Integrating Uncertainty in Atmospheric Profile Validation

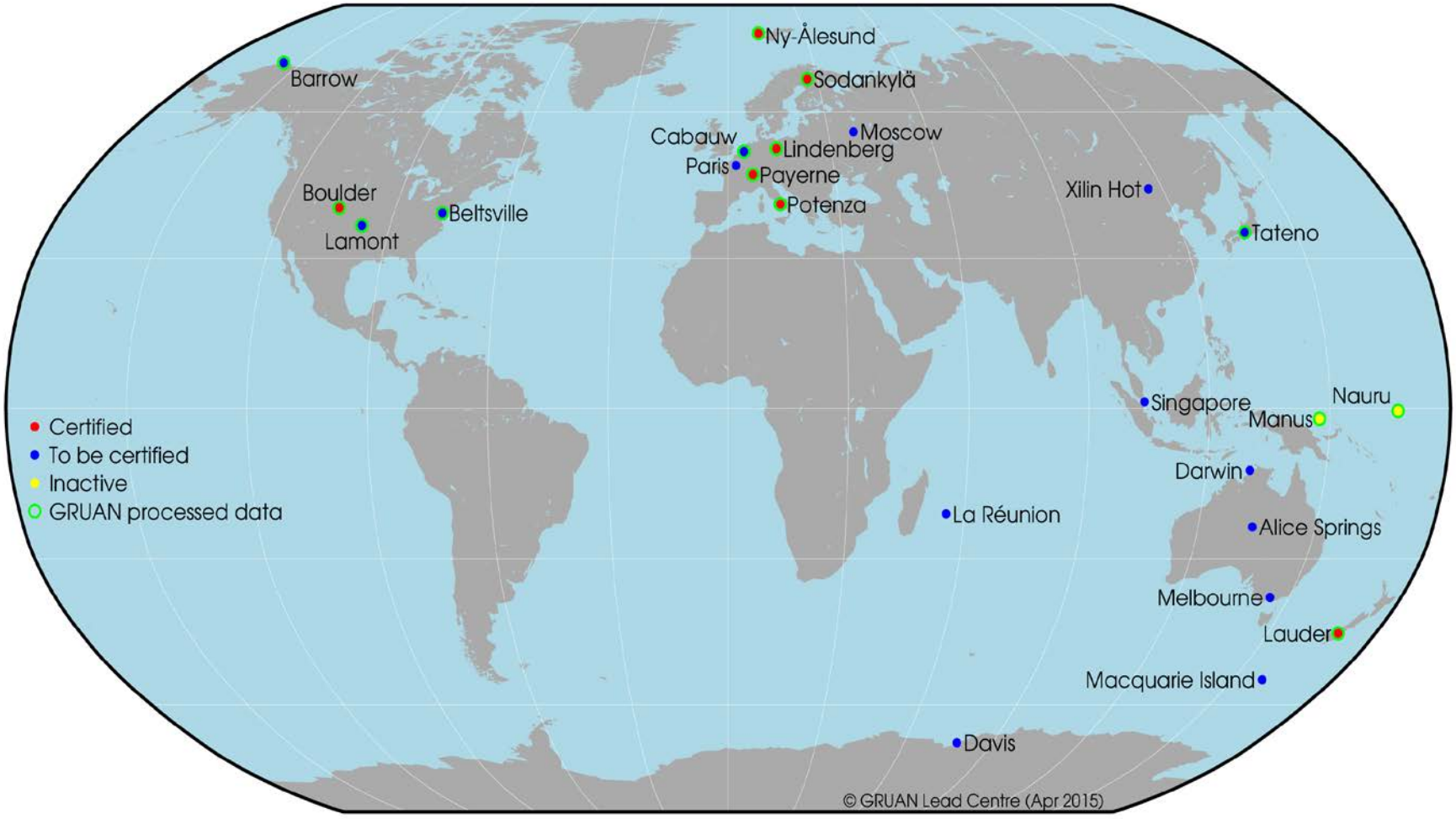
Xavier Calbet AEMET
Tony Reale NOAA

ITSC-20
Lake Geneva, Wisconsin
Oct 27 to Nov 3, 2015

OUTLINE

- GRUAN and Uncertainty
- NPROVS+
- Estimating uncertainty components (σ, u1 and u2)
  - GSICS Article (COSMIC/GRUAN)
- Estimating uncertainty components (σ, u1 and u2)
  - NPROVS+ (NUCAPS, AIRS, ECMWF: GRUAN)
- Summary

GCOS Reference Upper-Air Network



GRUAN processed RAOB include traceable uncertainty estimates for T, RH

(see Poster 12p.01)

GRUAN Reference Measurement Principles

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

"k" .le. 2

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

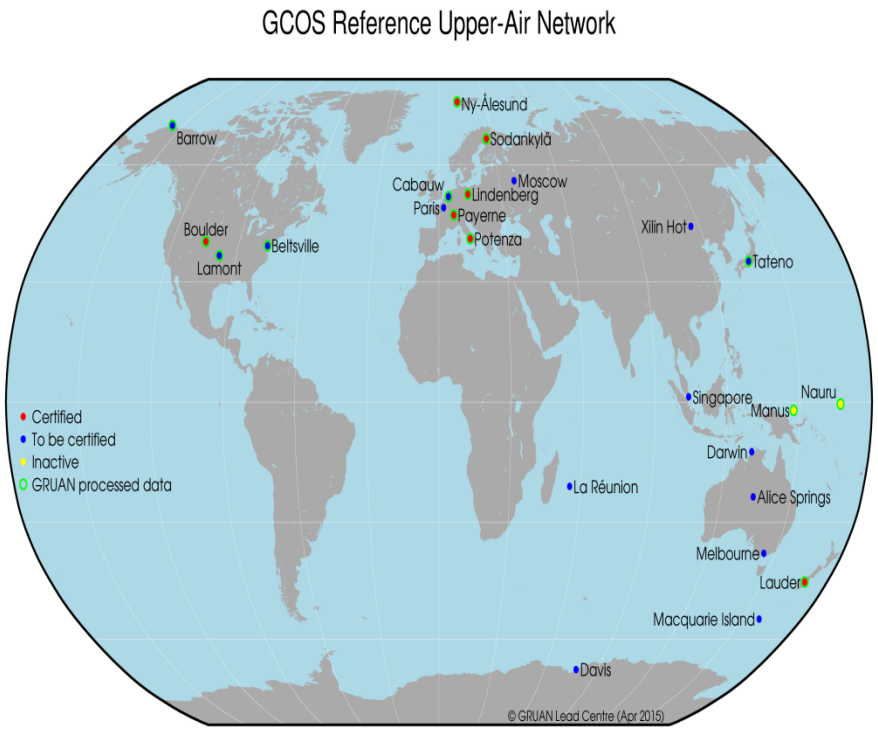
---

u2 is GRUAN uncertainty … given

u1 is SAT (or NWP) profile uncertainty … needed

σ is systematic variability between platform pair… needed

N P R O V S +



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

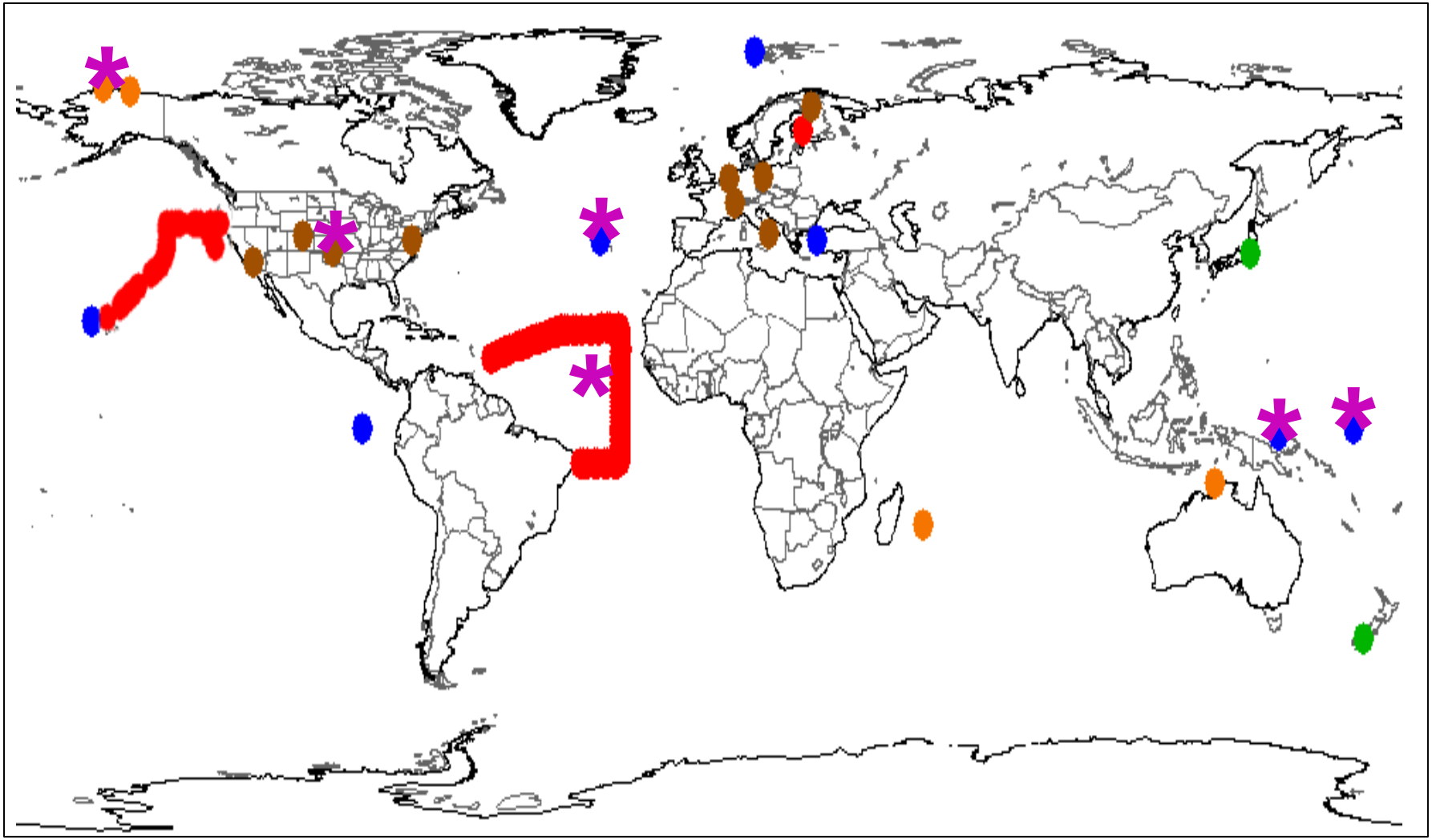
+

JPSS Funded Dedicated RAOB

- DOE ARM (SGP, NSA, ENA)
  - ✓CIMSS
  - ✓(2) per week
  - ✓**GRUAN processed**
  - ✓ dual vs single, etc
- AEROSE
- CALWATER
- PMRF
- Sterling Test Site …

... need better coordination with “other” intensive field experiments particularly if synchronized with S-NPP

N P R O V S +



Integrated GRUAN and JPSS Funded (*) Dedicated (S-NPP) RAOB Sites
Over 12,000 RAOBS (2000 Dedicated) since July 2013 … *and counting*

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

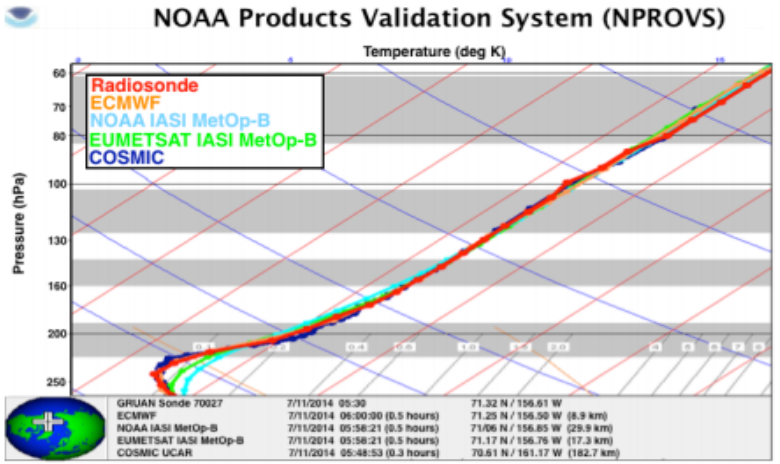


Figure 1: Collocated temperature profiles from GRUAN RAOB, COSMIC (Tdry), MetOp-B IASI soundings from NOAA and EUMETSAT and European Center for Medium-Range Weather Forecasts (ECMWF) analysis within 30 minutes and 30 km of RAOB except for COSMIC at 183 km.

http://docs.lib.noaa.gov/noaa_documents/NESDIS/GSICS_quarterly/v9_no2_2015.pdf

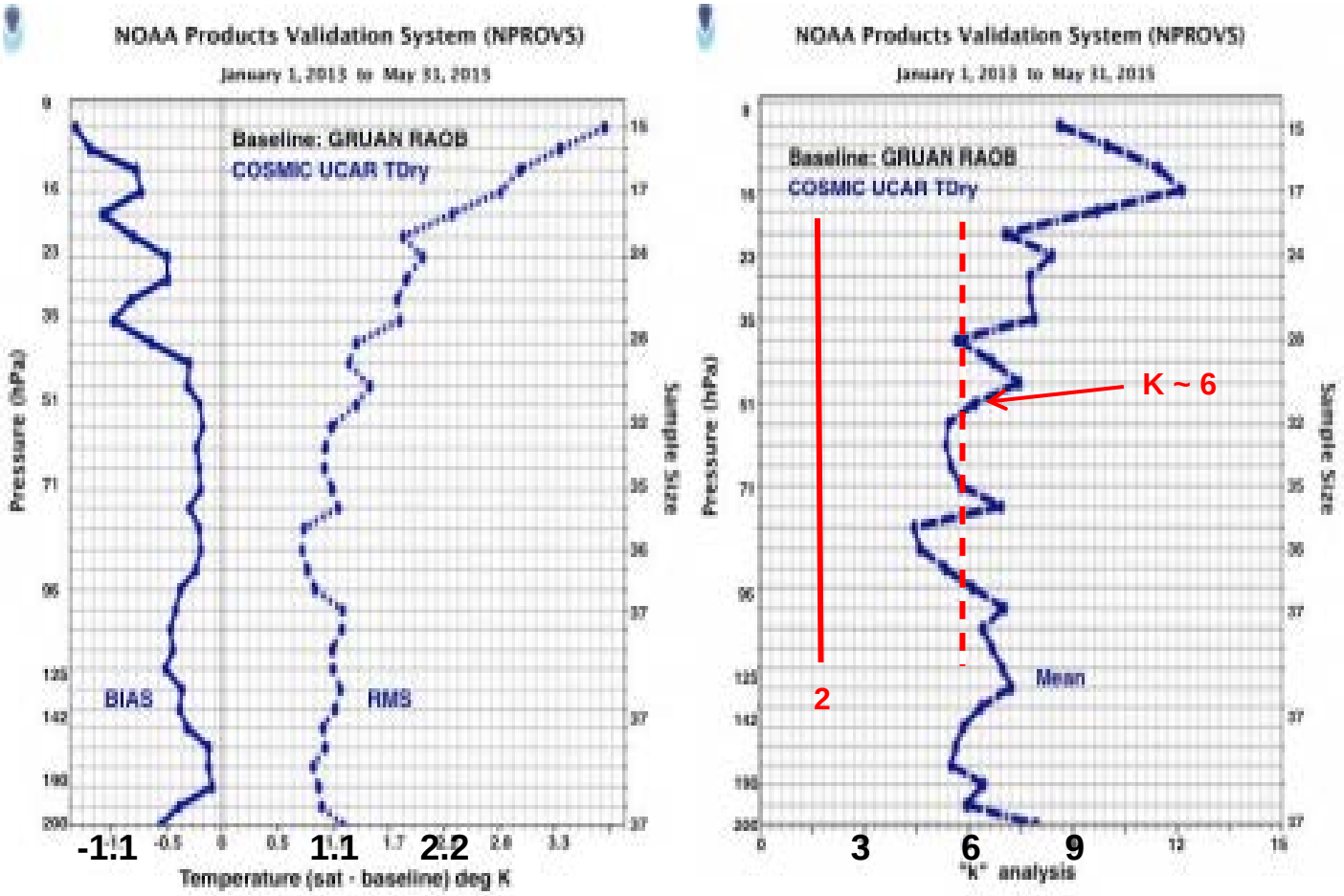


Figure 2: COSMIC Tdry-minus-RAOB T Bias and RMS error (left) and associated "k" profile analysis (right) above 200 hPa.

for k=2, sum under square root (1) is 9 (u12)**
assuming u1 ~ u2 (0.15), then σ ~ 0.4K thru layer

Integrating
1) uncertainty based “k” profiles analysis
and
2) traditional specification based satellite products cal/val
provides
more robust cal/val approach :

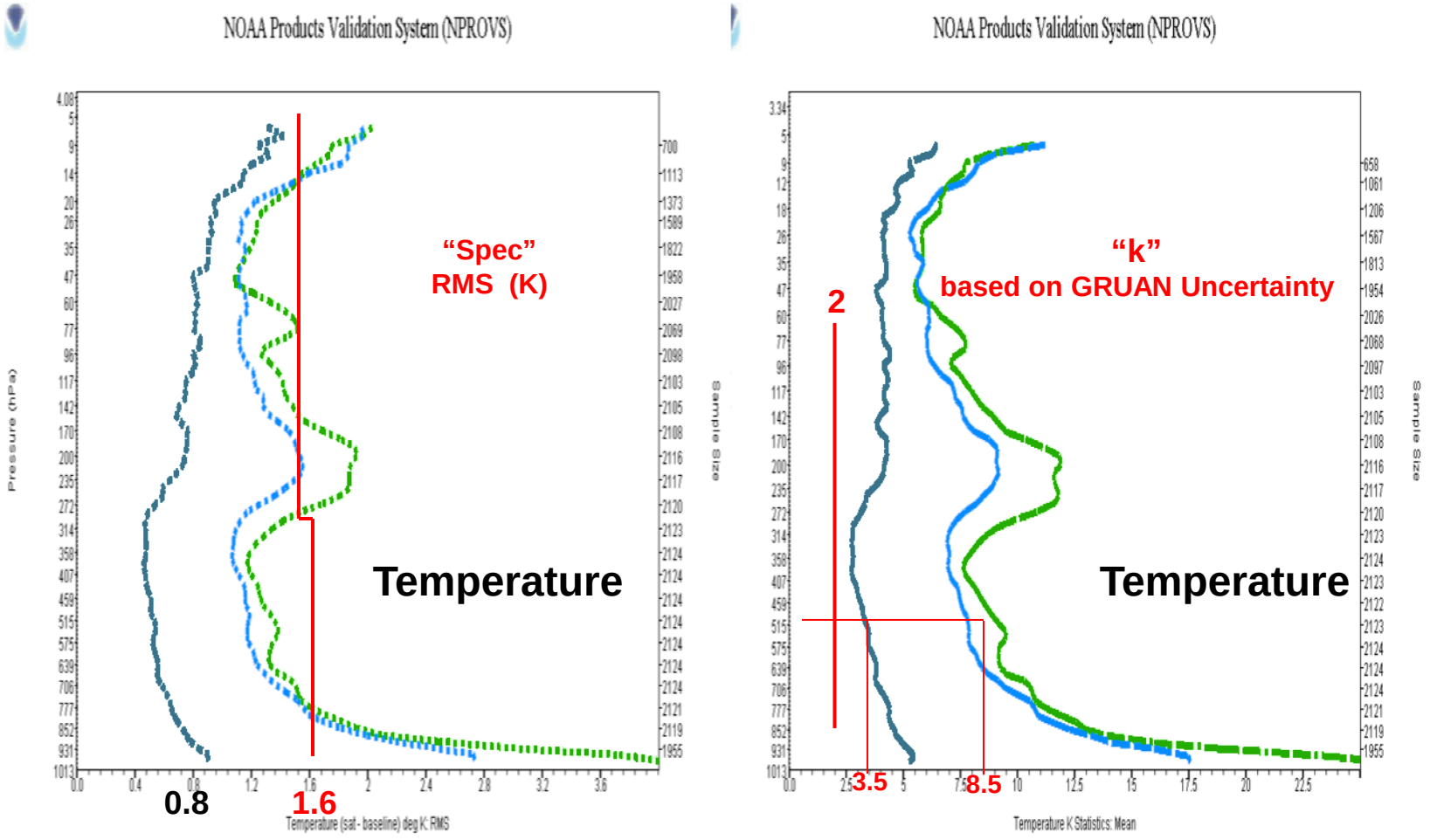
NOAA NUCAPS

ECMWF

NASA AIRS v.6 (contain error estimates)

Unlike COSMIC Tdry,
projection of the uncertainty of SAT Temp (or H20)
as some multiple of GRUAN uncertainty
is not justified,
thus we can only address the sum under the square root (1)

However, for NWP Temp,
projection that uncertainty is on order of the GRUAN uncertainty
somewhat justified …

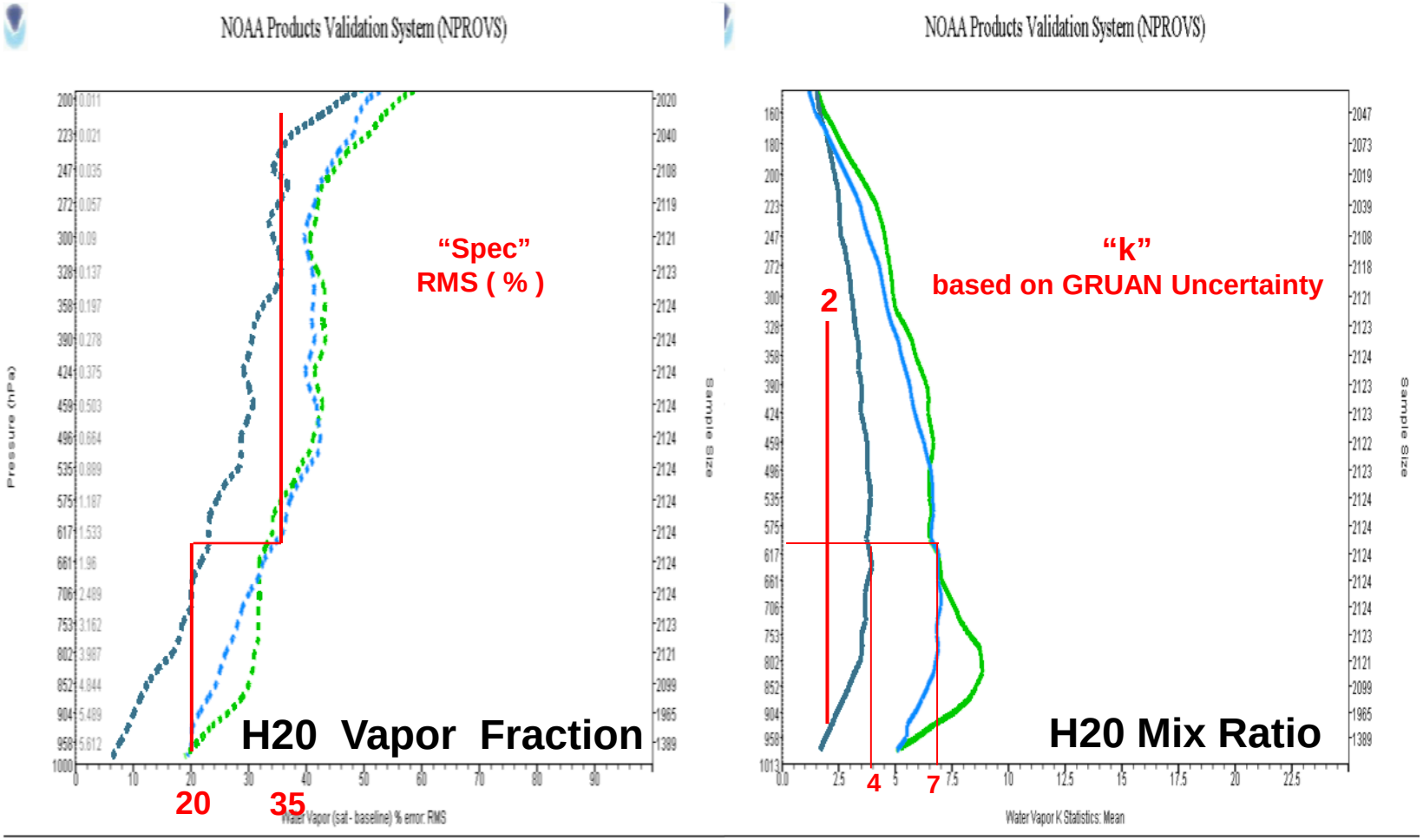


Baseline: GRUAN Radiosonde

AIRS AQUA **ECMWF** **NUCAPS NPP**

for "k"=2, sum uncertainty under square root (1) in vicinity 500 hPa:
for SAT is 18(u12) … for ECMWF is 3(u1**2)**

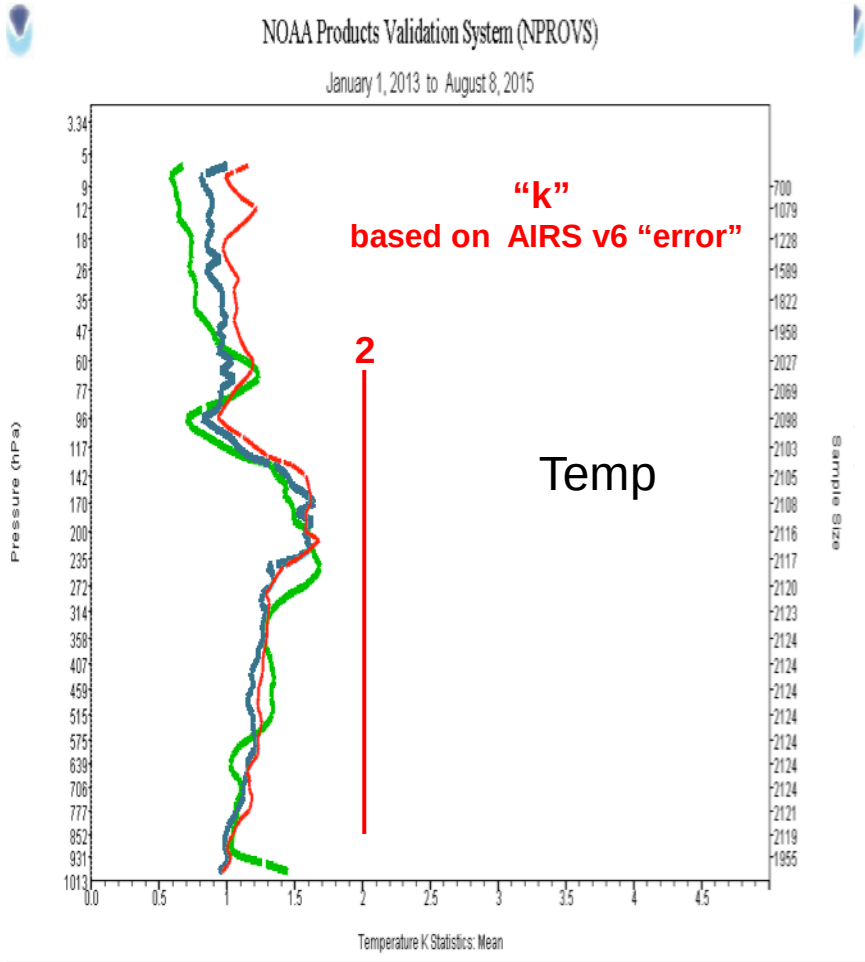
2)For ECMWF, assuming u1 ~ u2 (0.13K), then σ ~ 0.1K thru layer

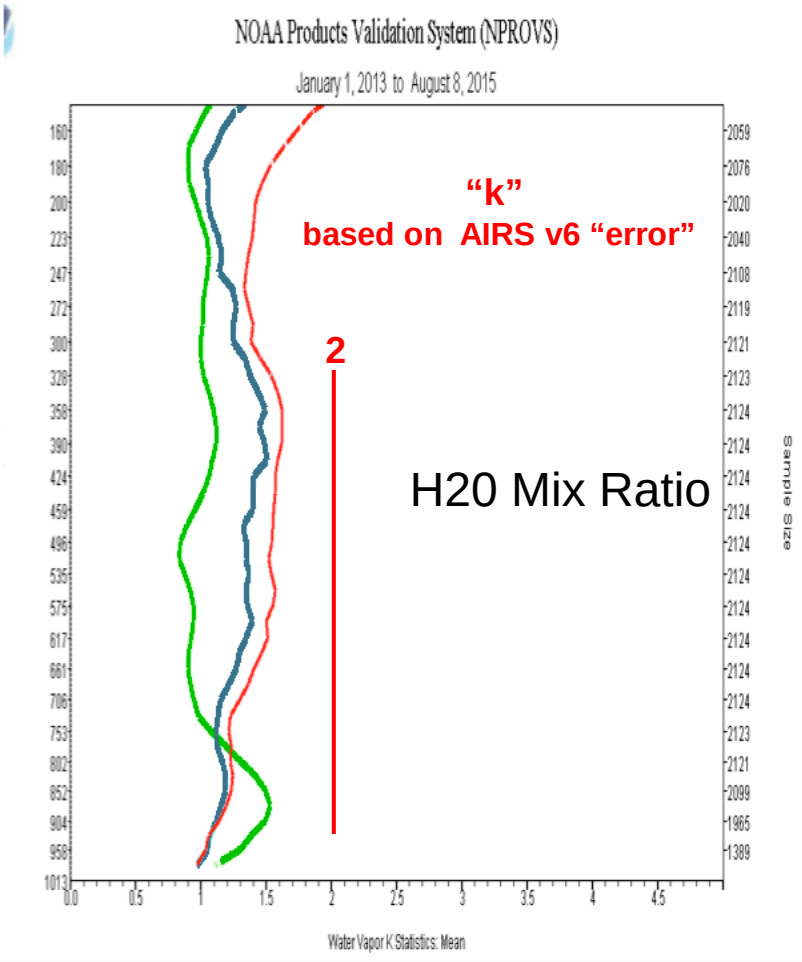


Baseline: GRUAN Radiosonde

AIRS AQUA **ECMWF** **NUCAPS NPP**

for "k"=2, sum uncertainty under square root (1) in vicinity 600 hPa
for SAT is 12(u12) … for ECMWF is 4(u1**2)**





Baseline: NASA AIRS v.6

GRUAN Radiosonde **ECMWF** **NUCAPS NPP**

All platforms have "k" less than 2 suggesting that reported AIRS v.6 "errors" much larger than actual AIRS v.6 "uncertainty"

SUMMARY

- **GRUAN reference RAOB provide traceable uncertainty**

- **NPROVS+ analytic interface (PDISP) includes preliminary capability to integrate GRUAN uncertainty in "k" profile analysis**

- **Need uncertainty for all profiles (*u1*) and "σ" for respective profile pairs**

- **Analytic directions (GSICS article) and order magnitude estimate of 0.4K for "σ" in stratosphere for COSMIC Tdry vs GRUAN (u1 ~ u2)**

- **Analytic directions for more robust satellite products cal/val integrating RMS and "k" profile statistics**

- **Preliminary estimate of 0.1K for "σ" in vicinity 500 hPa for ECMWF Analysis vs GRUAN (u1 ~ u2)**

- **Evolving GRUAN / NOAA satellite synergy … *3G, GAIA-CLIM, etc***