2017 JPSS Annual Meeting
NUCAPS Session Opening Remarks

Chairs:

Antonia Gambacorta, Nick Nalli, Tony Reale

Topics of this session

Part I: Focus on the latest upgrades of the NOAA Unique Combined Atmospheric Processing System (NUCAPS)

Co-chair: N. Nalli

ATMS block 2 upgrades

1. MIT Rapid Transmittance Algorithm (RTA)
2. ATMS block 2 RTA bias tuning
3. ATMS block 2 RTA standard deviation error

CrIS Full Spectral Resolution (FSR) upgrades

1. CrIS FSR SARTA Rapid Transmittance Algorithm (RTA) (Larrabee Strow's talk Thu. h10:10 – 10:30)
2. CrIS FSR RTA bias tuning
3. CrIS FSR RTA standard deviation error
4. CrIS FSR NEDT file
5. CrIS FSR channel selection
6. CrIS FSR regression LUTs:
    a. Eigenvector file
    b. All sky regression coefficient file
    c. Cloud cleared radiance regression file

Topics of this session

Part II: A detailed validation assessment to prove that performance requirements are met

Co-chairs: Nick Nalli, T. Reale

- Global focus days
- Dedicated in situ measurements
- NPROVS routine in situ measurements
- Today's focus is on temperature and water vapor
- Tomorrow's focus is on atmospheric gases
- New results from single FOV retrieval experiments

Topics of this session

Part III: JPSS Proving Ground and Risk Reduction initiatives

Co-chair: A. Gambacorta

Goal: to demonstrate NUCAPS capabilities under weather regimes of societal value and develop real time users applications

I. **NUCAPS in AWIPS-II**: training & improvements
II. **Aviation Weather Testbed (AWT)**: Cold Air Aloft
III. **Hazardous Weather Testbed (HWT)**: Convective Initiation
IV. **Hydrometeorology Testbed (HMT)**: Pacific field campaigns (2014, 2015 CalWater & 2016 ENRR)
V. **Carbon Monoxide and Methane product evaluation** (NESDIS/STAR & OAR/ESRL/CSD) (To be discussed tomorrow, in the trace gas session)
VI. **Use of NUCAPS Ozone in hurricane extratropical transition applications**

Status of the NOAA Unique Combined Atmospheric Processing System (NUCAPS)

Antonia Gambacorta (1), Nick Nalli (2), Flavio Iturbide-Sanchez(2), Changyi Tan(2), Kexin Zhang(2), Xiaozhen Xiong(2), Bomin Sun(2), Mike Wilson(2), Tish Suillard(2), Tom King(2)

With contributions from:
Chris Barnet(1), Tony Reale(3), Mark Liu(3), Larrabee Strow(4), Lihang Zhou(3), AK Sharma(3), Walter Wolf(3), Mitch Goldberg(5)

2017 JPSS Annual Meeting – NUCAPS Session

[1]STC; [2] IMSG; [3] NOAA/NESDIS/STAR; [4]UMBC; [5]NOAA JPSS

Outline of this talk

- I. Introduction on the NUCAPS system
- II. Overview of the NUCAPS Full Spectral Resolution (FSR) upgrades
- III. Current activities and future directions

N as in NUCAPS

NOAA	NOAA's mandate: ensuring highest computational efficiency and state of art inversion methods to maximize utilization of large volumes of data for a weather ready nation
Unique	A mathematically sound, globally applicable (land/ocean, day/night, all season, all sky, TOA-surface) hyperspectral retrieval code
Combined	… that can fully exploit all available satellite assets: infrared, microwave, visible
Atmospheric	… to generate a full suite of retrieval products: cloud cleared radiances, skin temperature, vertical profiles of temperature, water vapor, O3, CO, CH4, HNO3, N2O, SO2, CO2 (future: HN3)
Processing	… by the use of a modular design compatible with multiple platforms: Aqua, MetOp, SNPP, JPSS, EPS-SG
System	NUCAPS has been running operationally at NOAA since 2004. it is now in AWIPS II. It has been installed in CSPP DB.

Nominal vs Full Spectral Resolution CrIS

- **The Cross-Track Infrared Sounder (CrIS)** is a Fourier spectrometer covering the longwave (655-1095 cm^{-1}, “LW”), midwave (1210-1750 cm^{-1}, “MW”), and shortwave (2155-2550 cm^{-1}, “SW”) infrared spectral regions.

- **Past operations (NUCAPS Phase 1-3):**
  - Maximum geometrical path *L* of 0.8 cm (LW), 0.4 cm (MW) and 0.2 cm (SW)
  - Nyquist spectral sampling (*1/2L*): 0.625 cm^{-1}, 1.25 cm^{-1} and 2.5 cm^{-1}

- **Experimental since 2013 – Operational in August 2017 (NUCAPS Phase 4):**
  - Maximum geometrical path *L* of 0.8 cm in all three bands
  - Nyquist spectral sampling (*1/2L*): 0.625 cm^{-1} in all three bands

Overview of NUCAPS Phase 4 CrIS FSR and ATMS block 2 LUT updates

ATMS block 2 upgrades

1. MIT Rapid Transmittance Algorithm (RTA)
2. ATMS block 2 RTA bias tuning
3. ATMS block 2 RTA standard deviation error

CrIS Full Spectral Resolution (FSR) upgrades

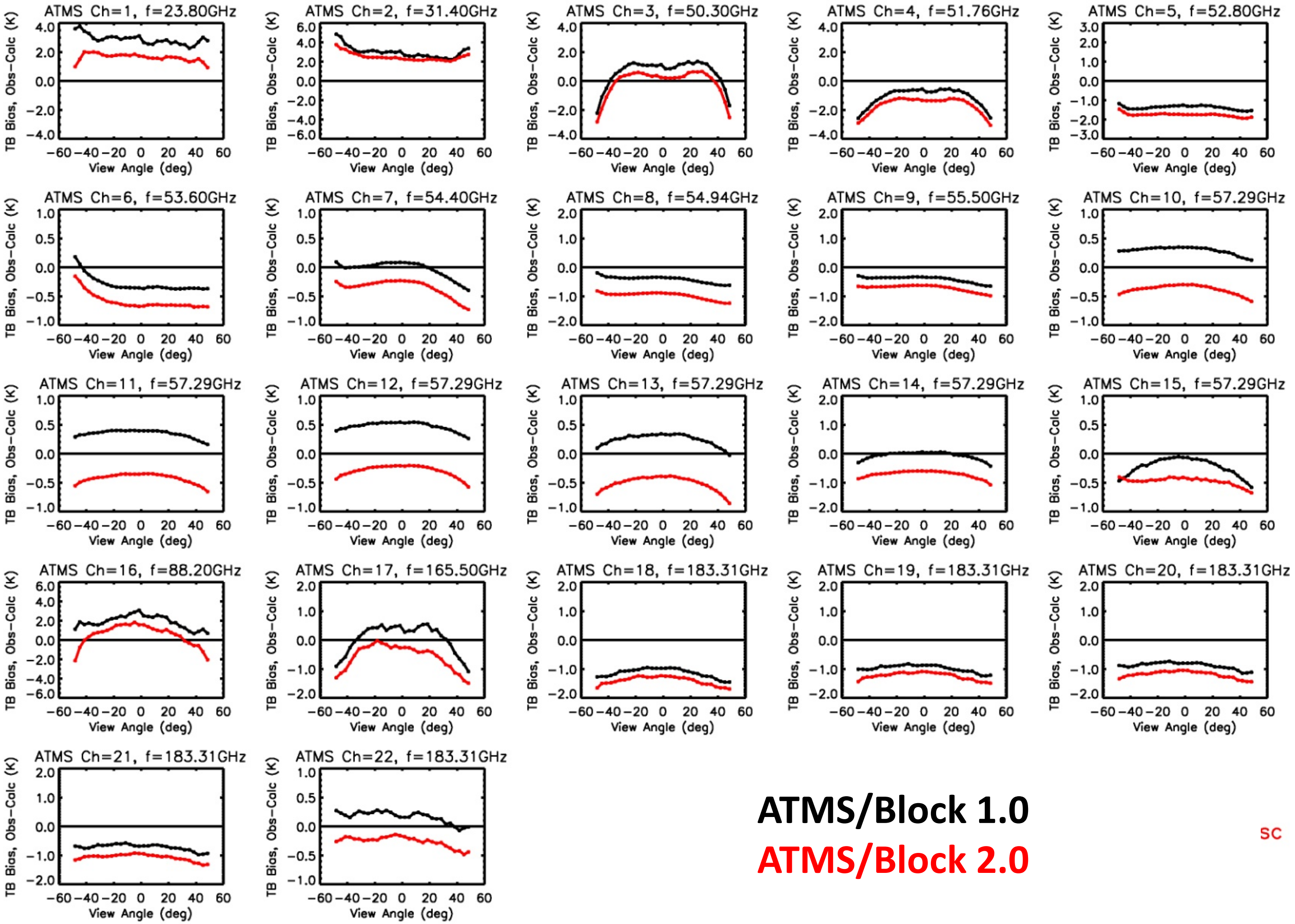
1. CrIS FSR SARTA Rapid Transmittance Algorithm (RTA) (Larrabee Strow's talk Thu. h10:10 – 10:30)
2. CrIS FSR RTA bias tuning
3. CrIS FSR RTA standard deviation error

Changyi Tan's poster (Tue. 5-7:30pm)

4. CrIS FSR NEDT file
5. CrIS FSR channel selection
6. CrIS FSR regression LUTs:
   a. Eigenvector file
   b. All sky regression coefficient file
   c. Cloud cleared radiance regression file

Kexin Zhang's poster (Tue. 5-7:30pm)

MW RTA Bias Correction: ATMS/TDR Block 1.0 vs Block 2.0



ATMS/Block 1.0

ATMS/Block 2.0

SC

CrIS Full Spectral Resolution (FSR) SARTA Rapid Transmittance Algorithm (RTA)

Upgrades in the CrIS FSR SARTA RTA (L. Strow's talk in the trace gas session)

- CrIS high-resolution ILS
- HITRAN 2012 (vs 2008 in original CrIS RTA)
- LBLRTM Line Mixing for CO2 and CH4, H2O continuum
- UMBC line-by-line for water vapor
- Improved reflected thermal component for high secant angles
- Tested on 750+ profiles (from ECMWF selected subset), regressed on 49 profiles
- Error covariance estimates available from 750+ profile testing

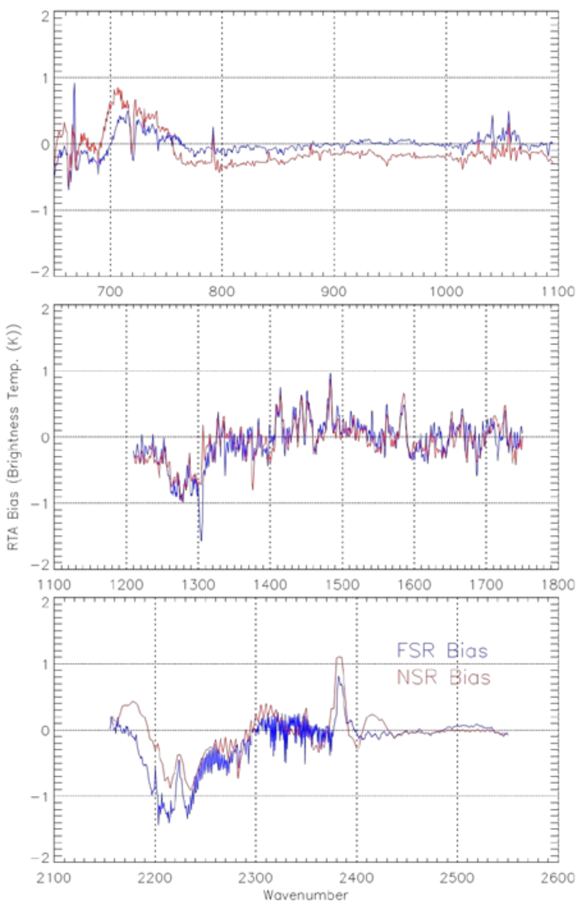
CrIS FSR SARTA bias tuning and sdev

Bias

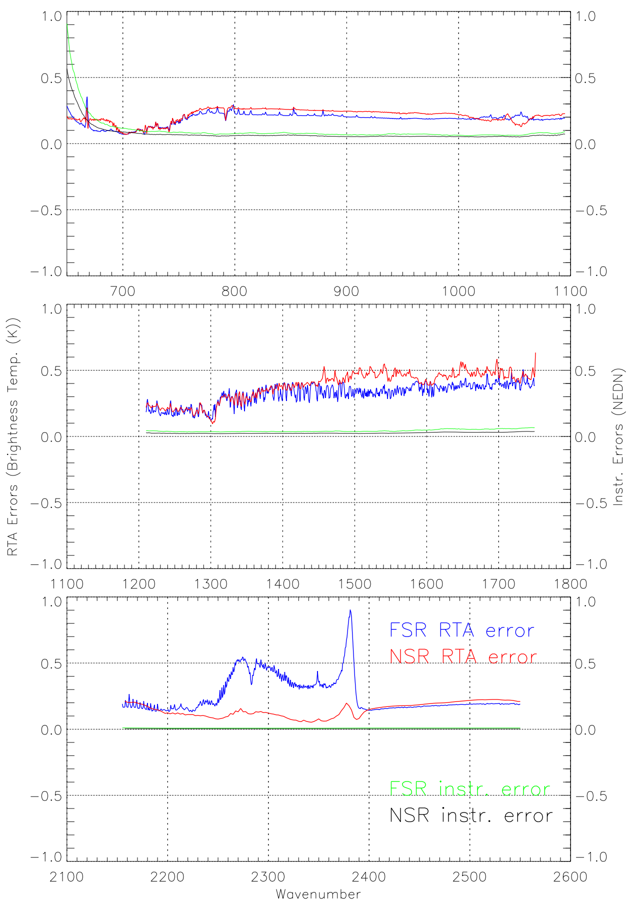
FSR LW window benefited from VIIRS cloud filtering

Water vapor region stays consistent

SW band appears better behaved



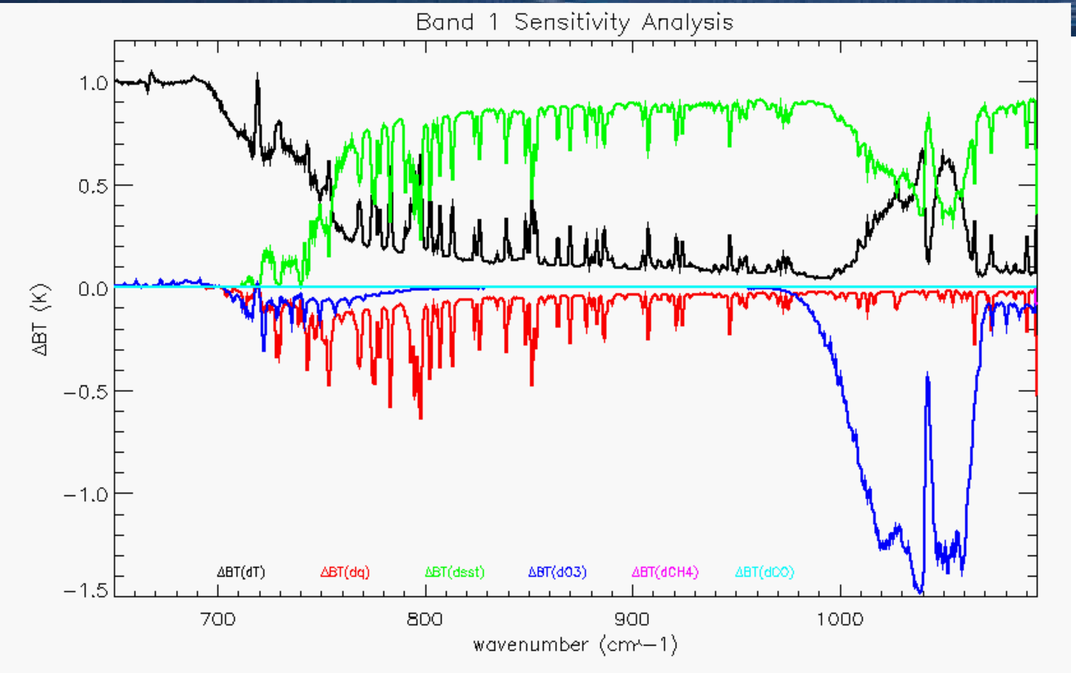
Standard deviation



Original NSR st dev was divided by two to account for errors in the truth.

In the improved training methodology, this division is not needed any longer

CrIS FSR Channel Selection



Perturbation Applied

SST	1K
T	1K
H2O	10%
O3	10%
CH4	2%
CO	1%

Brightness temperature difference (ΔBT) terms represent the sensitivity of each channel to a given perturbation species and are indicative of the degree of *"spectral purity"* of each channel.

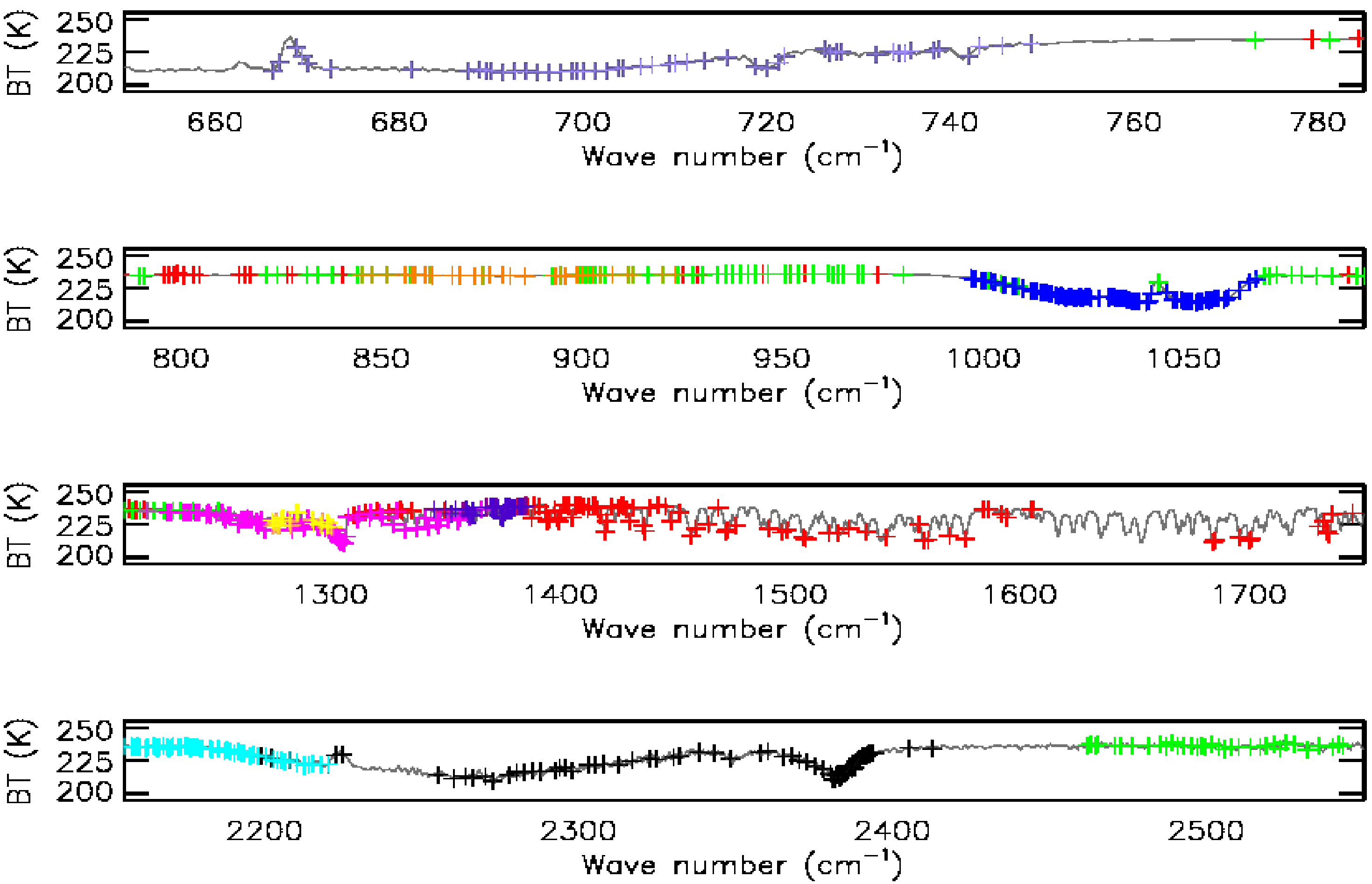
•For each atmospheric species, we select channels with:

- **the highest degree of spectral purity** (the highest sensitivity to the species of interest and the lowest sensitivity to all other interfering species).
- **the lowest noise sources** (NEDT, calibration & apodization corr., RTA errors)
- **unique spectral features** (to capture atmospheric variability, maximize vertical resolution)

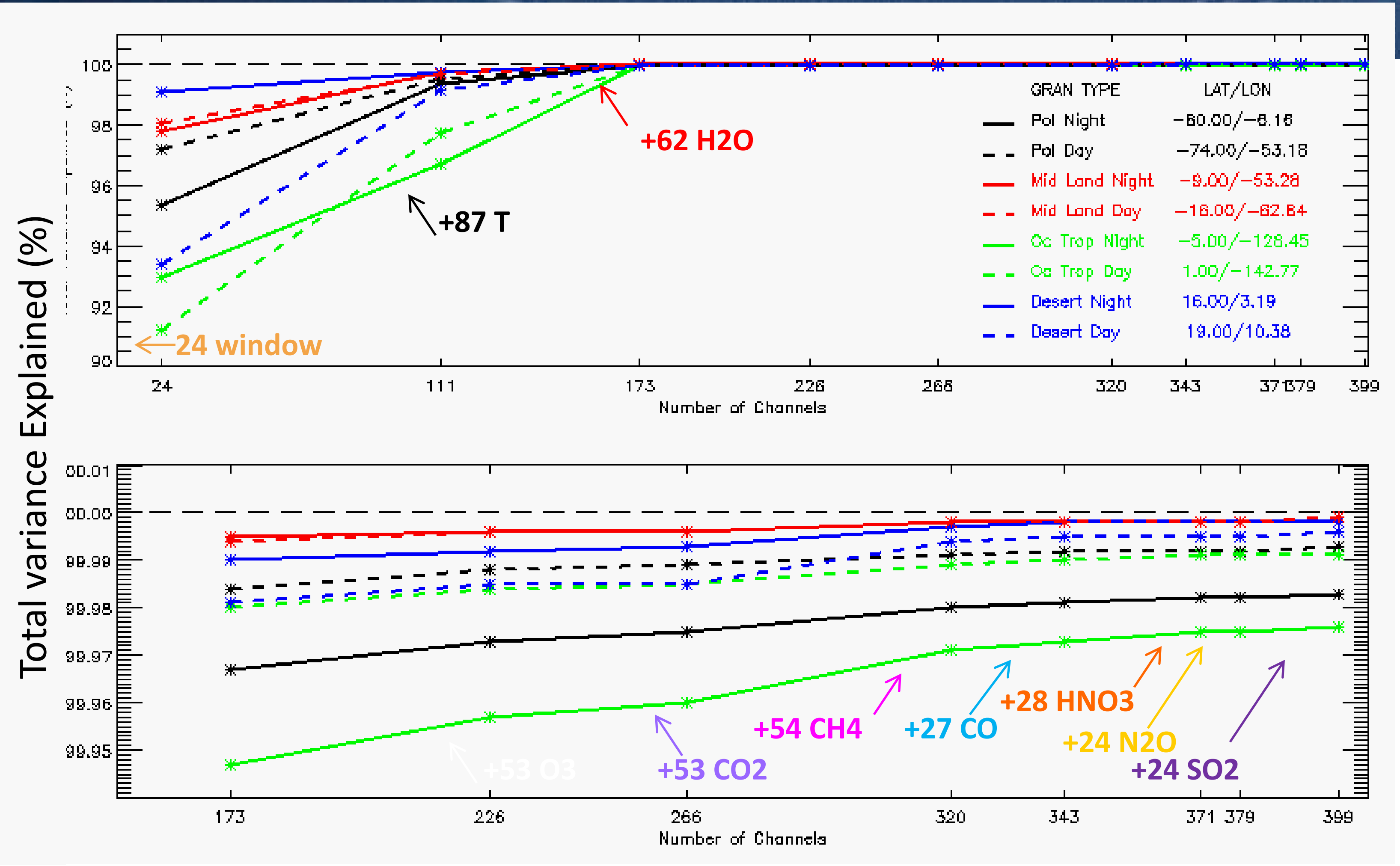
REF: A. Gambacorta and C. Barnet., Methodology and information content of the NOAA NESDIS operational channel selection for the Cross-Track Infrared Sounder (CrIS), IEEE, Vol. 51, Issue 6, 2013

NUCAPS Operational FSR CrIS channel selection (610 channels)

EDR	#chns
Temp	116
Surf	136 (62)
HO2	123 (62)
O3	77
CO	52
CH4	84
N2O	21
SO2	31
HNO3	30
CO2	50 (T LW)

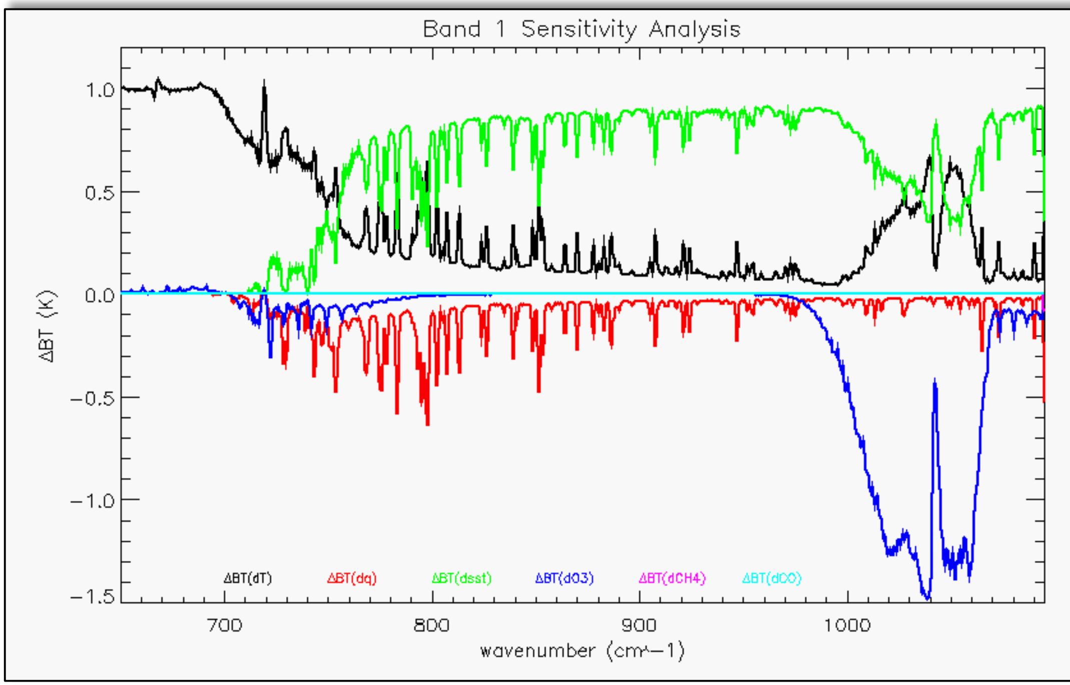


Total Variance Explained



- The full list of 399 selected channels explains ~99.9% of the total atmospheric variance, consistently across all geophysical regimes.
- The first 173 channels (window, temperature and water vapor channels) alone explain ~ 99% of the total atmospheric variance. REF: Gambacorta et al., IEEE, 2013

NUCAPS: a sequential, iterated, linearized, regularized square fit



SST	1K
T	1K
H2O	10%
O3	10%
CH4	2%
CO	1%

$$\Delta R_n = K^i_{n,L} \Delta X^i_{n,L} + \varepsilon_n$$

$$\varepsilon_n = NEDT_n + \delta R_{CCR} + \delta RTA_n + \sum_{j \neq i} K^j \delta X^j$$

$$X_L = X^a_L + \left[K^T_{L,n} \cdot S^{-1}_{\epsilon n,n} \cdot K_{n,L} + S^{-1}_{a\,L,L} \right]^{-1} \cdot K^T_{L,n} \cdot S^{-1}_{\epsilon n,n} \cdot \left(R_n - K_{n,L} \cdot X^a_L \right) \pm \delta X$$

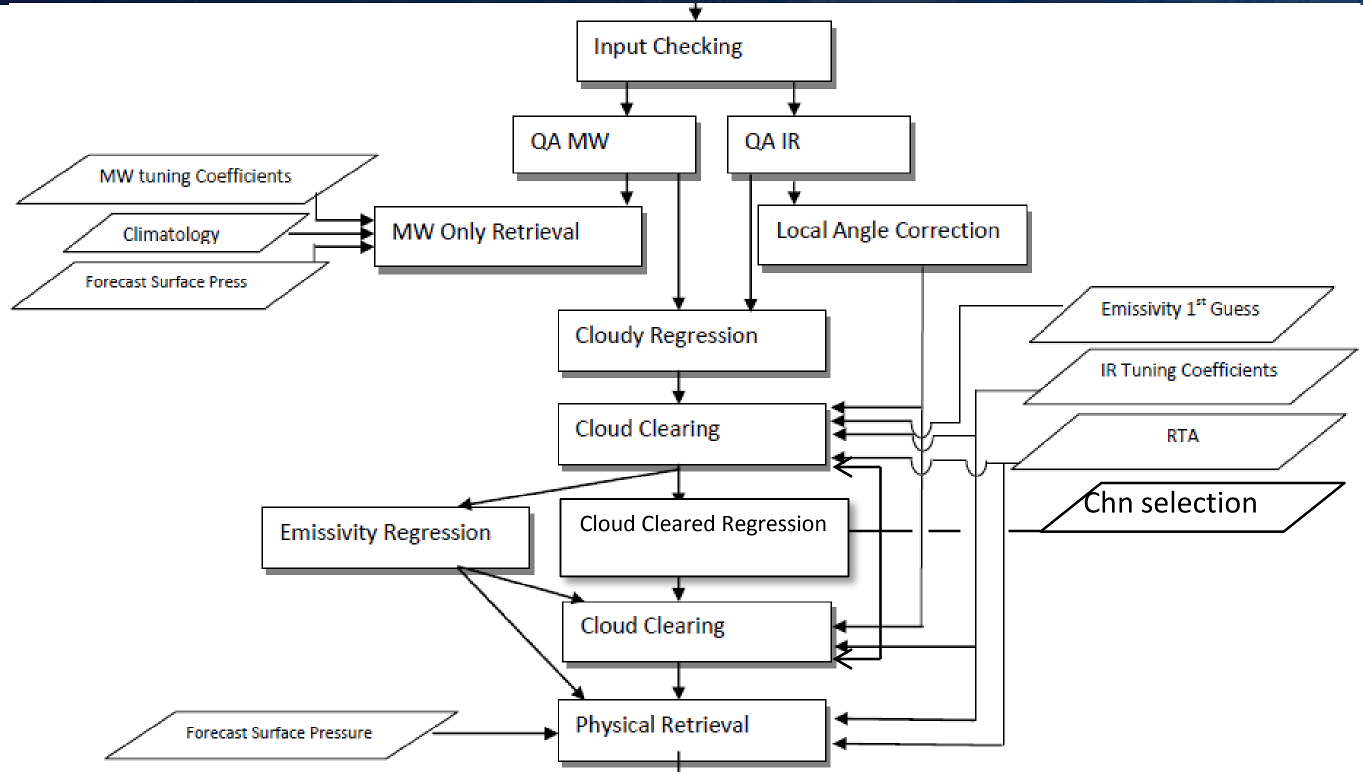
Clouds, clouds, everywhere

- **How does Cloud Clearing work?**
  - Utilizes a cluster of 9 FOVs and a subset of temperature sensitive channels to extrapolate the radiance signal that the instrument would see if there were no clouds.
  - Basic assumption: clouds are solely responsible for the variance in the cluster of FOVs. Works best over ocean, worse over land.
  - Sacrifices spatial resolution (9 FOV ~ 45km) to achieve global coverage: ~80% yield vs 5% clear scenes
- **Why Cloud Clearing?**
  - Goal is to retrieve TOA – Surface profiles.
  - Clouds radiative effects and geophysical correlation with other atmospheric parameters are highly non-linear.
  - Cloud geophysical a priori and spectral constraints are highly uncertain.
  - Simple concept: a small number of parameters can remove cloud contamination from thousands of channels. Does not require knowledge of cloud microphysics, nor cloud a priori. Works with complex cloud systems (multiple level of different cloud types).
  - Error introduced by cloud clearing is formally built into the measurement error covariance matrix and propagated through downstream retrieval error steps
  - Proper error characterization and propagation allows graceful degradation toward the microwave information with decreased information content
- **Can we still retrieve cloud parameters?**
  - Yes, cloud parameters are retrieved from Cloudy Obs – Calc LSQ minimization in the post-processing
- **Are there alternatives?**
  - Single FOV cloud clearing by the additional use of visible instruments.
    - See Jim Jung’s talk, Monday 2018-08-14, “Advanced Application Session, h13:00 – 13:15”
  - Single FOV all sky retrievals by the use of cloudy forward models and geophysical a priori
    - See Xu Liu’s talk today, “NUCAPS Session”, h 10:15 – 10:30”
    - See Larrabee Strow’s talk tomorrow, “Trace Gas Session”, h10:10 – 10:30

NUCAPS a priori choices

- NUCAPS is currently using a statistical operator (linear regression) as a priori
- Pro's:
  - Does not require a radiative transfer model for training or application.
  - Application of eigenvector & regression coefficients is VERY fast and for hyper-spectral instruments it is very accurate
  - Since real radiances are used, the regression implicitly handles many instrument calibration (e.g., spectral offsets) issues. This is a huge advantage early in a mission.
  - Since clouds are identified as unique eigenvectors, a properly trained regression tends to "see through" clouds.
- Con's:
  - Training requires a large number of co-located "truth" scenes.
  - Statistical operators inherently lack in computation of formal error estimates. They do not obey any convergence criteria. Ad hoc QC methods need to be introduced.
  - Statistical operators build in correlations between geophysical parameters. For example, retrieved O_3 in biomass regions might really be a *measurement* of CO with a statistical correlation between CO and O_3. They can introduce sub-resolved structures in the retrieval
- We have started exploring the possibility of a new a priori in the form of a climatology based on MERRA-2 reanalysis.

NUCAPS Retrieval Algorithm Flow Chart



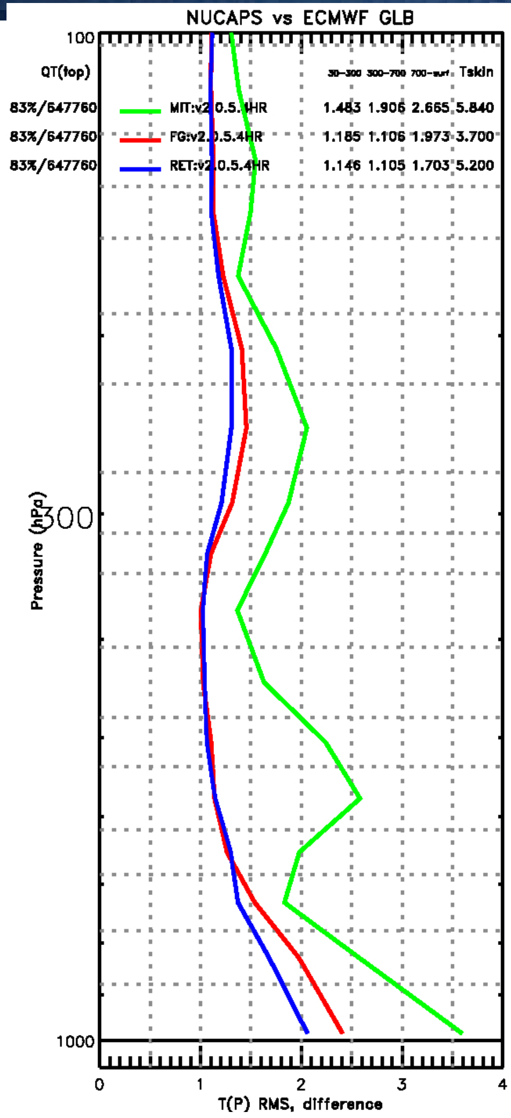
- **I. A microwave retrieval module** which computes Temperature, water vapor and cloud liquid water (Rosenkranz, 2000)
- **II. A fast eigenvector regression** retrieval that is trained against ECMWF and all sky radiances which computes temperature and water vapor (Goldberg et al., 2003)
- **III. A cloud clearing module** (Chahine, 1974)
- **IV. A second fast eigenvector regression** retrieval that is trained against ECMWF analysis and cloud cleared radiances
- **V. The final infrared physical retrieval** based on a regularized iterated least square minimization: temperature, water vapor, trace gases (O_3, CO, CH_4, CO_2, SO_2, HNO_3, N_2O) (Susskind, Barnet, Blaisdell, 2003)

Summary of current NUCAPS retrieval products

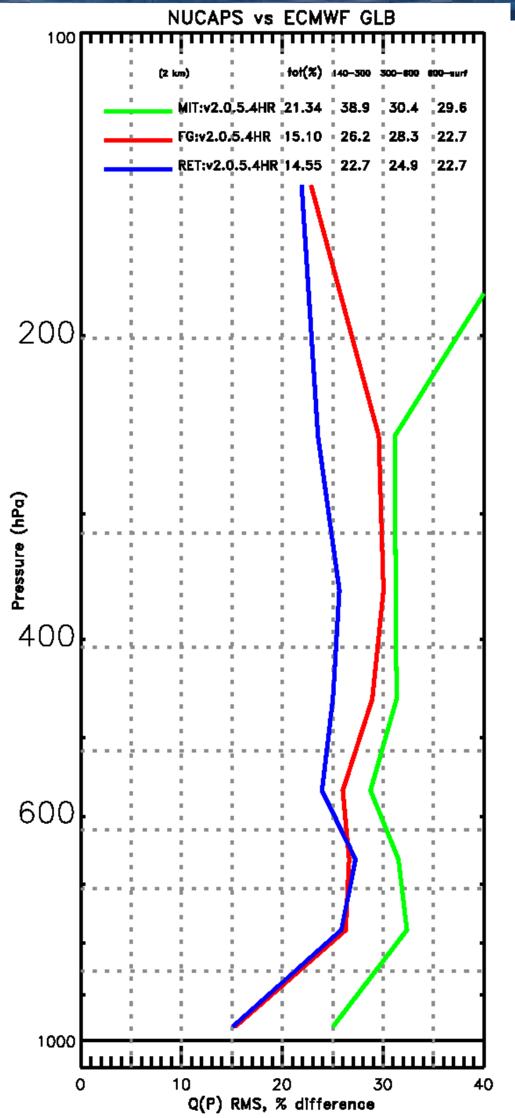
gas	Range (cm^{-1})	Precision	d.o.f.	Interfering Gases
T	650-800 2375-2395	1K/km	6-10	H2O,O3,N2O emissivity
H_2O	1200-1600	15%	4-6	CH4, HNO3
O_3	1025-1050	10%	1+	H2O,emissivity
CO	2080-2200	15%	≈ 1	H2O,N2O
CH_4	1250-1370	1.5%	≈ 1	H2O,HNO3,N2O
CO_2	680-795 2375-2395	0.5%	≈ 1	H2O,O3 T(p)
<u>Volcanic</u> SO_2	1340-1380	50% ??	< 1	H2O,HNO3
HNO_3	860-920 1320-1330	50% ??	< 1	emissivity H2O,CH4,N2O
N_2O	1250-1315 2180-2250	5% ??	< 1	H2O H2O,CO
$CFCl_3$ (F11)	*830-860*	*20%*	*-*	*emissivity*
CF_2Cl (F12)	*900-940*	*20%*	*-*	*emissivity*
CCl_4	*790-805*	*50%*	*-*	*emissivity*

Potential additions

Global Performance Summary: MW-only, First guess and MW+IR (RMS)



Temperature

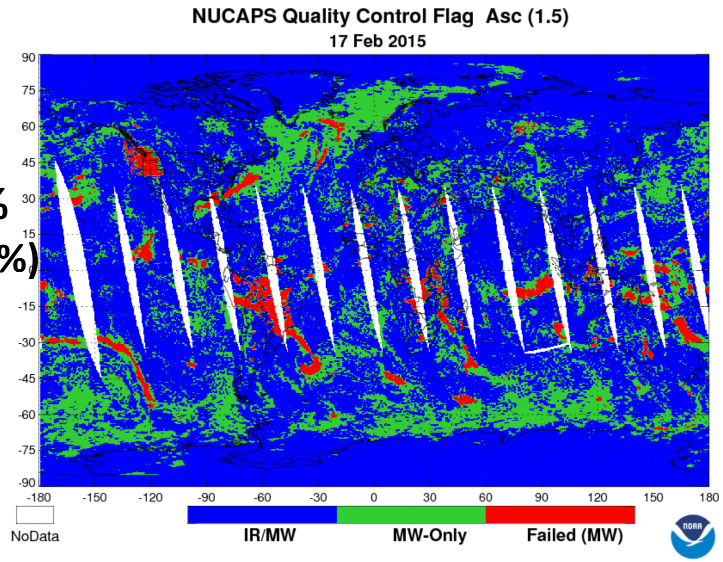


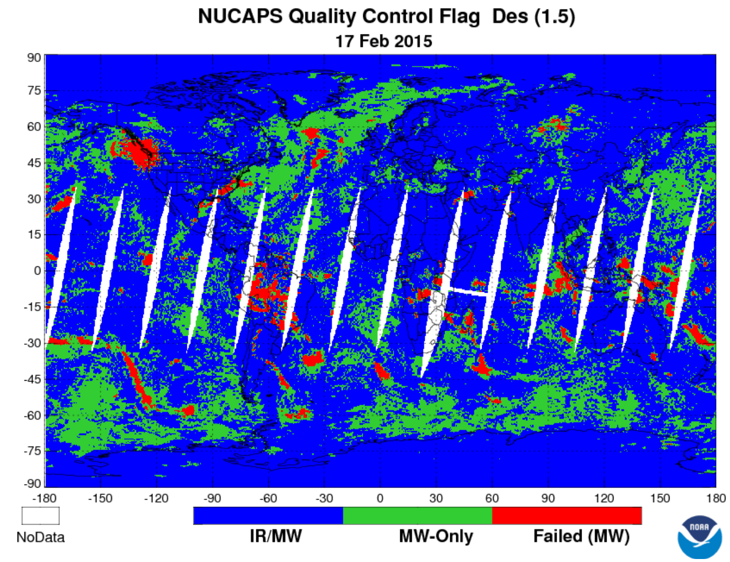
Water Vapor

NUCAPS Operational NSR vs FSR yield

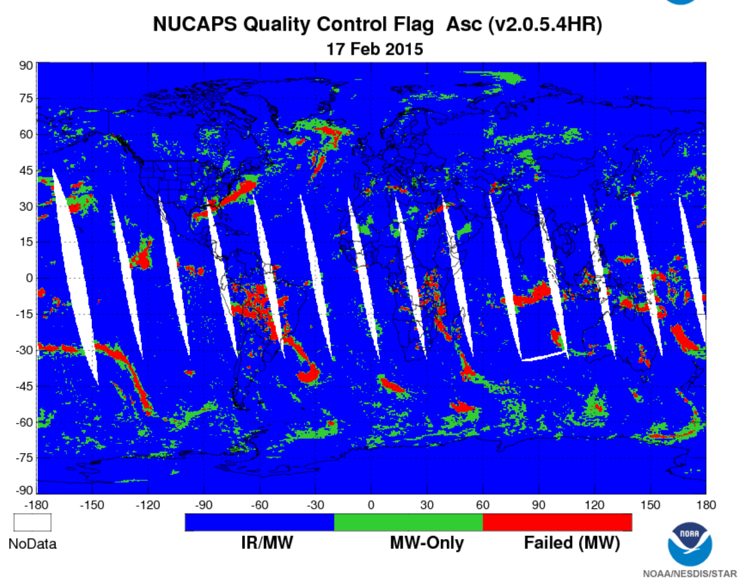
NSR Yield = 63 %

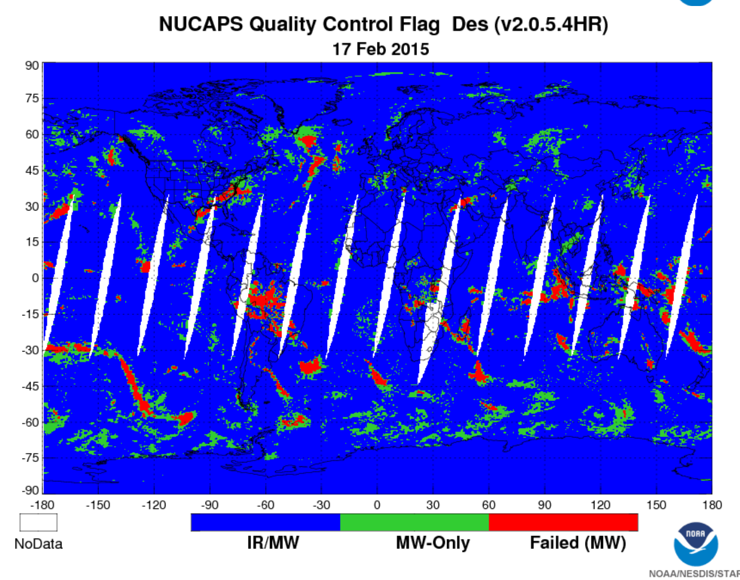
(NSR v1.7 yield = 70%)



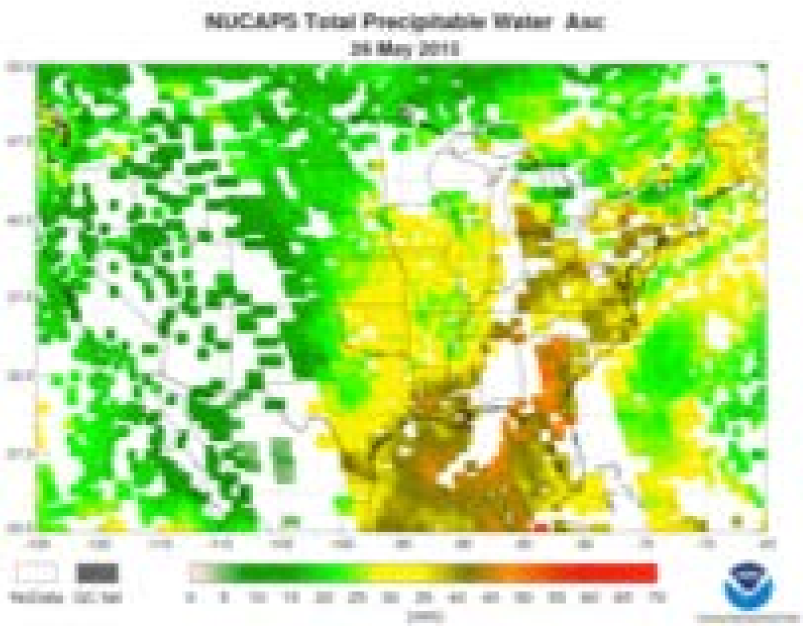


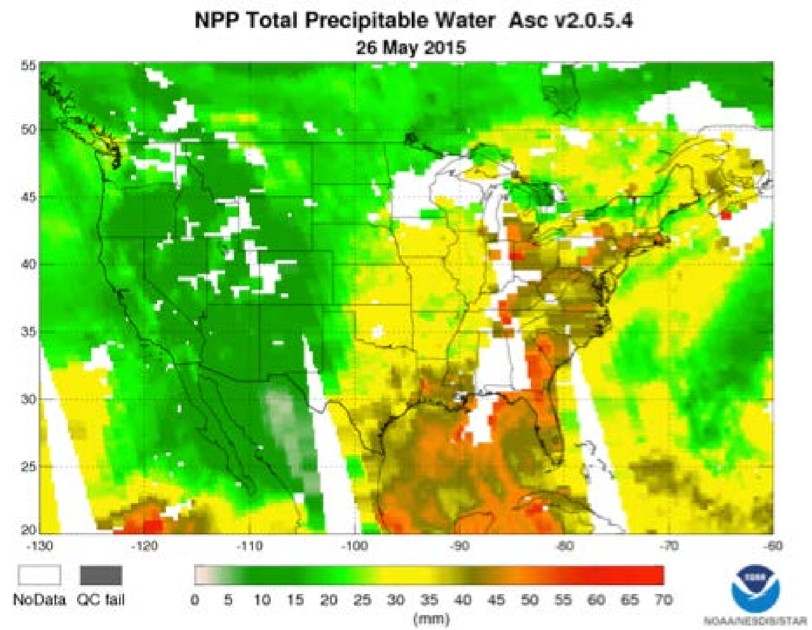
FSR Yield = 83 %





Significance to users applications





Operational NSR NUCAPS

Operational FSR NUCAPS

(S. De Silva's Poster Session, Tuesday 5-7:30pm)

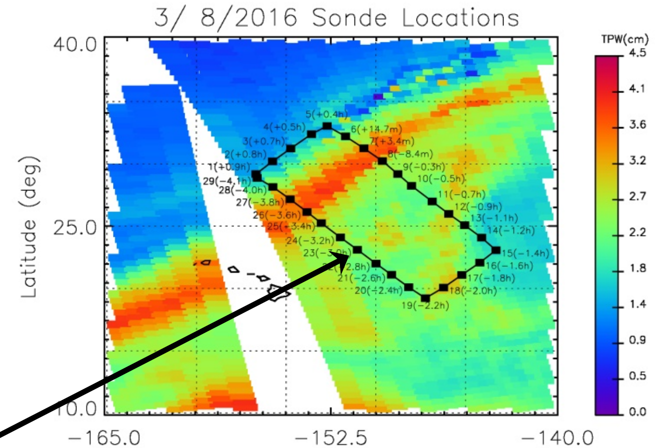
- Increased yield by ~20% enables uniform and more consistent global coverage
- This is essential to fill in the gaps of sparse in situ measurements and makes NUCAPS suitable for users applications.

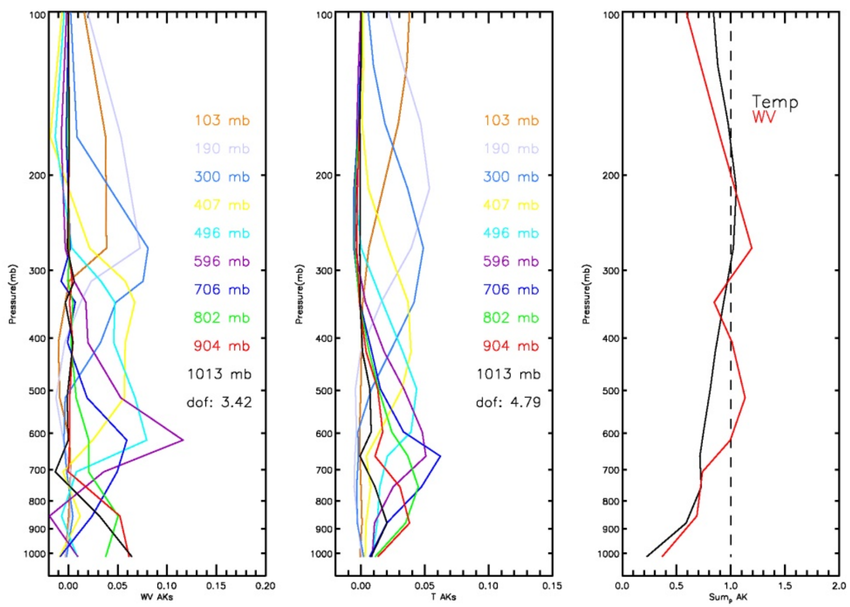
NUCAPS ultimate goal: a weather and climate quality retrieval algorithm

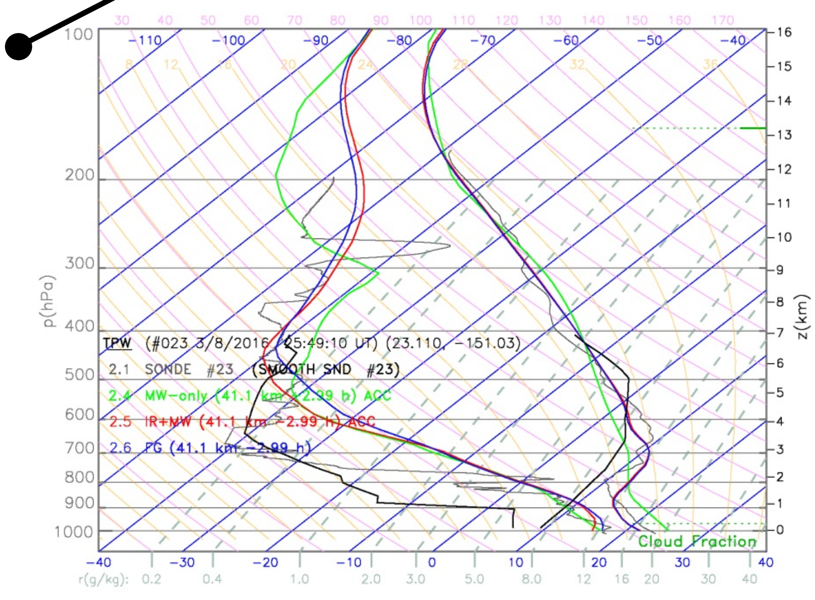
- **Why do we need a weather and climate quality retrieval algorithm?**
  - An independent, all-sky, global environmental data record
    - to add real time context to weather forecasting
    - to study atmospheric variability, feedbacks, trends.
- **Definition of a weather and climate quality algorithm**
  - A retrieval algorithm that can be characterized by explicitly evaluating the functional form of the relationship between the retrieved profile, the true atmosphere, and the various error sources.
- **How do we demonstrate NUCAPS capability to add value to weather forecasting and climate prediction?**
  - What are the dominant sources of NUCAPS uncertainties?
  - How does NUCAPS uncertainty vary by scene types?
  - How does NUCAPS uncertainty vary along the vertical domain?
  - What's NUCAPS effective vertical resolution?

A test case from the 2016 El Nino Rapid Response (ENRR) Campaign Mar. 8, 2016 Sonde #23

- Relatively warm w/ upper level dry layer and moist BL, higher clouds
- AK's have less T(p) skill below upper cloud
- But retrieval still captures the dry layer aloft, moist BL (mostly from regression) and marine T(p) inversion

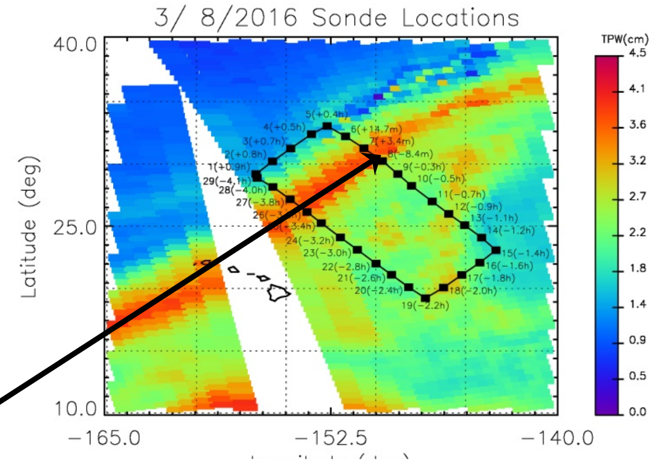


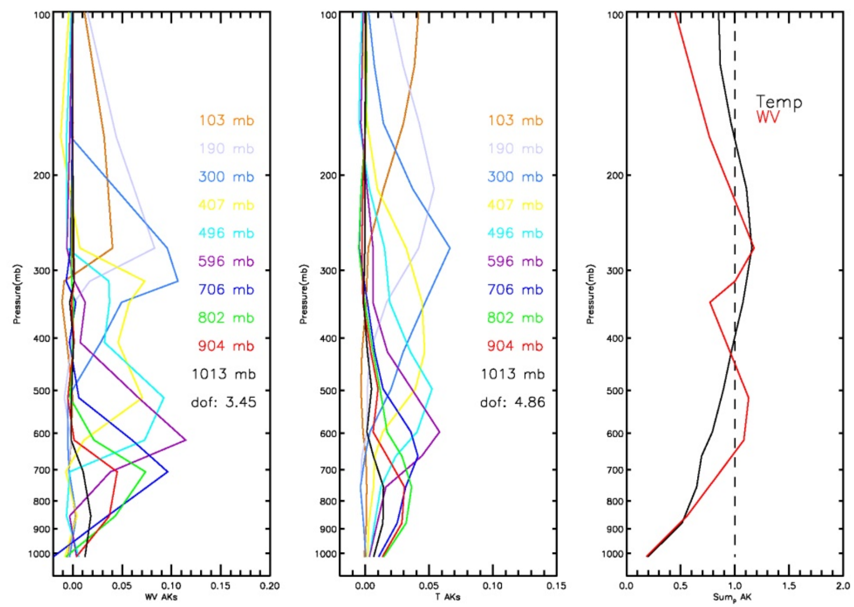


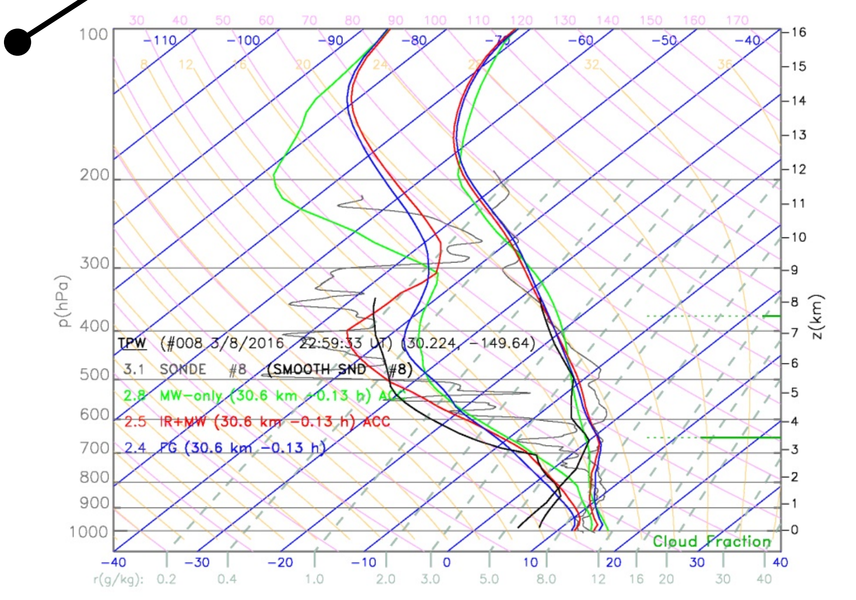


A test case from the 2016 El Nino Rapid Response (ENRR) Campaign Mar. 8, 2016 Sonde #08

- Very moist with both upper level (~15%) and lower level clouds (~60%)
- AK's do not have surface sensitivity. Both regression and physical know we have a lot of water







Coming next…

- Validation, demonstrations, applications
  - A global validation study to demonstrate NUCAPS retrieval skill (F. Iturbide-Sanchez Poster)
  - A detailed validation assessment to prove requirements are met (N. Nalli , T. Reale, L. Borg talks in today's session)
  - A focused list of proving ground and risk reduction initiatives to develop new users applications and provide indirect validation and demonstration of NUCAPS products (B. Sjoberg, B. Zavodski, M. Bowlan, E. Stevens, J. Dostalek talks in the second part of today's session; A. Wheleer and S. De Silva's posters).
- Thank you!

Status of SNPP NUCAPS Validation

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Acknowledgments

- **SNPP Sounder EDR Validation Dataset collection**
  - **U.S. DOE Atmospheric Radiation Measurement (ARM) program dedicated RAOBs**
    - D. Tobin (UW/CIMSS)**;** D. Holdridge and J. Mather (ARM Climate Research Facility)
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  - **PMRF Site:** A. K. Mollner, J. E. Wessel (Aerospace)
  - **Beltsville Site:** R. Sakai, B. Demoz, M. Oyola (HU/NCAS)
  - **GRUAN Lead Center:** Ruud Dirksen

- The **NOAA Joint Polar Satellite System (JPSS-STAR) Office** (**M. D. Goldberg, L. Zhou**, et al.) and the NOAA/STAR Satellite Meteorology and Climatology Division.

- **SNPP sounder validation effort (past and present)**: Q. Liu, A.K. Sharma, M. Pettey, C. Brown, M. Divakarla, W. W. Wolf (STAR); R. O. Knuteson (UW/CIMSS)

Outline

- **JPSS Sounder Validation Overview**
  - JPSS Level 1 Requirements
  - Validation Hierarchy recap
  - NUCAPS Algorithm
    - v1.5, nominal spectral-resolution (NSR) CrIS
    - v2.0 Phase 4, full spectral-resolution (FSR) CrIS
- **NUCAPS Validation Status**
  - **v1.5 NSR Review**
    - Global dedicated RAOB ensemble
  - **v2.0 FSR (Phase 4) Status**
    - Global Focus Day ECMWF
    - Dedicated RAOBs (March to July 2017)

SNPP NUCAPS Validation Status

JPSS SOUNDER VALIDATION OVERVIEW

JPSS Specification Performance Requirements
CrIS/ATMS AVTP/AVMP EDR Uncertainty

CrIS/ATMS Atmospheric Vertical Temperature Profile (AVTP) Measurement Uncertainty – Layer Average Temperature Error		
PARAMETER	THRESHOLD	OBJECTIVE
AVTP, Cloud fraction < 50%, surface to 300 hPa	1.6 K / 1-km layer	0.5 K / 1-km layer
AVTP, Cloud fraction < 50%, 300–30 hPa	1.5 K / 3-km layer	0.5 K / 3-km layer
AVTP, Cloud fraction < 50%, 30–1 hPa	1.5 K / 5-km layer	0.5 K / 5-km layer
AVTP, Cloud fraction < 50%, 1–0.5 hPa	3.5 K / 5-km layer	0.5 K / 5-km layer
AVTP, Cloud fraction ≥ 50%, surface to 700 hPa	2.5 K / 1-km layer	0.5 K / 1-km layer
AVTP, Cloud fraction ≥ 50%, 700–300 hPa	1.5 K / 1-km layer	0.5 K / 1-km layer
AVTP, Cloud fraction ≥ 50%, 300–30 hPa	1.5 K / 3-km layer	0.5 K / 3-km layer
AVTP, Cloud fraction ≥ 50%, 30–1 hPa	1.5 K / 5-km layer	0.5 K / 5-km layer
AVTP, Cloud fraction ≥ 50%, 1–0.5 hPa	3.5 K/ 5-km layer	0.5 K/ 5-km layer

"Clear to Partly-Cloudy"
(Cloud Fraction < 50%)
↕
IR retrieval

"Cloudy"
(Cloud Fraction >= 50%)
↕
MW-only retrieval

CrIS/ATMS Atmospheric Vertical Moisture Profile (AVMP) Measurement Uncertainty – 2-km Layer Average Mixing Ratio % Error		
PARAMETER	THRESHOLD	OBJECTIVE
AVMP, Cloud fraction < 50%, surface to 600 hPa	Greater of 20% or 0.2 $g \cdot kg^{-1}$ / 2-km layer	10%
AVMP, Cloud fraction < 50%, 600–300 hPa	Greater of 35% or 0.1 $g \cdot kg^{-1}$ / 2-km layer	10%
AVMP, Cloud fraction < 50%, 300–100 hPa	Greater of 35% or 0.1 $g \cdot kg^{-1}$ / 2-km layer	10%
AVMP, Cloud fraction ≥ 50%, surface to 600 hPa	Greater of 20% of 0.2 $g \cdot kg^{-1}$ / 2-km layer	10%
AVMP, Cloud fraction ≥ 50%, 600–400 hPa	Greater of 40% or 0.1 $g \cdot kg^{-1}$ / 2-km layer	10%
AVMP, Cloud fraction ≥ 50%, 400–100 hPa	Greater of 40% or 0.1 $g \cdot kg^{-1}$ / 2-km layer	NS

Global requirements defined for lower and upper atmosphere subdivided into 1-km and 2-km layers for AVTP and AVMP, respectively.

Source: (L1RD, 2014, pp. 41, 43)

Validation Methodology Hierarchy

(e.g., *Nalli et al., JGR Special Section,* 2013)

1. **Numerical Model (e.g., ECMWF, NCEP/GFS) Global *Comparisons***
   - Large, truly global samples acquired from Focus Days
   - Useful for sanity checks, bias tuning and regression
   - Limitation: *Not* independent truth data

2. **Satellite Sounder EDR (e.g., AIRS, ATOVS, COSMIC) *Intercomparisons***
   - Global samples acquired from Focus Days (e.g., AIRS)
   - Consistency checks; merits of different retrieval algorithms
   - Limitation: Similar error characteristics; must take rigorous account of averaging kernels of both systems (e.g., *Rodgers and Connor,* 2003)

3. **Conventional RAOB Matchup *Assessments***
   - WMO/GTS operational sondes launched ~2/day for NWP
   - Representation of global zones, long-term monitoring
   - Large samples after a couple months (e.g., *Divakarla et al.,* 2006; *Reale et al.* 2012)
   - Limitations:
     - Skewed distribution toward NH-continents
     - Mismatch errors, potentially systematic at individual sites
     - Non-uniform, less-accurate radiosondes
     - RAOBs assimilated into numerical models

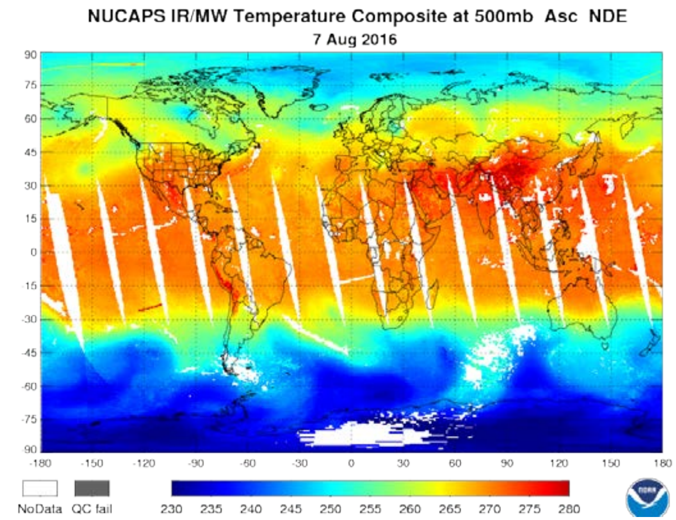
4. **Dedicated/Reference RAOB Matchup *Assessments***
   - *Dedicated* for the purpose of satellite validation
     - Known measurement uncertainty, optimal accuracy
     - Minimal mismatch errors
     - "best estimates" or "merged soundings"
   - Reference sondes: CFH, **GRUAN** corrected RS92/RS41
     - Traceable measurement
     - Uncertainty estimates
   - Limitation: Small sample sizes, geographic coverage
   - E.g., **ARM sites** (e.g., *Tobin et al.,* 2006), **AEROSE**, **CalWater/ACAPEX** , BCCSO, PMRF

5. **Intensive Field Campaign *Dissections***
   - Include dedicated RAOBs, some *not* assimilated into NWP models
   - Include ancillary datasets (e.g., ozonesondes, lidar, M-AERI, MWR, sunphotometer, etc.)
   - Ideally include funded aircraft campaign using IR sounder (e.g., NAST-I, S-HIS)
   - Detailed performance specification; state specification; SDR cal/val; case studies
   - E.g., **SNAP, SNPP-1,-2, AEROSE, CalWater/ACAPEX**, JAIVEX, WAVES, AWEX-G, EAQUATE

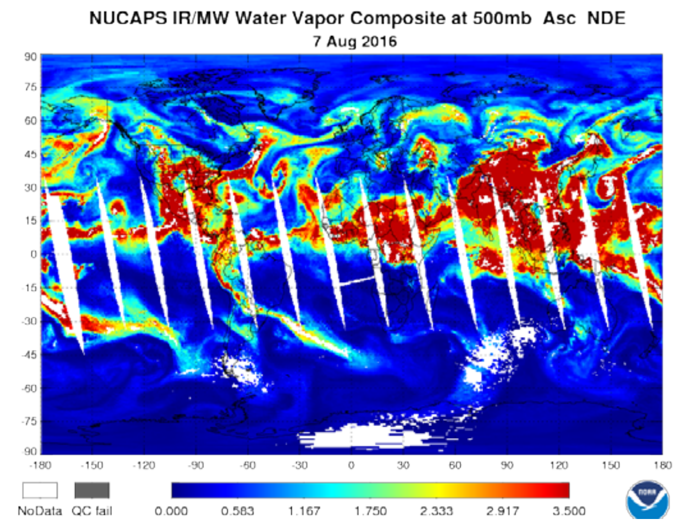
NOAA Unique Combined Atmospheric Processing System (NUCAPS) Algorithm (1/2)

- **Operational algorithm**
  - NOAA Enterprise Algorithm for CrIS/IASI/AIRS (*Susskind, Barnet and Blaisdell,* IEEE 2003; *Gambacorta et al.,* 2014)
  - Global non-precipitating conditions
  - Atmospheric Vertical Temperature , Moisture Profiles (**AVTP**, **AVMP**)
  - Trace gases (O_3, CO, CO_2, CH_4)

- **Users**
  - **Weather Forecast Offices (AWIPS)**
    - Nowcasting / severe weather
    - Alaska (cold core)
  - NOAA/CPC (OLR)
  - NOAA/ARL (IR ozone, trace gases)
  - NOAA TOAST product (IR ozone)
  - Basic and applied science research (e.g., *Pagano et al.,* 2014)
    - Via NOAA Data Centers (e.g., CLASS)
    - Universities, peer-reviewed pubs



NUCAPS AVTP



NUCAPS AVMP

Long Term Monitoring
http://www.star.nesdis.noaa.gov/jpss/EDRs/products_Soundings.php
http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/index.html

NOAA Unique Combined Atmospheric Processing System (NUCAPS) Algorithm (2/2)

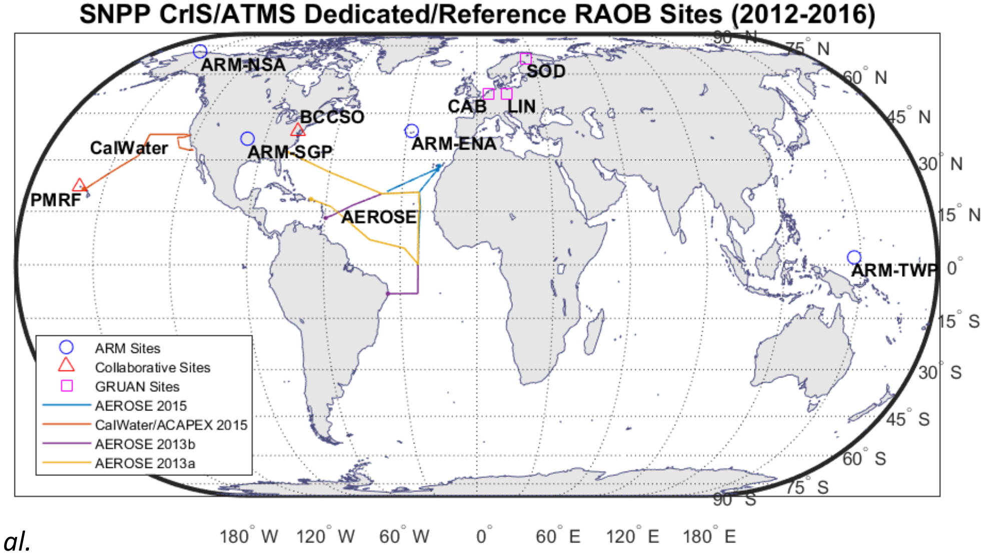
NUCAPS Offline Code Versioning

- **Version 1.5**
  - Operational system beginning in September 2013
  - Runs on CrIS nominal spectral-resolution (NSR) data
  - Validated Maturity for AVTP/AVMP EDR attained Sep 2014
- **Versions 1.8.x to 1.9.x**
  - Preliminary offline experimental algorithms in preparation for CrIS full-spectral (FSR) resolution data
  - *Ad hoc* CrIS full-resolution radiative transfer algorithm (RTA) and bias correction coefficients
- **Version 2.0 (Phase 4)**
  - Uses **UMBC CrIS full-res (FSR) RTA** (L. Strow et al.)
  - Includes **IR-only version** (risk-mitigation for ATMS loss)
  - **Phase 4 Algorithm Readiness Review (ARR)** delivered on 6 July 2017
    - Draft ATBD delivered August 2017
    - Code currently being delivered and transitioned into operations

SNPP NUCAPS Validation Status

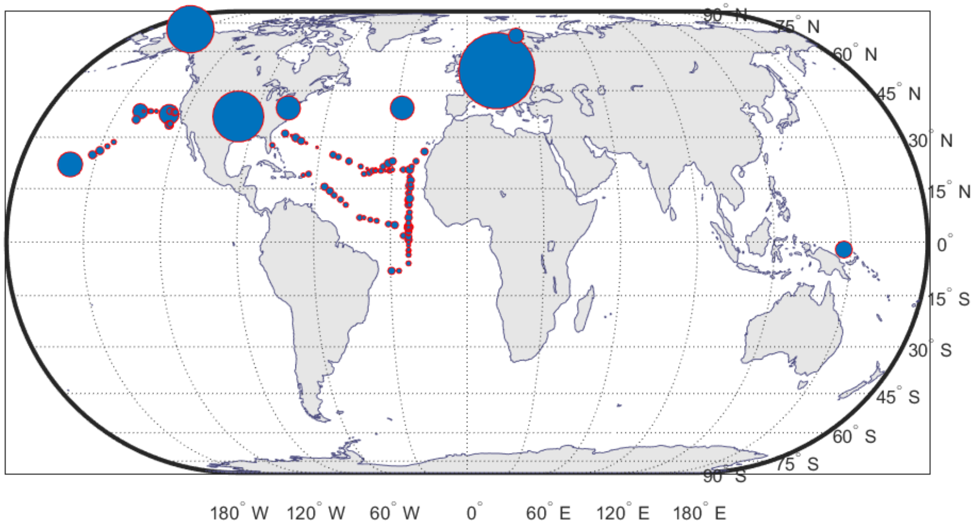
NUCAPS V1.5 NSR VALIDATION REVIEW

VALAR/NPROVS+ Dedicated/Reference RAOB-FOR Collocation Sample



JPSS SNPP-Dedicated and GRUAN Reference RAOB Sites

From Nalli et al. (2017a)



Geographic Sample Histogram (Equal Area)

FOR Collocation Criteria
$\delta x \leq 75$ km, $-60 < \delta t < 0$ min

NUCAPS v1.5 NSR IR+MW AVTP Coarse-Layer Statistics
VALAR Dedicated/Reference RAOB Collocation Sample

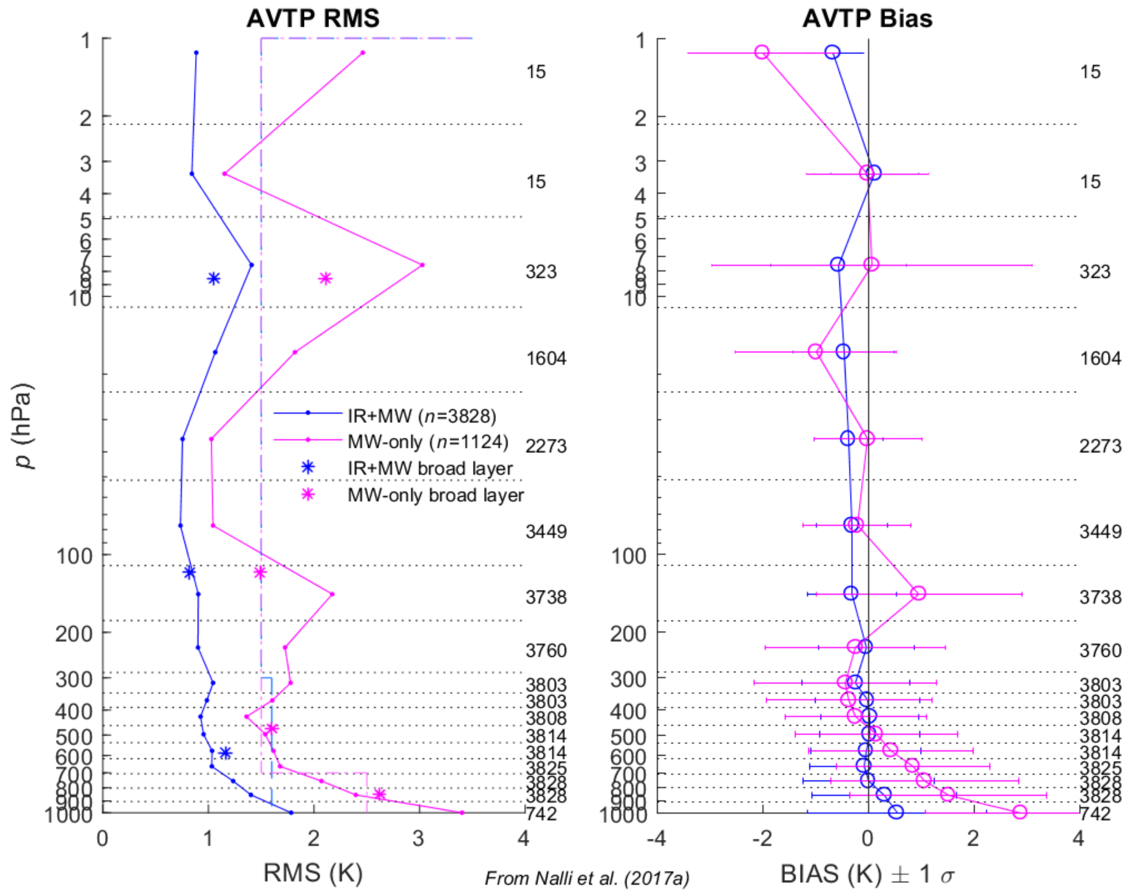
AVTP Versus RAOB

** Broad-Layer Stats (Per JPSS Level 1 Requirements)

IR+MW
MW-Only

IR+MW Yield
= 63.3%

MW-only Yield
= 91.9%



NUCAPS v1.5 NSR IR+MW AVMP Coarse-Layer Statistics VALAR Dedicated/Reference RAOB Collocation Sample

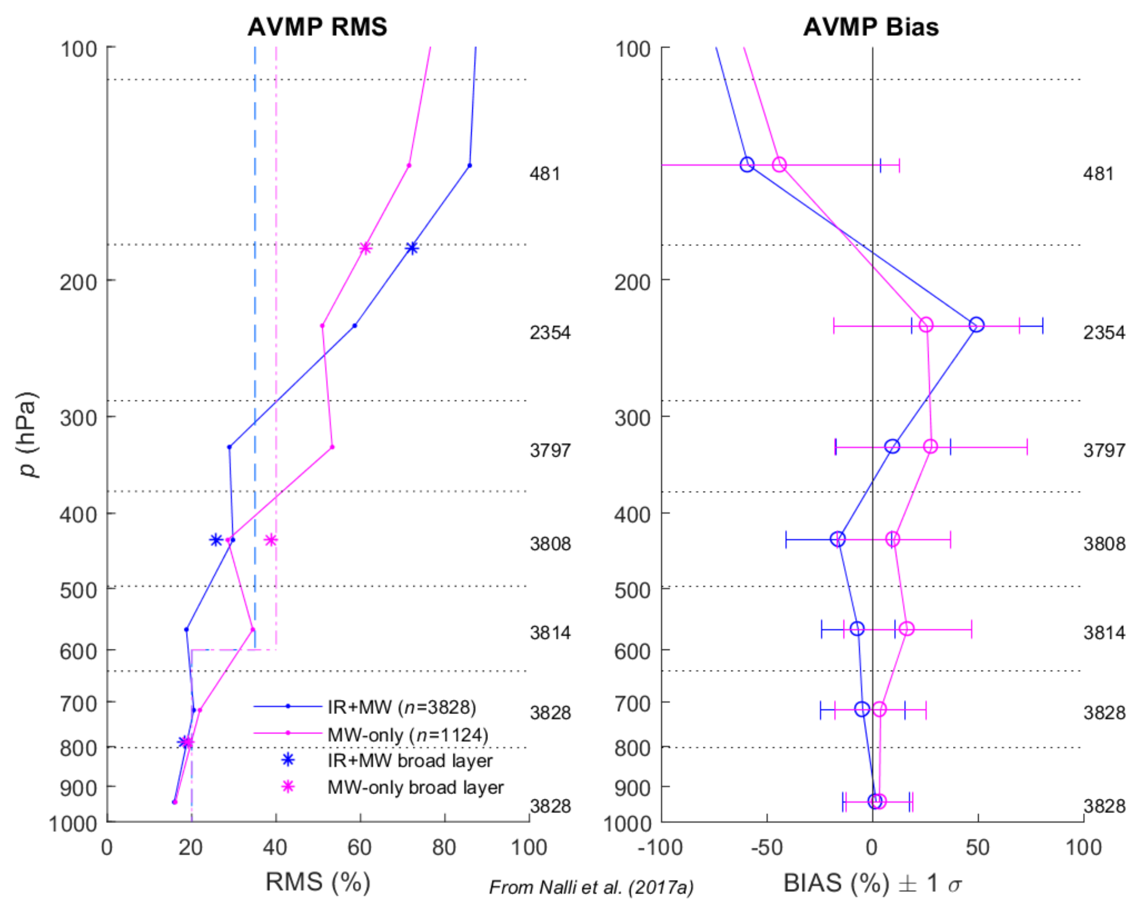
AVMP Versus RAOB

** Broad Layer Stats (Per JPSS Level 1 Requirements)

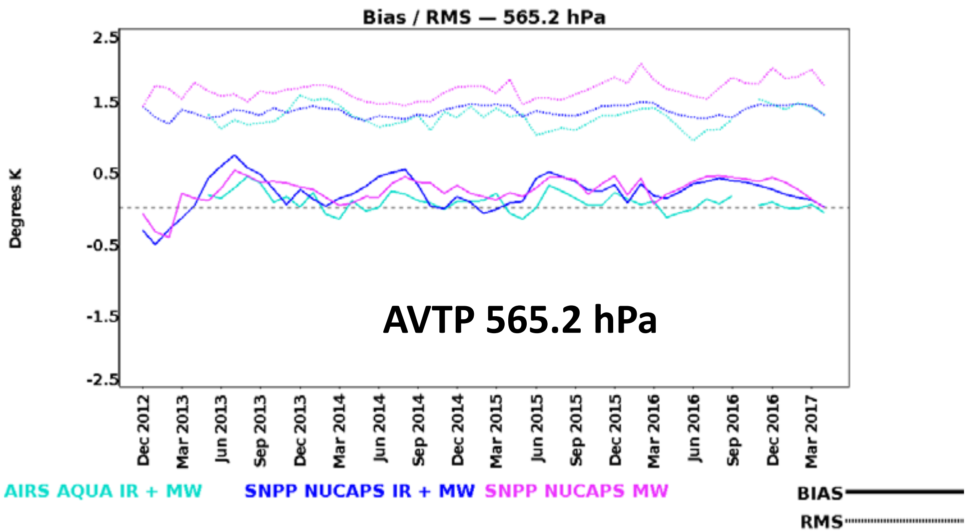
IR+MW
MW-Only

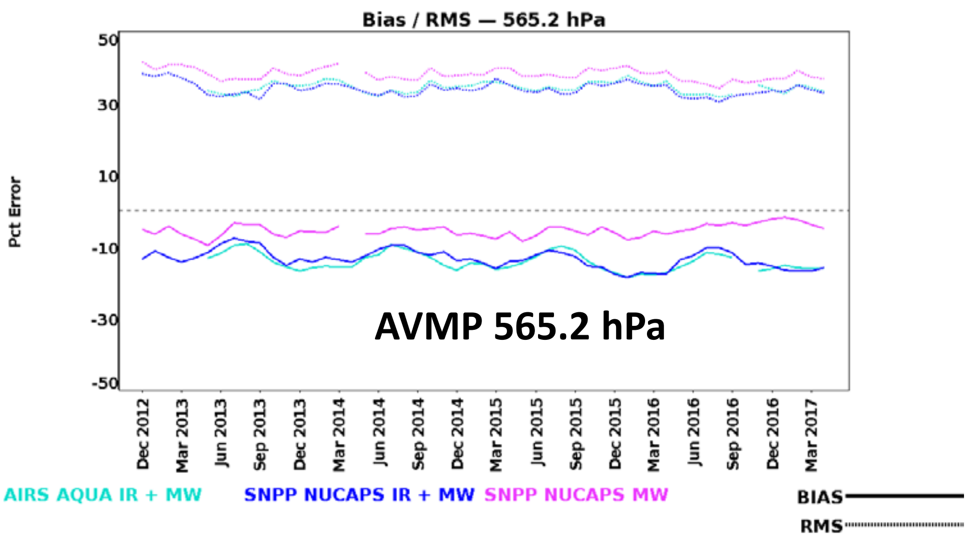
IR+MW Yield = 63.3%

MW-only Yield = 91.9%



Long-Term Monitoring NUCAPS

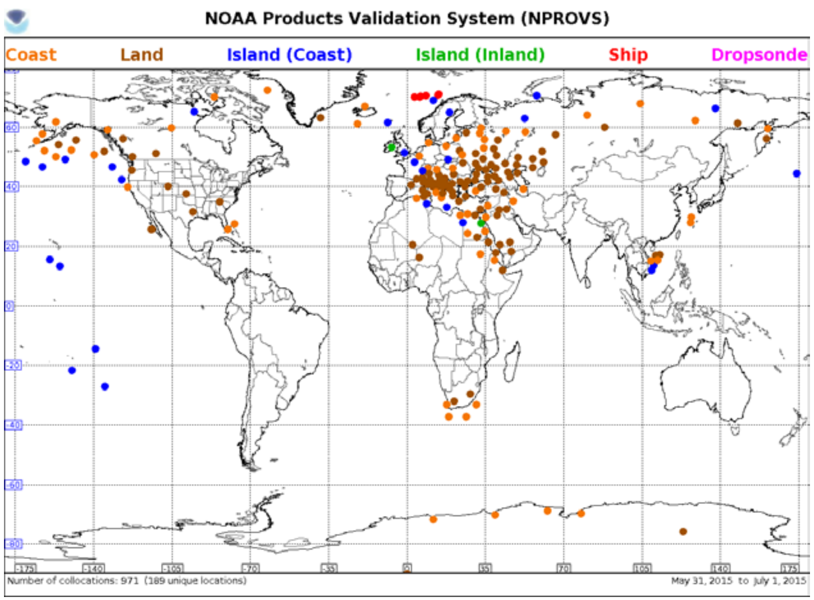




NPROVS Archive Statistics (NARCS) Utility
(*Reale et al.* 2012)

June 2015 NPROVS conventional RAOBs collocated with SNPP

single closest NUCAPS FOR within 50 km and 0-30 min following launches



SNPP NUCAPS Validation Status

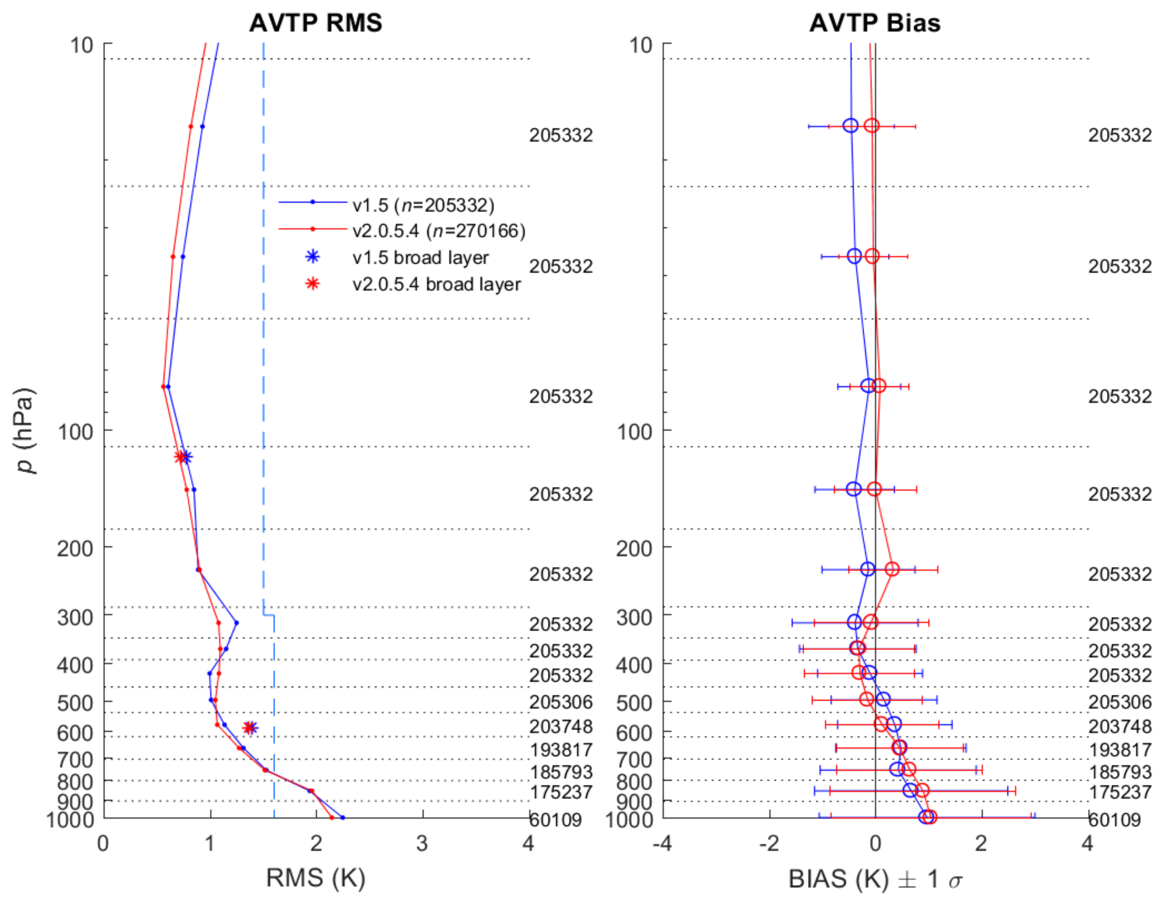
NUCAPS PHASE 4 V2.0 FSR VALIDATION STATUS

NUCAPS v2.0 FSR IR+MW AVTP Coarse-Layer Statistics
Global Focus Day 17-Feb-2015

AVTP Versus ECMWF

V1.5 IR+MW
V2.0 IR+MW

v1.5 Yield = 63.4%
v2.0 Yield = 88.5%

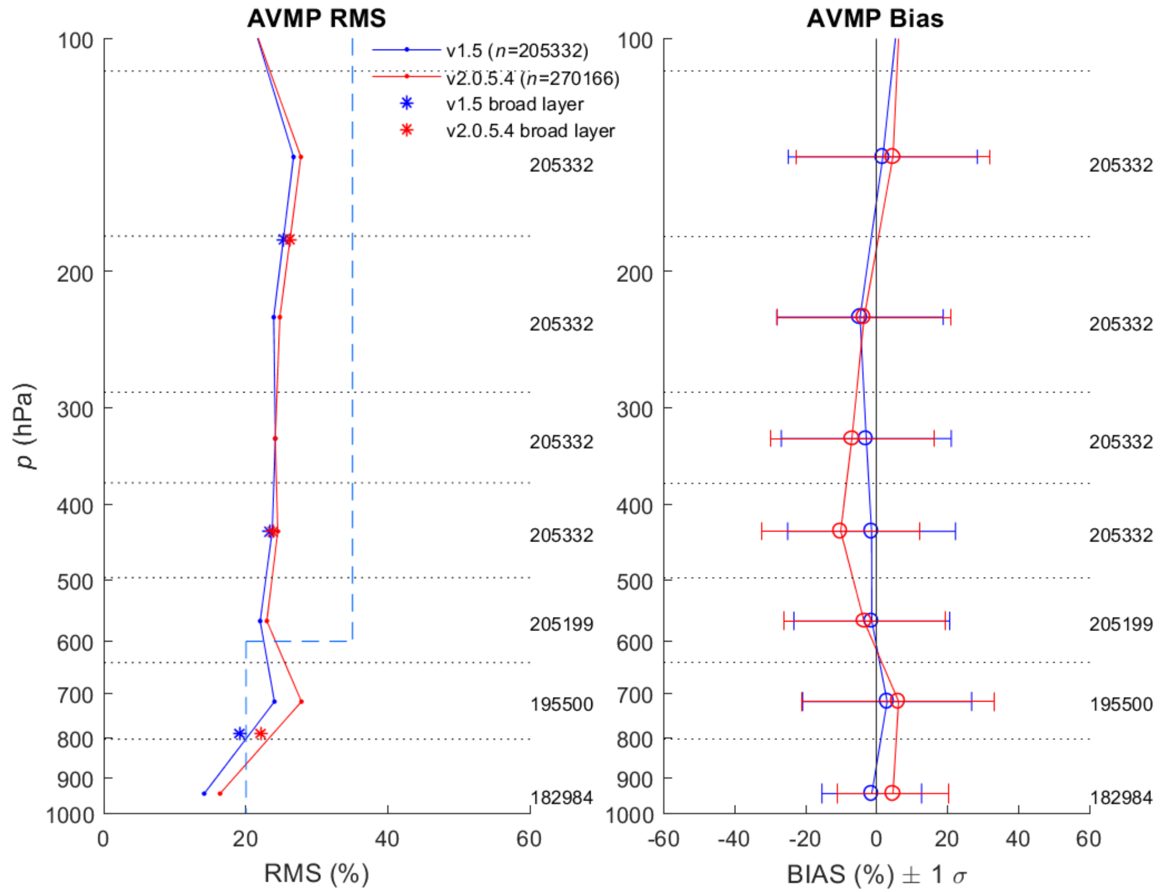


NUCAPS v2.0 FSR IR+MW AVMP Coarse-Layer Statistics Global Focus Day 17-Feb-2015

AVMP Versus ECMWF

V1.5 IR+MW
V2.0 IR+MW

v1.5 Yield = 63.4%
v2.0 Yield = 88.5%

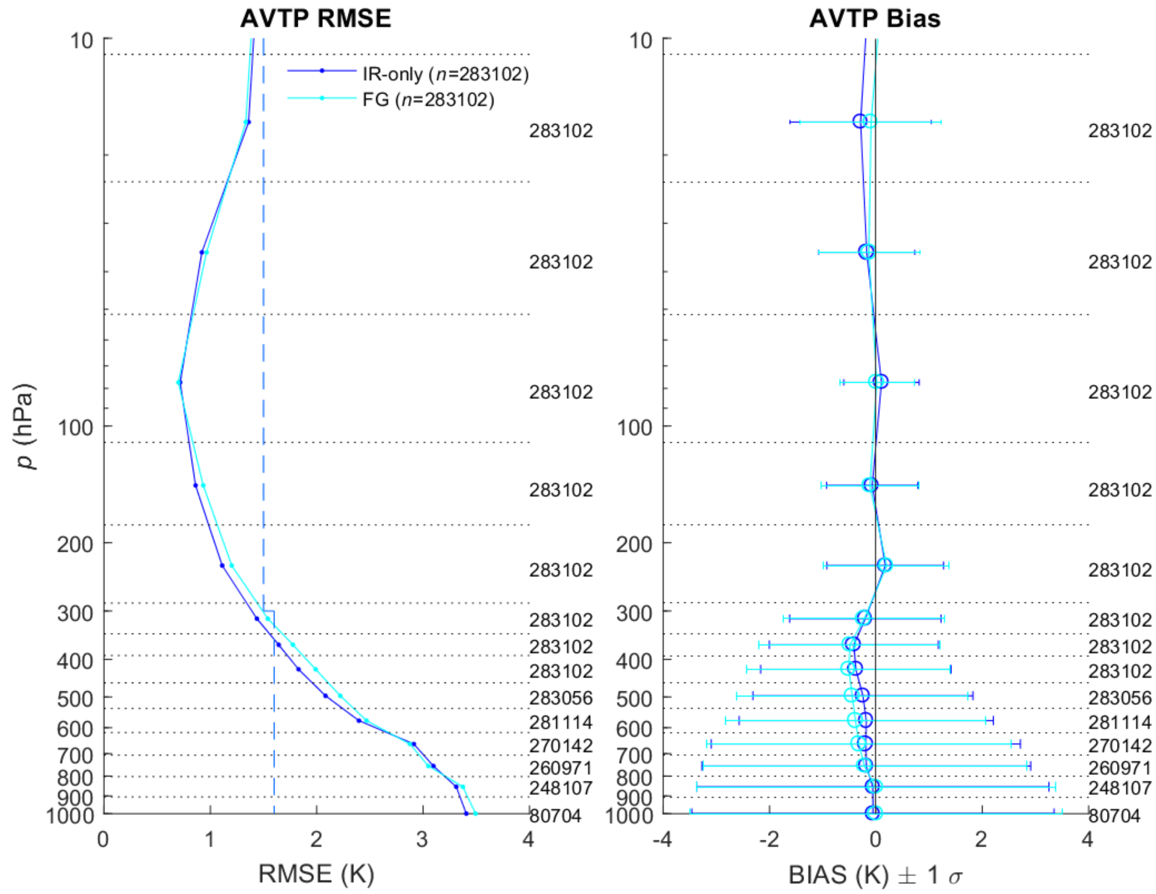


NUCAPS v2.0 FSR IR-Only AVTP Coarse-Layer Statistics Global Focus Day 17-Feb-2015

IR-Only
First Guess

IR-Only Yield = 87.4%

AVTP Versus ECMWF



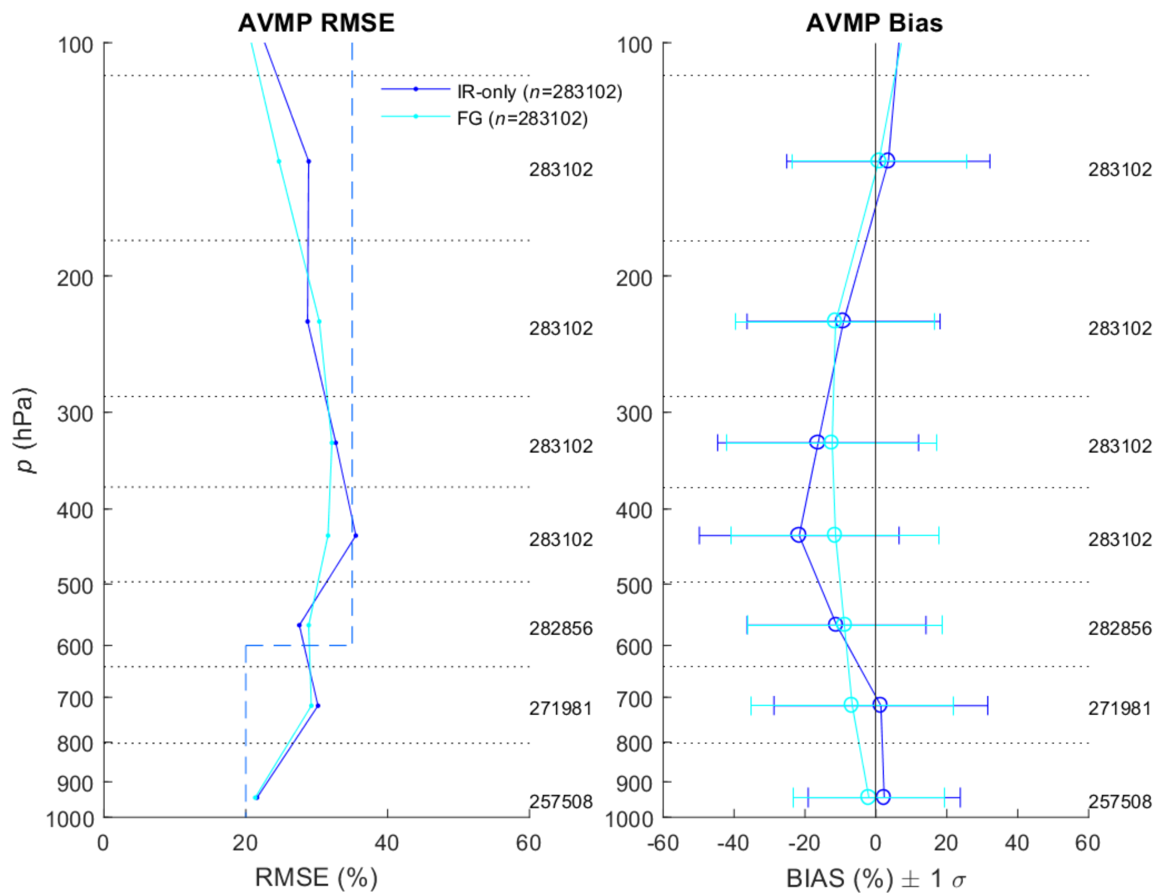
NUCAPS v2.0 FSR IR-Only AVMP Coarse-Layer Statistics Global Focus Day 17-Feb-2015

AVMP Versus ECMWF

IR-Only

First Guess

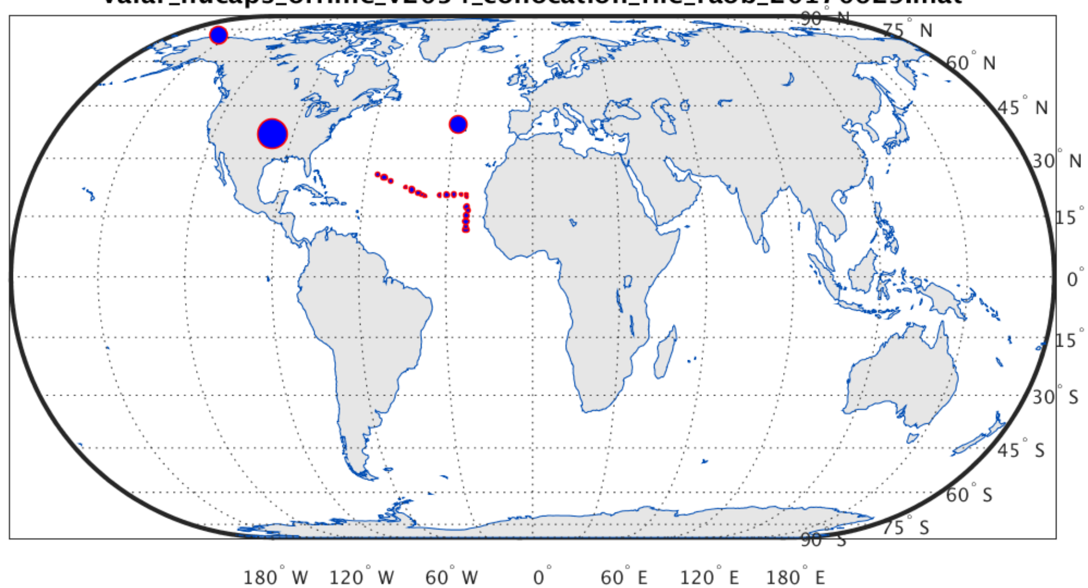
IR-Only Yield = 87.4%

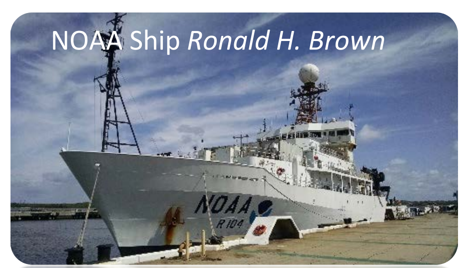


JPSS Dedicated RAOBs March to July 2017

- **Full-res CrIS SDRs** became operationally available on the STAR Central Data Repository (SCDR) beginning in March 2017
  - We have collected full-res CrIS granule collocations for **JPSS dedicated RAOBs** since this time
- **Atmospheric Radiation Measurement (ARM)** sites
  - Eastern North Atlantic (ENA)
  - Southern Great Plains (SGP)
  - North Slope of Alaska (NSA)
- **2017 NOAA AEROSE campaign** (*Nalli et al.* 2011)
  - Feb-Mar 2017, tropical Atlantic Ocean
  - Unfortunately, approximately only one-half the launched RAOBs could thus be utilized

NUCAPS-RAOB Collocations
JPSS Dedicated RAOBs
δx = 75 km, δt = −90 to +5 min





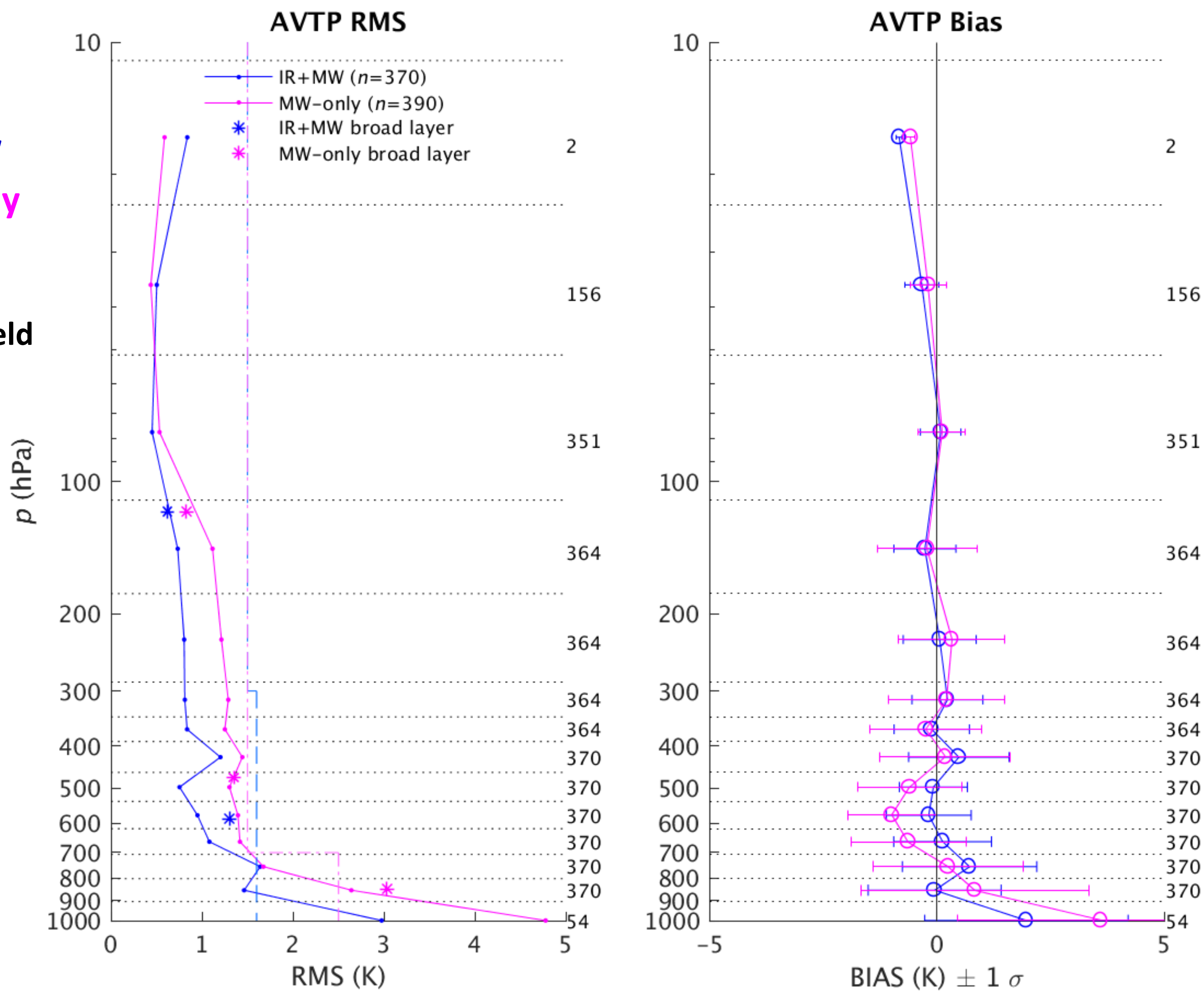
Coarse-Layer AVTP Stats

Versus VALAR JPSS Dedicated RAOBs

IR+MW

MW-Only

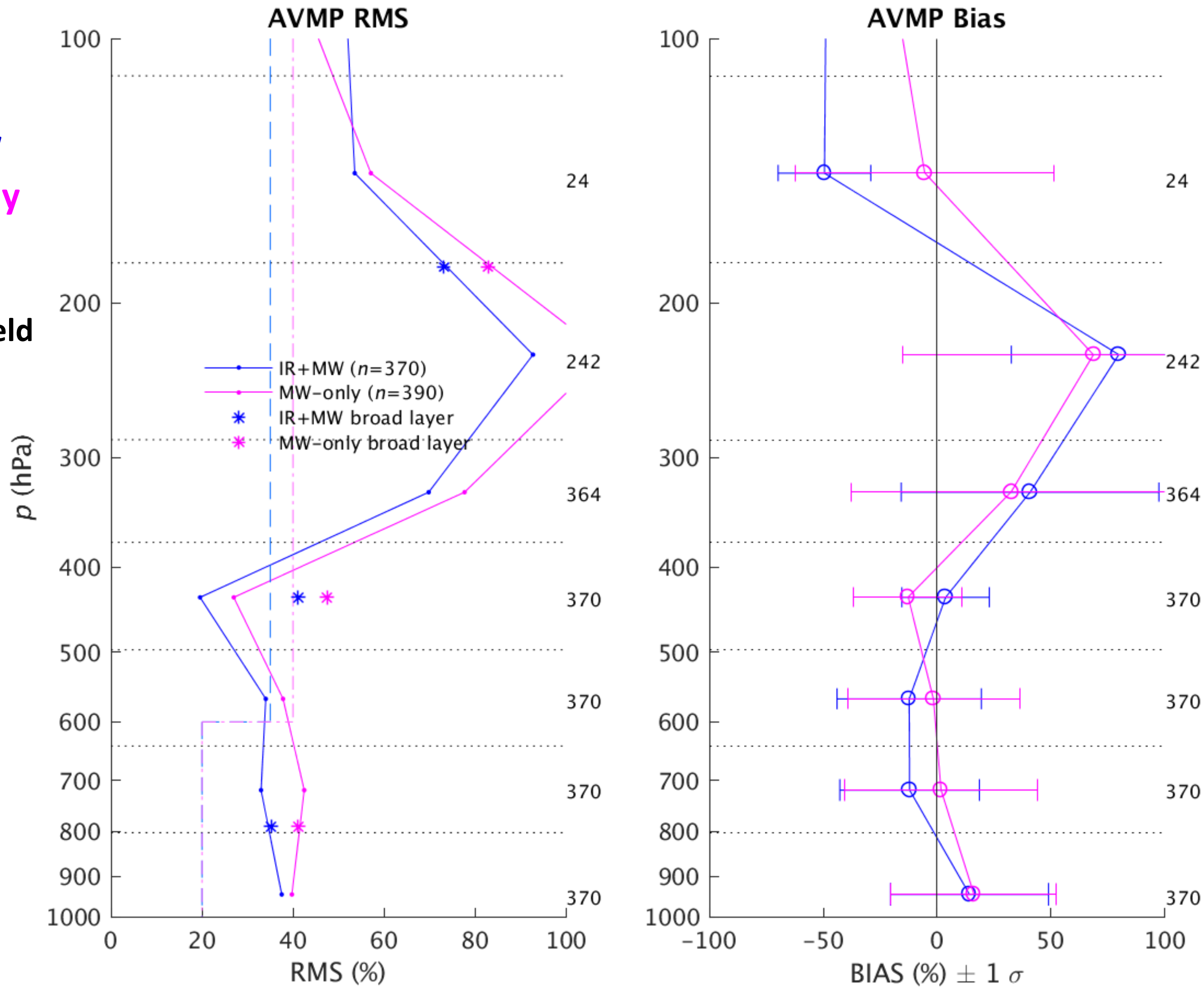
IR+MW Yield = 75.7%



Coarse-Layer AVMP Stats
Versus VALAR JPSS Dedicated RAOBs

IR+MW
MW-Only

IR+MW Yield = 75.7%



NUCAPS v2.0 AVTP Uncertainty Summary Table

Versus ECMWF

SUMMARY OF AVTP EDR VERSUS L1RD REQUIREMENTS		
Broad-Layer	**Result vs ECMWF**	**JPSS L1RD**
Cloud-Free to Partly Cloudy (IR+MW)		
1014 to 300 hPa	**1.3 K**	1.6 K
300 to 30 hPa	**1.1 K**	1.5 K
Cloudy (MW-Only)		
1014 to 700 hPa	**3.0 K**	2.5 K
700 to 300 hPa	**2.3 K**	1.5 K
300 to 30 hPa	**2.1 K**	1. 5 K

NUCAPS v2.0 AVMP (H_2O) Uncertainty Summary Table Versus ECMWF

SUMMARY OF AVMP EDR VERSUS L1RD REQUIREMENTS		
Broad-Layer	**Result vs ECMWF**	**JPSS L1RD**
Cloud-Free to Partly Cloudy (IR+MW)		
1014 to 600 hPa	**22.7% or 1.1 g/kg**	Greater of 20% or 0.2 g/kg
600 to 300 hPa	**24.9%, 0.2 g/kg**	Greater of 35% or 0.1 g/kg
300 to 100 hPa	**22.7%, 0.01 g/kg**	Greater of 35% or 0.1 g/kg
Cloudy (MW-Only)		
1014 to 600 hPa	**29.2%**	Greater of 20% or 0.2 g/kg
600 to 300 hPa	**35.6%**	Greater of 40% or 0.1 g/kg
300 to 100 hPa	**39.8**	Greater of 40% or 0.1 g/kg

NUCAPS EDR Maturity Status

Slide courtesy of Lihang Zhou, STAR/JPSS

S-NPP EDR Validated Maturity Oct. 2016-Current: NUCAPS

Sensor	Product	Priority	Validated Maturity Review Date & Status		Review Panel Recommendations
CrIS/ATMS	Atm. Vertical Moisture Profile (AVMP)	3	*	✓ V	September 2014
CrIS/ATMS	Atm. Vertical Temperature Profile (AVTP)	3	*	✓ V	September 2014
CrIS/ATMS	Ozone Profile EDR	3	Oct-2016	✓ V	Panel recommended the following: (1) Work with EMC and NWS on user applications (2) Validate against OMPS NP data (3) Extend validation to more ozonesondes
CrIS	Outgoing Longwave Radiation	3	Oct-2016	✓ V	Panel recommended the following: (1) Investigate the use of VIIRS for helping to understand the differences between OLR from CrIS and CERES. (2) Compare anomaly events from CERES OLR (e.g. ENSO, MJO) to CrIS OLR data (3) Provide information about how algorithm will be updated to utilize CrIS FS data
CrIS/ATMS	Carbon Monoxide	4	&	✓ P	Validated Maturity Review for Fall 2017
CrIS/ATMS	Carbon Dioxide	4	&	✓ P	Validated Maturity Review for Fall 2017
CrIS/ATMS	Methane	4	&	✓ P	Validated Maturity Review for Fall 2017

*Product reached validated maturity in September 2014.

&Product reached provisional maturity in January 2013. NUCAPS Phase IV/Part II ARR completed on July 6, 2017.

✓ Validated ✓ Provisional

Summary and Future Work

- **SNPP NUCAPS NSR (v1.5) AVTP/AVMP EDRs have met JPSS global requirements**
  - Validated Maturity for AVTP/AVMP EDR attained Sep 2014

- Offline **NUCAPS Phase 4 FSR (v2.0)** has been successfully implemented and tested. Based on Global Focus Day ECMWF model comparison and limited RAOB matchups
  - IR+MW EDR products have attained **Provisional Maturity**
  - IR-Only EDR products have been successfully implemented and show reasonable performance

- **Future Work**
  - **Ongoing NUCAPS development, Cal/Val and Long-Term Monitoring**
    - **Continue v2.0 algorithm optimizations**
    - **NUCAPS Trace Gas cal/val** (*Nalli et al.* presentation, trace gas session)
    - **Prepare for JPSS-1 launch**
    - Continue support of dedicated RAOBs (including ARM, AEROSE)
  - **Other Related Work**
    - **Apply averaging kernels** in NUCAPS error analyses, including ozone profile EDR
    - Collocation uncertainty estimates
    - calc − obs analyses (CRTM, LBLRTM, SARTA, etc.)
    - Support skin SST EDR validation
    - Support EDR user applications (AWIPS, AR/SAL, atmospheric chemistry users)

SNPP NUCAPS Validation Status

THANK YOU! QUESTIONS?

SNPP NUCAPS Validation Status

EXTRA SLIDES

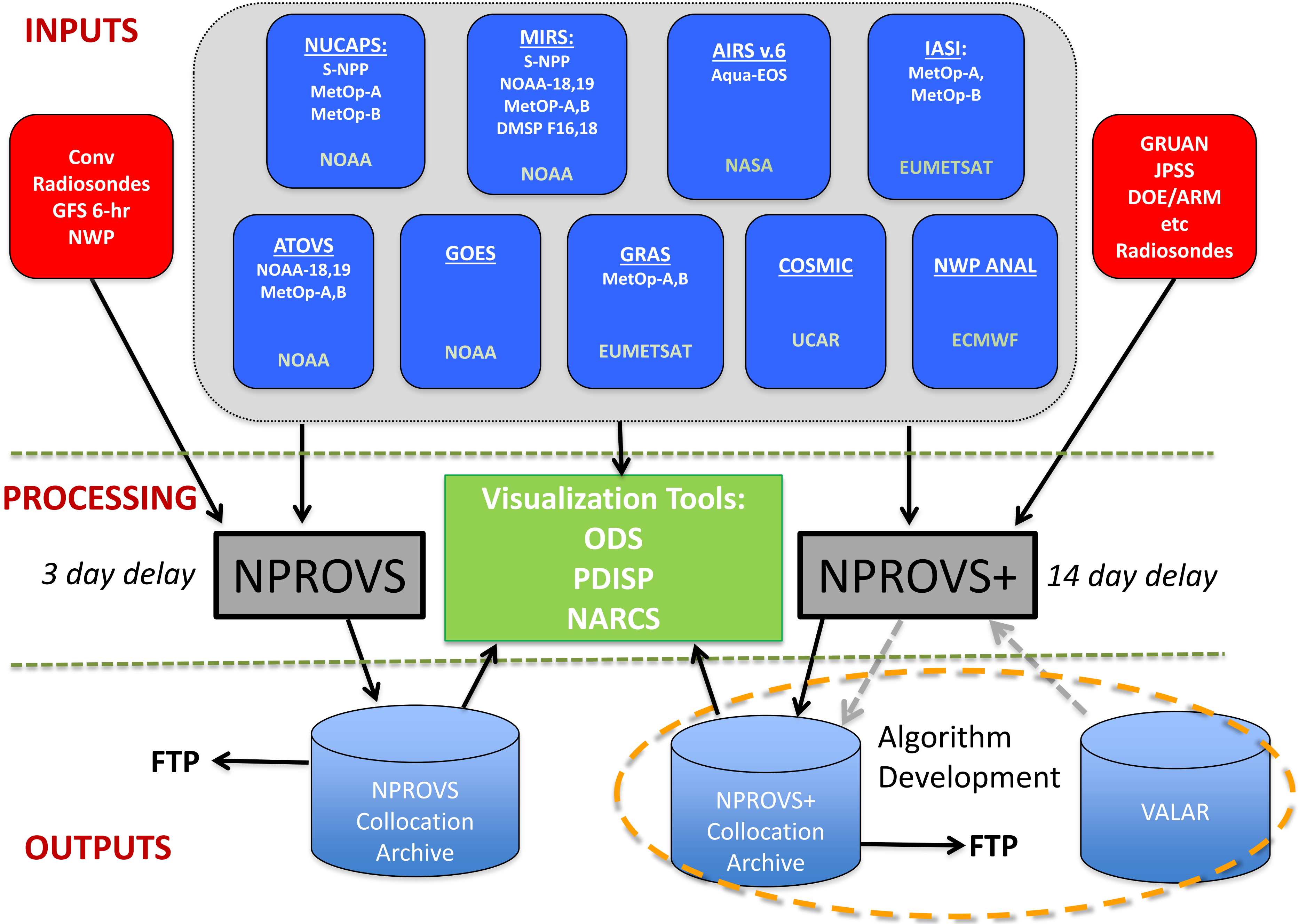
NOAA (SOUNDING) PRODUCTS VALIDATION SYSTEM (NPROVS) AND NUCAPS ASSESSMENT

TONY REALE
(STAR)
BOMIN SUN, MICHAEL PETTEY, NICK NALLI
(IMSG)
ANTONIA GAMBACORTA
(SGT)

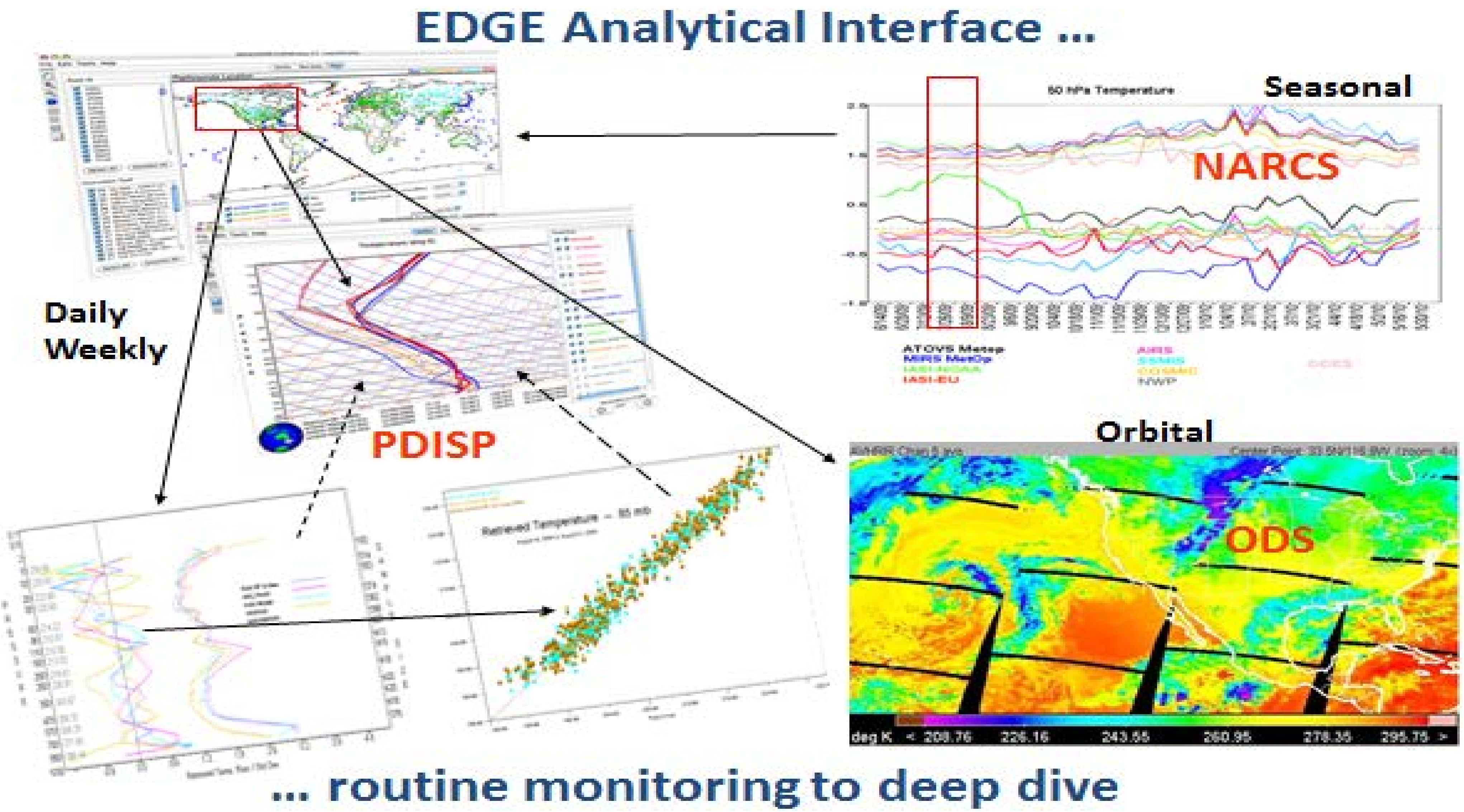
Outline

- NPROVS and NPROVS+ (Enterprise Validation)
- Staged FSR NUCAPS Sounding Assessment
    - ✓ *IR+MW*
    - ✓ *IR-only*
    - ✓ *MW only (including vs MiRS*
- IR-only and Microwave Retrieval Assessment
- NUCAPS in AWIPS
- Summary and Path Forward

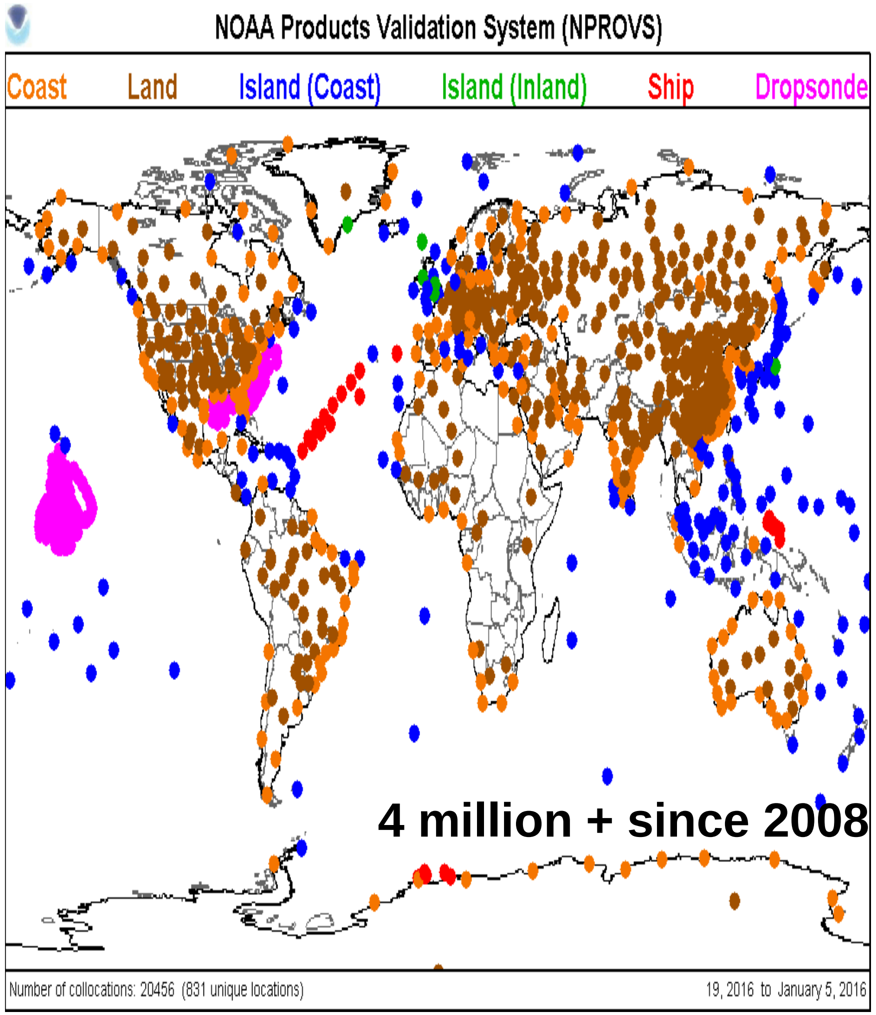
NPROVS/NPROVS+ Data Management Schematic

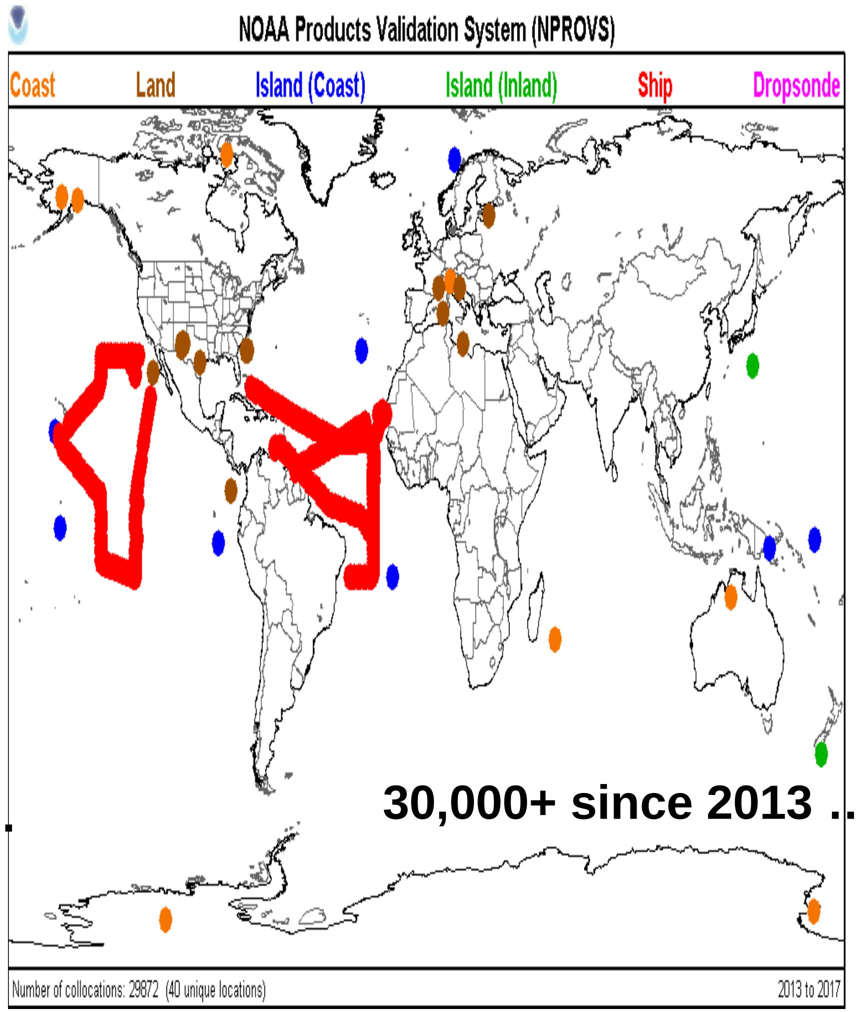


NPROVS Graphical Analysis Tools

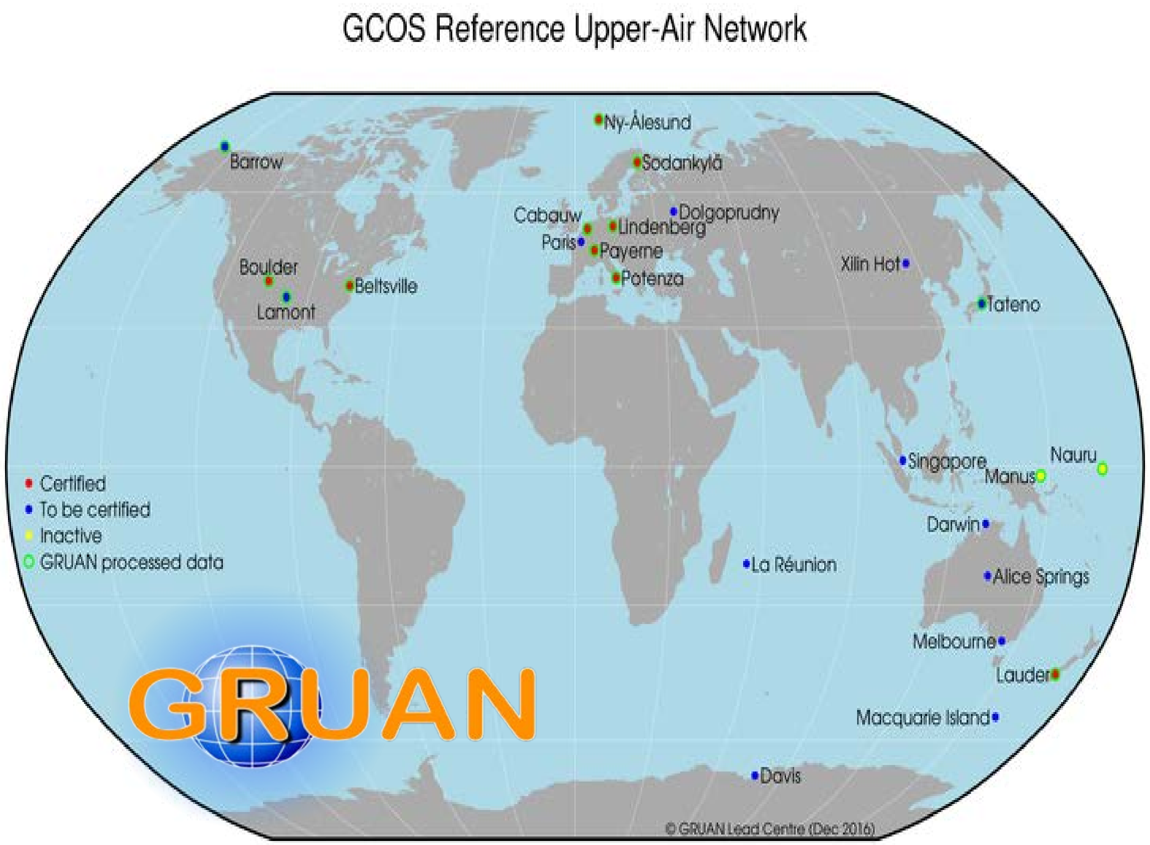


NPROVS NPROVS+





Global distributions of collocated RAOB and Satellite Observations for NPROVS (left, 10-day period) and NPROVS+ (right, Jan 2013 to present)



+

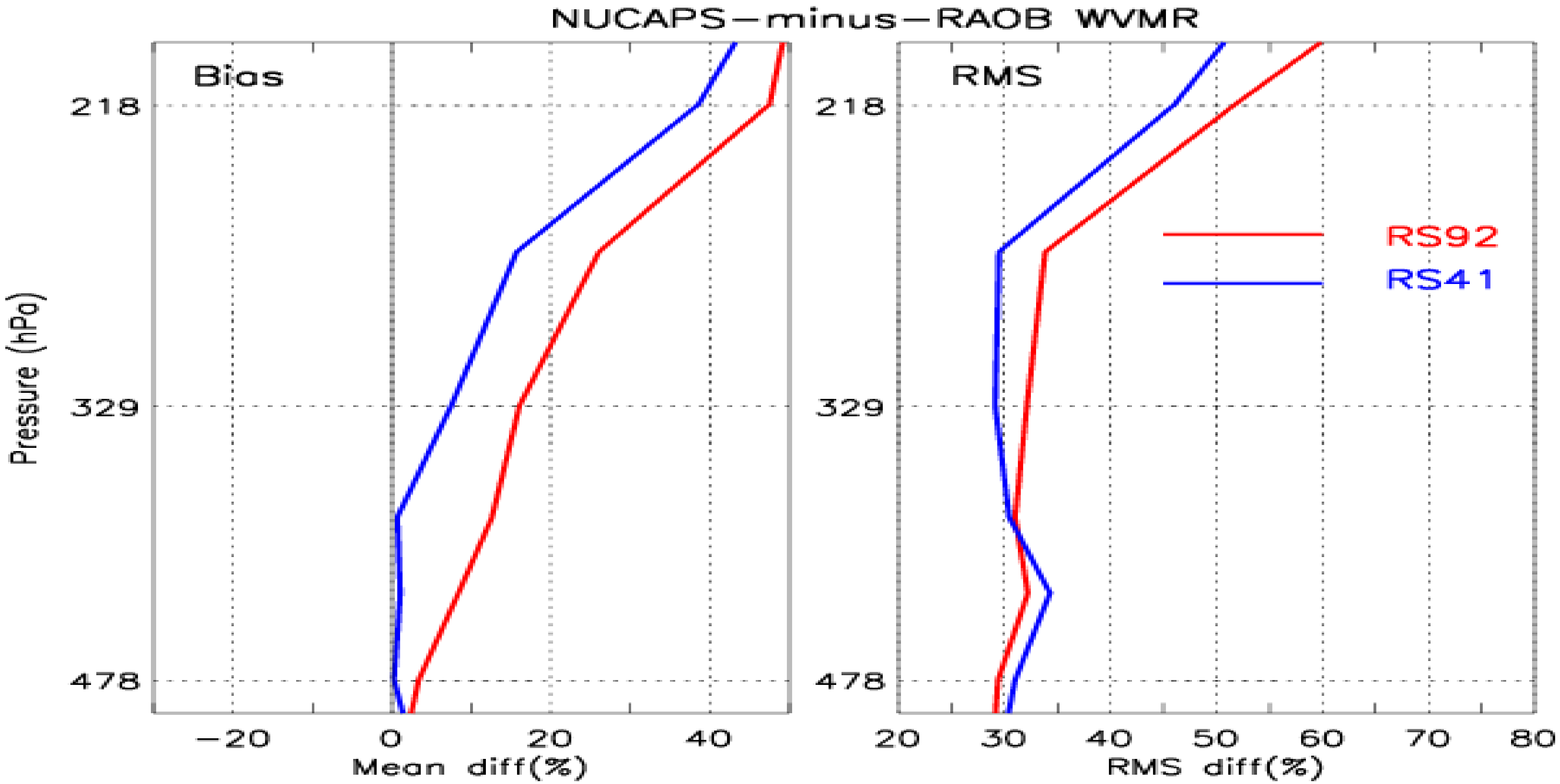
JPSS Funded Dedicated RAOB

- DOE ARM (SGP, NSA, ENA)
  - ✓SSEC / Madison
  - ✓(2) per week
  - ✓**GRUAN processed**
  - ✓ dual and single launches
- AEROSE (Saharan Dust)
- CALWATER (Atmospheric River)
- El-Nino Rapid Response

CIRA, PMRS
ARM Mobile Sites
Sterling Field Site Facility

New: Dual GRUAN RS92 / RS41

Radiosonde Intercomparison and VALidation (RIVAL) … Lori Borg (SSEC)



RS41 corrects for upper tropospheric moisture dry bias evident in RS92 …
NUCAPS shows reduced RMS and Bias wrt to RS41 vs RS92 …. *courtesy Bomin Sun*

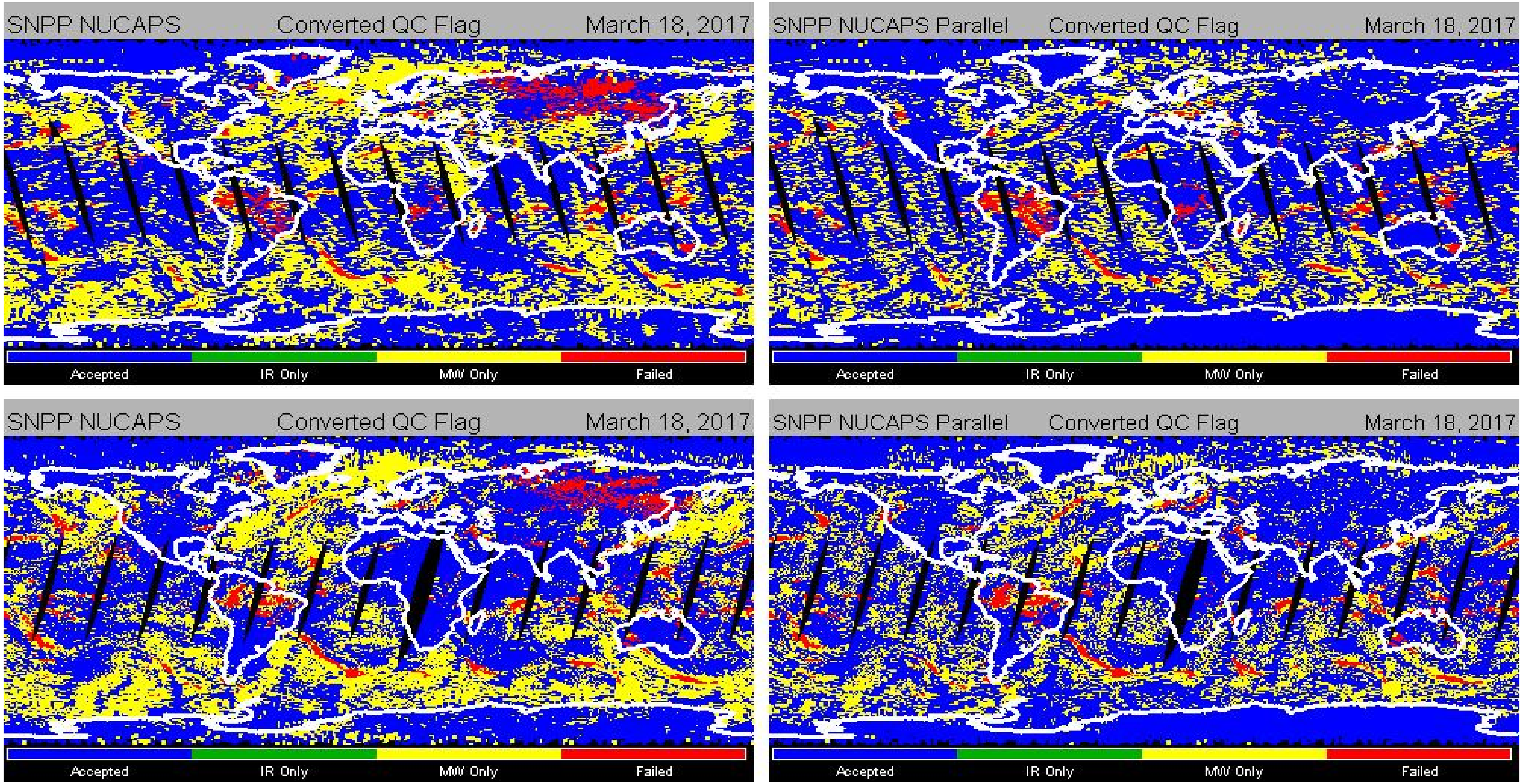
NPROVS Assessment of NUCAPS

Time-line for NUCAPS "FSR" Staged Upgrades in Parallel Test:

v1.9.3	up to March 3	
v2.0.1	March 3-13	*all-sky for MIT*
v2.0.2	March 13-17	*all-sky for MIT*
v2.0.4	March 17-30	IR+MW
v2.0.4.1	March 30	IR-only
v2.0.4	April 21	IR+MW
v2.0.5	**May 18**	**RTA tuning !!**
v2.0.5.4	June 22 16Z	Block 2 tuning
V2.0.5.?	July 14 19Z	IR-only

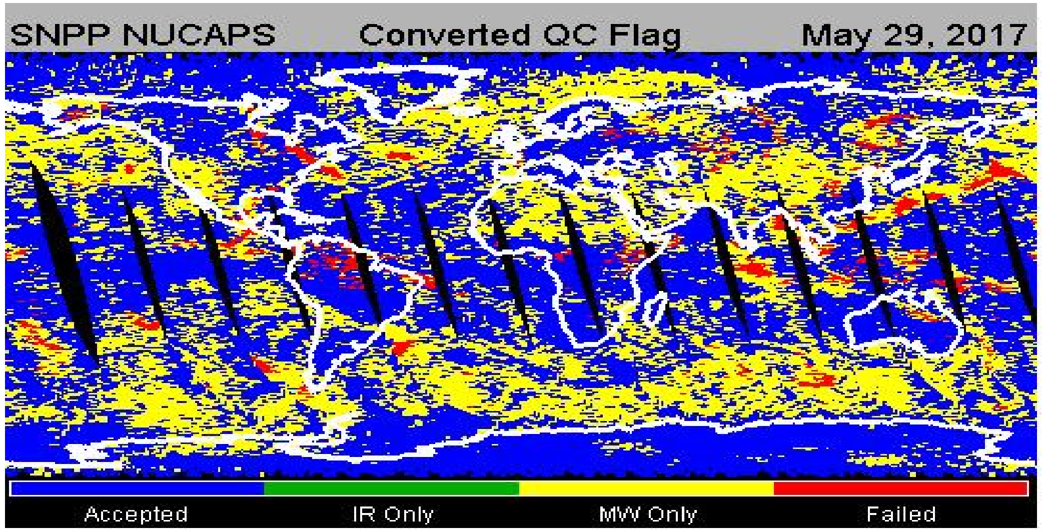
ATMS Block 1-2: March 8

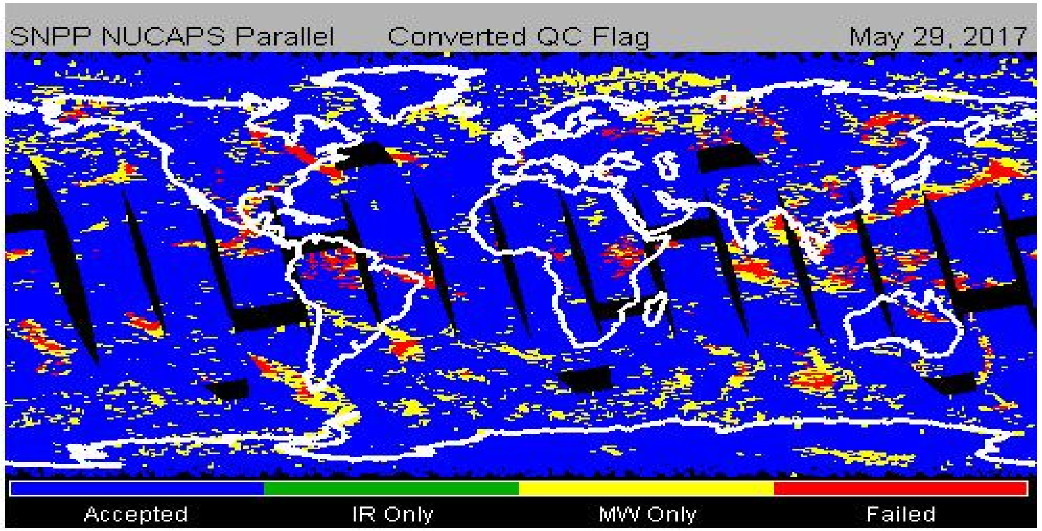
ODS … QC flag analysis

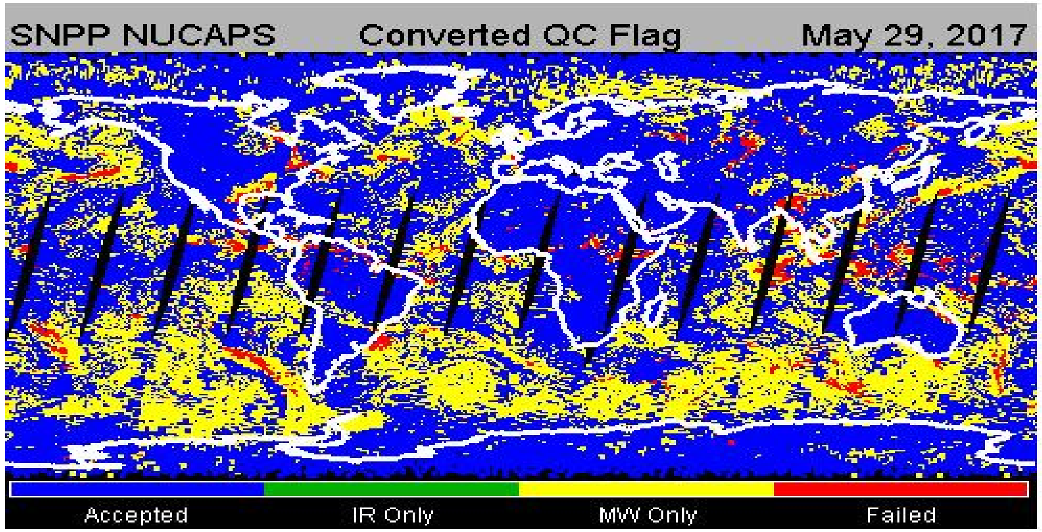


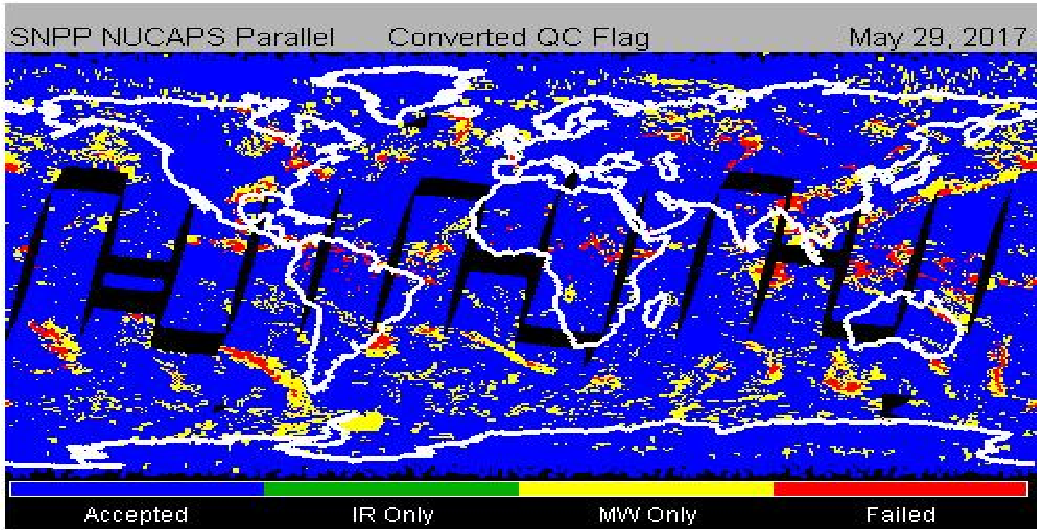
NUCAPS v1.5 (left) vs v2.0.4 … old IR RTA tuning (right)

ODS … QC flag analysis



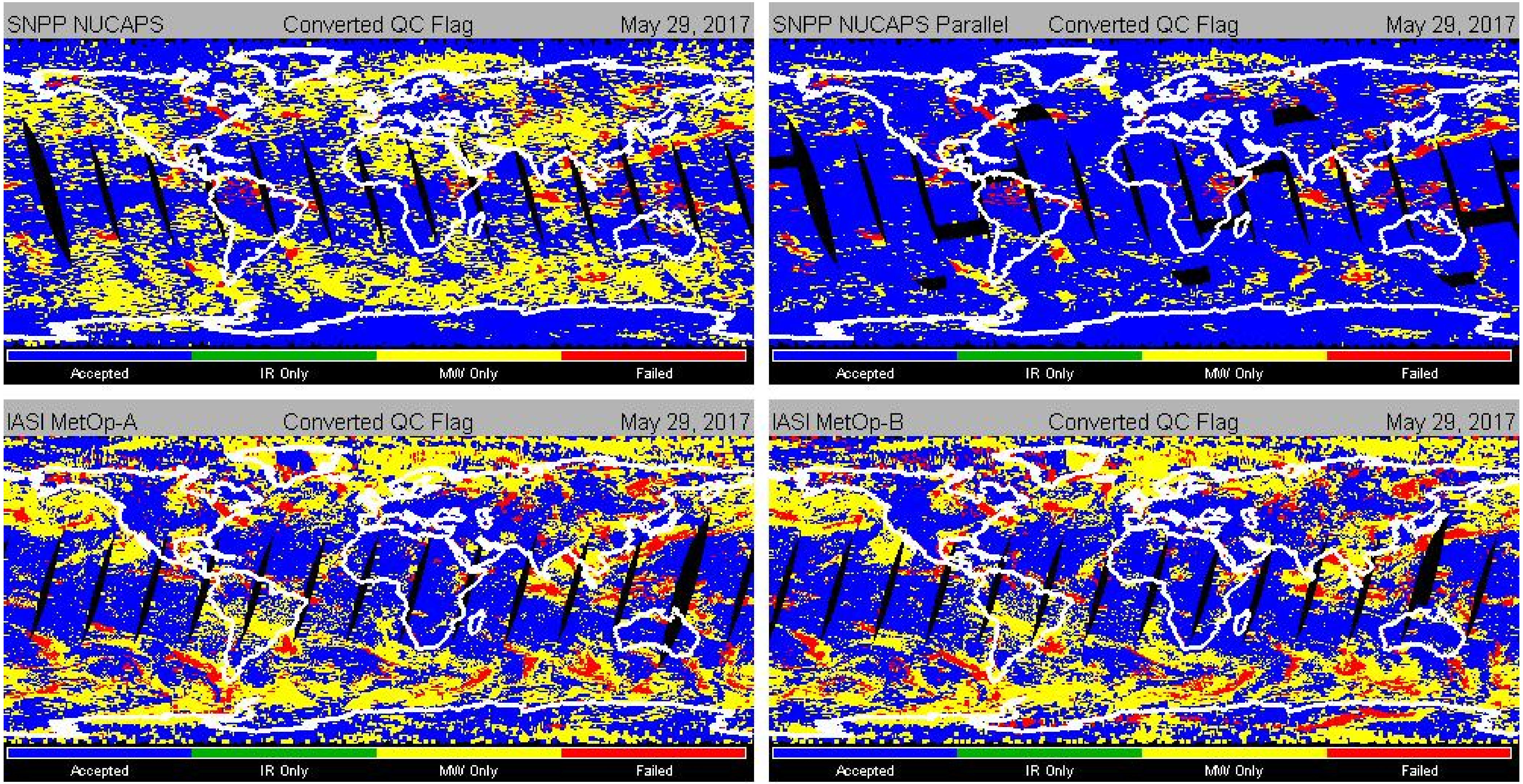






NUCAPS v1.5 (left) vs v2.0.5 … new IR RTA tuning (right)

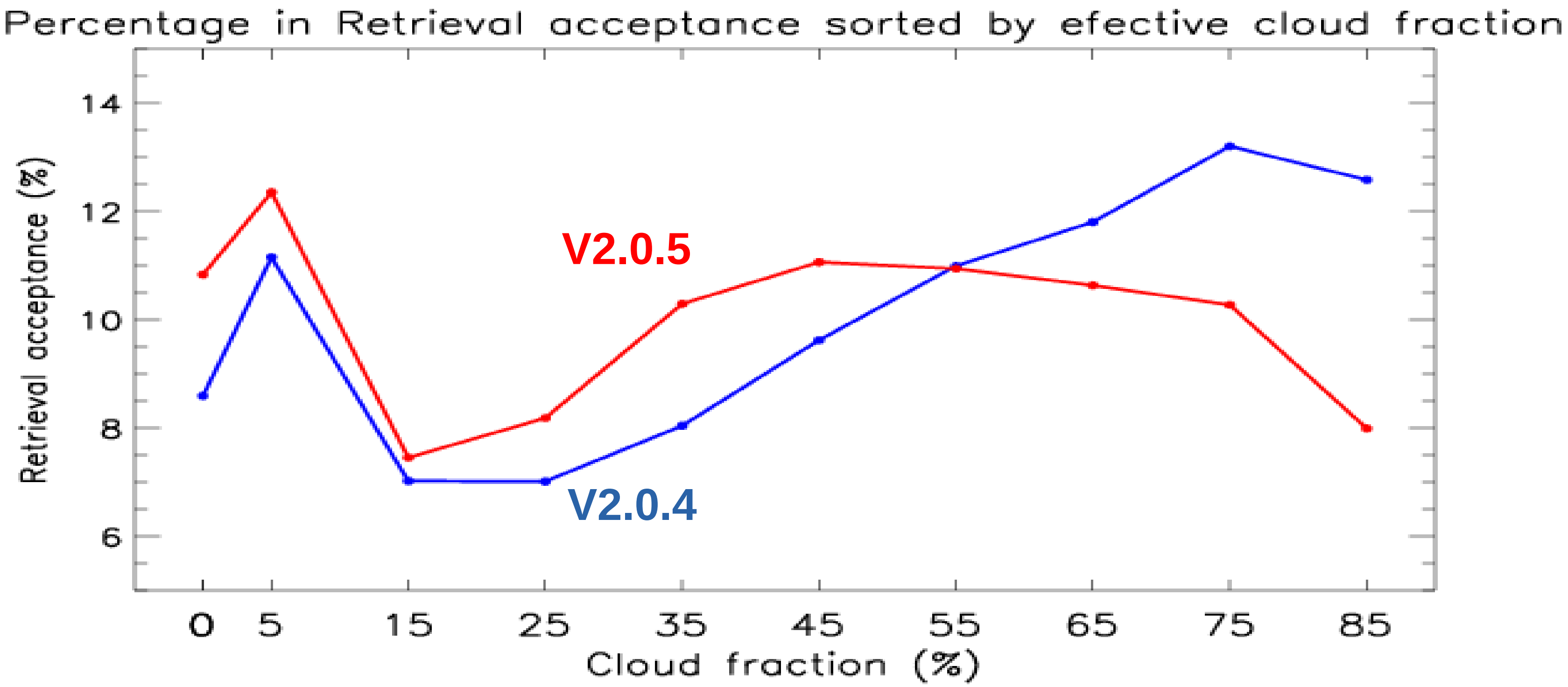
ODS … QC flag analysis



NUCAPS v1.5 (up left) vs v2.0.5 (up right) vs MetOp-A (low left) vs MetOp-B (low right)

V2.0.4 (old IR RTA) vs V2.0.5 (new IR RTA)

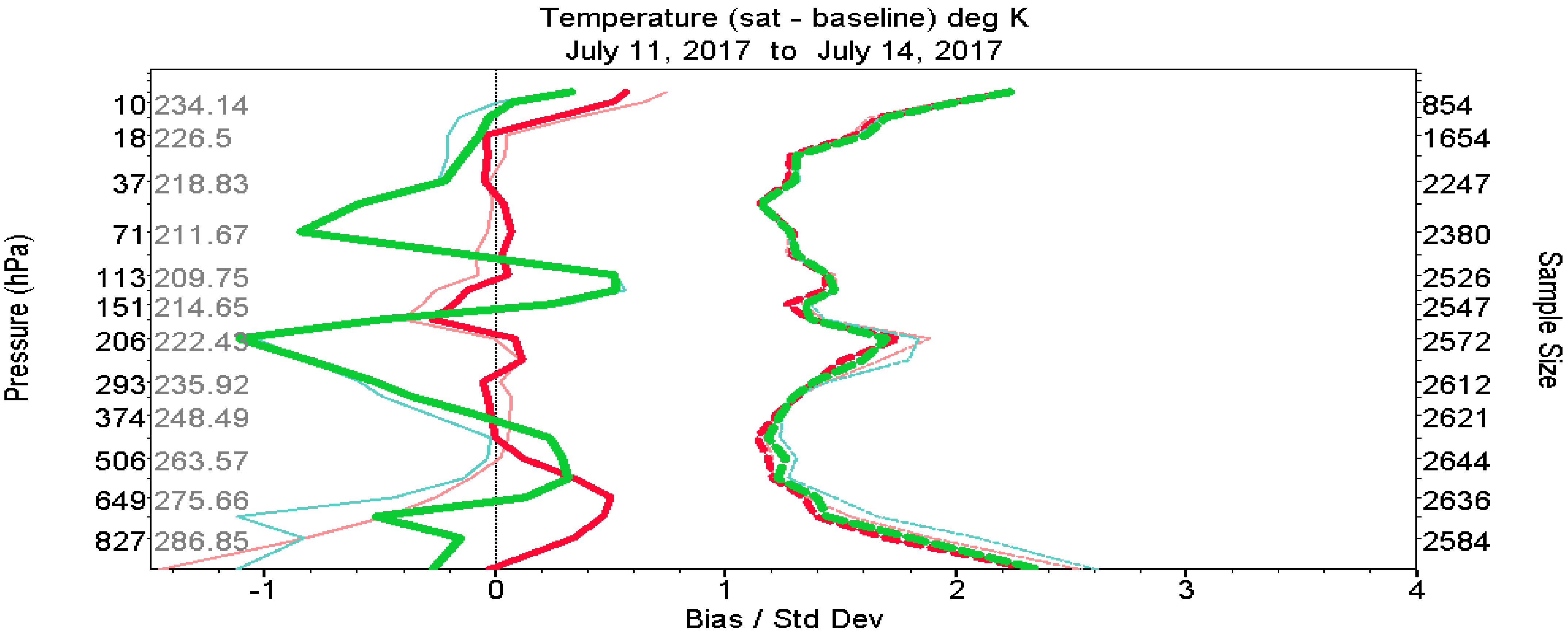
V2.0.4 yield: 70%
V2.0.5 yield: 85%



Note: The y-axis retrieval acceptance rate is the number of accepted retrievals associated with a certain cloud fraction divided by the total number of accepted retrievals.

12

PDISP



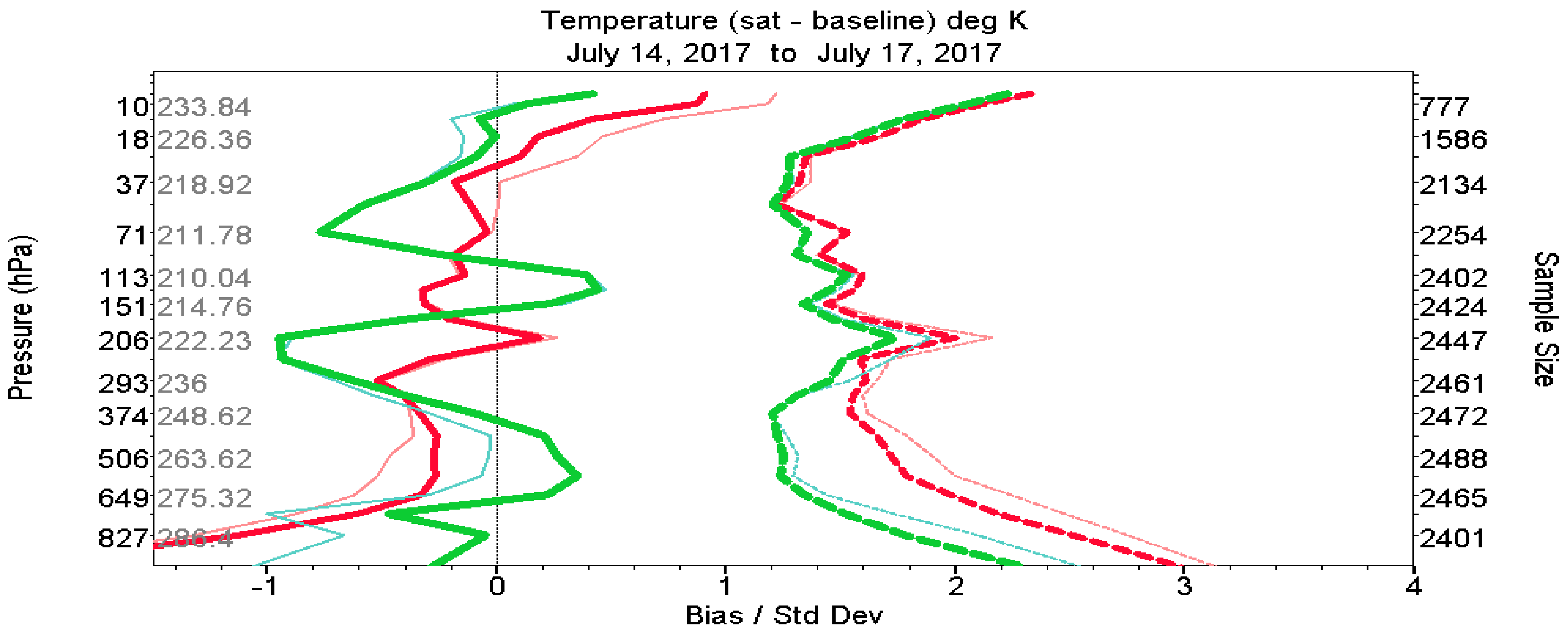
Baseline: SONDE

NUCAPS NPP   NUCAPS NPP First Guess   NUCAPS NPP TEST

NUCAPS NPP TEST First Guess

IR + MW v2.0.5

PDISP

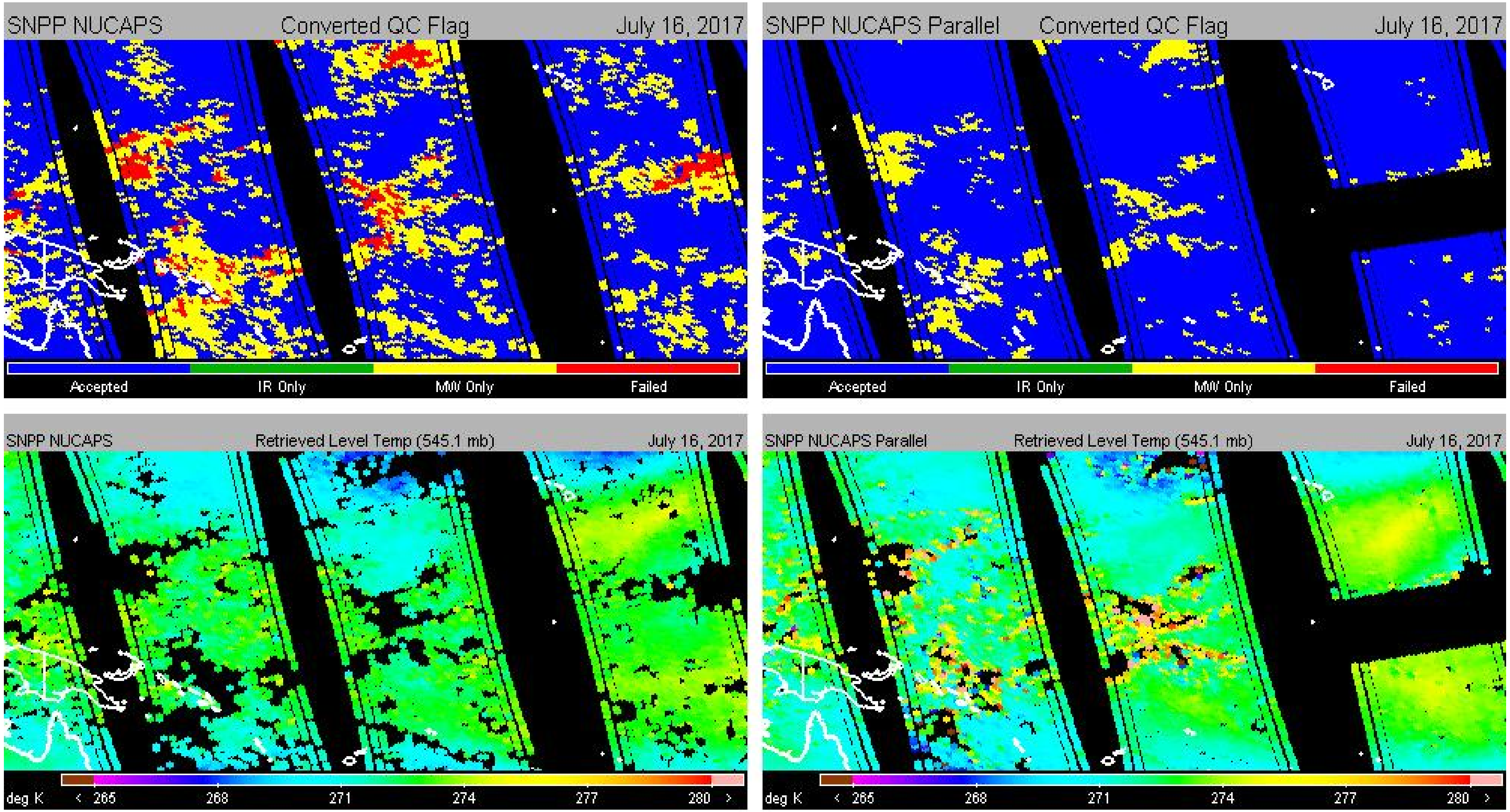


Baseline: SONDE

NUCAPS NPP | NUCAPS NPP First Guess | NUCAPS NPP TEST | NUCAPS NPP TEST First Guess

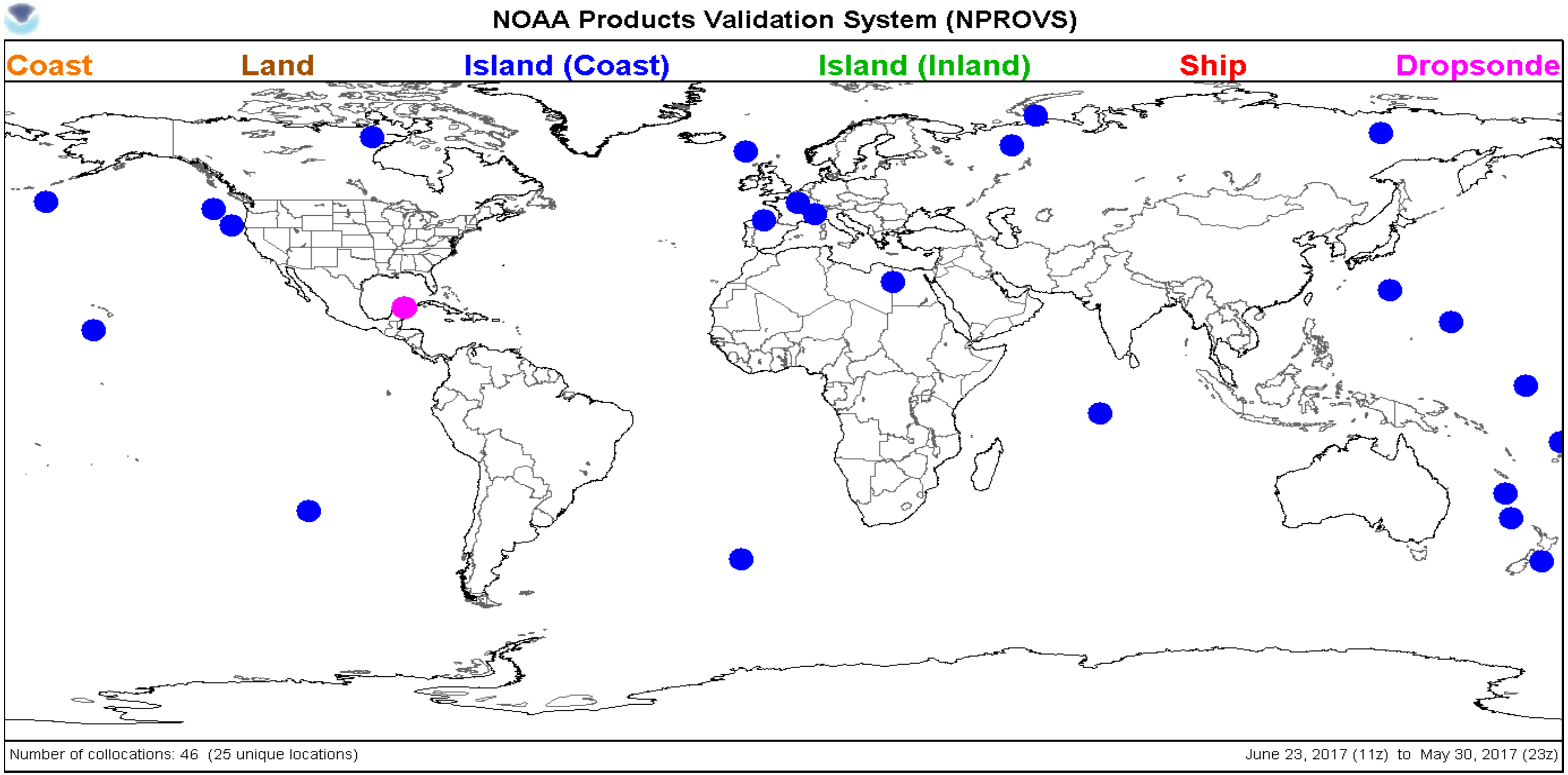
IR- only v2.0.5

ODS … QC flag (top), 545 hPa temp (bottom)



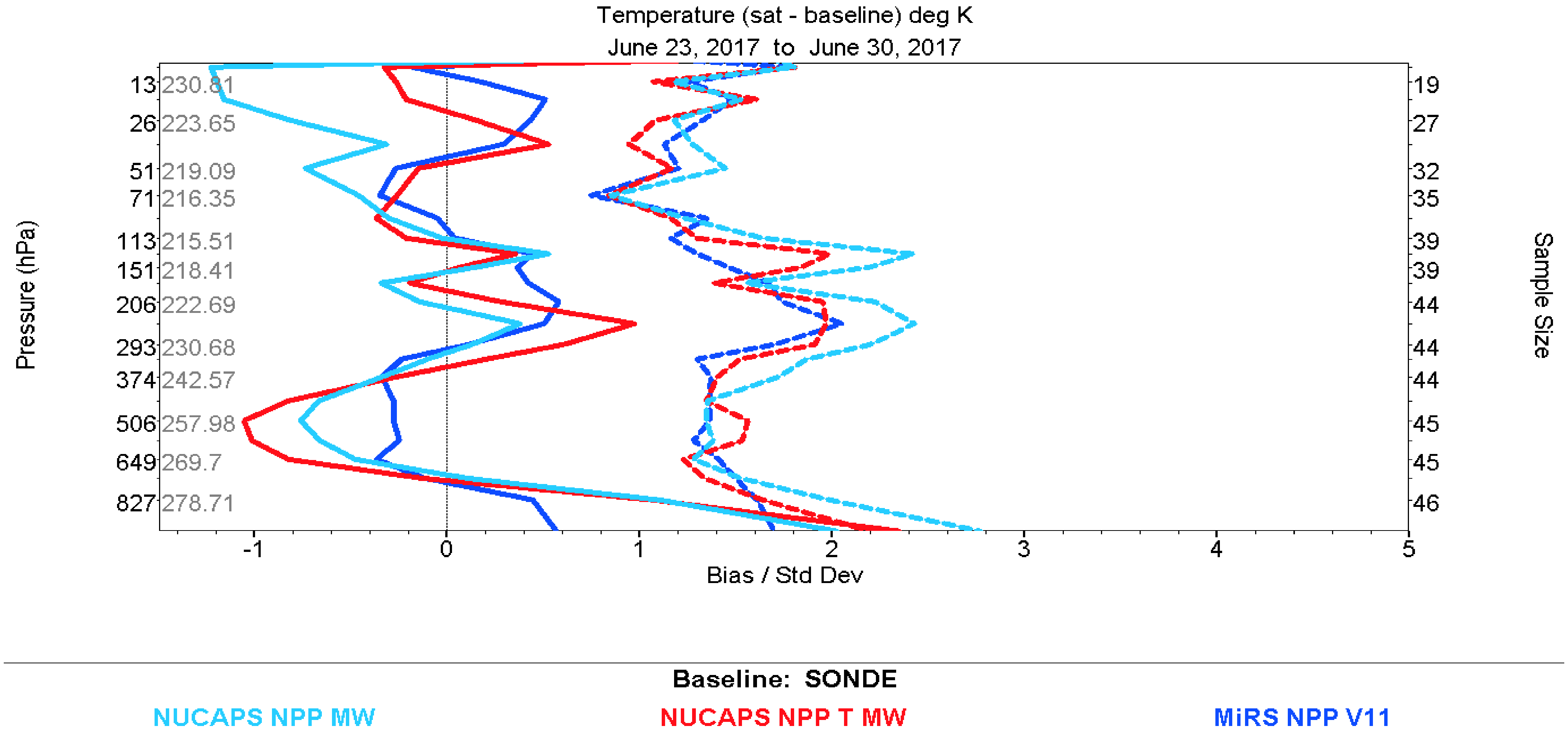
NUCAPS v1.5 (left) vs v2.0.5 … IR-only (right)

PDISP



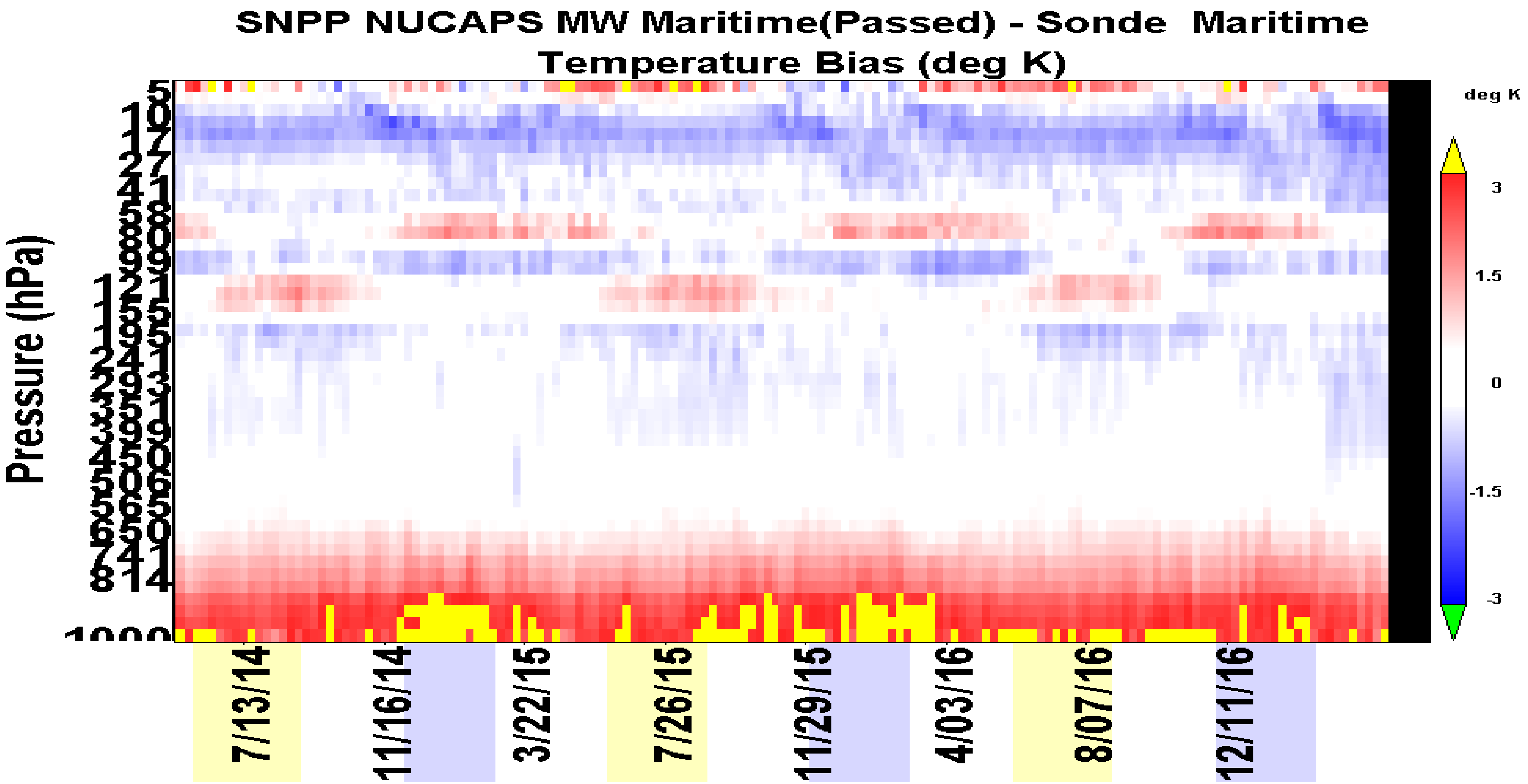
Collocations with NUCAPS MW-only and MiRS Sea observations

PDISP



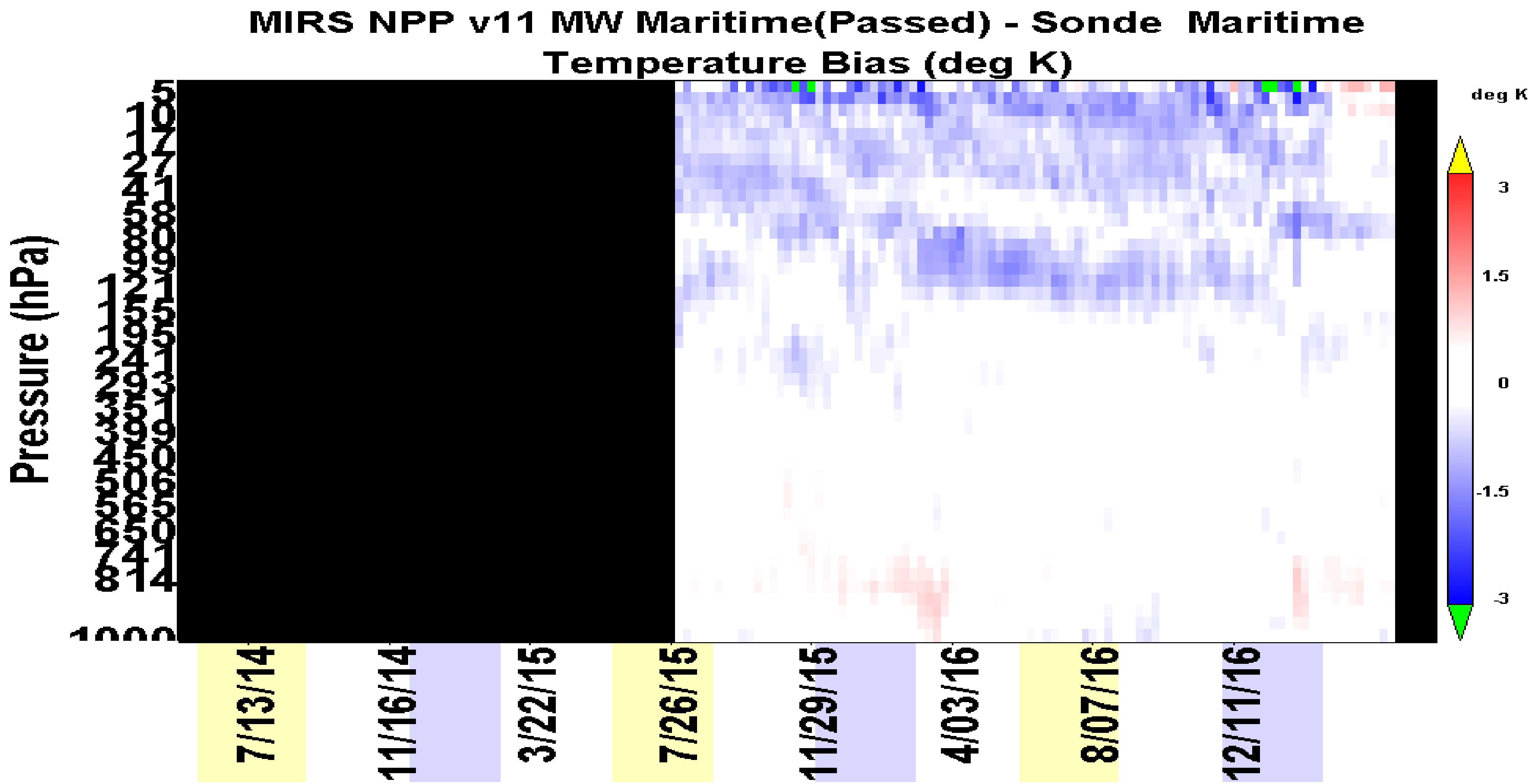
NUCAPS MW-only v1.5 and v2.0.5 vs MiRS

NARCS-LTM



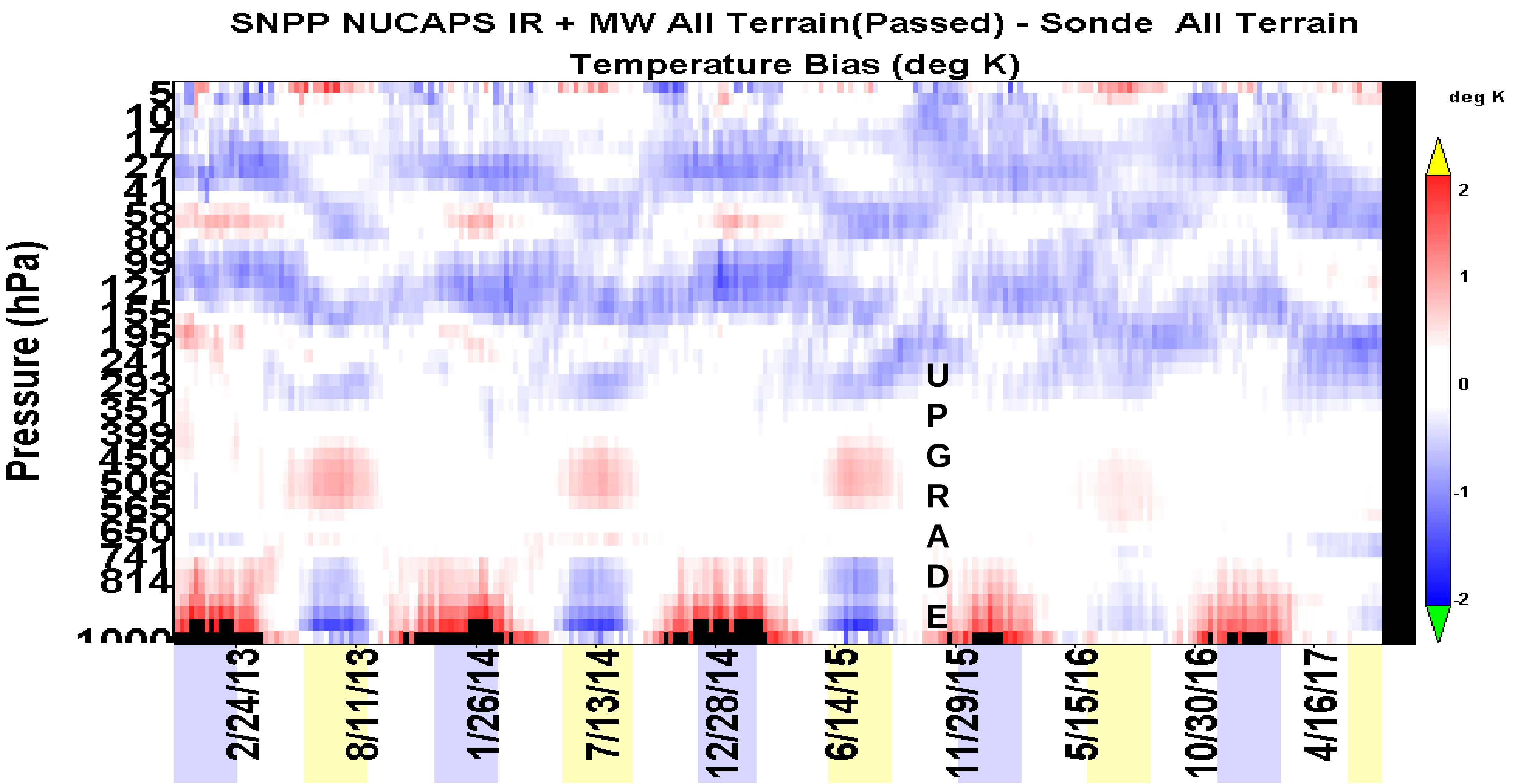
SNPP NUCAPS MW Maritime(Passed) - Sonde Maritime
Temperature Bias (deg K)
Pressure (hPa)
deg K
3
1.5
0
-1.5
-3
7/13/14
11/16/14
3/22/15
7/26/15
11/29/15
4/03/16
8/07/16
12/11/16

NARCS-LTM



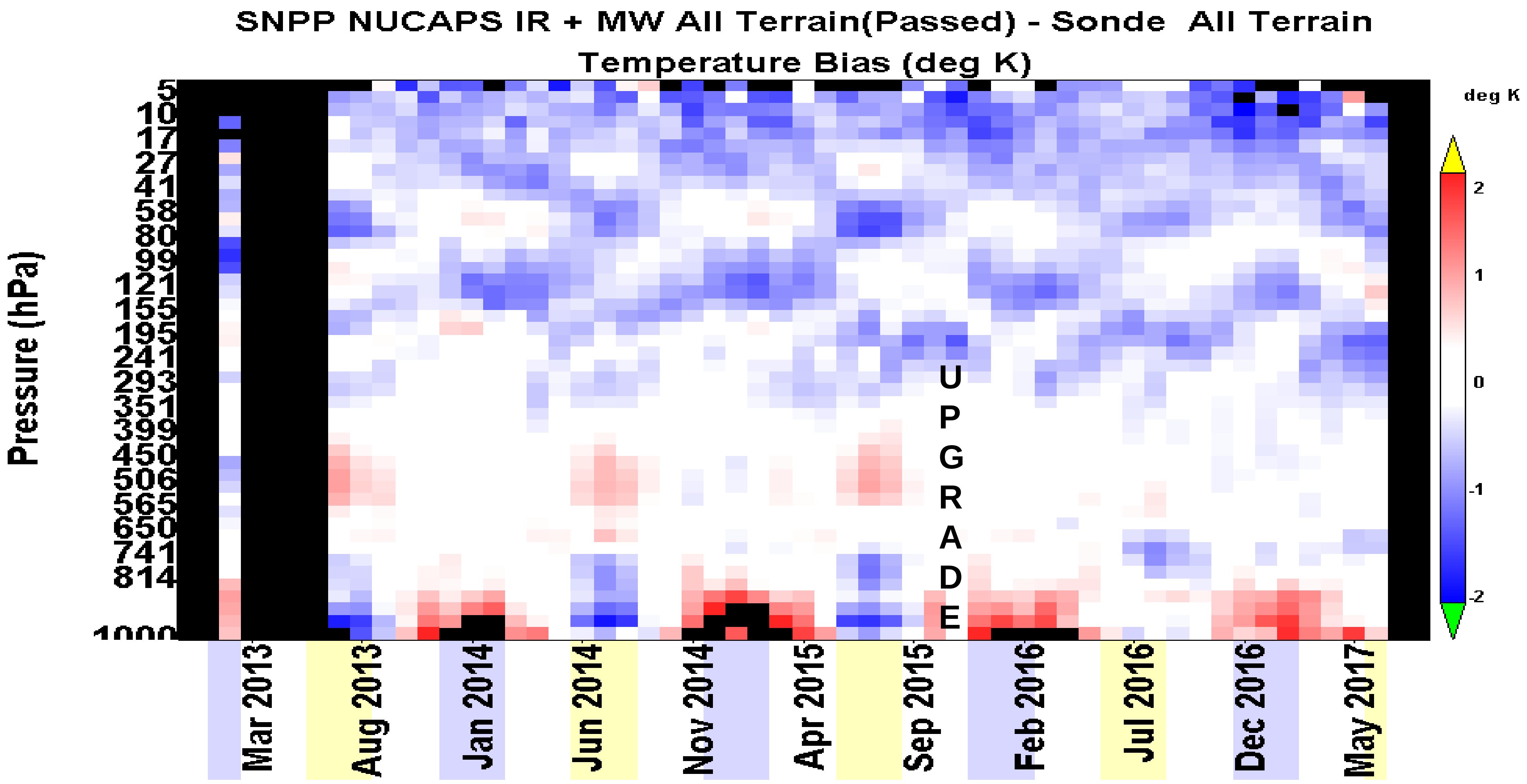
MIRS NPP v11 MW Maritime(Passed) - Sonde Maritime
Temperature Bias (deg K)
Pressure (hPa)
deg K
3
1.5
0
-1.5
-3
7/13/14
11/16/14
3/22/15
7/26/15
11/29/15
4/03/16
8/07/16
12/11/16

NARCS-LTM



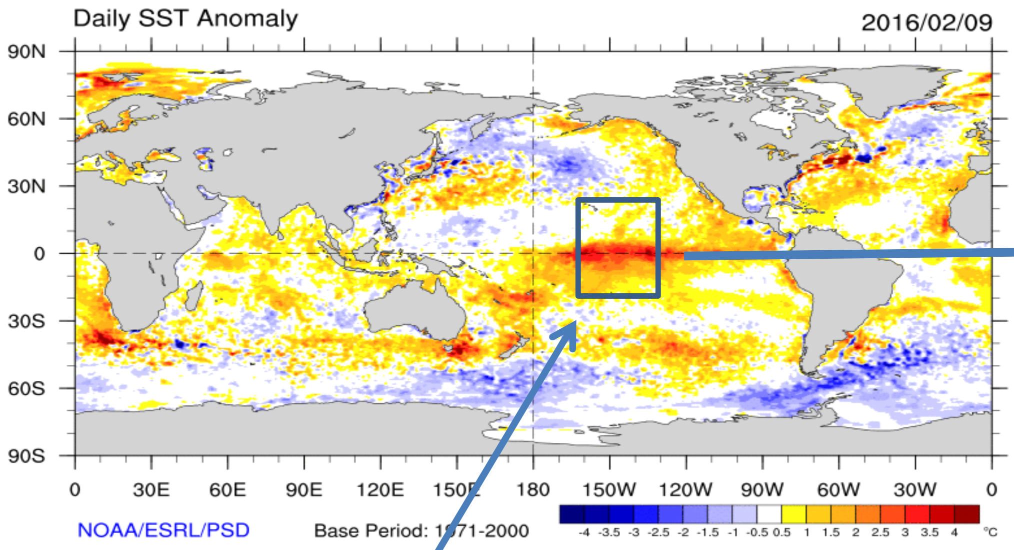
SNPP NUCAPS IR + MW All Terrain(Passed) - Sonde All Terrain
Temperature Bias (deg K)
Pressure (hPa)
deg K
2
1
0
-1
-2
UPGRADE
2/24/13
8/11/13
1/26/14
7/13/14
12/28/14
6/14/15
11/29/15
5/15/16
10/30/16
4/16/17

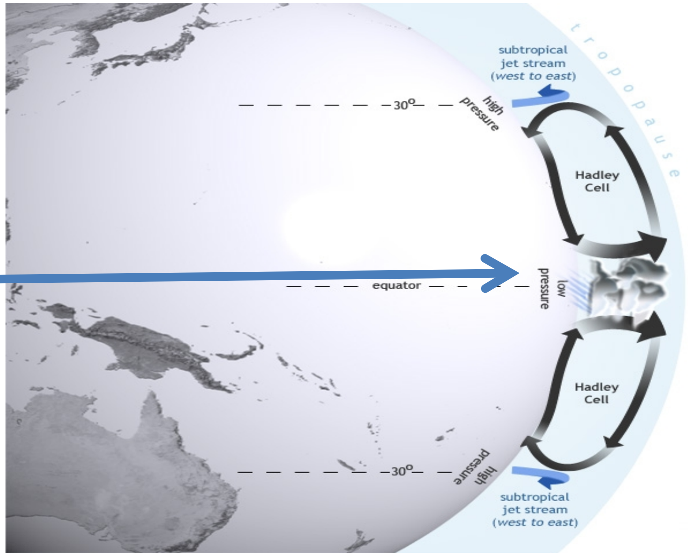
NARCS-LTM

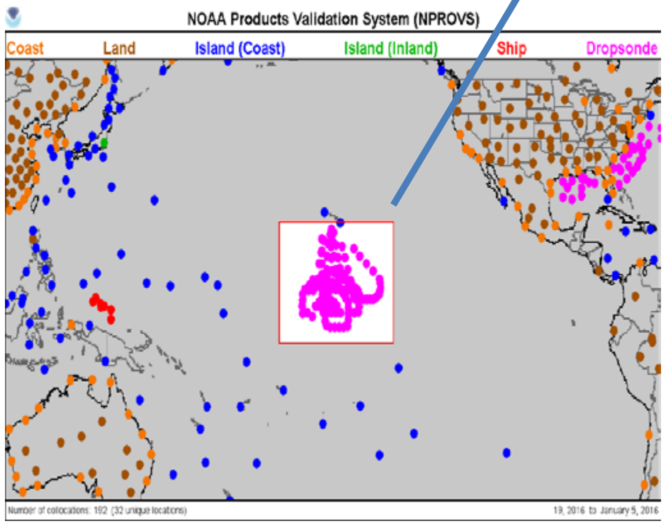


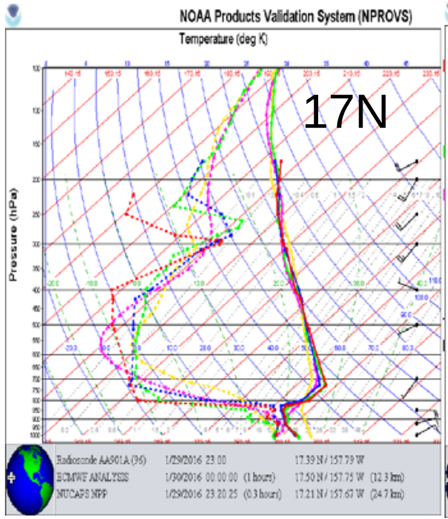
SNPP NUCAPS IR + MW All Terrain(Passed) - Sonde All Terrain
Temperature Bias (deg K)
Pressure (hPa)
5
10
17
27
41
58
80
99
121
155
195
241
293
351
399
450
506
565
650
741
814
1000
UPGRADE
Mar 2013
Aug 2013
Jan 2014
Jun 2014
Nov 2014
Apr 2015
Sep 2015
Feb 2016
Jul 2016
Dec 2016
May 2017
deg K
2
1
0
-1
-2

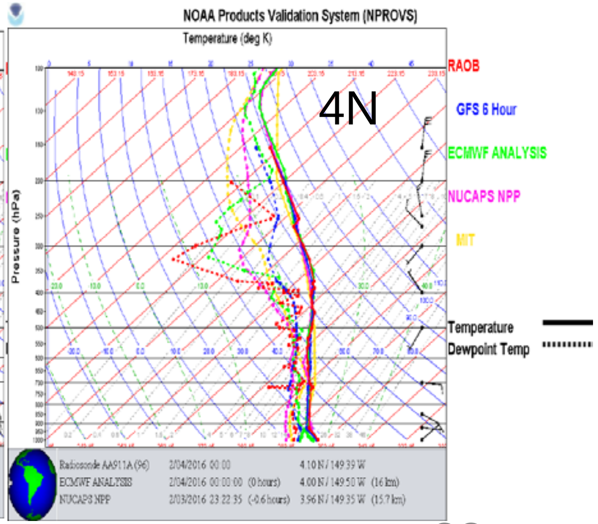
AWIPS-2 El-Nino Rapid Response 2016





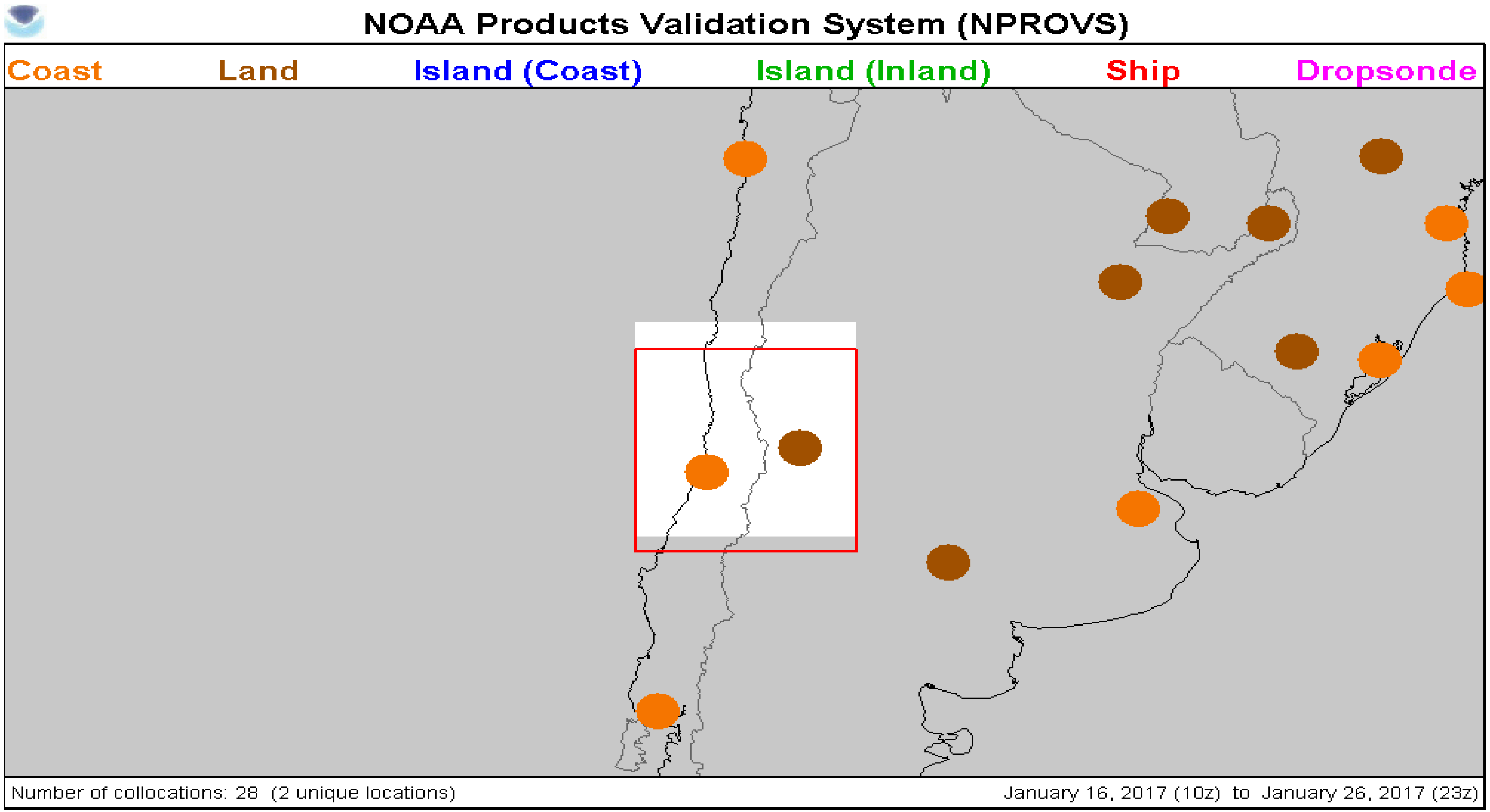






NUCAPS captures circulation regimes of the central pacific tropical/sub-tropical region

PDISP



AWIPS Chile Fire Support January 2017

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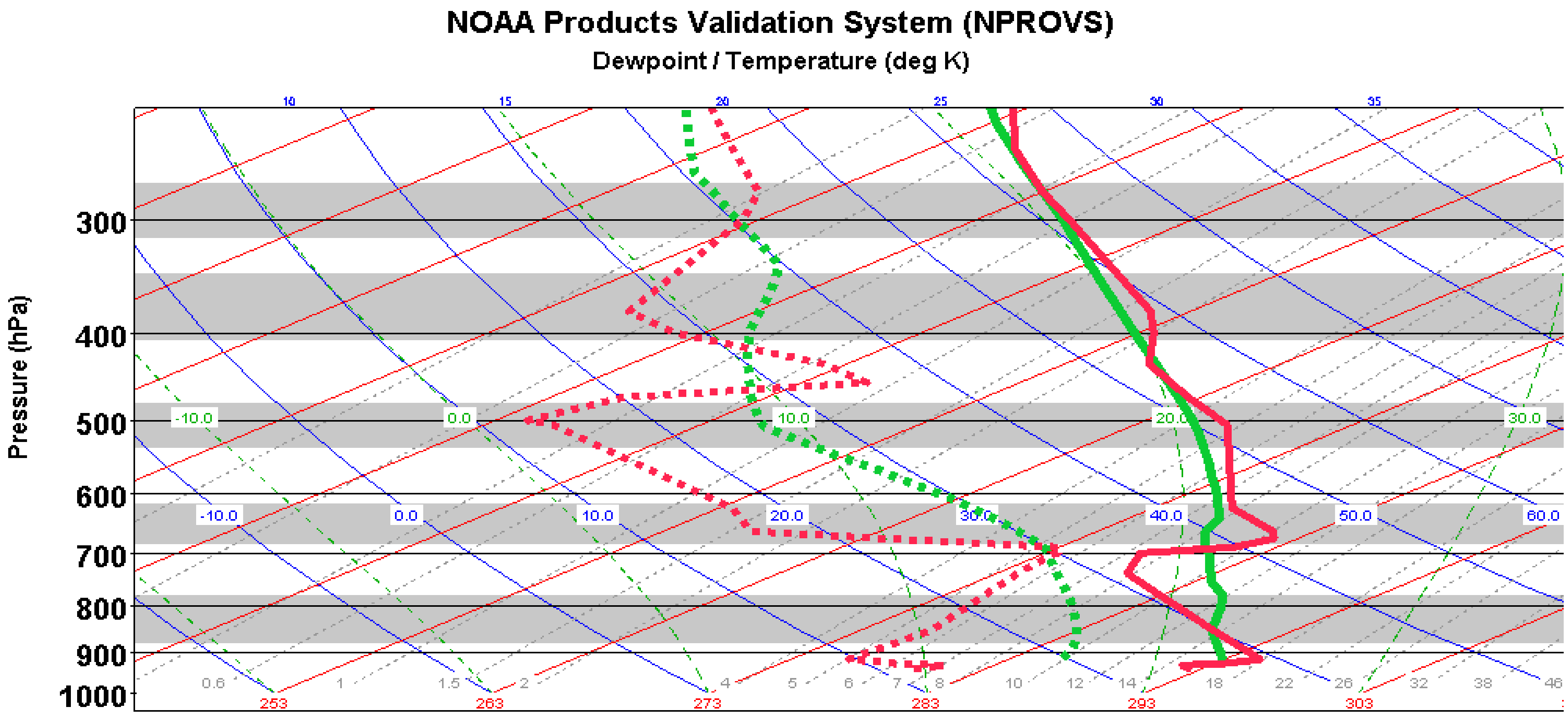
PDISP



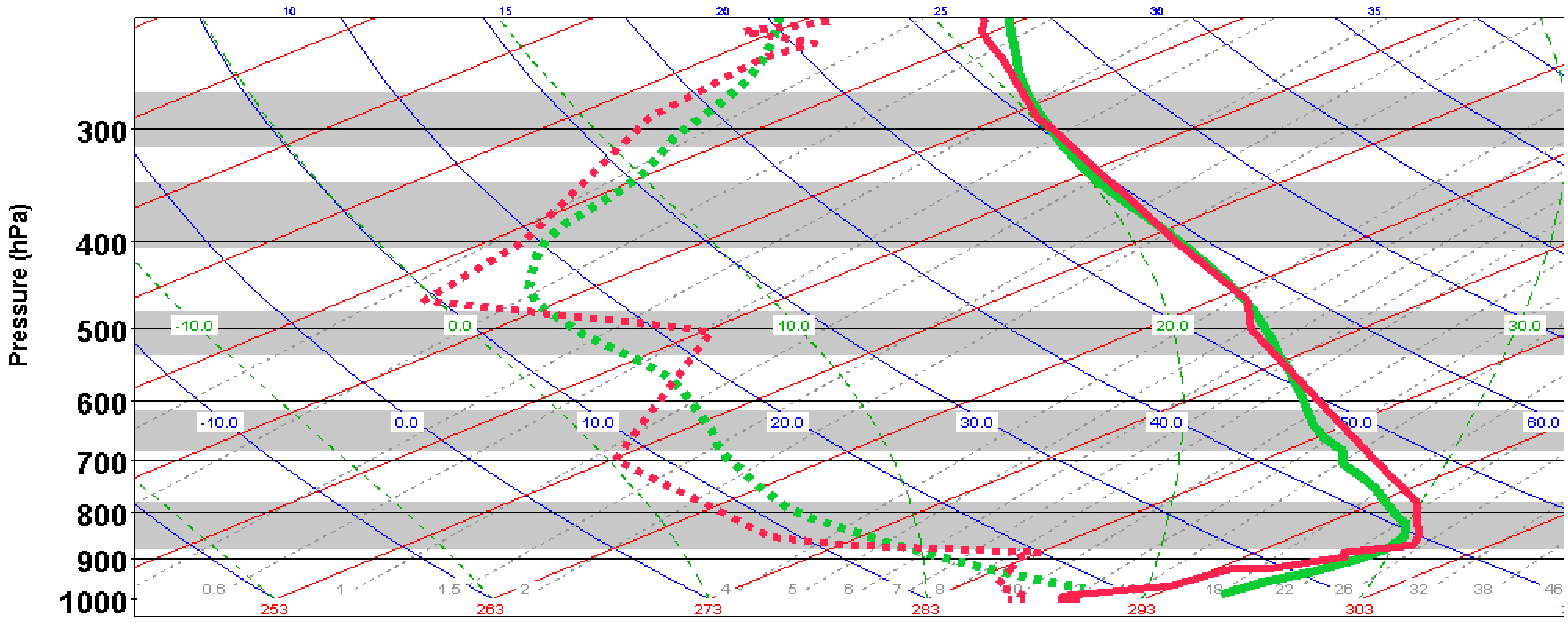
SONDE 87418 (177) SONDE 1/26/2017 11:02:00Z 32.8 S / 68.8 W

NUCAPS NPP 1/26/2017 5:31:07Z (-5.5 hours) 33.1 S / 68.6 W (32.7 km)

AWIPS Chile Fire Support January 2017

NOAA Products Validation System (NPROVS)

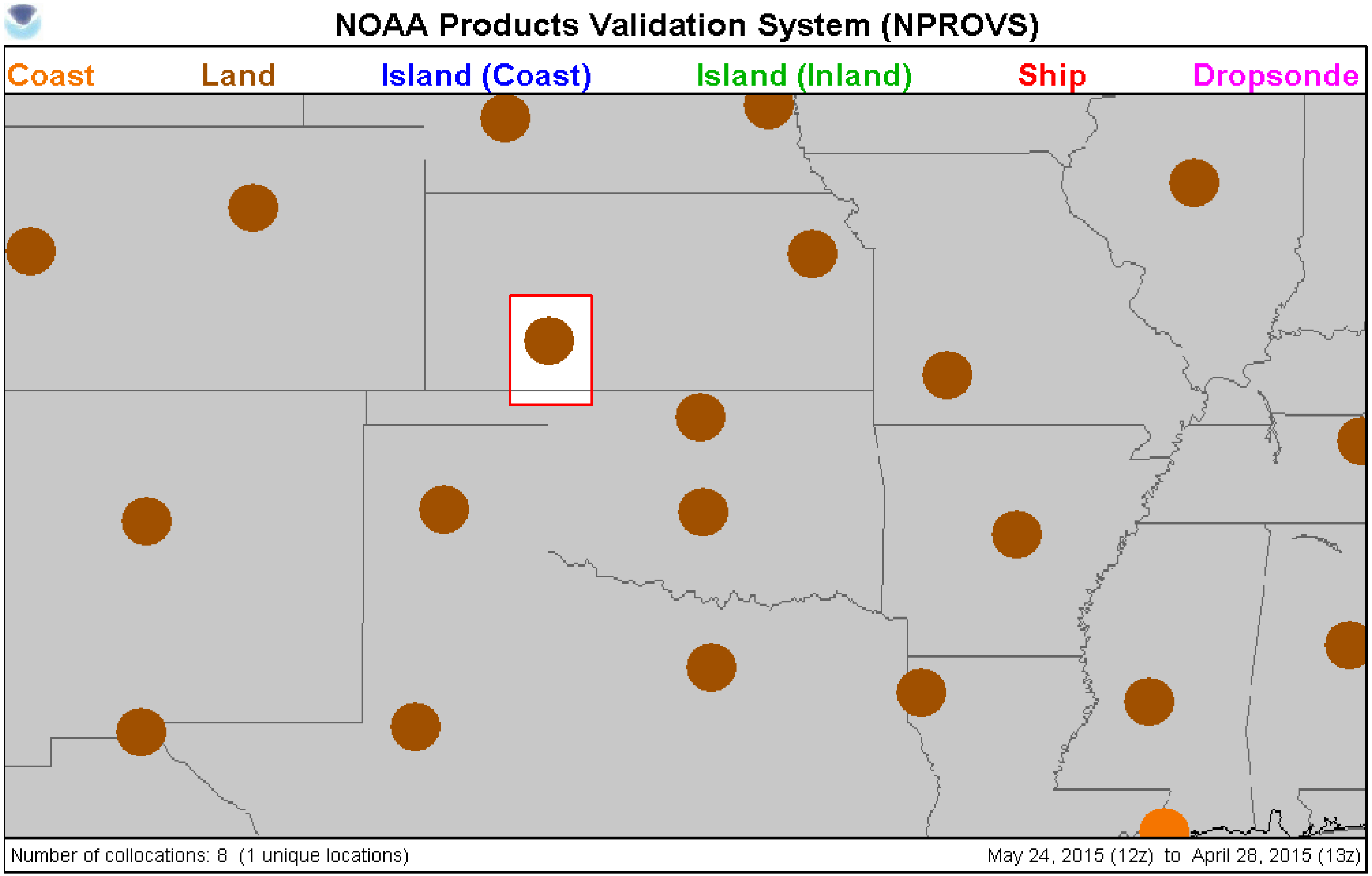
Dewpoint / Temperature (deg K)



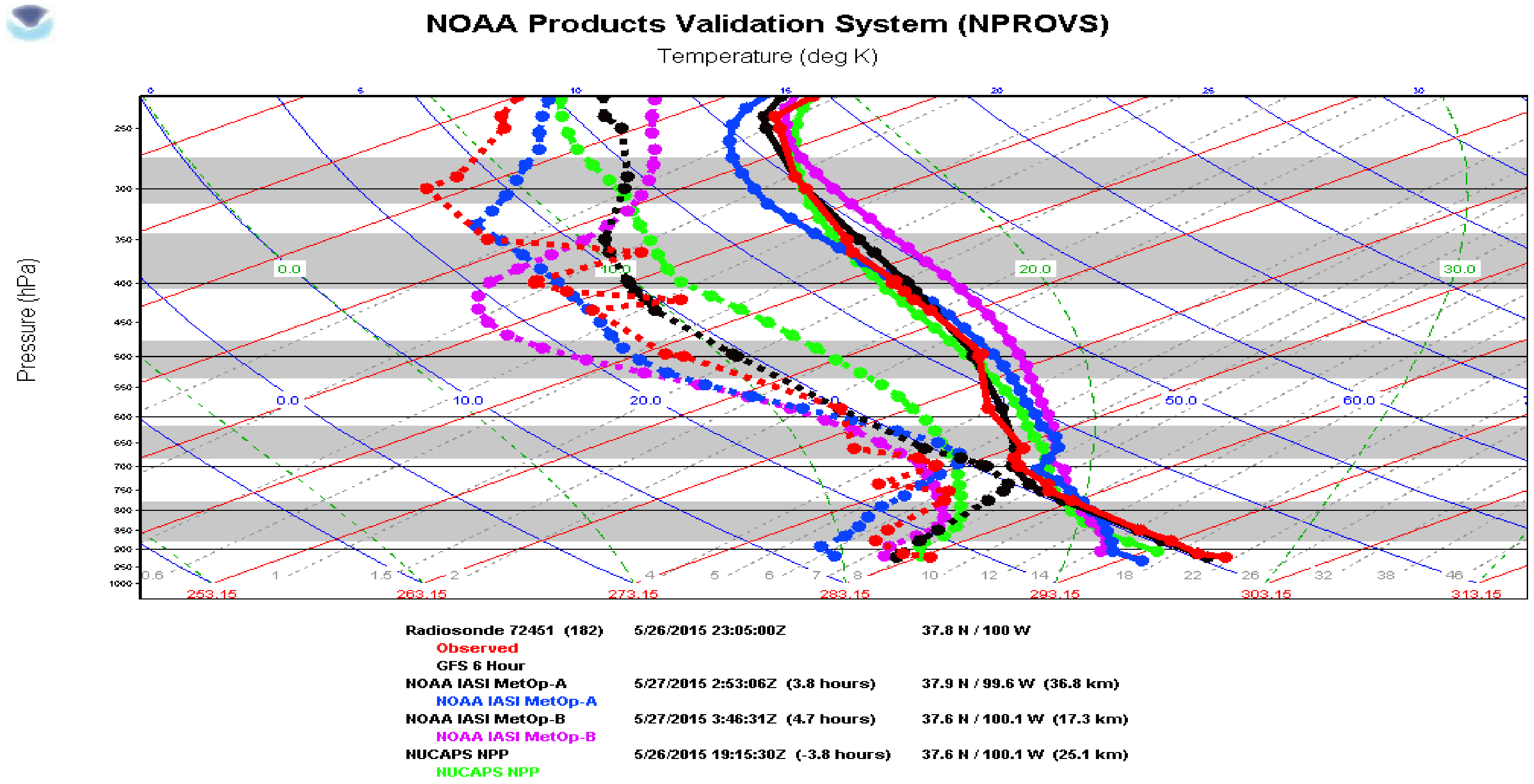
SONDE 85586 (141) SONDE 1/26/2017 11:30:00Z 33.6 S / 71.6 W

NUCAPS NPP 1/26/2017 5:31:24Z (-6 hours) 33.5 S / 71.8 W (18.4 km)

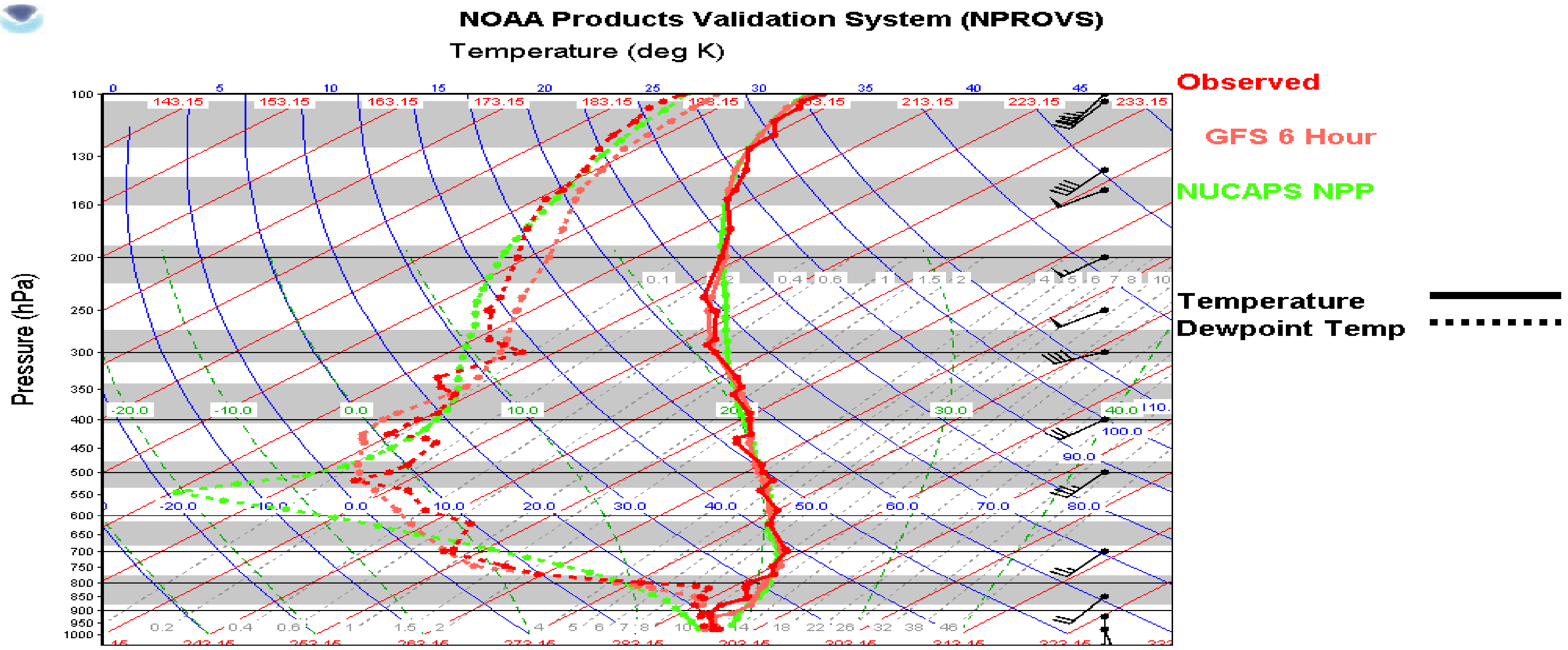
AWIPS Chile Fire Support January 2017



AWIPS-2 Dodge City Convective Case May 2015



AWIPS-2 Dodge City Convective Case May 2015



Norman, OK.

RAOB 11/4/2015 1105Z NUCAPS 0855Z 46.3 km

Summary

❖ NPROVS provides “Enterprise Validation” … same validation datasets for different sounding product suites

❖ *Restores semblance of Sounding Product Oversight Panel (SPOP)*

❖ Provides assessments using either conventional or “special” (JPSS funded dedicated, GRUAN)

❖ NUCAPS FSR provide almost 25% increase in “IR+MW” sounding yield with no degradation in product integrity … IR-only and Microwave-only need more work

❖ AWIPS-2 users benefit from NUCAPS …

Path Forward

❖ Integrate dual RS41 and RS92 launches from RIVAL that are collocated with satellite overpass (focus on J1) into NPROVS+

❖ Append SDR for "dedicated" selected NPROVS+ collocations (JPSS, RIVAL and GRUAN) and include SDR to facilitate "re-retrieval" in support of algorithm development assessment

❖ Support of GRUAN/GSICS "sensor assessments" feasibility studies

❖ Continue AWIPS-2 support

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Single Field of View Cloudy Retrievals

X. Liu[1], W. Wu[2], Q. Yang[2], Q. Liu[3], L. Zhou[3]

1. NASA Langley Research Center, VA
2. SSAI, Hampton, VA
3. NOAA STAR, College Park, MD

Outline

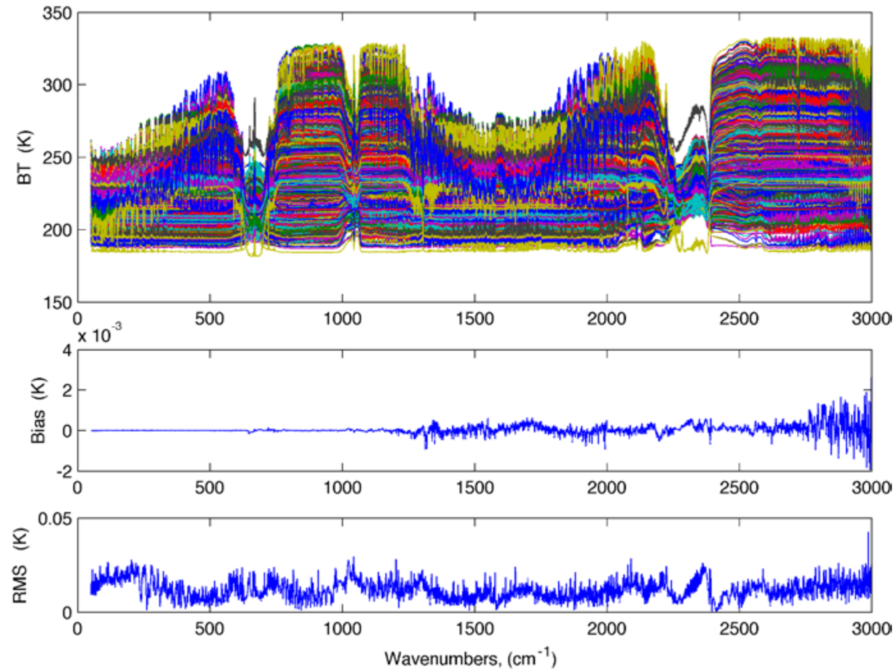
- Recent updates on cloudy radiative transfer modeling
- Single Field of View Retrieval Under All-sky Conditions
- Errors analysis on clouds, T, H_2O, and trace gases Retrievals
- Examples of single FOV retrievals on IASI, CrIS and ATMS
- Summary and Conclusions

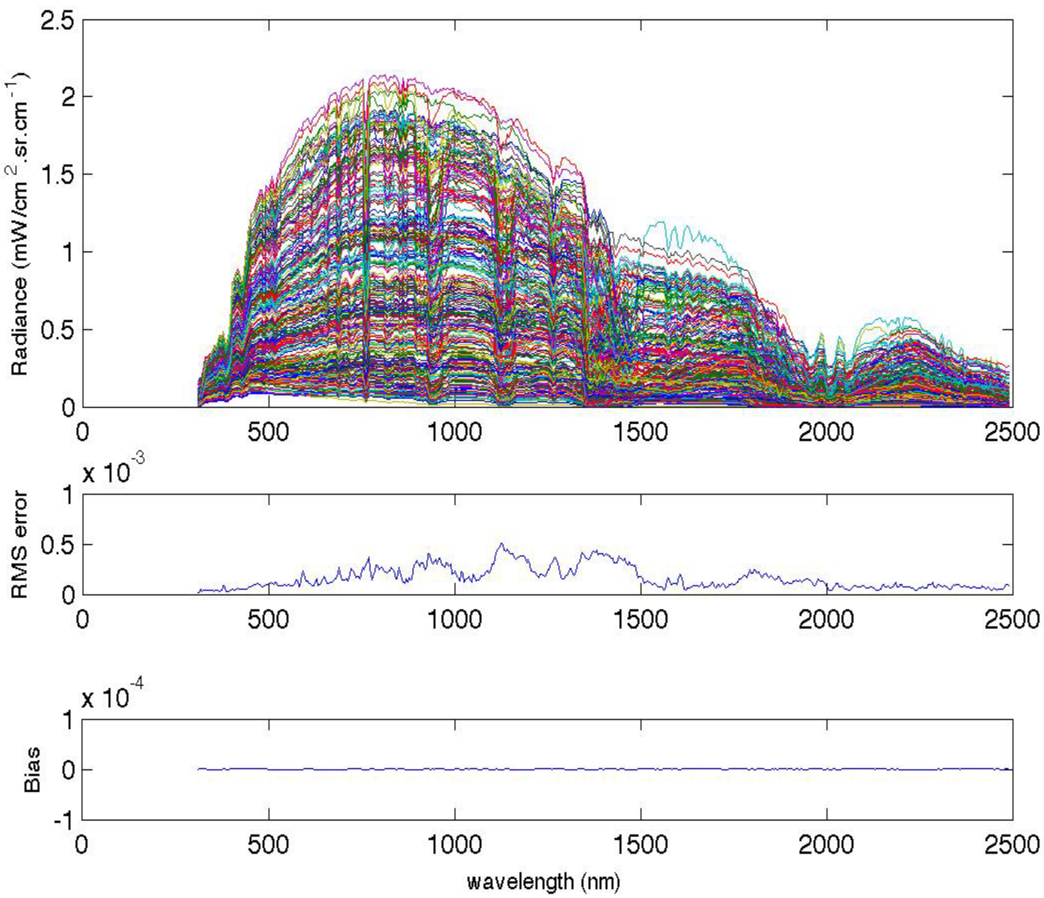
Recent Updates on Cloudy Radiative Transfer Model Development

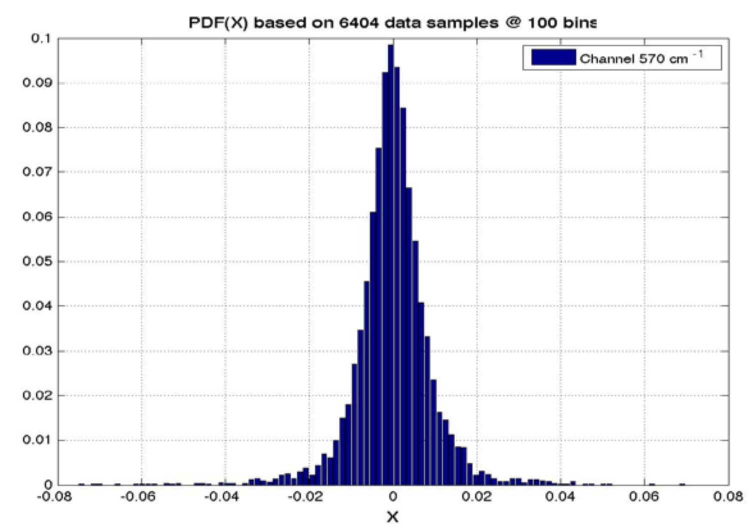
- PCRTM has been extended to far infrared and UV-Vis spectral regions
  - Several methods has been developed (Liu et al. App. Optics, 2016, Yang et al. Optic Express 2016, Liu et al, 14 presentations at CLARREO science team meetings, 2011-2017, more than 20 conference presentations and papers)
- Very fast parameterizations
  - Needed for hyperspectral data analysis
  - Achieved by both reduction in spectral domain and in multiple scattering domain
  - A few miliseconds per spectrum in IR
  - 3 orders of magnitude faster than MODTRAN in solar spectral region
- Very accurate relative to reference models
  - Better than 0.03 K accuracy from far-IR to near-IR
  - Better than 0.02% accuracy from near-IR to UV-vis
- Recent intercomparisons done with other RT models
  - Sergio et al. submitted to AMT 2017
  - Aunman et al. submitted to JGR 2017
- Applications of PCRTM to different problems
  - Wu et al 2017, Chen et al 2013, Seiji et al 2011, 2014, Liu et. al 2009, 2017, Huang et. al. 2014. Pan et al. 2015, 2017, Feldman et al.2013, 3014, 2015, 2017, Bantges et al. 2016, Rose et al. 2013

PCRTM covers spectral range from 0.3 μm to 100 μm, added multiple scattering in the presence of solar radiation

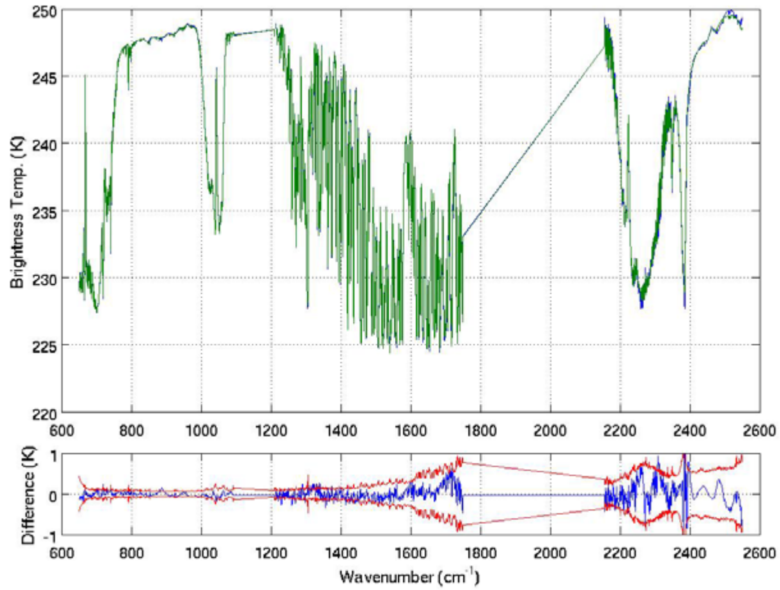
- Bias error relative to LBL is typically less than 0.002 K
- The PDF of errors at different frequencies are Gaussian distribution
- RMS error < 0.03K for IR and < 5×10^{-4} mW/cm^2/sr/cm^{-1} for solar (< ~0.02%)

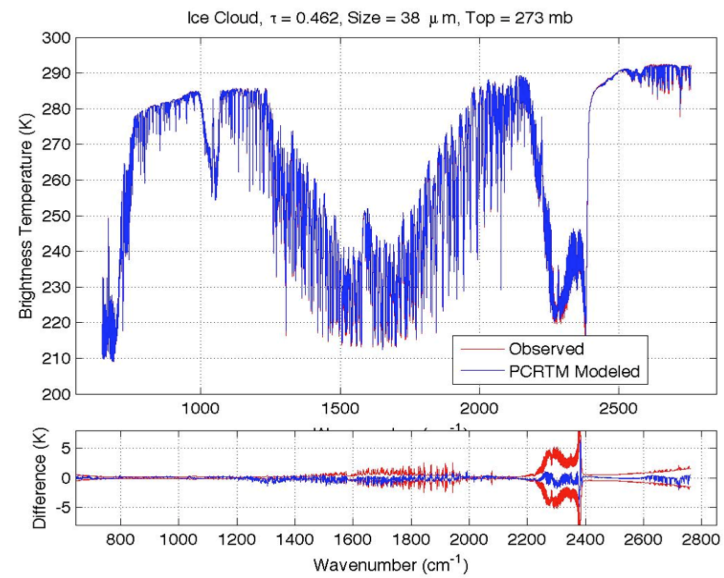


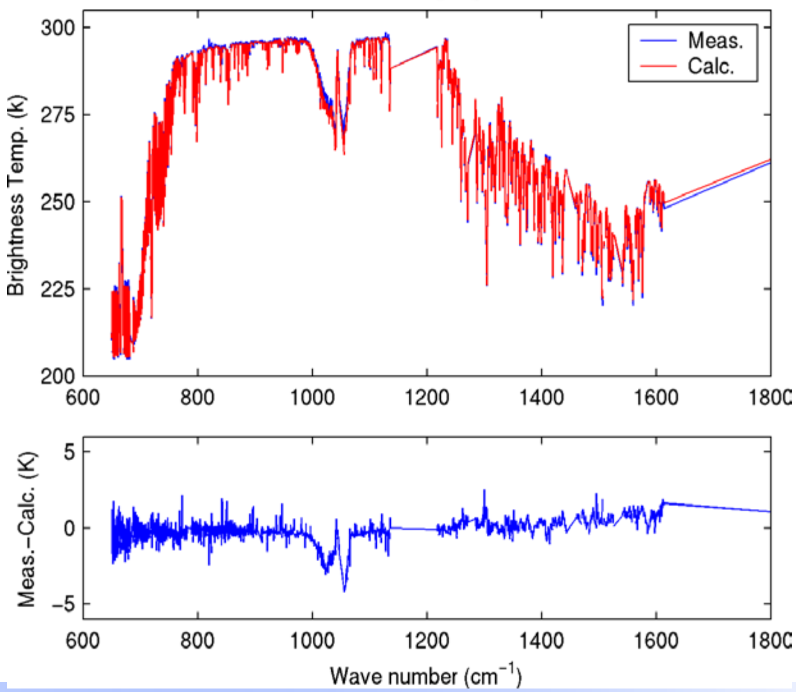


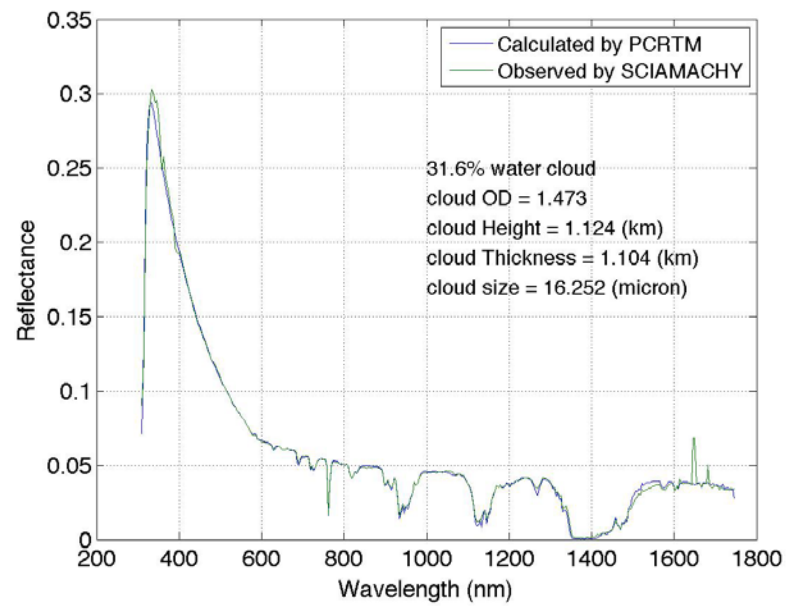


Examples of PCRTM Simulations of CrIS, IASI, AIRS, NAST-I, and SCIAMACHY real data

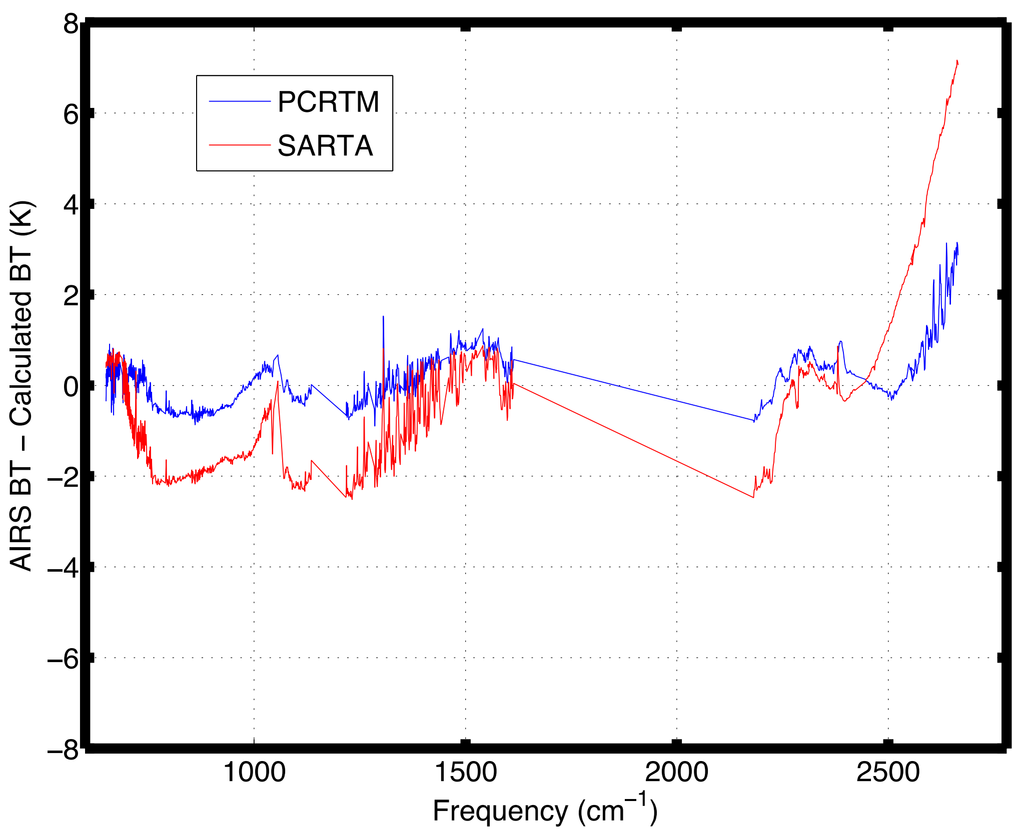


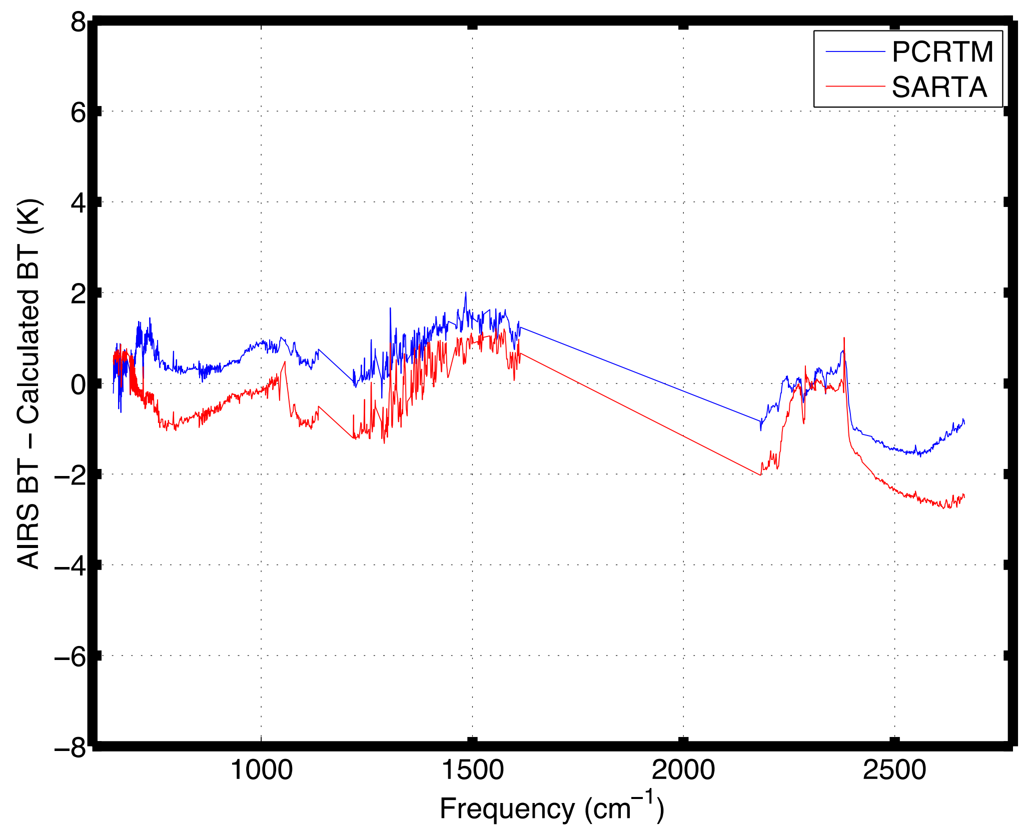






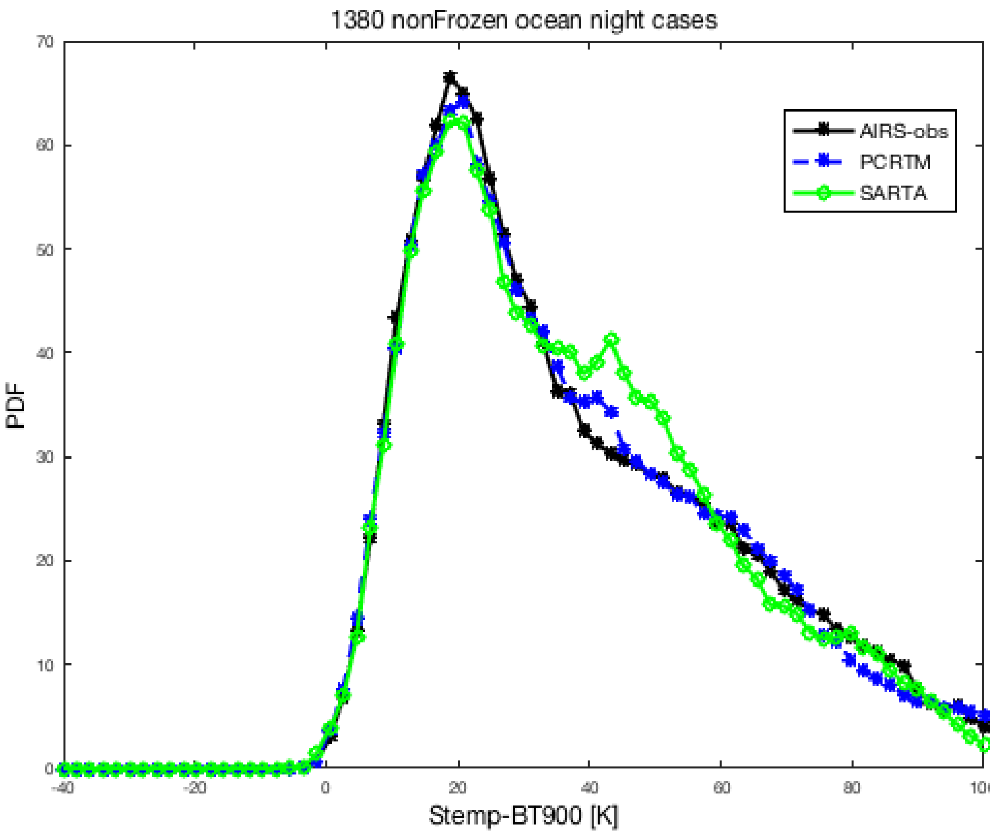
Recent Results on Simulating AIRS spectra in the using ECMWF cloud fields (Aunman and Sergio et al)

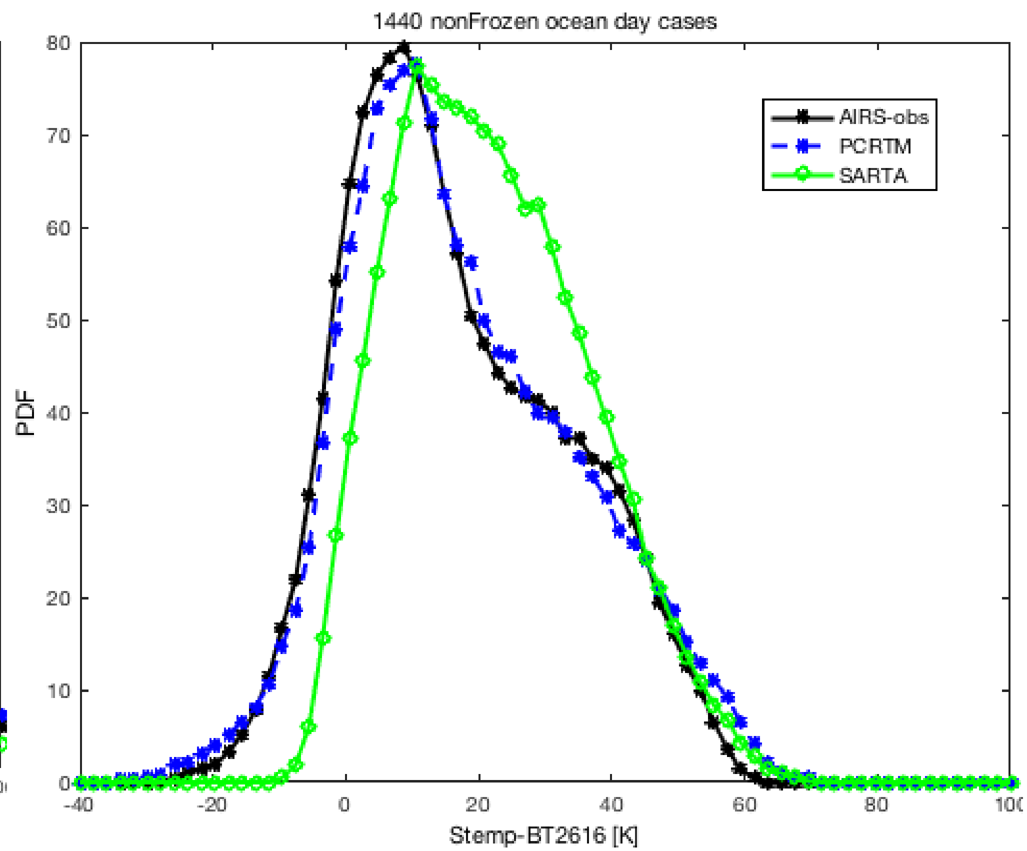




Thanks to Sergio and Aunman for providing the ECMWF model outputs, matched AIRS radiances, and SARTA results!

PDF of AIRS observed and RTM Simulated BT at two difference spectral regions

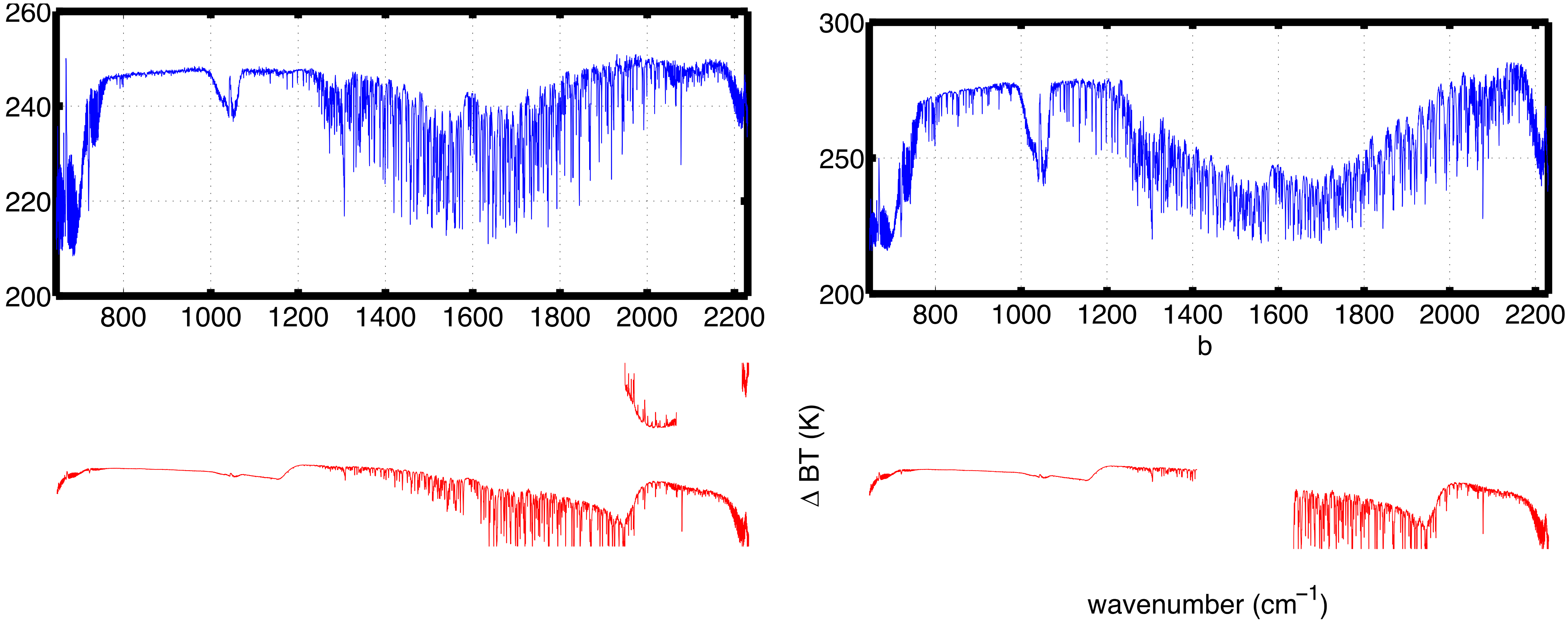




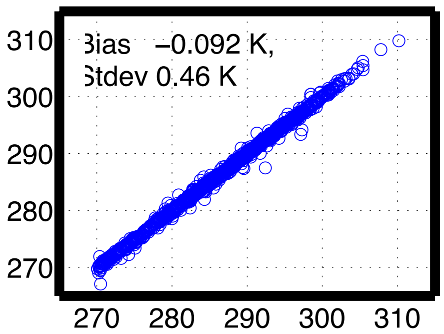
Recent Updates on Single FOV Cloudy Retrievals

- PCRTM Retrieval Algorithm (PCRTM-RA) performs single FOV retrieval of the following properties:
  - cloud phase, effective cloud height, cloud microphysical properties
  - atmospheric temperature, water vapor and trace gas profiles
  - Surface skin temperature and emissivity spectra
- PCETM-RA algorithm updates
  - Improved the capability to include microwave sensors to improve performance below thick clouds
  - Improved minimizations scheme
- Performed sensitivity studies on the PCRTM-RA in the presence of clouds
- Performed error analysis
  - Rigorous optimal estimation error estimates
  - Simulation retrieval studies
- Validate the retrieval performance using CALIPSO and ECMWF data

Cloud phase discerning



End-to-end simulation study
Tskin & cloud retrieval



ud Vis. Opt. Dep.

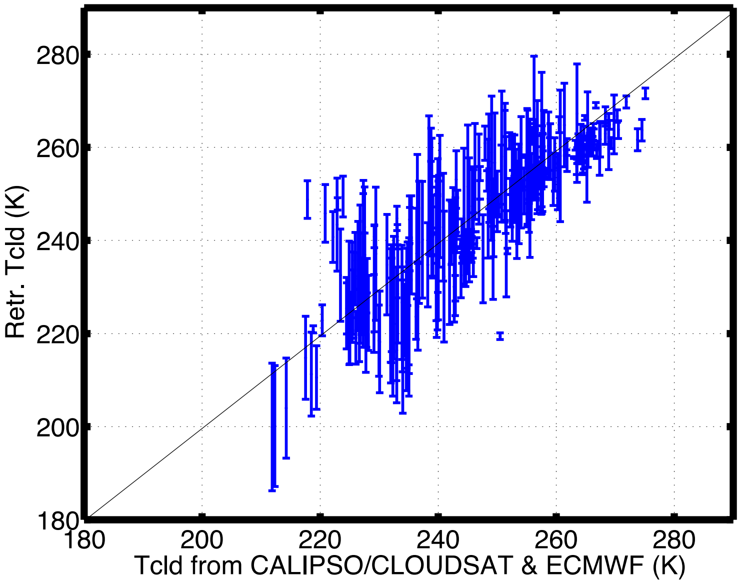
Bias −0.017,
Stdev 0.13

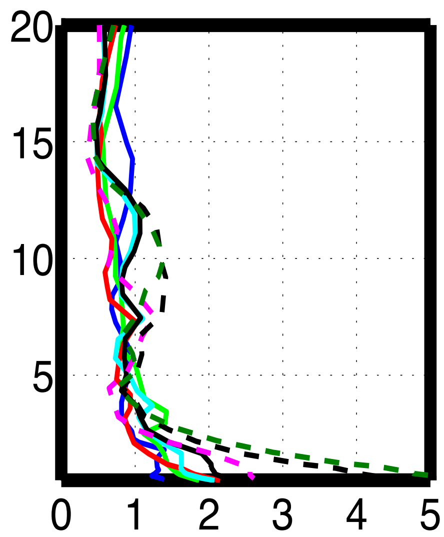
Confusion Matrix for Cloud Phase Retrieval

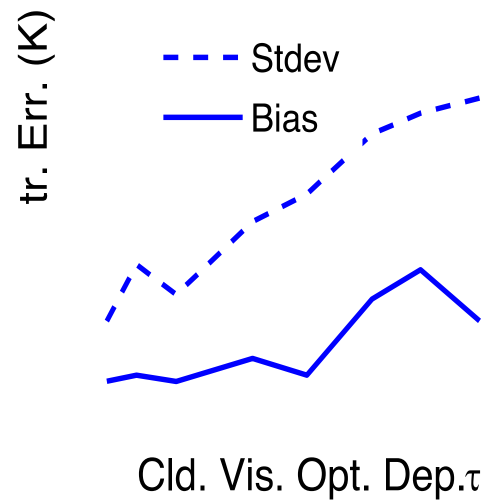
Output Class		Ice Cloud	Water Cloud	
	Ice Cloud	47.98% [1]50.15% [2]47.18% **A**	0.58% [1]0.31% [2]0.68% **B**	Sensitivity 98.81% [1]99.39% [2]98.58% **C**
	Water Cloud	0.91% [1]2.77% [2]0.23% **D**	50.53% [1]46.77% [2]51.91% **E**	Sensitivity 98.24% [1]94.54% [2]99.56% **F**
		Precision 98.15% [1]94.77% [2]99.51% **G**	Precision 98.87% [1]99.34% [2]98.71% **H**	Accuracy 98.52% [1]96.92% [2]99.09% **I**
	Target Class			

[1] over land, [2] over ocean

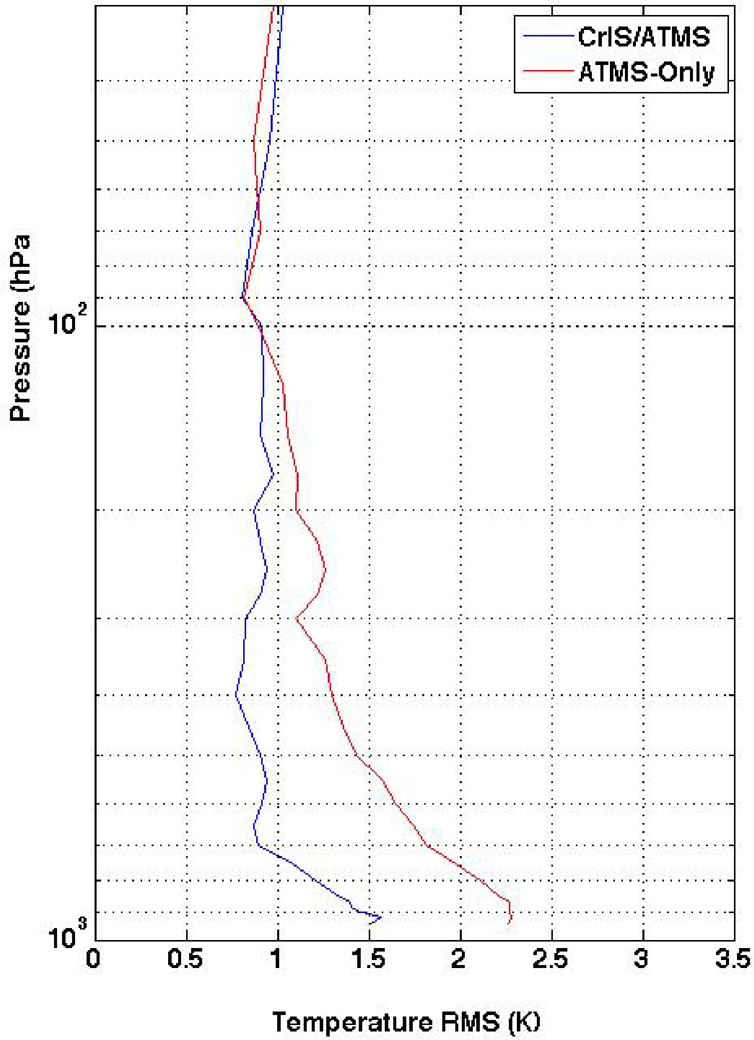
Validation of real data retrieval using ECMWF and CALIOP/CPR data

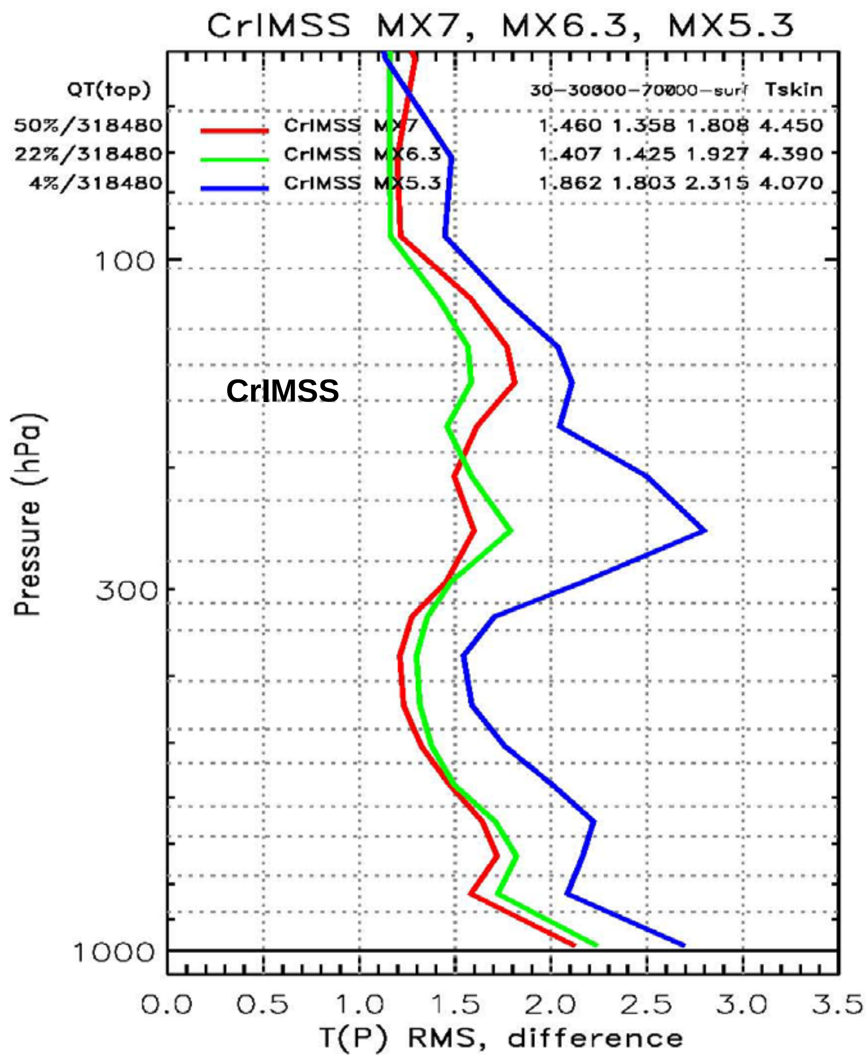




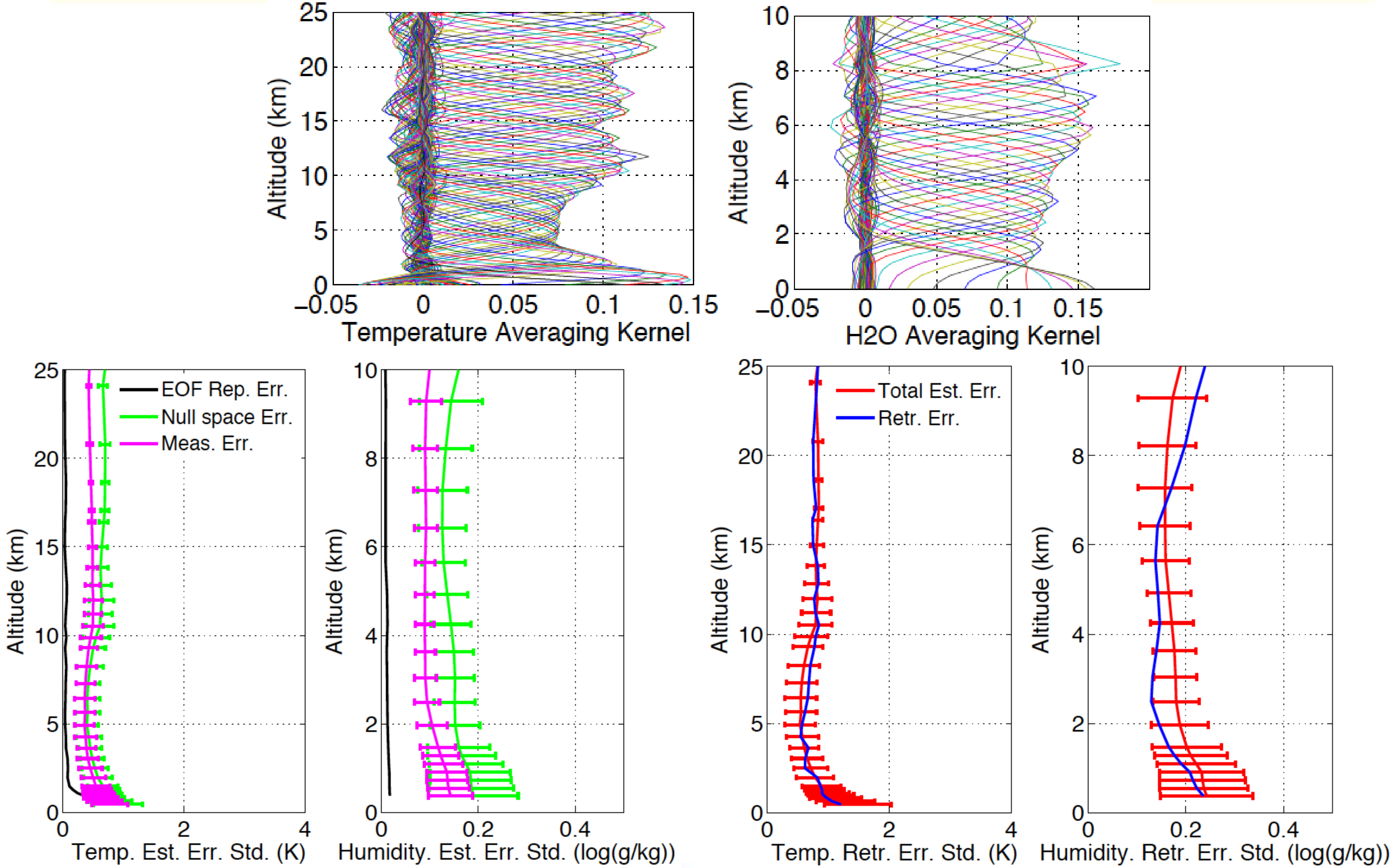


Atmospheric temperature profile retrieval with and without multiple spectral regions





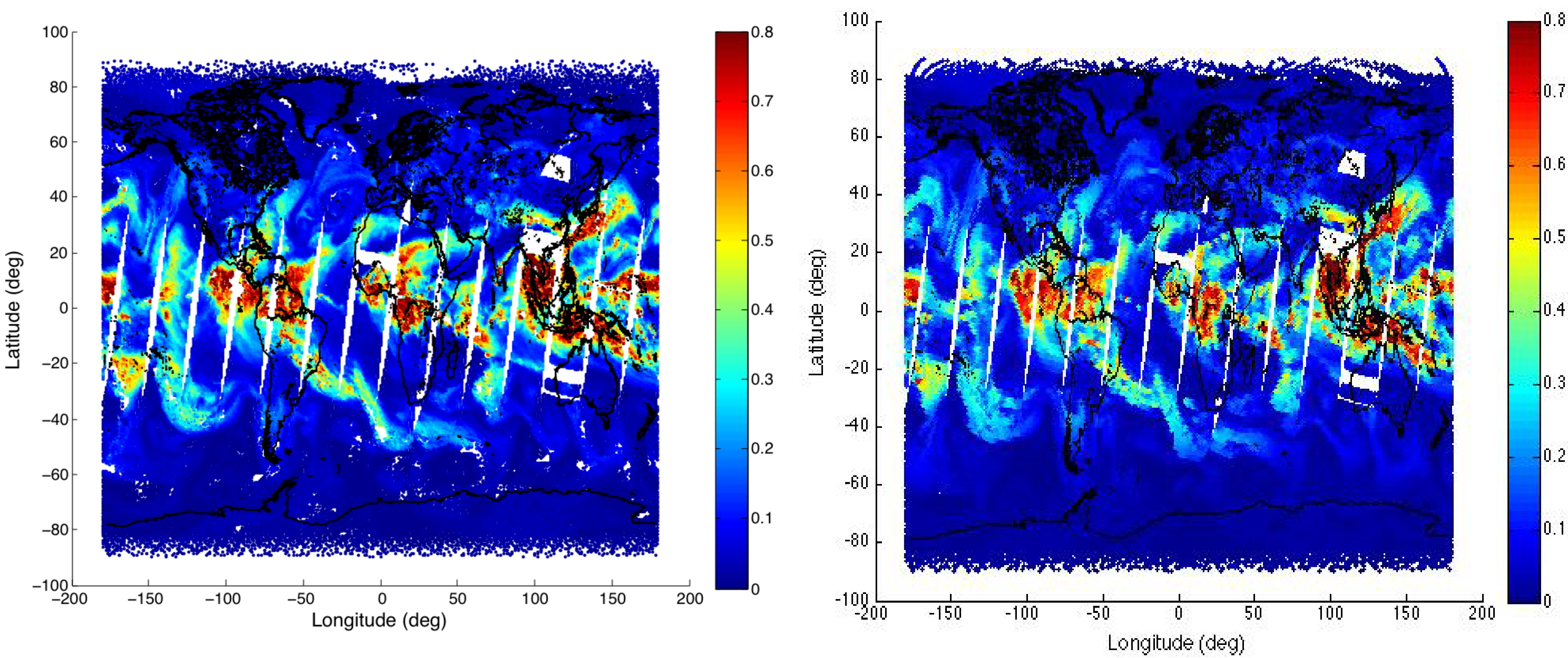
End-to-end simulation study T and h$_2$O retrieval



Comparison of PCRTM-RA Retrieved and ECMWF Atmospheric Water Vapor from focus day CrIS/ATMS data

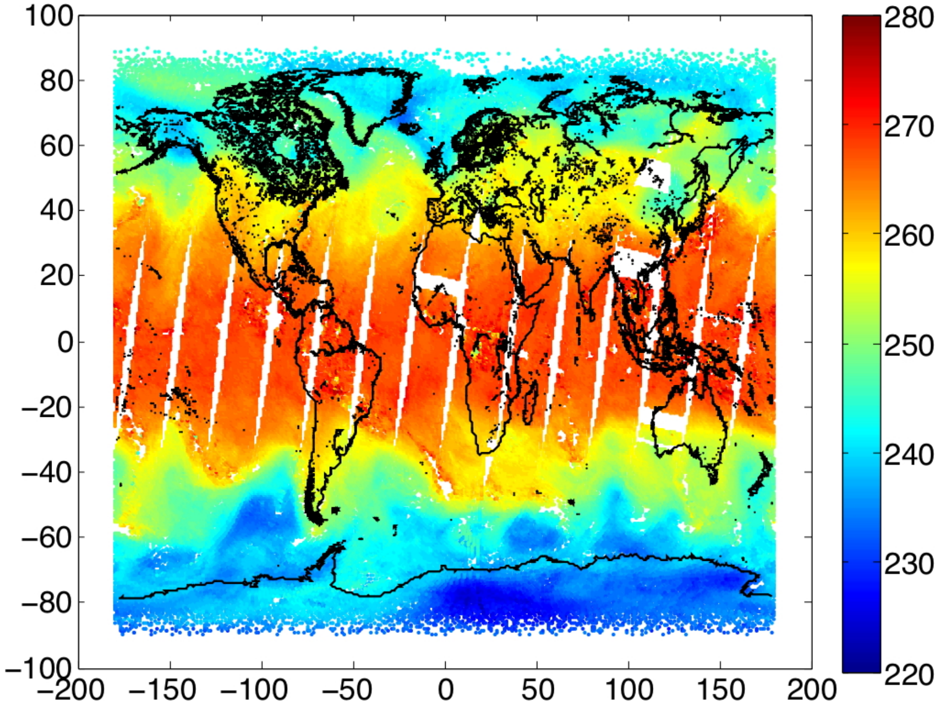
Retrieved 300 hPa from CrIS/ATMS using PCRTM-RA

300 hPa from ECMWF

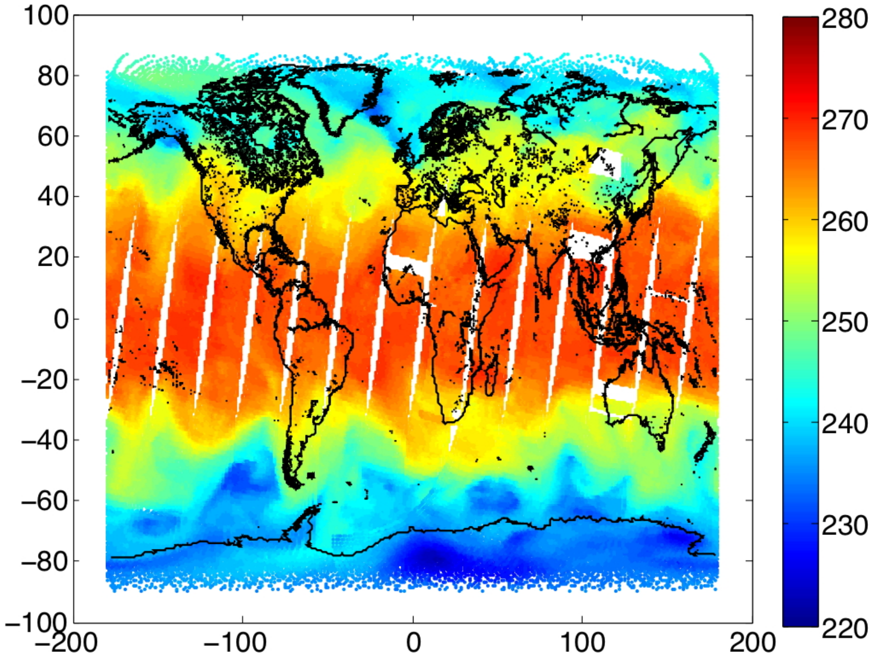


Comparison of PCRTM-RA Retrieved and ECMWF Atmospheric Temperature from focus day CrIS/ATMS data

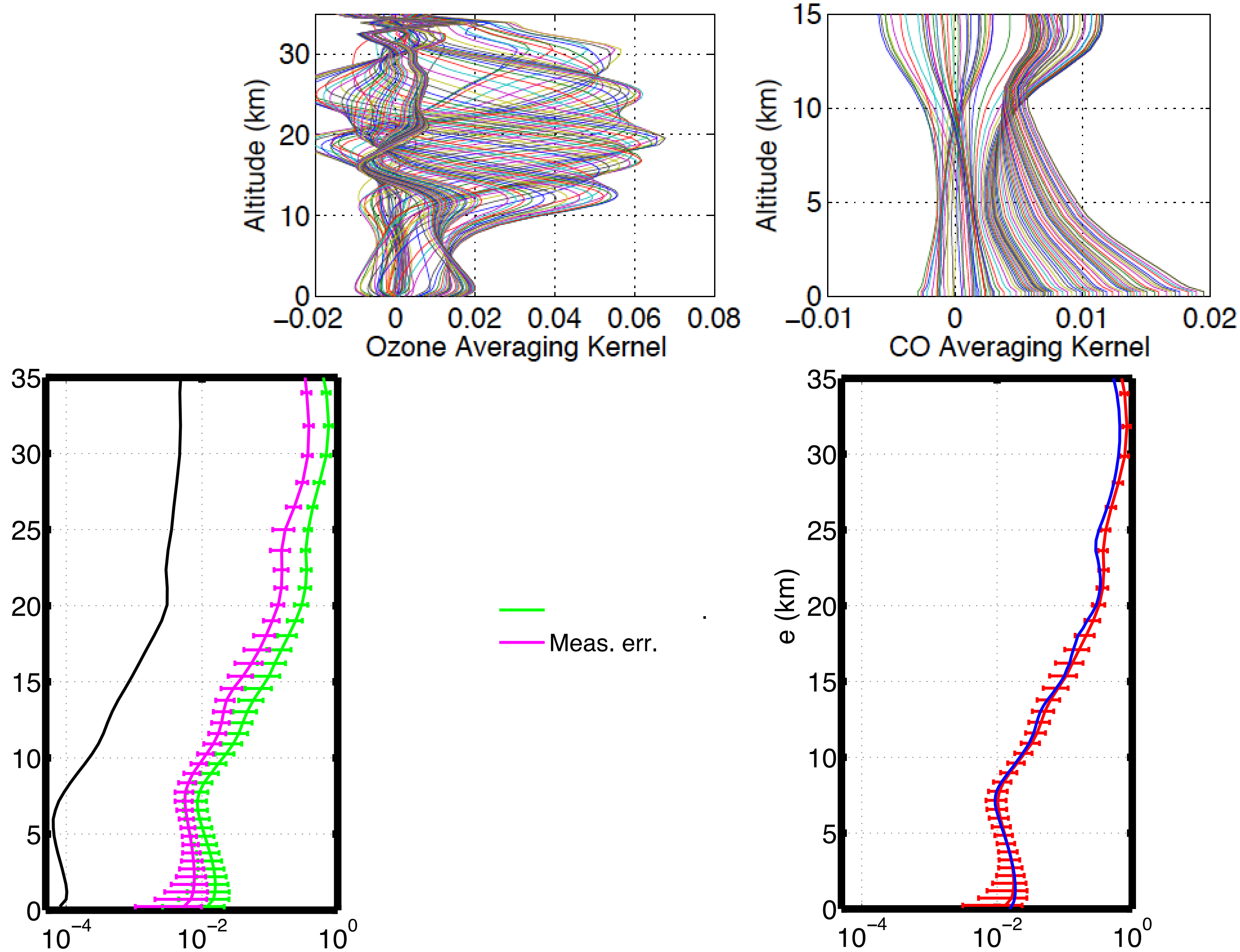
500 hPa Retrieved from ATMS/CrIS
using PCRTM_RA



500 hPa Temperature from ECMWF

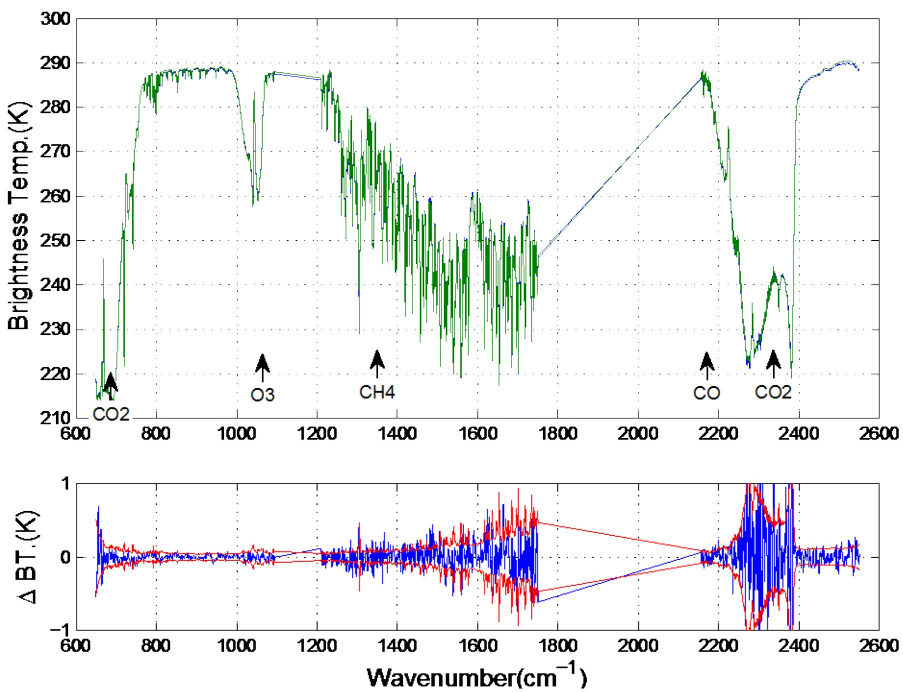


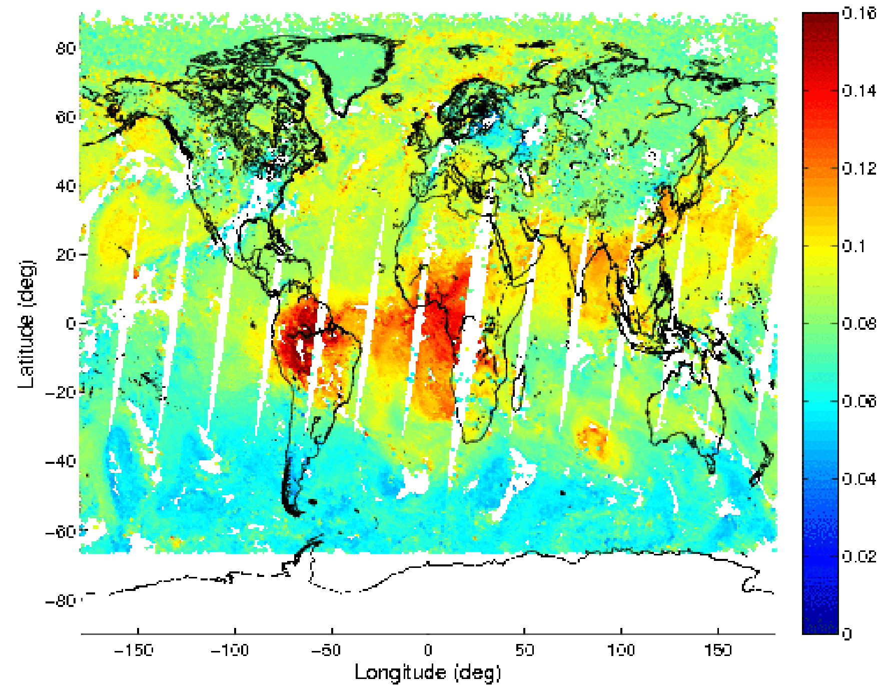
End-to-end simulation study
O_3 and CO retrieval



Atmospheric and Surface Property Retrieval using PCRTM

- PCRTM can be used to retrieve
  - Atmospheric temperature, water, trace gas vertical profiles
  - Cloud phase, height, temperature, particle size, optical depth
  - Surface emissivity, skin temperature
- The movie below shows global CO retrievals from December 21-27, 2016
  - CO mixing ratio at 300 mbar
  - Full spectral resolution CrIS data used





Summary and conclusions

- Accurate radiative transfer model capable of handling multiple scattering clouds are needed for the single FOV retrieval algorithm
  - PCRTM has been trained to work from far-IR to UV-Vis spectral regions
  - PCRTM has been updated to handle multiple scattering clouds
  - A few millisecod per spectrum in IR spectral region
  - 3 orders of magnitude faster than MODTRAN in solar spectral region
  - Accurate relative to line-by-line models
- Single FOV cloud retrieval algorithm is capable of retrieving
  - Atmospheric Temperature, Water, CO2, CO, CH4, O3, and N2O profiles
  - Cloud phase, height, temperature, size, optical depth
  - Surface emissivity spectrum and skin temperature
- Will further support NUCAPS product validation under cloudy sky conditions
  - Apply two independent algorithm to handle the same data set
  - With the ultimate goal to improve retrievals under cloudy conditions and obtained cloud microphysical properties

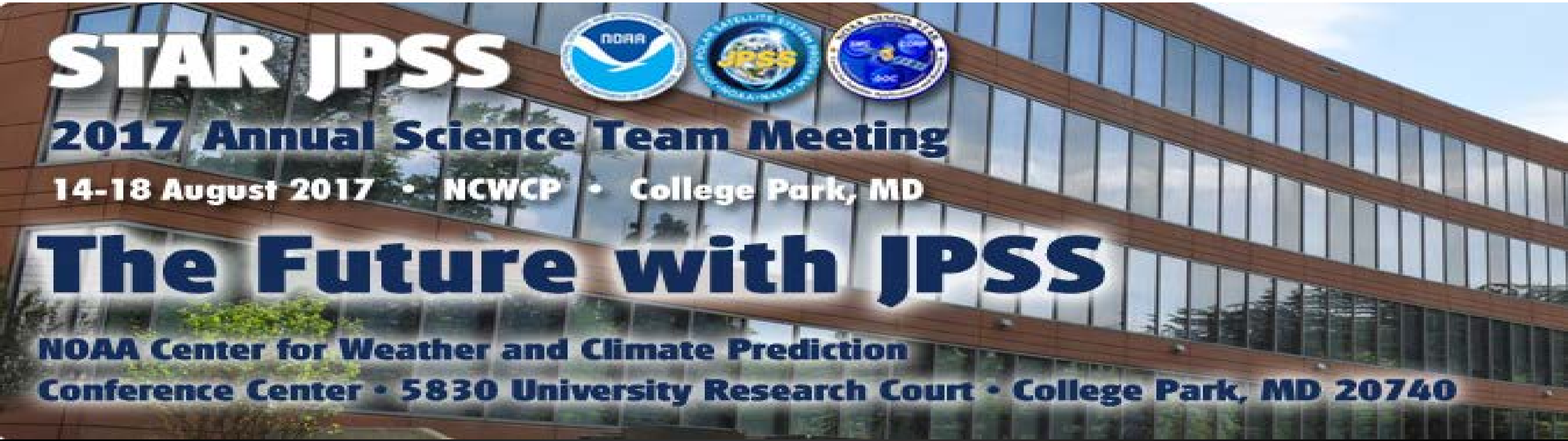
NOAA’s Joint Polar Satellite System’s

Proving Ground and Risk Reduction Initiatives

NUCAPS Initiative

Bill Sjoberg

16 Aug 2017



JPSS PGRR Background Definitions

- **Proving Ground**
  - Demonstration and utilization of data products by the end-user operational unit, such as a NWS Weather Forecast Office or Modeling Center.
  - Promote outreach and coordination of new products with the end users, incorporating their feedback for product improvements

- **Risk Reduction**
  - Development of new research and applications to maximize the benefits of JPSS satellite data
    - Example - use of Day Night Band for improved fog and low visibility products at night, benefiting transportation industry.
  - Encourages fusion of data/information from multiple satellite, models and in-situ data
  - Primary work is done at the algorithm and application developer's institution.
  - Address potential risk in algorithms and data products by testing alternative algorithms.

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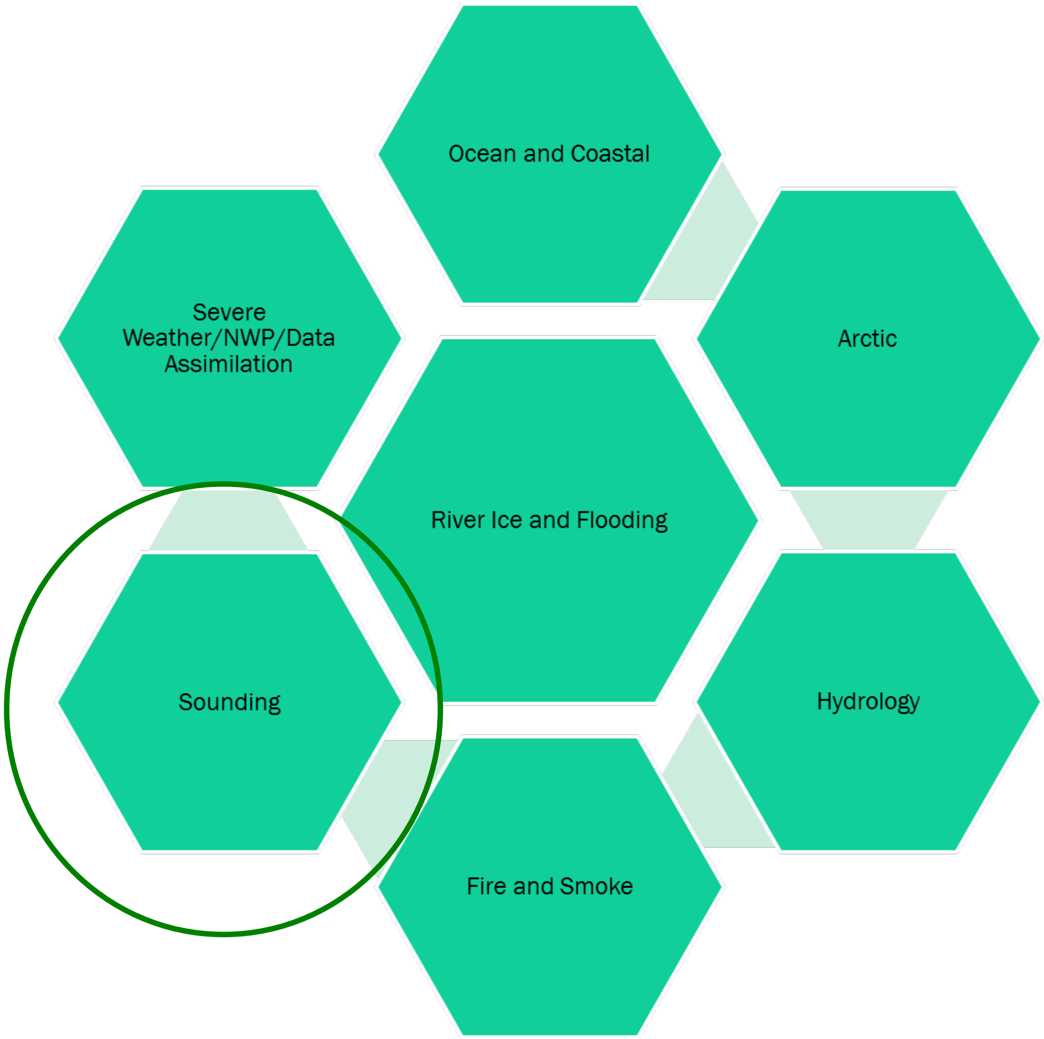
JPSS PGRR Background

- The PGRR Program was established in early 2012, following the launch of the Suomi National Polar Partnership (SNPP) satellite on 28 Oct 2011
- Call-for-Proposals (CFPs)
  - The initial CFP in Jan 2012 resulted in 100 teams providing Letters-of-Intent (LOIs) with nearly 40 projects selected for funding
  - A second PGRR Program CFP went out in Dec 2014. PGRR Initiatives were used as a focus for the responses to this CFP. Over 130 LOIs were received
  - A third CFP will be prepared during the Fall of 2017
- These proposals went through a rigorous user-led selection – between 40-50 projects selected for funding each time
- Project managers work with the users to determine how best to use new JPSS data, and to quickly transition these capabilities to operations.

PGRR Proving Ground Initiatives
Responding to User Feedback

- The River Ice and Flooding Initiative was the first attempt at this new partnership and it was established in response to Galena AK flooding in May 2013.
- The Initiative included River Ice and River Flooding Project teams, direct broadcast SMEs, and National Weather Service River Forecast Center forecasters.
- The success of River Ice and Flooding Initiative led to creation of other initiatives that guided the 2014 PGRR CFP.
- Initiatives have proven to be critical forums where JPSS personnel, product developers, and users interact. The effort is to evaluate current and future JPSS Capabilities in operational environments to determine which of these capabilities should be transitioned to operations.

PGRR Proving Ground Initiatives Partial List

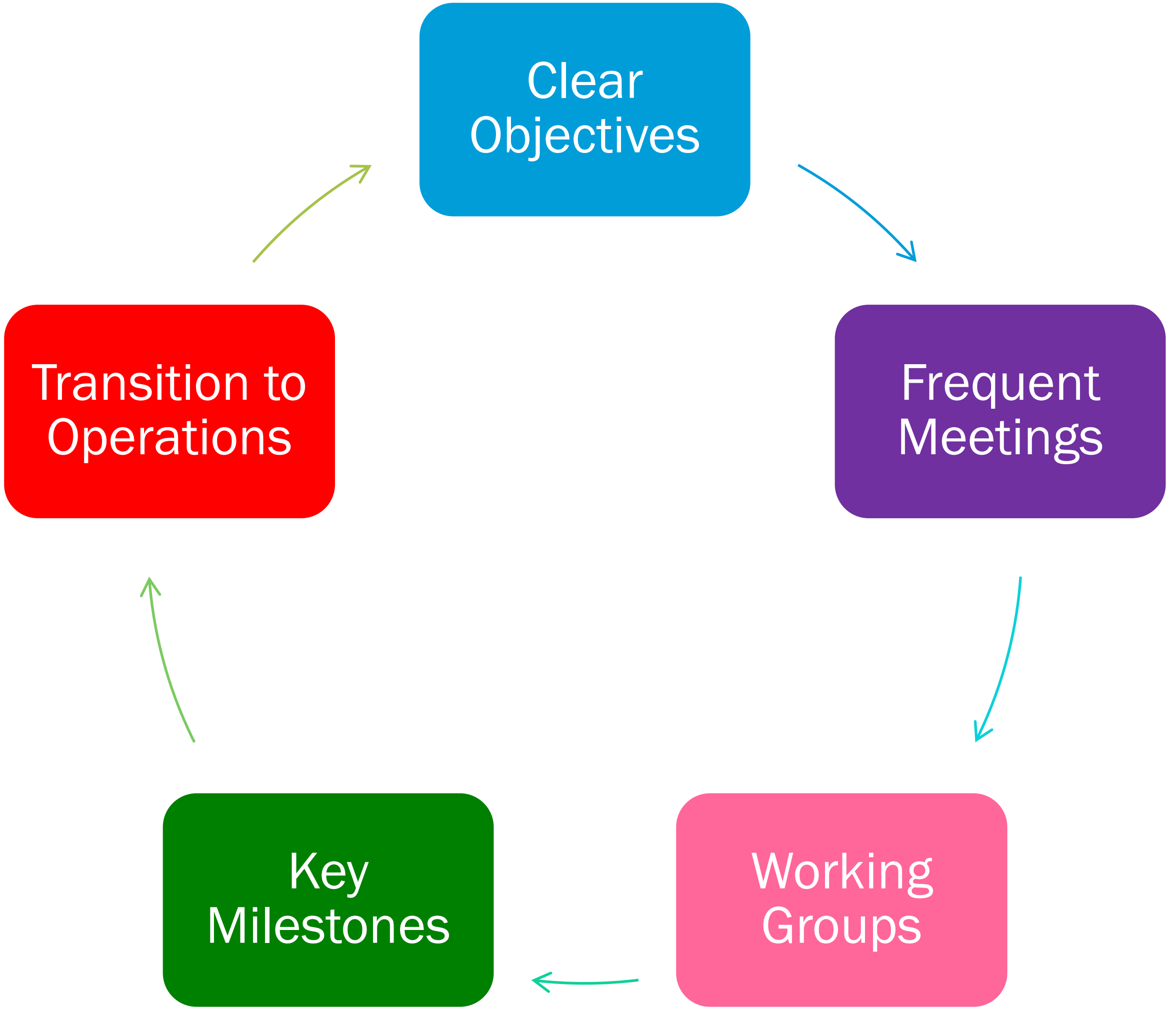


PGRR Initiatives

Initiative	Start Date
River Ice and Flooding	November 2013
Fire and Smoke	May 2014
Sounding Applications NOAA Unique CrIS/ATMS Processing System (NUCAPS)	July 2014
OCONUS and NCEP Service Centers AWIPS Initiative	June 2015
Hydrology	July 2015
Ocean and Coastal	March 2016
Severe Weather/NWP/Data Assimilation	March 2016
Arctic Initiative	June 2016

PGRR Proving Ground Initiatives Partners

PGRR Proving Ground Initiatives Best Practices



NUCAPS Initiative Initial Objectives

- Organize a forum to allow stakeholder supporting NUCAPS development to interact with key users of the capabilities.
- Evaluate how NUCAPS soundings will look in AWIPS II and work to get field the correct visualization showing the soundings' Quality Control (G, Y, R).
- Discuss actions to prepare for a ops demo for Cold Air Aloft in AK during Winter 2014-2015
- Discuss actions needed to evaluate NUCAPS in HWT Spring Experiment 2015.
- Establish NUCAPS Training for WFO that currently have NUCAPS and have the training available for those WFOs upgrading to AWIPS II. Training would be a module in the Commerce Learning Center.
- Work to justify and then implement NUCAPS pre/post-processor for Metop-A/B AMSU/MHS/IASI. This allows NUCAPS products to be available at both 9:30 and 13:30 overpasses.
- As the Initiative Team met over the months and years, actions were taken to implement these objectives, and new objectives were identified and worked.

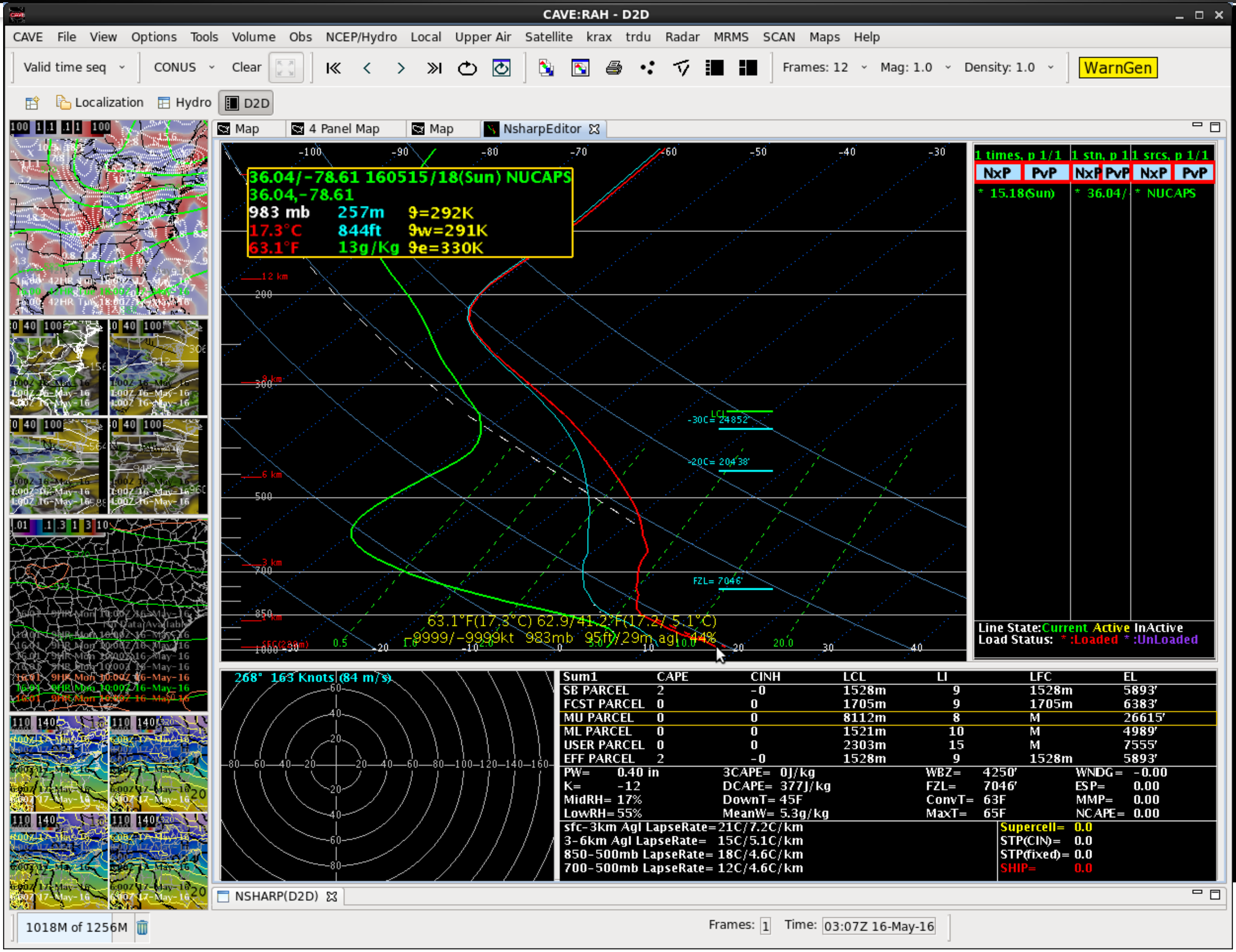
Initiative Participants

Name	Organization	Name	Organization
Chris Barnet	STC	AK Sharma	STAR
Emily Berndt	SPoRT	Bill Sjoberg	JPSS
Jack Dostalek	CIRA	Nadia Smith	CIMSS
Antonia Gambacorta	STAR	Eric Stevens	GINA
Chad Graville	NWS	Jorel Torres	JPSS Training Liaison
Brian Motta	NWS	Elisabeth Weisz	CCMIS
Nick Nalli	STAR	Ashley Wheeler	STC
Kim Rink	NWS	Brad Zavodsky	SPoRT

Initiative Activities

- NUCAPS Soundings only available in AWIPS II Weather Forecast Offices – had to provide instructions on how to install
- NUCAPS Training was not widely available
- NUCAPS Quality Flags
- Cold Air Aloft in AK – when air is colder than -65F jet fuel begins to jell.
- Evaluated NUCAPS in three consecutive Spring Experiments at the Hazardous Weather Testbed in Norman OK (is NUCAPS available, does it look right…..)
- Operational testing of NUCAPS in convective environments in CONUS and Alaska in various environments
- Worked to create an IASI NUCAPS Products to take advantage of MetOp early morning orbits.
- Provided NUCAPS soundings for aircraft operations in several CalWater Experiments.
- Evaluated use of NUCAPS during Pineapple Express Atmospheric Event.
- Participated in El Nino Rapid Response Field Campaign.
- Used NUCAPS to study extratropical transition of tropical cyclones and hurricanes.
- NUCAPS provide stability info for IMETs on the fire line in convective environments
- AND MORE………………..

NUCAPS in AWIPS – Skew Ts

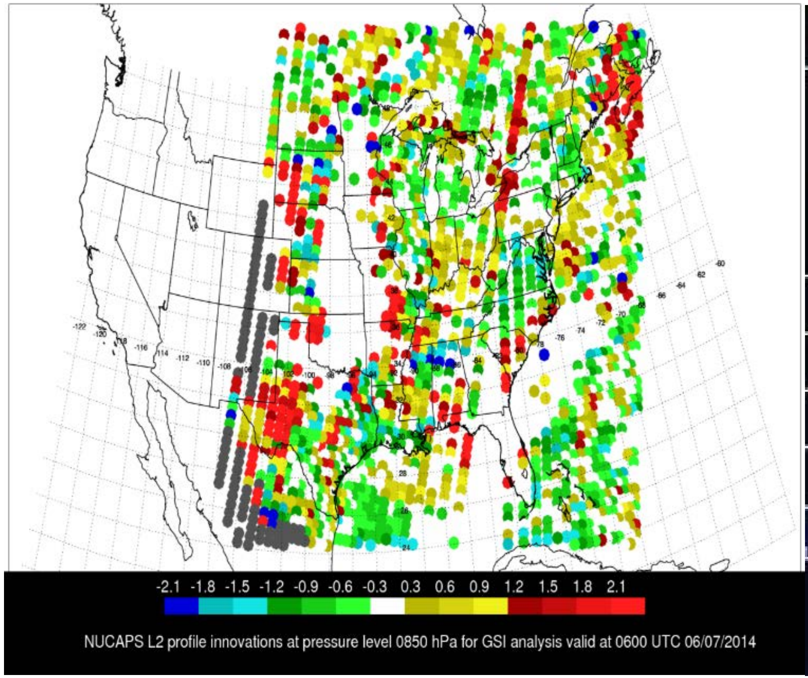


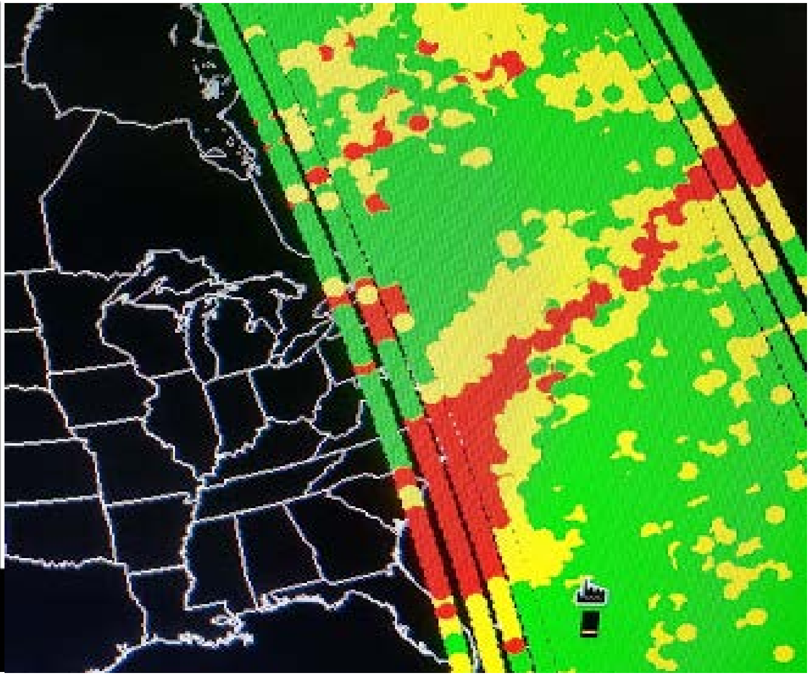
High <u>vertical information</u> content

Allows comparison to Radiosondes and Model soundings

But…
- Which dot to click on?
- NOT visible in Volume Browser

Quality Flags (QFs)





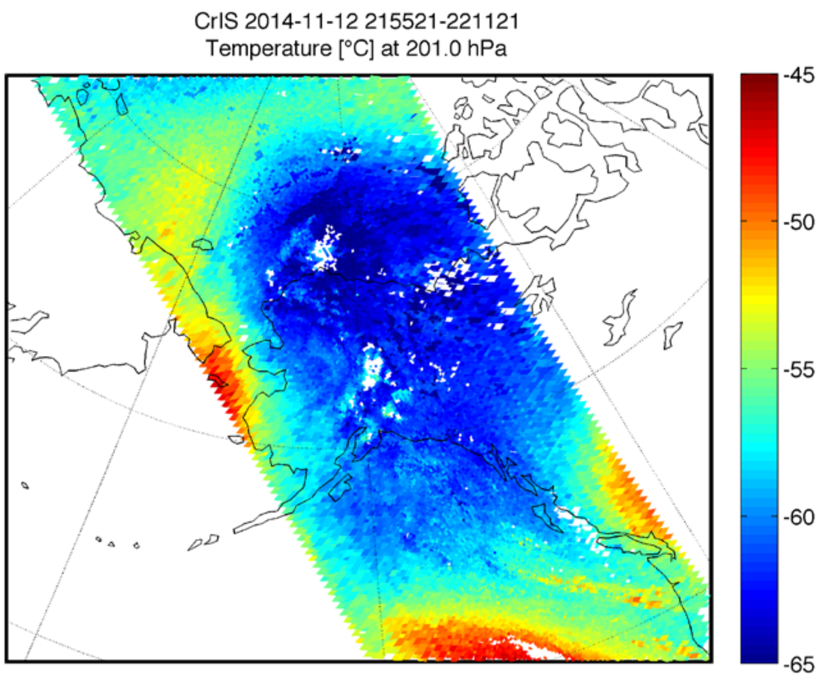
Red means the MW retrieval failed (by default that also means the IR failed)

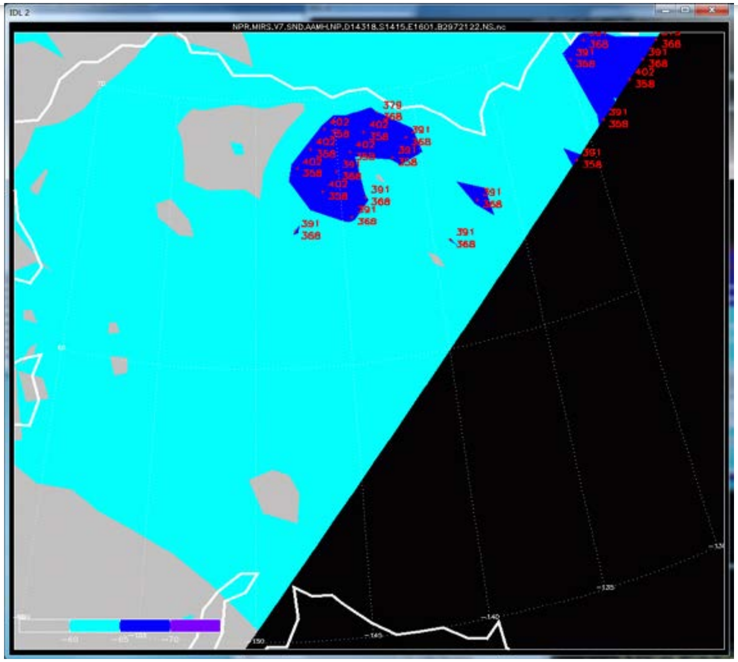
Yellow mean the MW retrieval passed but the IR retrieval failed (IR not used, microwave only)

Green means the IR retrieval passed (its actually an IR+MW retrieval, the point being the IR was used)

- Original NUCAPS deployment did not have QFs
- Once QFs were ready they had to wait for a AWIPS II Build to be available to the forecasters
- Had to provide forecasters description of QFs

Cold Air Aloft Visualization





- Different visualizations were presented and discussed with the Anchorage Center Weather Service Unit (located in the FAA Air Route Traffic Control Center)
- Based on her feedback and the product that her group is responsible for delivering, single-swath, plan view images with identified flight levels (bottom and top) of the -65C air are optimal
- Forecasters can use the location of coldest air obtained from plan view data to further investigate NUCAPS soundings already in AWIPS II in more detail

2016 Spring Experiment at HWT
Forecaster Feedback

"[Today, we use NUCAPS for] tracking trends in mid/upper level drying." *Forecaster, End-of-Day Survey*

"I used them to see how the 0C and -20C levels were changing over the afternoon (they decreased in height a few thousand feet each). This was key for warning operations." *Forecaster, End-of-Day Survey*

"[We used NUCAPS] to look at instability in a fairly data sparse region in the Pueblo CWA." *Forecaster, End-of-Day Survey*

"IASI soundings were able to confirm the very low levels of CAPE values that RAP and GFS analysis are showing." *Forecaster*, "Mesoscale setup for Pueblo 5/11/16", *GOES-R HWT Blog*

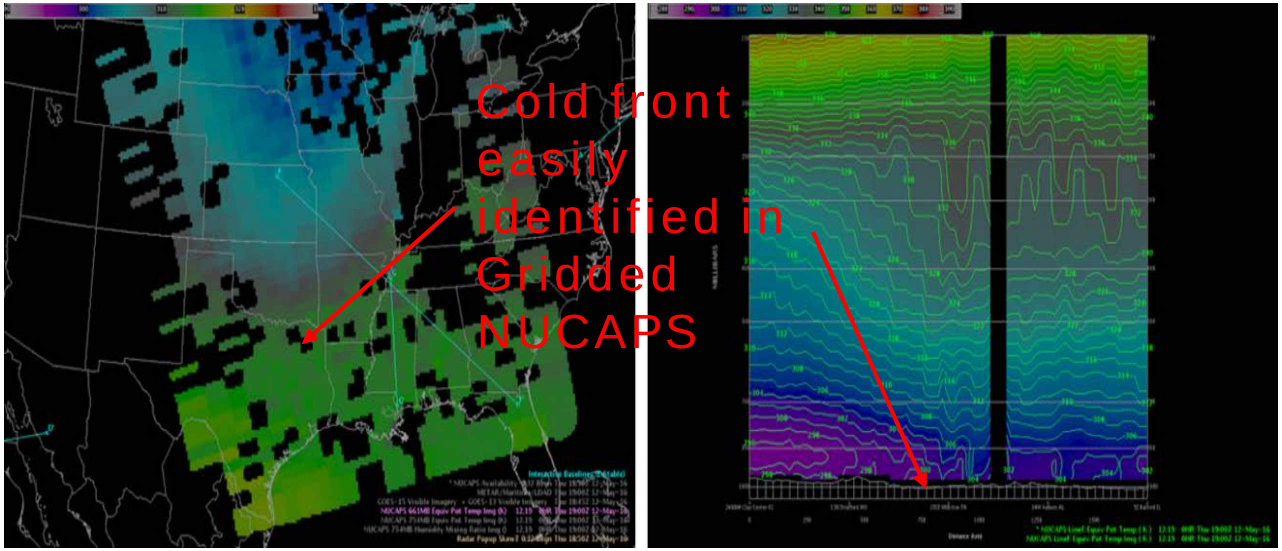
"I used [NUCAPS] to look at how instability was evolving during the day. We had an 18Z OUN supplemental sounding, with a 20Z NUCAPS sounding showing how much instability had increased a couple of hours later." *Forecaster, End-of-Day Survey*

Spring Experiment
More Feedback

"We also used a cross-sectional view of Theta-E in the afternoon to determine the location of our cold front (Fig. 17)." *Forecaster, End-of-Day Survey*

"The plan view fields were more helpful than the actual soundings. I enjoyed looking at the mixing ratio field for this product and can see the utility of having plan view and cross sections available for NUCAPS fields such as LRs, CAPE, RH, Dewpoints, etc." *Forecaster, End-of-Day Survey*

"I would like to say that having the IASI soundings was very helpful and getting them 4 times per day would be great. This could also help with your buy in because getting data in between the synoptic times is always helpful." *Forecaster, End-of-Week Survey*



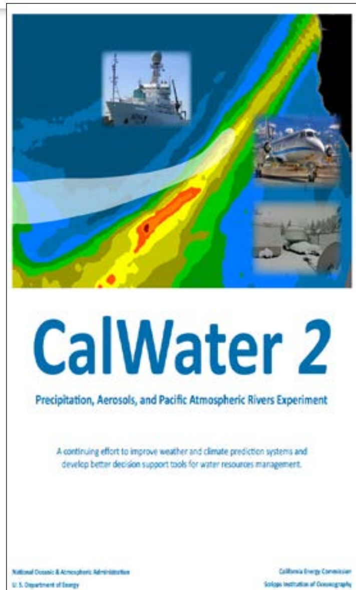
Spring Experiment
Suggested Improvement Feedback

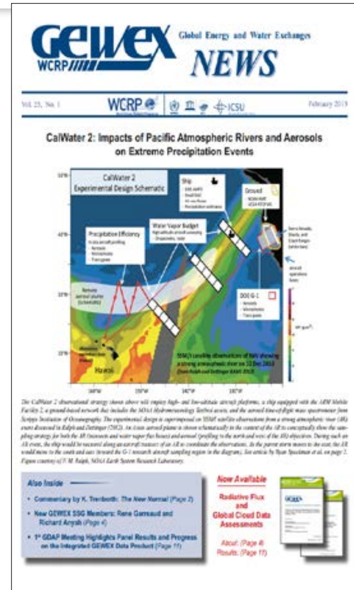
"With some improvement to the lower levels, this could be a very useful operational tool to check against model derived fields and the current state of the atmosphere. After careful thought, as a forecaster I would like to keep all data coming from NUCAPS observational, even if this means that the quality of the data is a bit suspect at times. By introducing model data to the process you could make it look better but you are introducing a second possible source of error into the product." *Forecaster, End-of-Day Survey*

"The smoothed nature of the soundings limits the potential usefulness of the soundings. The inability to see capping inversions and saturated layers is a real drawback." *Forecaster, End-of-Week Survey*

"Automated modification in the 850-500 hPa layer is important as this is the portion of the sounding where the CAP is most prevalent." *Forecaster, End-of-Week Survey*

The CalWater 2 Field Campaign





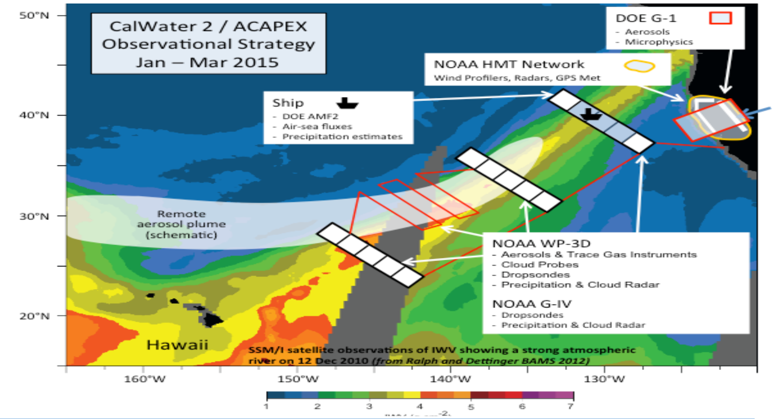
- CalWater 2 is a 5-year broad interagency vision to address key water cycle science gaps along the US West Coast

Objective: to examine the development and structure of ARs before landfall to improve forecasts of extreme precipitation events along the US West Coast

An opportunity for us to (1) evaluate NUCAPS moisture products in extreme environments; (2) to train and develop new user applications.

CalWater 2/ACAPEX Field Campaign

- Interagency Campaign:
  - Scripps (Marty Ralph, Kim Prather)
  - NOAA (Allen White, Ryan Spackman)
  - DOE (PI: L. Ruby Leung) ACAPEX = ARM Cloud Aerosol Precipitation Experiment
- White paper at http://esrl.noaa.gov/psd/calwater



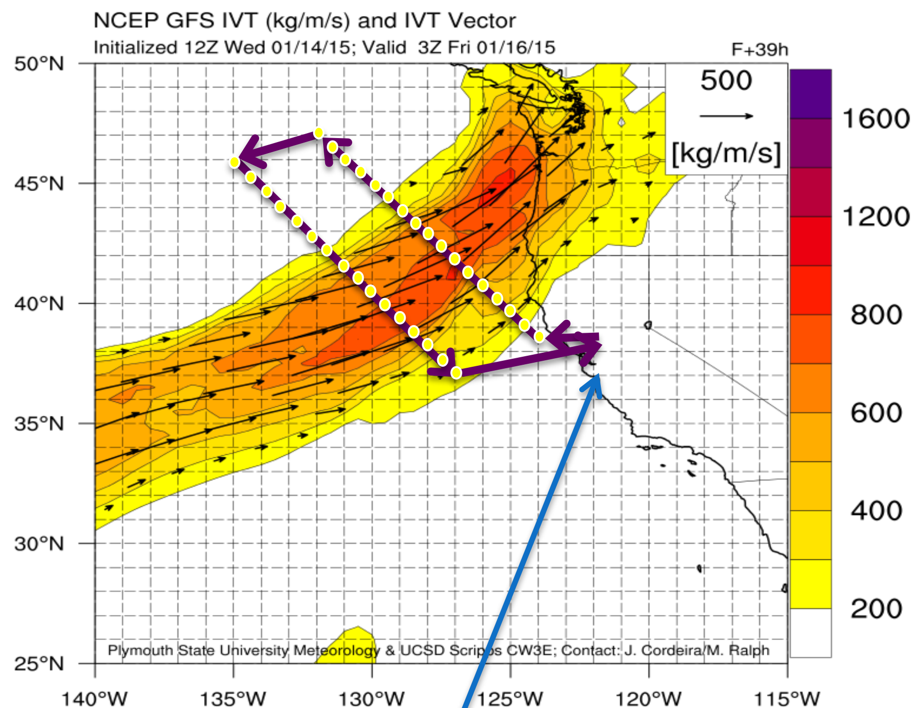
Platform	Range of Obs	Duration	Types of sensors
AR Observatories and Hydro-Met Testbed	ARO sites: CA(4), OR(2), WA(1)	Full campaign	Snow level radar (S-band), 449 MHz wind profilers, soil moisture, 10 meter surface tower
NOAA WP-3D	1-22 kft, 4000 km range	80h over 4 weeks	~150 dropsondes, W-band radar (clouds), IWRAP Radar, Tail Dopper Radar, Cloud Probes, SFMR
NOAA G-IV	1-45 kft	90h over 6 weeks	~300 dropsondes, Tail Doppler Radar, NOAA O3, SFMR
DOE G-1 with ~40 instruments	1-23 kft	120h over 8 weeks	Cloud properties (Liq/water content, size), aerosol properties (concentration, size, CCN), trace gases (H2O, O3, CO)
NOAA R.H. Brown	Can move ≤ 5 deg/day to stay within AR	30 days	AMF2: Aerosol Observing System, Ka ,X, W-Band Cloud Radars, DOE, Micropulse LIDAR, Wind Speed, Rain Guages RS-92 Sondes: ~260 (~half dedicated overpass time)

Example of Jan. 15, 2015 flight planning: Integrated Vapor Transport (IVT) forecast

Vertical structure of water vapor in ARs is crucial to forecast integrated vapor transport correctly

The 2014 CalWater campaign suggested NUCAPS retrievals from CrIS and ATMS could improve land falling forecasts

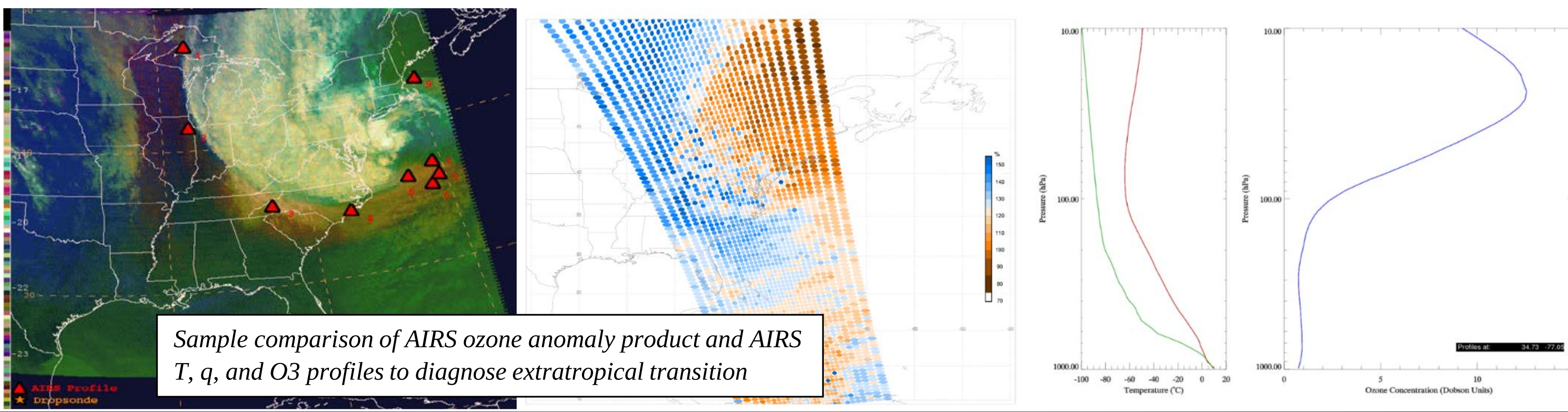
In CalWater 2015 we demonstrated the capability to provide real time direct broadcast NUCAPS retrievals to a field campaign.



NOAA G-IV aircraft flight track
Take off time: 2100UT on 2015-01-15;
Landing time: ~0300UT on 2015-01-16
(flight duration ~ 6 hours)

Extratropical Transition Project

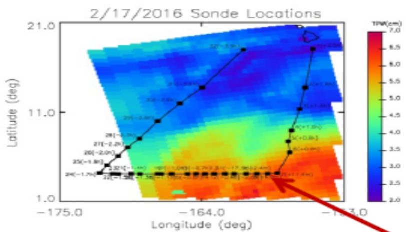
- Investigate utility of NUCAPS T, q, and O3 profiles to diagnose hurricane extra-tropical transition
- Since ET events often occur over data sparse regions, satellite retrievals would provide a wealth of data where ground based observations are lacking
- NUCAPS soundings are already in AWIPS-II and available to forecasters, this project would provide feedback to JPSS management, NUCAPS product developers, NOAA training developers, satellite liaisons, and forecasters on the benefit S-NPP/JPSS data can provide for forecasting unique events.



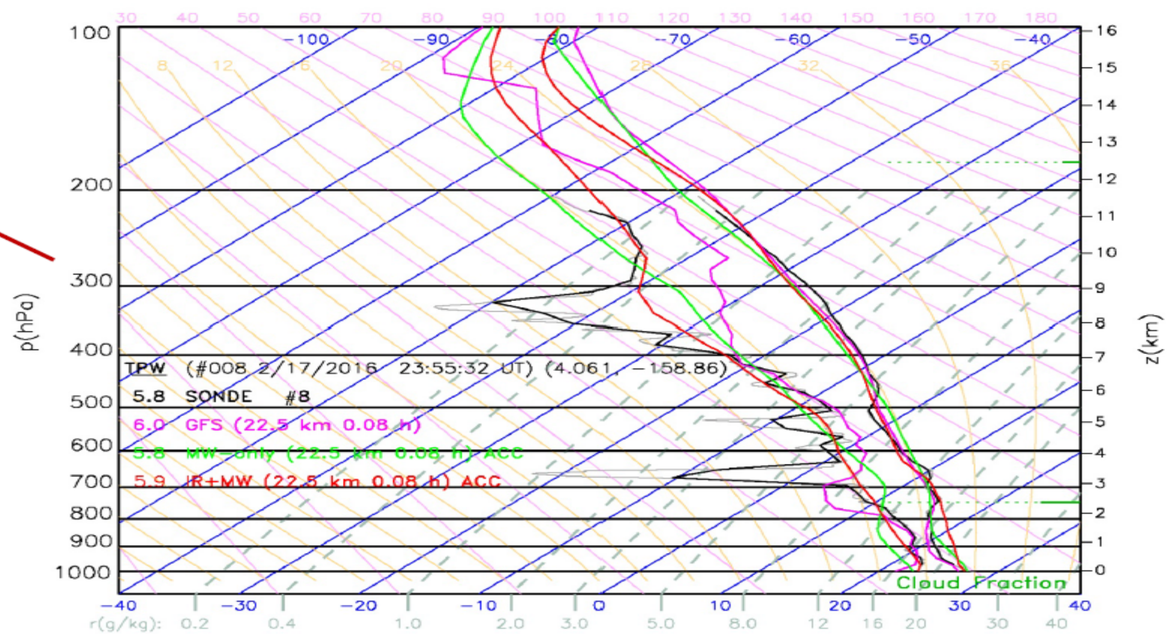
Sample comparison of AIRS ozone anomaly product and AIRS T, q, and O3 profiles to diagnose extratropical transition

El Nino Rapid Response Field Campaign - 2016

Feb. 17, Sonde #8: near overpass time



NUCAPS is capturing large scale vertical structures



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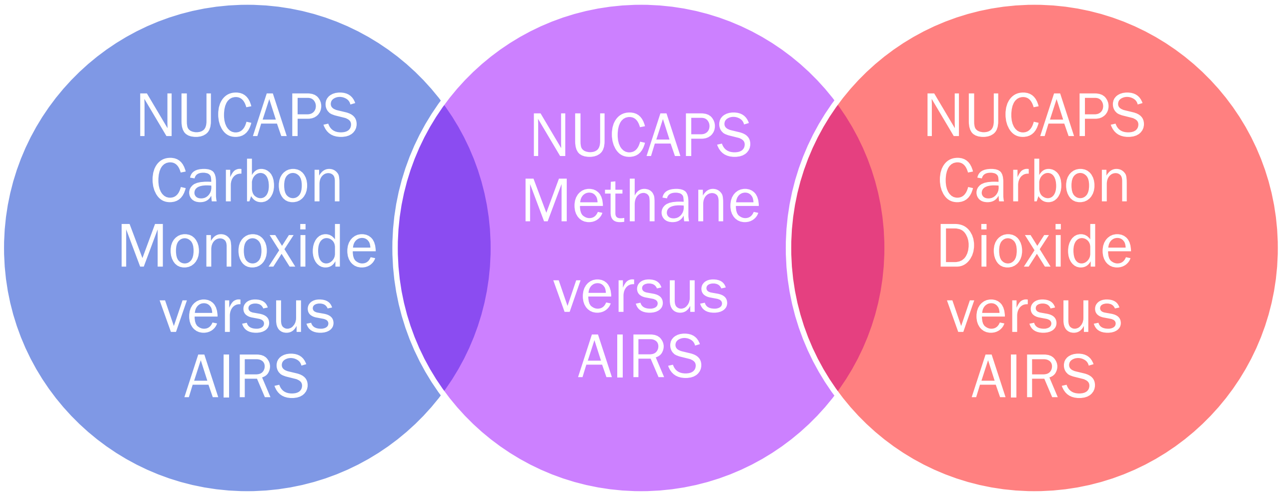
NUCAPS CrIS Full-Resolution Carbon Trace Gas Validation



Other Variables

- CrIS Full Resolution Baseline
- CrIS Full Resolution IR +MW
- AIRS v6 Baseline

Way Forward

- Format and tailor NUCAPS Training for NWS Foundational Course
- Evaluate Results from Spring Experiment 2017 to determine additional changes for SE 2018
- Prepare for NUCAPS evaluation in NWS Operational Proving Ground in 2018 – evaluate NUCAPS in winter environments.
- Work with AWIPS II Developers to include IASI NUCAPS and NUCAPS horizontal cross sections
- Respond to new ideas from the field

Summary

- The Initiative Process is a journey not a destination.
- A fully engaged Initiative Team is key to success…. New ideas can spring from anywhere.
- Initial success builds momentum to long-term effectiveness
- If the right people aren't engaged….find them and invite them to participate!
- A little organization goes a long way. Meeting note, action items, and standardized agendas have been successful.
- Do initiatives ever end? Don't know yet…there always seems to be a lot more work to do!

Early Results from NUCAPS Demonstration in the 2017 HWT Satellite Proving Ground Experiment

Michael Bowlan
University of Oklahoma/CIMMS & NOAA/NWS/NCEP/SPC

2017 JPSS Annual Science Team Meeting
August 16, 2017

HWT Experimental Warning Program (EWP)

- Mission: Improve prediction of severe convective weather at the "warning scale" (0-2 hours).

- Norman has a large community of researchers, operational meteorologists, students, industry.

- But, we serve all National Weather Service WFOs and CWSUs nationwide.

- A vital component to the Research To Operations (R2O) process.

2017 GOES-R/JPSS Experiment

- 4 weeks (19 June, 26 June, 10 July, 17 July)
  - 3 NWS forecasters, 1 broadcast meteorologist per week
- Using AWIPS-II
- Forecasters issue experimental mesoscale forecast updates (via a blog) and severe thunderstorm and tornado warnings (WarnGen)
- We want forecasters to think about how they are using the experimental products in nowcast and warning decision making.

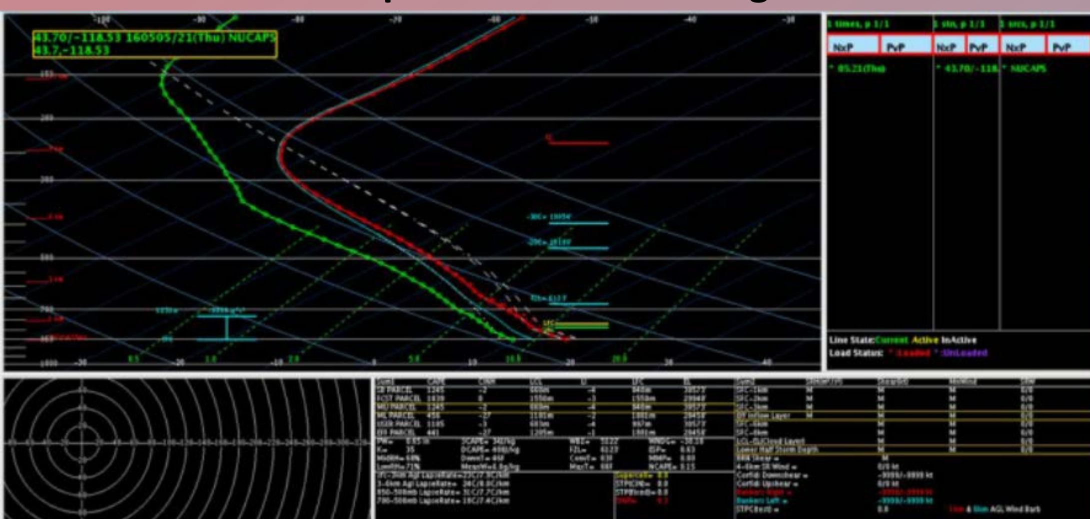
Forms of Feedback

- Daily survey (Mon-Thurs) for all products
- End-of-Week Survey (Friday morning)
- Debrief Discussions (Tues-Fri mornings)
- Real-time discussions
- **Blog**
  - **Mesoscale forecast updates**
  - **Reasoning behind warning decisions**
  - **Updates to previous warnings/forecasts**
  - **Best practices**
  - **Ideas for improvement**
  - **Any thoughts/feedback, good/bad, about the experimental products**
  - **HWT Satellite Proving Ground Blog**
- Weekly Webinar

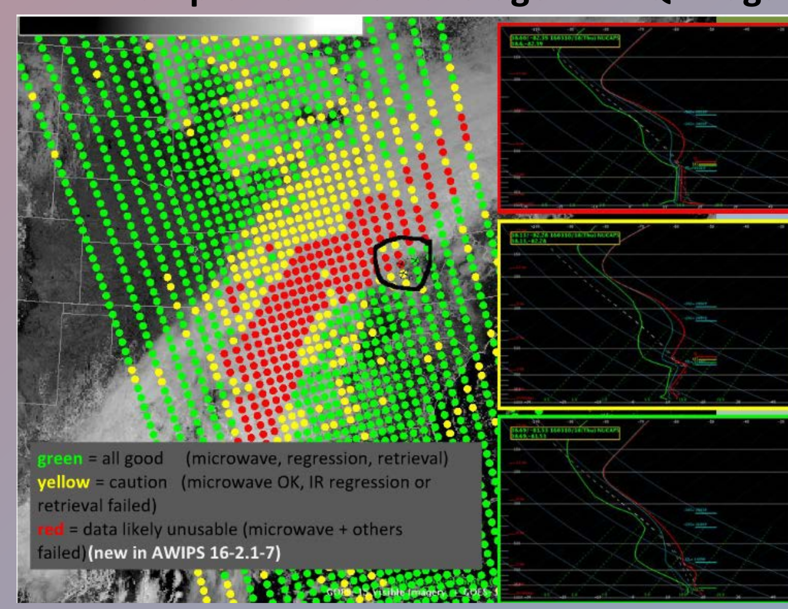
NOAA Unique Combined Atmospheric Processing System (NUCAPS) in the 2017 Experiment

- NUCAPS algorithm generates temperature and moisture profiles using information from instruments aboard the Joint Polar Satellite System (JPSS) Suomi-NPP polar-orbiting satellite.
- Products include:
  - NUCAPS Profile Availability (Time/Location) with quality control flags
  - NUCAPS Vertical Temperature and Moisture Profiles (SNPP, MetOp-A, and MetOp-B)
  - Experimental modified NUCAPS Vertical Temperature and Moisture Profiles
  - Multi-level, gridded plan views of NUCAPS thermodynamic info

Example NUCAPS Sounding

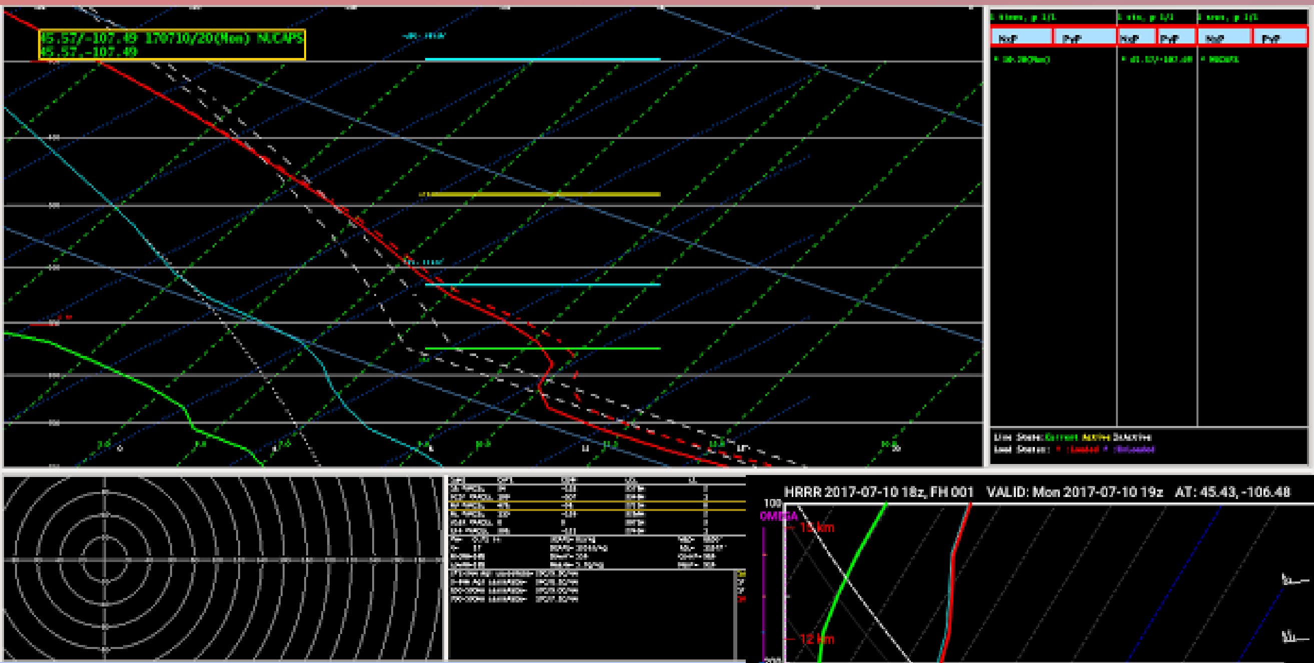


Example NUCAPS Coverage with QC flags

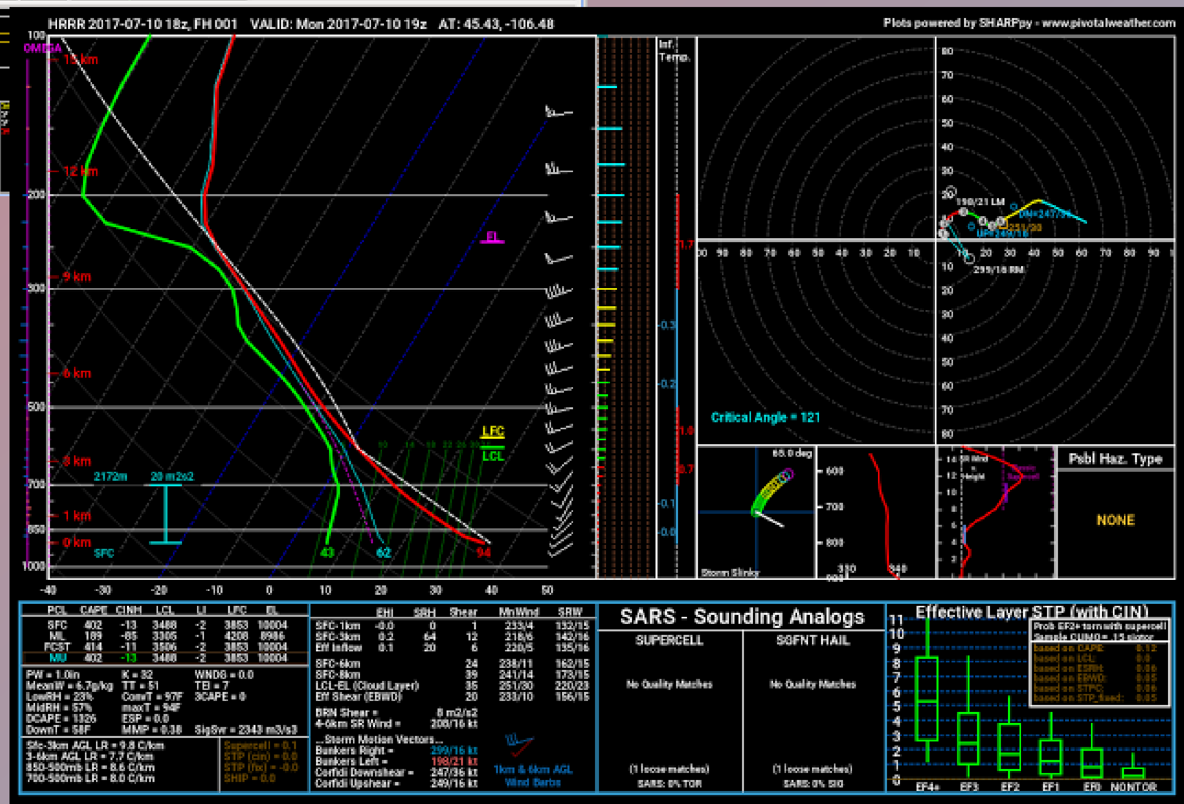


Example Cases and Feedback

NUCAPS Used in Fire Case



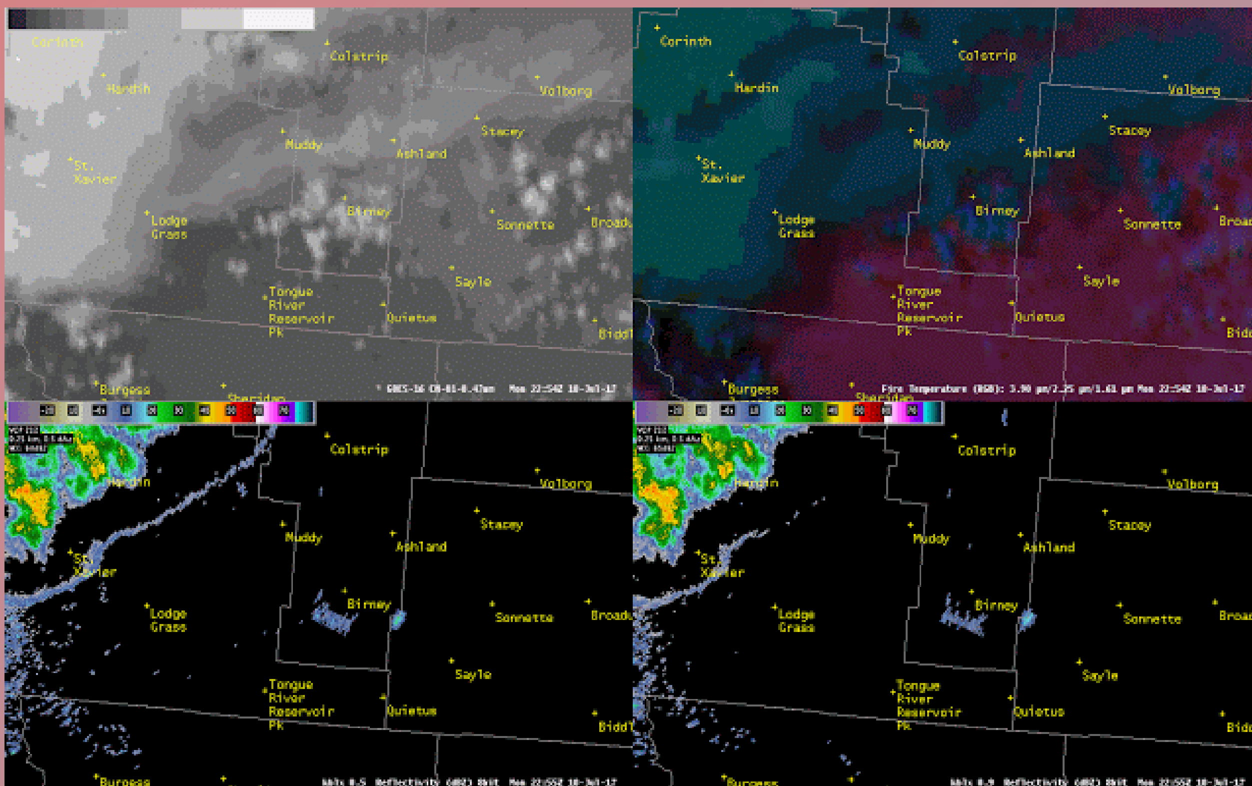
HRRR Forecast Sounding



NUCAPS Sounding

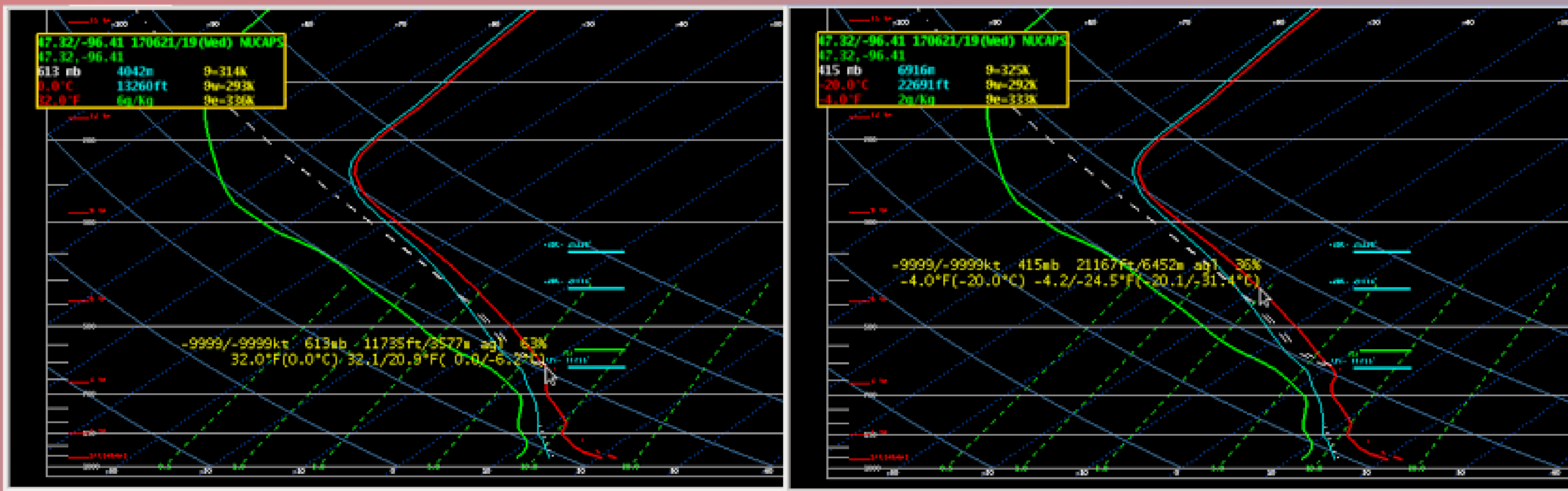
- A noticeable inversion was detected near/just above 700mb.
- Compared to HRRR, RAP, and NAM soundings taken at a similar time, guidance was unable to detect this feature.
- Decided to investigate a smoke plume seen from KBLX radar

NUCAPS Used in Fire Case



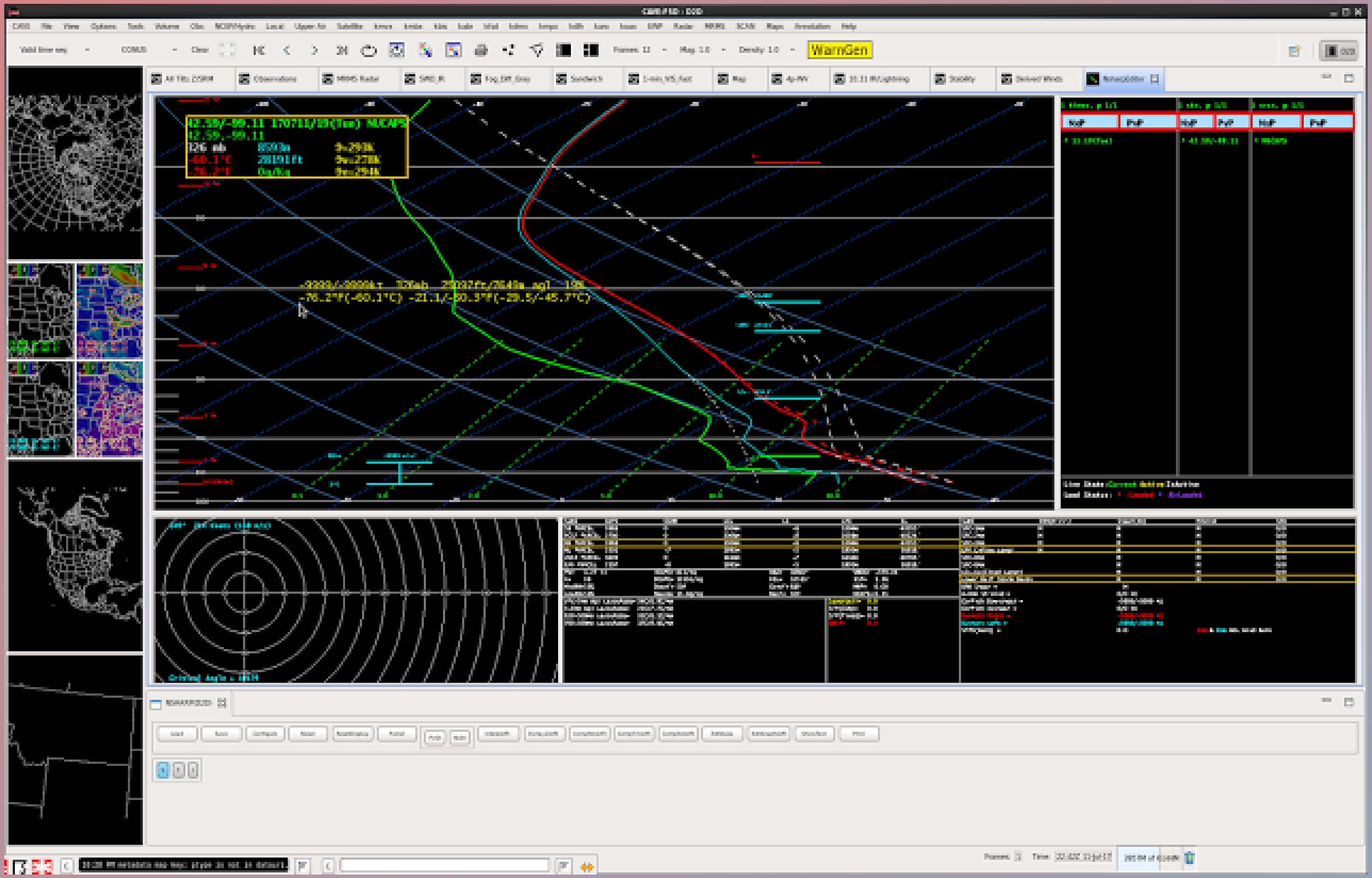
- “The placement of the fire and smoke plume suggests some accuracy of the NUCAPS capture of the inversion, which is missing from model guidance.”
- “Additionally, it has been noticed that as convection has pushed eastward this afternoon, it's intensity has been decreasing, which could be an impact of the inversion.”

Using NUCAPS During Storm Interrogation

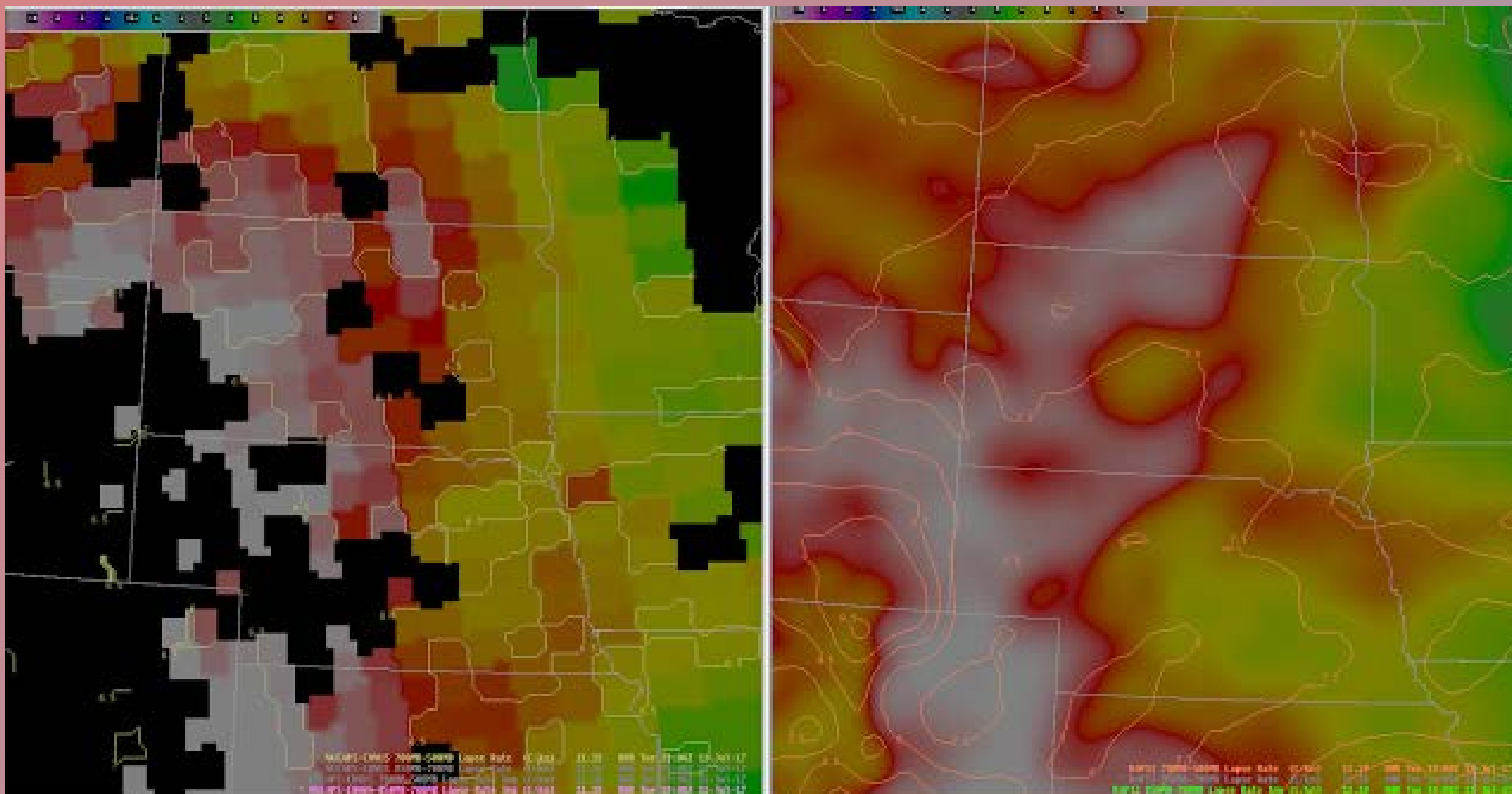


- Another use of the NUCAPS soundings is to quickly identify the 0C and -20C levels from an actual observation.
- “I found this information very valuable during warning operations.”
- “I used these heights when assessing heights of 50 and 60 dBZ, which helped in my warning issuance. ”

Operational vs. Experimental Soundings



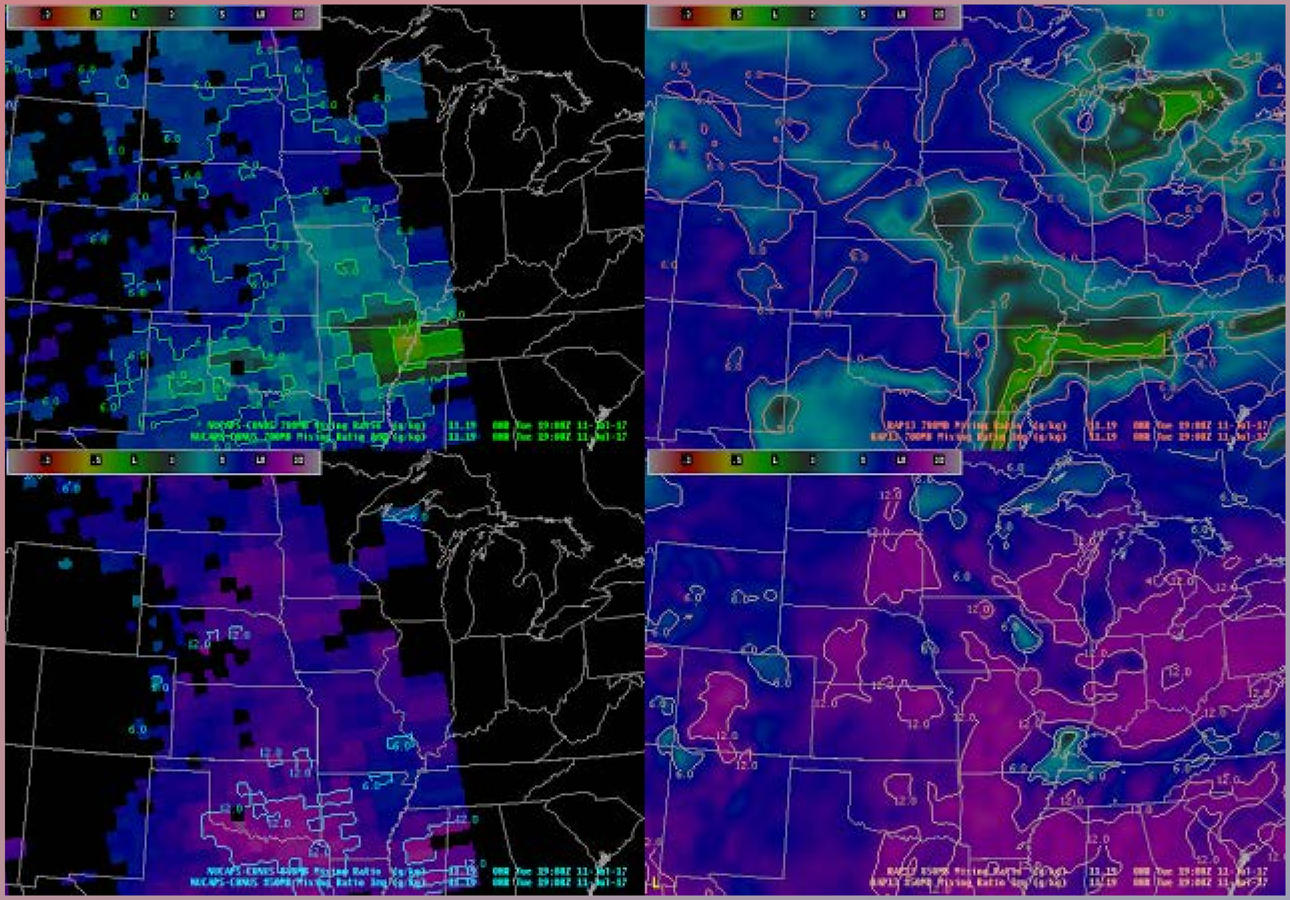
Gridded NUCAPS



NUCAPS (left) and RAP (right) with a gridded 850-700mb Lapse Rates and 700-500mb LRs contoured.

“Overall, I think the NUCAPS data provides a good assessment of the mid level conditions in this case.”

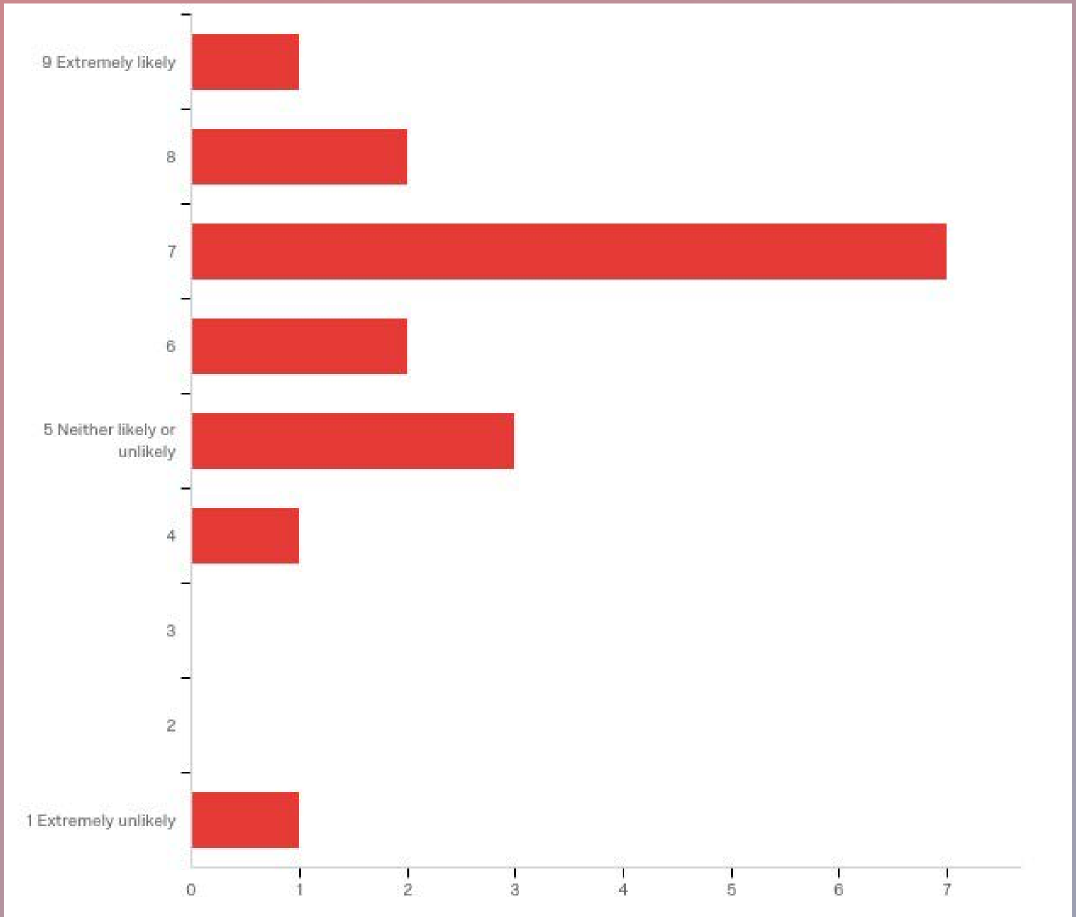
Gridded NUCAPS



"Thus, confidence may be a bit better at levels at or above 700mb, but not so good for 850mb or lower. Overall, as you get closer to the surface, it looks like there is a tendency for NUCAPS to trend towards a drier solution than the models."

Summary and Initial Feedback

How likely are you to use NUCAPS Products at your home office?



Summary and Initial Feedback

- Found the availability of NUCAPS soundings very beneficial in the field particularly for offices in the western U.S. and other data void regions.
- Some work can be done to increase its utility in the field (better temporal resolution, tailored fields of interest for a forecast, better gridded data viewing...little ragged at times, and training for forecast operations).
- It would very useful in the field to be able to get multiple passes during the day to be able to monitor evolution of fields of interest Like mixed layer depth evolution, monitoring inversion (stable layers) which are critical for downslope wind storms, air quality, convective suppression or cap breaking, and stability evolution (assuming better temporal resolution).
- Most see the utility in having both the operational NUCAPS soundings available alongside the experimental surface obs adjusted values. Even though the correction may be oversimplified in assuming a perfectly well mixed layer of moisture, it is still useful to see.
- Most like having both soundings and gridded data to get the full potential of the NUCAPS data.
- The gridded NUCAPS were found to be a little clunky at first but currently there are no easy menu options to view data and has to be built using the volume and product browsers. This would need to be streamlined greatly. The high vertical resolution is also valuable in that it allows you to evaluate plan views of temperature, moisture, possibly even heights of temperature surfaces (example freezing levels, -20, inversion heights) and whatever pressure level is available.
- Latency is still the main issue from using regularly in ops.

Improvement Ideas

- Would like to see a readout, similar to a ProbSevere readout, when sampling the dots of some important parameters such as: CAPE, Lapse Rates, Freezing Level, etc…
- Need some type of labeling (station ID) to identify the sounding points from each other, the Lat/Lon readout is insufficient to remember which point was chosen.
- Would like to be able to overlay multiple soundings at once. (May be AWIPS issue)
- Similarly, forecasters like the idea of using the pop-up Skew-T, but would like the readout of some parameters along with the pop-up sounding.
- Need more useful parameters for the gridded data like SBCAPE and other surface based indices instead of having to choose pressure levels. (Ex. 1000mb CAPE only along coasts and 925mb CAPE misses surface features most places besides the mountains.)
- Would like to see some type of winds get integrated within the soundings if possible.

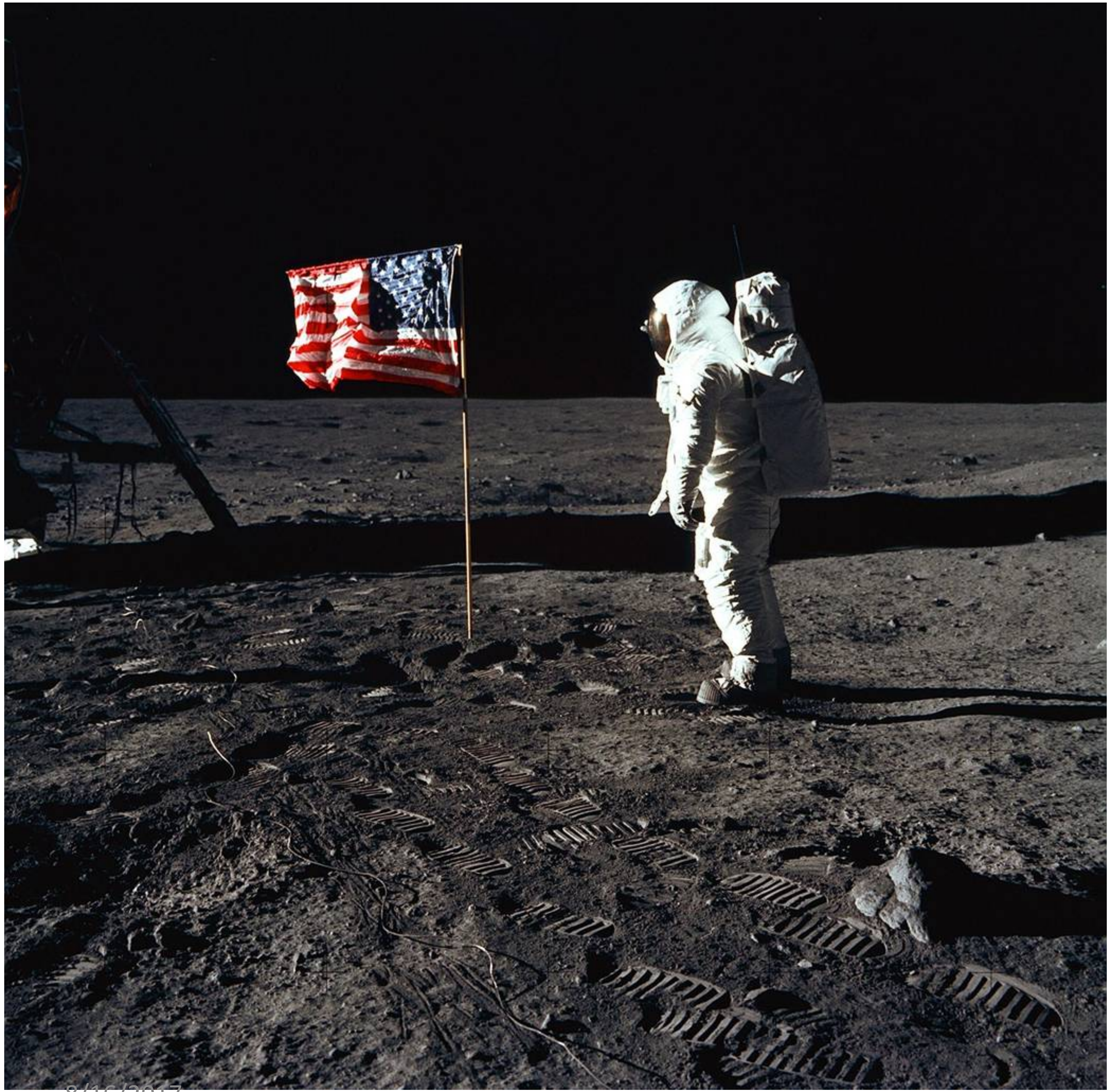
Thank You!

NUCAPS in Forecast Operations in Alaska

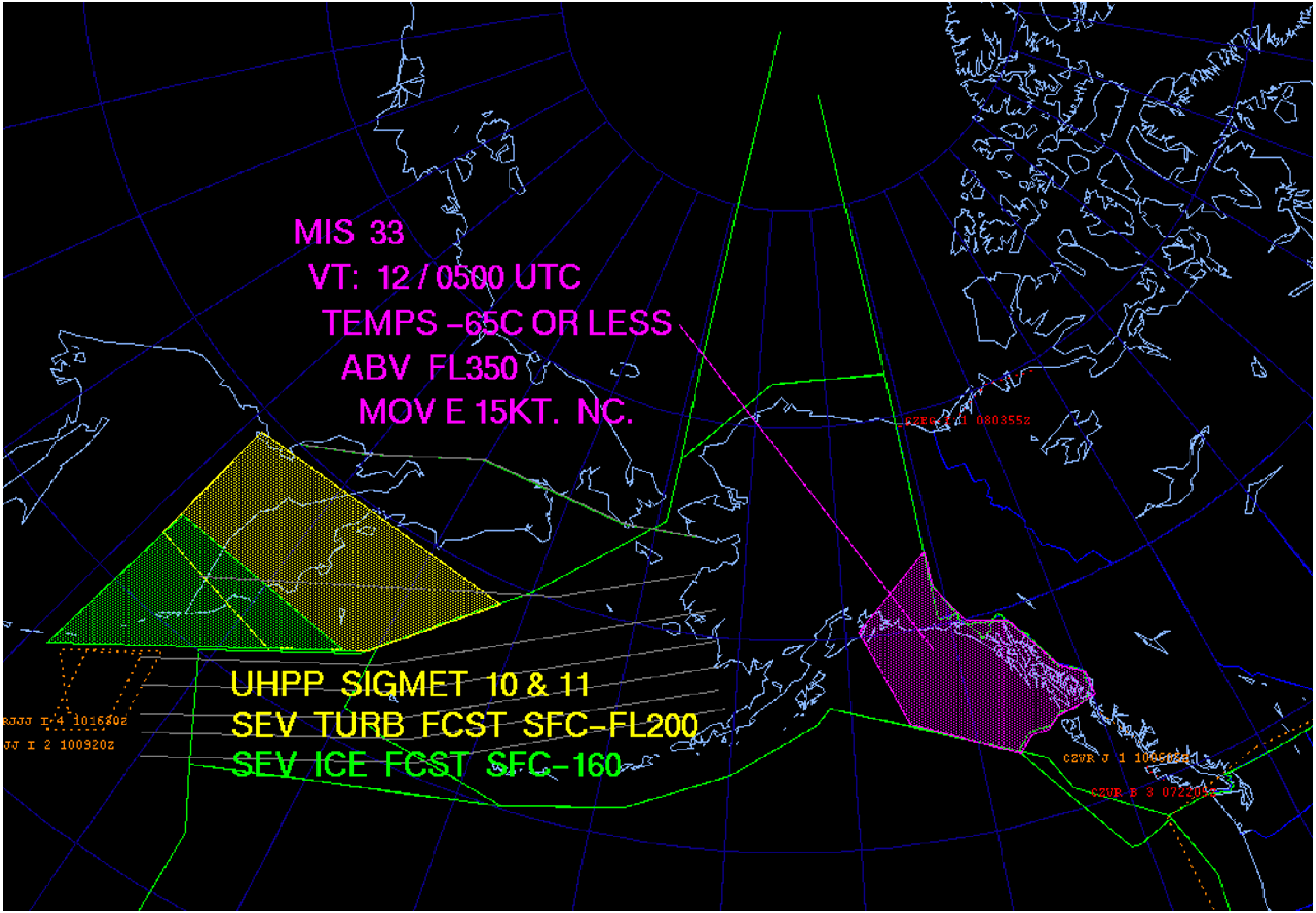
Eric Stevens

University of Alaska Fairbanks,

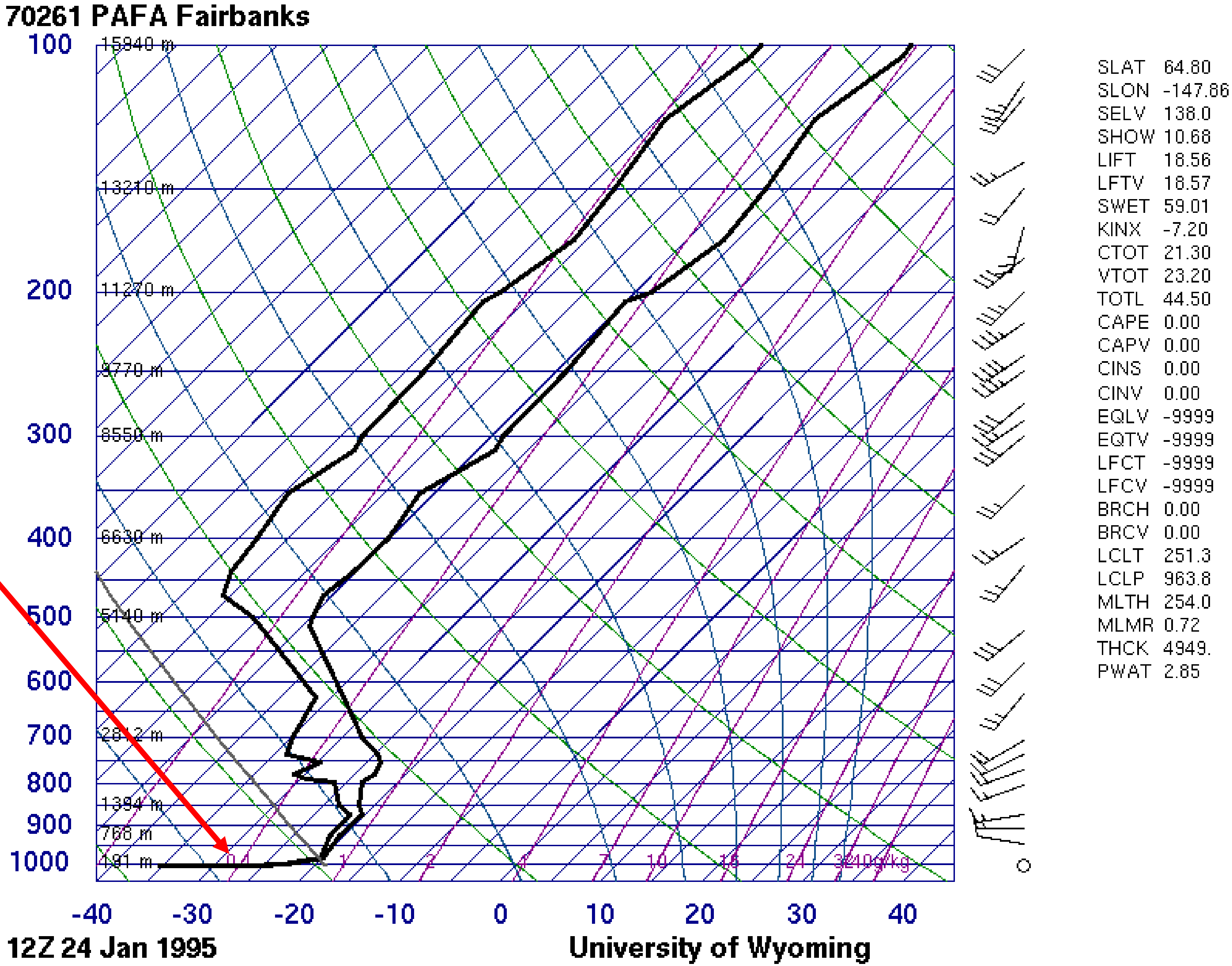
Geographic Information Network of Alaska



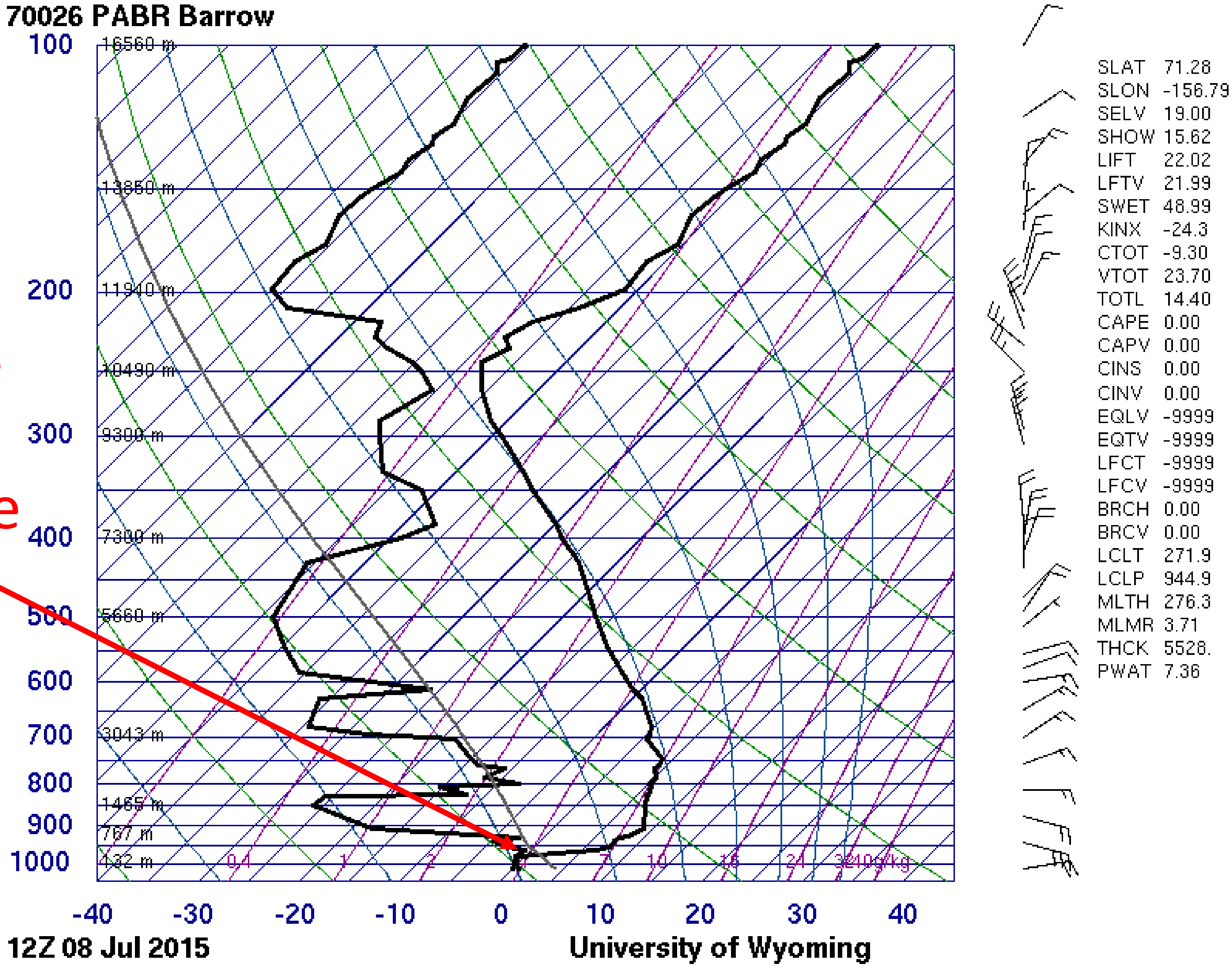

United States
Discovery

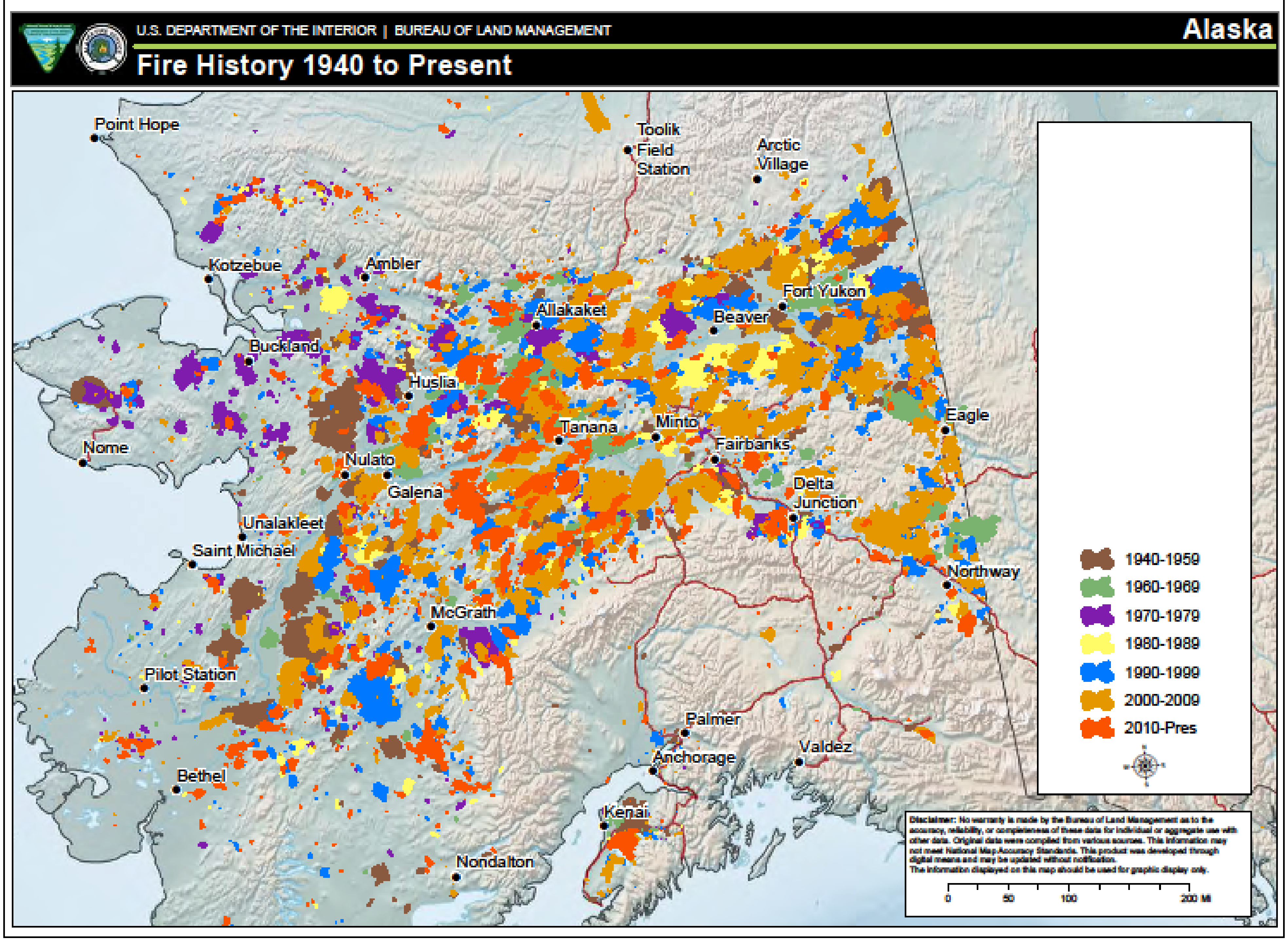

MIS 33
VT: 12 / 0500 UTC
TEMPS -65C OR LESS
ABV FL350
MOV E 15KT. NC.
UHPP SIGMET 10 & 11
SEV TURB FCST SFC-FL200
SEV ICE FCST SFC-160

Temperature rise of 15F in bottom 174ft of the atmosphere



Ceiling 300ft.
Visibility 2 miles…
but variable
between 11/4 mile
and 4 miles




U.S. DEPARTMENT OF THE INTERIOR | BUREAU OF LAND MANAGEMENT
Alaska
Fire History 1940 to Present
Point Hope
Toolik Field Station
Arctic Village
Kotzebue
Ambler
Fort Yukon
Allakaket
Beaver
Buckland
Huslia
Eagle
Tanana
Minto
Fairbanks
Nome
Nulato
Galena
Delta Junction
Unalakleet
Saint Michael
Northway
McGrath
Pilot Station
Palmer
Valdez
Anchorage
Bethel
Kenai
Nondalton
1940-1959
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
2010-Pres
0
50
100
200 MI

NUCAPS and Wildfires in Alaska: Challenges

- Tame wildfire seasons in 2016 and 2017
- Wildfire behavior dependent on more than just weather
  - Firstly, something has to be on fire
  - Topography
  - Fuels
  - Firefighting Efforts
- Swing for the fences: A variant of the “Haines Index” that works well for Alaska

GOES-R • NOAA • JPSS

OCONUS

SATELLITE PROVING GROUND

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NUCAPS Boundary Layer Corrections in Pre-Convective Environments

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Connecting Models and Observations

Hazardous Weather Testbed/Experimental Warning Program (HWT/EWP)

"…to test and evaluate new applications, techniques, and products to support NWS Weather Forecast Office (WFO) severe convective weather warning operations."

- Joint Project NWS/NSSL
- Conducted in Spring (Started in 2008)
- NWS and broadcast meteorologists travel to Norman to practice warning on severe weather events while evaluating both operational and experimental products
- NUCAPS retrievals among the tested products

NUCAPS in the Experimental Warning Program

Survey Question:
"Will you use the NUCAPS soundings at your home office?"

Common Sentiment:
"Yes, I will start Using NUCAPS as is. I will start using it now to get a sense of the environment but I will find it much more reliable when the low-level modification is automated."

Data Fusion

- Near-surface values of NUCAPS temperature and dewpoint prone to error
- Errors in CAPE and CIN can result
- Replace lower-levels of NUCAPS temperature and dewpoint with values based on surface observations from the Real-Time Mesoscale Analysis (RTMA)
  - More than just replacing surface temperature and dewpoint temperature – replace several near-surface levels
  - Create a mixed layer and blend with the NUCAPS retrieval in the free atmosphere
  - Resulting CAPE values more like the mixed-layer CAPE preferred by NWS forecasters over the surface-based CAPE
- Not generally applicable, developed for the warm, moist air masses in pre-convective environments

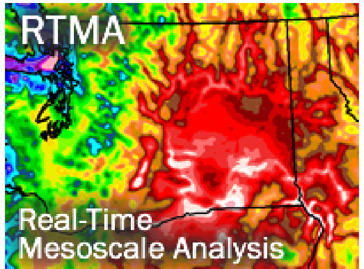
Modification of Lowest Layers of NUCAPS Temperature and Moisture Profile (Theory)

$$z_{i+1} = \left[z_i^2 + \frac{2}{\gamma} C_H |\boldsymbol{V}| (\theta_{Skin} - \theta_{Air}) \Delta t \right]^{\frac{1}{2}}$$

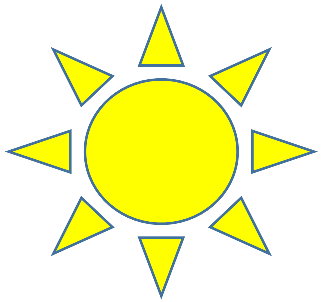
Stull, *Introduction to Boundary Layer Meteorology*

z: height of mixed layer
Θ_{Skin}: Potential temperature of surface skin (GOES-16 11/12 µm)
Θ_{Air}: Potential temperature of surface air (RTMA)
|**V**|: Wind speed (RTMA)
γ: Lapse rate of free atmosphere (NUCAPS T profile)
C_H: Exchange coefficient

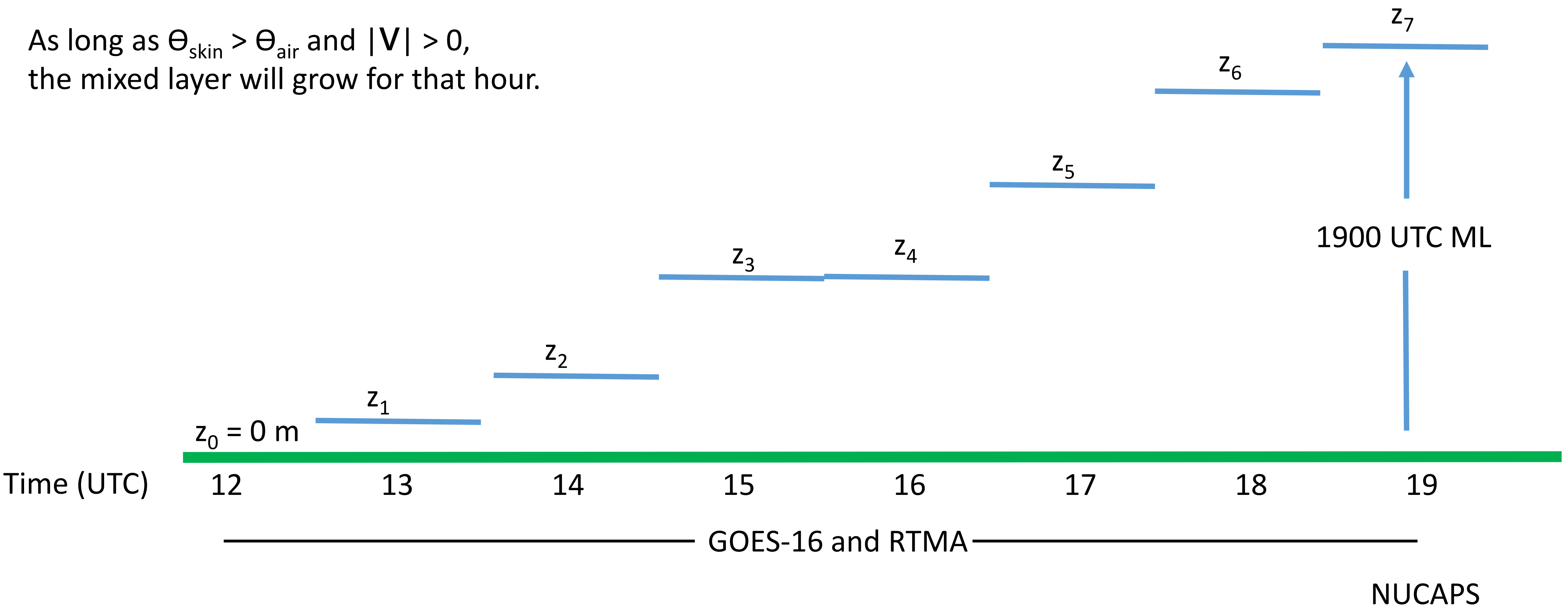
Apply equation to get mixed layer depth as function of time.

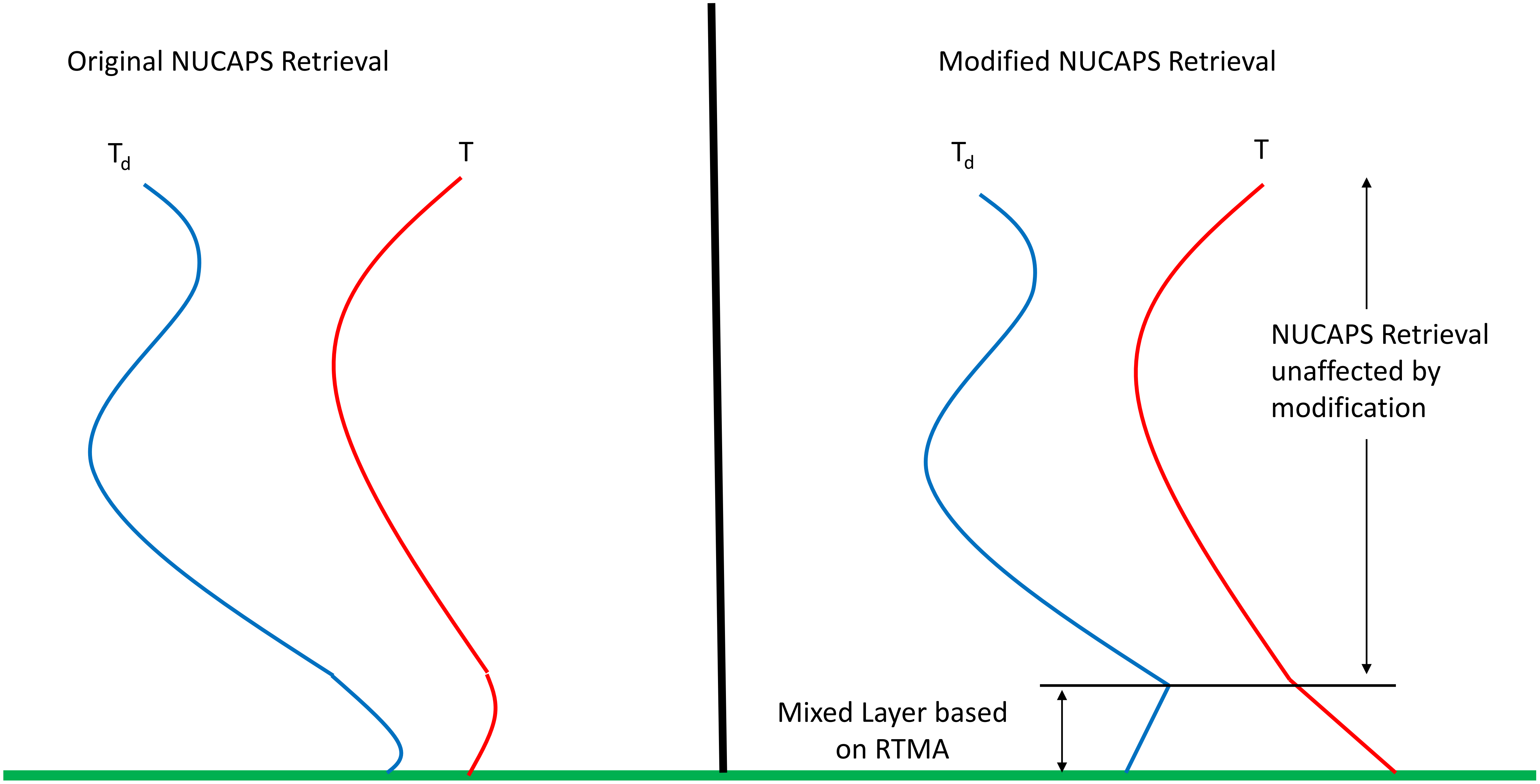


For 1900 UTC Overpass



As long as $\Theta_{skin} > \Theta_{air}$ and $|\mathbf{V}| > 0$,
the mixed layer will grow for that hour.




Original NUCAPS Retrieval
Modified NUCAPS Retrieval
T_d
T
T_d
T
NUCAPS Retrieval unaffected by modification
Mixed Layer based on RTMA

EXAMPLES

Blog Post from 2017 HWT Spring Experiment (20 June 2017)

"The modified NUCAPS soundings have shown significant improvement when compared to the operational NUCAPS soundings.

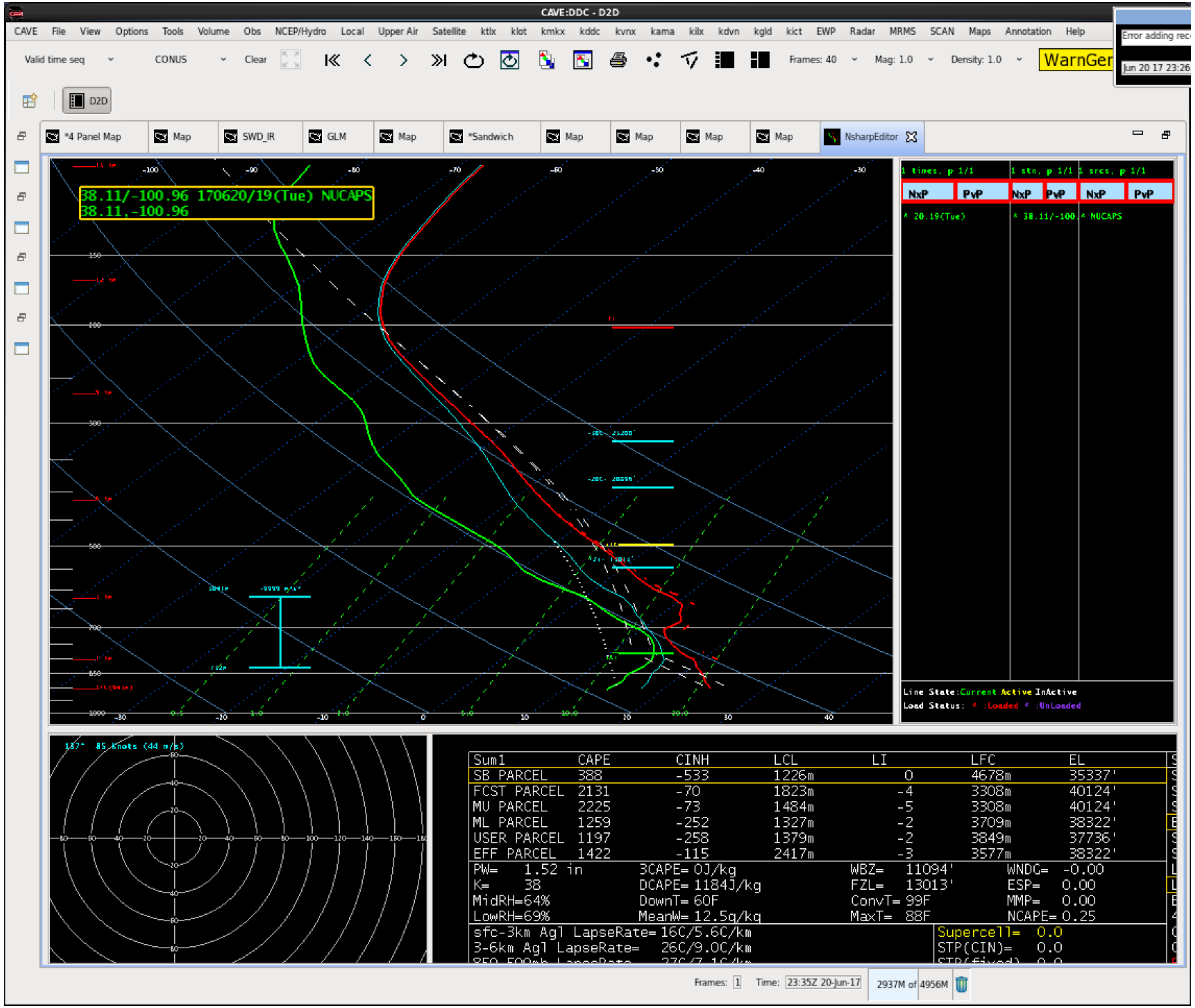
Here is an example where SBCAPE increased from 388 J/kg to 2770 J/kg in a modified NUCAPS sounding:

Even more significant is change in CINH from -533 J/kg to -27 J/kg--essentially going from a very strong (unbreakable) cap to a weakly capped environment.

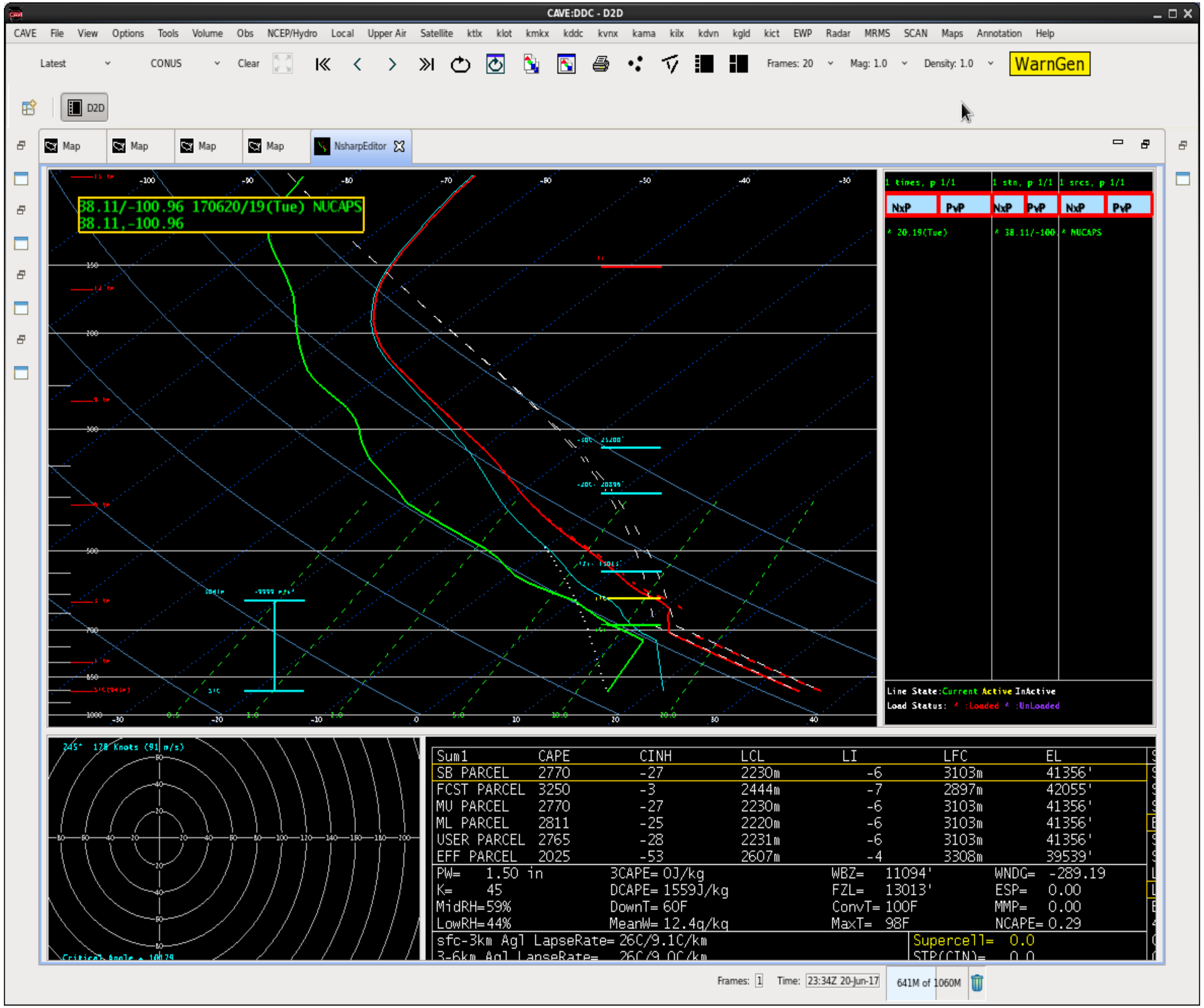
Thunderstorms rapidly intensified as they moved into the environment sampled by the sounding.

Therefore, it seems reasonable that the modified sounding is a better representation of the thermodynamic environment than the operational sounding."

Operational NUCAPS Retrieval (1900 UTC Southwestern Kansas)

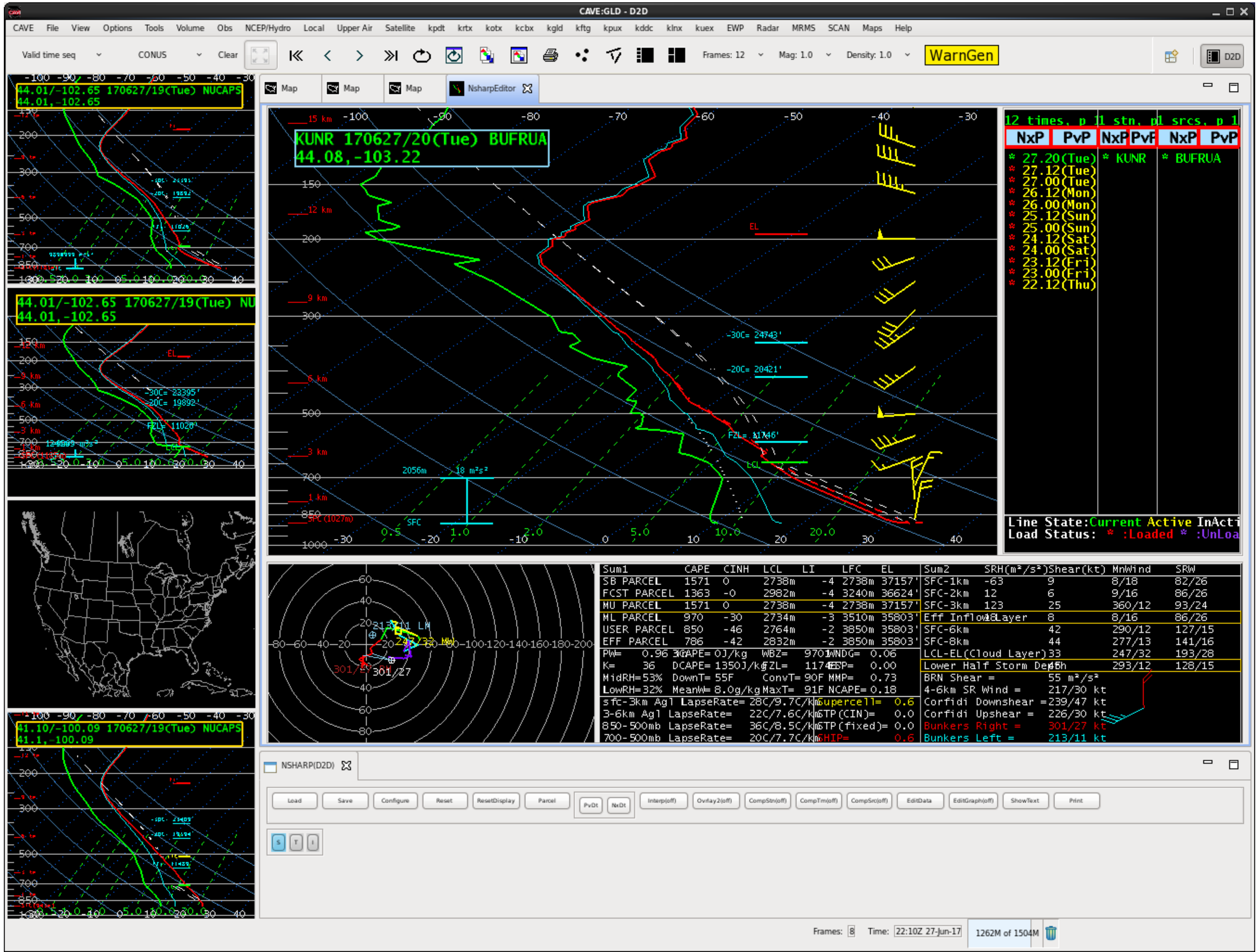


Experimental NUCAPS Retrieval

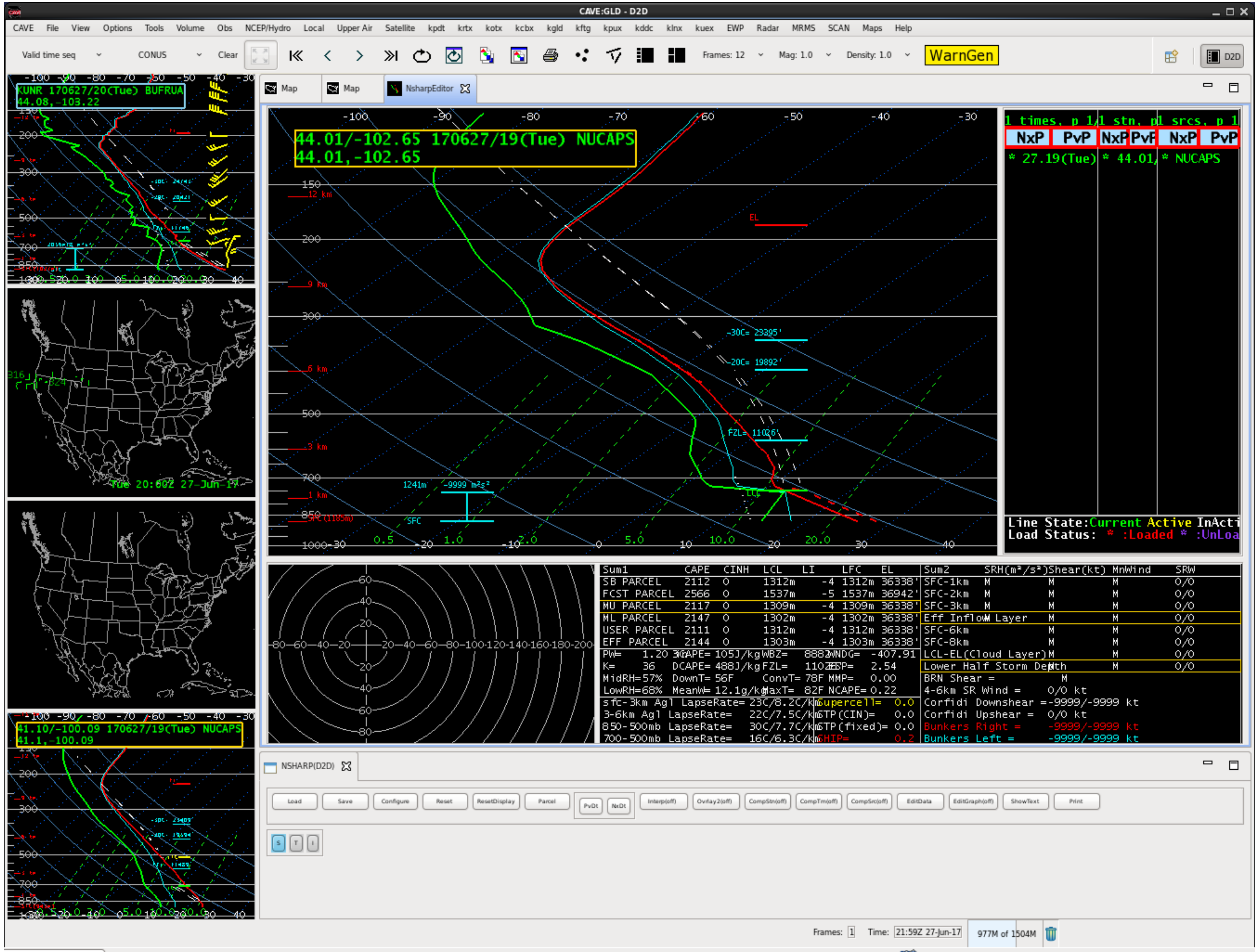


The experimental retrieval depends on the accuracy of the RTMA and the assumption of a well-mixed near-surface layer …

Rapid City, SD 2000 UTC Radiosonde 27 June 2017



Collocated Experimental NUCAPS Retrieval 1900 UTC



Next Steps

1) Work on improvements
    a) Boundary layer, particularly moisture, is not always well mixed
    b) In contact with NUCAPS development team (Antonia Gambacorta, Nadia Smith, Chris Barnet)
    c) More sophisticated algorithm may be needed
2) Continued Testing/Feedback
    a) Prepare for further evaluation at 2018 Spring Experiment
    b) Make available to interested WFOs
3) Latency
    a) Original NUCAPS usually comes in two hours old, experimental arrives 30 minutes later
    b) Direct Broadcast