Improved Methods for Blending Extrapolation-based and Model Forecasts

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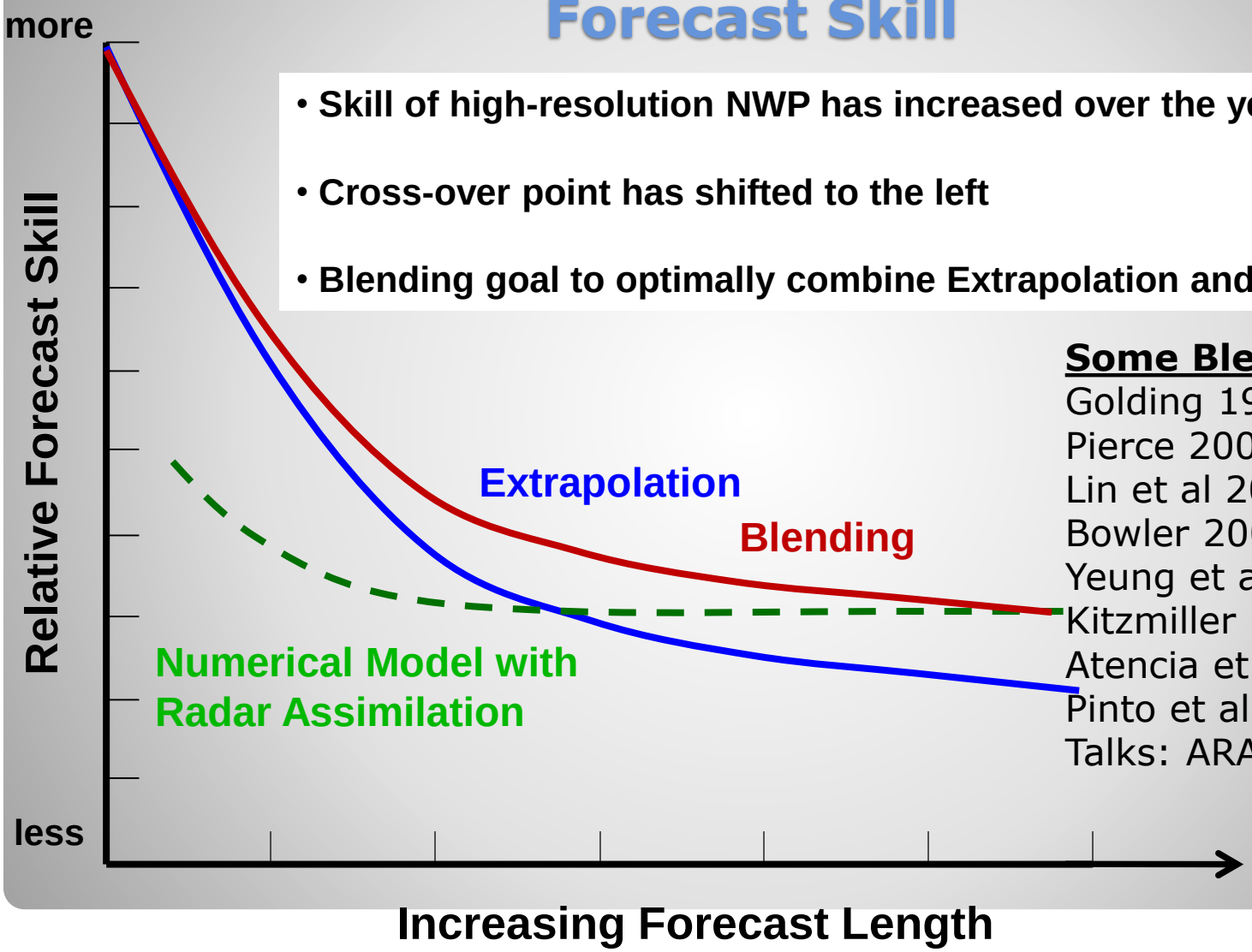
Schematic Representation of Short-term Forecast Skill



- Skill of high-resolution NWP has increased over the years
- Cross-over point has shifted to the left
- Blending goal to optimally combine Extrapolation and NWP

Some Blending REFS

Golding 1998
Pierce 2001
Lin et al 2005
Bowler 2006
Yeung et al. 2009
Kitzmiller 2010
Atencia et al. 2010
Pinto et al. 2010
Talks: ARAM14 3.3, 4.4

CoSPA Blending Algorithm Overview

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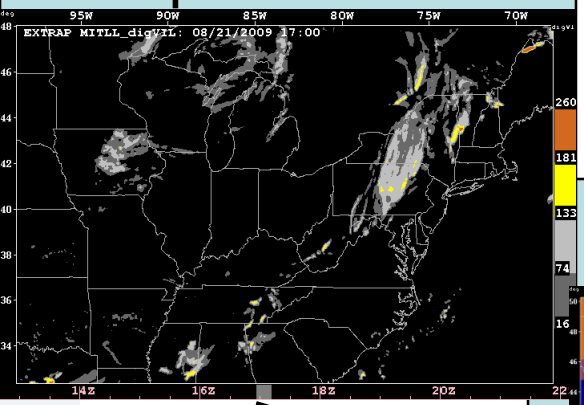
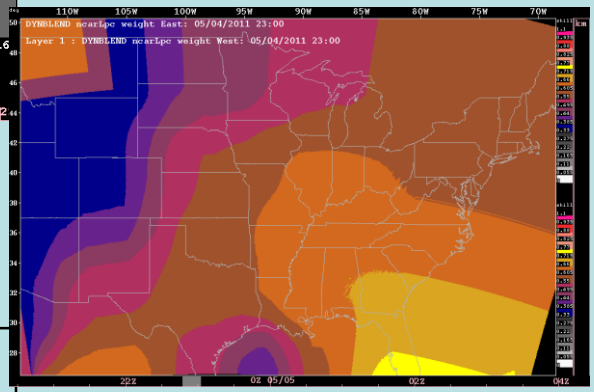
Extrapolation

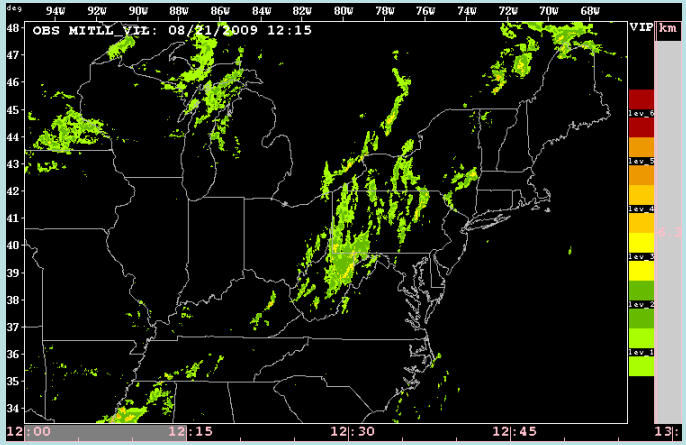


Dupree et al. 2009
Based on MIT-LL CIWS
Multi-scale Advection
Heuristic (G/D and Initiation)

Dynamic Weighting

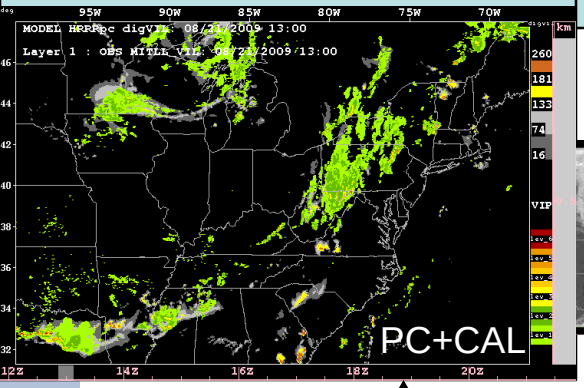


Blended Forecast

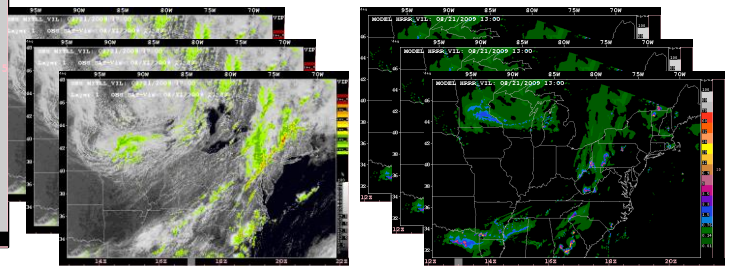


Dupree et al. 2009
Pinto et al. 2010

Calibration + Phase Corr



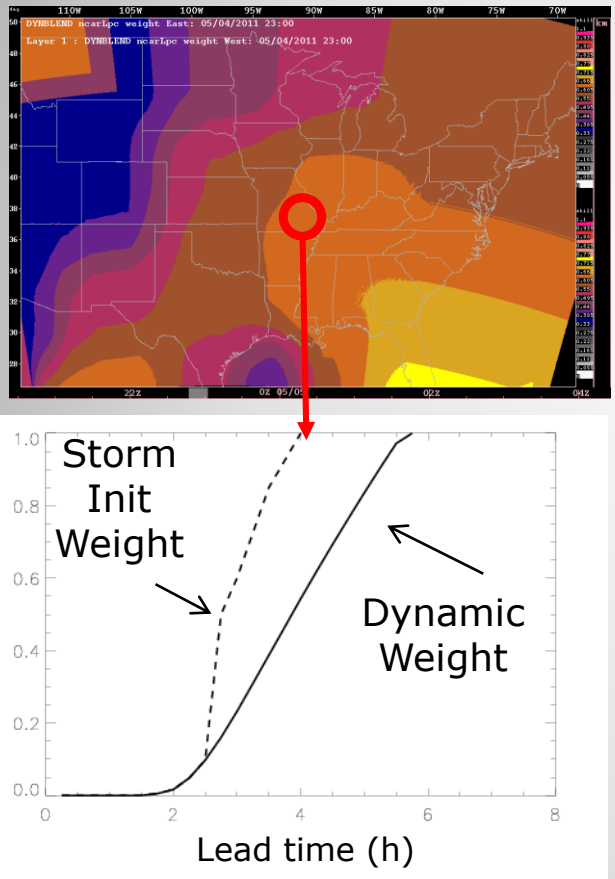
Radar Mosaic +
Extrapolation



HRRR: Talks 1.3,1.4, 10.1
Brewster et al. 2003

CoSPA Blending Weights

Model Wt(gen = 13utc, lead = 5 h)



Weight = F(FSSm,FSSe) * Aw

$$FSS = 1 - \frac{\frac{1}{N}\sum_{i=1}^{N}(P_{fcst} - P_{obs})^2}{\frac{1}{N}\sum_{i=1}^{N}P_{fcst}^{\ 2} + \frac{1}{N}\sum_{i=1}^{N}P_{obs}^{\ 2}}$$

- Skill determined using fractions skill score (Roberts and Lean 2008)
  - Scale = (150 km)^2 & Threshold = level 3
- Weights based on 21-day running mean performance
- Weights vary by time of day, lead time.

Aw(Init = True & Lead > 2 h) = constant

Treatment of Storm Initiation in CoSPA

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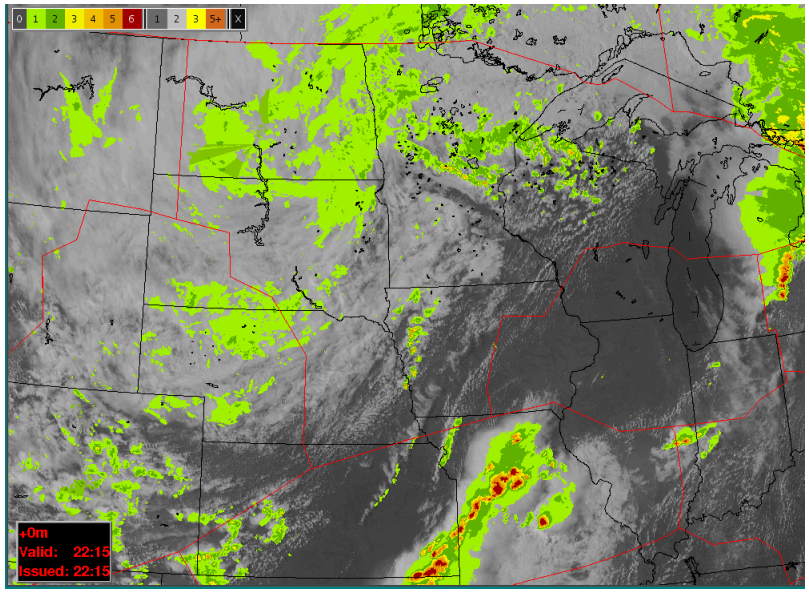
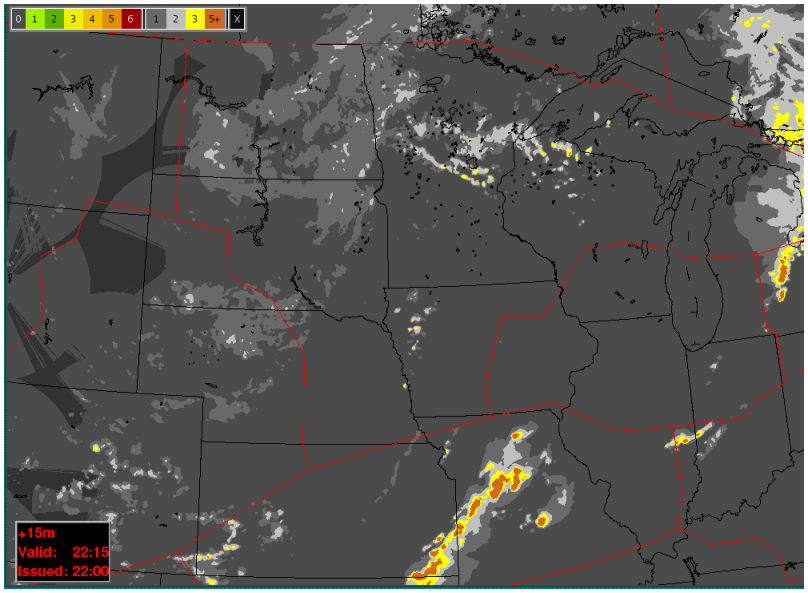
Satellite and VIL from MIT-LL CIWS

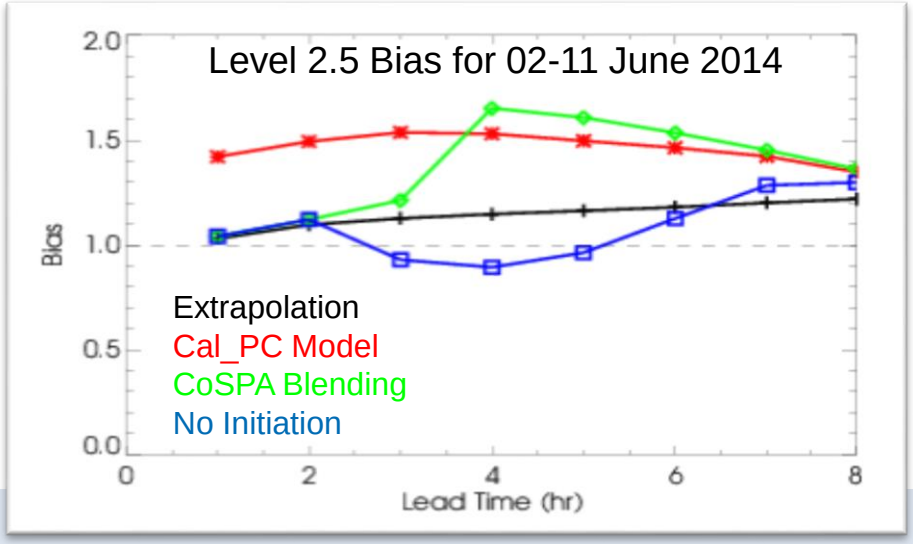


2 hr CoSPA Forecast



- CI event over Iowa
- Existing storms over Missouri

- Treatment of CI in 1-4 hr time frame critical to performance of blending



Goal:

Improve blending in 1-4 hour timeframe by earlier selective introduction of model data using ensemble-based forecast uncertainty information.

New Weights

Weight = F(FSSm,FSSe) * Aw(**Pr**,Init = True ~~& Lead > 2 hr~~)

Pr = Probability of Convective Storms with Dmax > 100 km

- Pr obtained using object-based technique applied on HRRR time-lagged ensemble

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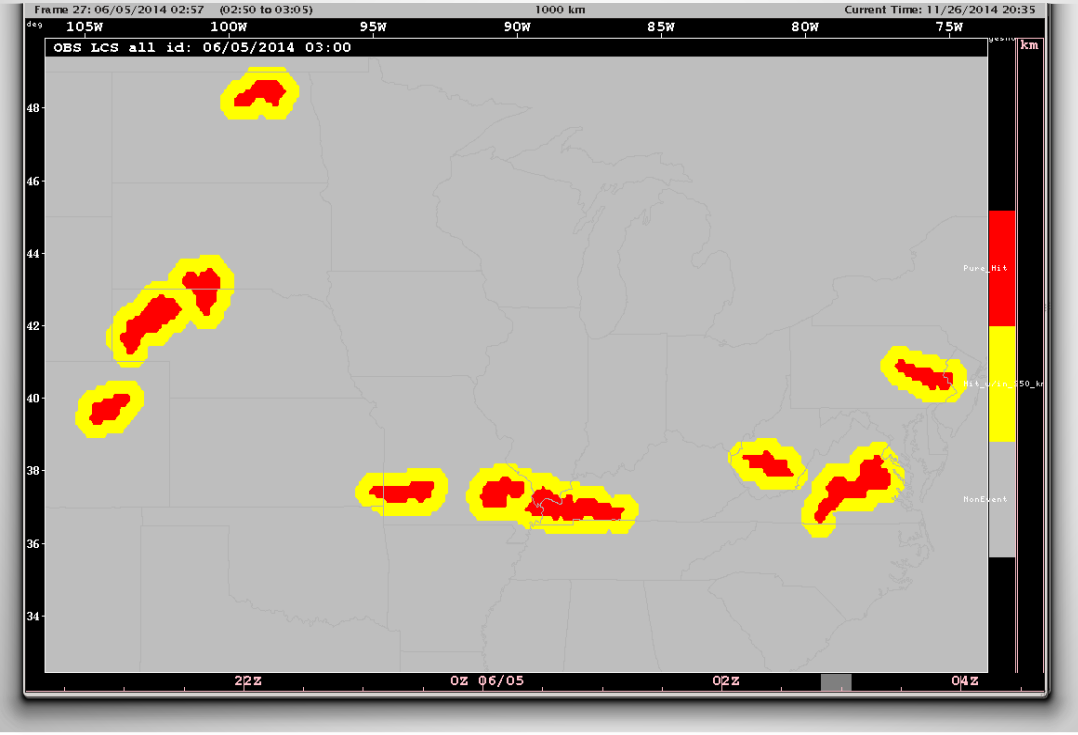
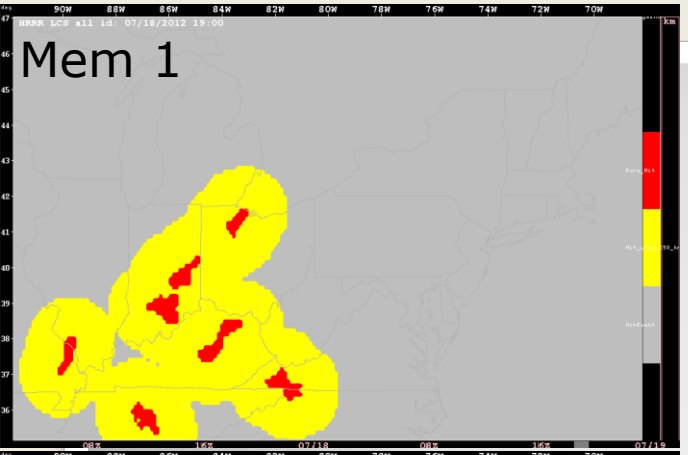
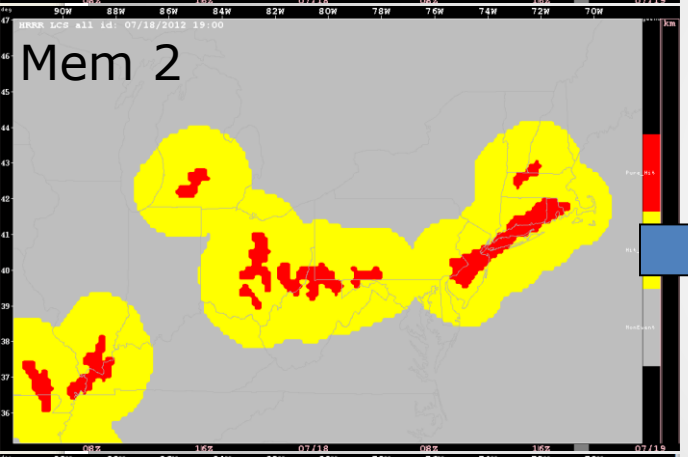
Storm Detection Algorithm

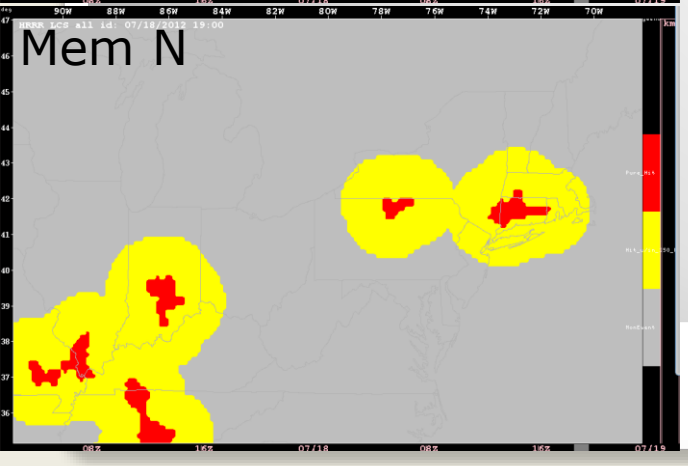
- Set allowable size of gaps between convective elements (30 km)
- Choose desired VIL threshold (3.5 kg m^{-2}) to ID storm objects
  - Uses TITAN (Dixon and Wiener 1993)
  - Method similar to MODE (Davis et al. 2006)
- Set size criteria (e.g., Dmax > 100 km)

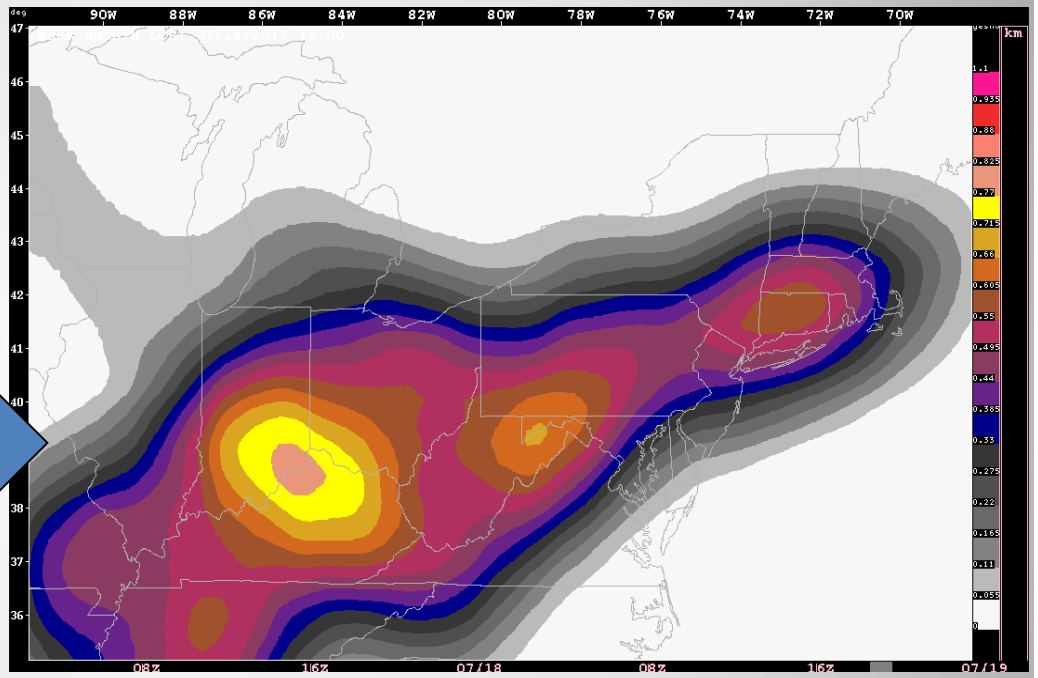


Computation of Storm Likelihoods









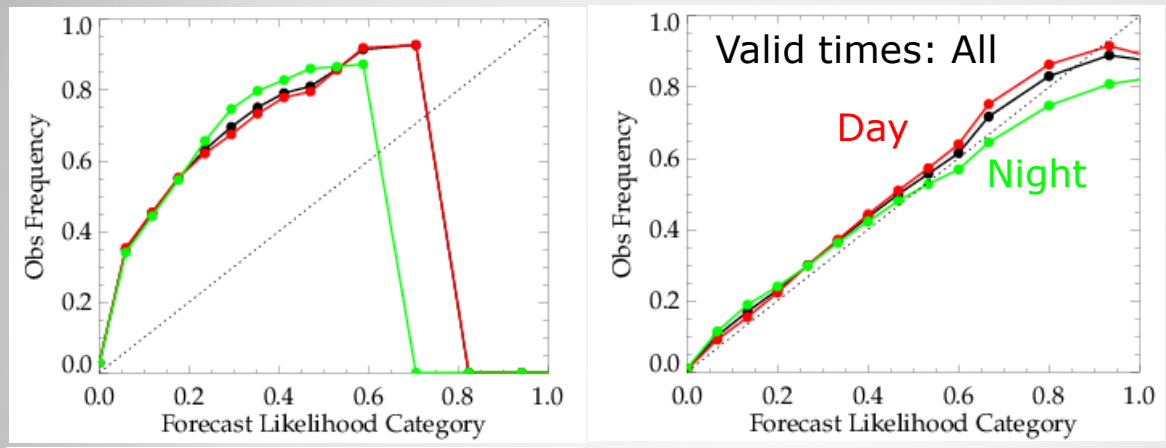
~ find optimal threshold (See talk 12.4)
~ use HRRR time-lagged ensemble.
~ apply LCS ID algorithm each available forecast.
~ smooth in space and lead time.
~

Calibrated Storm Likelihood

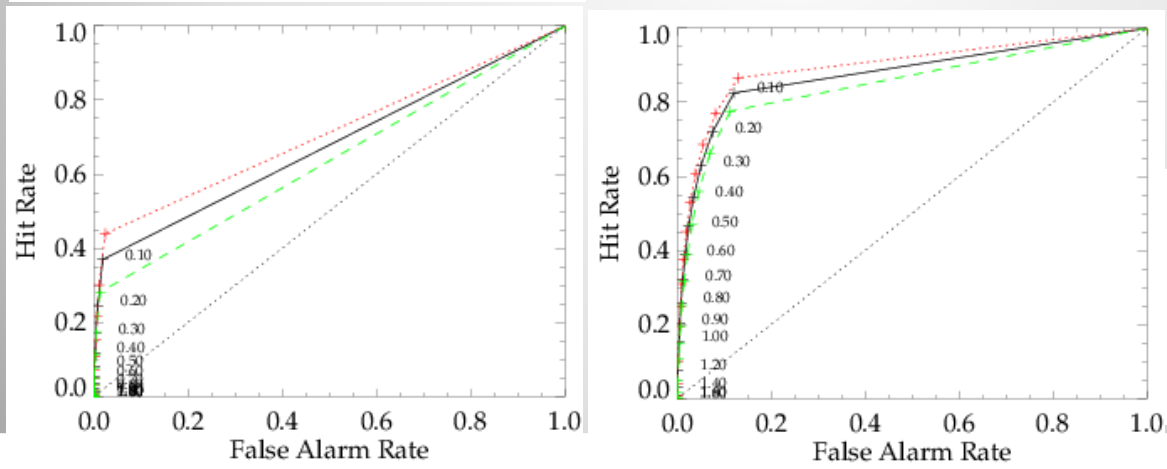
Thresholds optimized using iterative procedure.

Fixed VIL Threshold=3.5 kg m^{-2}

Optimized VIL Thresholds

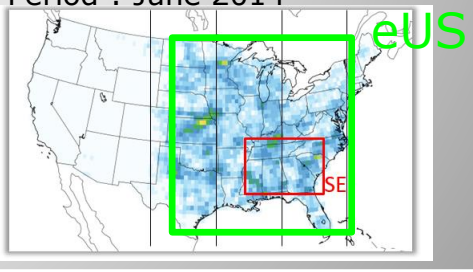


Reliability



ROC Discrimination

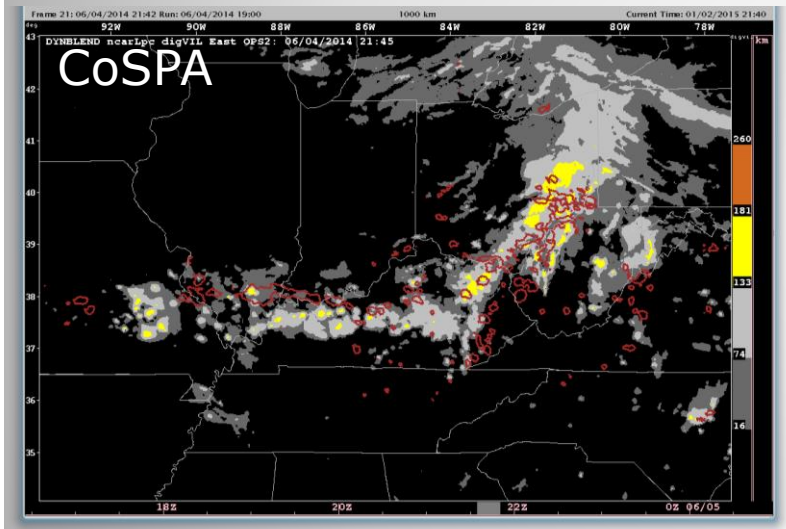
Evaluation Domain: eUS
Period : June 2014



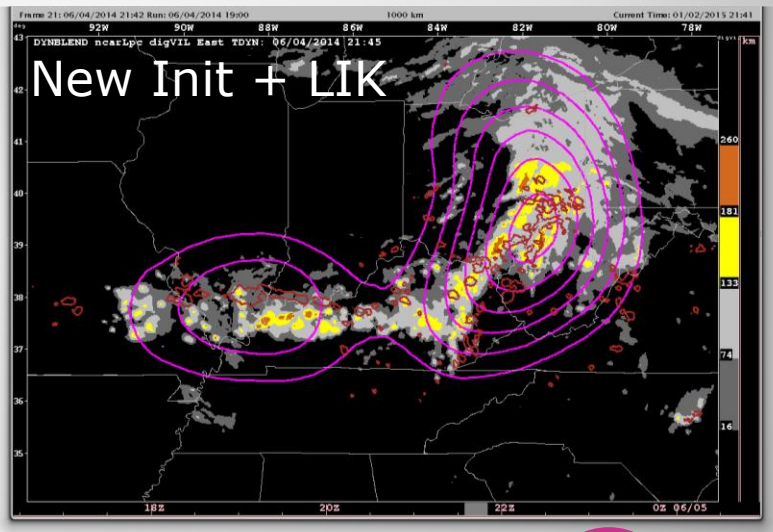
Case Study # 1

Initiation of Broken Line of Storms over Ohio River Valley

Lead = 2:75 hr



Lead = 2.75 hr



OBS VIL>133 (Level 3)

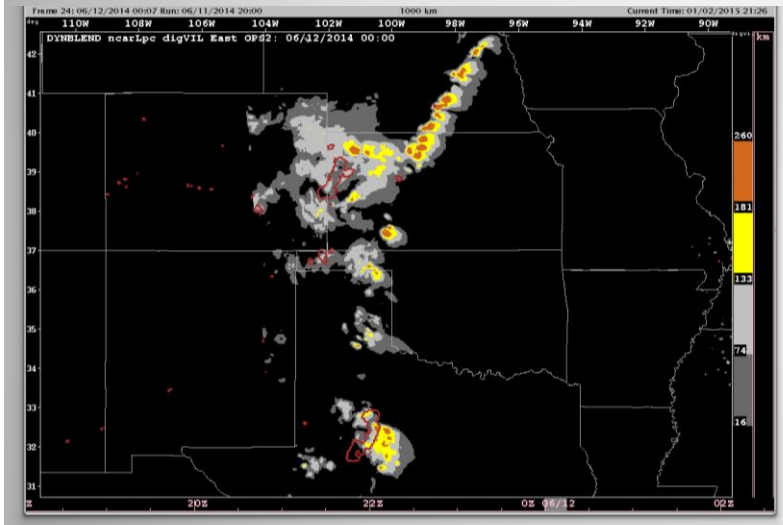
>30%

LCS Likelihood

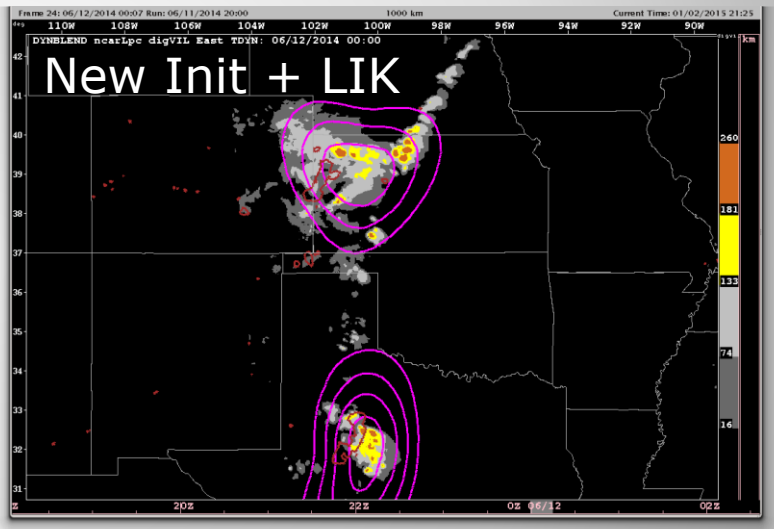
Case Study # 2

Great Plains False Alarm Line Storm

Lead = 3.5 hr



Lead = 3.5 hr



OBS VIL>133 (Level 3)

>30%

LCS Likelihood

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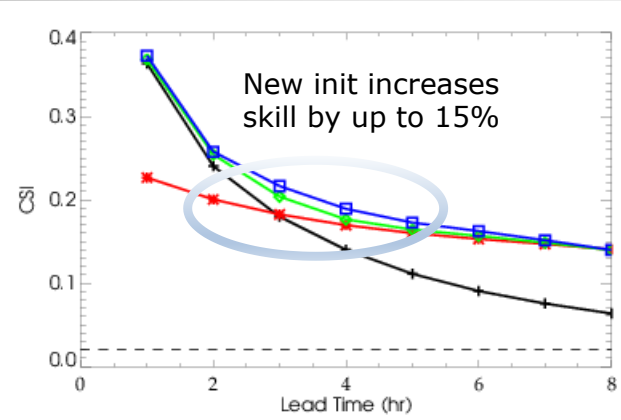
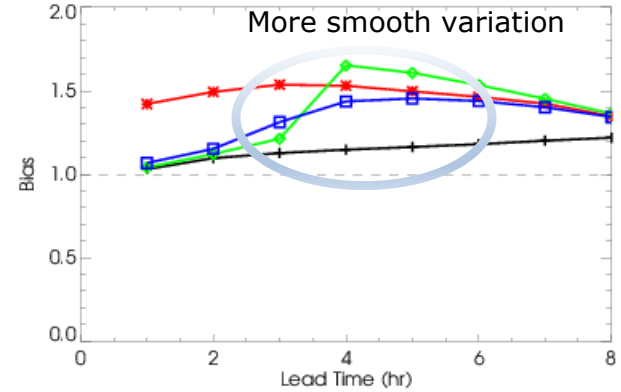
Stats for Various Blending Tests

Eastern U.S., 2-11 June 2014 Level 2.5

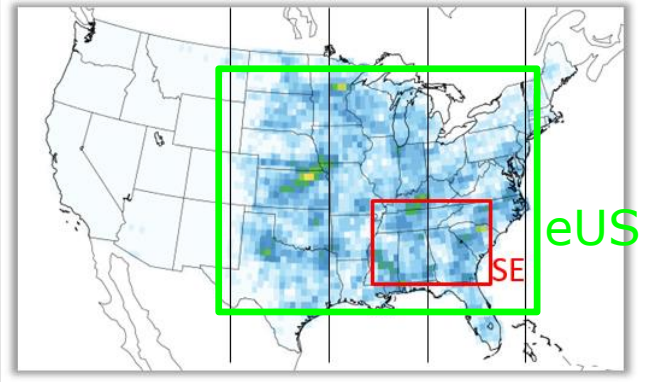




Legend

Extrapolation
Cal_PC Model
Live Blending
New Init Using
LCS Likelihood

Evaluation Domain: eUS



Summary

- Introduced a method to improve treatment of storm initiation in blending used in CoSPA
  - Applicable to other model / extrap pairings.
- Uses scale-dependent forecast uncertainty information
  - Convective areas > 100 km
  - Future work - Expand to multiple scales.
- Important to account for biases in model VIL prior to calculation of probabilities.
- Demonstrated use of model forecast uncertainty information can improve blending:
  - 10-15% increase in CSI.
  - More smoothly varying forecast bias.

These improvements would improve decision making (DSTs) in the 1-4 hour time frame.

Thank You!

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References

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- **Dixon, M. and G. Wiener**, 1993: TITAN: Thunderstorm identification, tracking, analysis and nowcasting – A radar-based methodology. *J. Atmos. Ocean. Tech*., 10, 785-797.
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