WVSS and TAMDAR: Humidity

Joint ECMWF/EUMETNET Workshop on ABO

ECMWF, Reading UK

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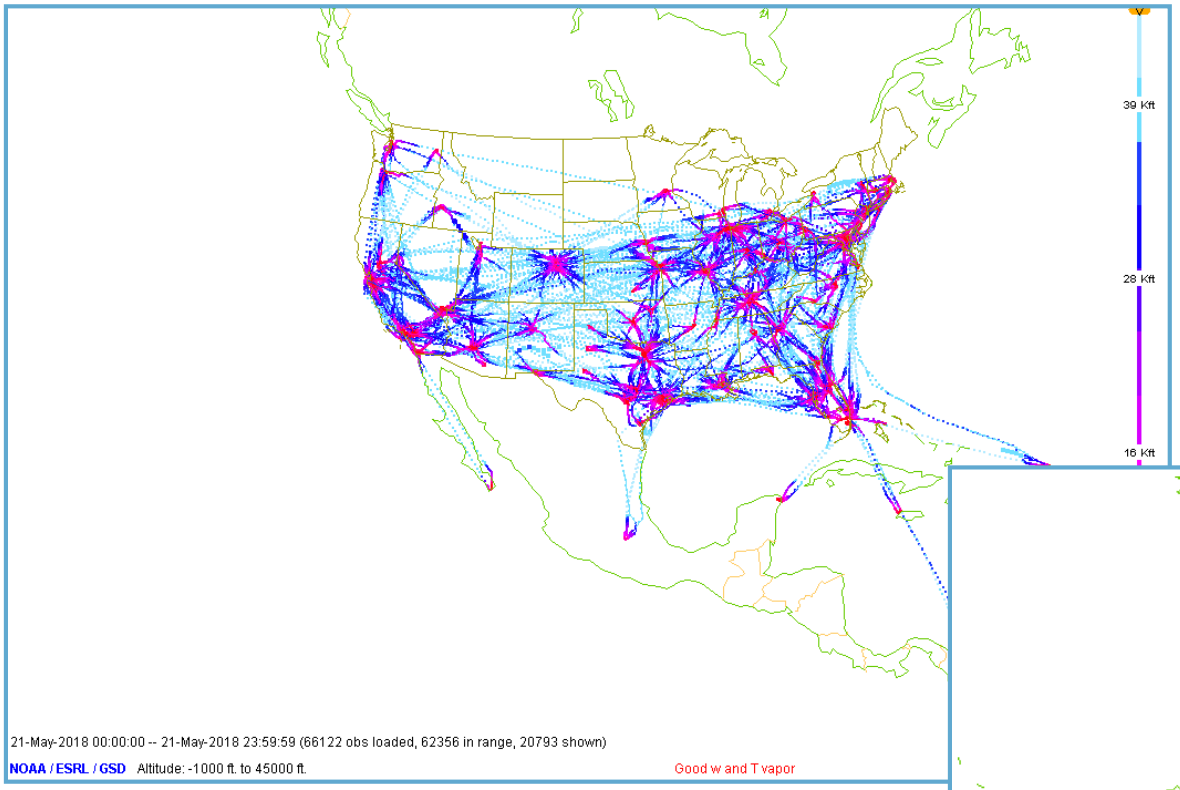
USA AMDAR Program Manager

February 13, 2020

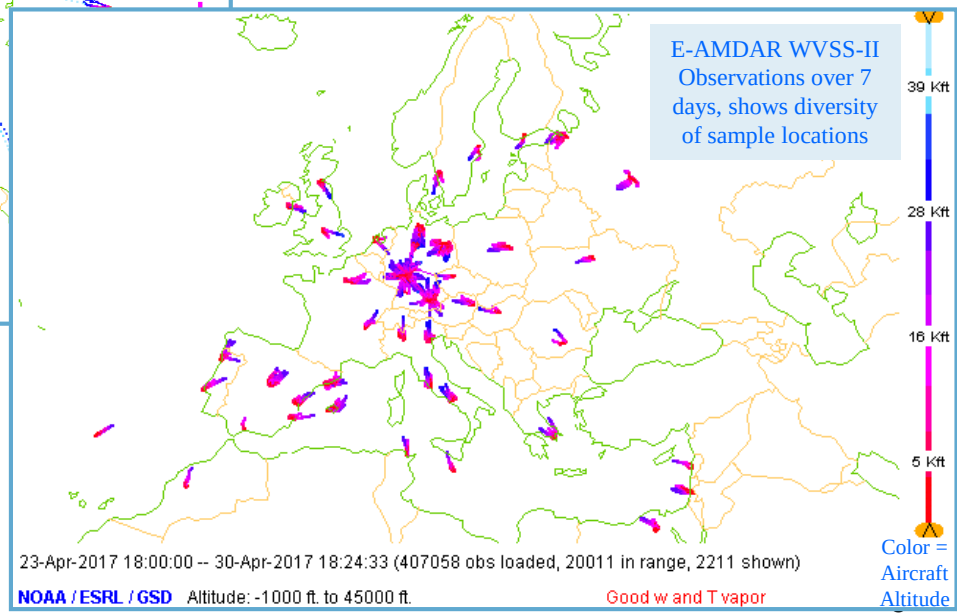
WVSS: Background

148 aircraft worldwide

WVSS: Background

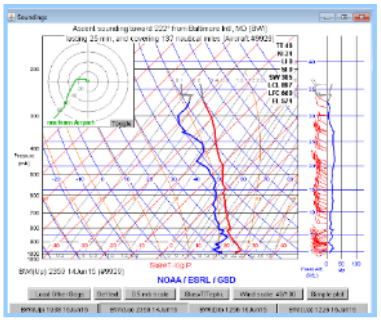


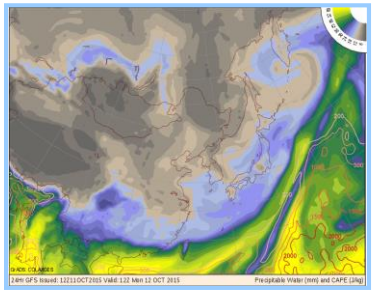
Target 1000 soundings per day in vicinity of major US hubs

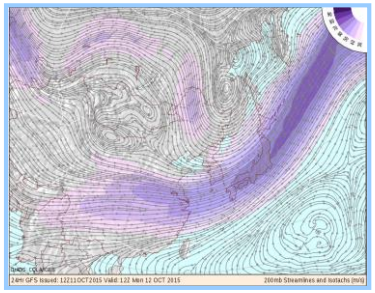


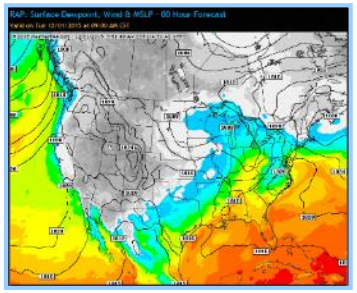
WVSS: Background

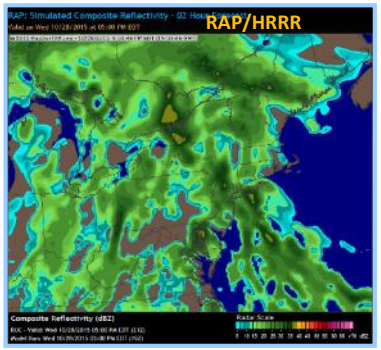
- **Increased Availability of complete Upper Air Observations**
  - Beyond just the normal 00 UTC and 12 UTC RAOBs
- **High Data Quality, for all meteorological applications**
  - Numerical Weather Prediction modeling
  - Traditional Thermodynamic Analysis
  - WVSS-II equipped aircraft satisfy WMO accuracy requirements for Upper Air Observations and Regional Forecast applications*
- **Upper Air Observations Improve Forecasting**
  - Thunderstorms - Convective initiation, stability
  - Fog, Ceilings, Visibility, Icing, Precipitation intensity and type
  - Fire Weather, Winter Weather, etc.



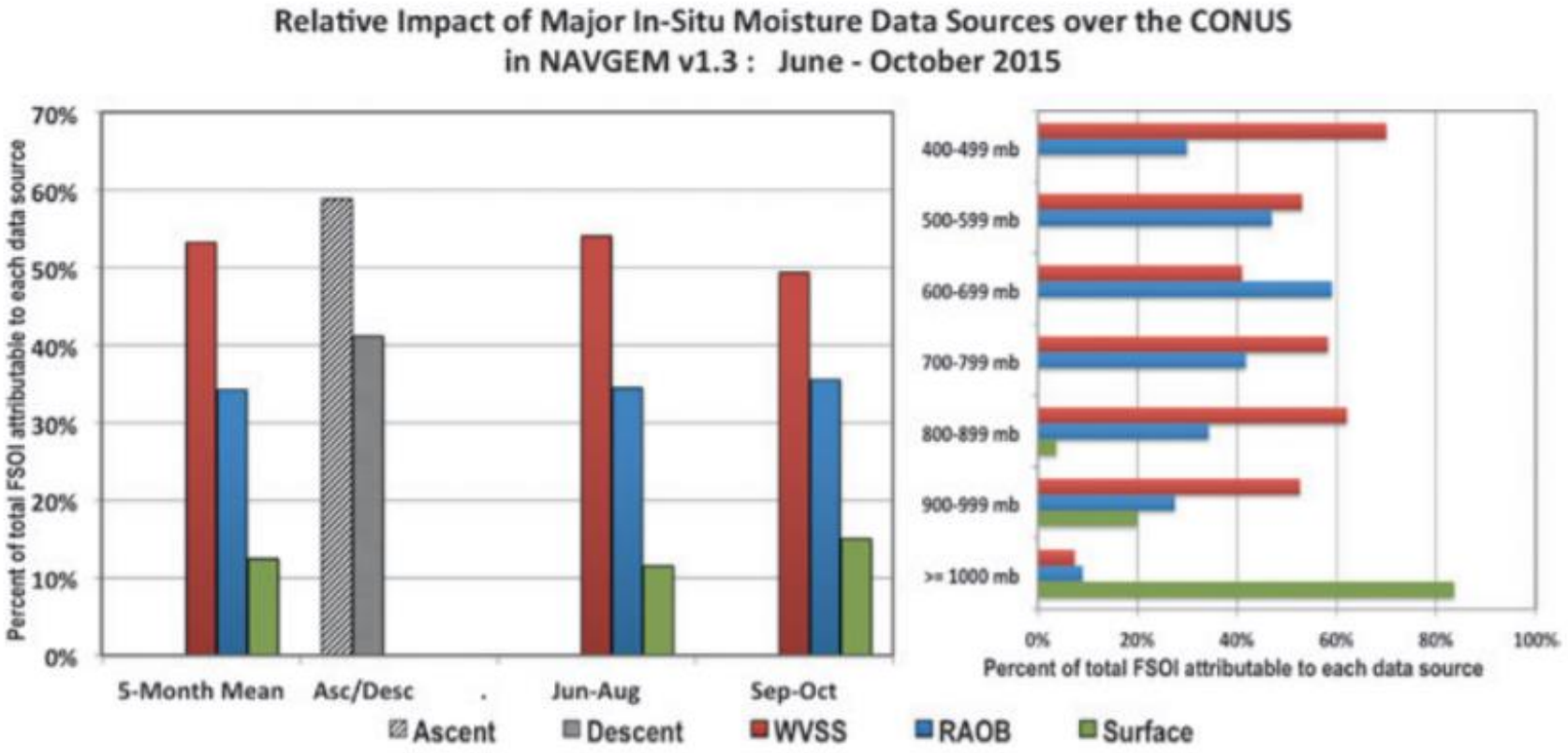








WVSS: Utility



From Petersen et al., BAMS 2016

WVSS: Utility

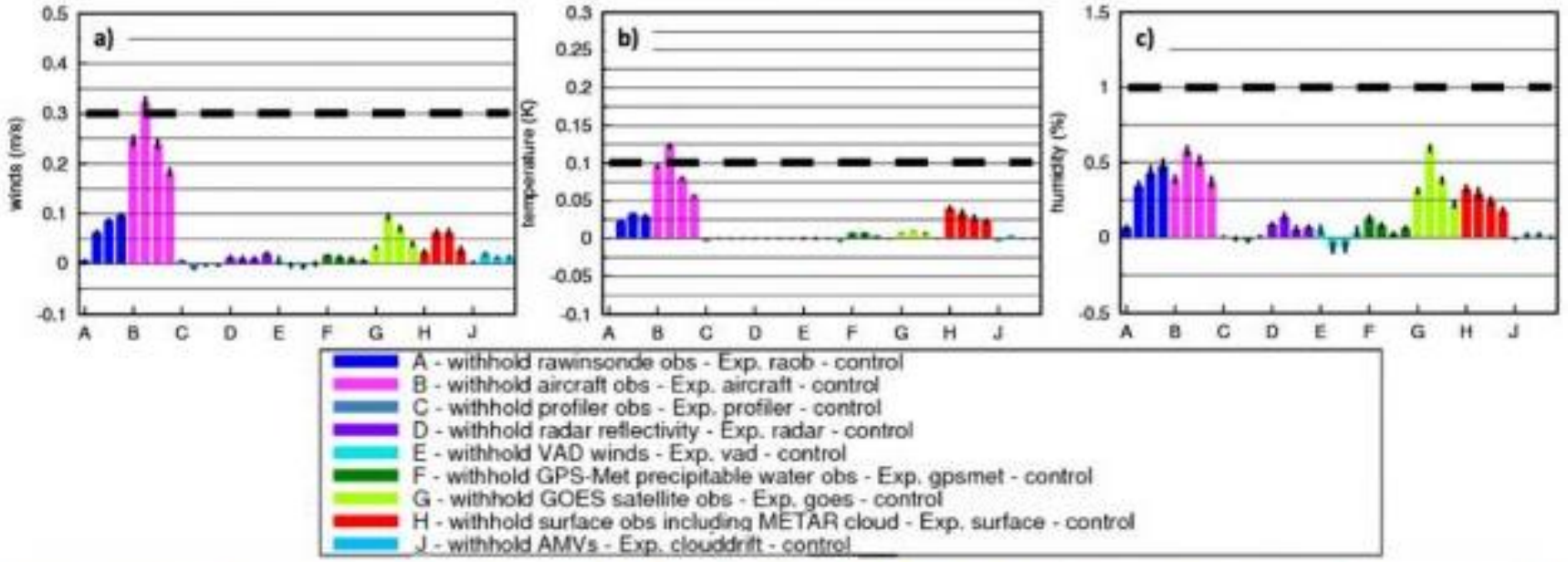


FIG. 7. Observation impact results integrated over all three seasons, similar to Figs. 4–6, showing (a) wind, (b) temperature, and (c) RH. The horizontal black dashed lines indicate the level of 25% forecast error reduction, as shown in Table 5.

From Benjamin et al., 2016

TAMDAR: Background

AeroMexico Connect
AirAsia
Ravn Air Group (Pen Air, Ravn, Corvus)
Horizon
Icelandair
Malindo
Pen Air
Silver

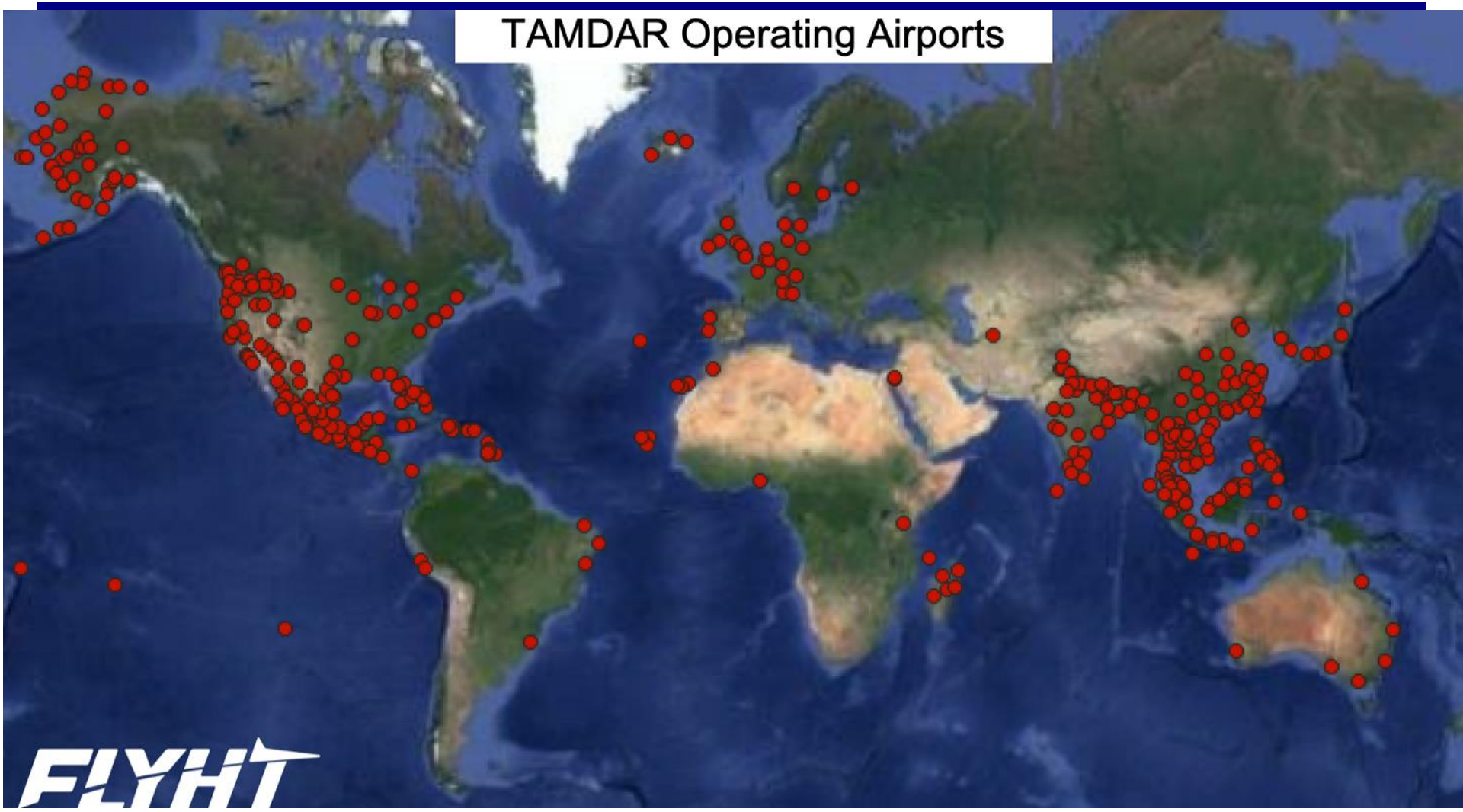
Focuses on smaller, regional airlines and planes (including prop planes)

TAMDAR

Wind
Temperature
Moisture (RH)
Icing
Turbulence (EDR)
Pressure Alt
GPS Alt

Each TAMDAR probe has **3 RH sensors** inside.

TAMDAR: Background



TAMDAR: Background

All flights Jan 4 – Feb 4 2020

TAMDAR: Utility

NOAA / FAA 4-Year TAMDAR Study Results (Benjamin et al. 2016 and Jacobs et al. comments)

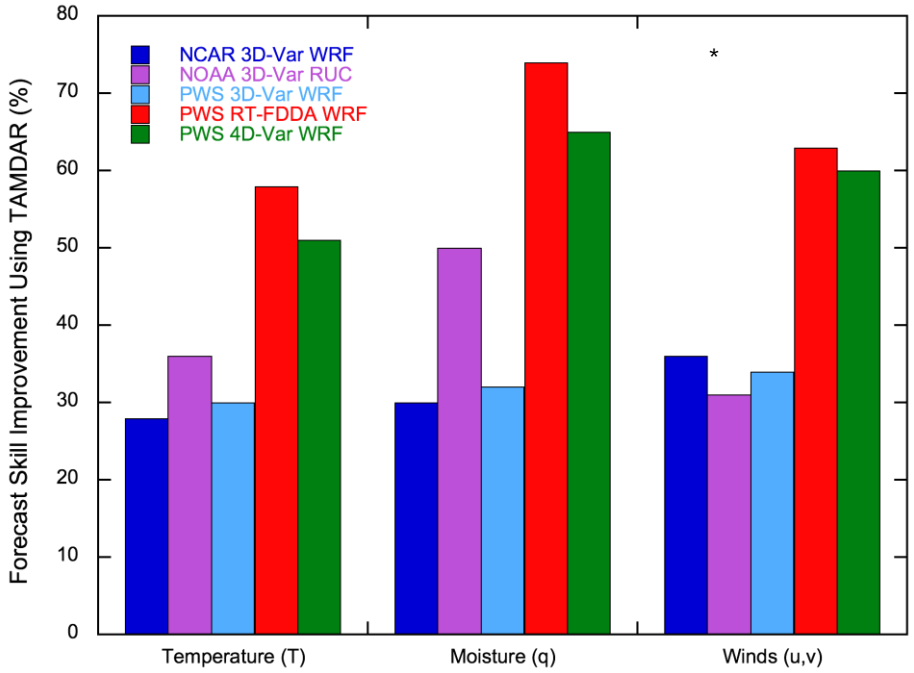


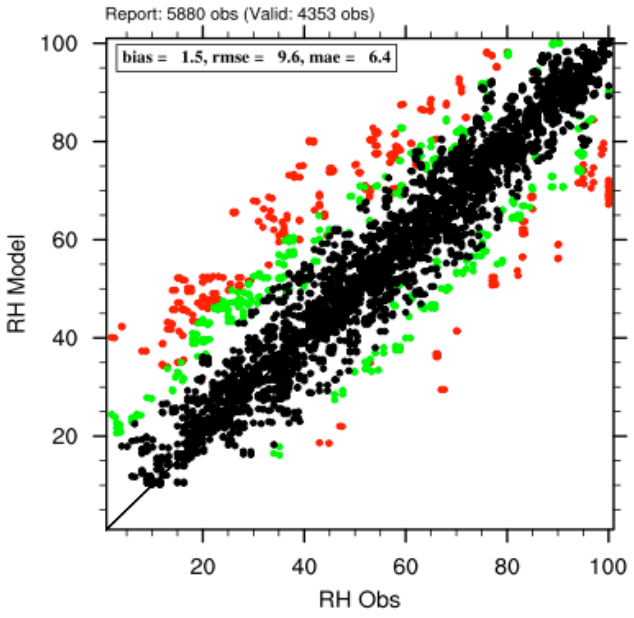
Chart of improvements in forecast skill of the experimental (with TAMDAR) over the control (without TAMDAR) All forecasts were verified using RAOBs as "truth"

NOAA's most optimized model for aircraft data is RUC

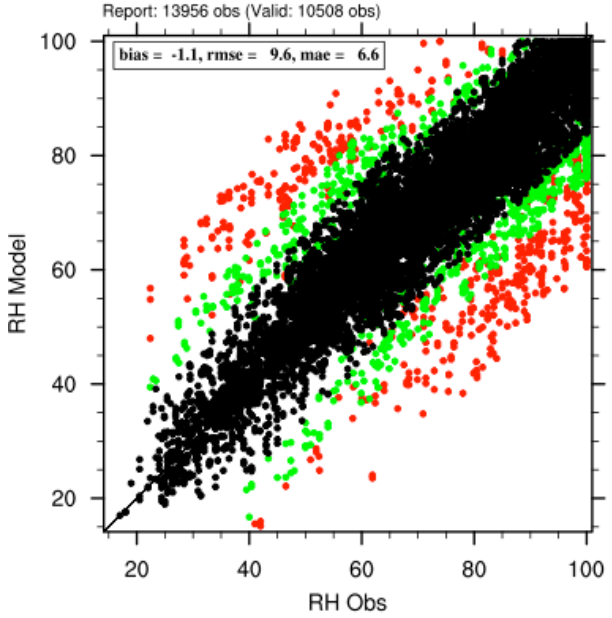
PWS 3D-Var WRF is essentially the same code as NCAR 3D-Var WRF

PWS RT-FDDA and 4D-Var WRF are best suited to utilize *asynoptic* observations

TAMDAR: Quality



Radiosonde



TAMDAR

WVSS and TAMDAR Quality Comparison

From analysis by Tim Wagner (Univ of Wisconsin) using all 2018 possibilities of:

- < 50 km from balloon
- +/- 30 min
- +/- 10 hPa
- Only use sonde observations that are matched to both AMDAR and TAMDAR

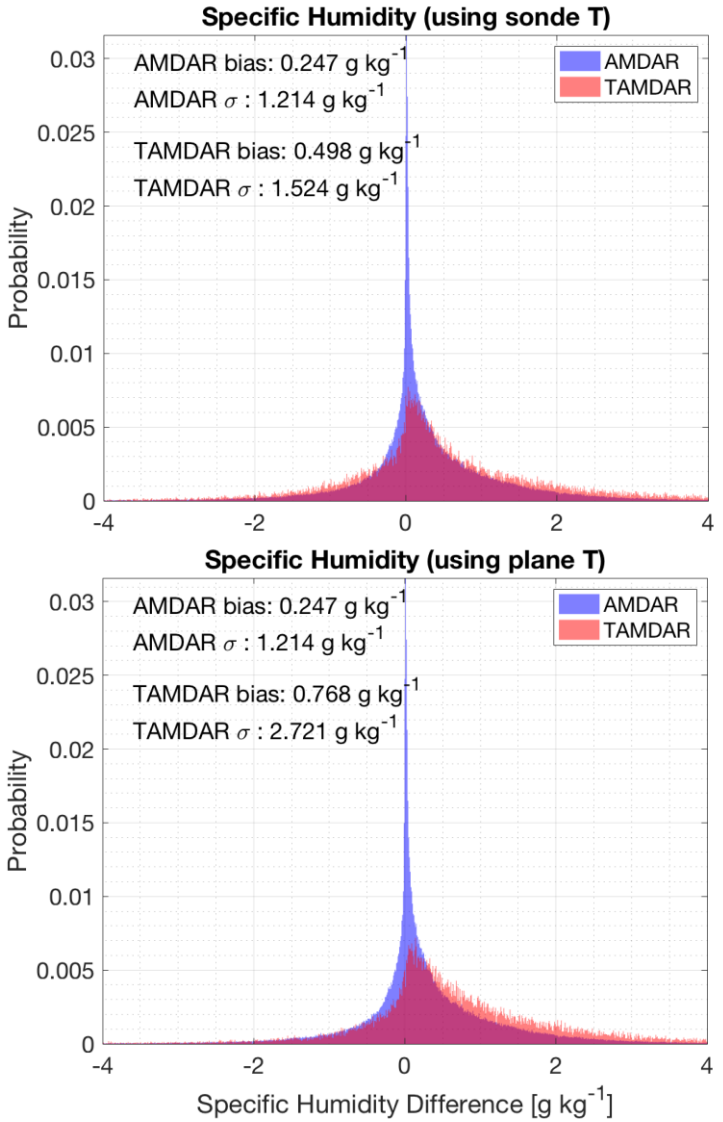
WVSS observes specific humidity

TAMDAR observes relative humidity

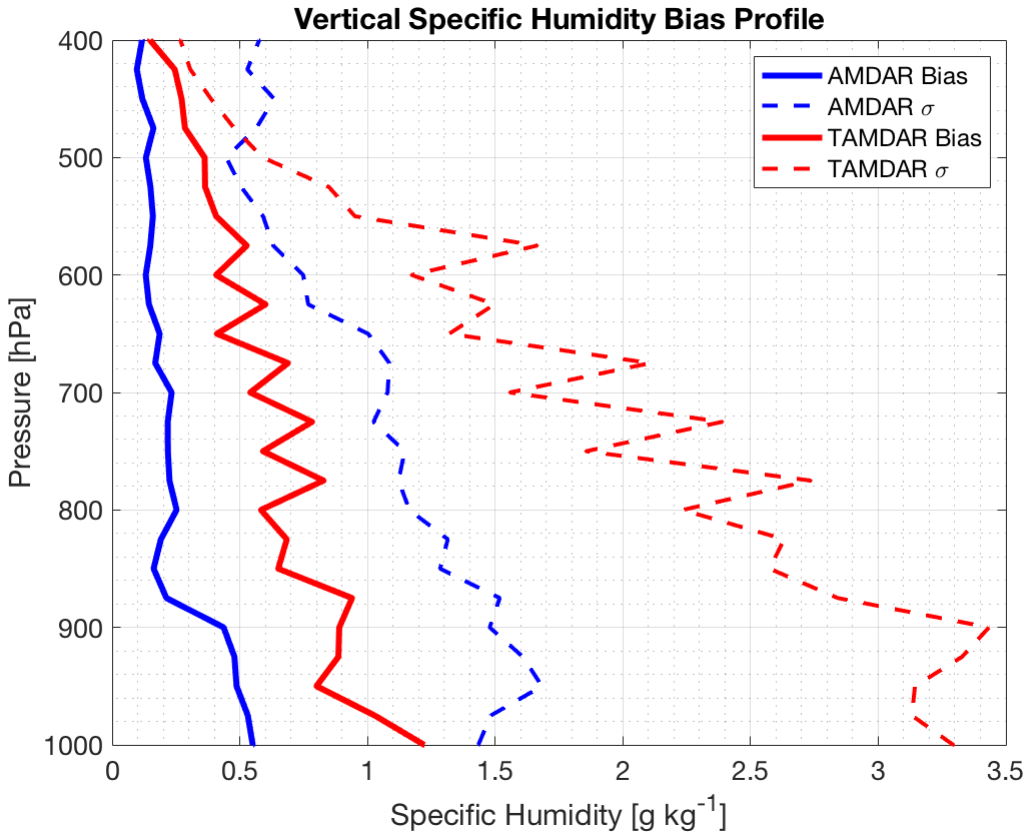
Models assimilate specific humidity

Using sonde T for conversions allows for unbiased analysis; using plane T represents real-world use case.

WVSS has 1/3 the bias and 1/2 the random error of TAMDAR but all data has utility if error stats well characterized



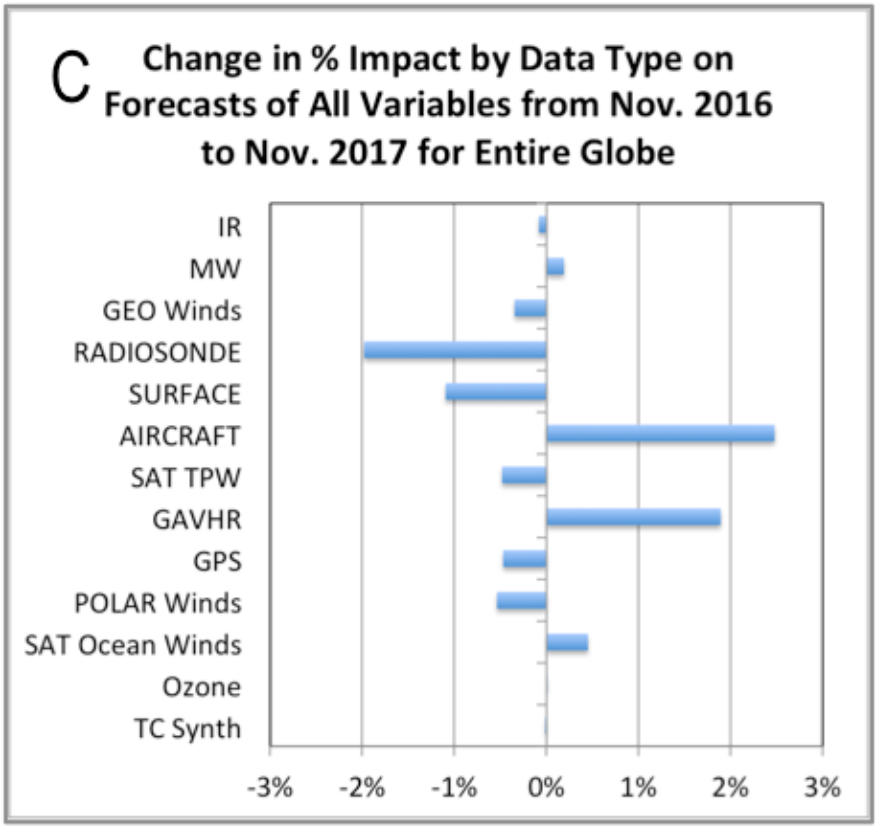
WVSS and TAMDAR Quality Comparison

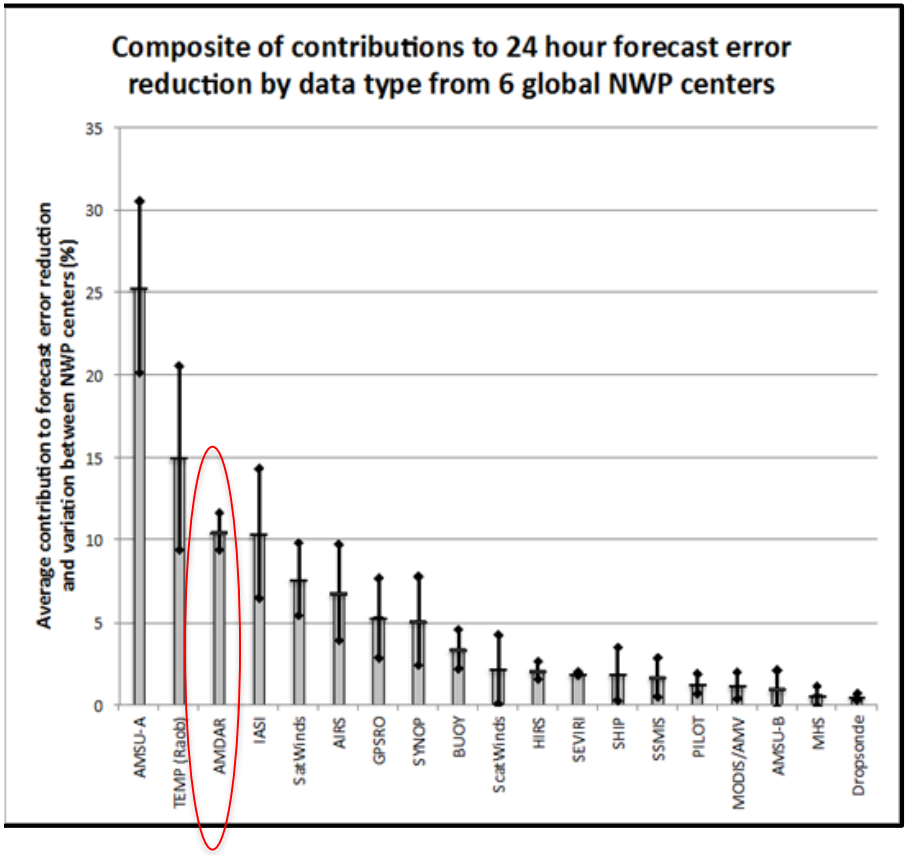


Both systems show decreasing bias and random error with increasing height

- Absolute H_2O vapor content decreases with height

Food for Thought





Left graphic shows impact of one additional airline. Right shows AMDAR third-most important across all major global NWP. What if the entire global pie of aircraft include humidity observations and all data was available to all Global NWP centers?

Final Thoughts

- No growth in US WVSS footprint since 2012
- US future growth efforts focused on RAIII (e.g., LATAM and Copa)
- Cost-benefit analysis between WVSS and TAMDAR in need up updating
  - given significant growth in TAMDAR footprint
  - given significant reduction in TAMDAR unit price
- Acquisition of Panasonic Weather Solutions by FLYHT opens up interesting opportunities (e.g., utilization of AFIRS communications pathway)