COSMO-Ru: operational mesoscale numerical weather prediction system of the Hydrometcenter of Russia. Current status and recent developments

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Introduction

In 2009 Roshydromet became a member of the meteorological COnsortium for Small-scale MOdeling (COSMO, http://cosmo-model.org). All consortium members have the right to use a common limited-area non-hydrostatic atmospheric COSMO model for operational weather numerical predictions for free and must contribute to the model development. In this paper the current status of the operational COSMO-based prognostic system in Russia is overviewed, its recent development is discussed, and the prospects are formulated.

Operational prognostic COSMO-based system in Russia

The Russian numerical weather prediction system based on the COSMO model is called COSMO-Ru. Six configurations of the system run operationally at the Hydrometcenter of Russia with different model resolutions and integration domains (Fig.1). According to the Consortium rules, the designations of these configurations are composed of the model name, the abbreviated country name (Ru corresponds to Russia), and the model horizontal resolution in km. Sometimes an abbreviation indicating a region is added. The detailed characteristics of the system are given in Table and in [1]. In addition to COSMO-Ru runs at the Hydrometcenter of Russia, the Siberian Regional Hydrometeorological Research Institute (SibNIGMI) issues operational numerical weather forecasts for Siberia (see Fig. 1) using the COSMO-Ru13-Sib configuration (13.2 km L40 with initial&boundary conditions provided by ICON), which was prepared jointly by the Hydrometcenter of Russia and SibNIGMI.

Table. Characteristics of COSMO-Ru system

Name	Resolution	Forecast initial time,UTC /forecast length, h	Domain	Domain size, km	Initial&boundary conditions. Data assimilation
COSMO-Ru13-ENA	13.2 km L40	00/120, 06/78, 12/120, 18/78	European, North Asian and Arctic Russia	13200* 6100	ICON*
COSMO-Ru7	7 km L40	00/78,06/48, 12/78,18/48	Europe, the Urals, and Eastern Siberia	4900*4340	ICON*
COSMO-Ru2	2.2 km L50	00/48,06/48, 12/48,18/48	Southern region of Russia (around Sochi)	900*1000	COSMO-Ru7 +nudging
COSMO-Ru2	2.2 km L50	00/48,06/48, 12/48,18/48	Central part of Russia (around Moscow)	900*1000	COSMO-Ru7 +nudging
COSMO-Ru2	2.2 km L50	00/48,06/48, 12/48,18/48	Volga region (around Kazan)	900*1000	COSMO-Ru7 +nudging
COSMO-Ru1	1.1 km L50	00/36,06/36, 12/36,18/36	Southern region of Russia	210*210	COSMO-Ru2 +nudging
* Kindly provided by DWD since 2015 (GME 20 km L60 before). The horizontal resolution of the ICON model is 13 km with a refinement to 6.5 km in Europe; it has 90 levels up to 75 km in vertical.					

Application of COSMO-Ru system

The COSMO-Ru system is the basic source of operational numerical short-range weather forecasts at the Hydrometcenter of Russia. It is also useful for medium-range forecasting as COSMO-Ru13-ENA runs for 5 days. COSMO-Ru prognostic maps and meteograms are regularly distributed to weather forecasters all over Russia and posted at the site of the Hydrometcenter of Russia (www.meteoinfo.ru). Additionally, the COSMO-Ru7-ART system [2] is used for daily quasi-operational forecasts of air pollutant concentrations in the central region of Russia.

The Hydrometcenter of Russia weather forecasts for special occasions and events are mostly based on COSMO-Ru. The COSMO-Ru system was applied for meteorological support of such important sport events as the Sochi-2014 Winter Olympic Games [3], the summer Universiade 2013 in Kazan, and the winter Universiade 2017 in Almaty. Now the COSMO-Ru system is considered as the most important source of numerical forecasts for the winter Universiade 2019 in Krasnoyarsk. In 2016-2018 the COSMO-Ru prognostic information was widely used in the WMO SWFDP-CA project [4]. COSMO-Ru simulations with high resolution (500 m) contributed to the international project ICE-POP related to the winter Olympic Games 2018 in Korea. For each of these events special configurations of the system were developed, tuned and tested.

Research and development

The performance of COSMO-Ru is permanently improving (Fig. 2). The progress in the forecast skill is related to the development of the Consortium common model, to the application of more precise initial&boundary conditions from ICON (instead of GME), and - the last but not least - to the domestic upgrades of the system, the most important of which are the new analysis of the snow water equivalent [5], assimilation of radar data using nudging [6], and soil and surface temperature analysis.

Several algorithms and systems were developed for research purposes, including a convection-permitting ensemble prediction system (COSMO-Ru2-EPS) [7] and an algorithm for application of initial and boundary conditions from the domestic spectral model T339L31. COSMO-Ru2-EPS was used in operational mode during the Sochi-2014 Olympics [3]. At the moment, the most important directions of COSMO-related research in Russia are the studies of polar cyclones and their properties [8]; the investigation of the role of aerosol climatology in radiation scheme and its modification [9];

description of model-related uncertainties in EPS [10]; estimation of the influence of landscape features on the weather-climate regime. The work is mostly held within various research projects of the COSMO consortium and the results are shared with all the participants.

Prospects

Recently a new supercomputer CRAY XC40-LC with a peak performance of about 1.293 petaflops has been installed at the Hydrometcenter of Russia. This provides a possibility to increase the integration domains and to improve the model resolution. The operational COSMO-Ru system will be supplemented by a new high-resolution configuration for deterministic forecasts in the Moscow region accompanied by a convection-permitting EPS. With new computer resources research tasks will be held more efficiently.

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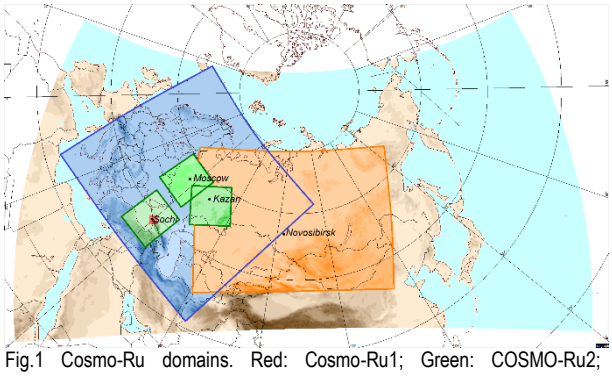

Fig.1 Cosmo-Ru domains. Red: Cosmo-Ru1; Green: COSMO-Ru2; Blue:Cosmo-Ru7; Orange:COSMO-Ru13-Sib; Light blue: COSMO-Ru13-ENA.

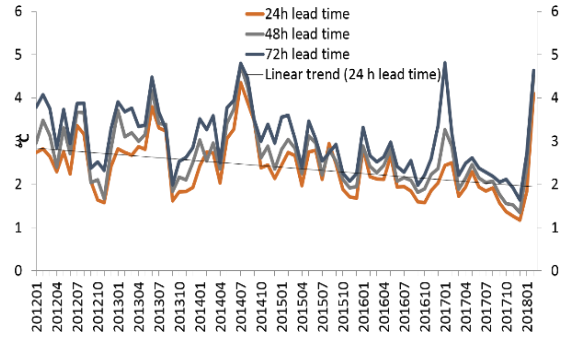

Fig.2. RMSE of COSMO-Ru7 forecasts of 2-m temperature in 2012-2017. The straight line shows the linear trend. Initial forecast time was 00UTC.

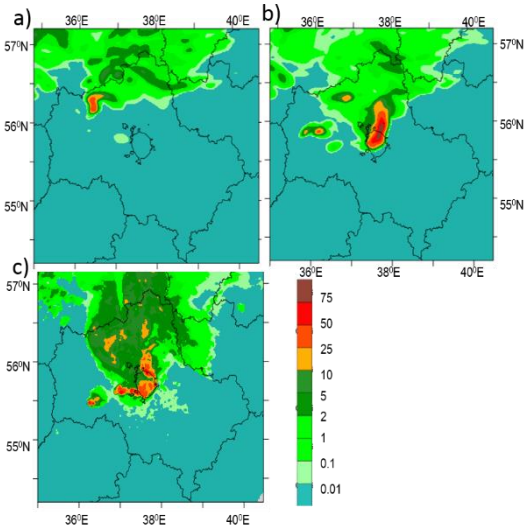

Fig.3. Improvement of precipitation forecast due to assimilation of local observations via nudging for a case of strong thunderstorm and heavy rain on July 13, 2016.Total precipitation (kg/m^2) obtained without (a) and with (b) latent heat nudging and radar data (c). 150min assimilation run from 13.07.2016/18UTC.COSMO-Ru2 (central part of Russia).

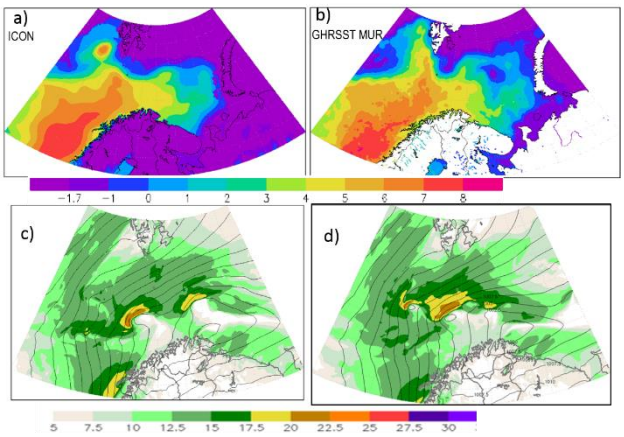

Fig.4. High sensitivity of polar cyclones to SST. Upper row: Surface temperature from ICON (left) and SST from GHRSST MUR analysis. Lower row: 57-h simulations with COSMO-Ru model (Δx~ 6.6 km L40) with SSTs presented in the upper row. The right bottom plot demonstrates two polar cyclones instead of one in the left bottom plot. 17.03.2015/00UTC. There were two cyclones according to MODIS data (not shown).