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Supplementary information

Arctic sea-ice loss fuels extreme European snowfall

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Supplementary Figures

Arctic sea-ice loss fuels extreme European snowfall

Hannah Bailey[1]*, Alun Hubbard[2], Eric S. Klein[3], Kaisa-Riikka Mustonen[1], Pete D. Akers[4], Hannu Marttila[5], and Jeffrey M. Welker[1,6]

[1] Ecology and Genetics Research Unit, University of Oulu, 90014 Oulu, Finland

[2] Centre for Arctic Gas Hydrate, Environment and Climate, Department of Geosciences, UiT the Arctic University of Norway, 9037 Tromsø, Norway

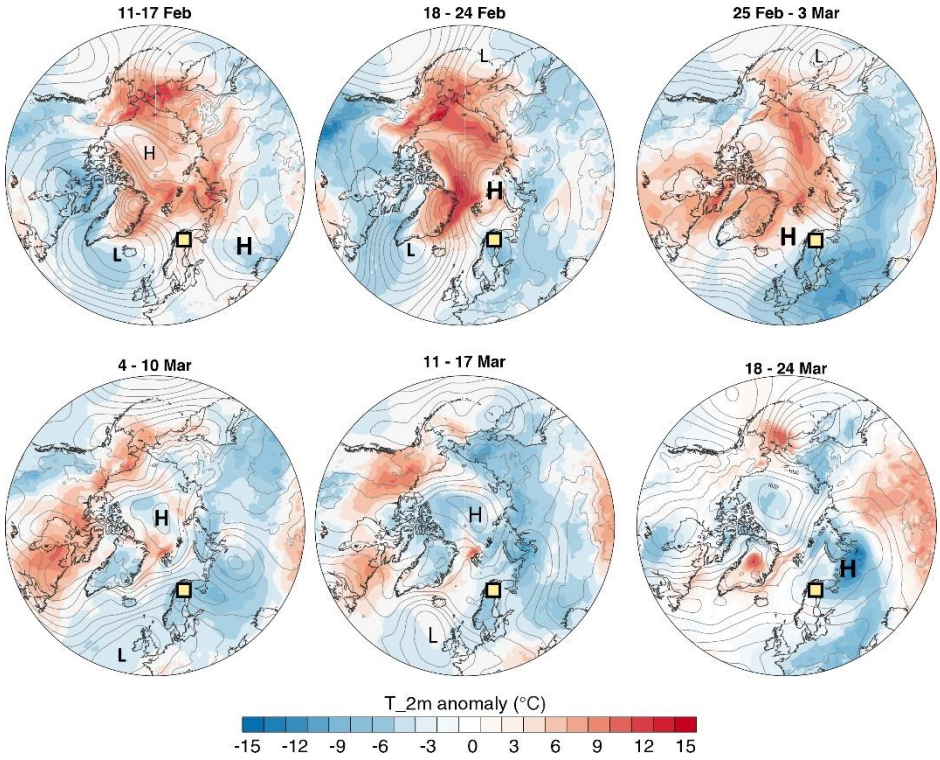
[3] Department of Geological Sciences, University of Alaska Anchorage, Anchorage, AK 99508, U.S.A.

[4] Institut des Géosciences et l'Environnement, National Centre for Scientific Research, Grenoble 38400, France

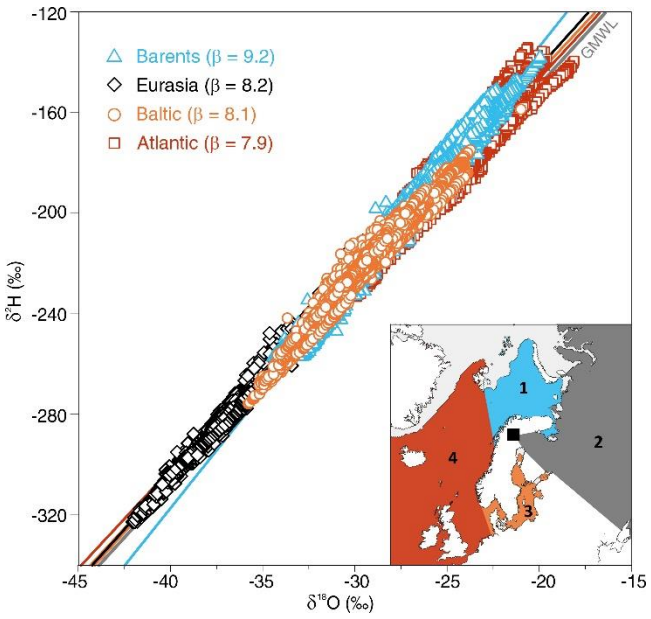
[5] Water, Energy and Environmental Engineering Research Unit, University of Oulu, 90014 Oulu, Finland

[6] Department of Biological Sciences, University of Alaska Anchorage, Anchorage, AK 99508, U.S.A.

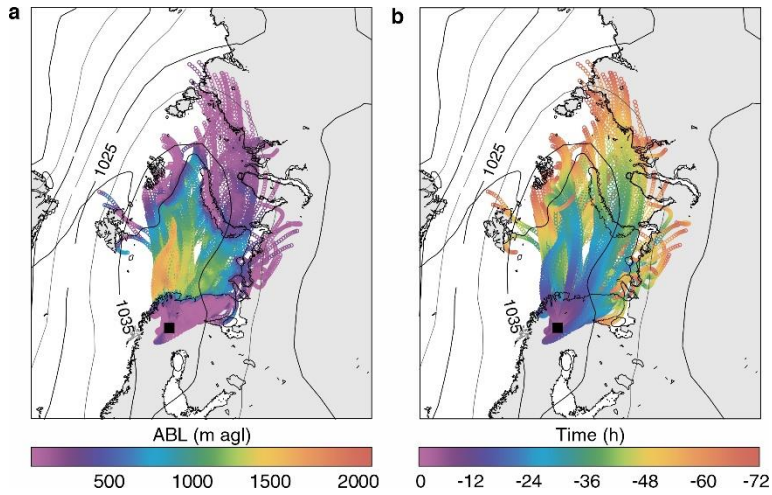
*Correspondence to Hannah.Bailey@oulu.fi



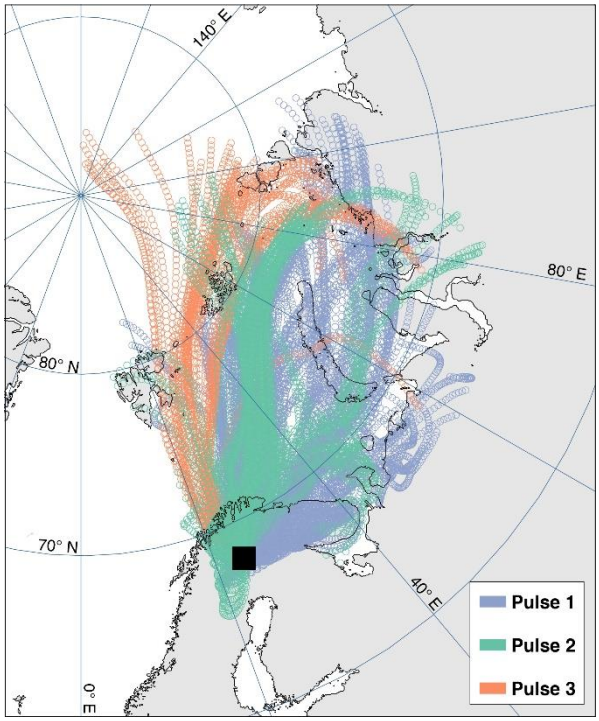
Supplementary Figure 1. Temporal evolution of synoptic climatology during the 2018 Beast from the East. Shaded contours show ERA5[1] reanalysis weekly composited near surface (2 m) air temperature anomalies relative to the 1981-2010 baseline. Grey contours represent weekly composited sea level pressure (4 hPa intervals) with dominant high (H) and low (L) pressure centres indicated. Square indicates Pallas-Yllästunturi National Park, Arctic Finland. Base maps derive from the ETOPO5 gridded elevation dataset (http://www.ngdc.noaa.gov/mgg/global/etopo5.HTML).



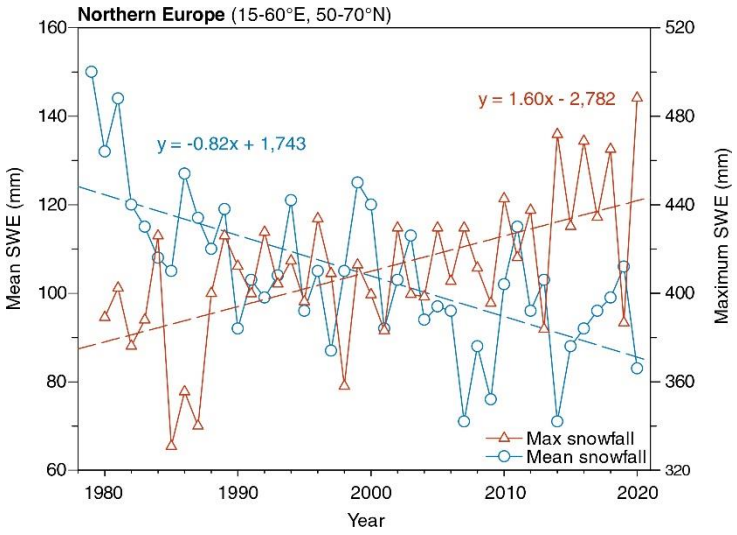
Supplementary Figure 2. Winter 2017-18 Pallas water vapour isotope data relation to moisture source region. Linear relation between Pallas vapour $\delta^{18}O$ and $\delta^{2}H$ between 20 December 2017 and 31 March 2018 (5-minute averages). Symbols and isotopic water vapour lines are categorised into vapour source regions (inset) identified using HYSPLIT trajectory analysis: (1) Barents (2) Eurasia (3) Baltic, and (4) Atlantic. Marine boundaries between the Barents – Atlantic – Baltic regions derive from the National Snow and Ice Data Centre. The location of Pallas-Yllästunturi National Park, Finland, is indicated (black square), and the mean February 2018 sea ice cover is depicted in light grey shading[2]. Base map derives from the ETOPO5 gridded elevation dataset (http://www.ngdc.noaa.gov/mgg/global/etopo5.HTML).



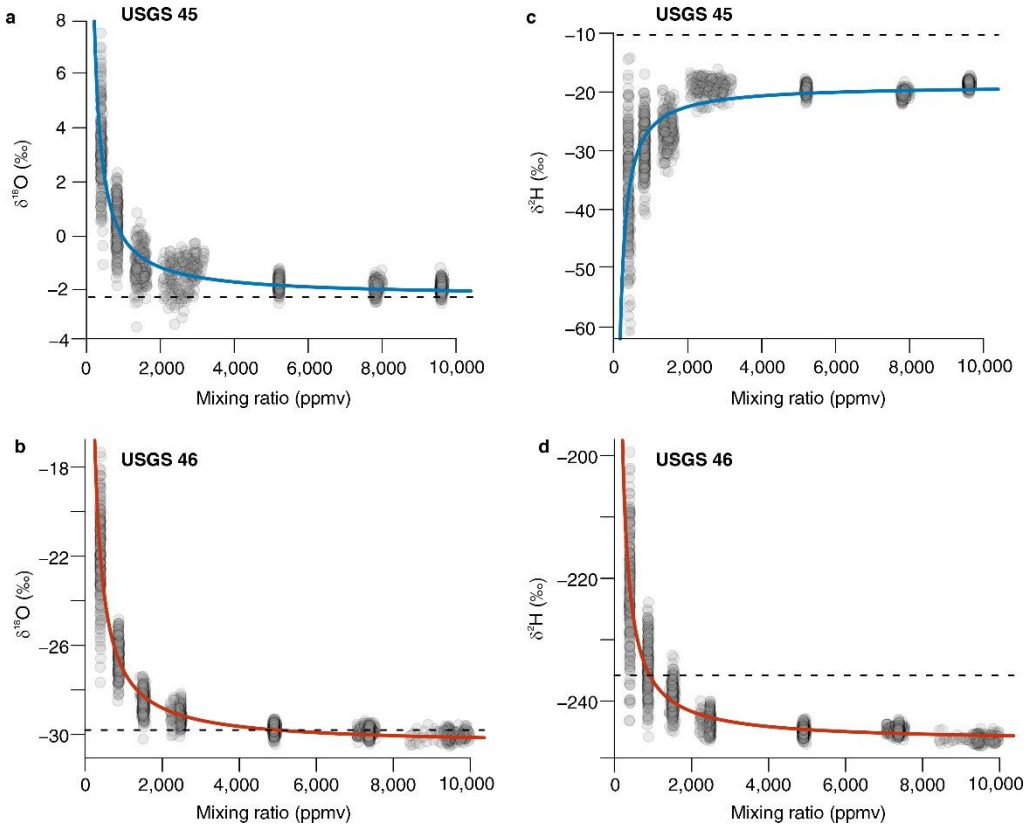
Supplementary Figure 3. Pallas back-trajectories during Barents Pulse. Modelled 72 h back-trajectories initiated at Pallas (square) every hour during the period 19 – 27 February 2018 using the Global Data Assimilation System (GDAS) atmospheric reanalysis. Coloured circles along trajectories depict hourly values of air parcel (**a**) atmospheric boundary layer (ABL) height above ground level (agl), and (**b**) time from Pallas. Contour lines represent mean sea level pressure during the corresponding interval from ERA5 reanalysis[1], and the black solid lines show the mean sea ice edge during the corresponding interval[2]. Base maps derive from the ETOPO5 gridded elevation dataset (http://www.ngdc.noaa.gov/mgg/global/etopo5.HTML).



Supplementary Figure 4. Pallas back-trajectories during Barents Pulse 1-3. Modelled 72 h back-trajectories initiated at Pallas (square) every hour using the Global Data Assimilation System (GDAS) atmospheric reanalysis. Coloured trajectory clusters depict the air parcel position at hourly intervals during Pulse 1 (19 Feb – 4 March 2018), Pulse 2 (14–20 March 2018), and Pulse 3 (23–28 March 2018) of Barents Sea moisture advected to Pallas. Base map derives from the ETOPO5 gridded elevation dataset (http://www.ngdc.noaa.gov/mgg/global/etopo5.HTML).



Supplementary Figure 5. Northern Europe March snowfall trends. Timeseries show mean (circle) and maximum (triangle) March snow water equivalent (SWE) from 1979 to 2020[1]



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108 **Supplementary Figure 6. Pallas Picarro humidity-isotope response calibration curves.**

109 Graphs depict values for (**a, b**) $\delta^{18}O$ and (**c, d**) $\delta^{2}H$ of USGS standards 45 (blue) and 46 (red).

110 Grey circles represent individual 1-second measurements, and the solid line shows the non-

111 linear regression used to correct ambient isotope data as a function of cavity humidity.

112 Dashed line shows the known isotopic value of the standard water.

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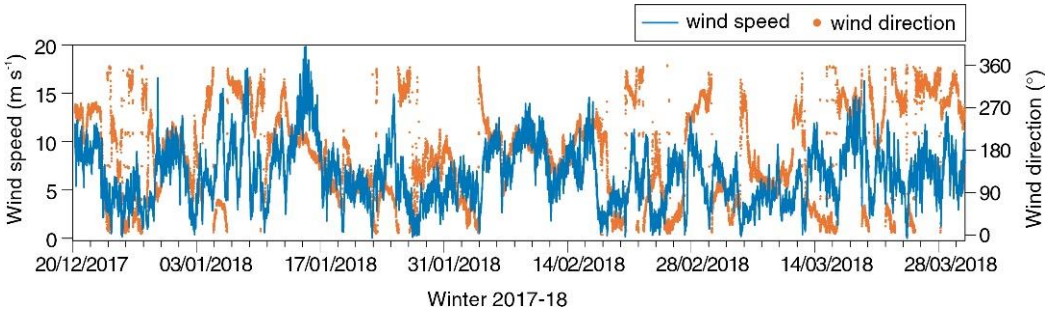

Supplementary Figure 7. Winter 2017-18 wind speed and direction measurements.

Timeseries show 5-minute mean wind speed and wind direction (570 m asl) recorded at FMI Sammaltunturi station in Pallas between 20 December 2017 – 31 March 2018.

Supplementary References.

1. Hersbach, H. *et al.* The ERA5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society* (2020) doi:10.1002/qj.3803.

2. Fetterer, F., Knowles, K., Meier, W. N., Savoie, M. & Windnagel, A. K. Sea Ice Index, Version 3 | National Snow and Ice Data Center. (2017).