Supplementary material of

Important role of the mid-tropospheric atmospheric circulation in the recent surface melt increase over the Greenland ice sheet

Fettweis et al., 2012

Table of Contents

1 The same as Fig. 1

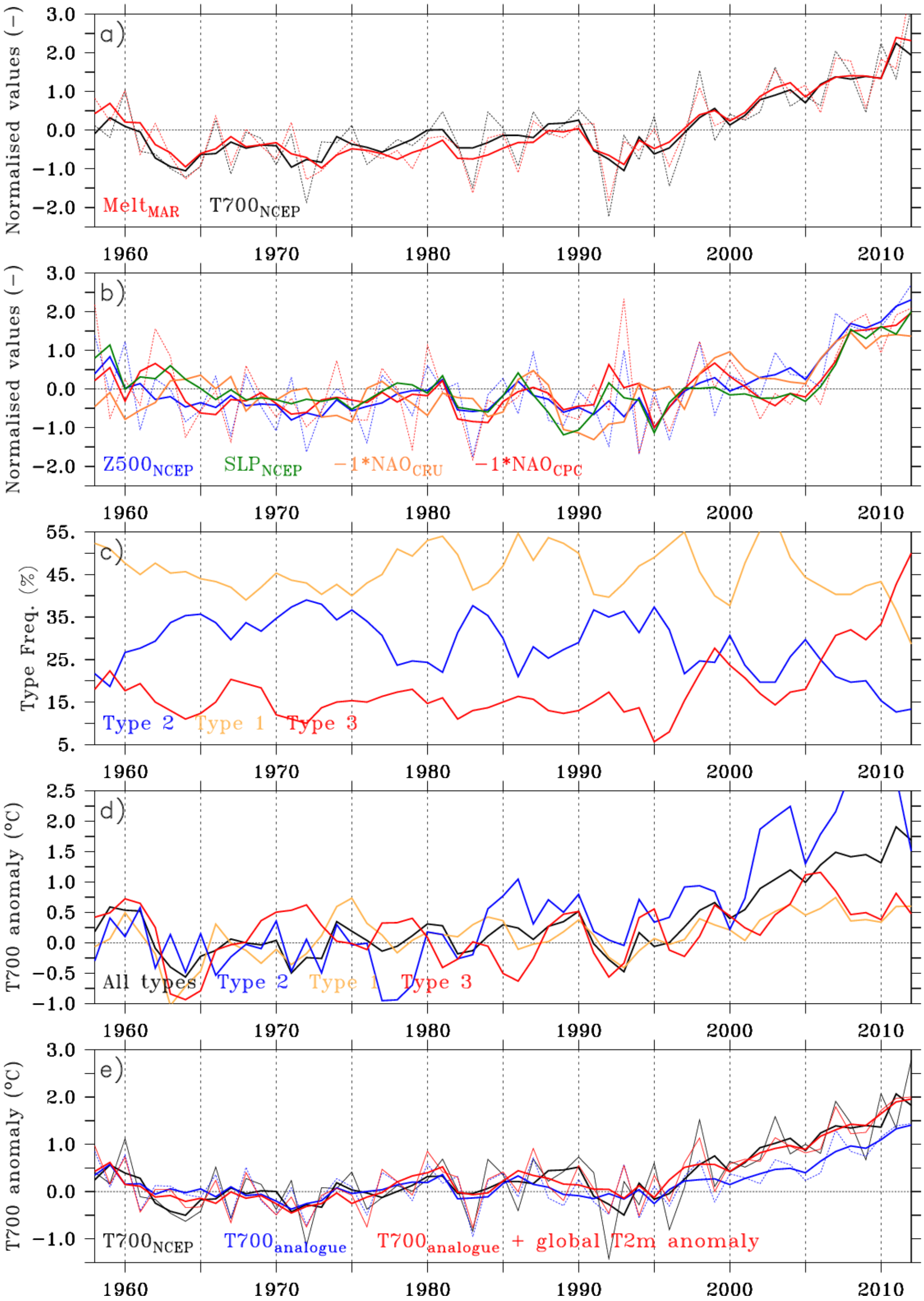


Fig. S1b: The same as Fig. 1 but using a 3-yr running for smoothing the curve.

Important role of the mid-tropospheric atmospheric circulation in the recent surface melt increase over the Greenland ice sheet

Fettweis et al., 2012

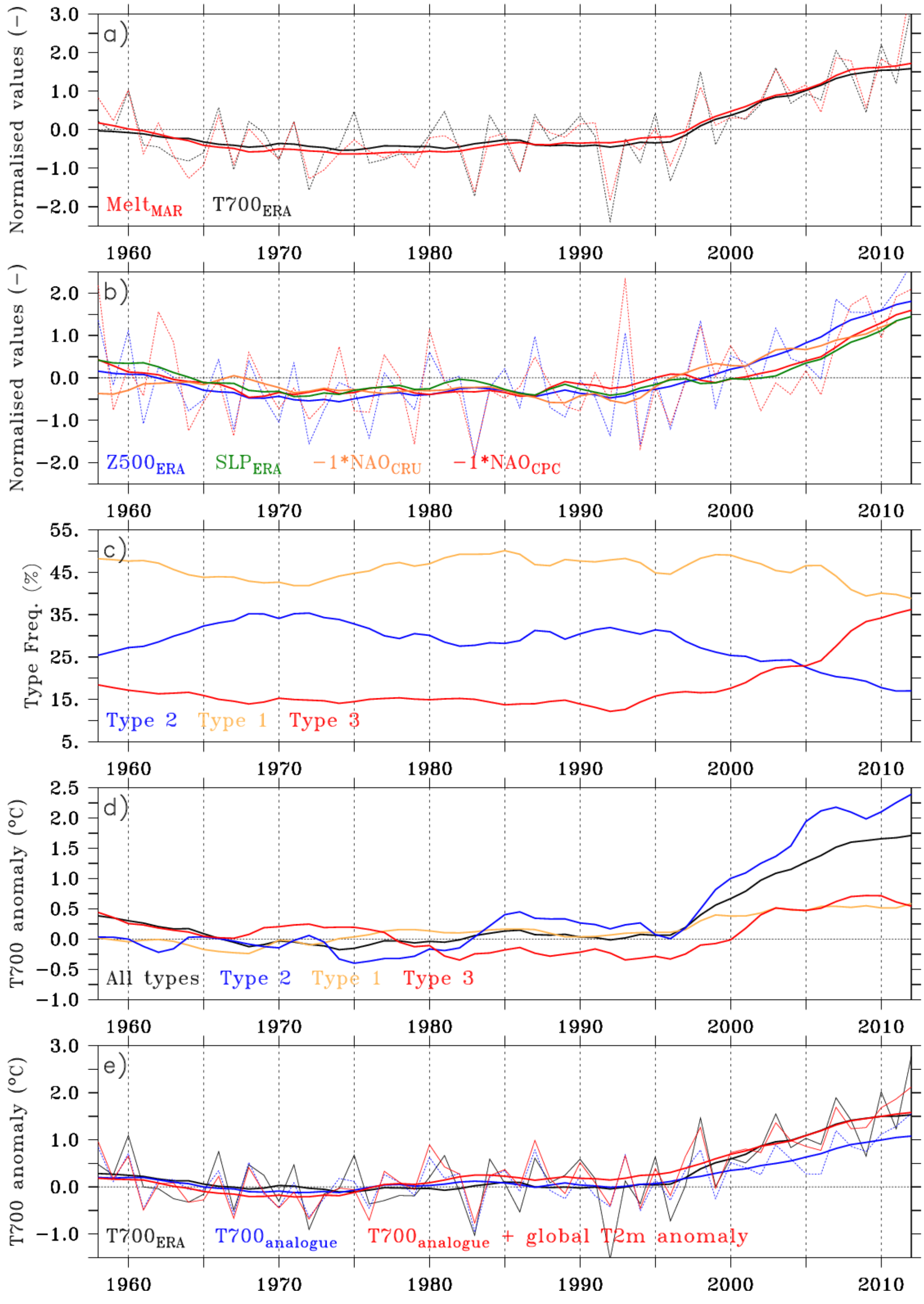


Fig. S1a: The same as Fig. 1 but using the ECMWF reanalysis.

2 The same as Fig. 2

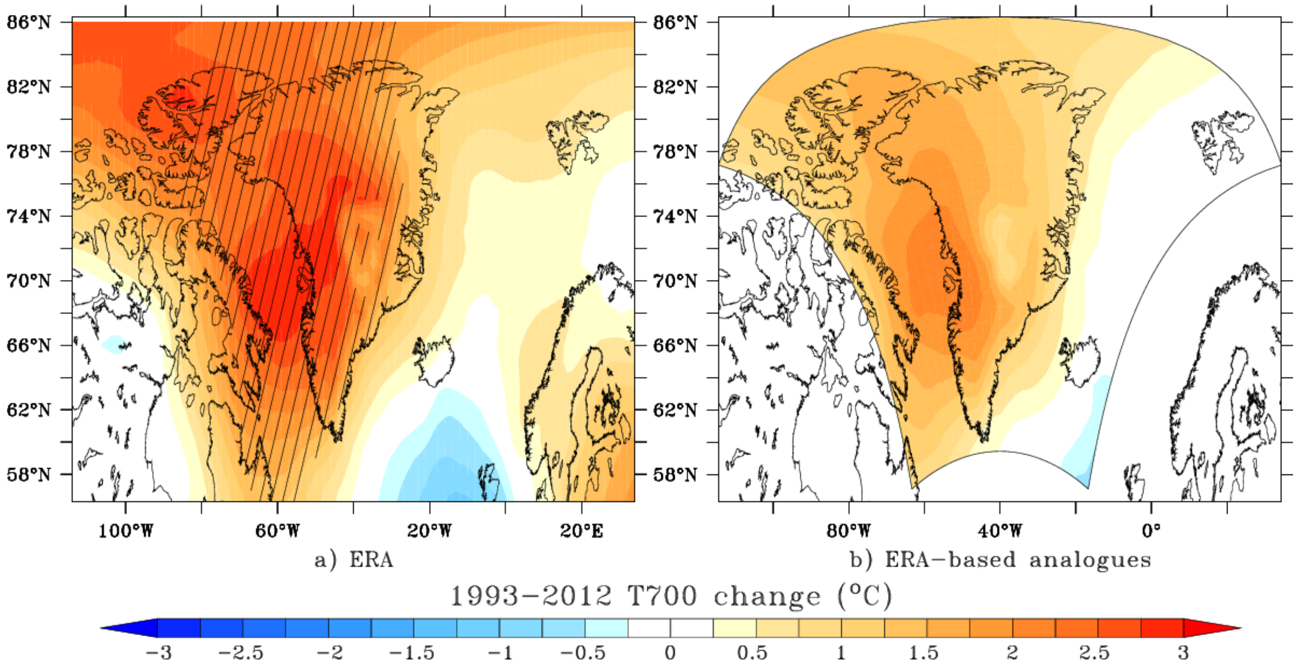


Fig. S2: The same as Fig. 2 but by using the ERA-INTERIM reanalysis.

3 The same as Fig. 3

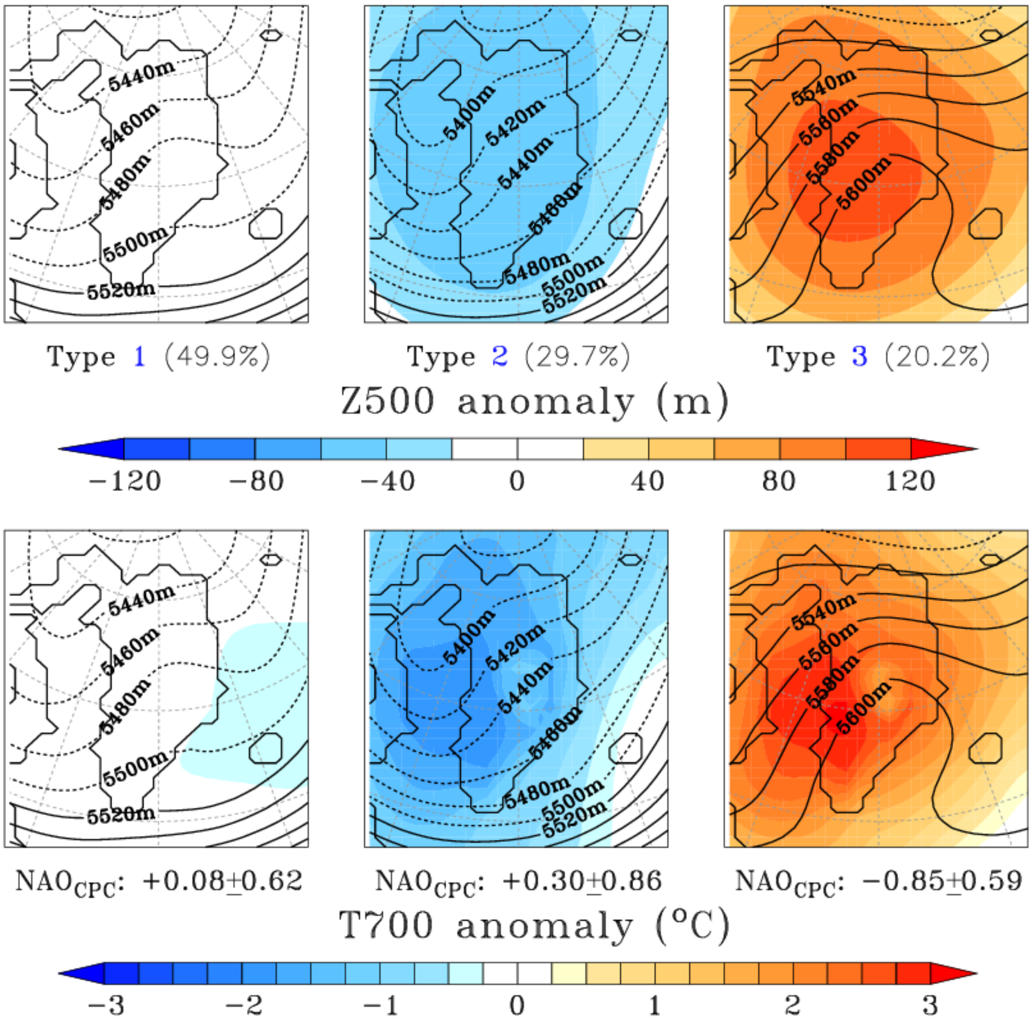


Fig. S3: The same as Fig. 3 but by using the ECMWF reanalysis (ERA-40 over 1958-1978 and ERA-INTERIM over 1979-2012).

4 SLP based CTC

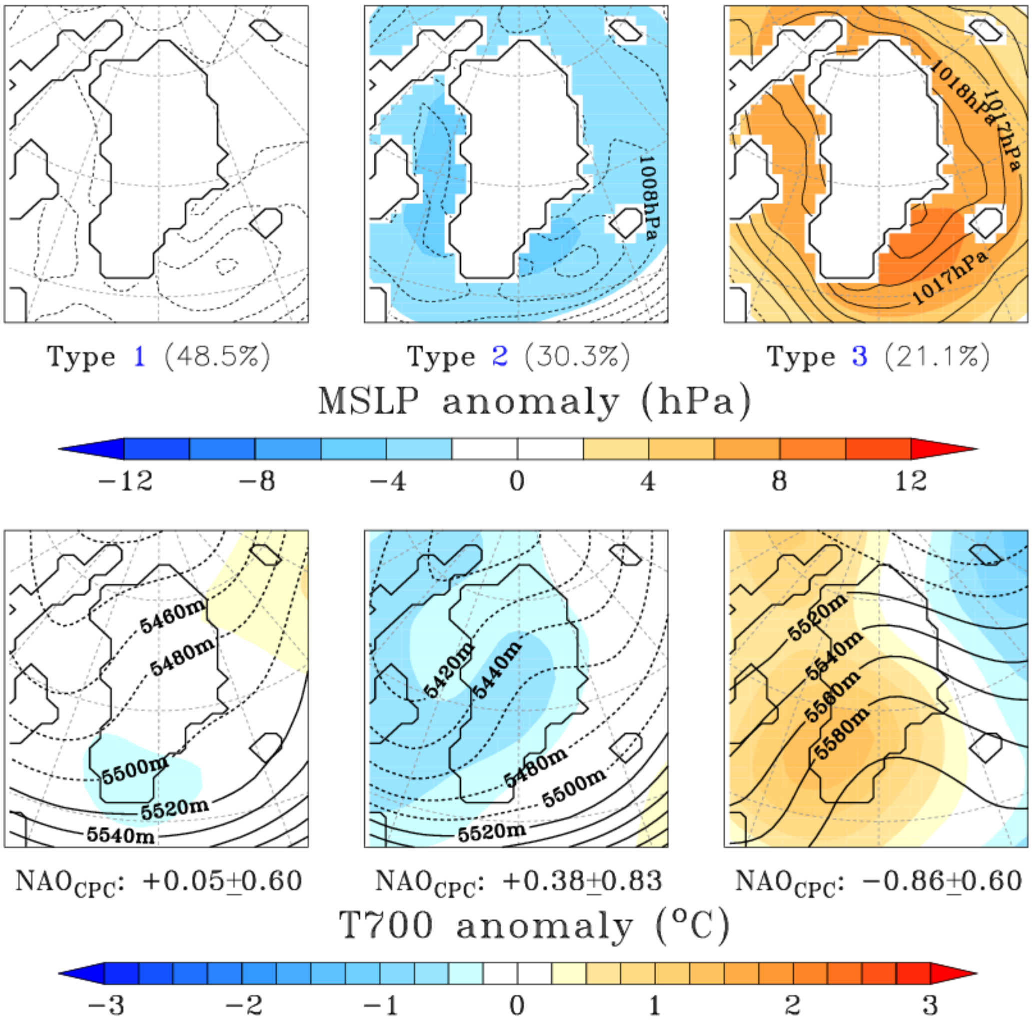


Fig. S4a: The same as Fig. 3 but by using the same CTC with a similarity index based on SLP from the NCEP-NCAR reanalysis instead on Z500. The top figures shows the SLP anomalies in respect to the JJA SLP mean over 1958-2012 as well as the isobars for each classes. The corresponding T700 and Z500 are shown bellow.

Important role of the mid-tropospheric atmospheric circulation in the recent surface melt increase over the Greenland ice sheet

Fettweis et al., 2012

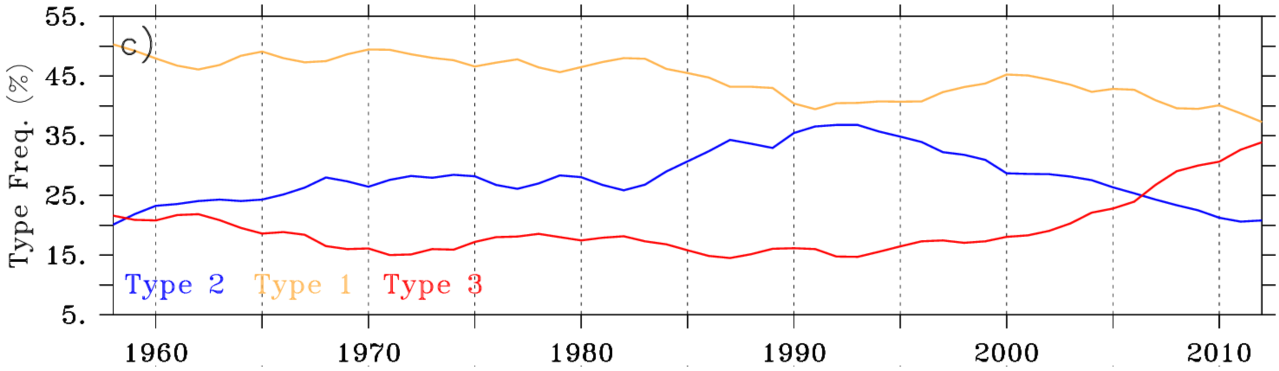
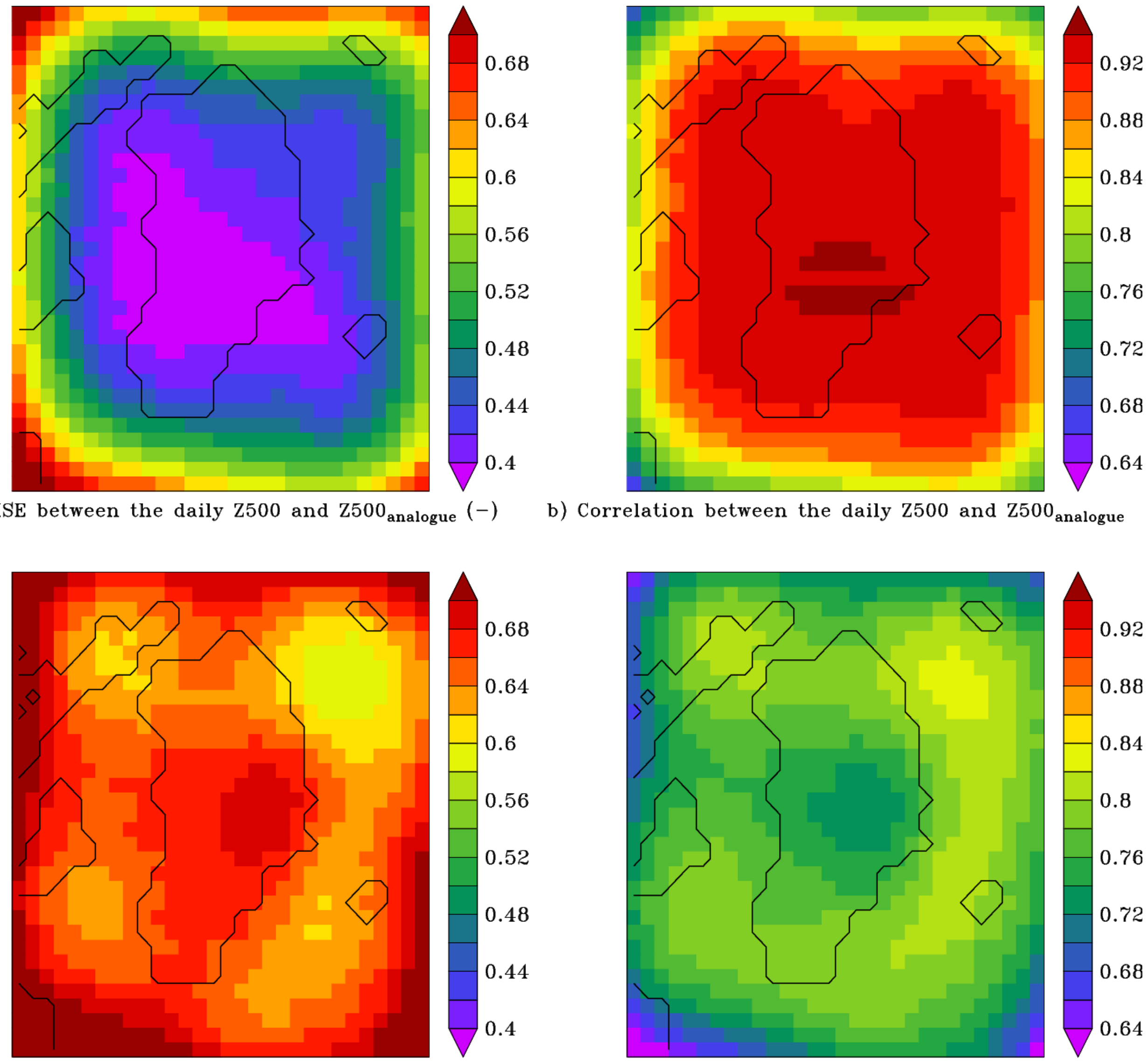


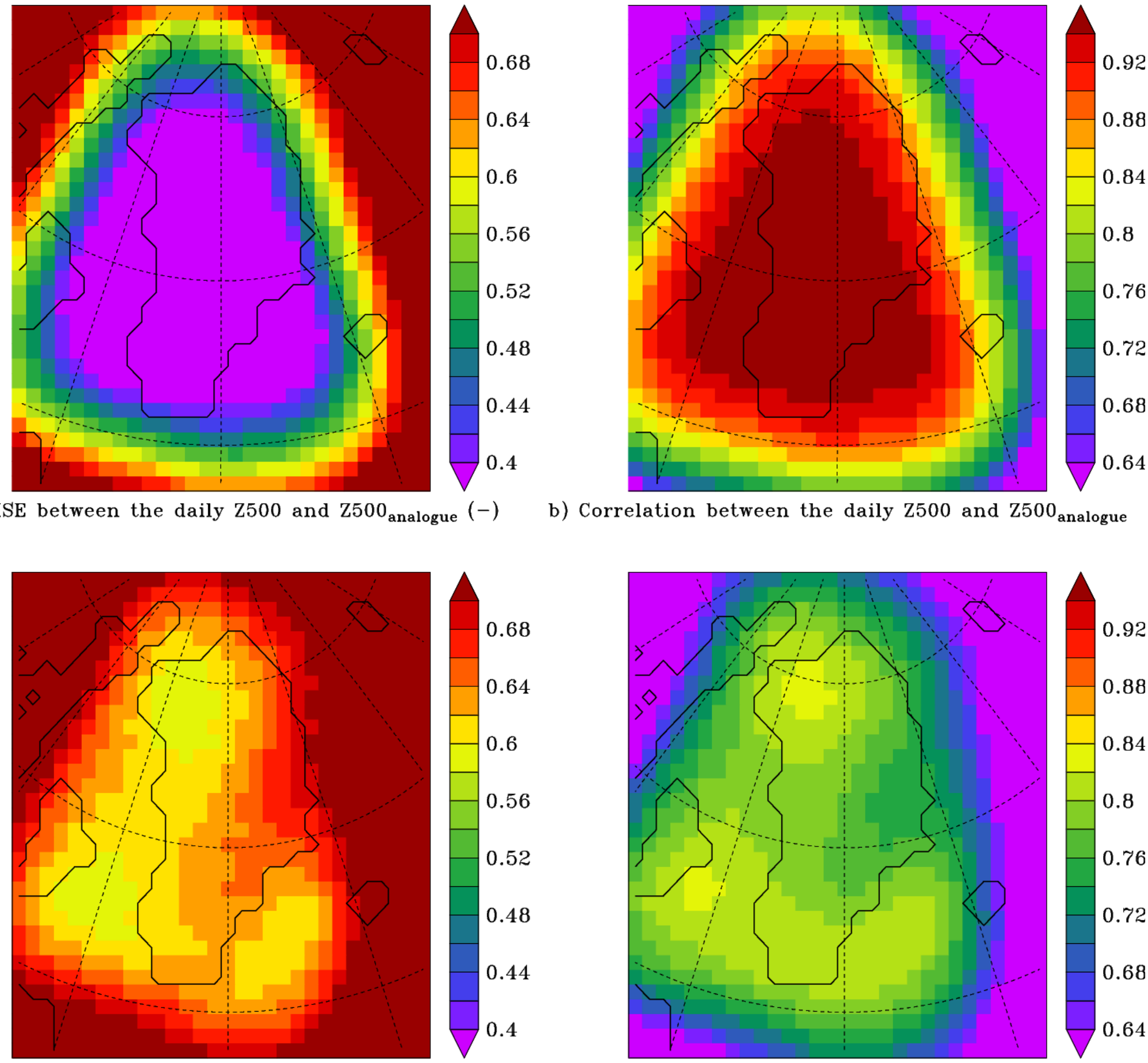
Fig. S4b: The same as Fig. 1C but for the SLP-based CTC.

5 Comparison between Z500/T700 and analogue based Z500/T700



a) RMSE between the daily Z500 and $Z500_{analogue}$ (−)
b) Correlation between the daily Z500 and $Z500_{analogue}$
c) RMSE between the daily T700 and $T700_{analogue}$ (−)
d) Correlation between the daily T700 and $T700_{analogue}$

Fig. S5: a) RMSE of the Z500 analogue surface for each day of the summers 1993-2012 (20 yrs x 92 days = 1840 days) in respect to the corresponding daily Z500 surface. The RMSE is normalised here by the standard deviation of the daily Z500 surfaces over the summers 1993-2012. b) Correlation coefficient between the daily Z500 analogue surface and the corresponding daily Z500 surface. c) Same as a) but for T700. d) Same as b) but for T700.



a) RMSE between the daily Z500 and $Z500_{analogue}$ (−) b) Correlation between the daily Z500 and $Z500_{analogue}$

c) RMSE between the daily T700 and $T700_{analogue}$ (−) d) Correlation between the daily T700 and $T700_{analogue}$

Fig. S5b: The same as Fig. S5a but with a similarity index (used to find analogues) computed only over the area covering Greenland (lon: 70°W-20°W; lat: 60°N-85°N).

6 Sensitivity of parameters in our analogue flow method

Tables S1: Sensitivity of the parameters in the analogue flow method.

	R_{Z500}	$RMSE_{Z500}$	R_{T700}	$RMSE_{T700}$	$Trend_{1993-2012}$	$Trend_{1983-2012}$
CTRL run	0.99	13.2	0.86	1.28	70%	67%
40-day windows instead of 30-day	0.99	11.7	0.85	1.29	74%	72%
20-day windows instead of 30-day	0.99	15.3	0.86	1.27	67%	64%
15 years instead of 10 years	0.99	15.5	0.86	1.28	68%	65%
5 years instead of 10 years	0.99	13	0.84	1.29	69%	68%
daily anomaly instead of raw value	0.97	18.5	0.85	1.3	61%	57%
average instead of median	0.99	13.5	0.86	1.32	67%	65%
1958-2012 as reference period instead of 1961-1990	0.99	10.3	0.86	1.21	71%	69%
ECMWF reanalysis instead of NCEP-NCAR	0.99	13.2	0.86	1.25	64%	60%

where R_{Z500} (resp. $RMSE_{Z500}$) is the average correlation (resp. RMSE) over the area covering the GrIS of the daily Z500 surfaces and the analogues based one over 1993-2012 and $Trend_{1993-2012}$ is the percentage of the T700 1993-2012 trend over the area covering the GrIS resolved by the analogues based one.

7 Evaluation of the CMIP5 based JJA NAO index

The table below lists the min and max JJA NAO index over 1961-1990 from NCEP-NCAR and simulated by 28 GCMs from the CMIP5 database. The min/max is given in normalised value (i.e. divided by the standard deviation over 1961-1990) as well as in hPa. The average and standard deviation (inter-annual variability) of the JJA NAO index over 1961-1990 are also given in hPa. The JJA NAO index is defined here as the JJA sea level pressure difference between the Azores (27 °W, 39 °N) and south-west Iceland (22 °W, 64 °N).

	JJA NAO index over 1961-1990					
	Max	Min	Max	Min	Ave	Std. Dev.
	Normalised by the standard deviation		in hPa			
NCEP-NCAR v1	**1.88**	**-2.29**	**5.03**	**-6.14**	**13.95**	**2.68**
ACCESS1-0	2.16	-1.49	6.12	-4.23	11.18	2.84
ACCESS1-3	1.83	-2.63	6.92	-9.93	12.68	3.78
BCC-CSM1-1	2.14	-1.69	5.59	-4.41	14.08	2.61
BNU-ESM	1.85	-2.04	5.68	-6.26	14.37	3.07
CanESM2	1.71	-1.73	3.62	-3.65	16.11	2.11
CCSM4	1.85	-2.07	4.88	-5.46	15.68	2.64
CESM1-BGC	2.03	-2.41	5.77	-6.86	15.99	2.84
CMCC-CM	1.71	-2.51	5.17	-7.59	11.90	3.02
CNRM-CM5	1.95	-1.89	6.68	-6.49	9.81	3.43
CSIRO-Mk3-6-0	1.98	-2.20	4.76	-5.28	12.58	2.40
FGOALS-s2	2.41	-1.47	6.84	-4.18	9.48	2.84
FIO-ESM	1.89	-2.75	6.09	-8.88	10.87	3.23
GFDL-CM3	1.66	-2.01	5.42	-6.59	13.24	3.28
GFDL-ESM2M	1.84	-2.05	5.81	-6.48	11.59	3.17
GISS-E2-R	2.45	-1.61	5.74	-3.76	7.78	2.34
HadGEM2-AO	1.92	-1.80	5.25	-4.90	12.43	2.73
HadGEM2-CC	1.75	-2.73	4.55	-7.12	11.96	2.61
HadGEM2-ES	1.80	-2.89	4.43	-7.13	11.65	2.47
INMCM4	2.01	-1.41	5.20	-3.64	9.18	2.59
IPSL-CM5A-MR	3.00	-1.49	7.04	-3.50	10.79	2.35
IPSL-CM5B-LR	2.16	-2.03	5.43	-5.10	2.67	2.52
MIROC5	1.90	-2.17	5.65	-6.47	12.06	2.98
MIROC-ESM-CHEM	2.18	-1.80	5.78	-4.77	9.77	2.65
MIROC-ESM	3.06	-1.94	7.73	-4.91	10.77	2.53
MPI-ESM-LR	1.68	-2.19	4.54	-5.91	14.83	2.70
MPI-ESM-MR	2.32	-2.09	5.88	-5.28	14.81	2.53
MRI-CGCM3	1.96	-1.88	7.09	-6.80	8.20	3.61
NorESM1-M	2.09	-1.68	5.57	-4.49	13.54	2.67
CMIP5 mean	***2.05***	***-2.02***	***5.69***	***-5.72***	***11.79***	***2.80***

Tables S2: List of the 28 CMIP5 models used for Fig. 4 as well as some NAO stastistics over current climate. The model plotted in black in Fig. 4 is BNU-ESM (RCP 8.5 scenario)

As we can see, most of GCMs are able to simulate the inter-annual variability of the NAO index over 1961-1990 as well as extreme negative values similar to the one derived from the NCEP-NCAR reanalysis v1 over 1961-1990. Therefore, we can conclude that most of them are able to simulate such negative NAO values as those currently observed (~ -2 for the normalised NAO) but they fail to simulate the current succession of summers with negative JJA NAO values.

For the evaluation of the CMIP5 GCMs over current climate by using our CTC, we refer to Belleflamme et al. (2012)[1].

1 Belleflamme A., Fettweis X., Lang C. and Erpicum M: Current and future atmospheric circulation at 500 hPa over Greenland simulated by the CMIP3 and CMIP5 global models. Climate Dynamics, doi: 10.1007/s00382-012-1538-2, 2012. http://www.springerlink.com/content/m765331048634740/