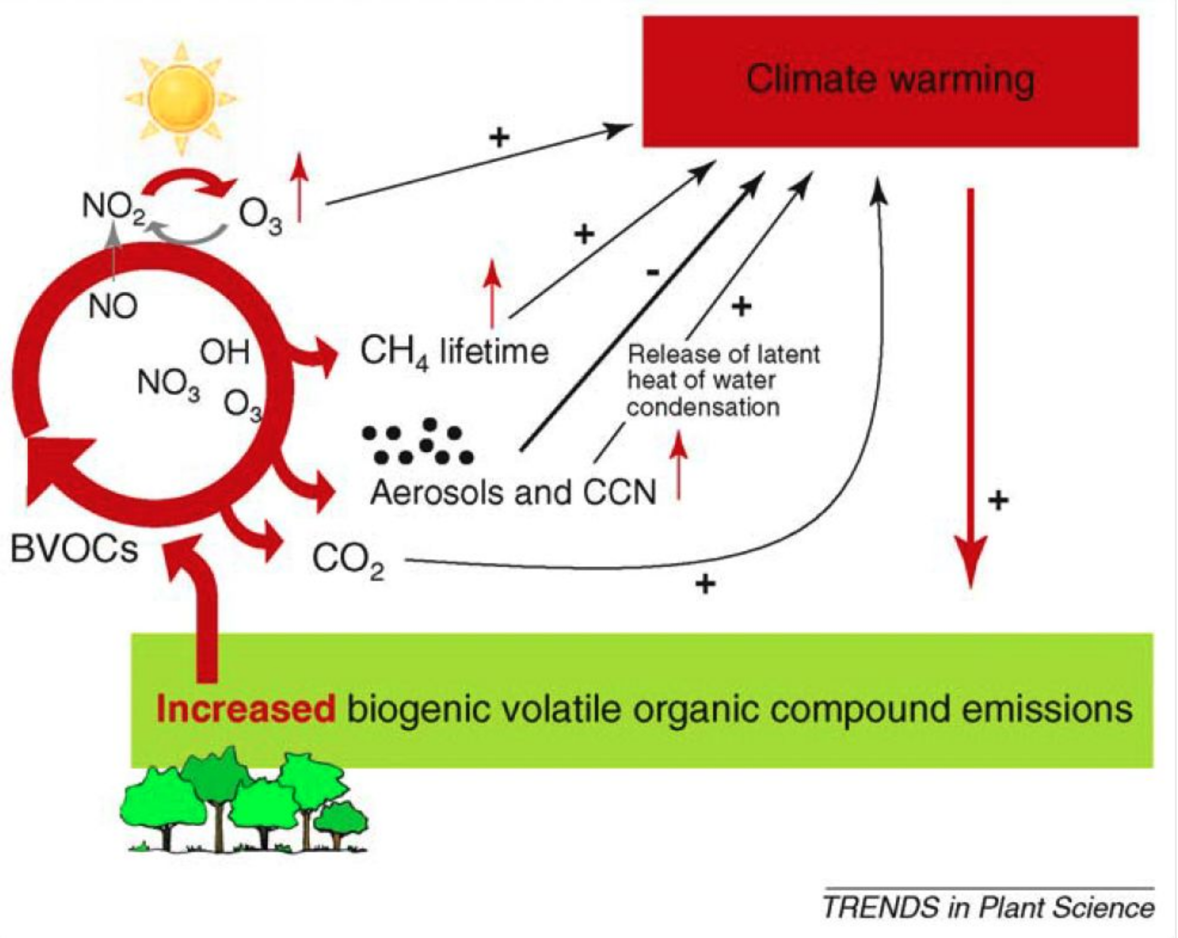
BIOGENIC EMISSIONS AND AEROSOL RESPONSE ON THE NORTH SLOPE
BEAR-oNS
NSF

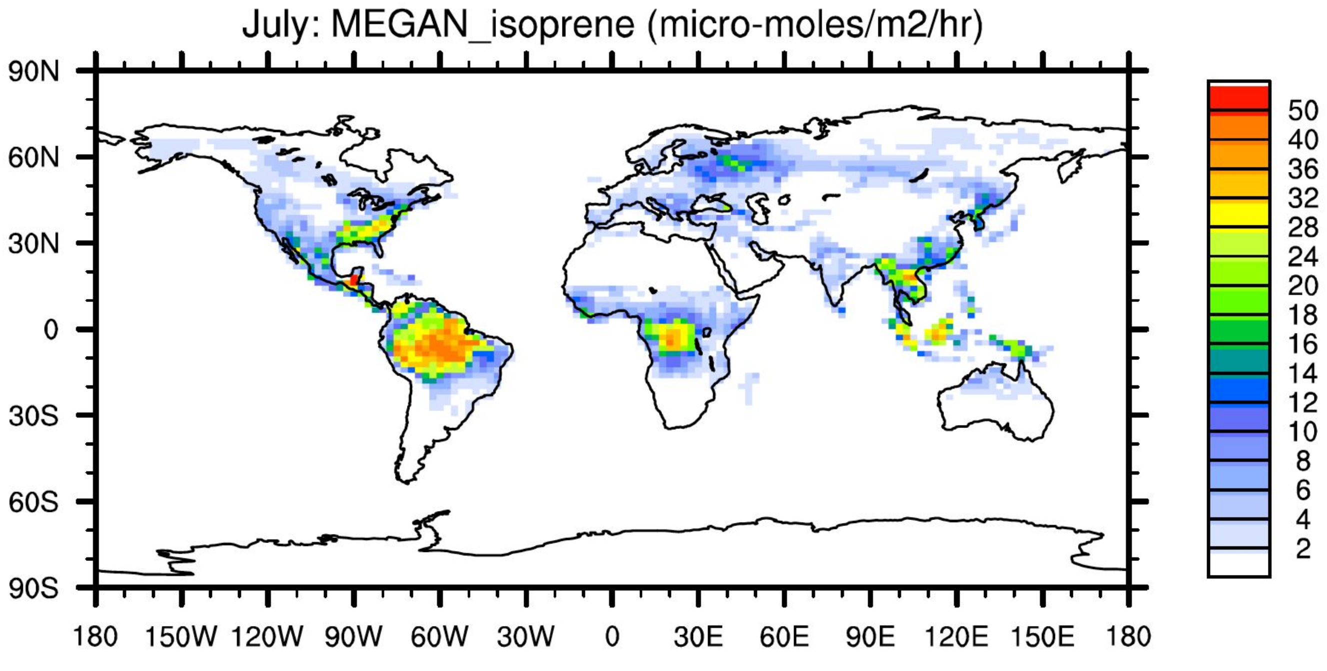
Interactions between BVOCs and climate



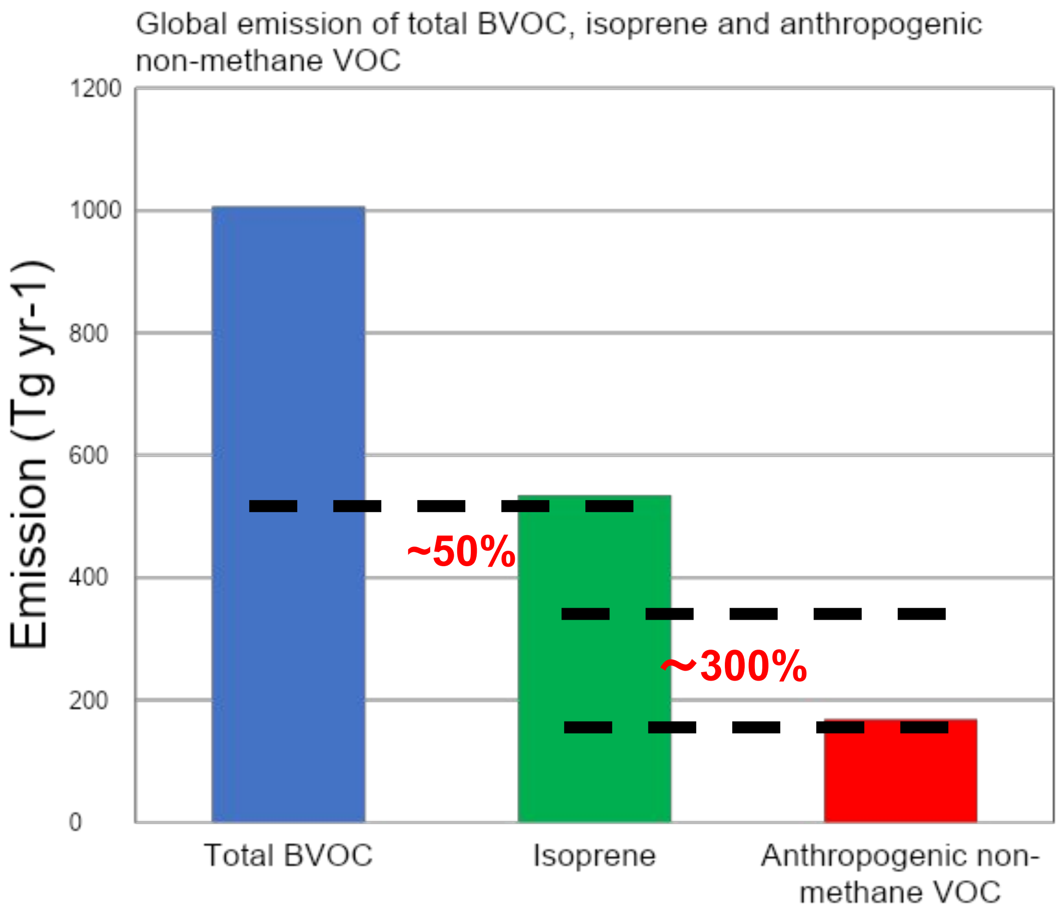
(Penuelas and Staudt, 2010)

BVOCs emission Modeling

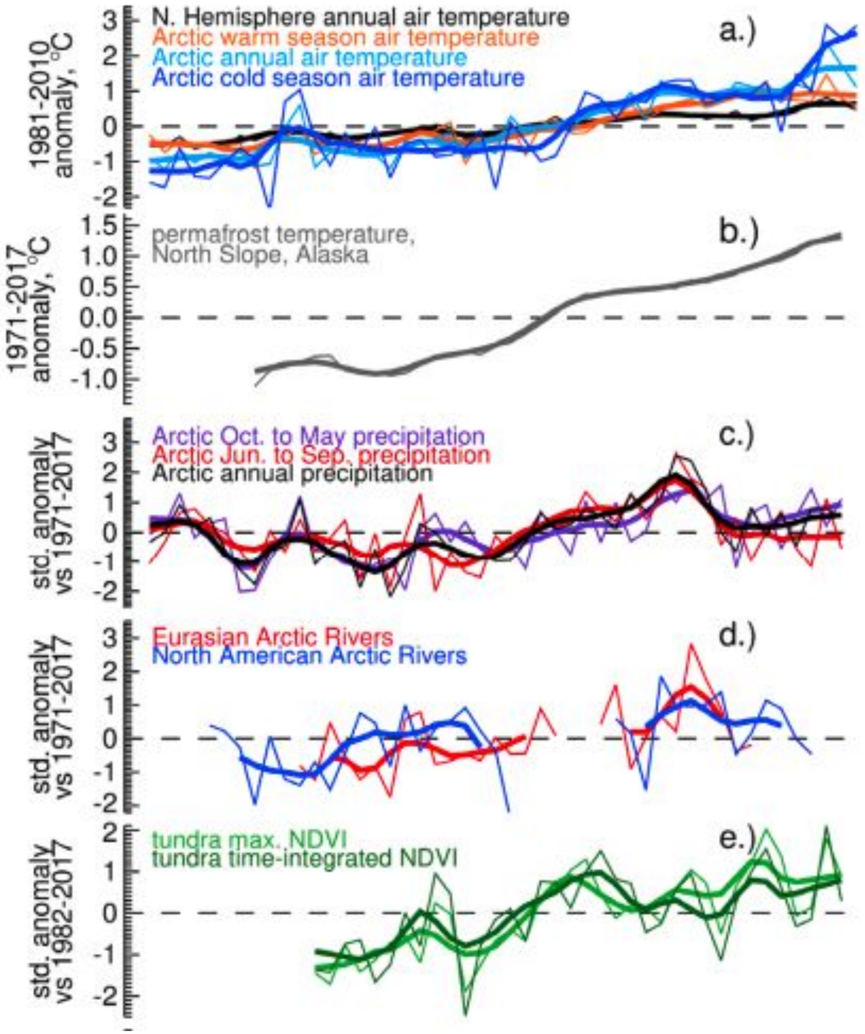
The Model of Emissions of Gases and Aerosols from Nature (MEGAN)



(Guenther et. al, 2012)



Rapid changes of climate in the Arctic



a. Air temperatures after NCEP/NCAR Re-analysis data.

b. Average of Northern slope of Alaska permafrost temperatures from West Dock, Deadhorse and Franklin Bluffs after Romanovsky et al (2017).

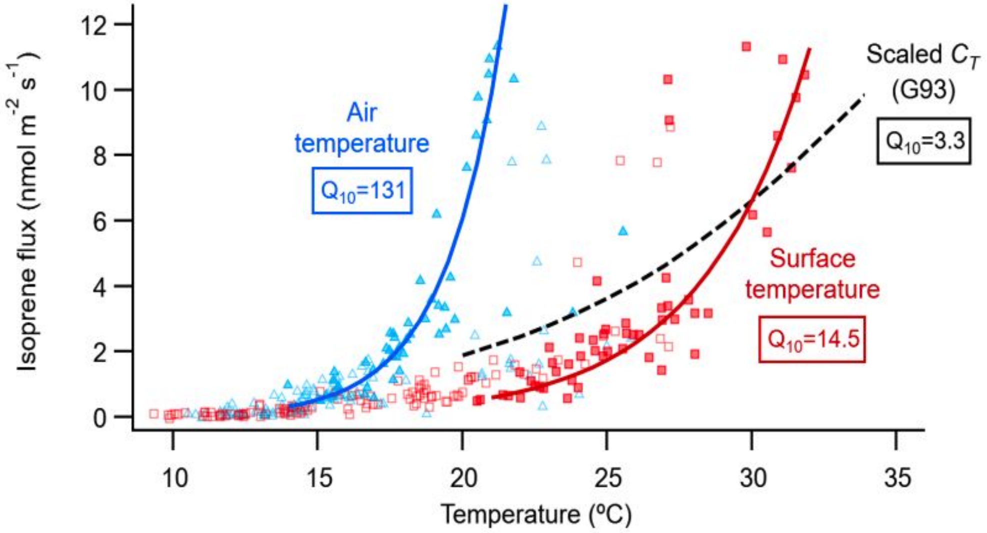
c. precipitation data are after NCEP/NCAR Re-analysis

d. Global Runoff Data Centre, 56068 Koblenz, Germany Arctic river discharge totals from from Eurasian (Ob, Pechora, Severnaya Dvina, Yenisei, Lena) and Kolyma) and North American regions (Mackenzie and Yukon). Shown are totals for years when all rivers in each region provide data.

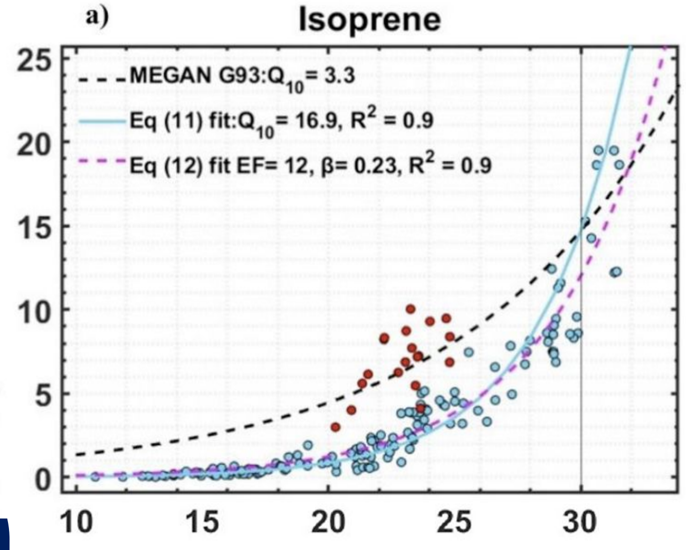
e. Pan-Arctic tundra maximum NDVI for elevations below 300 m, occurring in late July or early August averaged over Arctic tundra defined by the Walker et al (2005) circumpolar Arctic vegetation map from the AVHRR-based GIMMS NDVI3g v1.1 data (Pinzon and Tucker 2014).

(Box et al., 2019)

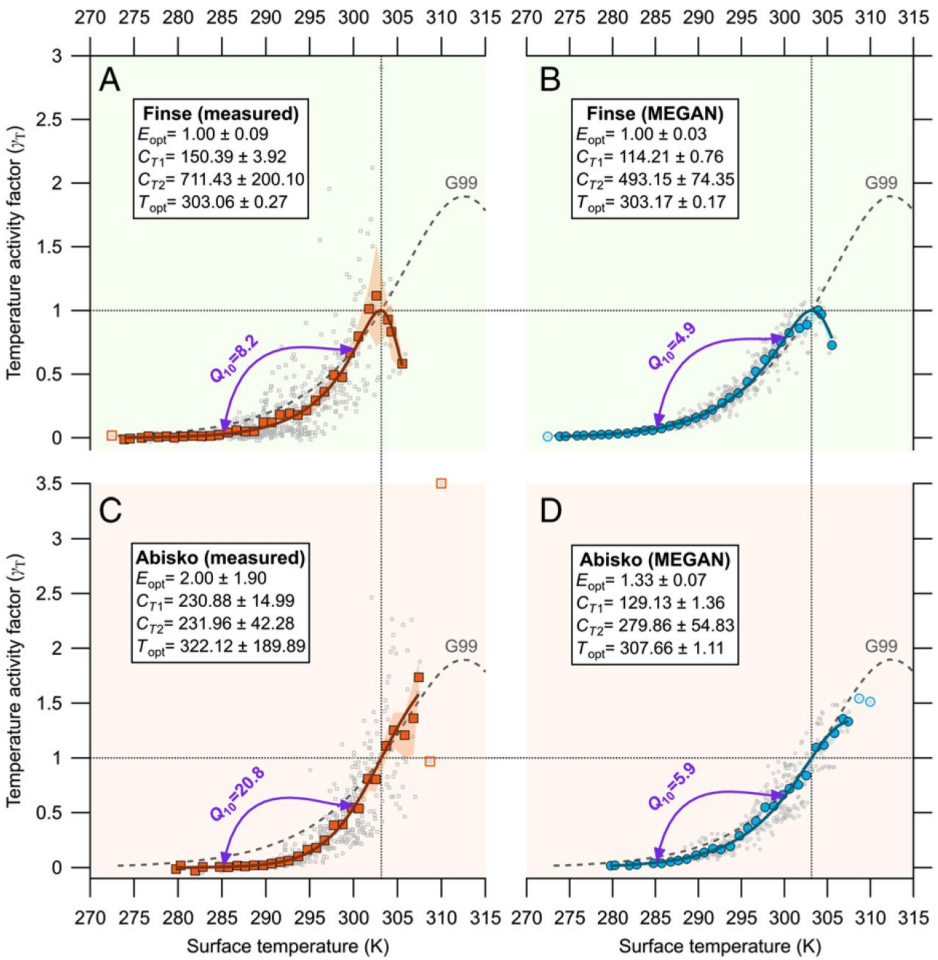
Strong temperature response of isoprene in the Arctic



(Seco et al., 2020)



(Vettikkat et al., 2023)



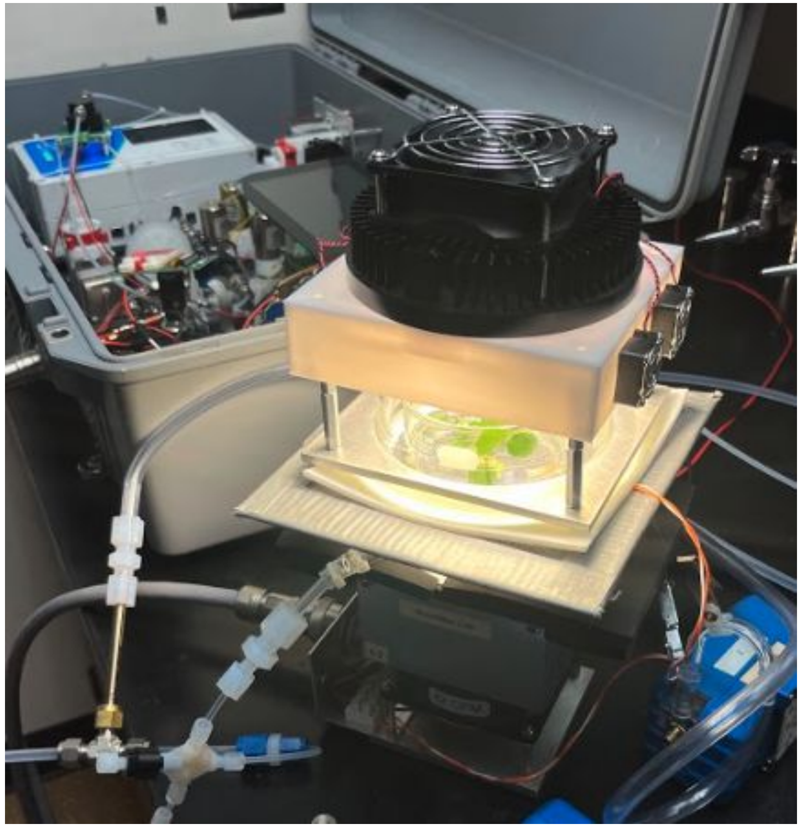
(Seco et al., 2022)

BEAR-oNS: **B**iogenic **E**missions and **A**erosol **R**esponse **o**n the **N**orth **S**lope

- First field campaign :
  July – August 2022;

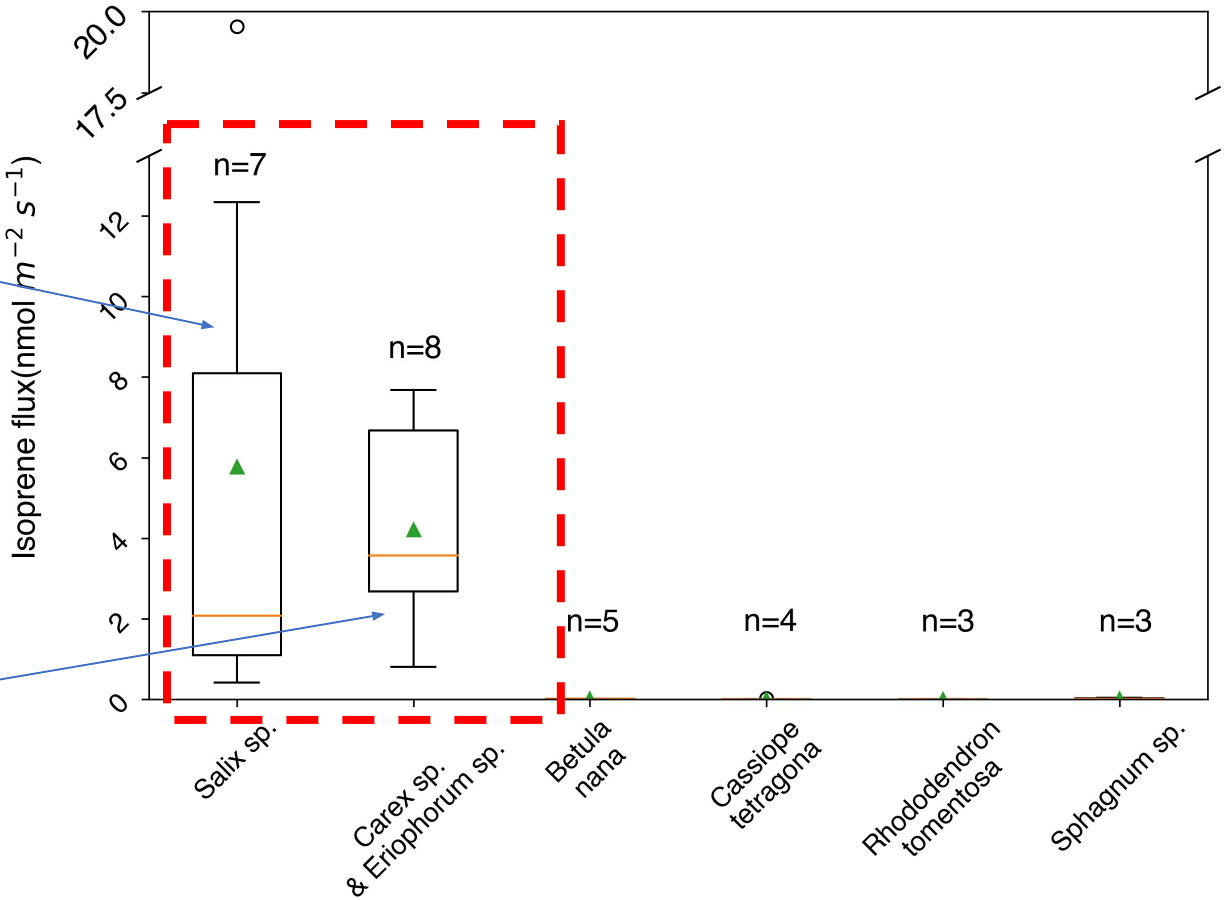
- Campaign location: The transition of vegetation zones in the Alaskan Arctic along a transect across the NSA (from Toolik to Prudhoe Bay).

Chamber experiments for tundra vegetations



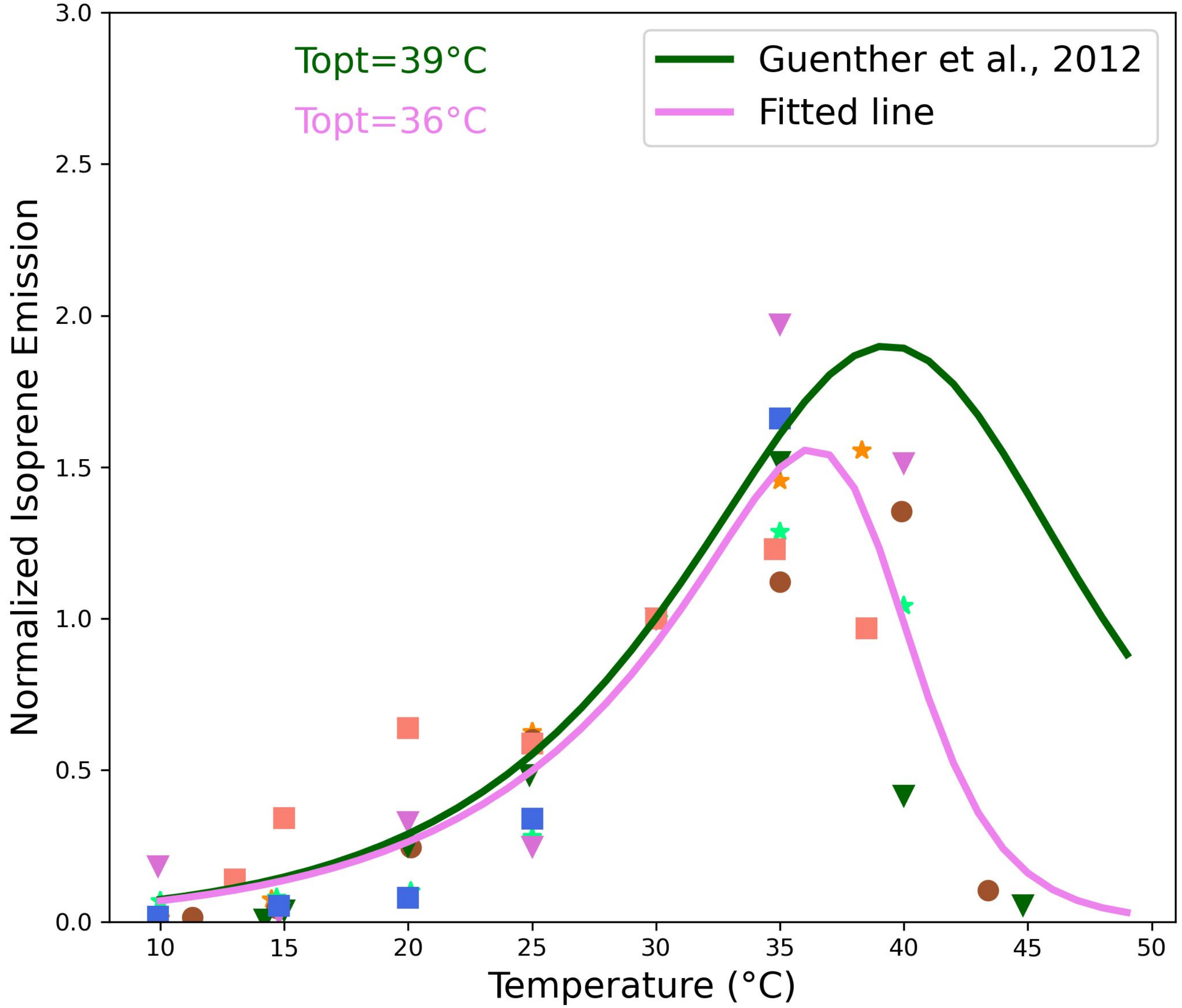
The gas-exchange chamber system from UCI BAI lab

Willows and sedges are the main isoprene emitters



- The standard emission factors (T=30°C and PAR = 1000 µmol m^{-2} s^{-1}) of isoprene from the plants in Arctic

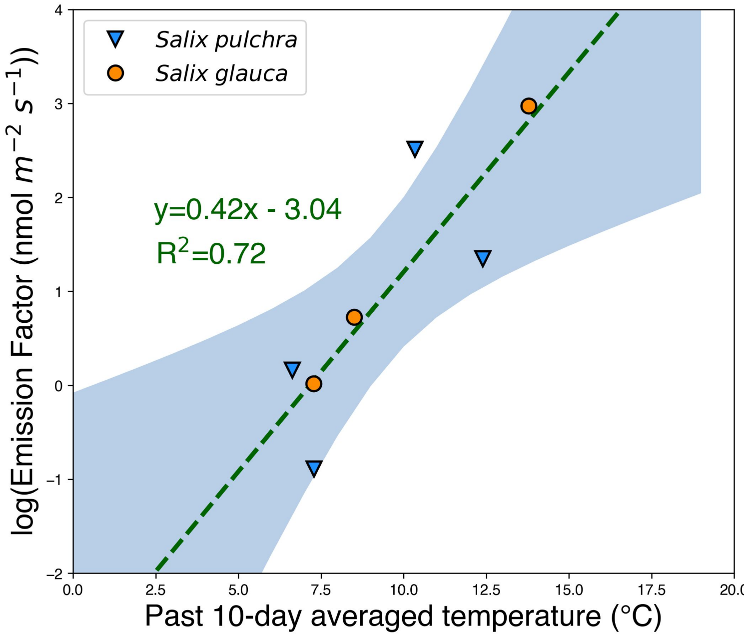
Willows in the Arctic follows current isoprene emission alogrithm in MEGAN

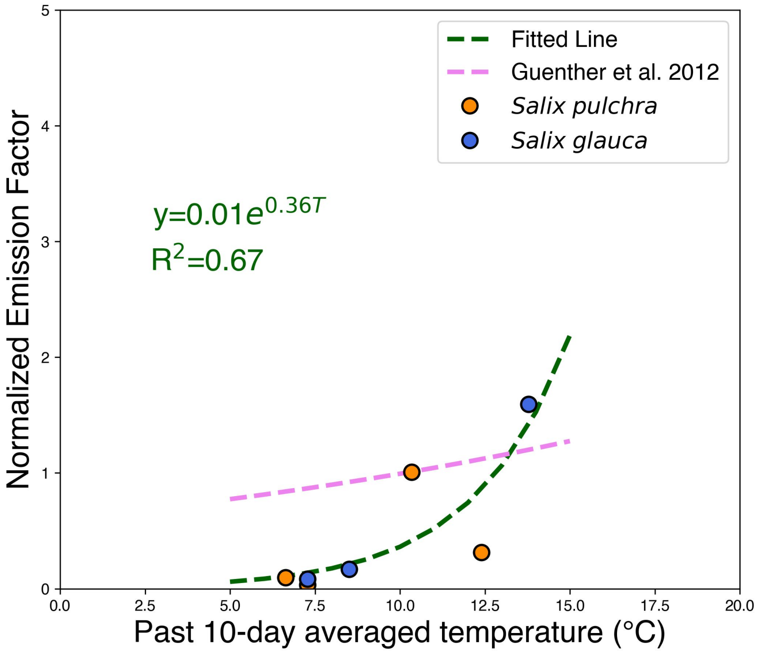


The temperature history can change the emission capacity of willows

The standard emission factors of willows:

- Salix Pulchra: 4.45 (± 5.48) nmol m^{-2} s^{-1}
- Salix Glauca: 7.19 (± 10.44) nmol m^{-2} s^{-1}
- Salix Pulchra (Potosnak et al., 2013): 6.85 (± 5.87) nmol m^{-2} s^{-1} (T=25 °C)





- The temperature history could change the emission factor of willows in a wide range.

Sedges have a much stronger temperautre response than the willows as well as the MEGAN model

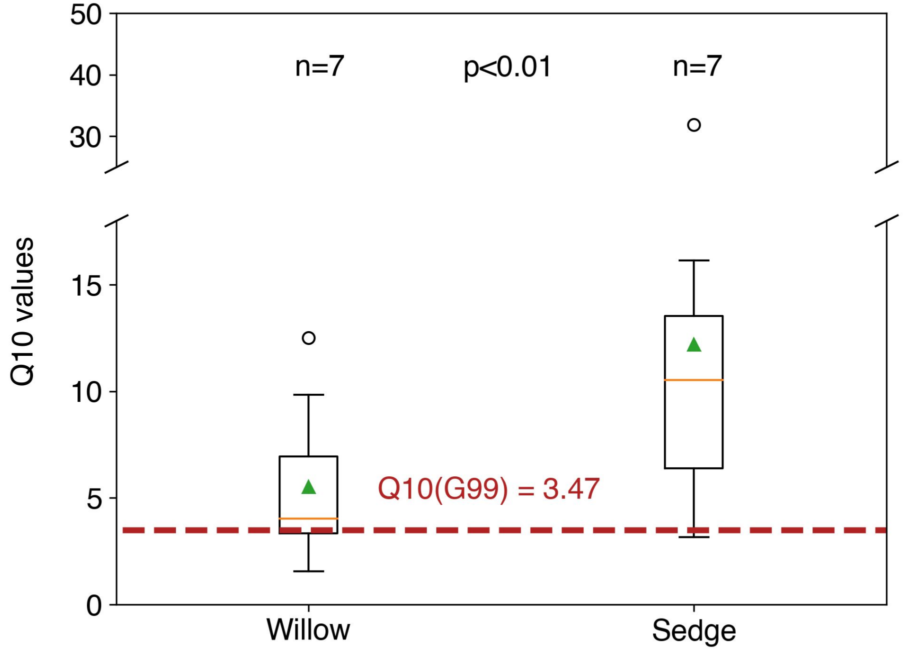
The Q_{10} is calculated as:

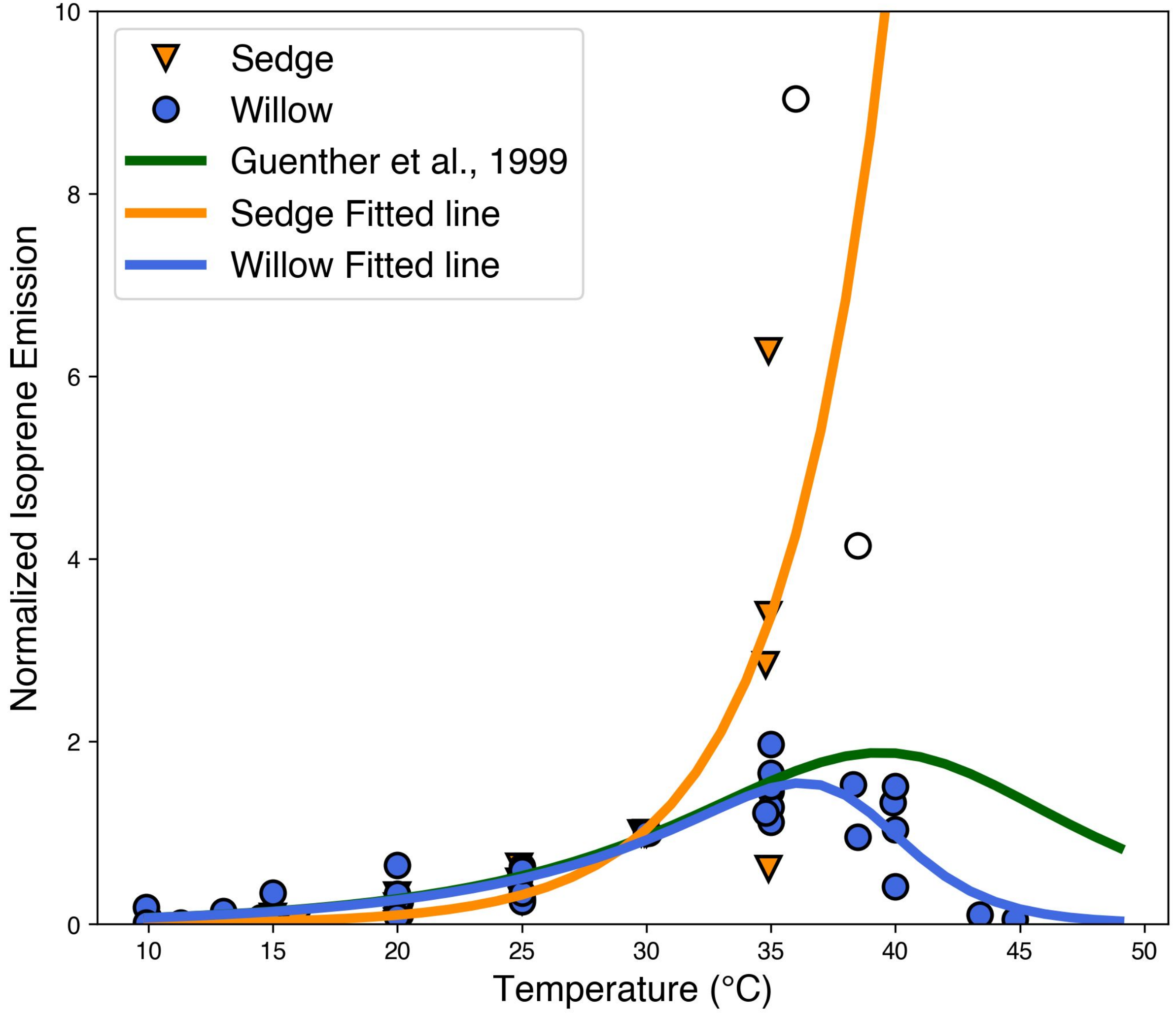
$$Q_{10} = \left(\frac{R_2}{R_1}\right)^{10\,^\circ\mathrm{C}/(T_2 - T_1)}$$

where;

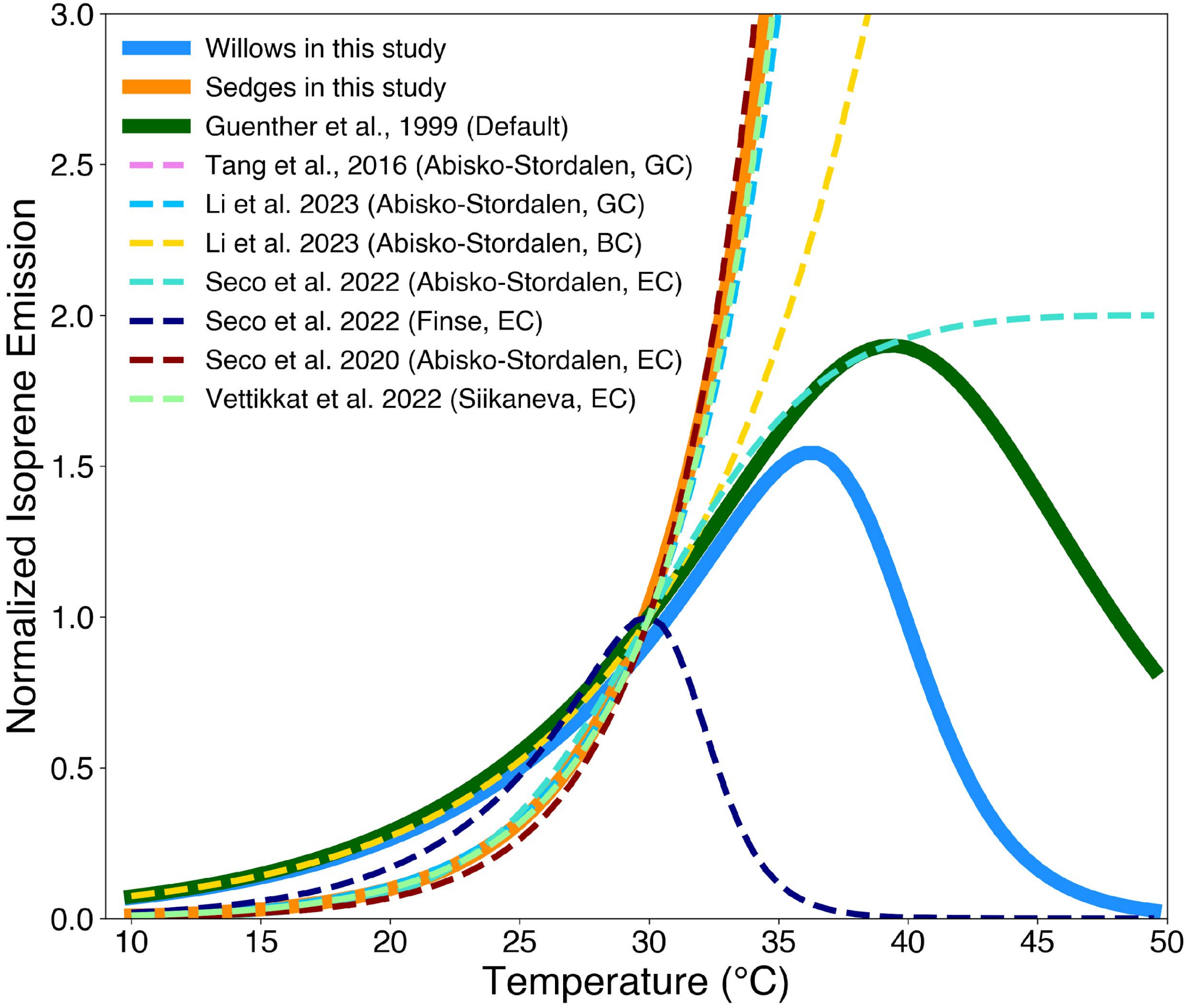
R is the rate

T is the temperature in Celsius degrees or kelvin.

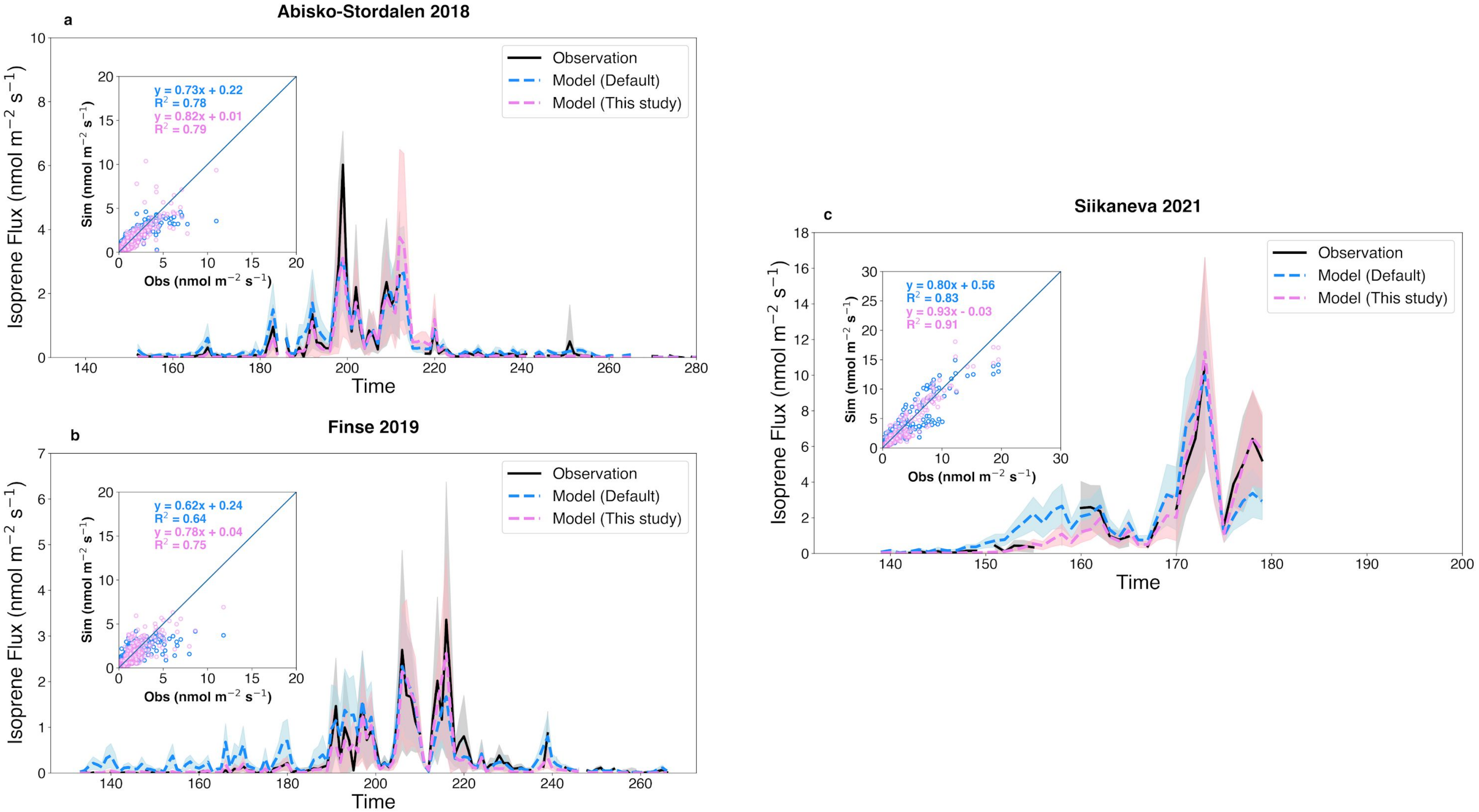




Temperature response curves

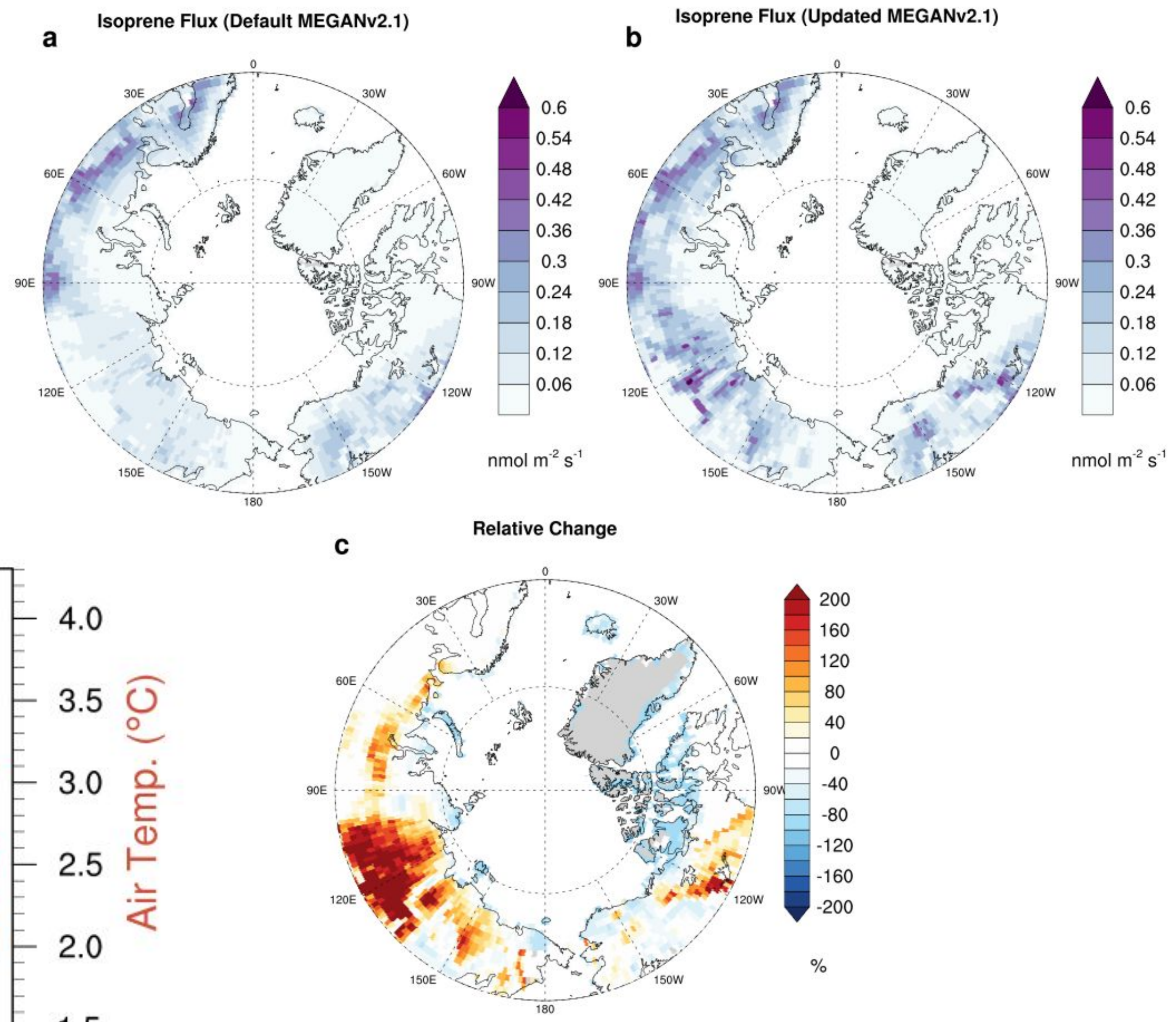


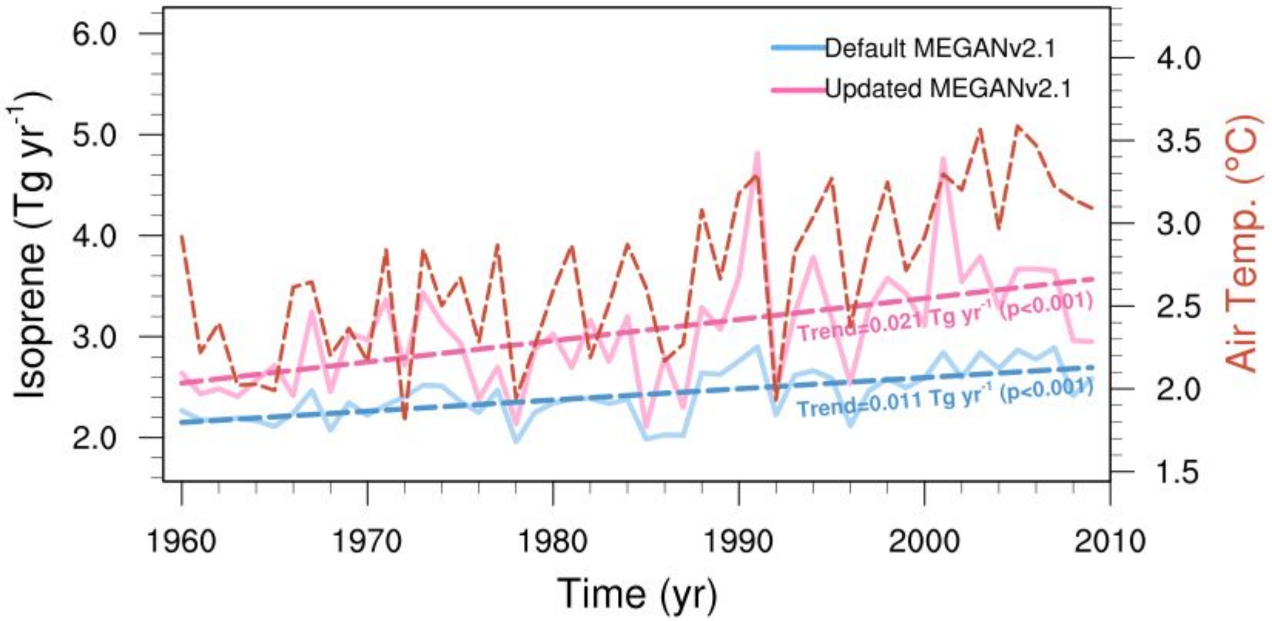
The updated model can better explain flux measurements



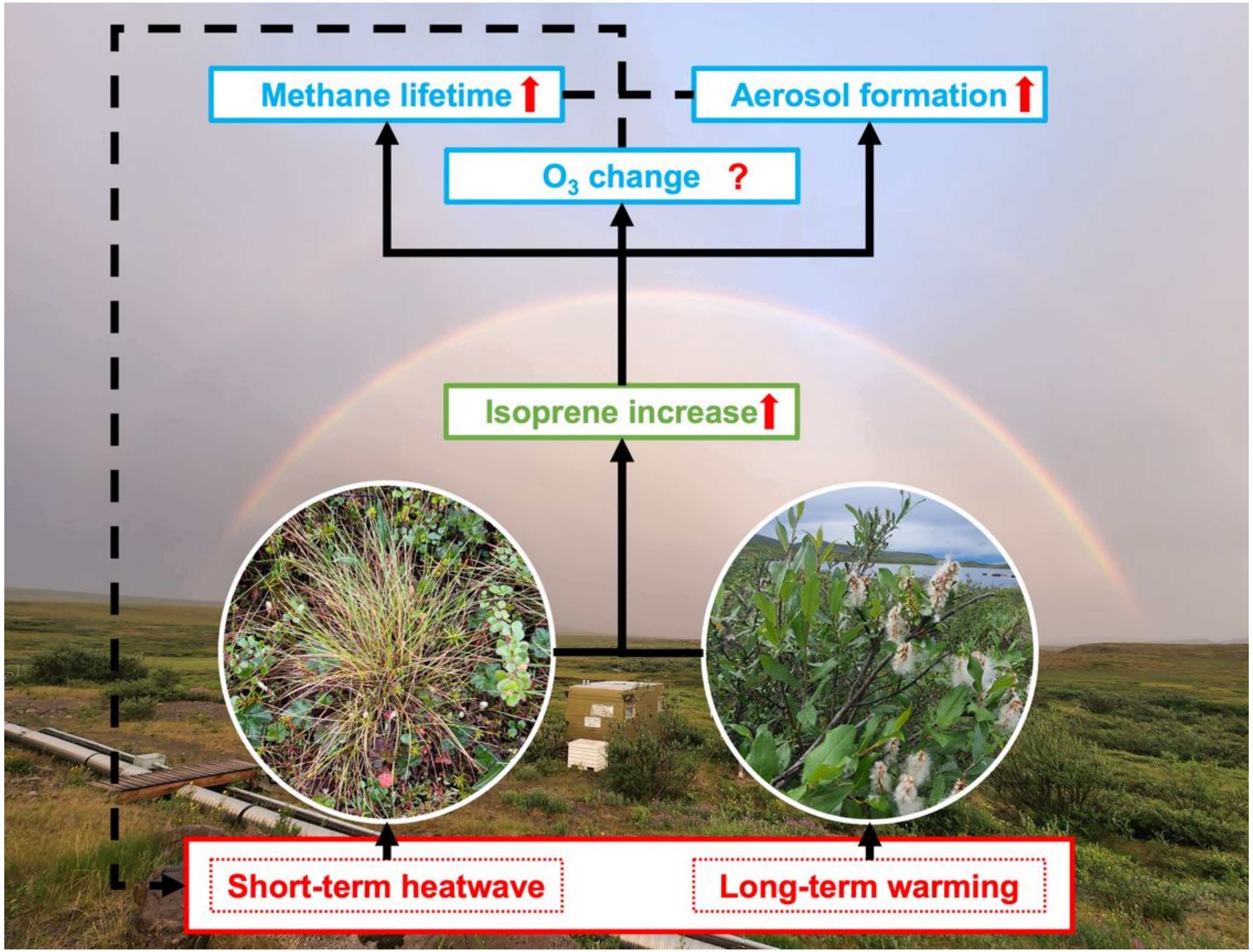
Global-scale estimation

- The averaged isoprene emission during 2000-2009 in the high latitude regions (>60° N) increase ~31% according to the Community Land Model (CLM).
- The updated model can simulate the nearly doubled increase trend of isoprene in the Arctic.





The impact of warming on the future isoprene emission in the Arctic

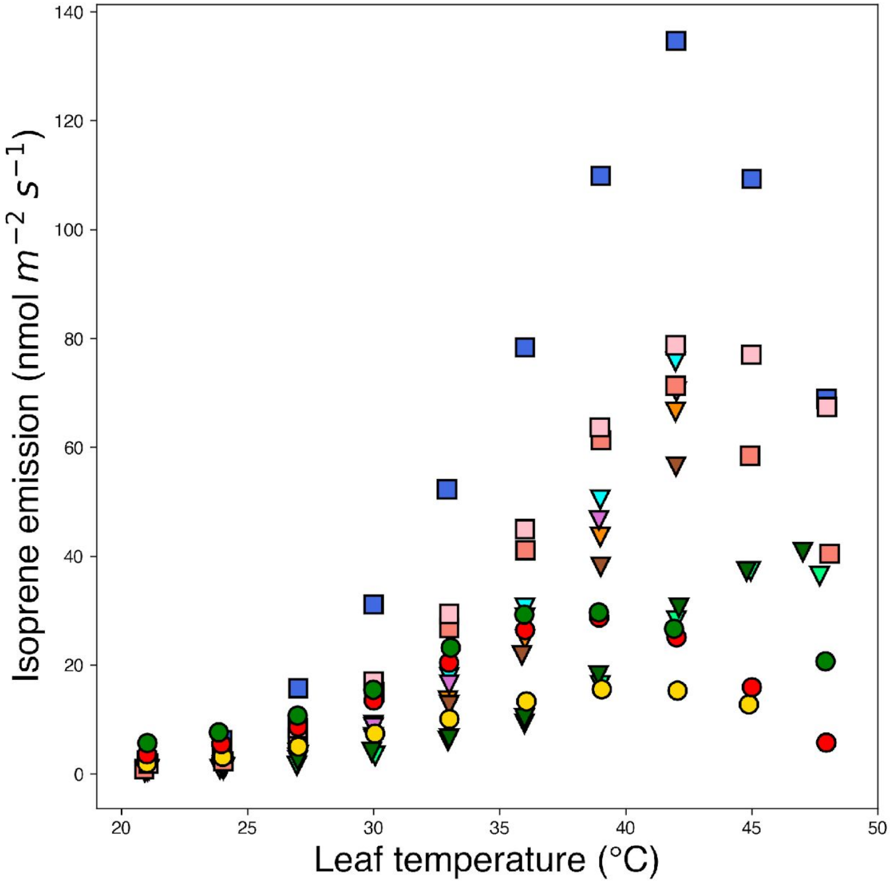


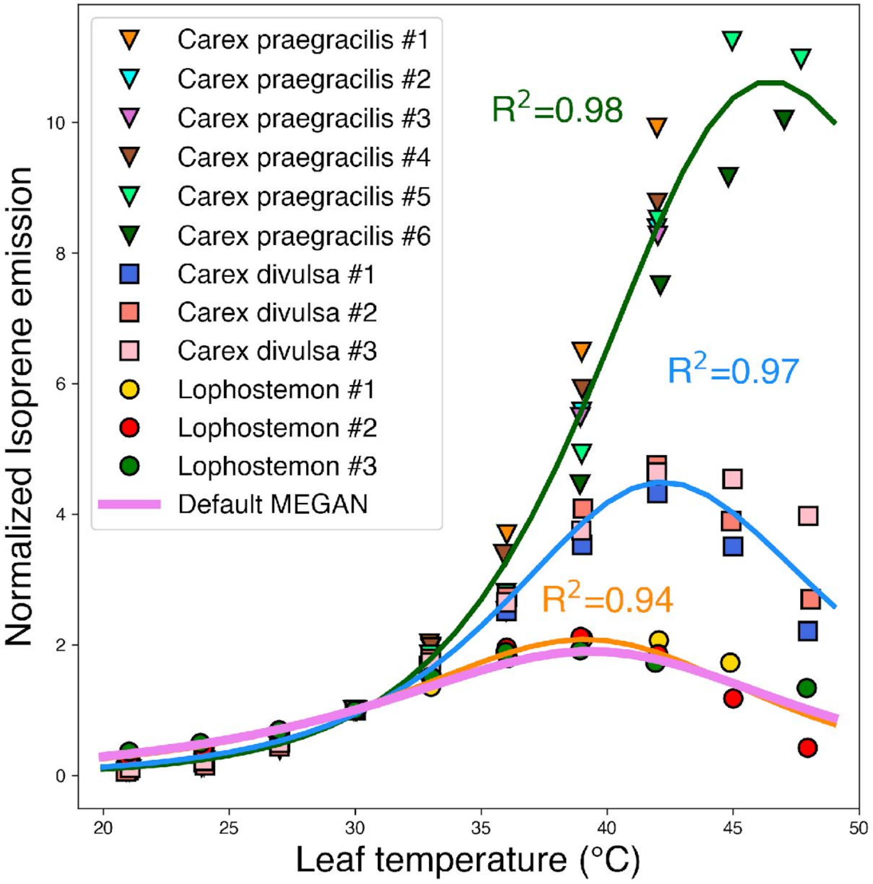
(Wang et al., in prepare)

Conclusions

- The gas-exchange chamber experiments conducted in this study confirm the strong isoprene temperature response curve reported for Arctic ecosystem-level flux measurements.
- An isoprene emission model could simulate flux observations in the three high-latitude sites by integrating findings from this study.
- We also found that emission of this strong temperature response caused ~31% underestimation of isoprene emission for the high-latitude in Community Land Model Version 5 (CLM5).
- We found that the current model underestimated the long-term trend of isoprene emission during 1960-2009 in the boreal regions would by 91%.

But that’s not it….





California field sedge

European grey sedge