

Justification for NUCAPS / CrIMSS EDR Stage-1 Maturity Jan. 8, 2014 NCWCP

Tony Reale, CrIMSS EDR Validation and Algorithm Lead
Richard Cember, CrIMSS EDR JAM

Significant inputs were made from the entire CrIMSS EDR
Algorithm and Validation Team Members.





OUTLINE



- **Team Members**
- **Project Goals**
- **Activities / Achievements**
- **Validation Results**
- **Summary**



TEAM MEMBERS



Lead for Activity	Organization	Task
Tony Reale	NOAA/NESDIS/STAR	CrIS/ATMS EDR Cal/val and Alg Dev (Divakarla, Xiong, Nalli, Iturbide, Tan) ... IMSG
Tony Reale	NOAA/NESDIS/STAR	NPROVS/NPROVS+ (Sun, Pettey, Brown, Tilley ...) IMSG
Ralph Ferraro	NOAA/NESDIS/STAR	Precipitation Flag

Lead for Activity	Organization	Task
Xu Liu	NASA/LaRC	CrIMSS EDR Algorithm Validation (Kizer)
Hank Revercomb	SSEC	AVMP/AVTP validation (Knuteson)
Dave Tobin	SSEC	ARM-RAOBS at NWP, SGP, NSA
Larrabee Strow	UMBC	OSS validation and comparisons to SARTA



TEAM MEMBERS



Lead for Activity	Organization	Task
Tony Reale	JPSS /ARM/ PNNL	VAISALA RS 92 Dedicated RAOB @ ARM (Nalli, Tobin, Mather ...) IMSG/CIMSS/ARM



TEAM MEMBERS



(never funded)

SDR/EDR	Lead for Activity	Organization	Task
ATMS SDR, CrIS SDR, CrIMSS EDR	Degui Gu / Denise Hagan / Xia-Lin Ma	NGAS	EDR /SDR Validation, code integration
ATMS TDR/SDR	Sid Boukabara	NOAA/STAR	MiRSEDR
CrIMSS EDR	Lars Peter Riishojgaard	JCSDA	NCEP analysis
CrIMSS SDR	Steven Beck	Aerospace Corp.	RAOB,LIDAR
CrIMSS SDR	Steven English	UKMET	UKMET analysis
AVTP/AVMP	Lee, Fishbein, Freidman ...	NASA/JPL	Sounder PEATE
CrIMSS SDR	Ben Rustin	NRL	NOGAPS/NAVDAS
Eric Maddy	STC	NUCAPS EDR Development and Validation	

A. Gambacorta ...	IMSG	NUCAPS EDR Development and Validation	
-------------------	------	---------------------------------------	--

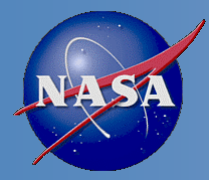


PROJECT GOALS



- **Algorithm Development**
 - a) **Finalize / Transition CrIMSS to NUCAPS**
 - b) **Troubleshoot and Upgrade NUCAPS**
 - c) **NOAA compatible algorithm; AIRS, IASI, CrIS**
 - d) **Product uncertainty**

- **EDR Validation**
 - a) **NPROVS** (*conv RAOB, legacy SAT, NWP...*)
 - b) **NPROVS +** (*ref/ded RAOB, legacy sat, ground, SSE ... SDR, re-retrieval ... **algorithm development***)
 - c) **leverage existing CrIMSS / NUCAPS** (*focus day, dedicated RAOB, SSE ...*)



ALGORITHM DEVELOPMENT

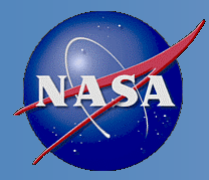


- **Objectives:**

- a) **Finalize / Transition CrIMSS to NUCAPS**
- b) **Troubleshoot and Upgrade NUCAPS**
- c) *NOAA compatible algorithm; AIRS, IASI, CrIS*
- d) *Entice users*

- **Methods:**

- a) **Merging of CrIMSS (IDPS) with NUCAPS (NDE) Programs**
- b) **Leverage Project Legacy, NPROVS and NPROVS+ Validation Capabilities**
- c) *tbd ...*
- d) *Product Uncertainty ...*



ALGORITHM DEVELOPMENT

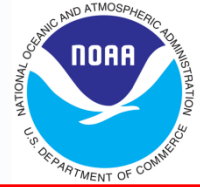


WHY SOUNDING EDR

- Product of Prime Interest for Weather / Climate
- ***Demonstration of Complete Sensor Capability***
- Legacy
- RT Model Validation
- Users (NWS, Research ...)



ALGORITHM DEVELOPMENT



Users of CrIMSS EDR

In reality, Sounding EDR has (very) limited user base

- NOAA-TOAST product considering use of CrIMSS O3-IP (within NDE)
- **AWIPS has decided to use the NOAA-Unique CrIS/ATMS Processing System (NUCAPS) products**
 - Desire 100 level product
 - Desire continuity with IASI product EDR formats
 - Desire rapid R2O environment
 - NUCAPS had a successful Alg. Readiness Review on Jan. 14, ready for operations
 - Product will be available to users from CLASS in summer 2013
- CrIMSS-EDR is a baseline operational product
 - Physical-only 1DVAR approach is unique for hyperspectral IR
 - Can explore capabilities for NWP applications.
 - Retrievals are a “test-bed” for exploitation of CrIS radiances.
 - These capabilities are usually imbedded directly into NWP
 - Other developers use it as a “standard” to explore trade-offs in methodologies
- Historically, the users of these kinds of products are varied (e.g., climate, air-quality, process studies, etc.)
 - Users tend to be access data as needed for their study, not a 24/7 user.
 - AIRS EDR products are used in ~30-40 publications/year in recent years.
 - AIRS project has identified 100’s of unique users of it’s EDR standard and support products; however, it is not clear how much volume of data they use.
 - NASA/AIRS team reprocesses the entire Aqua/AIRS dataset at maturity level transitions (v3 beta, v4 provisional, v5 stage.1, v6 stage.2, etc.) → could attract users.



Overview of EDR Data Products (2/4)

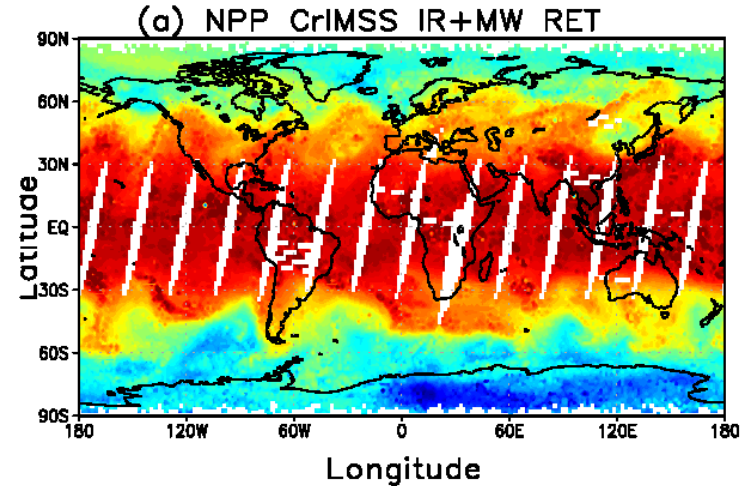


Atmospheric Vertical Temperature Profile (AVTP).

Used for initialization of high-resolution NWP models, atmospheric stability, etc.

Lower tropospheric temperature are no-longer KPPs.

Parameter (Lev 3; no KPP)	IODR-II, JPSS-L1RD
AVTP Partly Cloudy, surface - 300 mb	1.6 K/1-km layer
AVTP Partly Cloudy, 300 to 30 mb	1.5 K/3-km layer
AVTP Partly Cloudy, 30 mb to 1 mb	1.5 K/5-km layer
AVTP Partly Cloudy, 1 mb to 0.5 mb	3.5 K/5-km layer
AVTP Cloudy, surface to 700 mb	2.5 K/1-km layer
AVTP Cloudy, 700 mb to 300 mb	1.5 K/1-km layer
AVTP Cloudy, 300 mb to 30 mb	1.5 K/3-km layer
AVTP Cloudy, 30 mb to 1 mb	1.5 K/5-km layer
AVTP Cloudy, 1 mb to 0.05 mb	3.5 K/5-km layer



Example of AVTP at 500 hPa on May 15, 2012 from the CrIMSS off-line EDR

Results are from the coupled algorithm without QC



Overview of EDR Data Products (1/4)

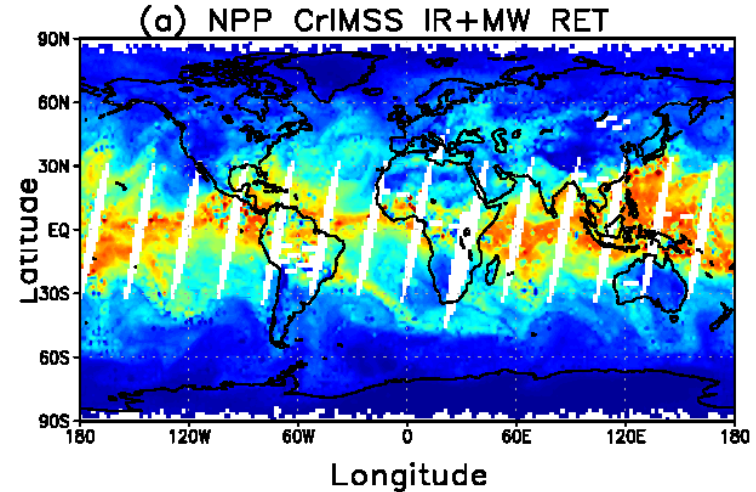


Atmospheric Vertical Moisture Profile (AVMP).

Used for initialization of high-resolution NWP models, atmospheric stability, etc.

Lower tropospheric moisture layers are no longer Key Performance Parameters (KPPs) .

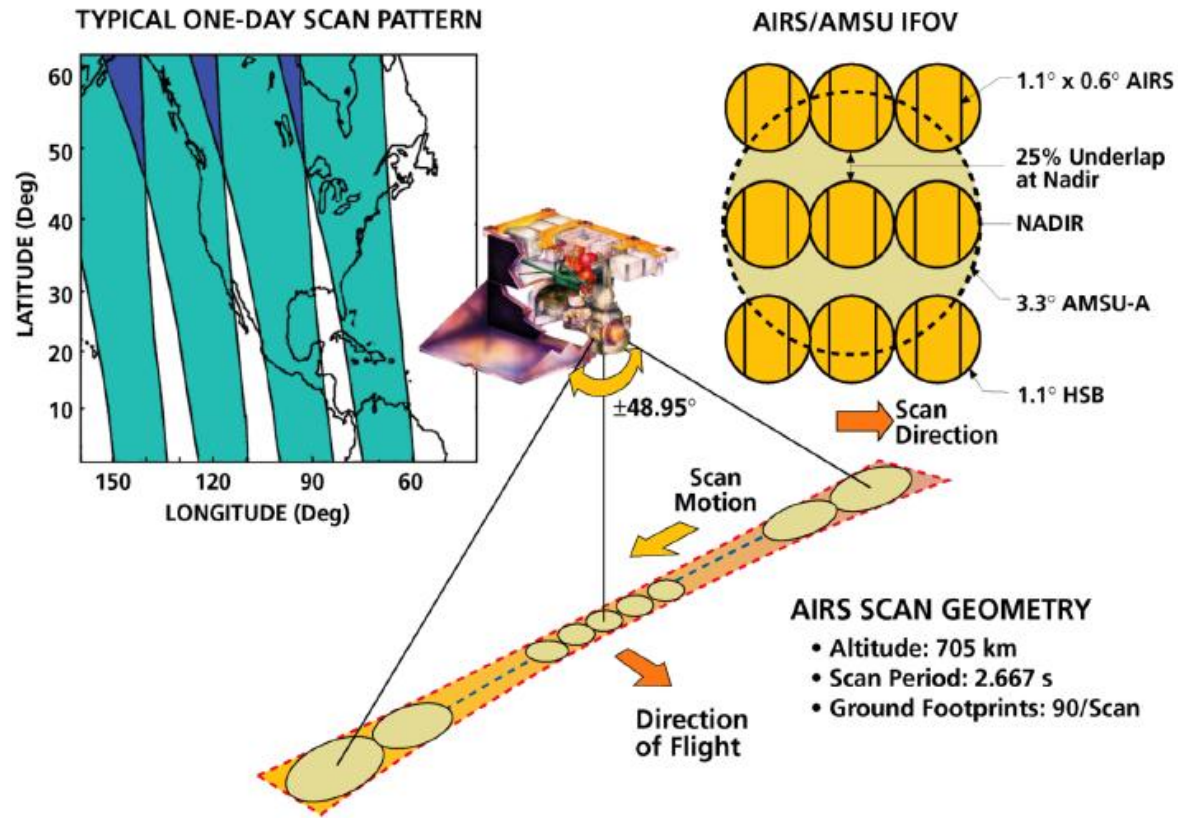
Parameter (KPP(Lev 3 ...))	IORD-II, JPSS-L1RD
AVMP Partly Cloudy, surface to 600 mb	Greater of 20% or 0.2 g/kg
AVMP Partly Cloudy, 600 to 300 mb	Greater of 35% or 0.1 g/kg
AVMP Partly Cloudy, 300 to 100 mb	Greater of 35% or 0.1 g/kg
AVMP Cloudy, surface to 600 mb	Greater of 20% of 0.2 g/kg
AVMP Cloudy, 600 mb to 300 mb	Greater of 40% or 0.1 g/kg
AVMP Cloudy, 300 mb to 100 mb	Greater of 40% or 0.1 g/kg



Example of AVMP (shown as total precipitable water) on May 15, 2012 from the CrIMSS off-line EDR

Results are from the coupled algorithm without QC

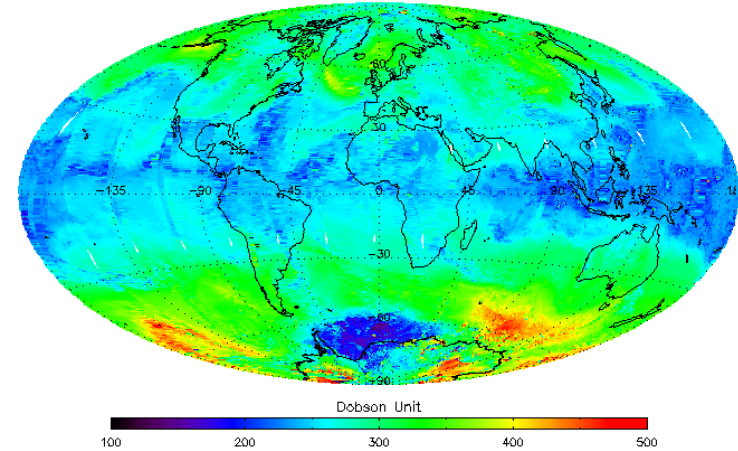
- Sounding is performed on 50 km field of regard (FOR).
- FOR is currently defined by the size of the microwave sounder footprint.
- IASI/AMSU has 4 IR FOV's per FOR
- AIRS/AMSU & CrIS/ATMS have 9 IR FOV's per FOR.
- ATMS is spatially over-sampled and can emulate an AMSU FOV.



... additional stamp info (500km area centered at RAOB) supports development

- Pressure product is a EDR derived product that requires validation.
- Ozone is an intermediate product (IP) used by the OMPS team.
- CO, CH4 and CO2 are pre-planned product improvements(P³I)
 - SOAT has recommended full-resolution RDR's for CrIS SW and MW bands to support these products..

CrIS/IIRD total column O₃ at 10/16/2012

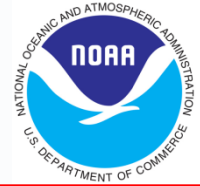


Example of CrIMSS total column ozone IP product (day+night) from CrIS for Oct. 16, 2012.

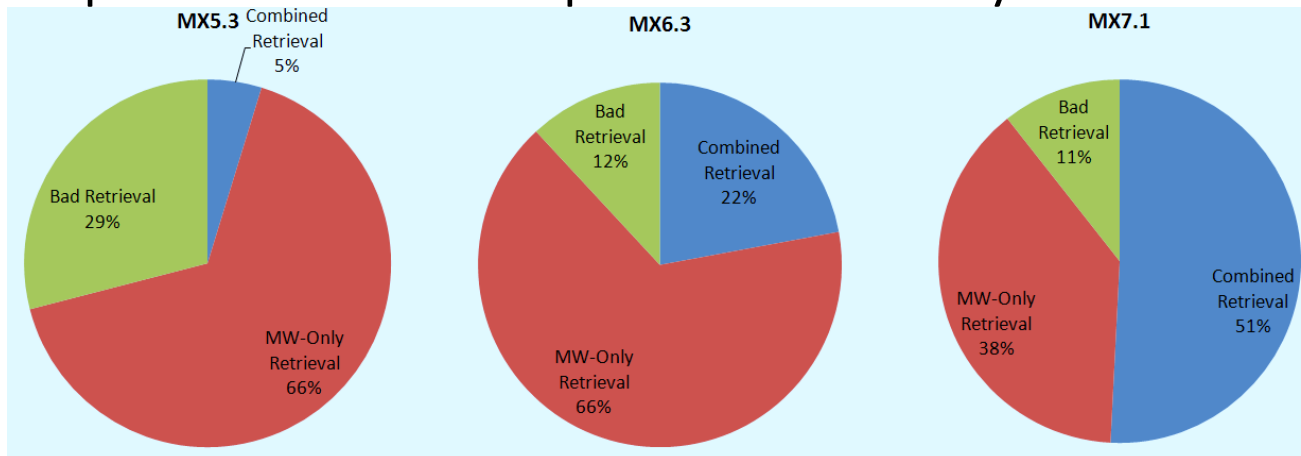
Parameter (P ³ I in Blue)	IORD-II / JPSS-L1RD
Pressure Profile	4 mb threshold, 2 mb goal
Ozone IP	20% precision for ~5 km layers from 4 hPa to 260 hPa
CH ₄ (methane) column	1% ± 5% / 1% ± 4% (precision ± accuracy)
CO (carbon monoxide) column	3% ± 5% / 35% ± 25% (precision ± accuracy)



Algorithm Achievements



- Mx5.3, operational since April 1, 2012
 - This is the *beta* maturity system
- Mx6.4 (a.k.a. Mx6.3), operational since Oct. 12, 2012
 - Added empirical bias corrections for ATMS, updated CrIS
- Mx6.6, expected to be operational in Feb. 2012
 - Fixed an indexing bug for non-LTE and ozone channels
 - Significant improvements in daytime yield (from 4% to 50%)
- Mx7.1, expected to be operational in June 2012
 - Improvements in both performance and yield





Algorithm Achievements



The following DRs were completed after MX7.1 (Provisional), and placed in MX8.0.

DR 3193: Typo in NEDN ratio.

Description: Currently the operation code uses a value of 4.246 as the ratio of the clear-radiance differences and the NEDN of the channel. The ATBD calls out a value of $3 \cdot \sqrt{2}$ or 4.2426 as the value. The code and ATBD should be consistent. Change all occurrences of 4.246 in the code to 4.2426. (Also, define 4.2426 as a constant, rather than having multiple occurrences of 4.246 in the code.)

DR 7116: Noise Amplification factor coding error

Description: The noise amplification factor was not done correctly when clear skies occur. For clear skies, this value was set to an error (999999) until a partly cloudy or cloudy profile occurred, at which point clear skies kept the last partly cloudy or cloudy value. This sets ccnaf properly to 1/9, which leads to a reported value of 0.333333 in the noise amplification factor.

DR 7119: Cloud Path Mismatch

Description: The definitions for cloudy, partly cloudy, and clear in the QC flags were not consistent with their usage in the code. Clear scenes should not use cloud clearing, partly cloudy scenes should be cloud cleared, and cloudy scenes should not execute the ir+mw portion of the code. The new definition connects clear, partly cloudy, and cloudy scenes to their usage to be consistent.

DR 7197: "Proper Assignment of Quality Control Flags for Combined Microwave and Infrared Retrieval that Terminates Early."

Description: QC flags were not properly assigned when the mw+ir retrieval terminated early. Under specific circumstances, such as overcast skies or high error, the mw+ir retrieval stops. For overcast skies, the QC pass/fail flag for the mw+ir run was based on the prior profile. For high error cases, this high error was intended to automatically fail this flag. However, the error was forgotten when the flag was calculated, resulting in high-error cases with passing QC flags.



Algorithm Achievements



The following DR's were intended for the future MX8.1.
However, they have not yet been implemented in operations:

DR 4068/4069: Precipitation Update

Description: The precipitation algorithm in the original EDR was outdated. This DR replaces the old algorithm with a new algorithm based on MSPPS.

DR 4923: Surface Pressure was not accurate.

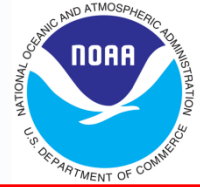
Description: The surface pressure ancillary input was corrected for surface elevation once too often, resulting in incorrect surface pressures over land. This was corrected by commenting out the second correction in `get_pres.f`

DR 7252: Modifications to Ozone and Water Vapor Retrievals

Description: Overcast profiles for water vapor and ozone contained IP data in the mw+ir product that differed from the microwave-only product. This should not be possible, since the combined mw+ir run never occurs so no data can even exist in the first place. The suggested fix is to report mw-only results in the mw+ir product except for ozone, which would be fill. (Ozone product does not exist for mw-only run.)



Algorithm Achievements



The following DR's already exist, but are still being worked on.
Some may need to be re-opened or resubmitted as DRs:

DR 4943: Change IR-ATM-NOISE and IR-NOISE LUTs.

Changes to these LUTs were based in more realistic noise LUTs for the CrIS instrument. However, they appear to be the culprit for introducing larger errors in the 100-200 mb temperatures over the polar regions. These DRs need to be re-addressed to correct the issues in the polar upper atmosphere.

DR 4944: Create new bias LUTs for CrIS and ATMS.

This has been an ongoing DR. Now that the MW SDRs have been modified to account for side lobes, the bias LUT for ATMS needs to be modified. Otherwise, the side lobes are being corrected for twice.

DR 7206: Add emissivity hinge points to improve the ozone product.

Xu Liu has proposed increasing the number of hinge points from 12 to 16. This would require a new LUT and a minor code change increasing the hinge point number to 16. The end result should be an improved ozone product.

DR 7207: Upgrade emissivity (in climatology LUT) to update emissivity values, and stratify by lat/long and month.

Xu Liu has proposed to stratify the emissivity LUT to stratify by categories such as latitude, longitude, and time of year. This would result in a much larger climatology LUT and changes to the code to incorporate the changes. At a minimum, adjust the emissivities to new values.



Algorithm Achievements



These DR's have either been done without our input (Raytheon), have been dropped due to funding (Northrop Grumman) or have otherwise not actively been pursued:

DR 7069: QF flags are incorrect when ATMS is missing.

This was a DR that was pursued by Raytheon. The off-line code at STAR does not run when ATMS data is missing, since the off-line code does not have access to NWP data. The ADL version may still be able to run.

DR 7118: Water vapor supersaturation is too restrictive in the upper atmosphere.

This was being pursued by Xu Liu, but we haven't seen any updates on this particular topic.

DR 7205: Overcast skies can be called clear.

This was being pursued by Northrop Grumman until funding was discontinued. Two suggestions were being considered: rejecting scenes which resulted in drastic changes of the surface temperature, and forcing clear scenes to have a cloud liquid water content of zero prior to the mw+ir run.

DR 7218: ProfDiff (QF value) is incorrect when ATMS is missing.

Again, this is something raised by Raytheon, which the off-line code is not capable of investigating.

Unassigned DR: Fix the calculation of altitude in making the EDR layered product. Suggested by Xu Liu but not pursued at this time.

Unassigned DR: Remove an incorrect calculation of combined IR noise variance when two separate noise values need to be combined (i.e. `iatmnoise==1`). In MX7.1, this value was hardwired to zero, so this code never gets executed. Therefore, there's no need to change it in operations. It should still be noted that this is a bug and should be removed from the offline code so that `iatmnoise==1` runs properly.



Algorithm Achievements



Transition to NUCAPS Underway



PROJECT GOALS



- **Algorithm Development**
 - a) **Finalize / Transition CrIMSS to NUCAPS**
 - b) **Troubleshoot and Upgrade NUCAPS**
 - c) **NOAA compatible algorithm; AIRS, IASI, CrIS**
 - d) **Product uncertainty**

- **EDR Validation**
 - a) **NPROVS** (*conv RAOB, legacy SAT, NWP...*)
 - b) **NPROVS +** (*ref/ded RAOB, legacy sat, ground, SSE ... SDR, re-retrieval ... **algorithm development***)
 - c) **leverage existing CrIMSS / NUCAPS** (*focus day, dedicated RAOB, SSE ...*)



EDR VALIDATION



- **Objectives:**

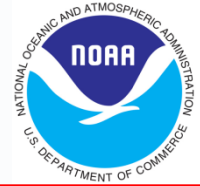
- Expand the Project EDR Cal / Val (Provisional) Capability ...
Stage 1, 2, 3
- Compare NUCAPS vs CrIMSS ... etc
 - *Long term (seasonal) ... stage 2, 3*
 - Short term (10-day)
 - *deep dive ...*

- **Methods:**

- Compile / analyze “expanded” NPROVS and NPROVS+ Collocation Datasets
- *Leverage with legacy project validation capability*



EDR VALIDATION



Validated Definition	Artifacts (Deliverables) All Applicable to Stages 1-4
<p>Validated Stage 1: Using a limited set of samples, the algorithm output is shown to meet the <u>threshold</u> performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions</p>	<p>The list of required artifacts supporting each stage of Validated Maturity are identical:</p> <ul style="list-style-type: none"> • Algorithm Assessment <ul style="list-style-type: none"> ○ Evaluation of algorithm performance to specification requirements ○ Evaluation of the effect of required algorithm inputs ○ Error Budget ○ Quality Flag analysis/validation ○ Input from key users • Identification of the processing environment <ul style="list-style-type: none"> ○ IDPS Build Number and effectivity date ○ Version of LUT(s) used ○ Version of PCT(s) used ○ Description of environment used to achieve particular stage of Validated • Documentation <ul style="list-style-type: none"> ○ Current or updated ATBD ○ Current or updated OAD (algorithm-related redline updates, if applicable) ○ README file for CLASS ○ Product User's Guide (Recommended) • User Precautions <ul style="list-style-type: none"> ○ Identification of known issues ○ List of closed Discrepancy Reports between previous maturity milestone and current maturity milestone. ○ Assessment of outstanding Discrepancy Reports
<p>Validated Stage 2: Using a moderate set of samples, the algorithm output is shown to meet the <u>threshold</u> performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions</p>	
<p>Validated Stage 3: Using a large set of samples representing global conditions over four seasons, the algorithm output is shown to meet the <u>threshold</u> performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions</p>	
<p>Validated Stage 4: Using a large set of samples representing global conditions over four seasons, the algorithm output is shown to meet or exceed the <u>objective</u> performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions</p>	

Stage 1 ... meet threshold performance using "limited" samples ...



EDR VALIDATION



Atmospheric Vertical Temperature Profile (AVTP)

Measurement Uncertainty – Layer Average Temperature Error

PARAMETER	THRESHOLD
AVTP Clear, surface to 300 mb	1.6 K / 1-km layer
AVTP Clear, 300 to 30 mb	1.5 K / 3-km layer
AVTP Clear, 30 mb to 1 mb	1.5 K / 5-km layer
AVTP Clear, 1 mb to 0.5 mb	3.5 K / 5-km layer
AVTP Cloudy , surface to 700 mb	2.5 K / 1-km layer
AVTP Cloudy, 700 mb to 300 mb	1.5 K / 1-km layer
AVTP Cloudy, 300 mb to 30 mb	1.5 K / 3-km layer
AVTP Cloudy, 30 mb to 1 mb	1.5 K / 5-km layer
AVTP Cloudy, 1 mb to 0.5 mb	3.5 K / 5-km layer

Clear ... IR+MW

Cloudy ... (MW only)

Atmospheric Vertical Moisture Profile (AVMP)

Measurement Uncertainty – 2-km Layer Average Mixing Ratio % Error

PARAMETER	THRESHOLD
AVMP Clear, surface to 600 mb	Greater of 20% or 0.2 g/kg / 2-km layer
AVMP Clear, 600 to 300 mb	Greater of 35% or 0.1 g/kg / 2-km layer
AVMP Clear, 300 to 100 mb	Greater of 35% or 0.1 g/kg / 2-km layer
AVMP Cloudy, surface to 600 mb	Greater of 20% of 0.2 g/kg / 2-km layer
AVMP Cloudy, 600 mb to 400 mb	Greater of 40% or 0.1 g/kg / 2-km layer
AVMP Cloudy, 400 mb to 100 mb	Greater of 40% or 0.1 g/kg / 2-km layer

Clear ... IR+MW

Cloudy ... (MW only)



EDR VALIDATION

(hierarchical ... *Nalli et al, JGR 2014*)



Dataset	Sampling	Characteristics
ECMWF/GFS	Global	± 3 hour, model errors, select “Focus Days”
NUCAPS EDR	Global, exact match	NOAA Unique using CrIS/ATMS Significant diagnostic capability
AIRS EDR Products	Global, near exact	NOAA Unique / NASA v6 after April 2013; Orbits are aliased, 16d repeat, different instrument
IASI EDR Products	Global, not so exact (except polar)	NOAA Unique, 4 hour orbit difference, different instrument
GPSRO (COSMIC)	Global ~ 1000 daily; RAOB anchor	Non synchronous; UTLS (T and H ₂ O) and Stratosphere (T up to 5mb); tropopause
Op. RAOB	~ 200 matchup/day	± 3 hours, ± 100 km, regional w.r.t. op.systems
Dedicated RAOB	~ 600 matchup/year	Only a handful of locations

CrIMSS EDR cal/val Team has maintained an “off-line” capability to provide reprocessing for these data sets on many systems (e.g., Mx5.3, 6.4, 6.6, 7.1) including individual changes made for each DR

- Allows demonstration of improvements on historical datasets
- Allows maximizing the impact of the investment in “truth” datasets

(Barnet, PROV)



EDR Validation

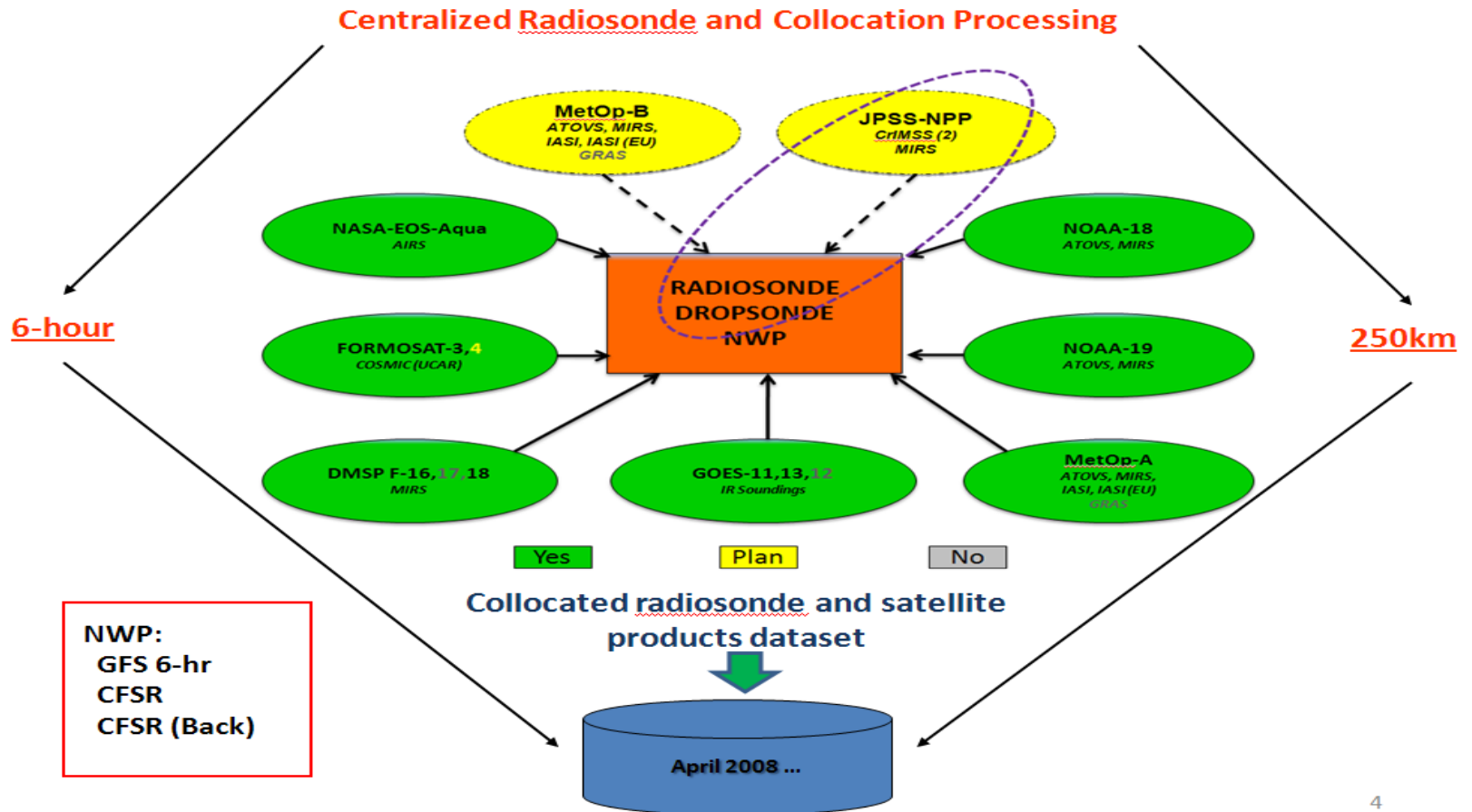


1) NPROVS

conventional RAOB
all legacy sat
large global sample



EDR VALIDATION

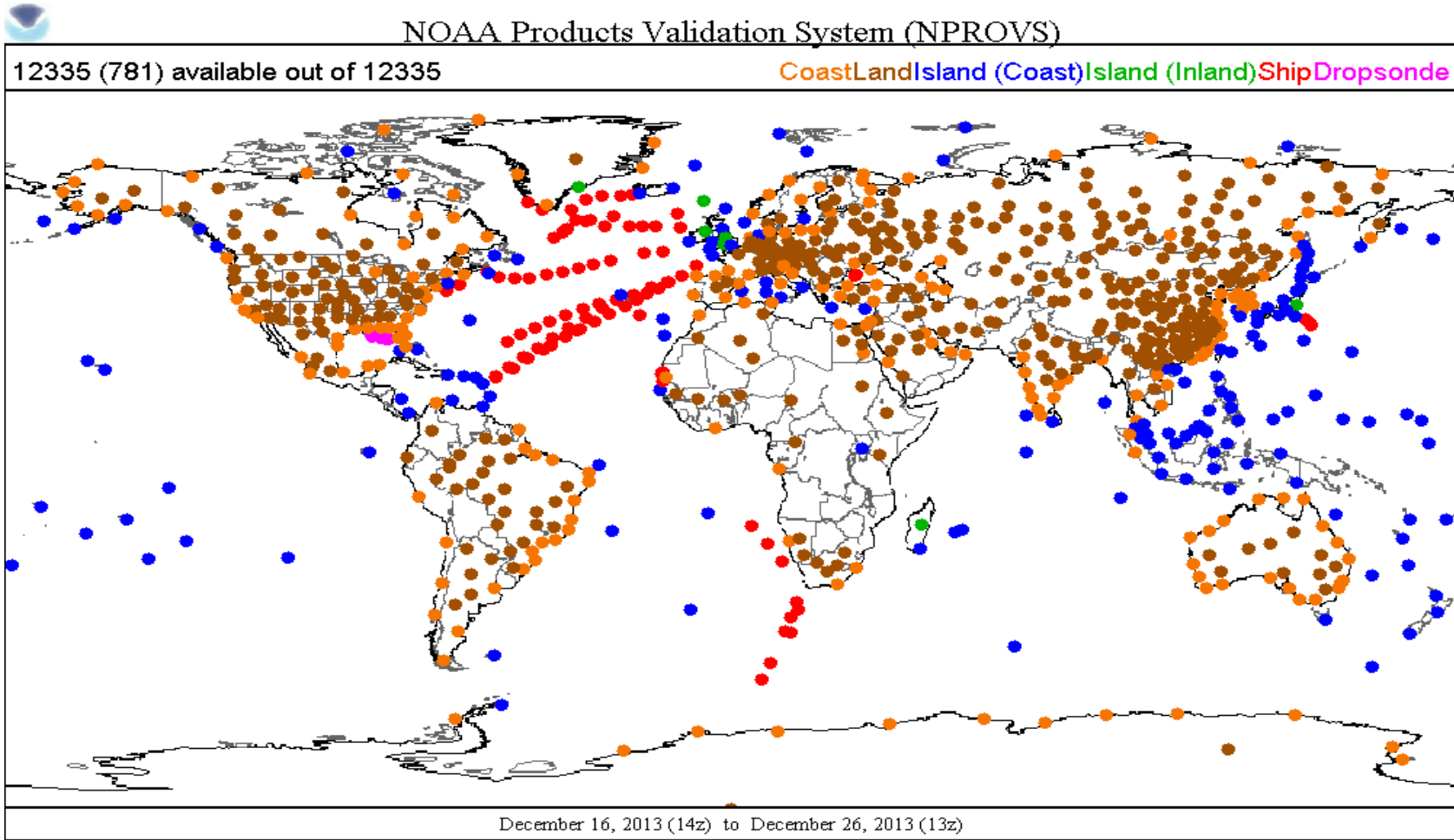


Conventional RAOB

NOAA Products Validation System (NPROVS)

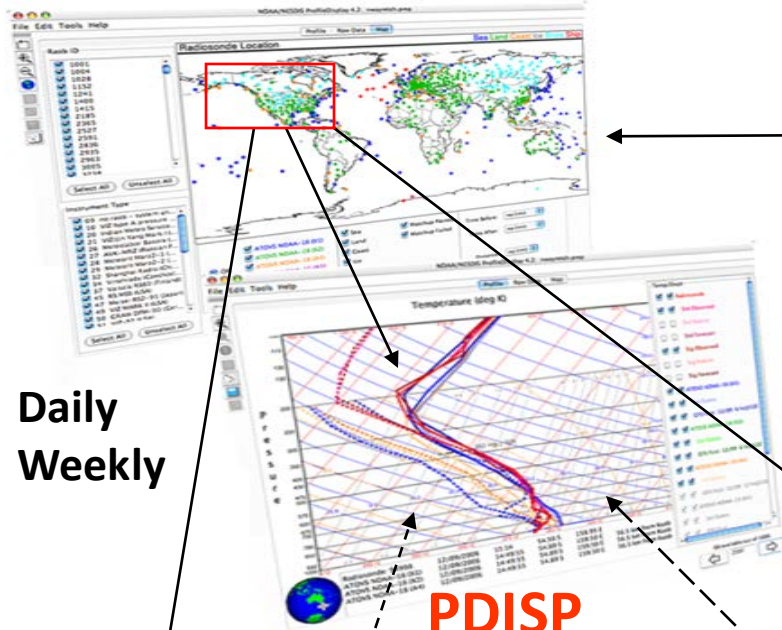


EDR VALIDATION



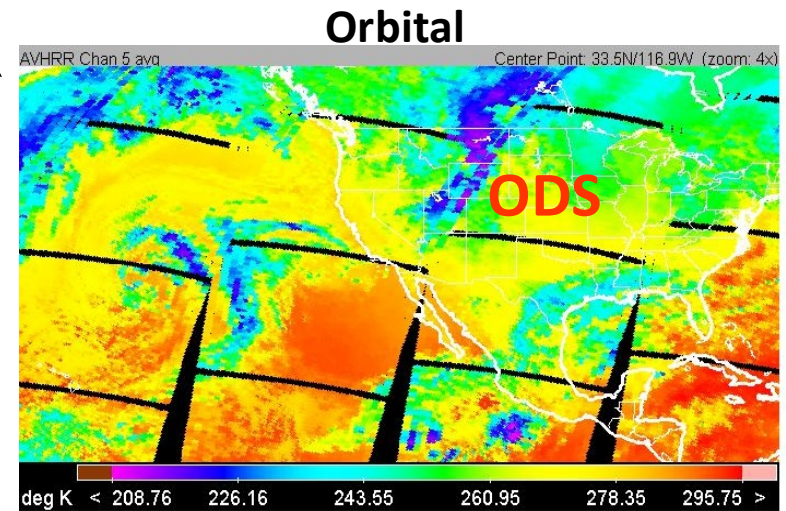
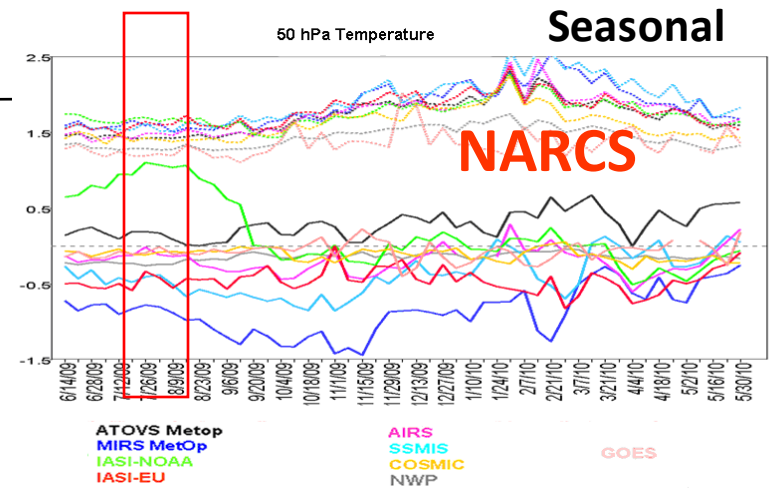
NPROVS Collocations 12/16 to 12/26 2013 ... 12,335

NPROVS Analytical Interface ...



Daily
Weekly

PDISP



... routine monitoring to deep dive



EDR Validation



2) NPROVS +

Ref/Ded RAOB

select legacy sat

Ground, SSE ...

"K" profile analysis

etc

"algorithm development"

SDR

Re-retrieval

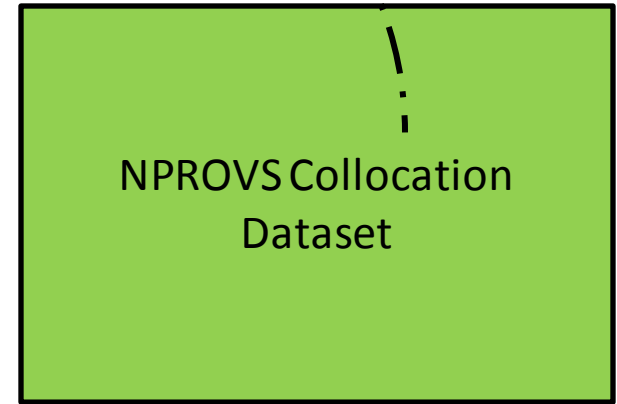
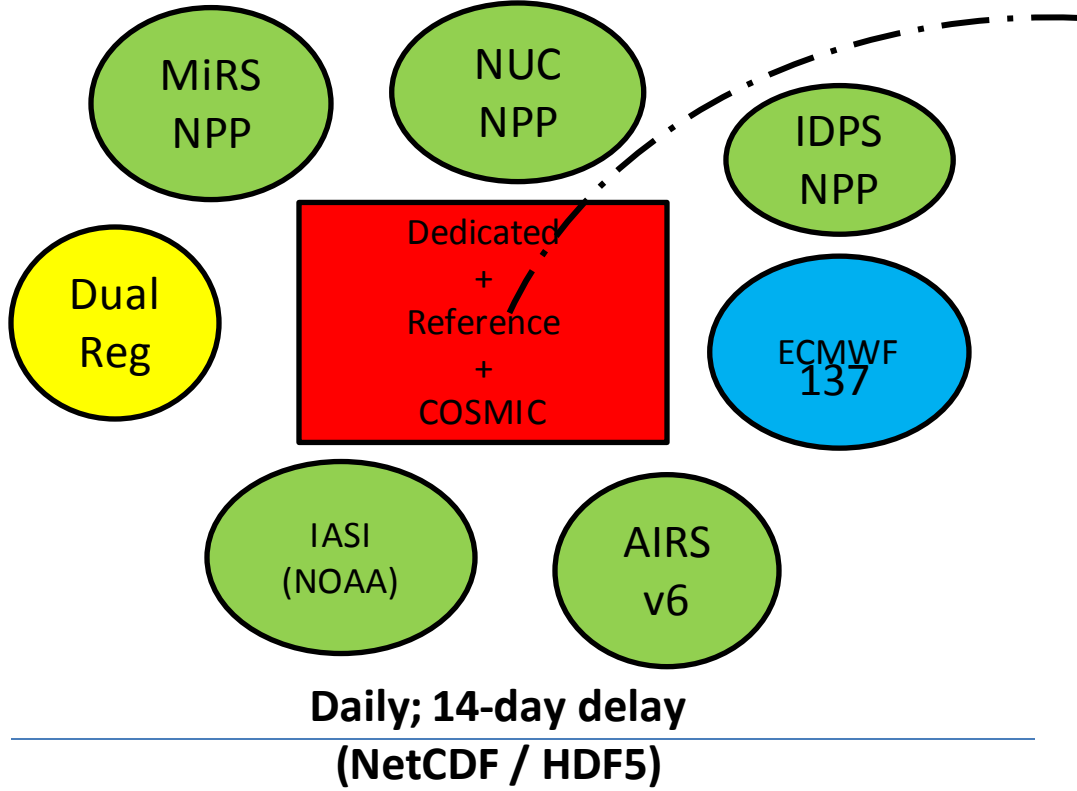
etc ...



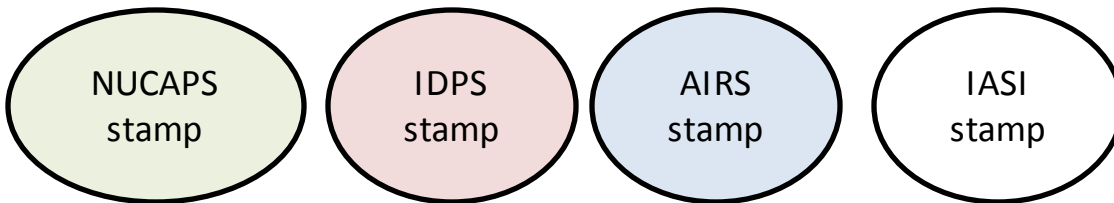
EDR Validation



GTS (CFRSR+GFS)



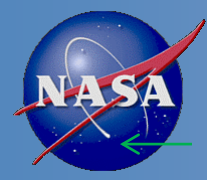
Daily; NRT



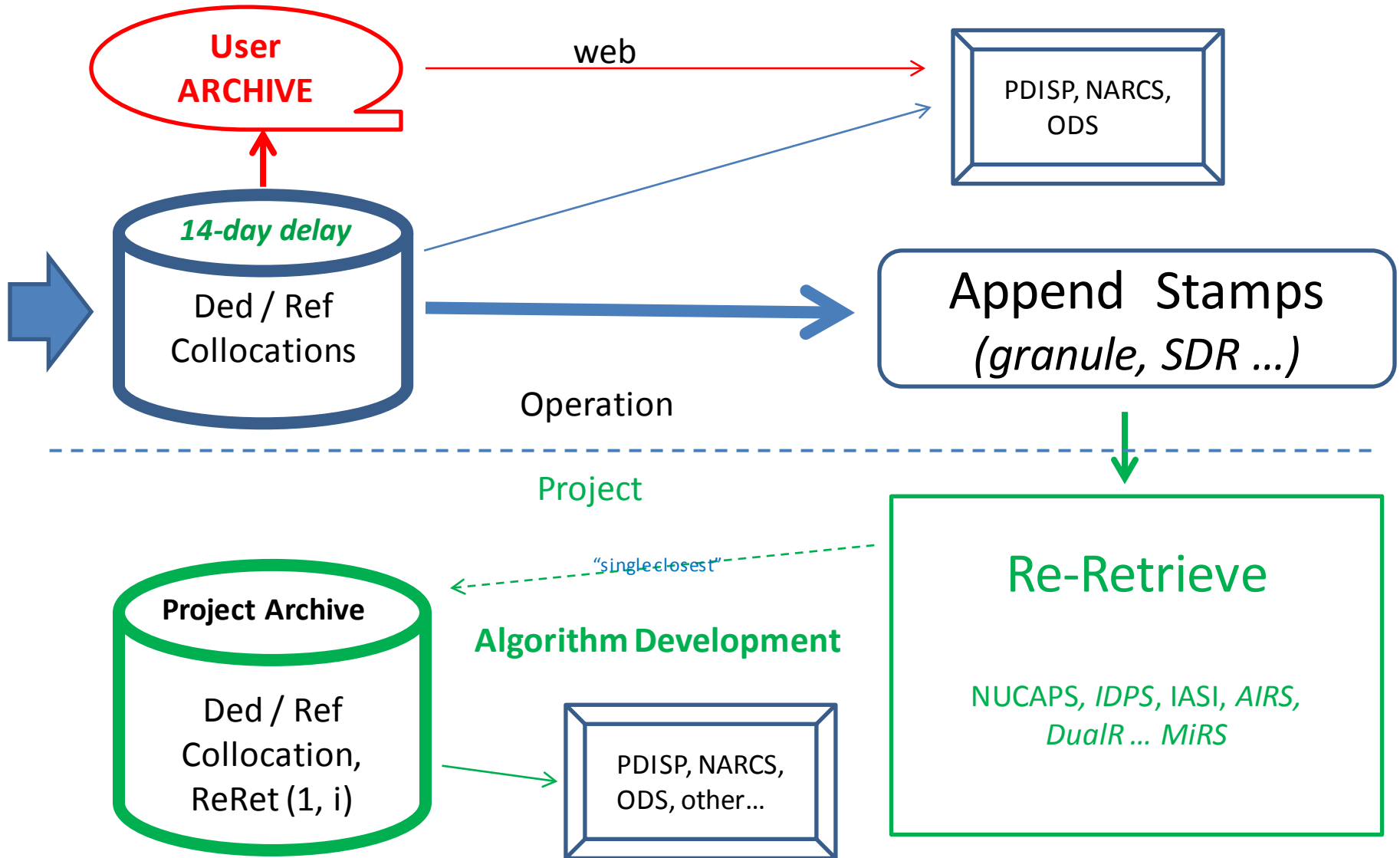
g r a n u l e s

SDRs: CrIS, ATMS, VIIRS, AIRS, MODIS, IASI, AVHRR...

NPROVS+

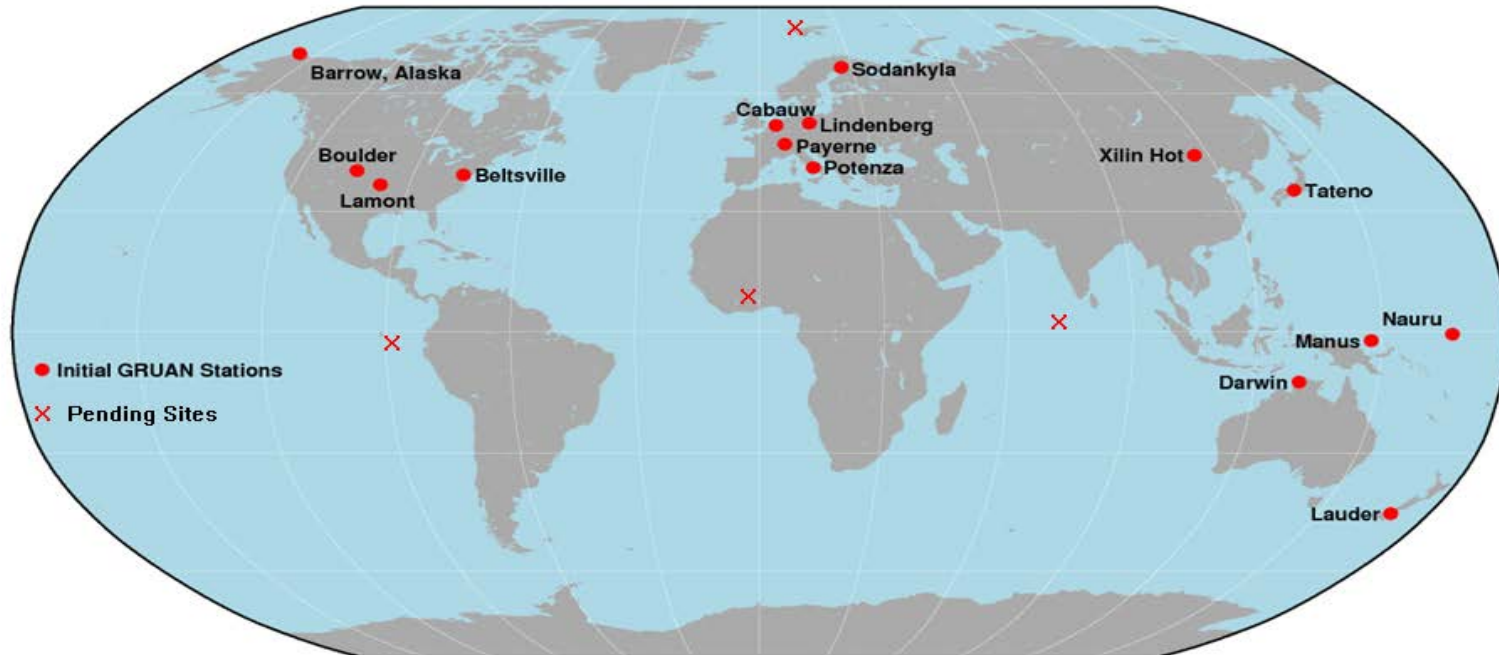


EDR Validation



NPROVS+ ... unified validation and development³¹

GCOS “Reference” Upper AIR Network (GRUAN)



GRUAN 6th International Coordination Meeting (ICM-6) March 10-14, GreenBelt, Hilton
... special Tuesday session on satellite synergies

... sites provide reference radiosonde (RS92) plus ancillary ground (lidar, MWR, FTIR ...) observations, adherence to best measurement practices GRUAN Manual and Measurement Guideline documents) including specification of “**Measurement Uncertainty**” with plans for up to 40 sites (5+ years)



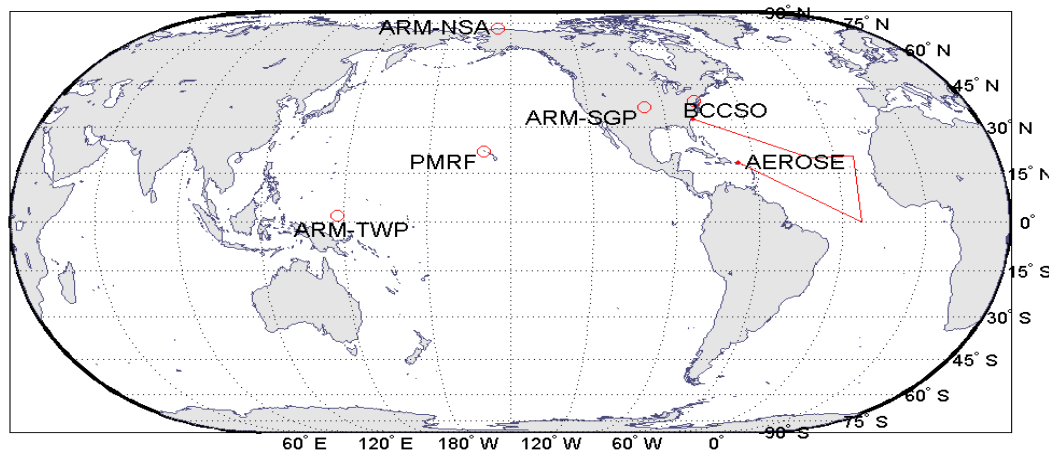
EDR Validation



Dedicated S-NPP RS92 RAOB funded by JPSS CrIMSS Project

	ARM-TWP	ARM-SGP	ARM-NSA		ARM-TWP	ARM-SGP	ARM-NSA	PMRF	BCCSO	NOAA AEROSE
Location	Manus Island, Papua New Guinea	Ponca City, Oklahoma, USA	Barrow, Alaska, USA	Location	Manus Island, Papua New Guinea	Ponca City, Oklahoma, USA	Barrow, Alaska, USA	Kauai, Hawaii, USA	Beltsville, Maryland, USA	Tropical North Atlantic Ocean
Regime	Tropical Pacific Warm Pool, Island	Midlatitude Continent, Rural	Polar Continent	Regime	Tropical Pacific Warm Pool, Island	Midlatitude Continent, Rural	Polar Continent	Tropical Pacific, Island	Midlatitude Continent, Urban	Tropical Atlantic, Ship
Planned N	90	180	180	Planned N	90	180	180	40	—	≈ 60–120
Launched n_1	42	92	93	Launched n_1	42	92	93	40	23	2
Launched n_2	—	88	90	Launched n_2	—	88	90	—	—	0
Time Frame	Aug–present	Jul–present	Jul–present	Time Frame	Aug–present	Jul–present	Jul–present	May, Sep	Jun–Jul, Sep–present	Jan–Feb 2013

NPP CrIMSS EDR ICV Dedicated RAOB Sites



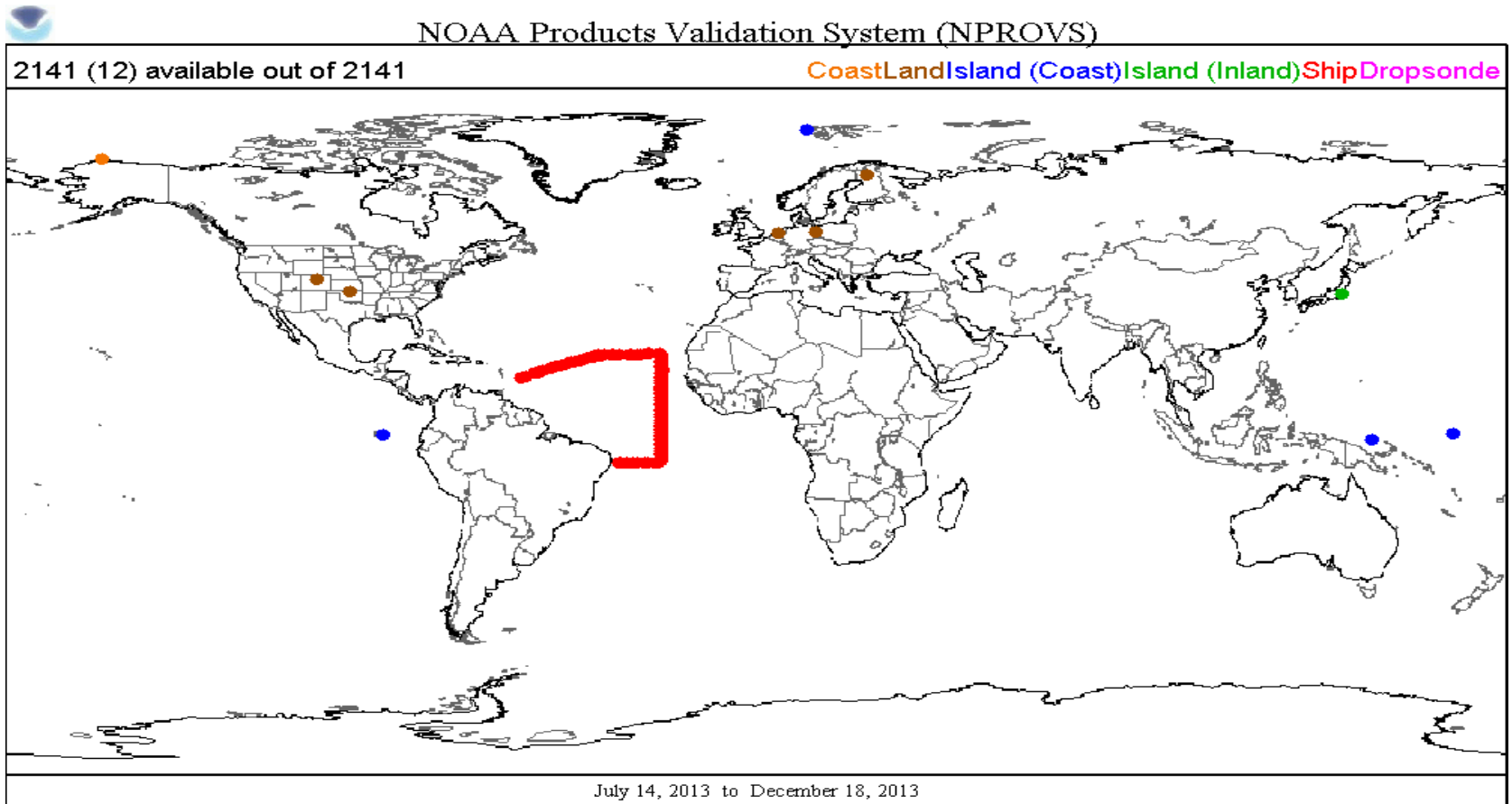
... ongoing re-structure of ARM scheduling to provide “sustained” year round coverage



EDR Validation



NPROVS+



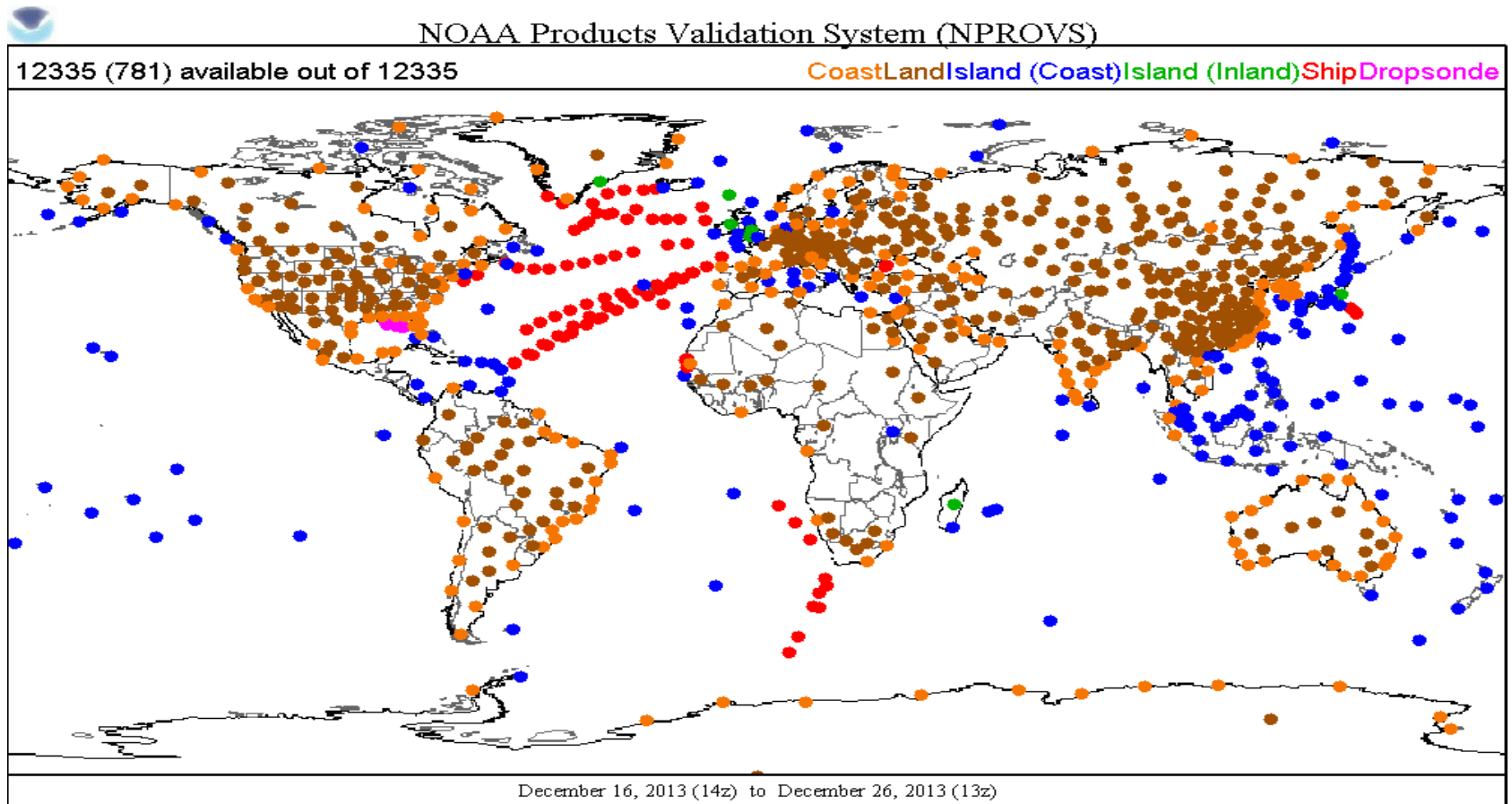
2050 collocations (350 Dedicated, 1700 GRUAN) ... 5mos



EDR Validation



NPROVS



12,335 Collocations 12/16 to 12/26 2013 ... 10-days



EDR Validation



Preview Results

CrIMSS IDPS Mx7.1 Problem



EDR Validation



IDPS MX 6.3 vs. MX 7.1 Yield Analysis

MX6.3	02/22	02/23	02/24	02/25	4 days	(10 day)
- IR+MW	20%	17%	18%	23%	19%	20%
- MW-only	61%	63%	64%	59%	61%	62%
- Poor	19%	21%	18%	19%	20%	18%

MX6.6	03/02	03/03	03/04	03/05	4 days	(10 day)
- IR+MW	35%	37%	37%	34%	36%	34%
- MW-only	50%	47%	44%	50%	47%	51%
- Poor	16%	16%	19%	16%	17%	15%

MX7.1	J U L Y					
- IR+MW						50.6
- MW-only						38.9
- Poor						10.4



EDR Validation



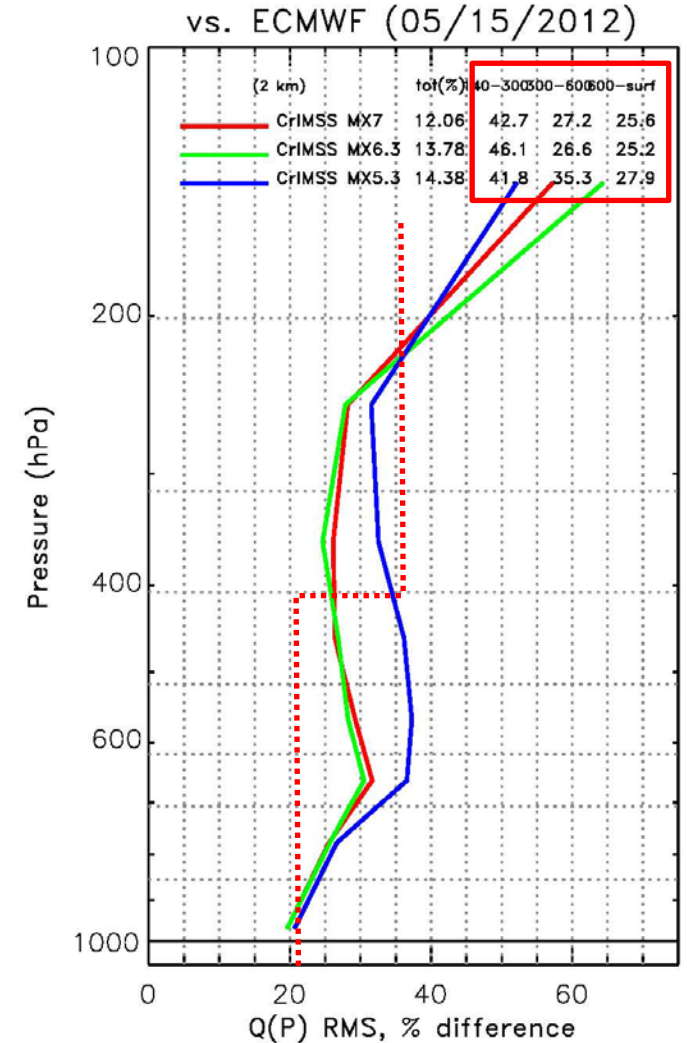
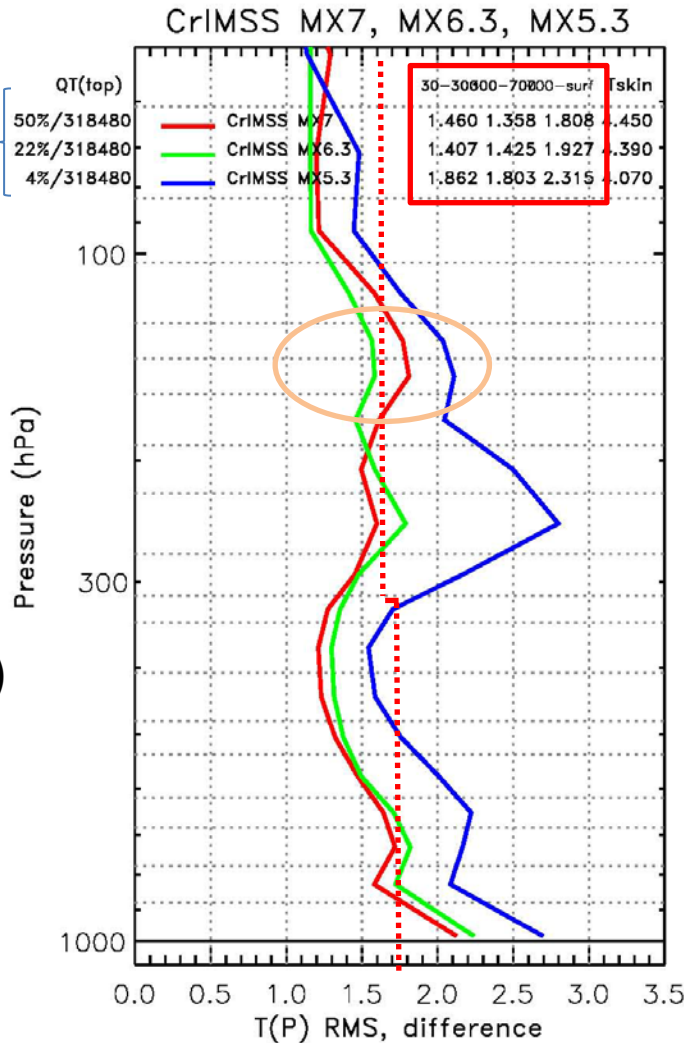
Provisional Maturity Evaluation (Focus Day) for May 15, 2012

Yield has increased from 4% (Mx5.3) to 50% (Mx7.1)

Results are shown w.r.t. ECMWF

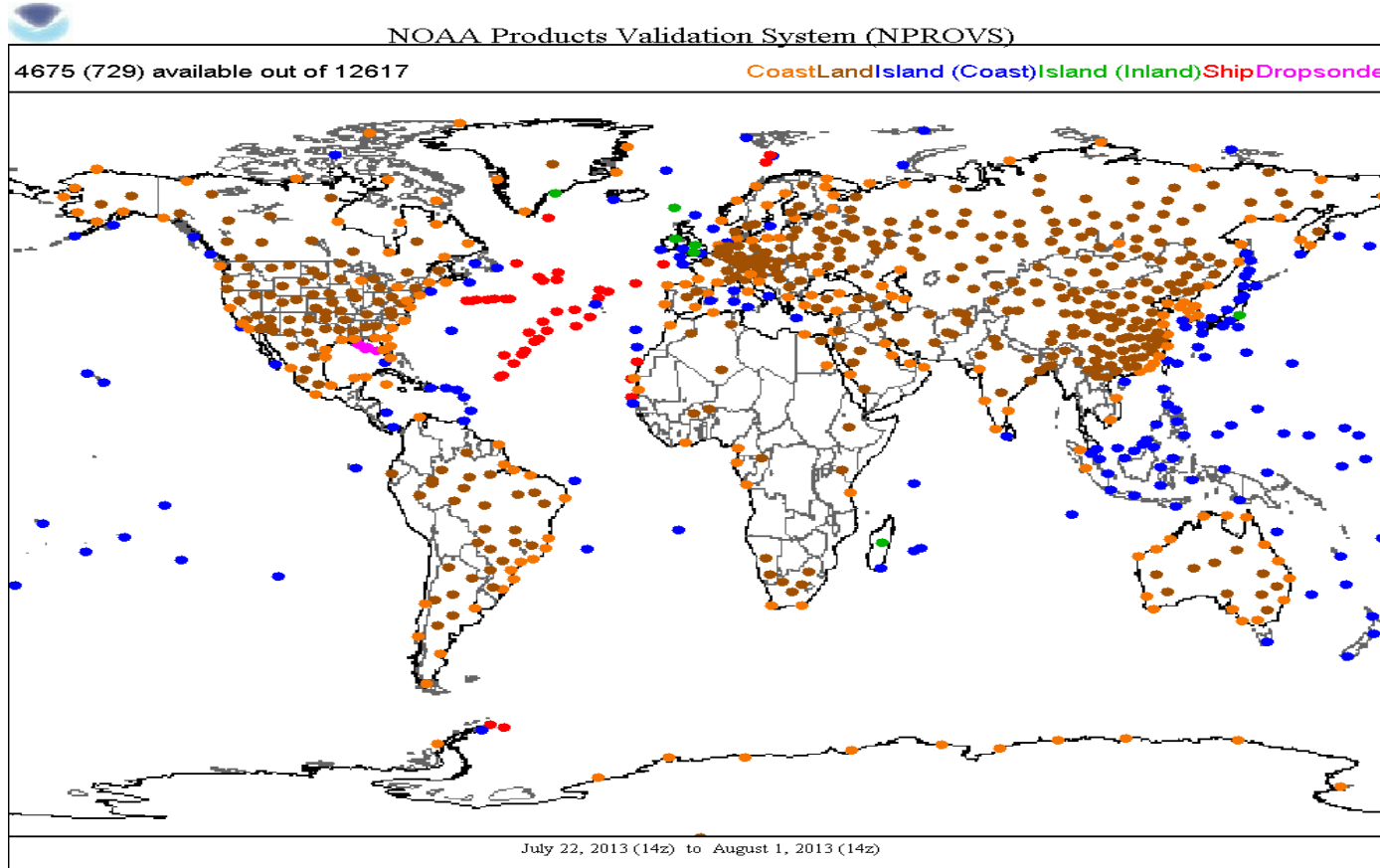
Specifications shown as dotted red line (only relevant for GLOBAL RMS) and numerical (red boxes)

Performance has improved with IDPS version (will be summarized in table later)





EDR Validation



Collocations containing (IR+MW) EDR from CrIMSS and NUCAPS which passed QC
(4675/12617 ... 37%)

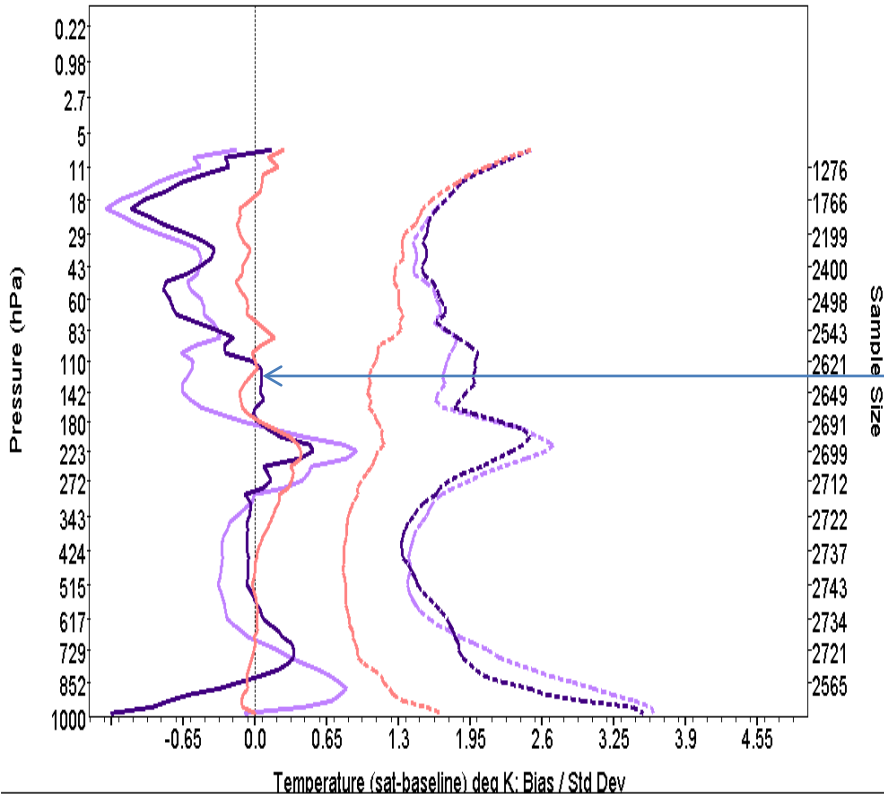


EDR Validation



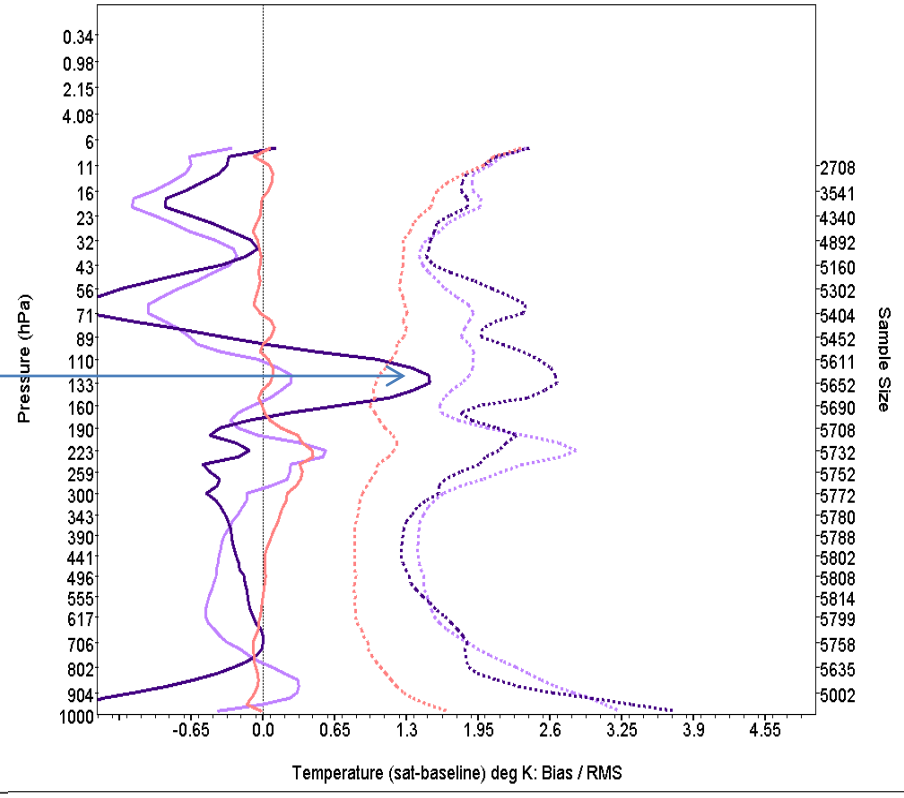
NOAA Products Validation System (NPROVS)

June 10, 2013 to June 20, 2013 **6.6**



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013 **7.1**



Radiosonde GFS 6 Hour

CRIMSS NPP Infrared (IP)

CRIMSS NPP Microwave (IP)

Radiosonde GFS 6 Hour

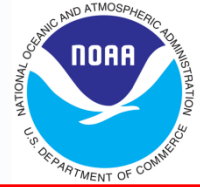
CRIMSS NPP Infrared (IP)

CRIMSS NPP Microwave (IP)

IR + MW pass

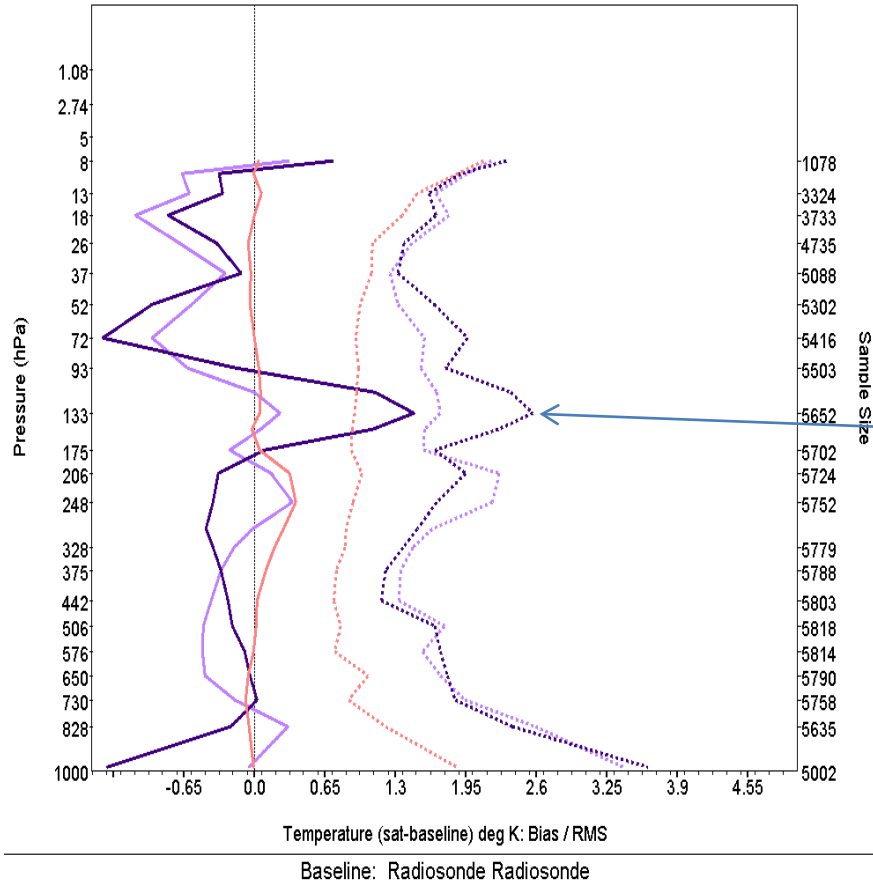


EDR Validation

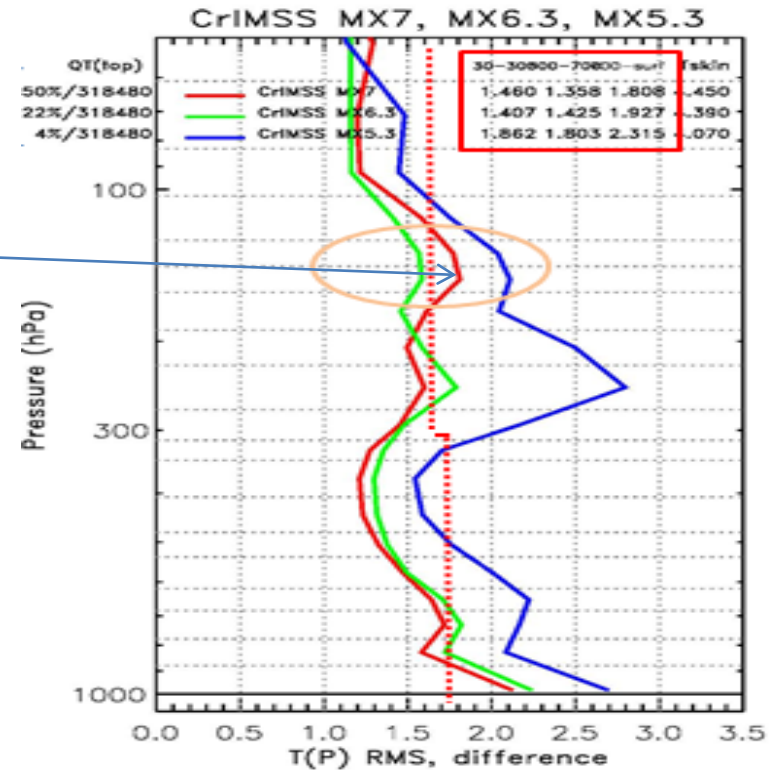


NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



Focus day 5-15-12



Radiosonde GFS 6 Hour

CRIMSS NPP Infrared (IP)

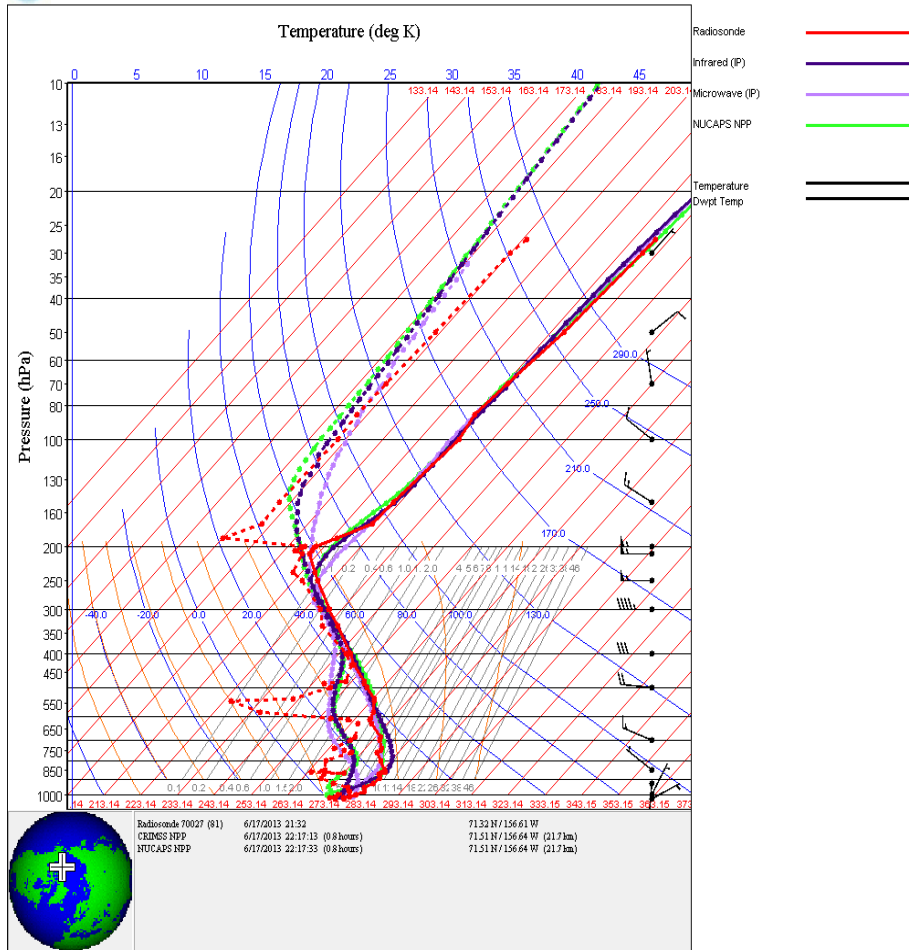
CRIMSS NPP Microwave (IP)



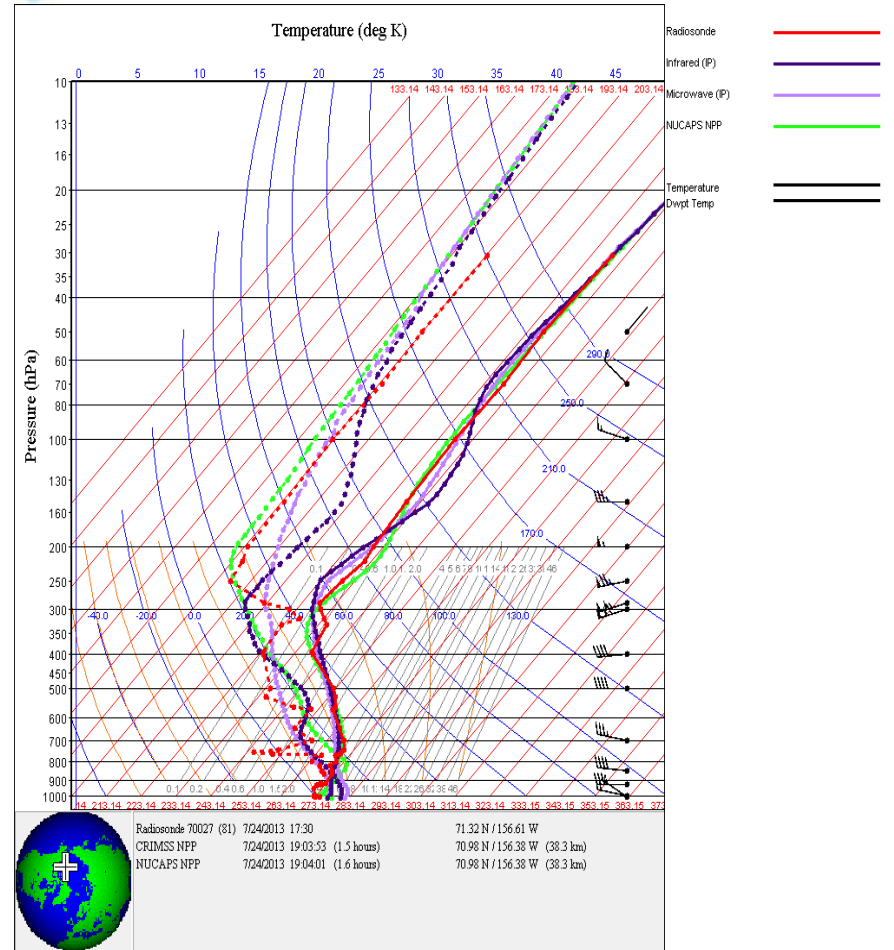
EDR Validation



NOAA Products Validation System (NPROVS)



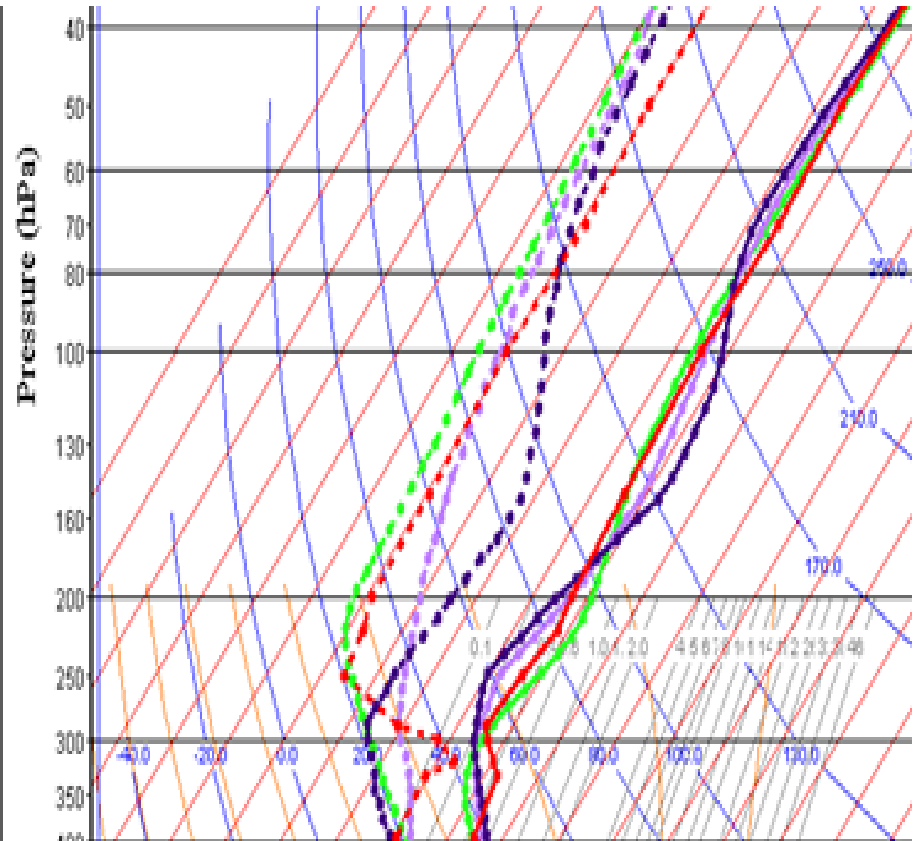
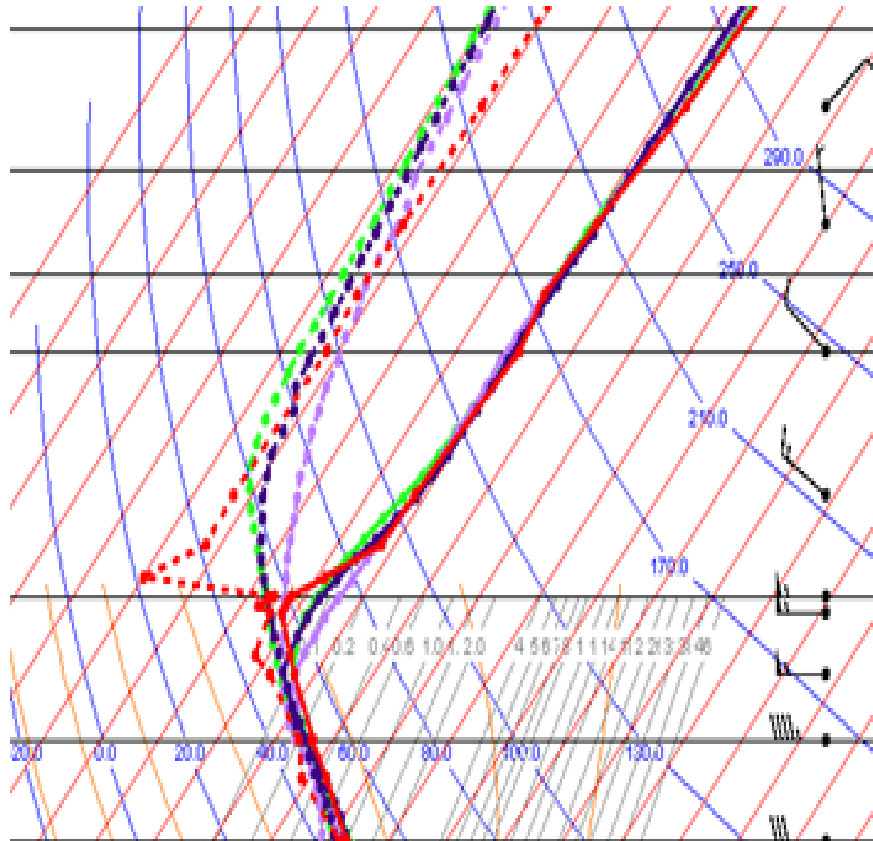
NOAA Products Validation System (NPROVS)



PDISP



EDR Validation



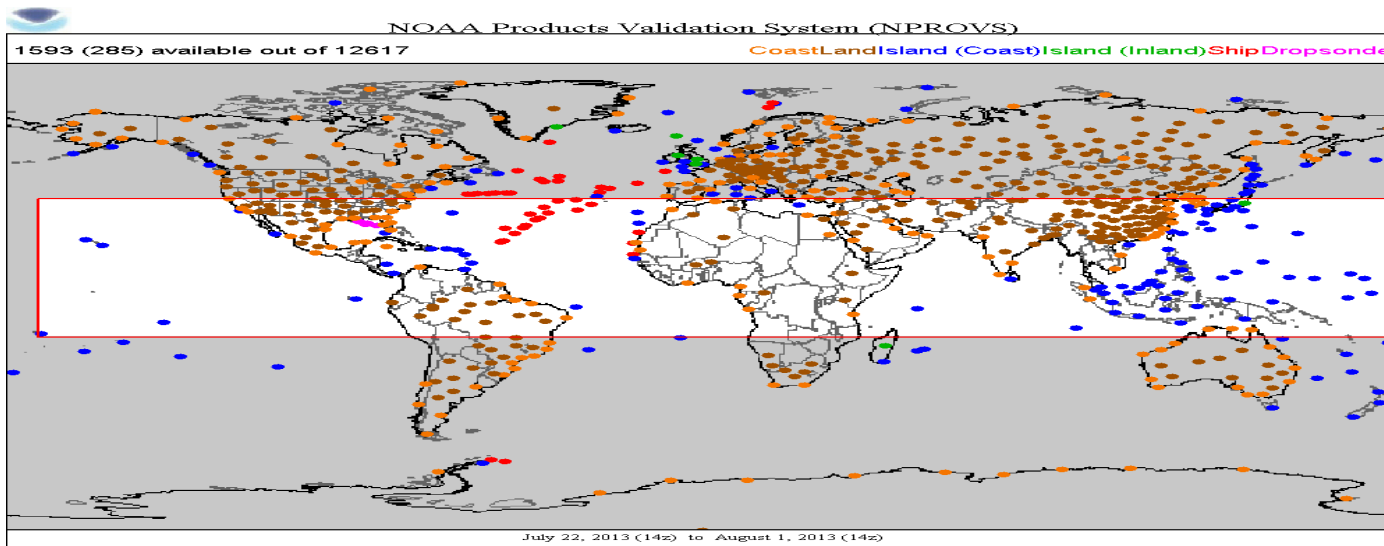
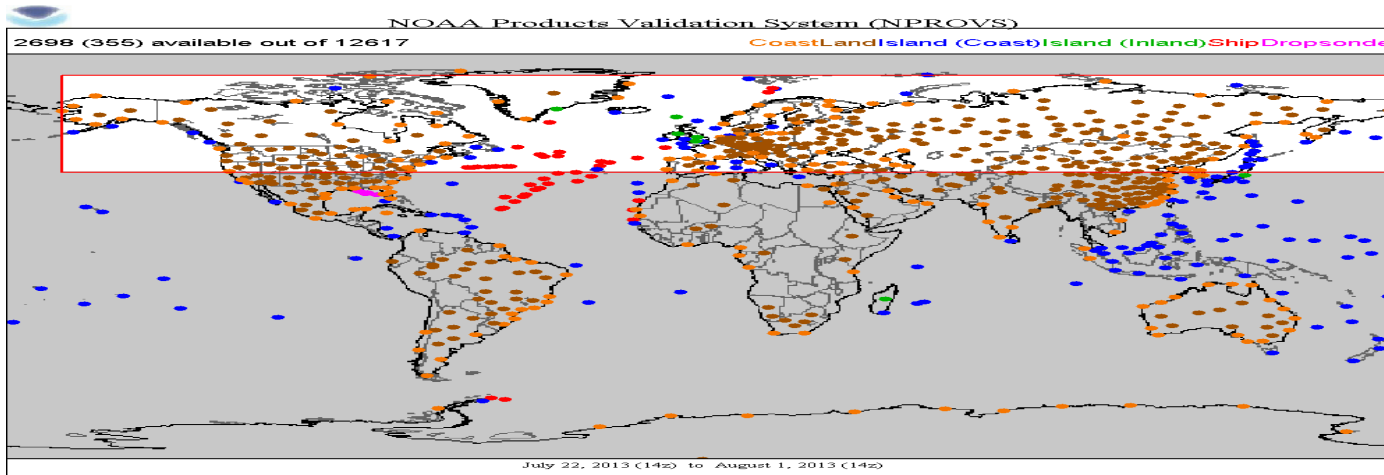
NUCAPS (IR+MW)

IDPS (IR + MW)

IDPS (MW)



EDR Validation



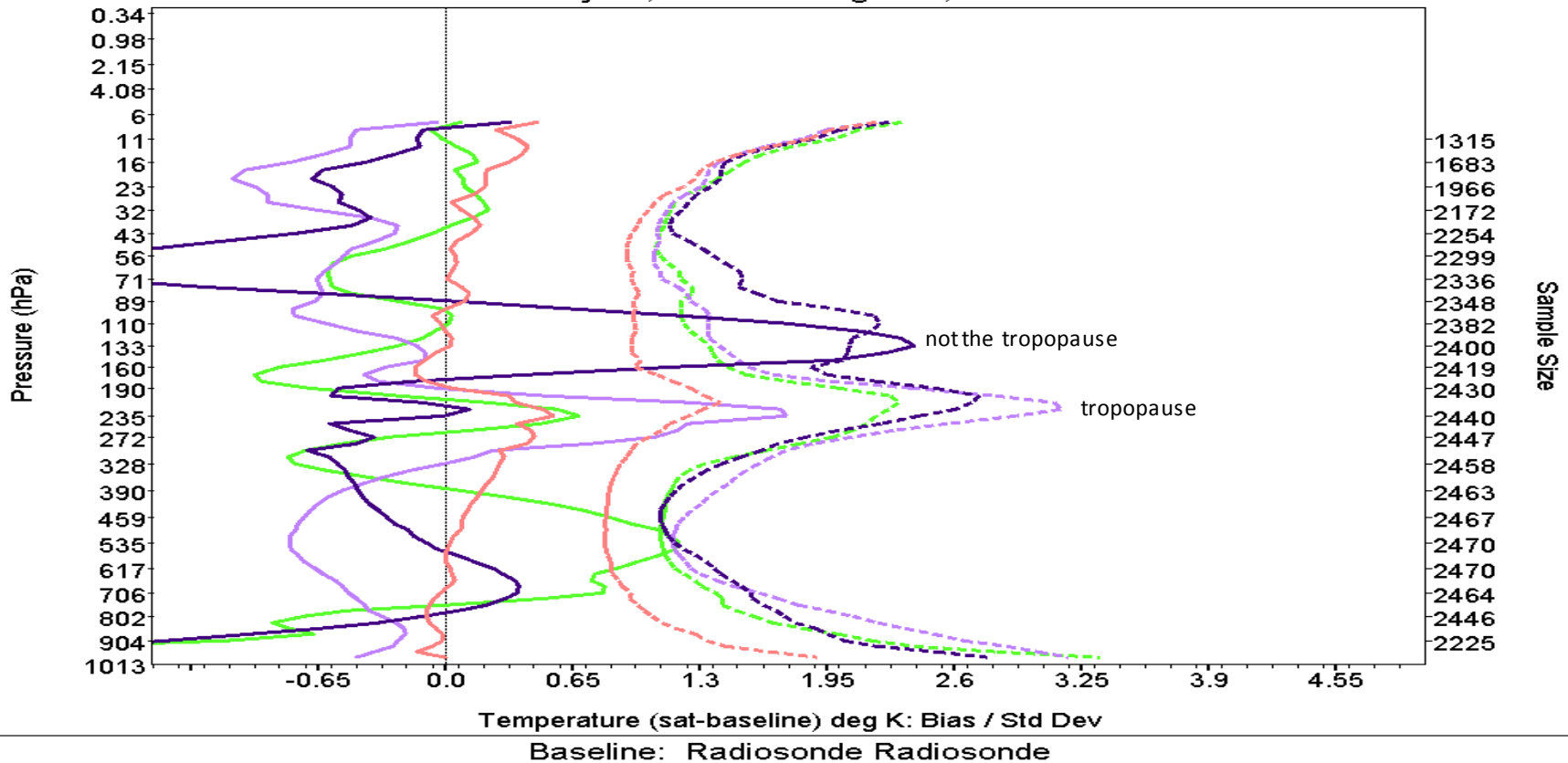


EDR Validation



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



Radiosonde GFS 6 Hour

CRIMSS NPP Infrared (IP)

CRIMSS NPP Microwave (IP)

NUCAPS NPP

90N - 50N

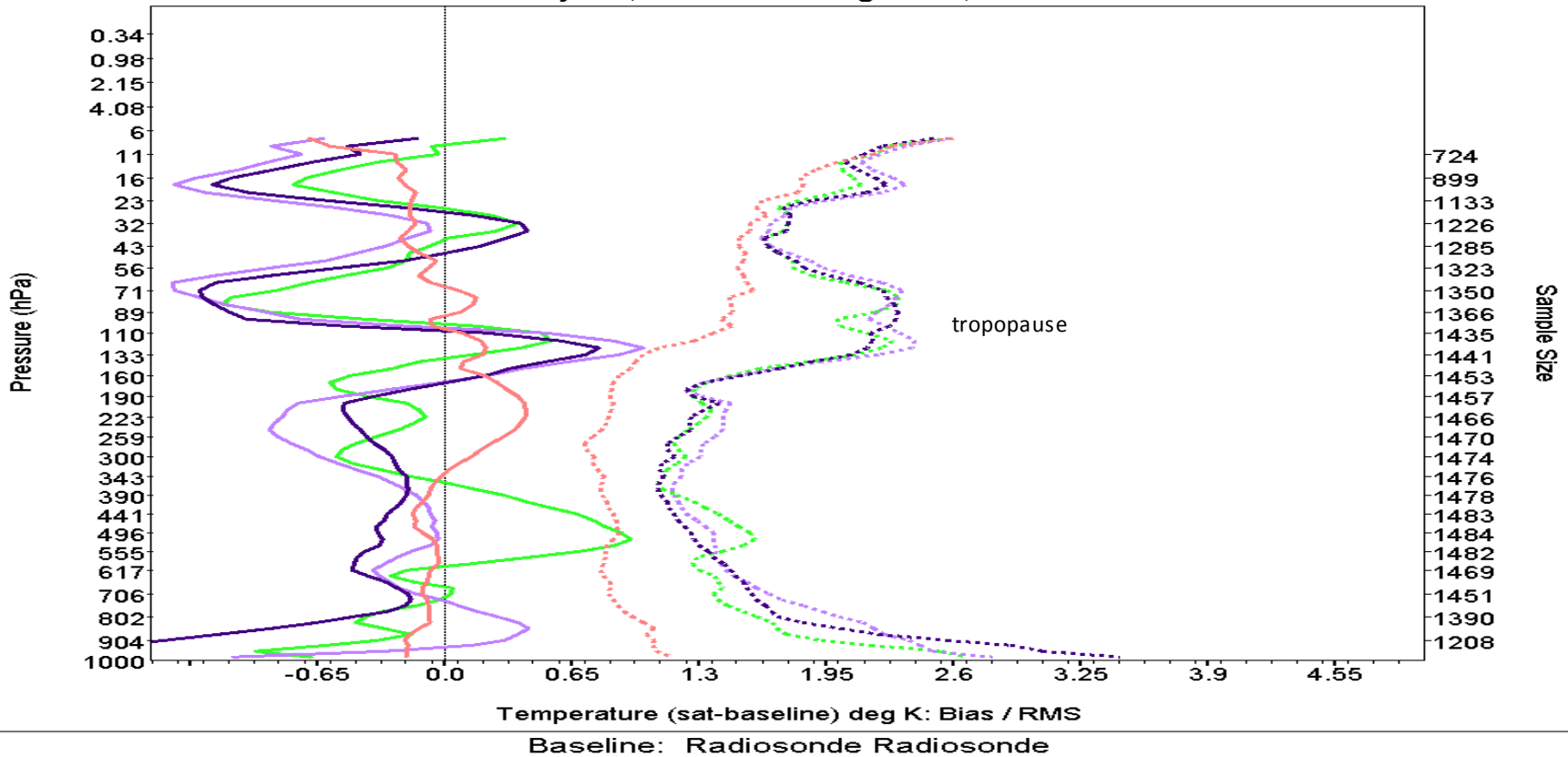


EDR Validation



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



Radiosonde GFS 6 Hour

CRIMSS NPP Infrared (IP)

CRIMSS NPP Microwave (IP)

NUCAPS NPP

30N to 30S

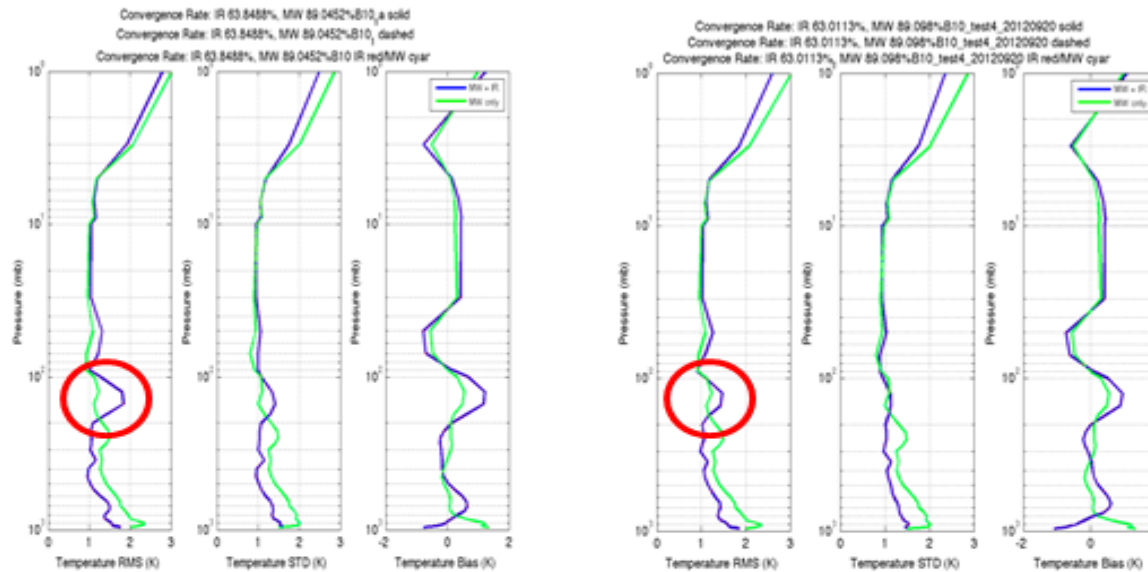


EDR Validation



... resulting investigations by
Xu Liu / S. Kizer
NASA Langley Research Center
(NARC)

- CrIMSS IDPS algorithm development identifies possible root cause for polar region stratospheric temperature sounding anomaly identified in IDPS version 7.1



- The above results provide plots comparing initial corrective actions to IDPS v7.1 with respect to stratospheric temperature anomaly
- The 3 left panels show the current method and the right panels the initial corrective approach; respective RMS, standard deviation and bias differences vs ECMWF for focus day 5-15-12 are shown
- The stratospheric anomaly illustrated by the RMS bump in the lower stratosphere is seen to decrease using the corrective approach
- The corrective approach reduces the problem but does not resolve it; work continues

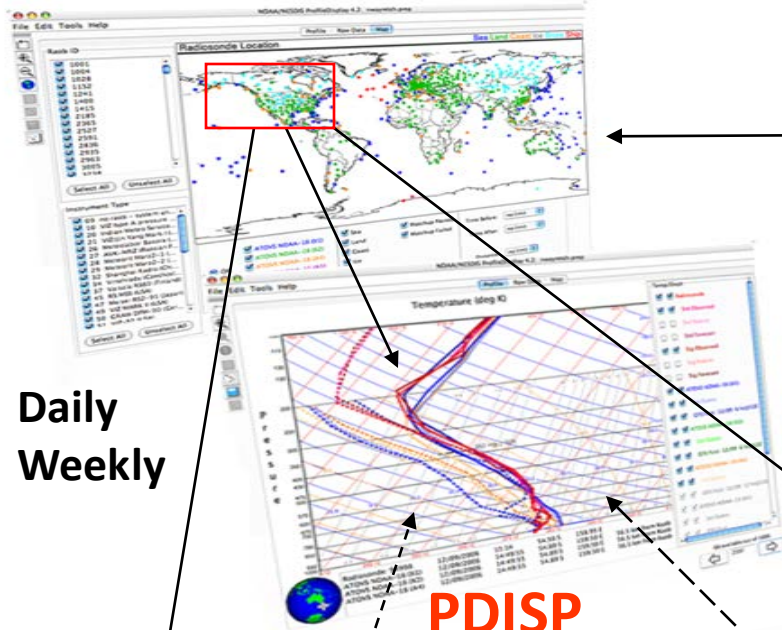


OUTLINE



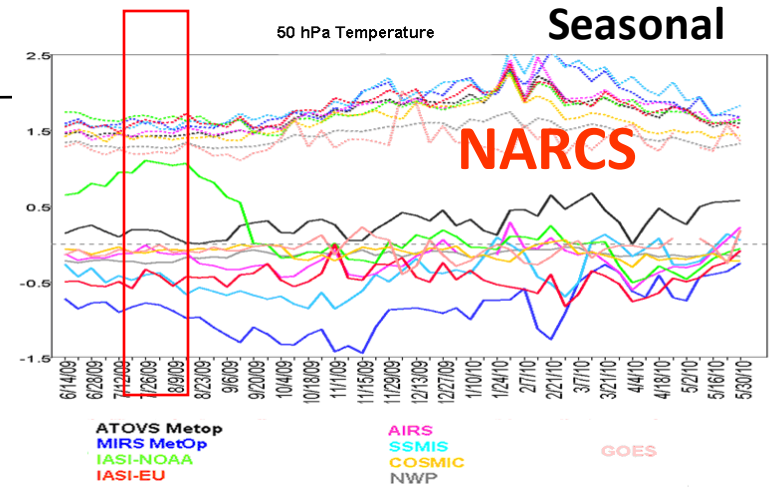
- **Team Members**
- **Project Goals**
- **Activities / Achievements**
- **Validation Results**
- **Summary**

NPROVS Analytical Interface ...

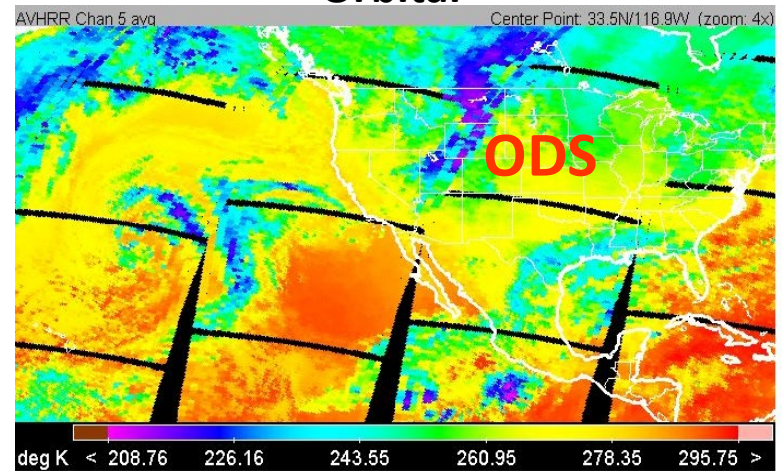


Daily
Weekly

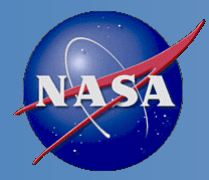
PDISP



Orbital



... routine monitoring to deep dive



EDR Validation Results



Validation Results

- NARCS
- PDISP
- *ODS*



EDR Validation Results



H2O Vapor Fraction Statistics Weighting

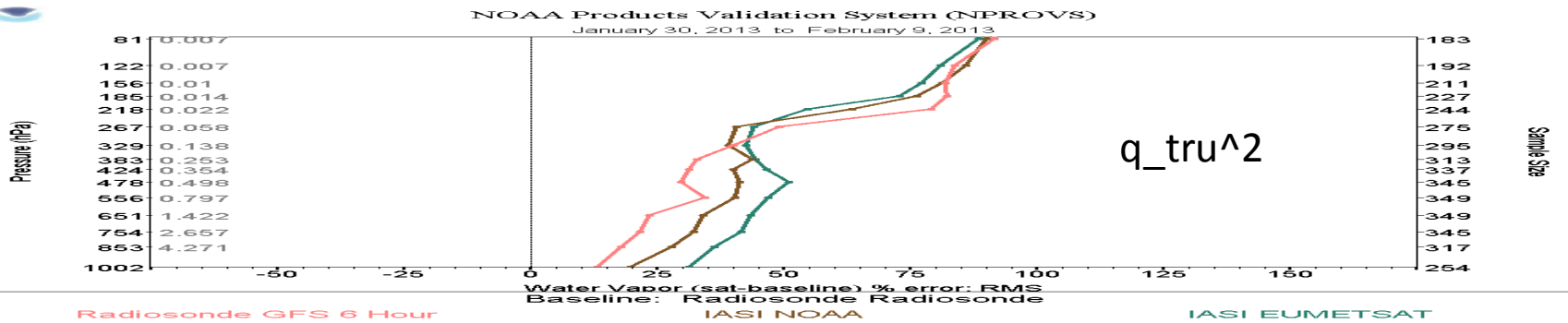
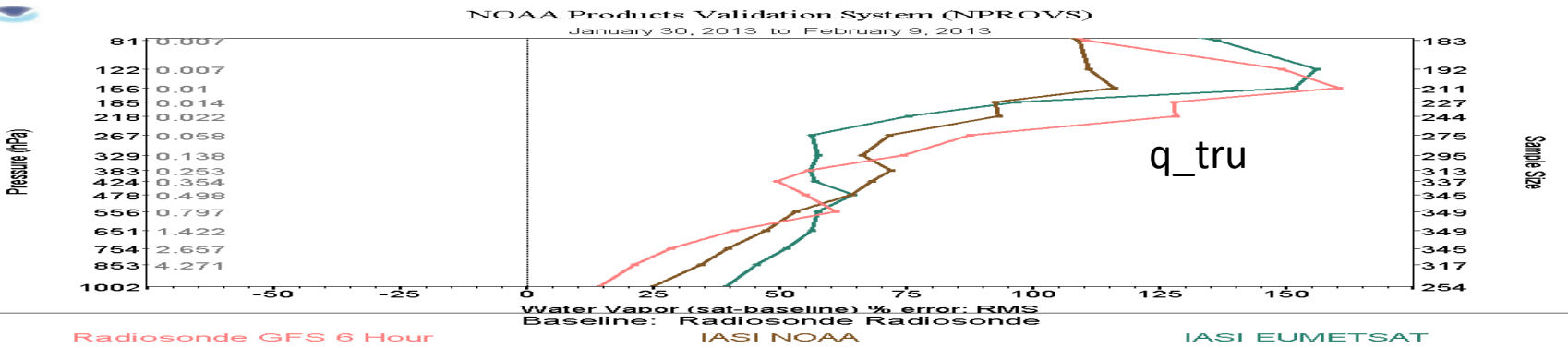
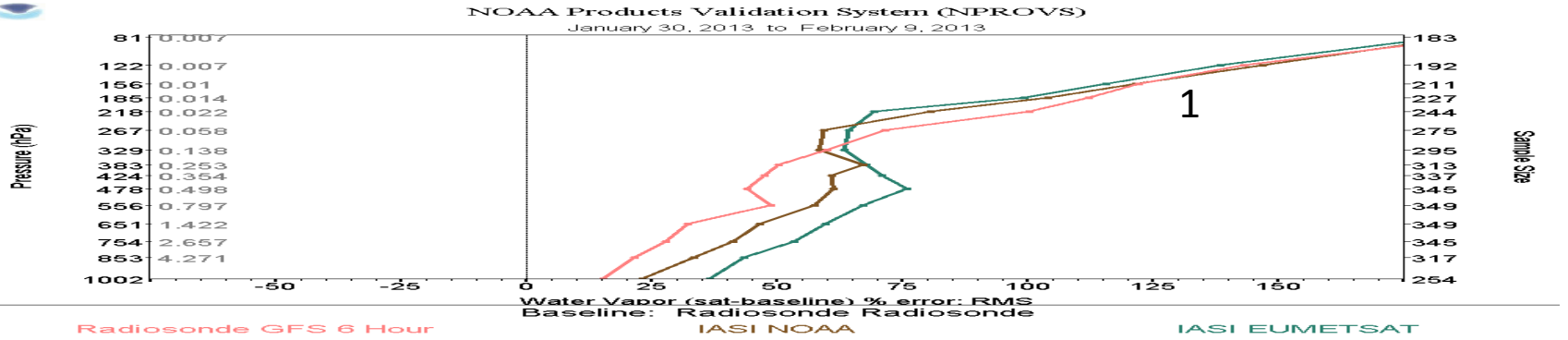
- Ran an experiment in which 3 weights were used
 - $W1 = 1$... *NARCS*
 - $W2 = q_tru$
 - **$W3 = (q_tru)^2$... *PDISP***
 - There is no change in the profiles themselves
 - Only difference are in the statistic itself
- Level-1 requirements document is sufficiently vague
 - Historically, these requirements were derived from the $w=q_tru^2$ weighting for RMS from AIRS simulation experiments.



EDR Validation Results



H2O Vapor Fraction Statistics Weighting





EDR Validation Results



N A R C S

Cheat Sheet

SAT-minus-RAOB per level:

- T (K) @ levels (101)
- H₂O vapor fraction (%) ... $\text{SAT-minus-RAOB} / \text{Mean RAOB}$ for H₂O vapor mixing ratio (g/kg) weighted by **(1)**
- “Independent” samples which passed respective qc for given system
(respective qc yield optimal per system, thus samples differ)
- NPROVS (conventional RAOB) collocations
- IR+MW only (except MiRS)



EDR Validation Results



Atmospheric Vertical Temperature Profile (AVTP) Measurement Uncertainty – Layer Average Temperature Error

PARAMETER	THRESHOLD
AVTP Clear, surface to 300 mb	1.6 K / 1-km layer
AVTP Clear, 300 to 30 mb	1.5 K / 3-km layer
AVTP Clear, 30 mb to 1 mb	1.5 K / 5-km layer
AVTP Clear, 1 mb to 0.5 mb	3.5 K / 5-km layer
AVTP Cloudy , surface to 700 mb	2.5 K / 1-km layer
AVTP Cloudy, 700 mb to 300 mb	1.5 K / 1-km layer
AVTP Cloudy, 300 mb to 30 mb	1.5 K / 3-km layer
AVTP Cloudy, 30 mb to 1 mb	1.5 K / 5-km layer
AVTP Cloudy, 1 mb to 0.5 mb	3.5 K / 5-km layer

Clear ... IR+MW

Cloudy ... (MW only)

Atmospheric Vertical Moisture Profile (AVMP) Measurement Uncertainty – 2-km Layer Average Mixing Ratio % Error

PARAMETER	THRESHOLD
AVMP Clear, surface to 600 mb	Greater of 20% or 0.2 g/kg / 2-km layer
AVMP Clear, 600 to 300 mb	Greater of 35% or 0.1 g/kg / 2-km layer
AVMP Clear, 300 to 100 mb	Greater of 35% or 0.1 g/kg / 2-km layer
AVMP Cloudy, surface to 600 mb	Greater of 20% of 0.2 g/kg / 2-km layer
AVMP Cloudy, 600 mb to 400 mb	Greater of 40% or 0.1 g/kg / 2-km layer
AVMP Cloudy, 400 mb to 100 mb	Greater of 40% or 0.1 g/kg / 2-km layer

Clear ... IR+MW

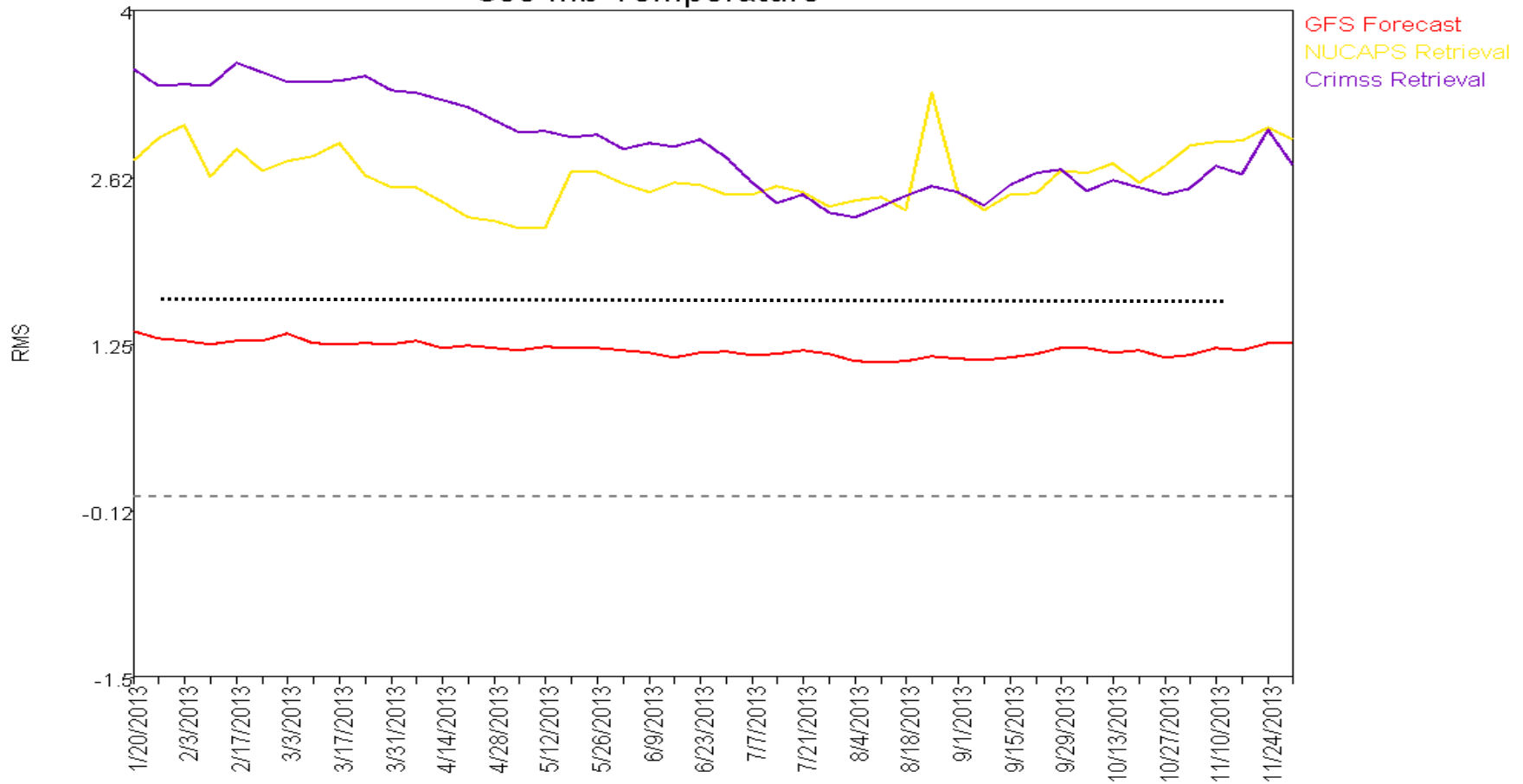
Cloudy ... (MW only)



EDR Validation Results



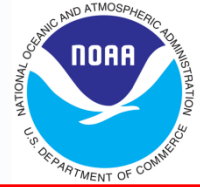
850 mb Temperature



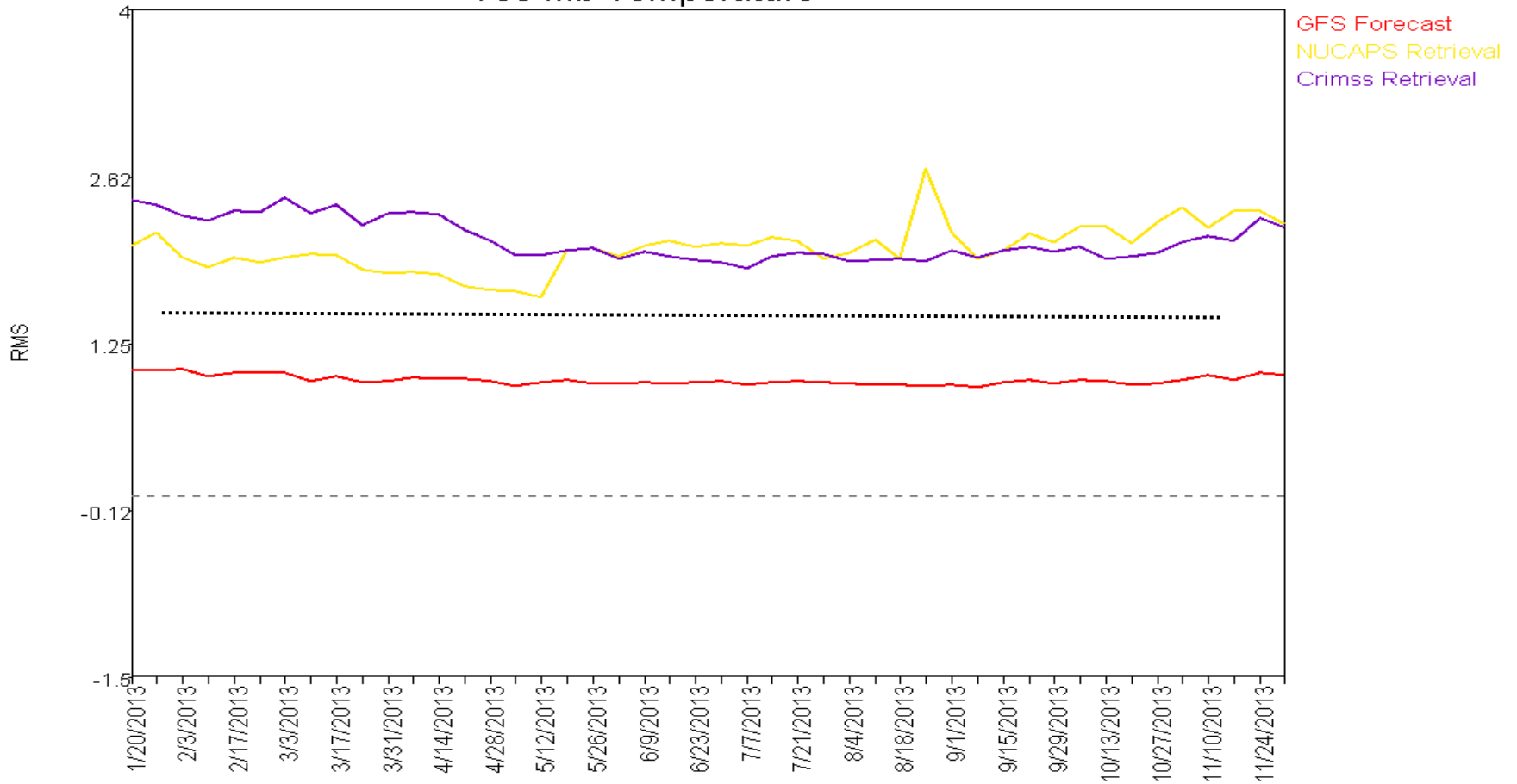
NARCS 12 months 2013



EDR Validation Results



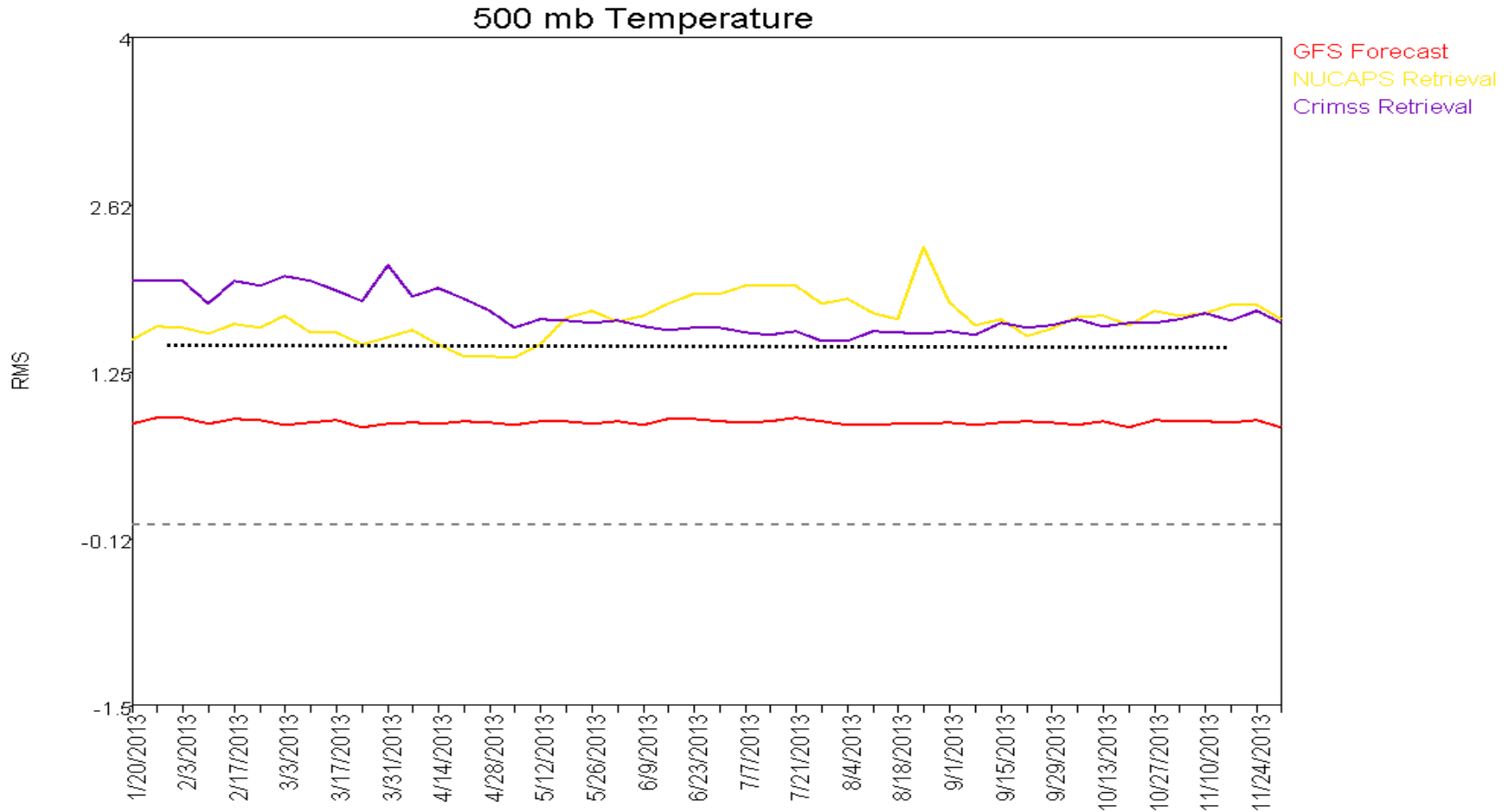
700 mb Temperature



NARCS 12 months 2013



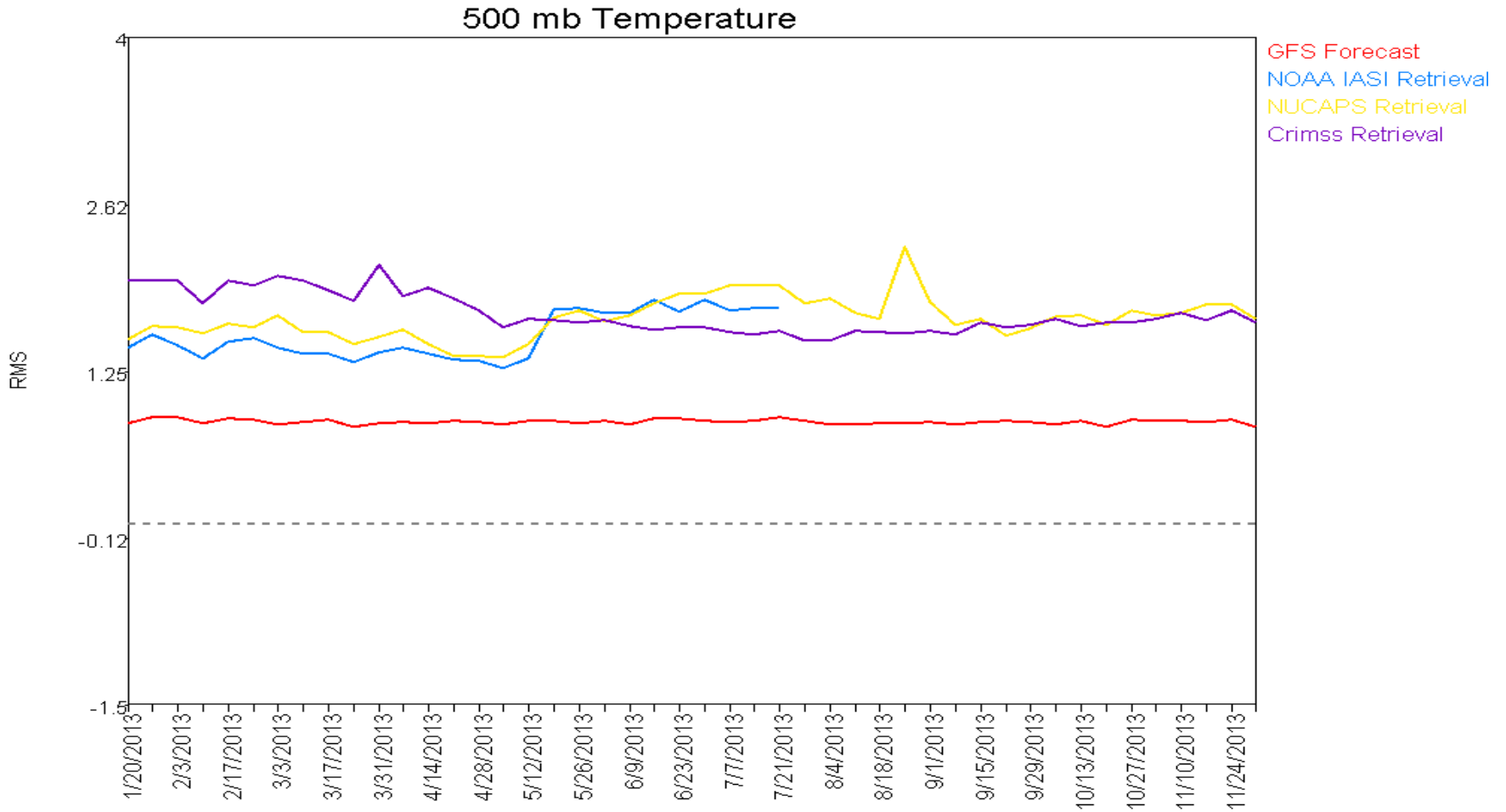
EDR Validation Results



NARCS 12 months 2013



EDR Validation Results



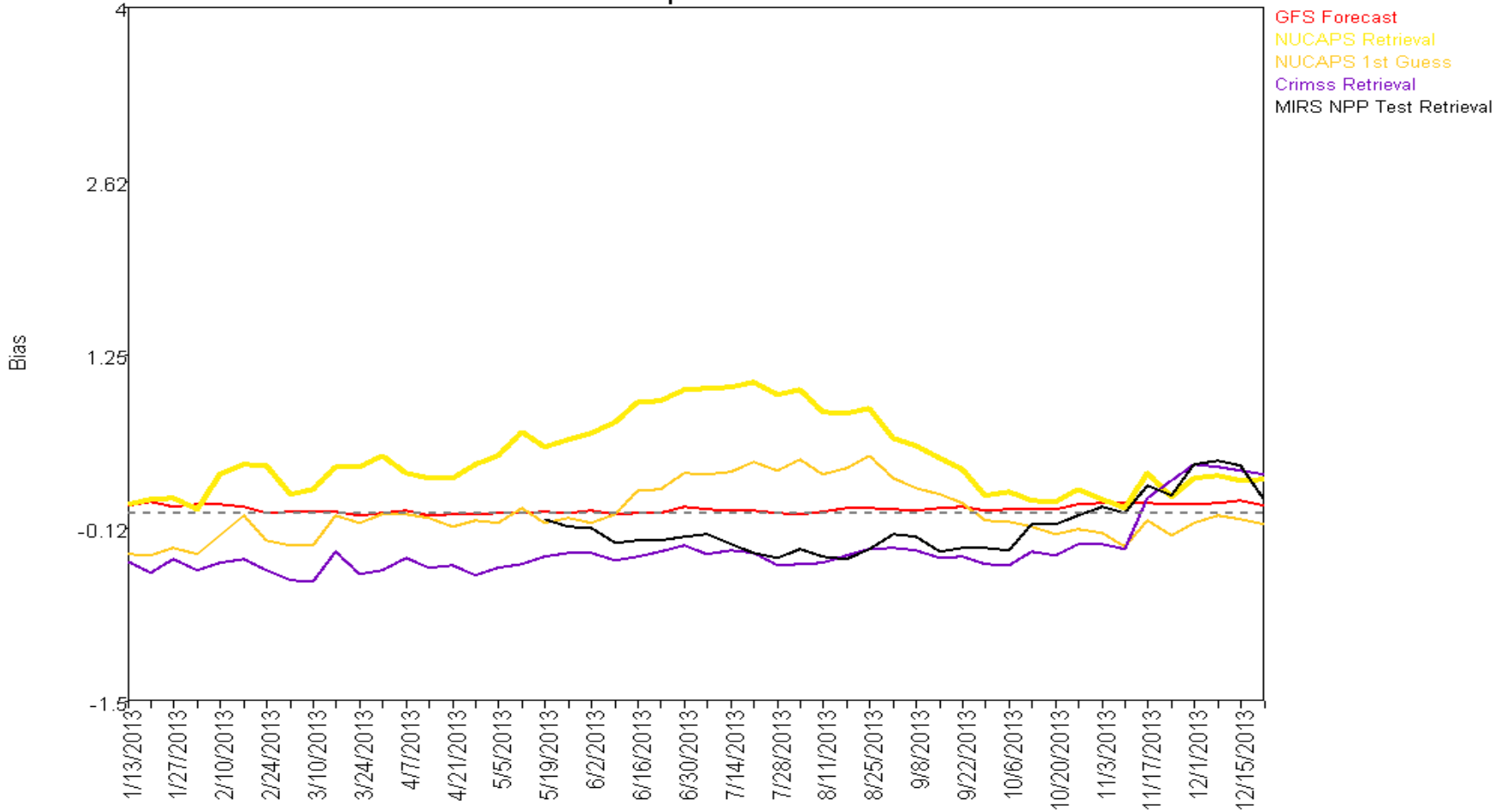
NARCS 12 months 2013



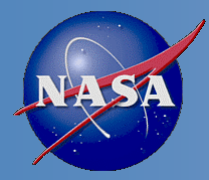
EDR Validation Results



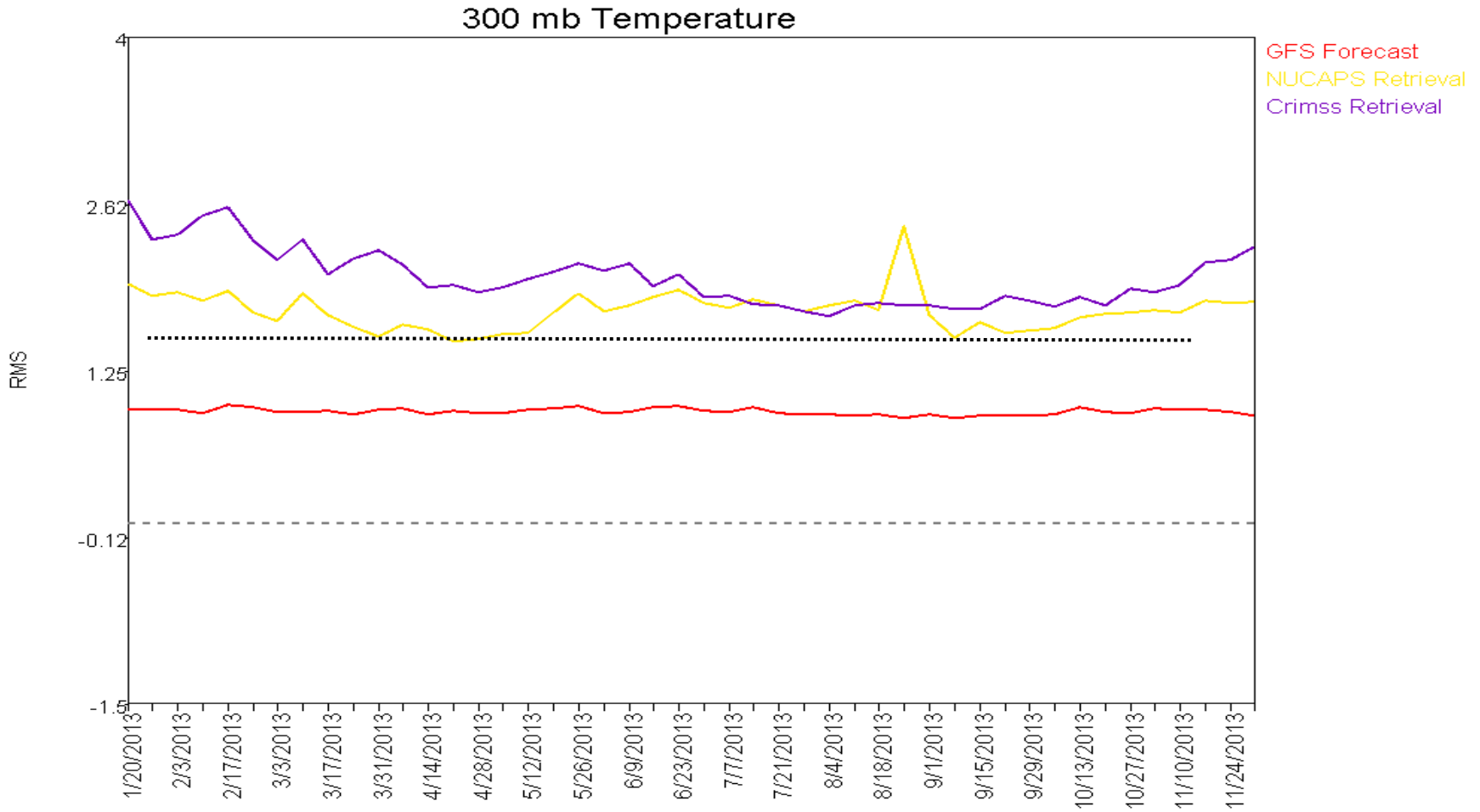
500 mb Temperature



NARCS 12 months 2013



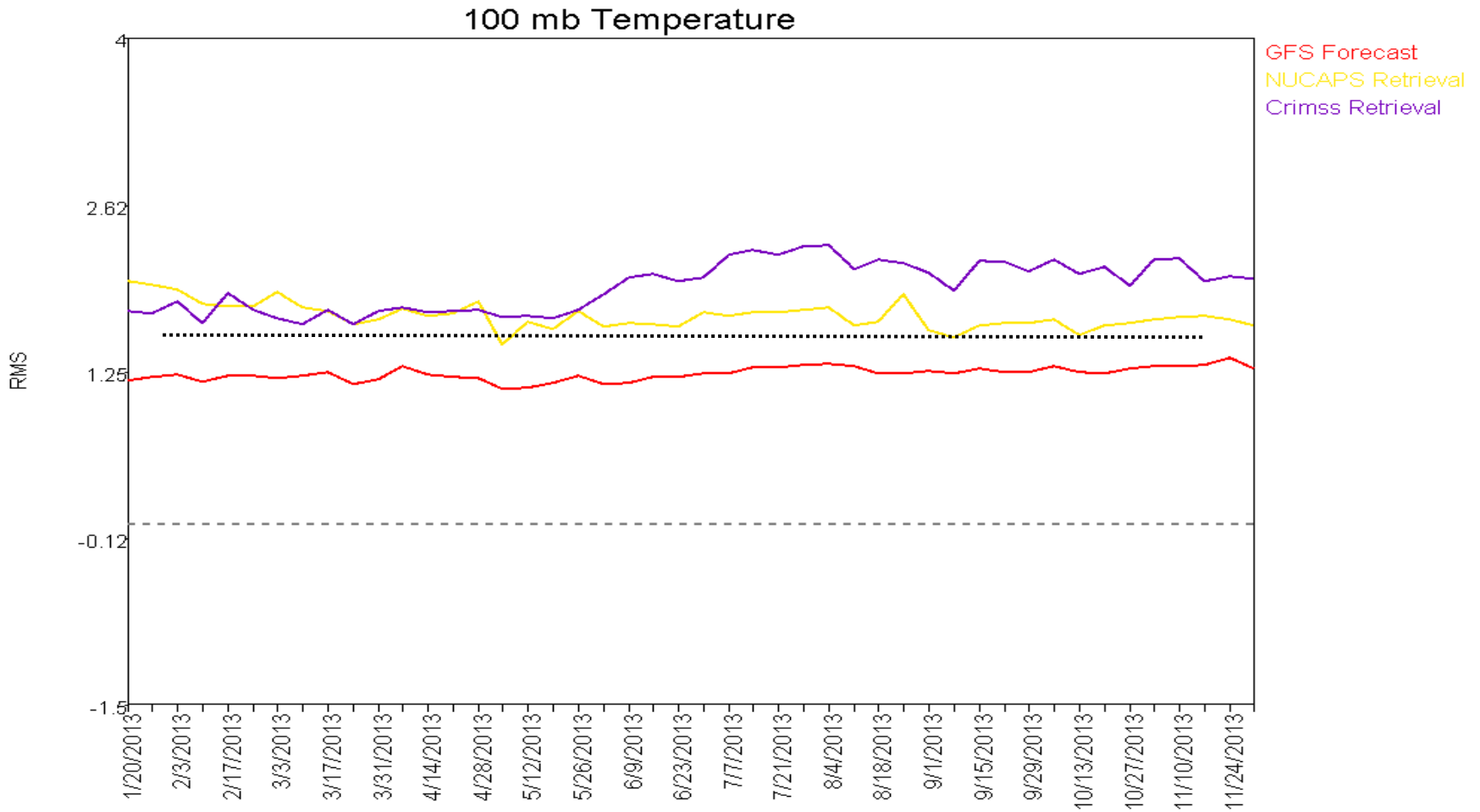
EDR Validation Results



NARCS 12 months 2013



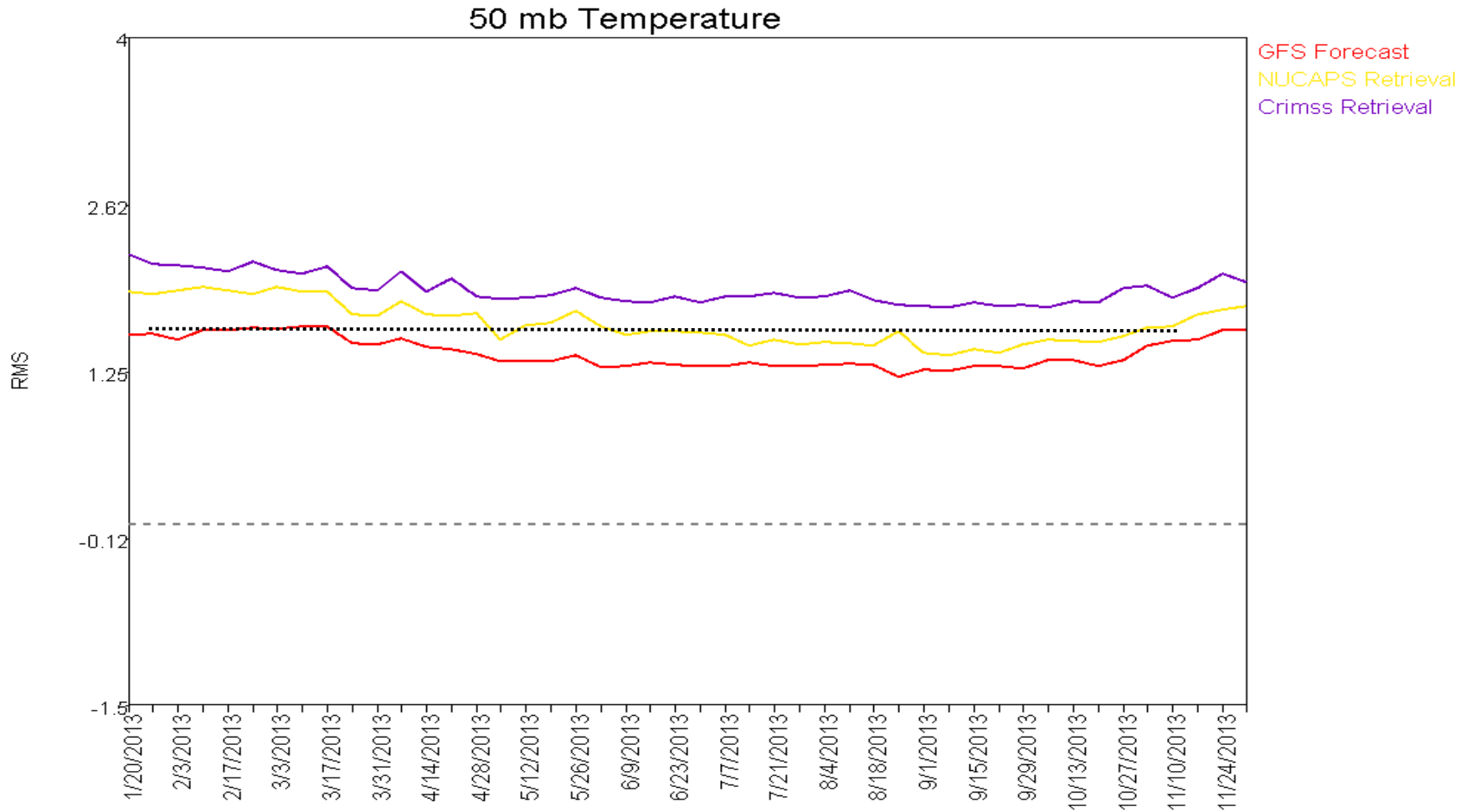
EDR Validation Results



NARCS 12 months 2013



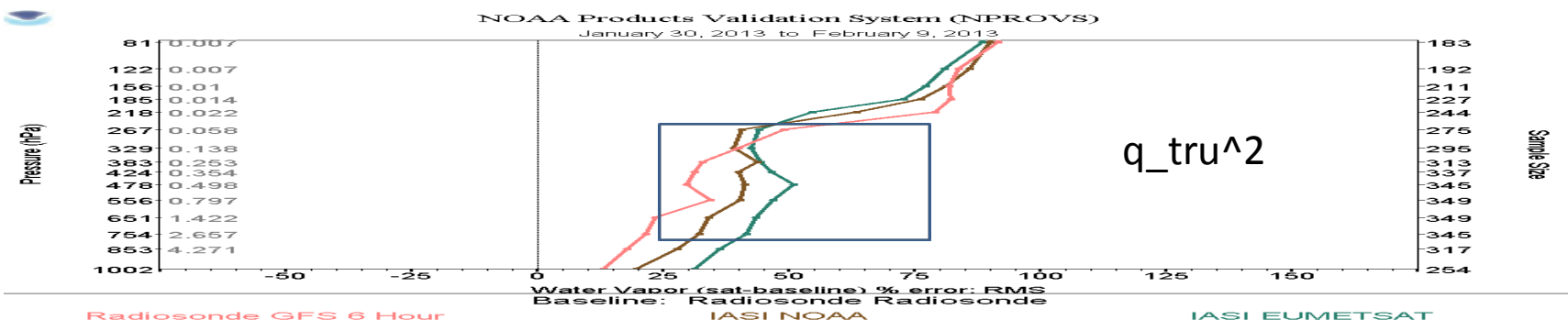
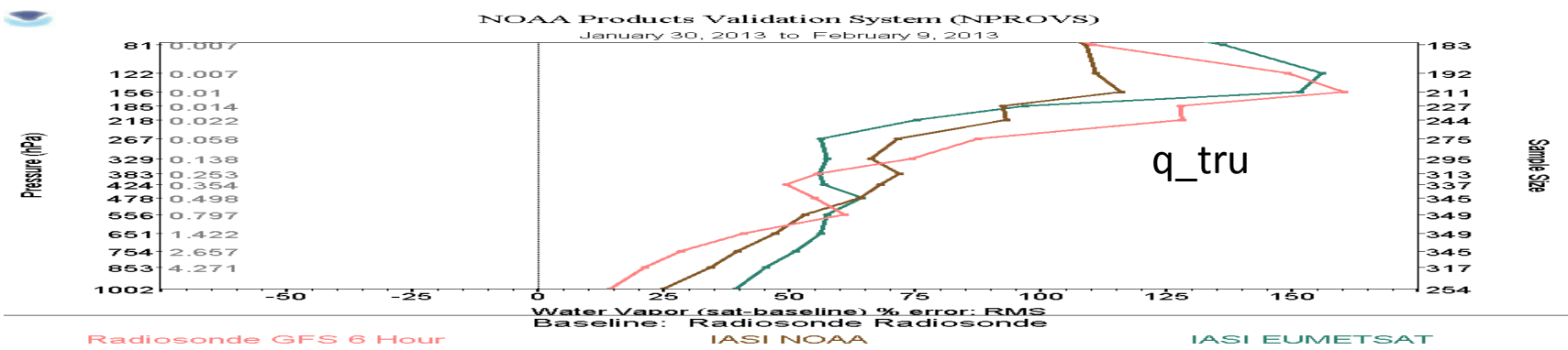
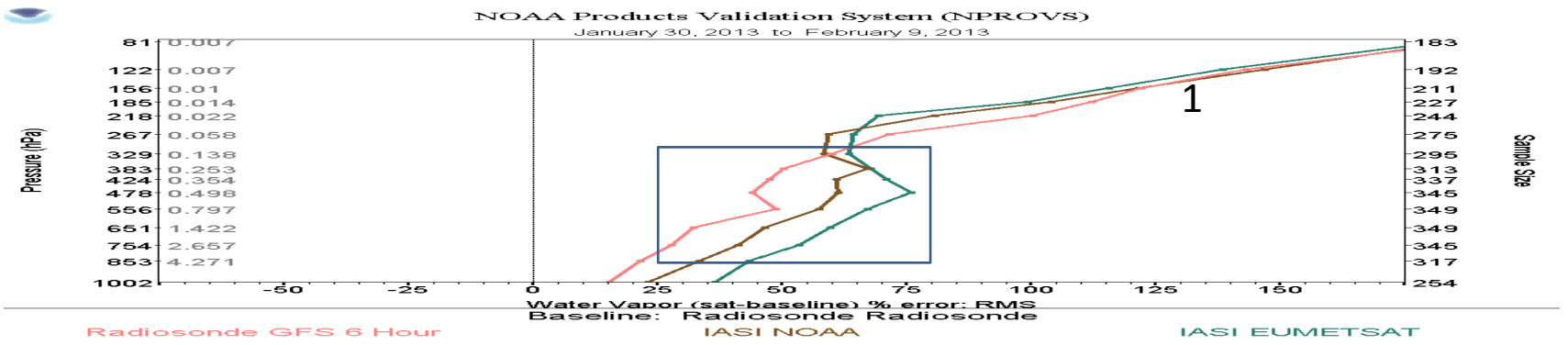
EDR Validation Results



NARCS 12 months 2013

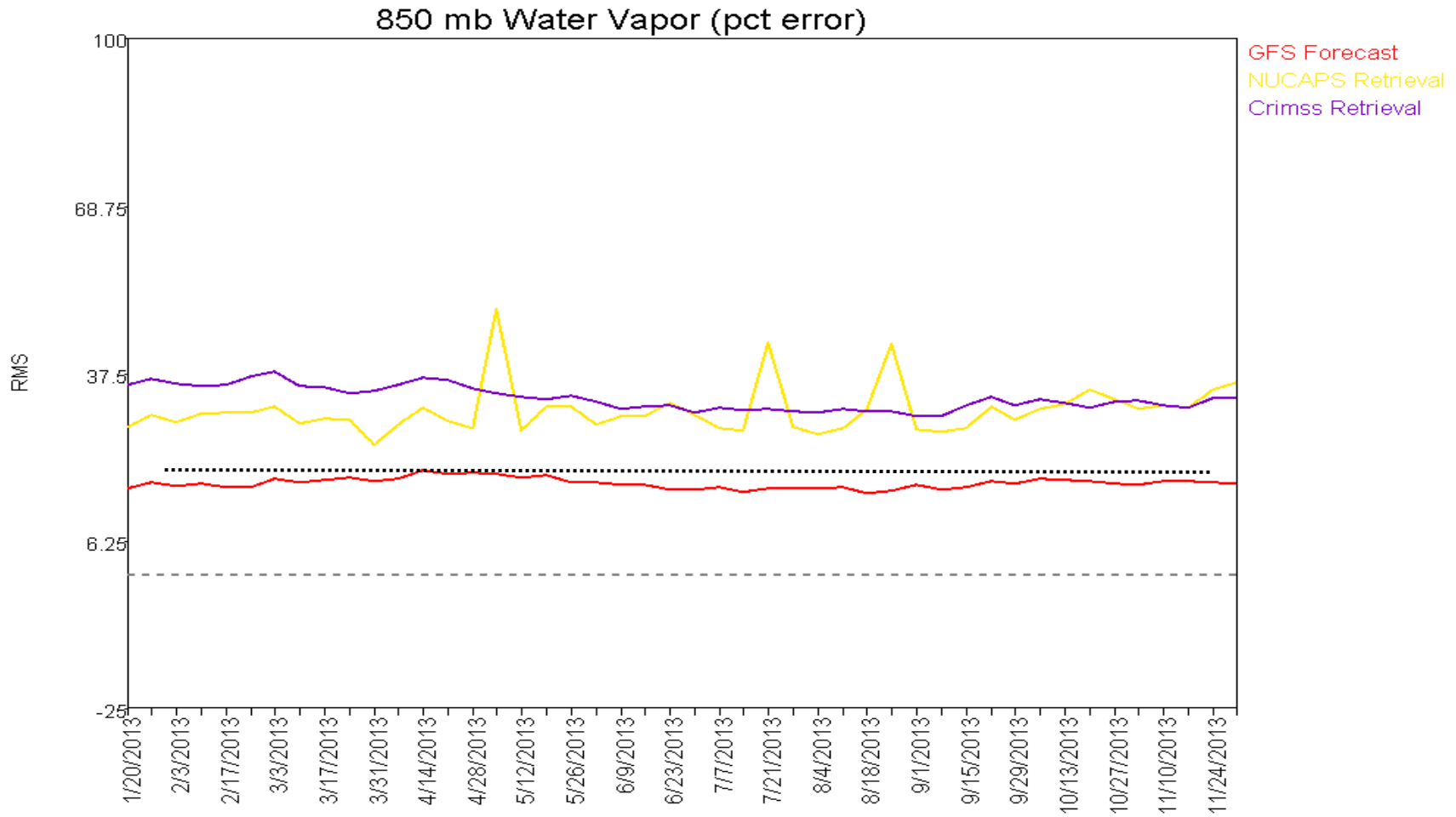
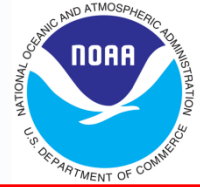


EDR Validation Results





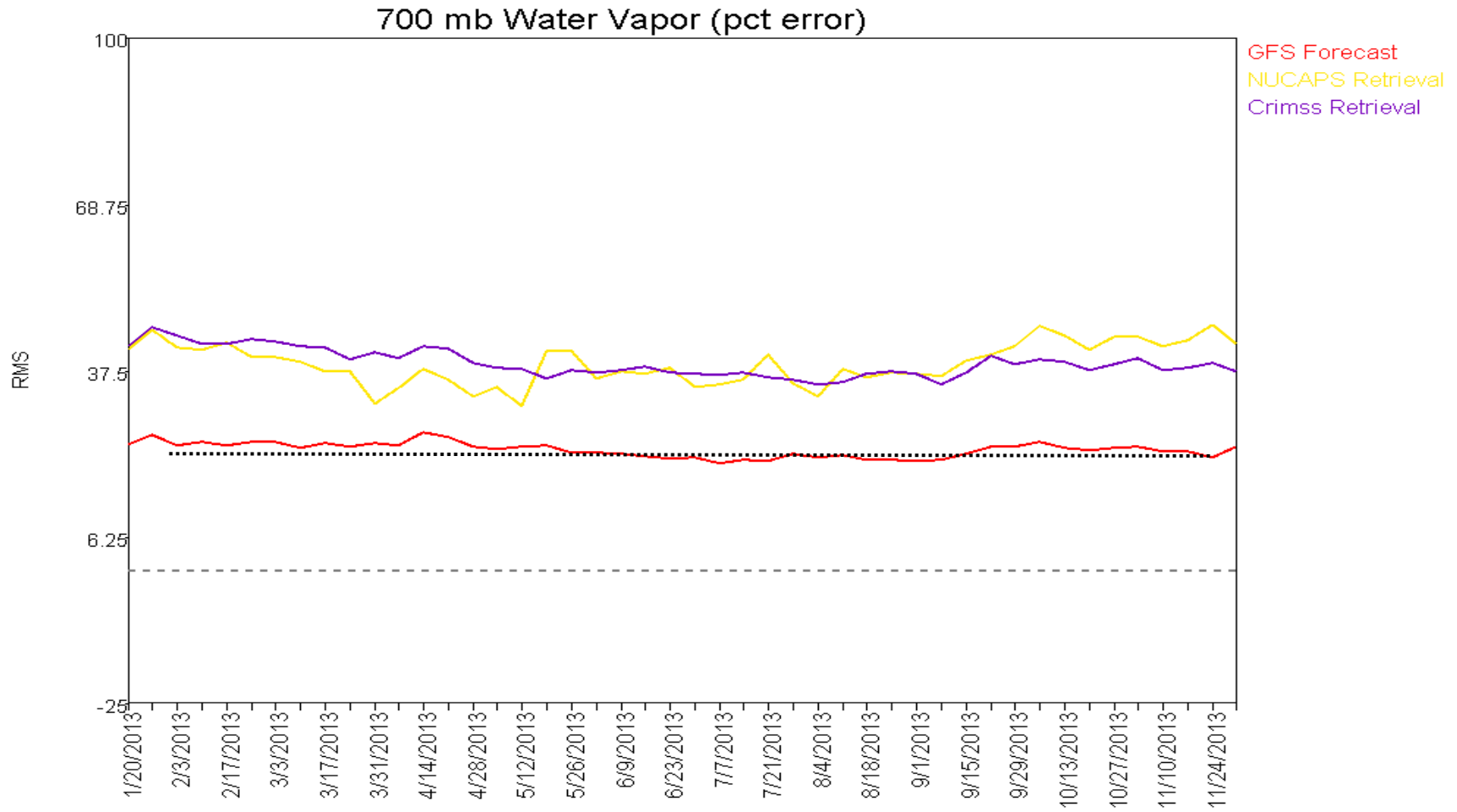
EDR Validation Results



NARCS 12 months 2013



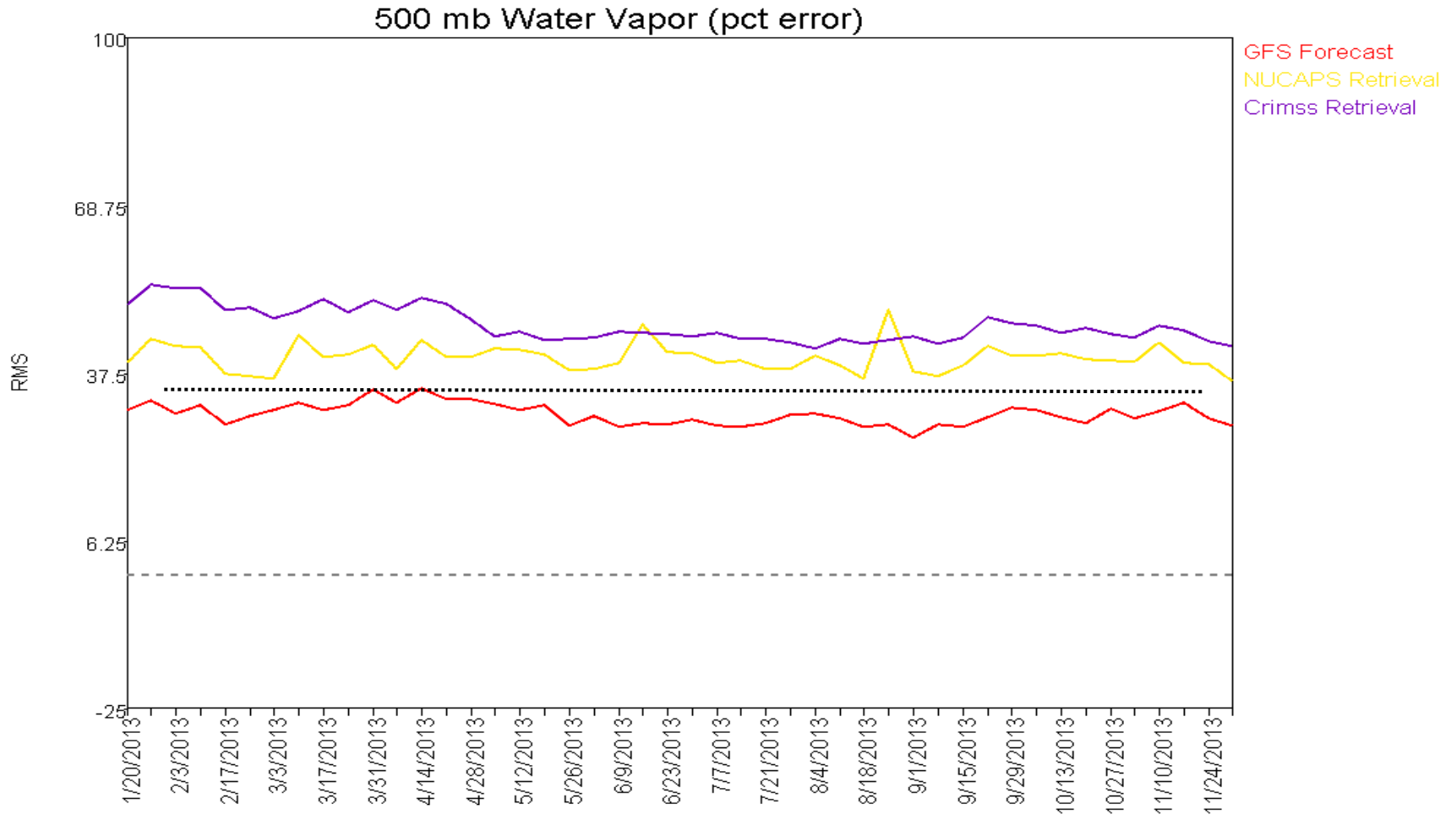
EDR Validation Results



NARCS 12 months 2013



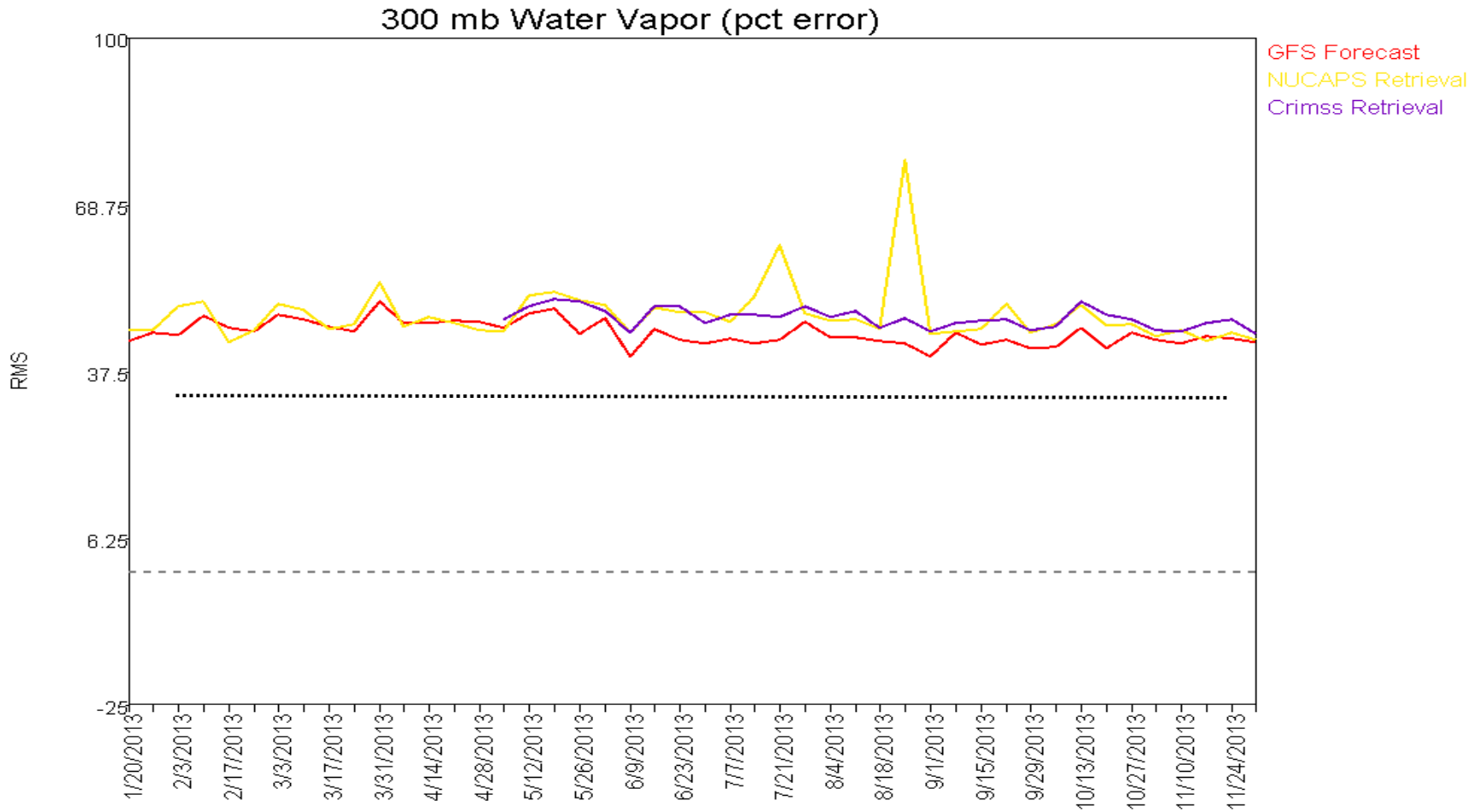
EDR Validation Results



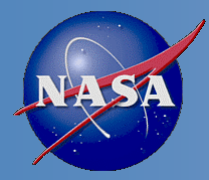
NARCS 12 months 2013



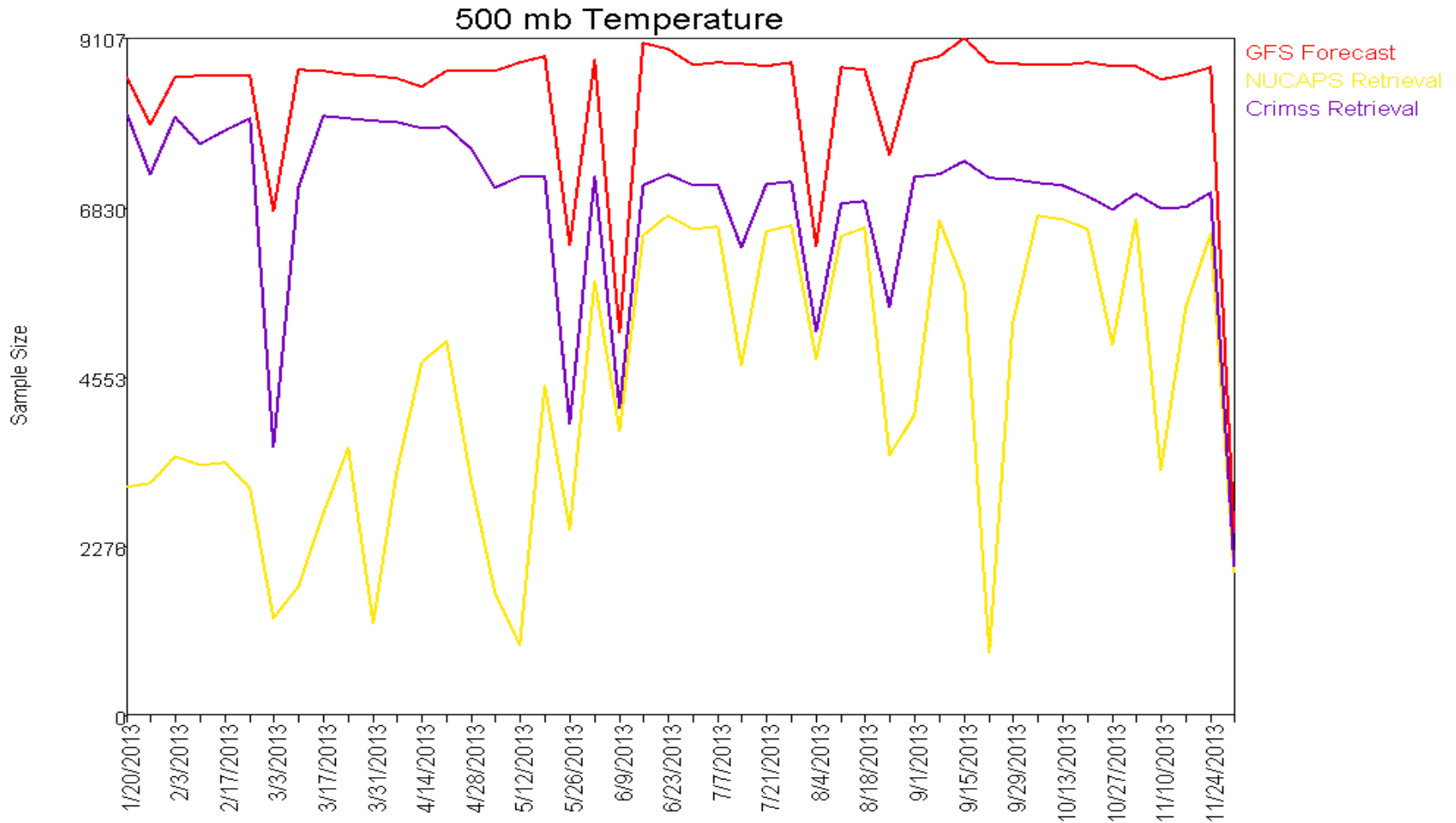
EDR Validation Results



NARCS 12 months 2013

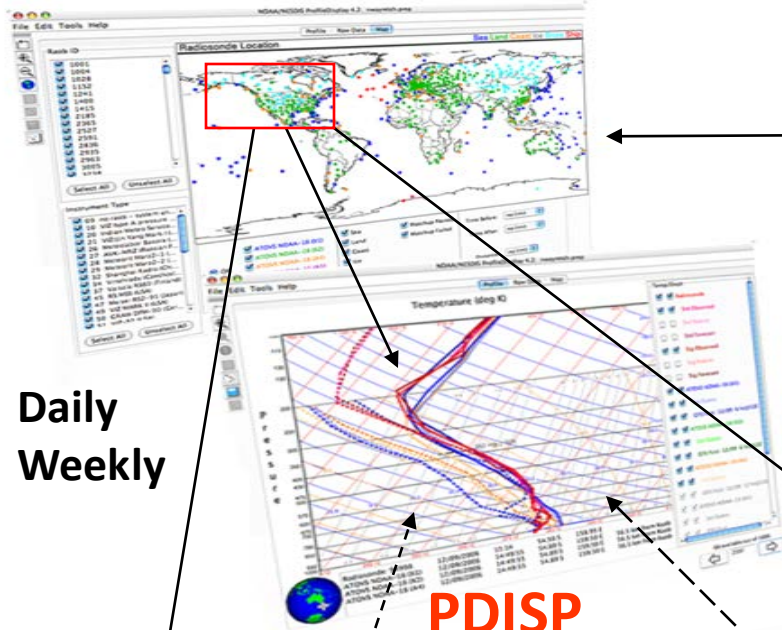


EDR Validation Results



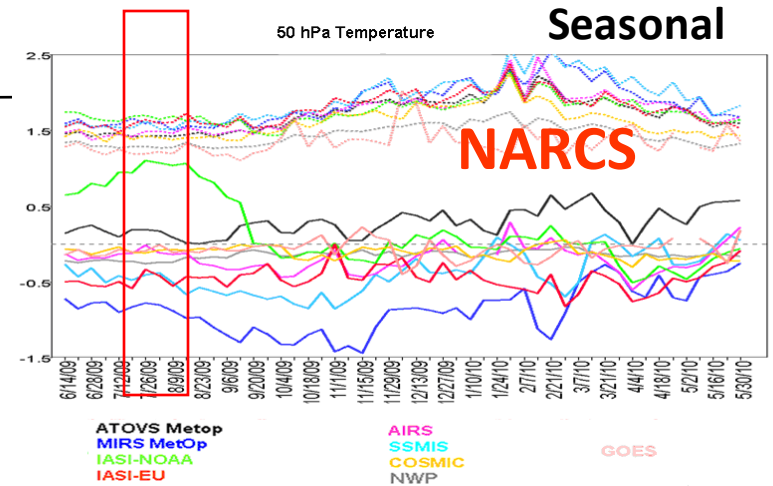
NARCS 12 months 2013

NPROVS Analytical Interface ...

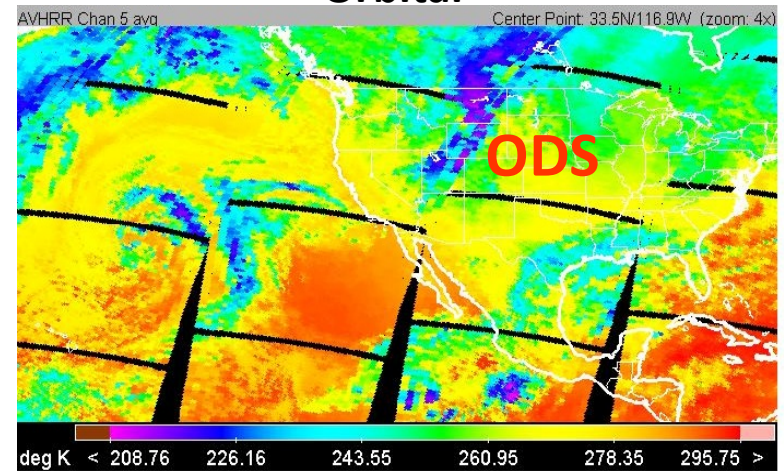


Daily
Weekly

PDISP



Orbital



... routine monitoring to deep dive



EDR Validation Results



P D I S P

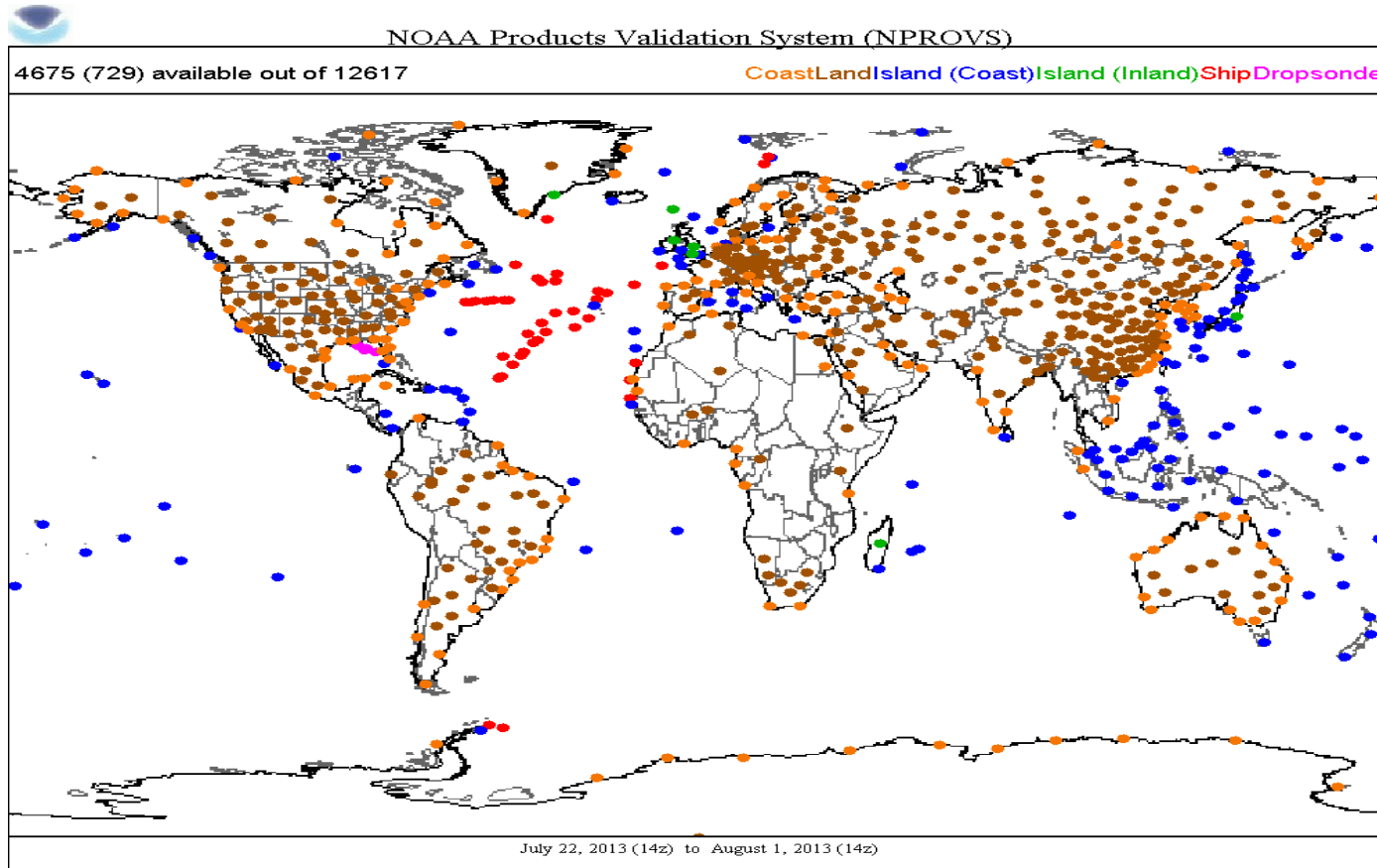
Cheat Sheet

SAT-minus-RAOB per level:

- T (K) @ 1km/2km layers
- H2O vapor fraction (%) ... SAT-minus-RAOB / Mean RAOB ... $(q_{tru})^2$
- “Common” samples which passed respective qc for given system
- IR+MW and MW-only
- Terrain / time window segregations



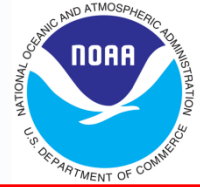
EDR Validation Results



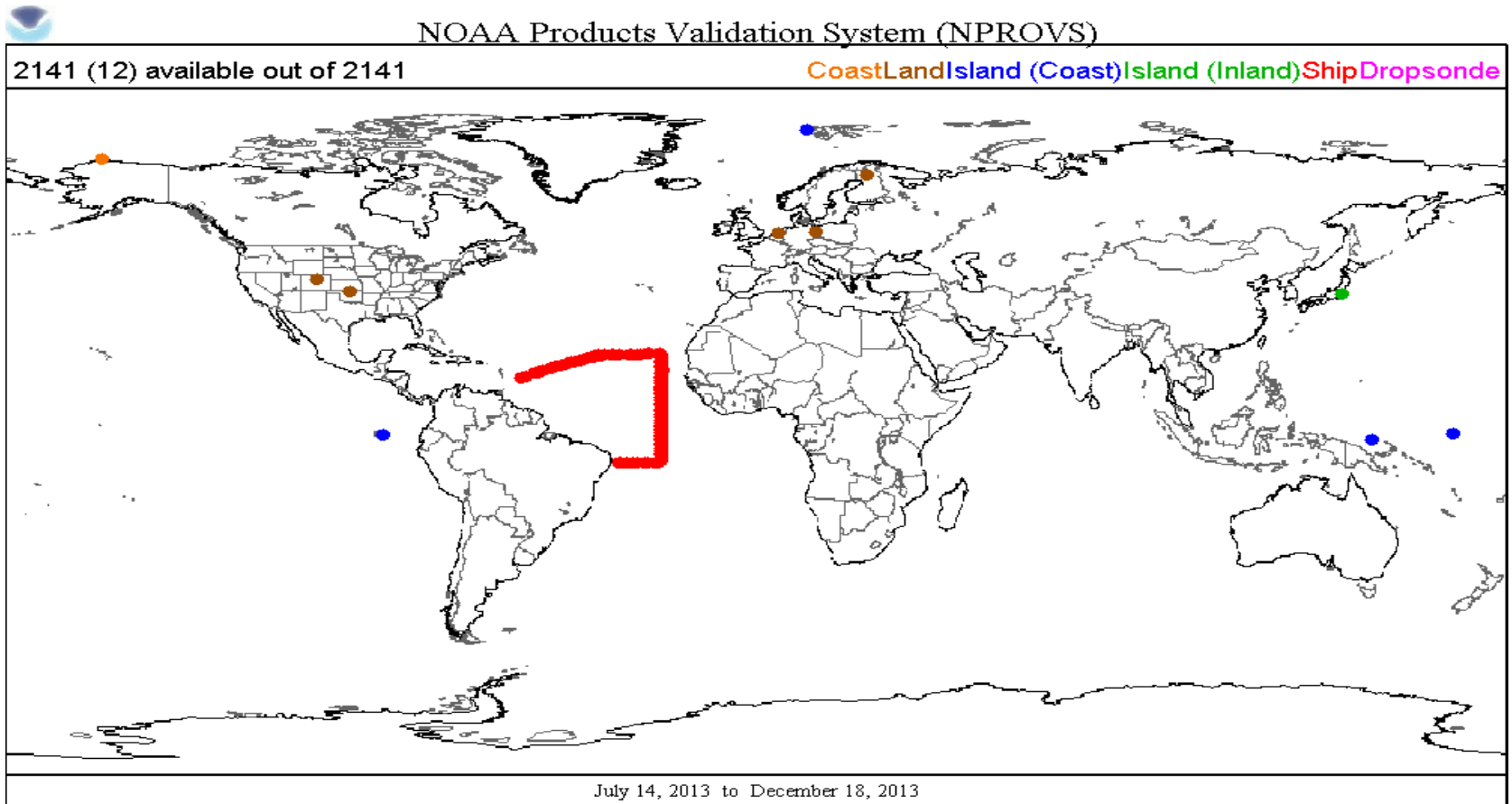
Collocations containing (IR+MW) EDR from CrIMSS and NUCAPS which passed QC
(4675/12617 ... 37%)



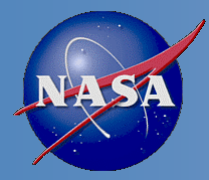
EDR Validation



NPROVS+



2050 collocations (350 Dedicated, 1700 GRUAN) ... 5mos



EDR Validation Results



PDISP

Part 1

a) IR+MW Only:

NPROVS vs NPROVS+

Summer vs Fall

b) MW only

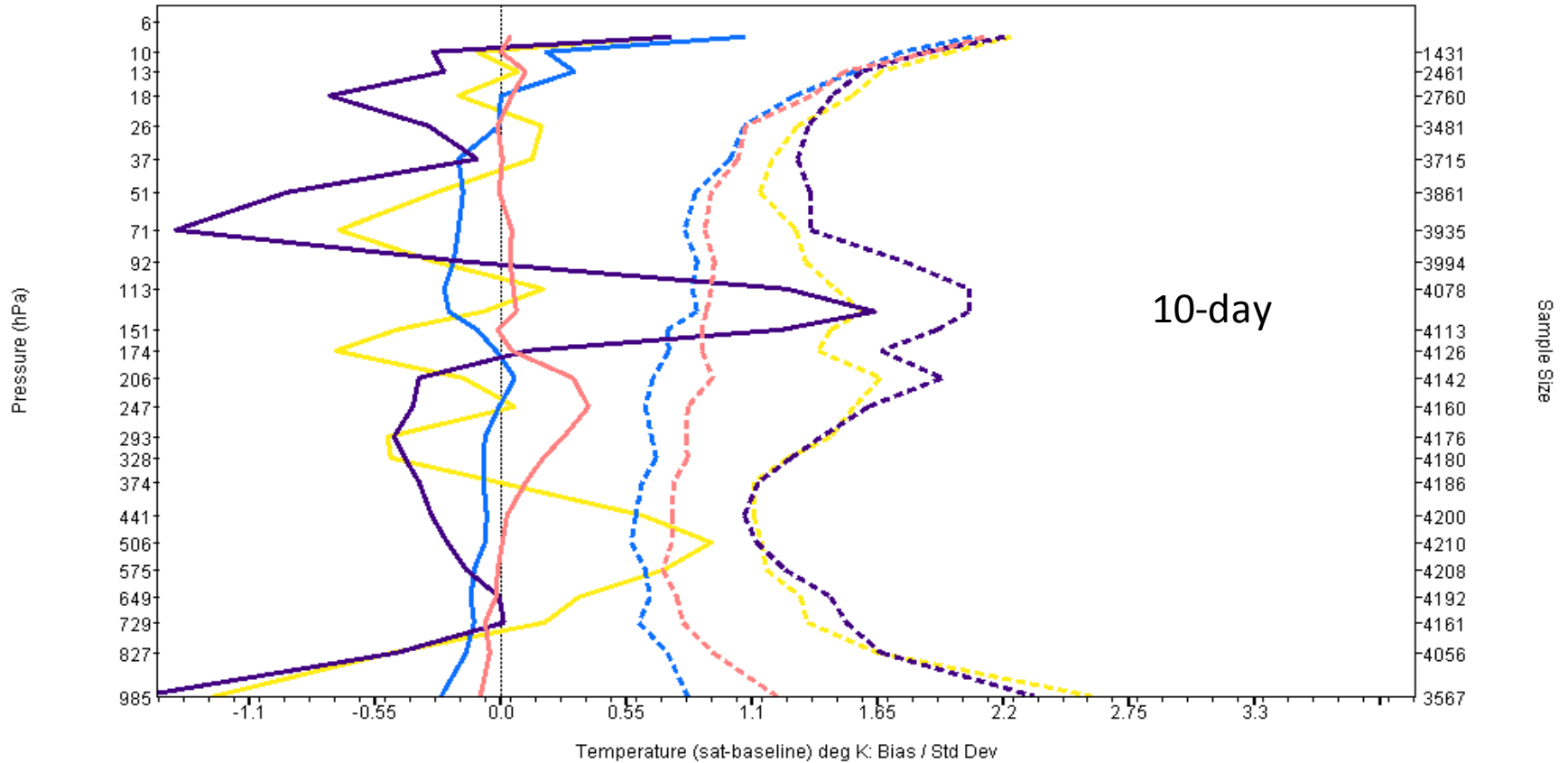


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



Baseline: Radiosonde Radiosonde

Radiosonde GFS 6 Hour

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP

NPROVS PDISP

Sample Size

1431
2461
2760
3481
3715
3881
3935
3994
4078
4113
4126
4142
4160
4176
4180
4186
4200
4210
4208
4192
4161
4056
3567

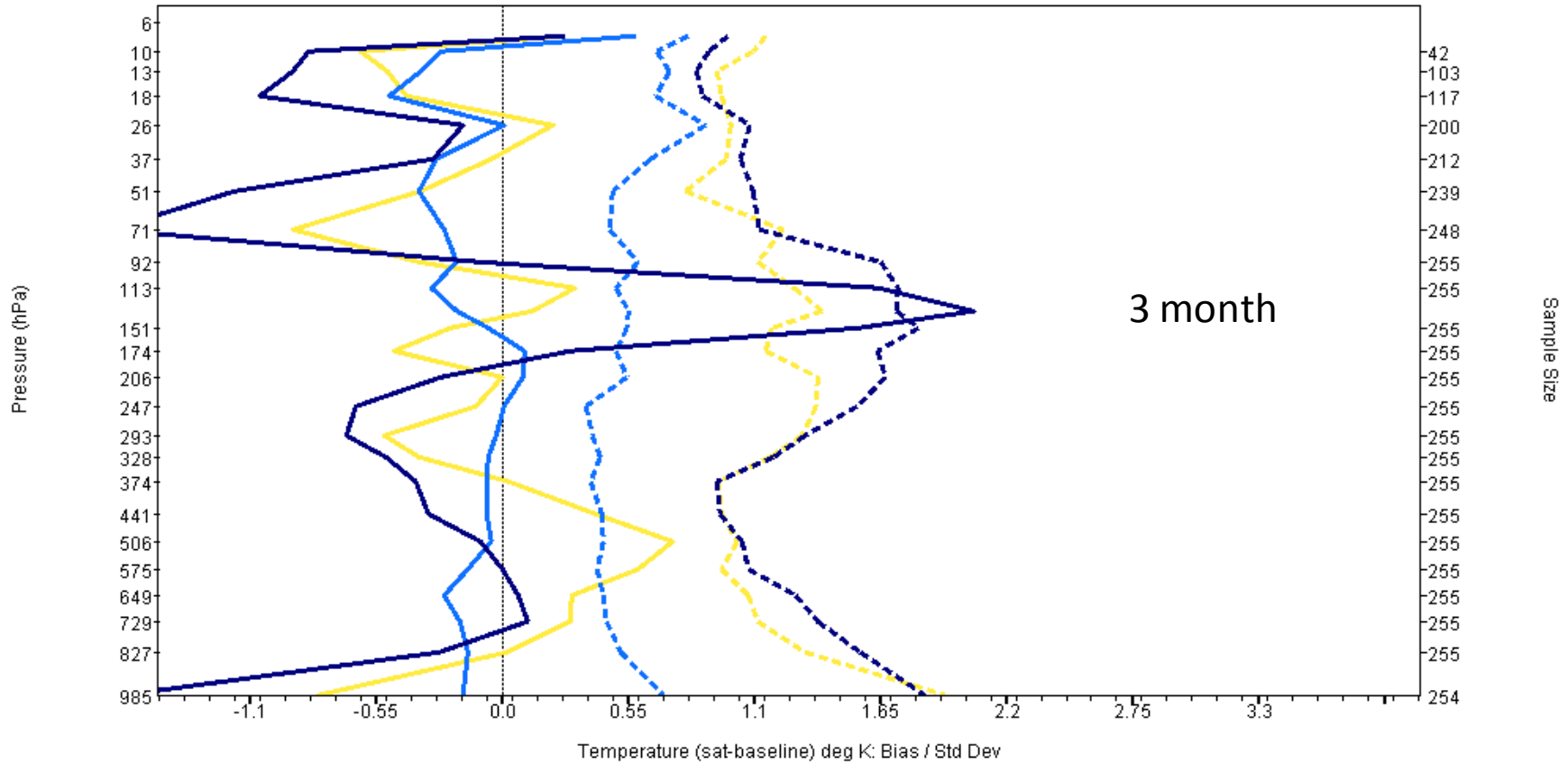


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 13, 2013 to October 17, 2013



Baseline: REFERENCE GRUAN RAOB

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP

NPROVS+ PDISP

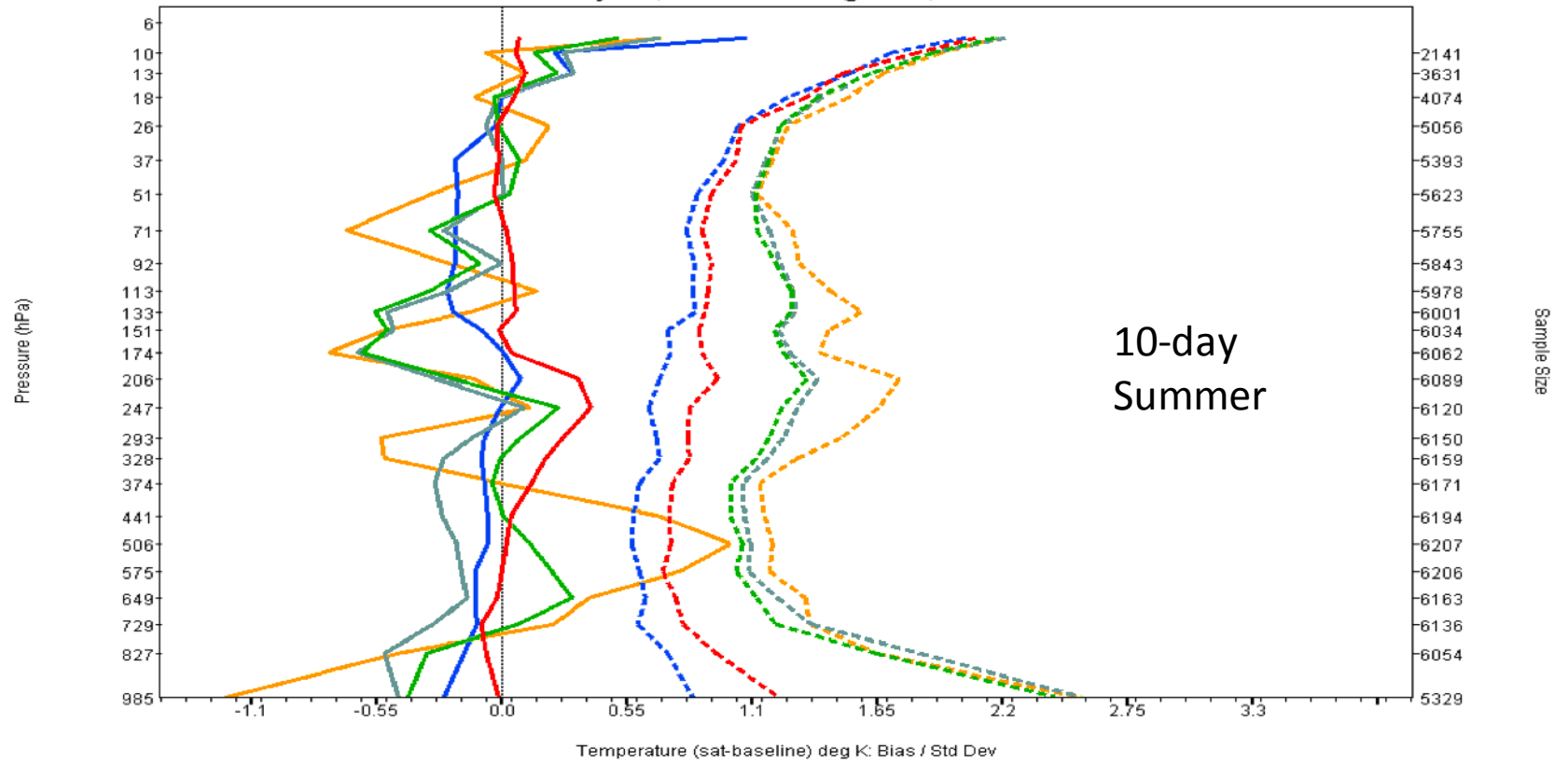


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



10-day Summer

Baseline: Radiosonde

Radiosonde GFS 6 Hour
ECMWF ANALYSIS

AIRS AQUA
NUCAPS NPP

AIRS AQUA First Guess

NPROVS PDISP

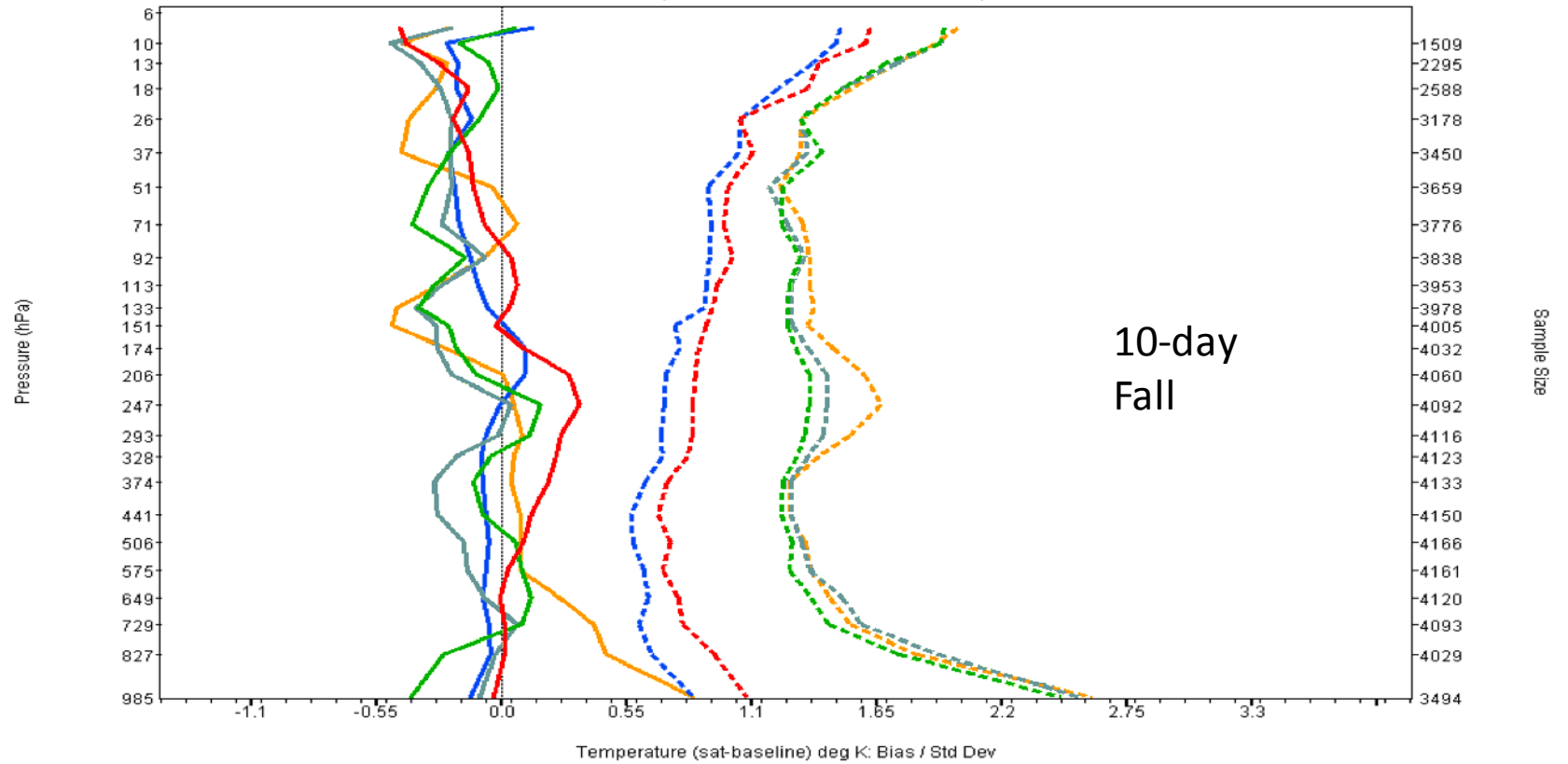


EDR Validation Results



NOAA Products Validation System (NPROVS)

October 29, 2013 to November 7, 2013



Baseline: Radiosonde

Radiosonde GFS 6 Hour
ECMWF ANALYSIS

AIRS AQUA
NUCAPS NPP

AIRS AQUA First Guess

NPROVS



EDR Validation Results



MW only Pass
(the so called “cloudy”)

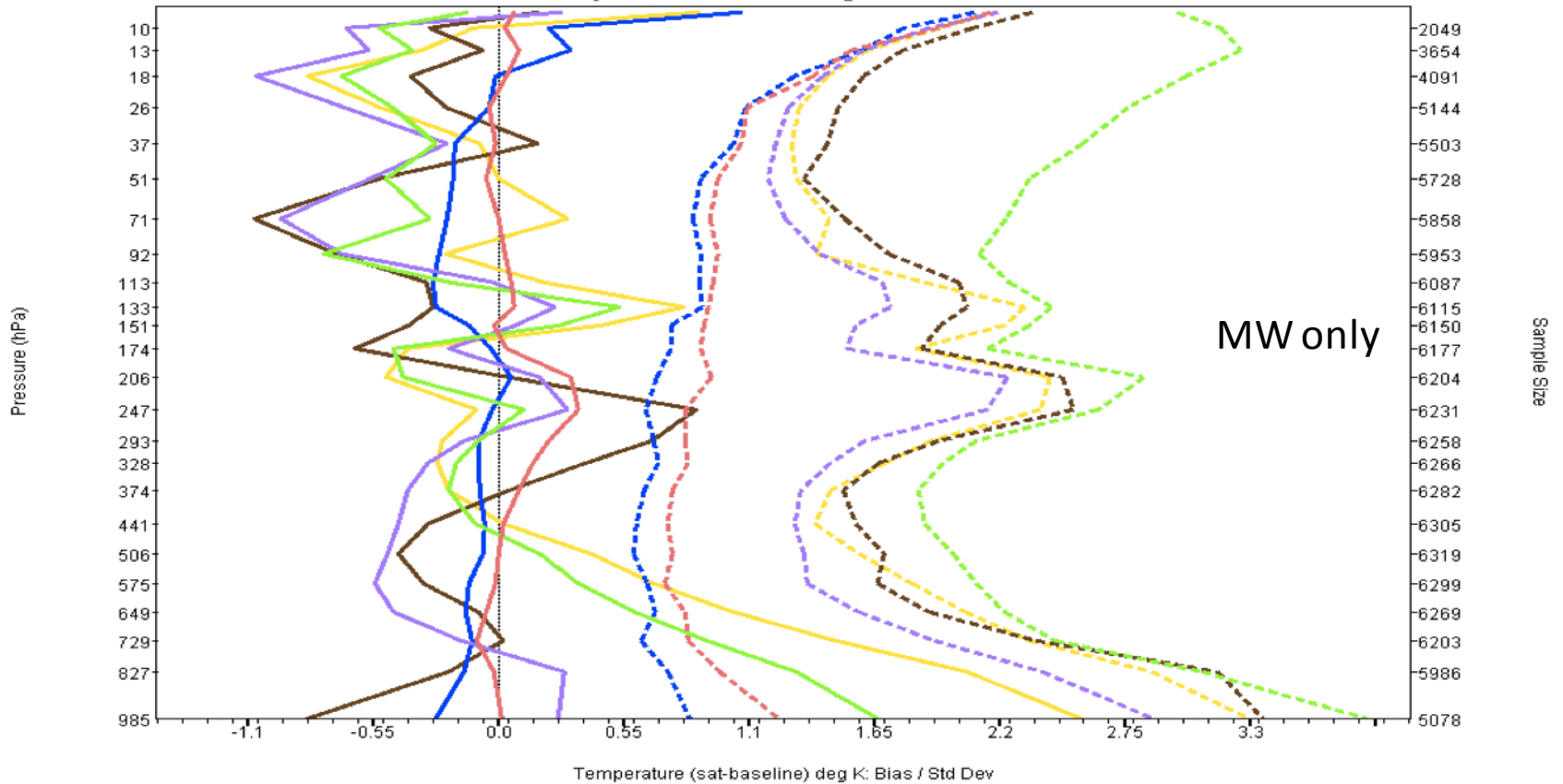


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



Baseline: Radiosonde

Radiosonde GFS 6 Hour
ECMWF ANALYSIS

IASI NOAA MIT
MIRS NPP

CRIMSS NPP Microwave (IP)
NUCAPS NPP MIT

MW only Pass QC

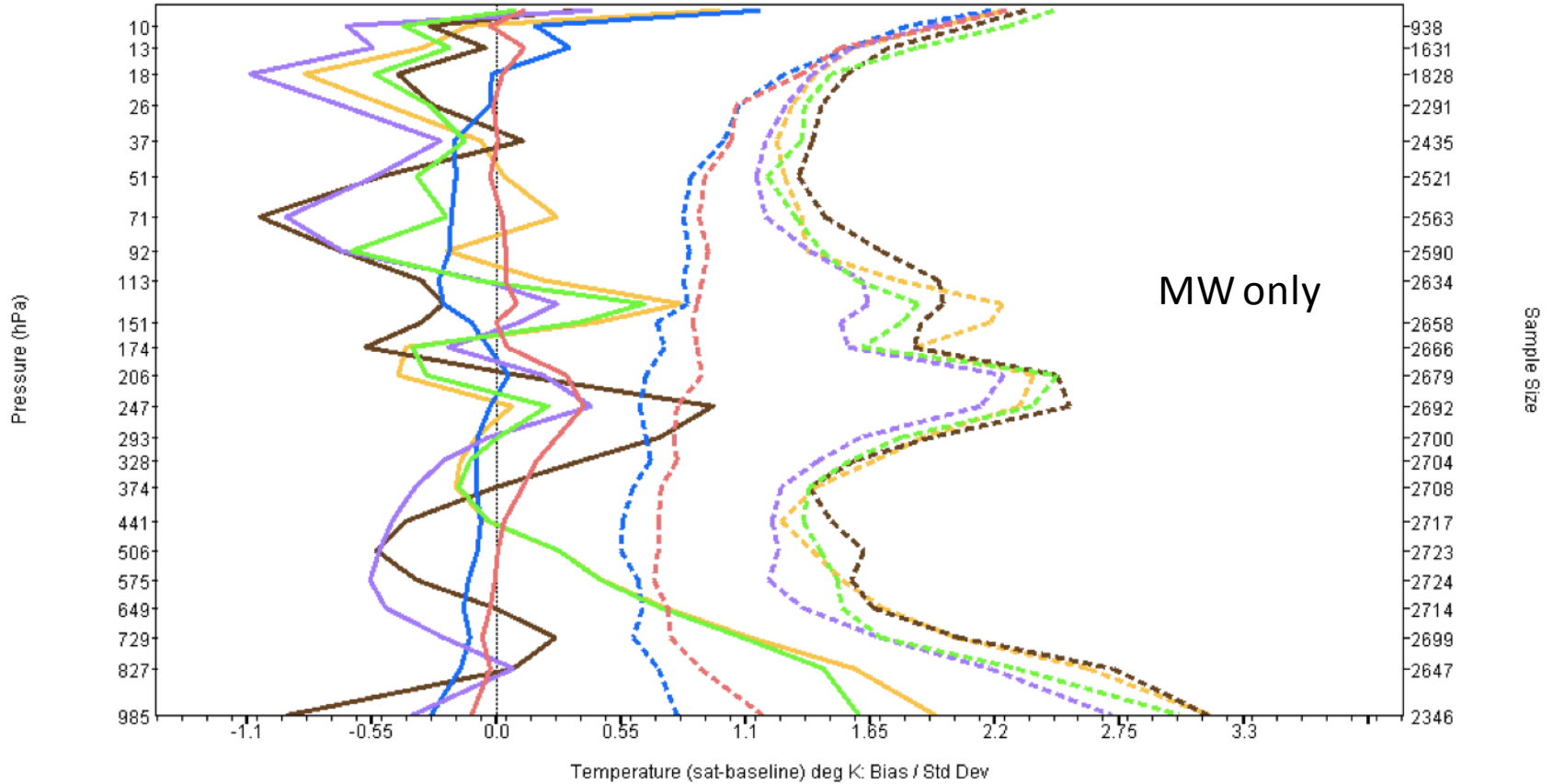


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



Baseline: Radiosonde

Radiosonde GFS 6 Hour
ECMWF ANALYSIS

IASI NOAA MIT
MIRS NPP

CRIMSS NPP Microwave (IP)
NUCAPS NPP MIT

IR + MW only Pass QC

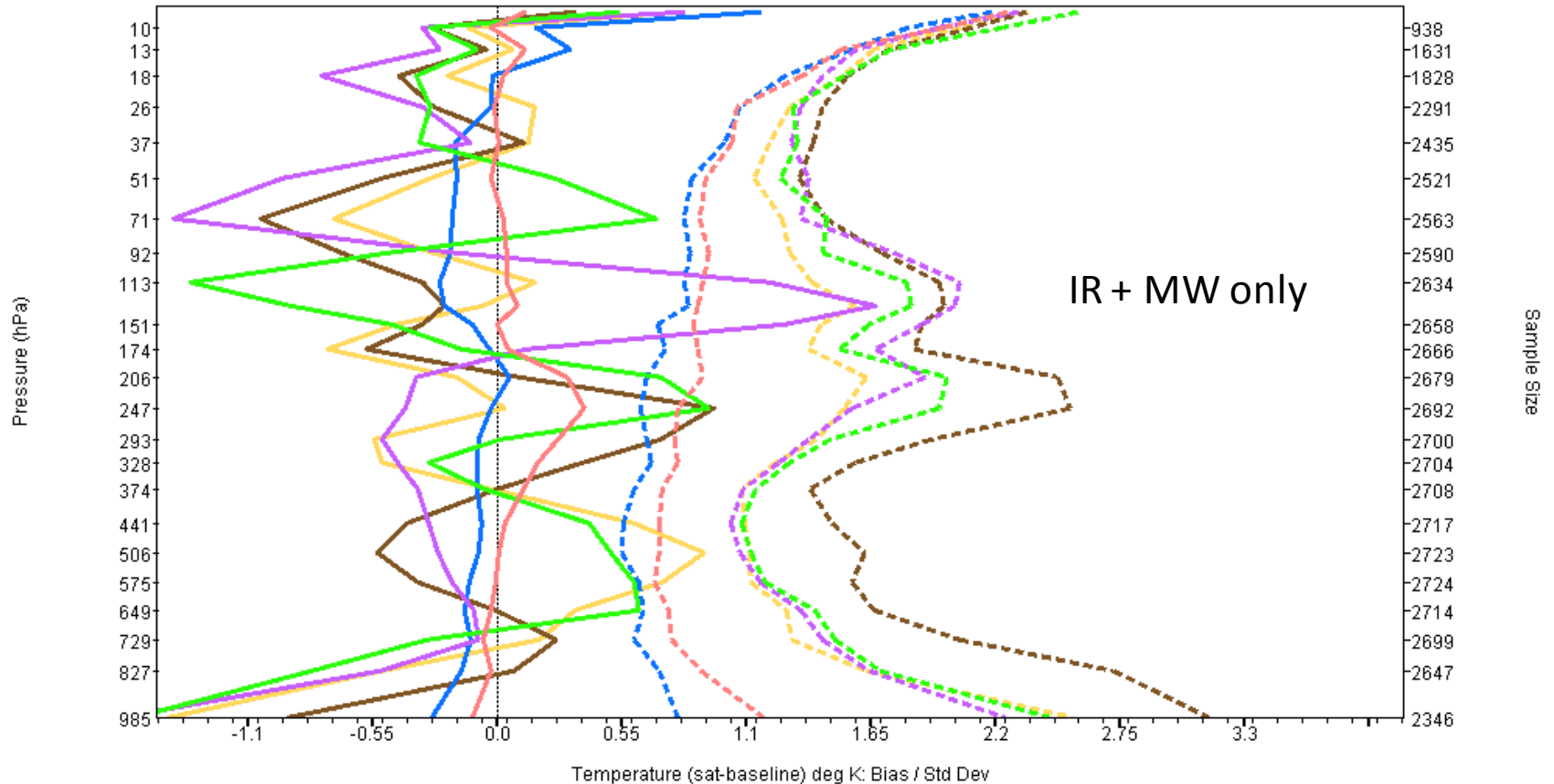


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 22, 2013 to August 1, 2013



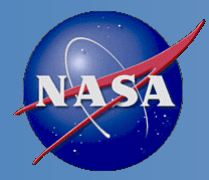
Baseline: Radiosonde Radiosonde

Radiosonde GFS 6 Hour
ECMWF ANALYSIS

IASI NOAA
MIRS NPP

CRIMSS NPP Infrared (IP)
NUCAPS NPP

IR + MW only Pass QC



EDR Validation Results



Part 2

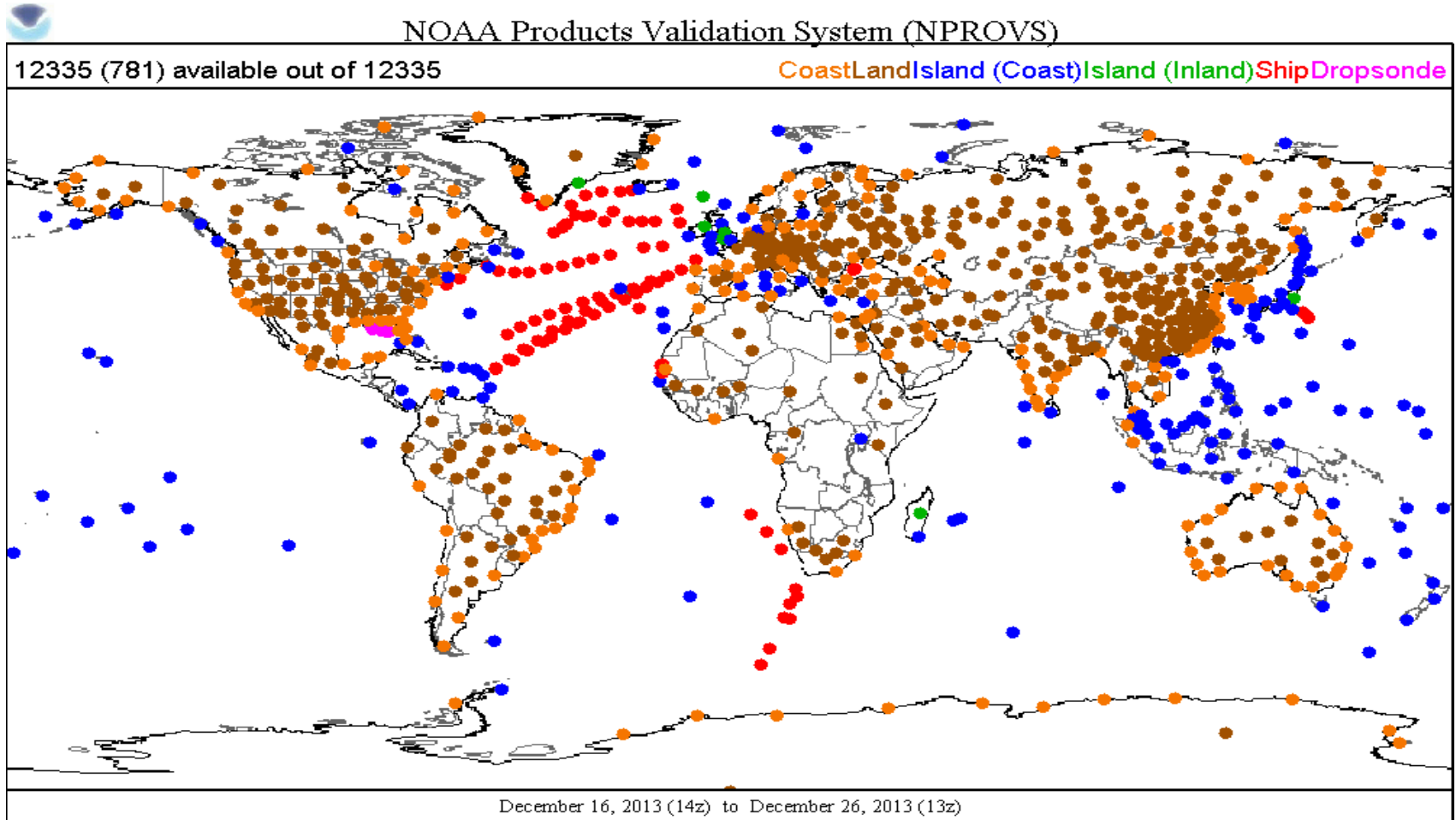
NPROVS

Dec 16-26

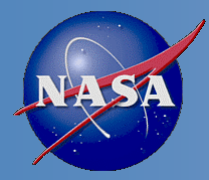
2013



EDR Validation Results



NPROVS Collocations 12/16 to 12/26 2013 ... 12,335



EDR Validation Results



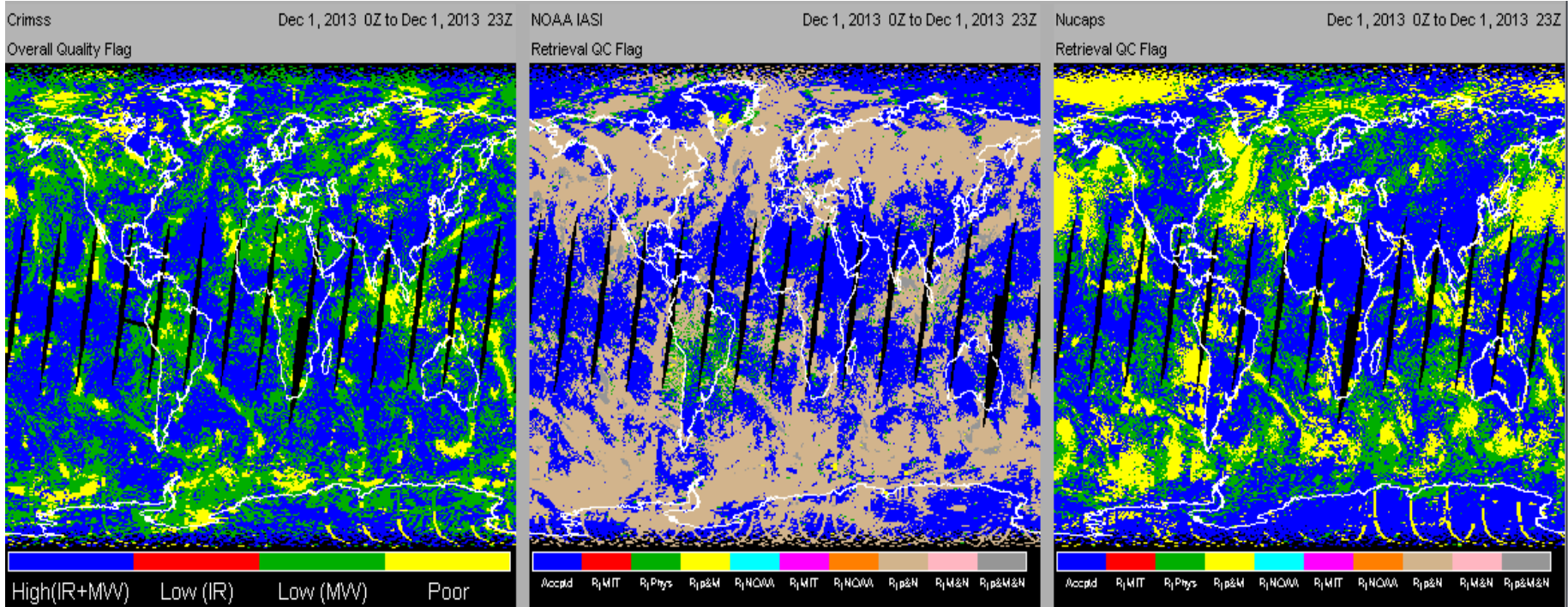
IASI	(11,180)	(December)
- IR+MW		43%
- MW-only		54%
- Poor		02%

NUCAPS	(11,355)	
- IR+MW		57%
- MW-only		21%
- Poor		22%

MX7.1	(11,347)	(July)
- IR+MW	43%	(50.6)
- MW-only	40%	(38.9)
- Poor	17%	(10.4)

Yield Analysis

NPROVS Collocations 12/16 to 12/26 2013 ... 12,335

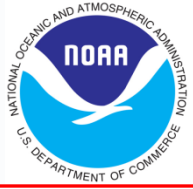


ODS indicates inconsistencies in the way we are “interpreting” IASI qc

NPROVS Collocations do not reflect oceanic yields ...



EDR Validation Results



IR + MW Pass QC:

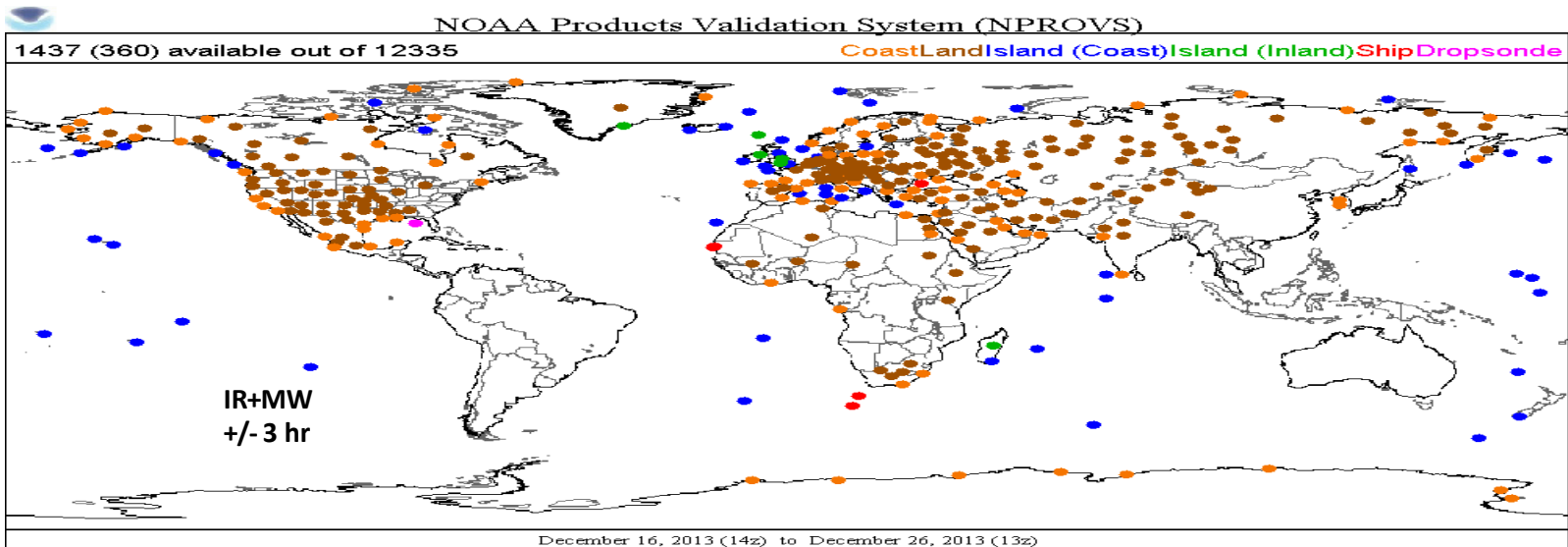
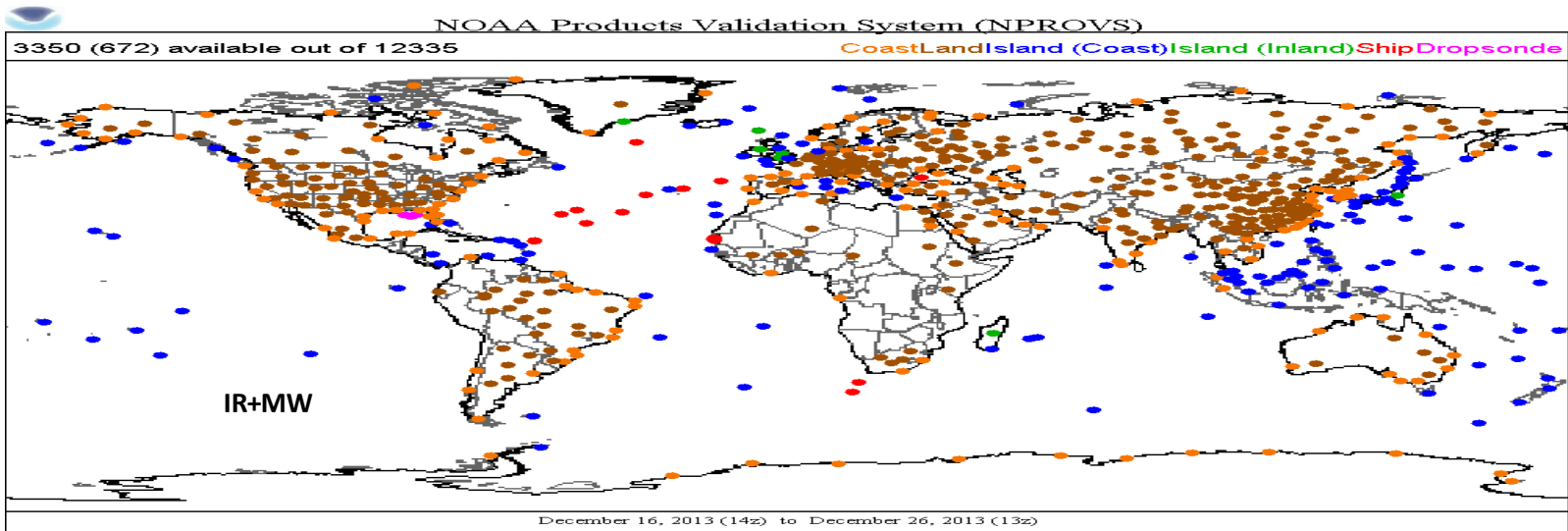
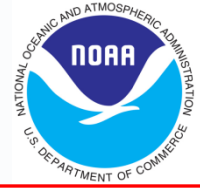
a) All Terrain ... (3000 / 12000)

b) All Terrain, +/- 3 hr / 100km ... (1000)

c) Maritime, +/- 3hr / 100km ... (150)

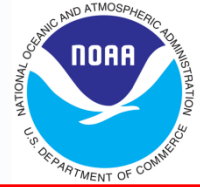


EDR Validation Results





EDR Validation Results



Atmospheric Vertical Temperature Profile (AVTP) Measurement Uncertainty – Layer Average Temperature Error

PARAMETER	THRESHOLD
AVTP Clear, surface to 300 mb	1.6 K / 1-km layer
AVTP Clear, 300 to 30 mb	1.5 K / 3-km layer
AVTP Clear, 30 mb to 1 mb	1.5 K / 5-km layer
AVTP Clear, 1 mb to 0.5 mb	3.5 K / 5-km layer
AVTP Cloudy , surface to 700 mb	2.5 K / 1-km layer
AVTP Cloudy, 700 mb to 300 mb	1.5 K / 1-km layer
AVTP Cloudy, 300 mb to 30 mb	1.5 K / 3-km layer
AVTP Cloudy, 30 mb to 1 mb	1.5 K / 5-km layer
AVTP Cloudy, 1 mb to 0.5 mb	3.5 K / 5-km layer

Clear ... IR+MW

Cloudy ... (MW only)

Atmospheric Vertical Moisture Profile (AVMP) Measurement Uncertainty – 2-km Layer Average Mixing Ratio % Error

PARAMETER	THRESHOLD
AVMP Clear, surface to 600 mb	Greater of 20% or 0.2 g/kg / 2-km layer
AVMP Clear, 600 to 300 mb	Greater of 35% or 0.1 g/kg / 2-km layer
AVMP Clear, 300 to 100 mb	Greater of 35% or 0.1 g/kg / 2-km layer
AVMP Cloudy, surface to 600 mb	Greater of 20% of 0.2 g/kg / 2-km layer
AVMP Cloudy, 600 mb to 400 mb	Greater of 40% or 0.1 g/kg / 2-km layer
AVMP Cloudy, 400 mb to 100 mb	Greater of 40% or 0.1 g/kg / 2-km layer

Clear ... IR+MW

Cloudy ... (MW only)

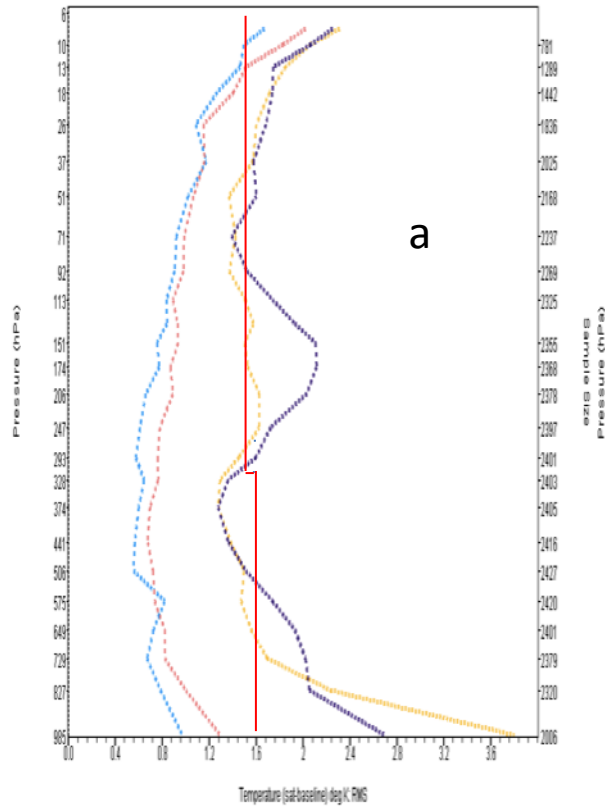


EDR Validation Results



NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



a

Baseline: Radiosonde

Radiosonde GFS 6 Hour

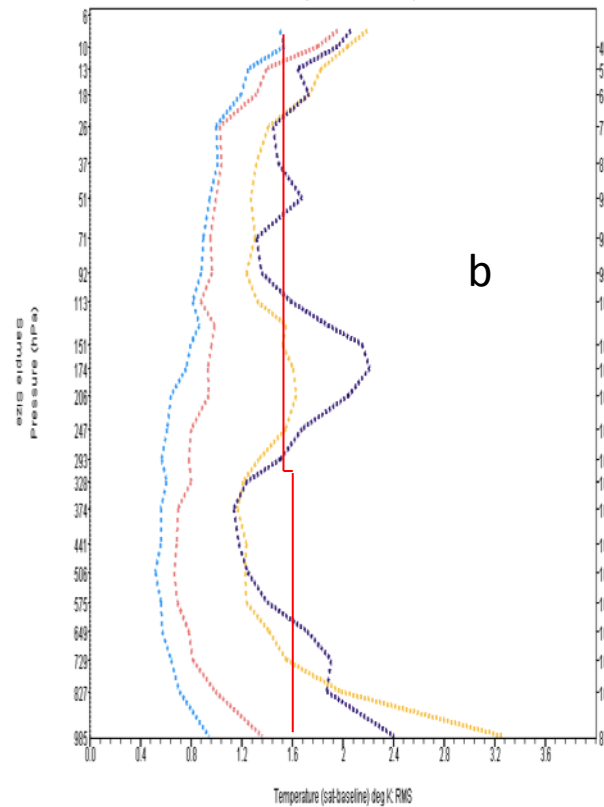
NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



b

Baseline: Radiosonde

Radiosonde GFS 6 Hour

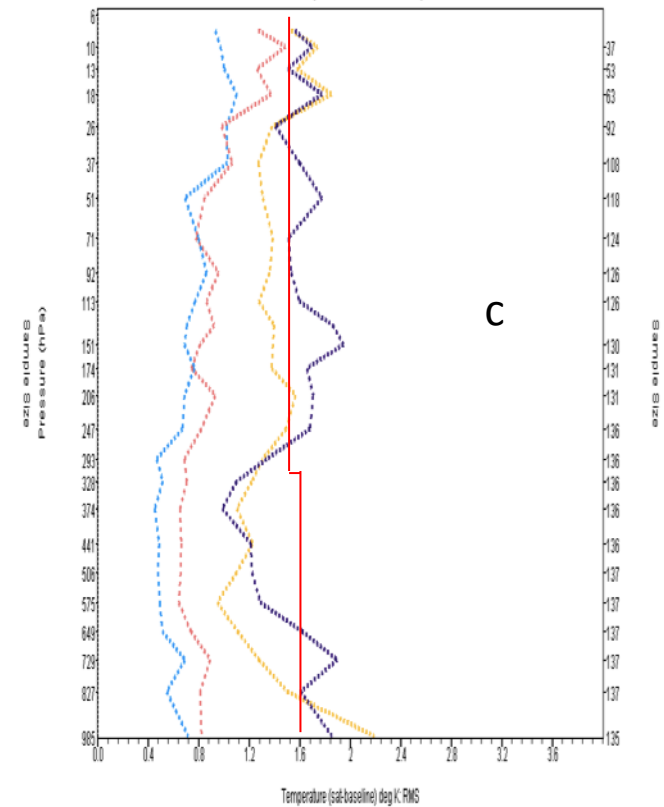
NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



c

Baseline: Radiosonde

Radiosonde GFS 6 Hour

NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

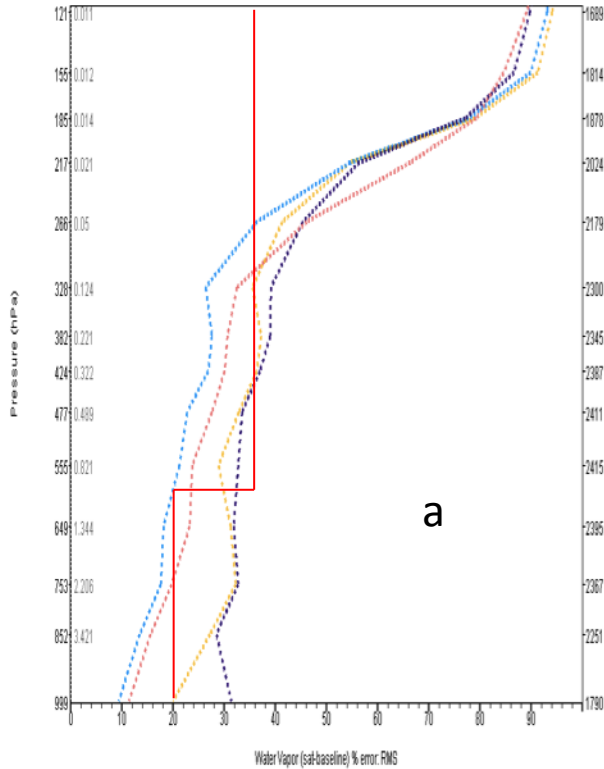


EDR Validation Results



NOAA Products Validation System (NPROVS)

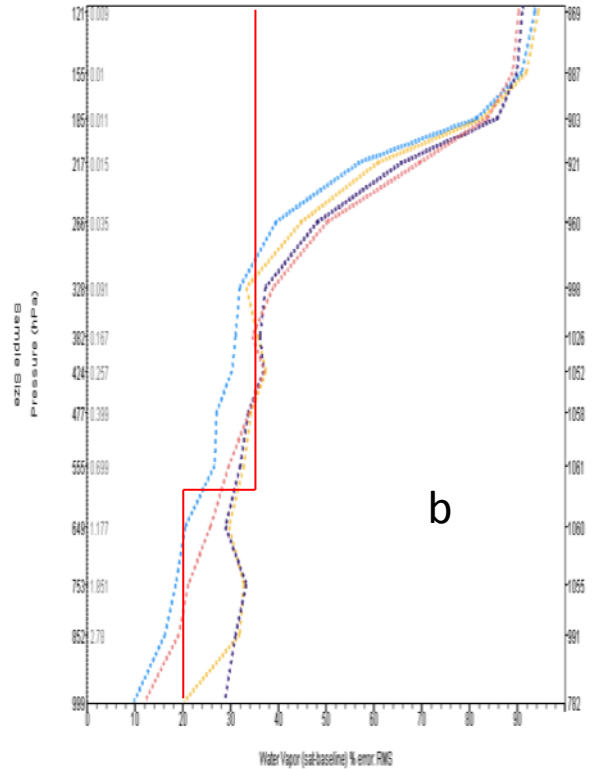
December 16, 2013 to December 26, 2013



a

NOAA Products Validation System (NPROVS)

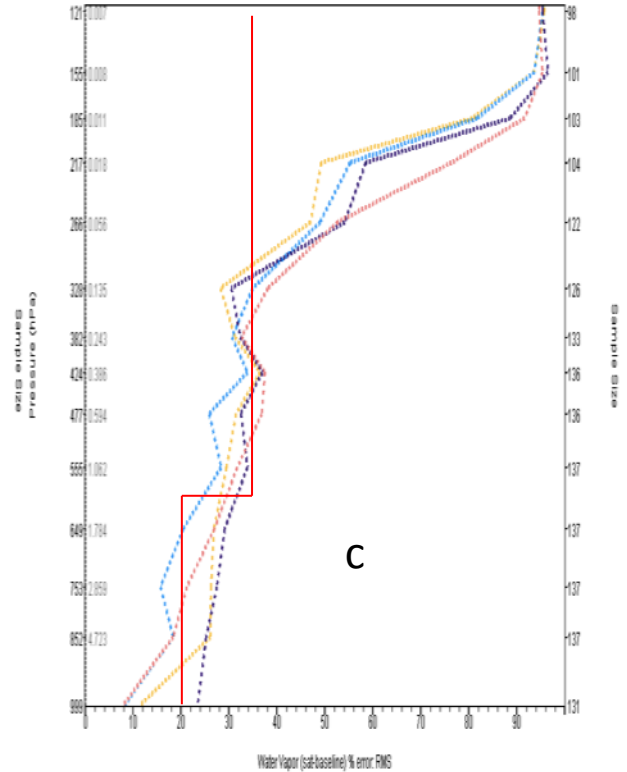
December 16, 2013 to December 26, 2013



b

NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



c

Baseline: Radiosonde

Radiosonde GFS 6 Hour

NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

Baseline: Radiosonde

Radiosonde GFS 6 Hour

NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

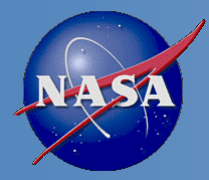
Baseline: Radiosonde

Radiosonde GFS 6 Hour

NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS



EDR Validation Results



MW Pass QC:

a) Maritime, +/- 3hr / 100km ... (250)

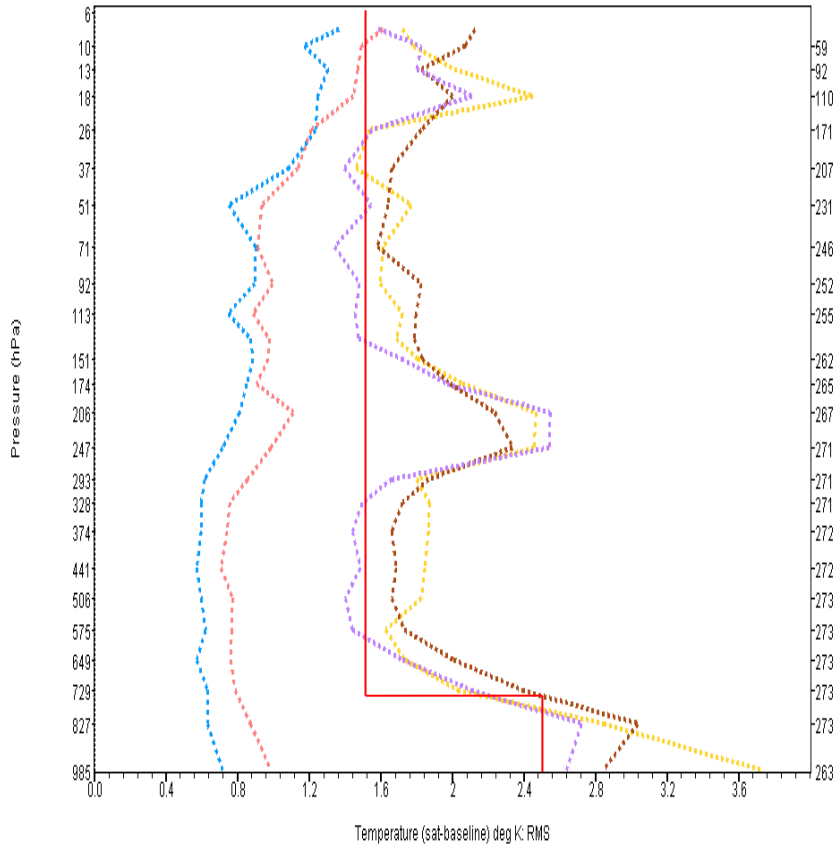


EDR Validation Results



NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



Baseline: Radiosonde Radiosonde

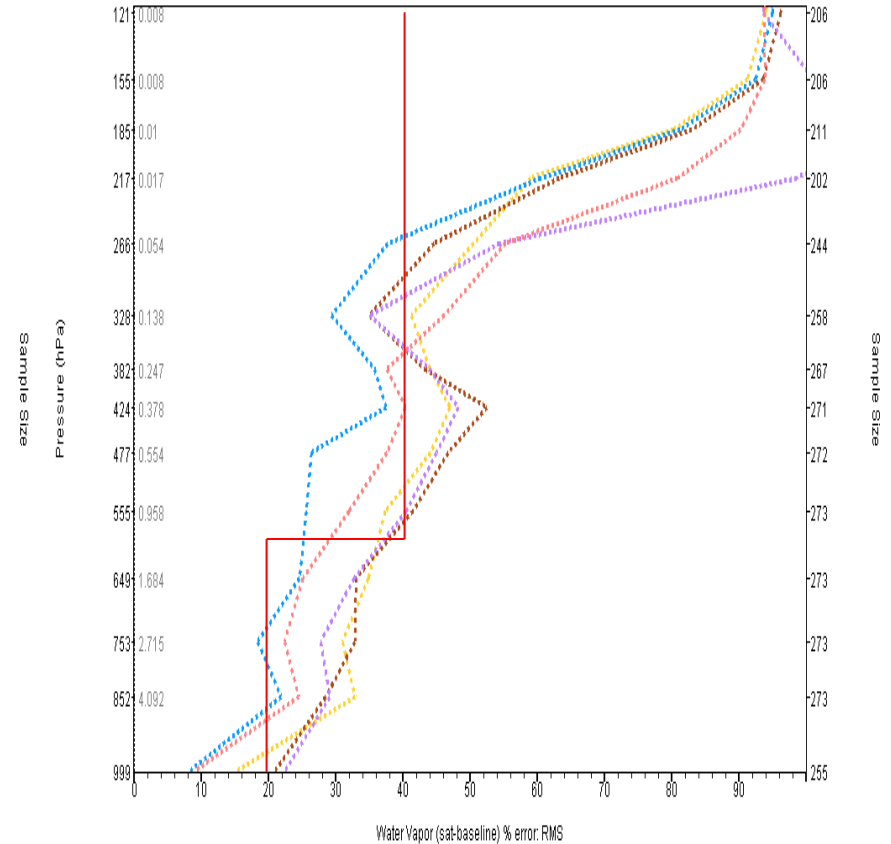
Radiosonde GFS 6 Hour
MIRS NPP

CRIMSS NPP Microwave (IP)
NUCAPS NPP MIT

ECMWF ANALYSIS

NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



Baseline: Radiosonde Radiosonde

Radiosonde GFS 6 Hour
MIRS NPP

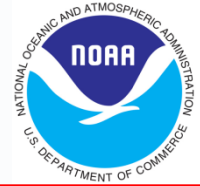
CRIMSS NPP Microwave (IP)
NUCAPS NPP MIT

ECMWF ANALYSIS

MW Only pass QC

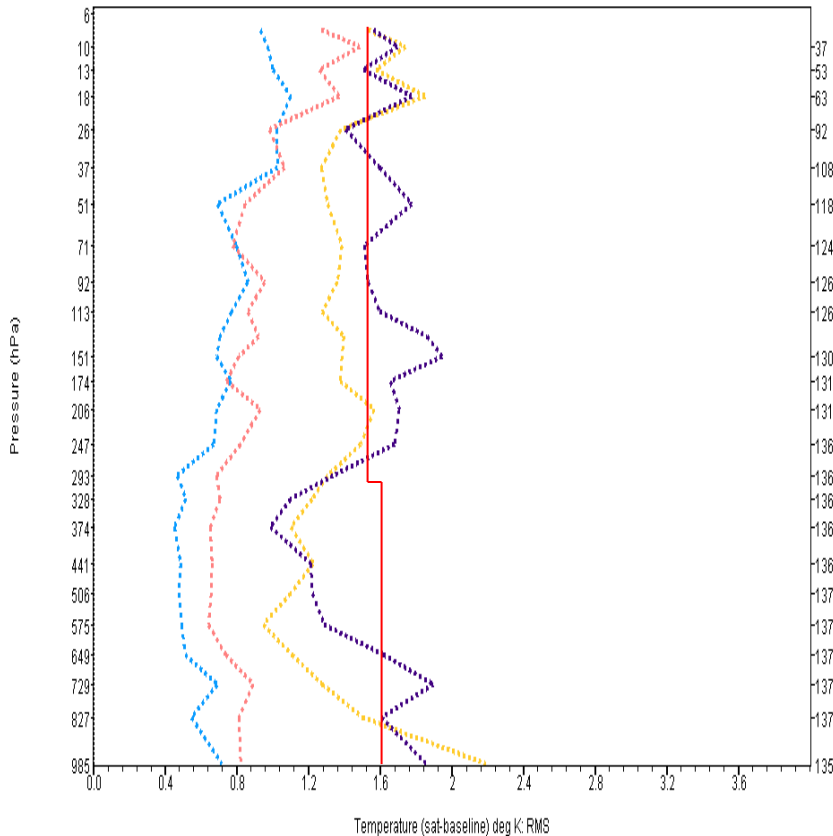


EDR Validation Results



NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



Baseline: Radiosonde Radiosonde

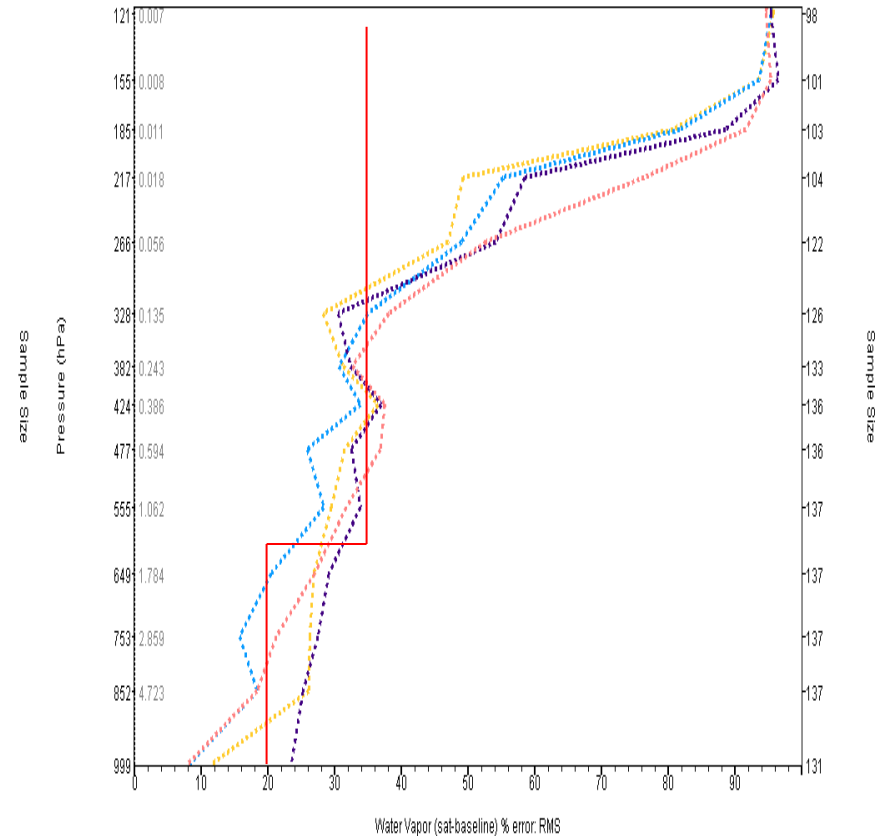
Radiosonde GFS 6 Hour
NUCAPS NPP

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



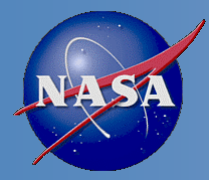
Baseline: Radiosonde Radiosonde

Radiosonde GFS 6 Hour
NUCAPS NPP

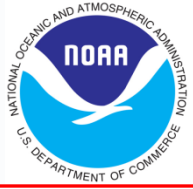
CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

IR + MW pass QC)



EDR Validation Results



Part 3

NPROVS +
July 15 to Dec 22
2013



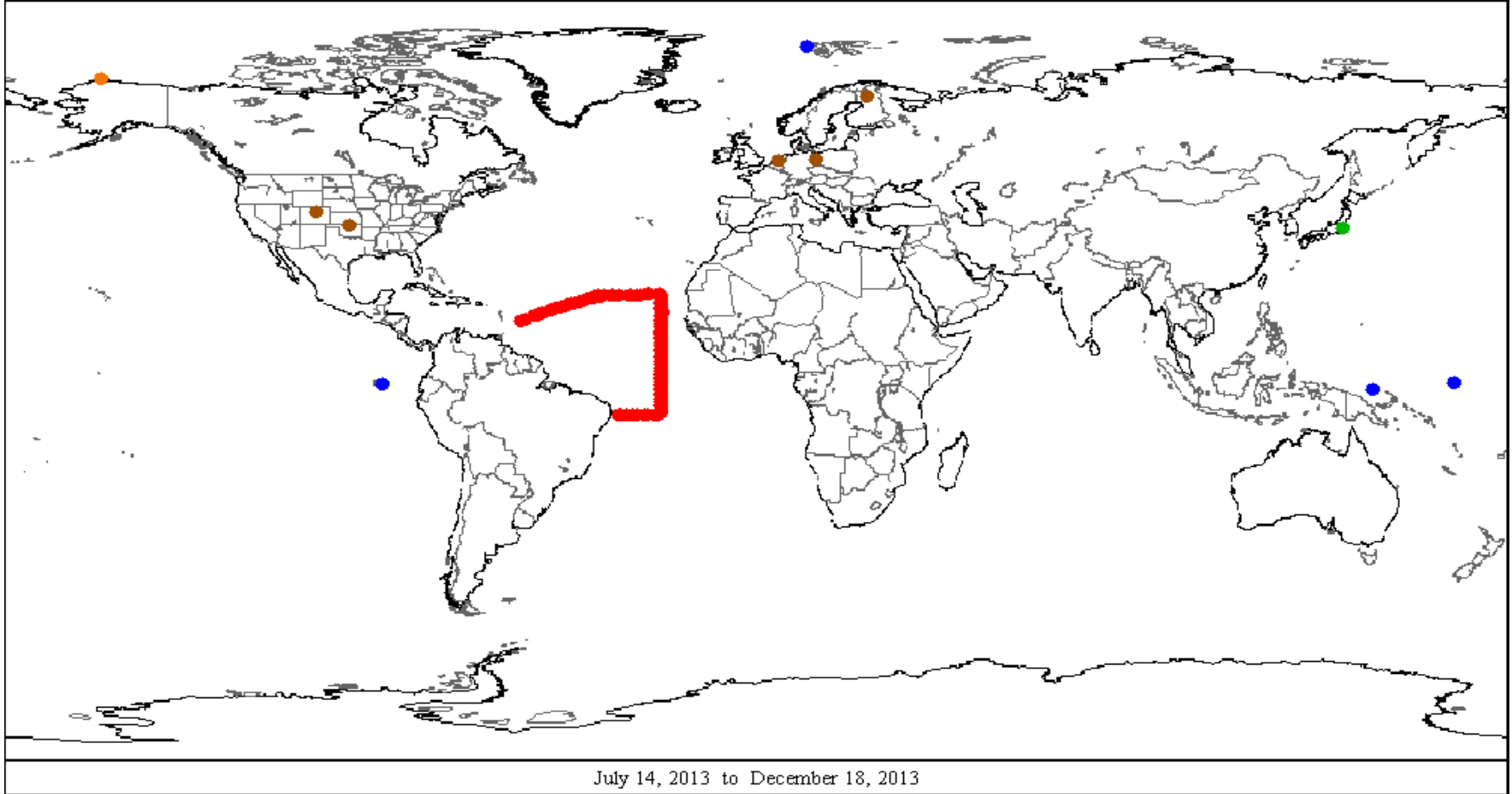
EDR Validation Results



NOAA Products Validation System (NPROVS)

2141 (12) available out of 2141

CoastLandIsland (Coast)Island (Inland)ShipDropsonde



350 Dedicated, 1790 GRUAN

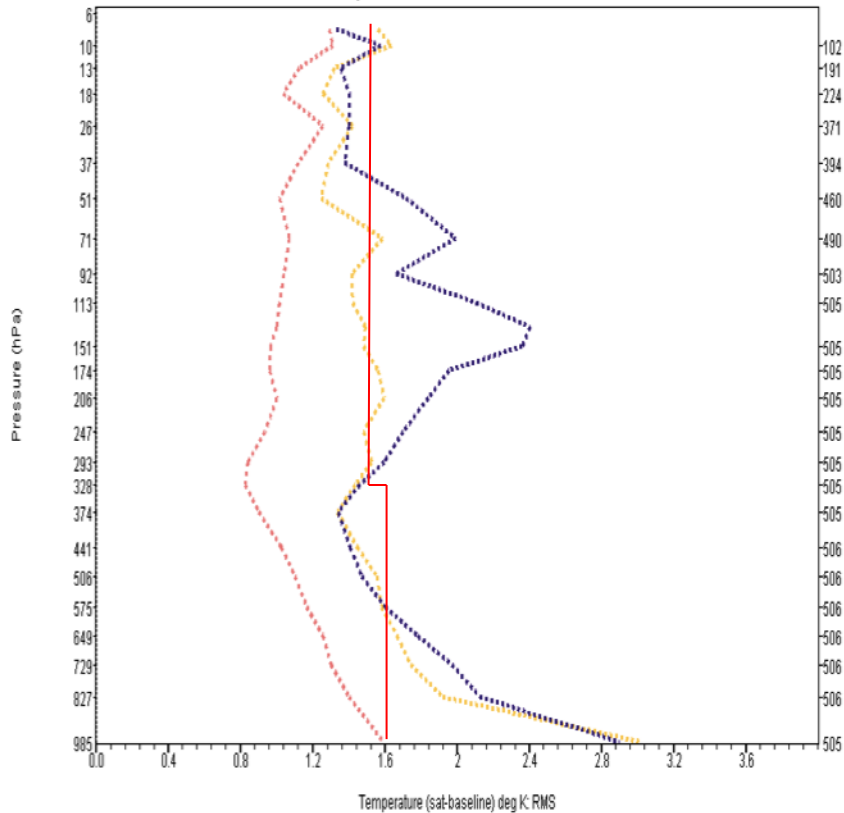


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 14, 2013 to December 18, 2013



Baseline: REFERENCE SONDE GRUAN RAOB

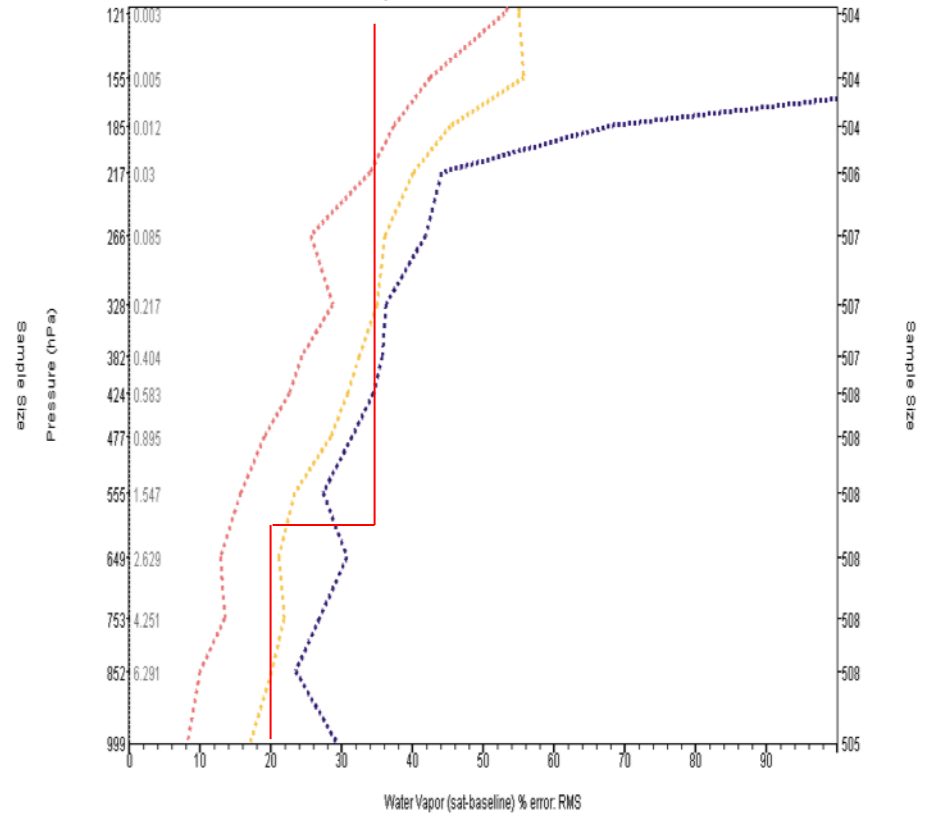
CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

NOAA Products Validation System (NPROVS)

July 14, 2013 to December 18, 2013



Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

2141: IR + MW Pass QC ... 1080 (NU), 870 (IDPS), 500 (both)

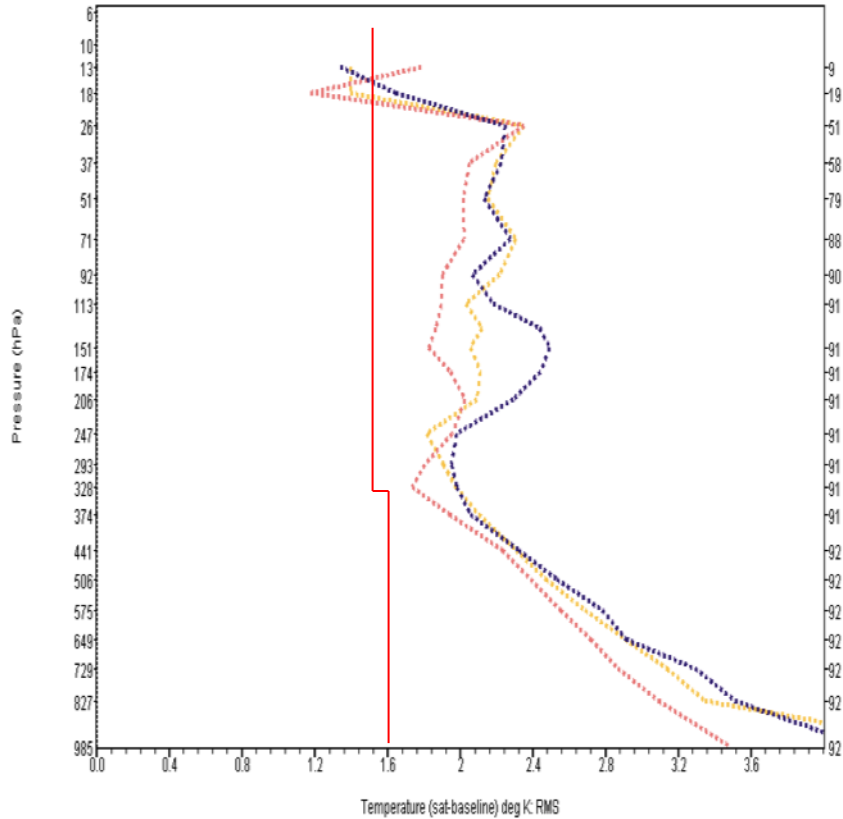


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 14, 2013 to December 18, 2013

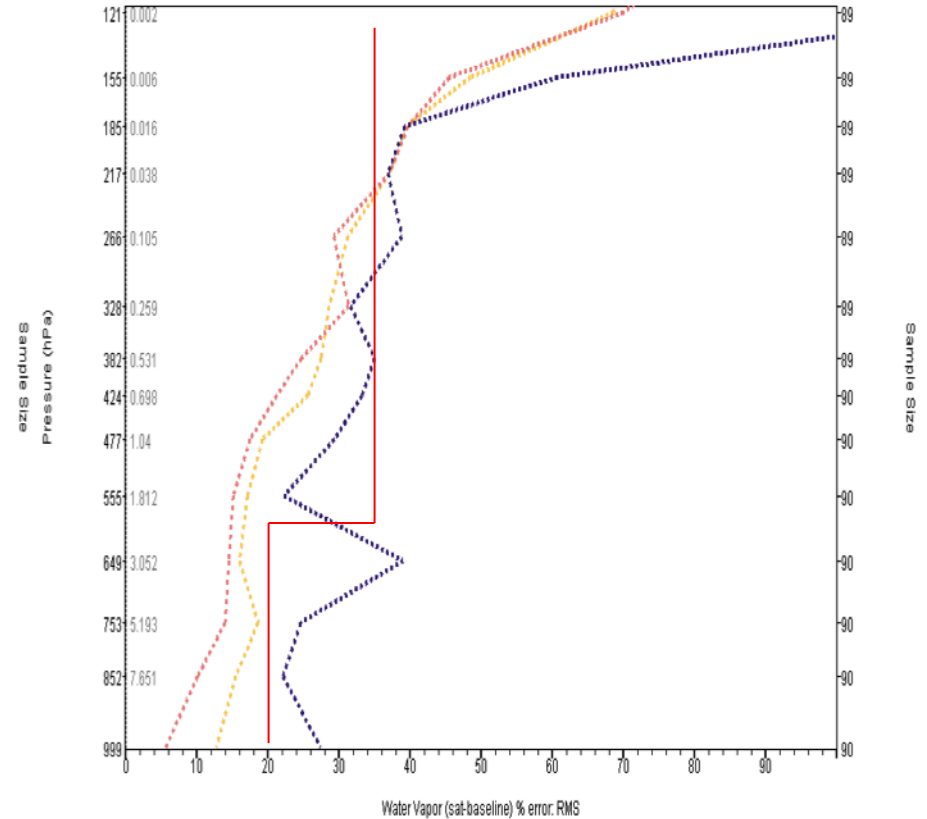


Baseline: REFERENCE SONDE GRUAN RAOB



NOAA Products Validation System (NPROVS)

July 14, 2013 to December 18, 2013



Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

CRIMSS NPP Infrared (IP)

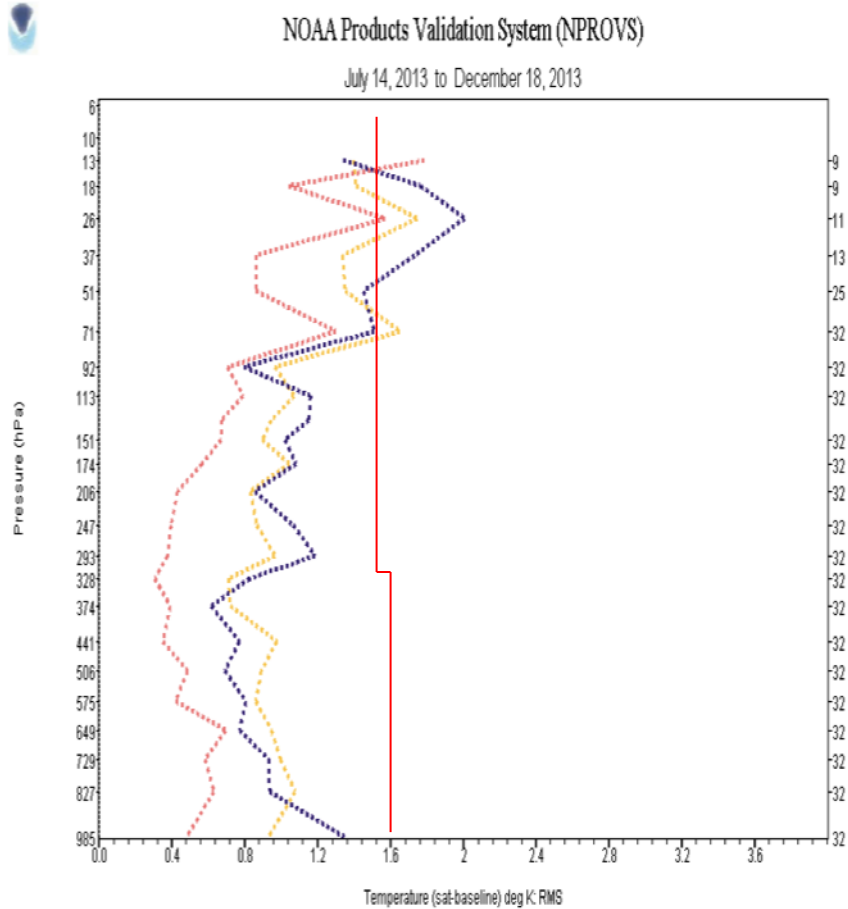
ECMWF ANALYSIS

NUCAPS NPP TEST

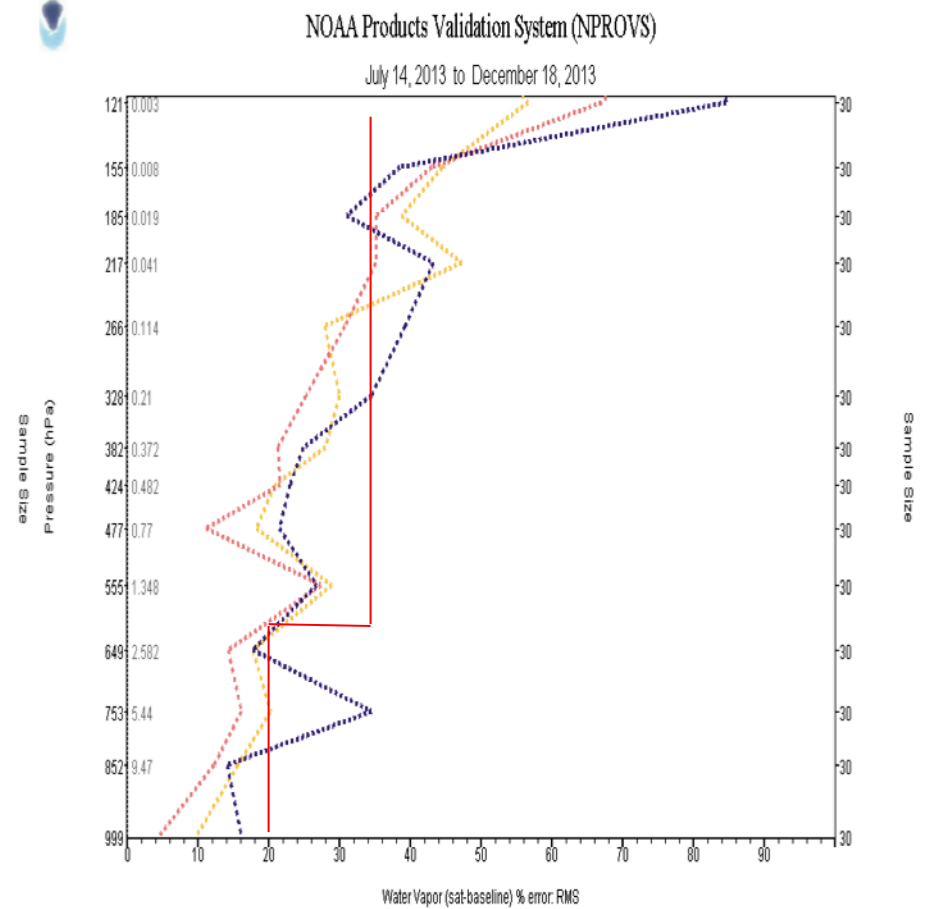
IR + MW Pass QC ... Dedicated only



EDR Validation Results



Baseline: REFERENCE SONDE GRUAN RAOB



Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

IR + MW Pass QC ... AEROSE only

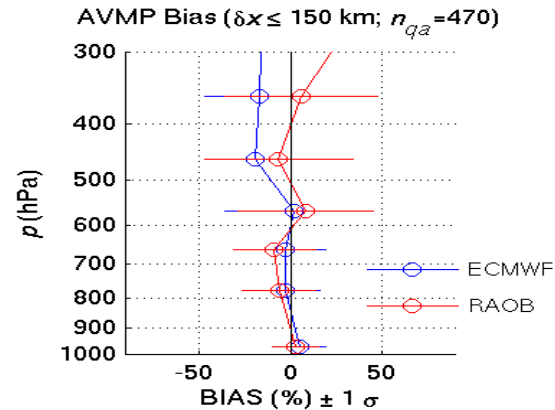
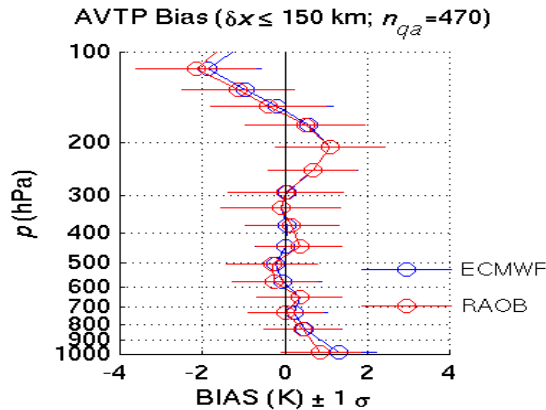
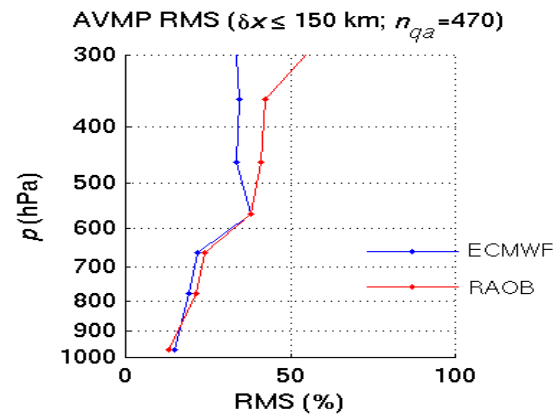
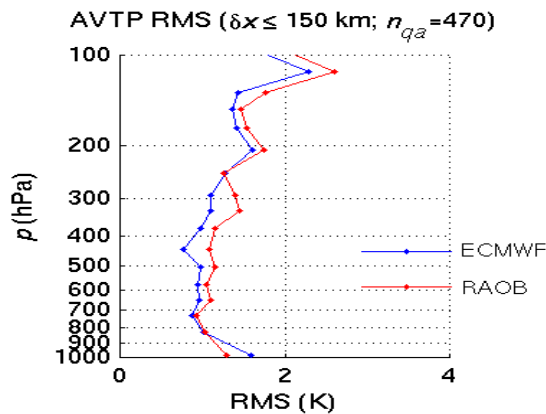


EDR Validation Results



Year 1 AEROSE/NUCAPS Phase 2 Validation Statistics

NUCAPS EDR (Year-1 AEROSE)

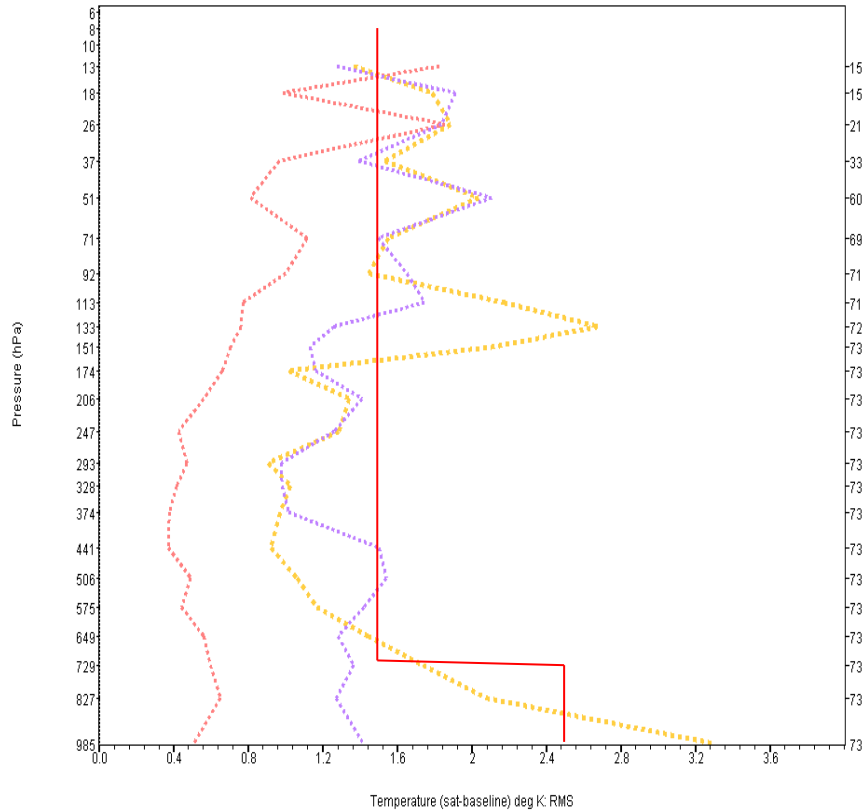




EDR Validation Results



NOAA Products Validation System (NPROVS)



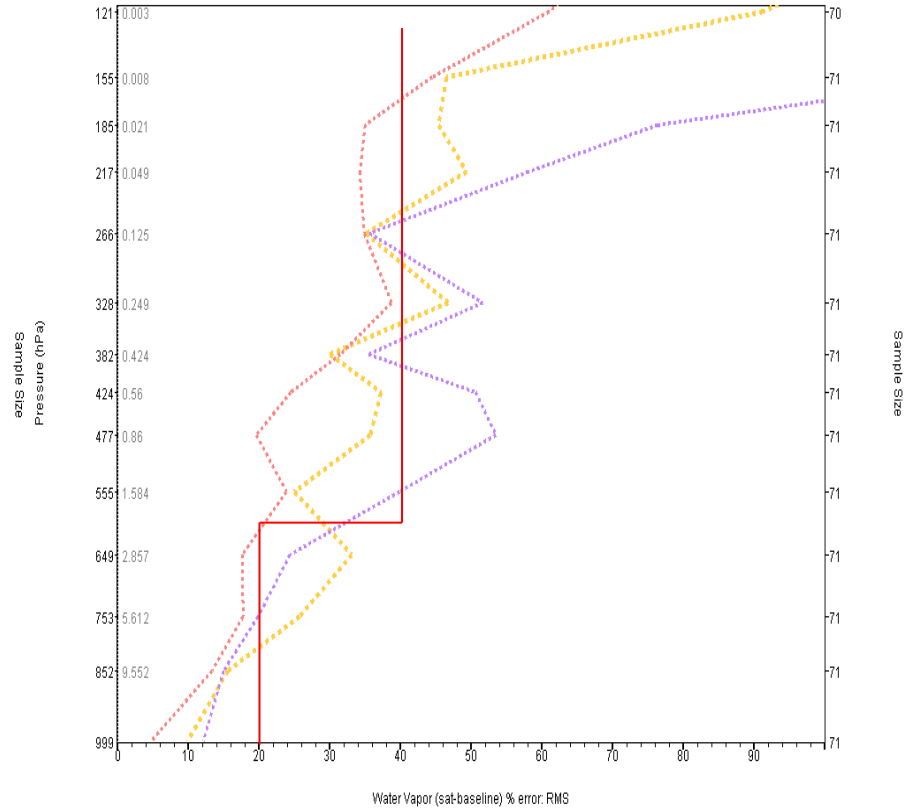
Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Microwave (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST MIT

NOAA Products Validation System (NPROVS)



Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Microwave (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST MIT

MW only Pass QC ... **AEROSE**

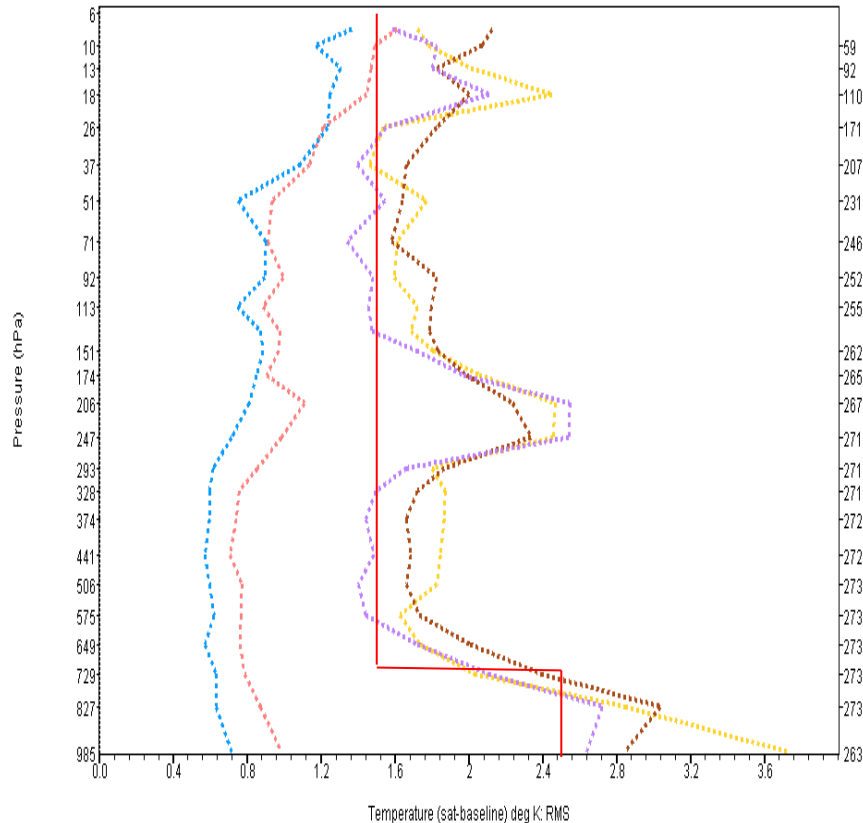


EDR Validation Results



NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



Baseline: Radiosonde Radiosonde

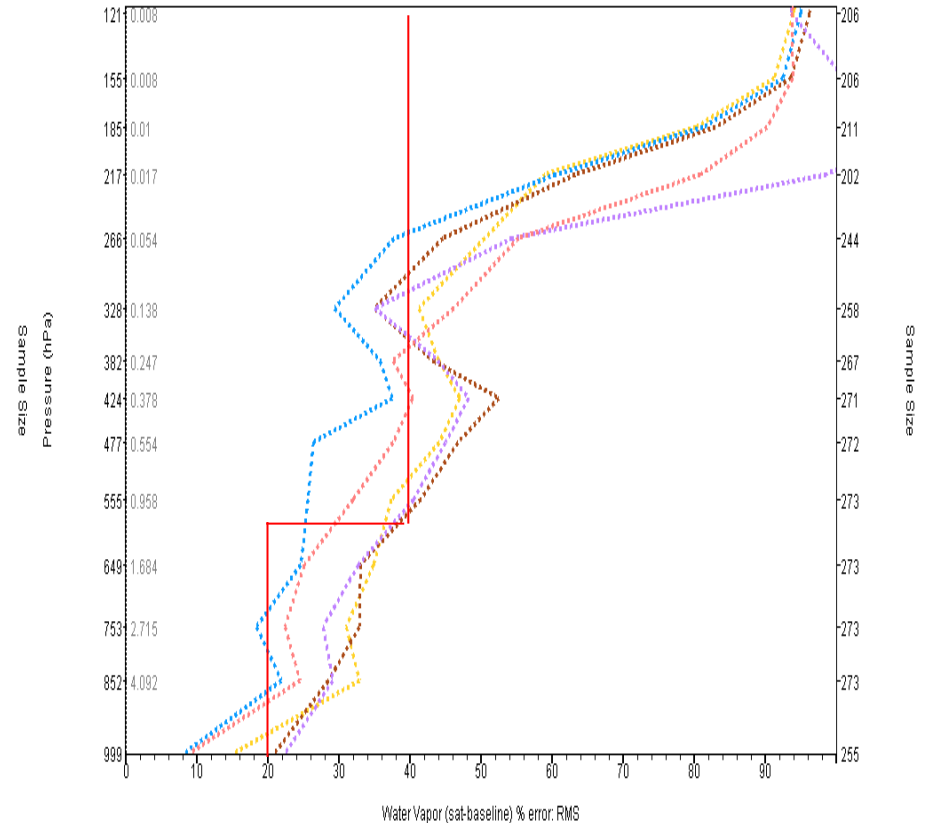
Radiosonde GFS 6 Hour
MIRS NPP

CRIMSS NPP Microwave (IP)
NUCAPS NPP MIT

ECMWF ANALYSIS

NOAA Products Validation System (NPROVS)

December 16, 2013 to December 26, 2013



Baseline: Radiosonde Radiosonde

Radiosonde GFS 6 Hour
MIRS NPP

CRIMSS NPP Microwave (IP)
NUCAPS NPP MIT

ECMWF ANALYSIS

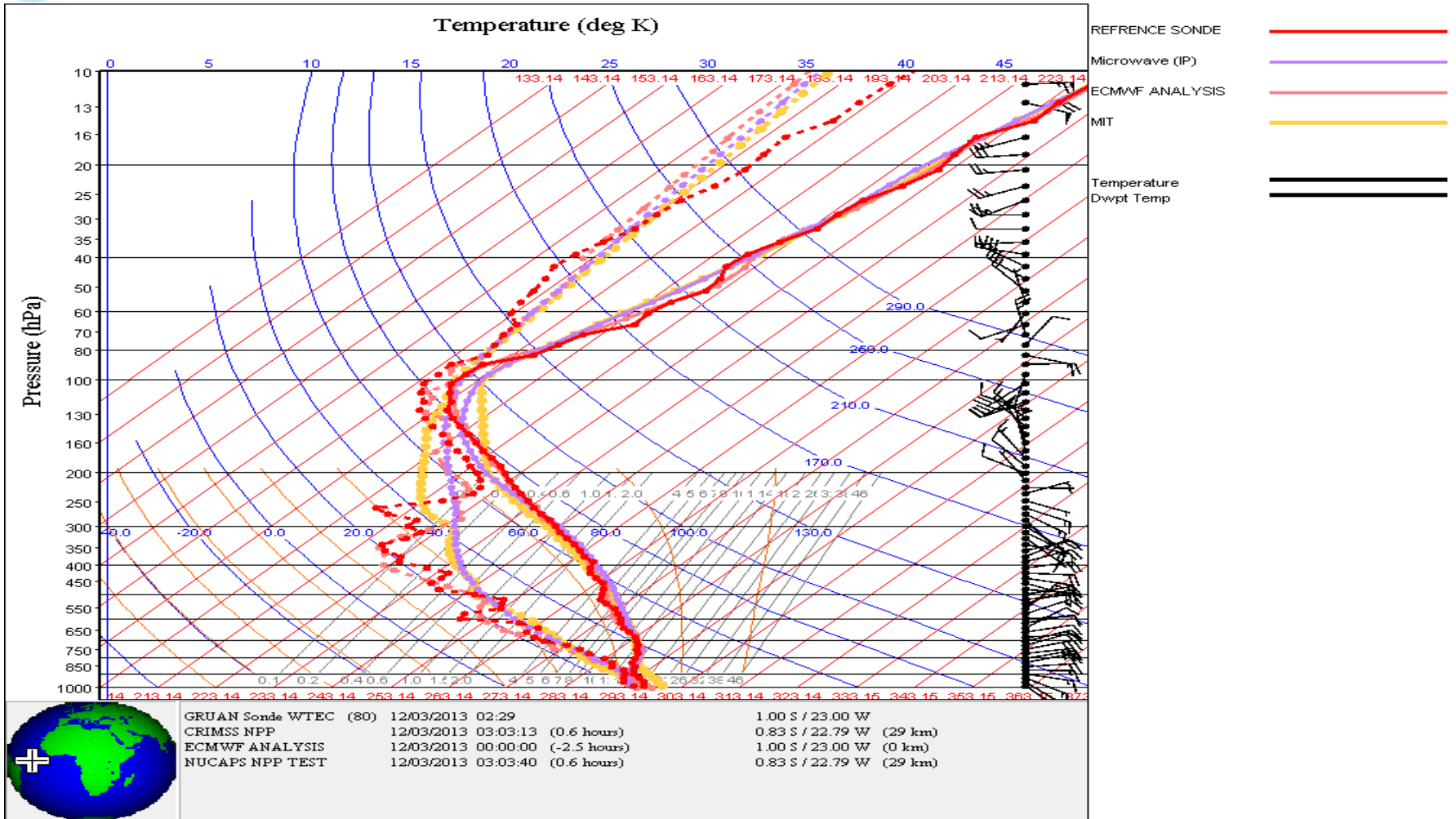
MW Only pass QC , Maritime, +/- 3 hr



EDR Validation Results



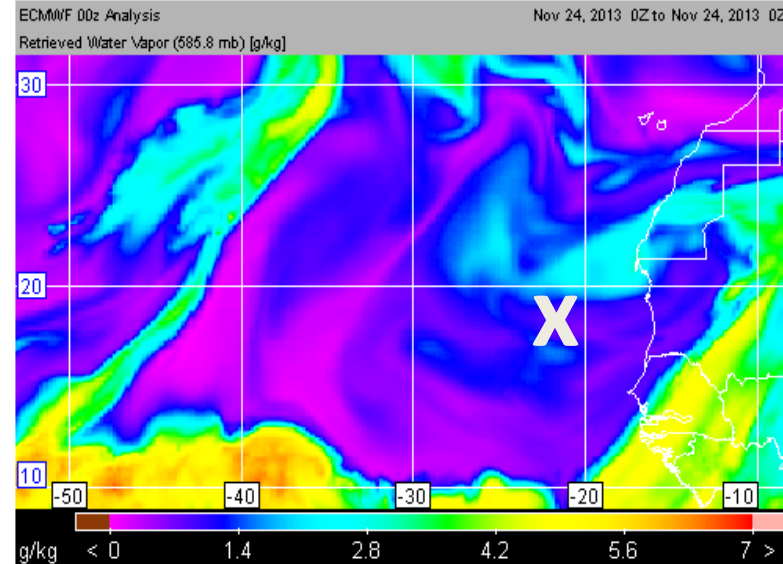
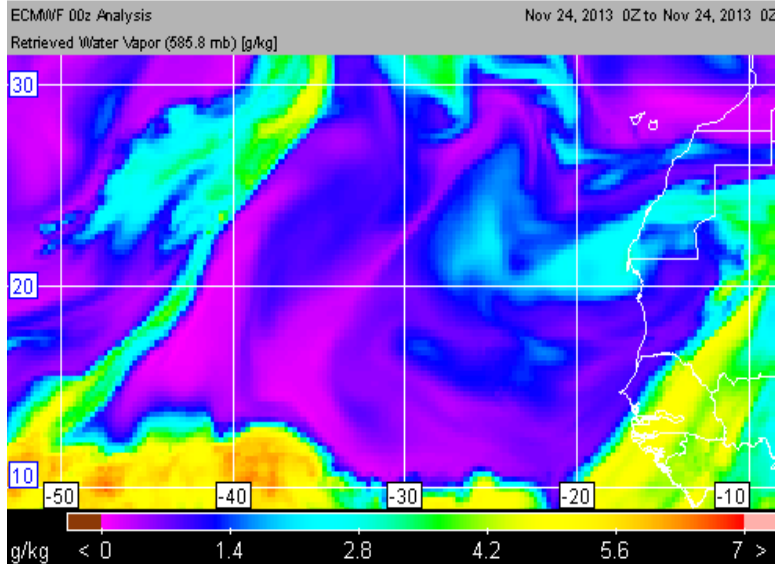
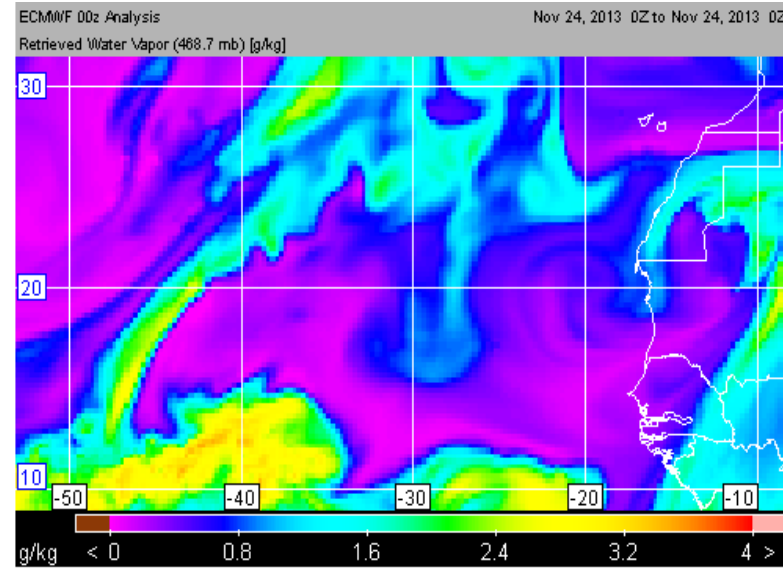
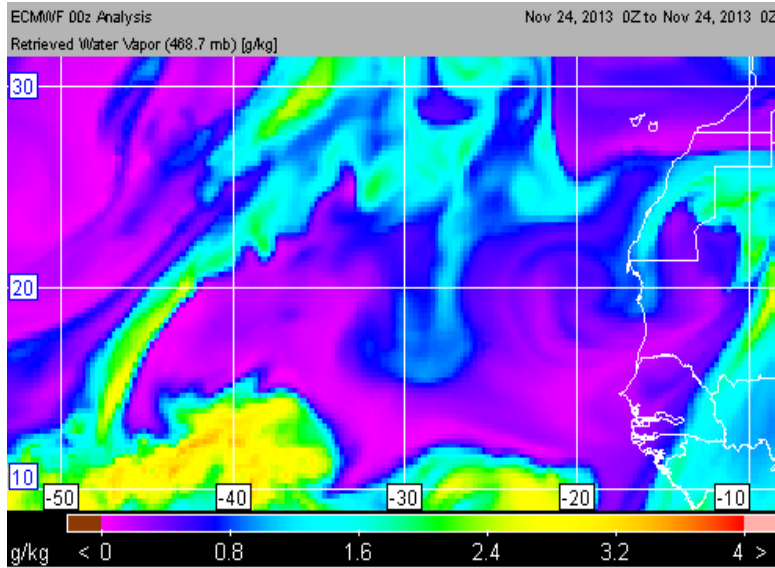
NOAA Products Validation System (NPROVS)



Outlier AEROSE MW only



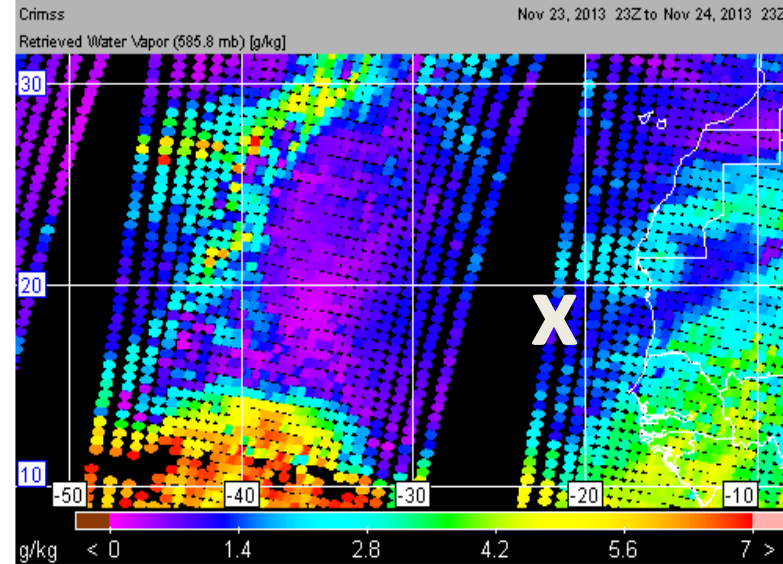
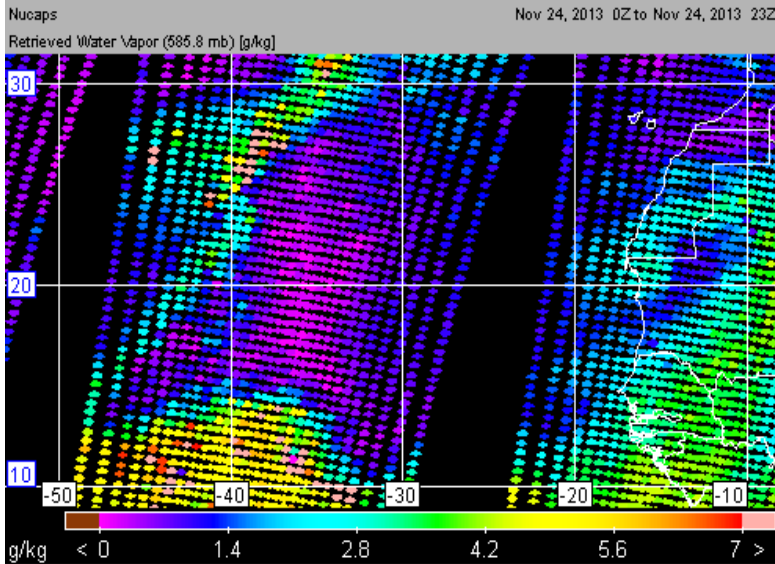
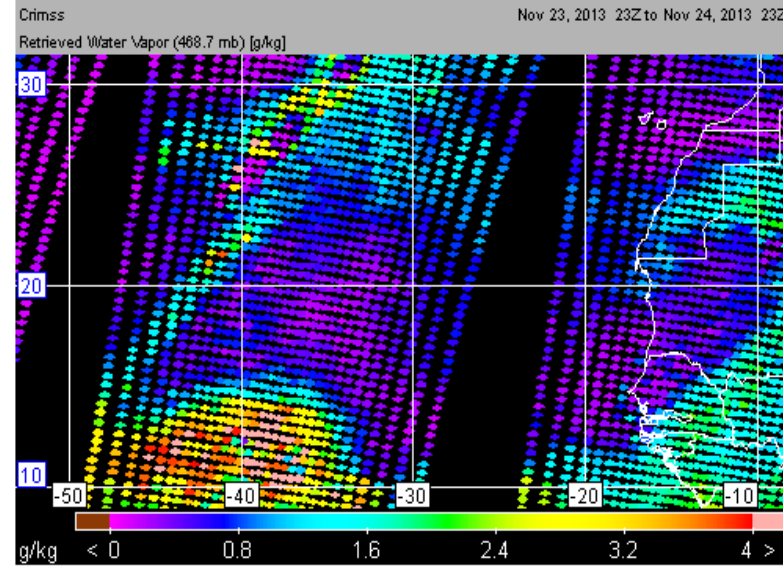
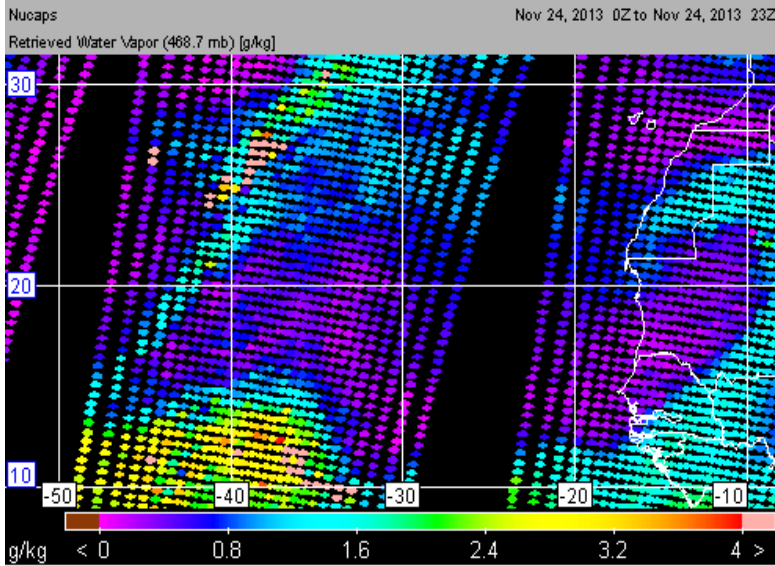
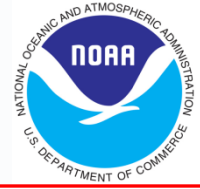
EDR Validation Results



AEROSE



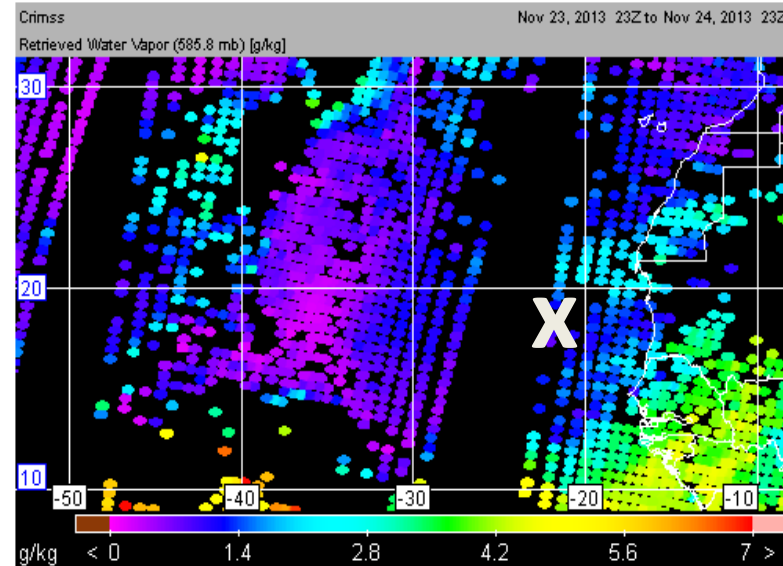
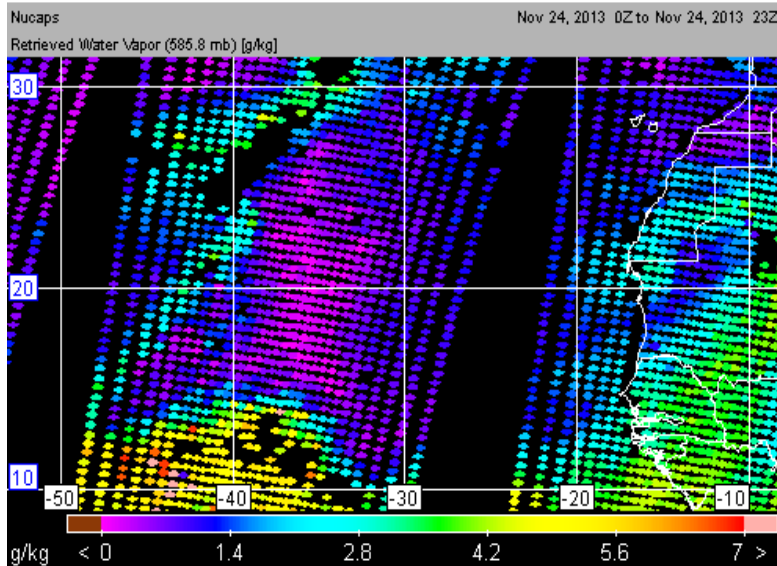
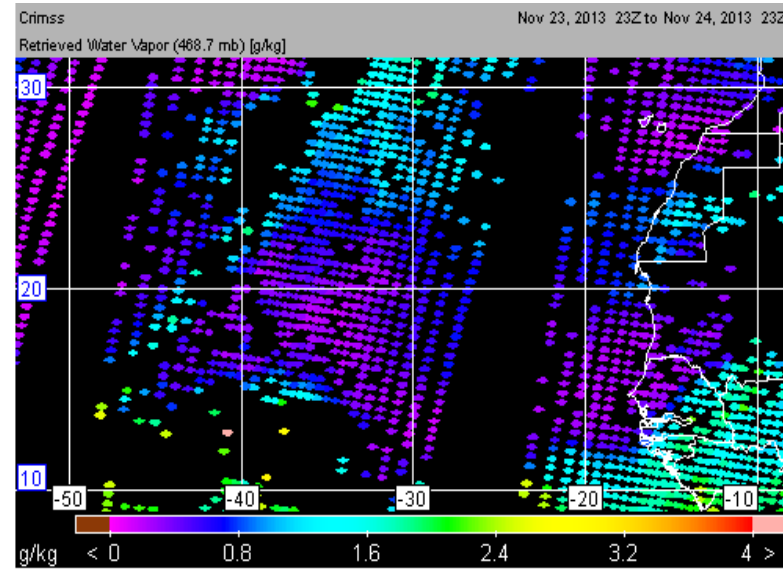
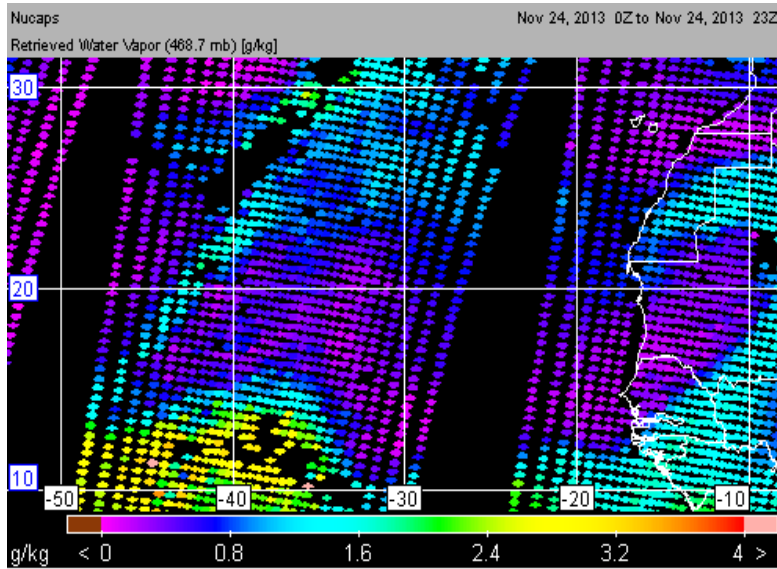
EDR Validation Results



AEROSE



EDR Validation Results



AEROSE

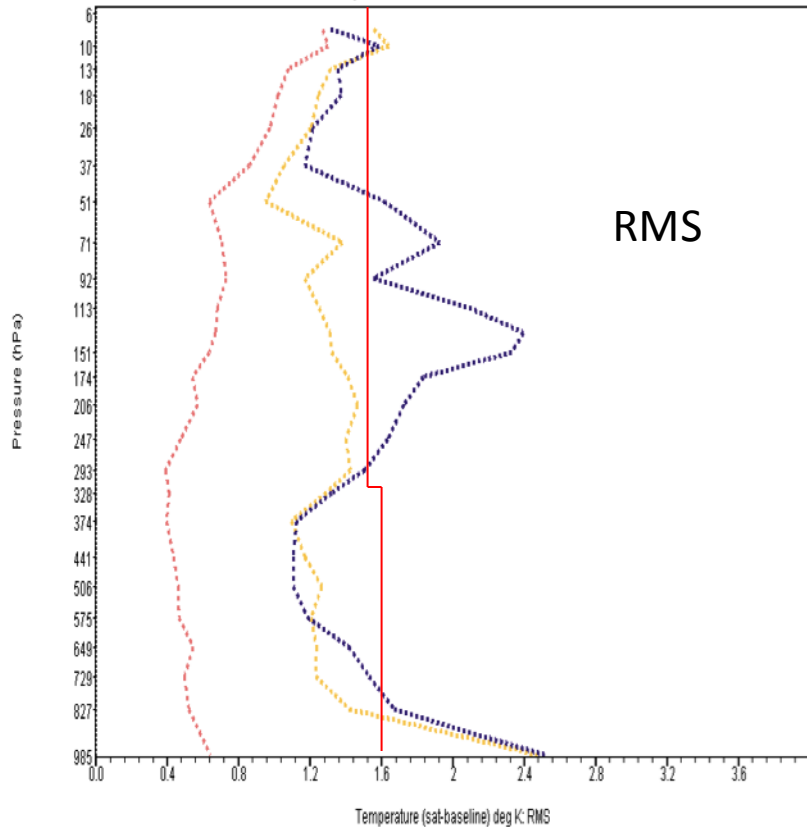


EDR Validation Results



NOAA Products Validation System (NPROVS)

July 14, 2013 to December 18, 2013



Baseline: REFERENCE SONDE GRUAN RAOB

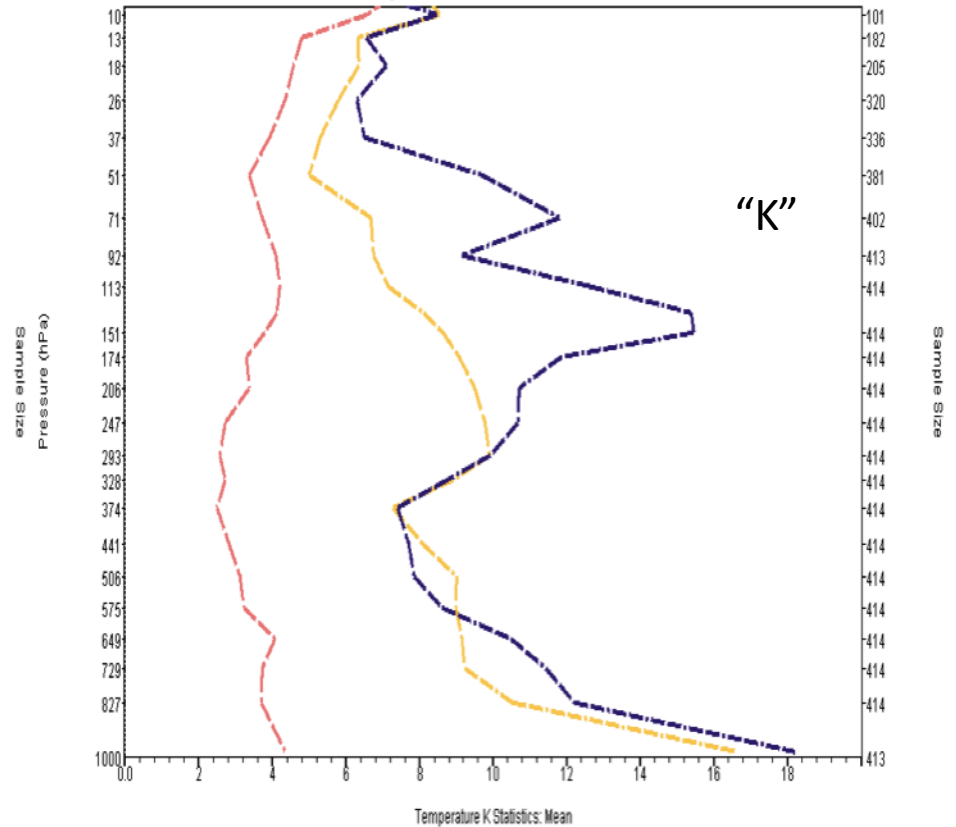
CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

NOAA Products Validation System (NPROVS)

July 14, 2013 to December 18, 2013



Baseline: REFERENCE SONDE GRUAN RAOB

CRIMSS NPP Infrared (IP)

ECMWF ANALYSIS

NUCAPS NPP TEST

GRUAN only ... Include Uncertainty Estimates ... "K" Profiles



EDR Validation Results



GRUAN Reference Measurement Principles

Consistency in a Finite Atmospheric Region

Co-location / co-incidence:

Determine the variability (σ) of a variable (m) in time and space from measurement or model

Two observations on different platforms are consistent if

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

... at this preliminary stage:

$$K = \text{ABS}(X - \text{GRUAN}) / \text{Uncertainty (u1)}$$

where “X” either SAT or NWP

“need uncertainty estimates for EDR”

COSMIC / GRAS (Stratosphere Reference from Space ...)

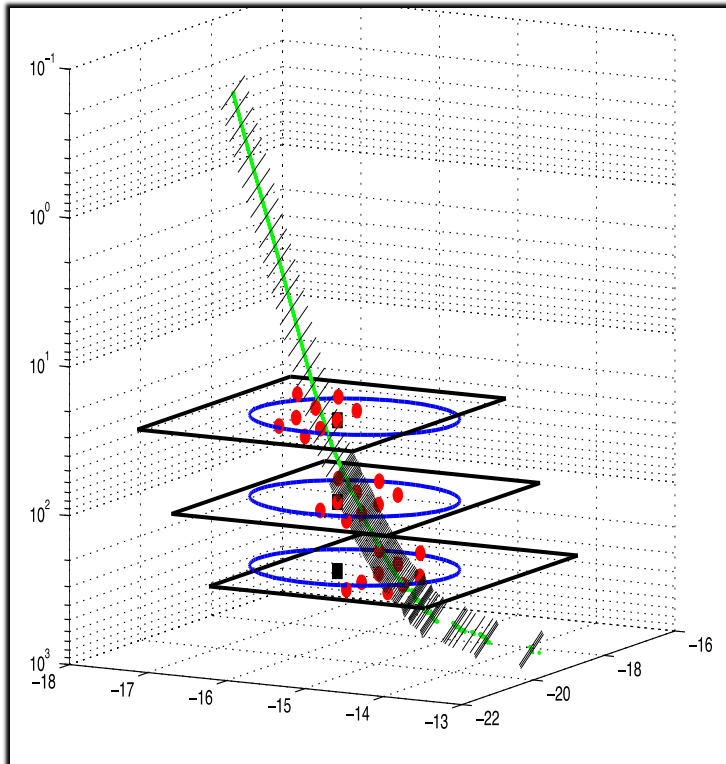
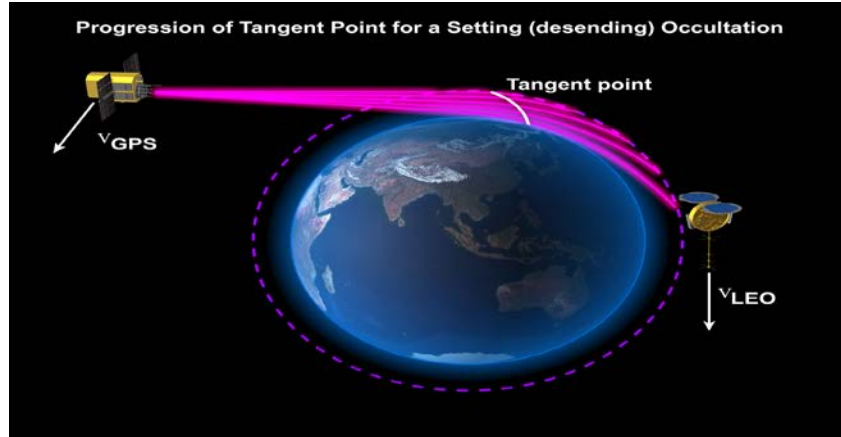
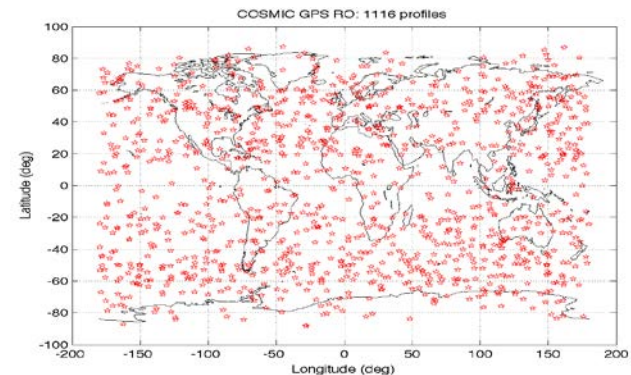


Illustration of the closest (black square), circular (blue circle), and ray path (red dots) methods for a single GPS profile (green) for the circle centered at the GPS RO level of 100 hPa



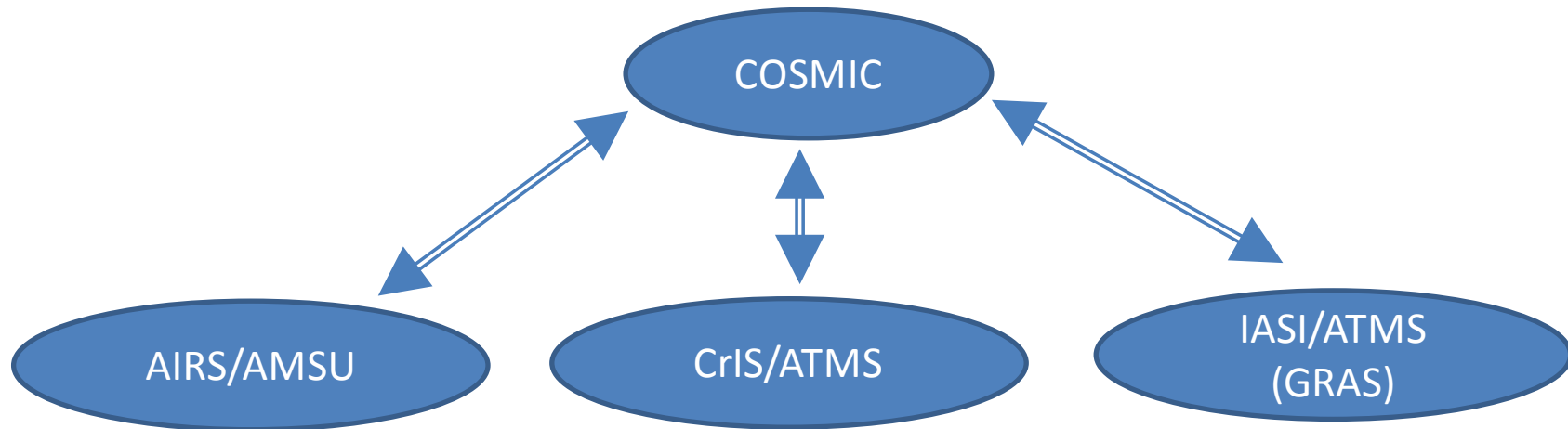
http://www.cosmic.ucar.edu/launch/GPS_RO_cartoon.jpg



One Day of COSMIC Profiles



EDR Validation Results

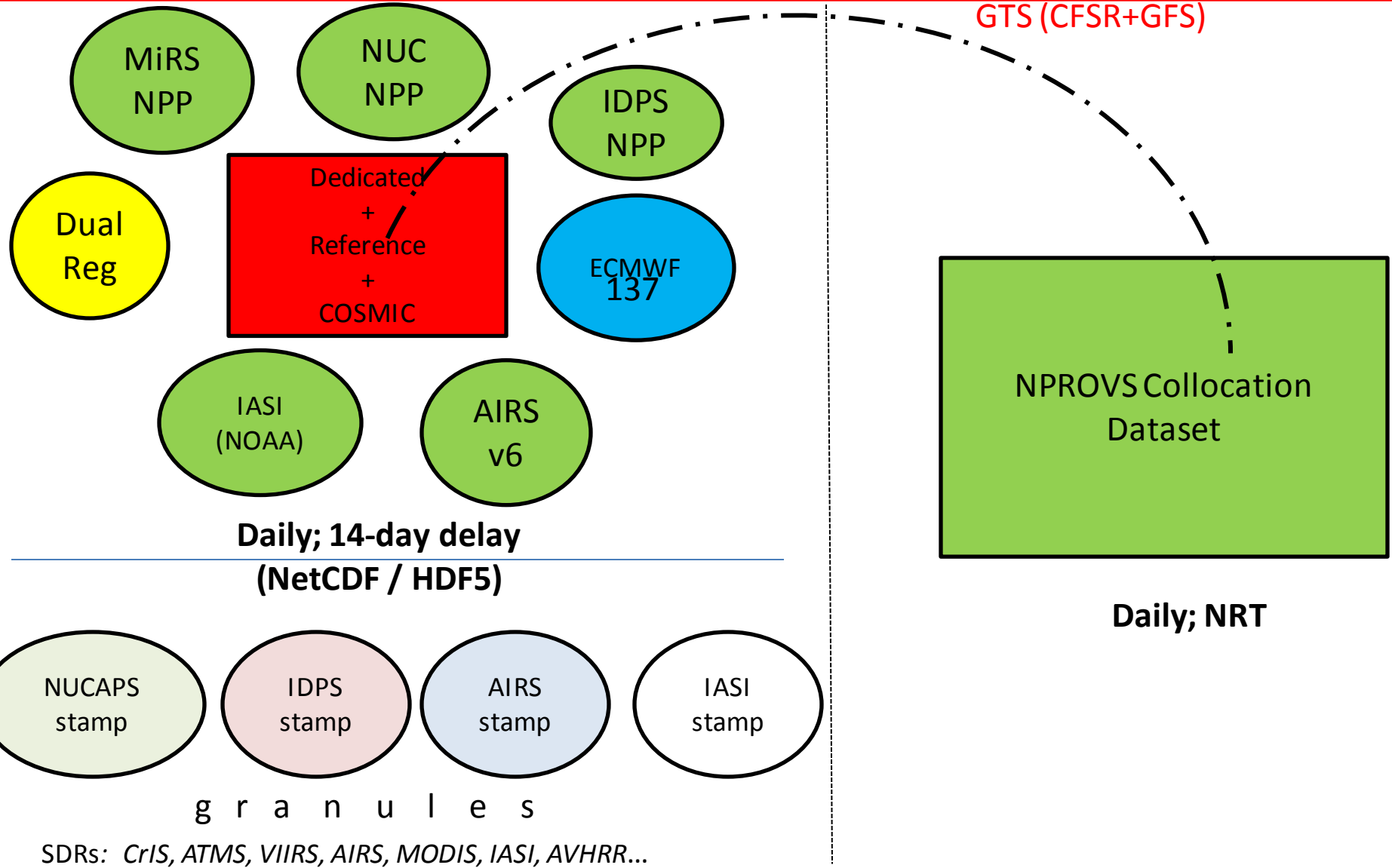


GPSRO Anchored Collocation

- Integrate STAR (Weng, Reale) and CIMSS (Knuteson / Feltz) approaches
- EDR and SDR
- GPS RO provides Reference for EDR, SDR and RTM



EDR Validation Results



... exclusive anchor to Ref / Ded RAOB and GPSRO....



EDR Validation Results



Conclusions on EDR Validation

- Final alignments of NARCS / PDISP wrt product qc flag, sensor combination ...
- NUCAPS IR + MW generally better IDPS v7.1; IDPS MW only better in low troposphere for T and about same for H2O
- Land: Below 700hPa, T and H2O not meeting spec (both); moisture less erratic. Above 700hPa, NUCAPS T and H2O meet spec for IR+MW but not for MW only ... 87-90, 94
- Maritime: NUCAPS IR+MW T and H2O meet spec (87c, 88c, 96); close for H2O. MW only T and H2O close to spec (Yes - AEROSE, No - maritime)
- Indications of seasonal bias in NUCAPS Temp (IR+MW)...
- Yield Concerns: Too many IR+MW land (?) and QC failures over sea (mid-Lat) ...
- Overall, NUCAPS satisfies Stage 1 (Stage 2) validation requirements



SUMMARY



- Project Goals and staffing discussed
- Integration and Unification of routine product and algorithm development validation strategies
- NPROVS and NPROVS+
- Seasonal (year) and short term (10-day) validation results presented for NUCAPS vs CrIMSS (v7.1)
- NUCAPS meets requirements for Stage 1 validation; problem areas identified



PATH FORWARD



- Project Lead
- CrIMSS to NUCAPS transition
- Stage 2 (3) Validation in July
- Compatible (AIRS - IASI- CrIS) /ATMS algorithms
- Entice Users ... EDR uncertainty estimates, *"K" profile statistics*
- NPROVS (RAOB / COSMIC) collocations basis for revising GFS RAOB Radiation Correction (RADCOR) (Sun, Ballish, Collard, Seidel ...)
- COSMIC anchored Satellite EDR/SDR collocations (Knuteson, Weng, Xiong, Sun ...)
- Sustained validation against Ref and Ded RAOB (NPROVS+) ...
- Publish / Survive !



Publications



Peer Review

Sun, B., A. Reale, S. Schrieder, D.J. Seidel, and B. Ballish: "Toward improved corrections for radiation-induced biases in radiosonde temperature observations". *Journal of Geophysical Research*, VOL. 118, 1–13, doi:10.1002/jgrd.50369, 2013.

Divakarla, M., C. Barnett, X. Liu, D. Gu, M. Wilson, S. Kizer, X. Xiong, E. Maddy, R. Ferraro, R. Knuteson, D. Hagan, X. Ma, C. Tan, N. Nalli, A. Reale, A. Mollner, W. Yang, A. Gambacorta, M. Feltz, F. Iturbide-Sanchez, B. Sun, and M. Goldberg, 2013 The CrIMSS EDR Algorithm: Characterization, optimization and validation, Accepted for publication in the JGR, Special issue.

Nicholas R. Nalli^{1,2,*}, Christopher D. Barnett³, Anthony Reale⁴, David Tobin⁵, Antonia Gambacorta^{1,2}, Eric S. Maddy^{2,3}, Everette Joseph⁶, Bomin Sun^{1,4}, Lori Borg⁵, Andrew K. Mollner⁷, Vernon R. Morris⁶, Xu Liu⁸, Murty Divakarla^{1,2}, Peter J. Minnett⁹, Robert O. Knuteson⁵, Thomas S. King^{1,2}, Walter W. Wolf² **Validation of satellite sounder environmental data records: Application to the Cross-track Infrared Microwave Sounder Suite** Article first published online: 26 DEC 2013 DOI: 10.1002/2013JD020436

Wang J., T. Hock, S.A. Cohn, C. Martin, N. Potts, A. Reale, B. Sun, and F. Tilley: "Unprecedented upper-air dropsonde observations over Antarctica from the 2010 Concordiasi Experiment: Validation of satellite-derived temperature profiles". *Geophysical Research Letters*, VOL. 40, 1–6, doi:10.1002/grl.50246, 2013.



Publications



Conference

Hagan, D., D. Gu, X. L. Ma, C. D. Barnet, and M. G. Divakarla, (2013), CrIMSS Single FOV EDR Retrieval, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Hagan, D., D. Gu, X. L. Ma, C. D. Barnet, and M. G. Divakarla, (2013), Calibration and Validation of the S-NPP Sensor Data Records and Environmental Data Records, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Wilson, M., C. D. Barnet, M. G. Divakarla, C. Tan, X. Xiong, X. Liu, S. Kizer, D. Gu, N. R. Nalli, A. Gambacorta, and E. Maddy, 2013, A Global Perspective of the Current and Future CrIMSS EDR Algorithm, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Tan, C., A. Gambacorta, M. G. Divakarla, S. Kizer, E. Maddy, G. Guo, M. Wilson, X. Xiong, X. Liu, and C. D. Barnet, (2013), On Empirical Bias Corrections of NPP CrIMSS OSS Forward Model, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Kizer, S., X. Liu, C. D. Barnet, M. G. Divakarla, D. Gu, X. L. Ma, D. K. Zhou, A. M. Larar, X. Xiong, G. Guo, A. Gambacorta, M. Wilson, (2013), Suomi NPP CrIMSS EDR Algorithms: Porting and Validation, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Liu, X., S. Kizer, C. D. Barnet, M. G. Divakarla, N. R. Nalli, D. Gu, D. K. Zhou, A. M. Larar, X. Xiong, A. Gambacorta, M. Wilson, W. J. Blackwell, (2013), NPP/JPSS CrIMSS EDR Algorithm Validation and Tuning, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Divakarla, M., and C. D. Barnet, X. Liu, S. Kizer, E. Maddy, C. Tan, and M. Wilson, (2013), Evaluation of CrIS/ATMS Proxy Data Generation Algorithms with Observed Radiances and Retrieval, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.

Divakarla, M., C. D. Barnet, M. Wilson, X. Xiong, C. Tan, E. Maddy, D. Gu, X. Liu, S. Kizer, A. Gambacorta, N. Nalli, X. Ma, D. Hagan, and M. Goldberg, (2013), Provisional Maturity Assessment of Cross Track Infrared Sounder (CrIS) Temperature and Moisture Profile Products, 93rd American Meteorological Society Annual Meeting, Ninth Annual Symposium on Future Operational Environmental Satellite Systems, 6-10 January, 2013, Austin, TX 78701.



Publications



Conference

Divakarla, M., Chris Barnet, Xu Liu, Degui Gu, Mike Wilson, Susan Kizer, Xiaozhen Xiong, Eric Maddy, Ralph Ferraro, Robert Knuteson, Denise Hagan, Xia-lin Ma, Changyi Tan, Nick Nalli, Andrew Mollner, Wenzhe Yang, Michelle Feltz, Antonia Gambacorta, Flavio Iturbide-Sanchez, Tony Reale, Bomin Sun, and Mitch Goldberg, (2013), The CrIMSS EDR Algorithm: Provisional Maturity and Beyond, presentation made for the Sounder Science Team Meeting, NASA, JPL, May 21.

Divakarla, M., Chris Barnet, Mike Wilson, Xu Liu, Degui Gu, Tony Reale, Nick Nalli, Xiaozhen Xiong, Changyi Tan, Eric Maddy, Susan Kizer, Xia Ma, Denise Hagan, Andrew Mollner, Antonia Gambacorta, Flavio Iturbide-Sanchez, Bomin Sun, and Mitch Goldberg, (2012), The CrIMSS EDR Algorithm: Optimization and Validation with In-situ Measurements, Model Analysis Fields, and Retrieval Products from Heritage Algorithms, International Geo-Science and Remote Sensing Symposium, IGARSS, July 21-27, Melbourne, Australia.

Planned

Divakarla, M., et al., (2014), Validation of CrIMSS AVTP and AVMP Retrievals with PMRF RAOBs, ECMWF Analysis Fields, and the Retrieval Products from Heritage Algorithms” abstract accepted for presentation in the Tenth Annual Symposium on New Generation Operational Environmental Satellite Systems,AMS 94th Annual Meeting, 2-6 February 2014 in Atlanta, GA.

Divakarla, M., et al., (2014) et al., The CrIMSS EDR Algorithm Assessment: Provisional Maturity and Beyond, abstract accepted for presentation in the Tenth Annual Symposium on New Generation Operational Environmental Satellite Systems,AMS 94th Annual Meeting, 2-6 February 2014 in Atlanta, GA.

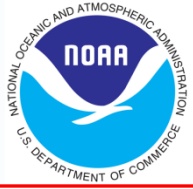
Andrew K. Mollner, John E Wessel, Kevin M Gaab, David M Cardoza, Stephen D LaLumondiere, Petras Karuza, William T Lotshaw, Nicholas R. Nalli, Anthony Reale, Antonia Gambacorta, Murty Divakarla, Christopher D. Barnet, Eric S. Maddy, Changyi Tan, Xiaozhen Xiong, Orson Porter, Mid-Pacific Ground-Truth Data for Validation of the CrIMSS Sensor Suite Aboard Suomi-NPP, abstract accepted for AGU, December 2013.

Nalli, N., C. D. Barnet, T. Reale, [A. Gambacorta](#), E. Maddy, B. Sun, E. Joseph, [L. A. Borg](#), A. Mollner, M. Divakarla, X. Liu, R. O. Knuteson, T. King, and W. Wolf, (2013), Validation Methods for Infrared Sounder Environmental Data Records: Application to Suomi NPP, abstract accepted for presentation in the Tenth Annual Symposium on New Generation Operational Environmental Satellite Systems,AMS 94th Annual Meeting, 2-6 February 2014 in Atlanta, GA.

Maddy, E.C., M. Divakarla, [N. R. Nalli](#), C. D. Barnet, T. Reale, [A. Gambacorta](#), and D. M. Goldberg, (2014) Using S-NPP Cal/Val datasets for Aqua/AIRS-V6 and future AIRS/MODIS/AMSU, algorithm development, improvement, and validation, abstract accepted for presentation in the Tenth Annual Symposium on New Generation Operational Environmental Satellite Systems,AMS 94th Annual Meeting, 2-6 February 2014 in Atlanta, GA.



Publications



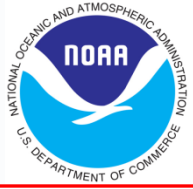
Planned

Sun, Bomin, A. Reale, M. Pettey, F. Tilley, C. Brown, N. Nalli, [A. Gambacorta](#), and M. G. Divakarla, (2013), Using NPROVS for Evaluation of Suomi NPP Atmospheric Sounding Retrievals against Conventional Radiosonde Observations, abstract accepted for presentation in the Tenth Annual Symposium on New Generation Operational Environmental Satellite Systems, AMS 94th Annual Meeting, 2-6 February 2014 in Atlanta, GA.

Wenze Yang, F. Iturbide-Sanchez, R. R. Ferraro, M. Divakarla, and T. Reale, (2014), Evaluation and Improvement of the S-NPP CrIMSS Rain Flag, abstract accepted for presentation in the Tenth Annual Symposium on New Generation Operational Environmental Satellite Systems, AMS 94th Annual Meeting, 2-6 February 2014 in Atlanta, GA.



Publications



CIMMS Group (SSEC, Madison)

Feltz, M. L., R. O. Knuteson, D. C. Tobin, and H. E. Revercomb, A Methodology for the Validation of Temperature Profiles from Hyperspectral Infrared Sounders Using GPS Radio Occultation: Experience with AIRS and COSMIC, *Journal of Geophysical Research: Atmospheres* (2014), accepted.

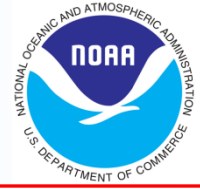
Feltz, M., R. Knuteson and Coauthors, Application of GPS Radio Occultation to the Assessment of Temperature Profile Retrievals from Microwave and Infrared Sounders , *Atmos. Meas. Tech.* special issue, in preparation (2014).

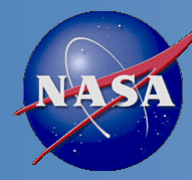
Another graduate student (Jacola Roman) has three publications on water vapor that have been partially supported by this EDR Cal/Val effort. Here are her citations:

Roman, J.A. et al. 2014: Time-To-Detect Trends in Precipitable Water Vapor with Varying Measurement Error. *J.Climate* (submitted)

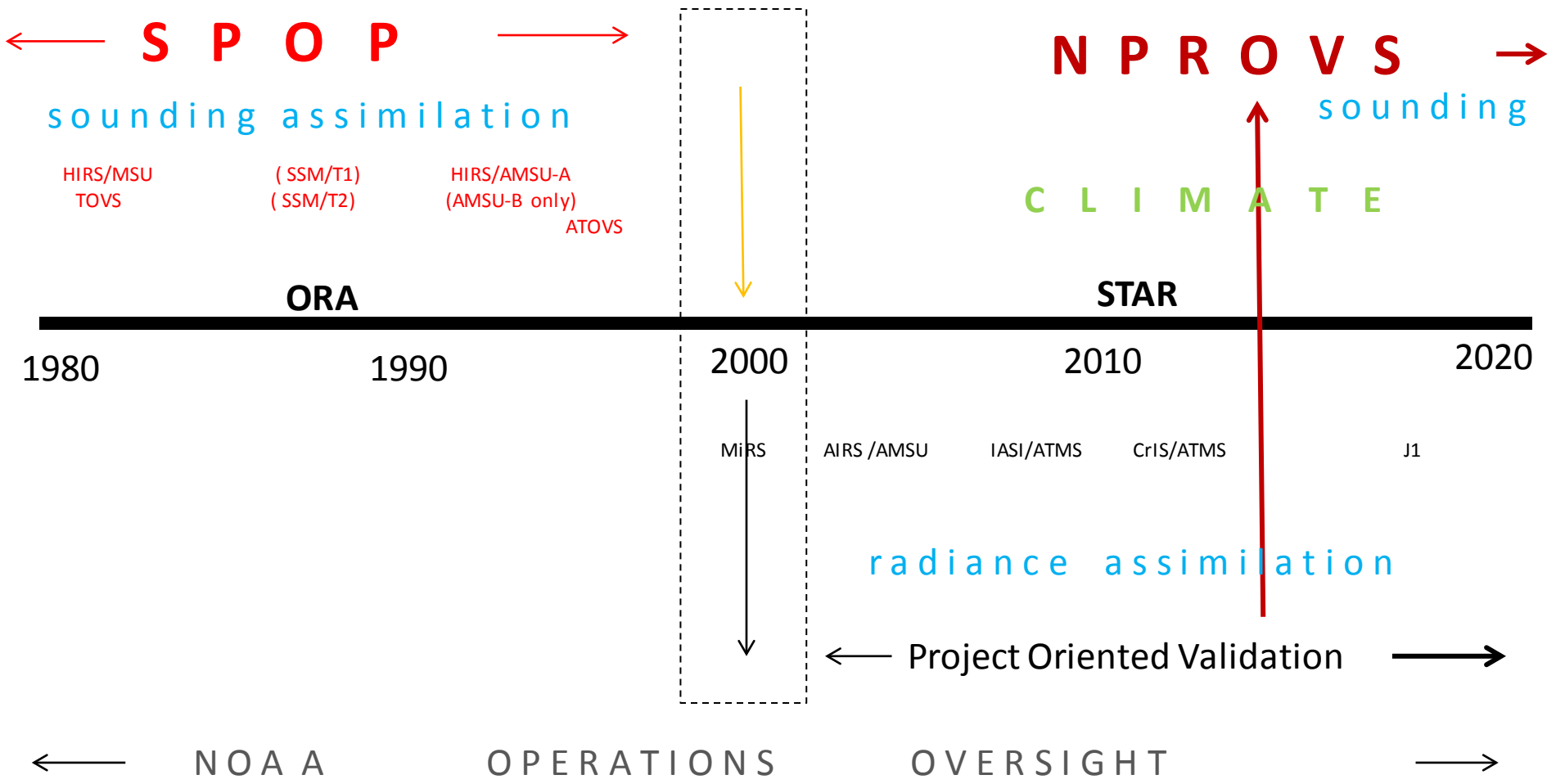
Roman, J.A. et al. 2013: Using AIRS to Assess the Precipitable Water Vapor in Global Climate Models (GCMs) with Regional Validation from SuomiNet. *AIP Conf. Proc.*, 1531, 480. doi: <http://dx.doi.org/10.1063/1.4804811>

Roman, J. A et al. 2012: Assessment of Regional Global Climate Model Water Vapor Bias and Trends Using Precipitable Water Vapor (PWV) Observations from a Network of Global Positioning Satellite (GPS) Receivers in the U.S. Great Plains and Midwest. *J.Climate*, 25, 5471–5493. doi: <http://dx.doi.org/10.1175/JCLI-D-11-00570.1>





Brief History NOAA Program for Soundings



Restore Project Independent **NOAA PROduct OVerSight**



Discussion on AVMP statistic definition (5/7)

A detailed look at 550 mbar region



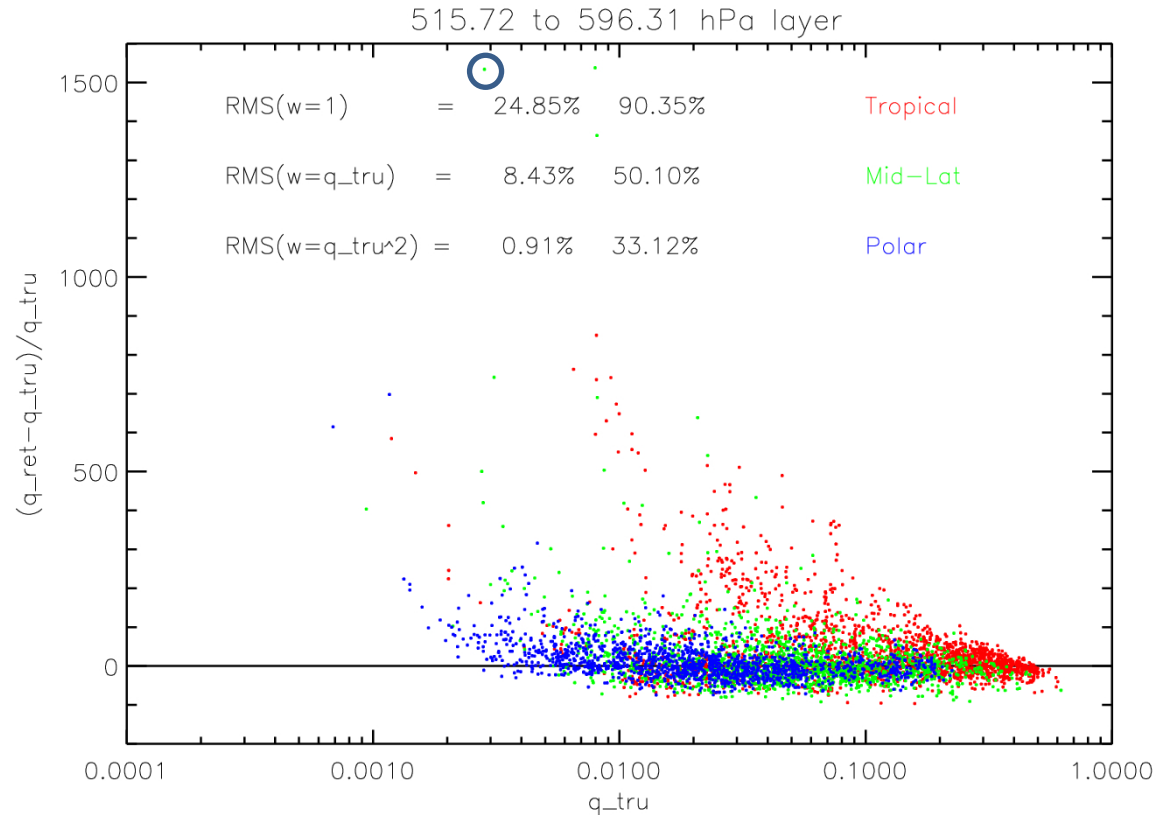
Below is a scatter plot of (g vs q_tru) the individual retrievals for the 515-600 hPa layer. The three colors show cases for tropical (red), mid-latitude (green), and polar (blue).

Also shown is the %bias and %rms statistic for the 3 weighting schemes for the global ensemble.

Circled point will be looked in the next slide

Note that in each latitude band (red, green, blue) there are large outliers, but these outliers and the overall error tends to increase for small q_tru in this layer.

Also, there are more positive outliers (wet retrieval) than there are negative outliers.



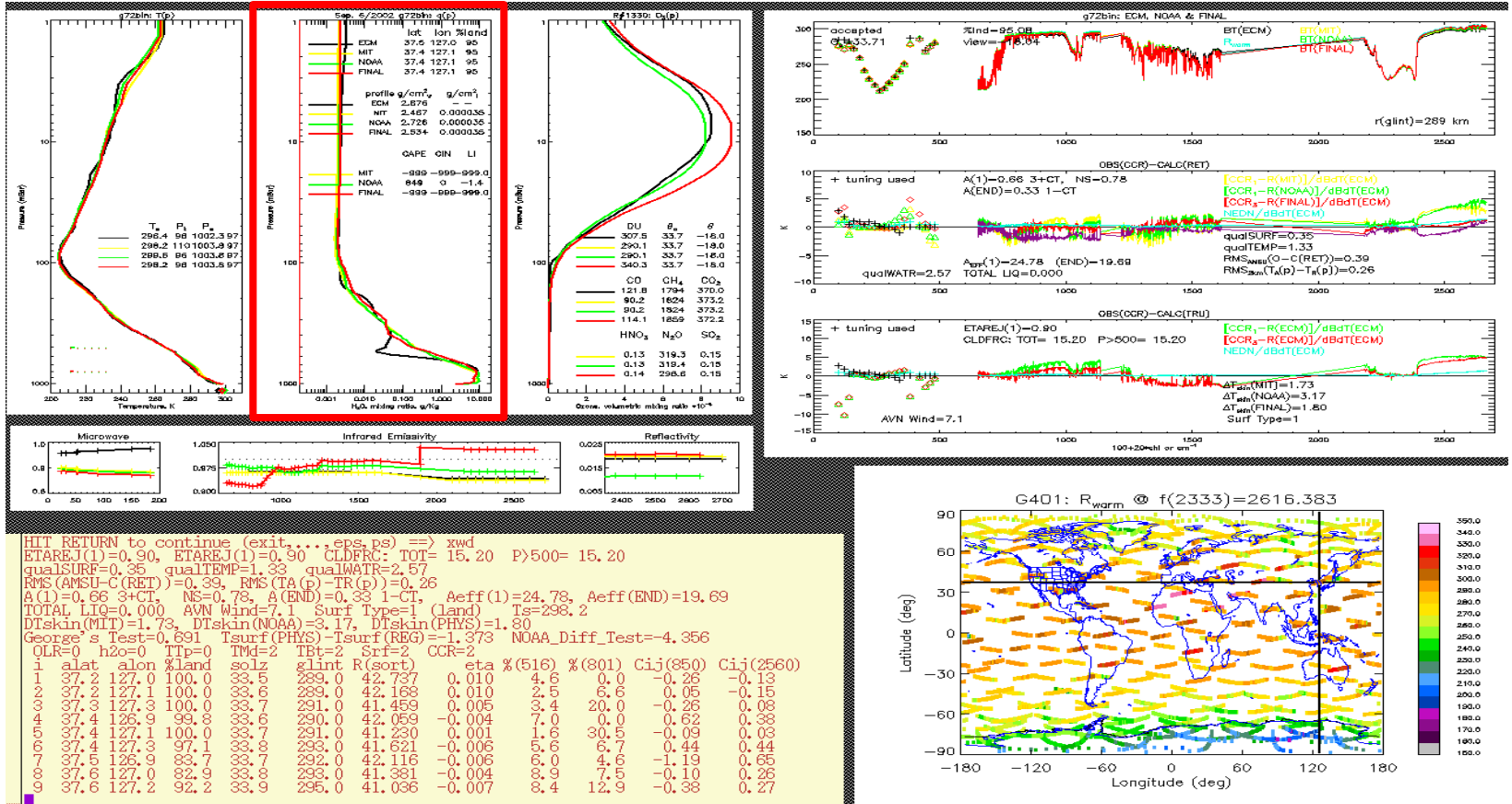


Discussion on AVMP statistic definition (6/7)

A detailed look at one case with large error.



Here is a detailed diagnostic for one of the mid-latitude outliers. Lots of info on this plot, but if you look at the 2nd panel in the upper left profile plot (highlighted in red) you will see that ECMWF has a dry layer (NOTE: this is a log scale) that the smooth retrieval doesn't capture – but this is a “good” retrieval. This case is the one in previous plot with $g=1533$, $q_tru=0.0028$ g/cm² at latitude=37.4 (index = 1330 in granule 401)

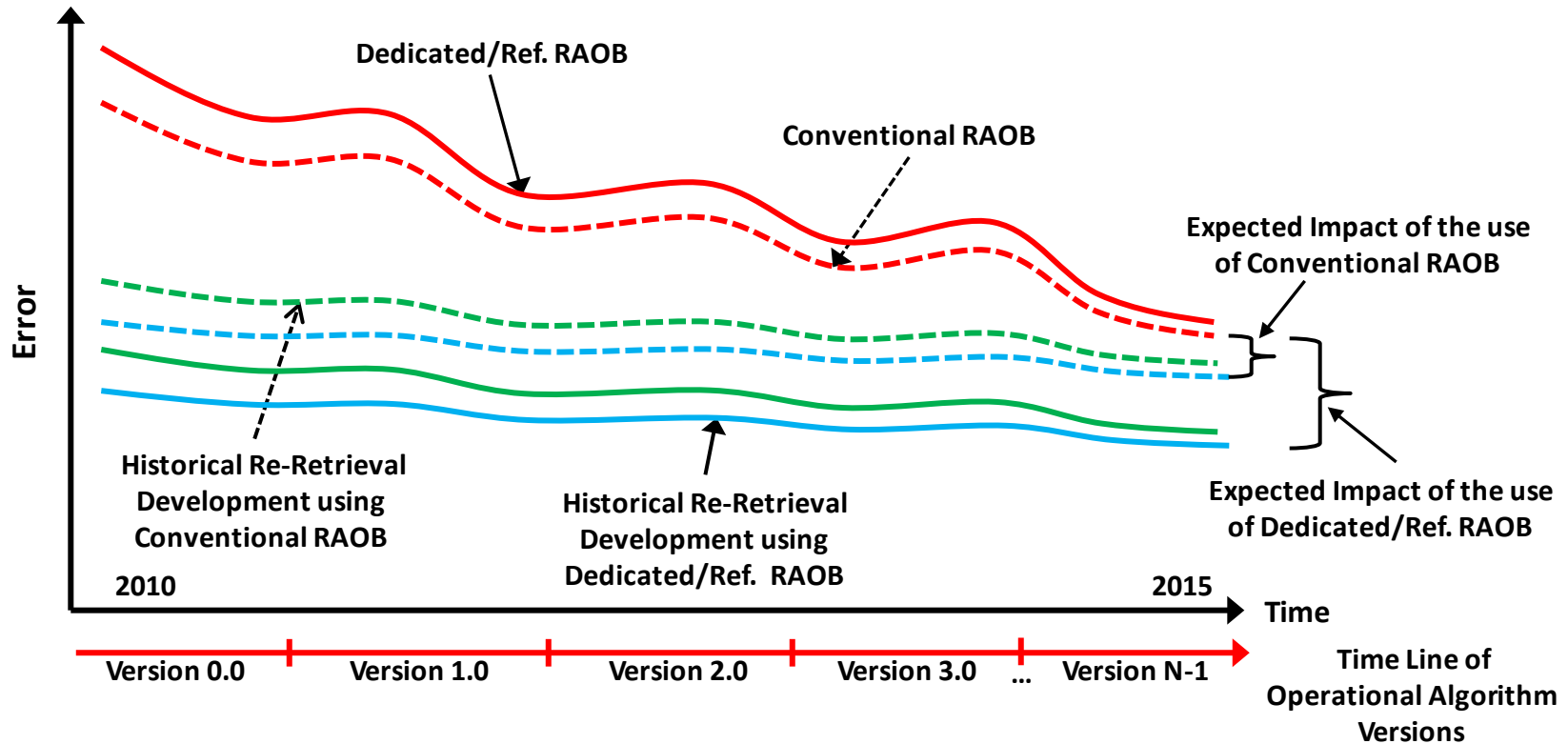


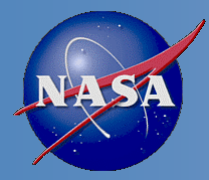


EDR Validation



Projected Performance of Operational (Red) and Development (Green and Blue) over Time when compared Against Conventional (dashed) and Ref/Dedicated (solid) RAOB



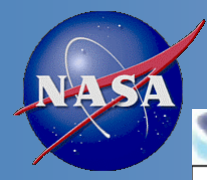


Case Study AEROSE H2O

Tony

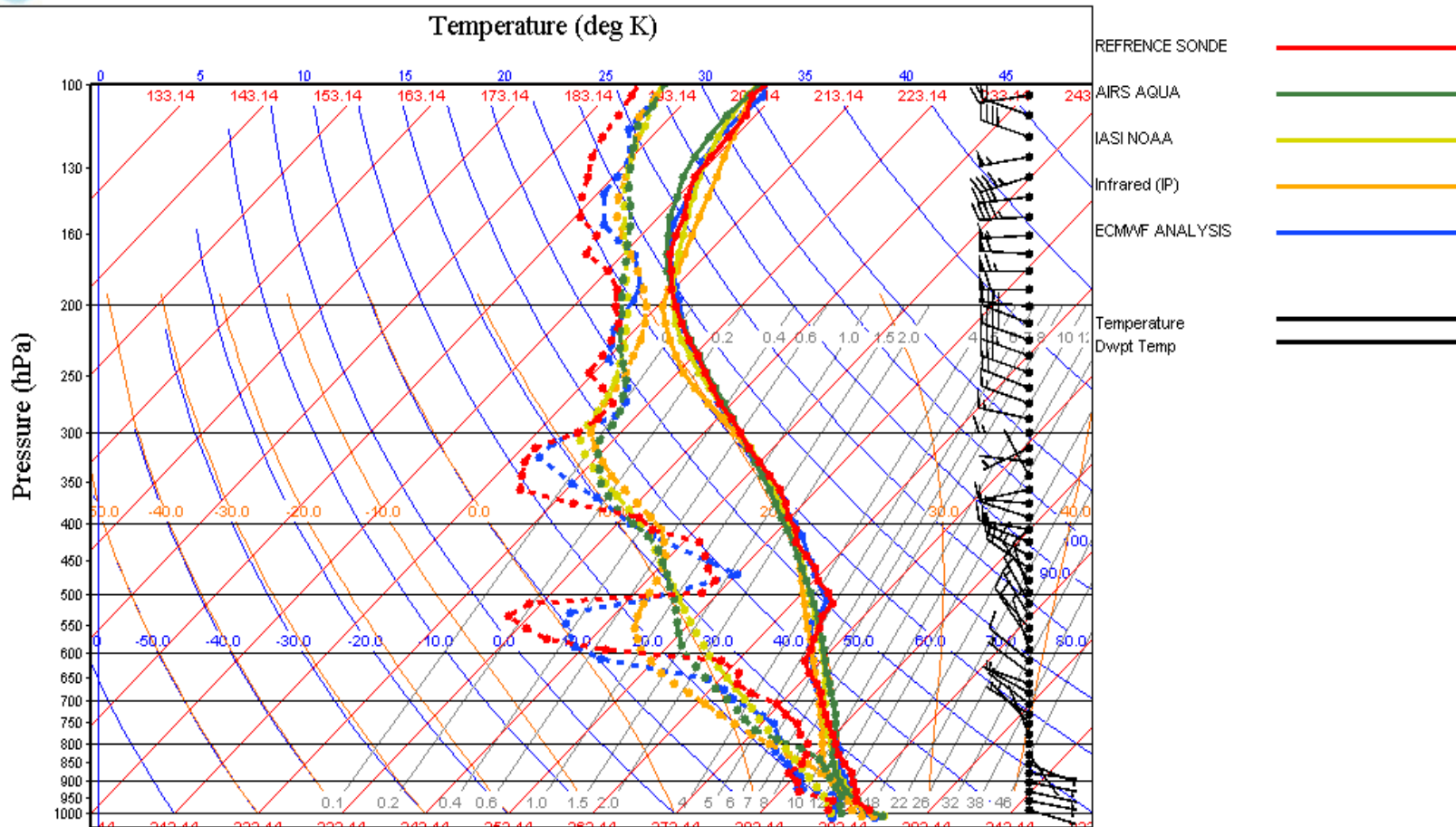
Jan 4 2013





NOAA Products Validation System (NPROVS)

Temperature (deg K)

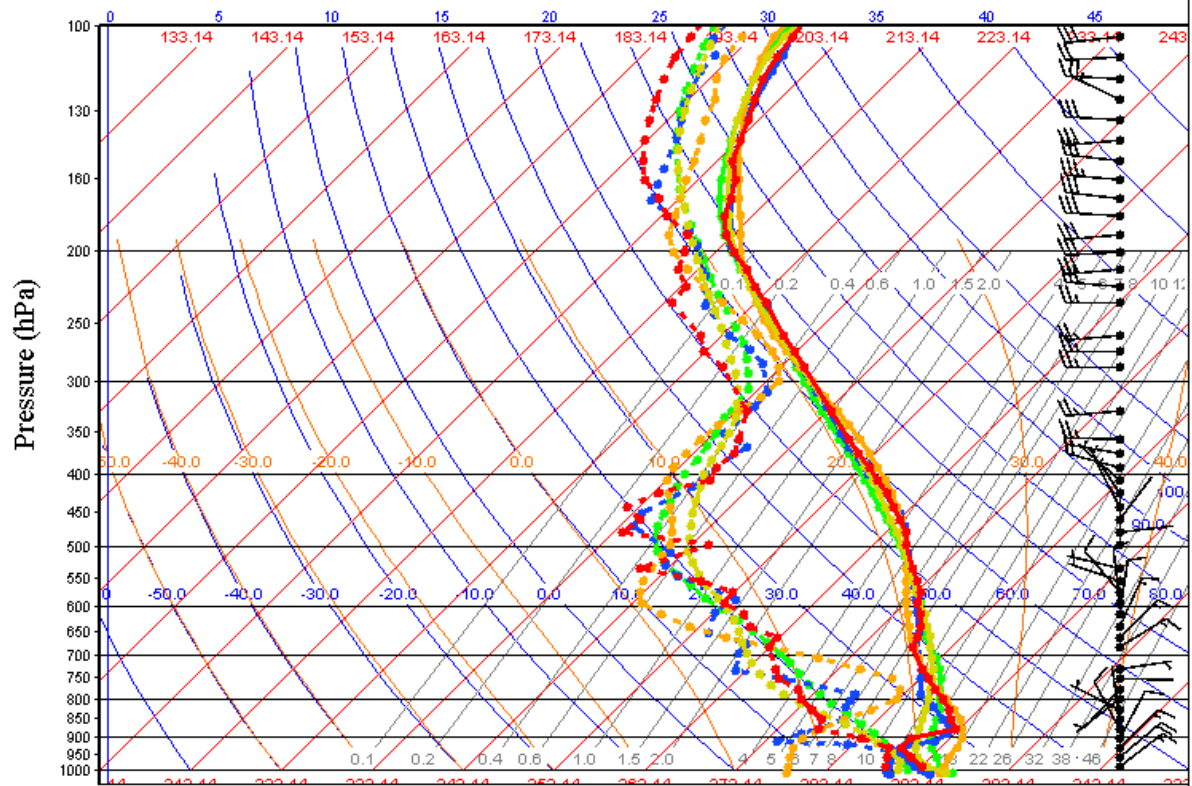


GRUAN Sonde WTEC (80)	11/17/2013 00:05	19.87 N / 38.38 W
AIRS AQUA	11/17/2013 04:04:16 (4 hours)	19.98 N / 38.36 W (12.3 km)
IASI NOAA	11/16/2013 23:27:46 (-0.6 hours)	19.82 N / 38.46 W (10.2 km)
CRIMSS NPP	11/17/2013 04:38:09 (4.6 hours)	19.96 N / 38.16 W (24.8 km)
ECMWF ANALYSIS	11/17/2013 00:00:00 (-0.1 hours)	20.00 N / 38.50 W (18.5 km)



NOAA Products Validation System (NPROVS)

Temperature (deg K)



- REFERENCE SONDE —
- IASI NOAA —
- Infrared (IP) —
- ECMWF ANALYSIS —
- NUCAPS NPP TEST —
- Temperature —
- Dwpt Temp —

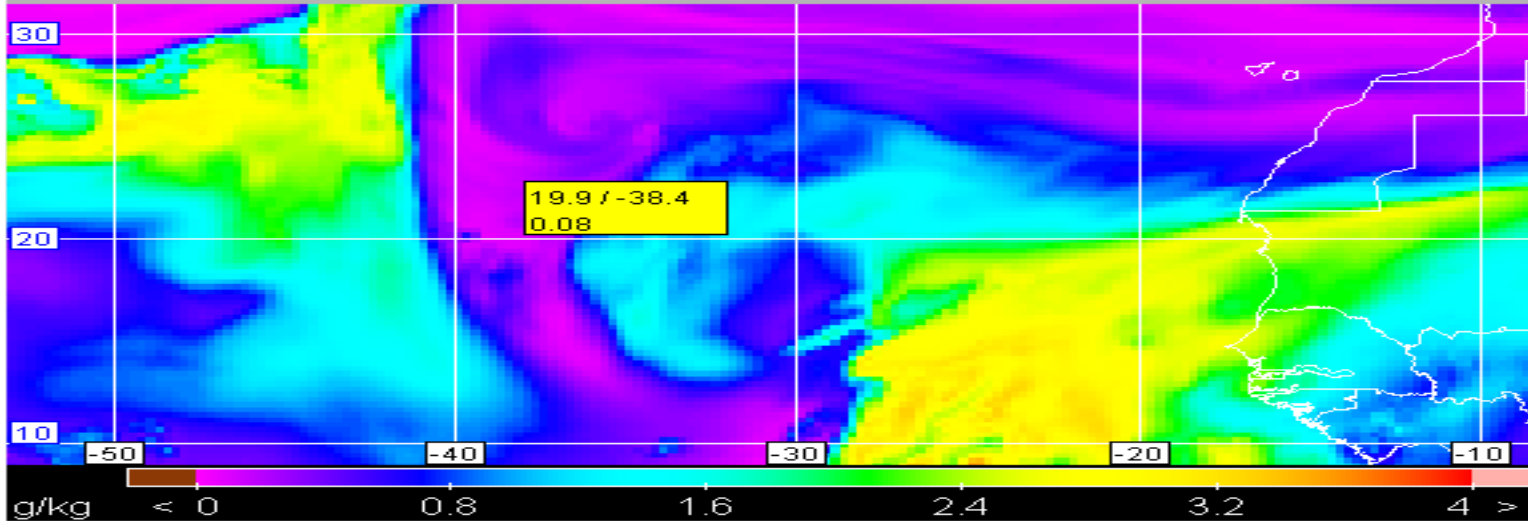


GRUAN Sonde WTEC (80)	11/23/2013 22:16	17.47 N / 23.00 W
IASI NOAA	11/23/2013 22:41:22 (0.4 hours)	17.58 N / 22.83 W (21.2 km)
CRIMSS NPP	11/24/2013 02:26:33 (4.2 hours)	17.31 N / 22.09 W (97.9 km)
ECMWF ANALYSIS	11/24/2013 00:00:00 (1.7 hours)	17.50 N / 23.00 W (2.6 km)
NUCAPS NPP TEST	11/24/2013 02:26:55 (4.2 hours)	17.31 N / 22.09 W (97.9 km)



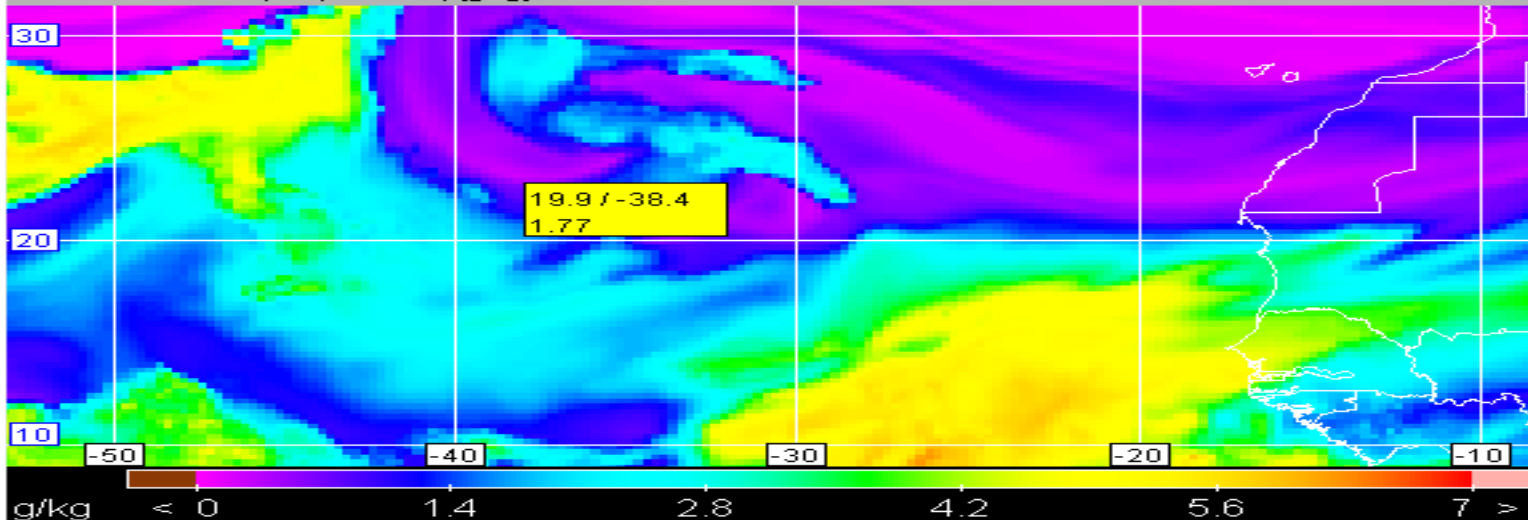
ECMWF 00z Analysis Nov 16, 2013 0Z to Nov 16, 2013 0Z

Retrieved Water Vapor (468.7 mb) [g/kg]



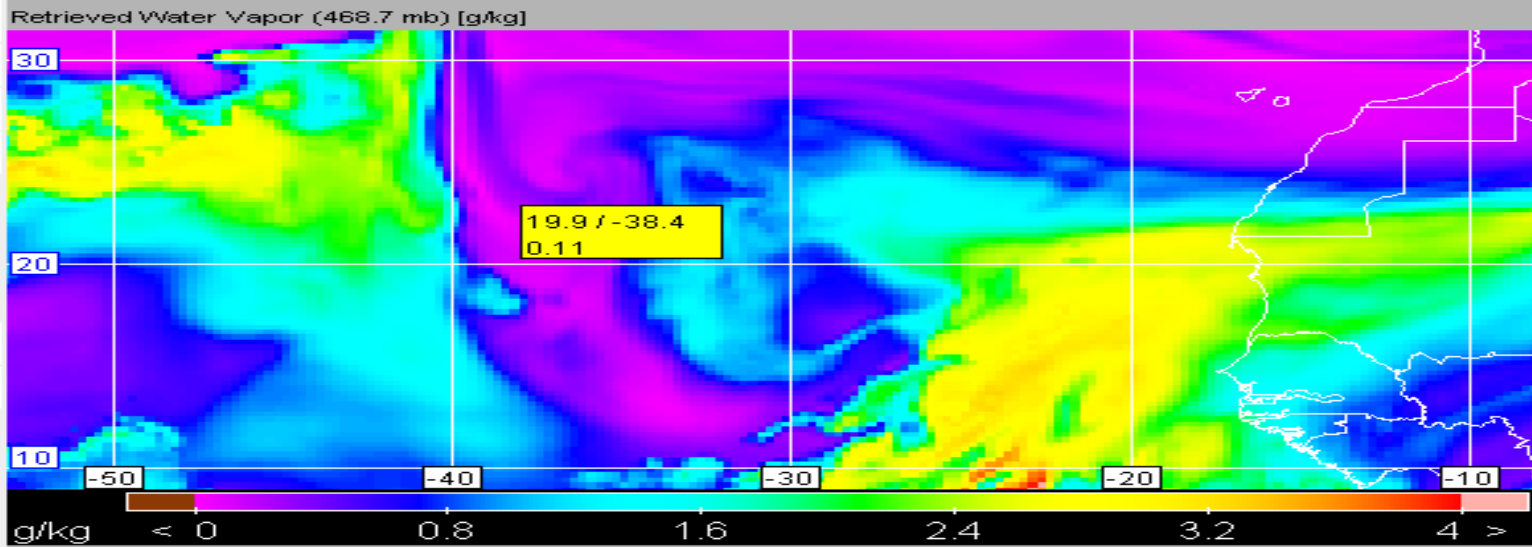
ECMWF 00z Analysis Nov 16, 2013 0Z to Nov 16, 2013 0Z

Retrieved Water Vapor (585.8 mb) [g/kg]

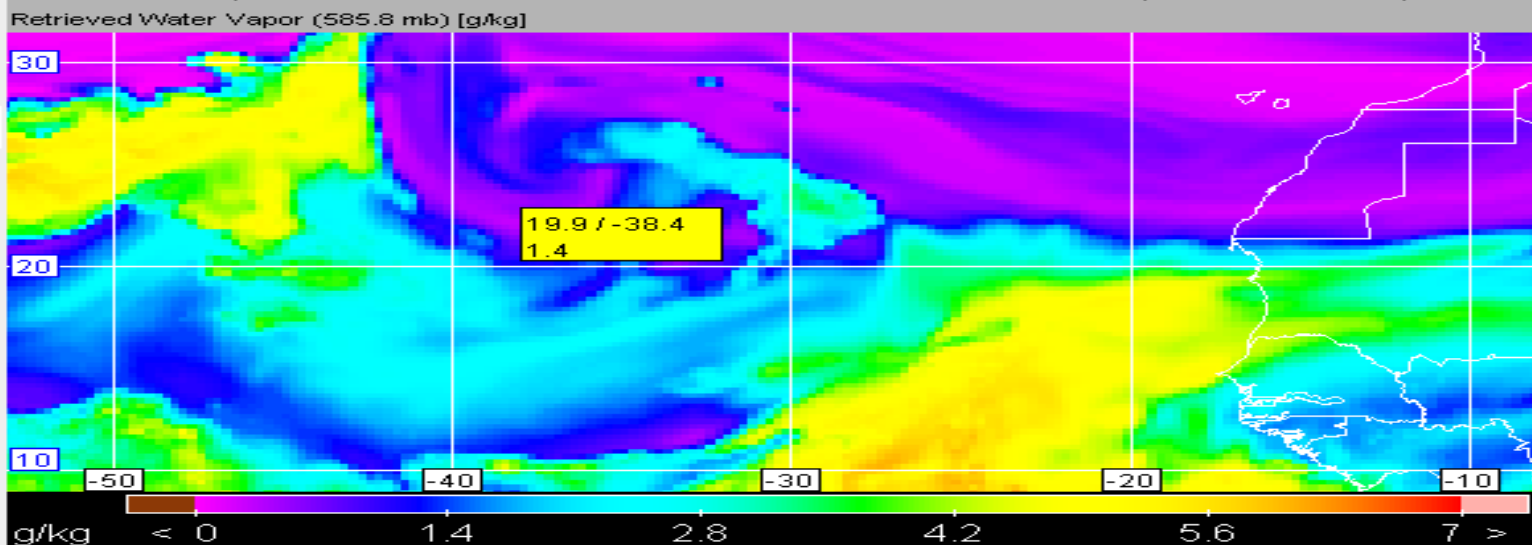


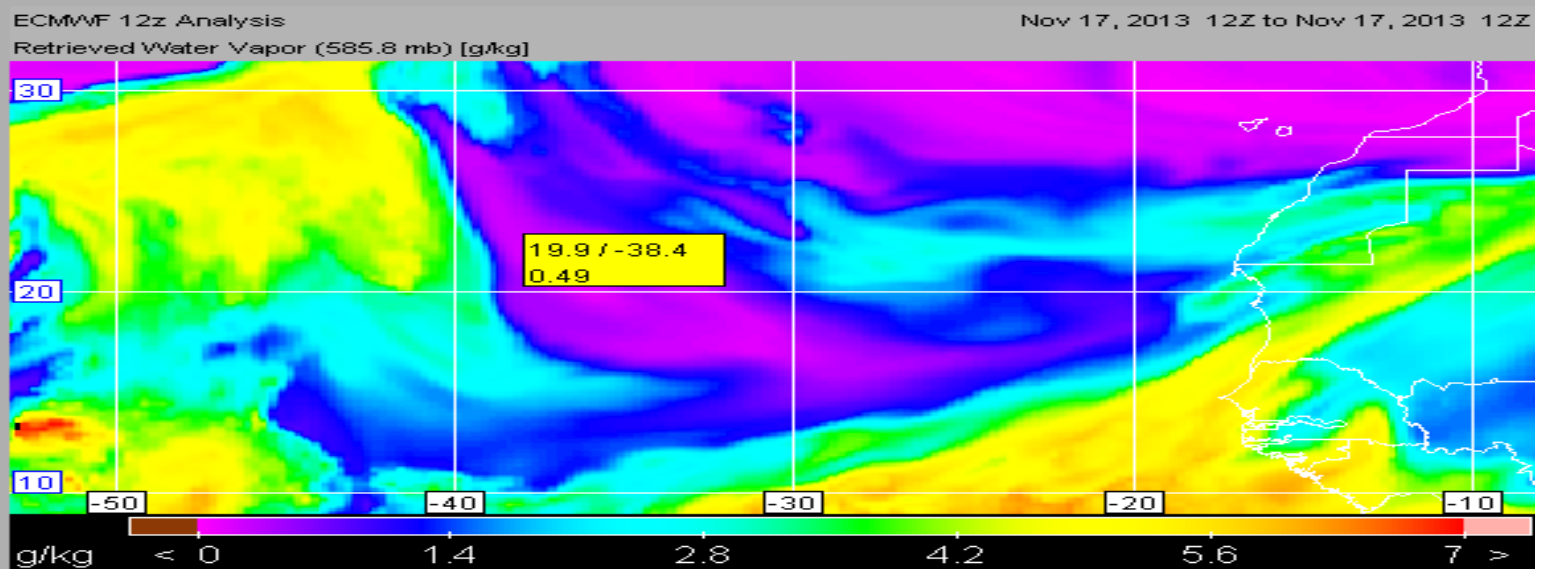
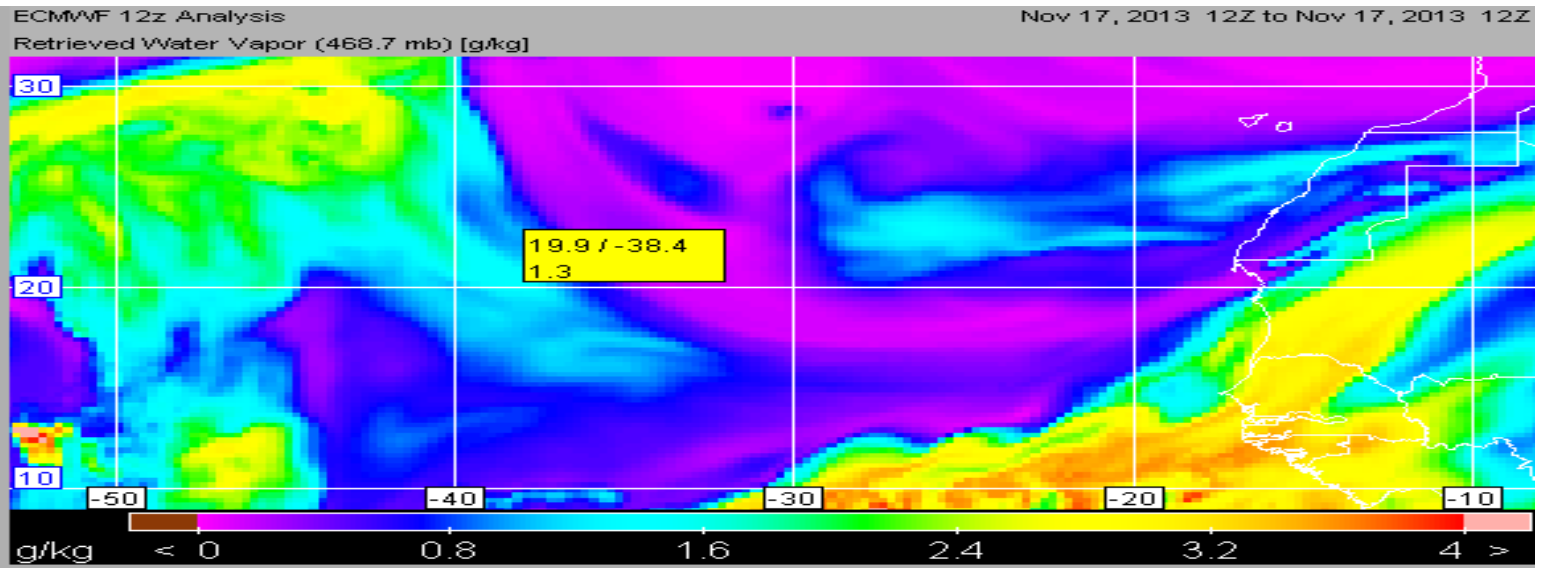


ECMWF 06z Analysis Nov 16, 2013 6Z to Nov 16, 2013 6Z



ECMWF 06z Analysis Nov 16, 2013 6Z to Nov 16, 2013 6Z

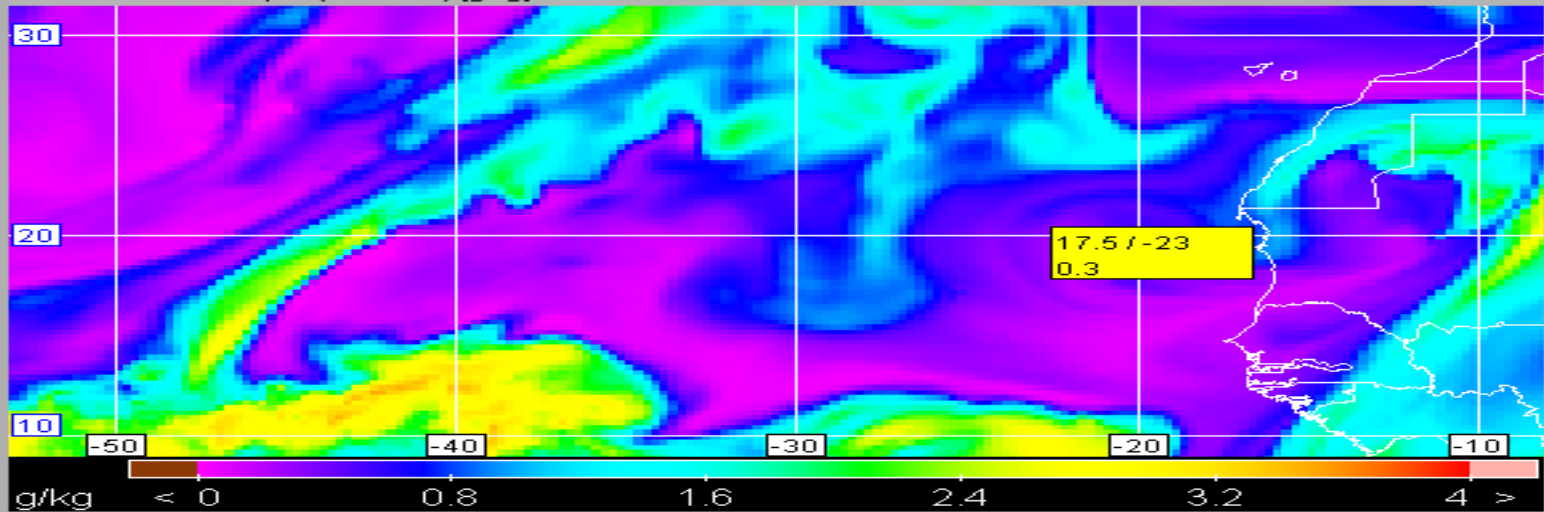






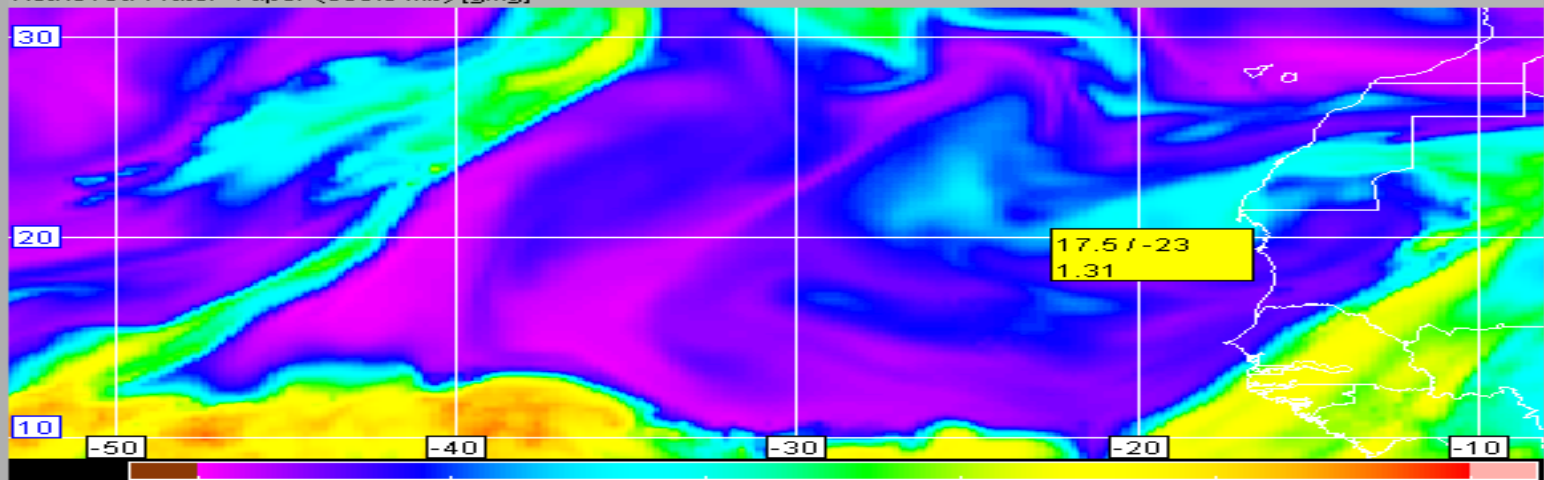
ECMWF 00z Analysis Nov 24, 2013 0Z to Nov 24, 2013 0Z

Retrieved Water Vapor (468.7 mb) [g/kg]



ECMWF 00z Analysis Nov 24, 2013 0Z to Nov 24, 2013 0Z

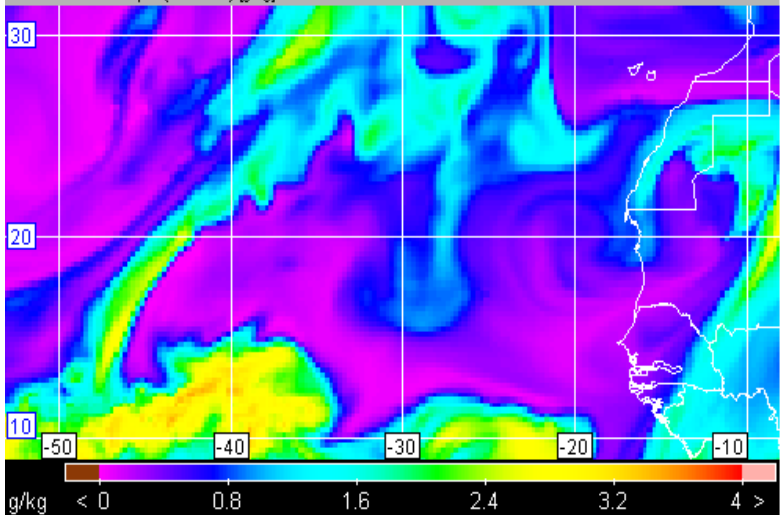
Retrieved Water Vapor (585.8 mb) [g/kg]





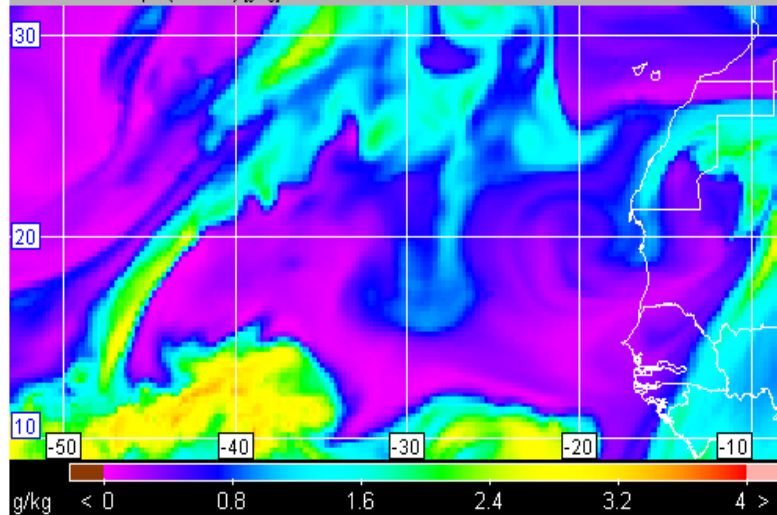
ECMWF 00z Analysis Nov 24, 2013 0Z to Nov 24, 2013 0Z

Retrieved Water Vapor (468.7 mb) [g/kg]



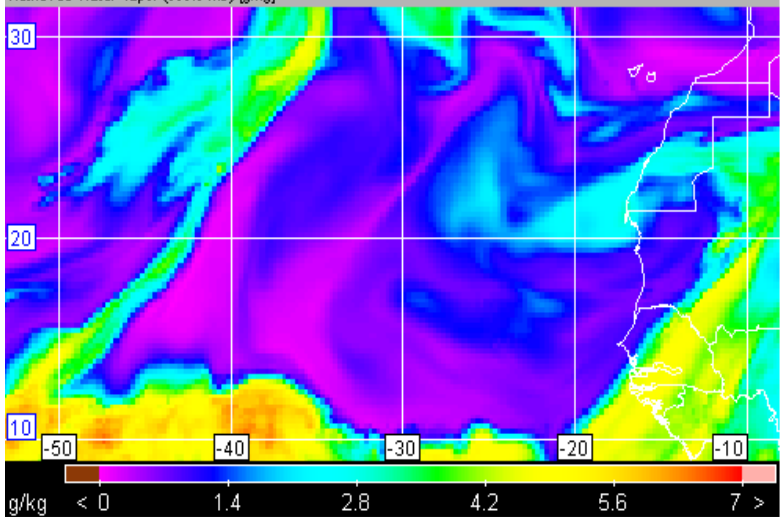
ECMWF 00z Analysis Nov 24, 2013 0Z to Nov 24, 2013 0Z

Retrieved Water Vapor (468.7 mb) [g/kg]



ECMWF 00z Analysis Nov 24, 2013 0Z to Nov 24, 2013 0Z

Retrieved Water Vapor (585.8 mb) [g/kg]



ECMWF 00z Analysis Nov 24, 2013 0Z to Nov 24, 2013 0Z

Retrieved Water Vapor (585.8 mb) [g/kg]

