Towards an Operational National HRDPS

Proposal for an Operational WEST 2.5-km Domain

(and general upgrade)

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Contributors:

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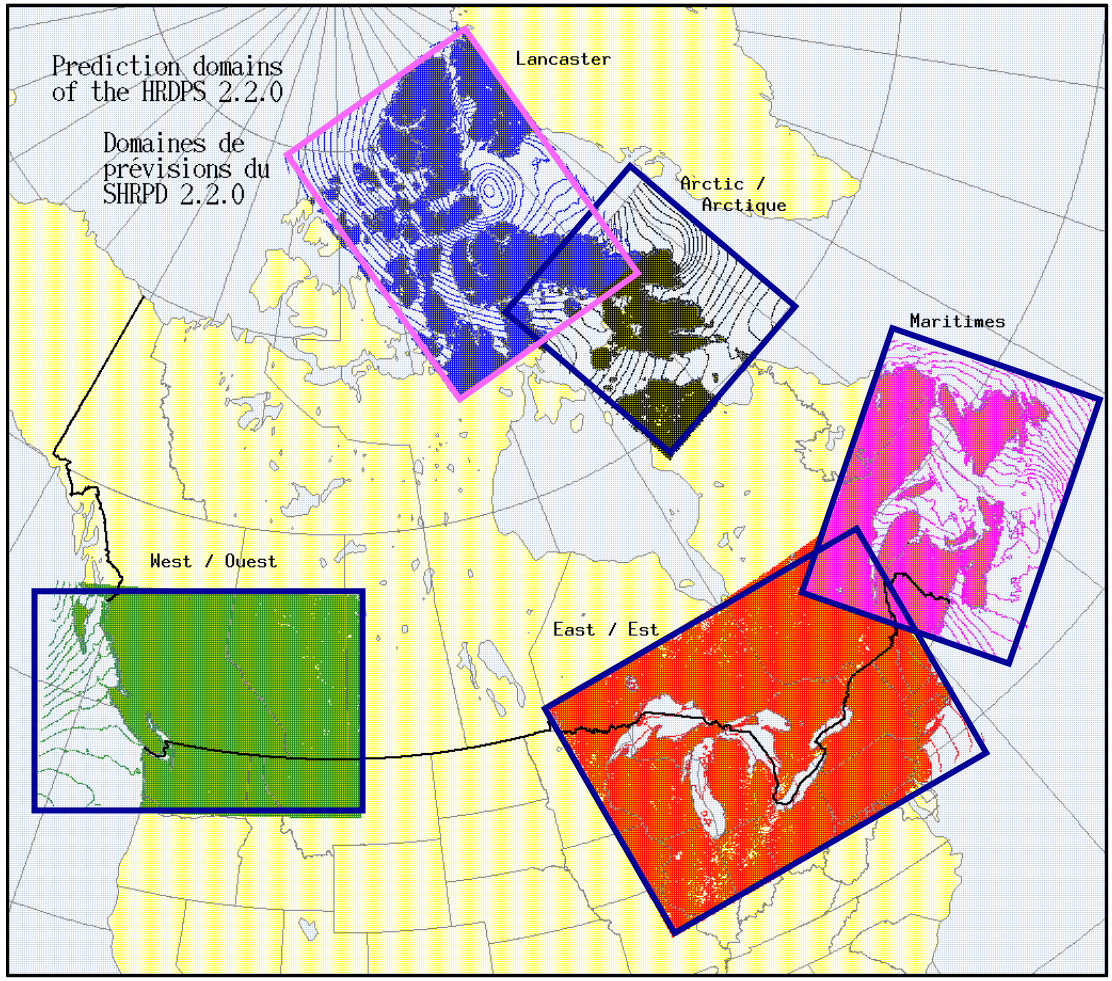
Pre-CPOP Seminar: May 10, 2012

Current Status of the HRDPS



- 4 “full-time” grids
- 1 “seasonal” grid
- Δz = 2.5 km
- 58 levels (staggered)
- one 24-h daily run (per domain)
- initialized from 00 UTC RDPS-15 run
- Intermediate 15-km LAMs
- GEM_v4.2.2
  - Li-Barker radiation
  - MY2 microphysics

Proposed Changes to HRDPS:

1. Upgrade for all domains

- switch to intermediate LAM-10 km grids (from LAM-15 km)
- switch to GEM_4.4.0 (from 4.2.2)

  + various bug fixes and improvements

  + evolving orography*
- switch sequencer to Maestro (from OCM)
- increased horizontal diffusion** to Hzd_lnr = 0.4 (from 0.2)
- snow depth limit (10 cm) over sea ice (as in RDPS)

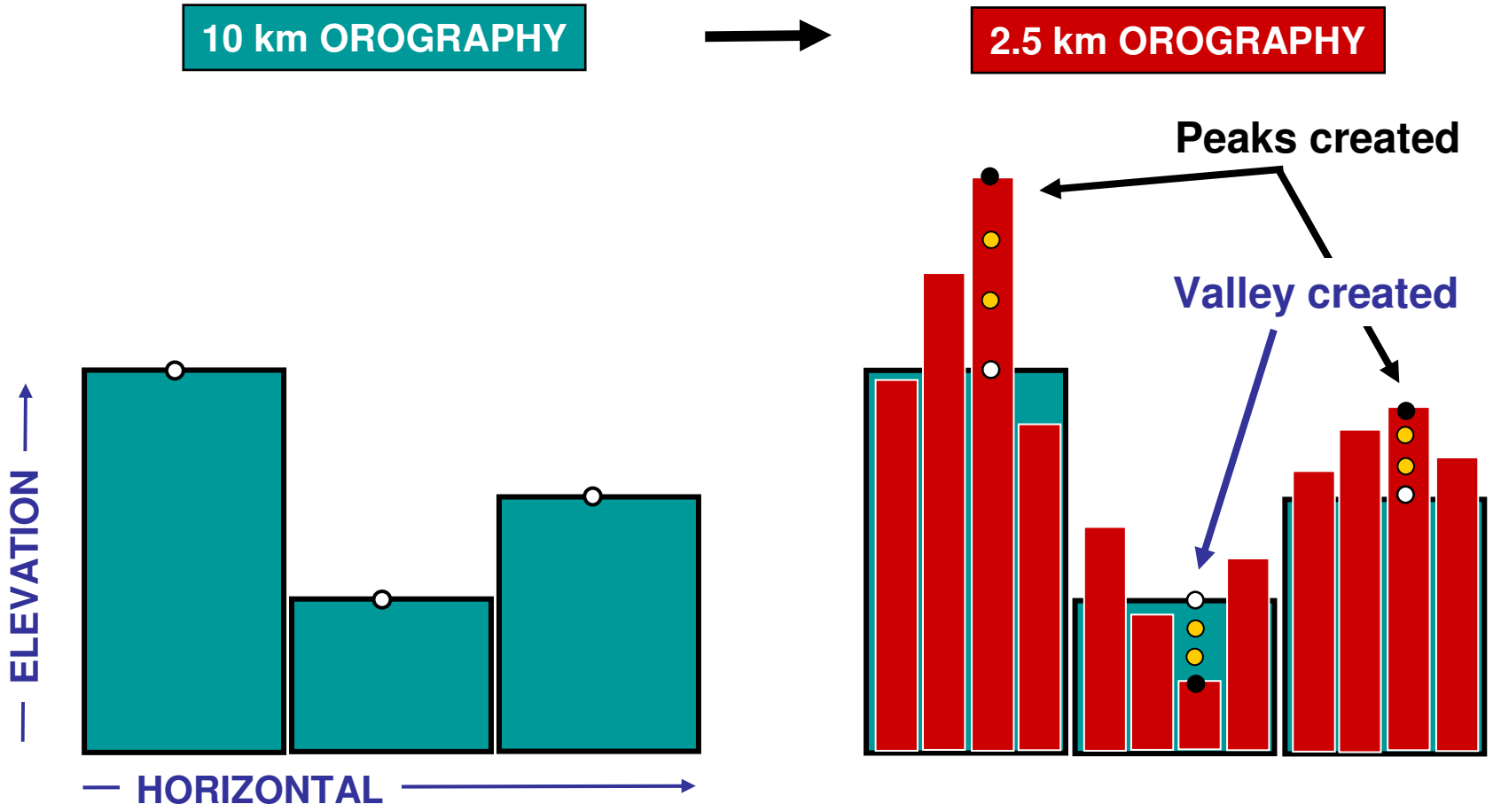
2. <u>Operational</u> status of WEST domain

- increase to TWO x 36-h integrations

* over 60 min period

** for all domains (as in current WEST)

Evolving Orography

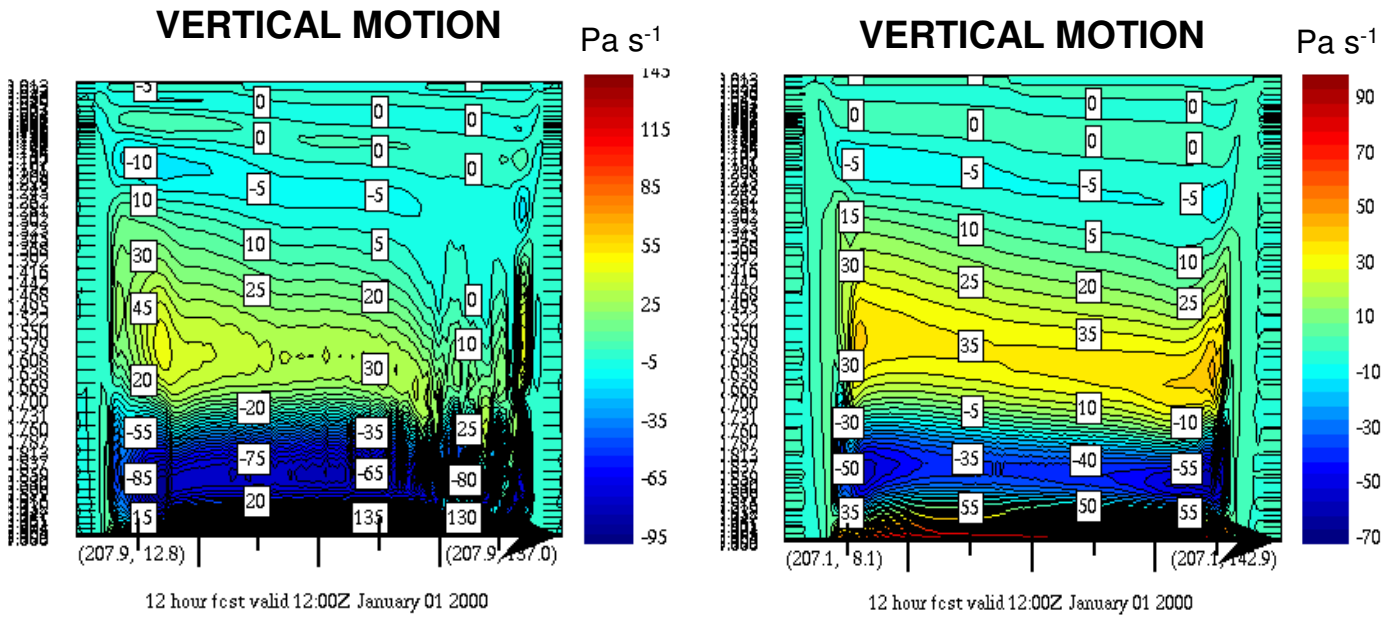


For 2.5-km integration, elevation an each grid point starts identical to 10-km grid and **<u>evolves gradually</u>** to final 2.5-km grid

Evolving Orography

Nesting from 10 km → 2.5 km involves orographic changes that cause imbalances during nesting:

- **Gravity waves** are generated as the dynamics come into balance



Vertical motion along an isolated ridge in an idealized simulation.

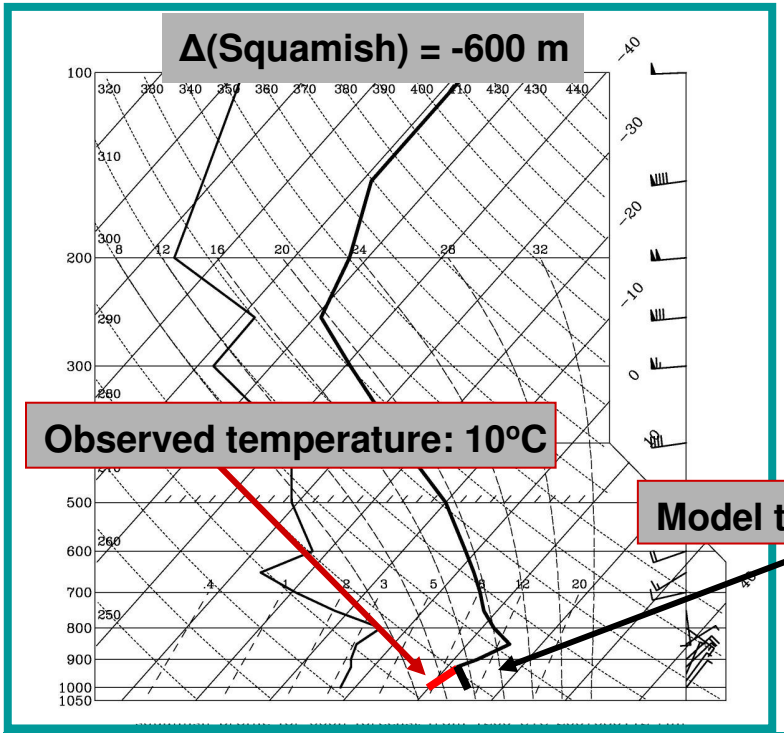
No evolving-orography (left) is compared with the final step of a **12-h** growth period (right).

c/o Ron McTaggart-Cowan

Evolving Orography

Nesting from 10 km → 2.5 km involves orographic changes that cause imbalances during nesting:

- **Gravity waves** are generated as the dynamics come into balance
- Effects of **subterranean extrapolation** can be long-lived



Extrapolated 6.5°C km^{-1} lapse rate and constant winds cause an initial error of 7ºC at Squamish on the 1-km grid.

Without evolving-orography, this nocturnal inversion cannot be re-established before sunrise in the model.

c/o Ron McTaggart-Cowan

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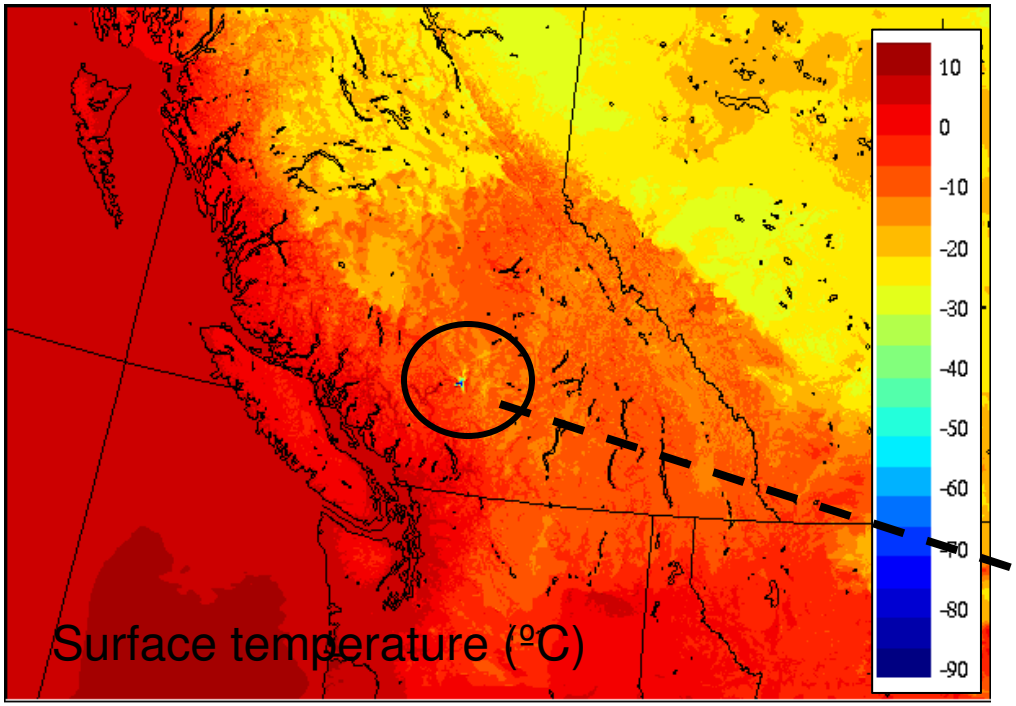
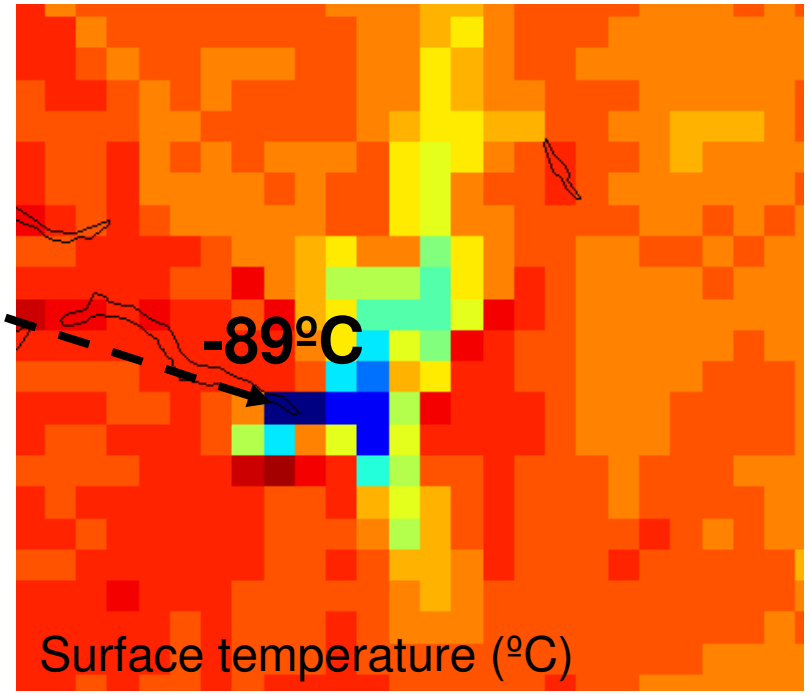
Migration to P7 – CRASH Case

(20 January 2012)



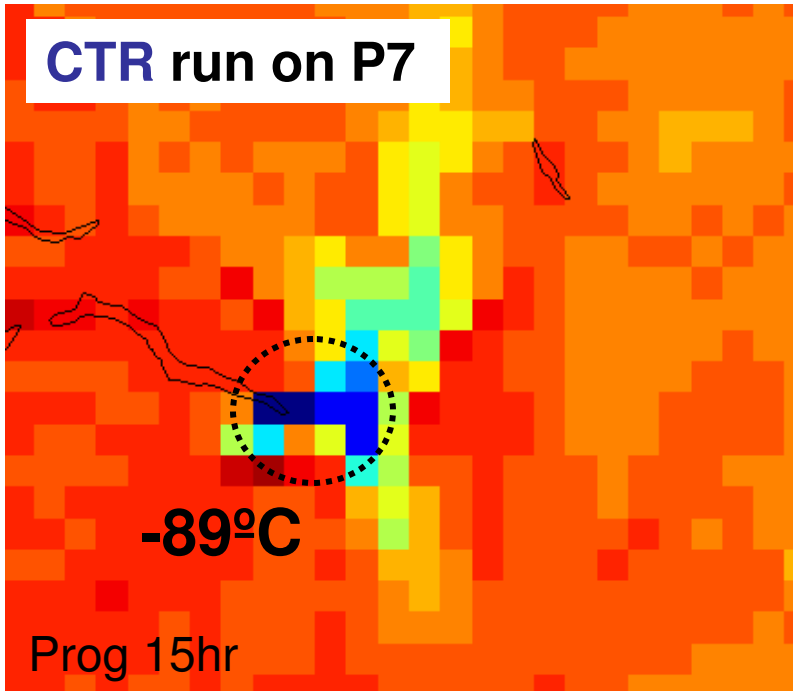


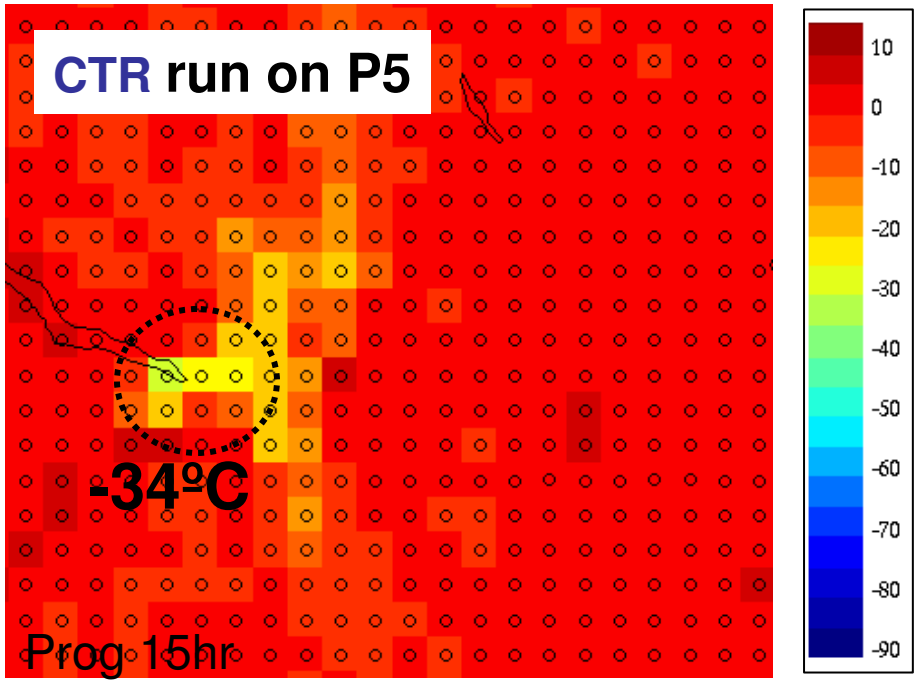
- Surface temperature drop to -114ºC
- Problem occurs in a valley with strong topography gradient

Migration to P7 – CRASH Case

(20 January 2012)

Surface temp. (just before crash)





GEM blocstat (at the time of P7 crash):

P7: timestep 1010: Min TT:[(322,229, 57) 0.1590266E+03] (-114ºC)

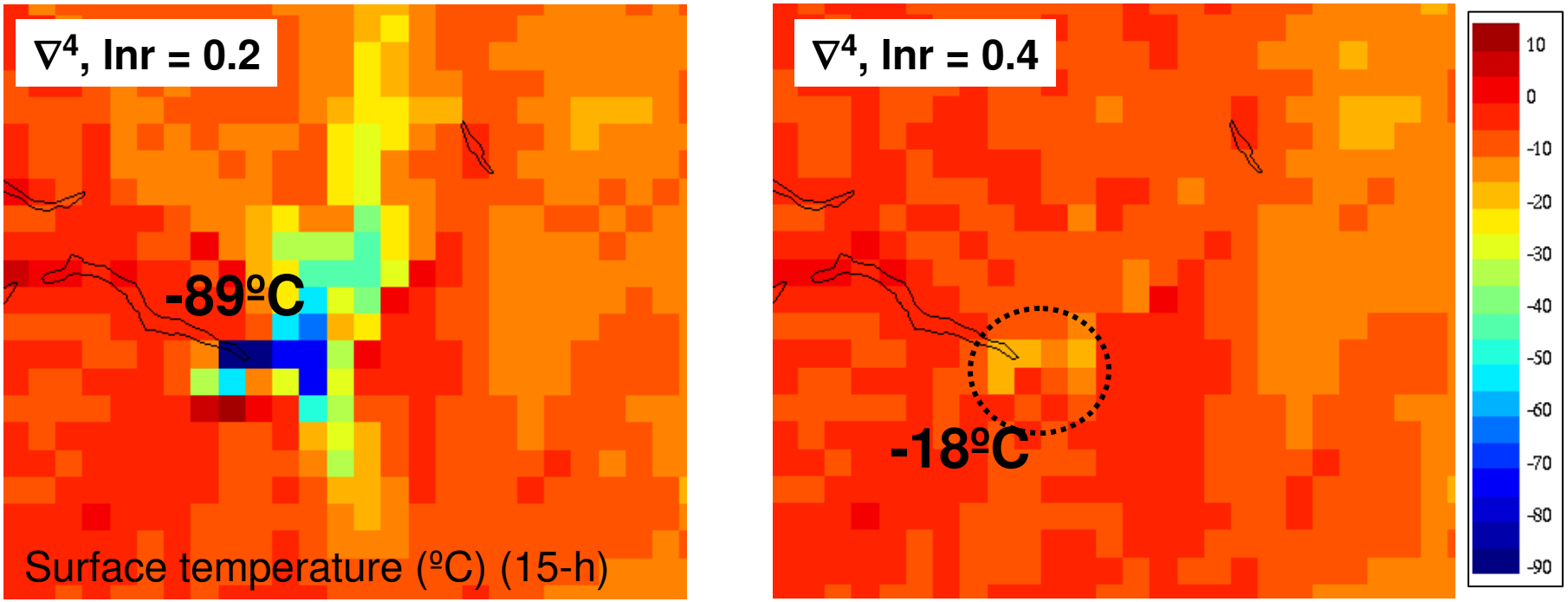
P5: timestep 1010: Min TT:[(322,229, 57) 0.1670150E+03] (-106ºC)

Migration to P7 – CRASH Case

(20 January 2012)

CTR:* Weak diffusion

EXP:* Moderate diffusion



Proposed solution:

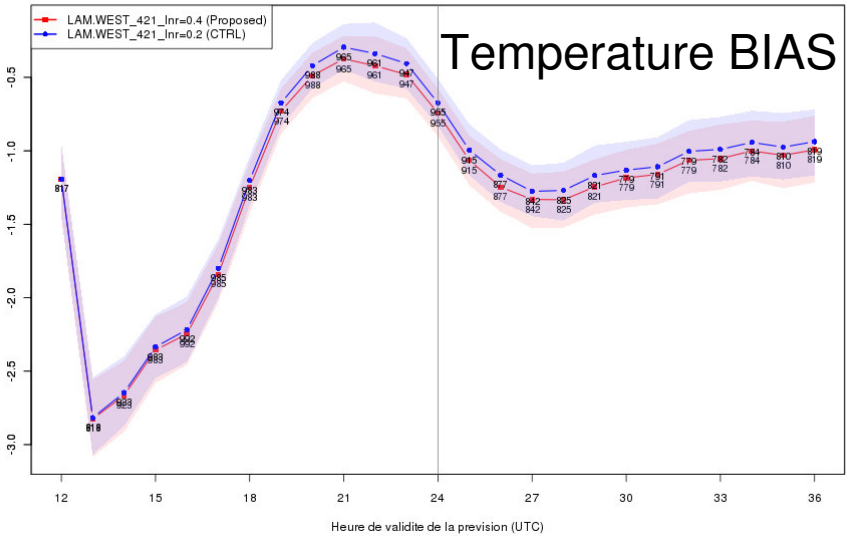
Increase horizontal diffusion ∇^4, Hzd_lnr = 0.4

* Both with unfiltered orography

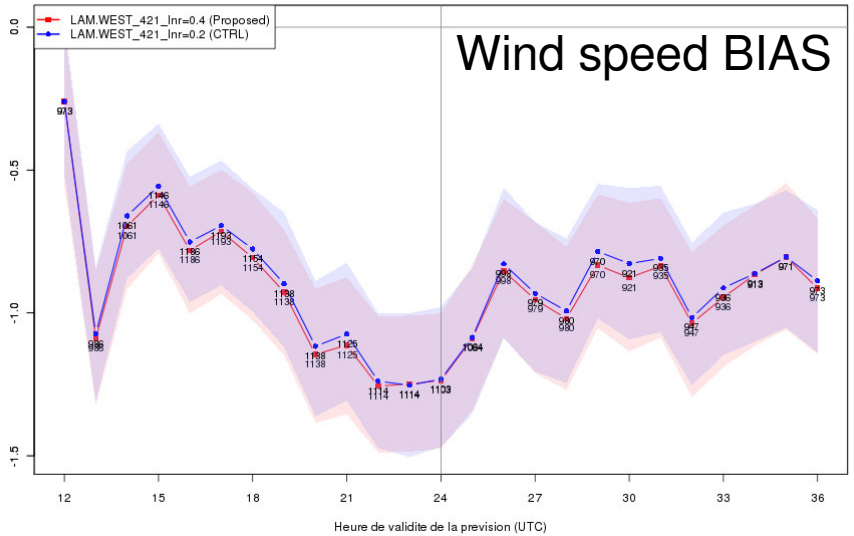
Testing Fix: Re-ran 15 winter cases

CTR (∇^4, lnr=0.2)
EXP (∇^4, lnr=0.4)

BIAIS (P-O) DE LA TEMPERATURE EN SURFACE (K)
periode du 2010-01-01 au 2010-02-13



BIAIS (P-O) DU MODULE DU VENT (NOEUDS)
periode du 2010-01-01 au 2010-02-13



ECART-TYPE DE LA TEMPERATURE EN SURFACE (K)
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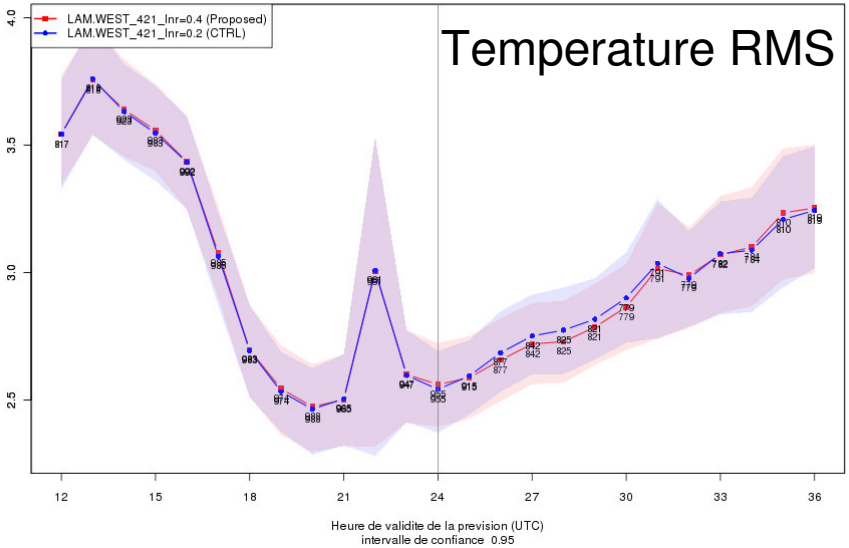
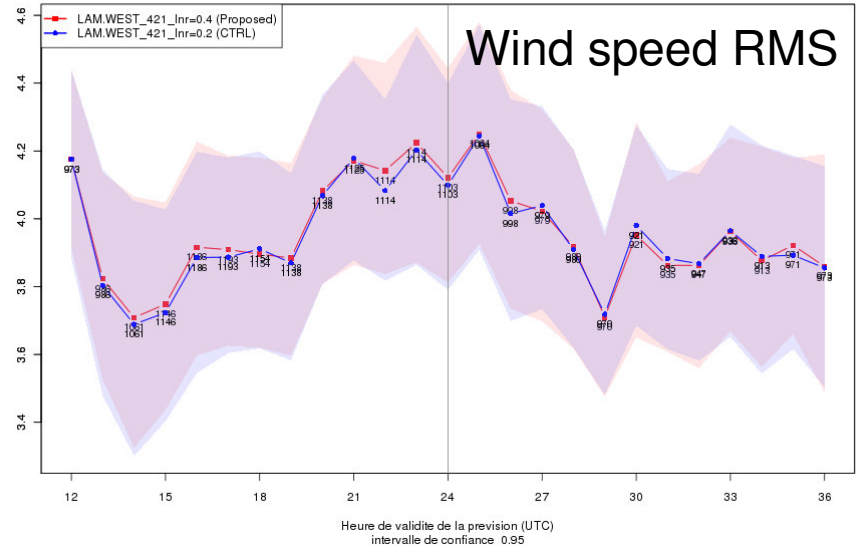


ECART-TYPE DU MODULE DU VENT (NOEUDS)
periode du 2010-01-01 au 2010-02-13



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2. <u>Operational</u> status of WEST domain

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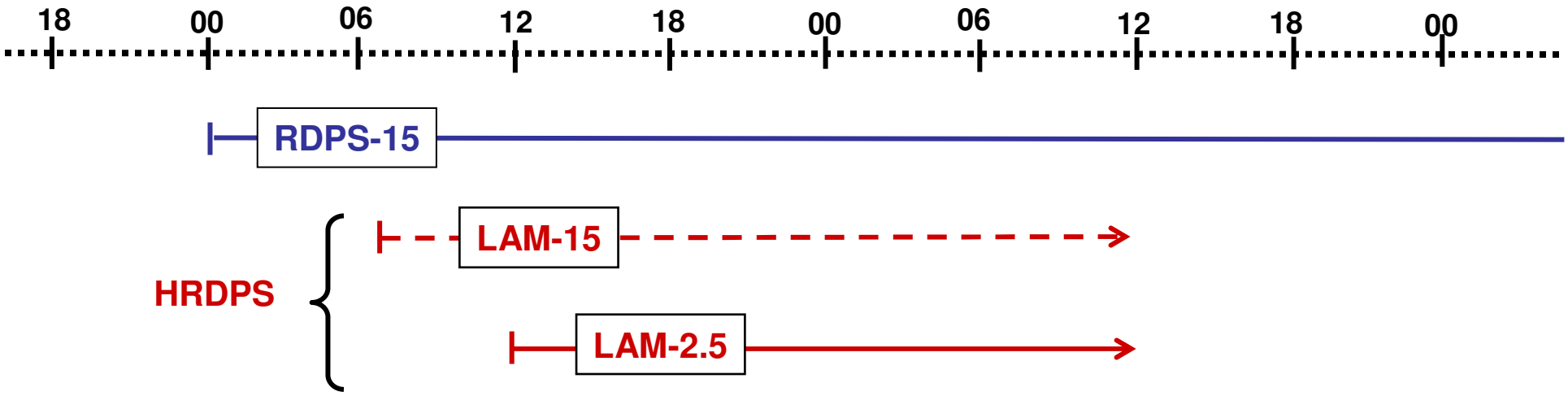
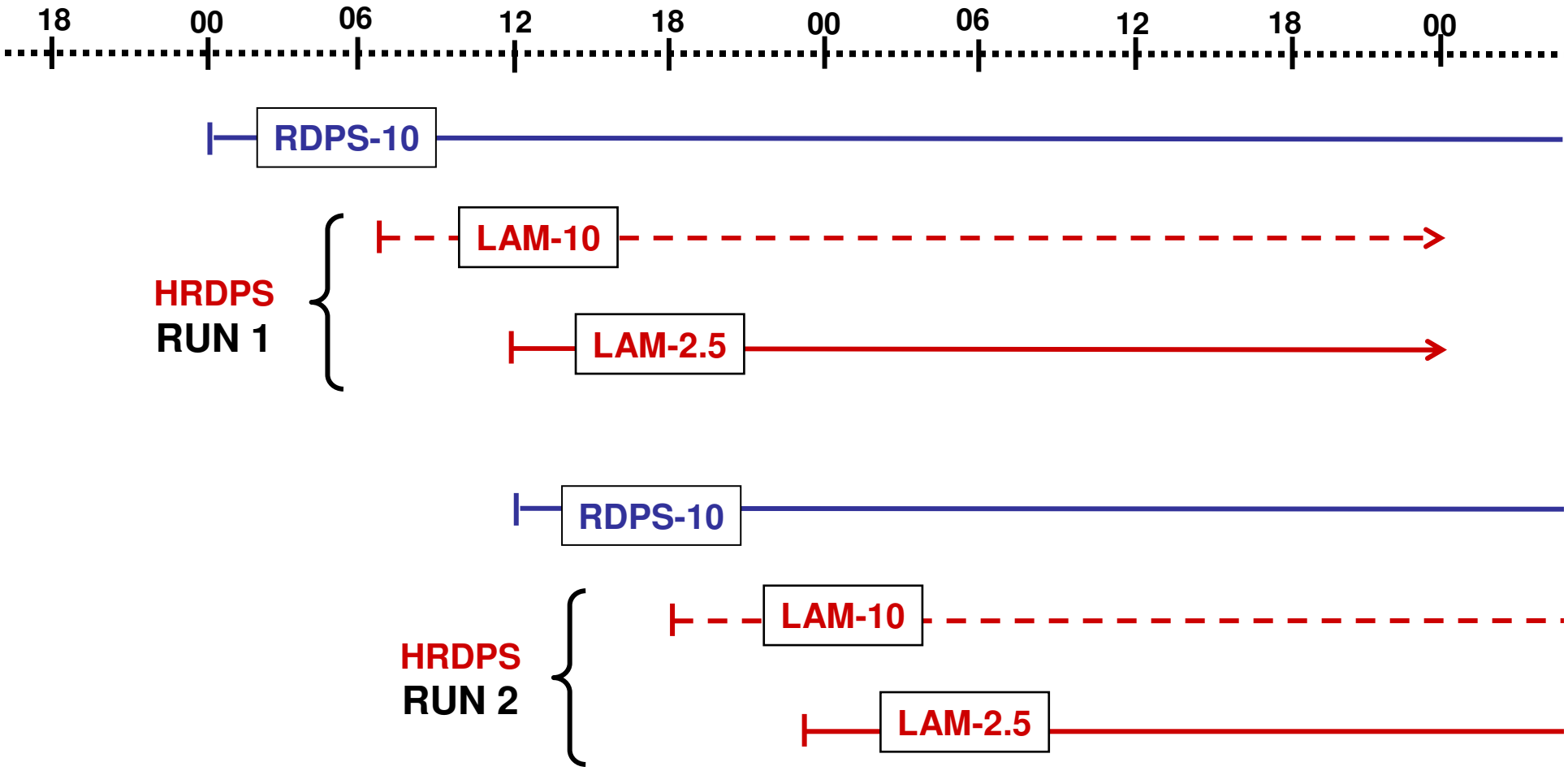
Current Experimental WEST Run

- 1 LAM-2.5km runs per day, 24-h
- Nested from 6-h forecasts of 00z-REG-15



Proposed Operational WEST Runs

- 2 LAM-2.5km runs per day, 36-h
- Nested from 6-h forecasts of 00z- and 12z-REG-10 runs



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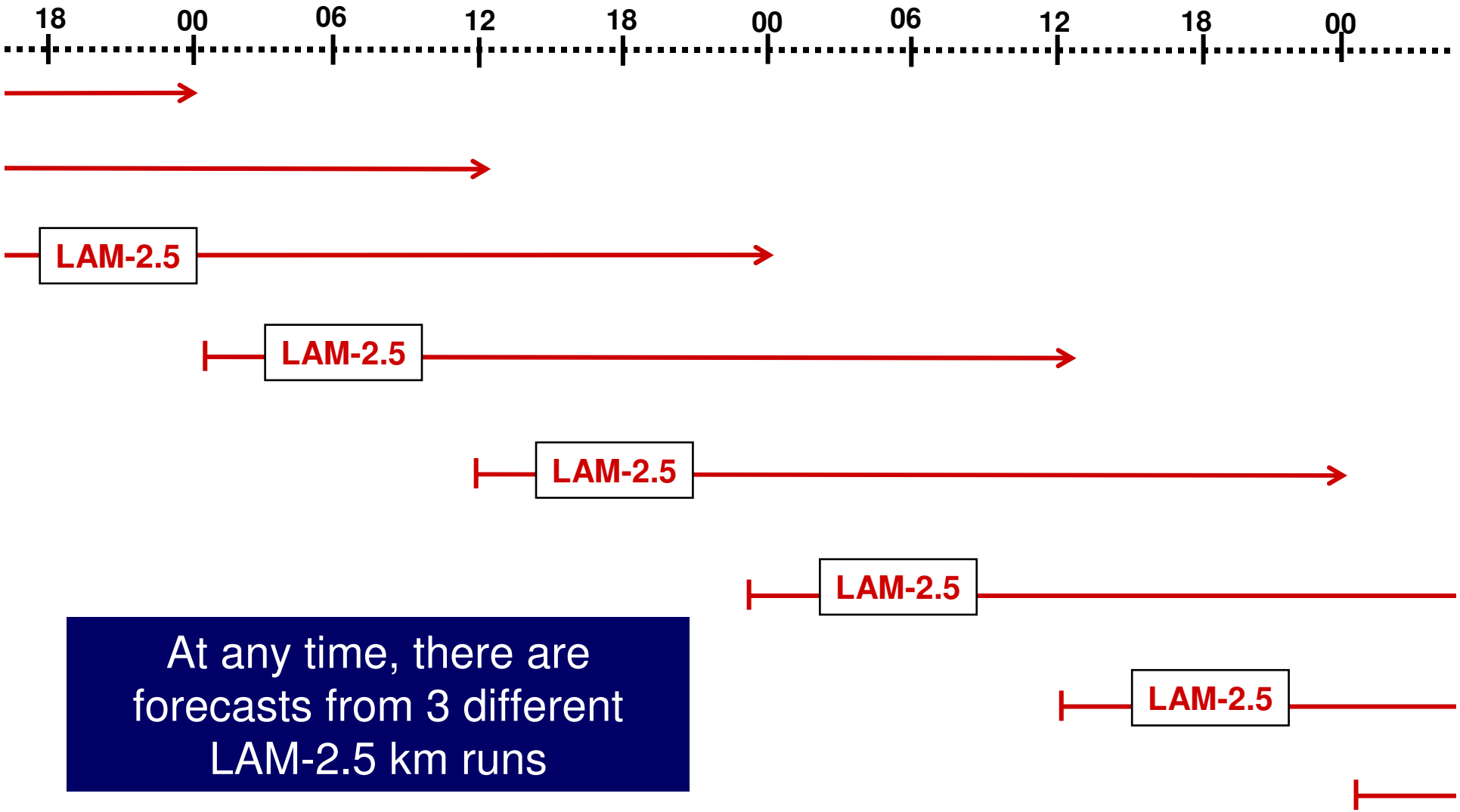


At any time, there are forecasts from 3 different LAM-2.5 km runs

Preparation for Proposed Upgrade

- Establishment of formal CPOP standards
- Consultation with primary clients (PYR, CMAC-West)
- Timing for new WEST runs (2×36 h)
- Test changes to experimental system (based on standards)
- Development of operational Maestro suite [in progress]
- pre-CPOP seminar [in progress]

Testing Changes

Experiment 1:

CTR_1: (RDPS-15) + **HRDPS_v2.2.0**

EXP_1: (RDPS-15) + **HRDPS_v2.3.0 (proposed)**

4 domains
(west, east, maritime, Arctic)

120 runs – 15 winter, 15 summer, 4 grids

Winter:	January 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, February 3, 6, 9, 12	(2010)
Summer:	July 1, 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, August 3, 6, 9, 12	(2010)

→ **Are the changes to the HRDPS (only) positive?**

Experiment 2:

CTR_2: **RDPS-15 + HRDPS_v2.2.0**

EXP_2: **RDPS-10 + HRDPS_v2.3.0 (proposed)**

1 domain
(west)

30 runs – 15 winter, 15 summer, 1 grids

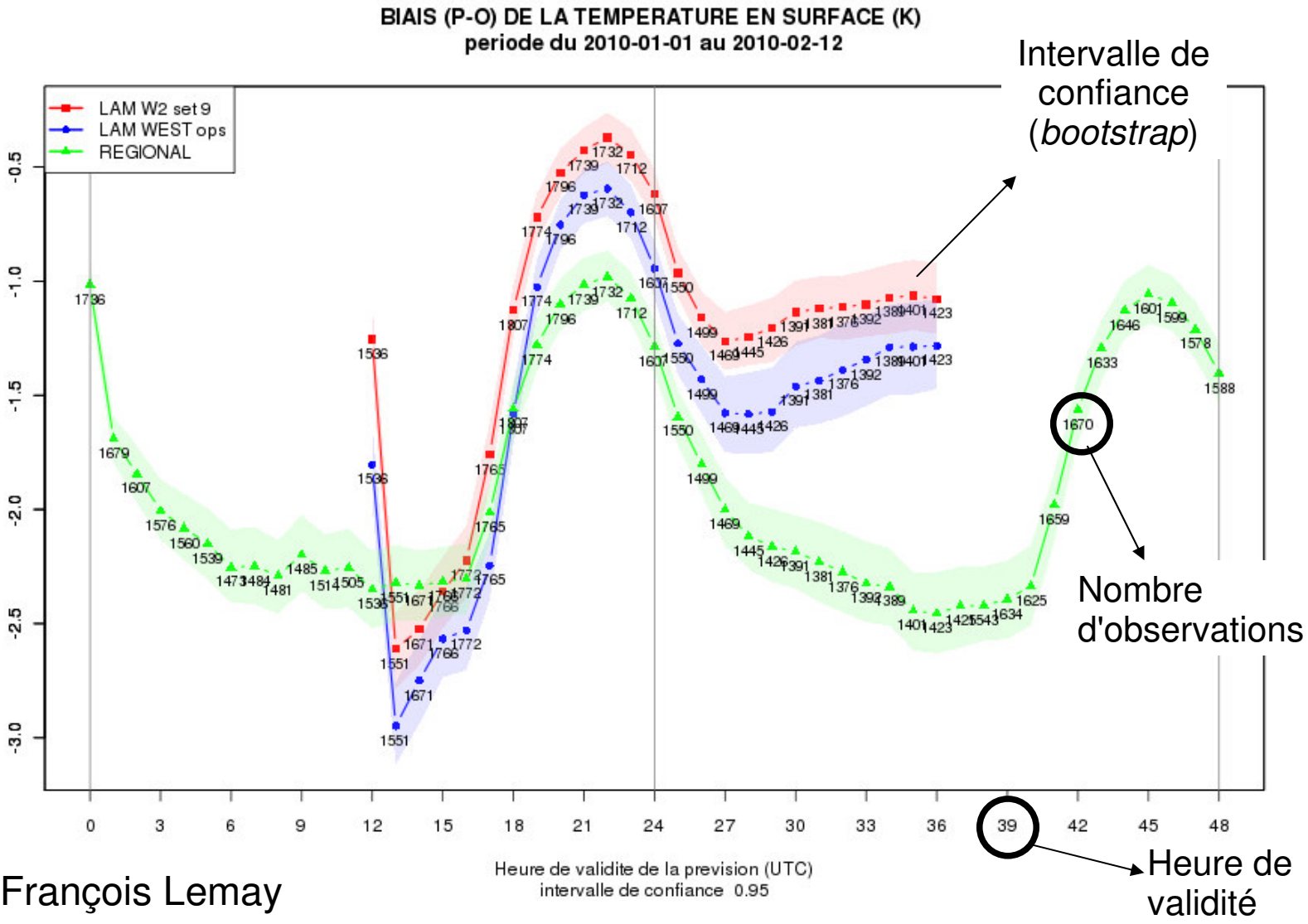
Winter:	Jan 22, 25, 28, 31, Feb 3, 6, 9, 12, 15, 18, 21, 24, 27, Mar 3, 6	(2011)
Summer:	May 17, 20, 23, 26, 29, June 1, 4, 7, 10, 13, 16, 19, 22, 25, 29	(2011)

→ **Will the combined changes to the RDPS and HRDPS be positive?**

EMET

Verification:

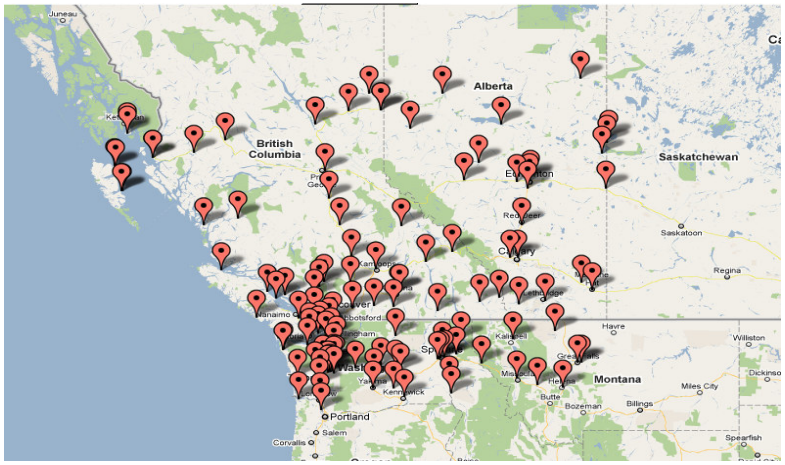
T (2 m), ***Td*** (2 m), ***V_speed*** (10 m), ***V_dir*** (10 m)



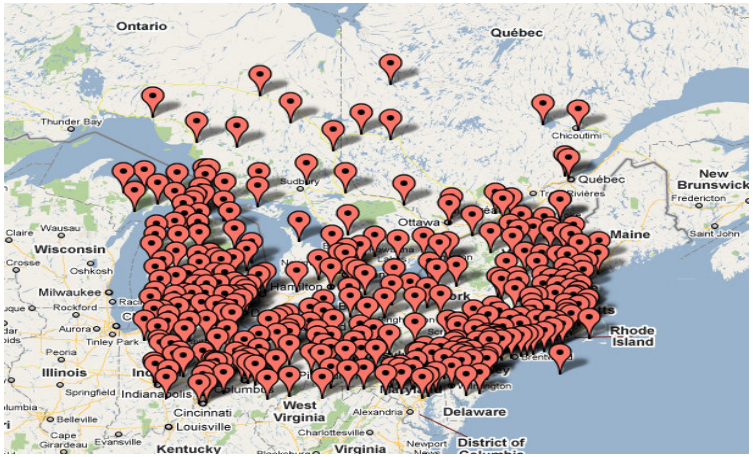
c/o François Lemay

Couverture des données METAR

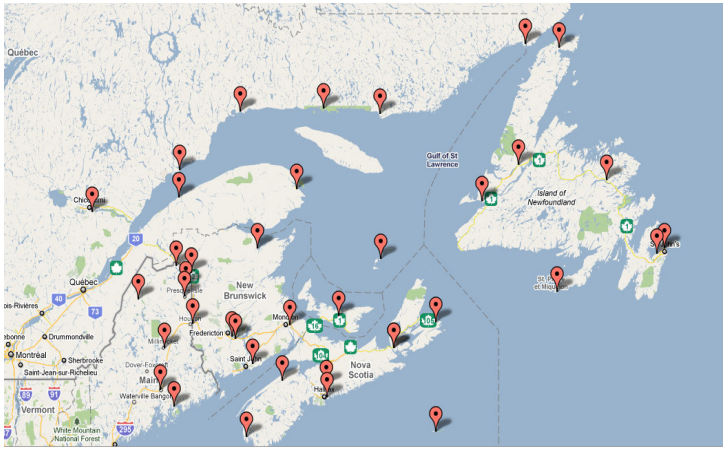
LAM-2.5 OUEST



LAM-2.5 EST



LAM-2.5 MARITIMES



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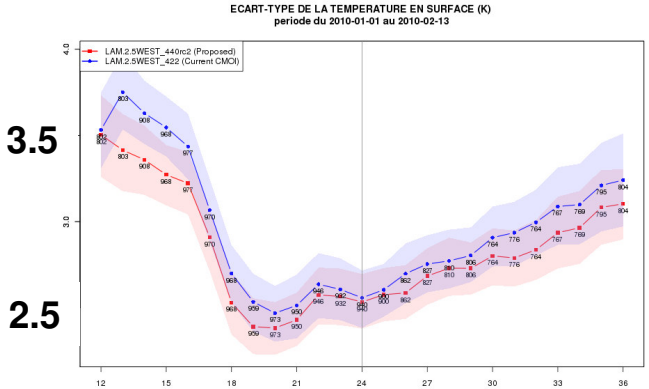
T (2 m)

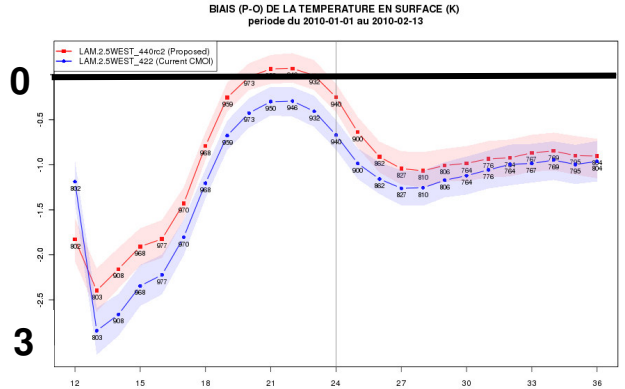
Hiver
Winter

Écart-type / *RMSE*
(biais corrigé / bias corrected)

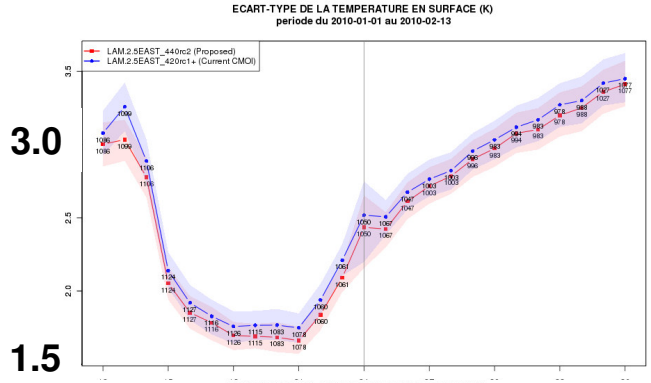
Biais / *Bias*

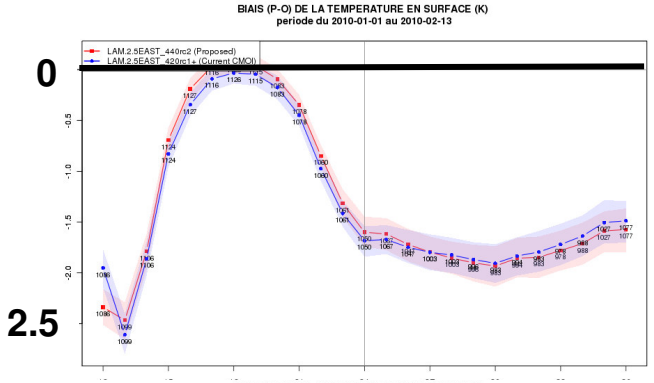
Ouest
West



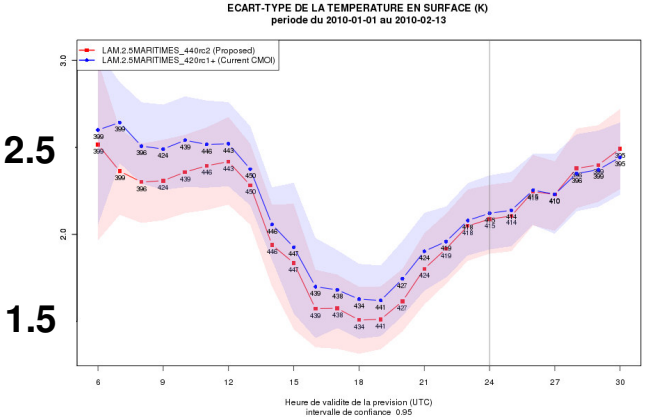


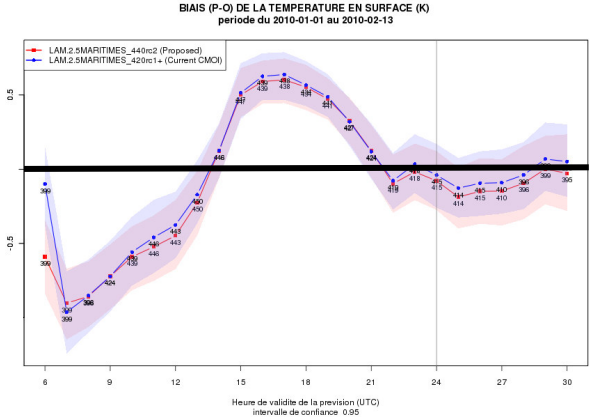
Est
East





Maritimes





Td (2 m)

Écart-type / *RMSE*
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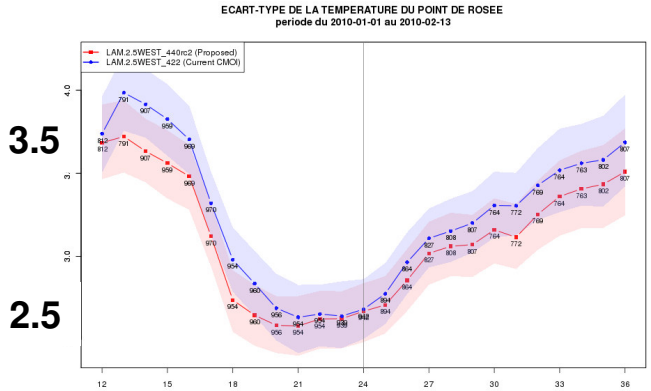
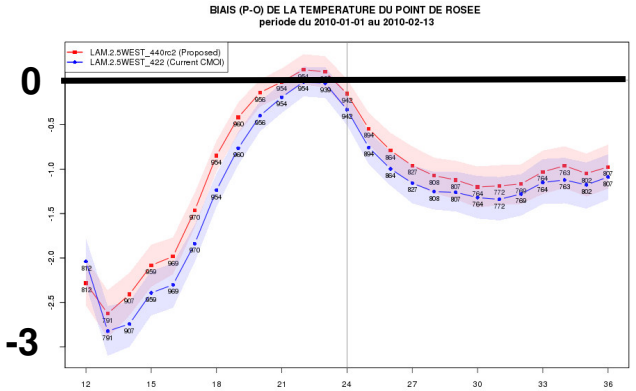
Biais / *Bias*

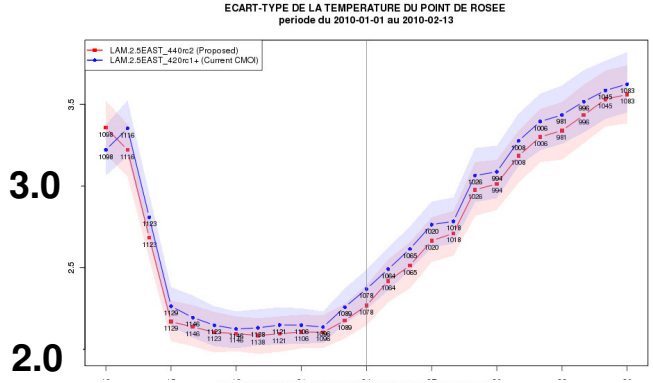
Hiver
Winter

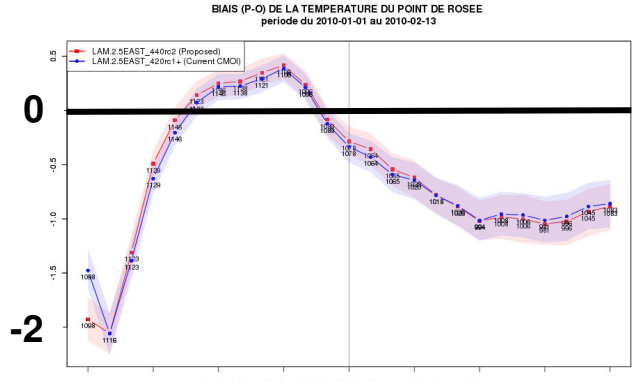
Ouest
West





Est
East





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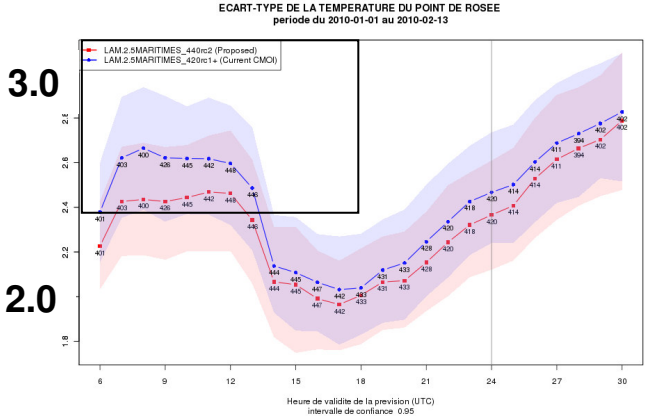
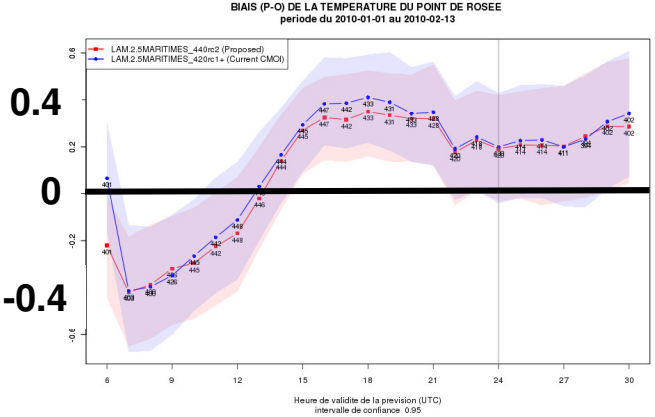




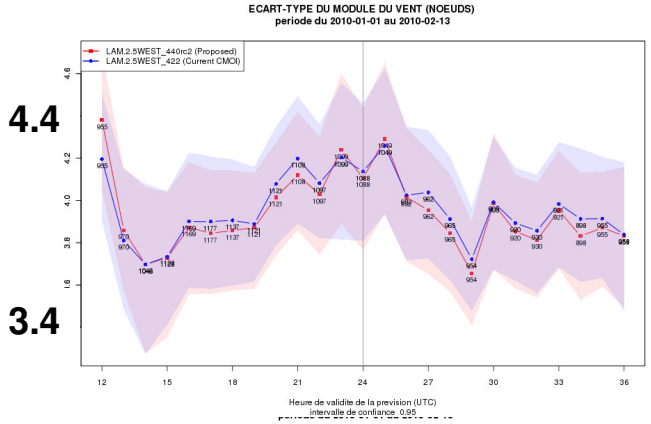
Vspd (10 m)

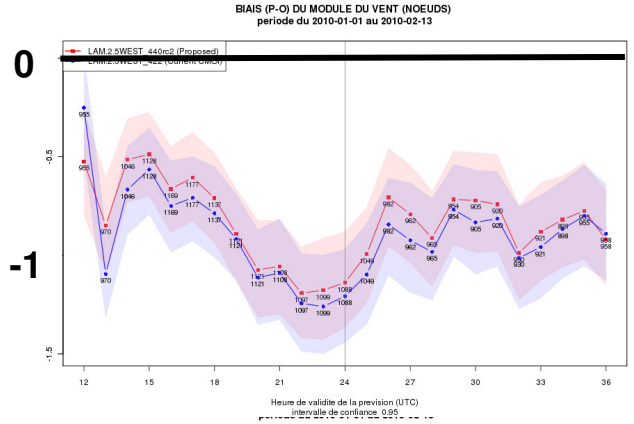
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

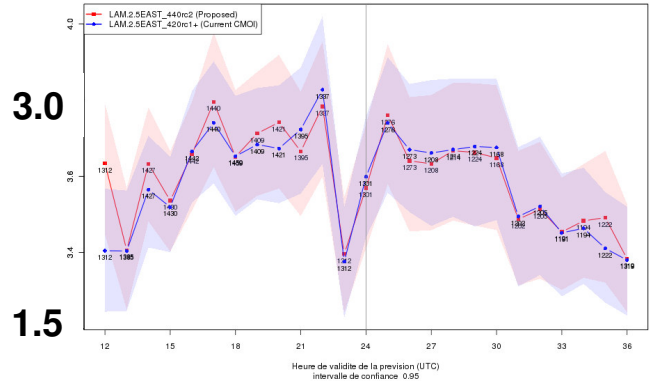
Hiver
Winter

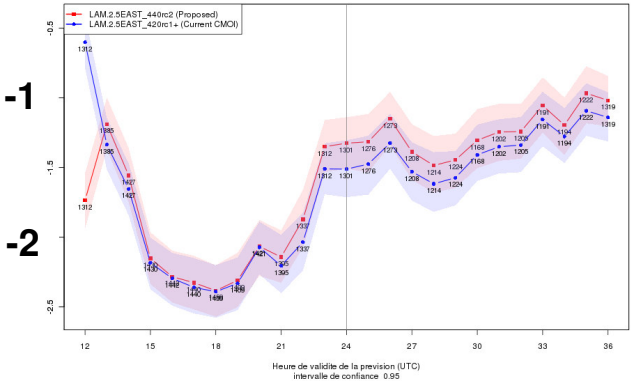
Ouest
West



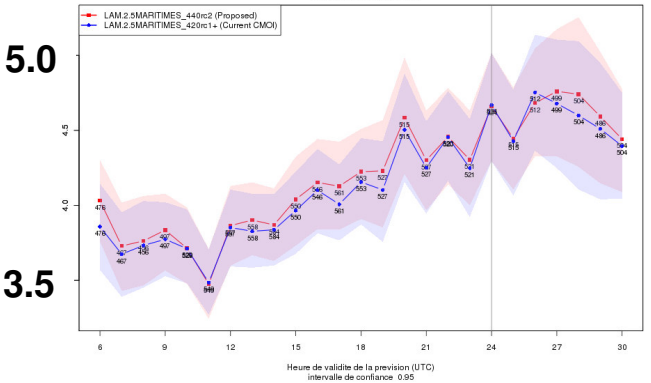


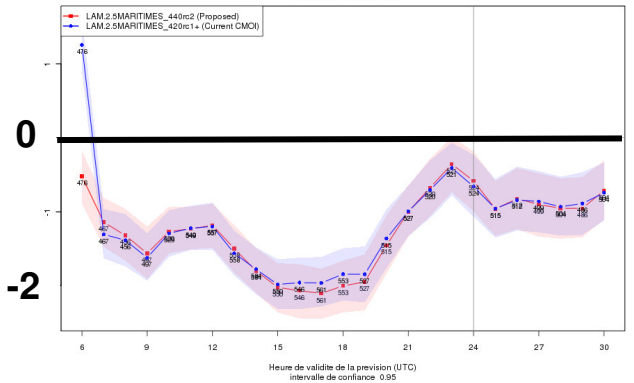
Est
East





Maritimes





Vdir (10 m)

Hiver
Winter

Écart-type / *RMSE*
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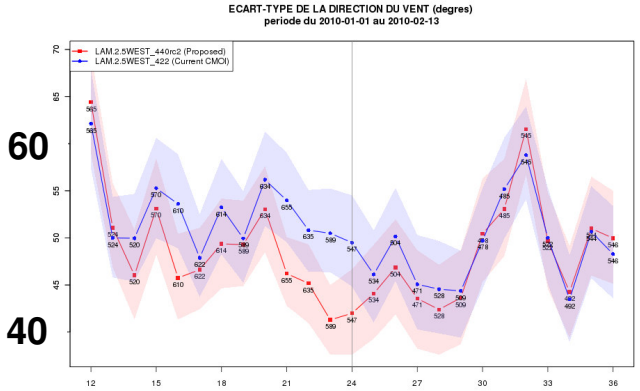
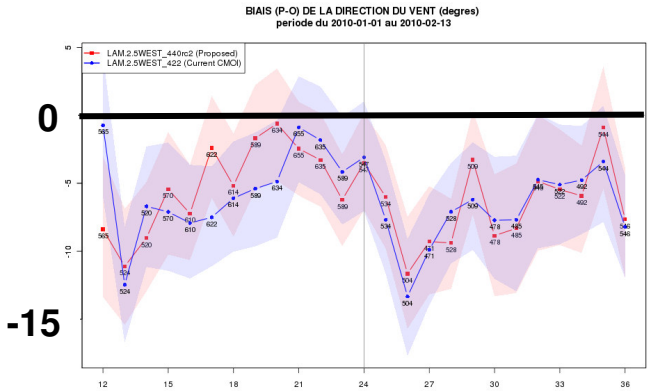
Biais / *Bias*

Ouest
West





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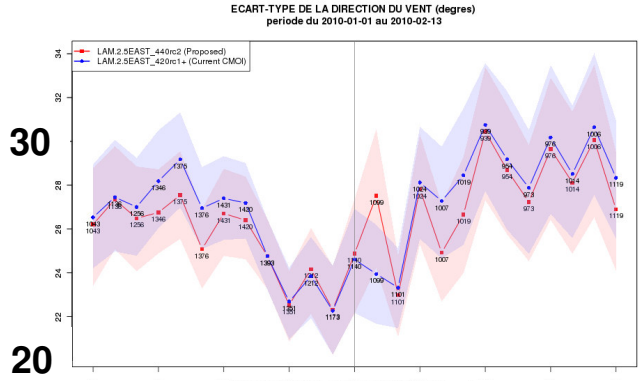
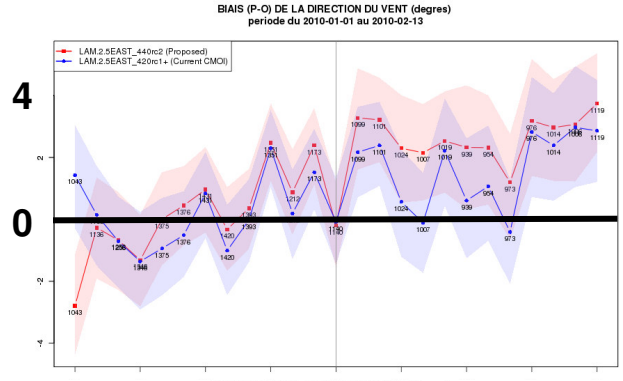
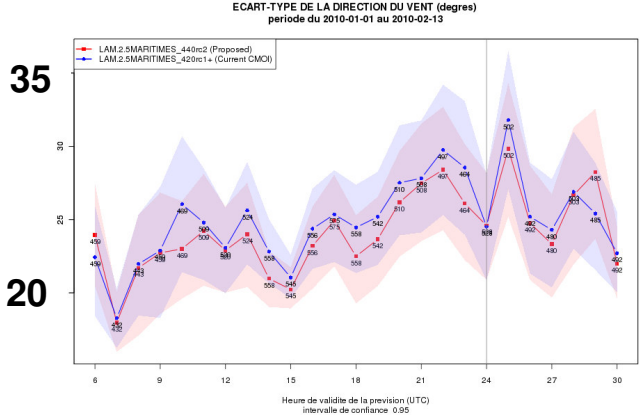
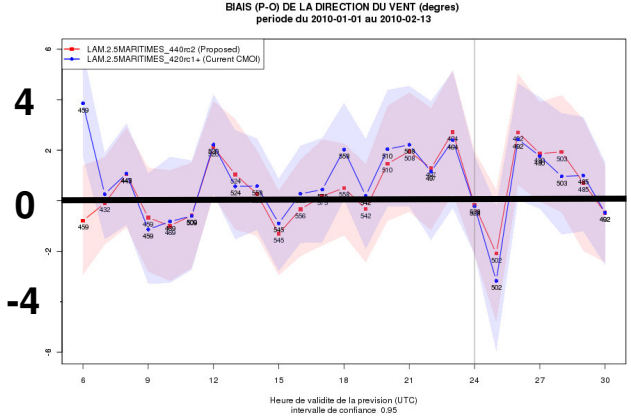




Maritimes





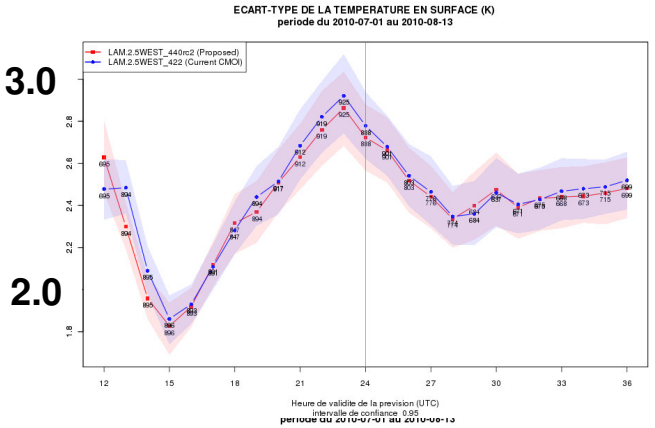
T (2 m)

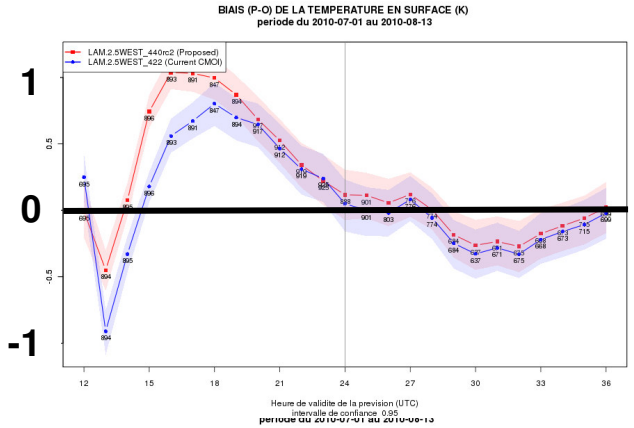
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

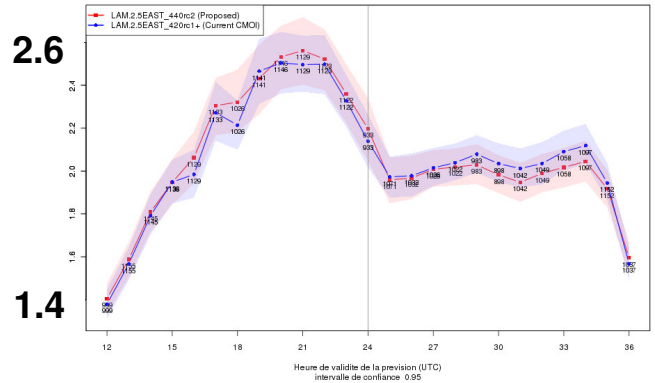
Summer
Été

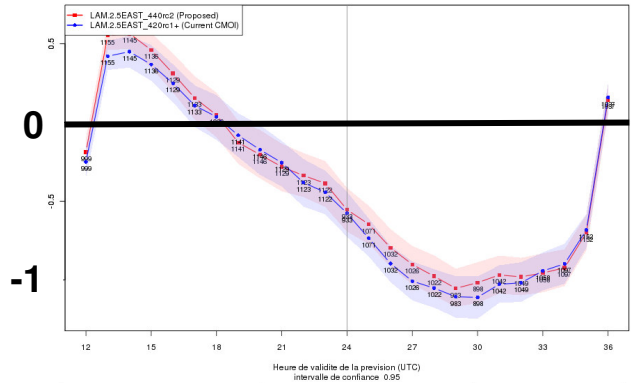
Ouest
West



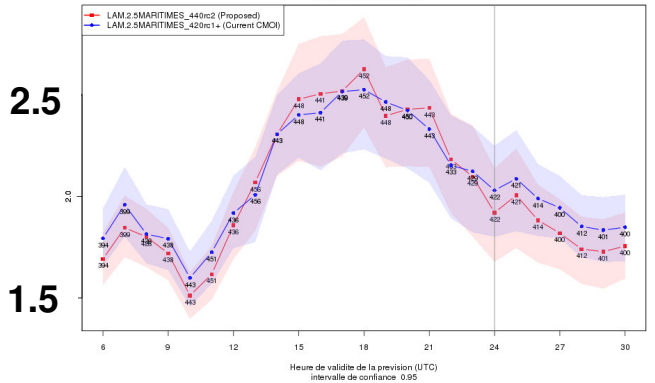


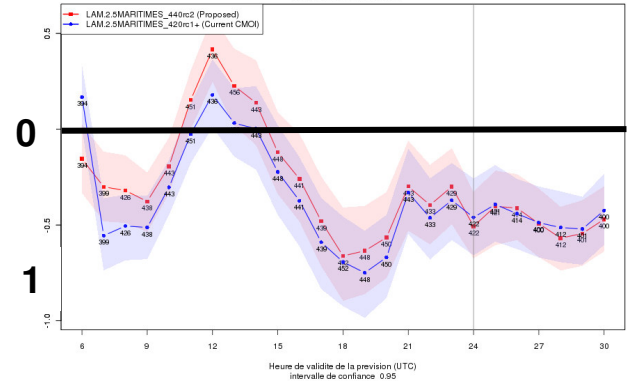
Est
East





Maritimes





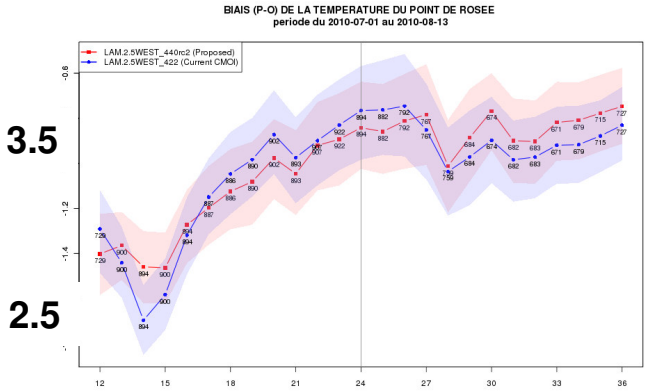
Td (2 m)

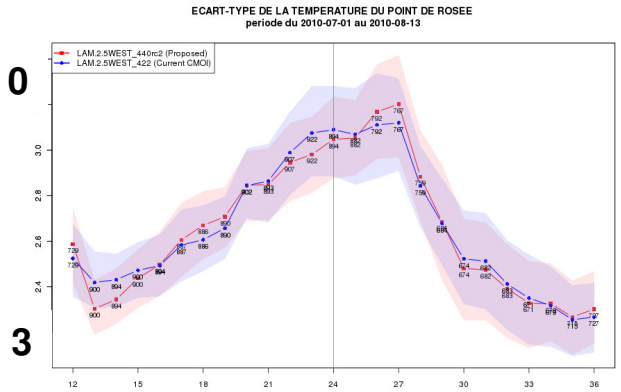
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

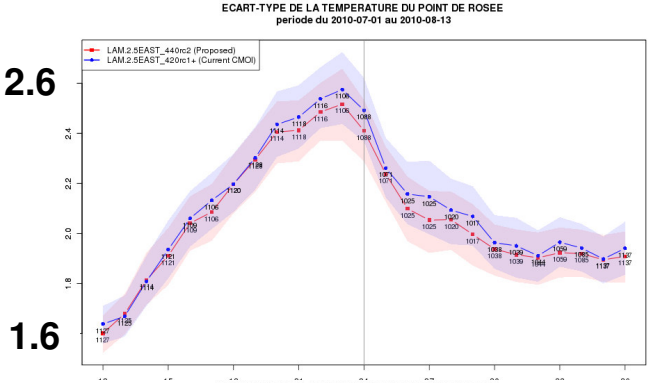
Summer
Été

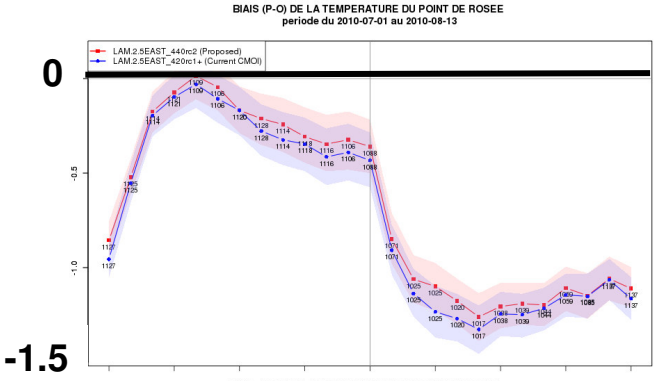
Ouest
West



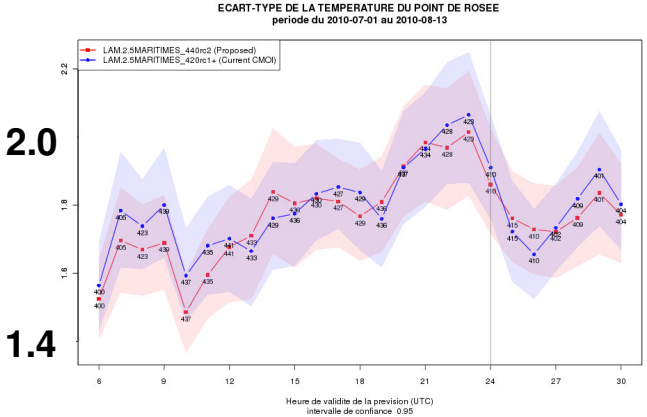


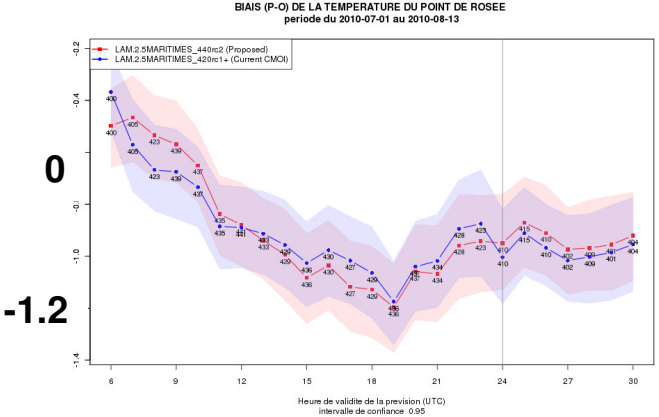
Est
East





Maritimes





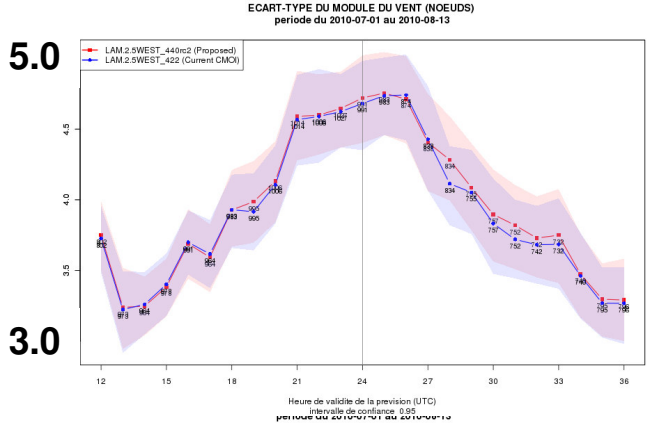
Vspd (10 m)

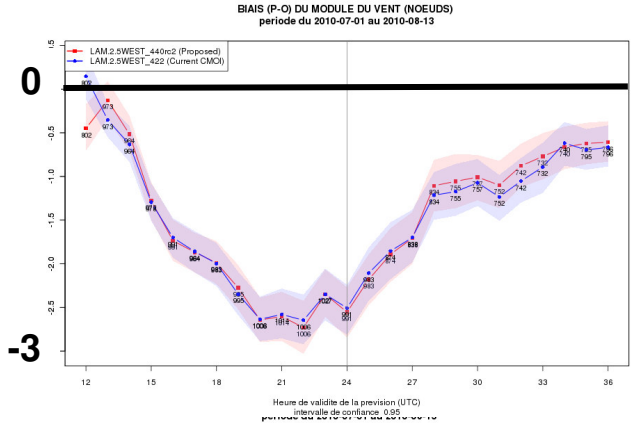
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

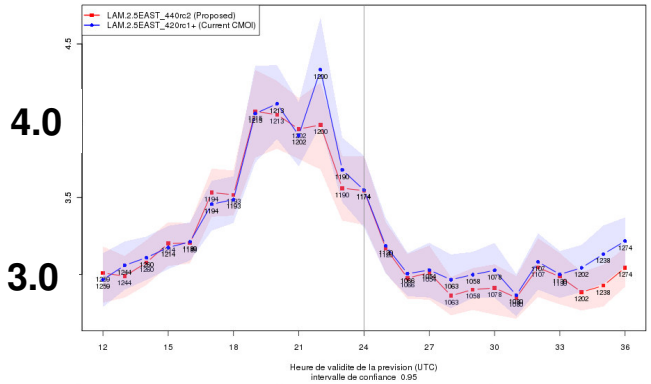
Summer
Été

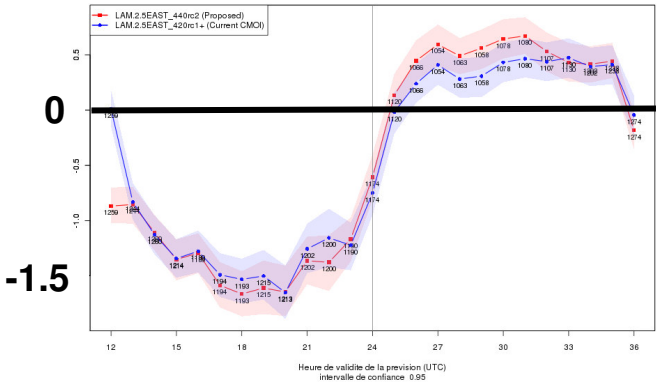
Ouest
West



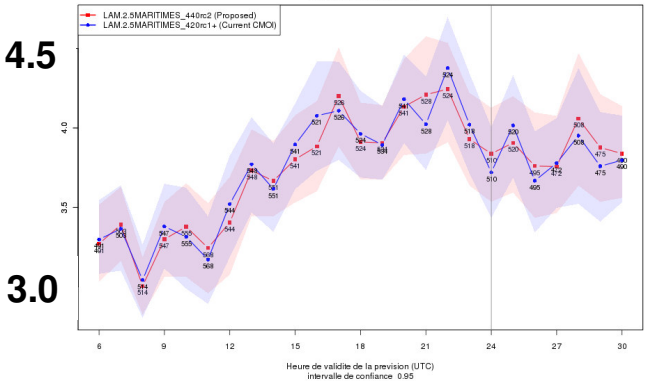


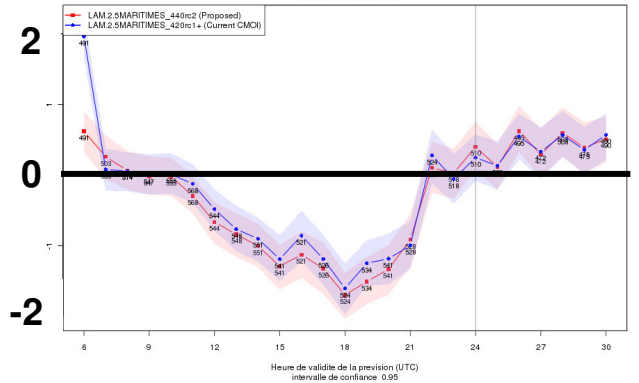
Est
East





Maritimes





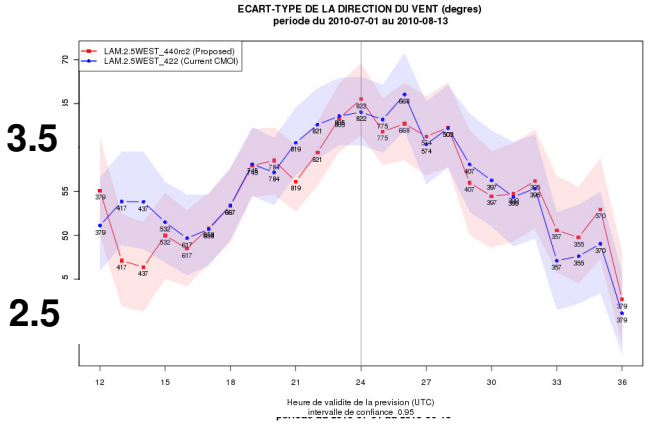
Vdir (10 m)

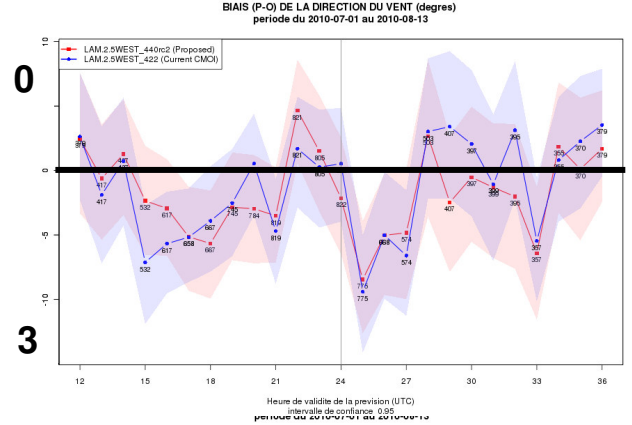
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

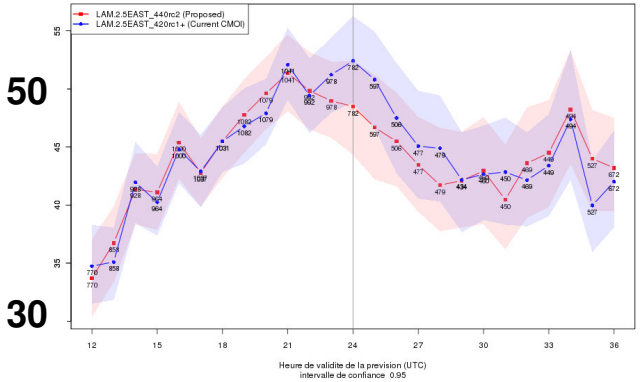
Summer
Été

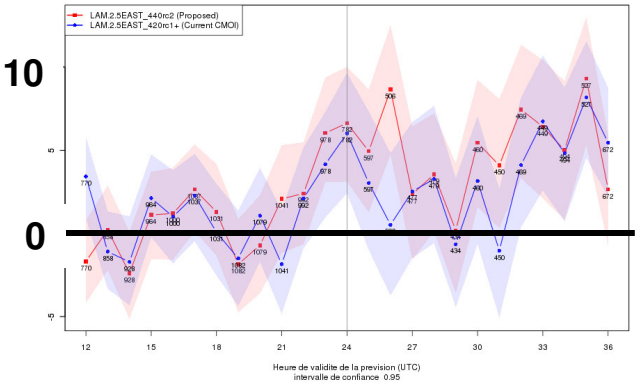
Ouest
West



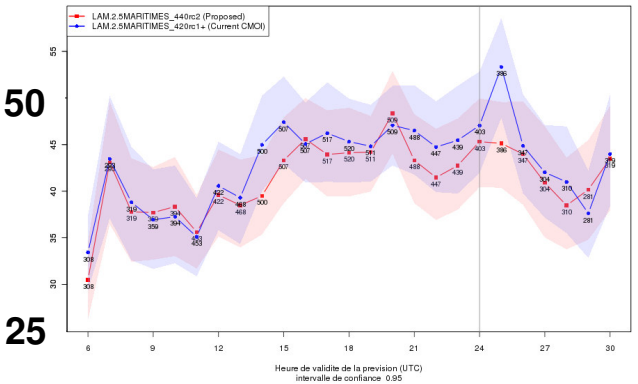


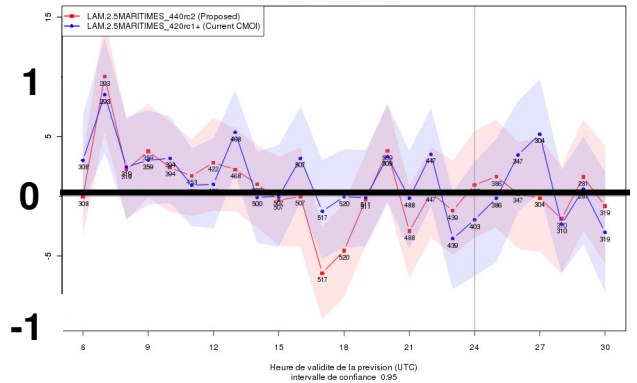
Est
East





Maritimes





Experiment 1*:

CTR_1: (RDPS-15) + **HRDPS_v2.2.0**

EXP_1: (RDPS-15) + **HRDPS_v2.3.0 (proposed)**

4 domains
(west, east, maritime, Arctic)

SUMMARY OF VERIFCATION:

- slight improvement in RMSE for T and Td (2 m)
- systematic increase in T and Td (2 m)
- negligible affect on winds (10 m)

* Due to changes to HRDPS only

Experiment 1:

CTR_1: (RDPS-15) + **HRDPS_v2.2.0**

EXP_1: (RDPS-15) + **HRDPS_v2.3.0 (proposed)**

4 domains
(west, east, maritime, Arctic)

Experiment 2:

CTR_2: **RDPS-15 + HRDPS_v2.2.0**

EXP_2: **RDPS-10 + HRDPS_v2.3.0 (proposed)**

1 domain
(west)

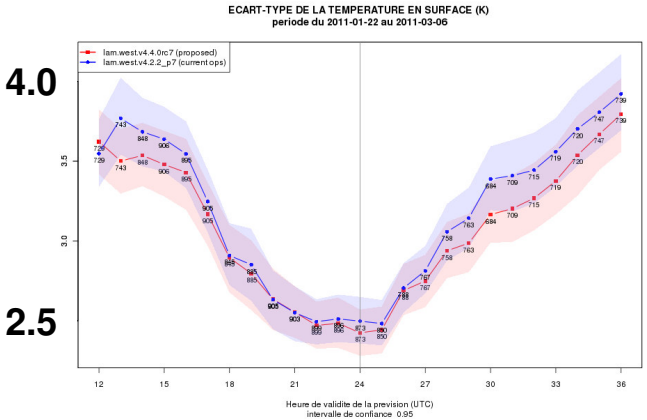
Ouest
West

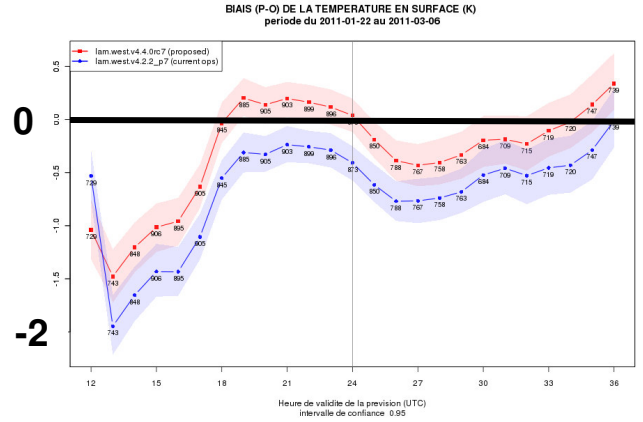
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

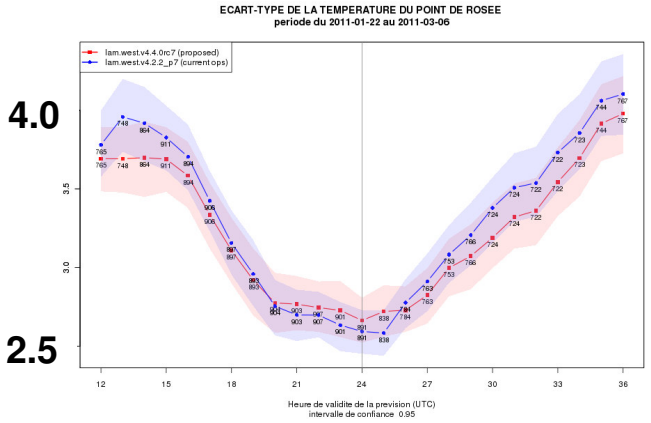
Hiver
Winter

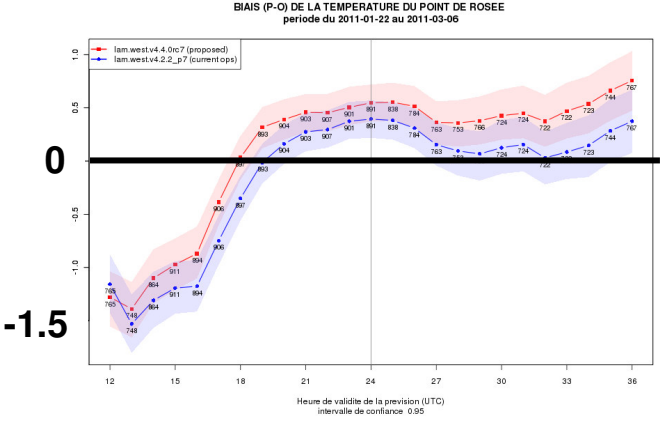
T (2 m)





Td (2 m)





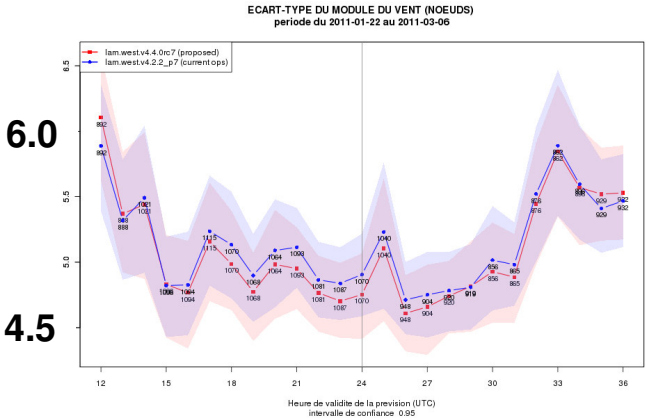
Ouest
West

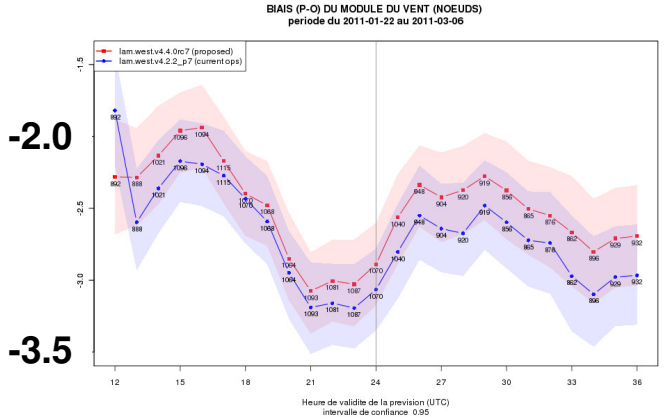
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

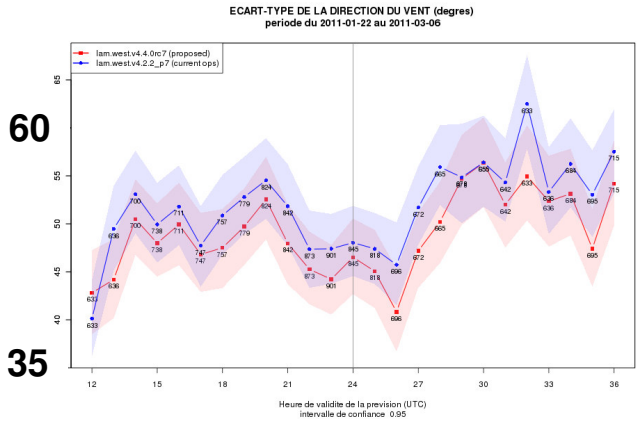
Hiver
Winter

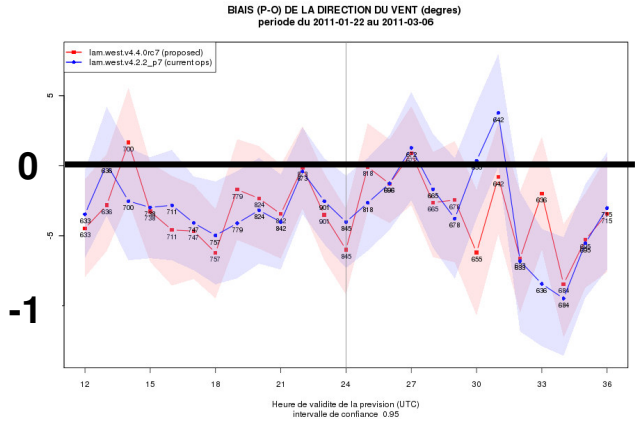
Vspd (10 m)





Vdir (10 m)





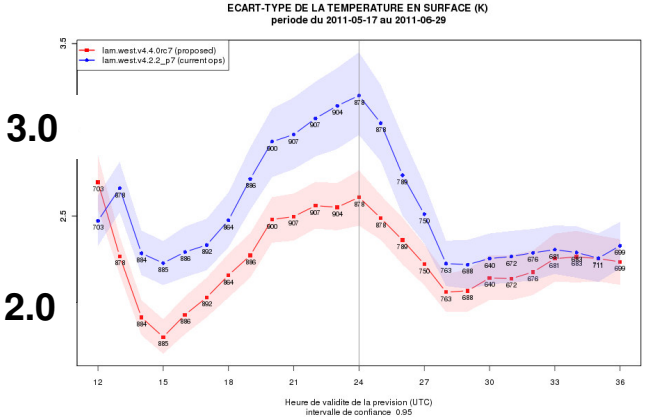
Ouest
West

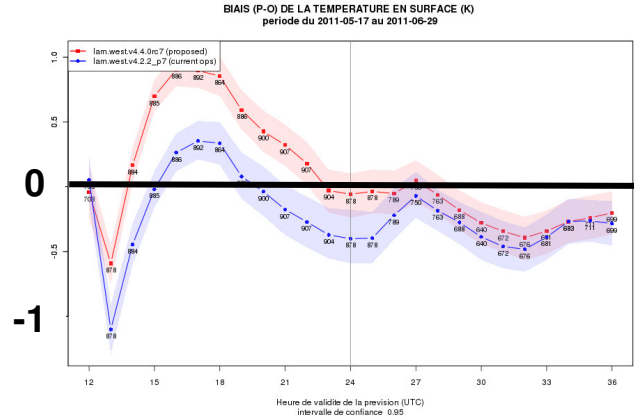
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

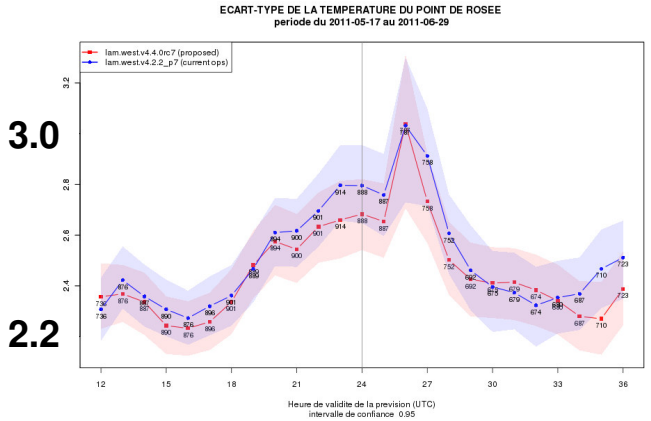
Summer
Été

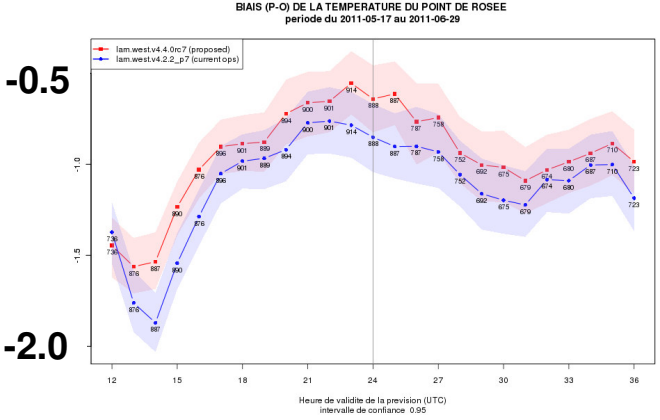
T (2 m)





Td (2 m)





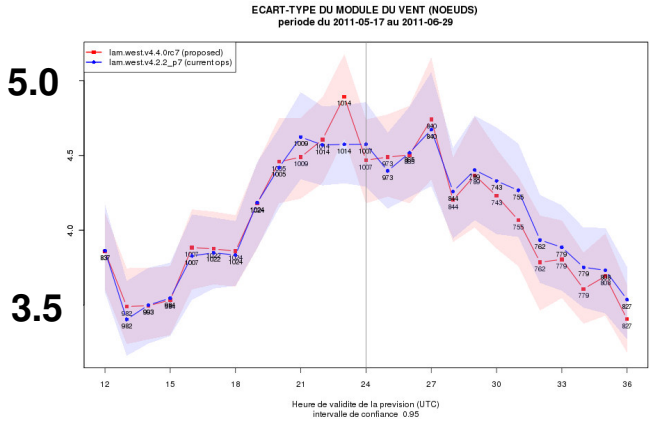
Ouest
West

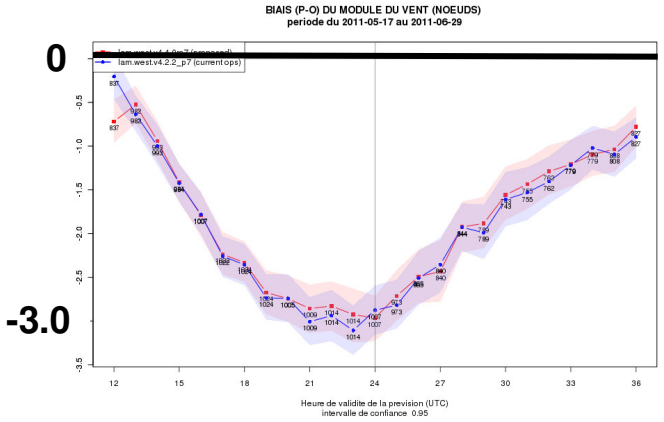
Écart-type / *RMSE*
(biais corrigé / bias corrected)

Biais / *Bias*

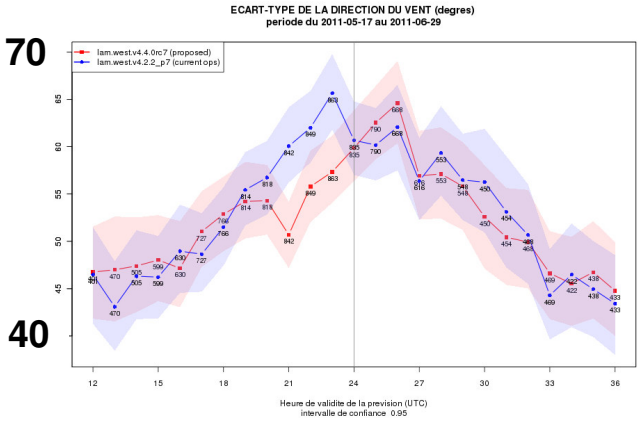
Summer
Été

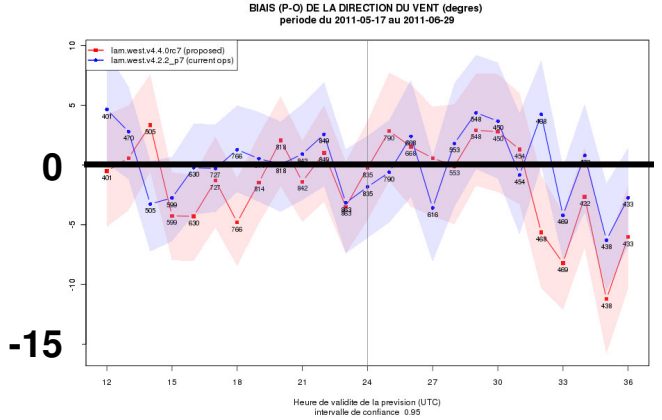
Vspd (10 m)





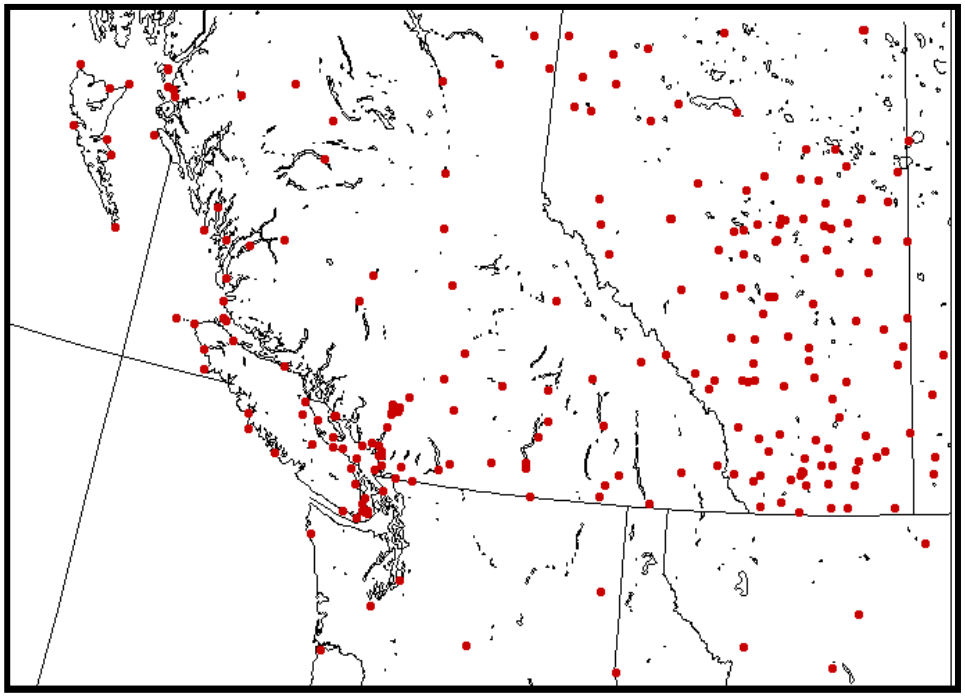
Vdir (10 m)





Verification: 6-h QPF

- From the Canadian Precipitation Analysis* (CaPA)
- Number of stations (WEST): **254**
- 6-h QPF scores, based on package by B. Casati / B. Denis



* Mahfouf et al. 2007

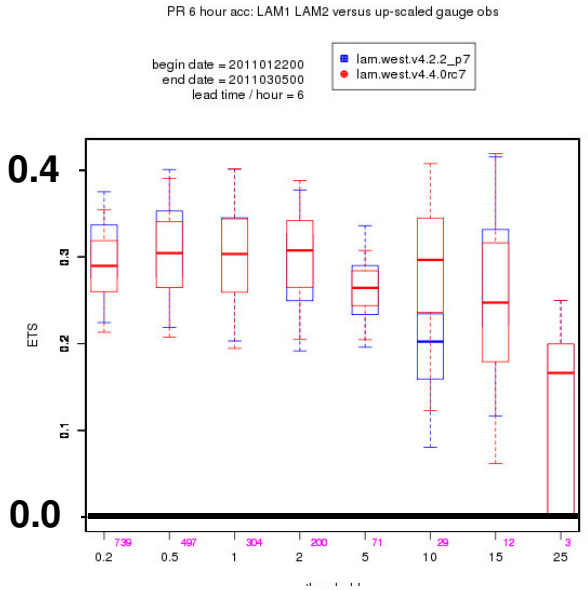
Ouest
West

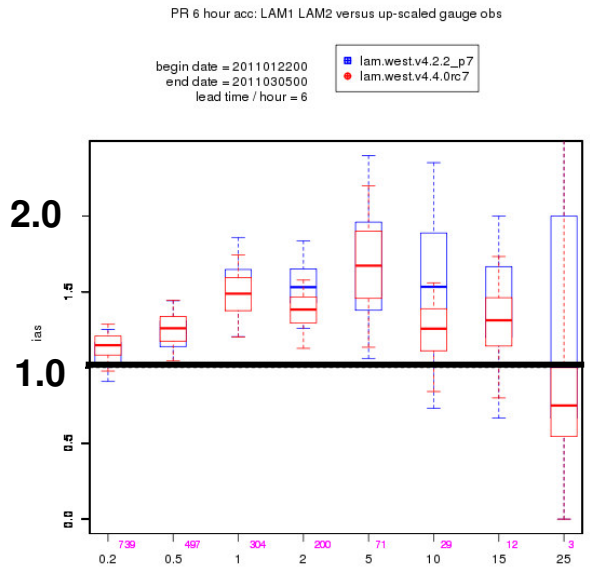
ETS

BS

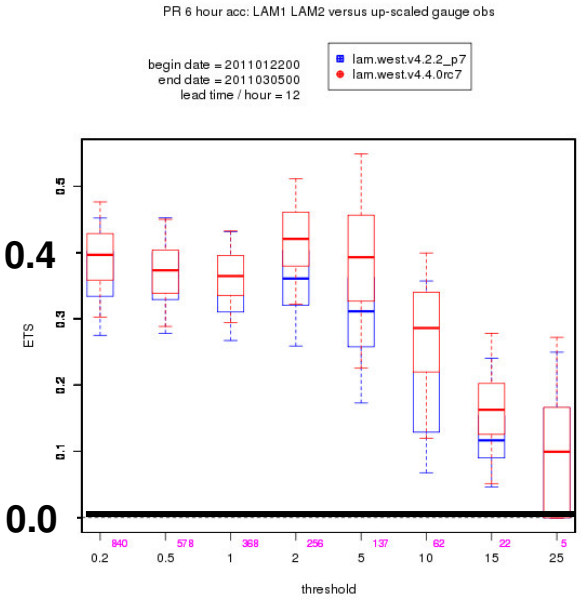
Hiver
Winter

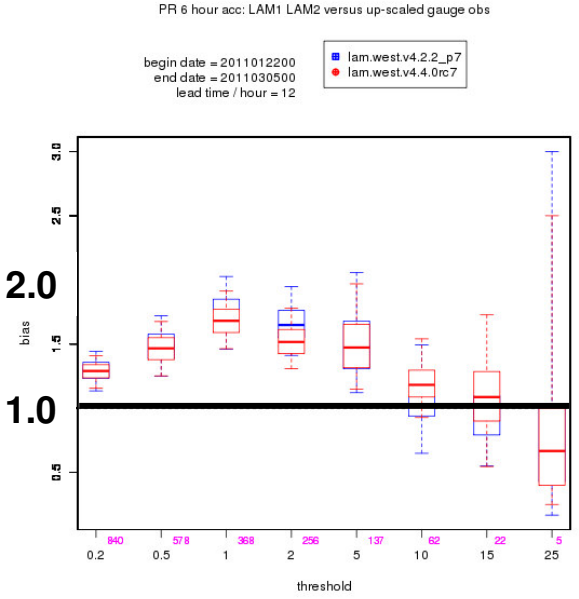
0-6 h





6-12 h





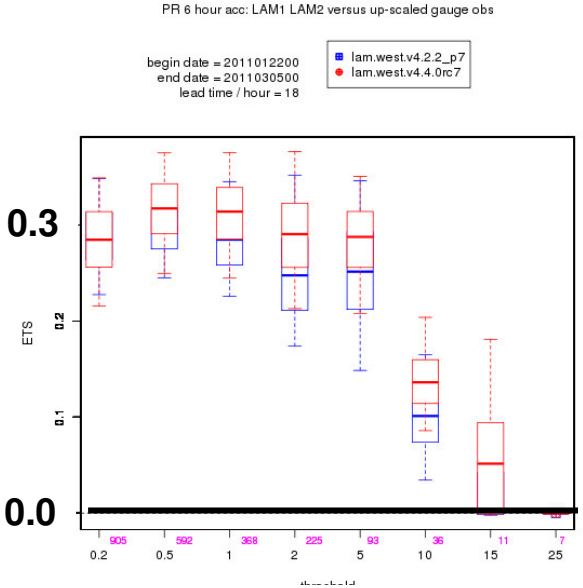
Ouest
West

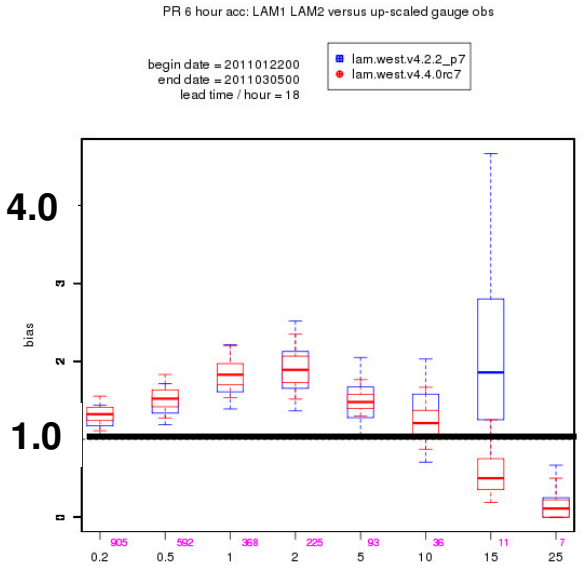
ETS

BS

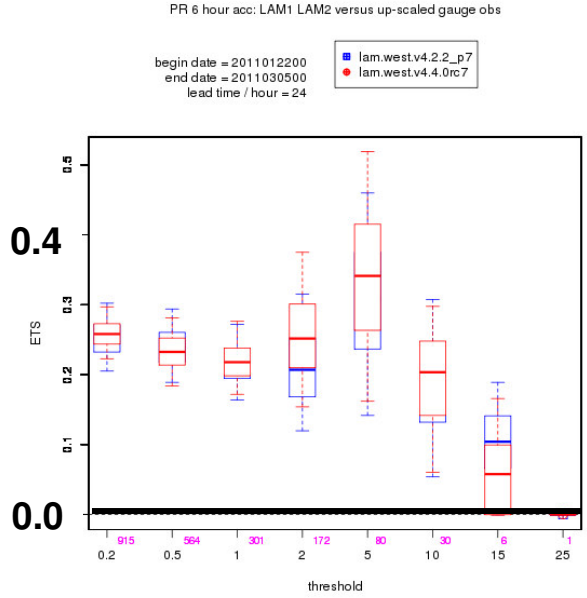
Hiver
Winter

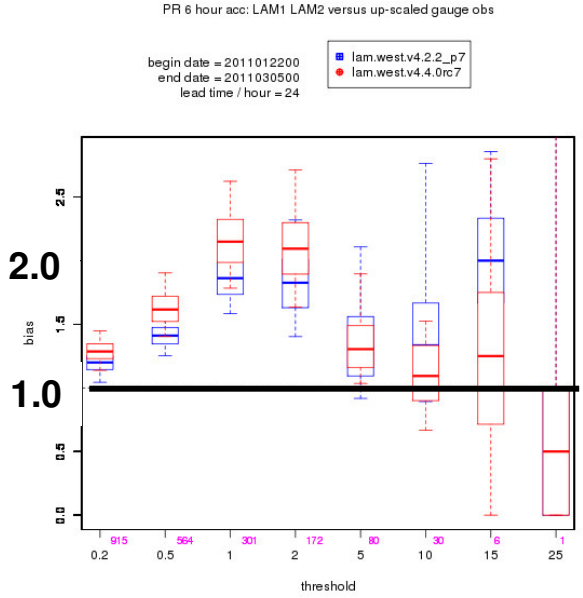
12-18 h





18-24 h





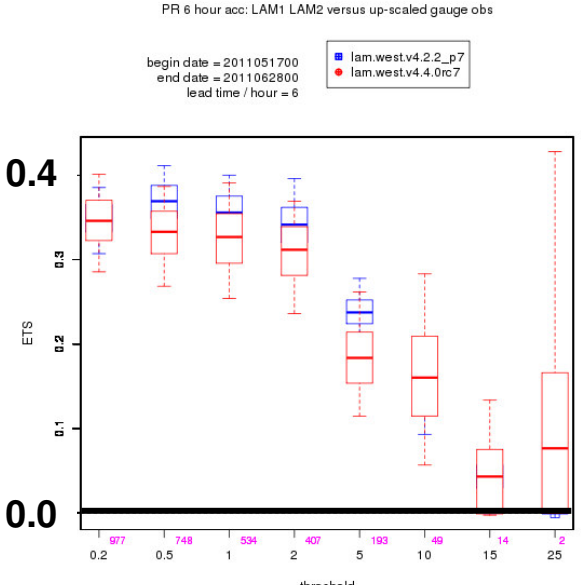
Ouest
West

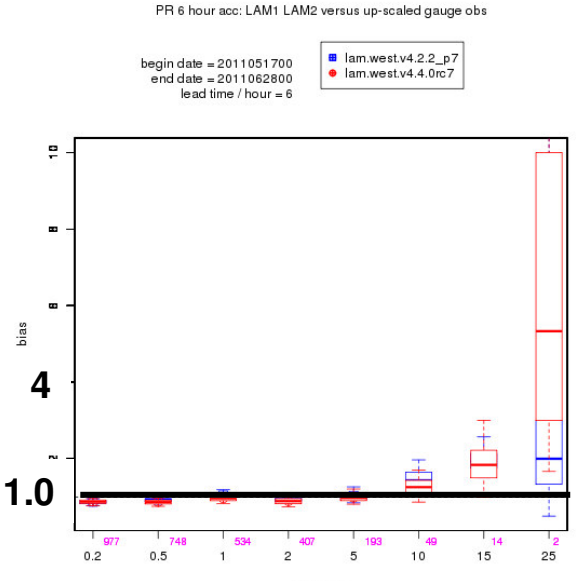
ETS

BS

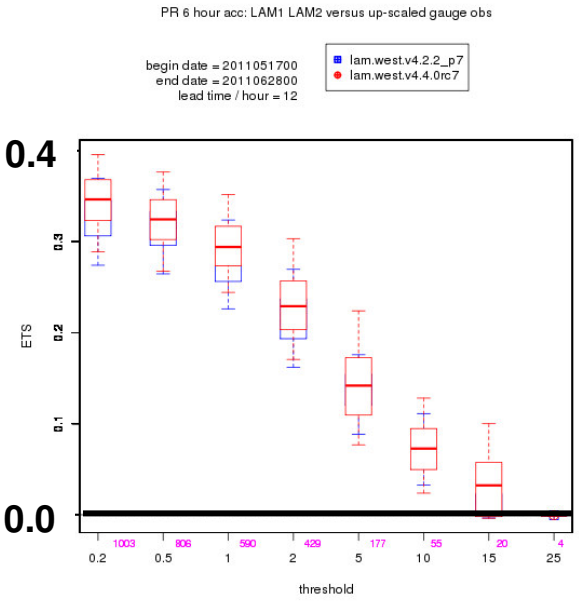
Summer
Été

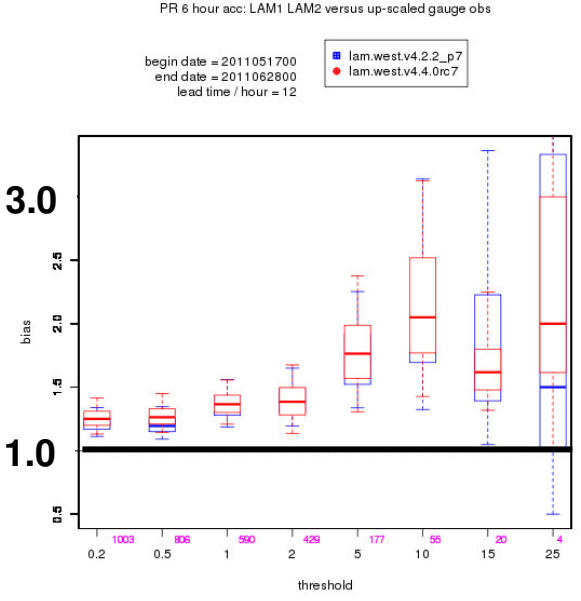
0-6 h





6-12 h

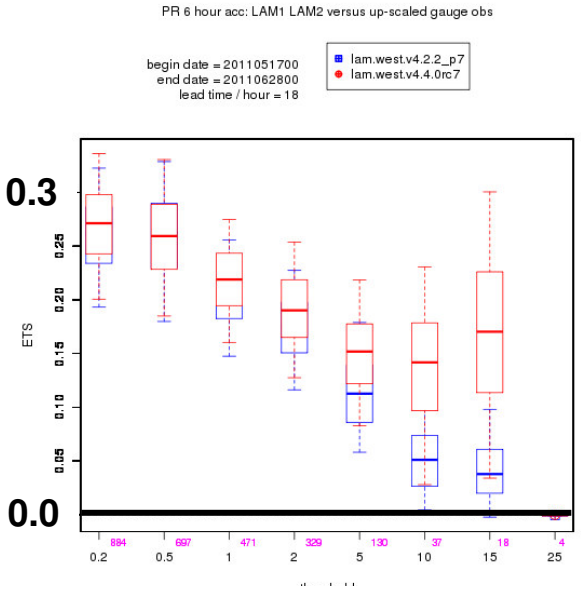


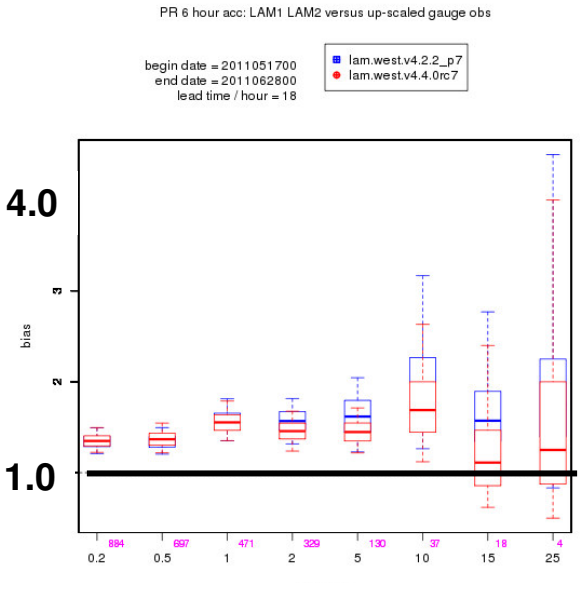


Ouest
West

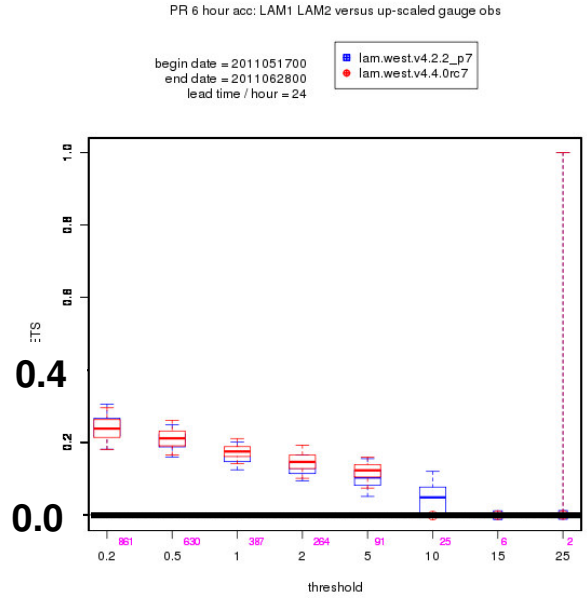
Summer
Été

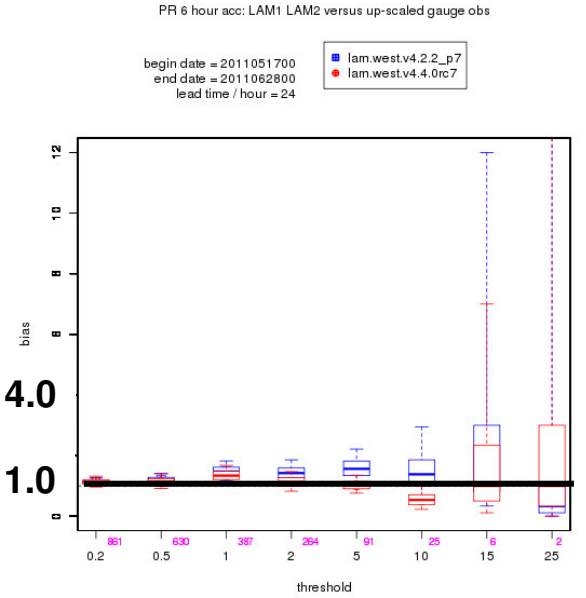
12-18 h





18-24 h





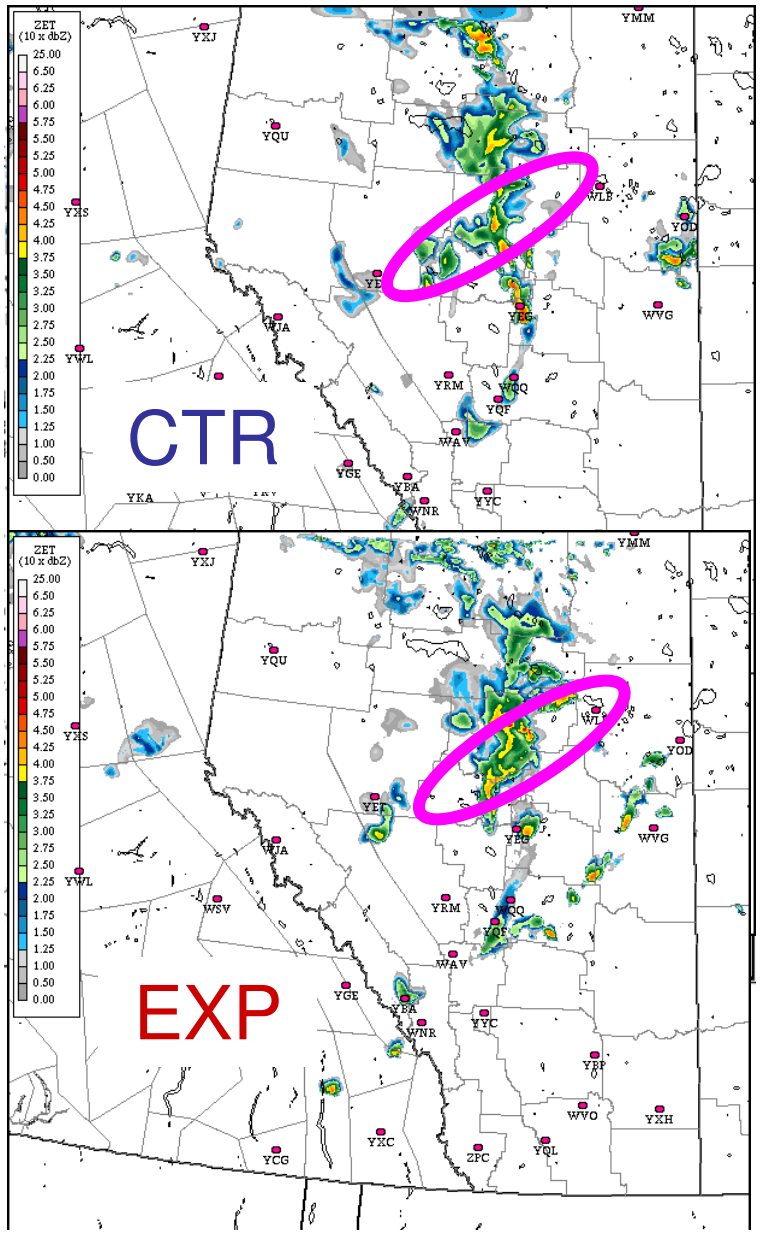
Note:

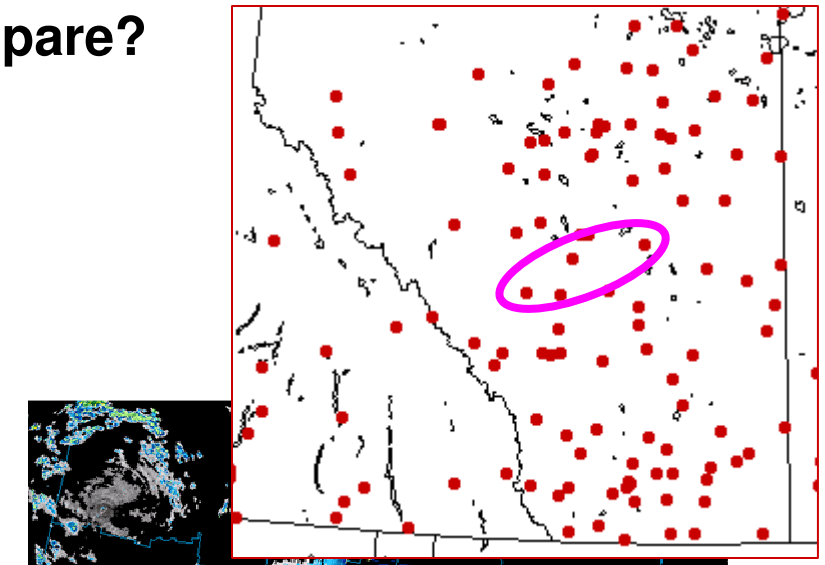
These are <u>not</u> the appropriate metrics to evaluate a high-resolution NWP model precipitation*

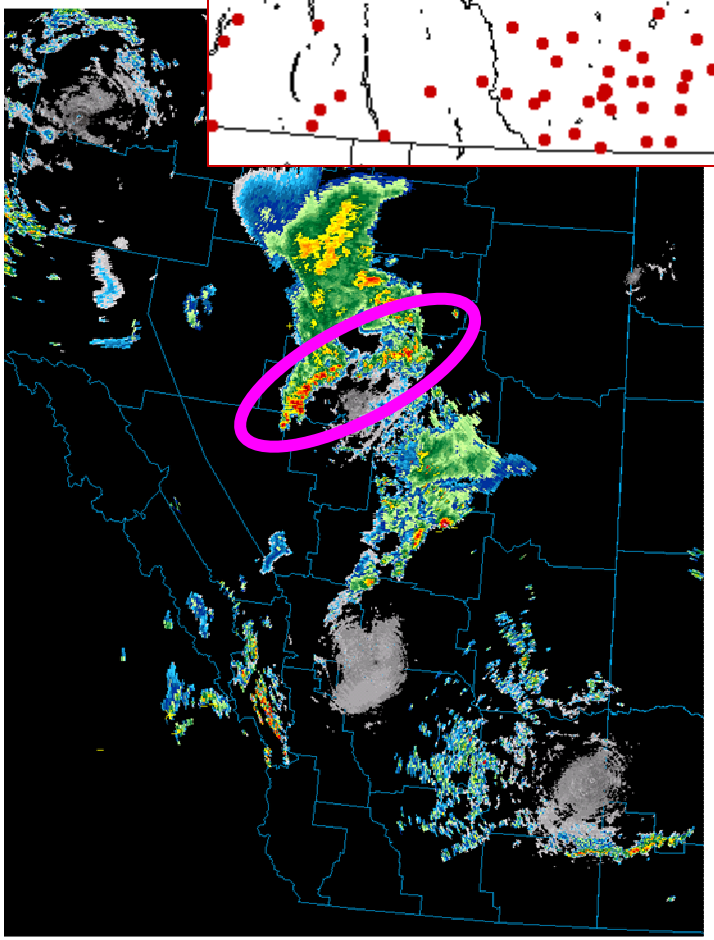
- gauge density and temporal resolution is insufficient
- small timing errors can heavily penalize model
- measuring snow precipitation quantity is very problematic

* **RECALL: Primary goal of the HRDPS is to improve the prediction of <u>HIGH-IMPACT WEATER</u>**

Use gauge-based scores to compare?

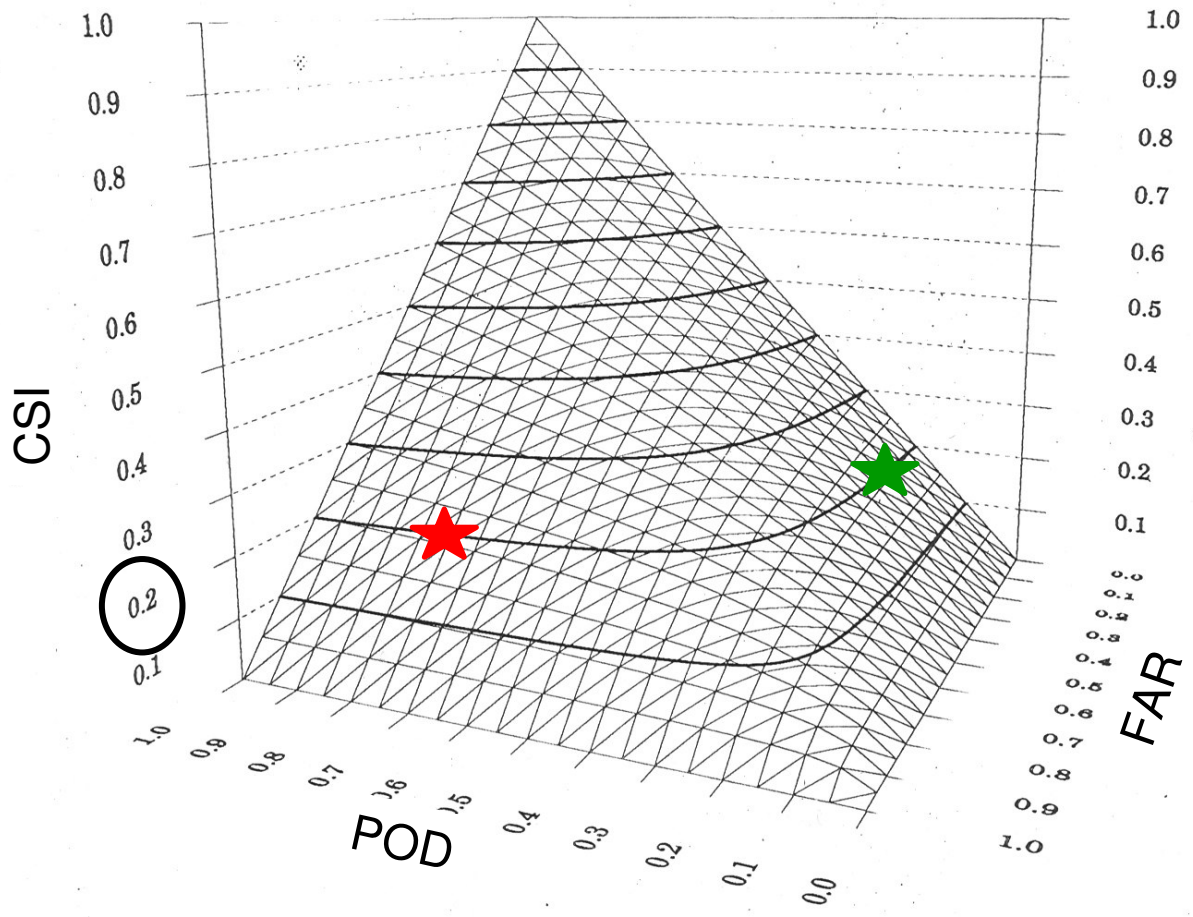






Note:

These are <u>not</u> the appropriate metrics to evaluate a high-resolution NWP model precipitation



$$CSI = \frac{1}{\frac{1}{POD} + \frac{1}{1 - FAR} - 1}$$

Very different combinations of FAR and POD lead to the <u>same CSI value</u>

c/o Barbara Brown (NCAR)

Note:

These are <u>not</u> the appropriate metrics to evaluate a high-resolution NWP model precipitation

Nevertheless:

- Major problems would probably have been spotted
- This is a step towards proper QPF verification (for high-res)

Experiment 2*:

CTR_2: **RDPS-15 + HRDPS_v2.2.0**

EXP_2: **RDPS-10 + HRDPS_v2.3.0 (proposed)**

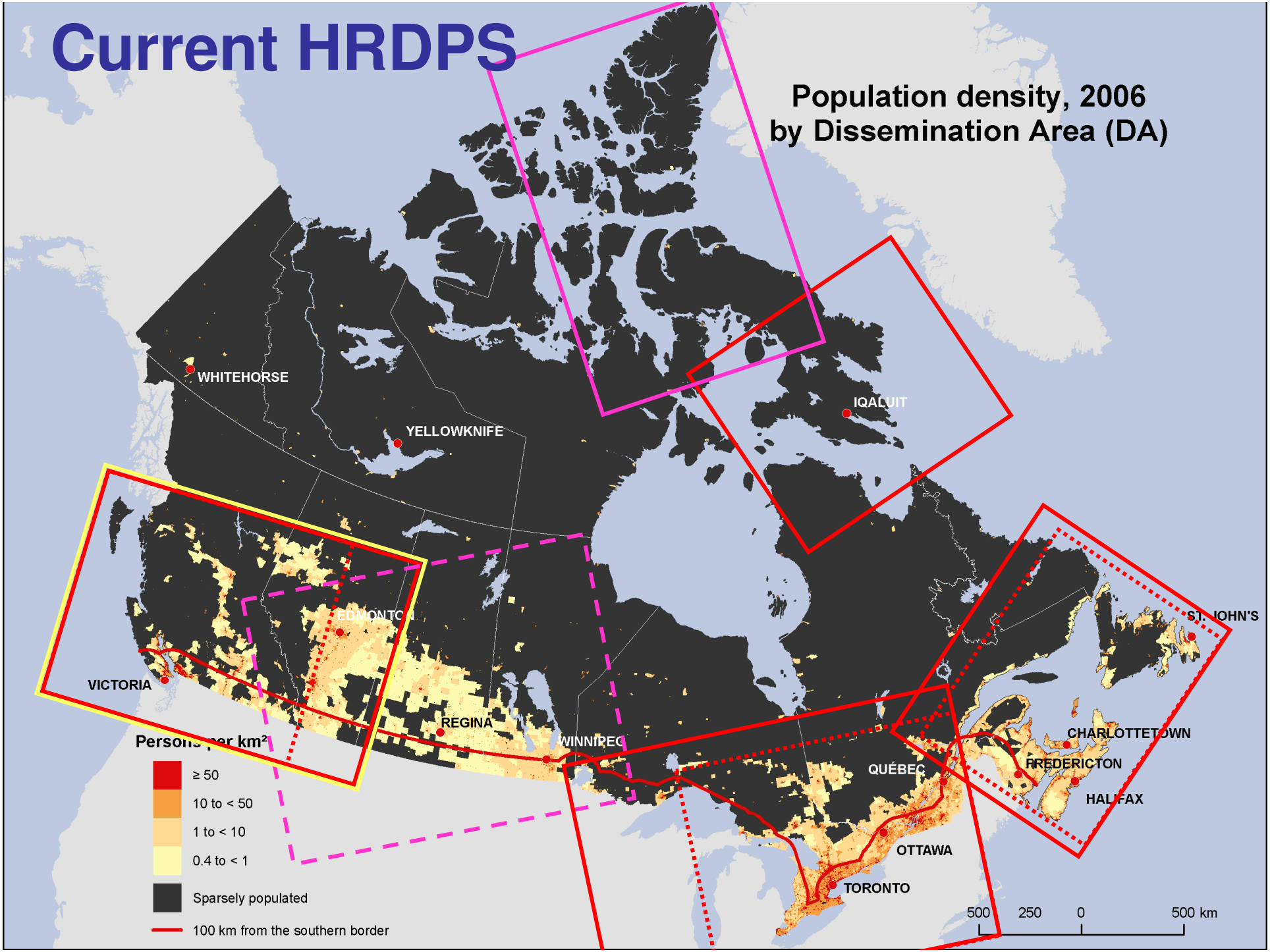
1 domain
(west)

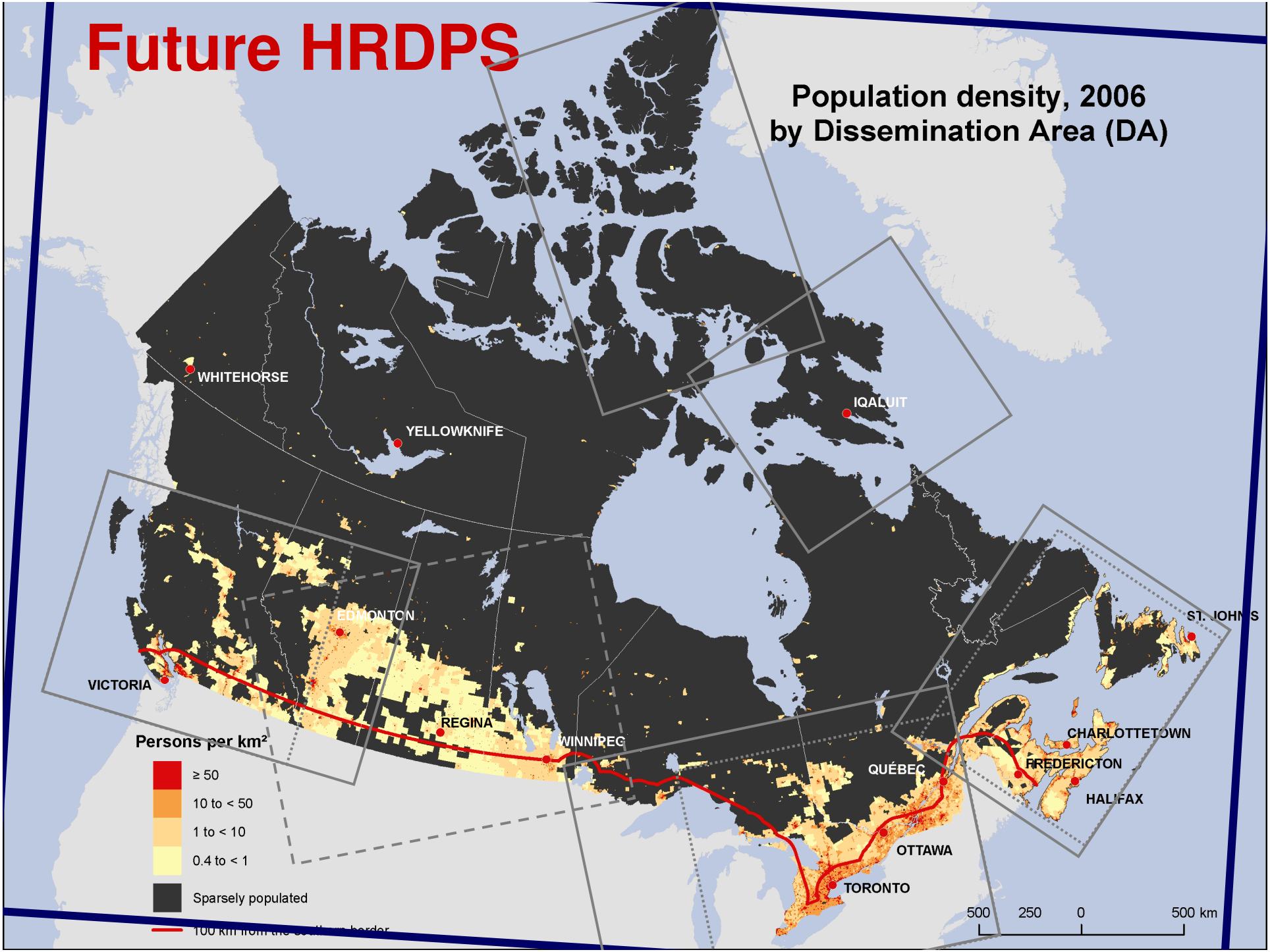
SUMMARY OF VERIFCATION:

- slight improvement in RMSE for T and Td (2 m)
- systematic increase in T and Td (2 m)
- negligible affect on winds (10 m)
- precipitation looks OK (slight overall improvement to 6-h QPF scores)

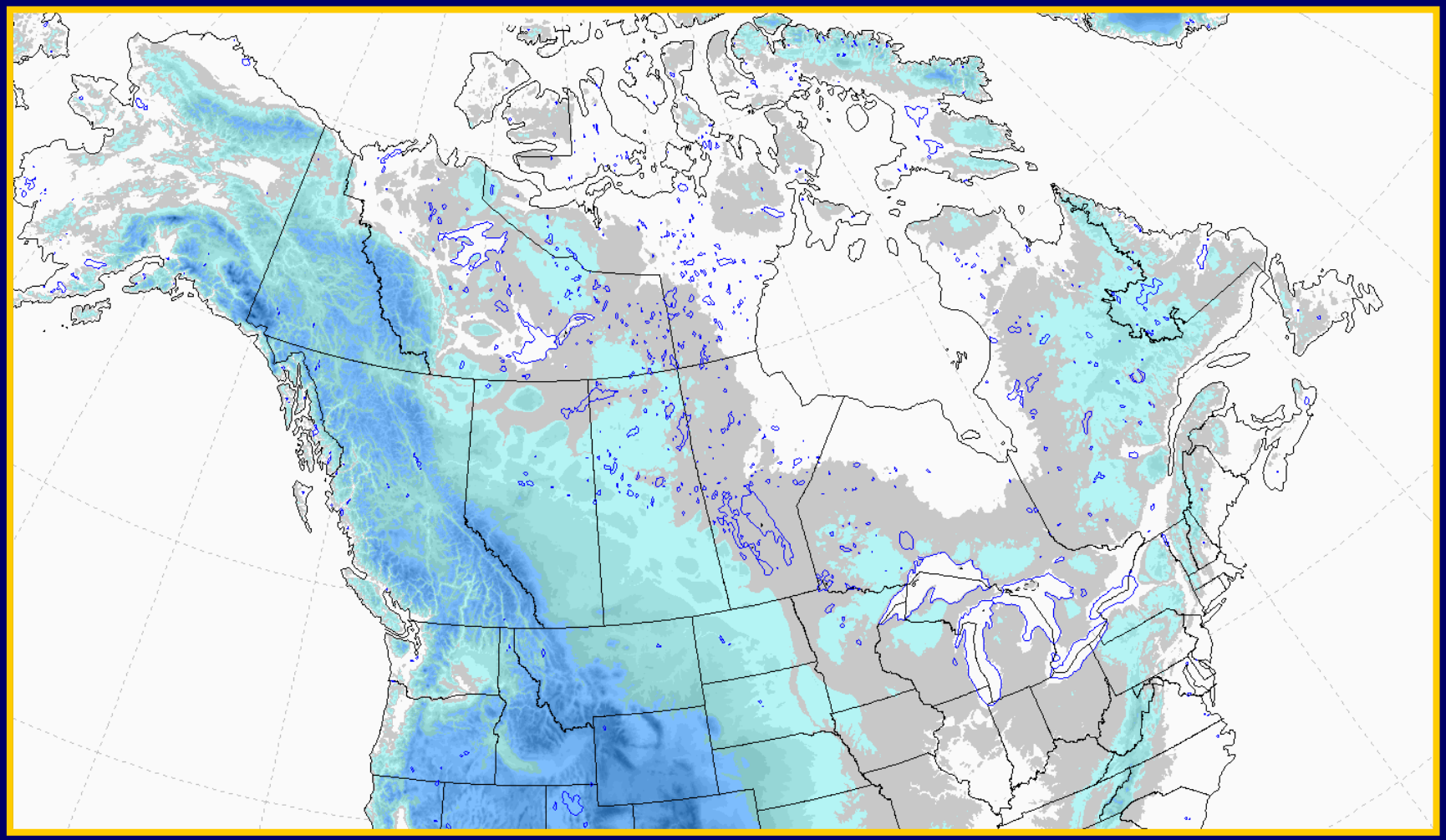
* Due to combined changes to RDPS and HRDPS

El Futuro…

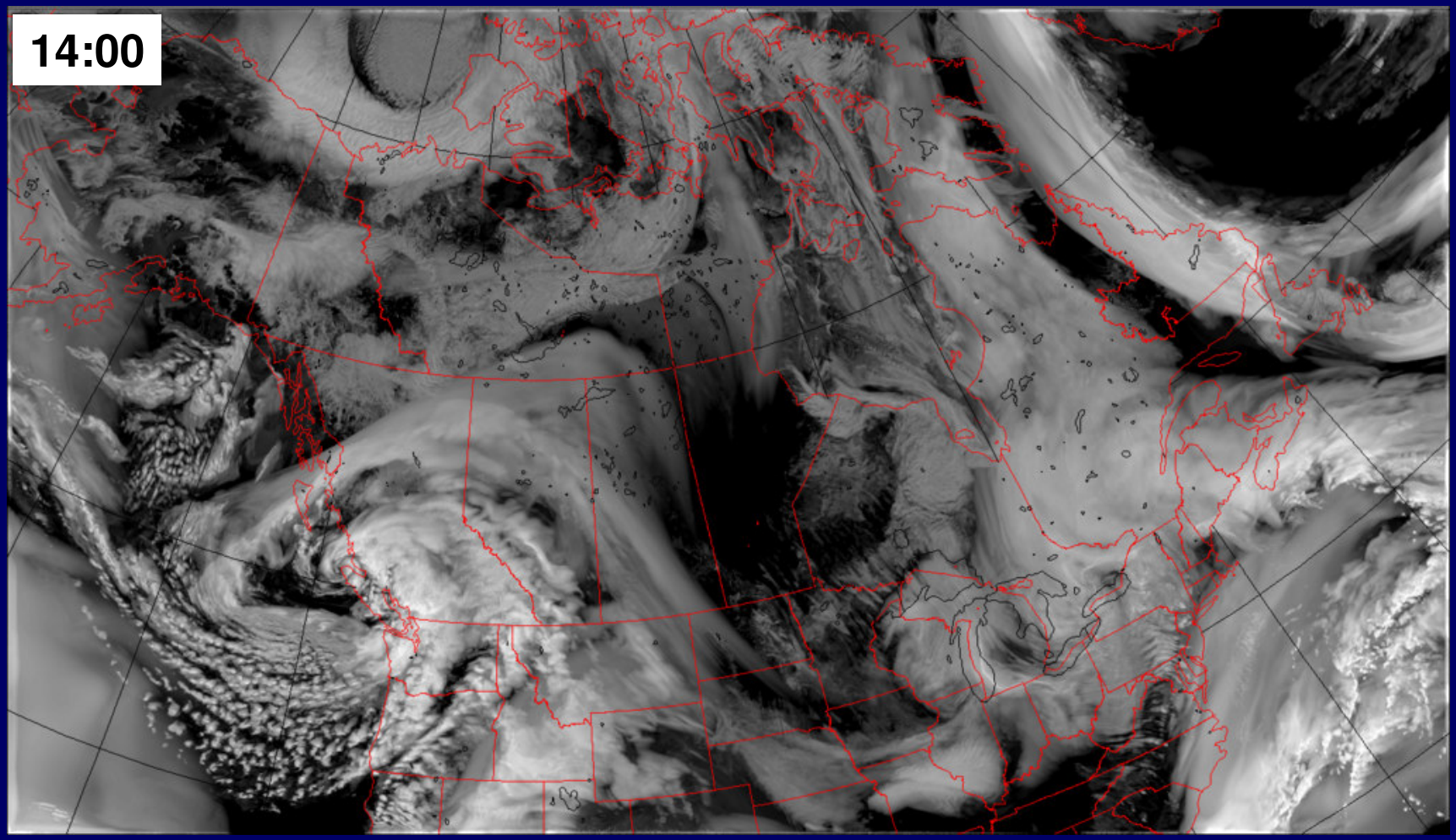

Current HRDPS
Population density, 2006
by Dissemination Area (DA)
WHITEHORSE
YELLOWKNIFE
IQALUIT
EDMONTON
VICTORIA
REGINA
WINNIPEG
QUÉBEC
OTTAWA
TORONTO
CHARLOTTETOWN
FREDERICTON
HALIFAX
ST. JOHN'S
Persons per km²
≥ 50
10 to < 50
1 to < 10
0.4 to < 1
Sparsely populated
100 km from the southern border
500 250 0 500 km


Future HRDPS
Population density, 2006
by Dissemination Area (DA)
WHITEHORSE
YELLOWKNIFE
IQALUIT
EDMONTON
VICTORIA
REGINA
WINNIPEG
QUÉBEC
OTTAWA
TORONTO
CHARLOTTETOWN
FREDERICTON
HALIFAX
ST. JOHN'S
Persons per km²
≥ 50
10 to < 50
1 to < 10
0.4 to < 1
Sparsely populated
500 250 0 500 km

Prototype National-2.5 Grid: (orographic height)



Prototype National-2.5: RUN 1



HRDPS Configuration

Current: (near future)

- multi-grid (2.5 km)
  - 2 x 36-h (west domain)
  - 1 x 24-h (other domains)
- downscaled from RDPS
- 58 levels
- IC surface fields from ISBA

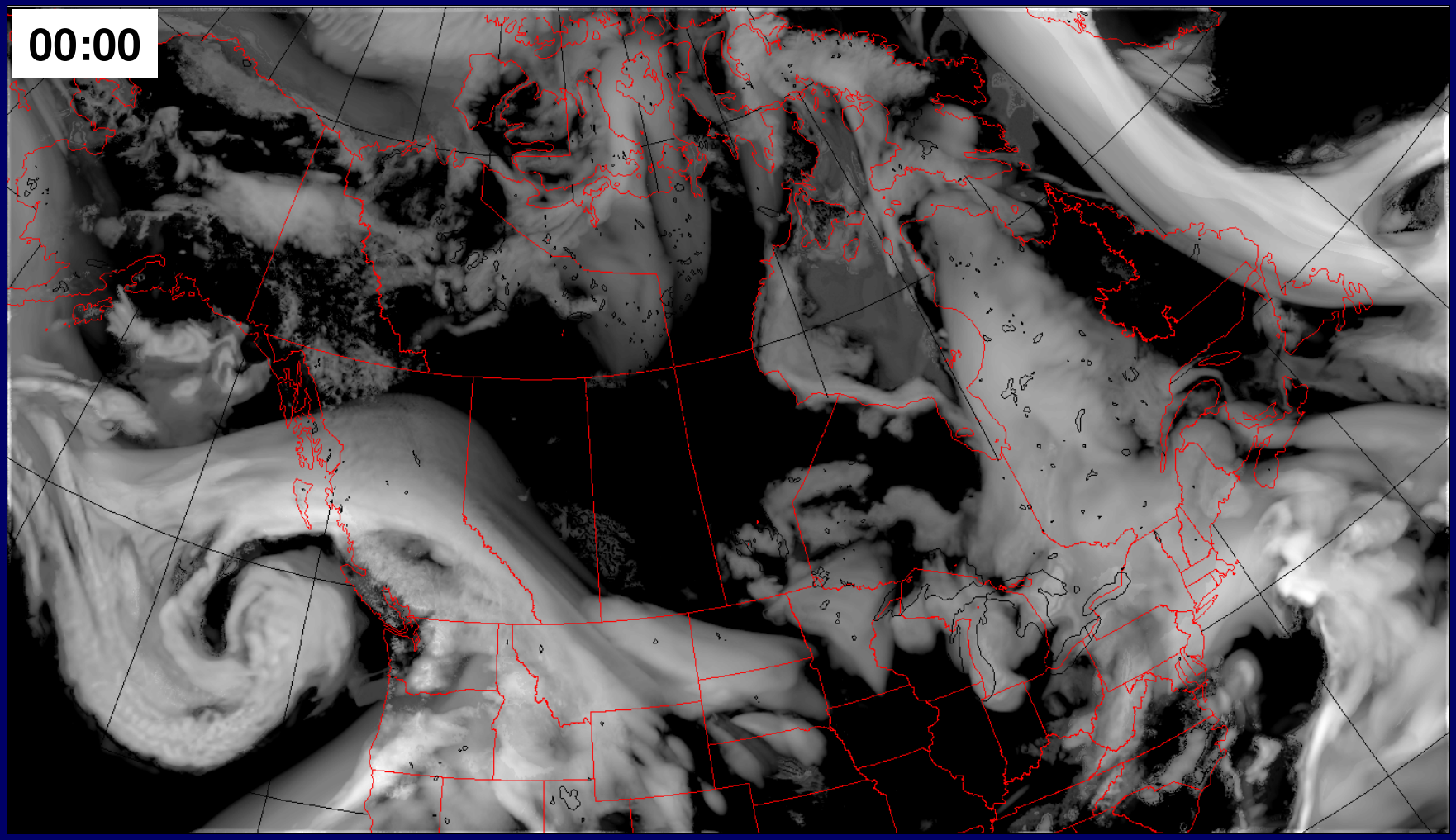
Future:

- single grid (2.5 km)
  - 4 x 36-h
- 70 - 80 levels
- IC surface fields from GEM-Surf
- upgraded microphysics
  - improved aerosols
  - prognostic graupel density
  - prognostic snow-liquid ratio
  - optimization
- recycling of PHY bus
- upper-air assimilation cycle

↓

Next generation HRDPS?

- **LAM 250-m grids** (e.g over cities)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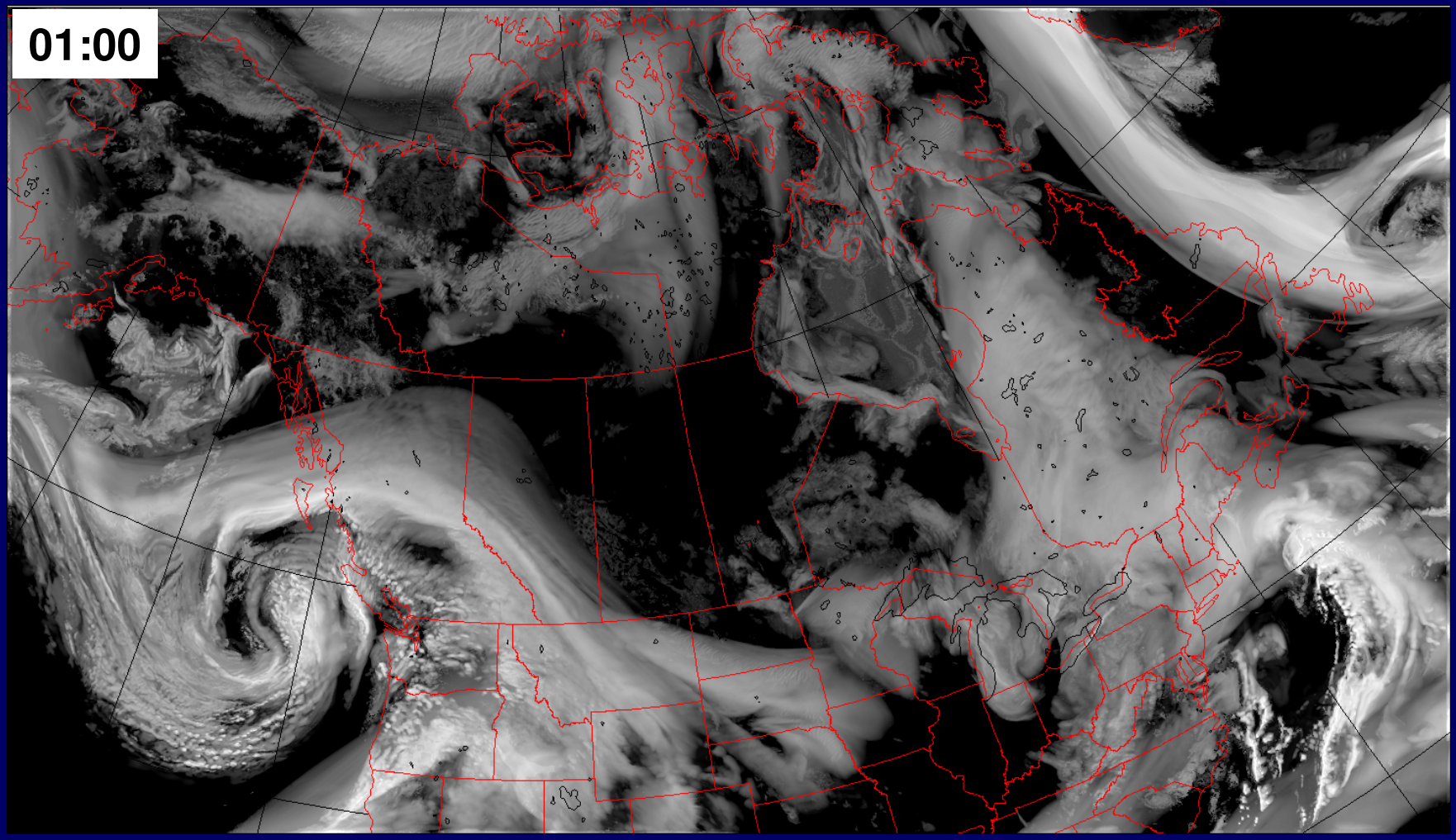
01:00

HRDPS Upgrade Plans

1. Operational WEST-2.5 domain (this proposal)

- operational status of WEST; 2 x 36-h
- upgrade of GEM version

→ ASAP

2. National-2.5 – STEP 1

- single, national grid
- 2 x 36-h
- increased vertical resolution
- high-resolution surface fields
- reduced spin-up (recycling PHY bus)
- upgrade to microphysics

→ 2013

3. National-2.5 – STEP 2

- 4 x 36-h
- upper-air data assimilation cycle

→ 2015


THANK YOU