Environnement Canada Environment Canada

Canada

The Canadian Regional Ensemble Prediction System (REPS)

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1. Recherche en prévision numérique atmosphérique
2. National Laboratory for Severe Weather
3. CMC-Development

Internal seminar

Dorval, Qc, April 14, 2011

Talk Outline

- Brief historical review
  - The different development stages since 2004
- Applications until now
  - Research tool during Olympic events (Beijing 2008, Vancouver 2010)
  - Experimental mode since May 2010 to help the Haitian Meteorological Services
  - Tests in winter 2009 and summer 2008
- System description
- Some objective verifications and comparisons
  - REPS (GEM v4.2.0) versus REPS (GEM v3.2.9)
  - REPS versus GEPS
- The future

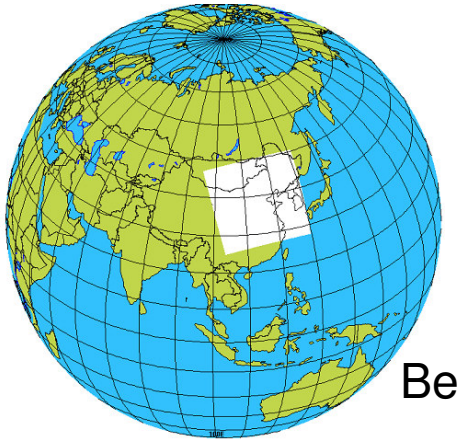
Development stages since 2004

- Summer 2004: Start work on downscaling of the operational global EPS (150 km resolution)
  - GEM-LAM at 15 km on North East of North America
  - Serious problems related to the global EPS initialization method
  - The approach is temporarily abandoned
- 2004-2006: Targeted singular vector approach and physical stochastic perturbations with Markov chains
  - Li, X., M. Charron, L. Spacek, and G. Candille (2008): A regional ensemble prediction system based on moist targeted singular vectors and stochastic parameter perturbations, *Mon. Wea. Rev.*, **136**, 443-462.
- 2006-2011: Following improvements to the global EPS, the downscaling (of the global EPS) approach is re-tested (paper to be submitted soon)

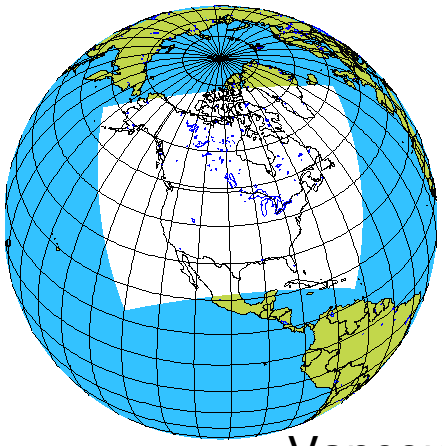
Applications until now

- Tests over China for the Beijing 2008 Olympics in summer 2006, 2007, and 2008. System at 15 km resolution for 36h forecasts. Comparison with 5 other systems (2xChina, USA, Japan, France-Austria).
- February 2008 and winter 2009 over North America. System at 33 km for 48h forecasts. Run for Vancouver 2010 pre-tests.
- November 2009 to May 2010: run twice daily from 00Z and 12Z
- May 2010 to present: run twice daily from 00 and 12Z over a domain covering the Caribbean and a large part of North America.

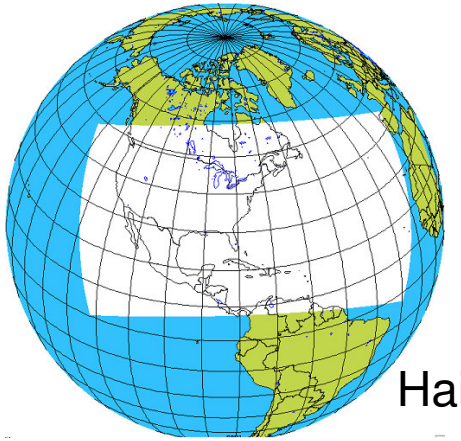
The different domains



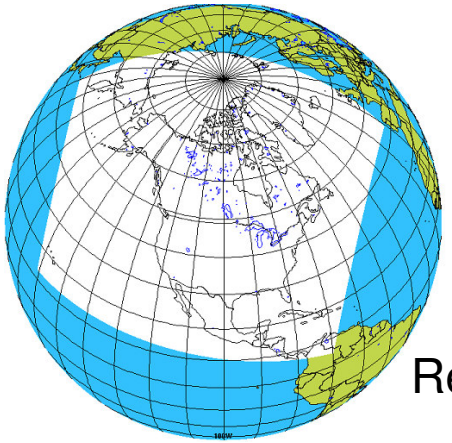
Beijing 2008



Vancouver 2010



Haiti



Regional

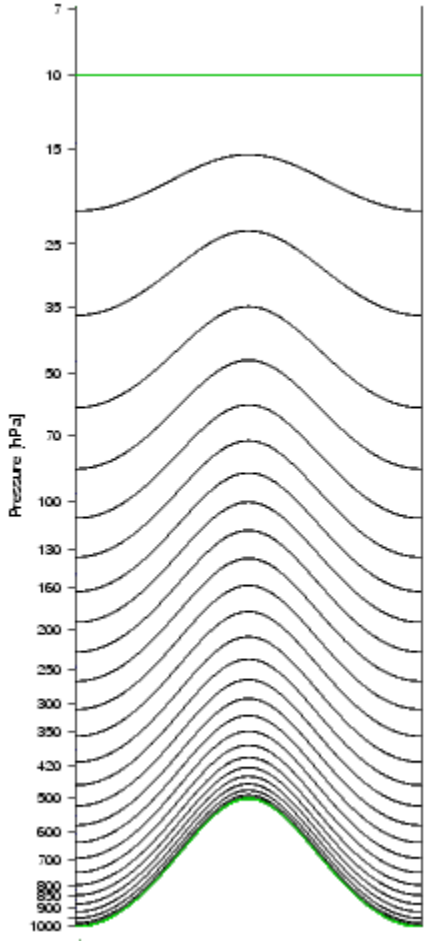
System Description

- Based on GEM 4.2.0 (vertical staggering)
- Physics almost identical to deterministic global system. Differences are :
  - no sponge in REPS
  - no methane oxidation
  - no non-orographic gravity wave drag
- Resolution: 0.3° x 0.3° (280 x 287 x L28 grid points)
- Use lid nesting technique

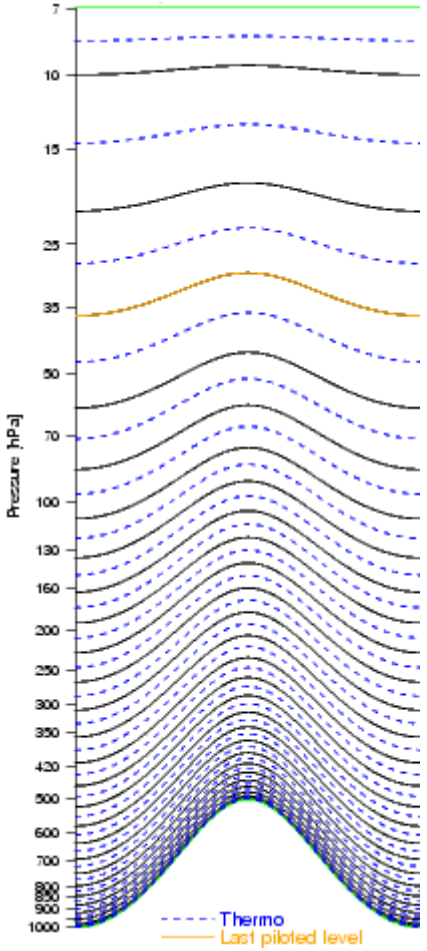
System description

- REPS model lid near 10 hPa
  - piloting between 10 and 35 hPa (3 levels)
  - blending between 35 and 100 hPa (3 levels)
- Piloted by the parallel GEPS with frequency of 3 hours
  - Parallel GEPS has lid at 2 hPa
- Initial conditions from the global EnKF (same as parallel GEPS)
- Lead time: 72 hours
- 20 members
- Stochastic perturbations of physical tendencies (see later)

System Description



Previously used levels – GEM 3



Currently used levels – GEM 4

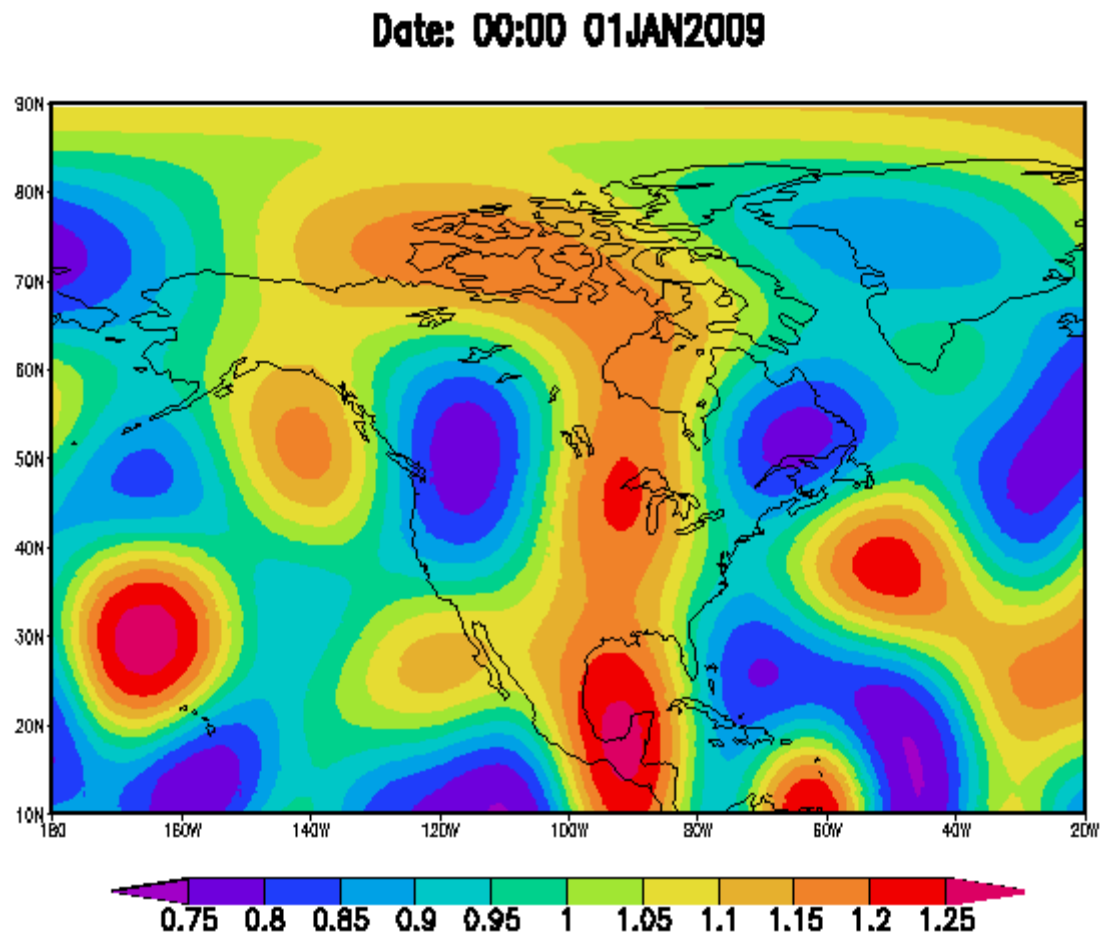
Physics Perturbations with Markov Chains

$$f(\lambda,\phi,t) = \mu + \sum_{l=L_{min}}^{L_{max}} \sum_{m=-l}^{l} a_{lm}(t) Y_{lm}(\lambda,\phi)$$

$$a_{lm}(t+\Delta t) = e^{-\Delta t/\tau} a_{lm}(t) + R(t)$$

L_{min} = 1
L_{max} = 14
τ = 24 h
μ = 1

Physics Perturbations with Markov Chains



Main differences with global EPS physics

	REPS	GEPS op	GEPS para
Radiation	Li and Barker	Fouquart/Bonnel+ Garand	Li and Barker
Surface	ISBA	ISBA and Force-restore	ISBA and Force-restore
Deep convection	Kain-Fritsch	Kain-Fritsch, Kuo, Kuo sym, RAS	Kain-Fritsch, Kuo
Gravity wave drag	One parameter	Multi-parameter	Multi-parameter
Mixing length	Bougeault	Bougeault, Blackadar	Bougeault, Blackadar
SKEB	No	Yes	Yes
Physical tendency perturbations	[0.7 , 1.3]	[0.5 , 1.5]	[0.5 , 1.5]
Grid spacing	33 km	100 km	66 km

Objective Verifications

- **REPS GEM 4.2.0 versus REPS GEM 3.2.9 (same pre-operational domain for both)**
  - REPS GEM 4.2.0
    - Pilot is parallel GEPS (GEM 4.2.0)
    - Physical tendency perturbations: [0.7 , 1.3]
  - REPS GEM 3.2.9
    - Pilot is operational GEPS (GEM 3.2.8)
    - Physical tendency perturbations: [0.5 , 1.5]

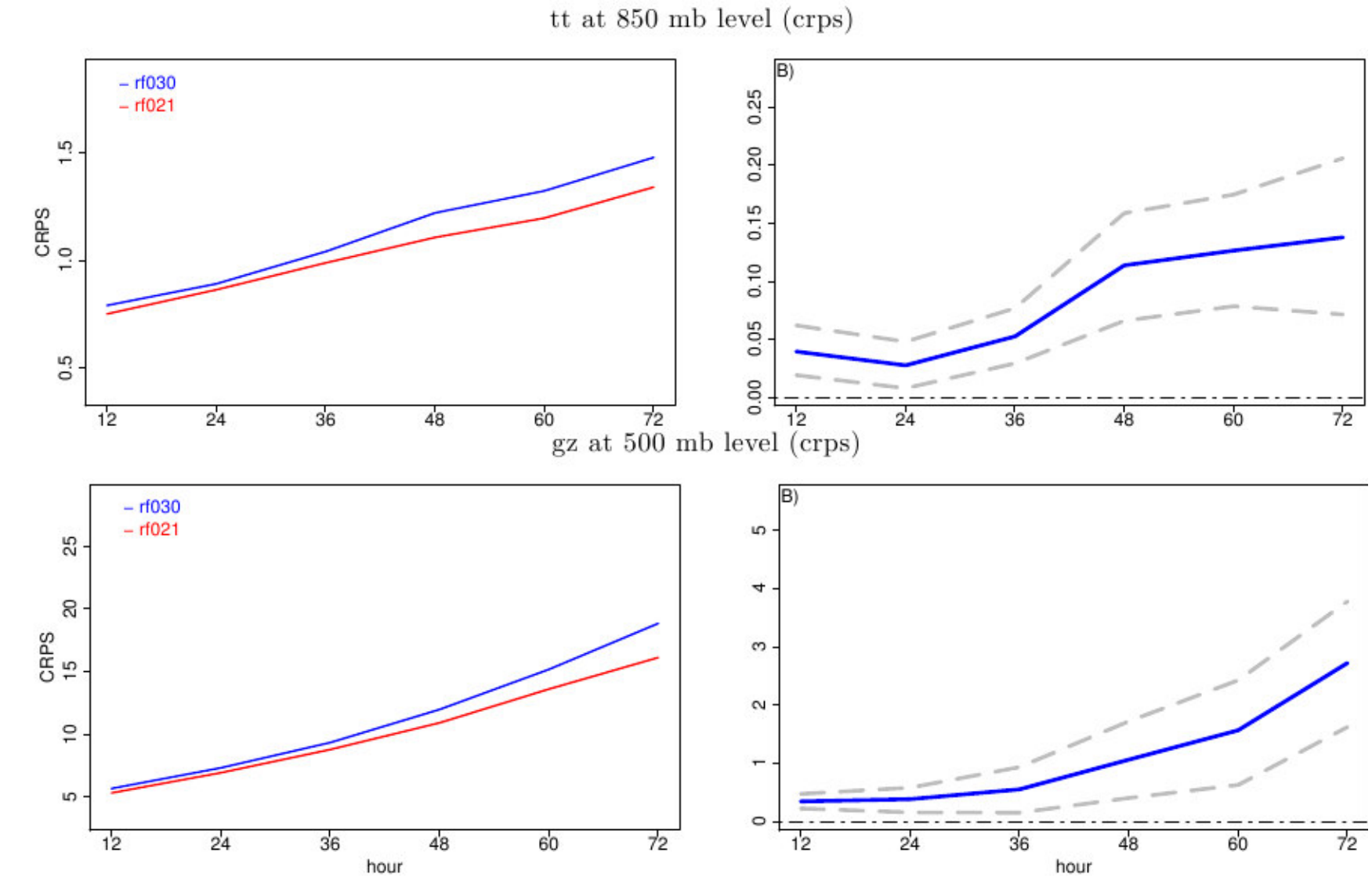
- **REPS GEM 4.2.0 versus REPS GEM 3.2.9 (current experimental domain covering the Caribbean)**
  - Proposed operational REPS versus currently experimental REPS at CMC

Objective Verifications

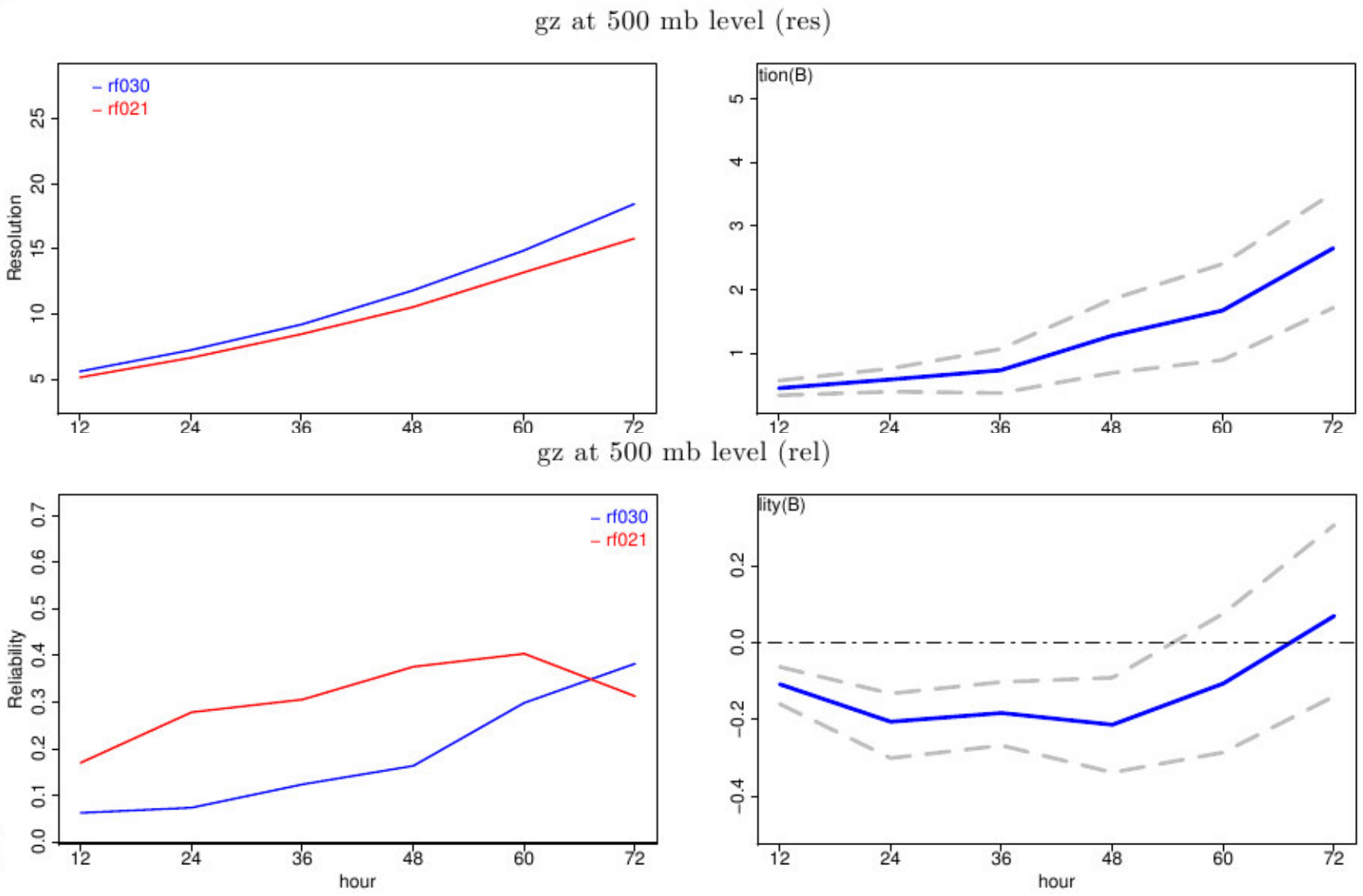
- **REPS GEM 4.2.0 versus GEPS GEM 3.2.8**
  - Proposed operational REPS versus operational GEPS
- **REPS GEM 4.2.0 versus GEPS GEM 4.2.0**
  - Proposed operational REPS versus parallel GEPS

- Winter period: Jan 1st, 2009 to Mar. 31st, 2009 (3 months)
- Summer period: Jul 1st, 2008 to Aug. 31st, 2008 (2 months)
- All verifications done every 12 hours (REPS vs REPS) or 36 hours (REPS vs GEPS)

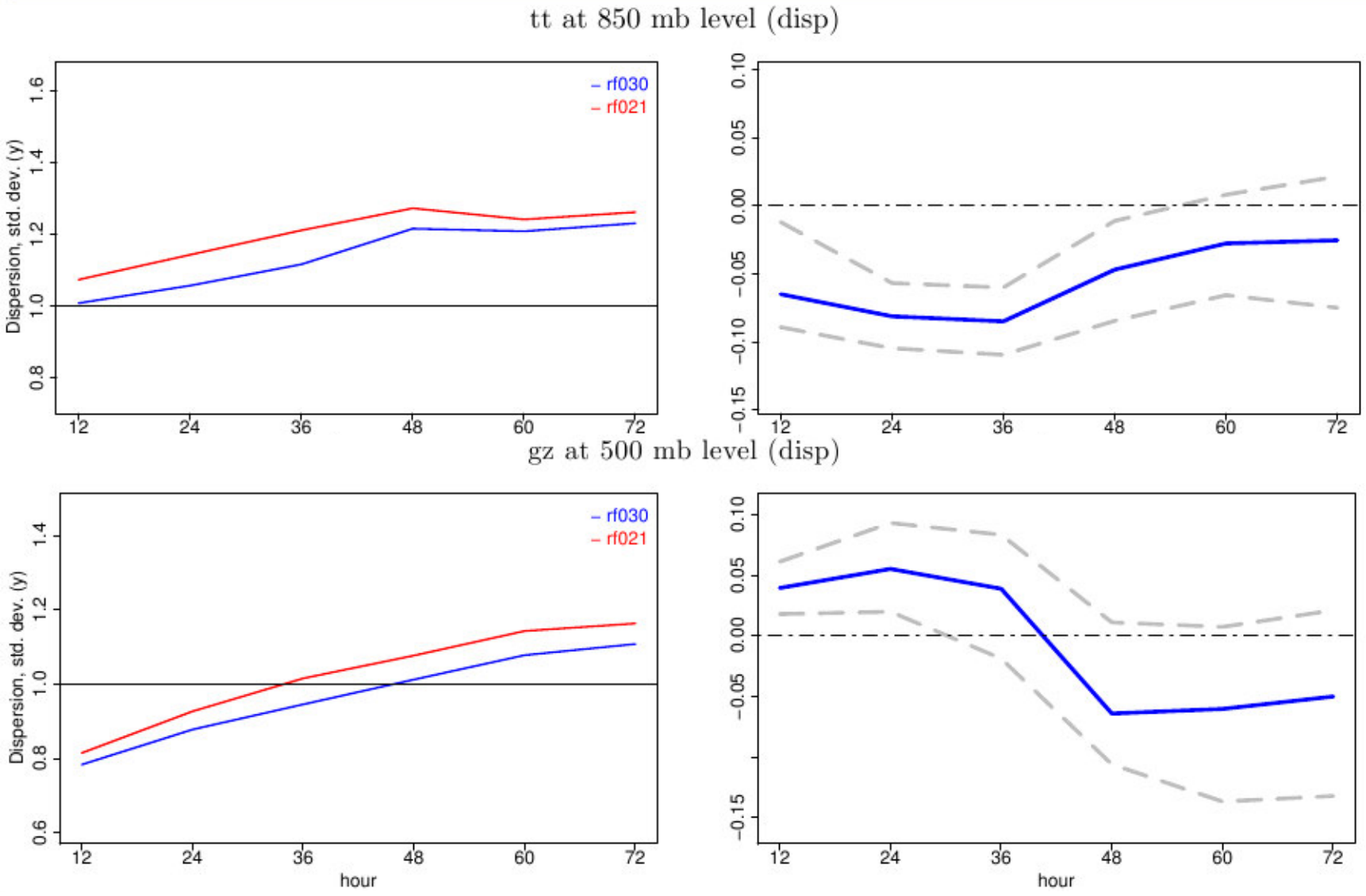
REPS: GEM 4.2 vs GEM 3.2 (regional domain) Winter



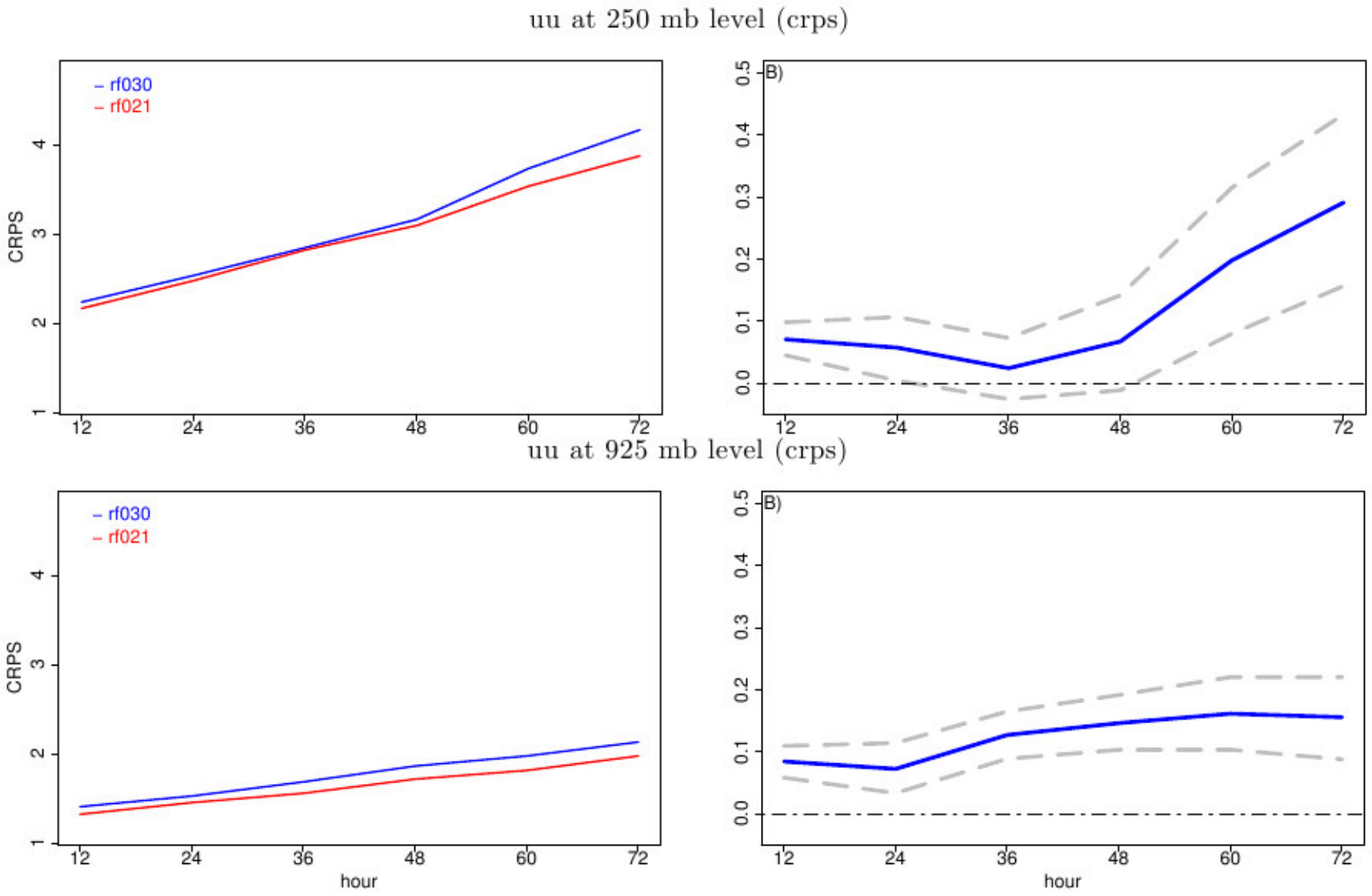
REPS: GEM 4.2 vs GEM 3.2 (regional domain) Winter



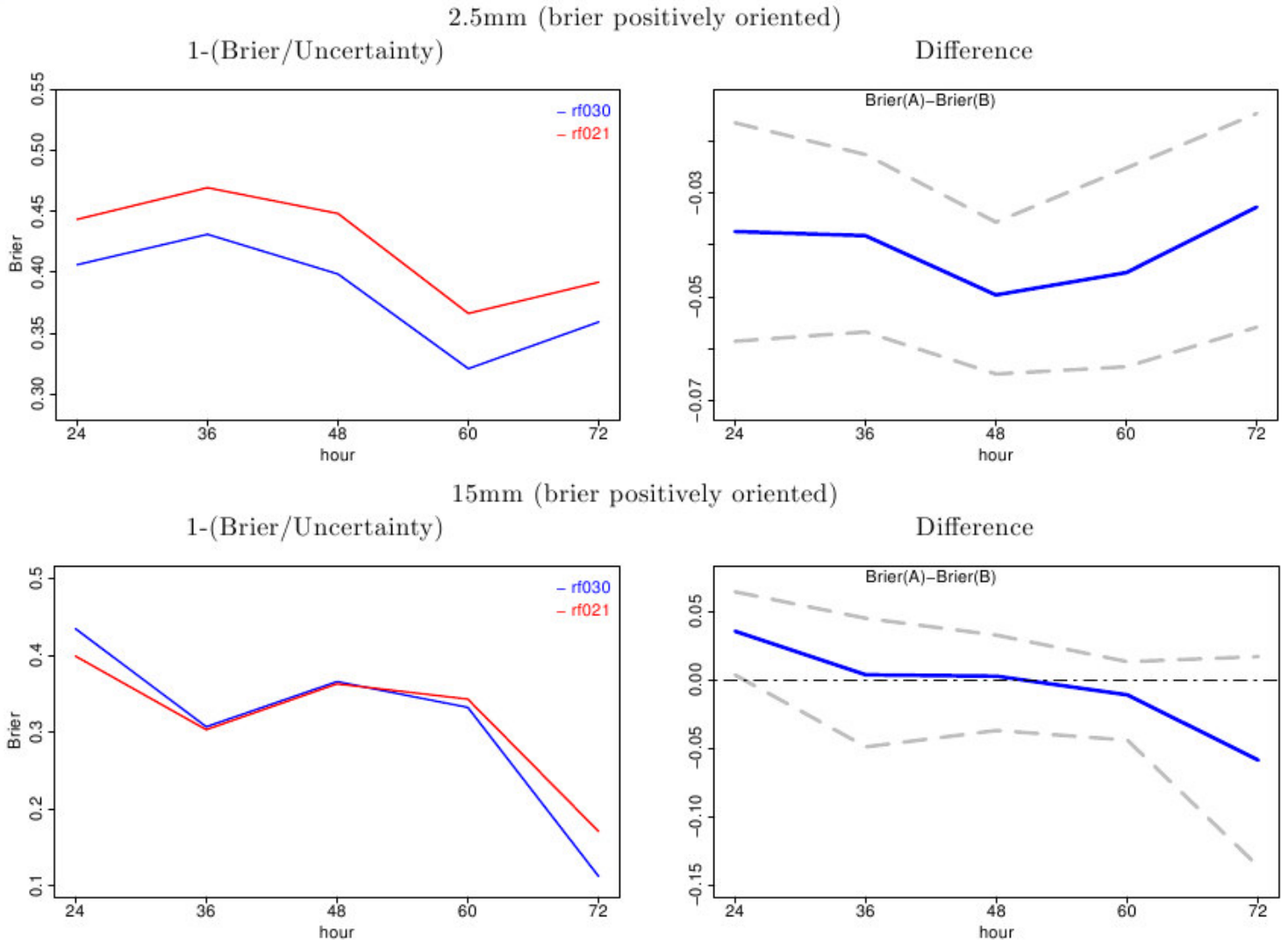
REPS: GEM 4.2 vs GEM 3.2 (regional domain) Winter



REPS: GEM 4.2 vs GEM 3.2 (regional domain) Winter

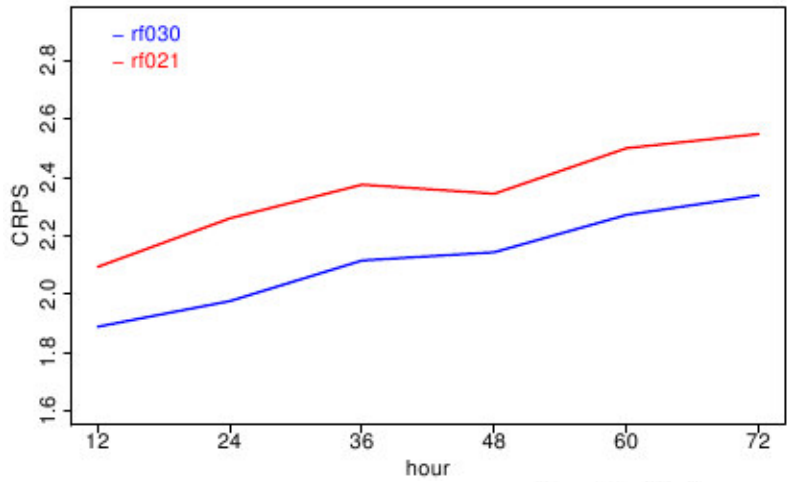


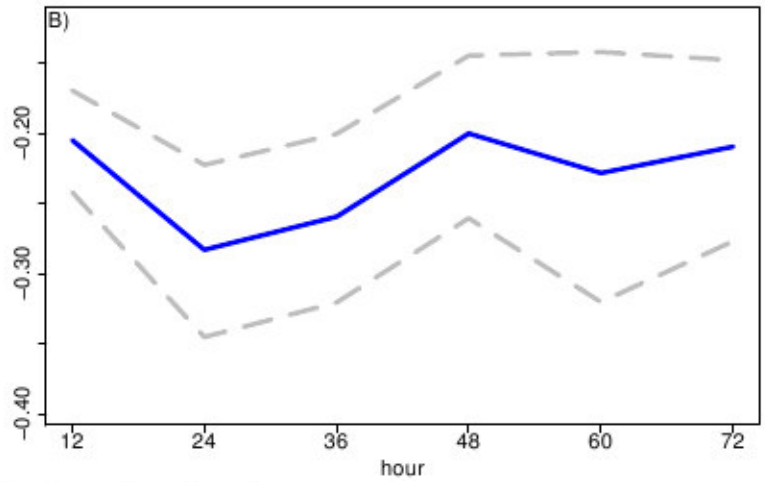
REPS: GEM 4.2 vs GEM 3.2 (regional domain) Winter



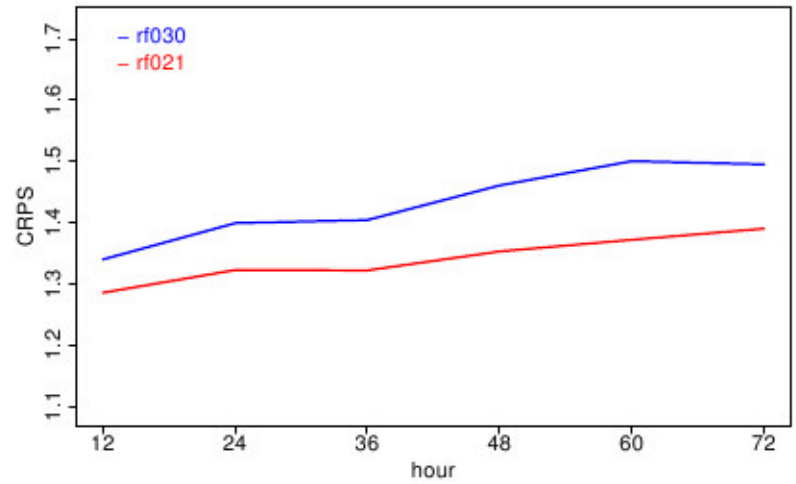
REPS: GEM 4.2 vs GEM 3.2 (regional domain) Winter

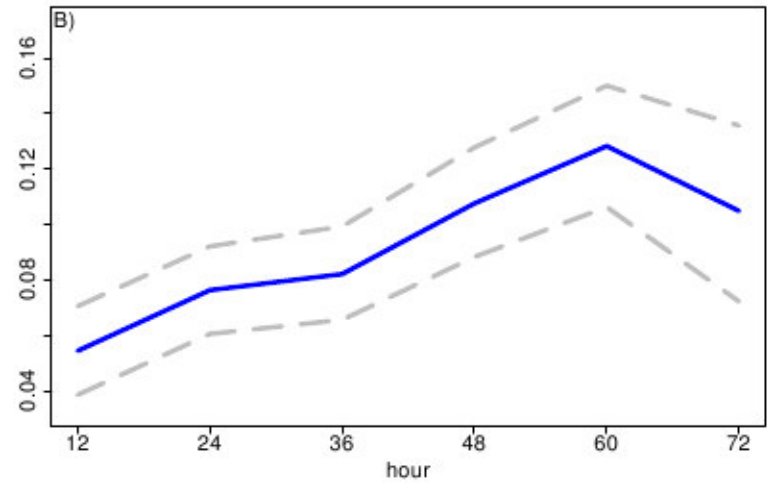
Air temperature at surface level



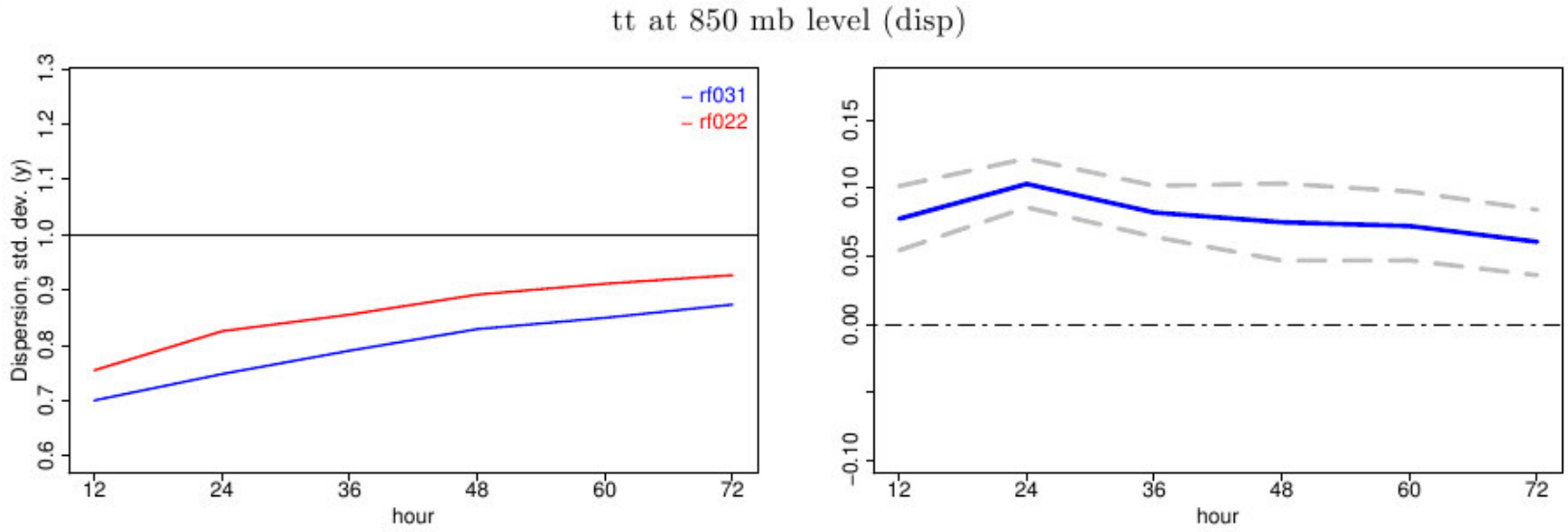


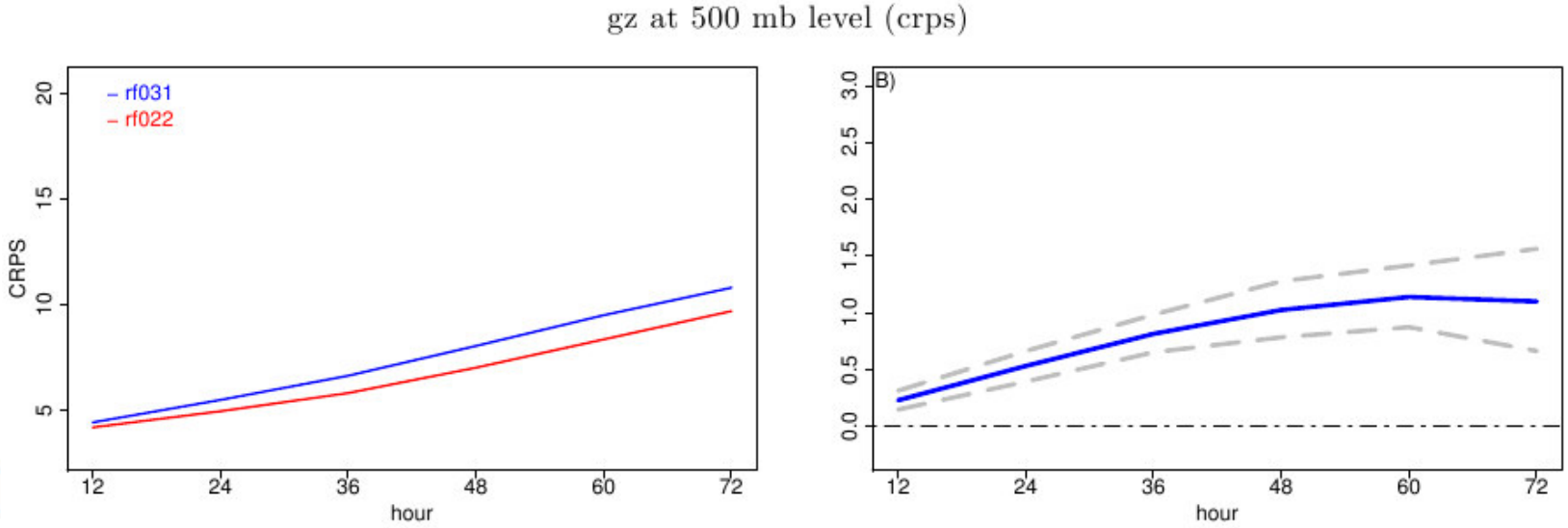
Zonal wind component at surface level



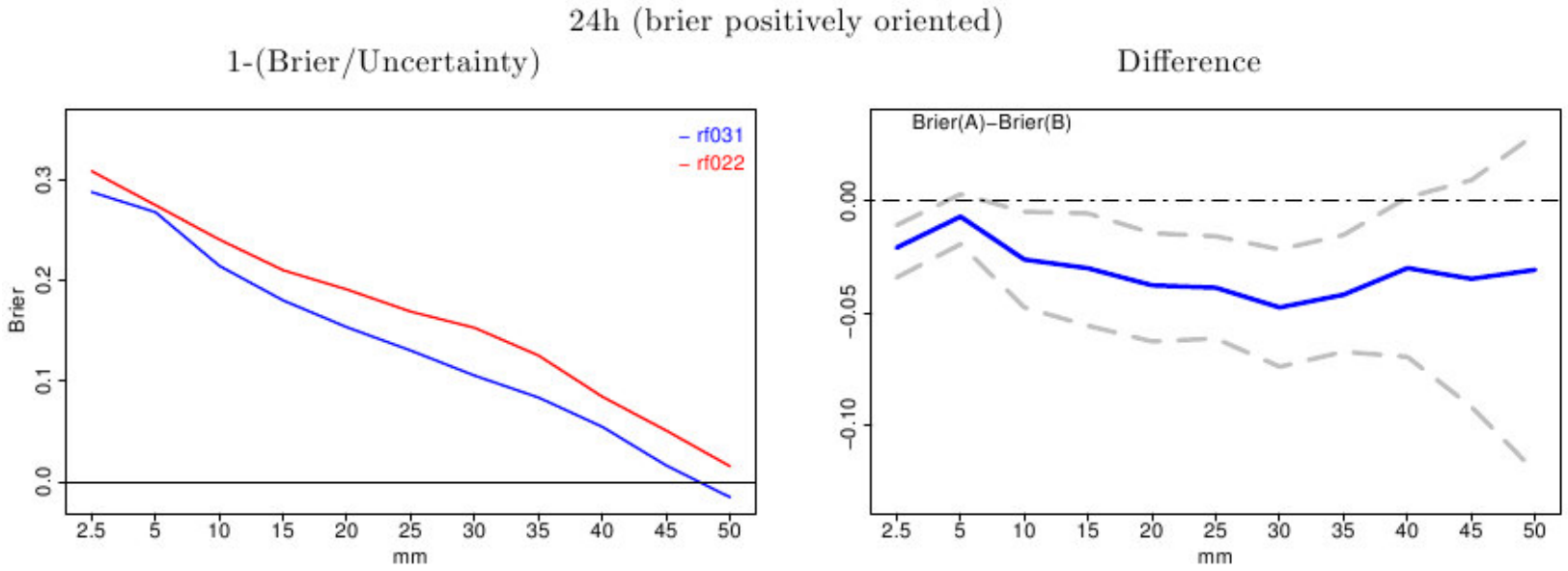


REPS: GEM 4.2 vs GEM 3.2 (regional domain) Summer





REPS: GEM 4.2 vs GEM 3.2 (regional domain) Summer



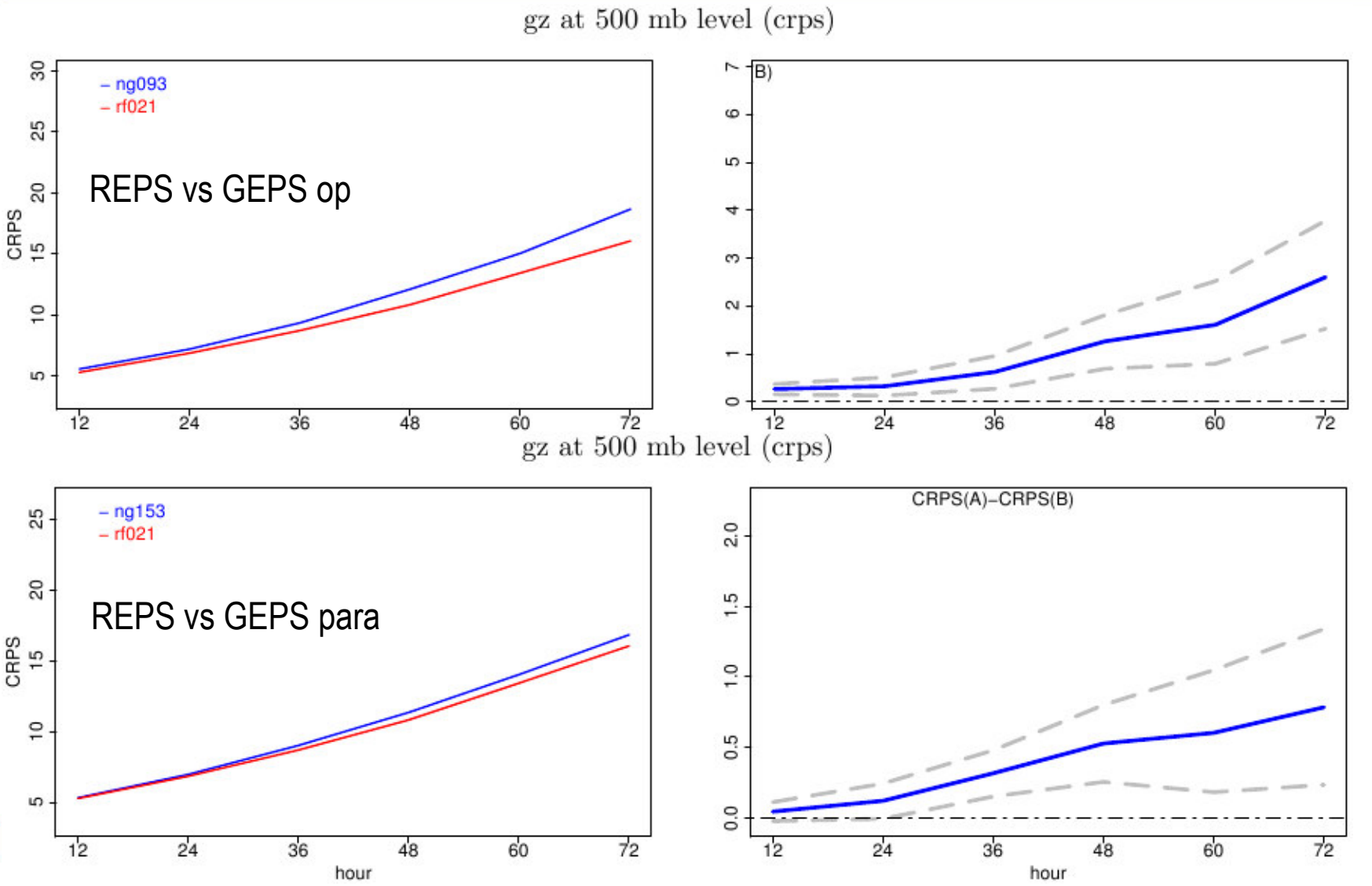
No significant differences for longer lead times

REPS: GEM 4.2 vs GEM 3.2 (regional domain)

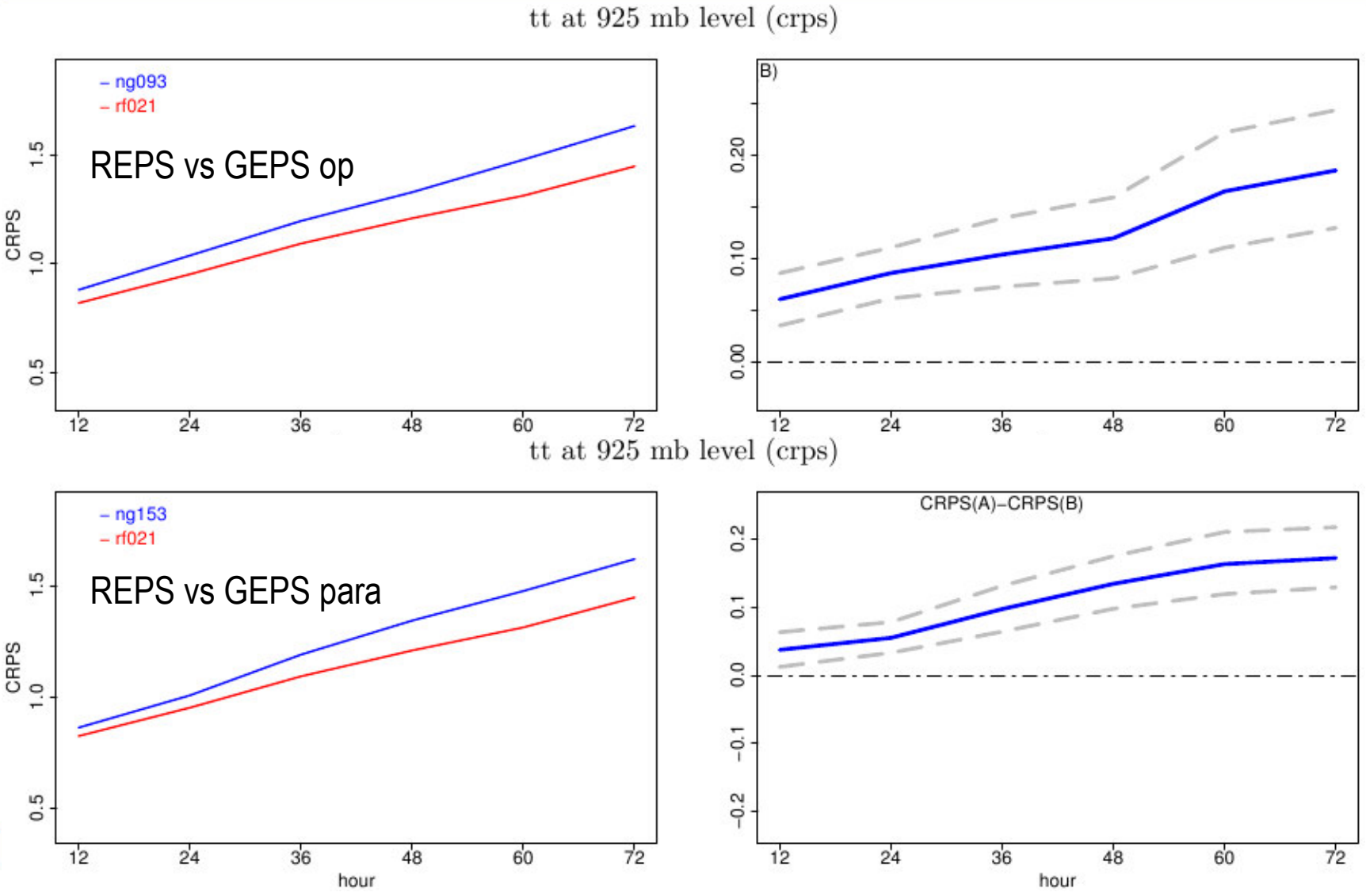
Main conclusions:

- Spread too large in summer, and too small in winter, for upper-air fields
- Surface fields significantly underdispersive
- In general, REPS based on GEM 4.2 outperforms REPS based on GEM 3.2
  - Only noticeable exception is temperature at 2 meters

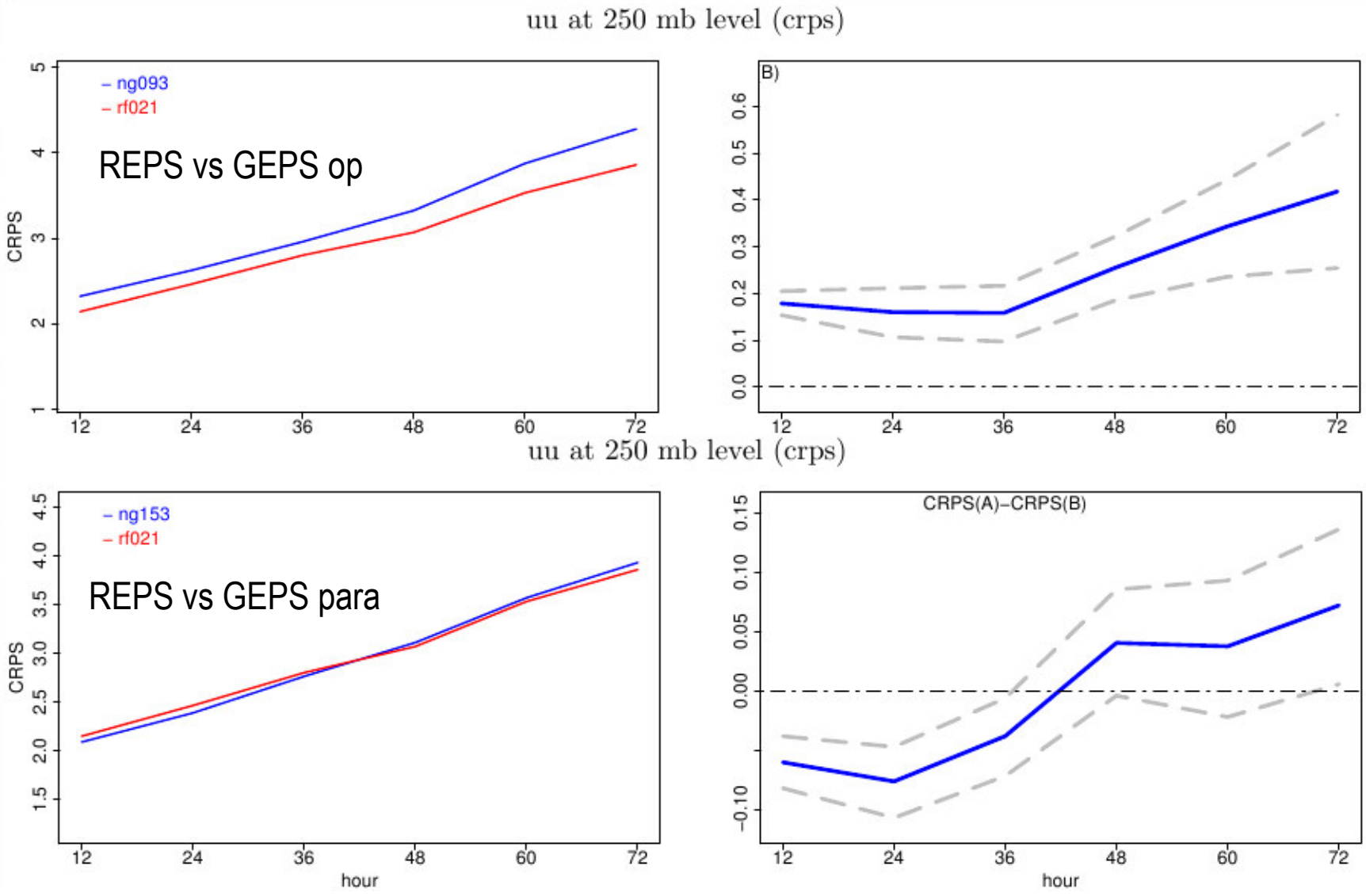
REPS vs GEPS
Winter



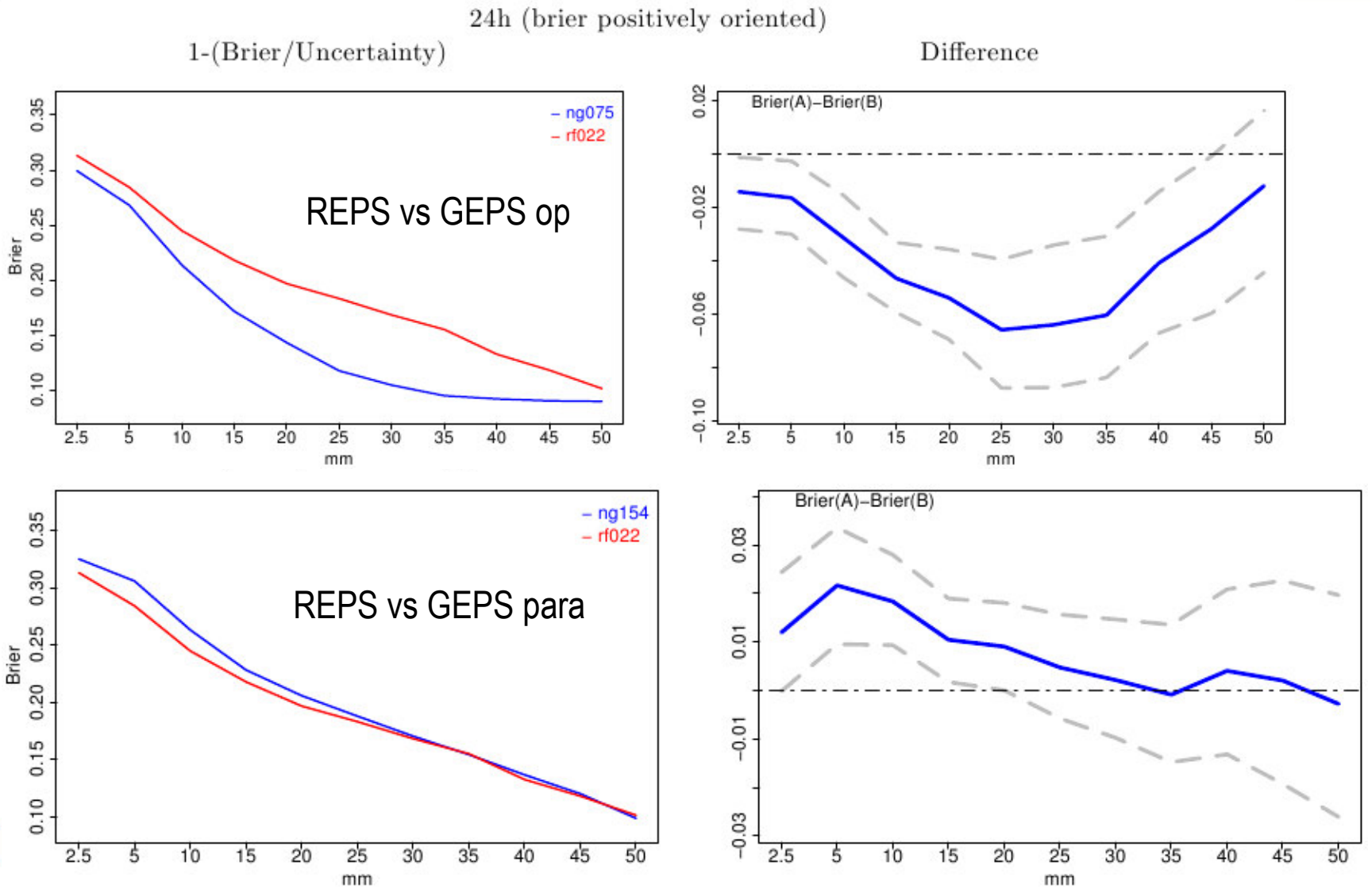
REPS vs GEPS
Winter



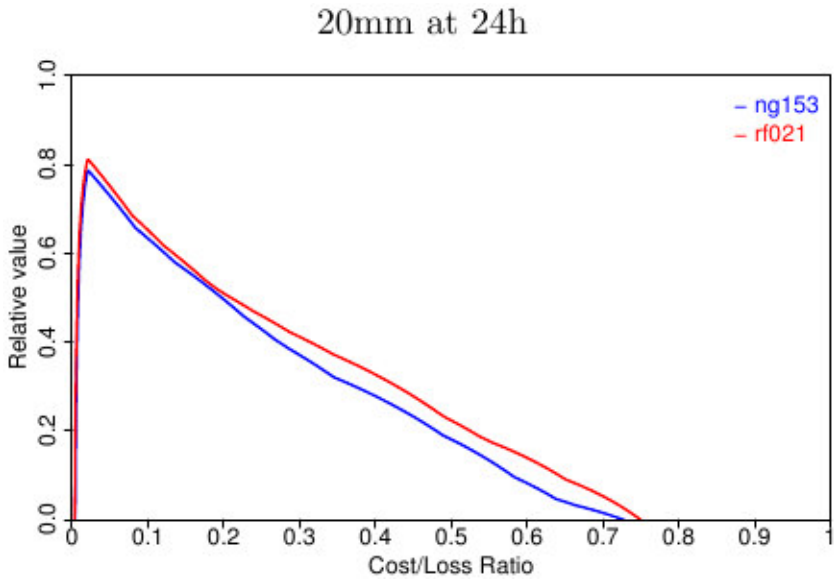
REPS vs GEPS
Winter



REPS vs GEPS Summer



REPS vs GEPS
Summer



Summary

- **REPS GEM 4.2 versus REPS GEM 3.2**
  - Proposed operational REPS outperforms experimental REPS, except for 2-m temperature
- **REPS GEM 4.2 versus parallel GEPS**
  - Upper-air fields of REPS mostly better
  - Surface fields of REPS mostly worse (not shown)
  - Precipitation of REPS not clearly better than GEPS (depends on score used)
- **REPS has good resolution, but reliability in winter can be improved**

Products

http://neige.wul.qc.ec.gc.ca/ensembles/index.html

The future

- Propose operational status at CPOP meeting next week
- Still need to continue to demonstrate the added value of the REPS to the Canadian global EPS
- We put the emphasis on having a good resolution component
- Still need to improve reliability
- A North American Ensemble Forecasting System with regional EPSs (NAEFS-LAM) is planned with NCEP

The future

- In R&D, we focus on
  - improving the representation of model error at the surface (C. Lavaysse)
  - connecting CaLDAS and the REPS (S. Bélair, B. Bilodeau, M. Carrera)
  - developing a regional ensemble Kalman filter (L. Fillion)
  - increasing horizontal grid spacing to 20 km by 2012
  - investigating the utility of increasing vertical resolution

Some remarks

- Currently, runs are at 00 and 12Z
- If we hypothesize that the role of the REPS will increase in the future, we need to think of a strategy to
  - Run 4x per day (implications with the GEPS)
  - Produce forecasts faster?

Complete Scores

EC's internal web site:

http://neige.wul.qc.ec.gc.ca/ensembles/verif/