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Supplement of

Anatomy and impact of a high Arctic atmospheric river driving extreme winter rain and snowfall

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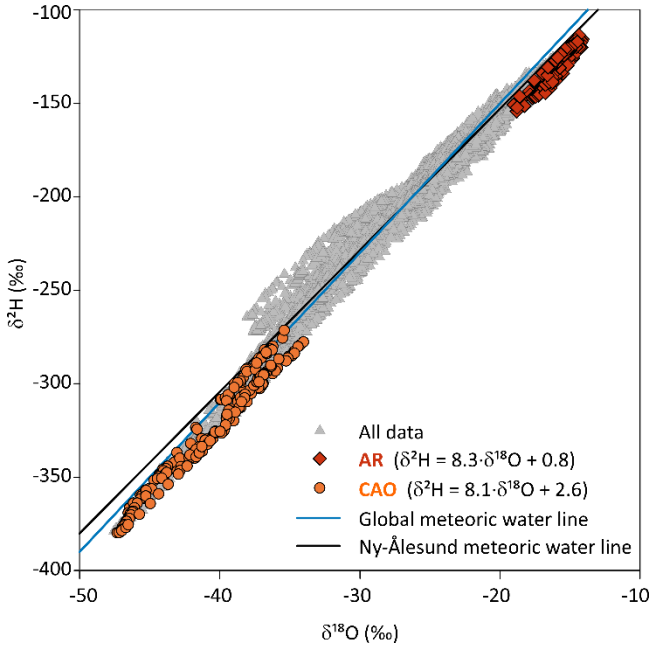

Figure S1: Atmospheric vapour isotopes during the March 2022 AR and CAO. δ^2H-$\delta^{18}O$ relationships for atmospheric water vapour measured at the Zeppelin Observatory during the March 2022 atmospheric river (AR) and subsequent cold air outbreak (CAO). Grey triangles show the full vapour isotope dataset for the observation period (1 January to 31 May 2022; 30-min averages), while coloured symbols indicate samples associated with the AR (red diamond) and CAO (orange circle) phases. Linear regressions are shown for the AR and CAO subsets. The global meteoric water line (GMWL) (Craig, 1961) and Ny-Ålesund meteoric water line (based on all campaign data) are shown for reference.

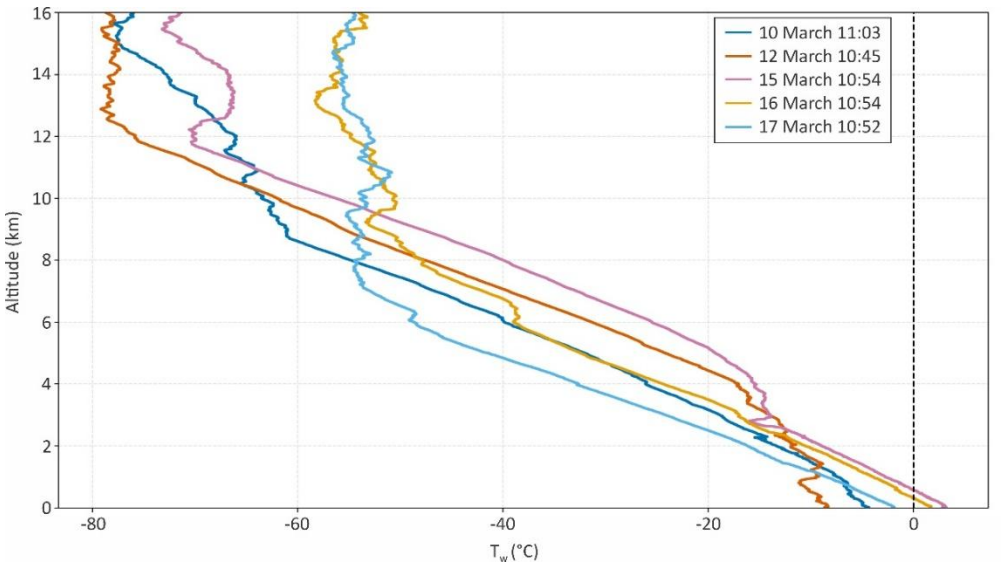

Figure S2: Vertical wet-bulb temperature profiles during the March 2022 AR. Vertical profiles of wet-bulb temperature (T_W) derived from radiosonde soundings launched at Ny-Ålesund on selected dates before, during, and after the March 2022 AR (Maturilli, 2022). The dashed vertical line indicates the 0 °C threshold used to estimate the melting level.

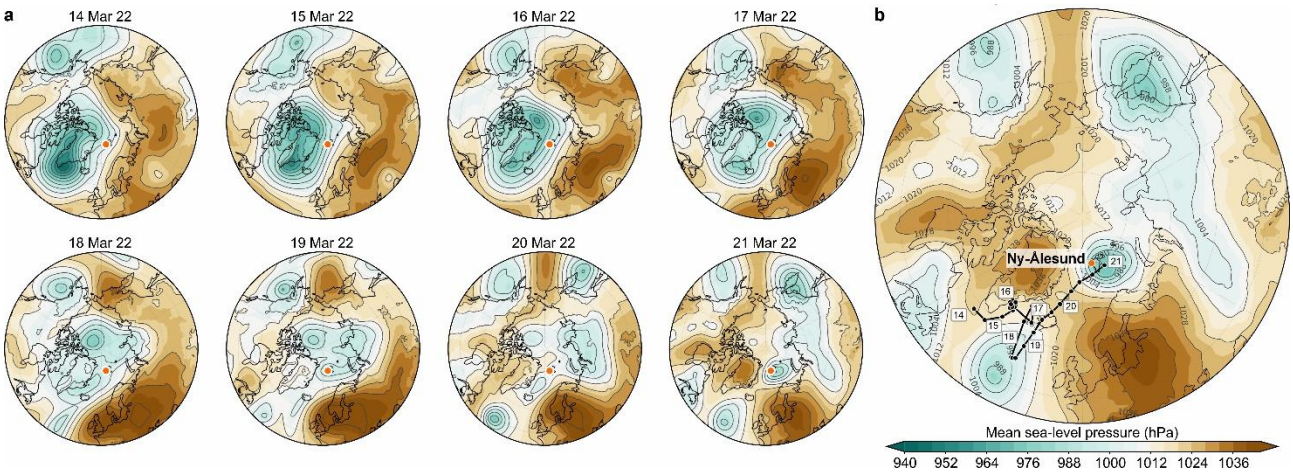

Figure S3: Synoptic evolution from the atmospheric river to the subsequent cold-air outbreak. (a) ERA5 daily mean sea-level pressure from 14-21 March 2022. Orange circle marks Ny-Ålesund. (b) Cyclone backtracking from the CAO-associated low near Svalbard on 21 March. Cyclone centre positions (black dots) were identified using a minimum-SLP tracking algorithm applied to spatially smoothed ERA5 6-hourly sea-level pressure fields; labels indicate daily 12 UTC positions. Shading and contours in panel b show ERA5 sea-level pressure at 12 UTC on 21 March. The backtrack (black line) links the low-pressure centre associated with the CAO to the Greenland Sea/Denmark Strait cyclone that drove the preceding AR landfall.

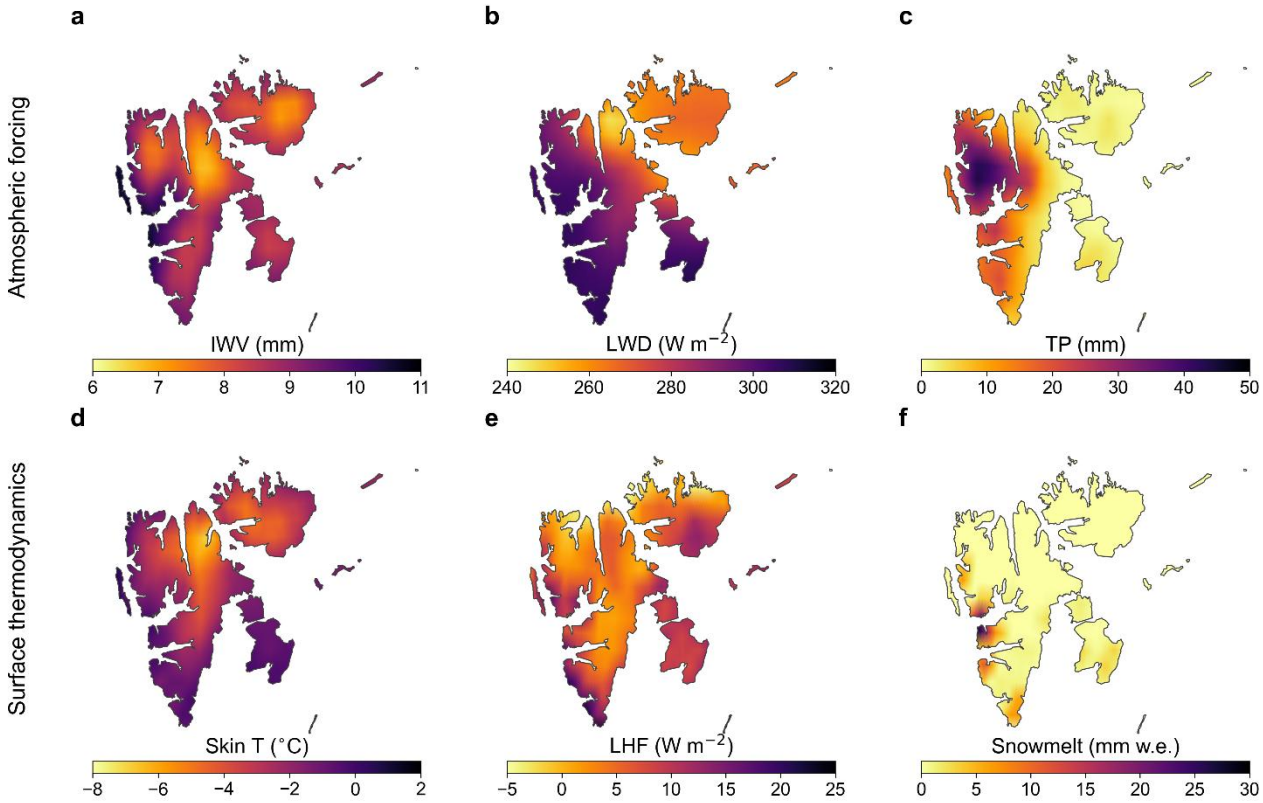

Figure S4: Atmospheric and surface conditions during the March 2022 AR. Spatial distribution of ERA5 (a) mean integrated water vapour (IWV), (b) mean downward longwave radiation (LWD), (c) total precipitation (TP), (d) mean skin temperature (T), (e) mean latent heat flux (LHF; positive downward), and (f) total snowmelt for 15-16 March 2022. Two-day means are shown for IWV, LWD, skin temperature and LHF, while precipitation and snowmelt are shown as accumulated totals over the two-day AR period.

Table S1. Snowfall stable isotope data from Ny-Ålesund.

Sampling date	δ^2H (‰)	$\delta^{18}O$ (‰)	d-excess (‰)
06/01/2022	-87.7	-15.65	37.5
08/02/2022	-62.7	-12.12	34.3
24/01/2022	-60.6	-9.71	17.1
01/02/2022	-100.8	-15.28	21.5
02/02/2022	-100.3	-15.76	25.8
08/02/2022	-189.8	-24.62	7.1
09/02/2022	-81.7	-13.79	28.6
22/02/2022	-81.8	-14.97	37.9
26/02/2022	-98	-16.92	37.4
26/02/2022	-104.1	-16.15	25.1
06/03/2022	-76	-11.54	16.3
09/03/2022	-137.8	-18.38	9.2
19/03/2022	-82.7	-12.57	17.8
16/04/2022	-128.1	-16.79	6.2
18/04/2022	-143.1	-19.53	13.1
26/04/2022	-162.9	-24.47	32.8
27/04/2022	-158.5	-24.03	33.8
05/05/2022	-86.1	-13.63	22.9
06/05/2022	-74.2	-12.01	21.9
08/05/2022	-186.6	-26.1	22.1
08/05/2022	-169	-24.12	23.9
16/05/2022	-48.9	-7.52	11.3
19/05/2022	-46.6	-8.86	24.3
22/05/2022	-40.2	-6.3	10.2

References

Craig, H.: Isotopic Variations in Meteoric Waters, Science., 133, 1702–1703, https://doi.org/10.1126/science.133.3465.1702, 1961.

Maturilli, M.: High resolution radiosonde measurements from station Ny-Ålesund (2022-03), https://doi.org/doi.org/10.1594/PANGAEA.914973, 2022.