Abstract—In order to provide weather services to the 2014 Winter Olympics, the observational network in the Sochi region was strengthened with more than 40 automatic weather stations, the dual polarization Doppler radar, temperature and wind profilers, micro-rain radars, etc. These observation facilities allowed using the Sochi testbed for the development, testing, and intercomparison of various technologies of nowcasting and short-range numerical weather forecast. It was accomplished in the framework of the international project of the World Weather Research Program of WMO called FROST-2014 (Forecast and Research in the Olympic Sochi Testbed). The prognostic products of the FROST-2014 project was used for the operational meteorological servicing of Olympic events. Presented are the main research directions and the project preliminary results.

DOI: 10.3103/S1068373915080026

Keywords: Nowcasting, short-range weather forecast, mountain meteorology, FROST-2014

1. INTRODUCTION

Timely provision of high quality meteorological information plays an important role for organizers, participants and spectators of Olympic activities. As a rule, in the areas where such events are planned, the meteorological observational networks are enhanced and modernized. This turns the regions of Olympic venues into a form of testbeds with enhanced facilities for testing and intercomparison of various forecasting technologies, as well as for various kinds of diagnostic studies. In recent years, these opportunities have been used for the organization of international research and development projects (RDP) and the forecast demonstration projects (FDP) of the World Weather Research Program (WWRP).

The first WWRP FDP focusing on the demonstration of the capabilities of various nowcasting systems was organized for the Sydney 2000 Olympic Summer Games. Two WWRP projects were related to the Beijing 2008 Olympic Summer Games. The first project (RDP) was aimed at short-term (for 6–36 hours) ensemble numerical weather prediction (NWP). The objective of the second project (FDP) was to demonstrate the capabilities of nowcasting systems with emphasis on high-impact weather prediction. The SNOW-V10 (Science of Nowcasting Olympic Weather for Vancouver-2010) project [13] was aimed at the nowcasting of winter weather in the region with complex mountainous orography using the example of the region where the Olympic Games Vancouver 2010 were held. The contemporary world experience in this area is very modest: most forecasting centers actively use their nowcasting systems mainly for summer convective phenomena.

The XXII Olympic and XI Paralympic Winter Games (hereinafter, the Games) were held in Sochi on February 7–23, 2014 and on March 7–16, 2014, respectively. Precipitation (amount and type), snow cover depth changes, visibility and cloud base height, wind and temperature were primary weather factors essential for the Games. In this case special attention was not necessarily restricted to the extreme values of meteorological variables. Any transitions through decision-making thresholds essential for the sports managers and organizers of the Games were important. For example, due to specifics of the “snow” sports, the high-impact weather for these competitions was also associated with temperature transitions through 0°C.

The high requirements that the International Olympic Committee have to the accuracy of forecast information, to its spatial and temporal refinement, and to the forecast update regime in the complex mountain-
ous region, were a serious challenge to the Olympic forecasters. Namely, hourly forecast update with 1-hour forecast resolution for the current day and 3-hour resolution for the next two days for each sport venue, were required for the information system of the Games. Forecasts with longer lead times were issued separately for the coastal cluster of the Olympic venues in Adler and for the Olympic mountain cluster in Krasnaya Polyana. Specialized forecast warnings on the weather worsening were issued beyond the regular schedule as the need arose.

Continued at the moment and linked with the Sochi Games international project FROST-2014 (Forecast and Research in the Olympic Sochi Testbed) was initiated in 2011. Later on it was given the status of RDP and FDP of the WWRP [3].

The FROST-2014 project objectives are as following:
— the creation of an information resource using the extended program of alpine winter meteorological observations; the resource should be open to the research community;
— the development of nowcasting systems for winter weather in complex terrain with emphasize on high impact weather phenomena, and of mesoscale deterministic and ensemble forecasting systems for the conditions of complex orography;
— the enhancement of information basis for the operational meteorological support of the Games Sochi-2014 with the products of the project forecasting systems;
— the deeper studying of the physics of the development of regional high impact meteorological phenomena;
— the evaluation of the developed forecasting systems and the assessment of their benefits.

Besides Roshydromet, the following representatives of the international mesoscale modeling consortium COSMO took part in the project field campaign: Norwegian and Finnish Meteorological Institutes representing the HIRLAM/ALADIN consortium; Environment Canada; Central Institute for Meteorology and Geodynamics (ZAMG, Austria); National Oceanic and Atmospheric Administration (NOAA, USA); Korea Meteorological Administration. The general concept and other project materials are available at the web-site http://frost2014.meteoinfo.ru.

2. THE INFORMATION BASE

For the meteorological support of the Games the observational network in the region of Sochi had been substantially strengthened during several preceding years. More than forty automatic weather stations were put into operation. In addition to temperature, humidity, wind speed and direction, a part of these stations registered precipitation type and intensity, visibility, cloud base height, radiation balance, snow cover, etc. By the winter of 2014 for the majority of the stations the basic sampling interval of observations was equal to 10 min. Four times per day upper air sounding with high spatial resolution was organized at the provisional aerological station in Sochi.

The development of the observational network in the region of the Games was not limited to the contact observations. At the end of 2012 the Doppler dual polarization weather radar WRM200 by Vaisala company was put into operation on Akhun mountain. In winter 2013/2014 an opportunity to use “volume files” data from Samsun, Trabzon and Simferopol radars was kindly provided by the Turkish and Ukrainian sides that for the first time made it possible to build a unified radar field for the central and eastern parts of the Black Sea. This information was supplemented by the data of the HATPRO temperature and humidity profiler produced by RPG METEK GmbH company, the LAP3000 sodar by Scintec Corporation, the temperature profiler MTP-5 developed by SPAATTEX and two micro-rain radars MRR-2 by METEK GmbH company.

The Sochi observational data also included the series of images from seven web-cameras, snow surveys, etc. As new sources of observations became available and data flows were organized, this information became a part of the FROST-2014 project archive. All international and domestic participants of the project were provided with access to the operational information of meteorological observations and could use it to produce their forecasts for the region of Sochi. Participants calculated these forecasts at their centers in real time and sent the results to the project server via Internet channels to support operational forecasting activities and to fill up the project archive. The forecasting component of the FROST-2014 project comprised data from six nowcasting systems, eight deterministic NWP systems, and six ensemble prediction systems. More specific information about these systems is presented below and in the presentations by the project participants (http://frost2014.meteoinfo.ru/presentations). During the Games the web-server of the project was also used to provide the Olympic forecasters and the project participants with various kinds of actual