

Appendix A

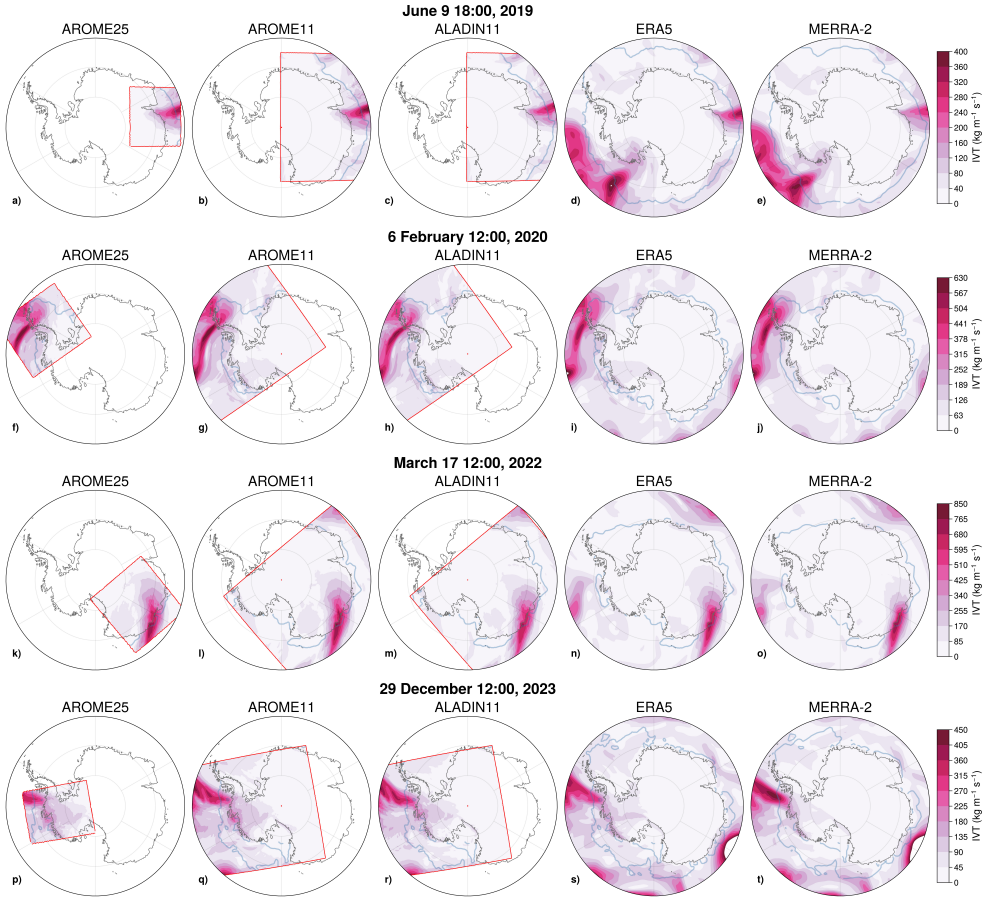


Fig. A1: Integrated vapour transport (IVT) during the peak intensity (6-hour window) of each AR event simulated by ERA5, MERRA-2 and the three HCLIM configurations (here based on ERA5). Red window represents the lateral boundaries of each domain (in the study we only compare the smallest window, i.e. AROME2.5).

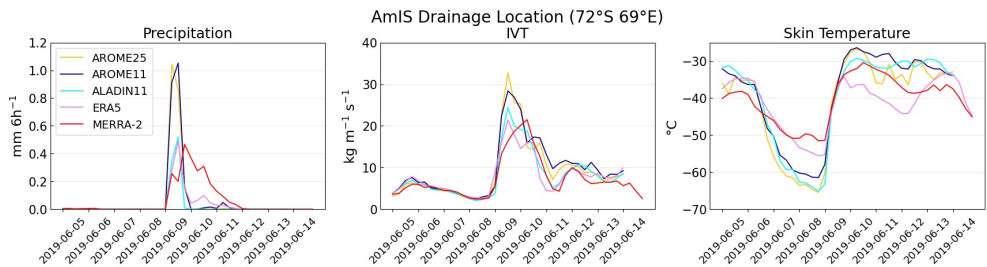


Fig. A2: As in Figure 2 but for precipitation, IVT and skin temperature over the location of the englacial lake drainage event that occurred between Jun 9-11, 2019.

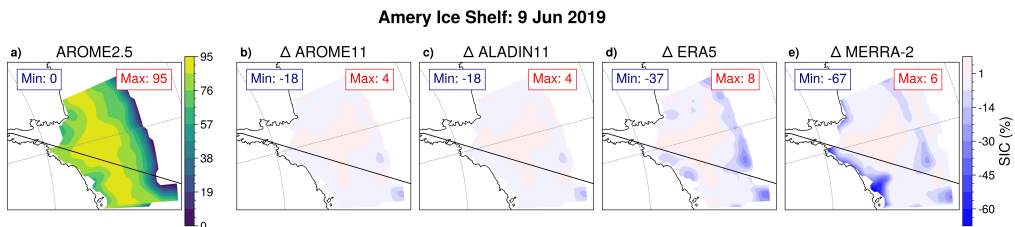
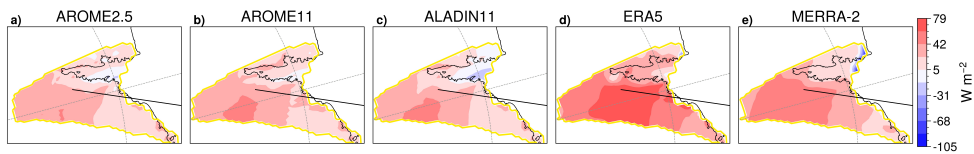


Fig. A3: Sea Ice Concentration near Amery and West Ice Shelf, simulated by AROME2.5 (a), before showing the difference based on other models (e.g. subfigure b represents AROME11-AROME2.5; red = 'overestimated').

9 Jun 2019: Sensible Heat Flux



9 Jun 2019: Latent Heat Flux

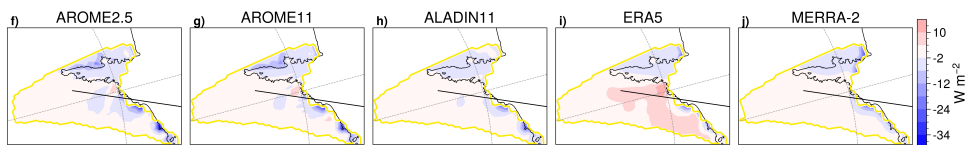


Fig. A4: Downward positive sensible and turbulent heat fluxes over the defined AR land domain including the Amery Ice Shelf, on Feb 9, 2019.

Appendix B

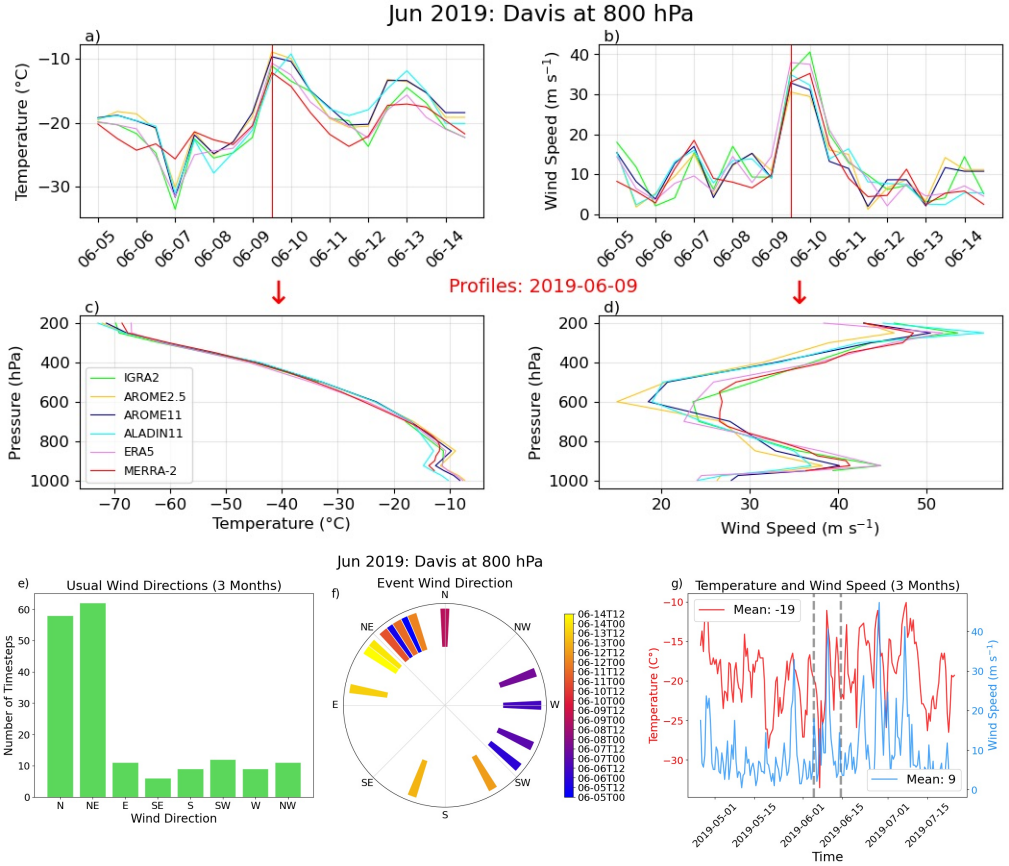


Fig. B1: Upper panel: 10-day time series of temperature (a) and wind speed (b) at 800 hPa at the site of the radiosonde sounding. Lower panel: Vertical profiles of temperature (c) and wind speed (d) at the time where the 800 hPa peak in temperature was reached in the 10 days (based on the radiosonde data). Vertical relative humidity (RH) profiles of ERA5 and MERRA-2 were derived by dividing specific humidity by the saturation vapour pressure (calculated with the Clausius-Clapeyron equation), adjusted by the ratio of the molecular weight of water vapour to dry air (0.622). e: Wind directions at 800 hPa grouped into eight standard compass directions (N, NE, E, SE, S, SW, W, NW), with the frequency of occurrence (usually 12-hourly) displayed as bar heights. Observational record covers three months centered around the selected event. f: Wind direction during the event with blue bars representing the start and yellow colours the end of the event. g: Air temperature and wind speed across the 3-month period with grey dashed lines marking the 10-day event simulation span. Labels indicate the 3-month average for both variables.

Feb 2020: Rothera at 800 hPa

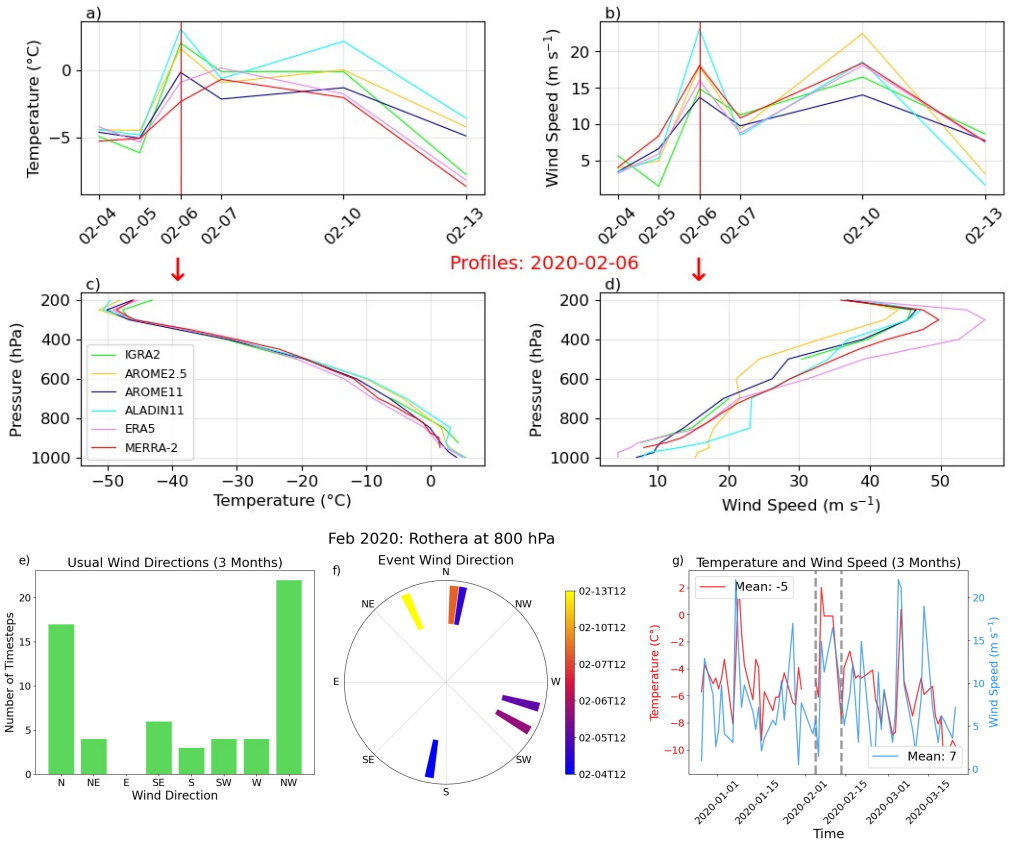


Fig. B2: As in Figure B2 but at Rothera station during the Feb 2020 event.

Mar 2022: Casey at 800 hPa

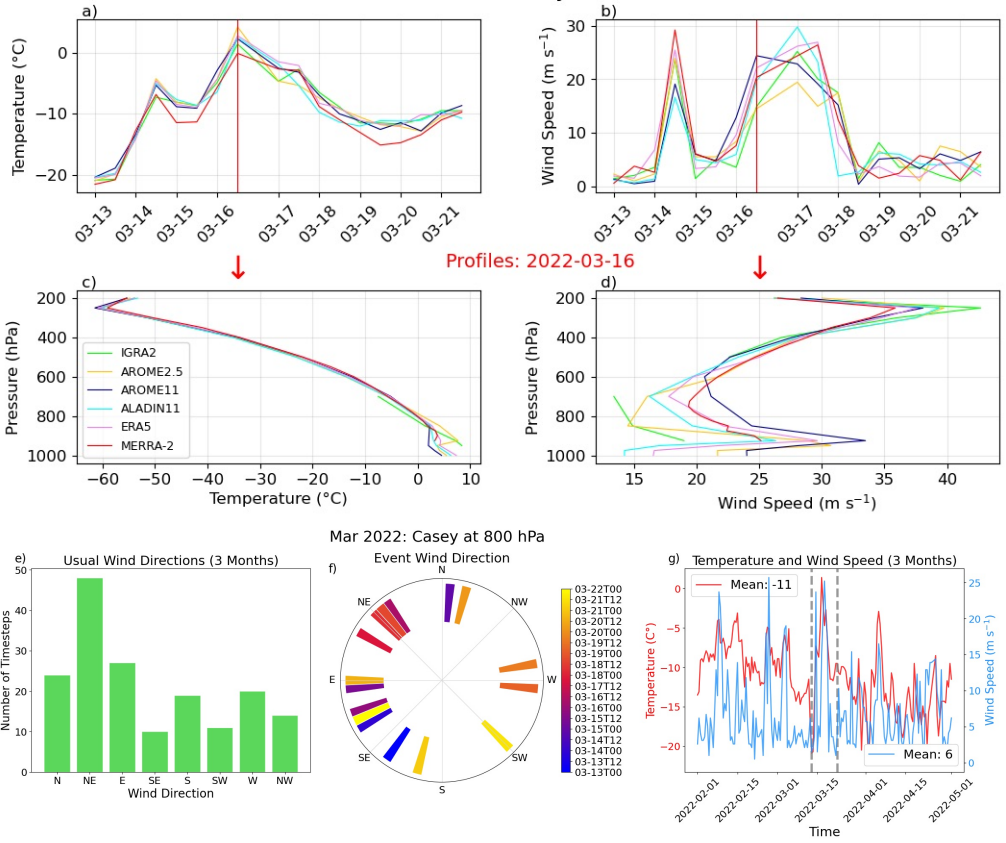


Fig. B3: As in Figure B2 but at Casey station for the Mar 2022 event.

Mar 2022: Dumont Durville at 800 hPa

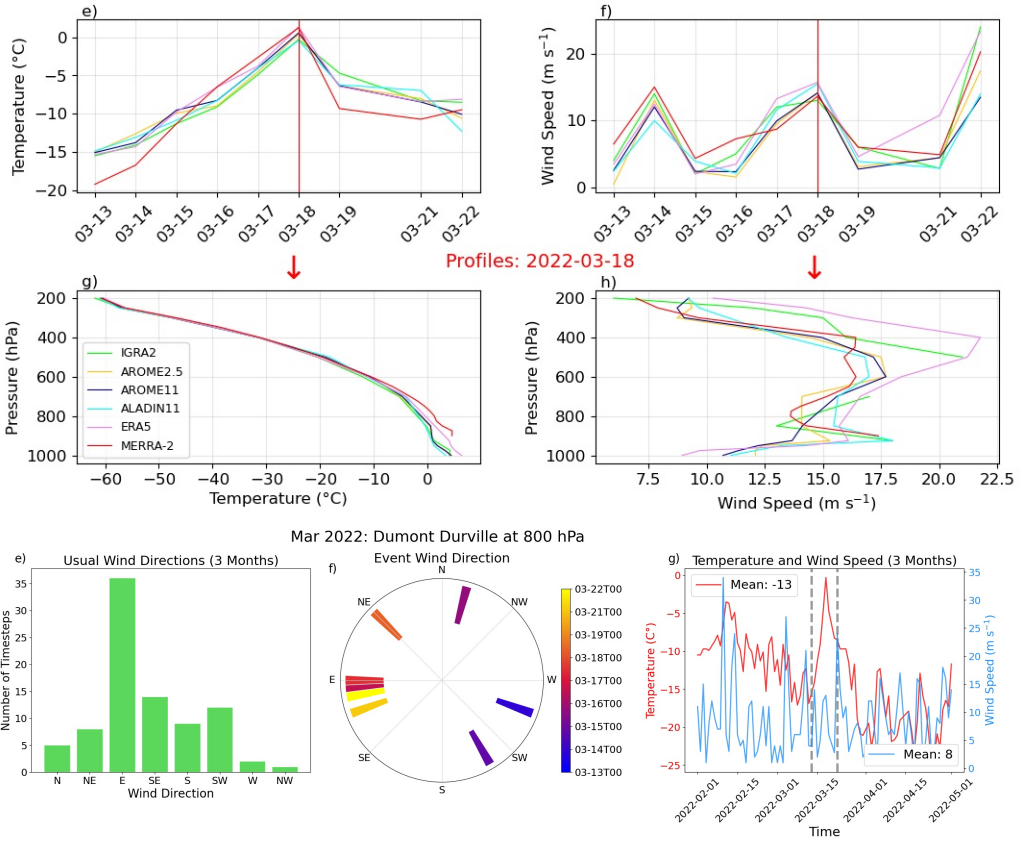
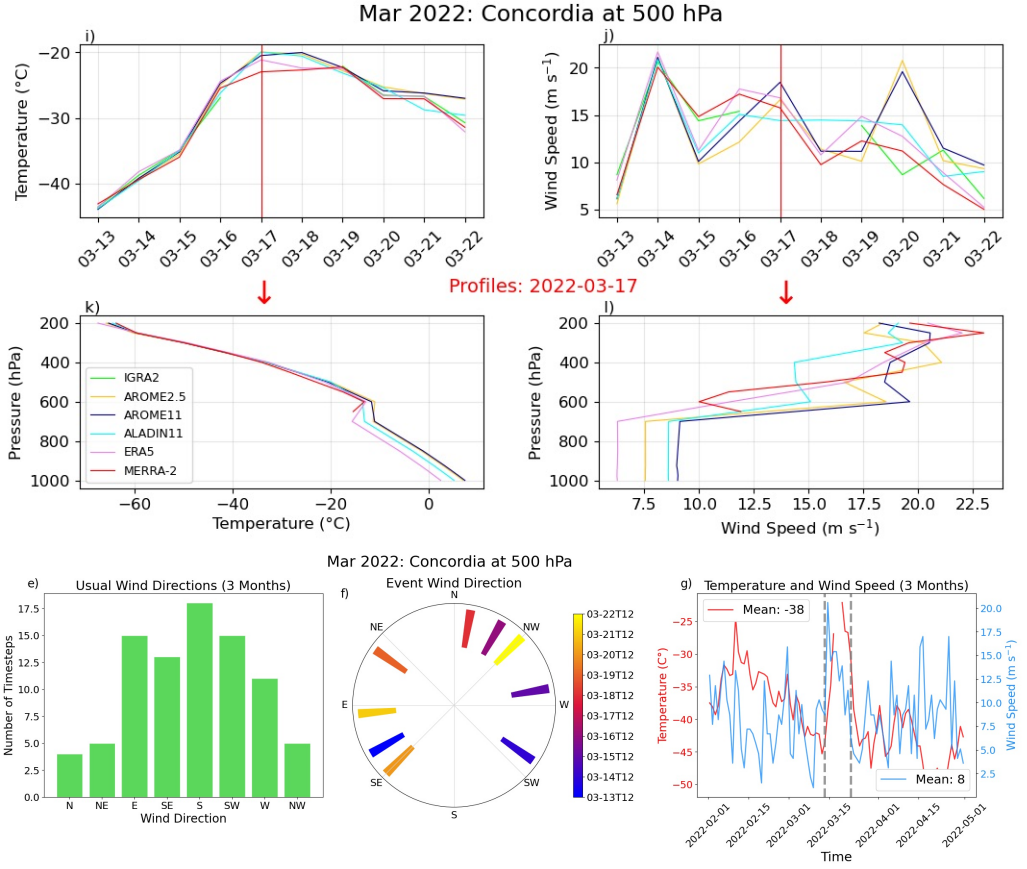
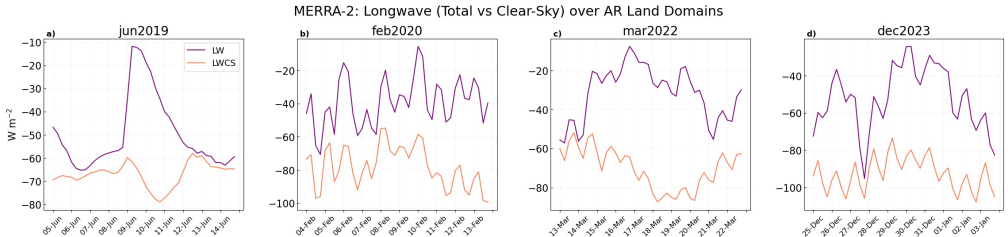


Fig. B4: As in Figure B2 but at Dumont-Durville station for the Mar 2022 event.



Appendix C



Jun 2019: AR Land Domain

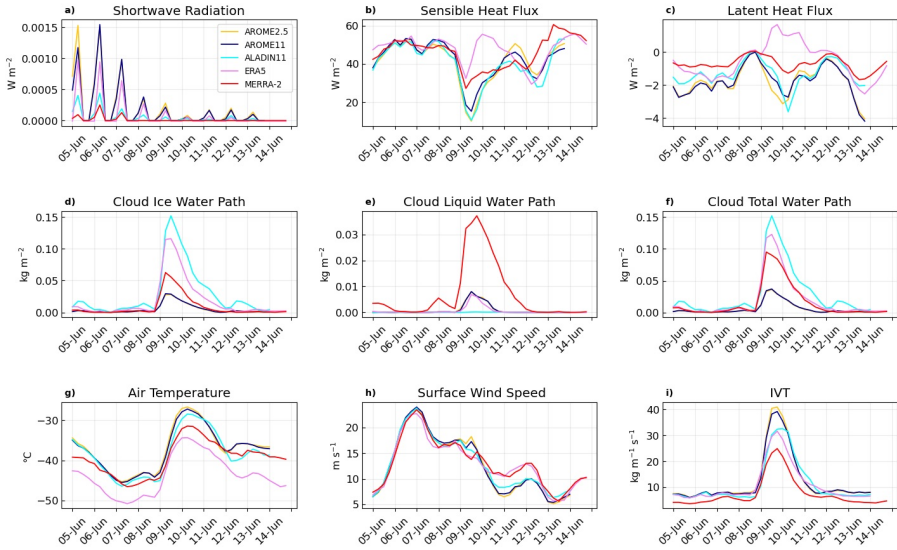


Fig. C2: As in Figure 2, but for the additional SEB terms, as well as the ice, liquid and total cloud water path, surface air temperature, wind speed and IVT. Surface wind speeds represent the winds at 600 hPa (lowest level with near-complete existing data during the AR event over the land domain in the non-extrapolating MERRA-2 reanalysis).

Feb 2020: AR Land Domain

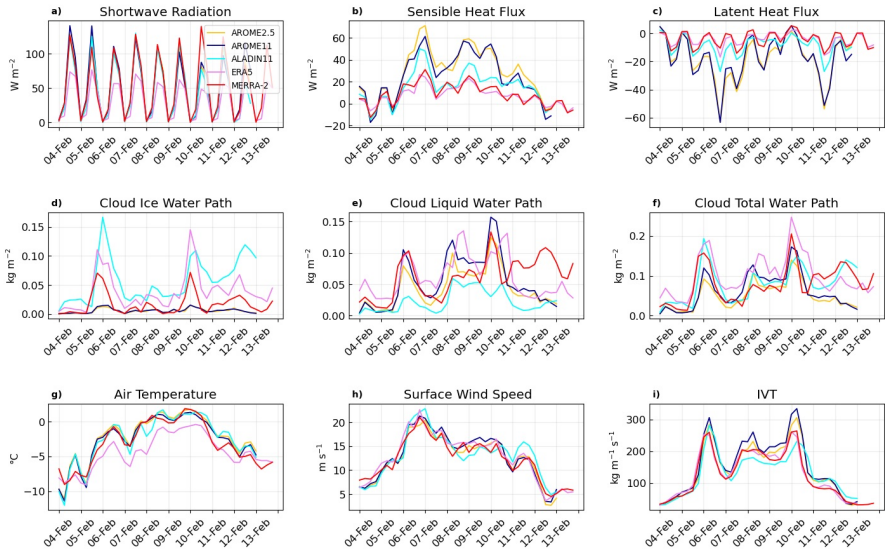


Fig. C3: As in Figure 7, but for the additional SEB terms, as well as the ice, liquid and total cloud water path, surface air temperature, wind speed and IVT. Surface wind speeds represent the winds at 600 hPa (lowest level with near-complete existing data during the AR event over the land domain in the non-extrapolating MERRA-2 reanalysis).

Mar 2022: AR Land Domain

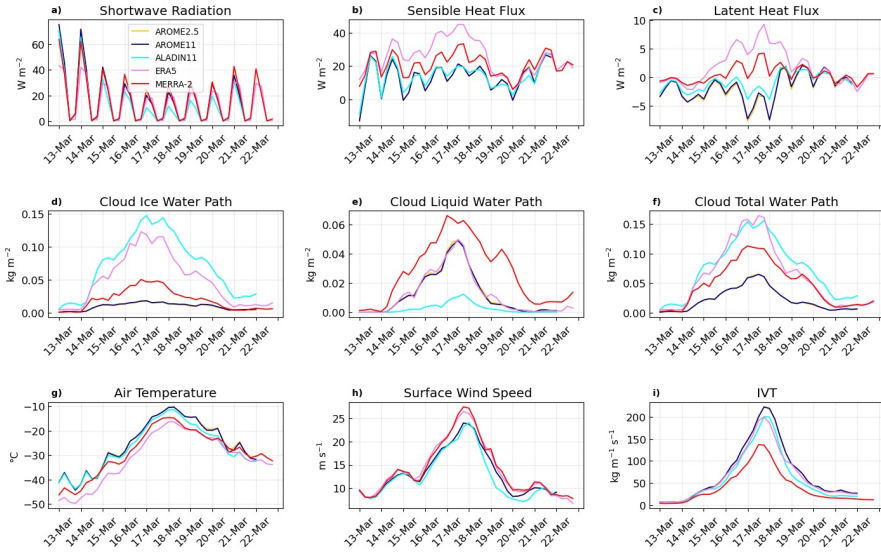


Fig. C4: As in Figure 11, but for the additional SEB terms, as well as the ice, liquid and total cloud water path, surface air temperature, wind speed and IVT. Surface wind speeds represent the winds at 600 hPa (lowest level with near-complete existing data during the AR event over the land domain in the non-extrapolating MERRA-2 reanalysis).

Dec 2023: AR Land Domain

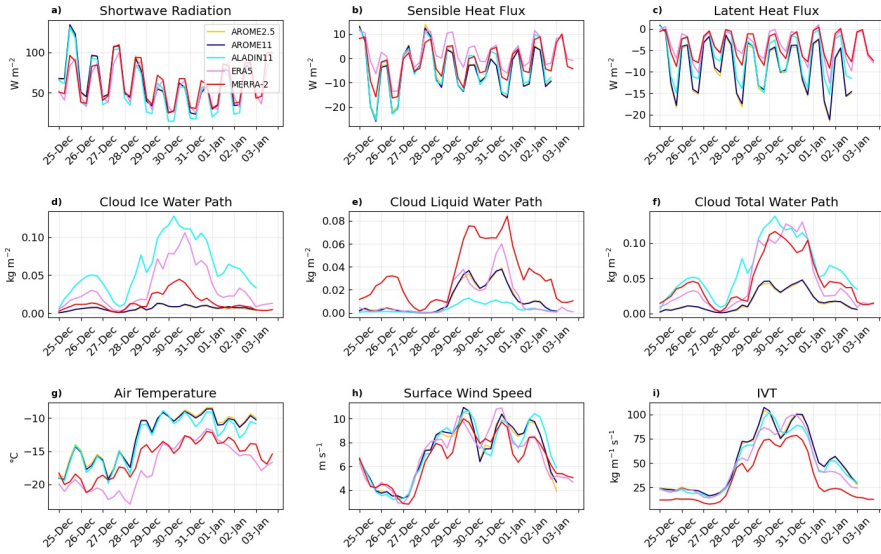


Fig. C5: As in Figure 15, but for the additional SEB terms, as well as the ice, liquid and total cloud water path, surface air temperature, wind speed and IVT. Surface wind speeds represent the winds at 600 hPa (lowest level with near-complete existing data during the AR event over the land domain in the non-extrapolating MERRA-2 reanalysis).

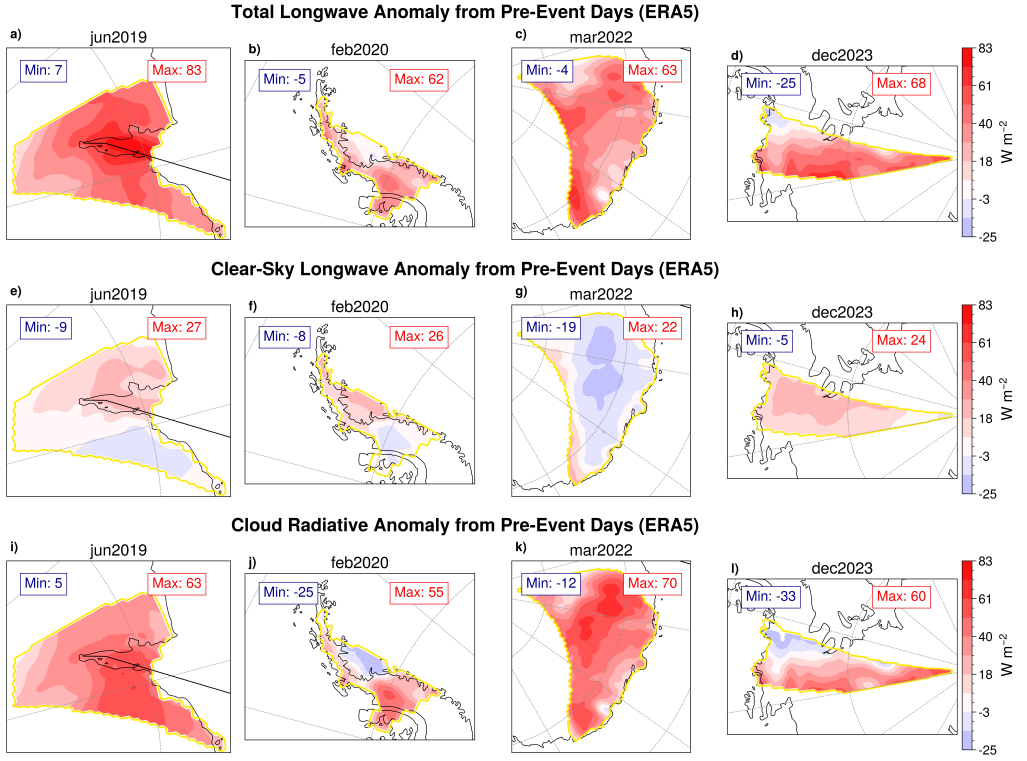


Fig. C6: Total downward longwave radiation (a-d), clear-sky longwave radiation (e-h) and the cloud radiate effect (LW-LWCS;i-l) based on ERA5 during the four AR events, averaged over the respective AR land domains (see Figure 1). Based on our findings and observational studies we suggest that the cloud radiative effect in ERA5 is overestimated in foehn-prone regions compared to HCLIM. Maps for MERRA-2 show the same patterns and can be provided upon request.

Appendix D

Jun 9, 2019: Cross-Sections of Clouds and SEB

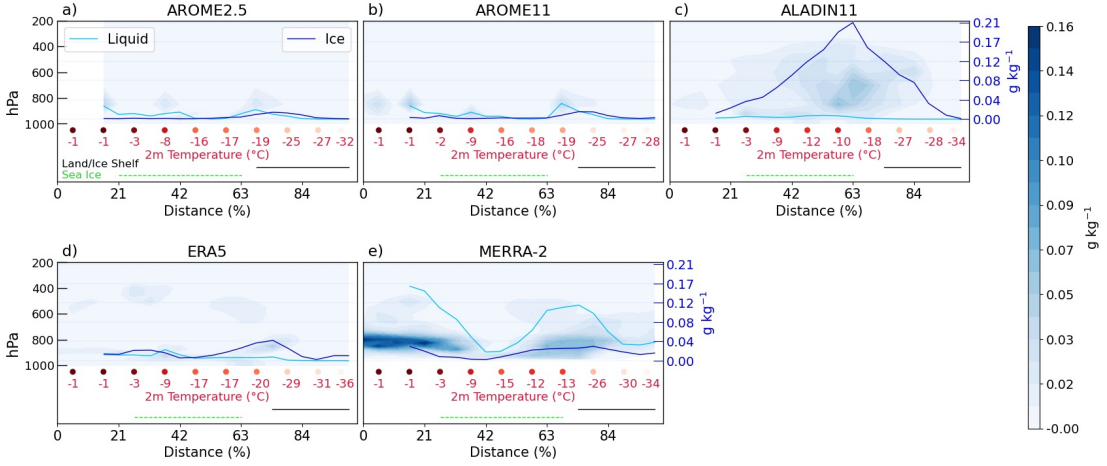


Fig. D1: As in Figure 4, but for the ice and liquid water content integrated over the vertical pressure levels.

Feb 6, 2020: Cross-Sections of Clouds and Liquid/Ice Water Content

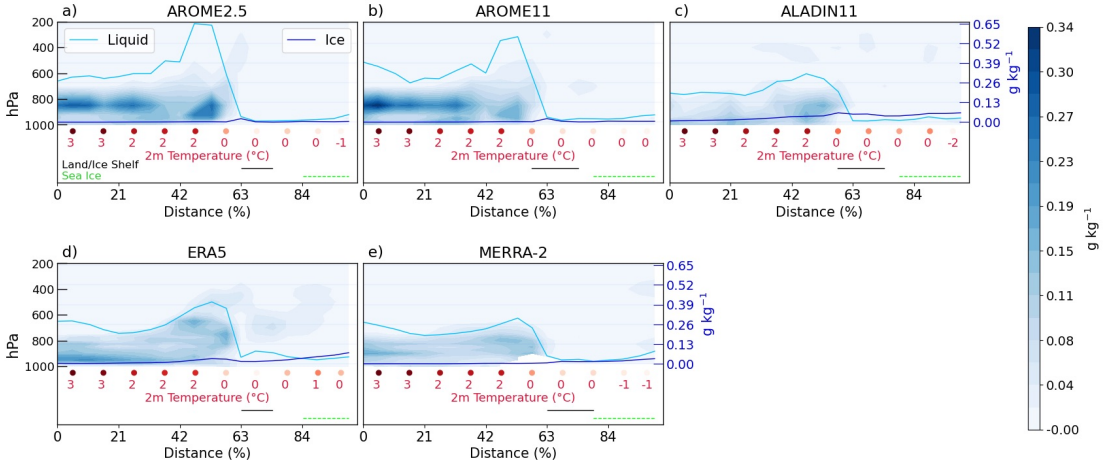


Fig. D2: As in Figure 9, but for the ice and liquid water content integrated over the vertical pressure levels.

Mar 17, 2022: Cross-Sections of Clouds and Liquid/Ice Water Content

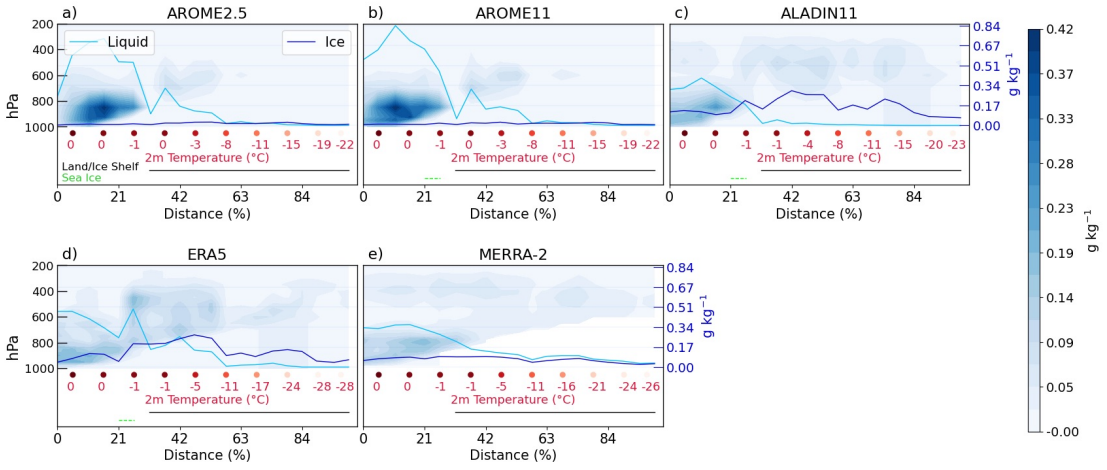


Fig. D3: As in Figure 13, but for the ice and liquid water content integrated over the vertical pressure levels.

Dec 29, 2023: Cross-Sections of Clouds and Liquid/Ice Water Content

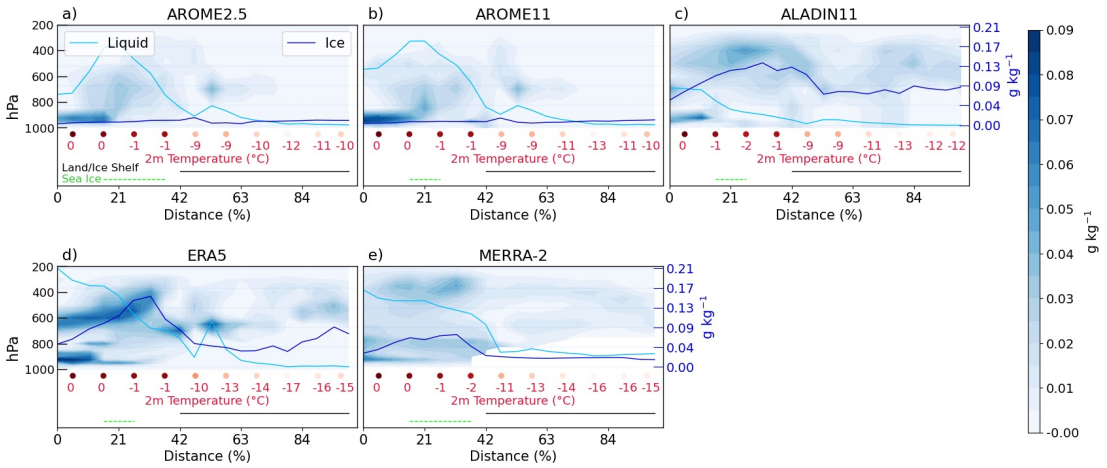


Fig. D4: As in Figure 17, but for the ice and liquid water content integrated over the vertical pressure levels.

Appendix E

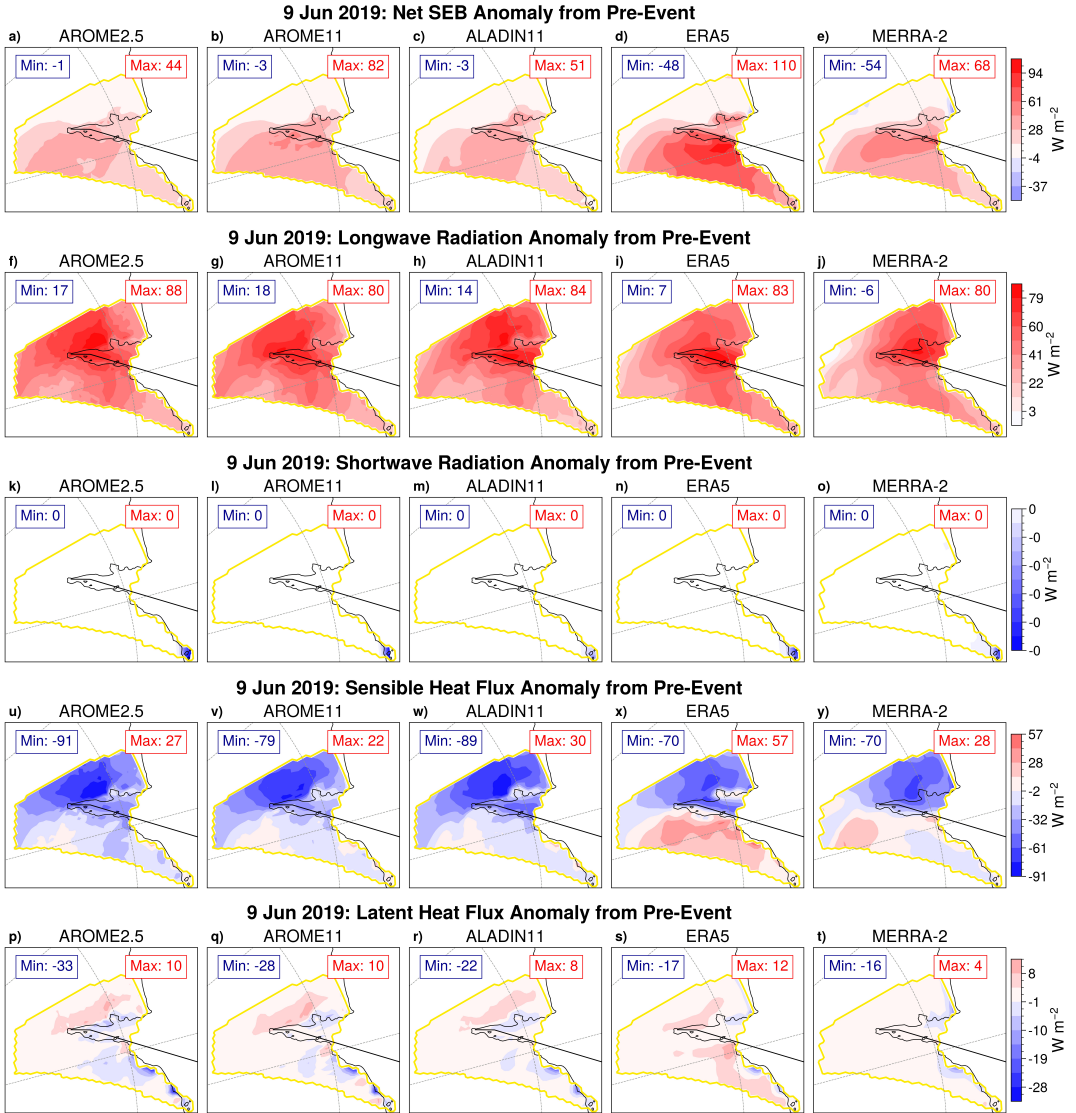
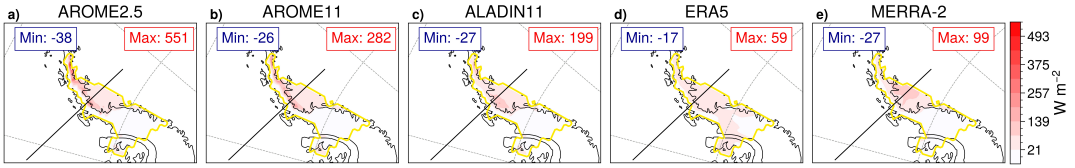
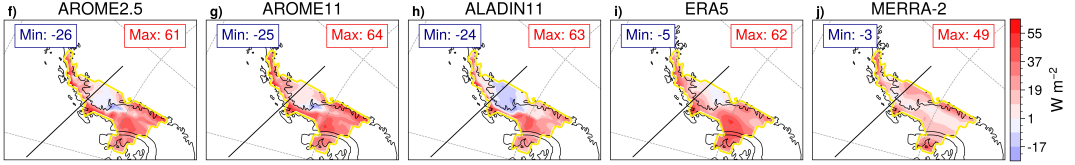


Fig. E1: SEB 'anomalies' inside the AR land domain as the difference between the main AR event day (Jun 9) to the 3-day pre-event average.

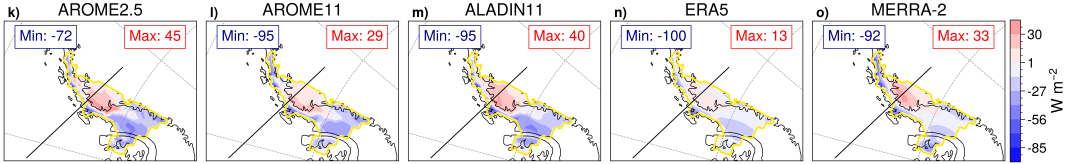
6 Feb 2020: Net SEB Anomaly from Pre-Event



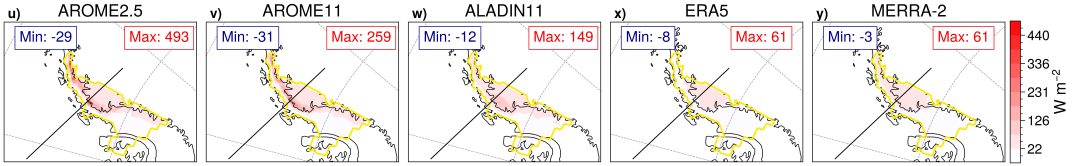
6 Feb 2020: Longwave Radiation Anomaly from Pre-Event



6 Feb 2020: Shortwave Radiation Anomaly from Pre-Event



6 Feb 2020: Sensible Heat Flux Anomaly from Pre-Event



6 Feb 2020: Latent Heat Flux Anomaly from Pre-Event

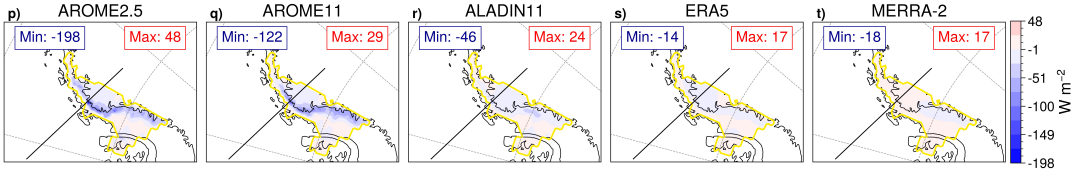


Fig. E2: SEB 'anomalies' inside the AR land domain as the difference between the main AR event day (Feb 6) to the 2-day pre-event average.

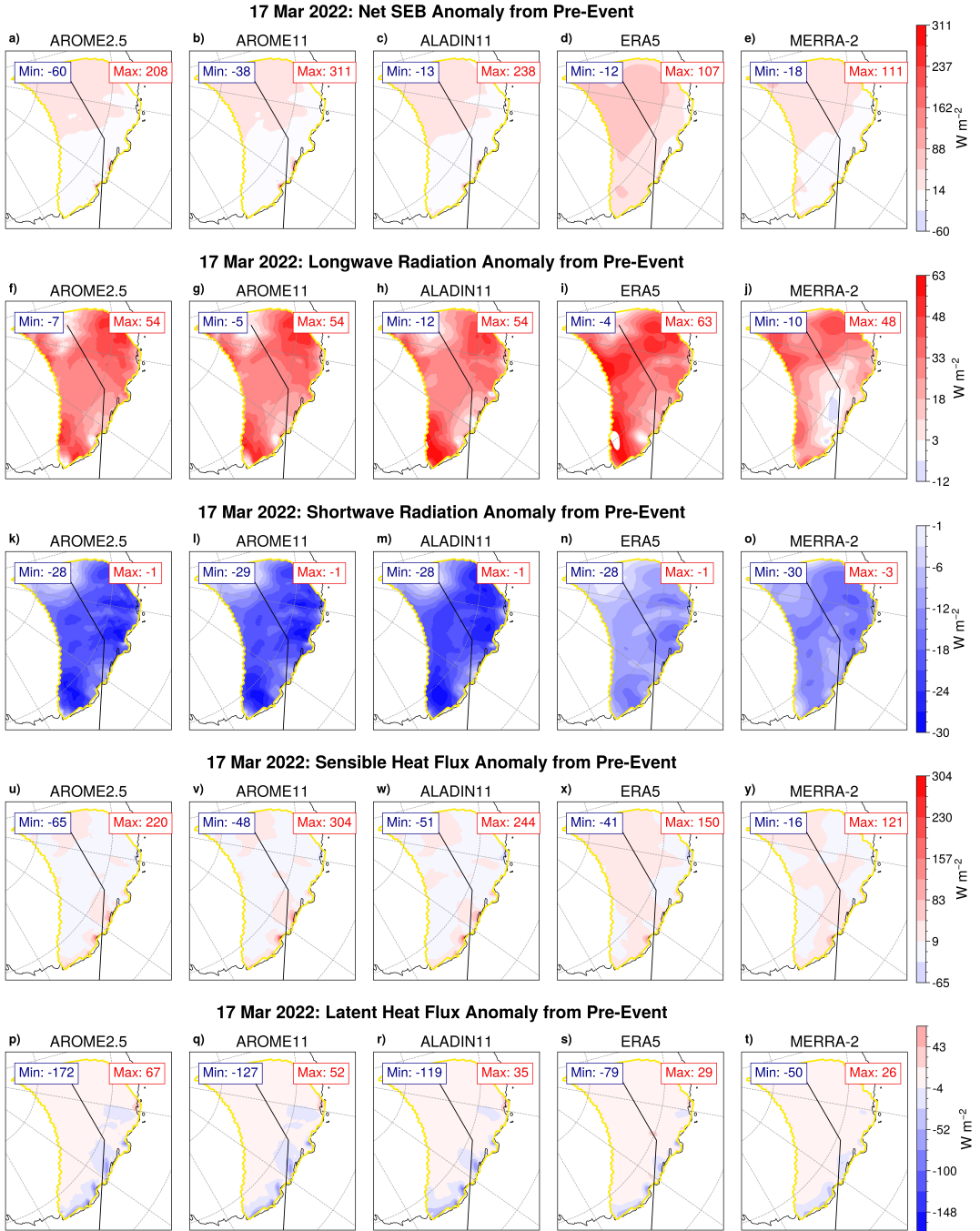
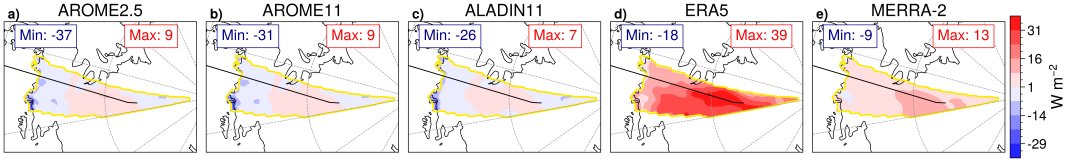
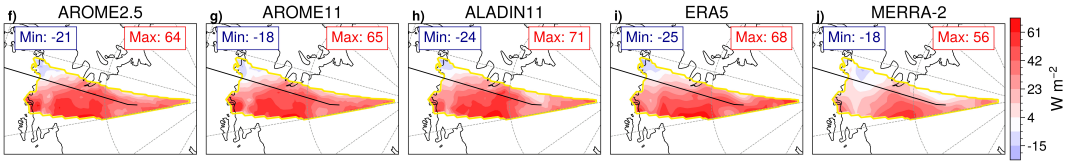


Fig. E3: SEB 'anomalies' inside the AR land domain as the difference between the main AR event day (Mar 17) to the 3-day pre-event average.

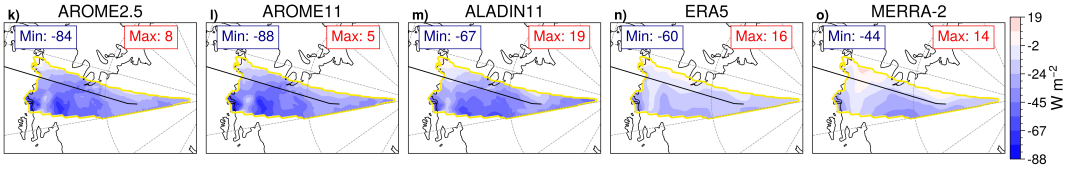
29 Dec 2023: Net SEB Anomaly from Pre-Event



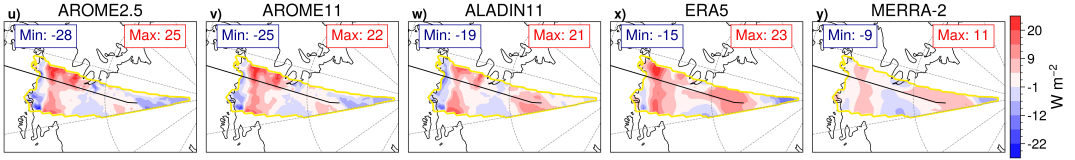
29 Dec 2023: Longwave Radiation Anomaly from Pre-Event



29 Dec 2023: Shortwave Radiation Anomaly from Pre-Event



29 Dec 2023: Sensible Heat Flux Anomaly from Pre-Event



29 Dec 2023: Latent Heat Flux Anomaly from Pre-Event

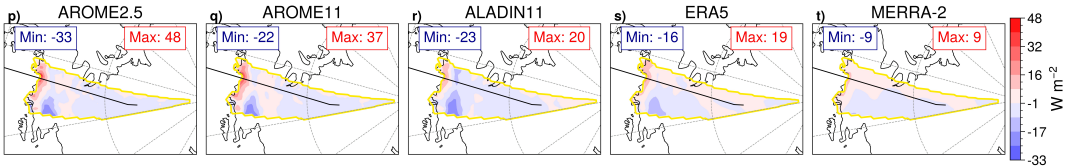


Fig. E4: SEB 'anomalies' inside the AR land domain as the difference between the main AR event day (Dec 29) to the 3-day pre-event average.

Appendix F

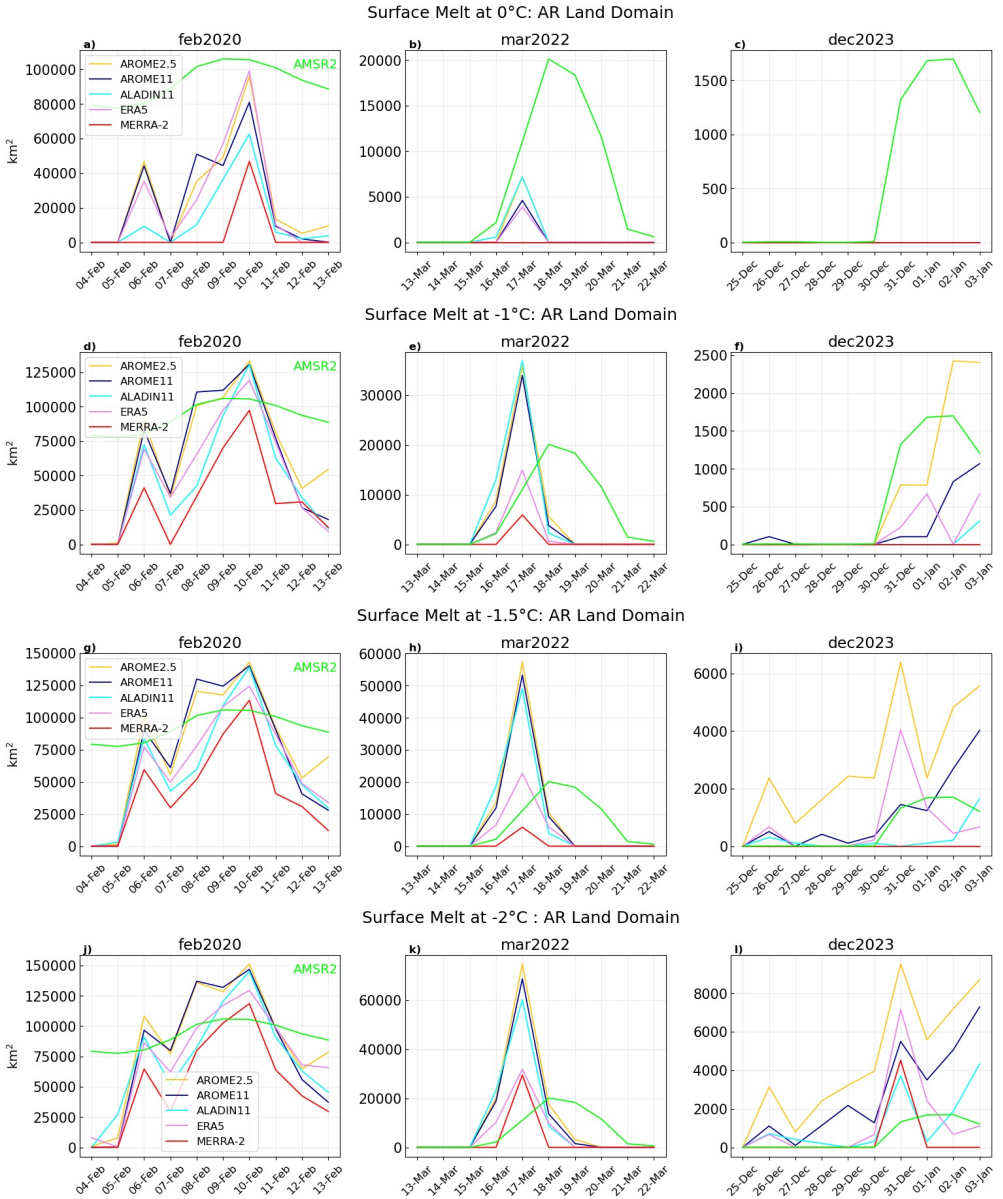


Fig. F1: a-c: Surface melt using 0°C as a threshold, as in Figures 7b-15b). Followed by surface melt with a melt threshold of -1°C threshold (d-f), -1.5°C (g-i), and -2°C (j-l).

Mar 2022: Precipitation at DDU (Nearest Grid Point)

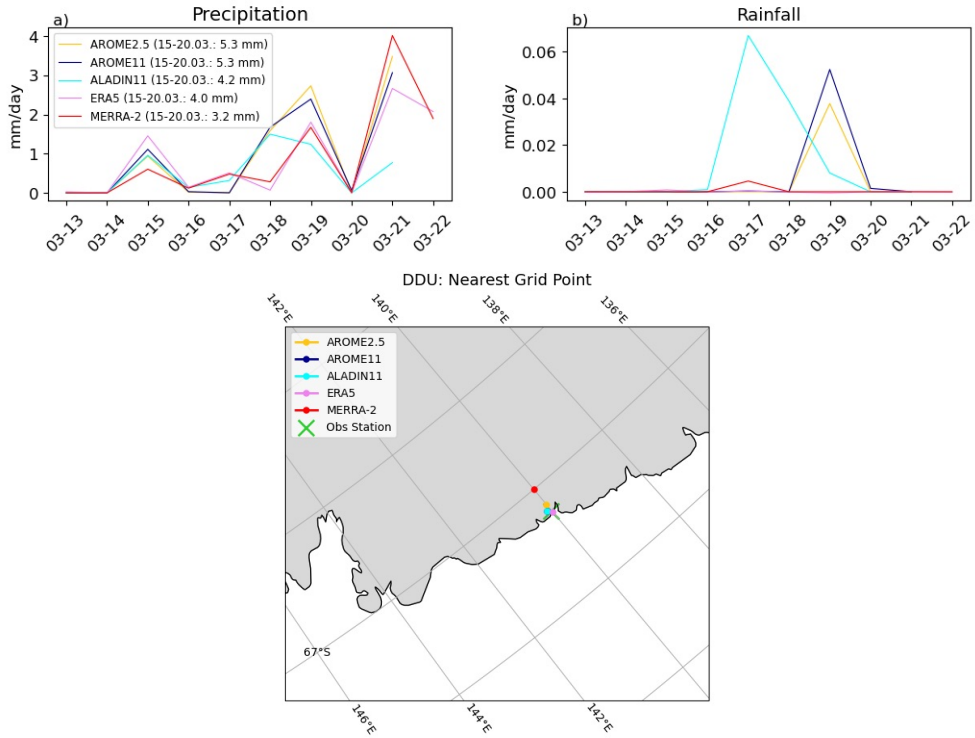


Fig. F2: Upper panel: Precipitation and rainfall at Dumont-Durville (DDU) over the March 2022 heatwave. Accumulated precipitation from Mar 15-20 is included in the legend to compare values to those reported in Wille et al (2024b) (9 mm of snowfall from Mar 15-20). The authors also observed rainfall on Mar 17, which our models did not simulate except for ALADIN11. Lower panel: Map showing the 'true' coordinate of DDU (green cross) and the nearest grid point for each model. Since MERRA-2 has the lowest accumulated precipitation and the most inland grid point, we recalculated precipitation using the nearest grid point to this MERRA-2 inland location for all other models (which were all close to MERRA-2's location or even more inland). This still showed MERRA-2 with the lowest precipitation, while other models remained similar to their original values.