Radius of reliability: A distance metric for interpreting and verifying spatial probability forecasts

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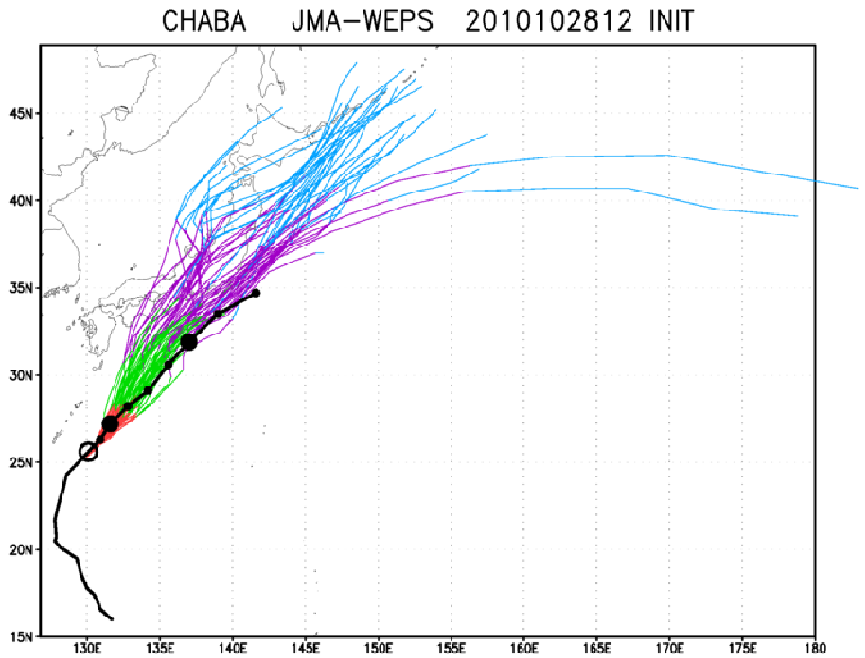
Introduction

- Wish to warn for high impact events well in advance
- Location and timing often highly uncertain
- Examples:
  - Tropical cyclones
  - Deep low pressure systems
  - Severe thunderstorms
- Ensemble approach



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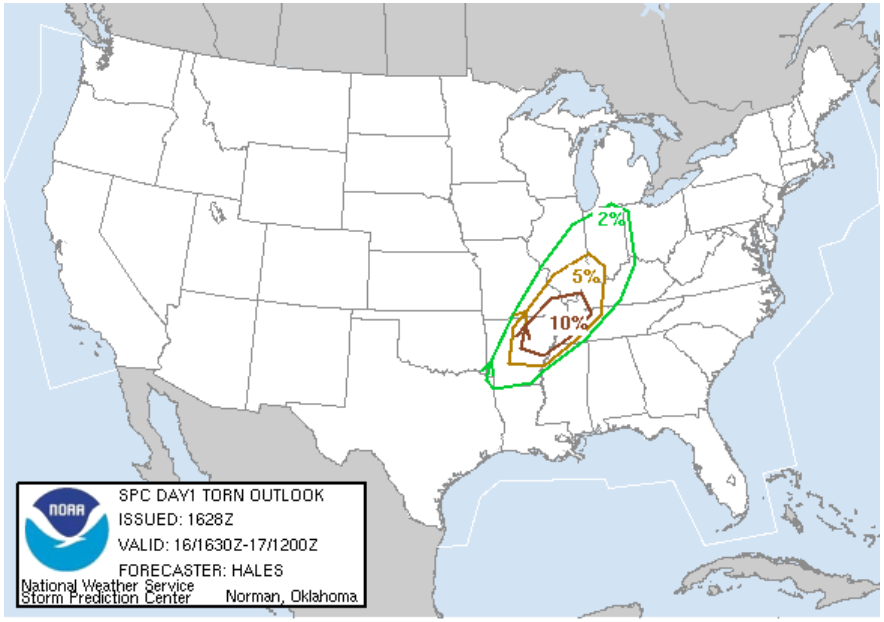
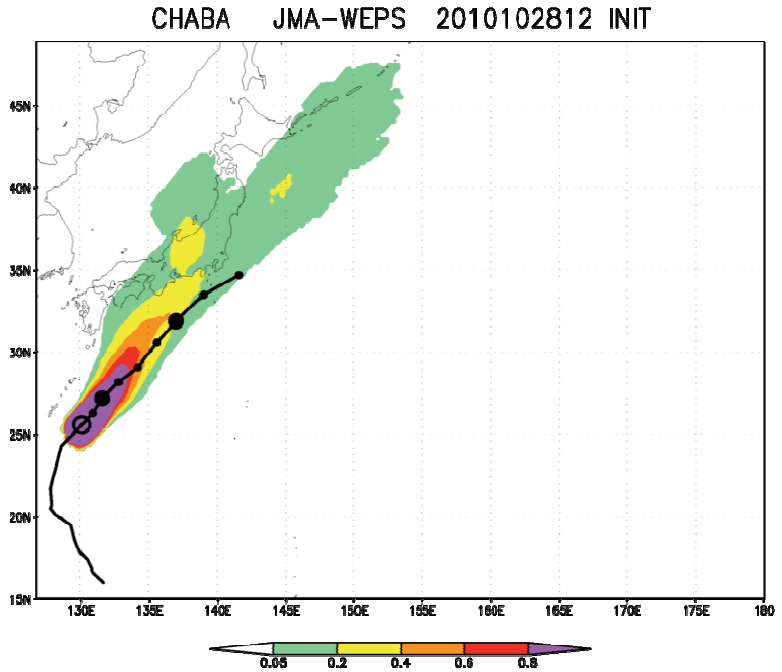
Spatial forecasts of high impact events

High resolution grid-scale probabilities often quite low

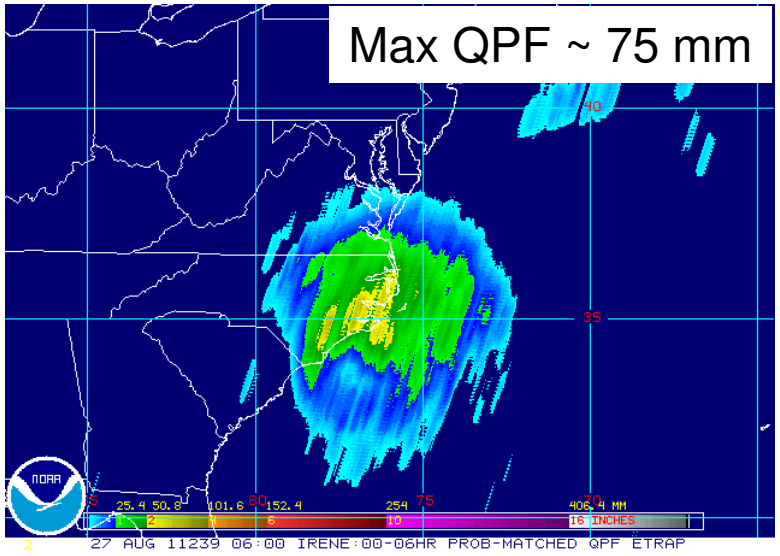
→ Predict probability of event occurring within radius *R*

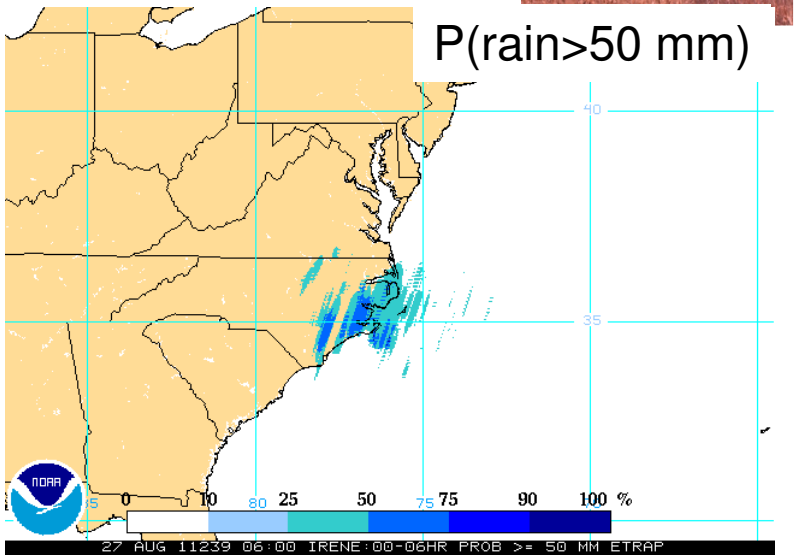


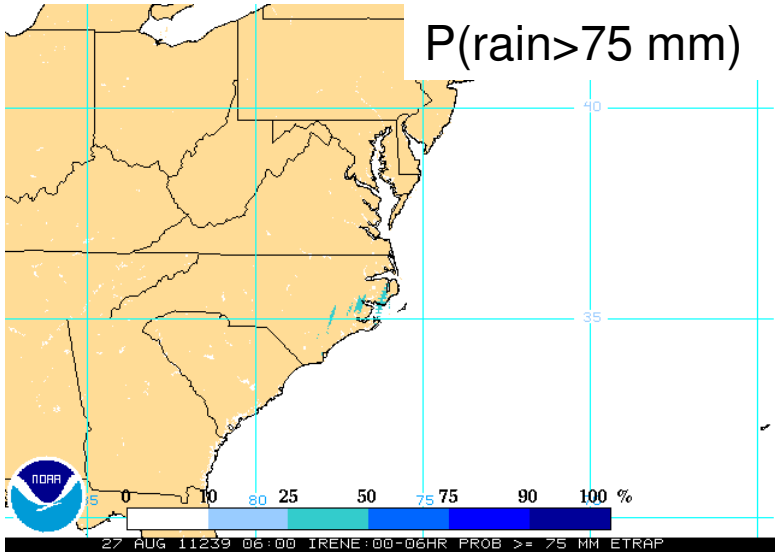


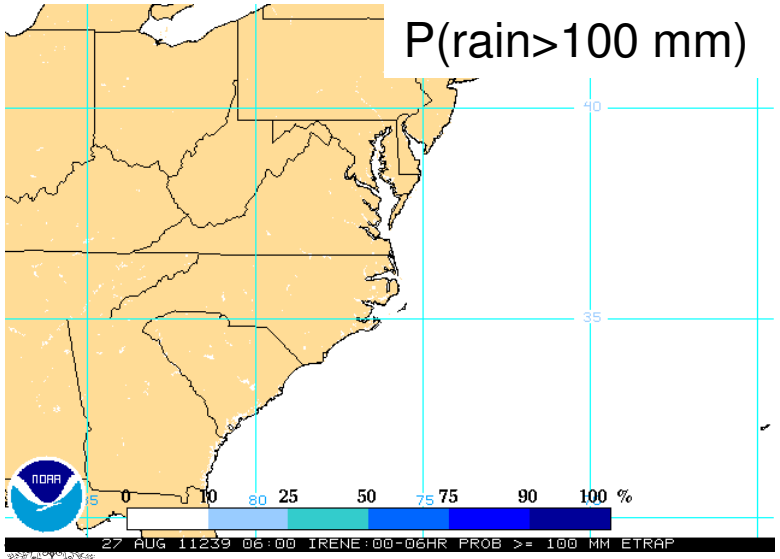
- Higher probabilities can more effectively prompt action
- What should *R* be?

Ensemble Tropical Rainfall Potential (eTRaP) forecast for 6h rain accumulation









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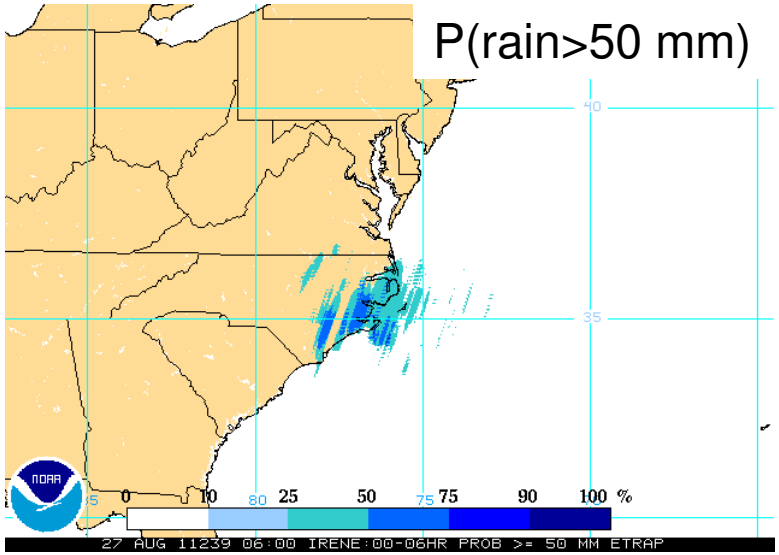
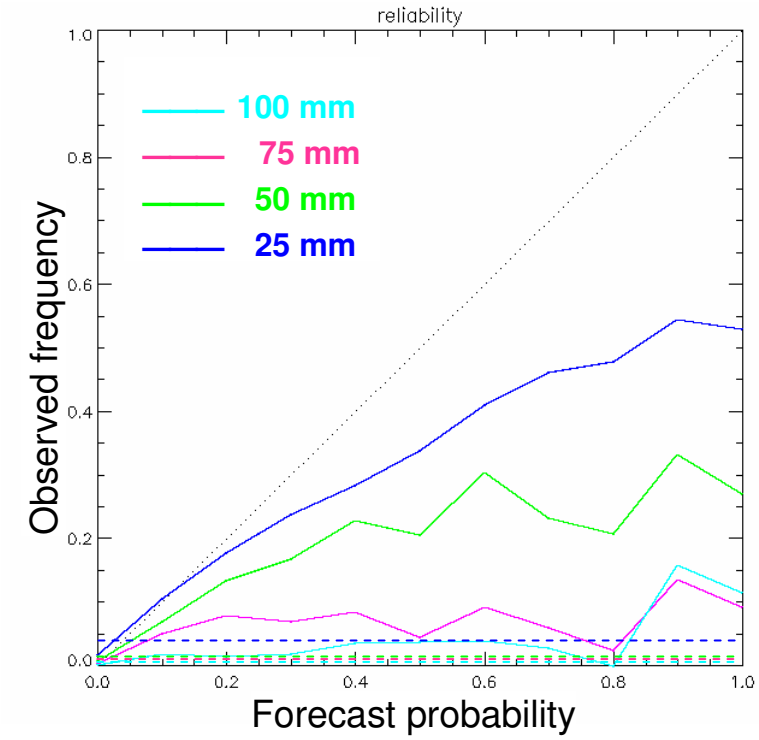
Interpretation of (uncalibrated) forecast

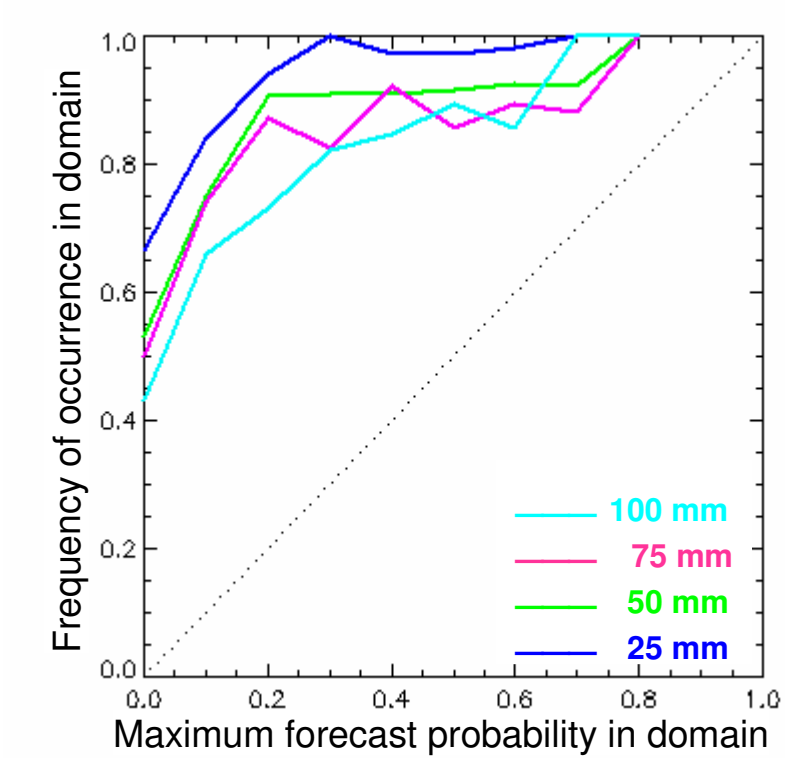


1. Probability of exceeding 50 mm in 6 hours in the individual grid box
2. Probability of storm 6 hour rainfall exceeding 50 mm

Verification of eTRaP 6h PQPFs
16 Atlantic hurricanes 2004-2008



Grid scale reliability



Storm scale reliability

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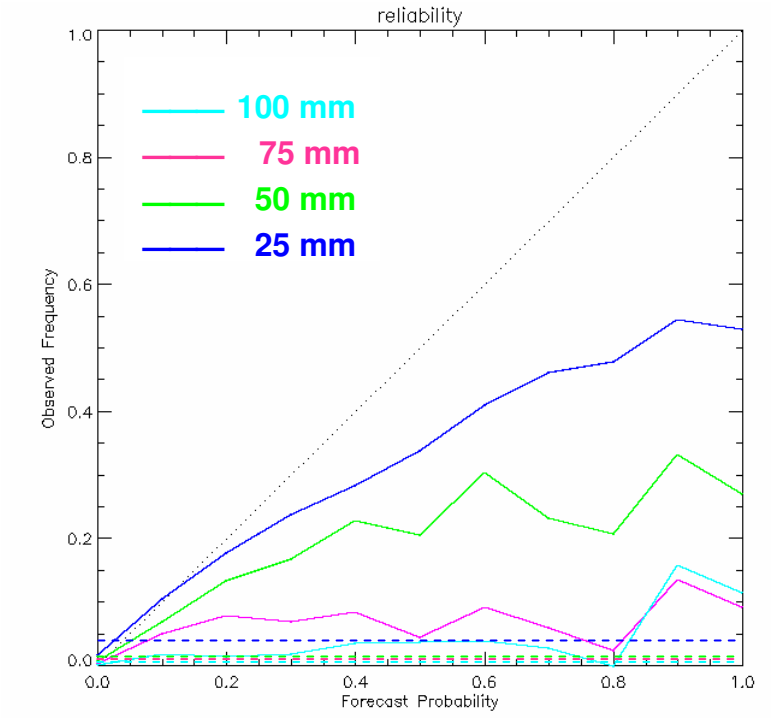
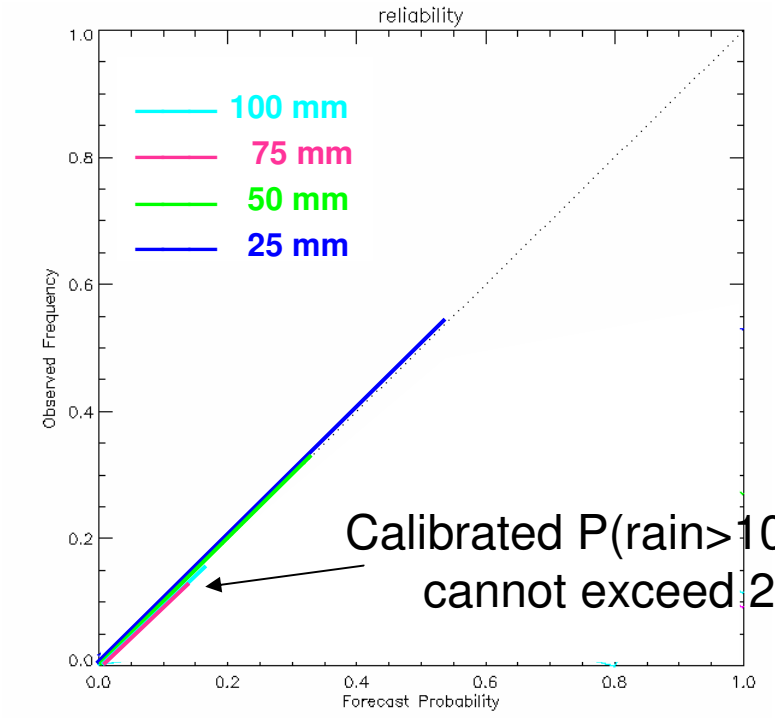
Probability calibration by "reassignment"





Grid scale (uncalibrated)

Grid scale (calibrated)

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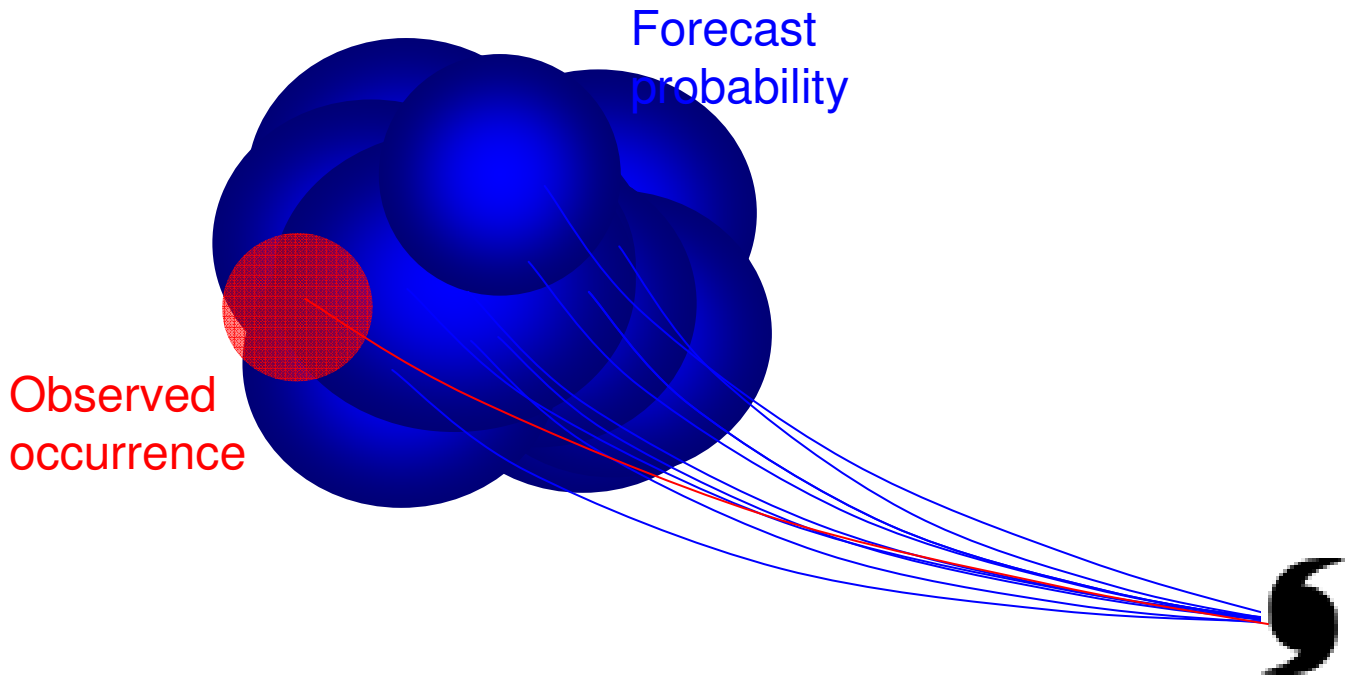
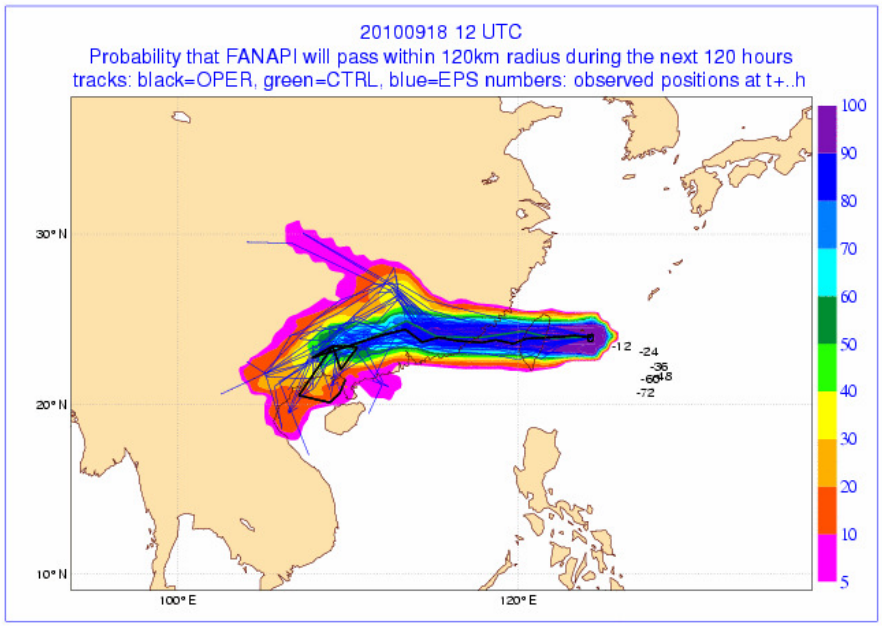
Part of the problem…

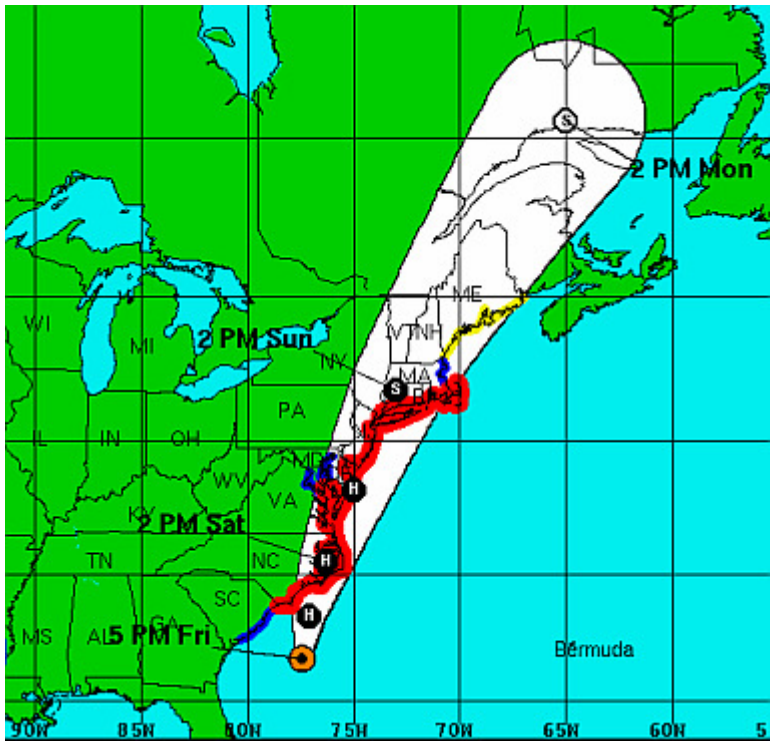


Location errors exacerbate under-dispersive behavior of ensemble forecasts

Ideas from track prediction…

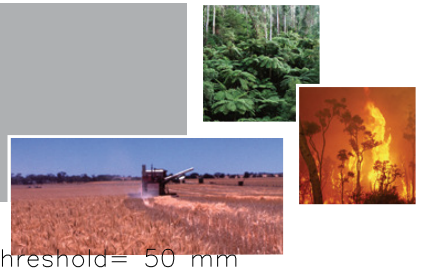


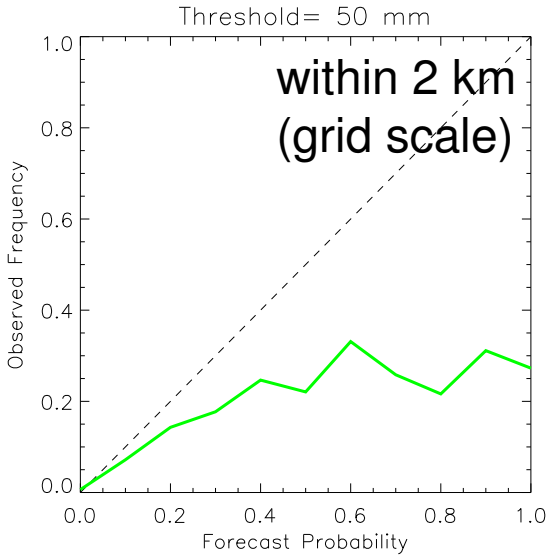
Strike probability

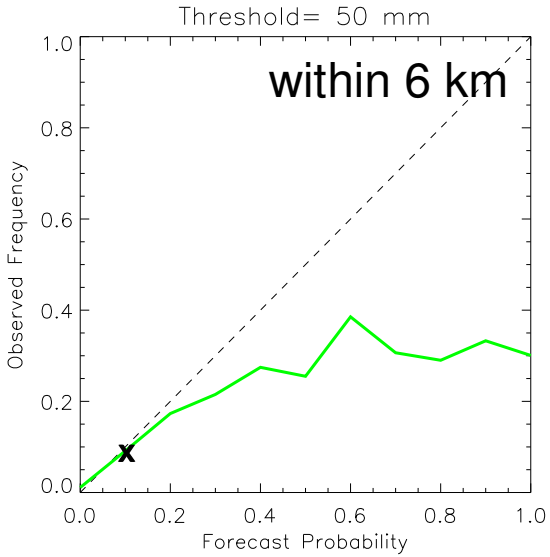


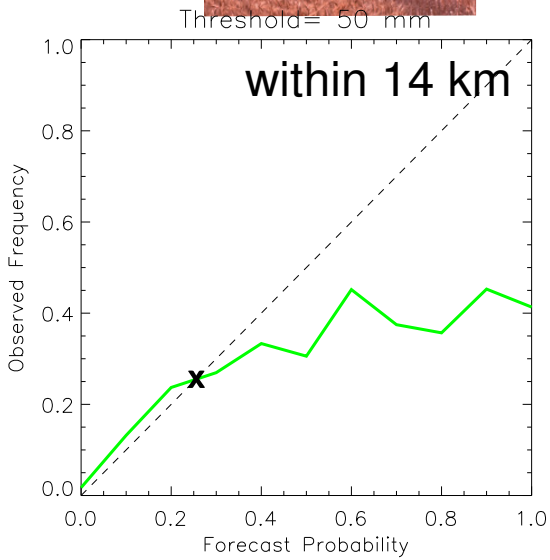
Cone of uncertainty

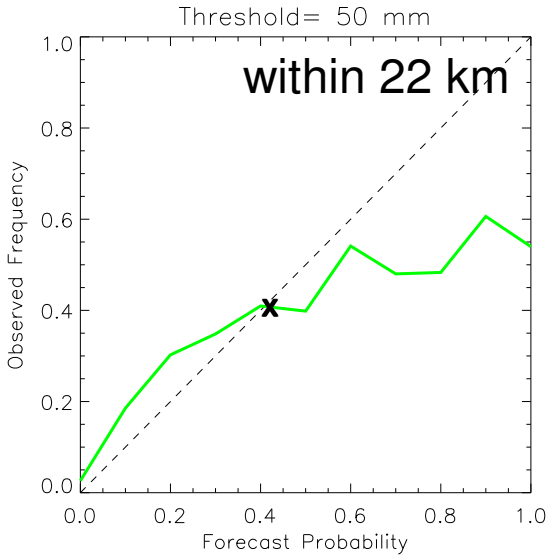
Verify forecast for observation within radius *R*

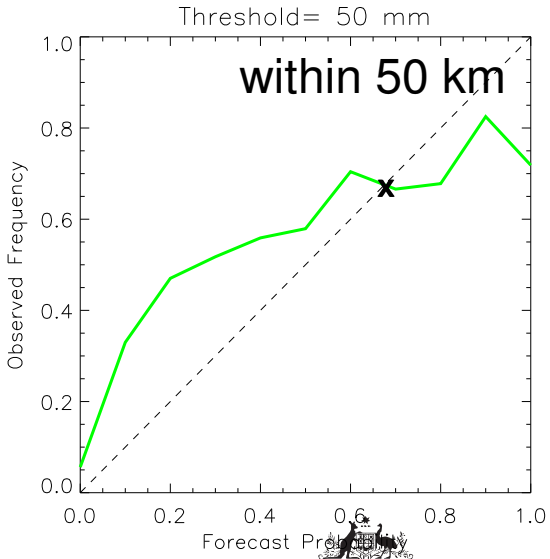






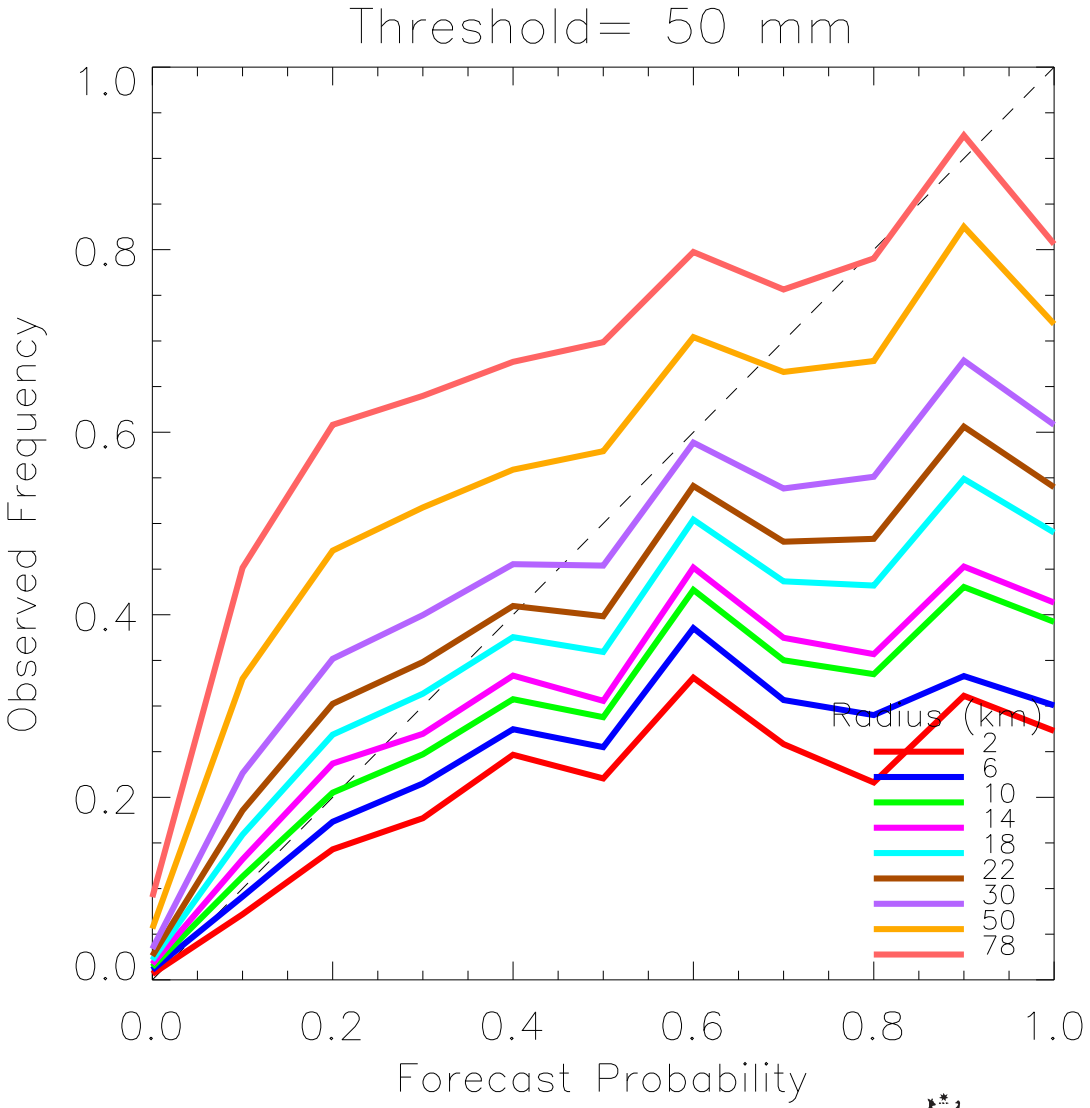






etc.

Radius of reliability – which curve crosses the diagonal



Forecast probability *P*	Radius of reliability ROR (km)
0.1	6
0.2	9
0.3	17
0.4	21
0.5	37
0.6	32
0.7	61
0.8	78
0.9	72

Verification of eTRaP 6h PQPFs for Atlantic hurricanes 2004-2008

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Radius of Reliability (ROR)

Rain threshold	Forecast probability for 6 h accumulation				
	0.1	0.3	0.5	0.7	0.9
25 mm	2 km	6 km	17 km	31 km	66 km
50 mm	7 km	17 km	37 km	61 km	71 km
75 mm	16 km	37 km	75 km		
100 mm	47 km	63 km			

Possible uses of Radius of Reliability

- Interpreting forecasts
  - Converts a probabilistic forecast that is over-confident at point scale into a reliable one within a spatial area defined by ROR
  - ROR undefined for under-confident forecasts
- Forecast quality metric
  - Reflects forecast uncertainty due to combined errors in location, intensity, spatial structure
  - Spatial precision of probability forecasts
  - Lower ROR → better quality, more reliable forecasts
- Calibration
  - Suggests appropriate spatial scale for issuing probabilistic forecasts

Additional thoughts

- Similar to neighborhood verification
  - Point forecasts matched to neighborhood of observations
  - Requires spatially dense observations
- ROR increases for increasing probability increases for rarer events
- What do users want?
  - Survey of eTRaP users (Mike Turk, NESDIS SAB)
    - 13/25 want point-based probability forecasts
    - 12/25 want area-based probability forecasts
  - NESDIS plans to issue eTRaP PQPFs both at point scale and at 40 km scale

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Thank you

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