EGU23-14587

Biogenic volatile organic compound emissions from Scots pine seedlings under prolonged heat and drought

Ugo Molteni[1,2], Arun Bose[1,3], Celia Faiola[2,4], Jonas Gisler[1], Shan Gu[2], Stefan Hunziker[1], Markus Kalberer[5], Na Luo[1,6], Tatiana Nazarova[1], Simone Maria Pieber[1,2], and Arthur Gessler[1]

[1] WSL Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland
[2] Department of Ecology and Evolutionary Biology, University of California Irvine, Irvine, California
[3] Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh
[4] Department of Chemistry, University of California Irvine, Irvine, California
[5] Department of Environmental Sciences, University of Basel, Basel, Switzerland
[6] Beijing Forestry University, Beijing, China

Introduction

Biogenic volatile organic compounds (BVOCs) comprise the largest, most highly complex, and diverse fraction of the volatile organic compounds (VOCs) emitted into the atmosphere (Sindelarova et al., 2014). By emitting BVOCs, plants communicate, fight herbivores and attract pollinators (Niinemets and Monson, 2013). Atmospheric oxidation of BVOCs affects the concentration of methane, carbon monoxide, and tropospheric ozone and leads to the formation of Secondary Organic Aerosol (SOA). Atmospheric aerosol load plays a crucial role in defining the radiative balance and negatively impacts air-quality standards (Seinfeld, John H. and Pandis, Spyros N., 2016).

Climate models project an increase in the average global temperature for the next decades, with Alpine regions expected to be over-proportionally more affected. Drought, heat, and insects feeding on plants cause stress in the organism, which the organism reacts to by changing the BVOCs emissions: certain compounds can be promoted, and others reduced. This may lead to subsequent changes in atmospheric chemistry and SOA properties depending on the cause of stress and the plant's reaction (Smith et al., 2021).

Within the experimental project **Acclimation and environmental memory** (AccliMemo) in 2022, we studied the impact of prolonged heat and drought on BVOC emission from Scots pine (*Pinus Sylvestris*) seedlings. Seedlings were grown from seeds collected from selected mother trees from the long-term irrigation experiment Pfynwald, with different long-term water availability. This allowed us also to examine the additional consequence of transgenerational memory on BVOC emissions (Bose et al., 2020).

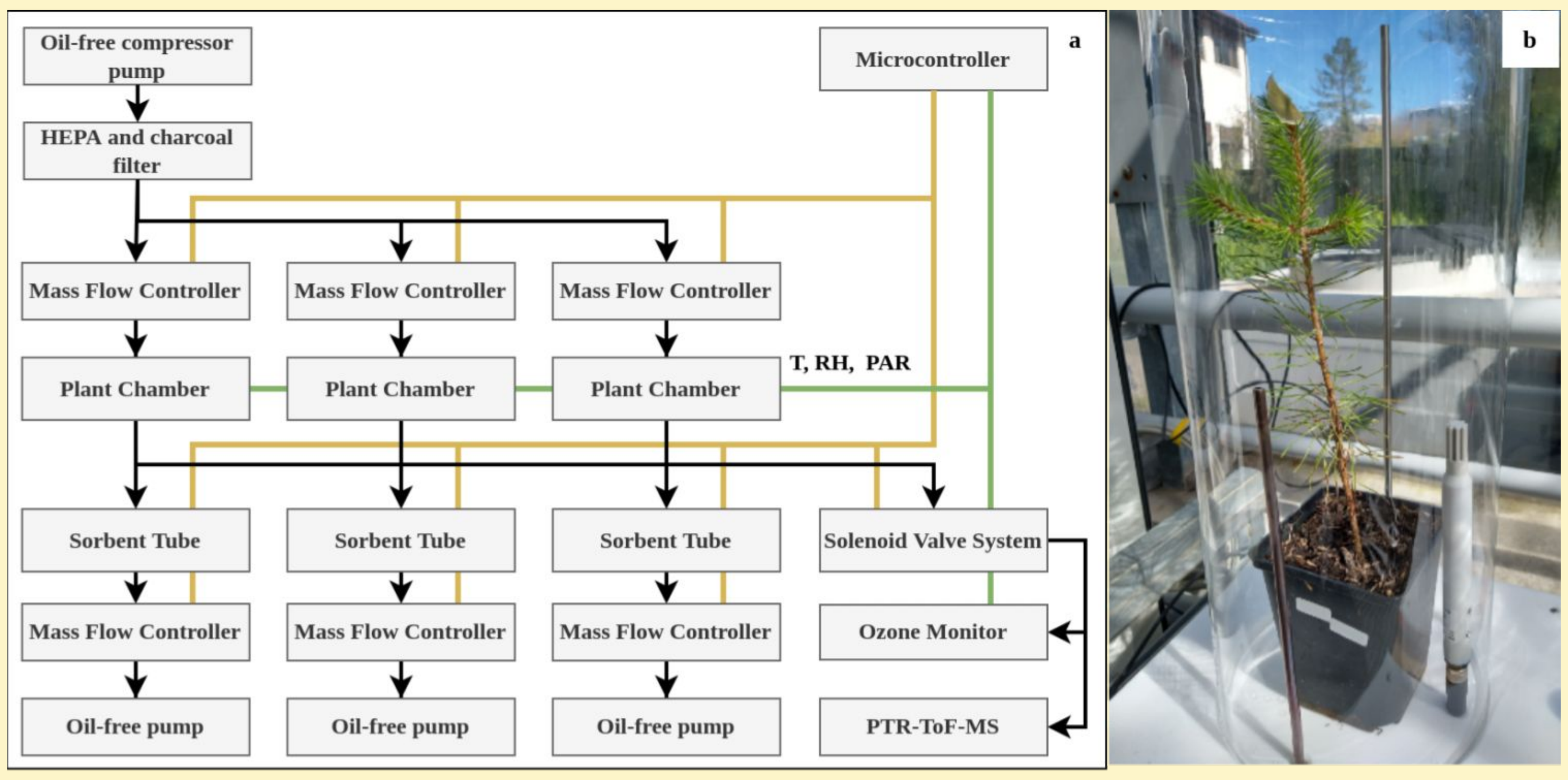

Figure 1

Methodology

Plant Chamber Development

We designed and built a novel pant chamber to conduct BVOC experiments.

Figure 1a presents the schematics of the experimental setup. The setup consists of an oil-free compressor, HEPA, and charcoal filters to remove particles, VOCs, and ozone from the compressed ambient air, mass flow controllers (MFCs), and 3 plant chambers for a parallel sampling of up to 3 plants and a sampling system for connecting PTR-ToF-MS inlet and sorbent tubes (off-line analysis). A microcontroller orchestrates MFCs, and solenoid valves and logs data from light, temperature, and humidity sensors, as well as an ozone monitor.

Figure 1b shows a detail of the plant chamber during a Scots pine BOVCs experiment with inlet and outlet lines in the fore and background, respectively and a temperature and humidity sensor to the right of the Scots pine sample.

The plant chamber consists of a 300x300x16 mm Teflon plate (**figure 2**) that provides support to the tree pot and allows for gas lines and sensors connection. A glass enclosure of a cylindrical shape completes the setup. A ring engraved in the Teflon plate guarantees a good fastening.

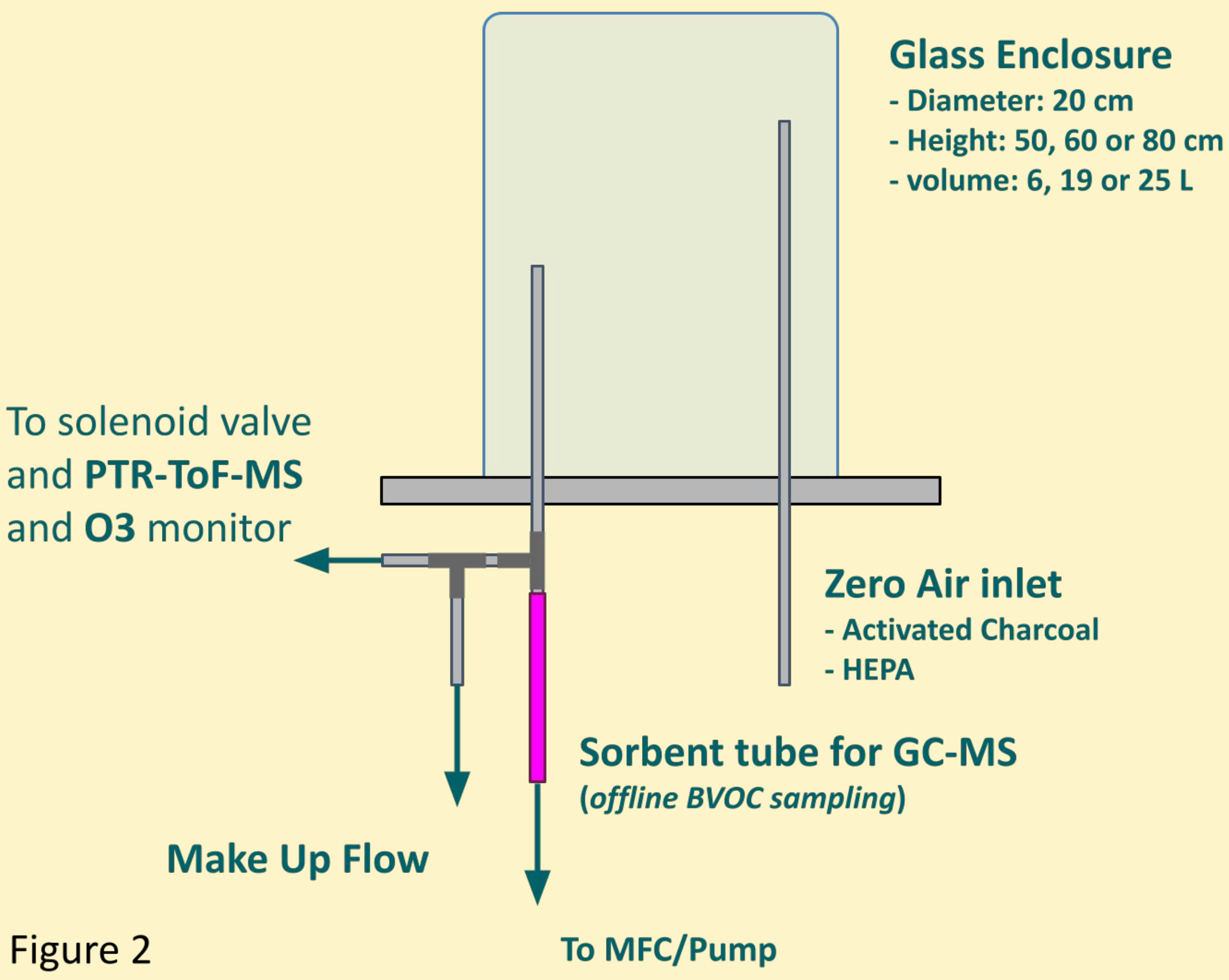

Figure 2

Experimental design

Within the **AccliMemo 2022** campaign, we investigate the impact of water scarcity and seed legacy on BVOC emissions levels and composition (**figure 3**). Therefore, we designed the experiment to supply two water levels to the seedlings (control and drought). At the same time, we had three categories relative to seedling legacy (control, irrigation, and irrigation stop). This consists of a total of 6 possible combinations (figure 3). Seedling legacy corresponds to seeds collected from different mother trees, at the "Long-term irrigation experiment Pfynwald" (Canton Valais - Switzerland).

Seedlings are labeled as follows:

- "**control**" are from mother trees that experienced **natural dry conditions** over the past decades (~ 657 mm/y),
- "**irrigation**" are from mother trees that, since 2003, received a double amount of water via irrigation,
- "**irrigation stop**" are from mother trees that received **double water** via irrigation between 2003 and 2013 and, from 2014, returned to **natural dry conditions**.

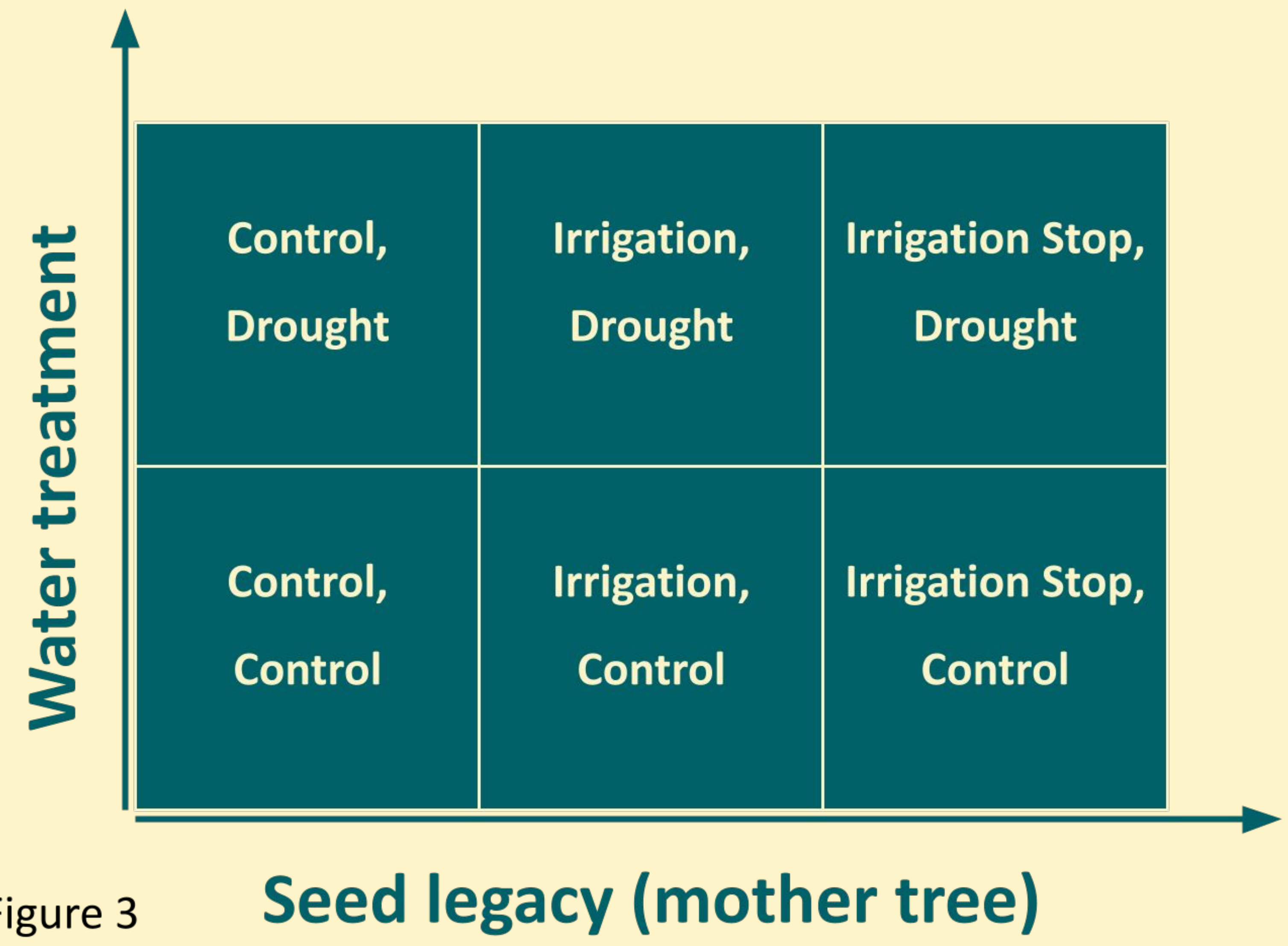

Figure 3

Measurements

The approaches used to identify and quantify the BVOCs consisted of three analytical methods (**figure 4**). On the one hand, we collected needles from each Scots pine tree and stored them at -80 °C. In the lab, we extracted the terpene fraction and analyzed the extracts with a GC-FID/MS technique to identify and quantify the secondary metabolite fraction. On the other hand, we sampled the emitted BVOCs from the seedlings using the plant chamber. The BVOCs were collected on sorbent tubes for offline analysis and aside also monitored in-situ using an online PTR-ToF-MS instrument. The offline analysis allows for the speciation and quantification of the mono- and sesquiterpene components via TD-GC-MS analysis, while the the in-situ measurements elucidate diurnal patterns in the BVOC emissions.

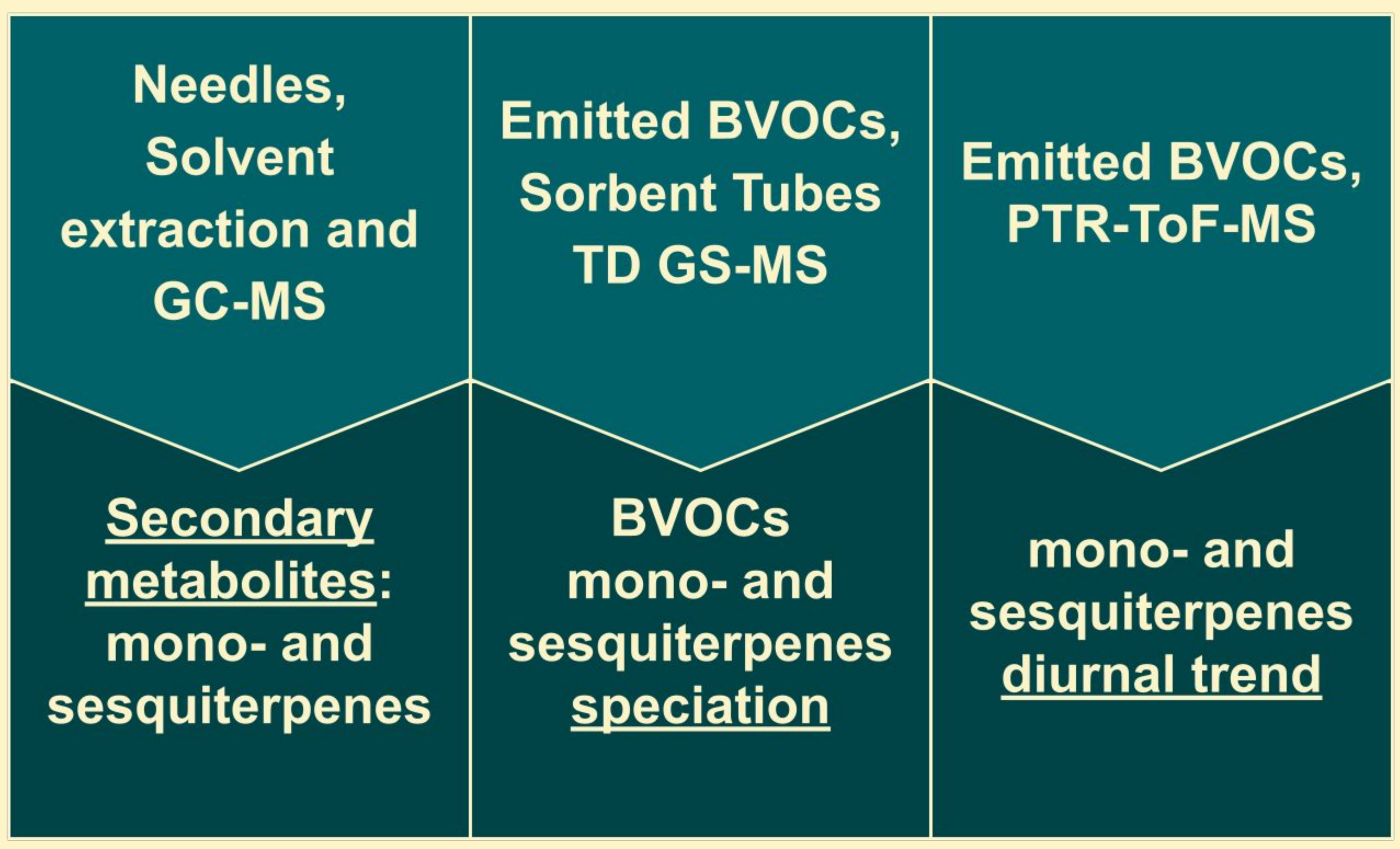

Figure 4

Bibliography

Bose et al. Memory of environmental conditions across generations affects the acclimation potential of scots pine, Plant Cell Environ., 43, 1288–1299, https://doi.org/10.1111/pce.13729, 2020.
Niinemets and Monson. Biology, Controls and Models of Tree Volatile Organic Compound Emissions, Springer Netherlands, Dordrecht, https://doi.org/10.1007/978-94-007-6606-8, 2013.
Seinfeld and Pandis. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 3rd Edition., Wiley, 1152 pp., 2016.
Sindelarova et al. Global data set of biogenic VOC emissions calculated by the MEGAN model over the last 30 years, Atmospheric Chem. Phys., 14, 9317–9341, https://doi.org/10.5194/acp-14-9317-2014, 2014.
Smith et al. Viscosity and liquid–liquid phase separation in healthy and stressed plant SOA, Environ. Sci. Atmospheres, 1, 140–153, https://doi.org/10.1039/D0EA00020E, 2021.

Funding

We acknowledge funding from the Swiss National Science Foundation (SNSF) under grant numbers P400P2_199317 and P400P2_194390.