Supplementary Materials: On the radiative impact of biomass-burning aerosols in the Arctic: the August 2017 case study

This Supporting Information are a complement to the manuscript "On the radiative impact of biomass-burning aerosols in the Arctic: the August 2017 case study". They provide extended temporal information and details regarding the analysis discussed in the main text. Moreover, dataset not available online are available in compressed folder along with the Supporting Information.

1. Dataset

Dataset of aerosol sampling for chemical composition: "On_the_radiative_impact_of_biomass-burning_aerosols_in_the_Arctic_the_August_2017_case_study.zip"

2. HYSPLIT Model

The National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory's (ARL) Hybrid Single-Particle Lagrangian Integrated Trajectory model (HYSPLIT, 1) was used in this study to reconstruct backward trajectories of the air masses observed at THAAO. The HYSPLIT model was run backward in time [2] for 144 hours with a 3-hour time step starting on 15 August. The trajectories end-point is centred on THAAO. Each trajectory is verified against its reverse trajectory, running the model in the opposite direction to assess the integration error and increase the consistency of simulations. Only pairs of backward and forward trajectories with a relative error (distance between the ending point of the backward trajectory and the starting point of the forward trajectory with respect to the total travel distance) lower than 5% are considered. The NCEP dataset [3] was employed as the meteorological reanalysis input. The model was run with different target altitudes, grouped into three classes: the lower troposphere starting at 250, 500, and 750 *m* asl; the mid-troposphere starting at 1000, 2000, and 3000 *m* asl; and the upper troposphere starting at 7000, 8000, and 9000 *m* asl (Figure S6).

3. Aerosol sources

Characteristic elements (NO_3^-, Na, Ce, La, V, Al, Cr, Ti, Ni, S1a-i) and selected ratios between them (Ti/Al, Ni/Al, V/Al, Cr/Al, Ce/Al in Figure S1j-n can be used to individuate the possible soil source areas. As a general trend, we can observe that in the periods 16 - 24 August, other than Al (the main marker of crustal aerosol), all the above-reported elements show increased concentration. Becagli *et al.* [4] showed that Ti/Al ratio higher than 0.07 (dashed line GS in Figure S1j-k) are characteristic of local source areas due to the presence of ilmenite soil enriched in Ti with respect to continental long-range transported dust. Indeed, especially on 14 - 17 August, the Ti/Al ratio is still higher than 0.07, decreasing in the following days. The ratios Ni/Al, V/Al, (Figure S1l,m) and Cr/Al and Ce/Al (Figure Figure S1j,n) increase starting on 22 August, especially in the 20 - 23 August. Becagli *et al.* [4] also indicate that V, Ni and Cr in the aerosols sampled at THAAO have a source in the south-western coast of Greenland due to the presence of these metals in the soil. The south-western Greenland soil is also enriched in rare Earth elements, explaining the concurrent increase in Cr/Al and Ce/Al ratios.

4. Tables

Table 1: Summary table of instruments and data considered in the study. Information referring to the dataset shown in the Supplementary Materials are reported in square brackets. The dataset only briefly cited in the manuscript are written in *italics*.

Period	Instrument	Info
14-25 August 2021 [14-25 August 2021]	FTIR	H_2CO, NH_3, HCN, C_2H_6, CO
	MODIS	MCD43 (Level-3 Bidirectional Reflectance Distribution Function and Albedo) MOD08 and MYD08 (Level-3 Atmosphere Daily Global Product)
	Eppley Precision Spectral Pyranometers	SW up and down
	Kipp&Zonen CGR4, Eppley Precision Infrared Radiometer	*LW up and down*
	Licor Li-190R quantum sensors	PAR up and down
	Cimel Sun Photometer	AOD total, coarse and fine aerosol fraction
	Campbell weather station	Temperature, pressure, relative humidity
	[NCEP reanalysis]	
	Heitronics KT 19.85 II	*Brightness temperature*
	Skycam	
14-25 August 2021 [14-25 August 2021]	TECORA® Skypost sequential sampler	$nssSO_4^{2-}$, NH_4^+, $nssK^+$, Oxalate (Ox), Glycolate (Gly), Formate (For). [NO_3^-, Na, Ce, La, V, Al, Cr, Ti, Ni]
21 August 2017	RPG Humidity And Temperature PROfiler G2	Temperature and humidity vertical profiles
	OMI	Total Column Ozone
	Cimel Sun Photometer	AOD
21 August 2017 [20-22 August 2017]	CALIOP	Total attenuated backscatter [Type Attribution]

5. Figures

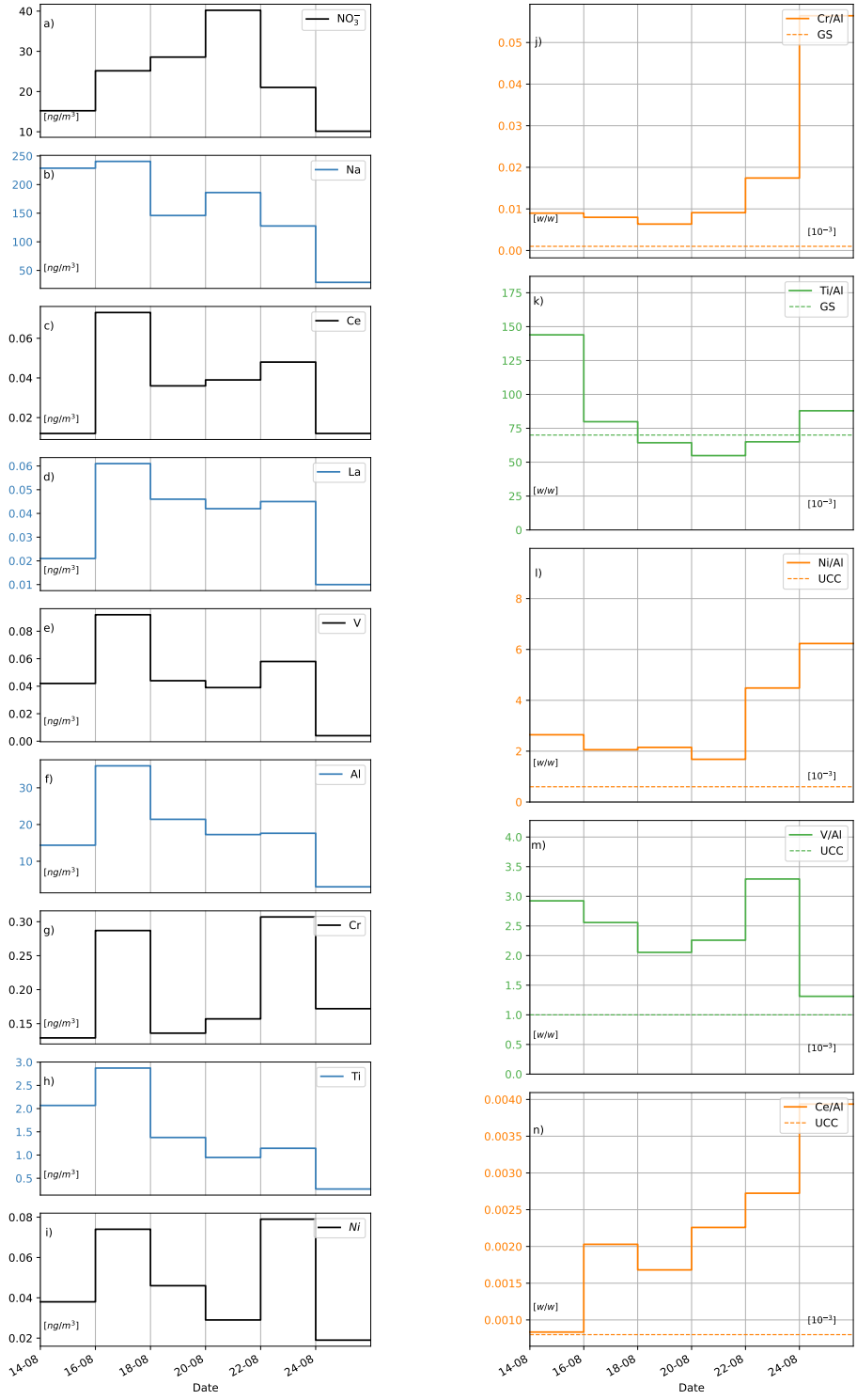
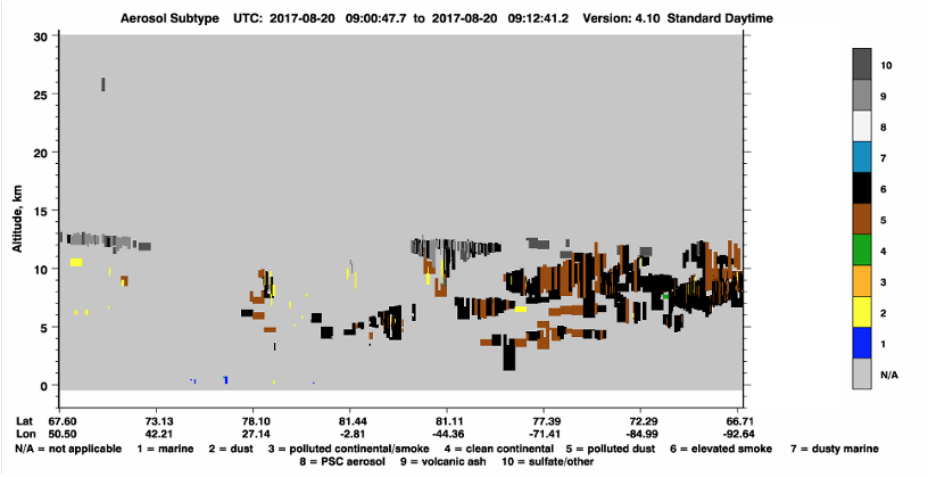
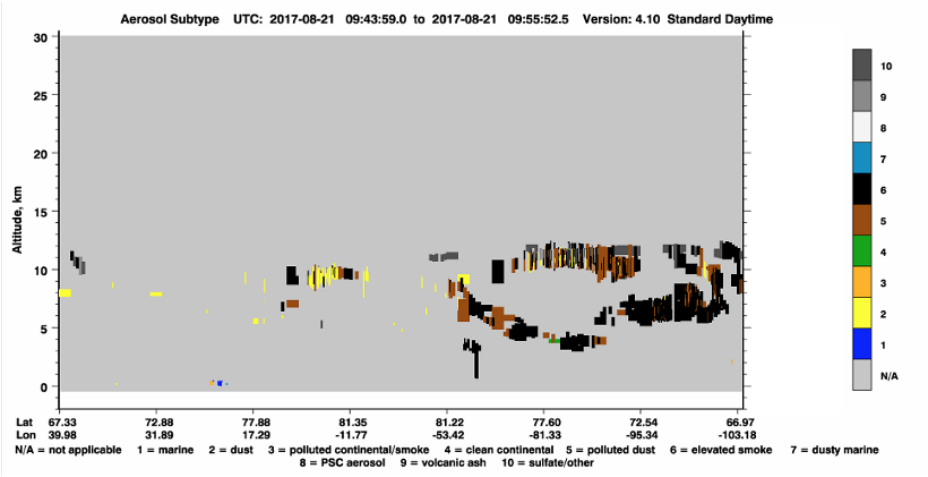


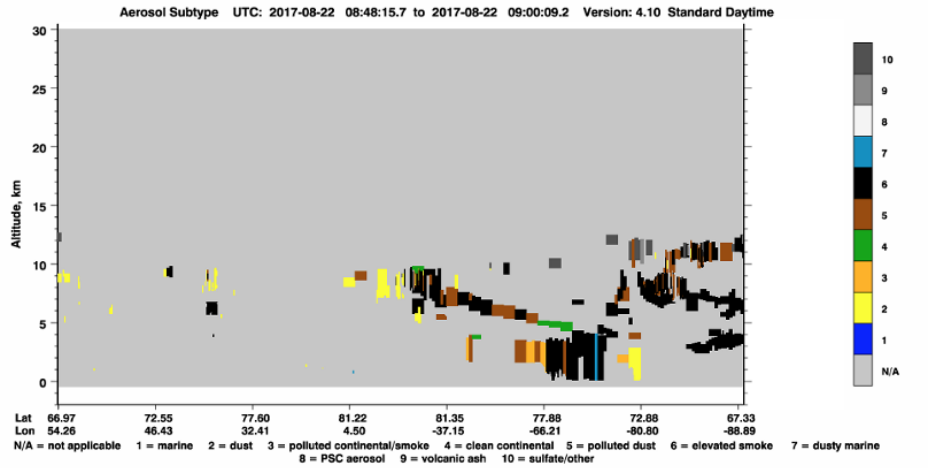
Figure S1. Time series of chemical species and ratios measured at the THAAO during August. The concentrations of NO_3^-, Na, Ce, La, V, Al, Cr, Ti, Ni were measured in PM10 samples (48-hour resolution). The same applies to Cr/Al, Ti/Al, Ni/Al, V/Al and Ce/Al ratios. The Greenlandic Soil reference (GS) was taken from Becagli *et al.* [4] whereas the UCC is derived from Henderson and Henderson [5].



(a) 20 August 2017



(b) 21 August 2017



(c) 22 August 2017

Figure S2. CALIOP aerosol type attribution for days 20-22 August.

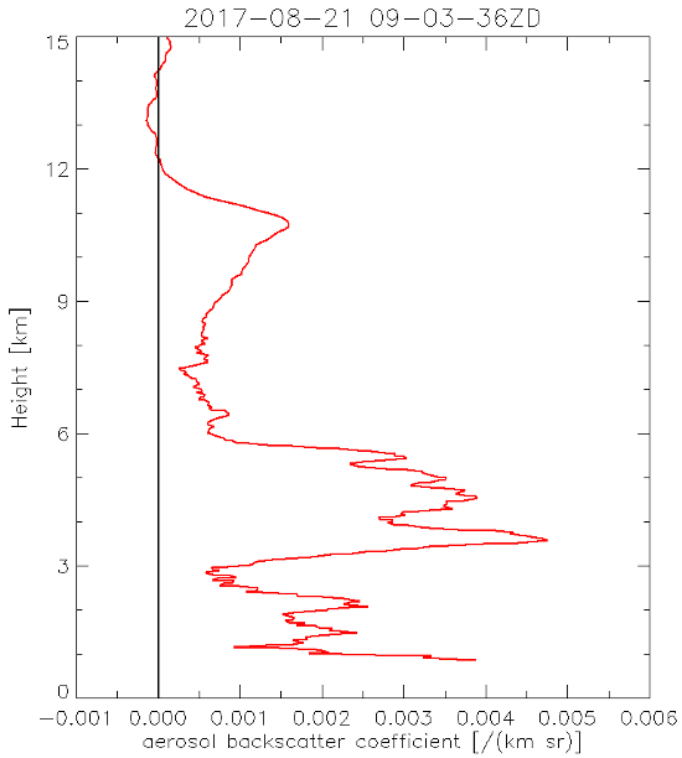


Figure S3. Profile of the aerosol backscattering coefficient retrieved from CALIOP data on 21 August 2017 around 9:51 UTC, around 300 *km* North of THAAO.

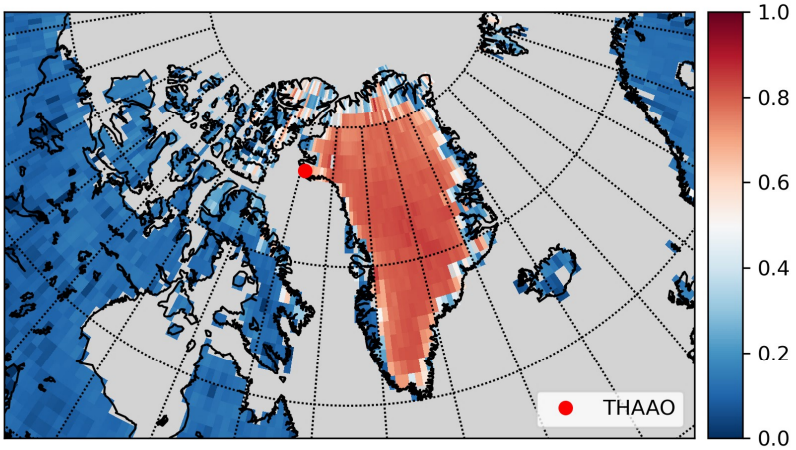


Figure S4. Albedo values from MOD43MCD regridded to $1° \times 1°$ (same resolution as MOD08_D3 and MYD08_D3 AOD).

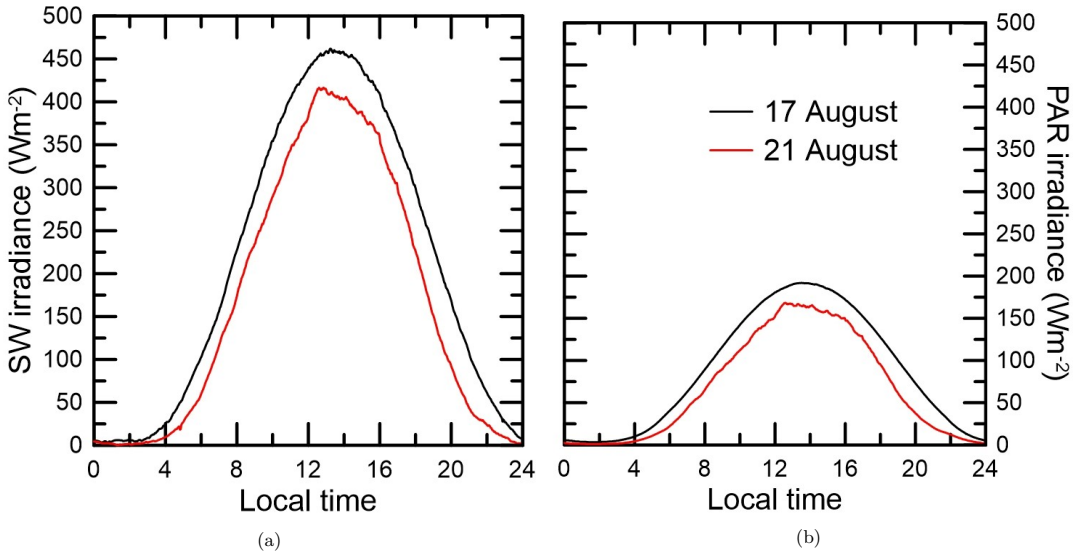
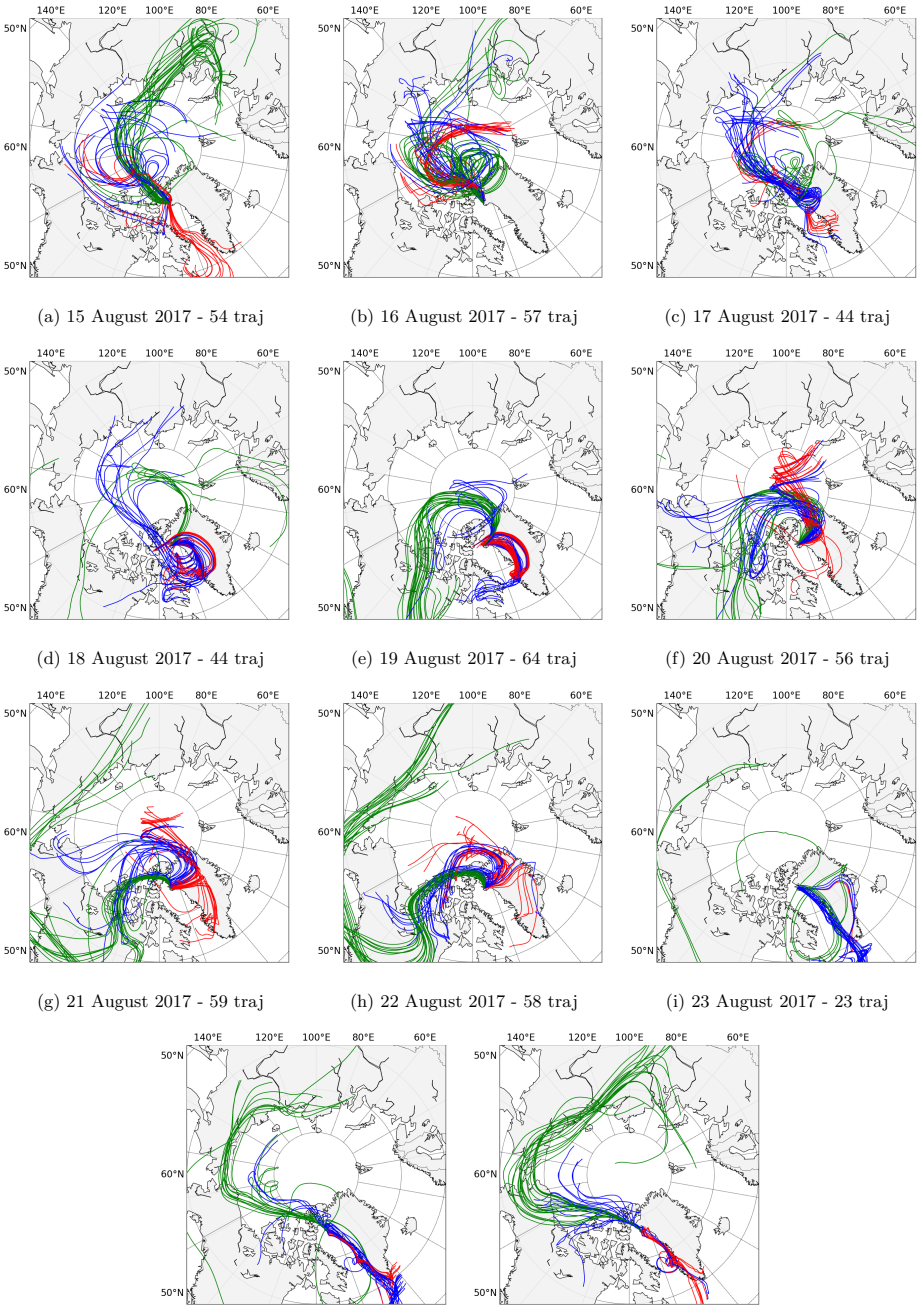


Figure S5. Daily evolution of **(a)** SW↓ and **(b)** PAR↓ irradiances on 17 August (an aerosol- and cloud-free day) and on 21 August (a day with transported BB aerosols). Local time at Thule during summer is UTC-3.



(a) 15 August 2017 - 54 traj (b) 16 August 2017 - 57 traj (c) 17 August 2017 - 44 traj

(d) 18 August 2017 - 44 traj (e) 19 August 2017 - 64 traj (f) 20 August 2017 - 56 traj

(g) 21 August 2017 - 59 traj (h) 22 August 2017 - 58 traj (i) 23 August 2017 - 23 traj

(j) 24 August 2017 - 47 traj (k) 25 August 2017 - 46 traj

Figure S6. Trajectories obtained from HYSPLIT model on the 15-25 August 2017, running 144 hours backwards in time at 3-hour time-step. Trajectories are subdivided into three classes according to their altitude: lower troposphere: 250, 500, 750 *m* asl in red; mid-troposphere: 1000, 2000, 3000 *m* a.s.l. in blue; upper troposphere: 7000, 8000, 9000 *m* asl in green. NCEP dataset was employed as the meteorological reanalysis input. See the text for further details.

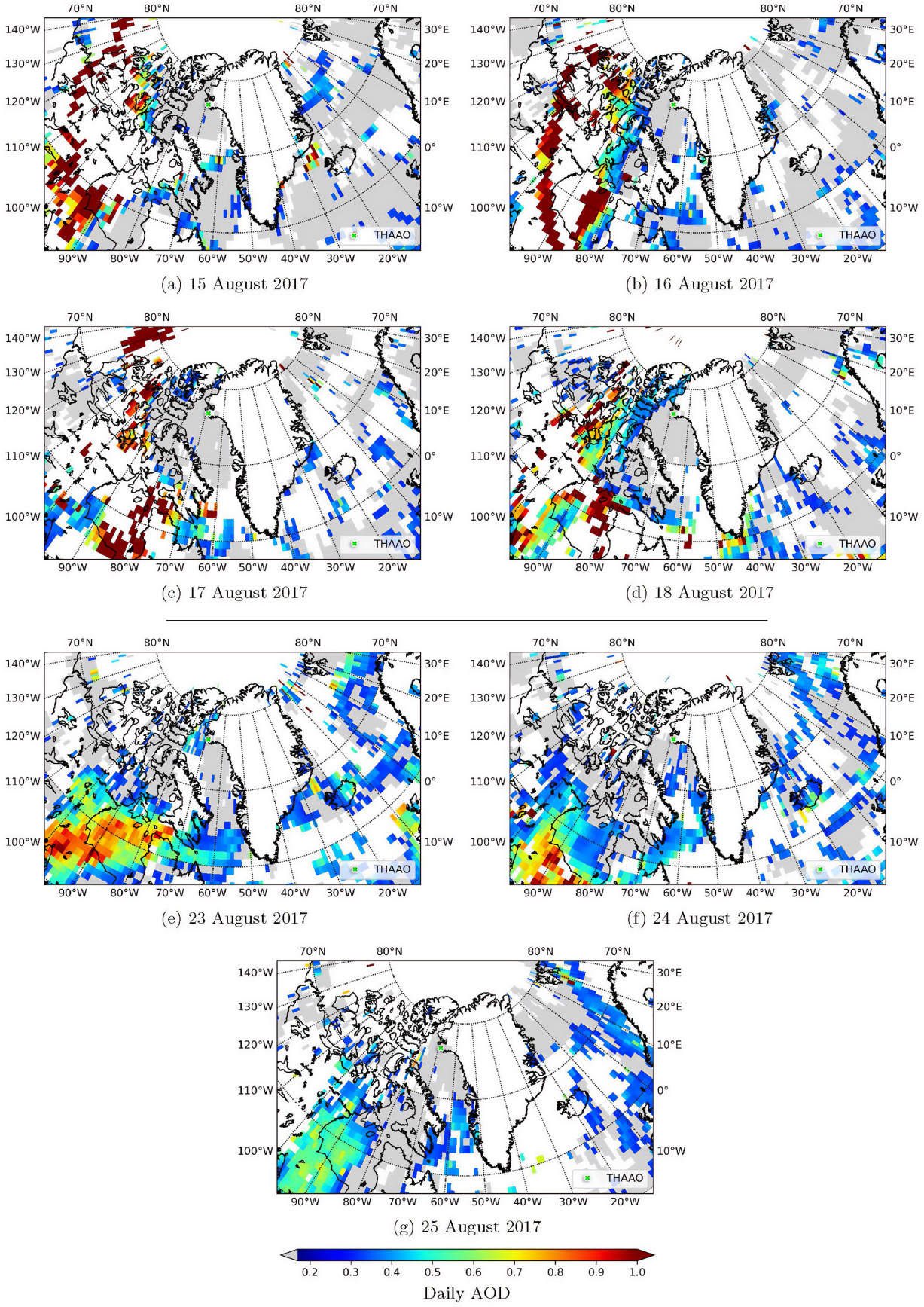


Figure S7. Daily AOD maps for 15-25 August 2017. White areas represent pixels where no MODIS AOD data were available. See text for further details.

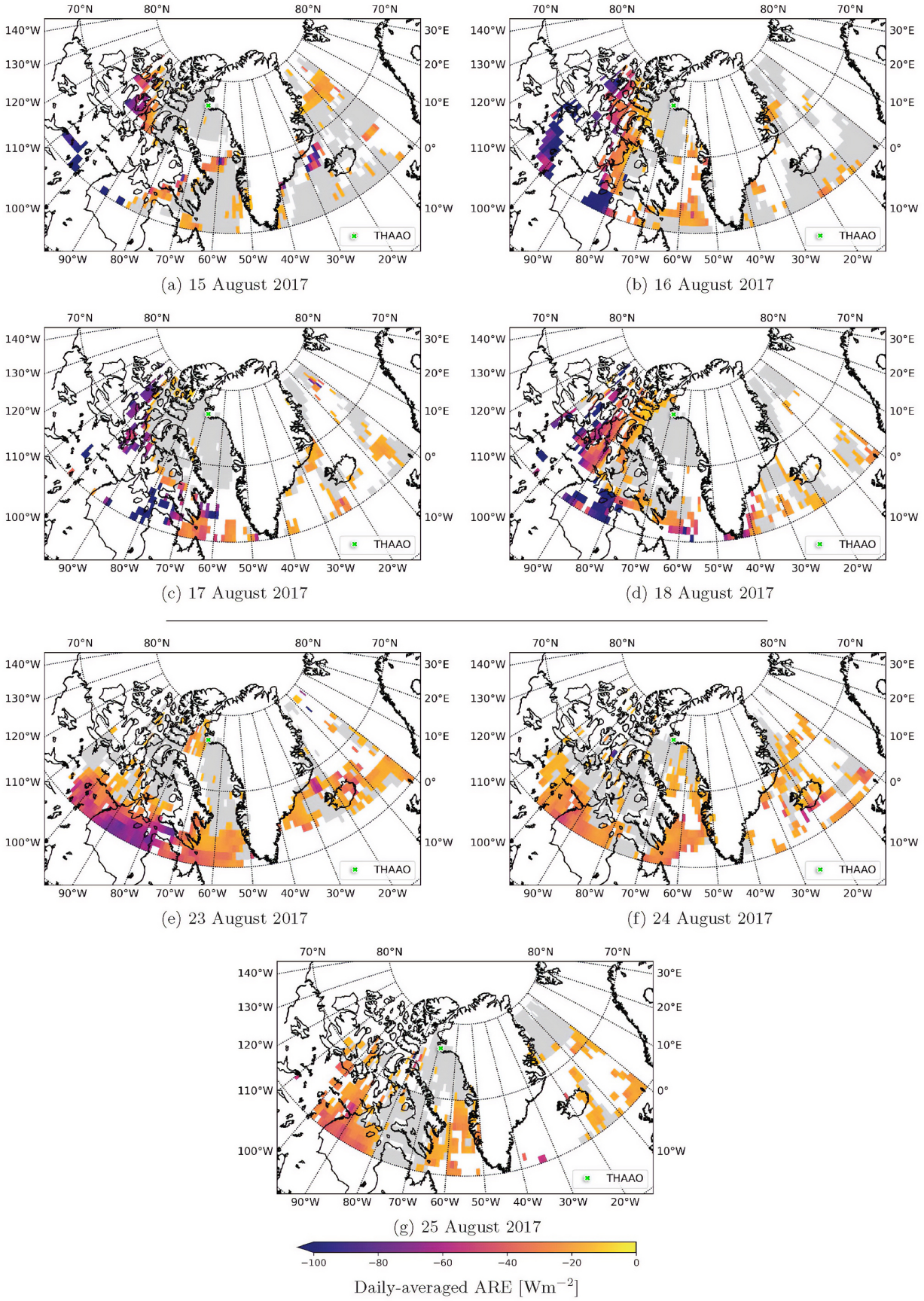


Figure S8. Daily ARE maps for 15-25 August 2017. White areas represent pixels where no MODIS AOD data were available or outside the considered domain. See text for further details.

References

1. Stein, A.F.; Draxler, R.R.; Rolph, G.D.; Stunder, B.J.; Cohen, M.D.; Ngan, F. Noaa's hysplit atmospheric transport and dispersion modeling system. *Bulletin of the American Meteorological Society* **2015**, *96*, 2059–2077. doi:10.1175/BAMS-D-14-00110.1.
2. Warner, M.S. Introduction to PySPLIT: A Python Toolkit for NOAA ARL's HYSPLIT Model. *Computing in Science & Engineering* **2018**, *20*, 47–62. doi:10.1109/MCSE.2017.3301549.
3. Kalnay, E.; Kanamitsu, M.; Kistler, R.; Collins, W.; Deaven, D.; Gandin, L.; Iredell, M.; Saha, S.; White, G.; Woollen, J.; Zhu, Y.; Leetmaa, A.; Reynolds, R.; Chelliah, M.; Ebisuzaki, W.; Higgins, W.; Janowiak, J.; Mo, K.C.; Ropelewski, C.; Wang, J.; Jenne, R.; Joseph, D. The NCEP/NCAR 40-Year Reanalysis Project. *Bulletin of the American Meteorological Society* **1996**, *77*, 437–471. doi:10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2.
4. Becagli, S.; Caiazzo, L.; Di Iorio, T.; di Sarra, A.; Meloni, D.; Muscari, G.; Pace, G.; Severi, M.; Traversi, R. New insights on metals in the Arctic aerosol in a climate changing world. *Science of The Total Environment* **2020**, *741*, 140511. doi:10.1016/j.scitotenv.2020.140511.
5. Henderson, P.; Henderson, G.M. *The Cambridge handbook of earth science data*; 2009.