Neighborhood-based Continous Ranked Probability Score for Ensemble Prediction Systems

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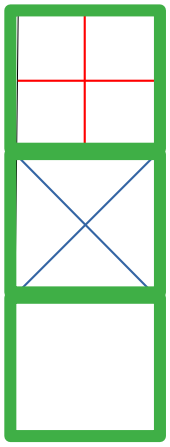
Outline

- Presentation of the neighborhood and CRPS
- Inclusion of the neighborhood in the CRPS
- Comparison of probabilistic and deterministic QPF
- Conclusions

Presentation of the neighborhood and CRPS



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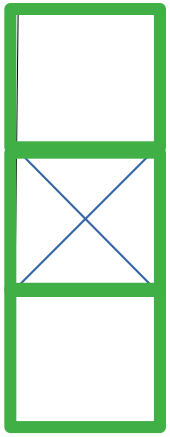

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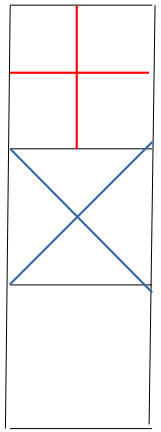
Classical Tables of contingency

Presentation of the neighborhood and CRPS

- Reward forecasts of events spatially slightly misplaced



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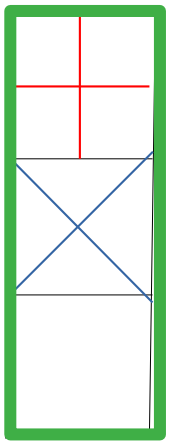
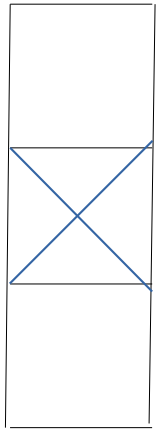


Regional frequency

FORECAST	OBSERVED
1/3	1/3
1/3	1/3
0/3	1/3



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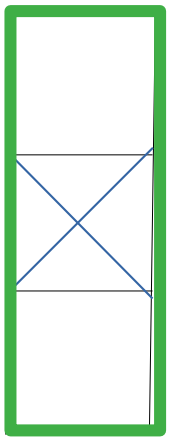


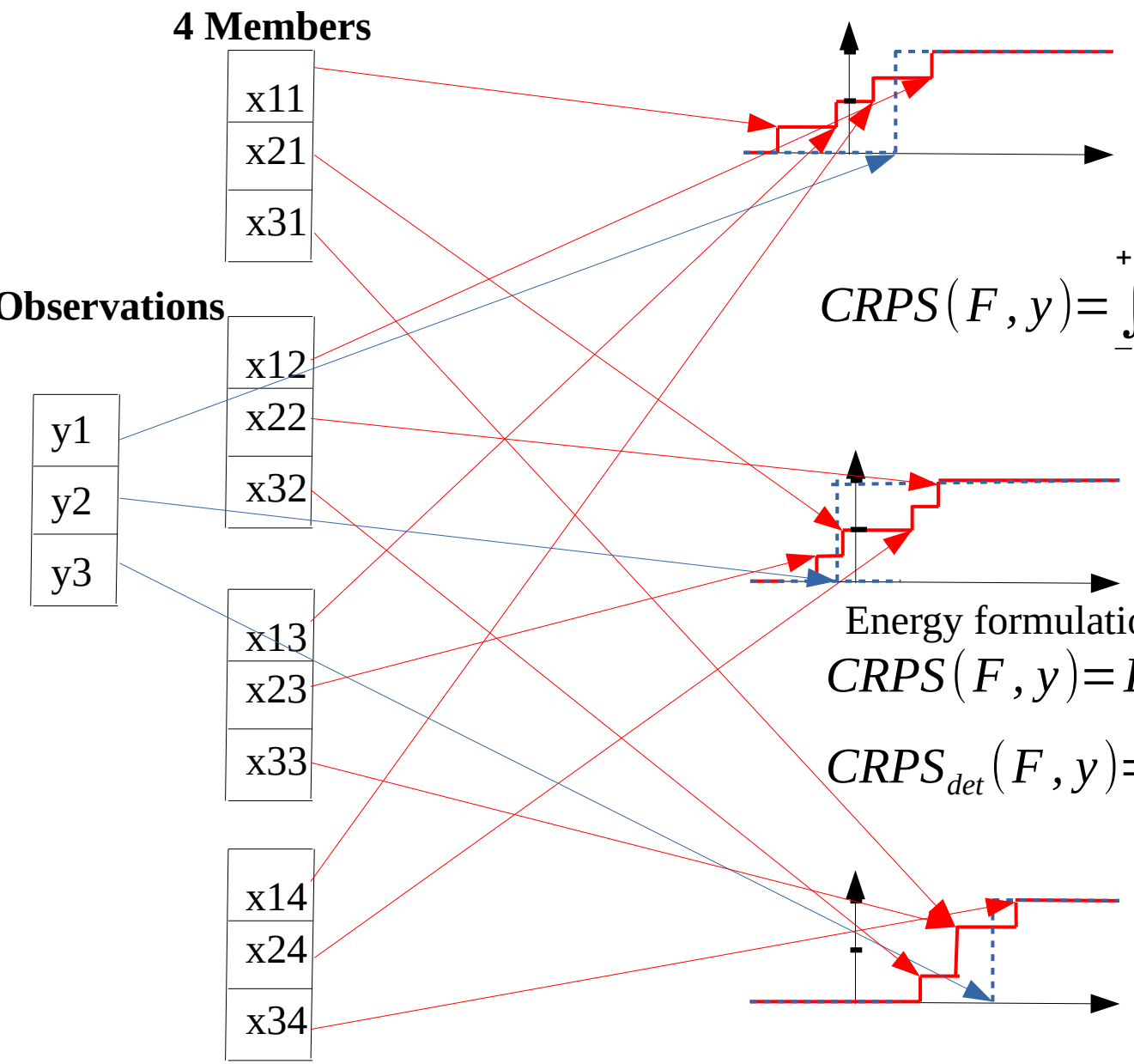
Regional frequency

FORECAST	OBSERVED
0/3	1/3
0/3	1/3
0/3	1/3

Classical Tables of contingency

FSS (Robert and Lean 2008)
and BSS (Amodei and Stein 2009)

Classical CRPS : separated estimates of local CRPS



(Hersbach 2000)

$$CRPS(F,y)=\int_{-\infty}^{+\infty}\left(F(x)-H(y-x)\right)^2 dx$$

Energy formulation (Gneiting and Raftery 2007)

$$CRPS(F,y)=E_{X,Y}(|X-y|)-0.5\,E_{X,X'}(|X-X'|)$$

$$CRPS_{det}(F,y)=MAE(x,y)=|x-y|$$

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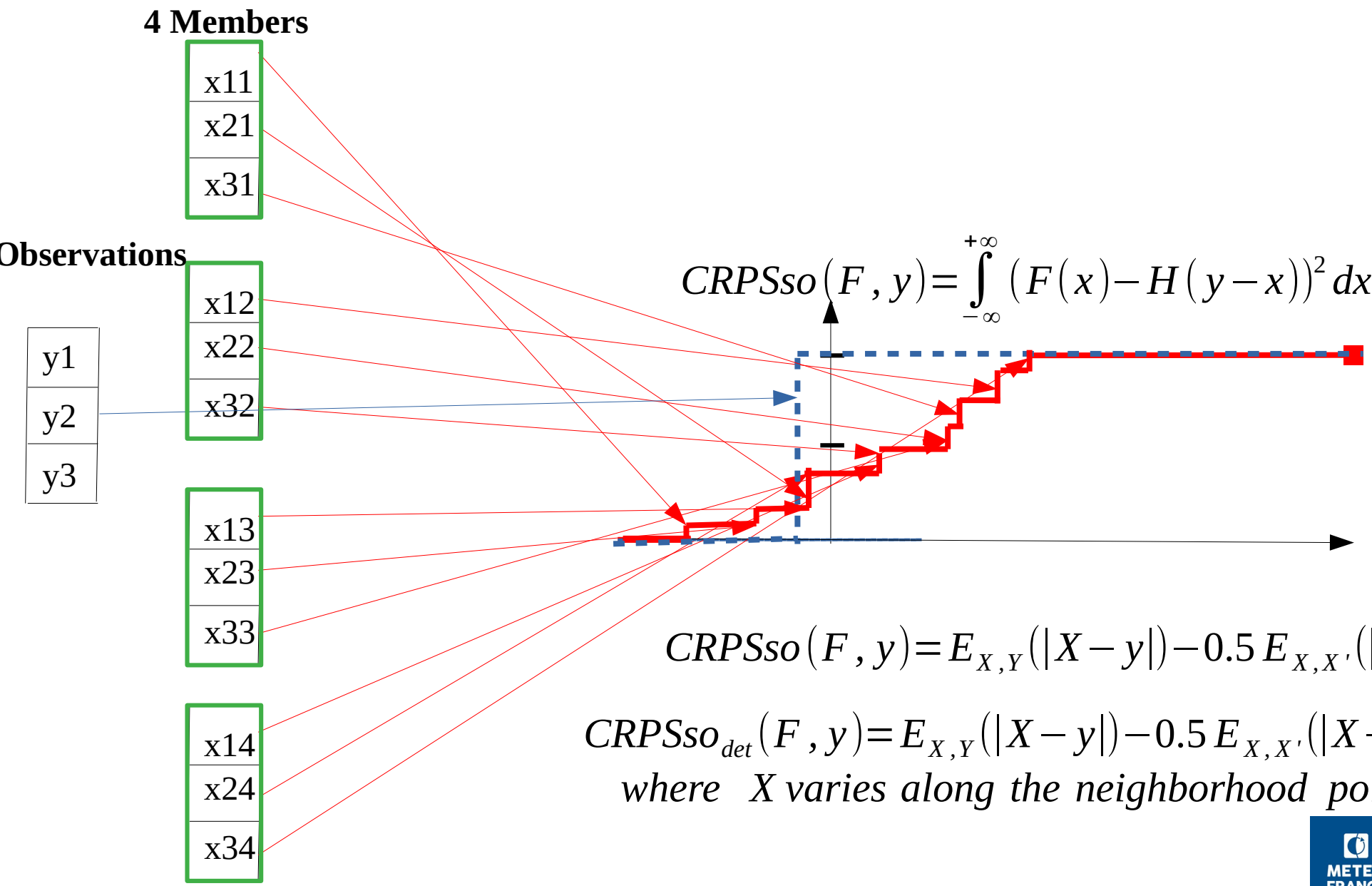
CRPSso : increase of the number of Members



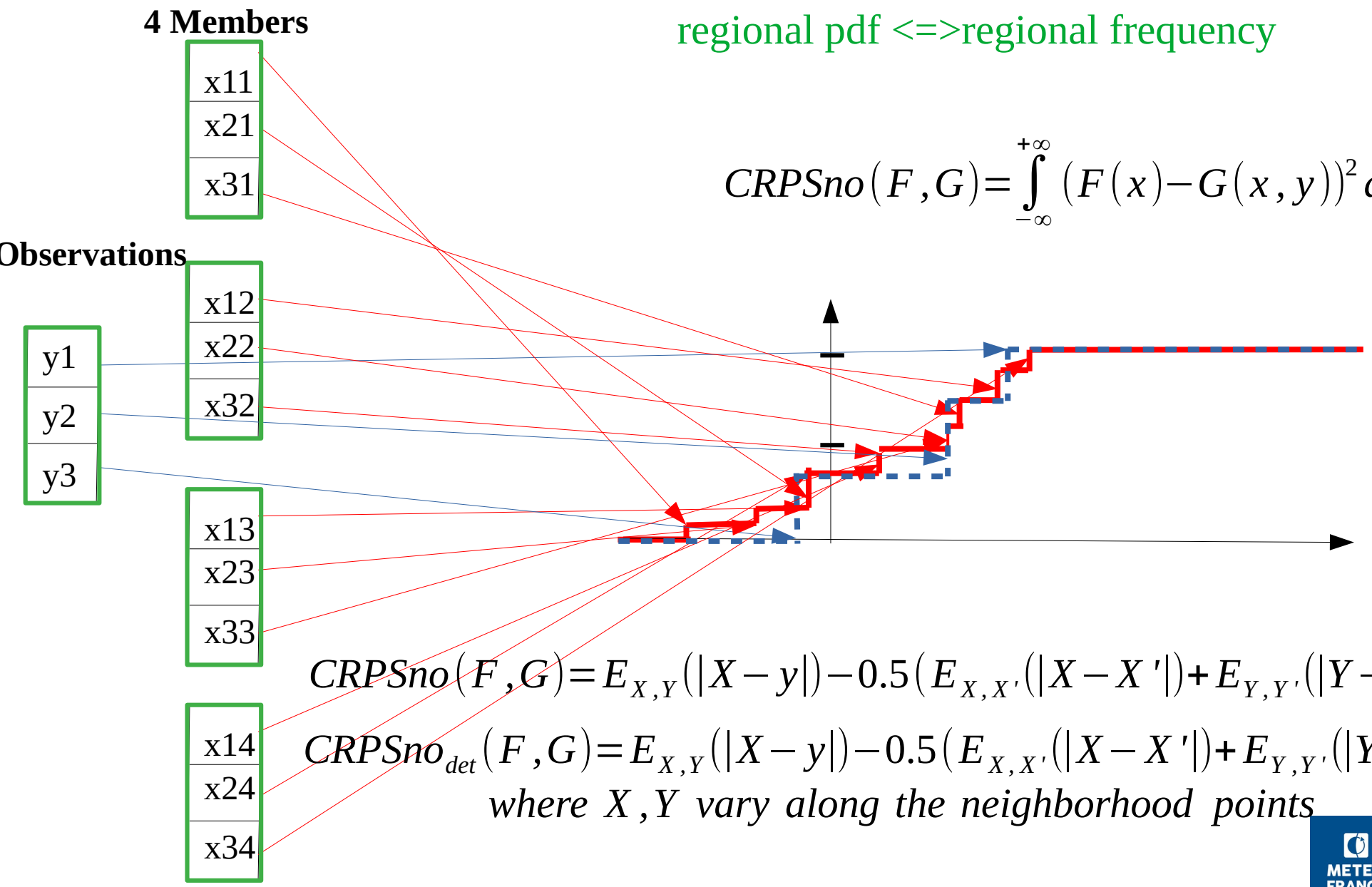
$$CRPSso(F,y)=\int_{-\infty}^{+\infty}\left(F(x)-H(y-x)\right)^2 dx$$

$$CRPSso(F,y)=E_{X,Y}(|X-y|)-0.5\,E_{X,X'}(|X-X'|)$$

$$CRPSso_{det}(F,y)=E_{X,Y}(|X-y|)-0.5\,E_{X,X'}(|X-X'|)$$

where X varies along the neighborhood points

CRPSno : comparison at the neighborhood scale



$$CRPSno(F,G)=\int_{-\infty}^{+\infty}(F(x)-G(x,y))^2\,dx$$

$$CRPSno(F,G)=E_{X,Y}(|X-y|)-0.5(E_{X,X'}(|X-X'|)+E_{Y,Y'}(|Y-Y'|))$$

$$CRPSno_{det}(F,G)=E_{X,Y}(|X-y|)-0.5(E_{X,X'}(|X-X'|)+E_{Y,Y'}(|Y-Y'|))$$

where X,Y vary along the neighborhood points

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Models and observations

- **ARPEGE** : hydrostatic global model ; 5 km over France
- **PEARP** : 35 hydrostatic global forecasts ; 7,5 km over France ; Singular vectors + EDA and 10 physics
- **AROME** : non-hydrostatic LAM nested in ARPEGE ; 1.3 km over France
- **PEAROME** : 16 non-hydrostatic forecasts nested in PEARP ; 2,5 km over France ; EDA and stochastic physics
- **ANTILOPE** : data fusion between french radar observations and raingaujes ; 1 km grid over France
- **Verification of QPF accumulated during 3 hours** : from 01 october to 31 december 2019 over France

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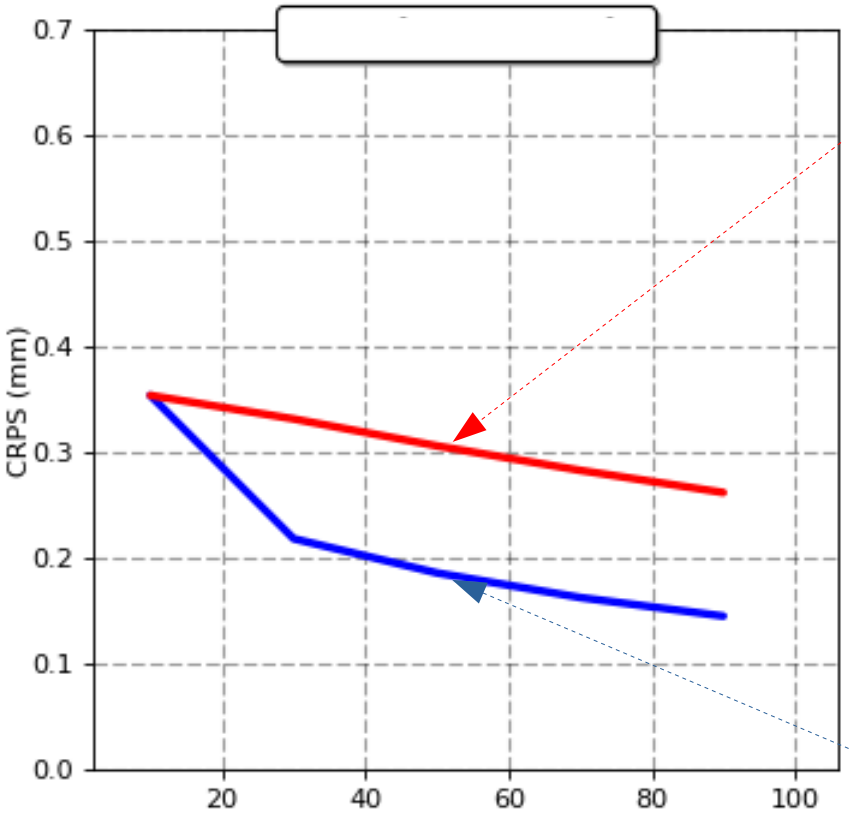
2 CRPS for the 3 months period valid at J+1 18 UTC

PEARP

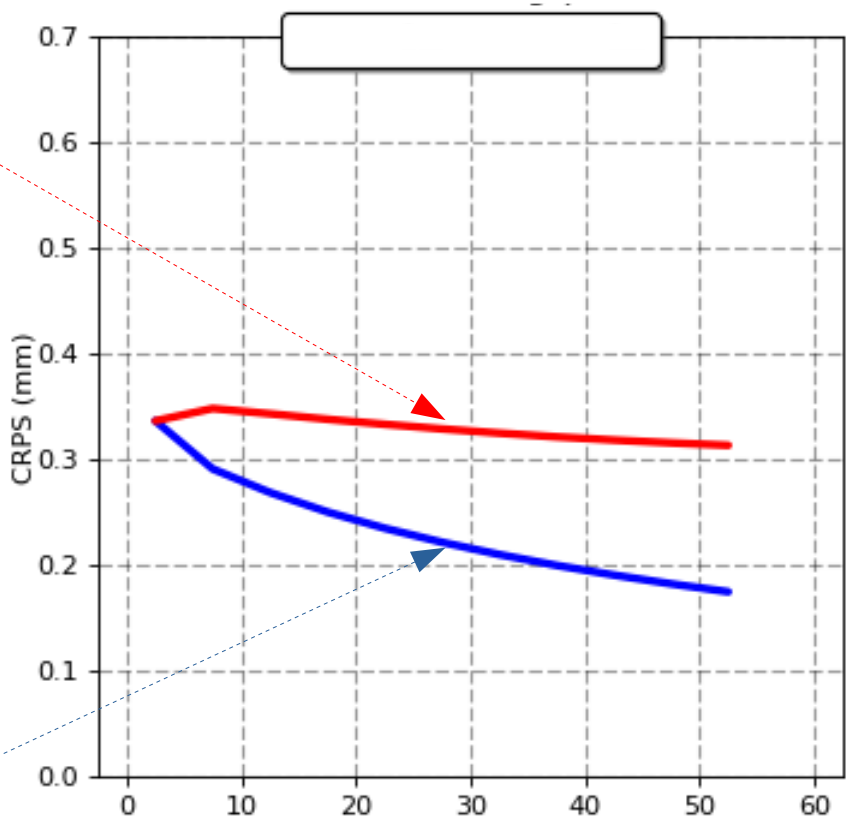


Neighborhood size (km)

CRPSso

CRPSno

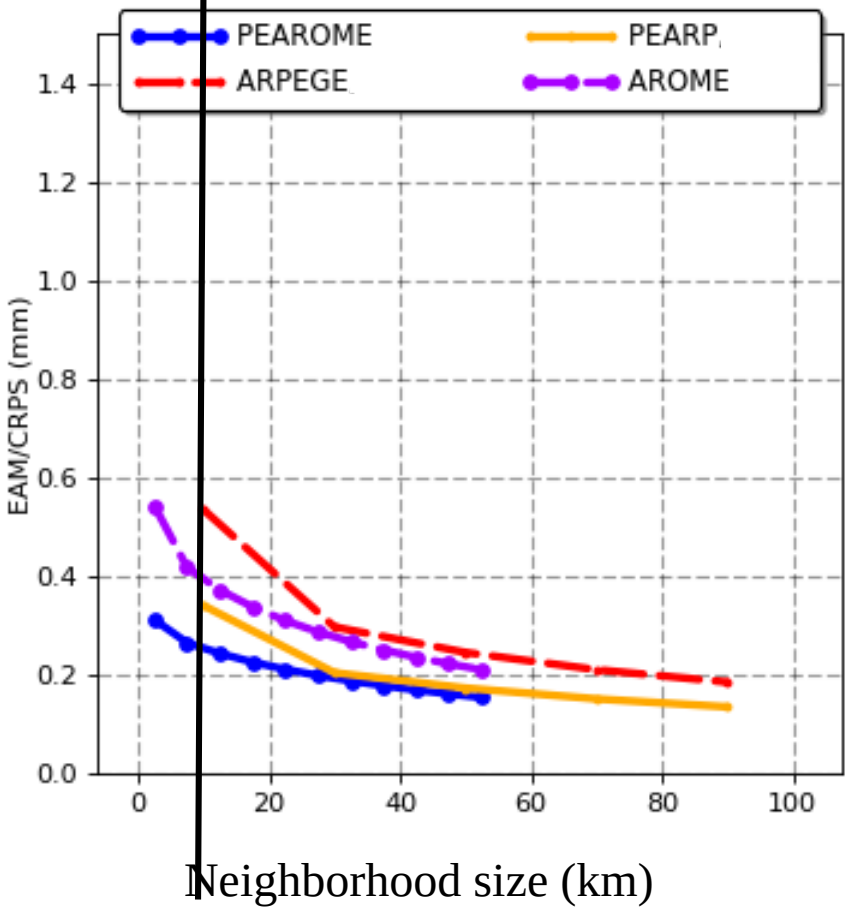
PEAROME



Neighborhood size (km)

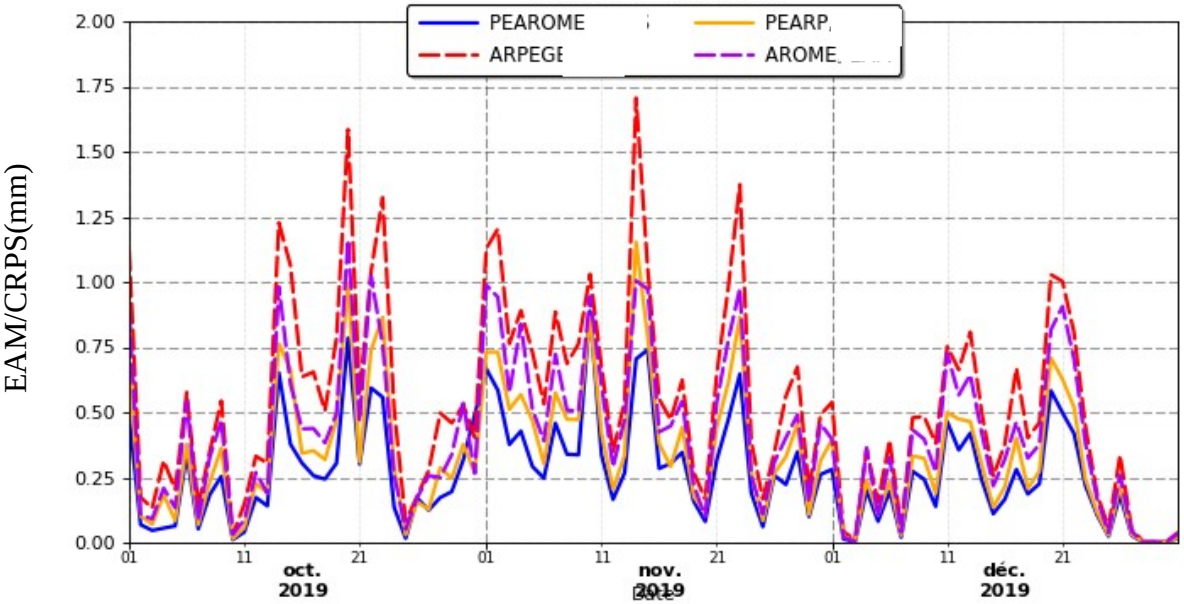
CRPSno valid at J+1 18 UTC for 4 forecasts

CRPSno averaged on 3 months



Neighborhood size (km)

Temporal serie of daily CRPSno for 10 km neighborhood



Conclusions

- Developpement of a neighborhood-based CRPS including regional pdf.
- Deterministic limit of CRPS comparable to CRPS for the ensembles of forecasts.
- CRPSso => impact of enlarging the number of members by using neighboring points to improve the PDF at the central point.
- CRPSno => observed and forecast PDF at the scale of the neighborhood.
- CRPSno => benefit of high-resolution ensembles at the resolution of low-resolution ensembles.
- CRPSno => convergence for larger neighborhoods : part of the double penalty is absorbed by using an ensemble of forecasts versus a deterministic forecast.

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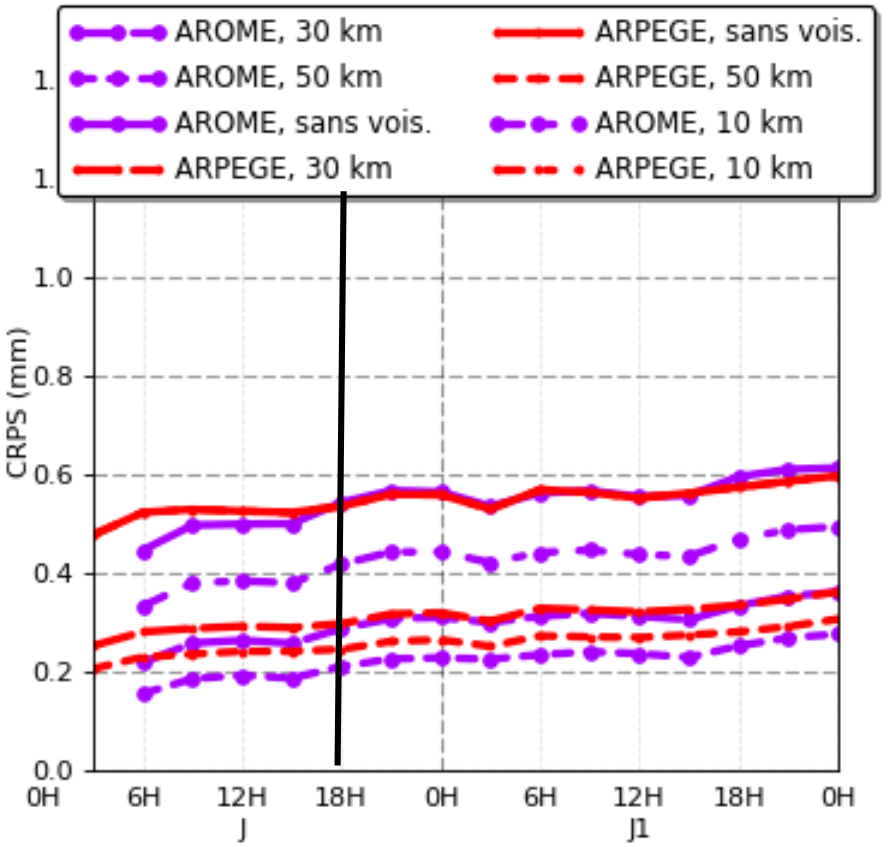
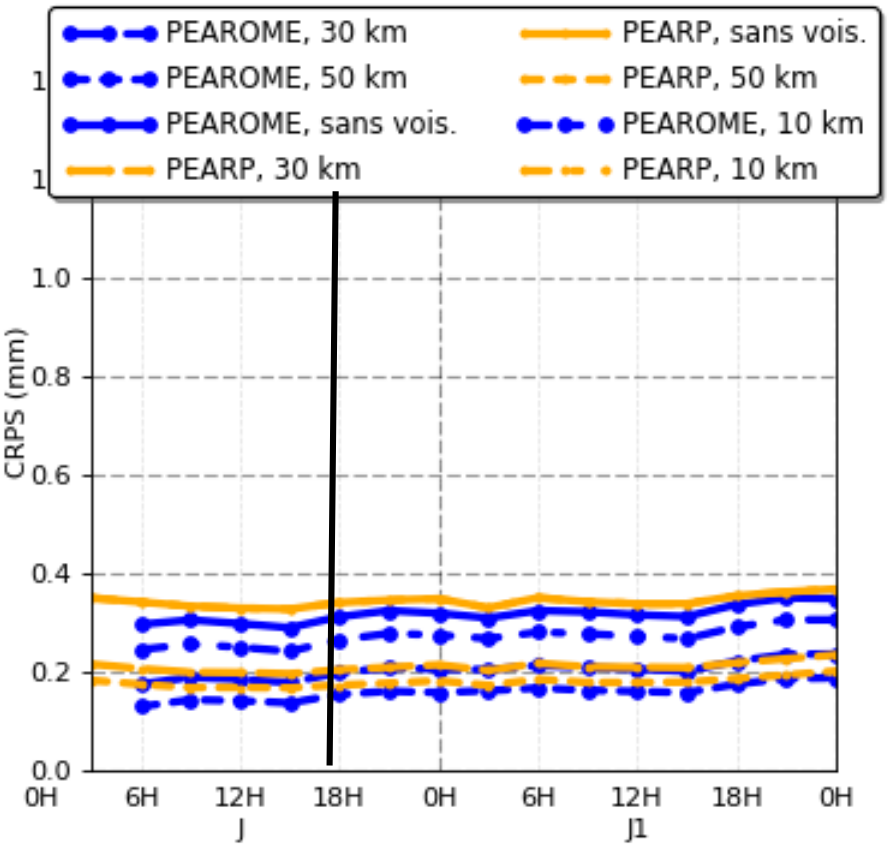
CRPSfno for 3 neighborhood sizes

Deterministic models



Lead Time

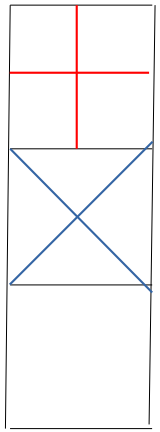
probabilistic models



Lead Time

Presentation of the neigborhood and CRPS

- Reward forecasts of events spatially slightly misplaced



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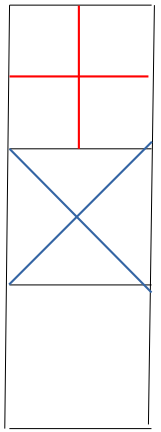
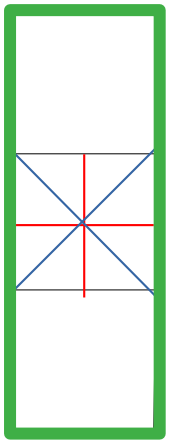


Regional frequency

=1/3 FORECASTED

=1/3 OBSERVED



Error compensation

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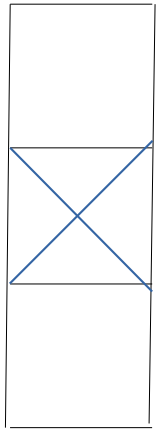

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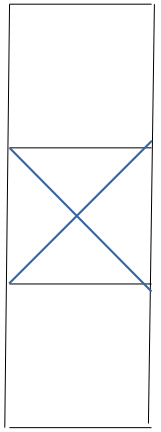
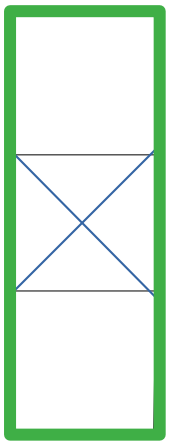


Regional frequency

=0/3 FORECASTED

=1/3 OBSERVED



Error compensation

1 Cor Rej

1 MISS

Classical Tables of contingency

FSS (Robert and Lean)
and BSS (Amodei and Stein)

New Tables of contingency
(Stein and Stoop 2019)

Unfair and fair estimators of CRPS (Ferro 2017)

- Unfair estimator (u) of CRPS are obtained by using biased estimator of the dispersion => CRPSuso, CRPSuno

$$E_{X,X'}\left(\left|X-X'\right|\right)=\frac{1}{Members^2}\sum_{m=1}^{Members}\sum_{n=1}^{Members}\left|X\left(m\right)-X'\left(n\right)\right|$$

- Fair estimator (f) of CRPS are obtained by using unbias estimator of the dispersion => CRPSfso, CRPSfno

$$E_{X,X'}\left(\left|X-X'\right|\right)=\frac{1}{Members\left(Members-1\right)}\sum_{m=1}^{Members}\sum_{n=1}^{Members}\left|X\left(m\right)-X'\left(n\right)\right|$$

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