Enterprise Comparison of Atmospheric Profiles Derived Polar Satellite and GNSS Constellations

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Outline

NOAA Products Validation System (NPROVS)

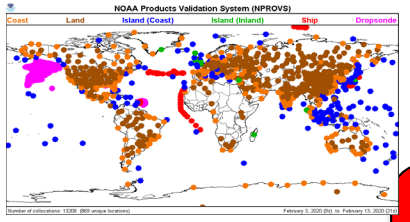
Enterprise Assessment

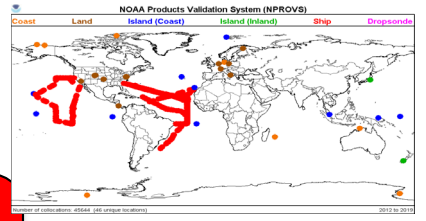
Sampling Strategy (Polar and GNSS)

Results

Paper supports ITOVS WG on Products and Software (WGPS) Action 4: Foster the continuous improvement of products through validation and inter-comparison studies among the different methods to derive level-2 data …

NOAA Products Validation System (NPROVS)





INPUTS

Conventional Radiosonde
GFS 6-hr
CFSR

Geophysical Profiles

NUCAPS
NOAA20
S-NPP
MetOp-A,B,C
NOAA

MIRS
S-NPP
NOAA20
NOAA-18,19
MetOp-A,B,C
NOAA

AIRS v.6
Aqua-EOS
NASA

IASI-L2
MetOp-A, B, C
EUMETSAT

ATOVS
NOAA-19
MetOp-B
NOAA

GOES
?
NOAA

GRAS
MetOp-A,B,C
EUMETSAT

COSMIC
UCAR
KOMPSAT
Korea

NWP
(Analysis)
NOAA
ECMWF

Special Radiosonde:
JPSS
DOE / ARM
GRUAN
NWS …

Parallel Test Systems
All

Collocation Processing (daily)

NPROVS-C

VisualizationTools
ODS
PDISP
NARCS

NPROVS-S

OUTPUT (Collocated Radiosonde and Satellite Observations)

Conventional
NPROVS Collocation Archive

Special
NPROVS-S Collocation Archive

Algorithm Development

SDR
VALAR
(Sensor)

FTP

GRUAN
GSICS

Enterprise Assessment

The capability to routinely inter-compare two or more data platforms against identical ground truth using the same sampling constraints

Sampling Constraints

- Single Closest to Raob per satellite suite: +/- 6hr, 100 km (250km for GNSS)
  - https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/

- Subsampled for Report: +/- 2hr, 100km (200km for GNSS); August 18-28, 2020

- **Polar Satellite Suites: MetOp-B**
  - NOAA Unique Combined Atmospheric Processing System (NUCAPS), IR+MW pass QC
  - EUMETSAT, IR+MW successful
  - NOAA Microwave integrated Retrieval System (MiRS), **Microwave-only** (RainRate = 0)

- **Global Navigation Satellite Systems (GNSS) Suites**
  - Constellation Observing System for Meteorology, Ionosphere and Climate-2 (COSMIC-2)
  - GNSS Receiver for Atmospheric Sounding (GRAS), MetOp-A,B,C … near-real-time **

** GRAS are "nrt" product and for demonstration only … we are working to replace with GRAS "post-processed" as recommended by EUMETSAT Satellite Application Facility (SAF, J Nielsen (DMI))

Sampling Constraints (cont)

- Statistics are at 100 effective pressure (approximate 1km layer means in troposphere) … *legacy from AIRS (RT model layers) and products distributed to Users (NWS forecasters …)*
  - Retrieval Temperature (K)
  - H20 Vapor Mixing Ratio Fraction (%) … *(Sat – Raob) / Raob*

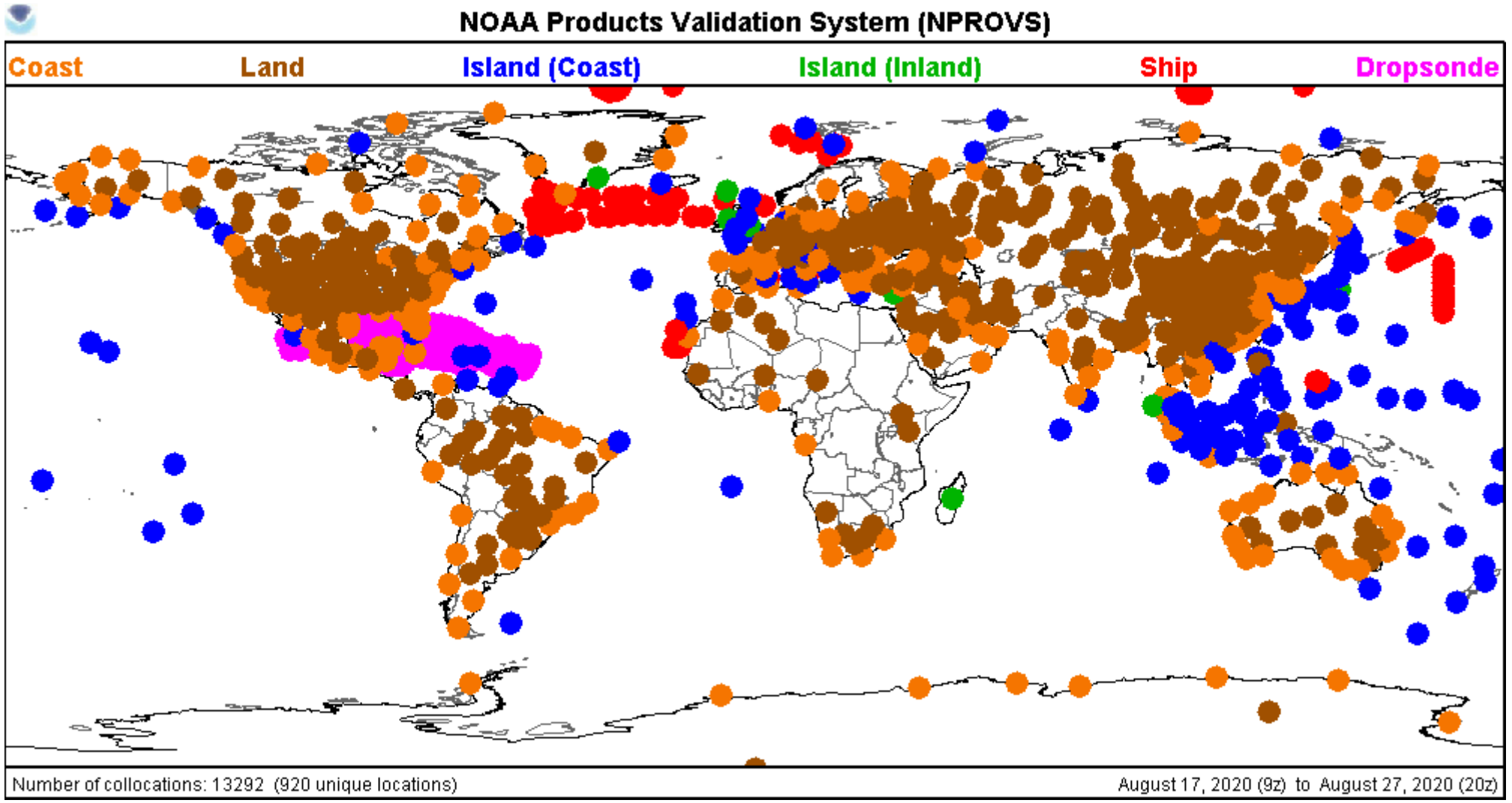
- Conventional Global Radiosonde, sorted by
  - All Radiosondes
  - Only Vaisala RS41

- Enterprise Assessment

Side Notes on Sampling Constraints

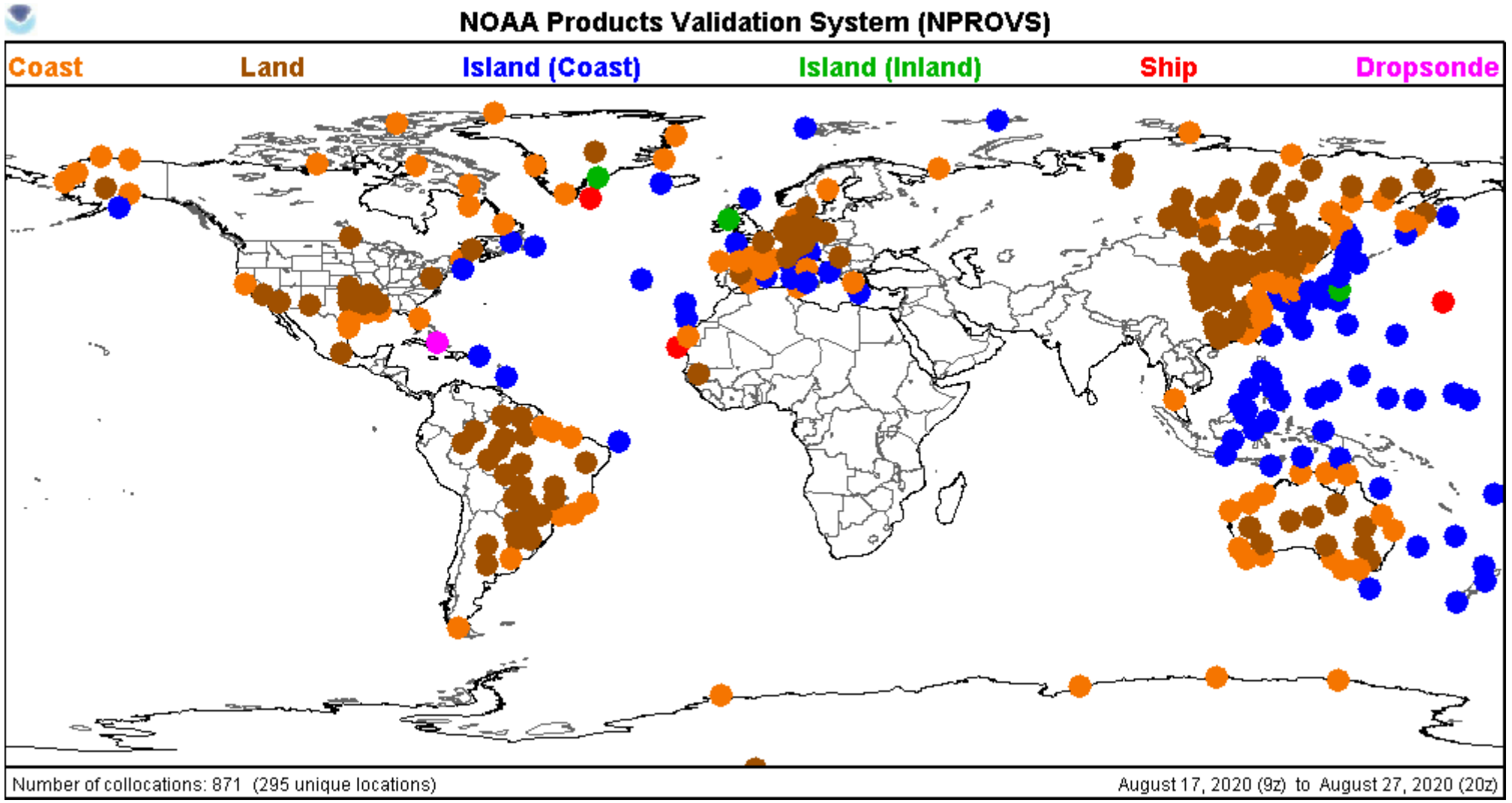
- Readily applied using NPROVS Profile Display (PDISP) application (JAVA), available at: https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/ … *includes datasets*
- Enterprise comparison works best for (polar) satellites in similar orbital configurations
- Mismatch constraints (time and distance) are relative to baseline (Raob) which means any given pair of collocated satellite observations could exceed this constraint … *more prevalent for GNSS*
- Mismatch constraint is determined (in NPROVS) at:
  - surface for polar satellites
  - 100 hPa for GNSS
- Disclaimer: GRAS are nrt product and for demonstration only … we are working to replace with GRAS post-processed as recommended by EUMETSAT Satellite Application Facility (J Nielsen, DMI)

August 17 – 27, 2020



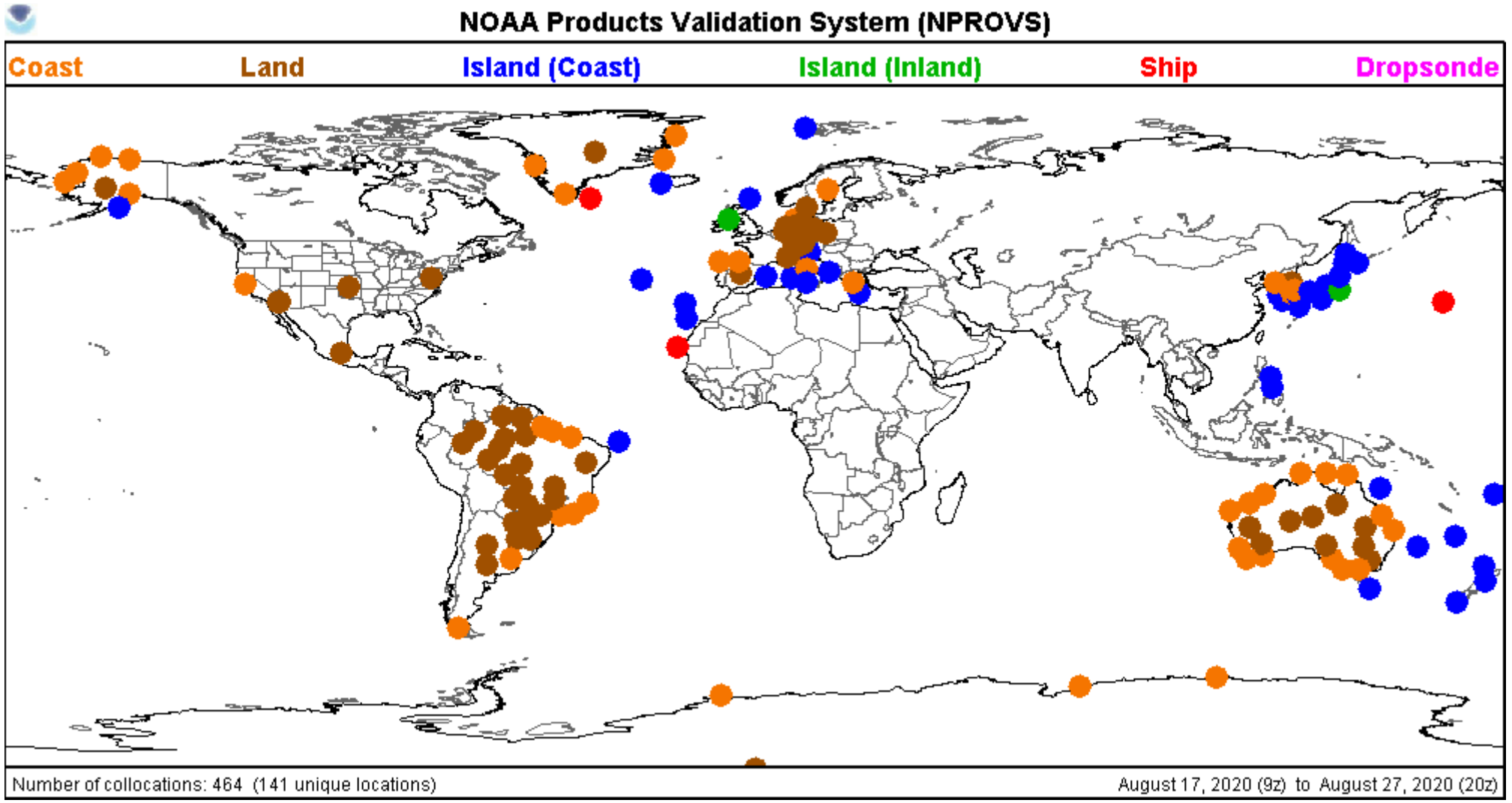
All Radiosonde Sites
(1320 at 920 locations)

August 17 – 27, 2020
All Radiosondes



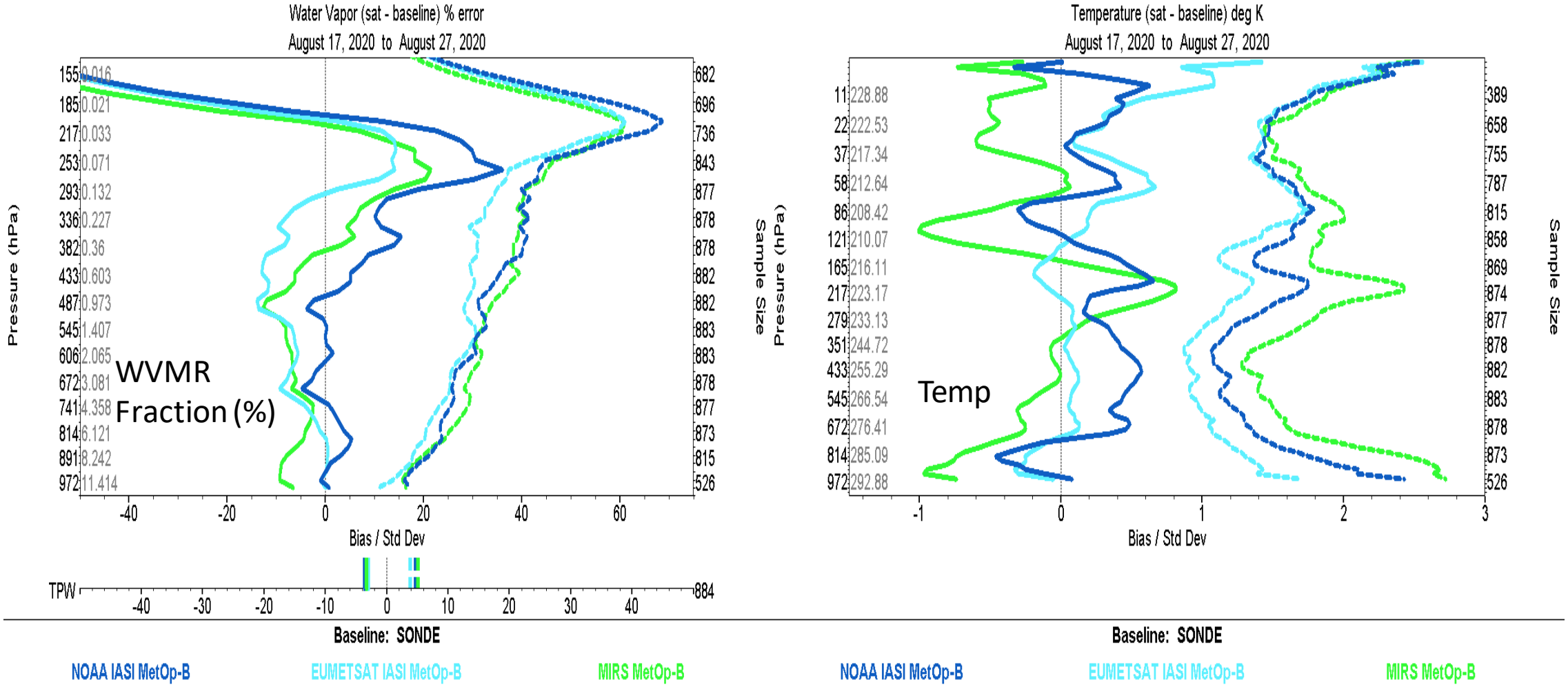
Collocated Radiosonde and MetOp-B NUCAPS, EUMETSAT and MiRS soundings; +/- 2 hours, 100km (871 Radiosondes at 295 sites)

August 17 – 27, 2020
Vaisala RS41 Radiosondes



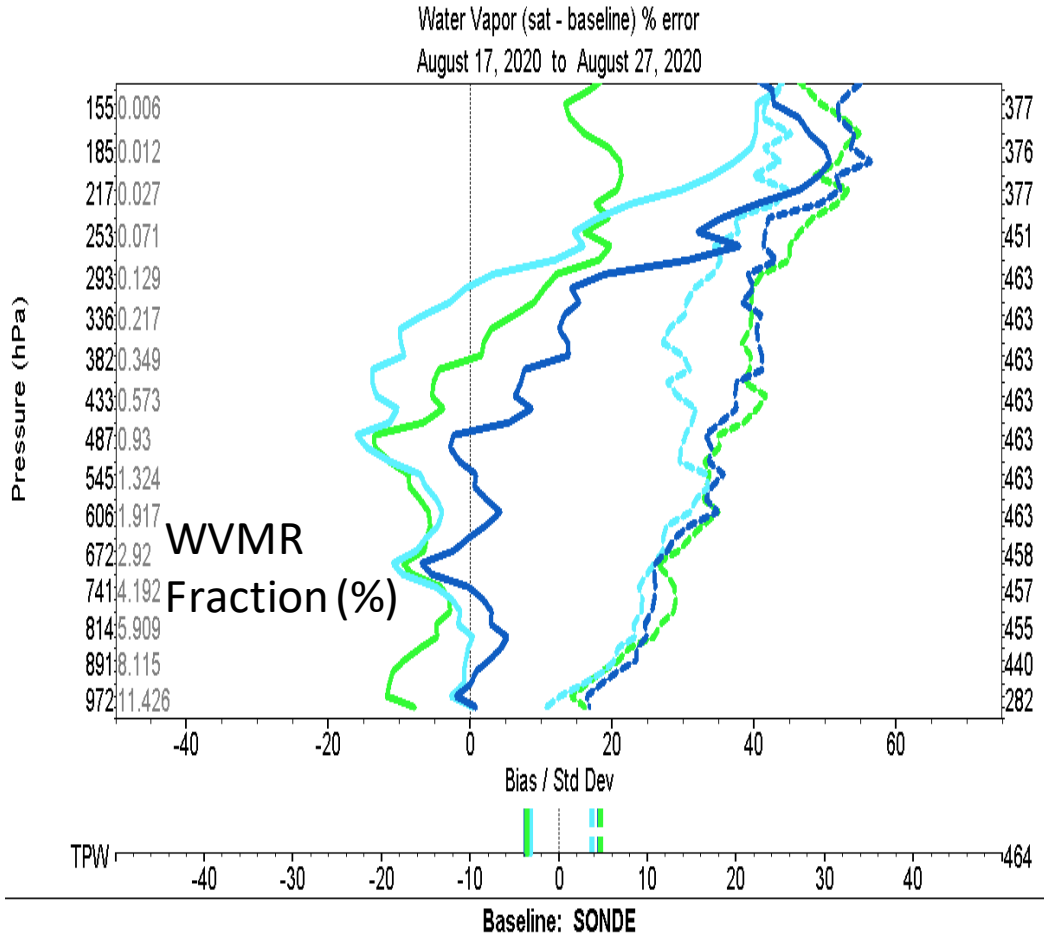
Collocated Radiosonde and MetOp-B NUCAPS, EUMETSAT and MiRS soundings; +/- 2 hours, 100km (464 Radiosondes at 141 sites)

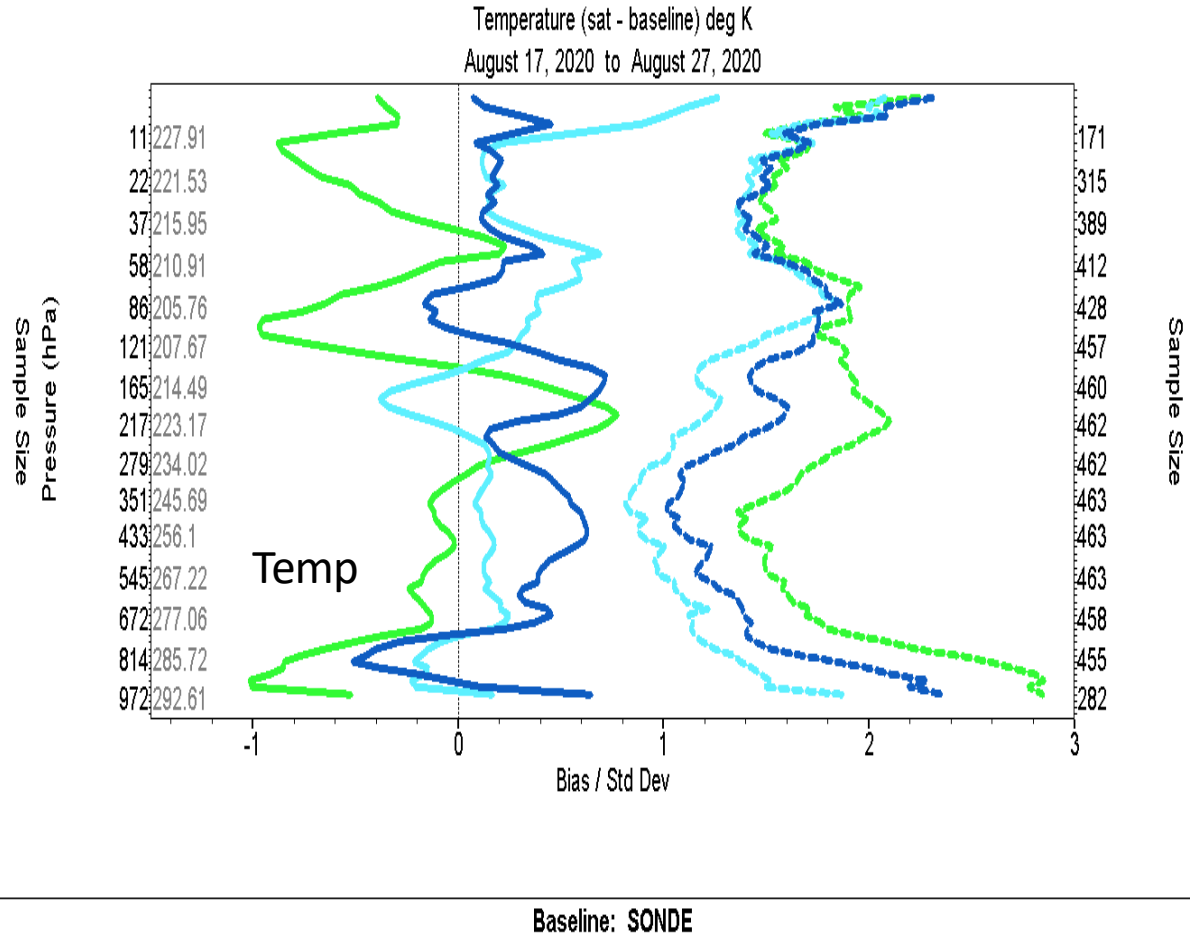
August 17 – 27, 2020
All Radiosondes



(X – Raob) Vertical Statistics for Bias (solid) and Standard Deviation (dash)
NUCAPS, EUMETSAT and MiRS soundings from MetOp-B
+/- 2 hours, 100km

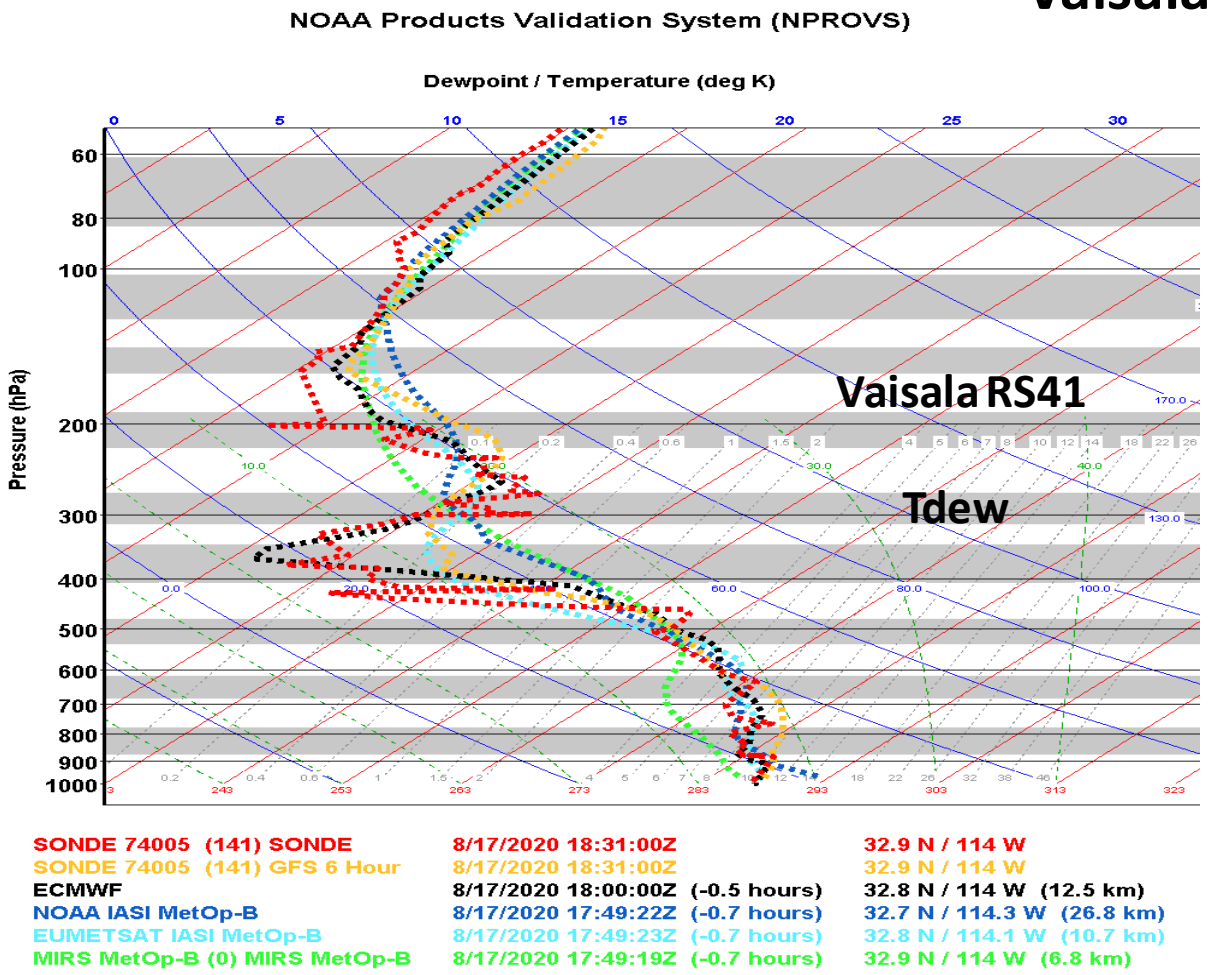
August 17 – 27, 2020
Vaisala RS41 Radiosondes

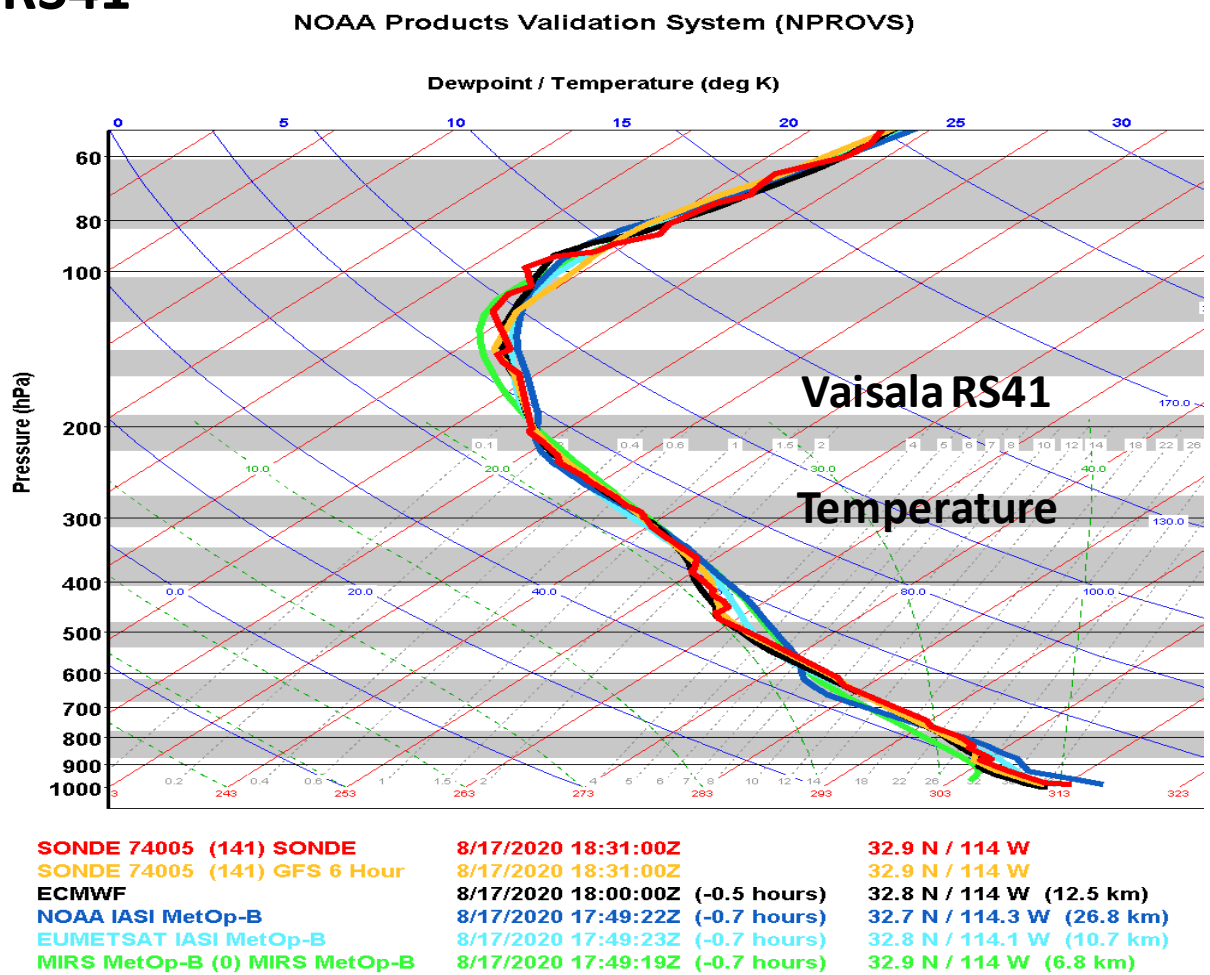




(X – Raob) Vertical Statistics for Bias (solid) and Standard Deviation (dash)
NUCAPS, EUMETSAT and MiRS soundings from MetOp-B
+/- 2 hours, 100km

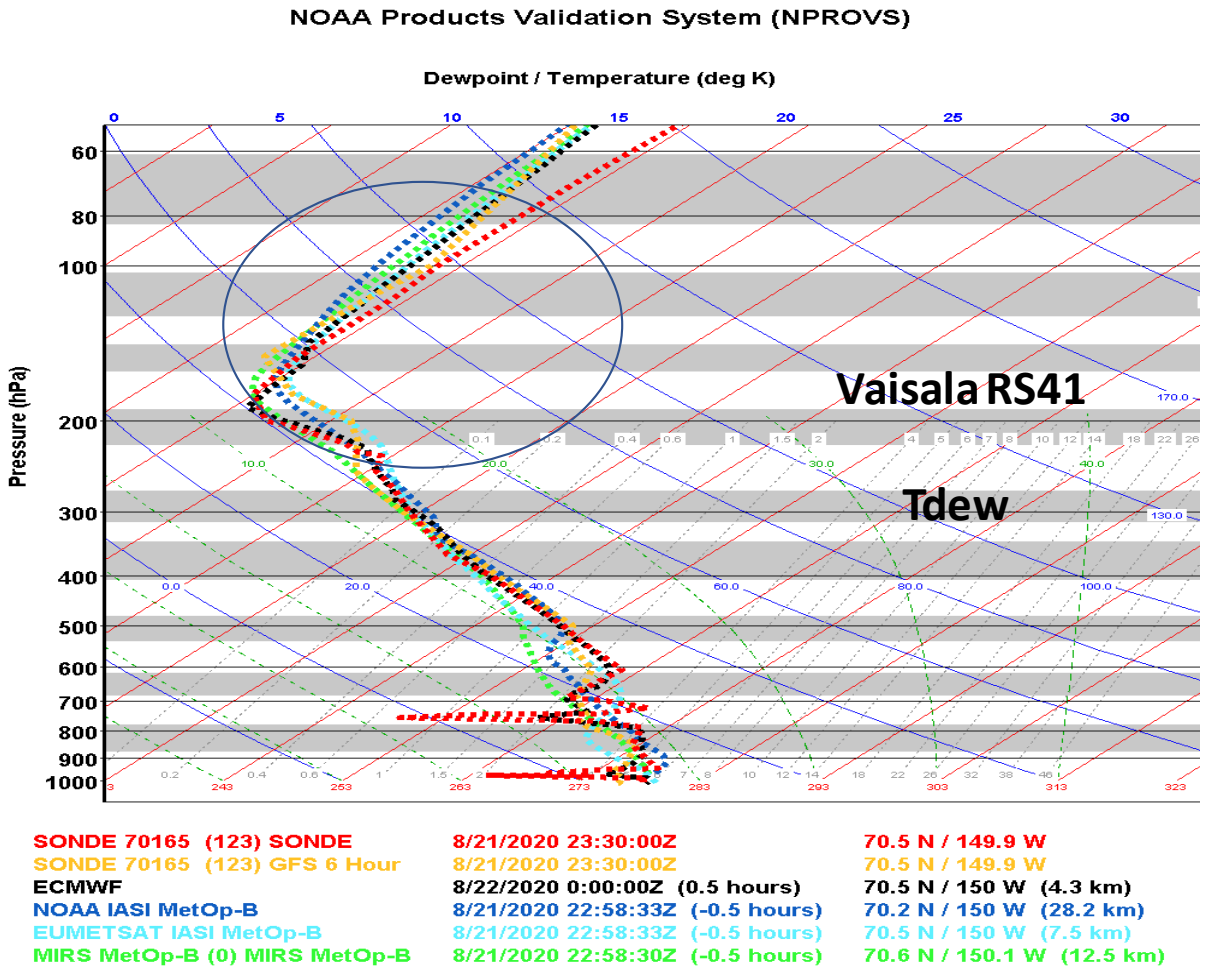
August 17, 2020 at 18Z
Vaisala RS41



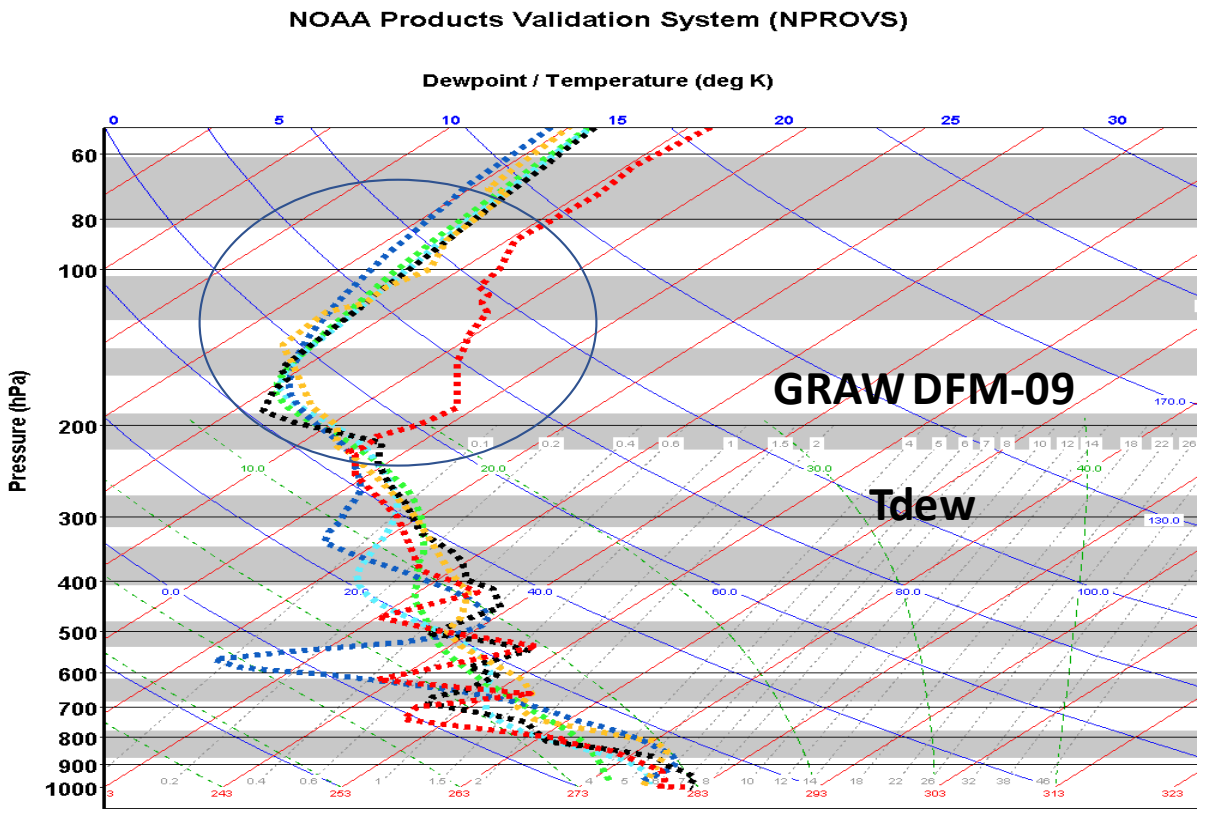


Example of collocated profiles, Tdew (left) and Temperature (right) for NUCAPS, EUMETSAT and MiRS soundings from MetOp-B, ECMWF Analysis and GFS 6-hr Forecast … Satellite soundings at nearly identical time and location

August 21, 2020 at 23Z

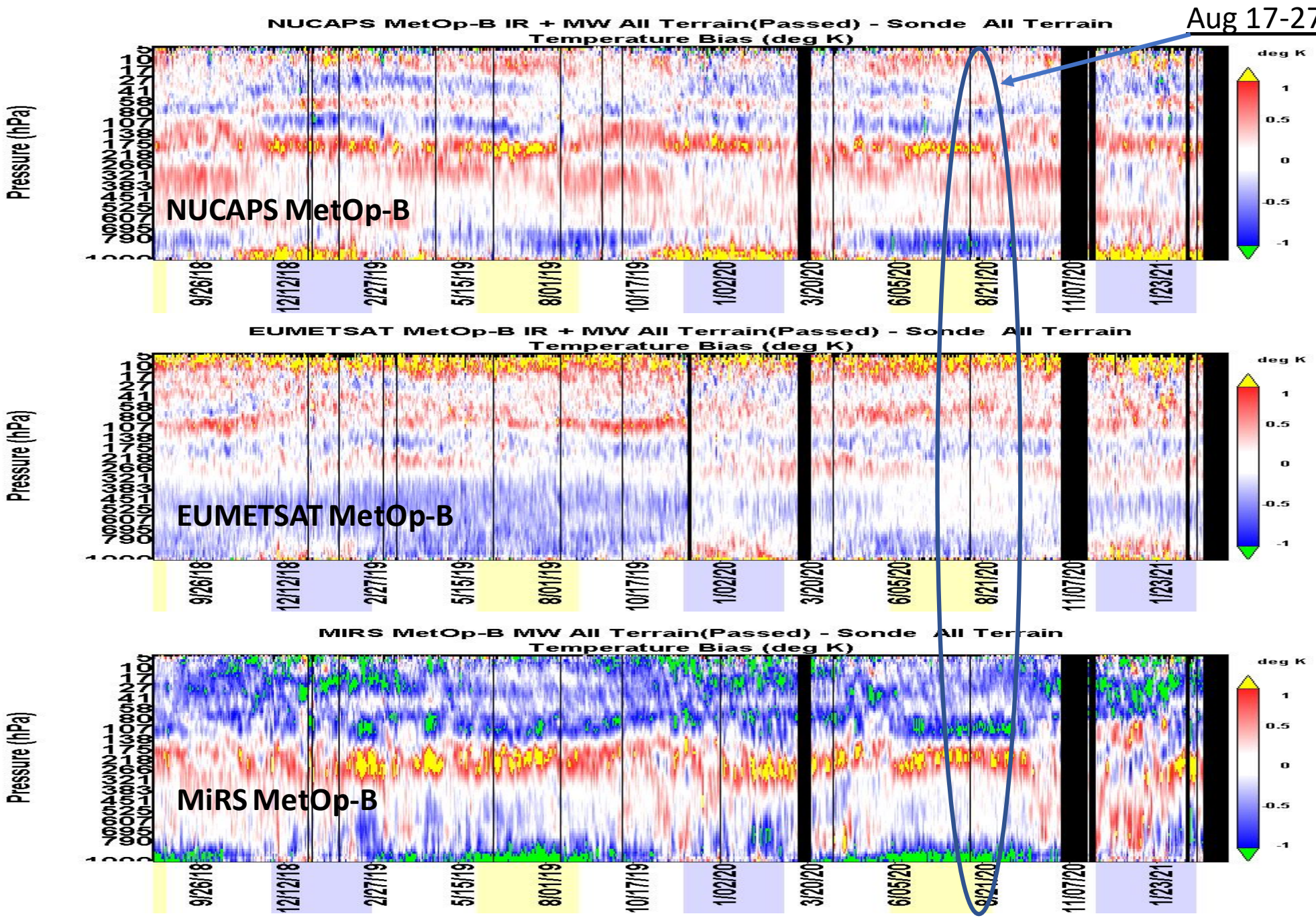


SONDE 70165 (123) SONDE	8/21/2020 23:30:00Z	70.5 N / 149.9 W
SONDE 70165 (123) GFS 6 Hour	8/21/2020 23:30:00Z	70.5 N / 149.9 W
ECMWF	8/22/2020 0:00:00Z (0.5 hours)	70.5 N / 150 W (4.3 km)
NOAA IASI MetOp-B	8/21/2020 22:58:33Z (-0.5 hours)	70.2 N / 150 W (28.2 km)
EUMETSAT IASI MetOp-B	8/21/2020 22:58:33Z (-0.5 hours)	70.5 N / 150 W (7.5 km)
MIRS MetOp-B (0) MIRS MetOp-B	8/21/2020 22:58:30Z (-0.5 hours)	70.6 N / 150.1 W (12.5 km)



SONDE 71957 (117) SONDE	8/21/2020 23:15:00Z	68.3 N / 133.5 W
SONDE 71957 (117) GFS 6 Hour	8/21/2020 23:15:00Z	68.3 N / 133.5 W
ECMWF	8/22/2020 0:00:00Z (0.8 hours)	68.2 N / 133.5 W (7.9 km)
NOAA IASI MetOp-B	8/21/2020 21:18:09Z (-1.9 hours)	68.6 N / 133.8 W (34.2 km)
EUMETSAT IASI MetOp-B	8/21/2020 21:18:09Z (-1.9 hours)	68.4 N / 133.7 W (14.8 km)
MIRS MetOp-B (0) MIRS MetOp-B	8/21/2020 21:18:11Z (-1.9 hours)	68.3 N / 133.4 W (3.9 km)

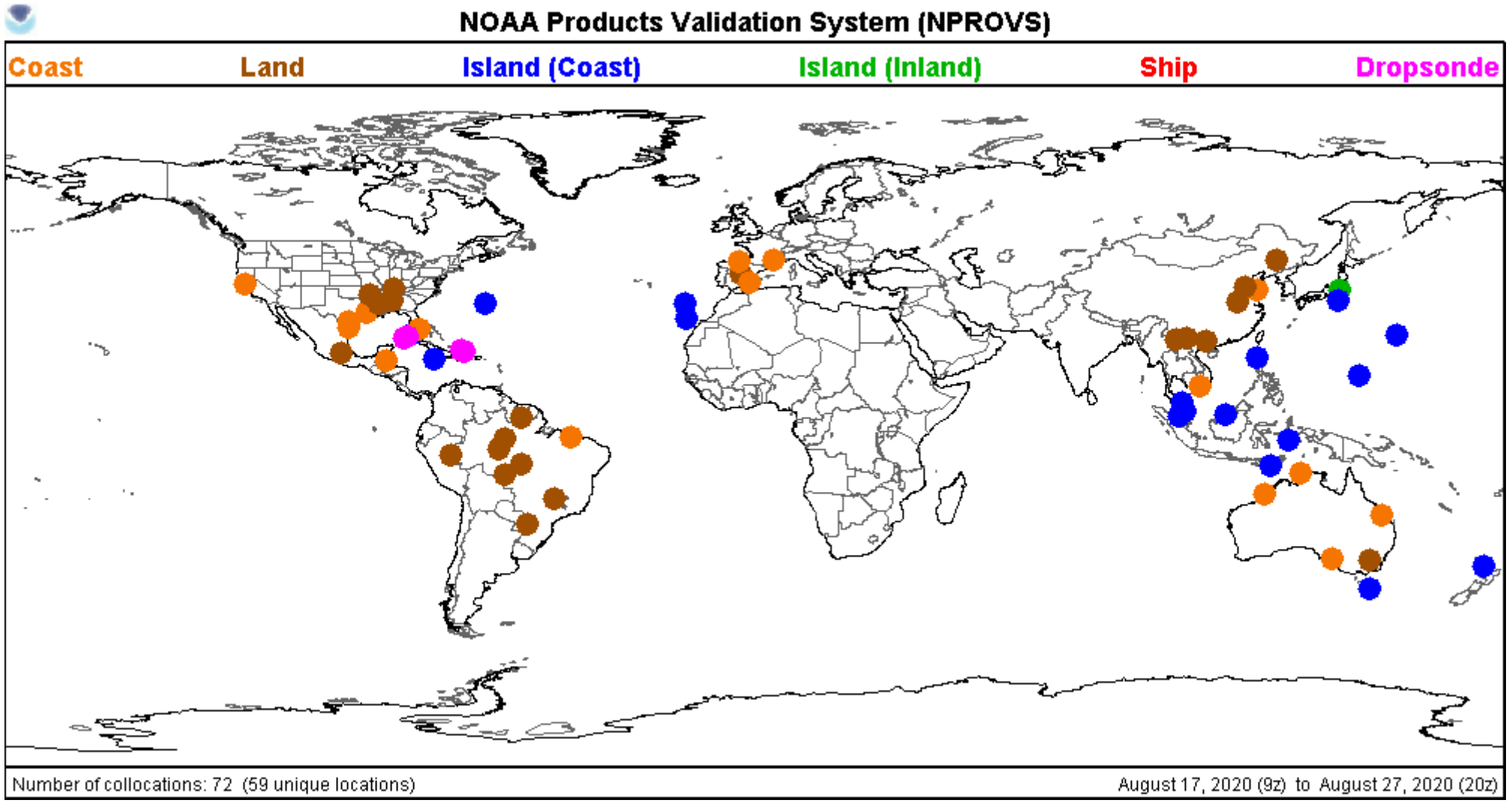
Example of collocated Tdew for RS41 (left) and GRAW DFM-09 (right) for NUCAPS, EUMETSAT and MiRS soundings from MetOp-B, ECMWF Analysis and GFS 6-hr Forecast … Satellite soundings at nearly identical time and location



Long Term Time Series (2018-2021), Temperature Bias; +/- 2hr, All Raobs … *not enterprise*

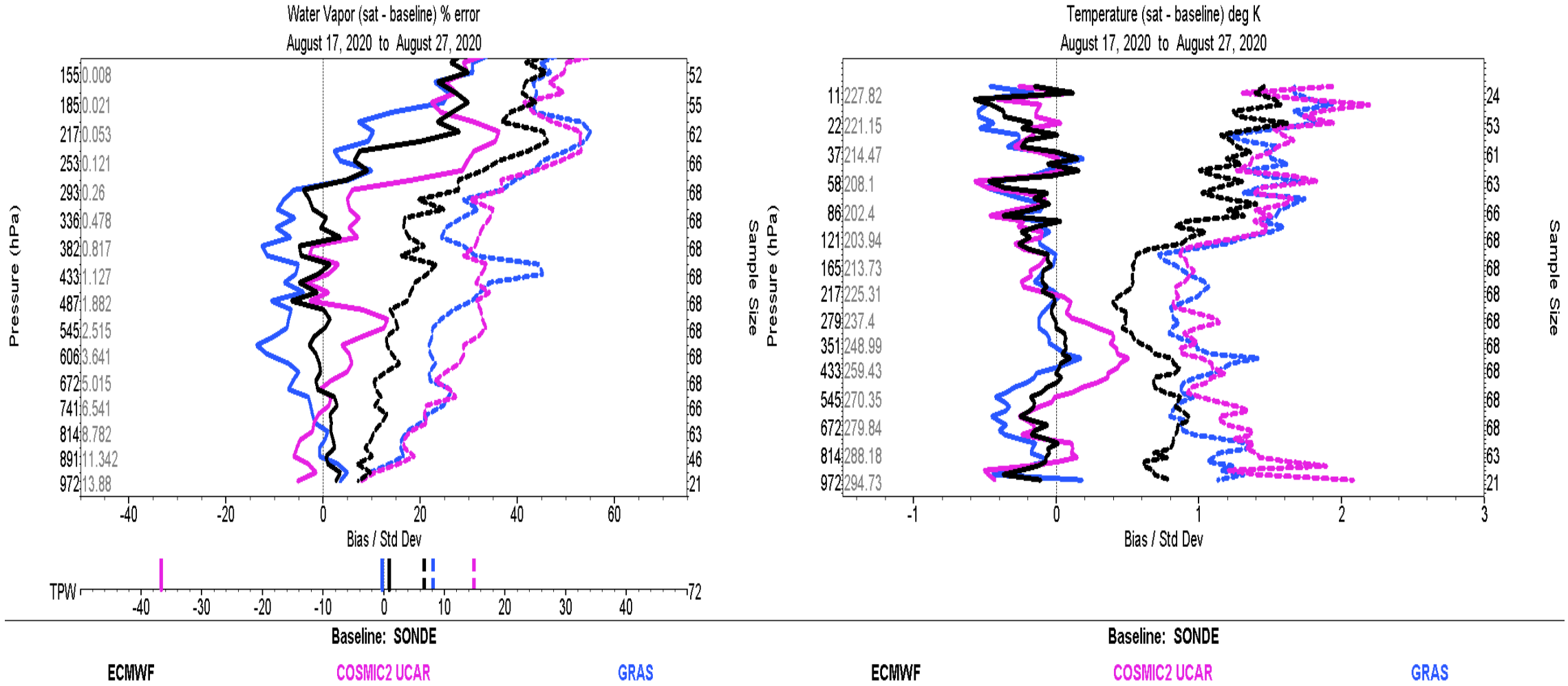
GNSS

August 17 – 27, 2020
All Radiosondes



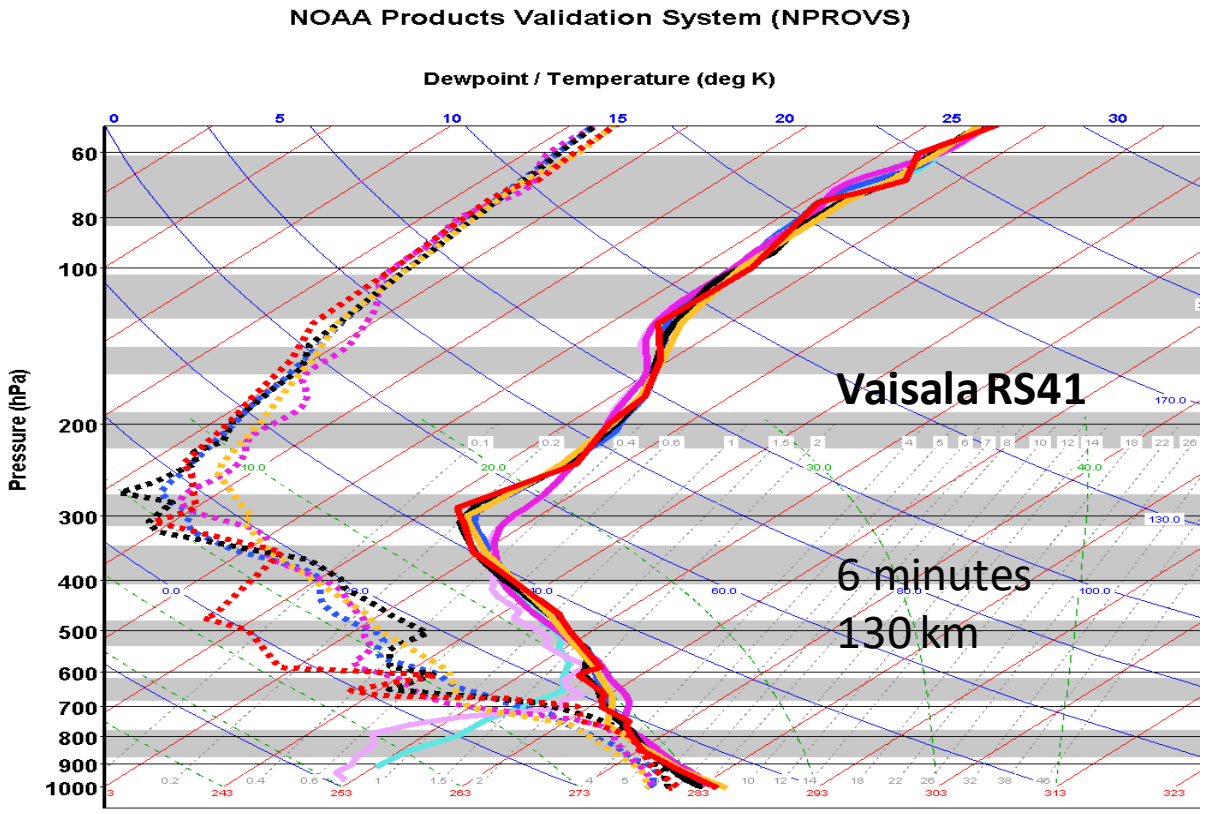
Collocated Radiosonde, COSMIC-2 (C2) and GRAS (MetOp) soundings; +/- 2 hours, 200km
(72 Radiosondes 69 sites)

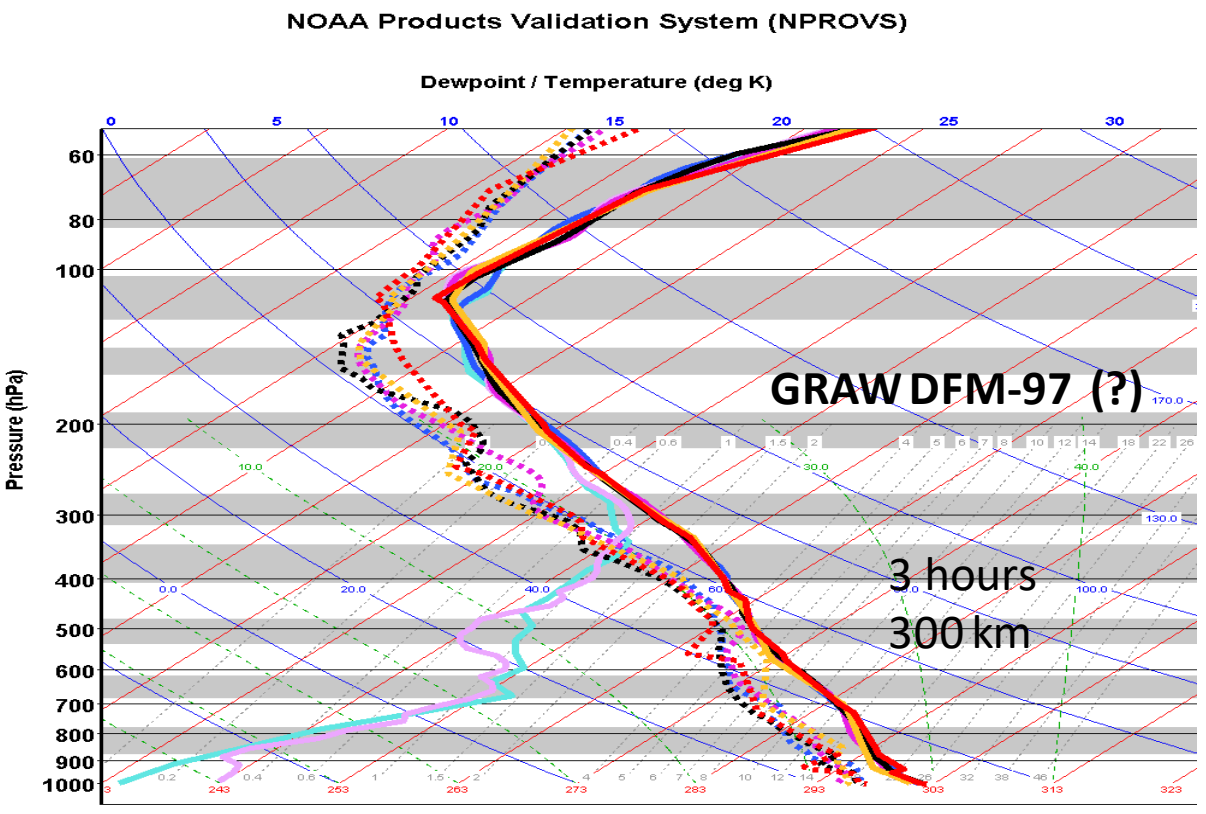
August 17 – 27, 2020
All Radiosondes



(X – Raob) Vertical Statistics for Bias (solid) and Standard Deviation (dash)
GRAS (MetOp), COSMIC-2 (UCAR), ECMWF Analysis (Black)
+/- 2 hours, 100km

August 20, 2020 at 11Z





SONDE 94672 (141) SONDE	8/20/2020 11:15:00Z	35 S / 138.5 E
SONDE 94672 (141) GFS 6 Hour	8/20/2020 11:15:00Z	35 S / 138.5 E
ECMWF	8/20/2020 12:00:00Z (0.8 hours)	35 S / 138.5 E (5.9 km)
COSMIC2 UCAR	8/20/2020 11:04:30Z (-0.2 hours)	34 S / 139.4 E (131.7 km)
COSMIC2 UCAR Raw Dry	8/20/2020 11:04:30Z (-0.2 hours)	34 S / 139.4 E (131.7 km)
GRAS	8/20/2020 11:09:29Z (-0.1 hours)	34.5 S / 138.2 E (62.4 km)
GRAS Raw Dry	8/20/2020 11:09:29Z (-0.1 hours)	34.5 S / 138.2 E (62.4 km)

SONDE 48615 (154) SONDE	8/20/2020 11:34:00Z	6.2 N / 102.3 E
SONDE 48615 (154) GFS 6 Hour	8/20/2020 11:34:00Z	6.2 N / 102.3 E
ECMWF	8/20/2020 12:00:00Z (0.4 hours)	6.2 N / 102.2 E (9.3 km)
COSMIC2 UCAR	8/20/2020 10:45:48Z (-0.8 hours)	5.2 N / 102.9 E (122.7 km)
COSMIC2 UCAR Raw Dry	8/20/2020 10:45:48Z (-0.8 hours)	5.2 N / 102.9 E (122.7 km)
GRAS	8/20/2020 13:31:36Z (2 hours)	7.4 N / 101 E (198.5 km)
GRAS Raw Dry	8/20/2020 13:31:36Z (2 hours)	7.4 N / 101 E (198.5 km)

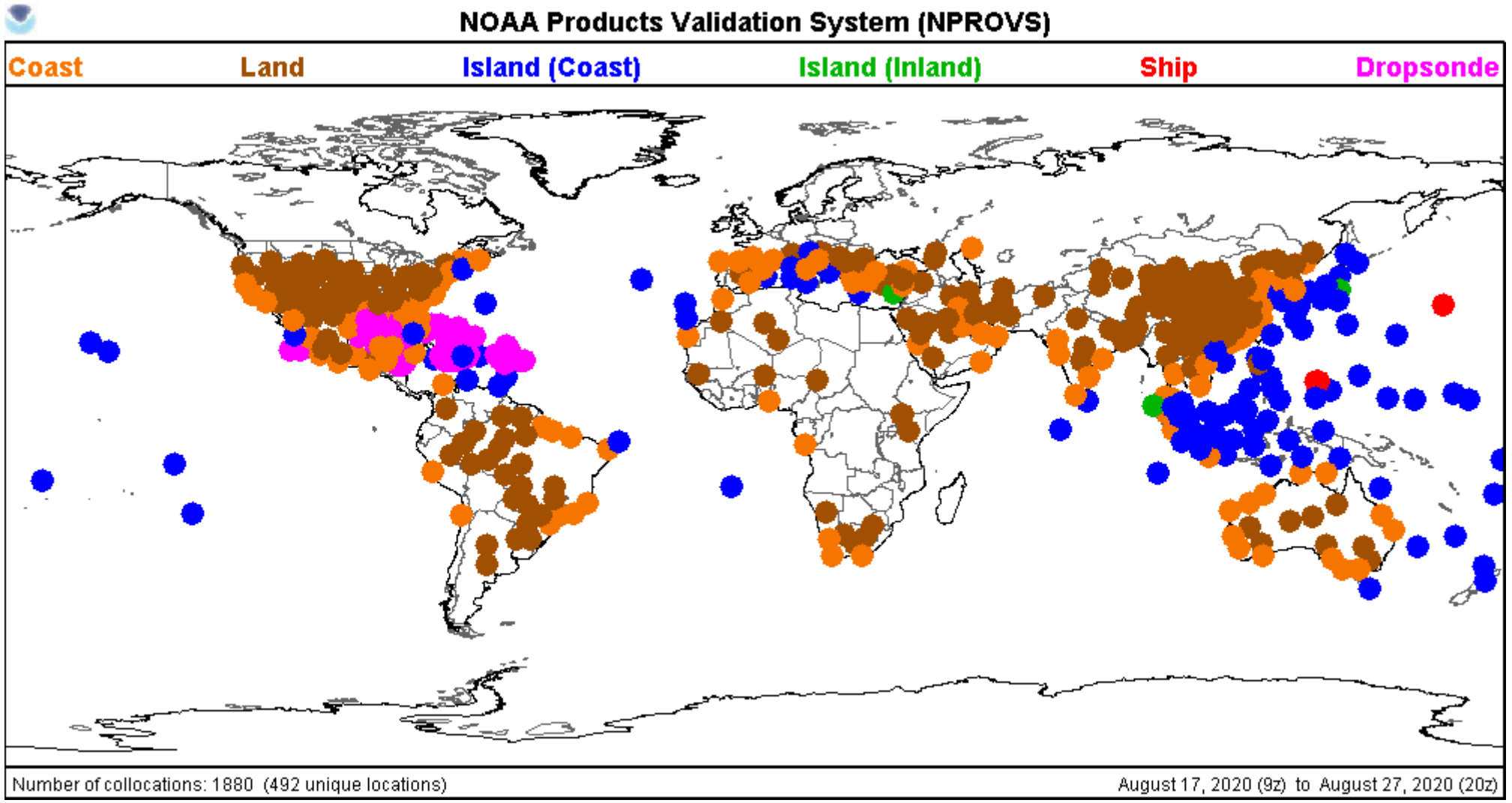
Example of collocated profiles, Tdew (dash) and Temperature (solid) for COSMIC-2, GRAS, ECMWF Analysis (black) and GFS 6-hr Forecast

… Satellite soundings on left within 6 minutes and 130km; on right within 3 hours and 300km

Too few C2 and GRAS within 2 hr/150km (of Raob) for comparison against Vaisala RS41 only … *larger period*

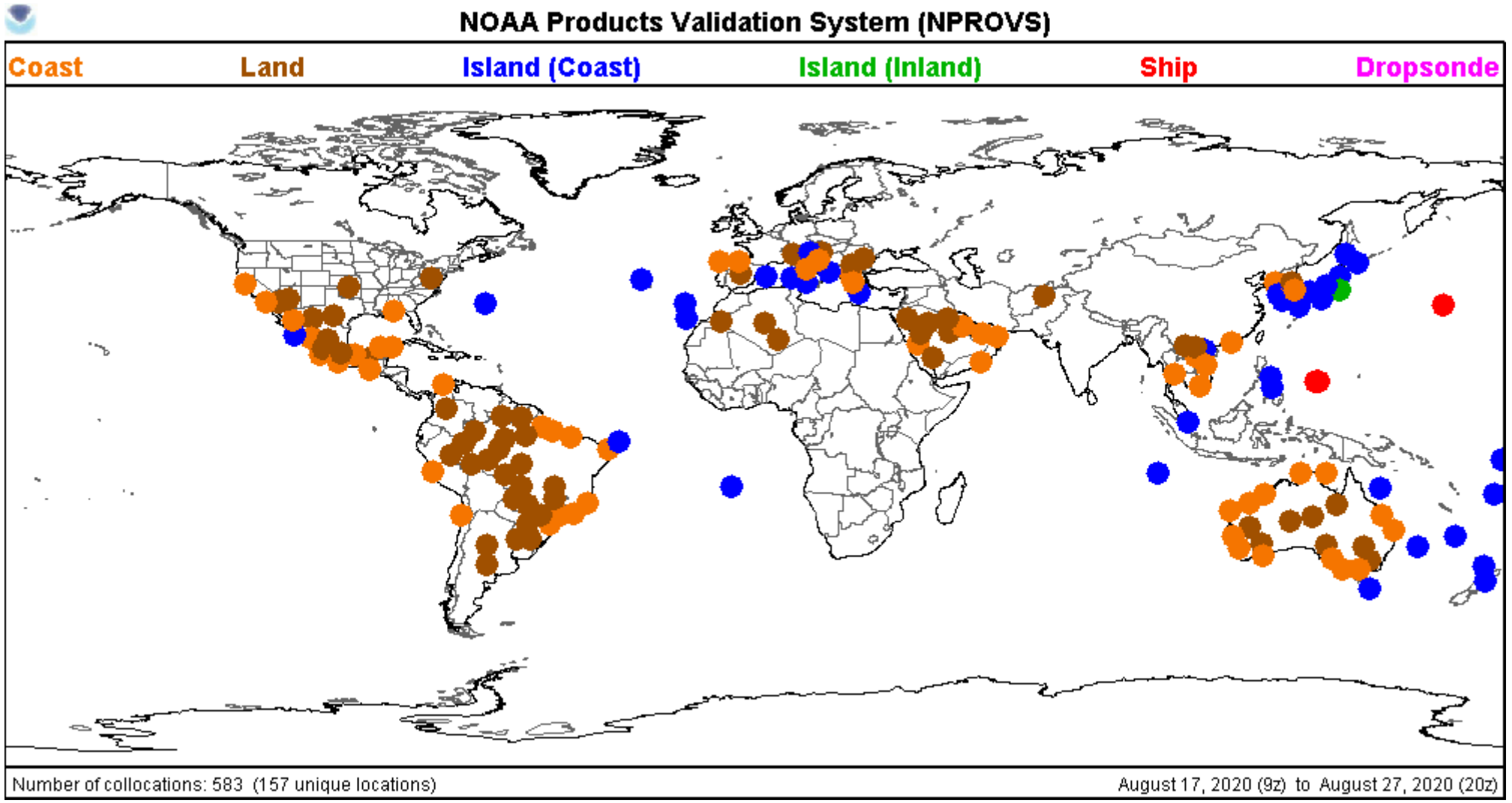
Compare C2 only against:
All Raob
RS41 Raob

August 17 – 27, 2020
All Radiosondes



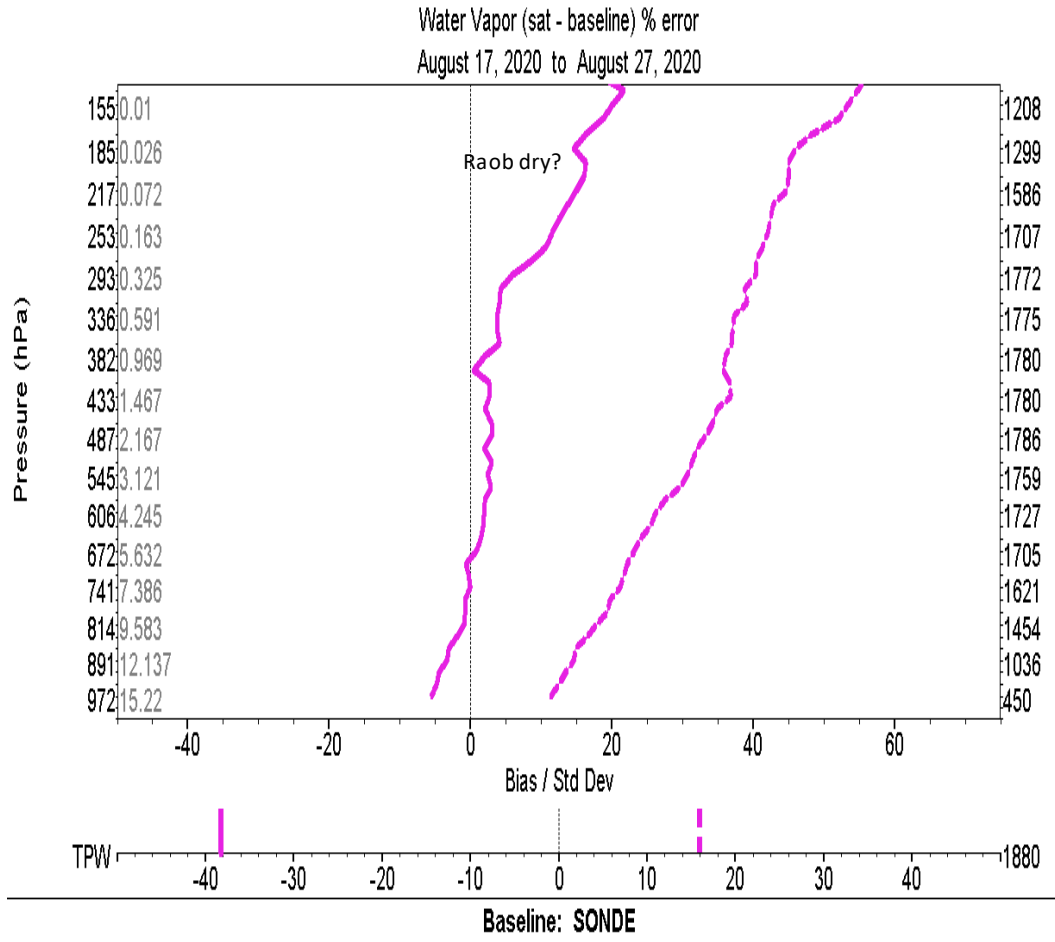
Collocated Radiosonde and COSMIC-2 (C2) soundings; +/- 2 hours, 200km
(1880 Radiosondes at 492 sites)

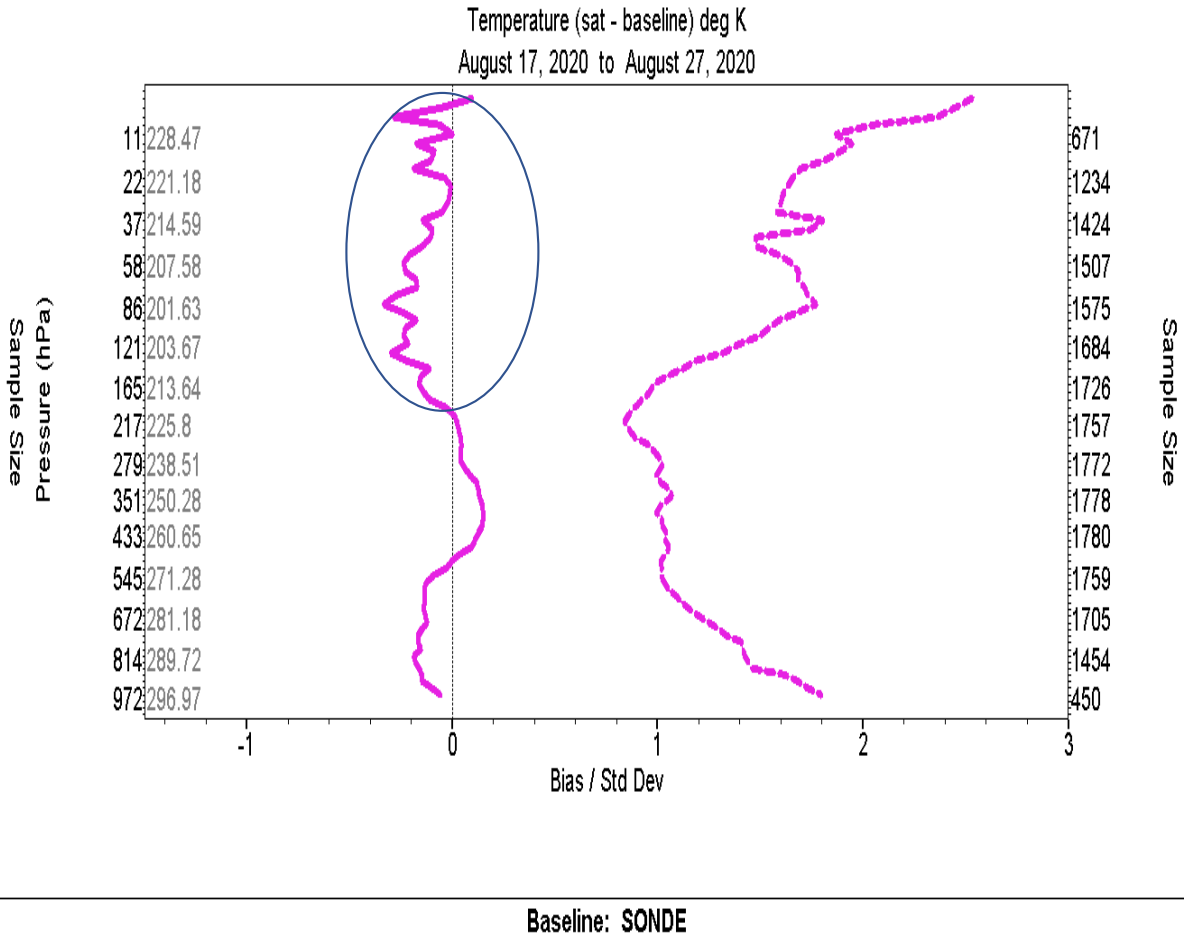
August 17 – 27, 2020
Vaisala RS41 Radiosondes



Collocated Radiosonde and COSMIC-2 (C2) soundings; +/- 2 hours, 200km
(583 Radiosondes at 157 sites)

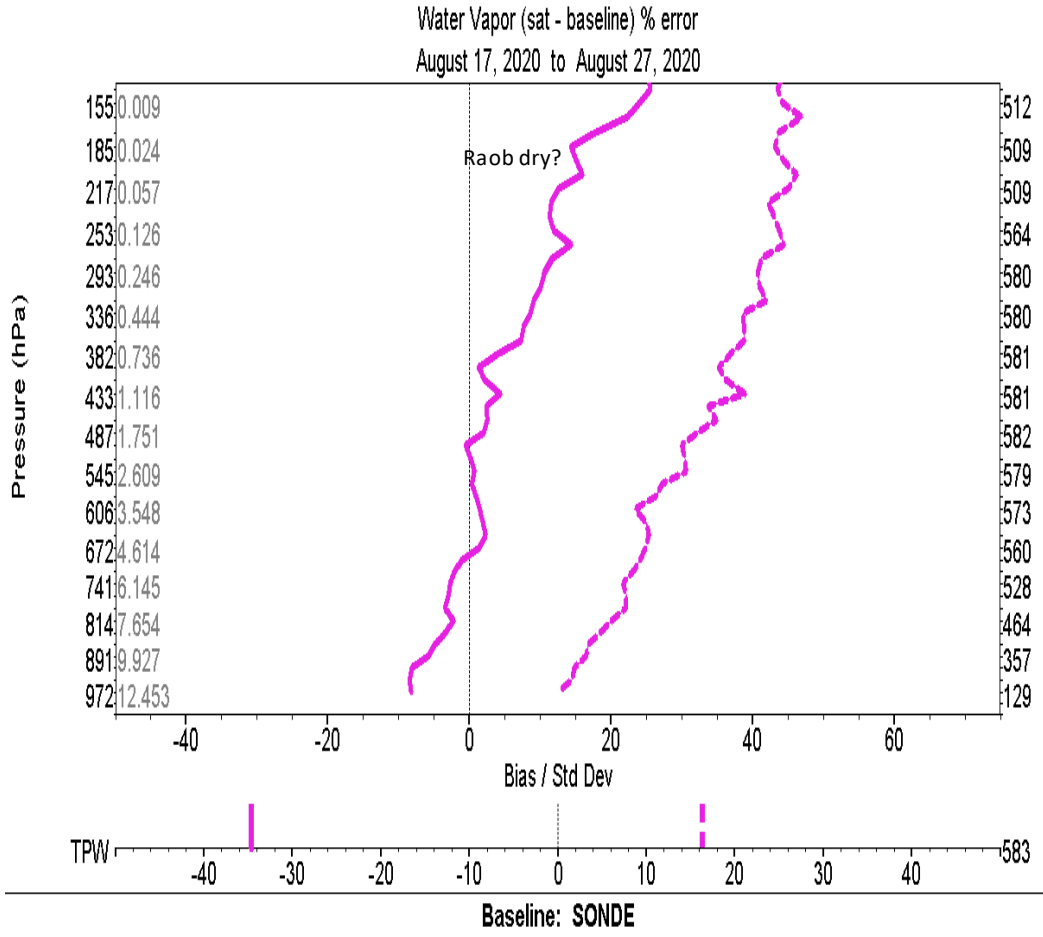
August 17 – 27, 2020
All Radiosondes

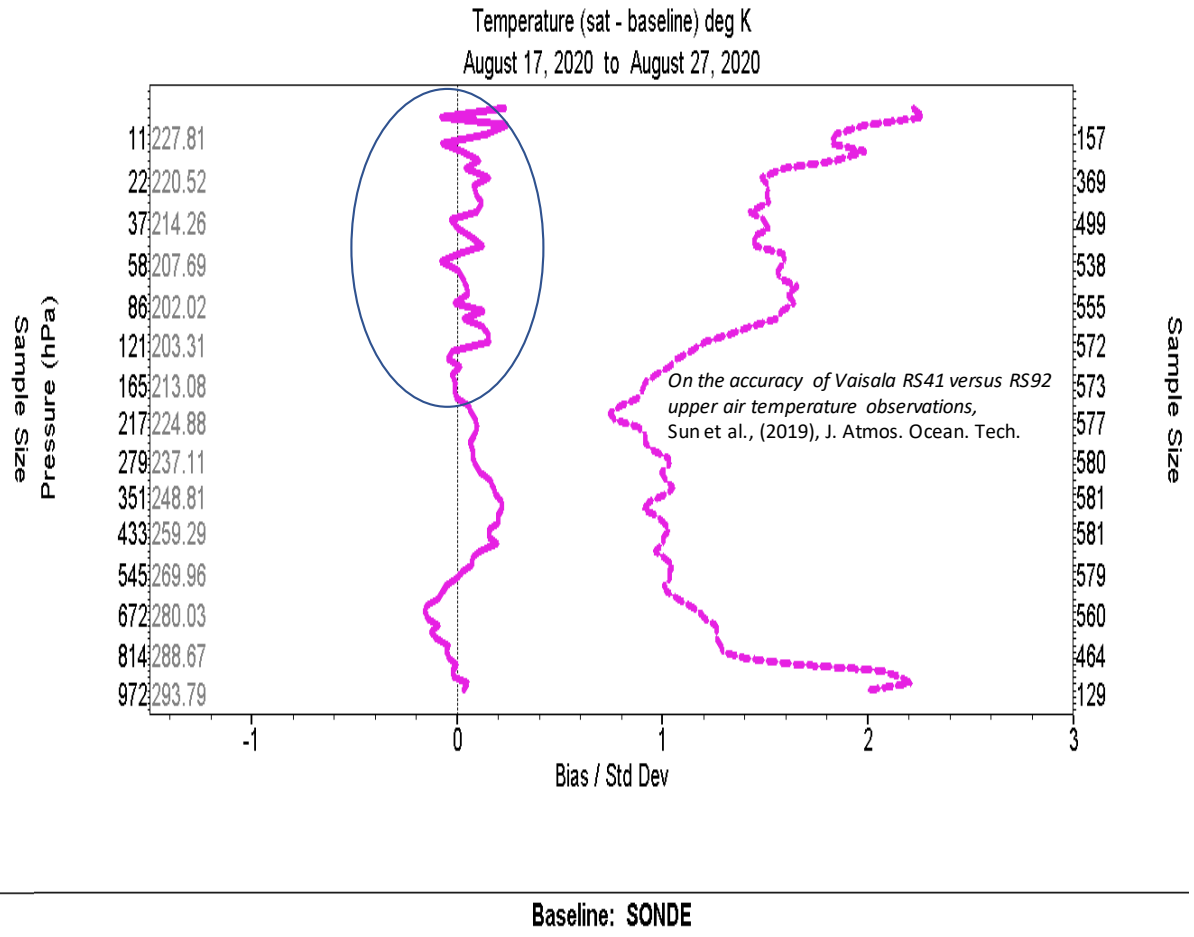




(SAT – Raob) Vertical Statistics for Bias (solid) and Standard Deviation (dash)
COSMIC-2 (UCAR); +/- 2 hours, 100km

August 17 – 27, 2020
Vaisala RS41 Radiosondes





(SAT – Raob) Vertical Statistics for Bias (solid) and Standard Deviation (dash)
COSMIC-2 (UCAR); +/- 2 hours, 100km

Summary

NOAA Products Validation System (NPROVS) provides routine compilation of collocated radiosonde and satellite observations from over 20 products suites facilitating enterprise assessment

Examples of sampling strategies are shown for selected polar satellite (MetOp-B) and GNSS (COSMIC-2 and GRAS) sounding product suites against global conventional radiosondes for a 10-day period in August, 2020.

Results comparing NOAA (NUCAPS) and EUMETSAT hyper-spectral IR based and NOAA (MiRS) MW-only soundings from MetOp-B are provided; **mismatch among these data are minimal lending high confidence**

Results comparing GNSS COSMIC-2 versus GRAS retrievals are provided; **mismatch among these data is larger (than for polar satellites) lending moderate confidence**

Overall, enterprise assessment differences among polar satellites appear larger (despite smaller mismatch) than for GNSS

Results comparing GNSS COSMIC-2 retrievals against RS41 radiosonde shows reduced C2 bias aloft consistent with improved RS41 radiation correction (order of 0.3K)

Ready to share (WGSP) …