Modeling of the extreme winds over the Russian Arctic basin using different COSMO-CLM model resolutions

Goals:

- simulation of extreme winds over the Arctic during different synoptic situations
- investigation of different COSMO-CLM model domains and resolutions
- investigation of model possibilities for reproducing the different wind extremes

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Motivation and definitions:

According to [Sornette, 2009] we used the terminology of '***black swans***' and '***dragons-kings***' for the specific wind velocity extremes sorted out from Russian Arctic observation data.

$$U(p) = \left(\frac{1}{A}\ln\frac{1}{1-p}\right)^{1/k}$$ (threshold *p* was accepted as *p=0.99*)

The Weibull distribution of wind velocities revealed two different characteristics, looked like essentially diverse samples. The first group of extremes was attributed as '***black swans***', and the second one as '***dragons-kings***'.

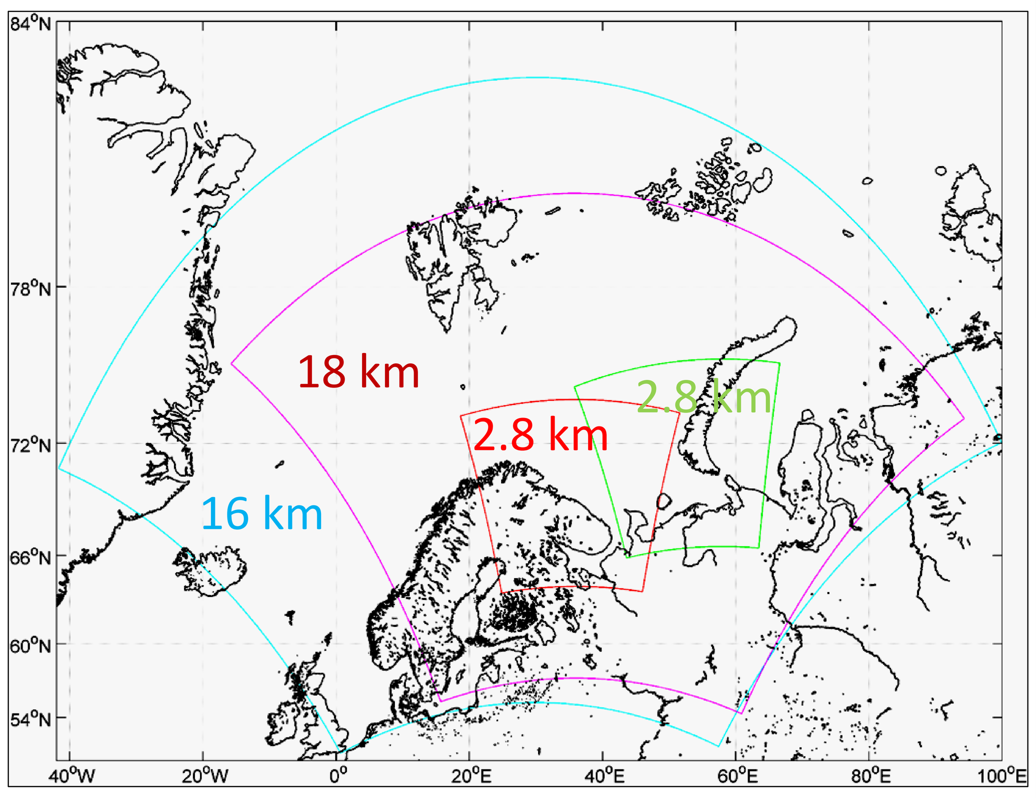
Some cases have been used for extreme winds simulation with COSMO-CLM-5.0 model: 29-30.10.2000, 26.01.2002, 12.12.2013 and January 2010.

COSMO scheme for diagnosis near-surface wind gusts ([Schulz, Heise, 2003]):

$$V_{\text{turb}} = (1+\alpha\sqrt{C_{\text{m}}})V_{\text{KE}} \qquad V_{\text{conv}} = \sqrt{\beta\int_0^H 2g\frac{\Delta\Theta}{\Theta}\text{d}z + V(H)^2} \qquad V_{\text{gust}} = \max(V_{\text{turb}}, V_{\text{conv}})$$

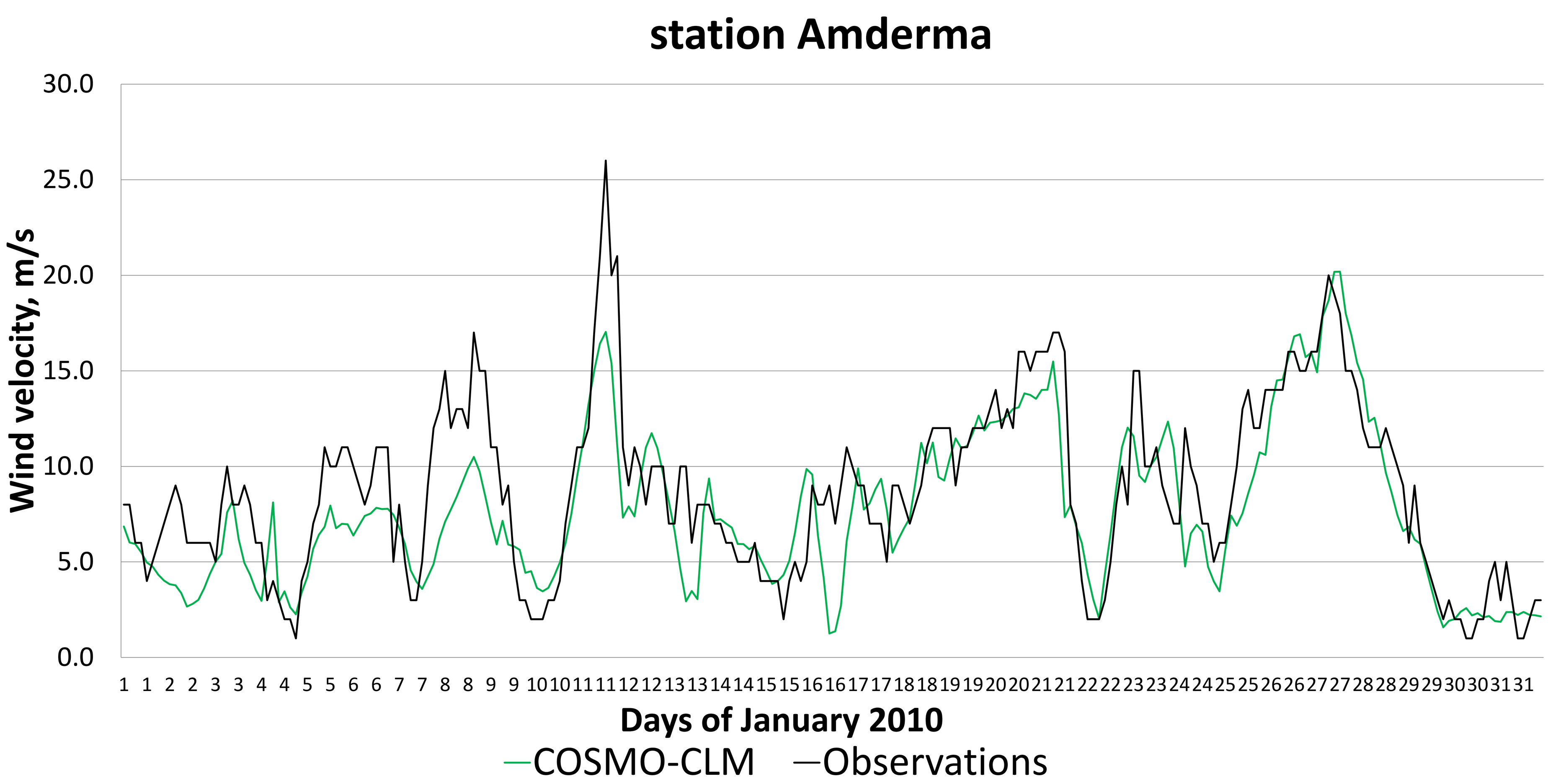
Model domains and experiments:

COSMO-CLM ver. 5.0 was used for experiments. Standard model configuration with R-K integration scheme (5th advection order) and Tiedtke convection scheme.



	Two domains with downscaling		Large domain (without downscaling)
Periods	Case studies (~7 days run)		January 2010
Resolution	0.165^0 (18km)	0.025^0 (2.8 km)	0.15^0 (16 km)
Domains size	164*146*40	380*400*40 326*364*40	245*190*50
dt	100	40	100
Forcing	ERA-Interim	COSMO 18km	NCEP-CFSR

Results for January 2010



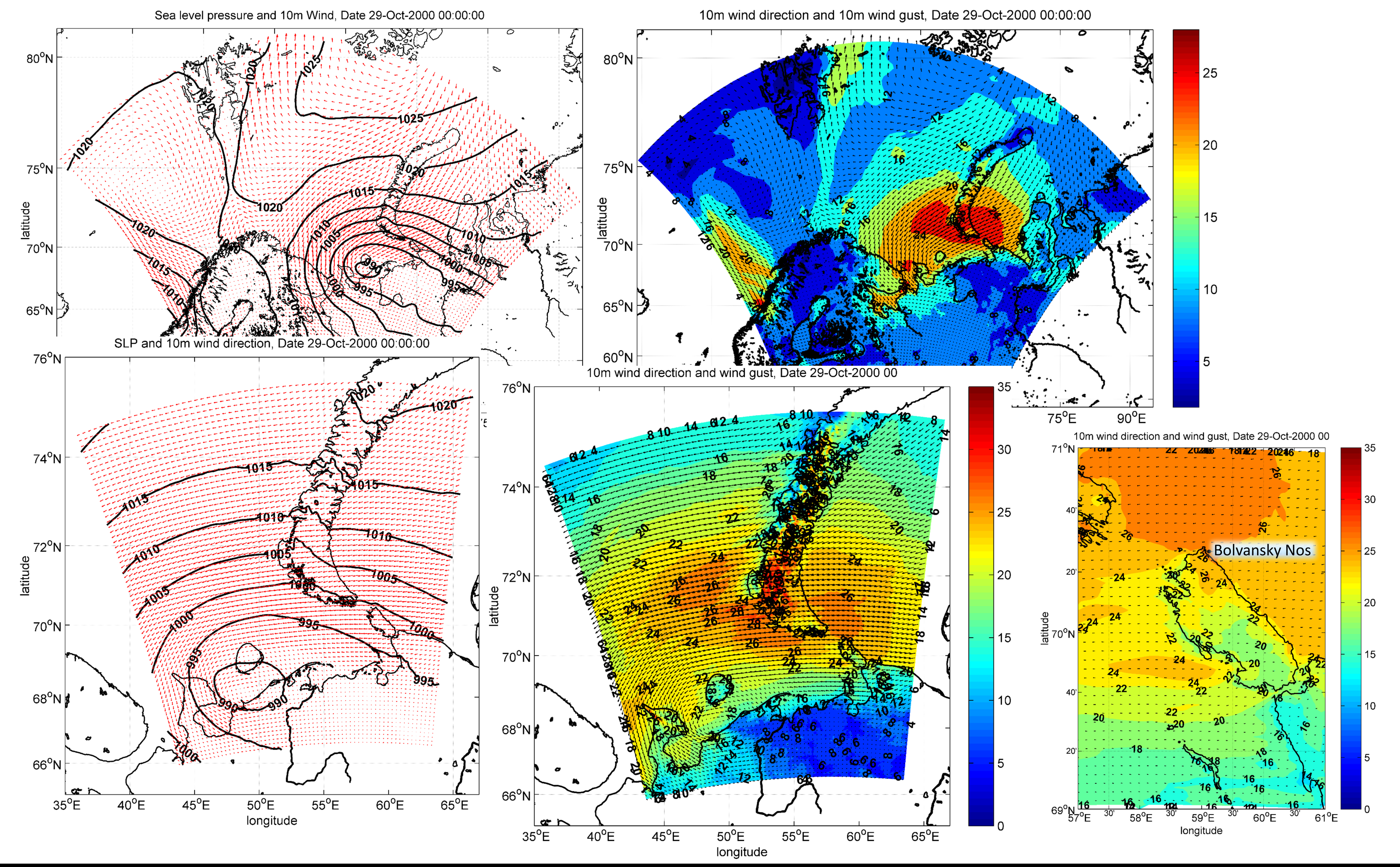
Stations' statistics	Mean error	Max error	RMS	Correlation	Mode (rounded)	Median
Amderma	-1,1	-9,9	2,62	0,82	1	-0,6
Barentsburg	0,9	12,1	3,43	0,57	0	0,7
Medvezhiy isl.	1,6	16,5	3,67	0,60	2	1,9
Malye Karmakuly	-2	-19,8	4,15	0,62	-2	-1,6
Kolguev Severnyi	0,8	7,0	2,27	0,86	1	1
Teriberka	-2,1	-13,4	3,48	0,72	-1	-1,7

References:

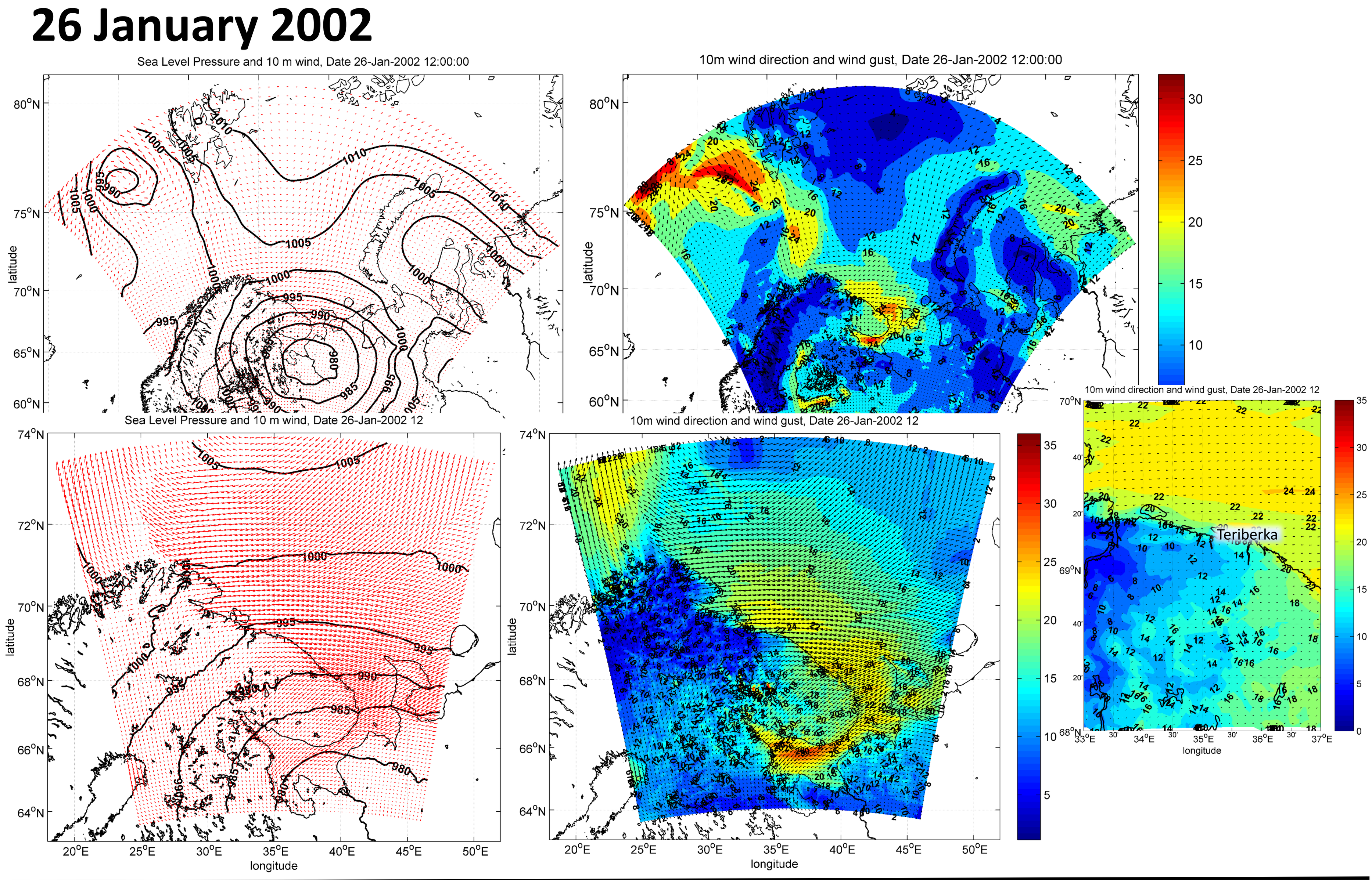
1. *D. Sornette, 2009*. Dragon-Kings, Black Swans and the Prediction of Crises – International Journal of Terraspace Science and Engineering 2(1), pp. 1-18.
2. *J.-P. Schulz, E. Heise, 2003*. A New Scheme for Diagnosing Near-Surface Convective Gusts. COSMO Newsletters №3, pp. 221 – 226.
3. ***A.V. Kislov, T.A. Matveeva, V.S. Platonov, 2015*. Wind Speed Extremes In Arctic Area. Fundamental And Applied Climatology (in Russian), Vol. 2, pp. 63 – 80.**

Results for other cases:

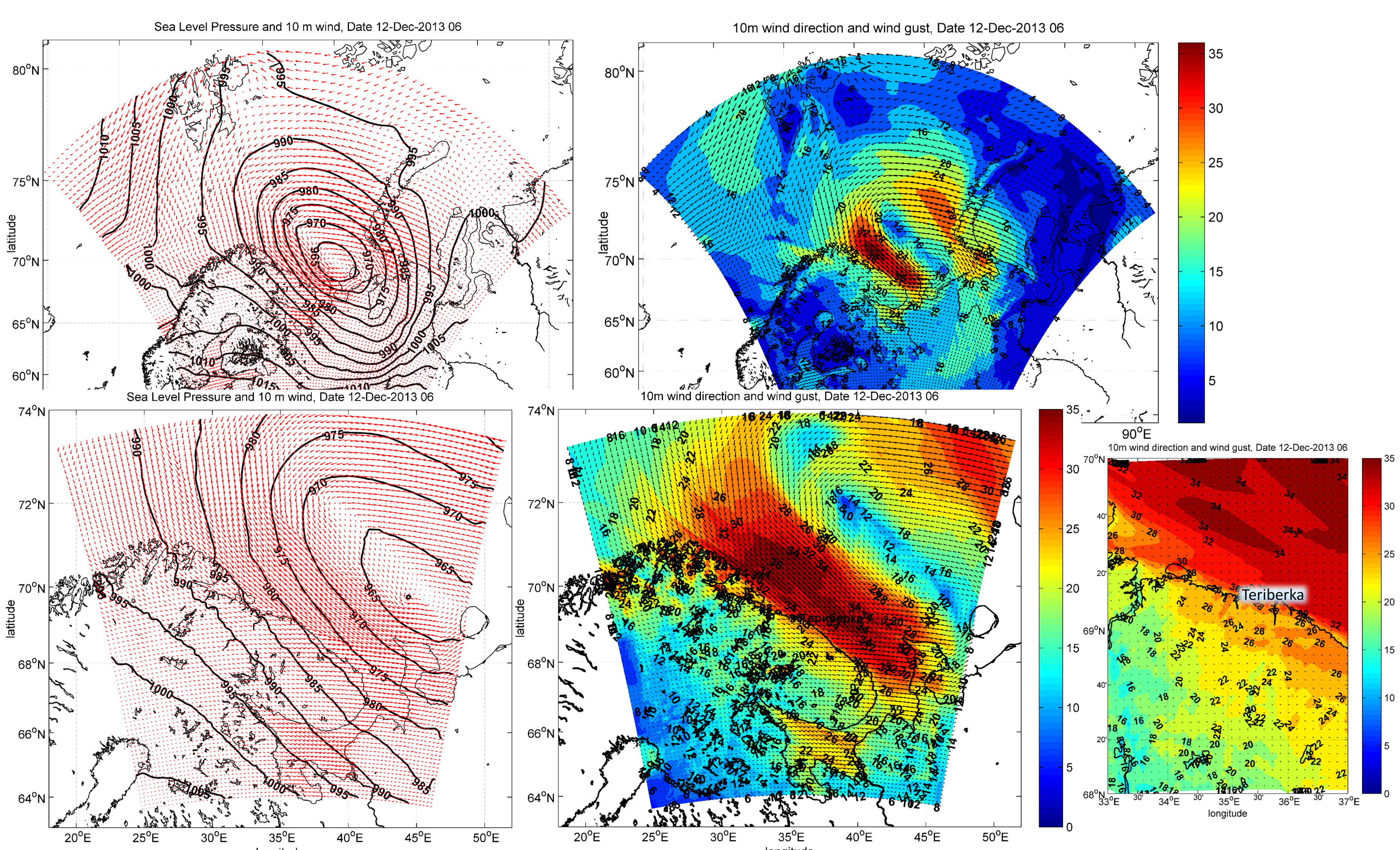
29 – 30 October 2000



26 January 2002



12 December 2013



Discussion and remarks

COSMO-CLM model reproduces different synoptic situations and spatial distribution of wind speed and gusts well using both resolutions. The coarse resolution runs underestimates wind gusts over coastal areas and seashores up to *4 – 5 m/s*. However, the mean error and the RMSE decreases to *2 – 3 m/s* after the downscaling to **2.8 km**. The spatial distribution of wind patterns in these cases turns more detailed and complicate, it is affected by the land-sea distribution, complex terrain and, perhaps, non-hydrostatic effects.

Future outlook: to search an optimal model configuration for this region, applicate it for the extreme wind fields reproduction, and use many additional opportunities for adaptation (e.g., spectral nudging or other parametrizations).