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Supplementary Information for
Strong isoprene emission response to temperature in tundra vegetation

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This PDF file includes:

Figures S1 to S4
Tables S1 to S2
SI References

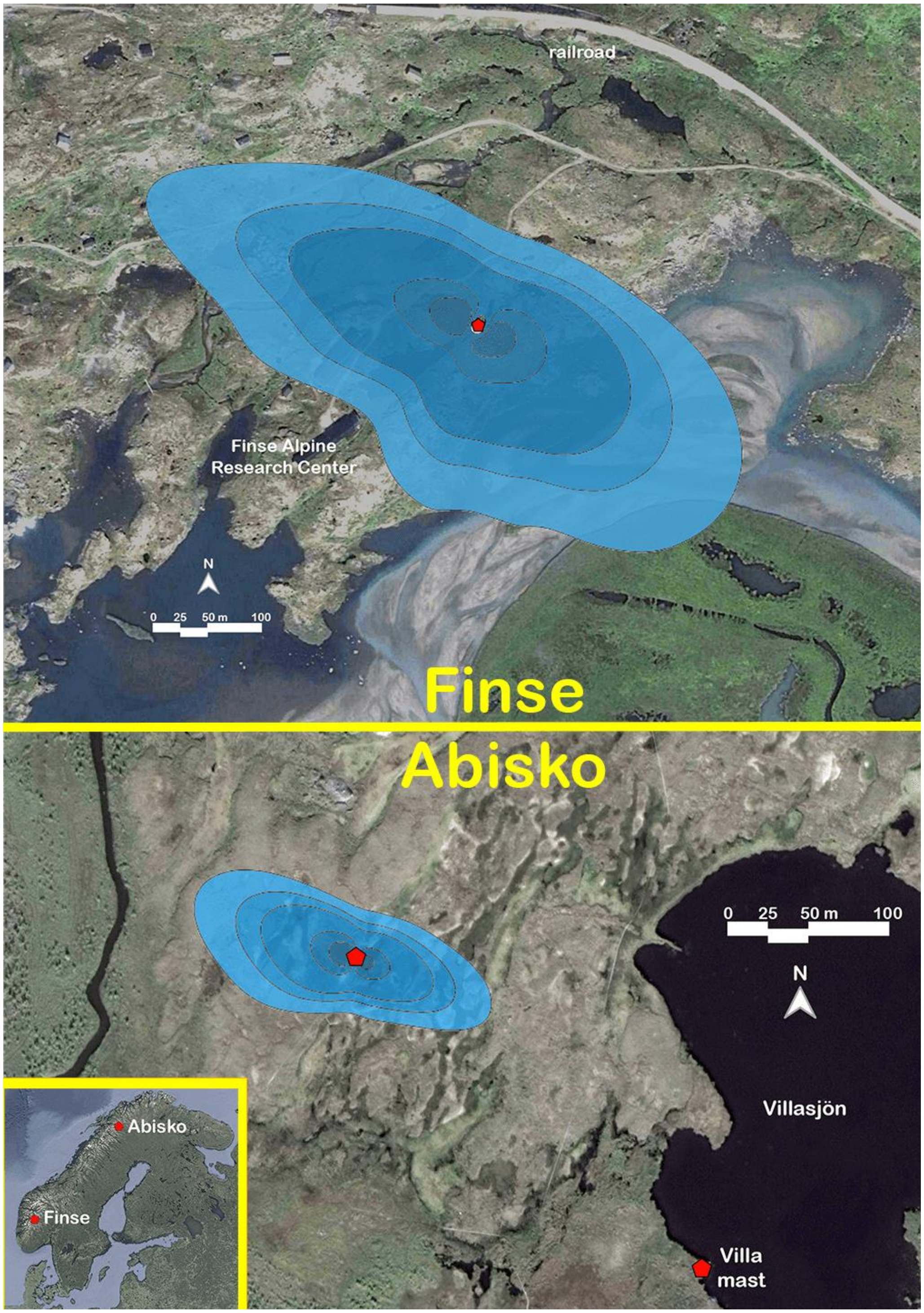

Fig. S1. Top: Map of the Finse study area, showing our EC tower (red-filled pentagon) nearby the Finse Alpine Research Center.
Bottom: Map of the Abisko Stordalen Mire study area, showing our EC tower at the ICOS Stordalen station (SE-Sto) and the nearby Villa mast (see Seco et al., 2020, for another EC study at the Villa mast) by the shore of Villasjön. The inset map shows the location of the sites within Scandinavia.
The blue shaded area represents the combined footprint for the whole season of EC measurements, at flux contribution intervals of 85%, 80%, 75%, 50%, and 25%. Note the different scales of the maps. The base map images are © Google Earth (images provided by DigitalGlobe and Maxar Technologies).

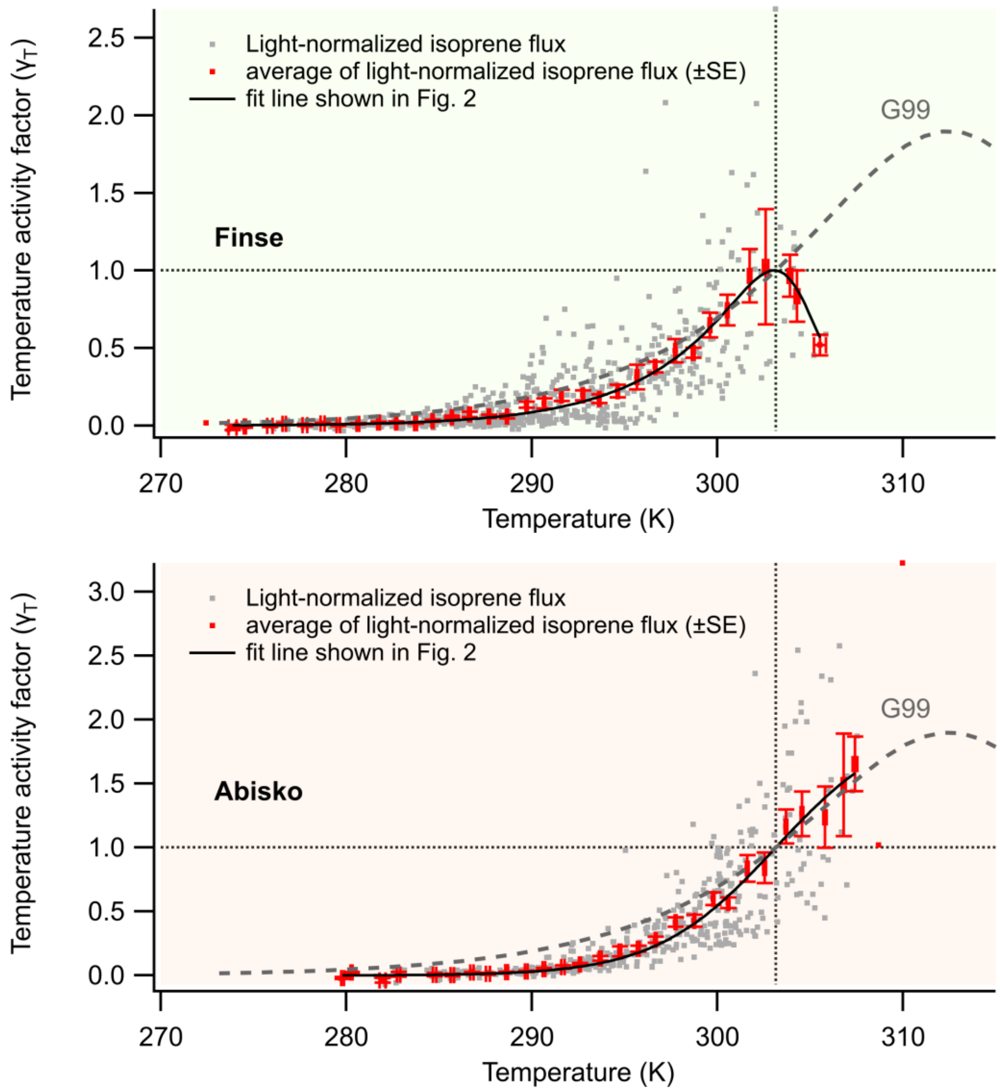

Fig. S2. To remove the possible influence of light on the temperature response of isoprene fluxes, we normalized our measured fluxes by dividing them by γ_P, the light activity factor embedded in MEGANv2.1. Because isoprene features a completely light-dependent emission (i.e., light-dependent fraction of emissions, LDF=1), we calculated γ_P by solving Equations 4-6 in Guenther et al. (2012) with our measured PPFD data and using the default "standard conditions for sun leaves" (Ps = 200 μmol m^{-2} s^{-1}). These equations calculate γ_P taking into account not only the instantaneous light conditions, but also the light conditions of the past 1 and 10 days.

We treated the flux data normalized by γ_P just as we treated our original, non-normalized data: taking only the data points with PPFD above 1000 μmol m^{-2} s^{-1} and normalizing their value so that it equaled 1 at 30 ℃ (303.15 K), obtaining the equivalent to temperature activity factors (γ_T). Then we calculated their temperature response curve as shown in Fig. 2 of the main text for our original data. The resulting graphs are shown here (Finse on top, Abisko below).

The flux data points normalized by γ_P are shown in grey and their 1-K bin averages (±SE) are shown in red. The G99 curve is shown as a grey dashed line. Interestingly, the solid black line is the fit to the binned averages of the original data exactly as is shown in Fig. 2 of the main text. That is, the temperature response of the data normalized by γ_P is virtually indistinguishable from that of the original data (non-normalized by γ_P). Thus, removing the influence of light with the available knowledge about the isoprene light response generates almost the same result as just taking the original data. This clearly demonstrates that our temperature response analysis was not affected by light.

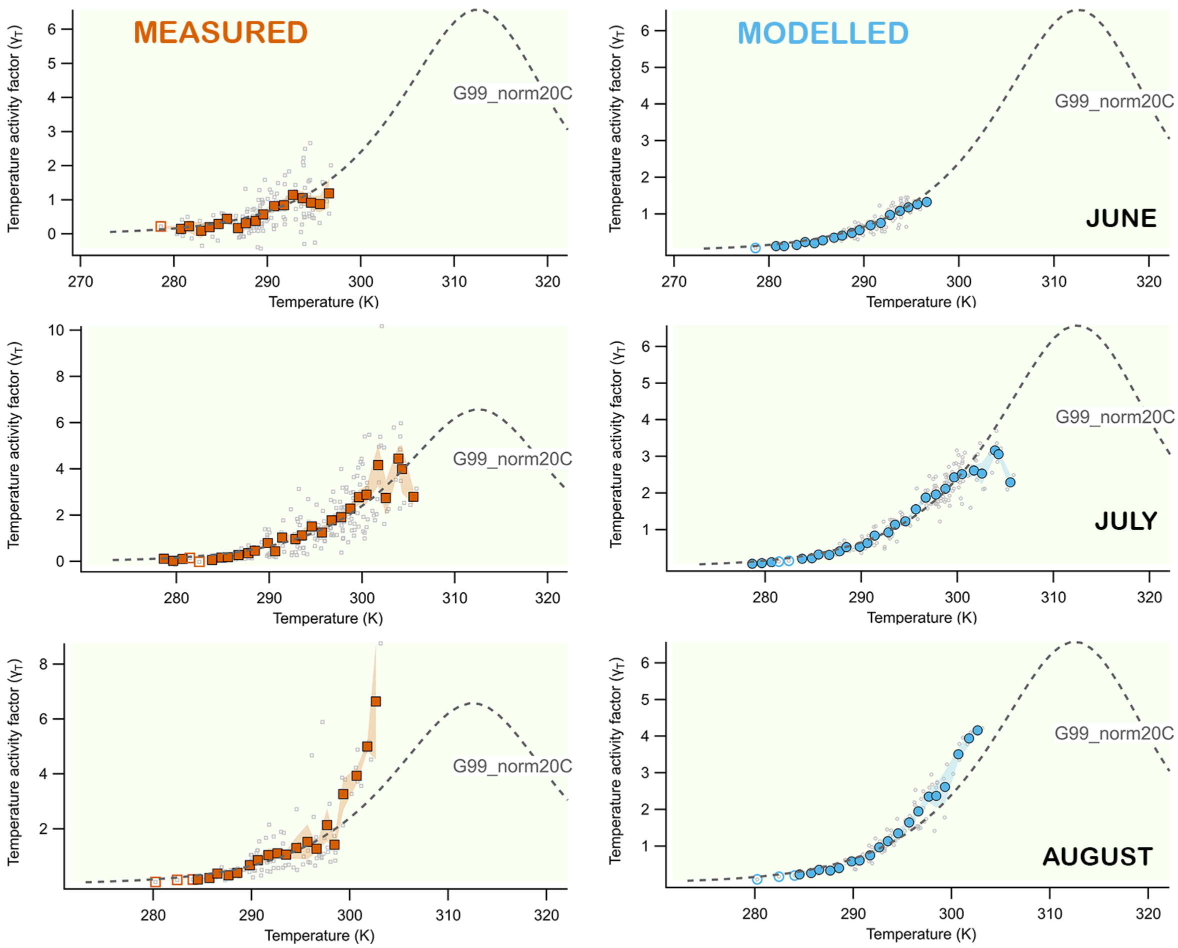

Fig. S3. Temperature response of isoprene emissions in different months in Finse. To investigate the possible influence of phenology on the temperature response, we calculated the temperature response for each of the central months of the campaign (June, top; July, middle; August, bottom) and separately for the measured (left-hand panels) and modelled (right-hand panels) fluxes. Due to the lack of data points at 30 ℃ (=303.15 K) in some months, here the emissions were normalized to equal 1 at 20 ℃ (=293.15 K), as was the G99 response curve. The symbols depict the same as in Fig. 2 in the main manuscript. The small grey open symbols depict the individual temperature activity factors derived from the individual 30-min fluxes (n=156, 216, and 127 for June, July, and August, respectively) that passed the eddy covariance quality criteria and were not limited by available sunlight (PPFD ≥ 1,000 μmol m^{-2} s^{-1}). Note that only MEGAN simulated fluxes that corresponded with an available measured flux, and vice versa, were used in this comparison. The bigger, closed colored symbols represent the averages of the 1 K bins and their shading represents their standard error. We did not fit Eq. 1 to these data because the algorithm is not well suited to the data normalized at 20 ℃. Note that the vertical axis has different ranges in each subplot.

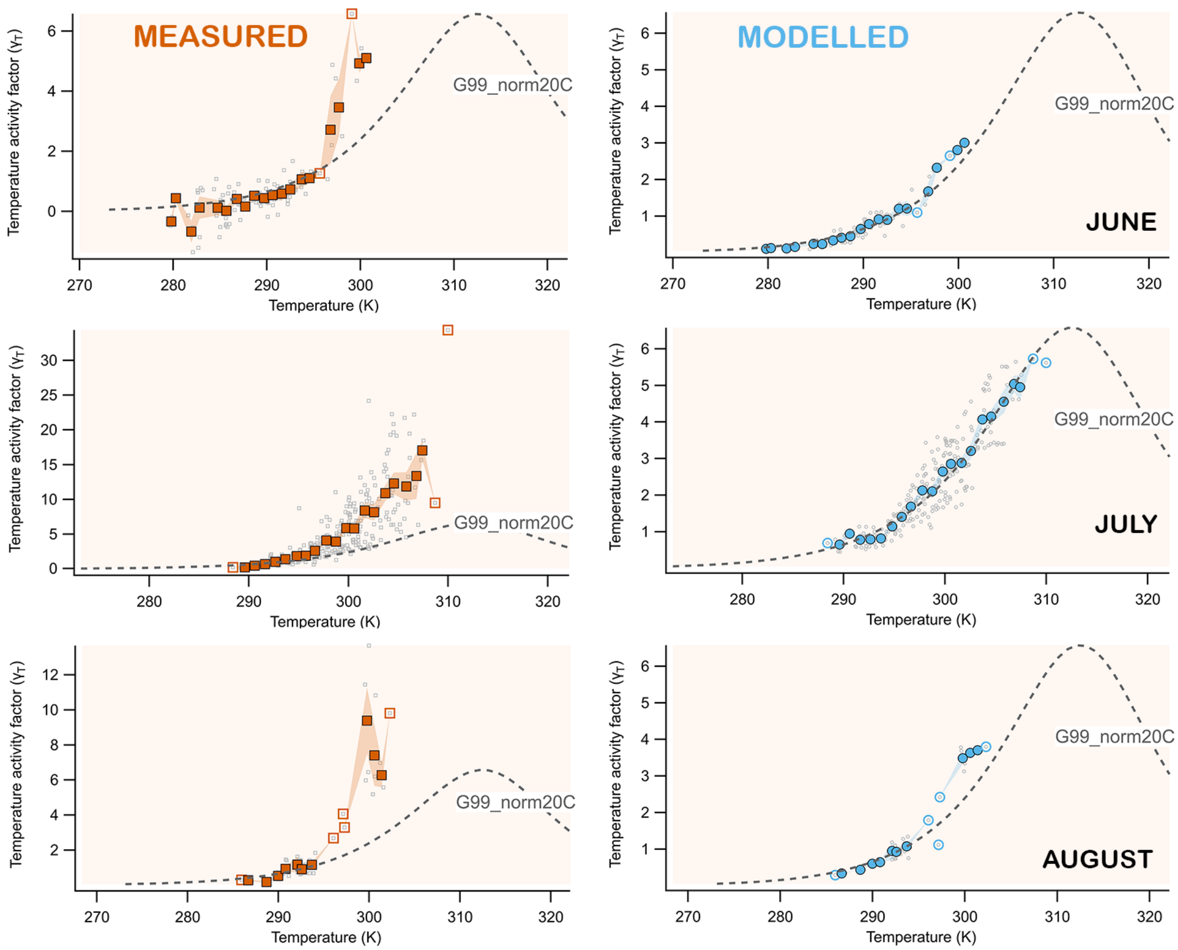

Fig. S4. Temperature response of isoprene emissions in different months in Abisko, normalized to equal 1 at 20 ℃ (=293.15 K). The number of valid individual 30-min fluxes were n=108, 268, and 48 for June, July, and August, respectively. See the caption of Fig. S3 for further details.

Table S1. Isoprene emission factors (EF, expressed as averages in μg m^{-2} h^{-1} ± 95% confidence intervals) for MEGANv2.1 calculated from the observed ecosystem-level fluxes and the MEGAN activity factors (see Methods for details) using data points measured when PPFD was at least 1000 μmol m^{-2} s^{-1}. The number of data points (N) used to calculate each average EF is shown next to the EF.

PPFD >= 1000 μmol m^{-2} s^{-1}	Finse		Abisko	
	Average EF (± 95% CI)	N	Average EF (±95% CI)	N
All season	1959 (± 139)	554	1212 (± 76)	414
May	1283 (± 353)	55	-	-
June	606 (± 66)	142	743 (± 138)	90
July	1987 (± 135)	212	1438 (± 94)	268
August	3712 (± 357)	127	928 (± 155)	48
September	2003 (± 488)	18	628 (± 214)	8

Table S2. Isoprene emission factors (EF, expressed as averages in μg m^{-2} h^{-1} ± 95% confidence intervals) for MEGANv2.1 calculated from the observed ecosystem-level fluxes and the MEGAN activity factors (see Methods for details) using data points measured when PPFD was at least 400 μmol m^{-2} s^{-1}. The number of data points (N) used to calculate each average EF is shown next to the EF.

PPFD >= 400 μmol m^{-2} s^{-1}	Finse		Abisko	
	Average EF (±95% CI)	N	Average EF (±95% CI)	N
All season	2009 (± 108)	1211	1362 (± 74)	1286
May	1715 (± 559)	97	-	-
June	649 (± 58)	266	1413 (± 206)	303
July	1759 (± 116)	422	1500 (± 74)	567
August	3174 (± 196)	318	1082 (± 73)	270
September	3170 (± 578)	108	1077 (± 365)	140

SI REFERENCES

Guenther, A.B., Jiang, X., Heald, C.L., Sakulyanontvittaya, T., Duhl, T., Emmons, L.K., Wang, X., 2012. The Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1): an extended and updated framework for modeling biogenic emissions. Geosci. Model Dev. 5, 1471–1492. https://doi.org/10.5194/gmd-5-1471-2012

Seco, R., Holst, T., Matzen, M.S., Westergaard-Nielsen, A., Li, T., Simin, T., Jansen, J., Crill, P., Friborg, T., Rinne, J., Rinnan, R., 2020. Volatile organic compound fluxes in a subarctic peatland and lake. Atmos. Chem. Phys. 20, 13399–13416. https://doi.org/10.5194/acp-20-13399-2020