Snow modelling activities at Russian Hydrometcenter

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Directions of researches 2009 -2010

- T2m – simulations

  with the use of old and new snow parameterization schemes (In TERRA) during period of snow melting for an extensive plain part of Russia
- Influence of snow fractional cover parameter on simulations of T2m with the use of new snow scheme. (T2m is a good indicator of “health” of land-surface schemes)
- Testing of snow height and snow water equivalent forecasts by observation data over Russian plain regions

Why is it necessary to define snow?

- **For NWP: → boundary conditions for model (first, improvement of modelling of PBL stratification conditions)**
  → Influence via Albedo – the complex feed-back into model
  → T2m forecasts are more important for users

∗Snow cover is one of the most difficult land-surface processes to simulate

∗ The fractional snow cover effects are very difficult for modelling

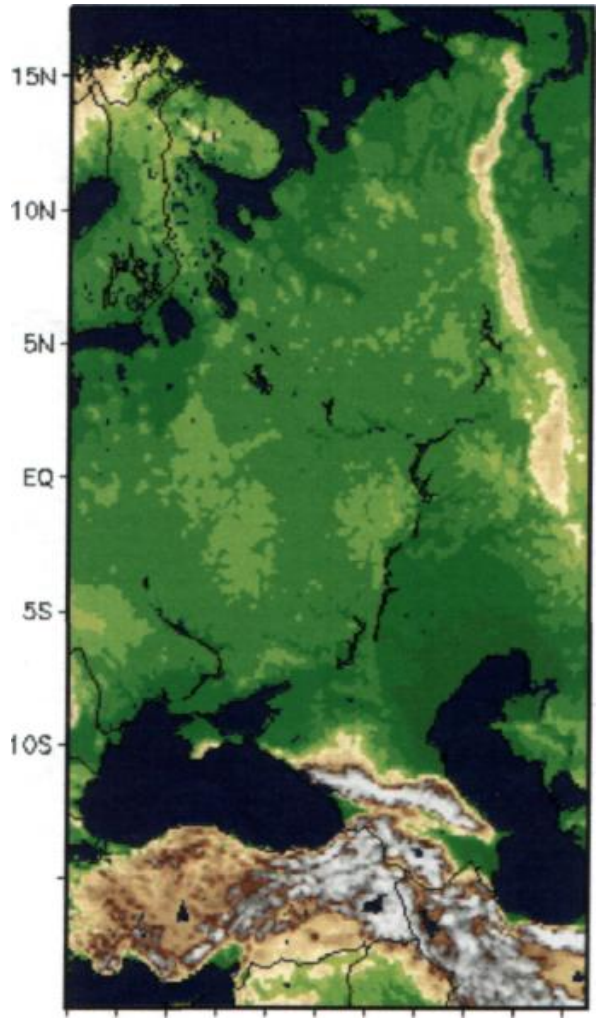
T2m – simulations with the use of old and new snow parameterization schemes (In TERRA) during period of snow melting for an extensive plain part of Russia

- Russian- European plane is a suitable region for testing the snow cover parameterizations alone, without the influence of mountains effects, and for the long period of a snow covering

New multilayer snow scheme (E.Machulskaya, V.Lykosov)

- **radiative heat flux is calculated according to exponential extinction law $R = R_0 e^{-\beta z}$ (it is assumed that all long-wave radiation is absorbed by the uppermost snow layer)**
- **phase conversion of water**
- **account of melt water's percolation with its next freezing and its heat release**
- **gravitational compaction and compaction due to metamorphism**

COSMO-RU14: domain



Research period: March 2009, 11-29 (snow melting in central, western and south regions)

Comparison of 24h, 36h, 48h, 60h, 72h forecasts with observation data stations

Old version

station	BIAS					RMSE					corr coef				
	24	36	48	60	72	24	36	48	60	72	24	36	48	60	72
Murmansk	-0,9	-2,2	-0,5	-1,6	-0,5	4,0	2,7	3,6	2,4	2,2	0,71	0,85	0,75	0,74	0,92
Sankt-Peterburg	-2,0	-2,8	-0,9	-2,7	-1,5	2,5	3,5	2,3	3,3	3,4	0,86	0,17	0,69	0,17	0,42
Arhangelsk	1,1	0,5	0,9	0,1	1,3	3,0	3,3	2,9	3,2	3,5	0,87	0,64	0,75	0,67	0,67
Moscow	-2,2	-3,4	-3,6	-3,4	-3,0	2,6	3,8	4,5	4,0	4,6	0,88	0,57	0,56	0,34	0,07
Kaluga	-0,2	-2,1	-1,6	-2,2	-1,8	2,3	2,8	3,4	3,3	4,5	0,66	0,47	0,53	0,25	0,19
Smolensk	-0,6	-2,2	-0,3	-2,3	-0,8	2,4	3,0	2,6	3,1	3,5	0,79	0,41	0,71	0,40	0,48
Kursk	-3,7	-3,2	-3,8	-3,6	-3,5	4,3	3,7	4,6	4,0	5,0	0,83	0,51	0,78	0,61	0,55
Bryansk	-2,6	-2,3	-3,3	-2,7	-3,5	3,1	2,7	4,1	3,4	5,3	0,87	0,44	0,73	0,21	0,15
Saratov	-3,5	-2,3	-3,1	-2,8	-3,3	4,3	2,7	4,1	3,5	4,1	0,84	0,67	0,86	0,46	0,84

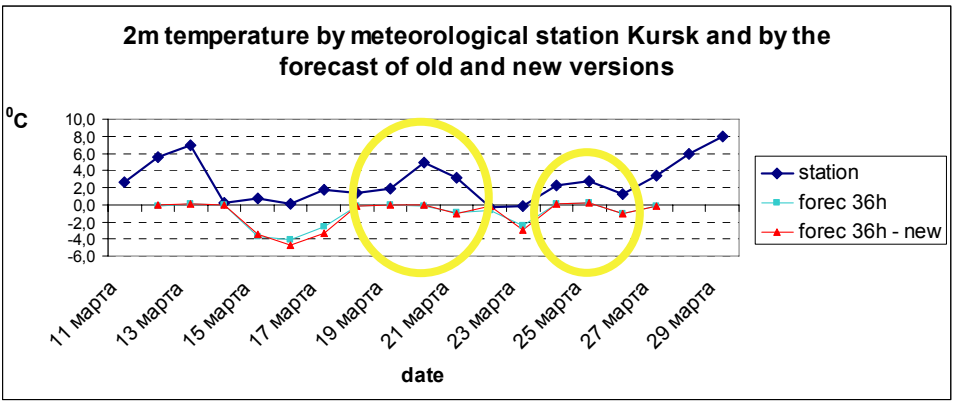
New version

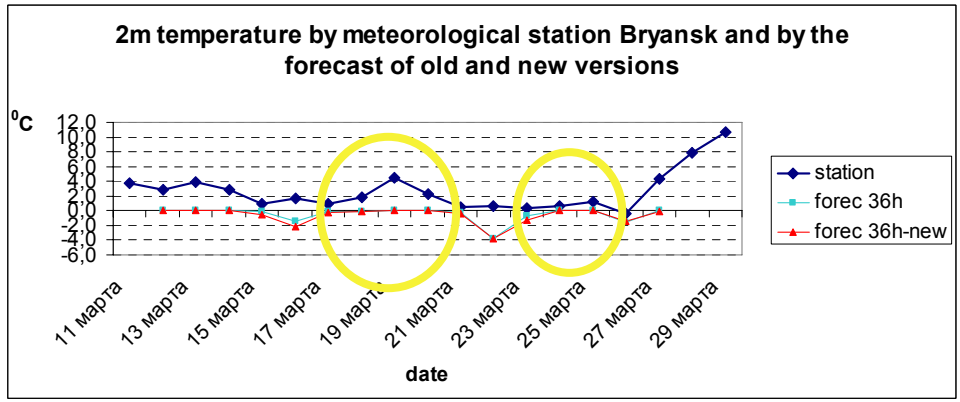
station	BIAS					RMSE					corr coef				
	24	36	48	60	72	24	36	48	60	72	24	36	48	60	72
Murmansk	-1,1	-2,3	-0,7	-1,7	-0,5	3,9	2,7	3,6	2,4	2,2	0,75	0,86	0,75	0,78	0,92
Sankt-Peterburg	-1,8	-3,0	-1,1	-2,7	-1,2	2,5	3,6	2,9	3,3	3,0	0,84	0,18	0,59	0,14	0,53
Arhangelsk	0,8	0,4	0,7	0,1	1,1	3,0	3,3	3,0	3,2	3,5	0,85	0,60	0,71	0,65	0,66
Moscow	-2,0	-3,4	-3,2	-3,5	-2,7	2,7	3,7	4,2	4,1	4,7	0,87	0,62	0,63	0,37	0,16
Kaluga	0,2	-2,1	-1,2	-2,4	-1,4	2,3	2,8	3,7	3,4	4,6	0,70	0,51	0,55	0,26	0,22
Smolensk	-0,1	-2,2	0,1	-2,4	-0,3	2,0	2,9	2,8	3,2	3,2	0,84	0,45	0,66	0,34	0,59
Kursk	-3,2	-3,3	-3,6	-3,5	-3,0	4,1	3,8	4,6	4,0	5,1	0,84	0,48	0,80	0,48	0,60
Bryansk	-1,8	-2,4	-3,3	-2,8	-3,3	2,8	2,8	4,6	3,5	5,5	0,90	0,45	0,76	0,23	0,19
Saratov	-3,0	-2,5	-2,6	-2,9	-2,9	4,2	2,9	4,1	3,5	3,9	0,85	0,67	0,87	0,54	0,89

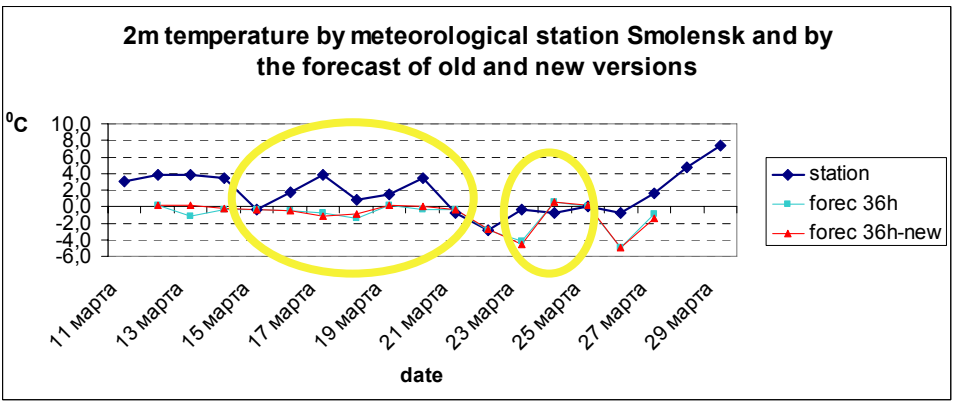
- T2m forecasts are sensitive to the change of snow scheme
- Old and new versions mostly underestimate T2m up to $3,5^0$C, especially in big cities (Moscow, Sankt-Peterburg, Kursk).

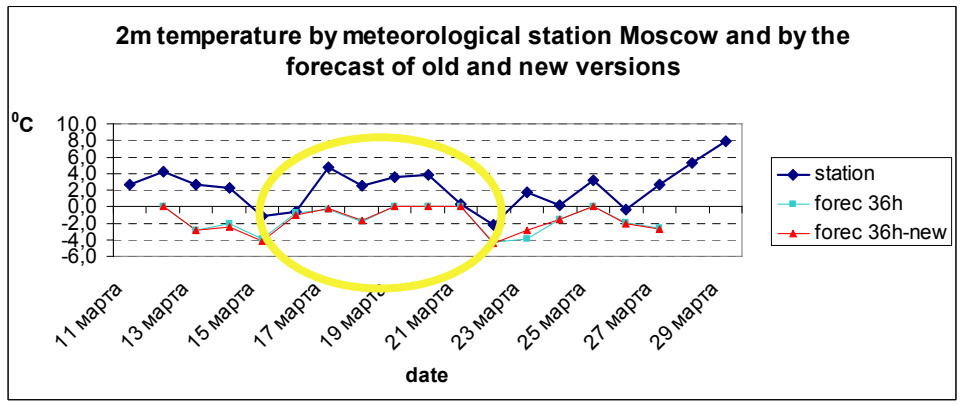
  Daily errors of T2m forecasts are bigger then the night ones

Day



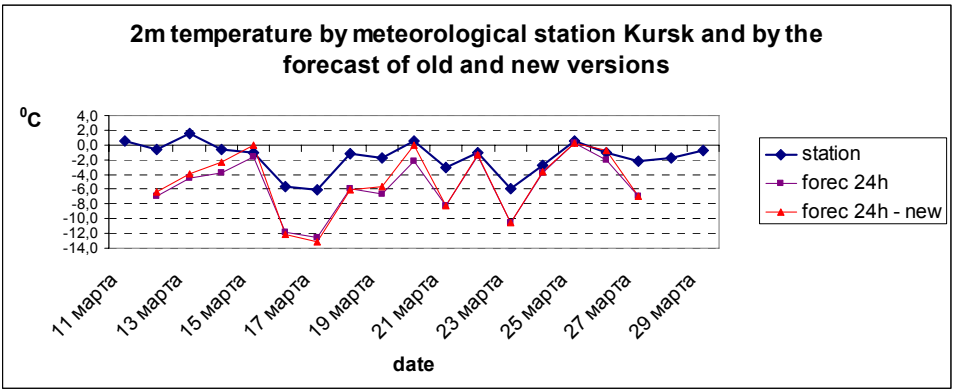


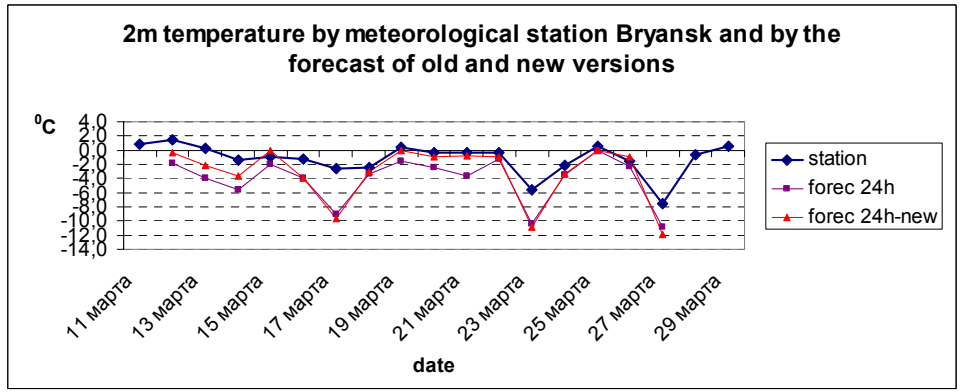


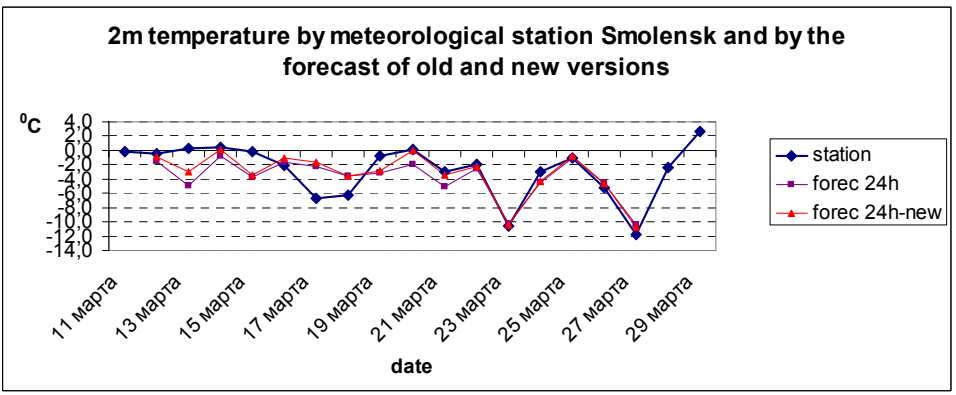


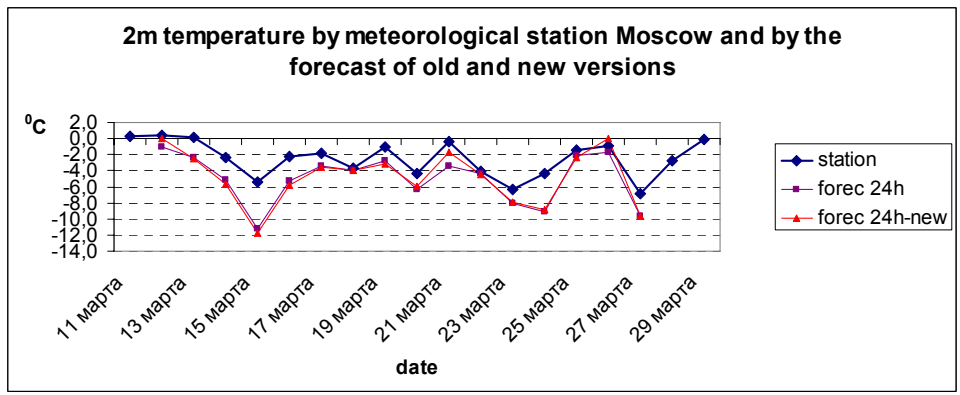
Start – 00UTC

Night









Start – 00UTC

- **South regions with thin snow cover or experiencing oscillations of snow cover are more sensitive to the snow scheme change for night periods (error reduction for T2m on 1-2^{0}C)**
- **BUT (!) Daily values of T2m (observations data) of melting period can be >0^{0}C,**

  model results – not, until there isn't a finish of snow melting completely

. The extreme values of BIAS are 10-15 Degrees for both schemes!

In COSMO snow covered fraction is determined due to use the special parameter – **cf_snow**.

zrss = MAX(0.01, MIN(1.0, zwsnow(i,j)/cf_snow))

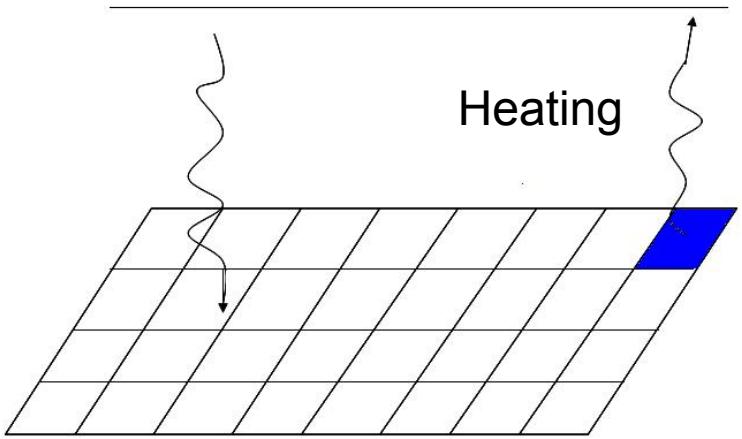
zrss – snow covered part of grid element, zwsnow (ie,je) – snow water equivalent (m H20)

cf_snow=0.05

zwsnow=0.05 m

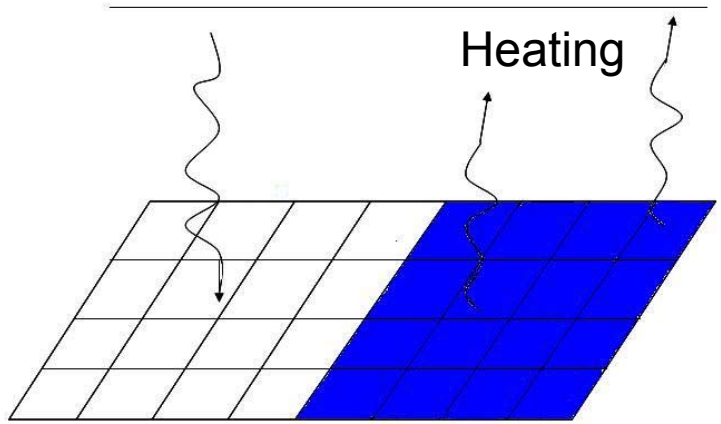
zwsnow/cf_snow=1 it means, that grid cover of snow is full!

Ta

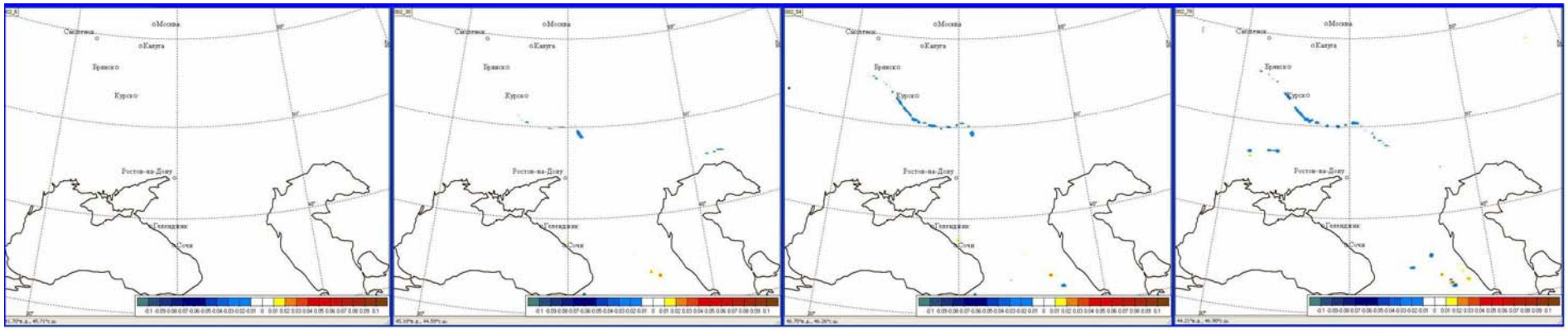


zwsnow/cf_snow < 1

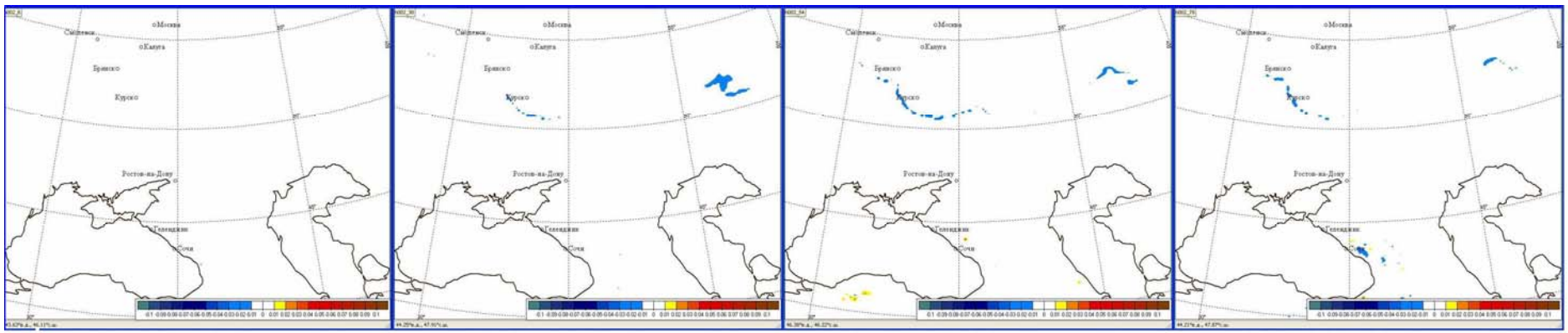
Ta

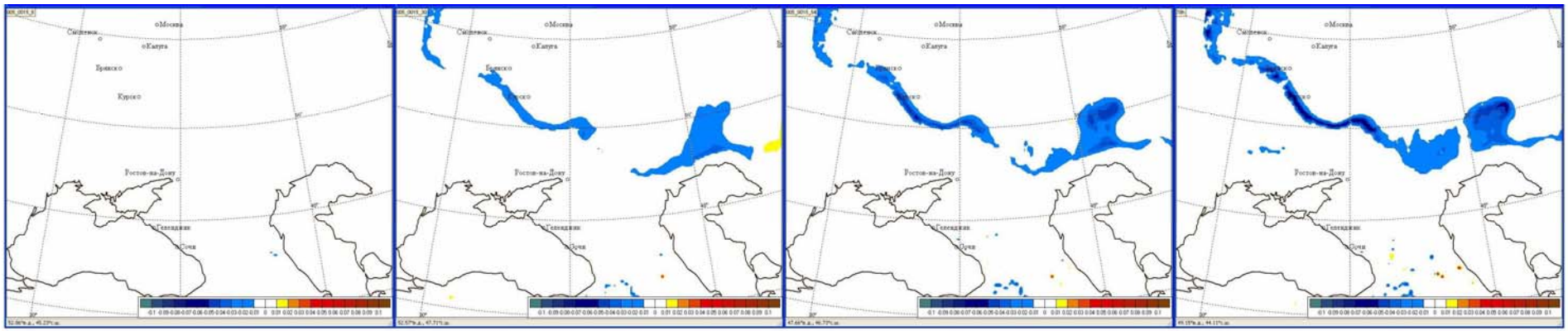


zwsnow/cf_snow < < 1

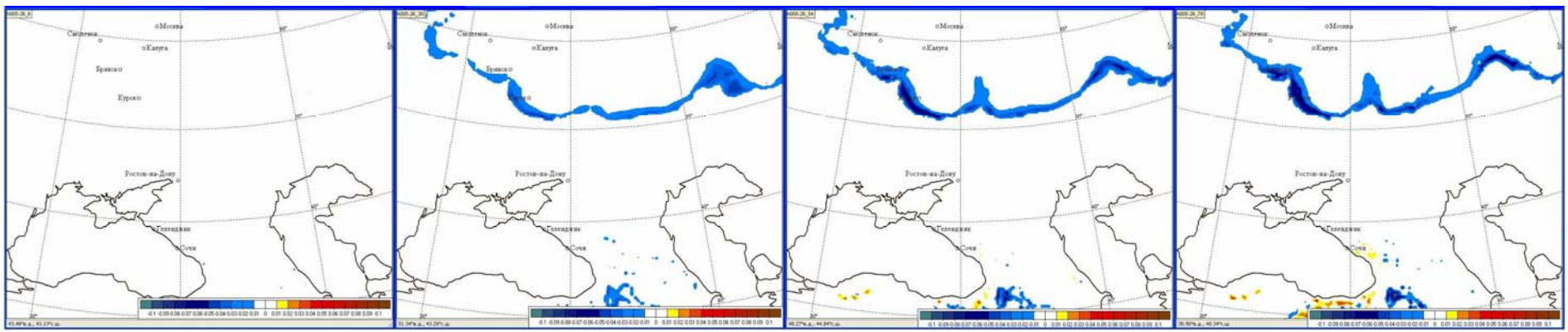


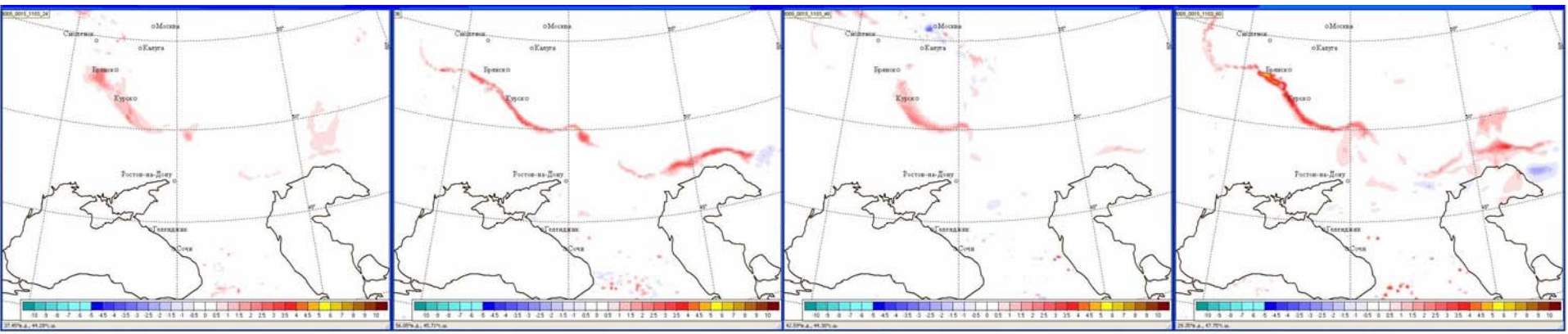
Difference between forecasts of snow height on 6, 30 ,54 and 78h with "standard" cf_snow=0.015 m and with cf_snow=0.02 m. 11 March 2009 (upper pic.) and 26 March 2009 (bottom pic.)



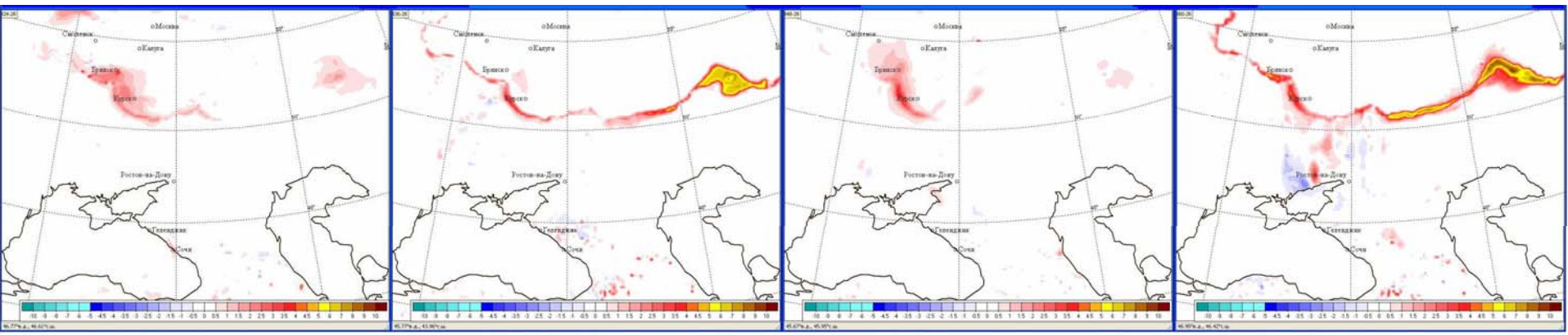


Difference between forecasts of snow height on 6, 30 ,54 and 78h with "standard" cf_snow=0.015 m and with cf_snow=0.05 m. 11 March 2009 (upper pic.) and 26 March 2009 (bottom pic.)



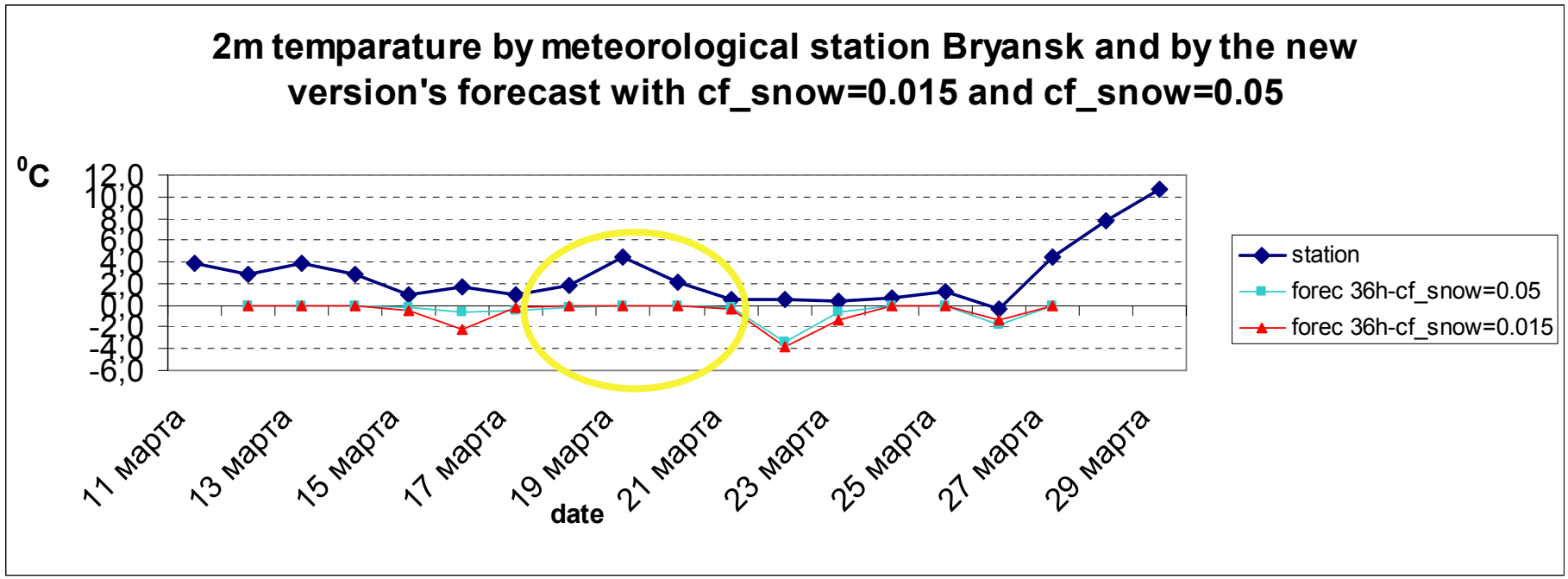


Difference between forecasts of 2m temperature on 24, 36 ,48 and 60h with "standard" cf_snow=0.015 m and with cf_snow=0.05 m. 11 March 2009 (upper pic.) and 26 March 2009 (bottom pic.)



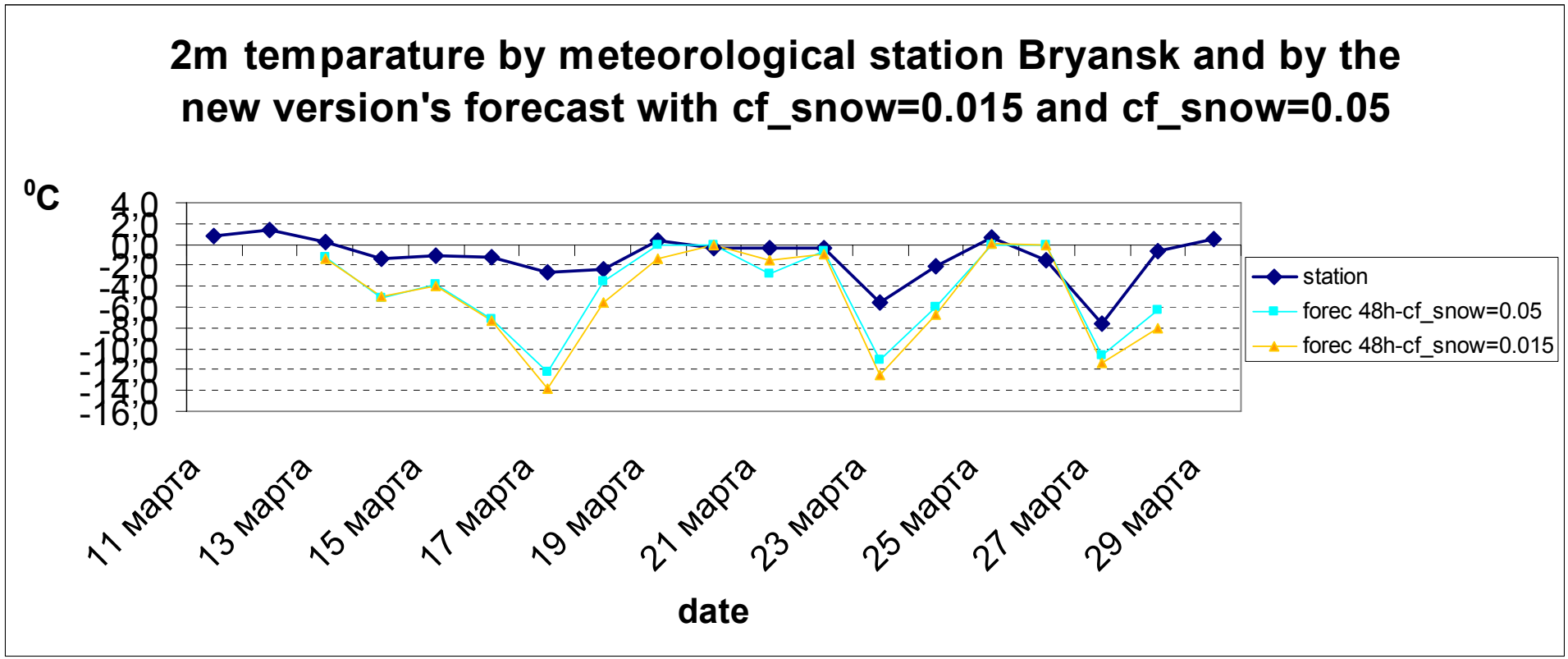

РОСГИДРОМЕТ
ROSHYDROMET
КАФЕДРА МЕТЕОРОЛОГИИ И КЛИМАТОЛОГИИ
МГУ

Day


2m temparature by meteorological station Bryansk and by the new version's forecast with cf_snow=0.015 and cf_snow=0.05
°C
12,0
10,0
8,0
6,0
4,0
2,0
0,0
-2,0
-4,0
-6,0
11 марта
13 марта
15 марта
17 марта
19 марта
21 марта
23 марта
25 марта
27 марта
29 марта
date
station
forec 36h-cf_snow=0.05
forec 36h-cf_snow=0.015


РОСГИДРОМЕТ
ROSHYDROMET
КАФЕДРА МЕТЕОРОЛОГИИ И КЛИМАТОЛОГИИ
МГУ

Night


2m temparature by meteorological station Bryansk and by the new version's forecast with cf_snow=0.015 and cf_snow=0.05
°C
4,0
2,0
0,0
-2,0
-4,0
-6,0
-8,0
-10,0
-12,0
-14,0
-16,0
11 марта
13 марта
15 марта
17 марта
19 марта
21 марта
23 марта
25 марта
27 марта
29 марта
date
station
forec 48h-cf_snow=0.05
forec 48h-cf_snow=0.015

- **Changes of the parameter cf_snow are most significant in regions with thin snow cover (border of a cover) and in mountains**

- **The greatest distinctions in similated snow height (up to 7 sm) and of 2m temperature (up to 9^0C) in these regions can be achieved for very narrow strip of a thin snow cover with the use of the bigger values of cf_snow**

- **But: the problem of «2m temperature over 0^0C» exists in large domain in spring, even making cf_snow=0.05**

  didn't help to "rise" 2m temperature over 0^0C

- So, experiments with some conditions

(if $t<-0,5^0C$ cf_snow=0.015

If $-0,5<=t<0^0C$ cf_snow=0.02

If $0<=t<0,5^0C$ cf_snow=0.03

If $0,5<=t<1^0C$ cf_snow=0.04

If $t>=1^0C$ cf_snow=0.05) didn't give positive results for testing points.

Plans for Mar - Aug. 2010:

- To pick up the mathematical description for definition of cf_snow – depending on **zwsnow**, Ta (if Ta near 0^0C)?

  How correctly describe this parameter, "to catch" wider range of conditions of occurrences of thawed patches in the spring

- Testing experiments with new snow scheme and comparison snow height and SWE between model results and observation data

Thank you for your attention!