ABO in NOAA Mesoscale/Convective Scale Weather Modeling

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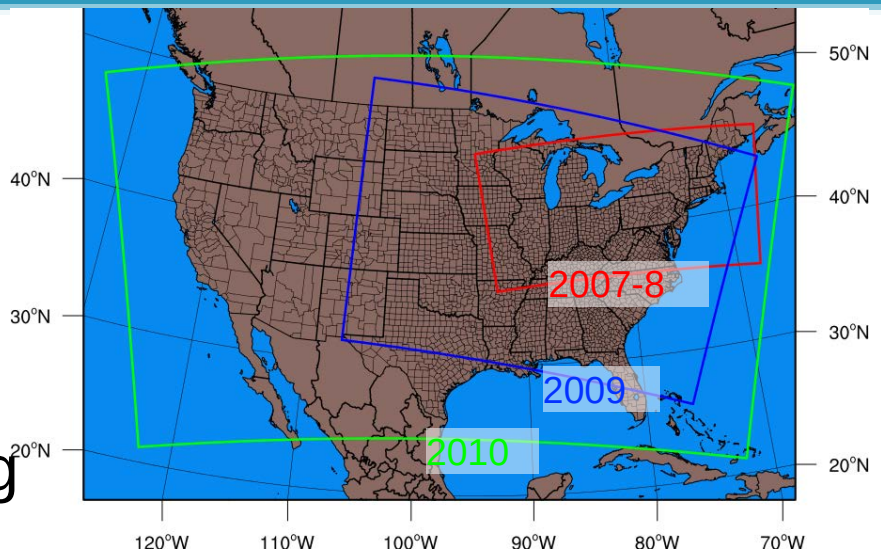
and the RAP/HRRR development team at GSD

NOAA/ESRL

GLOBAL SYSTEMS DIVISION

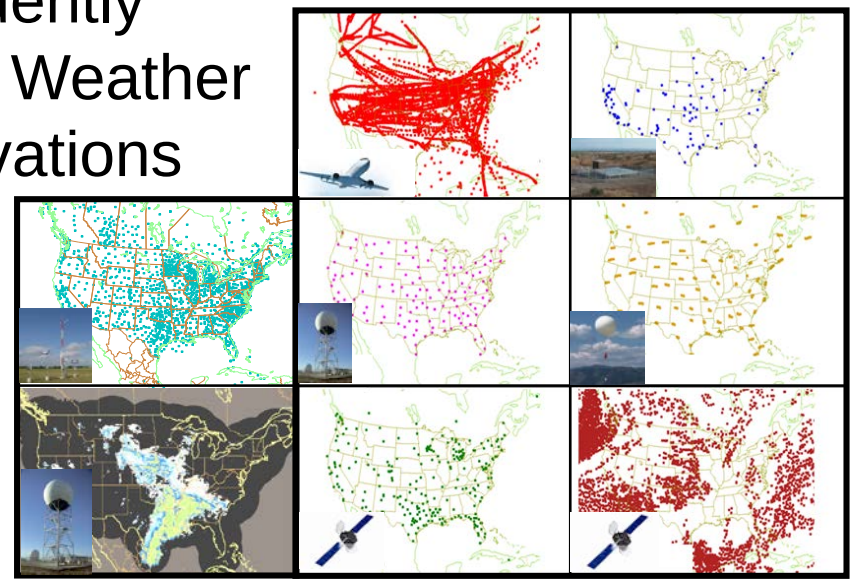
Hourly Updating Computer Weather Forecasts

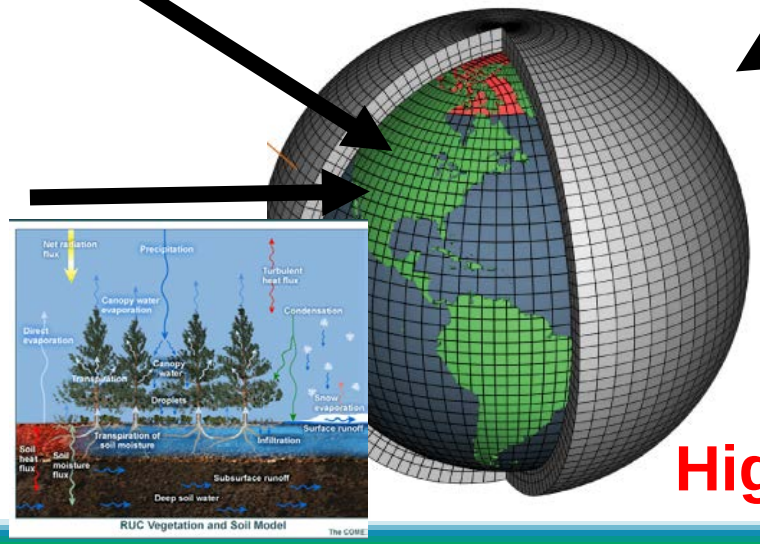
Increased Supercomputing Power



More Grid Point Calculations

Frequently Updating Weather Observations





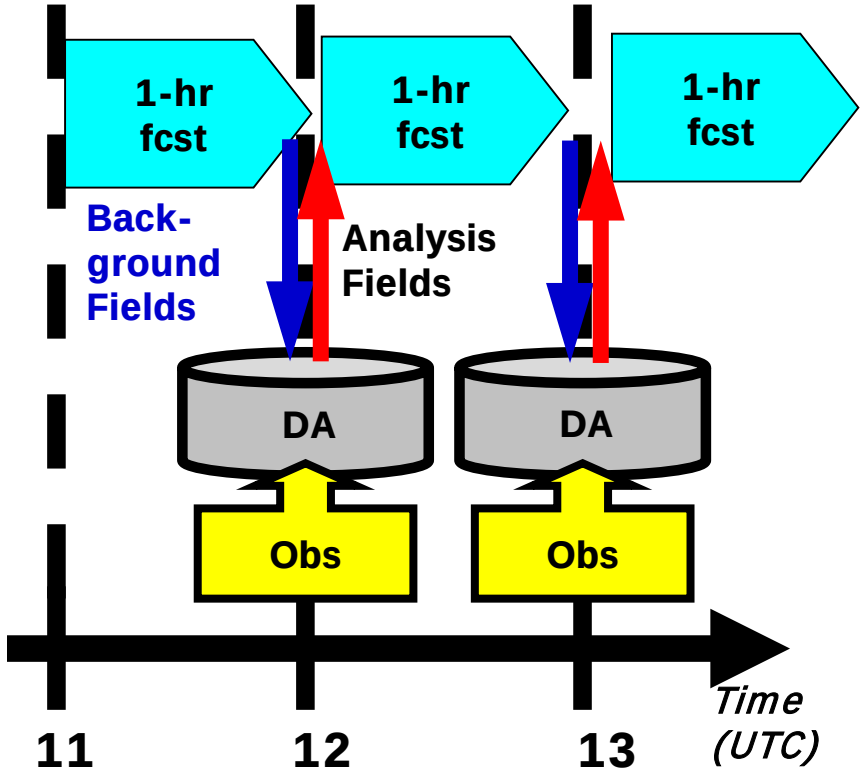
Accurate Computer Representation of Weather Processes

= Powerful Computer Forecasts

Rapid Refresh (RAP)
High-Resolution Rapid Refresh (HRRR)

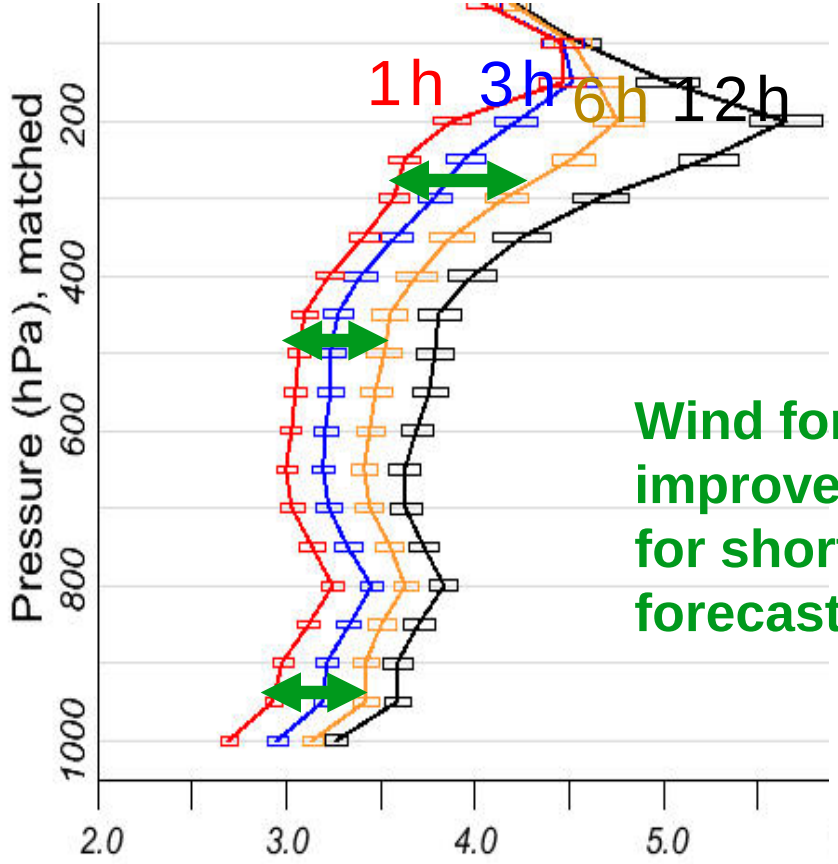
Rapid Refresh Hourly Cycling Improves Guidance

Hourly Update Cycles



Use latest observations EACH HOUR to obtain fresh, most accurate “snapshot” of atmospheric state

Wind Forecast Errors



Get more accurate short-range weather forecasts for decision making

Observations Assimilated

Hourly Observation Type	Variables Observed	Observation Count
Rawinsonde	Temperature, Humidity, Wind, Pressure	120
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

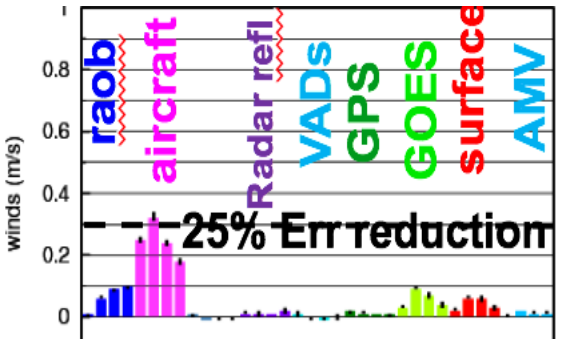
Observation gaps are a major limiting factor for forecast accuracy, even over CONUS

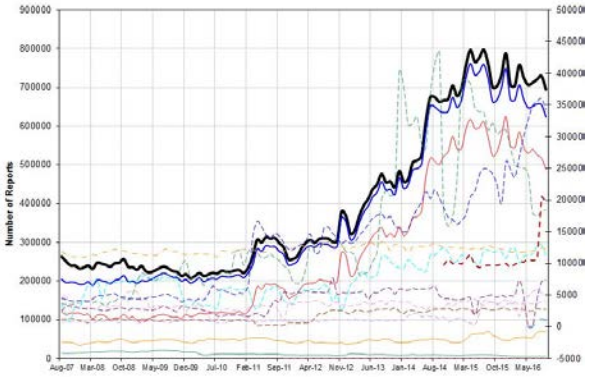
ABO Impact on Weather Models: Key Points

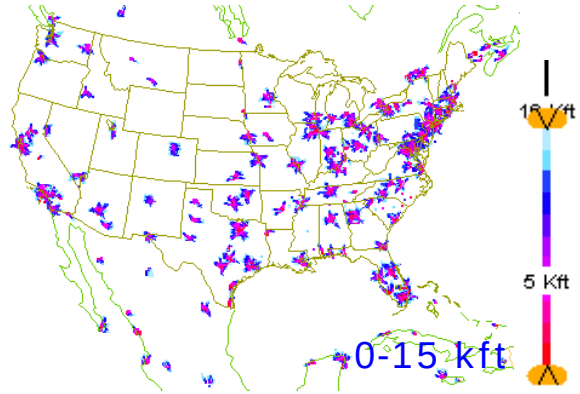
1. Aircraft data most important observation type over North America for 0-12 hour forecast accuracy

2. Increased aircraft data has improved US (and global) forecast skill

3. Geographical and temporal gaps in aircraft data provide opportunity for improved forecast accuracy through improved aircraft participation



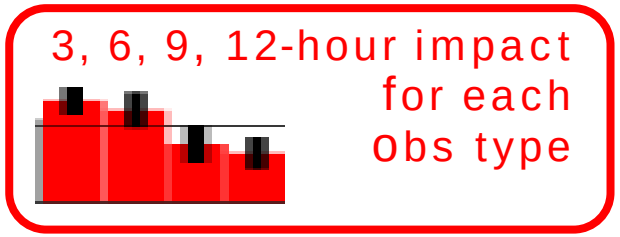


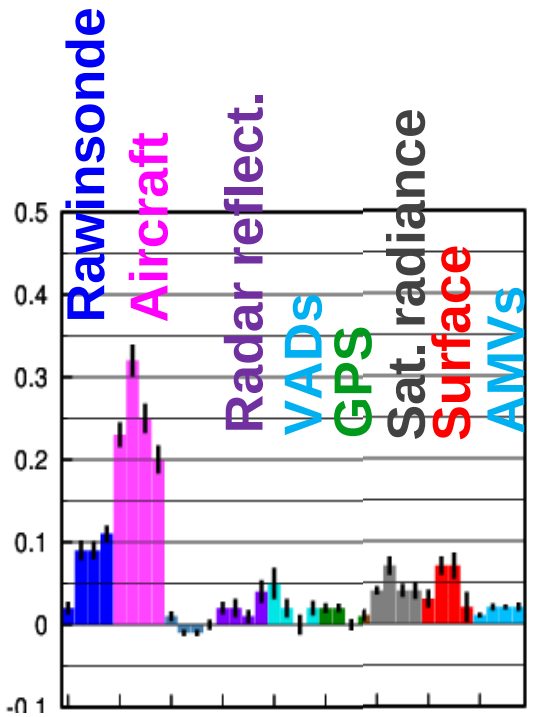


Forecast Impact by Observation Type

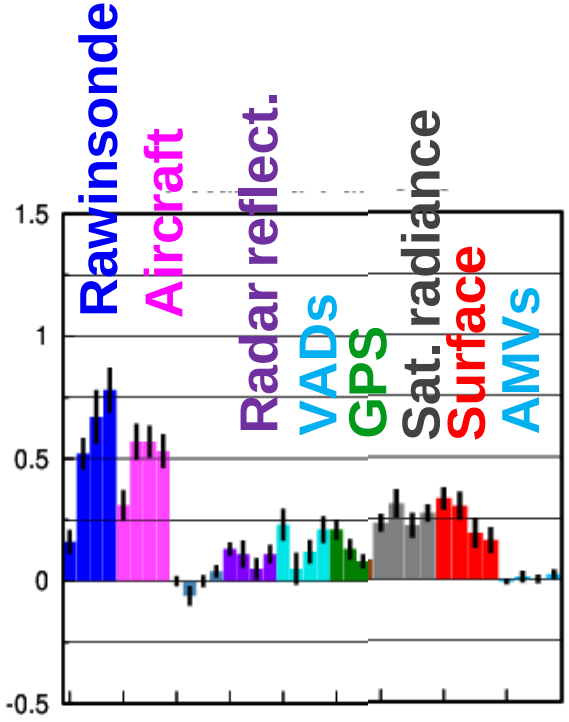
Retrospective Experiment

Vertical Average (1000-100 mb) RMS Error Impact

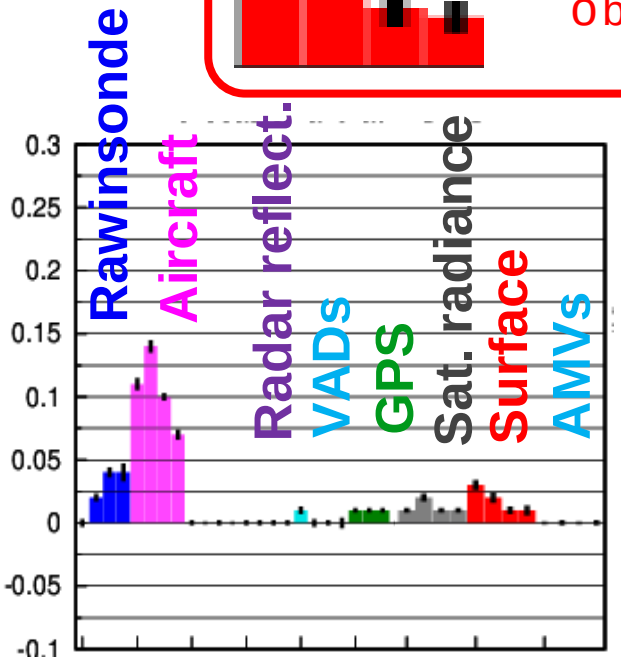




Wind
Impact (m/s)



Relative Humidity
Impact (%)

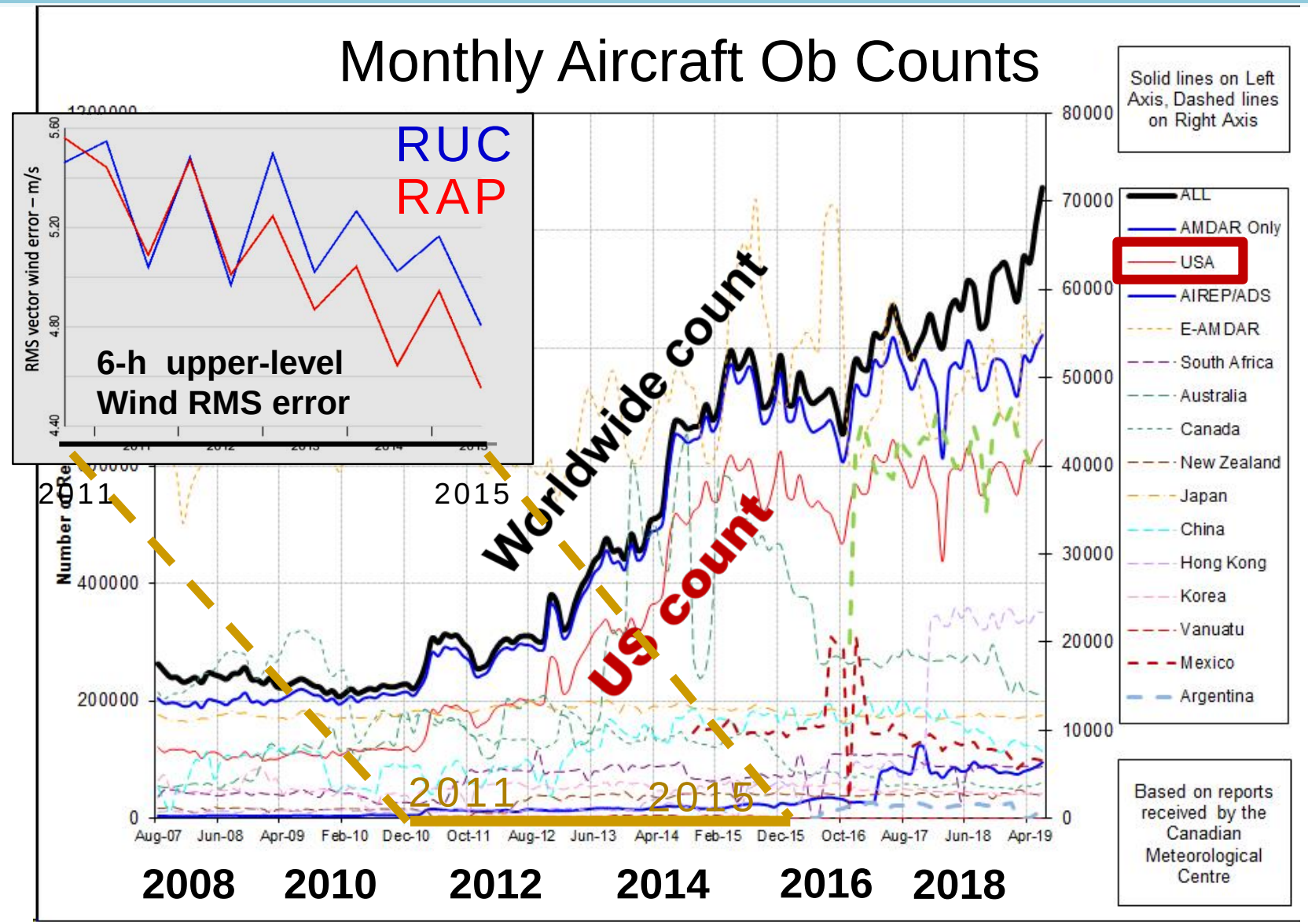


Temperature
impact (k)

- Aircraft obs most important for wind accuracy at all forecast lengths
- Significant impact also from rawinsonde and surface observations

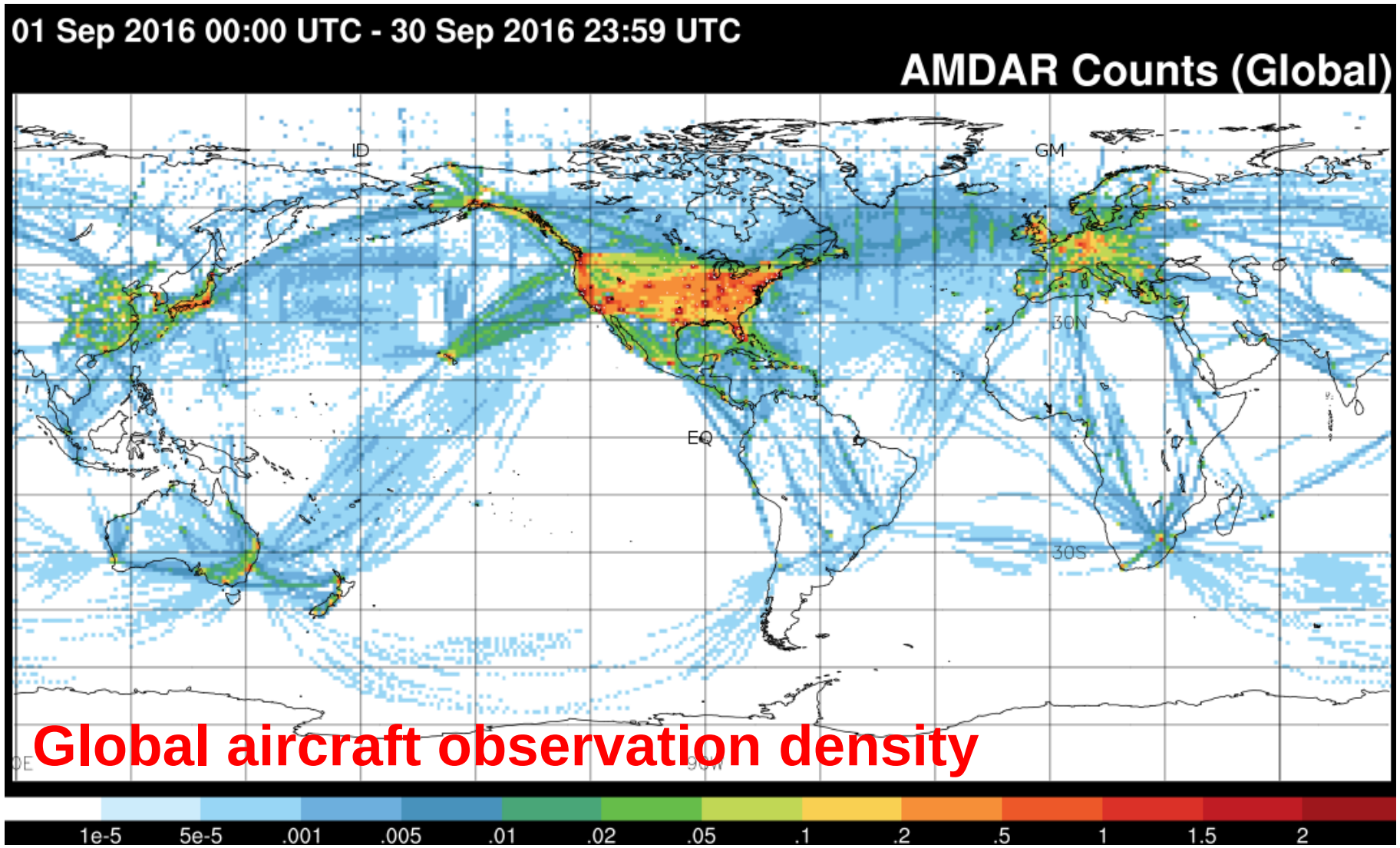
Skill Improved with More ABO

RUC model frozen, skill improvement solely from more obs

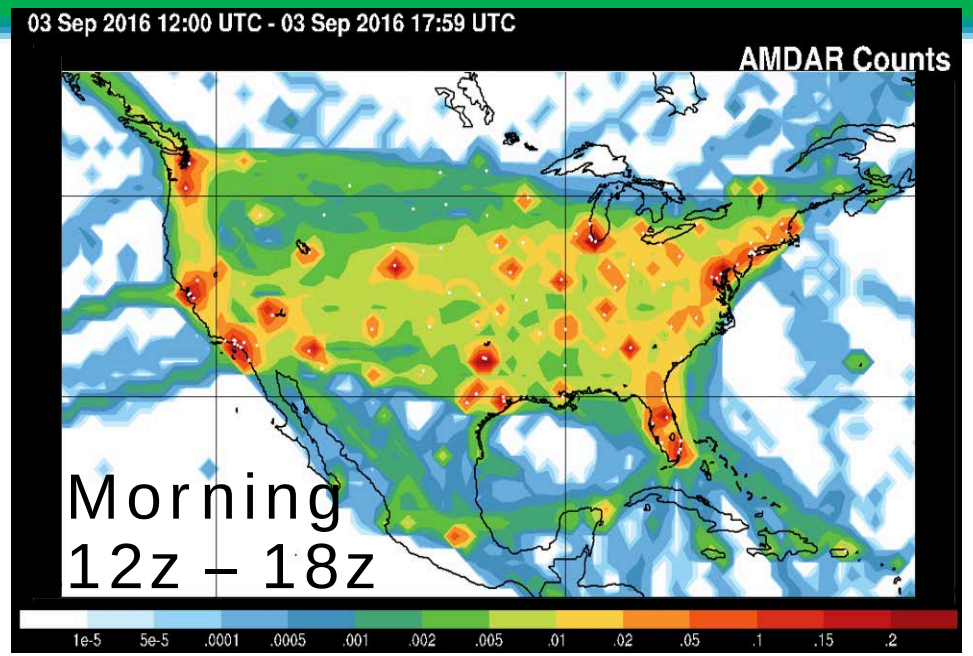


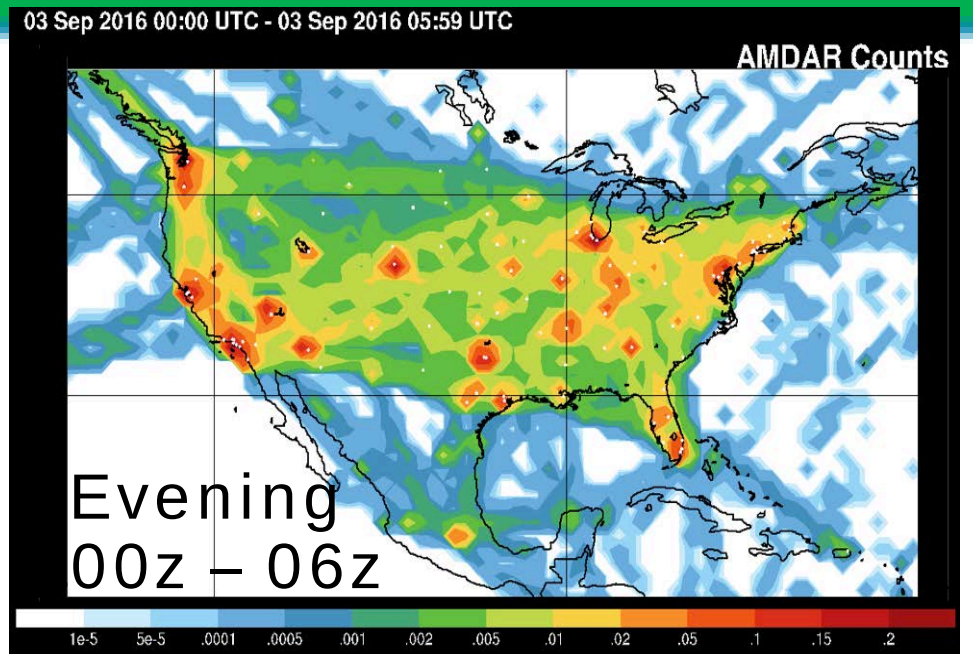
*Rapid Update Cycle (RUC) is the predecessor of the RAP

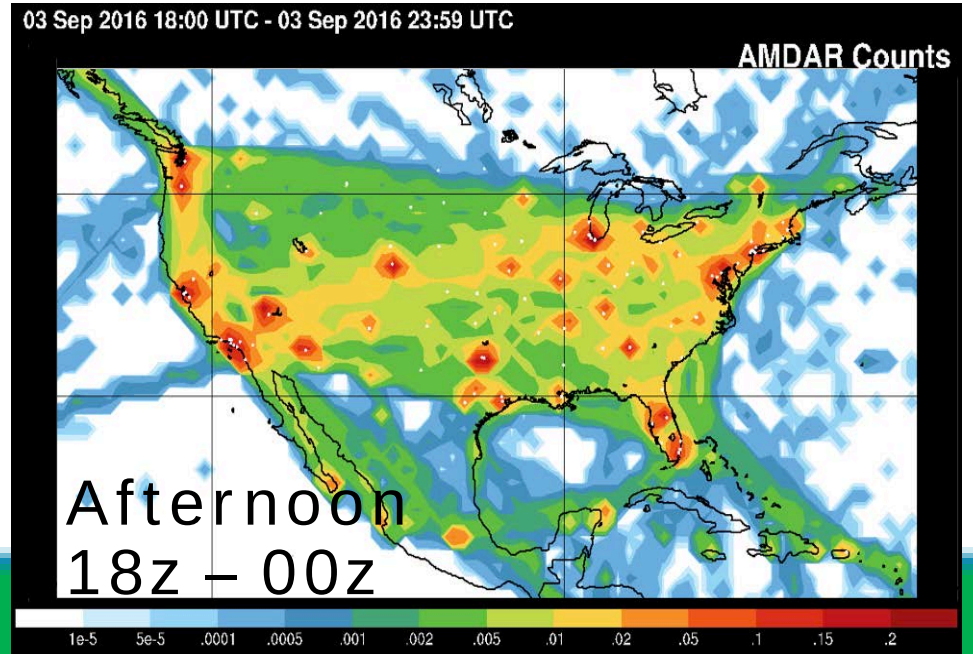
Global aircraft observation importance will increase as global models start hourly cycling

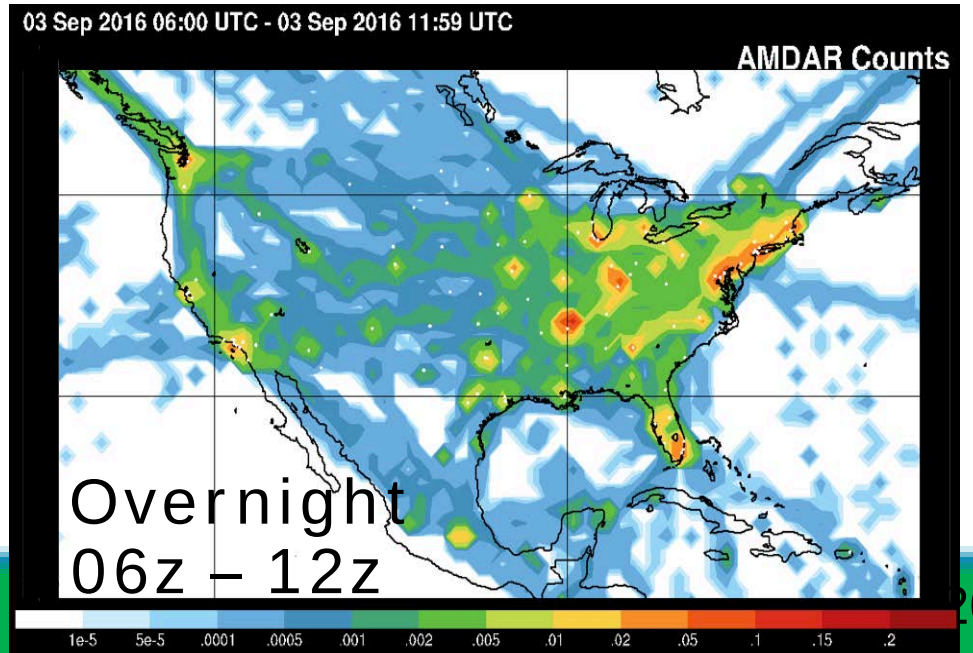


AMDAR Obs Density -- Time of Day Example

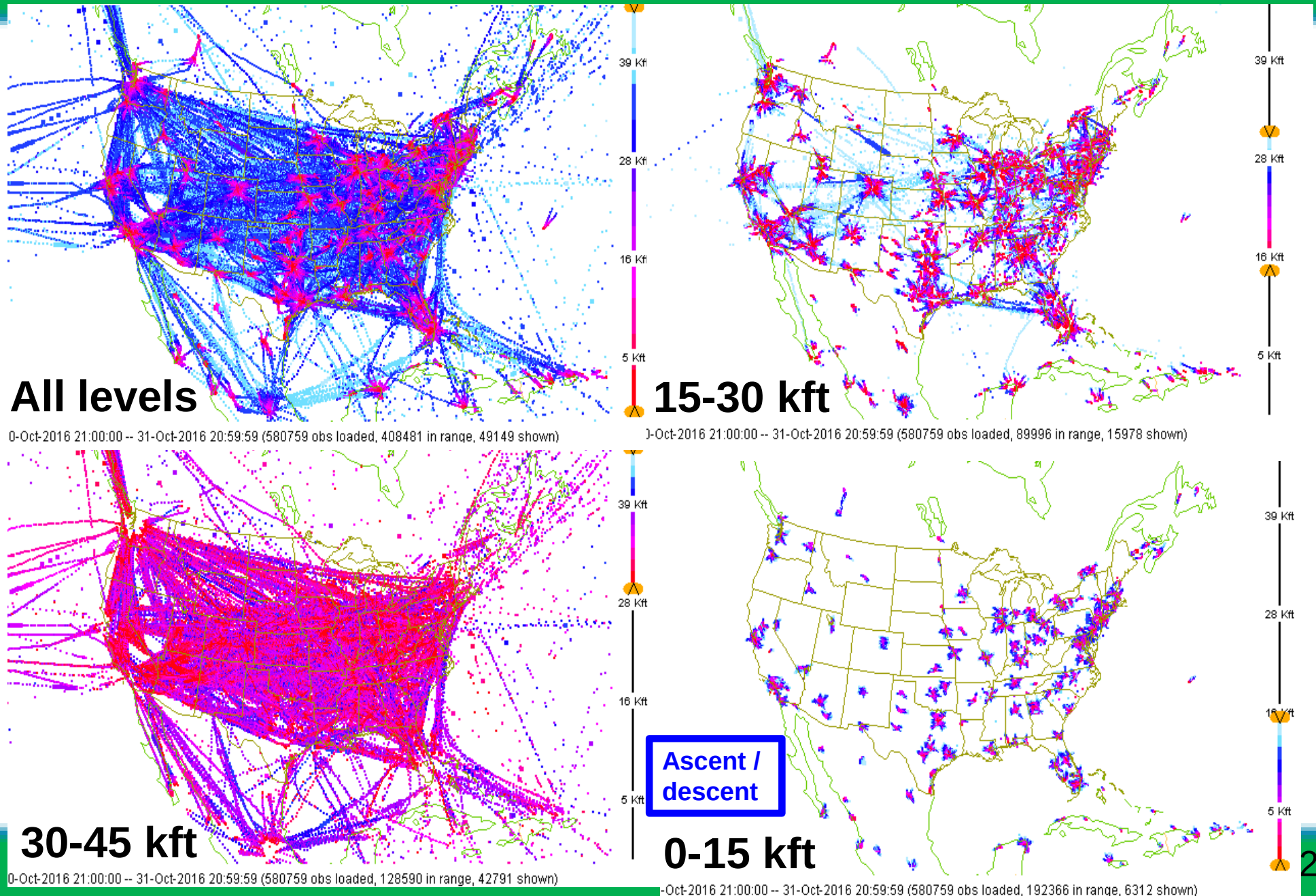








AMDAR Obs by Elevation – Full Day Example

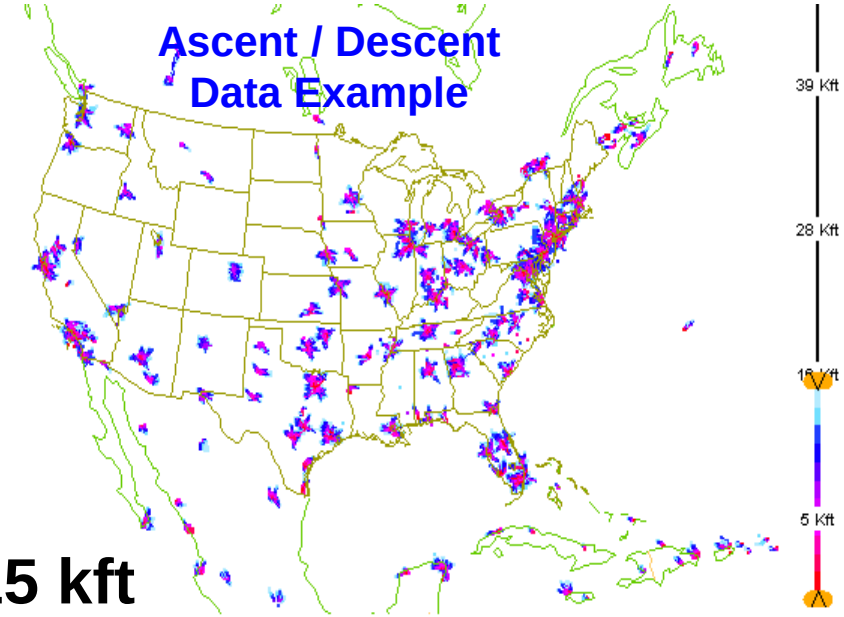


Opportunity: Geographical and Temporal Gaps

Current geographical and temporal gaps in aircraft data provide opportunity for improved forecast accuracy

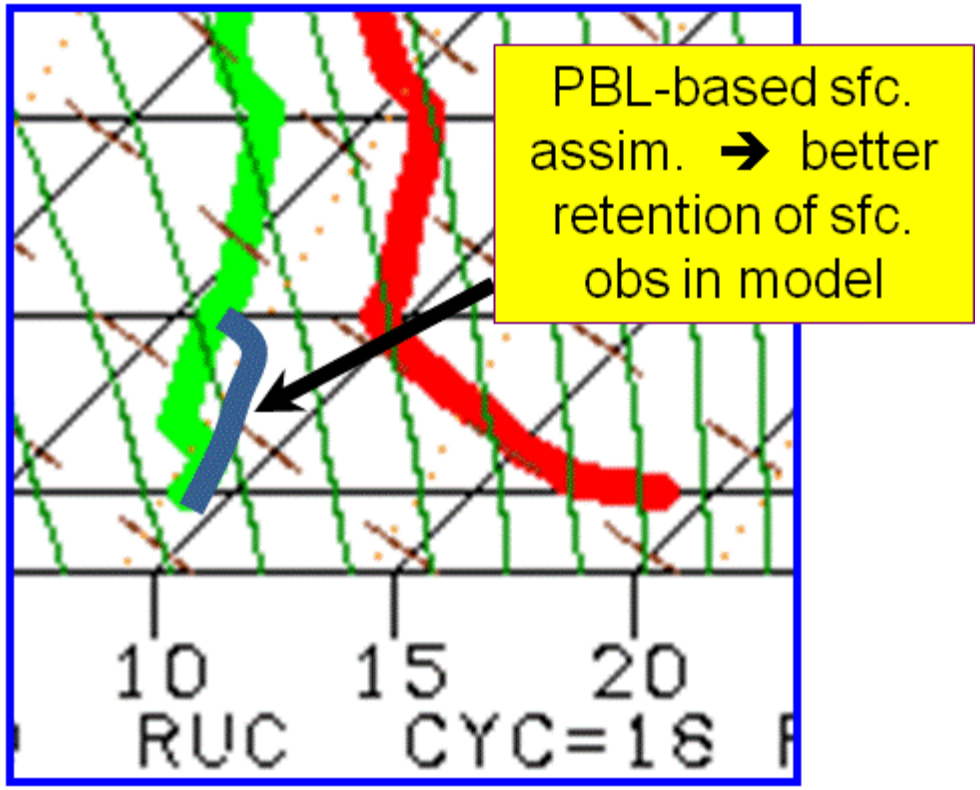
- Frequent profile data for hourly and sub-hourly assimilation
- Consistency in diurnal coverage
- Smaller, regional airports could provide needed increase of data coverage
- Expected significant improvement in
  - Analyses
  - Forecasts - hours to days time frame
  - Especially for mesoscale and storm-scale features (e.g. cold fronts, marine stratus cloud, convection, etc.)

What are the coverage expansion priorities For improved model skill?



0-15 kft

Importance of Planetary Boundary Layer Observations

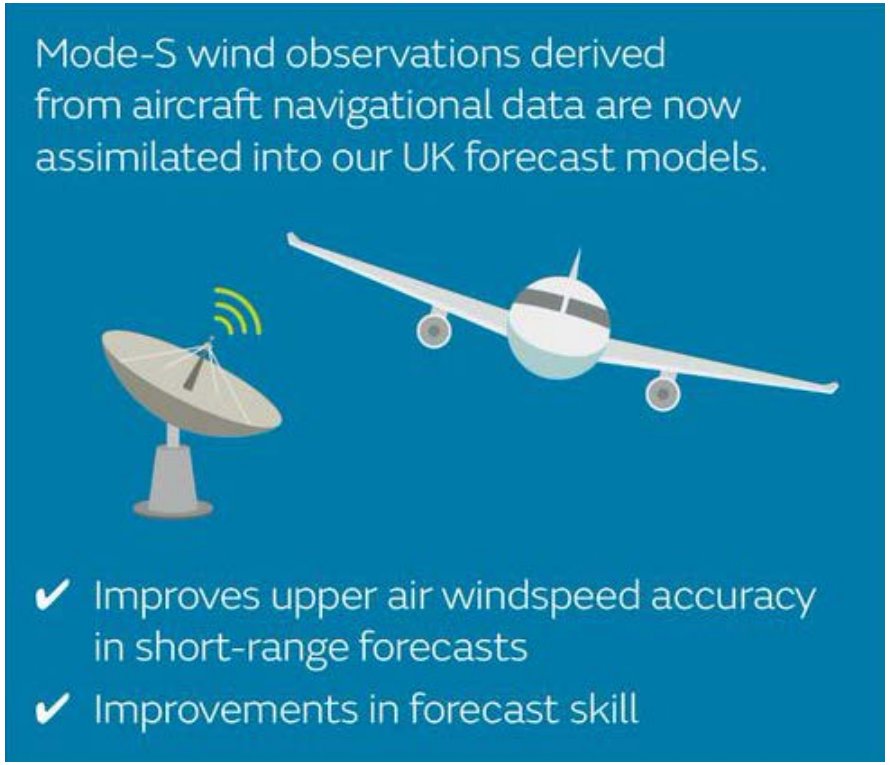


- Pseudo-PBL obs are generated based on surface observations
- Pseudo-PBL obs have improved short HRRR forecasts

- Authentic obs in the PBL have potential to make a big impact
  - Especially moisture near the top of the PBL, that area is sensitive to small changes for processes like convective initiation and cloud bases

Mode-S use in Europe

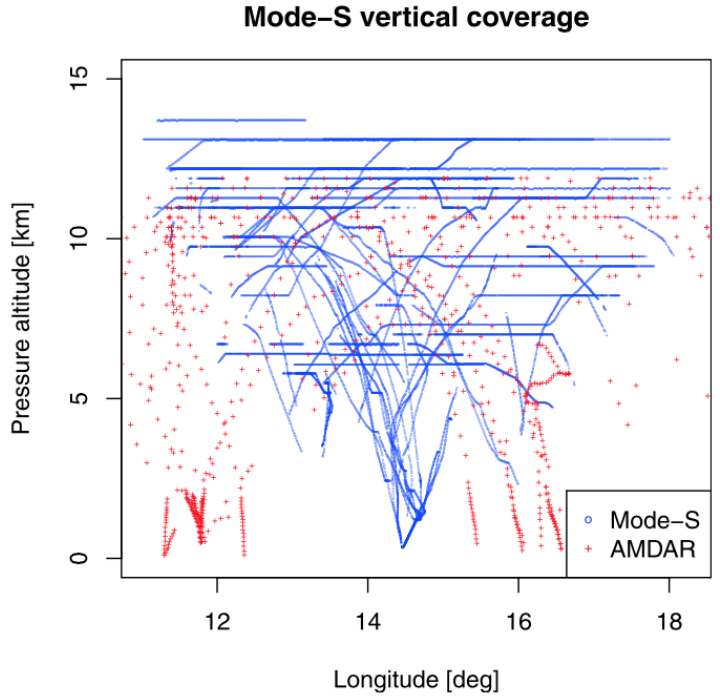
Mode-S EnHanced Surveillance (EHS)



From Dale Barker @ UK Met Office

- wind and temperature data are lower quality
- Still provides benefit

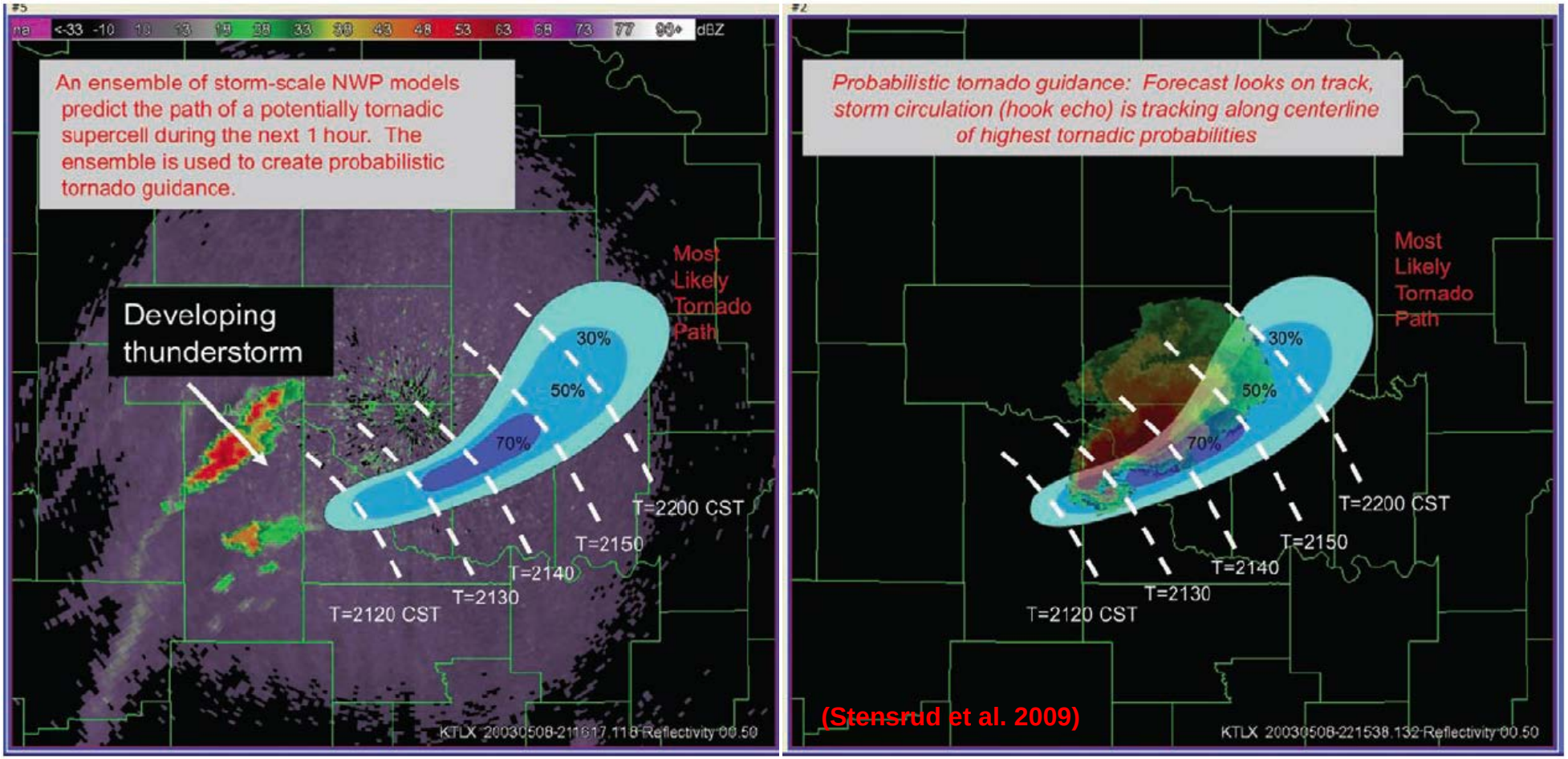
Mode-S Meteorological Routine Air Report (MRAR) *Not mandatory, limited aircraft report



From Benedikt Strajnar @ Slovenian Environment Agency

- wind and temperature are of sufficient accuracy
- fully comparable to the quality of AMDAR

Hypothesis – Mode-S high-resolution data can significantly improve weather analysis & forecast



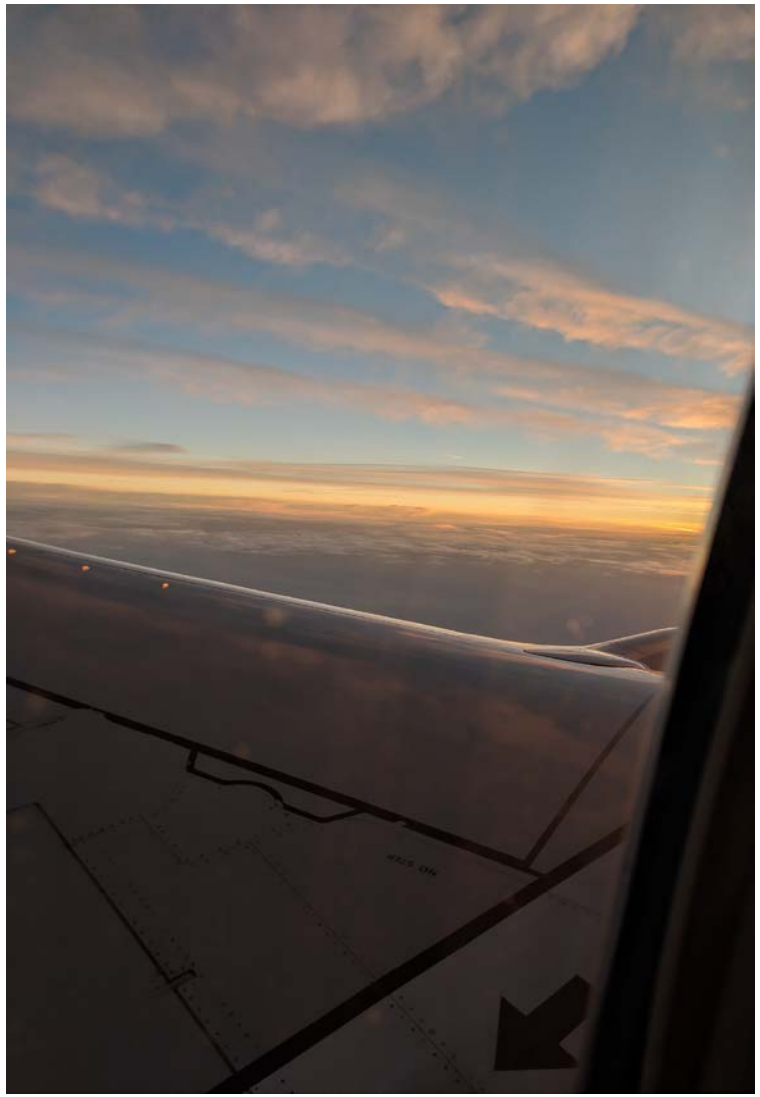
(Stensrud et al. 2009)

- Sub-hourly data needed
- Resolution could provide more detail for UAS guidance

Automatic Dependent Surveillance-Broadcast (ADS-B) Version 3

- ADS-B Version 3 Weather would enable further weather analysis and forecast improvements
- Making it a mandatory requirement is important for increased observation coverage
- Future aviation weather forecasts benefits

Questions?



GSD subject matter experts: GSD.Model.QA@noaa.gov

James, EP and SG Benjamin (2017), **Observation System Experiments with the Hourly Updating Rapid Refresh Model Using GSI Hybrid Ensemble-Variational Data Assimilation.** *Mon. Weather Rev.* Version: 1 *145* (8) 2897-2918, issn: 0027-0644, ids: FF8YW, doi: 10.1175/MWR-D-16-0398.1

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