STAR Center for Satellite Applications and Research
formerly ORA — Office of Research and Applications

GRUAN/NPROVS

Tony Reale
Bomin Sun, Frank Tilley, Michael Pettey, Nick Nalli

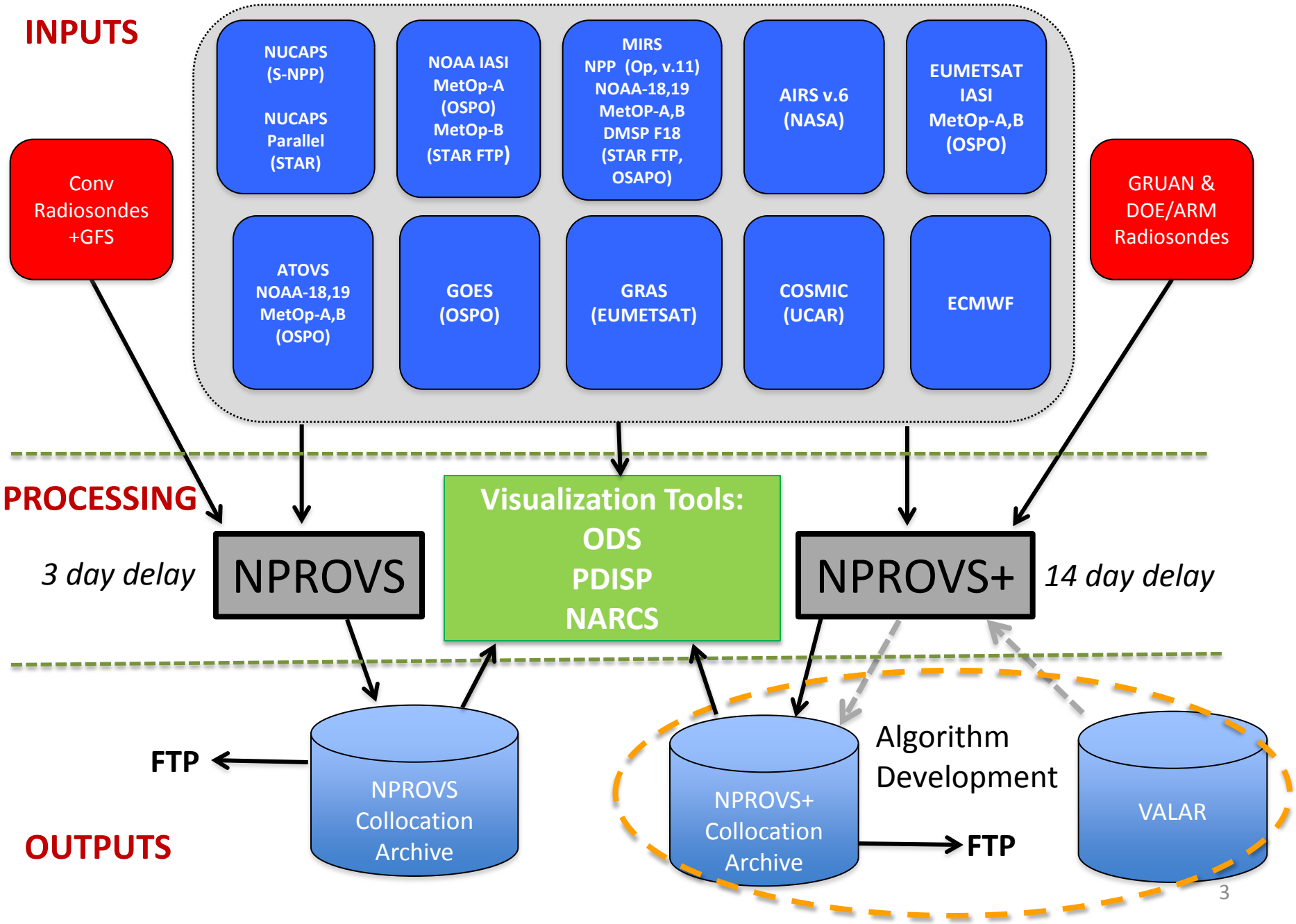
NOAA
Center for Satellite Applications and Research (STAR}
College Park, Md

GRUAN ICM-8
April 25-29, 2016
Boulder Colorado

Outline

- NPROVS/NPROVS+ status
- NPROVS+ is Expanding (dedicated RAOB, field experiments, Sterling … AM , SASBE)
  - "3G" connection
- GRUAN Uncertainty Integration
  - Analysis and Feedback
- Sterling / Beltsville
- Helping out more
  - RAOB v3, transition to RS41 …

NPROVS/NPROVS+ Data Management Schematic



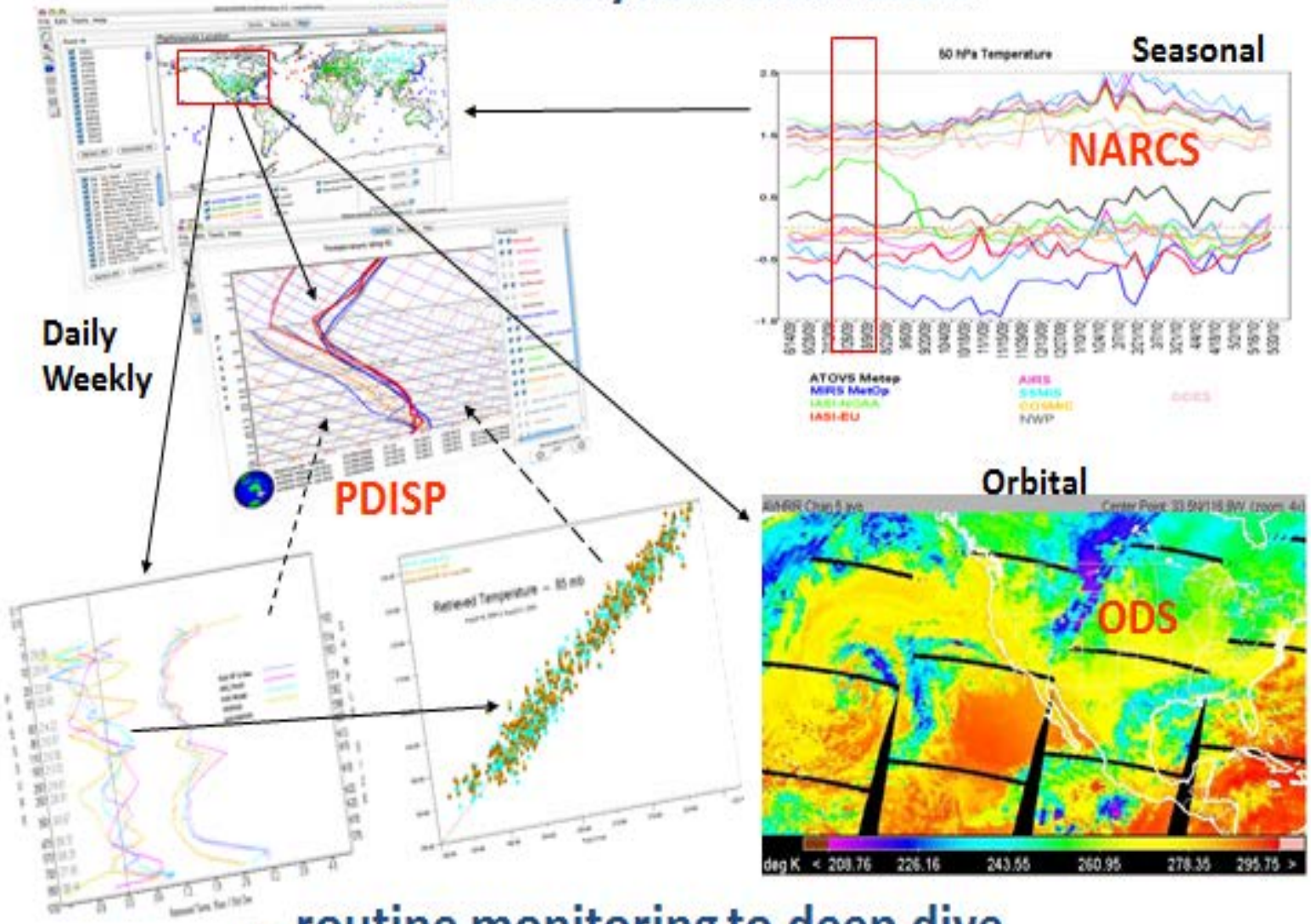
Collocation Criteria:

+/- 6-hour

250 km

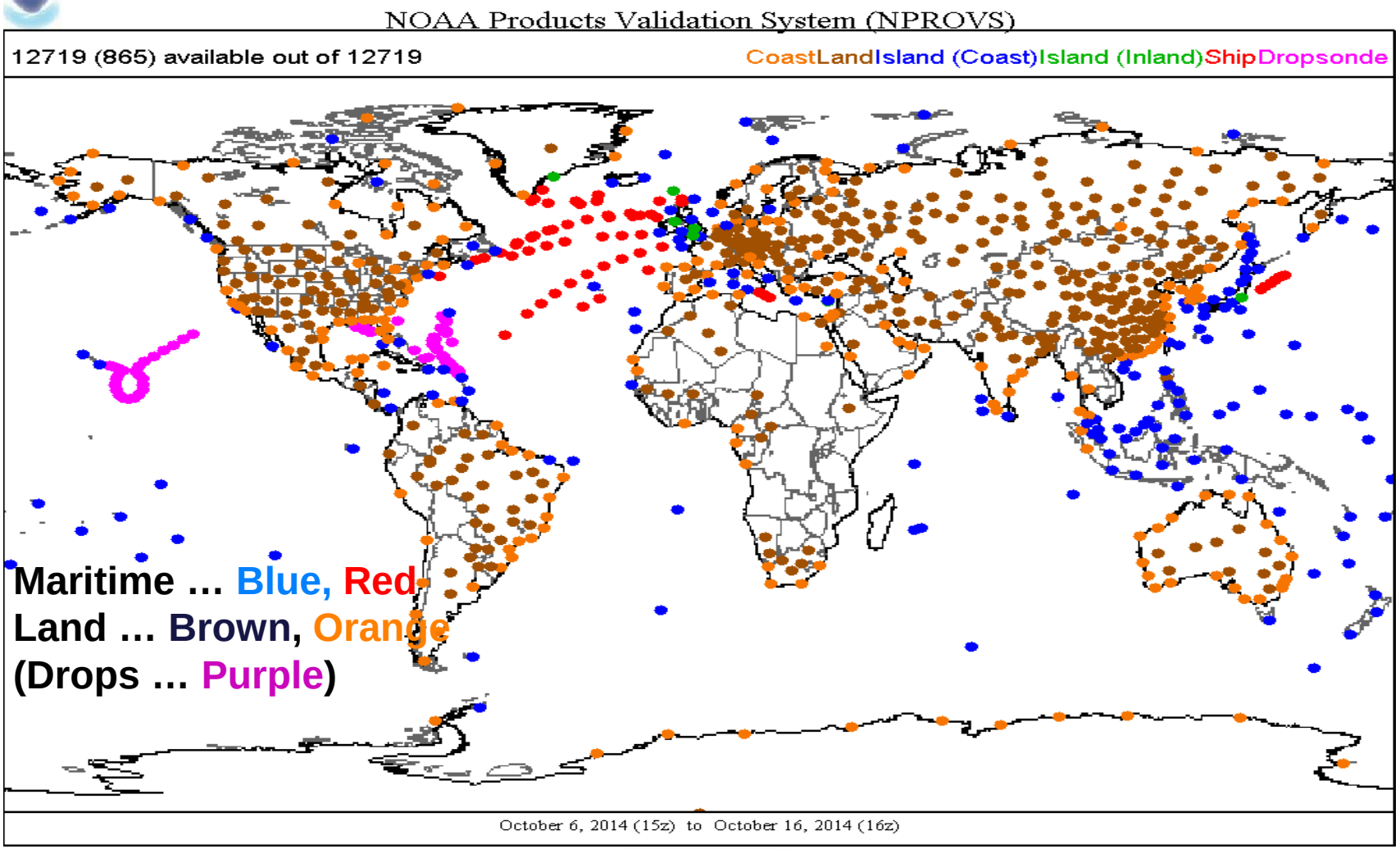
Single Closest

EDGE Analytical Interface …



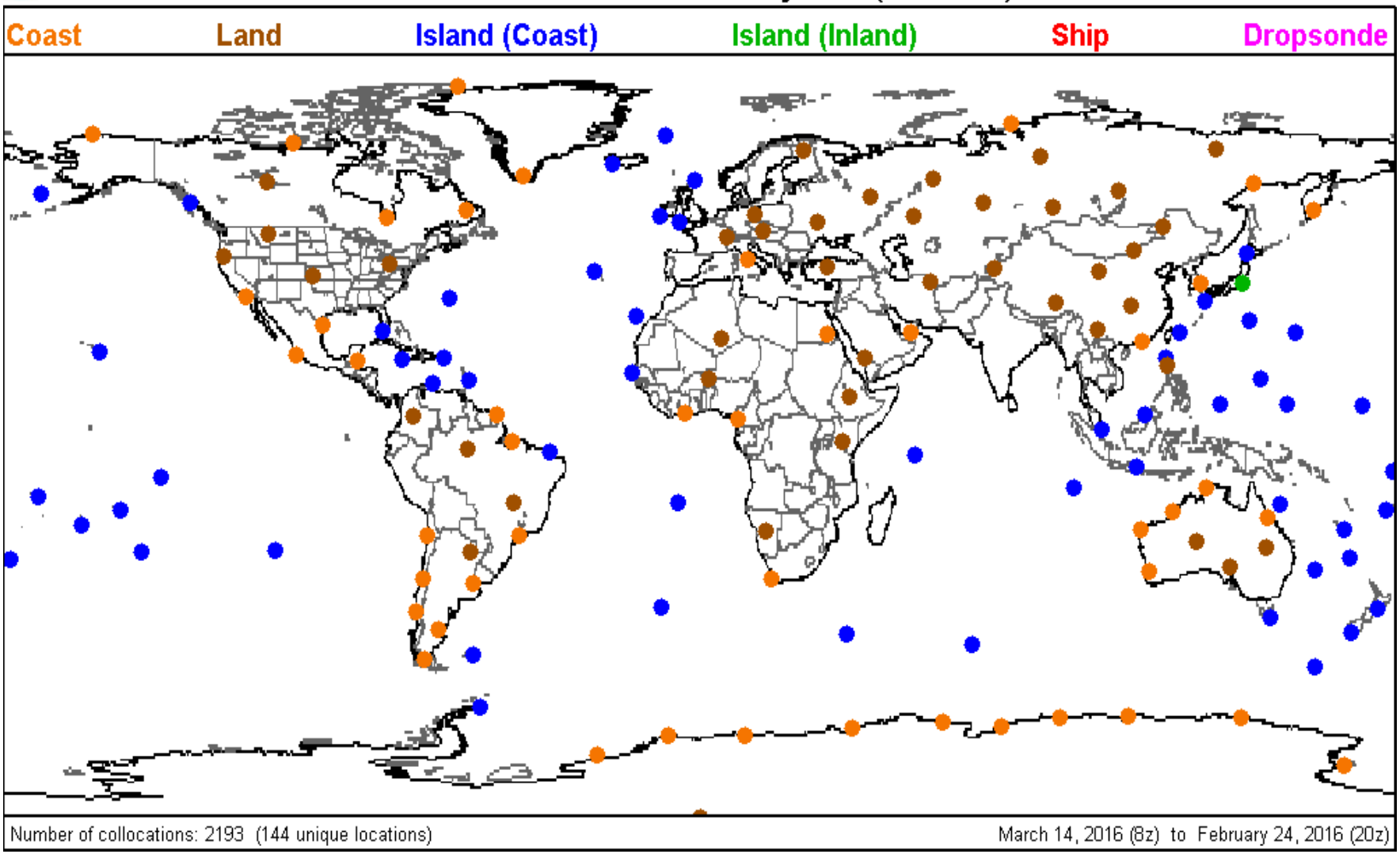
… routine monitoring to deep dive

N P R O V S

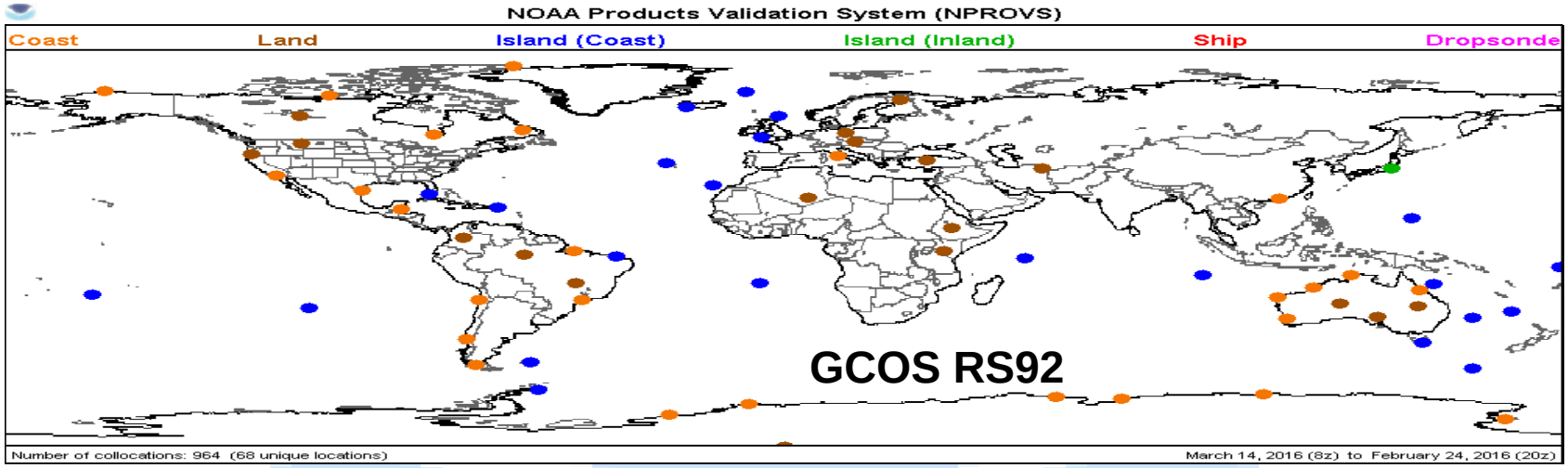


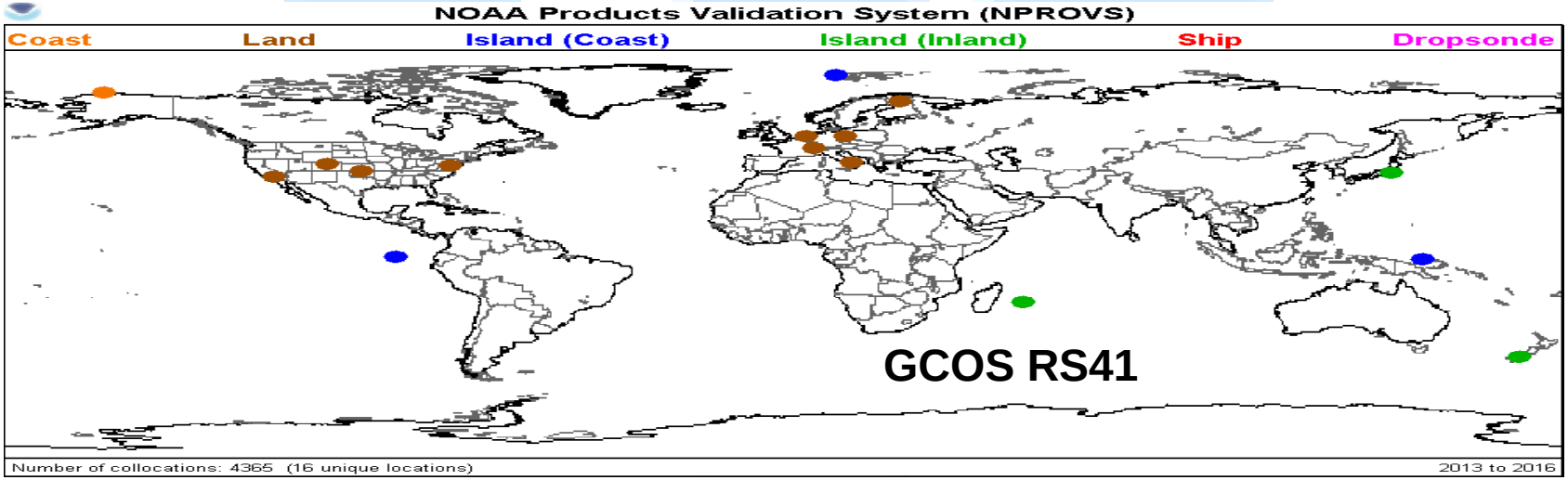
Typical NPROVS Global Collocation Dataset
(1000 collocation records per day)

NOAA Products Validation System (NPROVS)

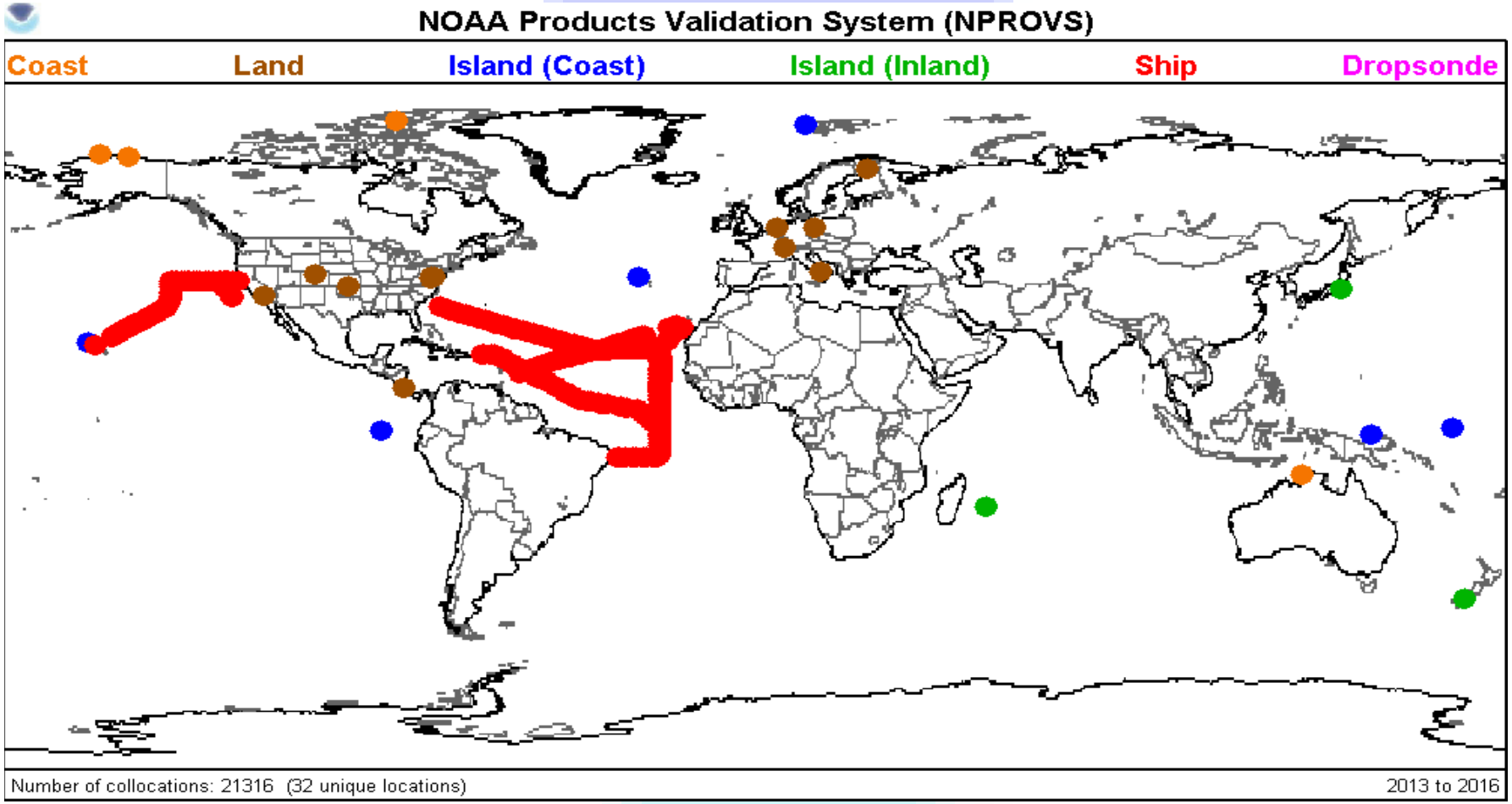


GCOS Subset


NOAA Products Validation System (NPROVS)
Coast
Land
Island (Coast)
Island (Inland)
Ship
Dropsonde
GCOS RS92
Number of collocations: 964 (68 unique locations)
March 14, 2016 (8z) to February 24, 2016 (20z)


NOAA Products Validation System (NPROVS)
Coast
Land
Island (Coast)
Island (Inland)
Ship
Dropsonde
GCOS RS41
Number of collocations: 4365 (16 unique locations)
2013 to 2016

N P R O V S +



GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 20,000 RAOBS (2000+ Dedicated) available since July 2013 thru April 2016

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
- Sterling Test Site …

GAIA-CLIM Coordination

3G Coordination (GRUAN, GPSRO, GSICS)

GEWEX-GVAP

2015 inputs to NPROVS+ via LC and/or respective site

Site	within 7 days	60-days+	Received from site
BAR	523	819	851
BEL	0	0	53
SGP	1172	1534	1752
BOU	8	47	
CAB	344	375	
ENA			390
LAU	8	15	50
LIN	1382	1446	
NYA	350	363	
OLI			274
PAY	20	53	
POT	28	32	
REU	5	19	
SCR	17	17	
SOD	161	693	
Sterling			252
TAT	53	53	

… feedback to GRUAN

connect between GRUAN and GSICS could be:

"GSICS could provide travelling reference (in space, eg CrIS, ATMS) standards for GRUAN stations, while GRUAN with Radiative Transfer Models (RTM) could
provide references for MW, IR *calibration"…*

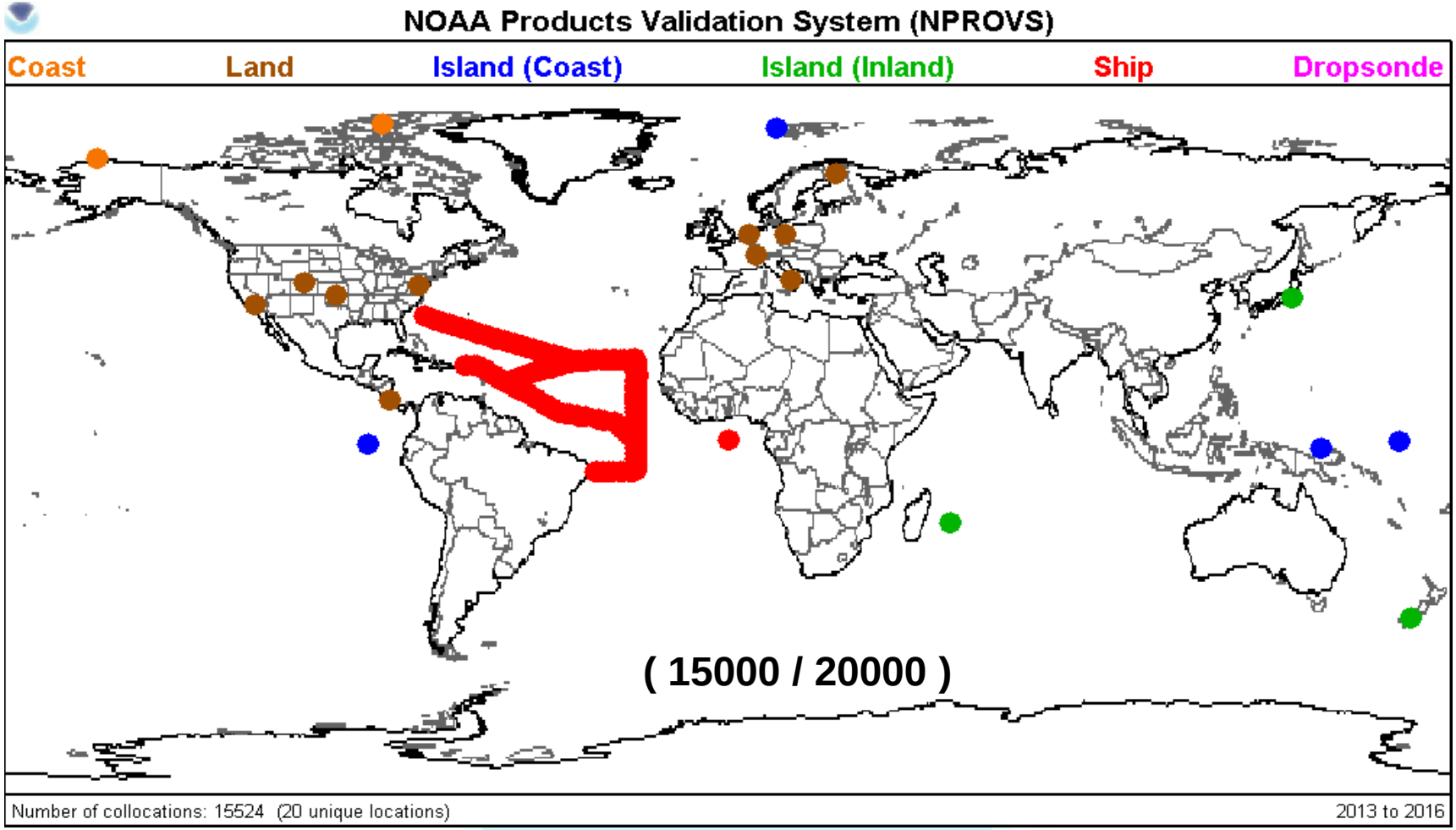
highlighted by Mitch Goldberg in GSICS Executive Panel meeting …

"3G" Coordination (RAOB launch)

- JPSS funds dedicated RS92 RAOB at ARM, Beltsville, etc
  - includes dual sequential (30 minutes apart…)
- Expand to target GPSRO (COSMIC) and GSICS (ATMS, CrIS…)
  - GRAS (MetOp) via EUMETSAT ?
- RTM calculation installed (via GAIA-CLIM …)
  - RTTOV, CRTM …
- Sterling (Test Site) / Beltsville synchronized dedicated launch
  - includes simultaneous sequential (Test Site)
  - target GPSRO
- Other …

Integrating Uncertainty in

NPROVS+ analytic interface (PDISP)



NPROVS+ Subset that are GRUAN processed RAOB

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

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

… in following plots :

"k" = ABS(X – GRUAN) / u2

where u2 is GRUAN uncertainty

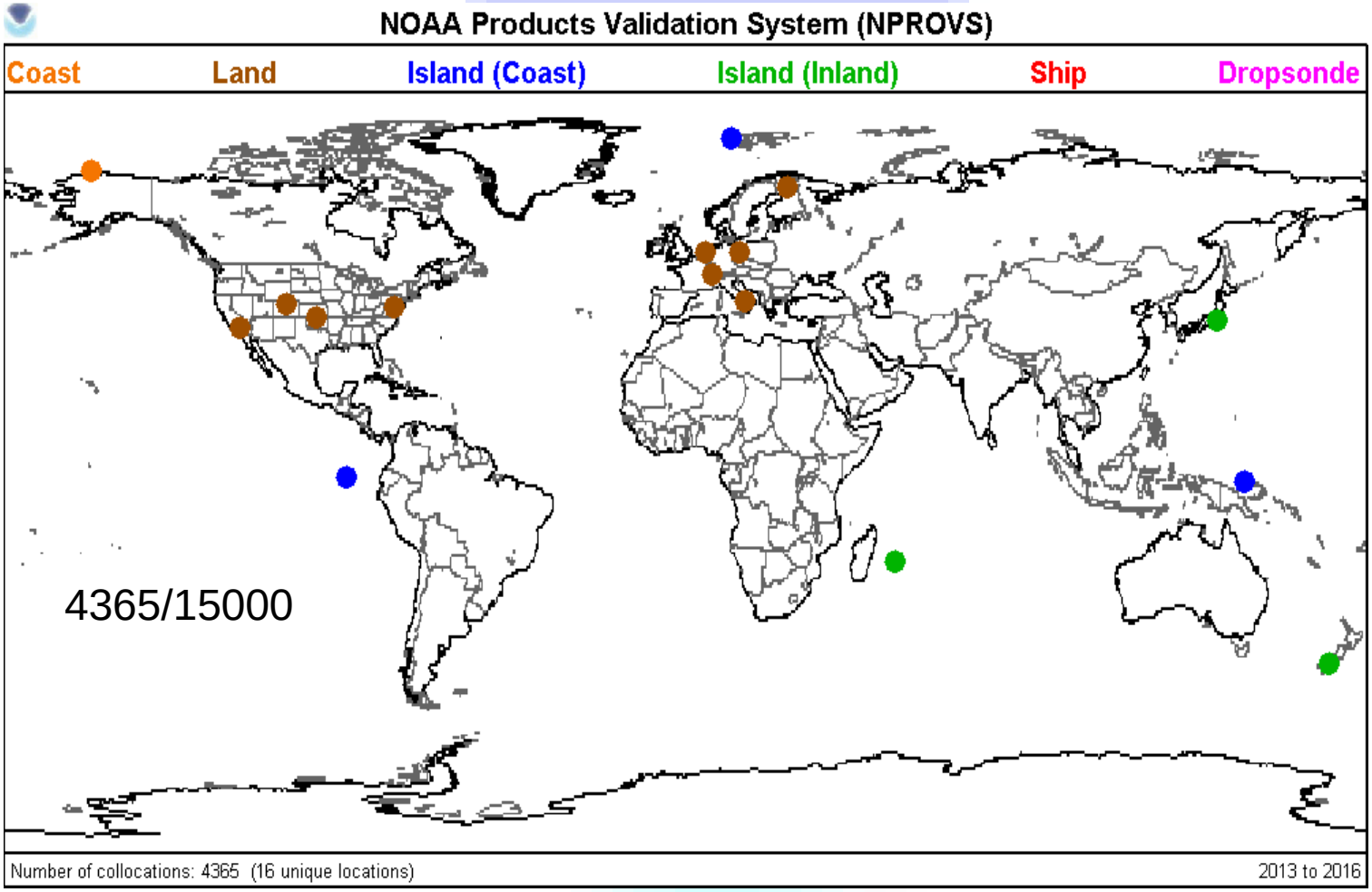
$\sigma^2 + u_1^2$ ~ (("k"/2)^2 –1) (u2)^2 ; $u_1 = a(u_2)$

σ^2 ~ (("k"/2)^2 –1 – a^2) (u2)^2

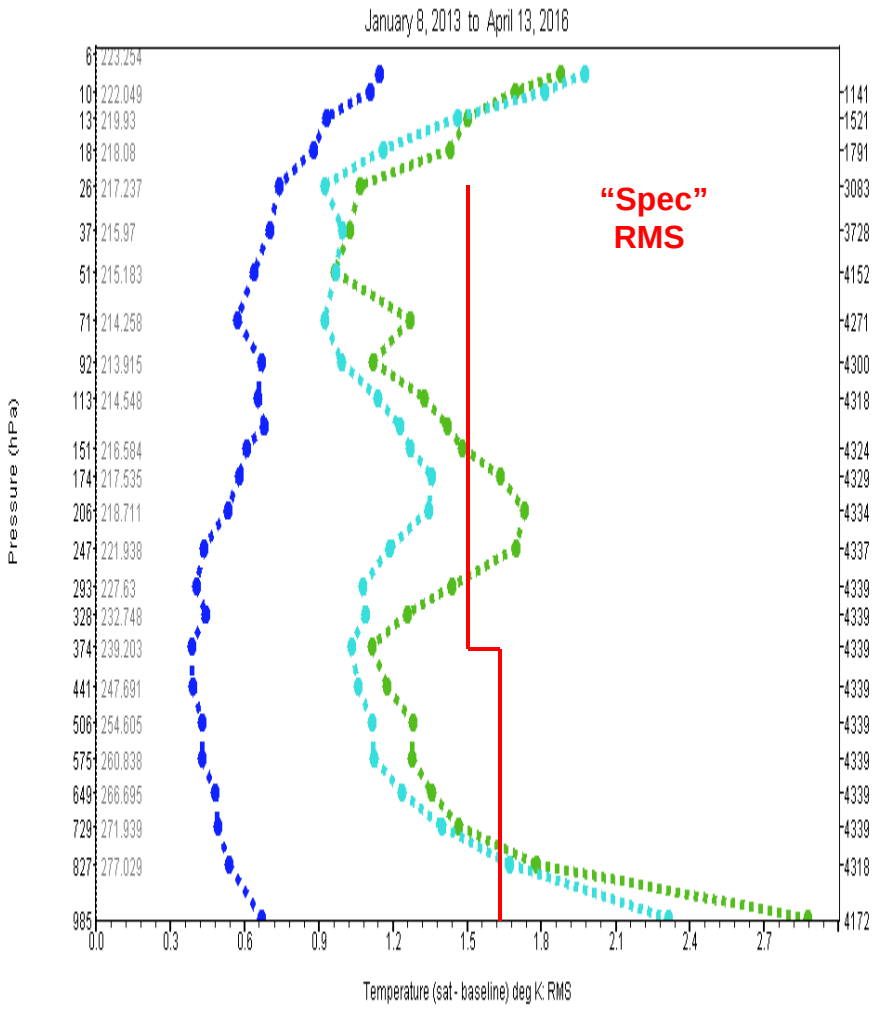
Integrating Uncertainty in

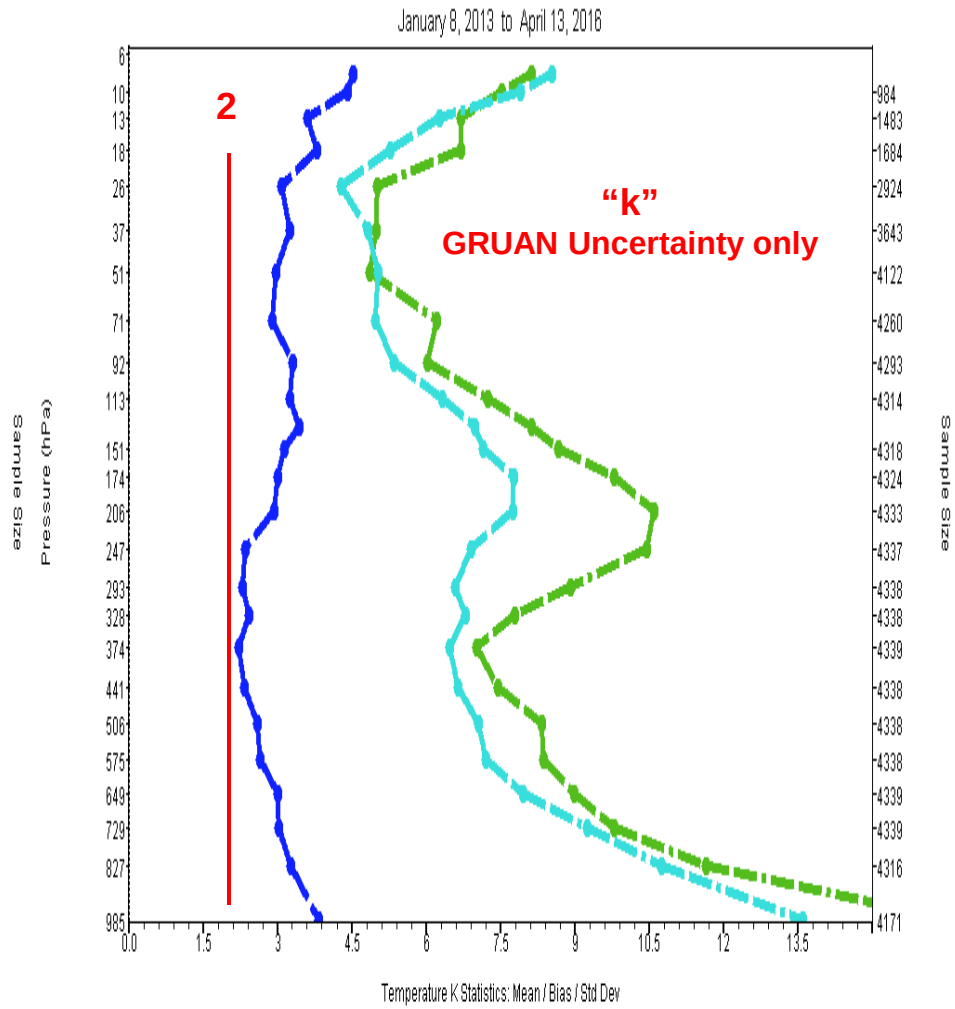
NPROVS+ analytic interface …

Provides more robust satellite product cal / val



GRUAN collocations with high quality satellite derived Sounding (NUCAPS, AIRS and ECMWF)





Baseline: Sonde

AIRS AQUA ECMWF NUCAPS NPP

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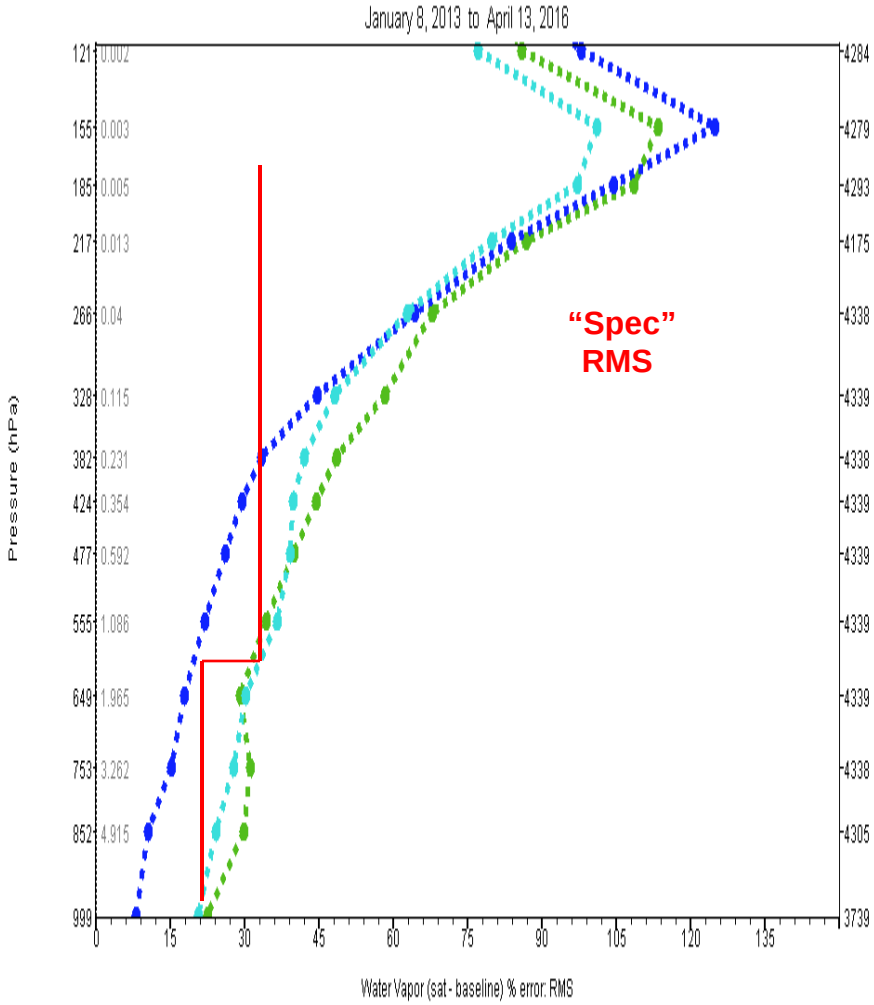
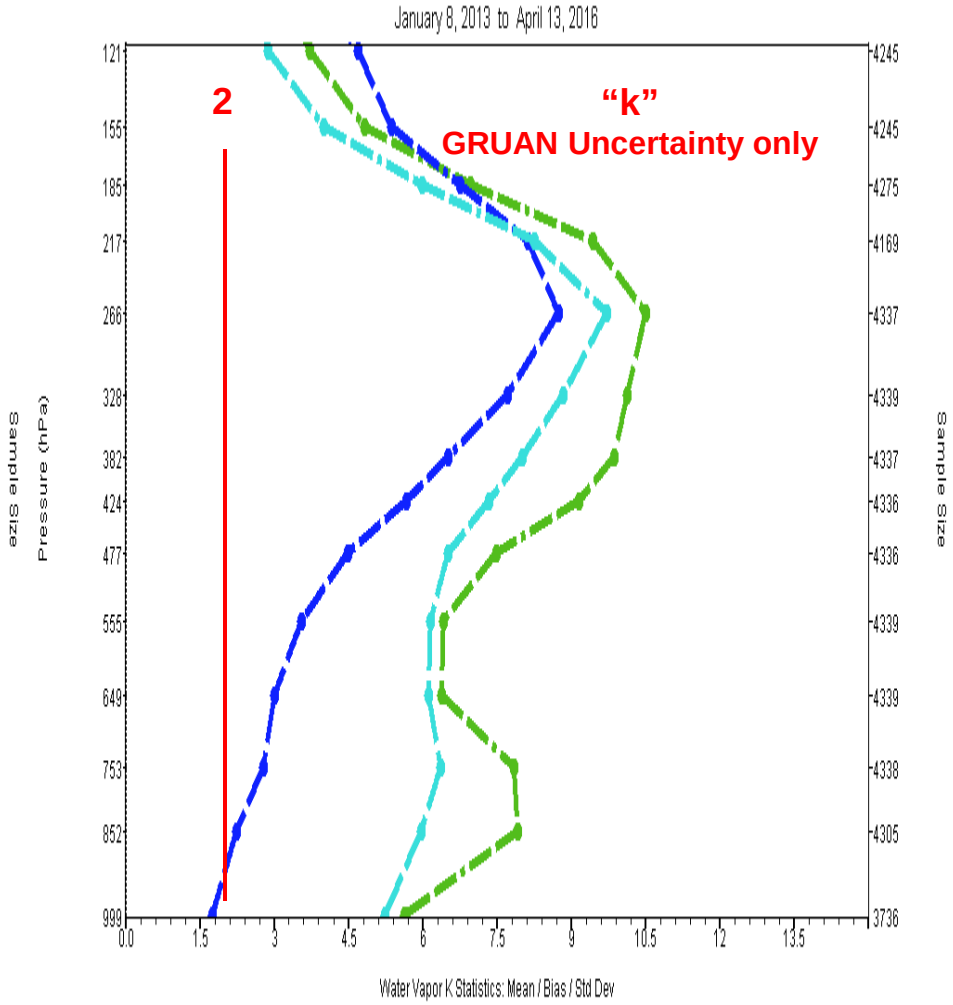
AIRS AQUA ECMWF NUCAPS NPP





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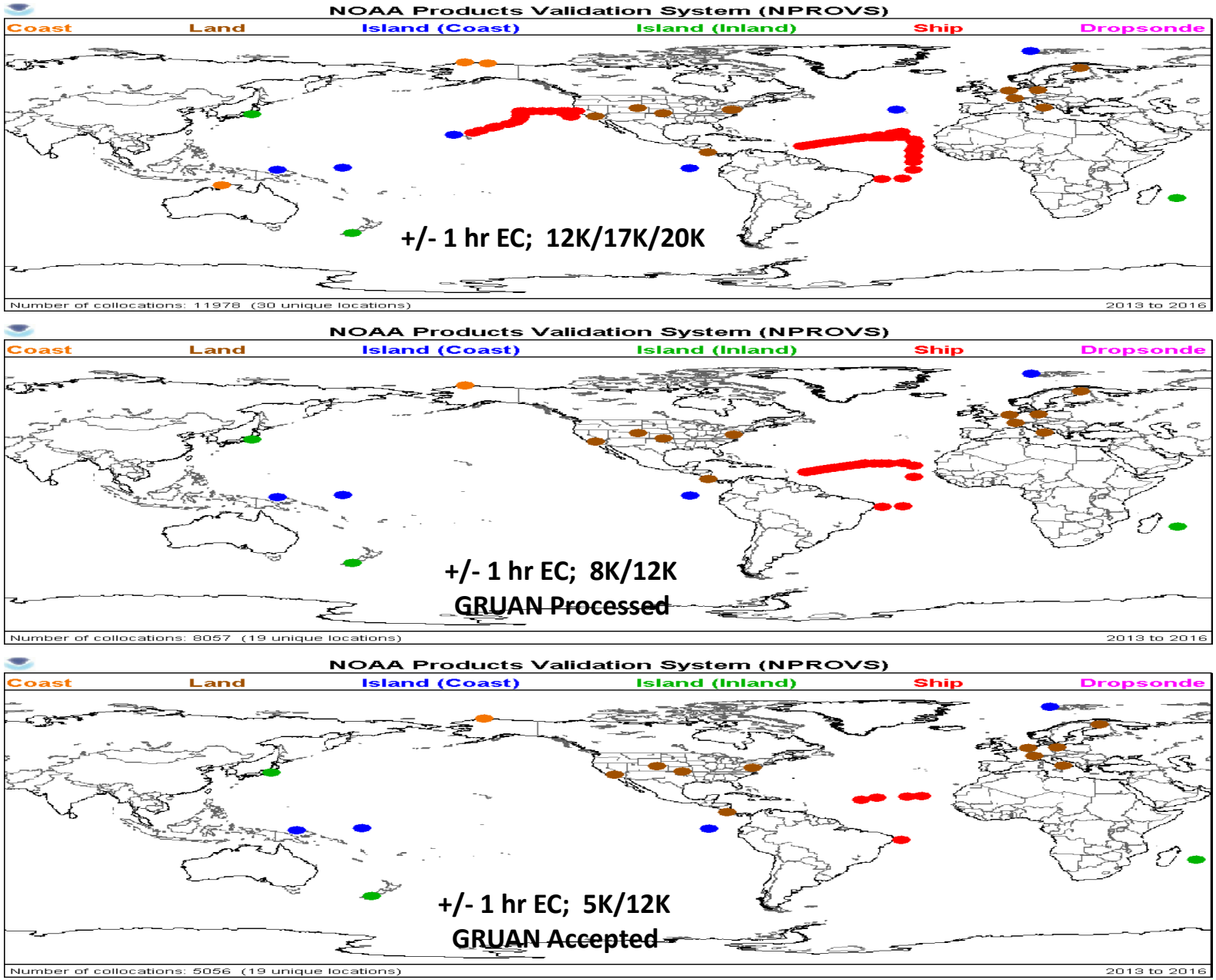
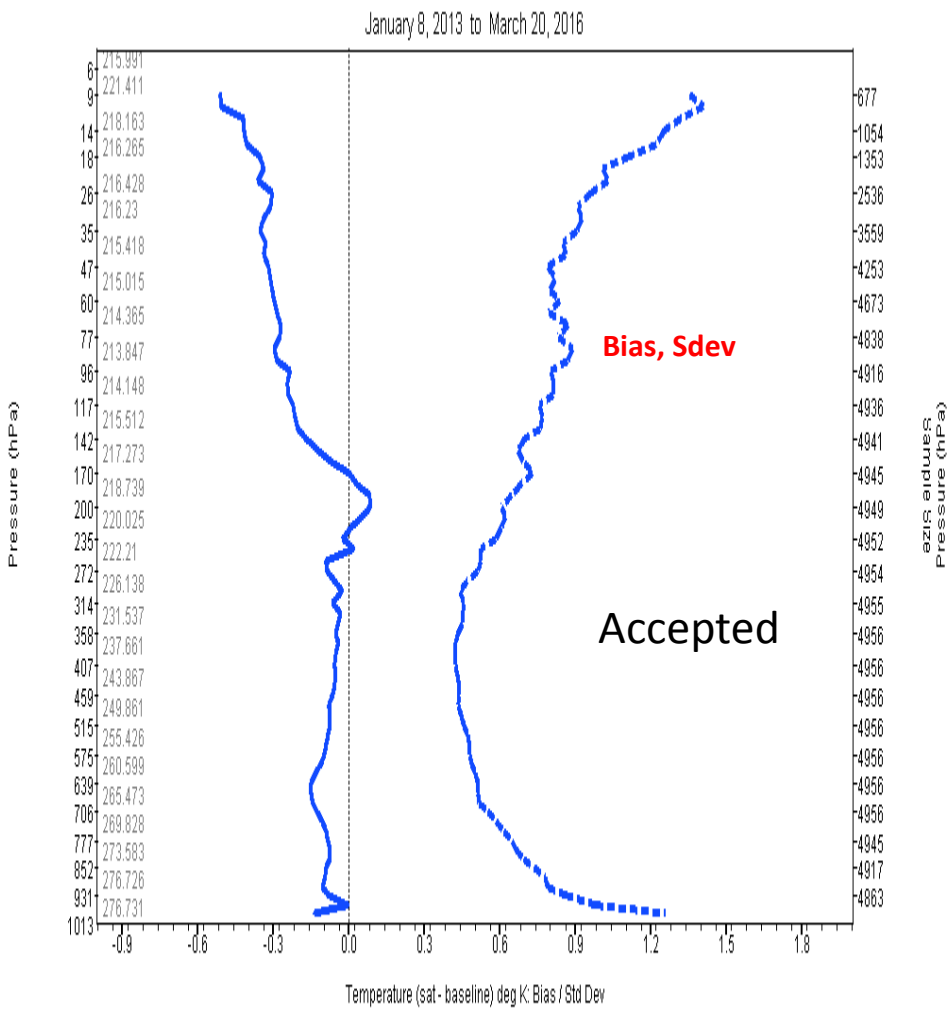
Integrating Uncertainty in

NPROVS+ analytic interface …

Characterize GRUAN RAOB and ECMWF

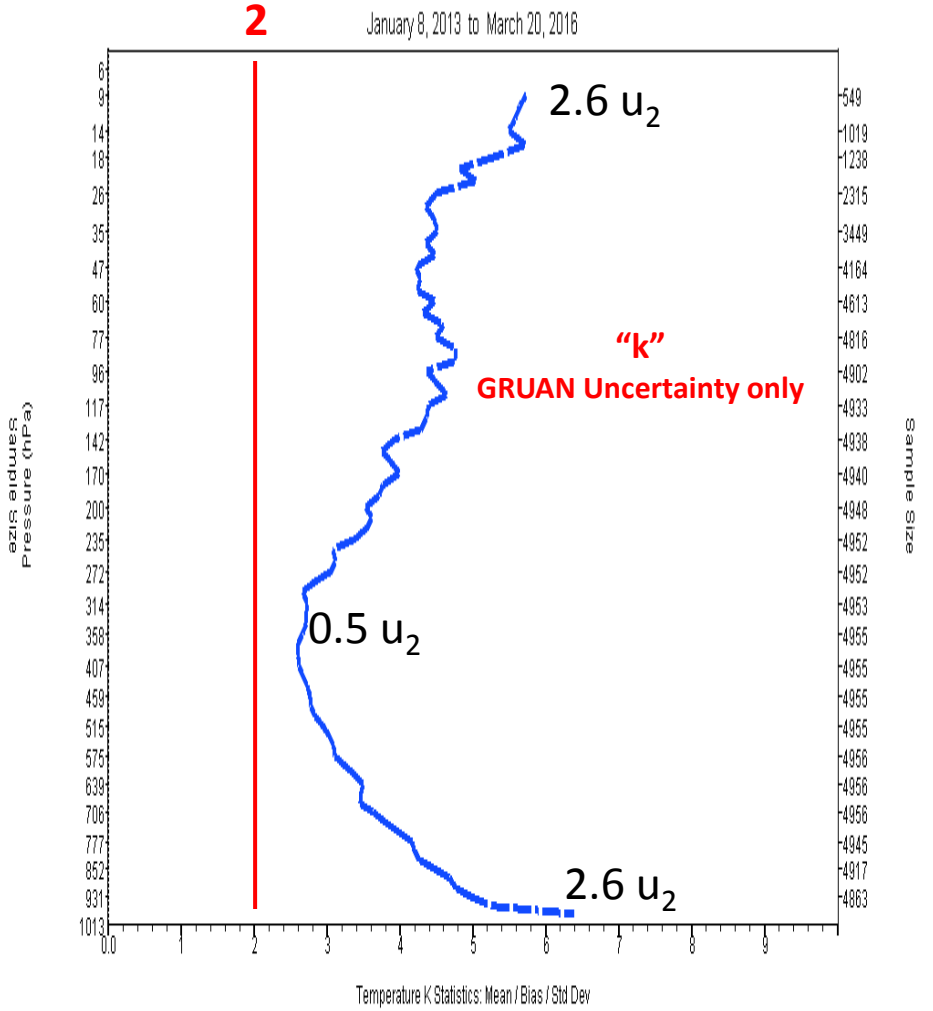


GRUAN collocations with ECMWF



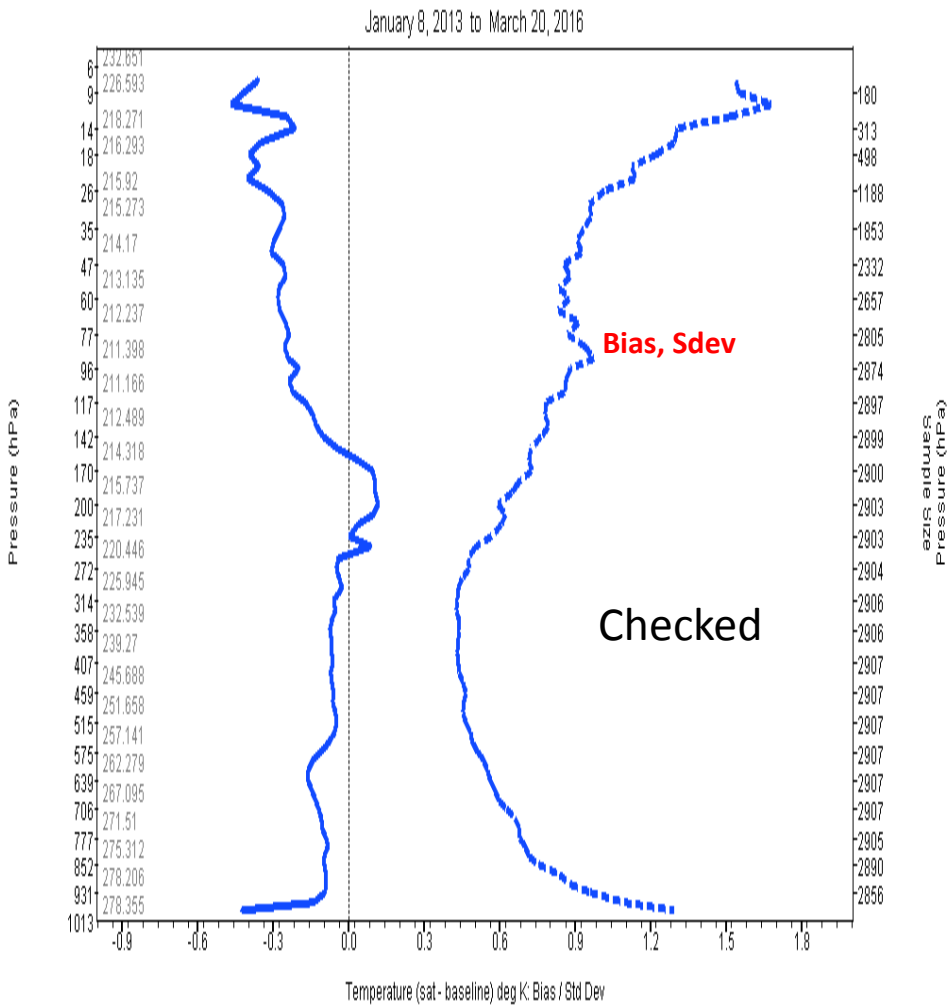
Baseline: Sonde

ECMWF



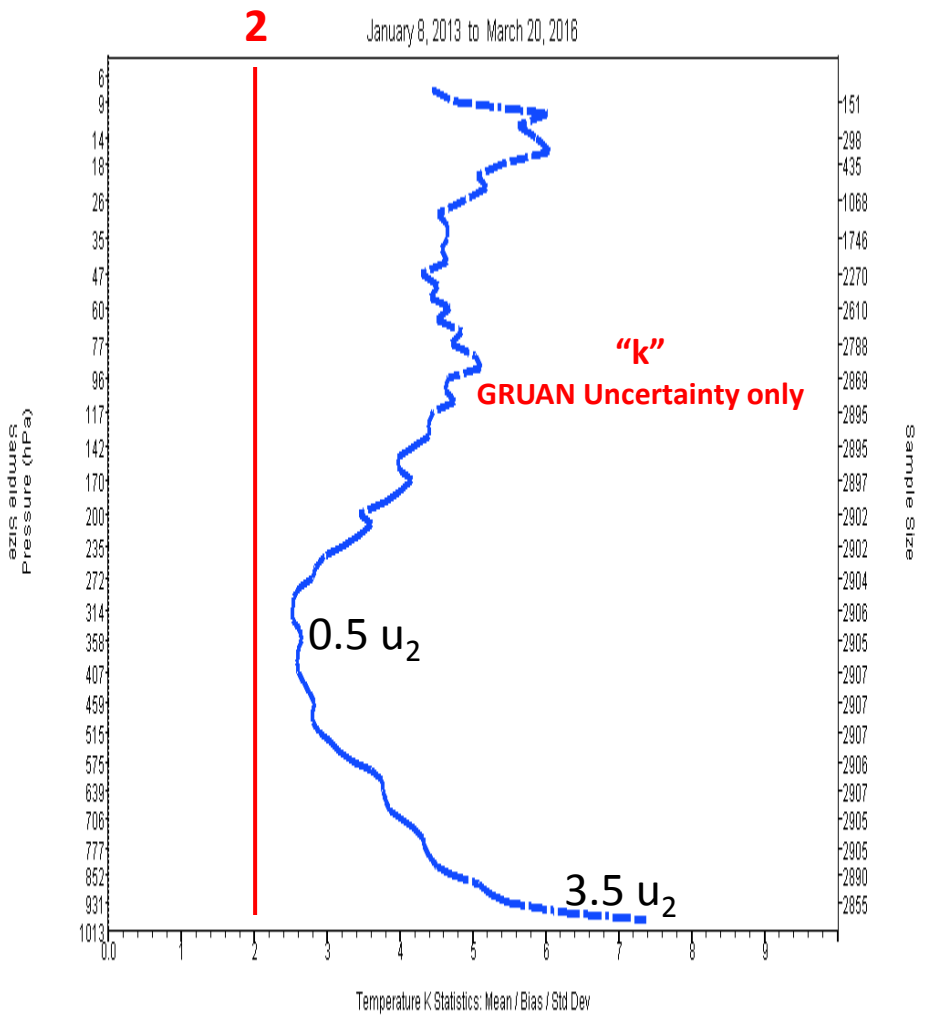
Baseline: Sonde

ECMWF



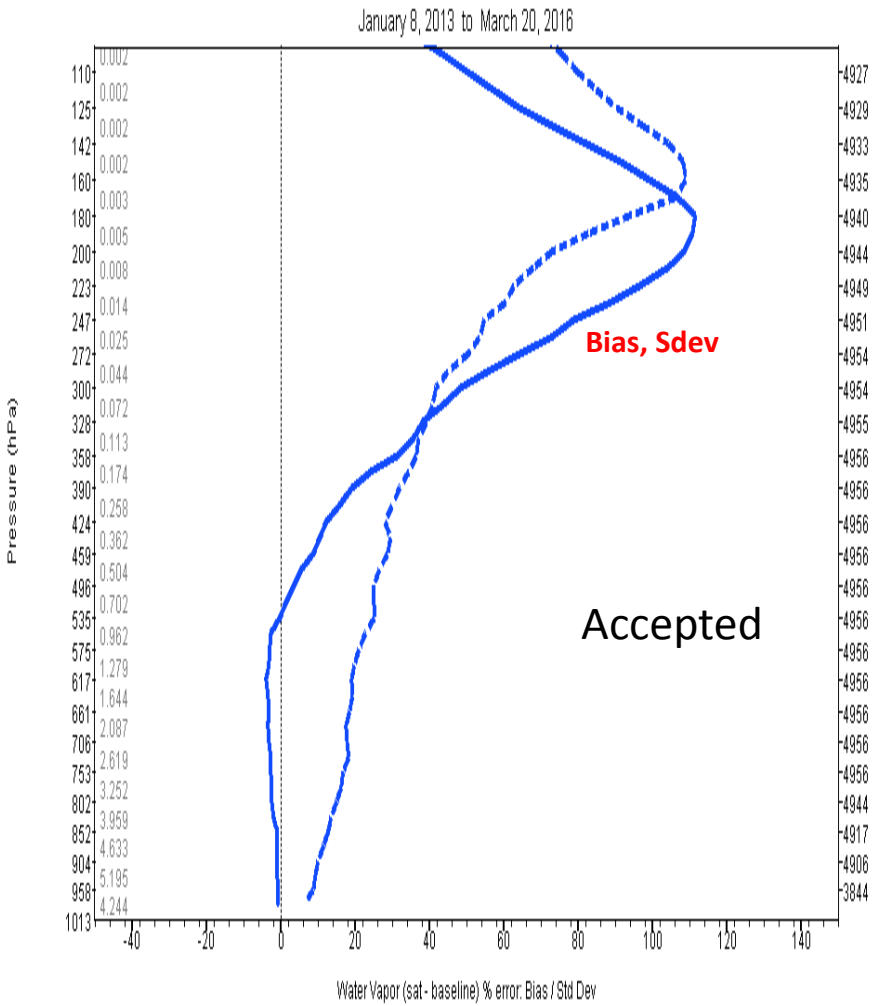
Baseline: Sonde

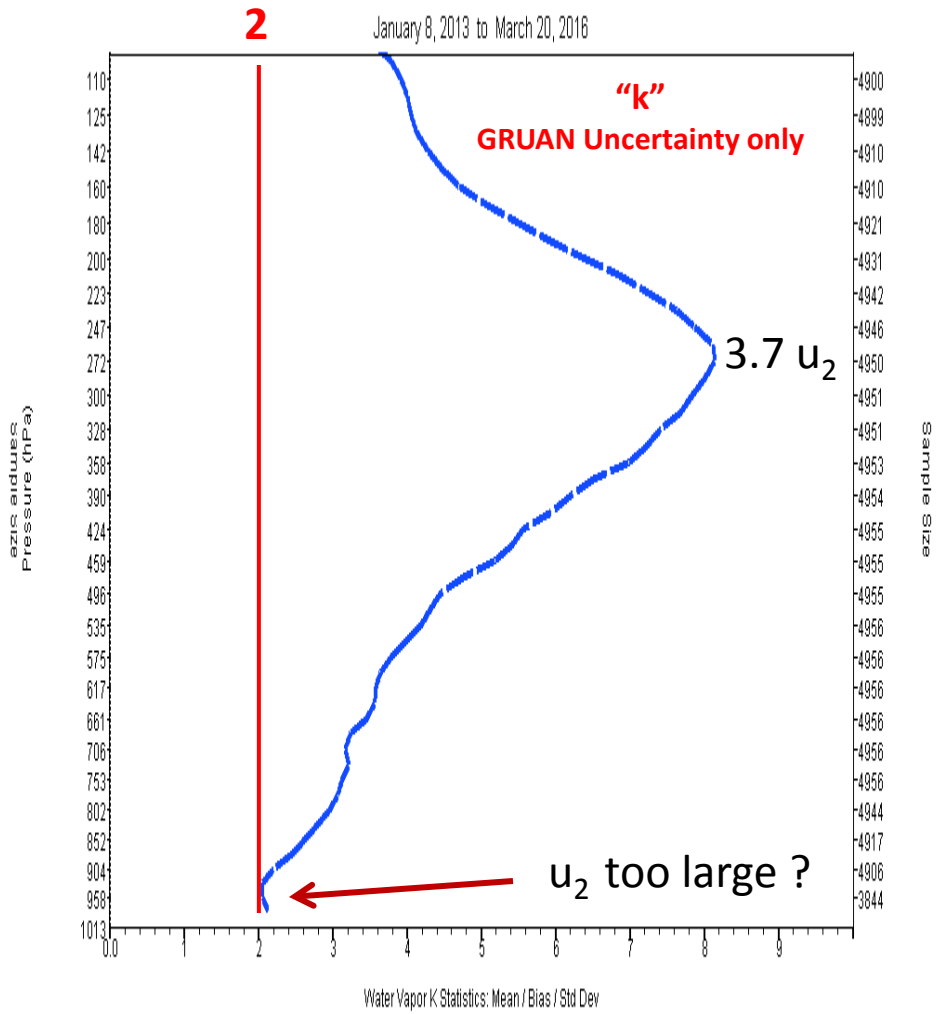
ECMWF



Baseline: Sonde

ECMWF



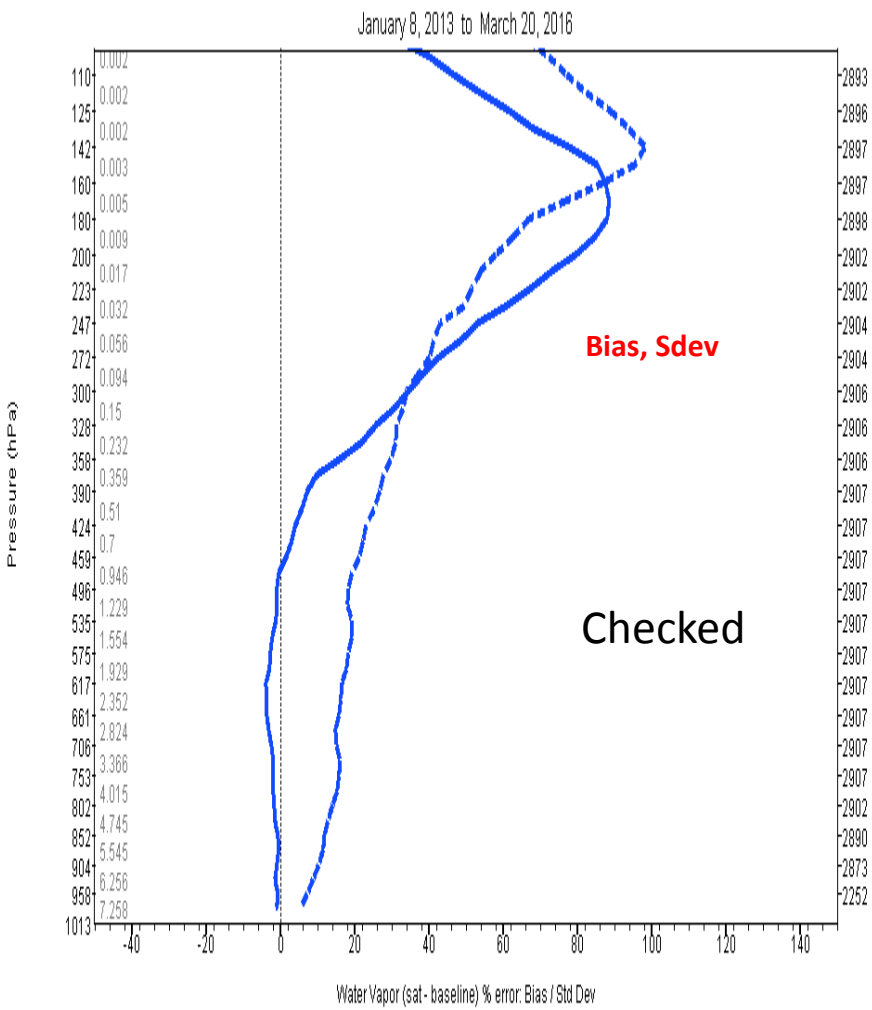


Baseline: Sonde

ECMWF

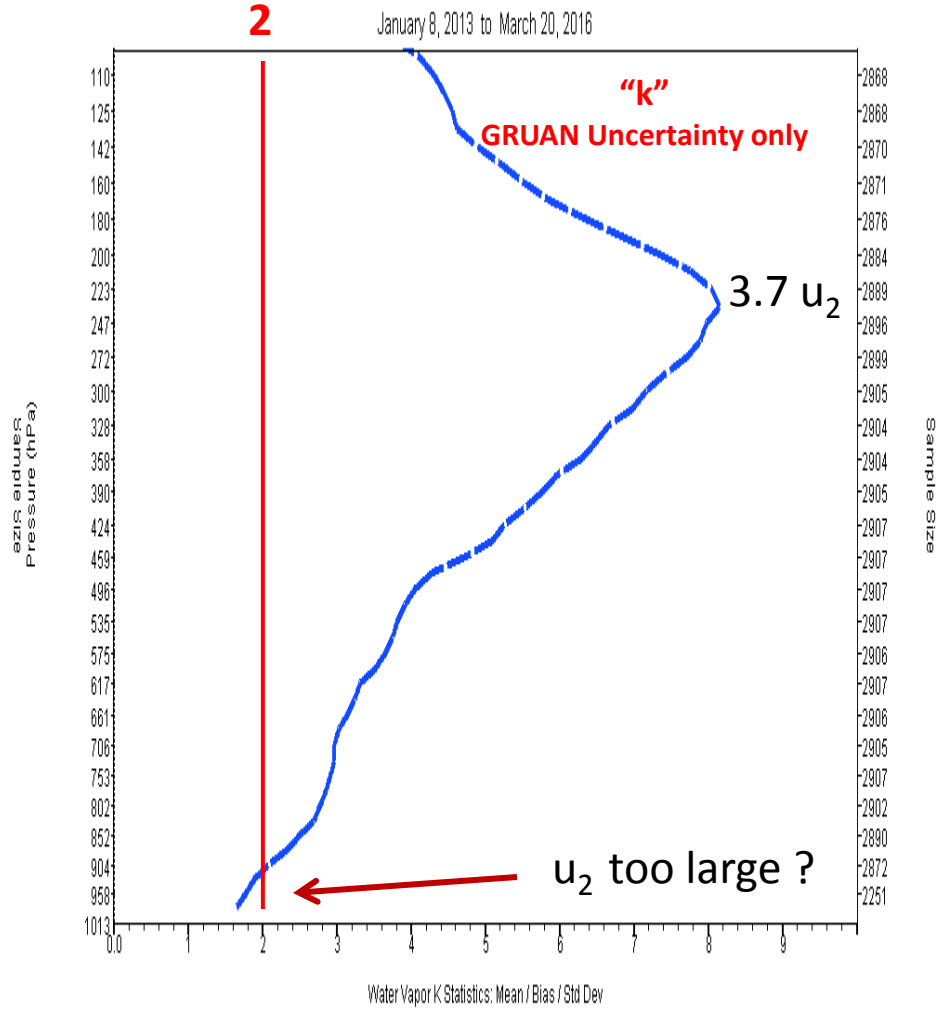
Baseline: Sonde

ECMWF



Baseline: Sonde

ECMWF



Baseline: Sonde

ECMWF

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

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

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

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

Integrating Uncertainty in

NPROVS+ analytic interface …

Characterize GRUAN RAOB and GPSRO (Tdry)

GSICS Global Space-based Inter-Calibration System
Quarterly
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

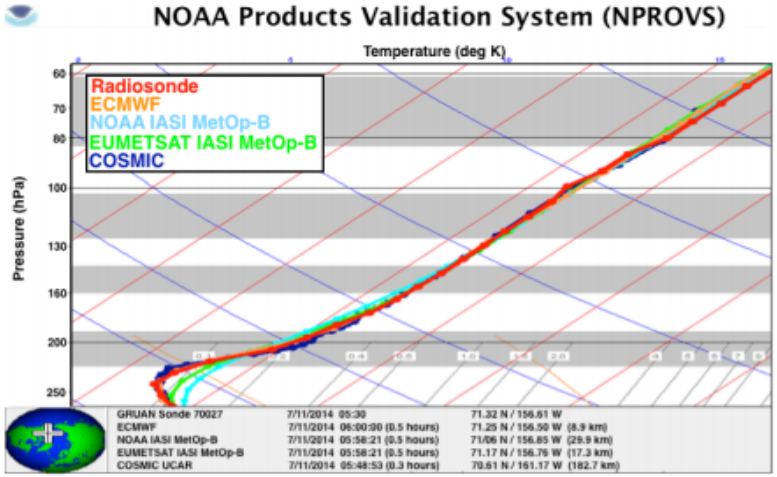
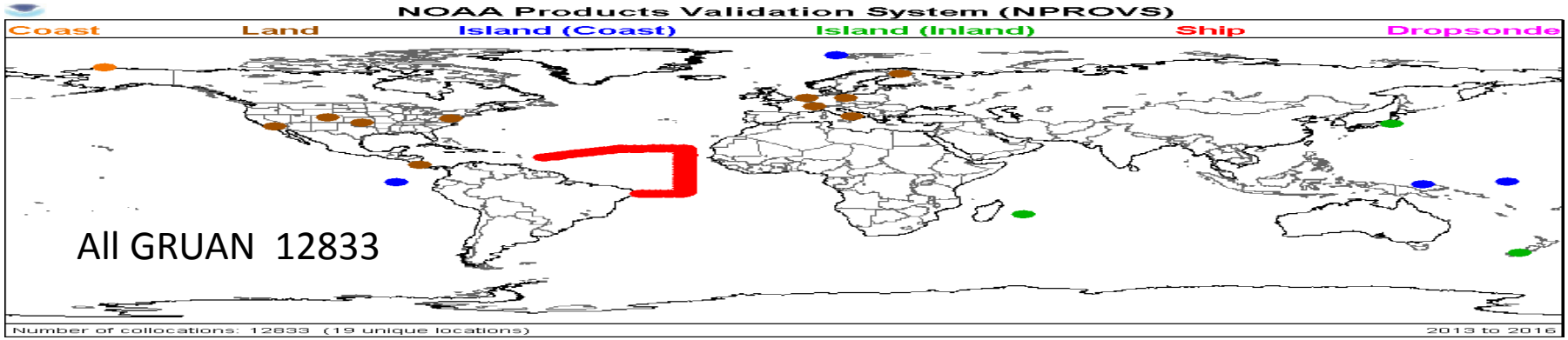
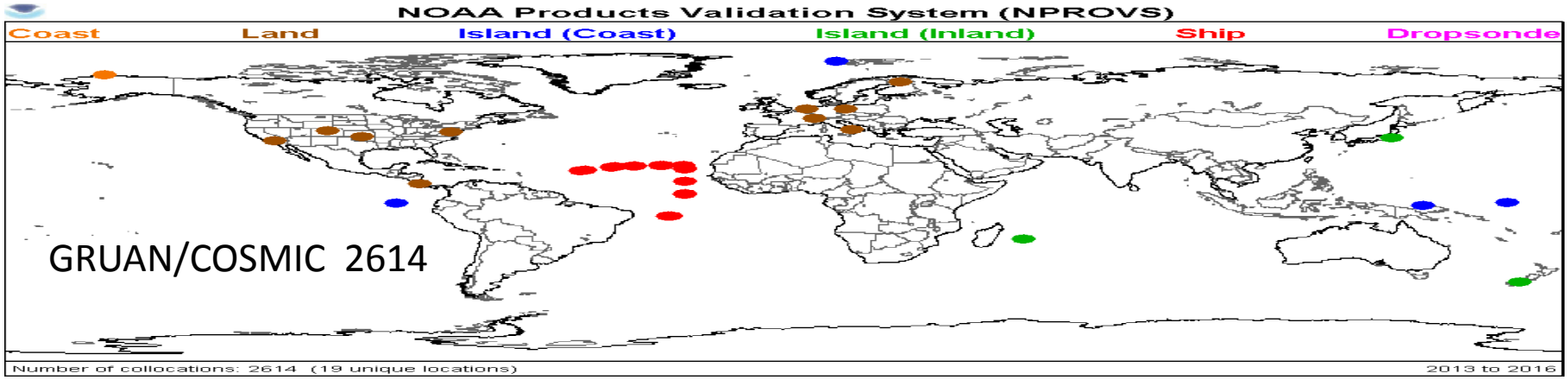
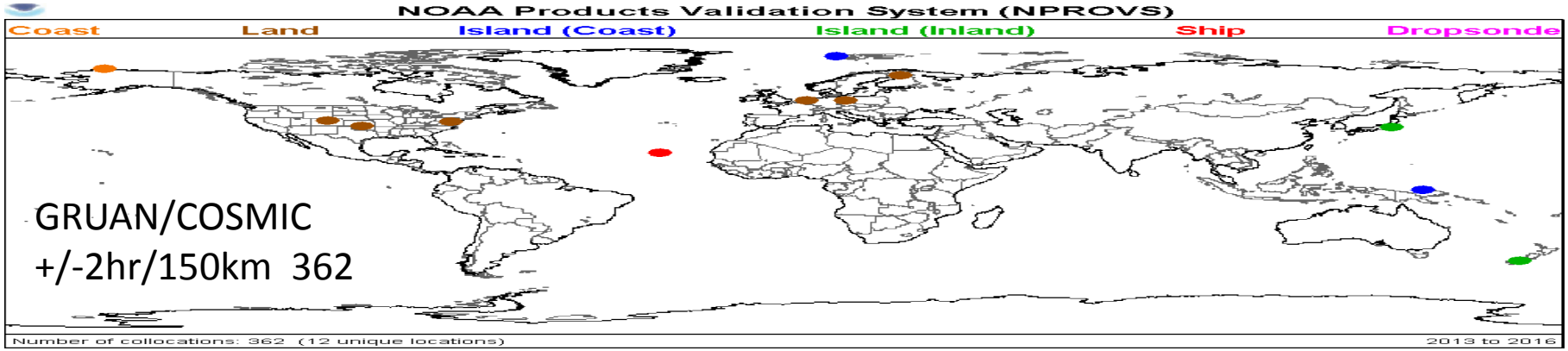


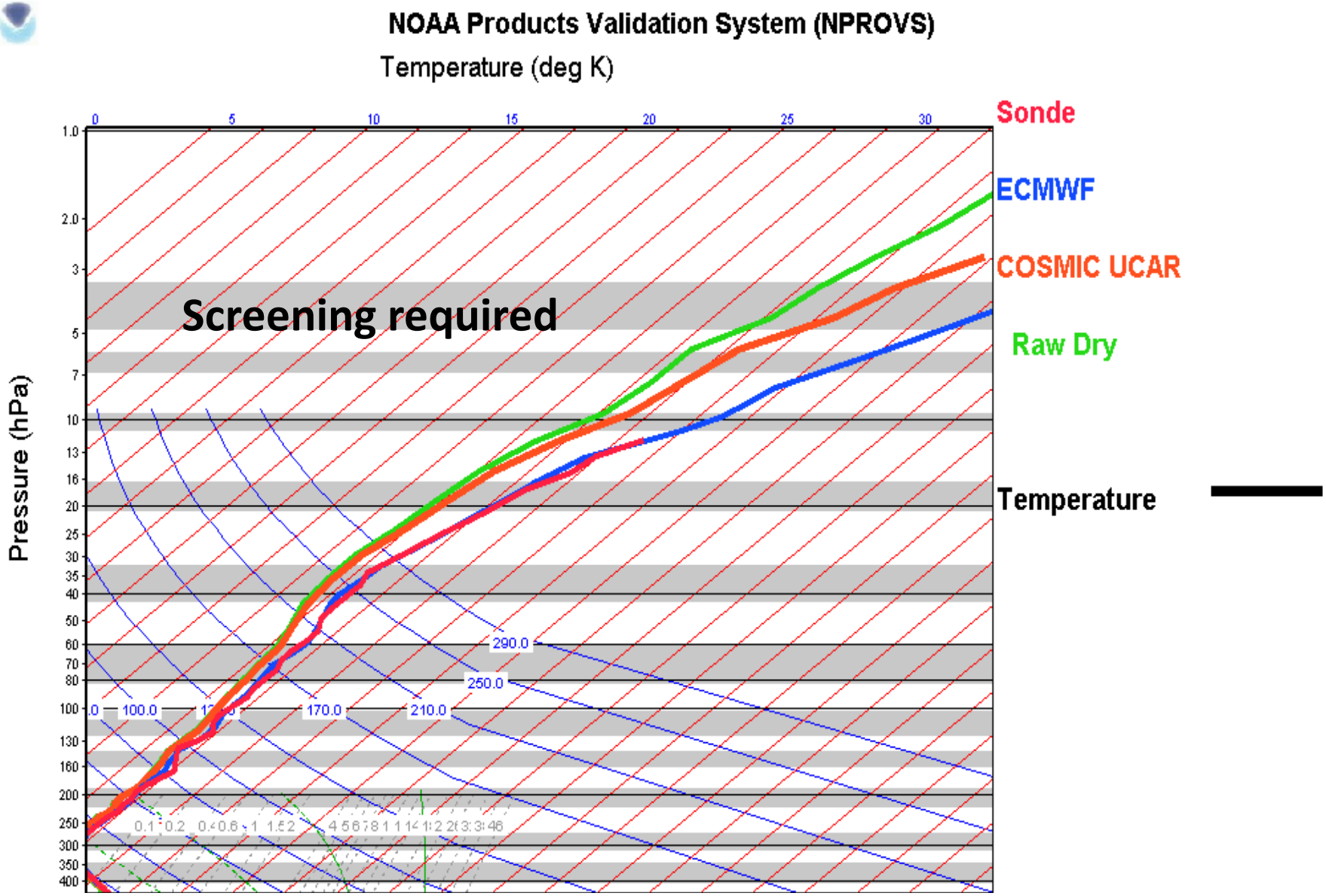
Figure 1: Collocated temperature profiles from GRUAN RAOB, COSMIC (Tdry), MetOp-B IASI soundings from NOAA and EUMETSAT and European Center for Medium-Range Weather Forecasts (ECMWF) analysis within 30 minutes and 30 km of RAOB except for COSMIC at 183 km.



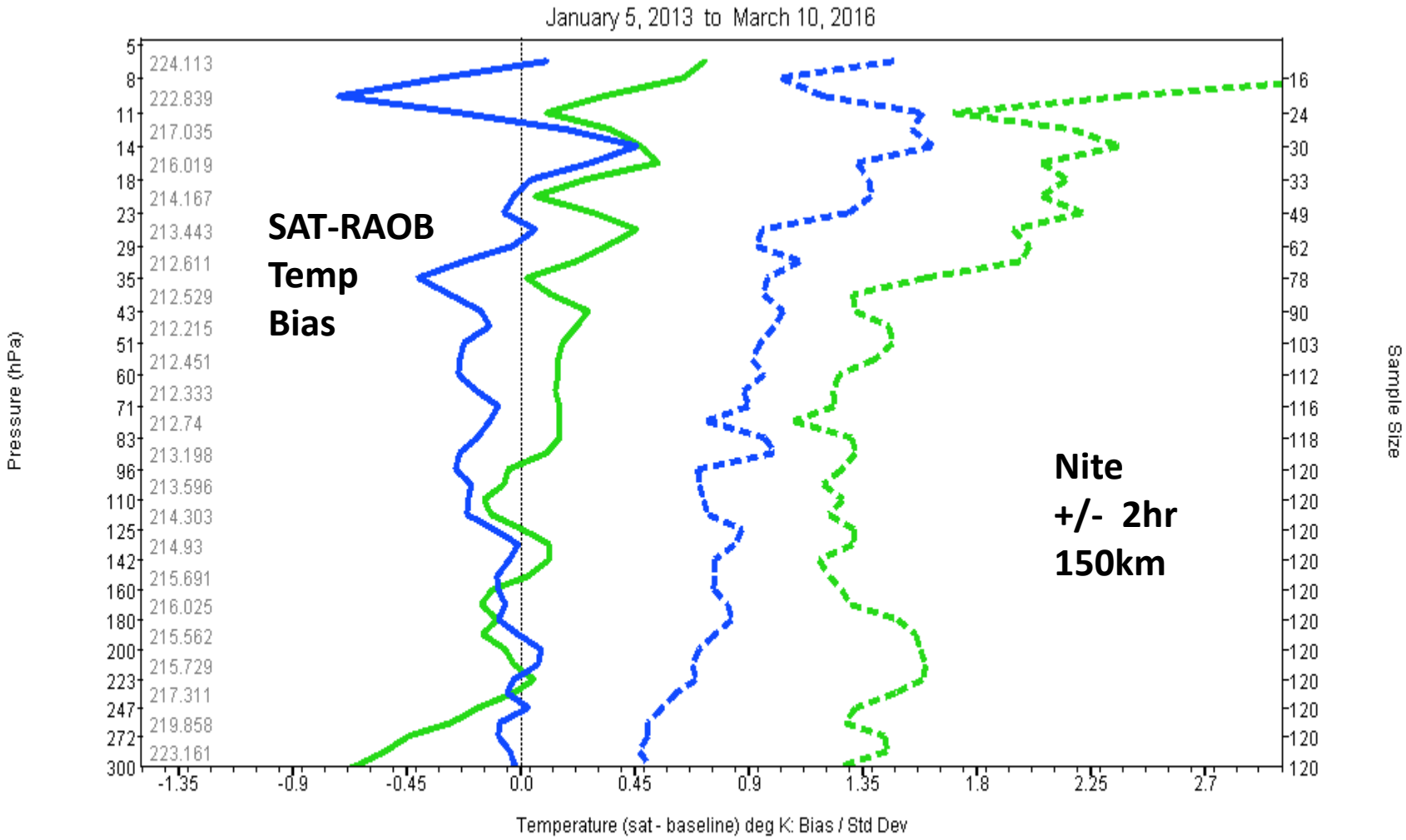




GRUAN collocations with COSMIC GPSRO (and GRAS)

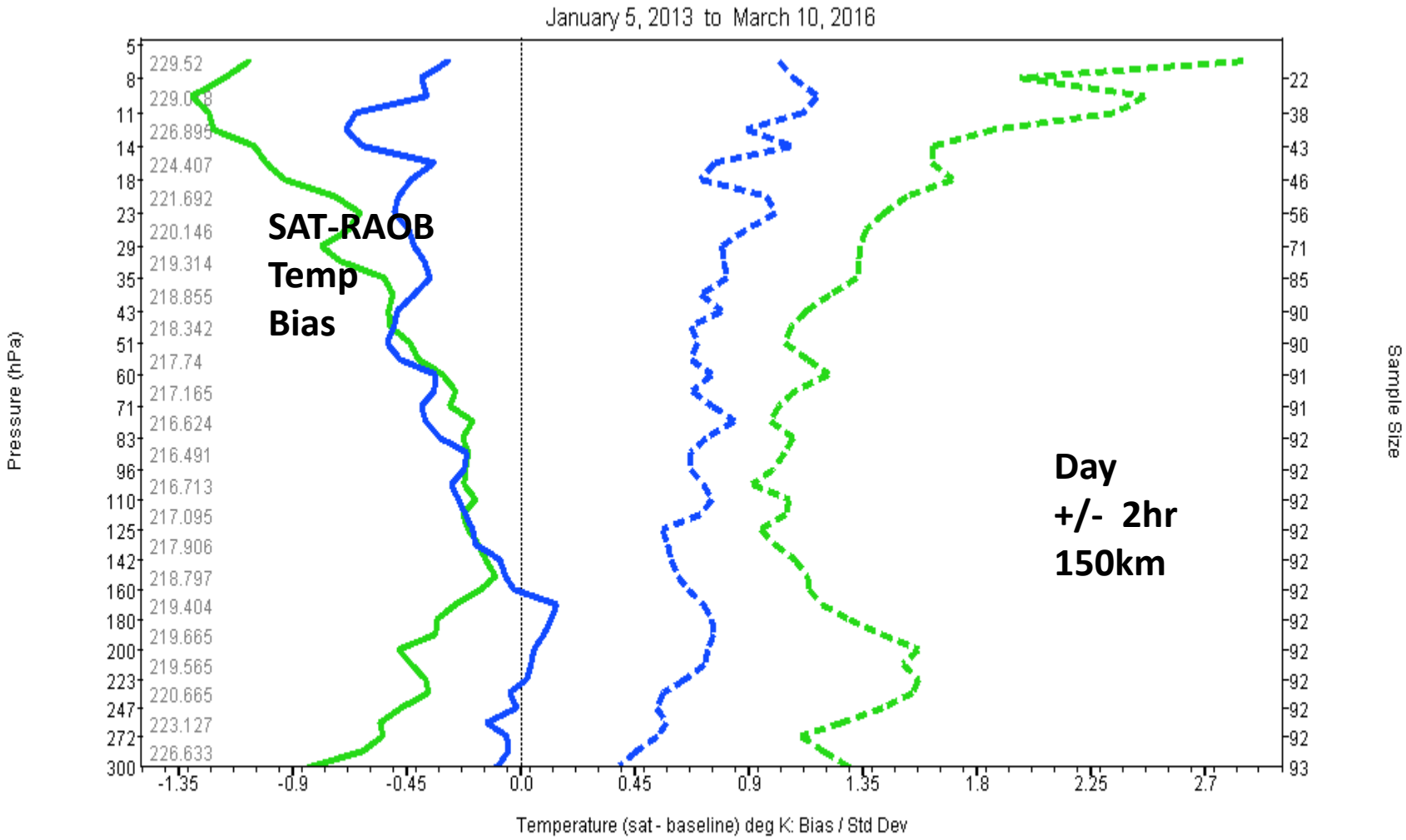


01004 1/5/2015 1112Z 78.9, 11.9E; EC 12Z 79N 12E 9km; COS 1219Z 78.1, 13.3E
Nite



Baseline: Sonde

ECMWF COSMIC UCAR Raw Dry



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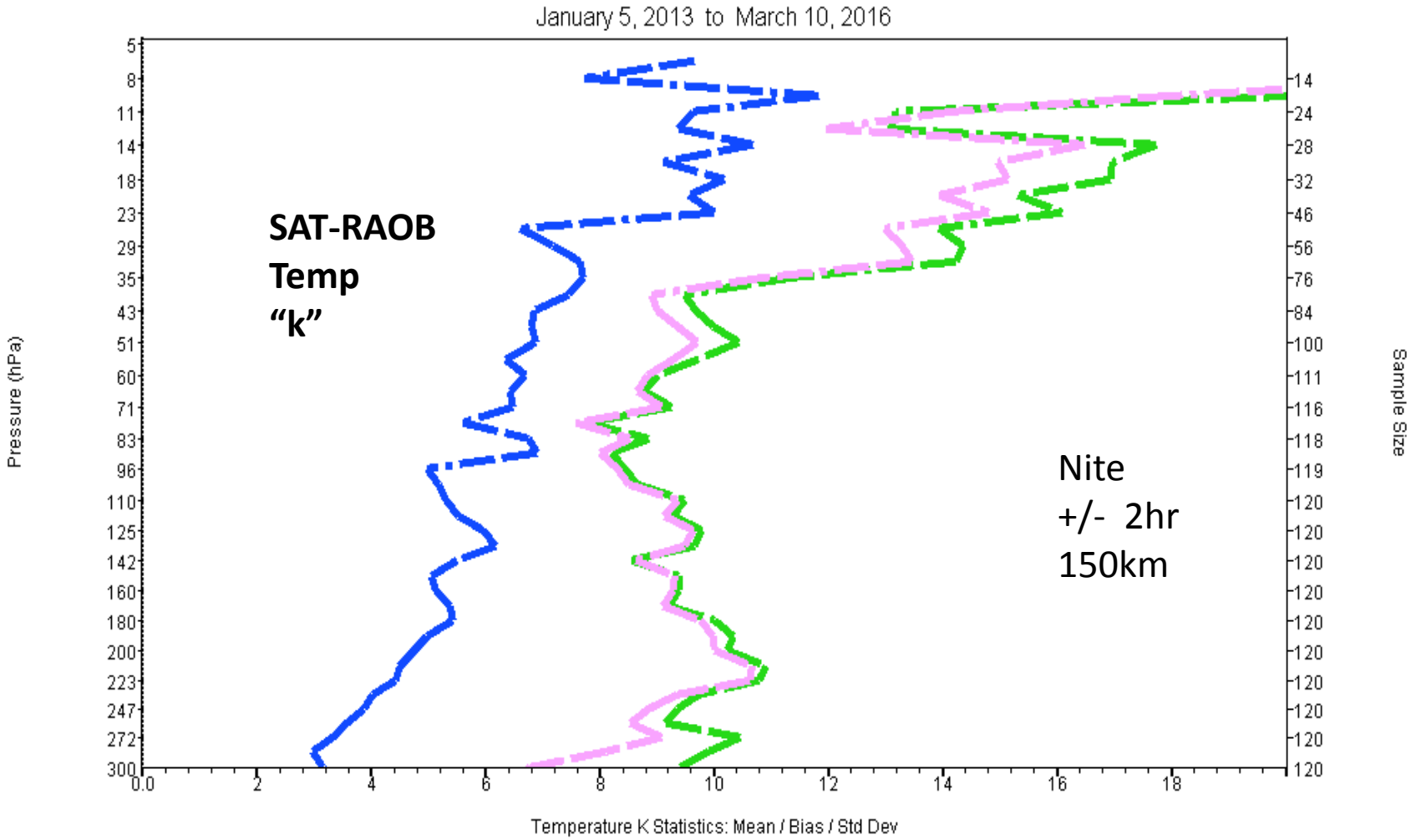

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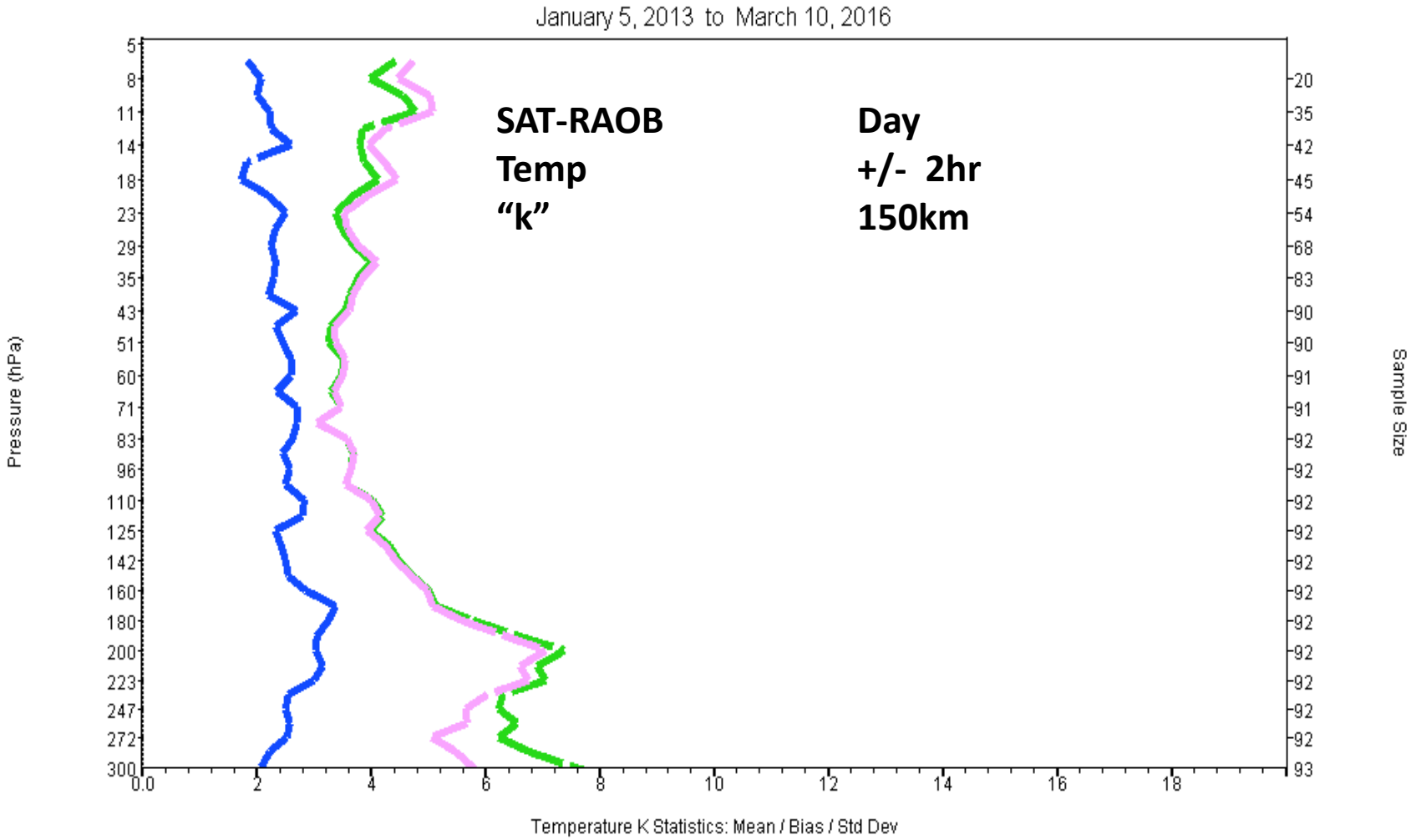

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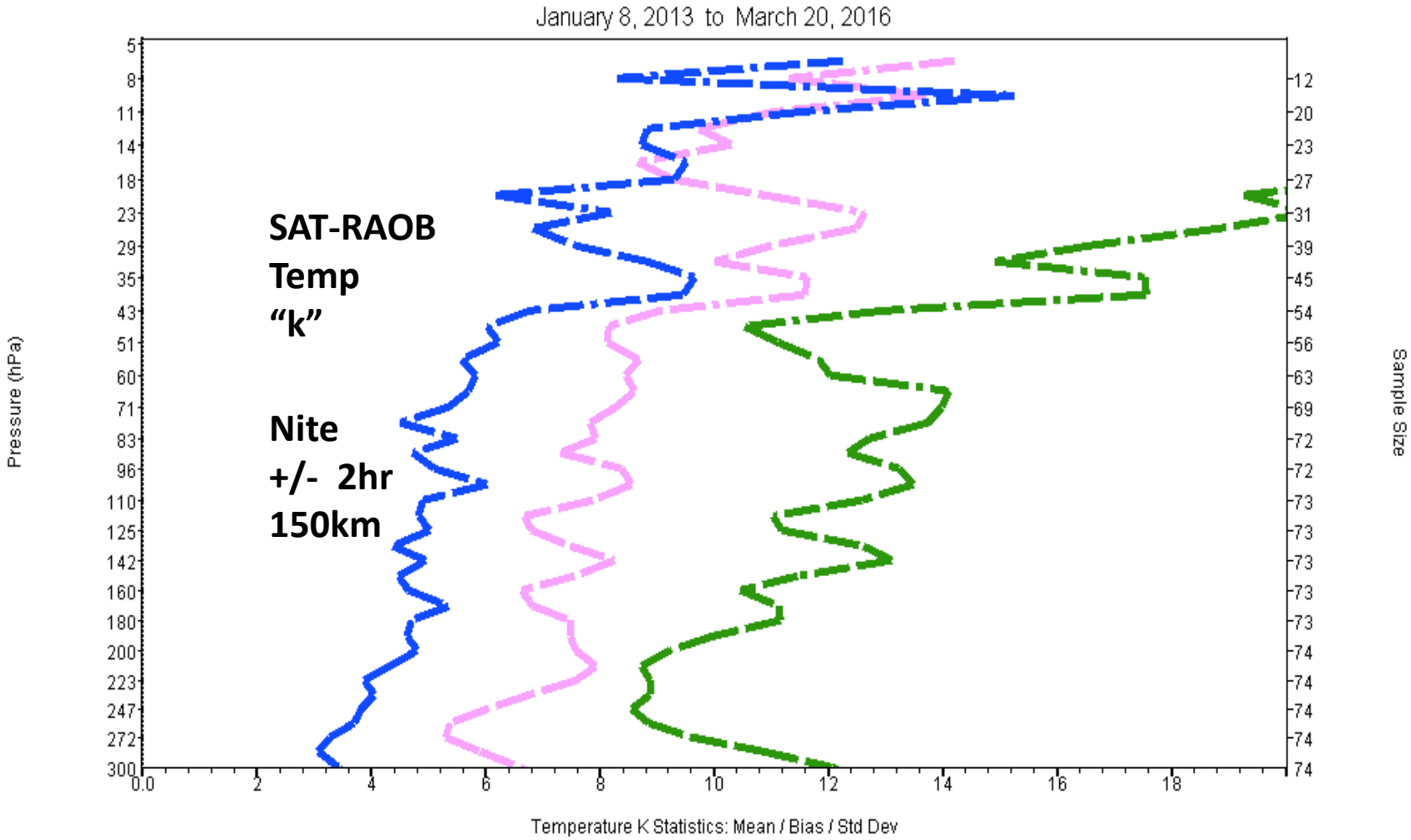

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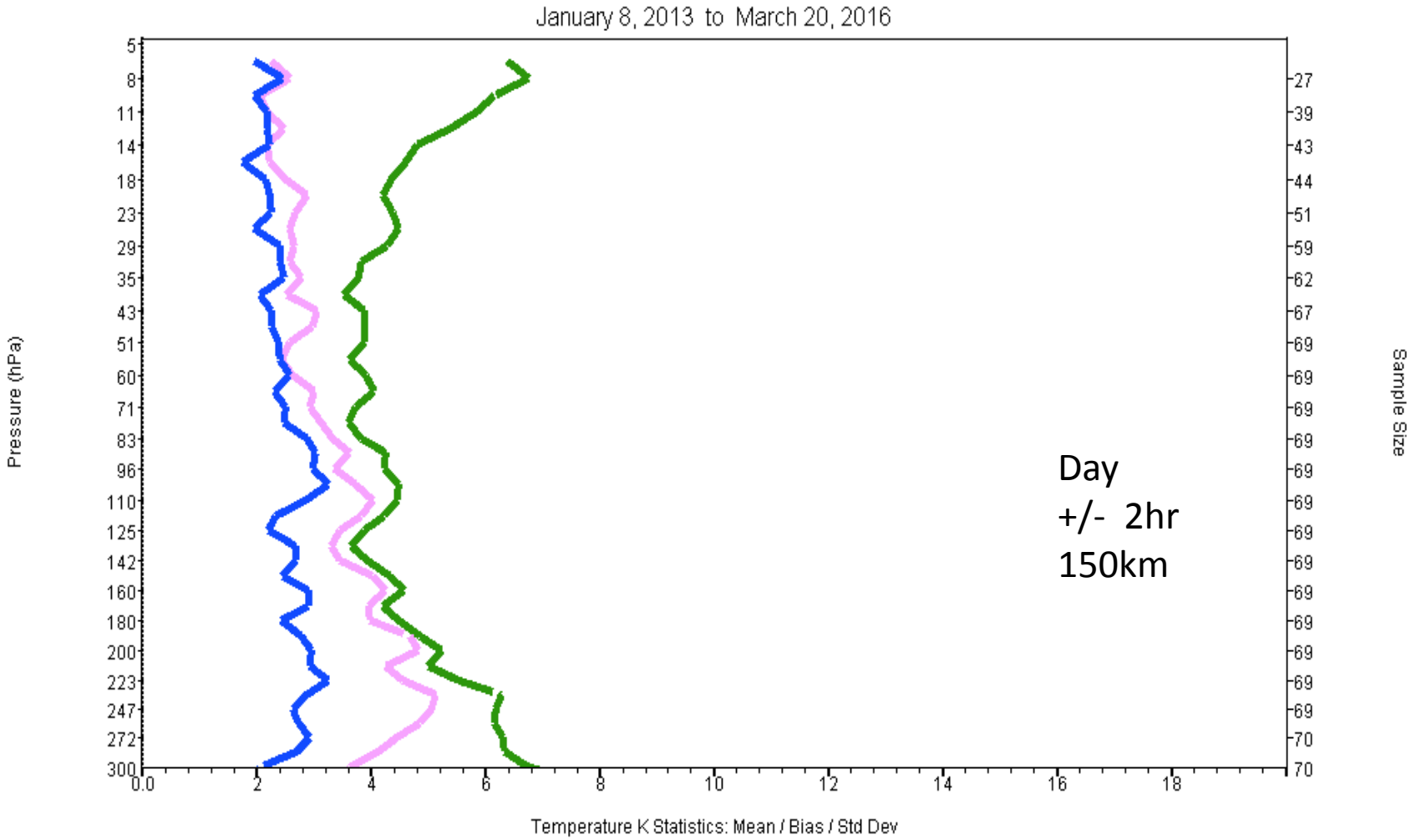
ECMWF GRAS GRAS Raw Dry



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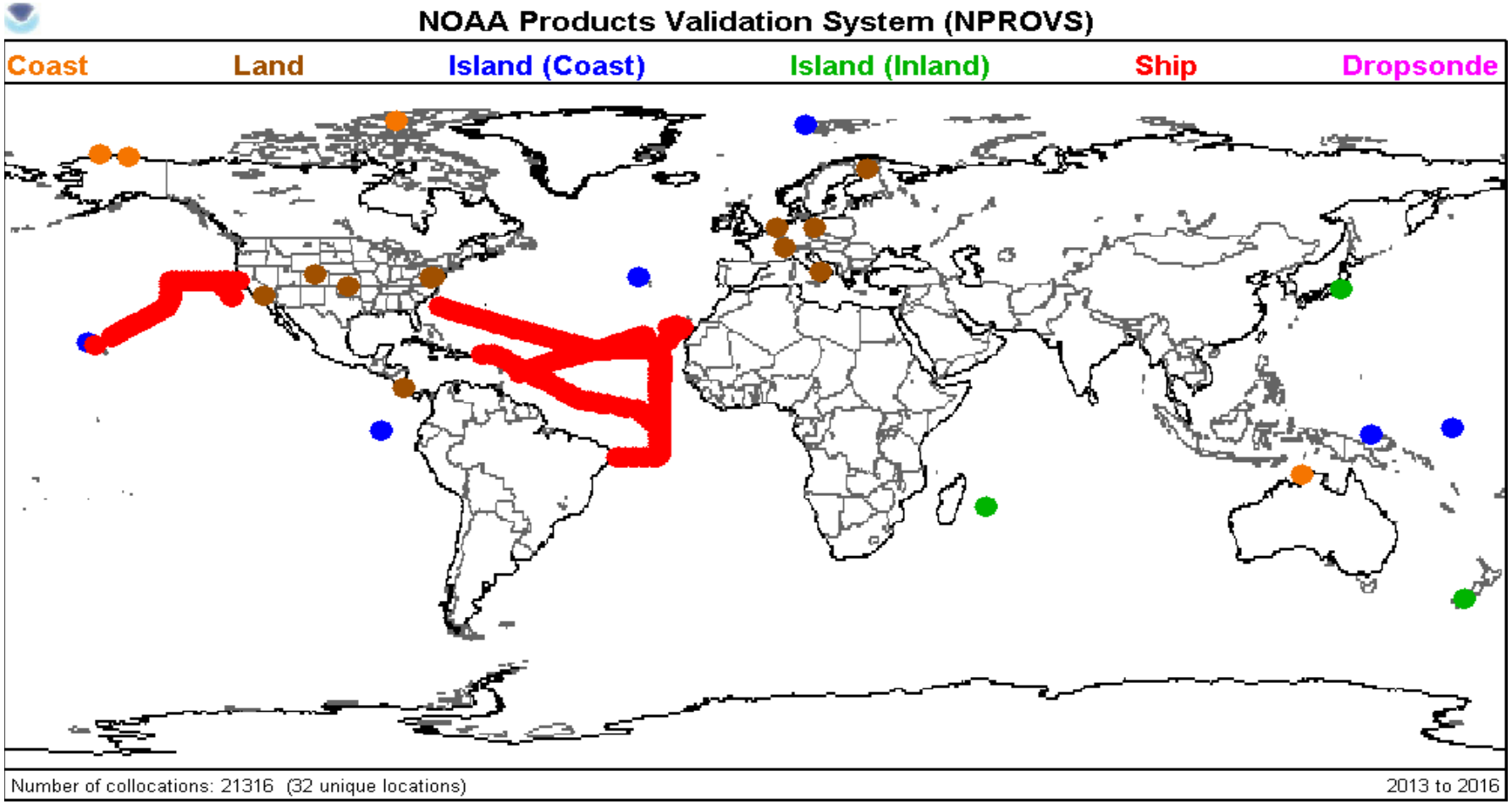
  - includes dual sequential (30 minutes apart…)
- Expand to target GPSRO (COSMIC) and GSICS (ATMS, CrIS …)
  - *GRAS (MetOp) via EUMETSAT ?*
- *RTM calculation (GAIA-CLIM , Met Office GRUAN Processor … ?)*
  - *RTTOV, CRTM …*
- AM and SASBE applications
- Other …

Sterling / Beltsville /STAR

GRUAN Mid-Atlantic Contingent (G-MAC)

N P R O V S +



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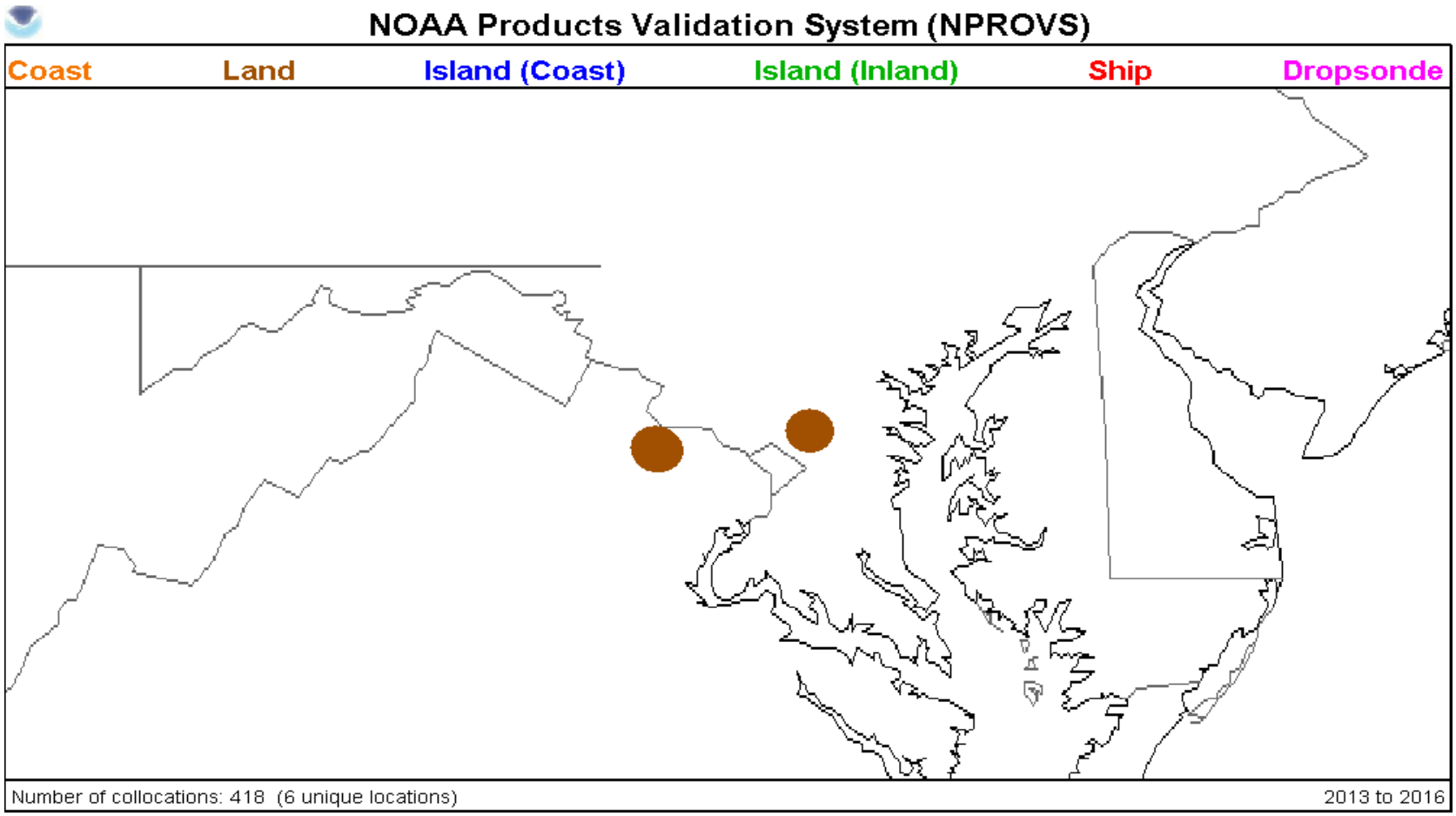
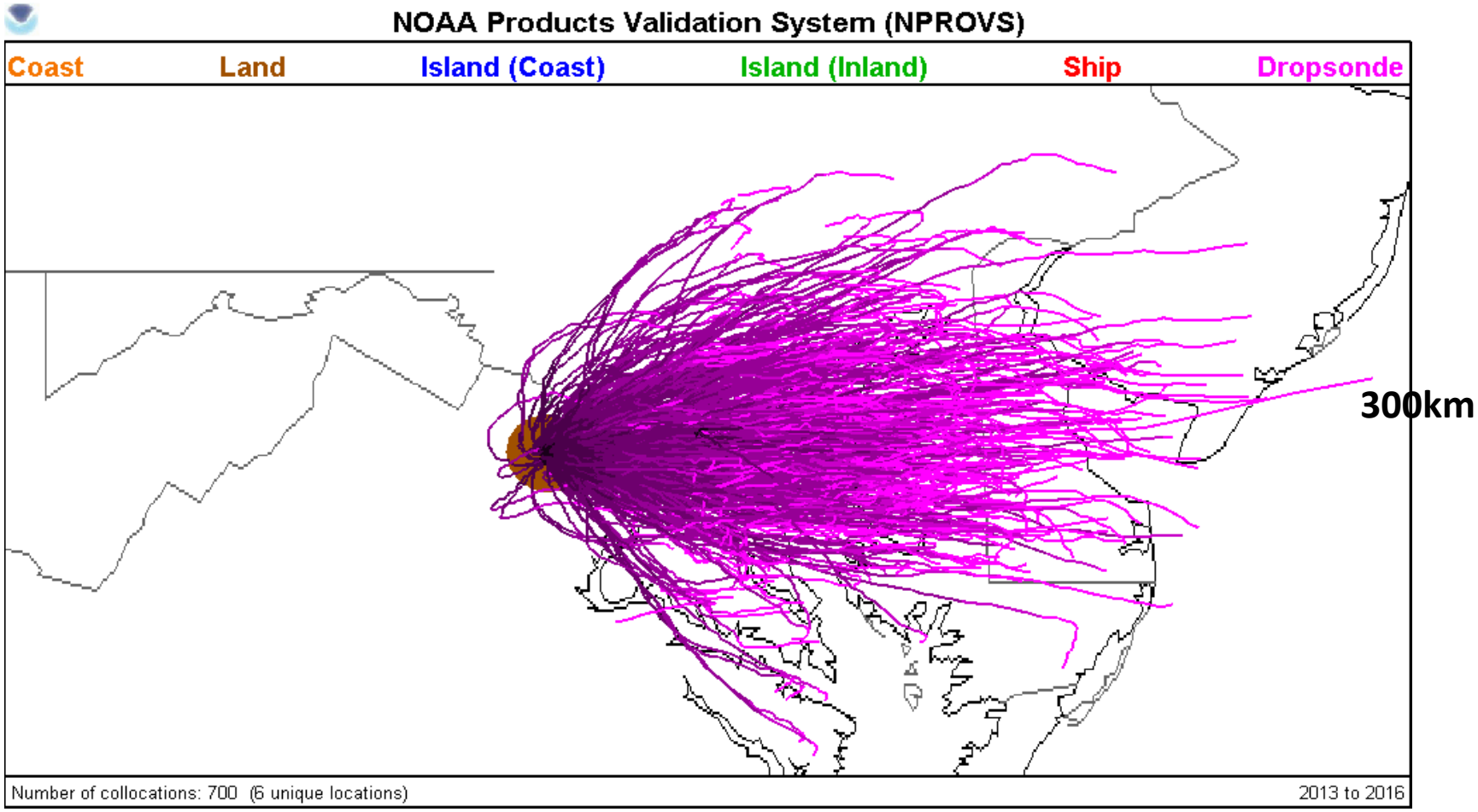


Beltsville … 158

Sterling … 542


NOAA Products Validation System (NPROVS)
Coast
Land
Island (Coast)
Island (Inland)
Ship
Dropsonde
300km
Number of collocations: 700 (6 unique locations)
2013 to 2016

Sterling (542/344/13)

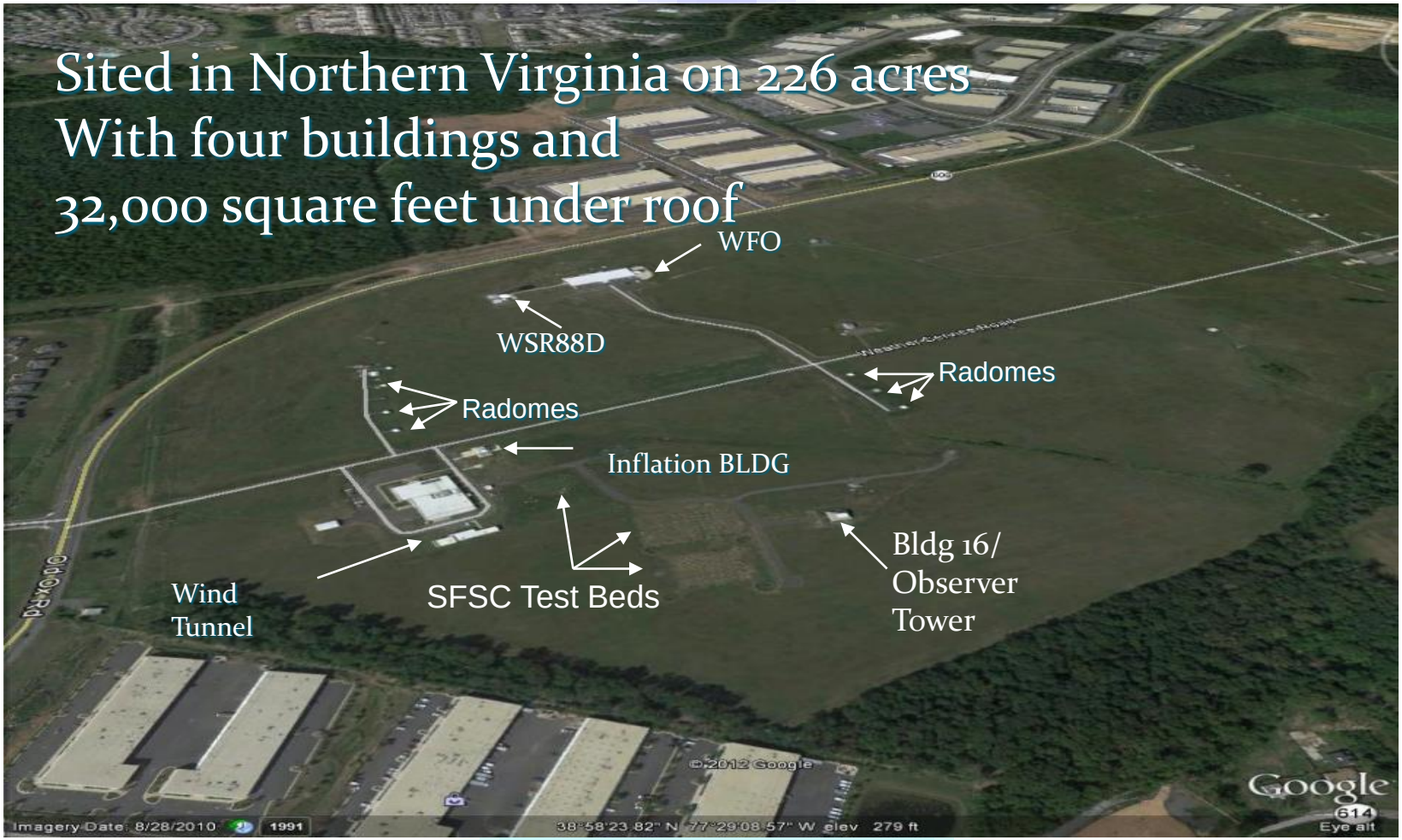
(10/9 2015 to 4/13/2016)

70000	LMS-6		182	(20)	(3)
70001	LMS-6	(dual simultaneous)	182	(17)	(2)
71000	VRS92	Autosonde	81	(206)	(4)
72000	VRS92	NGP InterMet (IMS2000)	152	(7)	(2)
72403	LMS-6	operational	182	(294)	(2)

Beltsville (158/135/103)

(1/10/2013 to 4/6/2016)

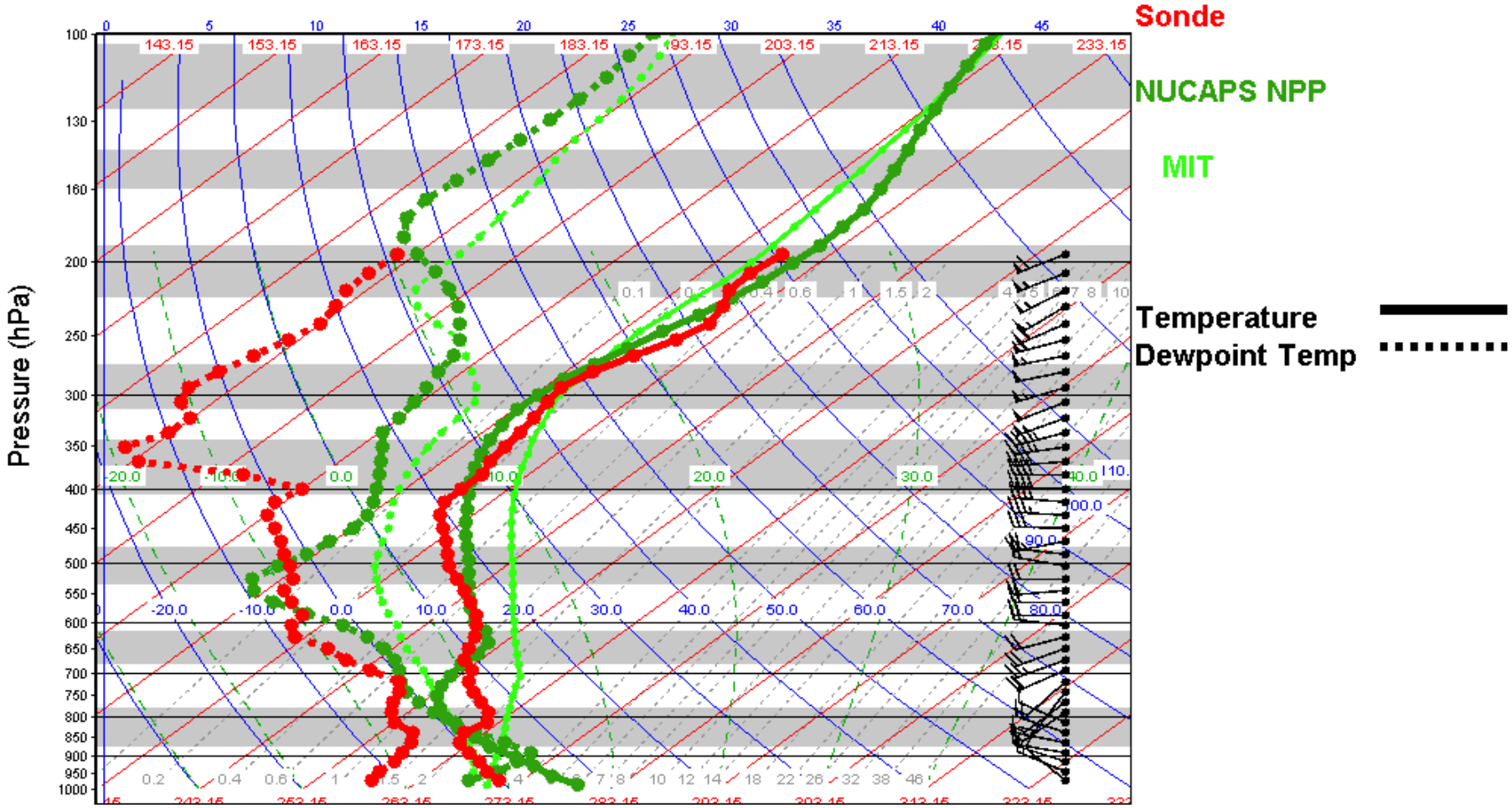
BELTSV	VRS92	DG3	80	(67)	(32)
	VRS92	DCoraMW41	114	(73)	(58)
	VRS92	GRUAN	272	(18)	(13)



The Sterling Field Support Center is a one of a kind facility. Our mission is to ensure that NWS observing systems produce scientifically sound data which conforms to National and International standards for Upper Air, Surface and Climatological reporting.

NOAA Products Validation System (NPROVS)

Temperature (deg K)

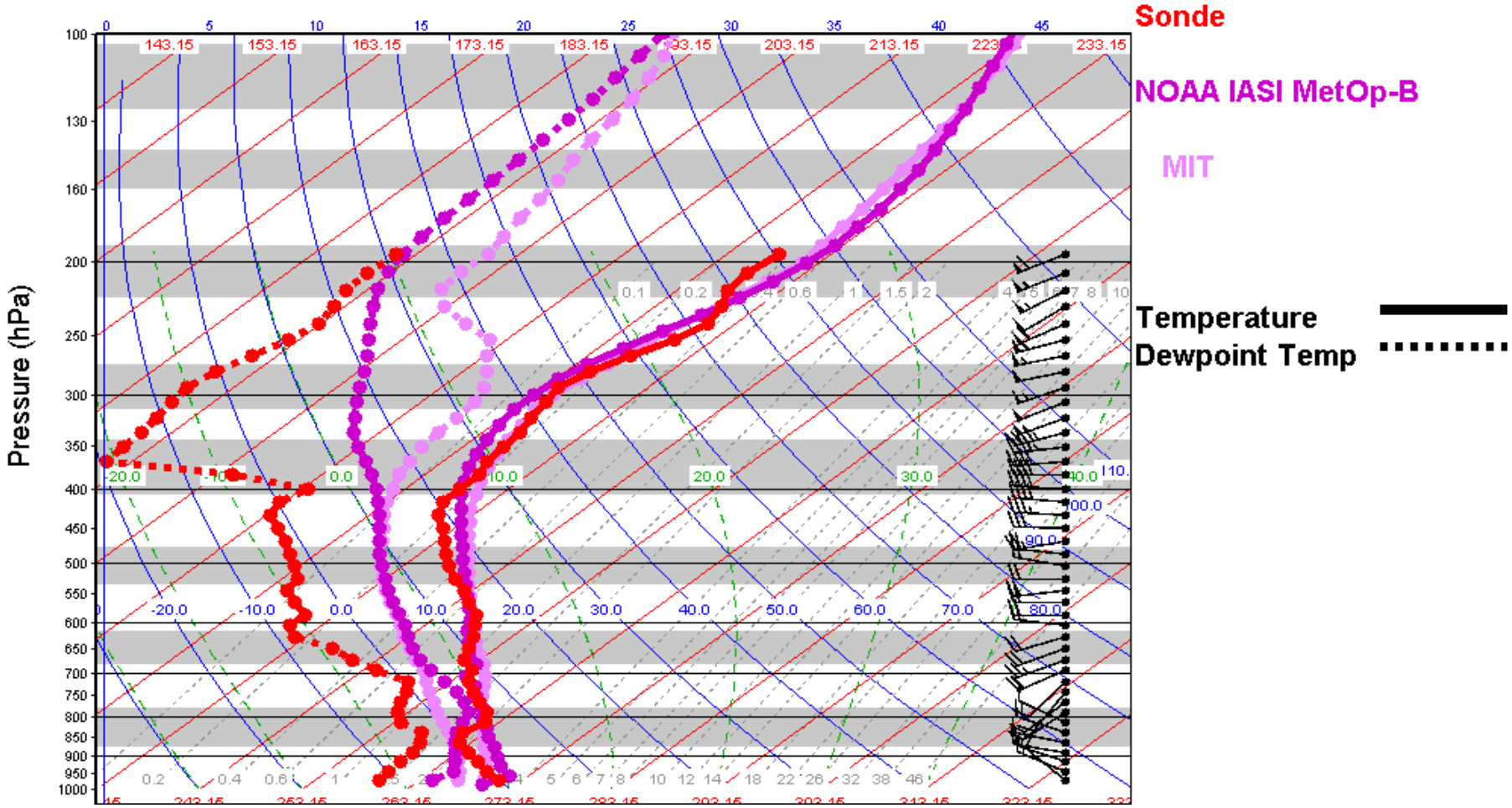


2/10/2016 1701Z

Dual Simul @Sterling +/- 1 hr of NUCAPS … MW pass … 1756Z

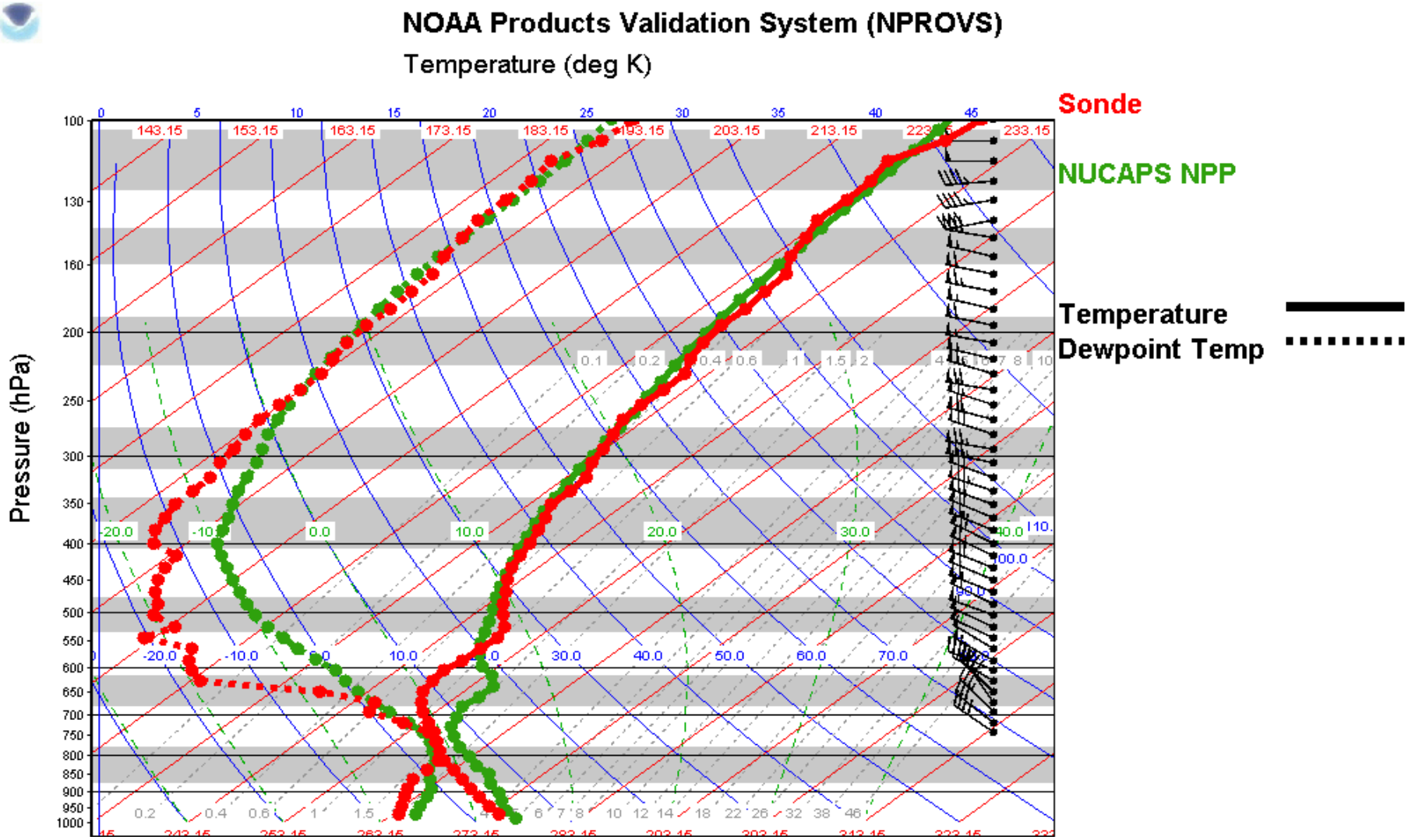
NOAA Products Validation System (NPROVS)

Temperature (deg K)



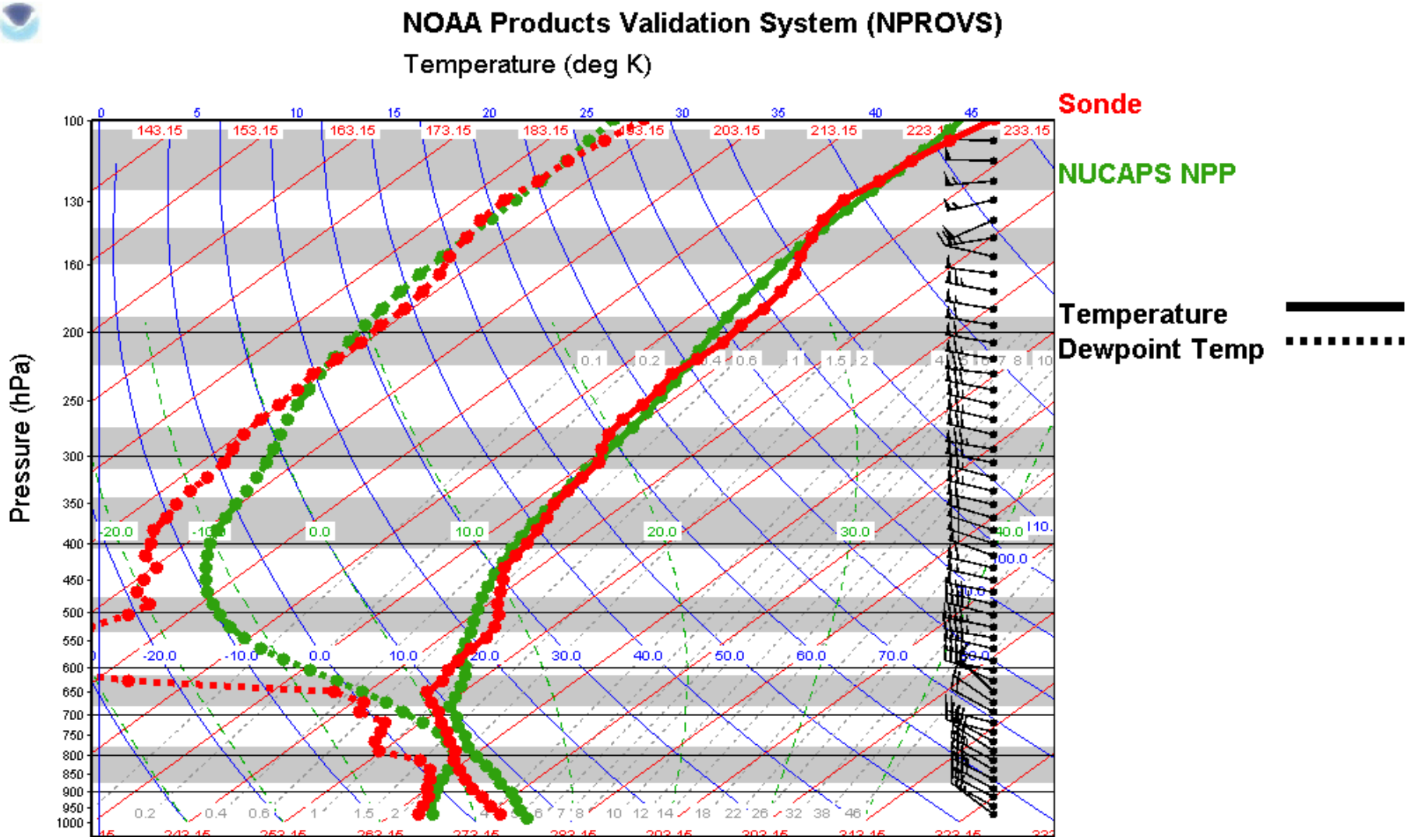
2/10/2016 1701Z

Dual Simul @Sterling - 2 hr of IASI/MetOp-B … Both Pass … 1503Z



1/29/2015 1751Z … Sterling (71000)

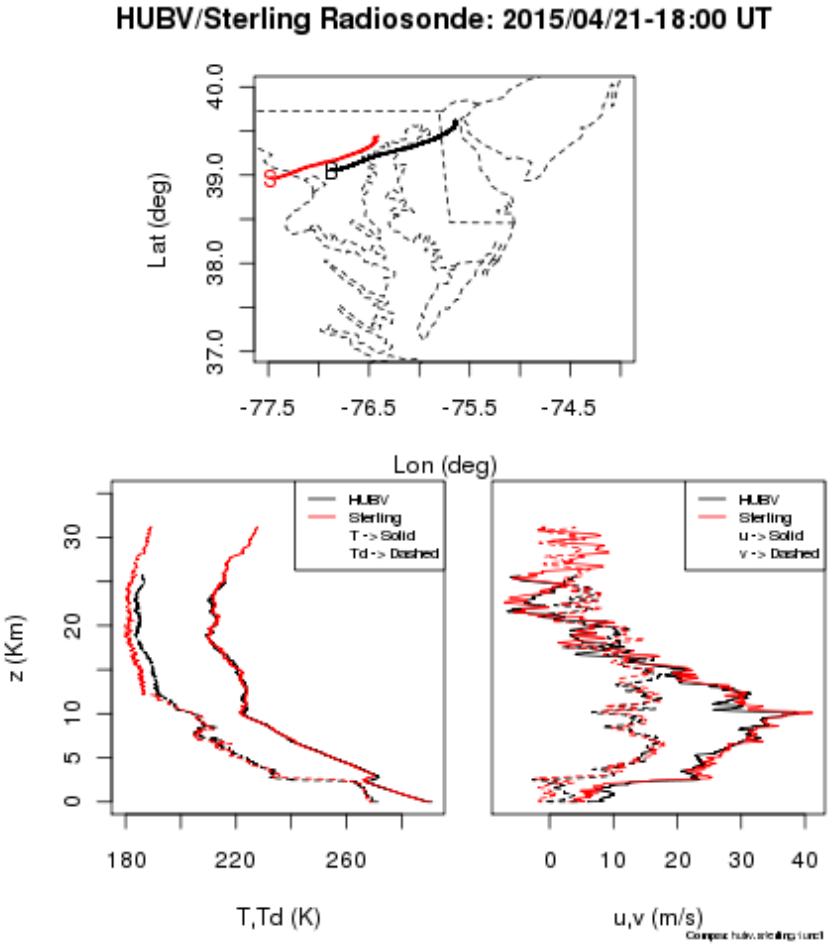
Sterling / Beltsville Sync, +/- 1 hr of NUCAPS … Both pass … 1821Z (7.5km)

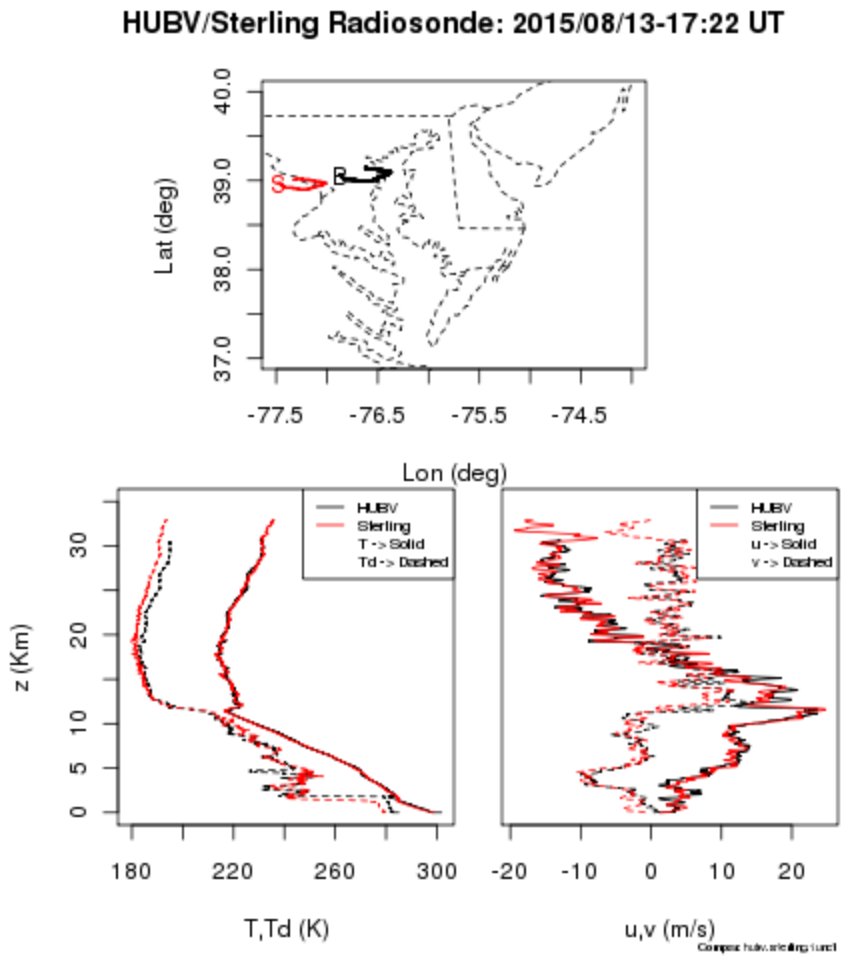


1/29/2015 1805Z … Beltsville (114)

Sterling / Beltsville Sync, +/- 1 hr of NUCAPS … Both pass … 1821Z (4km)

Well mixed vs. Stagnant



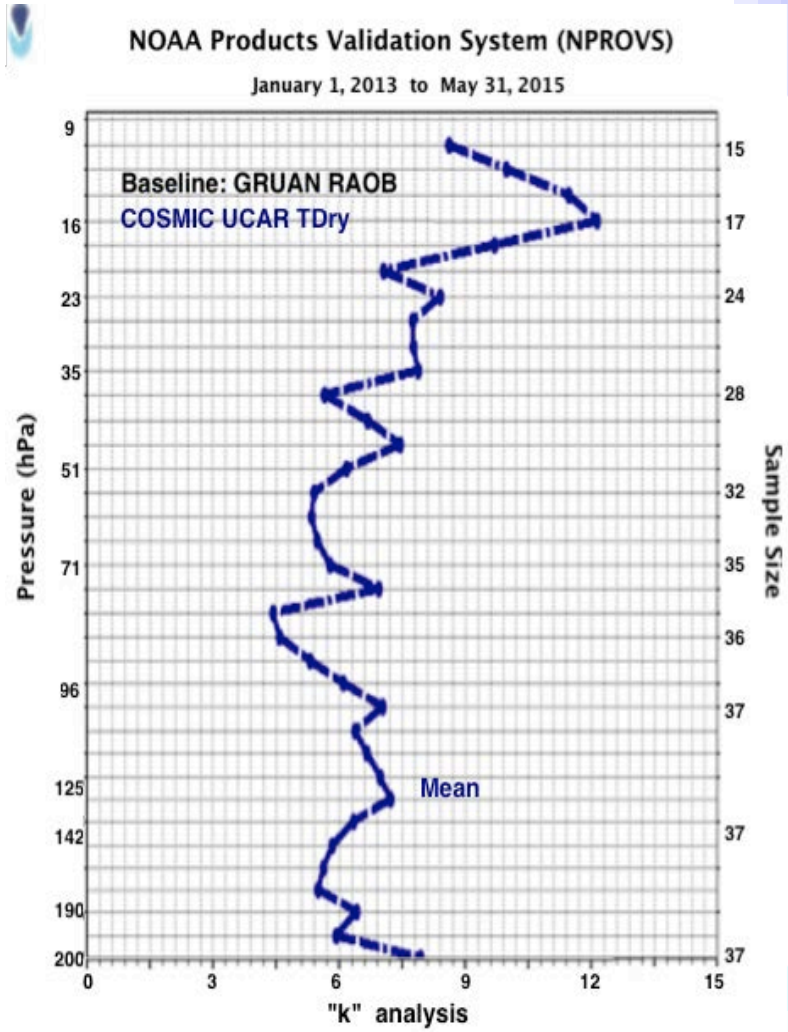


Moniques Paper …

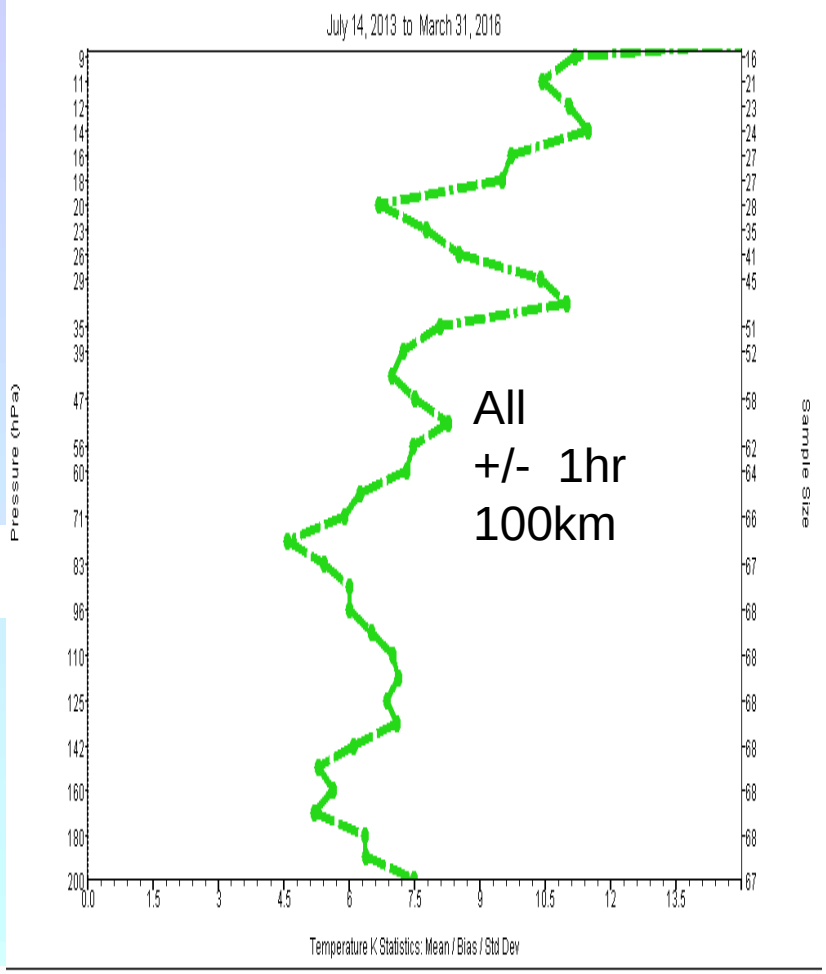
Summary

- NPROVS+ … analysis and feedback
- 3G … SAT synchronized RAOB launch
- Integrated uncertainty and some interesting results about UT H20
- Integrated uncertainty and some interesting results about GPSRO Strato T
- G-MAC

EXTRAS



… thru March 2016



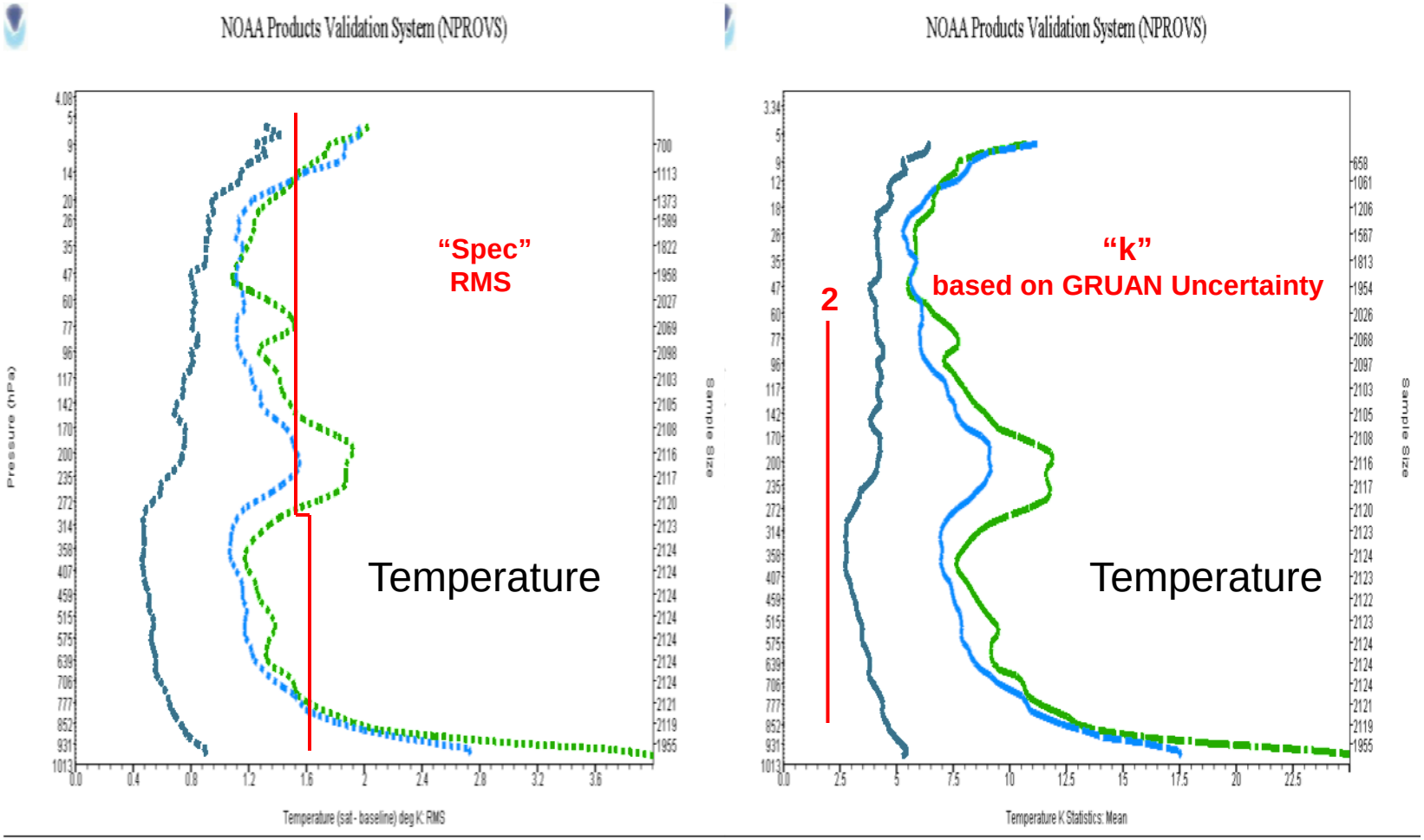
Baseline: Sonde

COSMIC UCAR Raw Dry

Integrating Uncertainty in

NPROVS+ analytic interface …

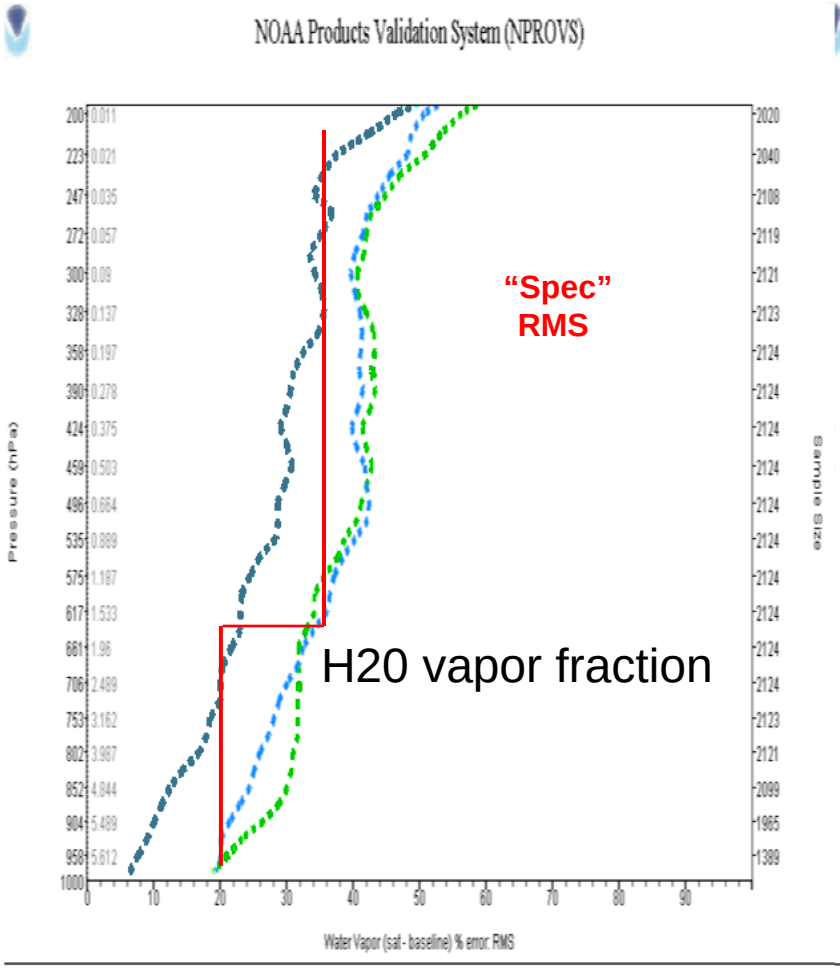
Provides more robust satellite product cal / val

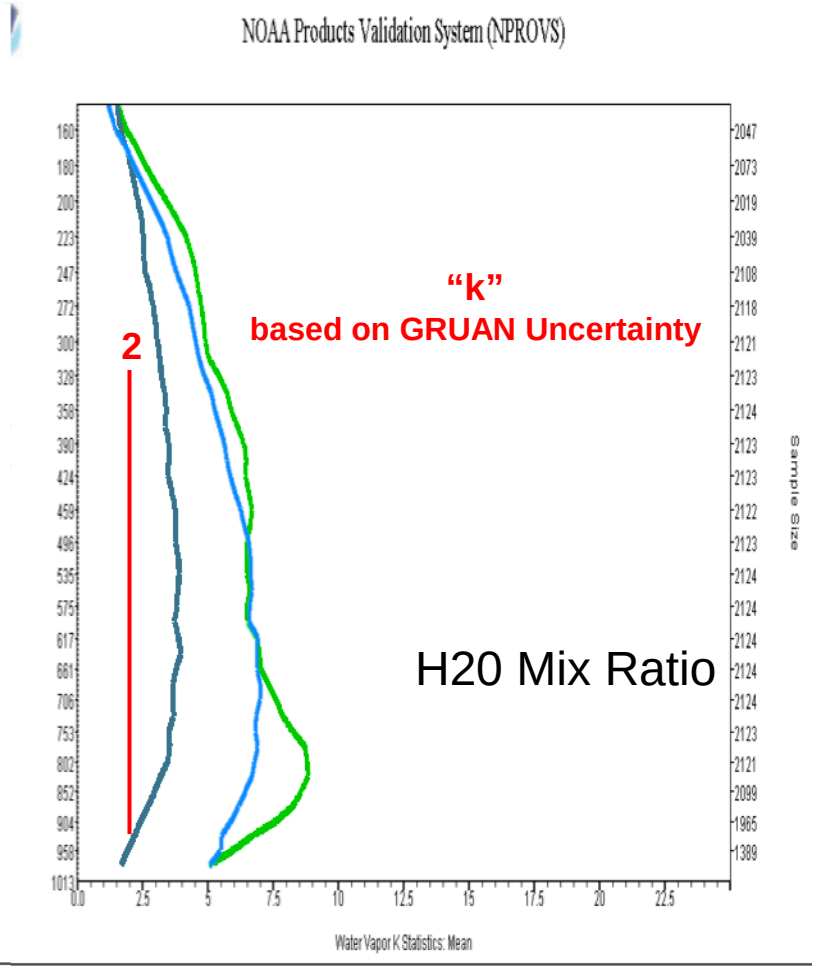


Baseline: GRUAN Radiosonde

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

"k" based on GRUAN Uncertainty

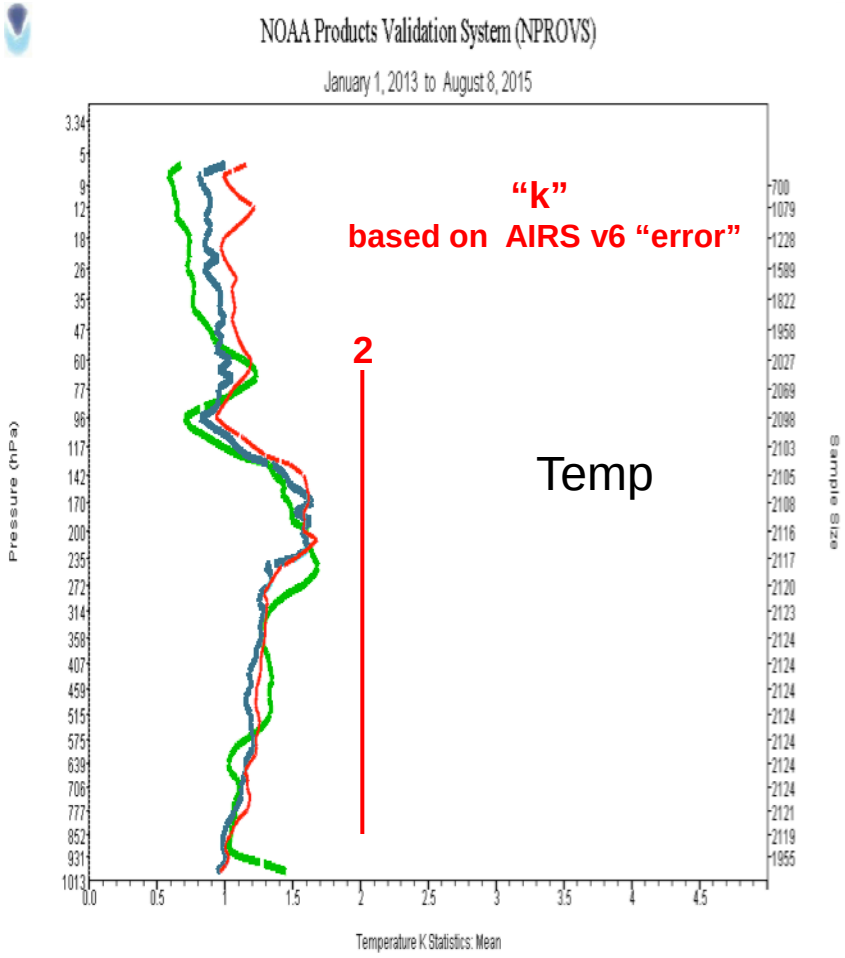


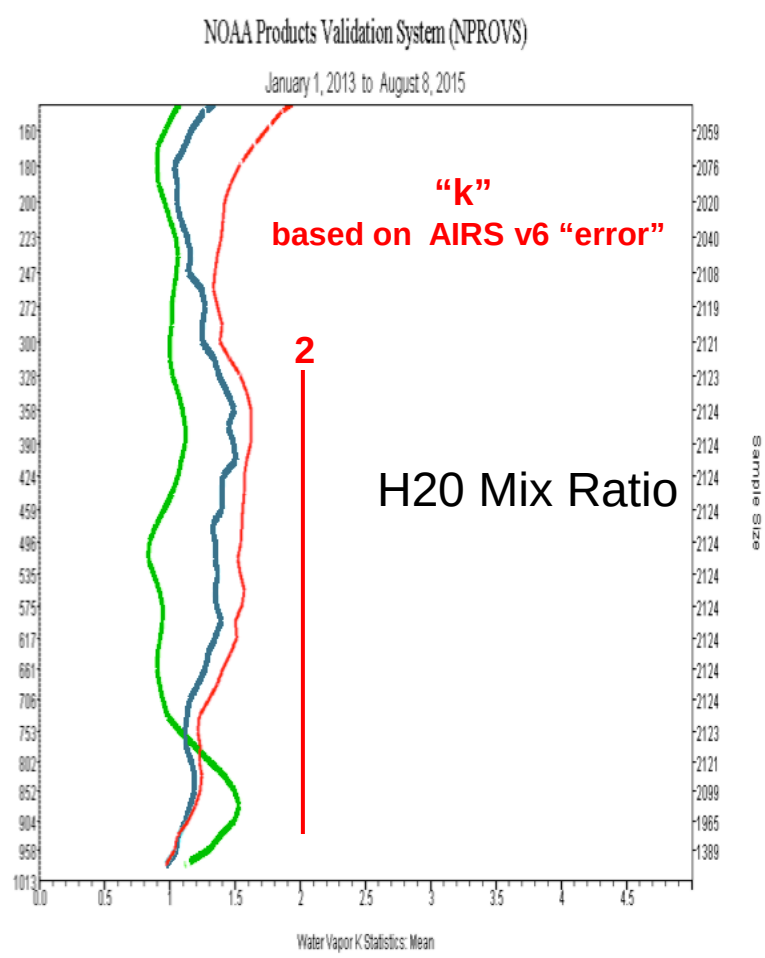


Baseline: GRUAN Radiosonde

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

"k" based on GRUAN Uncertainty

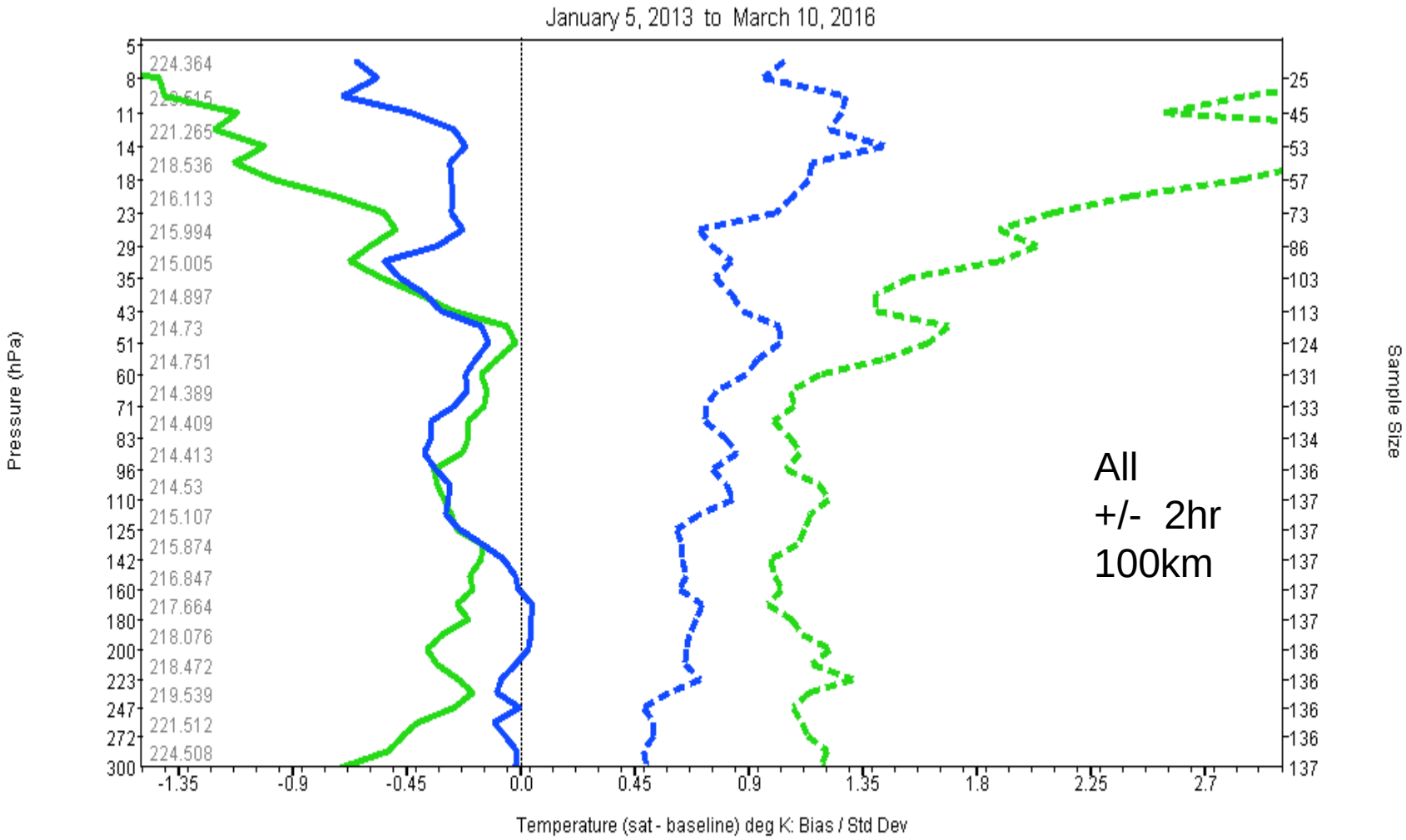




Baseline: AIRS AQUA

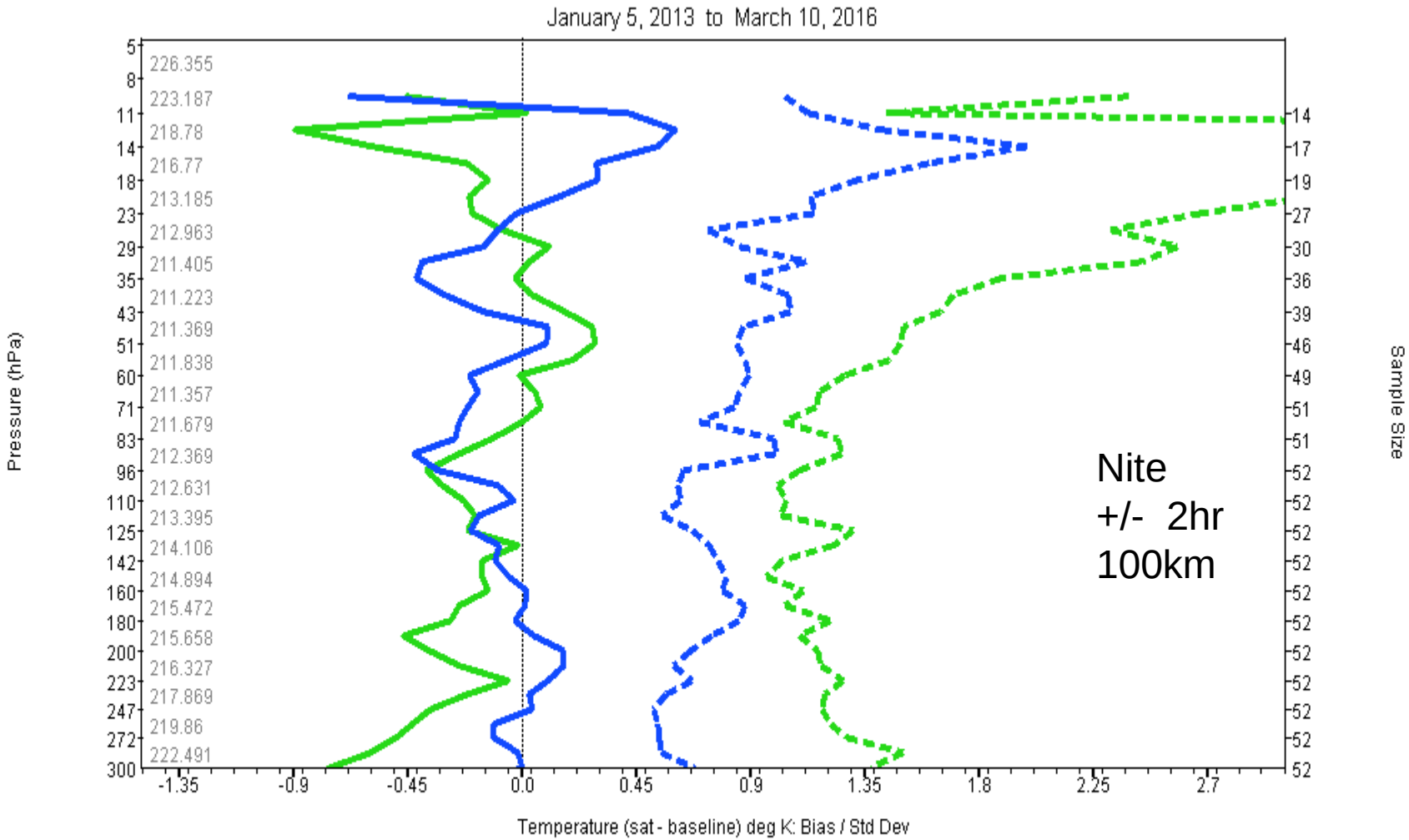
GRUAN Radiosonde **ECMWF** **NUCAPS NPP**

"k" based on AIRS v.6 (Uncertainty … too high)



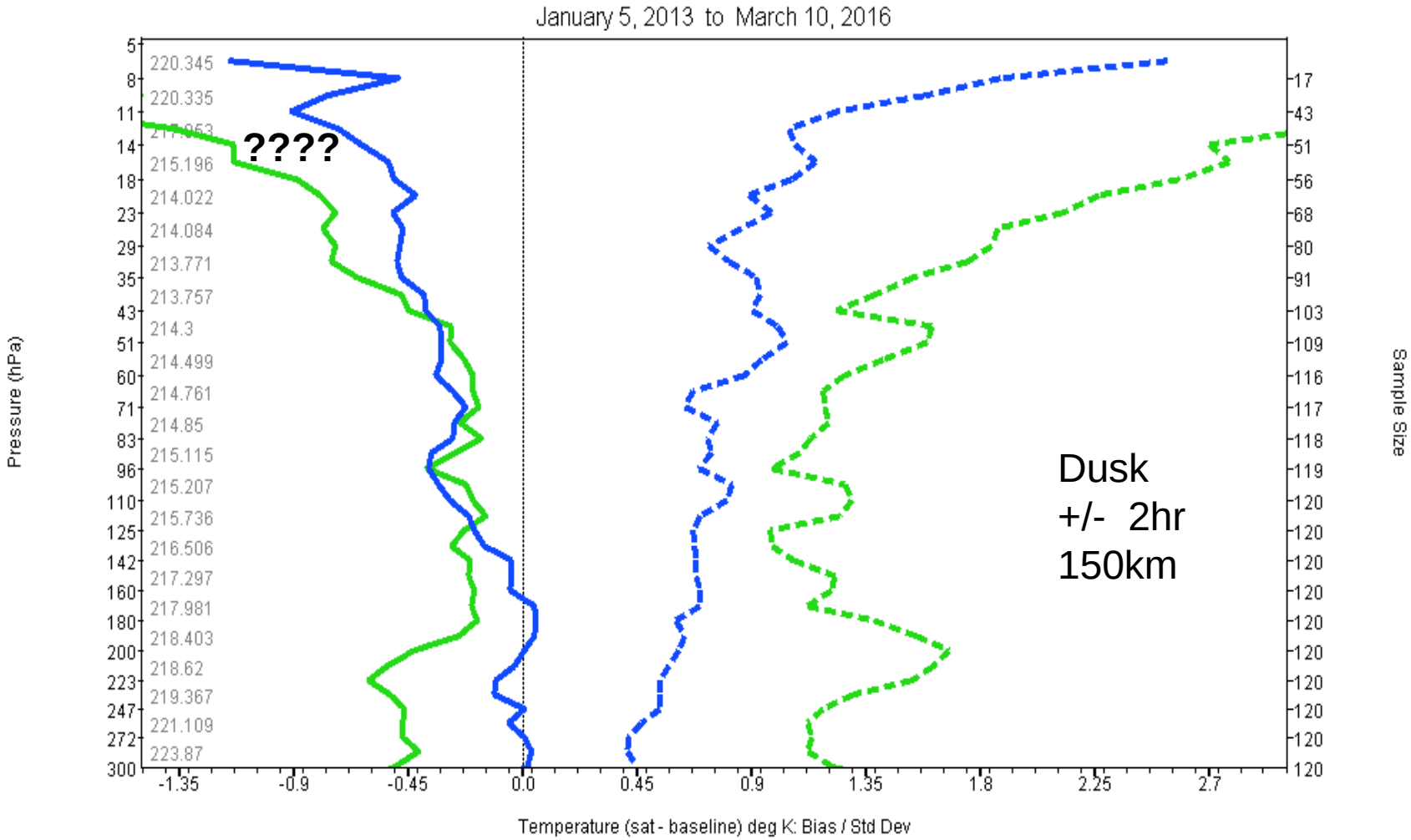
Baseline: Sonde

ECMWF COSMIC UCAR Raw Dry



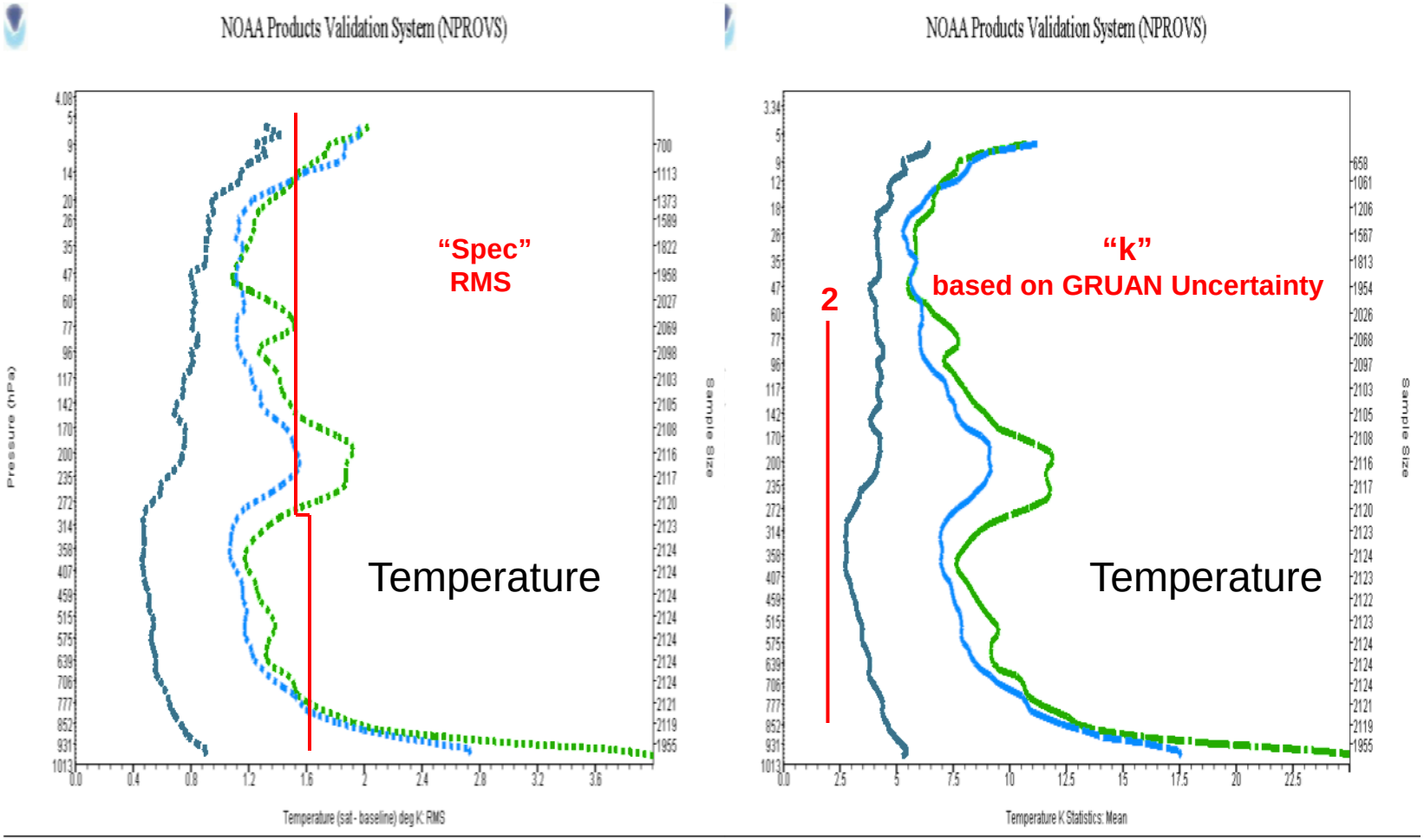
Baseline: Sonde

ECMWF COSMIC UCAR Raw Dry



Baseline: Sonde

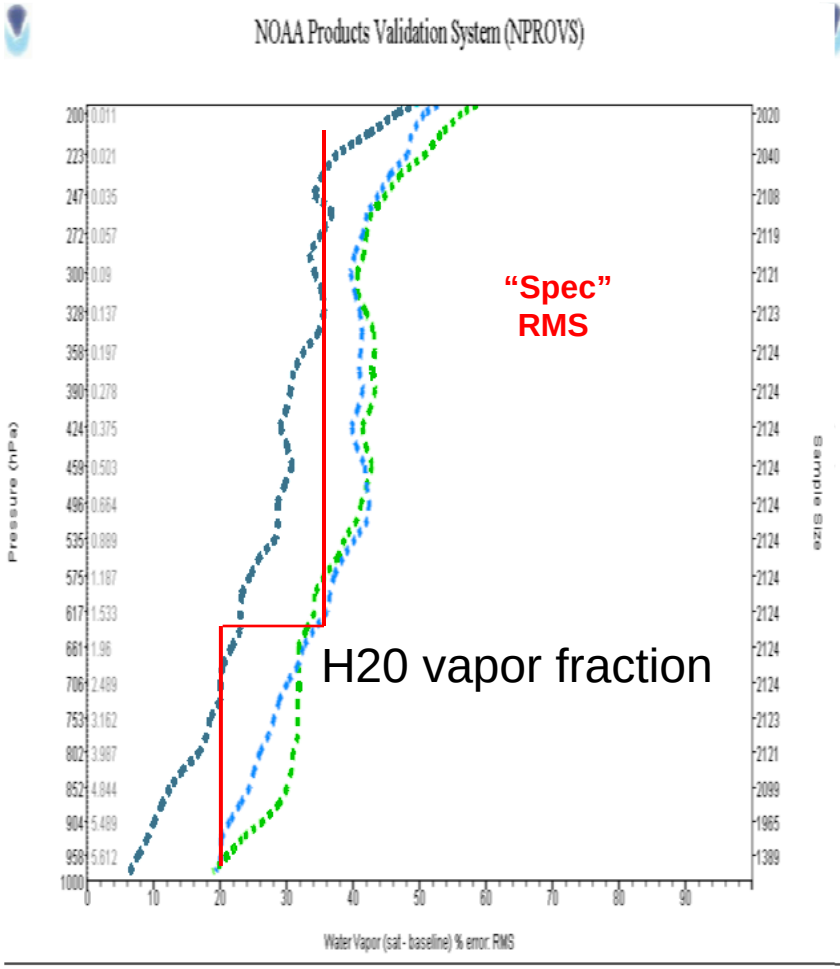
ECMWF COSMIC UCAR Raw Dry

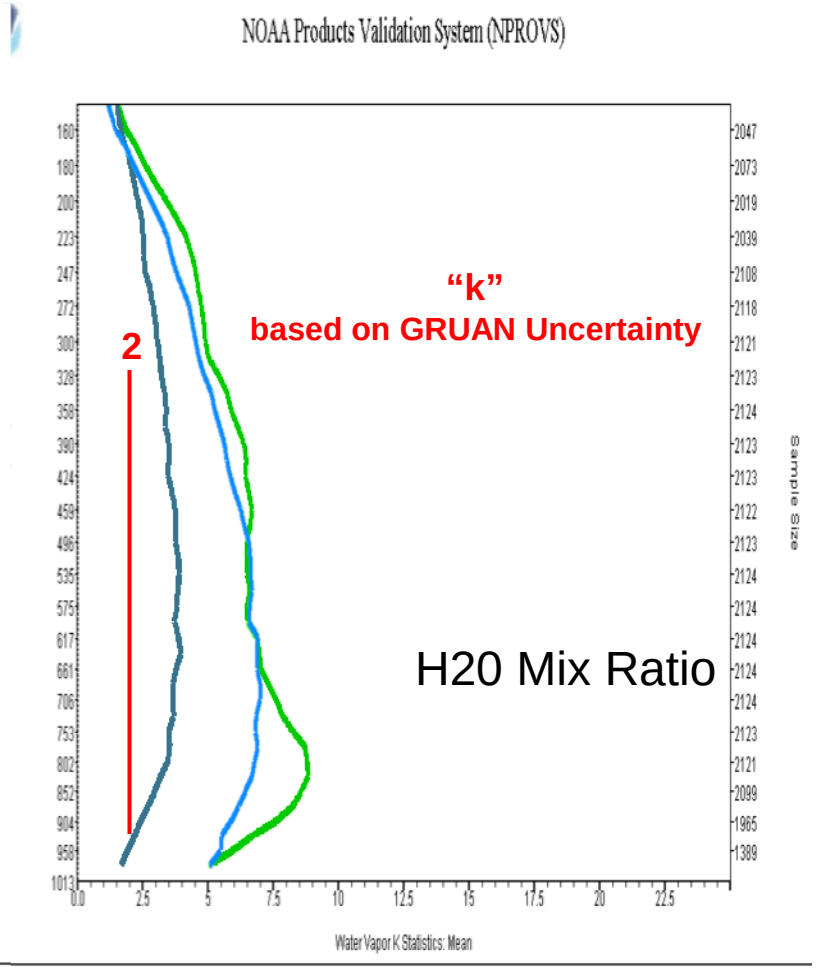


Baseline: GRUAN Radiosonde

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

"k" based on GRUAN Uncertainty





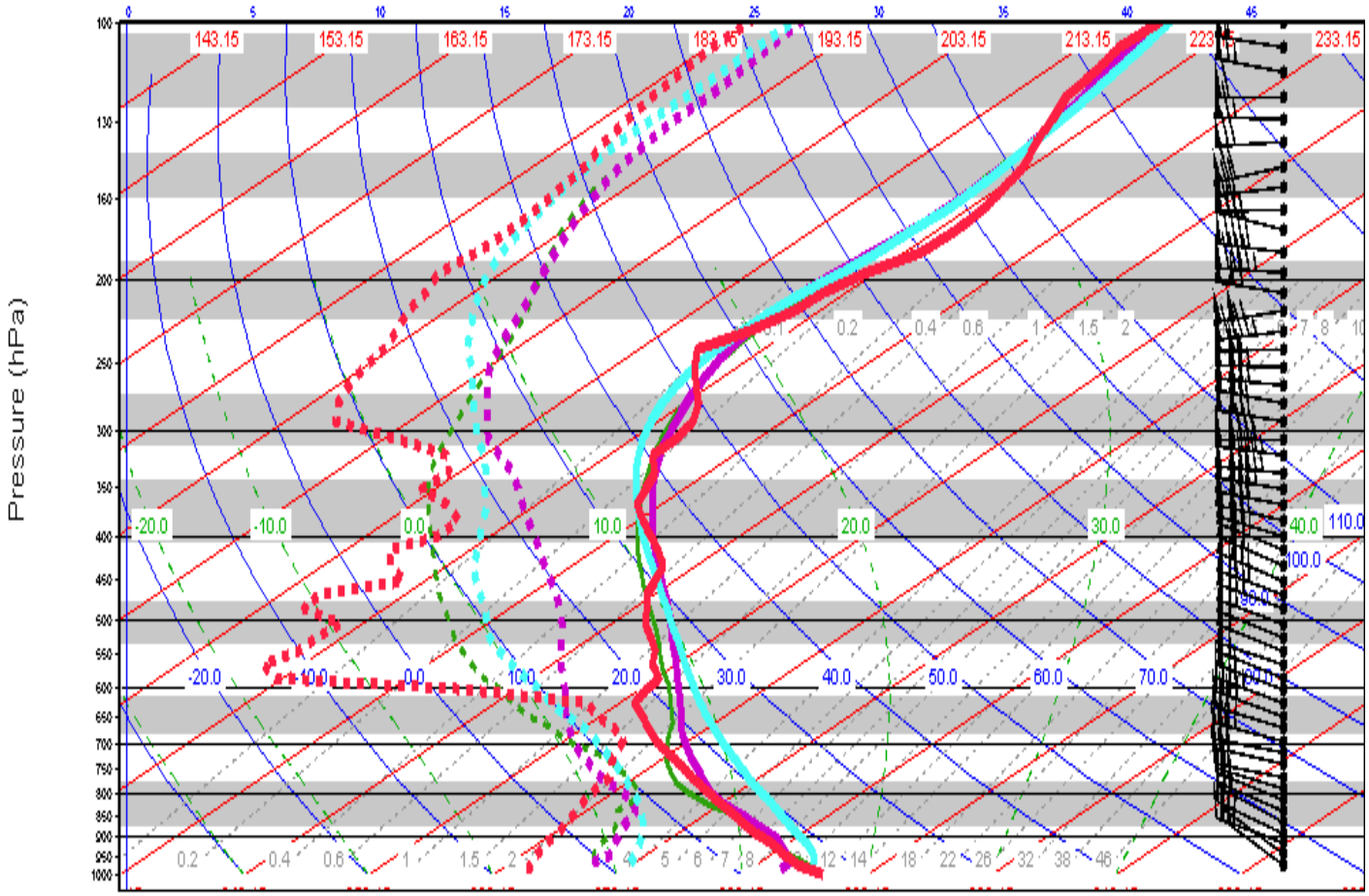
Baseline: GRUAN Radiosonde

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

"k" based on GRUAN Uncertainty

NOAA Products Validation System (NPROVS)

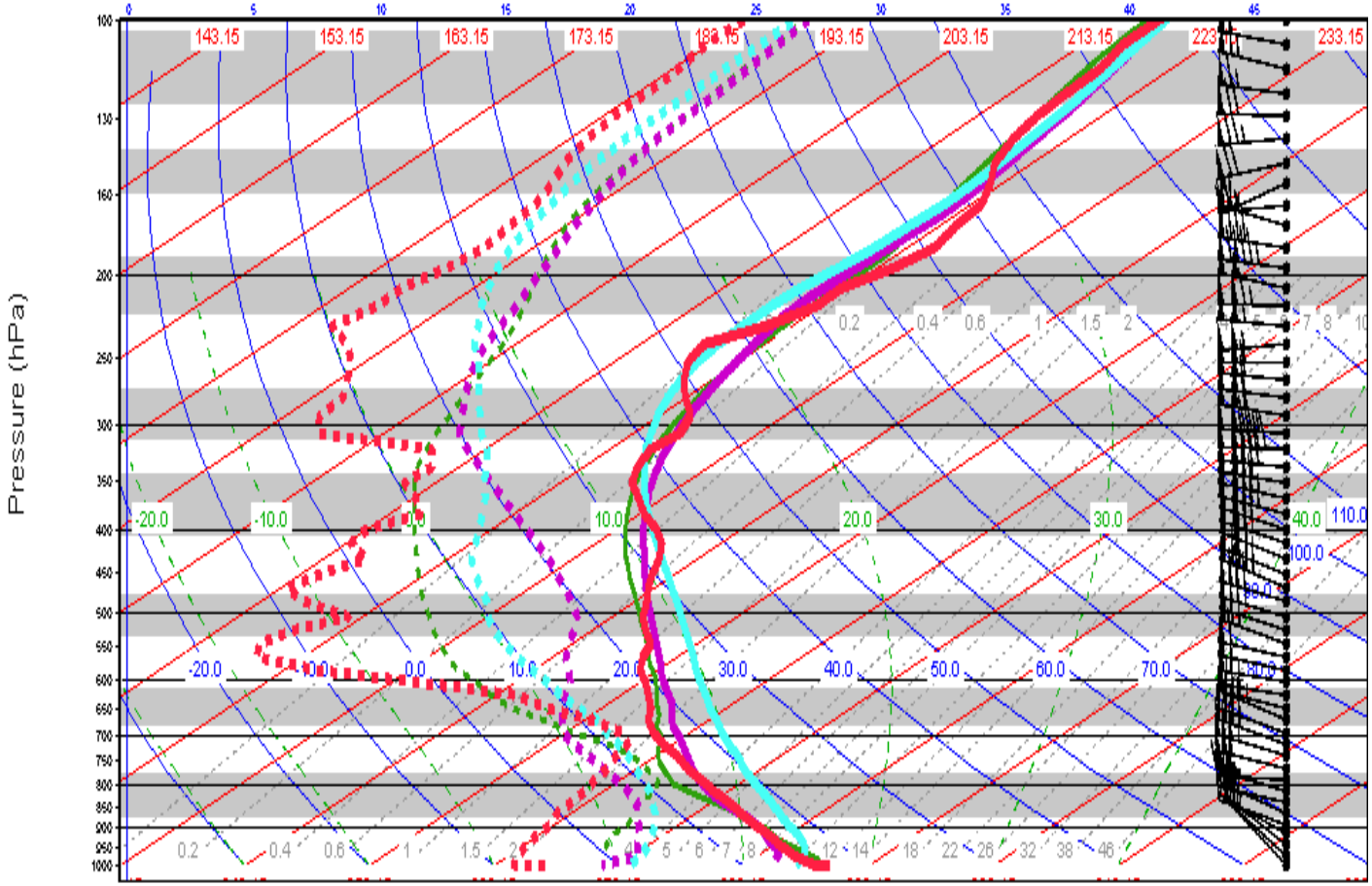
Temperature (deg K)



Radiosonde 72000 (152)	3/18/2016 17:32:00Z	39 N / 77.5 W
Sonde		
MIRS NPP (0.6)	3/18/2016 18:02:11Z (0.5 hours)	39 N / 77.4 W (5.4 km)
MIRS NPP		
NOAA IASI MetOp-B	3/18/2016 15:37:38Z (-1.9 hours)	38.9 N / 77.9 W (39.8 km)
NOAA IASI MetOp-B		
NUCAPS NPP	3/18/2016 18:02:03Z (0.5 hours)	39.1 N / 77.5 W (13.9 km)
NUCAPS NPP		

NOAA Products Validation System (NPROVS)

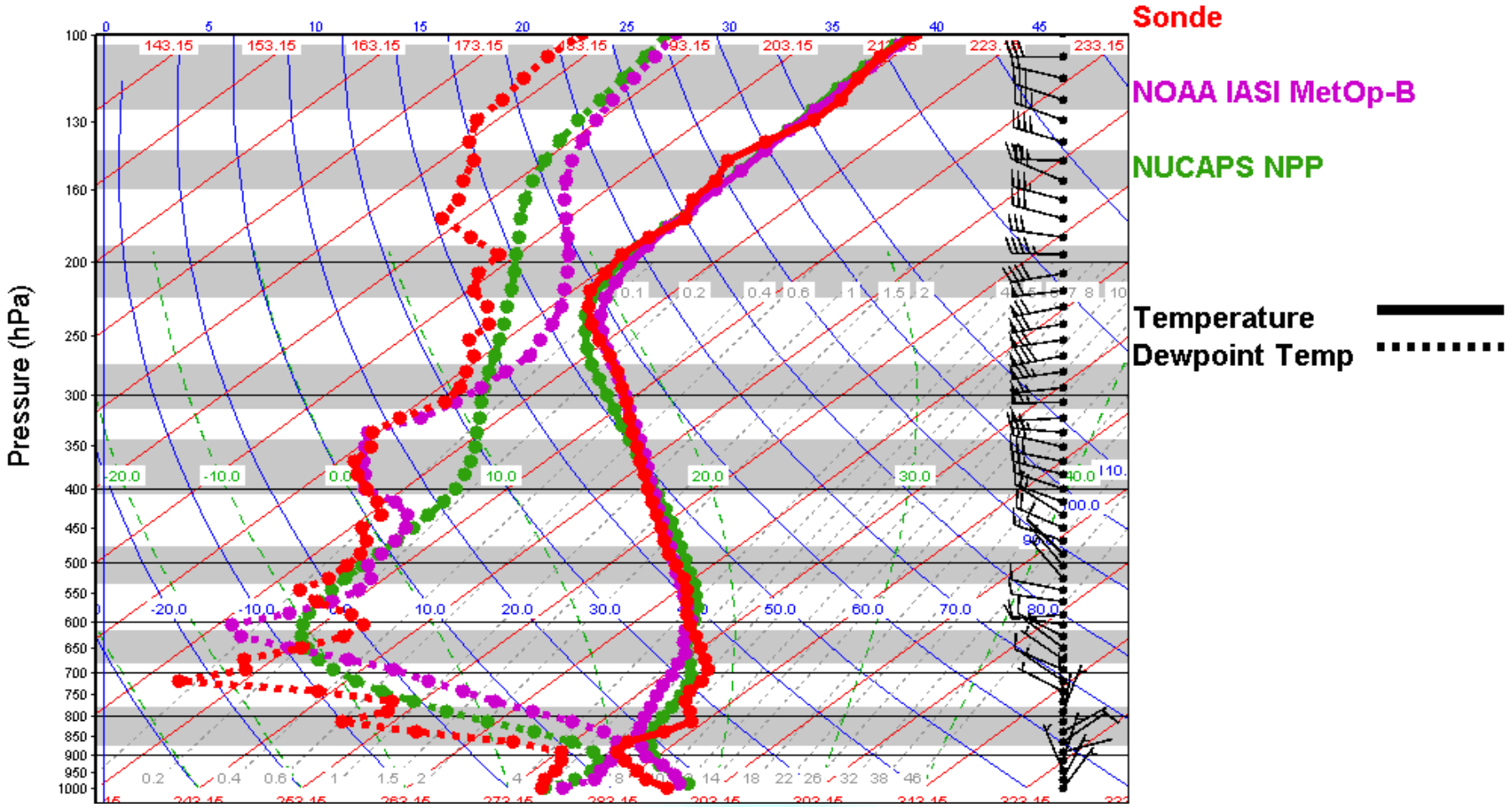
Temperature (deg K)



Radiosonde BELTSV (114)	3/18/2016 17:31:00Z	39 N / 76.9 W
Sonde		
MIRS NPP (0.5)	3/18/2016 18:02:12Z (0.5 hours)	39.1 N / 76.9 W (5.3 km)
MIRS NPP		
NOAA IASI MetOp-B	3/18/2016 15:37:30Z (-1.9 hours)	39.1 N / 76.8 W (8.6 km)
NOAA IASI MetOp-B		
NUCAPS NPP	3/18/2016 18:02:03Z (0.5 hours)	39.2 N / 76.9 W (17.7 km)
NUCAPS NPP		

NOAA Products Validation System (NPROVS)

Temperature (deg K)

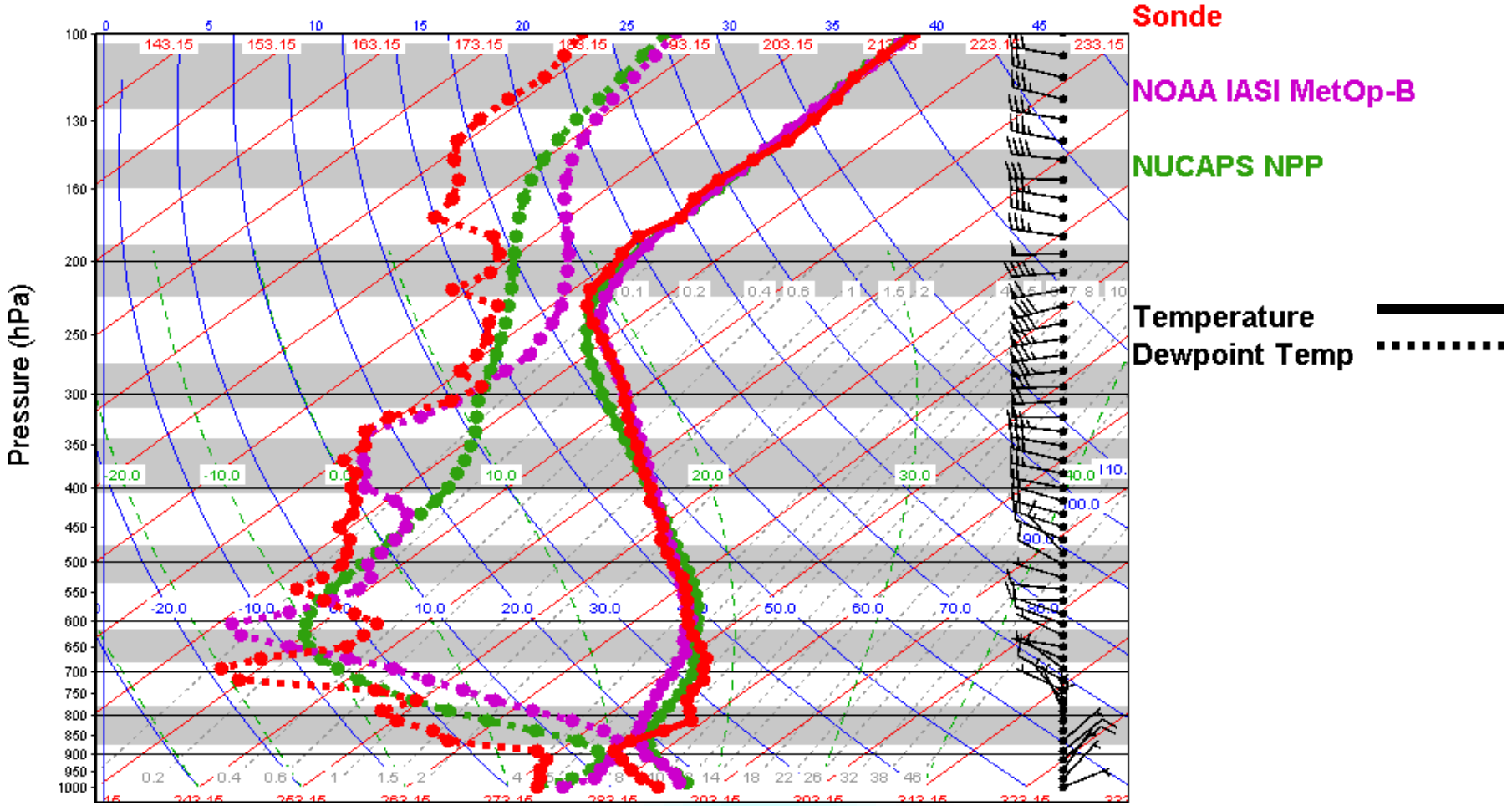


10/10/2015 1733Z … Sterling (71000)

Sterling / Beltsville Sync, +/- 1 hr of NUCAPS …**1804Z (11km); 1550Z (44km)**

NOAA Products Validation System (NPROVS)

Temperature (deg K)



10/10/2015 1733Z … Beltsville (114))

Sterling / Beltsville Sync, +/- 1 hr of NUCAPS …**1804Z (16km); 1550Z (11km)**

STAR Center for Satellite Applications and Research
formerly ORA — Office of Research and Applications

WEB Site

STAR ICVS Integrated Calibration / Validation System Long-Term Monitoring
Monitoring and characterizing satellite instrument performance in orbit for weather, climate and environmental

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» Instrument Performance Monitoring

Suomi NPP
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- ATMS
- CrIS
- CrIS FSR
- VIIRS
- OMPS Nadir Mapper
- OMPS Nadir Profiler
- OMPS Limb Profiler

MetOp-B
- AMSU-A
- MHS
- AVHRR
- HIRS

NOAA-19
- AMSU-A
- MHS

STAR ICVS Long-Term Monitoring

2015 STAR ICVS Instrument Performance Review
May 8, 2015 - Presentations

Benefits of Integrated Calibration/Validation

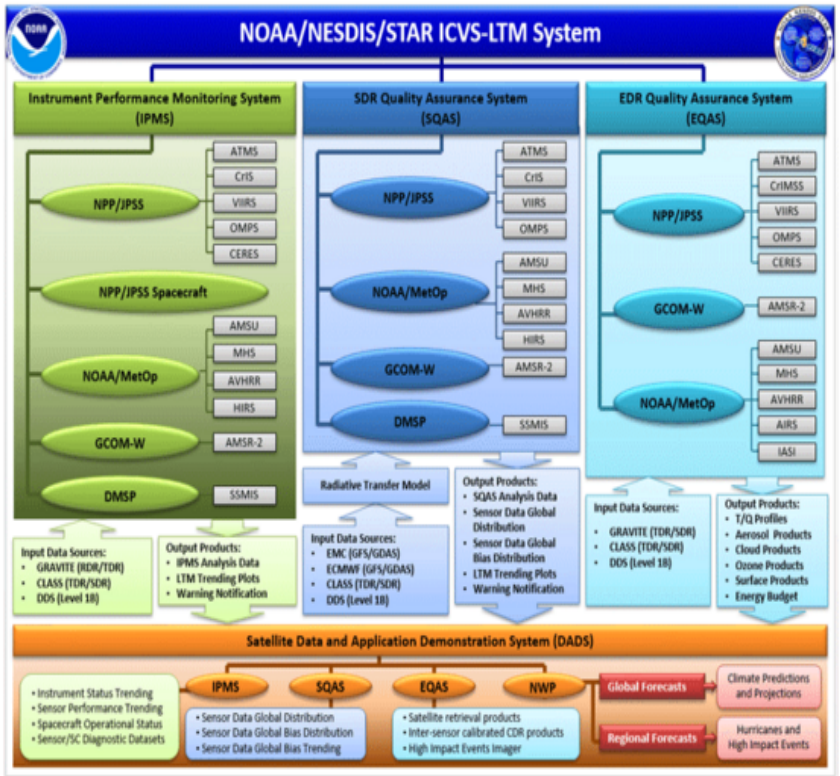
- Turn instrument measurements into accurate environmental parameters.
- Ensure high-quality satellite imagery for forecasts (e.g., hurricane tracking and monitoring).
- Deliver accurate products for weather forecasts and environmental monitoring
- Ensure the integrity of the climate data records from broader satellite instruments.

ICVS Vision

Satellite observations are intercomparable and tied to international standards for weather, climate, ocean and other environmental applications.

ICVS Goals

1. Provide real-time environmental satellites performance monitoring.
2. Reduce the uncertainty in climate trend detection and prediction through vigorous calibration and reprocessing.
3. Increase accuracy of satellite data for weather and environmental prediction models.



SDR

http://www.star.nesdis.noaa.gov/icvs/

Site Atmospheric State Best Estimate (SASBE)

ARM
CLIMATE RESEARCH FACILITY

Site **A**tmospheric **state** **B**est **E**stimate

GRUAN

SASBE as a metric for site assessment