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Assessment of NUCAPS S-NPP CrIS/ATMS Sounding Products Using Reference and Conventional Radiosondes

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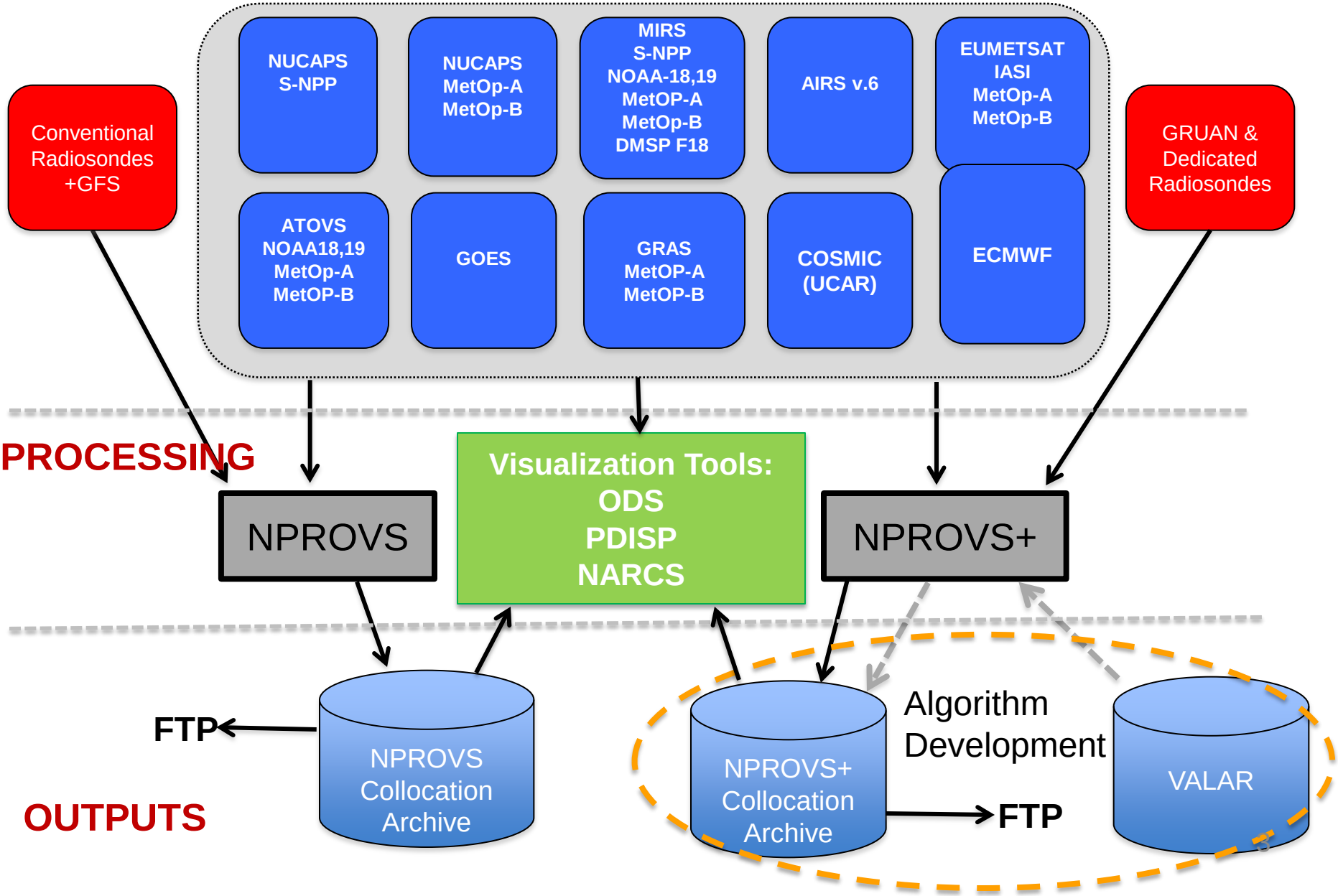
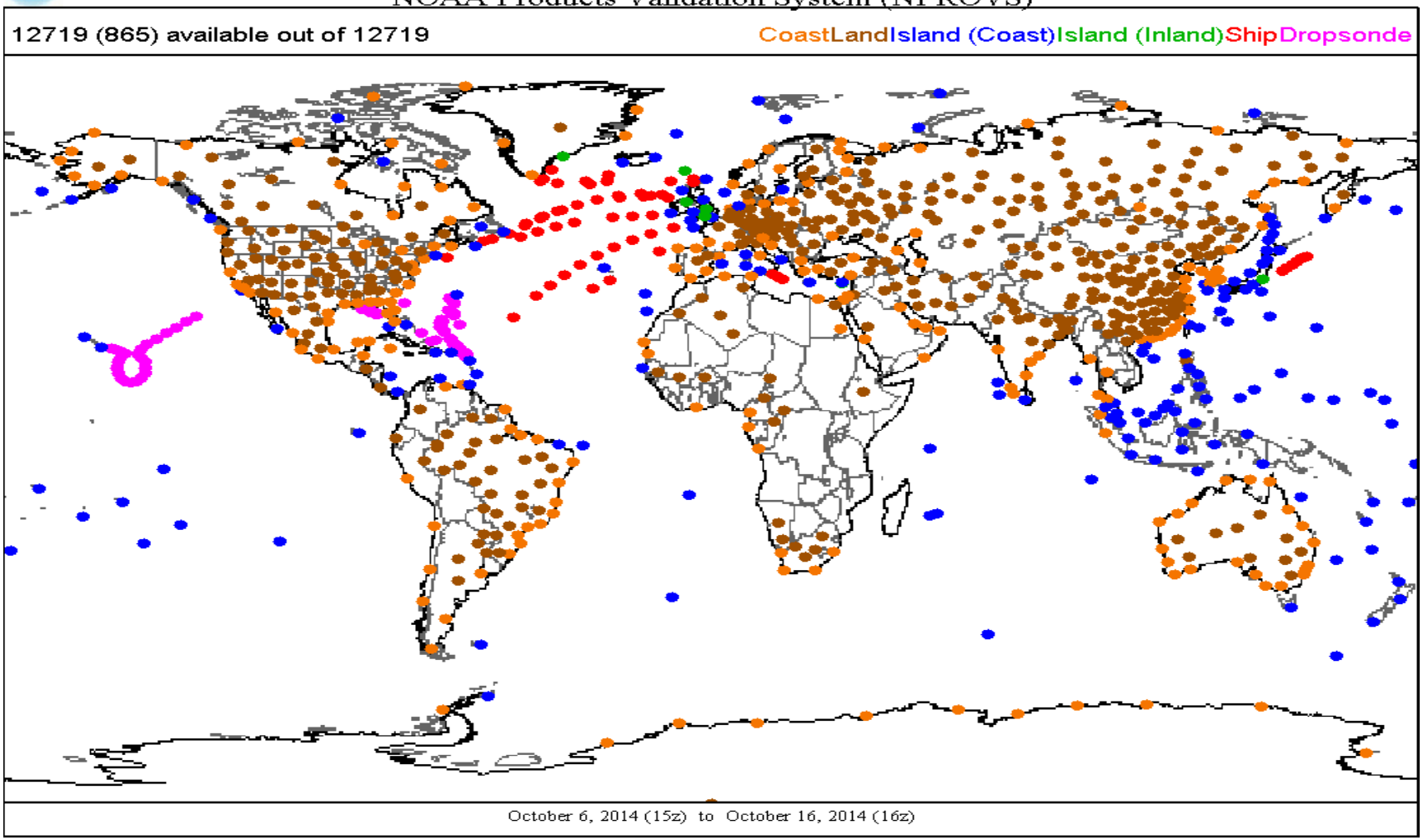
Outline

- The NOAA Products Validation System (NPROVS) & and its expansion (NPROVS+)
- Discussion on uncertainty arising from
  - Time/space mismatch in radiosonde and satellite observations
  - Radiosonde measurement accuracy
  - Radiosonde and satellite vertical resolution differences
- Analysis of S-NPP CrIS/ATMS temperature and water vapor retrievals (IR+MW) based on collocations with Reference (3-yr) and conventional RAOBs (6 mons).
  - Global
  - Individual sites

NOAA Products Validation System: NPROVS and NPROVS+



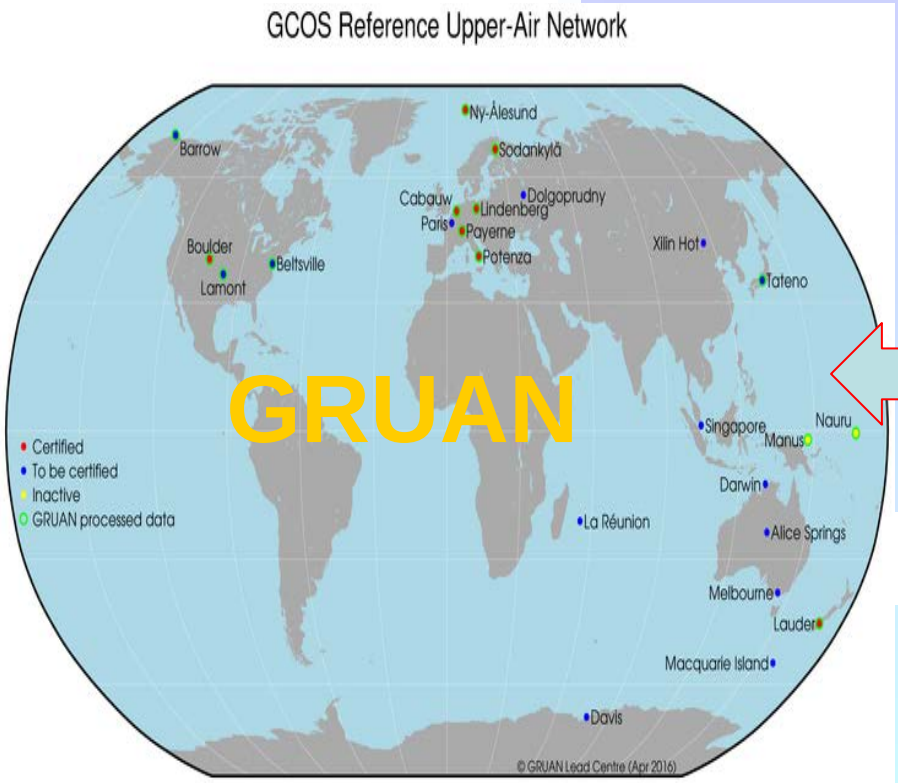
NPROVS



Typical NPROVS Global Collocations (1000 per day)

Vaisala RS92 (28%), Vaisala RS41 (6%)

N P R O V S +: Reference RAOBs in satellite cal/val



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

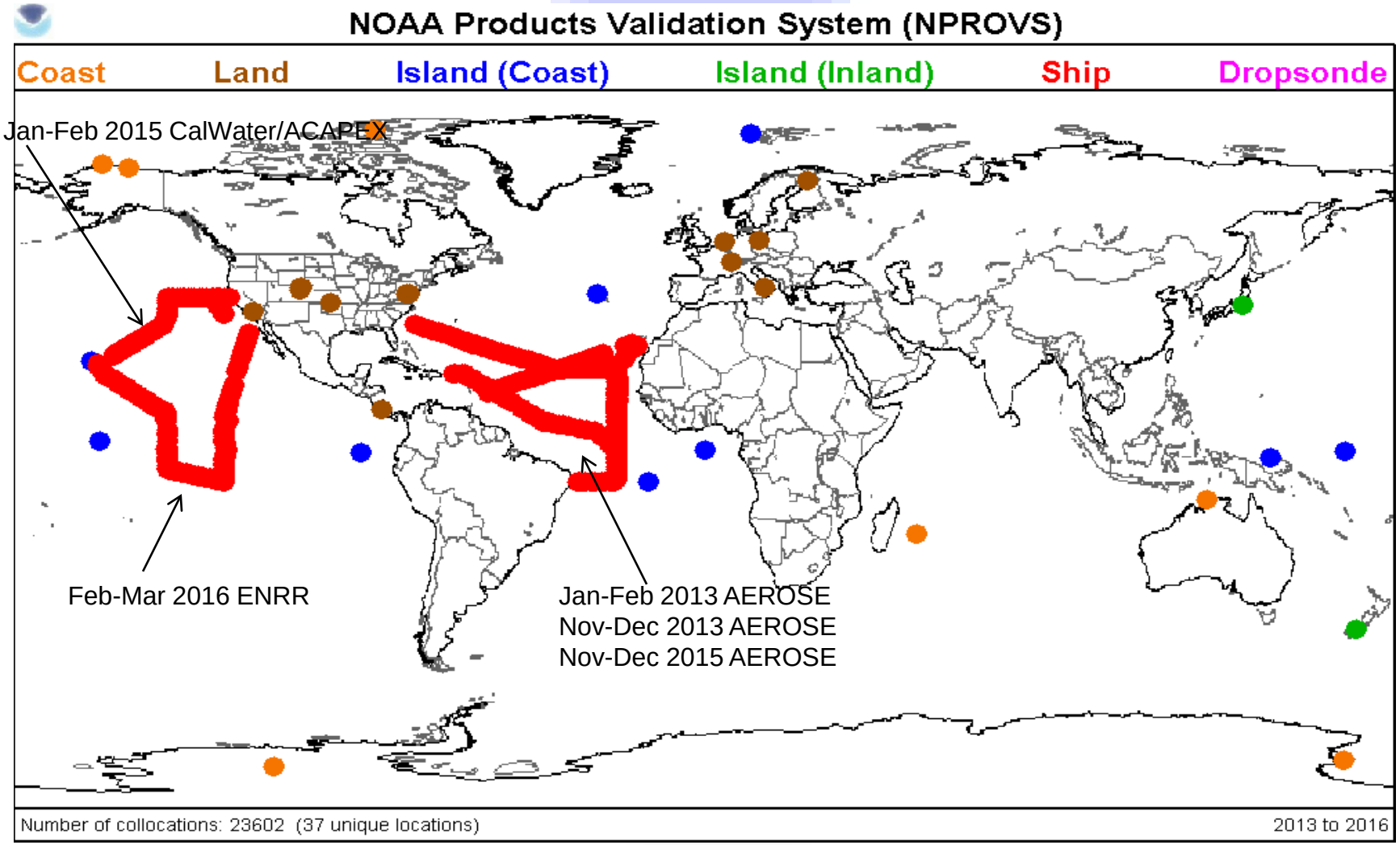
JPSS Funded Dedicated RAOB

- DOE ARM (SGP, NSA, ENA)
  - ✓SSEC/Madison …
  - ✓(2) per week
  - ✓ dual vs single, etc
- AEROSE
- CALWATER
- El Nino Rapid Response
- **GRUAN processed**

Ongoing coordination with “other” field experiments particularly if synchronized with S-NPP

- Sterling Test Site
- ARM Mobile Sites
- CIRA/CSU

NPROVS+



GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites

Of 23,600 RAOBs, 5,600 are synchronized (1373 via JPSS/ARM) since Jan 2013 thru Jun 2016

GRUAN/Dedicated radiosonde sites and date ranges January 2013 to mid-July 2016 (01)

RAOB Site	Date Range & Number of launches	Active
Ascension Island ARM site (ASCENS, 80)	2016-04-29 to (175)	yes
CIRA/CSU (CIRA, 114)	2016-05-06 to 2016-06-28 (18)	No
AWARE Antarctic ARM site (AWARE, 80)	2015-12-04 to 2016-01-18 (169)	No
Barrow, AK ARM site (70027, 272, 81, 80)	2013-07-01 to (2579)	Yes
Beltsville, MD (BELTSV,114, 80, 272)	2013-07-01 to (178)	Yes
Boulder, CO (BOULDE, 272)	2013-07-09 to (147)	Yes
Cabauw, Netherlands (06260, 272)	2013-07-01 to (1201)	Yes
Kritimati Island ENRR (CXENRR, 80)	2016-01-26 to 2016-03-13 (96)	No
Darwin, Australia ARM site (94120, 80)	2014-04-01 to 2015-01-14 (714)	No
Eastern North Atlantic Azores ARM site (GRACIO, 80)	2013-09-28 to (2086)	Yes
Lauder, New Zealand (LAUDER, 123)	2013-07-03 to (234)	Yes
Lindenberg, Germany (10393, 272)	2013-07-01 to (4357)	Yes
Manus Island, Papua New Guinea ARM site (92036, 272, 80)	2013-07-01 to 2014-07-06 (110)	No
McMurdo, Antarctica ARM site (89664, 80)	2015-11-30 to 2016-03-31 (364)	No

GRUAN/Dedicated radiosonde sites and date ranges January 2013 to mid-July 2016 (02)

RAOB Site	Date Range & Number of launches	Active
Nauru Island ARM site (91532, 272)	2013-07-01 to 2013-08-26 (717)	No
Ny-Alesund, Norway (01004, 272)	2013-07-01 to (1270)	Yes
Oliktok Point, AK ARM site (OLIKTO,80)	2013-09-10 to (944)	Yes
Payerne, Switzerland (06610, 272)	2013-07-02 to (106)	Yes
Potenza, Italy (16300, 272)	2013-12-19 to (73)	Yes
La Reunion Island, France ARM site (REUNIO, 272) Indian ocean away from Africa	2015-05-05 to 2016-05-28 (19)	No
San Cristobal Island, Ecuador (84008, 272) sea terrain	2013-07-26 to 2015-01-26 (142)	No
Southern Great Plains, OK ARM site (74646, 272, 80)	2013-07-01 to (4740)	Yes
Juan Santamaria, Costa Rica (78762, 272)	2013-07-11 to 2014-02-21 (39)	No
Sodankyla, Finland (02836, 272)	2013-07-03 to (2250)	Yes
Sterling, VA 71000 (81) 72403 (182) 72000 (152)	2015-10-28 to (724)	Yes
Tateno, Japan (47646, 272)	2013-07-01 to (296)	Yes
Table Mountain Facility, CA (TMFJPL, 272)	2014-12-05 to (27)	Yes
Pacific Missile Range Facility, HI (91162, 80)	2014-04-11 to 2014-04-26 (23)	No

GRUAN/Dedicated radiosonde sites and date ranges January 2013 to mid-July 2016 (03)

RAOB Site	Date Range & Number of launches	Active
Eureka, Northwestern terrority of Canada (71917, 272)	2013-01-10 to 2013-02-13 (17)	No
AEROSE Jan-Feb 2013	2013-01-09 to 2013-02-13 (109)	No
AEROSE Nov-DEC 2013	2013-11-12 to 2013-12-07 (96)	No
AEROSE Jan-Feb 2015	2015-11-17 to 2015-12-13 (90)	No
CalWater/ACAPEX Jan-Feb 2015	2015-01-12 to 2015-02-10 (171)	No
ENRR Feb-Mar 2016	2016-02-16 to 2016-03-16 (166)	No

Roles of NPROVS in sounding EDR cal/val

- Routine product monitoring (e.g., anomaly/outlier detection and long-term stability).
- Characterize product performance in a variety of meteorological conditions.
- Identify problem areas in retrieval algorithm in support of algorithm development.
- Provide independent oversight for operational product implementation.
- Provide support to AWIPS for NUCAPS applications in severe weather detection and prediction.

Outline

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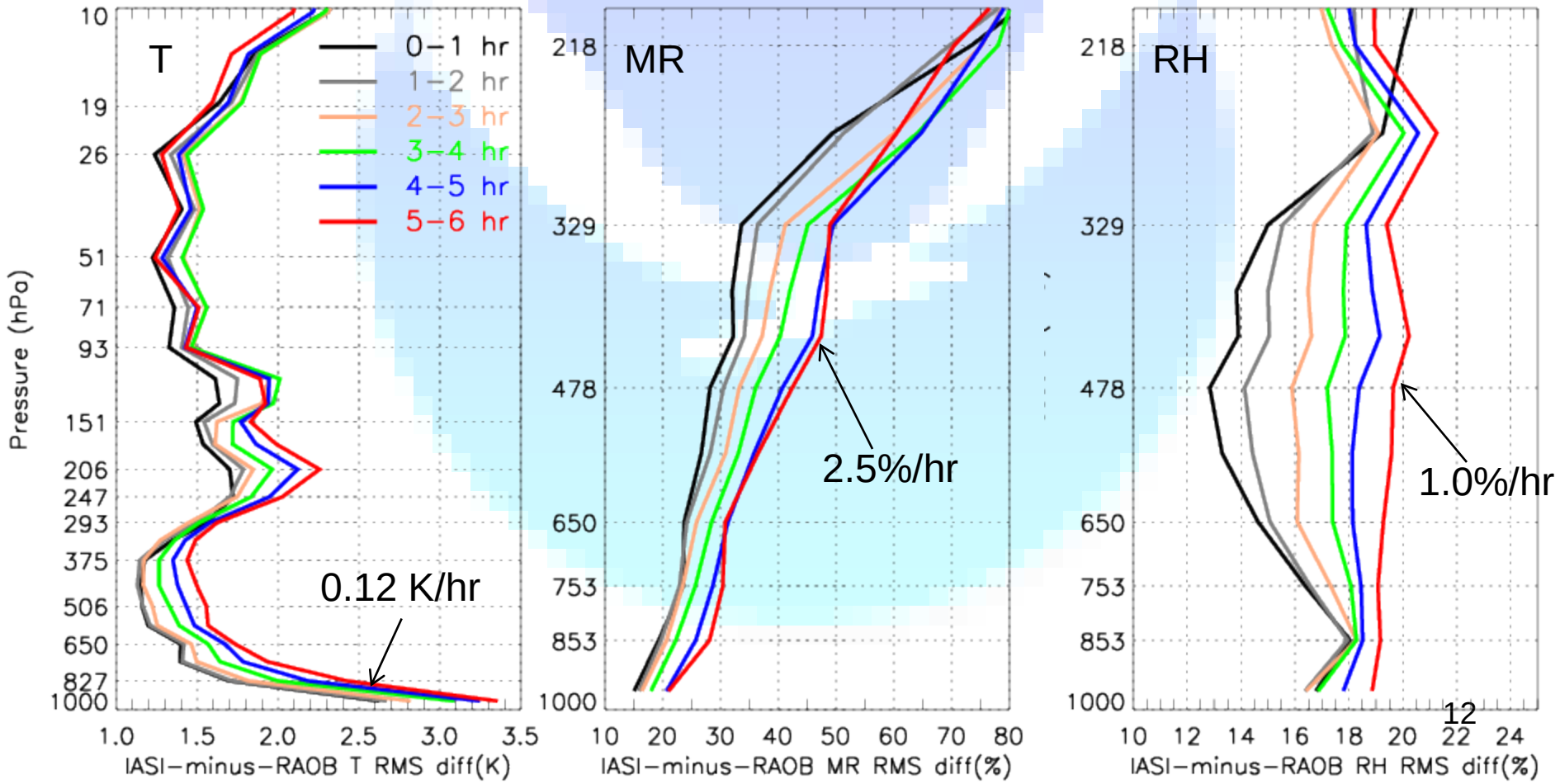
- **Discussion on uncertainty arising from**
  - **Time/space mismatch in radiosonde and satellite observations**
  - **Radiosonde measurement accuracy**
  - **Radiosonde and satellite vertical resolution differences**

- Analysis of S-NPP CrIS/ATMS temperature and water vapor retrievals (qc-accepted IR+MW)
  - Global collocations
  - Individual sites

Satellite-RAOB Time Mismatch Impact

RMS error changes with time mismatch

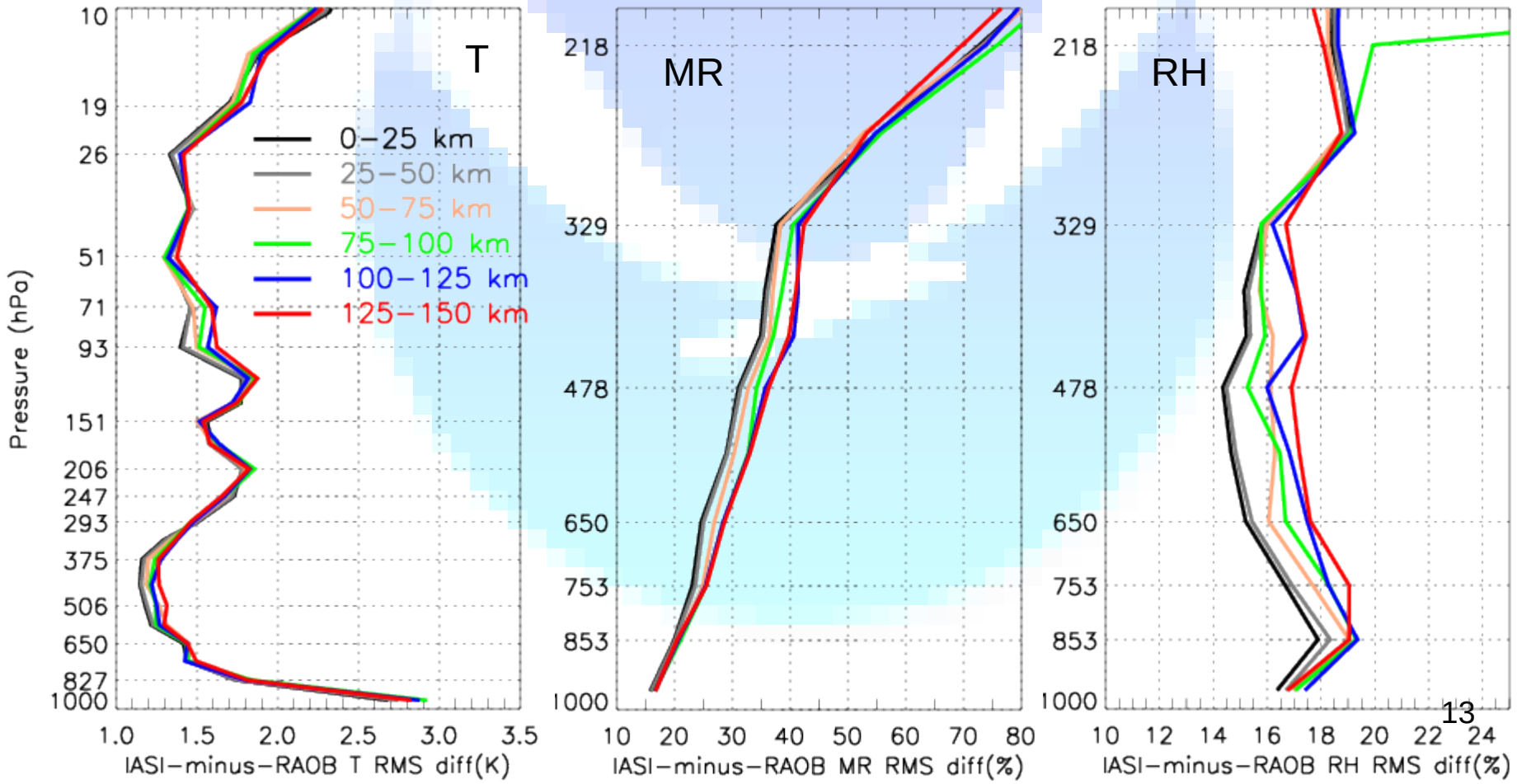
- Based on the analysis of 3-yr global IASI-RAOB collocations (506,354)



Satellite-RAOB Distance Mismatch Impact

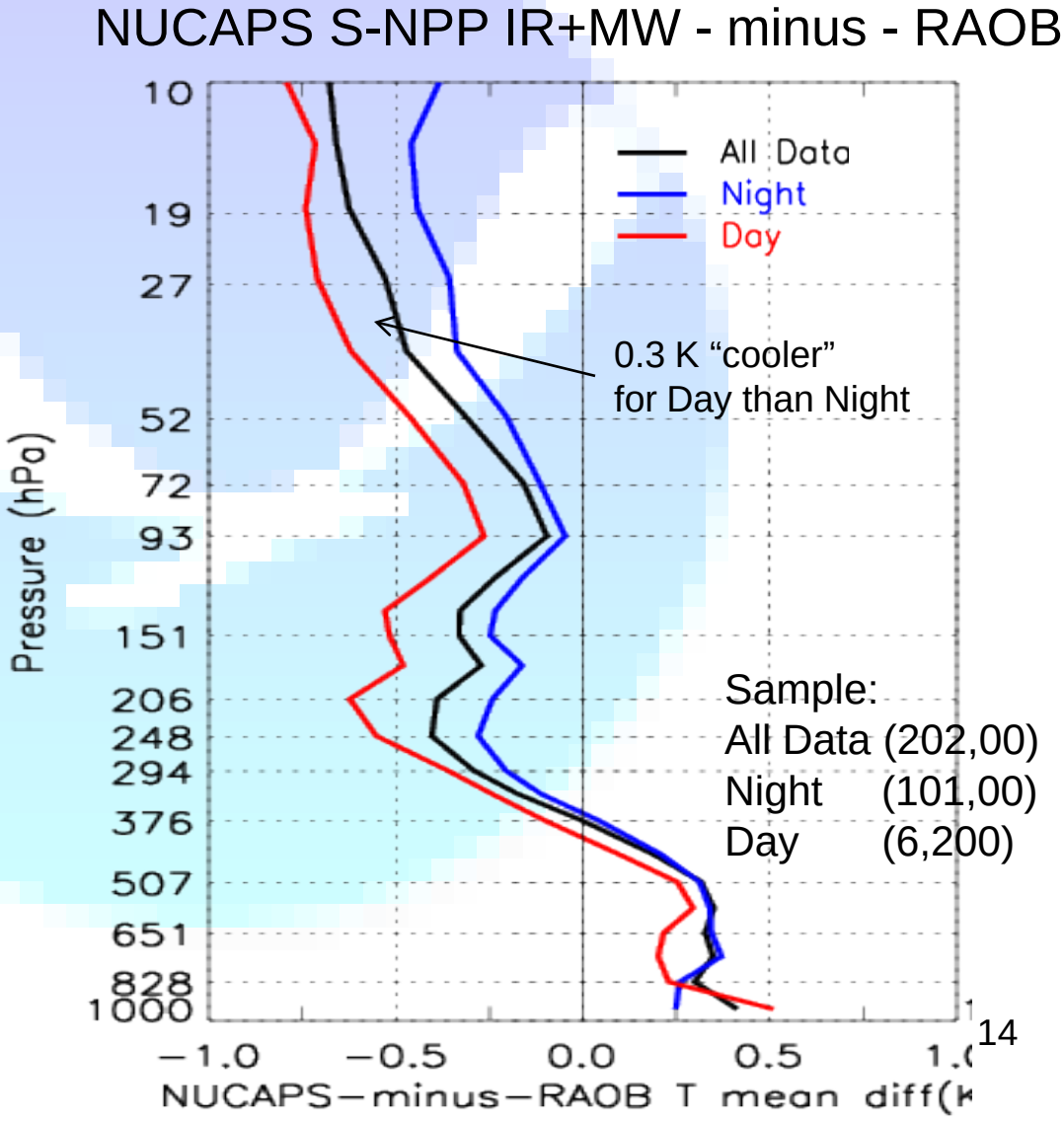
RMS error changes with distance mismatch

- Based on the analysis of 3-yr global IASI-RAOB collocations (506,354)



Radiosonde temperature radiation bias impact

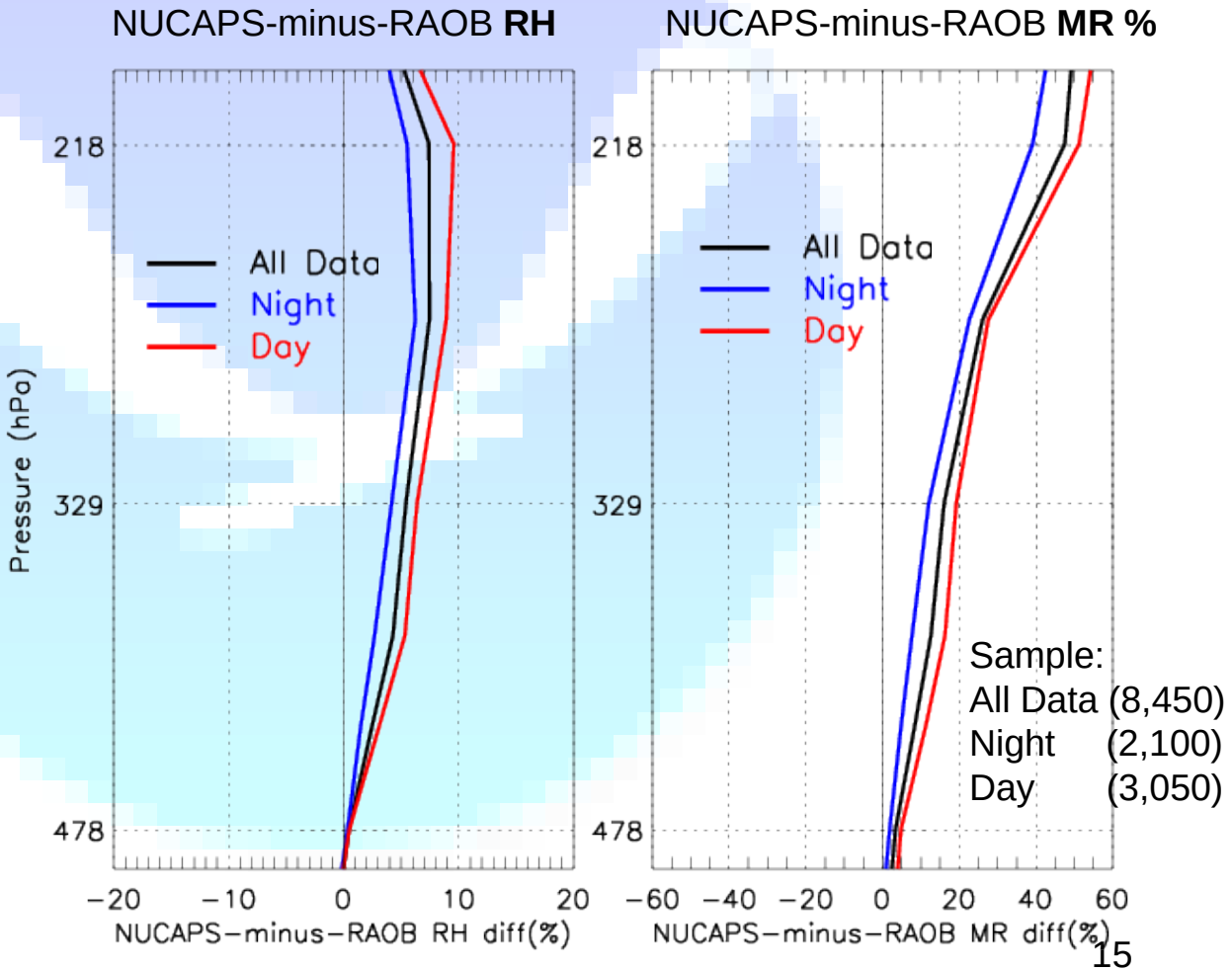
- **Radiosondes tend to have a radiation induced warm bias in the UTLS during daytime.**
- **The RAOB T bias at 10-70 hPa is 0.18 K for all-the –day and 0.39 K for daytime (Sun et al., JGR 2013)**



Radiosonde Humidity Dry Bias Impact

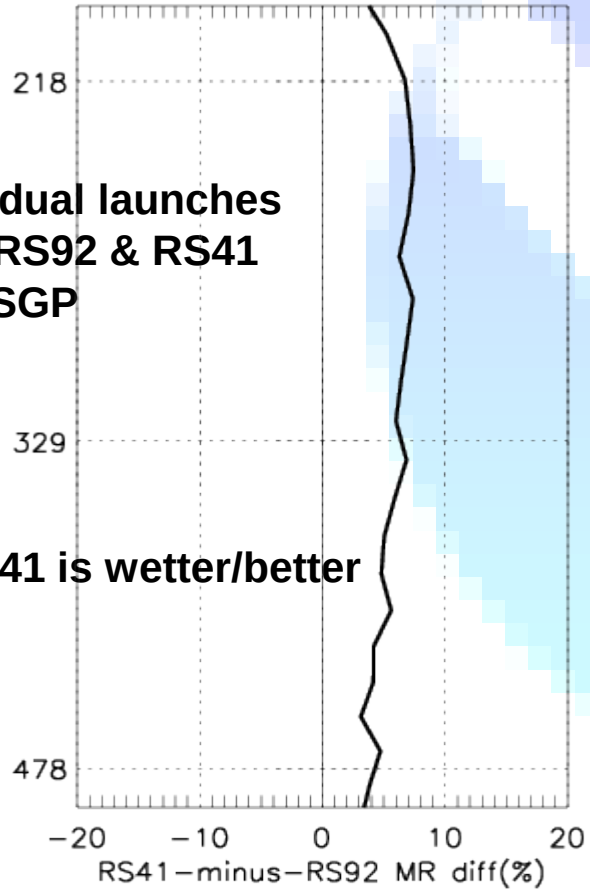
(Vaisala RS92 as an example *vs* S-NPP NUCAPS IR+MW)

- **Most radiosondes tend to have a dry bias in the UTLS particularly daytime.**
- **The RAOB RH bias at 300 hPa is ~7% for Day and ~3% (Sun et al., JGR 2011)**



RS41 Improvement over RS92

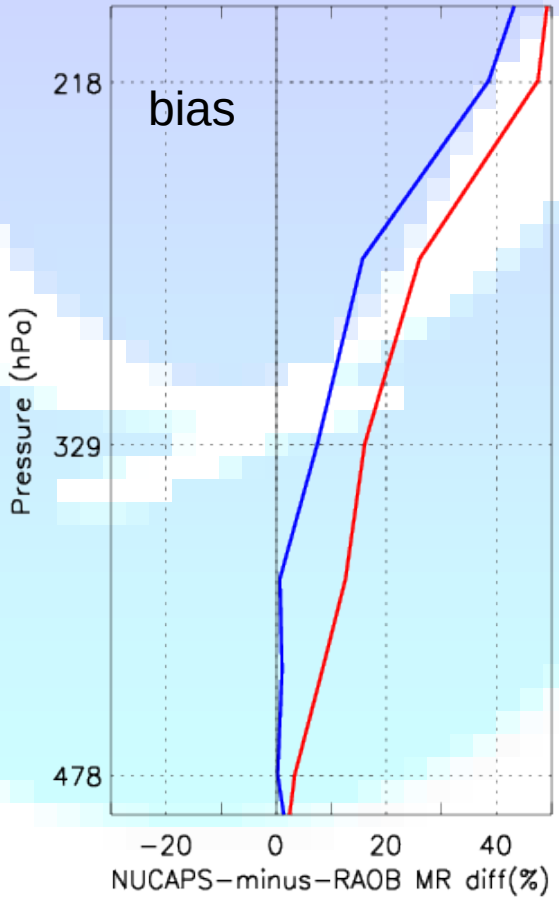
RS41-minus-RS92 MR %

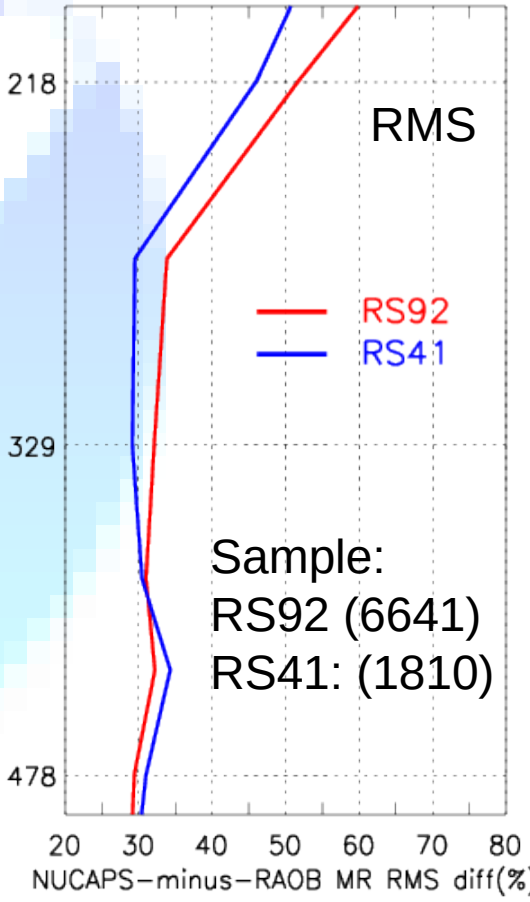


20 dual launches of RS92 & RS41 at SGP

RS41 is wetter/better

S-NPP IR+MW - minus - RAOB MR (%)

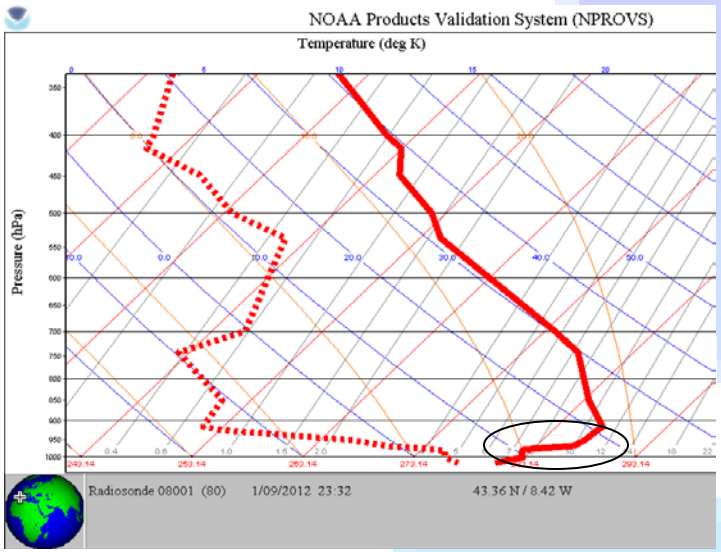


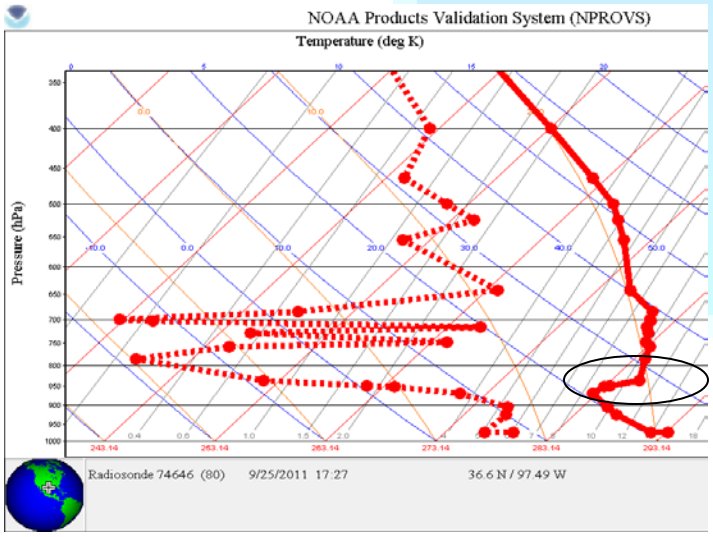


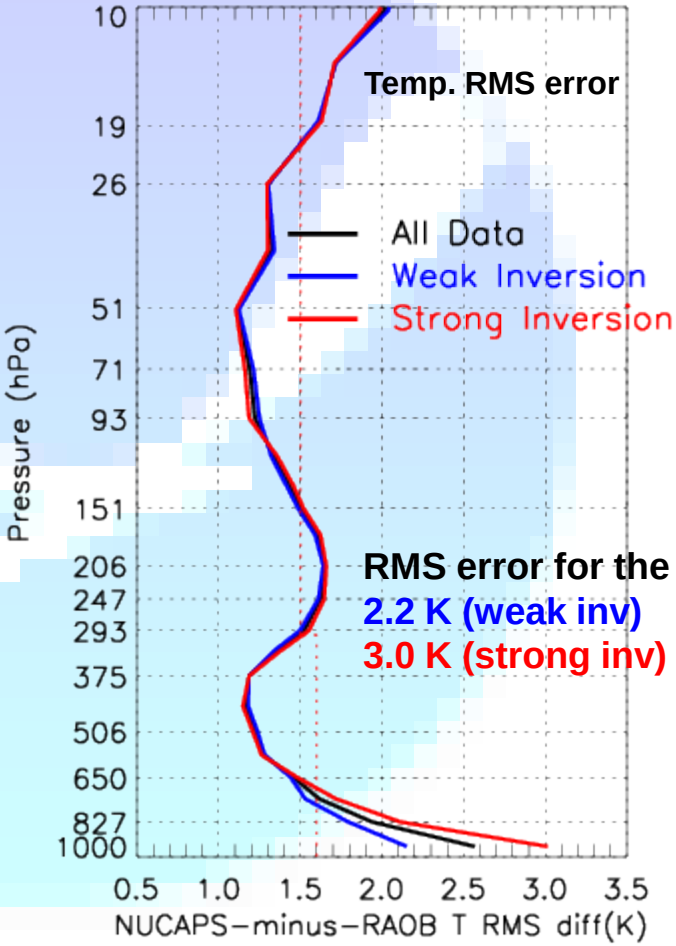
Sample:
RS92 (6641)
RS41: (1810)

Radiosonde *vs.* Satellite Vertical Sensitivity Impact

(example of Temp inversion)







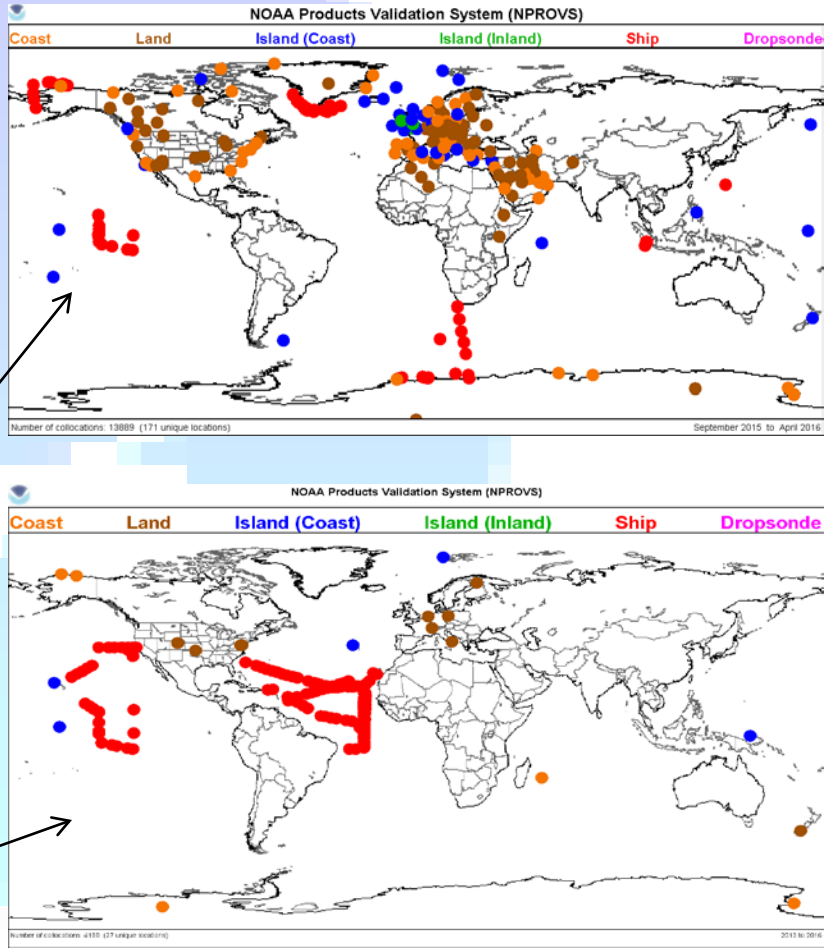
RMS error for the low layer:
2.2 K (weak inv)
3.0 K (strong inv)

Sample:
Strong inv (13,500)
Weak inv (10,500)

Datasets used for S-NPP NUCAPS retrieval analysis

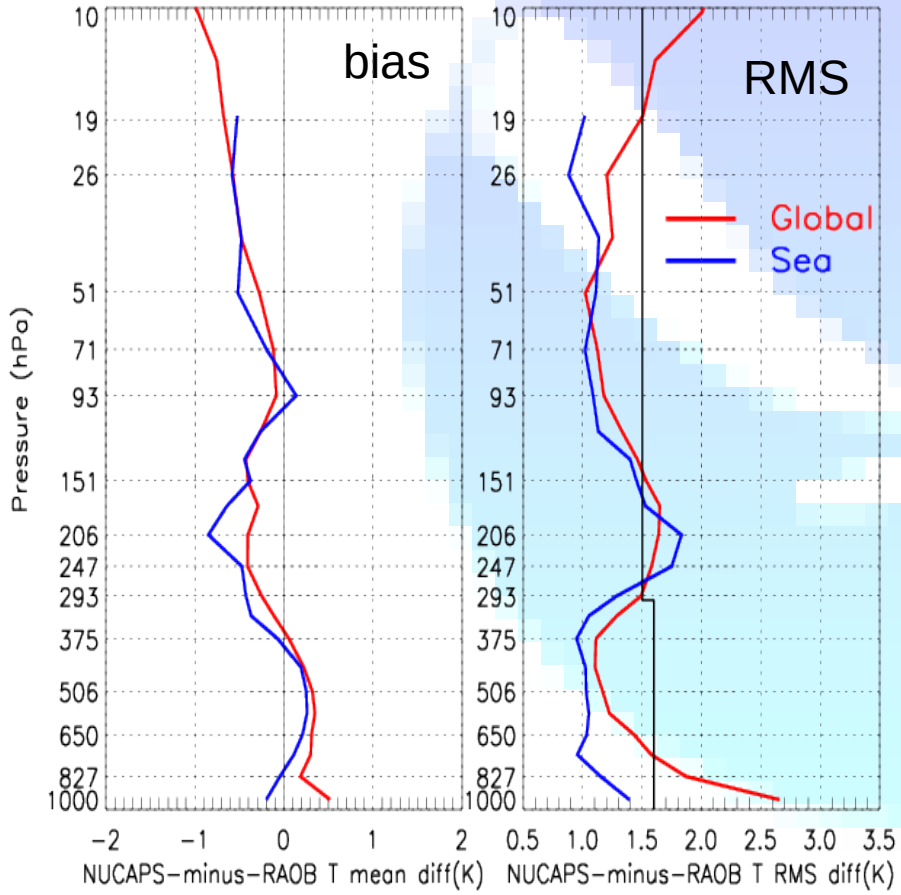
- NUCAPS-RAOB collocation data
  - Time mismatch: <1 hr
  - Distance mismatch: < 50 km
- Sonde types
  - Vaisala RS92 and RS41 **(conventional)**
  - Vaisala RS92 **(Reference)**

- **Conventional RAOBs (NPROVS, 6 mons)**
  - 14, 000 (global), 255 (sea)
- **Reference RAOBs (NPROVS+, 3 yrs)**
  - 4, 200 (global), 167 (sea)



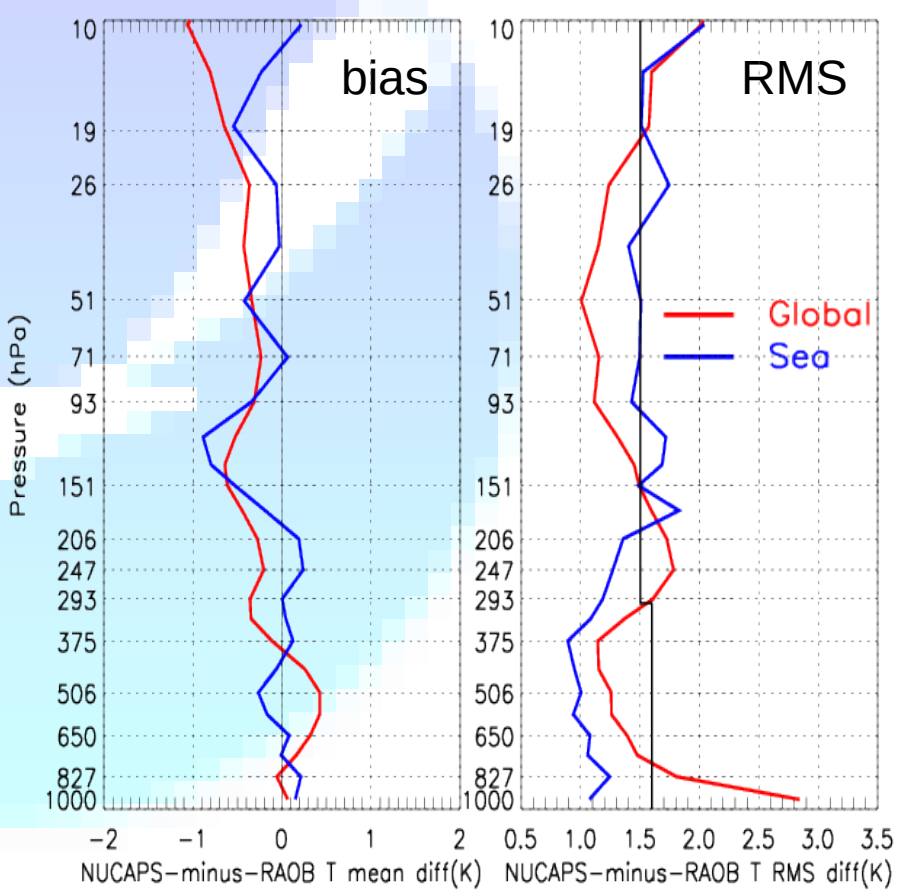
S-NPP NUCAPS IR+MW Temperature Statistics (K)

Relative to **Conventional** RAOBs



8881 (global), 101 (sea)

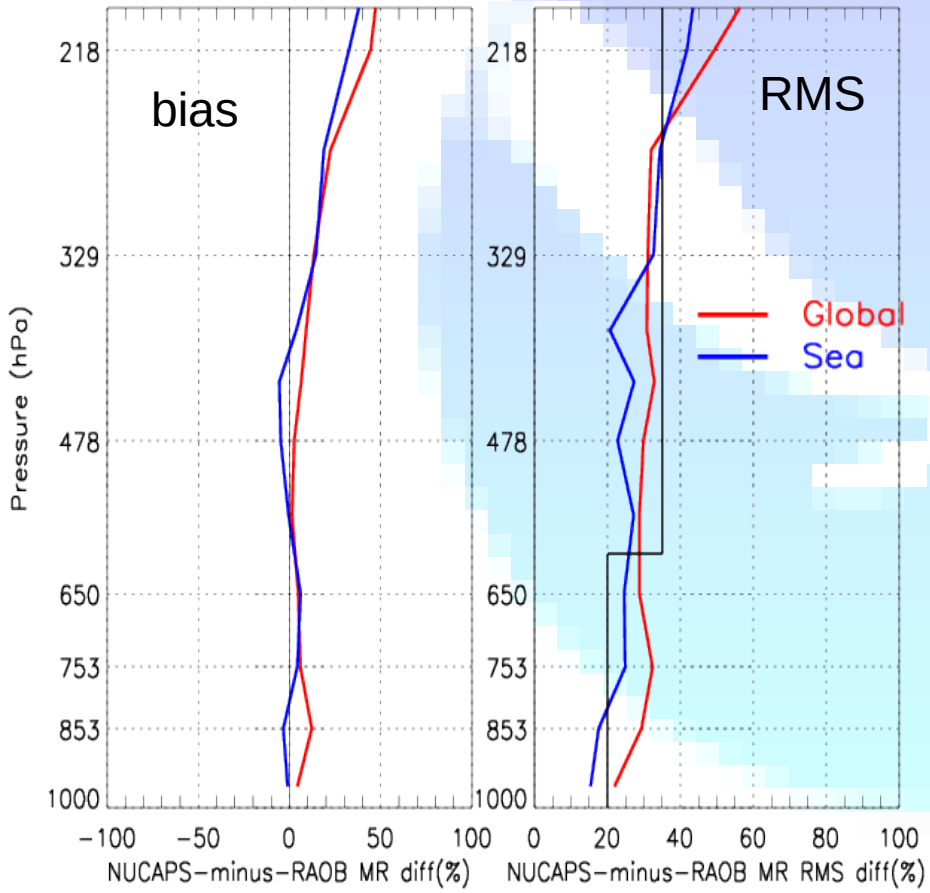
Relative to **Reference** RAOBs



3074 (global), 167 (sea)

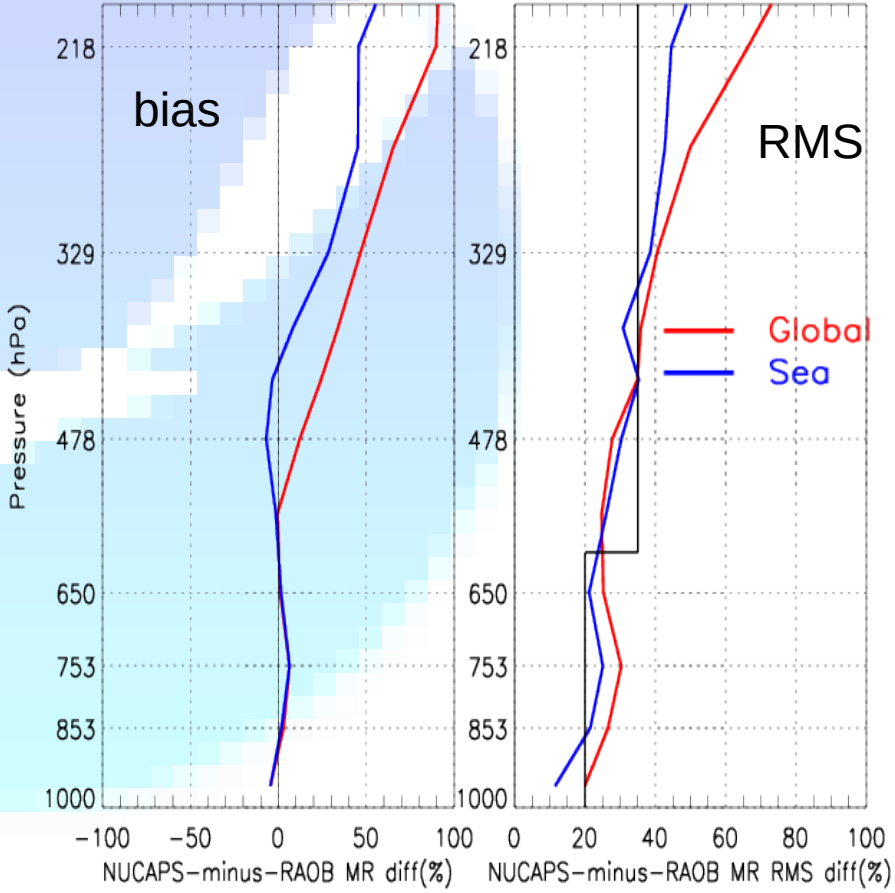
S-NPP NUCAPS IR+MW H20 Vapor MR Statistics (%)

Relative to **Conventional** RAOBs



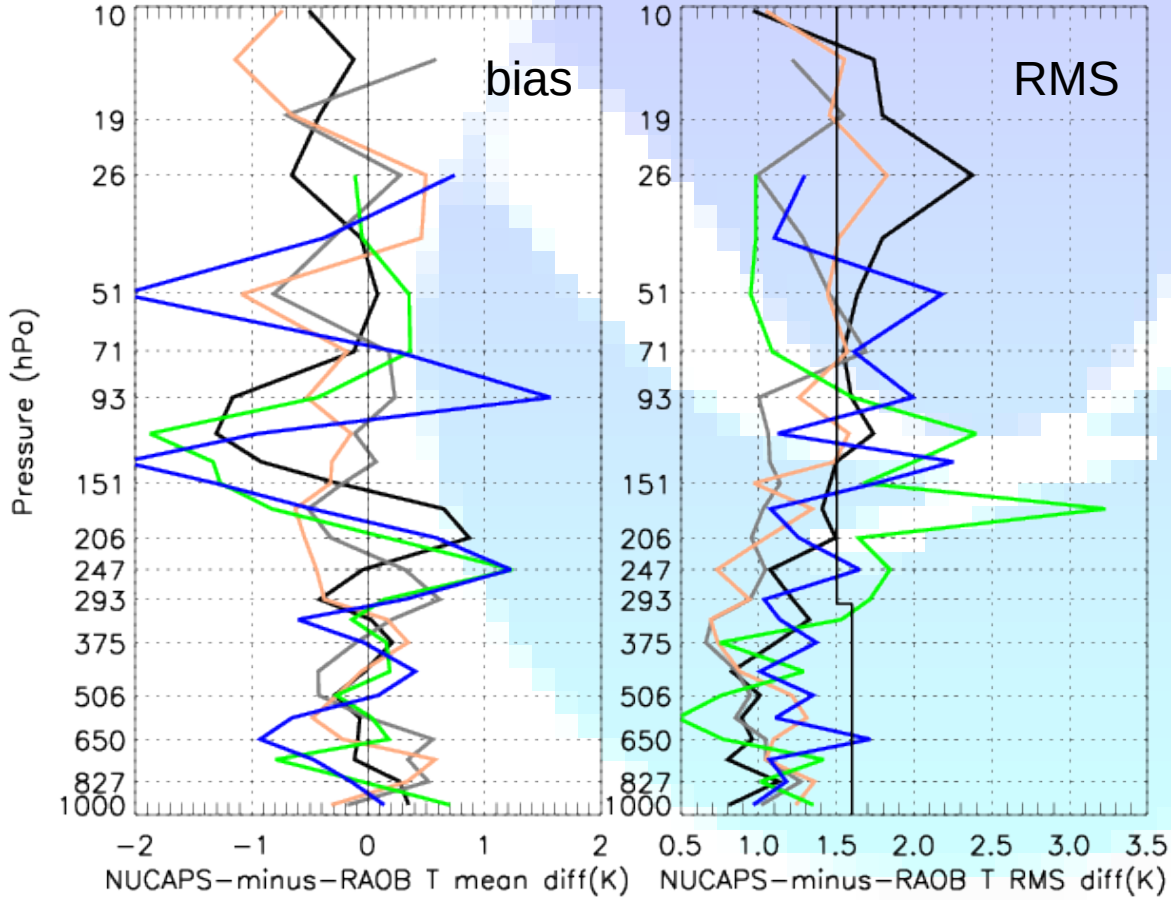
8881 (global), 101 (sea)

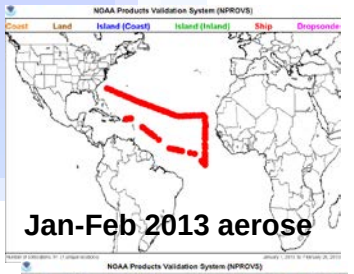
Relative to **Reference** RAOBs

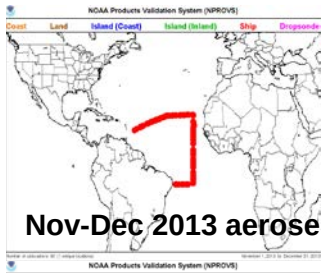


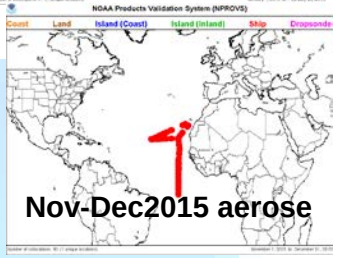
3074 (global), 167 (sea)

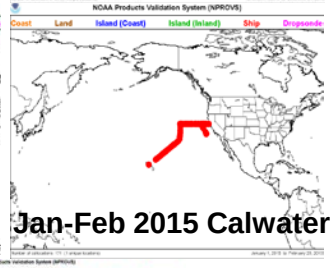
Suomi-NPP NUCAPS IR+MW Temperature Statistics





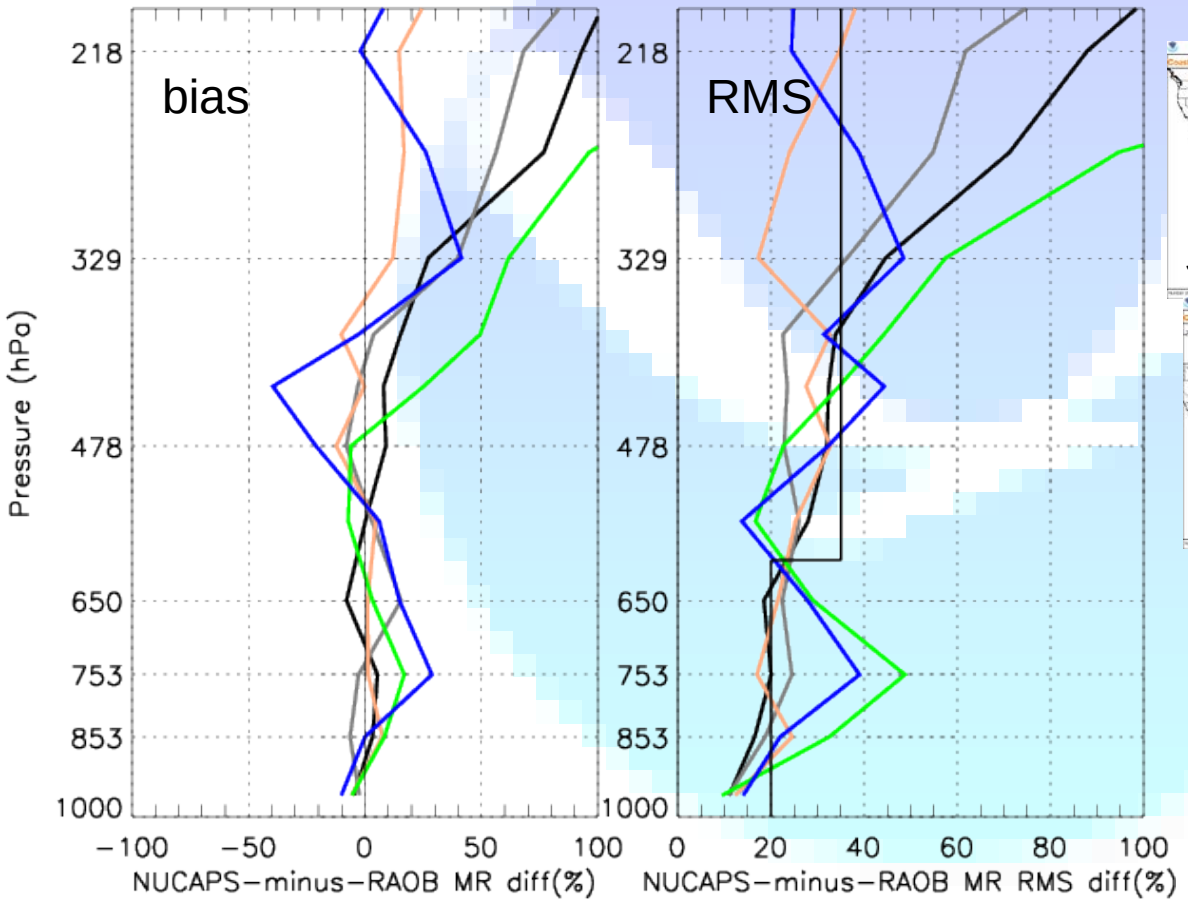


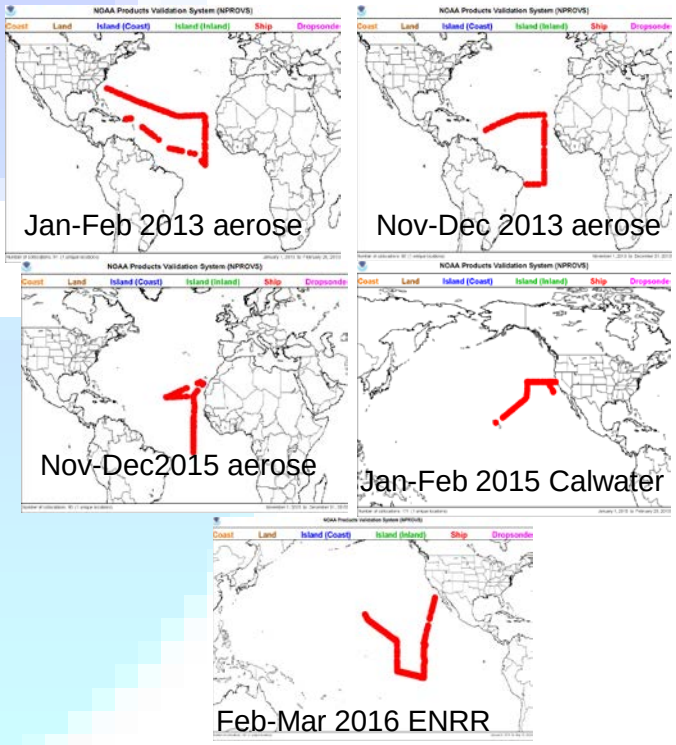




Jan−Feb 2013 AEROSE
Nov−Dec 2013 AEROSE
Nov−Dec 2015 AEROSE
Jan−Feb 2015 CALWATER
Feb−Mar 2016 ENRR

Suomi-NPP NUCAPS IR+MW Water Vapor Statistics



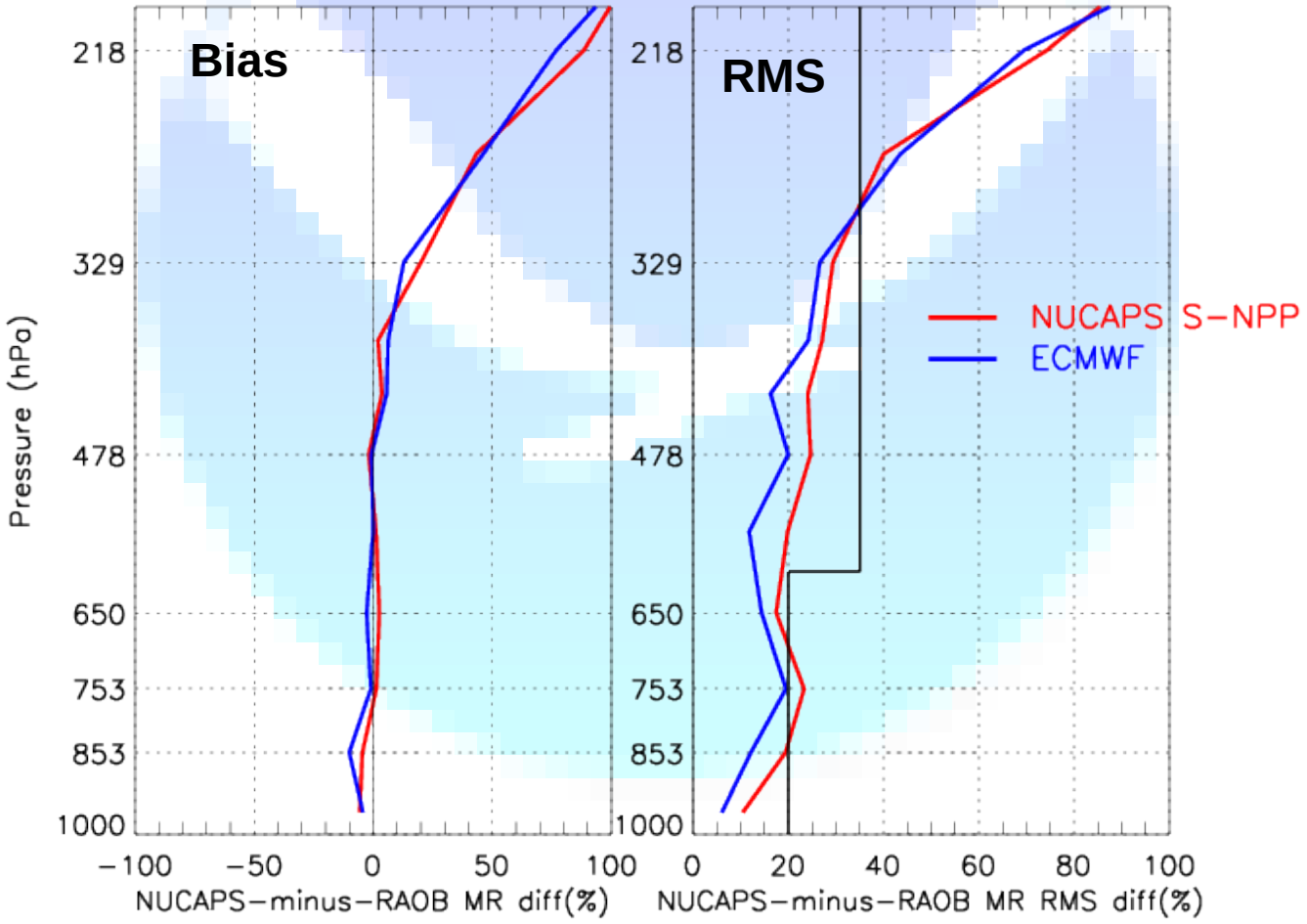


Jan−Feb 2013 AEROSE
Nov−Dec 2013 AEROSE
Nov−Dec 2015 AEROSE
Jan−Feb 2015 CALWATER
Feb−Mar 2016 ENRR

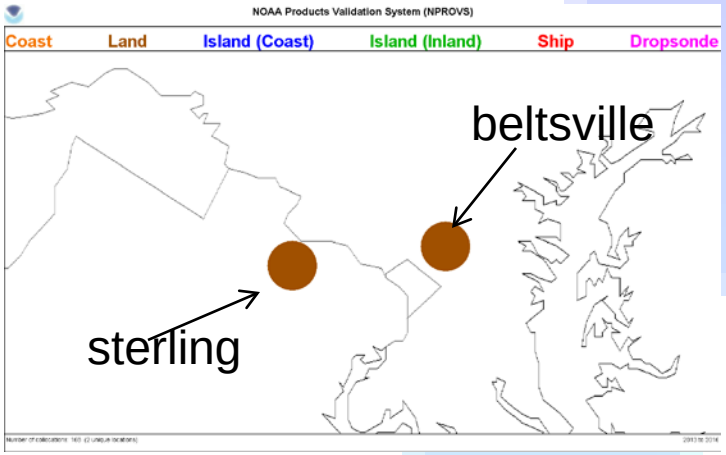
NUCAPS IR+ MW *vs.* ECMWF analysis

relative to JPSS funded field campaign ship RAOBs

Water Vapor Mixing Ratio % diff.



Beltsville & Sterling RAOBs for S-NPP Evaluation

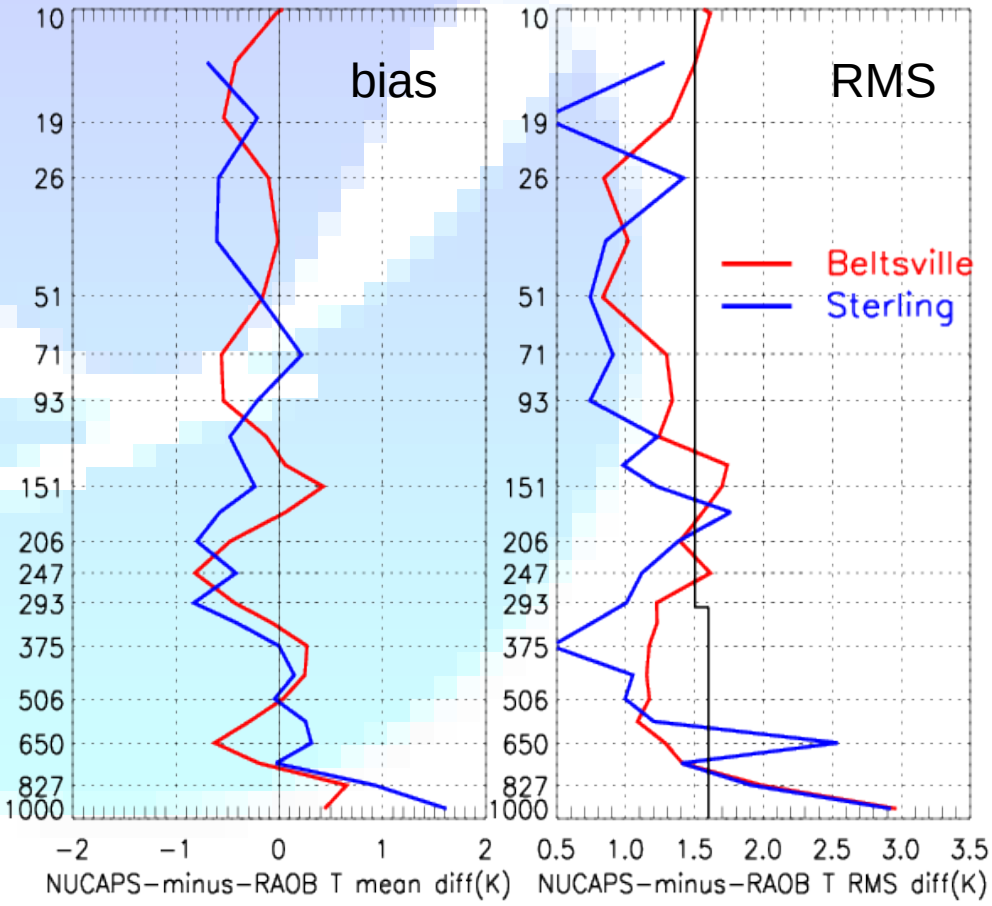


Launch Synchronizations Summary

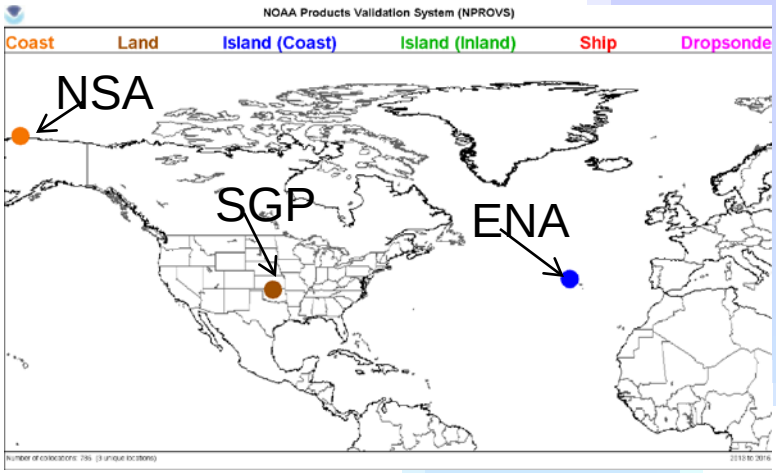
- **8** Sterling synchronized to S-NPP
- **90** Beltsville synchronized to S-NPP
- 4 Sterling / Beltsville synchronized to S-NPP:

• 10/10/15	7100	1733 Z
• 3/18/16	7200	1730 Z
• 4/15/16	7100	1705 Z
• 4/18/16	7100	0700 Z

S-NPP IR+MW Temperature

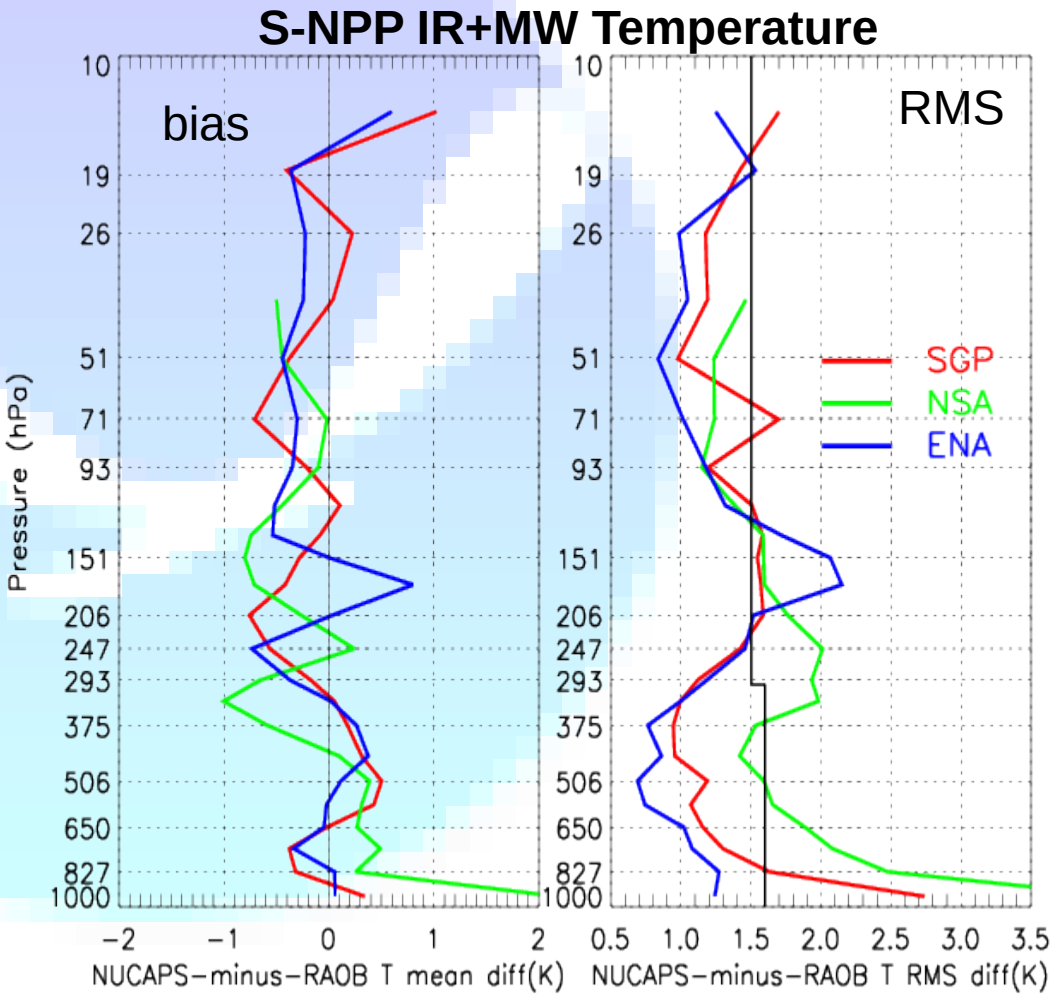


ARM RAOBs for S-NPP Evaluation

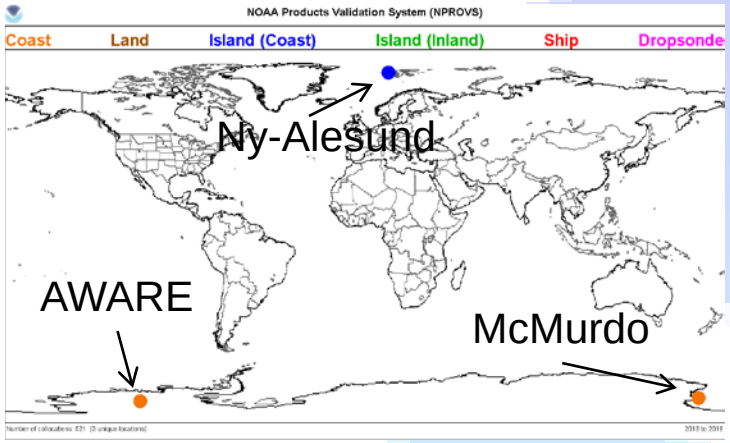


RAOB Launches synchronized with S-NPP

- **367 at SGP site**
- **341 at NSA site**
- **73 at ENA**



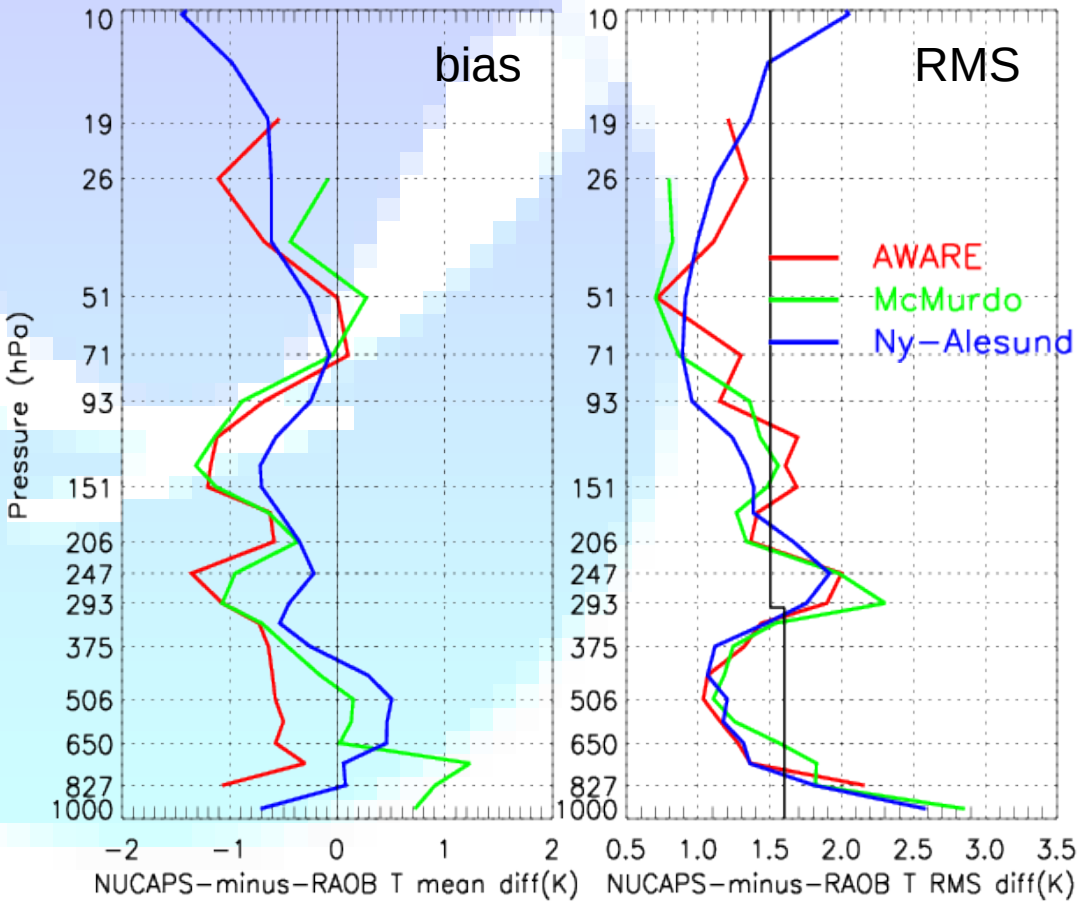
North and South Polar RAOBs for S-NPP Evaluation



RAOB Launches within 1hr/50km of S-NPP

- **30 at AWARE ARM site**
- **28 at McMurdo ARM site**
- **398 at Ny-Alesund, Norway**

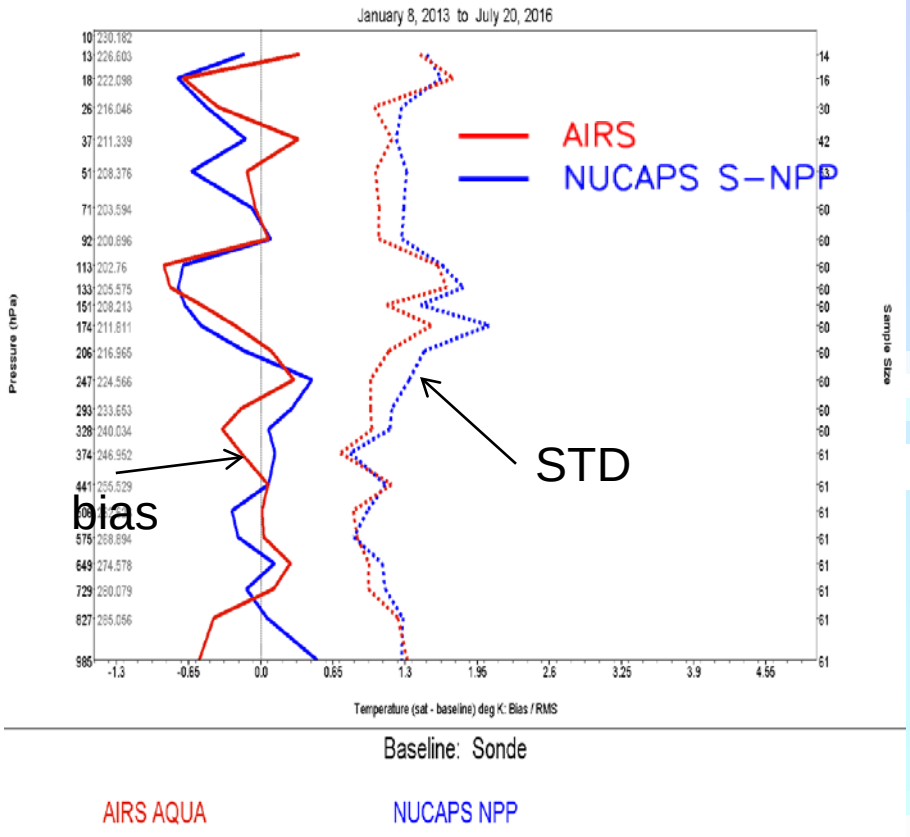
S-NPP IR+MW Temperature



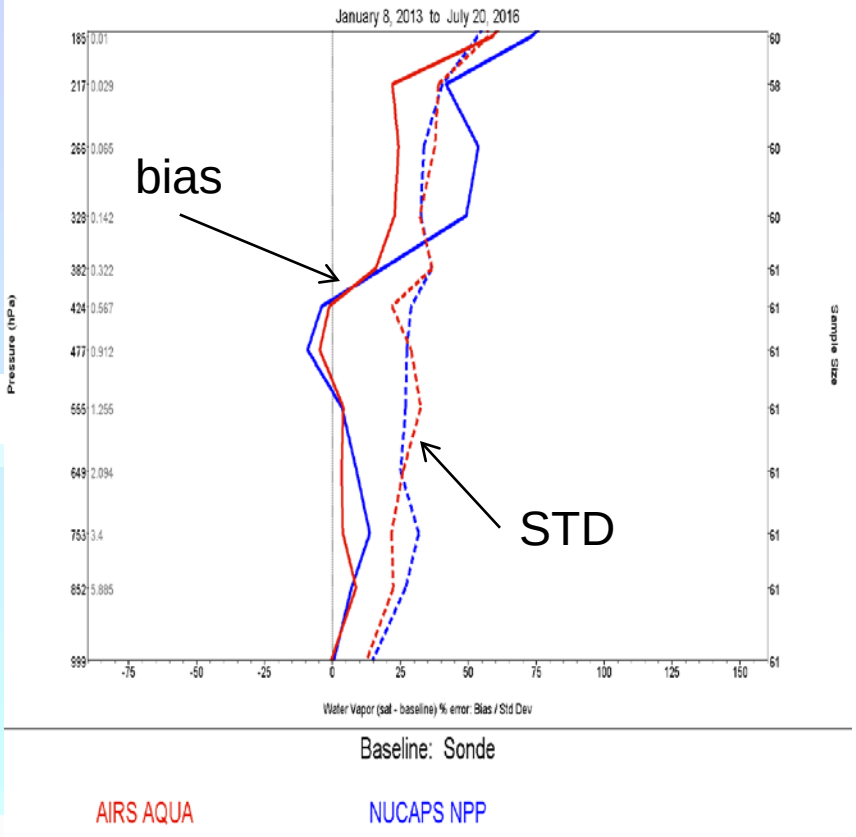
IR+MW NUCAPS S-NPP vs. AIRS Retrieval Statistics

(Sea data, relative to Reference sondes)

Temperature



Water Vapor Mixing Ratio



Sample: 60 collocations (+/- 1.5 hr & 50 km)

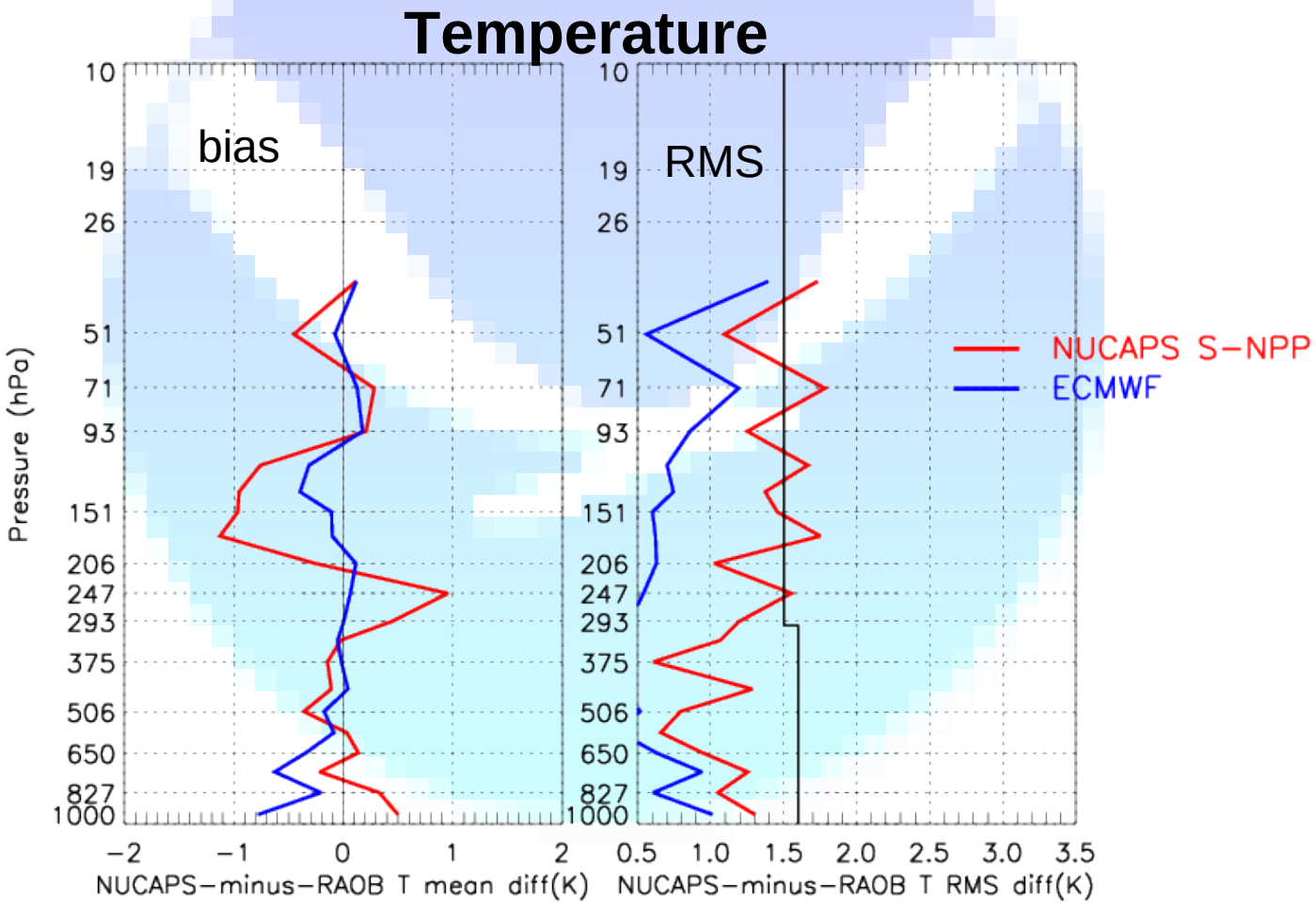
Summary

- NPROVS+ (anchored to Reference RAOBs) and NPROVS (anchored to *conventional* RAOB) are complementary in support of JPSS atmospheric sounding EDR cal/val
- Analysis of satellite collocations with conventional (6 months) and with Reference RAOBs (3 yrs), done globally and at individual sites, indicated
  - NUCAPS IR+MW temperature and water vapor retrievals perform well
- Uncertainties were discussed in the context of hyperspectral sounder retrieval validation:
  - Time mismatch matters
  - Satellite *vs*. radiosonde vertical resolution inconsistency
  - Radiosonde accuracy including warm T and dry humidity at the upper levels

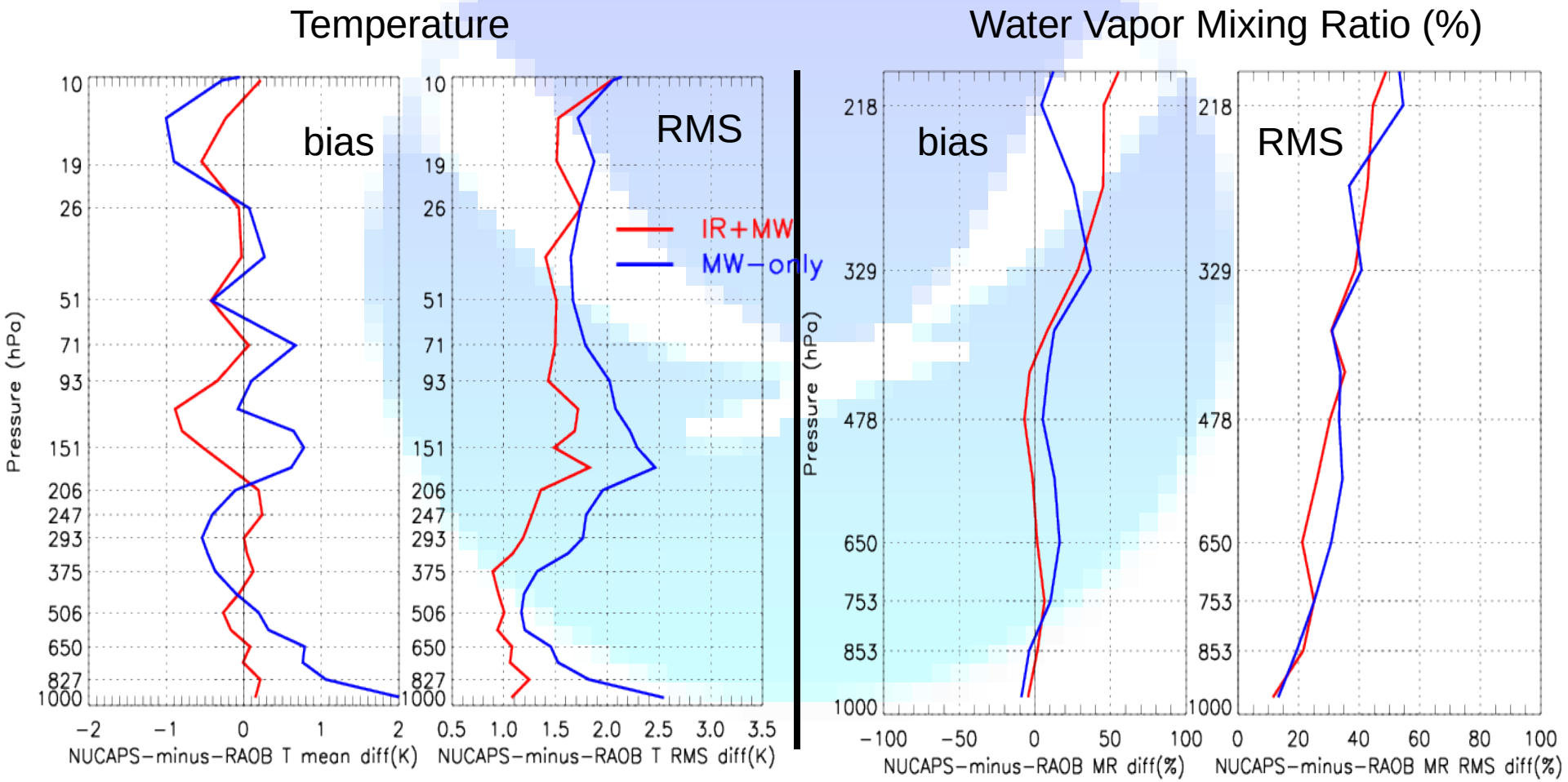
- END

NUCAPS IR+ MW *vs.* ECMWF analysis

relative to NOAA field campaign ship RAOBs



S-NPP NUCAPS IR+MW *vs*. MW-only Retrieval Statistics (Sea data; relative to Reference sondes)



IR+MW (122), MW-only (185)