Environment Canada’s
High Resolution Deterministic NWP System for FROST-2014

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St. Petersburg, 10-12 April 2013
1. CONTEXT – Reason for EC (RPN) involvement in FROST-2014

Environment Canada

Science and Technology Directorate

Air Quality Research

Climate Research

Meteorological Research

Cloud Physics and Severe Weather Research

- George Isaac
- Paul Joe

Numerical Weather Prediction Research (RPN)

- Stéphane Bélair
- Jason Milbrandt
- Anna Glazer

Data Assimilation and Satellite Meteorology Research
1. CONTEXT – Reason for EC (RPN) involvement in FROST-2014

**Numeral Weather Prediction Research (RPN)**

- Global Uniform
- Global Variable
- Limited Area (LAM)
- Yin-Yang

**GEM:**
- non-hydrostatic
- fully compressible
- semi-implicit
- semi-Lagrangian
- one-way self-nesting
- staggered vertical grid (Charney-Phillips)

1. CONTEXT – Reason for EC (RPN) involvement in FROST-2014

Numerical Weather Prediction Research (RPN)

Examples of models and applications at RPN/CMC

- 2.5 km operational system
- 250 m experimental systems
  - 2015 Pan-American Games
  - TOMACS

Spatial scale (horizontal resolution)

Time scale (forecast range)

- 10 years
- 1 year
- 10 days
- 48 h
- 24 h
- 1 h
2. CURRENT SET-UP of Deterministic NWP System

Configuration for FROST-2014
2. CURRENT SET-UP of Deterministic NWP System

SOCHI UTC

GLOBAL (25 km)  LAM (10 km)  LAM (2.5 km)  LAM (1 km)  LAM (250 m)

Set-up for FROST

* Tentative - to be changed as needed
2. CURRENT SET-UP of Deterministic NWP System

Configuration Details for FROST-2014

for 2.5-km and 1-km, and 250 m domains:

- 2-moment microphysics scheme
- moistTKE PBL scheme
- no CPS
- correlated-K distribution radiative transfer scheme
- ISBA land-surface scheme
- evolving orography
- 58 staggered vertical levels
- lid at 0.1 hPa
- $\Delta t = 60 \text{ s (2.5 km)} / 30 \text{ s (1 km)} / 10 \text{ s (250 m)}$
Global GEM model (and 4D-Var system) run operationally

FROST GEM-LAM system set-up*:

- run in real-time (subject to CPU availability)
- raw model output available for EC nowcasting system
- automatic conversion of 3D output to GRIB2 and time series to XLM; FTPed to Roshydromet

* Nested 10 km, 2.5 km, 1 km, 250 m domains over Sochi
3. DEMOS – Cases from 2013 Winter

<table>
<thead>
<tr>
<th>DATE</th>
<th>EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 Jan</td>
<td>heavy snowfall</td>
</tr>
<tr>
<td>24 Jan</td>
<td>torrential rain; snow higher in mountains</td>
</tr>
<tr>
<td>14-15 Feb</td>
<td>Foehn, 10°C warming</td>
</tr>
<tr>
<td>12-13 Mar</td>
<td>heavy rain</td>
</tr>
</tbody>
</table>

GEM simulations were done in real-time
(file conversion and automatic FTP were not ready at the time)
3. DEMOS – 24 Jan 2013 (heavy rain/snow)

2.5 km run:

QPF (24 h) valid 00 UTC 25 Jan 2013
1 km run:

QPF (24 h) valid 00 UTC 25 Jan 2013

Model Elevation
3. DEMOS – 24 Jan 2013 (heavy rain/snow)

250 m run:

QPF (24 h) valid 00 UTC 25 Jan 2013
24-h Accumulated SNOW

For simulated precipitation over low mountains:

- 2.5 km run ≠ 1 km run
- 1 km run ≈ 250 m run

250 m Model Elevation
Differences are not due to precipitation phase; 2.5-km run appears to underestimate the orographic enhancement.
3. DEMOS – 24 Jan 2013 (heavy rain/snow)

Near-surface winds:

2.5 km
3. DEMOS – 24 Jan 2013 (heavy rain/snow)

Near-surface winds:

1 km
Near-surface winds:

250 m
3. DEMOS – 24 Jan 2013 (heavy rain/snow)

250 m
### Previous (2012):
- GEM-Global 33 km
  - 4D-Var
- GEM-LAM 10 km
- GEM-LAM 2.5 km
  - 58 levels
  - ISBA surface fields
- GEM-LAM 1 km
  - 58 levels
  - ISBA surface fields

### Current (2013):
- GEM-Global 25 km
  - 4D-Var
- GEM-LAM 10 km
- GEM-LAM 2.5 km
  - 58 levels
  - ISBA surface fields
- GEM-LAM 1 km
  - 58 levels
  - ISBA surface fields
- GEM-LAM 250 m
  - 58 levels
  - ISBA surface fields

### Future (2014):
- GEM-Global 15 km
  - En-Var
- GEM-LAM 10 km
- GEM-LAM 2.5 km
  - 72 levels (?)
  - GEM-Surf fields
- GEM-LAM 1 km
  - 72 levels
  - GEM-Surf fields
- GEM-LAM 250 m
  - 72 levels
  - GEM-Surf fields

**PLUS:** Image production for special fields
4. FUTURE CHANGES to NWP system

**Future (2014):** Increased **vertical** resolution

nk = 58
nk = 72
4. FUTURE CHANGES to NWP system

Modifications to microphysics scheme*

CURRENT: 2-moment (all categories)

**SNOW**
\[ \rho_s = f(D_s) \]
\[ V = a_s D^{bs} \]

**GRAUPEL**
\[ \rho_g = 400 \text{ kg m}^{-3} \]
\[ V = a_g D^{bg} \]

\[ Qs, Ns \]

* abrupt conversion

NEW: Prognostic graupel density

**SNOW**
\[ \rho_s = f(D_s) \]
\[ V = a_s D^{bs} \]

**GRAUPEL**
\[ \rho_g \text{ is predicted} \]
\[ V = a_g(\rho_g) D^{bg(\rho_g)} \]

\[ Qs, Ns \]

* smooth conversion

\[ Qg, Ng, \rho_g \]

* Milbrandt-Yau
INITIATION:

- From snow: \( \rho_{g\_init} = \rho_s(D_s) \)

[Can be used to predict solid-liquid ratio; see Milbrandt et al. (2012), MWR]
Adjustments:

if $T < 0^\circ C$:

$$f_{liq} = \frac{q_r}{q_r + (q_i + q_g + q_s)}$$

$$F_v = (1 - f_{liq}) \cdot F_v' + f_{liq} \cdot F_{v_{liq}}$$

e.g. Assume $D_s = 5$ mm $\rightarrow$ $\rho_s(D_s) = 26$ kg m$^{-3}$:

$$\rho_{s_{melting}} = 0.95(26 \text{ kg m}^{-3}) + 0.05(1000 \text{ kg m}^{-3}) = 75 \text{ kg m}^{-3}$$

$$\rho_{s_{melting}} = 0.50(26 \text{ kg m}^{-3}) + 0.50(1000 \text{ kg m}^{-3}) = 513 \text{ kg m}^{-3}$$
24-h Accumulated SNOW (liquid-equivalent)

But what is the forecasted snow depth?
Real-time example from Vancouver 2010

FLUFFY SNOWFLAKES  SNOW PELLETS
Большое спасибо

Thank you