Международный проект CORSO и его первые результаты по консолидации оперативтиных и исследовательских работ для метеообеспечения Сочи 2014

И.А.Розинкина, Г.С.Ривин, Е.Д,Астахова

Приоритетный проект **CORSO** консорциума COSMO

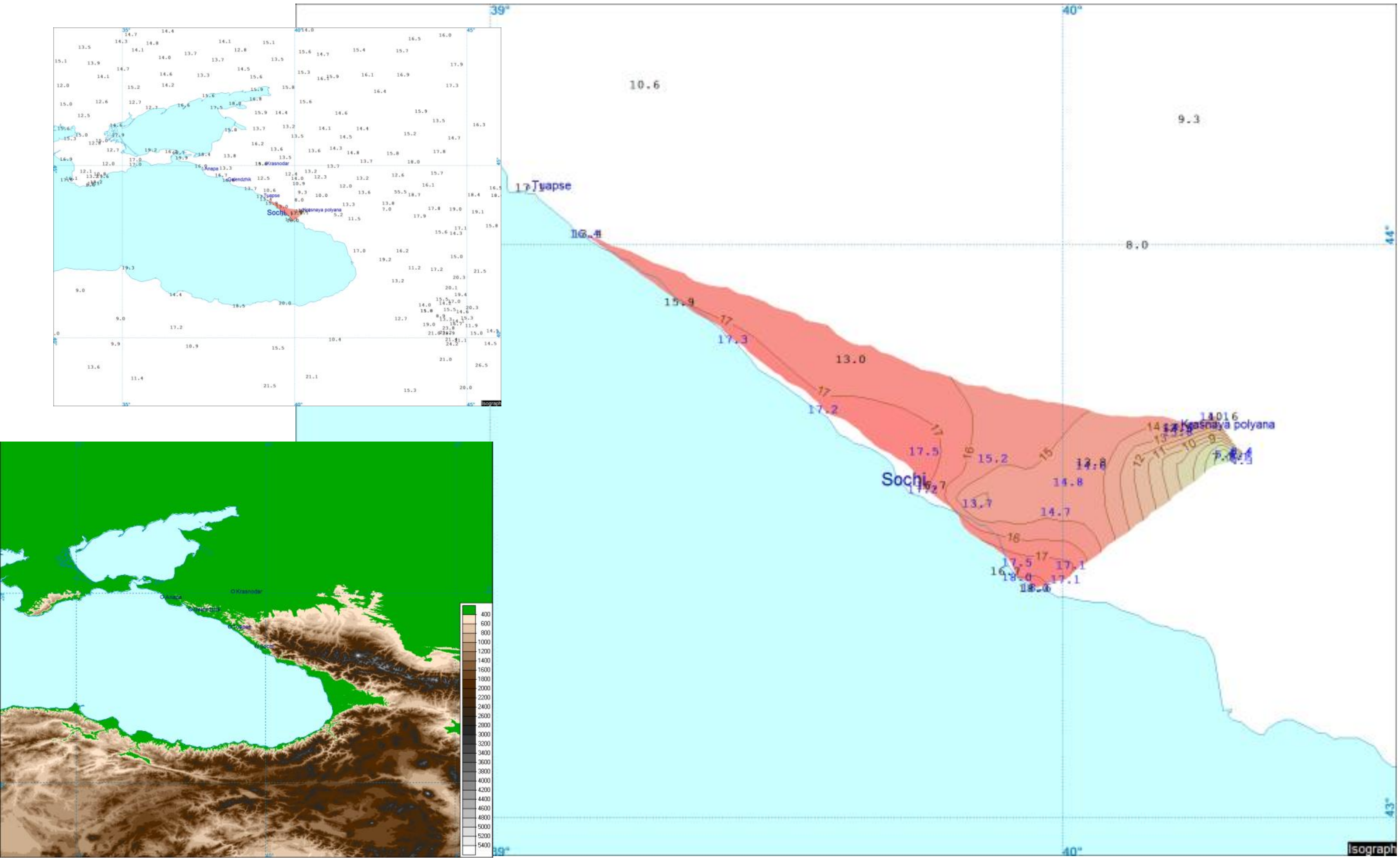
Consolidation of
Operation and
Research results for
Sochi
Olympic Games"

Участники: Россия, Германия, Швейцария, Италия, Греция

Цель проекта:

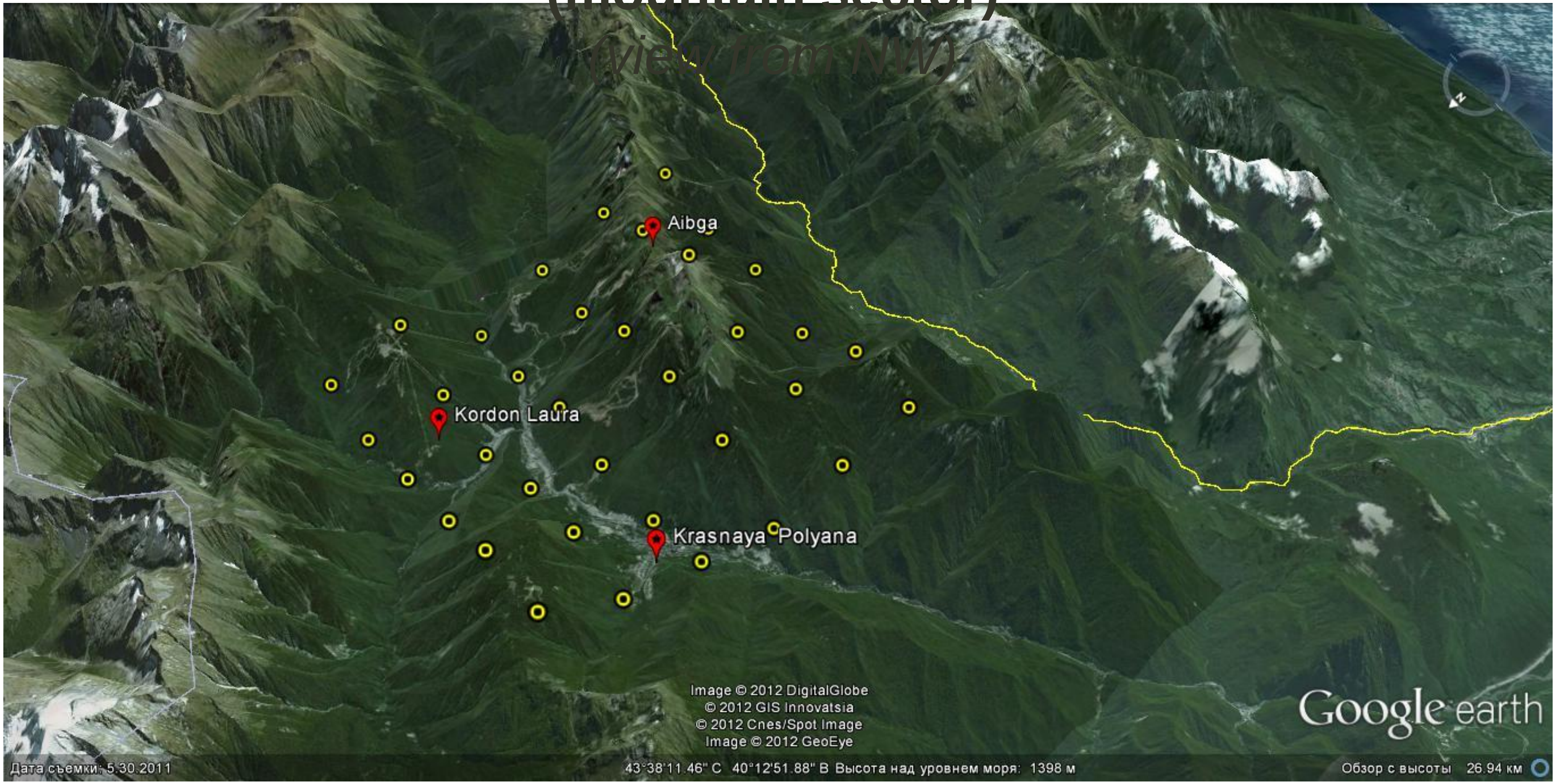
Объединить , реализовать и продемонстрировать возможности оперативных технологий по краткосрочному численному прогнозированию погоды стран консорциума на базе модели COSMO для зимних условий горной местности для практического использования результатов в ходе метеообеспечения Зимней Олимпиады 2014 г.

The area of conventional SYNOPs in the domain of COSMO 2.2 km



Location of the meteorological stations and COSMO-RU2,2 (Sochi) model's grid-points (mountain sector)

(view from NW)




Технологии оперативност и счета и доведения до потребителя
Обработка результатов, включая их коррекцию
Начальные данные
Модель атмосфер ы
Свойства земной поверхност и
Верификация
Интерпретация и обучение синоптиков
Приложения, включая ансамбли

СТРУКТУРА ПРОЕКТА CORSO

TASK 1. High resolution COSMO-modeling for mountainous regions

Task Leader: Gdaly Rivin

1.1. Improvement of technology of deterministic forecasting of weather conditions with model resolution 2.2.km for the North-Caucasian area (SOCHI-2014), (including the operational support)

1.2. Development of COSMO-So-1km

TASK 2. Downscaling / postprocessing for Sochi area and applications

Task Leader: Inna Rozinkina

2.1. Adapted down-scaling techniques for winter conditions in the mountains and IOC requirements

2.2. Determination of typical COSMO-model inaccuracies for typical climatological /synoptic situations

TASK 3. Development and adaptation of COSMO EPSs for Sochi region

Task Leaders: Elena Astakhova, Andrea Montani

3.1. Adaptation of COSMO LEPS 7 km to the Sochi region and to specific requirements of winter Olympics. Operational ensemble forecasts during the Olympics

3.2. Development and verification of COSMO-RU-LEPS 2.2 km for the Sochi region (with ICs and BCs from SOCHMEL7)

СТРУКТУРА ПРОЕКТА CORSO

НАПРАВЛЕНИЕ 1. Моделирование с высоким разрешением для горных районов

(Рук. Г.С.Ривин)

1.1. Усовершенствование технологии детерминисткого пронгозирования погодных условий с разрешением модели 2x2 км для Северо-Кавказского региона

1.2. Развитие COSMO—RU-SO с шагом 1 км

НАПРАВЛЕНИЕ 2. Даунскайлинг – постпроцессинг и приложения

(Рук. И.А.Розинкина) I

2.1. Развитие адаптированных техник дун-скейлинга для зимних горных условий с учетом требований МОК

2.2. Выявление типичных ошибок моделей для типичных метеороллоических-синоптических условий

НАПРАВЛЕНИЕ 3. Развитие адаптация системы COSMO-EPS для региона Сочи

(Рук. Е.Д, Астахова, А.Монтани)

3.1. Адаптация COSMO LEPS 7 к региону Сочи 2014 и требованиям МОК. Обеспечение оперативными ансамблевыми прогнозами в периоды соревнований

3.2. Развитие и адаптация COSMO-RU-LEPS 2.2 к региону Сочи (с условиями на границах из COSMO LEPS 7

18 staff members Roshydromet CORSO:

(12 - PhD, 4 – postgraduates (3 – MSU)),

Task 1 High resolution COSMO-modeling for mountainous regions

G.Rivin, Yu..Alferov, D.Blinov, M.Chumakov, E.Kazakova, A.Kirsanov V.Perov, A. Revokatova, I.Rozinkina, M.Schatunova, M. Tsirulnikov, D. Uktuzova, M.Zaichenko;

Task 2 Downscaling / postprocessing for Sochi area and applications

I. Rozinkina, D.Blinov, A.Bundel, E.Kazakova, V.Kopeikin, A.Muravjov, G.Rivin, I. Ruzanova M.Schatunova, D. Uktuzova;

Task 3 Development and adaptation of COSMO EPSs for Sochi region

E.Astakhova, D.Alferov, G.Rivin.

Task 1	Result
1.1: Improvement of technology of deterministic forecasting of weather conditions with model resolution 2.2.km for the North-Caucasian area (SOCHI-2014), (including the operational support)	
1.1.1. Assess and improve the quality of the deterministic forecasts of COSMO–Ru7/So2.2	**The controlled and corrected external parameters (for Black-Sea and North-Caucasian region for COSMO-Ru7/So2 was obtained. Description of geographical conditions of points of measurement and corresponding points of COSMO-Ru7/So2 meteograms was obtained.** **The algorithms of TERRA was corrected by including of the additional level of vegetation. In cases of partial snow cover the significant improvement the forecast of T2m was obtained (error from 4-7°C decreases to 1-2°C) .**
1.1.2 . Improving of initial values of	**For correction of initial data for COSMO-RU02 the preliminary technology (decoding, interpolation, sea-mask and orography correction) for snow mask based on NOAA multisensory snow cover maps information**

Task 1	Result
1.1: Improvement of technology of deterministic forecasting of weather conditions with model resolution 2.2.km for the North-Caucasian area (SOCHI-2014), (including the operational support)	
1.1.3. **Implementation of data assimilation and using of different boundary conditions for COSMO-Ru7/So2**	**1.1.3.1. The modeling results for winter 2011/2012 as a result of DWD technology including DAS, adapted for COSMO-Ru07 region, was transferred and collected in RHMC. The comparison with RHMC system showed the largest differences first jf all in fields of T2m. The differences in Sochi region was not significant. After the discussions during CUS, FROST meeting and expert meeting in DWD was decided to repeat the experiments for winter 2012/2013 with use the new available data of SOCHI region.** **1.1.3.2. The description of geographical conditions of points of measurement, available for participants of CORSO/COSMO and data description tables for all regular and additional stations of SOCHI region was obtained. The preliminary software for quality control was obtained.** **1.1.3.3. FDP: The nudging for COSMO-Ru7/So2 with use the software of COSMO was developed. The methodical consultations of DWD was take account/ The first results was obtained**

Task 1	Result
1.2: Development of COSMO-So-1km, (RDP) 0,6 FTE / year	
1.2.1. ***Choice of strategy***	**Expert meeting in Meteoswiss (Zurich) and in ARPA-SIMC, Bologna: 2011: Dec: strategic discussions, algorithms, preliminary experiments.** **The some preliminary numeric experiments with modified software (COSMO-1) was developed for filtered orography.**
1.2.2. ***Development of 1-km version of COSMO Model***	**Each country received some preliminary results for own area. The results of experiments of MeteoSwiss and APRA SIMC will be discussed on CGM.**

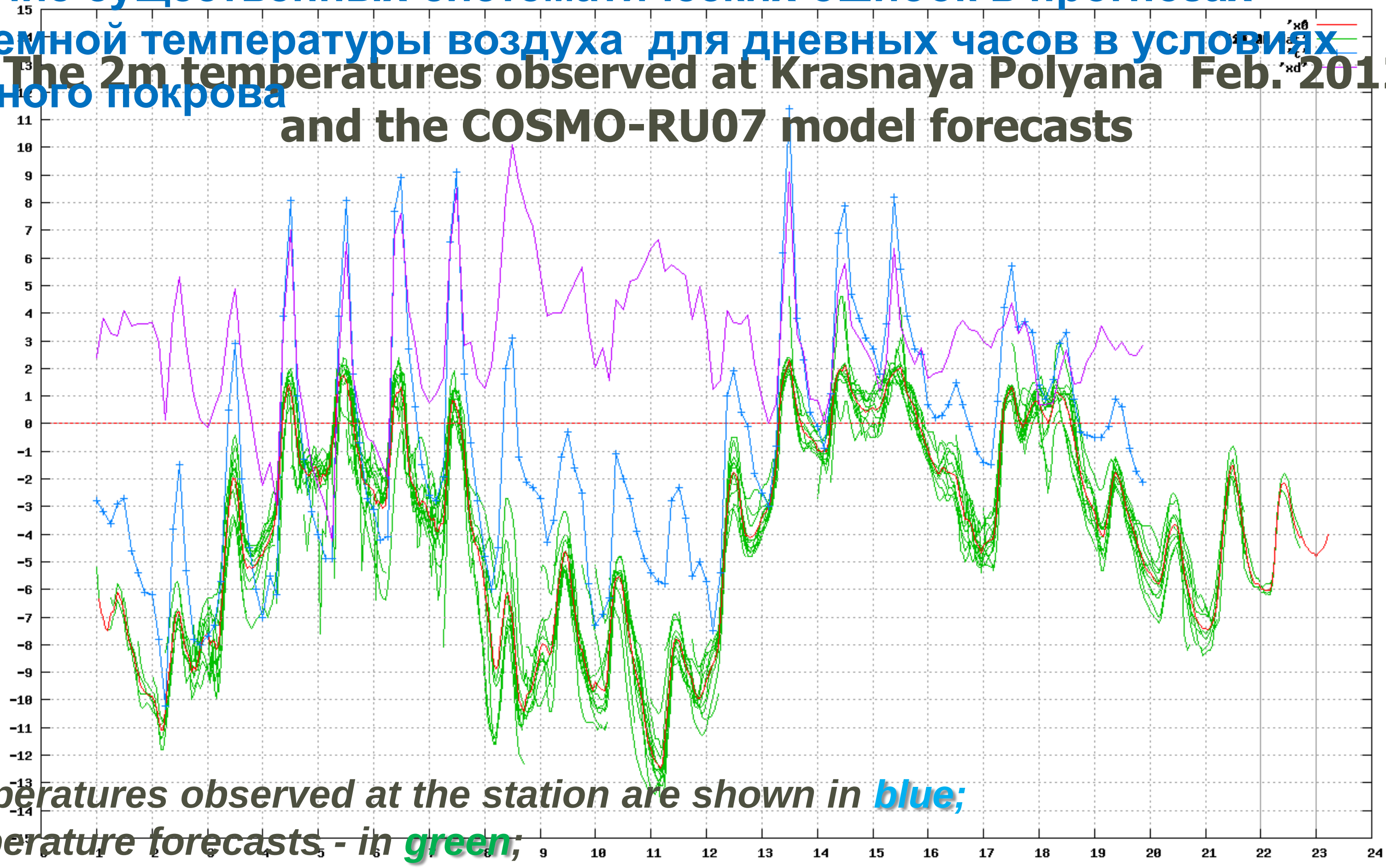
Направление 1 (Усовершенствование технологий детерминистского моделирования)

1.1. Усовершенствование технологий детерминисткого моделирования погодных условий с разрешением модели 2x2 км для Северо-Кавказского региона

1.1.1 Усовершенствование алгоритмов модели в части описания взаимодействия с подстилающей поверхностью :

На основе эксплуатации модели COSMO-Ru было выявлено наличие существенных систематических ошибок в прогнозах приземной температуры воздуха для дневных часов в условиях снежного покрова

The 2m temperatures observed at Krasnaya Polyana Feb. 2012 and the COSMO-RU07 model forecasts



*The temperatures observed at the station are shown in **blue**;*
*the temperature forecasts - in **green**;*
*the averaged forecast - in **red**;*
*the difference between the observed temperature and the averaged forecast is depicted in **violet***

Эффект от включения дополнительного растительного яруса в схему подстилающей поверхности TERRA в COSMO

T2м, прогнозы на 36ч от 25 марта 2010

Ivanovo

ctrl	exp	measured
-4.2	-0.4	4.0

Dmitrov

ctrl	exp	measured
-2.5	0.1	7.0

Moscow

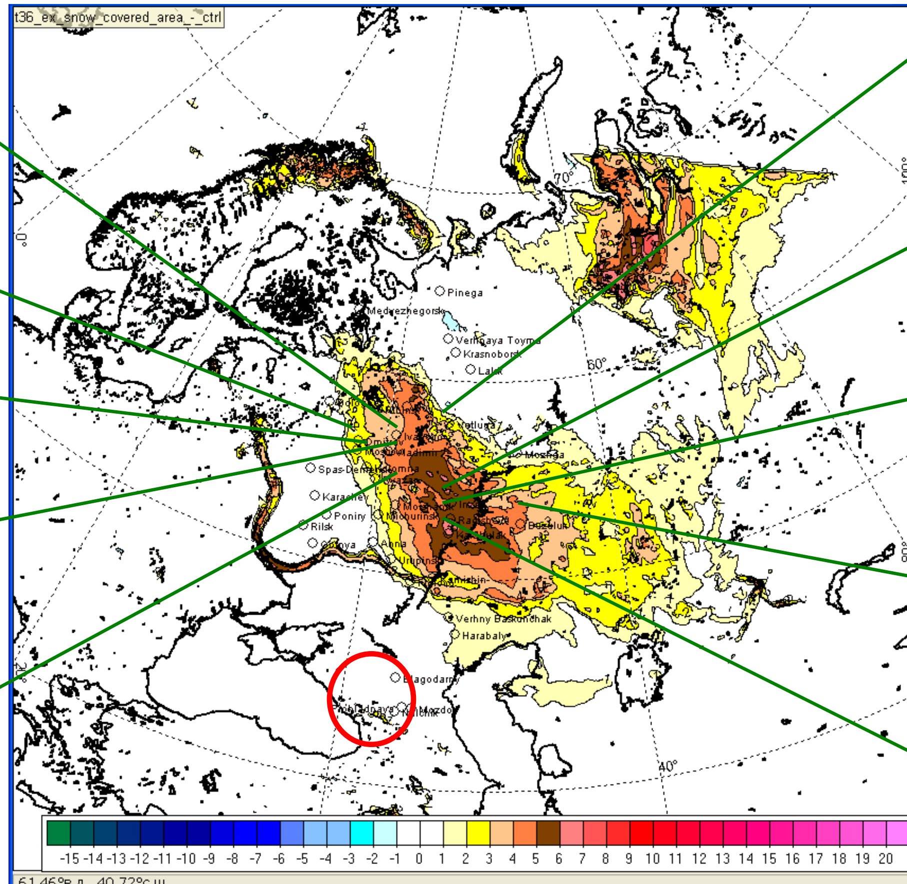
ctrl	exp	measured
-2.3	0.1	8.3

Vladimir

ctrl	exp	measured
-4.5	-0.5	3.8

Ryazan

ctrl	exp	measured
-2.0	0.1	3.9



Vetluga

ctrl	exp	measured
-3.8	-1.0	0.4

Inza

ctrl	exp	measured
-5.3	0.0	1.0

Radishevo

ctrl	exp	measured
-6.3	-0.4	0.7

Buzuluk

ctrl	exp	measured
-5.0	-0.4	-0.6

Karabulak

ctrl	exp	measured
-6.6	-0.3	-2.4

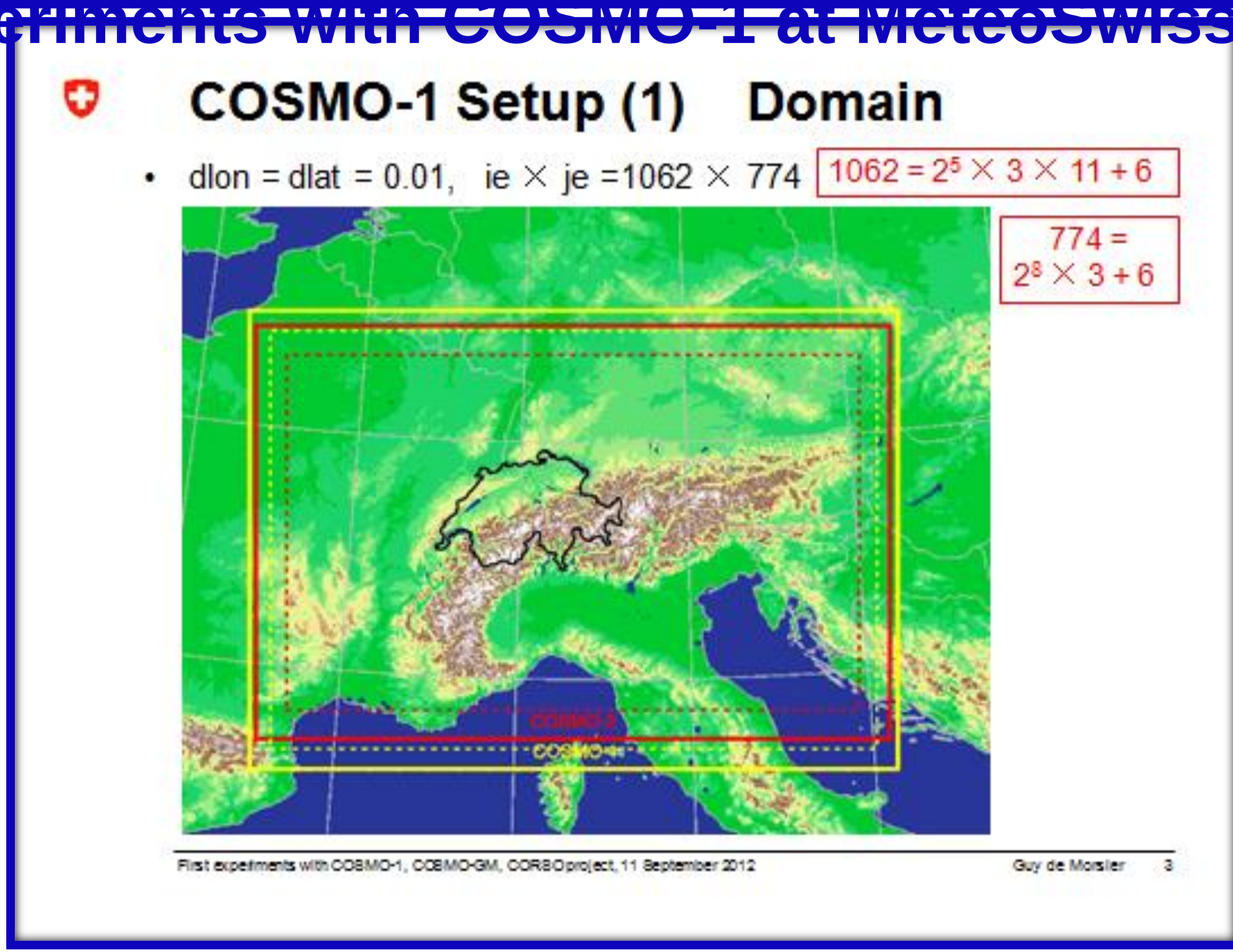
Направление 1 (Усовершенствование технологий детерминистского моделирования)

1.2. Развитие версии модели COSMO с шагом 2 км для горных областей

ИЗМЕНЕНИЕ ДИНАМИЧЕСКОГО ЯДРА !!!!!!

Guy de Morsier with contributions Oliver Fuhrer

First experiments with COSMO-1 at MeteoSwiss



Направление 1 (Усовершенствование технологий детерминистского моделирования)

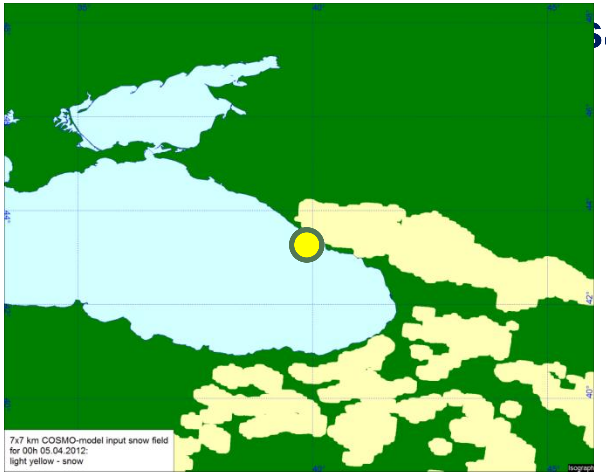
1.1. Усовершенствование технологий детерминисткого моделирования погодных условий с разрешением модели 2х2 км для Северо-Кавказского региона

1.1.2 Развитие регионального усвоения данных

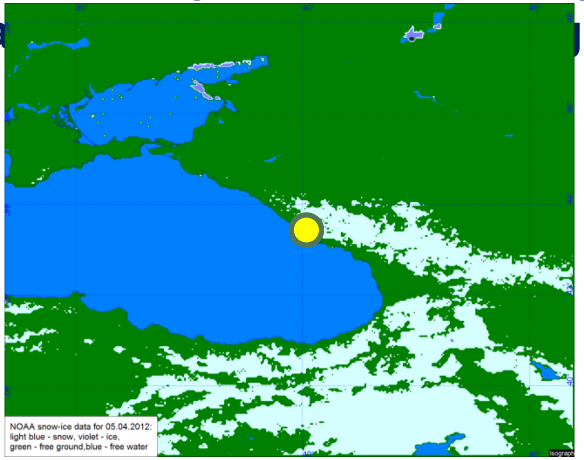
- ДАННЫЕ НАЗЕМНОЙ НАБЛЮДАТЕЛЬНОЙ СЕТИ
- СВЕДЕНИЯ О СНЕЖНОМ ПОКРОВЕ

Повышение детализации начальной информации о наличии снега с использованием доступных спутниковых данных

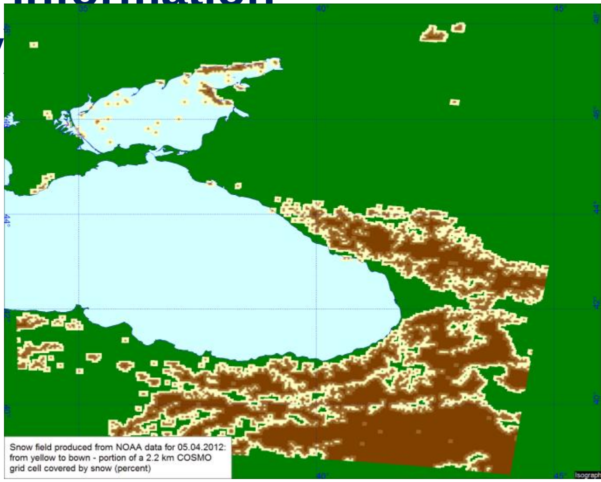
pre-operational technology for Snow OA with flexible resolution based on available NOAA multisensory snow cover maps information



Input COSMO snow field on a 20 km grid for 05.04.2012



Input NOAA multisensor snow/ice cover product on 4 km grid

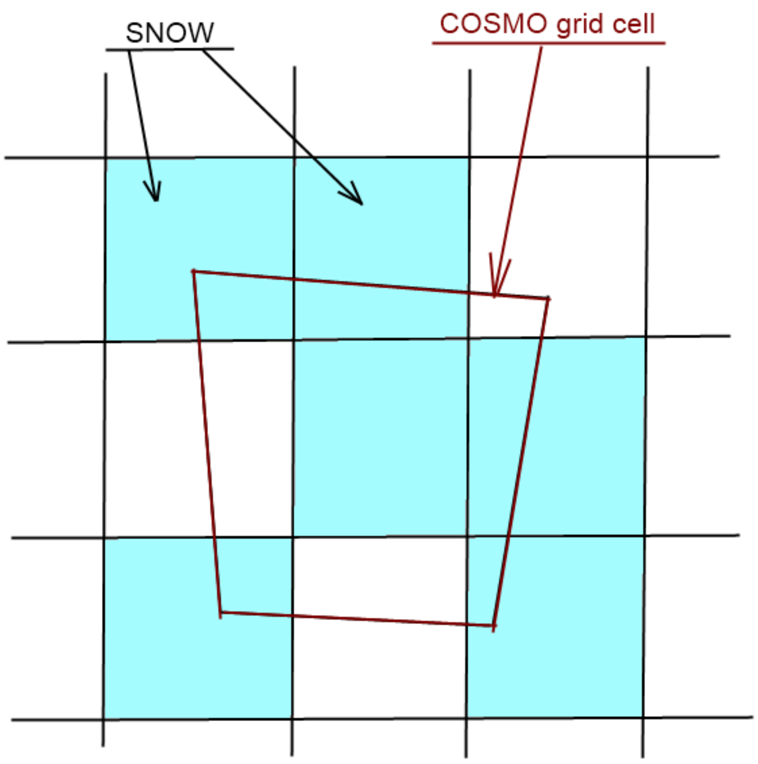


output: Snow field for COSMO model 2.2 km produced from NOAA data

Input snow field is too smoothed for 2.2 km COSMO model grid

To improve it

- Use NOAA snow-ice satellite product on lon/lat grid with step 0.04° (approx. 4 km)
- Ice = snow, usually ice is covered by snow
- For each model grid cell determine square of overlays with snow covered cells of NOAA product



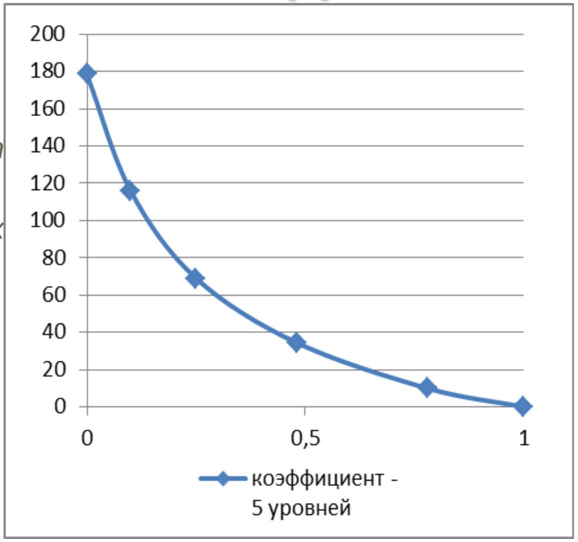
$$F_{snow} = \frac{\sum_i S_{snow}^i}{S_{COSMOcell}}$$

This is a geometric problem

Технология коррекции начальных значений температуры нижних слоев воздуха и почвенных слоев по данным измерений Т2м

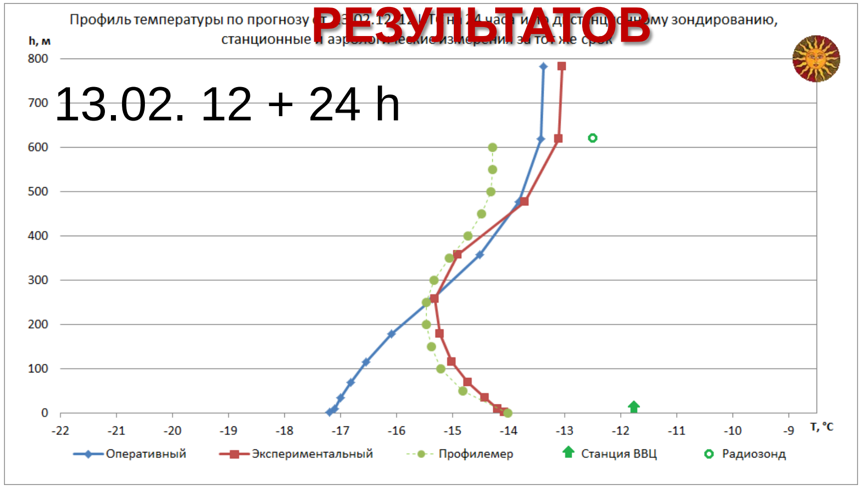
- Cressman method for OA T2m

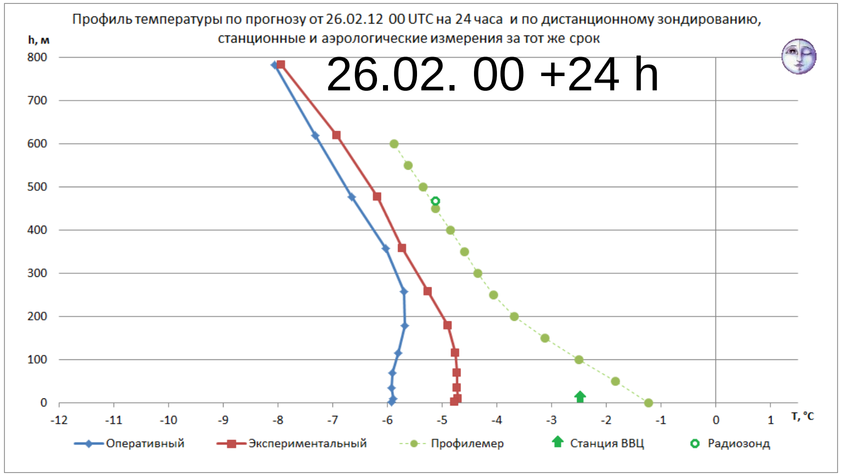
$w_k^m = h_k^m v_k^m$, $h_k^m = 0.5\ [a\ 1 + \cos(\pi\ \rho_h^{k,m}/R_{scan})]$, $v_k^m = 0.5\ [a\ 1 + \cos(\pi\ \rho_v^{k,m}/H_{max})\ /\ (1+0.8\ \rho_v^{k,m}/H_{max})]$, $H_{max} = \max(\rho_v^{k,m}, Z_{max})$.

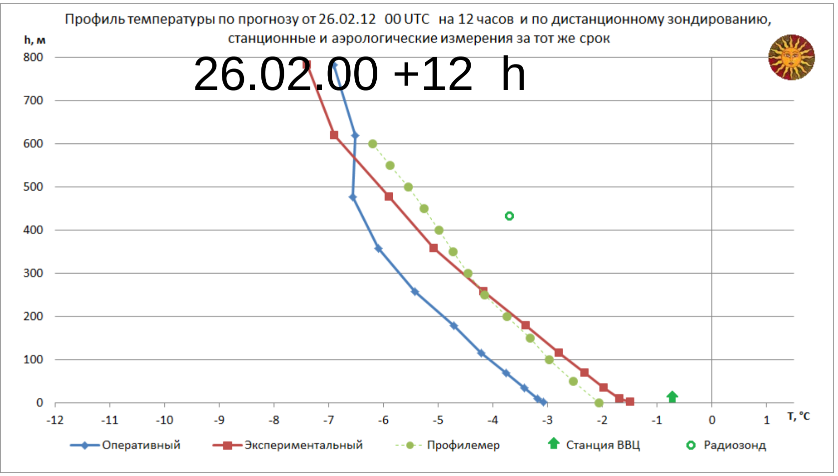


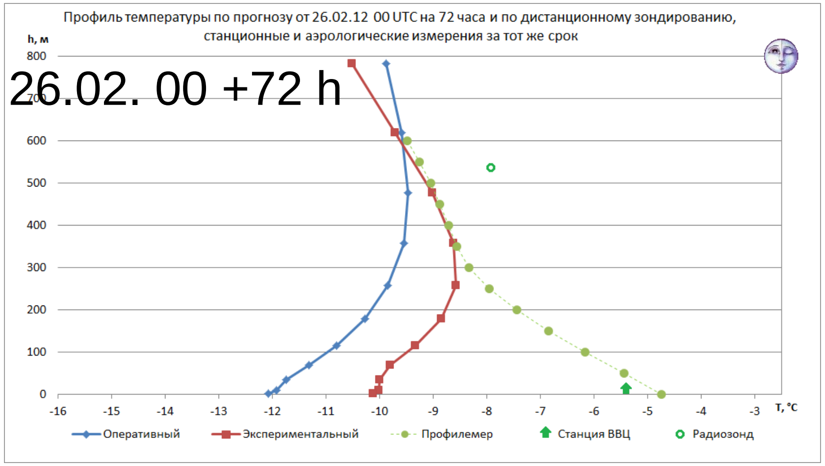
- Correction (adaptation) of T for 6-8 bottom levels (log- profiles for discrepancies)
- Correction of T for soil levels (linear functions for discrepancies)

ТЕХНОЛОГИЯ КОРРЕКЦИИ ПО T2M : АНАЛИЗ РЕЗУЛЬТАТОВ



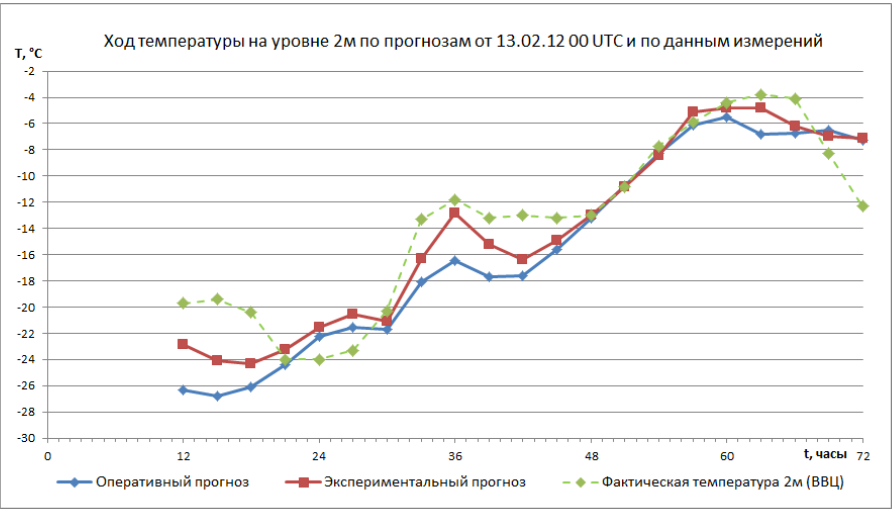


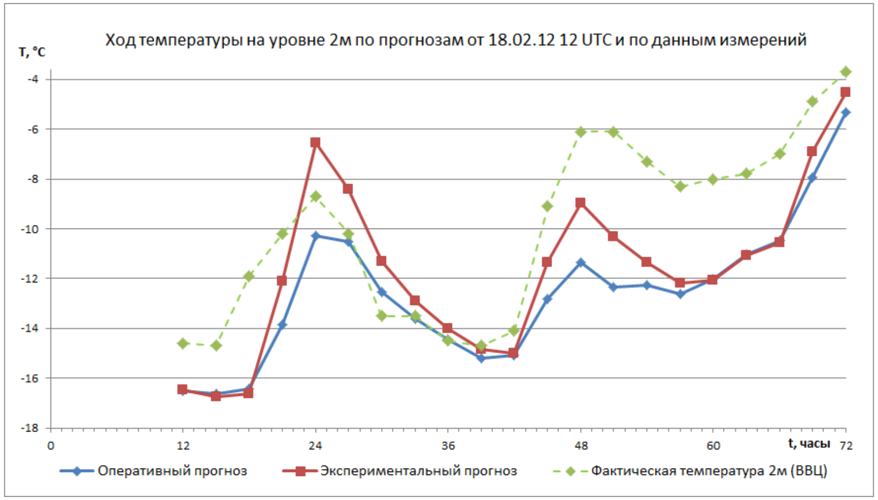


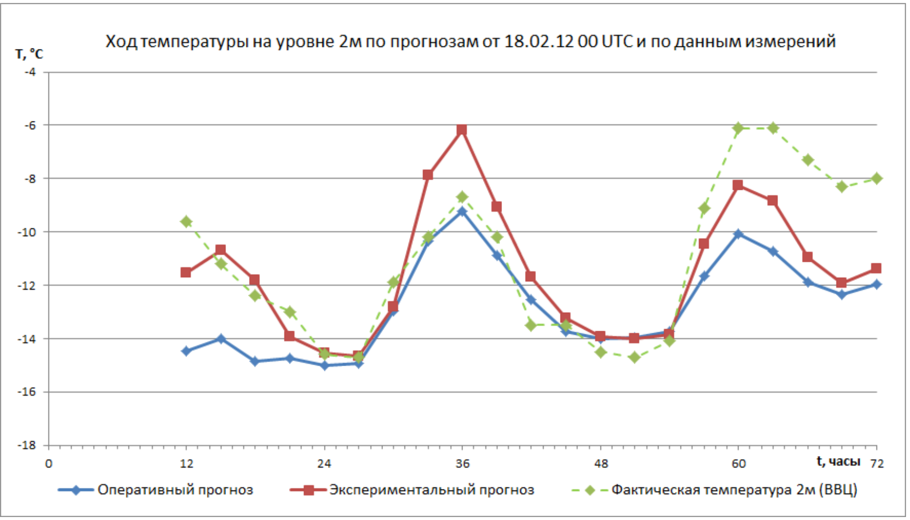


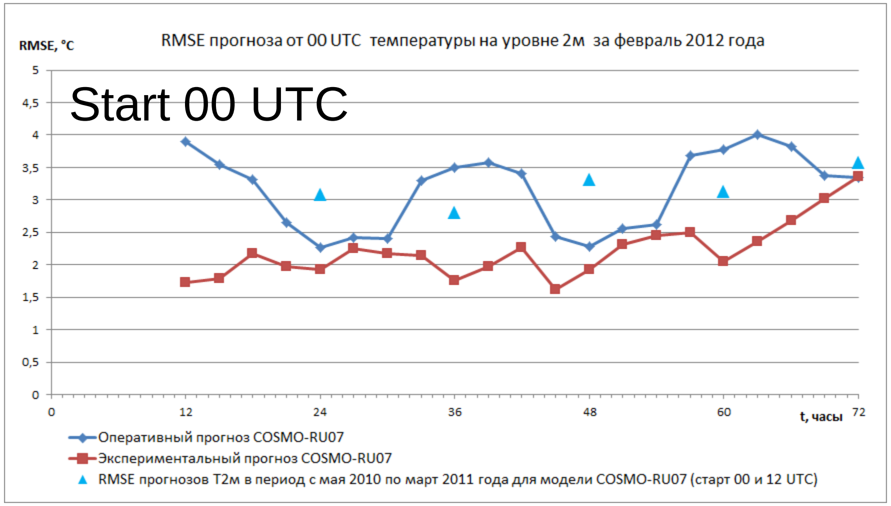
Examples of forecasts of T profiles with comparison with data of atmospheric sounding

ТЕХНОЛОГИЯ КОРРЕКЦИИ ПО Т2М : АНАЛИЗ РЕЗУЛЬТАТОВ



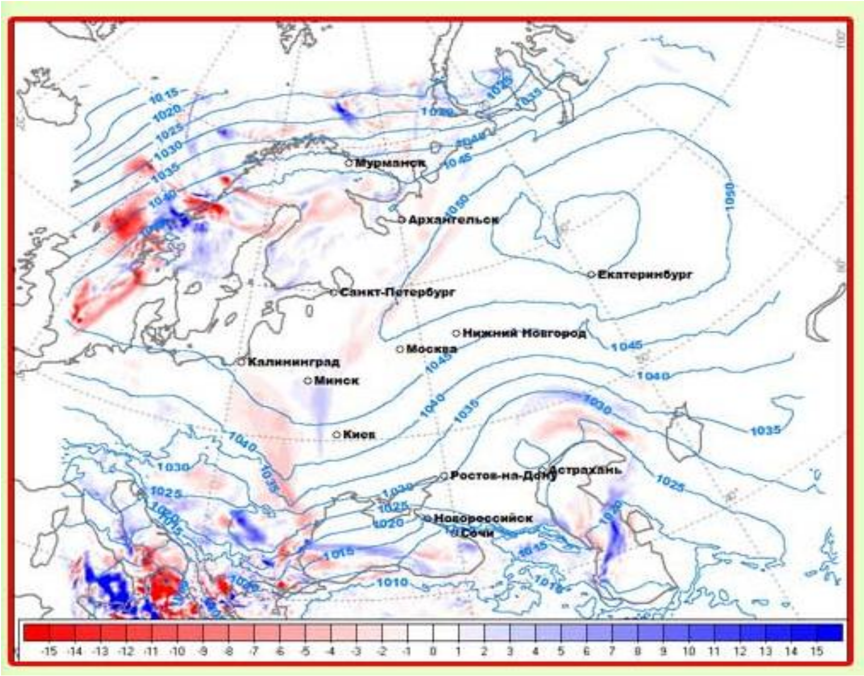




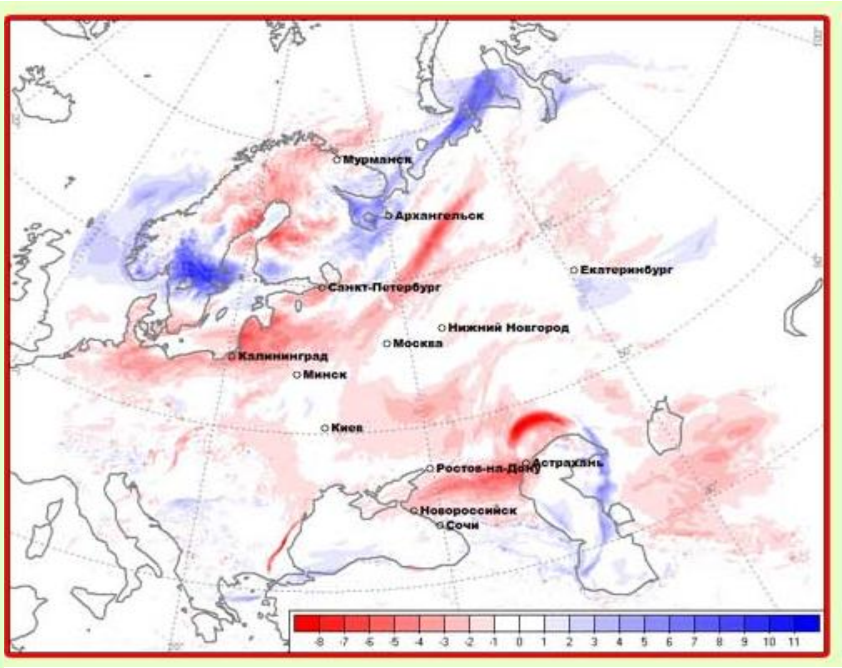


РЕГИОНАЛЬНОЕ УСВОЕНИЕ ДАННЫХ: ПРИМЕРЫ СРАВНЕНИЯ РЕЗУЛЬТАТОВ COSMO-RU07 И COSMO- EU (DWD)

ОСАДКИ



T2M



РЕГИОНАЛЬНОЕ УСВОЕНИЕ ДАННЫХ: РЕАЛИЗАЦИЯ ТЕХНОЛОГИИ «NUDJING» в ГИДРОМЕТЦЕНТРЕ РОССИИ

download GME	00UTC	06UTC	12UTC	18UTC
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end	03:25	09:10	15:25	21:10
Time work	00:35	00:20	00:35	00:20

00UTC	06UTC	12UTC	18UTC	RU07
02:50	08:50	14:50	20:50	start
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00:40	00:20	00:40	00:20	Time work

00UTC		06UTC		12UTC		18UTC	
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01:40	01:40	01:40	01:40	Time work

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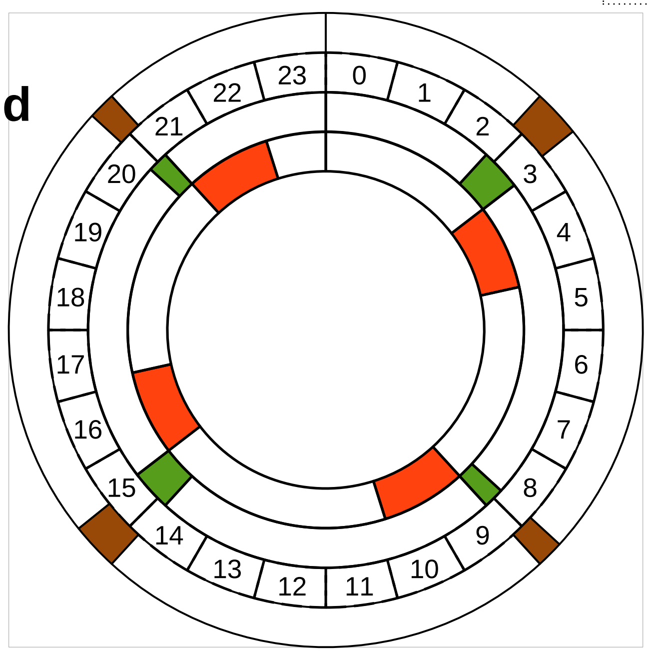
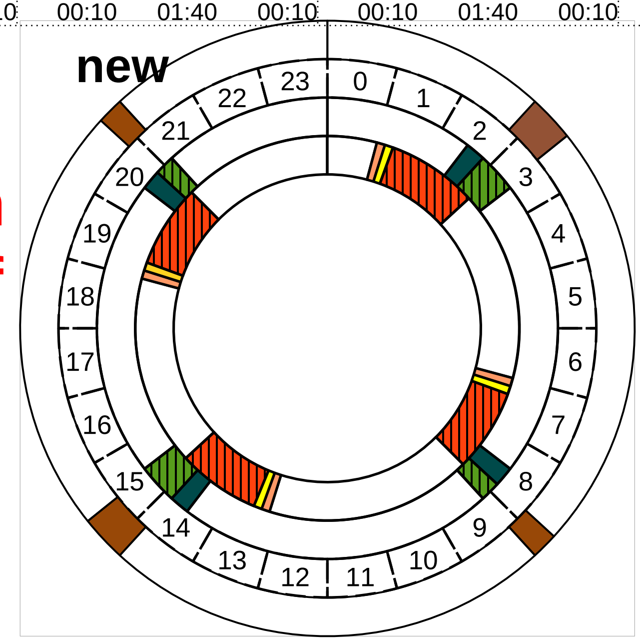
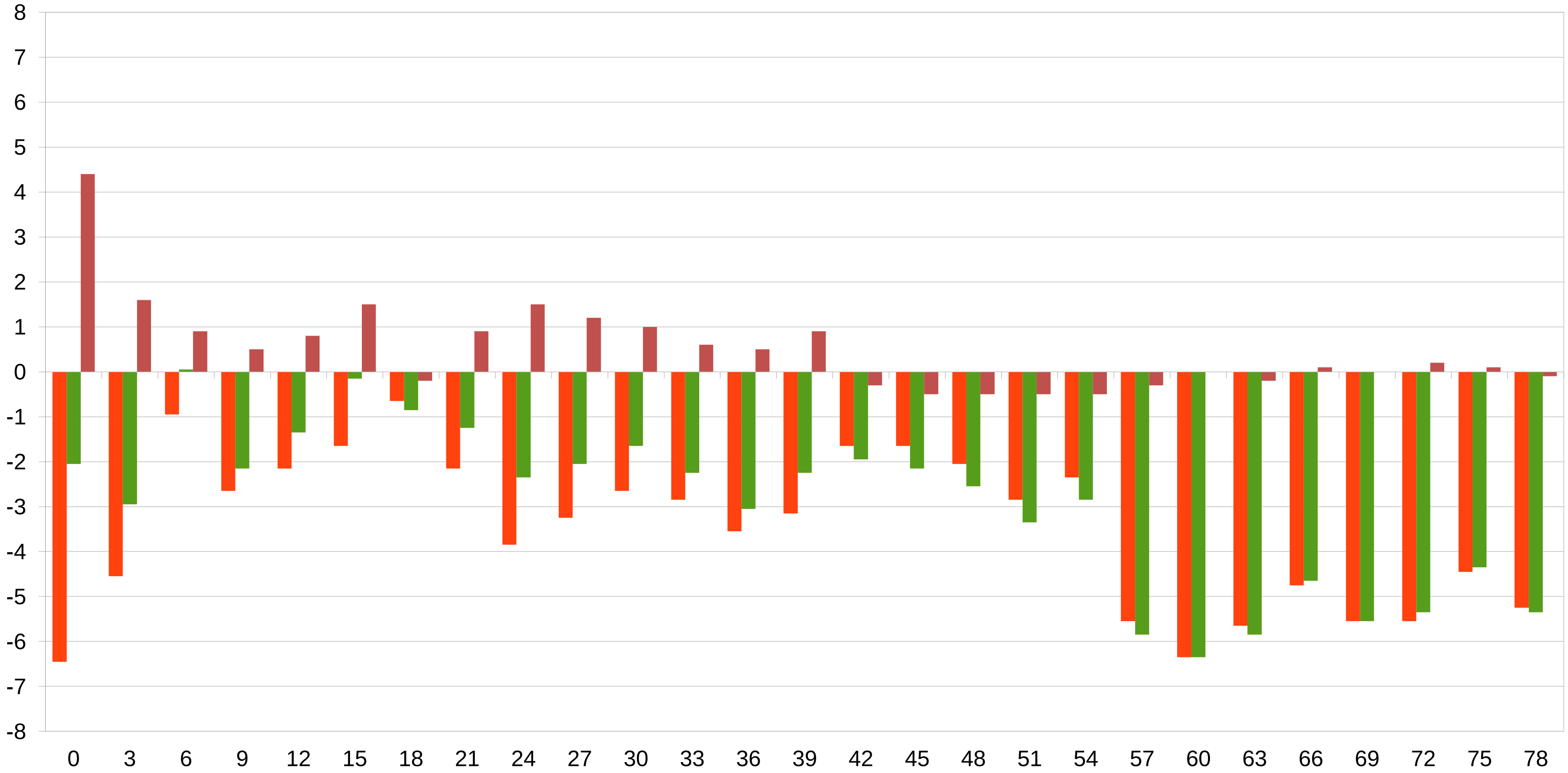
old



operational runs of COSMO-RU07 и COSMO-RU02

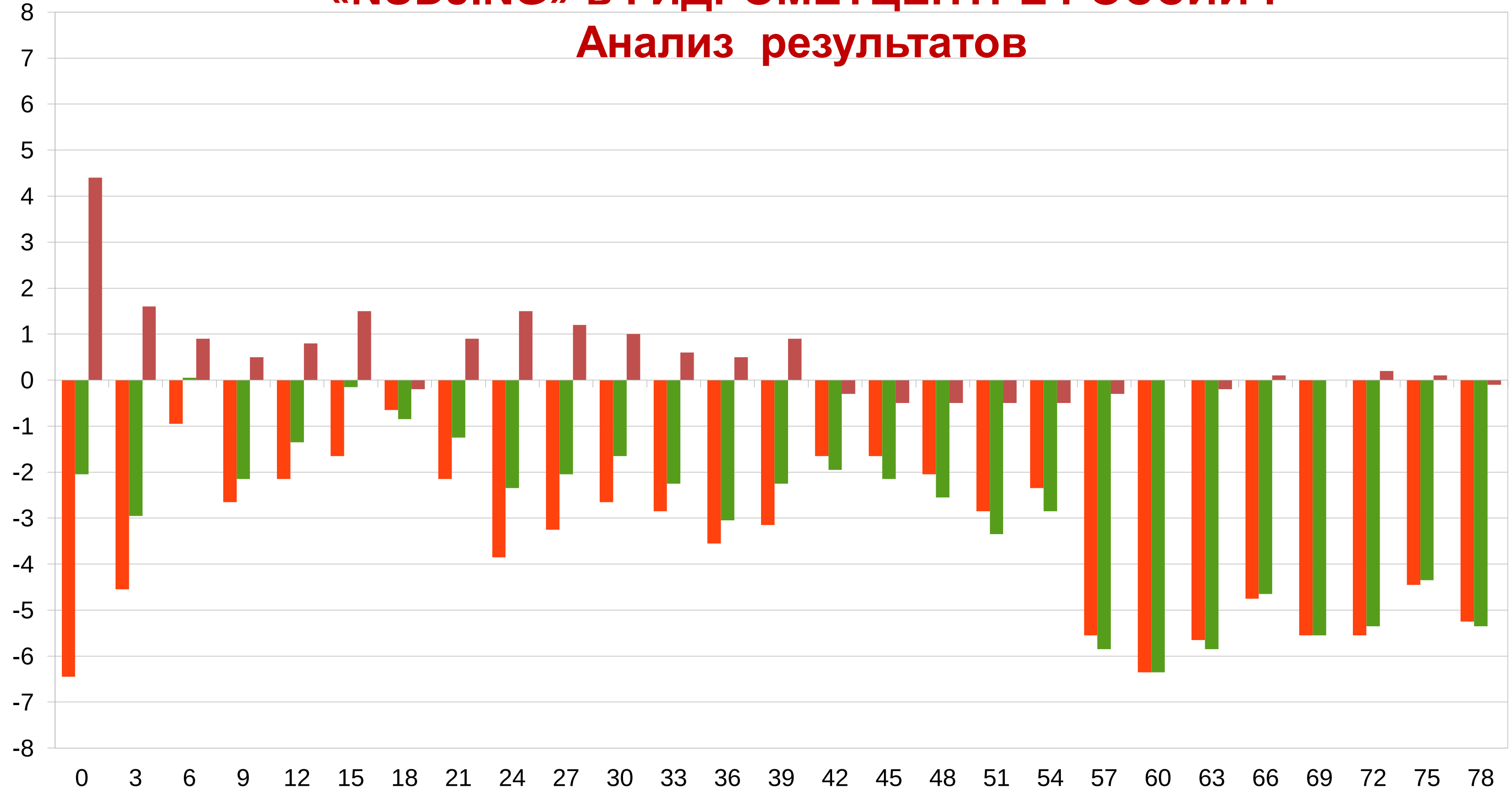


РЕГИОНАЛЬНОЕ УСВОЕНИЕ ДАННЫХ: РЕАЛИЗАЦИЯ ТЕХНОЛОГИИ «NUDJING» в ГИДРОМЕТЦЕНТРЕ РОССИИ



РЕГИОНАЛЬНОЕ УСВОЕНИЕ ДАННЫХ: РЕАЛИЗАЦИЯ ТЕХНОЛОГИИ «NUDJING» в ГИДРОМЕТЦЕНТРЕ РОССИИ :

Анализ результатов



ERROR OF T2M OF "OPER" AND "NUDGCAST".

DIFFERENCE: ERROR OPER - ERROR NUDGCAST:

POSITIVE - FORECAST WITH DA IS BETTER,

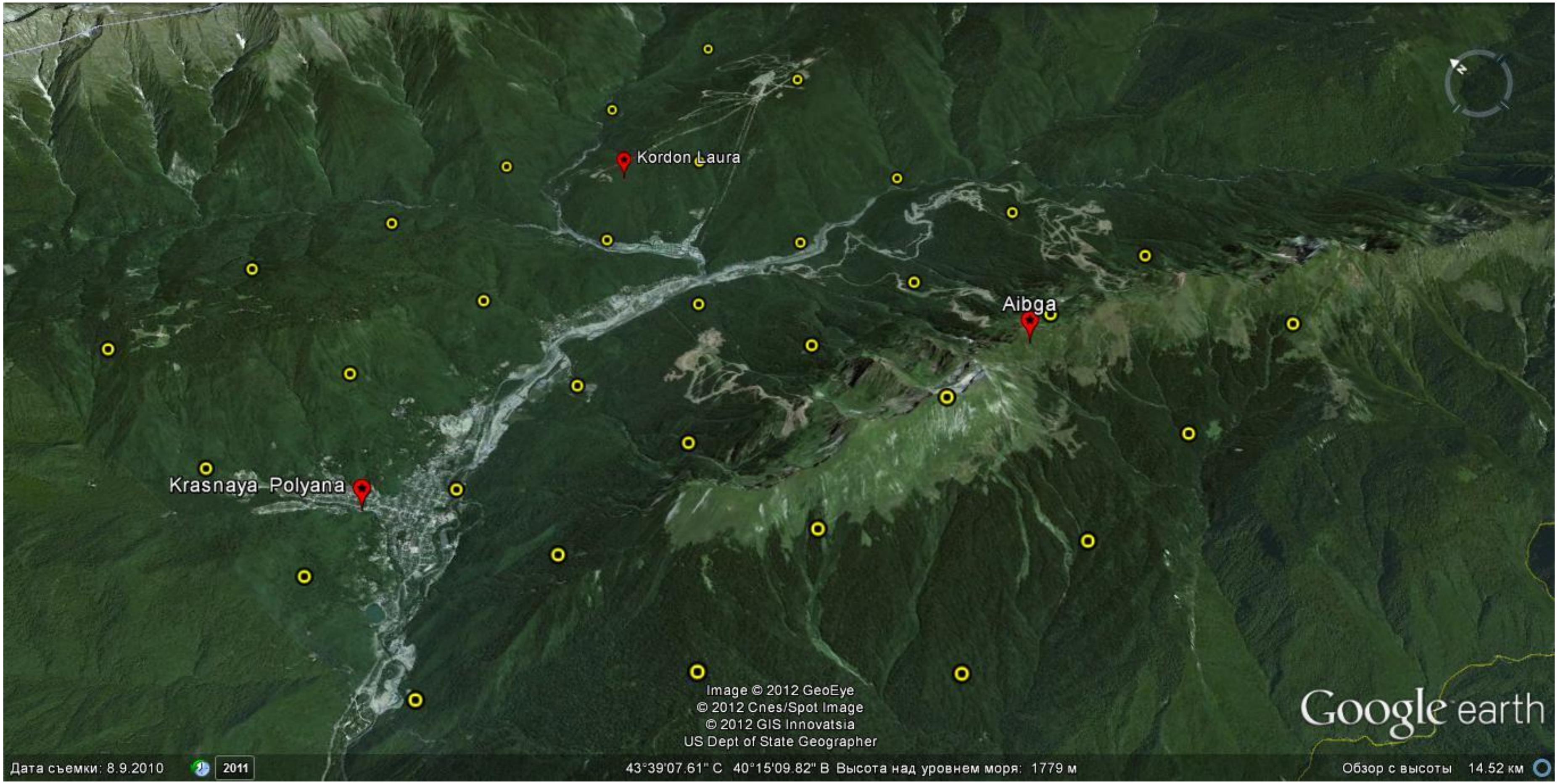
NEGATIVE - FORECAST WITH DA IS WORSE.

Направление 2 (Прогнозирование в точках соревнований)

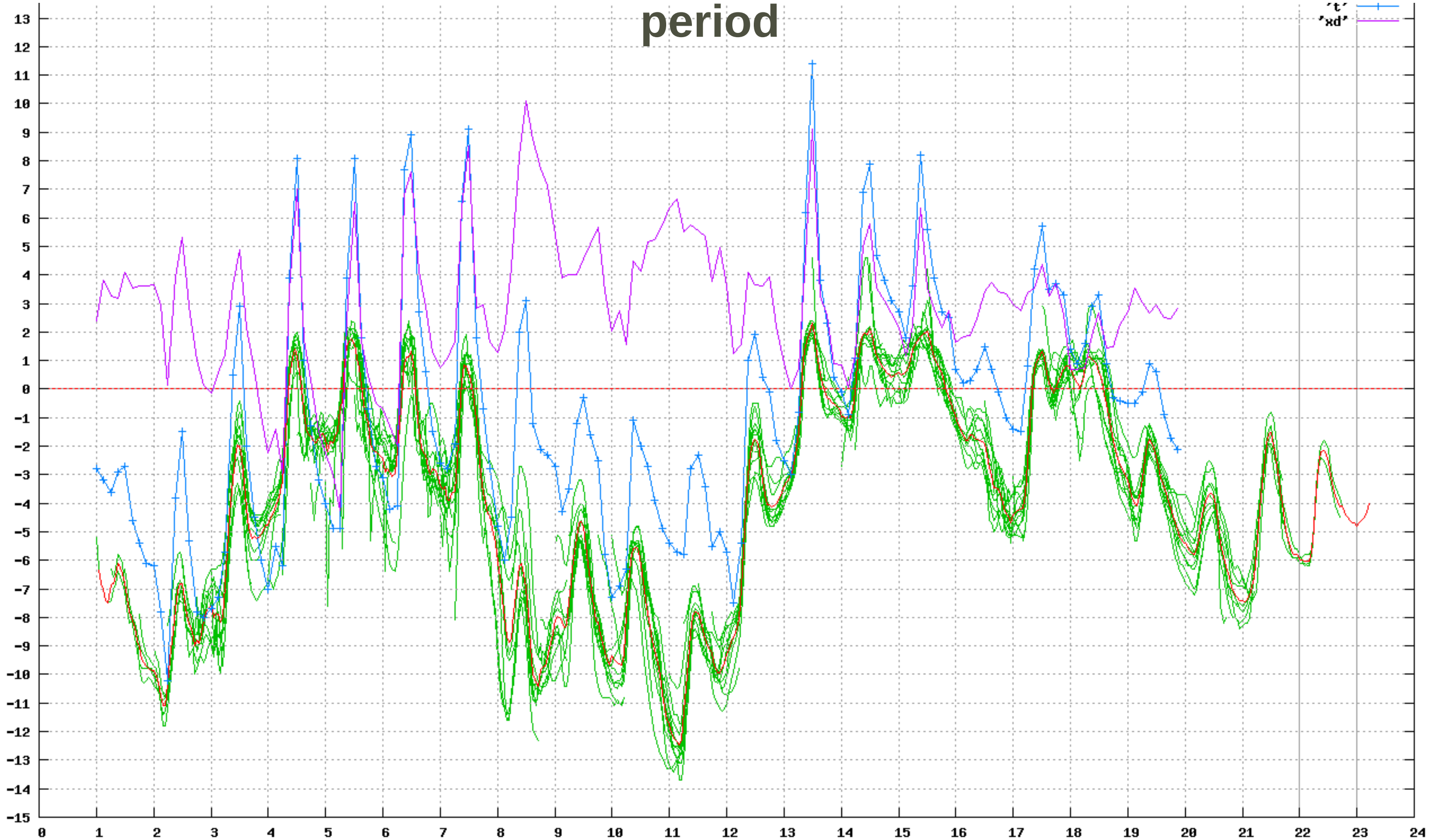
1.1. Развитие статистического пост-процессинга для даун-скайлинга

- СТАТИСТИЧЕСКАЯ КОРРЕКЦИЯ С «КОРОТКИМ» ПЕРИОДОМ НАСТРОЙКИ

Расположение метеорологических станций Росгидромета и вычислительная сетка COSMO-RU2,2



The 2m temperatures observed at Krasnaya Polyana station in February, 2012 and the COSMO-RU07 model forecasts at the nearest grid point over the same period



The temperatures observed at the station are shown in blue;
the temperature forecasts - in green;
the averaged forecast - in red;
the difference between the observed temperature and the averaged forecast is depicted in violet;

Kalman Filter

Predict

Predicted (*a priori*) state estimate $$\hat{\mathbf{x}}_{k|k-1} = \mathbf{F}_k \hat{\mathbf{x}}_{k-1|k-1}$$

Predicted (*a priori*) estimate covariance $$\mathbf{P}_{k|k-1} = \mathbf{F}_k \mathbf{P}_{k-1|k-1} \mathbf{F}_k^T + \mathbf{Q}_k$$

Correction:

Innovation or measurement residual $$\tilde{\mathrm{y}}_k = \mathrm{z}_k - \mathbf{H}_k \hat{\mathbf{x}}_{k|k-1}$$

Innovation (or residual) covariance $$\mathbf{S}_k = \mathbf{H}_k \mathbf{P}_{k|k-1} \mathbf{H}_k^T + \mathbf{R}_k$$

Optimal Kalman gain $$\mathbf{K}_k = \mathbf{P}_{k|k-1} \mathbf{H}_k^T \mathbf{S}_k^{-1}$$

Updated (*a posteriori*) state estimate $$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{K}_k \tilde{\mathrm{y}}_k$$

Updated (*a posteriori*) estimate covariance $$\mathbf{P}_{k|k} = (I - \mathbf{K}_k \mathbf{H}_k) \mathbf{P}_{k|k-1}$$

x – model's variables
F – *transition matrix from step k-1 to step k*
P – *covariance matrix describes the accuracy at each step*
Q – *covariance matrix describes the mathematical model accuracy*
H – *matrix for receipt of observations from the mathematical model*
z – in situ observations
y – the mathematical model's deviation at each step
K – *Kalman matrix*

http://en.wikipedia.org/wiki/Kalman_filter.html

The temperature T observed at the station at time t is represented as

$$T_t = Xp_0 + \sum_{n=1}^{N_p} \left[Xp_{2n-1} \cos\left(tn \frac{2\pi}{Tp} \right) + Xp_{2n} \sin\left(tn \frac{2\pi}{Tp} \right) \right]$$

where Tp is the window width used for expanding the temperature forecasts (4-7 days)
and Np is the number of harmonics used (Tp multiplied by (1, 2, or 3)),

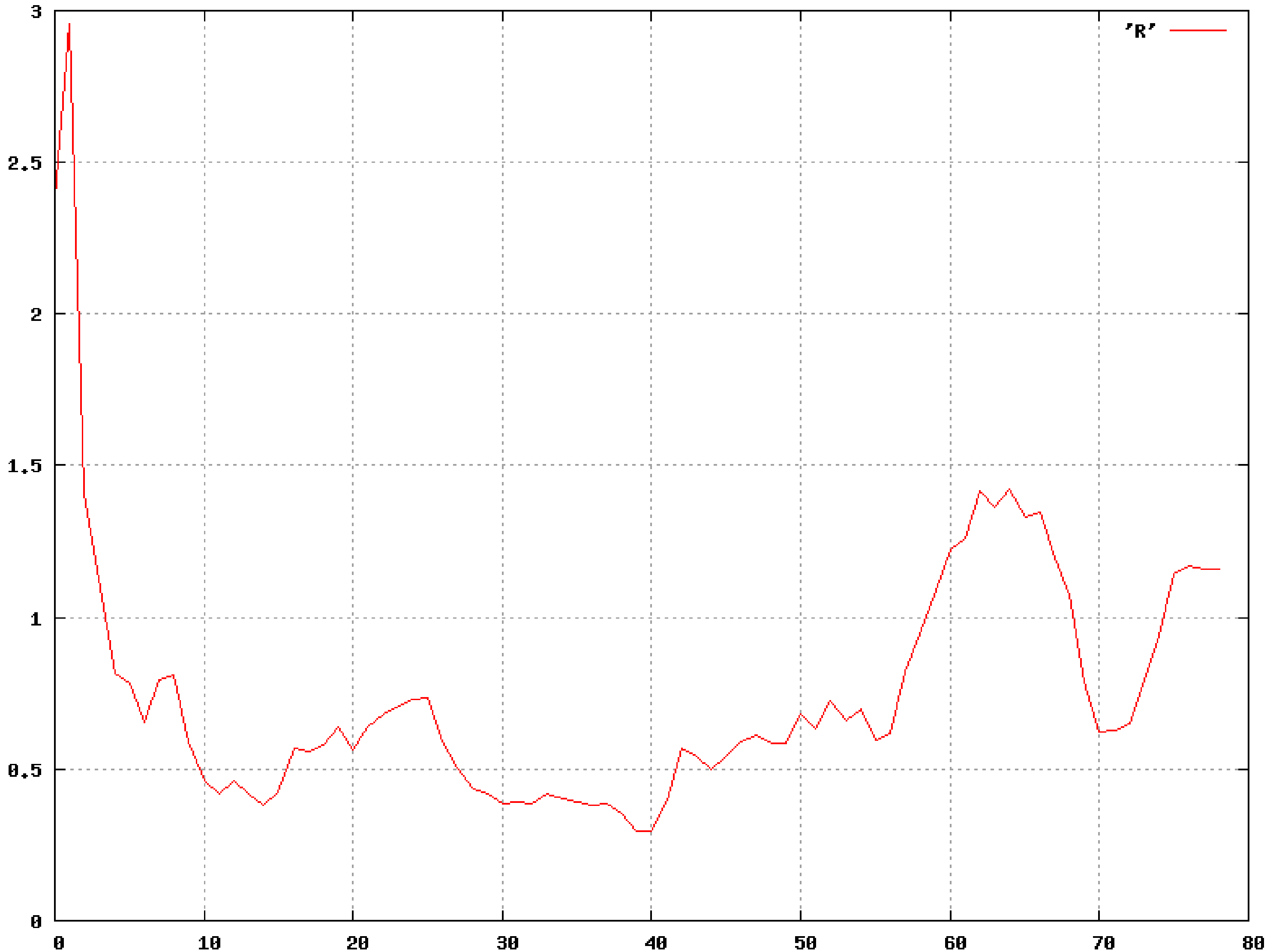
The difference D between the observed temperature and the averaged forecast at time *t* is represented as

$$D_t = Xd_0 + \sum_{n=1}^{N_d} \left[Xd_{2n-1} \cos\left(tn \frac{2\pi}{Td} \right) + Xd_{2n} \sin\left(tn \frac{2\pi}{Td} \right) \right]$$

where Td is the window width used for expanding D (1 day) and Nd is the number of harmonicas used (1, 2, or 3),

The forecast at the time *t* is calculated using the formula $T_t - D_t$

The second part of R, i.e. the root-mean-square deviation of the forecast from the averaged forecast is depicted as a function of forecast range



Corrected 2m temperature for Tp=7 days, Td=1 day, and various Np and Nd

The 2m temperature forecast at Krasnaya Polyana station was corrected over February, 2012 by applying the described method,

The errors in the initial forecasts:

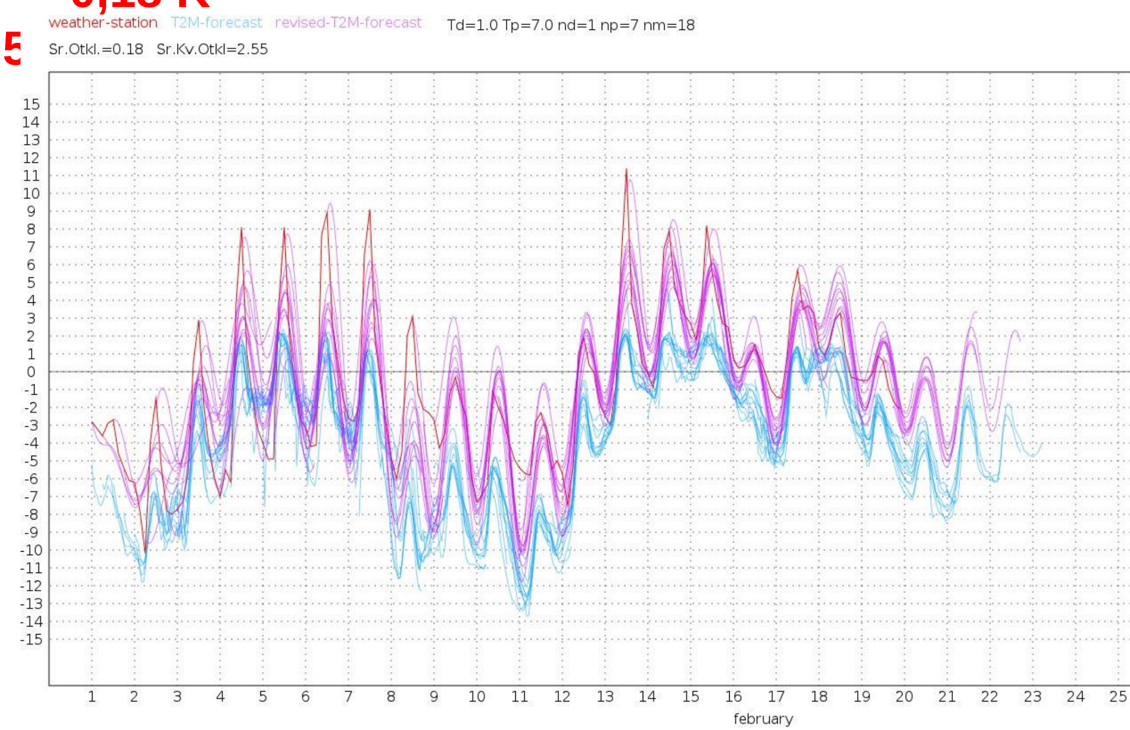
average deviation: 2,86 K

root-mean-square deviation: 3,89 K

For Np=7 and Nd=1, the errors of the corrected forecasts:

average deviation: 0,18 K

root-mean-square deviation: 2,5



- *observed data*
- *T2forecasts*
- *revised T2 forecast*

Corrected 2m temperature for Tp=7 days, Td=1 day, and various Np and Nd

The 2m temperature forecast at Krasnaya Polyana station was corrected over February, 2012 by applying the described method,

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average deviation: 2,86 K

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For Np=7 and Nd=1, the errors of the corrected forecasts:

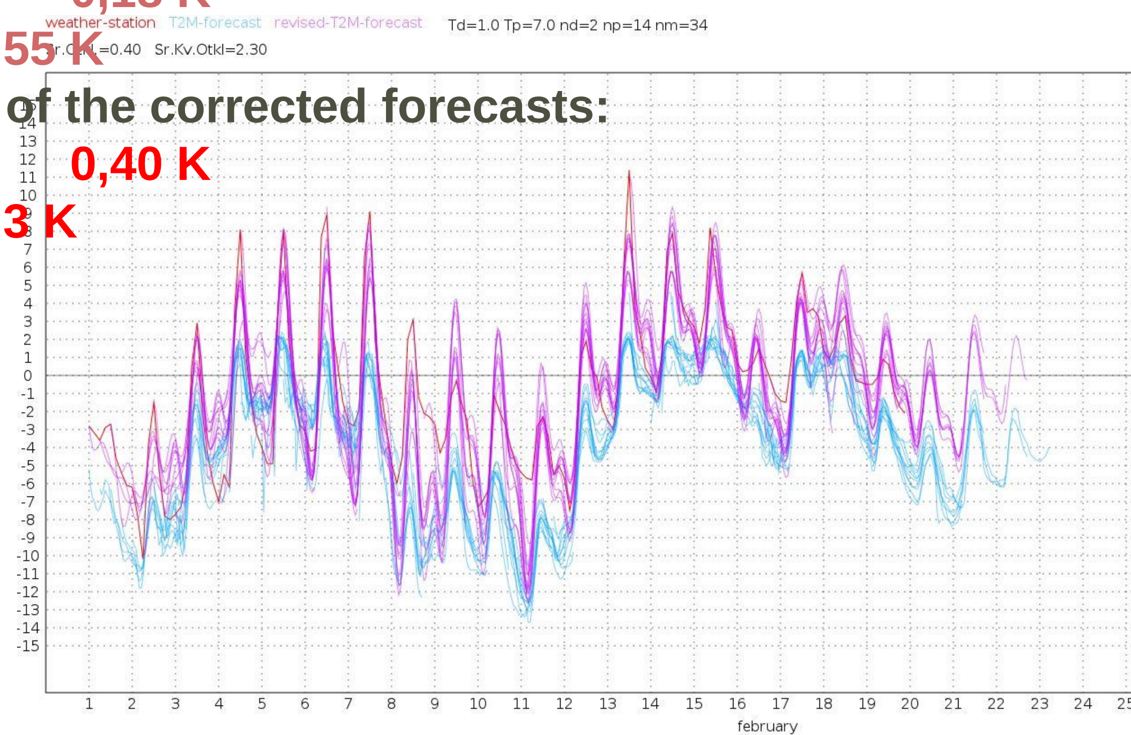
average deviation: 0,18 K

root-mean-square deviation: 2,55 K

For **Np=14** and **Nd=2**, the errors of the corrected forecasts:

average deviation: 0,40 K

root-mean-square deviation: 2,3 K



- *observed data*
- *T2forecasts*
- *revised T2 forecast*

Corrected 2m temperature for Tp=7 days, Td=1 day, and various Np and Nd

The 2m temperature forecast at Krasnaya Polyana station was corrected over February, 2012 by applying the described method,

The errors in the initial forecasts:

average deviation: 2,86 K

root-mean-square deviation: 3,89 K

For Np=7 and Nd=1, the errors of the corrected forecasts:

average deviation: 0,18 K

root-mean-square deviation: 2,55 K

For Np=14 and Nd=2, the errors of the corrected forecasts:

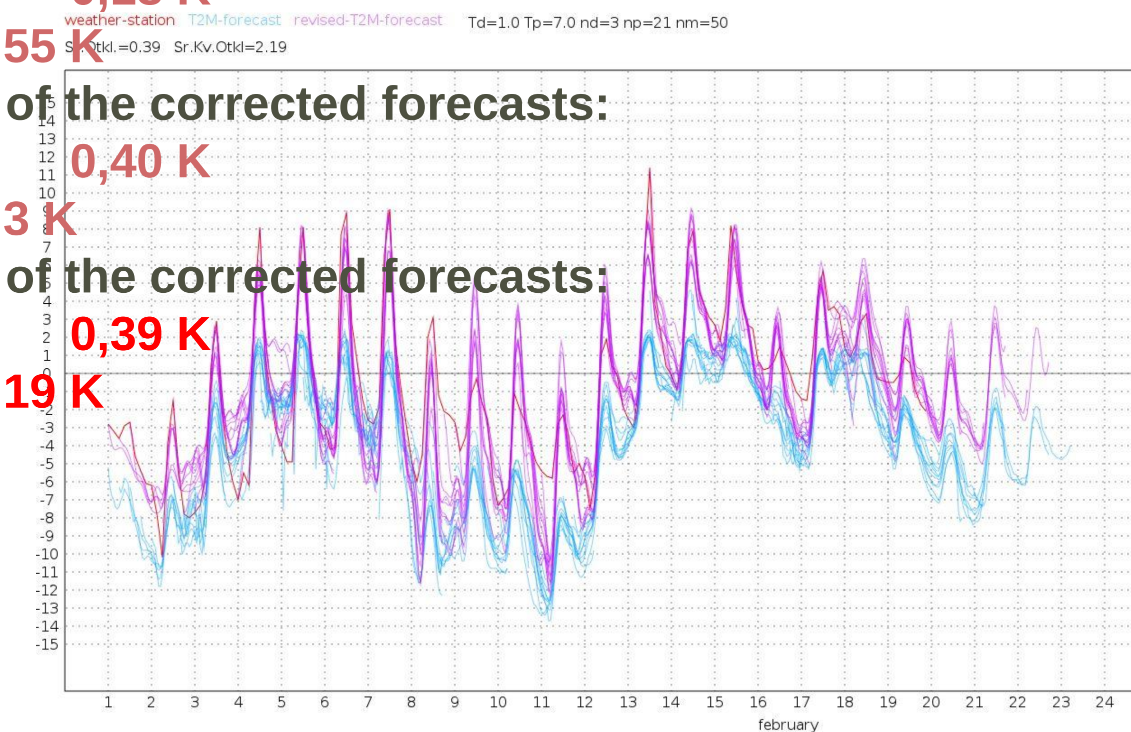
average deviation: 0,40 K

root-mean-square deviation: 2,3 K

For Np=21 and Nd=3, the errors of the corrected forecasts:

average deviation: 0,39 K

root-mean-square deviation: 2,19 K



- *observed data*
- *T2forecasts*
- *revised T2 forecast*

Errors of the forecasts from the observations before and after the correction for various filter parameters, feb2012

(mean deviation (upper), and root-mean-square deviation (lower))

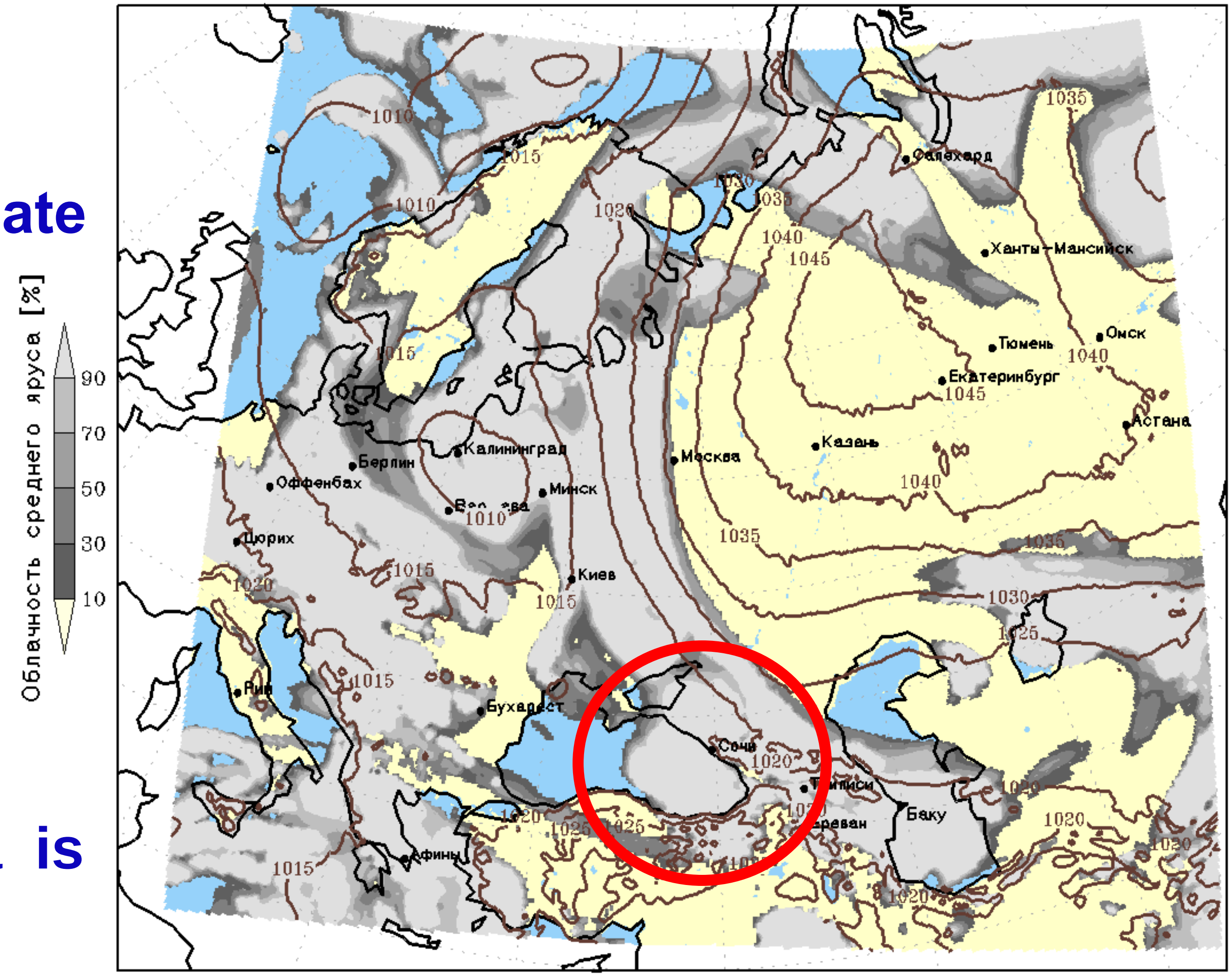
Weather station	Initial forecast	Tp=7; Td=1 np=7; nd=1	Tp=7; Td=1 np=14; nd=2	Tp=7; Td=1 np=21; nd=3
Krasnaya Polyana	2,86 3,89	0,18 2,55	0,4 2,3	0,39 2,19
Aibga	-1,86 3,48	0,38 2,59	0,26 2,72	0,2 2,78
Kordon Laura	5,3 6,17	0,41 3,14	0,46 2,95	0,47 2,91

ГИДРОМЕТЦЕНТР РОССИИ

04:00 24янв 2012 (МСК): Р ур.моря, облачность, осадки

The local cyclones didn’t indicate into PMSL fields and forecasters often can’t see it

But more dangerous phenomena is due to this local cyclones



Прогноз на 0ч. от 04:00 24янв 2012 (МСК)
COSMO-RU 7км

Давление на уровне моря

Направление 3 (Мезомасштабное ансамблевое моделирование)

3.1. Адаптация системы COSMO-LEPS -7 «COSMO-FROST» для Региона и оперативная передача и обработка результатов

3.2 Развитие системы COSMO- FROST-SO2

-

COSMO-FROST-EPS @ ECMWF: PRESENT STATUS

d d+1 d+2 d+3

ECMWF EPS

clustering interval

4 variables
Z U V Q

3 levels
500 700 850 hPa

Cluster Analysis and RM identification

2 time steps

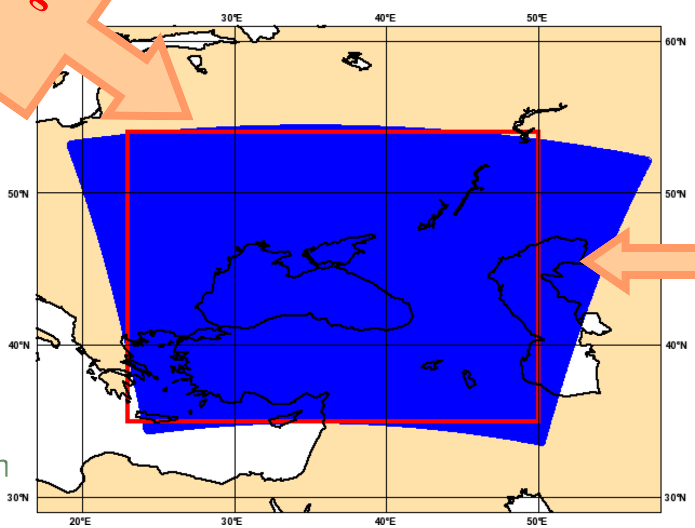
Black-Sea area

Complete Linkage

10 Representative Members driving the 10 COSMO-model integrations (weighted according to the cluster populations)

employing either Tiedtke or Kain-Fristch convection scheme (randomly choosen)
+
perturbations in turbulence scheme and in physical parameterisations

clustering area



Integration Domain

- Δx ~ 7 km; 40 ML; fc+72h;
- initial time: 00/12 UTC;
- At the moment, computer time (~ 2 million BUs for 2012) is provided by an ECMWF Special Project;
- suite managed by ARPA-SIMC;
- contributions from ECMWF member states could be needed in the future.

A.Mon
LEPS

DISSEMINATED PRODUCTS

All post-processing is done using with COSMO-software **fieldextra**:

- probability fields for the exceedance of thresholds for surface fields;
- ensemble mean and ensemble standard deviation for some fields;
- individual ensemble members for the generation of point-forecasts;
- hourly boundary conditions (from fc+0h to fc+48h) for convective-resolving ensemble (RDP part).

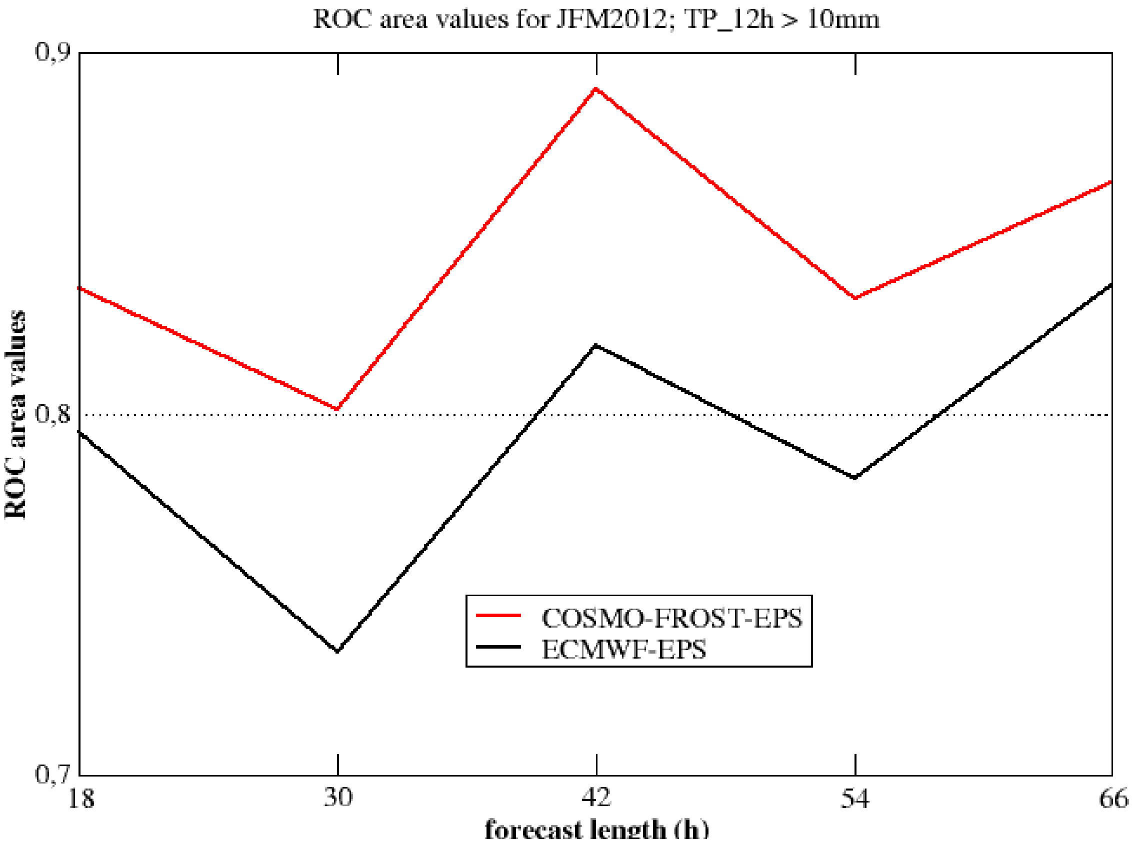
- 10 perturbed COSMO-model runs (ICs and BCs from 10 selected EPS members): start at 00UTC and 12UTC; $\Delta t = 72h$;
- *1 deterministic run (ICs and BCs from the deterministic ECMWF forecast) to "join" deterministic and probabilistic approaches: start at 00UTC* ***and*** *12UTC;* $\Delta t = 72h$;

ROC AREA

- Area under the curve in the HIT rate vs FAR diagram; the higher, the better …
- Valuable forecast systems have ROC area values > 0.6.
- Consider the event: 12-hour precipitation exceeding 10 mm

- COSMO-FROST-EPS outperforms ECMWF-EPS for all forecast ranges.
- 12-hour cycle of the score for both systems, which better predict precipitation occurring during daytime (6-18Z).
- ROC area values show little dependence on the threshold (not shown).

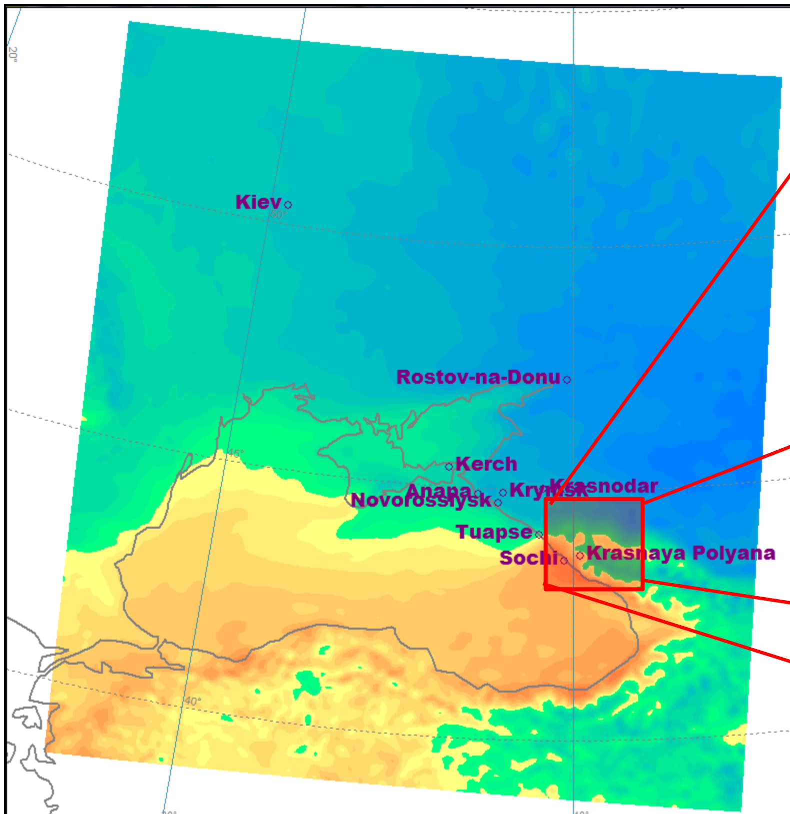
These results need to be confirmed over higher-resolution observational networks.



ГИДРОМЕТЦЕНТР РОССИИ

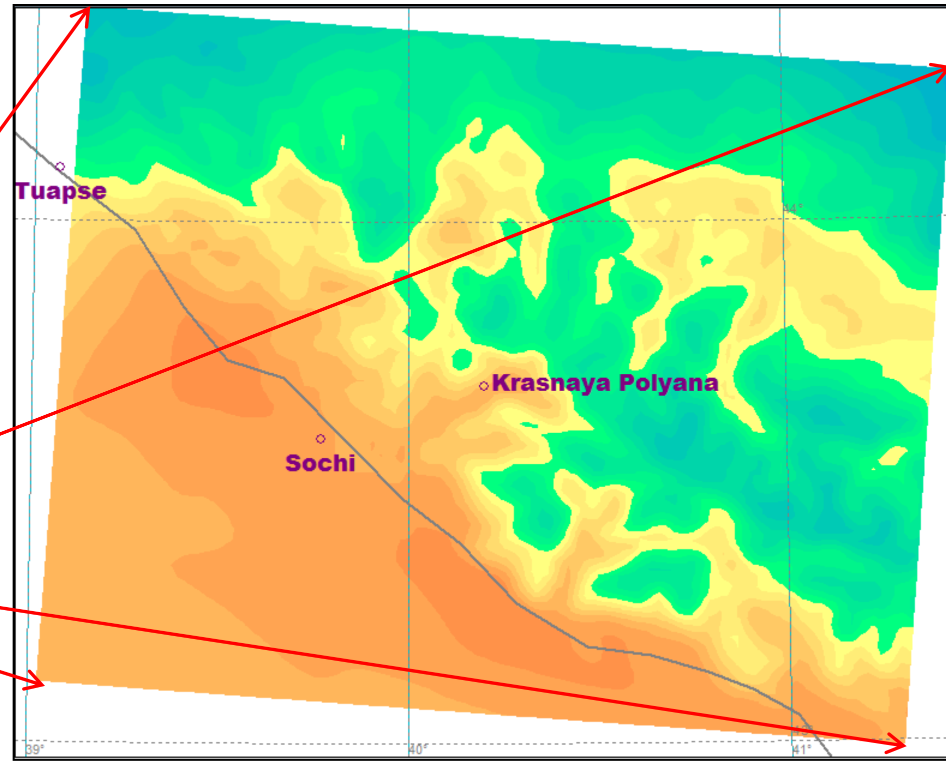
COSMO-RU-LEPS- 2.2 KM

- 10 members; BCs & ICs from COSMO-FROST-EPS
- No physical parameters perturbed or modified
- ~ 2h (min ~ 70 minutes) on 120PE (10*12)
- Forecast length 48 h; output time step 1h



COSMO-FROST-EPS

Domain: 1575 km * 1680 km
Grid: 226*241, 40 lev
Step: 7 km

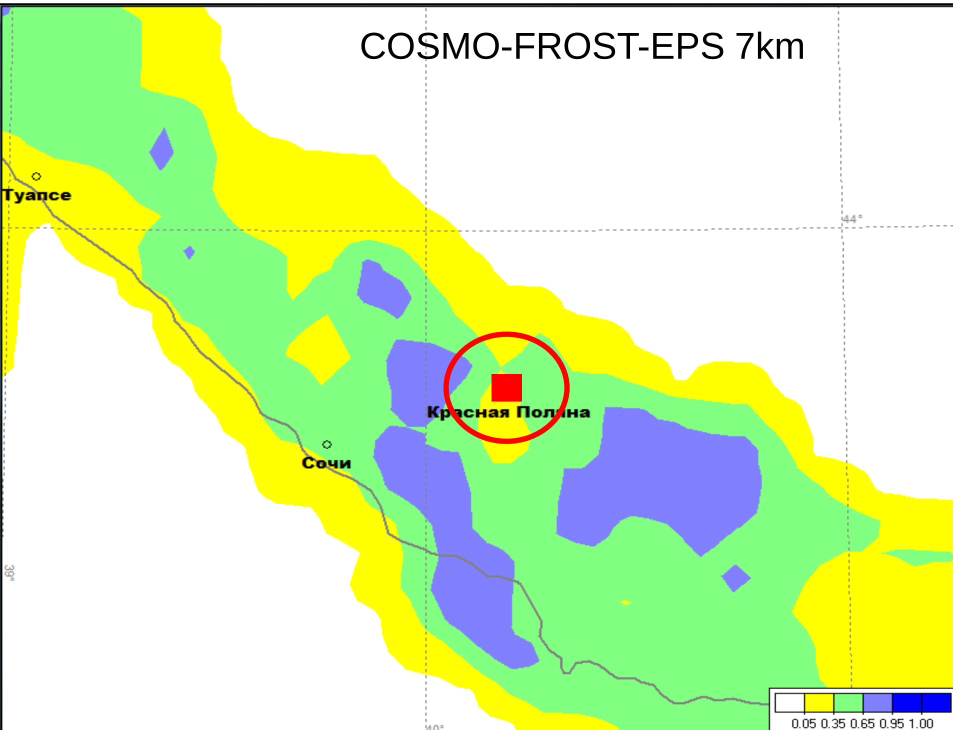


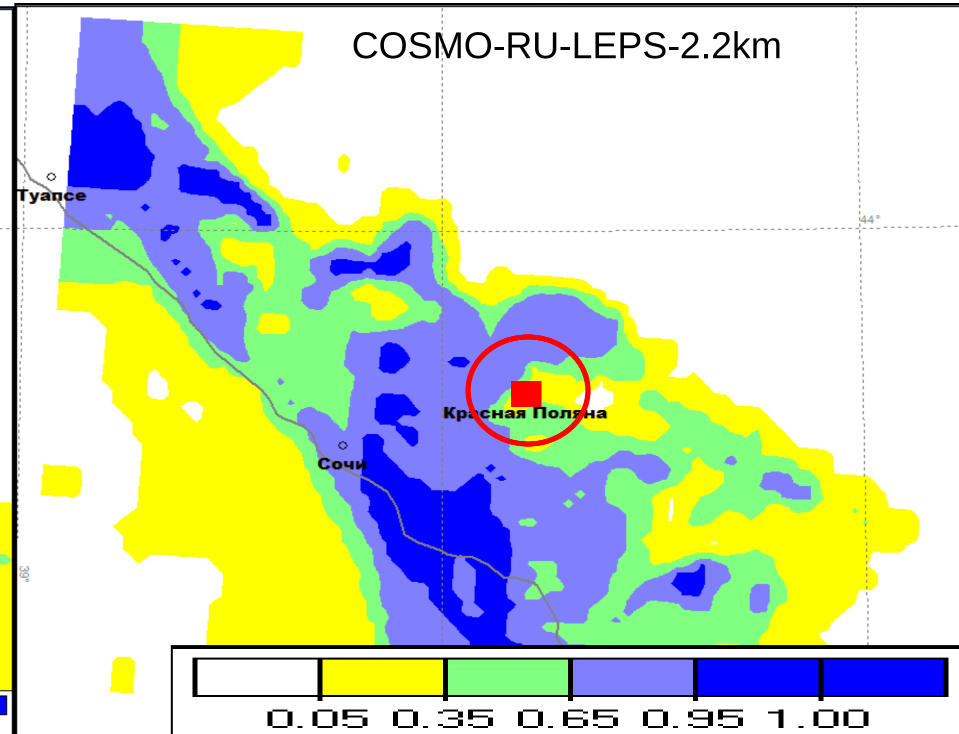
COSMO-RU-LEPS- 2.2 km

Domain: 187 km * 143 km
Grid: 86*66, 50 lev
Step: 2.2 km

COSMO-FROST-EPS 7km vs. COSMO-RU-LEPS-2.2km:

probability of precipitation exceeding 10 mm/12h





■ Krasnaya Polyana

Initial time: 12 UTC 15.02.2012 (Lead time 15 h)

Valid: 15 UTC 15.02.2012 – 03 UTC 16.02.2012

•More detailed reproduction of meteorological fields by 2.2km model can improve probability forecasts !

ЗАКЛЮЧЕНИЕ

-Разработки проекта ведутся с учетом потребностей метеобслуживания других крупнейших спортивных мероприятий, в первую очередь- Универсиады в Казани

-В результате выполнения работ по проекту CORSO ожидается получение новой технологической ветки, прогнозирования по модели COSMO, элементы которой могут быть включены в другие оперативные технологии численного ПП, а также - будет получен и распростаранен методический опыт

- Внедрение ряда разработок планируется к XI-XII 2012 г., с учетом необходимости их использования во время тестовых соревнований в Сочи

СПАСИБО ЗА ВНИМАНИЕ!

THANK YOU FOR YOUR ATTENTION!