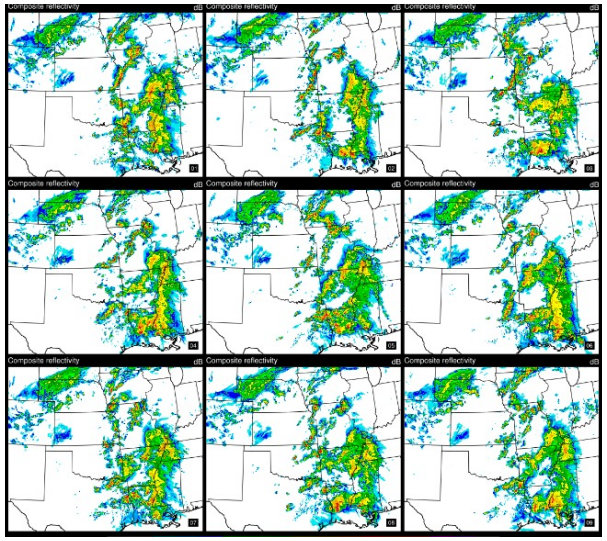
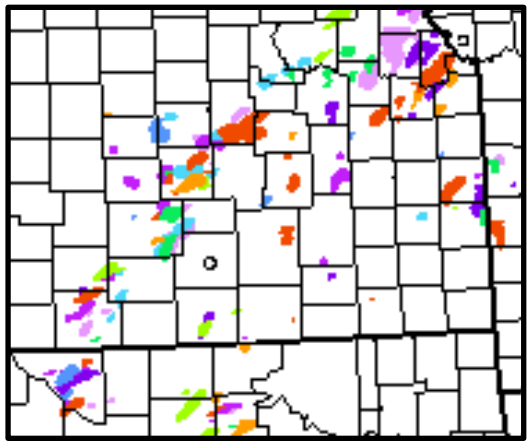
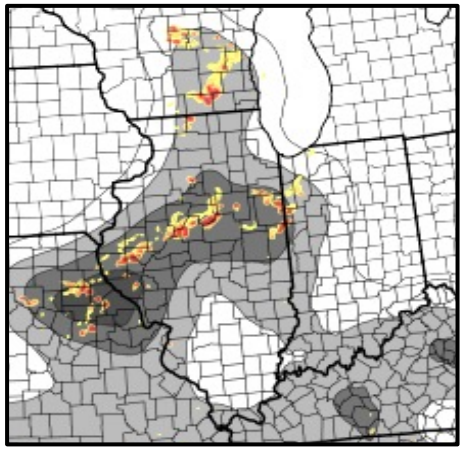
Creation and Use of Probabilistic Forecasts in Aviation: the Ensemble Rapid Refresh Forecast System (RRFS)



All the different forecasts



Distribution of extreme events



Probabilities & most likely scenario

1. **In 2024 NOAA will implement a 10-member high-resolution ensemble prediction system (RRFS-ensemble)**
2. **We are already using all kinds of ensemble techniques**

How can we best use high-resolution ensemble information?

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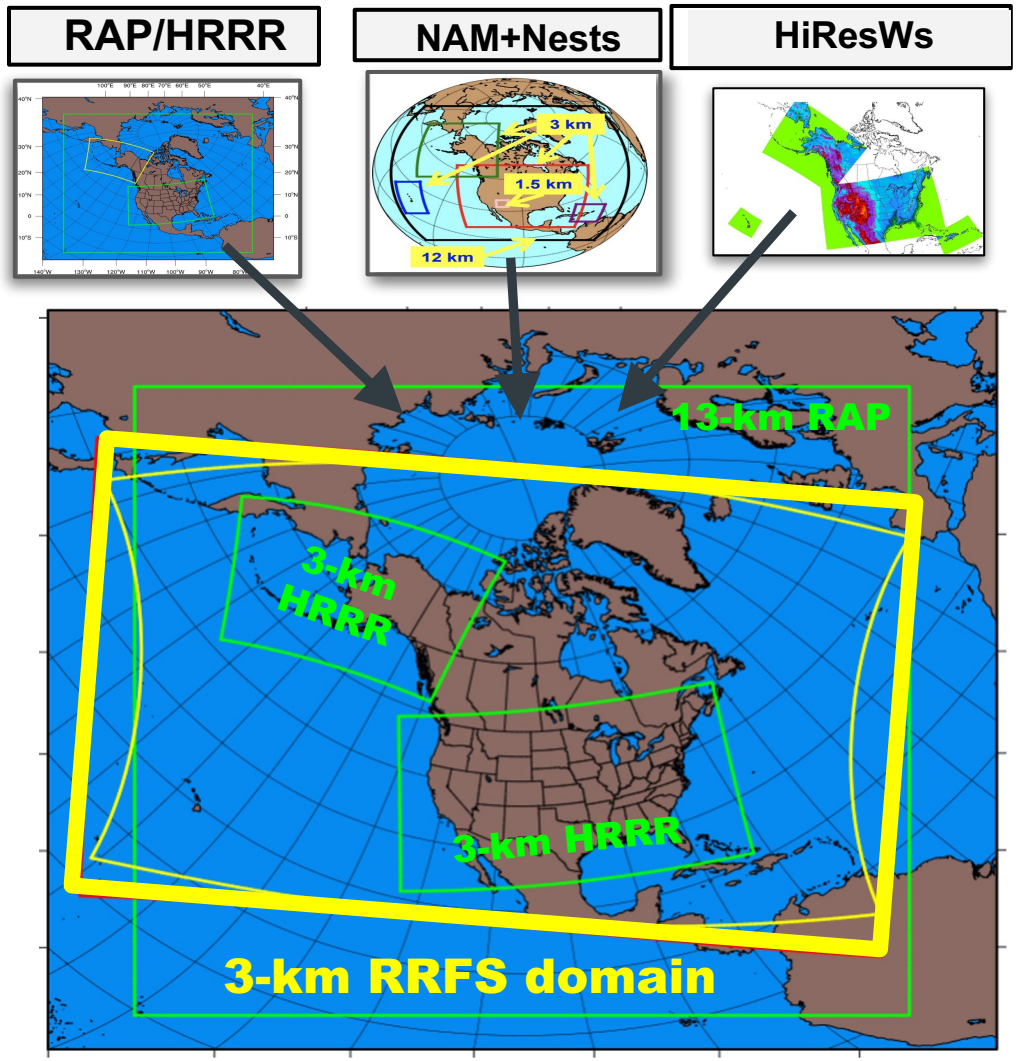
Rapid Refresh Forecast System (RRFS)

- **Keep hourly updating using all observations**
- **Keep 3 km grid horizontal grid spacing**
- **Expanded domain compared to HRRR**
- **Increased vertical resolution**
  (65 vertical levels vs. 50 for HRRR)
- **Deterministic forecasts to 18h every hour**
- **Ensemble forecasts to 60h every 6 hours**
  10 different forecasts ➔ "range of outcomes"

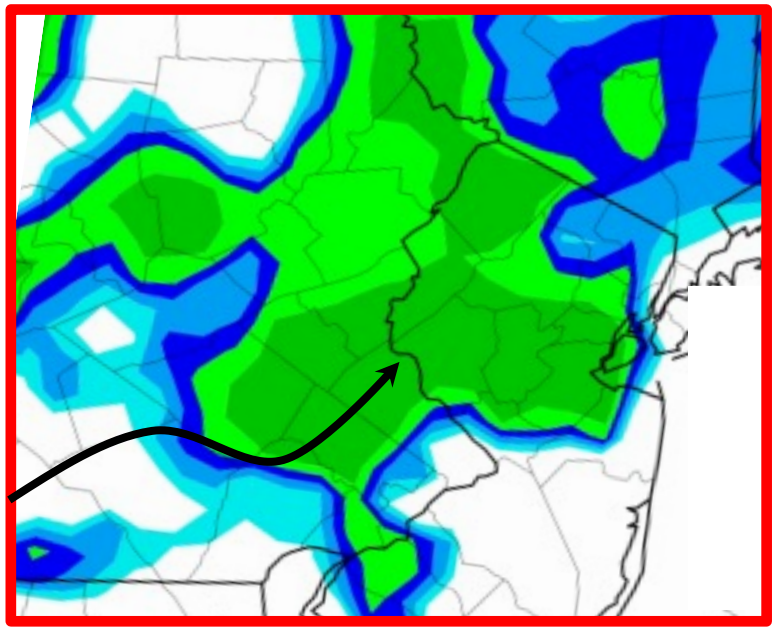
- Ensemble spread → forecast confidence
- Probability forecasts for specific weather hazards (convection, icing, low C&V, turbulence, winds)
- Identify potential extreme outlier events

Unification of existing NCEP systems

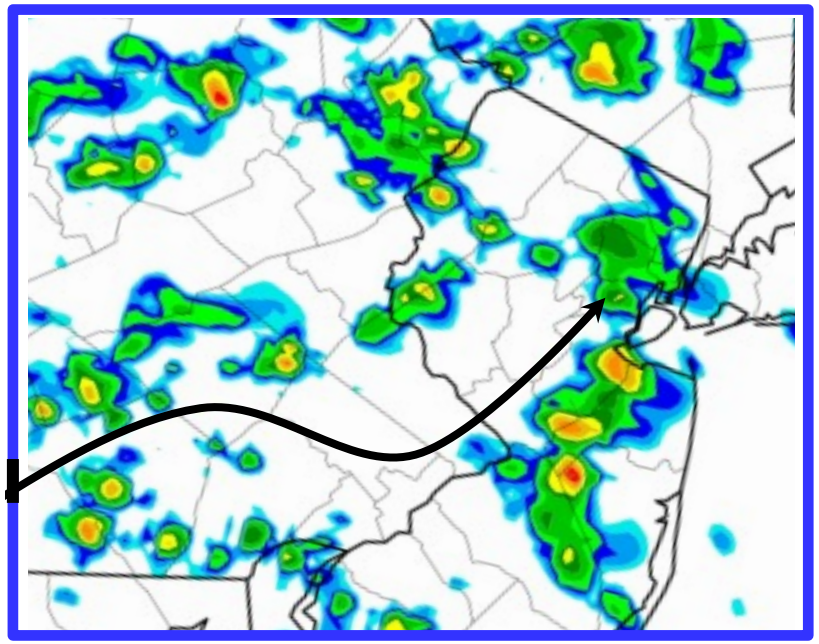


More detailed model more accurate overall, features do not have 1:1 match with observations

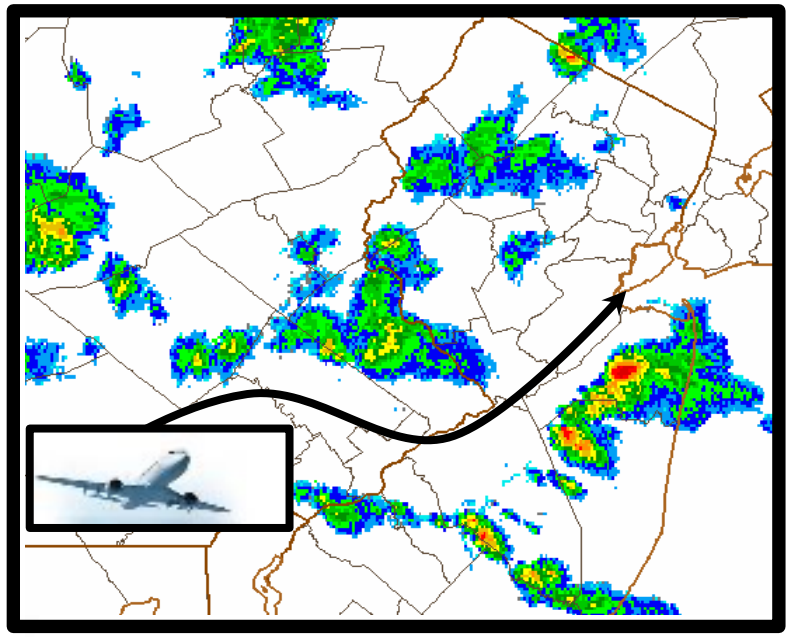
RAP 13 km



HRRR 3 km

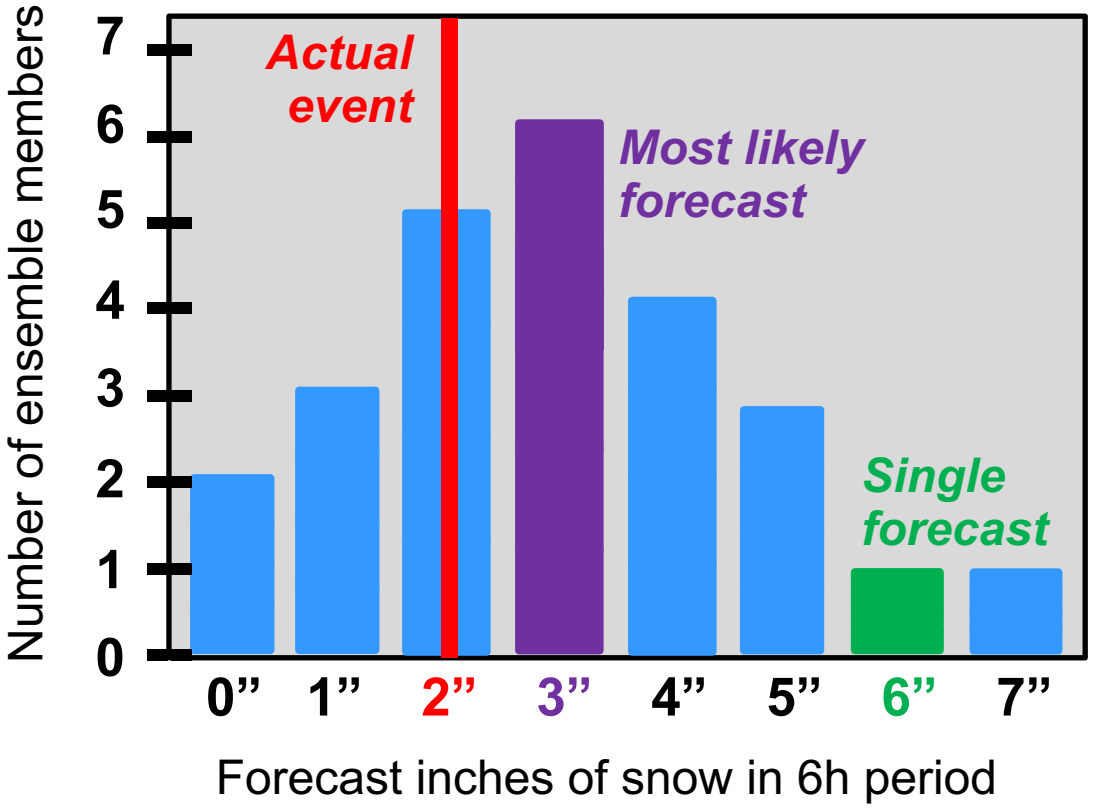


Radar Observations



Need to find optimal “translations” to map from very detailed forecast to most useful guidance

What do we get from an ensemble weather prediction system?

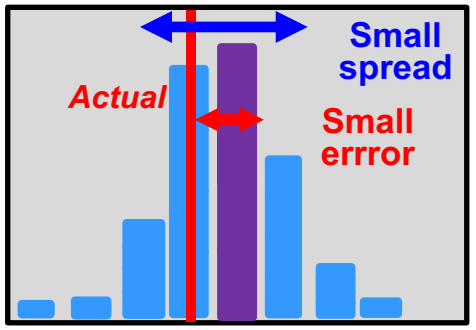


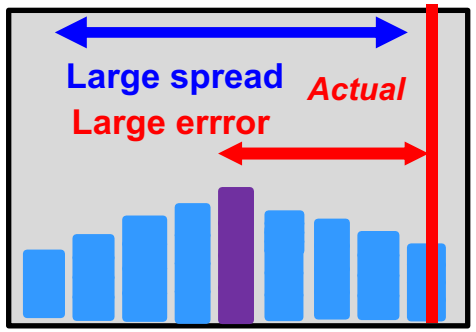
Sample 25 member ensemble spread of forecasts of 6-h snow (inches) at an airport

1. **The “ensemble” provides a good estimate of the “range of possible weather outcomes”**
2. **If we just have a single “deterministic” forecast, we might be getting a less likely forecast**
3. **On average, the “most likely forecast” from the ensemble will be better than the single “deterministic” forecast**
4. **If a single forecast scenario is desired, it can be constructed from the ensemble**

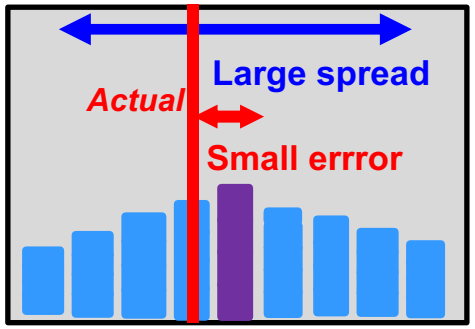
What makes a good ensemble and two key questions

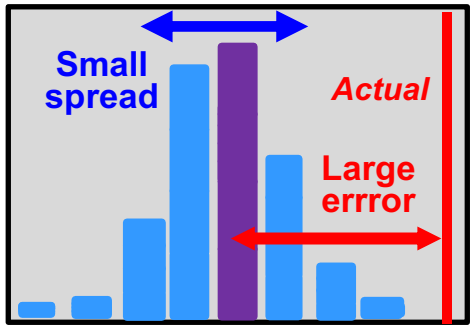
1. The ensemble should have a good "spread-skill" relationship
2. The observed event should be included within the "range" of the ensemble





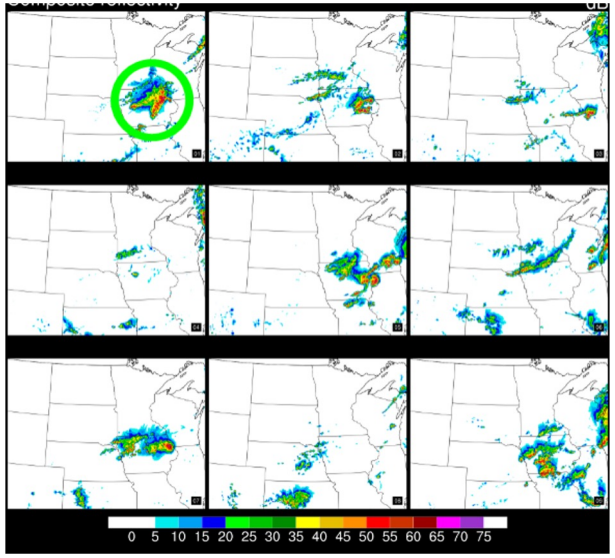
Good



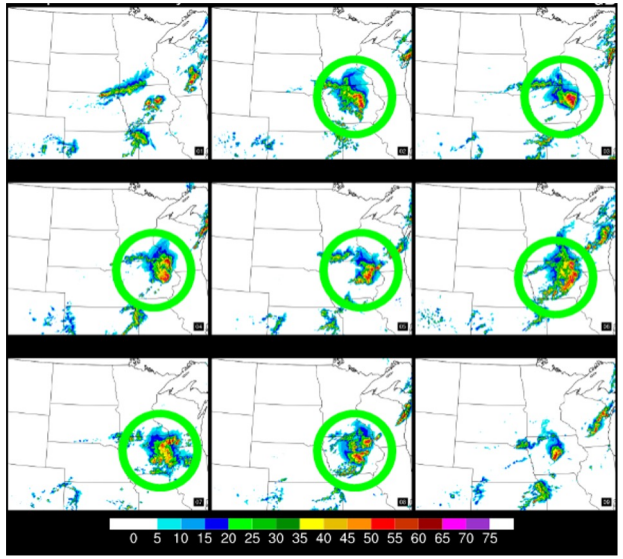


Bad

1. How can we most effectively present and use "spread" information?
2. At what lead-time should we "act" on ensemble outlier information?



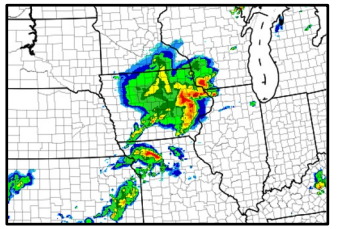
1/9 "hits" at 30-h lead time



7/9 "hits" at 12-h lead time

Radar observations
18z 10 Aug. 2020

IA/IL derecho 10 Aug. 2020



Key points for hi-resolution, frequently updated ensemble model guidance for aviation

1. High resolution, frequent updating models provide best chance to accurately depict weather details with greatest lead-time (especially with more observations to “guide” the model)
2. Highest resolution model features will not be 1:1 with observations, need translation algorithm to best use hi-res information.
3. Ensembles can provide helpful information on range of outcomes, can use to generate probabilities and “most likely” specific scenarios
4. Model producers need to maximize skill AND spread-skill relationship to enable maximum confidence a maximum amount of the time
5. Knowledge of model ensemble characteristics as function of forecast lead time AND of application specific cost-loss aspects can guide optimal use of ensembles and especially outlier information.