The Framework of the WMO/WWRP FROST-2014 Forecast Verification Setup and Activities

Other FROST-2014 Presentations in this Session (10 Sep 2015)

2. Operational Forecast Verification, *by D. Kiktev et al*
3. End-user Precipitation Forecast Verification, *by L. Nikitina et al*
4. Deterministic NWP Verification, *by A. Bundel et al*
5. High-impact Weather Forecasts Verification, *by A. Muraviev et al*
6. Spatial Verification of Precipitation Fields, *by A. Bundel et al*

(*) Acknowledgements: WWRP FROST-2014 Expert Team & FMI Verification System Development Team
Forecast & Research in the Olympics Sochi Testbed - FDP & RDP -

FDP ~ Forecast Demonstration Project
RDP ~ Research Demonstration Project
Focus: High-impact Weather ⇔ Forecast Verification

Here: High-impact ⇔ Specific Forecast Thresholds
End-users ⇔ Olympics Participants, Audiences

Outline:

1. FROST-2014 goals and general setup
2. FROST-2014 components and participants:
   - Observations
   - Nowcast Systems
   - Deterministic NWP
   - Probabilistic EPS
   - More details in next talks
3. Verification
   - FMI Verification System
   - Some Results
   - Impacts
   - Much more results in next talks
4. Future visions
World Weather Research Program

FDP ~ Forecast Demonstration Projects
RDP ~ Research Demonstration Projects
Goals of FROST-2014: RDP + FDP

1. To develop a comprehensive data resource of high altitude winter weather observations ⇒ Testbed

2. To exploit and improve in complex terrain winter environment:
   - Now-cast systems of high-impact weather phenomena - wind, precipitation type and intensity, visibility, etc.
   - High-resolution deterministic meso-scale forecasts
   - Regional, meso-scale ensemble forecasts

3. To improve the understanding of physics of high-impact weather phenomena

1. To deliver deterministic and probabilistic forecasts to Olympic weather forecasters and decision-makers in real-time ⇒ End-users

2. To assess the benefits of forecast improvement ⇒ Verification
Participants of FROST-2014

COSMO, Env. Canada, FMI, KMA, METN, NOAA, ZAMG + Roshydromet, IRAM

supervision by WWRP WGs on Nowcasting, Mesoscale Forecasting & Forecast Verification Research
**FROST Nowcast Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>Timing</th>
<th>Resolution, grid</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTW (EC)</td>
<td>Every 10 min</td>
<td>Pointwise</td>
<td>Model-based</td>
</tr>
<tr>
<td>ABOM (EC)</td>
<td>Every 10 min</td>
<td>Pointwise</td>
<td>Model-based</td>
</tr>
<tr>
<td>CARDS (EC)</td>
<td>Every 10 min</td>
<td>Pointwise</td>
<td>Radar-based</td>
</tr>
<tr>
<td>INCA (ZAMG)</td>
<td>00.00...23 hourly Precipitation: every 10 min</td>
<td>1 km grid</td>
<td>Blended: NWP+Radar-based</td>
</tr>
<tr>
<td>MeteoExpert (IRAM, Russia)</td>
<td>Every 10 min</td>
<td>Pointwise</td>
<td>NWP+Radar-based</td>
</tr>
<tr>
<td>Joint (Roshydromet)</td>
<td>Hourly, integrated with SR NWP + 48hrs</td>
<td>Pointwise</td>
<td>Model-based</td>
</tr>
</tbody>
</table>

**FROST Deterministic Forecast Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>Runs/Day</th>
<th>Lead time / Time resolution</th>
<th>Spatial resolution</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSMO-RU (Roshydromet)</td>
<td>4</td>
<td>78 hr</td>
<td>7 km</td>
<td>Nudging-based DA with 1.1 km spacing 3D-Var with COSMO-RU2 model.</td>
</tr>
<tr>
<td>GEM (EC)</td>
<td>1</td>
<td>GEM-2.5: 27 / 1 hr</td>
<td>2.5 / 1.0 km</td>
<td>Downscaling from 26 km global run with 4D-Var</td>
</tr>
<tr>
<td>Harmonia (FMI)</td>
<td>4</td>
<td>36 hr / 1 hr</td>
<td>1 km</td>
<td>Site-specific forecasts from global model</td>
</tr>
<tr>
<td>NMMB (NOAA / NCEP)</td>
<td>2 - 4</td>
<td>24 hr / 1 hr</td>
<td>1 km</td>
<td></td>
</tr>
<tr>
<td>KMA</td>
<td>2</td>
<td>5 days / 3 hr</td>
<td>Pointwise</td>
<td></td>
</tr>
</tbody>
</table>

**FROST Ensemble Forecast Systems**

<table>
<thead>
<tr>
<th>System</th>
<th>Runs</th>
<th>Lead time / Time resolution</th>
<th>Spatial resolution</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>COSMO-S14-EPS (ARPA-SIMC Italy)</td>
<td>00.12 UTC</td>
<td>72 hr / 3 hr</td>
<td>7 km</td>
<td></td>
</tr>
<tr>
<td>COSMO-RU2-EPS</td>
<td>00.12 UTC</td>
<td>2.2 km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLAMEPS / HIRLAM (METNorway)</td>
<td>00.18 UTC</td>
<td>54 hr / 3 hr</td>
<td>~ 11 km</td>
<td></td>
</tr>
<tr>
<td>GLAMEPS / HIRLAM (Calibrated Temp. with rapid update)</td>
<td>Hourly</td>
<td>48 hr / 1 hr</td>
<td>-</td>
<td>1-hour update cycle</td>
</tr>
<tr>
<td>ALADIN-LAEF (ZAMG)</td>
<td>00.12 UTC</td>
<td>72 hr / 3 hr</td>
<td>Interp. from native 11km to 7 km grid</td>
<td></td>
</tr>
<tr>
<td>NMME-EPS (NOAA / NCEP)</td>
<td>00.12 UTC</td>
<td>72 hr / 3 hr</td>
<td>7 km</td>
<td></td>
</tr>
<tr>
<td>HIRLAM (METNorway)</td>
<td>06, 18 UTC</td>
<td>36 hr / 3 hr</td>
<td>2.5 km</td>
<td></td>
</tr>
</tbody>
</table>
No-show-snow might be an issue...

Road weather is an issue...?
Note the sign...! (Visibility is an issue)

Visibility might be an issue...?
Some Forecast Verification Issues

✓ All modelers always verify their own fc products ⇔ General practice!
  ... BUT can be biased ⇔ NOT sufficient / adequate in FROST context

✓ Centralized by Roshydromet AND ”External” verification by FMI
  ... also to “validate verification results” ⇔ enables comparisons
  - Due to our FMI Harmonie model runs, FMI was not “external” anymore

✓ FMI : Point Verification ⇔ User needs
  - Users require thresholds for their decisions ⇔ Impacts
  - Sports activities and events take place at (or along) points

FMI state-of-the-art, on-line, point verification package was “tuned” for Sochi ⇔ HUGE undertaking

- Enhanced observation network by using 31 selected stations

Formal verification period : 15 January – 15 March = 2 months
Properties & Features

- Web-based; Interactive; Menu-driven; 2 languages
- Daily forecast vs. observation comparison
- Monthly, seasonal and annual statistics
- All basic – and some novelty - verification metrics
- Comparison: Forecaster end-product vs. model + model vs. model
- Database: Gridded data + stations over Finland

Sochi Olympics version
FMI Operational Verification System
Web User Interface
Verification User Interface
Adapted for Sochi 2014 Olympics
NB : NOT used in real-time
Valley (c. 600m)

Ski Jump

Ski Biathlon (Laura, top 1400m)

Alpine Ski (Rosa Khutor, top 2300m)

FMI Verification User Interface
Adapted for Sochi 2014 Olympics
### FROST-2014: Weather variables – Potential Impact Thresholds

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>T &lt; -20</th>
<th>-20 ≤ T &lt; -5</th>
<th>-5 ≤ T &lt; -2</th>
<th>-2 ≤ T &lt; 0</th>
<th>0 ≤ T &lt; 2</th>
<th>2 ≤ T &lt; 5</th>
<th>T ≥ 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed (m/s)</td>
<td>WS ≥ 3</td>
<td>WS ≥ 4</td>
<td>WS ≥ 5</td>
<td>WS ≥ 7</td>
<td>WS ≥ 11</td>
<td>WS ≥ 15</td>
<td>WS ≥ 19</td>
</tr>
<tr>
<td>Horizontal visibility (m)</td>
<td>V &lt; 100</td>
<td>V &lt; 300</td>
<td>V &lt; 1000</td>
<td>V &lt; 10 000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precipitation amount</td>
<td>RR &lt; 0.3</td>
<td>RR ≥ 0.3</td>
<td>RR ≥ 1.0</td>
<td>RR ≥ 5.0</td>
<td>RR ≥ 10.0</td>
<td>RR ≥ 15.0</td>
<td></td>
</tr>
<tr>
<td>1-hr and 24-hr (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**High-impact ⇔ What is High-impact? ⇔ Thresholds**

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HARMONIE best during day, worst during night is the feature in the mountains

COSMO worst

00UTC forecast runs (available for Olympics forecasters in the morning) used in verification statistics
XXII Olympic Winter Games

**Deterministic models**
- GEM 0.25km and JOINT best
- HARMONIE "in the middle"
- Lo-res model, COSMO 7km, worst

**Mountain cluster**

Wind speed, 10 min. avg. $\geq 3$ m/s


- 00UTC forecast runs (available for Olympics forecasters in the morning) used in verification statistics

FROST Verification: FMI examples

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FROST Verification : FMI examples

**EPS models**

- Calibrated + hourly T-updated GLAMEPS best
- Raw GLAMEPS worst

**Mountain cluster**

- temperature, 10 min. avg \(0 \leq T < 2 \, ^\circ\text{C}\)
- non-coastal stations, 2014-02-08 - 2014-02-24

\(\checkmark\) All forecast runs used in the EPS verification statistics

NB: Actual Olympics two-week period
End-user = Finnish skiing service team, Feedback:

- "HARMONIE was superior"
- "HARMONIE visibility forecasts were excellent"
- "HARMONIE precipitation and cloud height fcs were highly useful"
- "HARMONIE five-panel user interface was really good"

<table>
<thead>
<tr>
<th>Date</th>
<th>Friction forecast gave a good estimate of slipperiness</th>
<th>FC storage terms (water, snow, ice) are realistic</th>
<th>Road weather forecast was useful</th>
<th>Notes (free text)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.2.2014</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>Precipitation, however road surface dried towards Adler</td>
</tr>
<tr>
<td>20.2.2014</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>Dry road surface, i.e. No real need for RW forecast</td>
</tr>
<tr>
<td>21.2.2014</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>Variable road surface humidity</td>
</tr>
<tr>
<td>23.2.2014</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>Dry road surface, i.e. No real need for RW forecast</td>
</tr>
</tbody>
</table>
Further Steps!

- Re-run statistics now that full, final data sets are available ⇔ Roshydromet…
- Comprehensive diagnostic verification and inter-comparison of the participating forecasting systems, case studies, numerical experiments, assessments of predictability ⇔ Ongoing / Roshydromet…
- Open FROST-2014 data access for international research community
- Joint reporting-publishing-presentations by FROST-2014 Partners
  - WWOSC, Montreal, Aug 2014
  - IUGG, Prague, June 2015
  - EMS-ECAM, Sofia, 10 Sep 2015
    - Special Issue in “Russian Meteorology and Hydrology”, Aug 2015; English version issued by Allerton Press in the US
    - AMS Special Collection in Journal of Applied Meteorology and Climatology, Weather and Forecasting & BAMS, Feb 2016

Dedicated FROST-2014 Verification Session
Durban, South Africa, 6 July, 2011

RDP & FDP @ 2018 Winter Olympics

Thank You

Questions?