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METEO FRANCE

Neighborhood pooling for evaluating ensemble forecasts of binary events with the Brier Divergence

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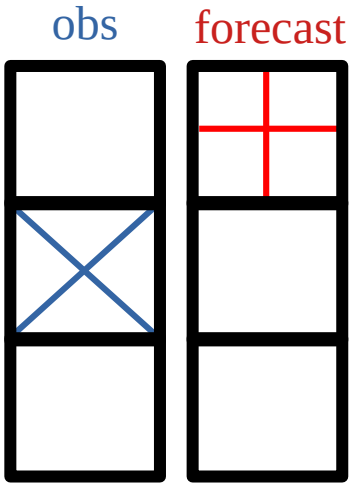
EWGLAM 27/09/2022

Outline

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

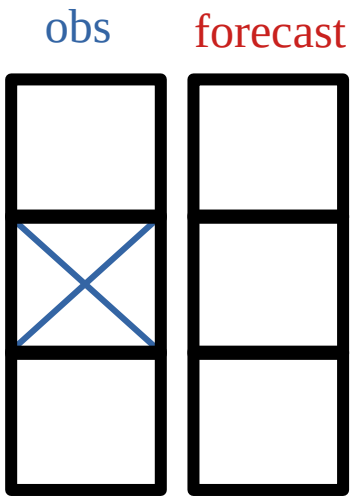
Interest of the neighborhood



1 FA

1 MISS

1 Cor Rej



1 Cor Rej

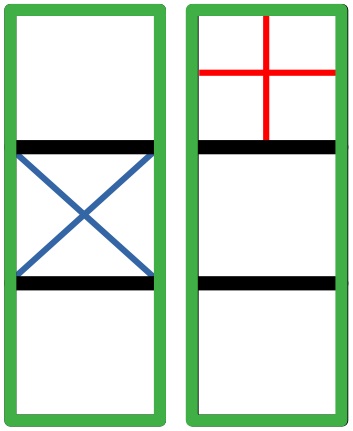
1 MISS

1 Cor Rej

Classical Tables of contingency

Interest of the neighborhood

obs forecast



1 FA

1 MISS

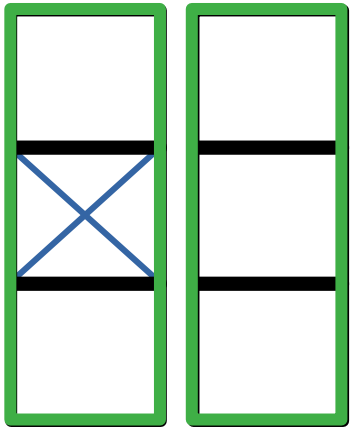
1 Cor Rej

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

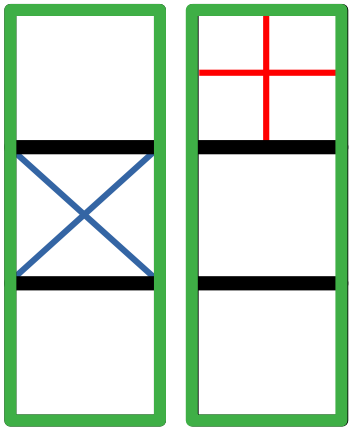
$$FBS = (fn - on)^2 = 1/9$$

Classical Tables of contingency

Interest of the neighborhood

Reward forecasts of events spatially slightly misplaced

obs forecast



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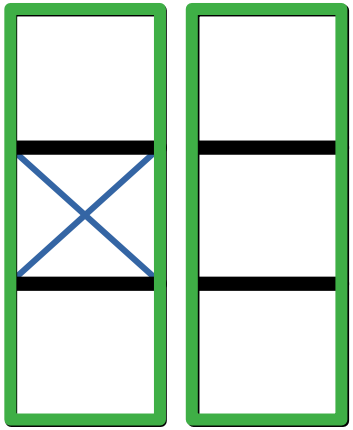

1 Cor Rej

1 MISS

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Neighborhood frequencies

observation 1/3 forecast 0/3

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

Classical Tables of contingency

Fraction Brier Score=> FSS (Roberts and Lean 2008) and BSS (Amodei and Stein 2009)

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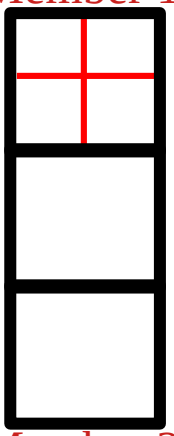
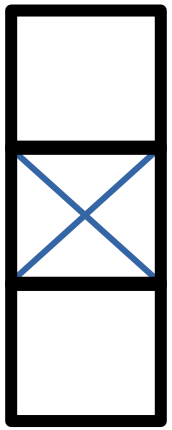
BS classical method

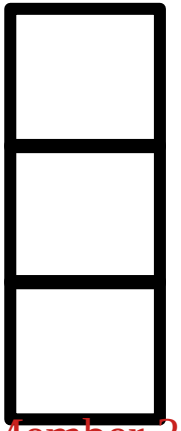
Member 1



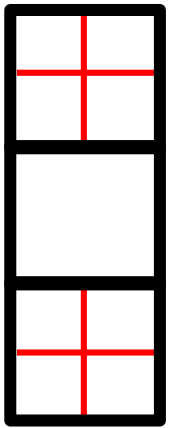
obs



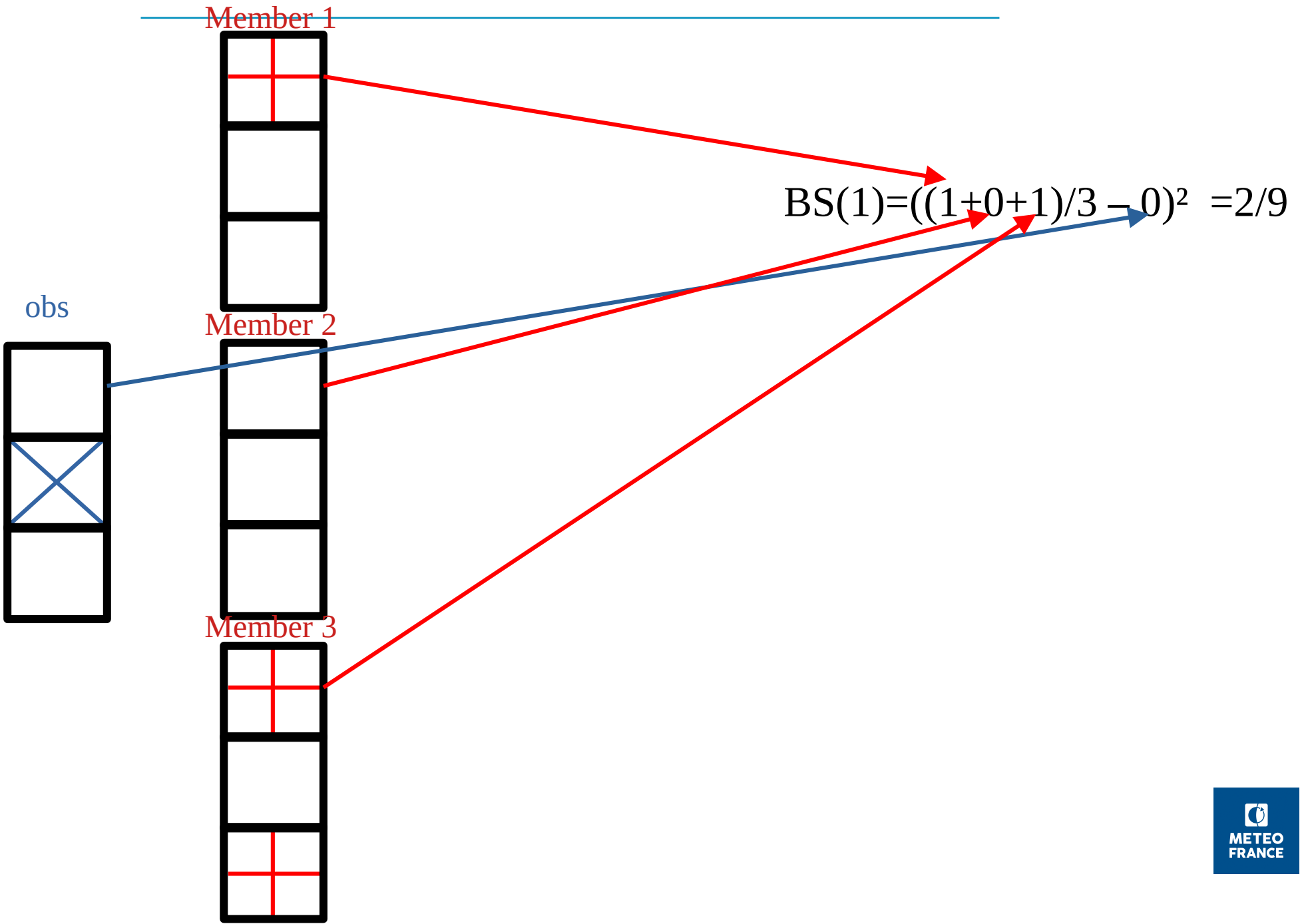
Member 2



Member 3



BS classical method



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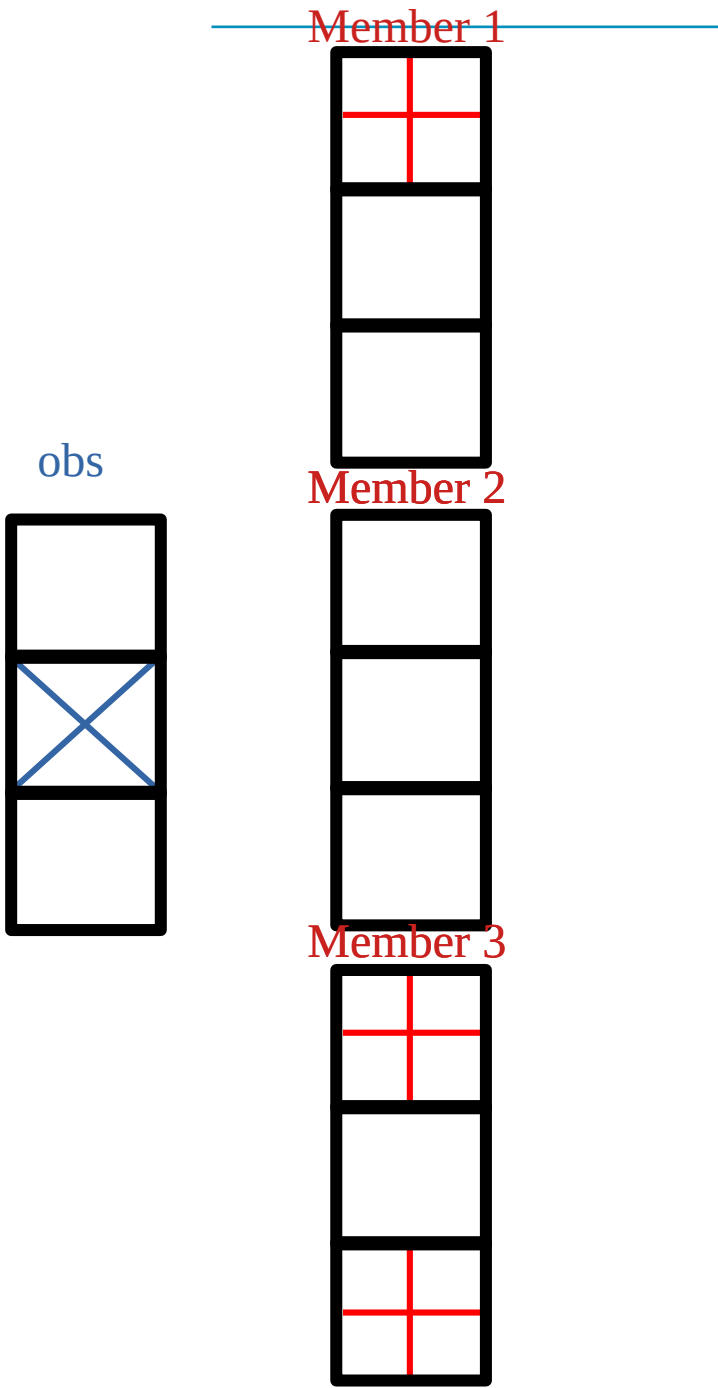


$BS(1)=((1+0+1)/3-0)^2=2/9$

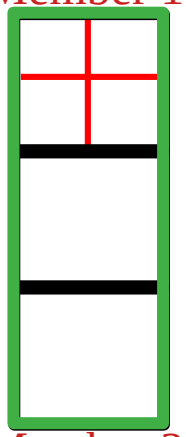
$BS(2)=((0+0+0)/3-1)^2=1$

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

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

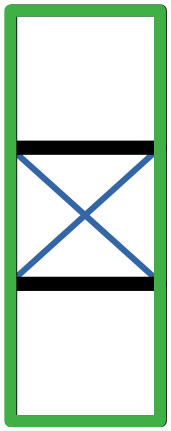
Neighborhood pooling and Brier divergence

Member 1

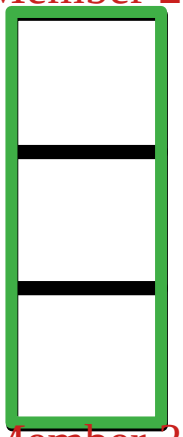


fn=1/3

obs



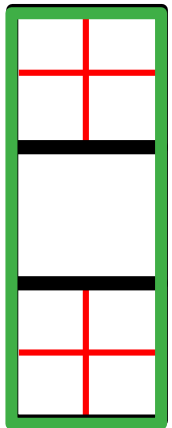
Member 2



fn=0/3

on=1/3

Member 3



fn=2/3

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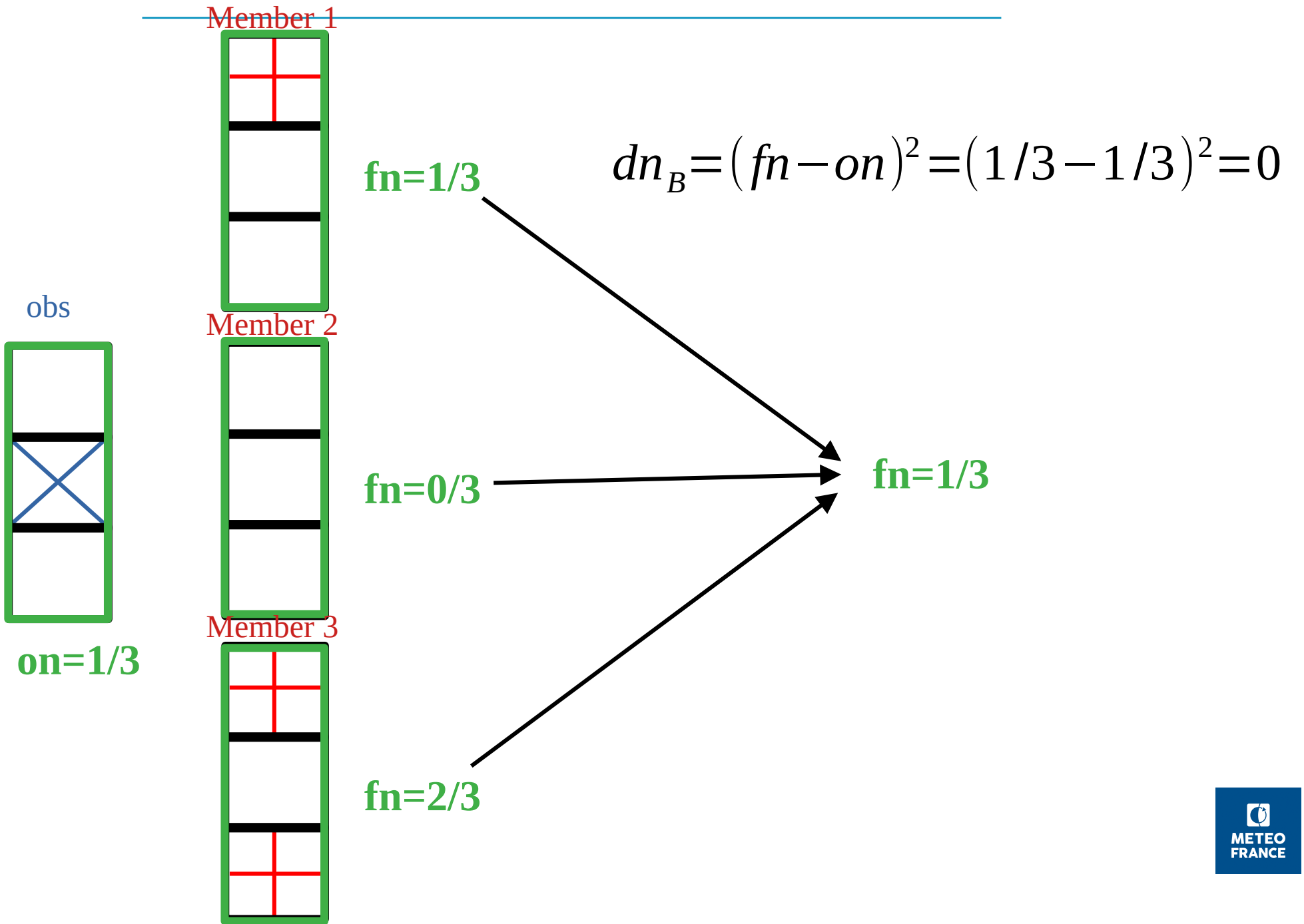
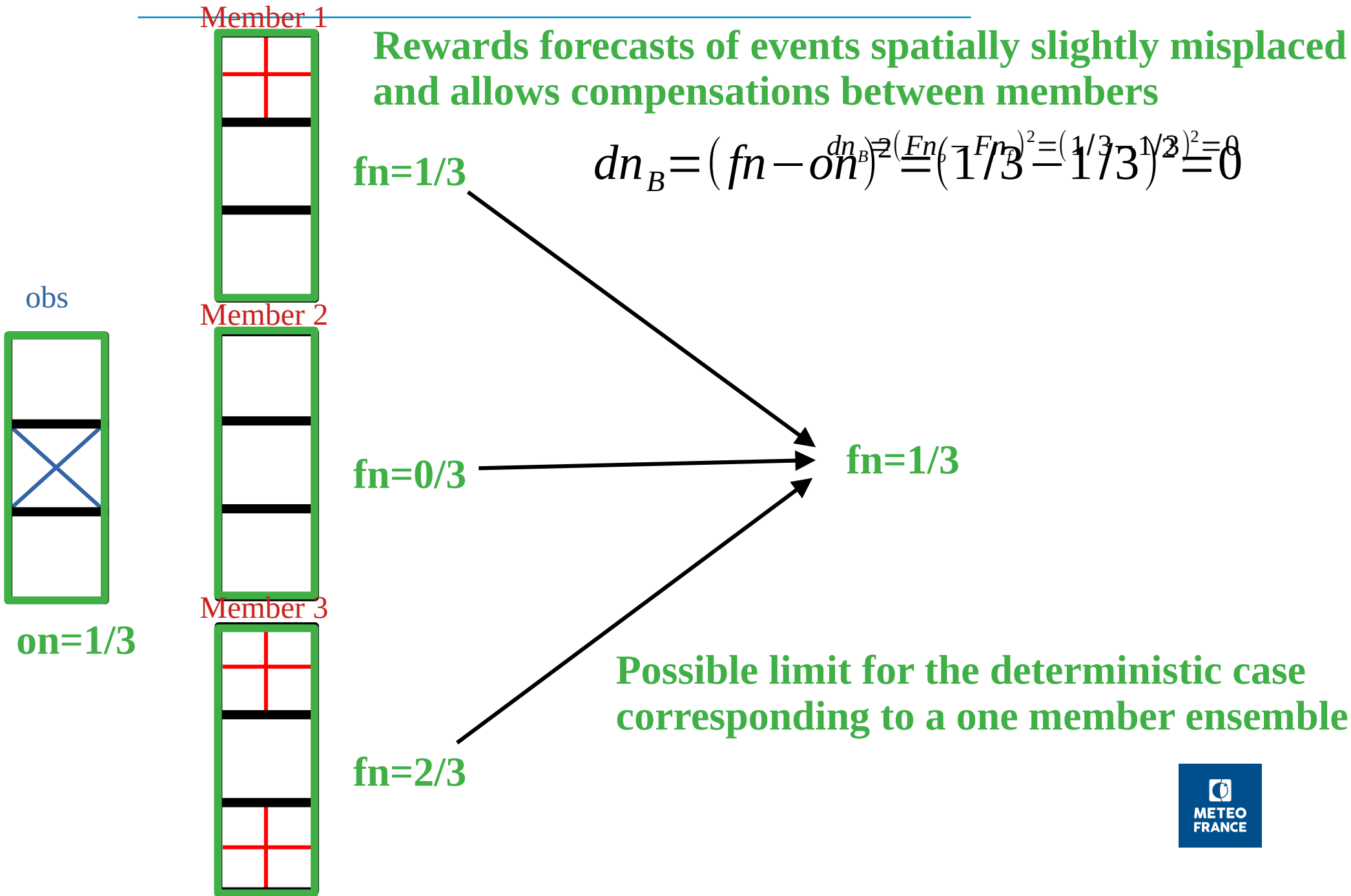
Neighborhood pooling and Brier divergence



Neighborhood pooling and Brier divergence



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

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

$dn_B = (Fn_p - Fn_o)^2 = (1/3 - 1/3)^2 = 0$

Possible limit for the deterministic case corresponding to a one member ensemble

Decomposition of the Brier divergence

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

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

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

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

$$GRES = RES - WBV + WBC$$

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

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

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

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

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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
- **AROME** : non-hydrostatic LAM nested in ARPEGE ; 1.3 km over France
- **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

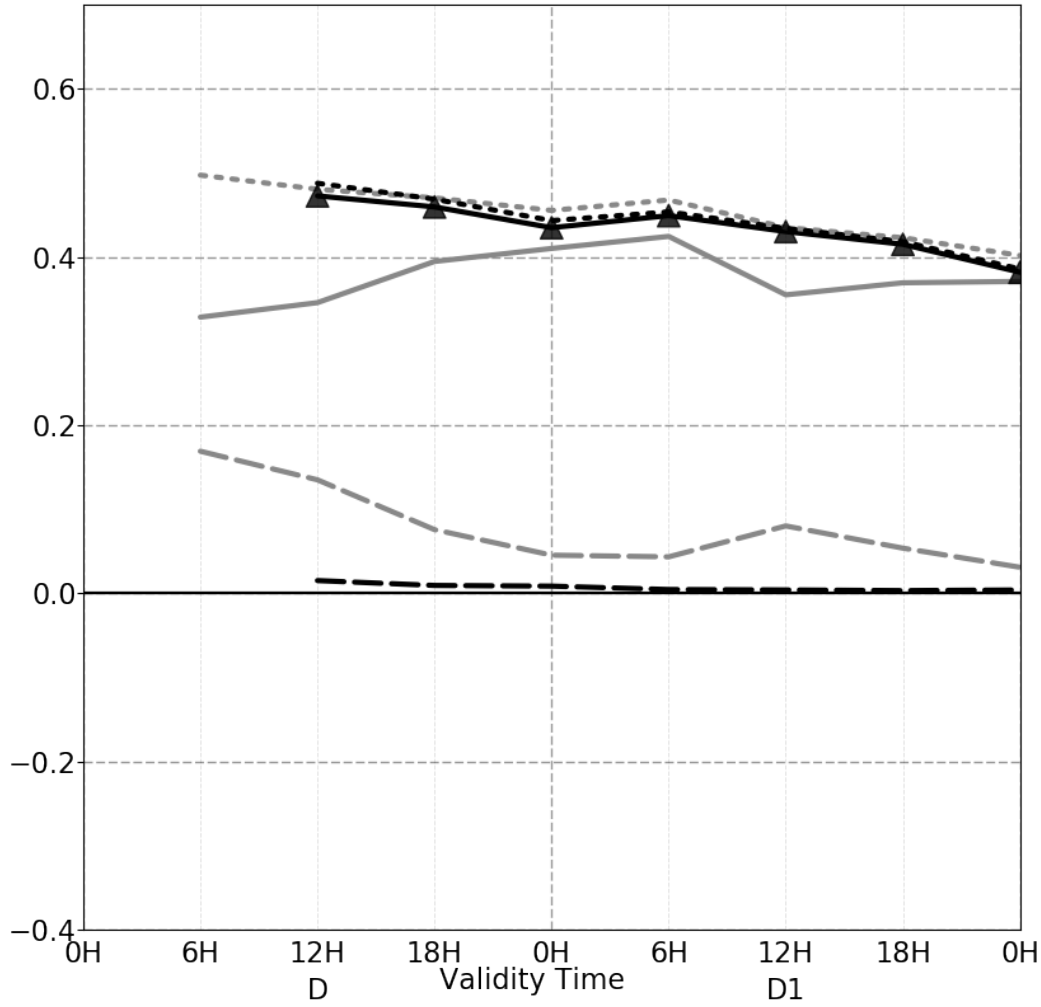
Comparison with dns_B of PEAROME and PEARP for the event rr6 > 0,5 mm/6H

dns_B | Reliability term | Generalized resolution term

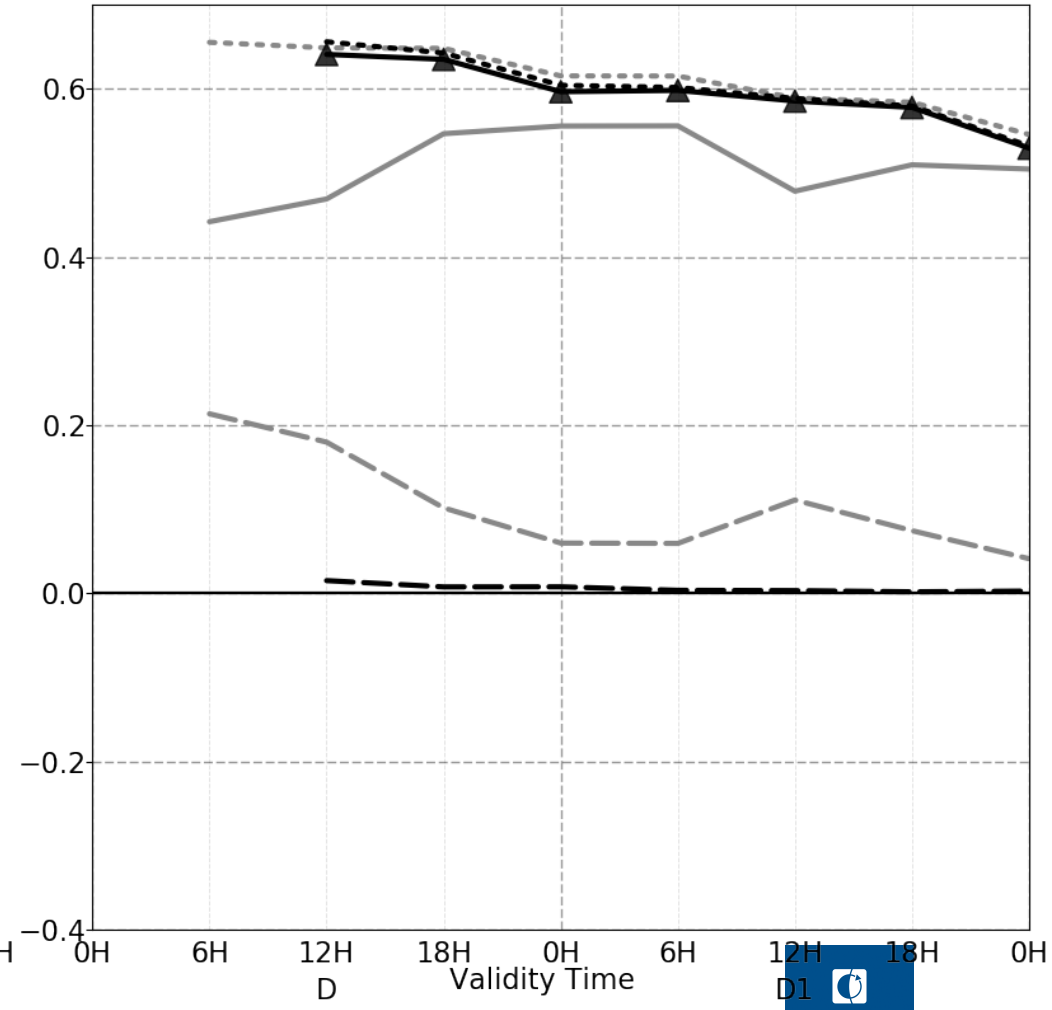
PEAROME

PEARP

▲ Significantly better at the 5 % level



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



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

Comparison with dns_B of PEAROME and PEARP for the event rr6 > 5 mm/6H

dns_B | Reliability term | Generalized resolution term

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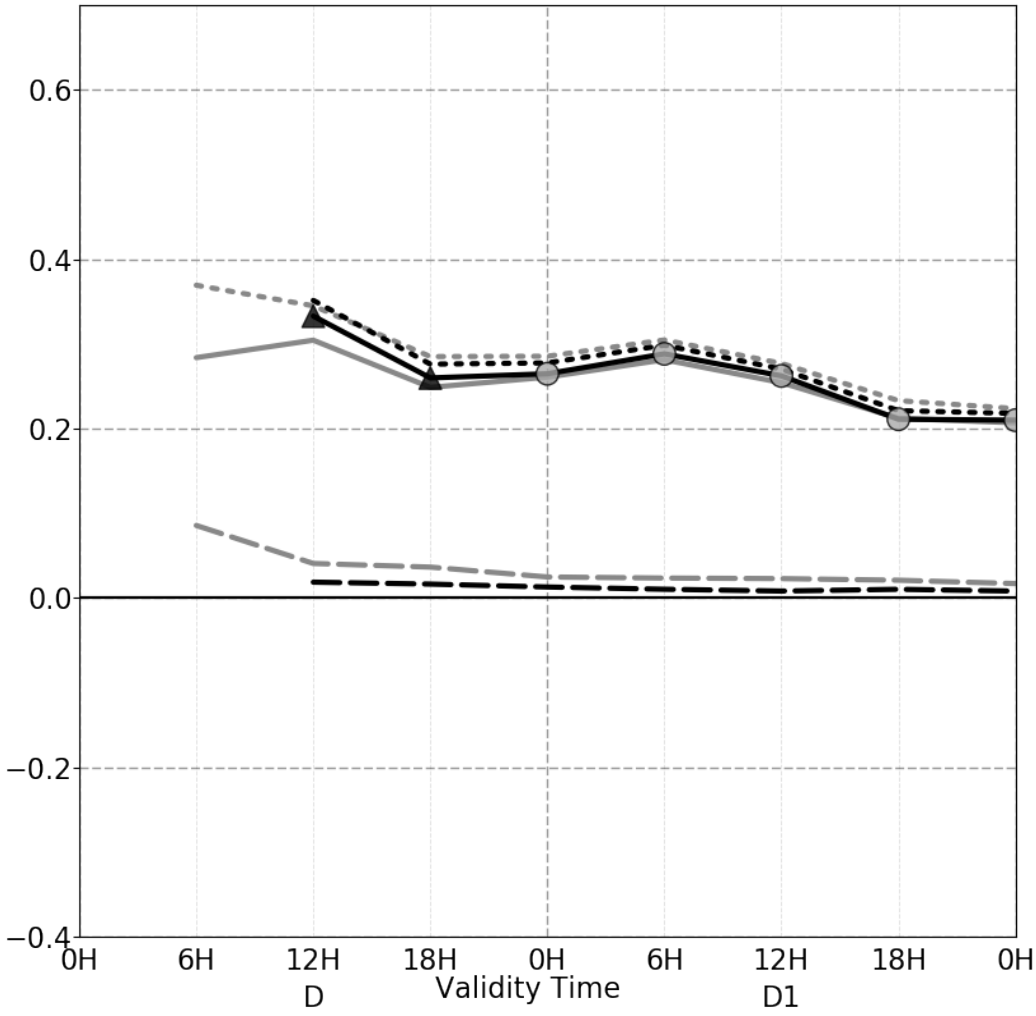

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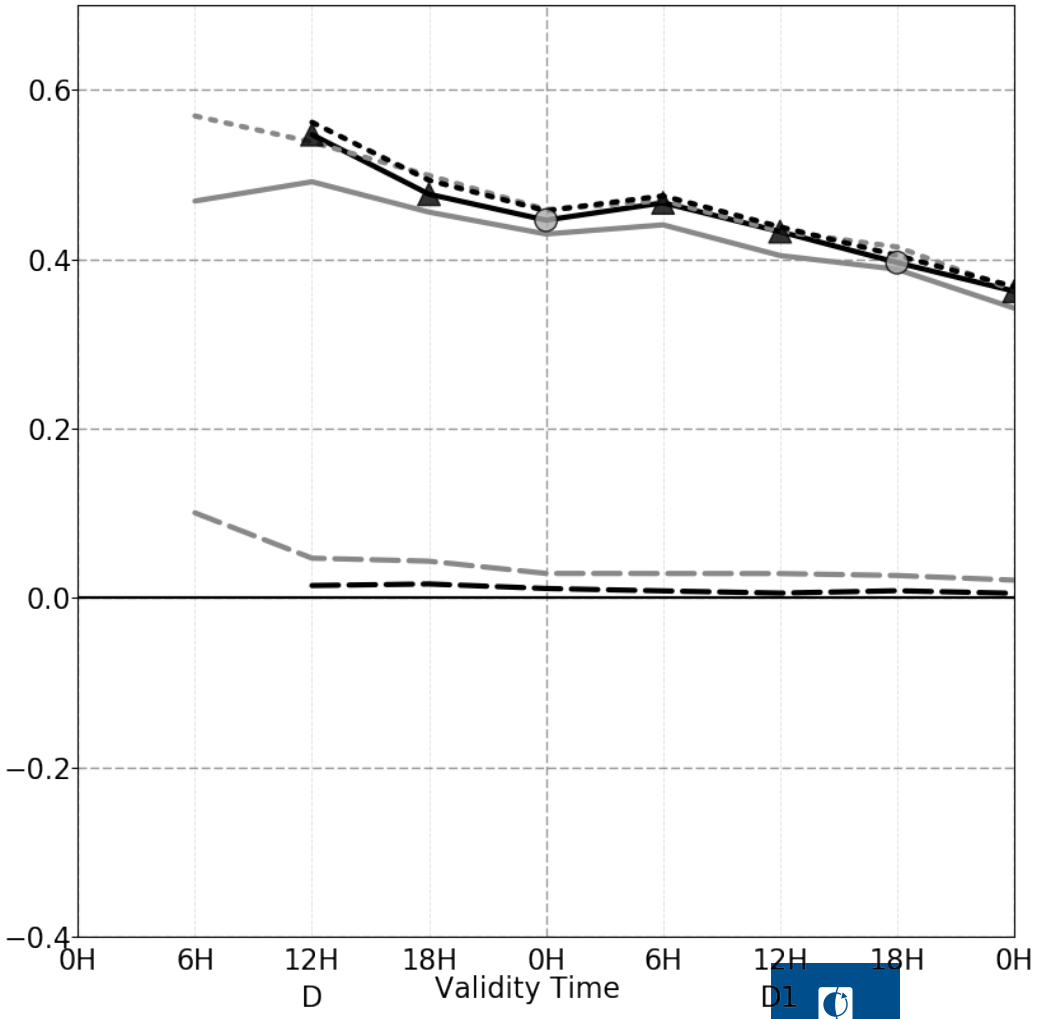

Neighborhood size 50 km
21x21=441 grid points, M=36

Comparison with dns_B of PEAROME and AROME for the event rr6 > 5 mm/6H

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PEAROME

AROME

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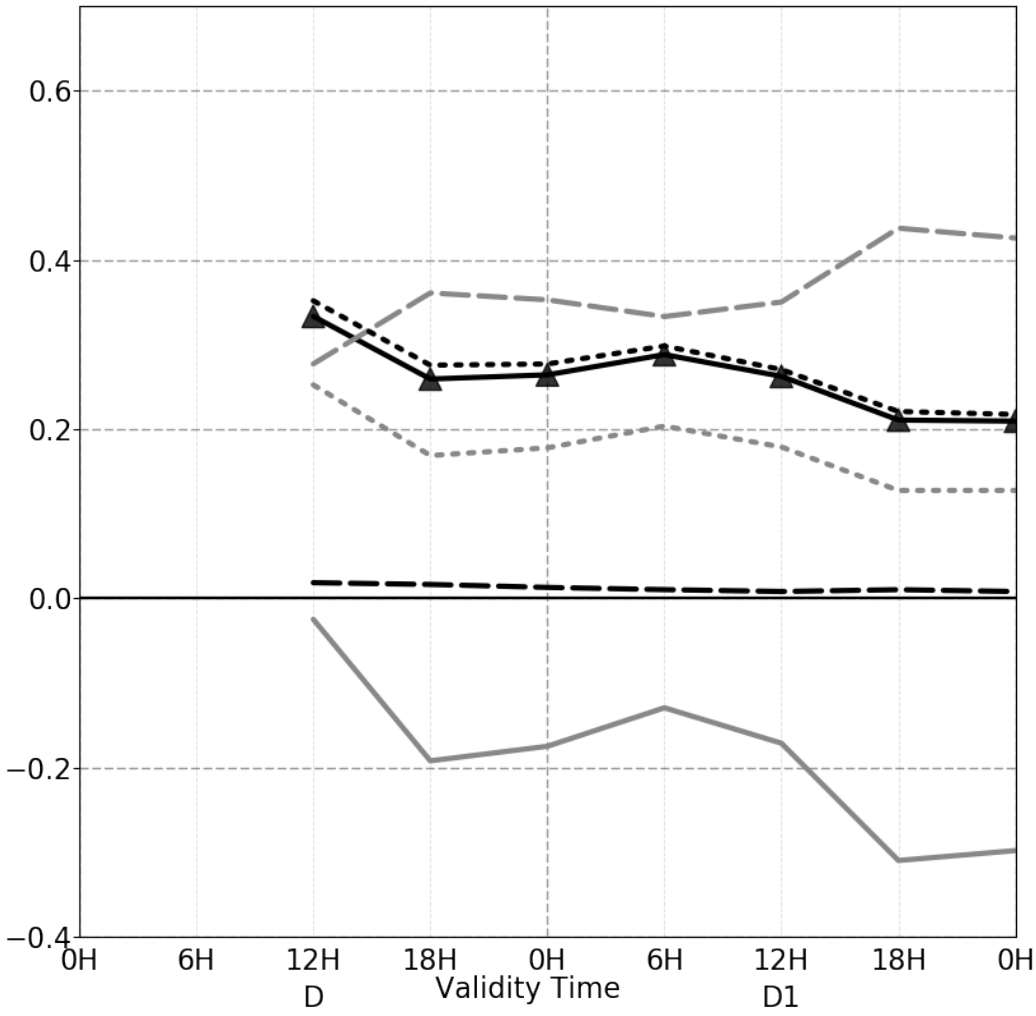

Neighborhood size 2,5 km
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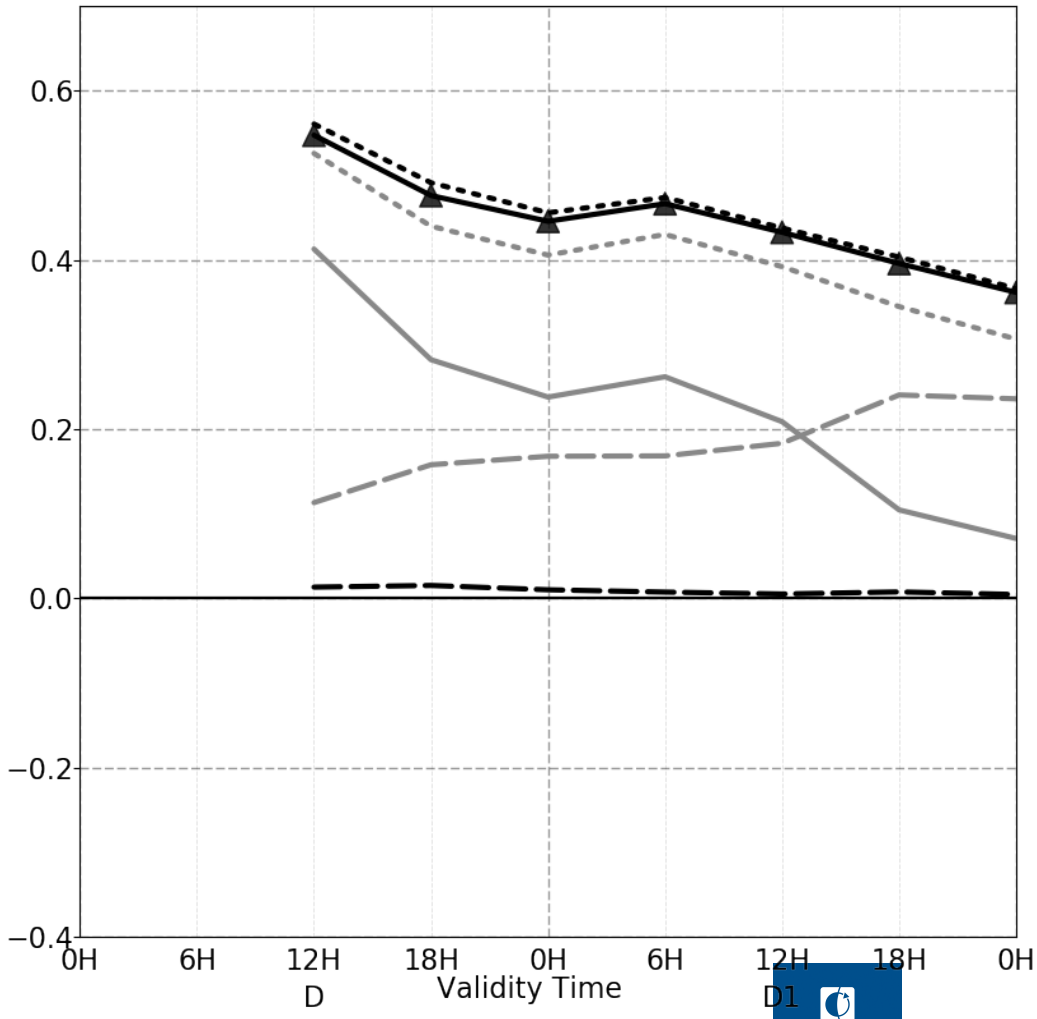

Neighborhood size 50 km
21x21=441 grid points M=17

Conclusions

- Generalization of the FBS for the ensemble forecasts by a two steps procedure : 1) pooling in the neighborhood 2) use of the Brier divergence for neighborhood frequencies
- Deterministic limit using an ensemble of one member.
- The double penalty is still present for ensemble forecasts but less active than for a deterministic forecast.
- Stein and Stoop (2022) submitted to Monthly Weather Review