Environment Canada's

Pan-Canadian 2.5-km Deterministic Prediction System

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Environment Canada

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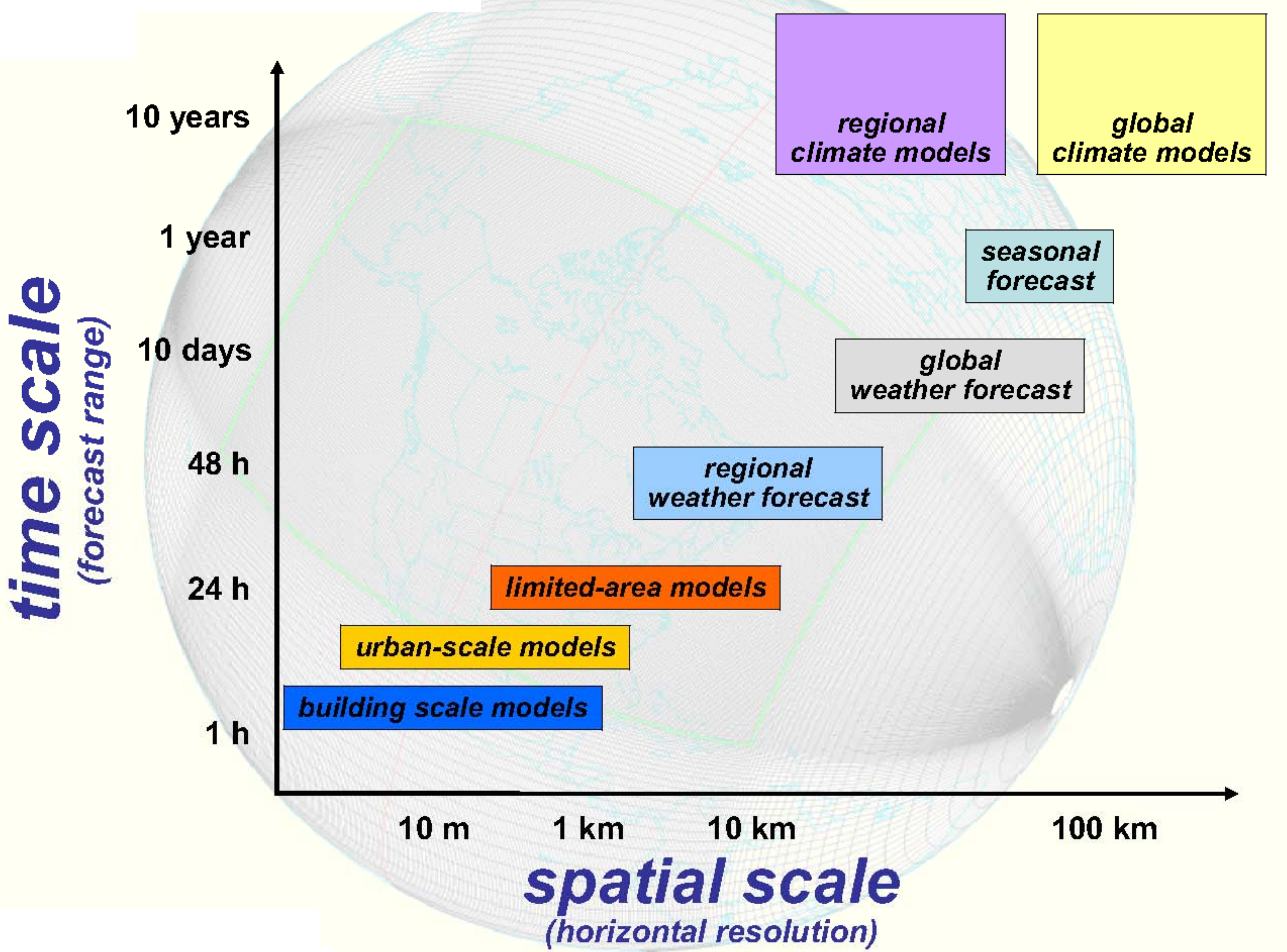
May 13-15, 2013

Modeling Systems and Applications at Environment Canada



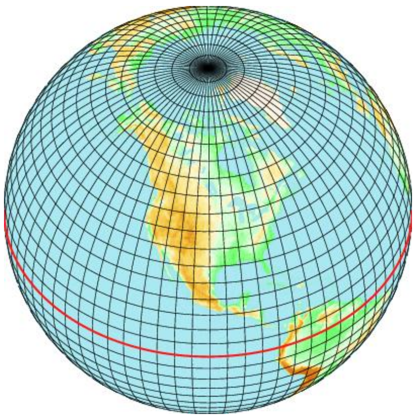
Environment Canada Environnement Canada

Environment Canada's NWP Model

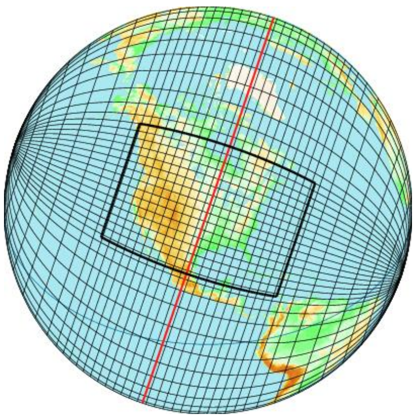
GEM (Global Environmental Multiscale)

Various grid configurations:

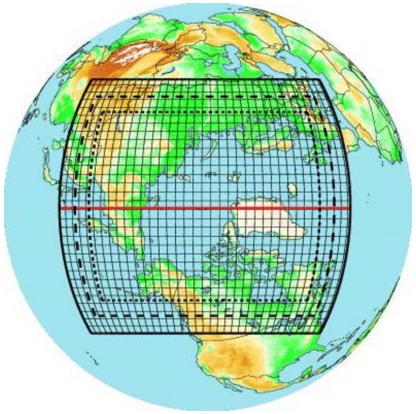
Global Uniform



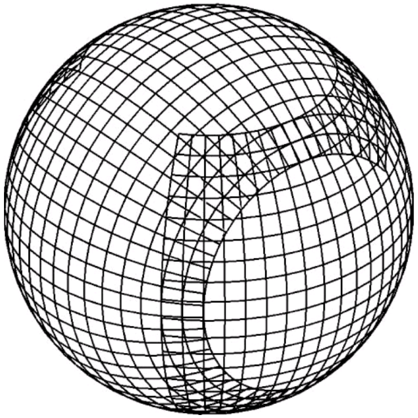
Global Variable



Limited Area (LAM)



Yin-Yang



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

Côté et al. (1998) *Mon. Wea. Rev.*

Advantages of cloud-scale NWP:

1. **Topographic forcing is better resolved**
   - orography, vegetation, land-water boundaries
2. **Better physics**
   - high-resolution surface data assimilation
   - can use more detailed parameterization of clouds/precipitation
   - no need for a CPS

→ Improved ability to forecast high-impact weather

Environment Canada's HRDPS

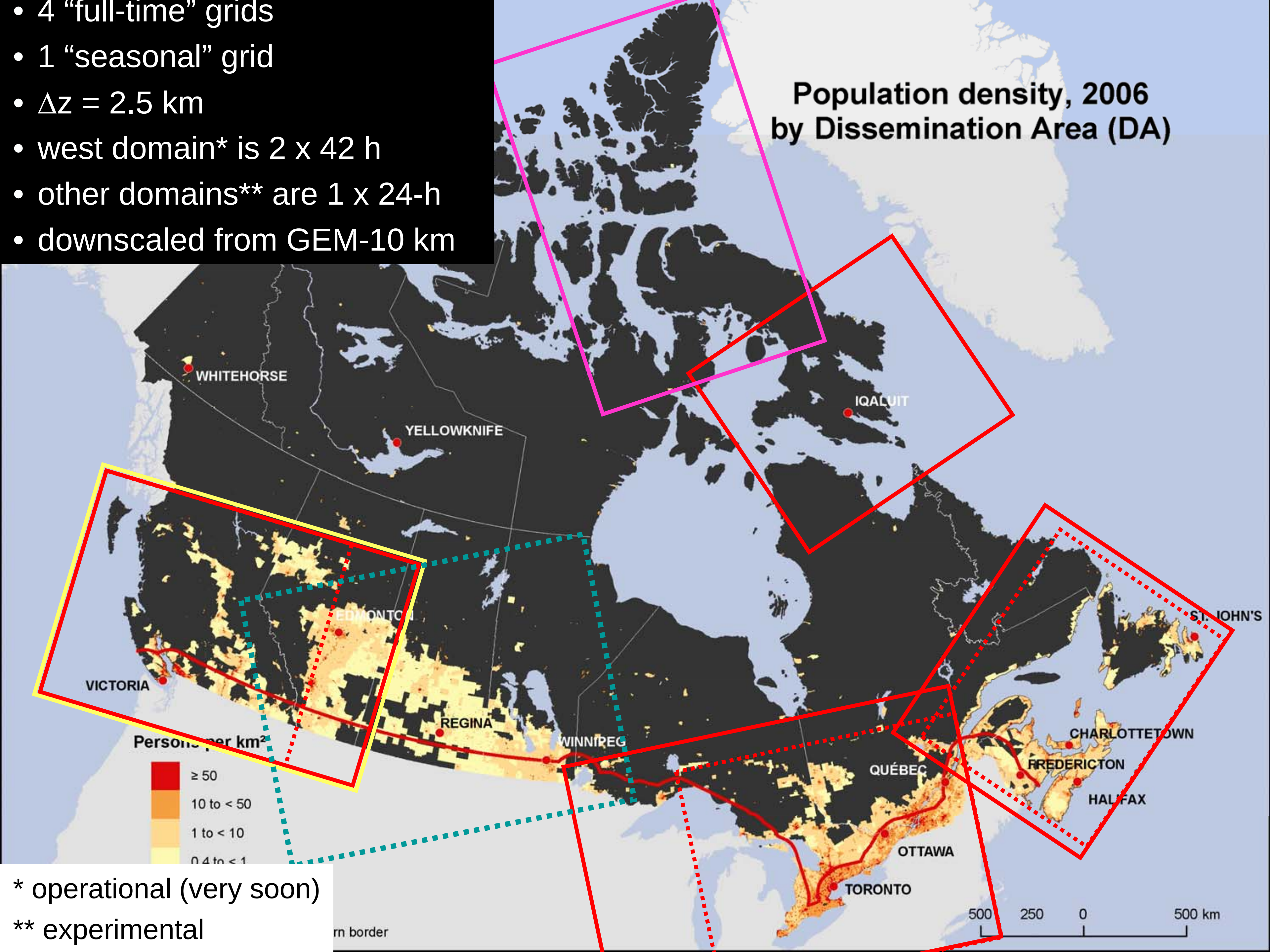
High Resolution Deterministic Prediction System

- 1997: Project initiated over Canadian Rocky Mountains
- 2002: Real-time experimental 2.5-km domains set up
- 2013: West-2.5 km domain is formally "operational"

Other related experimental systems:

- 2001: MAP
- 2007: MAP-DPHASE
- 2008: UNSTABLE (1-km domain over Alberta)
- 2010: Vancouver 2010 Winter Olympics/Paralympics
- 2014: Sochi 2014 Winter Olympics/Paralympics
- 2015: Pan-American Games (Toronto, Canada)

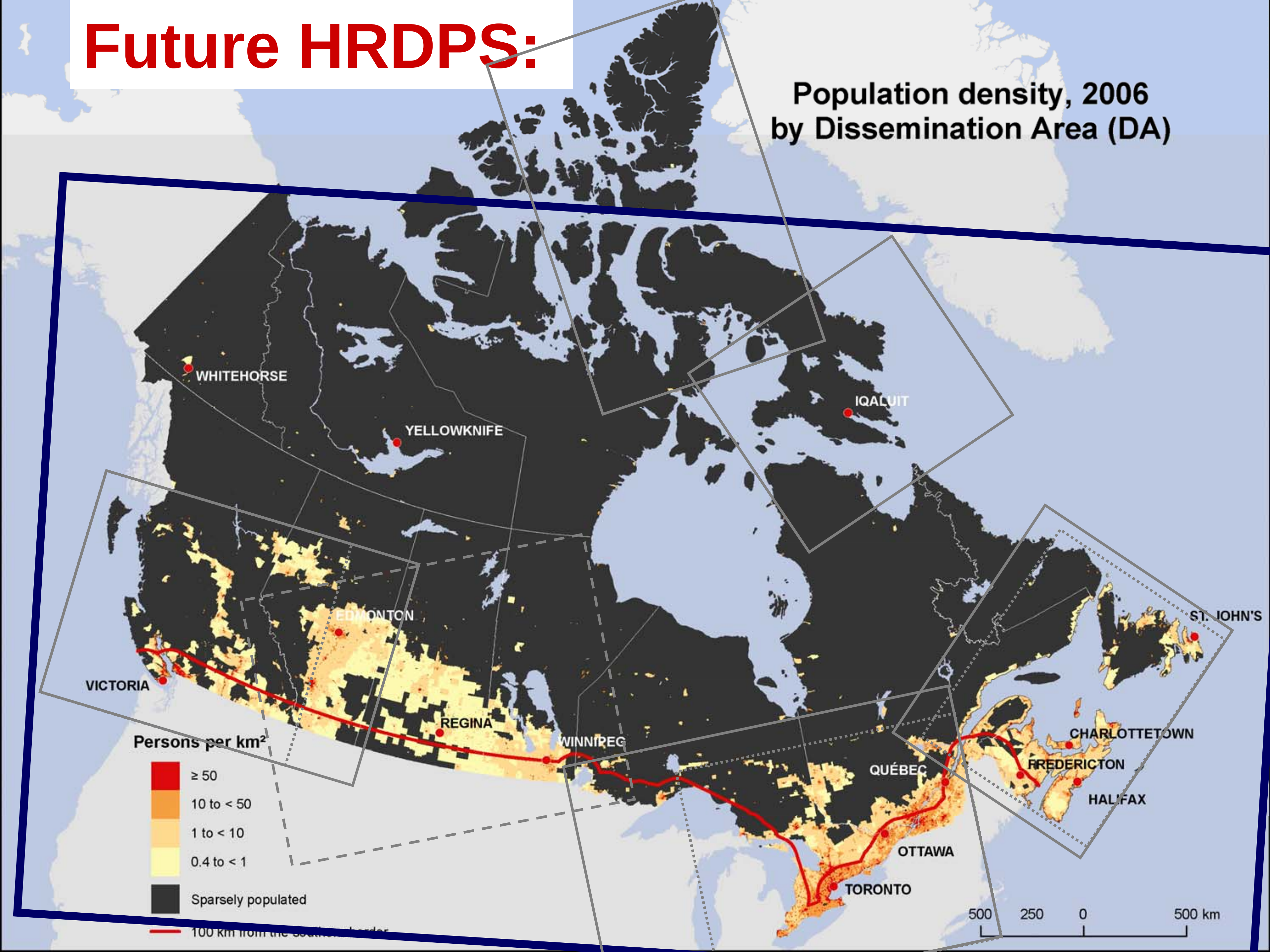
- 4 “full-time” grids
- 1 “seasonal” grid
- Δz = 2.5 km
- west domain* is 2 x 42 h
- other domains** are 1 x 24-h
- downscaled from GEM-10 km



* operational (very soon)

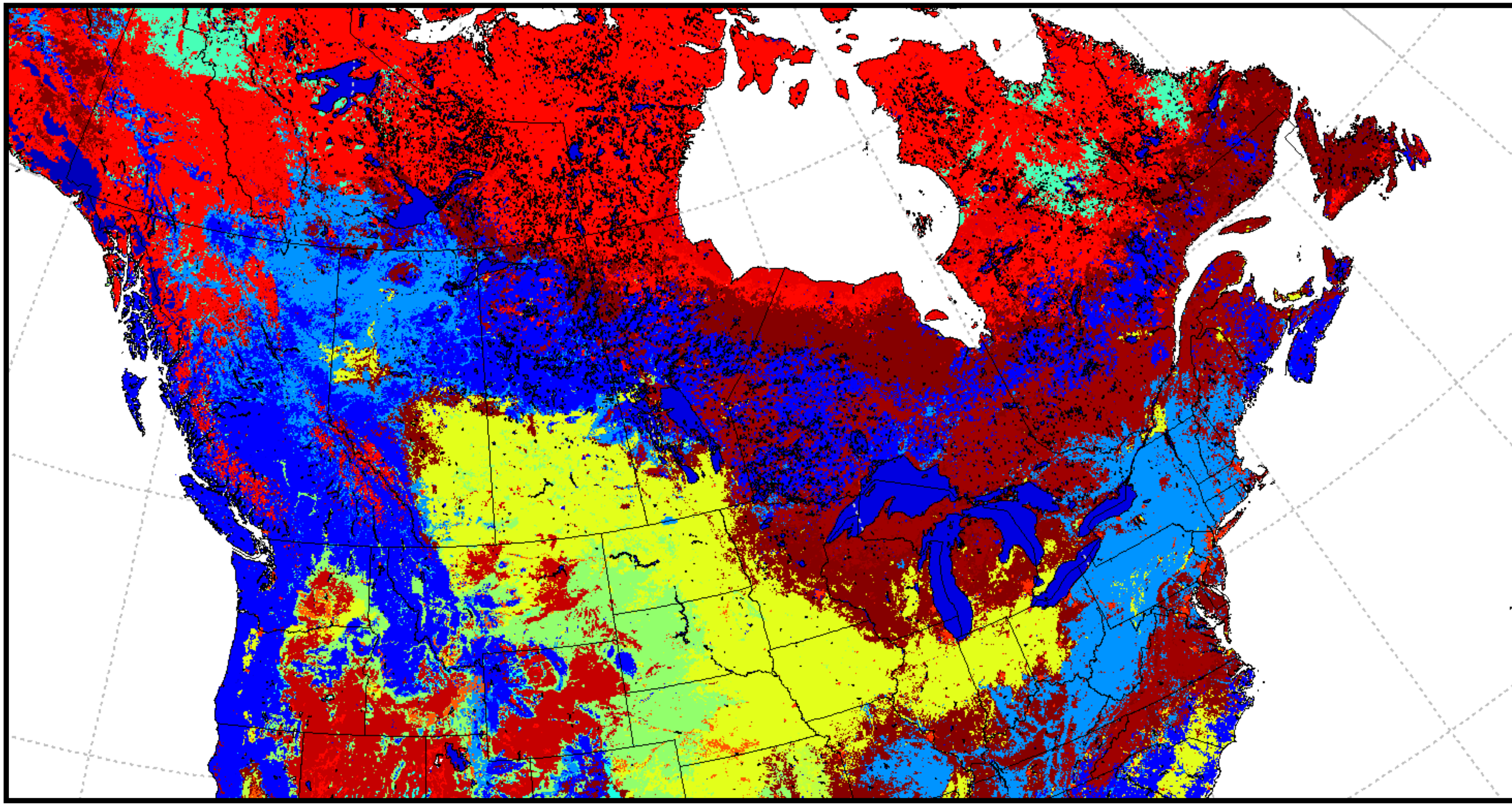
** experimental

Future HRDPS:



Future HRDPS:

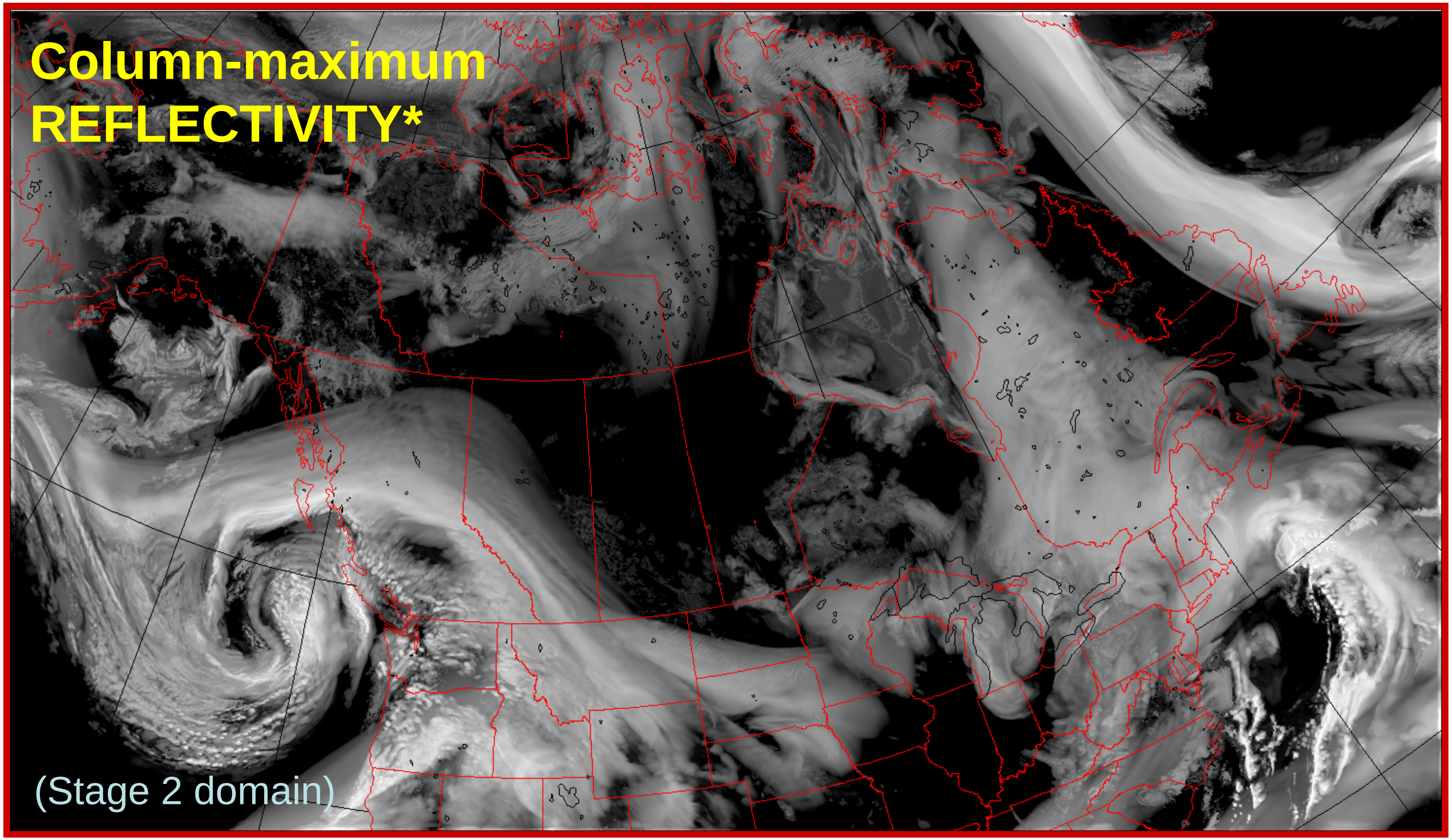
Phase 1 (2500 x 1300)



Δx = 2.5 km

Predominant vegetation
(ISBA land surface scheme)

Simulation with pan-Canadian 2.5-km HRDPS



* Computed from hydrometeor fields from microphysics scheme

HRDPS Development Plans

Downscaled from GEM-10 km (**4D-VAR**)

1. **Operational WEST-2.5 domain**
   - operational status of WEST; 2 x 42-h
   - 4 other experimental domains, 1 x 24-h

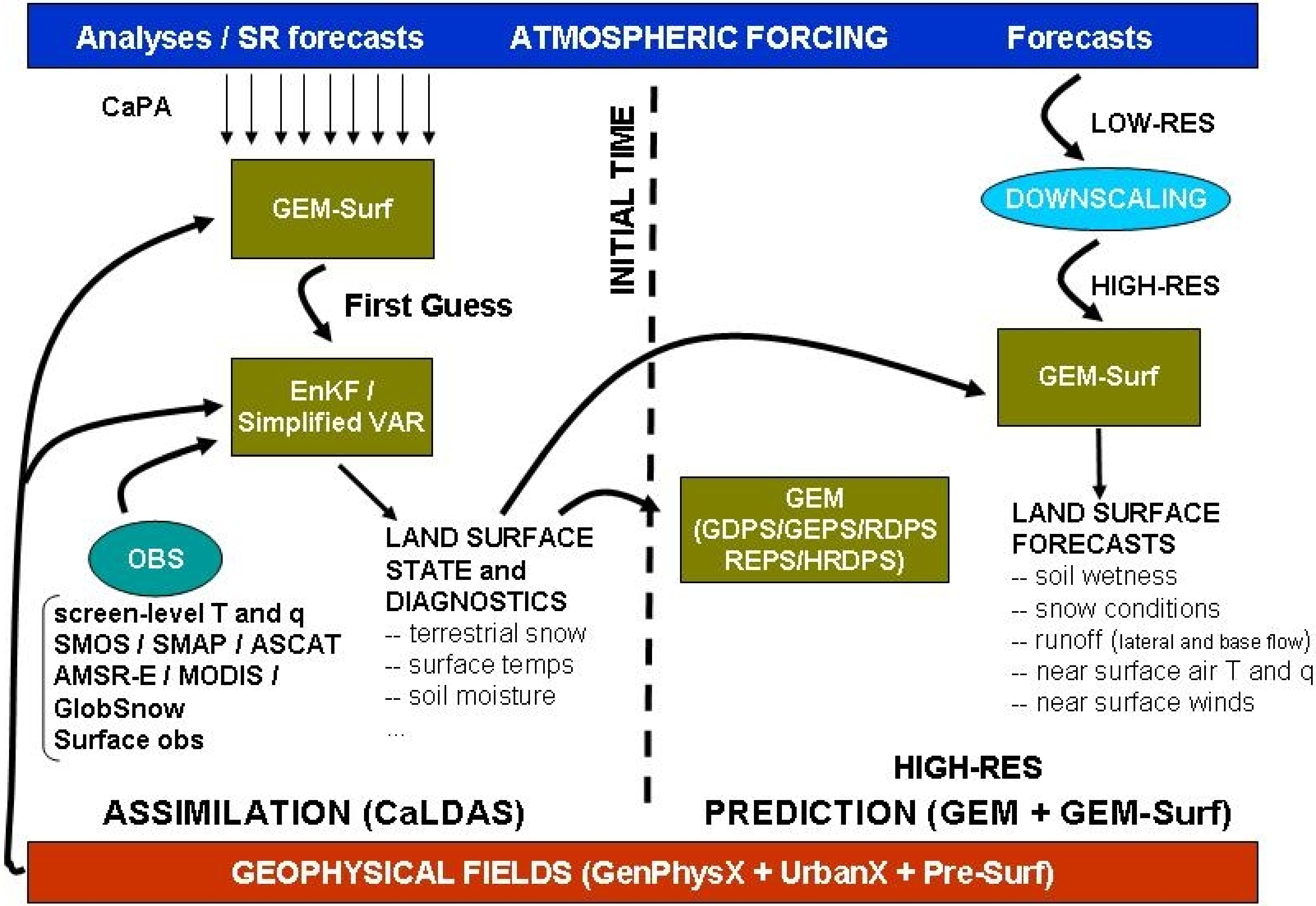
2. **National-2.5 – STAGE 1**
   - single, national grid
   - 2 x 48-h
   - high-resolution surface fields
   - reduced spin-up (recycling cloud fields)
   - improved microphysics
   - increased vertical resolution

   → 2014

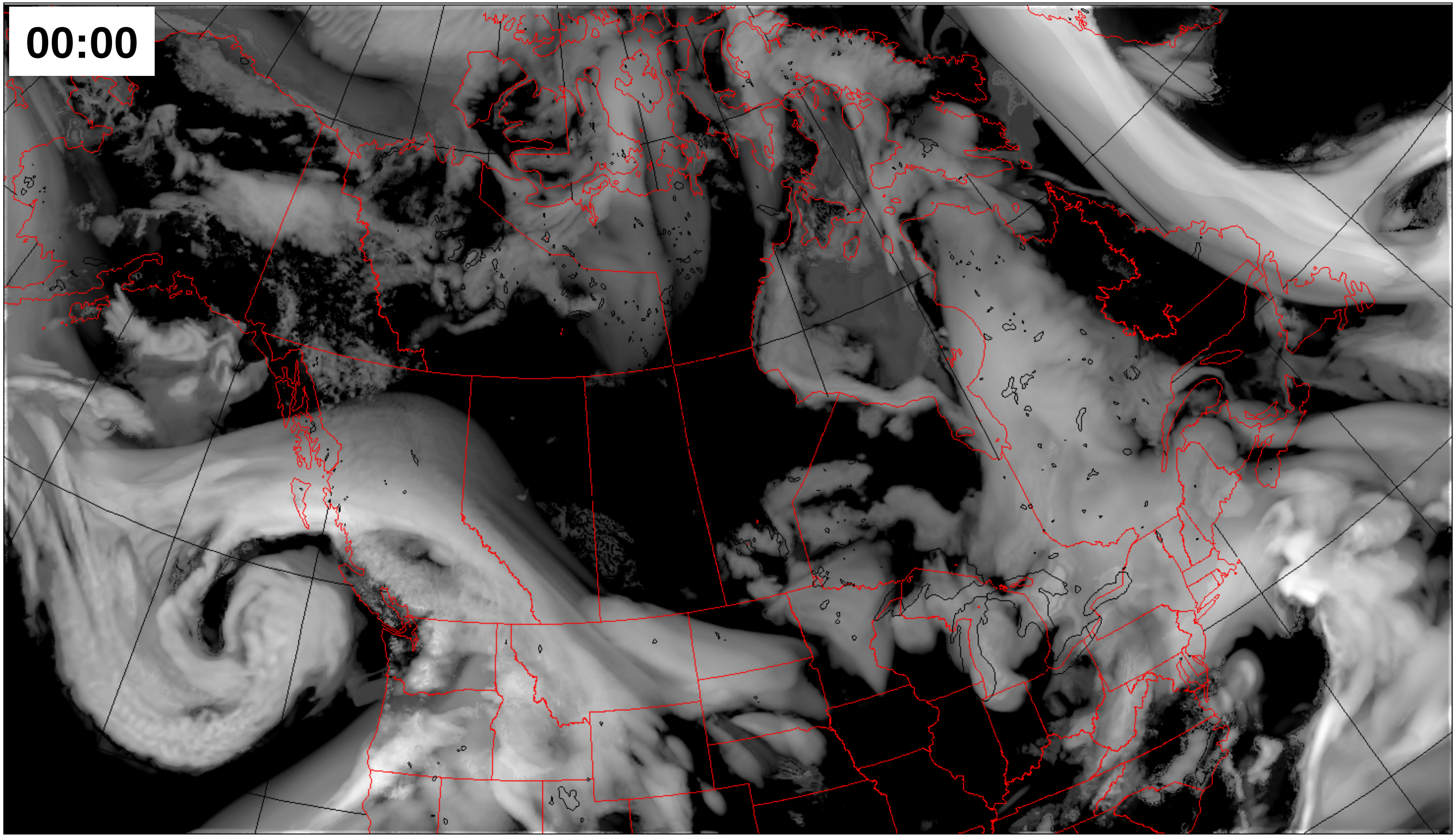
3. **National-2.5 – STAGE 2**
   - 4 x 48-h
   - upper-air data assimilation cycle (***En-Var**)

   → 2016

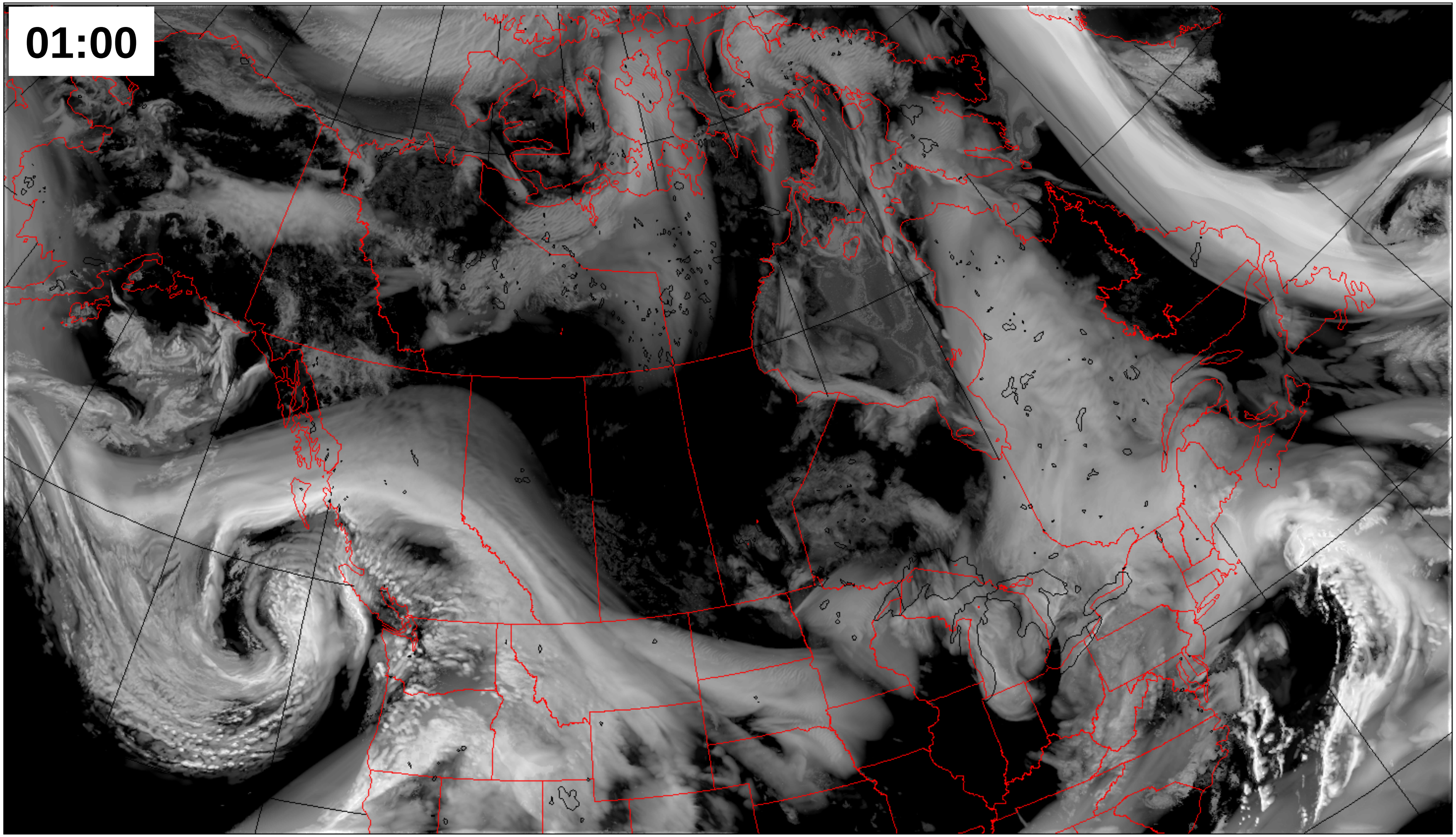
* Buehner et al. (2010a,b)


Analyses / SR forecasts
ATMOSPHERIC FORCING
Forecasts
CaPA
GEM-Surf
First Guess
EnKF / Simplified VAR
OBS
screen-level T and q
SMOS / SMAP / ASCAT
AMSR-E / MODIS /
GlobSnow
Surface obs
LAND SURFACE STATE and DIAGNOSTICS
-- terrestrial snow
-- surface temps
-- soil moisture
...
INITIAL TIME
GEM (GDPS/GEPS/RDPS REPS/HRDPS)
LOW-RES
DOWNSCALING
HIGH-RES
GEM-Surf
LAND SURFACE FORECASTS
-- soil wetness
-- snow conditions
-- runoff (lateral and base flow)
-- near surface air T and q
-- near surface winds
ASSIMILATION (CaLDAS)
HIGH-RES PREDICTION (GEM + GEM-Surf)
GEOPHYSICAL FIELDS (GenPhysX + UrbanX + Pre-Surf)

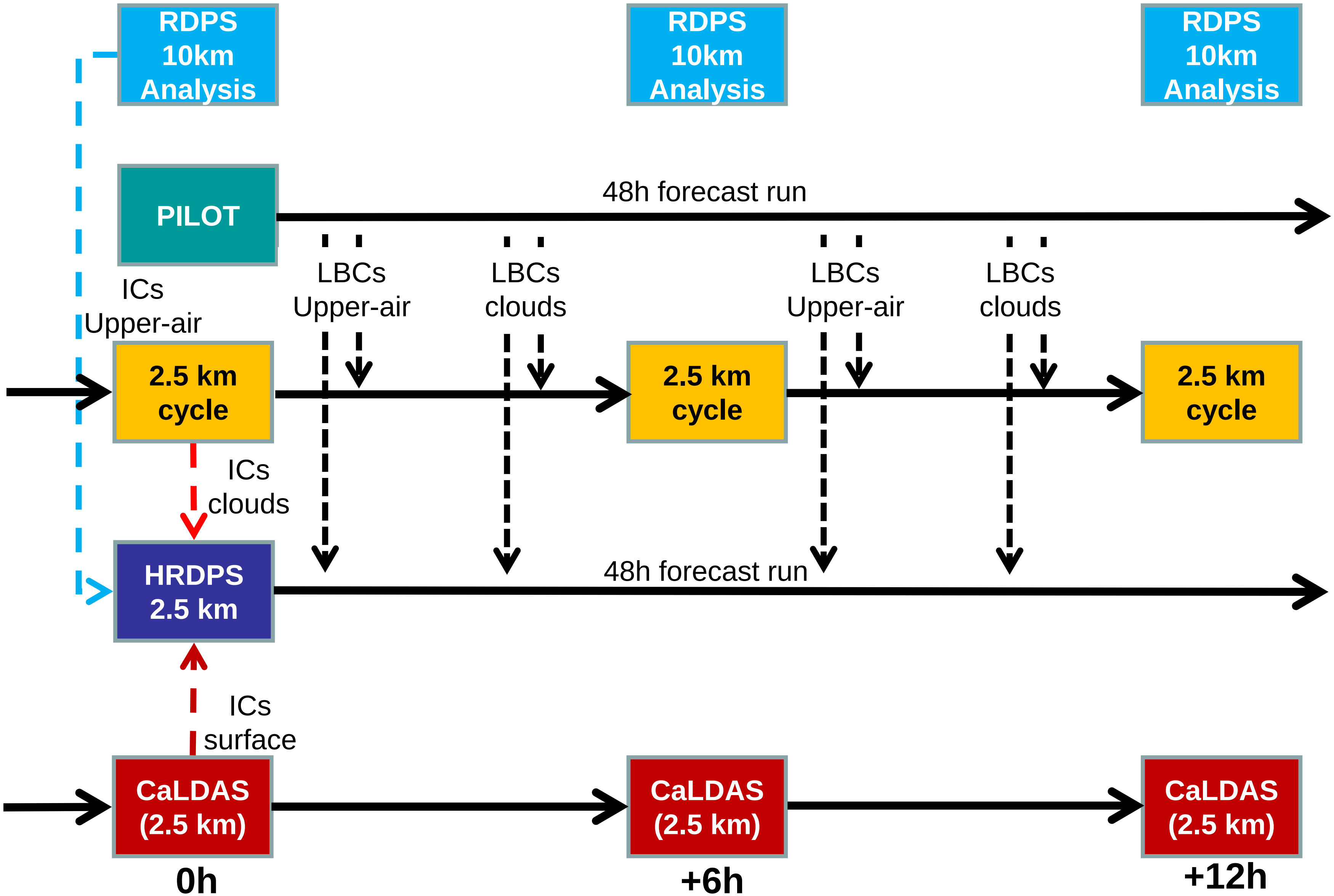
Initial cloud fields come from short-term forecast of 10-km parent model



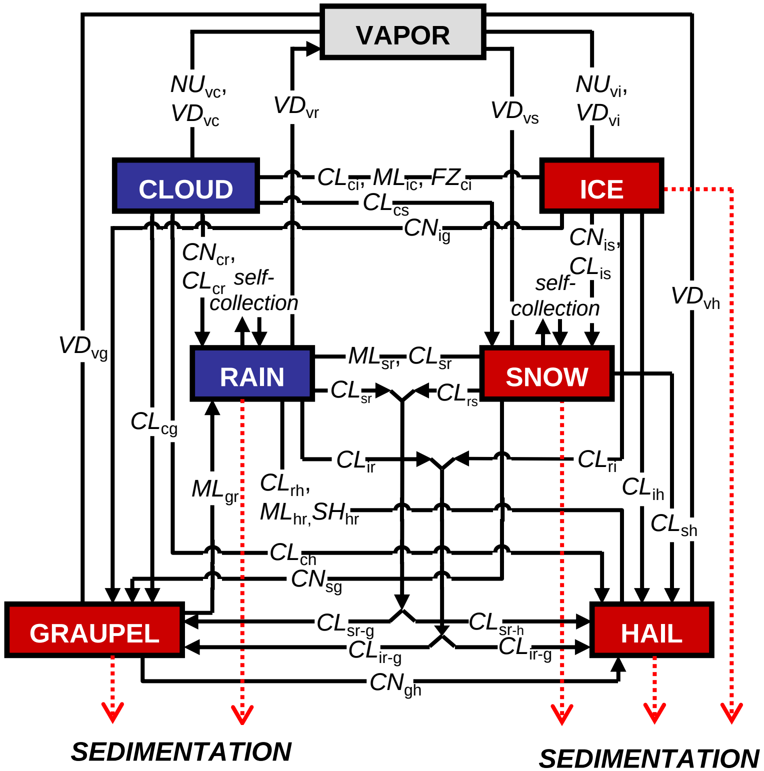
We want to reduce spin-up time such that the initial fields contain high-resolution detail



Future Sequence for ICs and BCs:



2-Moment Microphysics Scheme*



Six hydrometeor categories:

2 liquid: ***cloud***, ***rain***

4 frozen: ***ice***, ***snow***, ***graupel***, ***hail***

For each category *x = c, r, i, s, g, h*:

$$N_x(D) = N_{0x} D^{\alpha_x} e^{-\lambda_x D}$$

Prognostic variables

q_x, N_x (12)

* Milbrandt and Yau (2005a,b)

New Treatment of Rimed Ice in Microphysics

Current MY2 scheme:

SNOW
$\rho_s = f(D_s)$
$V = a_s D^{bs}$

GRAUPEL
$\rho_g = 400$ kg m^{-3}
$V = a_g D^{bg}$

HAIL
$\rho_h = 900$ kg m^{-3}
$V = a_h D^{bh}$

Modified MY2 scheme:

SNOW
$\rho_s = f(D_s)$
$V = a_s D^{bs}$

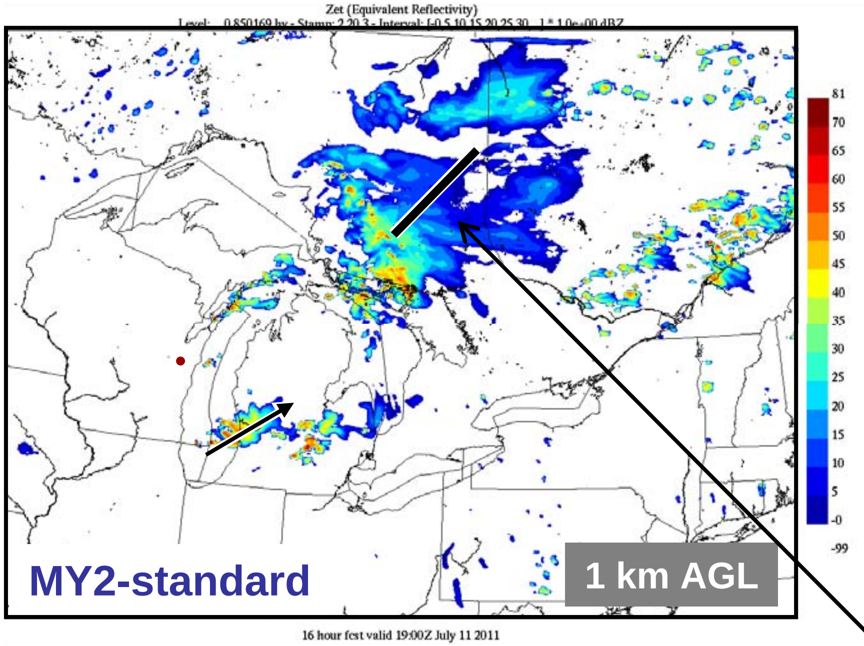
GRAUPEL
ρ_g is predicted
$V = a_g(\rho_g) D^{bg(\rho_g)}$

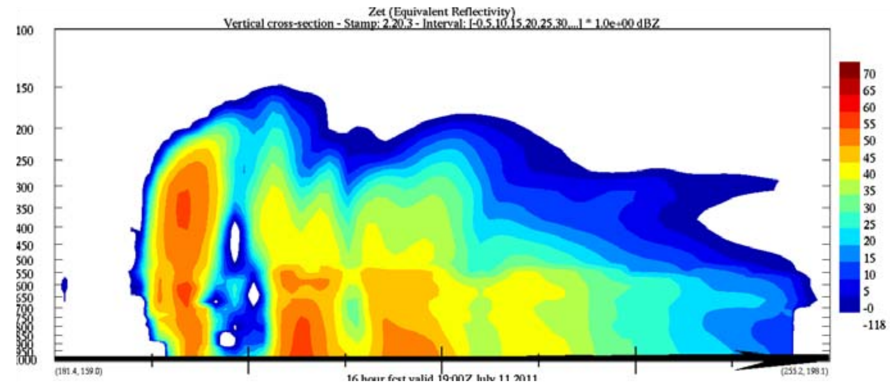
HAIL
$\rho_h = 900$ kg m^{-3}
$V = a_h D^{bh}$

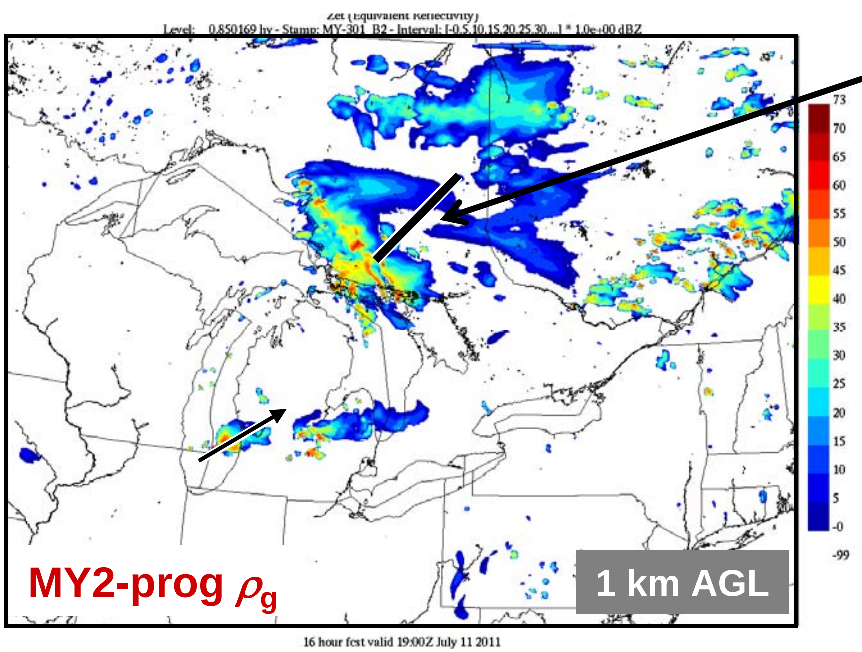
SMOOTHER TRANSITION
between categories

HRDPS-East domain (11 July 2011)

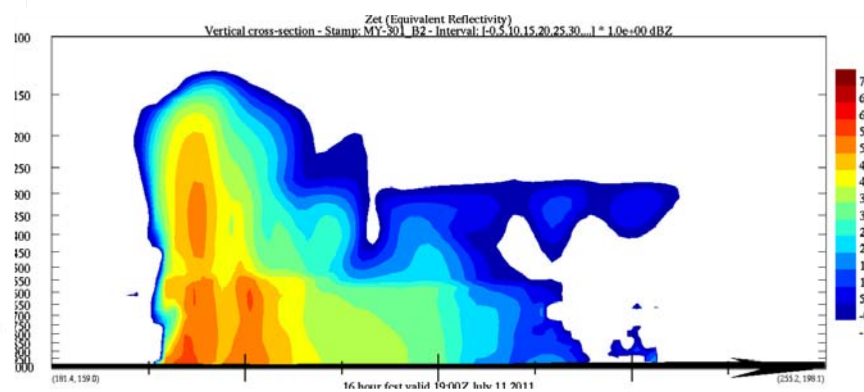
MODEL REFLECTIVITY







REDUCTION OF EXCESSIVE STRATIFORM REGION



INCREASED VERTICAL RESOLUTION

k	hyb	z (m)	Δz (m)
...			
32	3.7321E-01	6849.	450.
33	3.9816E-01	6399.	437.
34	4.2401E-01	5962.	426.
35	4.5079E-01	5536.	415.
36	4.7853E-01	5122.	405.
37	5.0722E-01	4717.	394.
38	5.3679E-01	4323.	384.
39	5.6725E-01	3940.	374.
40	5.9861E-01	3566.	365.
41	6.3089E-01	3201.	354.
42	6.6390E-01	2846.	340.
43	6.9721E-01	2506.	309.
44	7.2888E-01	2198.	281.
45	7.5897E-01	1916.	254.
46	7.8721E-01	1663.	231.
47	8.1378E-01	1432.	209.
48	8.3864E-01	1223.	190.
49	8.6186E-01	**1033**.	172.
50	8.8342E-01	861.	155.
51	9.0341E-01	706.	142.
52	9.2202E-01	564.	128.
53	9.3912E-01	436.	116.
54	9.5491E-01	321.	105.
55	9.6940E-01	216.	95.
56	9.8278E-01	121.	81.
57	9.9425E-01	40.	

8

57 levels (current)

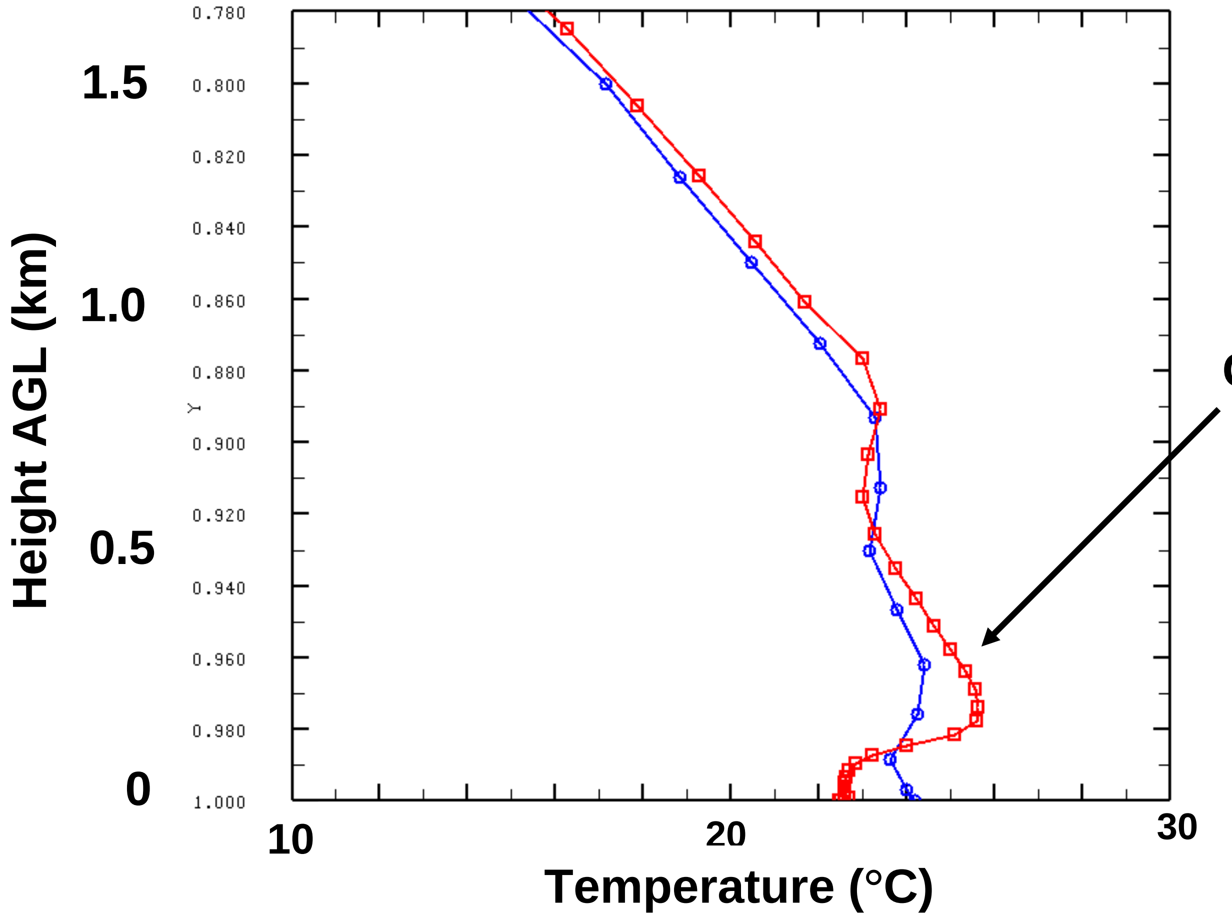
k	hyb	z (m)	Δz (m)
...			
47	8.5323E-01	**1103**.	130.
48	8.6939E-01	973.	117.
49	8.8416E-01	855.	105.
50	8.9762E-01	751.	94.
51	9.0983E-01	657.	84.
52	9.2086E-01	573.	75.
53	9.3080E-01	498.	66.
54	9.3972E-01	432.	59.
55	9.4770E-01	373.	52.
56	9.5481E-01	321.	46.
57	9.6112E-01	276.	40.
58	9.6672E-01	235.	35.
59	9.7166E-01	200.	31.
60	9.7600E-01	169.	27.
61	9.7982E-01	142.	24.
62	9.8316E-01	118.	21.
63	9.8607E-01	97.	18.
64	9.8860E-01	80.	15.
65	9.9080E-01	64.	13.
66	9.9270E-01	51.	11.
67	9.9434E-01	39.	10.
68	9.9575E-01	30.	8.
69	9.9696E-01	21.	7.
70	9.9799E-01	14.	6.
71	9.9888E-01	8.	5.
72	9.9963E-01	3.	

25

72 levels (testing)

INCREASED VERTICAL RESOLUTION

Example of Model Soundings
(pre-storm environment)



Capping inversion is better resolved

57 levels (current)

72 levels (testing)

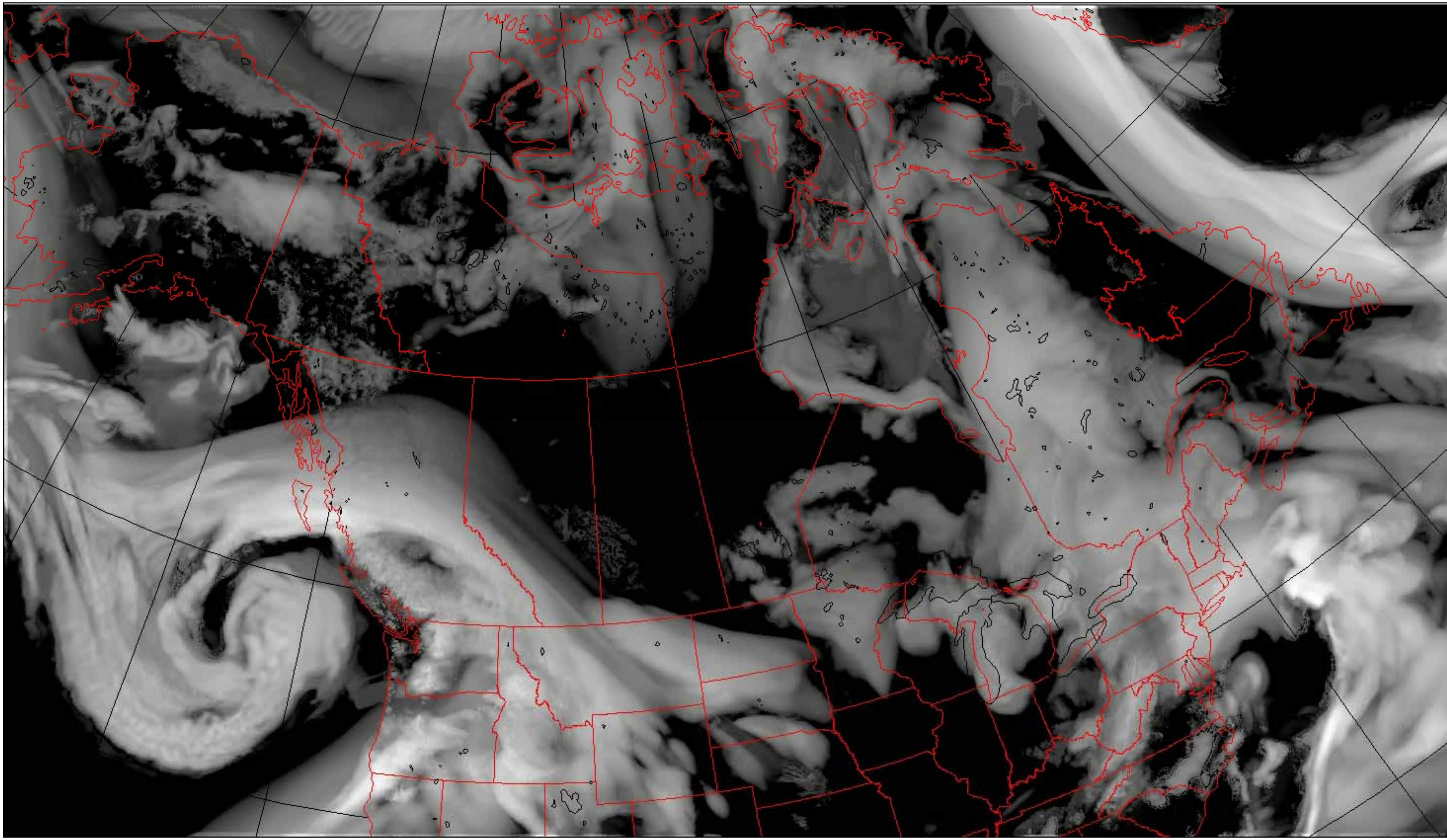
VERIFICATION

***CURRENT*:**

- **profiles of mass, temperature, humidity,** and **winds** based on comparison to observed soundings
- **near-surface temperature, humidity,** and **winds,** and **cloud cover** based on comparison to station observations
- **6-h QPF** based on station observations

FUTURE:

- **precipitation type** based on <u>station observations</u>
- **precipitation patterns/spatial distribution** based on <u>radar observations</u>
- **cloud coverage/spatial distribution** based on <u>satellite observations</u>




Danke!