GRUAN / NOAA (STAR) Coordination

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College Park, Md

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Outline

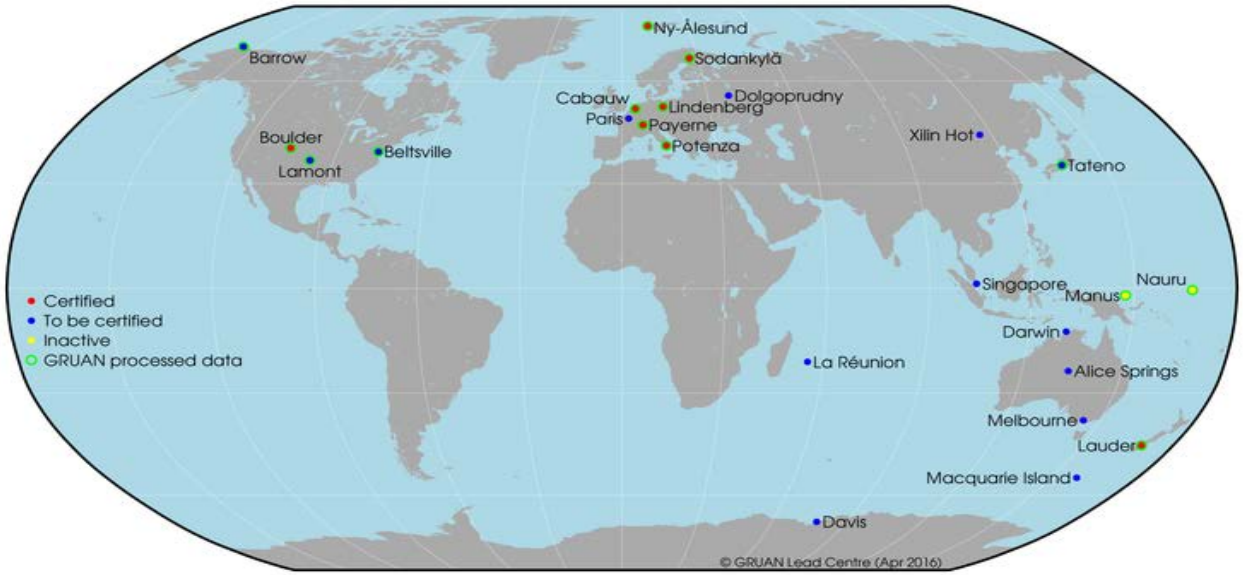
- GRUAN and NPROVS+
  - JPSS Products Cal/Val Support
- GRUAN and Uncertainty Integration Analytical directions
  - EDR cal/val … SDR cal/val
  - Examples (NUCAPS, NWP, GPSRO …)
- Summary

GRUAN

Peter Thorne (Maynooth, Ireland) , Greg Bodeker (New Zealand)
Ruud Dirksen (Lead Center, DWD, Lindenberg, Germany) …

GRUAN reference observations are calibrated through an unbroken traceability chain to SI or community standards with the uncertainty interval in each step in the chain "fully characterized", meaning the resulting estimates can be used with high confidence that the true measurement is within the interval …

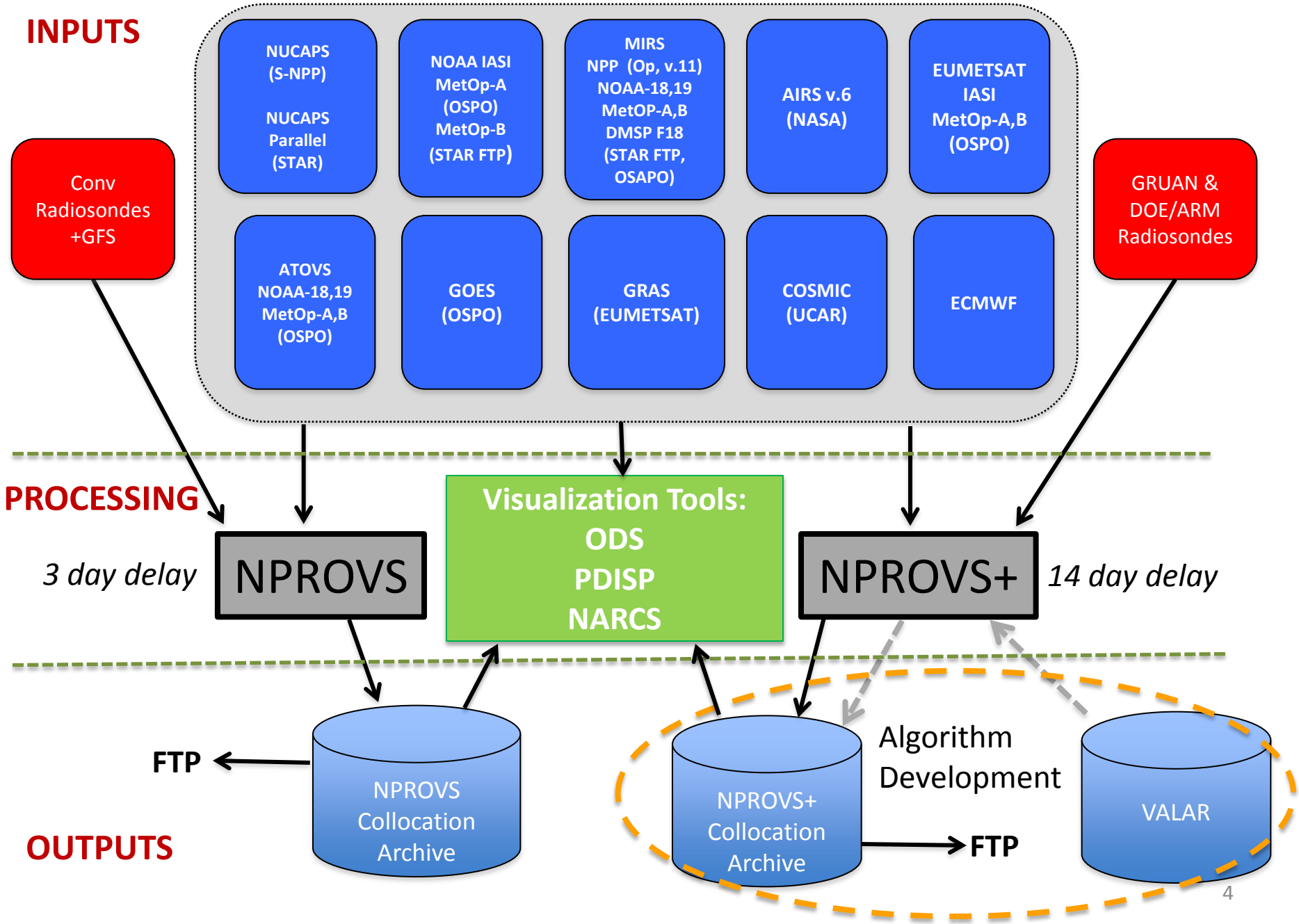
GCOS Reference Upper-Air Network



Among the primary objectives of GRUAN is the constraining and inter-calibration of data from other more spatially extensive observing systems such as satellites and the current radiosonde network.

WWW.GRUAN.ORG

NPROVS/NPROVS+ Data Management Schematic



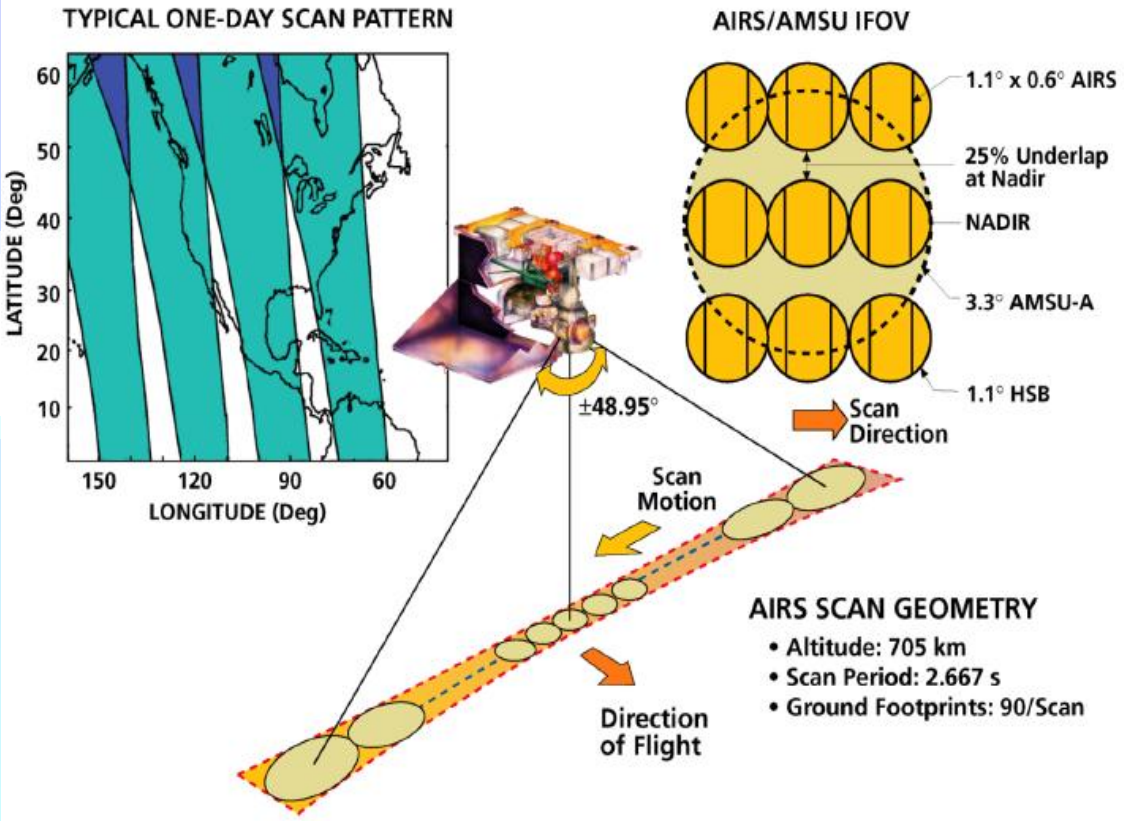
Collocation Criteria:

+/- 6-hour

250 km

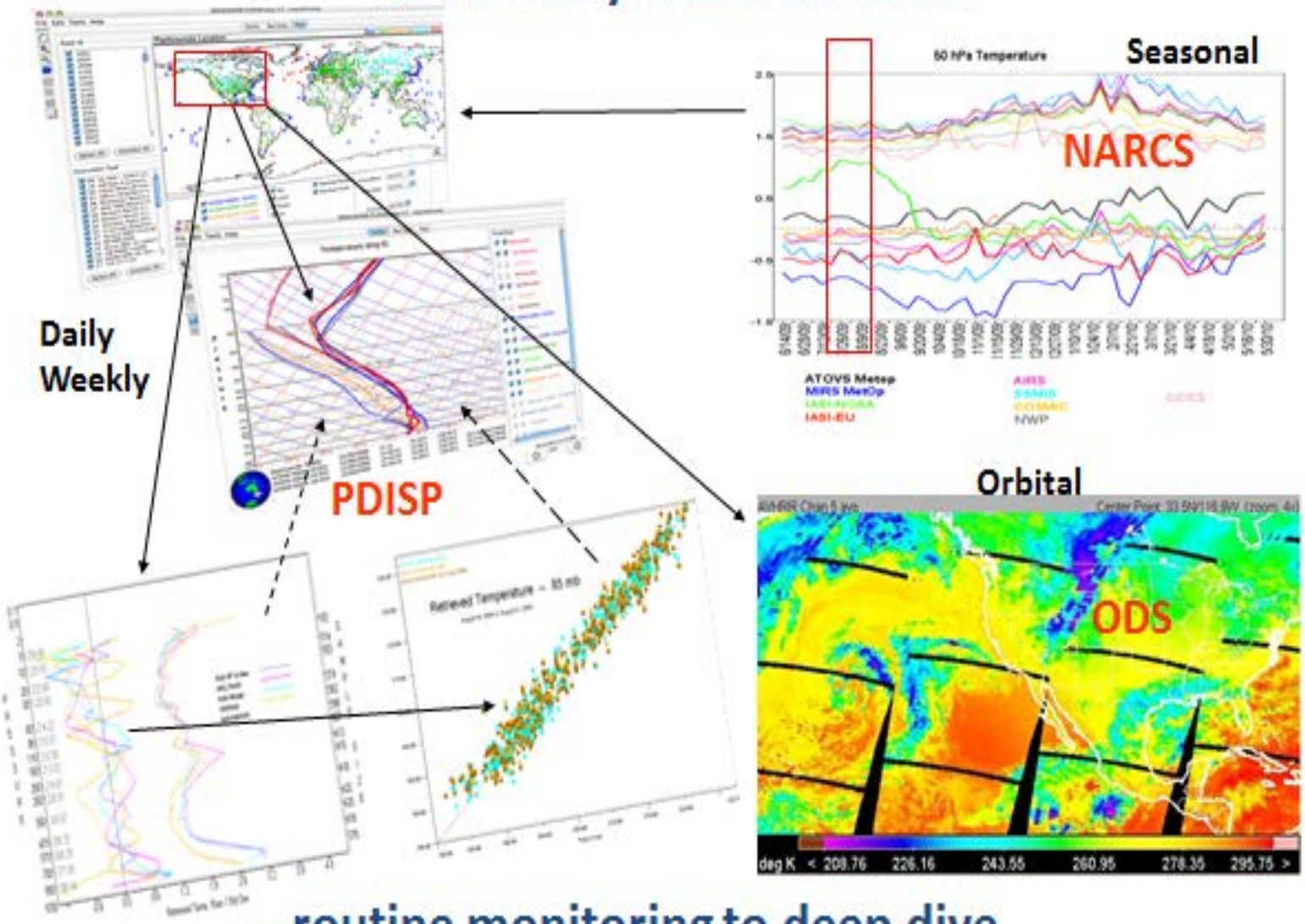
Single Closest
(anchored to Field-of Regard)

- **Sounding is performed on 50 km field of regard (FOR).**
- **FOR is currently defined by the size of the microwave sounder footprint.**
- **IASI/AMSU has 4 IR FOV's per FOR**
- **AIRS/AMSU & CrIS/ATMS have 9 IR FOV's per FOR.**



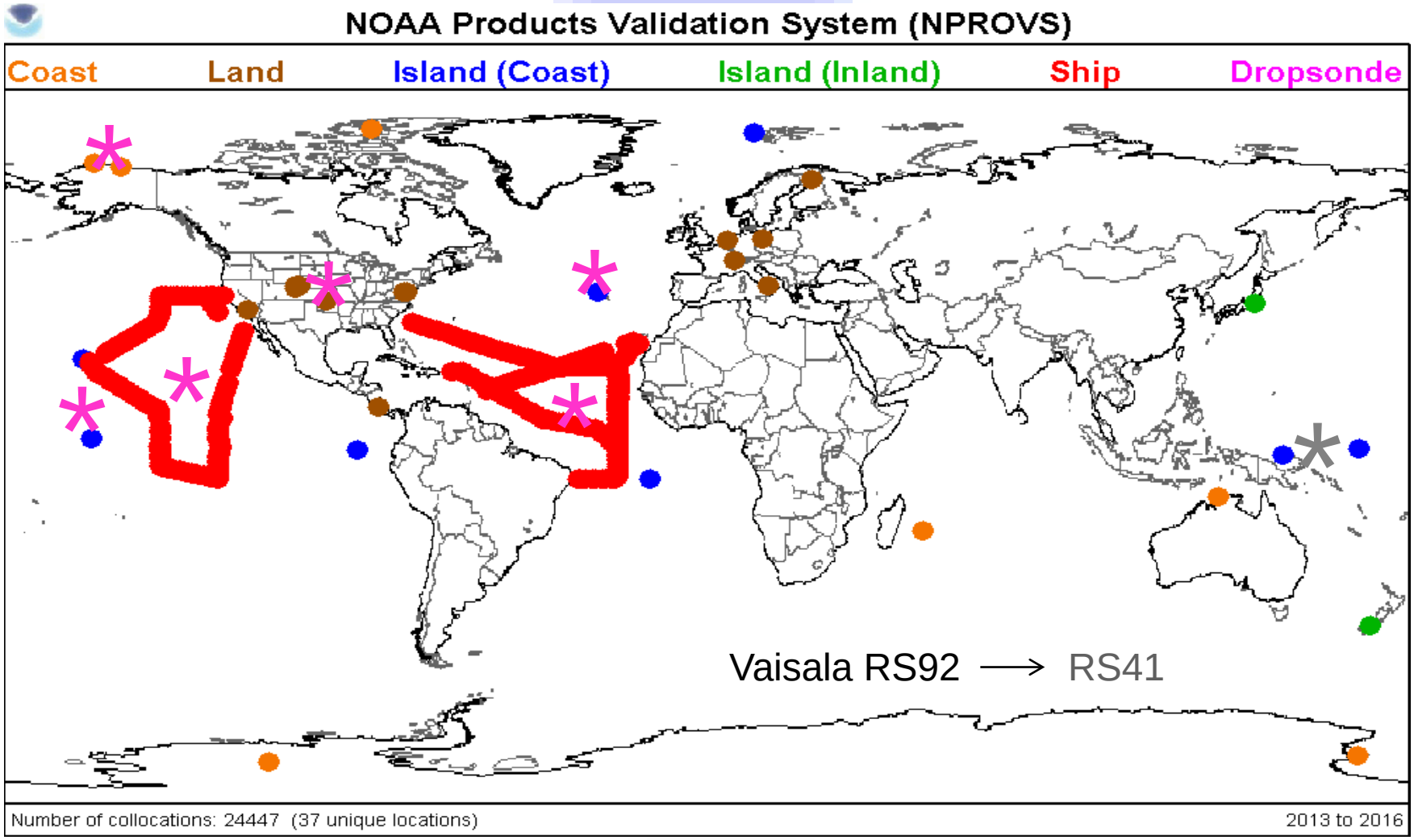
Barnet, Prov

EDGE Analytical Interface …



… routine monitoring to deep dive

N P R O V S +

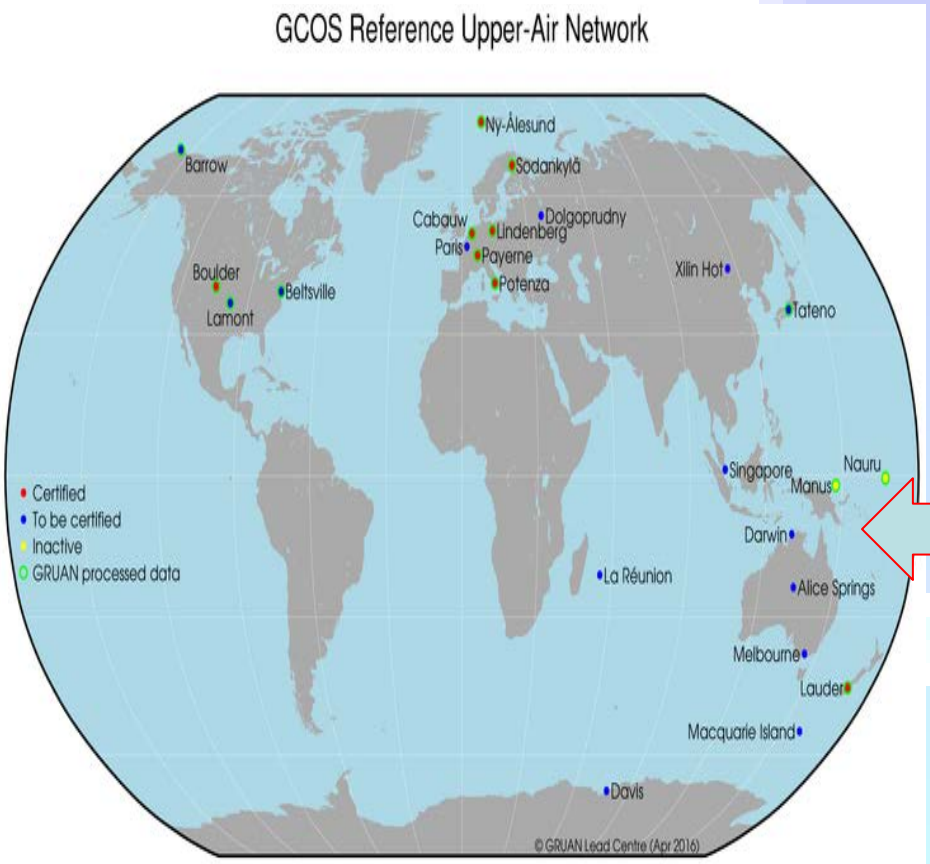


GRUAN and JPSS funded Dedicated (S-NPP *) RAOB Sites

January 2013 to July 2016

(JPSS / ARM provide significant global component of S-NPP synchronized Raob)

N P R O V S +



Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

JPSS/ARM Funded Dedicated RAOB

(Lihang Zhou (STAR), Lori Borg (SSEC), Donna Holdridge (Argonne) , Jim Mather (ARM) …)

- DOE ARM (SGP, NSA, ENA)
  - ✓SSEC, ANL …
  - ✓(2) per week
  - ✓**GRUAN Processed (v2 → v3)**
  - ✓ includes dual sequential …
- AEROSE **(GP)**
- CALWATER, El-Nino RR

- *ARM Mobile*
- *Sterling Test Site*
- *CIRA*

GRUAN Uncertainty Integrated in NPROVS+ analytic interface (PDISP)

GRUAN Reference Measurement Principles

Given two measurement (m1, m2), their uncertainty (u_1, u_2) and variability (σ), then two observations are consistent if:

"k" .le. 2:

$$|m_1 - m_2| < k\sqrt{\sigma^2 + u_1^2 + u_2^2}$$

Worst case "k" for SAT:

"k" = ABS(SAT – GRUAN) / u2

where u2 is GRUAN uncertainty, sigma and u1 equal 0

GRUAN Reference Measurement Principles

Given worst case "k" profile, what is value of $(\sigma^2 + u_1^2)$ such that that "k=2" ?

$\sigma^2 + u_1^2$ ~ (("k"/2)^2 –1) (u2)^2

Assume sigma small:

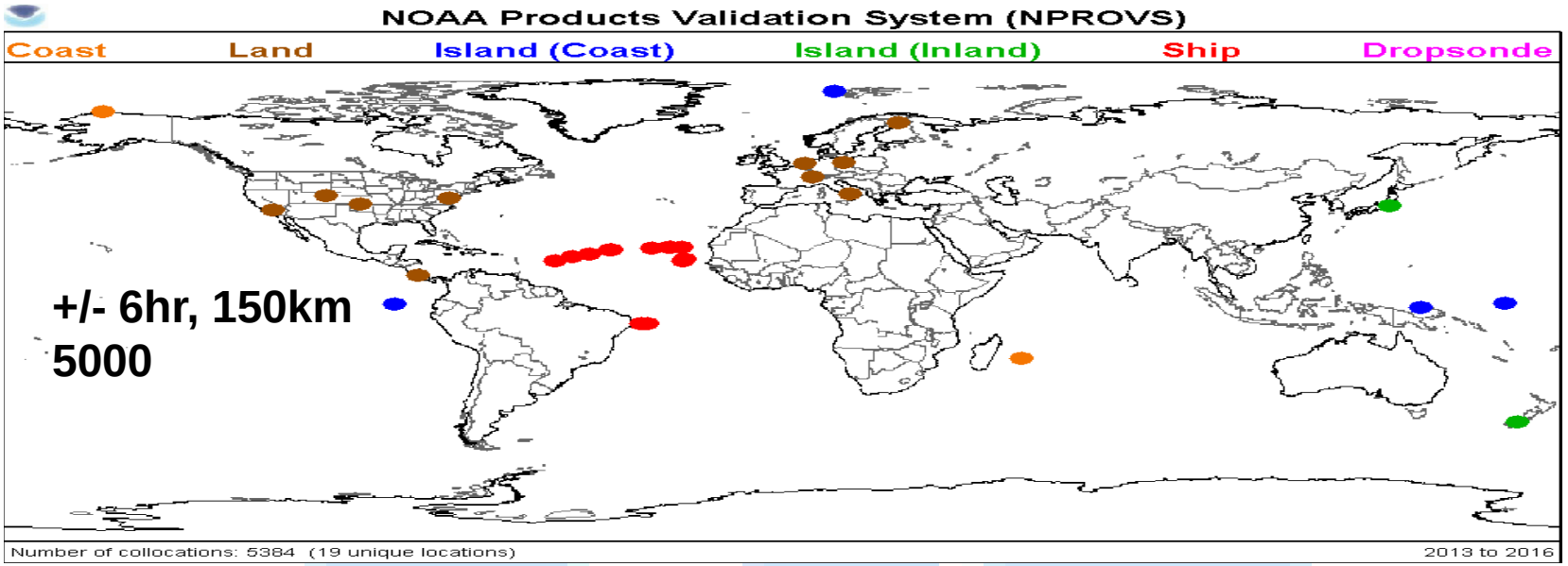
u_1 = (("k"/2)^2 –1)$^{1/2}$ (u2)

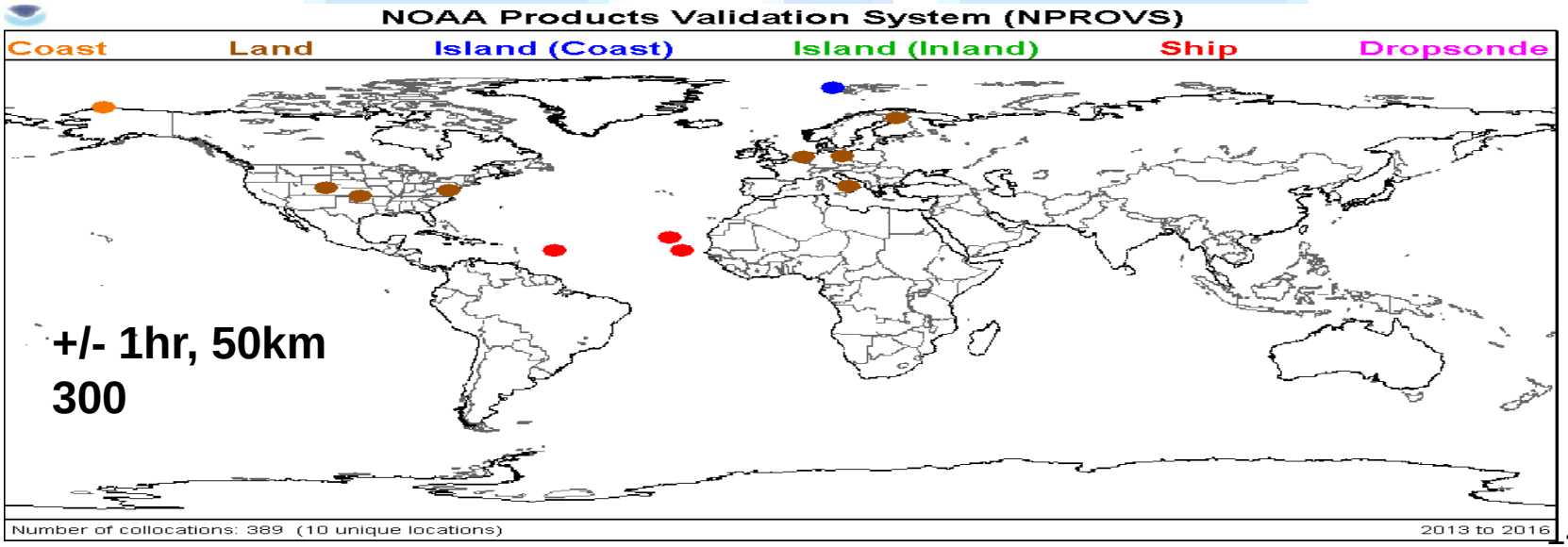
Assume $u_1 = a(u_2)$:

σ = (("k"/2)^2 –1 – a^2)$^{1/2}$ (u2)

… uncertainty due to measurement differences and mismatch

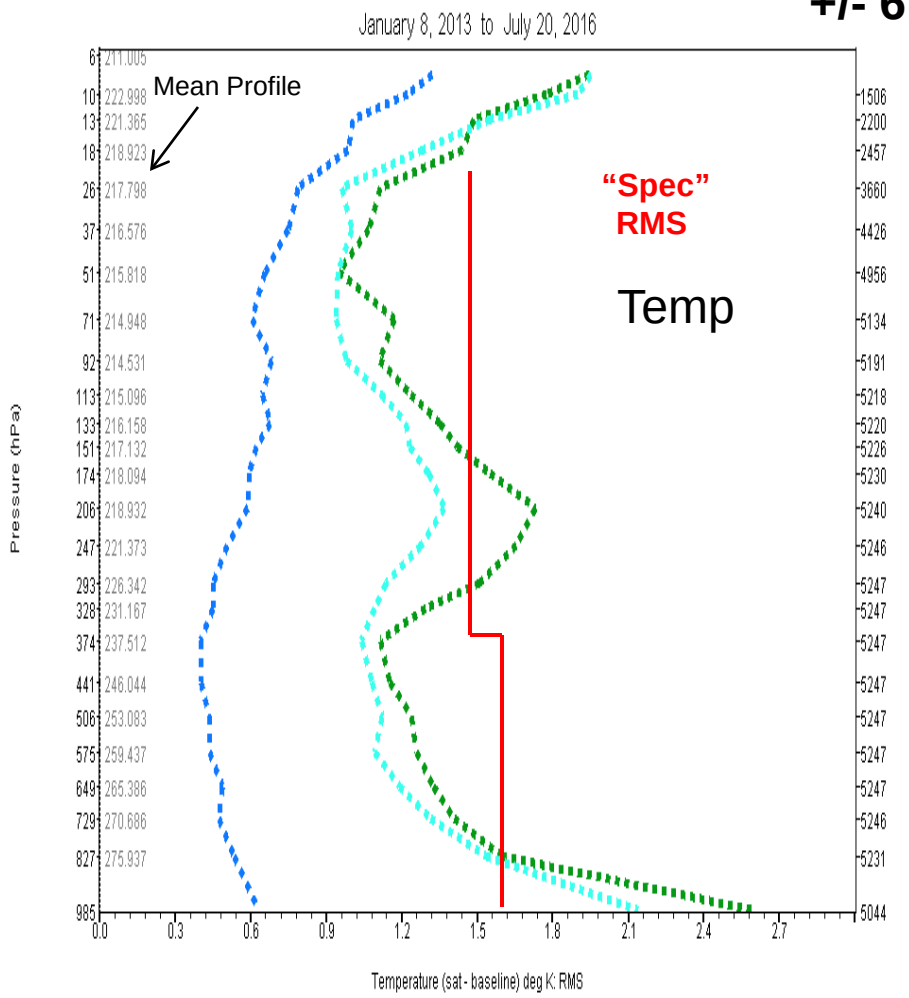
… estimate uncertainties for satellite products

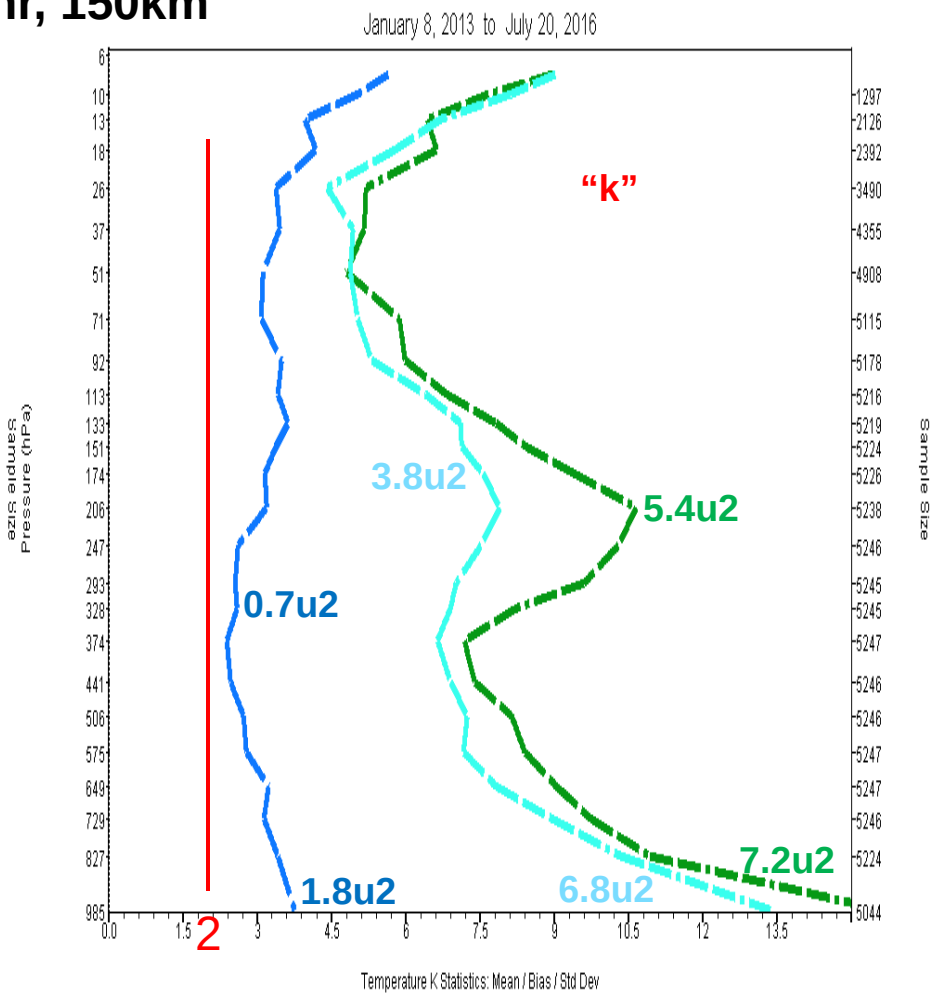




GRUAN Processed and Accepted; IR pass QC

+/- 6hr, 150km





Baseline: Sonde

AIRS AQUA ECMWF NUCAPS NPP

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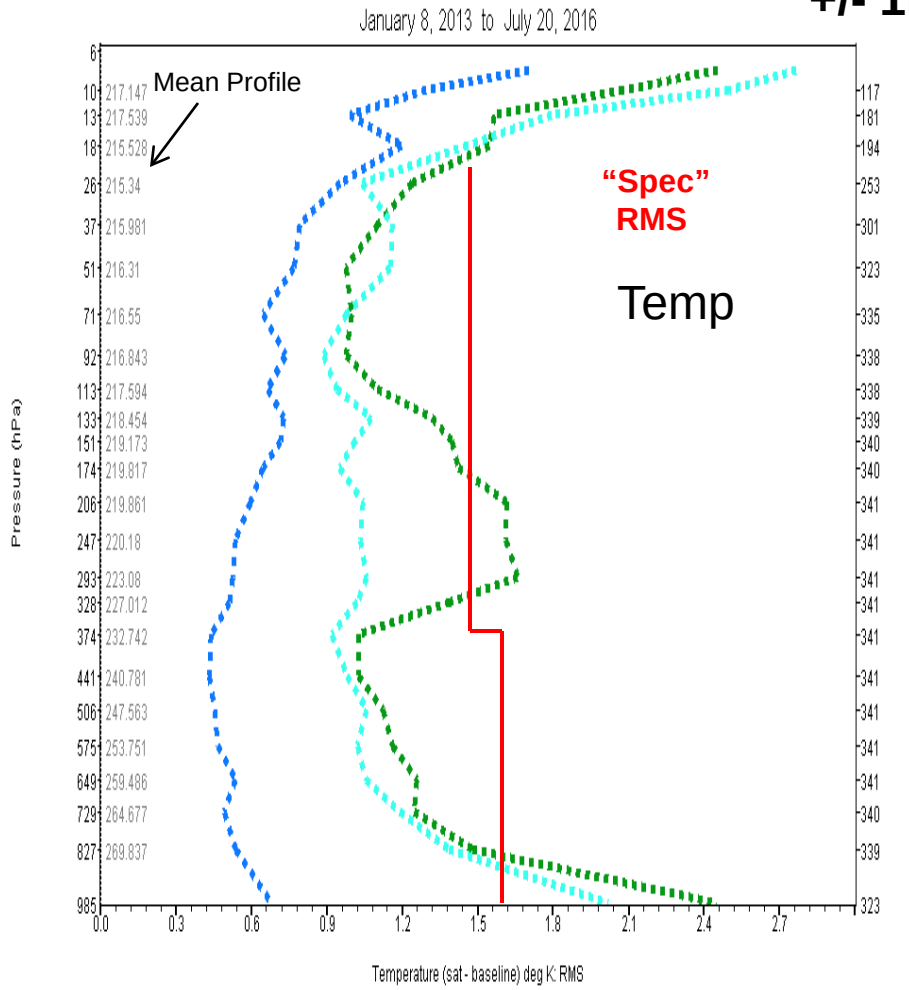
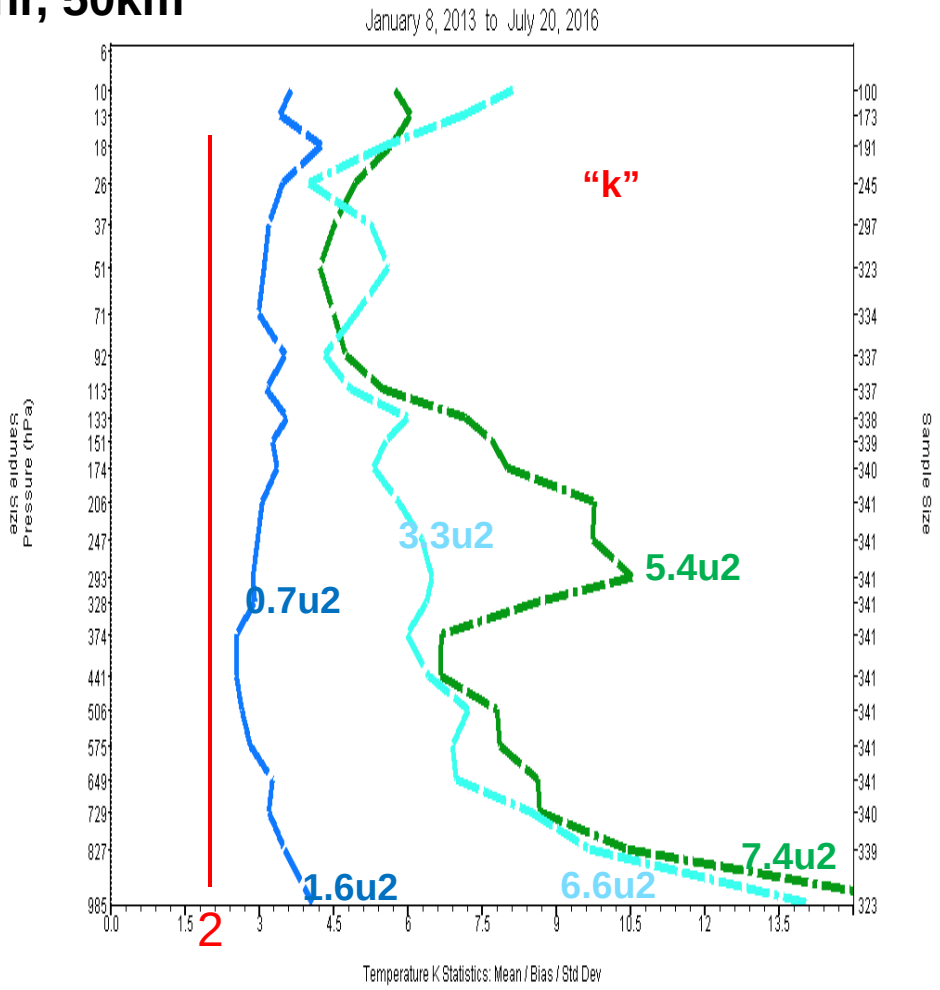
AIRS AQUA ECMWF NUCAPS NPP

GRUAN Processed and Accepted; IR pass QC

+/- 1hr, 50km





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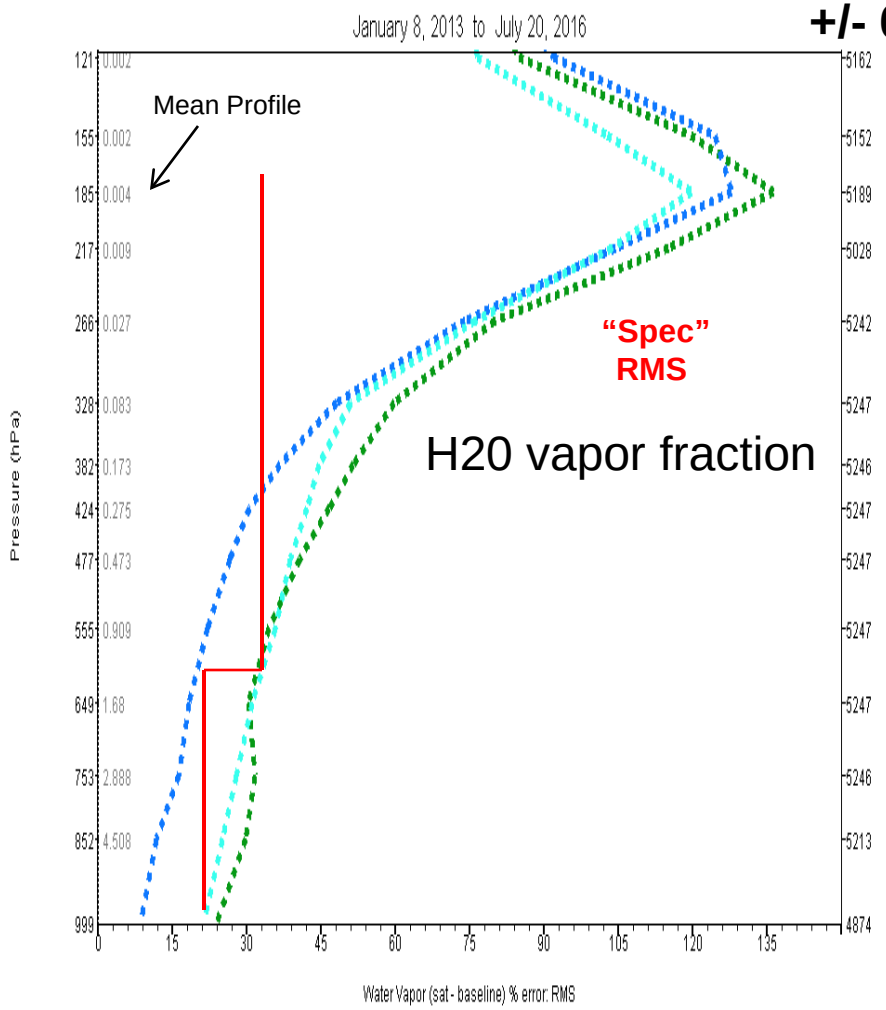

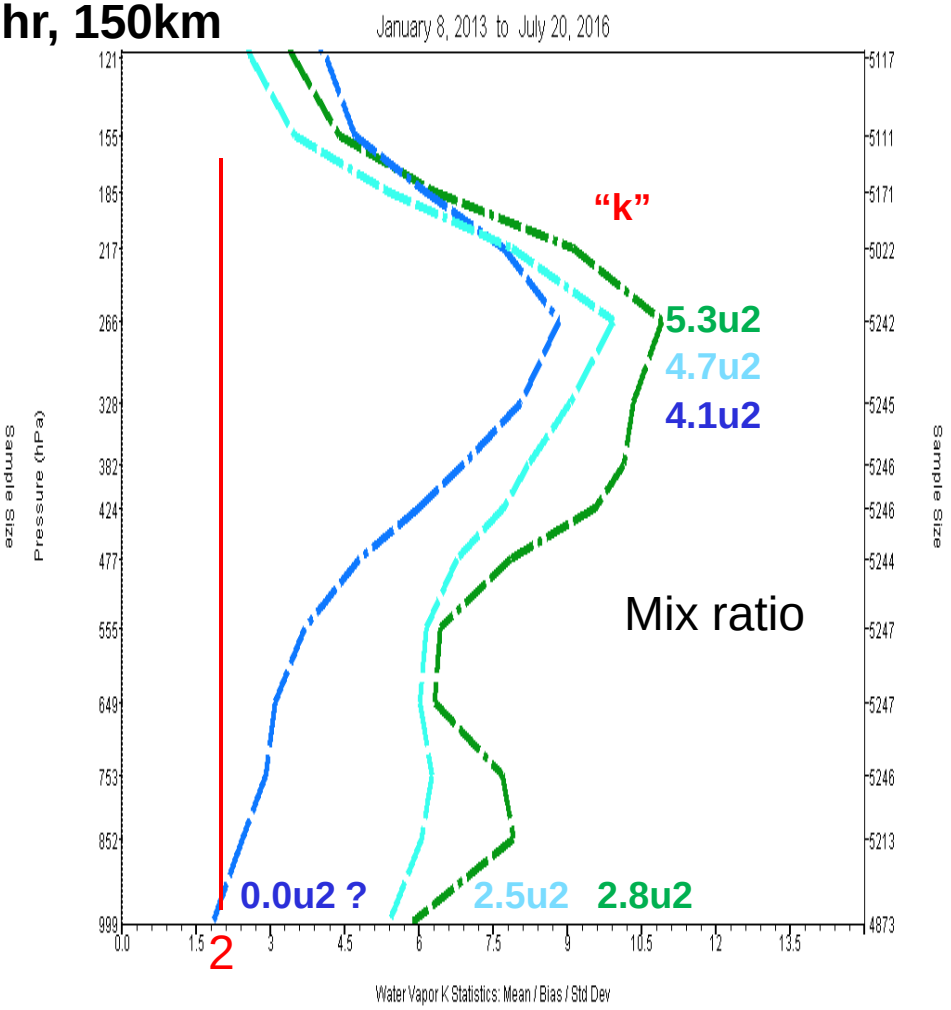

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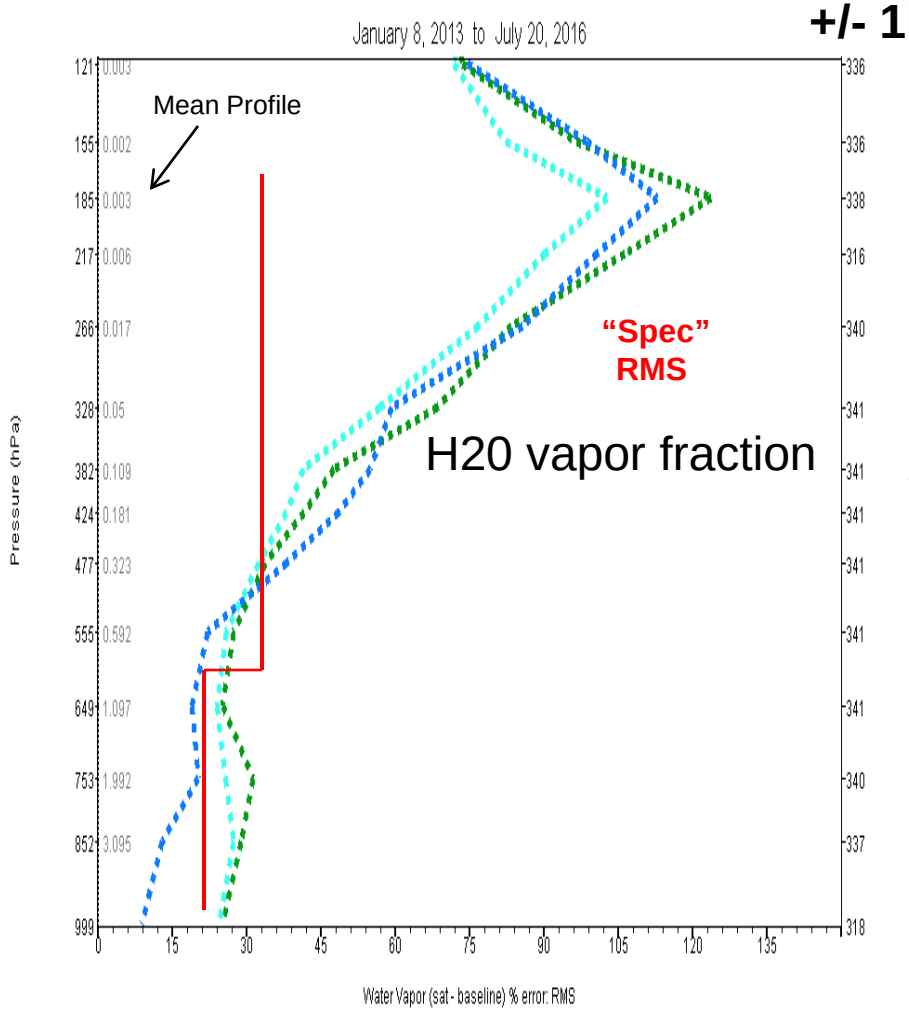

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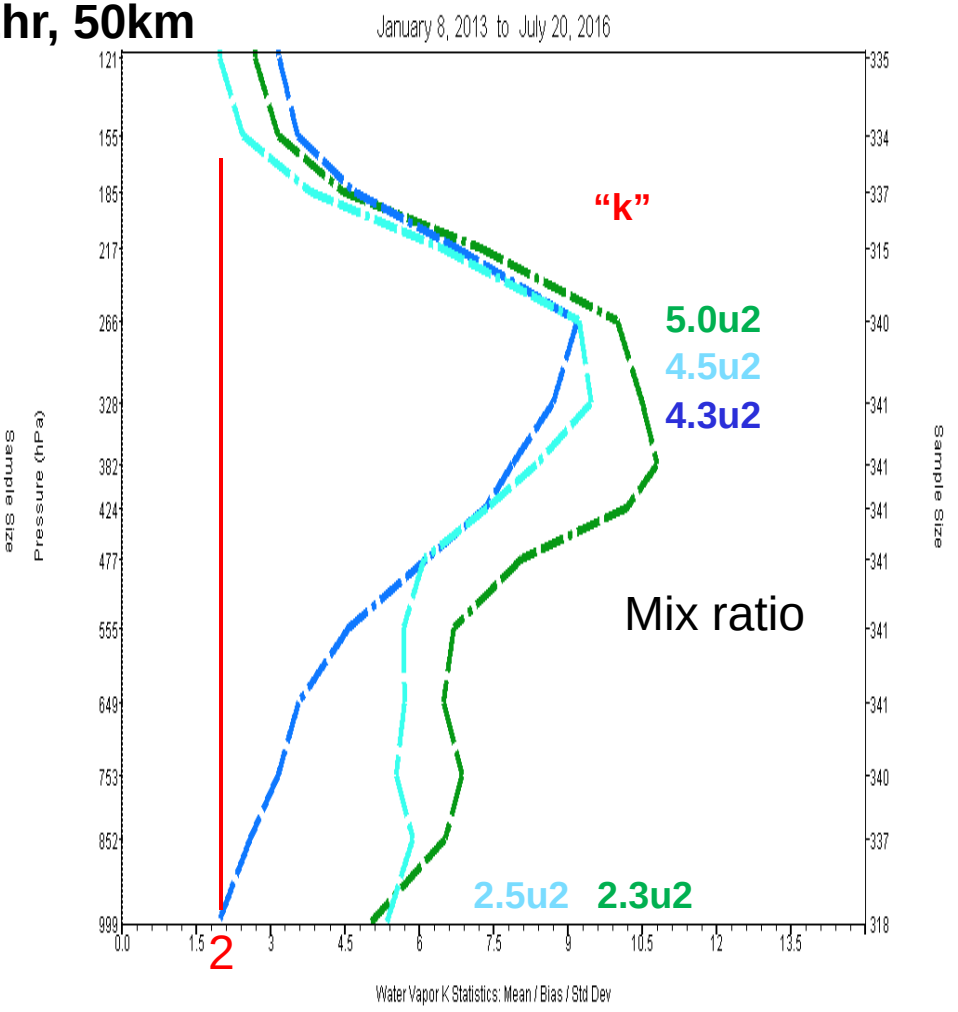


Baseline: Sonde

AIRS AQUA ECMWF NUCAPS NPP

GRUAN Processed and Accepted; IR pass QC

… informal email exchange Geir Braathen (WMO) and dale Hurst (NOAA ESRL)

Geir,
About a year ago I did a quick study of the UT water vapor biases between MLS and FPs at Hilo and Costa Rica (i.e., tropical sites). I looked only at 121 and 147 hPa because I was interested in the differences in the amounts of water vapor input to the TTL implied by the different data sets.
The mean biases at 147 hPa over both sites were 3-4 ppmv, with MLS drier than the FPs. The FP mixing ratios at 147 hPa ranged from 5-25 ppmv, most were 10-25 ppmv, and the 3-4 ppmv differences occurred at mixing ratios >15 ppmv.
Cheers, Dale

Hi Dale,
I did not think that you meant to claim that. But it was just good to make sure that I understood you correctly. I think the main conclusion is that we need many more water vapour measurements in the UTLS region.
Cheers, Geir

Hello again Dale,
Thank you for these details. Despite the dry bias of MLS that you describe, the MERRA and ERA Interim reanalysis remain quite wet compared to the FP measurements. The MLS dry bias you indicate is not enough to compensate for the 150% wet bias in the reanalysis, as far as I can see.
Cheers, Geir

Hi Geir,
I was not claiming that the wet biases in the reanalysis wrt MLS would go away if the MLS dry biases were considered, only that the wet reanalysis biases might be reduced when FPs are used instead.
Cheers,Dale

The Forgotten Water Vapor at High Altitudes

Scientists find that estimations of high-altitude atmospheric water, critical for the greenhouse effect, are not as accurate as previously thought.

https://eos.org/research-spotlights/the-forgotten-water-vapor-at-high-altitudes

… estimate “sigma”

GSICS Quarterly
Global Space-based Inter-Calibration System
Newsletter – Summer 2015 Issue
Volume 9 Number 2
2015
doi: 10.7289/V5XK8CHN
Manik Bali, Editor

CMA • CNES • EUMETSAT • IMD • ISRO • JAXA • JMA • KMA • NASA • NIST • NOAA • ROSHYDROMET • USGS • WMO

Quantifying uncertainty when comparing Space-based and Ground Observations

By Tony Reale, NOAA and Xavier Calbet, AEMET

A problem in satellite product cal/val is that uncertainty budgets are typically overlooked. Uncertainty originates in the native measurement space, for example the radiances from satellites or temperature from radiosonde observations (RAOB). Uncertainty is not solely an "intrinsic" property of the observations, but also has "secondary" components that are introduced when comparing measurements with different spatial and/or temporal characteristics including mismatch. Quantifying these components is needed for robust inter-comparison, validation and integration, for example, in WMO Integrated Global Observing System (WIGOS). Addressing such issues through strict comparison of reference RAOB, satellite IR/MW sounding

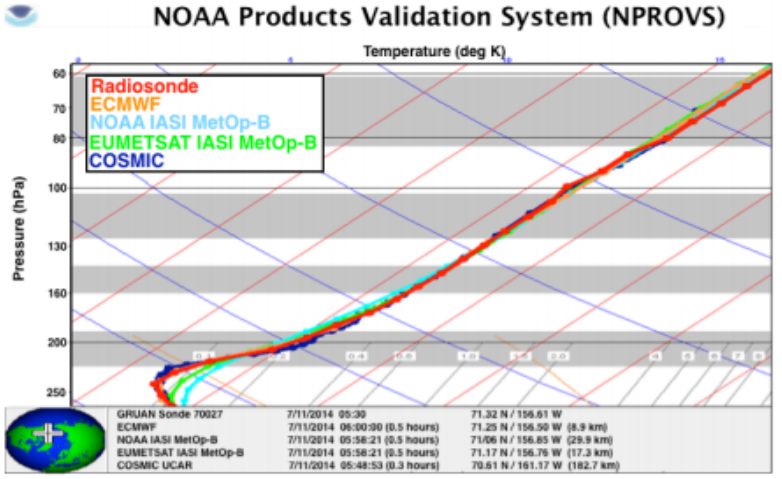
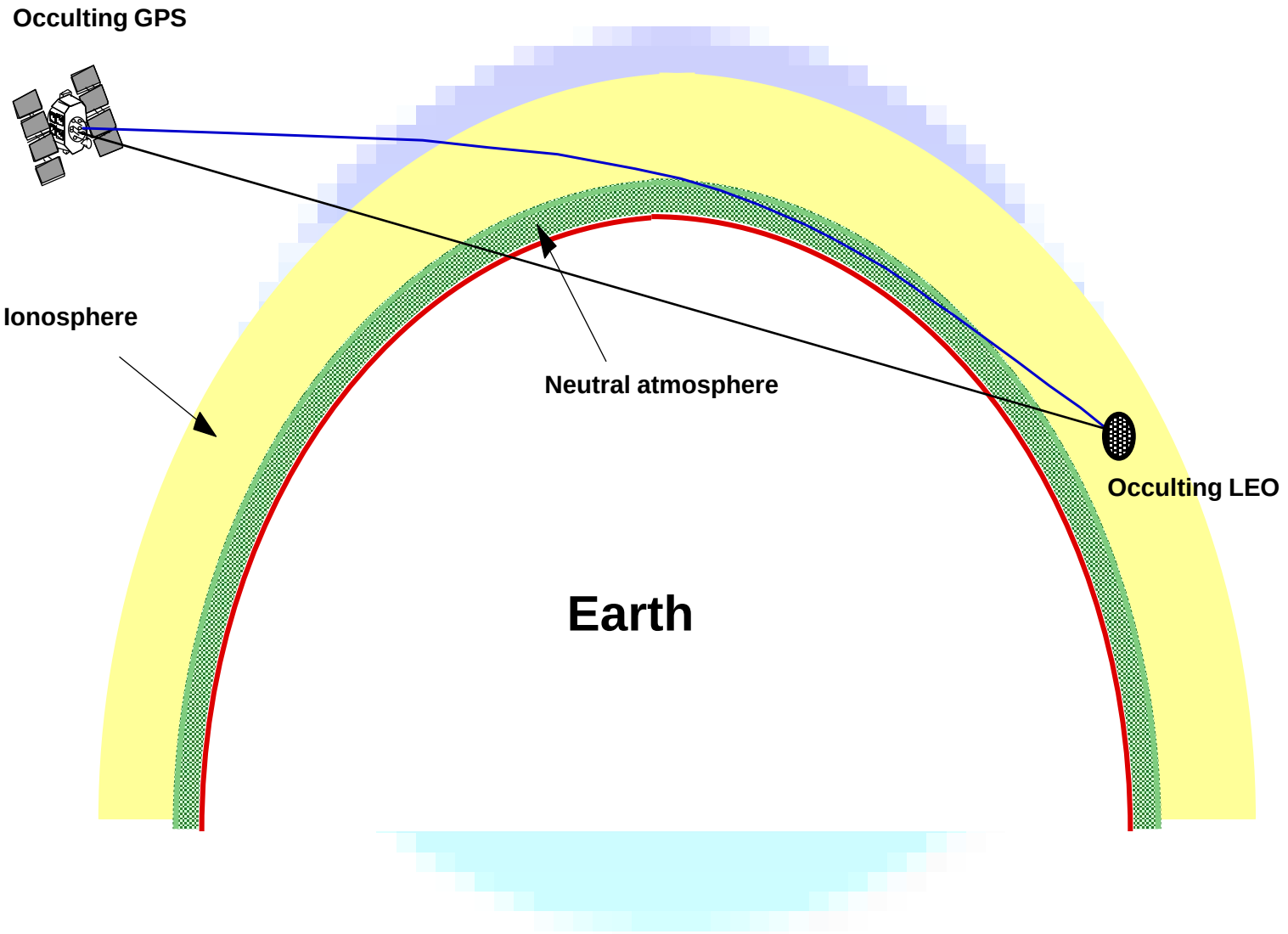
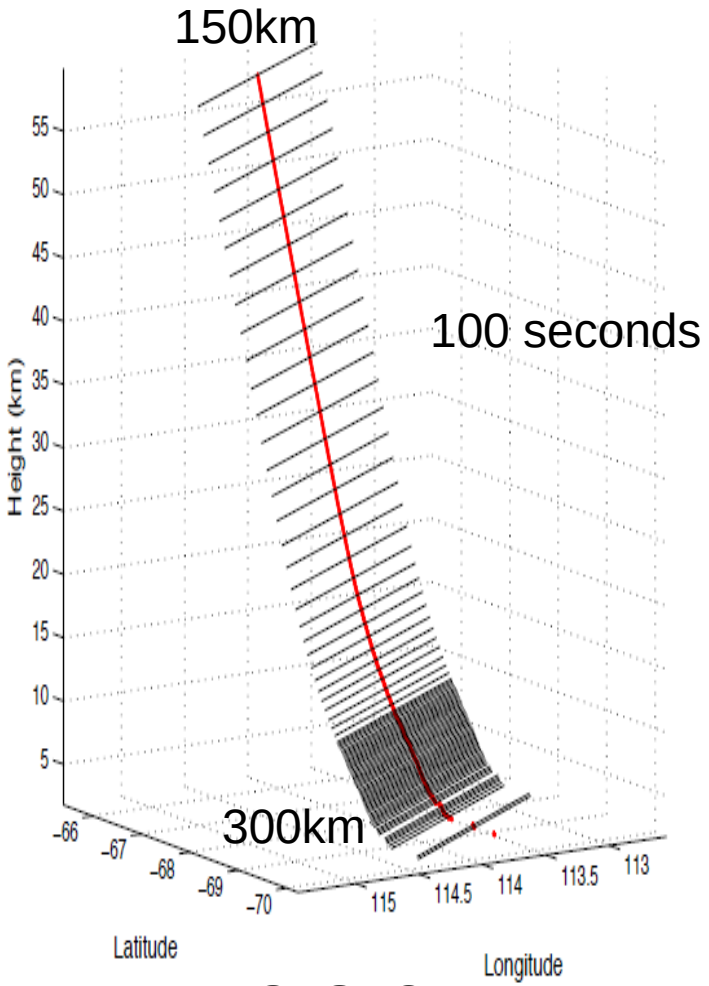


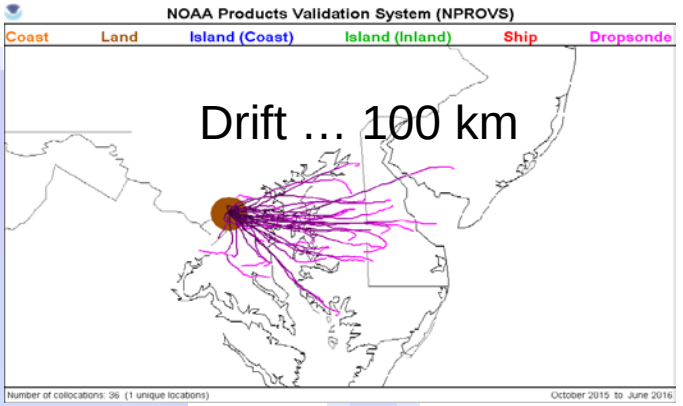
Figure 1: Collocated temperature profiles from GRUAN RAOB, COSMIC (Tdry), MetOp-B IASI soundings from NOAA and EUMETSAT and European Center for Medium-Range Weather Forecasts (ECMWF) analysis within 30 minutes and 30 km of RAOB except for COSMIC at 183 km.

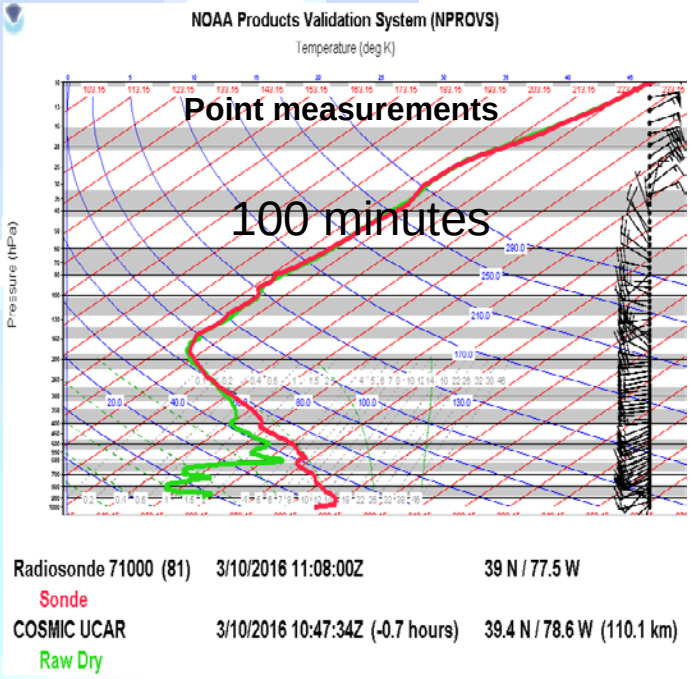


(COSMIC GPSRO provides candidate reference temperature in stratosphere)



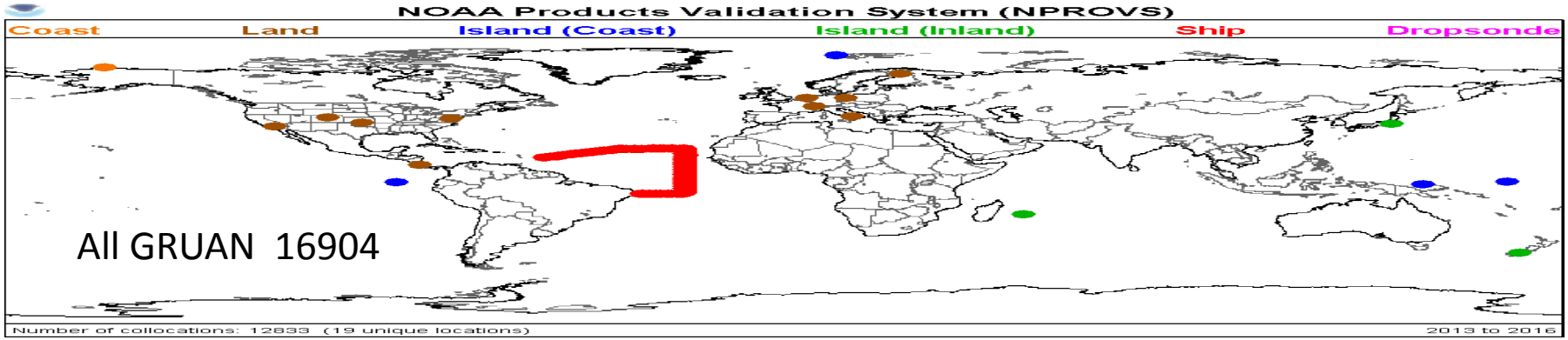
GPSRO

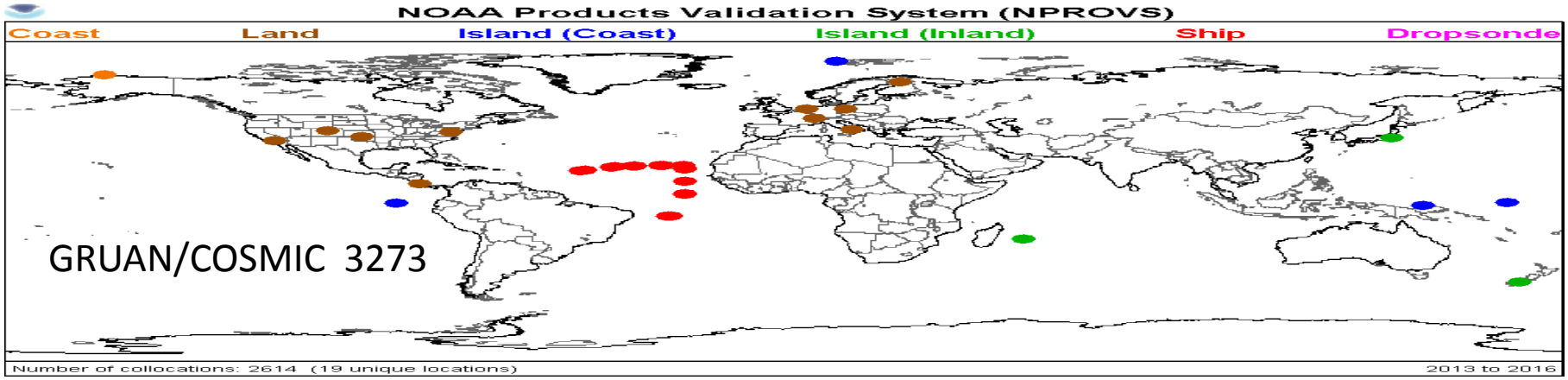


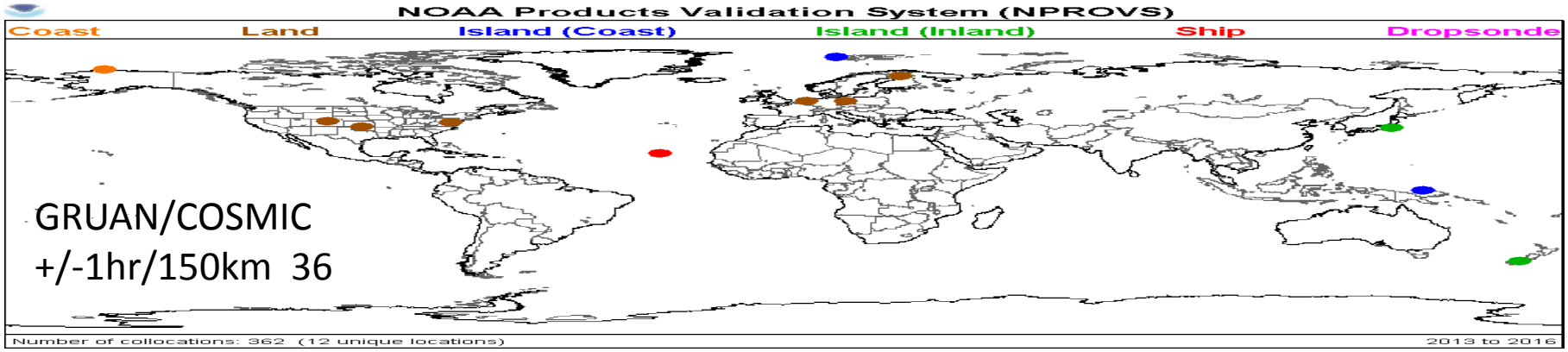


RAOB

"Sigma" for RAOB vs GPSRO can be significant even if observations timely



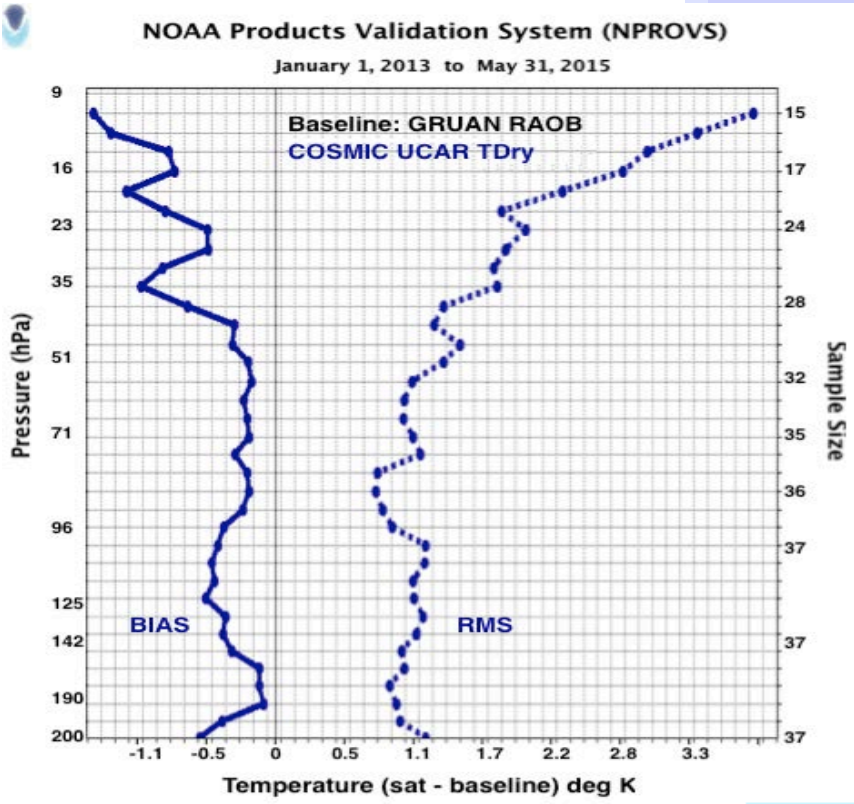


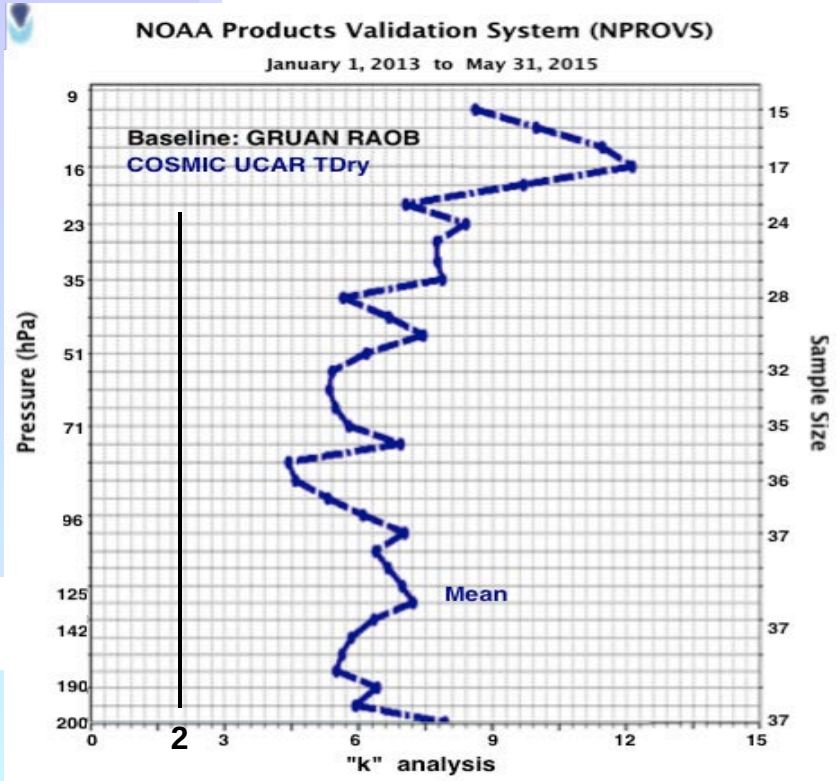


Need to better target GRUAN collocations with GPSRO (and polar satellites)

COSMIC-minus-GRUAN

"k" profile analysis … slide 19



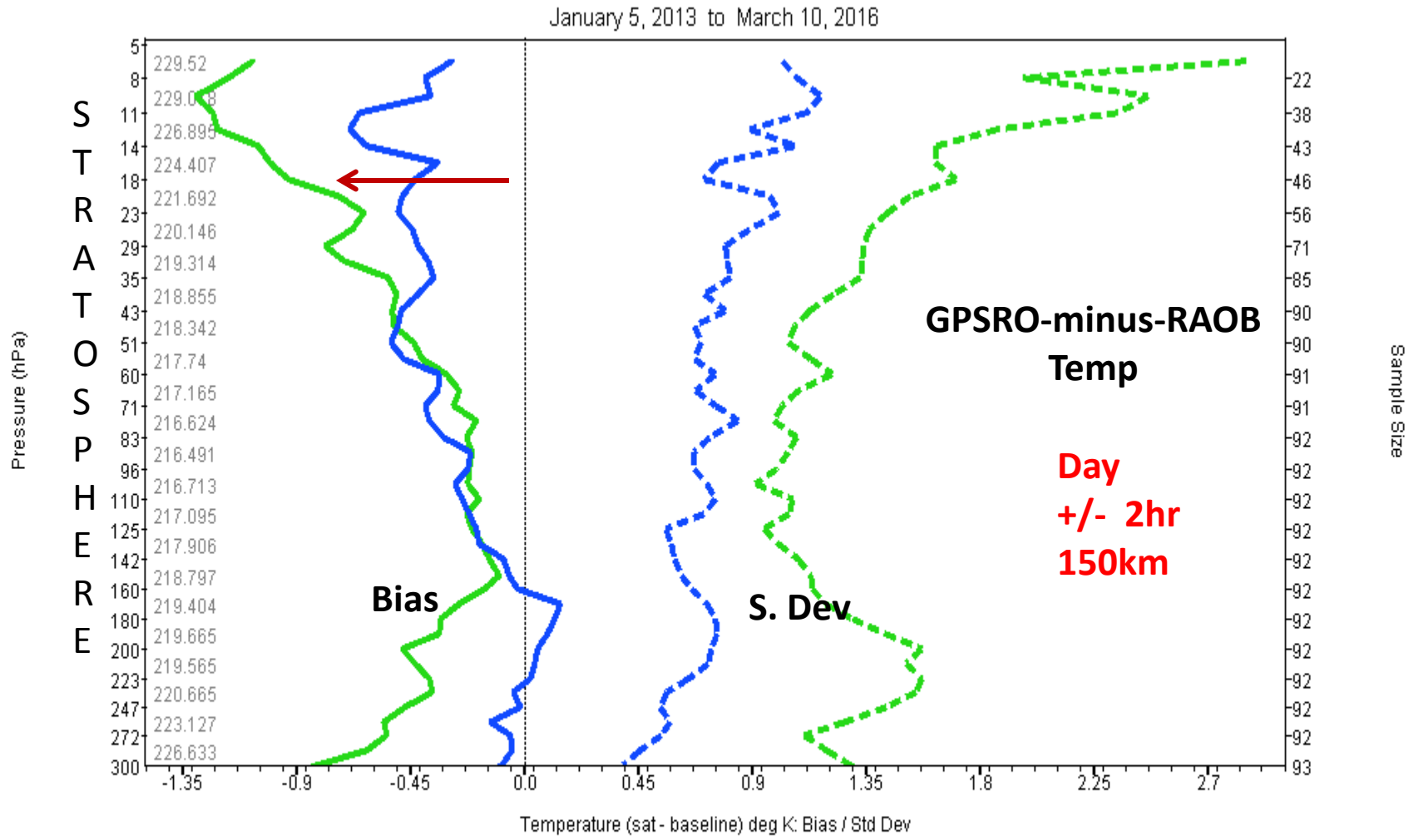


… assuming that u1 is some multiple of u2 simplifies an estimation of the more elusive σ. For example, setting u1 equal to u2, and substituting the mean u1 for the 36 profiles, approximately 0.15 K**, yields an order of magnitude estimate of 0.40 K for σ ("k~6") over the layer 100 to 50 hPa (see slide 13**).

Given these, Fig (2) suggests that 1.1 K RMS difference is within the margin of consistency for GRUAN RAOB and COSMIC temperature profiles collocated within one (1) hour and 100 km for the layer

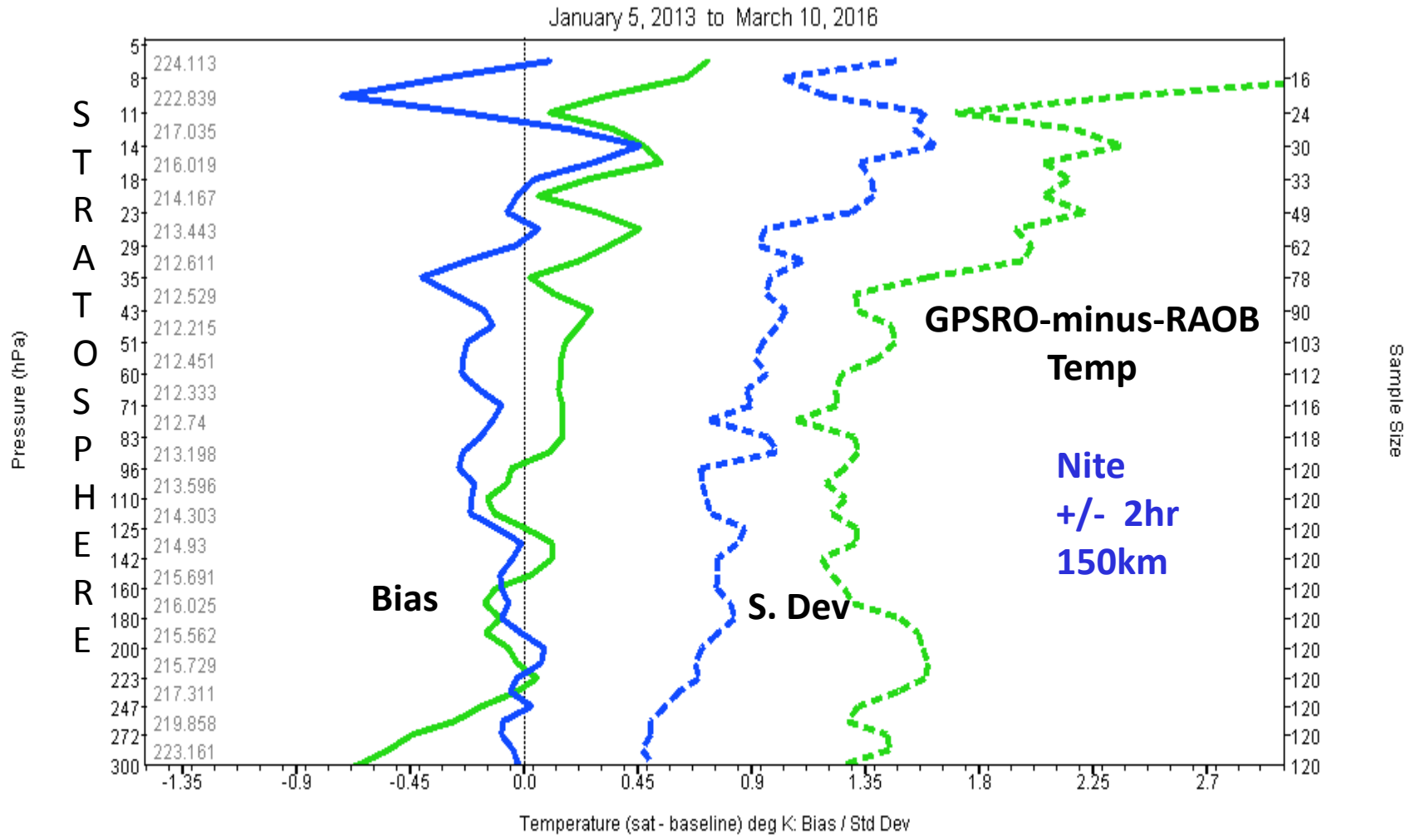
… feedback to GRUAN

Feedback to GRUAN …



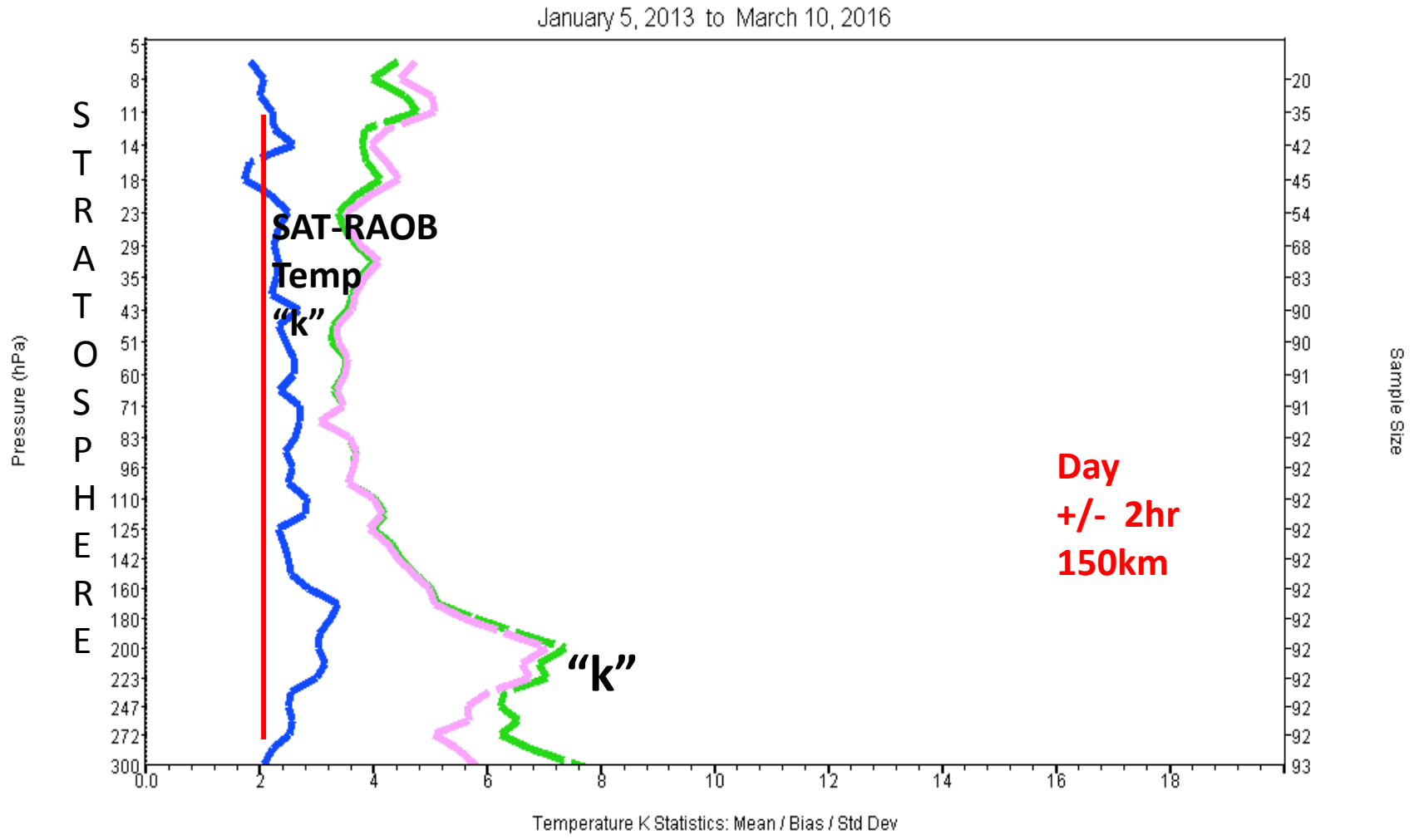
GPSRO suggest GRUAN (and ECMWF) too warm aloft during day … Sun et.al, JGR, 2013

Feedback to GRUAN …



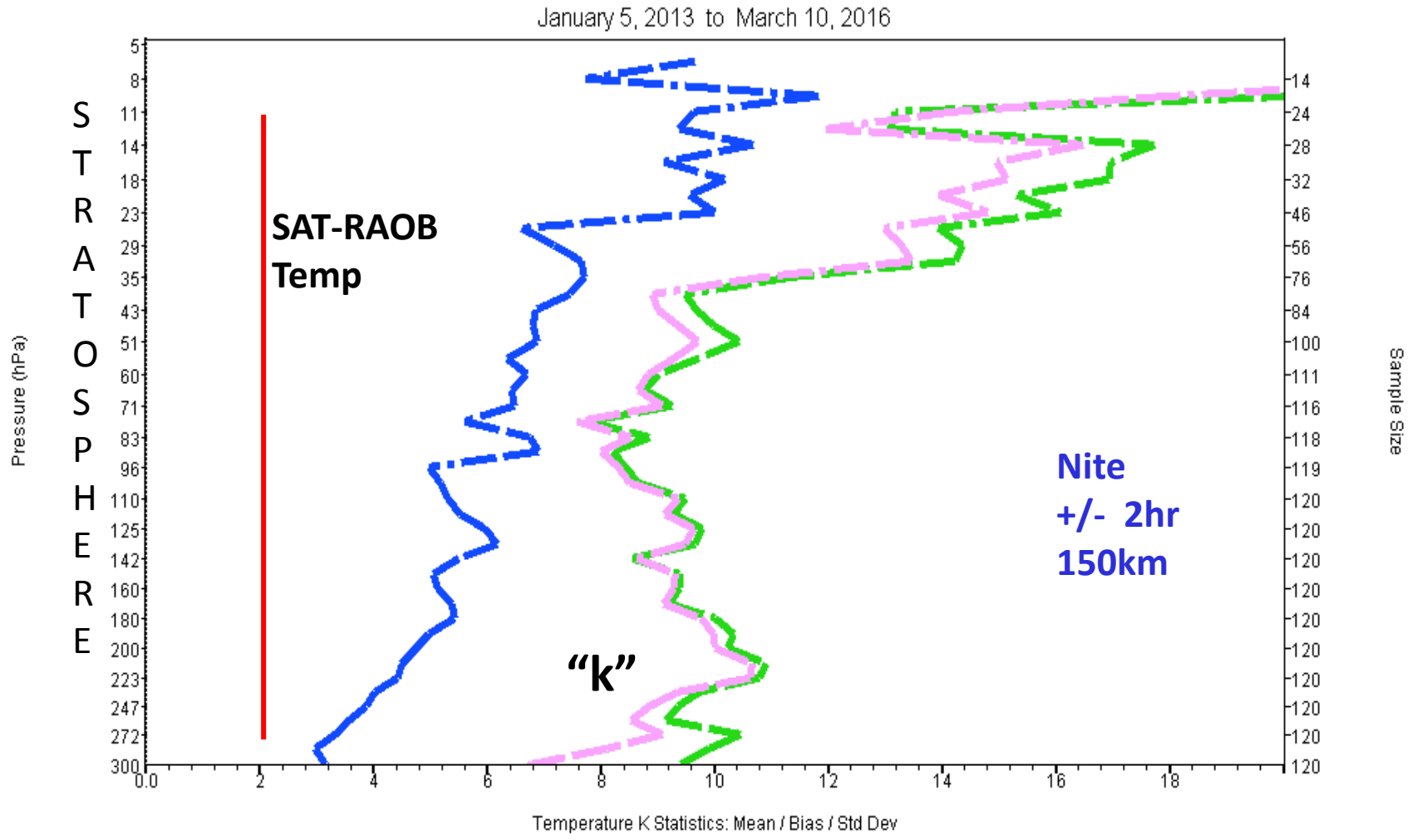
GPSRO suggest GRUAN (and ECMWF) OK at night … Sun et.al, JGR, 2013

Feedback to GRUAN …



"k" analysis suggests GRUAN uncertainty estimate may be too large during day …

Feedback to GRUAN …



"k" analysis suggests GRUAN uncertainty estimate may be too low during day …

Summary

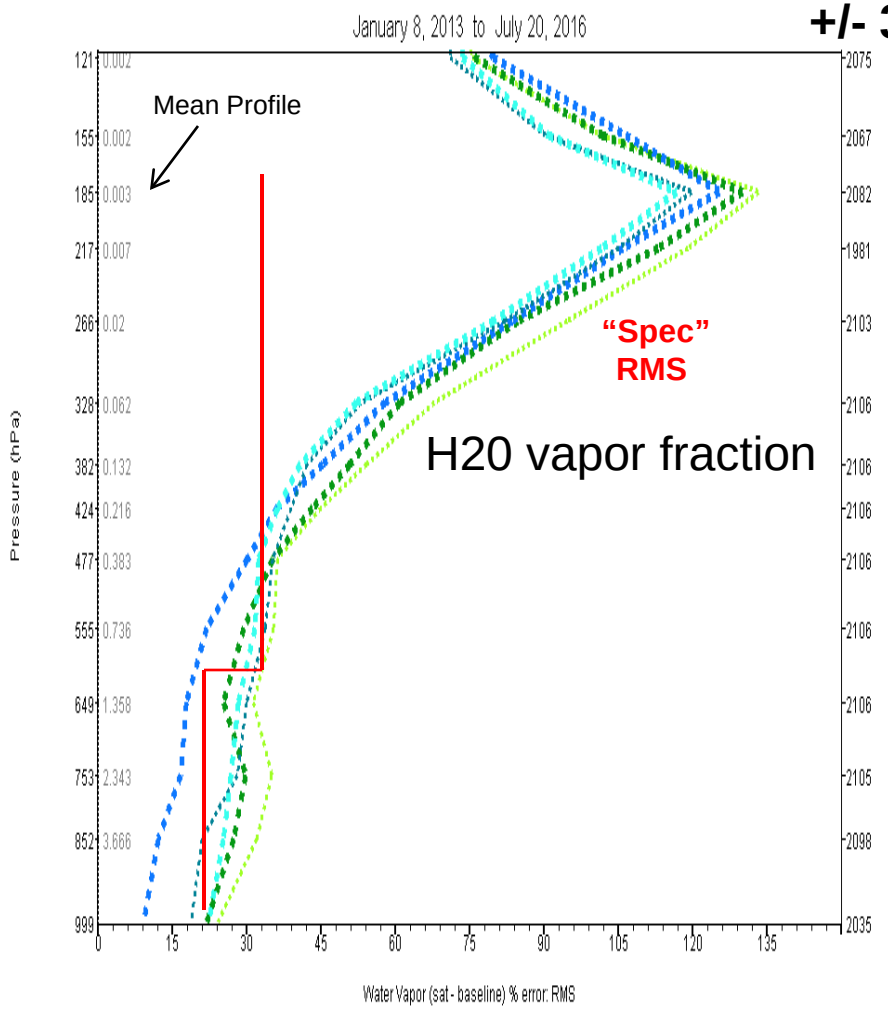
- NPROVS+ operated at STAR provides long-term stewardship of collocated GRUAN and (multiple) Satellite observations

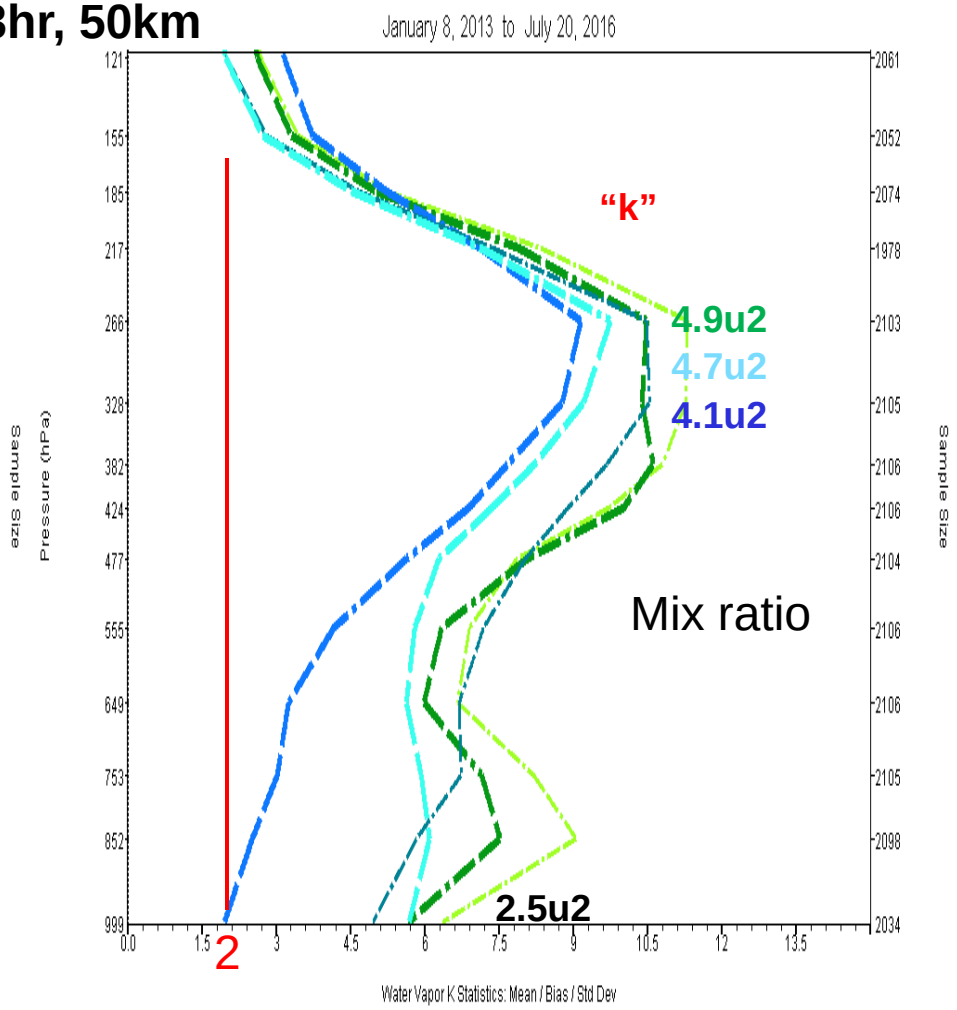
- Satellite synchronized (dedicated) radiosondes funded through JPSS (and ARM) effectively expands GRUAN and provide key observations for accuracy assessments

- Integration of the GRUAN uncertainty can provide estimates of satellite product uncertainty (albeit constrained to validation dataset) … *and sigma*

- Integration of the GRUAN uncertainty provides feedback to GRUAN

+/- 3hr, 50km





Baseline: Sonde

AIRS AQUA | AIRS AQUA First Guess | ECMWF

NUCAPS NPP | NUCAPS NPP First Guess

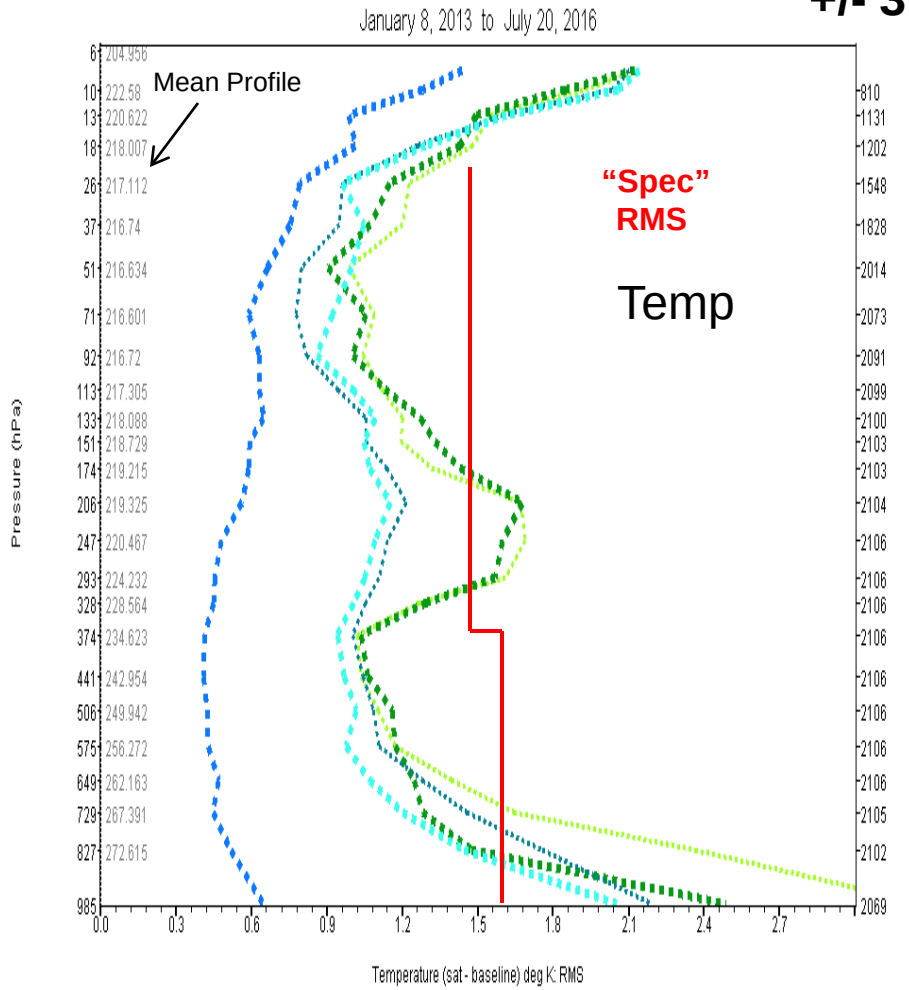
Baseline: Sonde

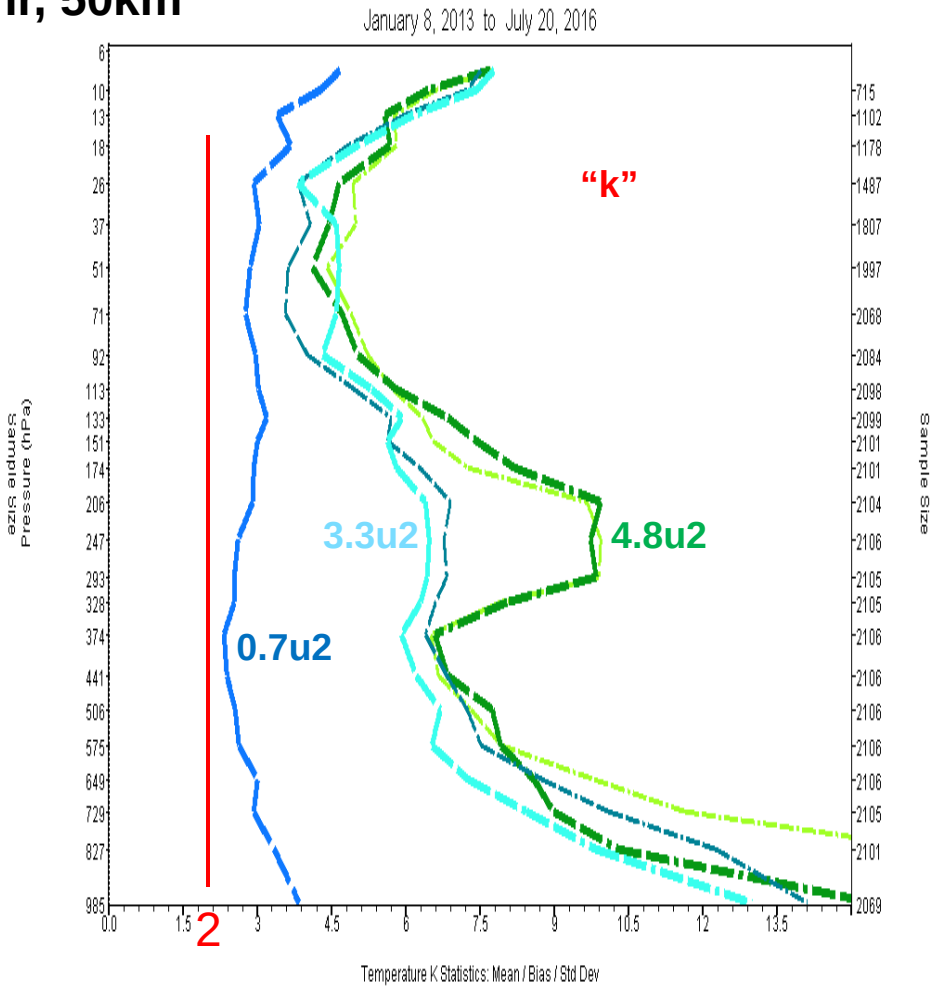
AIRS AQUA | AIRS AQUA First Guess | ECMWF

NUCAPS NPP | NUCAPS NPP First Guess

GRUAN Processed and Accepted; IR pass QC

+/- 3hr, 50km





Baseline: Sonde

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