NWP SYSTEMS OF THE HYDROMETCENTER OF RUSSIA: STATUS AND RECENT RESEARCH & DEVELOPMENT

Data assimilation

Operational global 3D-Var system

- Based on a parametric spatial-auto-regression covariance model
- Assimilates the following satellite data: AMSU-A, MHS, AMV (Geo, Polar, Leo-Geo), scatterometry (ASCAT), radio-occultation (COSMIC, GRAS)
- Works with the external background (6-h GFS forecast) and in the cycling mode with the RHMC semi-Lagrangian model SL-AV

Current research

Work on the Hierarchical Bayes Ensemble Filter (HBEF) is ongoing. The HBEF differs from EnKF in an explicit cycling of the background error covariance matrix.

Tsyrulnikov M. and Rakitko A. A Hierarchical Bayes ensemble Kalman Filter. Physica D, 2017, v.338, 1-16.

Calibration and assimilation of MTVZA-GY microwave observations from Russian Meteor-M series satellites

MTVZA-GY is a 29-channel microwave radiometer (somewhat similar to AMSU-A and MHS combined).

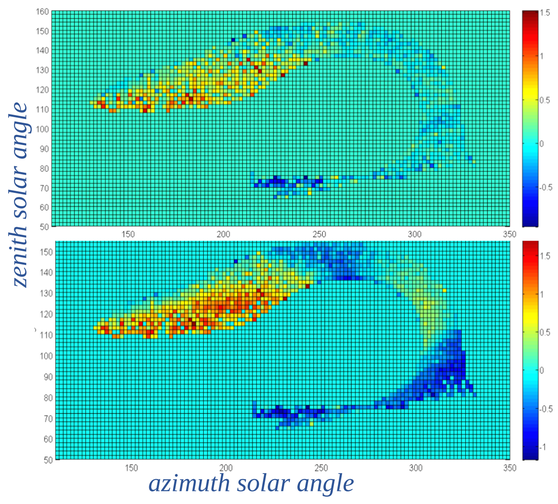
The radiative transfer model RTTOV now has the capability of handling MTVZA-GY, which enables assimilation of these data.

A post-launch external calibration technique is developed. The technique is the regression Tb=a*Ta + b, where Ta is the antenna temperature, Tb is the brightness temperature (to be assimilated), and a and b are functions of two variables: zenith and azimuth solar angles. The plots on the right demonstrate the reduction in observation bias.

Assimilation of MTVZA-GY data in the RHMC DAS led to an improvement of 24-72h forecasts in the Southern Hemisphere.

D.R. Gayfulin, M.D. Tsyrulnikov, A.B Uspensky, E.K. Kramchaninova, S.A. Uspensky, P.I. Svirenko, M.E. Gorbunov. Numerical experiments on the use of microwave MTVZA-GY observations in the data assimilation system of the HydroMetCentre of Russia. Russian Meteorology and Hydrology, 2017, N9.

Observation biases (w.r.t. 6h NCEP forecasts)



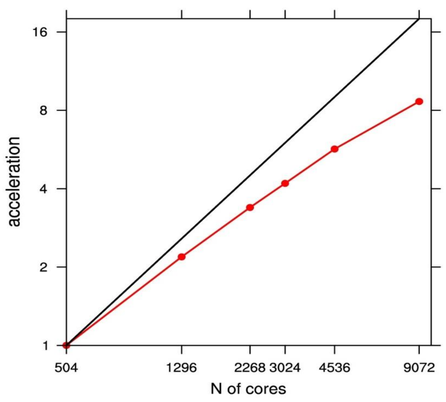
Global forecasting

Operational global atmosphere model SL-AV

- Semi-implicit semi-Lagrangian dynamical core of own development. Vorticity-divergence formulation, unstaggered Z-grid, 4th order finite-differences
- Most parameterizations algorithms developed by ALADIN/ALARO consortium, with some modifications
- CLIRAD SW and RRTMG LW radiation
- Multilayer soil model, INM RAS and SRCC MSU
- Resolution for medium-range prediction: (0.16-0.24)° in latitude, 0.225° in longitude, 51 levels
- Resolution for seasonal forecasts 0.9°x0.72° lon-lat, 28 levels

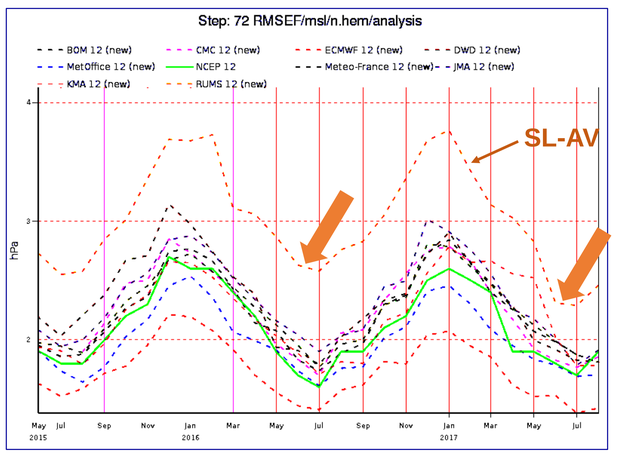
M.Tolstykh, V.Shashkin, R.Fadeev, G.Goyman, Vorticity-divergence semi-Lagrangian global atmospheric model SL-AV20: dynamical core. Geosci. Mod. Devel. 2017

Code parallelization



SL-AV parallel acceleration w.r.t. 504 cores at traditional x86 Broadwell system

Improvements due to changes in deep convection and cloudiness schemes and sea-ice temperature



RMSE of 72h mslp forecasts. 20-90N

Current research: New dynamical core development

Requirements:

- Non-hydrostatic
- Consistent (between air and small constituents) mass-conservative
- Scalable

Choices:

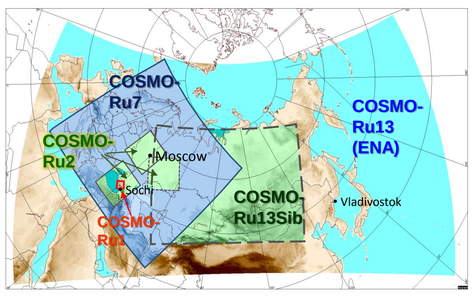
1) Reduced lat-lon grid
2) Semi-Lagrangian advection
3) Semi-implicit scheme
4) High-order approximations (FD or FV)

Operational global ensemble prediction system

- Two models: RHMC spectral model SMA, T169L31 + Semi-Lagrangian finite-difference model SL-AV 0.9x0.72 deg lon/lat, L28
- 14 members: 12 perturbed SMA , control (unperturbed) SMA, unperturbed SL-AV
- Perturbations of initial conditions: breeding with regional rescaling using total energy norm, breeding step 12 h

Regional forecasting

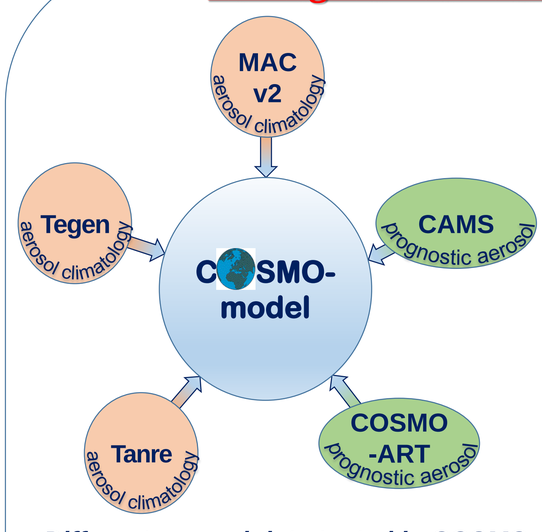
Operational systems based on COSMO model



System:	Resolution (km)	LBCs
COSMO-Ru13:	13.2	ICON (DWD)
COSMO-Ru7:	7	ICON (DWD)
COSMO-Ru2:	2.2	COSMO-Ru7
COSMO-Ru1 :	1.1	COSMO-Ru2

G.S.Rivin, I.A.Rozinkina et al, The COSMO-Ru system of nonhydrostatic mesoscale short-range weather forecasting of the Hydrometcenter of Russia: The second stage of implementation and development. Russian Meteorology and Hydrology, 2015,vol.40,iss.6,pp.400-410

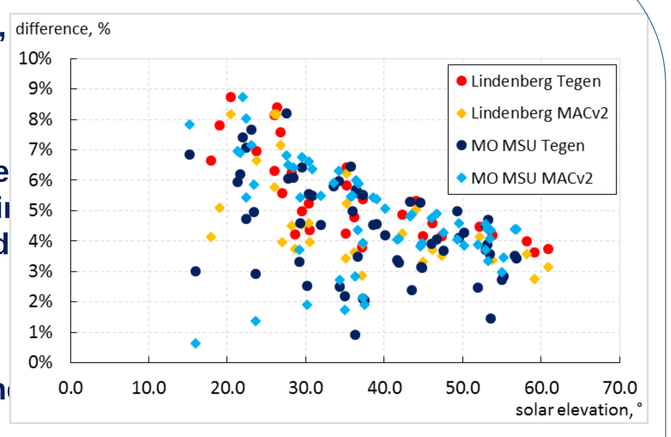
Testing new cloud-aerosol radiation scheme and aerosol climatologies in COSMO model



Different aerosol data tested in COSMO

- New aerosol climatology MACv2 (Kinne S. et al., 2006) has been implemented;
- The effect of different aerosol climatologies (Tanre, Tegen, MACv2) and prognostic aerosol (CAMS, COSMO-ART) on the simulated radiative characteristics and meteorological parameters in clear and overcast conditions is being assessed at different locations (see the results for Lindenberg and Moscow on the right);
- A new coupled aerosol-cloud microphysics scheme and new aerosol-cloud-radiation scheme (Blahak, Muskatel et al., 2016) is tested.

The work is within the COSMO project T2(RC)2.

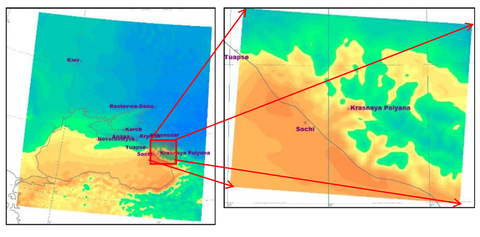


Errors of global net radiation simulated by COSMO with Tegen and MACv2 aerosol climatologies w.r.t. observational data at the stations in Lindenberg and Moscow (MO MSU). Clear sky conditions.

Chubarova N., Polukhov A., Gorlova I. Long-term variability of aerosol optical thickness in Eastern Europe over 2001-2014 according to the measurements at Moscow MSU MO AERONET site with additional cloud and NO2 correction. Atmos.Meas.Tech, doi: 10.5194/amt-9-313-2016.
Polukhov A., Chubarova N., Kinne S., Rivin G., Shatunova M., Tarasova T. Comparison between calculations of shortwave radiation with different aerosol datasets and measured data at the MSU MO (Russia). AIP Conference Proceedings 1810, 100006 (2017); doi: 10.1063/1.4975561

Research mesoscale ensemble prediction system

Δx= 2.2 km, L51, M10, fc+48h, IC&BCs from a clone of COSMO-LEPS for Sochi region



Taking into account model uncertainty using a stochastic pattern generator

- The stochastic pattern generator (SPG) is based on a third-order stochastic partial differential equation and produces (on-line) pseudo-random spatio-temporal fields
- The generator has been implemented to the COSMO code
- First experiments with COSMO-Ru2-EPS system with SPG perturbations (in additive mode) showed computational stability of model runs and a slight increase in the ensemble spread w.r.t. SPPT

M.Tsyrulnikov, D.Gayfulin. A limited-area spatio-temporal stochastic pattern generator for simulation of uncertainties in ensemble applications. Meteorologische Zeitschrift, DOI 10.1127/metz/2017/0815