Why Verify Spatial Scales?

Neighborhood and Scale-separation Approaches

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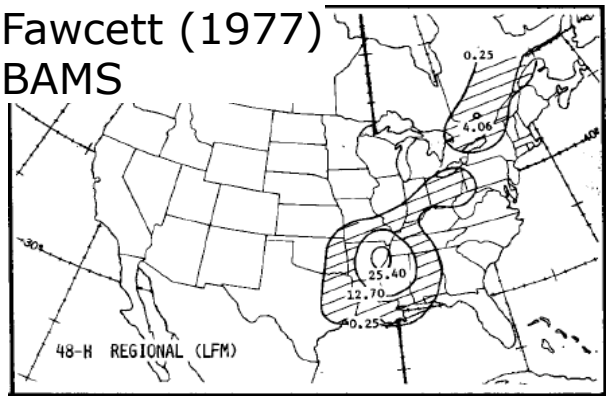
slides adapted from Gilleland and others

Challenge of Higher Resolution Models

- Resolving smaller features

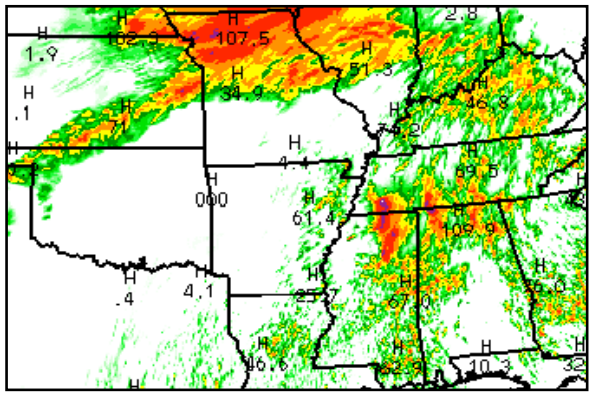
THEN

Fawcett (1977)
BAMS



190-km LFM

NOW

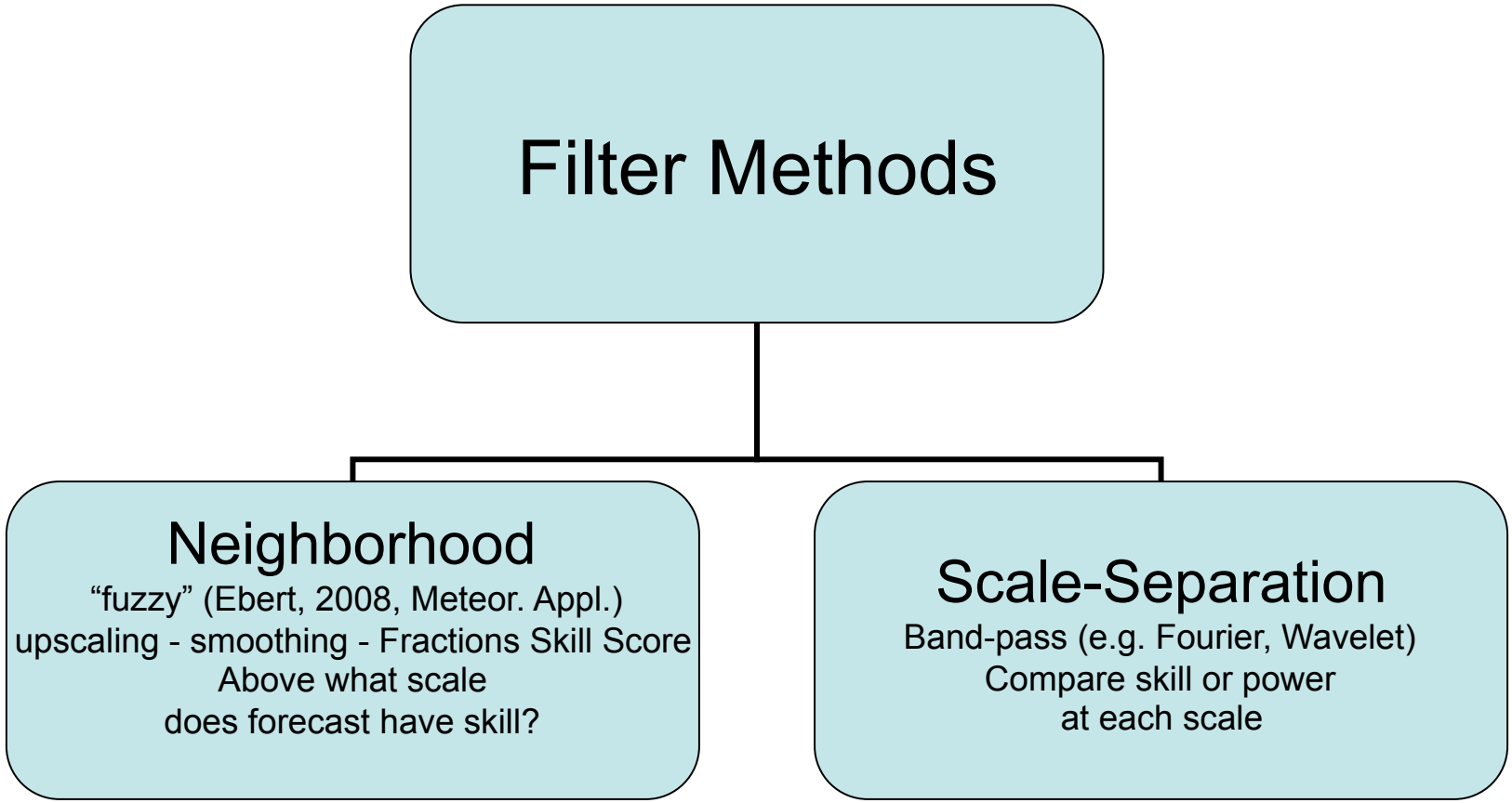


3-km WRF, 2009

•For traditional verification,

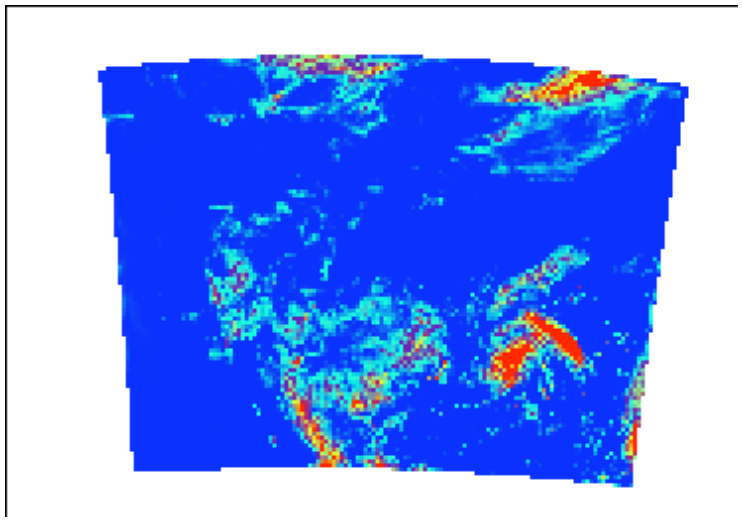
a *1* grid-point error is same as a *10* grid-point error.

Giving Credit for a Close Forecast

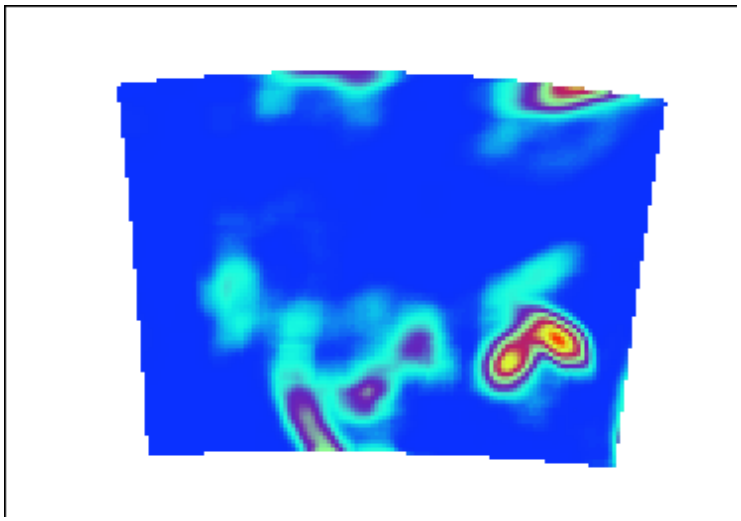


Neighborhood Methods Smoothing

- Minimum, Maximum, Median, Mean



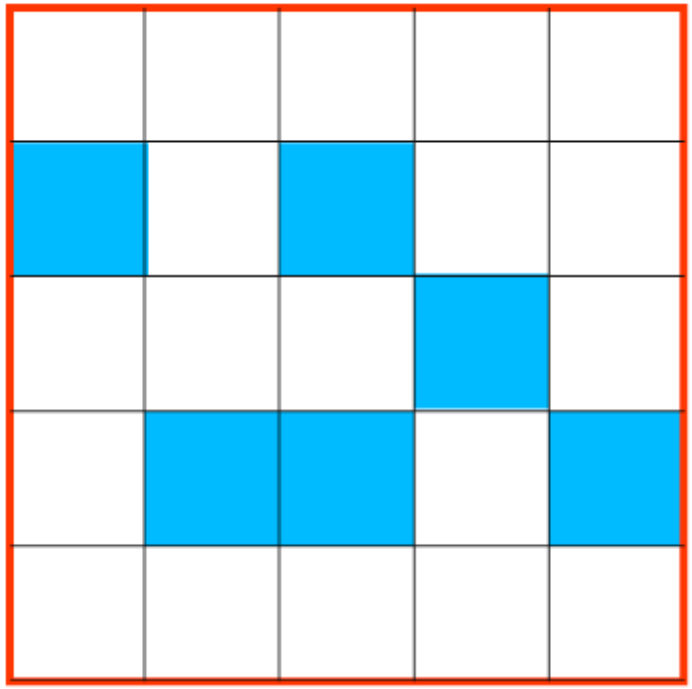
original



mean

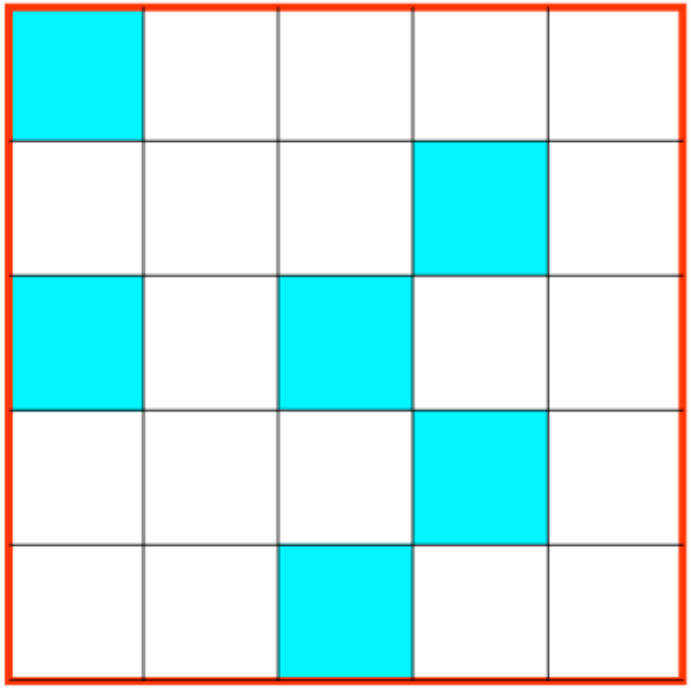
Neighborhood Methods
Fractional Coverage

observed



Fraction = 6/25 = 0.24

forecast



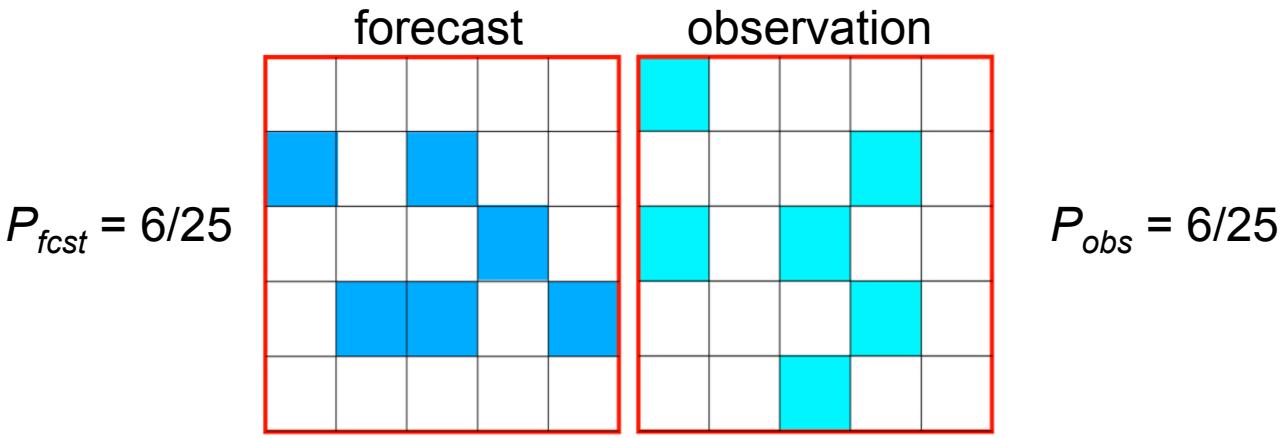
Fraction = 6/25 = 0.24

Intensity threshold exceeded where squares are blue

slide from Mittermaier

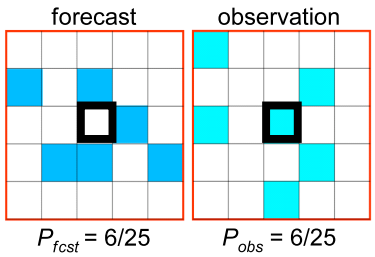
Neighborhood Methods

Defining fractional coverage scores



P is the fractional event frequency within the neighborhood

Neighborhood Methods



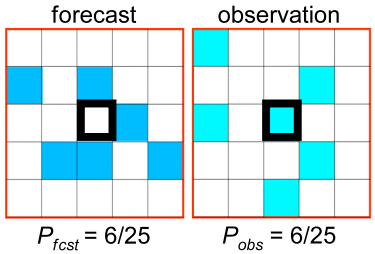
n = number of points in the whole domain

$$\frac{1}{n}\sum_{i=1}^{n}\left(P_{f\,cst}-P_{obs}\right)^2$$

Fractions Brier Score

Roberts and Lean (2008)

Neighborhood Methods



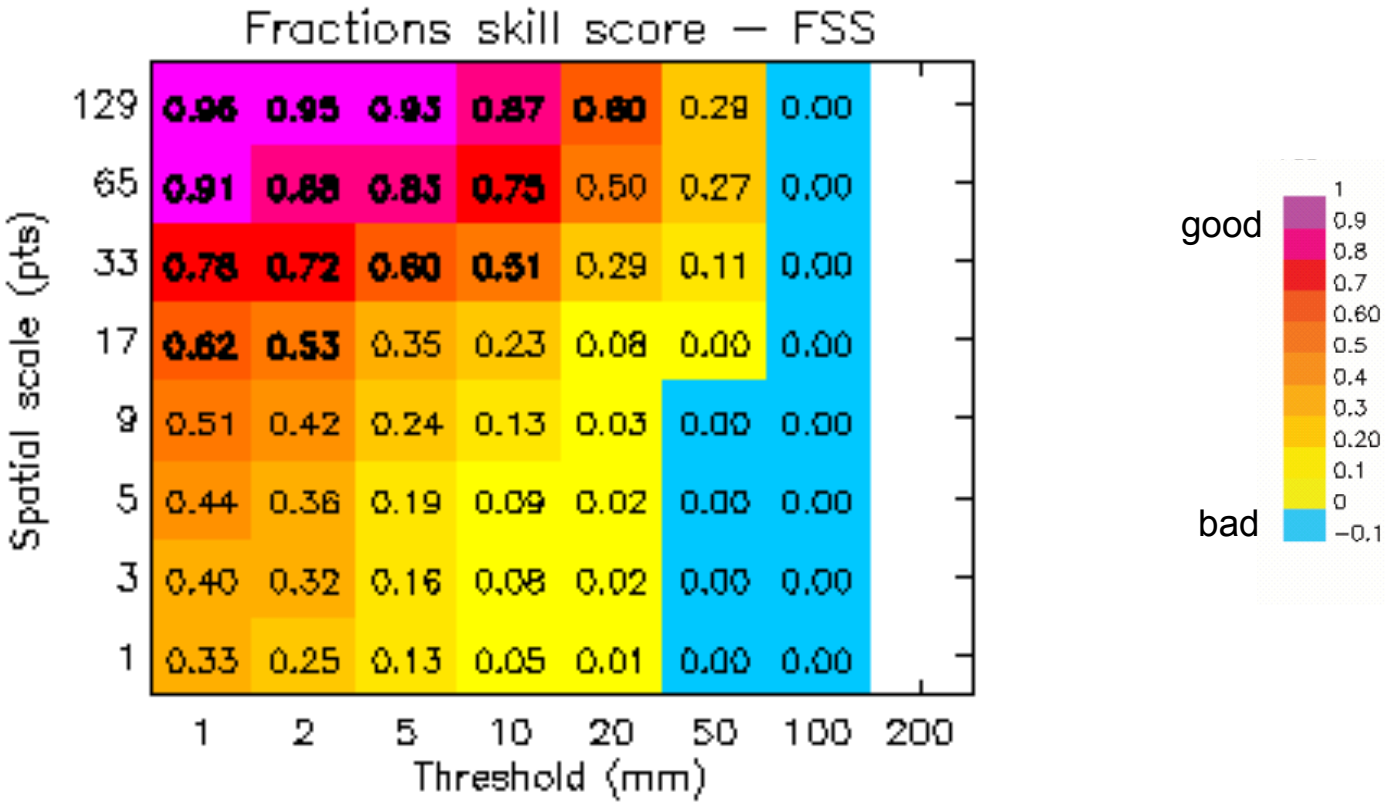
$$1 - \frac{\frac{1}{n}\sum_{i=1}^{n}\left(P_{f\,cst} - P_{obs}\right)^2}{\frac{1}{n}\sum_{i=1}^{n}\left(P_{f\,cst}\right)^2 + \frac{1}{n}\sum_{i=1}^{n}\left(P_{obs}\right)^2}$$

Fractions Skill Score

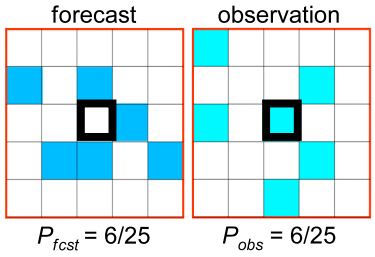
Roberts and Lean (2008)

Neighborhood Methods

Table courtesy of E Ebert.



Neighborhood Methods



$$FSS_{usef\ ul} = 0.5 + \frac{\overline{P_{obs}}}{2}$$

Fractions Skill Score must exceed this to be better than random forecast

$\overline{P_{obs}}$ is the observed frequency of the event over the full domain

Neighborhood Methods

- In MET, Neighborhood methods are in grid_stat tool.
- Smoothing filters in MET:
  - Minimum
  - Maximum
  - Median
  - Mean
- Fractional coverage
  - Fractions Brier Score
  - Fractions Skill Score
- See Ebert (2008) for a good summary and comparison of these techniques (and references).

Neighborhood Methods

Slide from E Ebert. See Ebert (2008) for full references.

Fuzzy method	Matching strategy*	Decision model for useful forecast
Upscaling (Zepeda-Arce et al. 2000; Weygandt et al. 2004)	NO-NF	**Resembles obs when averaged to coarser scales**
Minimum coverage (Damrath 2004)	NO-NF	**Predicts event over minimum fraction of region**
Fuzzy logic (Damrath 2004), joint probability (Ebert 2002)	NO-NF	**More correct than incorrect**
Fractions skill score (Roberts and Lean 2007)	NO-NF	**Similar frequency of forecast and observed events**
Area-related RMSE (Rezacova et al. 2006)	NO-NF	**Similar intensity distribution as observed**
Practically perfect hindcast (Brooks et al. 1998)	NO-NF	**Resembles a forecast based on perfect knowledge of observations**
Pragmatic (Theis et al. 2005)	SO-NF	**Can distinguish events and non-events**
CSRR (Germann and Zawadzki 2004)	SO-NF	**High probability of matching observed value**
Multi-event contingency table (Atger 2001)	SO-NF	**Predicts at least one event close to observed event**

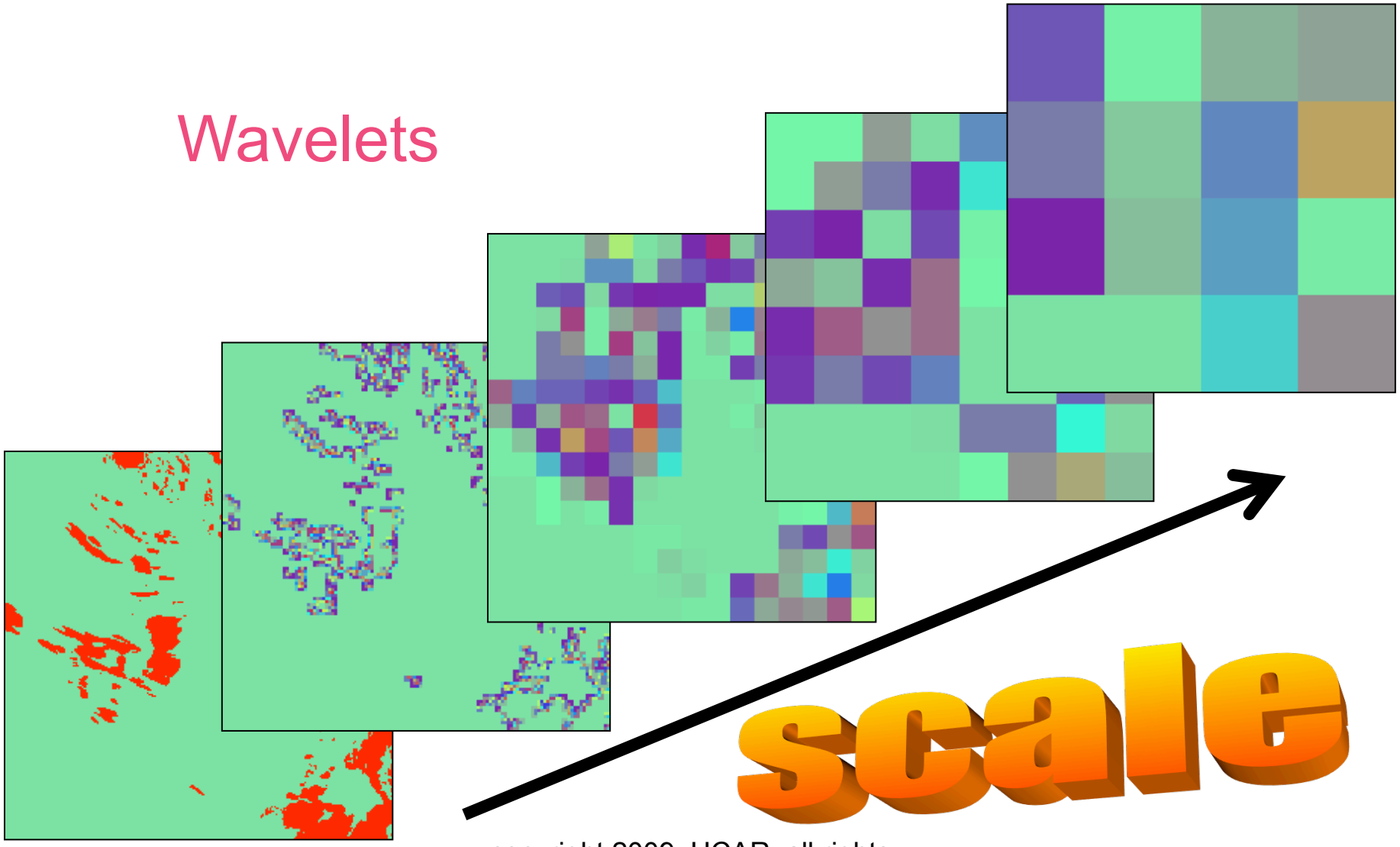
*NO-NF = neighborhood observation-neighborhood forecast,
SO-NF = single observation-neighborhood forecast

Scale-Separation Methods

- Fourier
  - Skamarock (2004), MWR **132**:3019-3032
  - Harris *et al*. (2001), J Hydrometeorol. **2**:406-418
  - Tustison *et al*. (2001), JGR **106**(D11): 11775-11784
  - *and many more*…
- Wavelet
  - Briggs and Levine (1997), MWR **125**:1329-1341
  - Casati *et al*. (2004). [In MET wavelet_stat tool]

Scale-Separation Methods

Wavelets

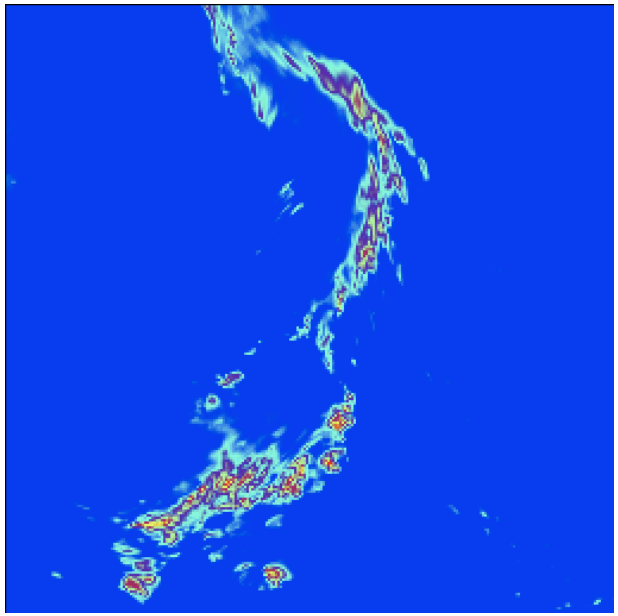


Scale Separation Methods

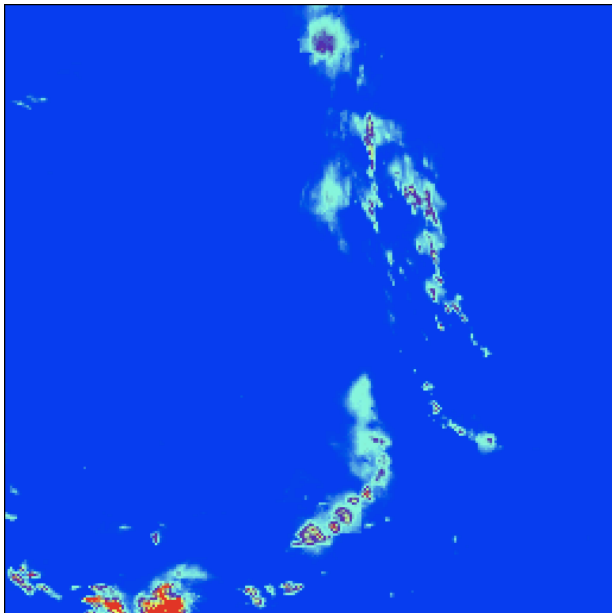
Intensity Scale (IS) (Casati *et al*., 2004)

1. Create binary fields for a threshold

forecast



observation



Scale Separation Methods

Intensity Scale (IS) (Casati *et al*., 2004)

1. Create binary fields for a threshold

forecast

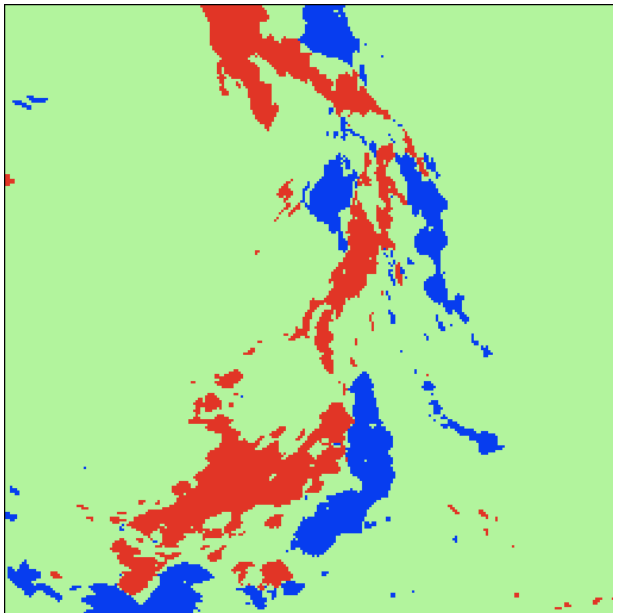
observation

Scale Separation Methods

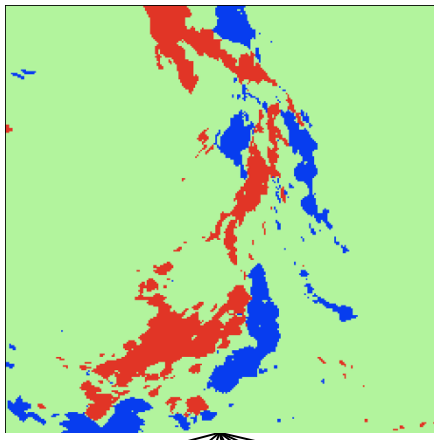
Intensity Scale (IS) (Casati *et al*., 2004)

Subtract binary fields for a threshold

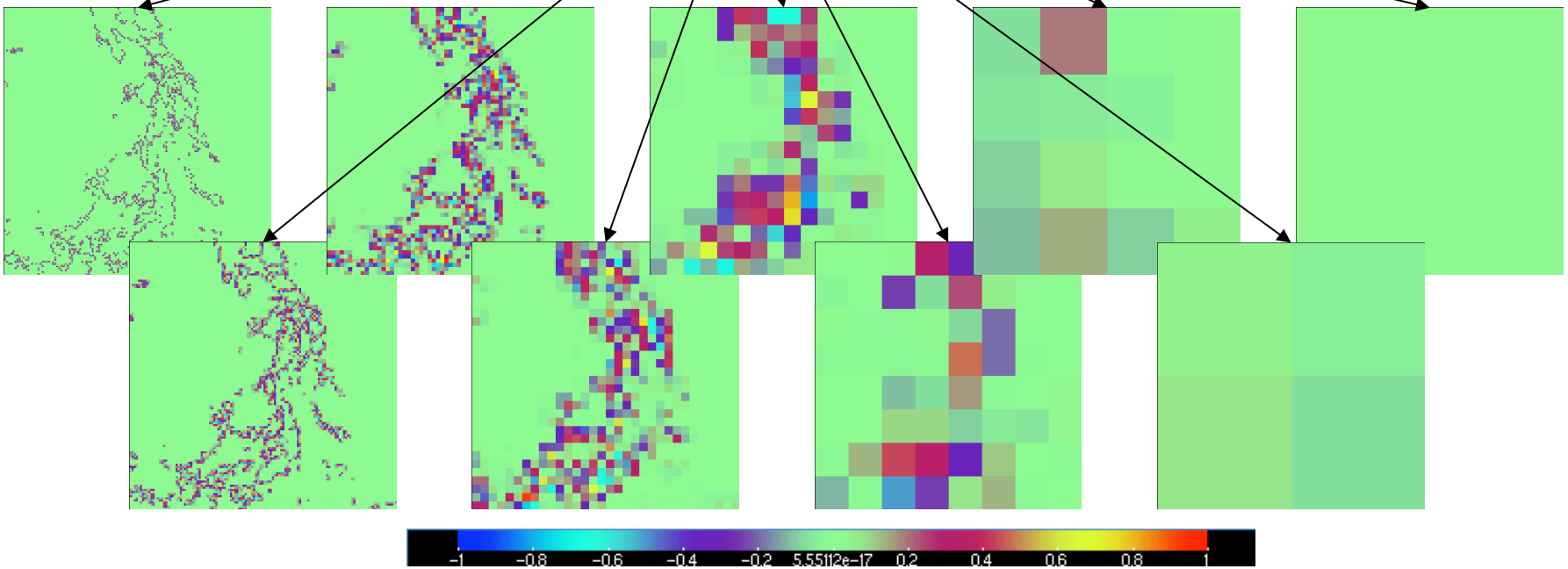
binary difference



binary difference



Decompose with Wavelet

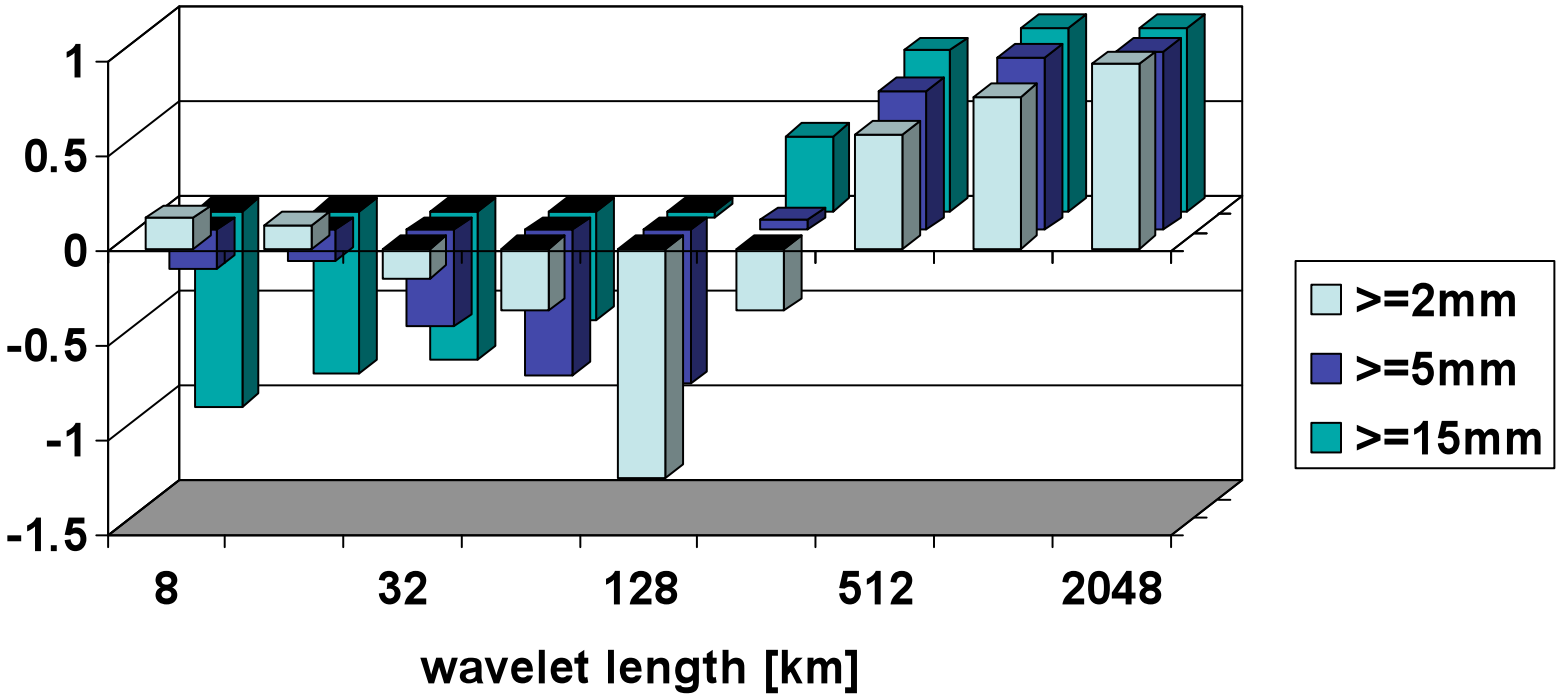


Scale Separation Methods

Intensity Scale (IS) (Casati *et al*., 2004)

1. Create binary fields for a threshold
2. Apply wavelet decomposition to binary difference
3. Calculate mean squared error MSE for each scale j
4. Find MSE for a random forecast based on the sample climatology
5. Intensity-scale Skill Score $$IS\ skill\ score_j = 1 - \frac{MSE_j}{\frac{MSE_{random}}{n+1}}$$
6. Repeat for multiple thresholds

Intensity-Scale Skill Score



Thank you…Questions?

References

Casati B, G Ross, and DB Stephenson, 2004. A new intensity-scale approach for the verification of spatial precipitation forecasts. *Meteorol. Appl*. **11**:141--154.

Ebert EE, 2008. Fuzzy verification of high resolution gridded forecasts: A review and proposed framework. *Meteorol. Appl*., **15**:51--64. DOI: 10.1002/met.25.

See also, http://www.ral.ucar.edu/projects/icp