Environnement et Changement climatique Canada | Environment and Climate Change Canada

The Regional Deterministic Prediction System (RDPS) version 5.0.0 of the Meteorological Service (MSC) of Canada

The RDPS 5.0.0 was implemented at MSC Canadian Meteorological Centre (CMC) Operations division on September 7, 2016, with the 12Z system run.

- A technical note (CMC-RDPS-5.0.0 2016) describing the latest modifications made to the Regional Deterministic Prediction system (RDPS-5.0.0) is available here:

  http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/docs/lib/technote_rdps-500_20160907_e.pdf

- The most recent changes to CMC's suite of prediction systems are described here:

  http://collaboration.cmc.ec.gc.ca/cmc/cmoi/product_guide/docs/changes_e.html

- La version française de ce document est ici:

  http://collaboration.cmc.ec.gc.ca/cmc/CMOI/product_guide/docs/tech_specifications/tech_specifications_RDPS_5.0.0_f.pdf

The RDPS is a forecast system based on a limited-area (LAM) configuration of the Global Environmental Multiscale (GEM) model (Côté et al., 1998a and 1998b) with a 10-km grid spacing covering North America. The LAM is driven by an early forecast from the GDPS. The RDPS is the main NWP guidance for forecast production of the Meteorological Service of Canada for day one and two.

The assimilation part of the RDPS is described in section 1 below, the lateral boundary conditions in section 2, and the forecast component in section 3. A few figures and a list of references follow at the end of the document.

Regional Deterministic Prediction System (RDPS)

1. Data assimilation and objective analysis

RDPS – Version 5.0.0 – Assimilation	
Model ***New***	Global Environmental Multiscale (GEM) model version 4.8.2
Assimilation approach	This forecast system adopts an intermittent upper-air cycling strategy where the 25-km analysis from the GDPS serves to initialize the LAM 6 hours before the analysis time *T*. This forecast then serves as the background for the analysis step at time *T*. See Caron et al. (2016) and references therein.
Control variables	T, Ps, U, V and log q (the log of the specific humidity)
Analysis Domain	Same as the forecasts: a LAM domain, covering North America and adjacent oceans. Only observations over that domain are assimilated.
Vertical Levels	80 hybrid levels (staggered) of the GEM model version 4.8.2
Analysis increment horizontal grid	0.45° x 0.45° global Gaussian grid. This global set of analysis increment valid at the analysis time is then clipped over the LAM domain and added to the 6-h LAM background.

Background fields	3 to 9-hour forecasts every 15 minutes
Assimilated radiance data **(number of channels)**	AMSU-A (11), AMSU-B (4), MHS (4), SSMIS (7), geostationary imagers (1), AIRS (142), IASI (142), ATMS (17), CrIS (103); inter-channel error correlation is taken into account for all infrared and microwave satellite data.
Other satellite data	GPS-RO refractivity, AMVs, scatterometer winds, ZTD from GB-GPS over North America.
Other data used	TEMP, PILOT, SYNOP/SHIP, BUOY/DRIFTER, ASCAT, aircraft data
Treatment of radiosonde and aircraft data	Radiosonde: use appropriate measured or computed time and horizontal position for each pressure level. Aircraft: static temperature bias correction
Satellite radiance bias correction	Coefficients computed by the GDPS (Global Deterministic Prediction System) from Obs-minus-Analysis using a separate 3DVar analysis that does not include radiances, based on last 7 days, 2 times per day, except static for AMSU-A channels 13-14.
Background-error covariances	Same as in the GDPS. Surface to ~40hPa: Blend (50/50) of homogenous and isotropic (obtain from the so-called NMC method) global covariances and 4D ensemble covariances derived from 256 ensemble members (EnKF) every hour over the 6 h assimilation window; Above ~10hPa: Gradual transition to 100% homogenous and isotropic global covariances (because the lid of the EnKF, 2 hPa, is lower than the lid of the RDPS, 0.1 hPa)
Frequency and cut-off time	Four analyses are produced each day at 00 UTC, 06 UTC, 12 UTC and 18 UTC. They are initiated from GDPS analyses valid 6-hour earlier (with cut-off times of 3:00 hrs at 00 UTC or 12 UTC; and 6:00 hrs at 06 UTC or 18 UTC) to generate the backgrounds for the LAM and the global driver. In each analysis step, the 4DEnVar analysis both for the global driver and the LAM uses a cut-off of 2:00 hours. Data within +/- 3 hours of analysis time are used.
Processing time	10 minutes for the analysis using 640 cores (not including processing of data, background check, treatment of the EnKF members, etc.).

2. Lateral boundary conditions

RDPS – Version 5.0.0 – LBCs
The LBCs are provided by an early forecast from the operational 25-km GDPS (v5.0.0, based on GEM 4.7.2). See Qaddouri et al. (2015). Using LBCs from a synchronous global driver allows the observations outside the LAM analysis domain to influence the LAM forecasts

3. Forecast

RDPS – Version 5.0.0 – Forecast	
LAM Model	
Model ***New***	Global Environmental Multiscale (GEM) model version 4.8.2
Model initialization scheme	Diabatic digital filter (Fillion et al., 1995).
Formulation	Hydrostatic primitive equations.
Domain	LAM domain.
Numerical technique	Finite differences: Arakawa C grid in the horizontal and Charney-Phillips grid in the vertical (Girard et al. 2014)
Grid ***New***	Rotated longitude-latitude grid with 1108 x1082 grid points, having a uniform 0.09º (~10 km) resolution covering North America and adjacent oceans Note: The rotation of the LAM follows the rotation of the Yin domain in the GDPS version 5.0.0 Lateral boundary conditions are refreshed every hour.
Levels ***New***	Levels are identical to those of the GDPS version 5.0.0: 80 staggered hybrid levels (same number of momentum and thermodynamic levels), plus 2 diagnostic levels at 10m and 1.5m for near-surface winds and temperature/specific humidity. Model lid at 0.1 hPa (Girard et al. 2014).
Time integration	Implicit, semi-Lagrangian (3-D), 2 time-level, 300 seconds per time step (Côté et al., 1998a and 1998b).
Independent variables	x, y, η and time.
Prognostic variables	Three-dimensional winds, virtual temperature, vertical coordinate displacement, geopotential, specific humidity pressure, cloud condensate mixing ratio, turbulent kinetic energy (TKE).
Derived variables	MSL pressure, relative humidity, QPF, precipitation rate, omega, cloud amount, boundary layer height and many others.
Geophysical variables:	**Surface and deep soil temperature and moisture; snow depth, snow albedo and snow density:** - Derived from analyses at initial time, predictive; Soil variables from ISBA scheme (Noilhan and Planton, 1989; Bélair et al. 2003a and 2003b); **Sea ice thickness:**. - Derived from climatology at initial time, fixed in time **Sea ice cover; sea surface temperature:** - Derived from analyses, fixed in time.

Geophysical variables: **(continued)**	**Others**: Orography, surface roughness length (except over water), subgrid-scale orographic parameters for gravity wave drag and low-level blocking, vegetation characteristics, soil thermal and hydraulic coefficients, glaciers fraction - Derived from a variety of geophysical recent data bases using in house software, fixed in time
Horizontal diffusion (explicit) ***New***	Del-4 operator applied on momentum variables (10%), except del-2 applied on temperature and momentum variables at the lid (top 6 levels) of the model, with conservation of the dry air mass. A del-6 operator (4%) is applied to the diffusion of potential temperature.
Orographic gravity wave drag	Parameterized (McFarlane, 1987; McFarlane et al., 1987).
Non-orographic gravity wave drag	Parameterized (Hines, 1997a,b).
Low level blocking ***- New -***	Parameterized (Lott and Miller, 1997; Zadra et al., 2003) **- *New* :** with enhanced drag coefficient (Wells et al 2008; Vosper et al 2009) **-**
Radiation	Solar and infrared using a correlated-k distribution (CKD) (Li and Barker, 2005).
Surface scheme	Mosaic approach with 4 types: land, water, sea ice and glacier (Bélair et al., 2003a and 2003b).
Surface roughness length over water	Charnock formulation for momentum. Deacu formulation for Z0T except constant in the tropics.
Boundary-layer turbulent mixing (vertical diffusion) with wet formulation	Based on turbulent kinetic energy (Benoît et al., 1989; Delage, 1988a and 1988b), with statistical representation of subgrid-scale clouds (Mailhot and Bélair, 2002; Bélair et al., 2005) but reduced flux enhancement factor (80%) over water. Mixing length from Blackadar 1962. Includes Richardson number hysteresis (McTaggart-Cowan and Zadra, 2015).
Shallow convection	Kuo Transient scheme (Bélair et al., 2005).
Stable precipitation	Sundqvist scheme (Sundqvist et al., 1989; Pudykiewicz et al., 1992).
Deep convection	Kain & Fritsch scheme. (Kain and Fritsch, 1990 and 1993).

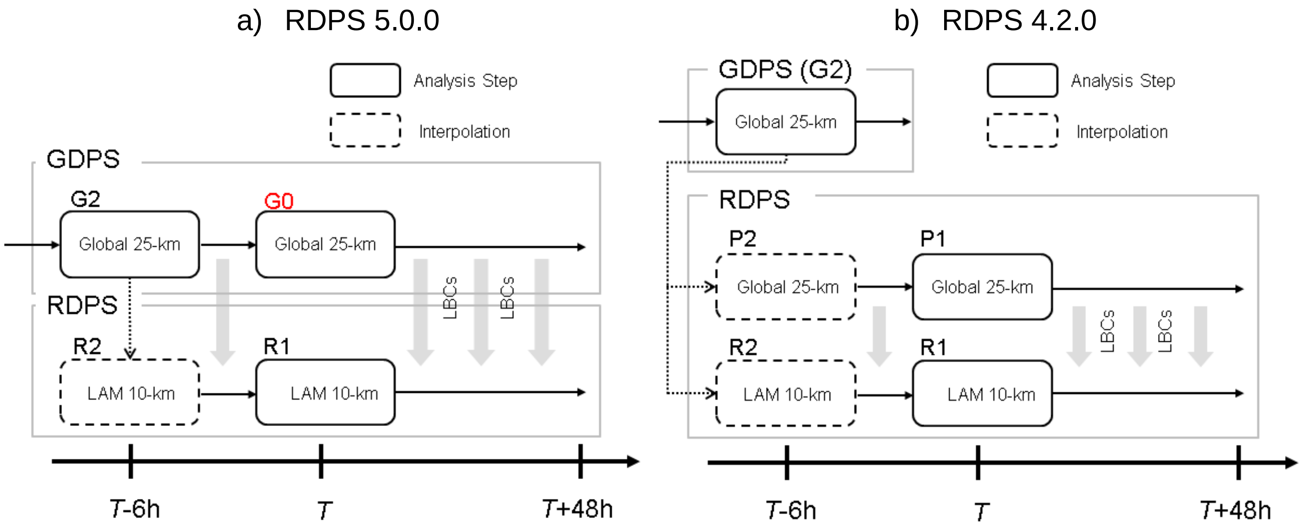

Figure 1. *Schematic of the RDPS intermittent upper-air cycling strategy showing its dependency on the GDPS for a) the new RDPS (5.0.0) and b) the previous RDPS (4.2.0).. The distances refer to the approximate horizontal grid spacing of the models. See text in section 2 for further details.*

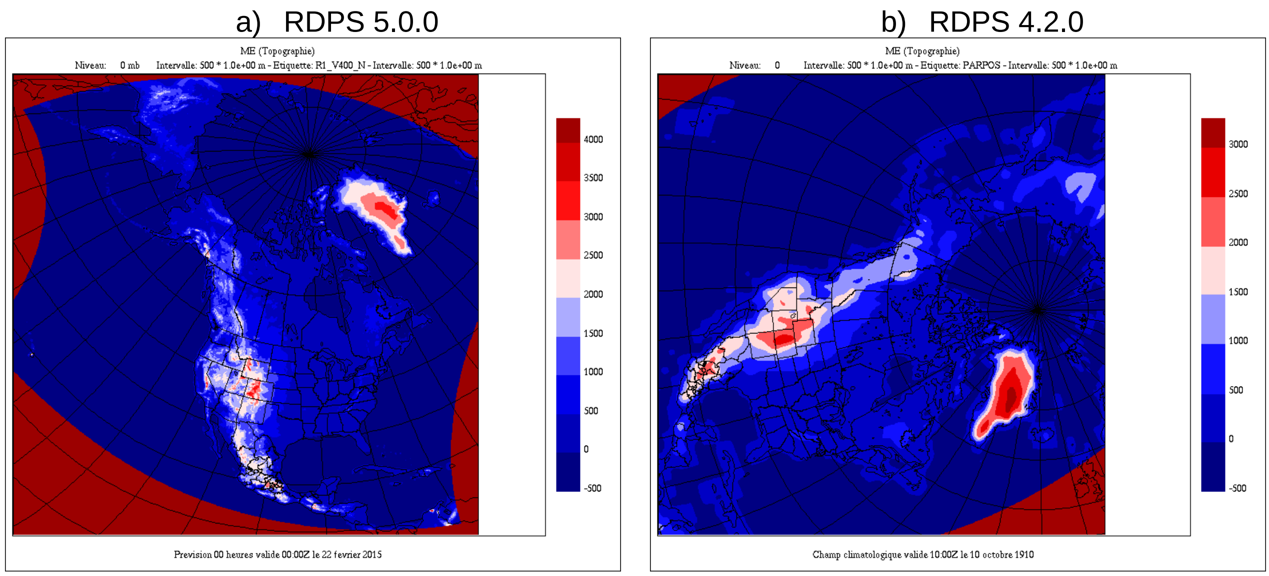

Figure 2. *Horizontal domain of the RDPS for: a) version 5.0.0; and b) version 4.2.0. A pseudo-topography field defined on the 4.2.0 (5.0.0) domain was interpolated onto the 5.0.0 (4.2.0) domain. Therefore, surrounding areas in the uniform reddish color depict in a) new areas covered by the 5.0.0 domain and in b) areas no longer covered by the 5.0.0 domain.*

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Document history			
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1.0	2016-07-05	Ayrton Zadra	First draft by RPN
2.0	2016-07-07	Jean-François Caron	Review of assimilation info by ARMA
3.0	2016-07-13	André Giguère	Links and figures added for COMET
4.0	2016-08-02	André Giguère	Corrections for translation
5.0	2016-08-16	André Giguère	Final adjustments following translation in French
5.1	2016-09-07	David Anselmo	Add date of implementation. Remove watermark.