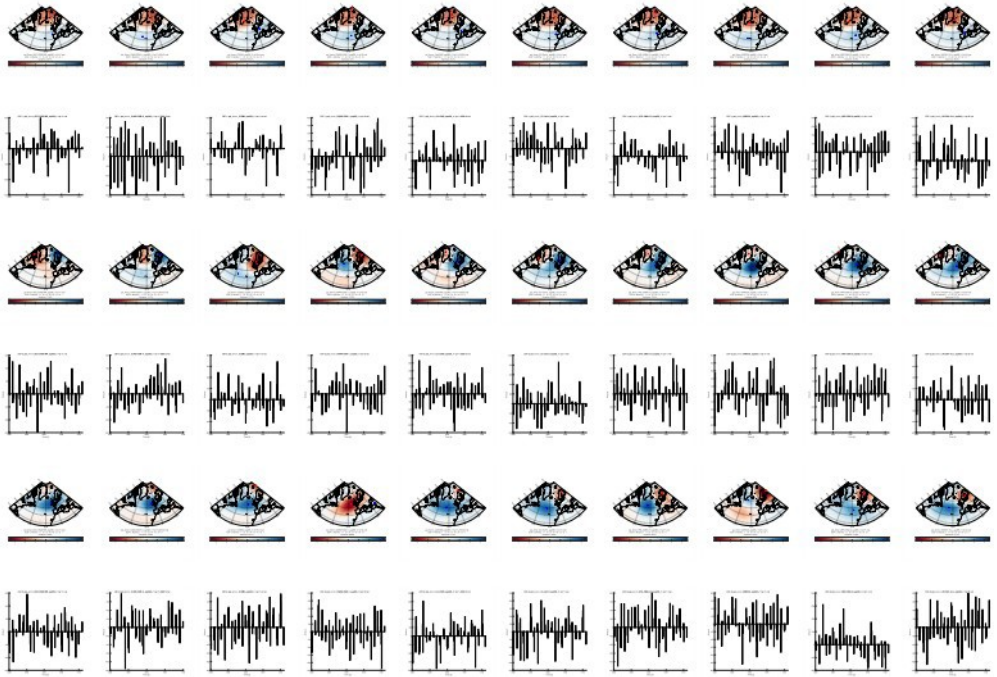
Selecting CMIP6 models for dynamical downscaling: The case of the NAO



Florian Sauerland, Susann Aschenneller (University of Bonn)

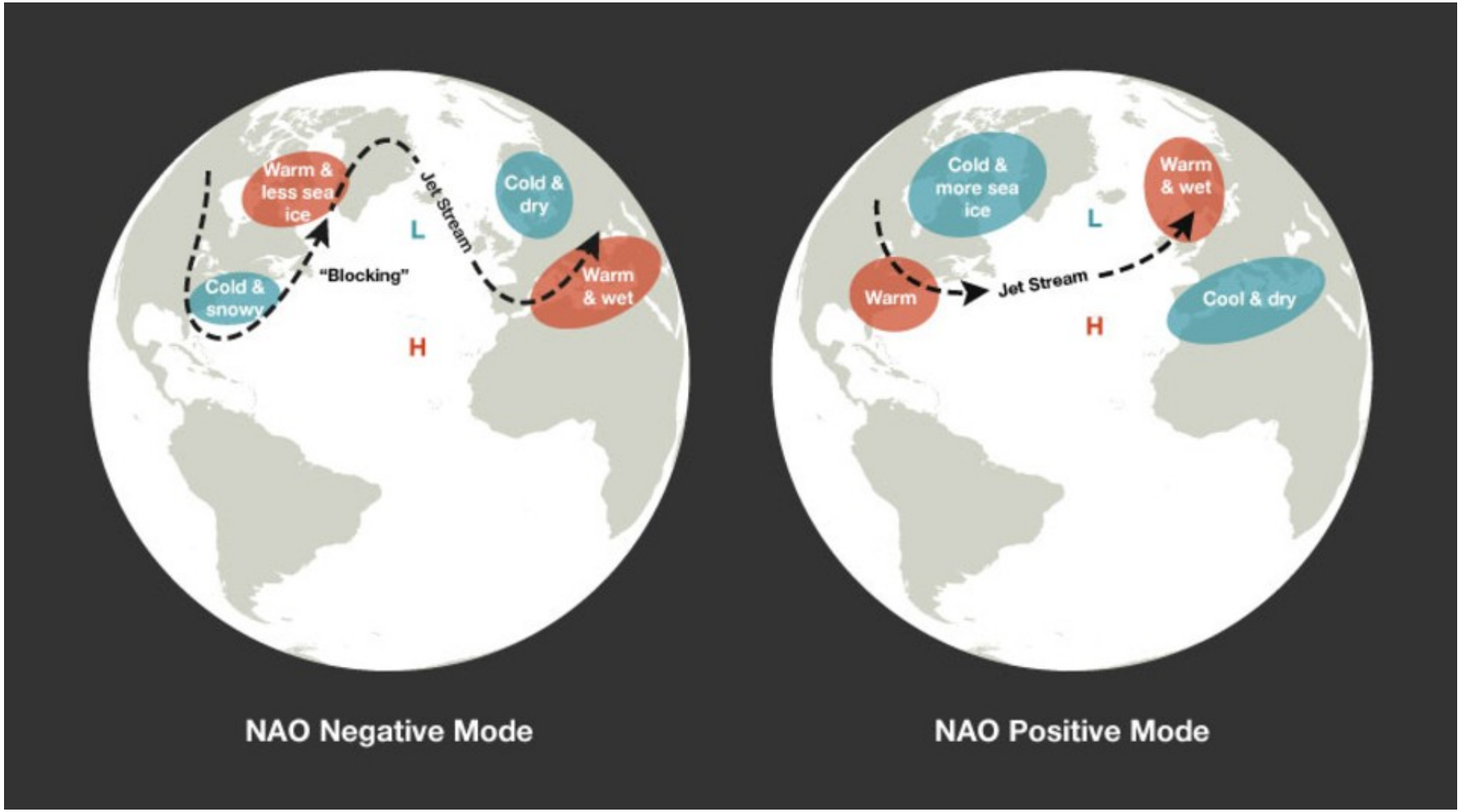
Ruth Mottram (Danish Meteorological Institute)

The challenge of CMIP6

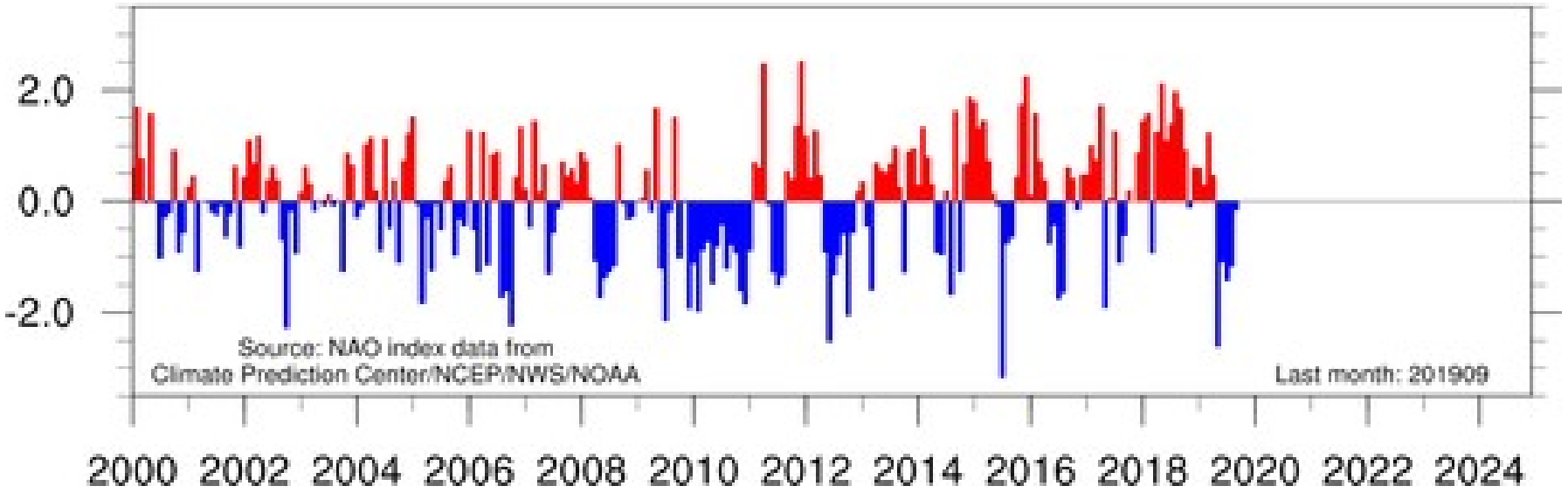
	CMIP 1996 -	CMIP2 1997 -	CMIP3 (2005-2006)	CMIP5 (2010-2011)	CMIP6 (2017-2020)
Number of experiments	**1**	**2**	**12**	**33**	287
Experiment description	present-day ctrl	pd-ctrl & 1pctCO2	Ctrl & 20C & 21C-SRES & AMIP & idealized CO2	Near- and long-term, core + tier 1 + tier 2	DECK + historical run & 23 MIPs
Centres participating	16	18	17	31	42
# of distinct models	**19**	**24**	**25**	**59**	109
Total data size	1 GB	500 GB	40 TB	2-3 PB	10-50 PB

courtesy Shuting Yang

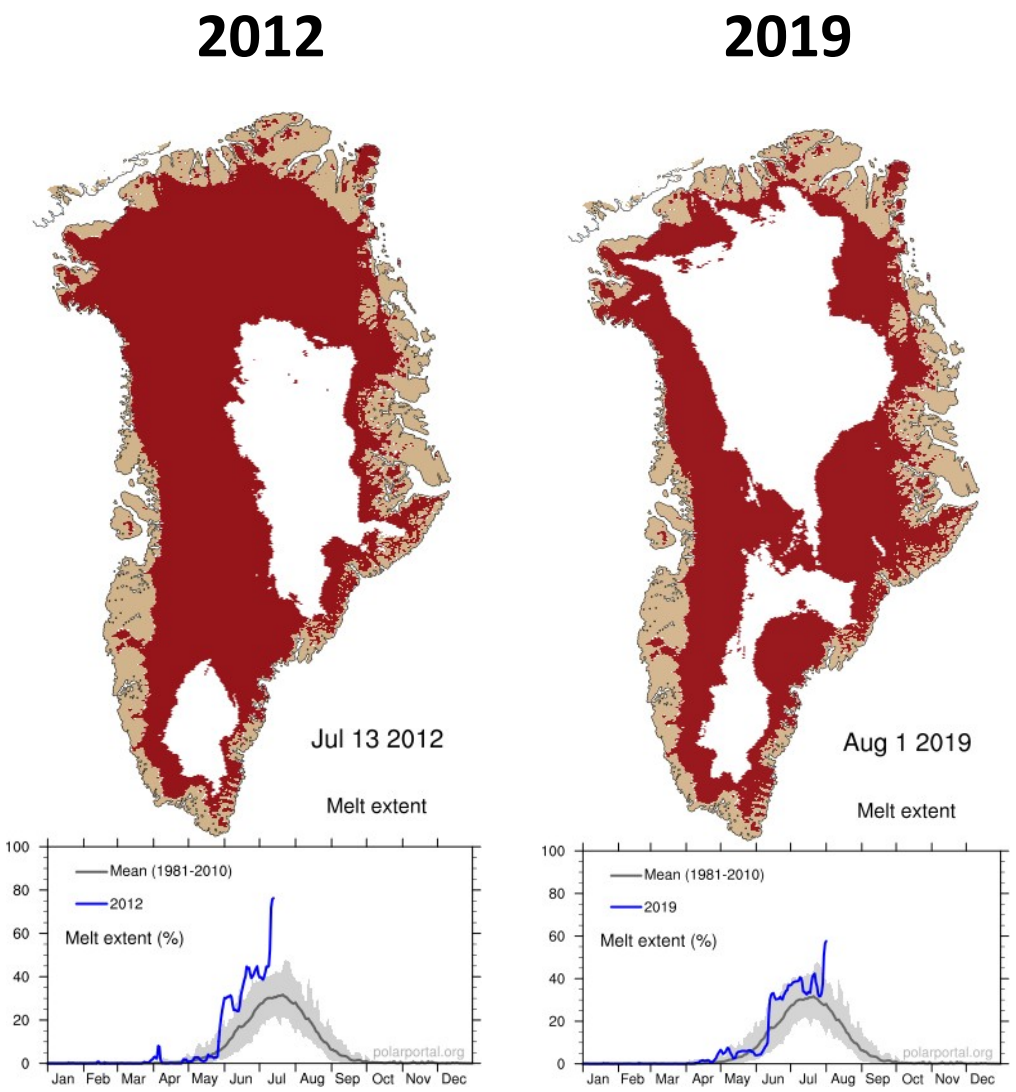
North Atlantic Oscillation



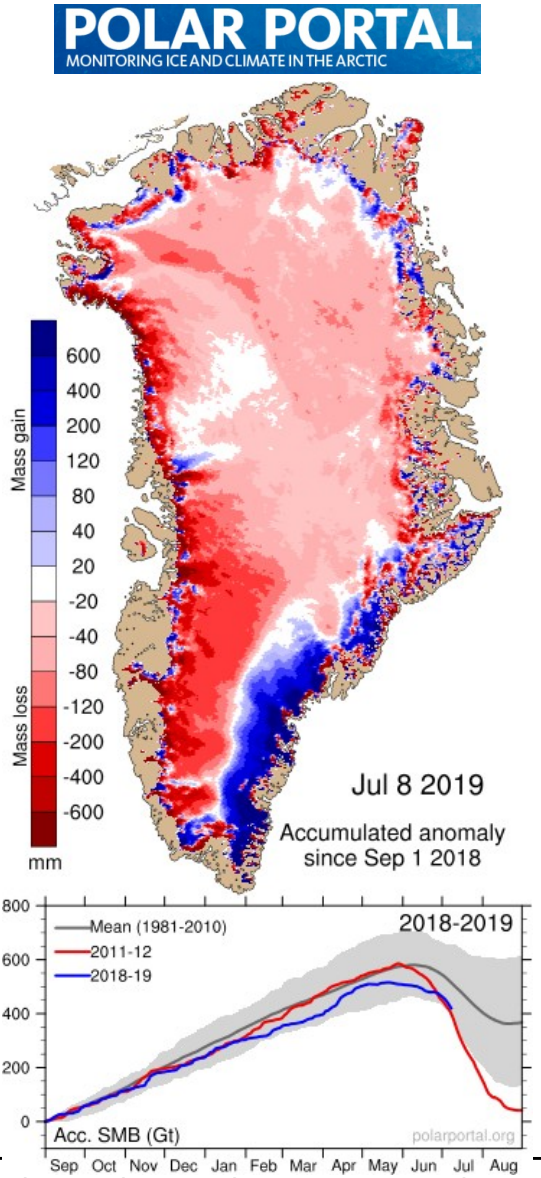
North Atlantic Oscillation

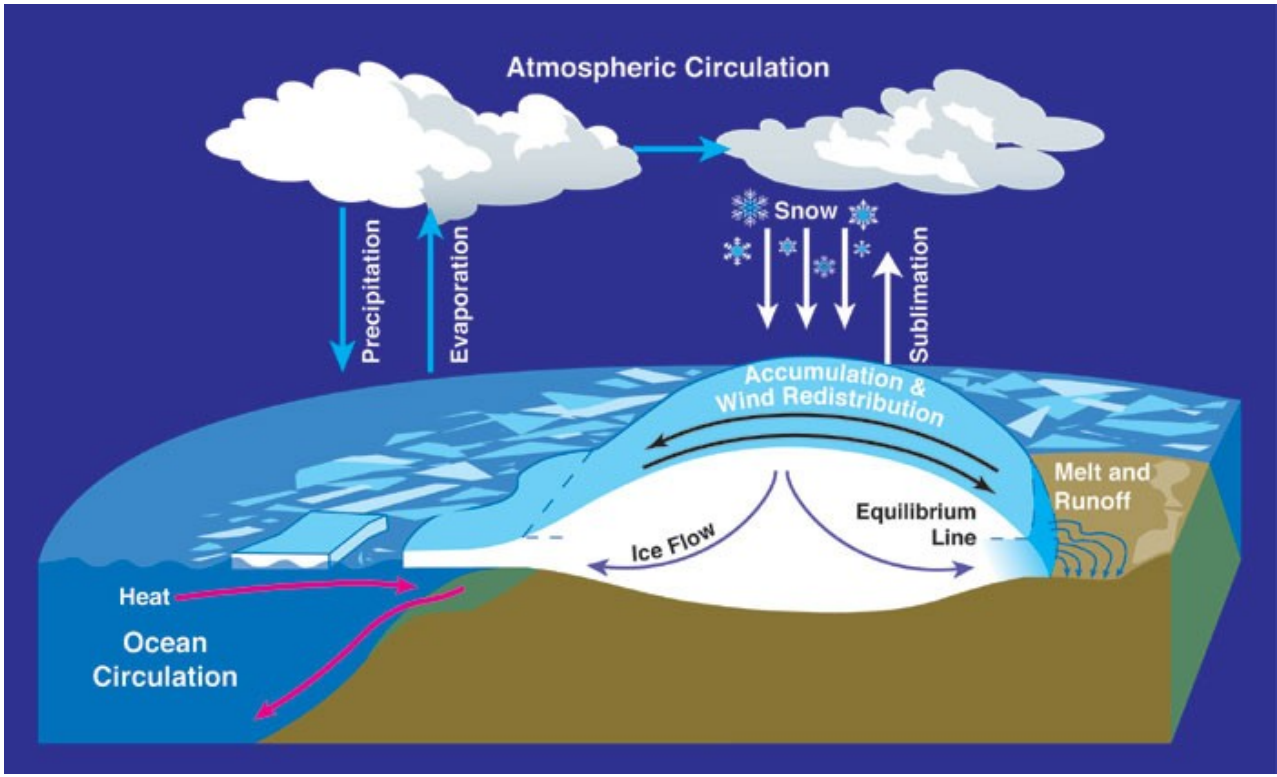


Persistent negative summer NAO associated with high ice sheet melt



NAO Effects on Ice Sheet Mass Balance

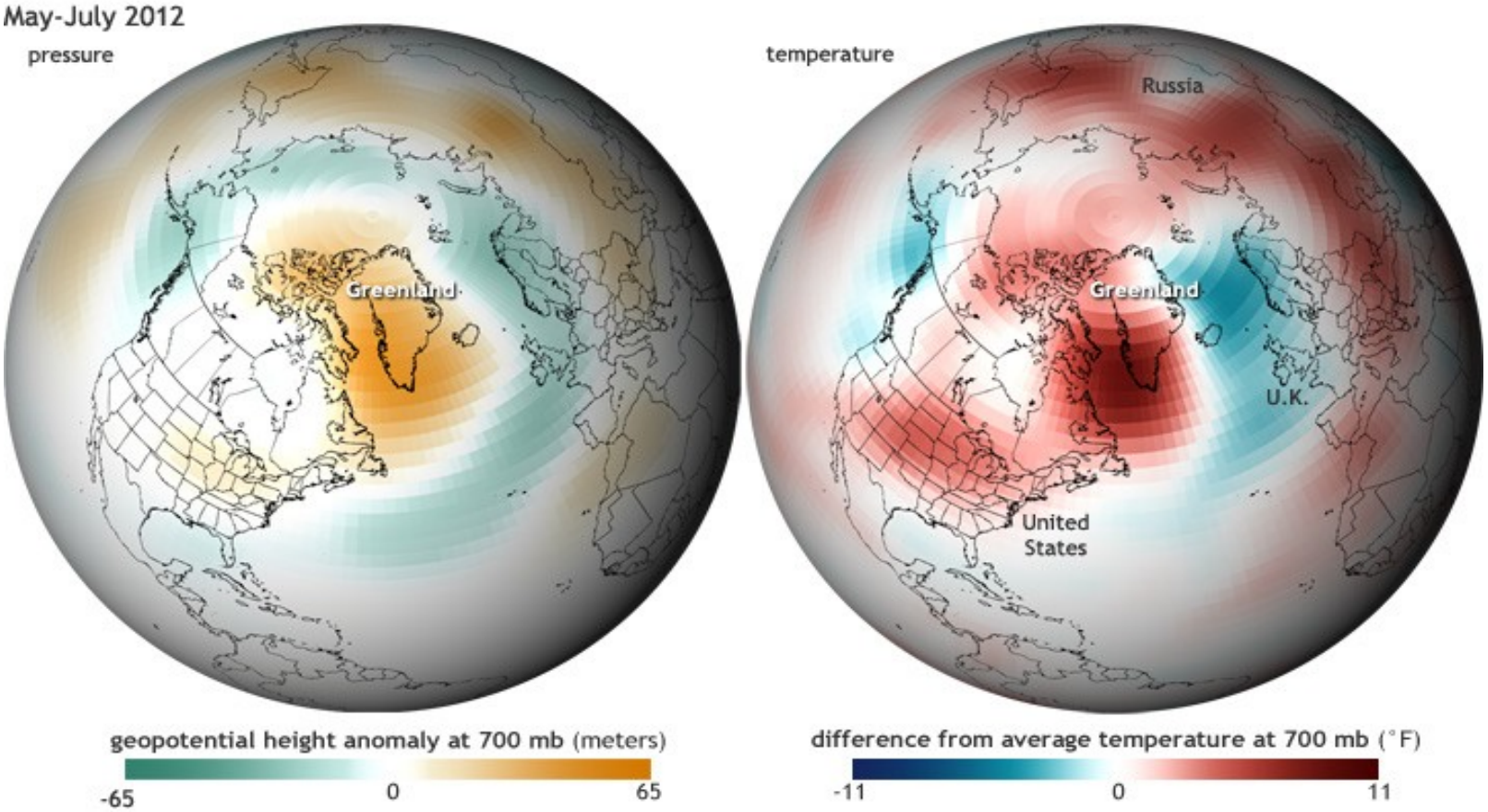




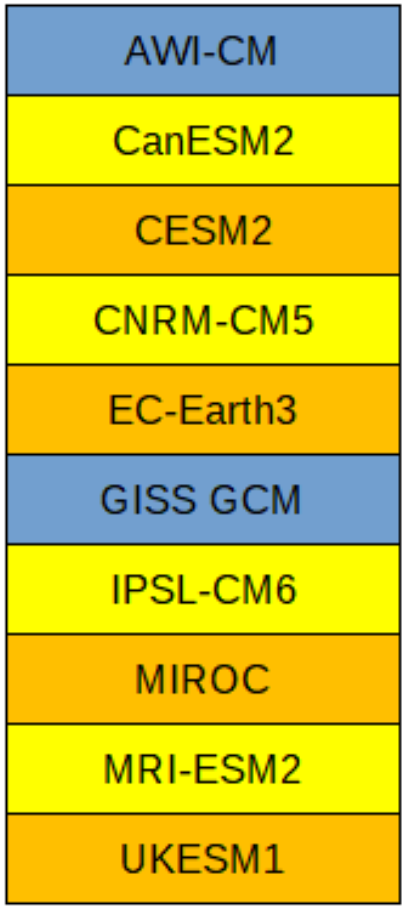
Greenland Blocking Index (GBI)

= geopotential height of 500 hPA area-averaged over Greenland

- Associated with NAO, high GBI also enhances ice sheet melt



Used Models

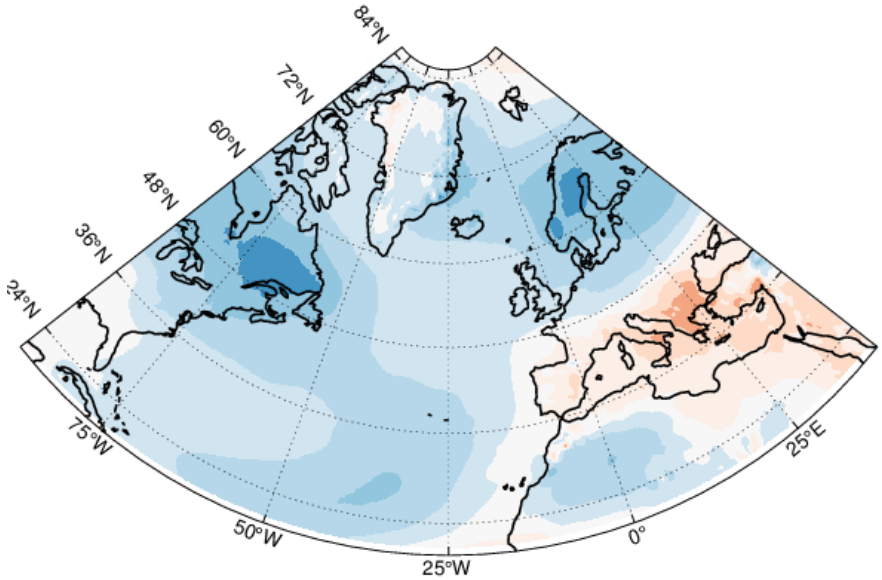


blue: only historical simulation available

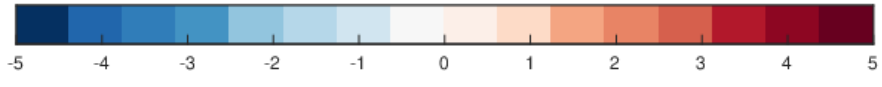
yellow/orange: historical simulation and future projections SSP245 and SSP585

Temperature anomaly summer months

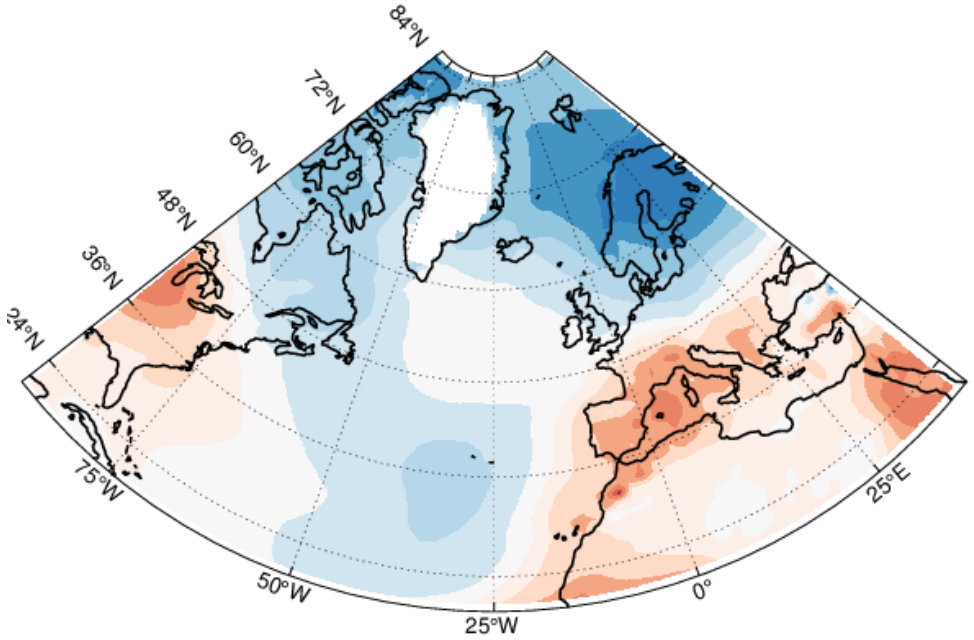
EC -Earth3



ta_Amon_EC-Earth3_historical.mat
versus ERA5_monthly-temp_85000.mat
Months: 0 0 0 0 0 1 1 1 0 0 0 0
Mean Temperature Difference: -0.99K



UKESM



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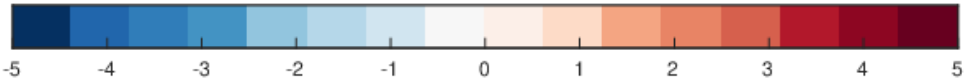
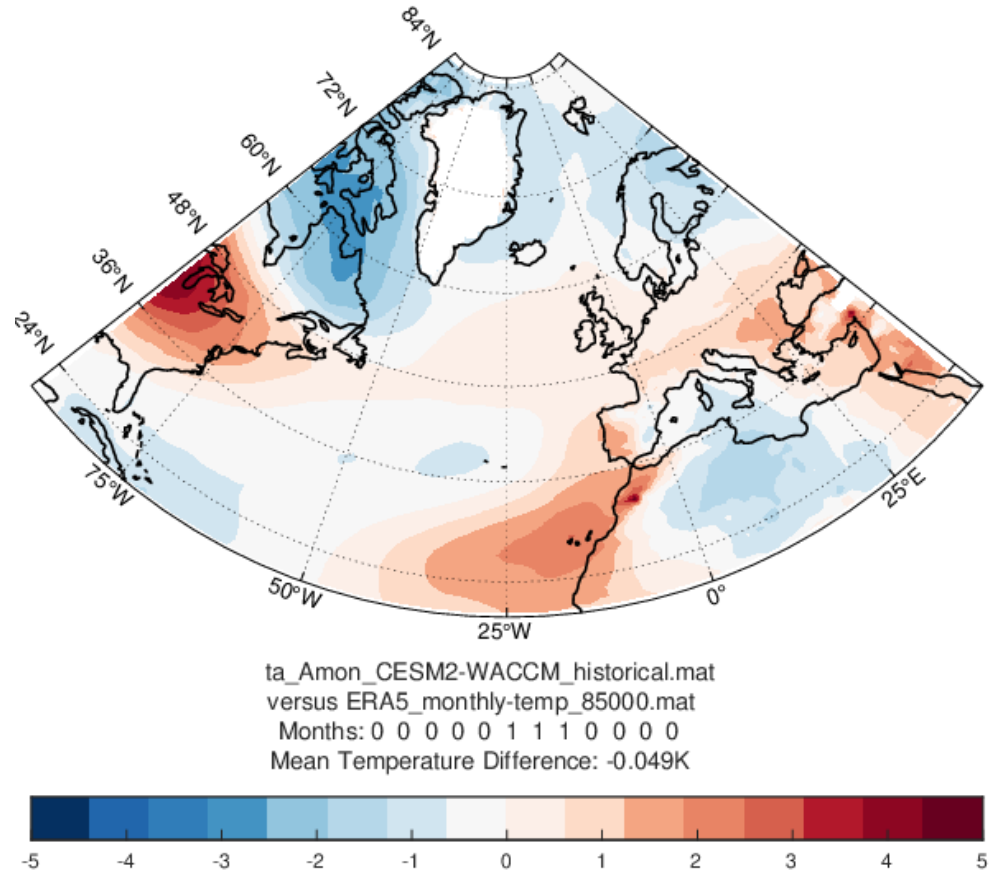
Mean Temperature Difference: -0.51K

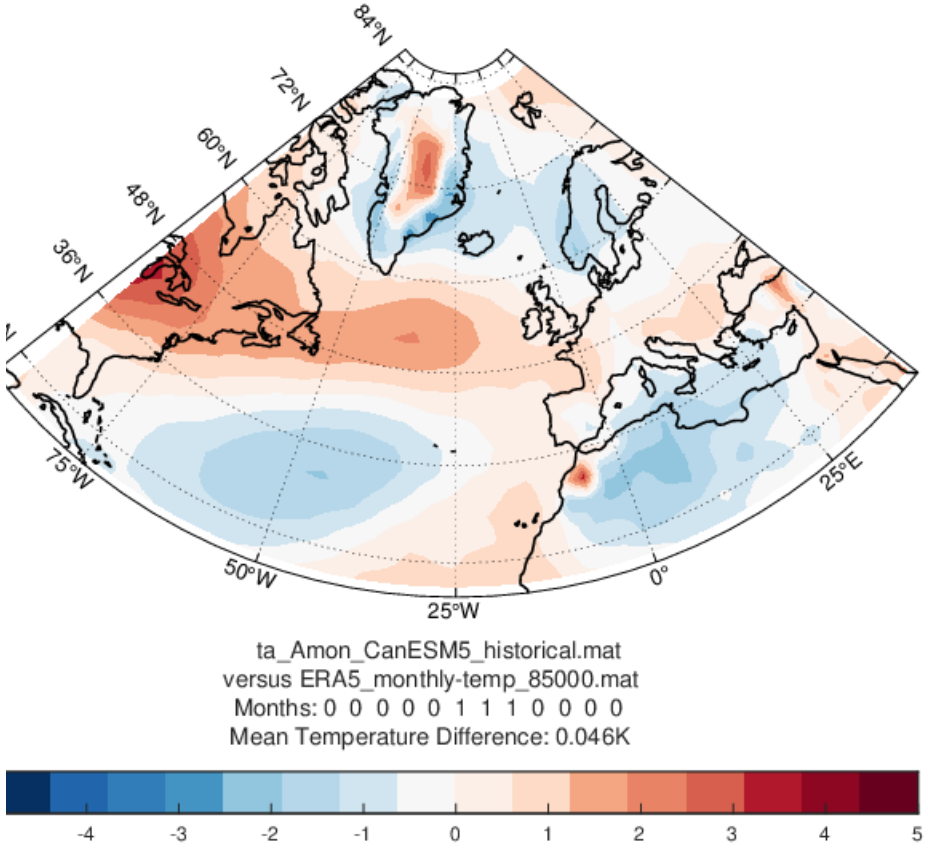


Temperature anomaly summer months

CESM2

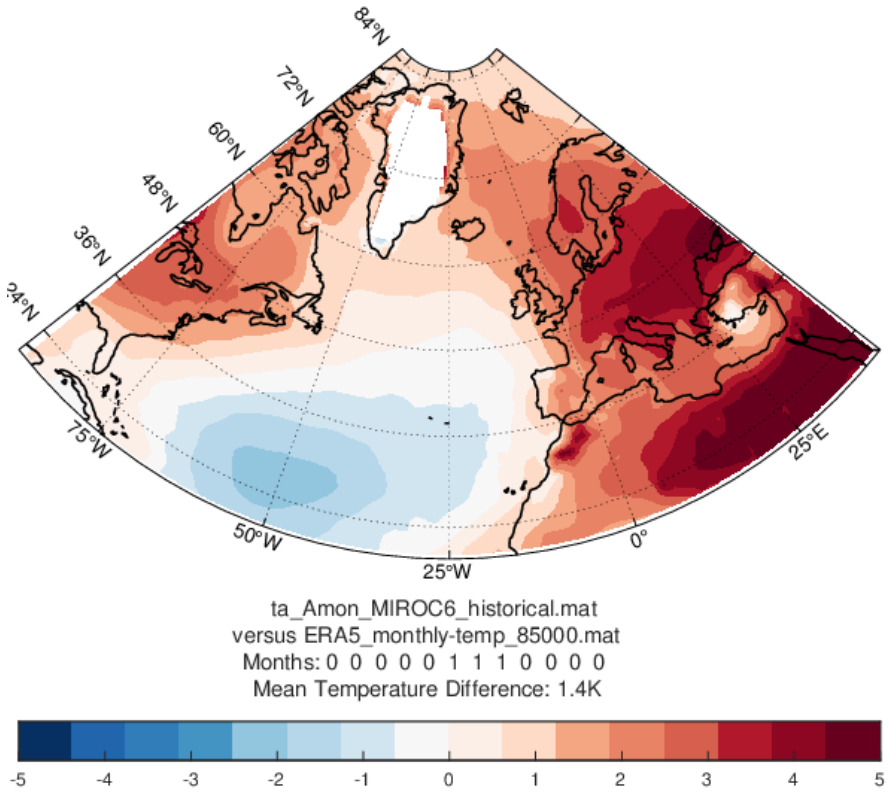


CanESM5



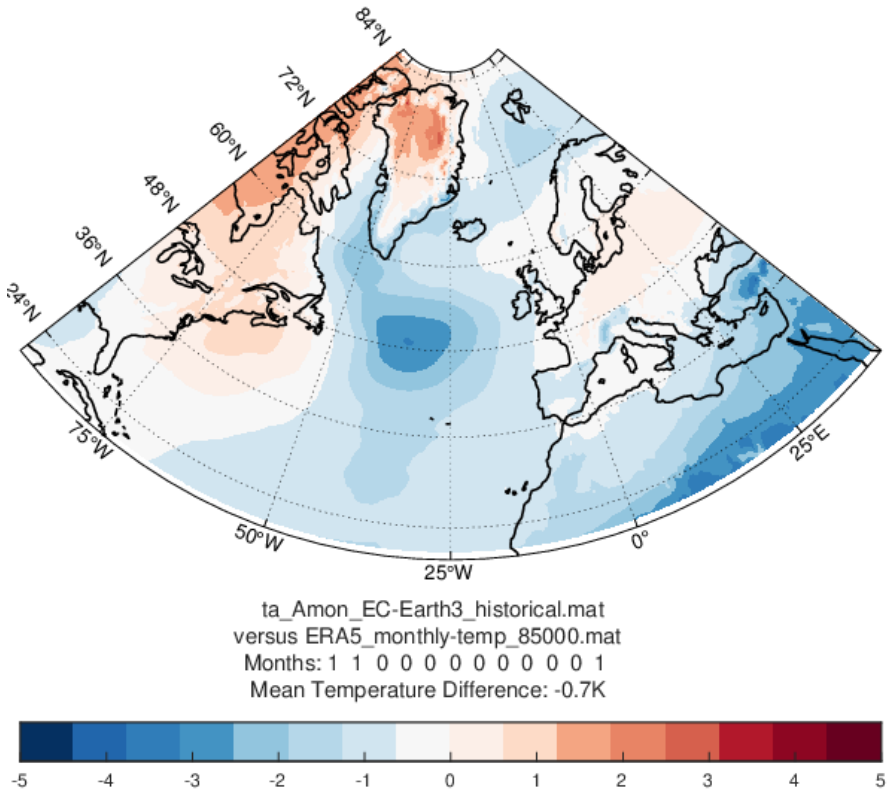
Temperature anomaly summer months

MIROC6

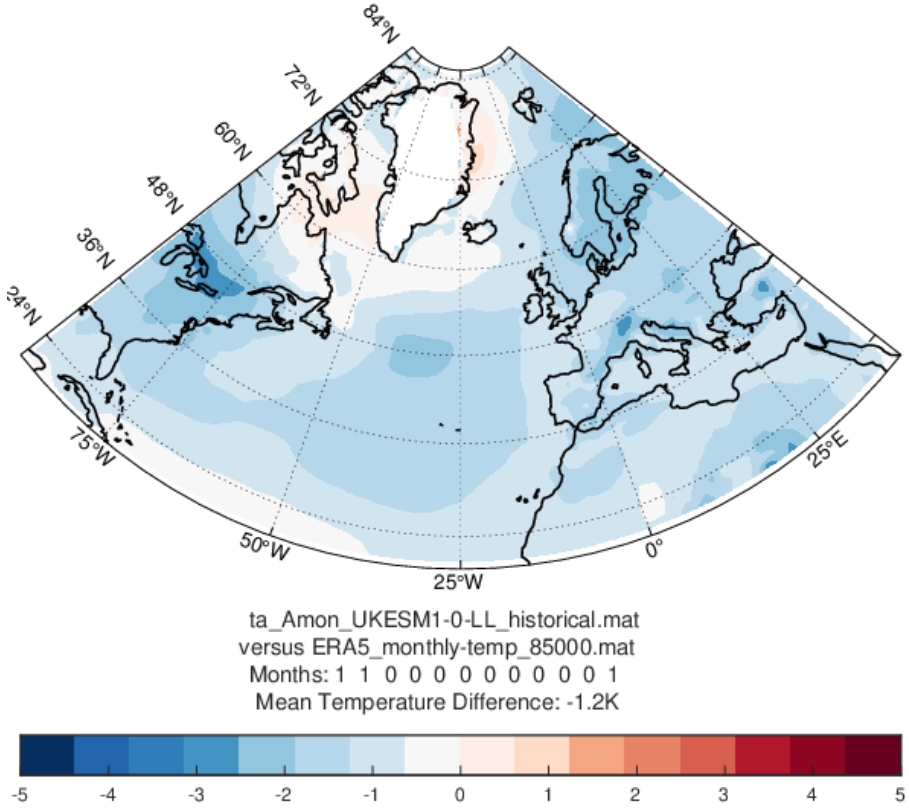


Temperature anomaly winter months

EC -Earth3

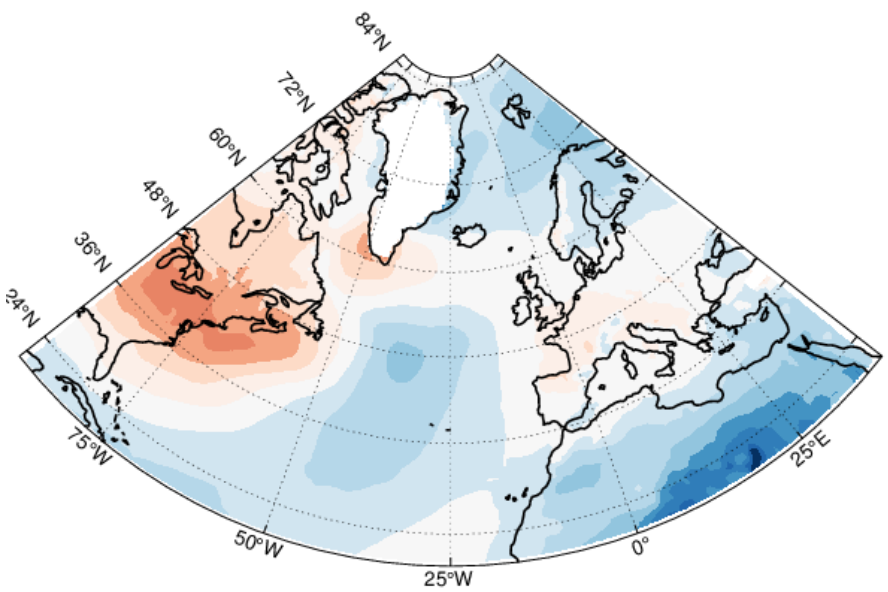


UKESM

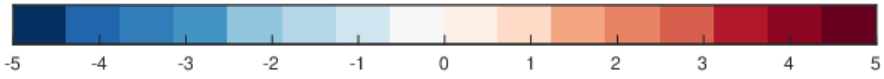


Temperature anomaly winter months

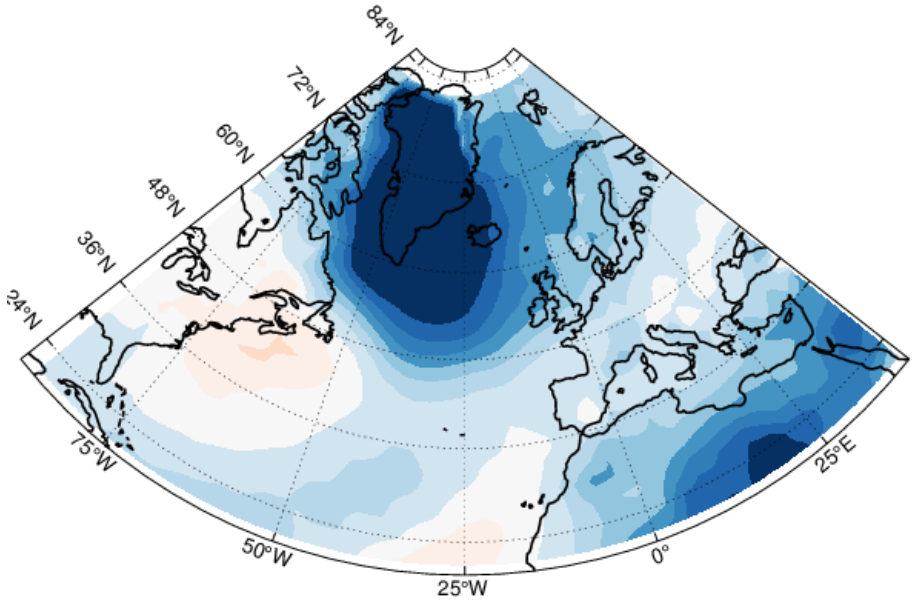
CESM2



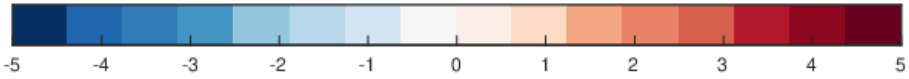
ta_Amon_CESM2-WACCM_historical.mat
versus ERA5_monthly-temp_85000.mat
Months: 1 1 0 0 0 0 0 0 0 0 0 1
Mean Temperature Difference: -0.57K



CanESM5

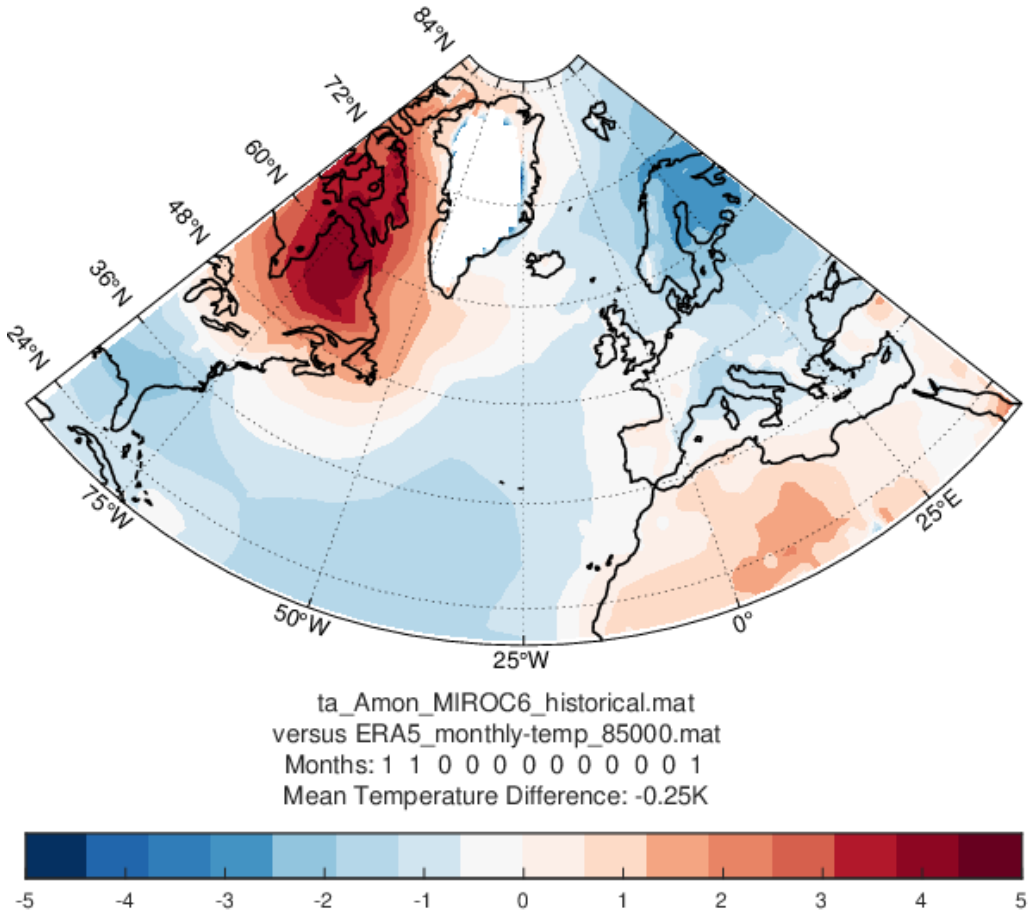


ta_Amon_CanESM5_historical.mat
versus ERA5_monthly-temp_85000.mat
Months: 1 1 0 0 0 0 0 0 0 0 0 1
Mean Temperature Difference: -2K

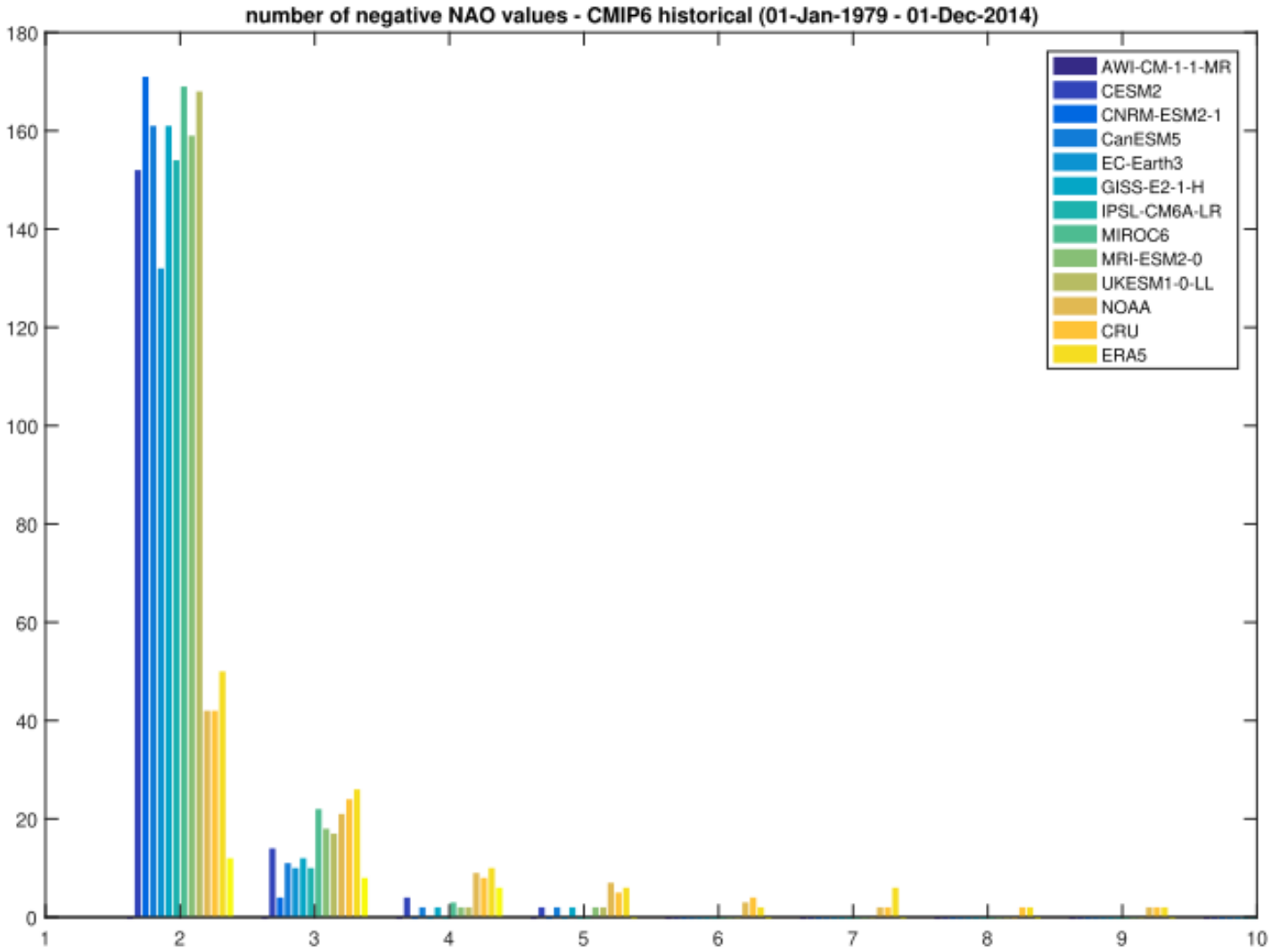


Temperature anomaly winter months

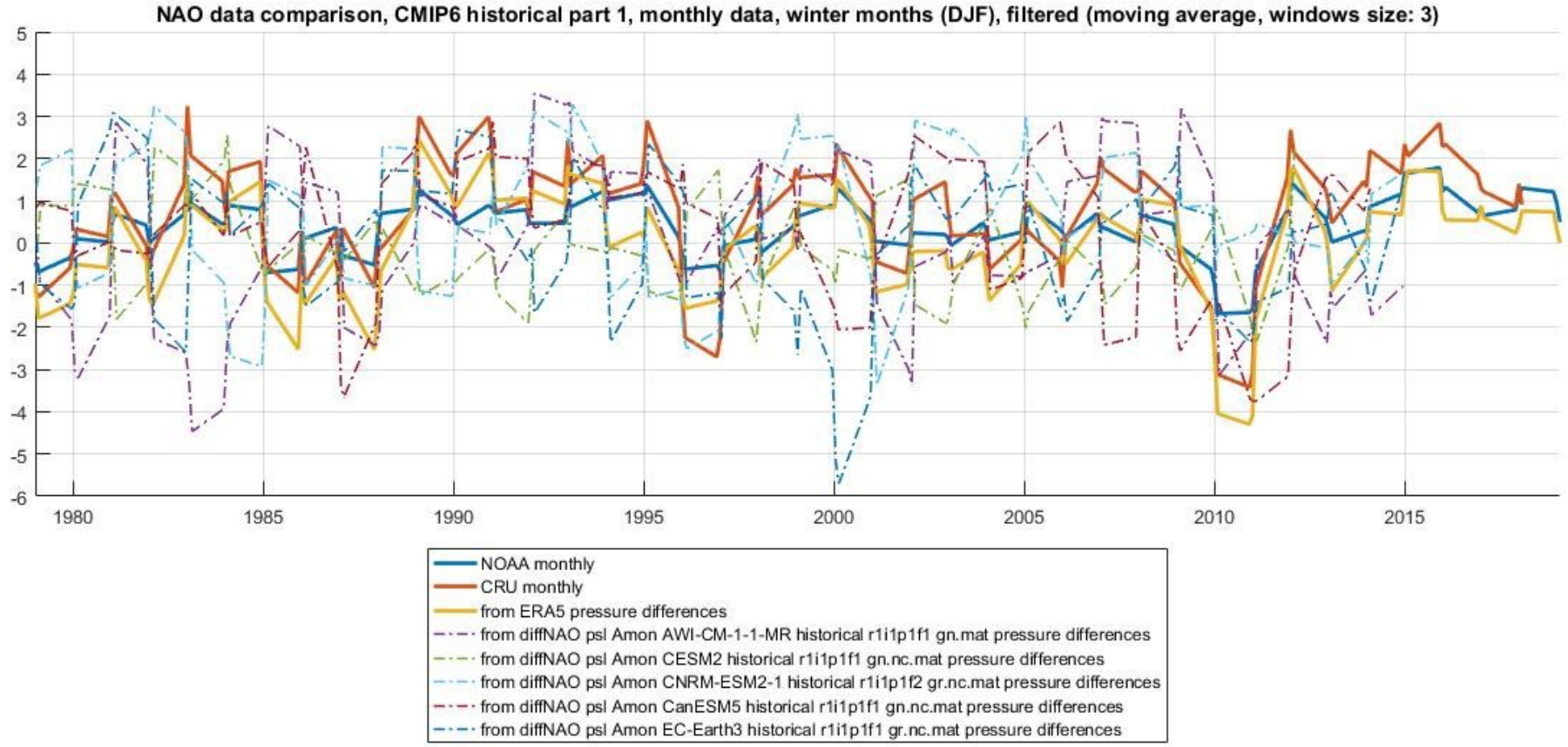
MIROC6



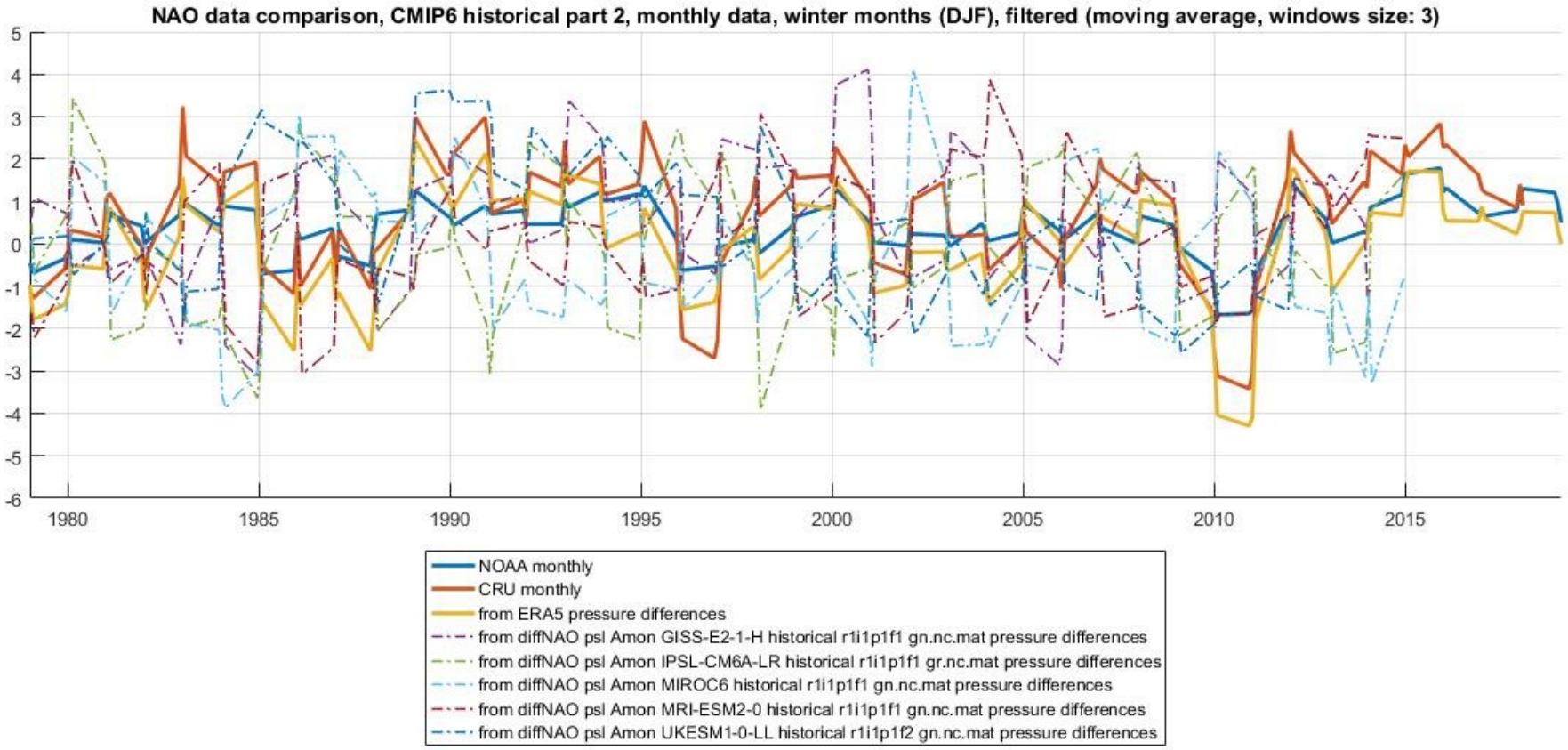
NAO Persistence



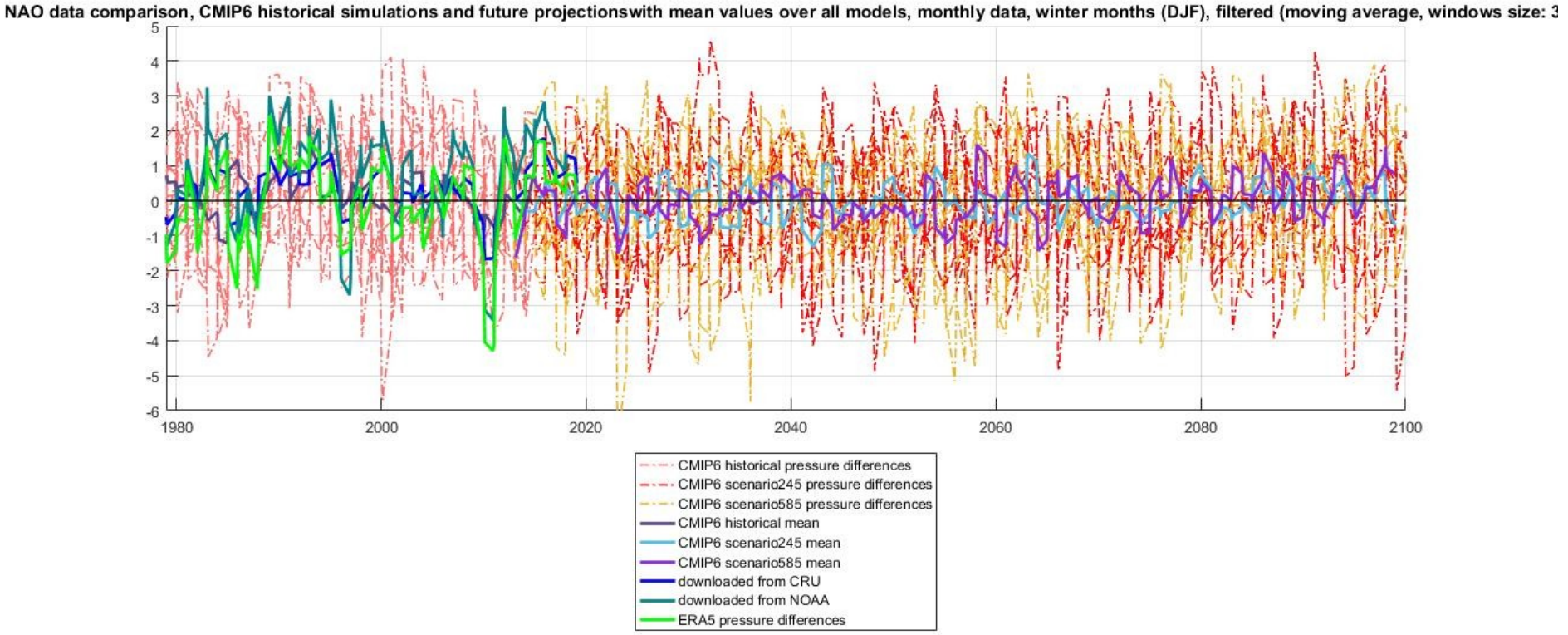
Modelled NAO Index



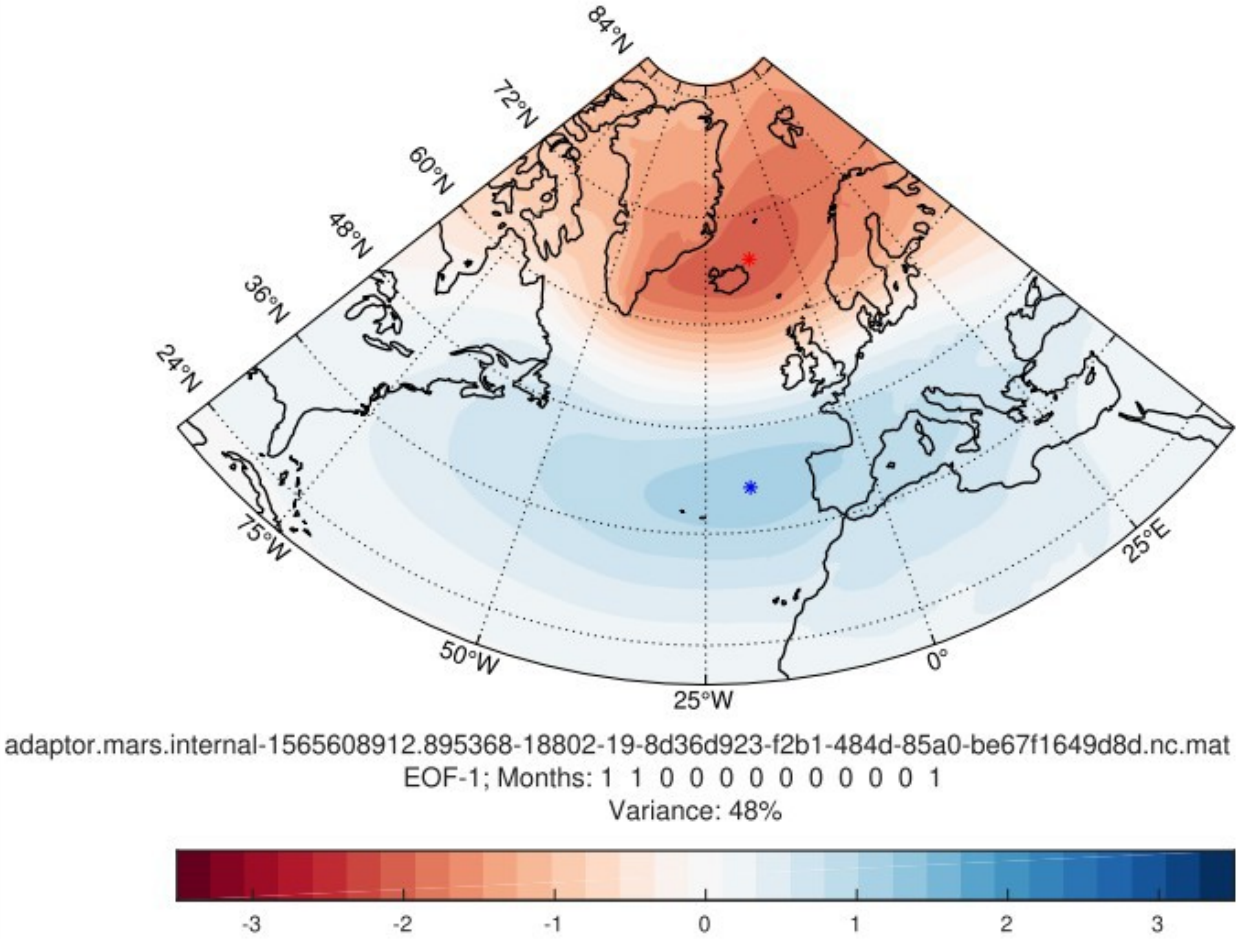
Modelled NAO Index



Modelled NAO Index



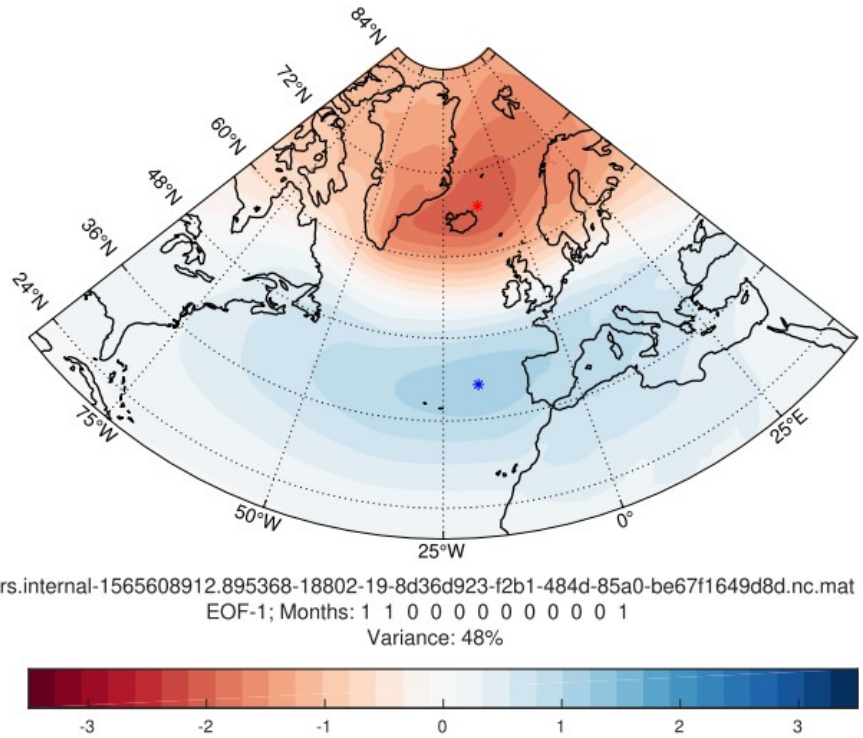
NAO from Principal Component Analysis - Empirical Orthogonal Function



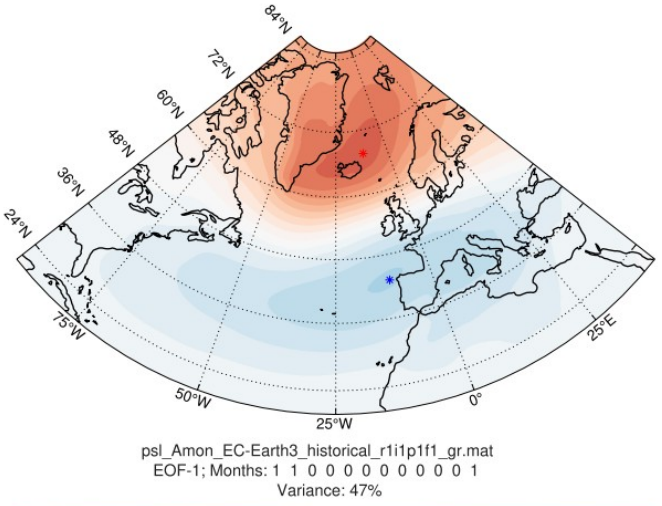
NAO - EC Earth and UKESM vs. ERA5

years 1979 - 2015

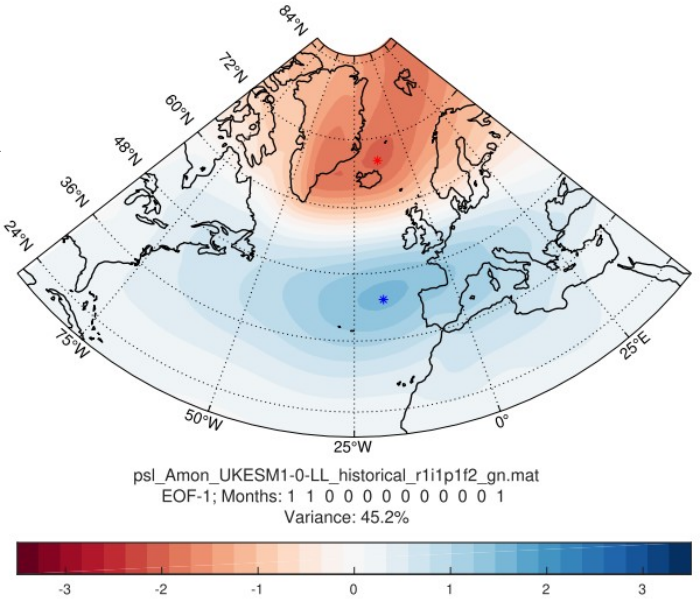
ERA5



EC-Earth →



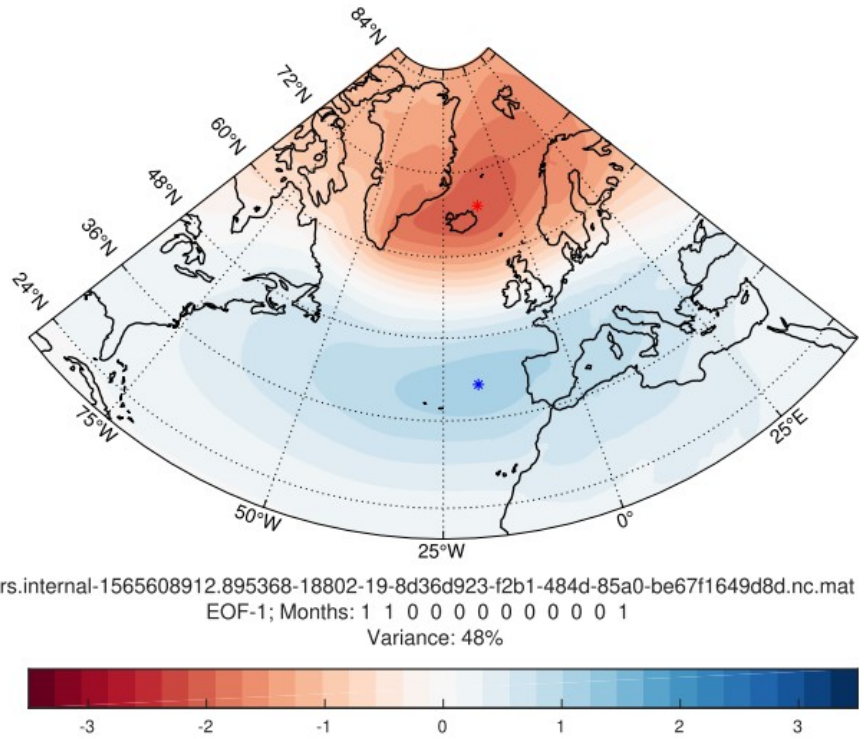
UKESM →



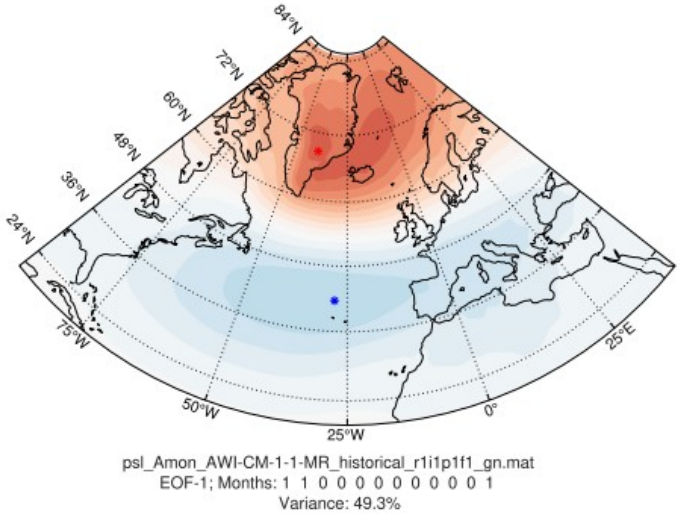
NAO - AWI-CM and CESM2 vs. ERA5

years 1979 - 2015

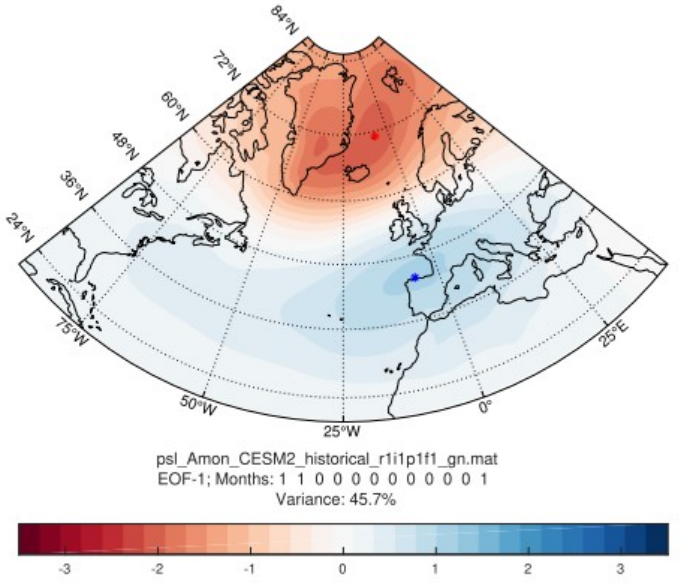
ERA5



AWI-CM



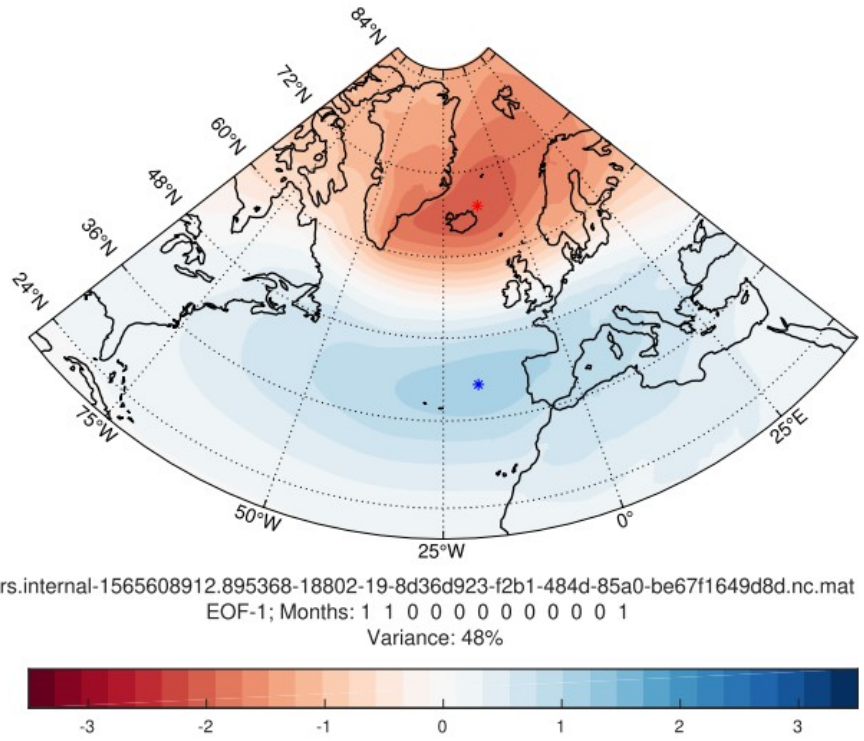
CESM2



NAO - CanESM5 and MIROC6 vs. ERA5

years 1979 - 2015

ERA5



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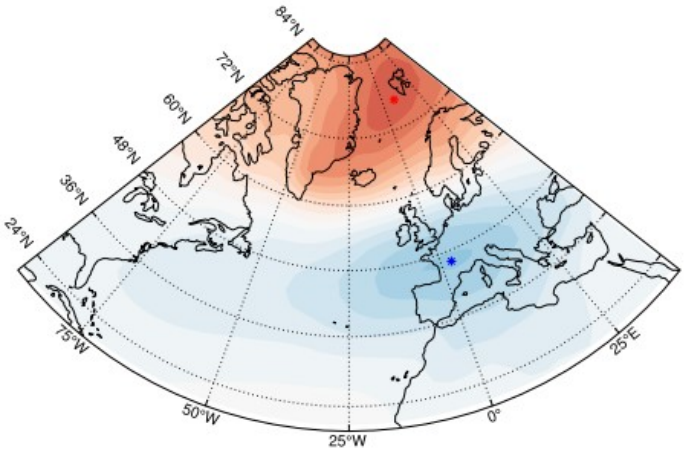
Variance: 48%

CanESM5 →



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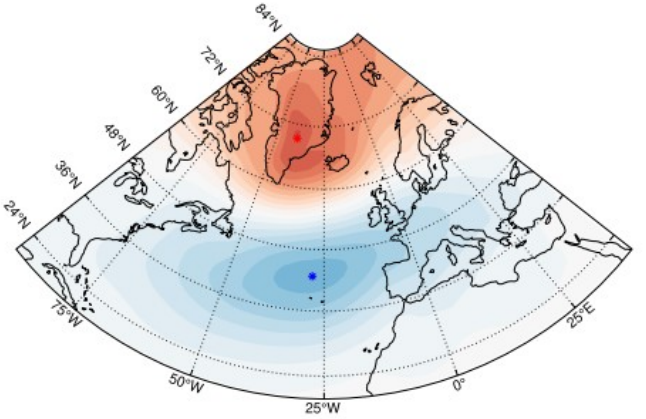
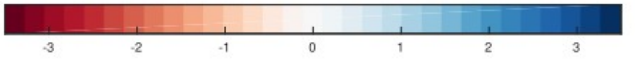
Variance: 46.6%

MIROC6 →



psl_Amon_MIROC6_historical_r1i1p1f1_gn.mat
EOF-1; Months: 1 1 0 0 0 0 0 0 0 0 0 0 1
Variance: 45.7%



distance ranking

and the winner is...

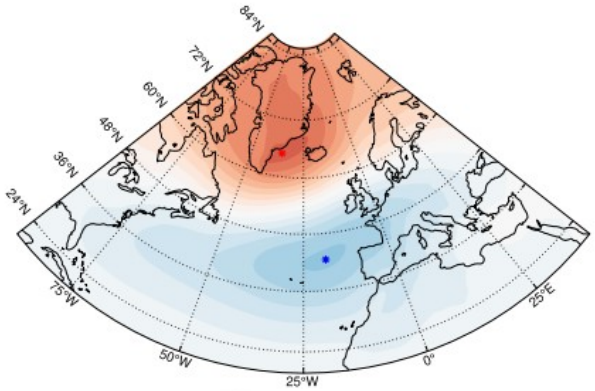
(okay, that's valid for this very special paramter...)

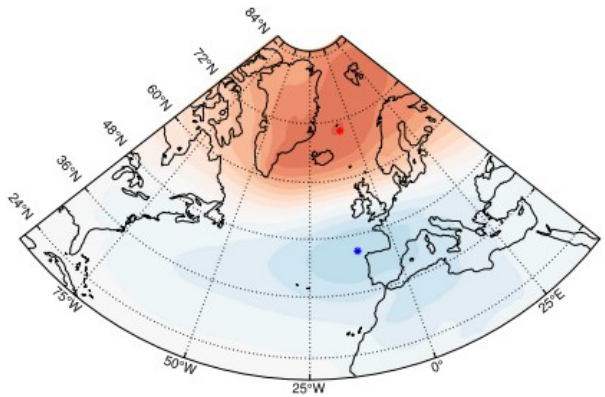
1	UKESM	381,03
2	EC-Earth3	741,71
3	CNRM	1041,65
4	IPSL	1111,92
5	GISS	1516,75
6	CESM2	1536,71
7	MRI	1900,37
8	AWI	1962,17
9	MIROC6	1972,86
10	CanESM5	3072,32

NAO - future projections

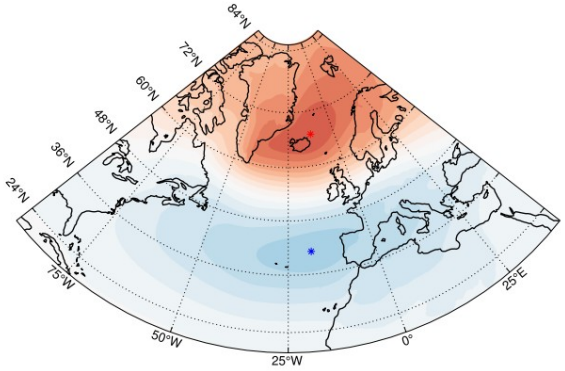
SSP 245 *years 2080 - 2100* **SSP 585**

EC-Earth

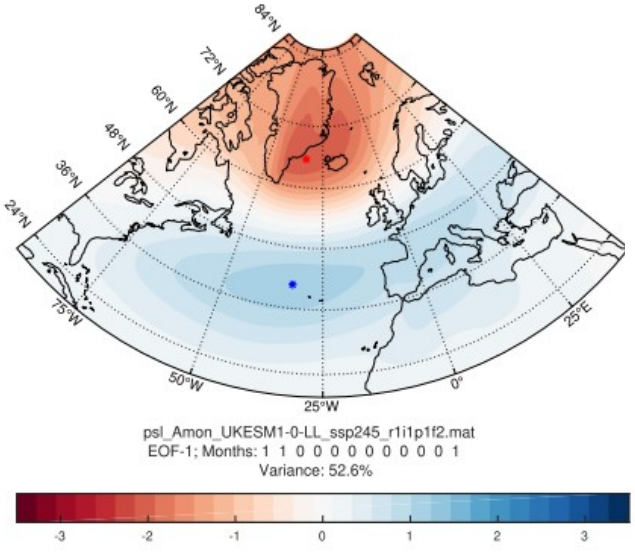


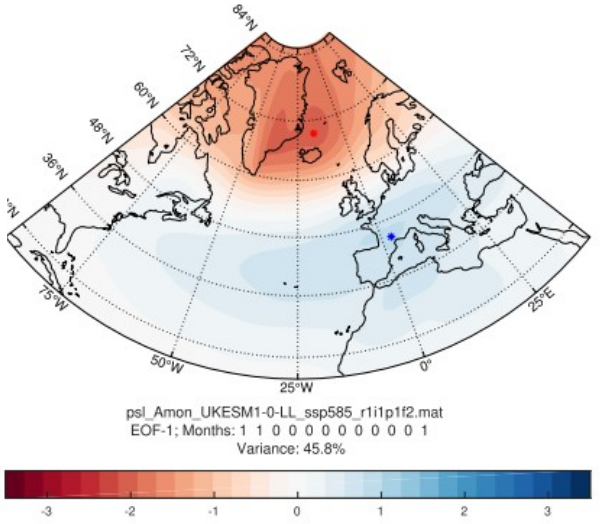


ERA5



UKESM



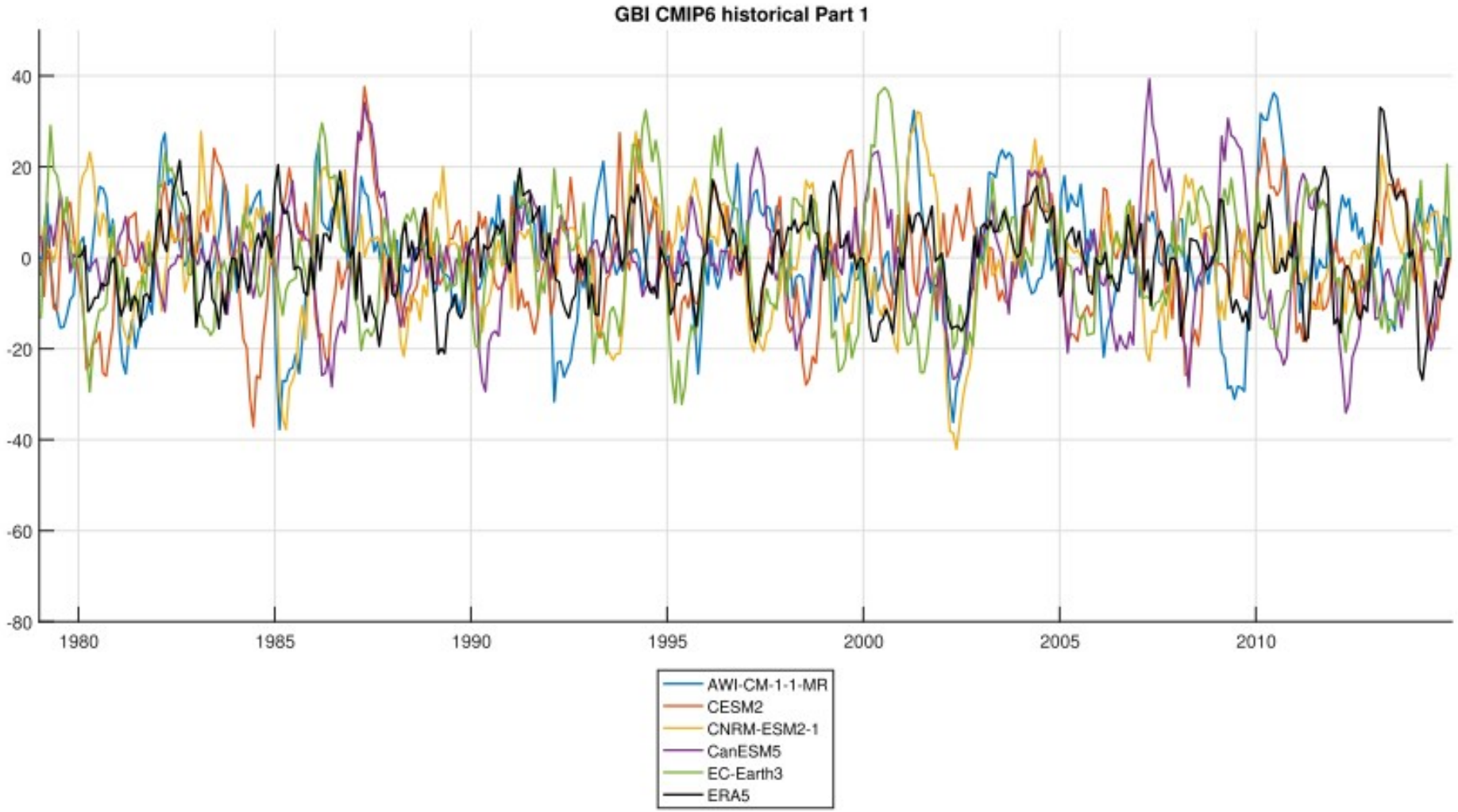


Take Away Messages

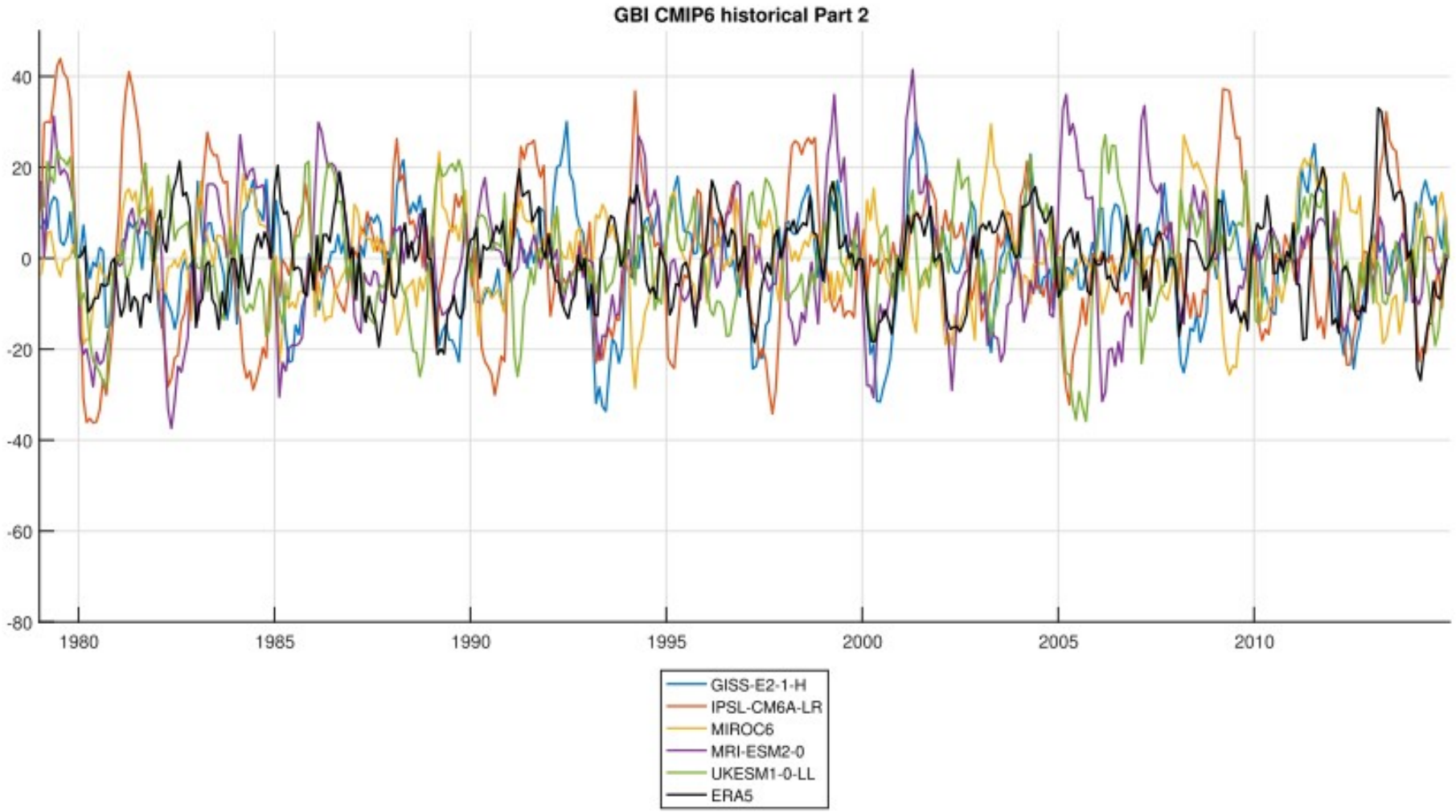
Danmarks Meteorologiske Institut

- It’s important to look not only on absolute, but also on large scale circulation indices like NAO
- The more extreme the scenarion, the more differences in the ensemble spread
- Have a look on the geographical distribution --> EOF analysis

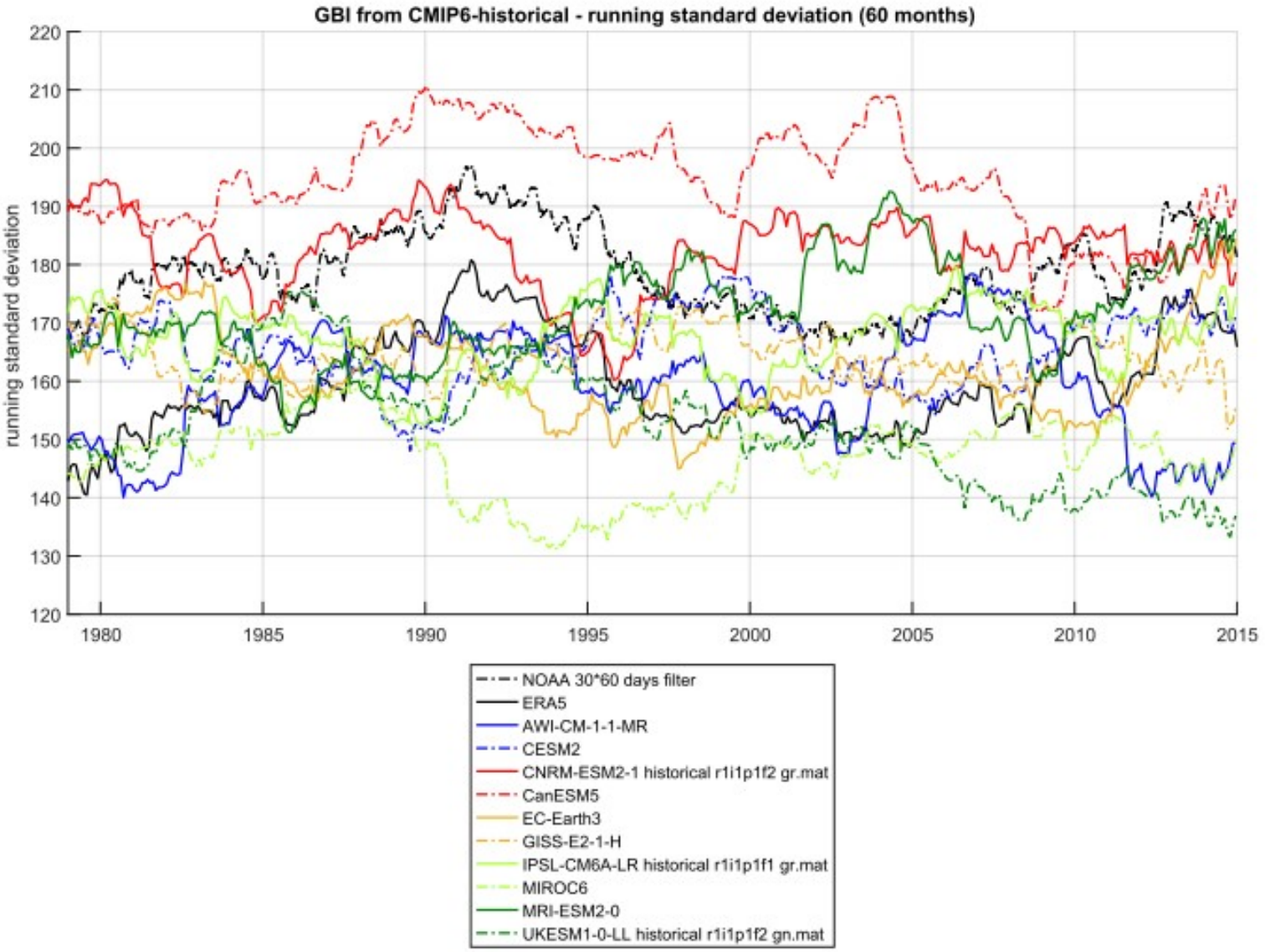
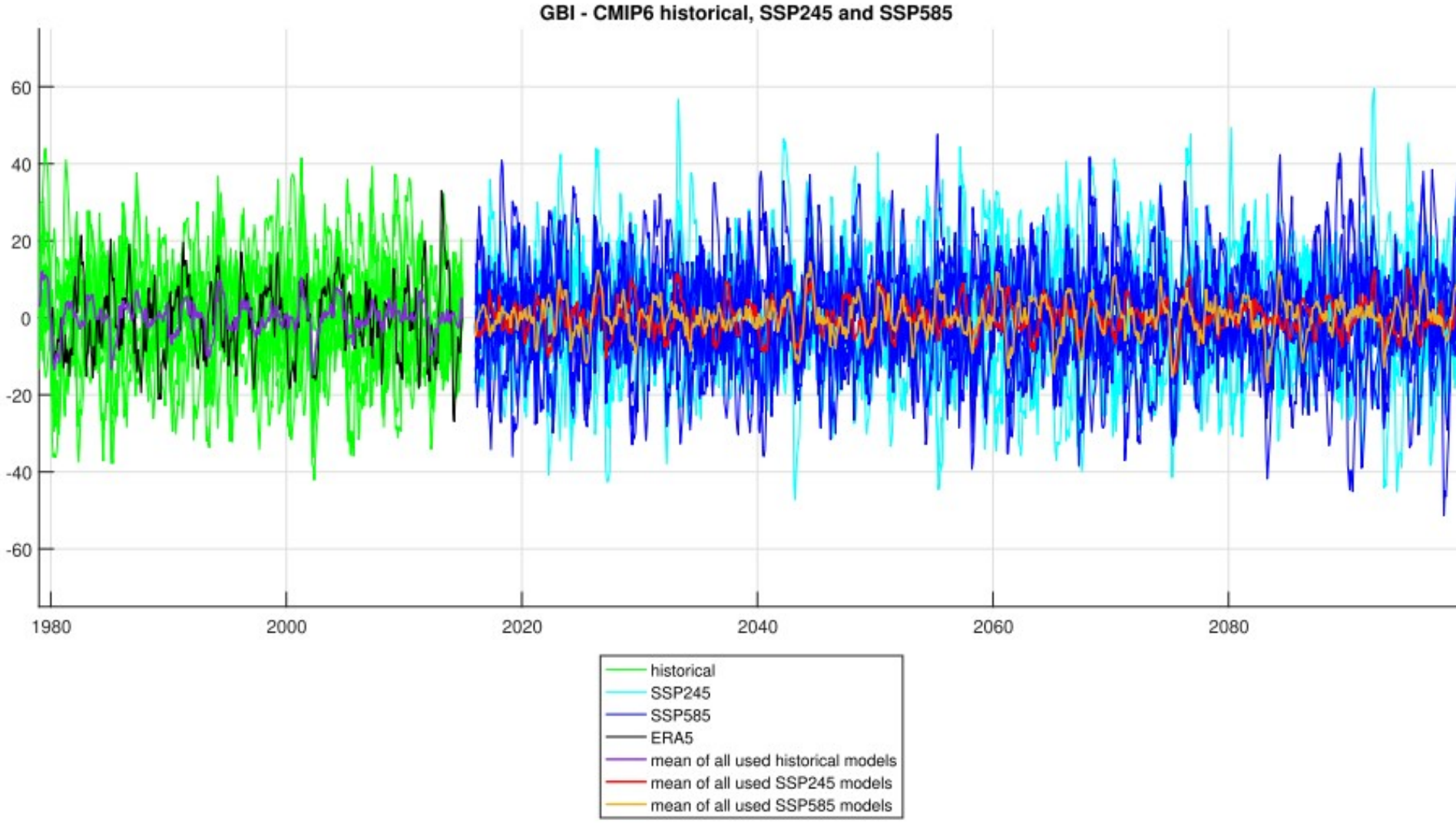
Outlook: GBI


GBI CMIP6 historical Part 1
40
20
0
-20
-40
-60
-80
1980
1985
1990
1995
2000
2005
2010
AWI-CM-1-1-MR
CESM2
CNRM-ESM2-1
CanESM5
EC-Earth3
ERA5

GBI


GBI CMIP6 historical Part 2
40
20
0
-20
-40
-60
-80
1980
1985
1990
1995
2000
2005
2010
GISS-E2-1-H
IPSL-CM6A-LR
MIROC6
MRI-ESM2-0
UKESM1-0-LL
ERA5

GBI - running standard deviation



GBI - mean over all used models