



# **JPSS Radiosonde Program**

## **Validation of NUCAPS at ARM Sites**

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# JPSS Radiosonde Program

## Who is involved?

- Coordinated effort involving:



## What is being done?

- Radiosondes launched from ARM sites coincident with S-NPP overpasses

## Goals:

- Obtain accurate & on-going validation data for assessment of S-NPP soundings

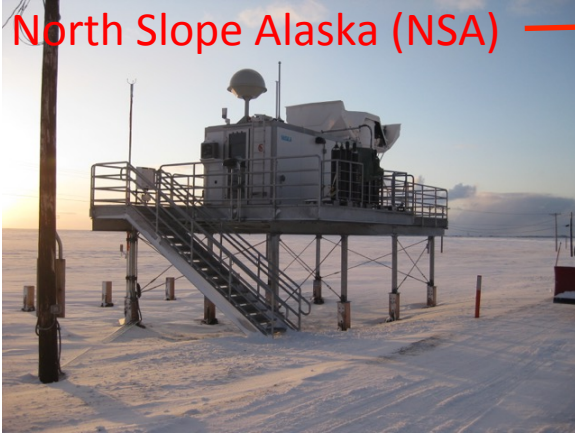
## Heritage:

- Follows efforts by Tobin et. al., 2006 in the assessments of AIRS temperature and water vapor soundings



# ARM Sites

North Slope Alaska (NSA)



Southern Great Plains (SGP)

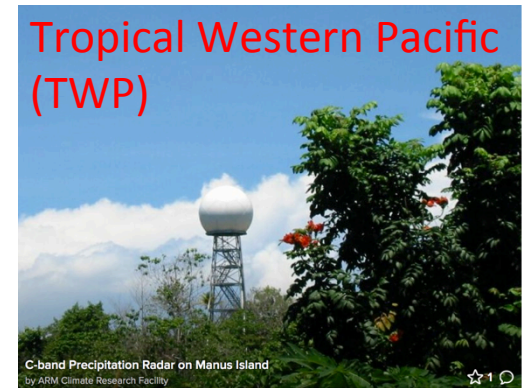


Eastern North Atlantic (ENA)



- S-NPP launches started Feb 2015

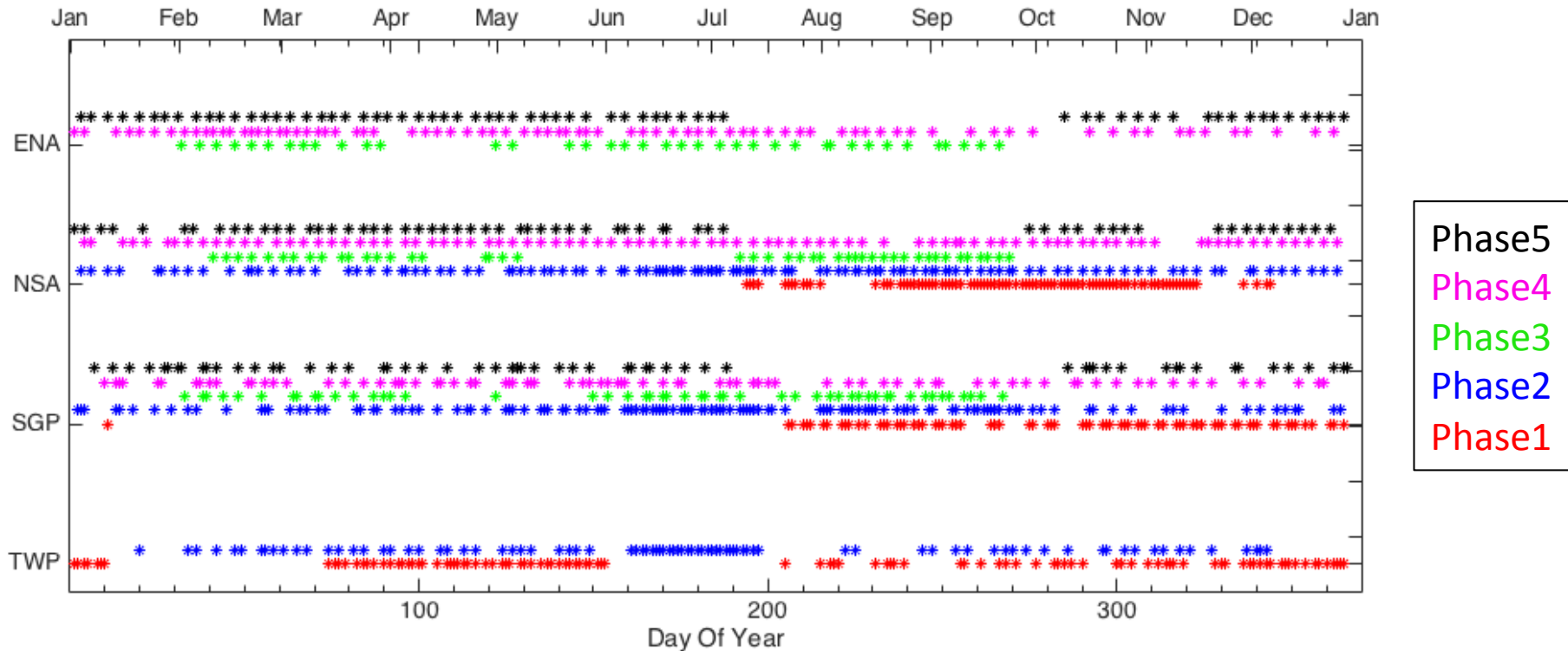
Tropical Western Pacific (TWP)



- site closed May 2014



# Radiosonde Launches



- S-NPP radiosonde launches began in July 2012 and are ongoing
- Radiosonde launches have occurred across seasons and have sampled a range of atmospheres at each site
- Phase-5 (black) began October 1, 2016 & runs through September 2017
- Phase-6 funding will target JPSS-1



# Logistics

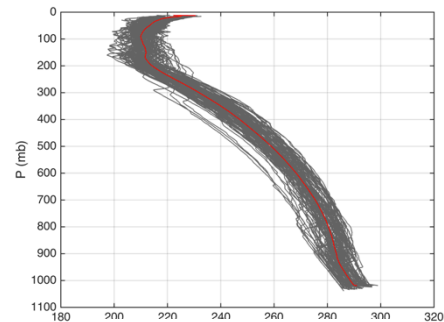
1. JPSS project provides funds for radiosondes to ARM
2. UW provides ARM with launch schedules for 'acceptable' overpasses at each site
  - meets view angle criteria ( $\leq 30$  deg)
  - not fully overcast and/or heavily precipitating as judged by site operator
3. ARM launches radiosondes

**ARM Sondes are Valuable!**

# Radiosonde Temperature & WV Profile Distributions

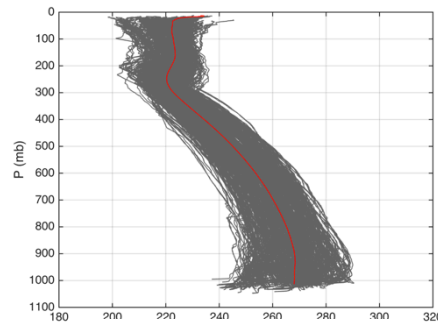
- While the collection sites are limited in number, the profiles consist of highly accurate measurements of a wide range of climatic conditions

**ENA**



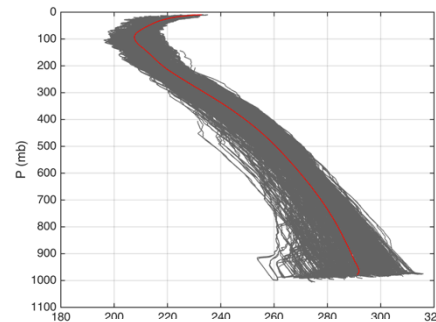
**Temperature (K)**

**NSA**



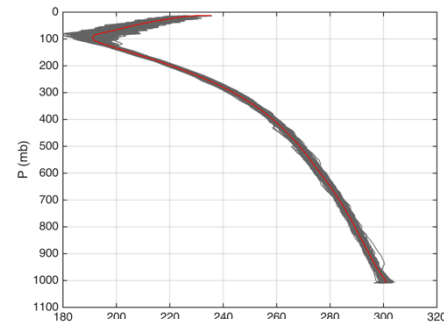
**Temperature (K)**

**SGP**



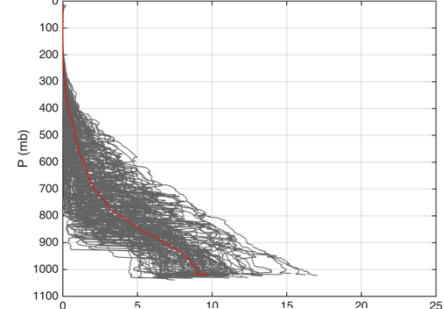
**Temperature (K)**

**TWP**



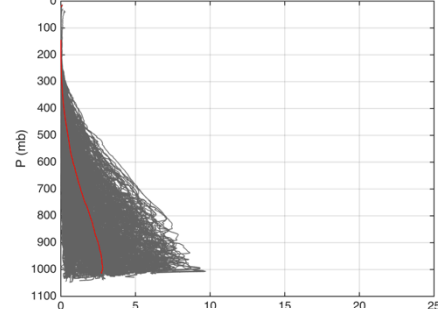
**Temperature (K)**

**ENA**



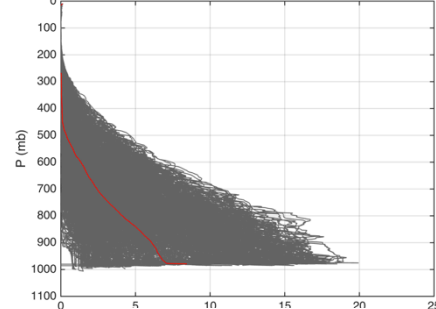
**H2O (g/kg)**

**NSA**



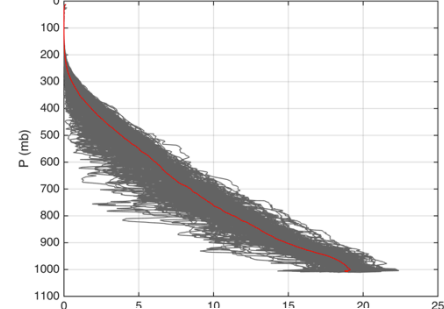
**H2O (g/kg)**

**SGP**



**H2O (g/kg)**

**TWP**



**H2O (g/kg)**

# Logistics

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## ARM Sondes are Valuable!

- Sondes are accurate and traceable to calibrated reference
- ARM providing:
  - Supplies & equipment

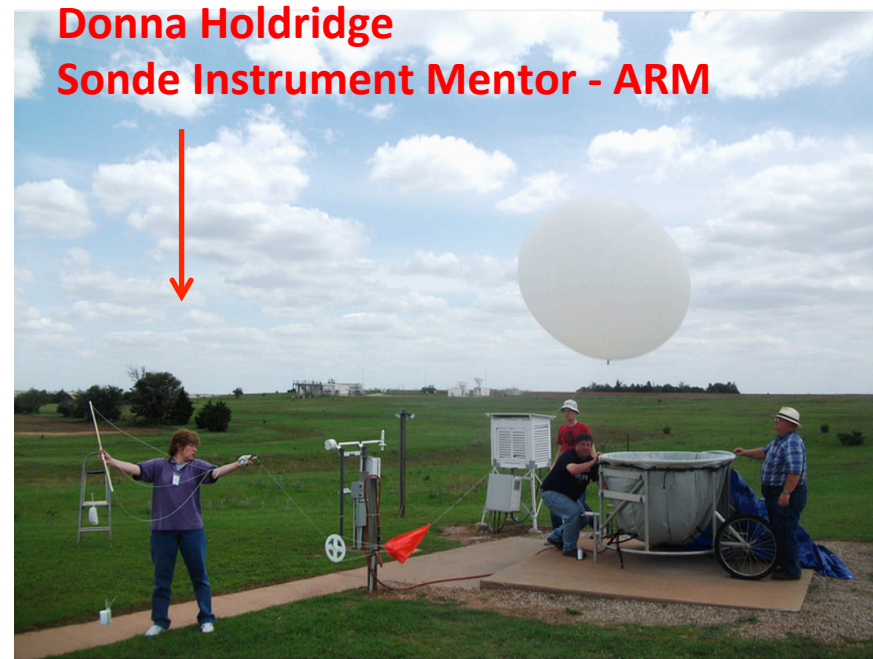


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## ARM Sondes are Valuable!

- Sondes are accurate and traceable to calibrated reference
- ARM providing:
  - Supplies & equipment
  - Expertise to launch sondes consistently at various sites
  - Suite ancillary measurements
    - Microwave radiometers
    - Ceilometers
    - AERI





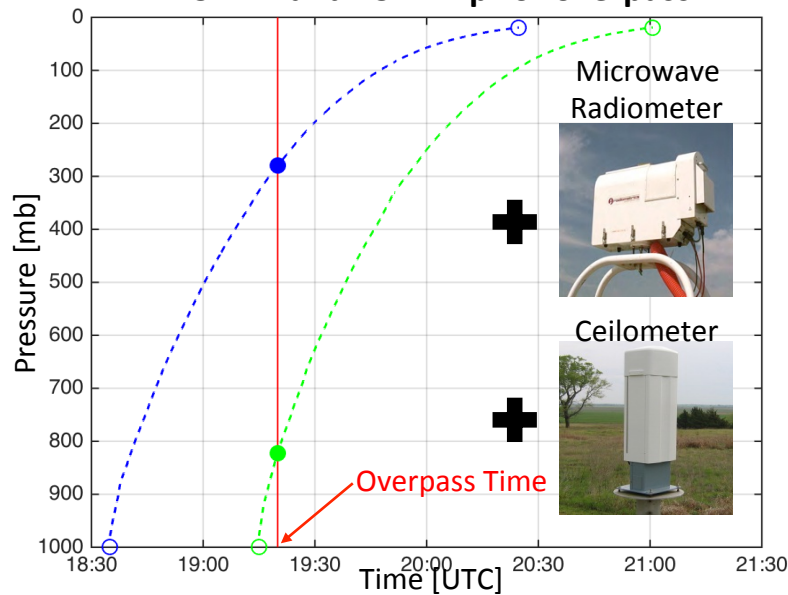
# JPSS Radiosonde Program

## Best Estimate of Atmospheric State (BE)

- Sondes interpolated to common pressure grid
- MWR PWV scaling applied to sonde RH & WVMR
- Sondes interpolated to overpass time (dual launch)

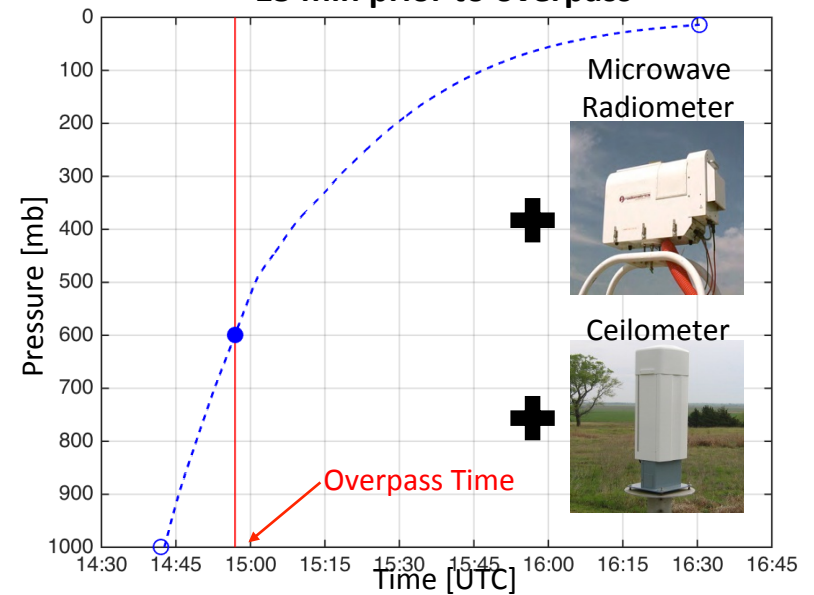
### Dual Launch Strategy: NSA & SGP

~45 min and ~5 min prior overpass



### Single Launch Strategy: ENA & TWP

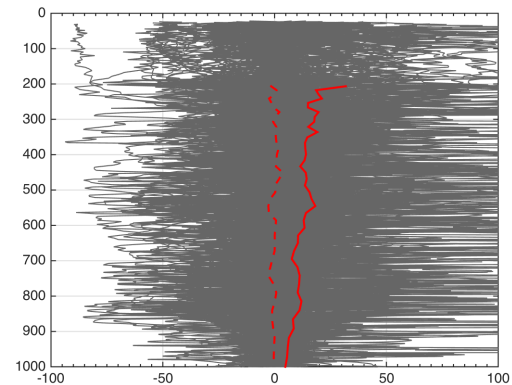
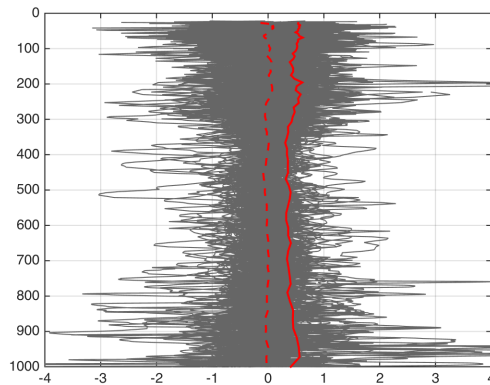
~15 min prior to overpass



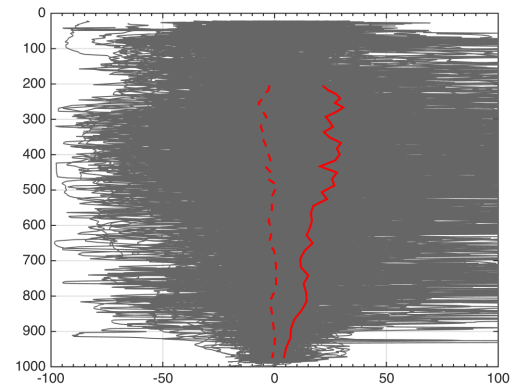
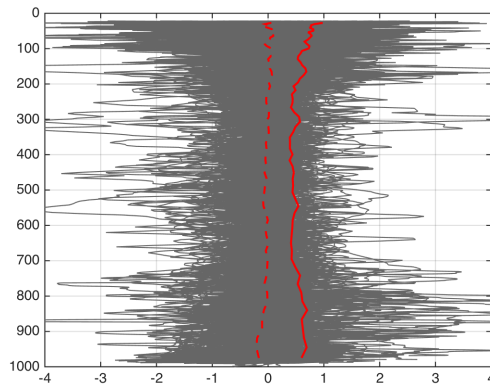
# Short Term Variability at NSA & SGP

- Differences between sonde pairs are shown
- mean (dashed) & RMS (solid) differences shown in red for 1km (temp) & 2km (h2o) layers
- The variability in temperature that occurs within ~40 minutes is  $3/4^{\circ}\text{K}$
- The water vapor RMS percent differences range from 5-30%

**NSA**



**SGP**

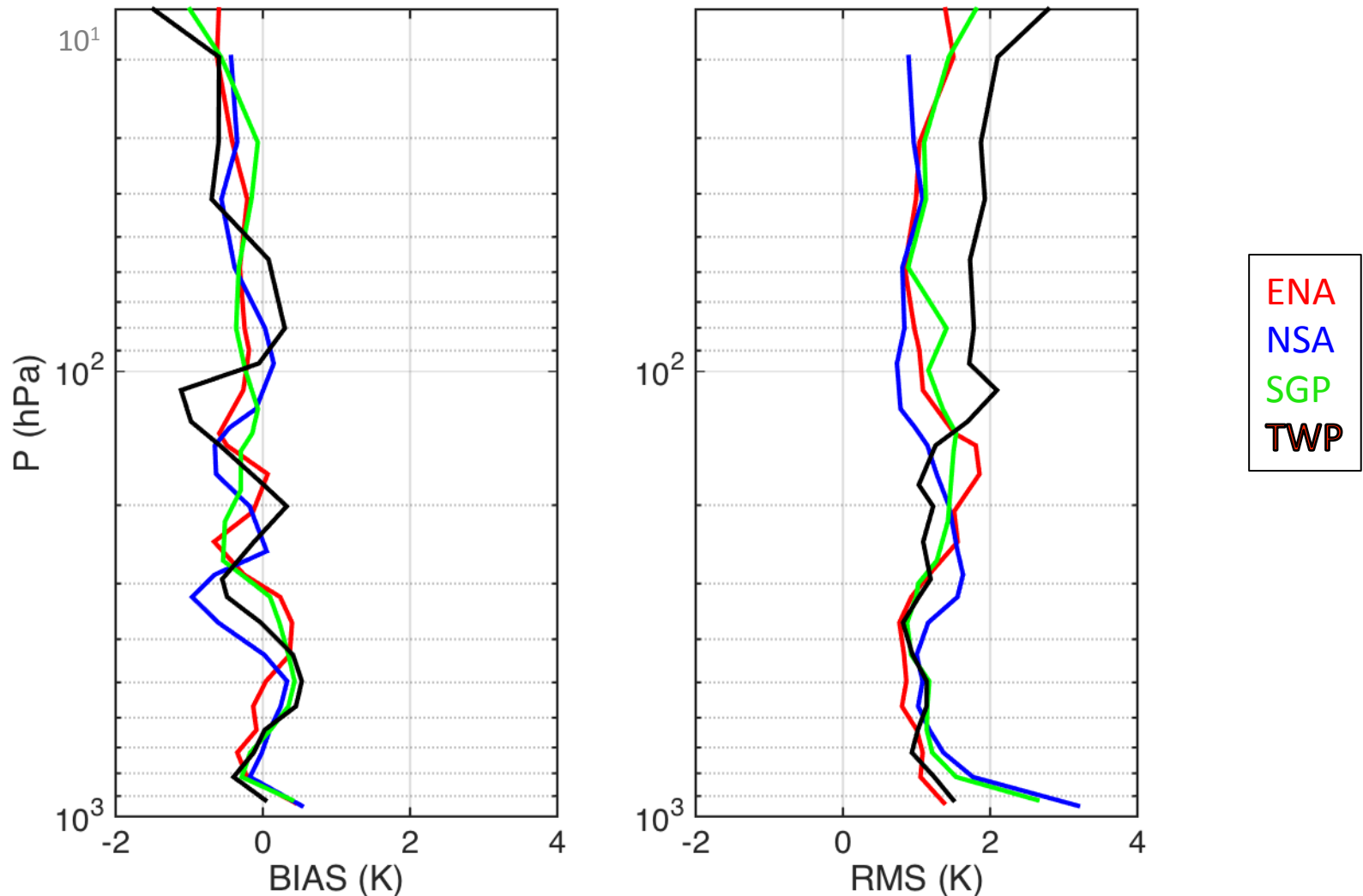


**Temperature (K)**

**H2O (%)**

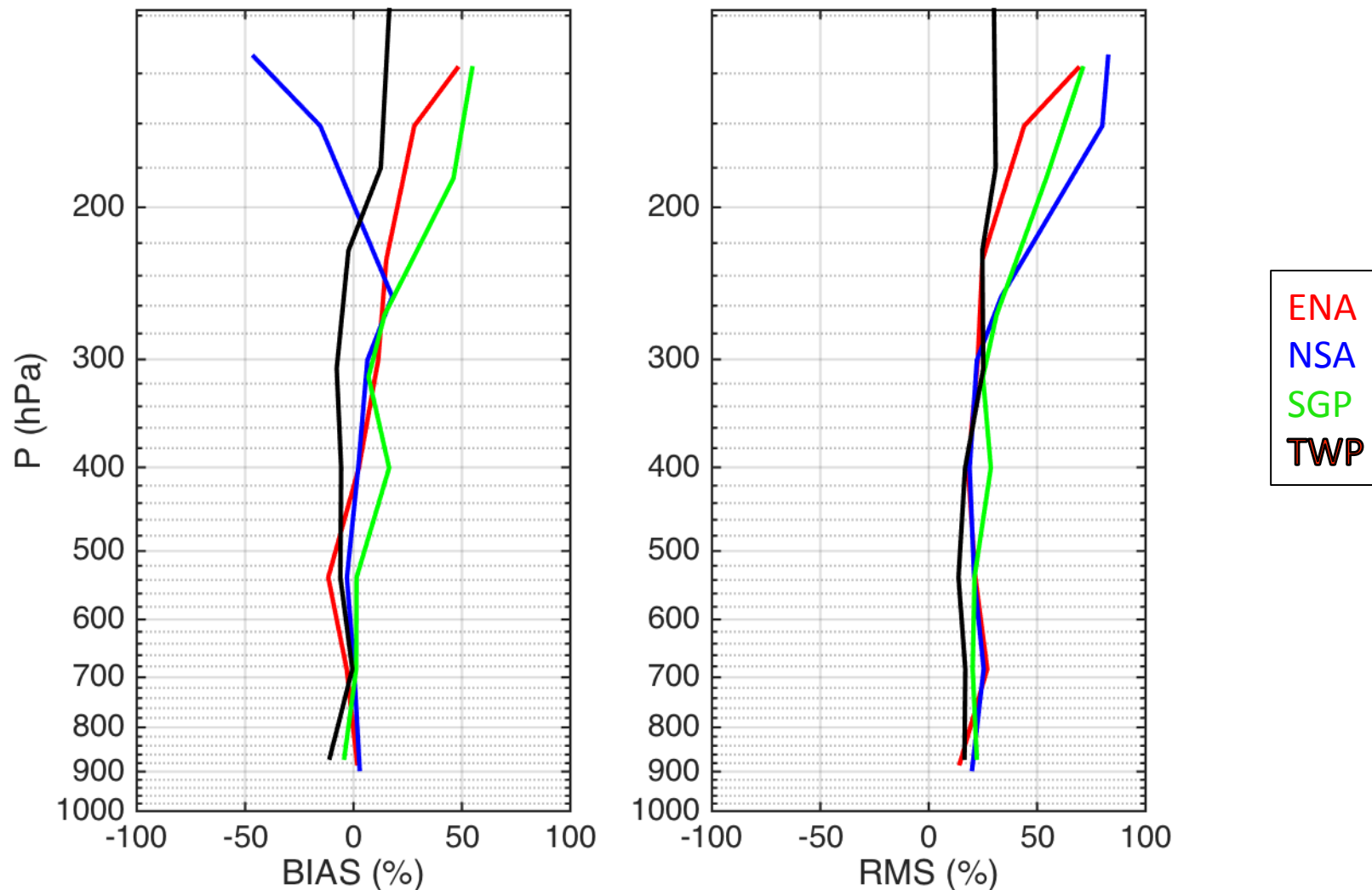
# Validation of NUCAPS Temperature Retrievals Using BE

- 1km layer Temp Differences (NU-BE) shown for each site and ALLSky conditions
- BIAS (left) & RMS (right)



# Validation of NUCAPS H2O Retrievals Using BE

- 2km layer H2O\_MR differences (NU-BE) shown for each site and ALLSky conditions
- BIAS (left) & RMS (right)







# Validation of NUCAPS

**Using a multi-year BE product to validate NUCAPS can be difficult ...**

- **Requires consistently processed NUCAPS dataset**
- **Which in turn requires consistently processed set of CrIS & ATMS SDRs**

**Accomplished using Community Satellite Processing Package (CSPP)**

# CSPP Overview

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The Community Satellite Processing Package (CSPP) is a collection of **freely available software** for processing data from LEO and GEO meteorological satellites.

CSPP supports the creation of **calibrated observational data, geophysical derived products, and mapped images** from visible, infrared, and microwave sensors.

The CSPP project is based at the **Space Science and Engineering Center** at the University of Wisconsin-Madison and is funded by **NOAA JPSS Program Office**.

# Satellites supported by CSPP

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CSPP LEO supports processing of data from these satellites in low earth orbit:

*Suomi NPP, Metop-A/B, NOAA-18/19, Terra, Aqua, GCOM-W1, and FY-3B/C.*

Data source is usually Direct Broadcast (DB) from the spacecraft. However, archived data are also supported (e.g., NOAA CLASS, NASA DAAC).



# Validation of NUCAPS

Using a multi-year BE product to validate NUCAPS is somewhat of a moving target ...

- Requires consistently processed NUCAPS dataset
- Which in turn requires consistently processed set of CrIS & ATMS SDRs

Accomplished using Community Satellite Processing Package (CSPP)

**Previous analysis is a validation of CSPP NUCAPS**

- **CrIS RDRs edited to contain consistent set of NL coefs**
- **CSPP v2.2.4 (equivalent to IDPS Mx8.11) used produce CrIS & ATMS NSR SDRs**
- **CSPP NUCAPS v1\_1 used produce NUCAPS retrievals**

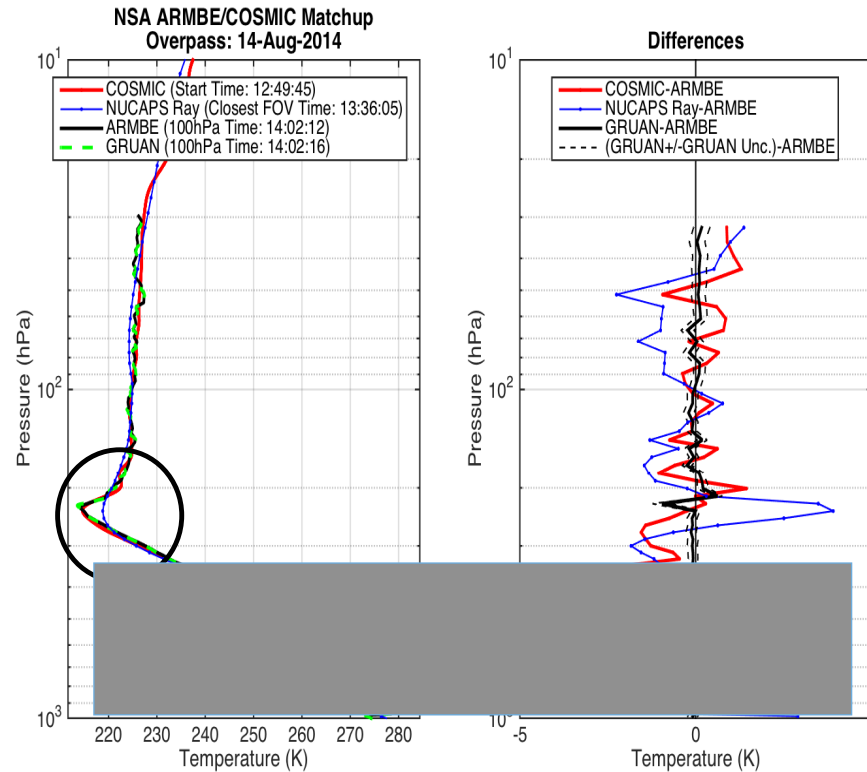
**Future of CSPP:**

- **Block2 build of CSPP is currently being tested**
- **Block2 version of CSPP will be capable of producing both NSR & FSR CrIS SDRs**



# Validation of NUCAPS Stratospheric Temperature Profiles

## COSMIC Case Study at NSA



### Matchup Criteria:

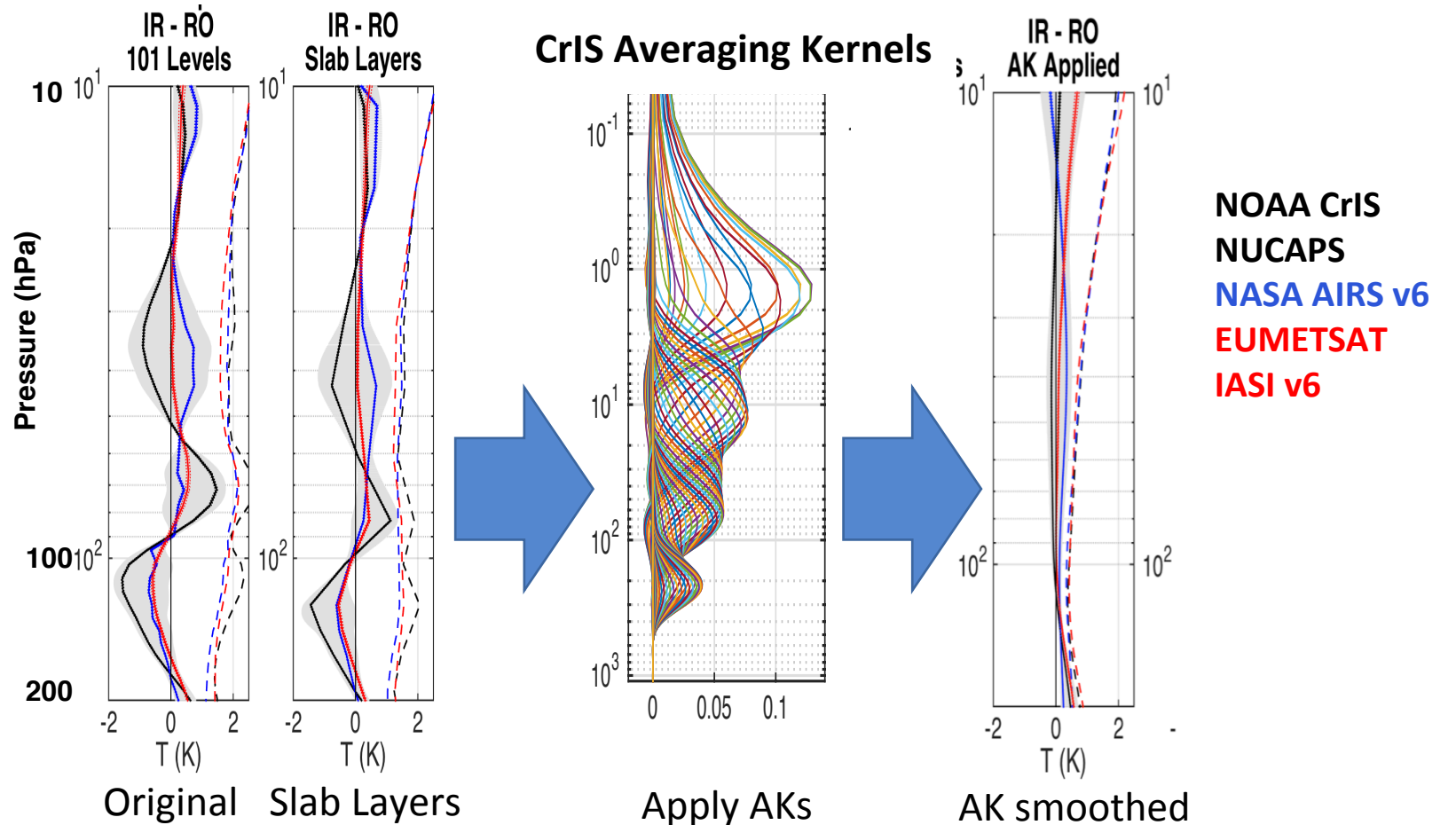
- 100km/1hr

Oscillation (blue line) is seen in NUCAPS statistics

- This is an example showing benefit of RO & sonde over IR sounder
- RO & sonde pick up coldest layer at tropopause
- NUCAPS captures general structure well, but not able to pick up finer vertical structures

# Validation of NUCAPS Stratospheric Temperature Profiles

**Tropical Zone: 30S – 30N**  
**DJF**



Recently Accepted: Feltz, M., et al., Assessment of NOAA NUCAPS Upper Air Temperature Profiles Using COSMIC GPS Radio Occultation and ARM Radiosondes, *JGR: Atmospheres*, doi: 10.1002/2017JD026504

# Validation of NUCAPS Stratospheric Temperature Profiles

ARM Radiosonde, COSMIC, and NUCAPS Matchup Statistics 40-100 hPa Average									
	AK*(NUCAPS-RO)			AK*(NUCAPS-Sonde)			RO-Sonde		
	Bias	2*Unc.	RMS	Bias	2*Unc.	RMS	Bias	2*Unc.	RMS
NSA									
Annual	-0.144	0.151	1.10	-0.203	0.0926	0.70	-0.130	0.258	1.78
SGP									
Summer	-0.291	0.199	0.796	-0.089	0.176	0.66	0.229	0.576	2.00
SGP									
Winter	-0.174	0.155	0.526	-0.145	0.293	0.95	-0.008	0.649	2.02
TWP									
Annual	-0.174	0.189	0.405	-0.171	0.176	0.371	-0.068	0.764	1.41

**Table.** ARM site radiosonde, COSMIC, and NUCAPS matchup statistics averaged over the 40 to 100 hPa vertical range for the 3 year time period April 2012 through May 2015. Uncertainties are 2 times the uncertainty of the mean ( $k=2$ ). Collocation criteria require the matchups to occur less than 300 km away from the ARM site and that the time of the radiosonde is within 3 hrs of the RO and NUCAPS matchup time (see text for details).

Recently Accepted: Feltz, M., et al., Assessment of NOAA NUCAPS Upper Air Temperature Profiles Using COSMIC GPS Radio Occultation and ARM Radiosondes, *JGR: Atmospheres*, doi: 10.1002/2017JD026504



# Validation of NUCAPS Stratospheric Temperature Profiles

Feltz, Michelle, R. Knuteson, L. Borg, D. Tobin, H. Revercomb, S. Ackerman (2017), **Assessment of NOAA NUCAPS Upper Air Temperature Profiles Using COSMIC GPS Radio Occultation and ARM Radiosondes**, *JGR: Atmospheres*, doi: 10.1002/2017JD026504 (in press)

- Radio occultation (RO) has highest temperature accuracy in the upper-troposphere, lower-stratosphere. Focus on UCAR COSMIC and EUMETSAT MetOp GRAS RO dry temperature.
- Comparison of NUCAPS retrievals with RO profiles offers a common reference point for comparison of NUCAPS with other IR/MW retrievals. This study compares NOAA NUCAPS (ATMS/CrIS) soundings with NASA AIRS v6, and EUMETSAT IASI v6 operational products.
- Analysis of the NUCAPS difference statistics should include vertical smoothing to degrade products to a common vertical resolution. Calculated vertical averaging kernels (AKs) lead to excellent agreement ( $< 0.3\text{K}$ ) for NUCAPS and ( $< 0.5\text{K}$  for AIRS & IASI, not shown).



# Radiosonde Intercomparison and VALidation (RIVAL)

JPSS Radiosonde Program will be collaborating with GRUAN in the RIVAL field campaign at ARM

## What is RIVAL?

- ARM field campaign starting ~Oct 2017
- Vaisala will stop producing RS92 radiosondes this month
- RS92 sondes will be replaced by RS41 model
- RIVAL is motivated by the need for a sustained intercomparison and validation campaign to fully quantify the RS92-RS41 sonde differences

## Benefits of RIVAL to JPSS Radiosonde Program:

- Twin soundings (RS92 & RS41 on same balloon) will occur weekly at ENA, NSA, and SGP coordinated with SNPP & J1 overpasses
  - JPSS provides RS41 & ARM provides RS92
- RRS92/RS41 differences will be assessed ensuring continuity of radiosonde dataset
- Better Best Estimate (BE) of atmospheric state

## What is GRUAN?

The Global Climate Observing System (GCOS) Reference Upper-Air Network

<https://www.gruan.org/>





# Conclusions & Future Work

## Conclusions:

- JPSS radiosonde program is ongoing and will target J1 after launch
- NUCAPS Temperature and H2O\_MR validations look good relative to BE, further analysis needed to determine what is happening at SFC at NSA & SGP
- CSPP integral to this analysis providing uniform algorithm for processing SDRs and EDRs
- When comparing NUCAPS/AIRS/IASI with RO vertical smoothing should be used to degrade products to common resolution. Excellent agreement ( $< 0.3K$ ) between NU-RO & NU-Sonde.

## Future Work:

- Refinement of BE
- Synchronize sonde launches with COSMIC (if RO can be predicted)
- Collaborate with RIVAL field campaign in assessing RS92/RS41 differences
- Supporting NUCAPS Validation Team in their Efforts
  - Providing Best Estimates for dedicated launches (& CalWater Cruise 2015)
  - Assessing Block2 CSPP NUCAPS using the BE



# JPSS Radiosonde Program

## Validation of NUCAPS at ARM Sites

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