Development of Quality Indicators for Meteorological Data Used in the Calculation of Aircraft ASE

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Contents

ASE Technical Interchange Meeting

History of Aircraft ASE Monitoring – Onboard Aircraft Monitoring

Generations of GPS Monitoring Units (GMUs)

1995

GPS Monitoring Unit GMU

2003

Enhanced GPS Monitoring Unit EGMU

Enhanced^2 GPS Monitoring Unit (E^2GMU)

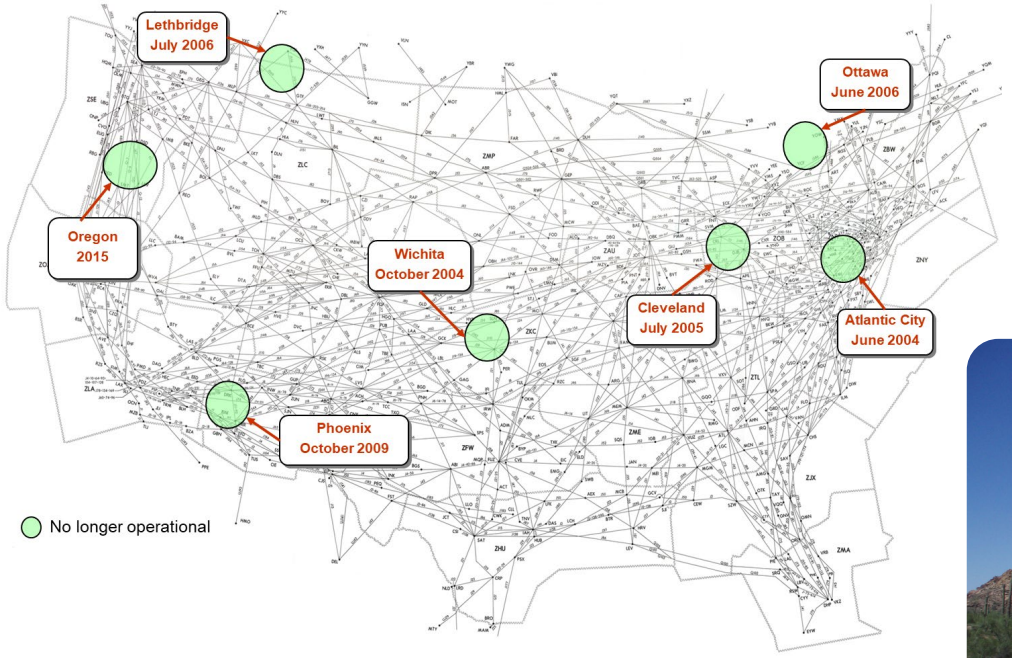
2013

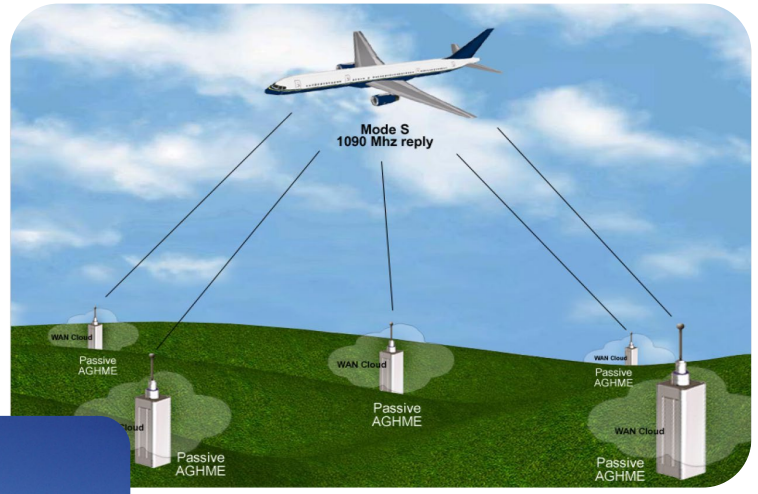
1995 2000 2010 2015

20YY 20YY 20YY 20YY

History of Aircraft ASE Monitoring – Ground-based Monitoring

Aircraft Geometric Height Measurement Element (AGHME)

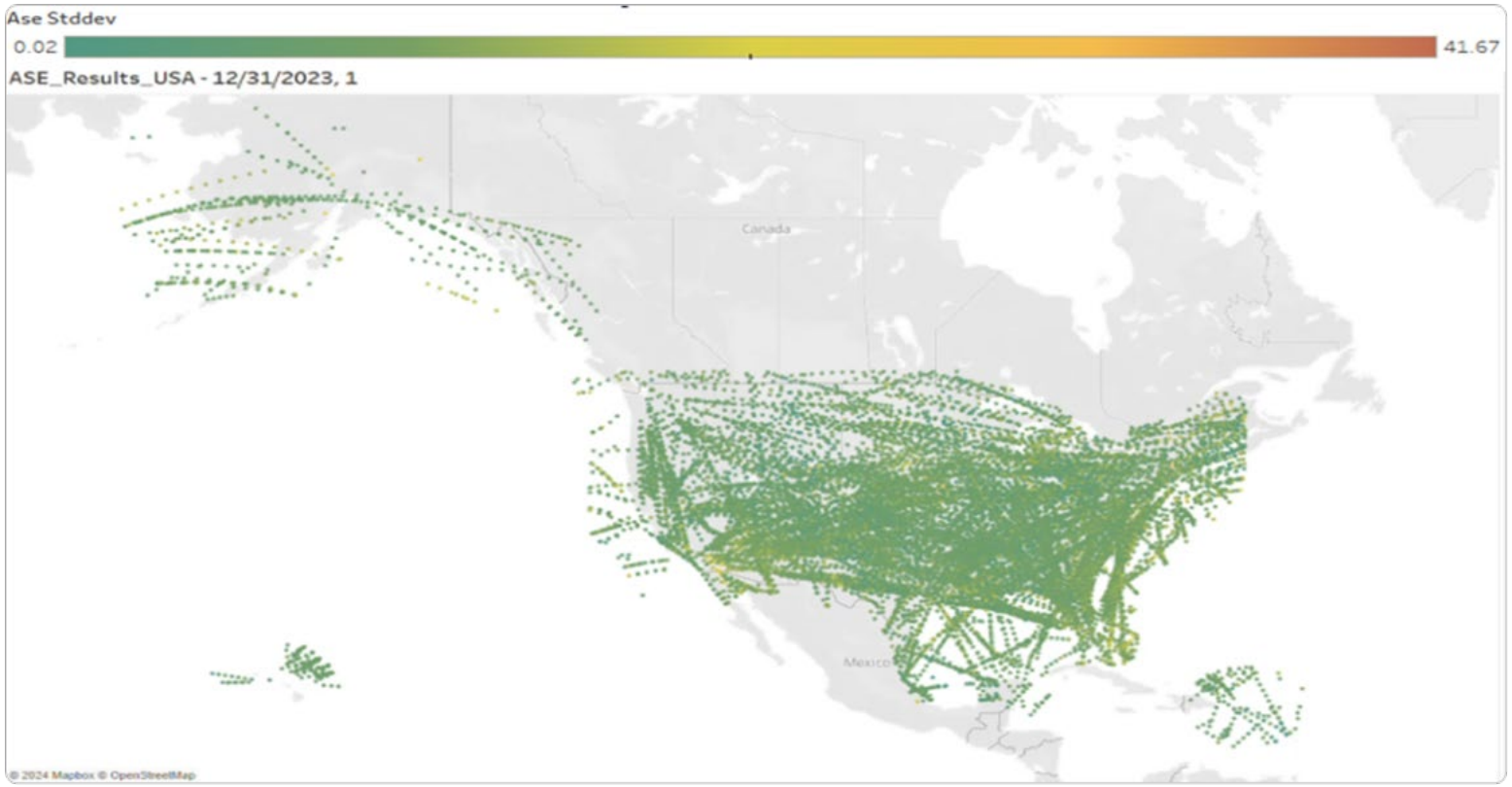


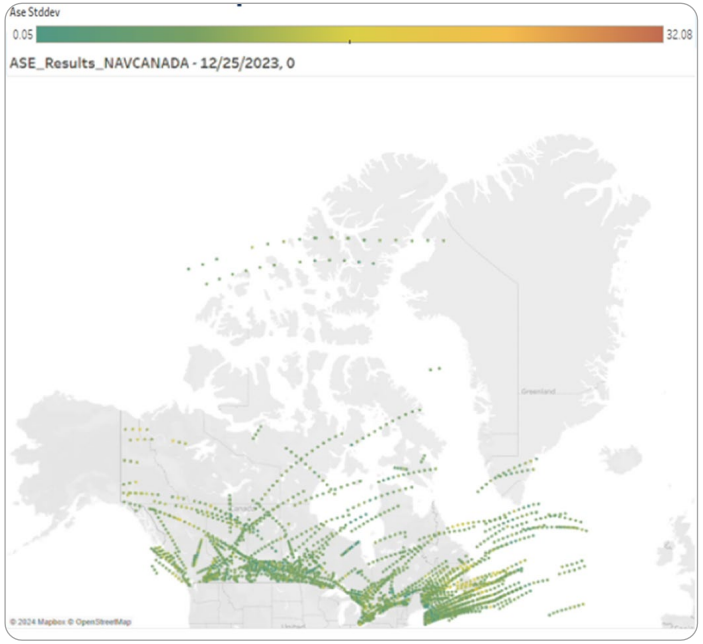


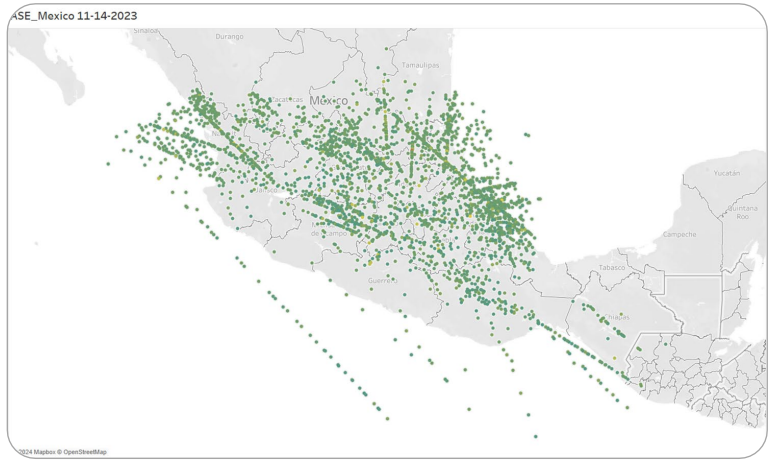
Aircraft ASE Monitoring Today

Daily process using NAS ADS-B data and NOAA meteorological data

- Canada and Mexico ADS-B data processed weekly

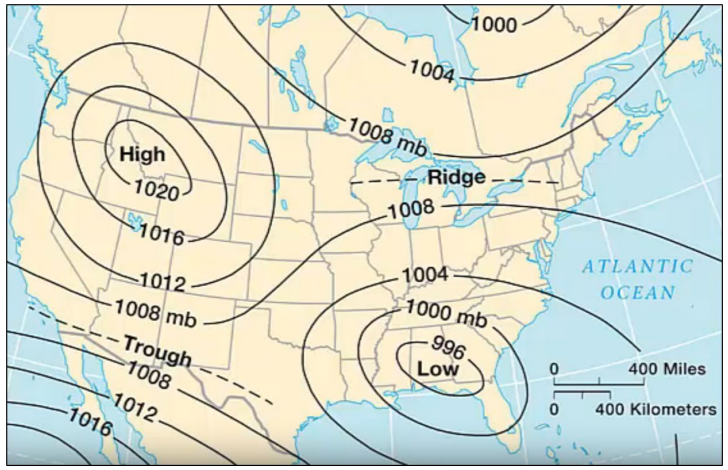


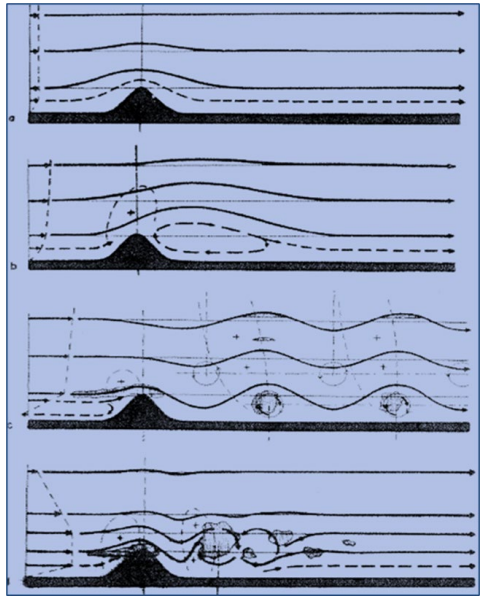


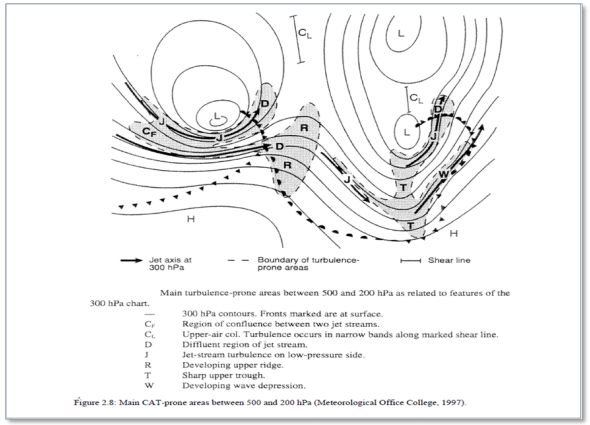


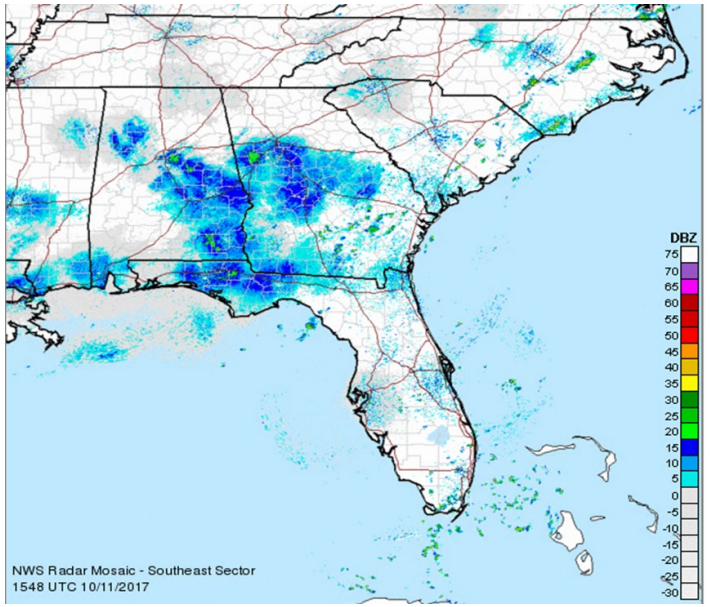
Quality Control Challenges

- Monitoring now covers the entire US
- Detect areas where NOAA GDAS (Global Data Assimilation System) does not accurately capture real-time met
- Clear-air turbulence (CAT)
- Icing
- Troughs and ridges
- Convection (storms)



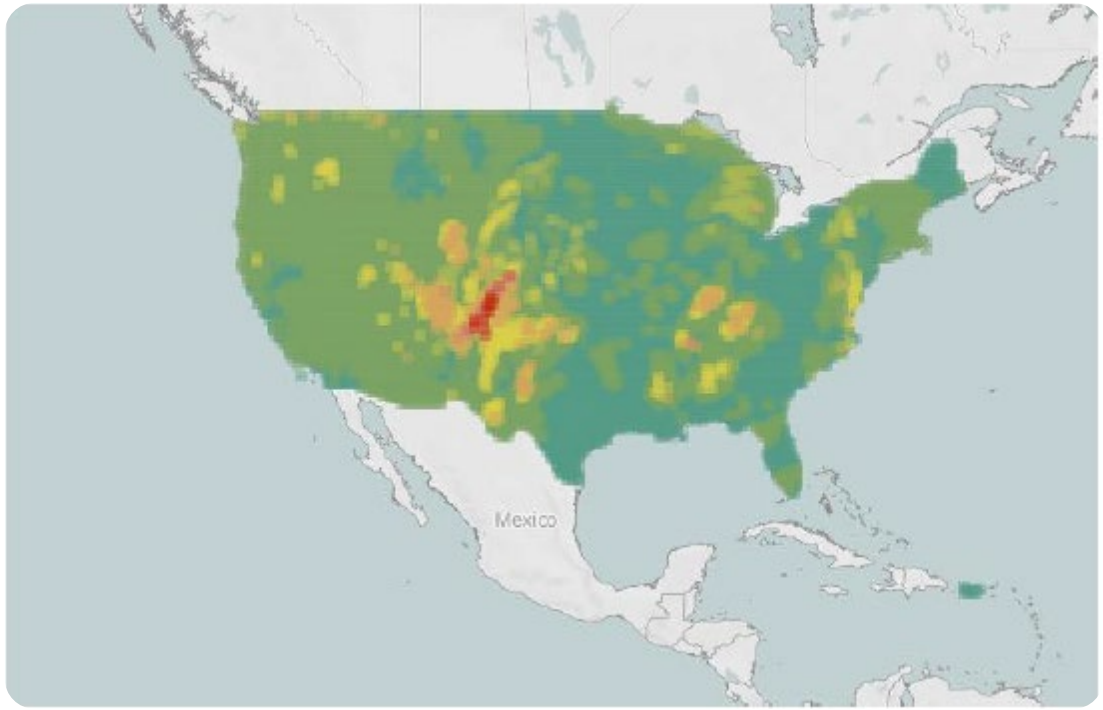






Assessing Meteorological Data

- Meteomatics is a company specializing in high-resolution commercial weather forecasting.
- They use advanced algorithms to interpolate and refine meteorological data, ensuring high accuracy.
- In the visualization,
  - ✓ Green represents high-quality data
  - ✓ Red indicates lower reliability.
- The image suggests that data over the Southwestern U.S. may be unsuitable for calculating ASE for the depicted day/time/FL, possibly due to a weather disturbance or another factor affecting the integrity of the calculations.

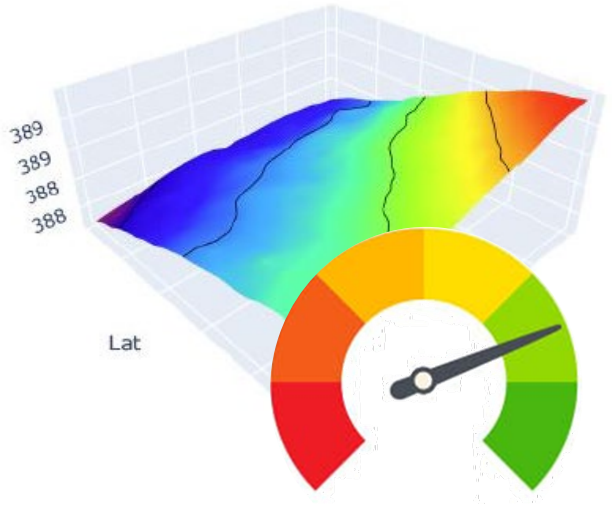


Quality indicators used by Meteomatics

Assessment of Meteorological Data

North American Approvals Registry and Monitoring Organization (NAARMO) initiated development of quality indicators for meteorological data used in the calculation of aircraft Altimetry System Error (ASE).

- The meteorological data is sourced from the Global Data Assimilation System (GDAS).
- The data contain the geopotential heights of flight levels180 – 670 for global positions.
- The global positions have a grid layout of latitude and longitude with a 0.25-degree × 0.25-degree resolution.
- There are twenty-four files for each day, each file represents an hour of the day.



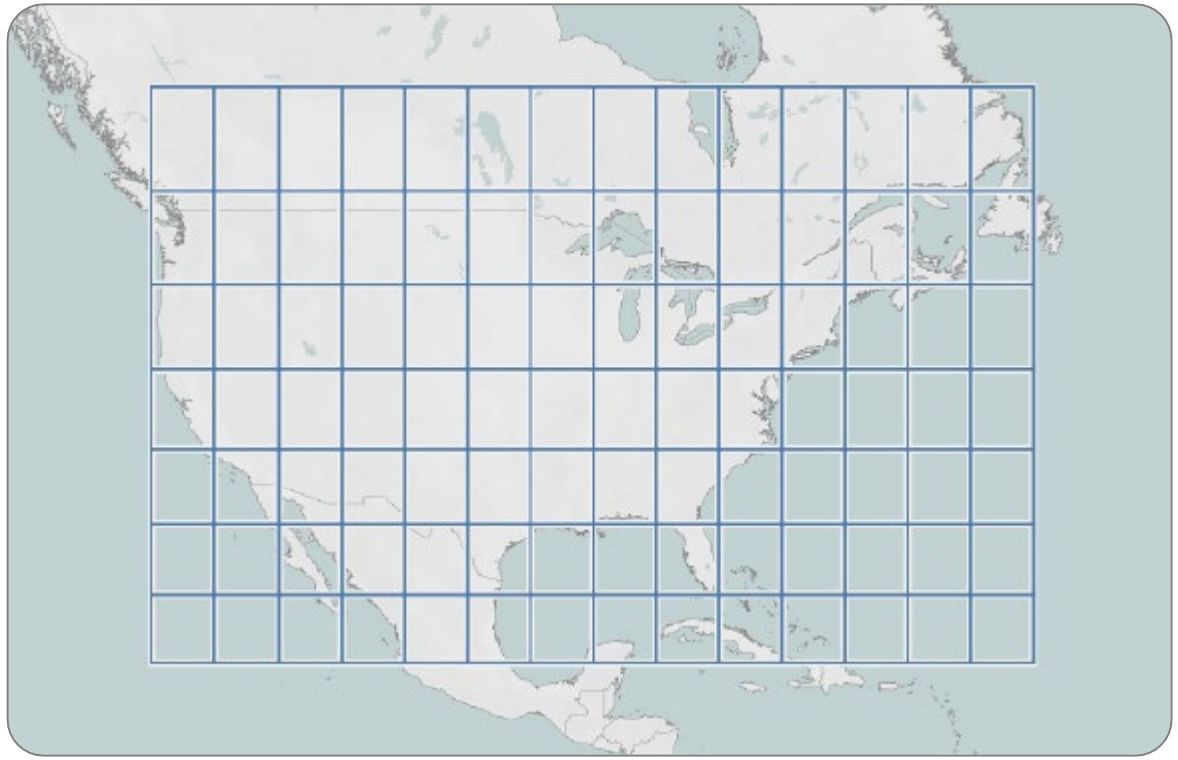
Assessment of Meteorological Data

- The ASE calculation software requires twenty-five meteorological files to calculate ASE for a day: twenty-four hourly files for the monitored day and the first hour of the following day.
- Meteorological data- such as pressure, temperature, and geopotential heights - contribute to the calculation of ASE.
- By developing reliable quality indicators, we can assess the integrity of the meteorological data used in ASE calculations.
- This ensures that only high-quality data are used, reducing the risk of false negative/positive results

First Step

- The contiguous United States (CONUS) is divided into 5-degree grid squares per flight level (ranging from FL290 to FL450) to enable organized geographic assessment of meteorological data.

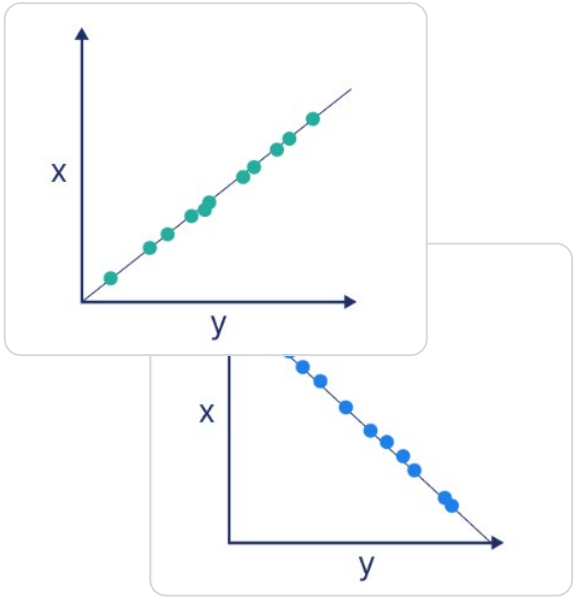
- tools look for evidence of localized turbulence, storms or other short-lived weather systems
- Method is to separate data into grids
- Examine relationship between geopotential heights and location with each grid



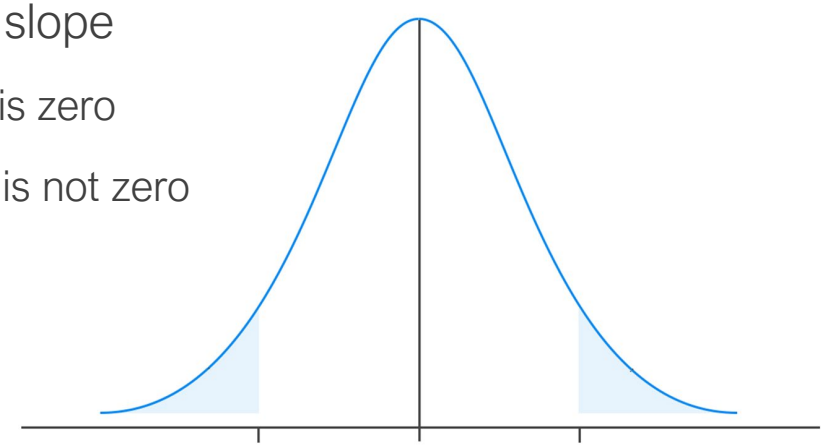
Geographic grid system over CONUS

Assessment of Meteorological Data

Within each square grid, the slope is calculated using longitude (vx) and geopotential height (vy), the correlation coefficient is computed to evaluate the quality of the fit.



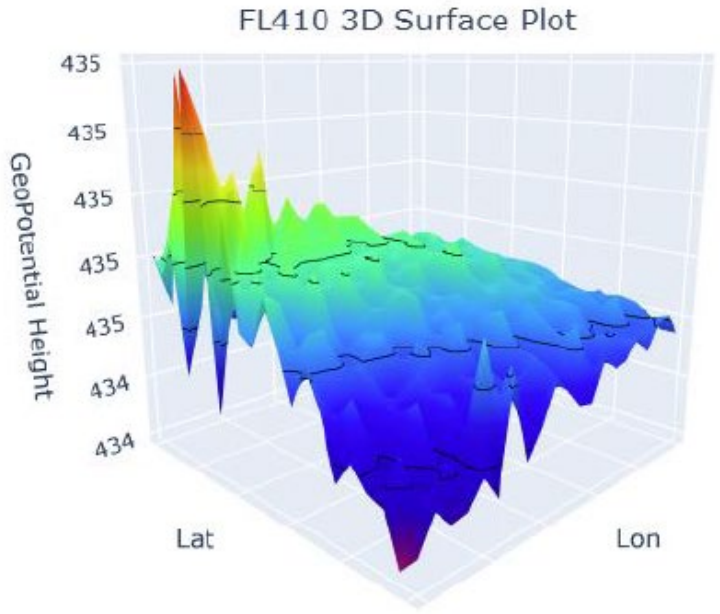
- The correlation coefficient measures the strength of the linear relationship between longitude and geopotential height.
- The correlation coefficient ranges from -1 to 1, where values closer to ±1 indicate a strong linear relationship, and values near 0 suggest little to no correlation.
- A two-tailed t-test is performed for the slope
  - Null hypothesis is the observed slope is zero
  - Test hypothesis is the observed slope is not zero



3D Surface Plots of Geopotential Heights

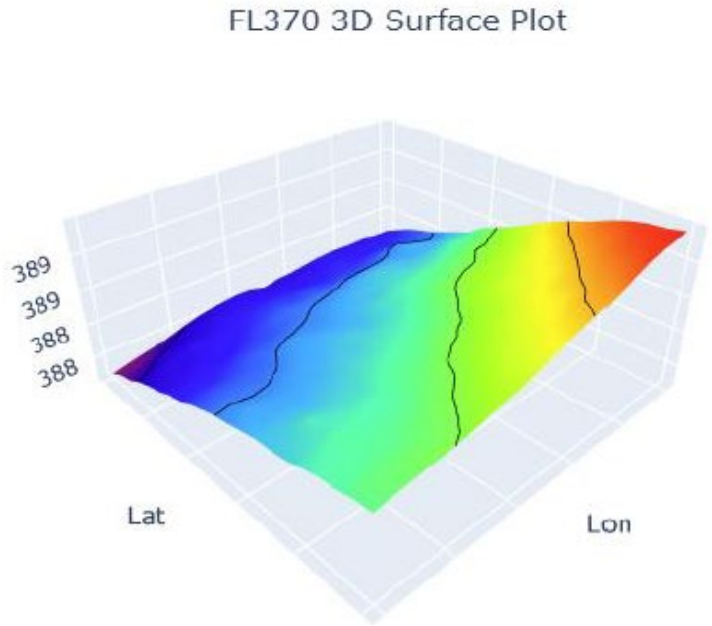
Differences in geopotential height variations between regions with low and high correlation.

3D surface plot corresponding to a grid with low correlation



The height field appears irregular.

These variations may result from localized turbulence, convection, or other short-lived atmospheric processes.



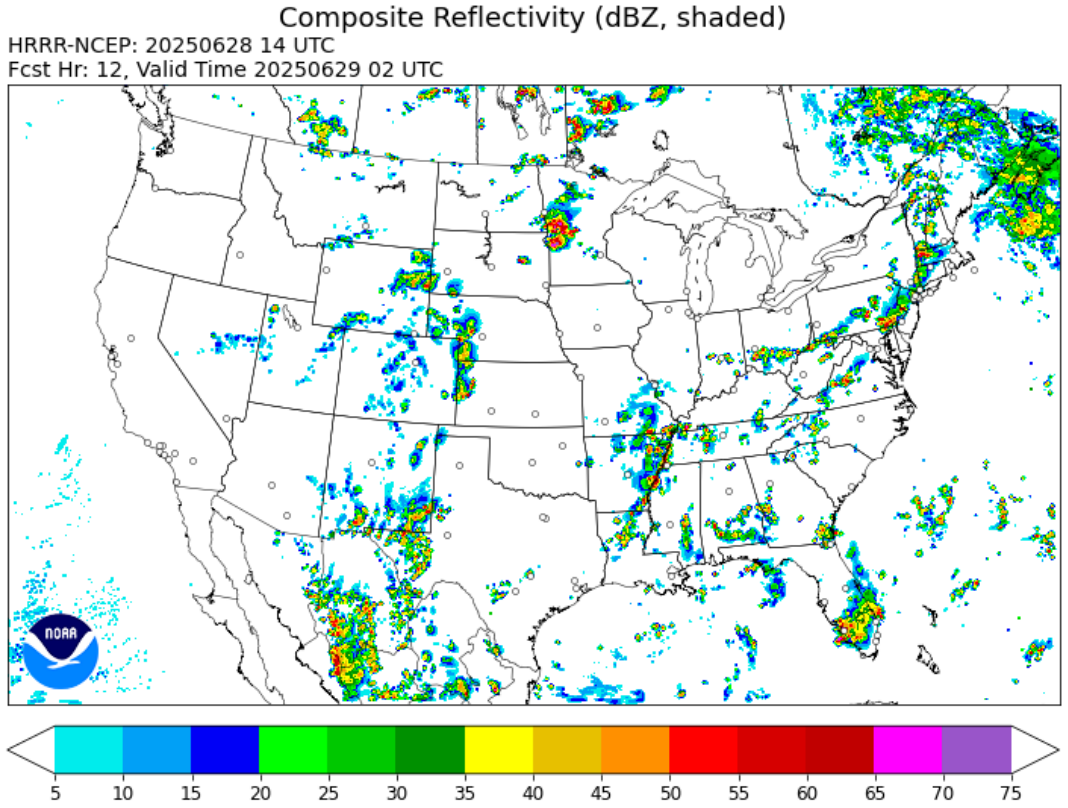
3D surface plot for a highly correlated grid

Smoother and more continuous height distribution.

This indicates more structured and predictable atmospheric behavior, often linked to larger-scale pressure systems or stable air masses.

Additional Meteorological Data

- Scores within each grid are applied to any ASE result obtained within that grid
- Next, High-Resolution Rapid Refresh (HRRR) NOAA product
  - Enhancing the QC score with the difference between HRRR and GDAS geopotential heights

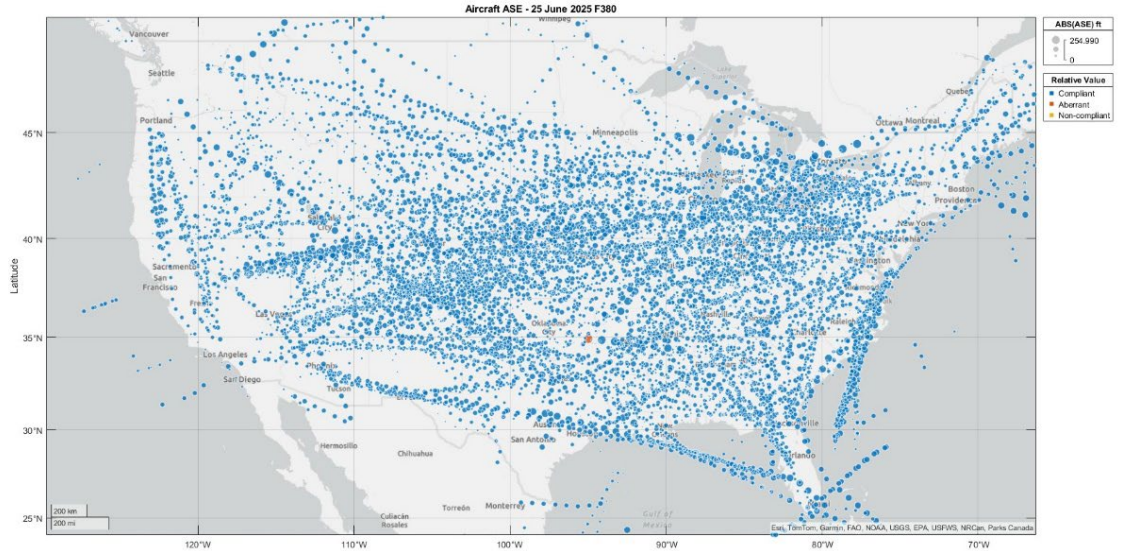


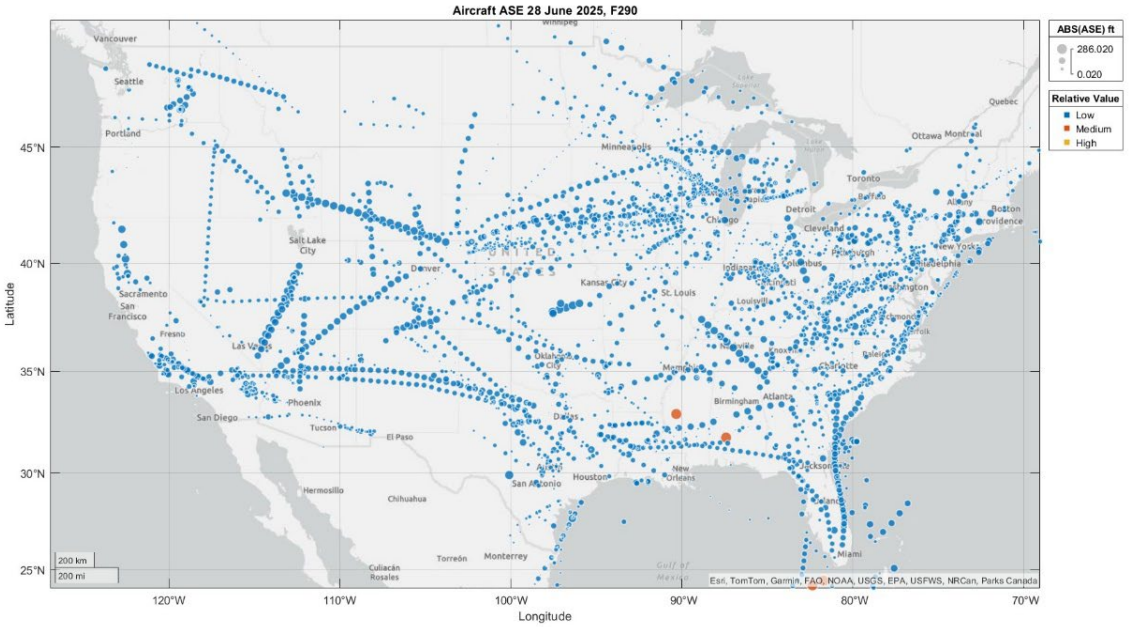
Quality Control Scoring

Process attaches a “score” to each ASE result

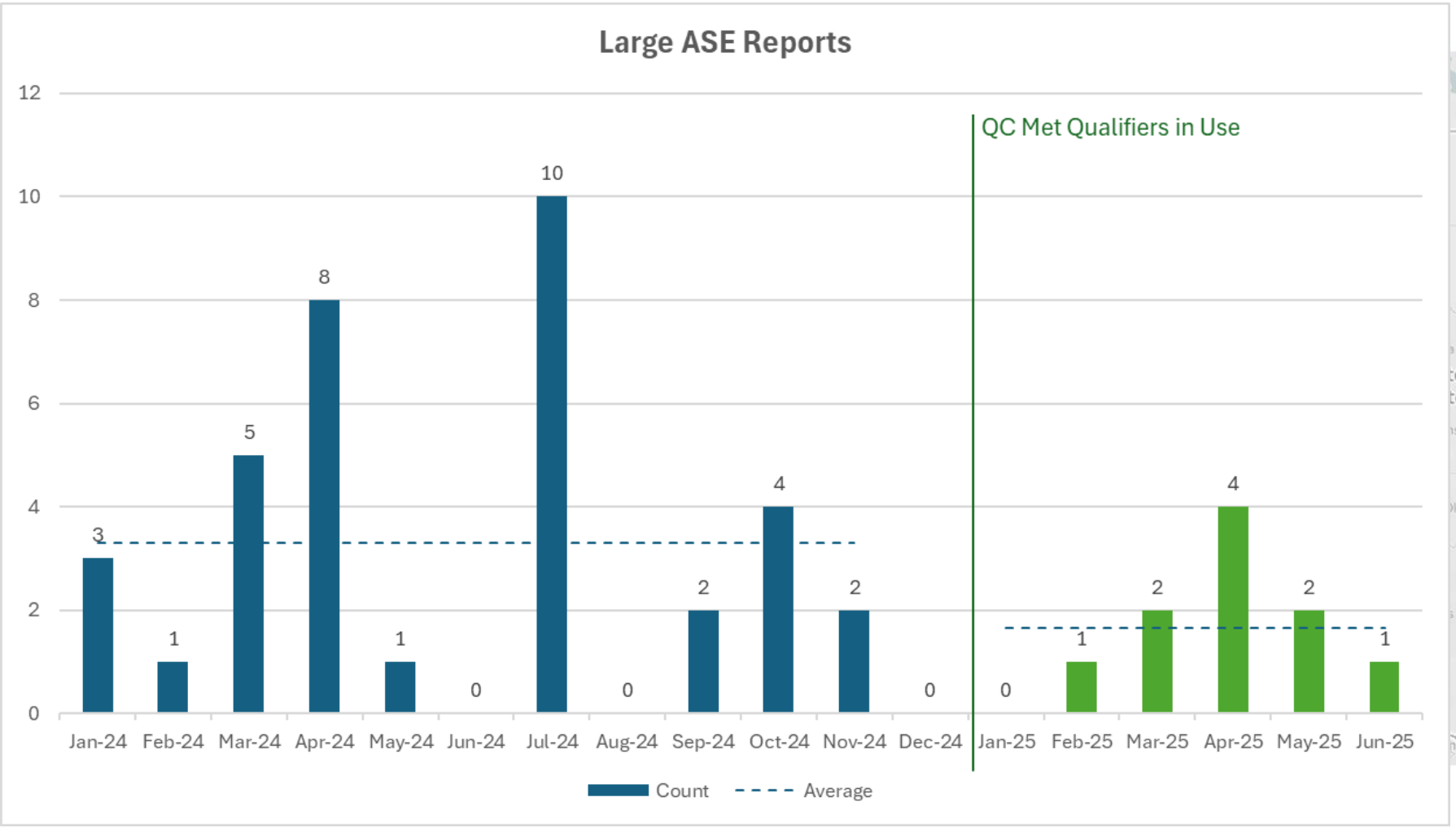
- Score for each ASE result provides 4 measures of quality
- Each scores ranges 1-9; 1=bad and 9=good

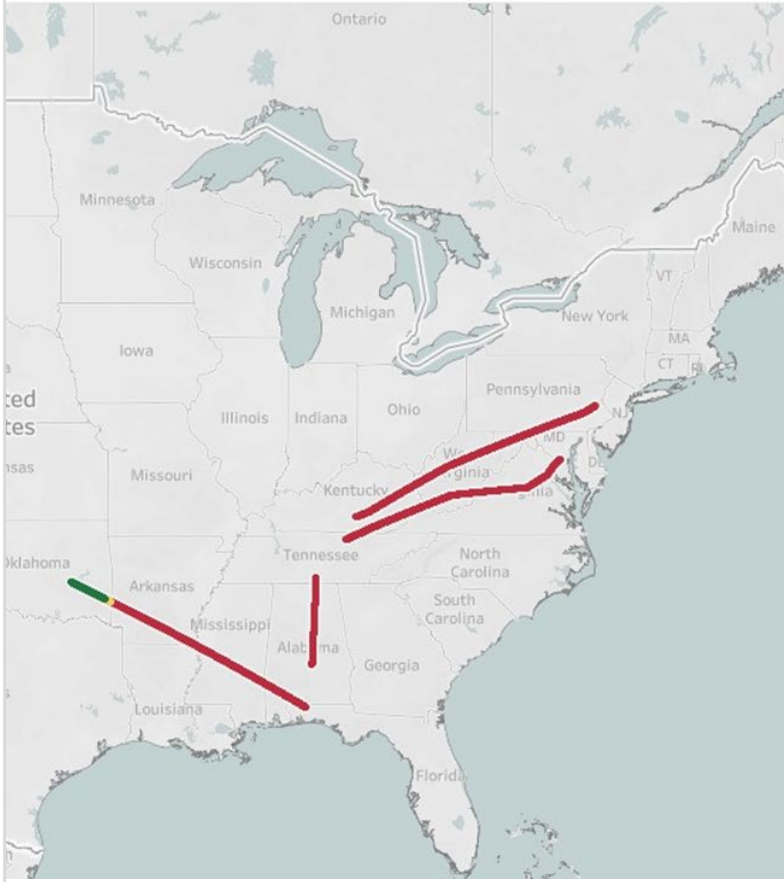
Geopotential heights	Gradient
GDAS vs HRRR	Height Difference
Wind Velocity	Wind Activity
Turbulence	Turbulence





Results – New Tools Allow Faster Reporting





Conclusion

- The development of quality indicator scores for meteorological data used in ASE calculations represents a step toward improving the overall process.
- As NAARMO continues refining the methodology, future enhancements, such as additional quality scoring will further improve the quality of the aircraft ASE results.
- Ultimately, these advancements will contribute to higher confidence in the aircraft ASE results.
    - Limit false positive/negative ASE results