

Supplementary Material: Modelling the climate and surface mass balance of polar ice sheets using RACMO2, Part 1: Greenland (1958-2016)

Brice Noël¹, Willem Jan van de Berg¹, J. Melchior van Wessem¹, Erik van Meijgaard², Dirk van As³, Jan T. M. Lenaerts⁴, Stef Lhermitte⁵, Peter Kuipers Munneke¹, C. J. P. Paul Smeets¹, Lambertus H. van Ulft², Roderik S. W. van de Wal¹, and Michiel R. van den Broeke¹

¹Institute for Marine and Atmospheric research Utrecht, University of Utrecht, Utrecht, Netherlands.

²Royal Netherlands Meteorological Institute, De Bilt, Netherlands.

³Geological Survey of Denmark and Greenland (GEUS), Copenhagen, Denmark.

⁴Department of Atmospheric and Oceanic Sciences, University of Colorado, Boulder, USA.

⁵Department of Geoscience & Remote Sensing, Delft University of Technology, Delft, Netherlands.

Correspondence to: Brice Noël (B.P.Y.Noel@uu.nl)

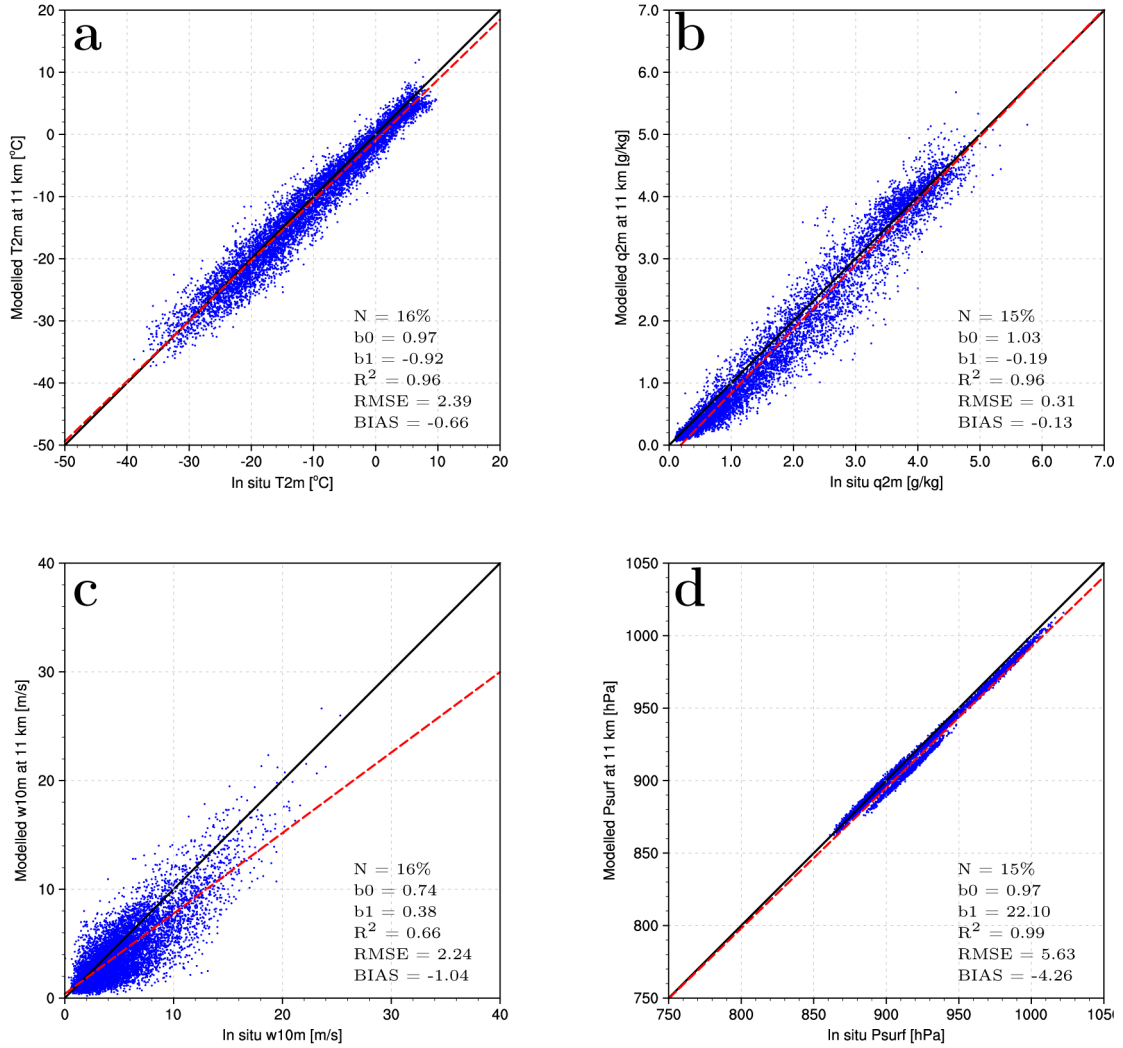


Fig. S1. North West Greenland (NW): comparison between modelled (RACMO2.3p2, 2004-2016) and observed a) 2-m temperature (T_{2m} , $^{\circ}\text{C}$), b) 2-m specific humidity (q_{2m} , g kg^{-1}), c) 10-m wind speed (w_{10m} , m s^{-1}) and d) surface pressure (Psurf , hPa) at 4 AWS located in NW Greenland (green dots in Fig. 1). For each variable, the linear regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the NW sector (N), regression slope (b_0) and intercept (b_1), determination coefficient (R^2), bias and RMSE are listed for each variable.

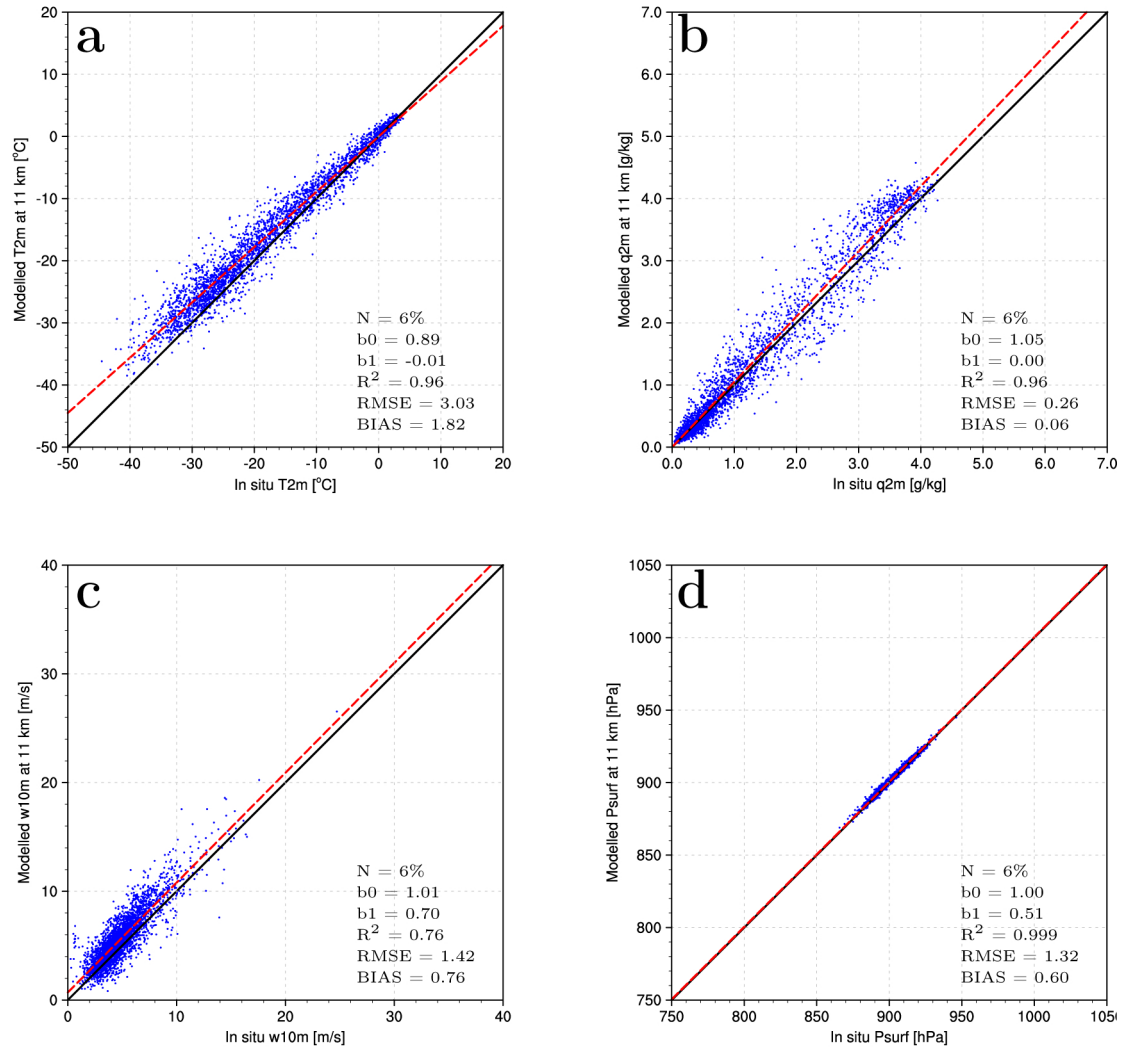


Fig. S2. North East Greenland (NE): comparison between modelled (RACMO2.3p2, 2004-2016) and observed a) 2-m temperature (T_{2m} , °C), b) 2-m specific humidity (q_{2m} , g kg⁻¹), c) 10-m wind speed (w_{10m} , m s⁻¹) and d) surface pressure (P_{surf} , hPa) at 2 AWS located in NE Greenland (green dots in Fig. 1). For each variable, the linear regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the NE sector (N), regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

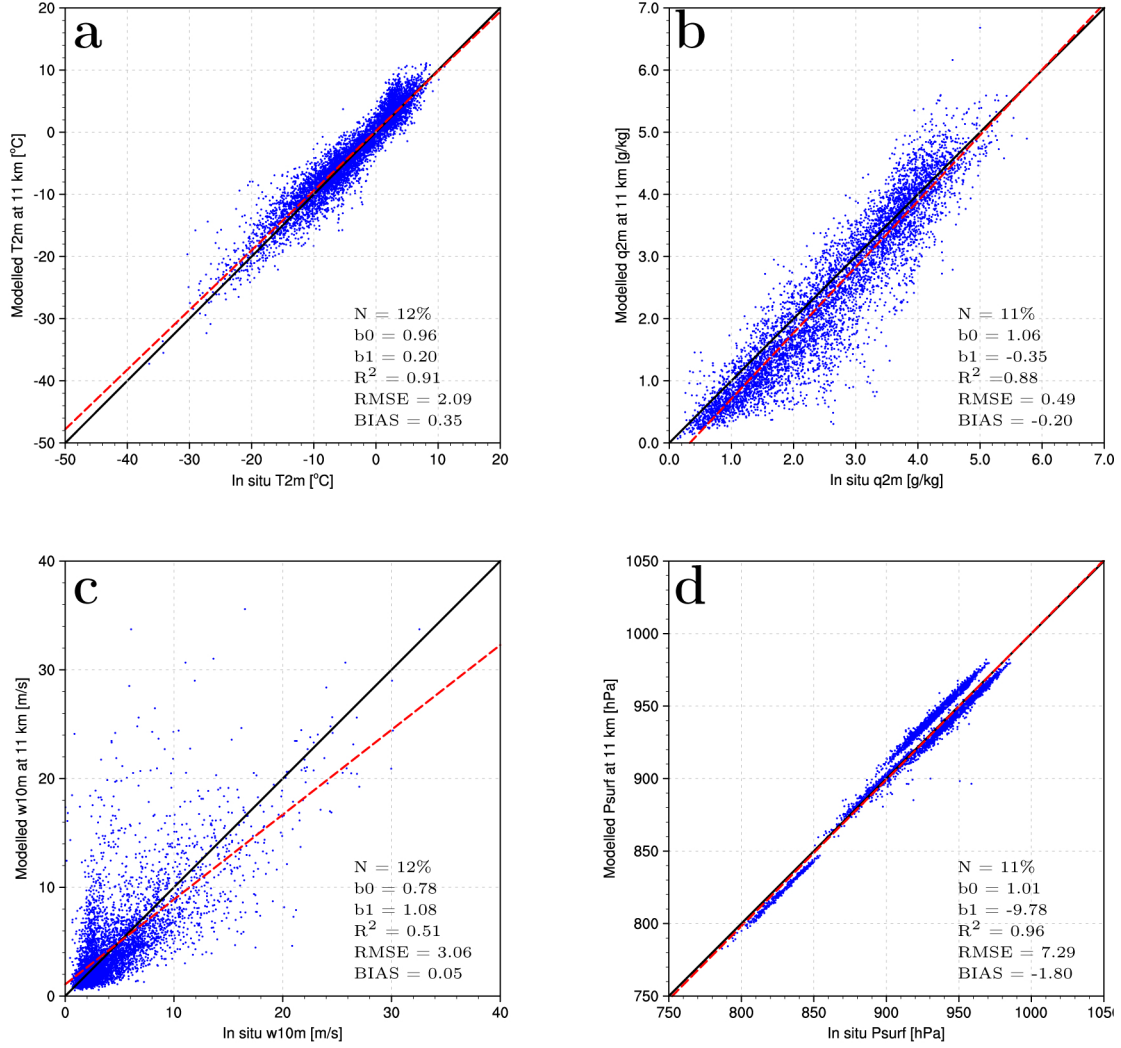


Fig. S3. South East Greenland (SE): comparison between modelled (RACMO2.3p2, 2004-2016) and observed a) 2-m temperature (T_{2m} , °C), b) 2-m specific humidity (q_{2m} , g kg^{-1}), c) 10-m wind speed (w_{10m} , m s^{-1}) and d) surface pressure (P_{surf} , hPa) collected at 4 AWS located in SE Greenland (green dots in Fig. 1). For each variable, the linear regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the SE sector (N), regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

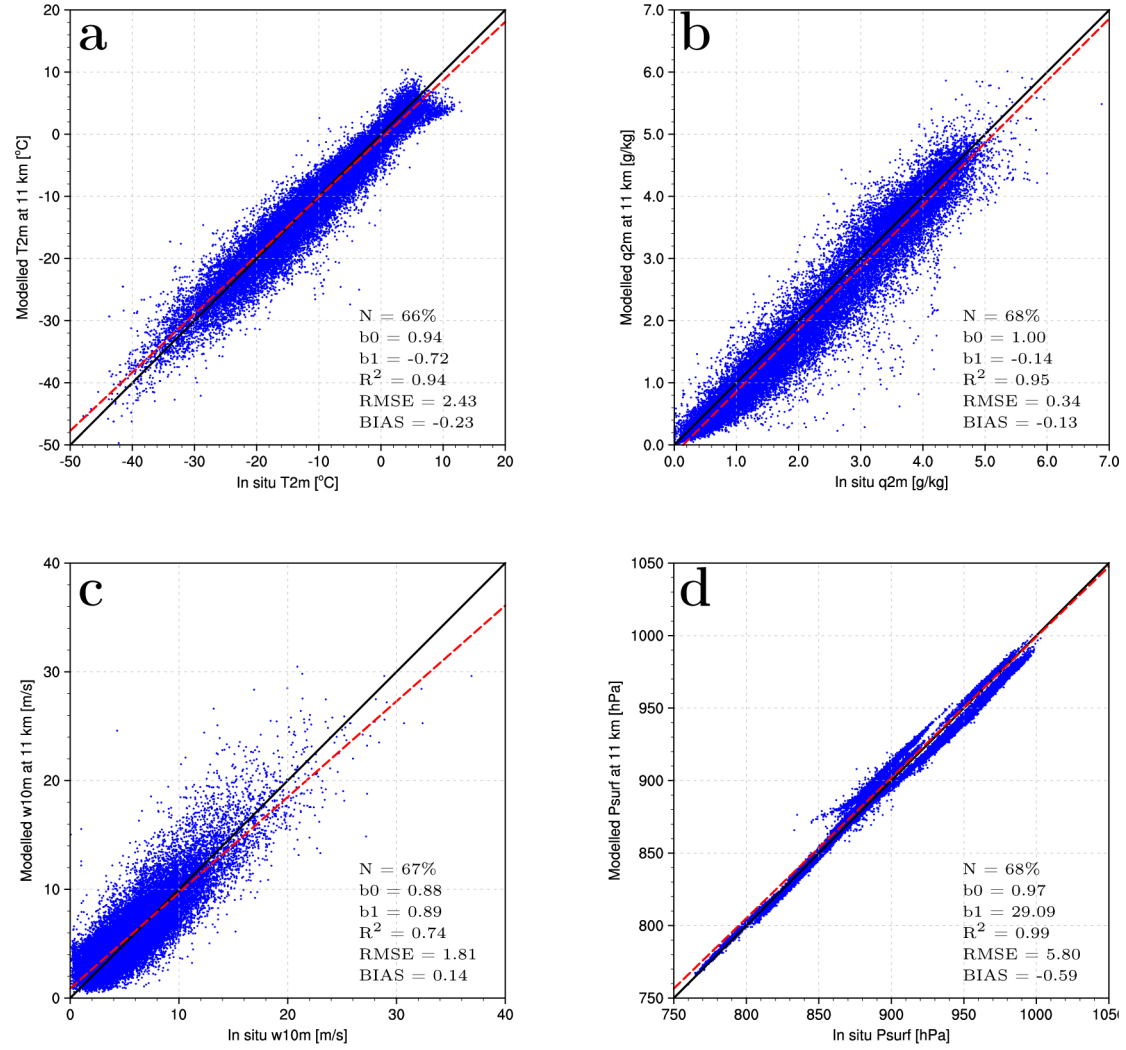


Fig. S4. South West Greenland (SW): comparison between modelled (RACMO2.3p2, 2004-2016) and observed a) 2-m temperature (T_{2m} , $^{\circ}\text{C}$), b) 2-m specific humidity (q_{2m} , g kg^{-1}), c) 10-m wind speed (w_{10m} , m s^{-1}) and d) surface pressure (P_{surf} , hPa) collected at 13 AWS located in SW Greenland (green dots in Fig. 1). For each variable, the linear regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the SW sector (N), regression slope (b_0) and intercept (b_1), determination coefficient (R^2), bias and RMSE are listed for each variable.

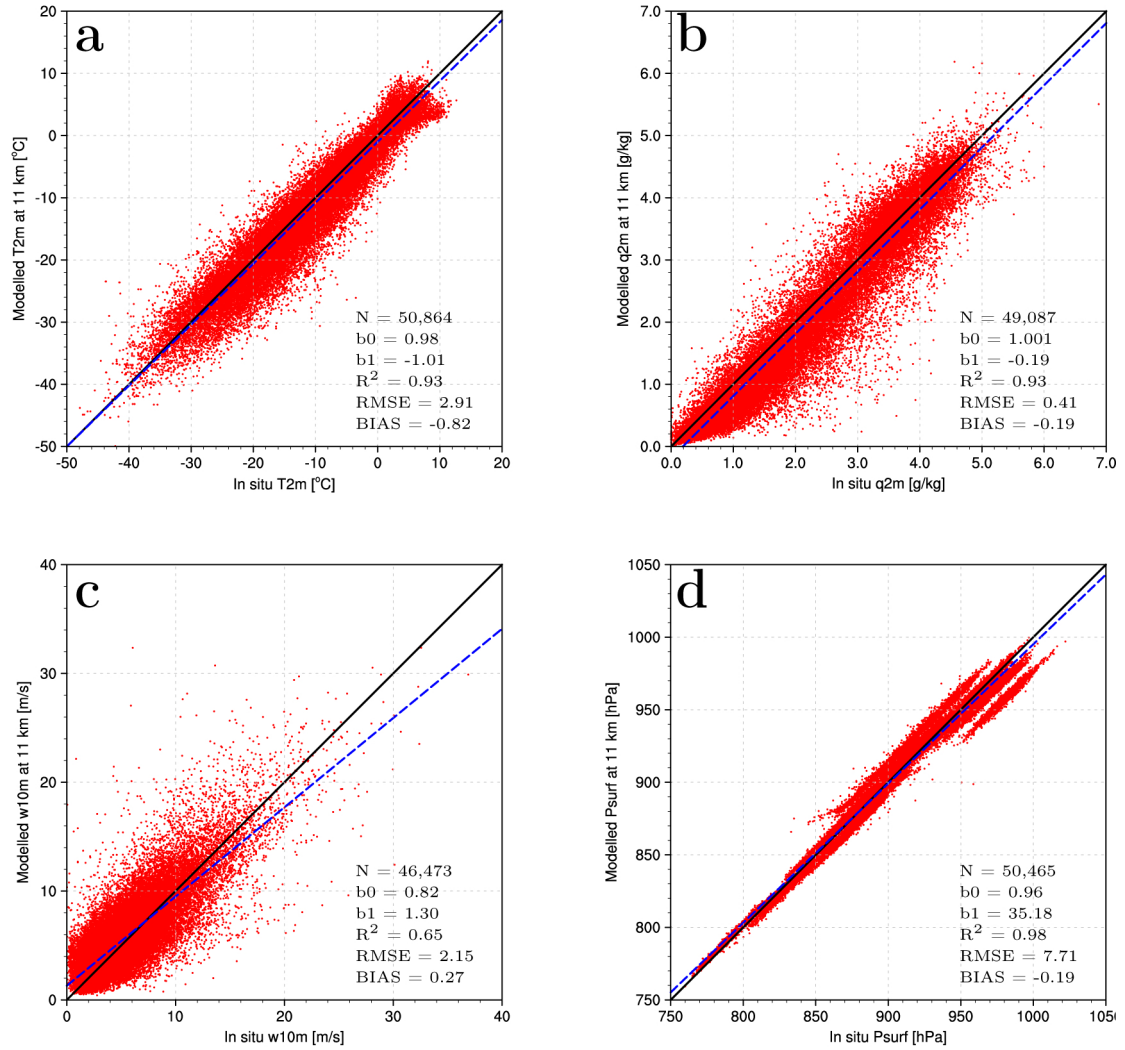


Fig. S5. Comparison between modelled (RACMO2.3p1, 2004-2015) and observed a) 2-m temperature (T_{2m} , °C), b) 2-m specific humidity (q_{2m} , g kg⁻¹), c) 10-m wind speed (w_{10m} , m s⁻¹) and d) surface pressure (P_{surf} , hPa) collected at 23 AWS (green dots in Fig. 1). For each variable, the linear regression including all records is displayed as blue dashed line. Statistics including number of records (N), regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

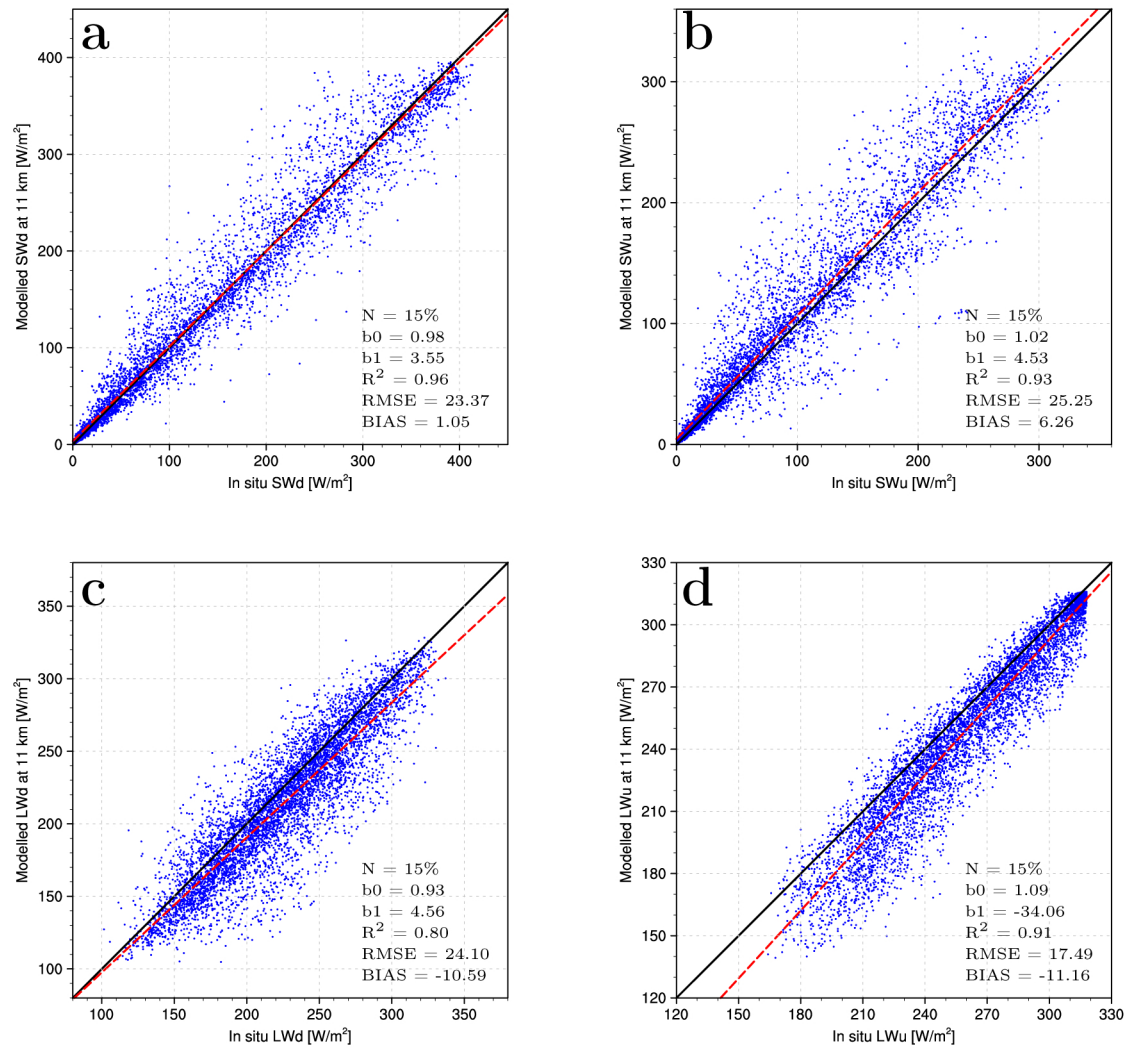


Fig. S6. North West Greenland (NW): comparison between daily average modelled (RACMO2.3p2, 2004-2016) and observed a) shortwave downward, b) shortwave upward, c) longwave downward and d) longwave upward radiation (W m^{-2}) collected at 4 AWS located in NW Greenland (green dots in Fig. 1). For each variable, regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the NW sector (N), the linear regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

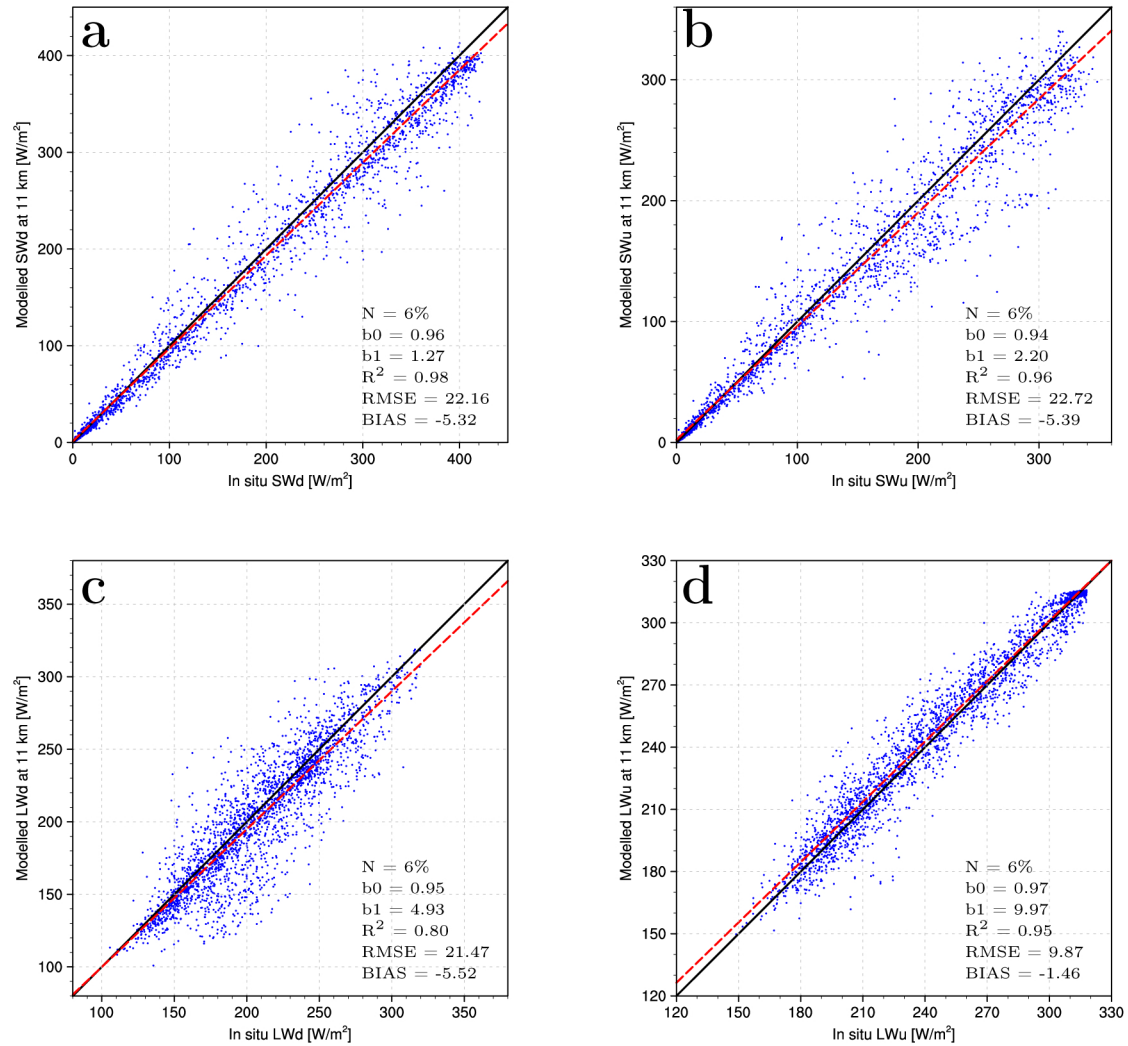


Fig. S7. North East Greenland (NE): comparison between daily average modelled (RACMO2.3p2, 2004-2016) and observed a) shortwave downward, b) shortwave upward, c) longwave downward and d) longwave upward radiation (W m^{-2}) collected at 2 AWS located in NE Greenland (green dots in Fig. 1). For each variable, regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the NE sector (N), the linear regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

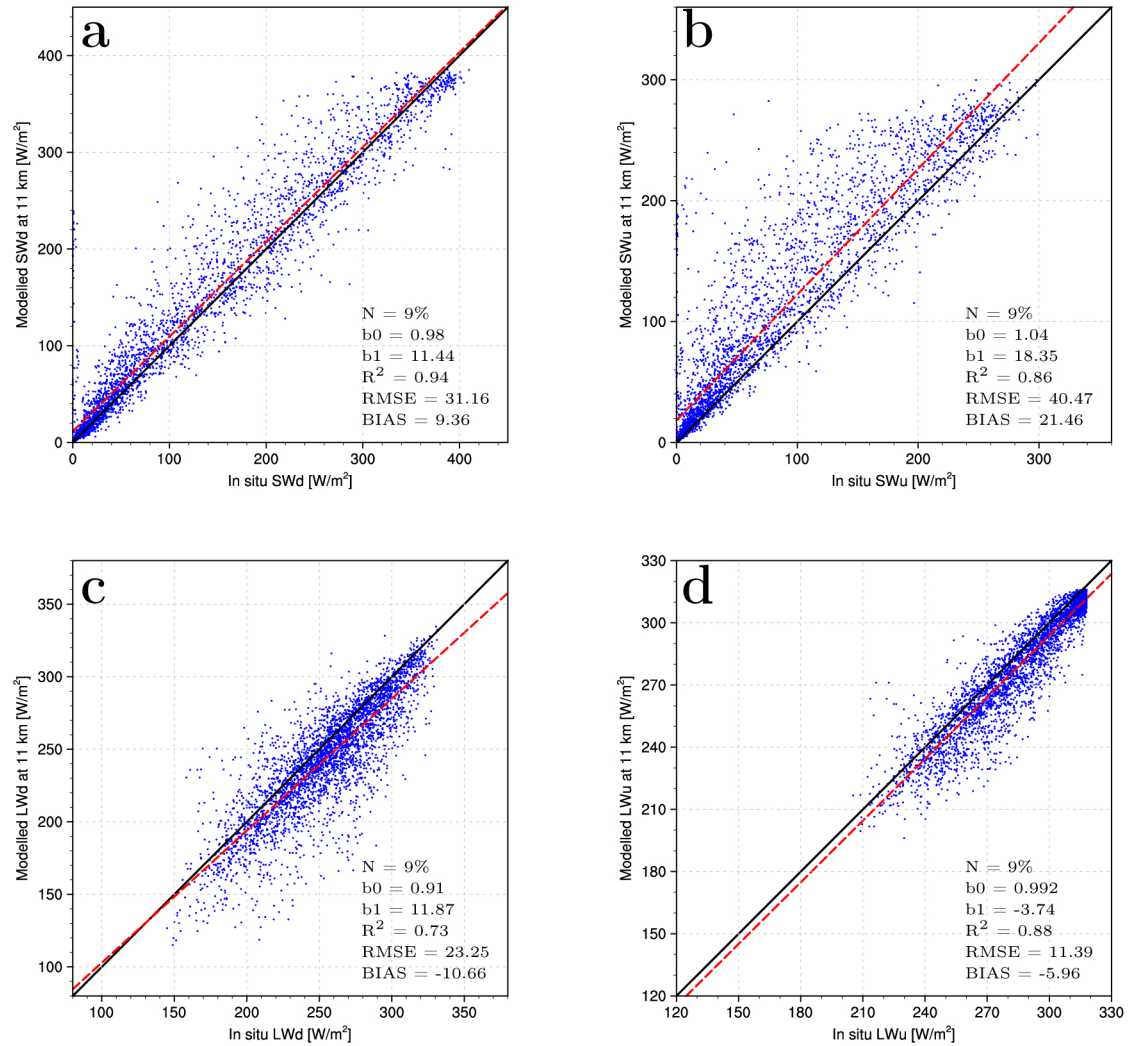


Fig. S8. South East Greenland (SE): comparison between daily average modelled (RACMO2.3p2, 2004-2016) and observed a) shortwave downward, b) shortwave upward, c) longwave downward and d) longwave upward radiation (W m^{-2}) collected at 4 AWS located in SE Greenland (green dots in Fig. 1). For each variable, regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the SE sector (N), the linear regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

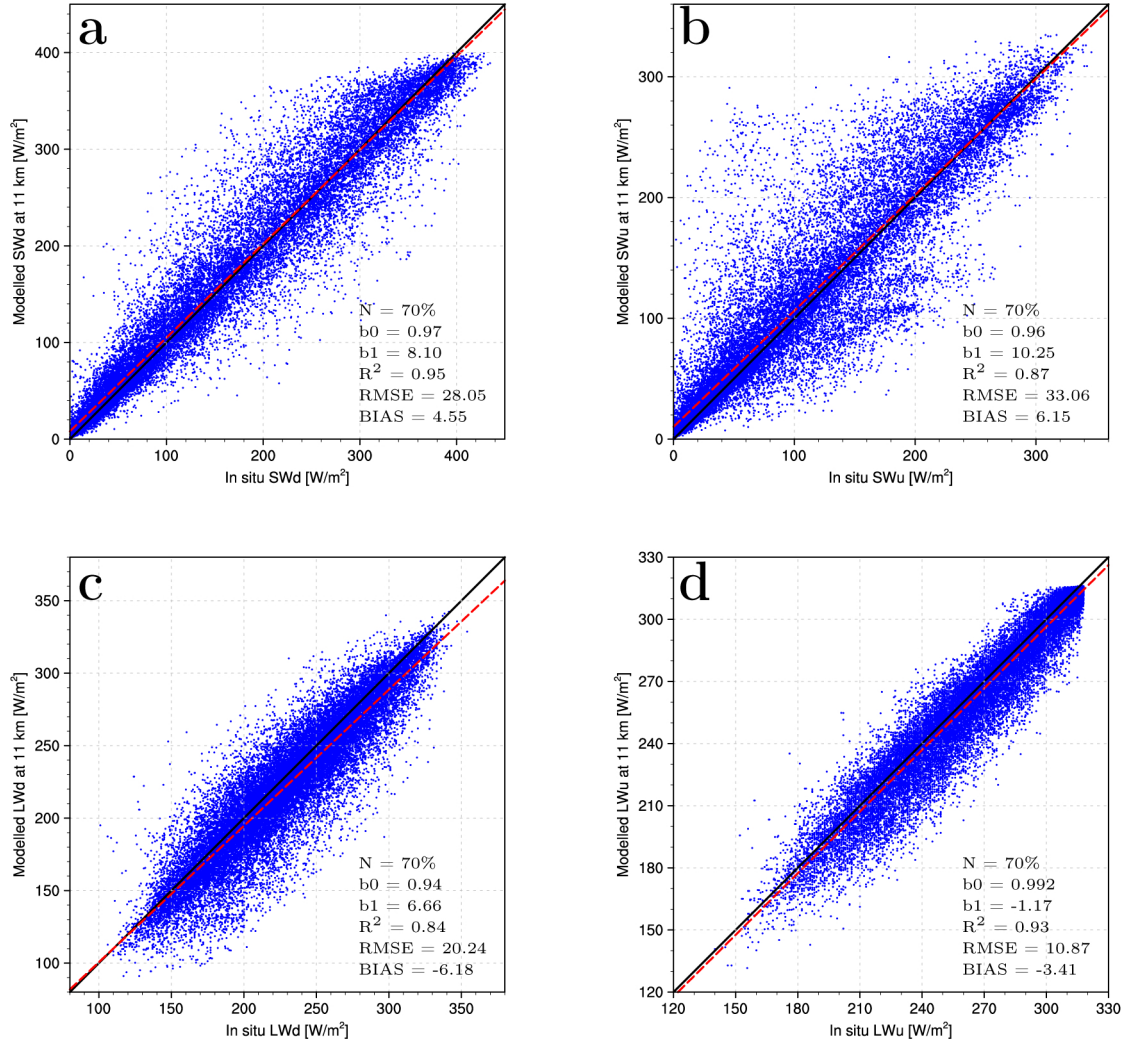


Fig. S9. South West Greenland (SW): comparison between daily average modelled (RACMO2.3p2, 2004-2016) and observed a) shortwave downward, b) shortwave upward, c) longwave downward and d) longwave upward radiation (W m^{-2}) collected at 13 AWS located in SW Greenland (green dots in Fig. 1). For each variable, regression including all records is displayed as red dashed line. Statistics including the percentage of measurements located in the SW sector (N), the linear regression slope (b_0) and intercept (b_1), determination coefficient (R^2), bias and RMSE are listed for each variable.

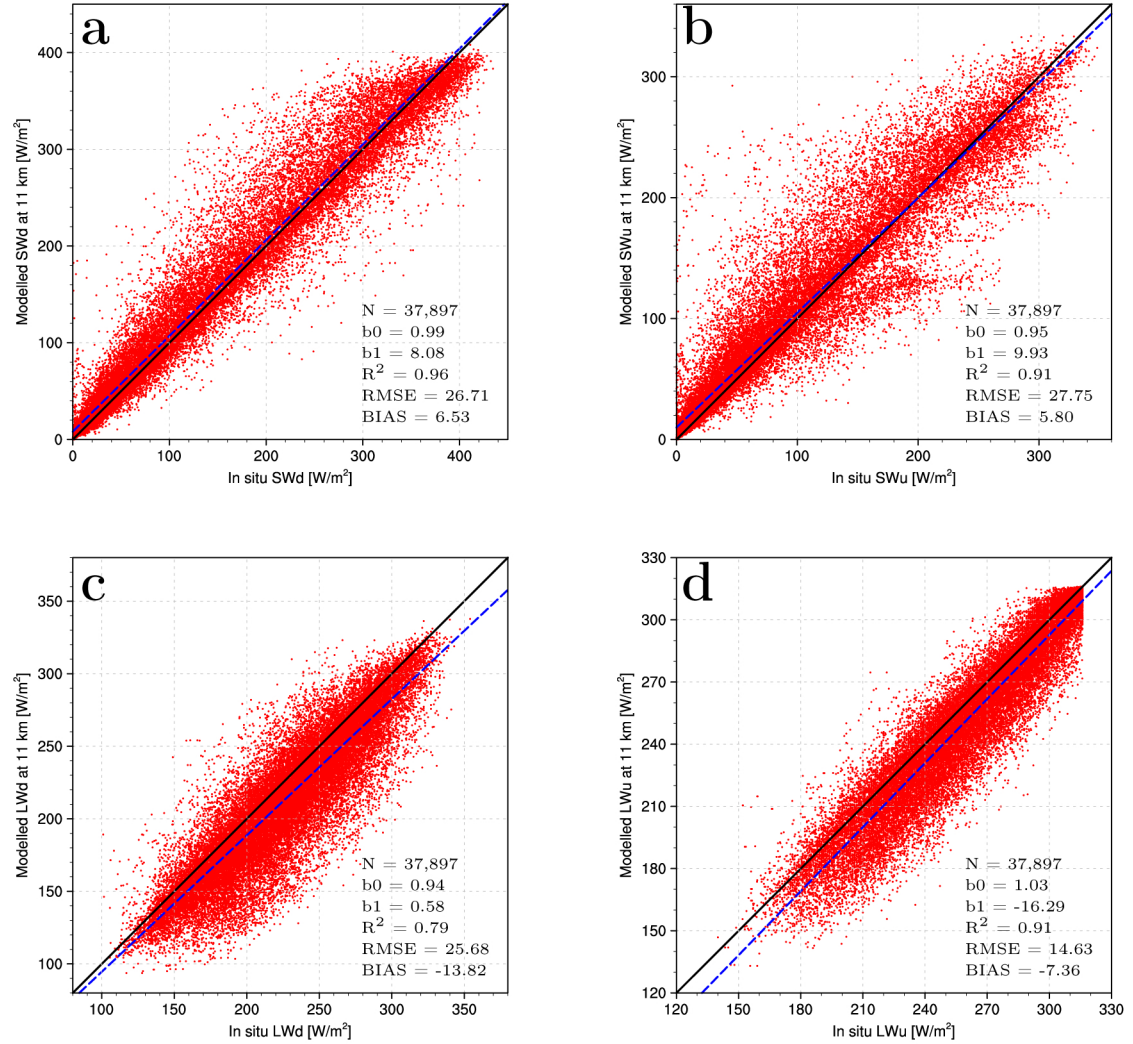


Fig. S10. Comparison between daily average modelled (RACMO2.3p1, 2004-2015) and observed a) shortwave downward, b) shortwave upward, c) longwave downward and d) longwave upward radiation (W m^{-2}) collected at 23 AWS (green dots in Fig. 1). For each variable, regression including all records is displayed as blue dashed line. Statistics including number of records (N), the linear regression slope (b0) and intercept (b1), determination coefficient (R^2), bias and RMSE are listed for each variable.

PROMICE	23 AWS	NW (4 AWS)			NE (2 AWS)			SE (4 AWS)			SW (13 AWS)		
Variable	unit	bias	RMSE	R^2	N (%)	bias	RMSE	R^2	N (%)	bias	RMSE	R^2	N (%)
T_{2m}	°C	-0.7	2.4	0.96	16	1.8	3.0	0.96	6	0.4	2.1	0.91	12
q_{2m}	g/kg	-0.1	0.3	0.96	15	0.1	0.3	0.96	6	-0.2	0.5	0.88	11
w_{10m}	m/s	-1.0	2.2	0.66	16	0.8	1.4	0.76	6	0.1	3.1	0.51	12
Psurf	hPa	-4.3	5.6	0.99	15	0.6	1.3	0.999	6	-1.8	7.3	0.96	11
SW_d	W/m^2	1.1	23.4	0.96	15	-5.3	22.2	0.98	6	9.4	31.2	0.94	9
SW_u	W/m^2	6.3	25.3	0.93	15	-5.4	22.7	0.96	6	21.5	40.5	0.86	9
LW_d	W/m^2	-10.6	24.1	0.80	15	-5.5	21.5	0.80	6	-10.7	23.3	0.73	9
LW_u	W/m^2	-11.2	17.5	0.91	15	-1.5	9.9	0.95	6	-6.0	11.4	0.88	9

Table S1. Difference between daily modelled RACMO2.3p2 (2004-2016) and observed meteorological data and SEB components collected at 23 AWS (green dots in Fig. 1) and clustered within four GrIS sectors: NW ($>40^\circ W$, $>70^\circ N$; 4 AWS), NE ($<40^\circ W$, $>70^\circ N$; 2 AWS), SE ($<40^\circ W$, $<70^\circ N$; 4 AWS) and SW ($>40^\circ W$, $<70^\circ N$; 13 AWS) Greenland. Statistics include model bias (RACMO2.3p2 - observations), RMSE of the bias, the determination coefficient of daily mean data as well as the percentage of measurements located in each GrIS sector. All fluxes are set positive.