Recent developments in NWP and climate modelling in Russia

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(also I.Rozinkina, G.Rivin, E.Astakhova, V.Shashkin,M.Tsyroulnikov, A.Shlyaeva)

Plan

- Progress in global and regional models
- Data assimilation
- Seasonal forecasts: coupled model
- Climate modelling at INM RAS

Short and medium-range numerical weather prediction

- Global models (SL-AV;T169L31 – no changes)
- Global ensemble prediction system– based on T169 and SL-AV global models – no changes
- LAM – COSMO-RU; developments in EPS
- ==========
- Computers: SGI ALtix4700 (11 Tflops peak); SGI Ice 8100 cluster (16 Tflops peak)+ RSK Tornado water cooled cluster (35 Tflops peak)

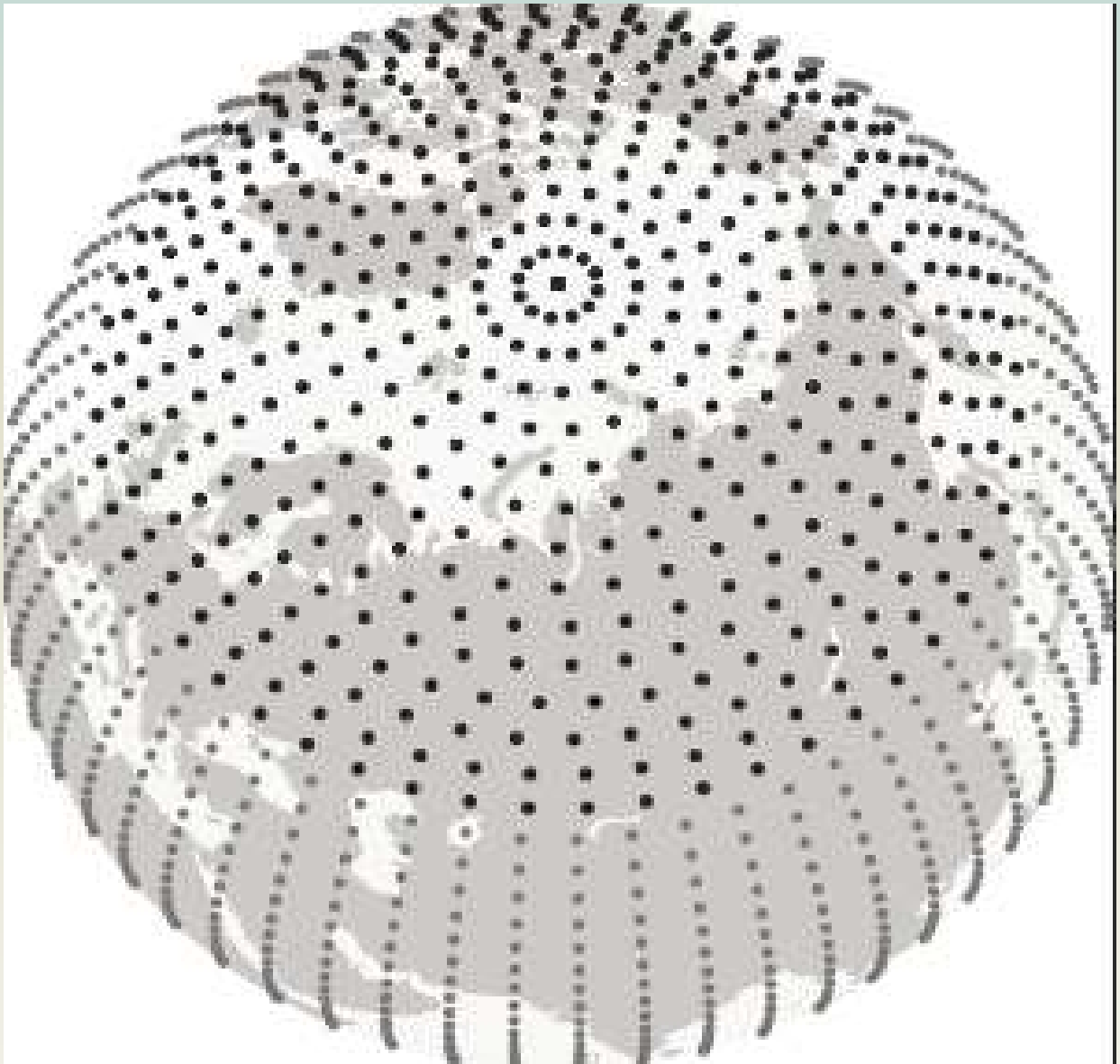
SL-AV model

- Semi-Lagrangian vorticity-divergence dynamical core of own development, mostly ALADIN/LACE parameterizations.
- Mire parameterization of own development.
- Currently, 0.9x0.72 degrees lon/lat, 28 levels, runs on Altix 4700 computer
- Principal global operational model of RHMC
- Version with the resolution 0.225x(0.18-0.23) degrees, 51 levels under testing.
- Implemented CLIRAD SW radiation parameterization, encouraging results in the stratosphere.
- Mass-conserving SL shallow water model on the reduced lat-lon grid – J.Comput.Phys. 2012

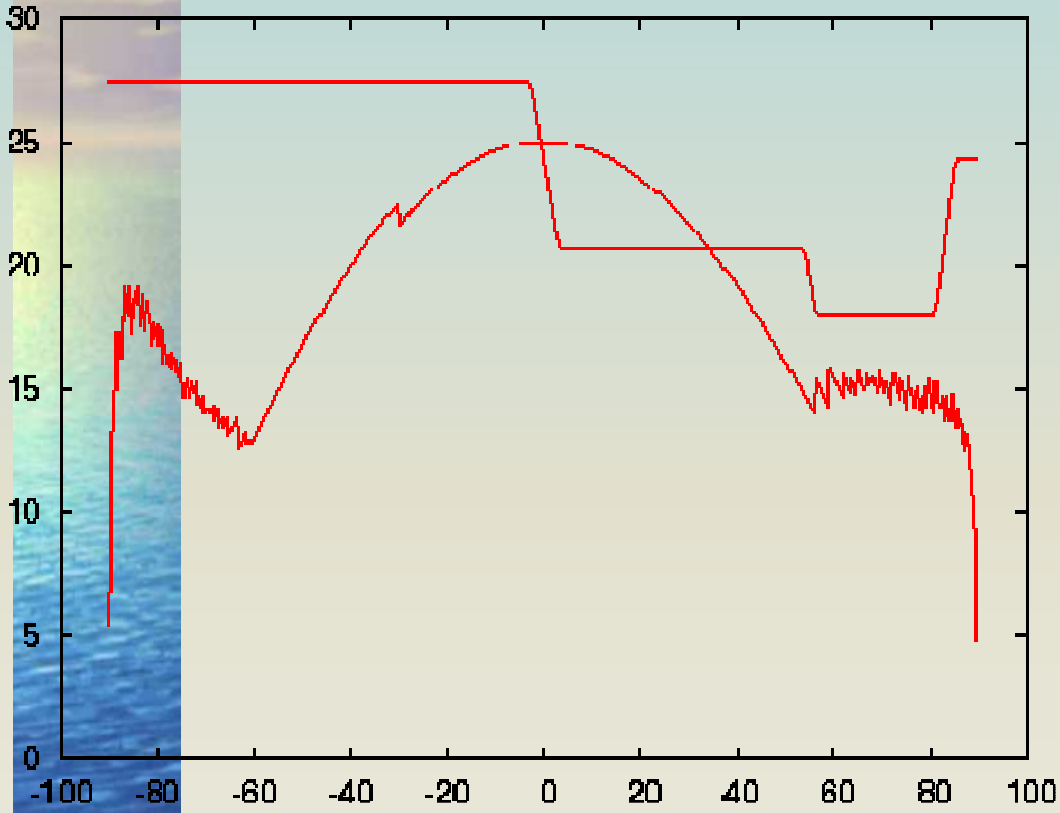
The works on SLAV model in 2012

- Implemented INM 8-layer soil model
- SLAV-20 with the old soil parameterization is now ready for parallel runs
- The version with CLIRAD SW still under evaluation
- Implementation of the 3D mass-conservative SL advection – testing phase

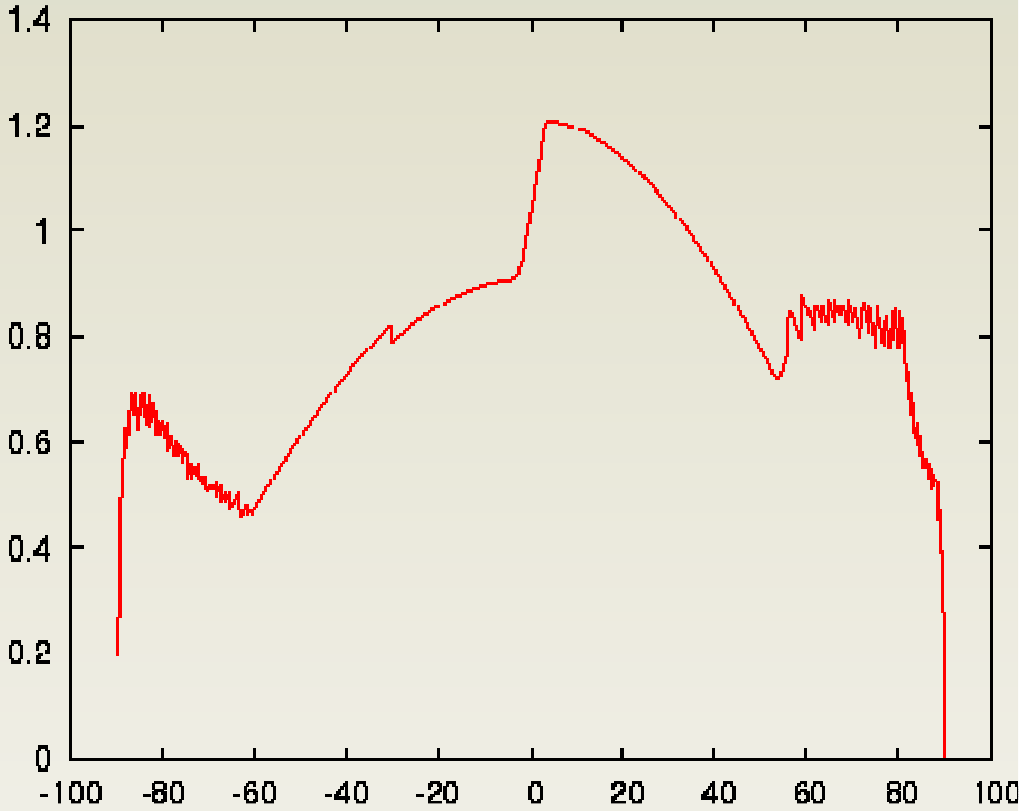
Sample of the reduced grid as constructed for the model (20 % reduction in number of points)



Grid step in latitude (upper curve) and longitude (lower curve), in km

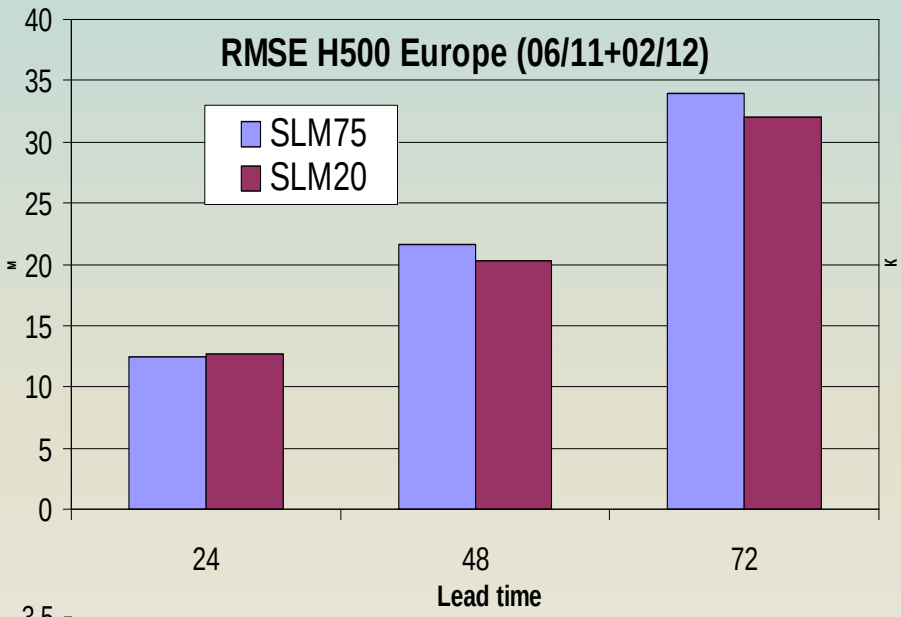


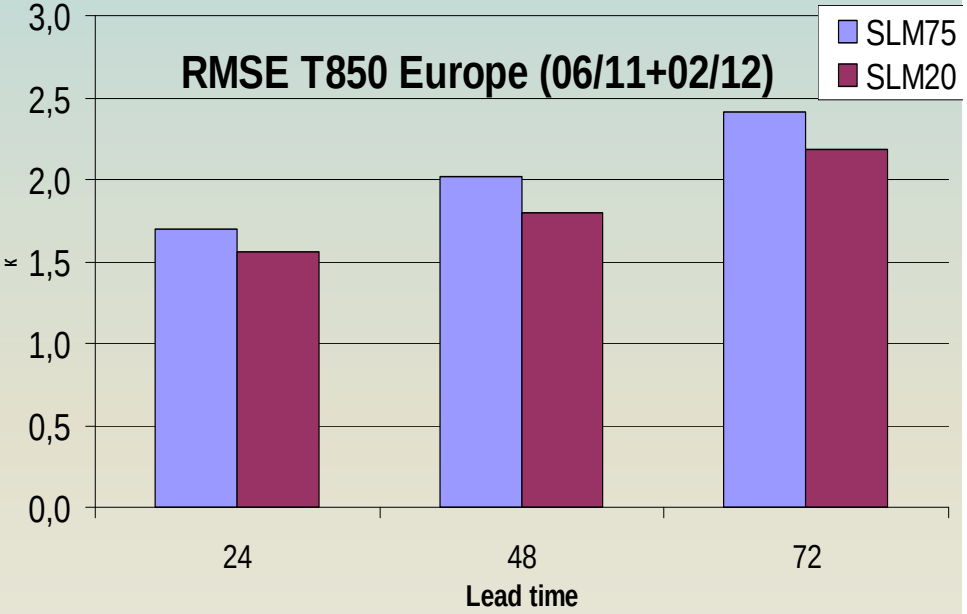
Proportion of ‘physical’ grid steps Max(dx/dy, dy/dx)

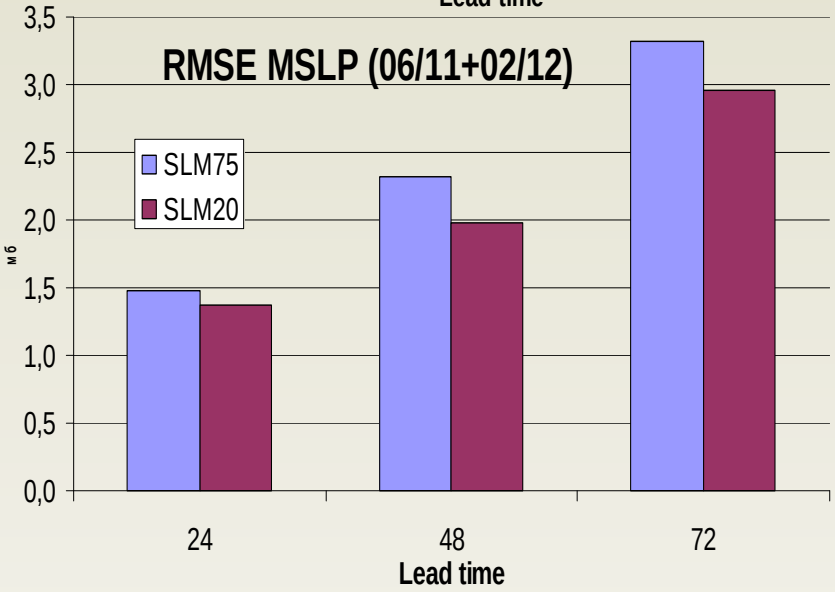


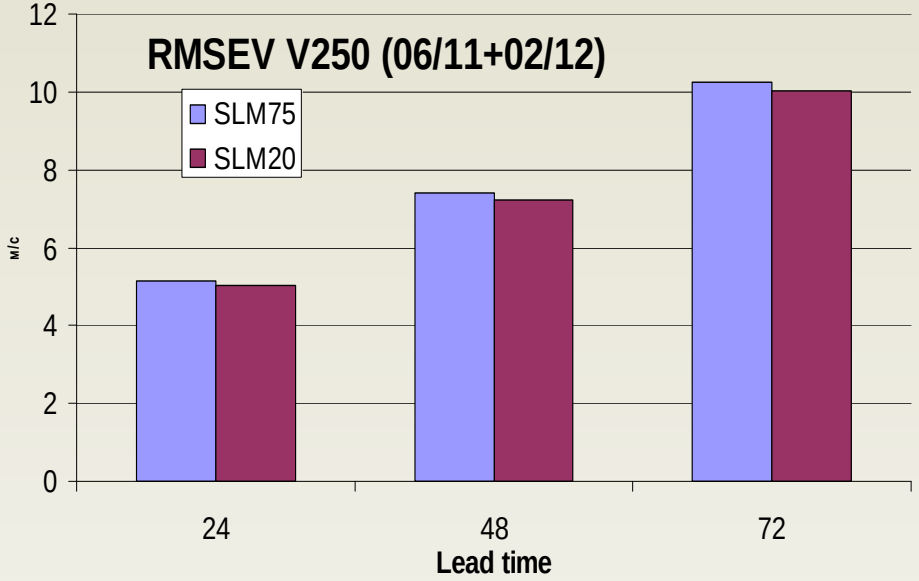
Comparison of oper SLAV version (0.9°x0.72° 28 levels) and new one(0.225°x(0.175-0.23)° 51 levels) NCEP initial data 1°x1°, scores for Europe

(similar results for Asia)



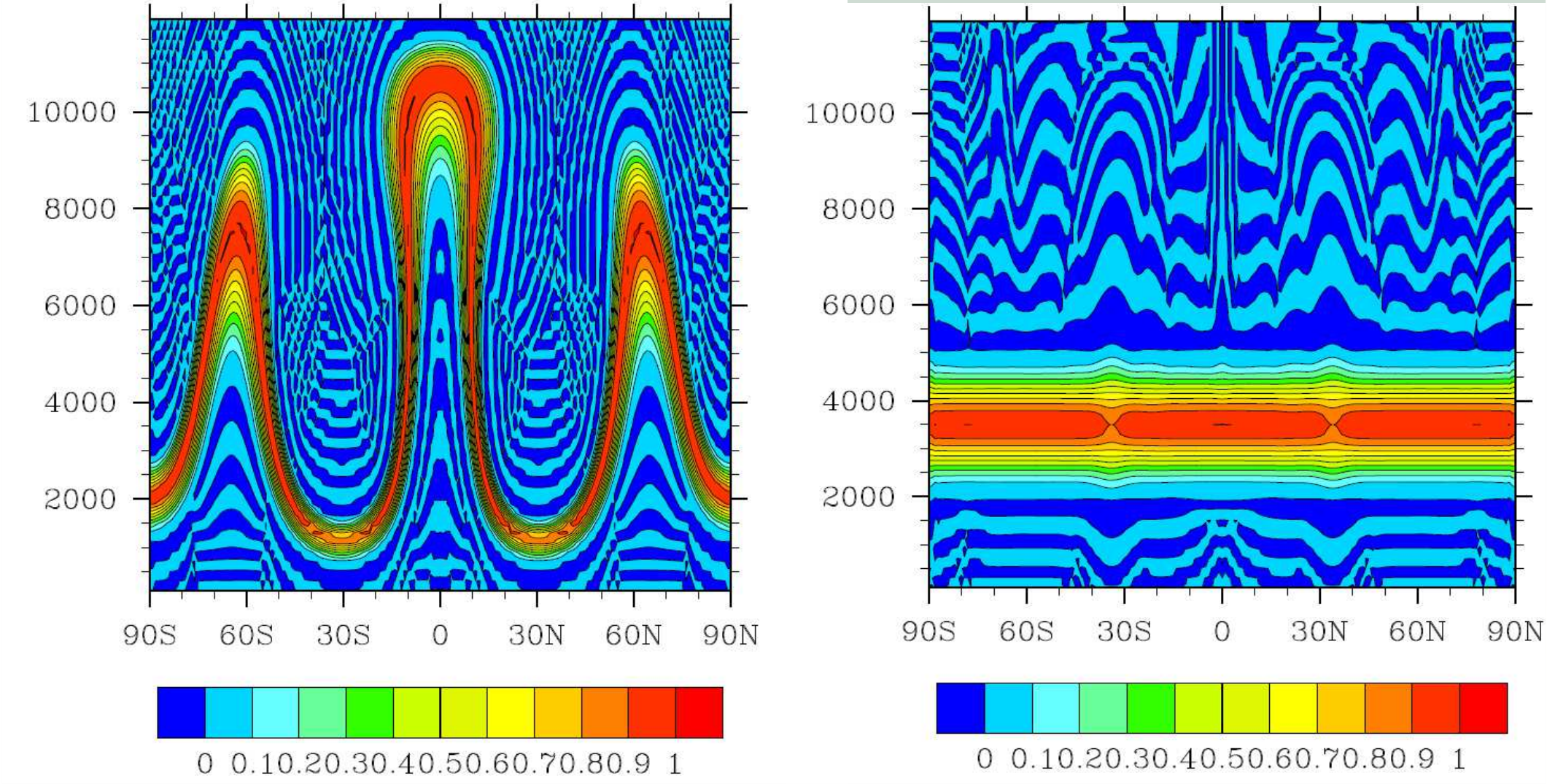






Mass-conservative 3D SL advection. Deformational flow in the vertical plane

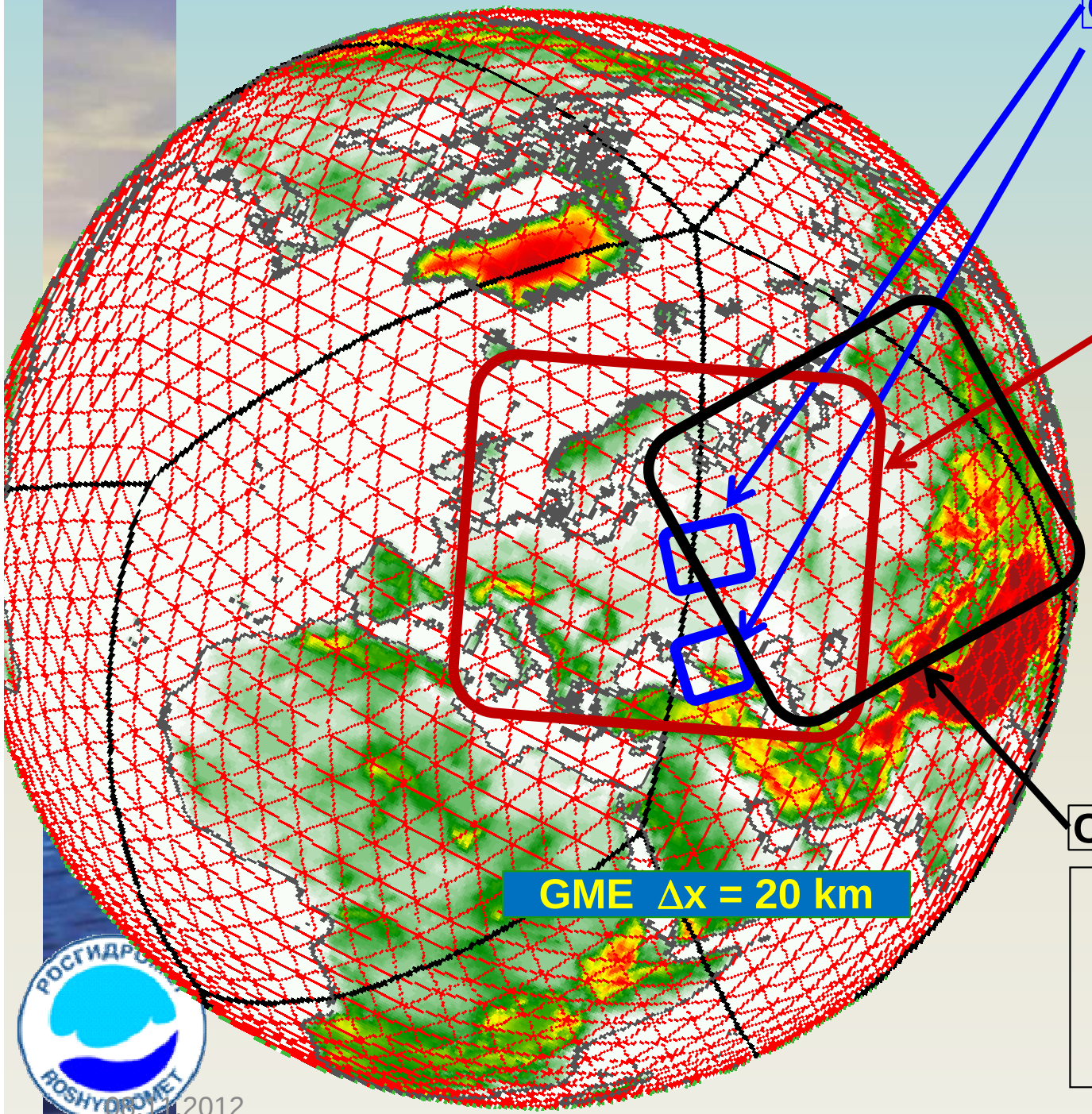
(DCMIP Test 1.2)



Further work for SL-AV development

- Development of the initialization scheme for 8-level soil (+multilayer snow) parameterization from INM climate model.
- 3-D mass conserving semi-Lagrangian advection on the reduced lat-lon grid.
- Plan for parallel runs of 20 km version in 2013.

COSMO-RU system



COSMO-RU2 Δx =2.2 km

Domain:	900 km * 1000 km
Grid:	420*470 * 50
Step:	2.2 km
Time step:	15 s
Forecast:	24 hours
Cores:	400

COSMO-RU7 Δx = 7 km

Domain:	4900 km * 4340 km
Grid:	700*620 * 40
Step:	7 km
Time step:	40 s
Forecast:	78 hours
Cores:	800

GME: initial and boundary data

COSMO-RUsib Δx =14 km

Domain:	5000 km * 3500 km
Grid:	360*250 * 40
Step:	14 km
Time step:	80 s
Forecast:	78 hours
Cores:	48.

Cosmo-Ru: 2012:

Runs:

-The COSMO-Ru02 (nested into COSMO-Ru07) for the Central and North-Caucasian regions of Russia was implemented in operational mode (4 times per day).

- The "nudging" (continuous data assimilation system) supported by the COSMO software for COSMO-Ru07 and COSMO-Ru02 was activated. First results demonstrating the efficiency of this system were obtained.
- The new configuration of COSMO-RU for the integration domain, which includes the entire territory of Russia (6.6-km spatial resolution) was developed (implementation is in progress).

EPS:

- The activities within the framework of the COSMO Perspective Project "CORSO" (TASK 3 «Development and adaptation of COSMO EPSs for the Sochi region») and WMO Project "FROST" was developed on the base of the COSMO-FROST-LEPS (step 7km).
- The operational technological processing line of COSMO-FROST-LEPS results for the Sochi region was developed (in cooperation with ARPA-SIMC colleagues).
- The runs of 2.2 -km version for Sochi region nested into COSMO-FROST-LEPS (7km)

were performed and selected case-studies were analyzed.

Pollution transport:

- The COSMO-RU07 - ART configuration was developed and implemented for Moscow region (once a day). Tests for transport and transformation of gaseous pollutants and spreading of smoke from forest fires were performed.

COSMO - METEOROLOGICAL SUPPORT FOR OLYMPICS "SOCHI-2014"

COSMO Perspective Project CORSO *(2012-2014)* :
Consolidation of Operation and Research results for the Sochi Olympic Games

The main goal:
to enhance and demonstrate the capabilities of COSMO-based systems of short-range numerical weather prediction in winter conditions for mountainous terrain and to assess the effect of practical use of this information during SOCHI-2014 Olympic Games

sochi.ru 2014

PP CORSO is the contribution of COSMO into WMO Demonstration Project FROST

Participants:
Russia, Italy, Germany, Switzerland and Greece

The modification of TERRA:
The additional snow-free level was implemented

At the picture: Differences between T2m forecasts with/without use the additional snow-free (canopy) level over land surface (T2M, lead time 36 h) start 25 march 2010)

Ivanovo

ctrl	exp	measured
-4.2	**-0.4**	**4.0**

Dmitrov

ctrl	exp	measured
-2.5	**0.1**	**7.0**

Moscow

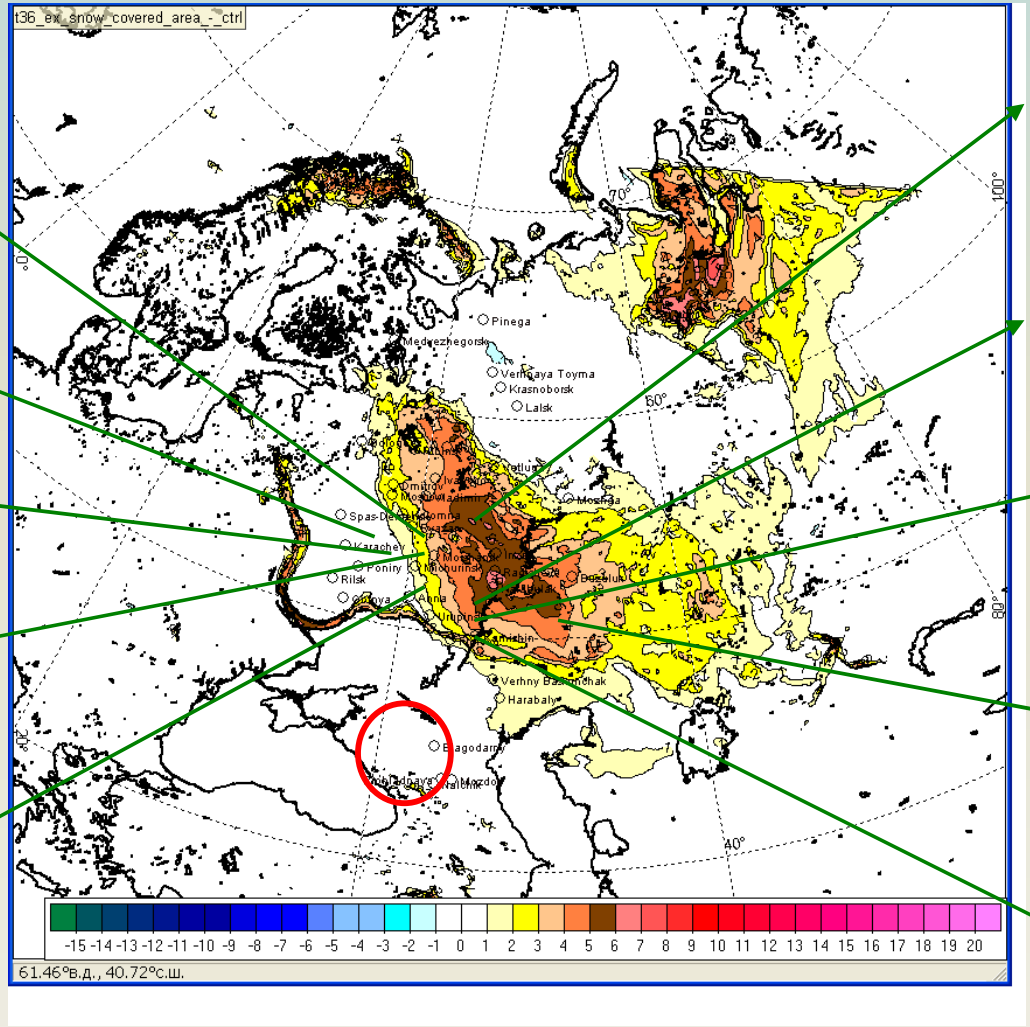
ctrl	exp	measured
-2.3	**0.1**	**8.3**

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

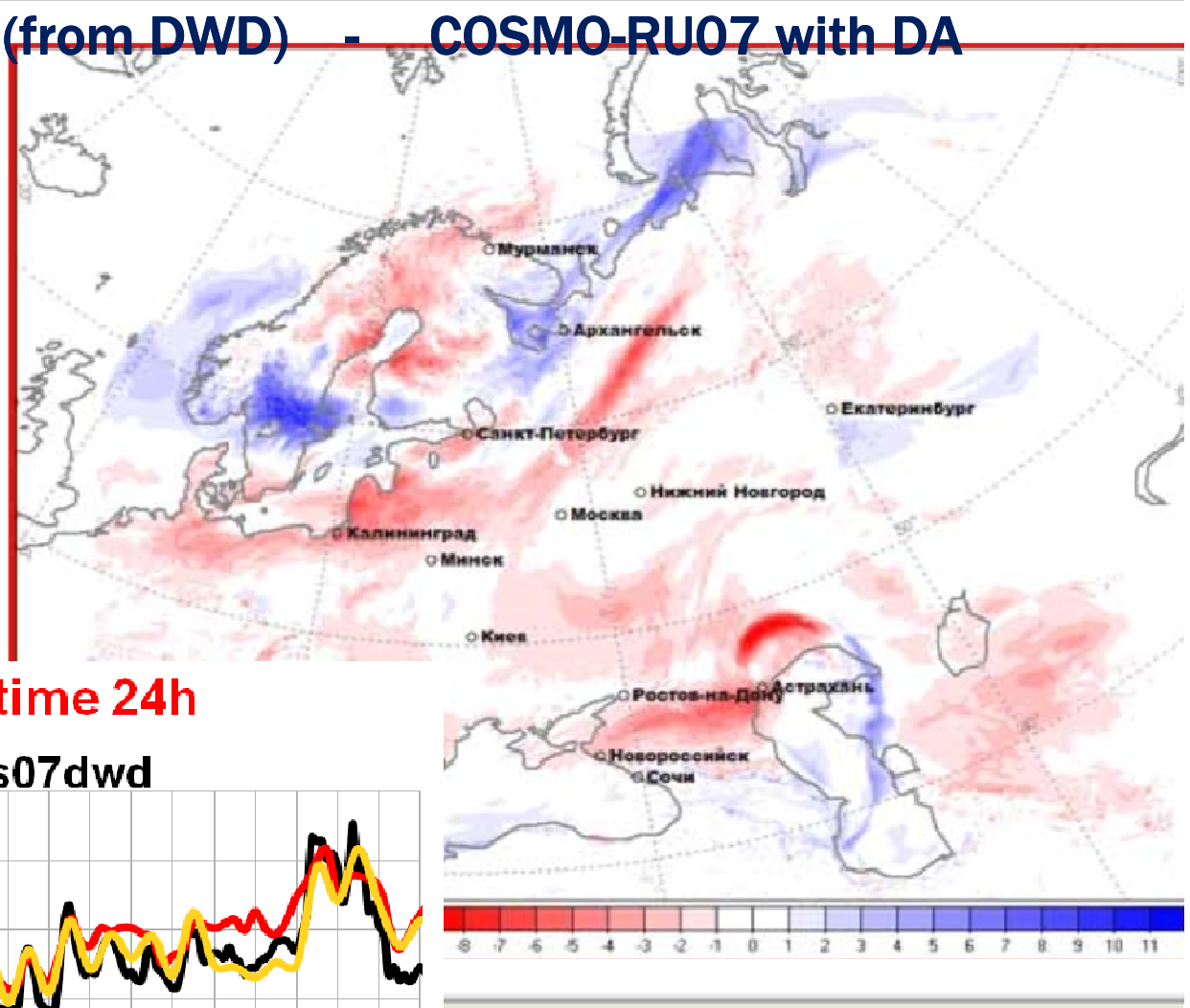
ctrl	exp	measured
-6.6	**-0.3**	**-2.4**

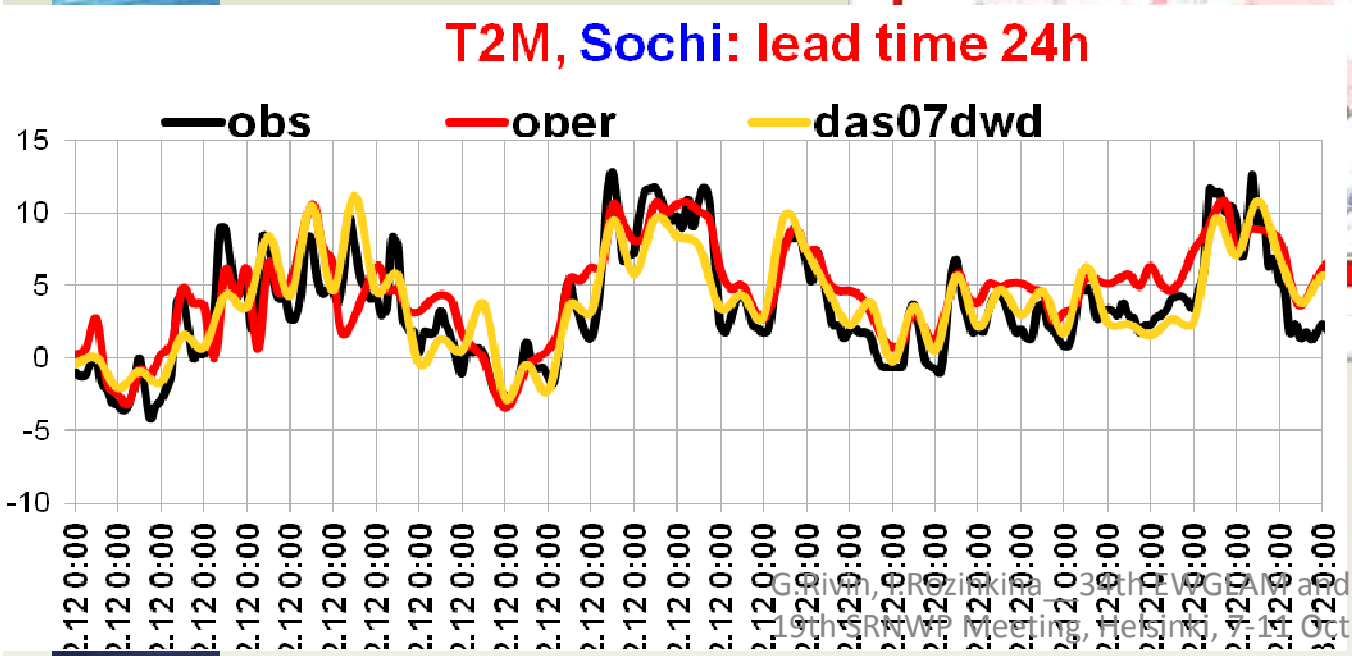
The maximum effect was obtained for the snow-covered area ***for sunny days***

The work will be finalized at 2013

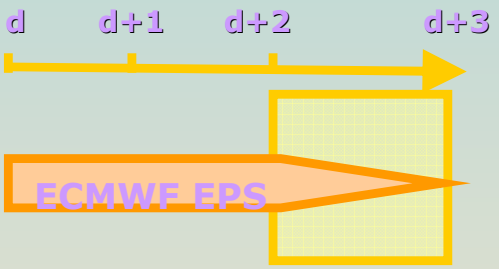
Results of comparison of the differences for T2m: COSMO-RU07 without DA (from DWD) - COSMO-RU07 with DA

The most significant differences are obtained in the T2m fields





TASK 3 COSMO-FROST-EPS @ ECMWF



clustering interval

4 variables
Z U V Q

3 levels
500 700 850 hPa

Cluster Analysis and RM identification

2 time steps

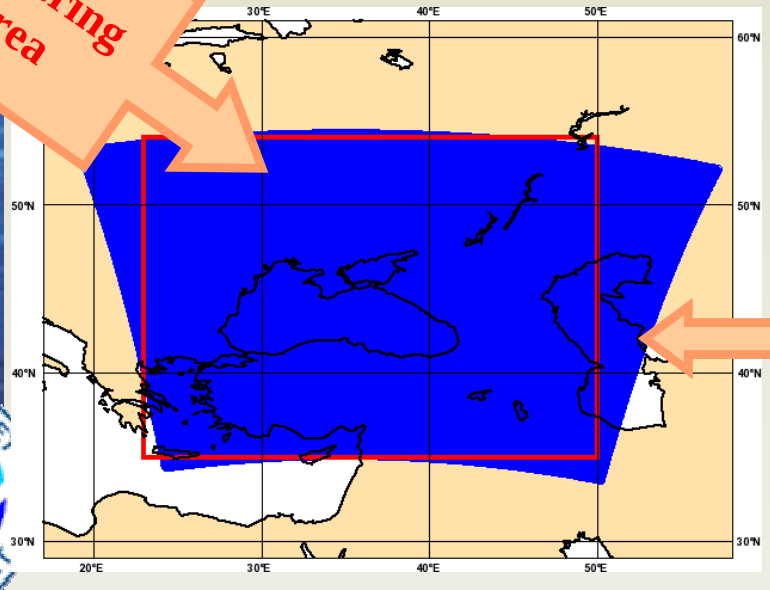
Black-Sea area

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

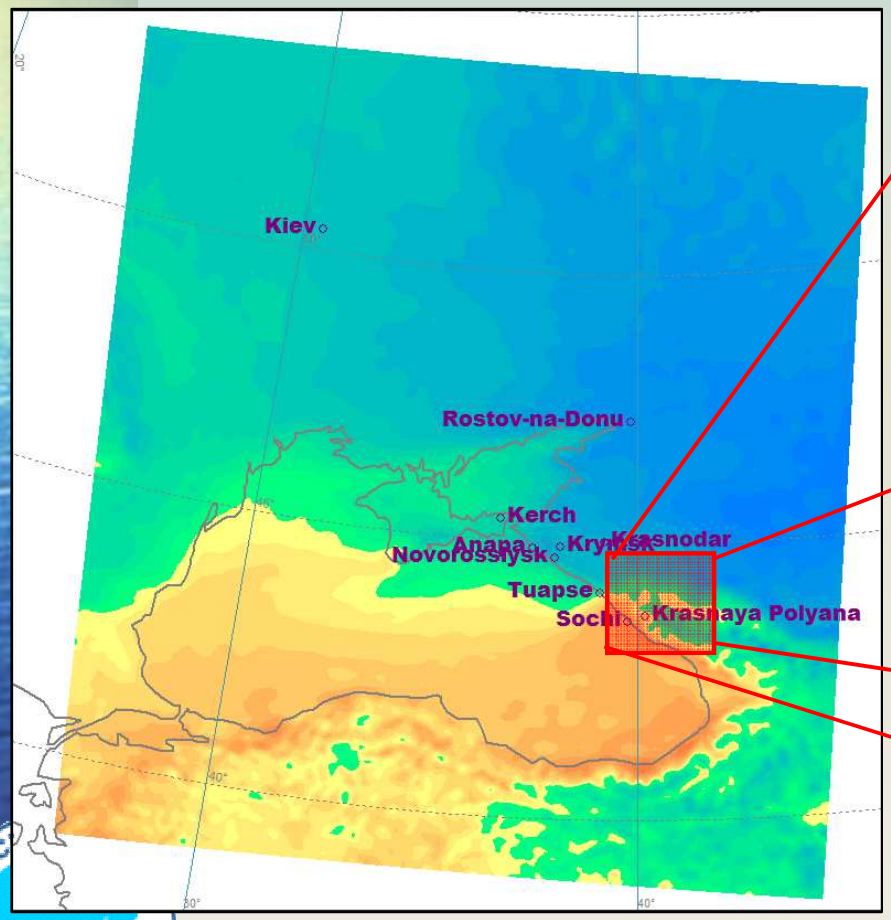


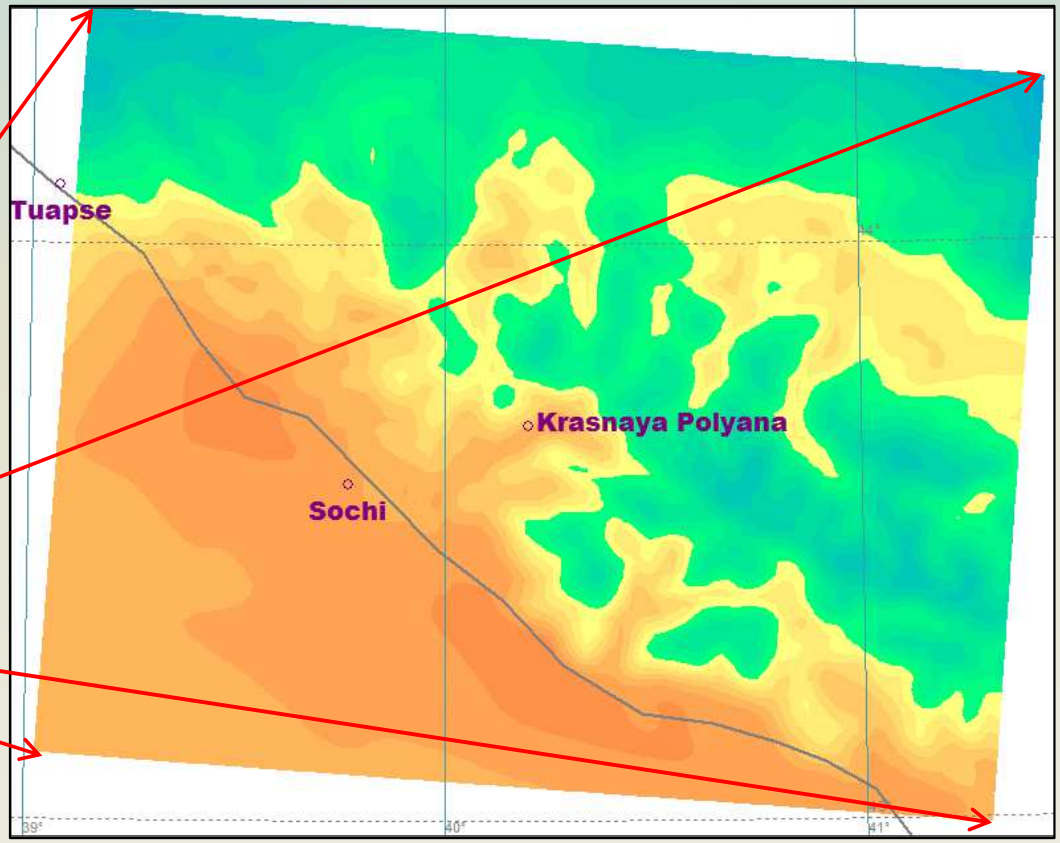
Integration Domain

- 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.

COSMO-RU-LEPS- 2.2 km

- 10 members; BCs & ICs from COSMO-FROST-EPS
- No physical parameters perturbed or modified
- Forecast length 48 h; output time step 1h





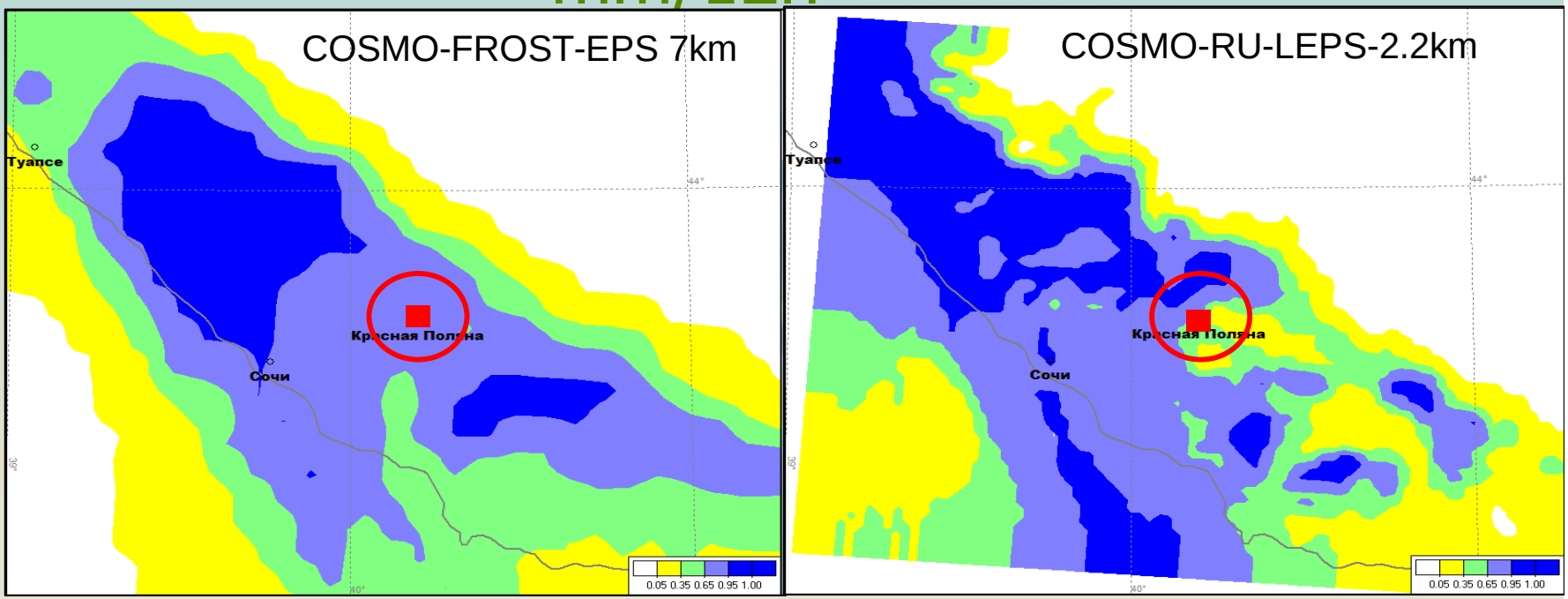
COSMO-FROST-EPS

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

0.05 0.35 0.65 0.95 1.00

Initial time: 12 UTC 14.02.2012 Lead time39h

Valid: 15 UTC 15.02.2012 – 03 UTC16.02.2012 (the amounts more 12 mm **was observed near Krasnaya Polyana**)

COSMO-RU-LEPS 2.2 km gives reasonable results describing precipitation fields in more detail than COSMO-EPS-FROST 7 km does

Case studies: conclusions

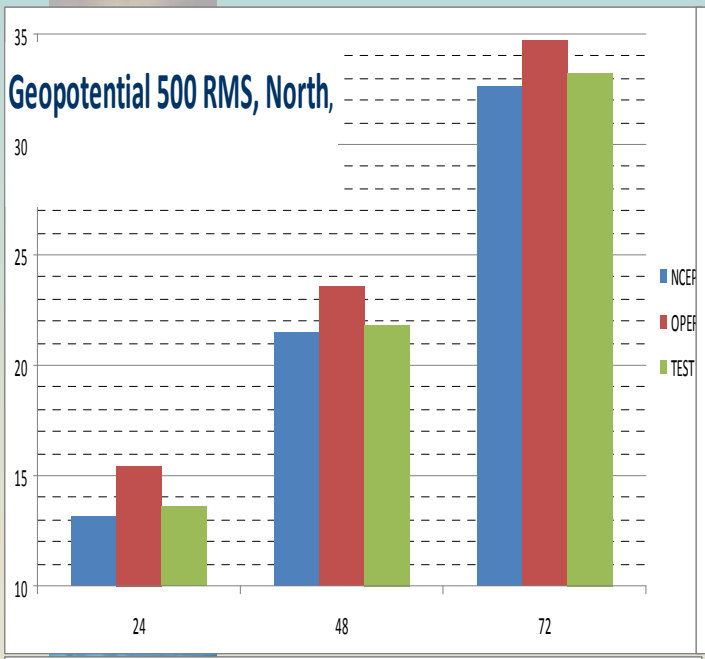
- COSMO-EPS-FROST 7 km gives valuable information for forecasters but failed to predict heavy enough precipitation on July 6-7 2012 (the flood in Kuban)
- COSMO-RU-LEPS 2.2 km gives reasonable results describing precipitation fields in more detail than COSMO-EPS-FROST 7 km does
- In some cases COSMO-RU-LEPS 2.2 km adds value, but not in all cases
- Further studies with COSMO-RU-LEPS 2.2 km are necessary to assess the forecast skill (e.g., verification for periods)

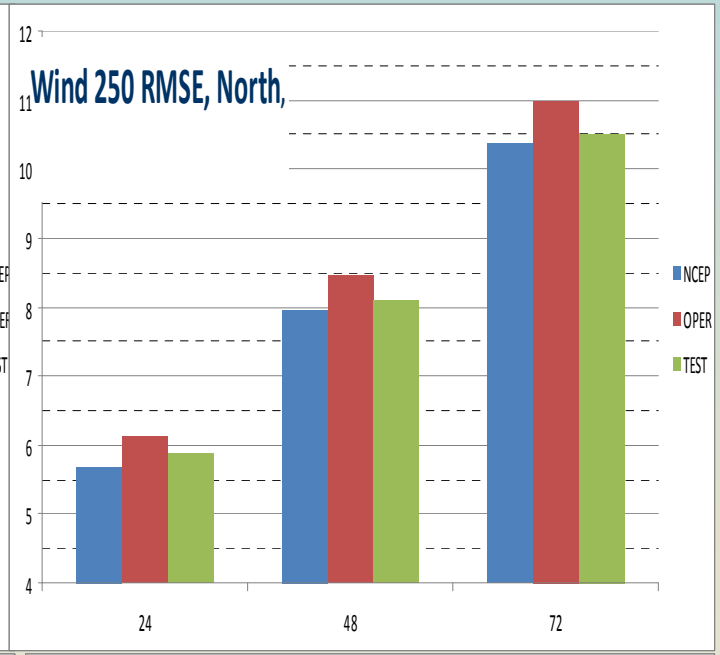
Data assimilation

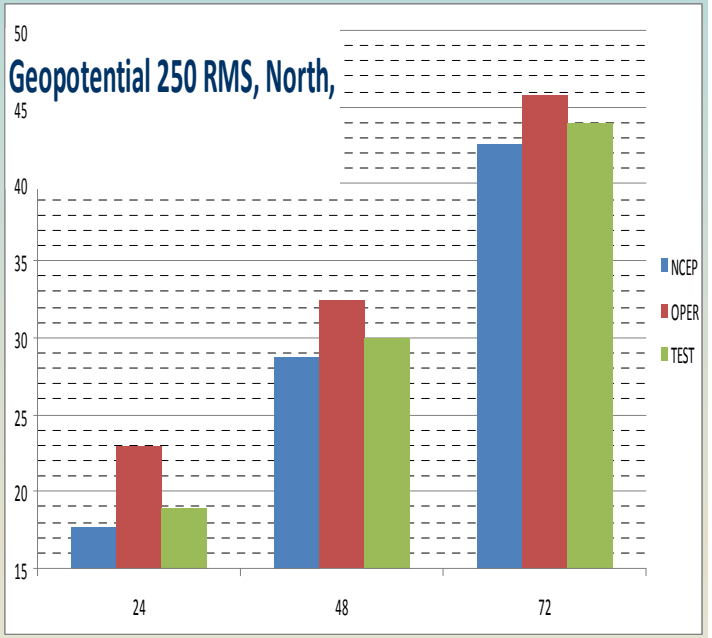
- 3D-Var analysis based on NCEP background for global models – parallel runs (M.Tsyrulnikov).
- LETKF for 3D SL-AV global model is being implemented (A.Shlyaeva).

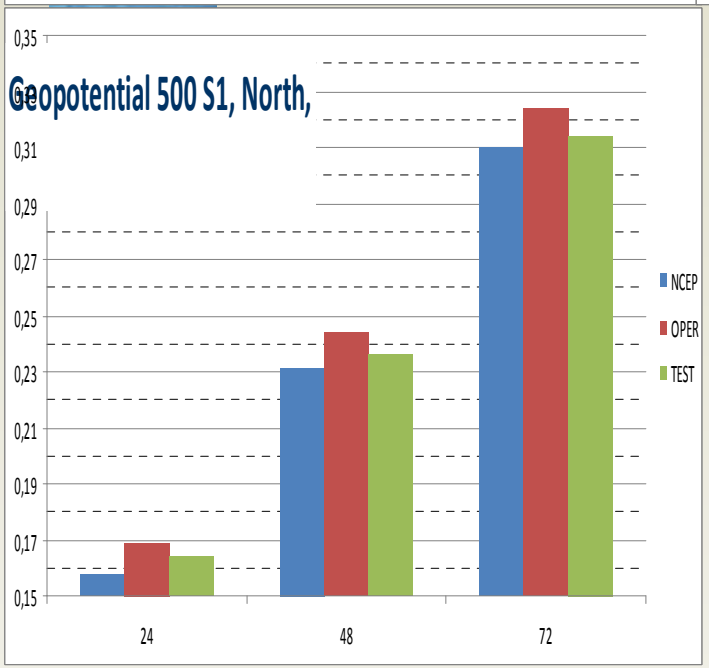
Comparison of oper SLAV forecast scores, 20-90N, December-May 2012

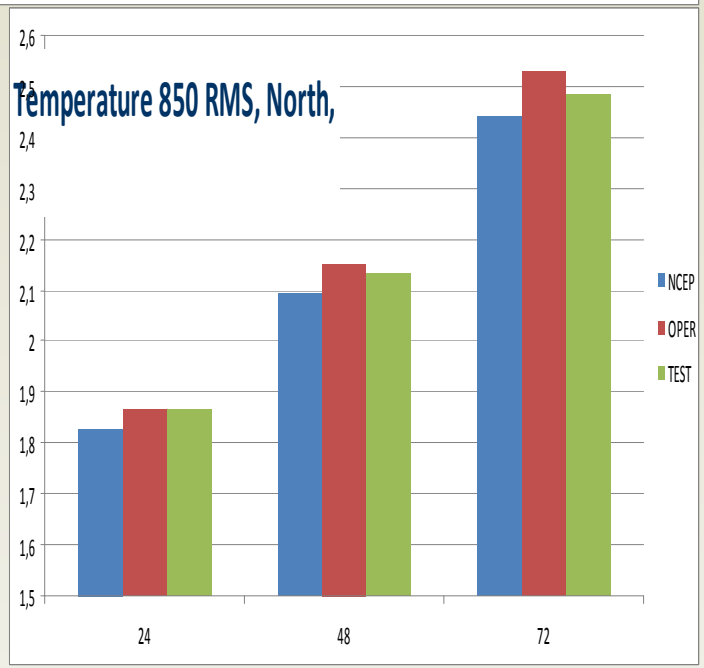
with different initial data. Blue - NCEP, red – oper OI, green – 3D-var

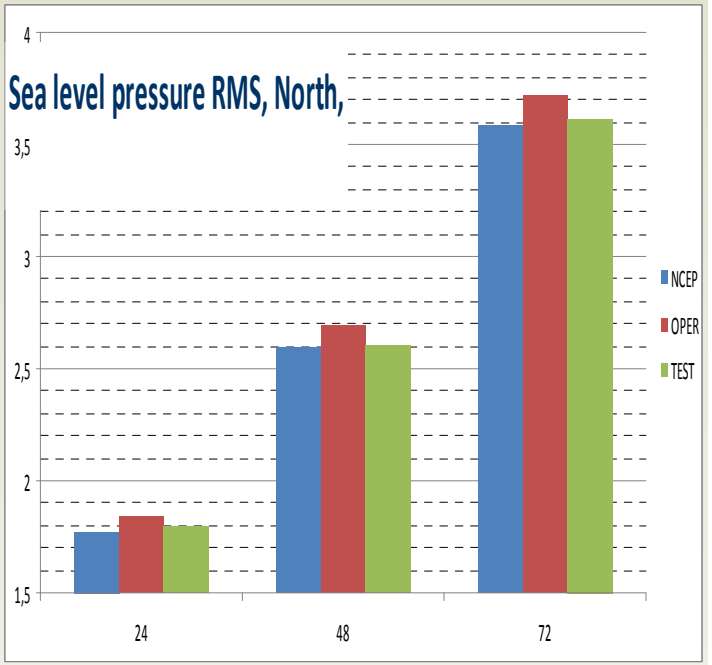




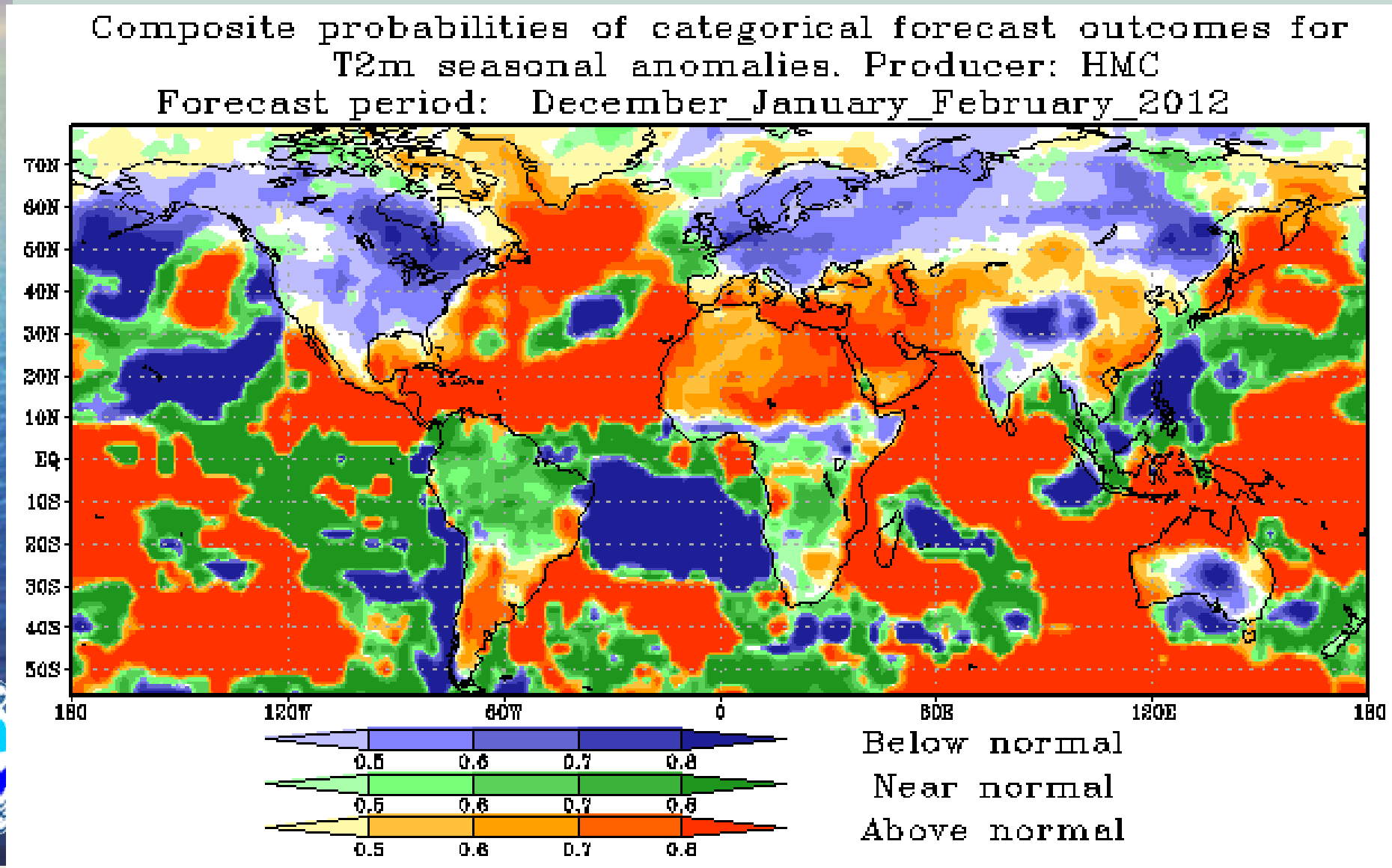








Developments in seasonal predicition
(Sample forecast at wmc.meteoinfo.ru/season)



Seasonal version of the SL-AV model

- Resolution 1.4x1.125 degrees lon/lat, 28 levels. Described in (*Tolstykh et al, Izvestia RAN, Ser. PhA&O, 2010)*
- Continue to improve the coupled model presented last year
- Experiments with CLIRAD SW radiation

Climate simulations at INM RAS in 2012

1. Climate model INMCM5 with resolution in the atmosphere 1.25*1*L128 and resolution in the ocean 0.167*0.125*L40 was constructed. Simulation of 30 years of present day climate was performed. In particular, the model is capable to reproduce such phenomena as

   a) Equatorial stratospheric QBO;

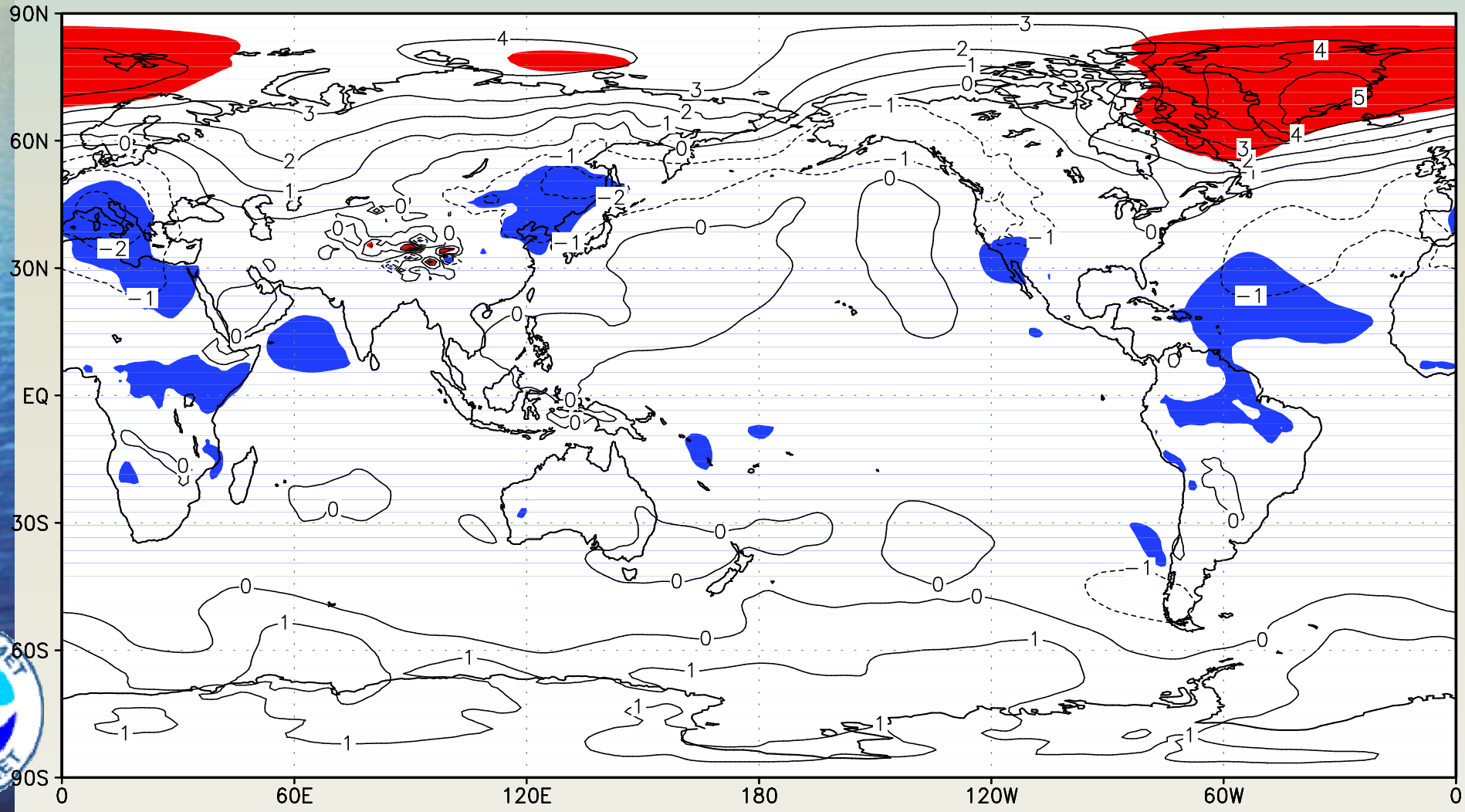
   b) connection October-November tropospheric wave flux → November-December stratospheric wave flux → December-February AO index.

2. Ensemble of 10-year runs with climate model INMCM4 was performed for estimation of potential predictability (PP) of natural climate variability at 10 year time scale. Oceanic meridional heat fluxes has high PP, especially in the Southern Ocean and North Atlantic. Maximum PP of SST locates also in the Southern Ocean.

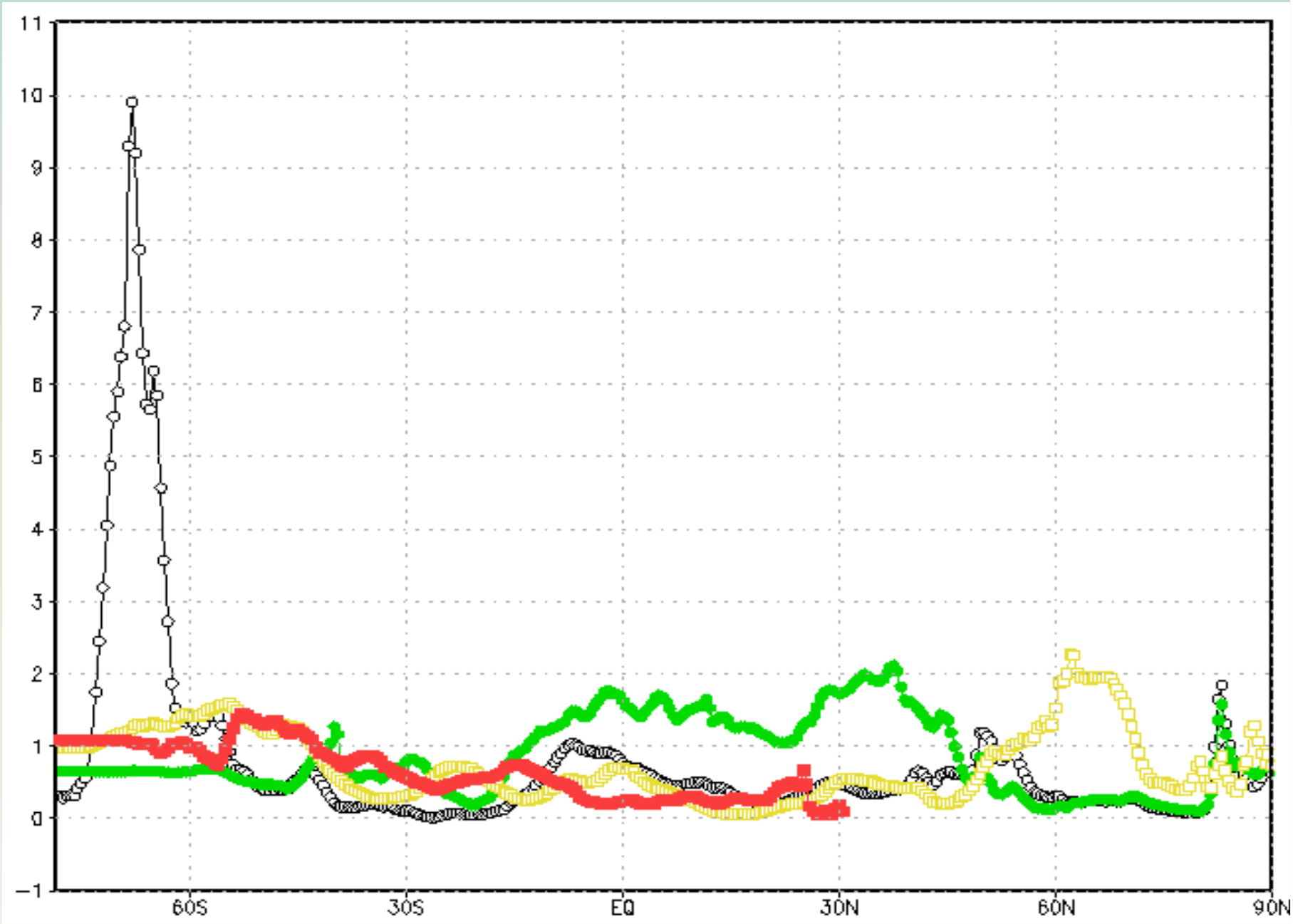
3. The mechanism of 30-50 year variability in Arctic – North Atlantic in INMCM4 was studied. It is similar to that proposed by Dijkstra et al. (2008), but with “density” Rossby waves rather than “thermal” Rossby waves.

4. The model of methane hydrates located at East Siberian Arctic shelf was included to climate model INMCM4. It was shown that at time scales of hundreds years feedback between CH4 emission from hydrates and global warming is small.

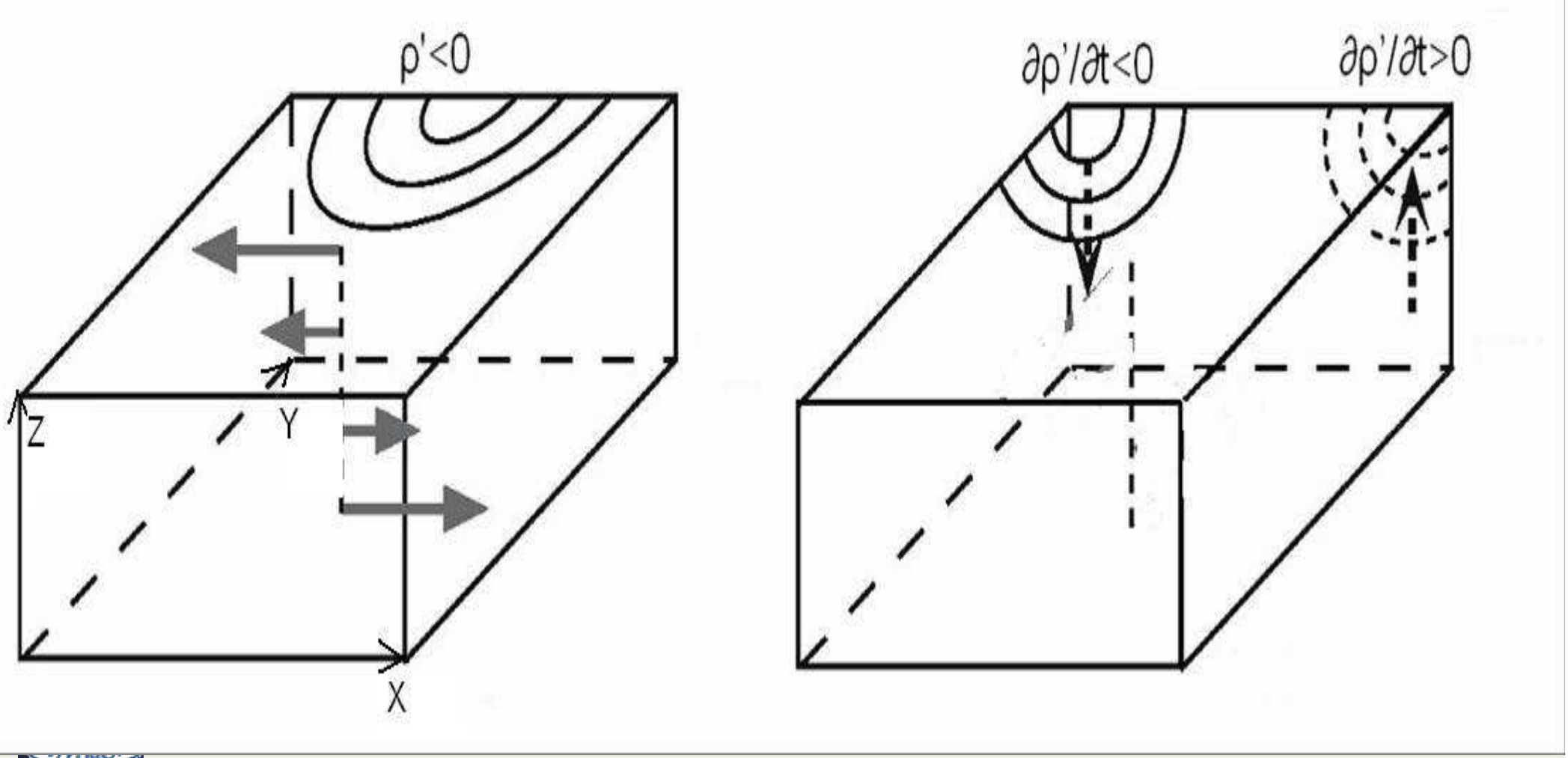
Anomaly of DJF SLP for ensemble of runs started at 01 Nov from initial states with high vertical wave flux. Shading means significance at 99% level



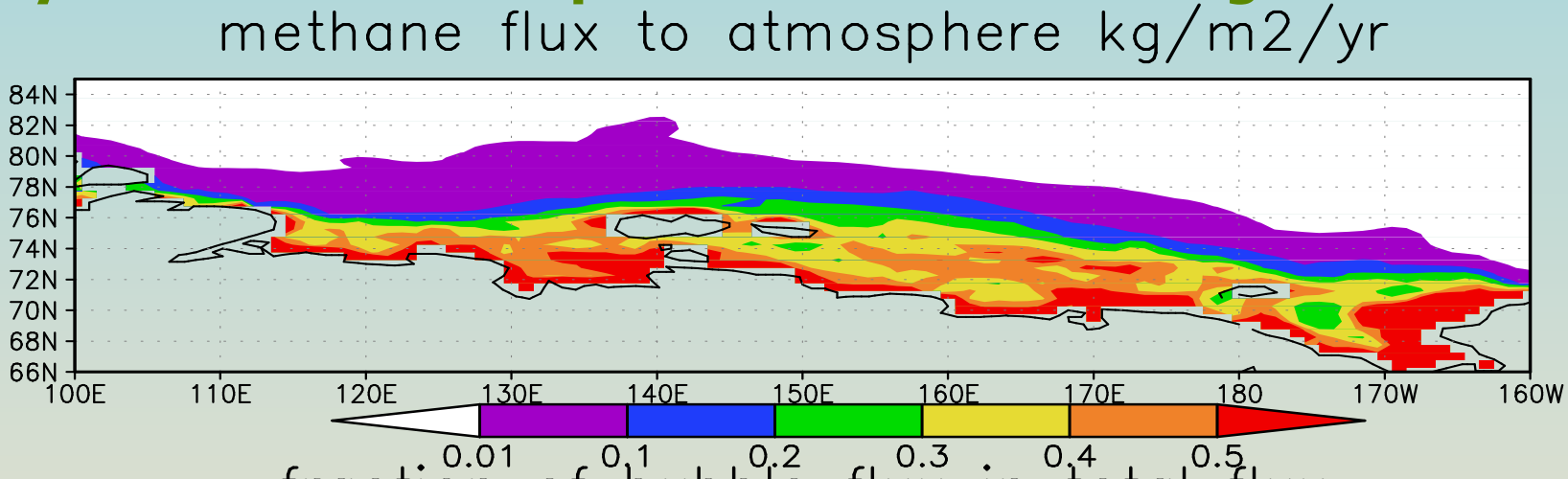
Potential predictability (signal-noise ratio) for 10 year mean ocean meridional heat flux. Black–GLB, green–ATL, yellow–PAC, red-IND

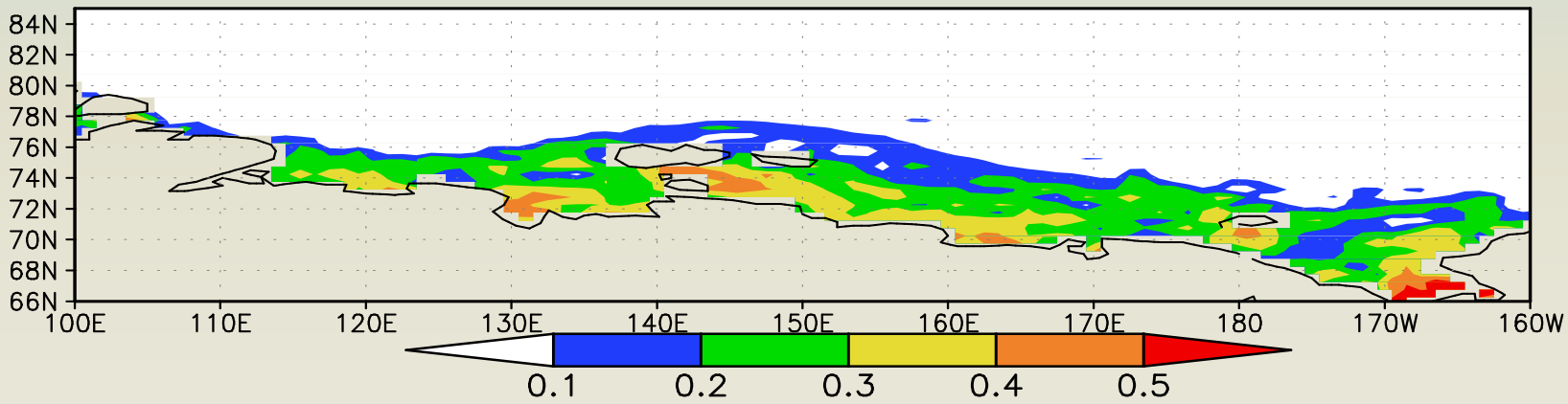


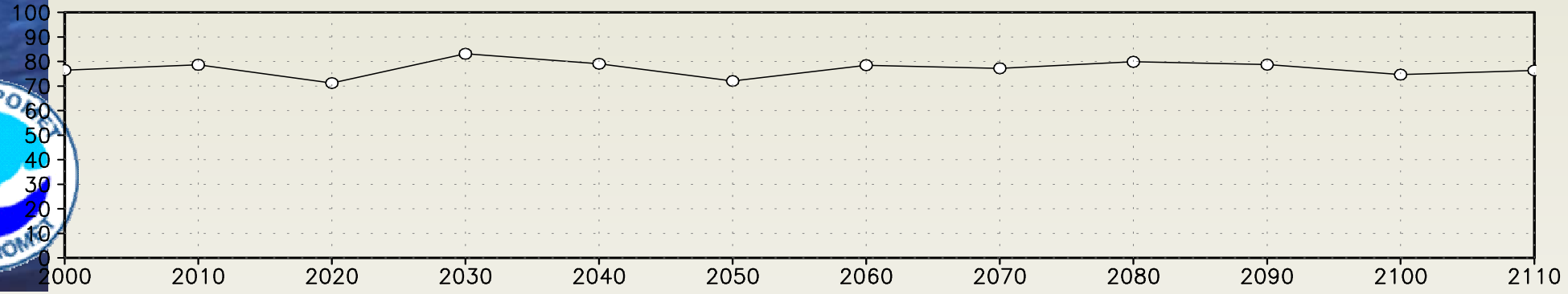
Mechanism of 30-50 year climate variability in Arctic - North Atlantic in INMCM4. Negative density anomaly generates thermal current (left) that induce upwelling and decrease of density eastward and downwelling and increase of density westward. This leads to westward propagation.



Methane flux from hydrates at Arctic shelf shows no increase in 21 century and therefore no positive feedback with global warming







Thank you for attention!