Initial Assessment of Forecast Performance in Predicting Wind Shear Conditions Conducive to Wind Compression

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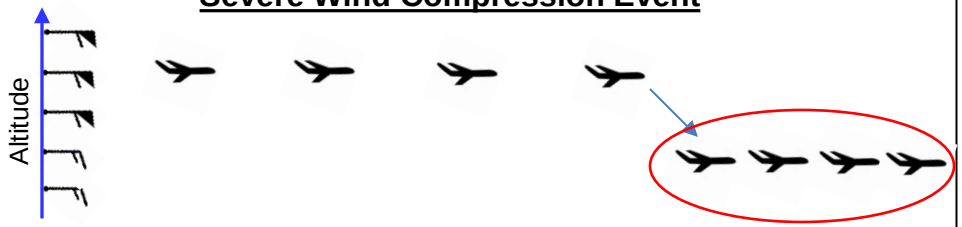
Two Components of Wind Compression Events

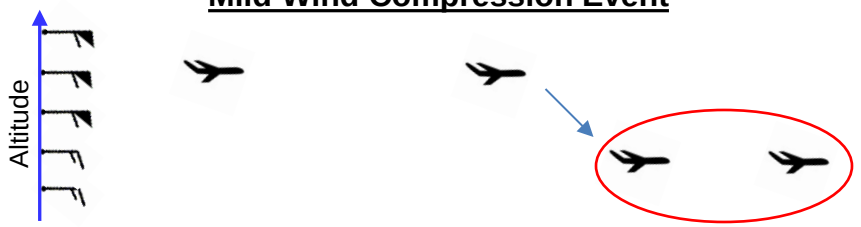
- Specific meteorological wind shear conditions may manifest as wind compression events of differing severity depending on air traffic volume and active airspace configuration (i.e., operational sensitivity)
  - Wind shear environment "sets the stage" for potential wind compression events
    - Not translated into a wind compression event unless it disrupts air traffic flow
    - Shear can have varying "magnitudes" depending on differences in wind vectors with altitude
  - Sufficient traffic demand, relative to operational capacity, necessary to create wind compression event
    - Per airport dependency (route congestion, arrival capacity, etc.)
  - Combination of wind shear environment and air traffic volume "magnitudes" dictates severity of wind compression event

Severe Wind Compression Event

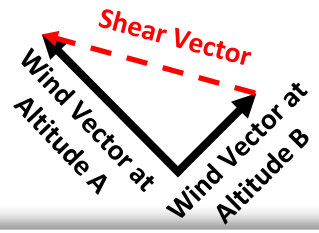


Severe shear **High** Operational Sensitivity

Mild Wind Compression Event



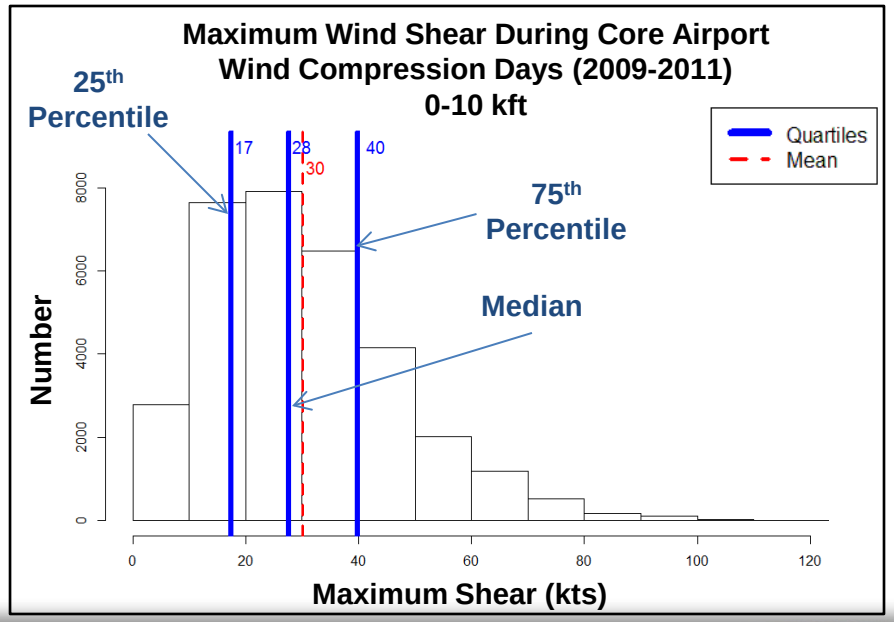
Severe shear **Low** Operational Sensitivity

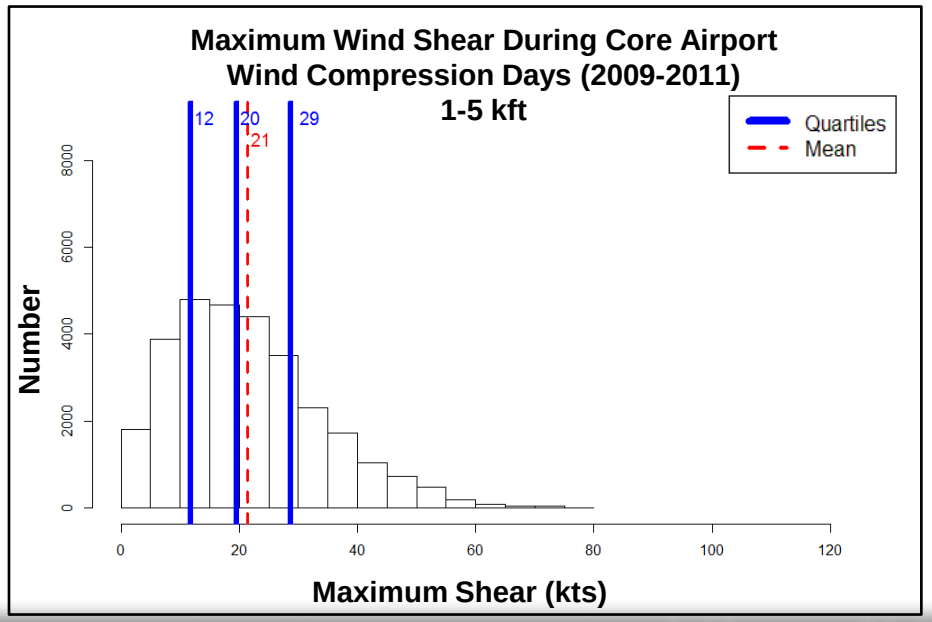


Wind Compression		Operational Sensitivity		
		Low	Moderate	High
Wind Shear	Mild			
	Moderate			
	Severe			

Identification of Critical Wind Shear Values

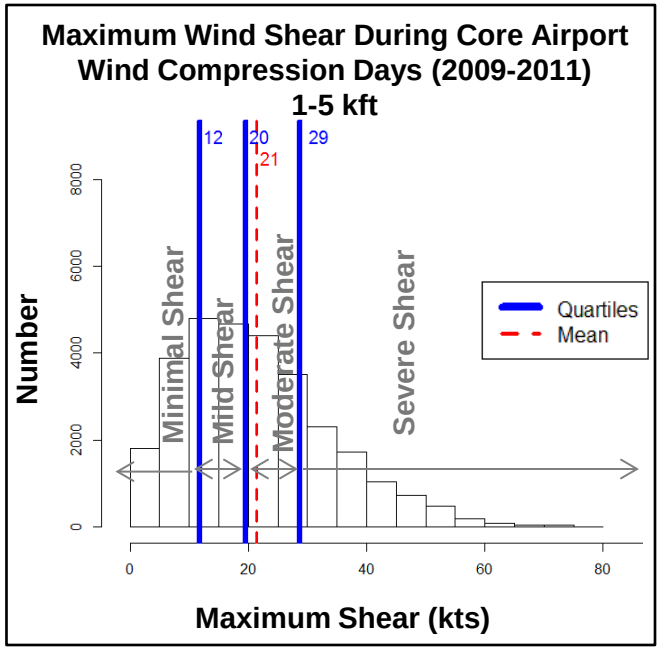
- Isolate key wind conditions conducive to wind compression events prior to consideration of operational dependencies
- Generated distribution of maximum wind shear values at Core airports during historical wind compression days (2009-2011) at both target altitude layers (0-10 kft, 1-5 kft)
  - Distributions are representative of wind shear conditions during wind compression at all airports
- Three critical statistically significant wind shear values identified from representative maximum wind shear distributions
  - Identified independently in both target altitude ranges (0-10 kft and 1-5 kft)
  - Can be used to define four categories of wind shear magnitude





Preliminary Wind Shear Magnitude Categories

- Four wind shear categories determined from critical values in representative maximum wind shear distributions
  - Identified independently for both altitude layers
    - Wind speeds greater at high altitudes, which can produce greater quartile shear values for 0-10 kft layer
    - Using same categories for both could cause mis-categorization of shear conditions
  - Round quartile values to nearest 10 kts
  - Categories defined by maximum wind shear ranges between critical thresholds

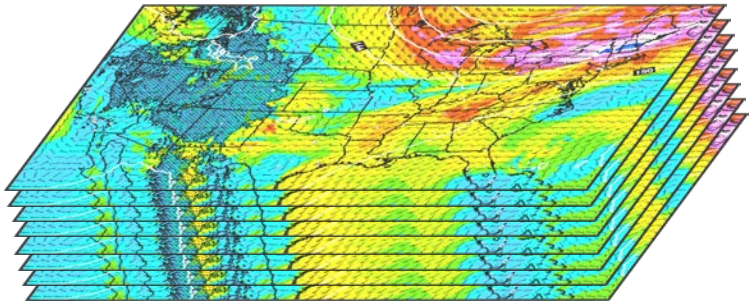


- These categories used to assess the skill of both forecast products (HRRR, SREF) at predicting wind shear conditions during historical wind compression events (Dec 2013 – Jan 2014)

	Minimal Wind Shear (kts)	Mild Wind Shear (kts)	Moderate Wind Shear (kts)	Severe Wind Shear (kts)
0-10 kft	< 20	20-30	30-40	> 40
1-5 kft	< 10	10-20	20-30	> 30

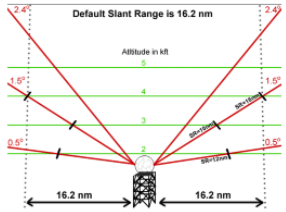
Target Wind Shear Products

High Resolution Rapid Refresh (HRRR) 3D Wind Forecast



- Wind predictions at 49 altitudes
- Operational in 2014 and currently used by ATM decision makers for situational awareness
- 3 km horizontal spatial resolution
- Issued hourly with 1 hour forecast increments out to 15 hours lead time

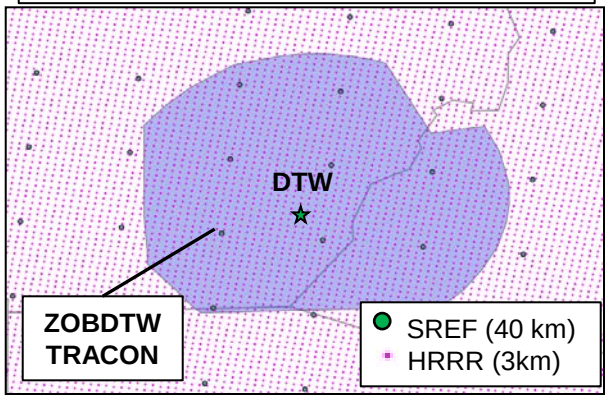
NEXRAD Vertical Wind Profile (VWP) Observations



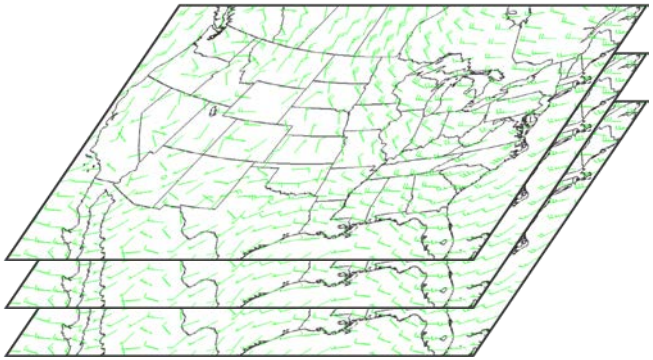
From Chrisman and Smith (2009)

- Radar locations within miles of the Core airports
- Observations taken every 10 minutes
- Vertical wind profile constructed from observations at various elevation angles

Forecast Grid Spacing



Short Range Ensemble Forecast (SREF) 3D Wind Forecast



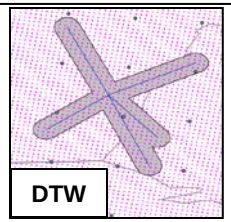
- Wind predictions at 8 altitudes
- Operational use for situational awareness
- 40 km horizontal spatial resolution
- Hourly forecasts issued four times a day (3Z, 9Z, 15Z, 21Z) out to 87 hours lead time

Forecast Analysis - Experiment Design

- Validate 1-6 hour forecasts of wind shear conditions at low altitudes at each hour during 69 NTML defined wind compression events from Dec 2013 – Jan 2014 at 8 target airports
  - Focus on airports with greatest frequency of events (ATL, DTW, EWR, JFK, LGA, LAX, PHL, DCA)
  - Validate forecasts for key arrival altitude layers (0-10 kft, 1-5 kft) on appropriate spatial scales

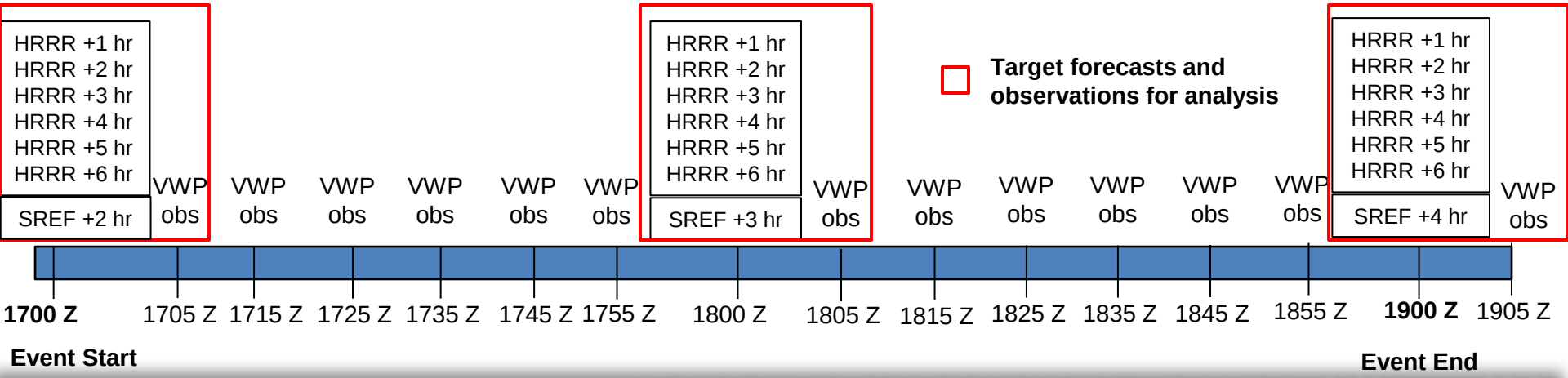
TRACON Scale

Arrival Flows



SREF (40 km)
HRRR (3km)

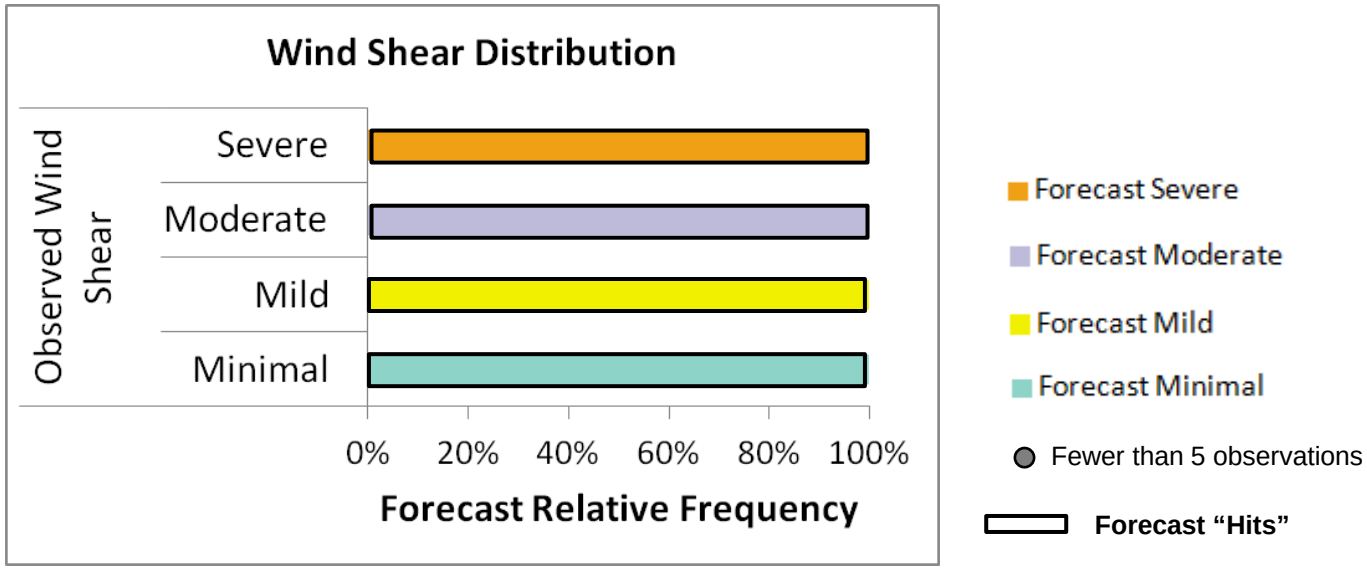
  - Compare each hourly lead time forecast to observations during target events
    - Only one lead time SREF forecast available at every hour during each event (03Z, 09Z, 15Z, 21Z only)
  - Enables evaluation of temporal performance needs for wind shear prediction



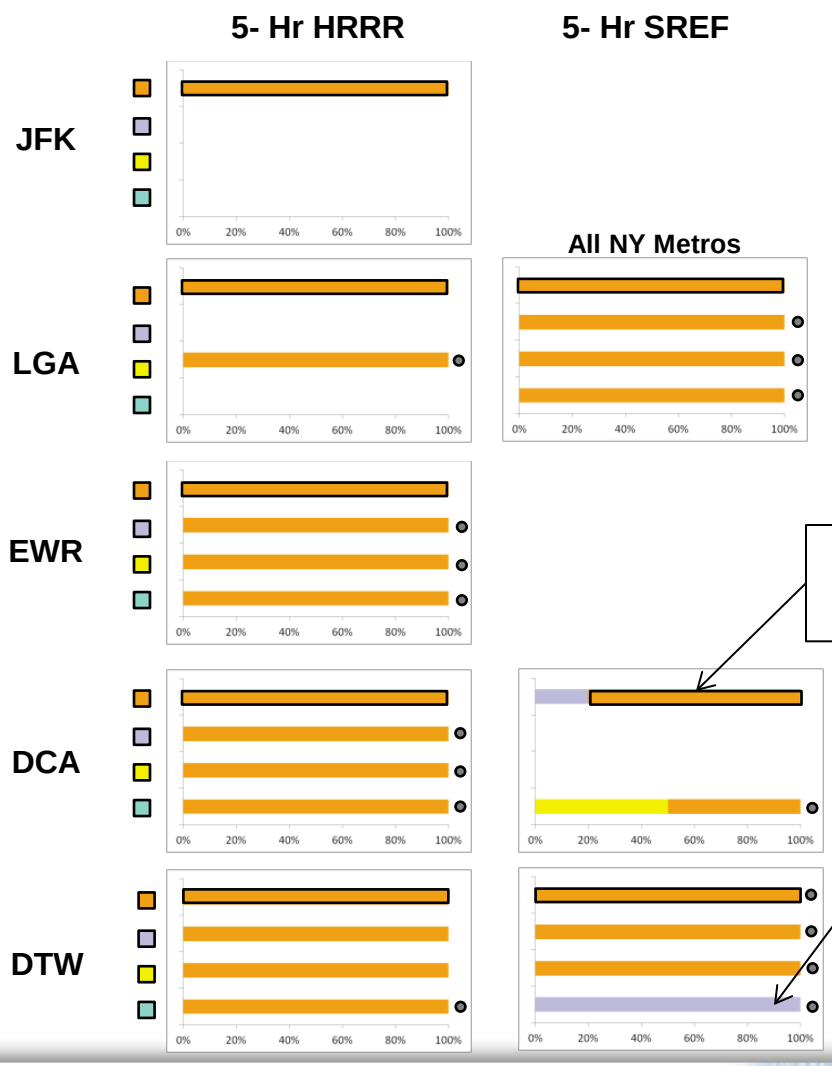
Assessing Forecast Performance

- Evaluate relative forecast frequency for observations in each wind shear category for each combination of lead time, airport, and altitude layer
  - Generated distribution of forecasted wind shear categories for those observations
    - No frequencies shown if there were no observations in a given wind shear category
  - Forecast accuracy expressed by percentage of observations correctly predicted (“hits”)
    - Large portion of correctly predicted observations (wider black box) indicates good forecast skill of that category
  - Small number of observations in a given wind shear category can produce misleading frequencies
    - Highlight scenarios with fewer than 5 observations in that wind shear category

Perfect forecast: 100% hits in each observed wind shear category →



Sample of Forecast Performance Results: 0-10 kft

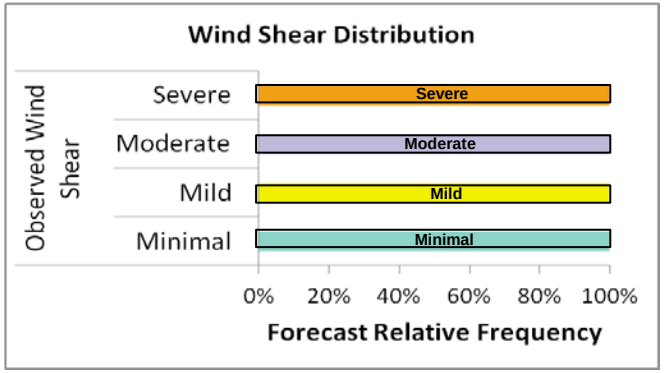


- Most observed severe wind shear events correctly predicted by HRRR and SREF at all target airports
- HRRR and SREF tended to significantly over-forecast mild or moderate wind shear observations
  - May create challenges in predicting potential for wind compression
  - May affect ability to predict event onset and cessation
- Limitation in sample size due to SREF issuance frequency (every 6 hours)
  - Results combined across NY Metro airports

80% of severe wind shear observations were **"hits"** (correctly predicted to be severe)

All minimal wind shear observations predicted to be moderate, indicating **over-forecasting**

Perfect forecast



Ongoing Efforts

- Generate refined airport-specific wind shear category definitions
  - More appropriate consideration of regional wind climatology
  - Will enable meteorological identification of significant wind shear events independent of operational impacts (NTML logs)

- Evaluate forecast performance at predicting operationally critical onset of significant wind shear conditions
  - Identify historical wind shear events using refined shear categories
  - Assess forecast performance at predicting timing and severity of wind shear conditions at their onset

- Assess utility and skill of wind shear forecasts relative to operational sensitivity
  - Incorporate considerations of traffic volume and active airspace configuration to more completely characterize wind compression and assess overall event prediction capability
  - Evaluate wind shear forecast performance relative to individual arrival flows
    - Explicitly consider direction of shear vector relative to traffic flow direction at each airport (headwind/tailwind)
    - Evaluate forecast accuracy along each arrival flow path independently

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