Integration (*and Assessment*) of Uncertainty in Satellite Profile Cal/Val (NPROVS+)

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OUTLINE

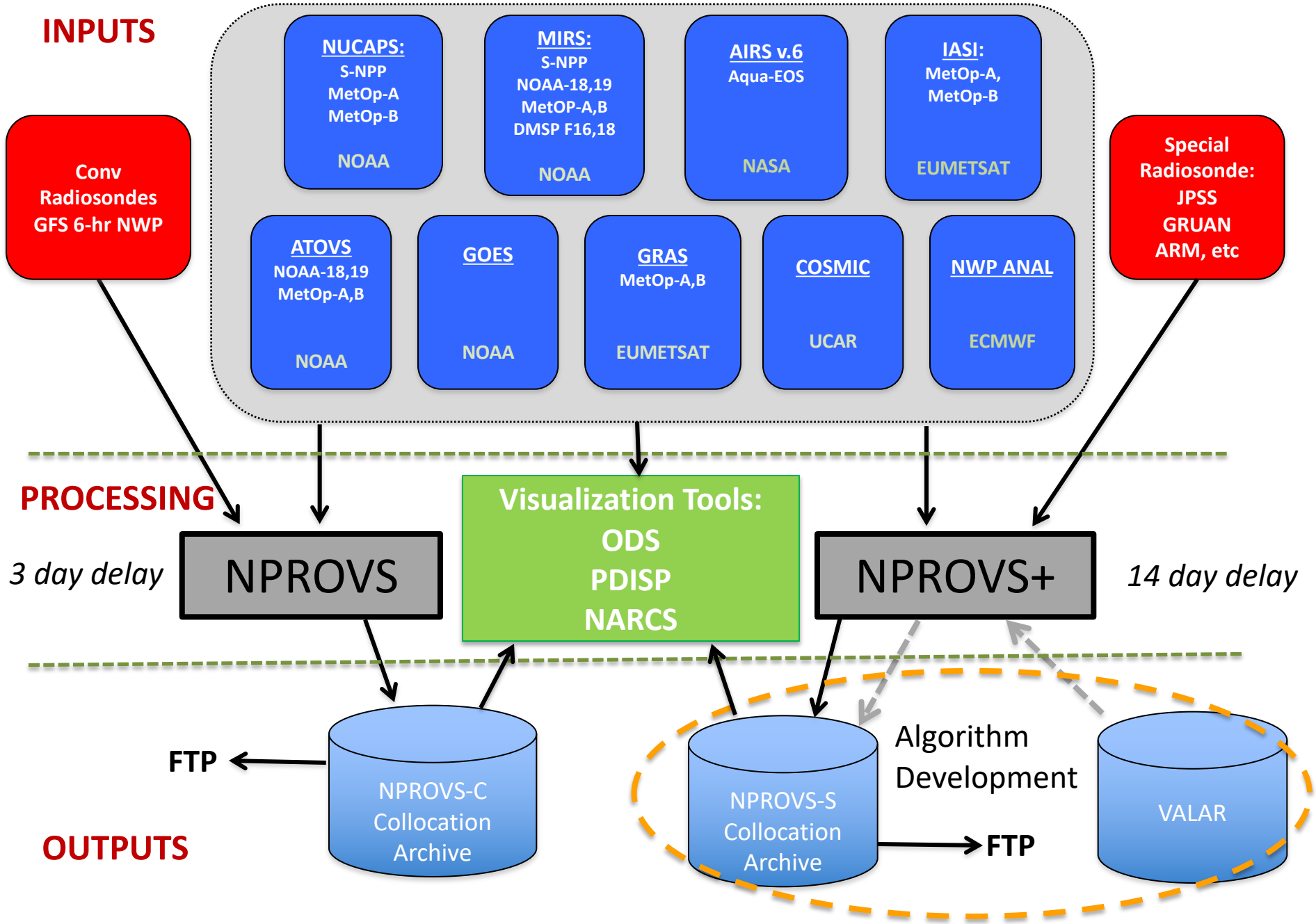
- NPROVS+ and collocations with GCOS Reference Upper Air Network (GRUAN) RS92 Radiosonde

- Strategy to estimate satellite (and NWP) atmospheric profile uncertainties

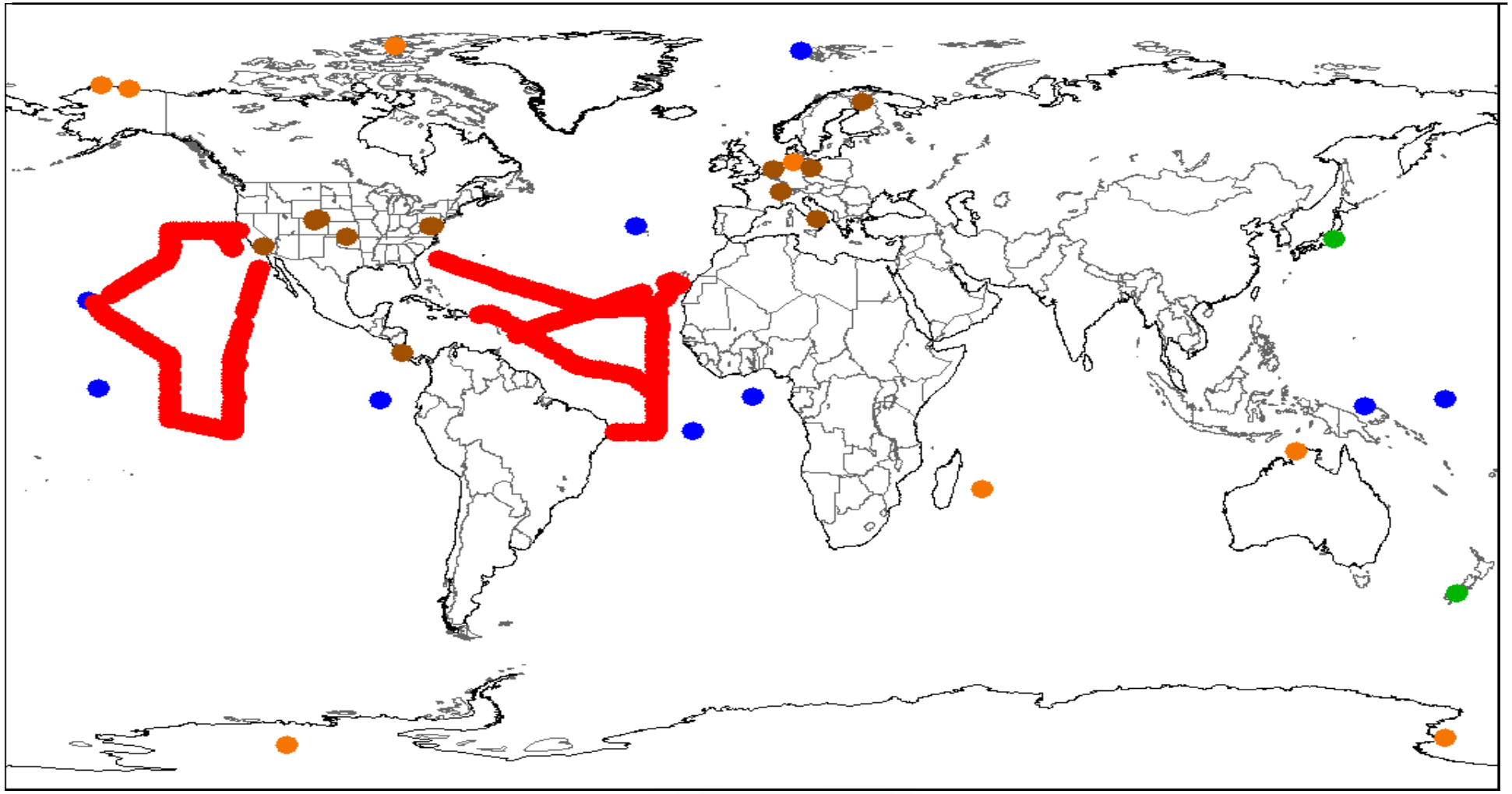
- Previous examples for Moisture and Temperature including feedback to GRUAN on its v2 uncertainty estimates

- Examples of current IASI sounding (EUMETSAT and NOAA), AIRS (v.6) and ECMWF uncertainty estimates, etc

NPROVS/NPROVS+ Schematic



Coast Land Island (Coast) Island (Inland) Ship Dropsonde

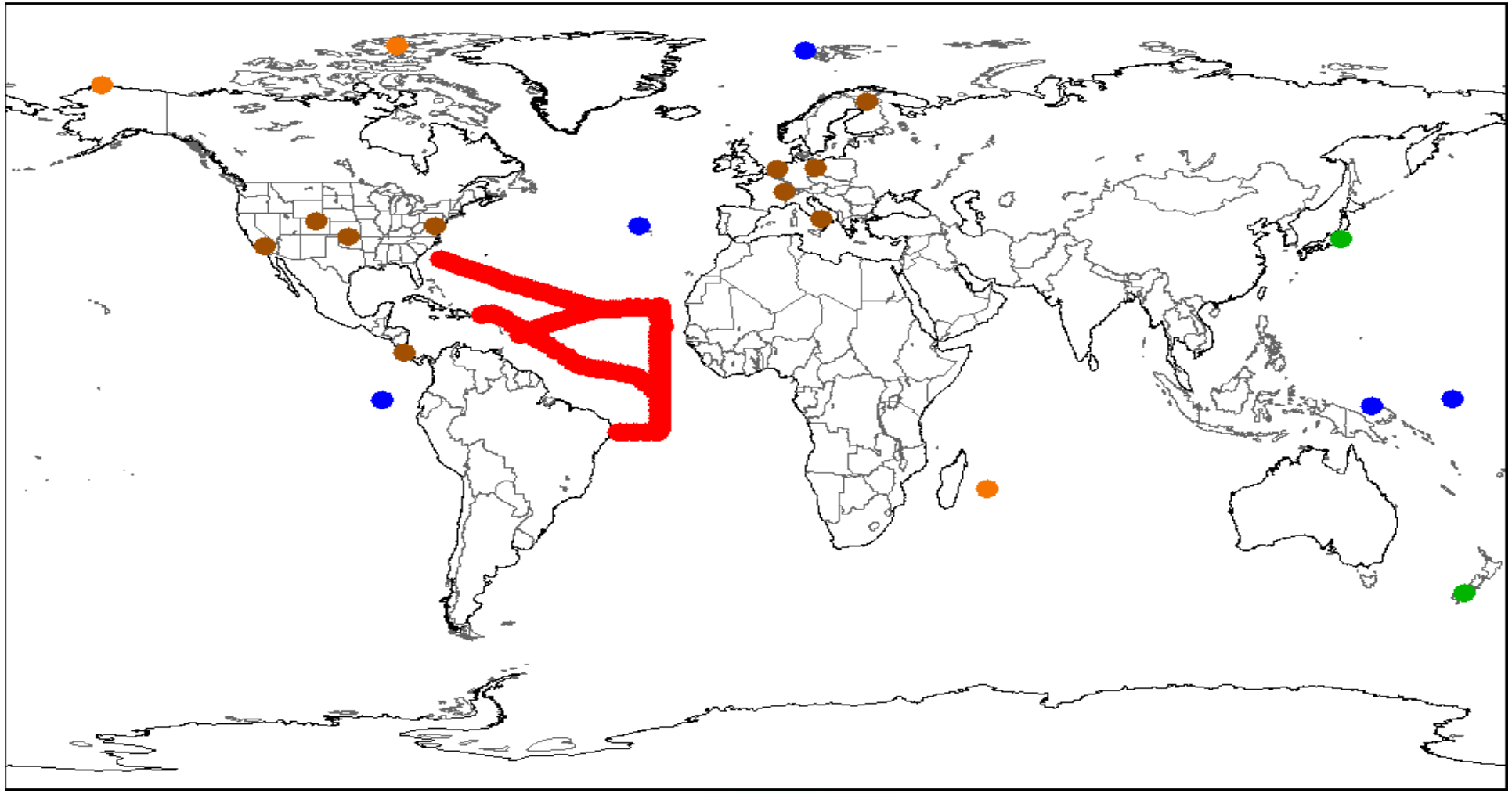


Number of collocations: 32,633 (42 unique locations)

2013 to 2017

NPROVS+ … All

Coast Land Island (Coast) Island (Inland) Ship Dropsonde



Number of collocations: 20,479 (22 unique locations) 2013 to 2017

NPROVS+ … GRUAN only

GRUAN Reference Measurement Principle

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

"k" .le. 2

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

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u2 is GRUAN uncertainty … given

u1 is SAT (or NWP) profile uncertainty … needed

σ is space & temporal variability between platform pair… needed

Approach

1) ABS (m1 – m2) > k $(\sigma^2 + u1^2 + u2^2)^{1/2}$

2) "k" = ABS (m1 – m2) / u2

for k=2 … consistent

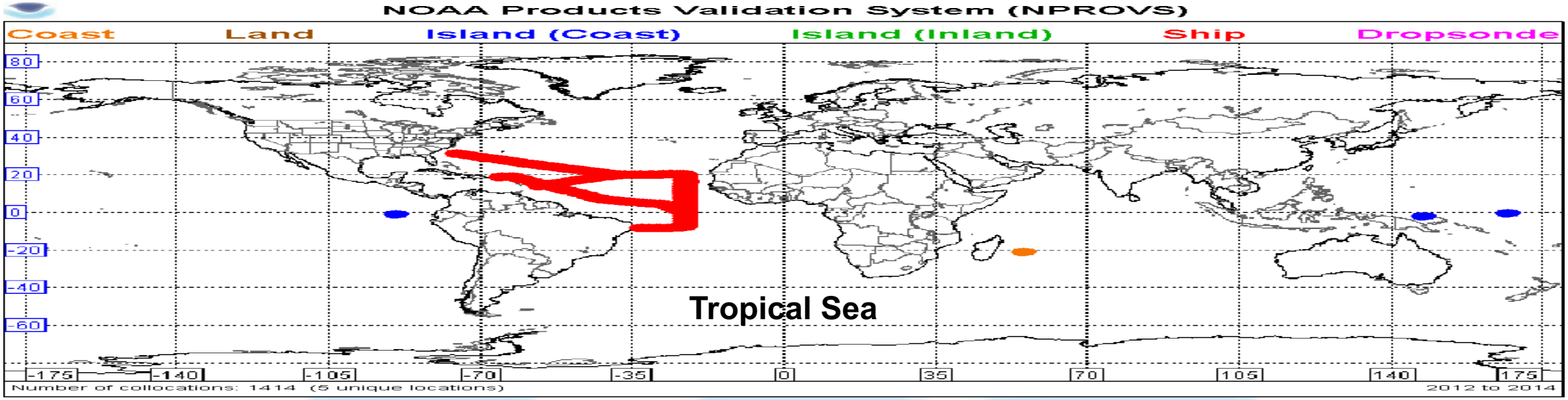
3) $\sigma^2 + u1^2 = (("k"/2)^2 - 1)\,(u2)^2$

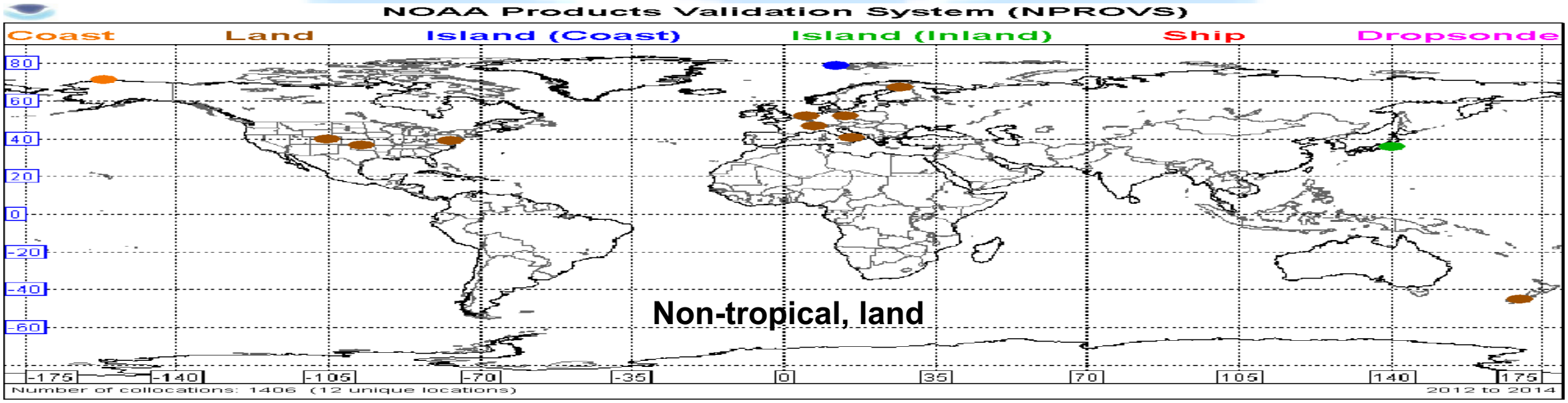
4) $u1 = (("k"/2)^2 - 1)^{1/2}\,(u2)$

… given u2, quantifying the $(\sigma^2 + u1^2)$ requires the assumption of consistent (k=2) observations … worst case estimate of u1

Convert RH uncertainty (%) to MR uncertainty (g/kg):

Uncertainty (MR) = Uncertainty (RH) x Saturation (T) MR





GEWEX Water Vapor Assessment … GVAP-5 … *Schroder et.al*

GEWEX Water Vapor Assessment … *GVAP-5 Final Report, Schroder et.al (in review)*

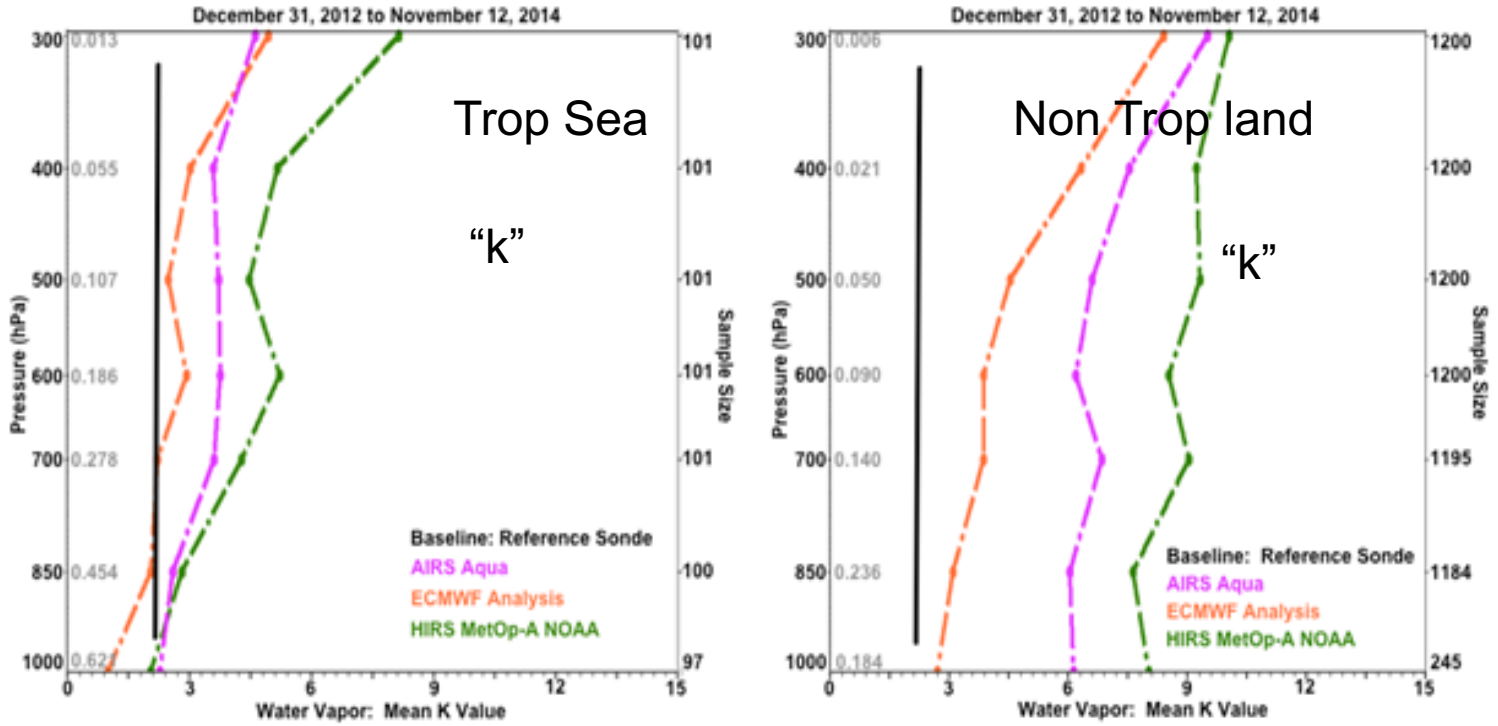


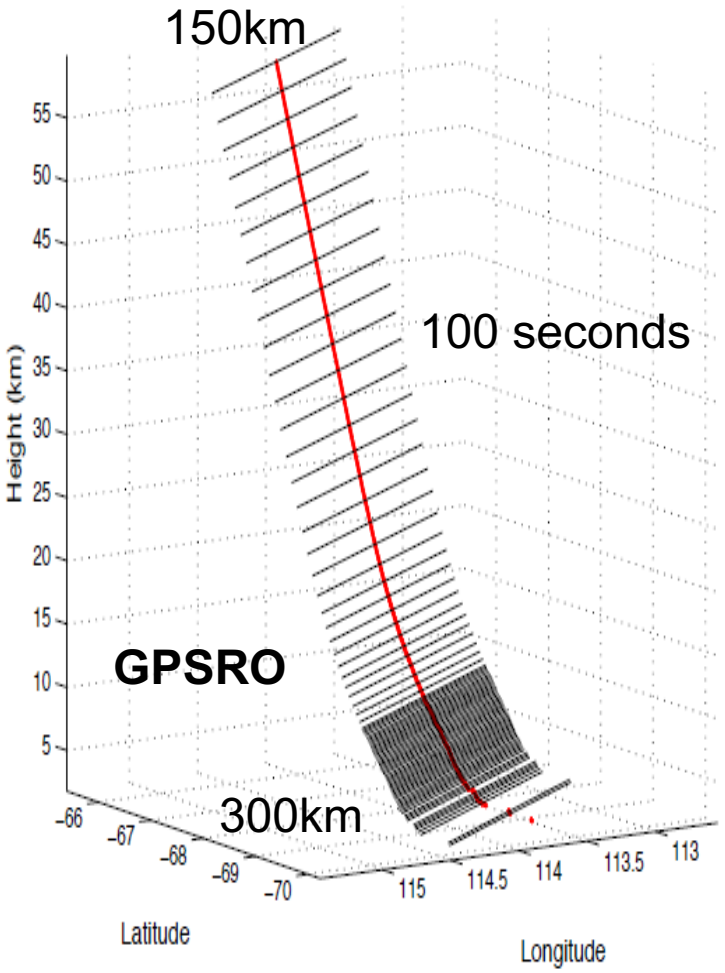
Figure 6: Mean "k" vertical profile using equation (3) for collocated GRUAN radiosonde, HIRS from Metop-A (green), Aqua AIRS v.5 which passed QC (purple) and the ECMWF Analysis (orange) over tropical sea (left) and non-tropical land (right) with GRUAN mean MR uncertainty along inside left and sample size along right axes; black line denotes k=2

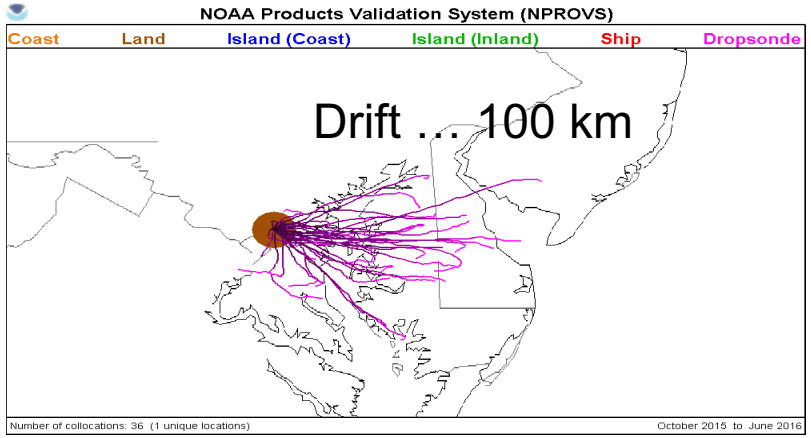
Summary Table (Tropic Sea)

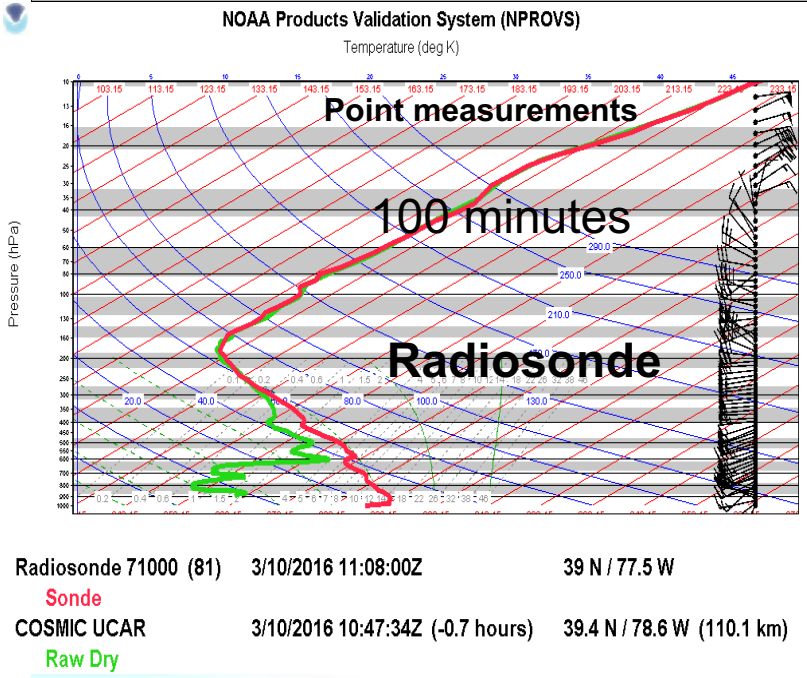
Tropical, Sea	AIRS / HIRS / ECMWF
300 hPa	0.025 / 0.052 / 0.028 0.013 4.4 / 8.3 / 4.8 0.17
500 hpa	0.18 / 0.20 / 0.09 0.107 3.9 / 4.4 / 2.3 1.6
700 hpa	0.46 / 0.53 / 0.16 0.273 3.9 / 4.4 / 2.3 5.6
1000 hPa	0.20 / --- / --- 0.626 2.1 / 1.7 / 1.0 16.0

Satellite (and ECMWF) MR uncertainties estimates (4); *u1*
GRUAN MR uncertainty; *u2*
"k" value
Mean GRUAN H20 MR

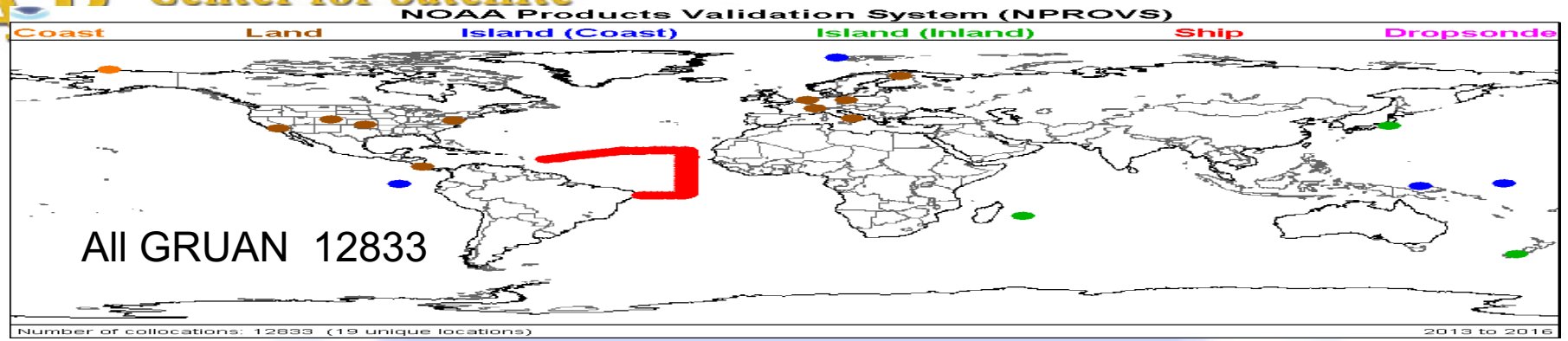
GEWEX Water Vapor Assessment … ***GVAP-5 Final Report, Schroder et.al (in review)***

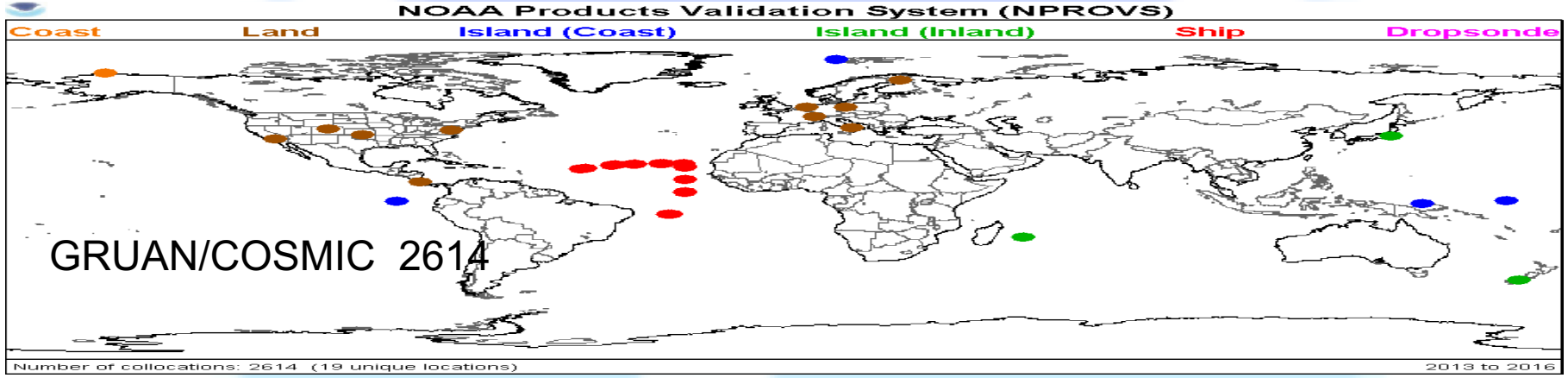


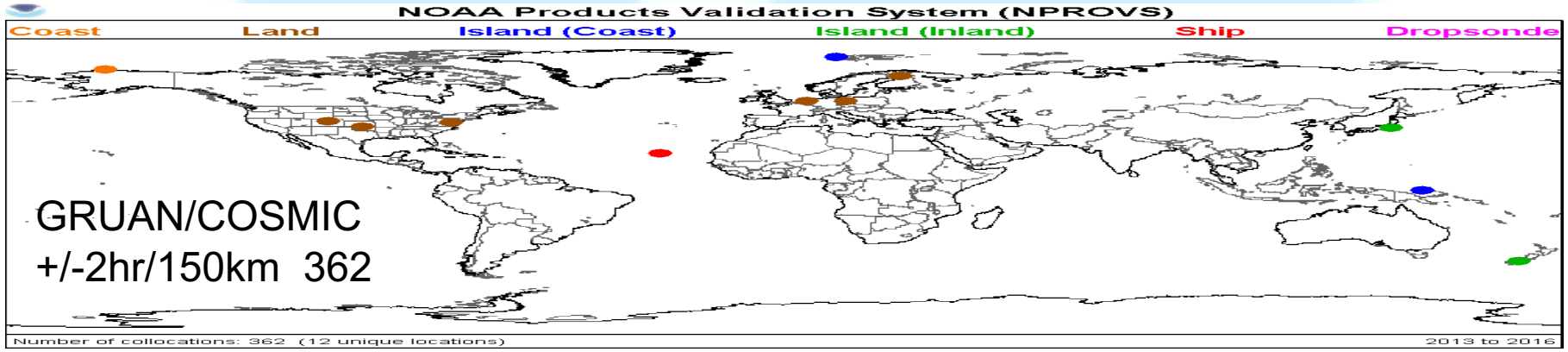




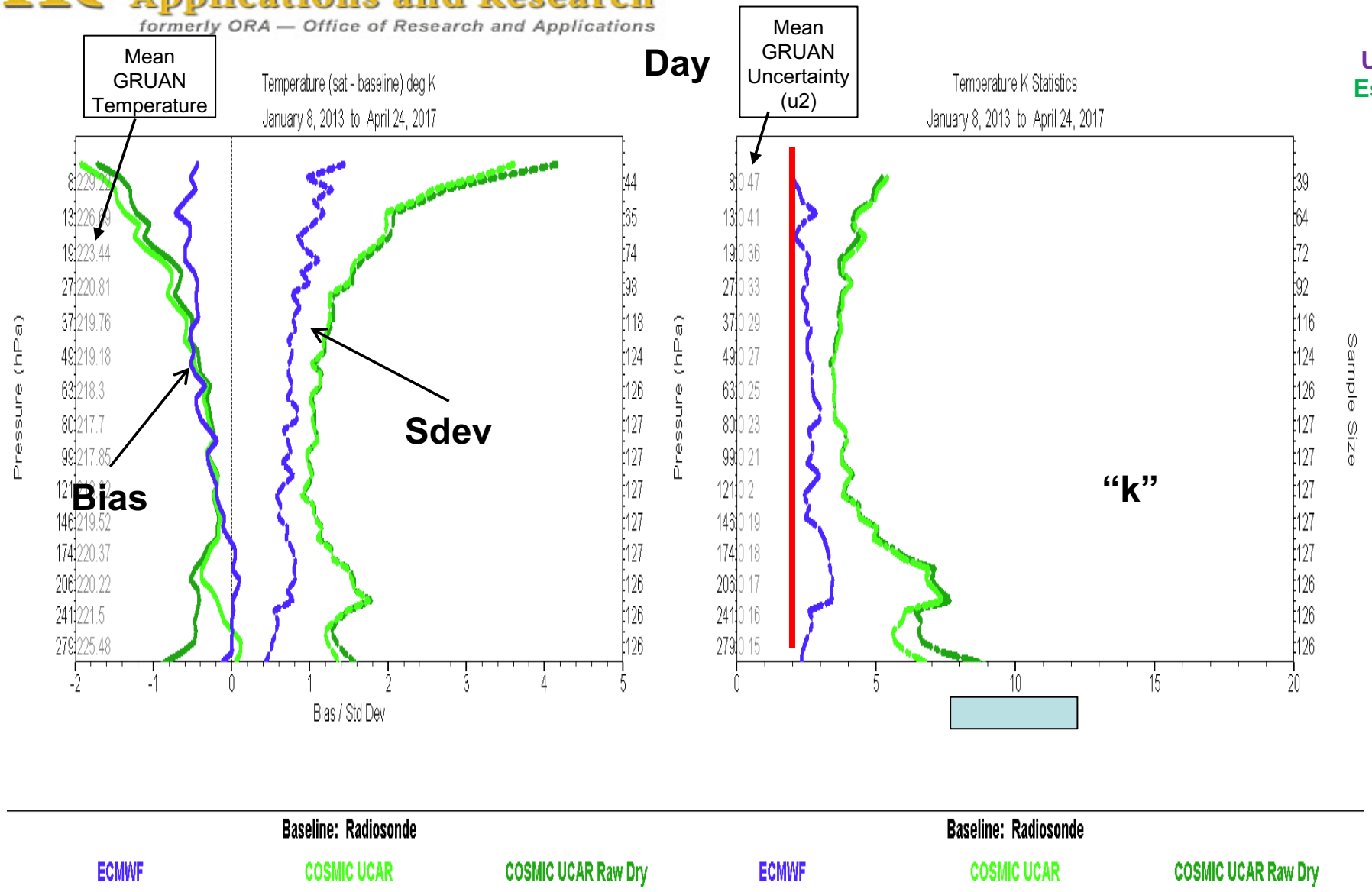
" σ " term for RAOB vs satellite (COSMIC) can be significant even if collocation mismatch is small







GRUAN collocations with COSMIC GPSRO (*or GRAS*)



Uncertainty Estimates (K) (u1)

--- , 1.2

.26, .62

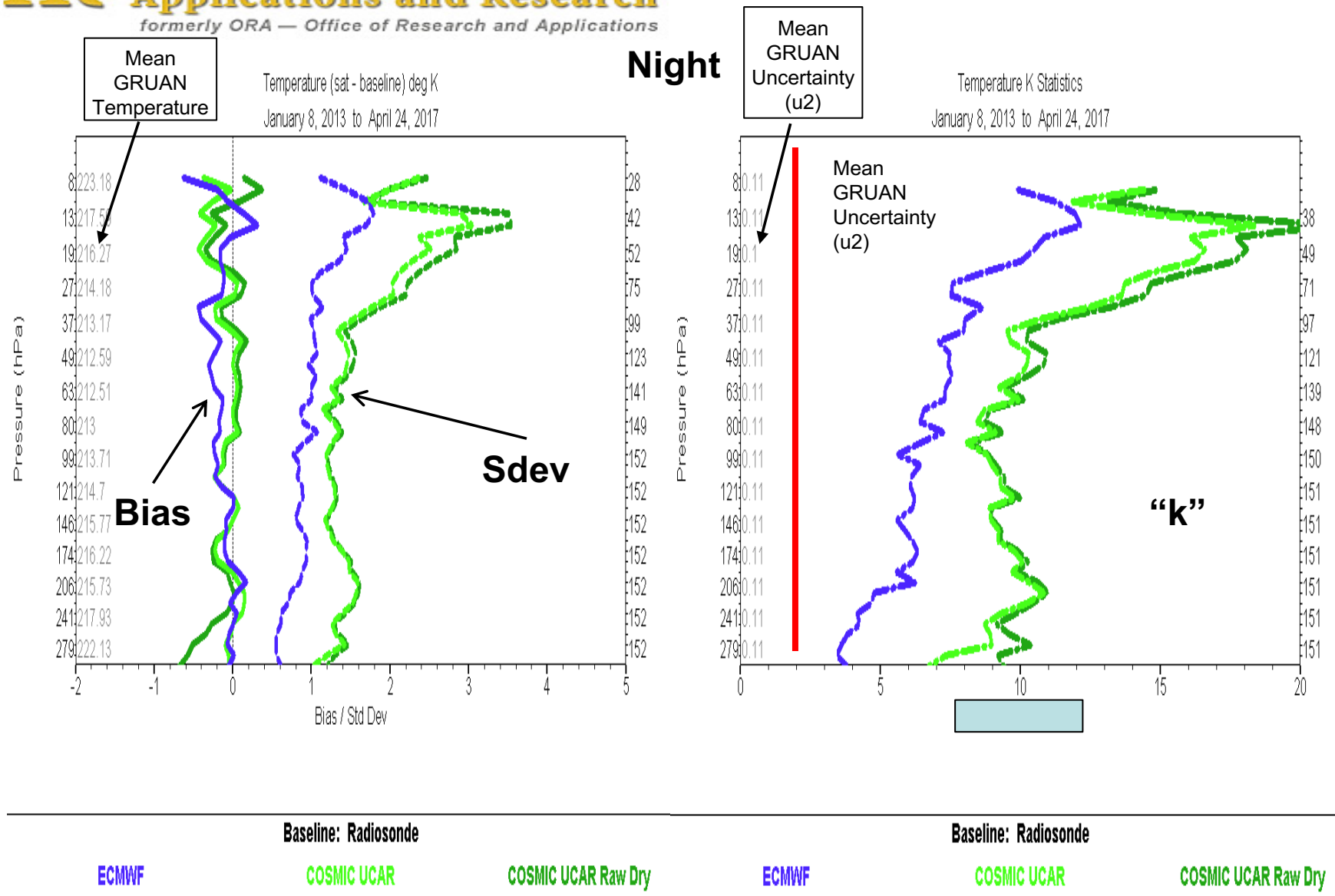
.17, .38

.26, .61

.12, .53

GRUAN collocations with COSMIC GPSRO; 200 to 5 hPa

*("k" profile "should" be more similar day vs night; **u2 too large, day ?**)*



Uncertainty Estimates (K) (u1)

.53 , 1.1

.31, .60

.31, .42

.31, .59

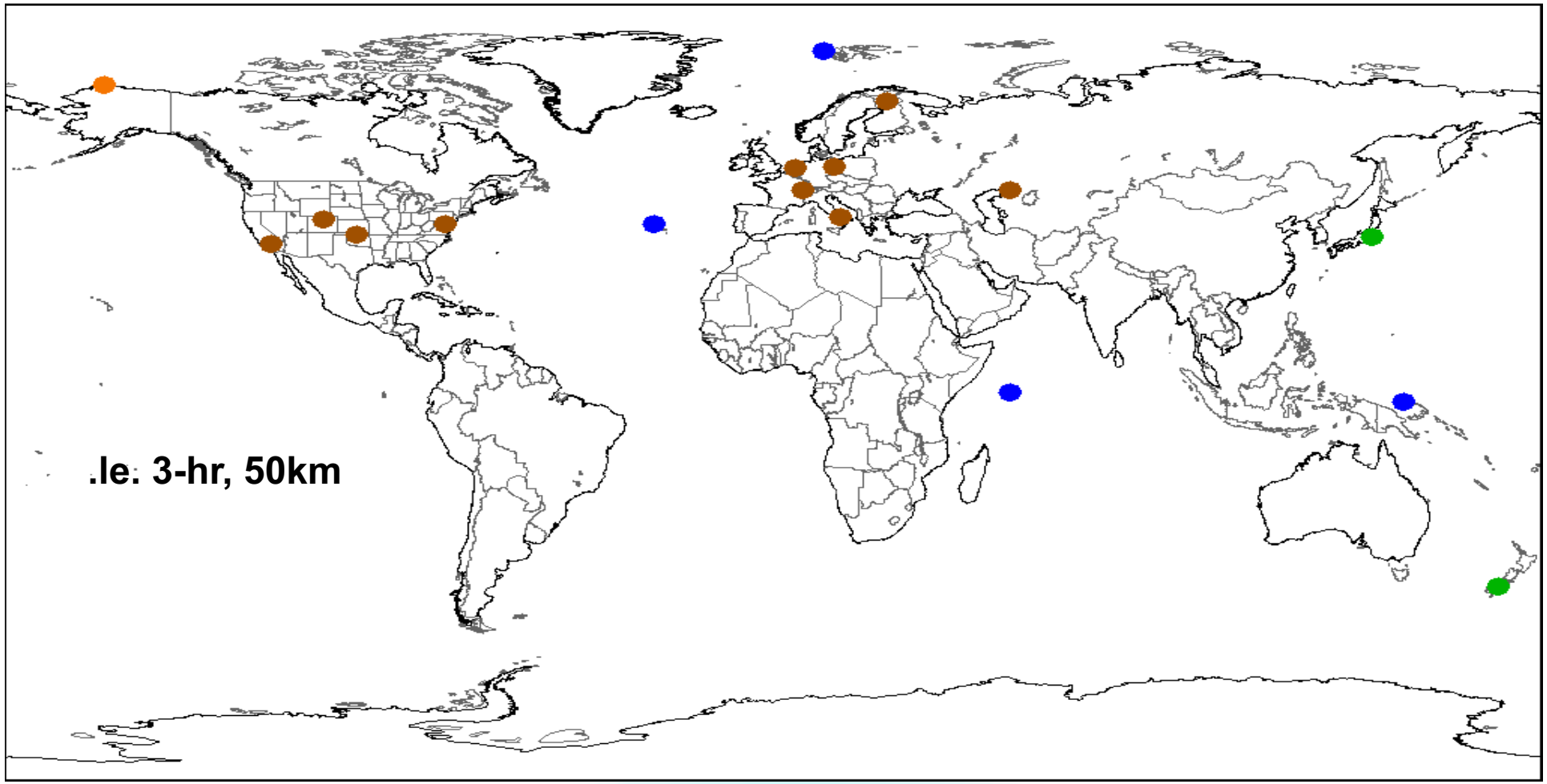
.19, .48

GRUAN collocations with COSMIC GPSRO; UT/LS

*("k" profile "should" be more similar day vs night; **u2 too small, night?**)*

NOAA Products Validation System (NPROVS+)

Coast Land Island (Coast) Island (Inland) Ship Dropsonde



Number of collocations: 1626 (16 unique locations)

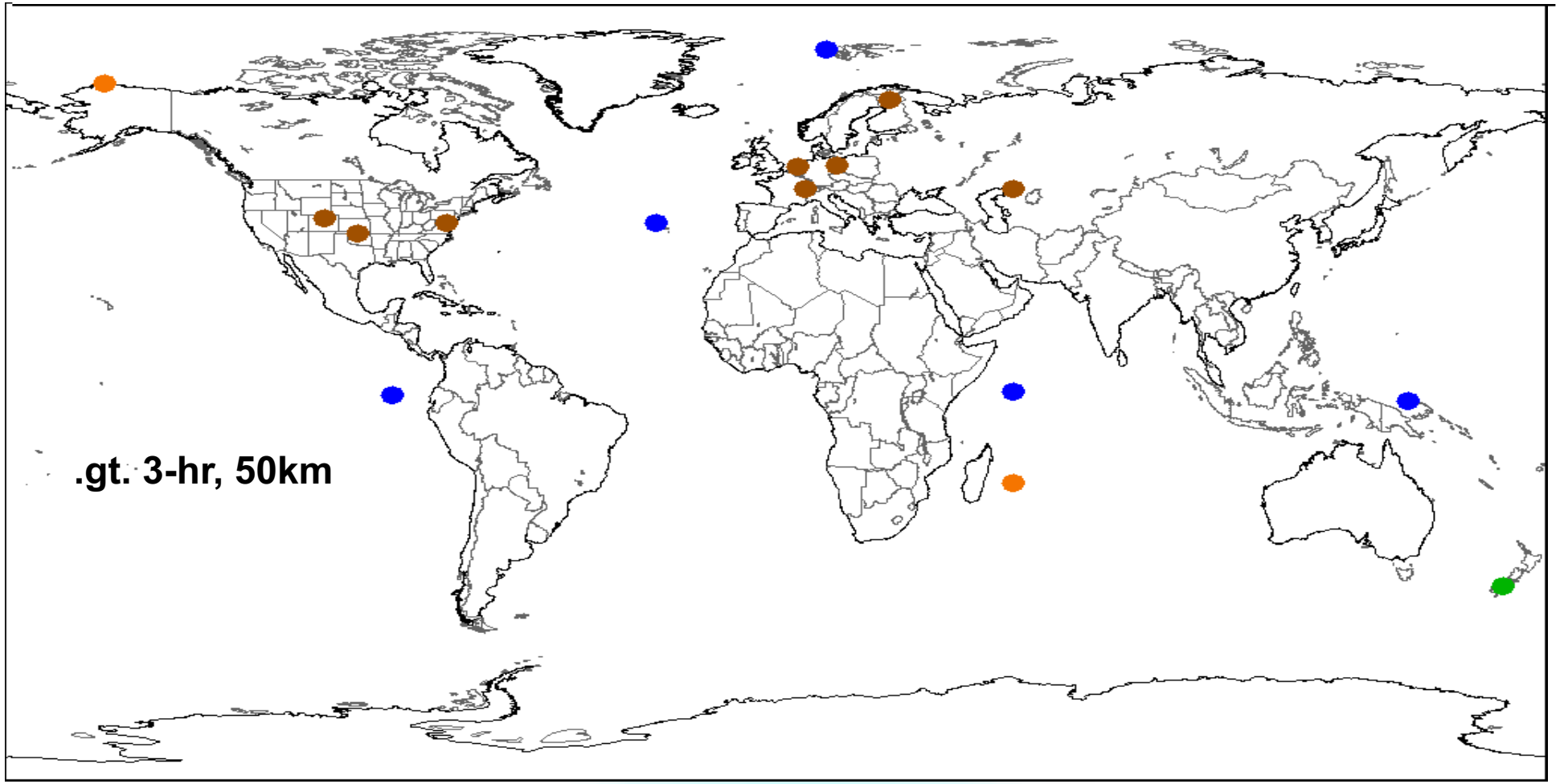
2012 to 2017

Collocation dataset of IASI EU and NUCAPS for IR pass QC .le. 3-hour, 50km

(EU 30% yield vs NOAA 55% yield)

NOAA Products Validation System (NPROVS+)

Coast Land Island (Coast) Island (Inland) Ship Dropsonde

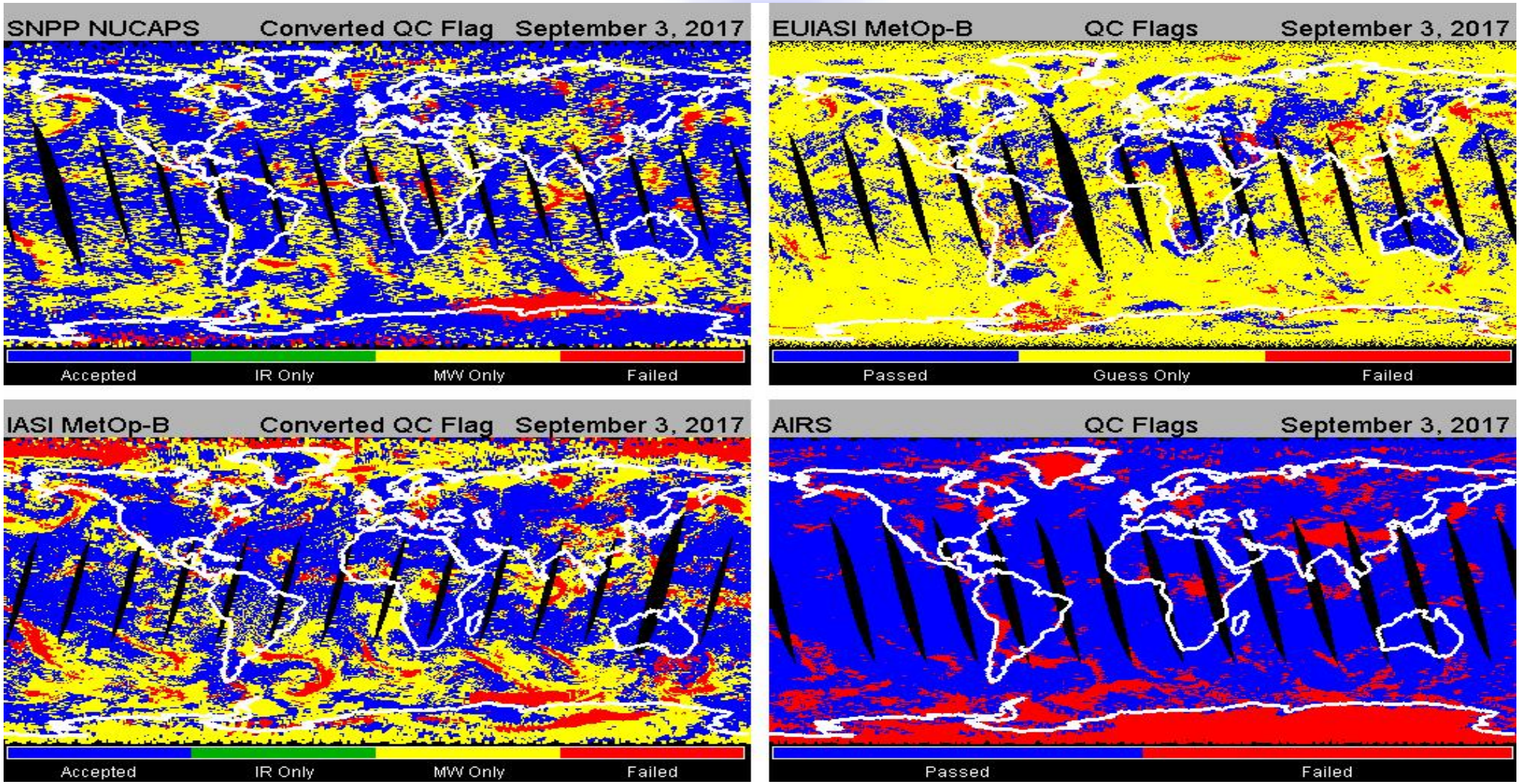


Number of collocations: 1003 (14 unique locations)

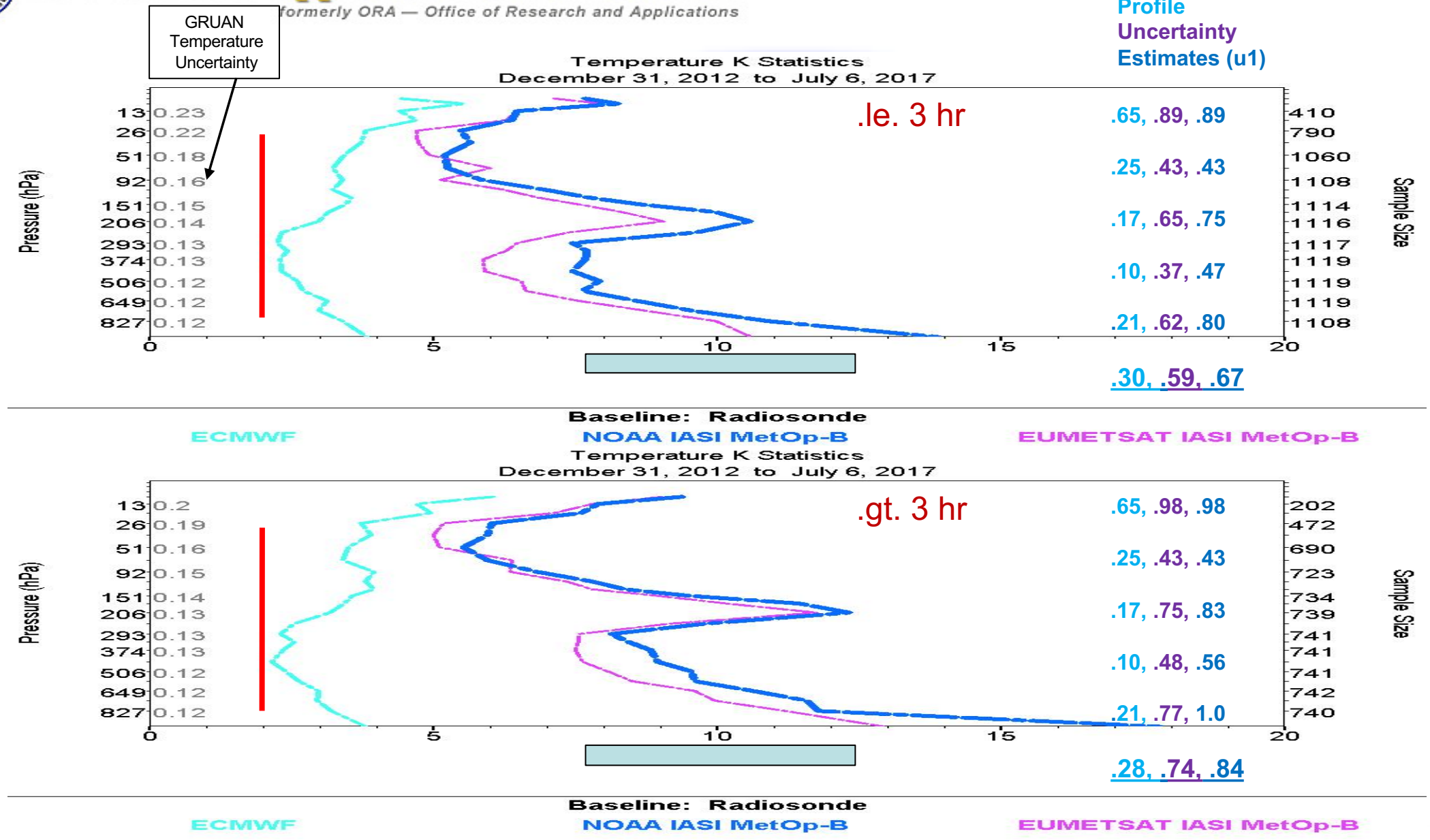
2012 to 2017

Collocation dataset of IASI EU and NUCAPS for IR pass QC .gt. 3-hour, 50km

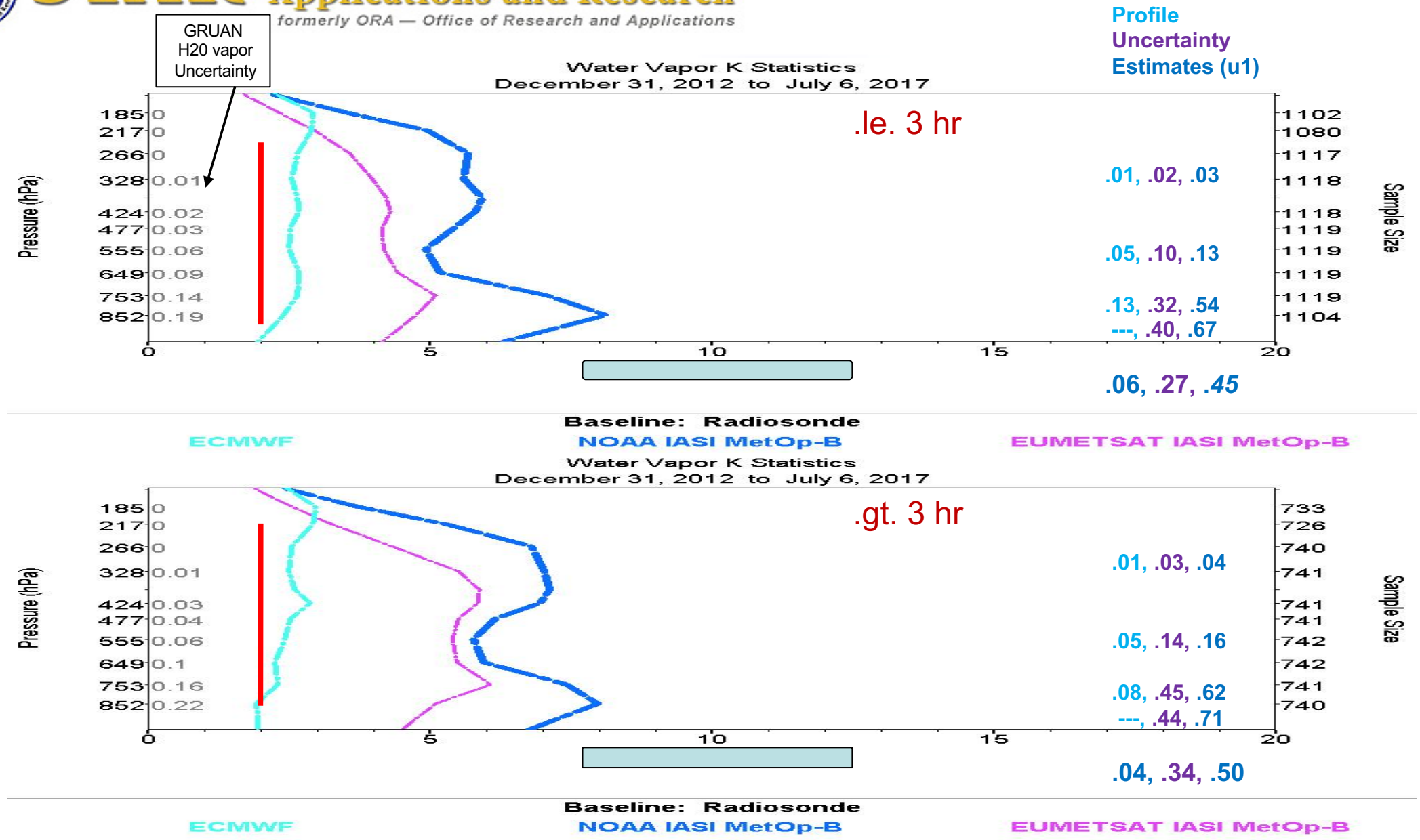
(EU 30% yield vs NOAA 55% yield)



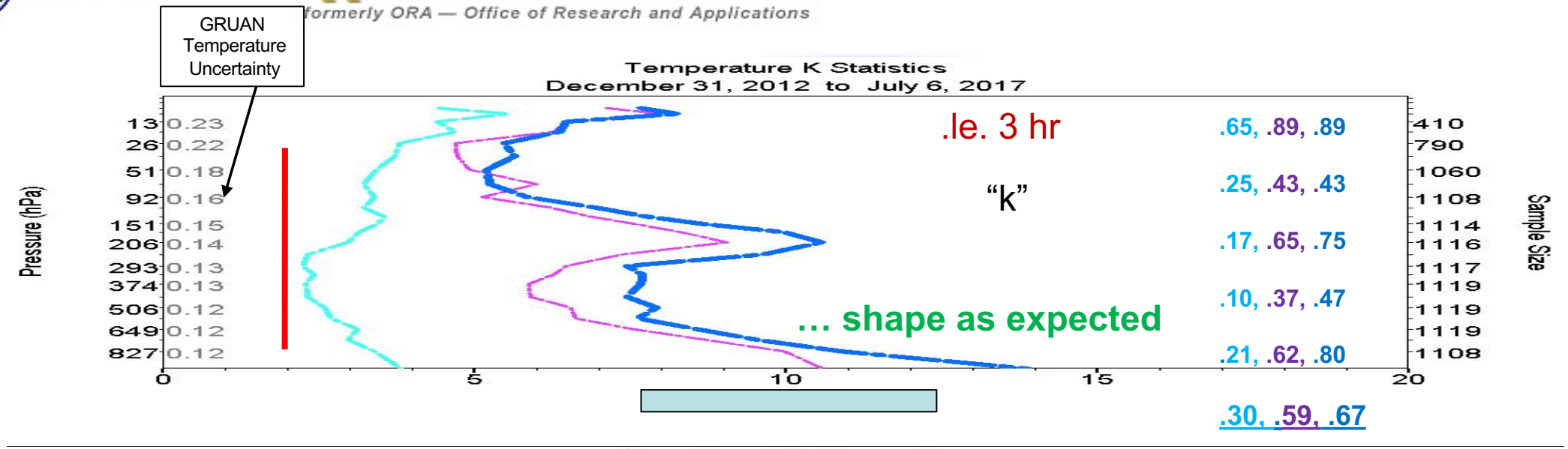
IR Pass QC are “blue”

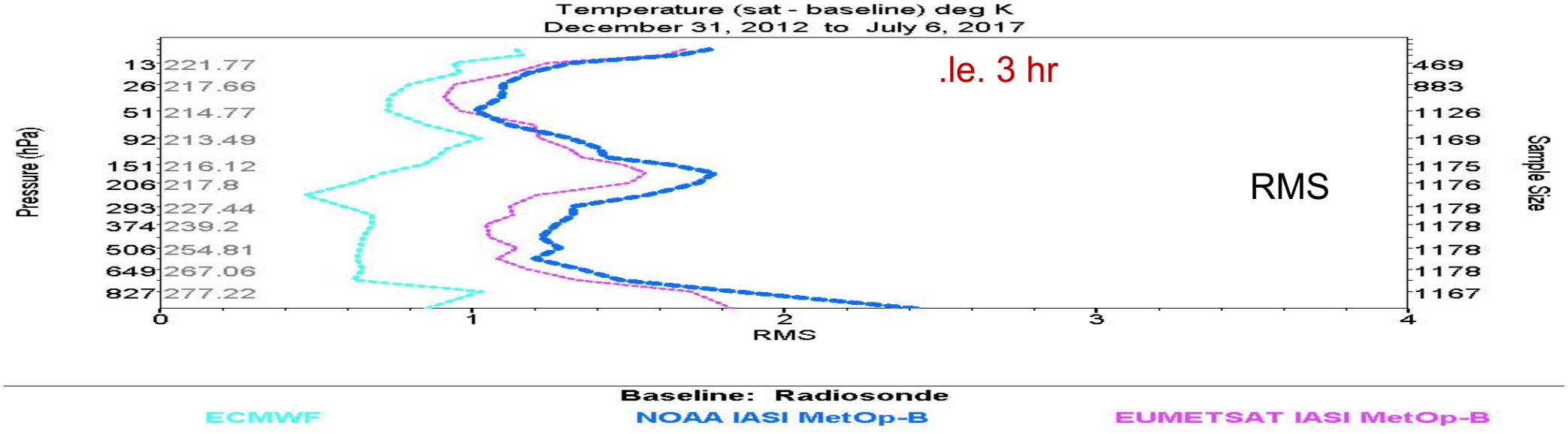


“k” for Temperature (K)

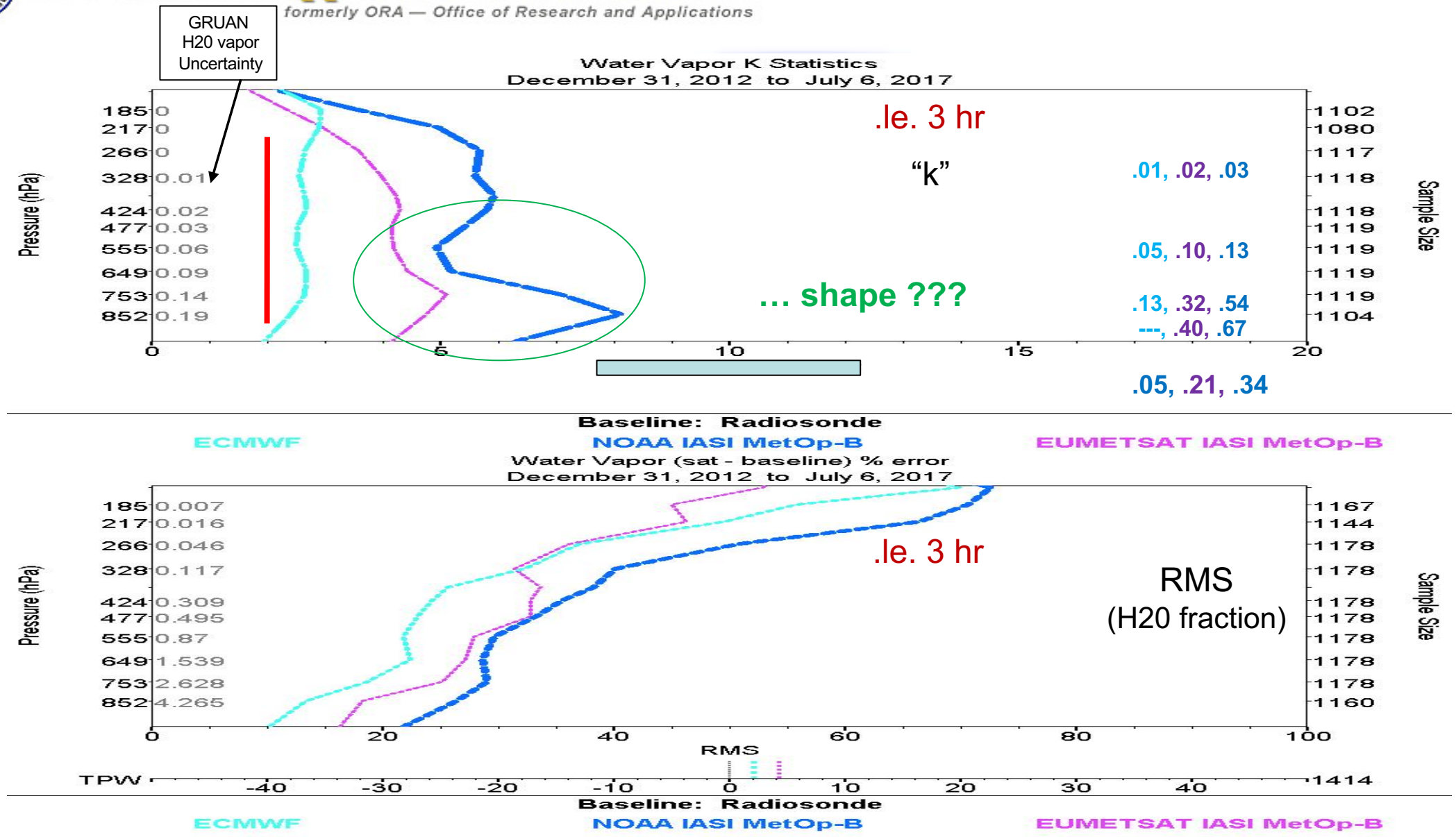


“k” for H20 Vapor (g/kg)

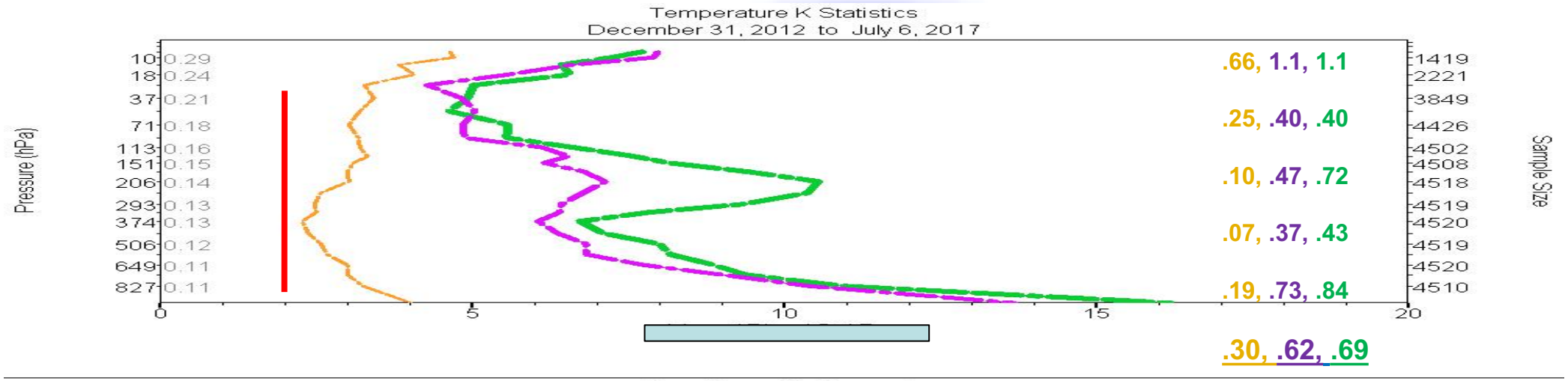


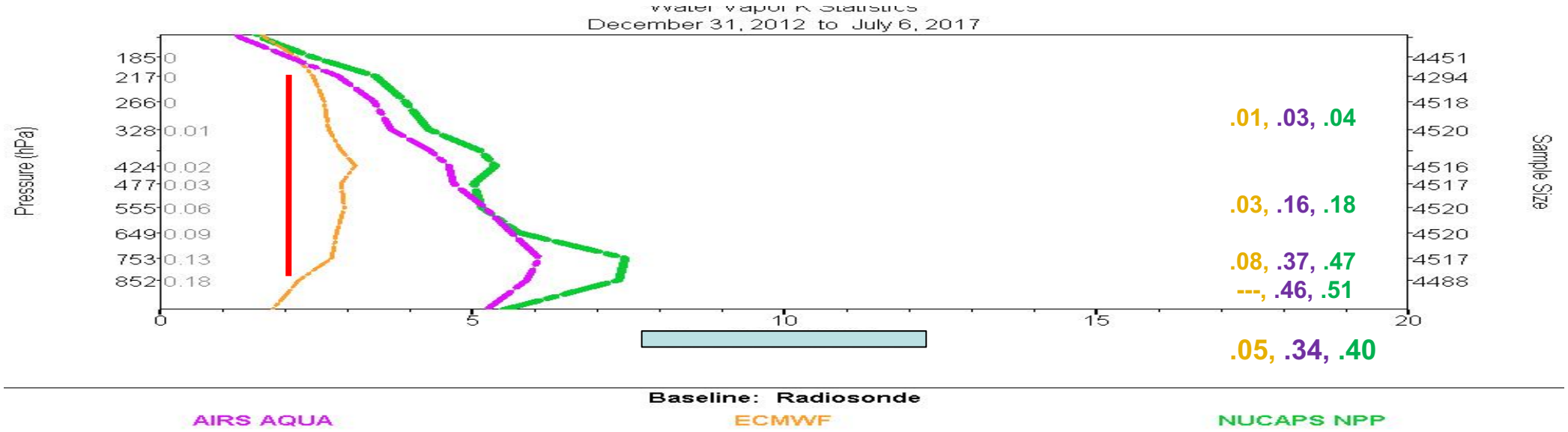


"k" vs RMS … Temperature



"k" vs RMS … H20 vapor (g/kg)





“k” for Temperature (top) and H20 vapor (bottom)(

Individual cases of max “k” value for:

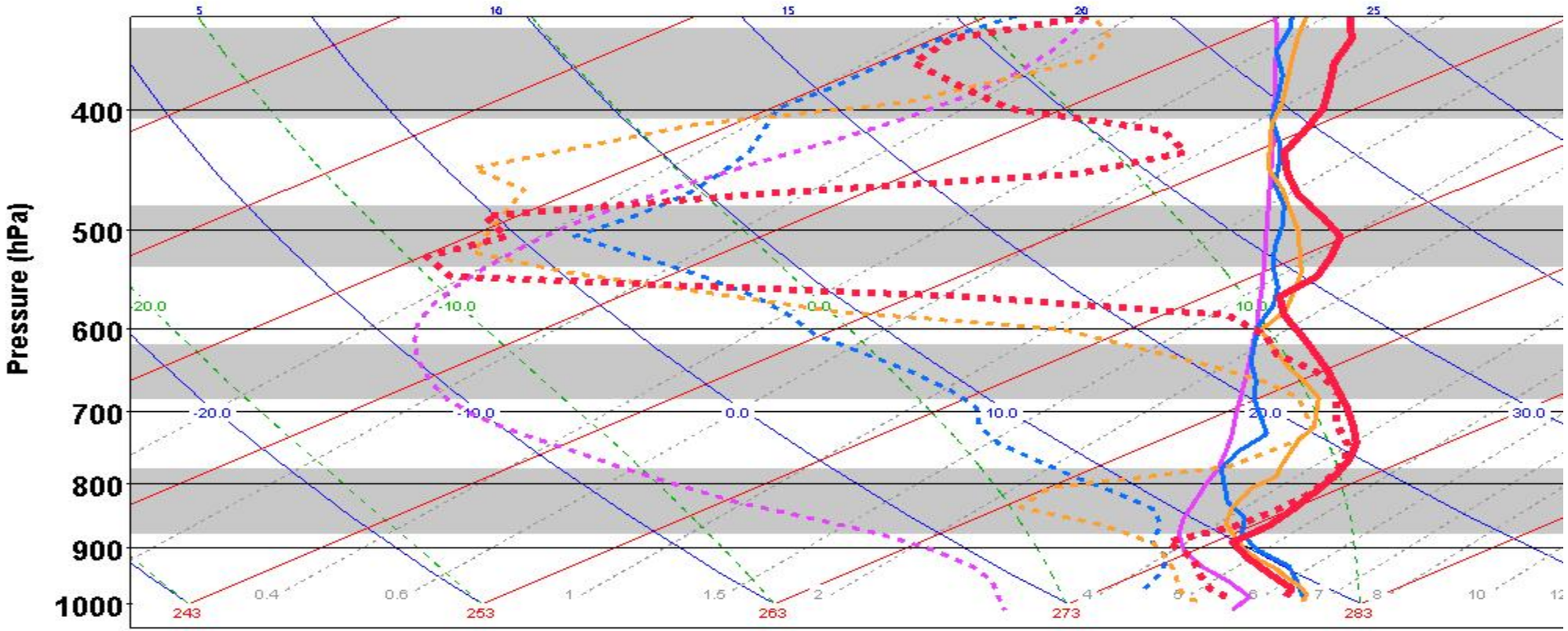
IASI-EU
IASI-NOAA
ECMWF
AIRS

For all cases:

Satellite passed QC for IR +MW retrieval
Within 3 hour and 50km
GRUAN RAOB accepted

NOAA Products Validation System (NPROVS)

Dewpoint / Temperature (deg K)

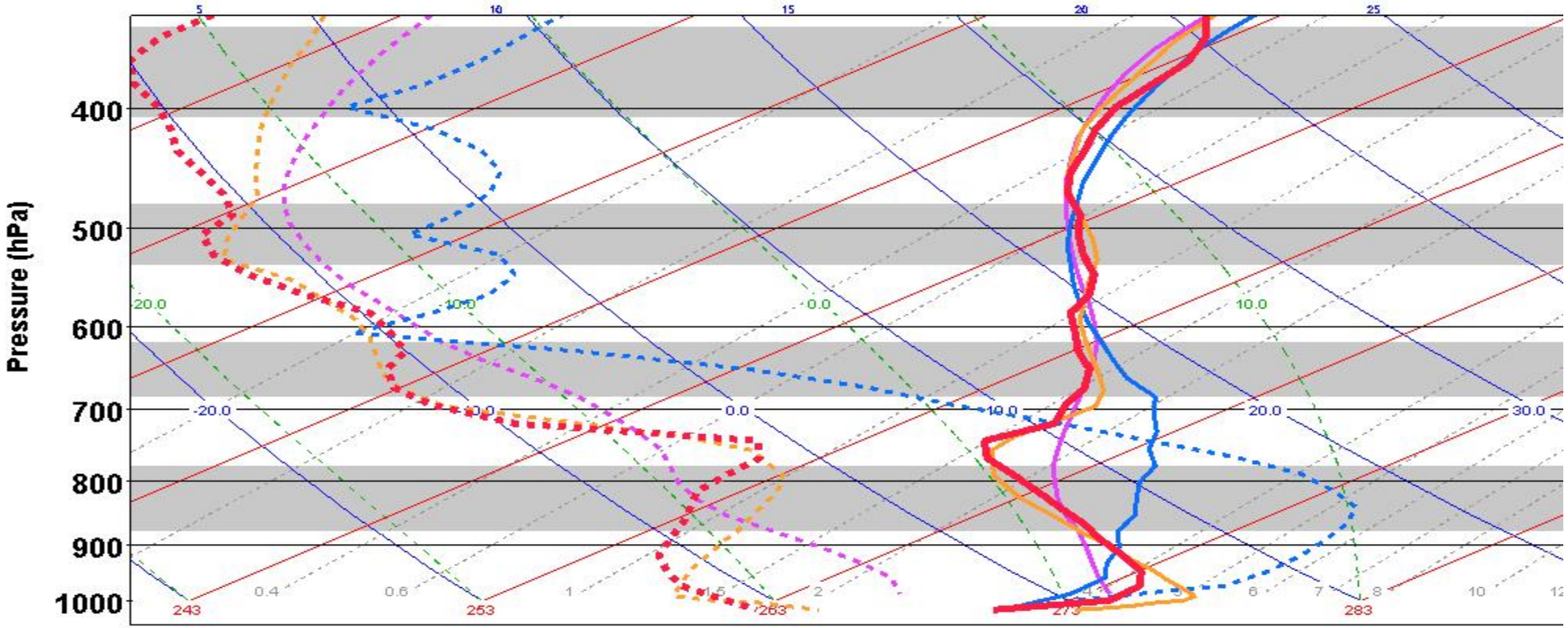


Radiosonde 10393 (272) Radiosonde	1/10/2015 16:50:00Z	52.2 N / 14.1 E
ECMWF	1/10/2015 18:00:00Z (1.2 hours)	52.2 N / 14 E (8.6 km)
NOAA IASI MetOp-B	1/10/2015 19:37:38Z (2.8 hours)	52.1 N / 14.6 E (34 km)
EUMETSAT IASI MetOp-B	1/10/2015 19:37:39Z (2.8 hours)	52 N / 14 E (20.9 km)

Max “k” case for IASI-EU … H20

NOAA Products Validation System (NPROVS)

Dewpoint / Temperature (deg K)

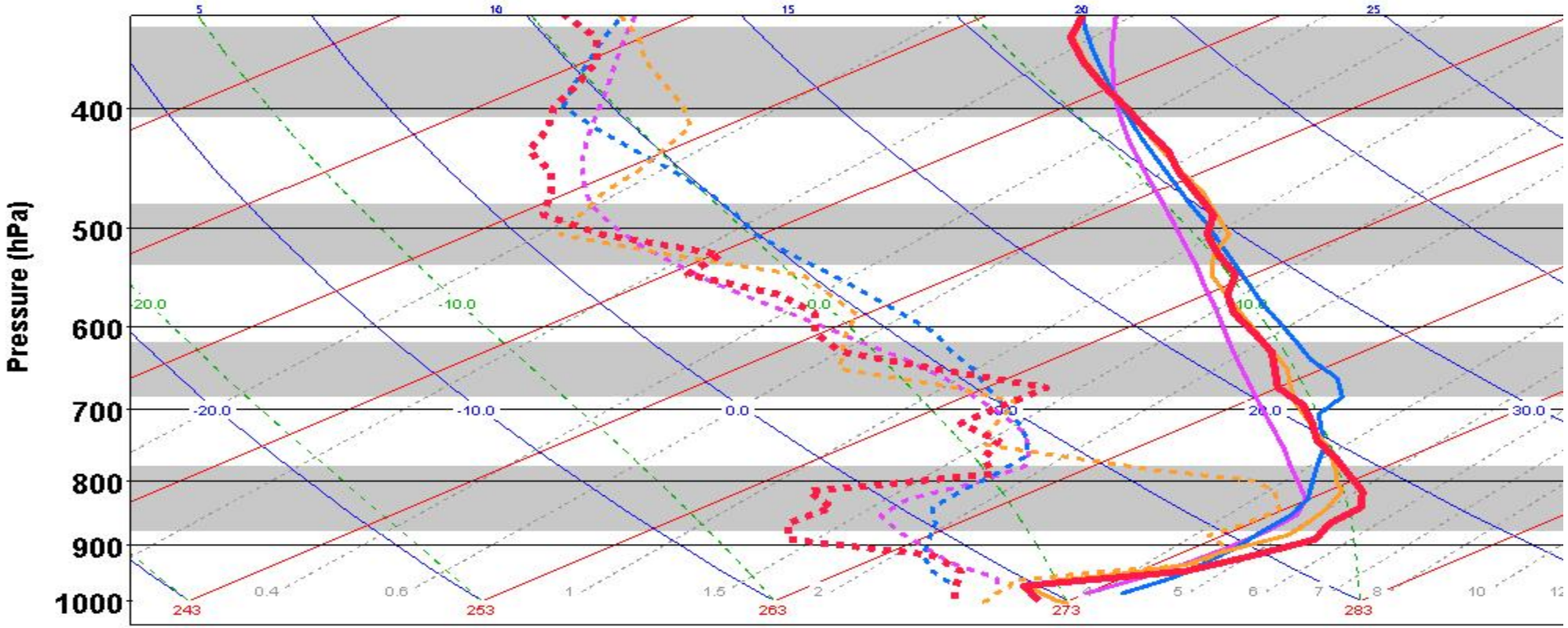


Radiosonde 47646 (272) Radiosonde	1/25/2016 11:30:00Z	36 N / 140.1 E
ECMWF	1/25/2016 12:00:00Z (0.5 hours)	36 N / 140 E (7.8 km)
NOAA IASI MetOp-B	1/25/2016 11:43:23Z (0.2 hours)	36 N / 140.1 E (5.7 km)
EUMETSAT IASI MetOp-B	1/25/2016 11:43:24Z (0.2 hours)	36.1 N / 140 E (9.2 km)

Max “k” case for IASI-NOAA … H20

NOAA Products Validation System (NPROVS)

Dewpoint / Temperature (deg K)

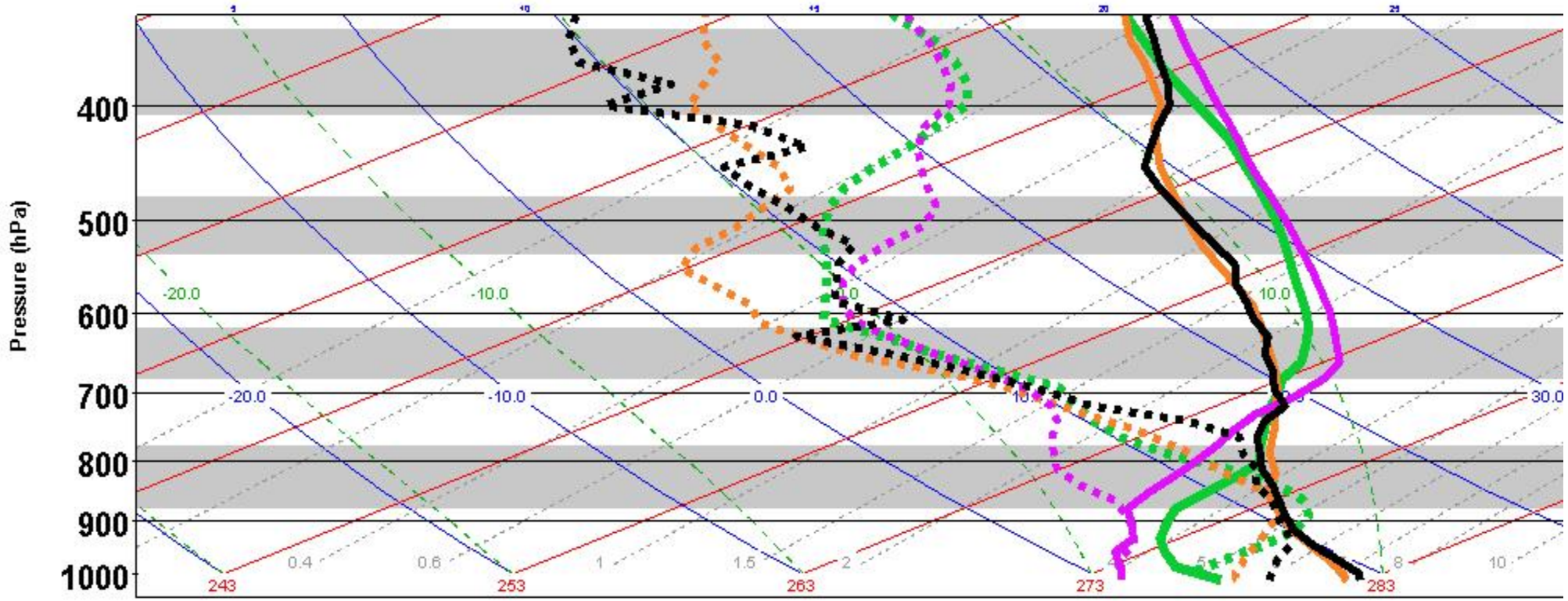


Radiosonde 10393 (272) Radiosonde	2/2/2017 10:45:00Z	52.2 N / 14.1 E
ECMWF	2/2/2017 12:00:00Z (1.2 hours)	52.2 N / 14 E (8.6 km)
NOAA IASI MetOp-B	2/2/2017 9:49:39Z (-0.9 hours)	52.5 N / 13.9 E (29.6 km)
EUMETSAT IASI MetOp-B	2/2/2017 9:49:40Z (-0.9 hours)	52.3 N / 14 E (13.9 km)

Max “k” case for ECMWF … H20

NOAA Products Validation System (NPROVS)

Dewpoint / Temperature (deg K)



Radiosonde 06260 (272) Radiosonde	3/18/2014 23:35:00Z	52.1 N / 5.2 E
AIRS AQUA	3/19/2014 1:14:40Z (1.6 hours)	52.3 N / 5.1 E (20.8 km)
ECMWF	3/19/2014 0:00:00Z (0.4 hours)	52 N / 5.2 E (12.5 km)
NUCAPS NPP	3/19/2014 1:22:14Z (1.8 hours)	52.3 N / 5.2 E (25.7 km)

Max “k” case for AIRS … Temp

Summary

• NPROVS collocations with GRUAN used to compare IR-based IASI, AIRS and ECMWF atmospheric profiles

• Assessment includes uncertainty estimates traceable to GRUAN v2 processing (*and specific to global sample used*)

• Overall, uncertainty estimates appear lowest for ECMWF followed by IASI EU and NOAA … *IASI EU also has about 35% lower global yield than IASI NOAA*

• Typical atmospheric uncertainty estimates for IASI-EU (0.6K and *0.30 g/kg*) and IASI-NOAA (0.7K and *0.45 g/kg*); *moisture below 500 hPa*

• Assessments suggest cases of:
  • suspicious GRUAN v2 uncertainty *(radiation and high moisture)*
  • suspicious satellite and ECMWF profiles in collocation dataset

• Cooperative exchange among NASA, NOAA, EUMETSAT and GRUAN encouraged