Update on NWP activity at the Hydrometcentre of Russia

Roshydromet

HYDROMETCENTER OF RUSSIA
About the weather - at first hand

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Forecasts > Uncategorised > Medium-range forecasts for cities of Russia

- Medium-range (1-week) forecasts for cities of Russia
  - Global medium-range forecasting system description
- Short-range limited area forecasts by COSMO-RU model: Meteograms
  - COSMO-RU model with grid spacing 7km: Forecast maps
  - COSMO-RU model with grid spacing 13km: Forecast maps
- Nowcasting of precipitation intensity
- Global forecast of ocean wave parameters
- Global medium-range forecast fields in GRIB format

Medium-range forecasts for cities of Russia

Country	Region of Russia	Station (city)
RUSSIA	MOSCOW AREA	MOSCOW

Actual weather   Look KASHIRA, MINERAL'NYE VO

1-week forecast | GRAPHS

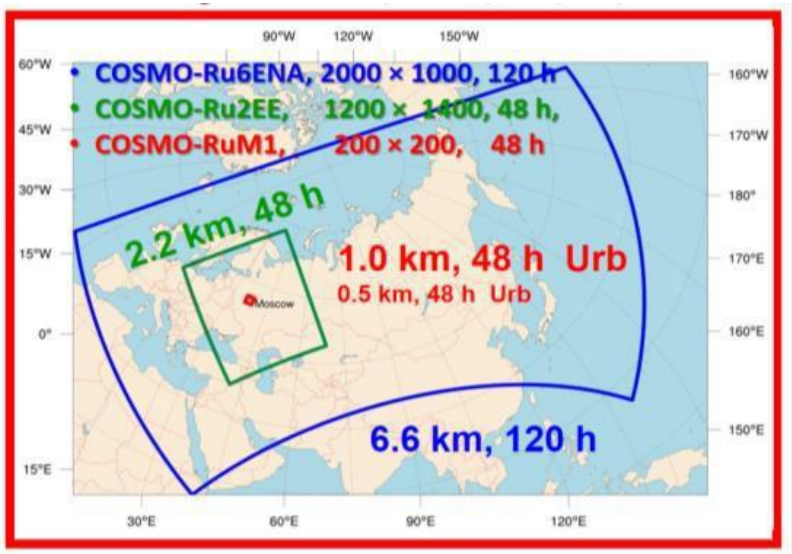
	Wednesday November, 3	Thursday November, 4	Friday November, 5	Saturday November, 6	Sunday November, 7	Monday November, 8	Tuesday November, 9
Day							
T max	7°	10°	12°	9°	6°	6°	2°
Precipitation, mm (probability)	0.4 (72%)	0	2 (91%)	0.2 (59%)	0	1.5 (79%)	0.3 (75%)
Wind, m/s	6	5	6	4	6	4	7
Pressure	751	753	748	747	747	743	748
Night							
T min	7°	5°	8°	5°	3°	2°	

Elena Astakhova, WGNE36, November 4, 2021

Operational NWP systems

Federal Service for Hydrometeorology and Environmental Monitoring
HYDROMETEOROLOGICAL CENTRE OF RUSSIA

Regional



Based on COSMO model
3 operational domains, horizontal step from 6.6 km to 1 km
1.0 km resolution over Moscow region with urban effects
On-going transfer from COSMO to ICON
Postprocessing using Neural Network

Global data assimilation: 3D-Var

EnVar under development

Global

10-days medium range forecasts

Operational: SLAV20, 0.225° in lon, 0.16°-0.24° in lat, 51 levels
New version: SLAV10, 0.1° in lon, 0.08°-0.12° in lat, 104 levels

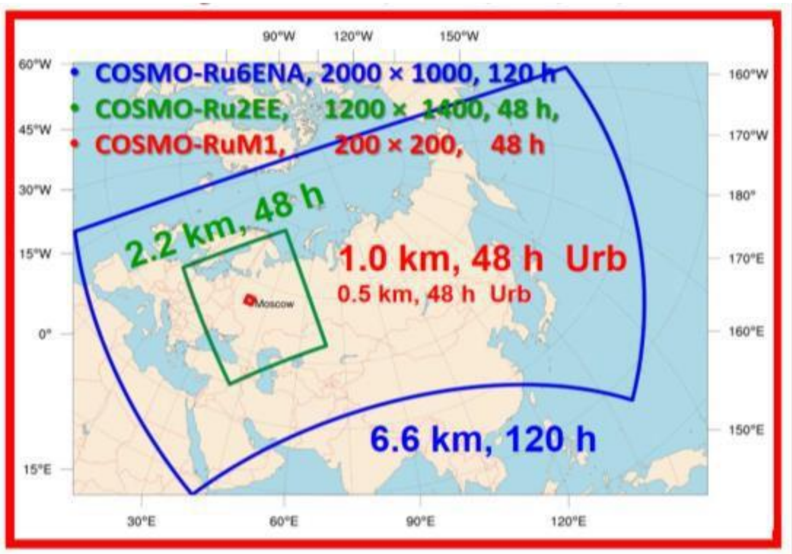
Speed up the SLAV10 with I/O from 32min/day @4000 cores to 13 min/day @2916 cores
- increase of time step value by factor 2.5 (algorithmic improvement)
- further code optimization (memory access)
- parallel I/O

Subseasonal-to-Seasonal S2S Prediction Project

Operational NWP systems

Federal Service for Hydrometeorology and Environmental Monitoring
HYDROMETEOROLOGICAL CENTRE OF RUSSIA

Regional



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LETKF-based ensemble prediction system

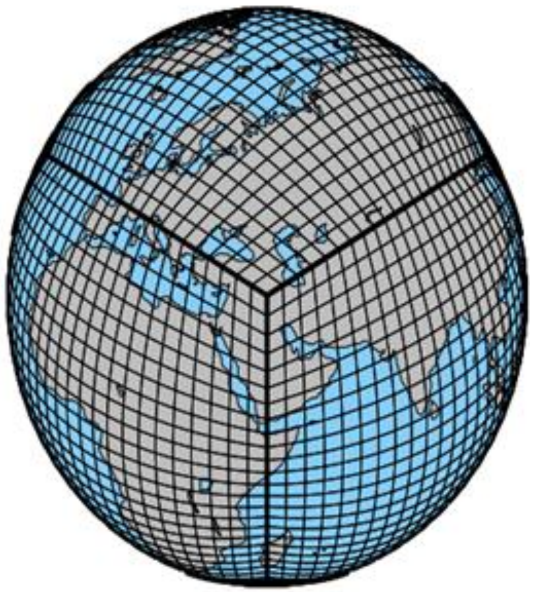
0.9° in lon, 0.72° in lat, 96 levels,M60, SPPT+SPP
Ensemble is centered to the HMC operational analysis

Subseasonal and seasonal probabilistic forecast

1.4°x1.1°L28 currently,
0.9°x0.72°L96 with top level 0.04 hPa by the end of this year.

Subseasonal-to-Seasonal S2S Prediction Project

Non-hydrostatic dynamical core using quasi-uniform horizontal grid

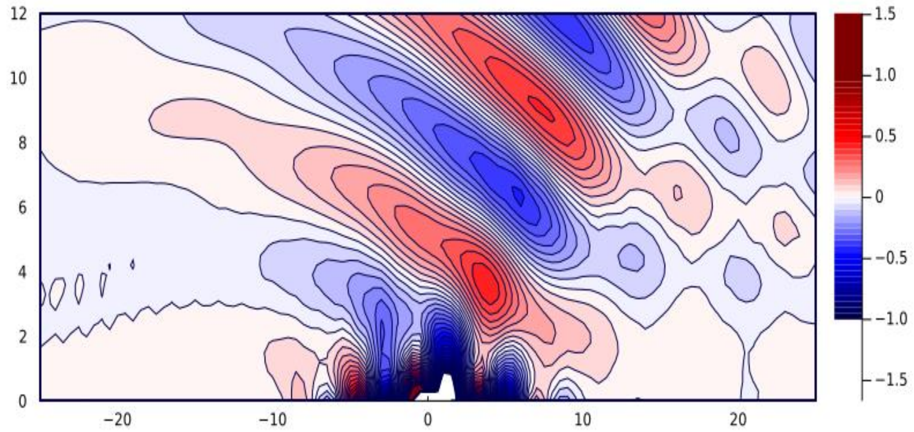


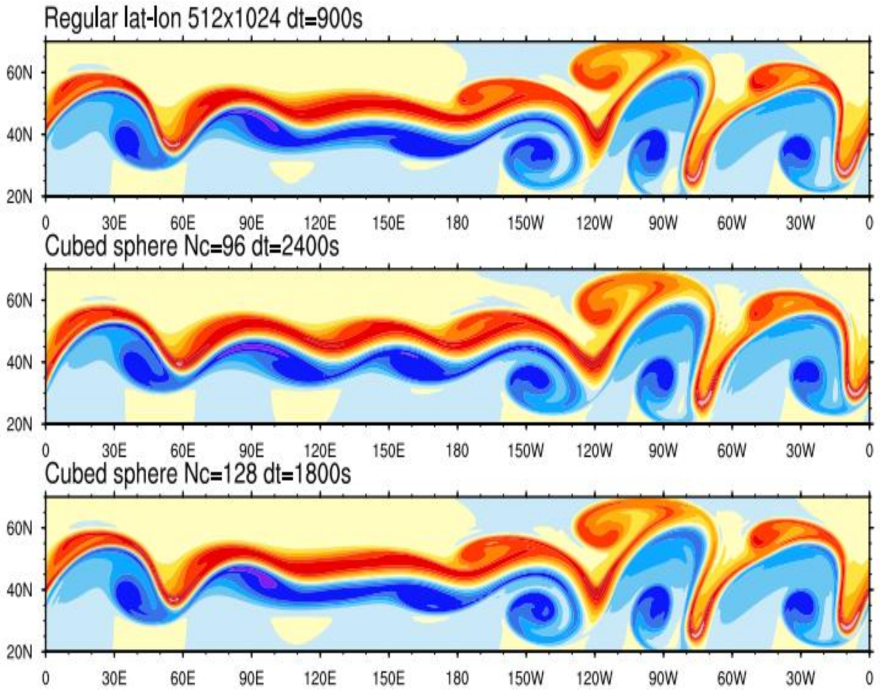
Features:

- Equiangular gnomonic cubed-sphere grid
- High-order finite-difference formulation
- semi-implicit semi-Lagrangian time integration
- vertical generalized z-coordinate system

Current state:

- Shallow water model
-2D vertical plane model
- Galewsky barotropic instability & Schar orographic wave shown





Courtesy M.Tolstykh

A new approach to generation of model-error perturbations: Additive Model perturbations scaled by Physical Tendency (AMPT)

$$\Delta P_i\,(x, y, \zeta, t) = \epsilon\, \xi_i\,(x, y, \zeta, t) \;\cdot\; \mathcal{P}_i\,(x, y, \zeta, t)$$

ΔP_i is the perturbation in tendency of *i*-th model variable,
ξ_i is the zero-mean, unit-variance random field,
ϵ is the magnitude parameter,
$\mathcal{P}_i\,(x, y, \zeta, t)$ is an area-averaged physical tendency

Differences with SPPT:

- Switch from pointwise physical tendency P_i to an area-averaged physical tendency $\mathcal{P}_i$.
- Specify independent random fields for different model variables ξ_i.
- Make ξ_i depend on the vertical coordinate.

Averaging of P_i

Gaussian
T, T_{soil}, u, v, p
Over the whole LAM domain

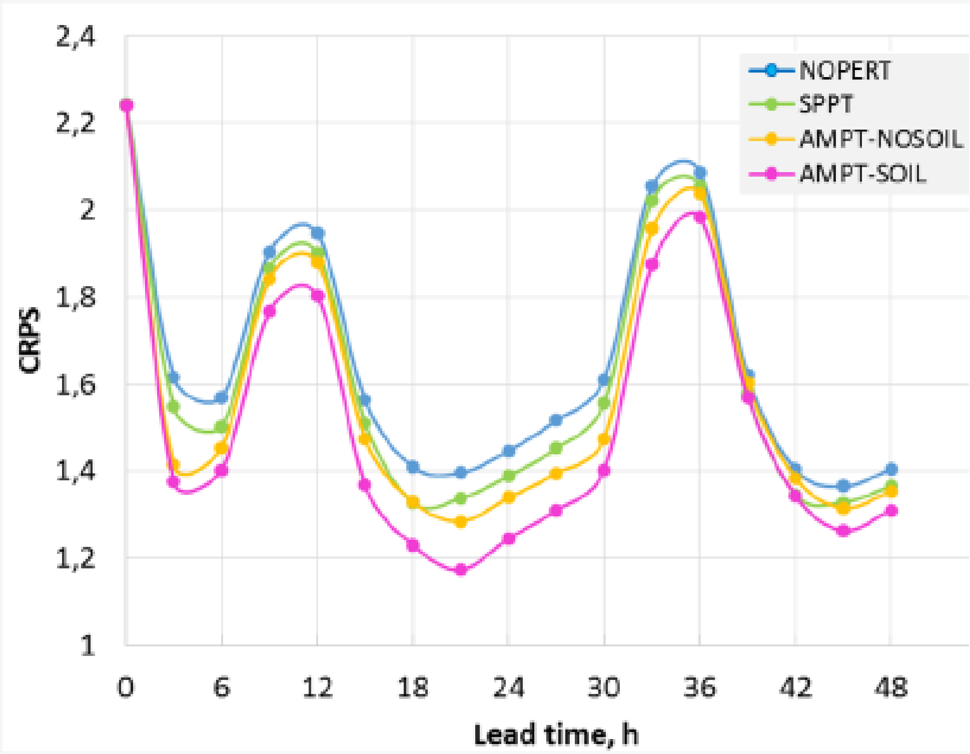
Non-Gaussian
q, W_{soil}
Over a small 2D moving window centered at the grid point in question

M Tsyrulnikov, E Astakhova, D Gayfulin

A new approach to generation of model-error perturbations: Additive Model perturbations scaled by Physical Tendency (AMPT)

- Tested over a two-month period in a COSMO-based EPS with a 2.2 km resolution.
- 4D random pattern ξ was generated by the Stochastic Pattern Generator (SPG, Tsyrulnikov, Gayfulin, 2017).
- SPG space and time scales: $L_\xi = 50$ km, $T_\xi = 1$ h
- T, u, v, ps, q, multi-level T_{soil},W_{soil} were perturbed.

Experiment	Model perturbations
NOPERT	None
SPPT	SPPT: atmosphere
AMPT-NOSOIL	AMPT: atmosphere
AMPT-SOIL	AMPT: atmosphere + soil



Results:

- A positive effect from perturbing T, u, v, T_{soil},W_{soil}, mixed effect from perturbing q.
- AMPT significantly outperformed SPPT for T2m, with nearly the same results for precipitation and near-surface wind.

M Tsyrulnikov, E Astakhova, D Gayfulin

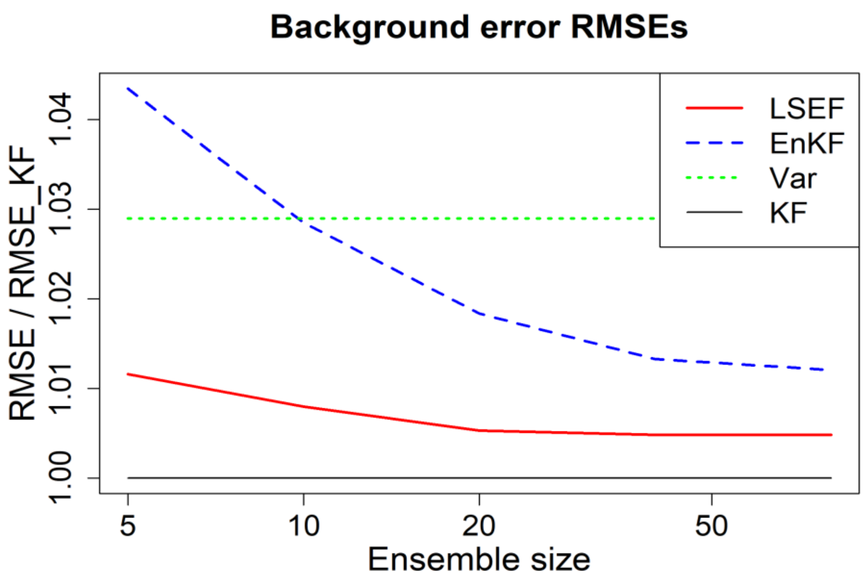
A new approach to ensemble-variational assimilation: The Locally Stationary Ensemble Filter (LSEF)

The idea is to learn a square root $\boldsymbol{W}$ of the background error covariance matrix $\boldsymbol{B} = \boldsymbol{W} \cdot \mathbf{W}^{\mathrm{T}}$ directly from the ensemble. (The $\boldsymbol{W}$ matrix is the key ingredient of any variational analysis.)

For $\boldsymbol{W}$ to be identifiable from the ensemble, a few constraints on its structure are introduced. The most important constraints are *local stationarity (or weak non-stationarity) and smooth local spatial spectra.*

In numerical experiments with a non-stationary (in time and space) 1D toy model of truth, LSEF outperformed both Var and EnKF for small to moderate-size ensembles.

A 3D version under development.



The technique is computationally tractable: its non-ensemble version has been used at our center for operational meteorological data assimilation for several years.

M Tsyrulnikov and A Sotskiy

Summary

- Most of NWP systems were upgraded following the increase in computer capacity :
the resolution of global deterministic model in medium-range and seasonal forecasting was improved, the domains for high-resolution regional forecasting were enlarged.

- The new global ensemble prediction system has been developed and operational trials are demonstrating its good skill (see additional slides).

- The new non-hydrostatic dynamical core for the SLAV global model is under development .

- The new scheme for generating model-error perturbations (Additive Model perturbations scaled by Physical Tendency) was suggested and its positive effect on T2m forecasting was demonstrated.

- A new approach to ensemble-variational assimilation was suggested termed the Locally Stationary Ensemble Filter (LSEF). LSEF outperformed both Var and EnKF for small to moderate-size ensembles.

Additional slides

SL-AV global atmosphere model

SL-AV: Semi-Lagrangian, based on Absolute Vorticity equation

- Finite-difference semi-implicit semi-Lagrangian dynamical core (Tolstykh et al, GMD 2017). Vorticity-divergence formulation, unstaggered grid (Z grid), 4th order finite differences. Possibility to use variable resolution in latitude.
- Many parameterizations algorithms for subgrid-scale processes developed by ALADIN/ALARO consortium.
- Parameterizations for shortwave and longwave radiation: CLIRAD SW + RRTMG LW.
- INM RAS- SRCC MSU multilayer soil model (Volodin, Lykossov, Izv. RAN 1998).

Results for SLAV-10

- Speed up the SL-AV10 with I/O from 32min/day @4000 cores to 13 min/day @2916 cores

  - increase of time step value by factor 2.5 (algorithmic improvement)

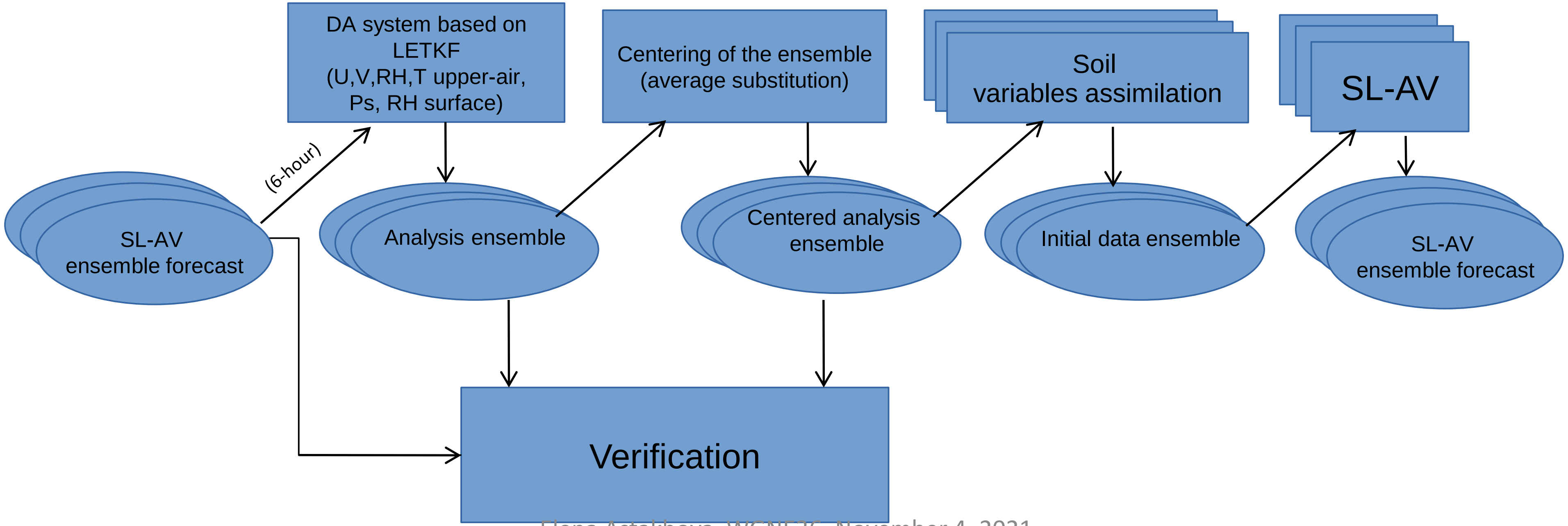
  - further code optimization (memory access)

  - parallel I/O

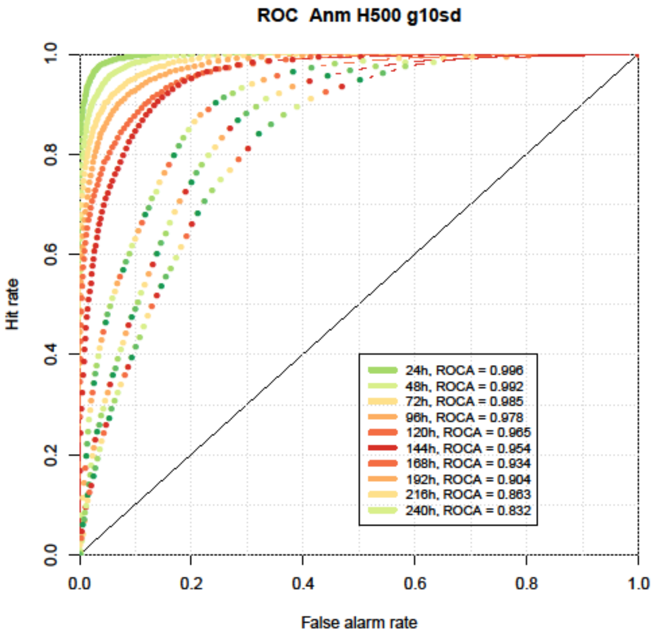
- Setup of operational technology, including gradual shift from GRIB to NetCDF
- Currently under tuning

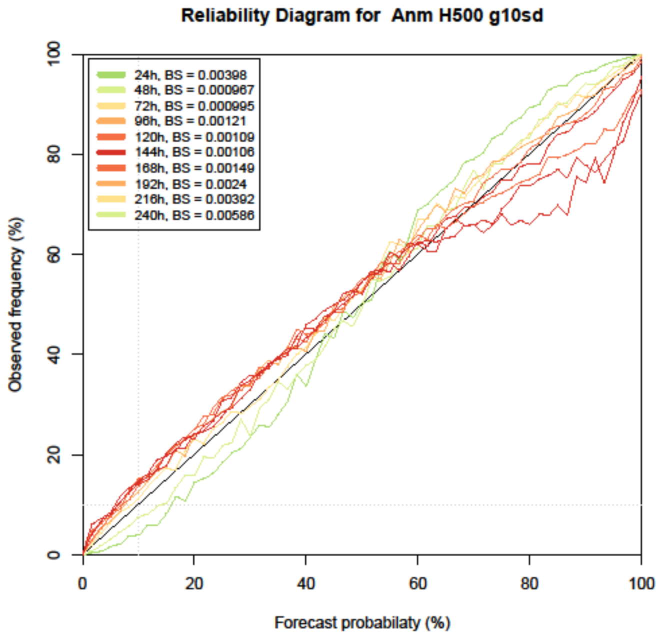
Ensemble prediction system

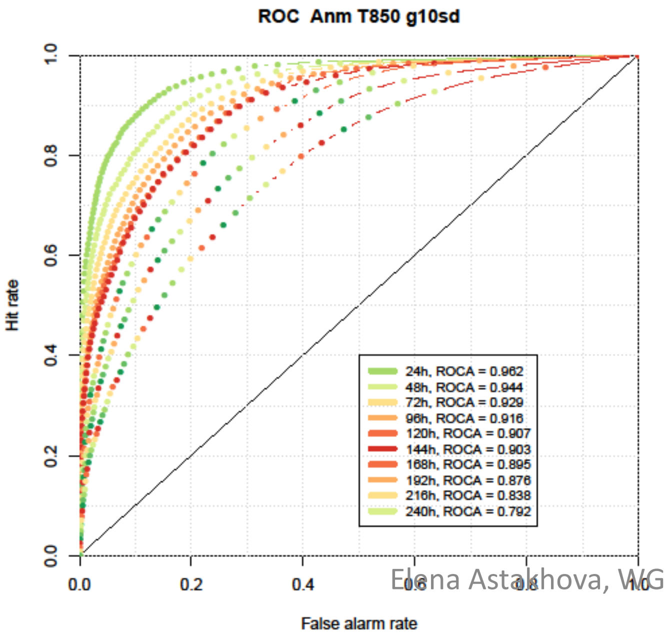
- Local Ensemble Transform Kalman Filter (LETKF) is used to generate perturbations in the ensemble of initial data
- Ensemble is centered to the HMC operational analysis
- SL-AV model incorporates SPPT for temperature and vorticity and SPP for 27 parameters in physical parametrizations
- Ensemble size – 60 members

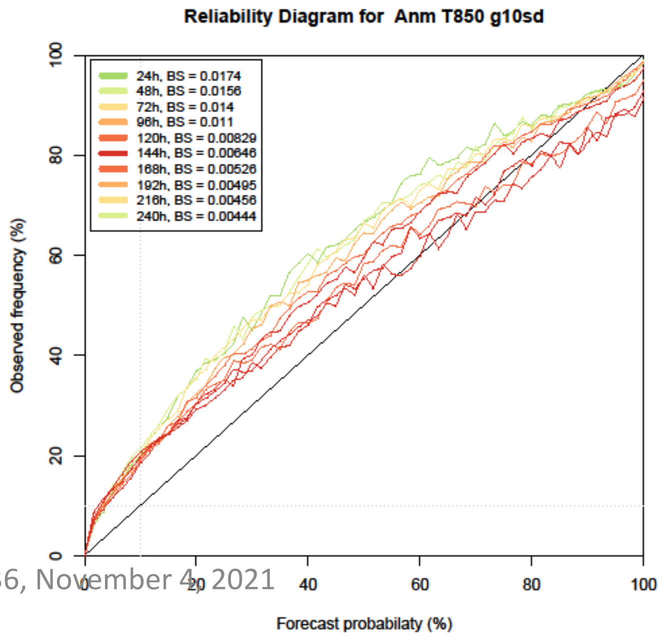


Reliability diagrams and ROC (Northern extratropics, Jan 2021)



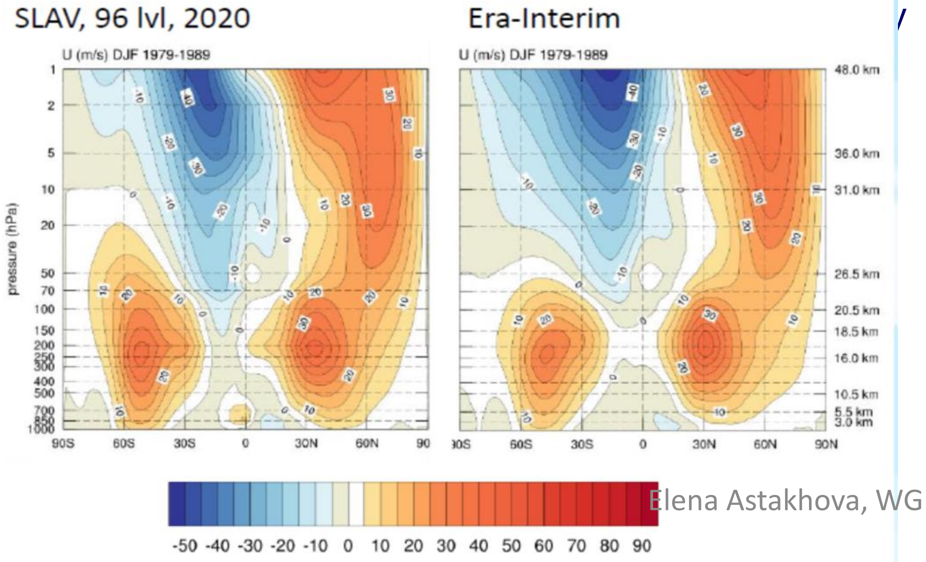


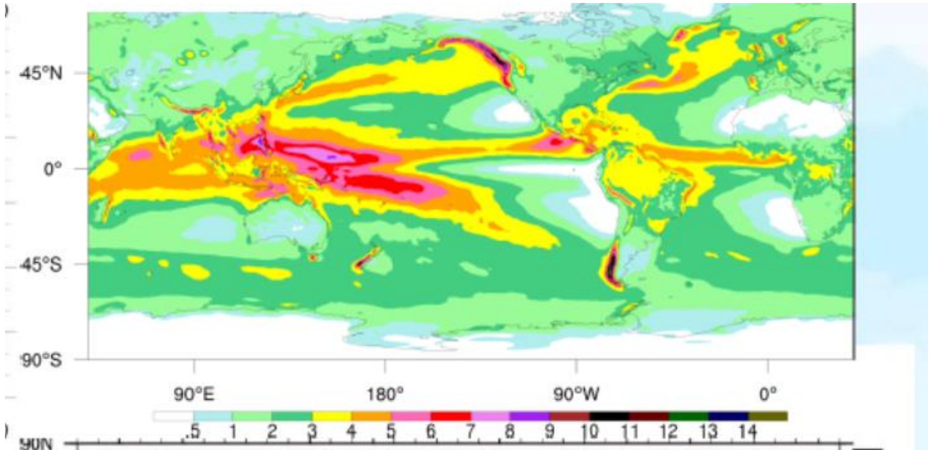


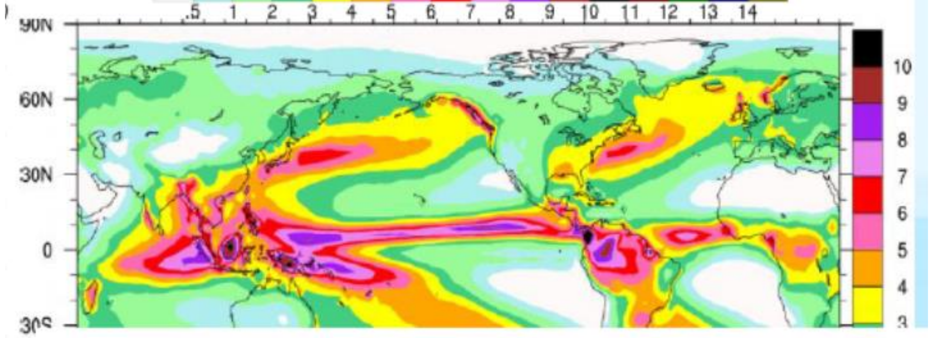


New long-range prediction system at Hydrometcentre of Russia

- Resolution 0,9x0,72° lon-lat, 96 levels
- Uppermost level at 0,04 hPa
- 500-700 m resolution in the stratosphere
- SW radiation: CLIRAD SW, LW radiation: RRTMG LW (11 + 16 spectral bands)
- Boundary layer: Bastak-Duran et al JAS 2014
- Marine stratocumulus, sea-ice T
- INM RAS multilayer soil scheme







TRMM: TROPICAL RAINFALL MEASURING MISSION.
https://climatedataguide.ucar.edu/climate-data/trmm-tropical-rainfall-measuring-mission