Producing Reforecast-Calibrated Extended-Range Probabilistic Tornado Forecasts

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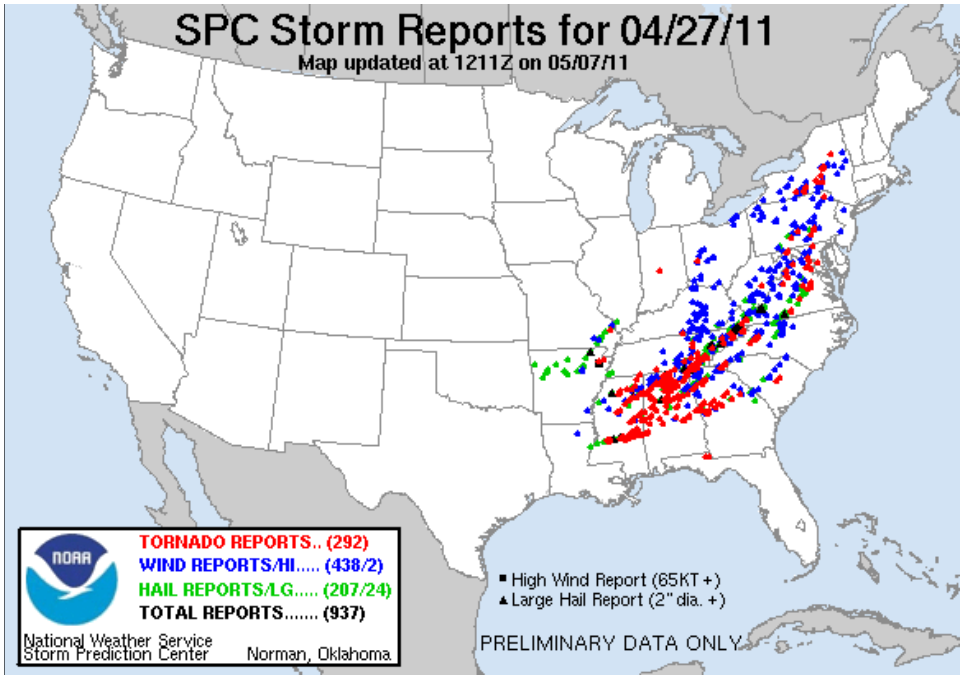
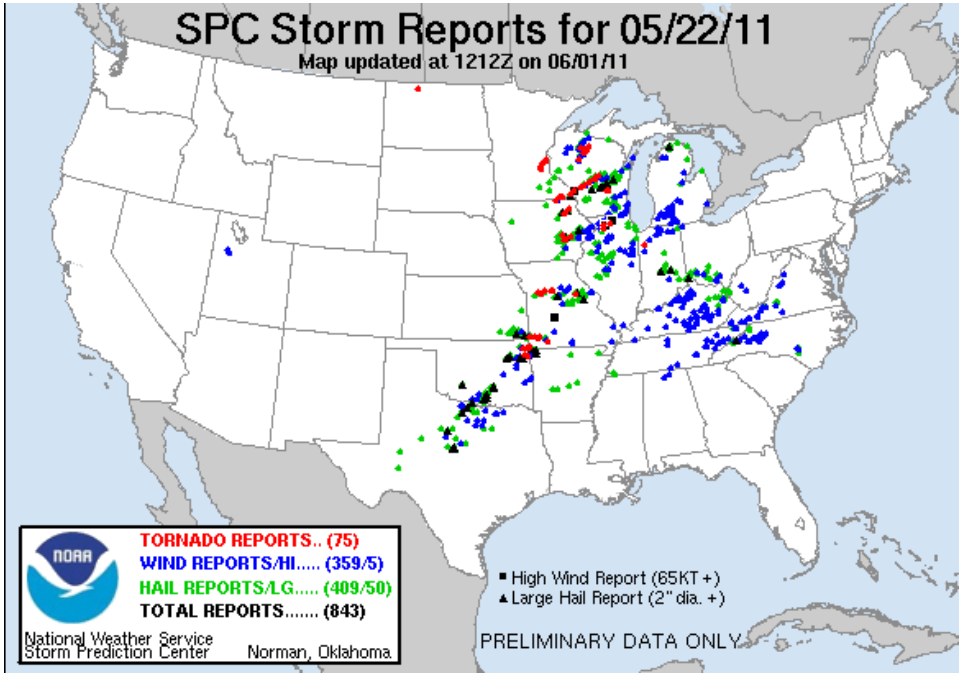
Why do we care about long-lead severe weather forecasting?

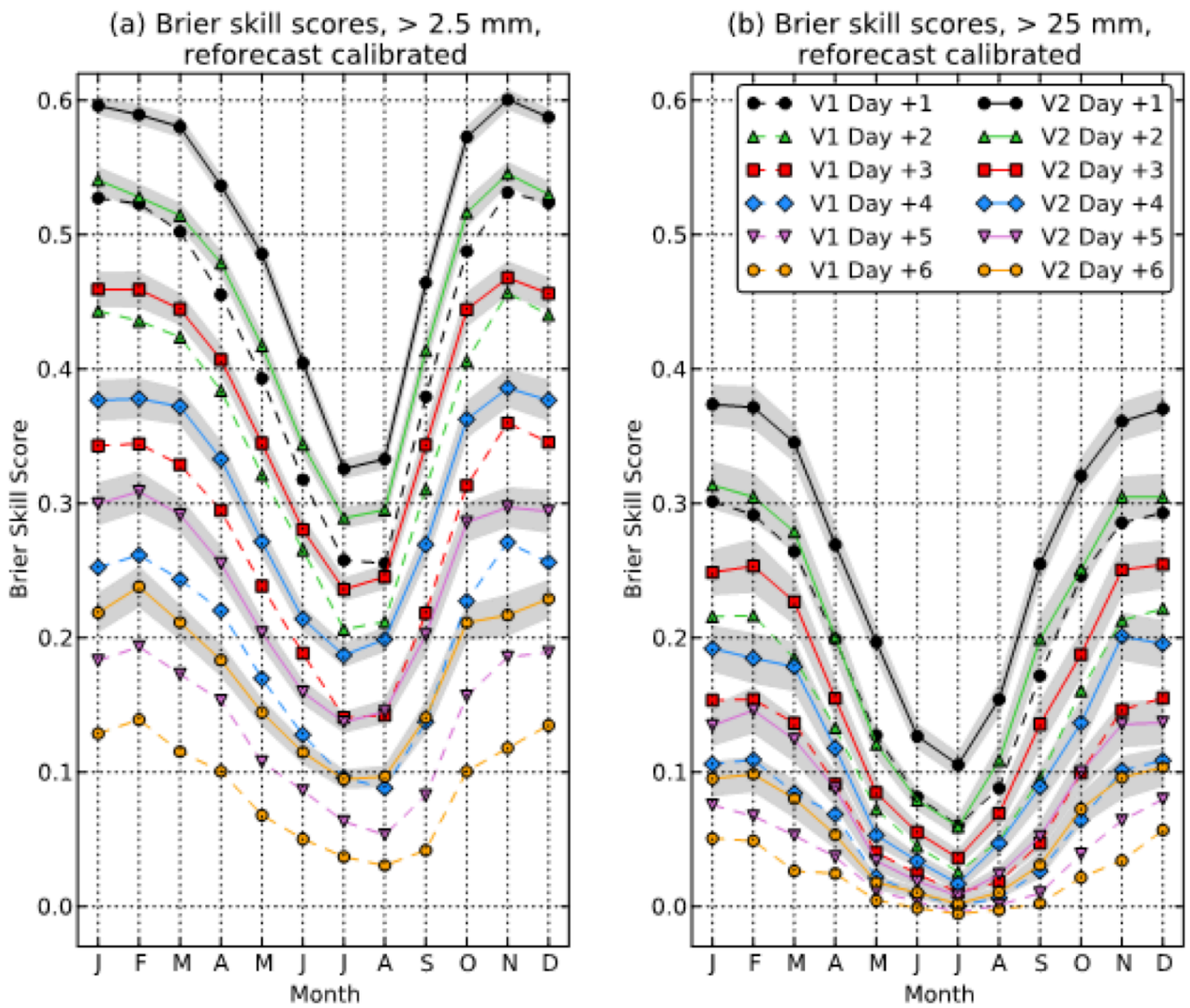




Reforecasts (hindcasts)

- Numerical simulations using the same forecast model (assimilation method, parameterization schemes, etc.), initialized with reanalysis and perturbed initial conditions.
  - Reforecasts ≠ Reanalysis!
- Previously, have demonstrated that skillful and reliable rare-event precipitation forecasts were possible, post-processed using reforecasts as training data.

Prior success with reforecasts & rare event forecasting



- Statistical post-processed forecasts benefitted from a larger sample size, especially rare/extreme precipitation forecasts.
- Big question: can a similar methodology allow for reliable, skillful forecasts of tornadic potential?

Data

- 2nd-generation GEFS reforecast dataset (1985-2011, ~0.5° grid resolution). See Hamill et al., BAMS, Oct 2013
- SPC tornado reports dataset used as verification (F1+ only, Verbout 2006.)
  - A grid point classified as tornadic (1) or nontornadic (0) based on whether a tornado was reported within a specific radius (ROI) from this grid point.

Analog post-processing methodology

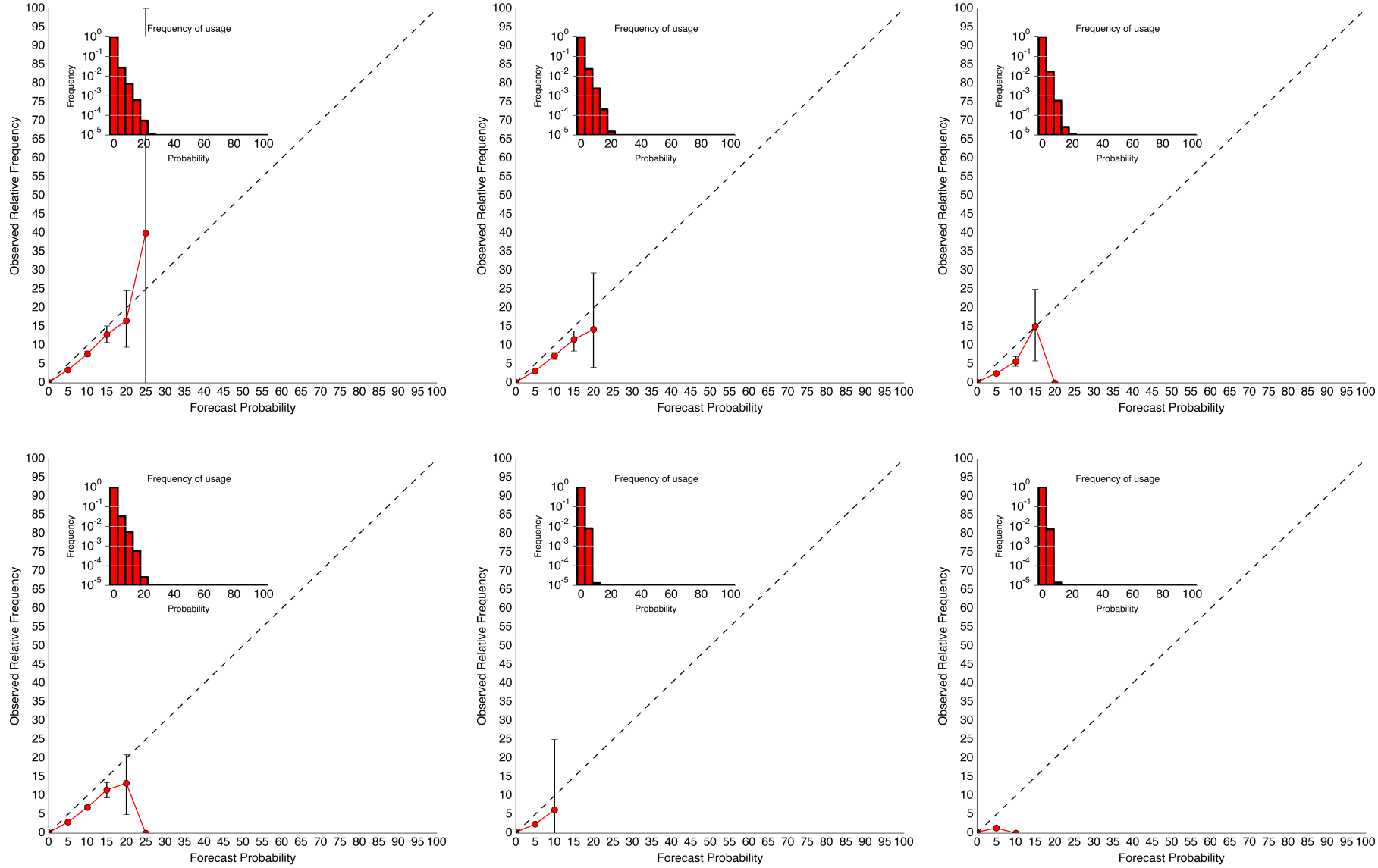
- For each grid point, find the N dates in the past where the past forecast weather at this grid point was closest to today's forecast weather conditions.
  - "Forecast weather" based on CAPE*0-6 km shear*CIN
  - Pattern match uses ± 3 grid points (N/S, E/W) around grid point of interest
  - With the N dates, determine the percentage of those dates that were tornadic based on the observed data.
  - Procedure is cross validated by year, e.g., 2000 trained on 1985-1999 and 2001-2011 data.
  - When performing pattern matches, consider only forecast data from current month and month before and after, given possibilities of seasonally dependent forecast biases.
- Perfect prog as reference forecast: pattern-match today's forecasts against reanalysis rather than reforecast data.

Reliability diagrams for tornado forecasts, 80 km ROI

Day 1, 12z-12z | Day 4, 12z-12z | Day 7, 12z-12z

Reforecast-Calibrated

Perfect Prognosis

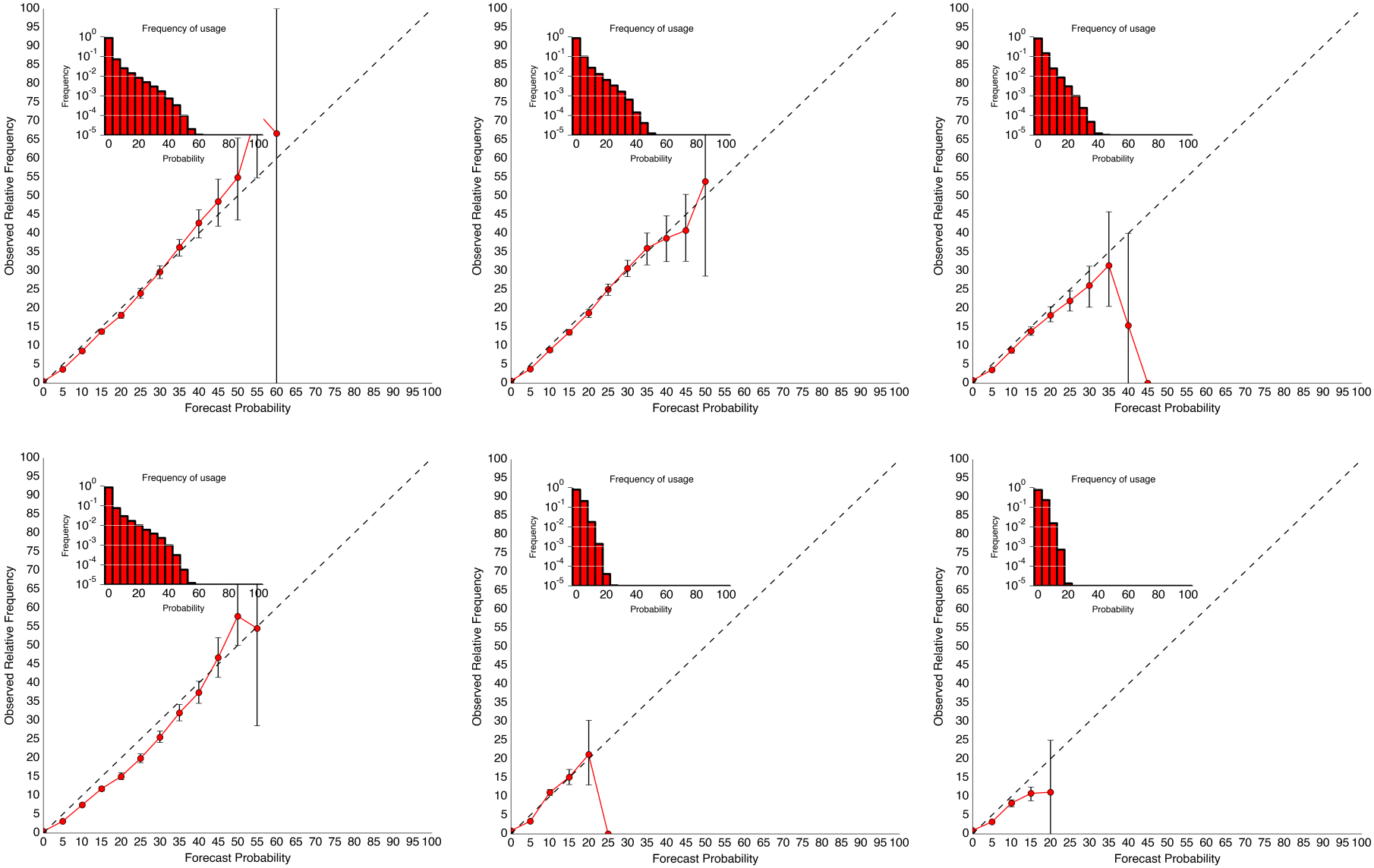


Reliability diagrams for tornado forecasts, 240 km ROI

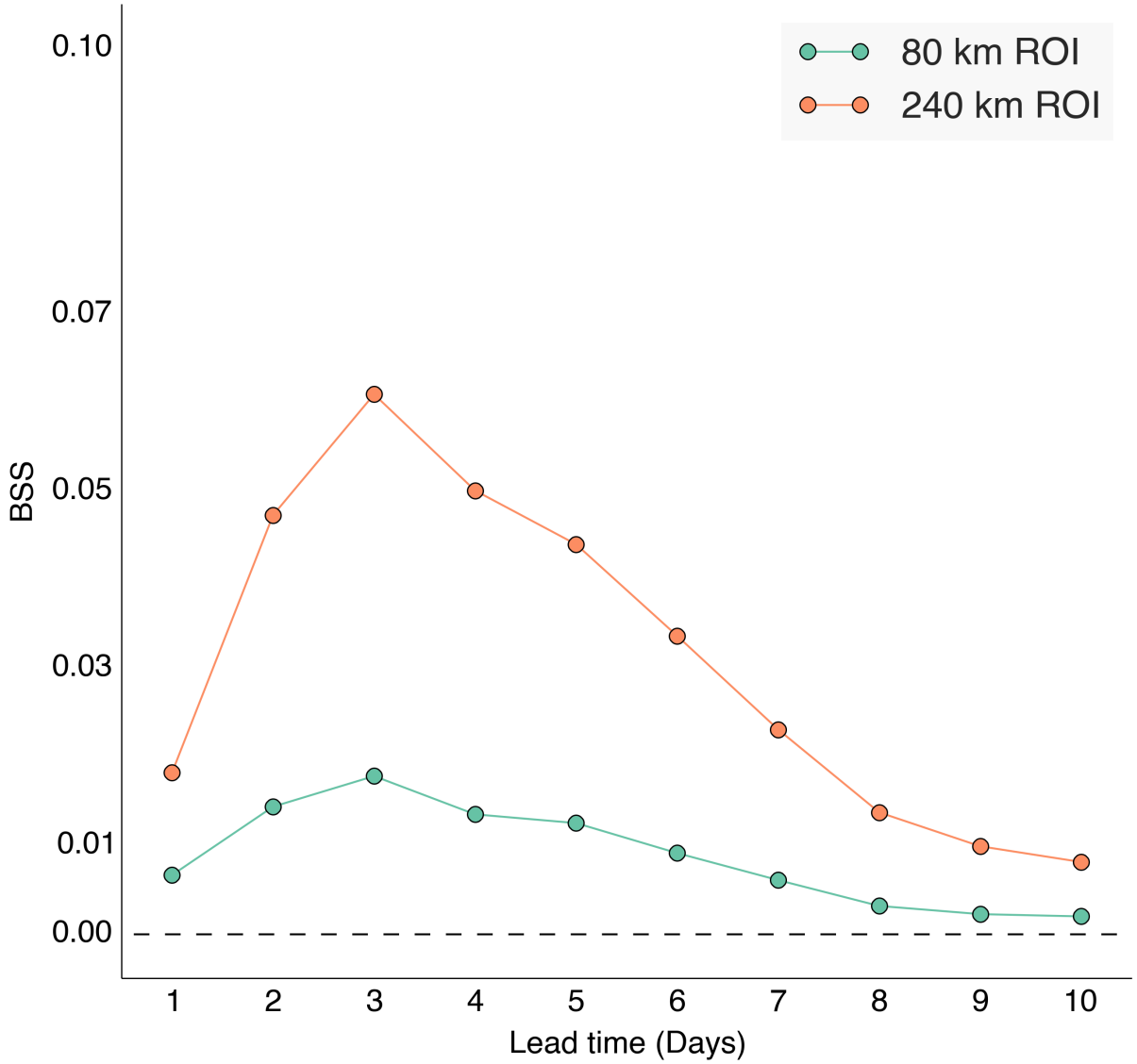
Day 1, 12z-12z | Day 4, 12z-12z | Day 7, 12z-12z

Reforecast-Calibrated

Perfect Prognosis



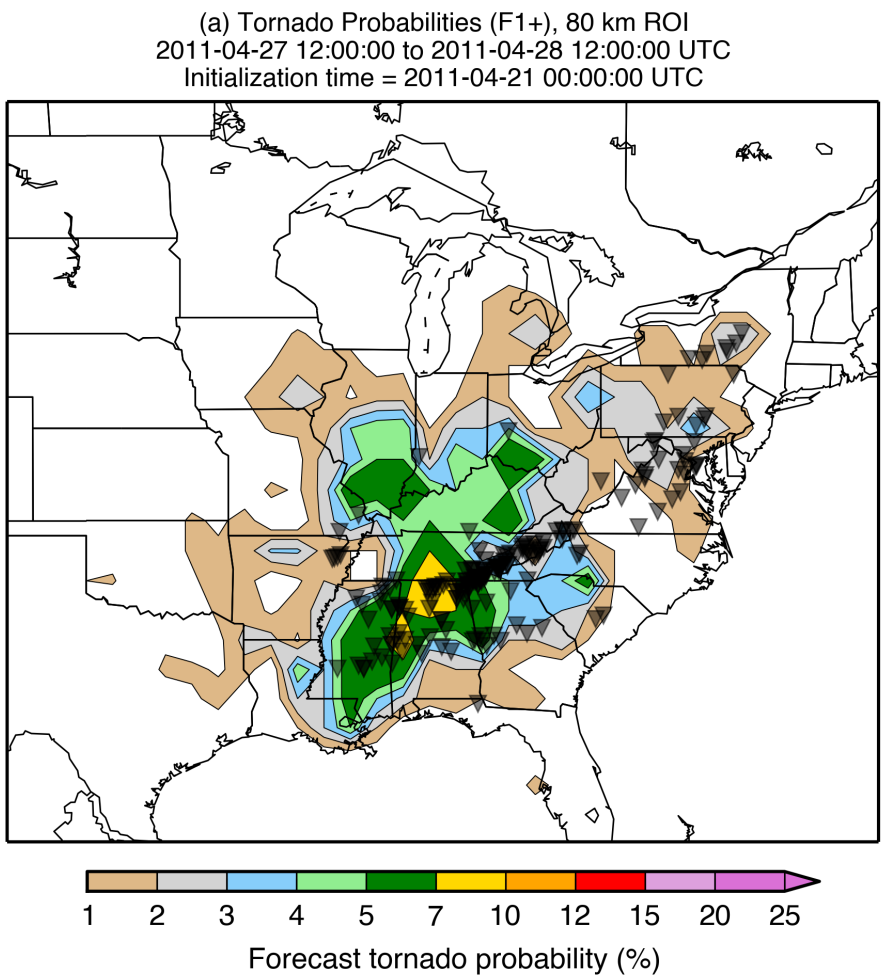
Brier Skill Score for tornado forecasts



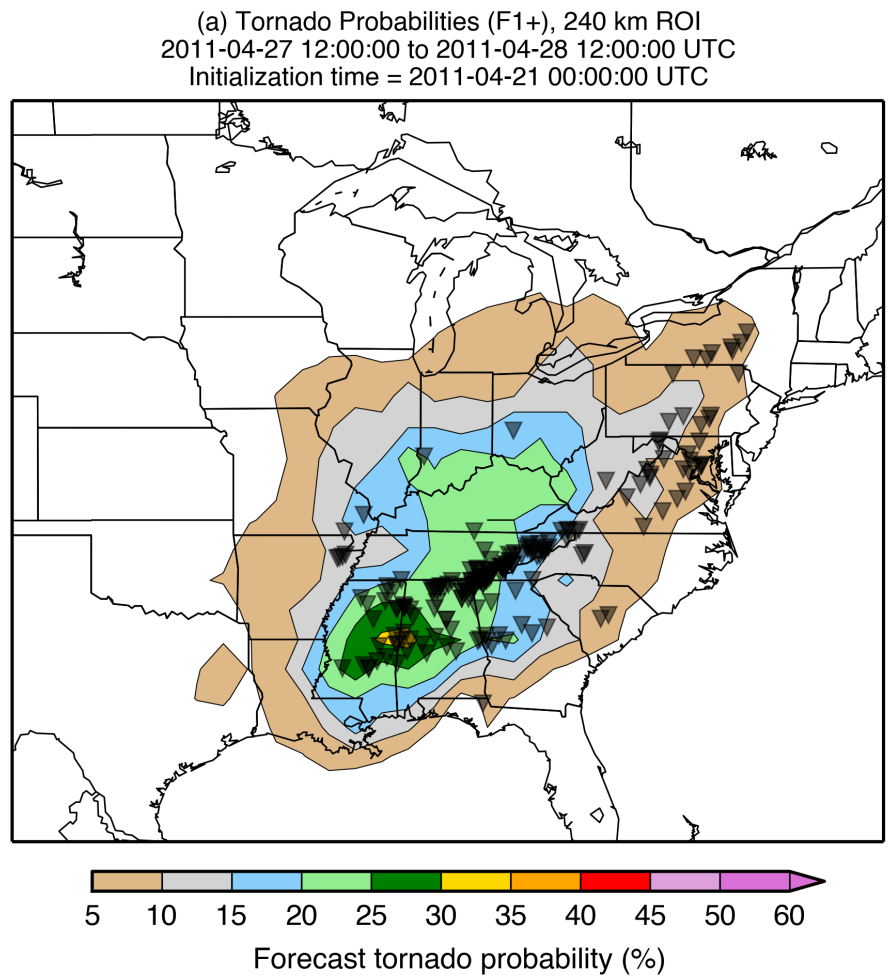
- Brier Skill Score using Perfect Prog as reference forecast.
- Skill highest at +2-4 Days as biases in forecasts increase, but good predictability still exists.
- Caveat: difficult to increase skill since majority of reference forecasts are ~0%.

27 April 2011, +7 day lead time

80 km ROI

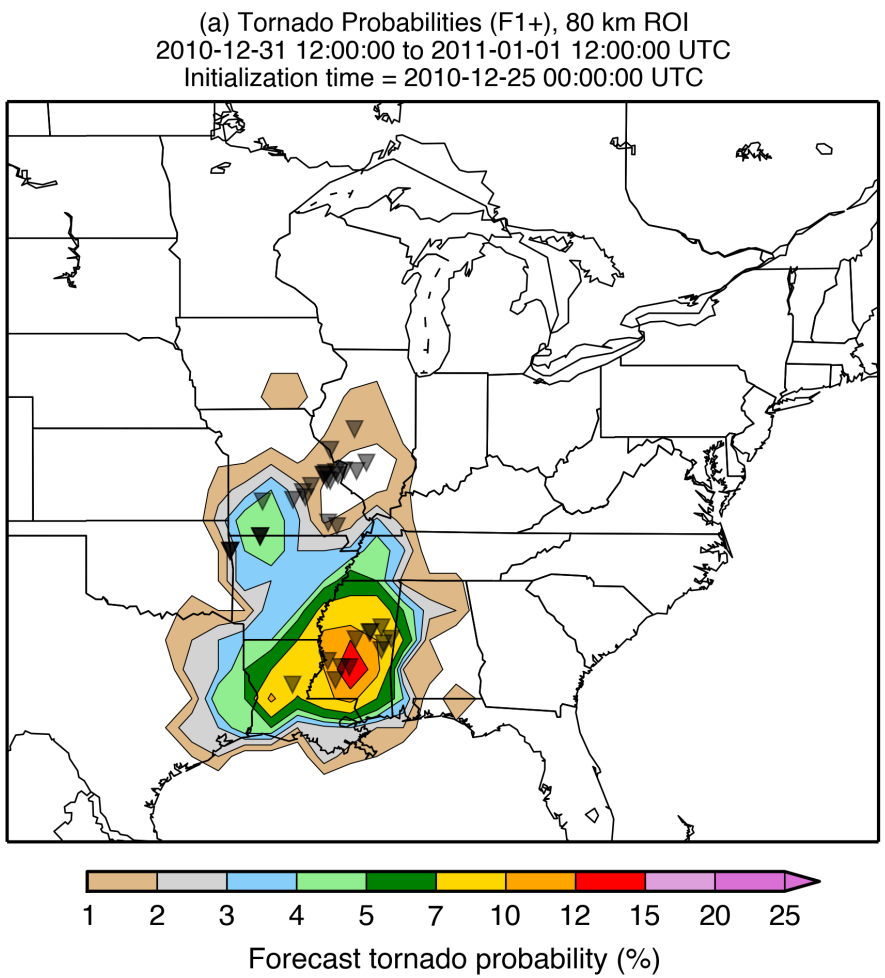


240 km ROI

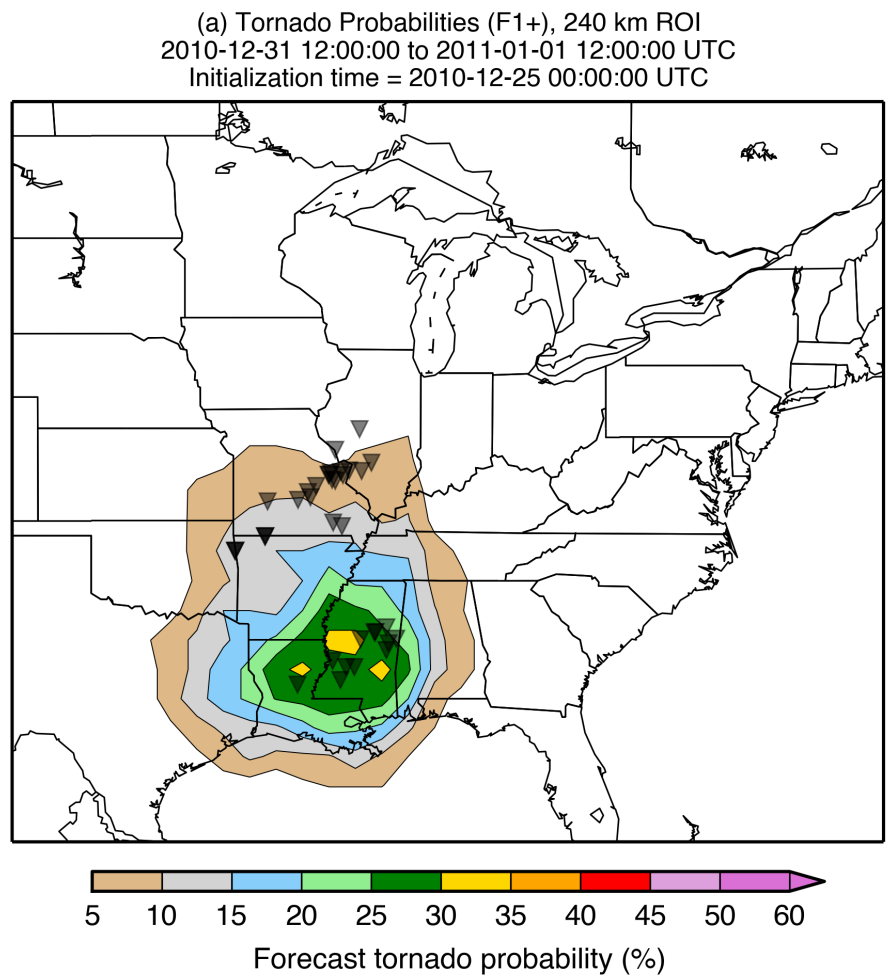


31 Dec 2010, +7 day lead time

80 km ROI

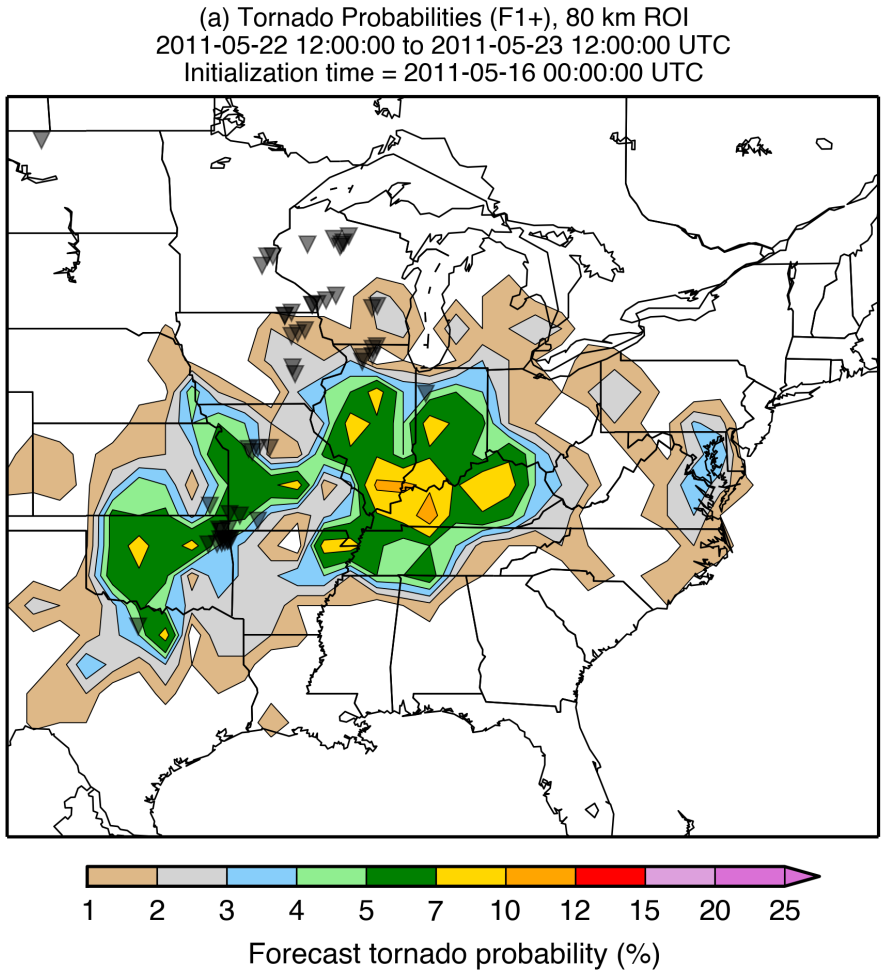


240 km ROI

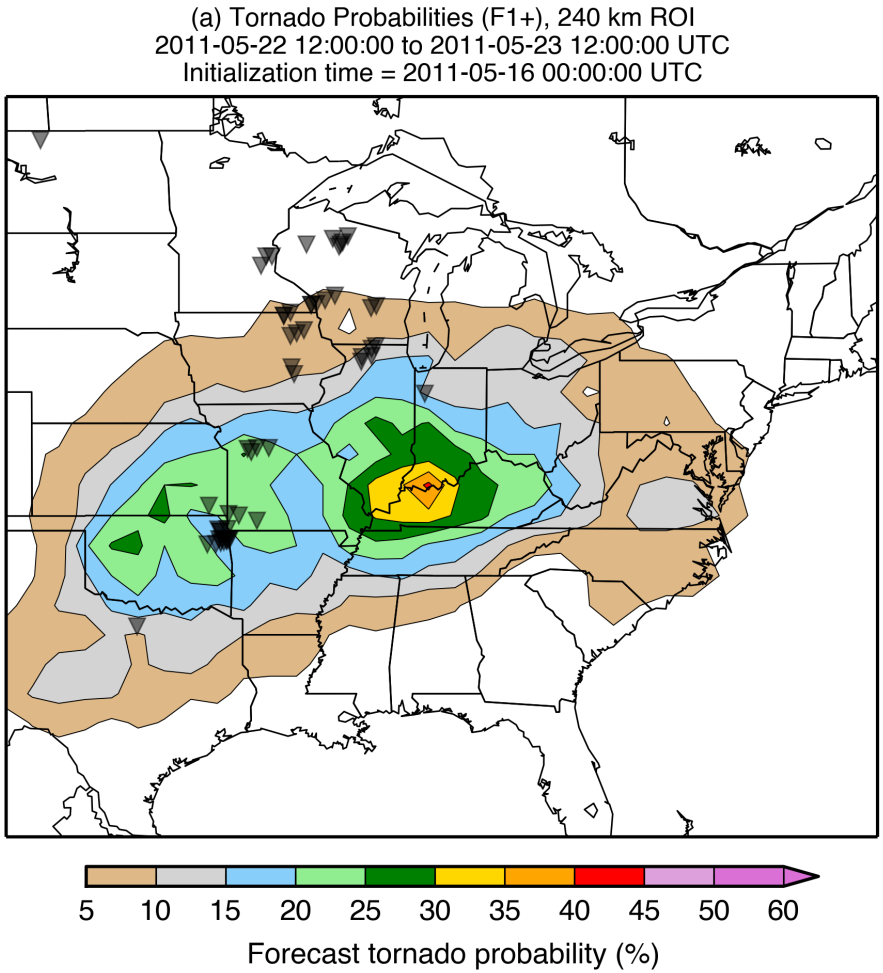


22 May 2011, +7 day lead time

80 km ROI



240 km ROI



Mapping probabilities from 240-km ROI to 80-km ROI to preserve desirable smoothness

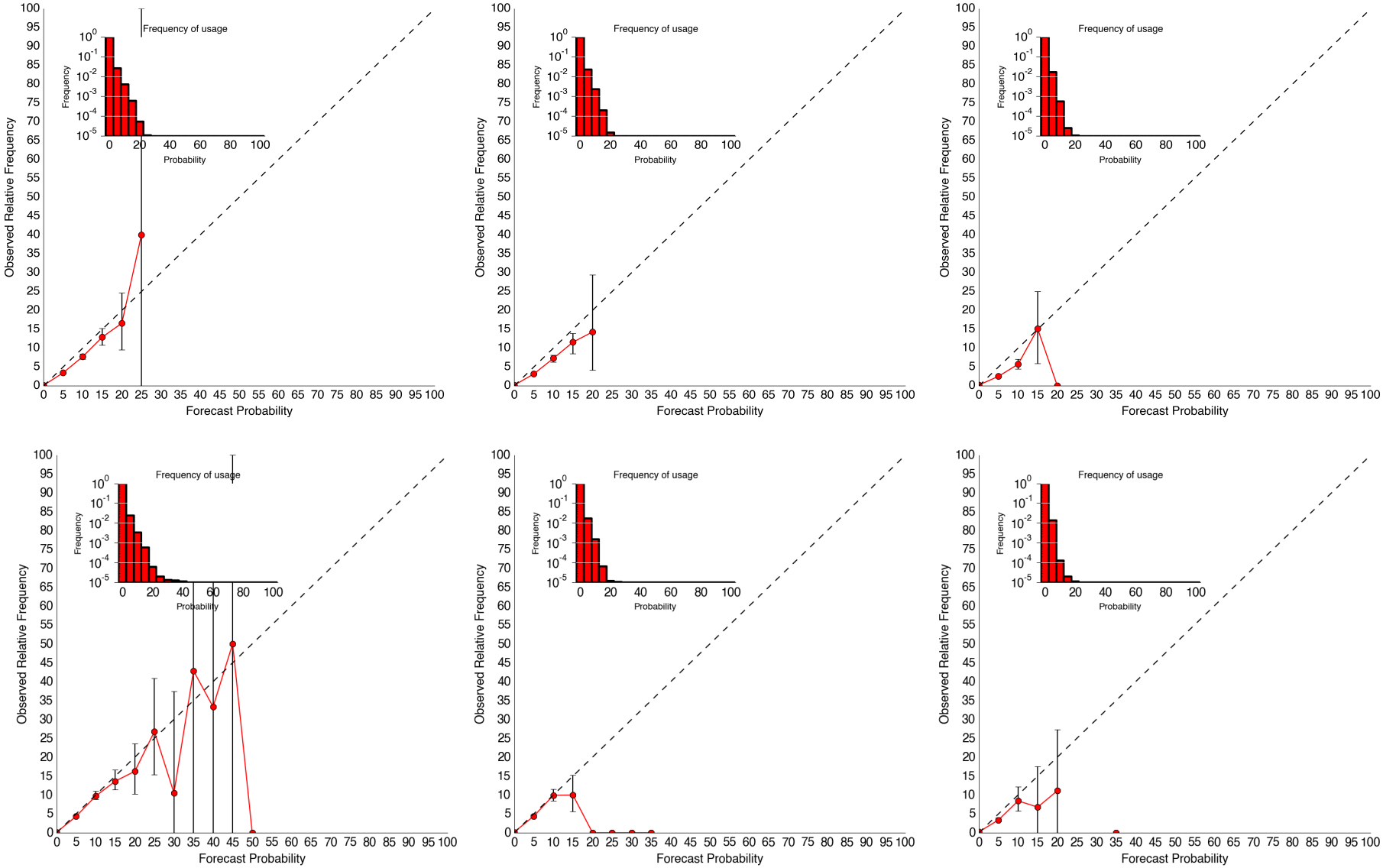
- Forecasting for a smaller radius (80 km) may be more consistent with SPC's procedures than for a larger radius, but analog procedure's 80-km probabilities are noisier, especially at longer lead times.
- Possible solution: develop a monotonic, statistical relationship between forecasts trained at larger ROI and verification at smaller ROI.
  - What is the probability of a tornado verifying at an 80-km ROI given a probability for a tornado occurring within 240-km ROI?

Reliability diagrams for tornado forecasts

Day 1, 12z-12z | Day 4, 12z-12z | Day 7, 12z-12z

80 km ROI

Remapped 80 km ROI



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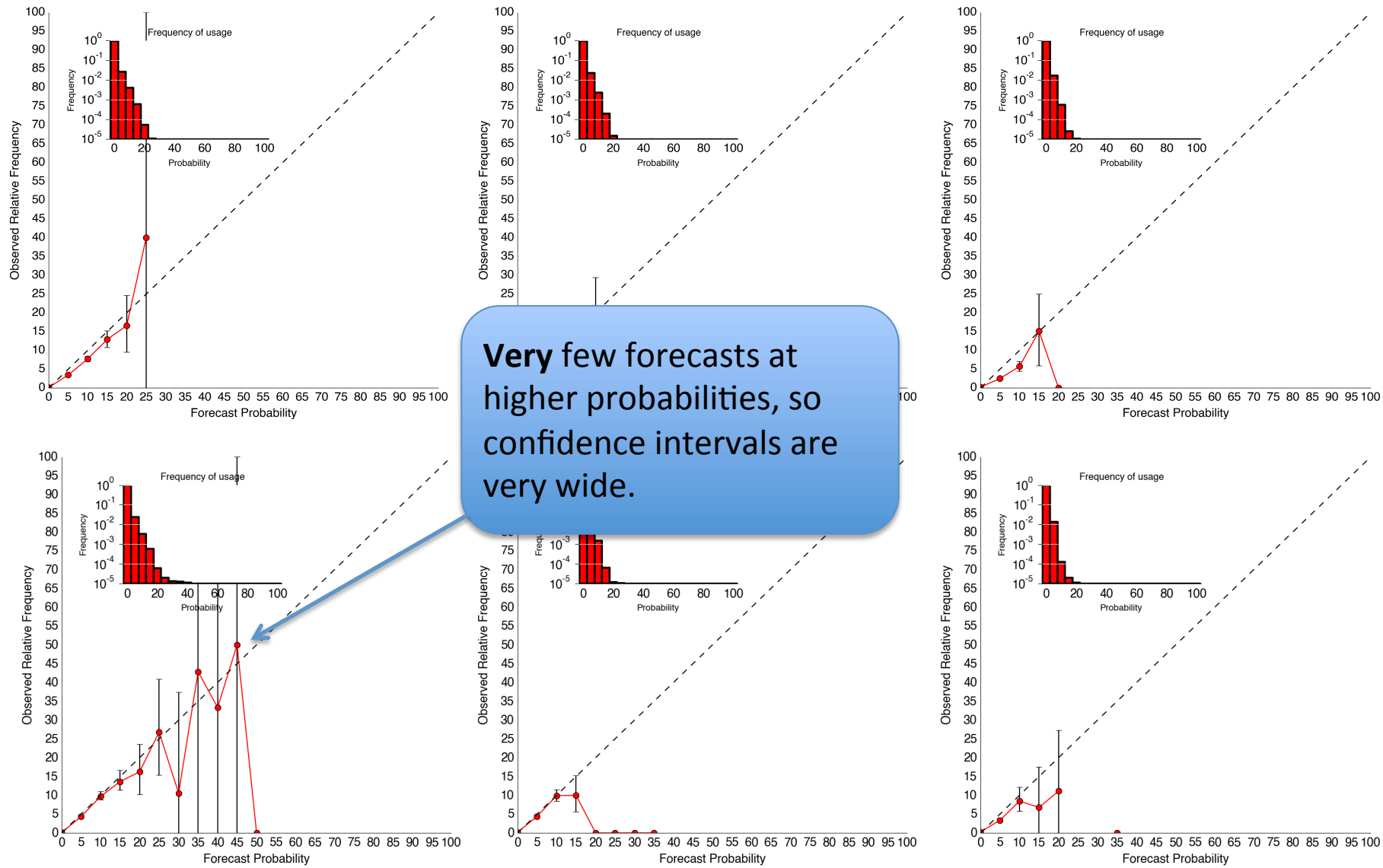
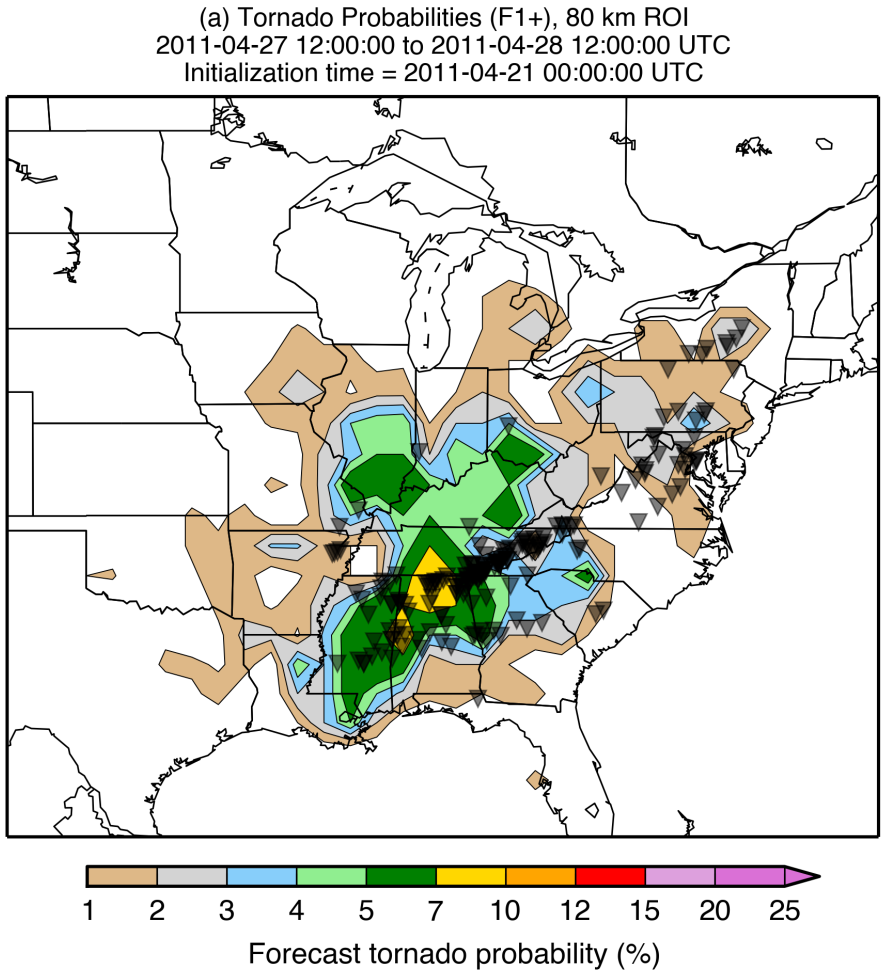


Very few forecasts at higher probabilities, so confidence intervals are very wide.

27 April 2011, +7 day lead time

80-km ROI



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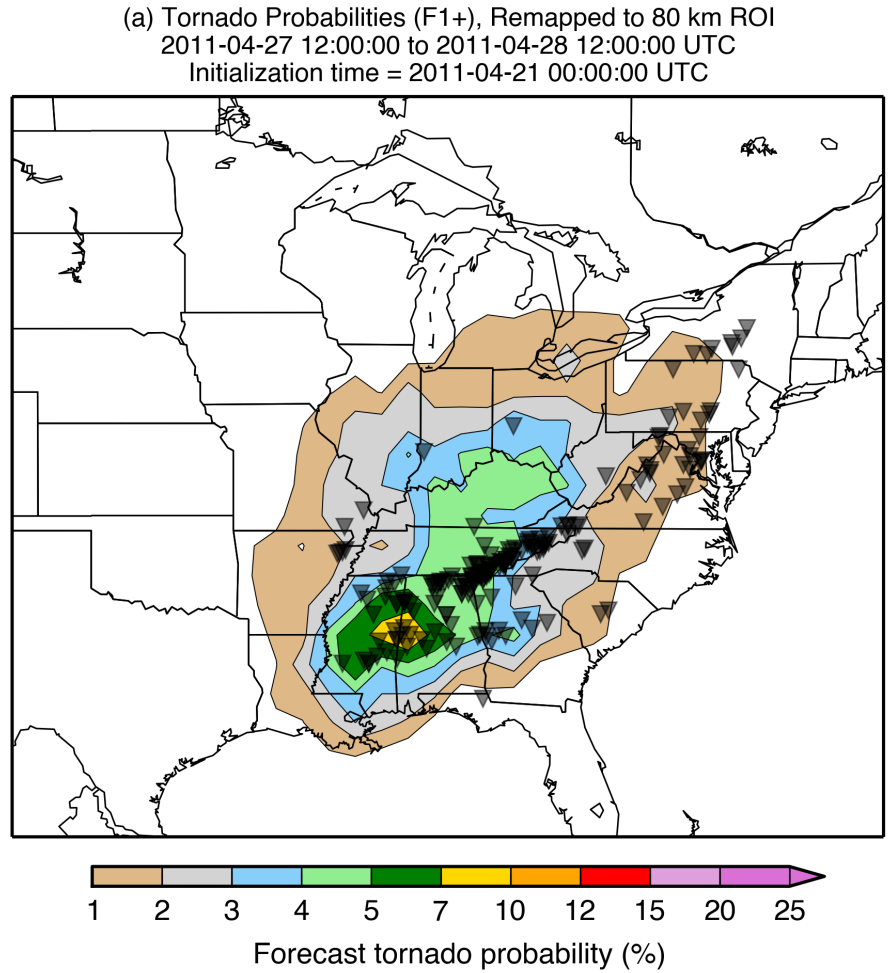
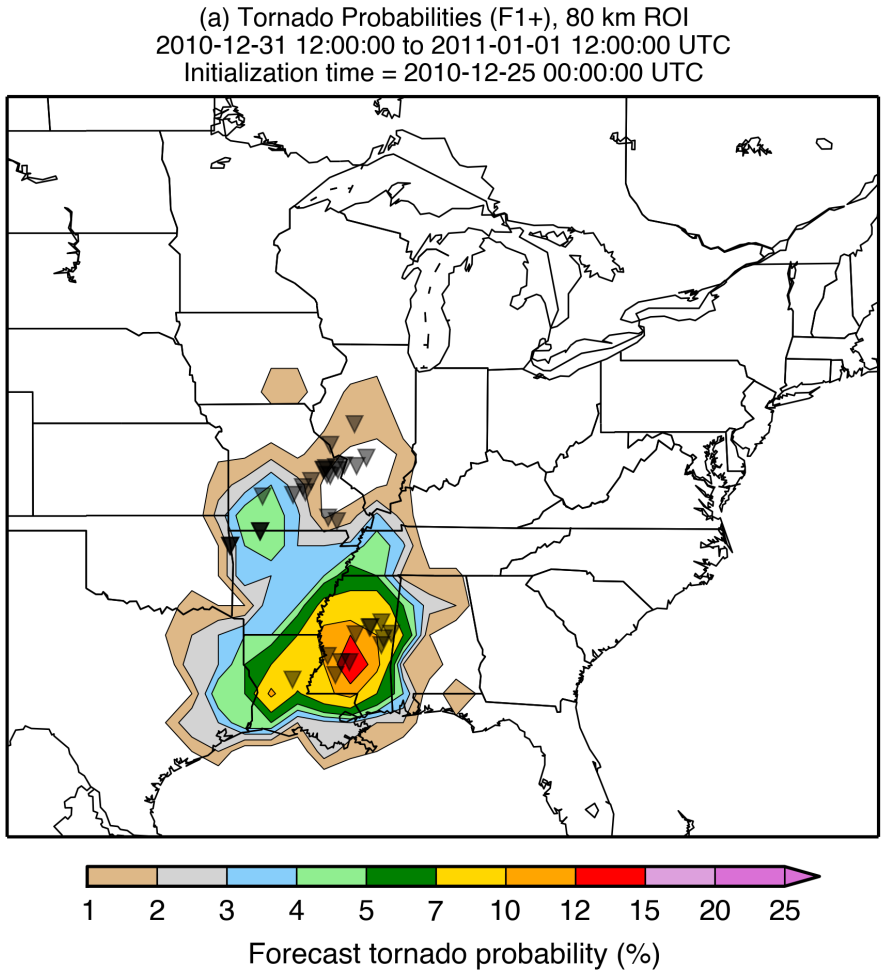


31 Dec 2010, +7 day lead time

80 km ROI



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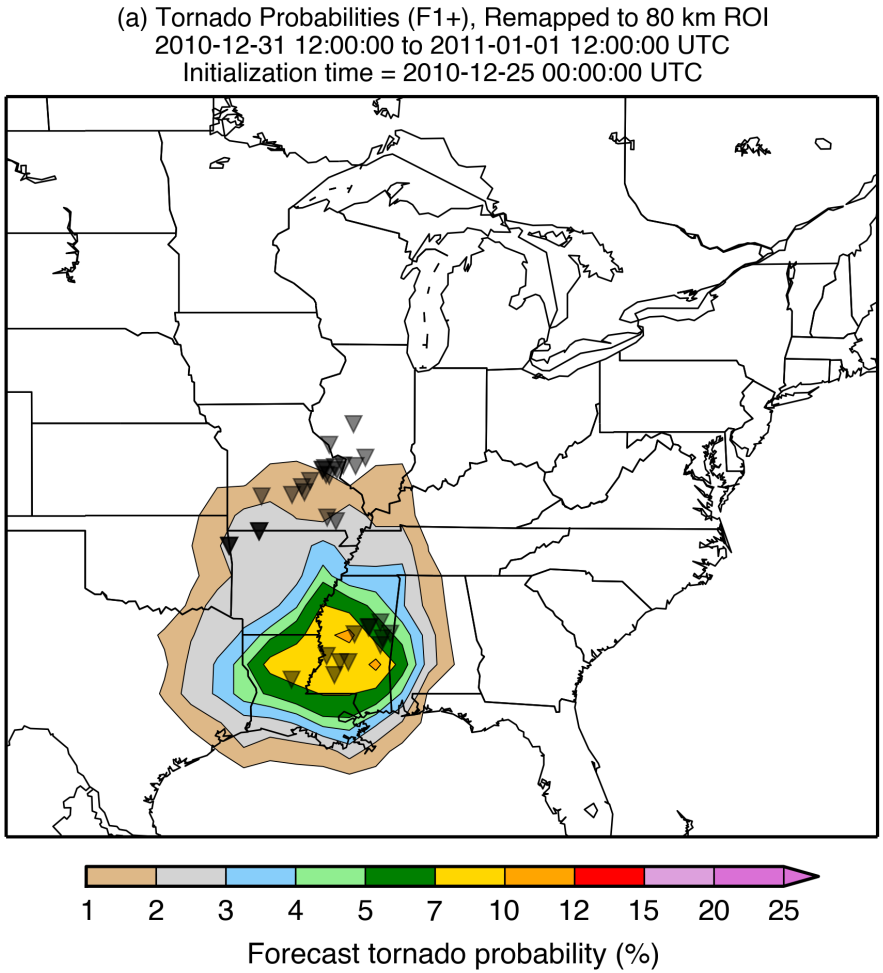
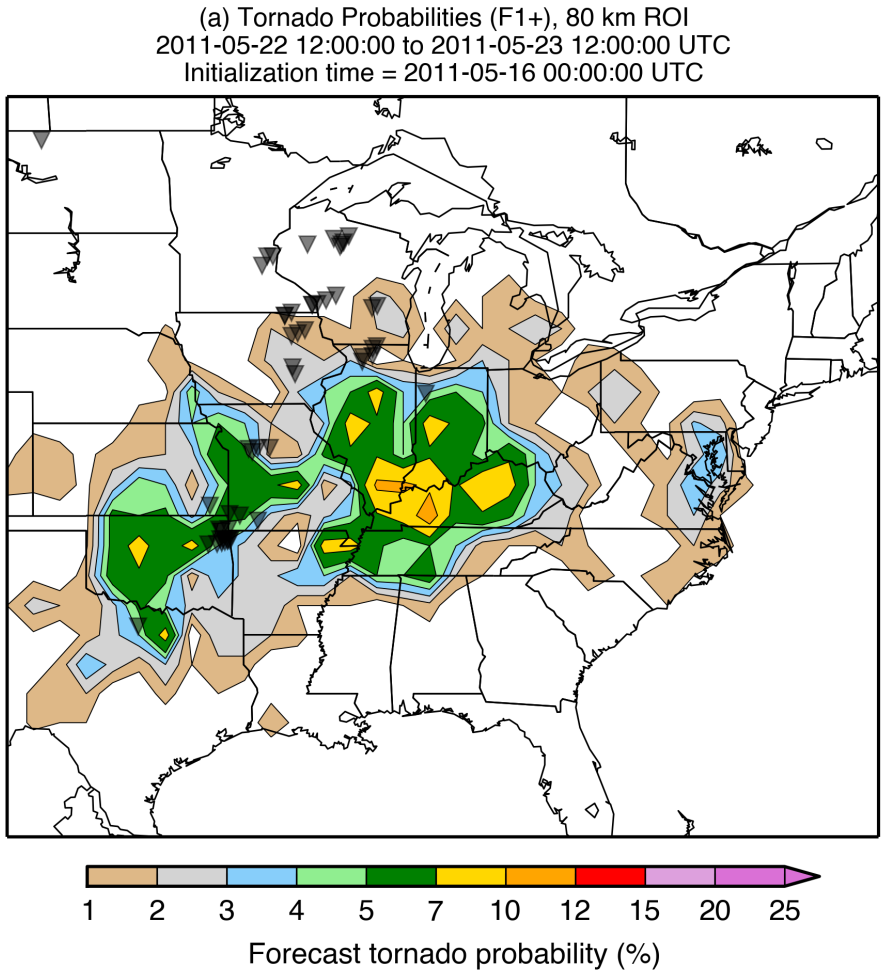
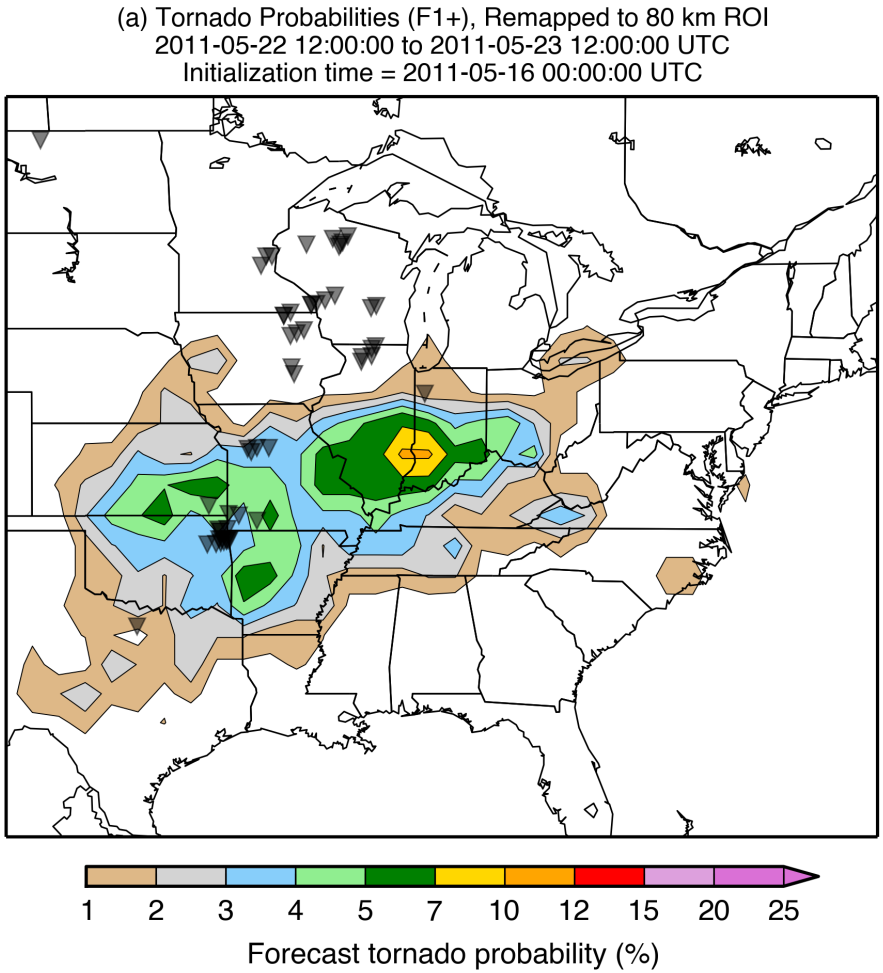


22 May 2011, +7 day lead time

80-km ROI

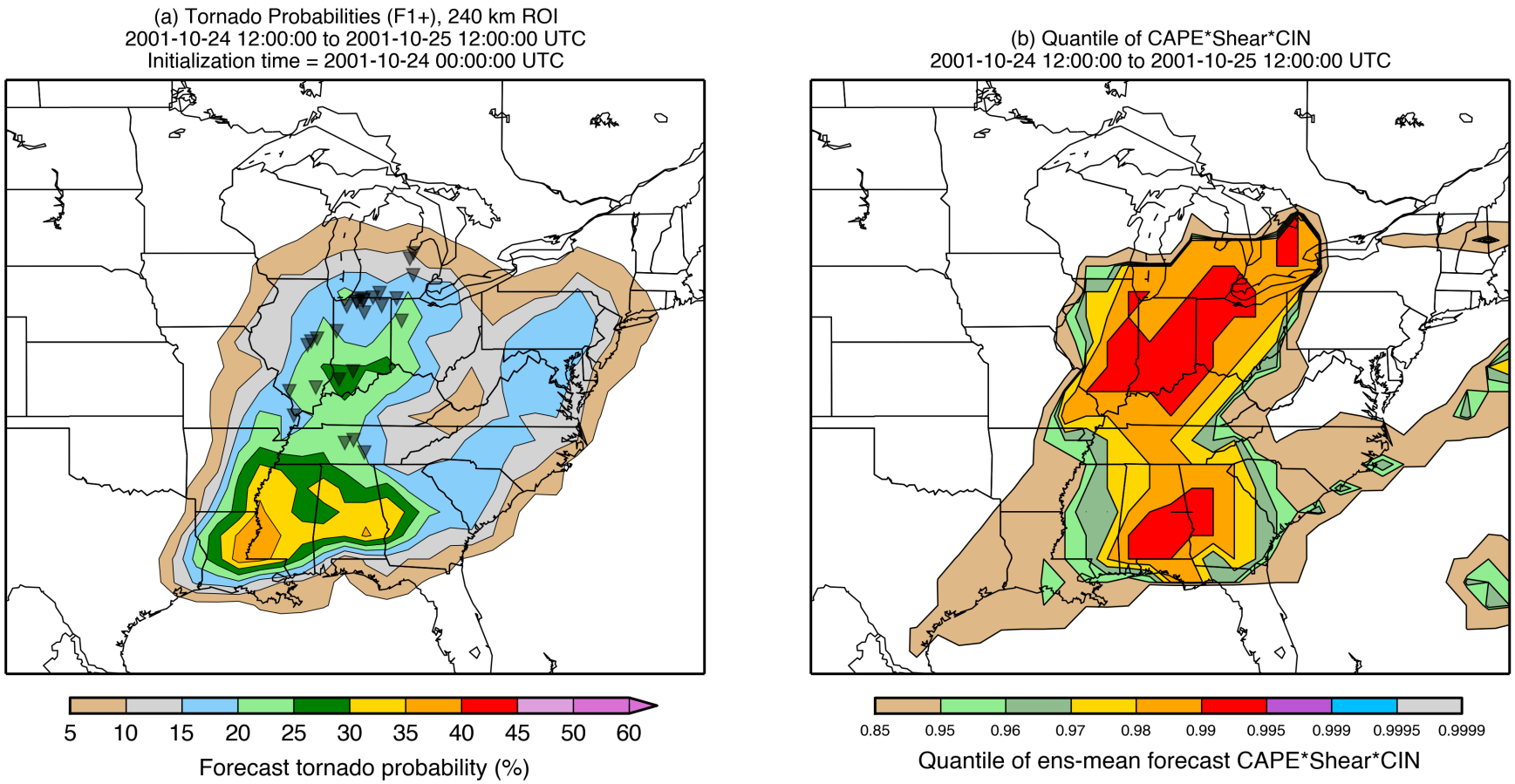


Remapped 80-km ROI



Challenges

- Adapting procedure to deal with tornadic events in regions and at times of the year where few tornadoes are exceptionally rare.



- Local analog procedure may need to be modified to include training data from other geographic locations.

Conclusions

- Reliable, somewhat skillful tornado probabilities at extended leads are possible, post-processing today's forecast using extensive reforecast data set
- Post-processing using larger ROI give more reliable and smoother forecasts at longer lead times.
  - Possible to have smoother forecasts at smaller ROI by applying a remapping procedure of probabilities between large and smaller ROI

Future work

- Hope to provide near real-time forecasts on ESRL's Reforecast 2 Project website this spring season.
- Work with SPC to evaluate this experimental forecast guidance to determine if it is a viable operational tool.