



# Event-based Verification and Evaluation of NWS Gridded Products: The EVENT Tool

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NOAA/ESRL/GSD

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# FIQAS

- Forecast Impact and Quality Assessment Section
- Mission: Advance the understanding and use of weather information through impact-based assessments and targeted information delivery to benefit decision making in response to high-impact weather events
- Primary activities
  - Independent assessments of quality and skill of aviation weather forecast products in or transitioning to NWS or FAA operations
  - Development of technologies to present and/or disseminate quality and skill information for analysis and decision support

# EVENT Background

- Tool development sponsored by NWS
- Supports NWS efforts to measure forecast accuracy relative to aviation traffic flow management decisions
- Skill information is framed by requirements established by the Traffic Flow Management Weather Requirements Working Group (TRWG)

# TRWG Requirements

DRAFT		Table N-4. Forecast Performance Values for Traffic Flow Management for Near- and Mid-Term Weather Support										DRAFT	
		Lead Time	Accuracy (minutes)		Probability of Detection		False Alarm Rate		Timing Error (minutes)		Location Error		
			Near Term	MOC	Near Term	MOC	Near Term	MOC	Near Term	MOC	Near Term	MOC	
Thunderstorms for Core Airports with: Probability ≥ 50% Area Diameter ≤ 150 nm	Time of Onset	0 - ≤ 2 h	± 15 min	± 10 min	≥ 80%	≥ 85%	≥ 20%	≥ 15%	± 15 min	± 10 min	≤ 3 nm	≤ 3 nm	
		> 2 - ≤ 4 h	± 30 min	± 20 min	≥ 75%	≥ 80%	≥ 25%	≥ 20%	± 30 min	± 20 min	≤ 3 nm	≤ 3 nm	
		> 4 - ≤ 6 h	± 45 min	± 30 min	≥ 70%	≥ 75%	≥ 35%	≥ 25%	± 45 min	± 30 min	≤ 3 nm	≤ 3 nm	
		> 6 - ≤ 8 h	± 60 min	± 45 min	≥ 65%	≥ 75%	≥ 40%	≥ 30%	± 60 min	± 45 min	≤ 3 nm	≤ 3 nm	
		> 8 - ≤ 18 h		± 60 min		≥ 70%		≥ 35%		± 60 min		≤ 3 nm	
		> 18 - ≤ 36 h		± 75 min		≥ 65%		≥ 40%		± 75 min		≤ 3 nm	
		> 36 - ≤ 48 h		± 90 min		≥ 60%		≥ 45%		± 90 min		≤ 3 nm	
	Time of Cessation	0 - ≤ 2 h	± 15 min	± 10 min	≥ 80%	≥ 85%	≥ 20%	≥ 15%	± 15 min	± 10 min	≤ 3 nm	≤ 3 nm	
		> 2 - ≤ 4 h	± 30 min	± 20 min	≥ 75%	≥ 80%	≥ 25%	≥ 20%	± 30 min	± 20 min	≤ 3 nm	≤ 3 nm	
		> 4 - ≤ 6 h	± 45 min	± 30 min	≥ 70%	≥ 75%	≥ 35%	≥ 25%	± 45 min	± 30 min	≤ 3 nm	≤ 3 nm	
		> 6 - ≤ 8 h	± 60 min	± 45 min	≥ 65%	≥ 75%	≥ 40%	≥ 30%	± 60 min	± 45 min	≤ 3 nm	≤ 3 nm	
		> 8 - ≤ 18 h		± 60 min		≥ 70%		≥ 35%		± 60 min		≤ 3 nm	
		> 18 - ≤ 36 h		± 75 min		≥ 65%		≥ 40%		± 75 min		≤ 3 nm	
> 36 - ≤ 48 h			± 90 min		≥ 60%		≥ 45%		± 90 min		≤ 3 nm		

# EVENT Techniques

- Event-based techniques developed as part of an assessment of NDFD as compared to other operational forecasts
- Evaluation of forecast performance in prediction of thunderstorms
- Terminal and en-route contexts
  - Terminal: Do forecasts accurately predict significant thunderstorms within a 75 nmi radius of the terminal?
  - En-route: Do forecasts accurately predict significant high-altitude thunderstorm activity that affects en-route flow along jetways in the northeast?
- Determine by lead time the temporal and spatial displacement error for event onset and cessation

# EVENT-based Techniques: Challenges

- Comparison of different forecasts ('apples-to-apples')
- Definition of an event
- Determining a forecast-observation event match
- Computing appropriate skill scores



# Forecasts

## Product

## Fields/Thresholds

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NDFD (5km)

Treated probabilistically, using Trace and Likely thresholds

RAP (hourly, 13.5km)

Convective Precip  $\geq$  1mm

LAMP (hourly, 2.5km)

Thunderstorm probability

# Observations

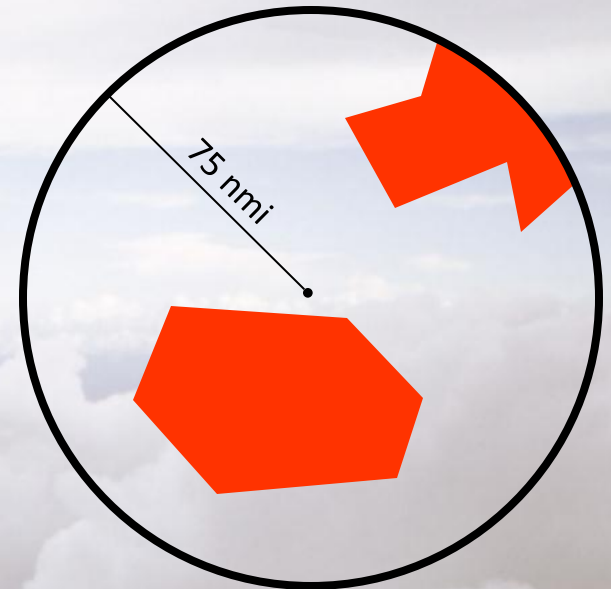
- Definition of a *thunderstorm*
  - Moist convection + lightning
- Thunderstorm observation produced by
  - Combining CIWS VIL (15 min, 1km) with National Lightning Data Network (NLDN) data

\*Note: Total lightning used to determine the CIWS VIL and NLDN strike characteristics needed to identify the presence of a thunderstorm

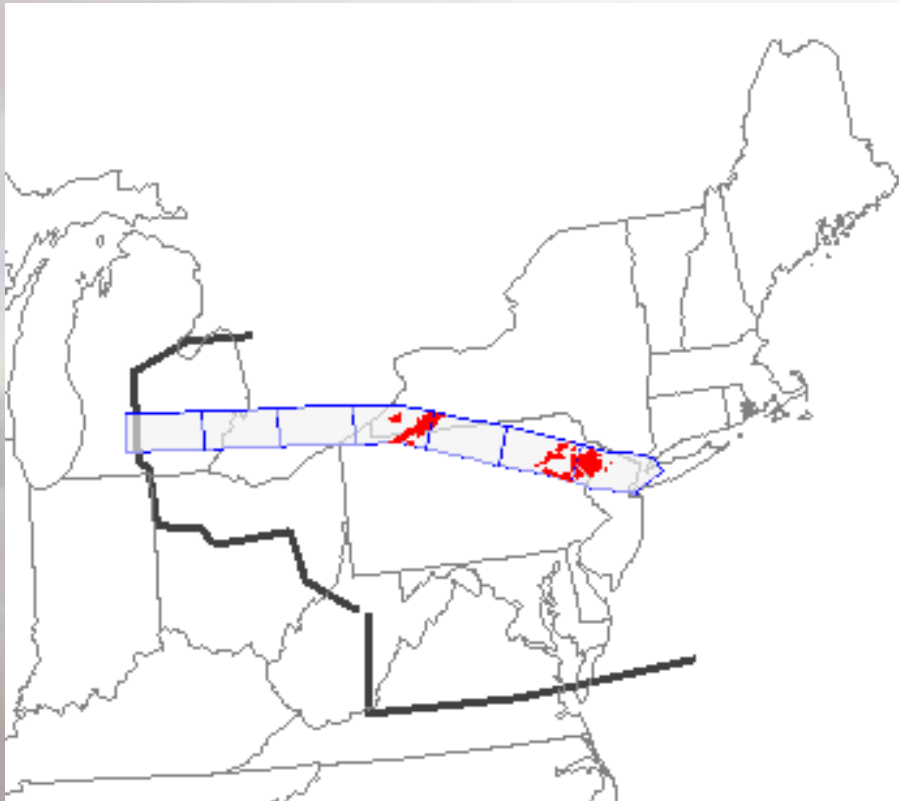


# Instantaneous Events: Terminal

- The domain of interest is 75-nmi radius around each of the core-30 airports
- Approach applies to both forecasts and observations
- The coverage of the forecast within terminal domain is computed
- Coverage weighted by probability for probabilistic forecasts
- If coverage exceeds 10%, an instantaneous thunderstorm event is identified



# Instantaneous Events: Jetway (En-route context)



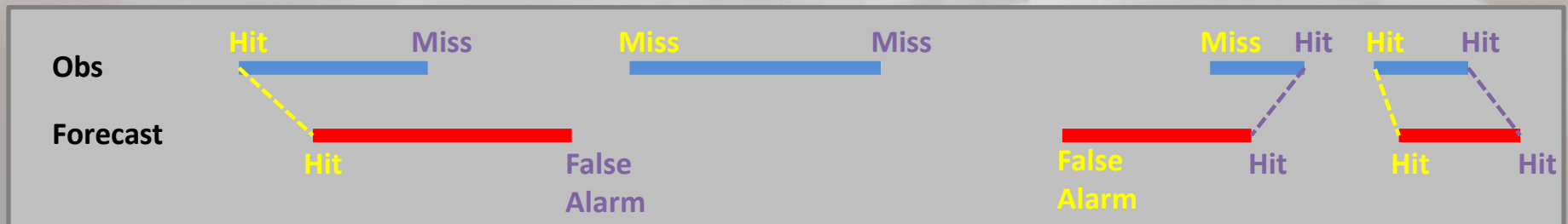
- High-traffic jetways intersecting/bounded by NE Flow Constrained Area boundaries (AFP 05 and 08)
- Three Jetway Regions
  - All, East-West, North-South
  - Combination of jet routes
- Jetway is buffered by 20nmi and partitioned into 40nmi segments
- If segment along a jetway is blocked with a Flow Constraint Index (FCI)  $\geq 0.5$ , then the jetway is blocked
- An instantaneous event occurs if 10% of all jetways within a region are blocked

# Merging Events

- Instantaneous events are merged, for both forecasts and observations, into events with duration
- Merging occurs per forecast lead
- ‘NDFD Centric’ merging criteria was applied: Instantaneous events are merged into a larger event if time between events is less than 3 hours
- If NDFD is excluded, 1 hour merging criteria is applicable

# Matching of Merged Events

- Onset and cessation are treated separately
- Matches are computed per forecast lead
- Temporal criteria for a match is applied using a 3 hour window
- Pairings are optimized according to the Gale-Shapley (1962) procedure

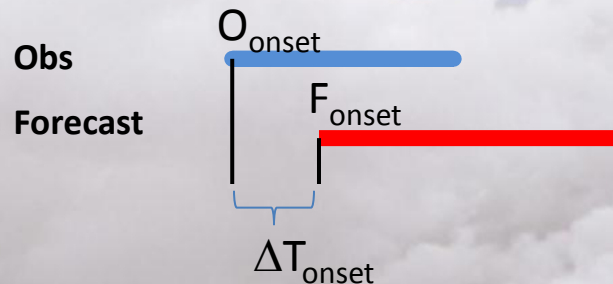


# Temporal Displacement

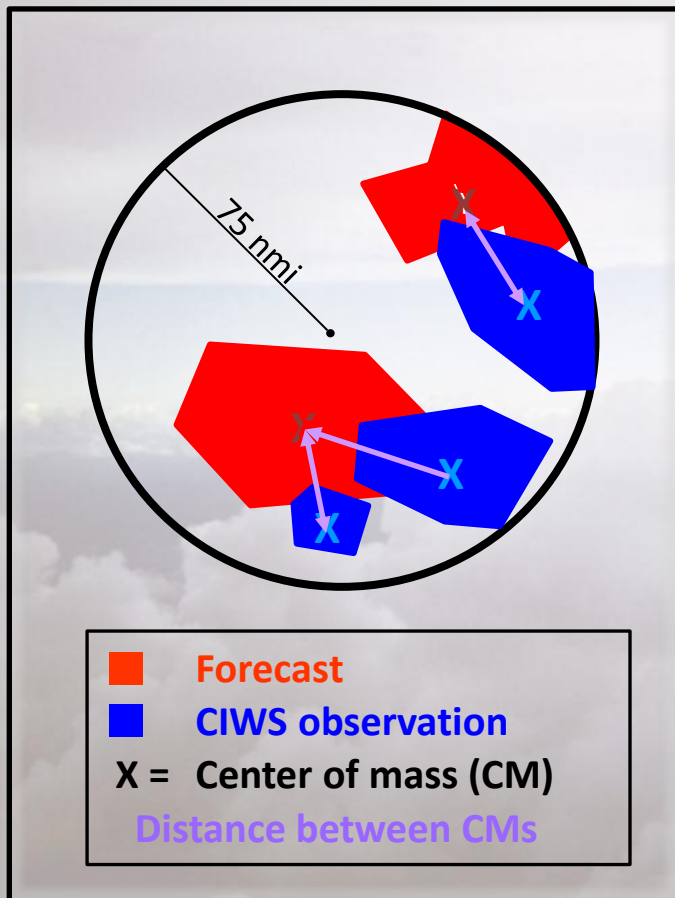
- Displacement can be calculated only for matched onsets and cessations

$$\Delta T_{\text{onset}} = F_{\text{onset}} - O_{\text{onset}}$$

$$\Delta T_{\text{cessation}} = F_{\text{cessation}} - O_{\text{cessation}}$$



# Spatial Displacement



- For all matched onset and cessation pairs
  - Center of mass is weighted by forecast probability
  - The average of the minimum distances between all forecast objects and observation objects yields the spatial displacement

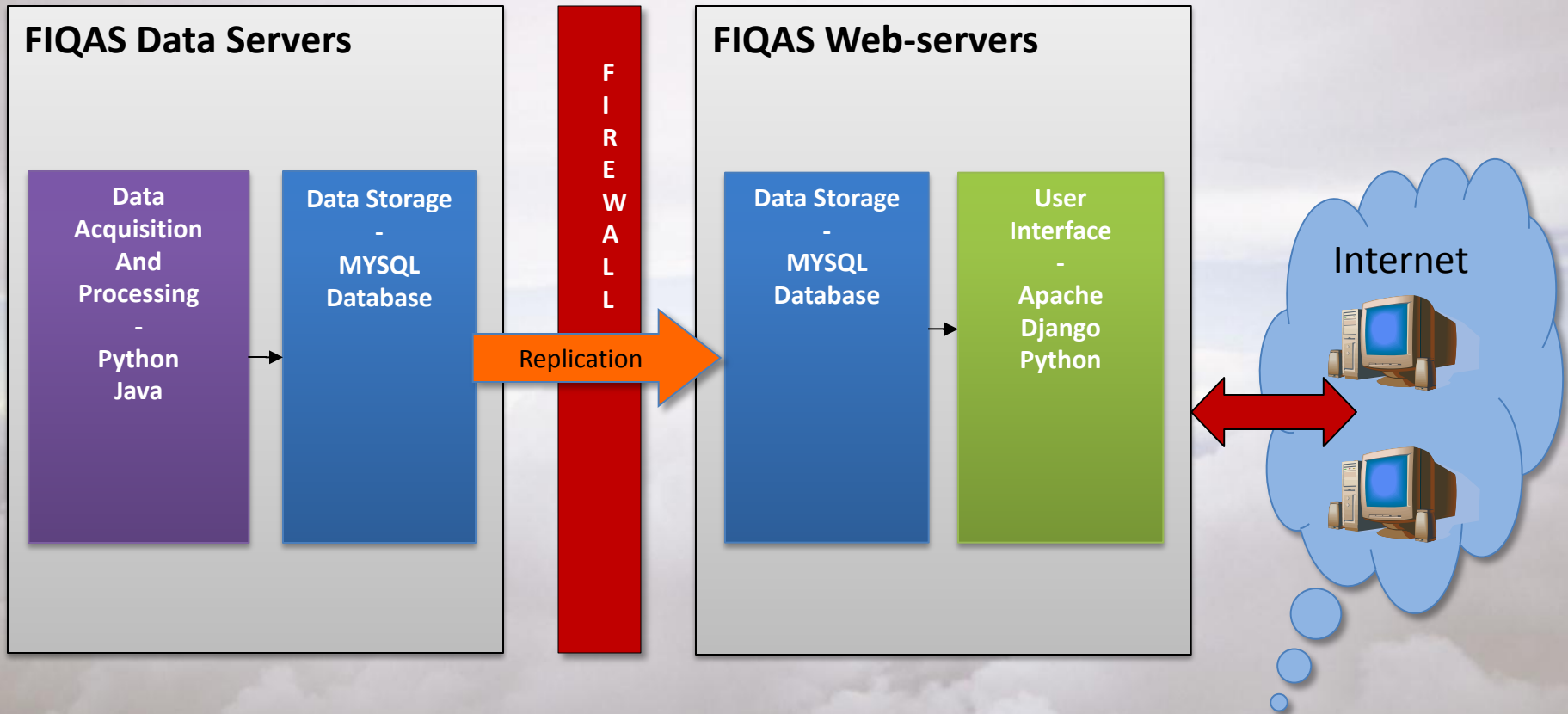


# Metrics

For onset and cessation, the following statistics are computed:

- POD—(Probability of Detection) Percentage of all observed events that are correctly forecast
- FAR—(False Alarm Ratio) Percentage of all forecasts that are incorrect
- CR— (Correspondence Ratio= ratio of intersection to union) A measure of agreement of forecasts and observations
- Displacement
  - Spatial
  - Temporal

# EVENT Architecture



# EVENT DEMO

An aerial photograph of a city, likely Los Angeles, viewed from a high altitude. The foreground is dominated by a thick layer of white, fluffy clouds. In the middle ground, a small airplane is visible in flight, positioned slightly to the left of the center. The city below is a dense grid of buildings, with some lights visible. The sky above is filled with soft, grey clouds, suggesting an overcast day.

# Future Work

- Incorporate HRRR into tool
- Incorporate MRMS as a replacement for CIWS
- Enhance en-route techniques (FCI)
- Develop 'Event viewer' to view accuracy for specific events

# QUESTIONS?

# More Information

- Contact: Missy Petty,  
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- EVENT URL:  
<http://esrl.noaa.gov/fiqas/tech/event/>