Mechanism of natural climate oscillation in Arctic from data of INM climate model

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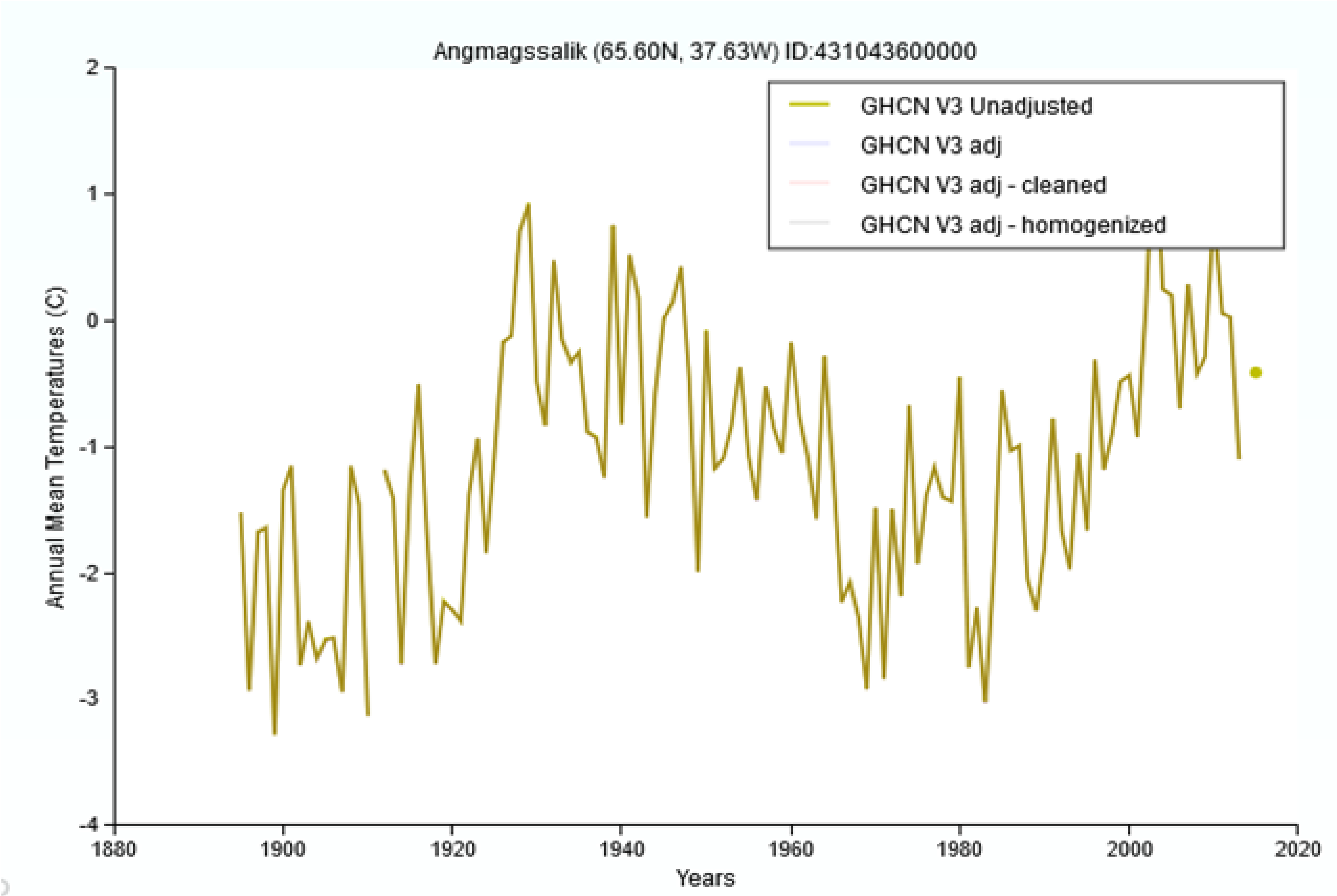
Time series of annual mean temperature in Angmagssalik (East Greenland). Oscillations with period of 60-70 years and 10-20 years can be seen

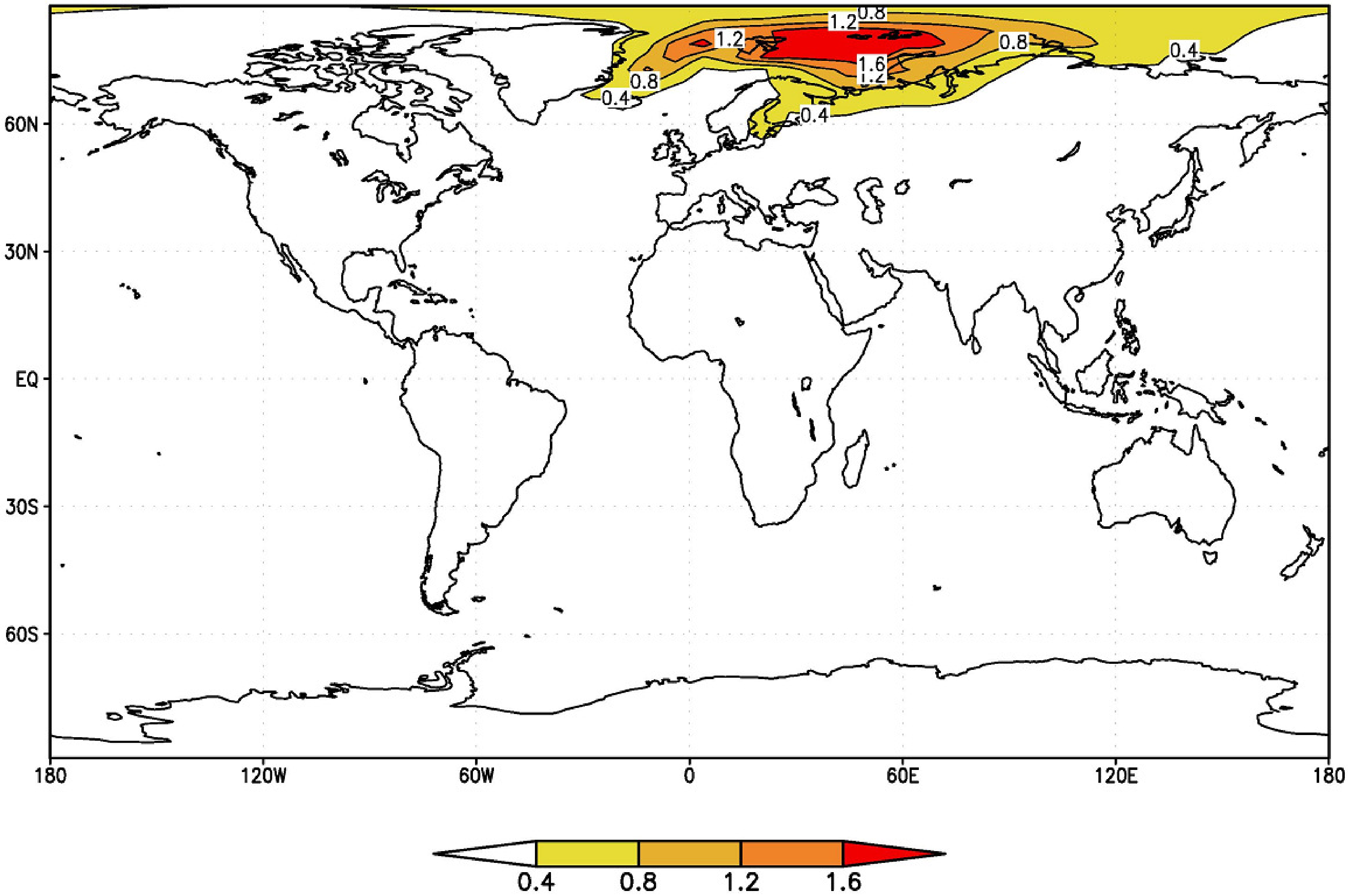


To study the mechanism of climate oscillation in Arctic, data of climate model INM-CM5 was used.

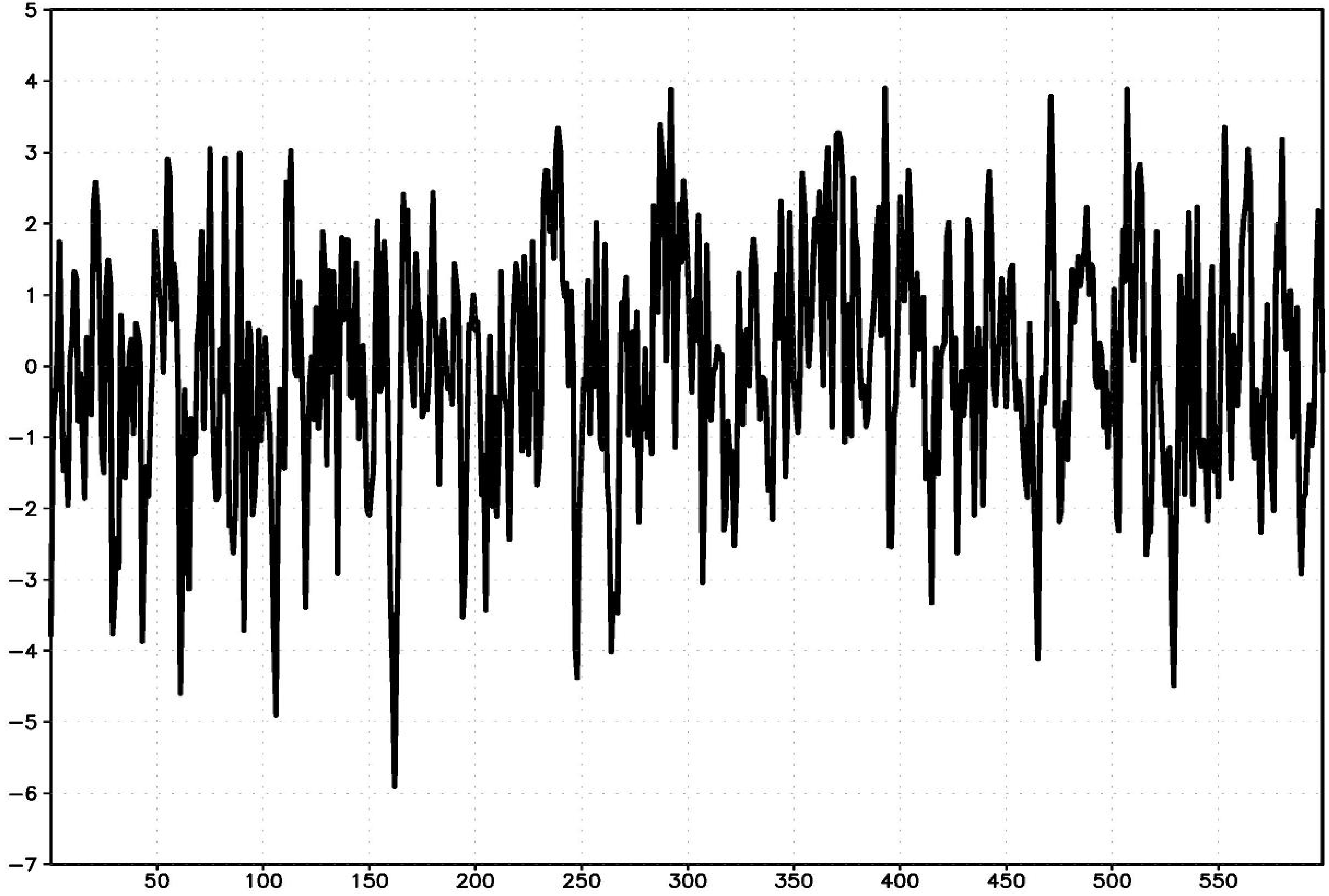
Model has spatial resolution in atmospheric block 2x1.5 degrees in longitude and latitude, and 73 levels up to 0.2 hPa (60 km). In oceanic block, resolution is 0.5x0.25 degrees and 40 levels.

Preindustrial run was performed with the model, where all forcings are fixed as in year 1850. Only natural climate variability can be seen in this run. Duration of run was 1200 model years. It takes about 6 months of real time and 360-720 cores to produce such model run!

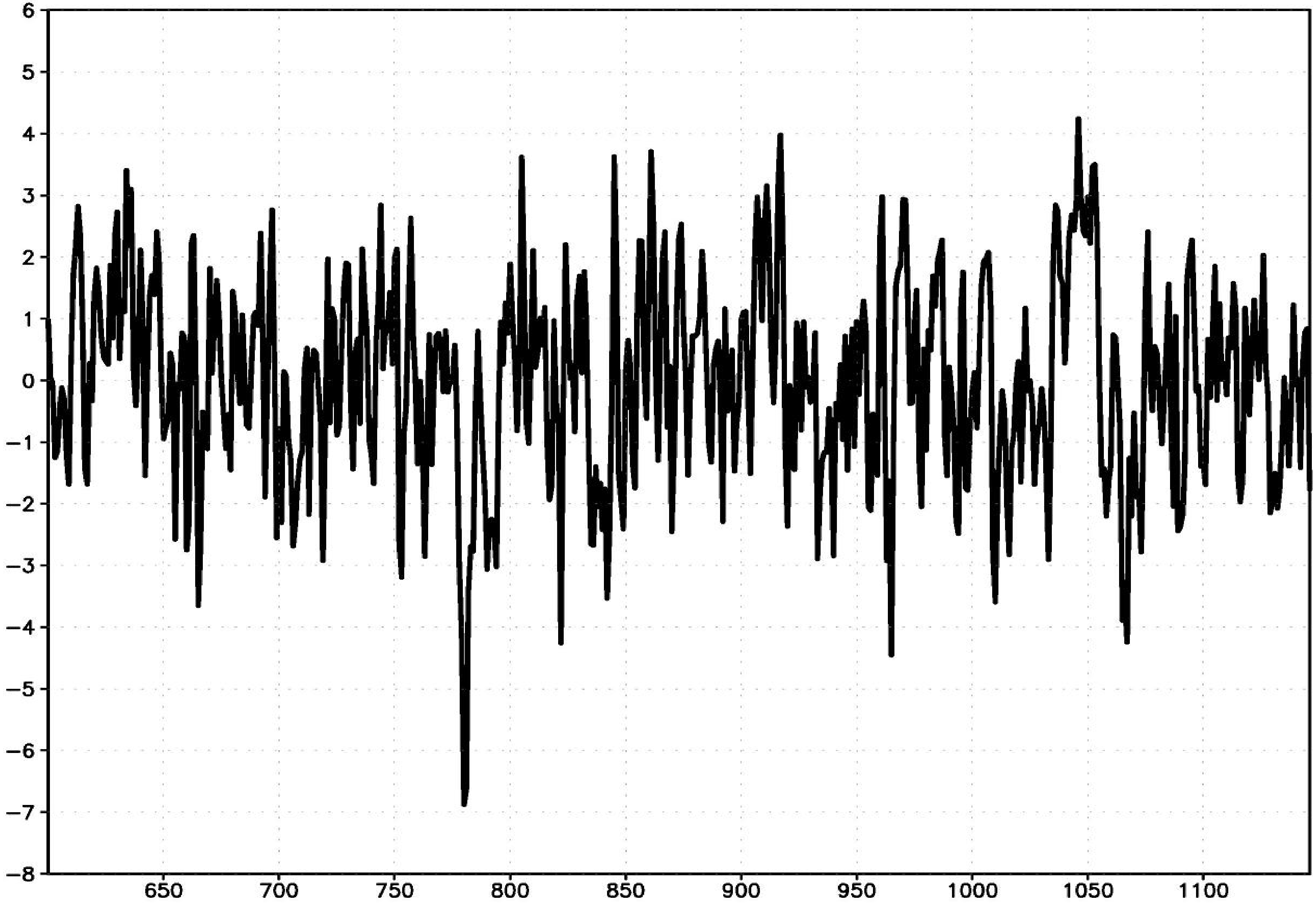
EOF-1 of 5-year mean temperature is localized in Arctic



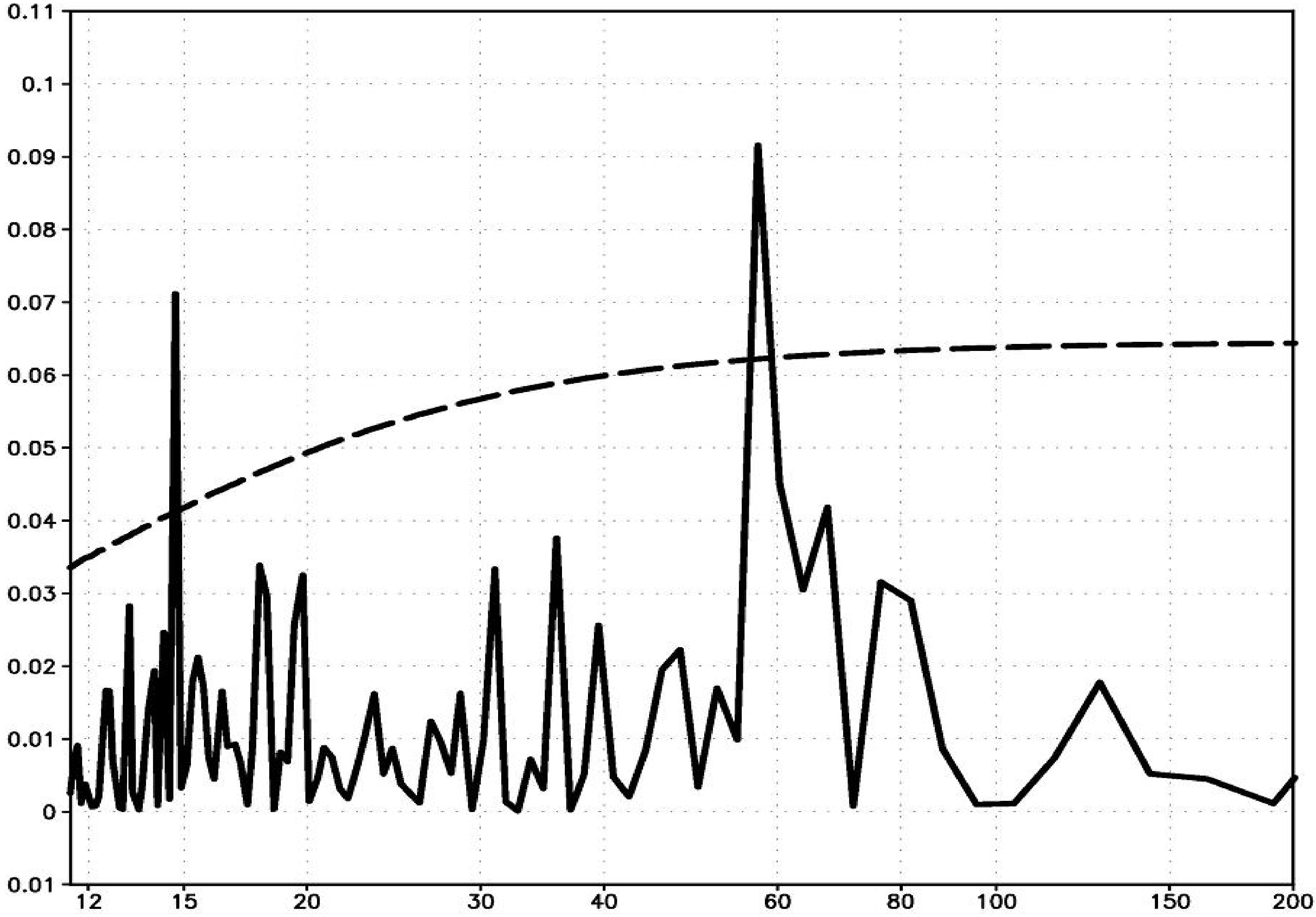
Time series of model annual mean temperature in Arctic for years 1-600

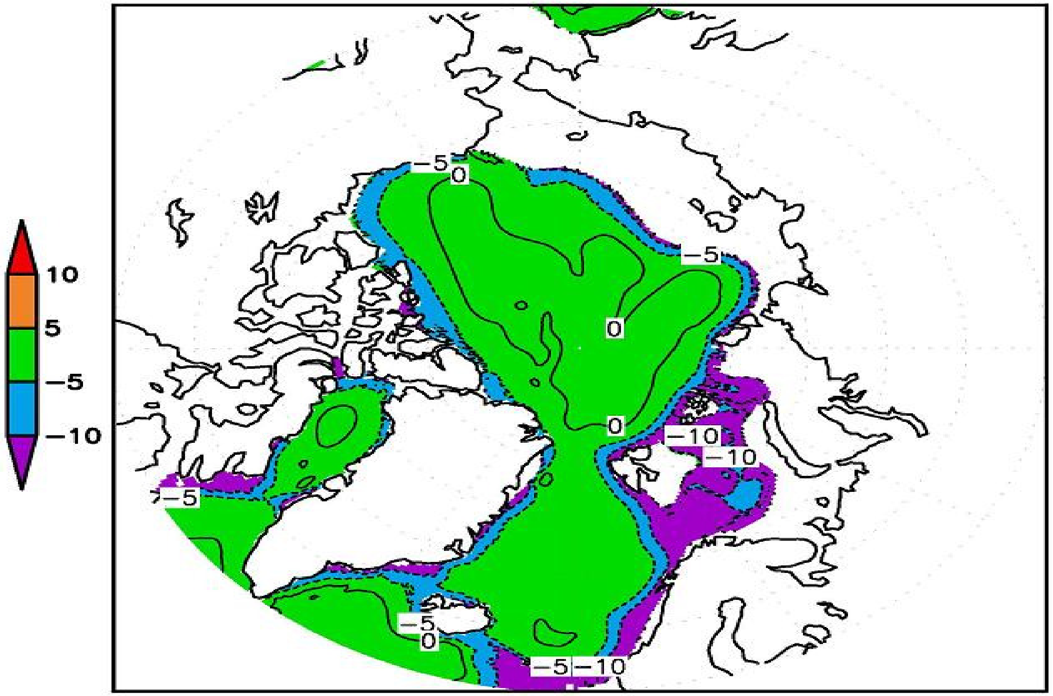


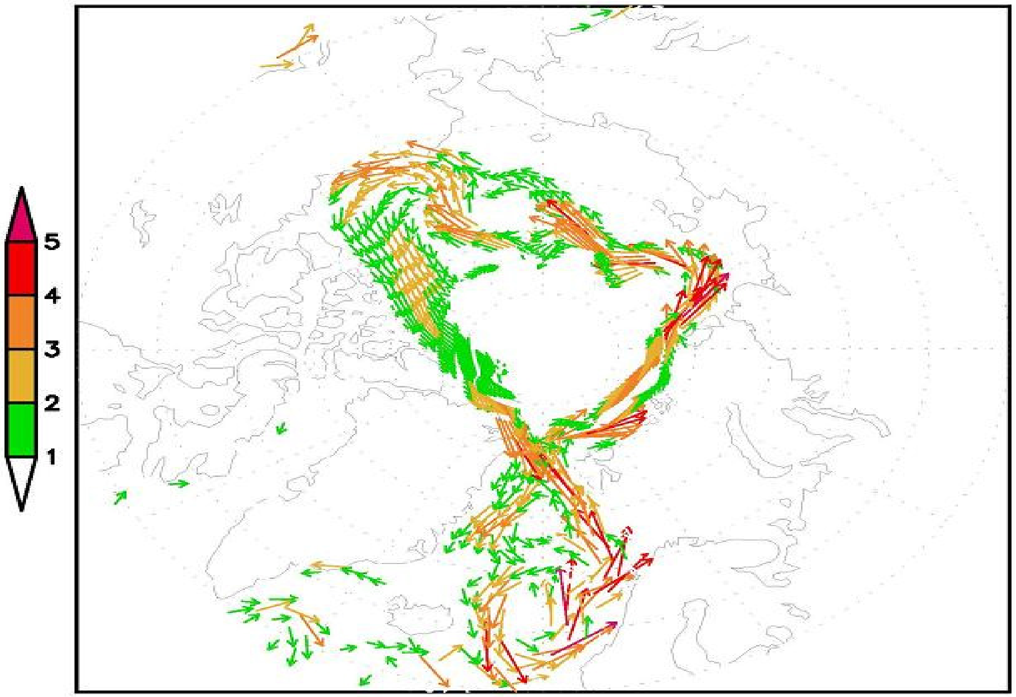
The same for years 601-1147



Time spectrum of expansion coefficient. Dashed line shows significance level at 99%.







Composite analysis: Anomalies of currents at 200 m depth (top) and salinity at 200-1000 m (bottom) during 15-year interval **before** Arctic warming

If X-axis directed along coastline, then:

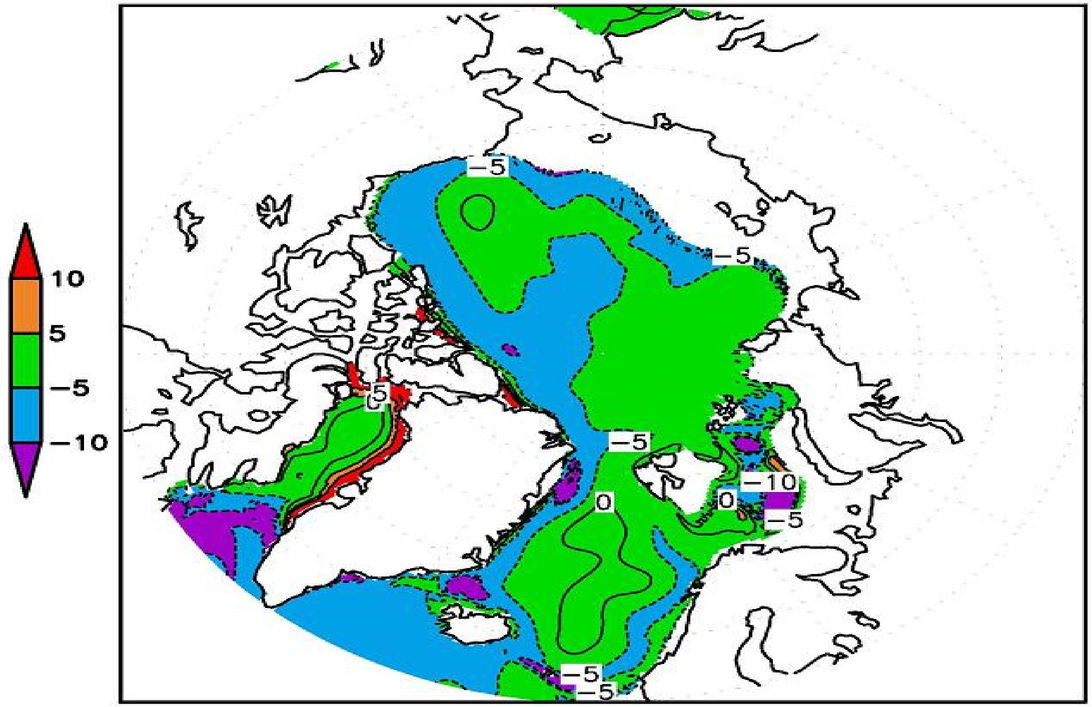
$$fUx = -\frac{1}{\rho_0}\frac{\partial P}{\partial y},$$ - geostrophic equation,

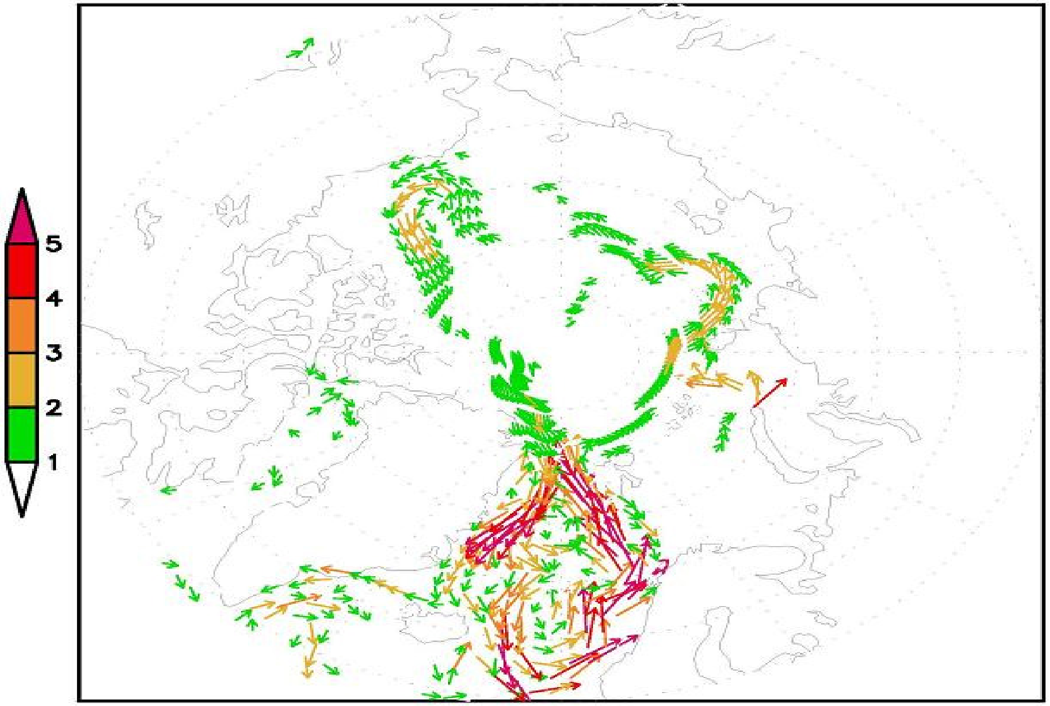
$$\rho = \rho_0 + \rho'(x, y, z),$$

$$\frac{\partial P}{\partial z} = -\rho g,$$ - hydrostatic equation,

and we can derive thermal current relation:

$$\frac{\partial Ux}{\partial z} = \frac{g}{f\rho_0}\frac{\partial \rho'}{\partial y}$$

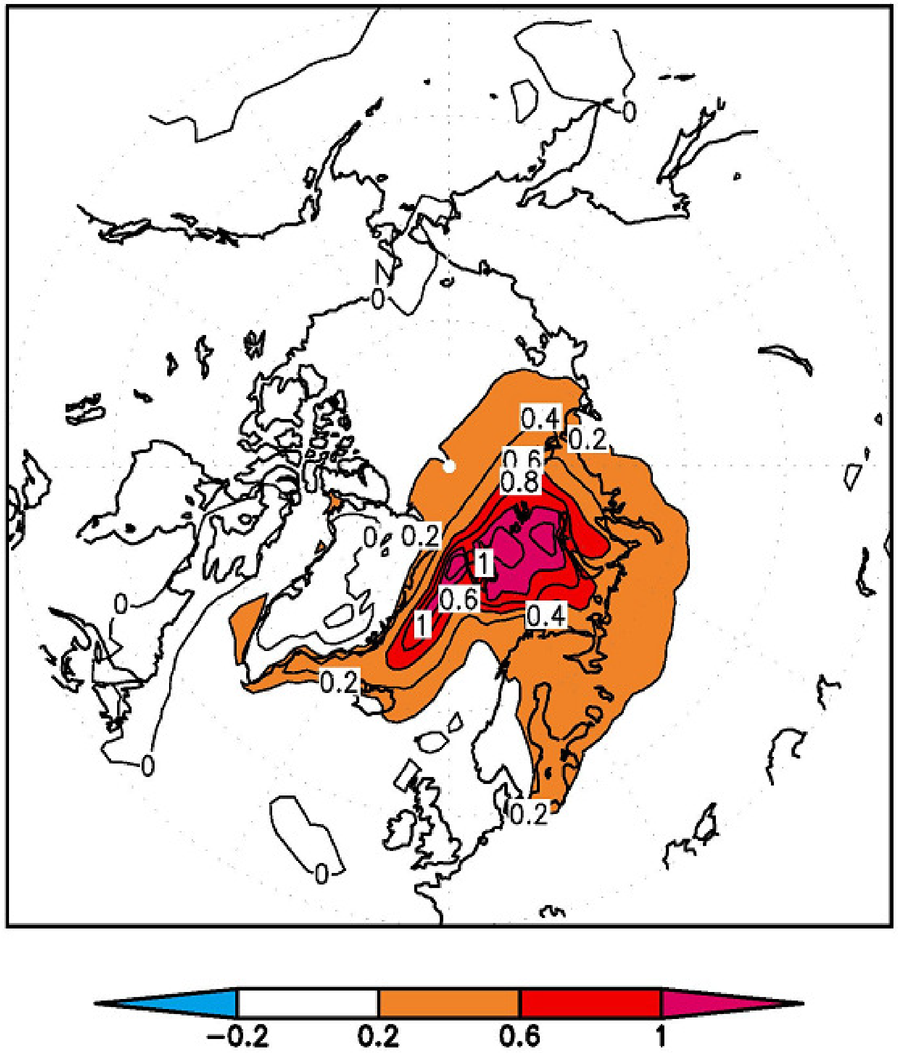




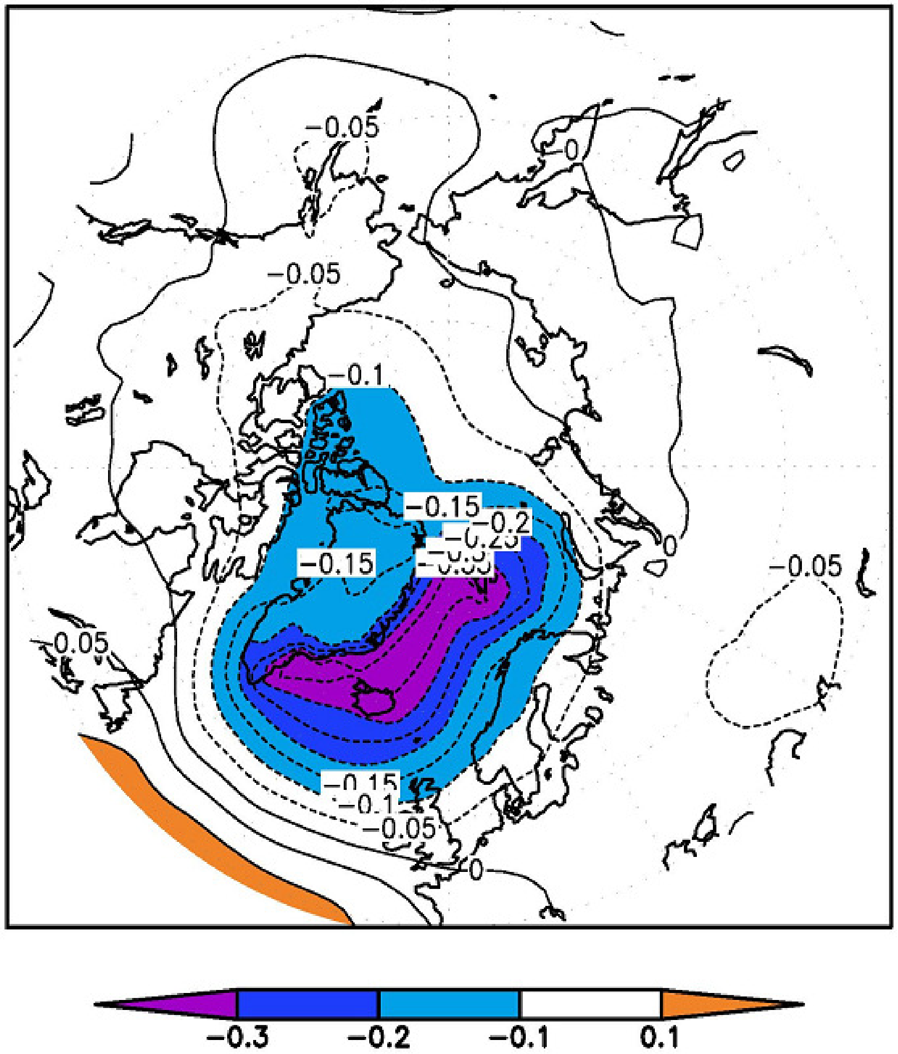
Composite of anomalies of current at 200m (top) and salinity at 200-1000m (bottom) during 15-year intervals of Arctic warming

Composite of surface temperature (left) and sea level pressure (right) anomalies

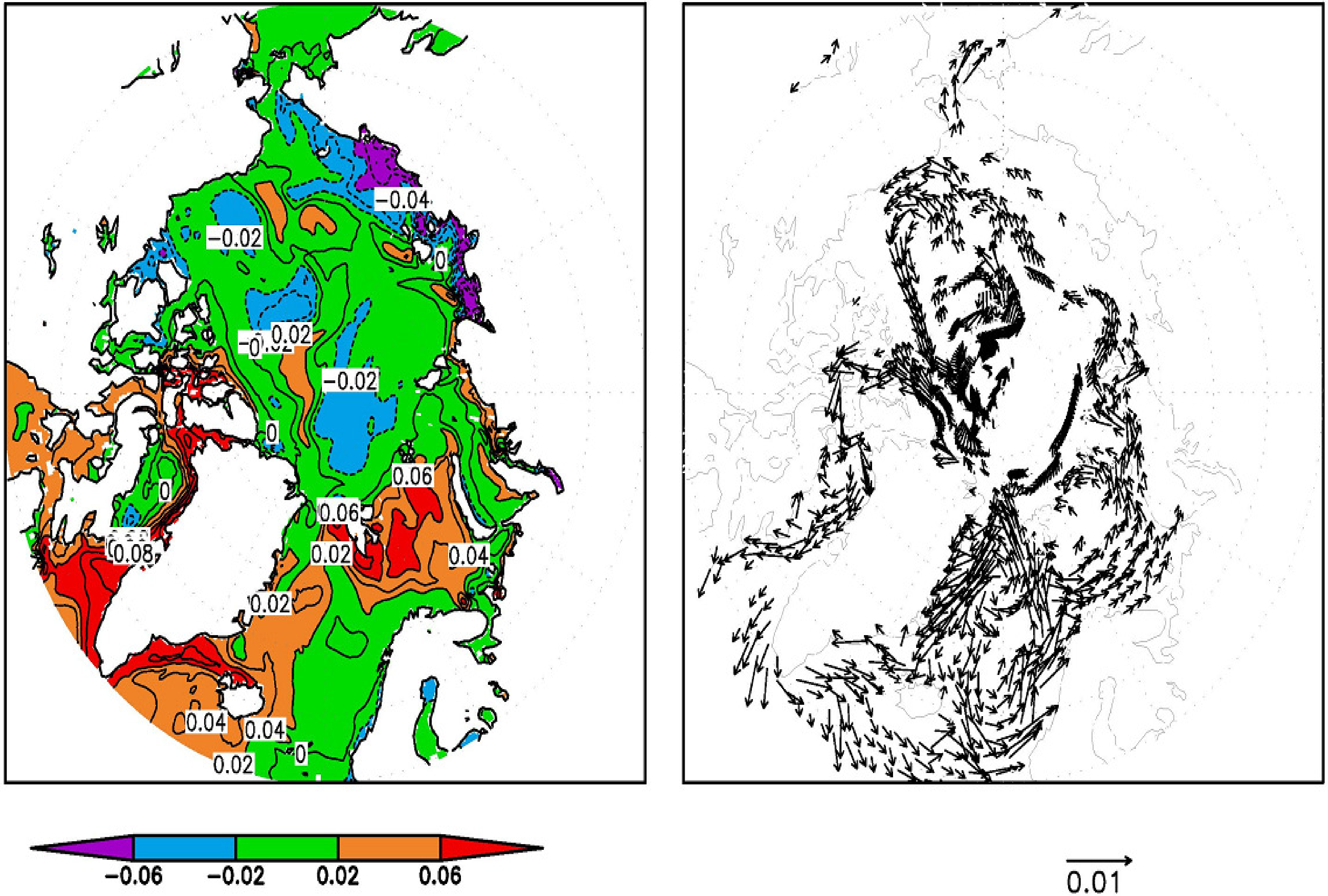
Surf. Temp. Arctic warming

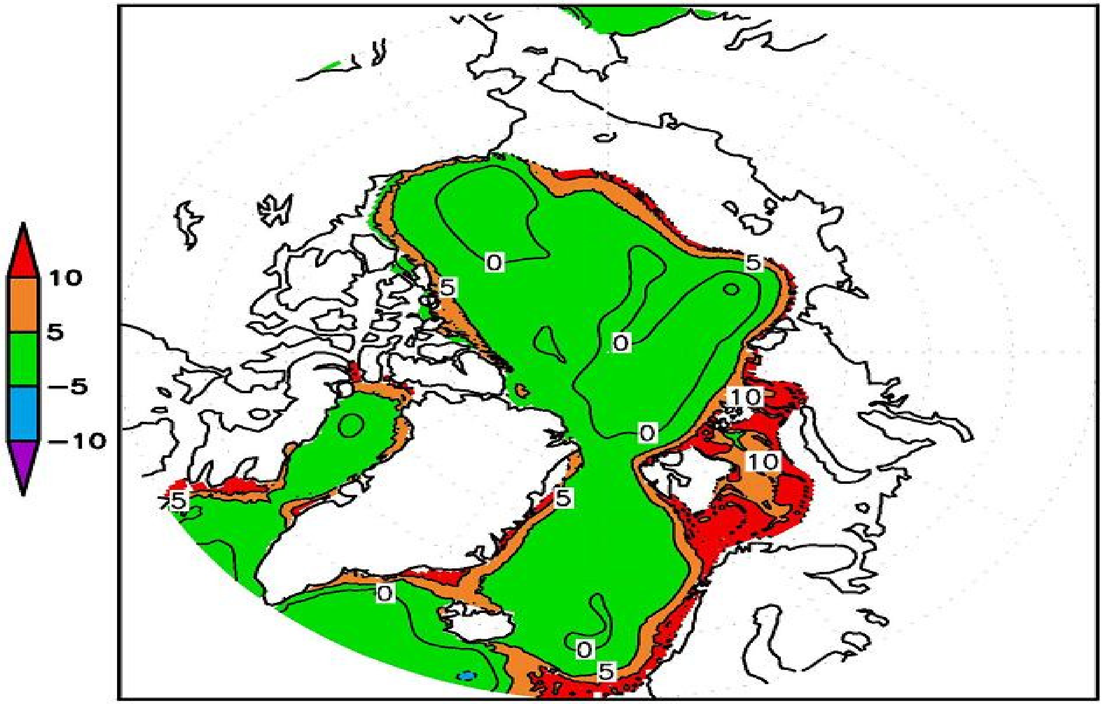


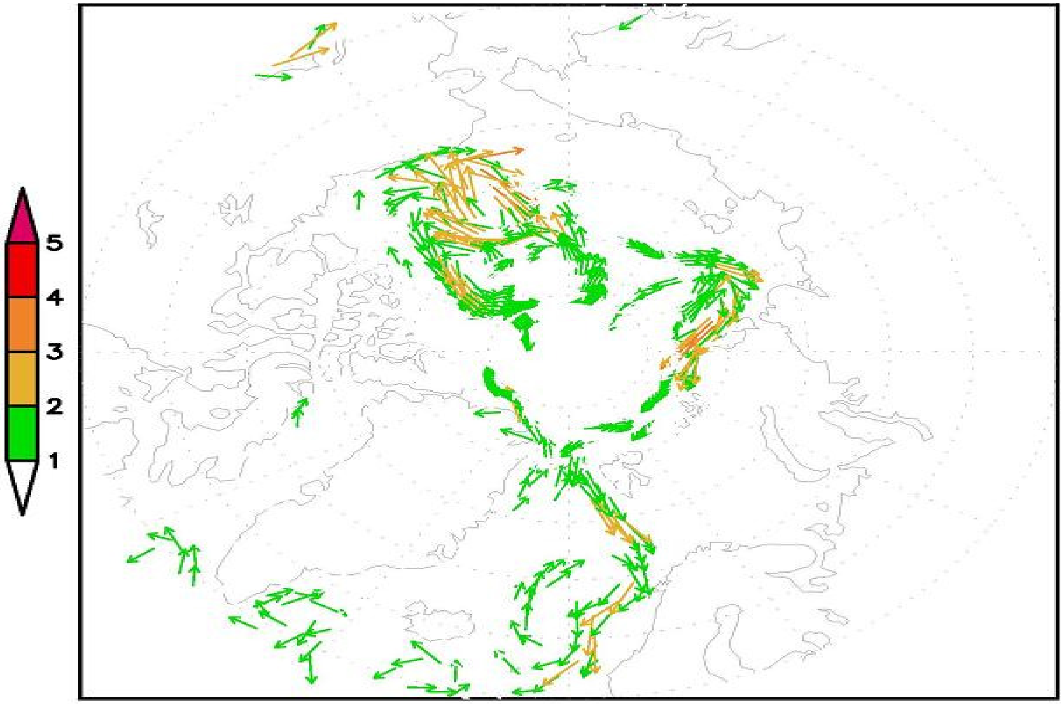
SLP Arctic warming



surface salinity and currents during Arctic warming







Composite analysis: Anomalies of currents at 200 m depth (top) and salinity at 200-1000 m (bottom) during 15-year interval **after** Arctic warming

Technique for oscillation analysis

If we have evolution equation for *C*:

$$\frac{\partial C}{\partial t} = \sum_{i=1}^{I} F_i$$

then we can perform Fourier transform for *C* and *Fi*:

$$C_n = CB(0) + \sum_{k=1}^{N/2} CA(k)\sin\left(2\pi\frac{nk}{N}\right) + CB(k)\cos\left(2\pi\frac{nk}{N}\right)$$

$$F_{in} = FB_i(0) + \sum_{k=1}^{N/2} FA_i(k)\sin\left(2\pi\frac{nk}{N}\right) + FB_i(k)\cos\left(2\pi\frac{nk}{N}\right)$$

If we define generation *G* as follows:

$$G = \frac{\partial(C^2/2)}{\partial t} = \sum_{i=1}^{I} CF_i$$

then generation of *k*-th harmonic by *Fi* will be calculated as:

$$G_i(k) = CA(k)FA_i(k) + CB(k)FB_i(k)$$

Also we can calculate the impact of each forcing *Fi* to evolution of oscillation phase of harmonic *k Pi(k):*

$$P_i(k) = \frac{-FA_i(k) \cdot CB(K) + FB_i(k) \cdot CA(k)}{\left(CA(k)^2 + CB(k)^2\right) \cdot 2\pi \frac{k}{N}}$$

Generation and impact to phase change of different terms for T and S.

ADV – advection, VD – surface fluxes and vertical diffusion, IS – isopycnal diffusion, RAD – solar radiation.

		FT_{ADV}	FT_{VD}	FT_{IS}	FT_{RAD}
T 0–100 m	G, $10^{-10} K^2/s$	4.03	–3.60	–1.62	1.38
	P	1.23	–0.10	–0.01	–0.10
T 100–1000 m	G, $10^{-10} K^2/s$	0.32	–0.12	–0.20	0.00
	P	0.74	0.05	0.12	0.00

		FS_{ADV}	FS_{VD}	FS_{IS}
S 0–100 m	G, 10^{-10} ‰$^2/s$	0.39	–0.39	0.02
	P	0.99	–0.13	0.00
S 100–1000 m	G, 10^{-14} ‰$^2/c$	9.9	13.9	–20.0
	P	0.93	–0.01	0.03

Generation of different terms for U and V.

ADV – advection, VD – surface fluxes and vertical diffusion, HD – horozontal diffusion, PC – pressure gradient.

		FU_{ADV}	FU_{VD}	FU_{HD}	FU_{PC}
U,V 0–100 m	G, 10^{-10} m^2/s^3	−3.6	43.0	−48.8	12.9
U,V 100–1000 m	G, 10^{-10} m^2/s^3	−7.46	−0.63	−10.7	19.0