A new detailed long-term hydrometeorological dataset: first results of extreme characteristics estimations over the Russia Arctic seas

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Motivation

- The **Arctic** is the region most sensitive to ***climate change*** on the globe.
- However, there are ***ambiguous estimates*** of the **climatological trends** over the Russian and other Arctic regions.
- ***Poor observational network*** and the increasing number of dangerous phenomena in the region requires ***more detailed*** hydrometeorological and climatic information.
- There are many data covering Arctic: ***satellite*** (QuikSCAT, AMSR-E, etc., grid >~20 km), ***reanalyses*** (e.g., ASR, 15 and 30 km grid). However, this resolution is ***not enough*** to reproduce mesoscale extreme events and many other important features.
- The most efficient tool to overcome this issue is **regional climate modeling**.
- The **task** of our study is to create a new **high-resolution dataset** over the western Arctic to provide the relevant information about Arctic climate, environment and its changes.

Methods

The main tool is the **COSMO-CLM** regional non-hydrostatic atmospheric climate model.

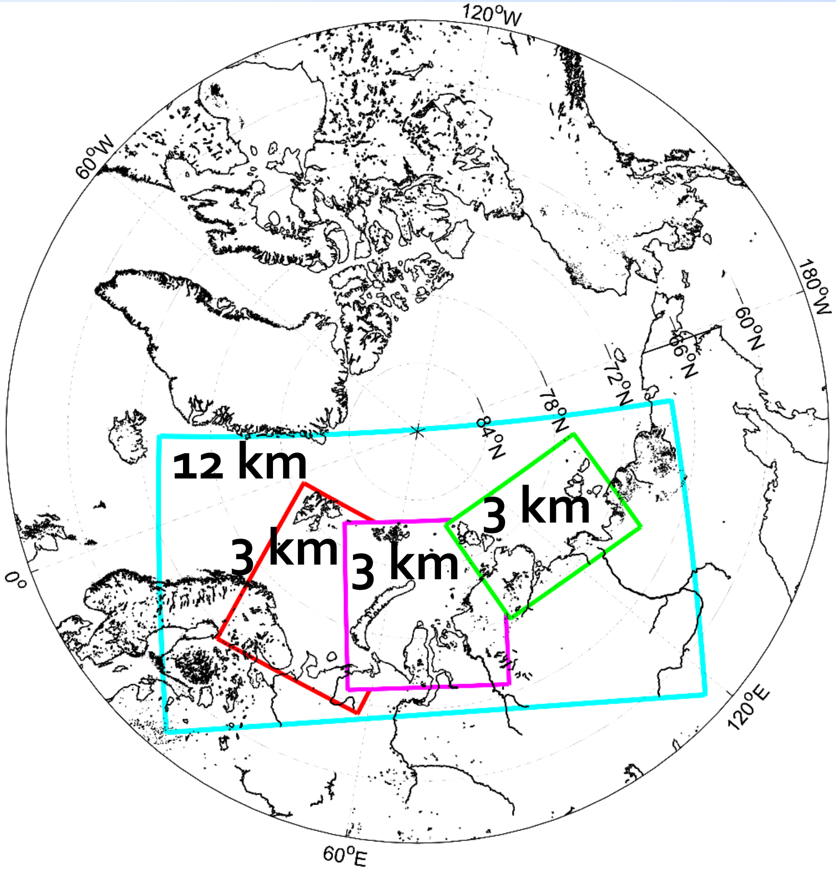
<u>COSMO-CLM</u> (ver. 5) is the <u>climate version</u> of the well-known mesoscale model **COSMO** developed by DWD and CLM-Community (https://wiki.coast.hzg.de/clmcom).

<u>Main characteristics of the supposed dataset:</u>

- **1980 – 2016** time period;
- MSU Supercomputer Complex **"Lomonosov-2"**;
- **50** vertical model levels;
- 2 steps of **dynamical downscaling** (~**12** and ~**3 km** horizontal resolution), **1-hour** temporal resolution;
- High-resolution (**~3 km**) domains over the **Barents**, **Kara** and **Laptev** Seas – **<u>in future</u>**;
- Many **dozens** of surface and model levels meteorological variables.

Experiments design

- **Downscaling scheme** included two steps of nested domains. The first step is the domain horizontal resolution ~12 km, ***forced by global reanalysis*** ERA-Interim.
- The second step will cover high-resolution domains over ***three Arctic seas***: Barents, Kara, Laptev (~3 km).



Brief model description
Runge-Kutta integration scheme with 5th advection order
height-based hybrid Gal-Chen coordinate
Ritter and Geleyn radiation scheme
bulk microphysics parameterization
Tiedtke mass-flux schemes used for moist and shallow convection
turbulence is described by a prognostic TKE-based scheme, with 2.5 order closure
Smagorinsky diffusion;

Based on test experiments and verification results, the following **optimal model configuration** will be chosen:

- ‘spectral nudging’;
- new model version 5.05 including turbulence scheme correction;
- ERA-Interim reanalysis used as driving conditions

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Additional soil data assimilation

Model was ***reinitialized monthly*** to control the *«long-term memory»* of climate system better.

U, V, T, TQV, TQC, TQI, TQG, TQR, TQS, T_S, T_SO[1,2], T_ICE, H_ICE, C_T_LK, DEPTH_LK, H_B1_LK, H_ML_LK, T_B1_LK, T_BOT_LK, T_MNW_LK, T_WML_LK, PP variables ***were used*** from the reanalysis **laf-file** in the model's last output **lffd-file**.

laf${YEAR}${MONTH}0100.nc

lffd${YEAR}${MONTH+1}0100.nc

laf${YEAR}${MONTH+1}0100.nc

Substitution of atmospheric variables from the last model output ***lffd…nc*** file into the reanalysis ***laf…nc*** file.

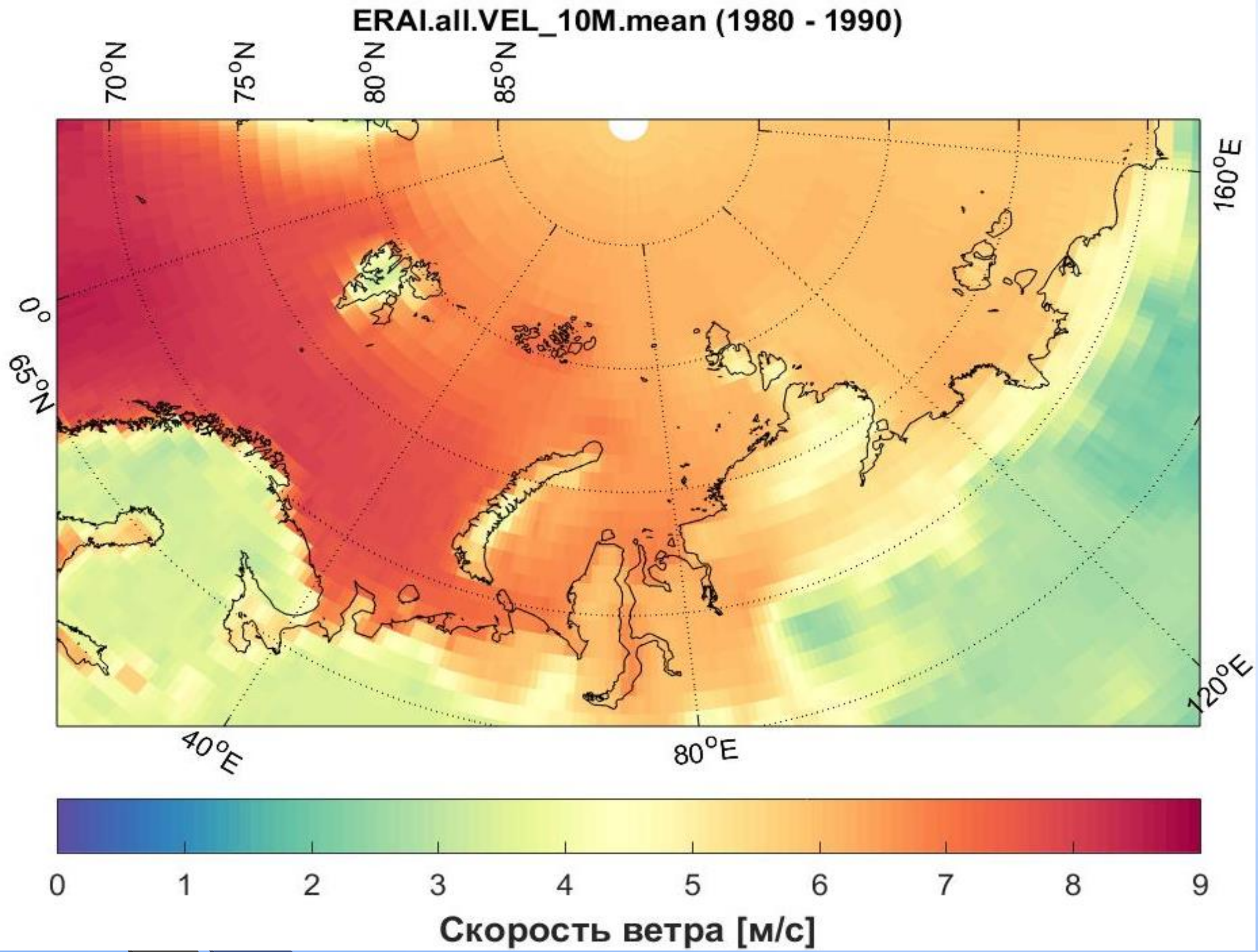
lffd${YEAR}${MONTH+2}0100.nc

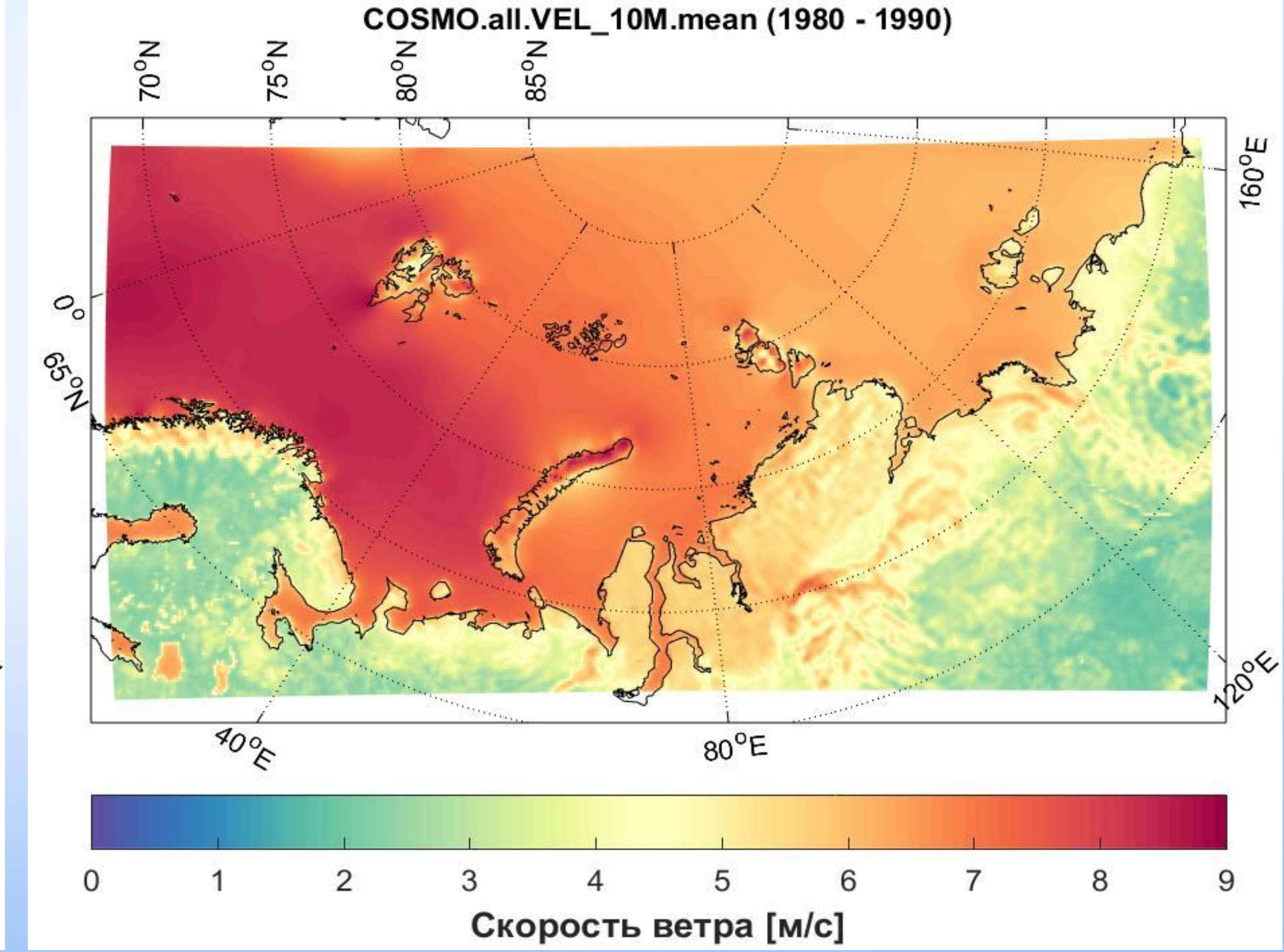
laf${YEAR}${MONTH+2}0100.nc

Etc. …

lffd…0100.nc

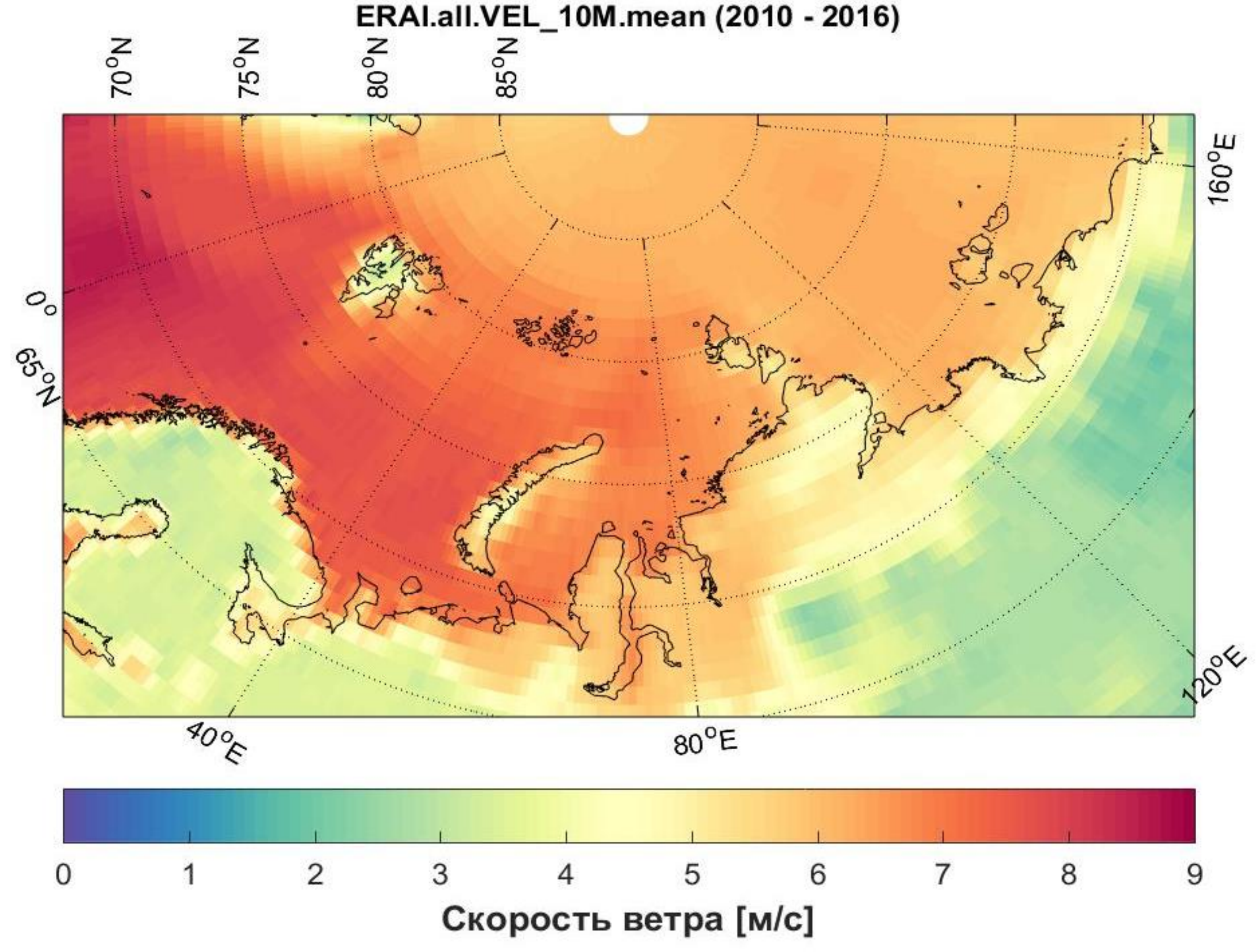
Results. Dataset and ERA-I comparison. Wind speed.

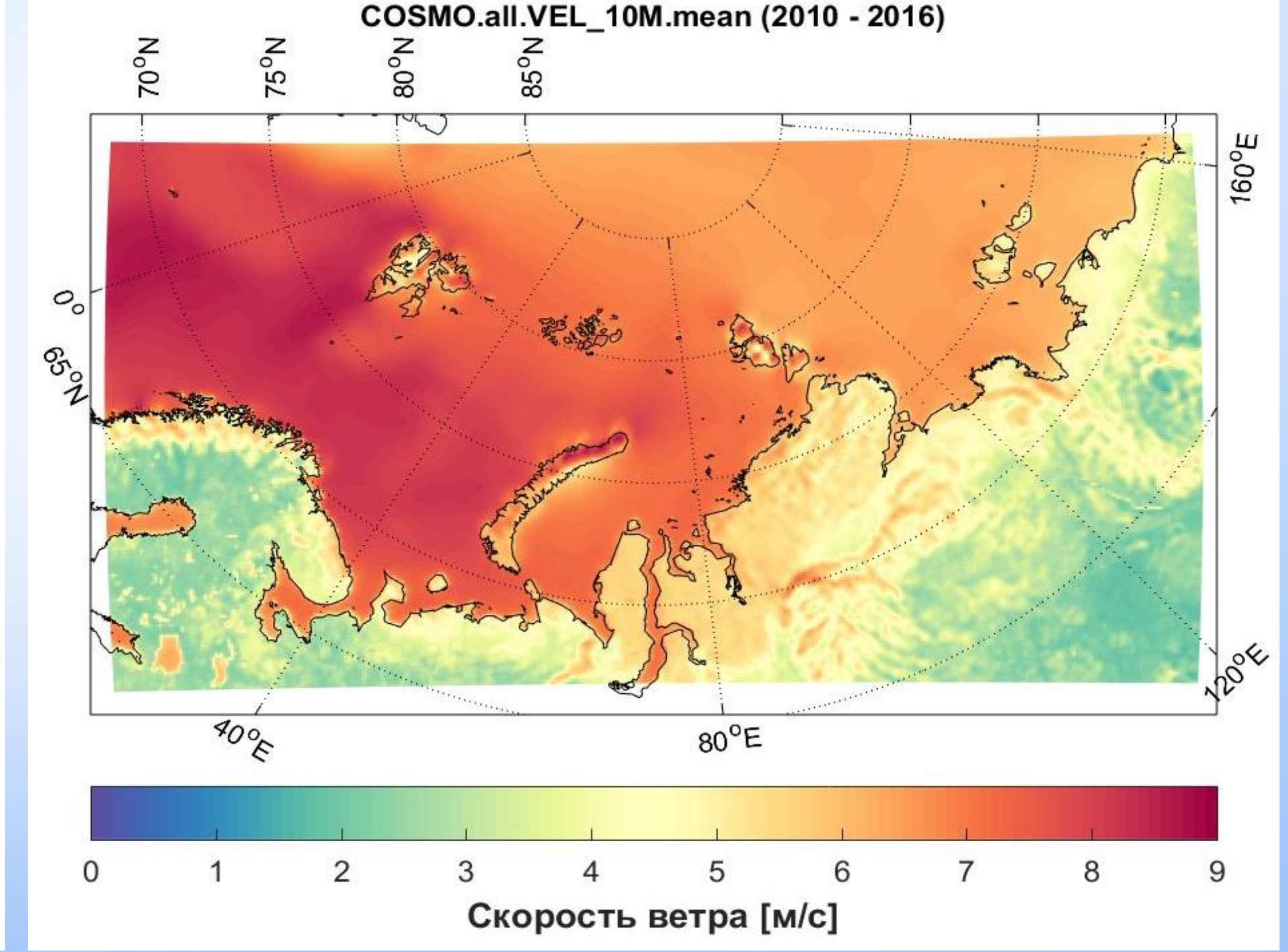




ERA-Interim (left) and COSMO-CLM dataset (right) – average 10 m wind speed (m/s) for 1980 – 1990.

Results. Dataset and ERA-I comparison. Wind speed.





ERA-Interim (left) and COSMO-CLM dataset (right) – average 10 m wind speed (m/s) for 2010 – 2016.

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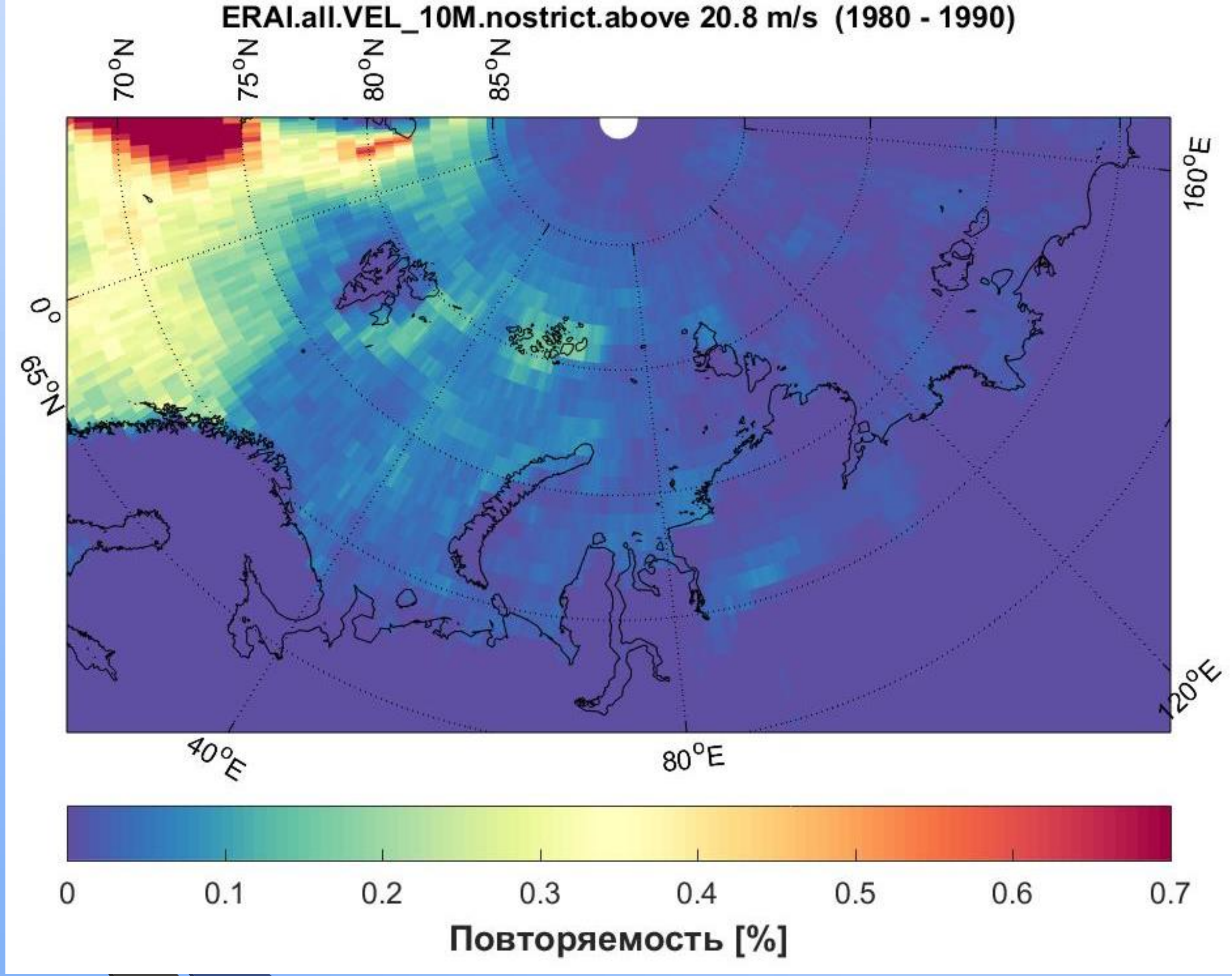
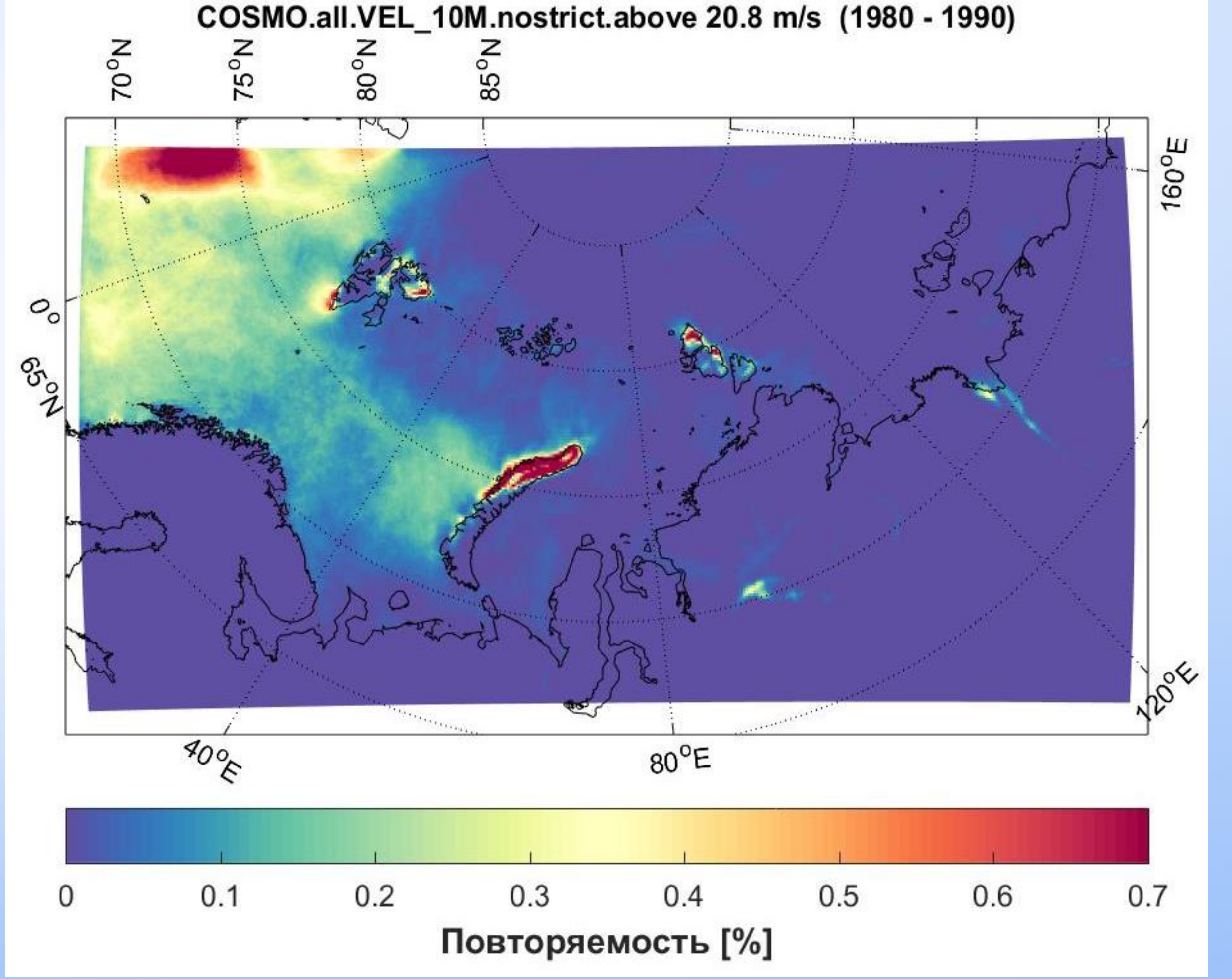
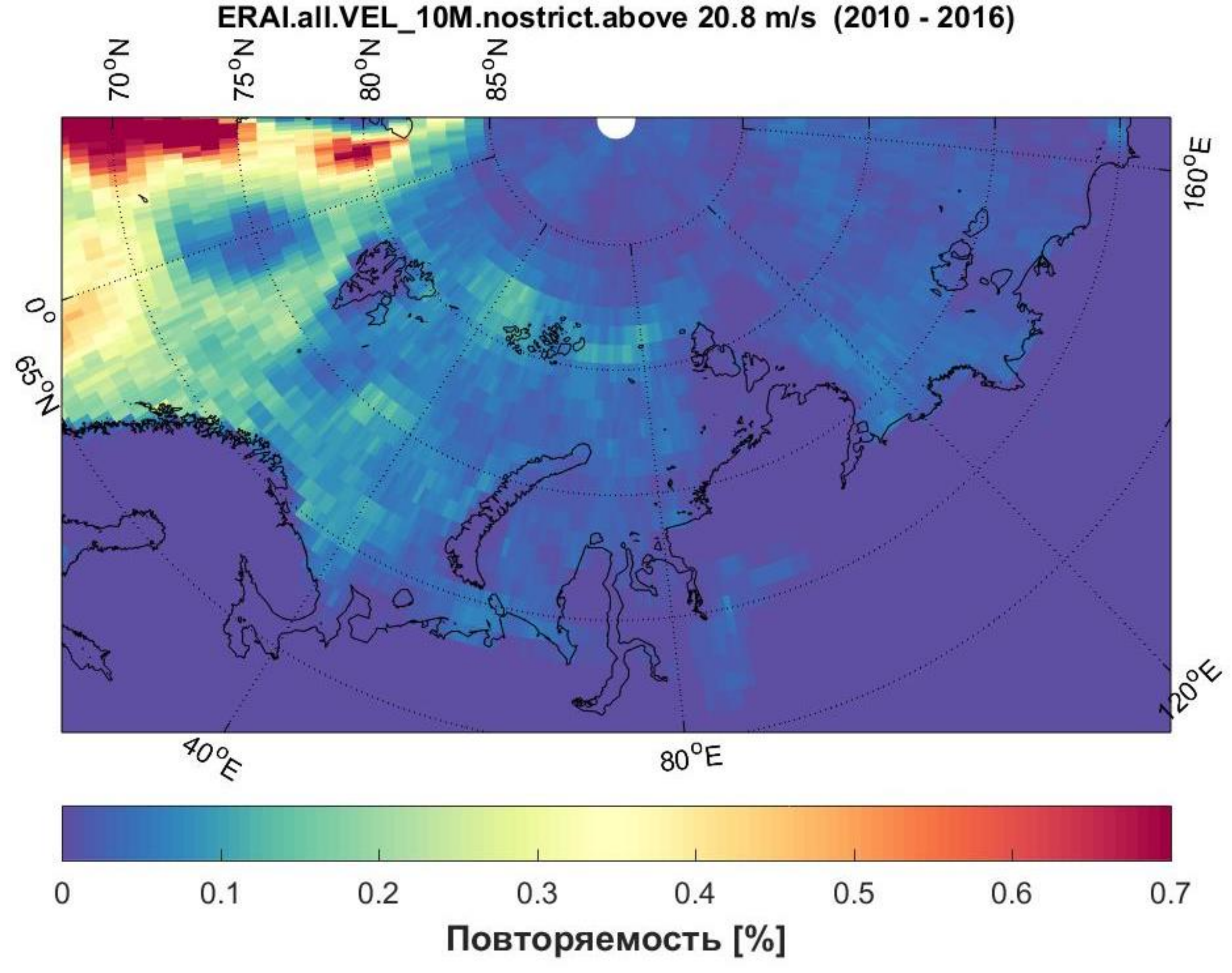
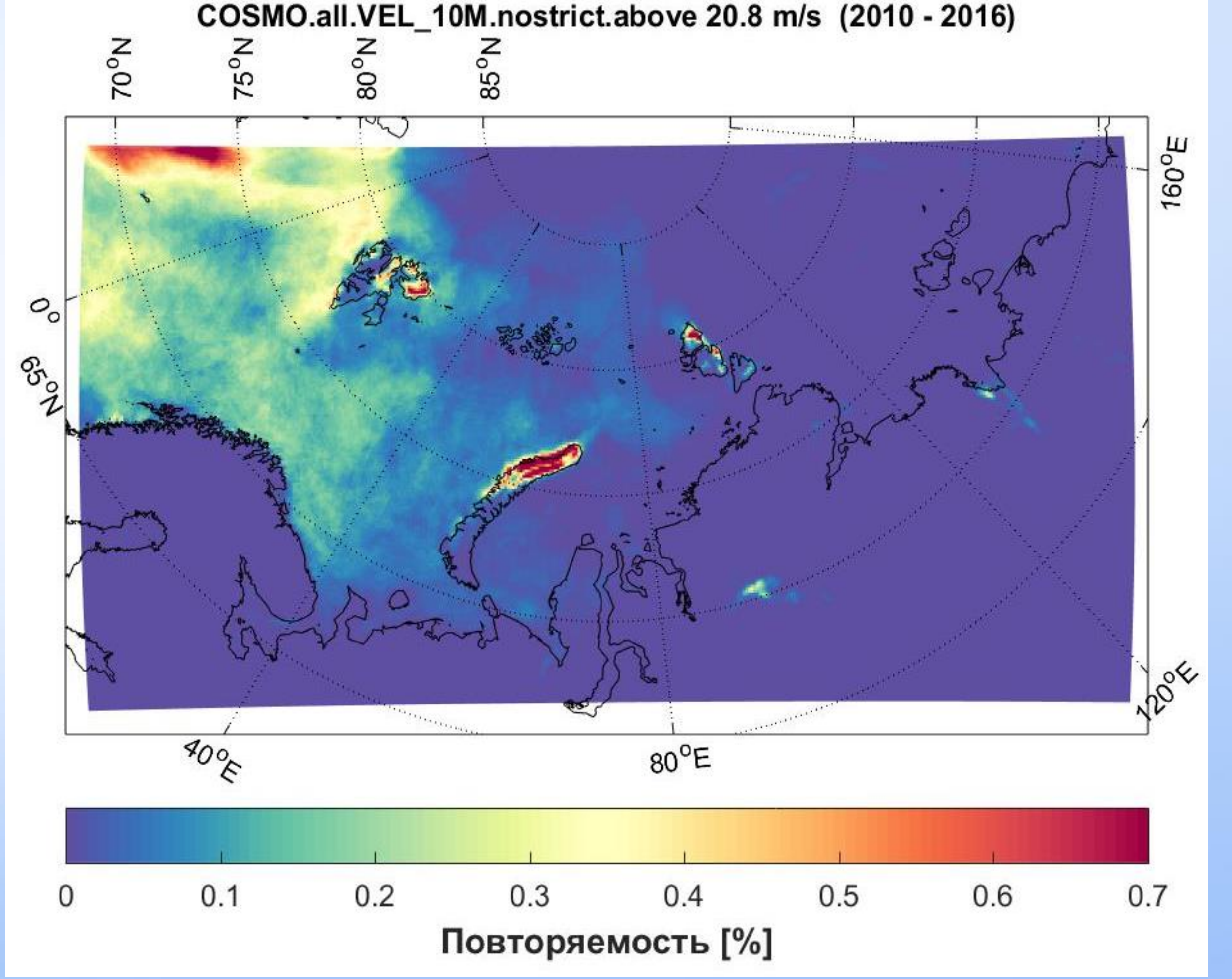




ERA-Interim (left) and COSMO-CLM dataset (right) – frequency (%) of 10 m wind speed above 20.8 m/s for 1980 – 1990.

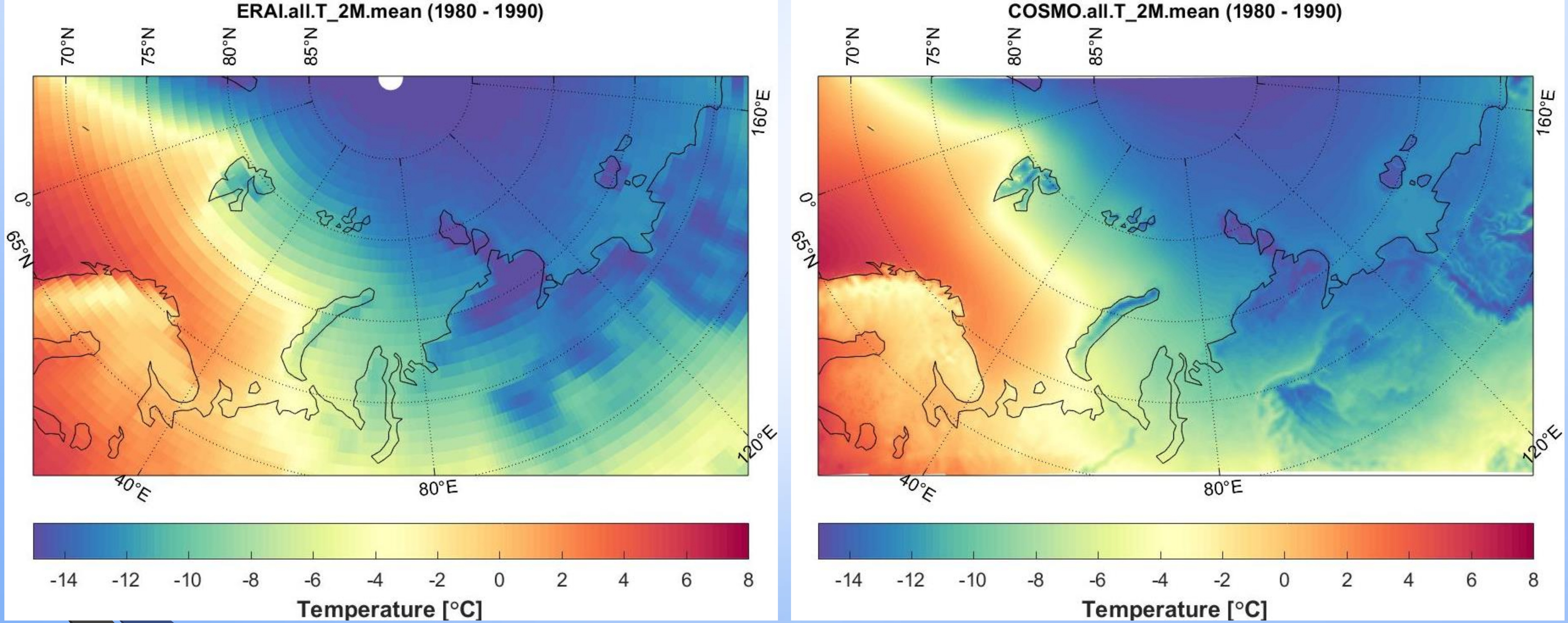
Results. Dataset and ERA-I comparison. Wind speed.





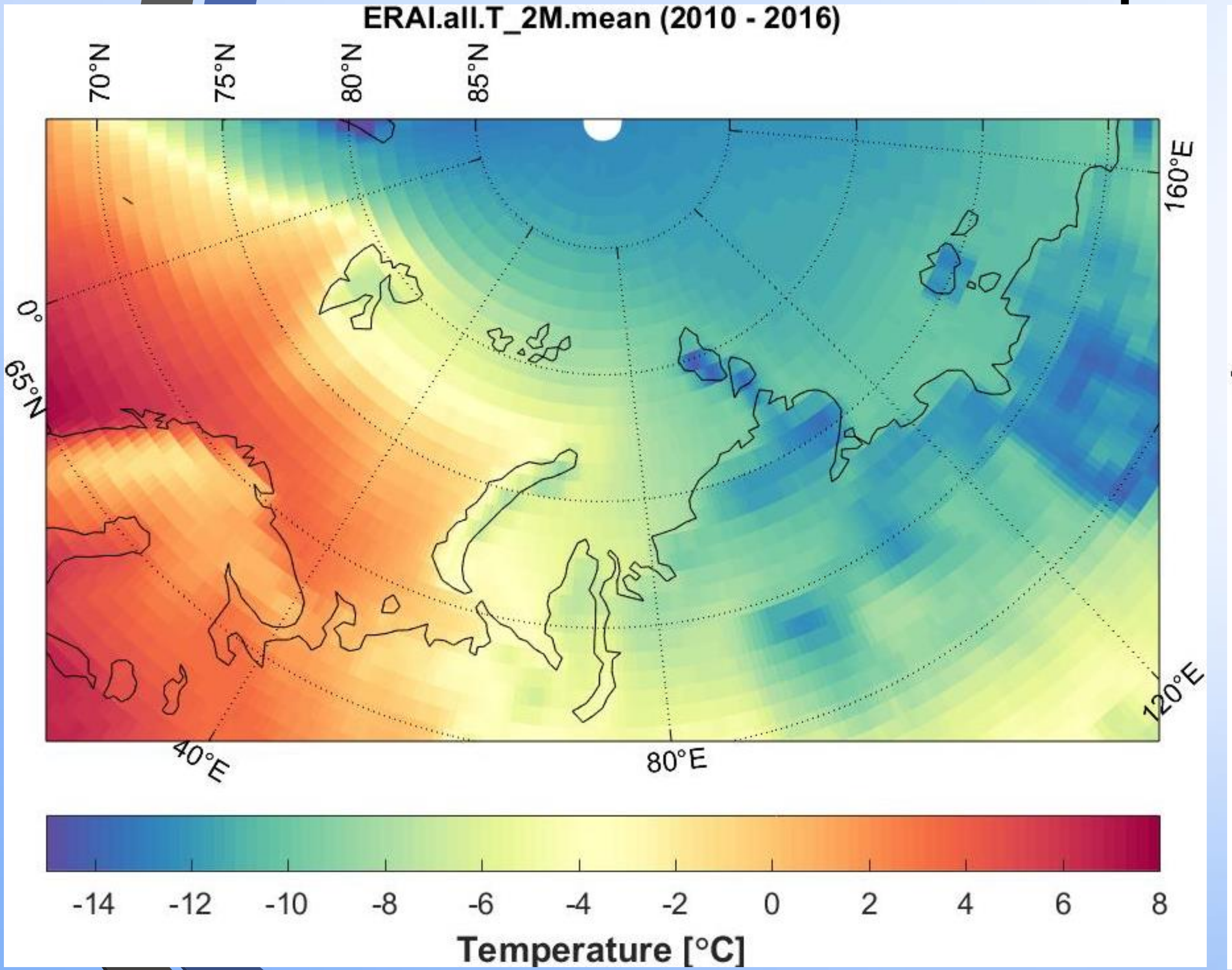
ERA-Interim (left) and COSMO-CLM dataset (right) – frequency (%) of 10 m wind speed above 20.8 m/s for 2010 – 2016.

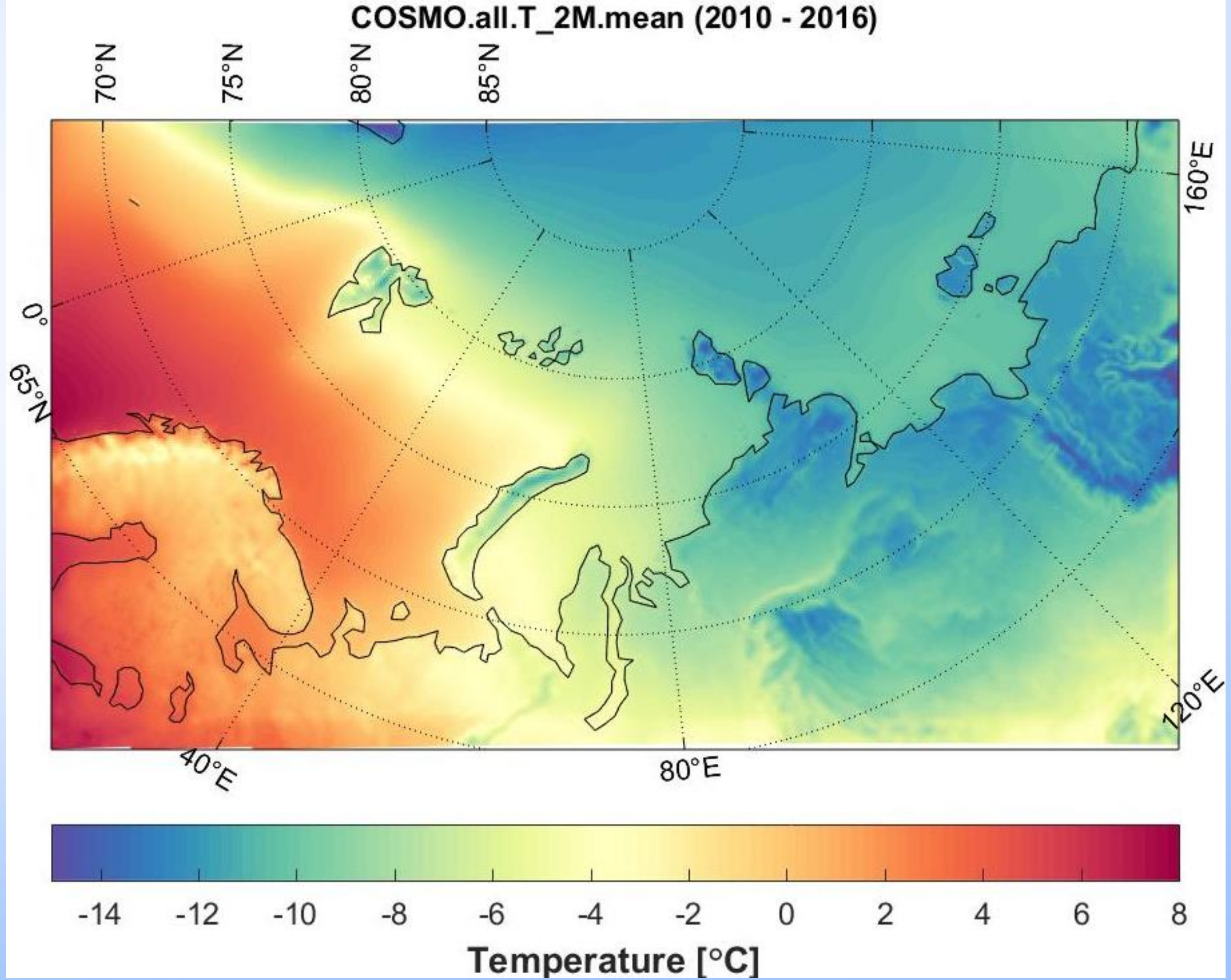
Results. Dataset and ERA-I comparison. Temperature.



ERA-Interim (left) and COSMO-CLM dataset (right) – mean temperature (^{0}C) for 1980 – 1990.

Results. Dataset and ERA-I comparison. Temperature.





ERA-Interim (left) and COSMO-CLM dataset (right) – mean temperature (^{0}C) for 2010 – 2016.

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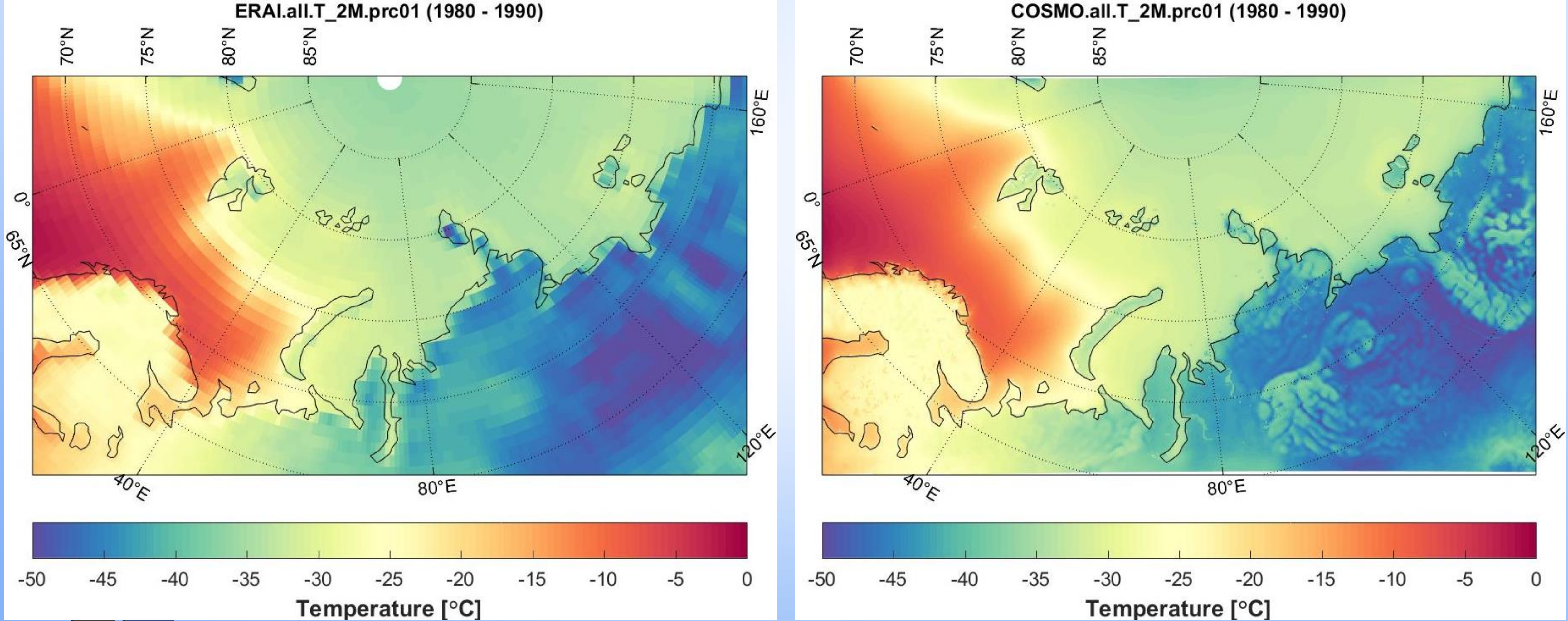
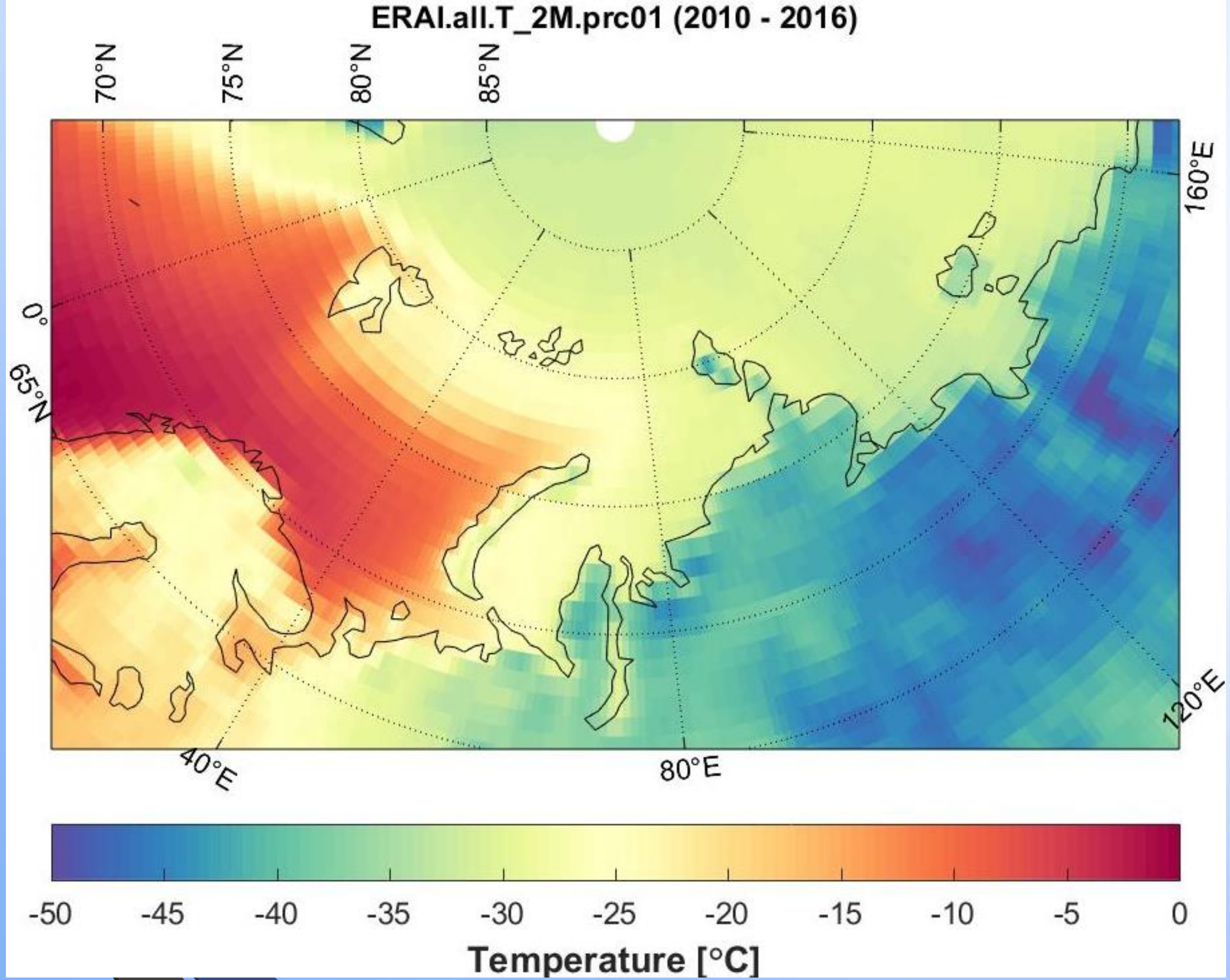
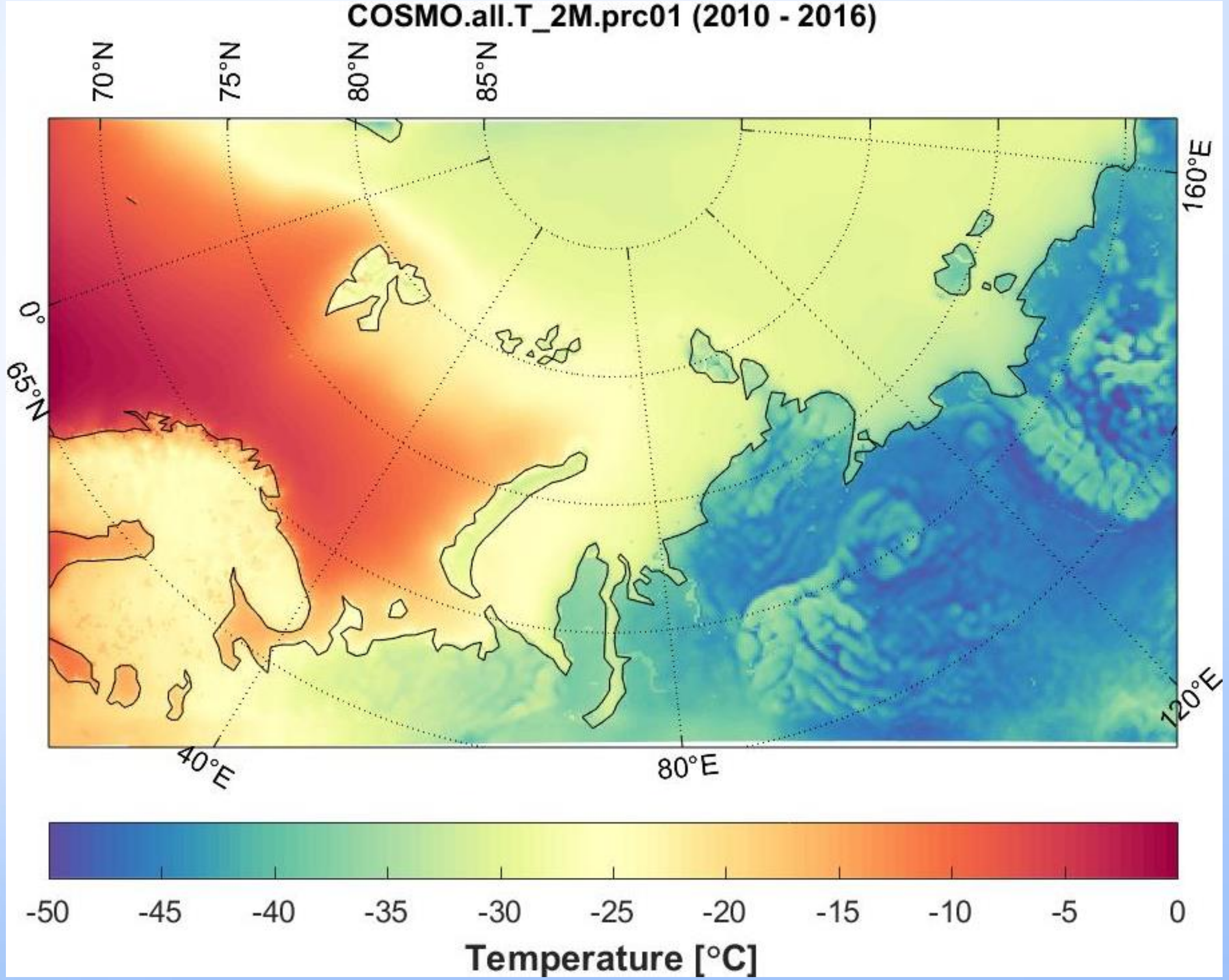


ERA-Interim (left) and COSMO-CLM dataset (right) – 1% temperature percentile (^{0}C) for 1980 – 1990.

Results. Dataset and ERA-I comparison. Temperature.





ERA-Interim (left) and COSMO-CLM dataset (right) – 1% temperature percentile (^{0}C) for 2010 – 2016.

Dataset characteristics

- **1980 – 2016** years period (currently 1980 – 2008, 2010 – 2016) with prospective extension to 2019;
- **Domain** with ~**13 km grid**, and prospective nested domains with ~**3 km grid** for the **Barents, Kara** and **Laptev** Seas;
- **Computational resources**: ~ **62 000** nodes-hours, more than **120 Tb** total dataset volume (at finish).

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V. Platonov and M. Varentsov. A new detailed long-term hydrometeorological dataset: first results of extreme characteristics estimations over the Russia Arctic seas. *Will be submitted to IOP Conference Series: Earth and Environmental Science in 2020.*

Conclusions

- ✓ First version of **COSMO-CLM long-term hydrometeorological dataset** was created for the Russian Arctic area, including dozens of variables with ~12 km grid.
- ✓ An additional **assimilation scheme of soil properties** from reanalysis was successfully applied using monthly reinitialization of the model.
- ✓ Preliminary assessments of the **wind speed climatology** based on COSMO-CLM dataset is very close to the ERA-Interim distribution, besides many details at different Arctic regions.
- ✓ **High wind speed frequencies** based on COSMO-CLM dataset **are increased** compared to ERA-Interim, especially over the Barents Sea, Arctic islands (Novaya Zemlya) and some seacoasts and mainland areas.
- ✓ Comparison of two analyzed periods (**1980 – 1990** and **2010 – 2016**) has shown that spatial distributions of high wind speed frequencies are very similar, but **there are some detailed differences**, which could be attributed as manifestations of climate changes in Arctic region.
- ✓ The problem of a **huge data volume**, its **storage** and **online sharing** to scientific community will be hopefully solved in the near future…

Future perspectives and potential dataset applications

- ❖ Dataset comparison with other archives and reanalyses (ERA5, ASR, QuikSCAT), dataset quality estimation;
- ❖ Extreme and severe events frequency and physical mechanisms investigation over Arctic area (e.g., Novaya Zemlya Bora; extreme temperatures; polar lows);
- ❖ Estimation of surface heat fluxes in Arctic area;
- ❖ Forcing data for ocean modelling (waves, circulation);
- ❖ Detailed regional Arctic climate changes assessment;
- ❖ Arctic climatic resources
- ❖ Etc. …

Collaboration is encouraged!

Variables description

Variable name	Variable description	Variable name	Variable description
U	U-component of wind	T_ICE	temperature of ice upper surface
V	V-component of wind	H_ICE	sea ice thickness
T	temperature	C_T_LK	shape factor of temperature profile in lake thermocline
TQV	precipitable water	DEPTH_LK	lake depth
TQC	vertical integrated cloud water	H_B1_LK	thickness of the upper layer of bottom sediments
TQI	vertical integrated cloud ice	H_ML_LK	thickness of mixed layer
TQG	total graupel content vertically integrated	T_B1_LK	temperature at bottom of upper layer of sediments
TQR	total rain water content vertically integrated	T_BOT_LK	temperature at water bottom sediment interface
TQS	total snow content vertically integrated	T_MNW_LK	mean temperature of water column
T_S	soil surface temperature	PP	deviation from reference pressure
T_SO [1,2]	soil temperature (1st and 2nd soil layers)		

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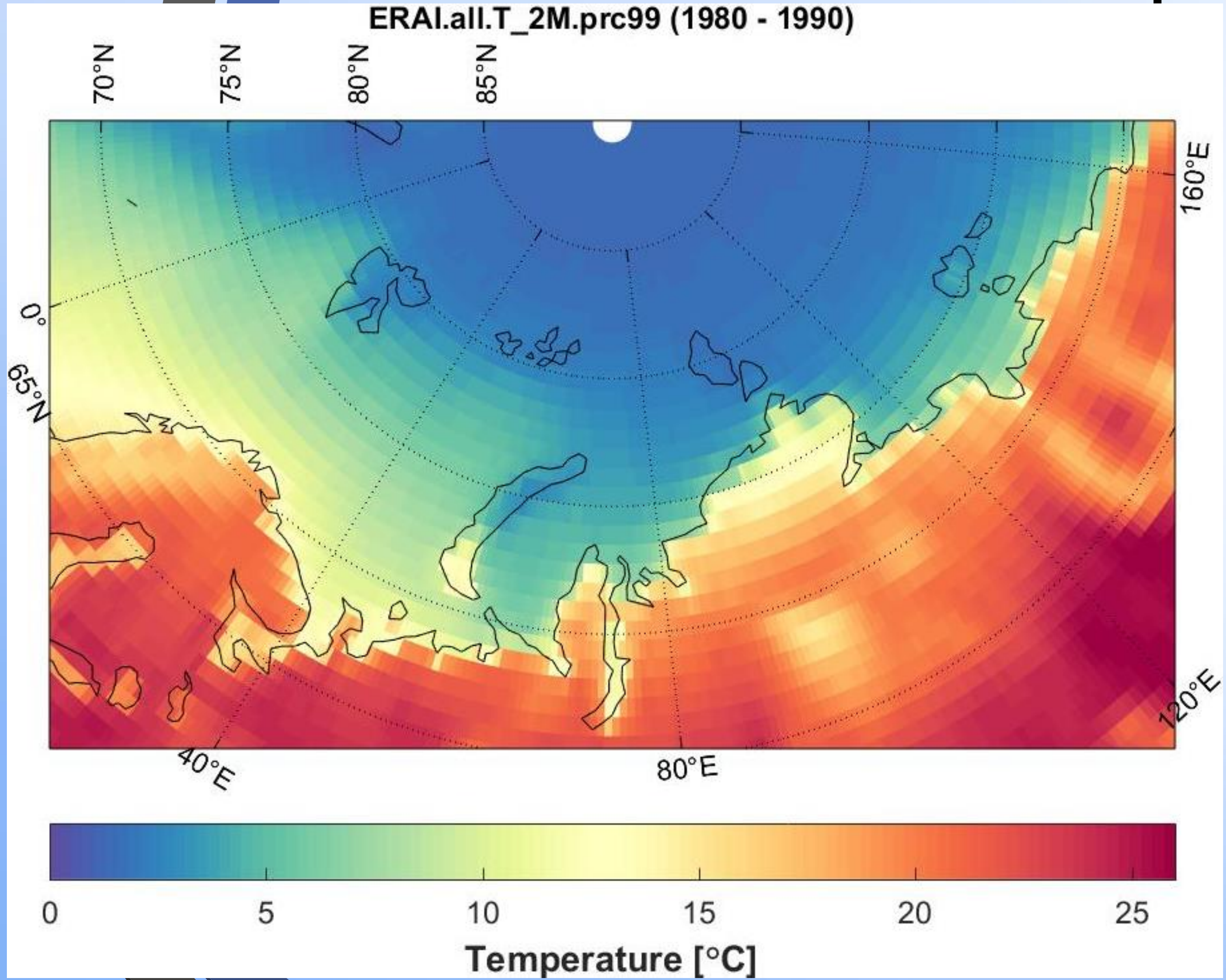

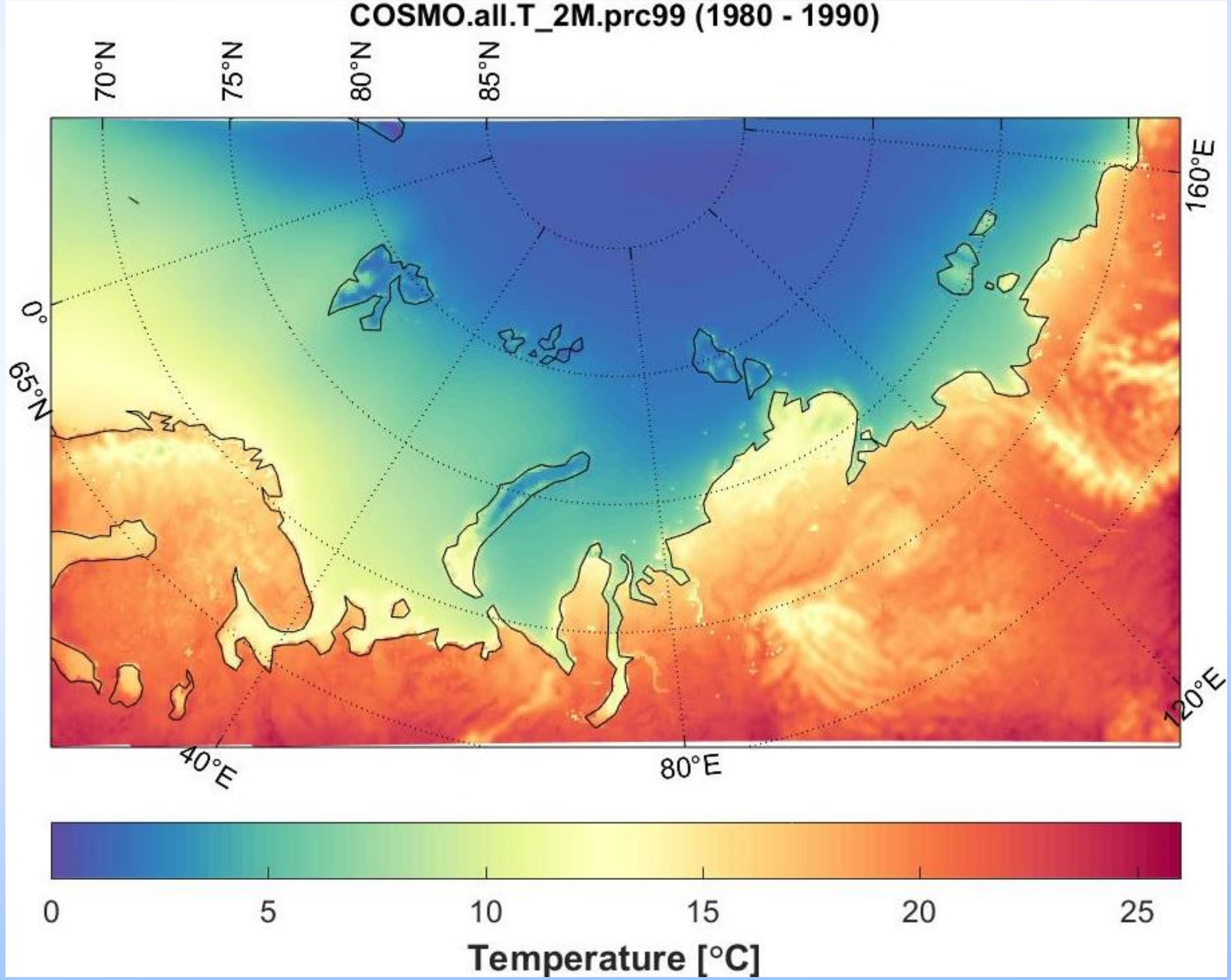

ERA-Interim (left) and COSMO-CLM dataset (right) – 99% temperature percentile (^{0}C) for 1980 – 1990; 2010 – 2016.

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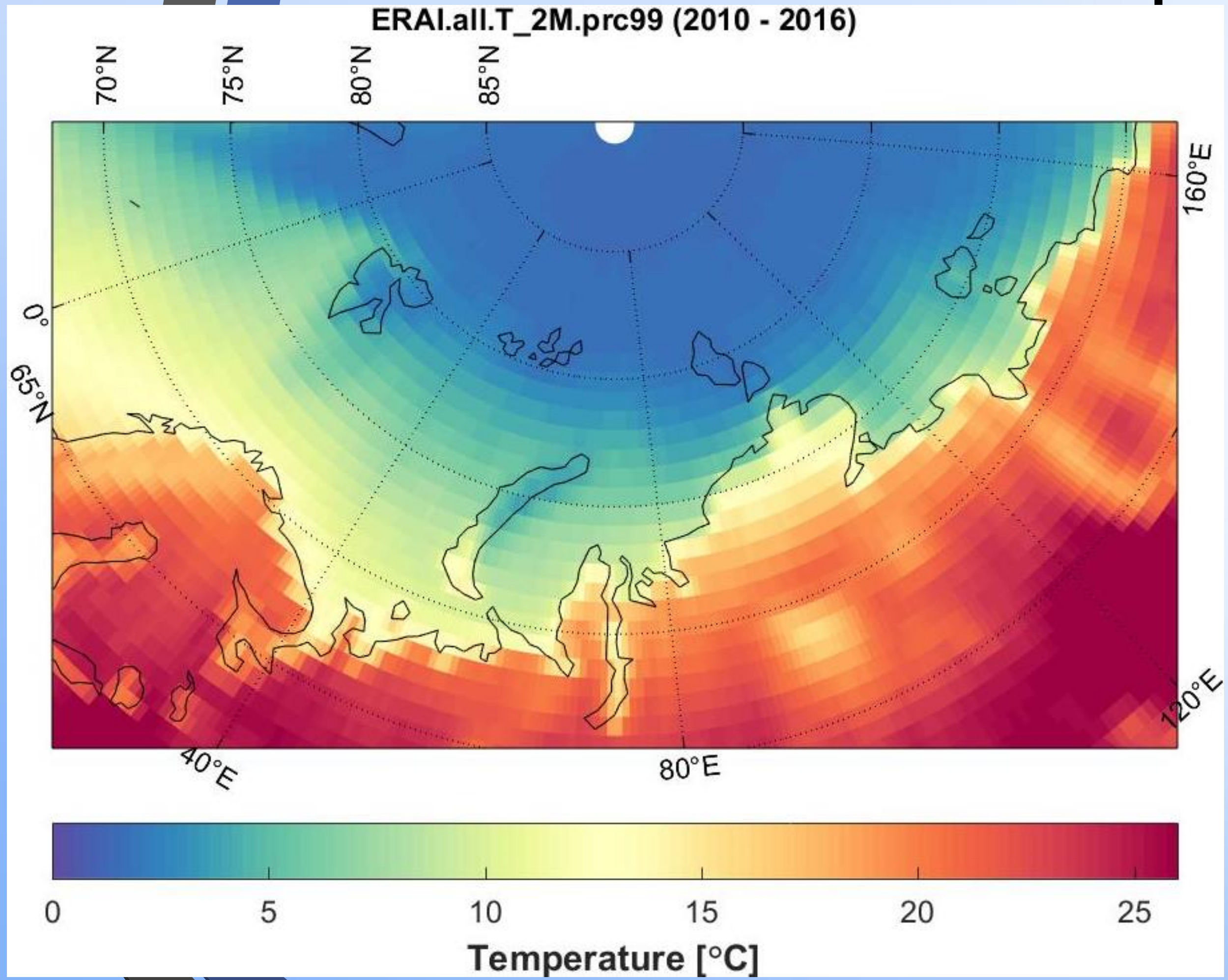

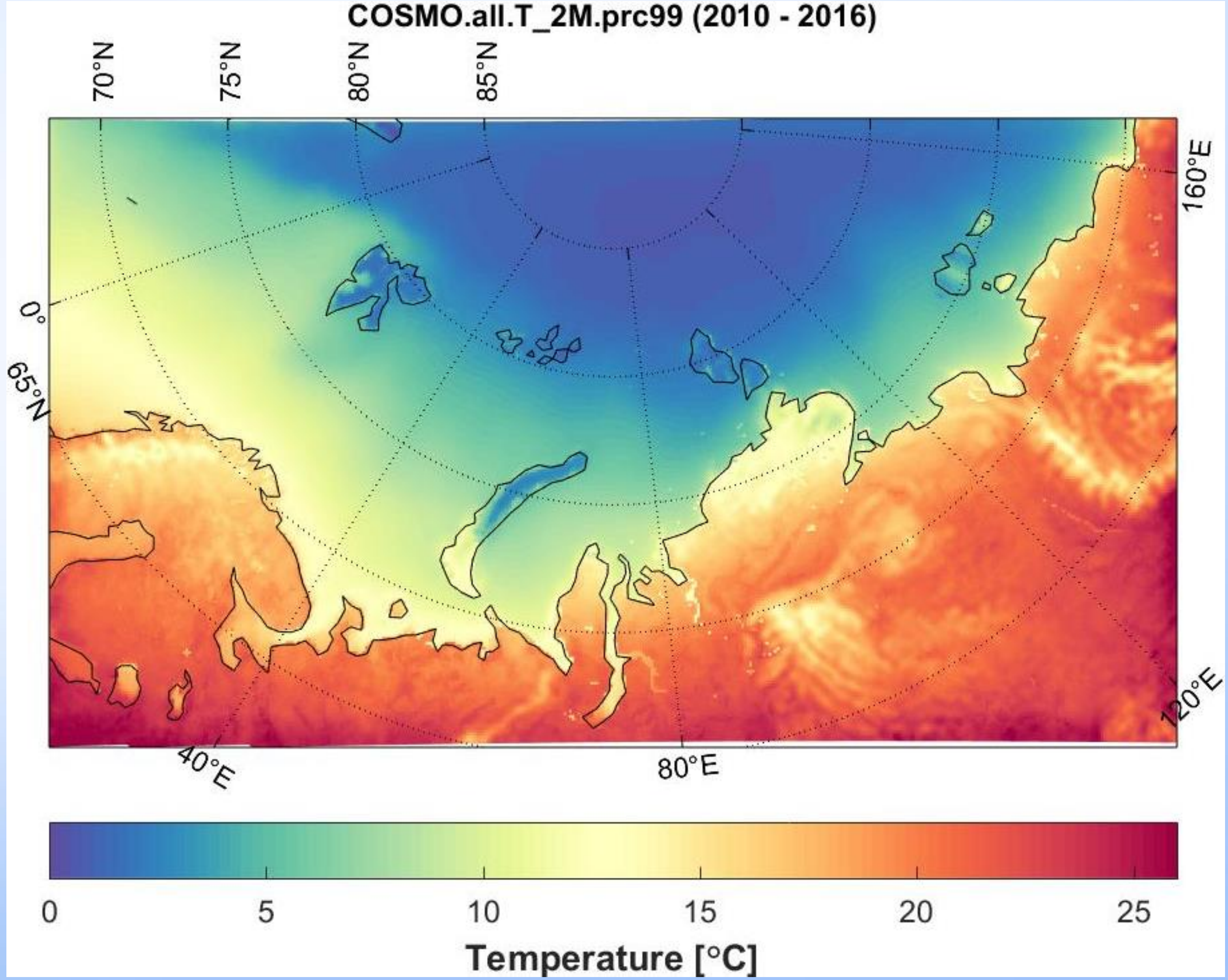

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