UPDATE: Aircraft-Derived Atmospheric Observation Data

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FPAW Fall Meeting

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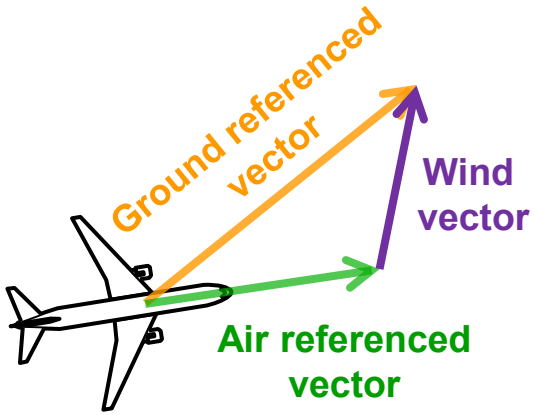
Outline

- Review of Summer FPAW Presentation
- Initial Comparison of MDCRS and EHS ADO Wind Estimates
- FAA Radars and Candidate Site Modifications
- Summary

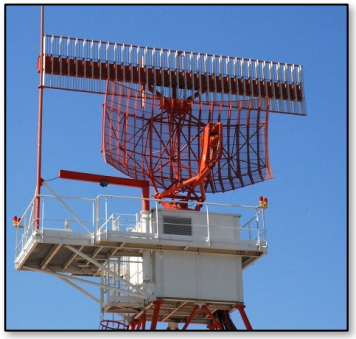
Aircraft-Derived Observations

- **Aircraft measurements can be used for atmospheric observations**



- **Meteorological Data Collection & Reporting System (MDCRS) is current airborne source**

- **Mode S Enhanced Surveillance (EHS) widely available now**



ADS-B = Automated Dependent Surveillance – Broadcast

Observation System Comparisons

Observation Source	Horizontal Coverage	Vertical Range	Update Period	Latency	Comment
ASOS	900 sites many at airports	Surface only	20 mins/ 1 min	<1 min	Used primarily for airport operations
Radiosondes	69 sites in CONUS	Ground to >100 kft	12 hours	< 2 hrs	Used primarily for forecast input data
MDCRS	Limited fleet coverage (~20% current US fleet)	Ground to typical cruise altitudes	1 min ascent/ descent 7 mins cruise	17 mins Average Range (7 → 60+ mins)	Used primarily for forecast input data
Mode S EHS	Growing fleet coverage (>50% current US fleet)	Ground to typical cruise altitudes	4.8-12 secs	Seconds	Useful for forecast & real-time operations
ADS-B Wx Out (future)	None now, could be meaningful % in future	Ground to typical cruise altitudes	~10 secs	Seconds	Specifications not planned until at least 2019

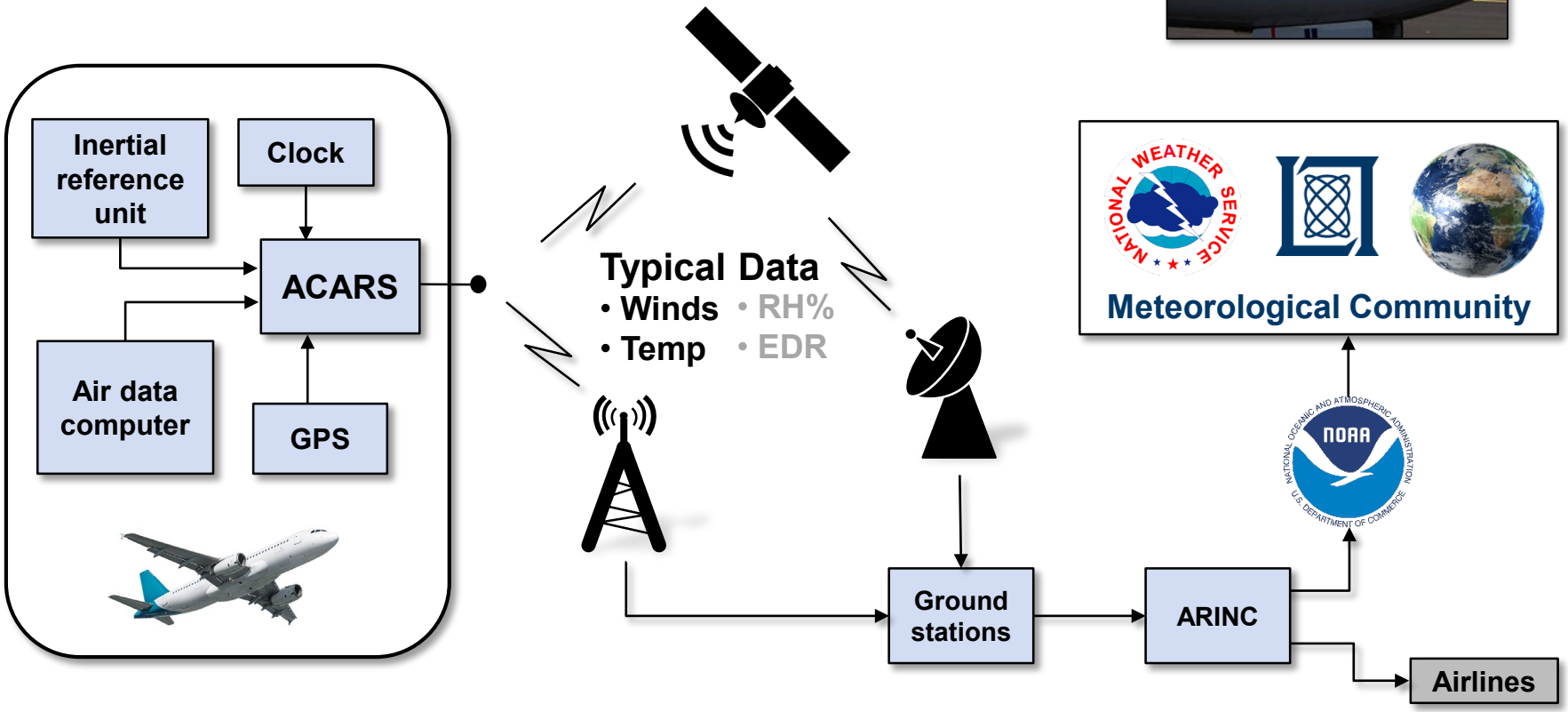
Available Aircraft-Derived Observations

Aircraft-derived observations via Mode S EHS can be generated today without modifications to aircraft

ASOS = Airport Surface Observation System
MDCRS = Meteorological Data Collection & Reporting System
Mode S EHS = Mode S Enhanced Surveillance

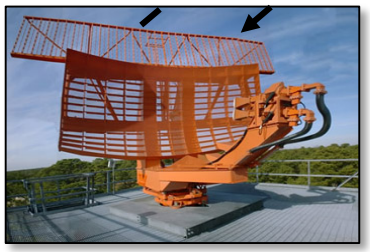
Current System Characterization

- **MDCRS: North American, 11 airlines reporting**
- **E-AMDAR: Europe, 14 airlines reporting**

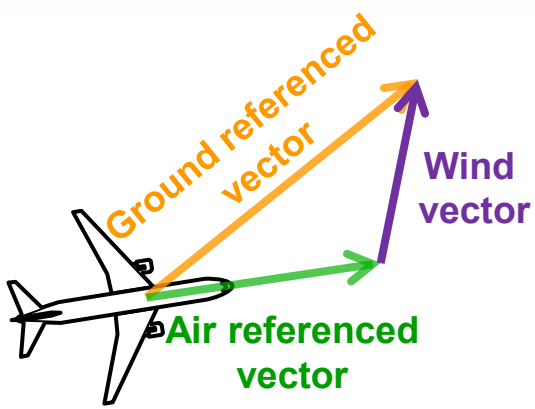


E-AMDAR = European Aircraft Meteorological Data Relay
ACARS = Aircraft Communications Addressing and Reporting System
RH = Relative Humidity EDR = Eddy Dissipation Rate

Mode S EHS Based Observation System



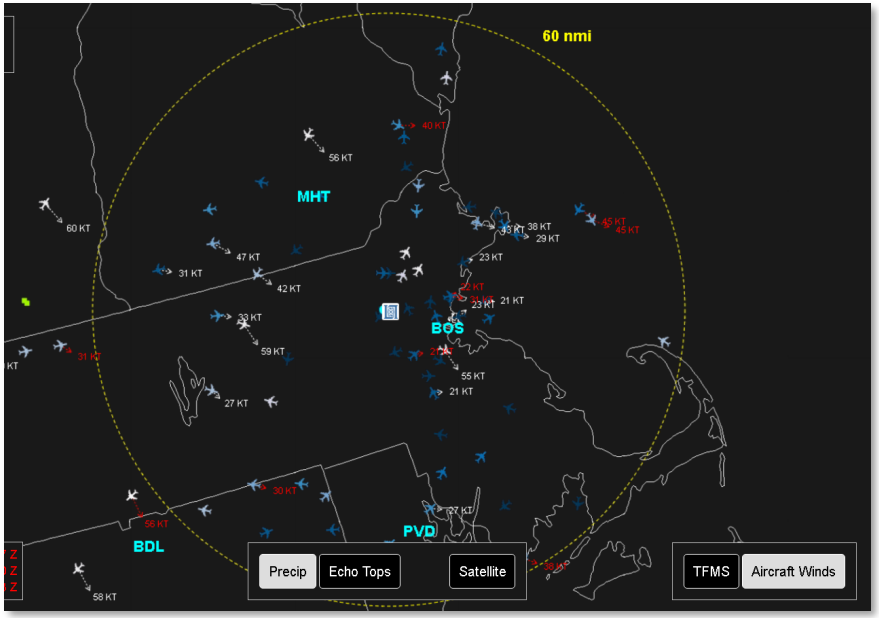
4.8 or 12 secs update rate



Register	Content	Comment
0x50	• Ground speed • True air speed • Roll angle • Track angle	Used to estimate • Wind speed • Wind direction • Temperature
0x60	• Mag heading • Mach • Altitude rate	
0x44	• Wind speed/dir • Temperature	About 5% of EHS A/C populate

Lincoln Mode S EHS Aircraft-Derived Observation Evaluation

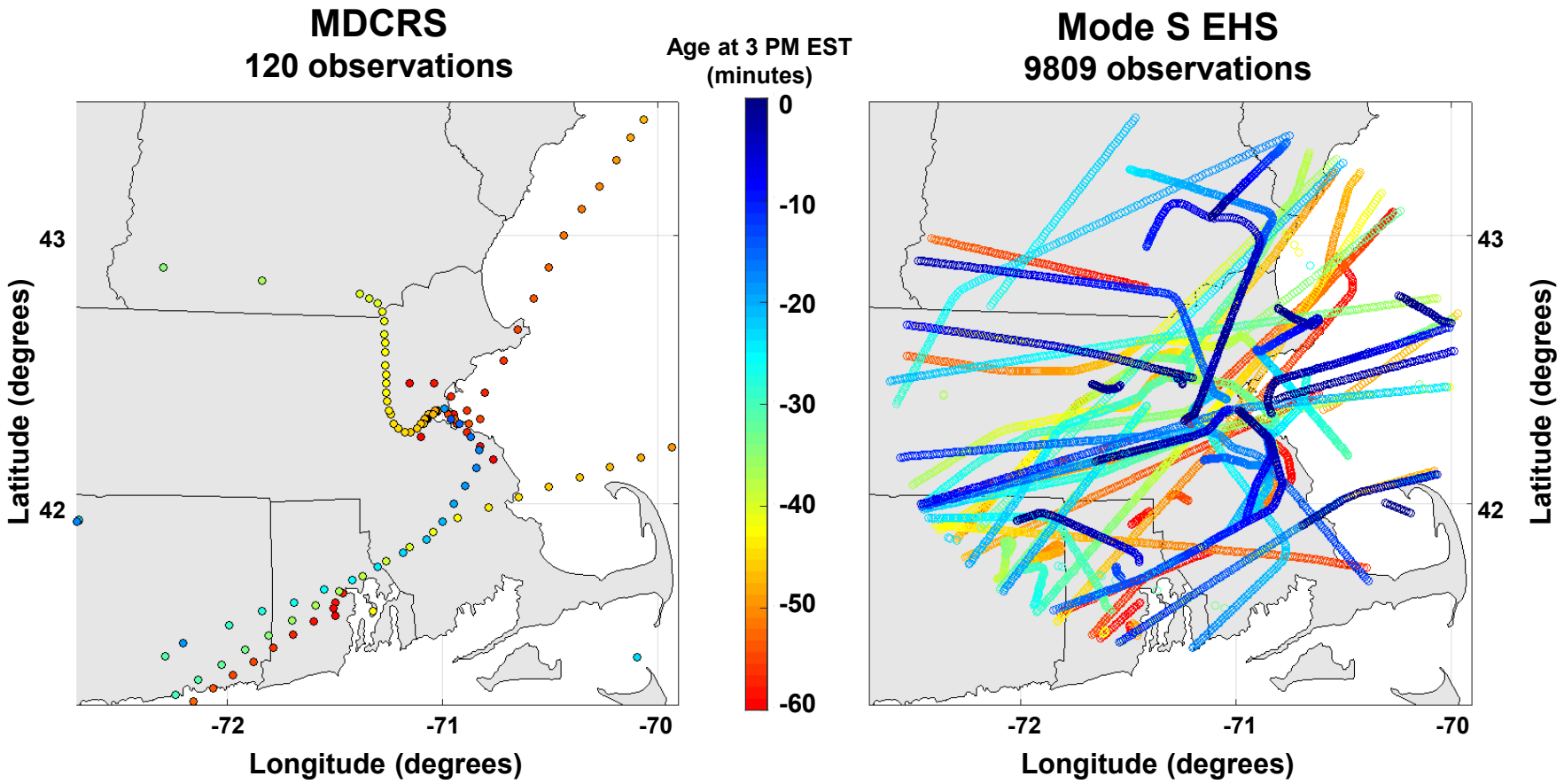
- **FAA Mode S radars do not currently interrogate relevant registers***
  - **Could do so with reasonable adaptations**
- **Lincoln MODSEF has been adapted to interrogate aircraft within range (60 nmi radius)**



*FAA's Fremont Valley BI6 radar at Edward's AFB, which feeds High Desert TRACON (E10), conducts EHS interrogations

Comparison of MDCRS & Mode S EHS Observations Around KBED/KBOS

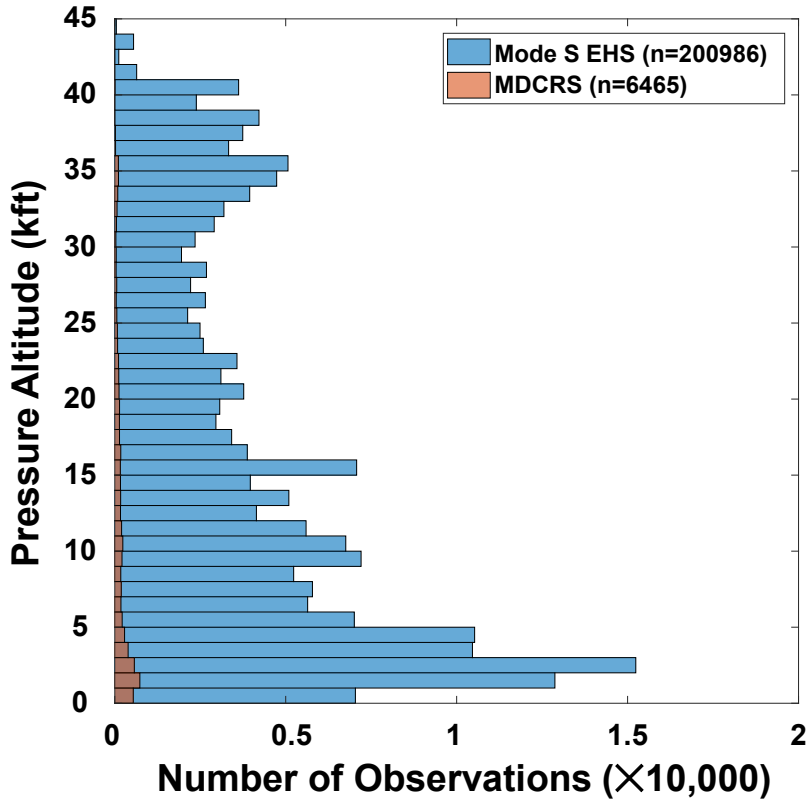
Nov 1, 2017
2-3:00 PM EST

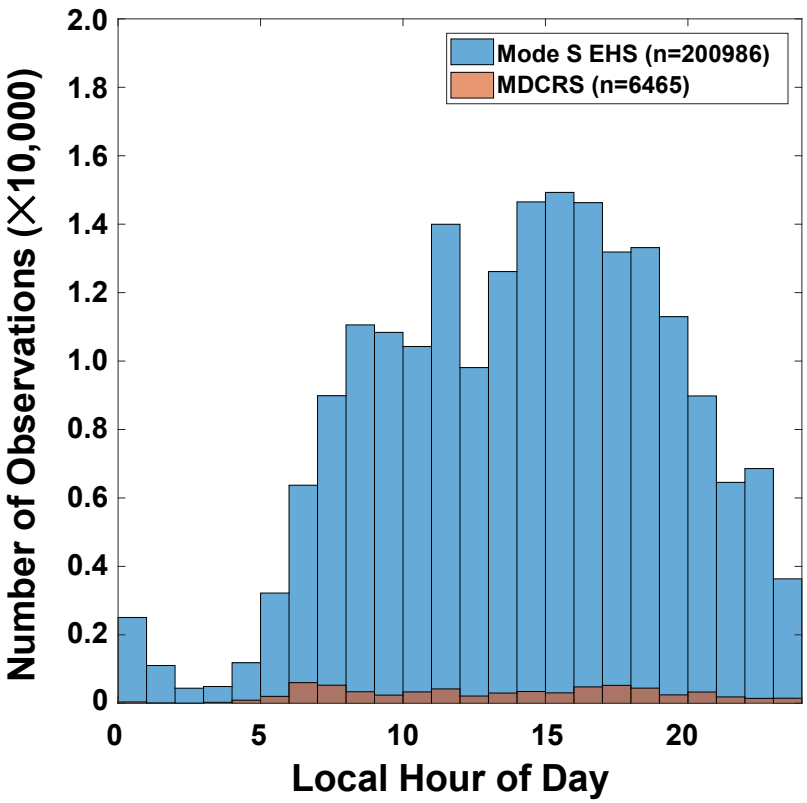


>80x increase in atmospheric observations with Mode S EHS vs MDCRS in this case

Comparison of MDCRS & Mode S EHS Observations Around KBED/KBOS

Nov 1, 2017
Observations across 24 hours

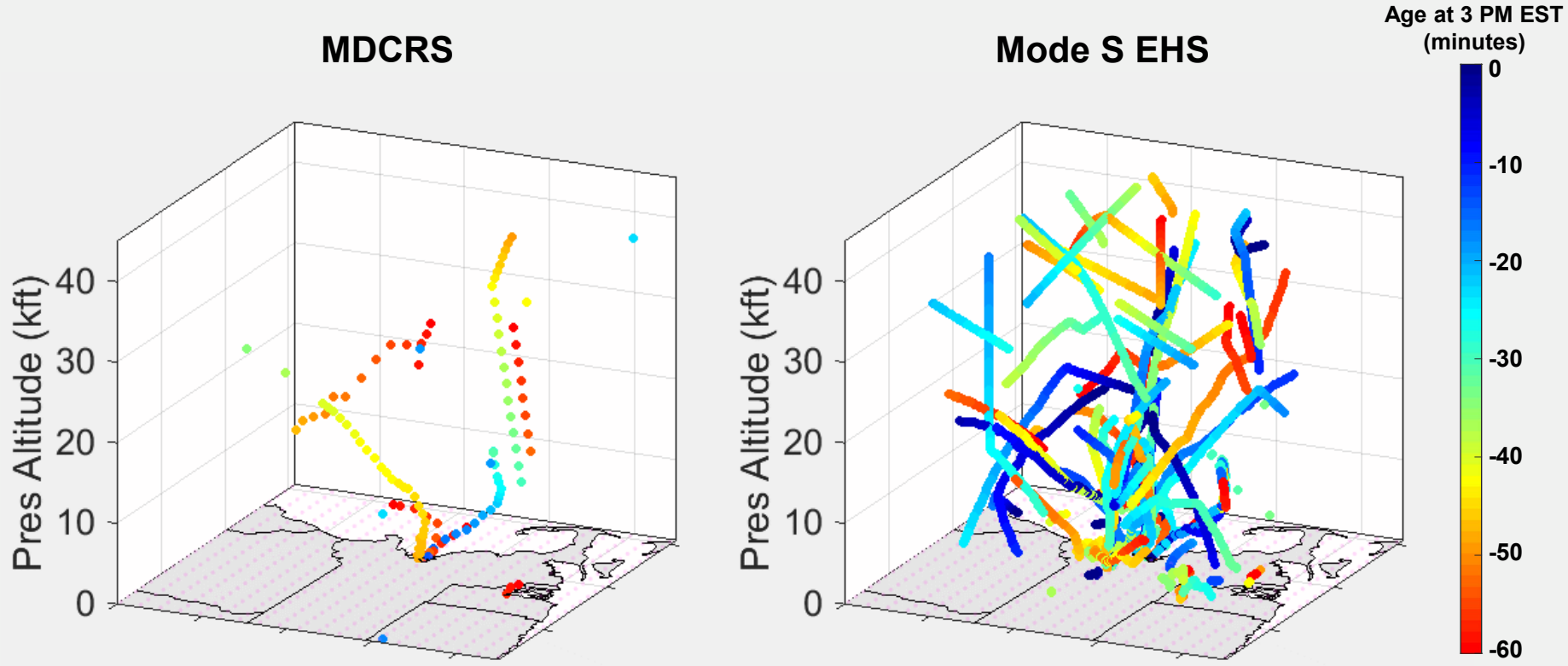




Significantly increased time and altitude coverage with Mode S EHS

MDCRS & MODSEF Observations Around KBED/KBOS

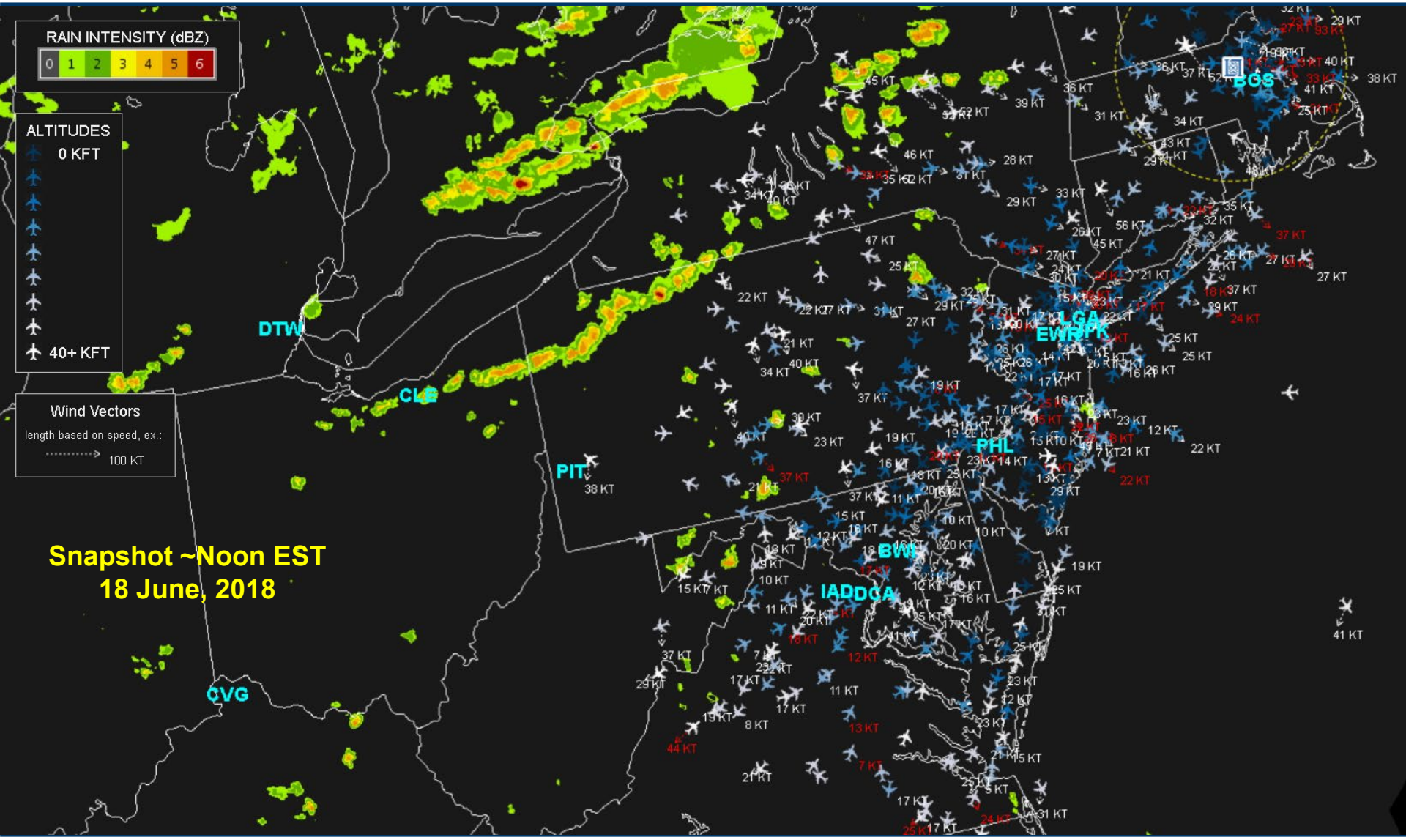
Magenta points in figures are RAP model grid points initialized from observation data



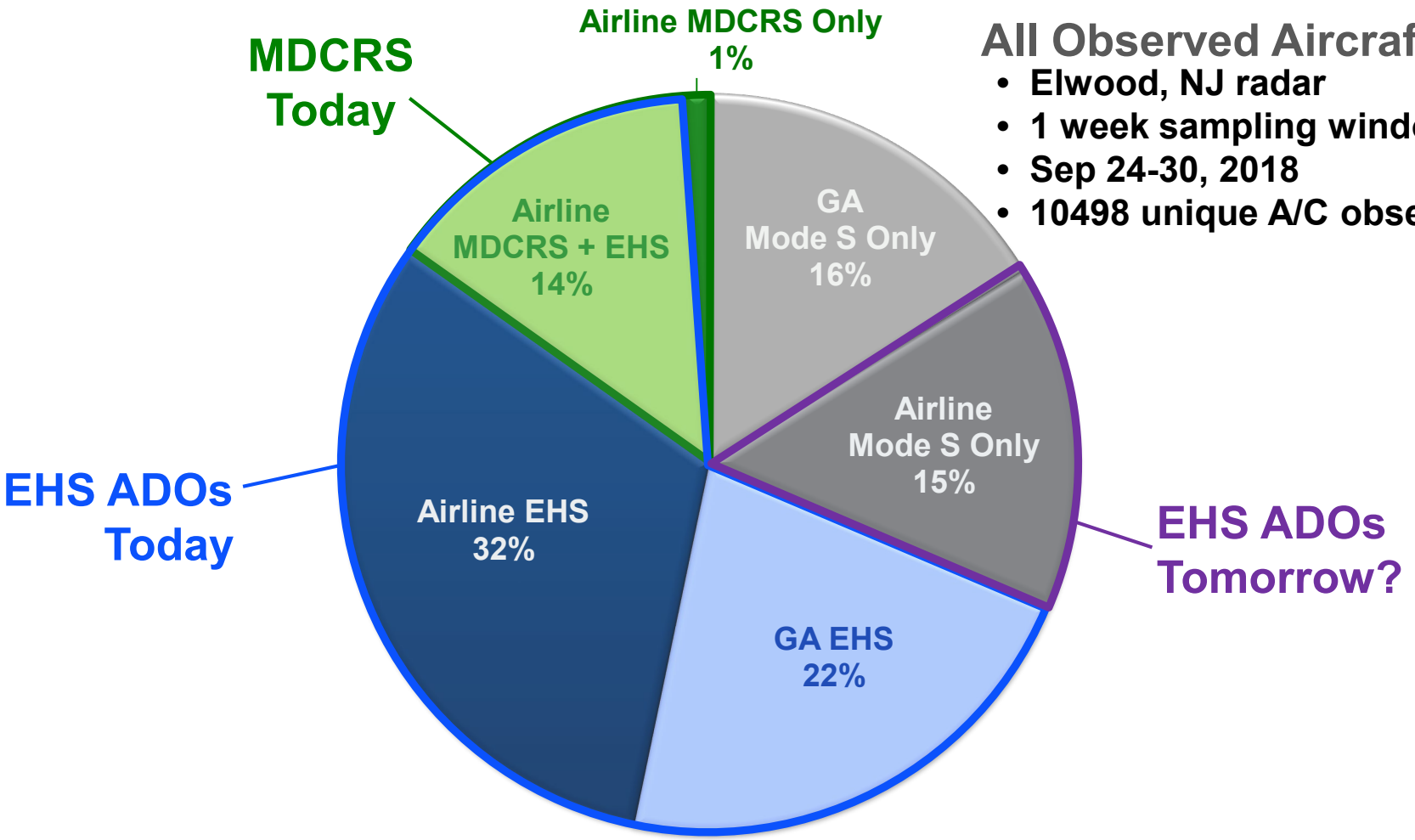
Opportunity for forecast models to assimilate higher quantities of more recent data

RAP = Rapid Refresh forecast model

Observation From MODSEF & Tech Center Radars



Observed Mode S Equipage (UPDATED)



All Observed Aircraft

- Elwood, NJ radar
- 1 week sampling window
- Sep 24-30, 2018
- 10498 unique A/C observed*

* Observed aircraft with Mode A and Mode C transponders not included in count

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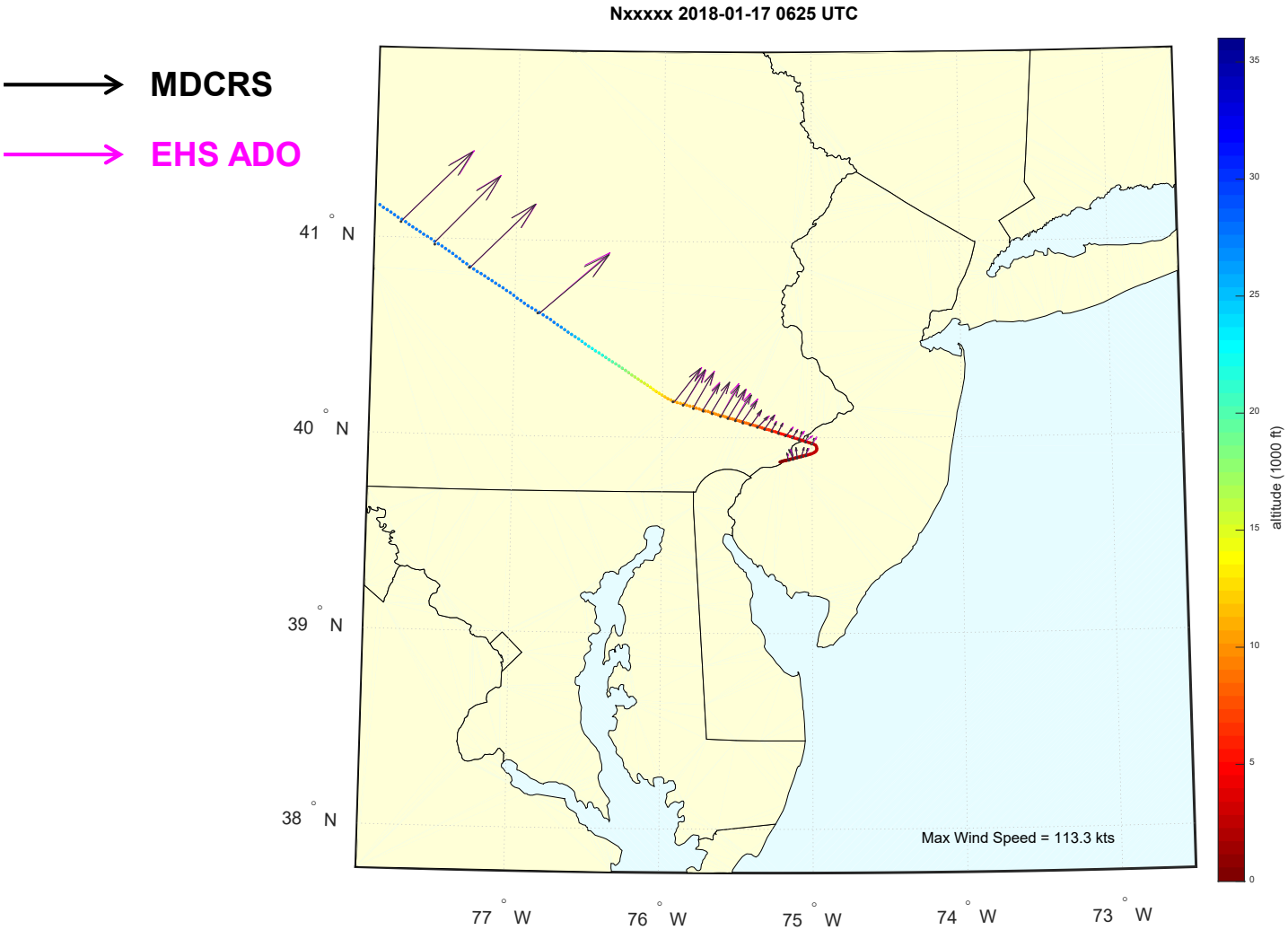
MDCRS vs ADOs from EHS Data

- **Outstanding question from Summer FPAW Mtg:**
  How do EHS ADO wind estimates compare to MDCRS'?

- **Analyzed 8 days of data of MDCRS aircraft arriving at KPHL**
  - **US registered A/C contributing to MDCRS were compared**

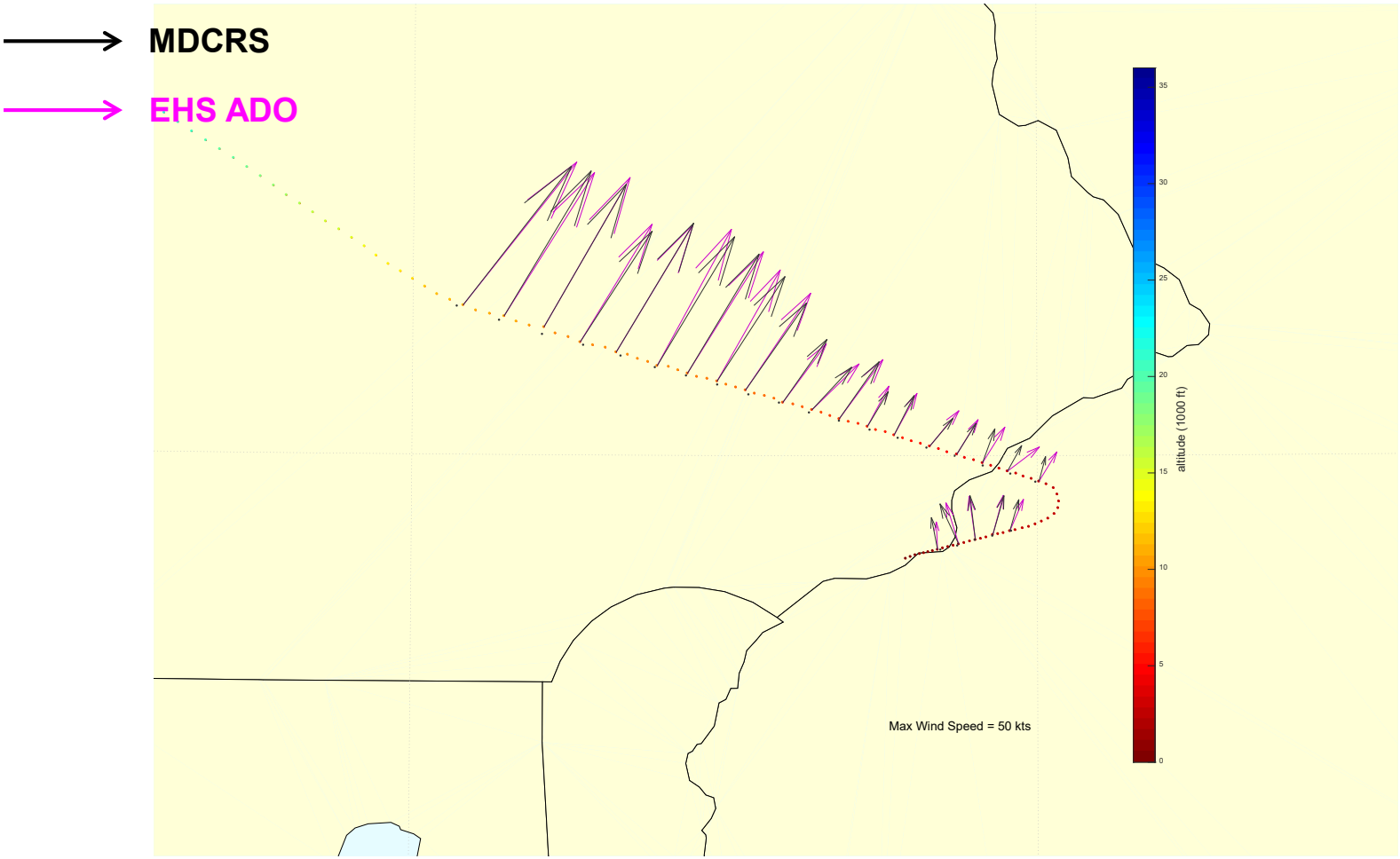
- **Compared each MDCRS report to geographically closest EHS ADO**
  - **Compared valid reports only (specified by roll flags, etc.)**
  - **Comparisons performed if both source had estimated wind speed of 5 knots or greater**
  - **EHS ADO were unfiltered**
    - **I.e., no smoothing**

Visual Comparison
MDCRS & EHS ADO Winds



Visual Comparison
MDCRS & EHS ADO Winds

Nxxxxx 2018-01-17 0625 UTC



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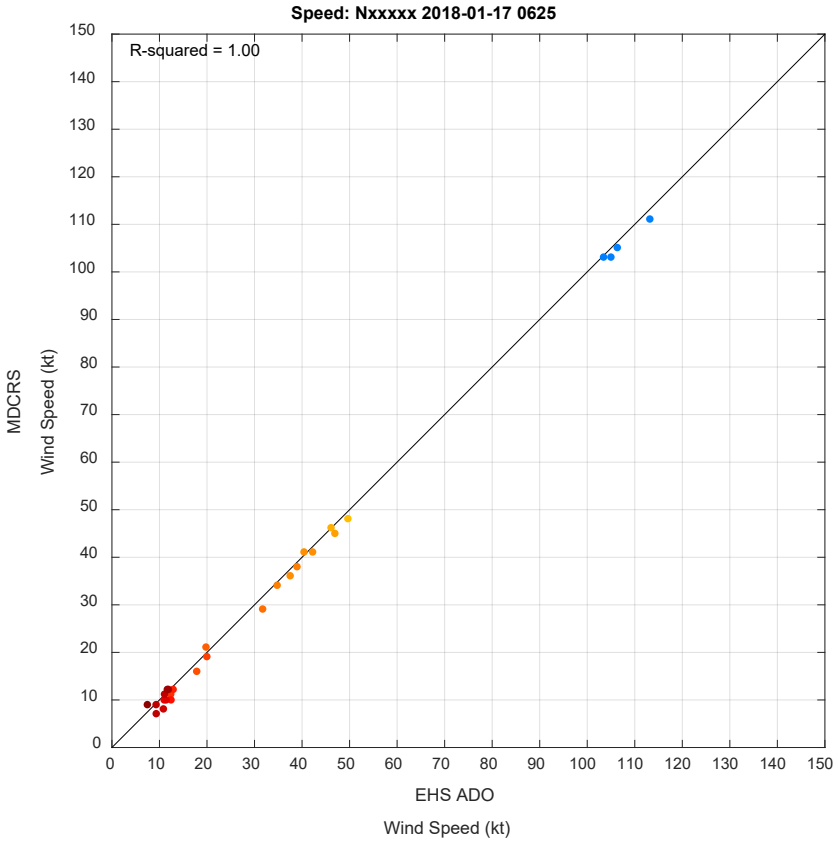

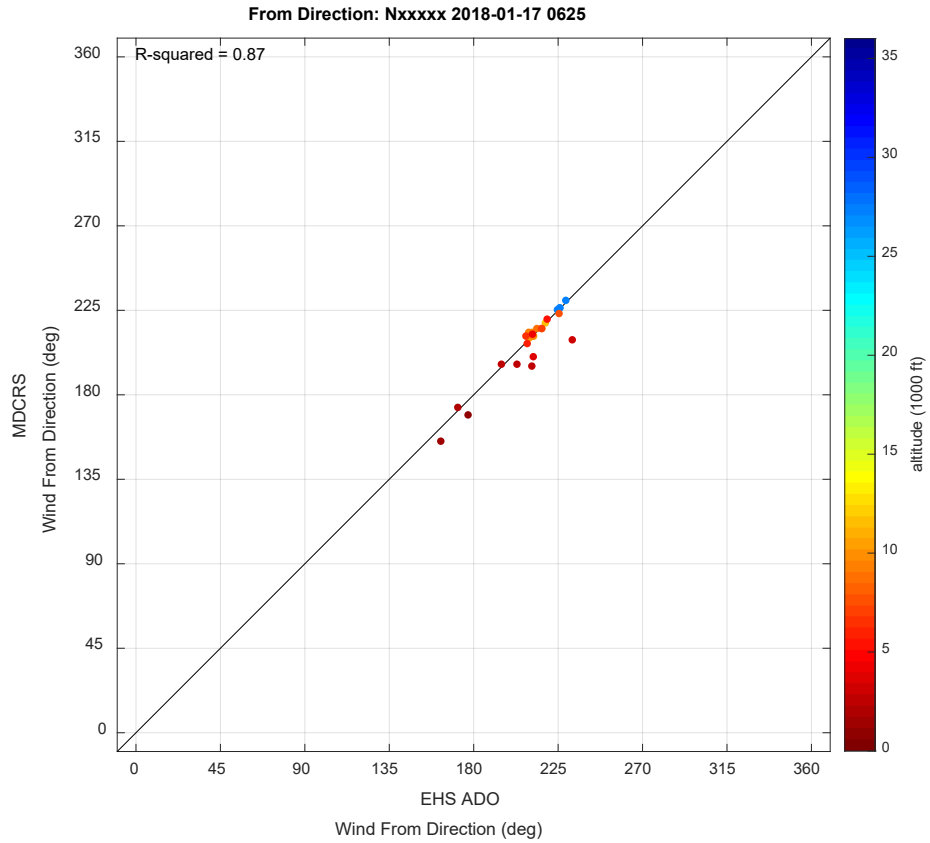

Visual Comparison
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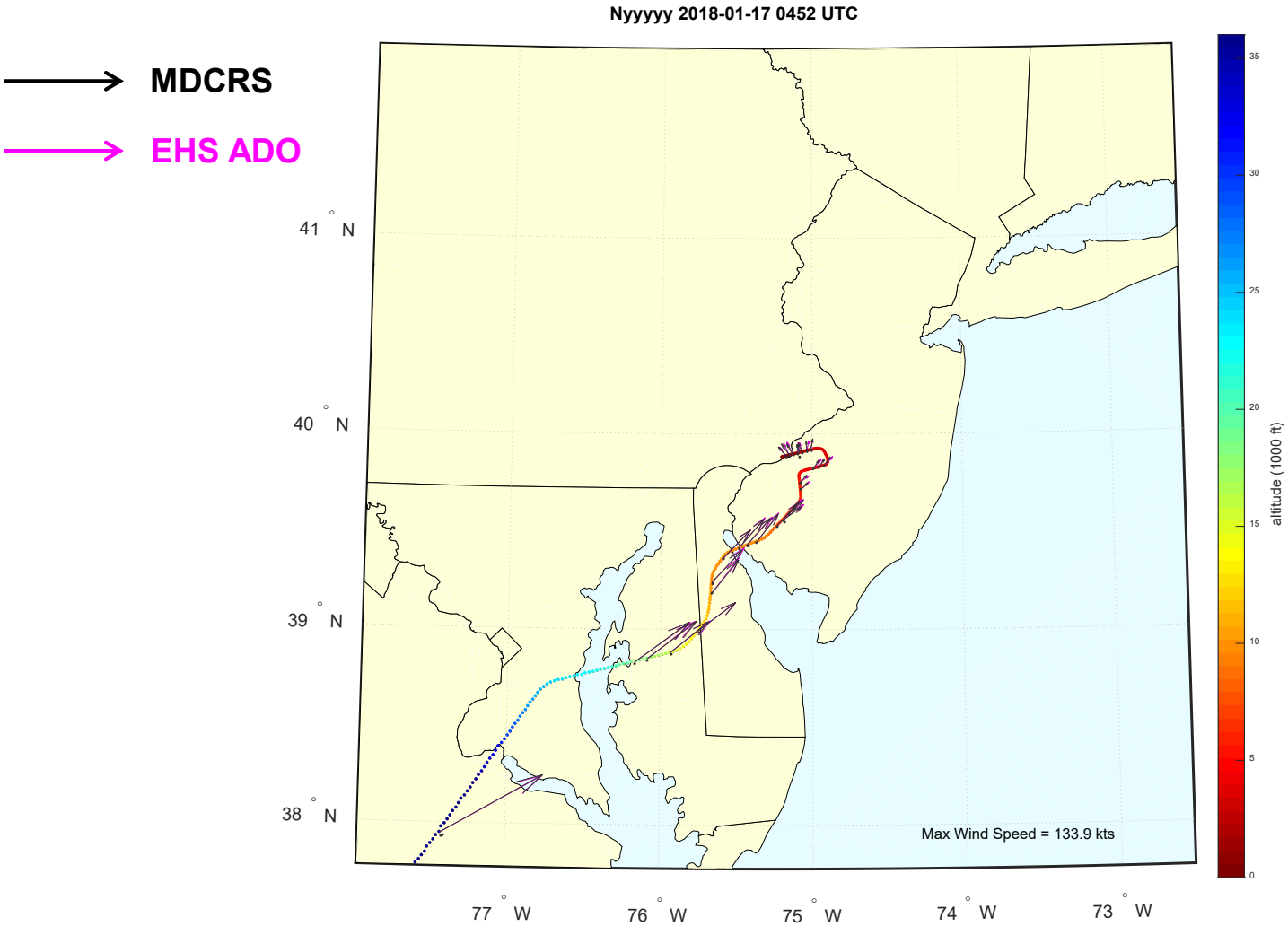
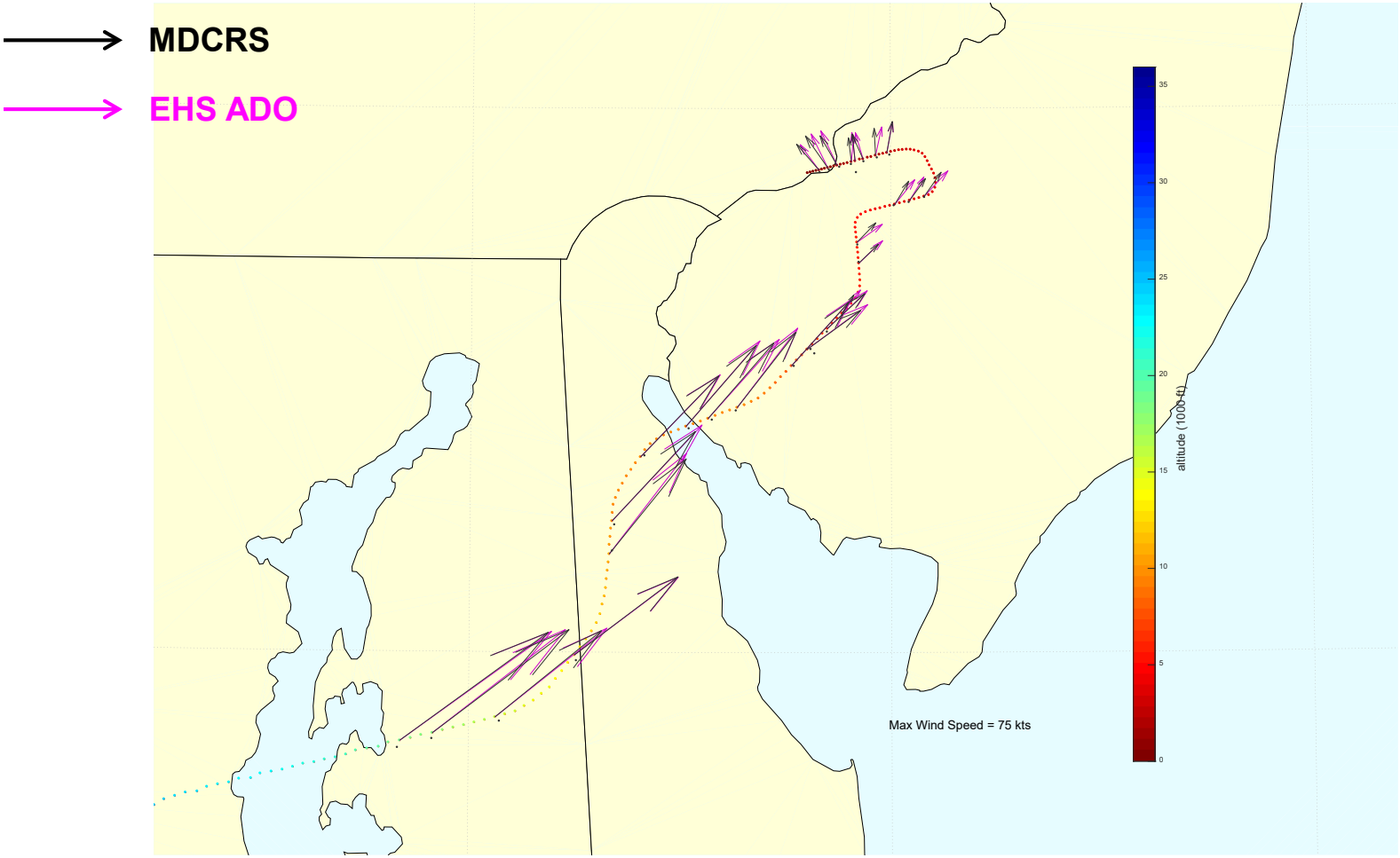
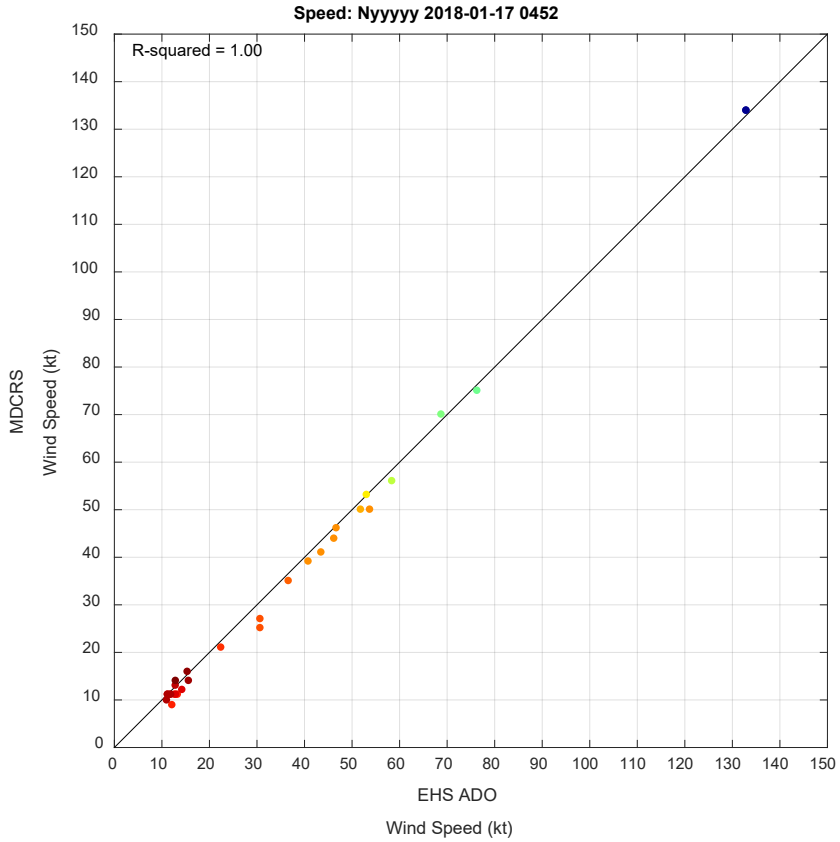


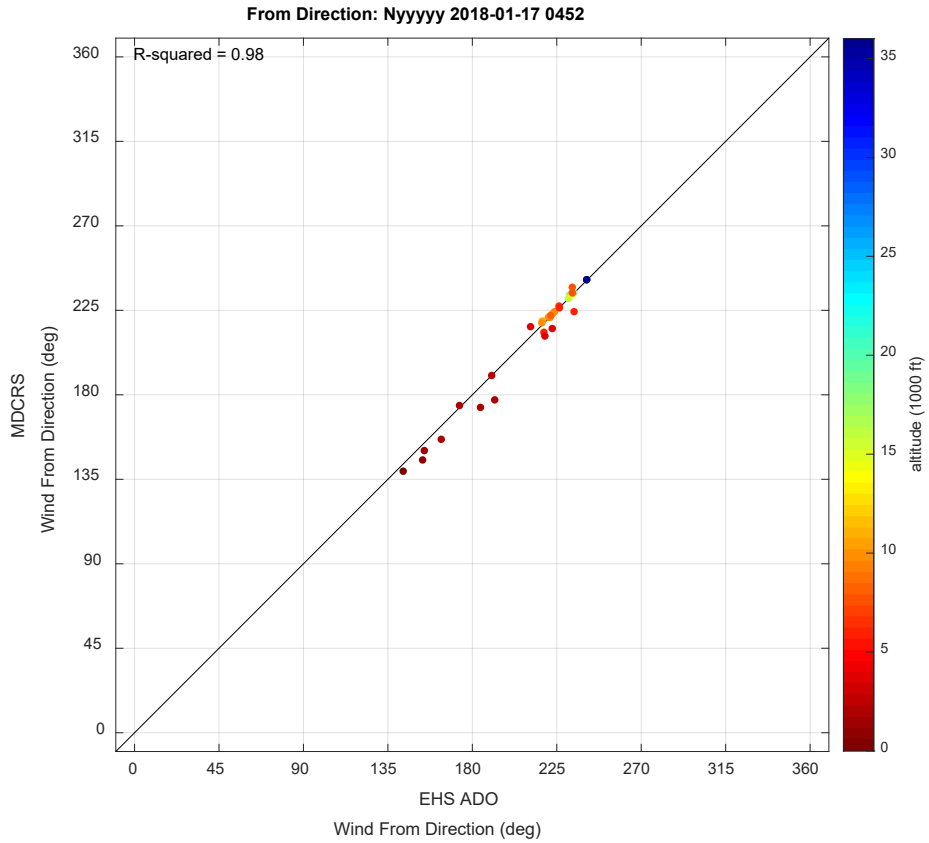
Visual Comparison
MDCRS & EHS ADO Winds

Nyyyyy 2018-01-17 0425 UTC



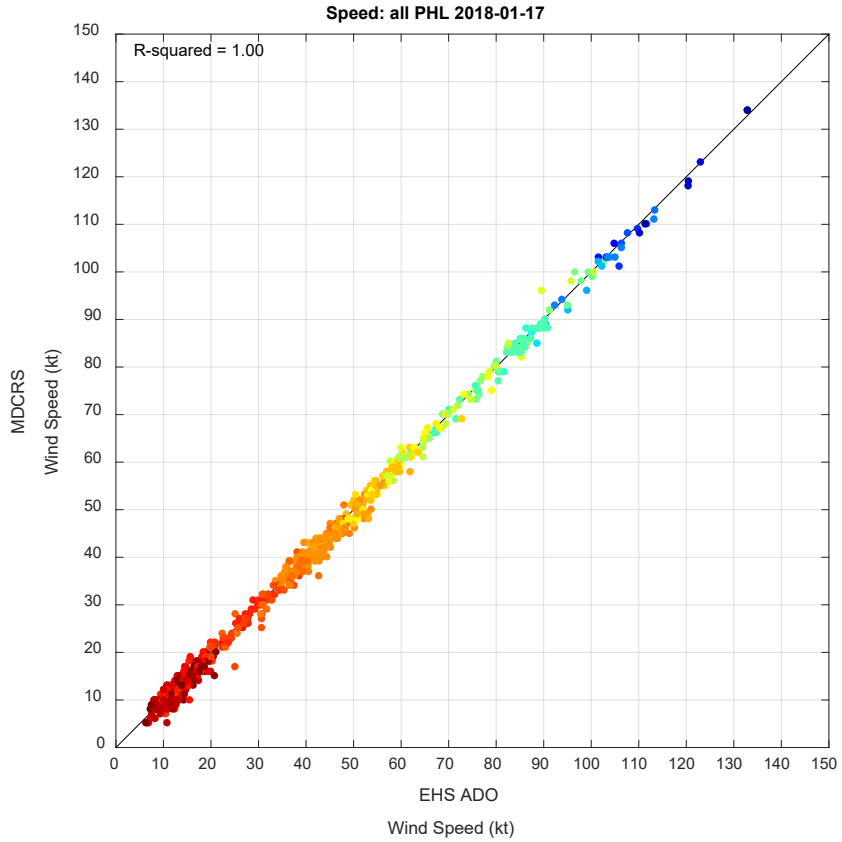
Visual Comparison
MDCRS & EHS ADO Winds





Visual Comparison
MDCRS & EHS ADO Winds

24 Hr Period, 24 Unique Aircraft, Num Samples = 761



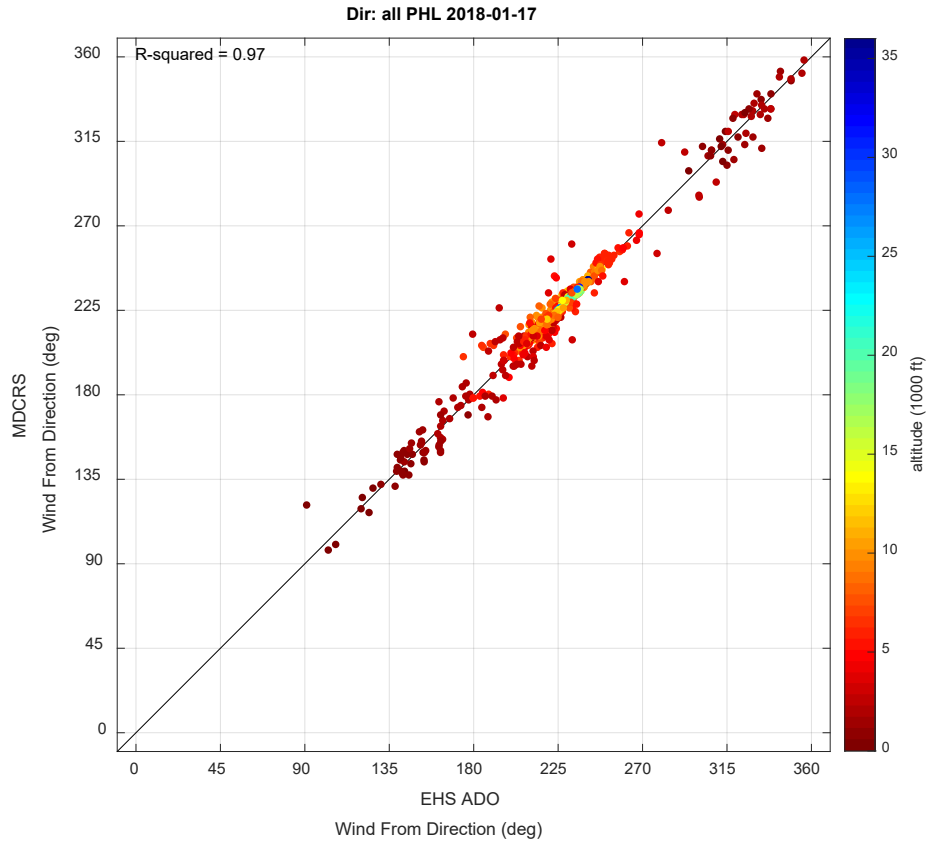


Table of Results

- **170 Sorties**
- **8 full days; Jan (x3), July (x2), August (x3)**
- **Num Samples = 5387**

	Wind Estimate Comparisons MDCRS to EHS ADOs		
	Vector (kt)	Speed (kt)	Direction (deg)
RMS Difference	2.8 (2.6)	2.0 (1.9)	5.6 (5.5)

( ) = Standard Deviation

- **For reference**
  - **ASOS Accuracy: +/- 2 kt, +/- 3 deg**
  - **TAMDAR Accuracy: +/- 4 to 6 kt Vector RMS**

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Existing Secondary Surveillance Radars

FAA Beacon Interrogators				
	Counts			
Type	Monted on Primary Radar	Secondary Radar Only	Can Interrogate Mode S Registers	Simplest EHS Adaptation
MSSR	65	0	✗	-
BI-5	48	1	✗	-
MODE S	133	4	✓	Sidecar PC
BI-6	101	32	✓	Config file edit

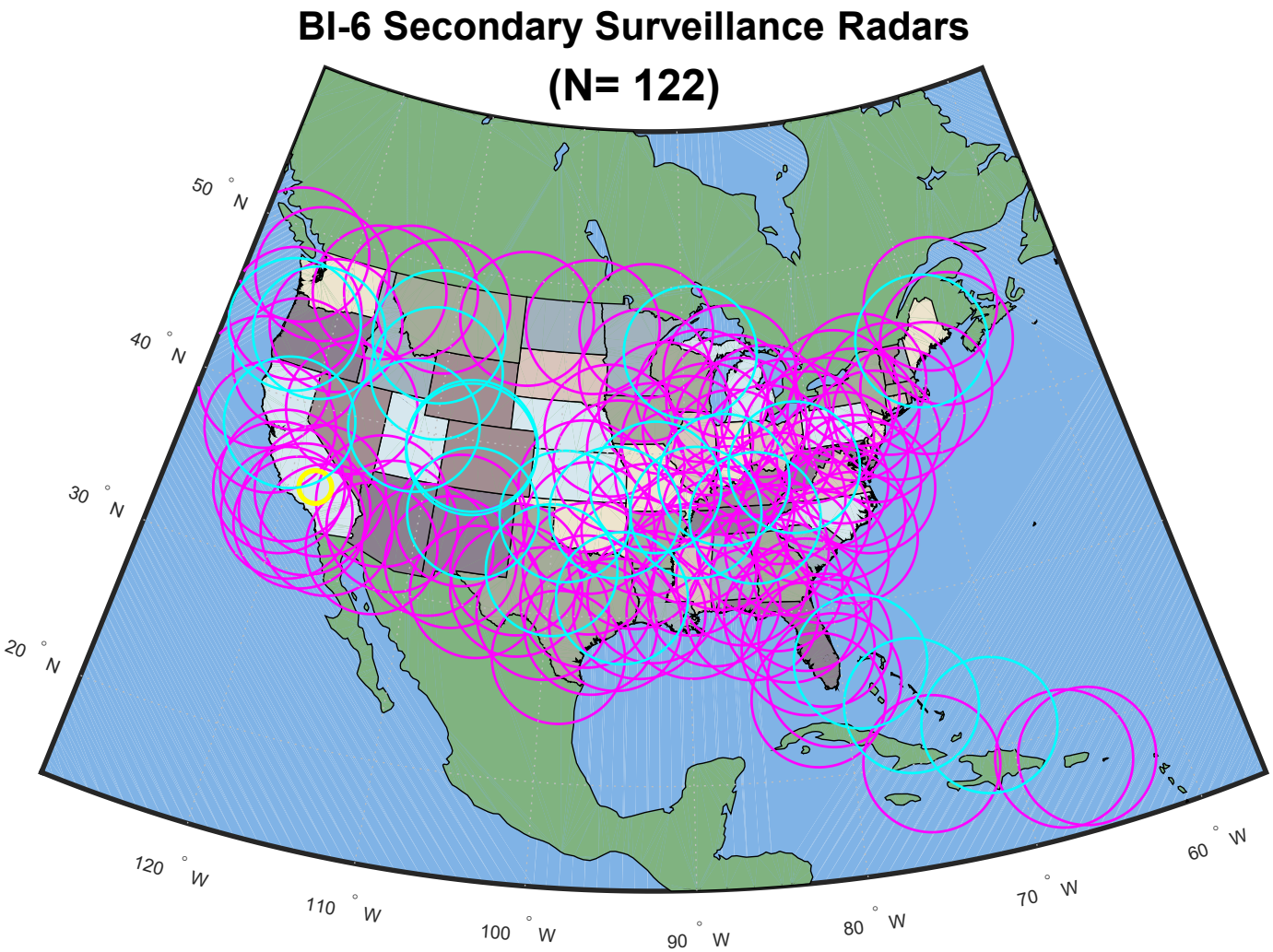
MIT/LL MODSEF

Tech Center radar

Typically 60 nmi range ASR

Typically 240 nmi range ARSR

Lower 48 & Caribbean BI-6 Radars



= 240 nmi radius, w/ primary = 60 nmi radius, SSR only = 240 nmi radius, SSR only

Changes to BI-6 to Enable EHS

- **From Tech Center BI-6 radar Config file**
  - **These lines were added:**

```
;  ***  Enhanced Surveillance ***
PS309OFF          ; Disable Surv. Only Mode (i.e. Enhanced Surveillance Enabled)
IAL 0 = G 40 3 4
IAL 1 = G 50 1 5
IAL 2 = G 60 1 5
```

- **Outstanding question: Are there ready means to move interrogated data off-site?**

Summary

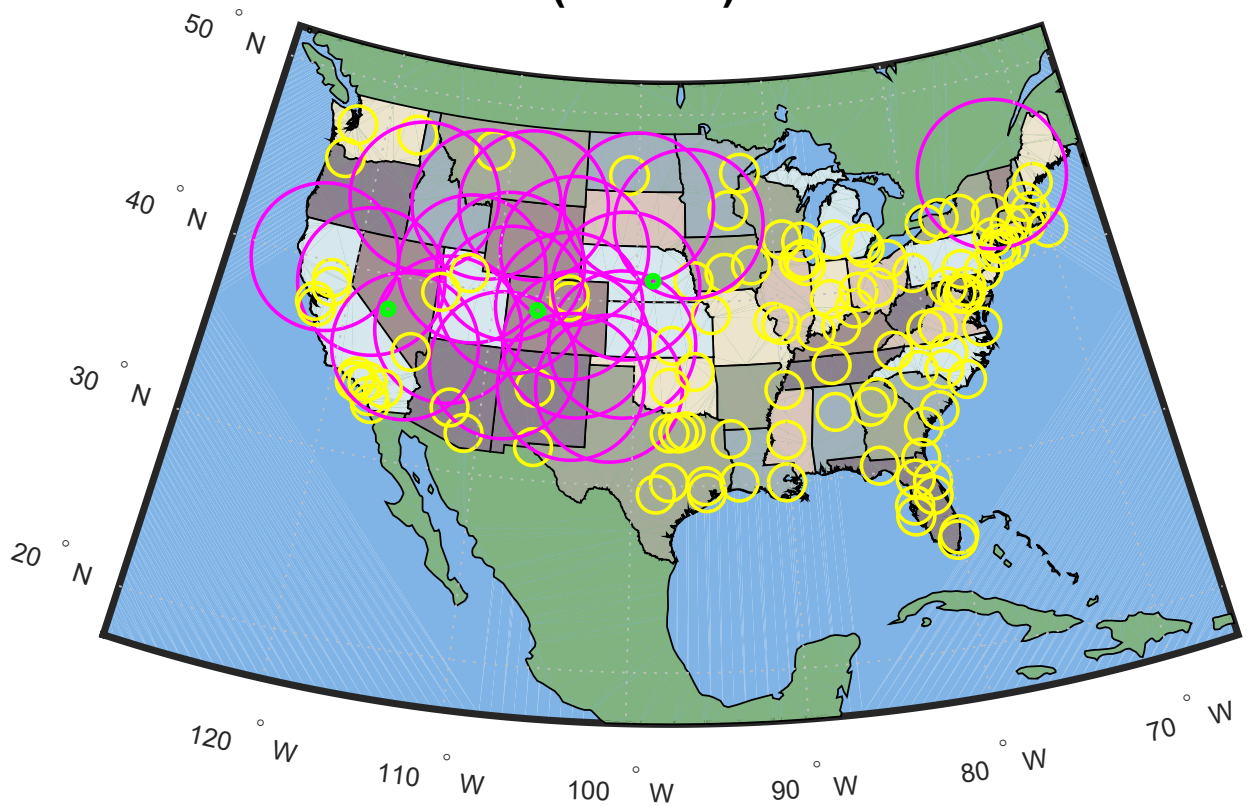
- **EHS ADO & MDCRS Wind Estimates are very similar**
- **Leveraging aircraft-derived operations holds significant promise for improving weather forecasting and real-time operations**
- **Mode S EHS is a currently-available technology enabling immediate access to aircraft-derived observations**

Backup

Lower 48 Mode S Beacon Interrogators

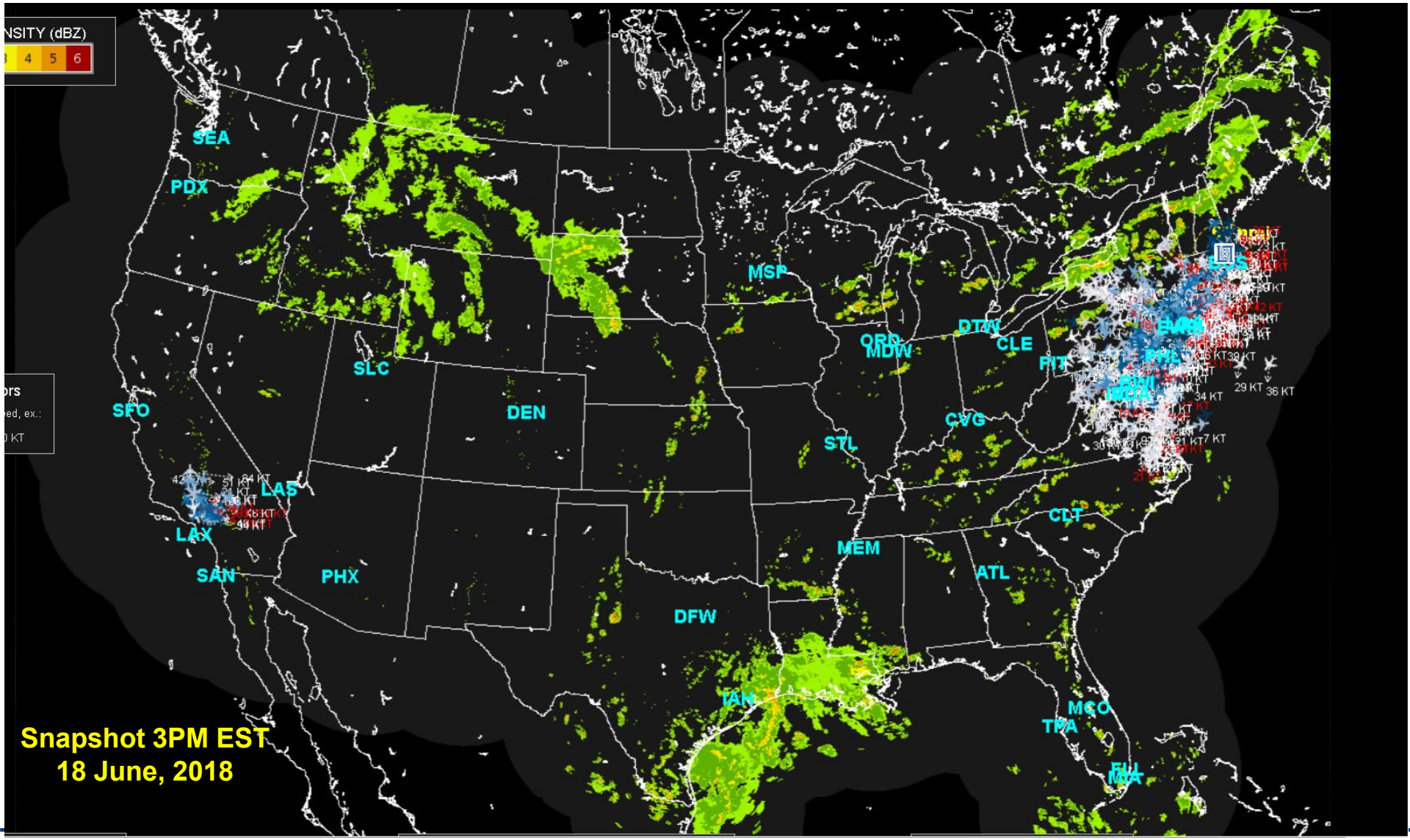
Mode S Secondary Surveillance Radars

(N= 138)



= 240 nmi radius, w/ primary **= 60 nmi radius, w/ primary** **= Unknown range, SSR only**

Fremont Valley, CA, Elwood, NJ, Lexington, MA Mode S EHS Radars



Snapshot 3PM EST
18 June, 2018

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