Neighborhood methods for precipitation forecasts from high resolution EPS

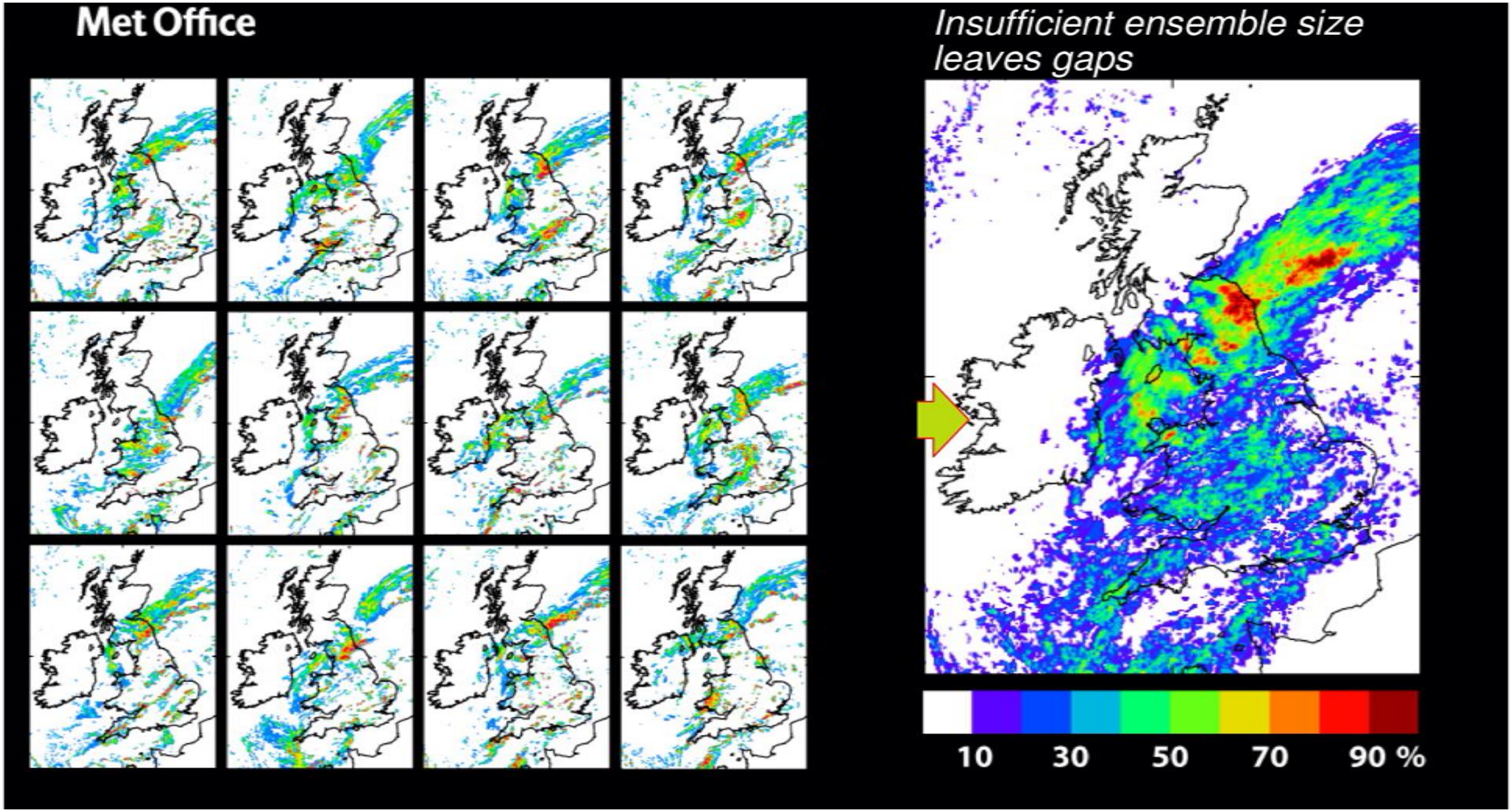
(and some other thoughts on calculating probabilities)

Andrew Singleton

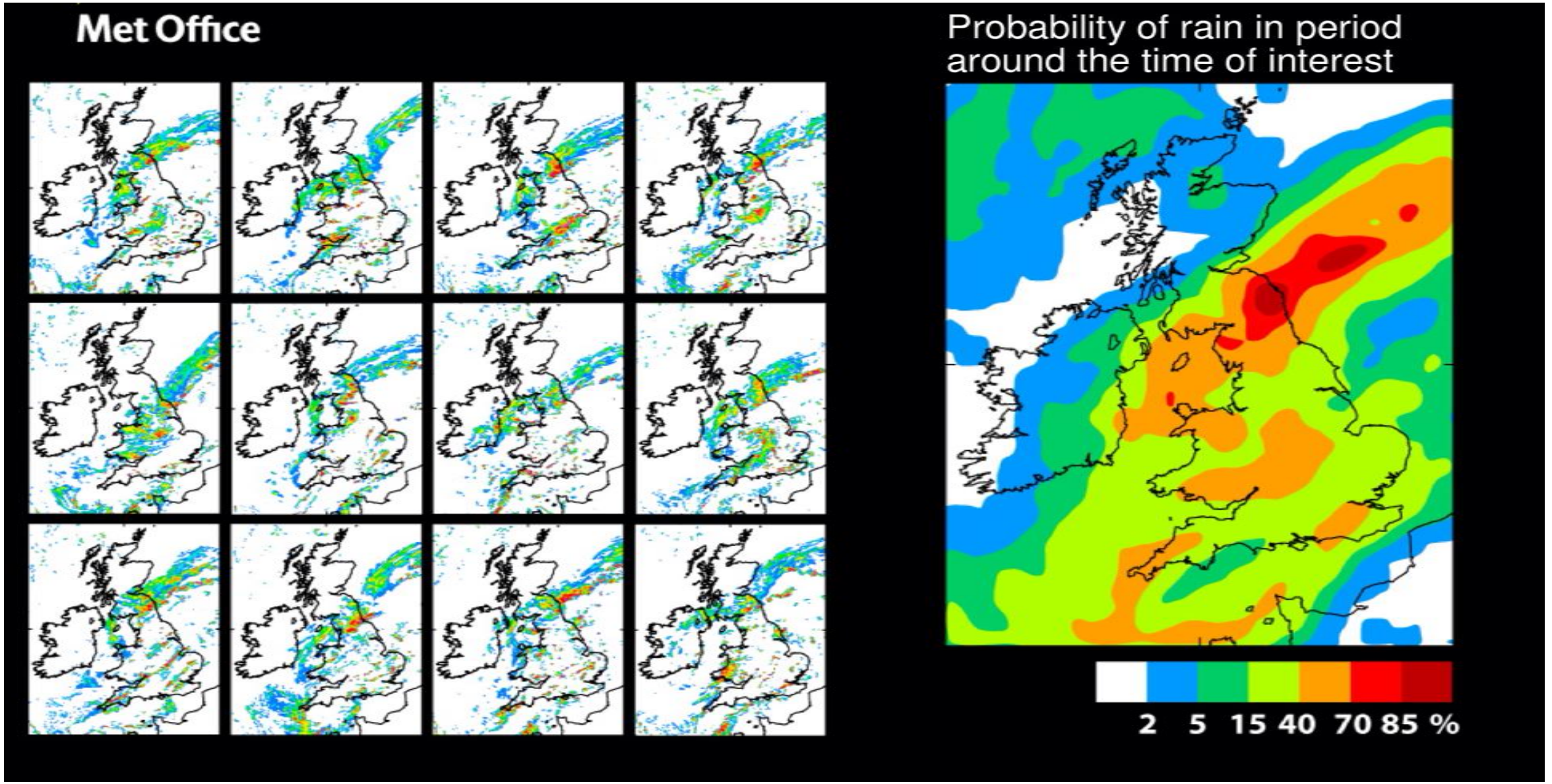
MET Norway

Why use neighborhood methods?

- Ideally EPS members should encompass entire range of atmospheric uncertainty – infinite number of members with perfect perturbations.
- Computational expense limits number of members for high resolution ensembles
- Neighbourhood methods can be used to "fill in the gaps" and create a super ensemble.
  - Assume all pixels in 3x3 neighborhood surrounding a grid square are equally likely – if the event occurs in 5 of these pixels, the probability at the central grid square is 5/9
  - If we then have 14 members, a 3x3 neighborhood would effectively result in 126 members.



Nigel Roberts, Met Office



Nigel Roberts, Met Office

How to determine neighborhood size?

1. **Fixed neighbourhood size**
   - Based on rule of thumb (e.g. 5 grid lengths)
   - Based on spatial verification (e.g. FSS) over a training period

   BUT

   - May penalise forecasts with good predictability
   - Neighbourhood may be too small when predictability is low

How to determine neighborhood size?

2. **Adaptive neighbourhood size**
   - Based on spatial scales of predictability

$$Var\left(\sum_{i=1}^{N} X_i\right) = \sum_{i=1}^{N} Var(X_i) + \sum_{i \neq j} Cov(X_i, X_j)$$

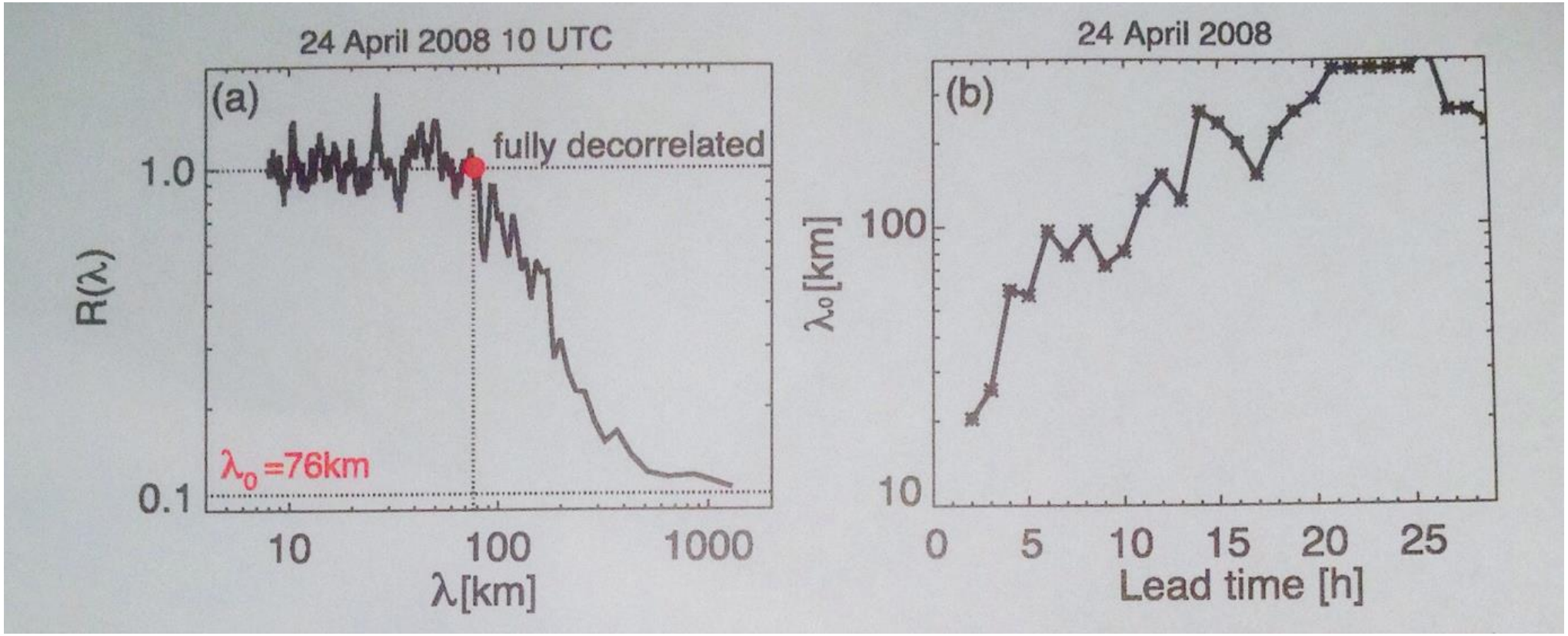
$$\frac{\sum_{i=1}^{N} Var(X_i)}{Var\left(\sum_{i=1}^{N} X_i\right)} = 1$$

$$R(\lambda) = \frac{\sum_{i=1}^{N} P_X(\lambda)}{P_{X_T}(\lambda)}$$

How to determine neighborhood size?

2. Adaptive neighbourhood size

- Based on spatial scales of predictability

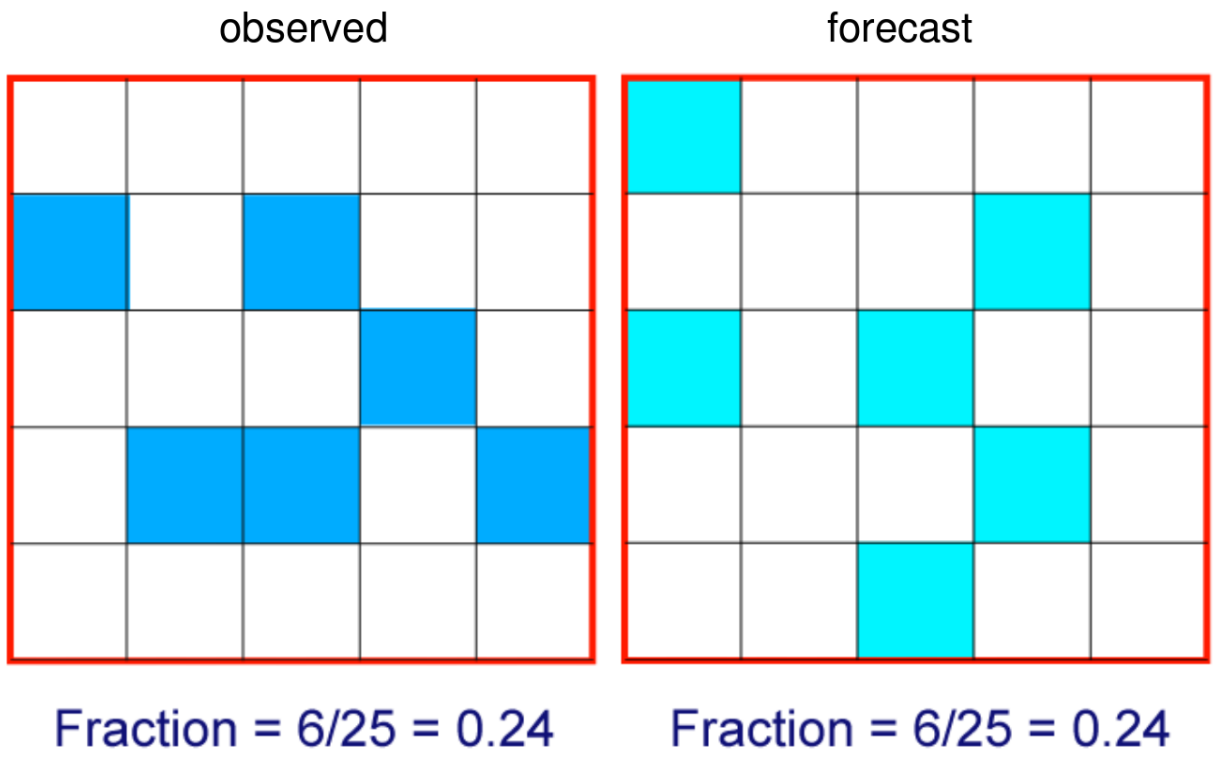


Surcel et al., 2015

How to determine neighborhood size?

2. Adaptive neighbourhood size

- Based on fractions skill score (FSS) between members



Nigel Roberts, Met Office

How to determine neighborhood size?

2. Adaptive neighbourhood size

- Based on fractions skill score (FSS) between members

Mean square error for the fractions – variation on the Brier score

$$\underset{\text{(Fractions Brier Score)}}{\text{FBS}} = \frac{1}{N}\sum_{j=1}^{N}(p_j - o_j)^2$$

$0 \leqslant p_j \leqslant 1$ forecast fractions

$0 \leqslant o_j \leqslant 1$ radar fractions

N number of points

Skill score for fractions/probabilities - Fractions Skill Score (FSS)

$$\text{FSS} = 1 - \frac{\text{FBS}}{\frac{1}{N}\left[\sum_{j=1}^{N}(p_j)^2 + \sum_{j=1}^{N}(o_j)^2\right]}$$

Nigel Roberts, Met Office

How to determine neighborhood size?

2. Adaptive neighbourhood size

- Based on fractions skill score (FSS) between members

For each lead time and threshold:

1. Compute FSS for each member against all other members
2. Compute $FSS_{uniform}$ for each member
3. Spatial scale at which FSS > $FSS_{uniform}$ is spatial scale for member pair
4. Mean of spatial scales for all member pairs is neighbourhood size (don't use maximum as gives too much weight to outliers).

Probabilistic forecasts
=
Better decisions, right?

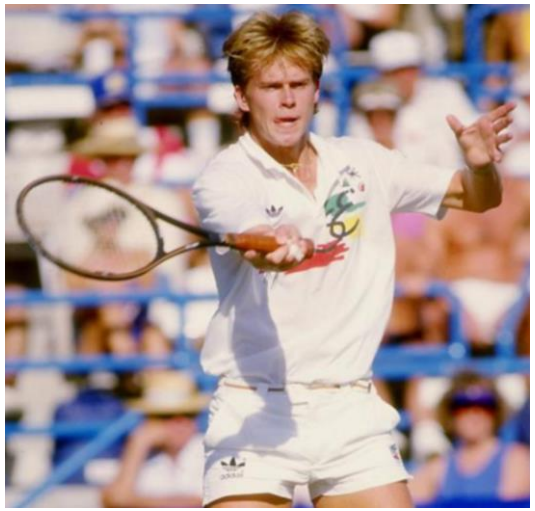
Maybe not!!!!

Björn

Björn

Borgköping

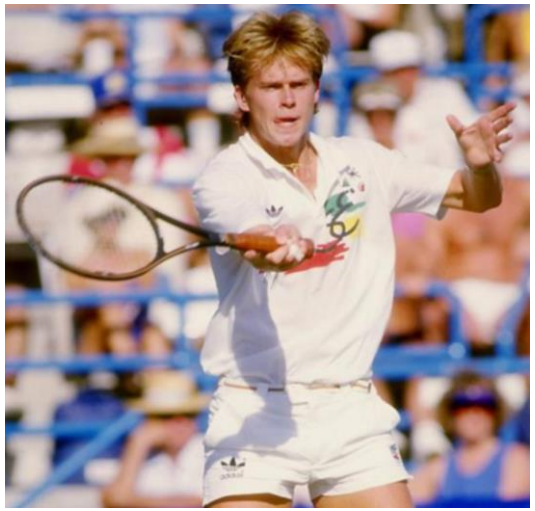
Stefan



Björn

Borgköping

Stefan

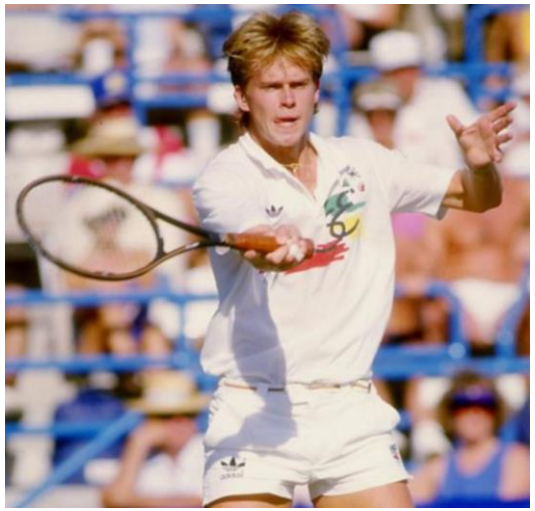


Edberg

Borgköping

Björn

Stefan



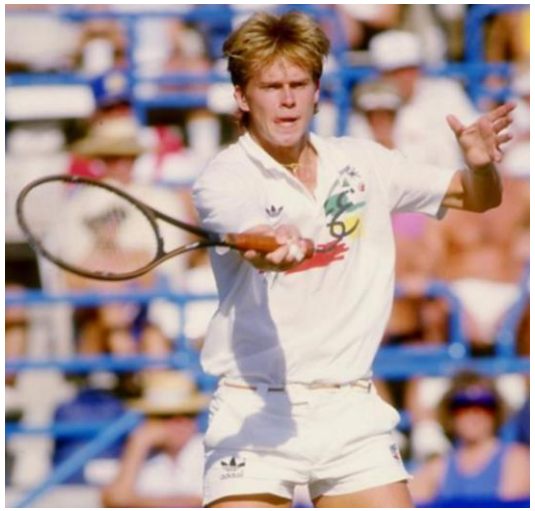
Snow

Edberg

Borgköping

Björn

Stefan



Snow

Edberg

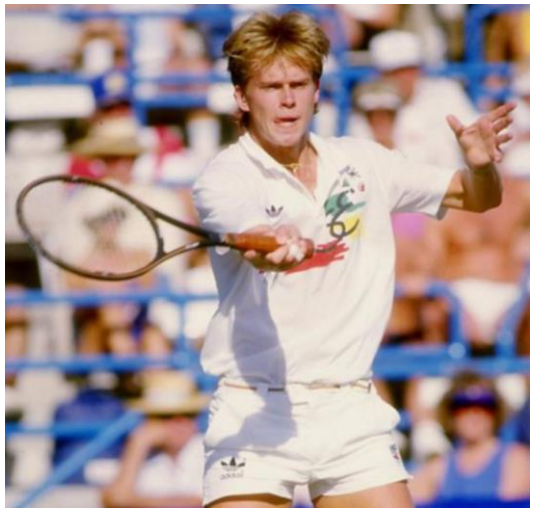
Mats

Wilandersholm

Borgköping

Björn

Stefan



Probability of snow

20%

40%

60%

80%

100%

Edberg

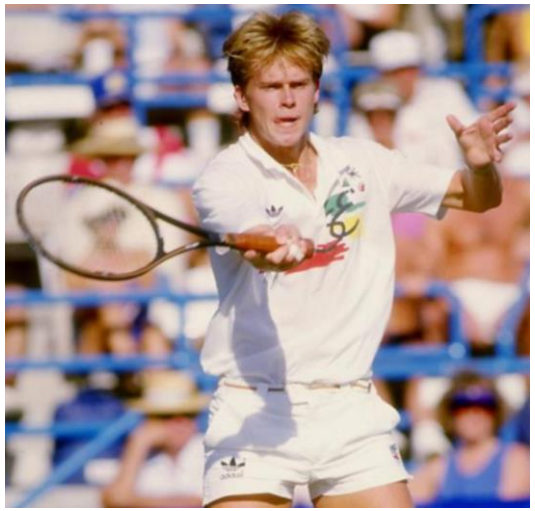
Mats

Wilandersholm

Borgköping

Björn

Stefan



Snow

Member 0

Edberg

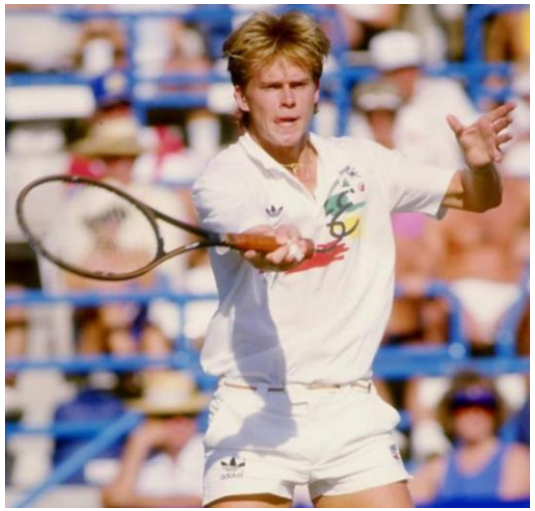
Björn

Mats

Borgköping

Wilandersholm

Stefan



Snow

Member 1

Edberg

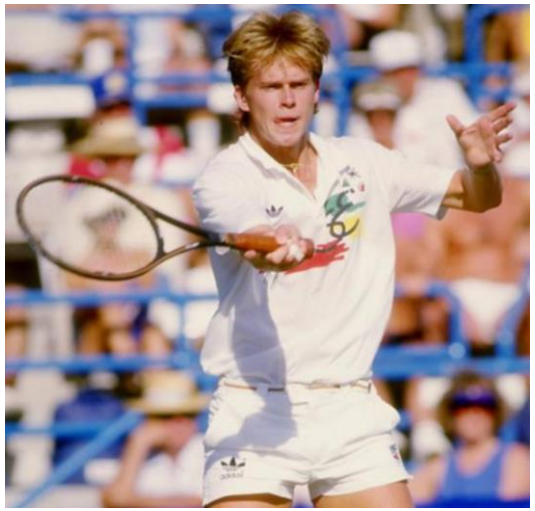
Mats

Wilandersholm

Borgköping

Björn

Stefan



Snow

Member 2

Edberg

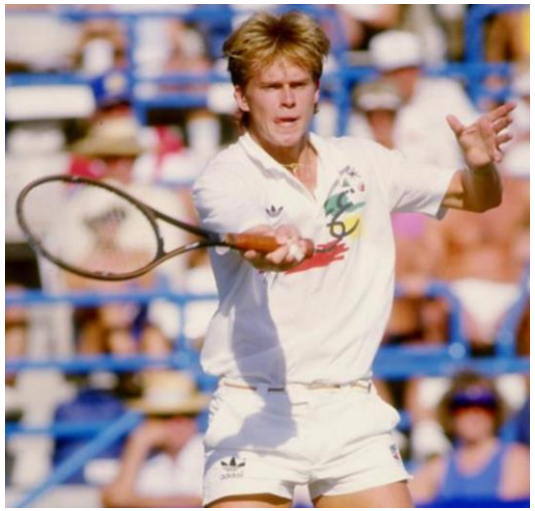
Mats

Wilandersholm

Borgköping

Björn

Stefan



Snow

Member 3

Edberg

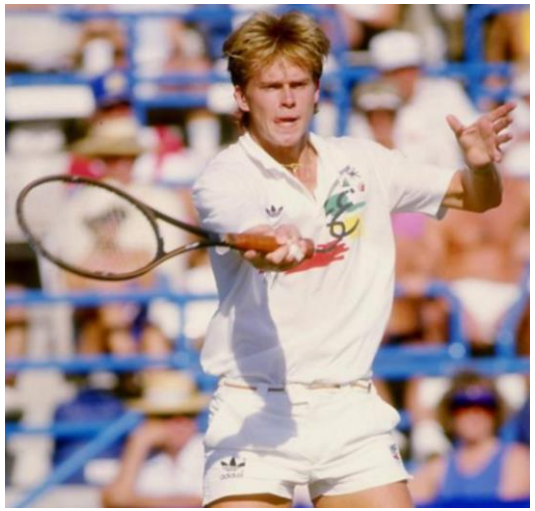
Mats

Wilandersholm

Borgköping

Björn

Stefan



Snow

Member 4

Edberg

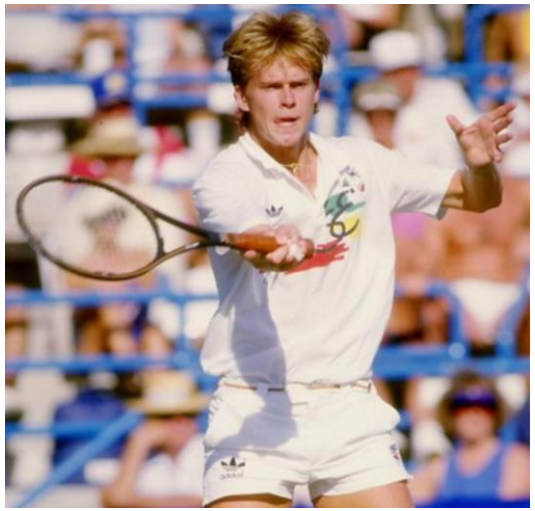
Mats

Wilandersholm

Borgköping

Björn

Stefan



Probability of snow

20%

40%

60%

80%

100%

Edberg

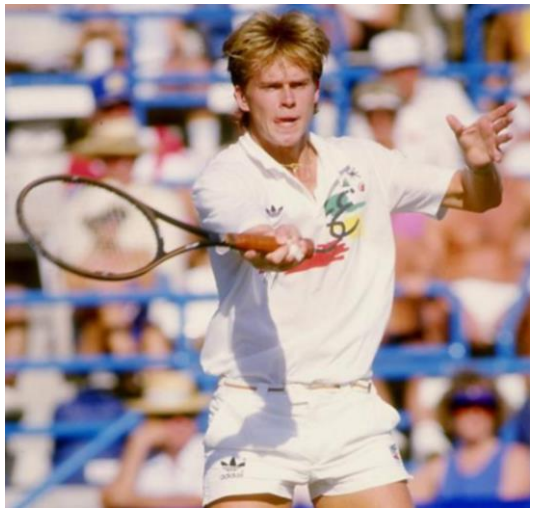
Mats

Wilandersholm

Borgköping

Björn

Stefan



Probability of snow

20%

40%

60%

80%

100%

Edberg

Björn

Mats

Borgköping

Wilandersholm

Petter

Petter

15:00

Petter

10:00

15:00

Fog

Petter

10:00

Deterministic : 12:00 – 13:00

15:00

Probability of fog

20%

40%

60%

80%

100%

Petter

10:00

10:00 – 11:00

15:00

Probability of fog

20%

40%

60%

80%

100%

Petter

10:00

11:00 – 12:00

15:00

Probability of fog

20%

40%

60%

80%

100%

Petter

10:00

12:00 – 13:00

15:00

Probability of fog

20%

40%

60%

80%

100%

Petter

10:00

13:00 – 14:00

15:00

Probability of fog

20%

40%

60%

80%

100%

Petter

10:00

14:00 – 15:00

15:00

Fog

Petter

10:00

Member 0 : 12:00 – 13:00

15:00

Fog

Petter

10:00

Member 1 : 14:00 – 15:00

15:00

Fog

Petter

10:00

Member 2 : 10:00 – 11:00

15:00

Fog

Petter

10:00

Member 3 : 13:00 – 14:00

15:00

Fog

Petter

10:00

Member 4 : 11:00 – 12:00

15:00

Probability of fog

20%

40%

60%

80%

100%

Petter

10:00

At any time 10:00 – 15:00

Probabilistic forecasts

=

Better decisions, right?

Only if the probability directly refers to the decision