Progress on the Use of GRUAN Uncertainty in Operational Sounding Products

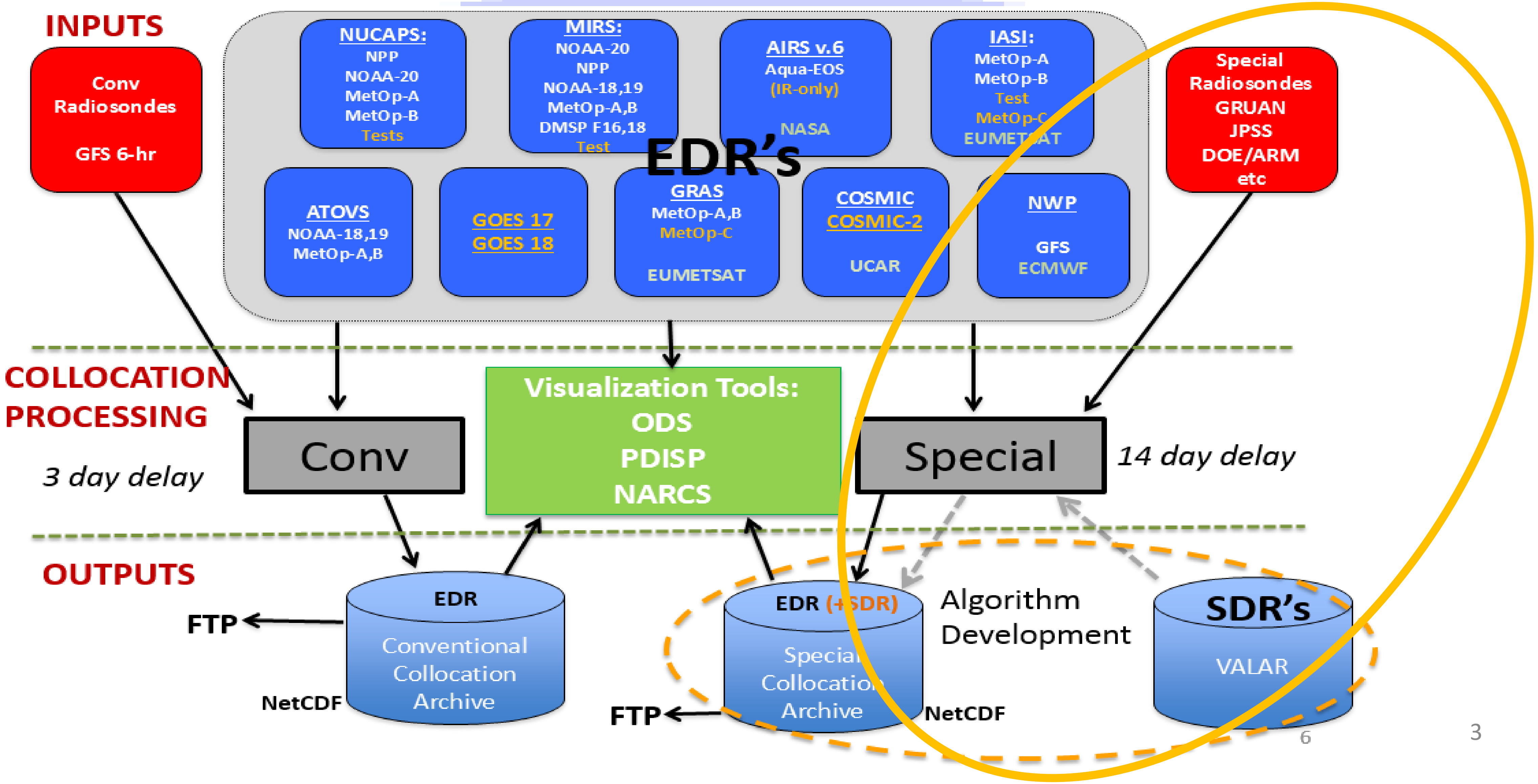
Tony Reale[1]
Bomin Sun[2], Michael Pettey[2] and Ryan Smith[2]

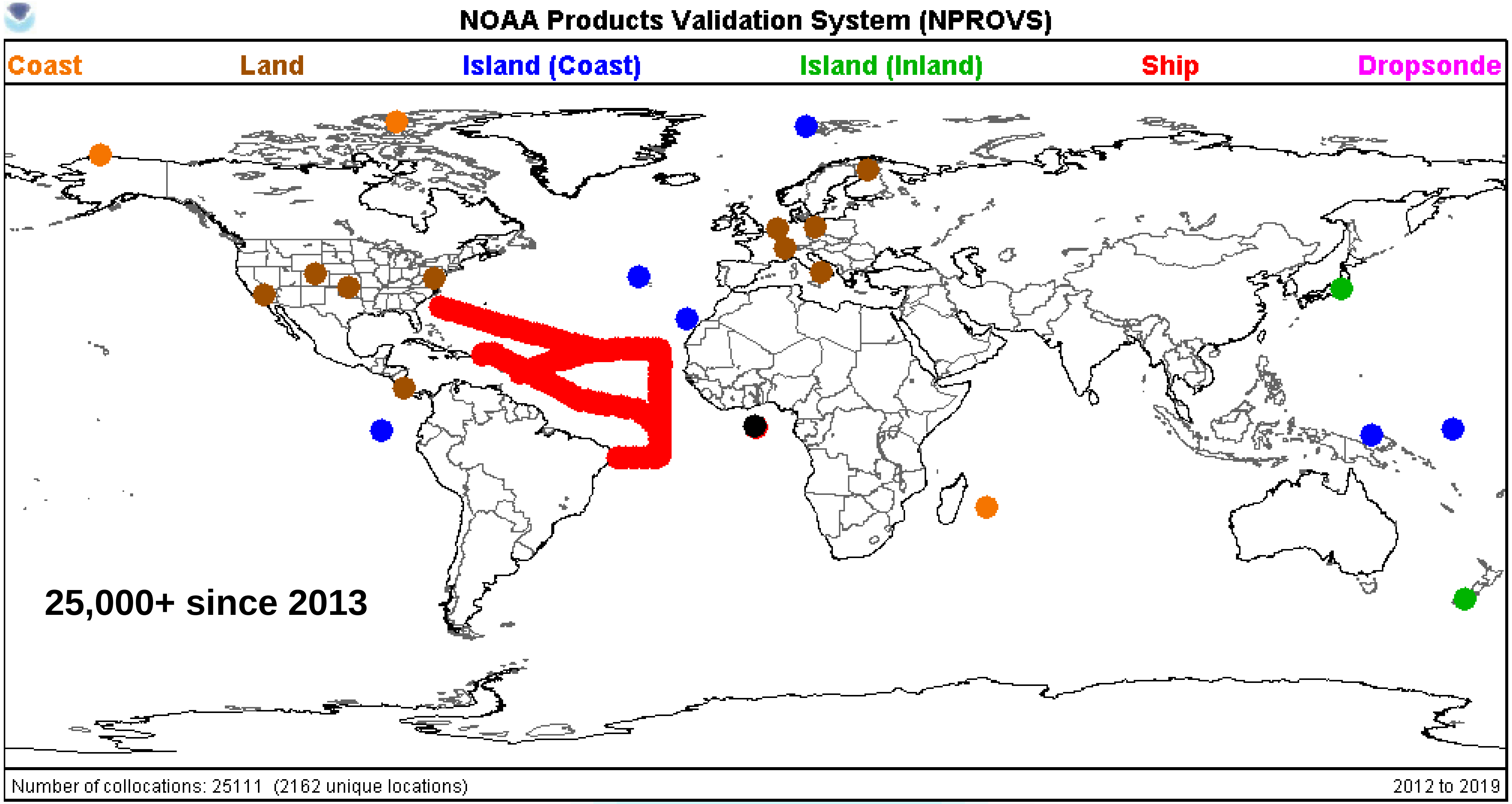
[1]NOAA / NESDIS /STAR
[2]IMSG Corporation

Outline

- ❖ NPROVS … 1 minute
- ❖ Uncertainty Application in Cal/Val (NUCAPS soundings) … 3 minutes
- ❖ Review some past results … 2 minutes
- ❖ Feedback to GRUAN wrt Uncertainty … 1 minute
- ❖ Review evolving current results (at SGP) … 2 minute
- ❖ Summary … 1 minutes

NOAA Products Validation System (NPROVS)





Collocation GRUAN radiosonde and satellite (and nwp) observations

Strategy

ABS (m1 – m2) = k $(\sigma^2 + u1^2 + u2^2)^{1/2}$ … Immler … (see shirt) (1)

(m1, m2) are Satellite, GRUAN geophysical profiles, (u1, u2) the associated uncertainty and "σ" the mismatch uncertainty

Since σ and u1 are "unknown" they are initially set to zero and "k_0" is defined:

"k_0" = ABS (m1 – m2) / u2 **initial "known" condition** **(2)**

u2 k_0 = ABS (m1 – m2) = k_x $(\sigma^2 + u1^2 + u2^2)^{1/2}$ … "k_x" denotes some target value **(3)**

$\sigma^2 + u1^2 = ((\text{"}k_0\text{"}/k_x)^2 - 1)\,(u2)^2$ **(4)**

Substituting k_x = 2 ("consistency" with GRUAN) *and ignoring the "σ "term*

u1 = $((k_0/2)^2 - 1)^{1/2}$ (u2) **uncertainty needed for "consistency" with GRUAN** **(5)**

u1 is "worst case" estimate for the satellite product uncertainty, that is, one which includes σ!

(for derived soundings "σ" typically less than 20% (+/- 2hr) of inherent error signal … *not case for "radiance"*)

Strategy

Also, GRUAN reports moisture uncertainty in terms of relative humidity (RH) whereas satellite sensors directly measure H20 water vapour molecules or mixing ratio (MR), thus the RH uncertainty is converted MR uncertainty

u2(MR) = u2 (RH) x Saturation (MR)

(at 300K, Saturation MR approximately 25 g/kg)

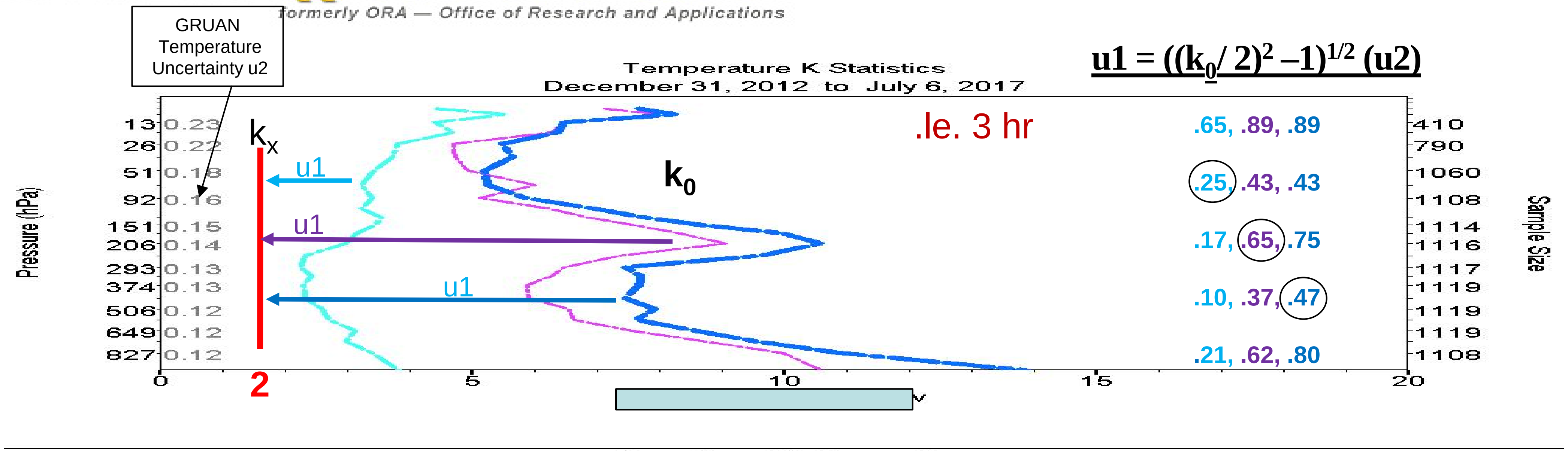
(The impact of respective uncertainty in temperature (and pressure) is not included as it is "relatively" small. For example, at 300K and 1013 hPa, and assuming typical uncertainty values of 0.2K, 0.5 hPa and 3% RH, the MR uncertainty is estimated as 0.67 +/- 0.01 (or +/- 1.5%) g/kg) … impact tends to decrease with height

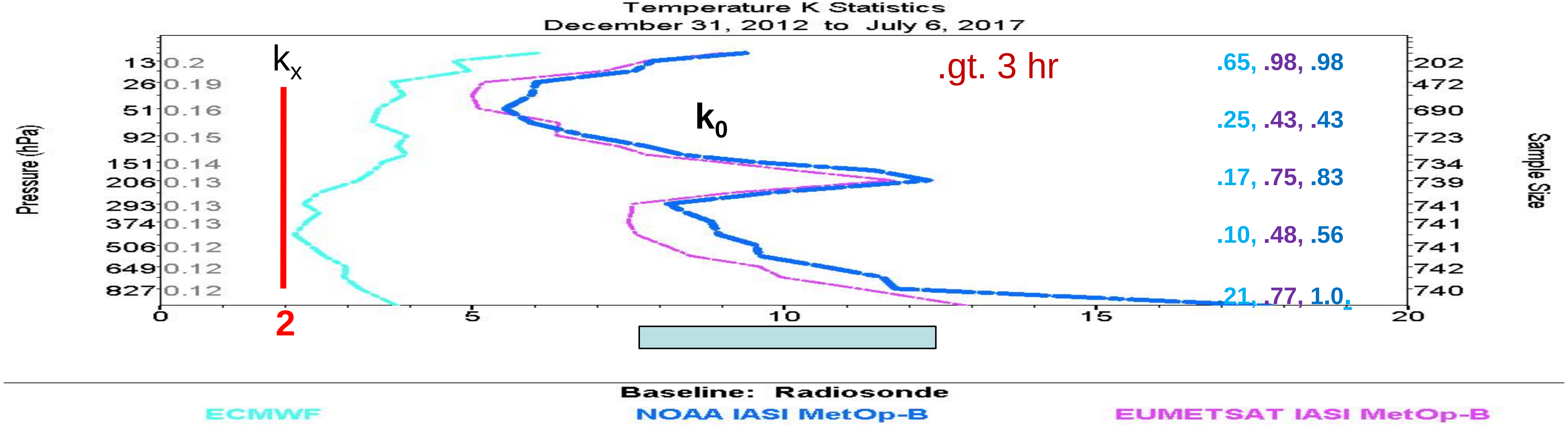
Maximum sensitivity of sounding moisture 20 ppm !

Past Results … Shown at Boulder ICM-9

and some Feedback to GRUAN

$u1 = ((k_0/2)^2 - 1)^{1/2}\ (u2)$





"k_0" and Uncertainty (u1) for Satellite (and ECMWF) Temperature (K)

STAR Center for Satellite Applications and Research
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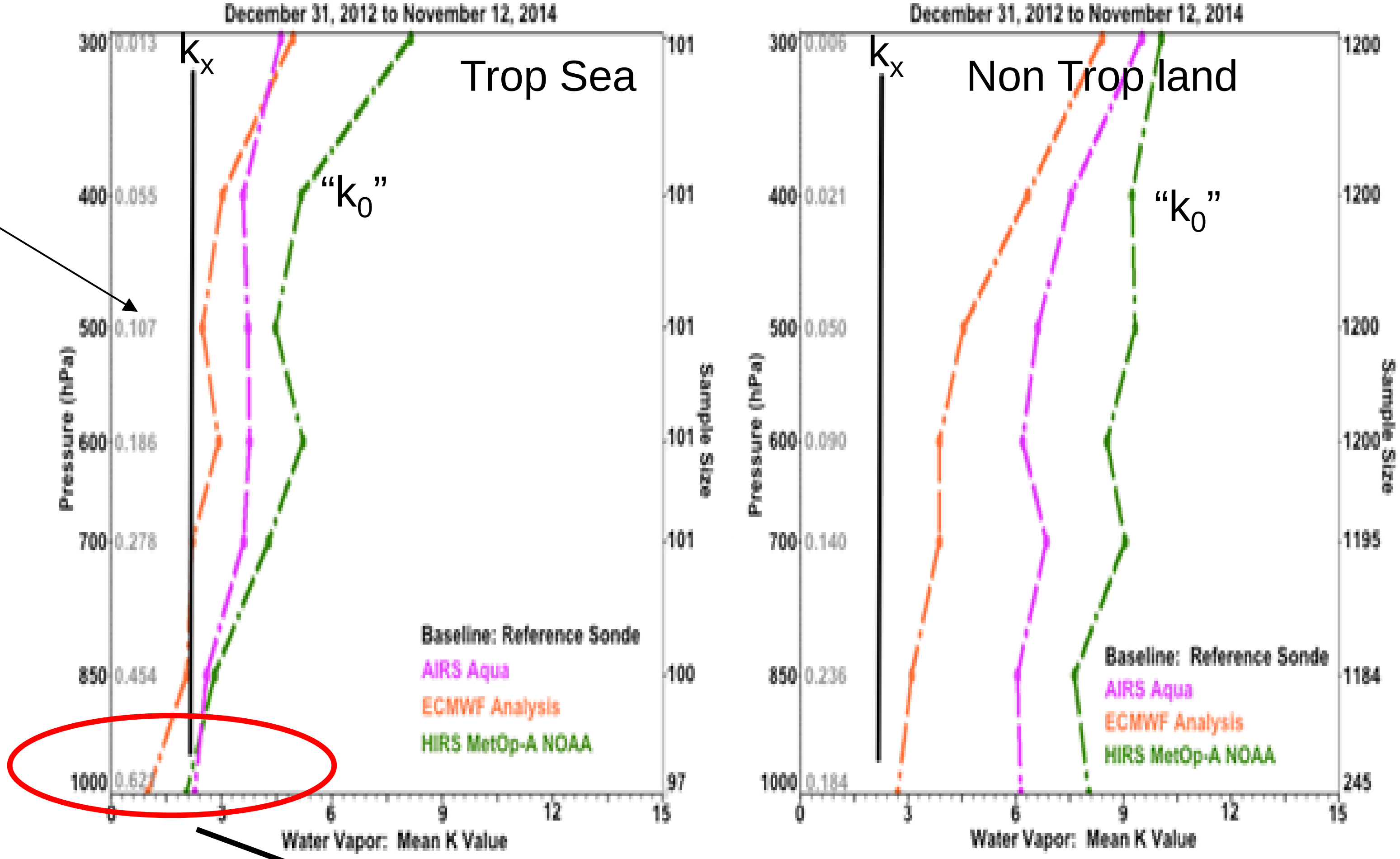
GEWEX Water Vapor Assessment … *GVAP-5 Final Report, Schroder et.al (in review)*

GRUAN
H20 Vapor
Uncertainty u2



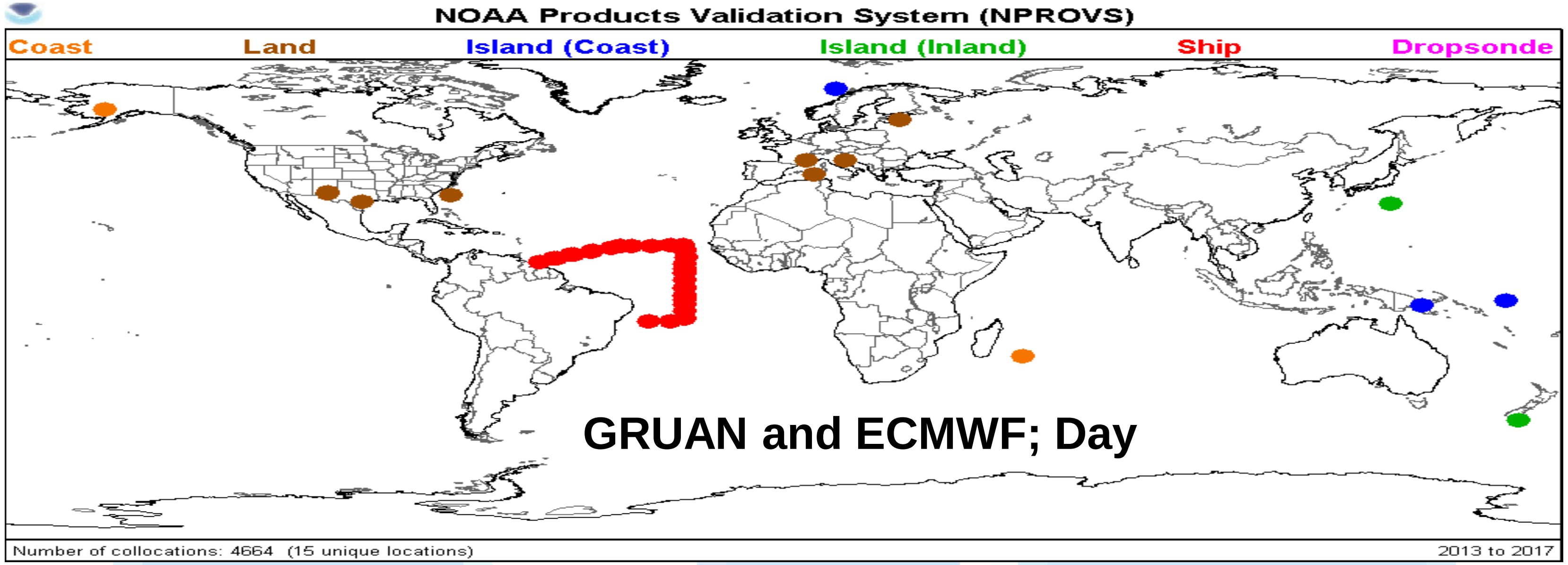
k_0 less than k_x … *unrealistic …*
(GRUAN uncertainty too large when moisture high …?)

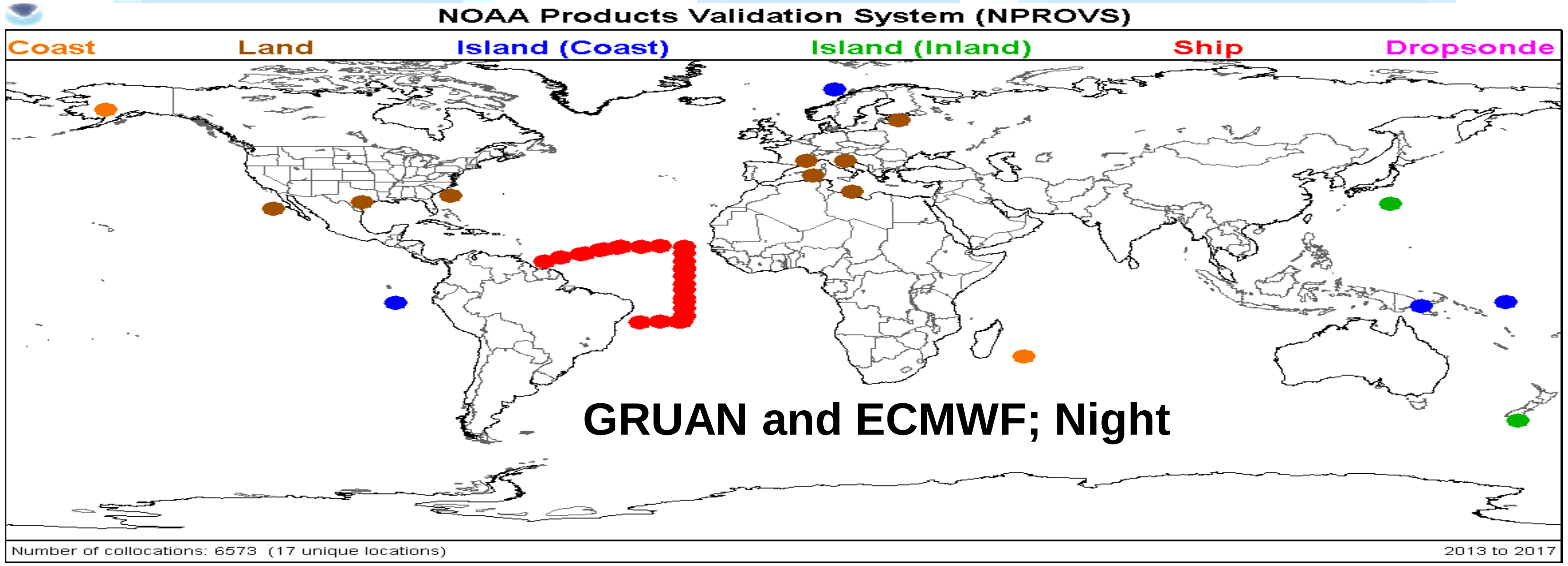
Tropical, Sea	HIRS	IASI / HIRS	AIRS / HIRS / ECMWF
300 hPa	0.061 0.175 0.014 9.0	0.051 / 0.061 0.172 0.013 8.1 / 9.6	0.025 / 0.052 / 0.028 0.166 0.013 4.4 / 8.3 / 4.8
500 hpa	0.23 1.87 0.115 4.5	0.18 / 0.23 1.68 0.113 3.8 / 4.5	0.18 / 0.20 / 0.09 1.59 0.107 3.9 / 4.4 / 2.3
700 hpa	0.59 5.51 0.272 4.8	0.46 / 0.56 5.52 0.268 4.0 / 4.6	0.46 / 0.53 / 0.16 5.63 0.273 3.9 / 4.4 / 2.3
1000 hPa	--- 16.6 0.651 1.9	--- / 0.49 12.9 0.537 1.6 / 2.7	0.20 / --- / --- 16.0 0.626 2.1 / 1.7 / 1.0

Table 1: Each element (box) includes four sets of mean values for:

Satellite (and ECMWF) MR uncertainties using (5),
GRUAN MR (g/kg),
GRUAN MR uncertainty
“k_o” value

H20 Vapor Uncertainty Tables … GEWEX *GVAP-5 Final Report, Schroder et.al*





ECMWF Uncertainty Assessments using NPROVS+)

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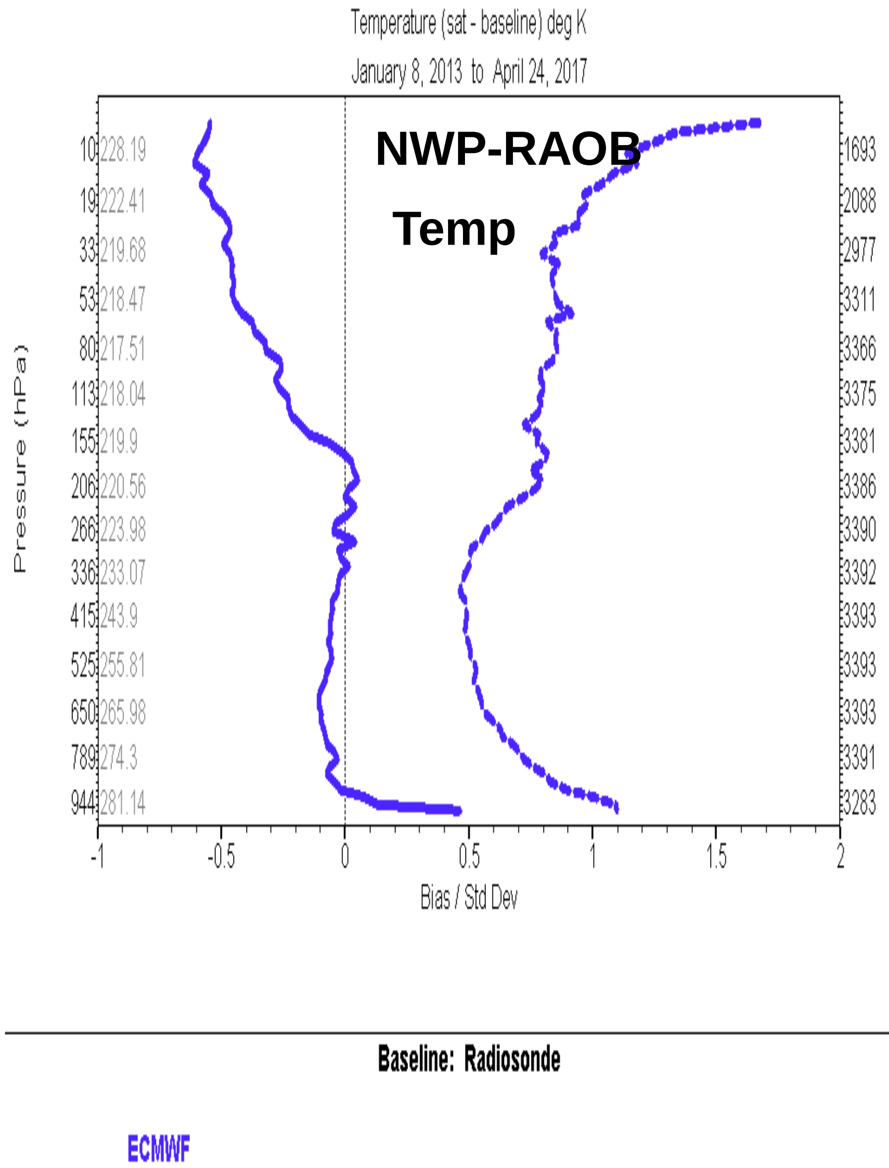
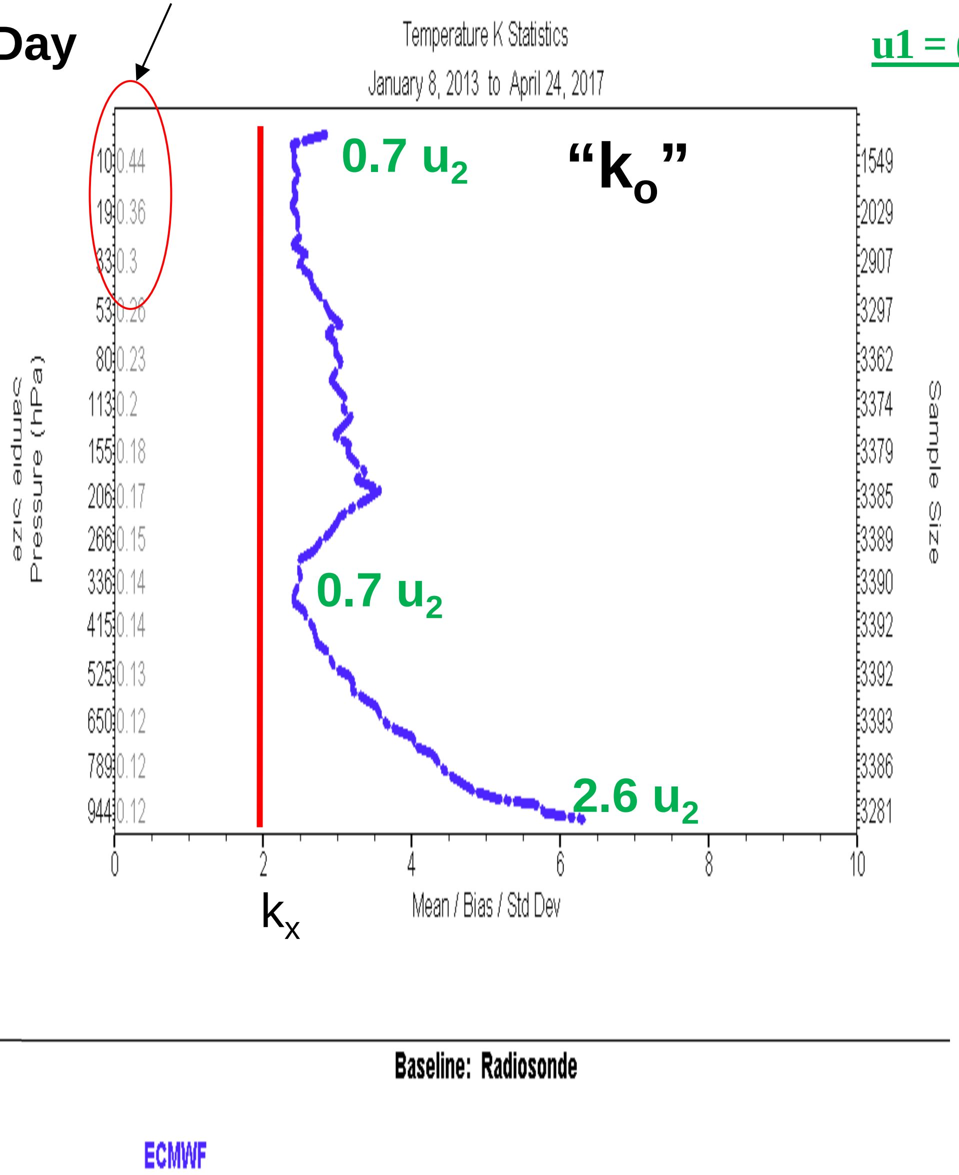
u2 ~ 0.2 for RS41 Alpha2

Day





$u1 = ((k_0/2)^2 - 1)^{1/2}\,(u2)$

0.30K

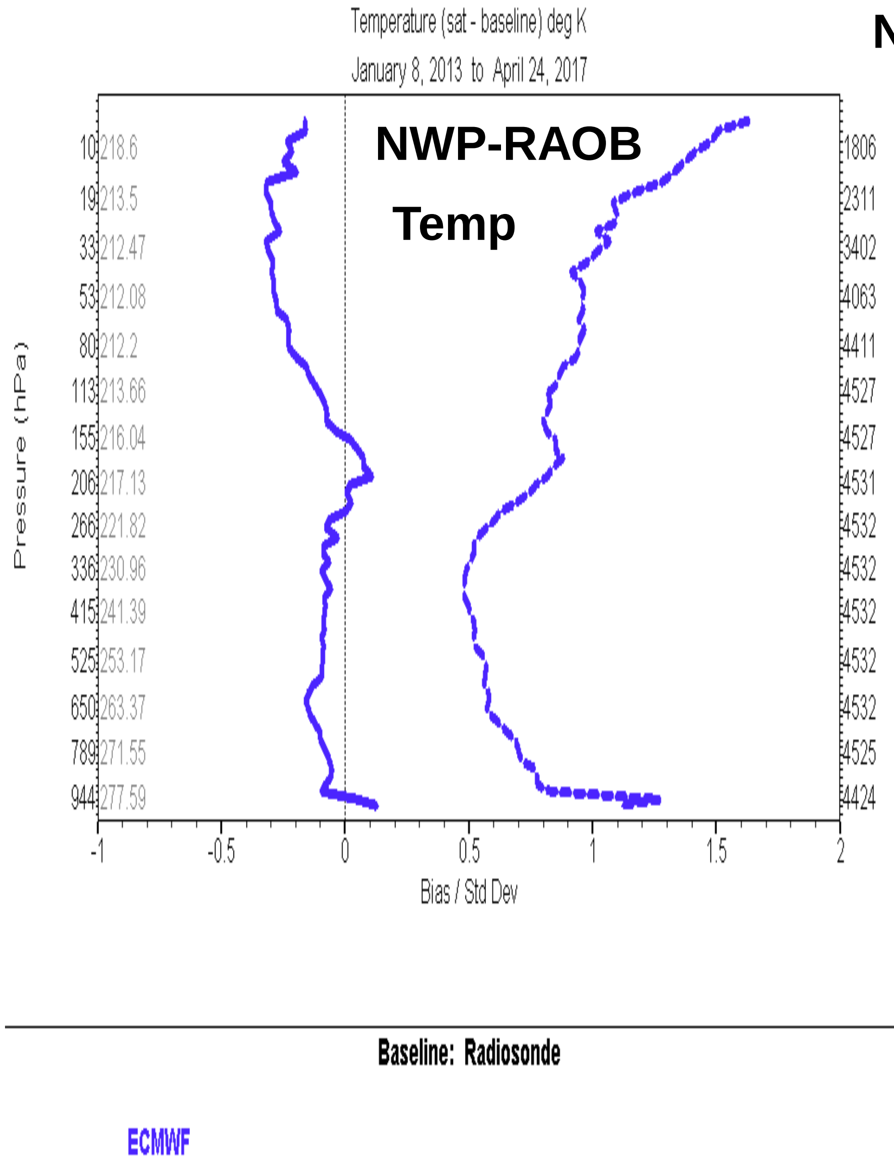
0.10K

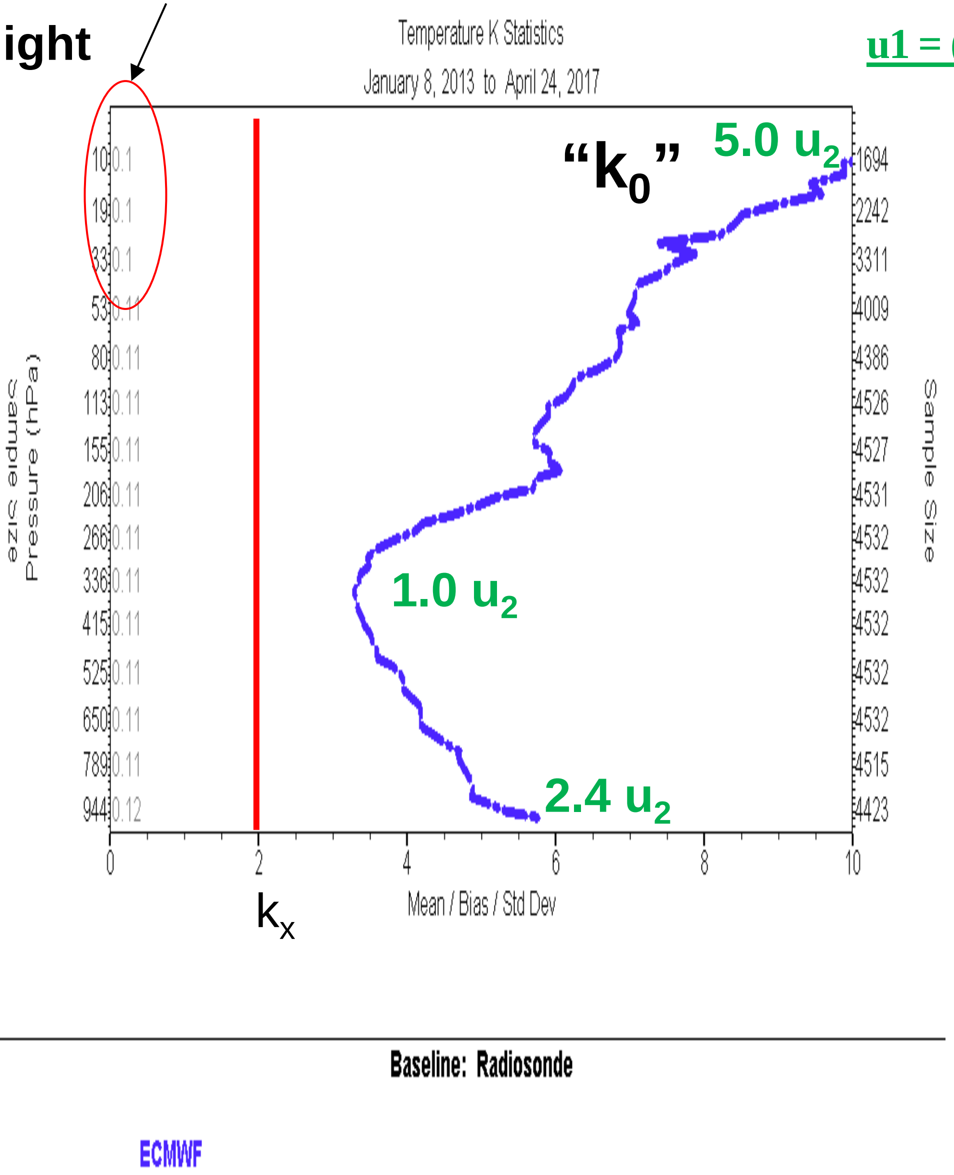
0.30K

ECMWF based assessment of GRUAN uncertainty (v2 RS92): Day … *uncertainty too high ?*

u2 ~ 0.2 for RS41 Alpha2

Night





$u1 = ((k_0/2)^2 - 1)^{1/2}\ (u2)$

0.50K

0.10K

0.30K

ECMWF based assessment of GRUAN uncertainty (v2 RS92): Night … *uncertainty too low ?*

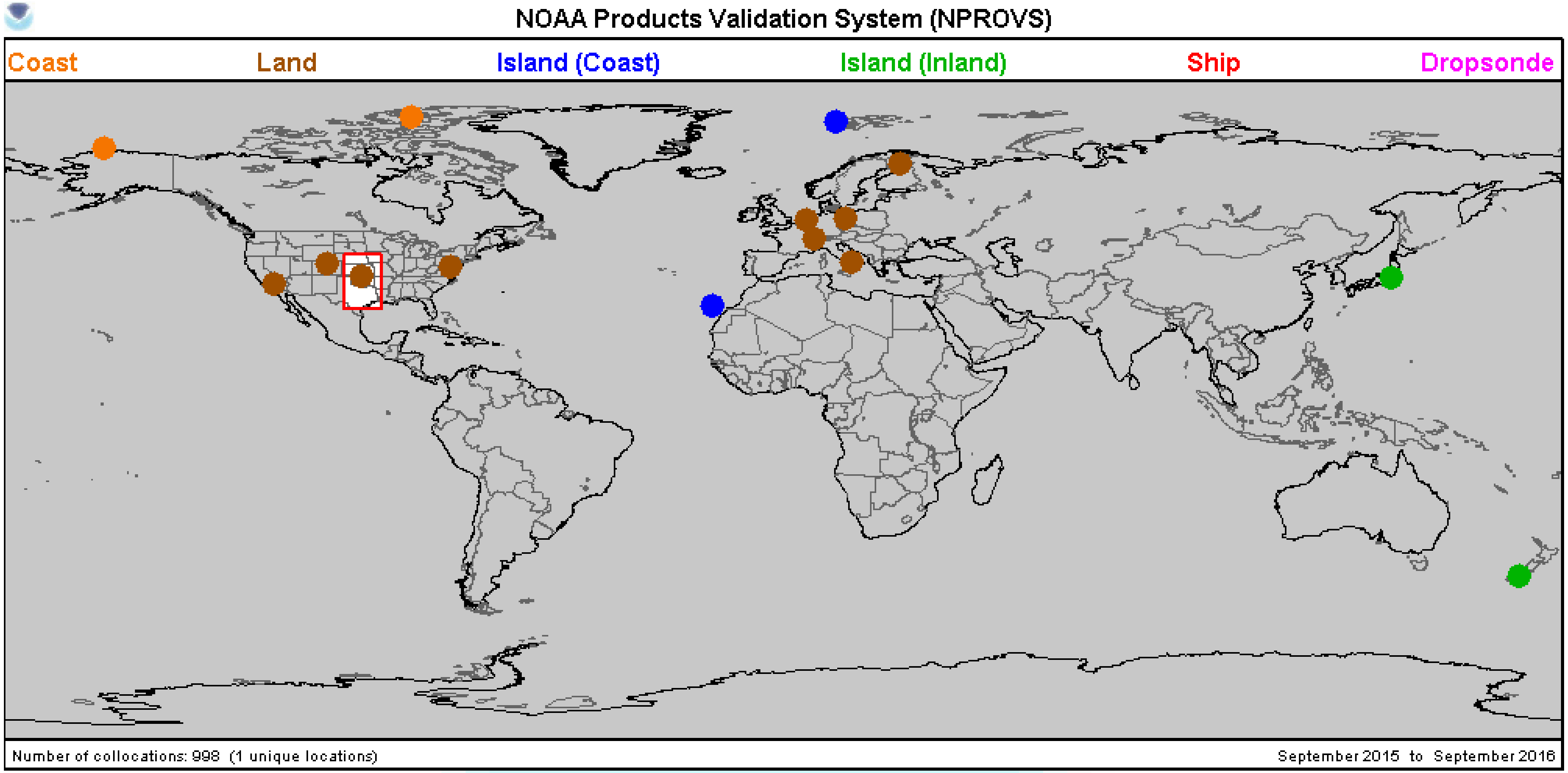
Currently

NOAA Unique Combined Atmospheric Processing System (NUCAPS) geophysical sounding products are distributed to NWS forecasters in the field via the NOAA NWS Advanced Weather Information Processing System (AWIPS) program.

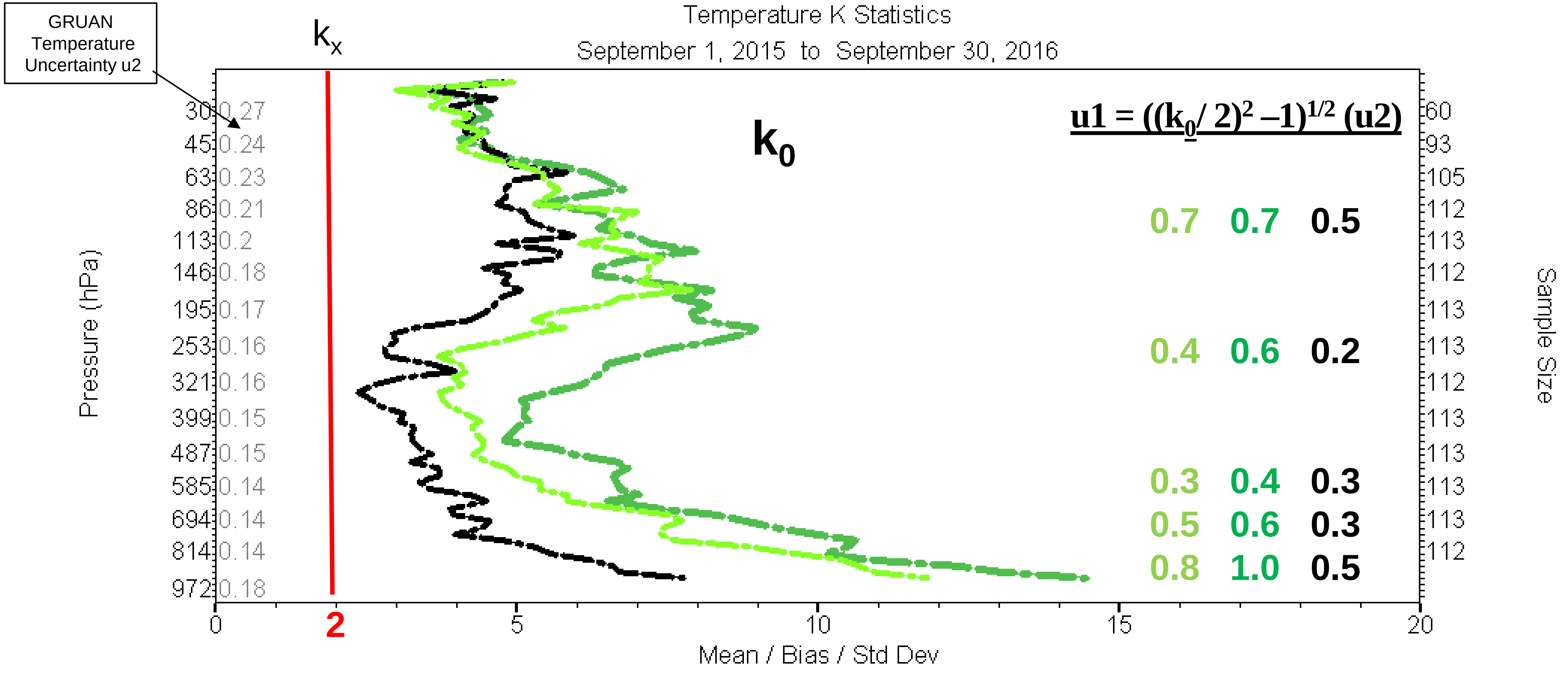
SGP is a strategic location in the realm of NOAA NWS Advanced Weather Information Processing System (AWIPS) program.

Having estimates of *“expected uncertainties of NUCAPS for cloud-cleared, IR based, geophysical soundings”*
at SGP (and also NSA and Beltsville) is a very big deal!

The fact that SGP is both a DOE/ARM and GRUAN site gives it high visibility at NOAA (STAR).



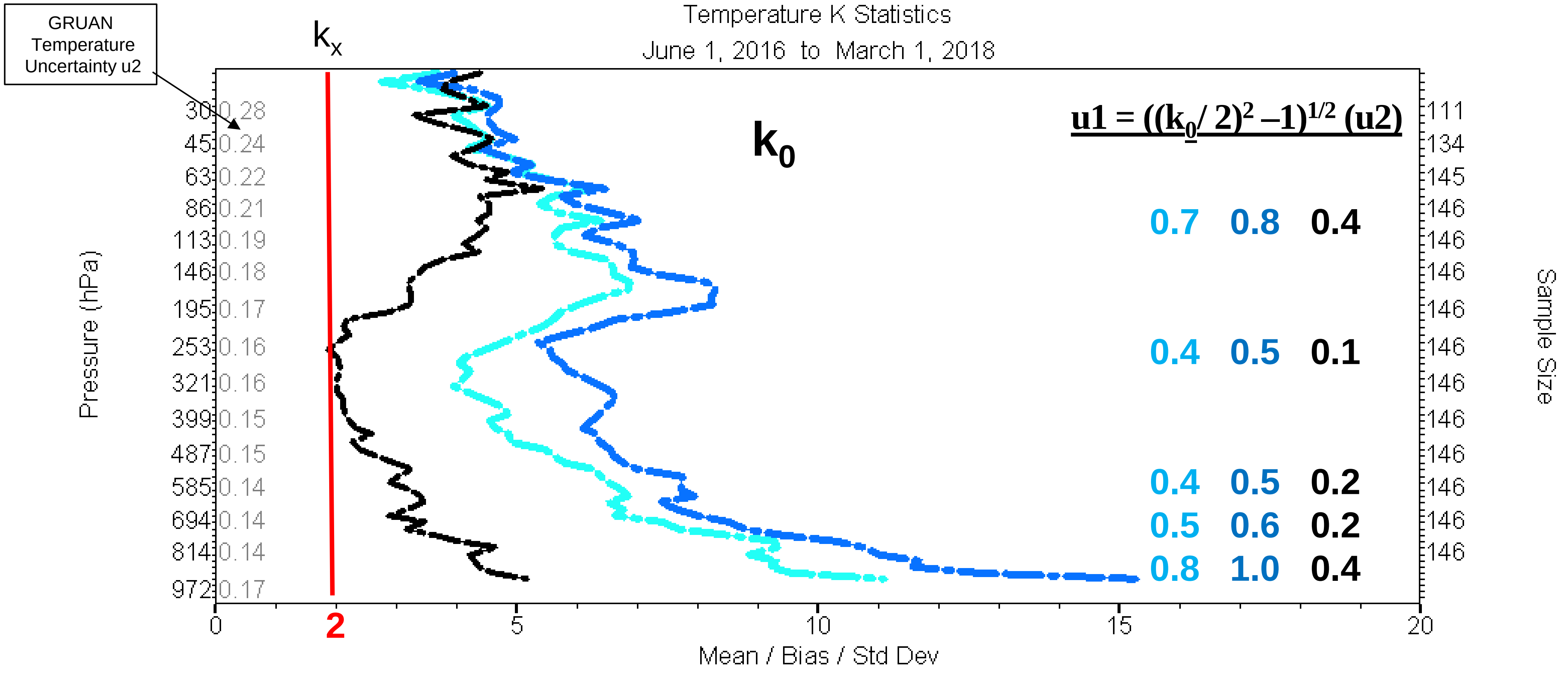
**SGP is strategic site for NOAA NWS users of NUCAPS satellite sounding …
estimating typical sounding uncertainty (albeit non-dynamic) is a very big deal !**



Baseline: Radiosonde

AIRS AQUA | ECMWF | NUCAPS NPP

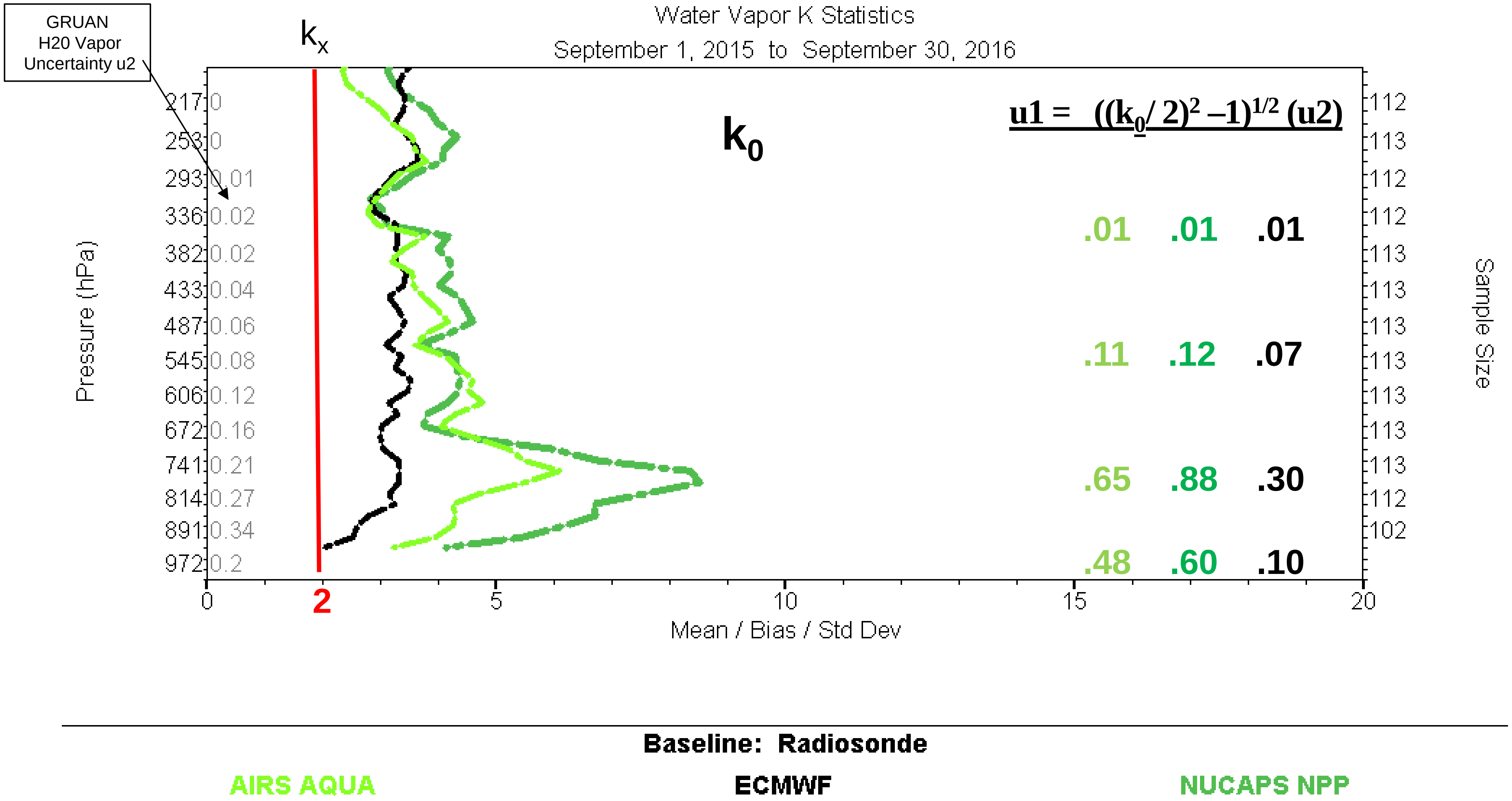
Uncertainty estimates based on GRUAN RS92 v2 for Temperature; **NUCAPS (SNPP), NASA AIRS (Aqua)** and **ECMWF Analysis; +/- 2hr**



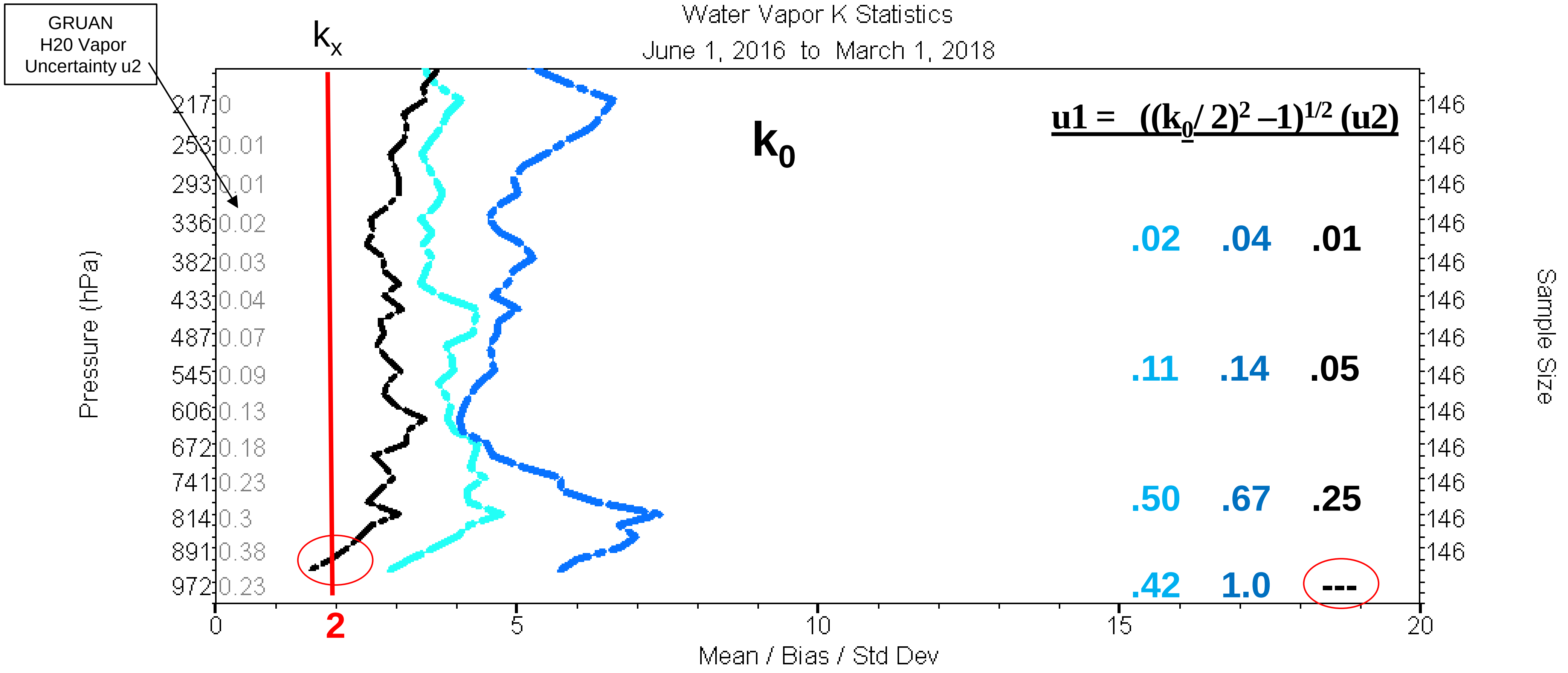
Baseline: Radiosonde

ECMWF **NOAA IASI MetOp-B** **EUMETSAT IASI MetOp-B**

Uncertainty estimates based on GRUAN RS92 v2 for Temperature; **NUCAPS (MetOp-B), EUMETSAT (MetOp-B)** and **ECMWF Analysis; +/- 2hr**



Uncertainty estimates based on GRUAN RS92 v2 for H20 Vaopor; **NUCAPS (SNPP)**, **NASA AIRS (Aqua)** and **ECMWF Analysis; +/- 2hr**



Baseline: Radiosonde

ECMWF **NOAA IASI MetOp-B** **EUMETSAT IASI MetOp-B**

Uncertainty estimates based on GRUAN RS92 v2 for H20 Vapor; **NUCAPS (MetOp-B), EUMETSAT (MetOp-B)** and **ECMWF Analysis; +/- 2hr**

Summary

- ❖ NPROVS Special Dataset w/GRUAN pivotal for NOAA Cal/Val for soundings …
  - We are GRUAN Users!

- ❖ Uncertainty Application Strategy for geophysical sounding products
  - *also "relevant" for sensor radiances … GSICS (Bomin Sun…)*

- ❖ Review some past results and feedback to GRUAN
  - Moisture uncertainty questionable in warm/moist condition
  - Radiation induced error bias (warm) evident in RS92 (but not RS41)
    - also see Bomin Sun publications …

- ❖ Current results on expected uncertainty estimates at SGP highly relevant for NWS AWIPS users of NUCAPS … it's a big deal!
  - Will be interesting to see how RS41 changes things !
  - Publication pending