Forecasting systems in Russia: current status and development

E.Astakhova, Hydrometcentre of Russia

with contributions of M.Tsyrulnikov, M.Tolstykh,I.Rozinkina,G.Rivin, D.Kiktev,P.Svirenko,M.Shatunova and many others

WGNE29, Melbourne, Australia

March 2014

Computer facilities at Roshydromet (WMC Moscow)

Computer	Vendor (country)	Rpeak, TFlops	cores/ cores per node
SGI Altix 4700	SGI(USA)	11	1664/128
SGI Altix ICE8200	SGI(USA)	16	1408/8
RSK Tornado	RSK(Russia)	35	1152/12
SGI Altix ICE-X	SGI(USA)	14	720/20
SGI Altix UV2000	SGI(USA)	2	96/96

Modification of computer system is planned in 2015 (~1 PFlops)

Data Assimilation at the Hydrometcenter of Russia (RHMC)

1. DAS based on variational/hybrid approach

M Tsyrulnikov, P Svirenko, M Gorbunov, D Gayfulin, A Ordin, A Rakitko

Operational global DAS

Research regional DAS

2. Experimental ensemble assimilation system for SL-AV global model (LETKF)

A.Shlyaeva, V.Rogutov, V.Mizyak, M.Tolstykh

Global 3D-Var

= based on a spatial-auto-regression covariance model. The model is highly parameterized -- with the intention to be used in an EnVar scheme

= assimilated satellite obs types: AMSU-A, MHS, AMV (Geo, Polar, Leo-Geo), scatterometry (ASCAT, OSCAT), radio-occultation (COSMIC, GRAS, GRACE).

= 3D-Var is working in real time both with the external background (6-h GFS forecast) and in the cycling mode with the RHMC semi-Lagrangian model SL-AV.

PLANS

- **A hybrid EnVar scheme: development has started**
- **Hyper-spectral satellite data.**
- **GNSS ZTD satellite data.**
- **Account of satellite error correlations.**

Satellite data assimilation

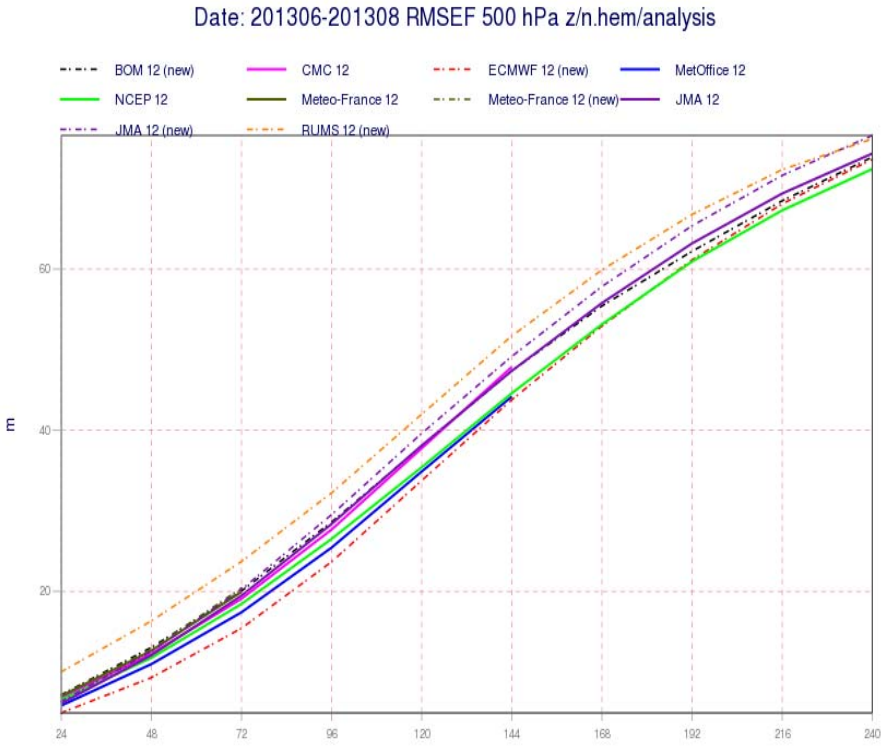
Collaboration with Environment Canada (P.Houtekamer and H.Mitchell) is underway on a technique aimed at optimal use of satellite observation-error correlations.

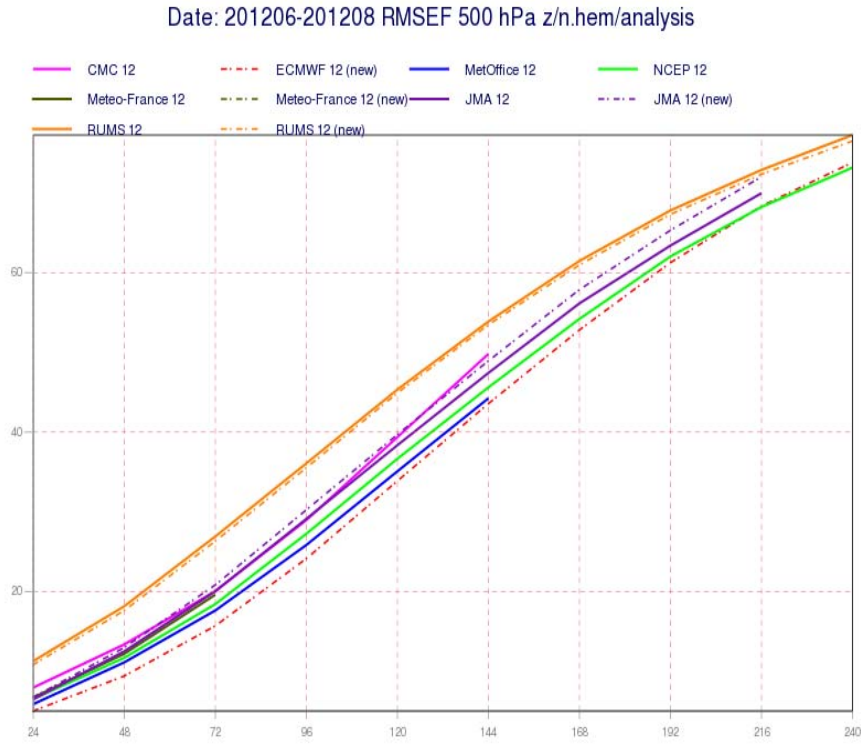
The proposed technique accounts for satellite error correlations without explicitly treating non-diagonal covariance matrices.

H500. 20N-90N. RMSE vs forecast lead time

SL-AV is orange (RUMS12)

(from http://apps.ecmwf.int/wmolcdnv/ **)**





Jun-Aug 2013

Jun-Aug 2012

Operational implementation of 3D Var improved the scores.
The prognostic model is almost the same as a year before

Regional 3D-Var

= based on the global 3D-Var scheme (stretched geometry)

= Doppler radar radial wind data assimilation: development underway.

= Works in the experimental mode over two domains: Sochi (2.2 km grid) and Siberia (14 km grid) with COSMO-Ru model.

PLANS

- **Switch to hybrid – after the global EnVar is ready.**
- **Assimilation of radar winds (and, later, reflectivities)**
- **Account of radar reflectivities error correlations.**

Regional 3D-Var with COSMO (Siberian region):

RMS error of 6-h COSMO forecasts (14 km resolution) started from assimilated analyses (averaging for the period 1-12 December 2013)

Configuration	H, m	T, K	U, m/s	Rel.Hum, %
NoOBS (Pure Downscaling)	20.5	2.52	2.76	22.1
Interpolated global DWD analysis	16.9	2.40	2.42	21.4
Regional cyclic 3D-Var: without AMSU	18.0	2.44	2.56	20.3
Regional cyclic 3D-Var: with AMSU	17.8	2.42	2.55	20.3

→ *The effect is bigger than for Sochi -- because of more observations per grid point assimilated here.*

Experimental ensemble assimilation system for SL-AV global model

- **Scheme: LETKF** [Hunt et al, 2007] **with multiplicative and additive inflation**
- **Assimilation for the global SL-AV model (0.9˚x0.72˚ lon-lat, 28 levels)**
- **Observations assimilated currently: synops, radiosondes, satobs, ships, aireps.**
- **Soil analysis** [Giard, Bazile, 2000] **in the assimilation cycle, separate analysis for T2m and RH2m**
- **The system works stably, results in** [Shlyaeva et al., Russ. J. Numer. An. & Math. Mod. 2013]
- **Current work: implement height reassignment scheme for AMVs**
- **Future plans: implementation of SPPT scheme in the model, assimilation of AMSU observations**

Authors: A.Shlyaeva, V.Rogutov, V.Mizyak, M.Tolstykh

Global modeling

- 2 global models (SL-AV; spectral)

- Global ensemble prediction system: 14 members, breeding, based on T169L31 and SL-AV global models –on operational trials, no changes in 2013, verification scores provided to the Lead Centre on Verification of Ensemble Prediction Systems http://epsv.kishou.go.jp/EPSv/

The global SL-AV model

Semi-Lagrangian vorticity-divergence dynamical core of own development (Tolstykh), mostly ALADIN/LACE parameterizations.

•Operational medium-range fcst version: 0.9x0.72 deg lon/lat, 28 levels

•Seasonal forecast version: 1.4x1.1 deg lon/lat, 28 levels

Nearly the same physics for medium-range and seasonal versions

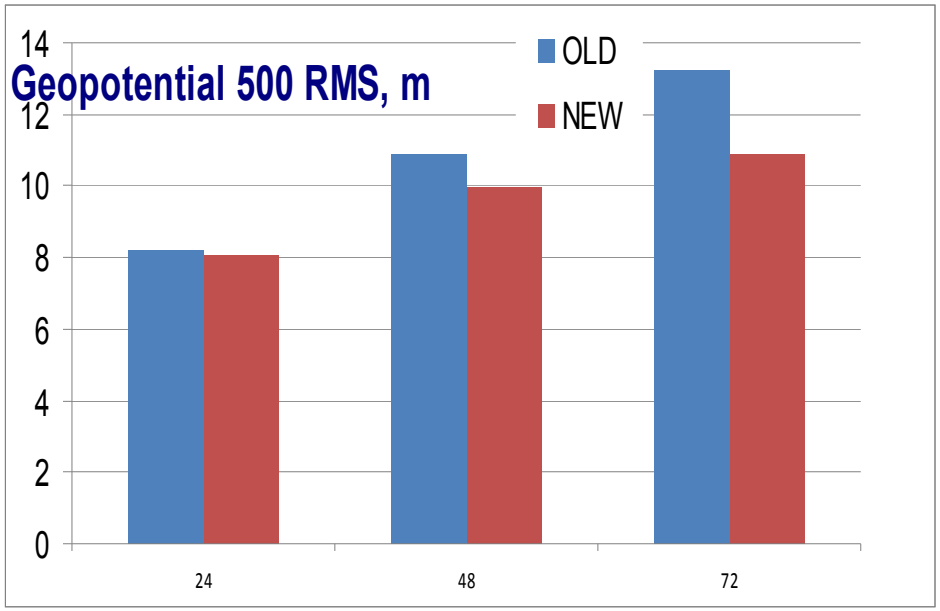
•A new version:0.225x(0.18-0.23) deg, 51 levels, improved physics

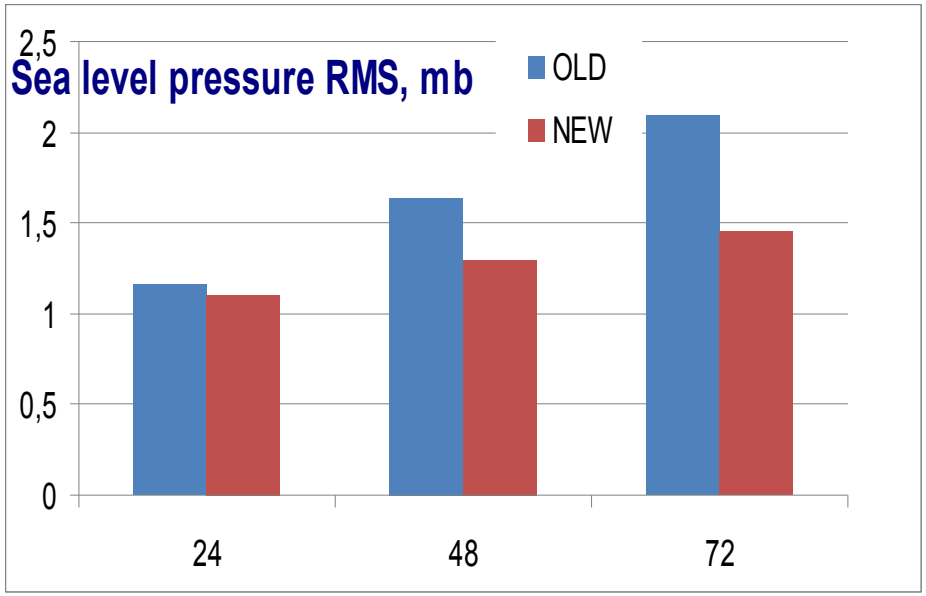
Developments since last WGNE session (included in the new version)

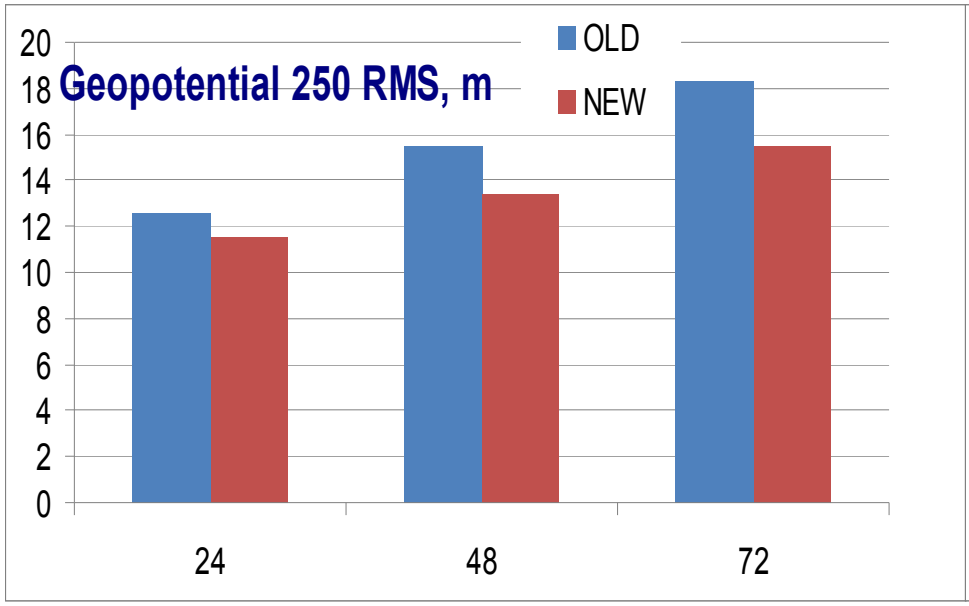
- climatic aerosols distribution (GISS climatology)
- modified cloud parameterization (ALARO/LACE developments)
- RRTM LW radiation - INM RAS multilayer soil model
- Improved effect of fresh snow albedo

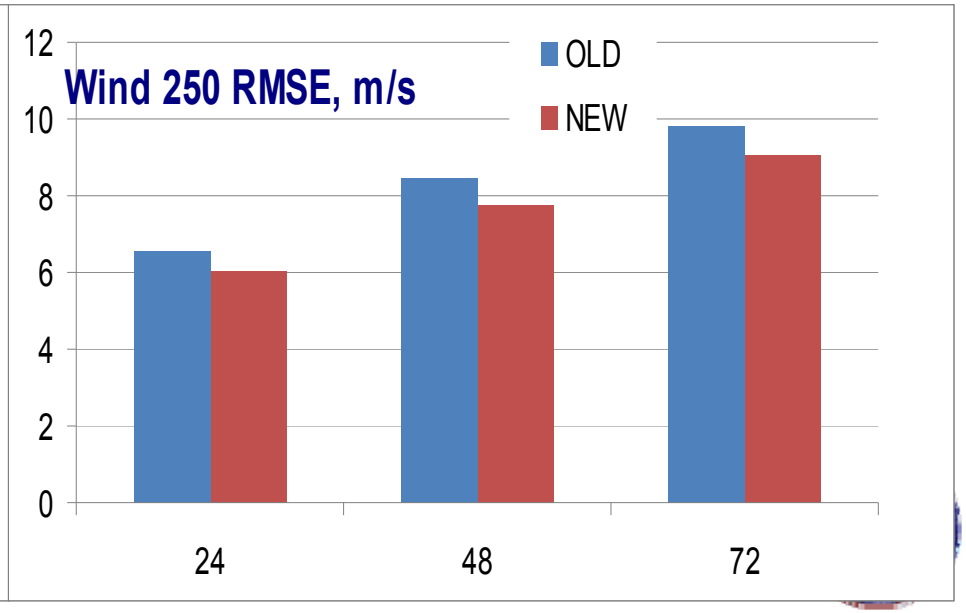
Operational version (0.9˚x0.72˚, 28 levs, OLD) and new version (0,225˚x0,18˚, 51 levs, NEW) of the SL-AV model:

RMS errors for tropics, May-Oct 2013

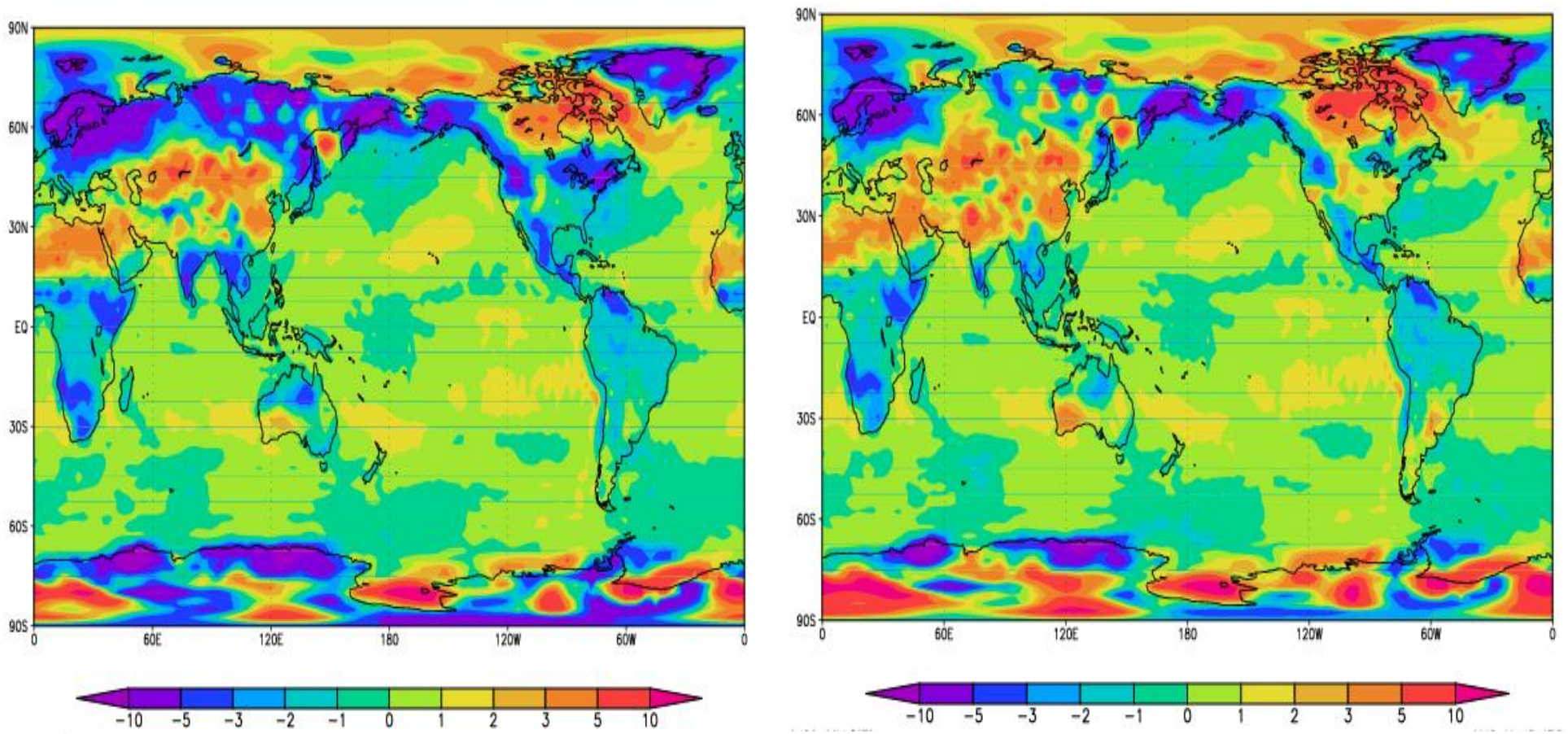








Role of snow albedo (fresh snow effect). Reforecast for Mar 1982 (started at end of Jan 1982). T2m bias: standard scheme (left), modified snow albedo (right) (A.Yurova)



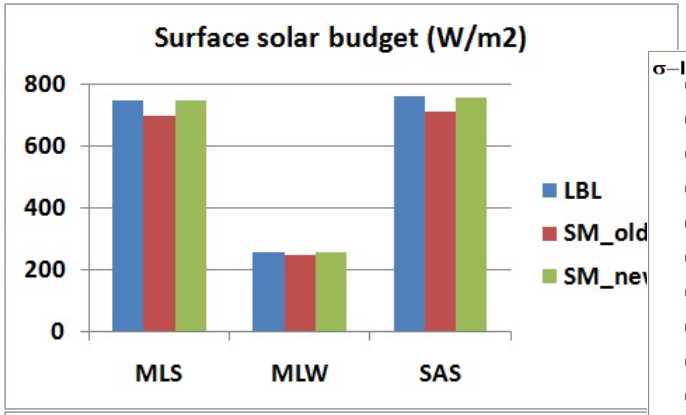
Global SL-AV model: Plans for further development

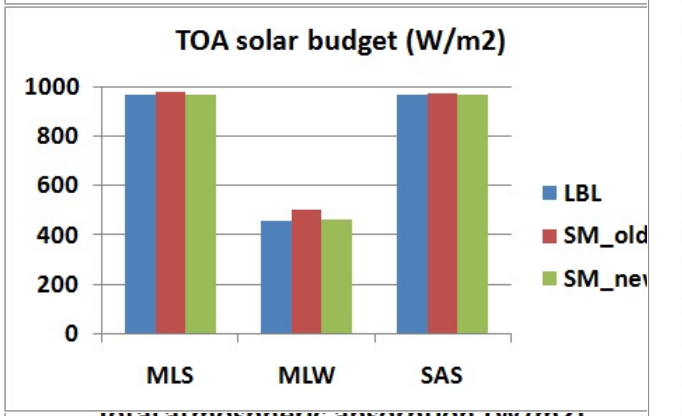
- Implement hybrid vertical coordinate instead of sigma
- Implement RRTM-G both LW and SW radiation with Monte-Carlo cloud simulator
- Implement ozone cycle (mass-conservative SL advection is ready)
- Convert current med-range model version (0.9x0.72, 28 levs) into seasonal fcst version

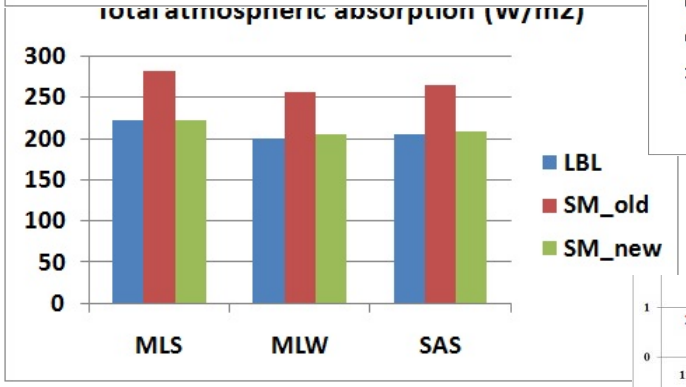
RHMC Global spectral model

- Spectral vorticity-divergence dynamical core
- Operational: T169L31
- Under pre-operational testing, ready for operational implementation : **T339L31**
- Upgraded radiation block (5 $\rightarrow$8 spectral intervals, new data for the gas absorption, 1 $\rightarrow$5 types of aerosols)
- Upgraded block of soil heat transfer calculations
- A new algorithm for initialization of snow-cover mask, based on high resolution satellite data

Implementation of upgraded radiation block (based on detailed Ritter-Geleyn scheme + new parameters for gas absorption and types of aerosols)

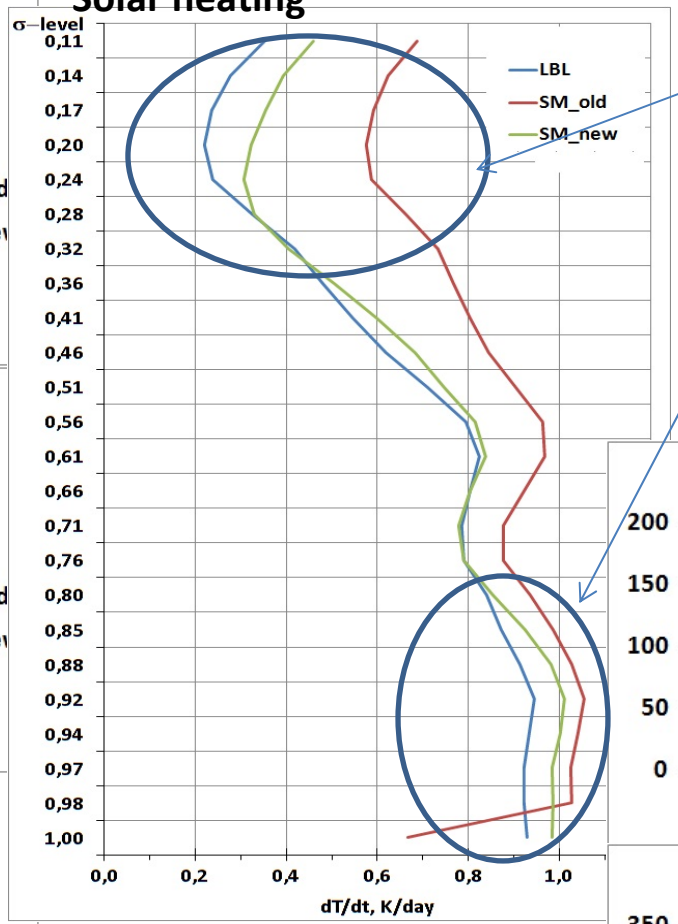




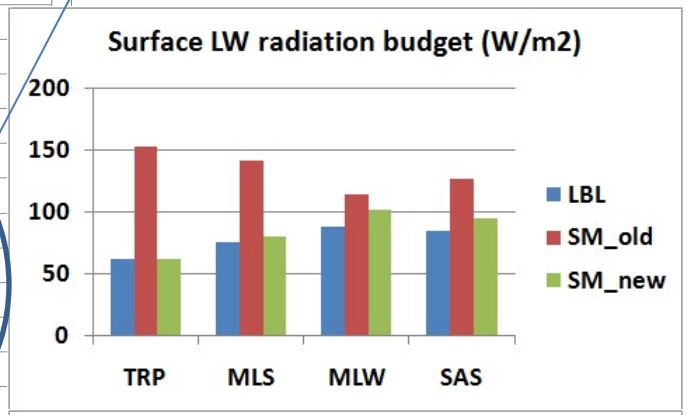


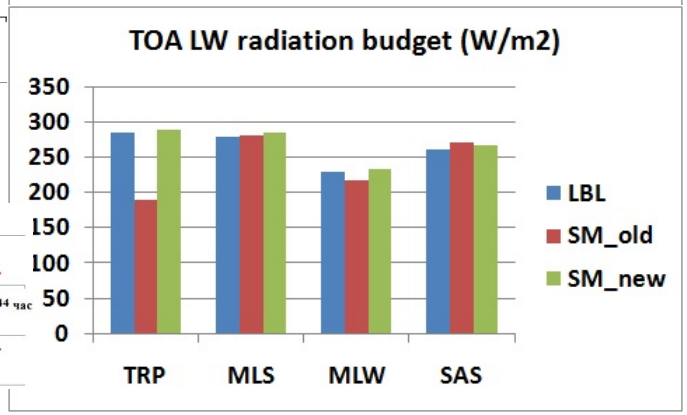
MLS - mid latitude summer MLW - mid latitu
SAS - sub arctic summer TRP - tropics

Solar heating

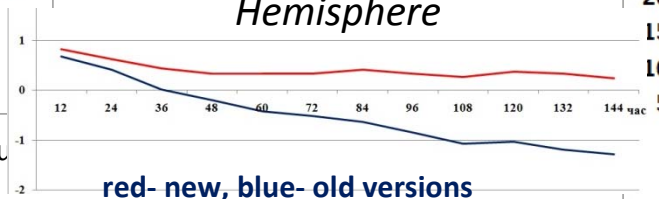


Example of more accurate reproduction of solar heating radiation in the lower and upper parts of the simulated atmosphere





The ME evaluation for H500 forecasts for North Hemisphere



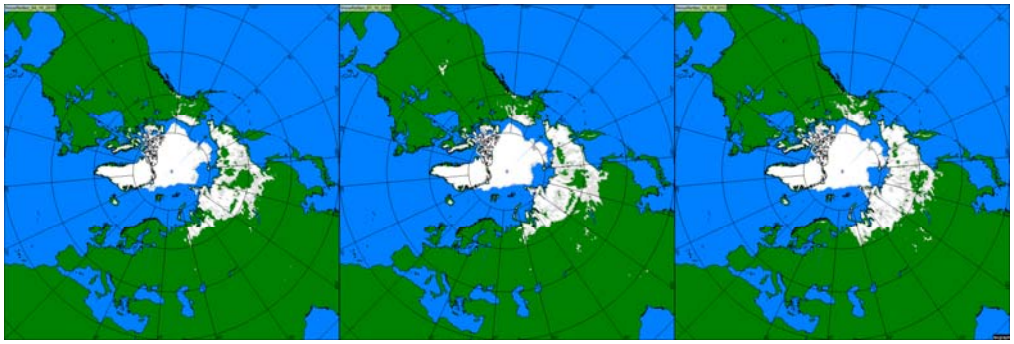
red- new, blue- old versions

Some aspects of T339L31 development

Usage of high resolution satellite data for snow cover

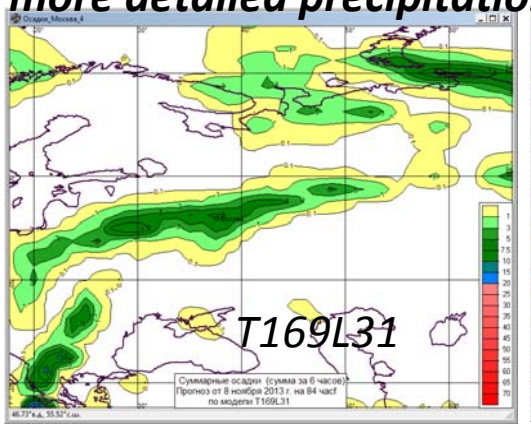
(NOAA multisensor data) :

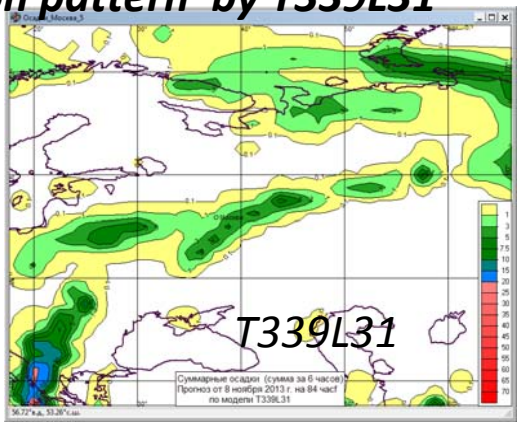
snow mask as input for T339L31 for Oct 7, 8,9 2013

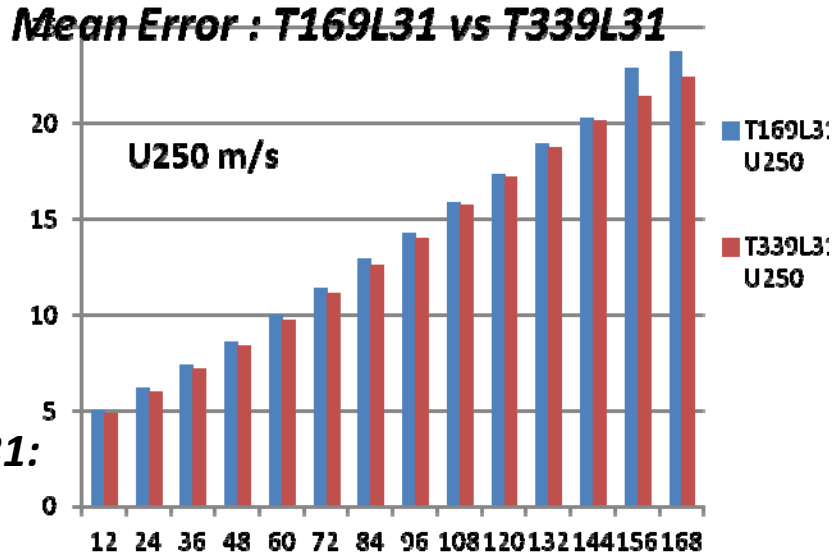


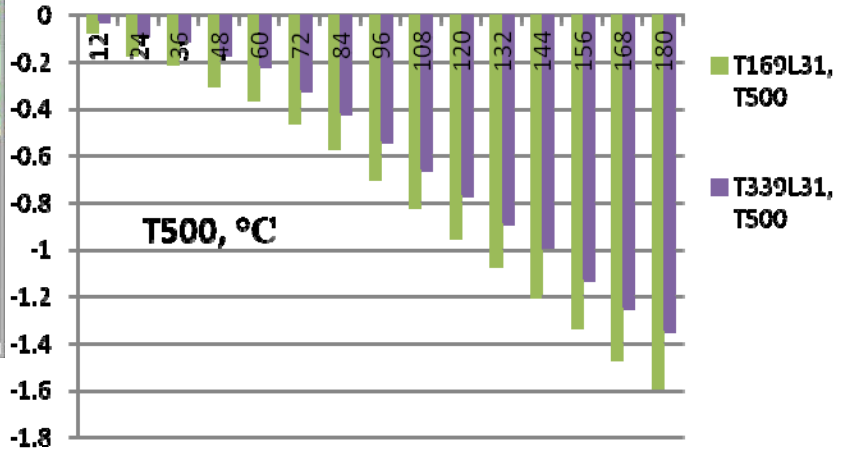
The simulated precipitation by T339L31 and T169L31:

more detailed precipitation pattern by T339L31

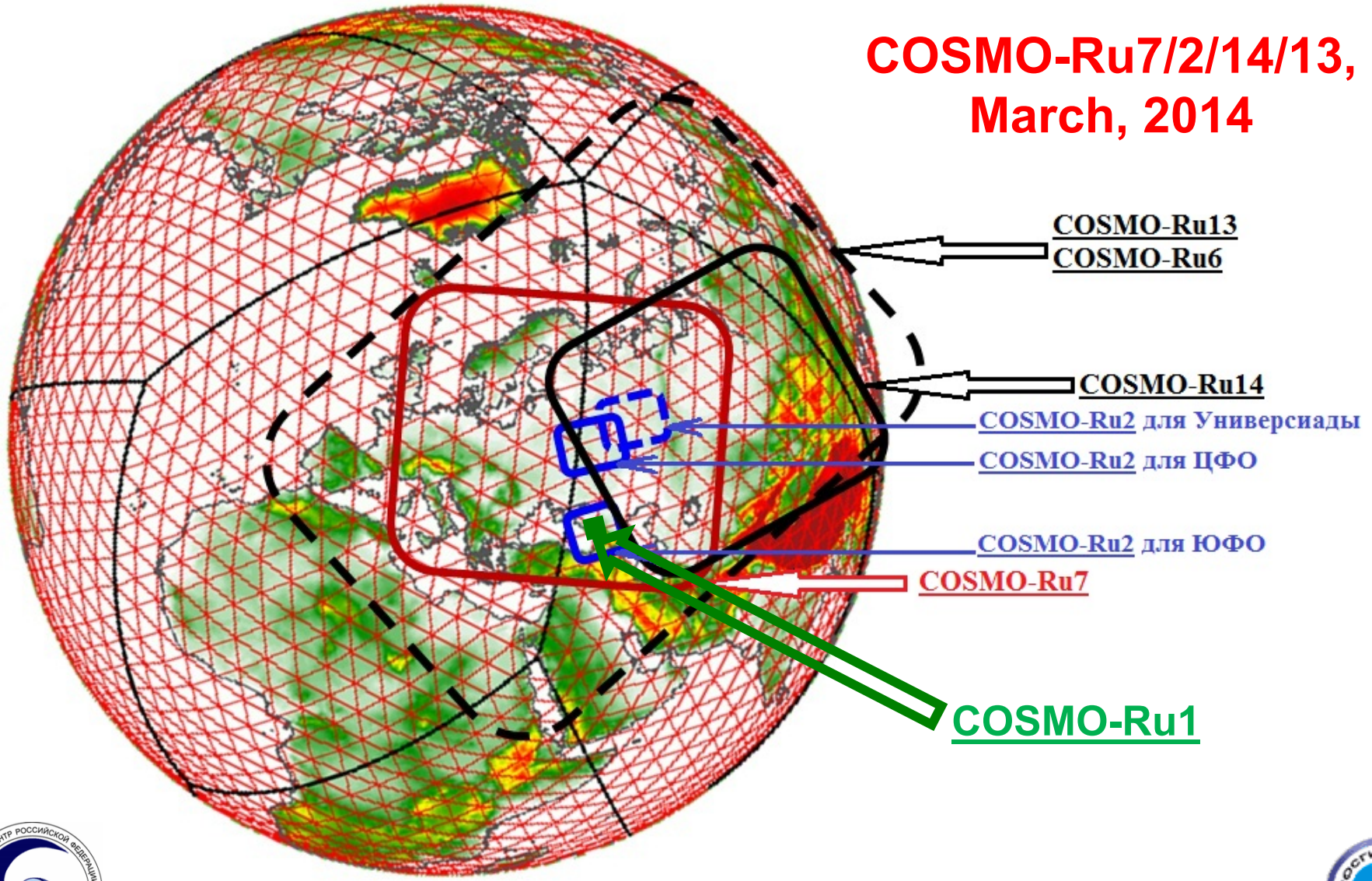




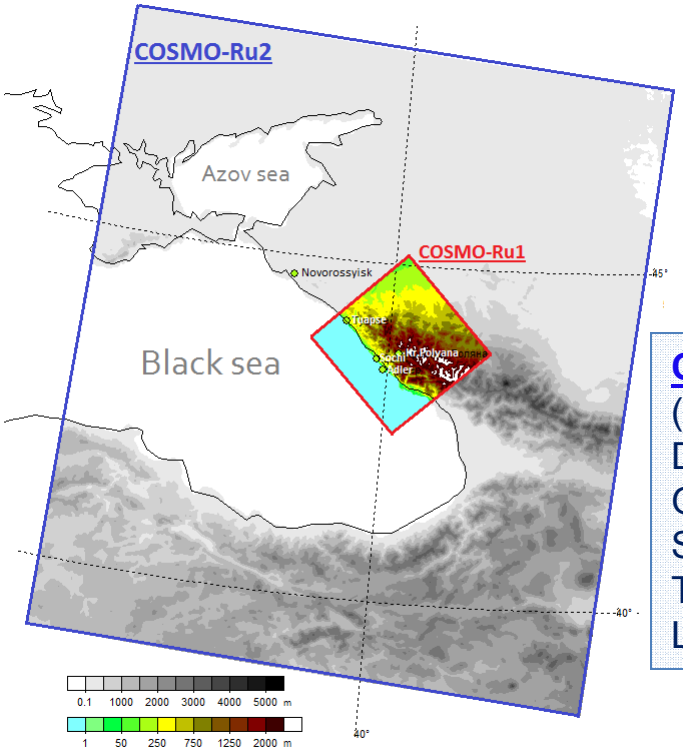




LAM: COSMO-Ru


COSMO-Ru7/2/14/13,
March, 2014
COSMO-Ru13
COSMO-Ru6
COSMO-Ru14
COSMO-Ru2 для Универсиады
COSMO-Ru2 для ЦФО
COSMO-Ru2 для ЮФО
COSMO-Ru7
COSMO-Ru1

High-resolution model COSMO-Ru1



✓**COSMO-Ru1** model's grid is embedded into the **COSMO-Ru2_SFO** model's grid from what it gets initial and boundary conditions

COSMO-Ru2
(for the **S**outhern **F**ederal Area)
Domain: 900 km x 1000 km
Grid: 420 x 470 x 50
Space step: **2.2 km**
Time step: 20 s
Lead time: 48 h

IC&BC

COSMO-Ru1
Domain: 210 km x 210 km
Grid: 190 x 190 x 50
Space step: **1.1 km**
Time step: 5 s
Lead time: 36 h

✓HMS & AMS data assimilation using ***nudging method*** for the forecast starts from -6h

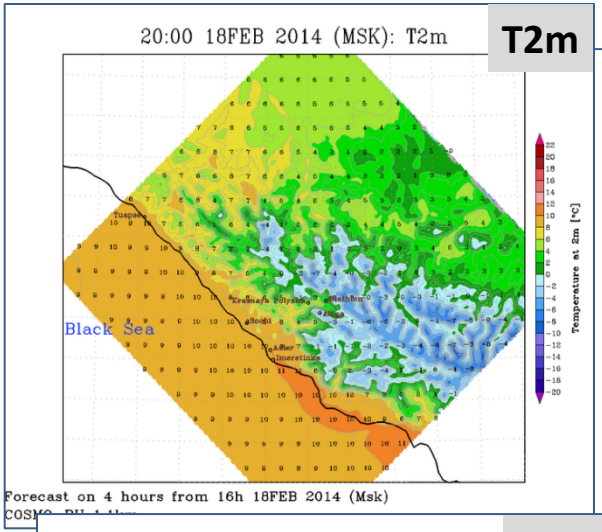
✓HMS & AMS data are using for verification also

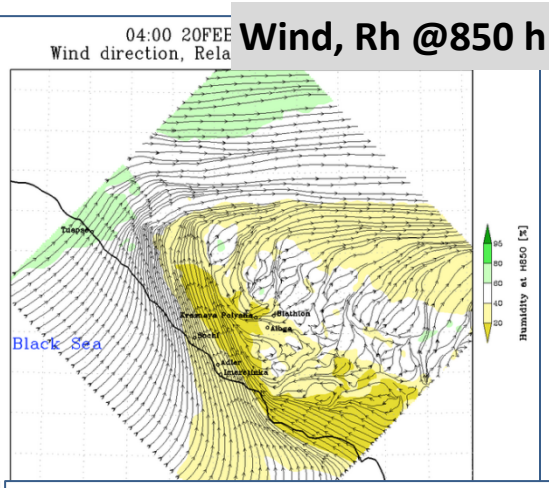
COSMO-Ru1 for the meteorological support of the SOCHI-2014 Olympic Games

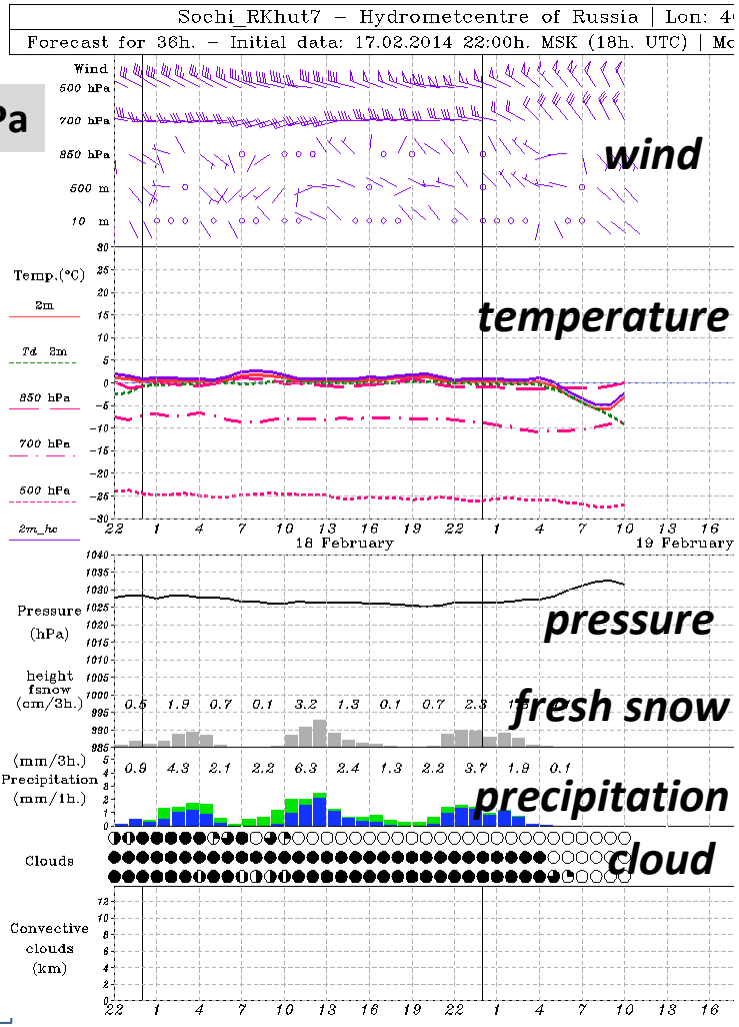
✓COSMO-Ru1 runs in operational mode 4 times per day.

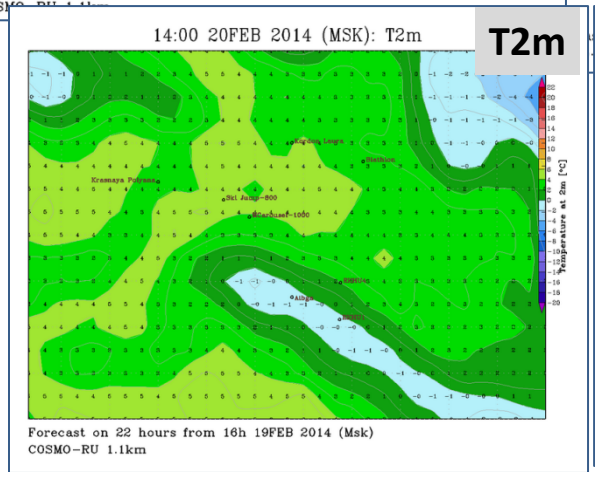
✓Forecast charts and meteograms for pre-specified sites are provided to forecasters and presented on the FROST web site.

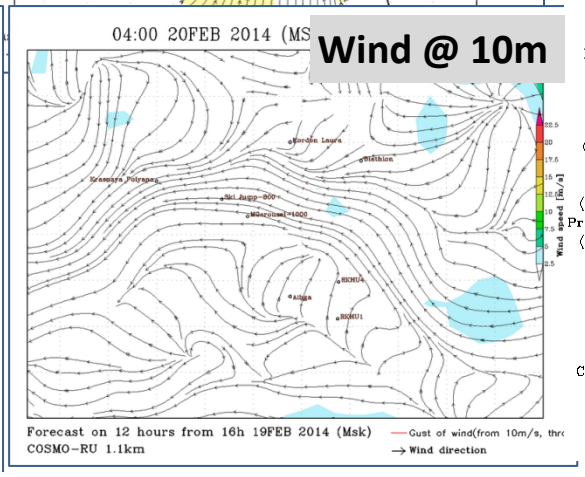
Examples of COSMO-Ru1 products









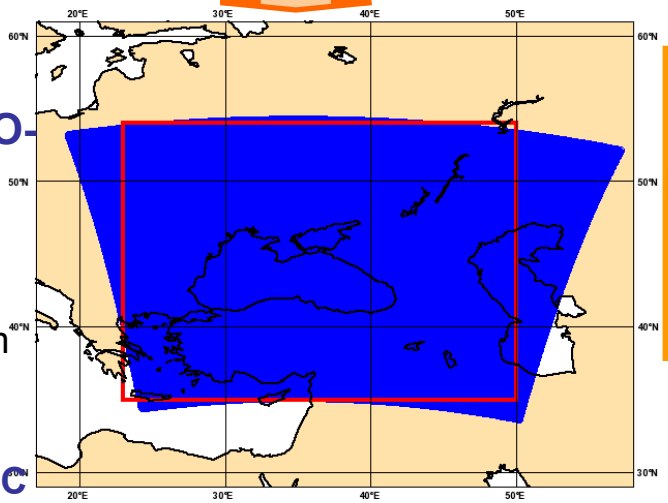


COSMO ENSEMBLES FOR SOCHI 2014

within the WWRP project FROST 2014 and COSMO Priority Project CORSO

ECMWF EPS forecasts

Clustering+ COSMO-LEPS for Sochi 2014



FDP

COSMO-S14-EPS

Δx~7 km
40 ML
fc+72h

ARPA-SIMC

All 10 forecasts for Sochi-mini Probability fields for the entire domain

RHMC

Preparation of epsgrams
Visualization
Operational dissemination
Forecasters' feedback

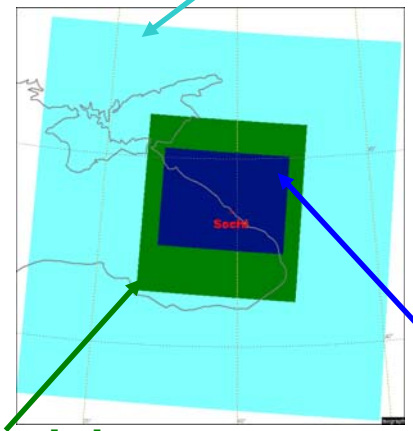
ICs&BCs

RDP

COSMO-RU2-EPS

Δx~2.2 km
50 ML
fc+48h

RHMC



Sochi-mini

Integration domain

RHMC

Visualization
Case studies
Verification

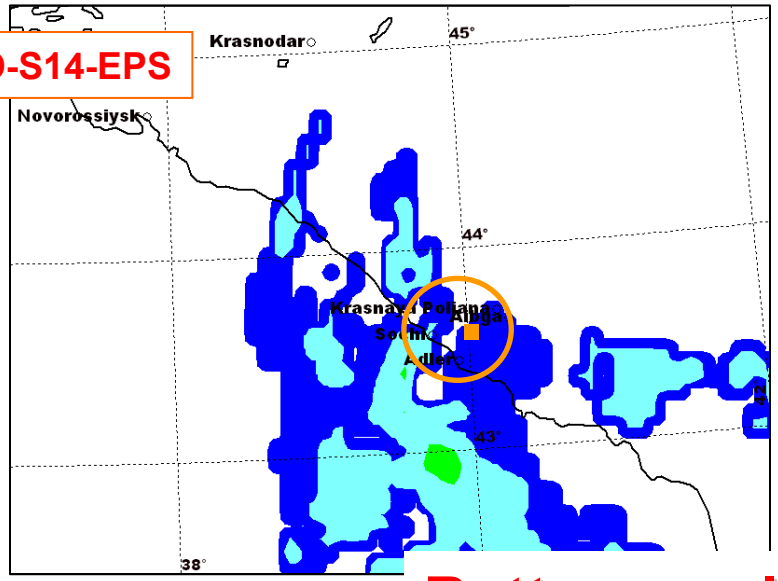
COSMO GM2013. E.Astakhova,D.Alferov,A.Montani etal

Probability of total precipitation exceeding 10 mm / 12 h

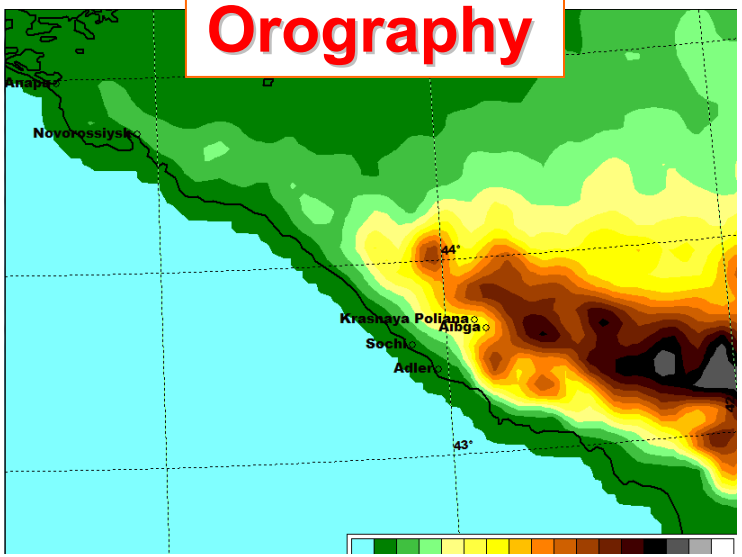
00 UTC 07.01.2013 - 12 UTC 07.01.2013

COSMO-S14-EPS

7 km



Orography

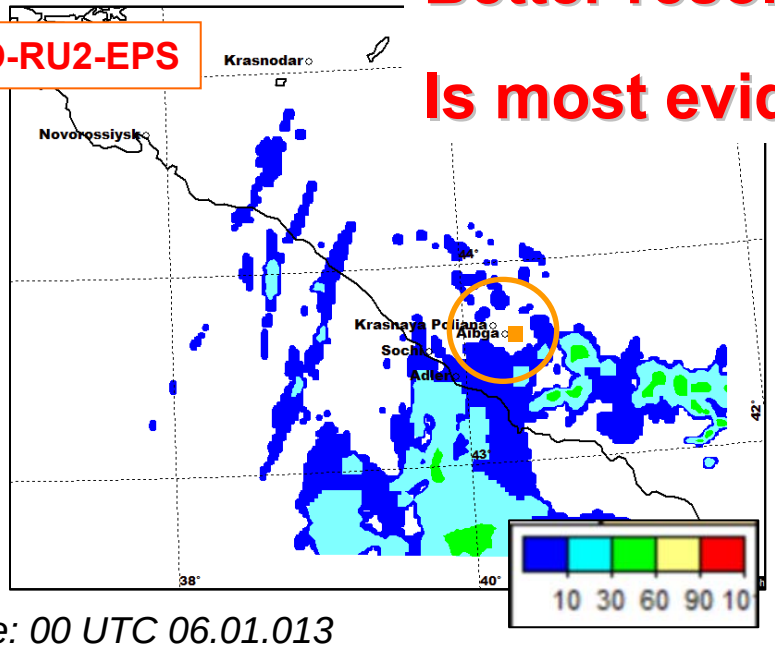


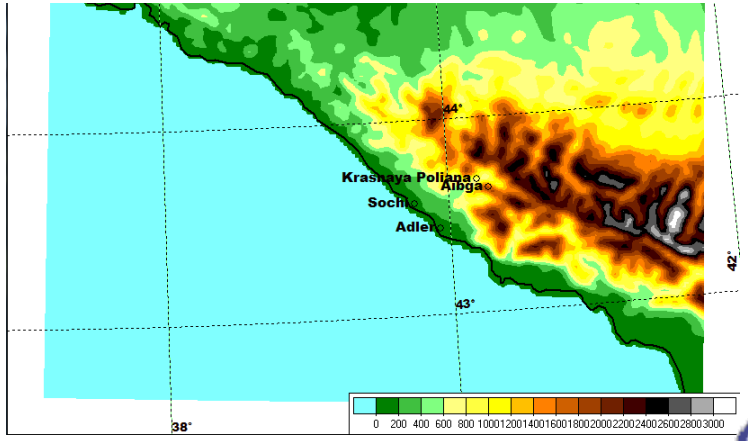
Better resolution, more details

Is most evident for small probabilities

COSMO-RU2-EPS

2.2 km





Initial time: 00 UTC 06.01.013

■ **Aibga**

COSMO GM2013. E.Astakhova,D.Alferov,A.Montani etal

FROST-2014 project (FROST = Forecast and Research in the Olympic Sochi Testbed)

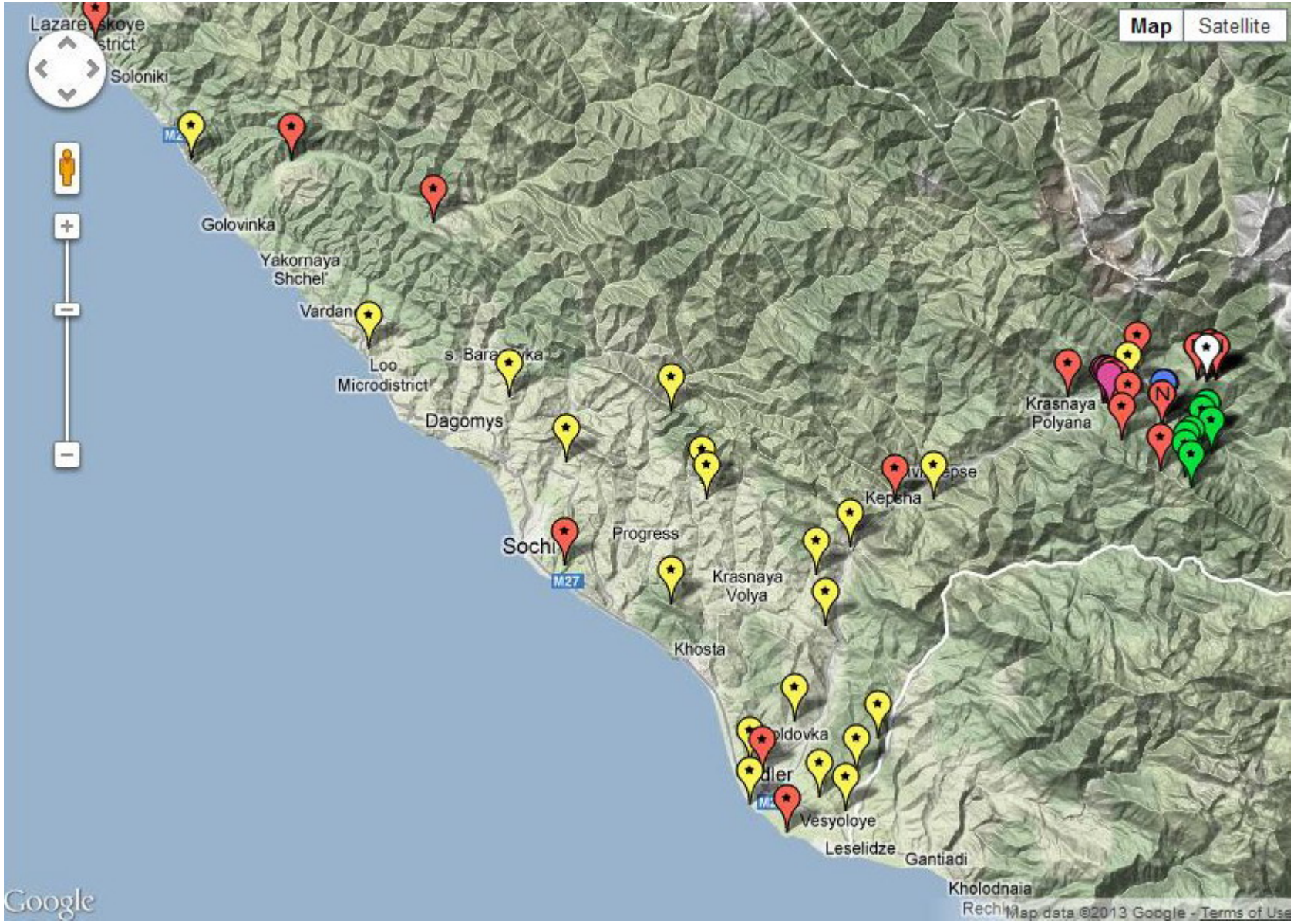
Participants:

- **COSMO,**
- **HIRLAM,**
- **ALADIN,**
- **EC,**
- **FMI,**
- **KMA,**
- **NOAA,**
- **ZAMG**

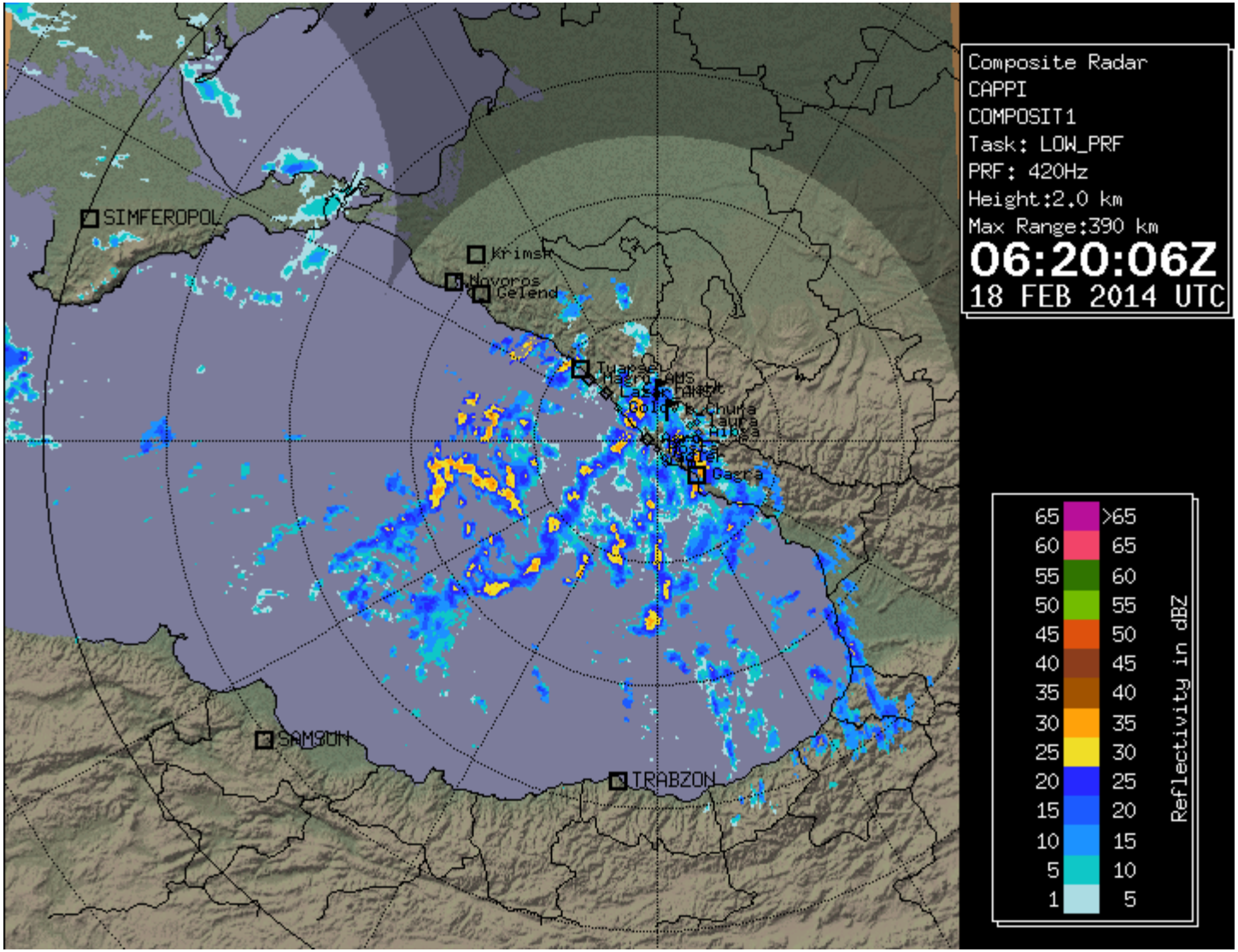
3rd meeting of the project participants (10-12 April 2013)

under supervision of the WWRP WGs on Nowcasting, Mesoscale Forecasting, Verification Research

Today's network of meteorological stations in the region of Sochi



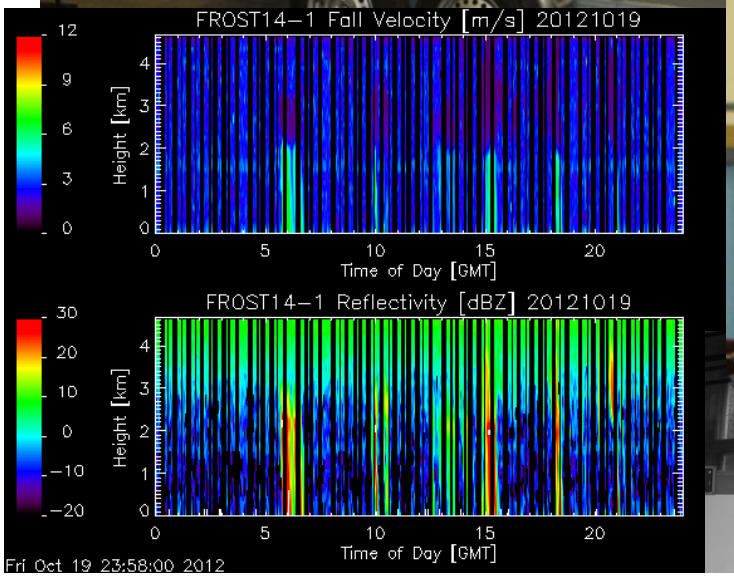
Vaisala C-band Doppler WRM200 is installed on Akhun mountain in Sochi

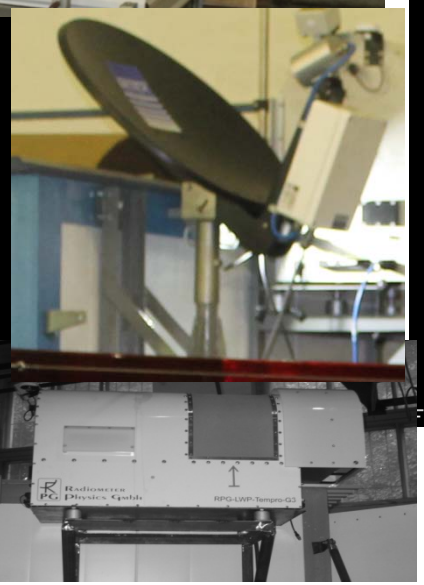


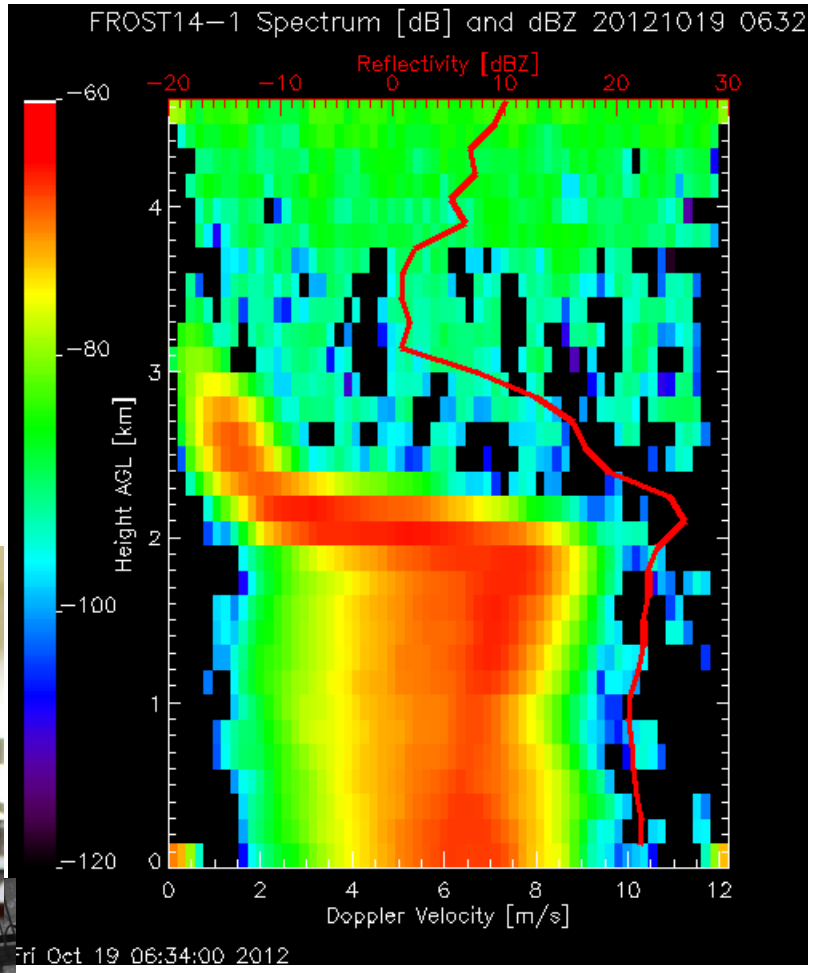
Akhun + Samsun (Turkey) + Trabzon (Turkey) + Simferopol (Ukraine) radar composite

Profilers

- Temperature/Humidity – HATPRO (RPG GmBh, Germany);
- Wind – Scintec-3000 Radar Wind Profiler (Scintec Corp, USA);
- Two METEK Micro Rain vertically pointing Radars (MRR-2)







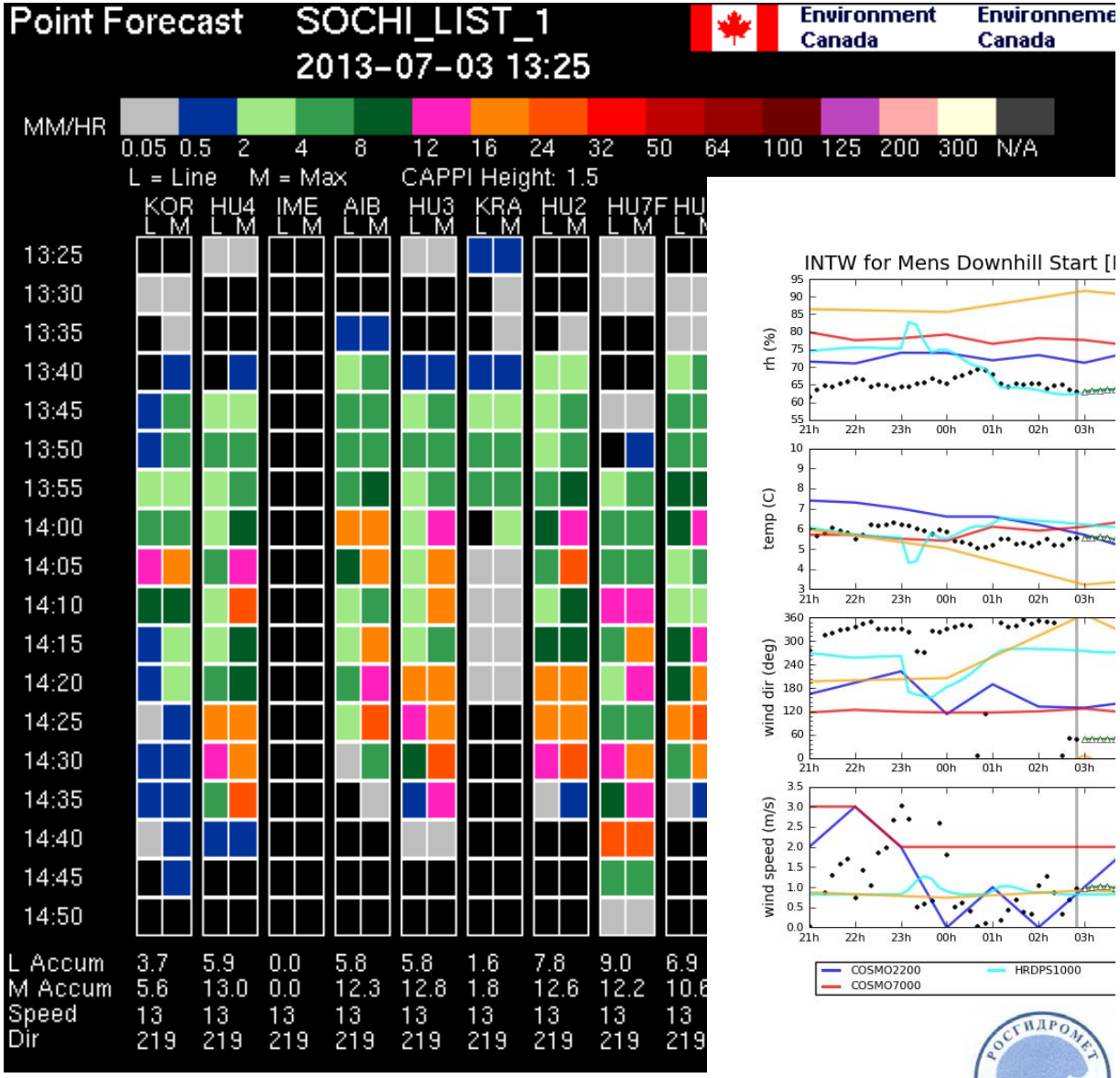
+ 4 times/day upper air sounding in Sochi

Nowcasting project component

Participating systems:

- ABOM,
- CARDS,
- INCA,
- INTW,
- MeteoExpert,
- Joint (Multi-system integration);

+ Nowcasting potential of participating NWP systems to be assessed



Joint Forecast

• F. Woodcock and C. Engel: Operational Consensus Forecasts, Weather and Forecasting, 2005;

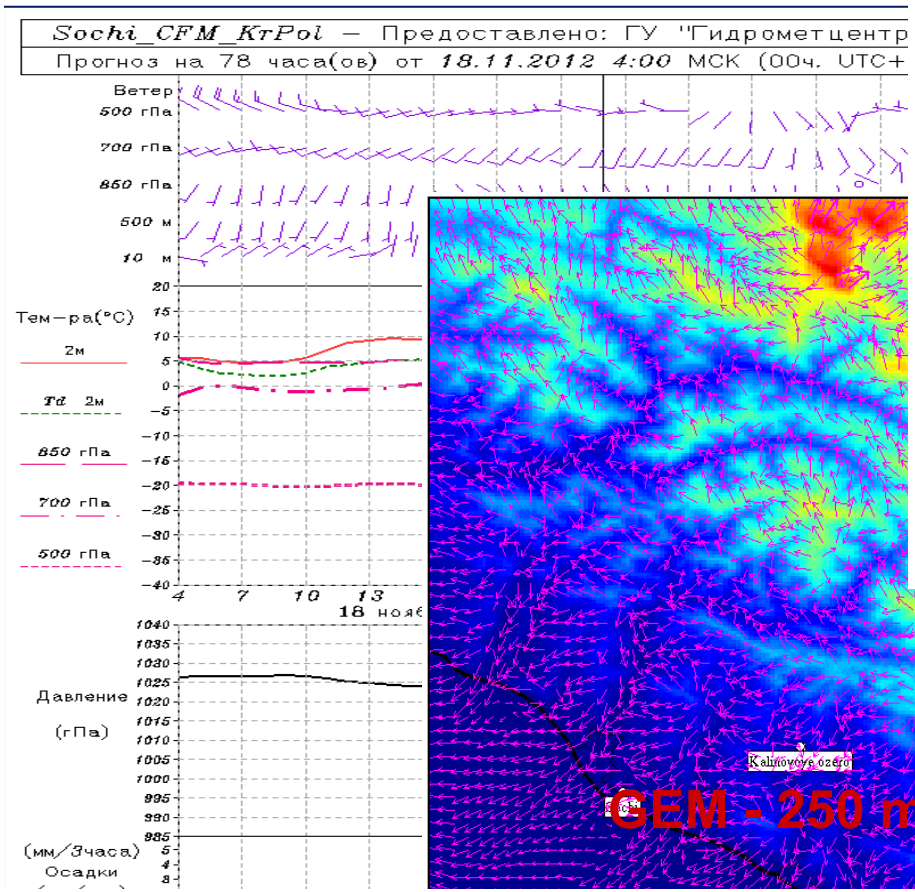
• L.X. Huang and G.A. Isaac: Integrating NWP Forecasts and Observation Data to Improve Nowcasting Accuracy, Weather and Forecasting, 2012

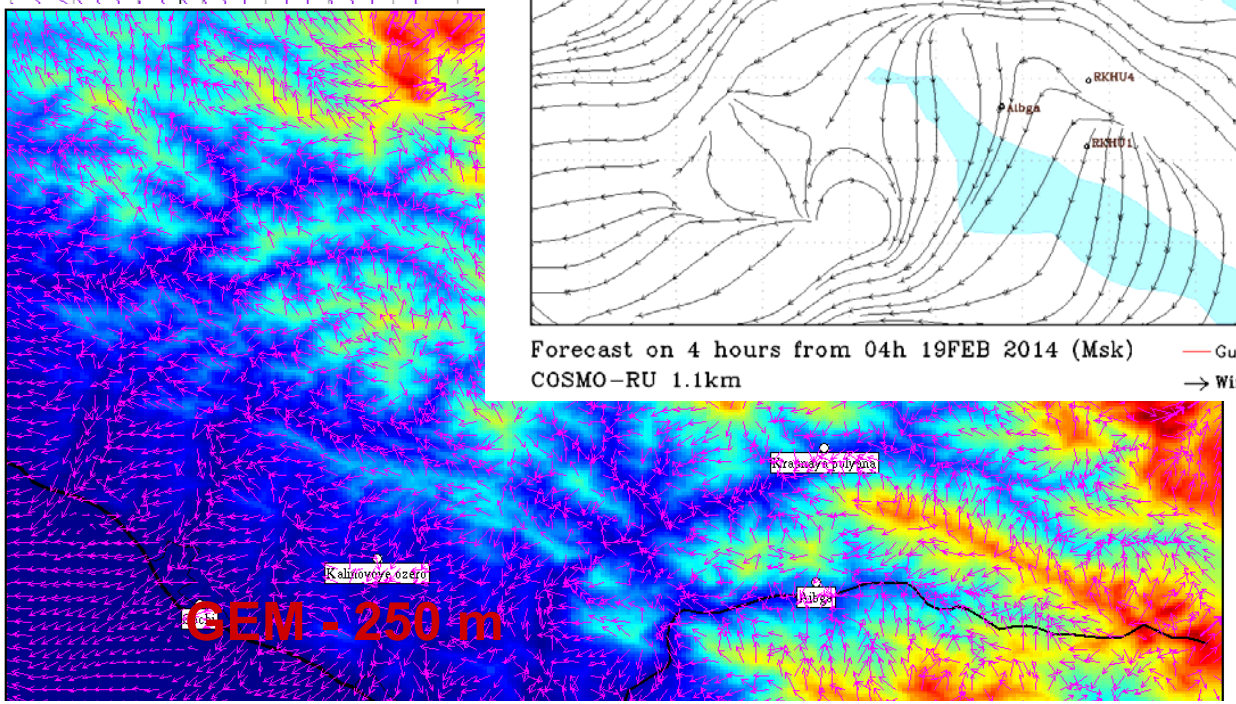
$$F(t) = \alpha(t) \cdot O + (1 - \alpha(t)) \sum_{i}^{N} \beta_i(t) \cdot (f_i(t) - b_i(t))$$

F(t) – integrated forecast (t – forecast time);
O – last available observation;
$f_i(t)$ – forecast of *i*-th participating forecasting system;
$\alpha(t)$, $\beta_i(t)$ - weights;
$b_i(t)$ - bias for *i*-th forecasting system

Deterministic NWP project component

- COSMO-RU with grid spacing 7 km, 2.2 km, 1.1 km;
- GEM with grid spacing 2.5km, 1km, 0.25km;
- NMMB – 1 km;
- HARMONIE - 2.5km;



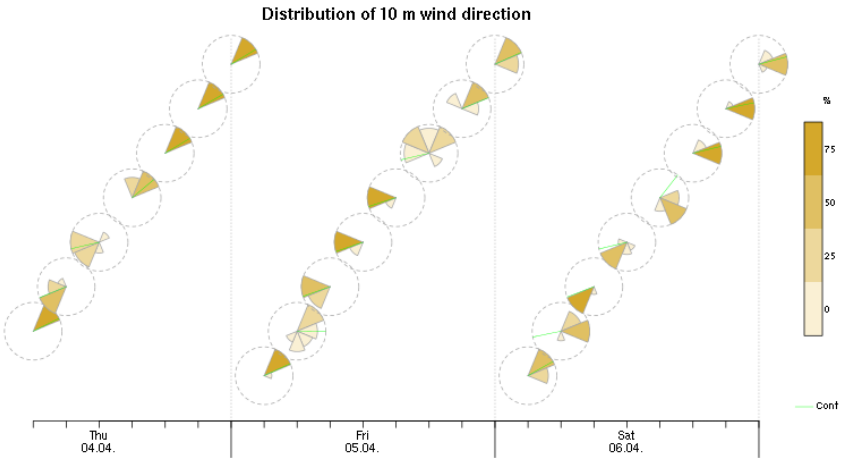


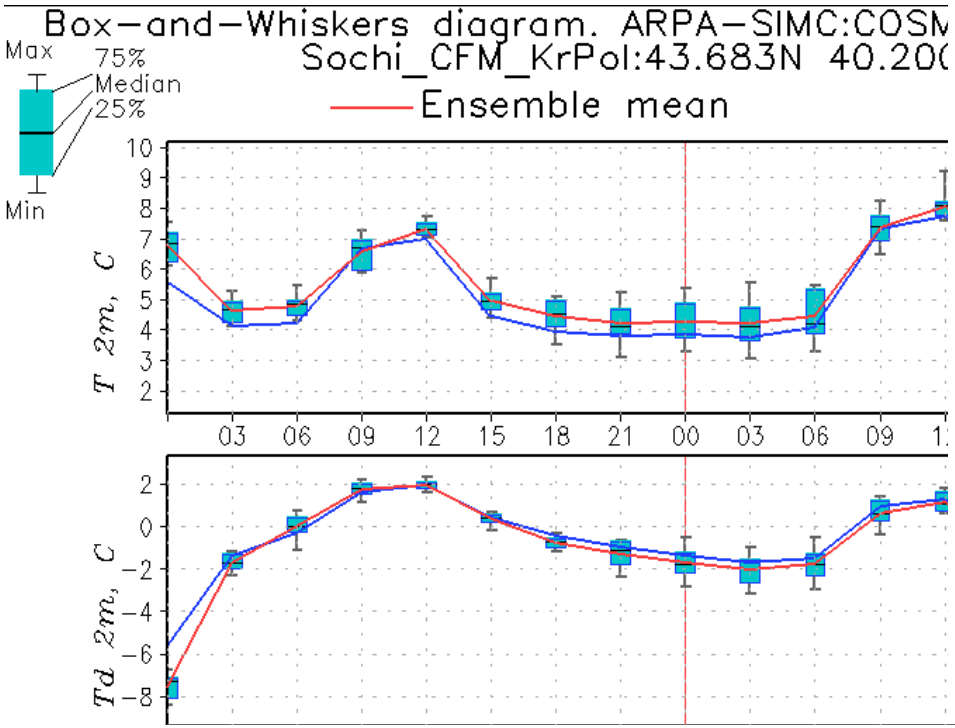
Ensemble project component

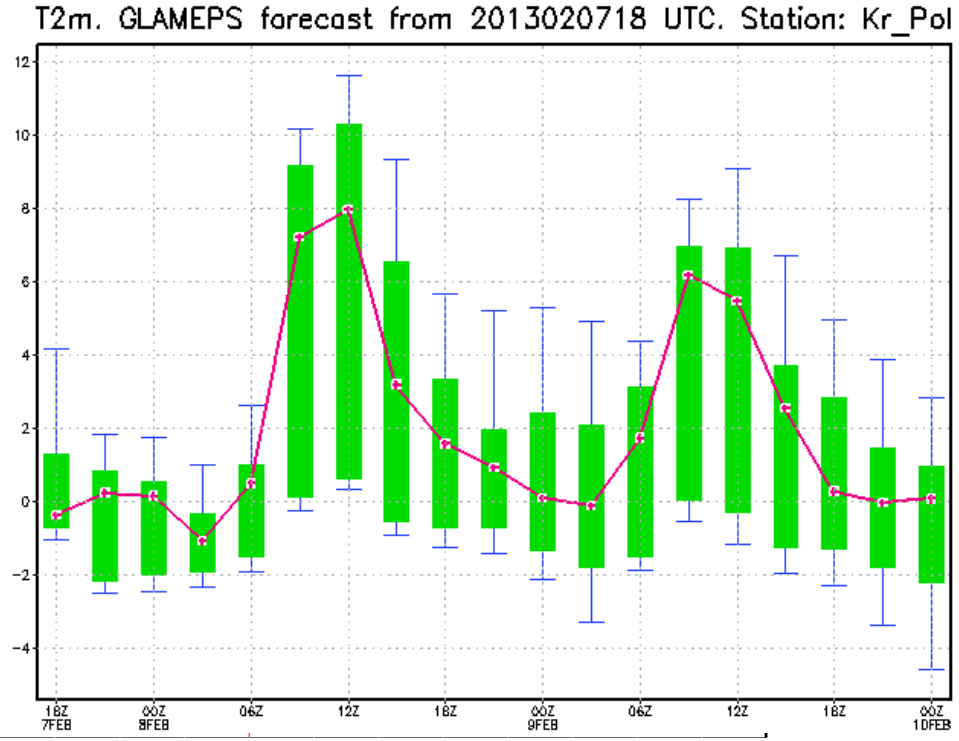
COSMO-S14-EPS, Aladin LAEF, GLAMEPS, NNMB-7km EPS, COSMO-RU2-EPS, HARMON-EPS

KMA's downscaling of probabilistic forecasts,

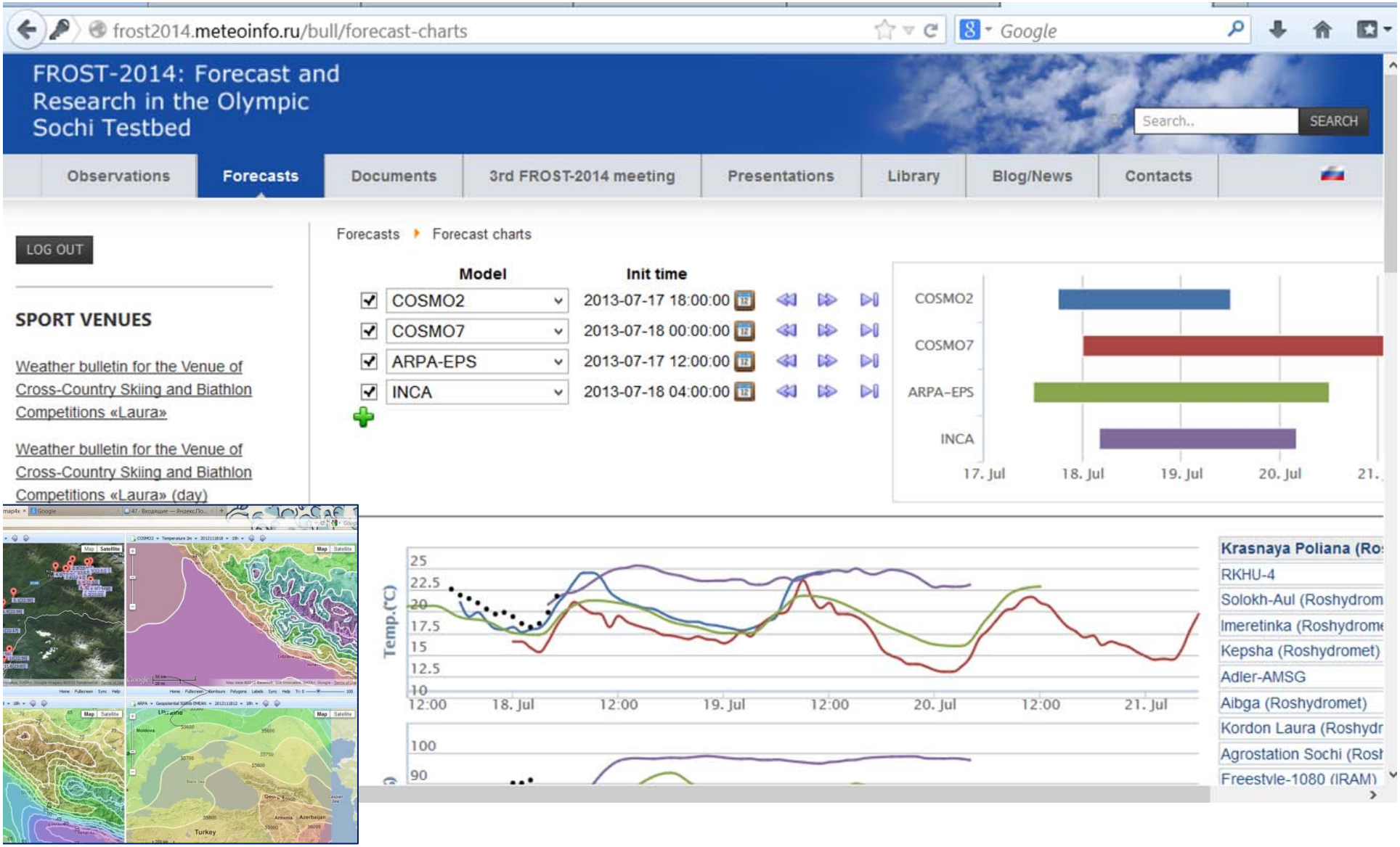
Poor man's ensemble of deterministic high-resolution models



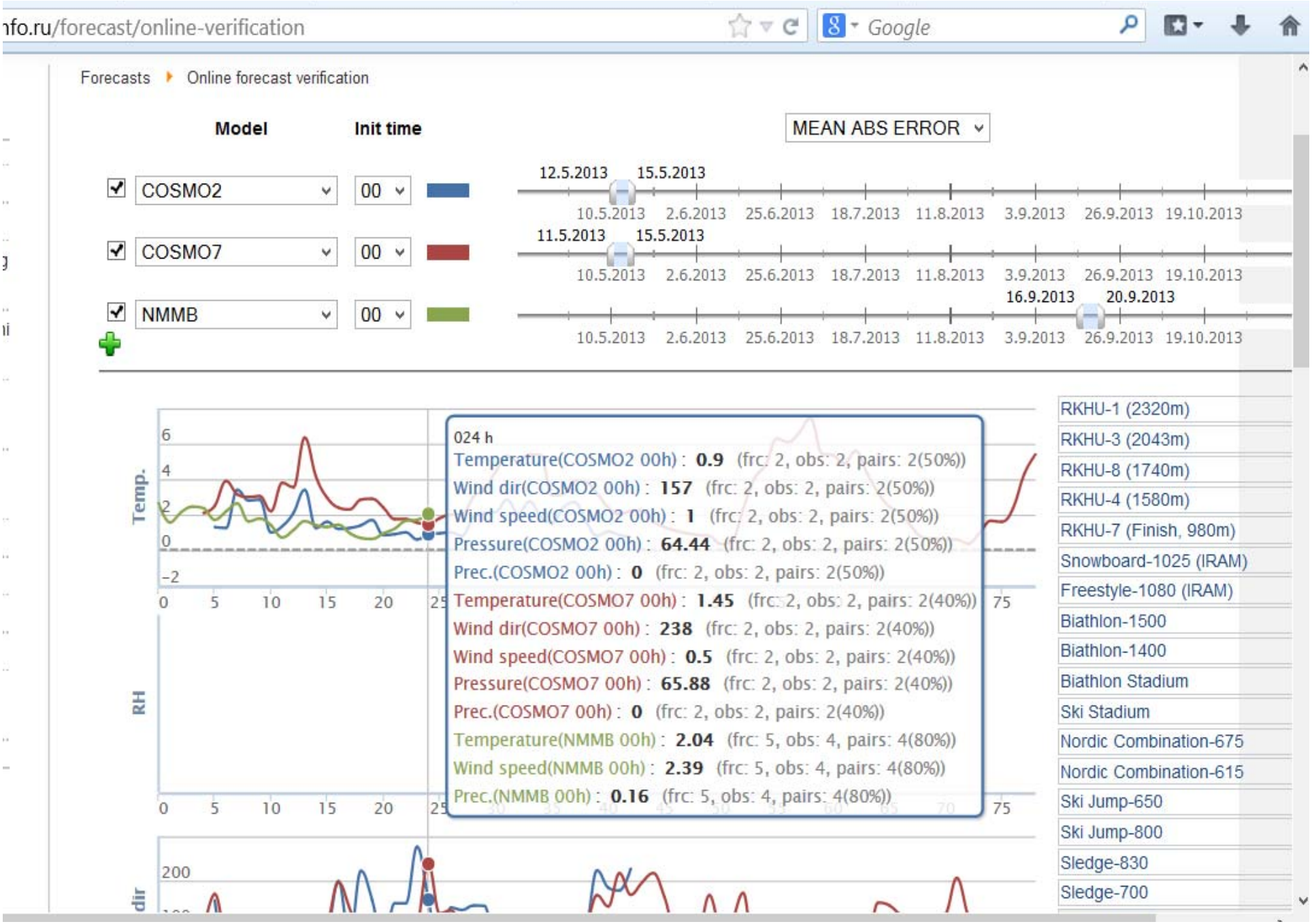




It is not simple for forecasters to deal with such an amount of information under the operational time constraints
=> compression of information data feeds is needed



FROST-2014 Online Monitoring of Forecast Quality

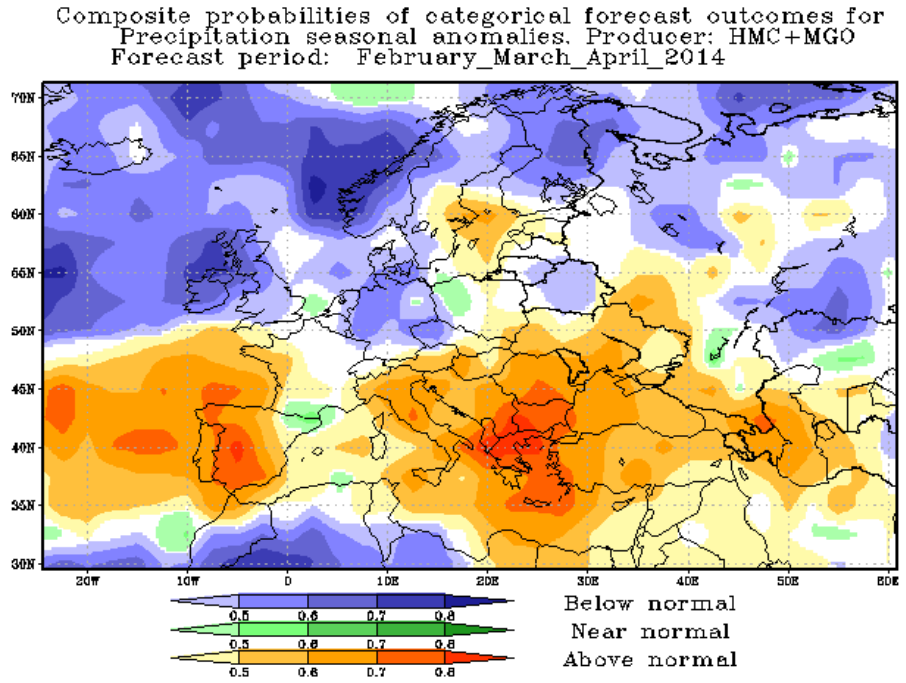


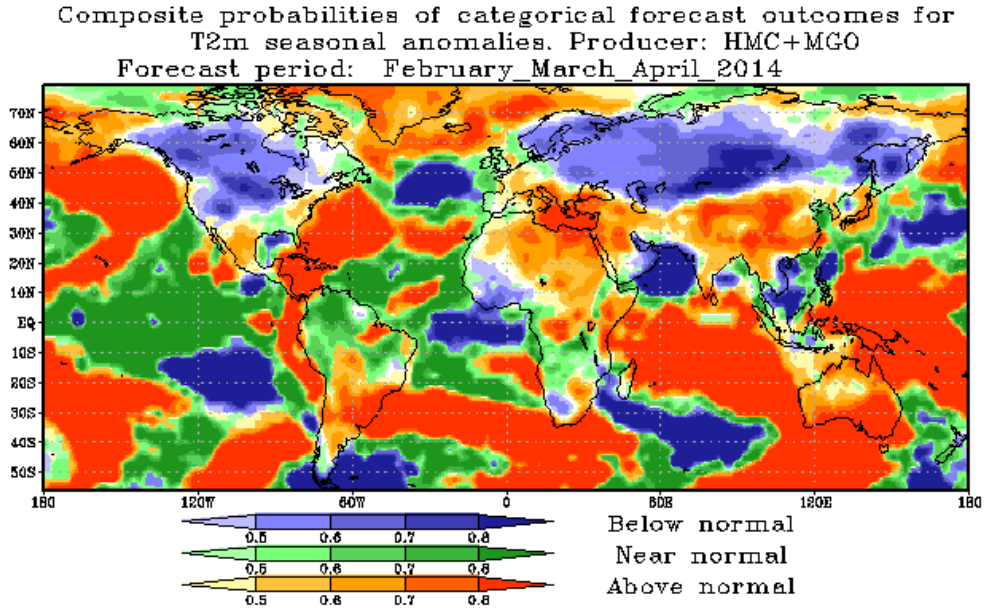
Seasonal Forecasting

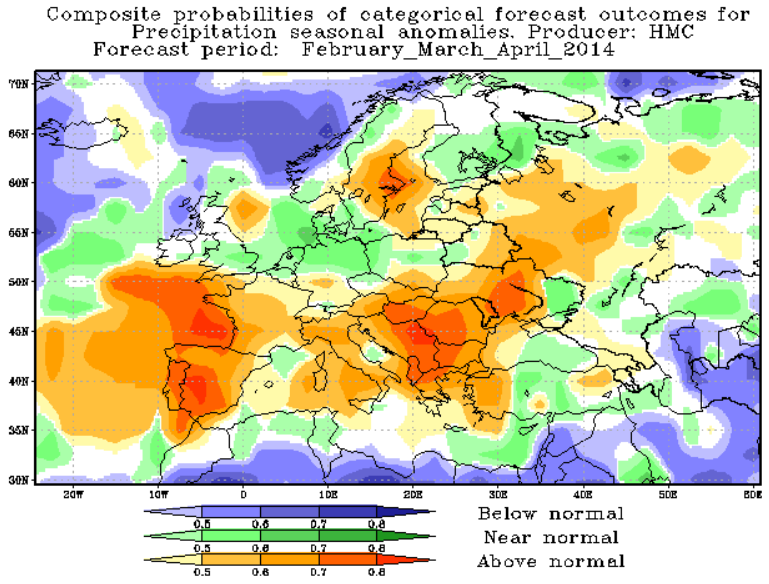
- Hydrometcentre of Russia is one of the WMO Global Producing Centres (GPC).

- Operational seasonal forecasts with 1-month lead time are issued by the Hydrometcentre of Russia and the Main Geophysical Observatory on the basis of “two-tier” systems.

Coupled systems of the Hydrometcentre of Russia and the Main Geophysical Observatory are being tuned and tested.





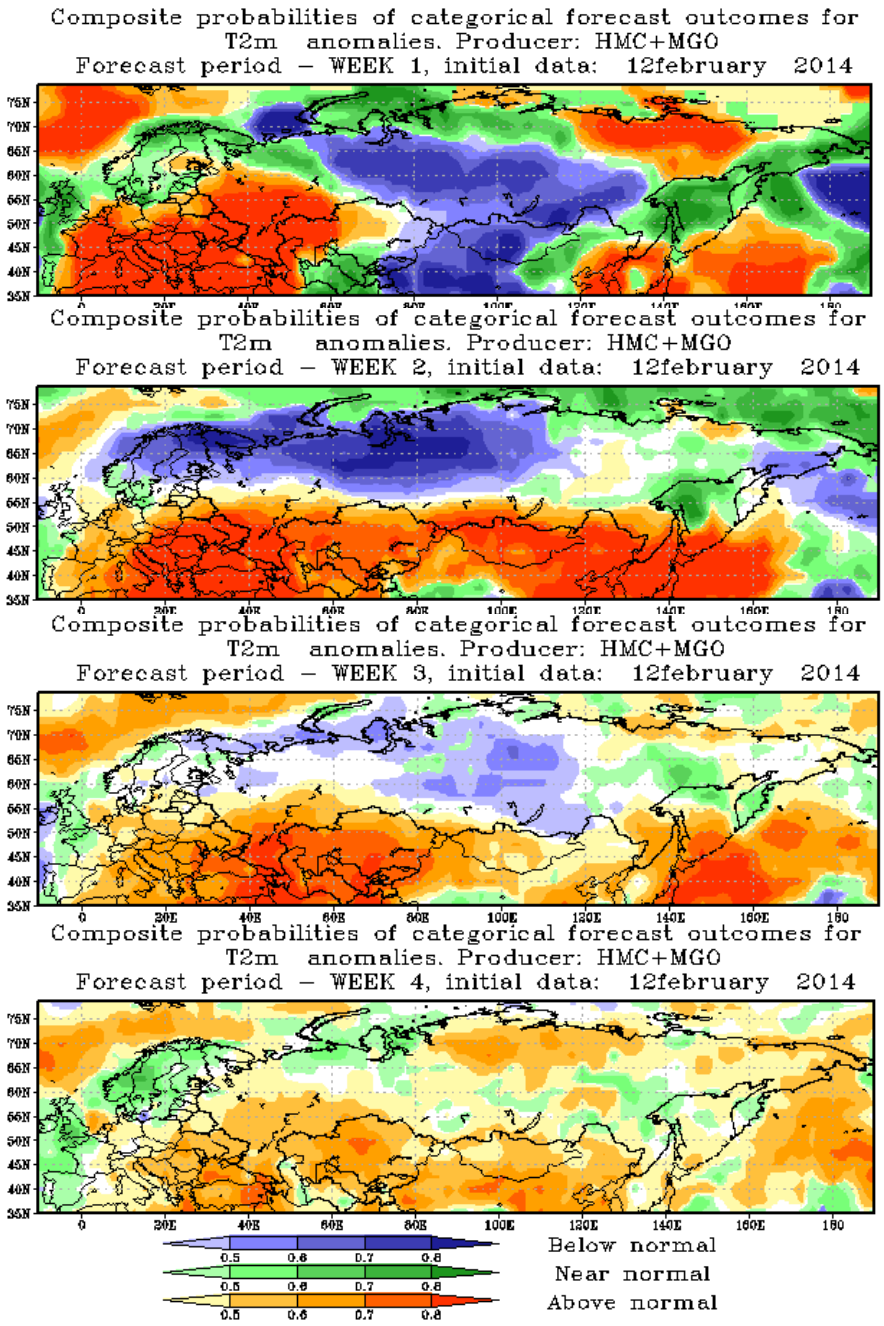


Subseasonal Forecasting in Roshydromet

- Forecasts of subseasonal variability are issued on weekly basis by the Hydrometcentre of Russia and the Main Geophysical Observatory.
At the moment these forecasts are under operational trial.

- The Hydrometcentre of Russia (GPC-Moscow) is a participant of the Subseasonal to Seasonal Prediction Project (S2S).
At the moment GPC-Moscow model output is being adjusted to the requirements of the S2S project.

- Forecasts of subseasonal variability provided a valuable input for the meteorological support of the Sochi Winter Olympic Games.



Climate modelling (INM of RAS)

Sensitivity experiment for quadrupling of CO2 was performed with climate model INMCM5 (atmosphere 1.25x1 L128, ocean 0.167x0.125 L40). It is shown that:

1. Equilibrium sensitivity for this model is 3.4K. It is smaller than in any present-day climate model. The reason is decrease of cloud radiation effect that appears rapidly after quadrupling of CO2 and is almost independent from global warming.
2. Ocean heat uptake in climate model with eddy-resolved ocean is almost the same as in the model INMCM4 (atmosphere 2x1.5L21, ocean 1x0.5L40) that doesn't resolve ocean eddies.

Most important results

- Global 3D-Var DAS working both with the external background (6-h GFS forecast) and in the cycling mode with SL-AV
- Regional 3D-Var DAS
- New SL-AV version with resolution 0.225x0.18 deg, 51 levels and improved physics
- T339L31 version with improved physics
- COSMO-Ru1 model (1.1 km resolution)
- Success of FROST2014 project in providing meteorological support to the SOCHI 2014 Olympic games

THANK YOU FOR YOUR ATTENTION!

СПАСИБО ЗА ВНИМАНИЕ!