Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP

Aircraft weather observations: Impacts for regional NWP models

Stephen S. Weygandt

Eric James, Stan Benjamin,

*Bill Moninger, Brian Jamison, Geoff Manikin**

NOAA Earth System Research Laboratory

**NOAA National Centers for Environmental Prediction*

Friends and Partners of Aviation Weather

NBAA Convention, Nov 2-3, 2016

Rapid Refresh and HRRR
NOAA hourly updated models

13km Rapid Refresh (RAP)

Version 3 -- NCEP implement 23 Aug 2016

Version 4 – GSD

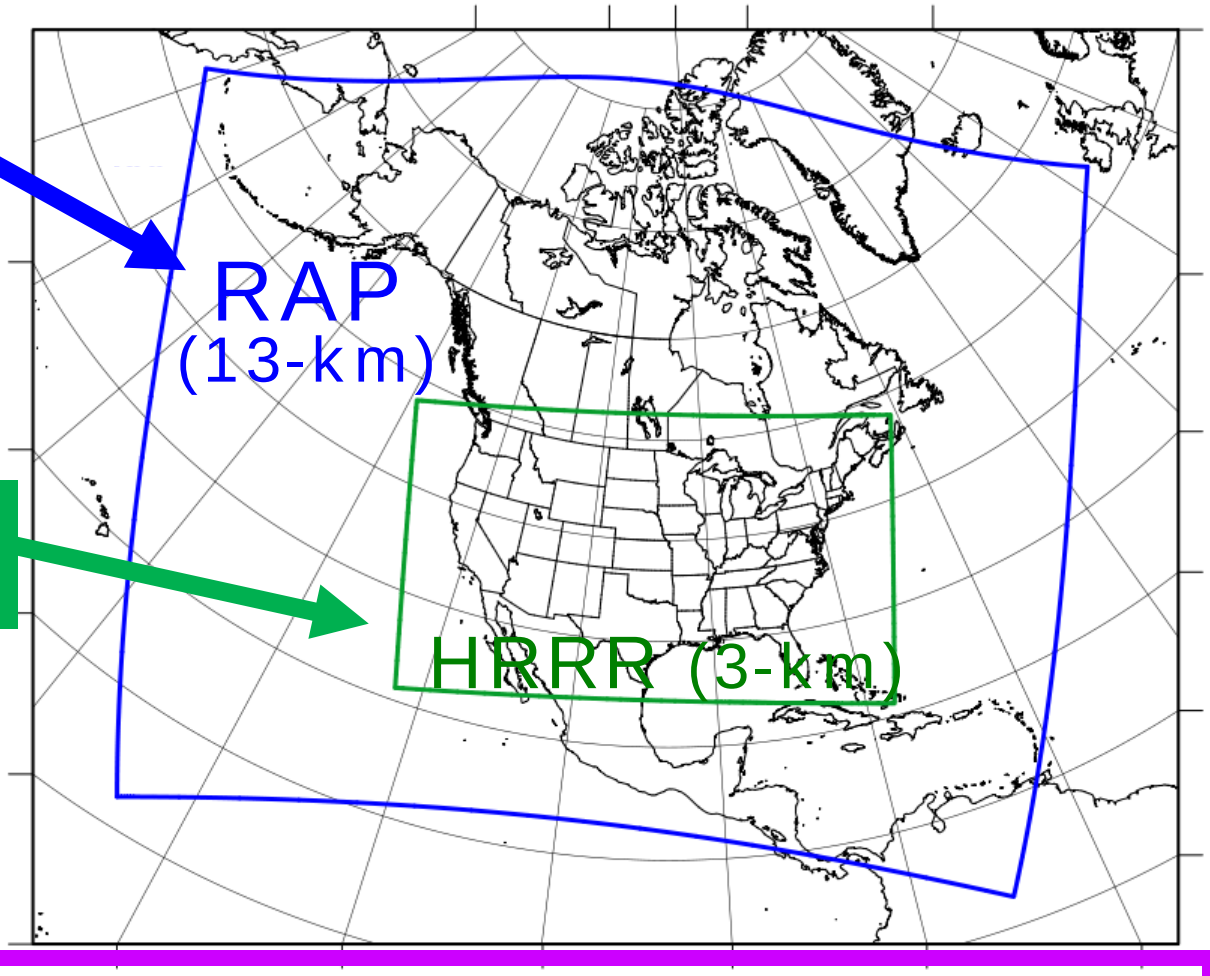
Planned NCEP – Early 2018

3km High Resolution Rapid Refresh (HRRR)

Version 2 – NCEP implement 23 Aug 2016

Version 3 – GSD

Planned NCEP – Early 2018



Hourly updating ➡ maximize asynoptic observation use

Observations assimilated: RAP and HRRR

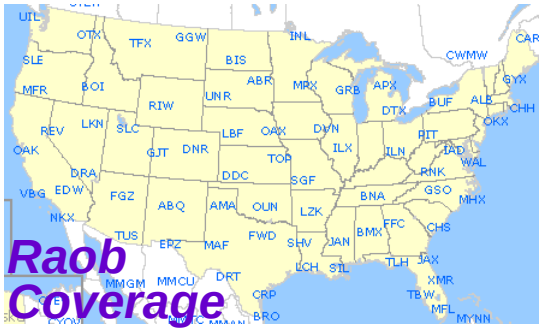
Observations in RAPv2 **Observations added for RAPv3**

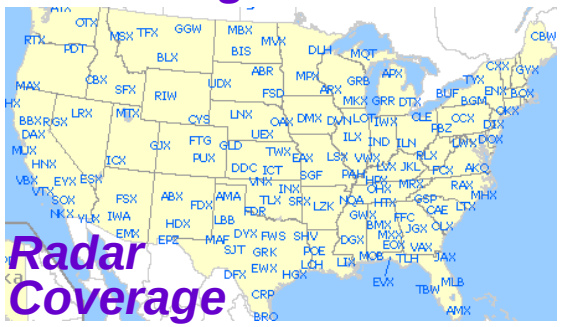
Hourly Observation Type	Variables Observed	Observation Count
Rawinsonde	Temperature, Humidity, Wind, Pressure	120
Profiler – 915 MHz	Wind, Virtual Temperature	20-30
Radar – VAD	Wind	125
Radar	**Radial Velocity**	**125 radars**
Radar reflectivity – CONUS	3-d refl ➔Rain, Snow, Graupel	1,500,000
Lightning	**(proxy reflectivity)**	**NLDN**
Aircraft	Wind, Temperature	2,000 -15,000
Aircraft - WVSS	Humidity	0 - 800
Surface/METAR	Temperature, Moisture, Wind, Pressure, Clouds, Visibility, Weather	2200 - 2500
Surface/Mesonet	**Temperature, Moisture, Wind**	**~5K-12K**
Buoys/ships	Wind, Pressure	200 - 400
GOES AMVs	Wind	2000 - 4000
AMSU/HIRS/MHS **(RARS)**	Radiances	1K-10K
GOES	**Radiances**	**large**
GOES cloud-top press/temp	Cloud Top Height	100,000
GPS – Precipitable water	Humidity	260
WindSat Scatterometer	Winds	2,000 – 10,000

Regional Observation Impact studies with RAP - GSD

- **Observation gaps are major source in limiting forecast accuracy, even over US**
- **New RAP observation impact study covering 3 seasons, 8 observation types**

Rawinsonde ***Aircraft obs***
Radar reflectivity ***VAD winds***
Surface obs ***GPS-Met***
AMV (winds) ***GOES clouds***





➔ **Aircraft data found to be most important observation type for wind, temperature and Relative humidity**

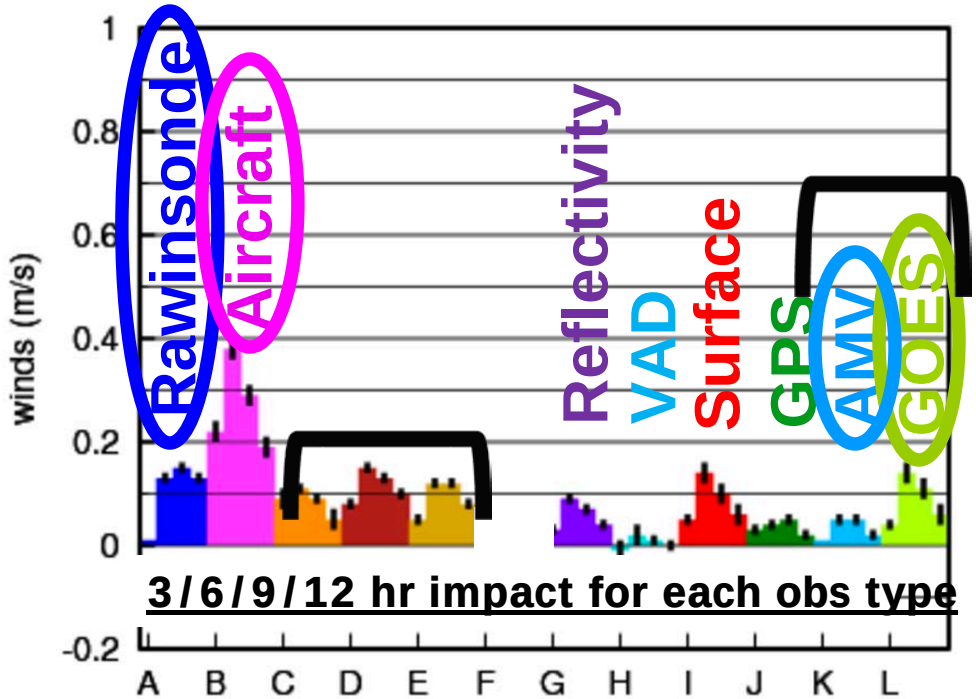
-- Ascent/descent observations both important

-- Water vapor observations (about 1/8 total) improve RH forecast accuracy (WVSS only, no TAMDAR available to NOAA at this time)

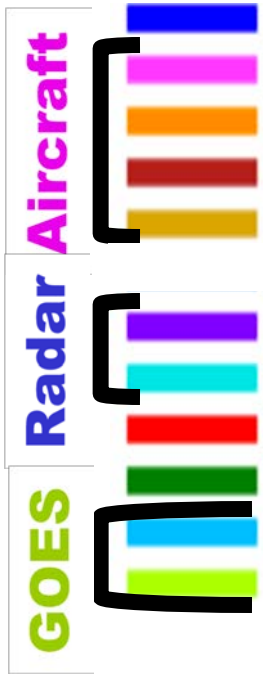
Sample aircaft obs coverage

Aircraft observations -- most important data source for weather prediction skill

Impact on WIND in 1000-100 hPa layer



Forecast degradation for <u>witholding each obs type</u>

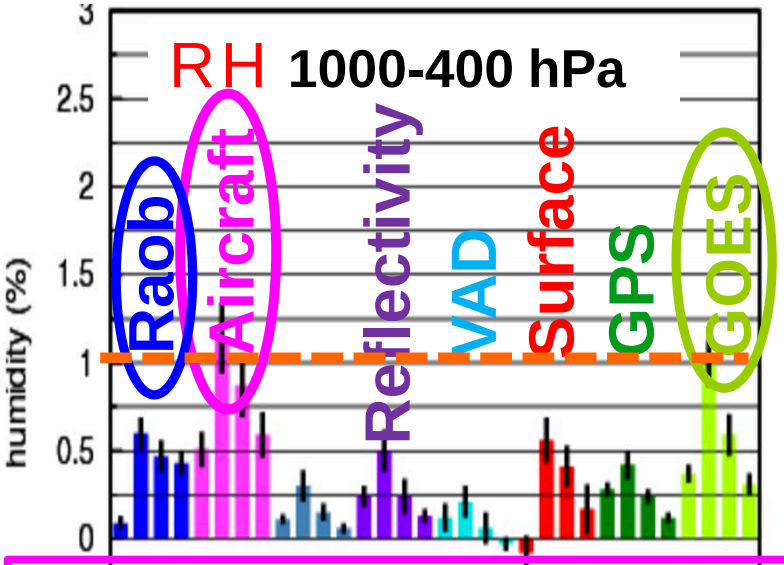


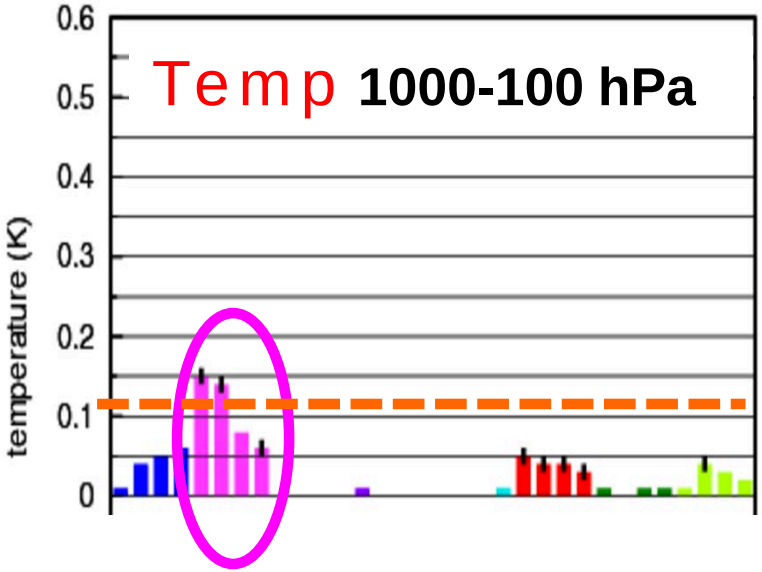
<u>Withold</u>:

- **A – ALL Rawinsonde**
- **B – ALL Aircraft**
- C – Aircraft above 350 hPa
- D – Aircraft below 350 hPa
- E – Aircraft temp/humidity
- **G – ALL Radar Reflectivity**
- **H – ALL VAD winds**
- **I – ALL surface obs**
- **J – ALL GPS-Met PW**
- **K – ALL AMVs winds**
- **L – GOES (winds/clouds)**

- *Aircraft obs most important for wind accuracy at all forecast lengths*
- ***Significant impact also from rawinsonde, surface observations, GOES observations (likely from clearing of spurious convection)***

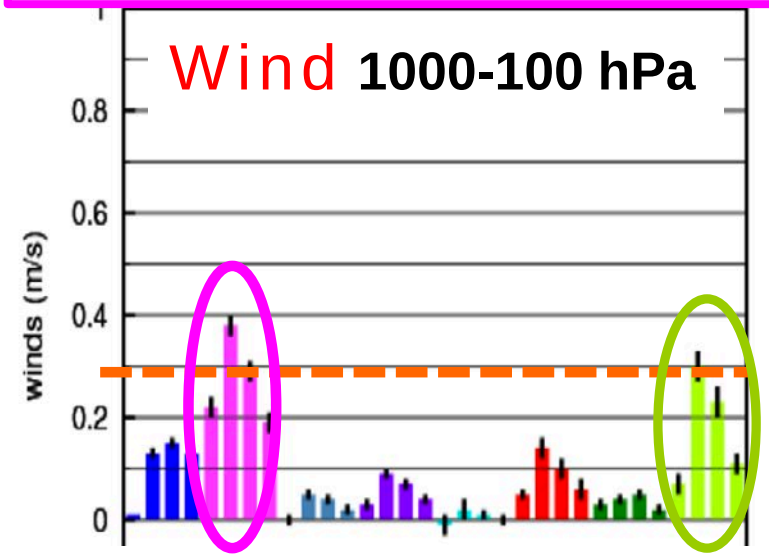
Observation impact: Raob, Aircraft, GOES





Aircraft observations most important for all variable, times

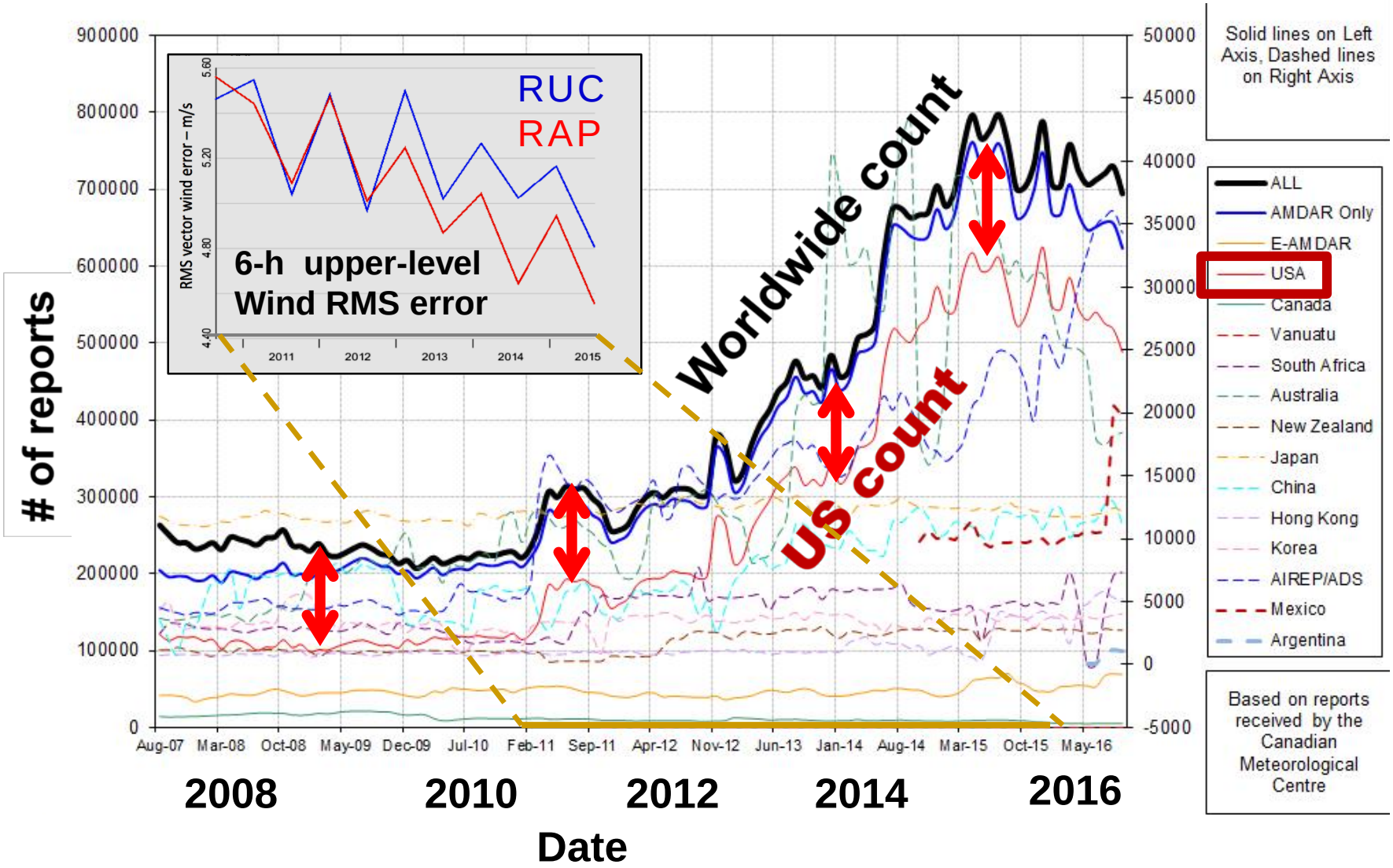
20% Error reduction (normalized by 6-h fcst – 0-h anx difference)



Withold:

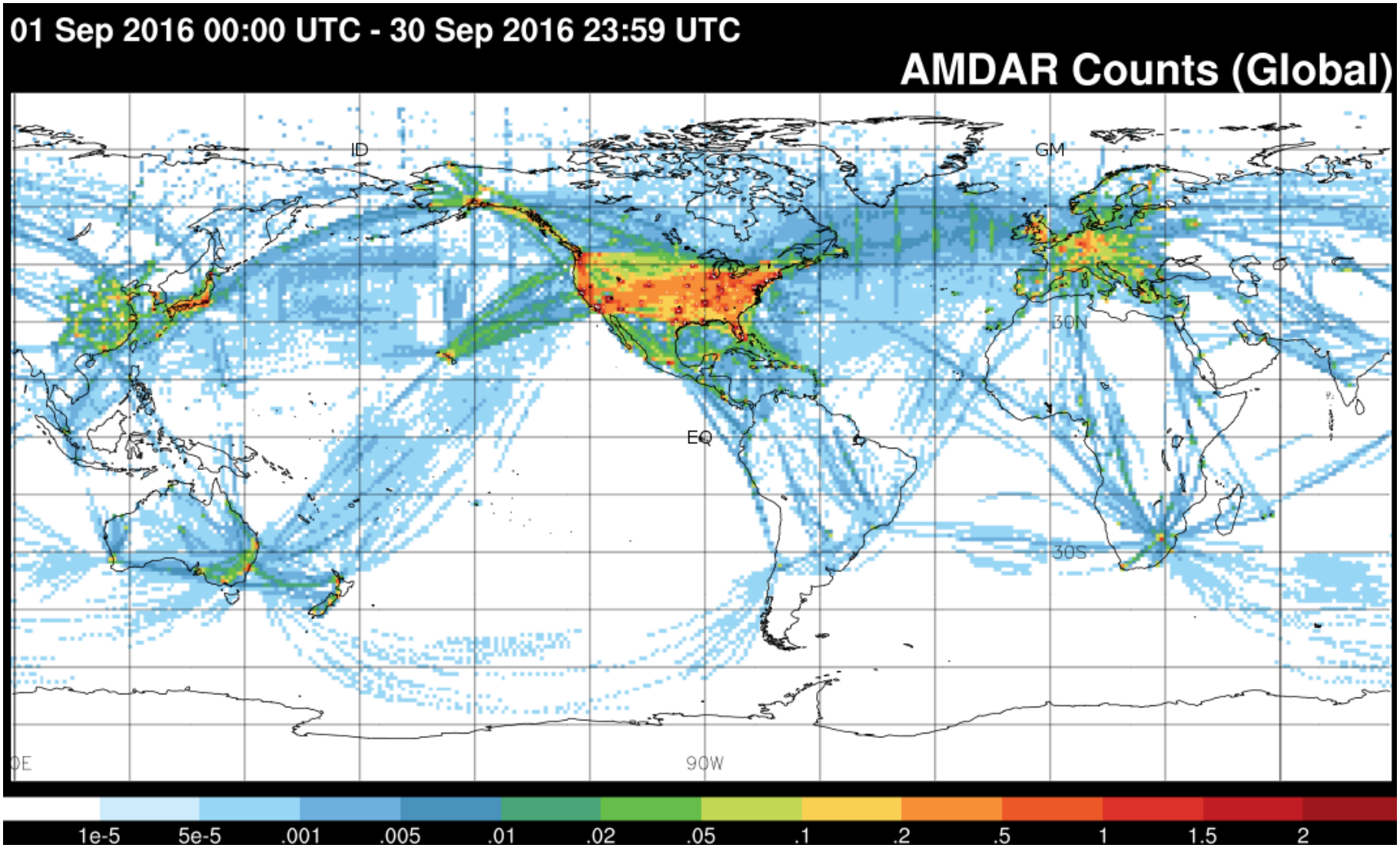
- ALL Rawinsonde
- ALL Aircraft
- ALL Profiler
- ALL Radar Reflectivity
- ALL VAD winds
- ALL surface obs
- ALL GPS-Met PW
- GOES (clouds / winds)

Smoothed monthly aircraft obs counts



http://www.wmo.int/pages/prog/www/GOS/ABO/data/statistics/aircraft_obs_cmc_mthly_ave_daily_reports_by_program.jpg

AMDAR obs density -- global

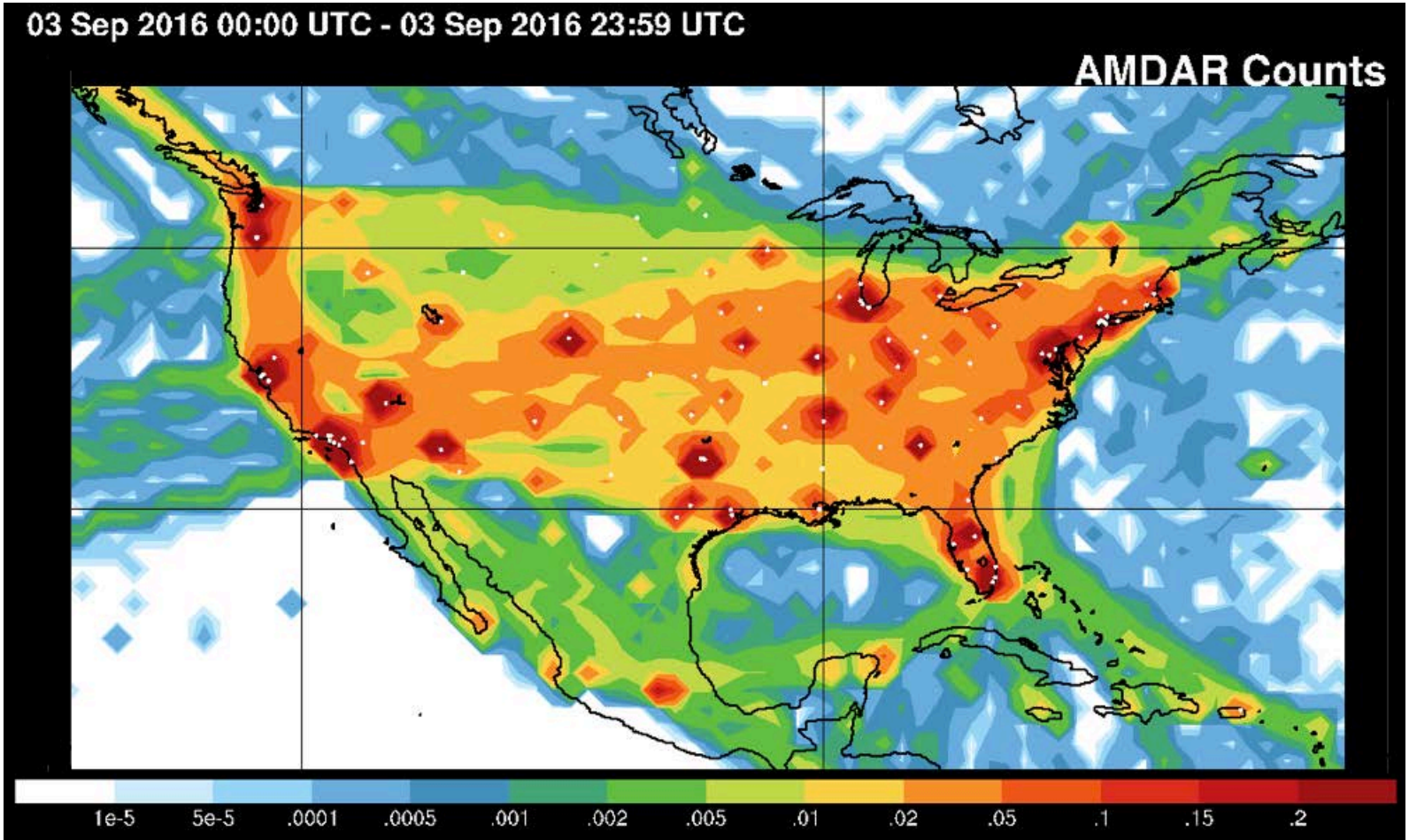


FAA aircraft obs study -- ongoing (GSD, AvMet)

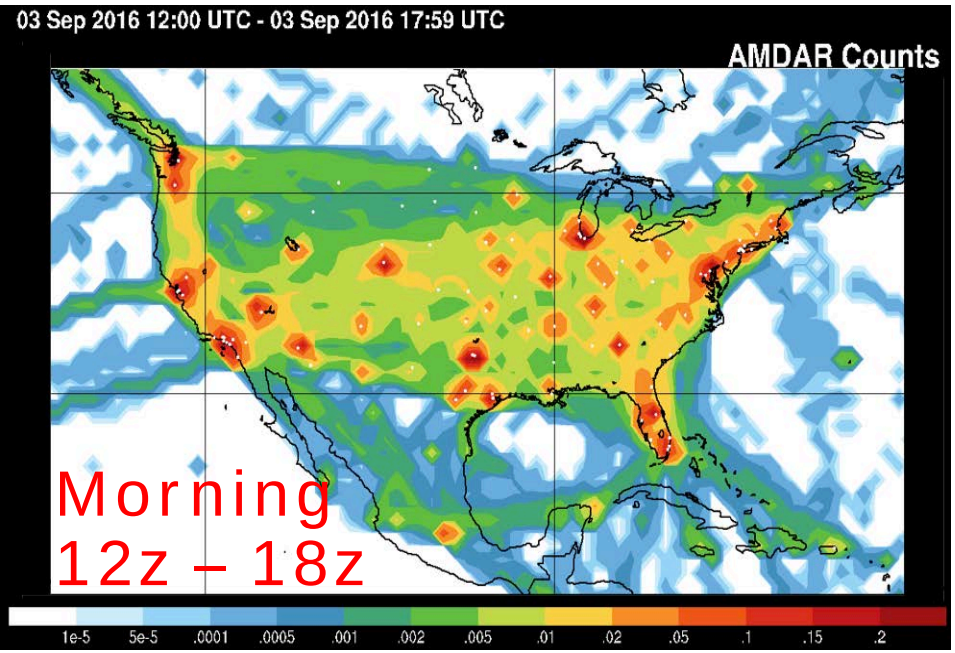
GOALS:

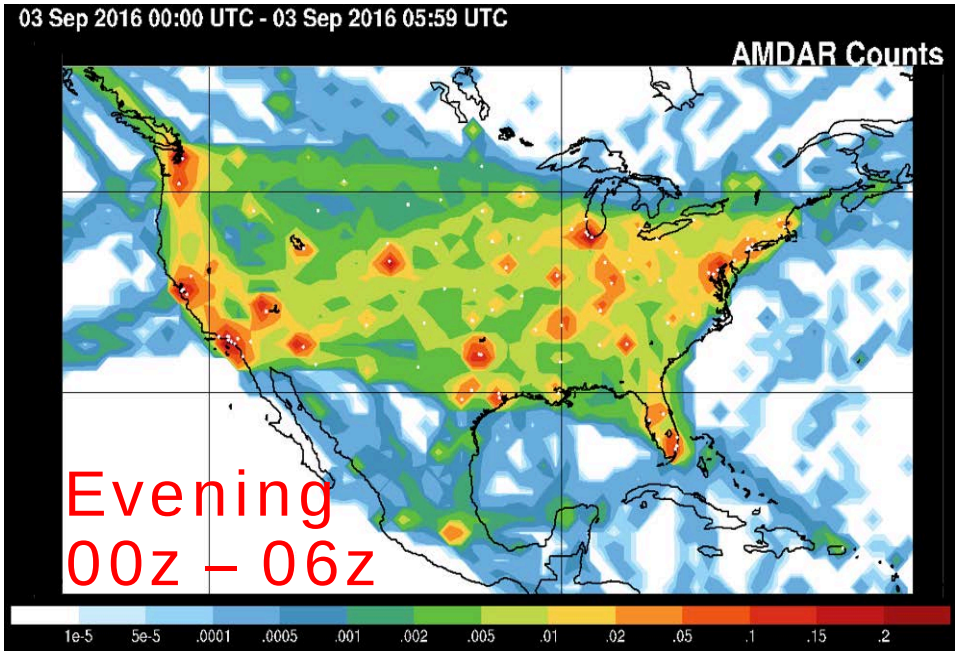
- **Quantify gaps in airborne observations**
  (spatial, temporal, parameter, etc,)
- **Identify most cost effective ways to obtain airborne data**

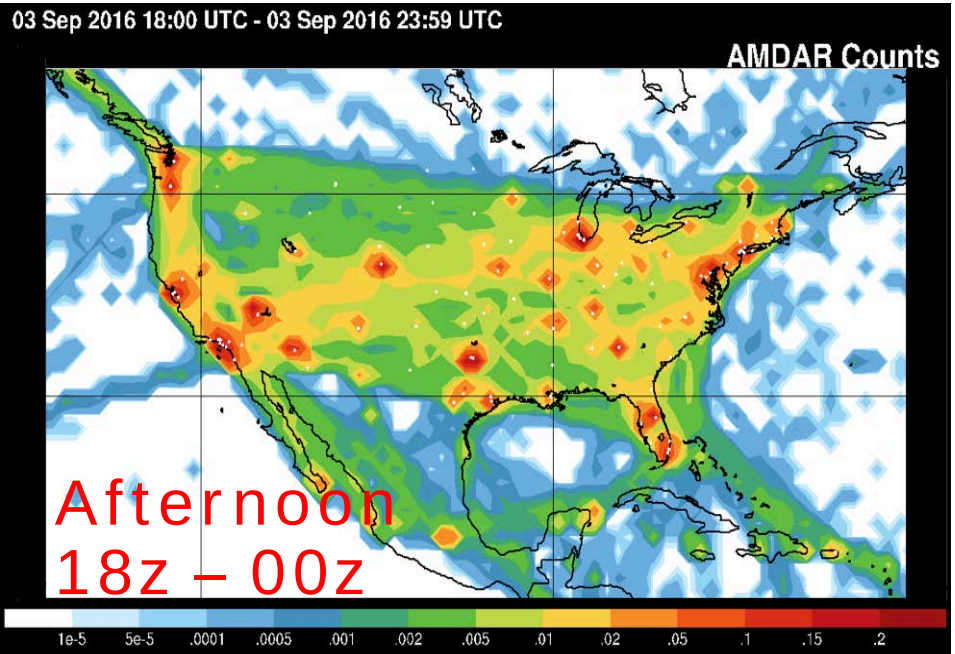
AMDAR obs density CONUS

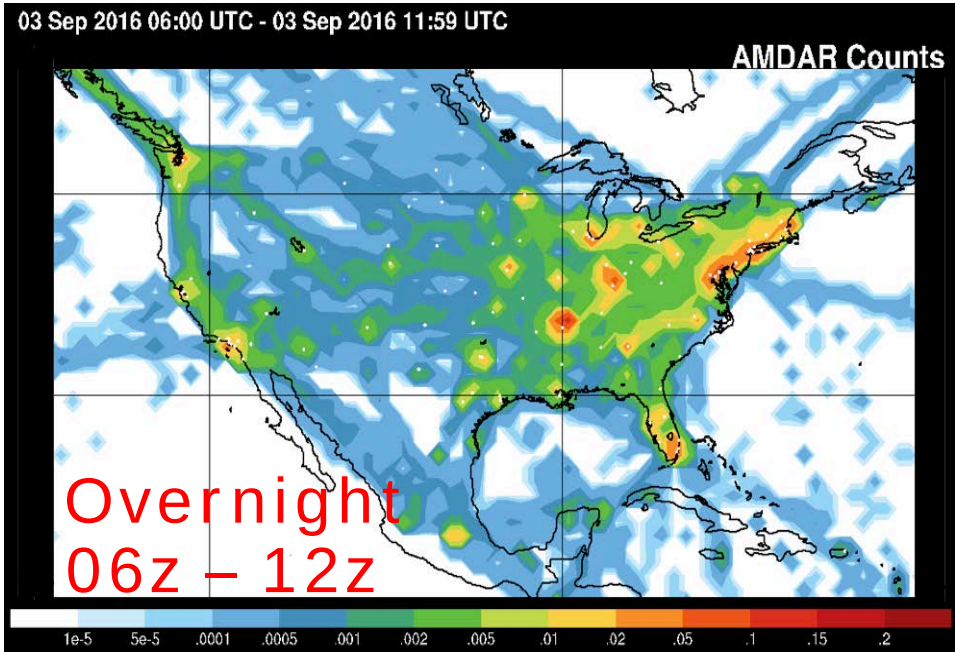


AMDAR obs densitry -- time of day -- CONUS

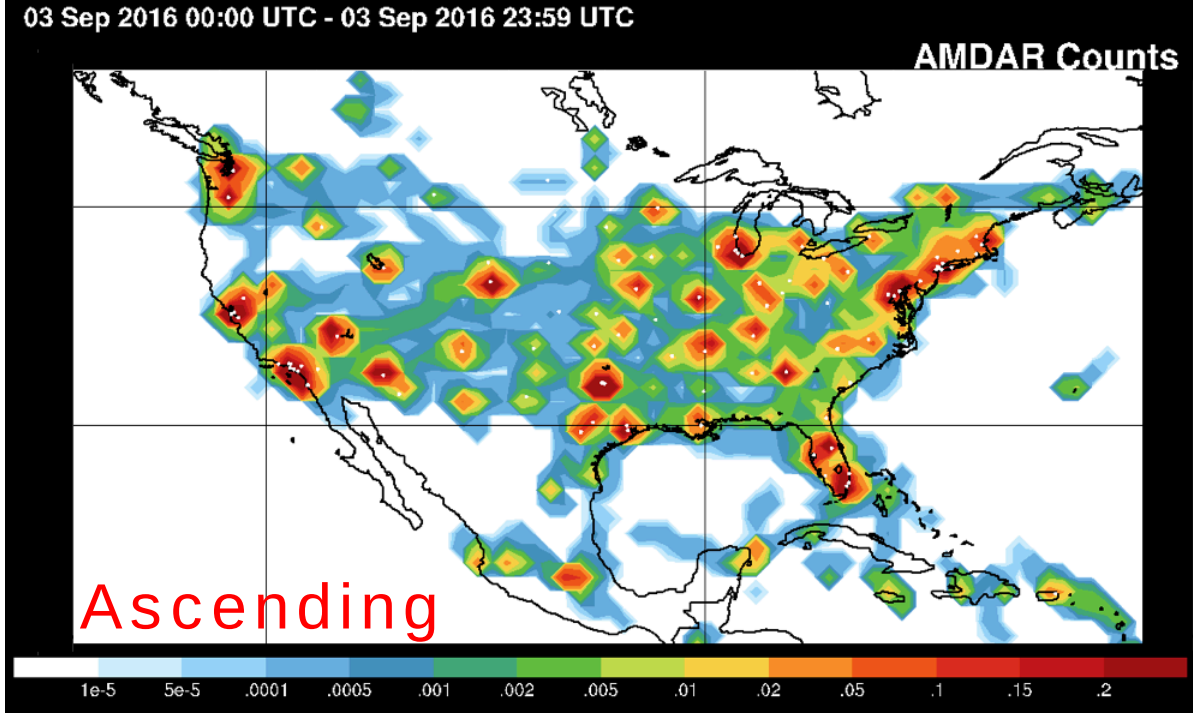


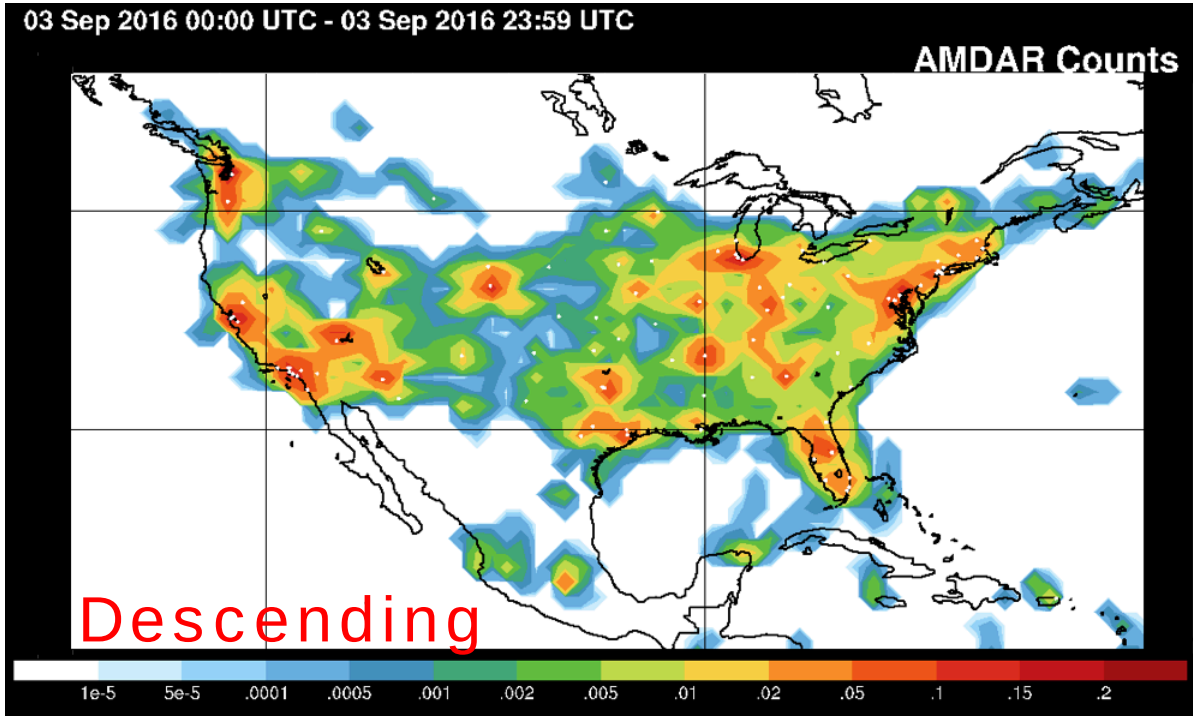






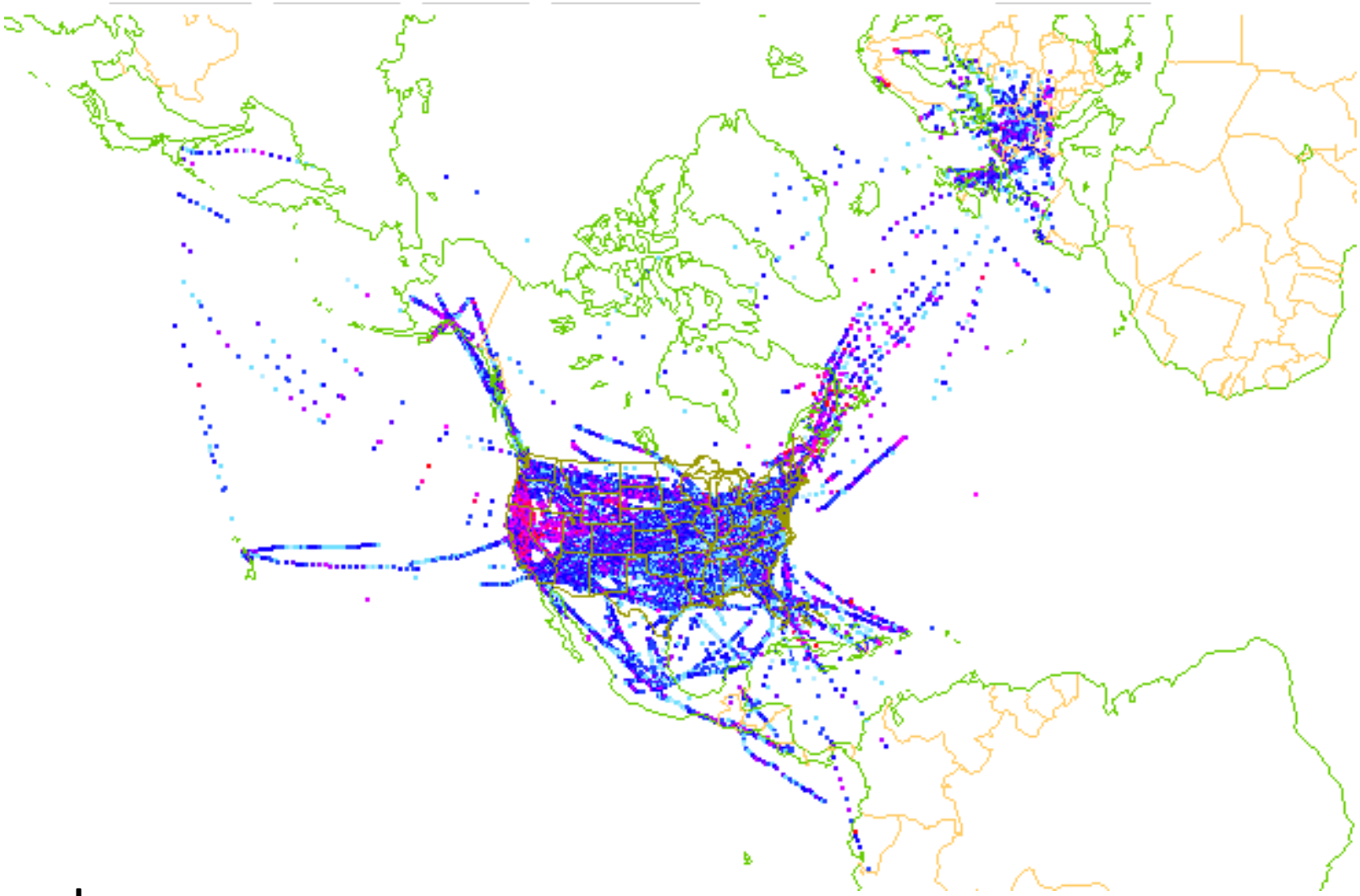
AMDAR obs density -- Ascending/descending -- CONUS





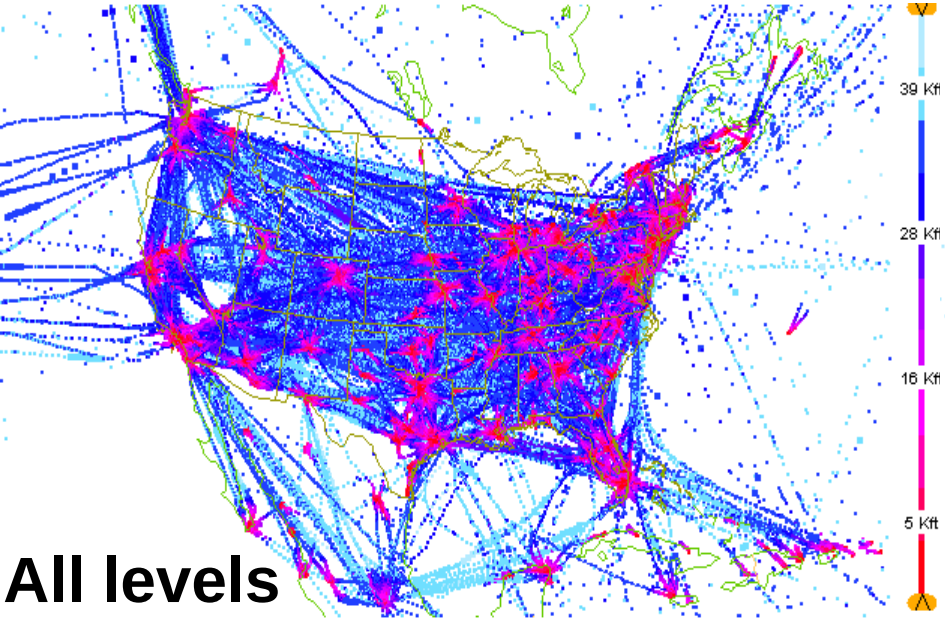
Color coded by vector difference from RAP background field

RAP-AMDAR statistics



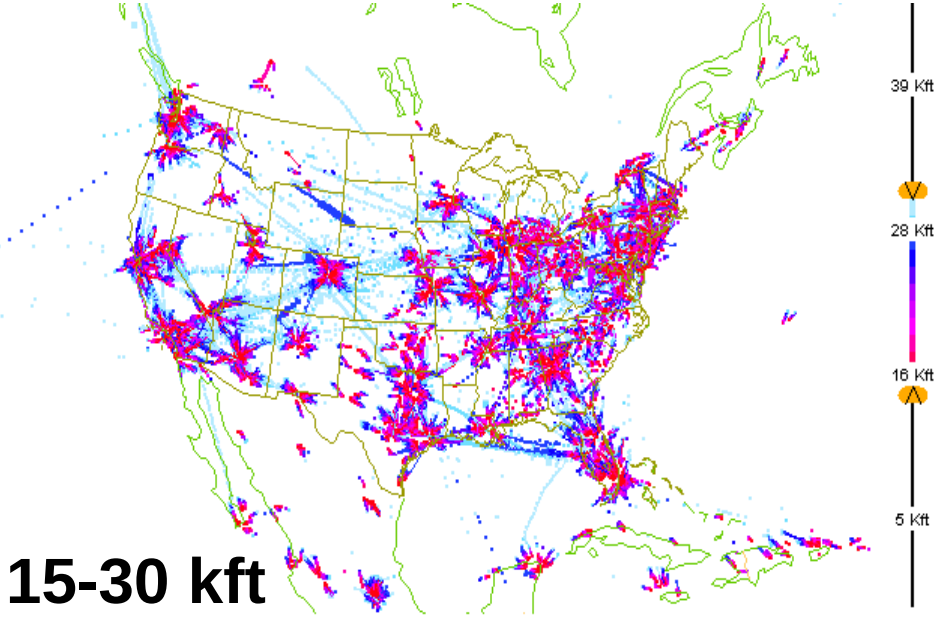
Amdar.noaa.gov

AMDAR obs by elevation – full day – CONUS



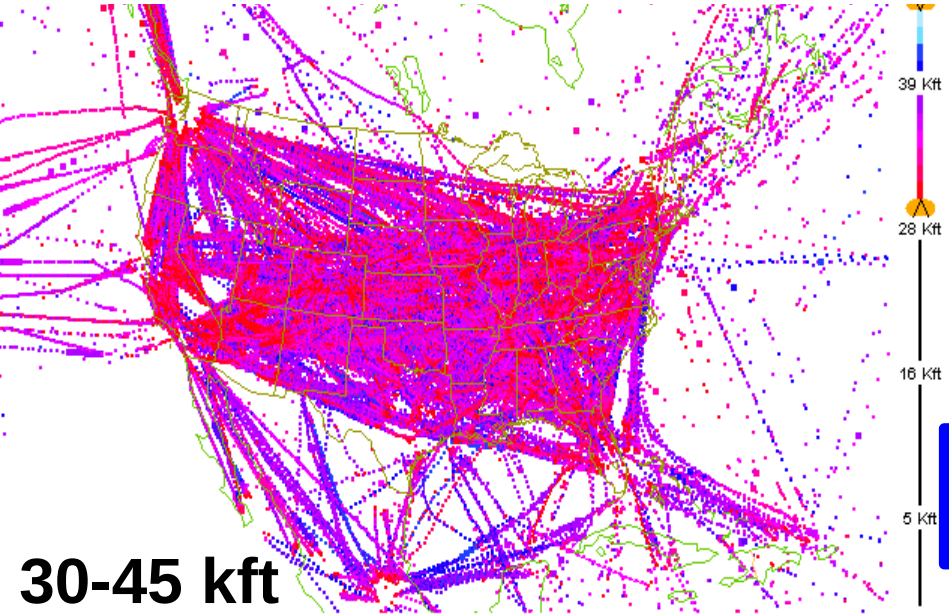
All levels

0-Oct-2016 21:00:00 -- 31-Oct-2016 20:59:59 (580759 obs loaded, 408481 in range, 49149 shown)



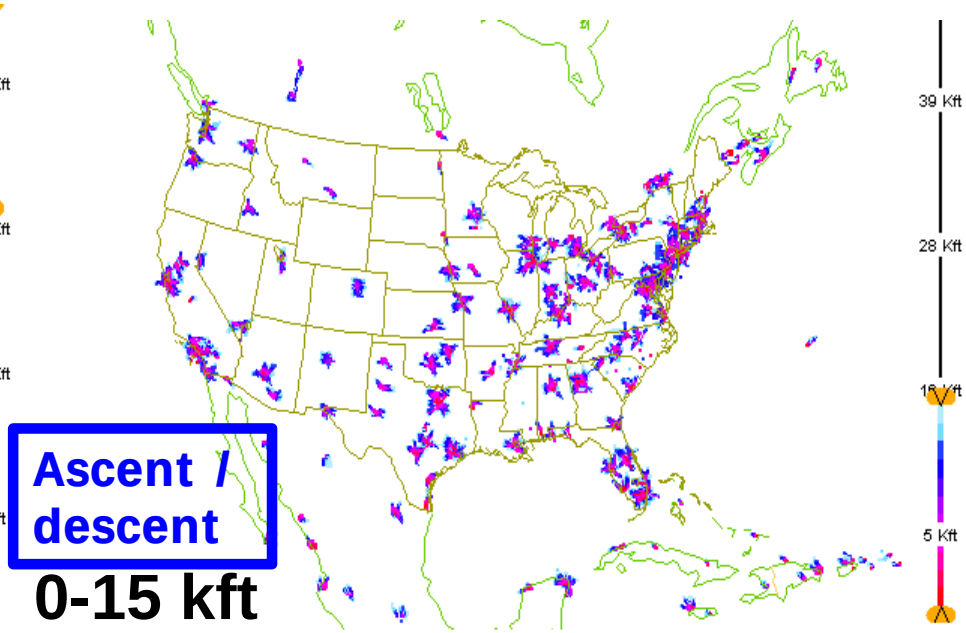
15-30 kft

)-Oct-2016 21:00:00 -- 31-Oct-2016 20:59:59 (580759 obs loaded, 89996 in range, 15978 shown)



30-45 kft

0-Oct-2016 21:00:00 -- 31-Oct-2016 20:59:59 (580759 obs loaded, 128590 in range, 42791 shown)



Ascent / descent

0-15 kft

-Oct-2016 21:00:00 -- 31-Oct-2016 20:59:59 (580759 obs loaded, 192366 in range, 6312 shown)

Regional Observation Impact studies with RAP - GSD

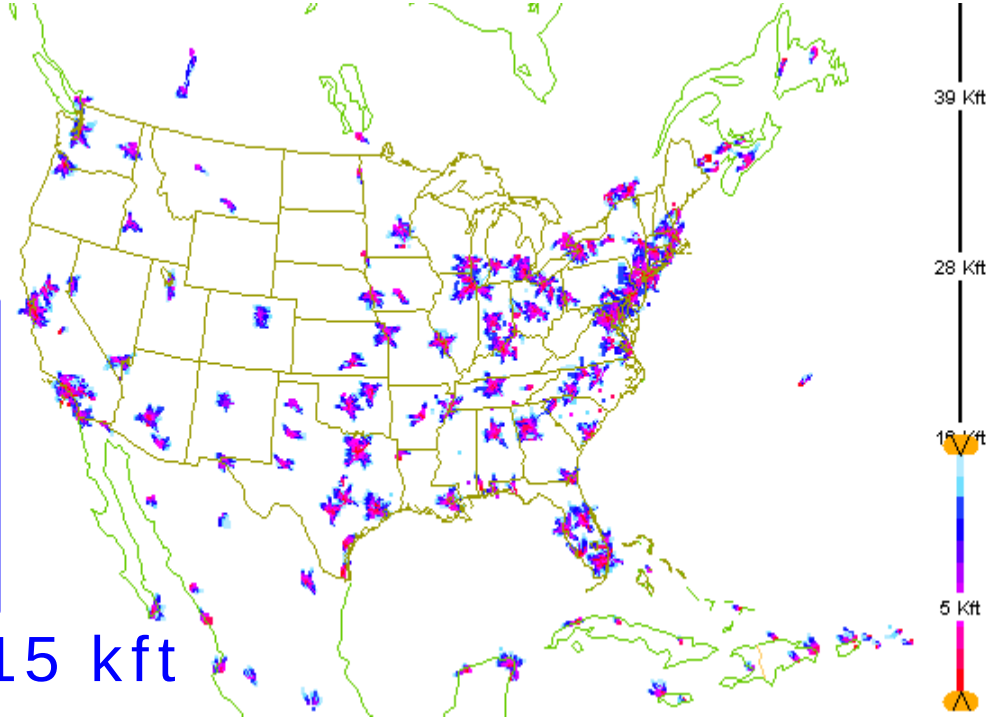
- **Significant gap to achieve profiles every 300 km/3h**
  -- achieving **frequent aircraft profiles** out of **regional airports** estimated to significantly improve forecast accuracy

- ***Ongoing airborne observation study sponsored by FAA (GSD, AvMet)***

- ***2017 article by James and Benjamin, MWR***

How can we expand this coverage?

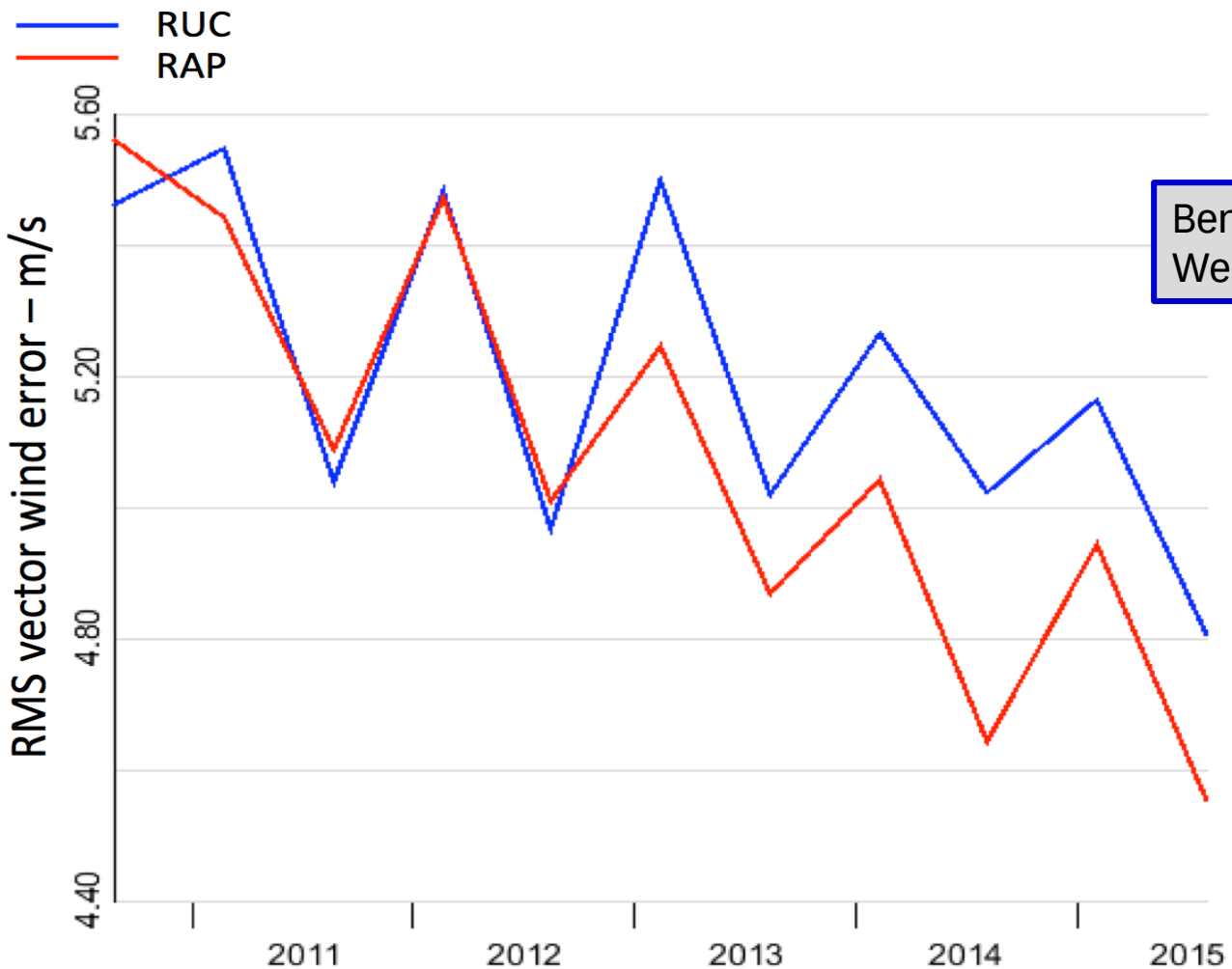
Ascent / descent Data for an entire day



0-15 kft

250 hPa RMS vector error vs. raobs over CONUS
RUC / RAP
2010-2015 – 6h forecasts

Steady progress in upper-level wind skill



Benj et al, 2016, Mon. Wea. Rev.