RDP/FDP FROST-2014: state of affairs

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Goals of RDP/FDP FROST-2014:

- To develop a comprehensive information resource of alpine winter weather observations;
- To improve and exploit:
  - high-resolution deterministic mesoscale forecasts of meteorological conditions in winter complex terrain environment;
  - regional meso-scale ensemble forecast products in winter complex terrain environment;
  - nowcast systems of high impact weather phenomena (wind, visibility, precipitation type and intensity etc.) in complex terrain.
- To improve the understanding of physics of high impact weather phenomena in the region;
- To deliver deterministic and probabilistic forecasts in real time to Olympic weather forecasters and decision makers.
- To assess benefits of forecast improvement (verification and societal impacts)
Participants of the FROST-2014 project: COSMO, EC, FMI, HIRLAM, KMA, NOAA, Roshydromet, ZAMG under supervision of the WWRP WGs on Nowcasting, Mesoscale Forecasting, Verification Research

3rd meeting of the project participants (10-12 April 2013, Saint Petersburg)
• About 50 automatic meteorological stations;
• Vaisala C-band Doppler radar WRM200 in Sochi;
• Temperature/Humidity Profiler HATPRO;
• Wind Profiler Scintec-3000;
• Two METEK Micro Rain Radars (MRR-2);
• 4 times/day upper air sounding in Sochi
The Olympic sport venues

- Each venue has one basic station and 1-4 supplementary stations;
- Each basic station has fixed set of sensors;
- Supplementary stations have variable set of sensors
Basic weather stations at the sport venues

Parameters:
• Temperature and humidity;
• Wind parameters (h=10m);
• Wind speed (h=2m);
• Pressure;
• Accumulated precipitation;
• Precipitation type;
• Visibility;
• Height of cloud base;
• Snow depth;
• Temperature of snow;
• Temperature of snow surface;
• Solar radiation
Sensors of the basic weather stations

- Anemometer WAA 252
- Wind direction WAV252
- Temperature sensor remote DST111
- Snow depth sensor IRU9000
- Present weather visibility sensor PWD22
- Humidity temperature probe HMP155
- Radiation shield DTR13
- Solar panel 33W
- junction box WA35269
- MAWS301
- BARO1
- interface for GSM modem (2)
- battery 52Ah
- CF card 2Gb
- DSU232
- DSI486
- Precipitation sensor Pluvio2
- wind shield XRS111
- Ground temperature sensor OMT110
- Platform
Supplementary weather stations

Fixed set of parameters:
- Temperature and humidity;
- Snow depth (except stations 39041, 39048);
- Temperature of snow (except st. 39041, 39048);
- Temperature of snow surface (except st. 39048);

Options (for some stations):
- Wind parameters (h=10m) (stations 39041, 39046, 39048);
- Wind speed (h=2m) (station 39043);
- Pressure (station 39043);
- Sum of precipitation (station 39046);
- Visibility and Type of precipitation (stations 39041, 39046, 39048)
Quality Control of station observations

• At the moment implemented partially for real-time data

• **Parameters:**
  T, humidity, wind, Pmsl

• **Components:**
  - Check of limits;
  - Spatial control - for observations at 00, 03, 06 ..21 UTC;
  - Temporal control – for 10-minute observations;
  - QC with respect to COSMO-2.2 forecasts (works better for temperature than for humidity);
  - Manual control
Snow Density Measurements

During snowfalls manual snow density measurements are curried out by the party of anti-avalunch service in Krasnaya Polyana.

According to AMS observations there were precipitation intensities up to 30 cm/hour at Roza-Khutor.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time (Moscow)</th>
<th>Measuring bar indications, cm</th>
<th>Snowfall Intensity, cm</th>
<th>Snow Increase, cm</th>
<th>Fresh Snow Density, g/cm³</th>
<th>Type of crystals</th>
<th>Size of crystals, mm</th>
<th>Precipitation type</th>
<th>Wetness of precipitation</th>
<th>Precipitation Amount (mm)</th>
<th>Air Temperature</th>
<th>Wind Speed and Direction</th>
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<td>Snow</td>
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</table>
Vaisala C-band Doppler radar WRM200 on Akhun mountain in Sochi was launched in September 2012

Altitude – 646 m
Location: 43°32′52,6″ N, 39°51′05,0″ E.

- Max reflectivity;
- wind&refl 2km-cappy;
- echo tops;
- 1-hour precipitation

Raw Turkish data are expected to be available
Composite map for the Akhun, Trabzon and Samsun radars
Profilers

- Temperature/Humidity – HATPRO (RPG GmBh, Germany);
- Wind – Scintec-3000 Radar Wind Profiler (Scintec Corp, USA);
- Two METEK Micro Rain vertically pointing Radars (MRR-2)

+ 4 times/day upper air sounding in Sochi
Input from the project participants:

Roshydromet: COSMO and other activities
Current state: Regular runs of COSMO-RU7, COSMO-RU2.
Expected: nudging-based data assimilation, more frequent update cycle.
COSMO-RU with ~1km spacing (together with MeteoSwiss and DWD).
3D-Var assimilation with COSMO-RU2, assimilation of satellite and Doppler radar radial winds. Attempts to introduce an ensemble data assimilation component.
Integrating multi-system nowcasting and short-range forecasting input.

ARPA-SIMC/COSMO
Current state: Regular generation of COSMO-S14-EPS products with 7-km grid spacing. Provision of boundary and initial conditions for COSMO-RU7-EPS. Improvement of soil initial conditions in COSMO-S14-EPS.
Provision of boundary and initial conditions for further downscaling in Roshydromet.
Intercomparison of COSMO-S14-EPS and ECMWF-EPS using SYNOP reports.
Expected: Continuous provision of COSMO-S14-EPS fields.

MeteoSwiss/COSMO: Development and experiments with 1 km COSMO version.
DWD/COSMO: Experiments with regional data assimilation
Input from the project participants-2:

**HIRLAM:**
Current state: Providing GLAMEPS output routinely
Calibration of GLAMEPS forecasts at observational sites in the Sochi area has not yet started. **Tests of HarmonEPS ongoing**

Expected: Run HarmonEPS for the area of Sochi.
Continue to deliver GLAMEPS output
Calibration of GLAMEPS forecasts in routine by 1 December at latest.

**Environment Canada:**
Current state: Real-time system now set up and running. Includes initial and boundary conditions from 25 km global run (GEM model) with one-way nests to 10 km, 2.5 km, 1 km, and 250 m grids.
4D-Var for 25 km global (driving) model.

Expected: Increase of vertical resolution with considerably higher resolution in the boundary layer. Modifications to the microphysics.
Global (driving) model with 4D-Var may switch from 25 km to 15 km by 2014.
External land surface modeling system (e.g. 100 m) and high-resolution snow analysis may be done by next year.
Input from the project participants-3:

Central Institute for Meteorology and Geodynamics (ZAMG)

Current state: INCA 1-hourly analysis and forecast grb files transfer started
Expected: Aladin LAEF (Test data are already on the FROST-2014 server)

FMI:

Expected:
Quasi-operational running of HARMONIE with 2.5 km spacing for Sochi region.
Testing of HARMONIE with different resolutions (1 - 1.5 - 2.5 km) and different orographic datasets
Quasi-operational running of FMI Road Weather Model for selected Sochi highways.
Close-to-real-time objective point verification with FMI verification package for model output that is available at common FROST-2014 ftp server; also final forecasts produced by meteorologists, if available

IRAM

Current state: MeteoExpert nowcasting system data transfer to the project server.
Input from the project participants - 4

NOAA

Current state:
Routine 1 km NMMB model run (4X/day) initialized from the GFS. Resolved some problems with gridded output products, began work on time series output at specific points.
Routine 7-member NMMB-based ensemble at 7 km grid spacing (2X/day).
Point forecasts in XML-format

Korean Meteorological Administration

Expected: Site-specific forecasts over Sochi-area by downscaling from global model (25km). High resolution forecast (1km) over Sochi-area. Several meter resolution Land Surface Process for game area by dynamic and statistical downscaling from 1km.
Site-specific probabilistic forecasts over Sochi-area by downscaling from global ensemble models.
Data assimilation: Depend on collected observation data (Successive Correction Method).
Objective verification of site specific forecasts.
Integrating multi-system forecast inputs at the Hydrometcentre of Russia

• F. Woodcock and C. Engel: Operational Consensus Forecasts, Weather and Forecasting, 2005;

• L.X. Huang and G.A. Isaac: Integrating NWP Forecasts and Observation Data to Improve Nowcasting Accuracy, Weather and Forecasting, 2012

\[
F(t) = \alpha(t) \cdot O + (1 - \alpha(t)) \sum_{i=1}^{N} \beta_i(t) \cdot (f_i(t) - b_i(t))
\]

\(F(t)\) – integrated forecast (t – forecast time);
\(O\) – last available observation;
\(f_i(t)\) – forecast of \(i\)-th participating forecasting system;
\(\alpha(t), \beta_i(t)\) - weights;
\(b_i(t)\) - bias for \(i\)-th forecasting system

In [Huang, Isaac, 2012] \(b_i(t) = \gamma_i(t) \cdot B\)
Nowcasting project component:

INTW, CARDS, ABOM, INCA, MeteoExpert, HMC’s system
Deterministic NWP project component

- COSMO-RU with grid spacing 2.2 km, 1 km (new);
- GEM with grid spacing 2.5km, 1km, 0.25km;
- NMMB – 1 km;
- HARMONIE - 2.5km
- KMA’s 1km version of UM
- …
Ensemble project component

**Current state:** COSMO-S14-EPS, GLAMEPS, NOAA-7km EPS, Aladin LAEF, COSMO-RU2

**Expected:** HARMON-EPS
KMA’s downscaling of probabilistic forecasts.
Poor man’s ensemble of deterministic high-resolution models

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Box-and-Whiskers diagram. ARPA-SIMC:COSK
Sochi_CFm_KrPol: 43.683N 40.20E

T2m. GLAMEPS forecast from 2013/02/18 UTC. Station: Kr_Pol
JSC5 Decisions /Actions Required

44. JSC endorsed the FDP/RDP proposal for Sochi Winter Olympic Games in 2014, but expressed concern that the proposal timelines would not provide a stable software environment for the forecasters, thus jeopardizing the provision of accurate forecast information. It was also suggested that trial periods and decided training activities be conducted to expose the Olympic forecasters to the new models.
Grapical Tools
Grapical Tools
Forecaster role: Best forecasts include a forecaster with conceptual models of local process evolution and access to automated tools.

- FROST-2014 is intended as an ‘end-to-end’ project. Its products will be used by local forecasters for meteorological support of the Olympics and preceding test sport events.
- The last chance to introduce new FDP-products to forecasters will be training in October 2013 (before that there will be training in August).

• Forecasters trainings are held on regular basis;
• Participants are involved into provision of meteorological services for sport test events.
Forecast Verification

• METv4.0+ (Model Evaluation Tool / NCAR) software was adapted for the FROST-2014 needs;

• Two papers on forecast verification for Sochi region were submitted;

• Official forecasts are planned to be available for further verification along with the project objective forecasts

• Distributed verification activity ? (Roshydromet–FMI (JWG on Verification Research))
Station-based diagnostic verification on example of COSMO-RU2 forecasts

Parameter: T2m
Station: RKHU1, (Aibga) 2250 m.
Period: winter 2011-2012

The values relate to the histogram bin centers. Green lines denote the bin sample volume of at least 20 pairs (sample stability).
Calibration implies a shift of the forecast mean-median to the leading diagonal.
The t2m area outside the green strip indicates sample instability (calibration uncertainty).
Importance of the above ‘diagnostic verification’ for decision-making.
Polygonal Verification for SOCHI_COAST (19 Stations), ADLER_COAST (8), KR_POLYANA (22), ALPICA(20)

Local Climatology: ‘Coastal zone’ (0 – 300 m), ‘Submountane zone’ (300-600 m), ‘Alpine zone’ (600 – 2500 m).
SKILL SCORING for the polygons

Category T2m > 0°C forecasts. Hanssen-Kuipers discriminant, (Peirce skill score).

**Period:** winter 2011-2012

**Obs-Frcs matching:** for every hour with ±10 min obs window; several interpolation methods to COSMO grid were tried

**Measures:** Categorical (contingency tables) and continuous scores, 95% confidence intervals
Sochi coast

coastal cluster

Kr Polyana

MEAN ERROR

a

b

c

d

e

RMSE

f
COSMO-RU2 T2m Mean Errors for “Krasnaya Polyana” polygon for two consequent winter seasons:
Mean Error changed its sign!

Potential reasons behind:
- effects of inter-annual changes in the large-scale circulation (winter 2012-2013 was unusually warm)?
- changes in the driving global model?
- ............
Radar max reflectivity versus NMNNB column max reflectivity and 1-hour precipitation total with 6 hrs lead time

With precautions it will be tried as a ground for spatial verification
Social and Economic Impacts

Socially significant project application areas:
- Education
- Understanding
- Transfer of technologies
- Practical forecasting – first guess for operational official forecasts.

Integrated project forecasts will be used as a first guess for the data feed to the Olympic information system (supported by IOC partner Atos Origin) and Olympic Broadcasting Services (OBS).

Two Earths (with and without FROST-2014) are needed for the project impact assessment!
Thank you!

http://frost2014.meteoinfo.ru