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METEO FRANCE

Use of the neighborhood Brier Divergence for ensemble forecasts verification

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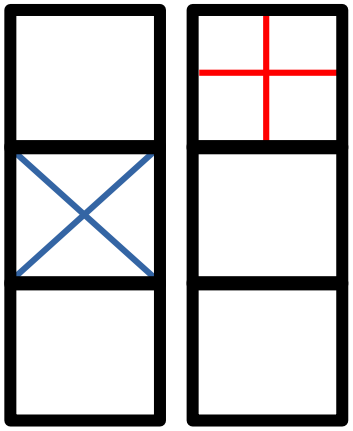
Météo-France
ACCORD Meeting 28/03/2023

Outline

- Interest of the neighborhood
- Neighborhood pooling, Brier Divergence and its decomposition
- Comparison of probabilistic QPF
- Conclusions

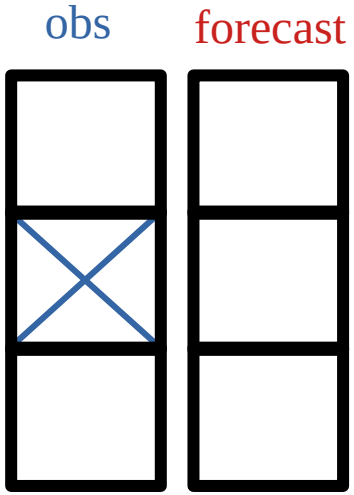
Interest of the neighborhood



1 FA

1 MISS

1 Cor Rej



1 Cor Rej

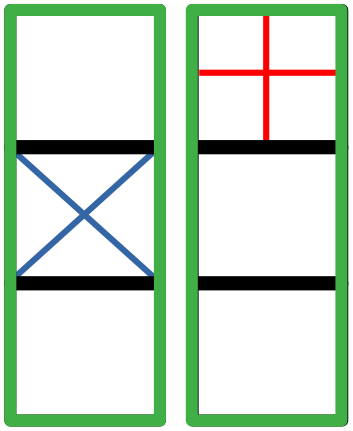
1 MISS

1 Cor Rej

Classical Tables of contingency

Interest of the neighborhood

obs forecast



1 FA

1 MISS

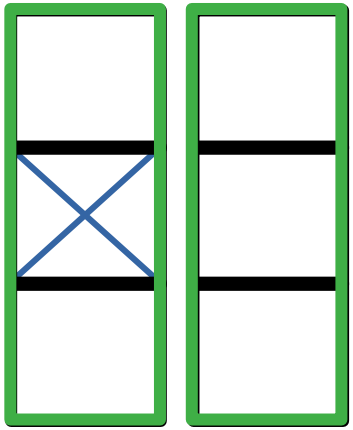
1 Cor Rej

Neighborhood frequencies

observation 1/3 forecast 1/3

$$fbs = (fn - on)^2 = 0$$

obs forecast



1 Cor Rej

1 MISS

1 Cor Rej

Neighborhood frequencies

observation 1/3 forecast 0/3

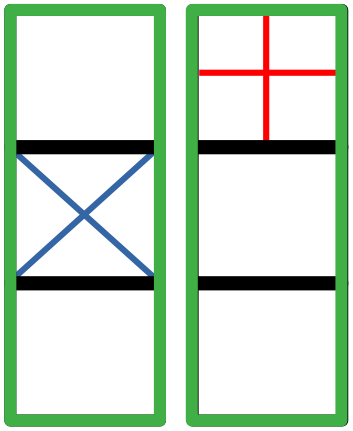
$$fbs = (fn - on)^2 = 1/9$$

Classical Tables of contingency

Interest of the neighborhood

Reward forecasts of events spatially slightly misplaced

obs forecast



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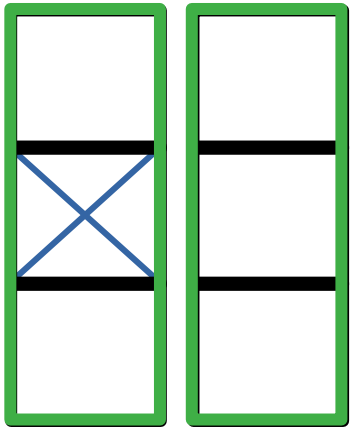

1 Cor Rej

1 MISS

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Neighborhood frequencies

observation 1/3 forecast 0/3

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Classical Tables of contingency

Fraction Brier Score=> fss (Roberts and Lean 2008) and bss (Amodei and Stein 2009)

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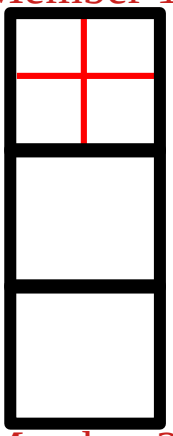
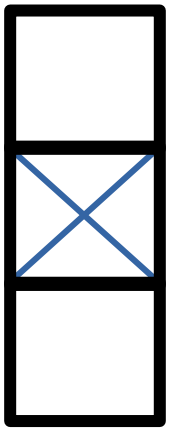
BS classical method

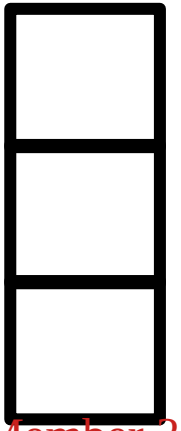
Member 1



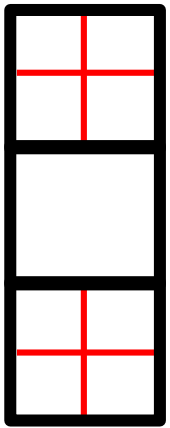
obs



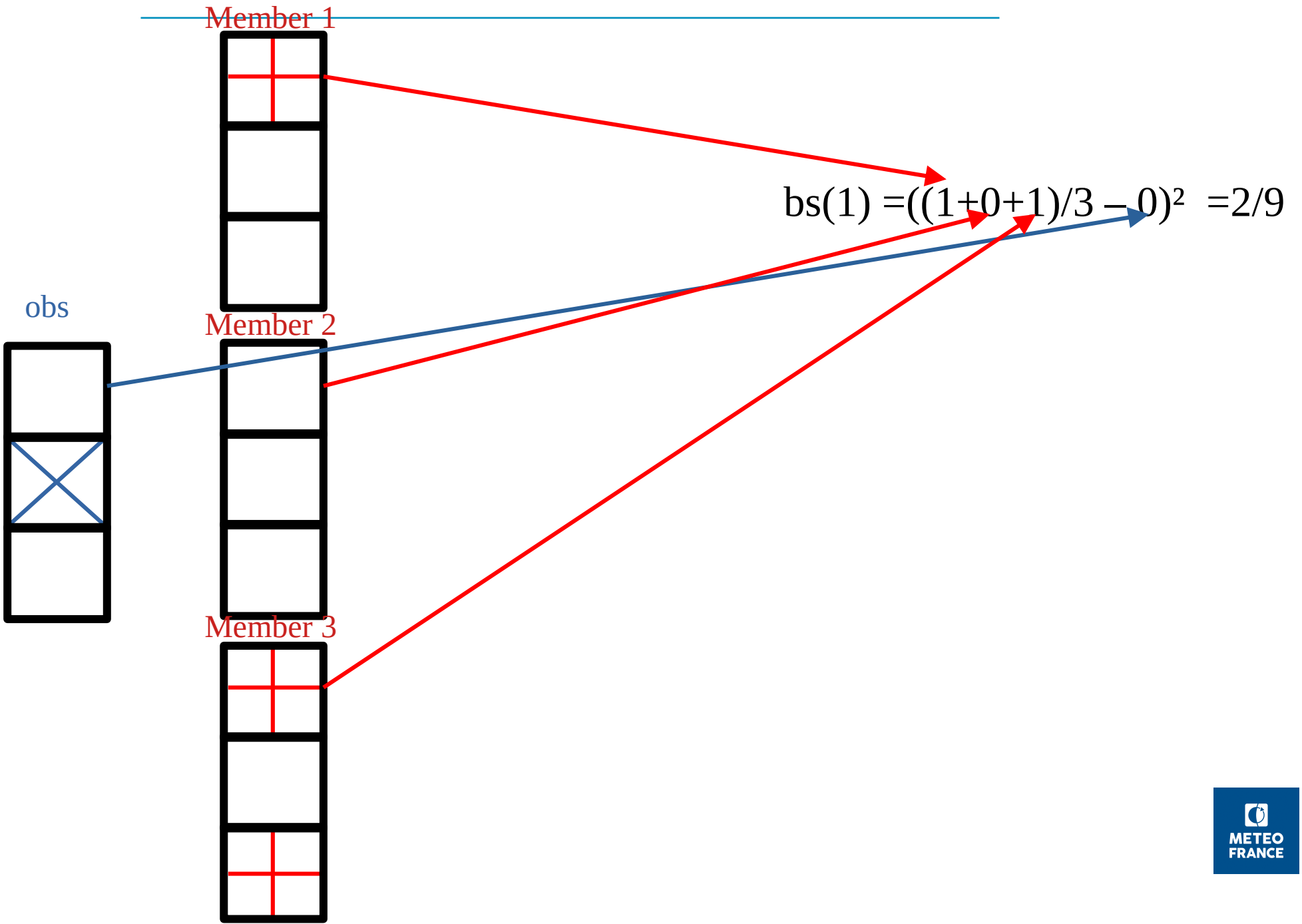
Member 2



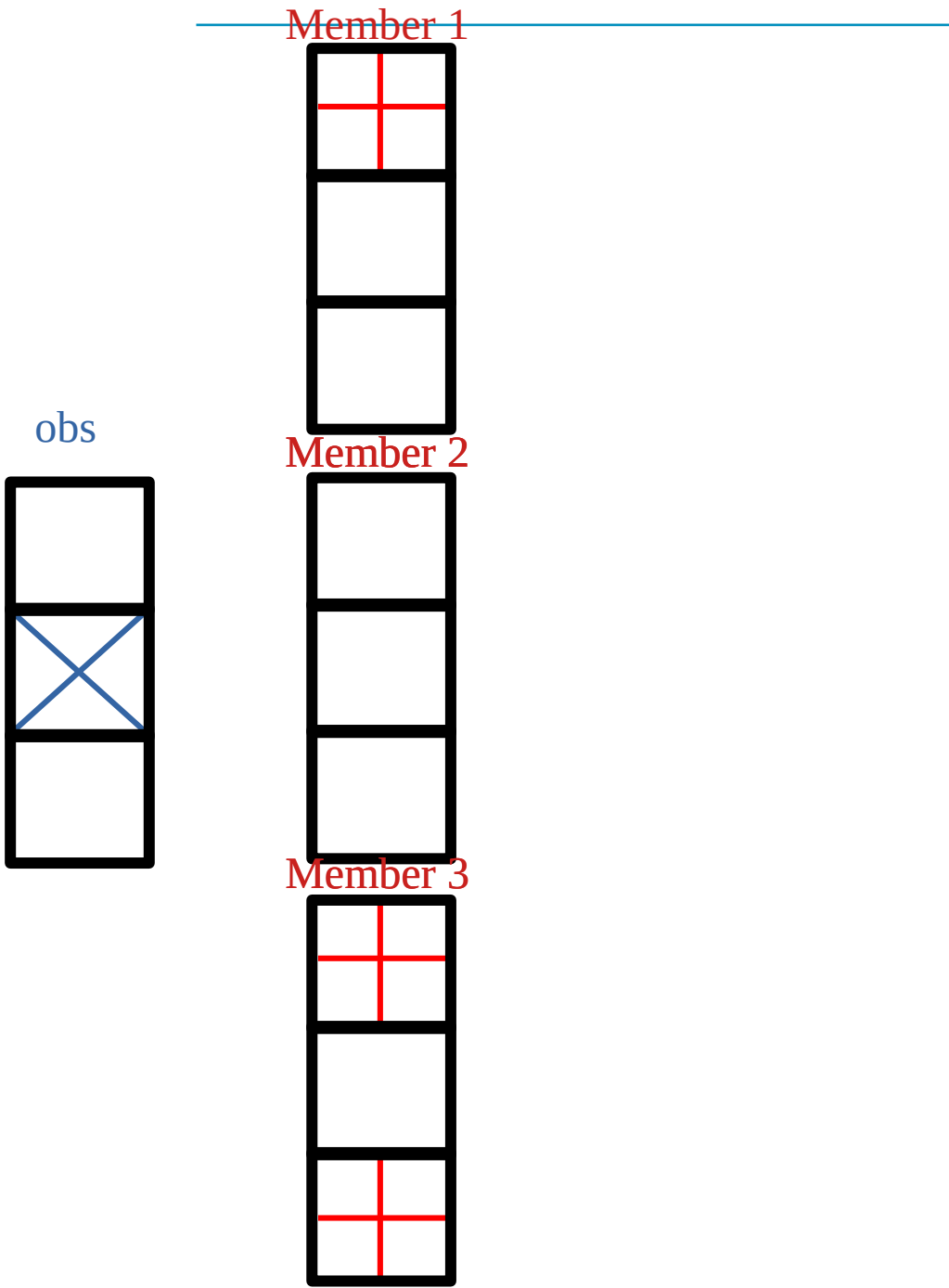
Member 3



BS classical method



BS classical method



$bs(1)=((1+0+1)/3 - 0)^2 = 2/9$

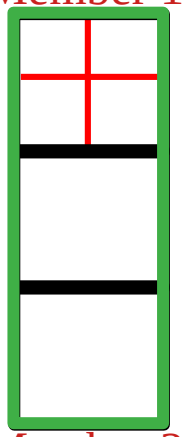
$bs(2)=((0+0+0)/3 - 1)^2 = 1$

$bs(3)=((0+0+1)/3 - 0)^2 = 1/9$

$bs=(bs(1)+bs(2)+bs(3))/3$
$=4/9$

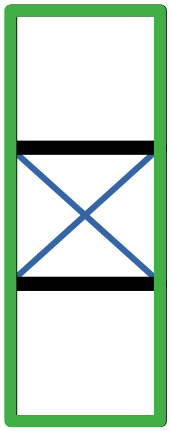
Neighborhood pooling and Brier divergence

Member 1

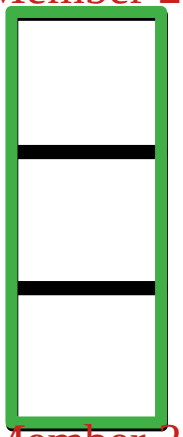


fn=1/3

obs



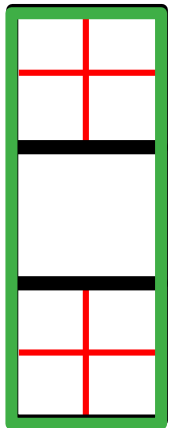
Member 2



fn=0/3

on=1/3

Member 3



fn=2/3

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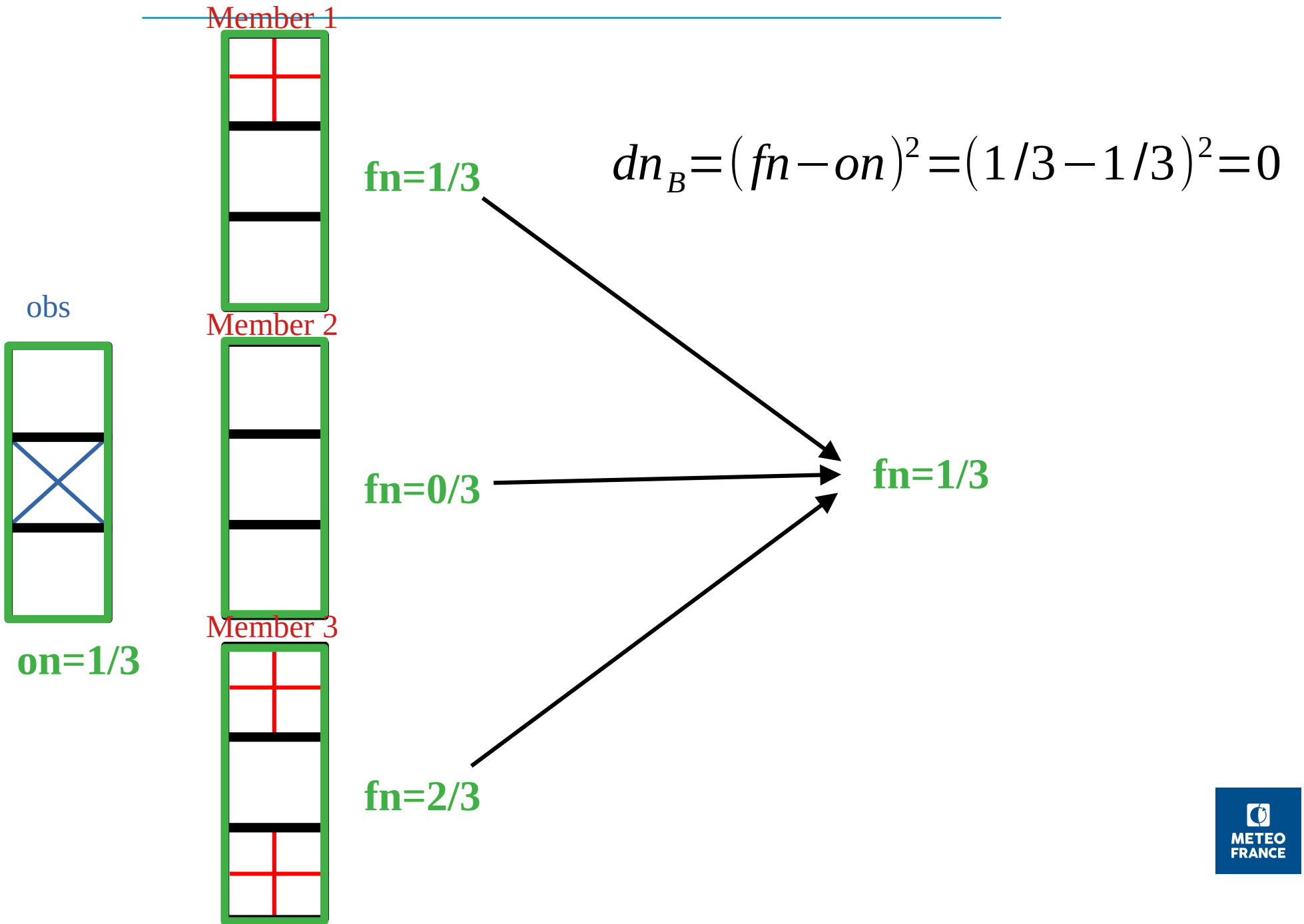
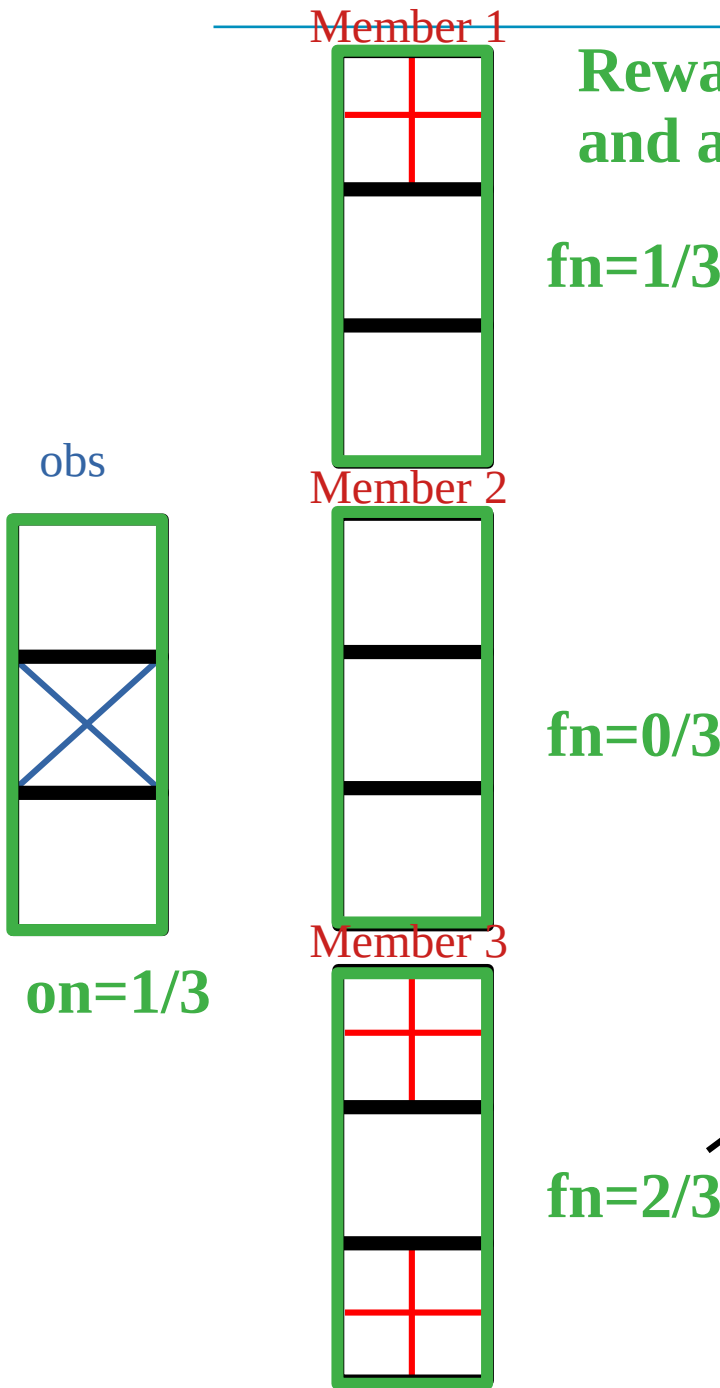
Neighborhood pooling and Brier divergence



Neighborhood pooling and Brier divergence



Rewards forecasts of events spatially slightly misplaced and allows compensations between members

$$dn_B = (fn - on)^2 = (1/3 - 1/3)^2 = 0$$

fn=1/3

fn=0/3

fn=2/3

fn=1/3

The limit for the deterministic case corresponds to a one member ensemble

It is a proper score

Decomposition of the Brier divergence

M disjoint arbitrary bins spanning [0,1] for fn, as in Stephenson etal 2008

$$\overline{dn_B} = \frac{1}{n}\sum_{k=1}^{M}\sum_{j=1}^{n_k}(fn_j - on_j)^2 = UNC + REL - GRES$$

$$UNC = \overline{on^2} - (\overline{on})^2$$

$$REL = \frac{1}{n}\sum_{k=1}^{M} n_k(\overline{fn_k} - \overline{on_k})^2$$

$$GRES = RES - WBV + WBC$$

$$RES = \frac{1}{n}\sum_{k=1}^{M} n_k(\overline{on_k} - \overline{on})^2$$

$$WBV = \frac{1}{n}\sum_{k=1}^{M}\sum_{j=1}^{n_k}(fn_j - \overline{fn_k})^2$$

$$WBC = \frac{1}{n}\sum_{k=1}^{M}\sum_{j=1}^{n_k}(fn_j - \overline{fn_k})(on_j - \overline{on_k})$$

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Decomposition of the Brier divergence

$$\overline{dsn_B} = 1 - \frac{dn_B}{UNC} = \frac{GRES}{UNC} - \frac{REL}{UNC}$$

$$\overline{fss} = 1 - \frac{\overline{dn_B}}{\overline{on}^2 + \overline{fn}^2}$$

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Models and observations

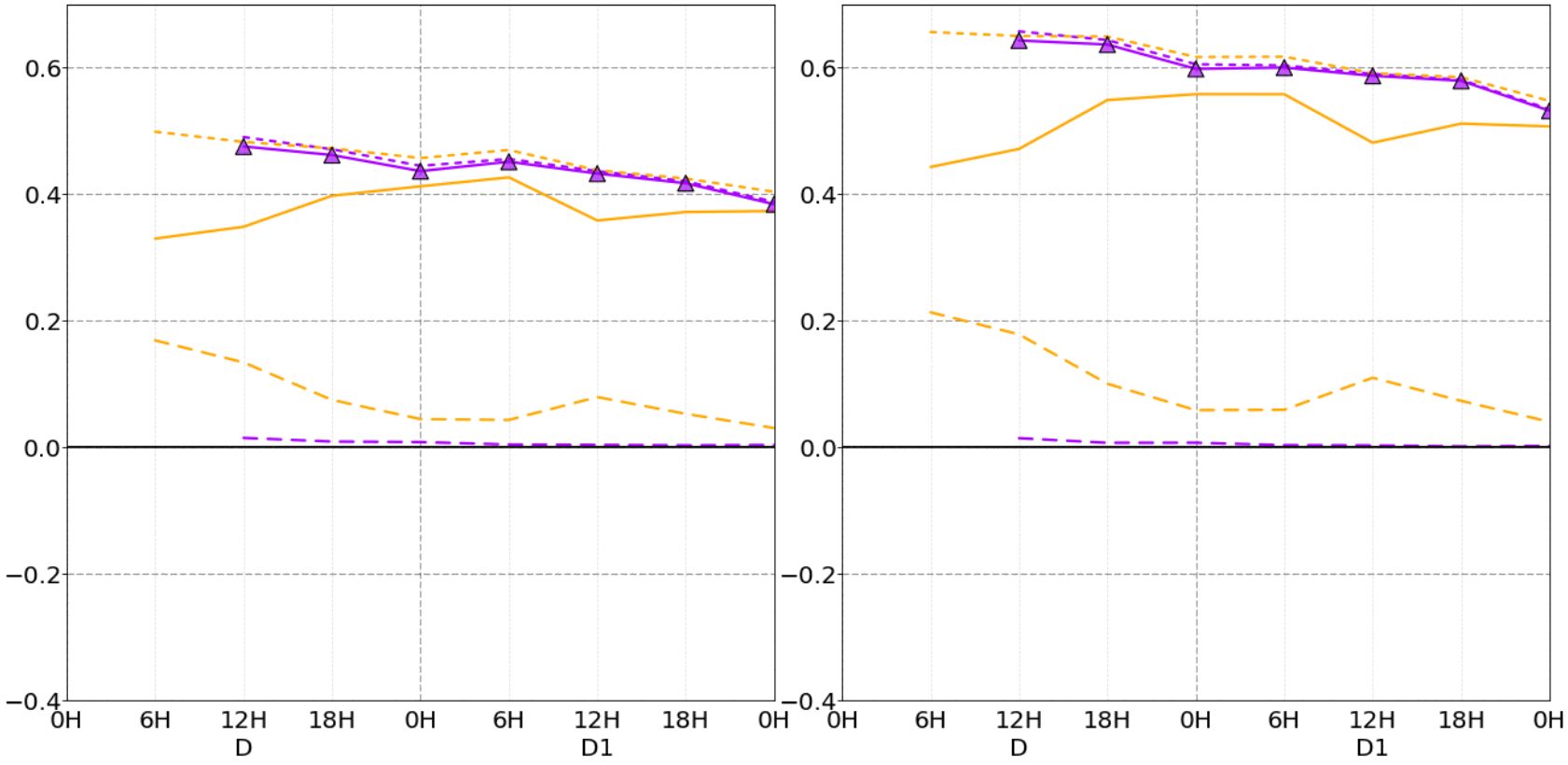
- **PEARP** : 35 hydrostatic global forecasts ; 7,5 km over France ; Singular vectors + EDA and 10 physics
- **PEAROME** : 16 non-hydrostatic forecasts nested in PEARP ; 2,5 km over France ; EDA and stochastic physics
- **ANTILOPE** : data fusion between french radar observations and raingaujes ; 1 km grid over France
- **Verification of QPF accumulated during 6 hours on the same grid (2,5 km)** : from 01 january to 31 december 2020 over France

Comparison with $\overline{dns}_B$ of PEAROME and PEARP for the event rr6 > 0,5 mm

	$\overline{dsn}_B$	REL/UNC	GRES/UNC
PEAROME	———	- - -	·····
PEARP	———	- - -	·····

▲ better than PEARP (5%)

▼ better than PEAROME (5%)

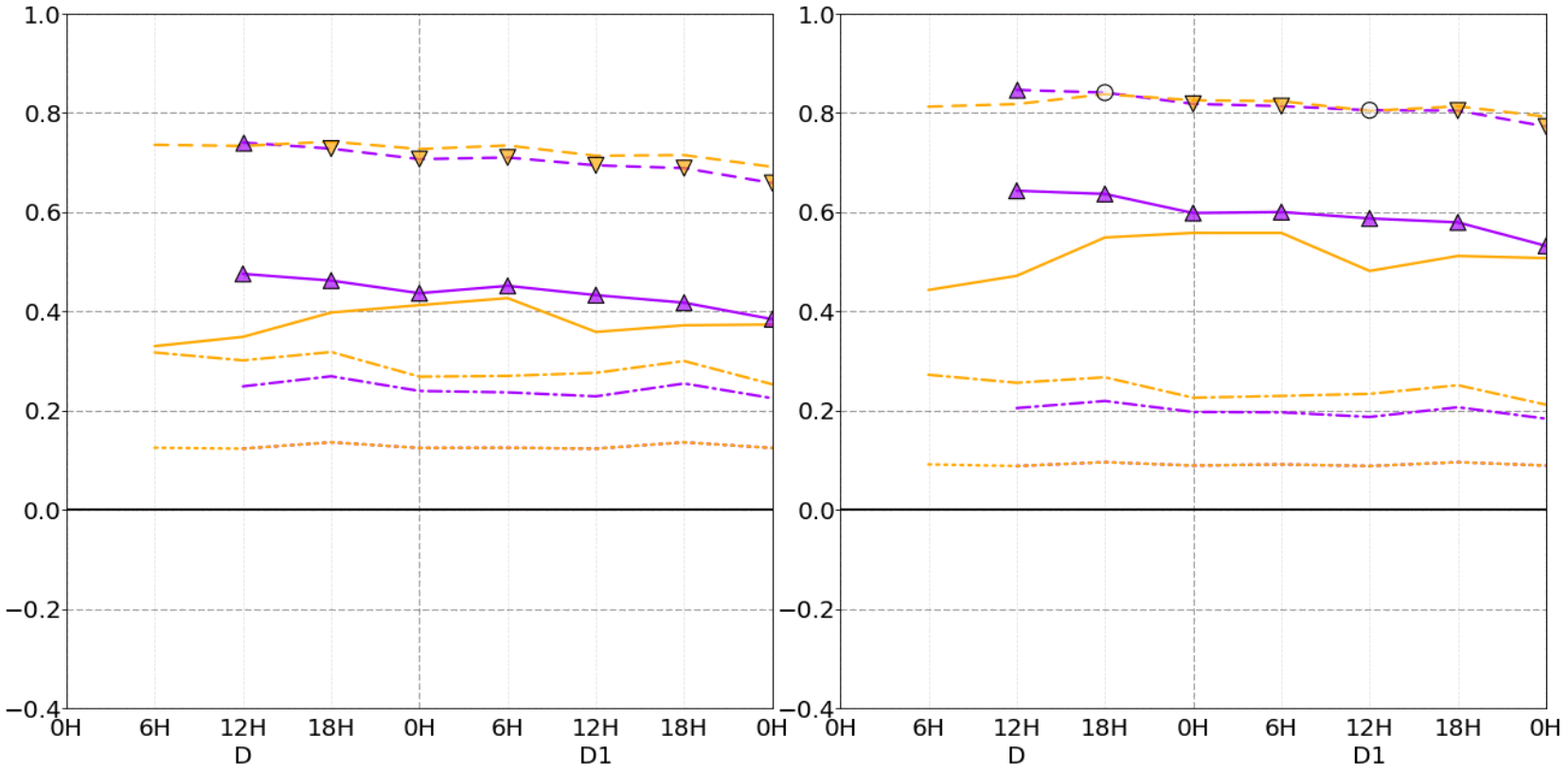


Neighborhood size 2,5 km
1x1 =1 grid point

Neighborhood size 50 km
21x21=441 grid points M=36

Comparison with $\overline{dns\_B}$ and $\overline{fss}$ of PEAROME and PEARP for the event rr6 > 0,5 mm/6H

	$\overline{dsn\_B}$	$\overline{fss}$	UNC	$\overline{on^2} + \overline{fn^2}$	
PEAROME	———	– – –	·····	– · – ·	▲ better than PEARP
PEARP	———	– – –	·····	– · – ·	▼ better than PEAROME



Neighborhood size 2,5 km
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Neighborhood size 50 km
21x21=441 grid points M=36

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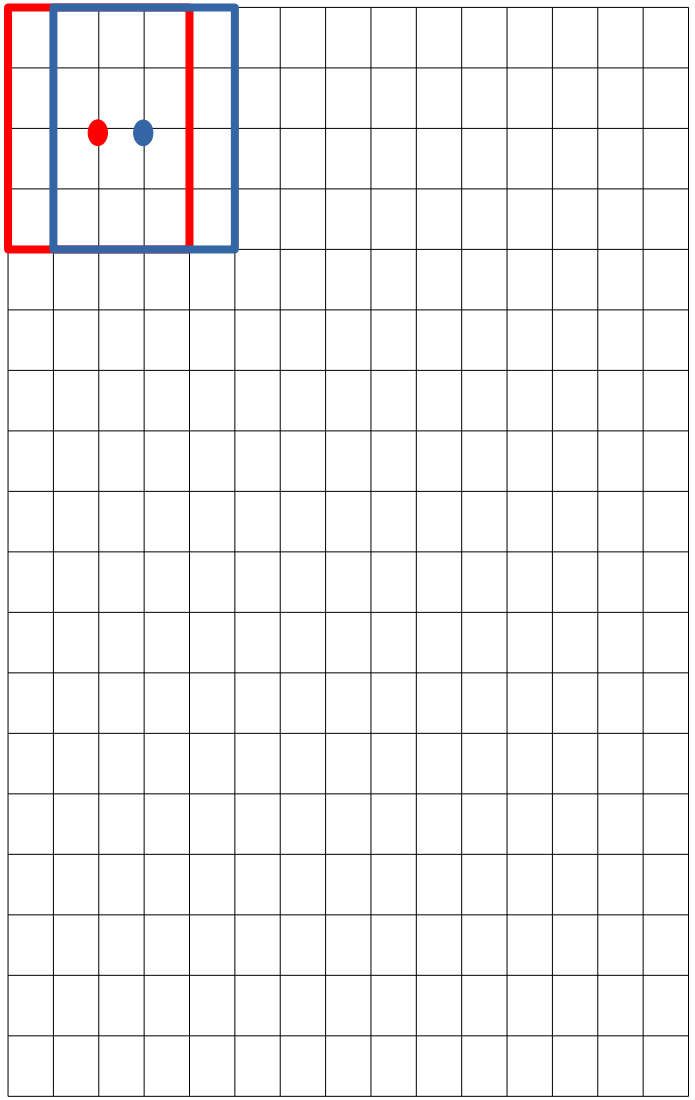
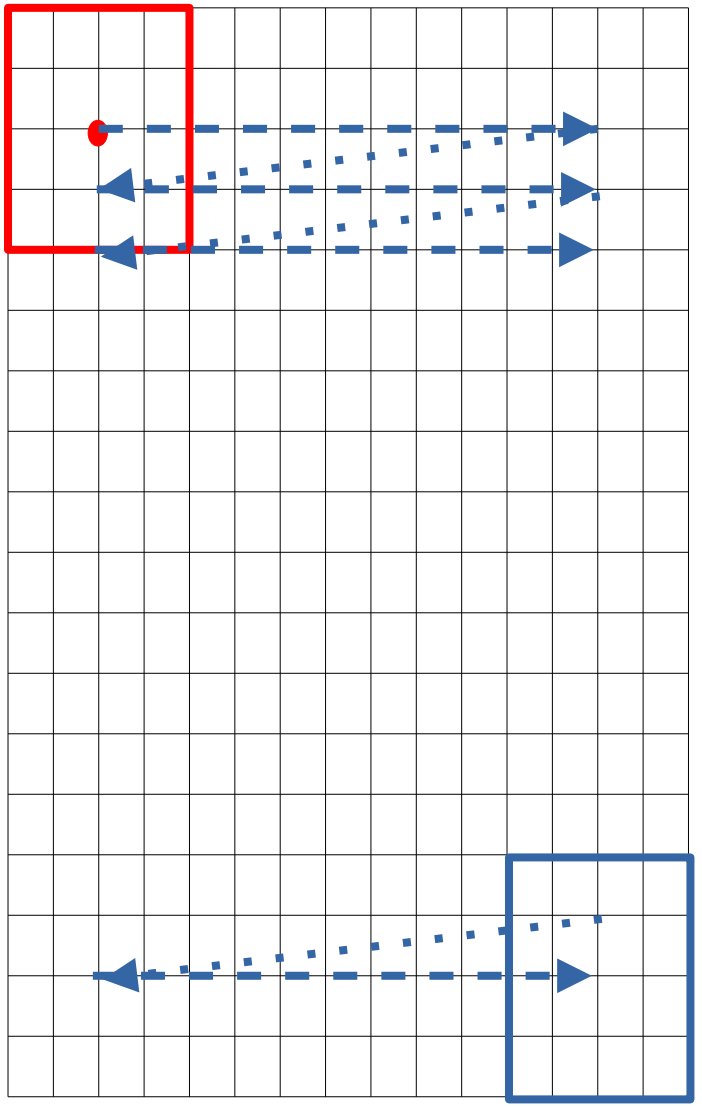
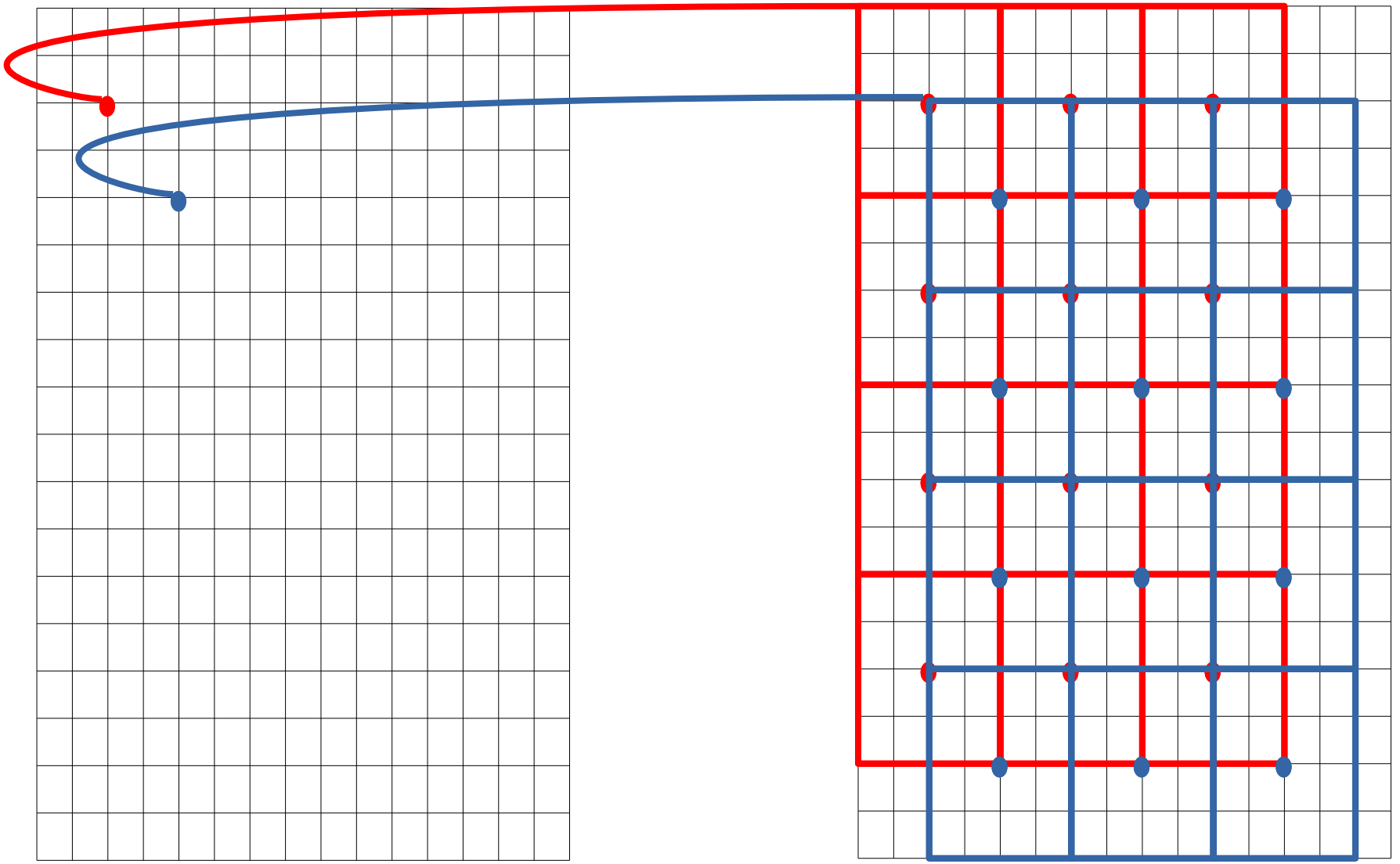
Conclusions

- Two steps procedure : 1) pooling in the neighborhood 2) use of the Brier divergence dn_B for neighborhood frequencies => Proper score for the scale given by the neighborhood size
- Reduces the double penalty by construction
- Decomposition of the Brier divergence into UNCertainty, RELiability, Generalized RESolution
- Skill score dsn_B using UNCertainty keeps the order given by the Brier divergence unlike fss
- Stein and Stoop (2023) in revision for Monthly Weather Review





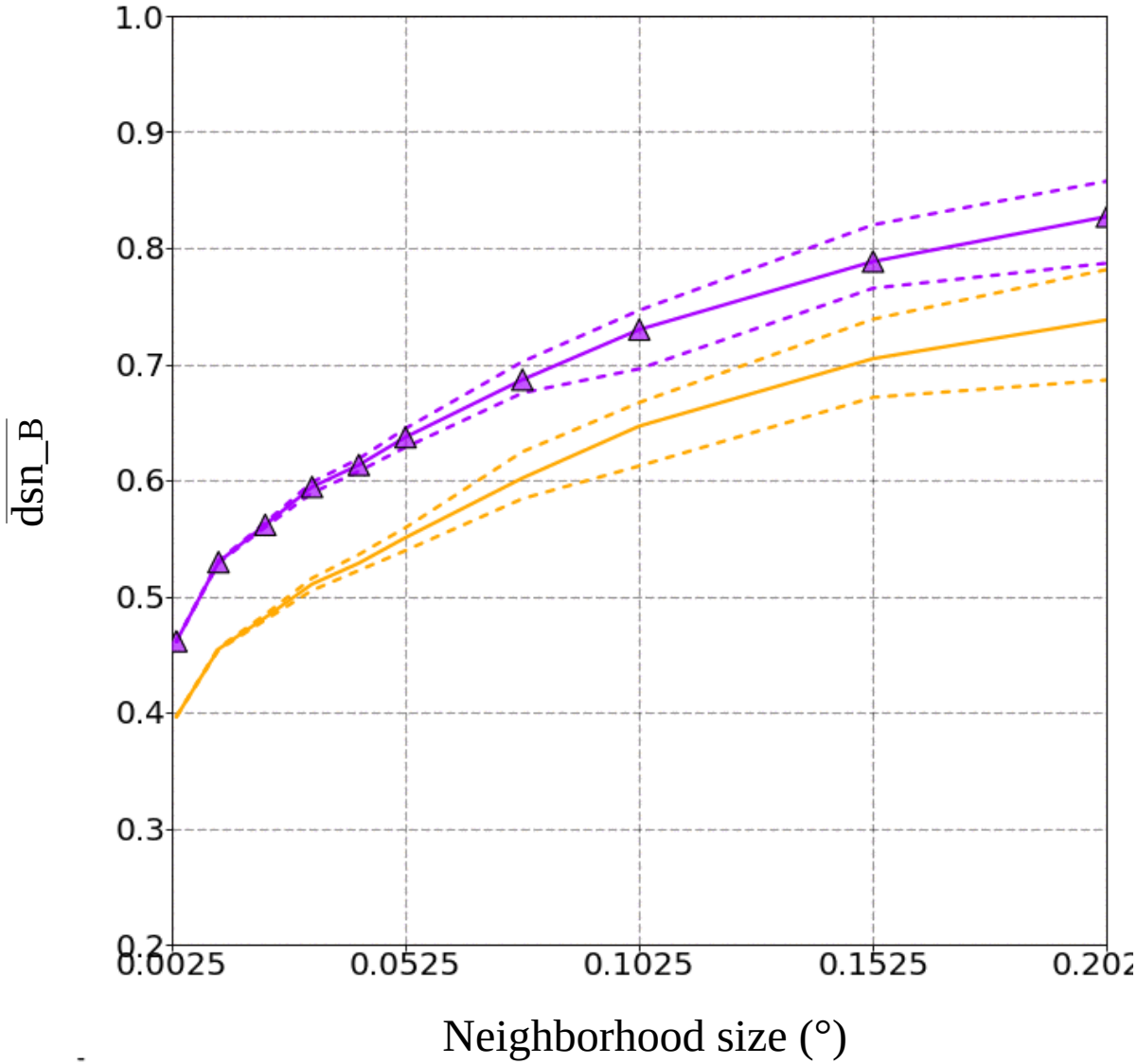


Comparison with $\overline{dns\_B}$ of PEAROME and PEARP for the event rr6 > 0,5 mm/6H

	$\overline{dsn\_B}$ min	$\overline{dsn\_B}$ mean	$\overline{dsn\_B}$ max
PEAROME	– – –	———	– – –
PEARP	– – –	———	– – –

▲ better than PEARP

▼ better than PEAROME



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