Some aspects of NWP on the basis of COSMO-Ru system for the Sochi Olympics

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Outlines

• Aspects of operational runs & assimilation
• Aspects of COSMO-Ru-Sochi products & dissemination
• Aspects of postprocessing
• Aspects of feed-back from forecasters
1. Some aspects of operational runs & data assimilation
COSMO-Ru13,2 ENA (Europe & North Asia)
Now: 13.2 km, planned since 2015, Aug: 6.6 km.
COSMO-Ru13 for Europe and North Asia (ENA13). Forecast from 2014070600 until 2014071003

00:00 06 Июля 2014 (UTC+0): H500

Typhoon "Neoguri"
COSMO-Ru domains in 2013-2014

COSMO-Ru7, Δx = 7 km
COSMO-Ru2 (CFO, Universiade, “Sochi-2014”), Δx = 2.2 km
COSMO-Ru1, Δx = 1.1 km
Model overview

**Domain**

- **COSMO-Ru7**
  - Domain: 4900 km x 4340 km
  - Grid: 700 x 620 x 40
  - Space step: 7 km
  - Time step: 40 s
  - Forecast: 78 h

- **COSMO-Ru2**
  - Domain: 900 km x 1000 km
  - Grid: 420 x 470 x 50
  - Space step: 2.2 km
  - Time step: 20 s
  - Forecast: 48 h

- **COSMO-Ru1**
  - Domain: 495 km x 495 km
  - Grid: 450 x 450 x 50
  - Space step: 1.1 km
  - Time step: 5 s
  - Forecast: 36 h

**Model domain**

- COSMO-Ru-Soch
COSMO-Ru system: Initial & Boundary Conditions

**GME**

COSMO-Ru7

- Domain: 4900 km x 4340 km
- Grid: 700 x 620 x 40
- Grid size: 7 km
- Time step: 40 s
- Forecast: 78 h
- Runtime: 50 min

COSMO-Ru2

- Domain: 900 km x 1000 km
- Grid: 420 x 470 x 50
- Grid size: 2.2 km
- Time step: 20 s
- Forecast: 48 h
- Runtime: 50 min

COSMO-Ru1

- Domain: 210 km x 210 km
- Grid: 190 x 190 x 50
- Grid size: 1.1 km
- Time step: 5 s
- Forecast: 36 h
- Runtime: 24 min

**RSK Tornado:**
Cluster-based architecture,
peak performance 35 TFLOPS, 1536 PEs
COSMO-Ru uses 288 PEs

COSMO PP CORSO
## Scheme of assimilation system

### Model grids and used observations

<table>
<thead>
<tr>
<th>Domain</th>
<th>Count horizontal grid points</th>
<th>OBSERVATIONS</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSMO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ru7</td>
<td>434 000</td>
<td>119</td>
<td>2700</td>
</tr>
<tr>
<td>CFO02</td>
<td>197.400</td>
<td>10</td>
<td>190</td>
</tr>
<tr>
<td>Ru2</td>
<td>197 400</td>
<td>6</td>
<td>170</td>
</tr>
<tr>
<td>VFO02</td>
<td>211.500</td>
<td>9</td>
<td>161</td>
</tr>
<tr>
<td>ENA13</td>
<td>500.000</td>
<td>295</td>
<td>4368</td>
</tr>
<tr>
<td>SIB14</td>
<td>90.000</td>
<td>78</td>
<td>1006</td>
</tr>
</tbody>
</table>

The number of grid points of the model COSMO-Ru7 more than stations in ~1600 for the temperature and ~32000 for COSMO-Ru2.

Not enough of upper-air stations for successfully correcting temperature. You must use t_2m observation from SYNOP.
Verification T_2m

Experiments with DWD assimilation and without for COSMO-Ru7, February 2012, for 145 station of domain COSMO-Ru2 (SFO)

ME T_2m [degree]

RMSE T_2m [degree]
The operational schemes
COSMO-Ru7 и COSMO-Ru2

Without DAS

With DAS
COSMO-Ru system: technological line

Start and end times of the nested models’ runs for 00 UTC analysis

Start and end times of the nested models’ runs for 00 UTC analysis:

- DA (0:00 - 1:05)
- Ru1 (1:05 - 1:25)
- Ru2 (2:50 - 03:40)
- Ru7 (03:40 - 04:25)

Forecasts by different nested models (COSMO-Ru7/2/1)

The structure of forecast runs was so complicated because of strict time requirements.
# Scheme of assimilation system

<table>
<thead>
<tr>
<th>Parameters</th>
<th>DA-M Ru7</th>
<th>DA-R Ru2</th>
<th>DA-M Ru2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>data_ini</strong> (U, V, P, W, T, QV)</td>
<td>GME — 6 h</td>
<td>DA-R — 6 h</td>
<td>DA-R — 6 h</td>
</tr>
<tr>
<td><strong>data_bd</strong></td>
<td>GME — 6 h</td>
<td>Ru7 — 6 h</td>
<td>Ru7 — 6 h</td>
</tr>
<tr>
<td><strong>data_ini_surf</strong> (T_S, T_SNOW, T_ICE, H_ICE, T_SO, W_SO)</td>
<td>GME — 6 h</td>
<td>GME — 6 h</td>
<td>GME — 6 h</td>
</tr>
<tr>
<td><strong>hstop</strong></td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td><strong>number of runs</strong></td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>cut-off time</strong></td>
<td>02:45</td>
<td>06:50</td>
<td>01:10</td>
</tr>
<tr>
<td><strong>hnudgend</strong></td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td><strong>synop</strong></td>
<td>2600</td>
<td>145</td>
<td>145</td>
</tr>
<tr>
<td><strong>temp</strong></td>
<td>119</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>
Some results of Verification of DAS-version

PMSL: Mean Error and RMSE

domain: COSMO-Ru-Sochi2

Time forecast from 00UTC (1 February 2014 - 16 March 2014)
## Availability of COSMO-Ru-Sochi 7/2/1 Products

### COSMO-1 (LT 36 h)
- 1.30 UTC (4.30 MT)
- 8.45 UTC (11.45 MT)
- 14.45 UTC (17.45 MT)
- 20.45 UTC (17.45 MT)

### COSMO-2 (LT 42)
- 5.20 UTC (8.20 MT)
- 11.20 UTC (14.20 MT)
- 16.20 UTC (19.20 MT)
- 22.20 UTC (1.20 MT)

### COSMO-7 (LT 78/48)
- 5.10 UTC (8.10 MT)
- 11.20 UTC (14.20 MT)
- 16.10 UTC (19.10 MT)
- 22.10 UTC (1.20 MT)
Operational runs & assimilation: Conclusions

• The cascade scheme of COSMO-Ru-Sochi 7/2/1 requires the cascade of IF&BC coupled with continuous data assimilation

• The nudging continuous assimilation was implemented for COSMO-Ru-Sochi system

• The significantly impact the nudging regional data assimilation affects the results for the first forecast hours

• The implementation of continuous assimilation has allowed to adapt the time of runs to requirements of IOC requirements
2. COSMO-Ru-Sochi
Products & dissemination
COSMO-Ru-Sochi 7/2/1 produced during Olympics daily

with runs every 6 hours:

Graphical files:
• ~3000 maps and
• ~1000 meteograms for different points

+ GRIB files.
Forecast charts for
- whole model domain

COSMO-Ru7: the analysis of large-scale process
Meteograms

COSMO-Ru7:
LT
78 hours

FROST-2014 4-th meeting
Moscow
Forecast charts for whole model domain

10:00 11MAR 2014 (MSK): Precipitation for previous 12 hours [mm]

14:00 11MAR 2014 (MSK): Pmsl, Middle Clouds, Precip

22:00 11MAR 2014 (MSK): Wind at 10m

09:00 12MAR 2014 (MSK): Height of fresh snow for 6h.

10:00 11MAR 2014 (MSK): Wind direction, Relative Humidity at H850

03:00 11MAR 2014 (MSK): T2m, T850

Forecast on 24 hours from 10h 10MAR 2014 (Msk)
COSMO-RU 2.2km

Forecast on 36 hours from 10h 10MAR 2014 (Msk)
COSMO-RU 2.2km

Forecast on 48 hours from 10h 10MAR 2014 (Msk)
COSMO-RU 2.2km

Forecast on 78 hours from 16h 10MAR 2014 (Msk)
COSMO-RU 2.2km

Moscow, Russia, 29-31.10.2014
Examples of meteograms with h-corrected T2m (COSMO-Ru2, LT48hours)
Forecast charts for:
- whole domain
- Sochi region
- mountain cluster

The forecasts of V10m is the more important product of COSMO-Ru1.

Model output (example)

COSMO-Ru1

Moscow, Russia, 29-31.10.2014
Model output (example)
COSMO-Ru1

Forecast charts for
- whole model domain
- Sochi region
- mountain cluster
Forecast V10m by COSMO-Ru1 showed no danger of strong winds in the mountain cluster, except Aibga.
Model output
COSMO-EPS (7&2) (some example)

Forecast from 12/10/2014, valid from 20/4/2014 to 21/4/2014
3h cumulated rainfall probabilities

Rainfall > 0.2 mm
Rainfall > 1 mm
Rainfall > 5 mm
Rainfall > 10 mm
• The design and the list of the model output must be coordinated with forecasters.

• The products of all COSMO-Ru Versions (7,2,1 km) are important for different analysis of forecasters.

• The use of Internet for dissemination of graphical products is important along with the use of GIS technology.

• The forecasters need the enough time (Some months) for adapt their work for the time of arrival of new kind of products and to understanding its skill.

• The trainings of forecasters are necessary.
3. Aspects of postprocessing
Postprocessing for Sochi-2014

- Tools for correction of forecasts
- Tools for calculation of new products (snow depth)
Main factors of T2m inaccuracies in mountain areas:

- Discrepancy between model and real surface height (the height differences for COSMO-Ru were up to 1000 m at some points of the Sochi2014 mountain cluster)
- Inadequate work of parameterization schemes

Two-step correction of forecasts for points (meteograms)

- Correction based on the forecast of T lapse rate within the boundary layer (H-correction)
- Statistical correction based on Kalman Filter (KF-correction)
Scheme of h-correction of T2m with use of forecasts of lapse rate

\[
\Delta T = \left( \frac{T_{k-2} - T_{k-1}}{H_{k-2} - H_{k-1}} \right) \times \Delta H
\]

CASE 2: \( H_{\text{real}} < H_{\text{model}} \)

\[
\Delta H = H_{\text{real}} - H_{\text{model}}
\]

CASE 1: \( H_{\text{real}} > H_{\text{model}} \)

\[
T_{2m \text{ corr}} = T_{2m \text{ model}} + \Delta T
\]
The examples of efficacy of $H$-correction

dT2m = $T_{ref} - THcorr$,   

**dT2m before correction (gray)**

**dT2m after correction (red)**

00 UTC

04.07.2014

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The examples of T2m correction with use the different T lapse rates over mountains:

Blue: observation
Red: reference
Yellow and Green: diff algorithms of H-correction (forecasts of lapse rate)
Brown: constant lapse rate of 0.0065 K/m
The 2-step correction: realization for the Sochi-2014 meteorological support

- Database FROST (Server)
- Selection of obs. data
- COSMO-RU runs
  - Meteograms
  - GRIB
  - Fieldextfra
- Vertical gradients of T
- H-Correction
- Corrected meteograms (step 1)
- KF correction
- Corrected meteograms (step 2)
- DISSEMINATION TO USERS

Corrected Meteograms for points
An example of meteograms with corrected T (violet)

Krasnaya polyana, h=650 m

COSMO-Ru7, h=1048 m

COSMO-Ru2, h=734 m
Postprocessing-2: examples of additional products

Fresh snow density values according to air temperature

The main differences are observed in cases:

\[ 0 < T2m \leq -7 \]

The Results of Class parameterisation have demonstrate the best concordance with Measurements in Sochi region
Fresh snow postprocessing, based CLASS formulations is done for COSMO-Ru output with the resolution of 7, 2.2 and 1.1 km four times a day for each prognostic hour.
Map of fresh snow depth (cm). COSMO-Ru 1.1 36-hour forecast from 00 UTC 17 February 2014. Territory detailization.
Example of fresh snow depth forecasts 12 UTC 5 March 2014
Aspects of postprocessing – recommendations for further metesupports:

• The postprocessing is the necessary element of NWP technology to adapt the model output for mountain conditions

• The two-step T-c correction is feasible for the mountain regions

• The fresh snow depth calculations must use the corrected T2m
4. Feedback from forecasters:
• **Feedback from forecasters:**
  - Understanding of features of synoptic processes
  - Trainings
  - Selection of more important forecast elements & Visualisation
To be useful, we need to look the same eyes!
Feedback from forecasters - conclusions

For successful developing the NWP Olympic systems is necessary:

• to study the climatic and weather features of region;
• to made the lections on the forecaster trainings;
• to study the features of work of forecasters and requirements;
• to visit the venues;
• to have the permanent feed-back from forecasters for select the optimal the model output.
COSMO-based technologies succeeded in meteorological support for the Sochi-2014 Winter Olympics and other important sport events in Russia in 2013-2014 (for example, Universiade Kazan-2013).

Sochi and Kazan forecasters considered COSMO-based products to be the primary material for preparing detailed weather forecasts.

High-resolution deterministic COSMO-Ru systems (7km/2.2km/1.1km) and COSMO-EPS systems (7km/2.2km) were developed and tested for the region of sport events. Higher-resolution systems added value.

Usage of very high-resolution orography and assimilation of additional data improved the forecasts considerably.

Development and implementation of temperature h-correction in postprocessing and fresh-snow parameterization schemes improved forecasts in the high-mountains region.
Acknowledgement

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Thank you!