Environnement Canada Environment Canada

Canada

The Canadian Regional Ensemble Prediction System (REPS)

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Talk Outline

- Brief historical review
  - The different development stages since 2004
- Applications until now
  - Research tool during Olympic events (Beijing 2008, Vancouver 2010)
  - Tests in winter and summer 2009
- A system based on targeted singular vectors (old)
- A system based on downscaling the Global EPS (current)
- Some objective verifications and comparisons
  - REPS: SV-based system versus current system
  - REPS versus GEPS (and sometimes GEM 15 km)

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.
- 2006-2009: Following improvements to the global EPS, the downscaling (of the global EPS) approach is re-tested (paper to be submitted soon)

Applications until now

- For the Beijing 2008 Olympics: System at 15 km resolution for 36h forecasts. Comparison with 5 other systems (2xChina, USA, Japon, France-Austria).
- January and July 2006 over North America. System at 33 km for 48h forecasts.
- 25 January 2009 to 30 July 2009: run daily from 00Z
- For the Vancouver 2010 Olympics: System at 33 km for 48h forecasts. Run twice daily from November 2009 to May 2010.
- To help Haïti: System at 33 km for 72h forecasts over the Tropics and up to Canada. Run twice daily from June 2010 to Fall 2010.

A REPS Based on Singular Vectors (old)

- 10 singular vectors are calculated on a low resolution global grid (240x120, or about 150 km)
- Initial norm is global; final norm is located over North America
- Optimization period is 24h and moist physics is included
- SVs are interpolated to the resolution of the pilot model (100 km res.)
- SVs are used to perturb the pilot runs producing an ensemble of boundary and initial conditions for 20 LAM integrations
- Horizontal resolution of REPS: 33 km
- 28 levels to 10 hPa
- Same physics as global model
- Physics tendency perturbations
- Some parameter perturbations

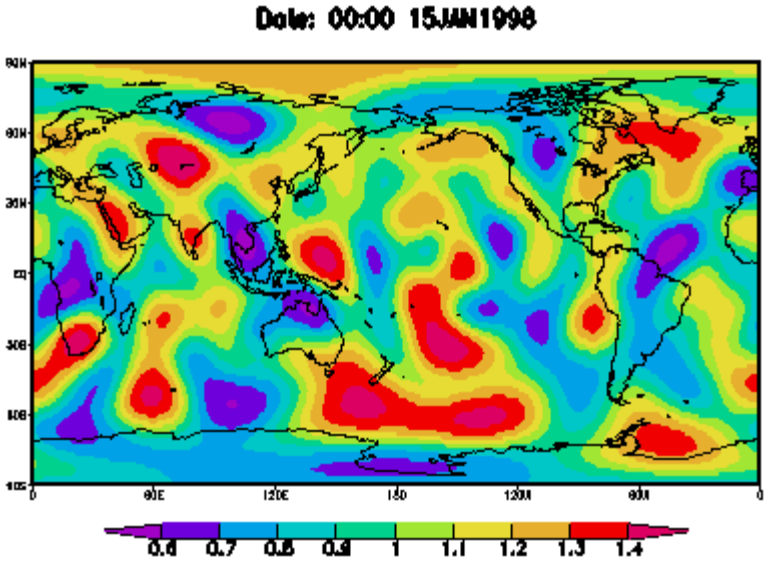
Downscaling the Global EPS (current)

- The pilot integrations:
  - Initial conditions for the operational Canadian Global EPS are provided by an Ensemble Kalman filter with 96 members
  - 20 members are used for medium-range weather forecasts
  - Multi-parameter, multi-parameterization approach with a single dynamical core (the GEM model)
  - Stochastic physics: physical tendency perturbations (à la ECMWF) and kinetic energy backscatter scheme (à la Shutts, 2005)
- The LAM integrations:
  - 20 GEM-LAM integrations at 33 km resolution
  - Stochastic perturbations of physical tendencies and/or some parameters
  - Boundary condition updating frequency: once per three hours
  - Same sub-grid scale parameterizations and resolution as deterministic global model

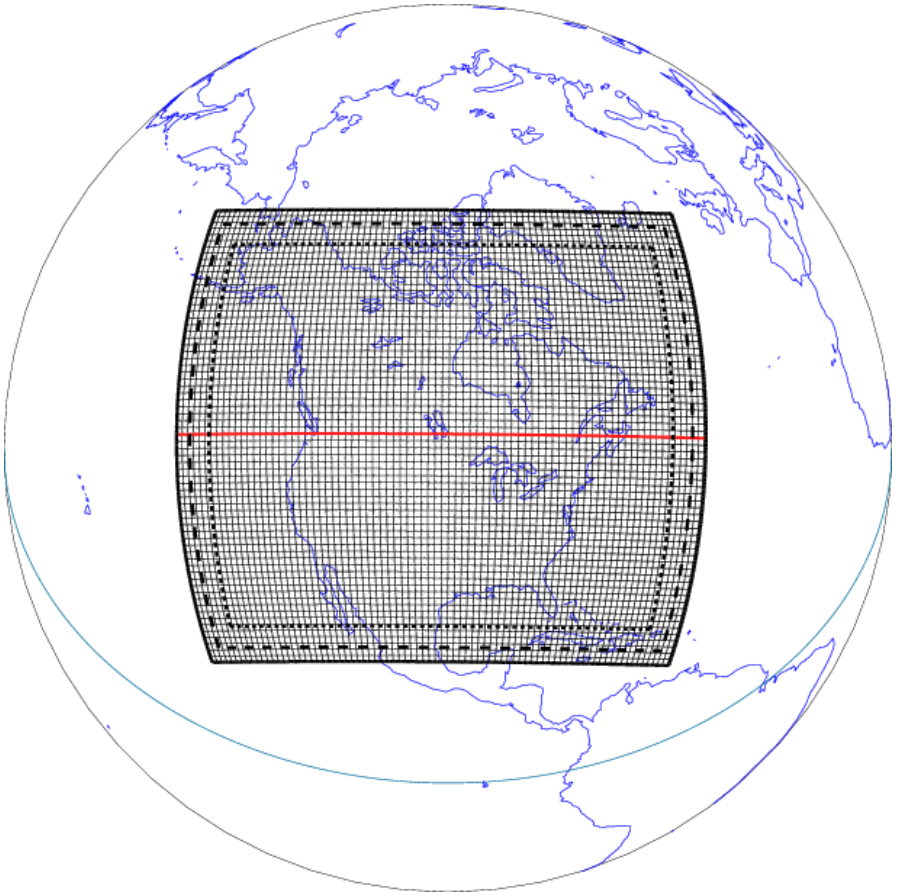
Physics Perturbations with Markov Chains

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

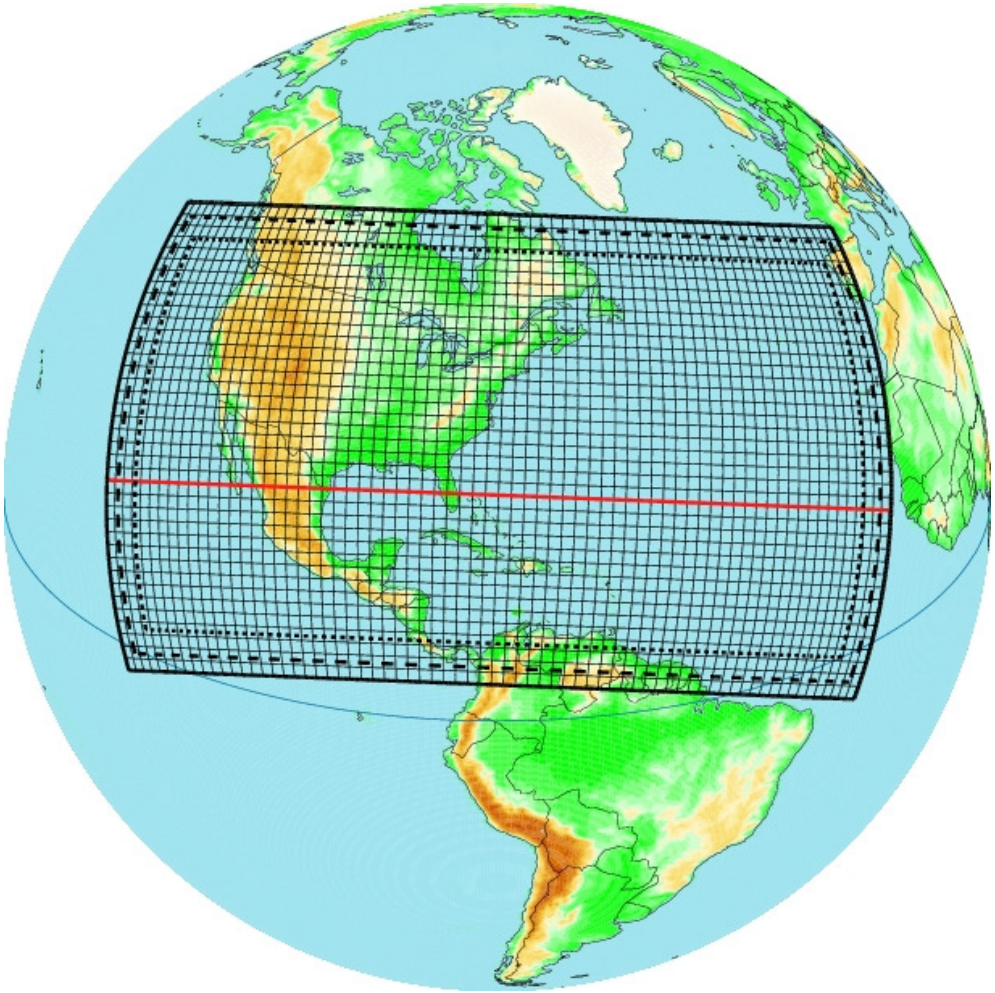
$$a_{lm}(t+\Delta t) = e^{-\Delta t/\tau} a_{lm}(t) + R(t)$$



Domain of the REPS



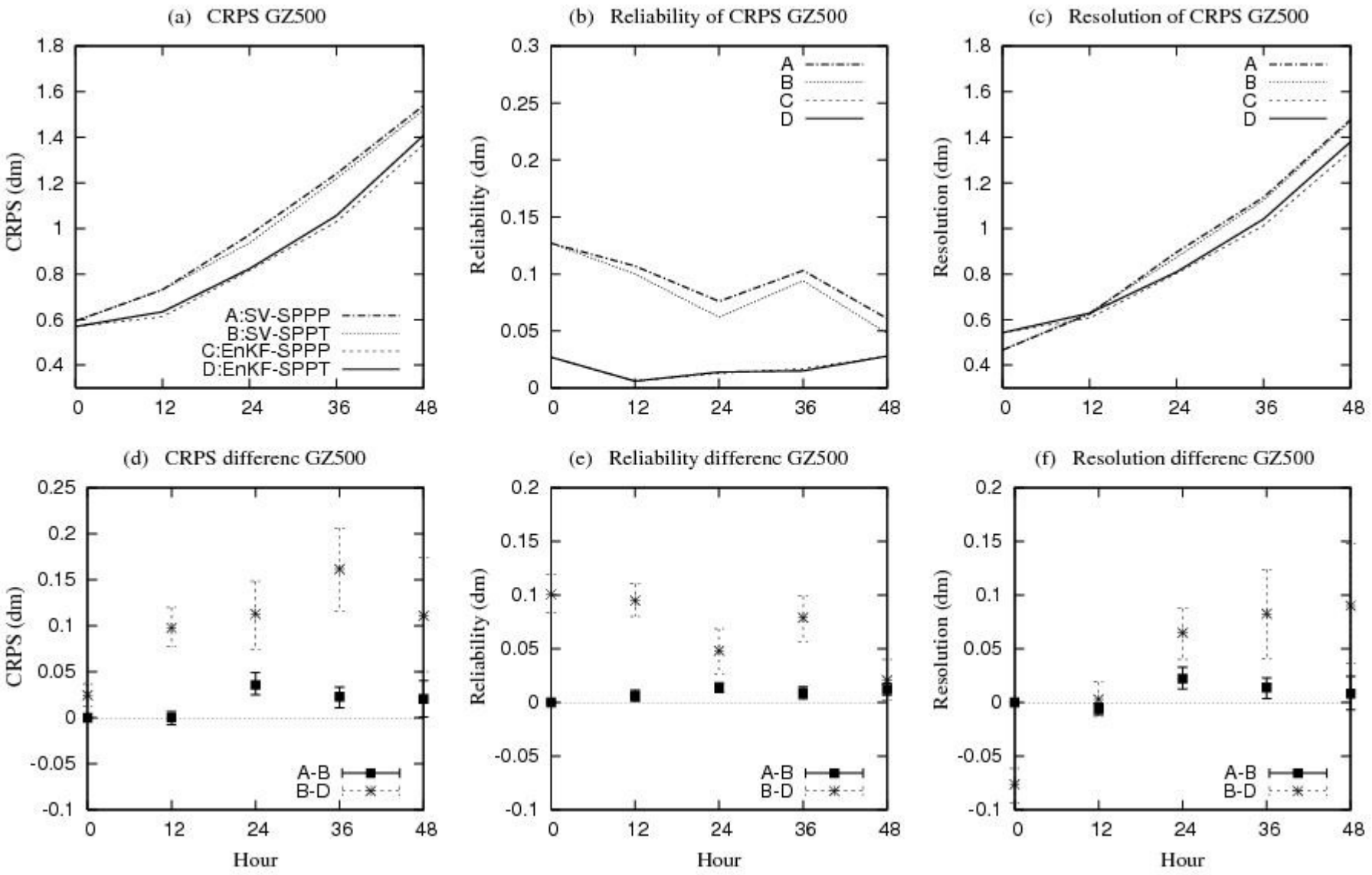
Grid for Haïti (Summer-Fall 2010)



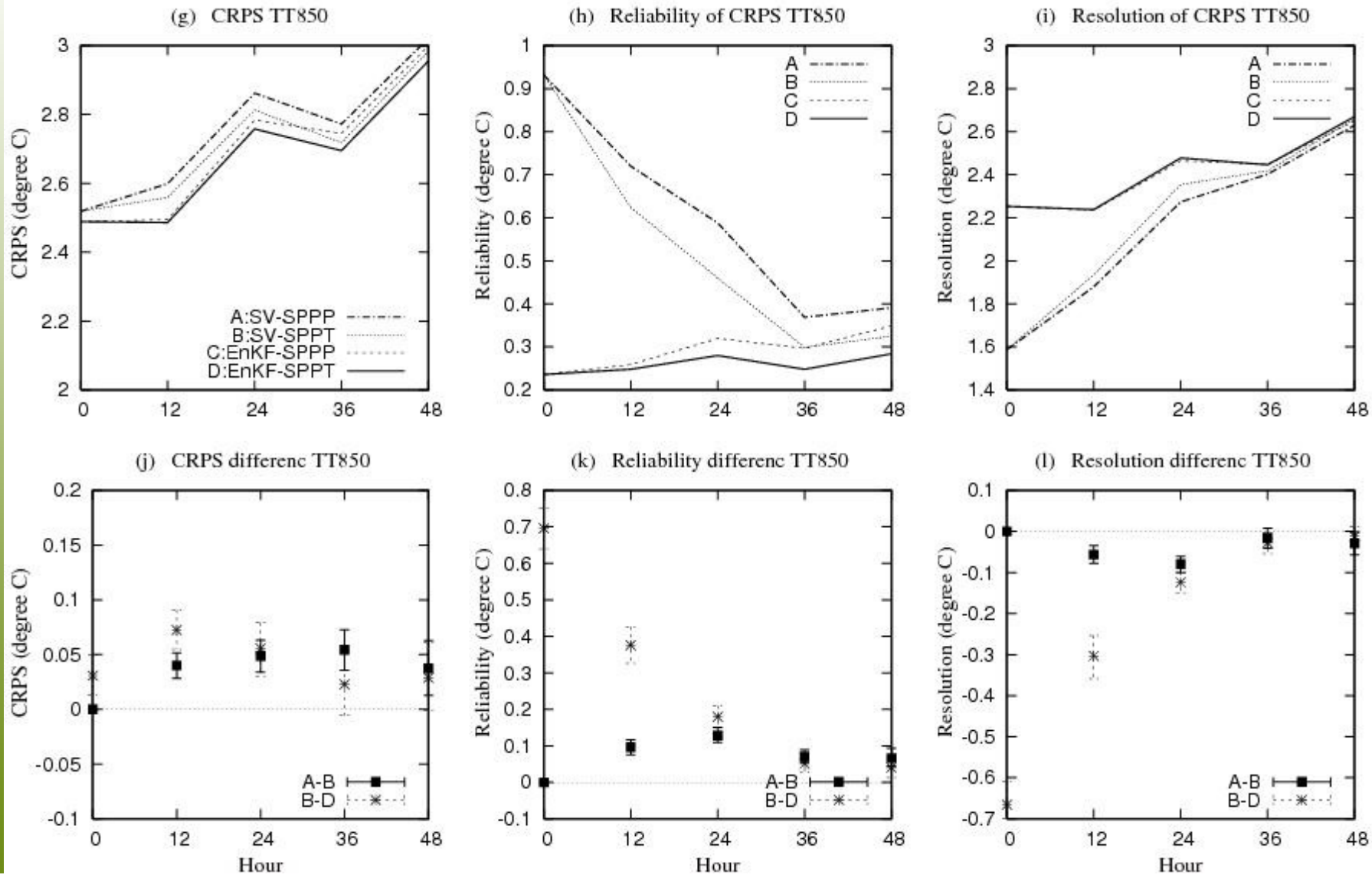
Definition of the Experiments

- **SV_sppp**
  - Singular vectors are used
  - Stochastic physics based on parameter perturbations
    - Threshold vert. velocity in Kain-Fritsch, threshold rh in Sundqvist
- **SV_sppt**
  - Singular vectors are used
  - Stochastic physics based on total tendency perturbations
- **EnKF_sppp**
  - Downscaling of GEPS
  - Stochastic physics based on parameter perturbations
    - Threshold vert. velocity in Kain-Fritsch, threshold rh in Sundqvist
- **EnKF_sppt**
  - Downscaling of GEPS
  - Stochastic physics based on total tendency perturbations

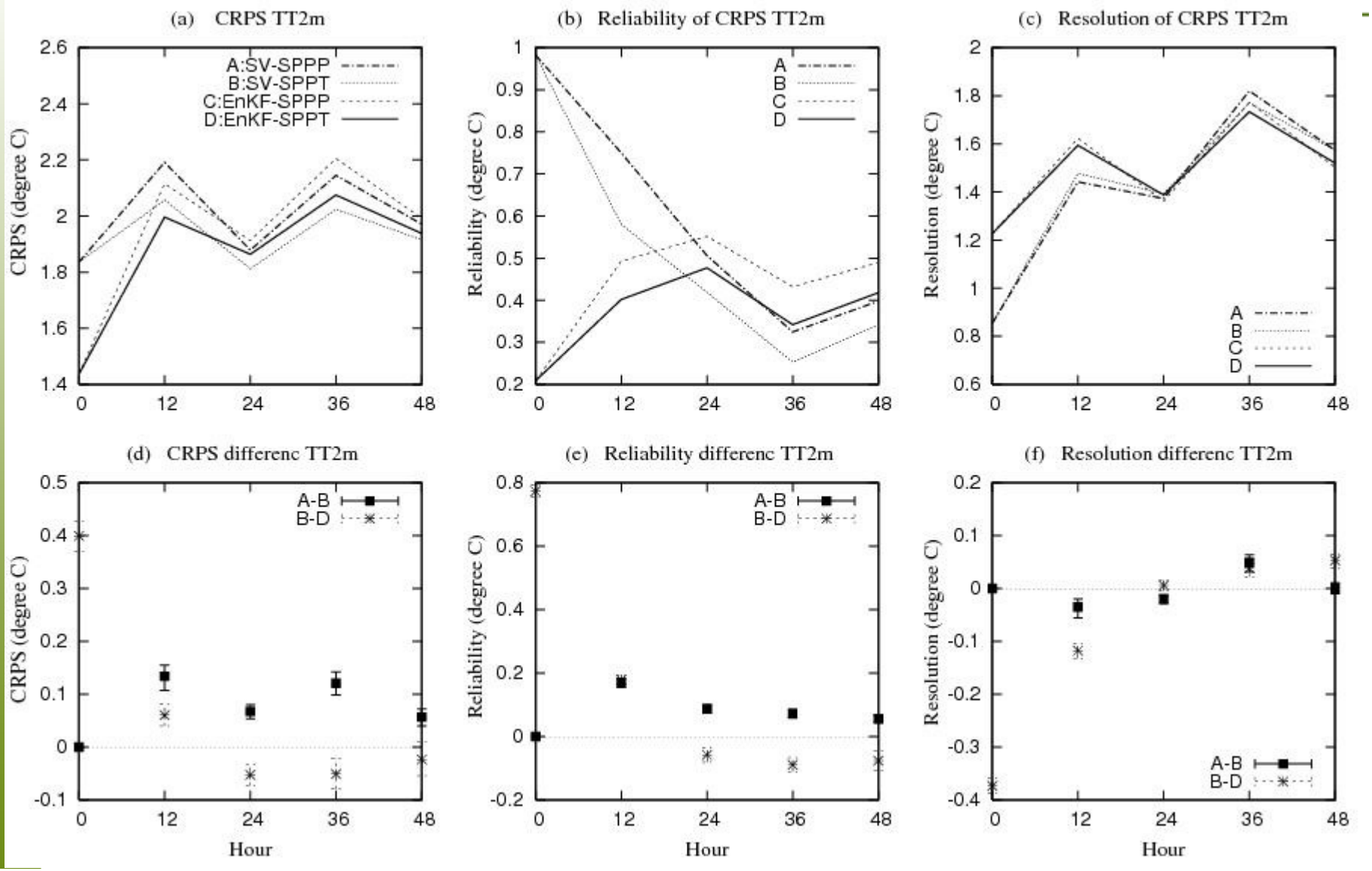
SV versus current approach (GZ500, Winter)



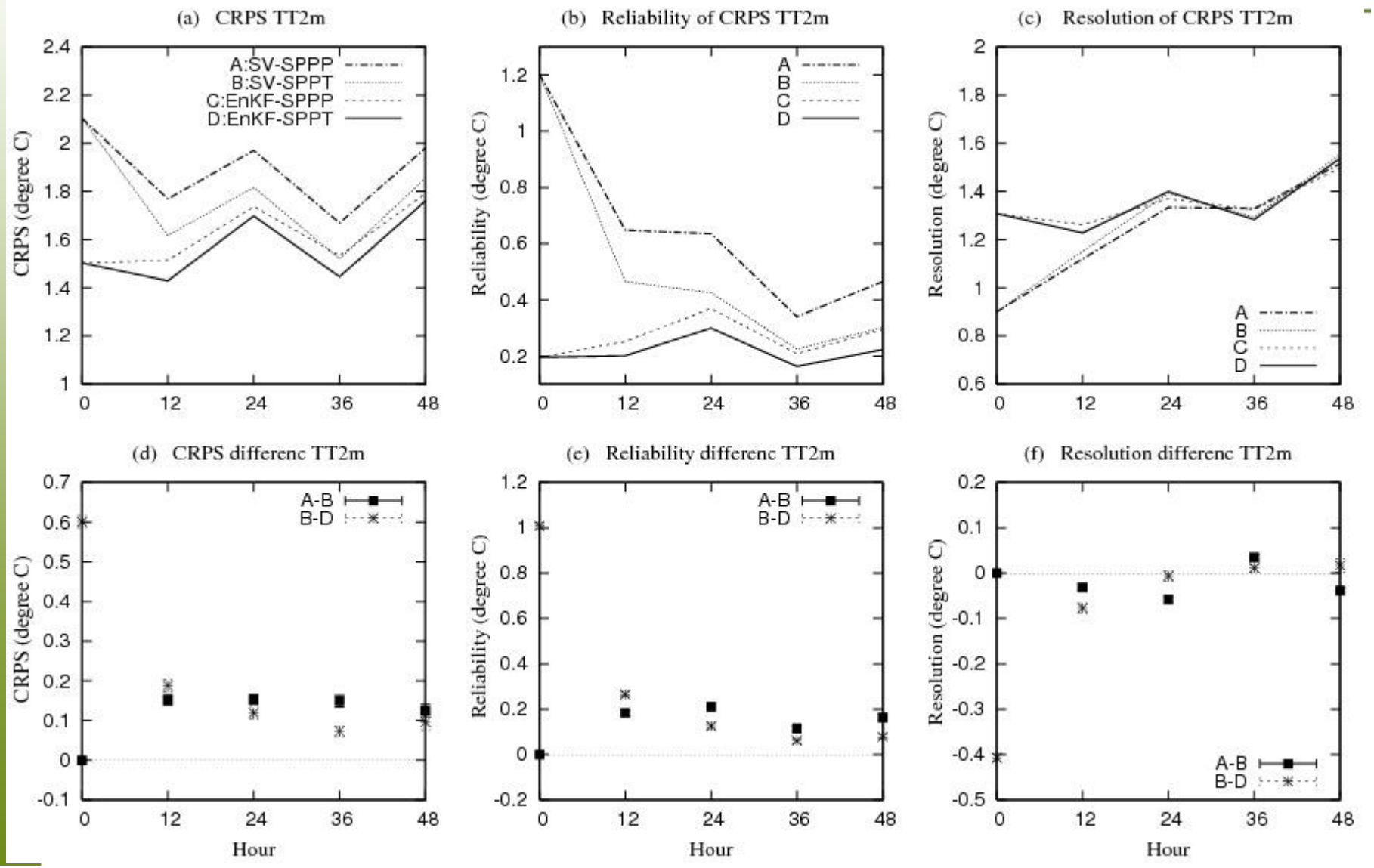
SV versus current approach (TT850, Winter)



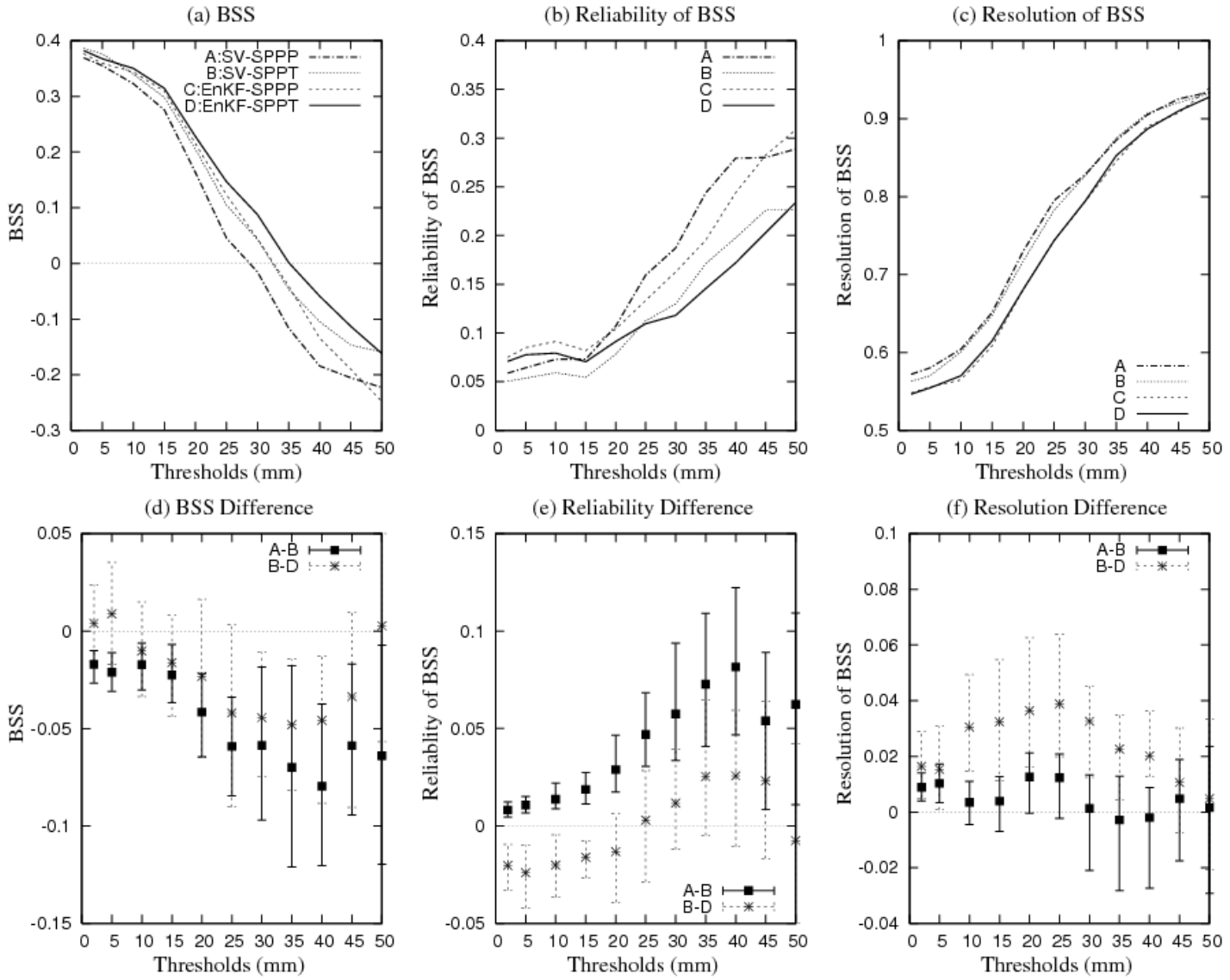
SV versus current approach (T2m, Winter)



SV versus current approach (T2m, Summer)



SV versus current approach (Precip, Winter)



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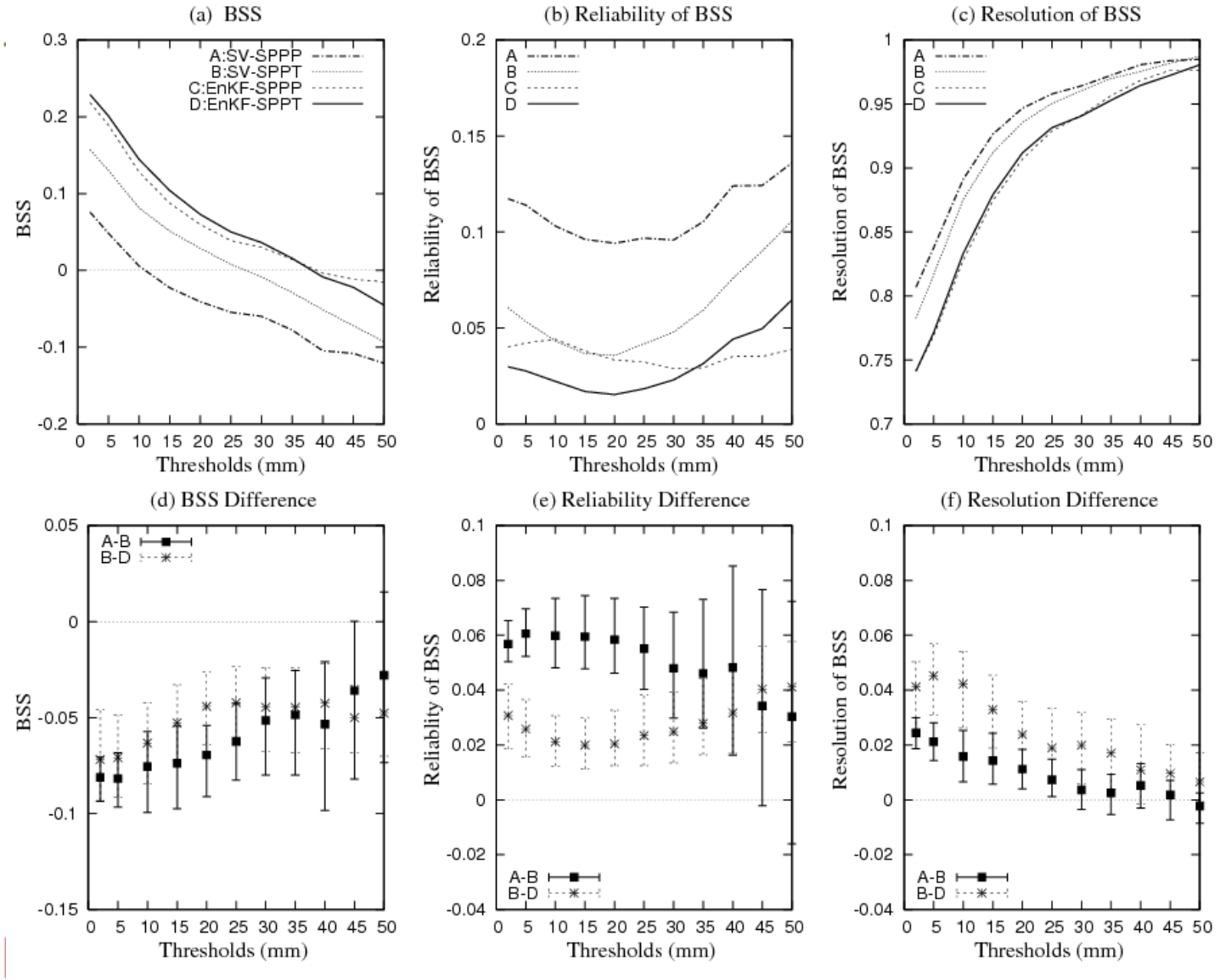
SV versus current approach (Precip, Summer)



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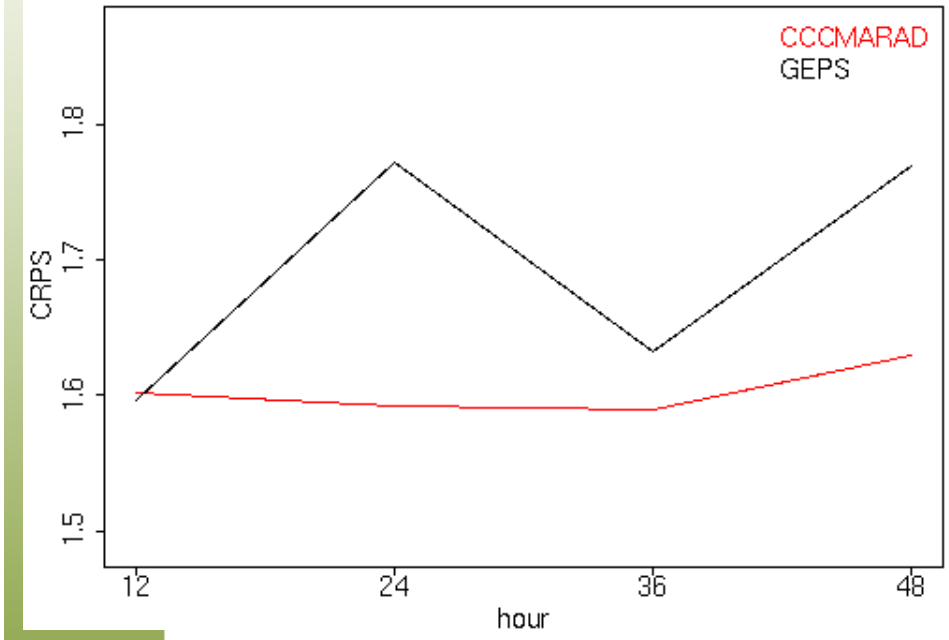
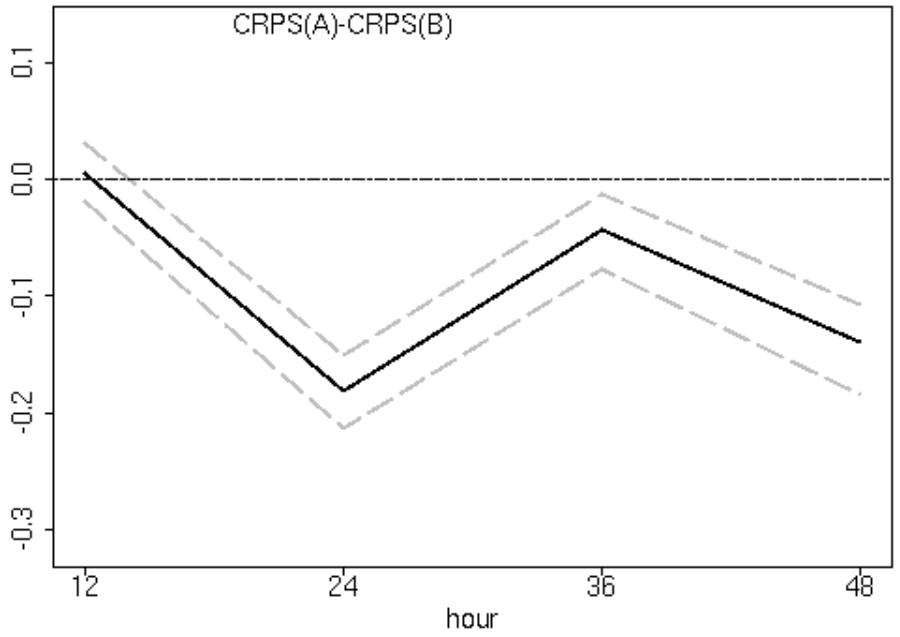
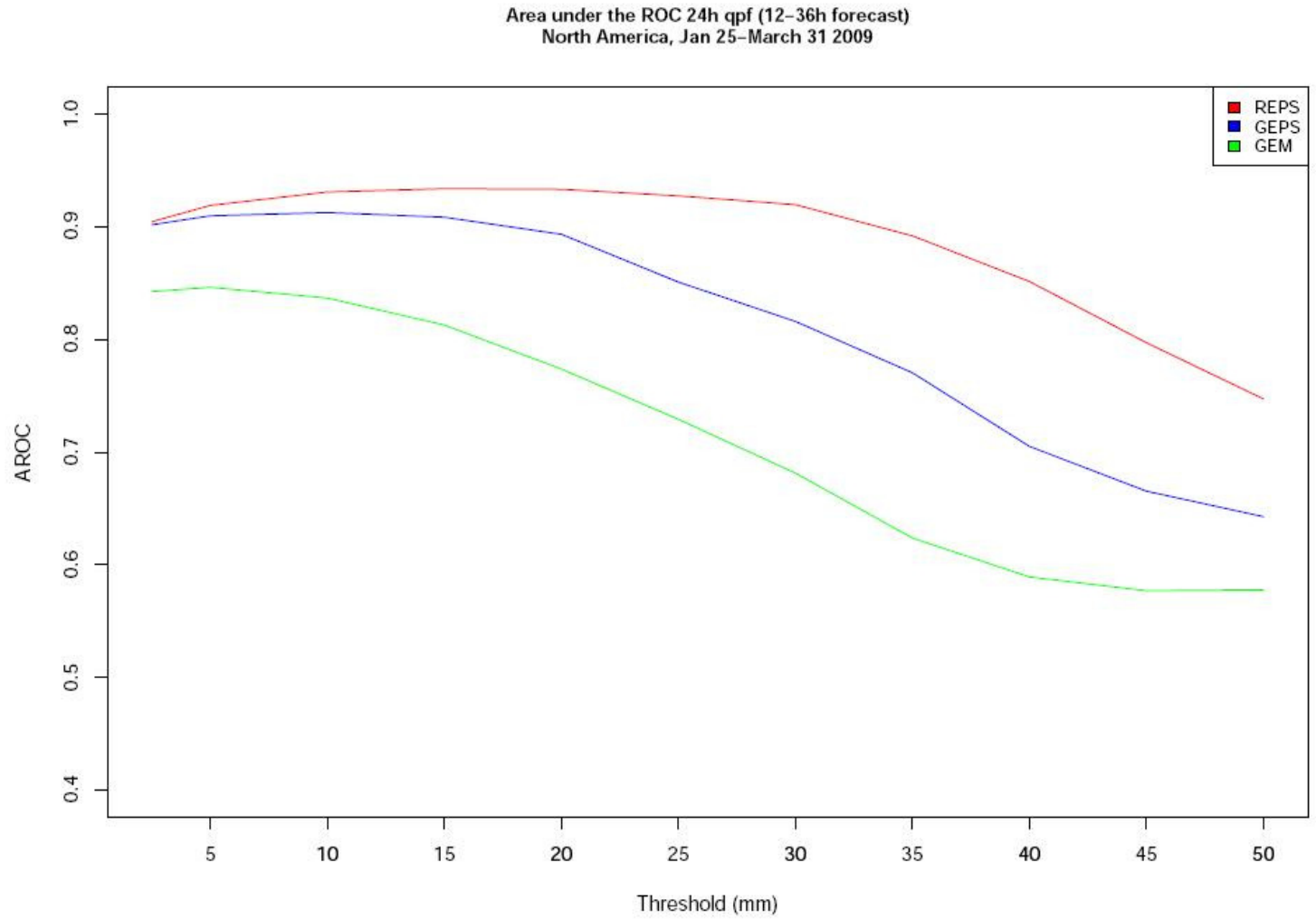
Regional EPS versus Global EPS
CRPS, Temperature at 2m, winter 2009





Regional EPS versus Global EPS
Area under ROC, 24h precip. accum. 12-36 h



Some remarks

- Piloting the LAM integrations with the Canadian global EPS provides better results than using targeted singular vectors
- Our aim is an operational status of the REPS in Fall 2010
- We put the emphasis on having a good resolution
- Still need to improve reliability
- We currently focus on
  - improving the representation of model error at the surface
  - develop a regional ensemble Kalman filter (will start soon)

Complete Scores

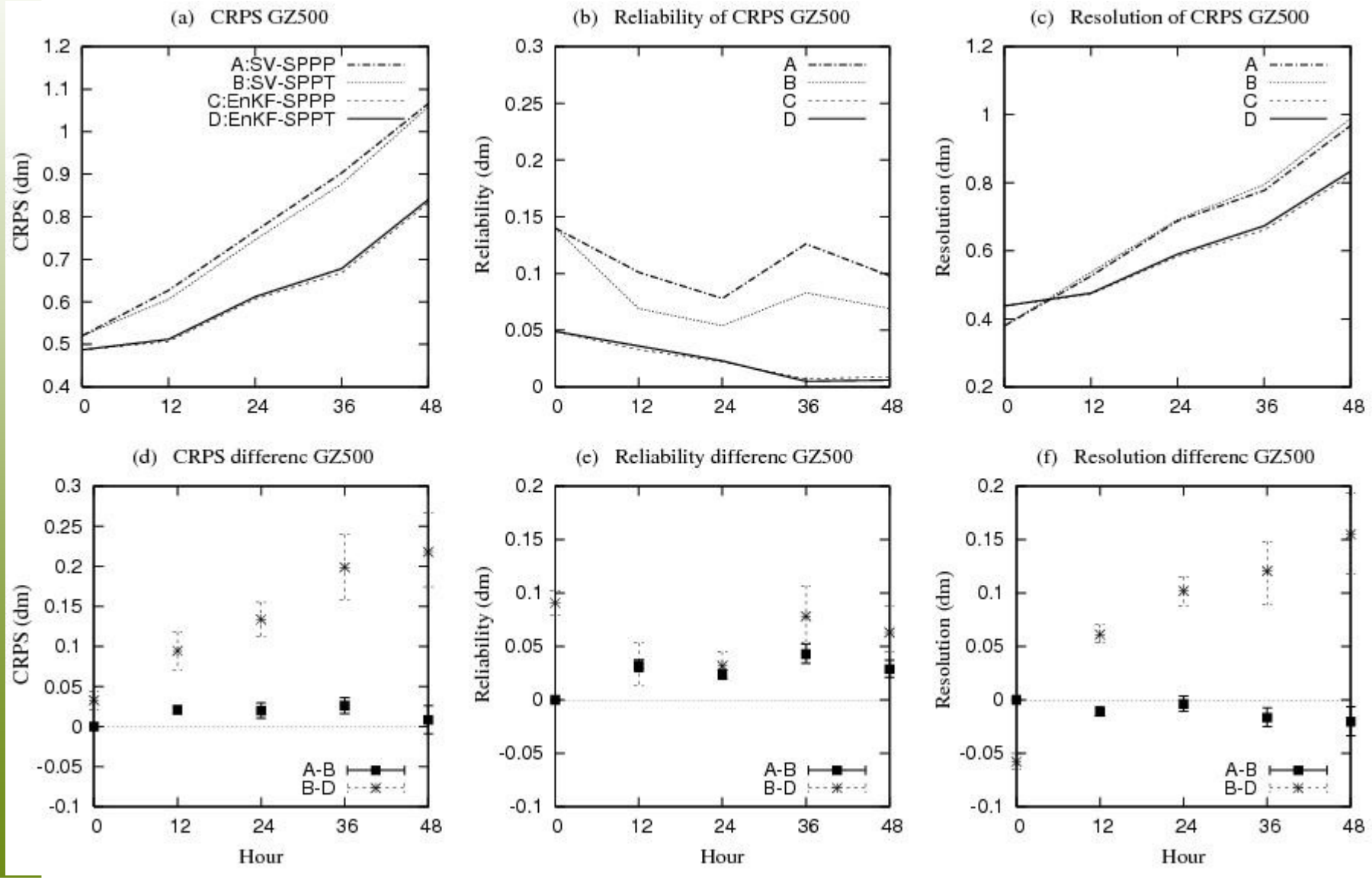
EC's internal web site:

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

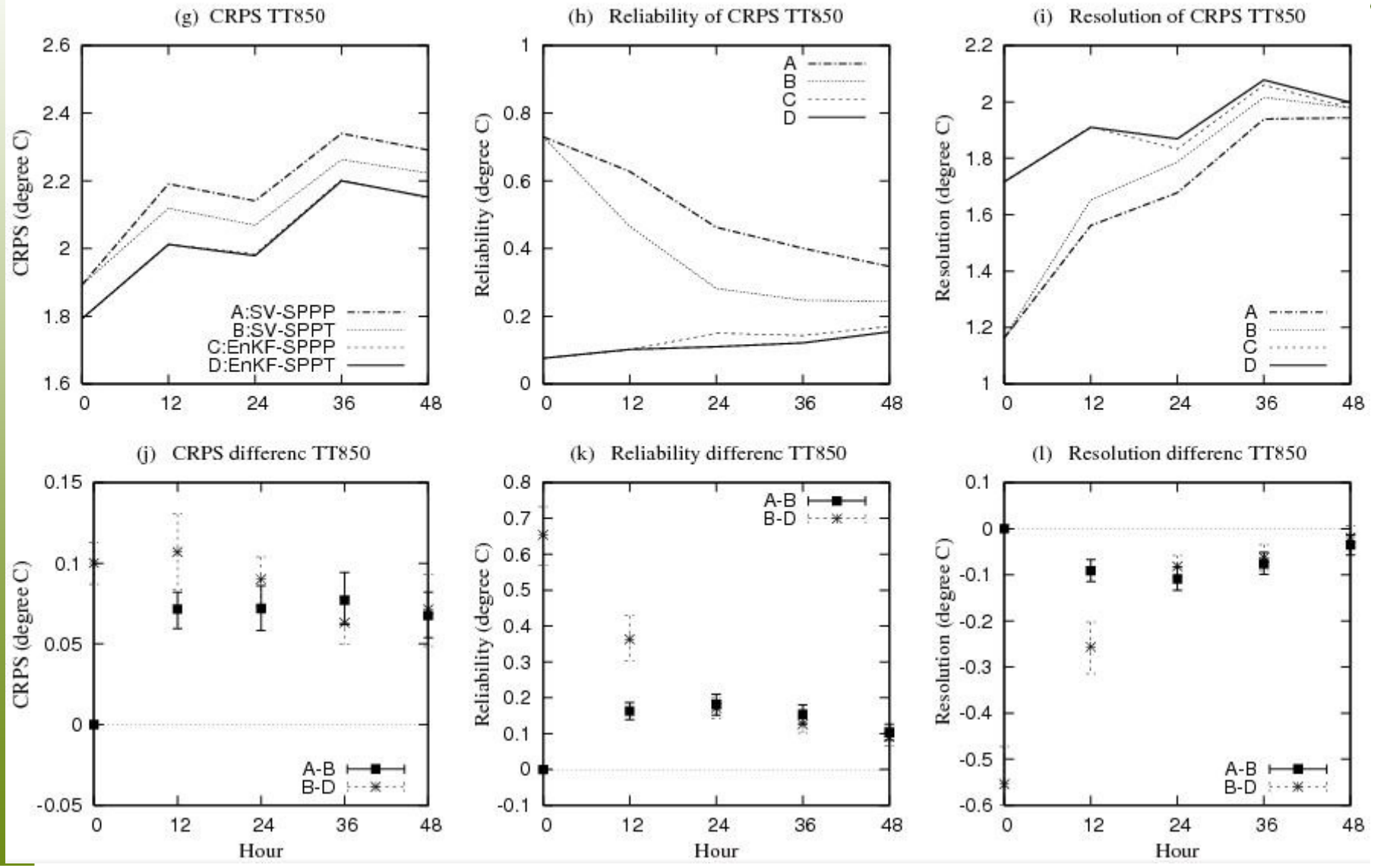
Main differences with global EPS physics

- Global EPS: Two surface scheme (Force-restore and ISBA)
- Regional EPS: Only ISBA
- Global EPS: Four deep convection schemes (Kain-Fritsch, Relaxed Arakawa-Schubert, 2 flavors of Kuo)
- Regional EPS: Only Kain-Fritsch
- Global EPS: Different parameter values for GWD and ABL schemes
- Regional EPS: All members have same parameter values
- Global EPS: Use SKEB
- Regional EPS: no SKEB
- Global EPS: Fouquart/Bonnel+Garand radiation scheme
- Regional EPS: Li and Barker (correlated-k)

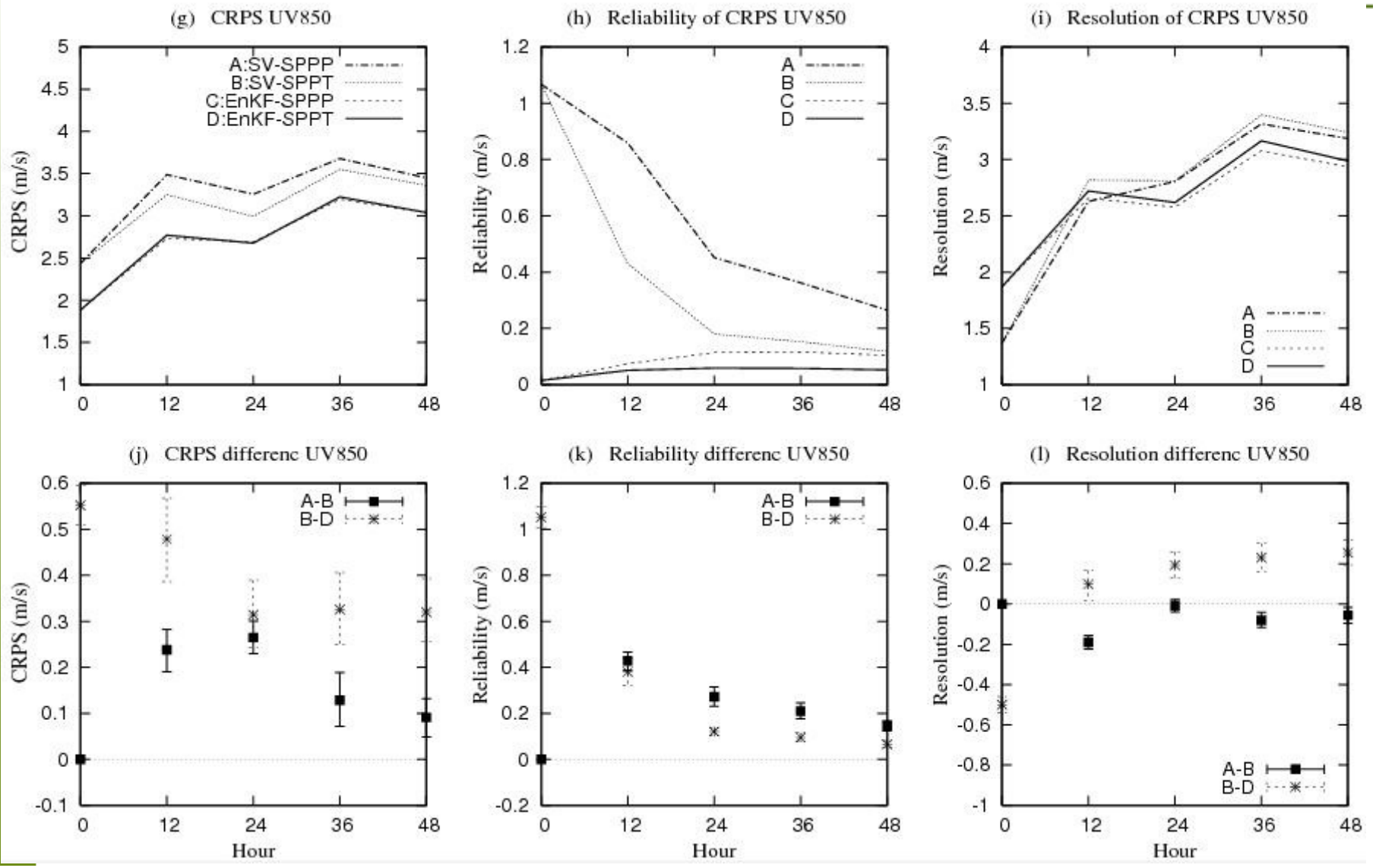
SV versus current approach (GZ500, Summer)



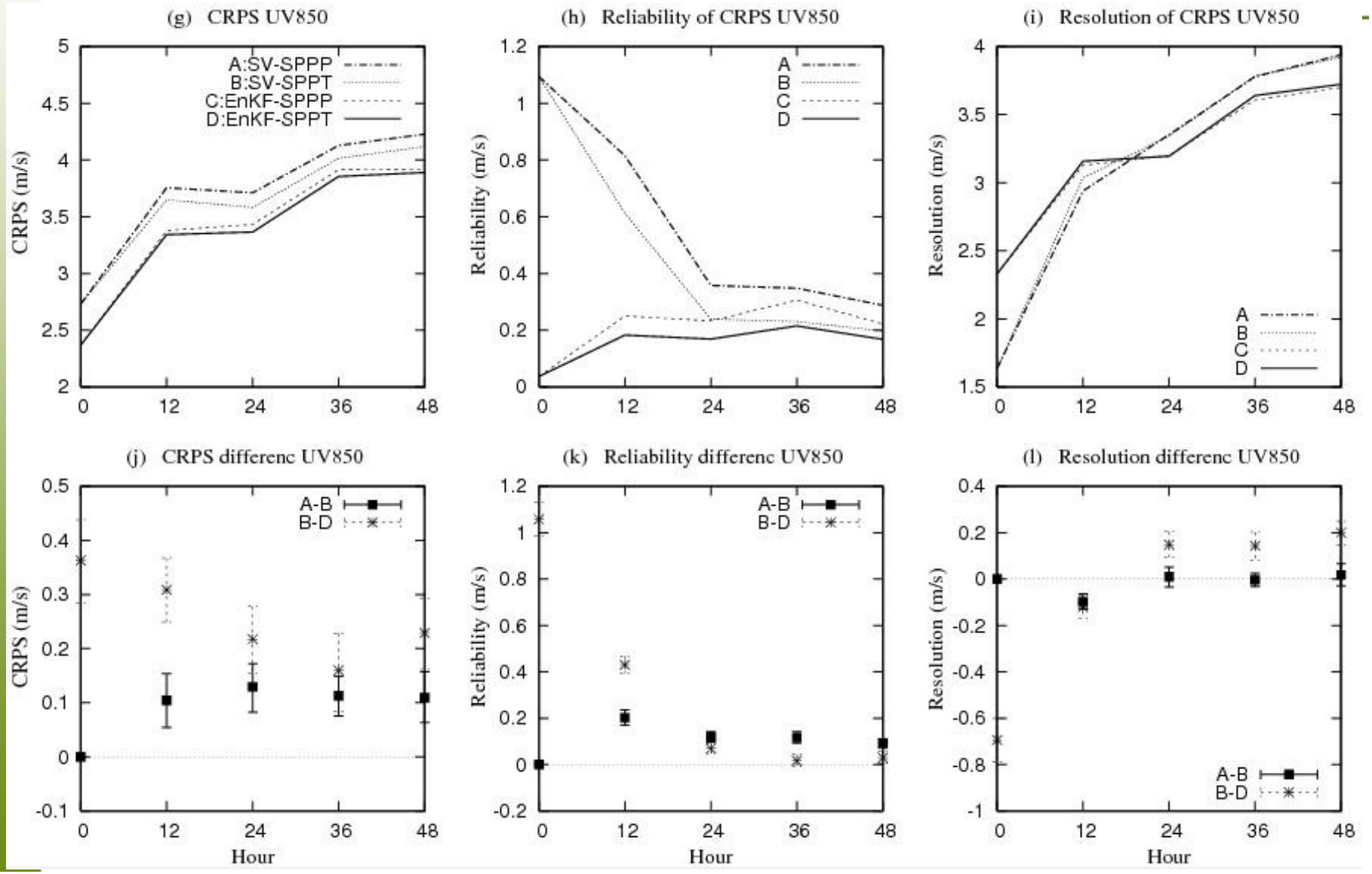
SV versus current approach (TT850, Summer)



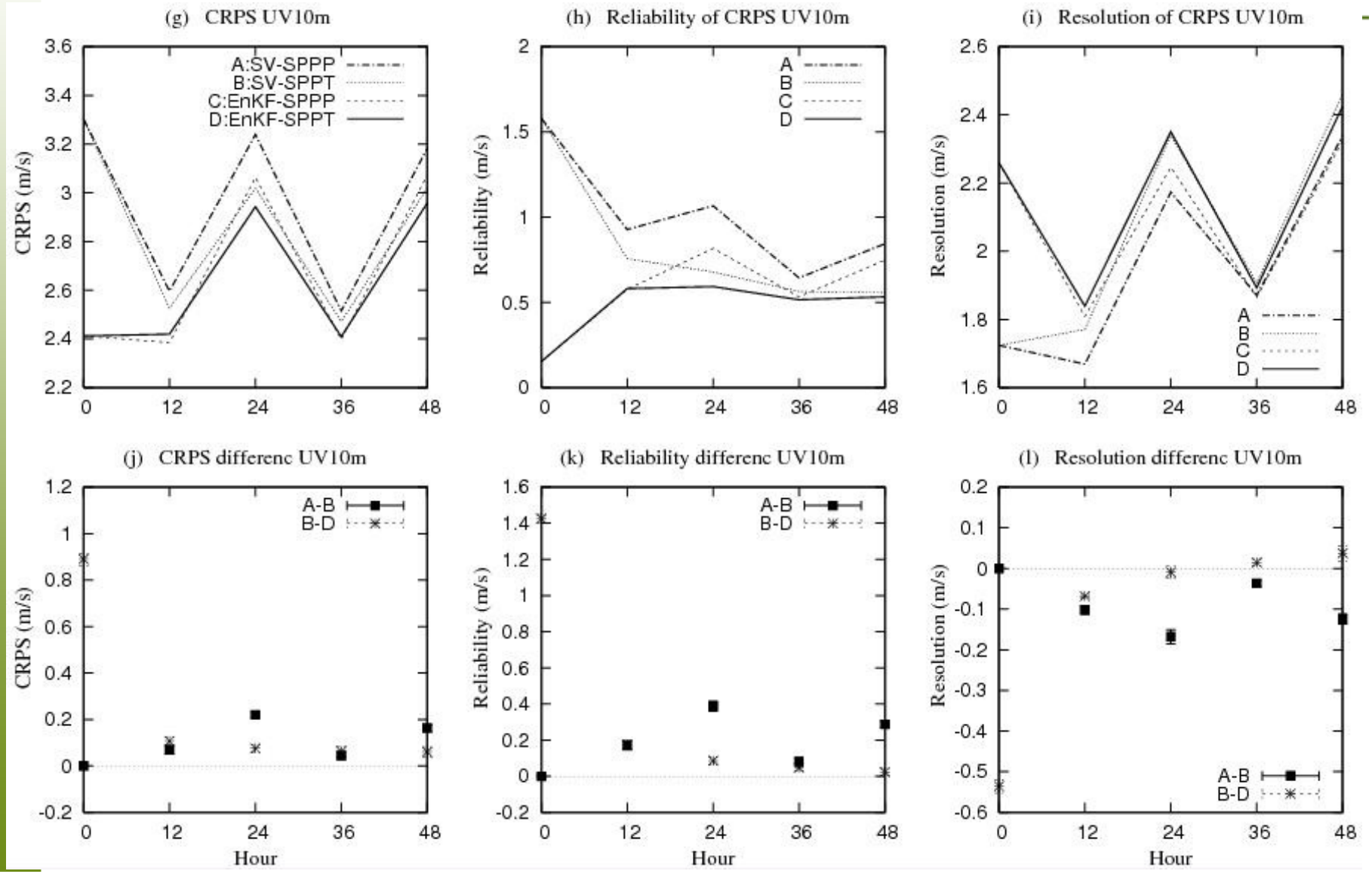
SV versus current approach (UV850, Summer)



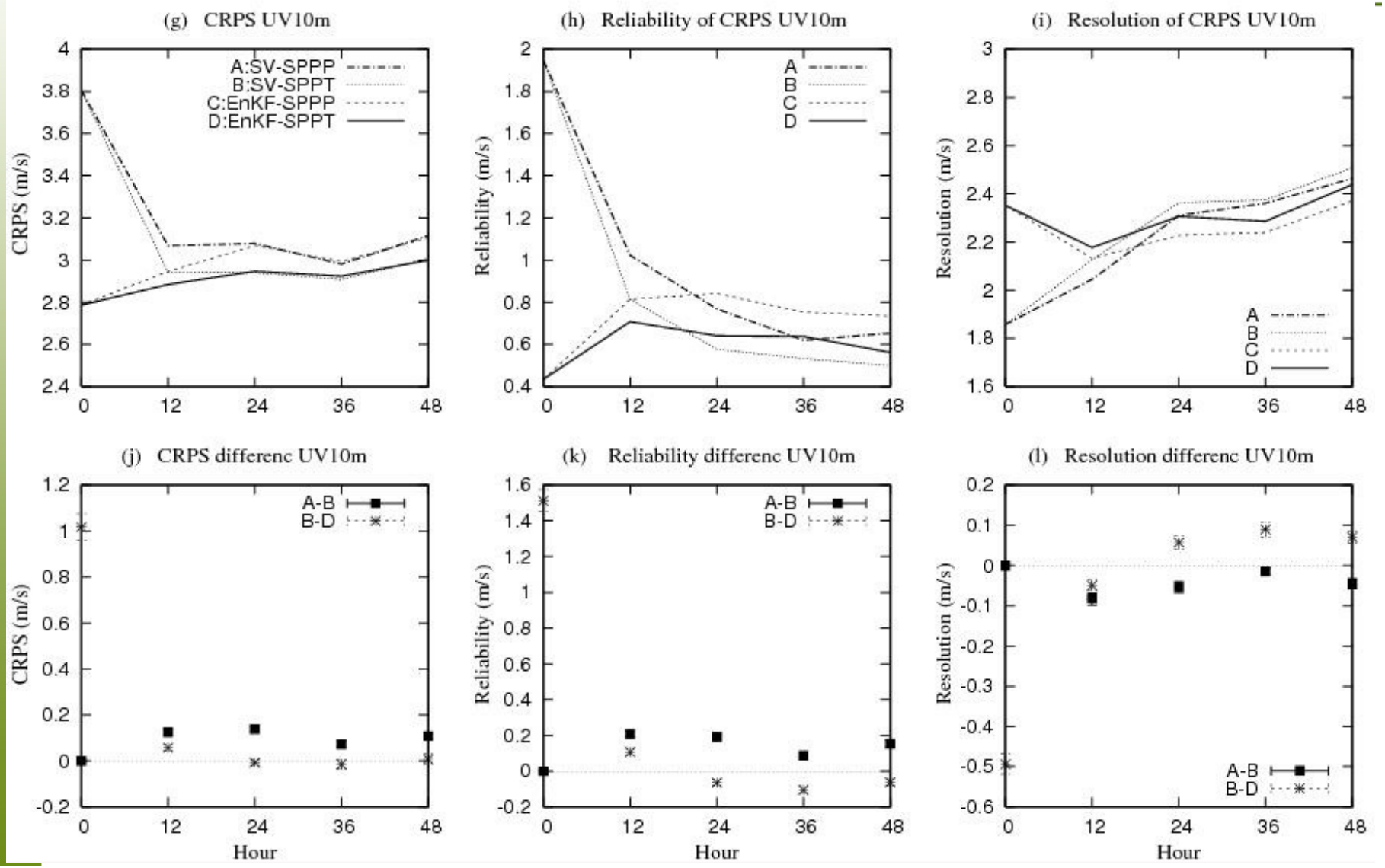
SV versus current approach (UV850, Winter)



SV versus current approach (UV10m, Summer)



SV versus current approach (UV10m, Winter)

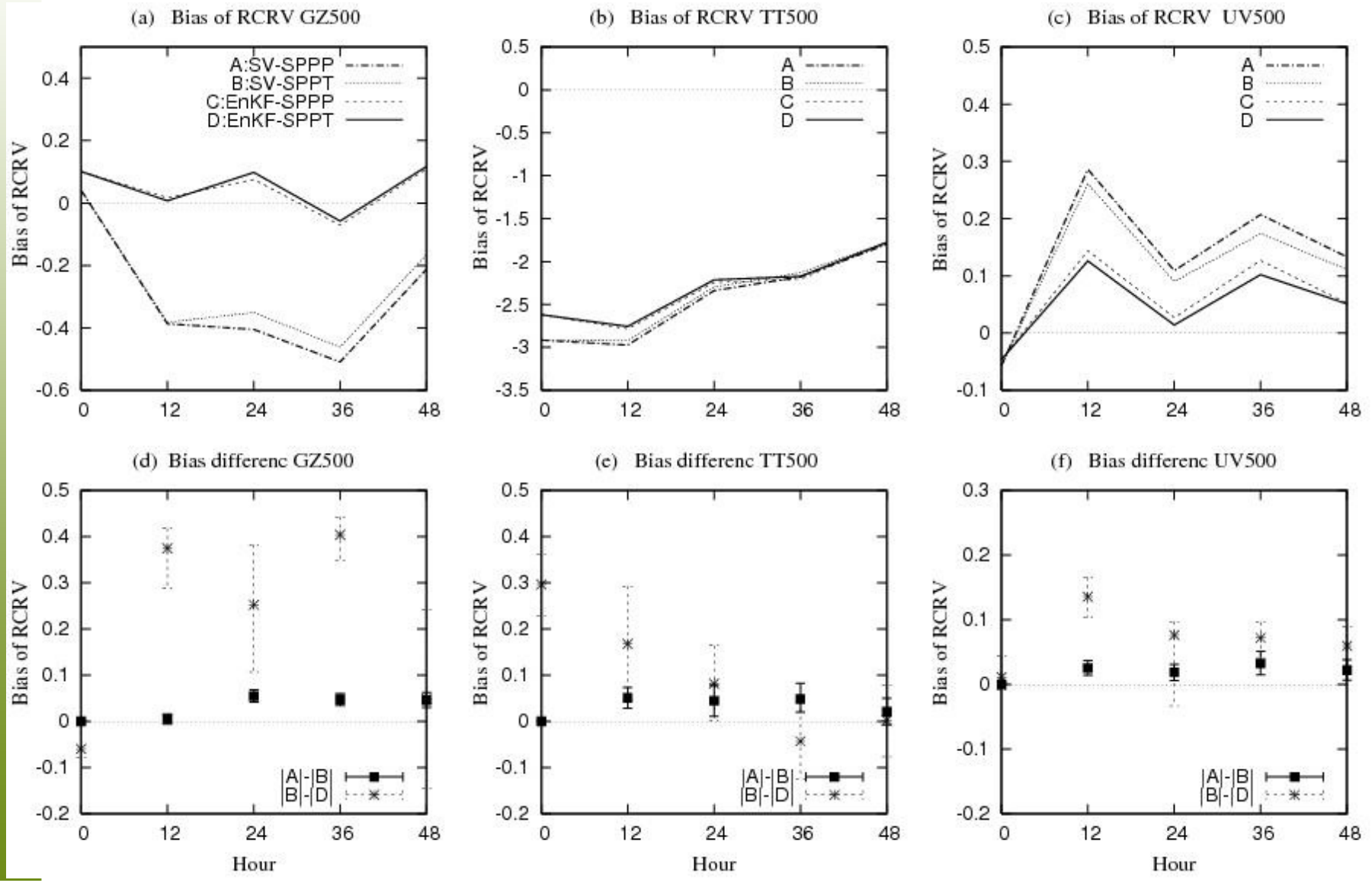


Reduced Centered Random Variable (RCRV)

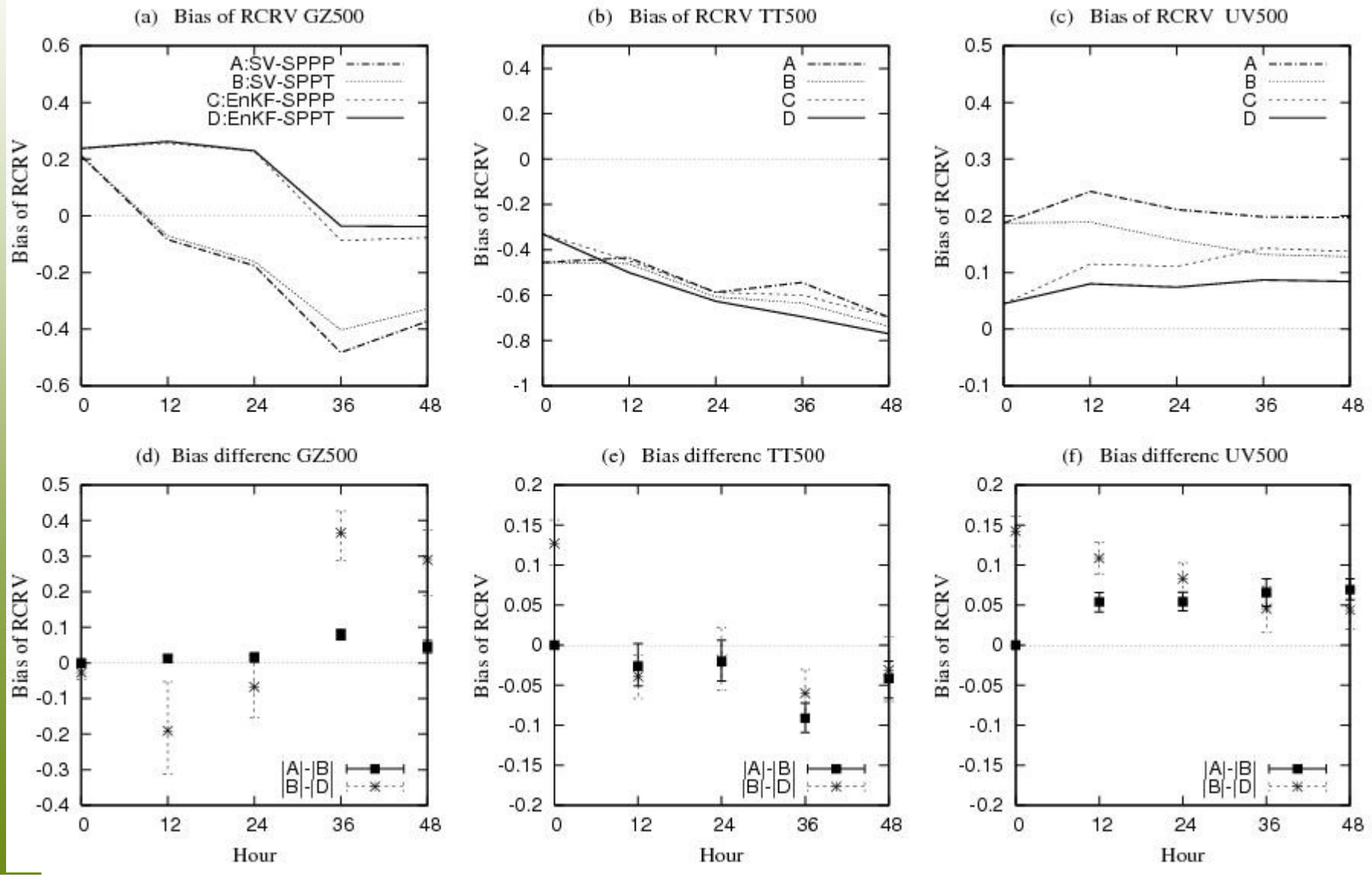
$$y = \frac{o - m}{\sqrt{\sigma_o^2 + \sigma_f^2}}$$

Bias:	Average of y	(ideal value is 0)
Dispersion:	Standard deviation of y	(ideal value is 1)

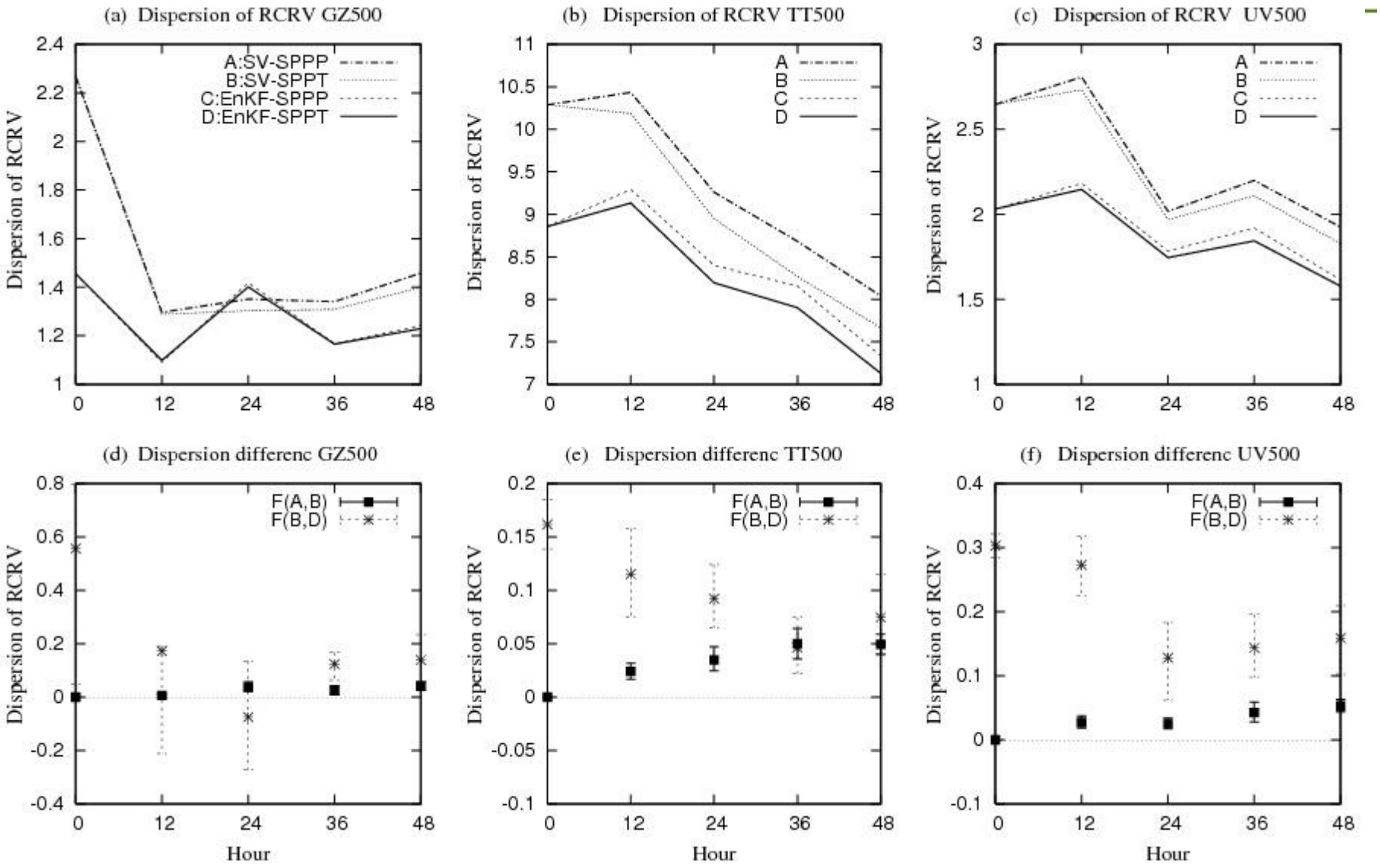
SV versus current approach (Biases, Winter)



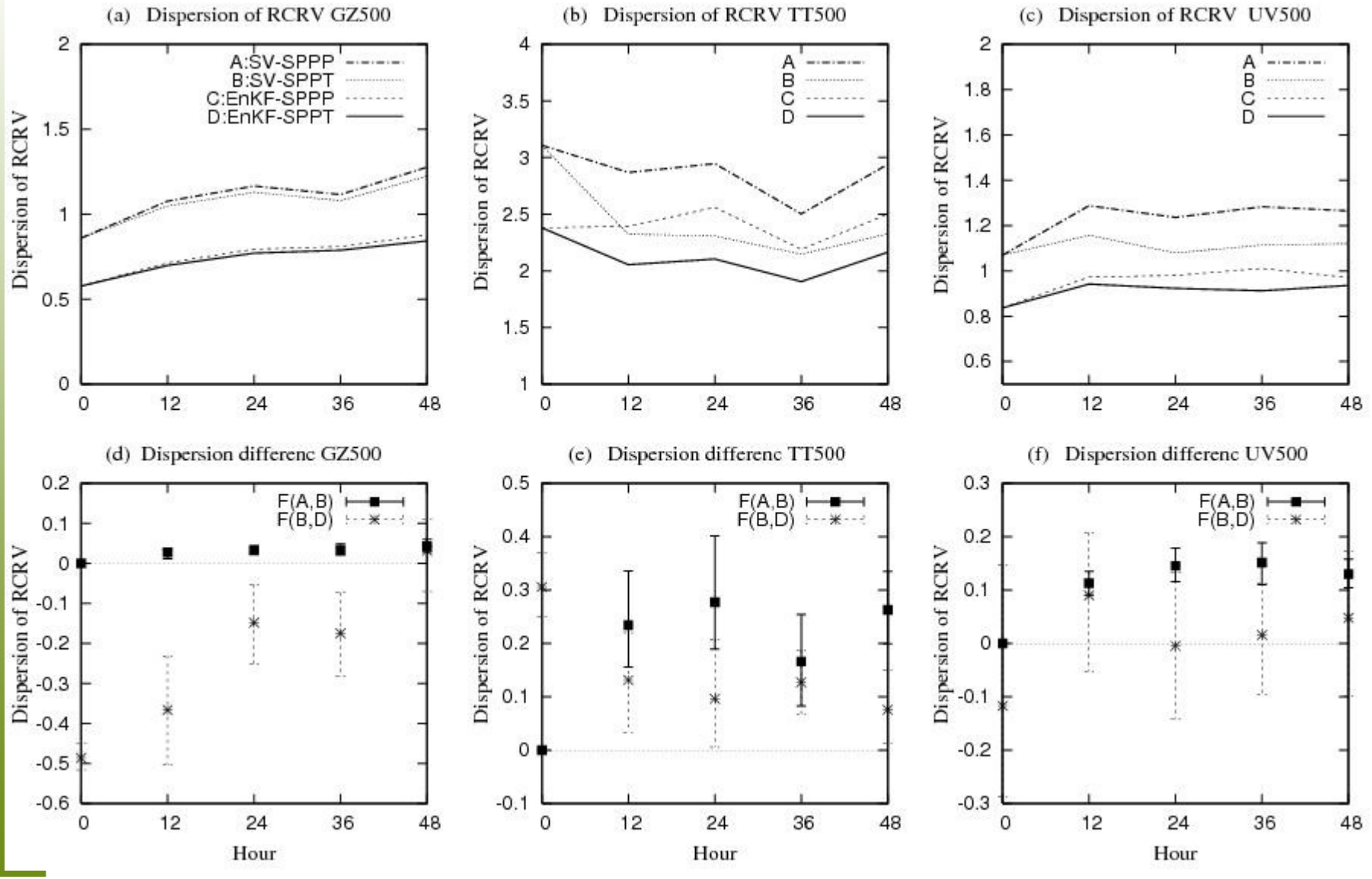
SV versus current approach (Biases, Summer)



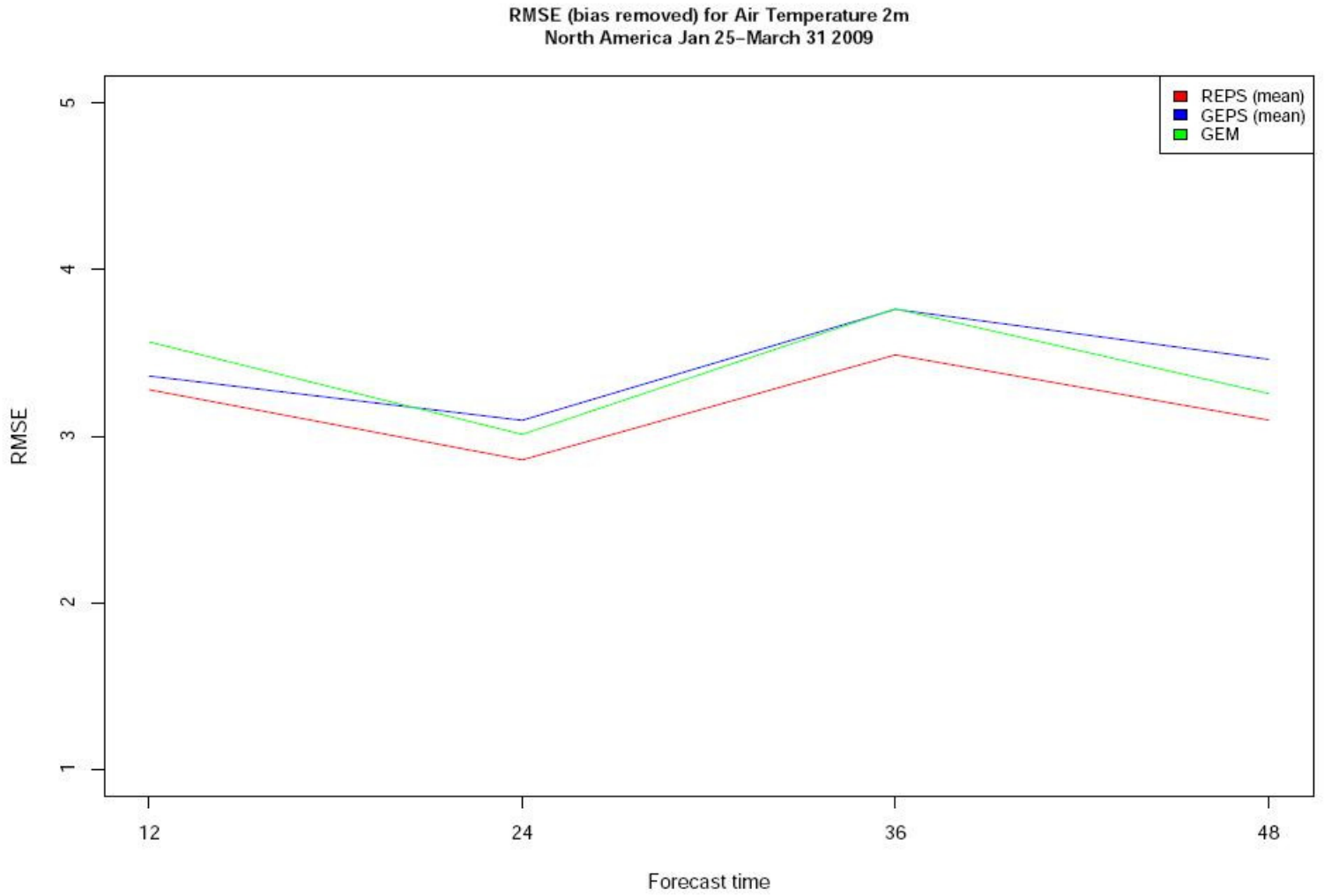
SV versus current approach (Disp, Winter)



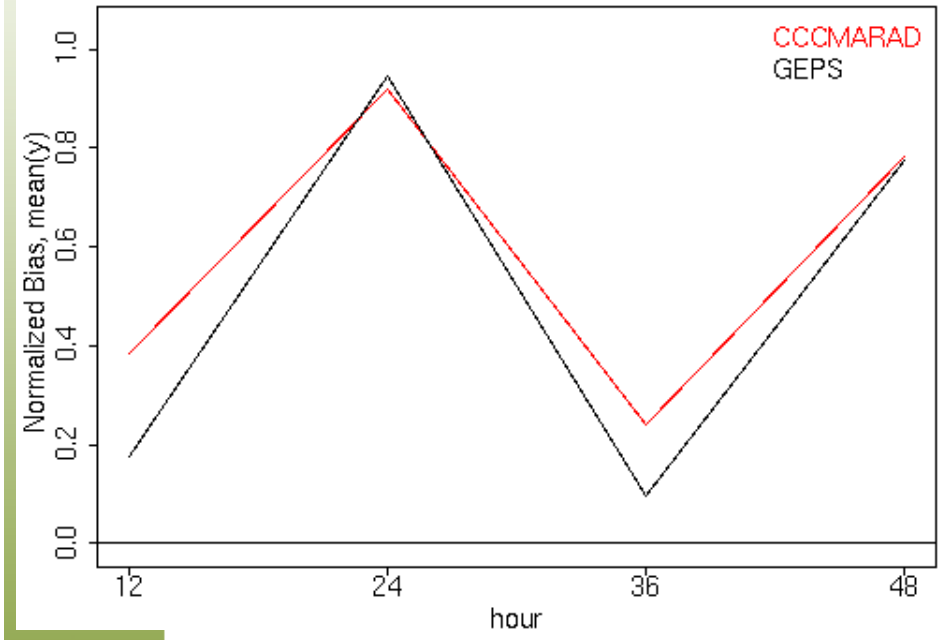
SV versus current approach (Disp, Summer)

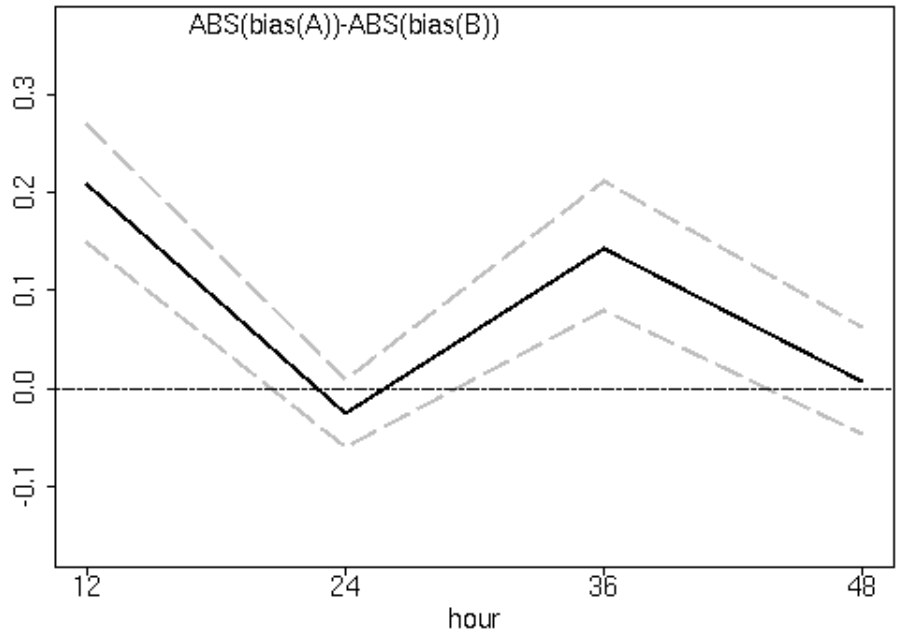


Regional EPS versus Global EPS
RMSED, Temperature at 2m, winter 2009

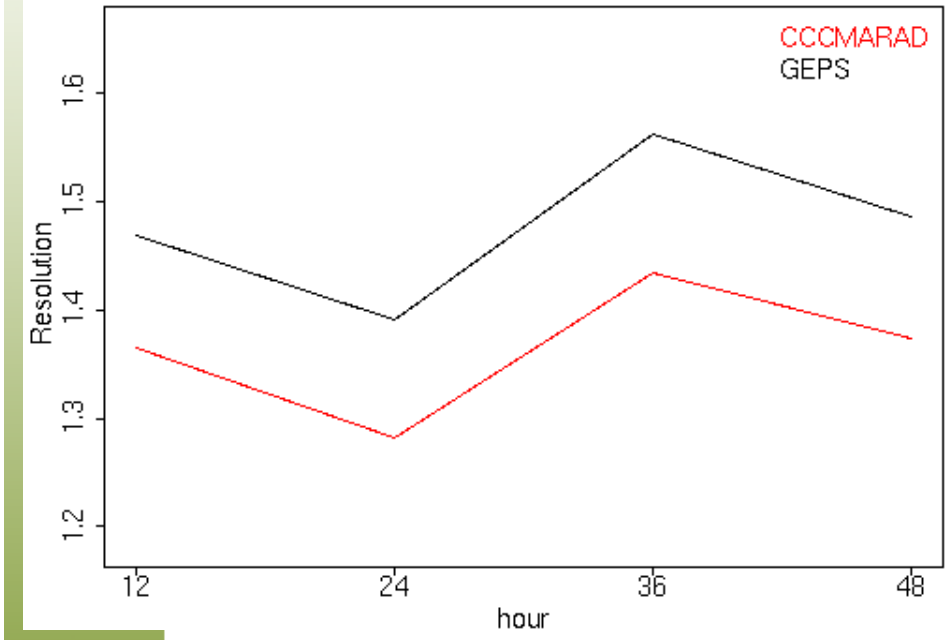


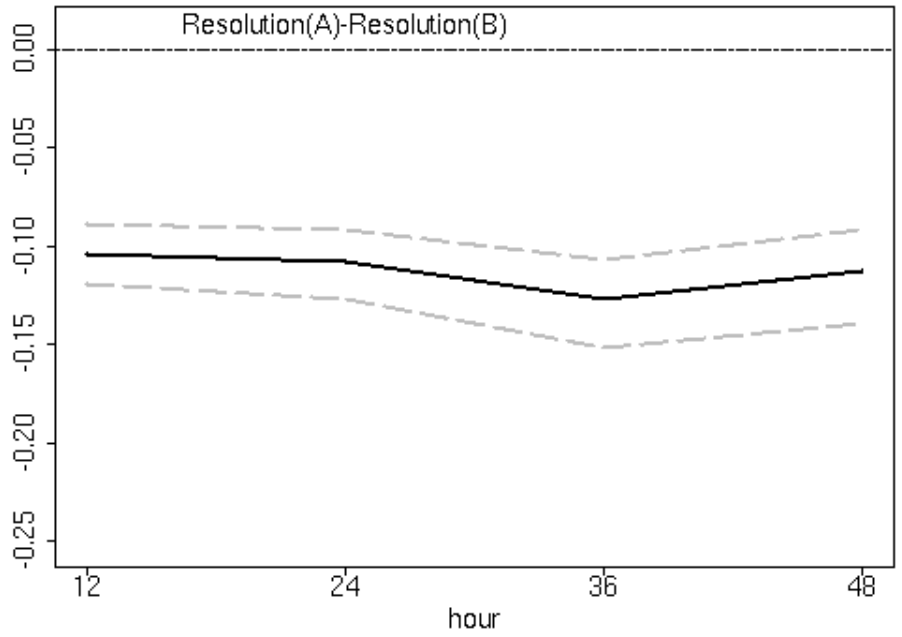
Regional EPS versus Global EPS
Bias, Temperature at 2m, winter 2009



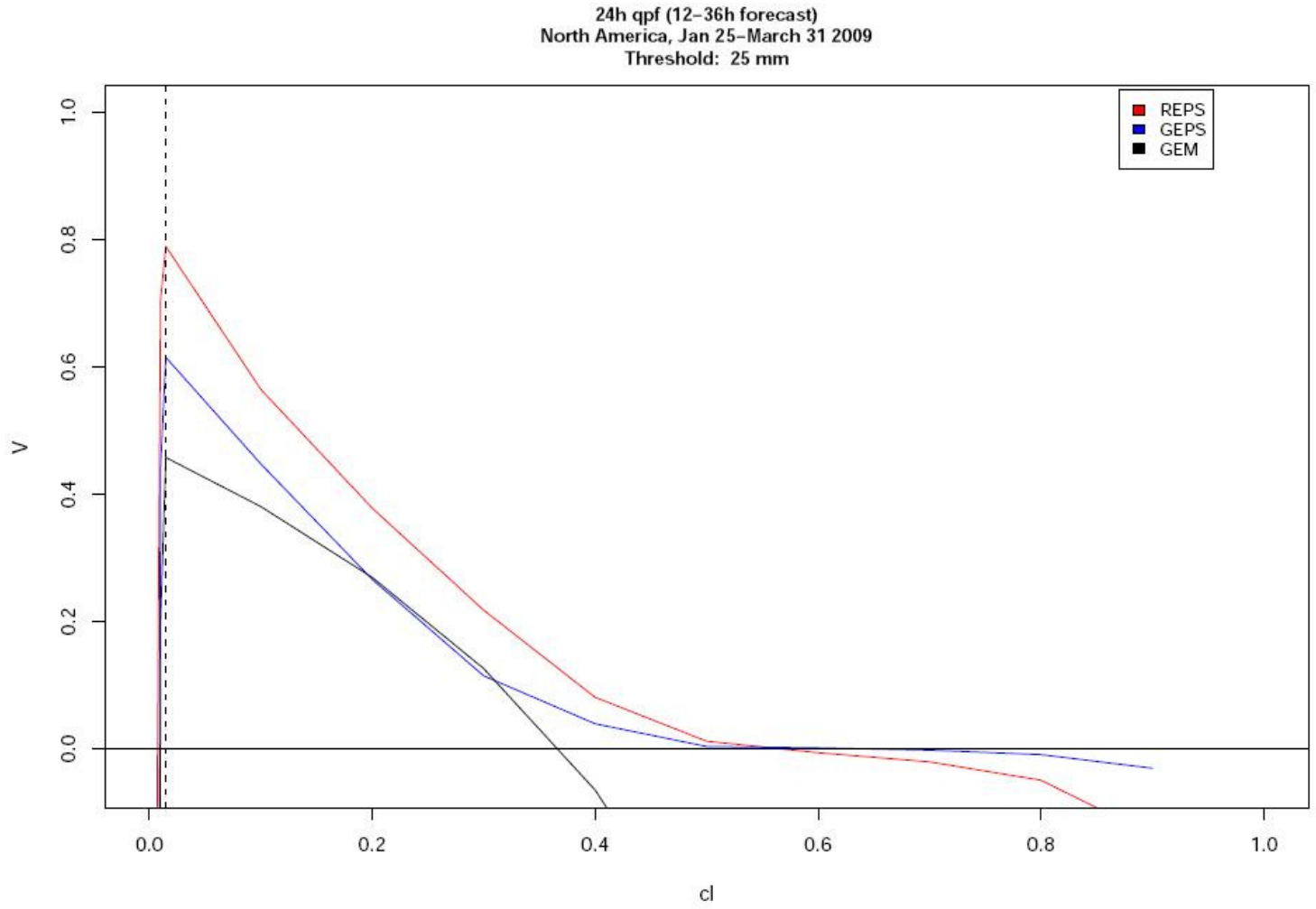


Regional EPS versus Global EPS
Resolution, Temperature at 2m, winter 2009

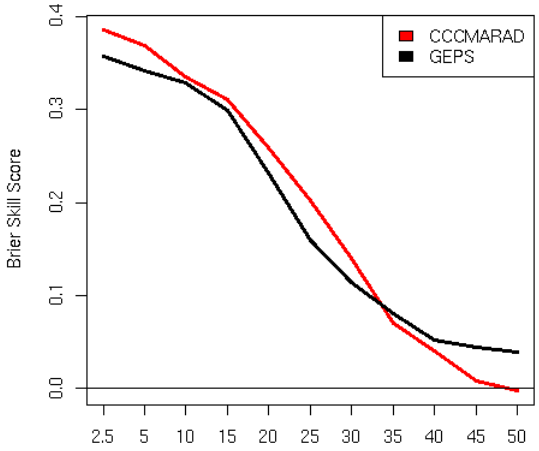


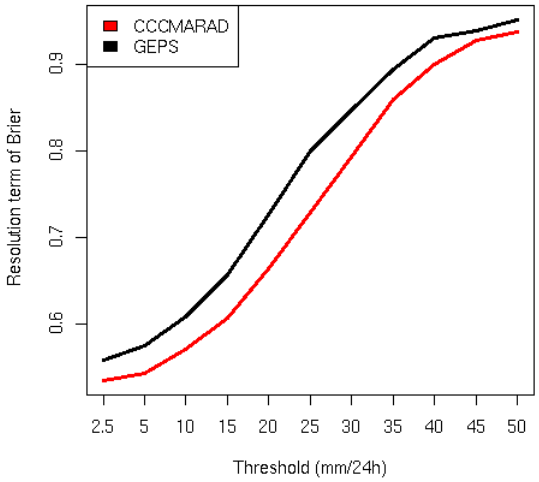


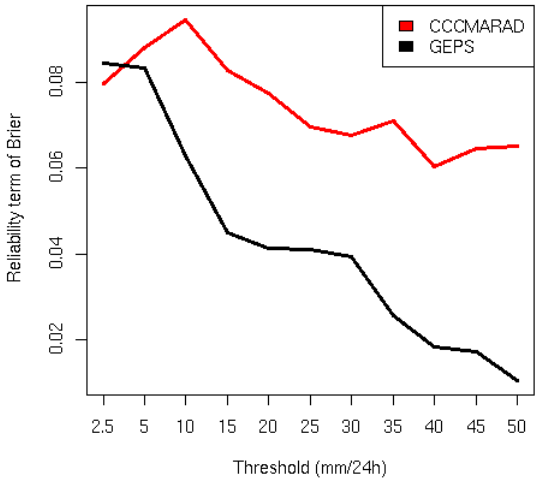
Regional EPS versus Global EPS
Economic value, precip. accum. > 25 mm



Regional EPS versus Global EPS
Brier Skill Score, 24h precip. accum. 12-36 h







Winter 2009

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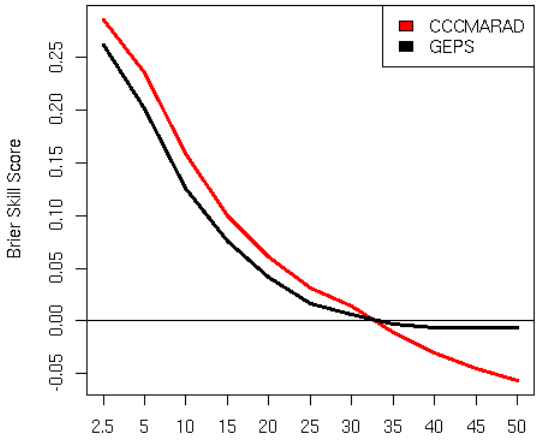
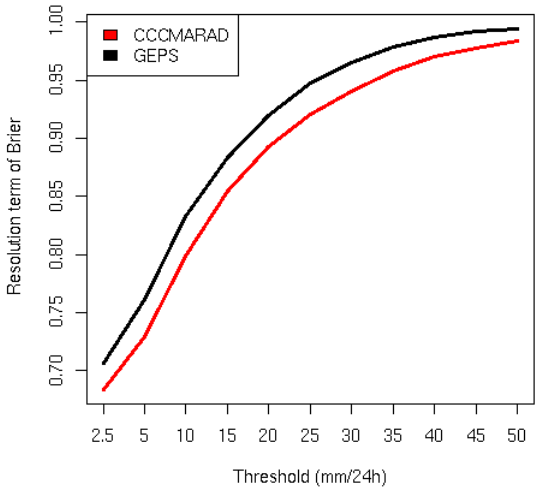
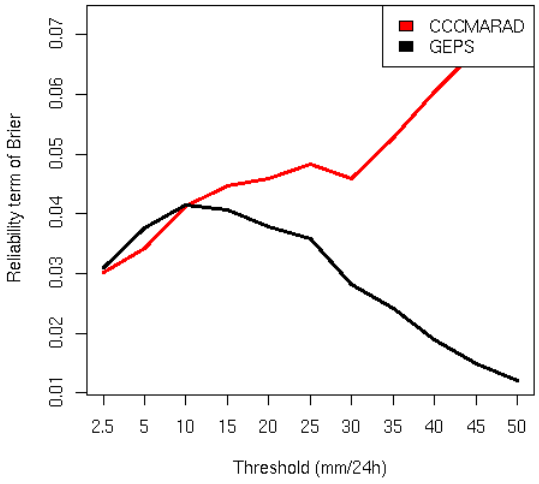
Regional EPS versus Global EPS
Brier Skill Score, 24h precip. accum. 12-36 h







Summer 2009

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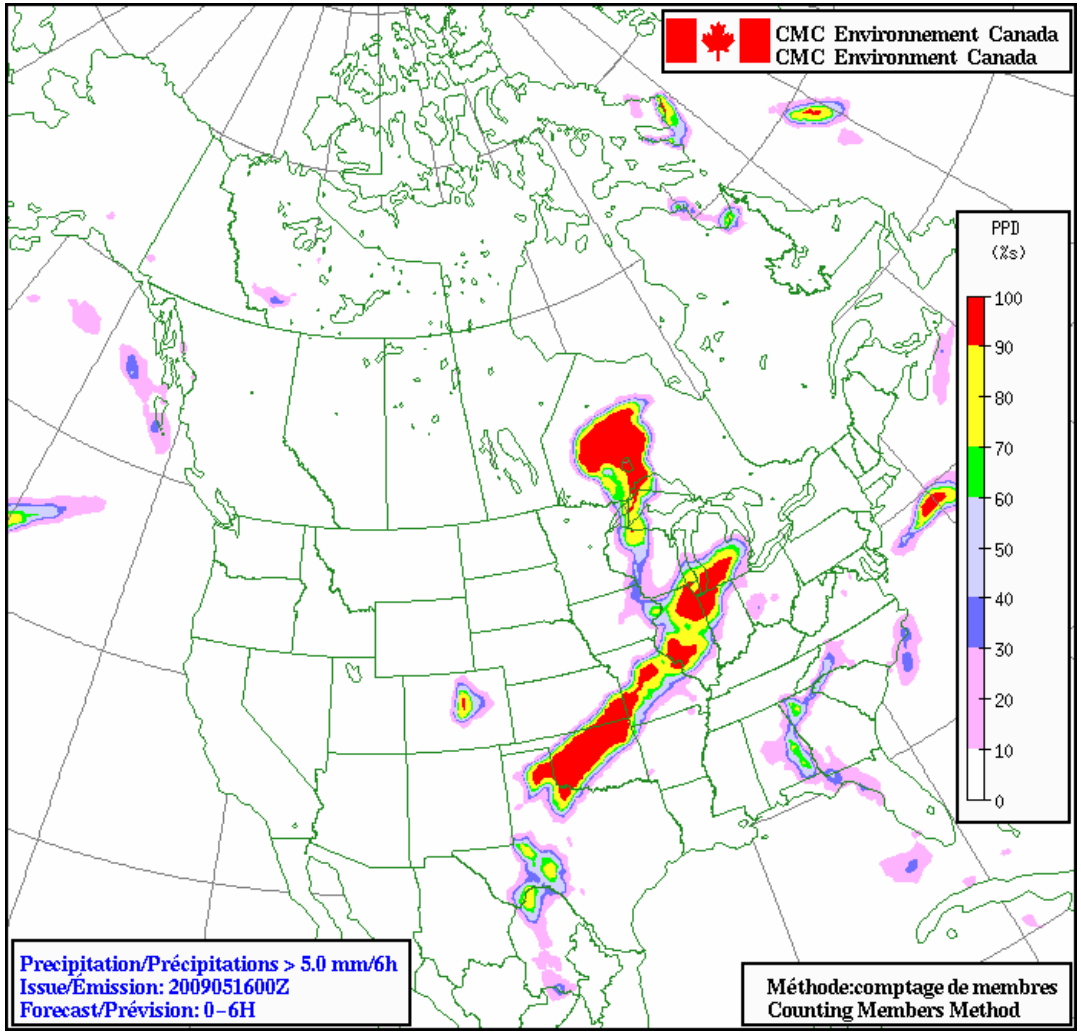
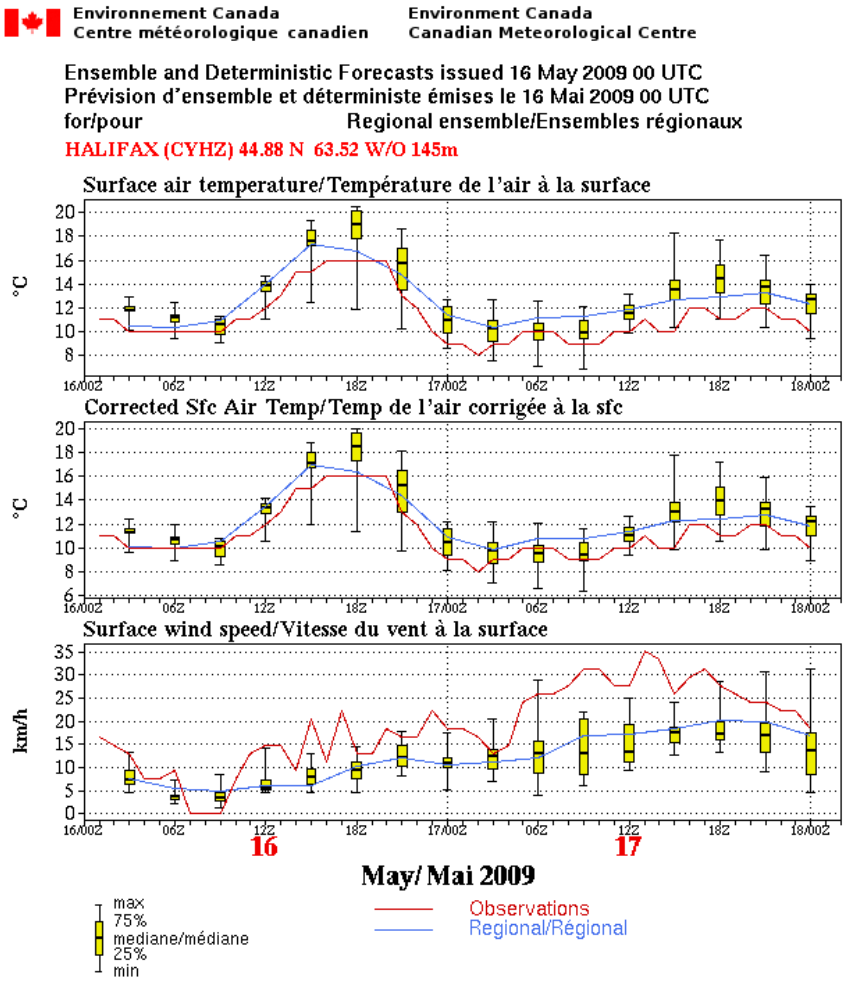
Examples of products



Examples of products



Interesting applications

- Short-range weather forecating
  - Probability of high-imppact weather
- Hydrological modelling
  - POP estimated from the REPS
- Wind energy forecasting?
  - Still need to improve low level winds

Regional EPS versus Global EPS
Reliability, Temperature at 2m, winter 2009