JPSS Soundings Product Program and Future Development

Mitch Goldberg, Program Scientist

August 2015 JPSS Science Meeting

REWIND TO JULY 7- 9, 2011 -- SOAT MEETING

SDR Validation Priorities

- SDR comparisons with IASI, AIRS, AMSU.
- SDR comparisons with airborne sensors for absolute calibration as long as SI traceability can be demonstrated.
- SDR comparisons with high quality radiosondes (DOE ARM Sites) via RTM
- SDR comparisons with NWP models
- Eigenvector analysis of SDRs
- ATMS asymmetry and limb adjustments

EDR Validation Priorities

- NPROVS up and running to evaluate the EDRs
- Intercompare with NDE NUCAPS retrievals (based on AIRS science team code), AIRS and IASI retrievals and other alternatives
- Intercompare ATMS only retrieval with NDE MIRS
- Some bias corrections
  - If AIRS, IASI and CrIS are in good agreement, we should come up with a good traceable approach for bias corrections

But NWP community are assimilating the radiances, who cares about the EDRs?

- We do!!
- Why - a successful and robust EDR algorithm will result in improved SDR radiance assimilation and perhaps use of EDRs
- Meeting the CriS/ATMS EDRs threshold and pushing towards objective requires accurate surface emissivity retrieval, cloud detection, cloud clearing and accounting for trace gases.
- These are also essential for optimal radiance assimilation
- Right now - radiance assimilation is suboptimal:
  - Poor surface emissivity, do not use channels over land
  - Discard most of the channels because of cloud contamination.
  - Water vapor channels are not treated properly – over tuned.
- Its important to engage the NWP community

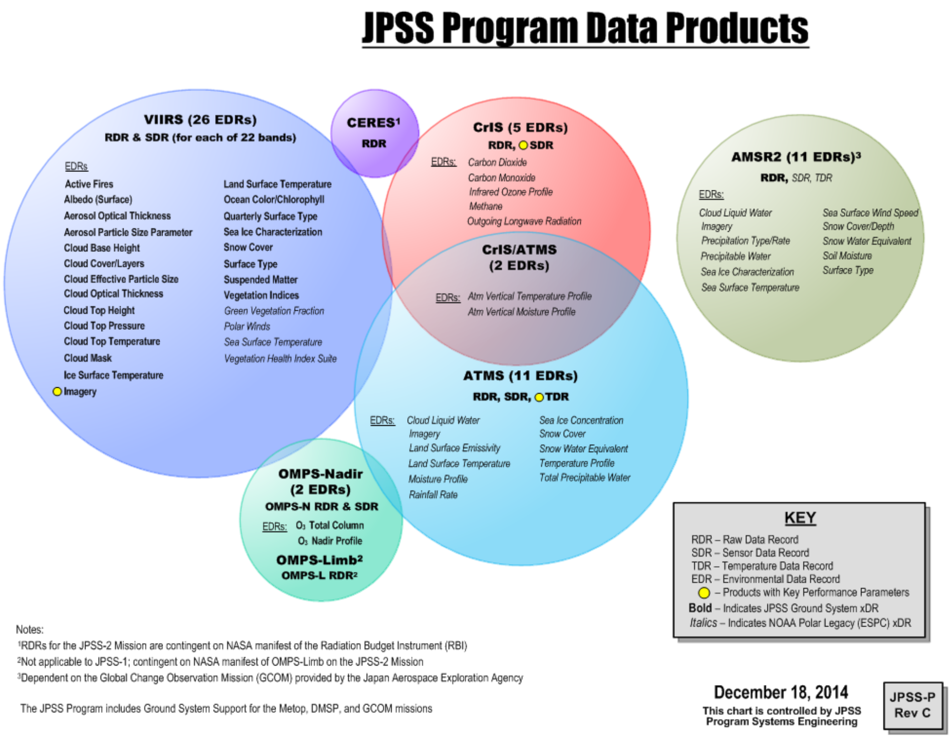
Summary

- We have a great team.
- Highest confidence that we will succeed.
- Make use of lessons learned from AIRS and IASI

Back to the present

Challenge

- User Readiness: Products to Applications
- Ensure users are ready for NPP/JPSS data and improve their key operational and research product and services
  - ✓ Severe weather forecasts and warnings
  - ✓ Aviation weather forecasts and warnings
  - ✓ Improve fire and air quality forecasts and warnings
  - ✓ Improve warnings and prediction of poor water quality in coastal regions
  - ✓ Improve drought, precipitation, snow and ice assessments and predictions
- Periodic feedback from keys users on the impact of NPP/JPSS data and to identify improvements needed for products and applications

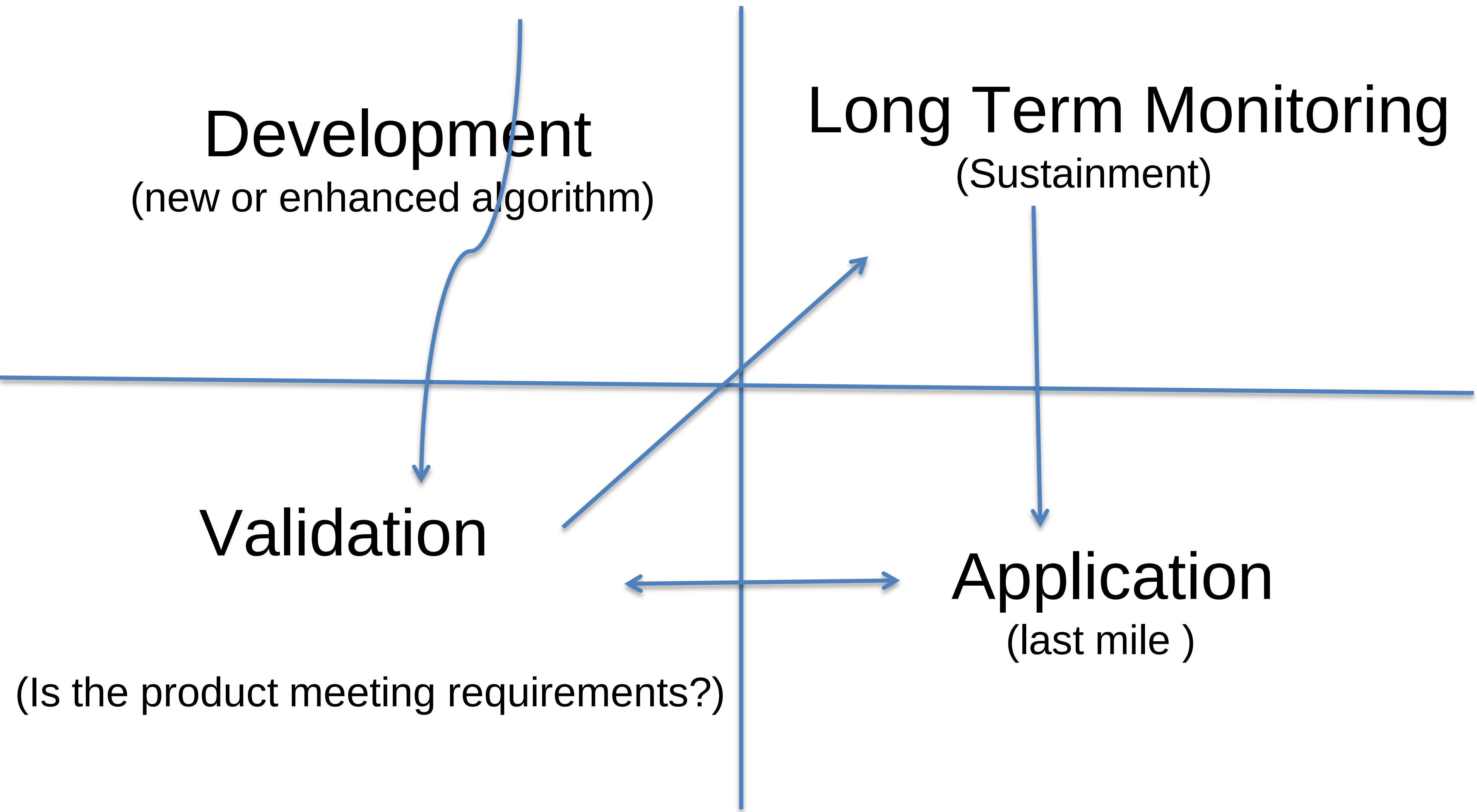


What is the Proving Ground & Risk Reduction Program for JPSS?

The JPSS Proving Ground and Risk Reduction (PGRR) program's primary objective is to maximize the benefits and performance of NPP/JPSS data, algorithms, and products for downstream operational and research users (gateways to the public) through:

- Engaging users to enhance/improve their applications through the optimal utilization of JPSS data.
- Education, Training and Outreach
- Facilitating transition of improved algorithms to operations.
- Detailed characterization of data attributes such as uncertainty (accuracy and precision) and long-term stability
- Provides user feedback to the cal/val program

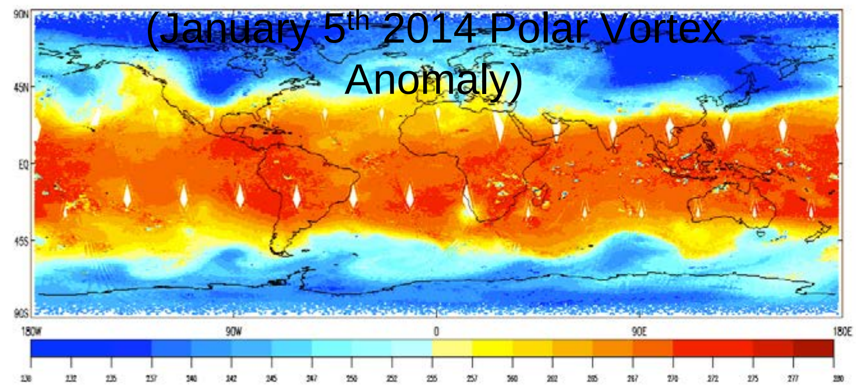
Lifecycle


Development
(new or enhanced algorithm)
Long Term Monitoring
(Sustainment)
Validation
(Is the product meeting requirements?)
Application
(last mile)

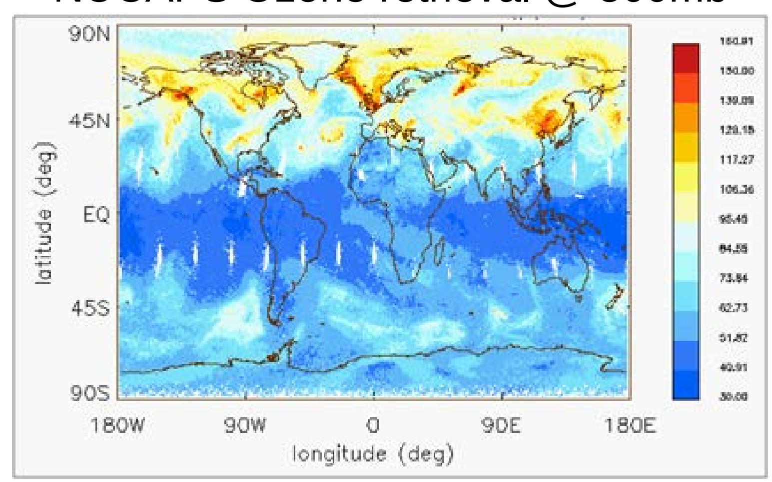
Sounding

- Assist WFOs to make better use of NUCAPS temperature and moisture soundings
- Support NWS/NCEP plans to improve data assimilation of radiances in cloudy conditions
- Use NUCAPS to solve for or derive trace gases

NUCAPS Temperature retrieval @ 500mb
(January 5th 2014 Polar Vortex Anomaly)



NUCAPS Ozone retrieval @ 500mb



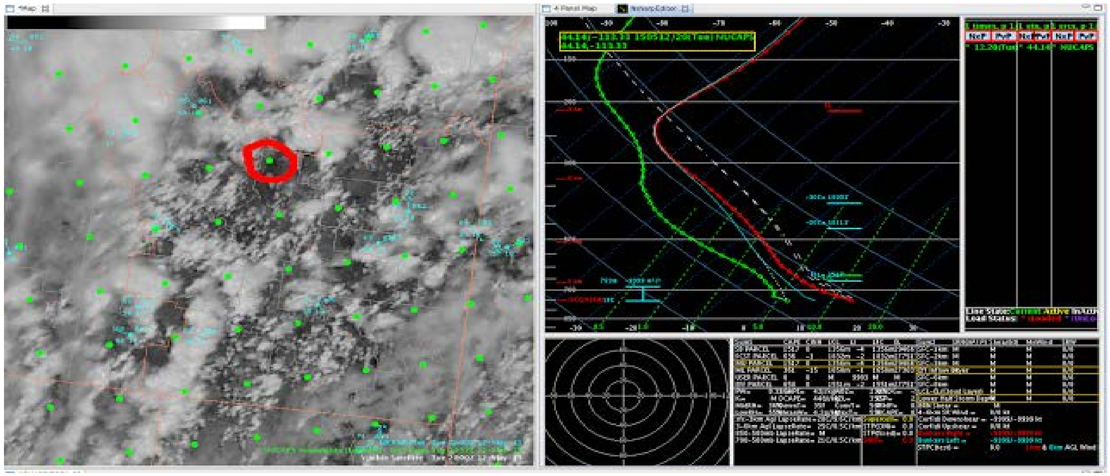
USER ENGAGEMENT PROJECTS

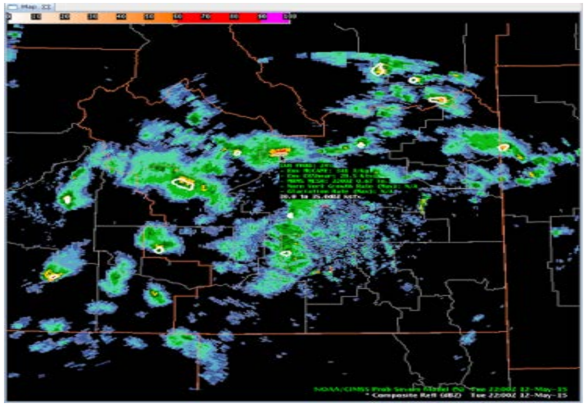
- NUCAPS IN AWIPS - Organized Initiative, Working with WFOs, we are providing training, we participate in the 2015 Hazardous Weather Testbeds - Very successful.

- NWS training liaison we hired from CIRA

NUCAPS Evaluated in NWS Hazardous Weather Testbed (HWT)

- Background
  - What is the HWT: a joint testbed in Norman OK managed by the NWS Storm Prediction Center, the NWS Weather Forecast Office and the National Severe Storms Laboratory
  - Purpose: plan and execute operational tests focused on national hazardous weather needs
  - Spring Experiment: annual, 5-week test periods. Researchers, forecasters, and broadcast meteorologists evaluate emerging research concepts and tools through experimental forecast and warning generation exercises. NUCAPS was a key focus area in the Spring Experiment 2015





Examples of Forecaster feedback

Waiting for deep convection to start. Denver's 18z special sounding showed a strong inversion around 700mb. The 20Z NUCAPS showed the lower levels not quite fully mixed. NUCAPS increased confidence that deep convection would occur but not quite yet. (comment edited)

NUCAPS sounding shows the presence of a cold pocket aloft and relatively low precipitable water values around a half an inch confirm elevated convection along with the scattered reports of severe hail in eastern Idaho.

A VIIRS Satellite Pass at 1944Z provided a NUCAPS Profile near some developing storms in Texas. It provided a nice snapshot of the atmosphere in between [radiosonde] soundings.

AWIPS-2 NUCAPS Training on Youtube

Thanks to Scott Lindstrom, Chris Barnet, Brian Motta and others

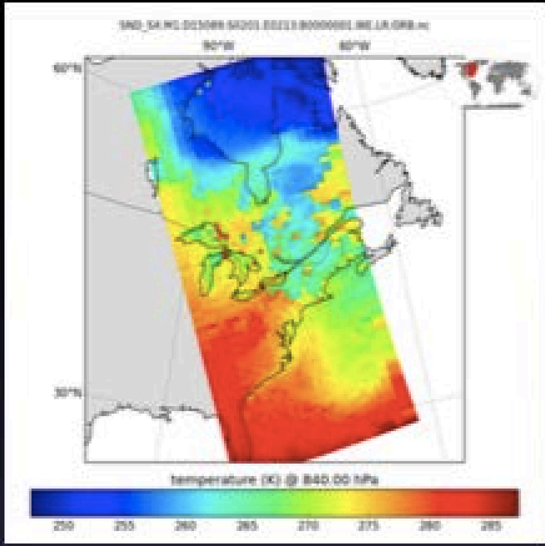
CSPP Software (Apr 2015)

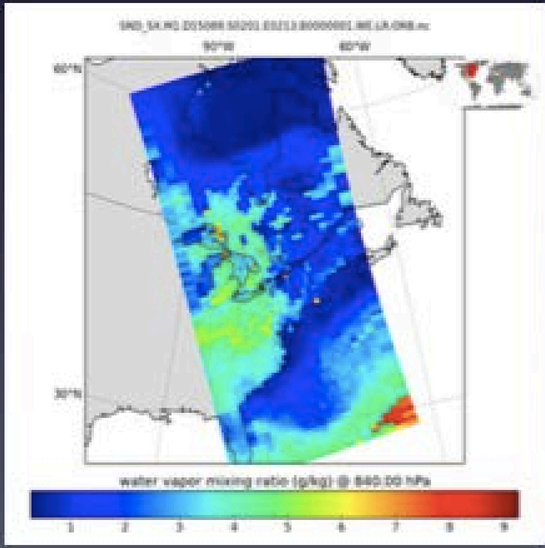
CSPP Software	Product Description
1. SDR	VIIRS, CrIS, and ATMS geolocated and calibrated earth observations.
2. VIIRS EDR	VIIRS imager cloud mask, active fires, surface reflectance, vegetation indices, sea surface temperature, land surface temperature, and aerosol optical depth.
3. HSRTV	Hyperspectral infrared sounder retrievals of temperature and moisture profiles, cloud properties, total ozone, and surface properties.
4. Polar2grid	Reprojected imagery (single and multi-band) in GeoTIFF and AWIPS formats.
5. Hydra	Interactive visualization and interrogation of multispectral imagery and hyper spectral soundings.
6. MIRS	Microwave sounder retrievals of temperature and moisture profiles; surface properties; snow and ice cover; rain rate; and cloud/rain water paths.
7. CLAVR-x	Multispectral imager retrievals of cloud properties; aerosol optical depth; surface properties; ocean properties.
8. NUCAPS	Combined hyperspectral infrared sounder and microwave sounder retrievals of temperature and moisture profiles, cloud cleared radiances, and trace gases.
9. IAPP	Combined infrared sounder and microwave sounder retrievals of temperature and moisture profiles, water vapor, total ozone, and cloud properties.
10. ACSPO	Multispectral imager retrievals of sea surface temperature.

MIRS Examples

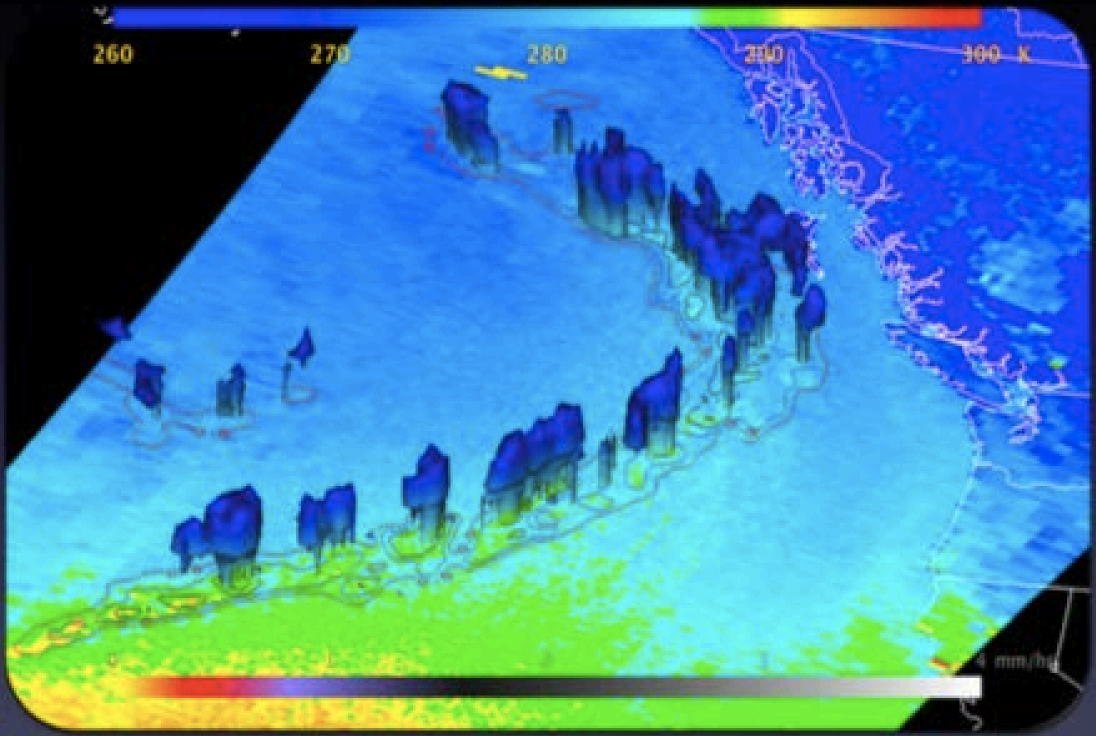
Metop-B 2015/03/30 02:01 UTC
SNPP 2015/03/18 11:03 UTC

Metop-B AMSU/MHS 840 hPa temperature and water vapor





SNPP ATMS Surface Skin Temperature with Rain Rate contours and isosurface of Rain Mass Profile



From the 2015 – 2018 Portfolio

2015 Joint Polar Satellite System (JPSS) Proving Ground and Risk Reduction Projects Portfolio

Supporting the NOAA Mission through Applications and Research

Edited by:
Mitch Goldberg, Julie Price, Bill Sjoberg, and Arron Layns

The contents of this portfolio were current as of June 2015.
Date revised 6/12/2015

Improving NUCAPS Soundings for CONUS Severe Weather Applications via Data

Daniel T. Lindsey

SYNOPSIS: This project's team members plan to use the NOAA Unique CrIS/ATMS Processing System (NUCAPS) vertical profiles of temperature and moisture from the JPSS satellites and combine them with observed surface observations and numerical model output to produce improved vertical soundings over the CONUS. These modified, "fused" data soundings will be displayed in AWIPS-2 for the National Weather Service.

WHY IS THIS RESEARCH IMPORTANT?

Sharp vertical variations in temperature and moisture are common near the surface prior to warm-season, severe convective events. These sharp gradients, along with the amount and depth of low-level water vapor, can be determining factors in whether convective storms initiate, and if they do, how those storms evolve. One of the key uncertainties on many days when severe weather is possible is whether the low-level temperature inversion, or "cap", will be eliminated due to daytime heating of the earth's surface or cooling above the surface. Currently, the only observations having adequate vertical resolution of temperature and moisture for severe thunderstorm applications are radiosondes. However, the major limitation of radiosonde data is inadequate temporal and horizontal resolution. Balloons are launched only at 00 and 12 UTC (and occasionally at 18 UTC), and the launch sites are 300-500 km apart in the central U.S.

Advancing Hyperspectral Sounder Applications in the Direct-Broadcast Environment

Elisabeth Weisz

SYNOPSIS: BY performing a rigorous validation and evaluation of the UW hyperspectral (dual-regression) retrieval system and the NOAA Unique CrIS/ATMS Processing System (NUCAPS), project team members aim to address concerns raised by users on how to best use these retrieval systems:. In addition, project team members will characterize product performance, such as attributes of accuracy and precision and their stability over time (both short- and long-term). This will contribute significantly to our continued efforts to serve DB users by making the best possible data products available.

WHY IS THIS RESEARCH IMPORTANT?

Hyperspectral infrared sounders, such as AIRS (Atmospheric Infrared Sounder) on EOS-Aqua, IASI (Infrared Atmospheric Sounding Interferometer) on MetOp-A and MetOp-B, and CrIS (Cross-track Infrared Sounder) on Suomi NPP (S-NPP), measure the top-of-atmosphere (TOA) radiance emitted by the Earth system with very high spectral resolution using several thousand channels. The great advantage of high spectral resolution is an increased sensitivity to changes in the vertical atmospheric column (from surface to TOA). Thus, hyperspectral measurements can be inverted into vertical temperature, moisture and ozone profiles, as well as information describing Earth surface and cloud properties. With hyperspectral sounder retrievals now operationally available from four

The Utility of NUCAPS Retrieved Profiles to Diagnose Extratropical Transition

Emily Berndt

SYNOPSIS: The goal of this proposal is to demonstrate how NUCAPS infrared retrieved temperature, moisture, and ozone profiles can complement the Air Mass RGB by giving forecasters insight about the vertical distribution of various atmospheric variables that are influencing the Air Mass RGB imagery and are important for anticipating a tropical to extratropical transition. Additionally, NOAA G-IV dropwindsondes will be used as a verification dataset to compare to the NUCAPS soundings and Air Mass RGB, especially over data sparse regions.

WHY IS THIS RESEARCH IMPORTANT?

Currently NOAA Unique CrIS/ATMS Processing System (NUCAPS) temperature and moisture soundings are available in AWIPS-II as a point-based display. Traditionally soundings are used to anticipate and forecast severe convection, however unique and valuable information can be gained from soundings for other forecasting applications, especially in data sparse regions. Forecasters at the National Centers (i.e. the National Hurricane Center (NHC), Weather Prediction Center (WPC), and Ocean Prediction Center (OPC)) have GOES-R/JPSS Proving Ground proxy products, such as the Air Mass RGB, to assist in monitoring extratropical transition of hurricanes. These extreme events often occur over the ocean in data sparse regions.

Understanding Emissions and Tropospheric Chemistry Using NUCAPS and VIIRS

Gregory Frost

SYNOPSIS: Project team members will develop an approach using NOAA aircraft field measurements and atmospheric chemical-transport models to deliver products to characterize NUCAPS (CrIS/ATMS) retrieval quality, with the goal of improving the accuracy of the NUCAPS daily global measurements of methane (CH4) and carbon monoxide (CO). The goals are to test and improve the accuracy of JPSS-retrieved data and demonstrate their usefulness in air quality and climate modeling studies.

WHY IS THIS RESEARCH IMPORTANT?

Methane

CH4 is an important climate-forcing agent and mediator of global tropospheric chemistry. Recent assessments using field and satellite data demonstrate significant knowledge gaps about the magnitude, trends, and location of CH4 sources in the US and globally. Current CH4 inventories for the US differ significantly from one another, and many inventories do not capture changes in emission from rapidly evolving sectors, such as fossil fuel production. Changes to drilling technology have significantly decreased the cost of producing oil and natural gas (ONG). Assessing the environmental benefits of natural gas vs. coal depends on accurate knowledge of natural gas leaks in extraction, processing and distribution.

Carbon Monoxide

CO, a regulated pollutant due to its air quality impacts, is produced predominantly by fossil fuel combustion, tropospheric oxidation of VOCs, wildfires, and agricultural burning. Data from aircraft, roadside monitoring, and regulatory networks demonstrate that CO emissions have been declining in US urban areas for many decades as light-duty gasoline vehicles have gotten cleaner (Warneke et al., 2012; Pollack et al., 2012; McDonald et al., 2013). While inventories capture these long-term declines in US CO emissions, inverse modeling using NOAA aircraft observations (Brioude et al., 2011; Brioude et al., 2013) demonstrates that inventories do not accurately quantify the magnitude of US CO emissions.

Howard University Support of NOAA's commitment to the Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN)

Belay Demoz

SYNOPSIS: The objective of this project is to address the overall Joint Polar Satellite System (JPSS) Proving Ground and Risk Reduction (PGRR) Program goal of maximizing the benefits and performance of the Suomi National Polar orbiting Partnership (S-NPP)/JPSS data, and products. This will be done by providing a well characterized GRUAN standard product for NUCAPS and other S-NPP data validation; enabling the engagement of the GRUAN climate science community in JPSS data products and providing feedback; and facilitating the use of the JPSS data in education and training of future scientists.

WHY IS THIS RESEARCH IMPORTANT?

Lack of proper documentation of upper air atmospheric state variable errors has hampered accuracy of derived climate trend estimates. To mitigate this issue, the GCOS Reference Upper Air Network (GRUAN) sites have started a rigorous documentation of highly accurate upper air soundings on routine and periodic intervals. The central GRUAN objective is to provide high quality observations using specialized radiosondes and complementary remote sensing profiling instrumentation that can be used for validation as a baseline for all other measurements and other purposes (GCOS112; Diamond et al. 2009). Satellite-Sonde validation activities address a component of the GRUAN goal; where GRUAN quality data can be transferred and scaled to global data sets. Satellite-based

Direct Readout Enhancement of Short-Range Forecast Impact for Global and Regional Models

Stanley G. Benjamin and Stephen S. Weygandt

SYNOPSIS: The goal of this research is to more effectively assimilate JPSS and S-NPP satellite data in rapidly updating (hourly) mesoscale and global models via application of direct readout data with lower latency. Enhanced skill for these rapidly updated short-range forecasts means improved decision-support guidance for hazardous weather, such as severe thunderstorms including aviation hazards (turbulence, icing, ceiling, visibility, convection for air-traffic management).

WHY IS THIS RESEARCH IMPORTANT?

The Rapid Refresh (RAP) and High-Resolution Rapid Refresh (HRRR) are closely linked hourly updated NOAA operational mesoscale prediction models (Benjamin et al. 2015, Alexander et al. 2015, respectively) run at the National Centers for Environmental Prediction (NCEP) to improve decision support guidance for weather events that endanger lives and economic activity. The RAP runs at a coarser 13km resolution and provides most of the information for initial conditions for the 3km HRRR model. Because of the increased water domain coverage of RAP compared with its predecessor, the RUC, satellite radiance data are playing an important role in the RAP assimilation and forecast skill, also affecting HRRR skill. In 2013, RAP was updated at NCEP to use hybrid variational/Ensemble Kalman Filter (EnKF) assimilation within GSI, using ensemble information from the 80 member GFS GDAS global ensemble data assimilation system. Consistent with the short

Title: The Cold Air Aloft Aviation Hazard: Detection Using Observations from the JPSS Satellites and Application to the Visualization of Gridded Soundings in AWIPS II

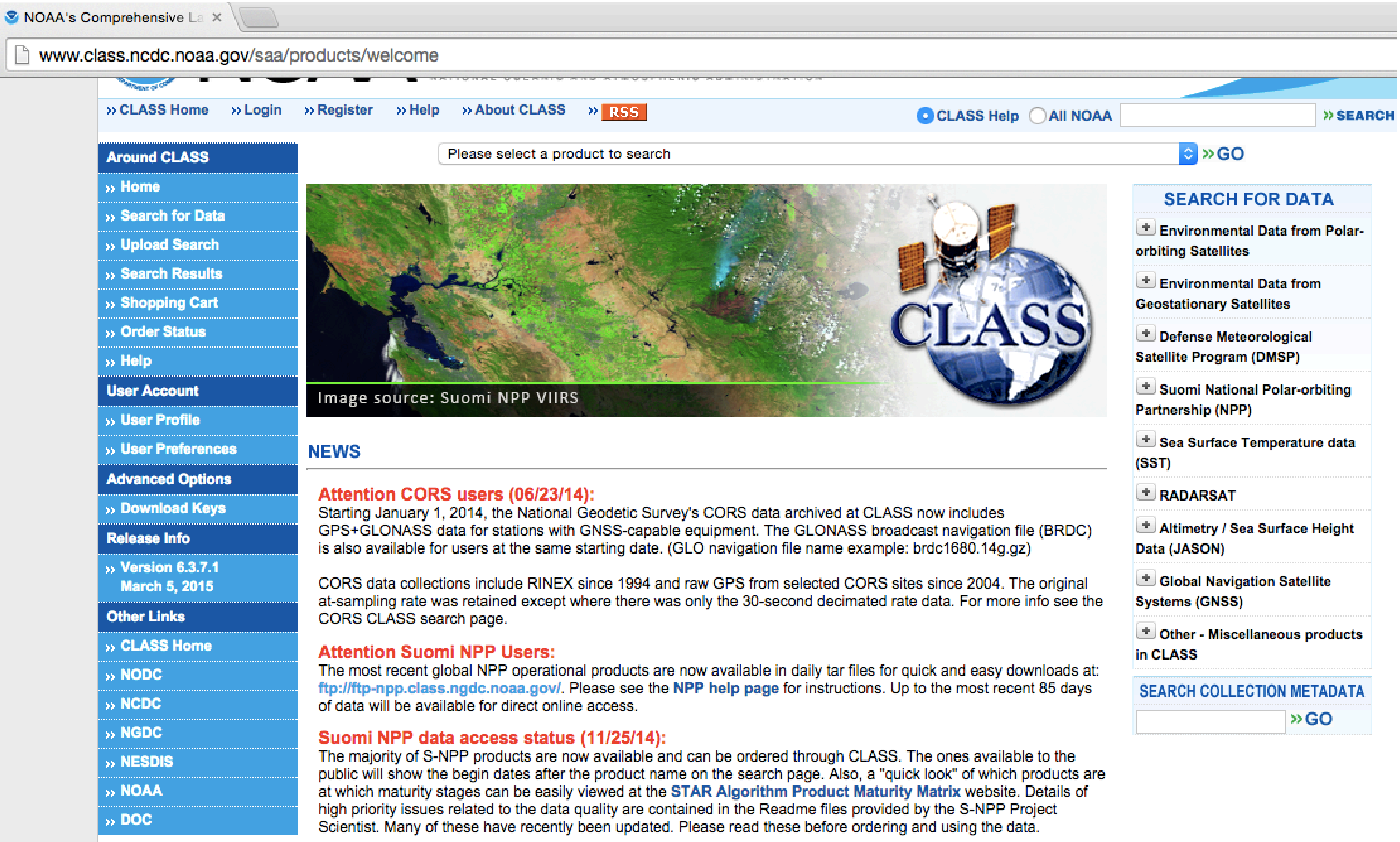
Principal Investigator:
Bradley Zavodsky (NASA SPoRT)

Co-Investigators:
Jack Dostalek (Colorado State University/CIRA)
Nadia Smith (University of Wisconsin/CIMSS/SSEC)
Eric Stevens (University of Alaska Fairbanks/GINA)

Collaborator:
Kristine Nelson (NOAA/NWS Anchorage CWSU)

Easy data access from CLASS

NOAA • NESDIS JPSS Joint Polar Satellite System



Easy Access - 85-day rotating server

NOAA's Comprehensive Larg | FTP root at ftp-npp.class

ftp://ftp-npp.class.ngdc.noaa.g

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07/09/2015 11:42AM      Directory 20150624
07/09/2015 11:56AM      Directory 20150625
07/09/2015 12:08PM      Directory 20150626
07/09/2015 12:21PM      Directory 20150627
07/09/2015 12:34PM      Directory 20150628
07/09/2015 12:47PM      Directory 20150629
07/09/2015 12:59PM      Directory 20150630
07/09/2015 01:09PM      Directory 20150701
07/09/2015 01:22PM      Directory 20150702
07/09/2015 01:37PM      Directory 20150703
07/09/2015 01:49PM      Directory 20150704
07/09/2015 02:00PM      Directory 20150705
07/09/2015 02:11PM      Directory 20150706
07/09/2015 10:47AM      Directory 20150707
07/09/2015 10:35AM      Directory 20150708
07/09/2015 10:47AM      Directory 20150709
07/10/2015 01:30PM      Directory 20150710
07/12/2015 05:15AM      Directory 20150711
07/12/2015 06:15PM      Directory 20150712
07/13/2015 01:30PM      Directory 20150713
07/14/2015 01:30PM      Directory 20150714
07/15/2015 01:30PM      Directory 20150715
07/16/2015 01:30PM      Directory 20150716
07/17/2015 01:30PM      Directory 20150717
```

NOAA's Comprehensive Larg | FTP directory /20150709

ftp://ftp-npp.class.ngdc.noaa.gov/20150709

FTP directory /20150709/ at ftp-npp.class.ng

Up to higher level directory

```
07/09/2015 04:00AM      Directory ATMS-SDR
07/09/2015 04:15AM      Directory ATMS-TDR
07/09/2015 06:00AM      Directory CRIS-SDR
07/16/2015 01:30PM      Directory NDE-DAILY
07/09/2015 10:48AM      Directory NDE-L2
07/09/2015 05:15AM      Directory OMPS-EDR
07/09/2015 05:45AM      Directory OMPS-IP
07/09/2015 05:46PM      Directory OMPS-RDR
07/09/2015 05:30AM      Directory OMPS-SDR
07/09/2015 09:09AM      Directory VIIRS-EDR
07/09/2015 10:00AM      Directory VIIRS-IPNG
07/09/2015 12:10PM      Directory VIIRS-SDR
07/09/2015 08:12AM      Directory VIIRSI-EDR
```

NOAA's Comprehensive Larg | FTP directory /20150709

ftp://ftp-npp.class.ngdc.noaa.gov/20150709/NDE-L2

FTP directory /20150709/NDE-L2/ at ftp-npp.class.ngdc.noaa.gov

Up to higher level directory

```
07/10/2015 01:06PM      Directory NUCAPS-Cloud-Cleared-Radiances
07/10/2015 01:06PM      Directory NUCAPS-Environmental-Data-Records
```

FTP directory /20150709/NDE-L2/NUCAPS-Environmental-Data-Records/ at ftp-npp.class.ngdc.noaa.gov

Up to higher level directory

```
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07/09/2015 10:47AM 1,369,025,024 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00001.tar
07/09/2015 01:01PM        65,021 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00002.manifest.xml
07/09/2015 01:01PM   268,244,992 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00002.tar
07/09/2015 09:08PM       210,934 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00003.manifest.xml
07/09/2015 09:08PM   877,337,600 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00003.tar
07/10/2015 01:06PM        45,501 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00004.manifest.xml
07/10/2015 01:06PM   186,891,264 NDE-L2_NUCAPS-Environmental-Data-Records_20150709_00004.tar
```

Reprocessing

- Successfully completed the first reprocessing of NUCAPS via Chris Barnet and UW team led by Liam Gumley.

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

NPROVS Utility in a Variety of Meterological and Cal/Val Scenarios

Tony Reale
STAR

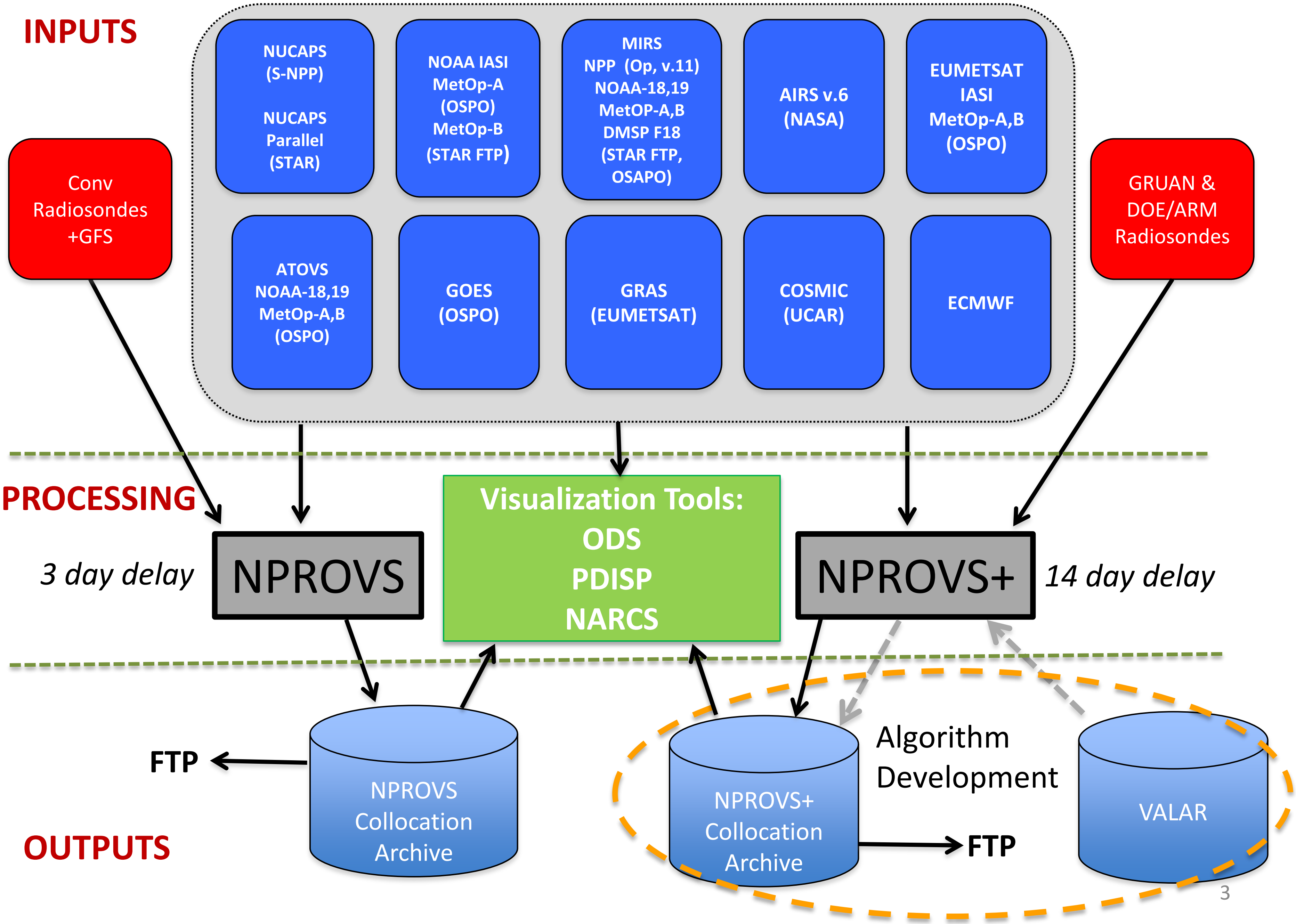
(Bomin Sun, Frank Tilley, Mike Pettey and Nick Nalli)
(IMSG)
June 2015

STAR /JPSS
2015 Annual Science Team Meeting
24-28 August 2015
NCWCP, College Park, Md.

Outline

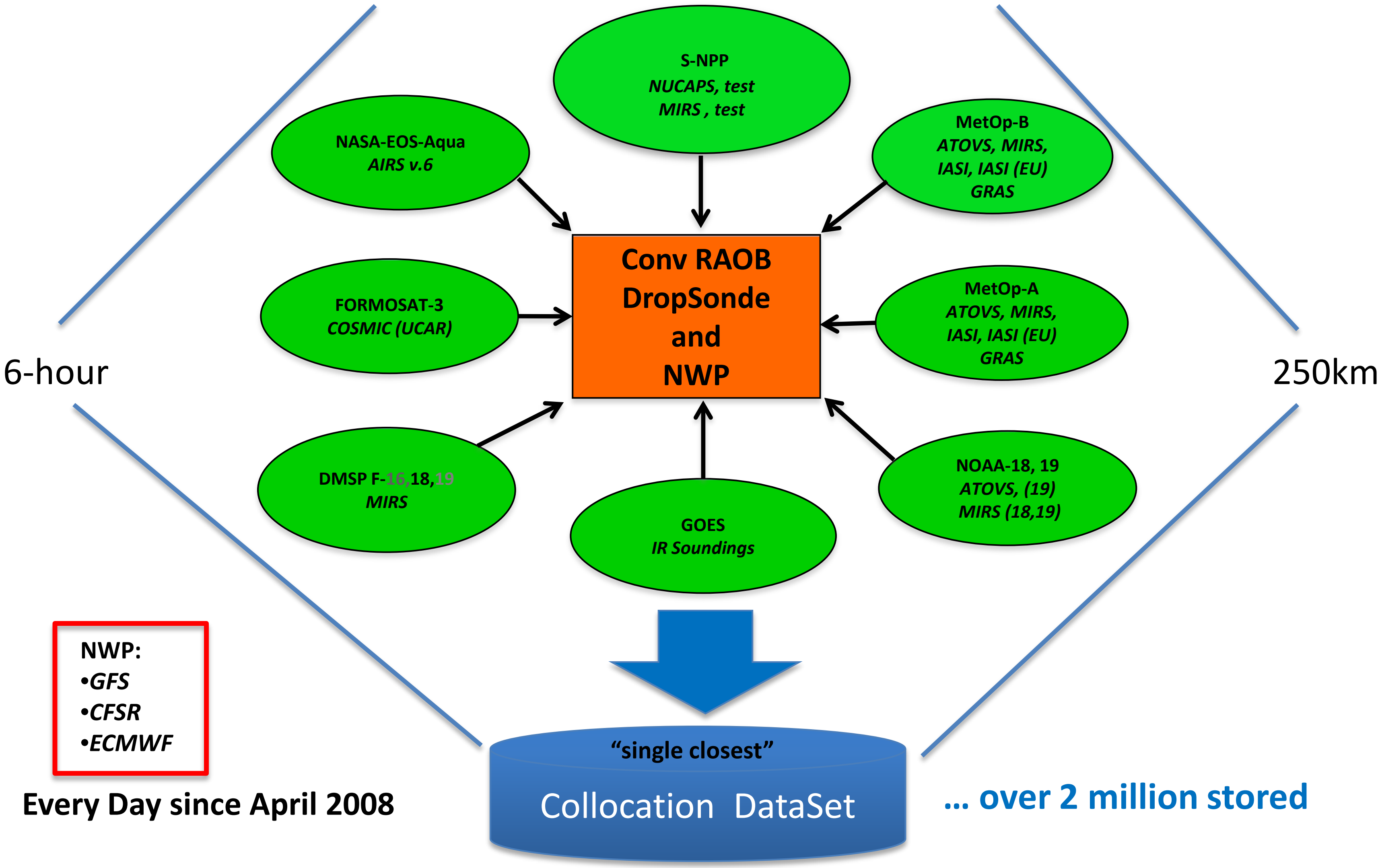
- ❖ About NPROVS
- ❖ Long Term Monitoring (LTM-NARCS)
- ❖ 10-day Collocation datasets (PDISP)
- ❖ AWIPS-2 Coordination
  - Cold Core
  - CALWATER
- ❖ Uncertainty

NPROVS/NPROVS+ Data Management Schematic



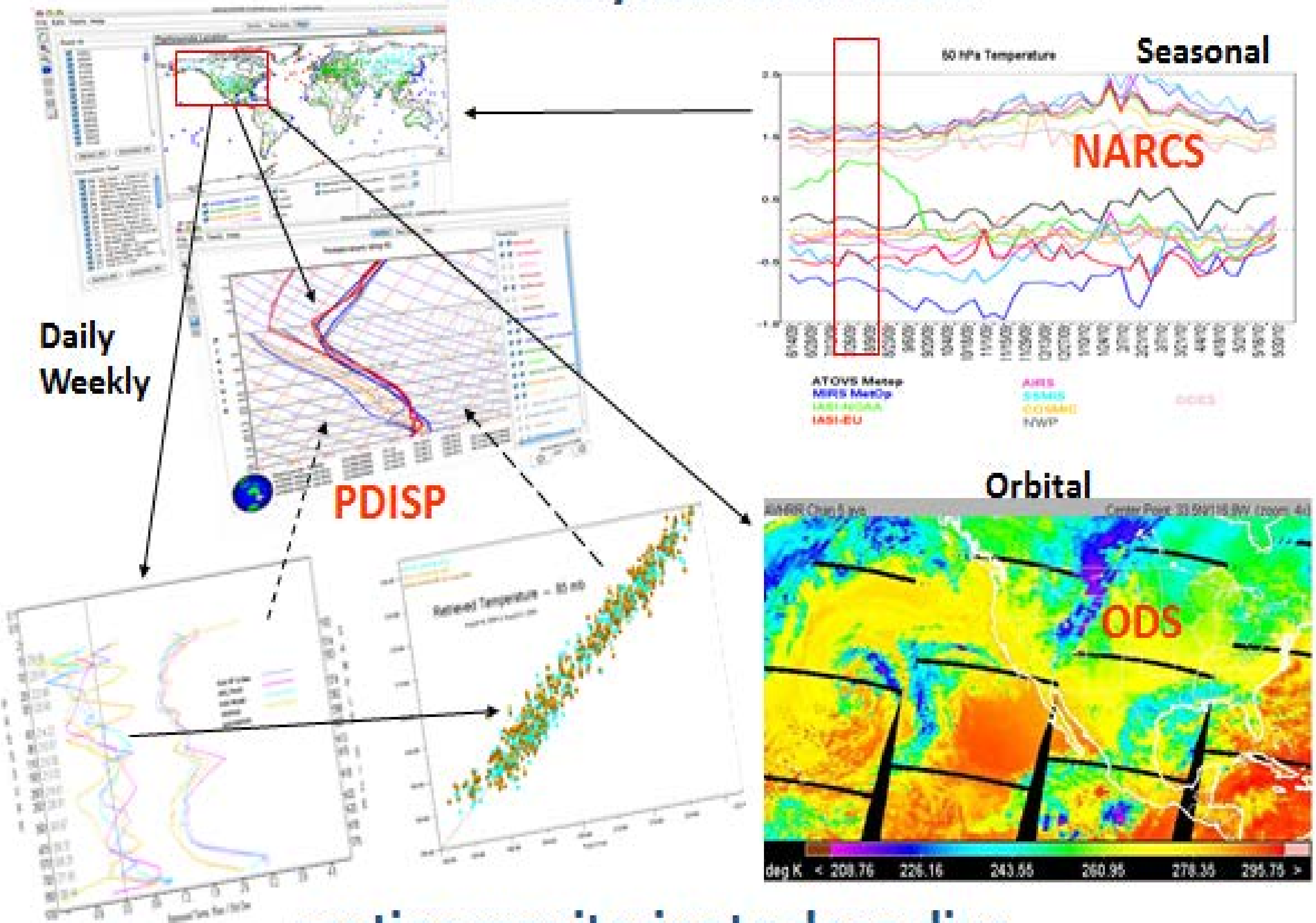
NOAA Products Validation System (NPROVS)

Centralized RAOB and Satellite Product Collocation

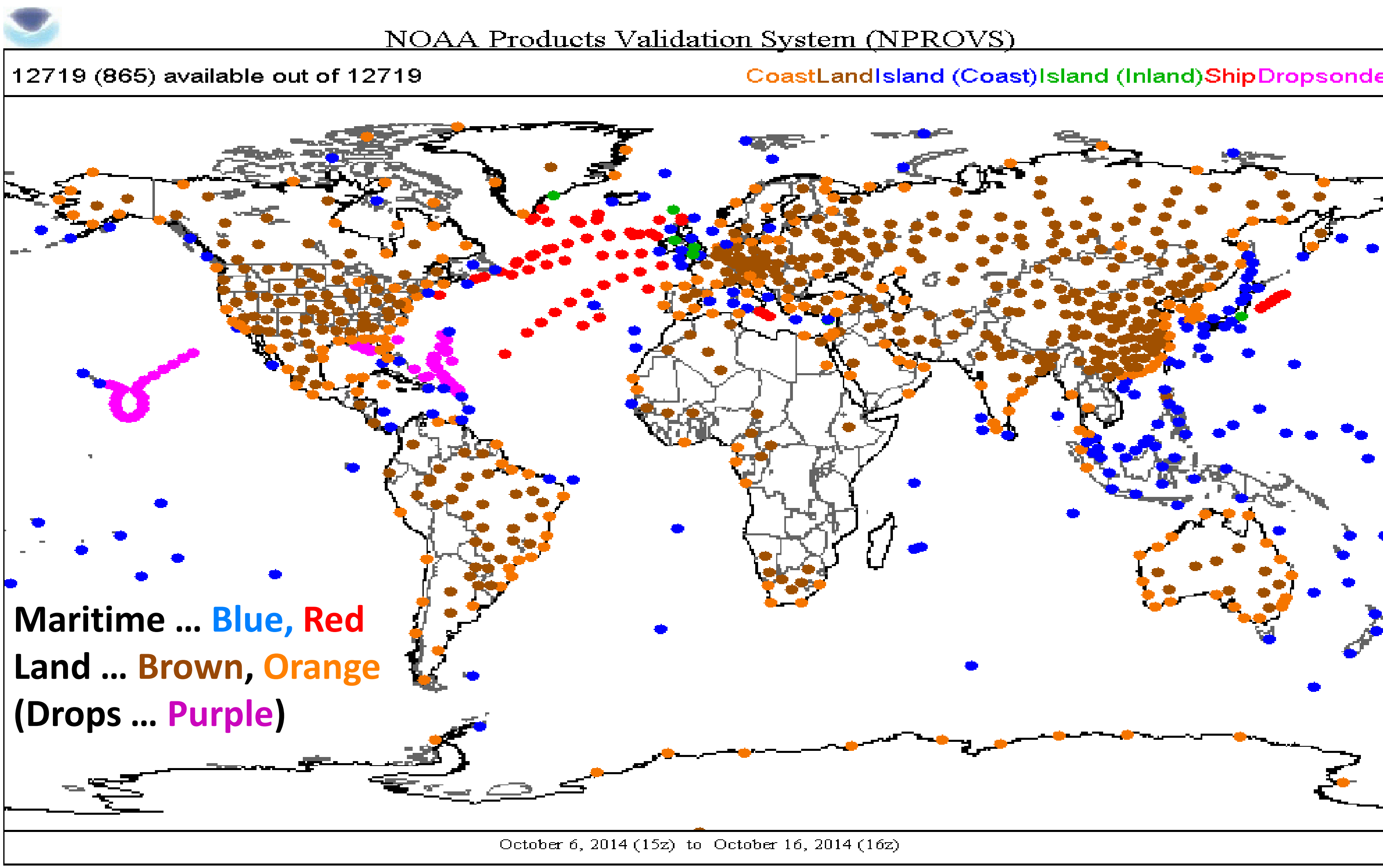


https://www.star.nesdis.noaa.gov/smcd/opdb/nprovs

EDGE Analytical Interface …

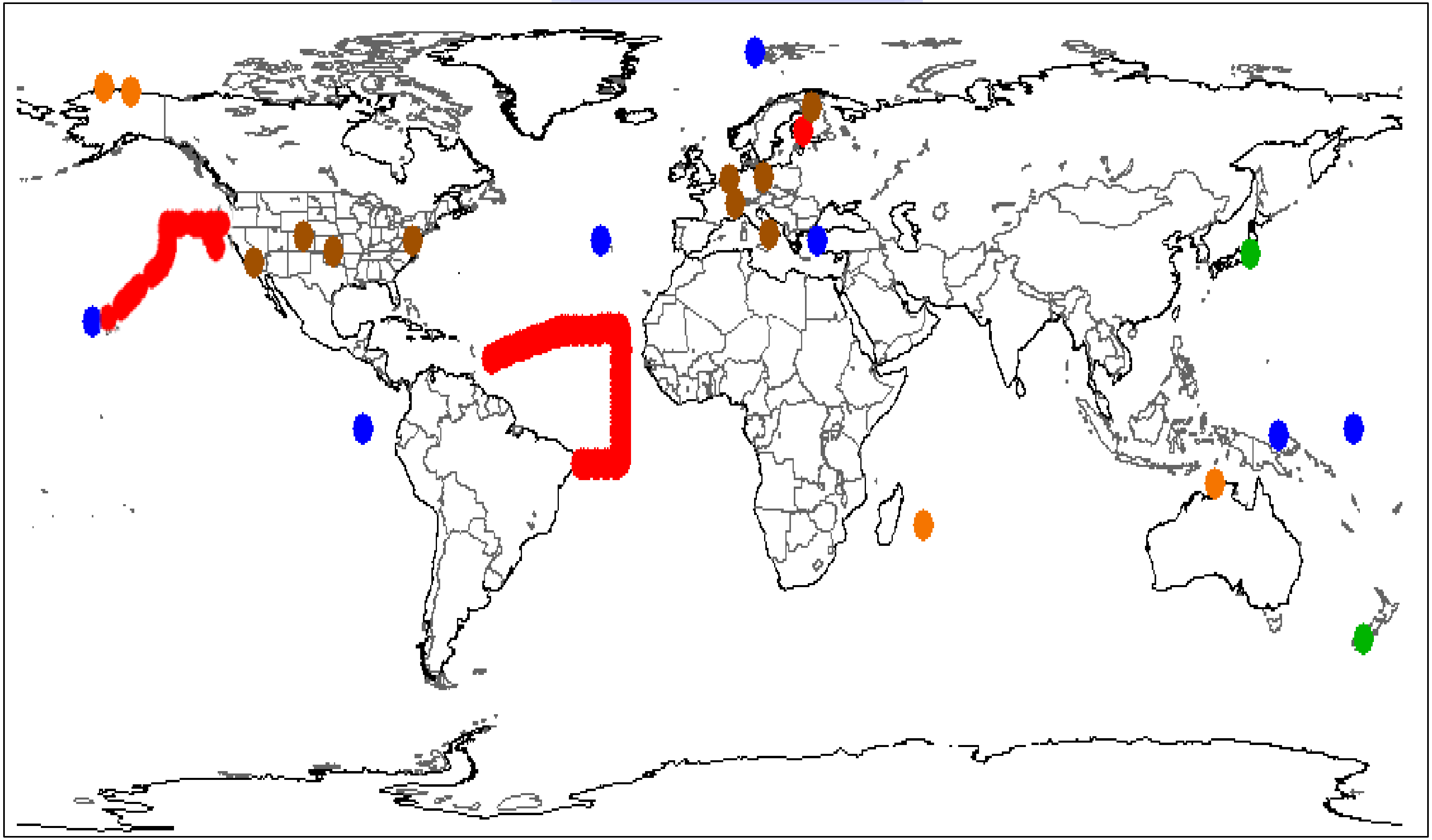


… routine monitoring to deep dive



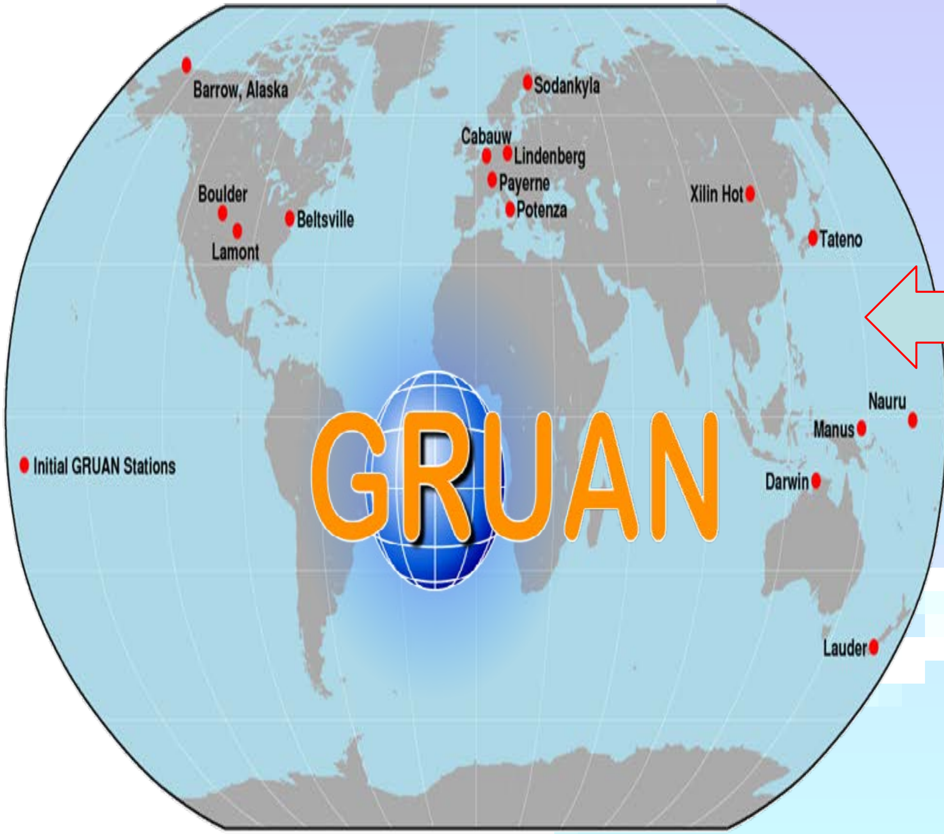
Typical NPROVS Global Collocation Dataset
(1000 collocation records per day)

NPROVS+



GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 10,000 RAOBS (1000 Dedicated) available since July 2013

N P R O V S +



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

NOAA/GRUAN Coordination Committee

JPSS Funded Dedicated RAOB

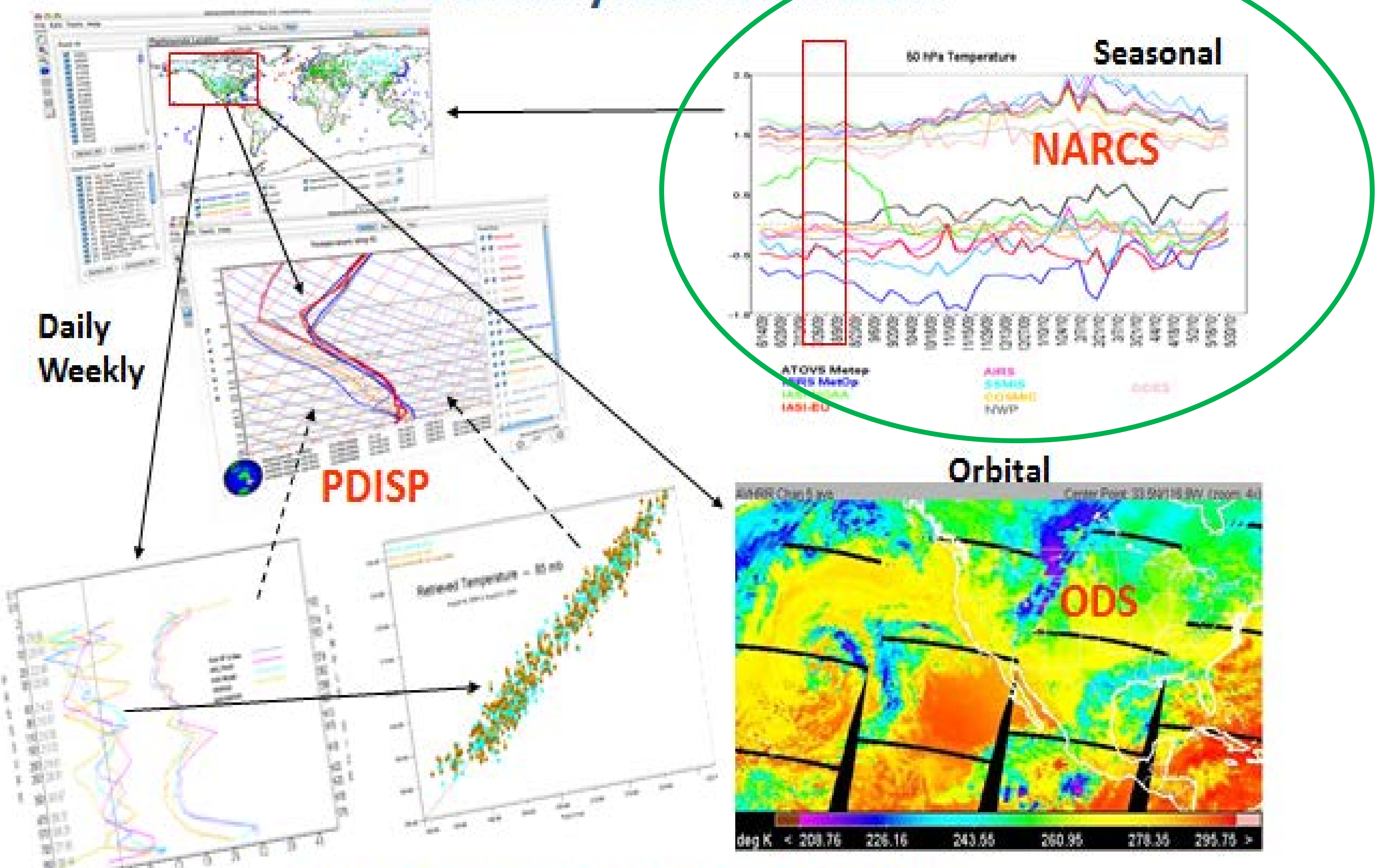
- DOE ARM (SGP, NSA, ENA)
  - ✓CIMSS
  - ✓(2) per week
  - ✓**GRUAN processed**
  - ✓ dual vs single, etc

- AEROSE
- CALWATER
- PMRF …

Request coordination with "other" intensive field experiments particularly is synchronized with S-NPP

Independent
(Enterprise)
Validation of Sounding Products at STAR

EDGE Analytical Interface ...



... routine monitoring to deep dive

NOAA Archive Summary (NARCS)

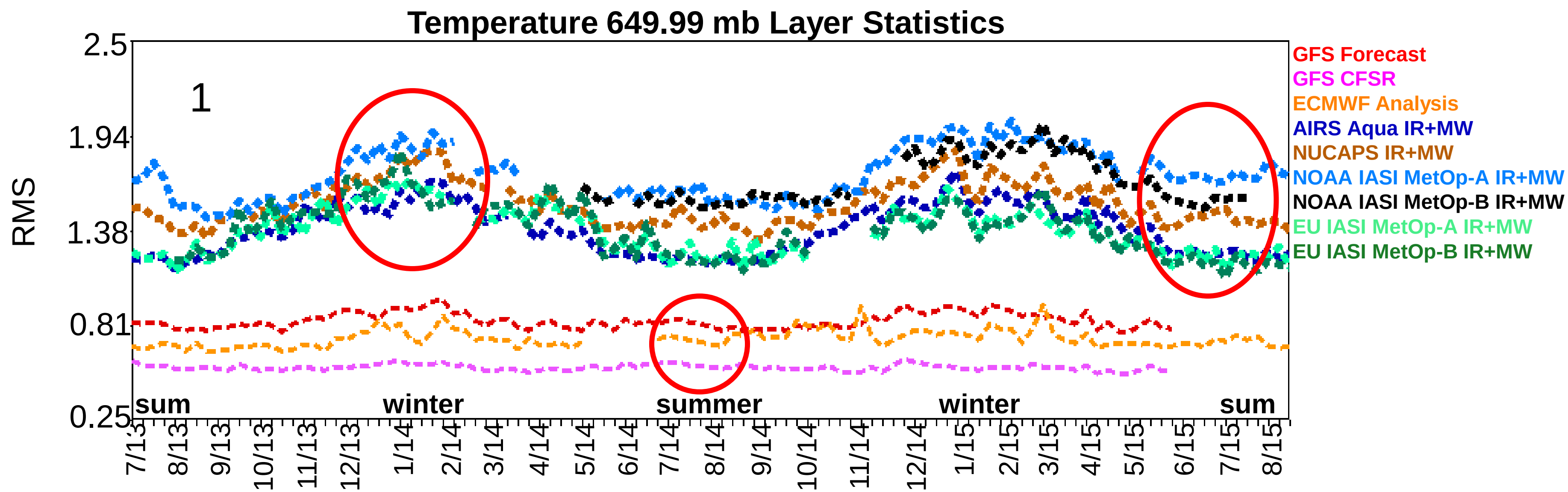
(Long Term Monitoring (LTM) of
SAT-minus-RAOB
2008-present)

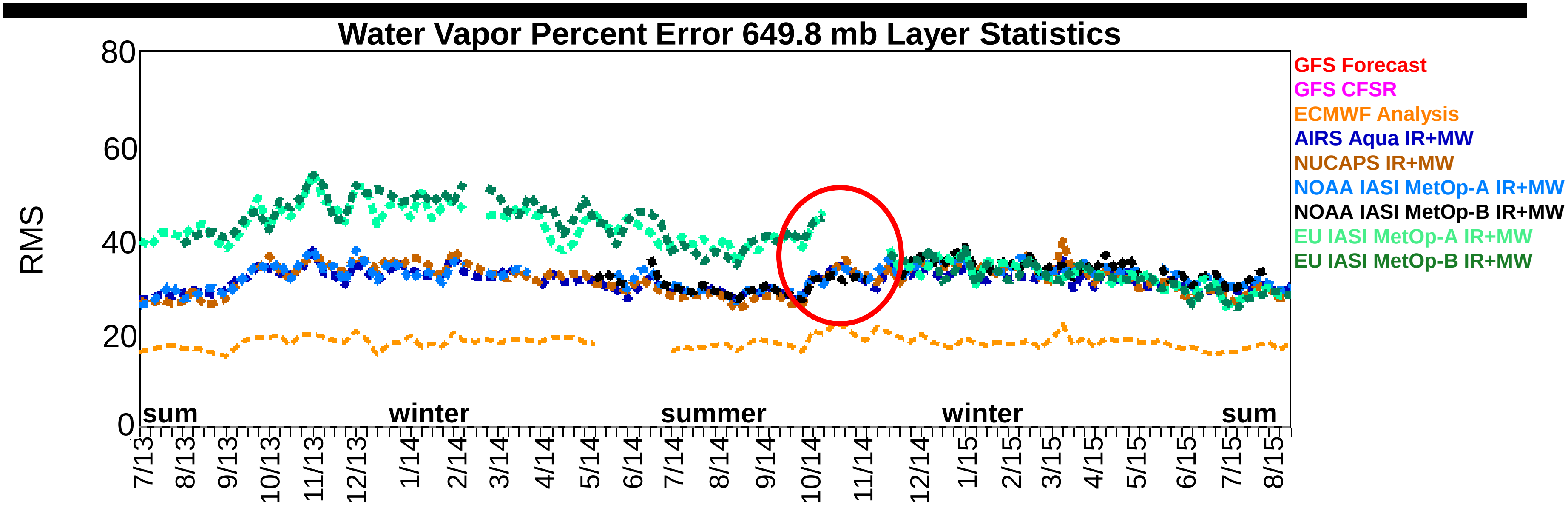
optimal sample per system

- ✓ 2013 to present
- ✓ Maritime vs Continental … Global
- ✓ NUCAPS, IASI (NOAA and EU), AIRS v.6, MiRS, NWP
- ✓ IR vs MW
- ✓ QC'd products
- ✓ Weekly average differences
- ✓ RMS
- ✓ 650 hPa
- ✓ T and H20 vapor fraction (W2)

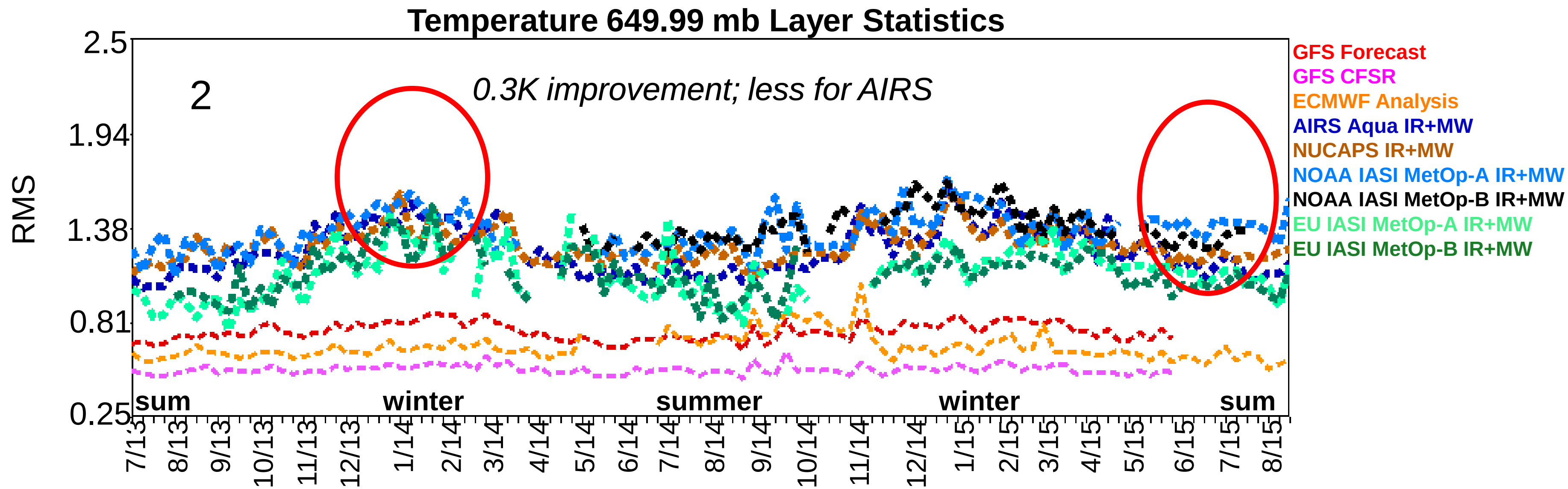
STAR Center for Satellite Applications and Research

formerly ORA — Office of Research and Applications





Continental IR


Temperature 649.99 mb Layer Statistics
2
0.3K improvement; less for AIRS
RMS
2.5
1.94
1.38
0.81
0.25
sum
winter
summer
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7/13
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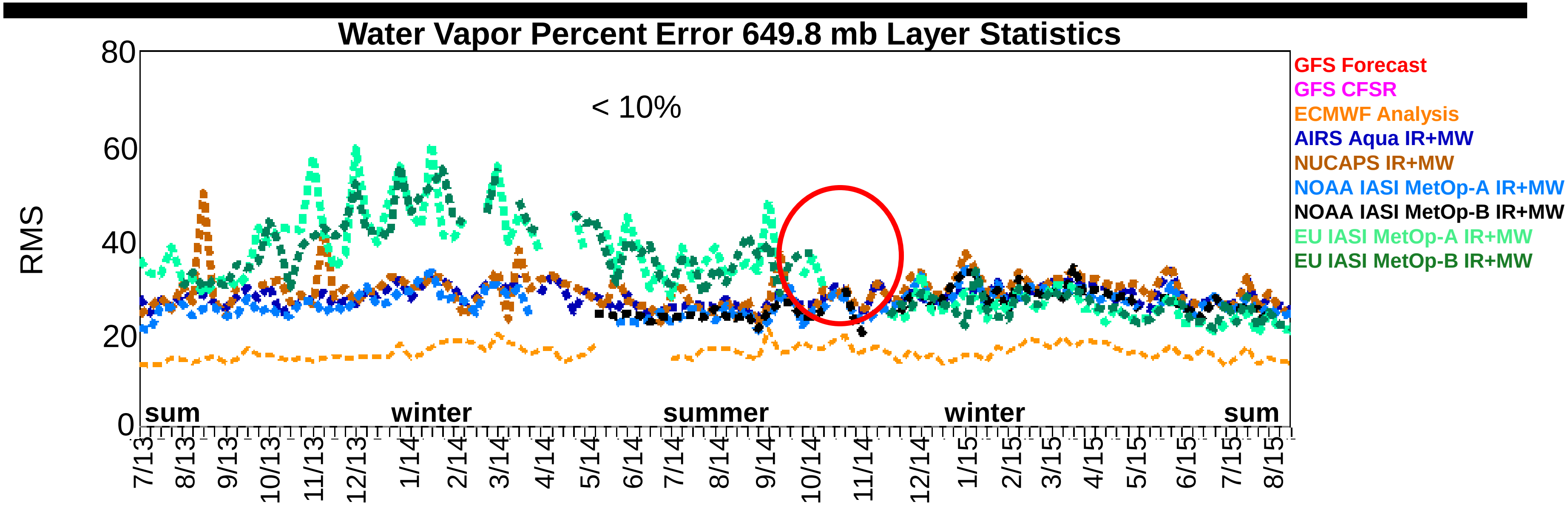
9/14
10/14
11/14
12/14
1/15
2/15
3/15
4/15
5/15
6/15
7/15
8/15
GFS Forecast
GFS CFSR
ECMWF Analysis
AIRS Aqua IR+MW
NUCAPS IR+MW
NOAA IASI MetOp-A IR+MW
NOAA IASI MetOp-B IR+MW
EU IASI MetOp-A IR+MW
EU IASI MetOp-B IR+MW


Water Vapor Percent Error 649.8 mb Layer Statistics
< 10%
RMS
80
60
40
20
0
sum
winter
summer
winter
sum
7/13
8/13
9/13
10/13
11/13
12/13
1/14
2/14
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EU IASI MetOp-B IR+MW

Maritime IR

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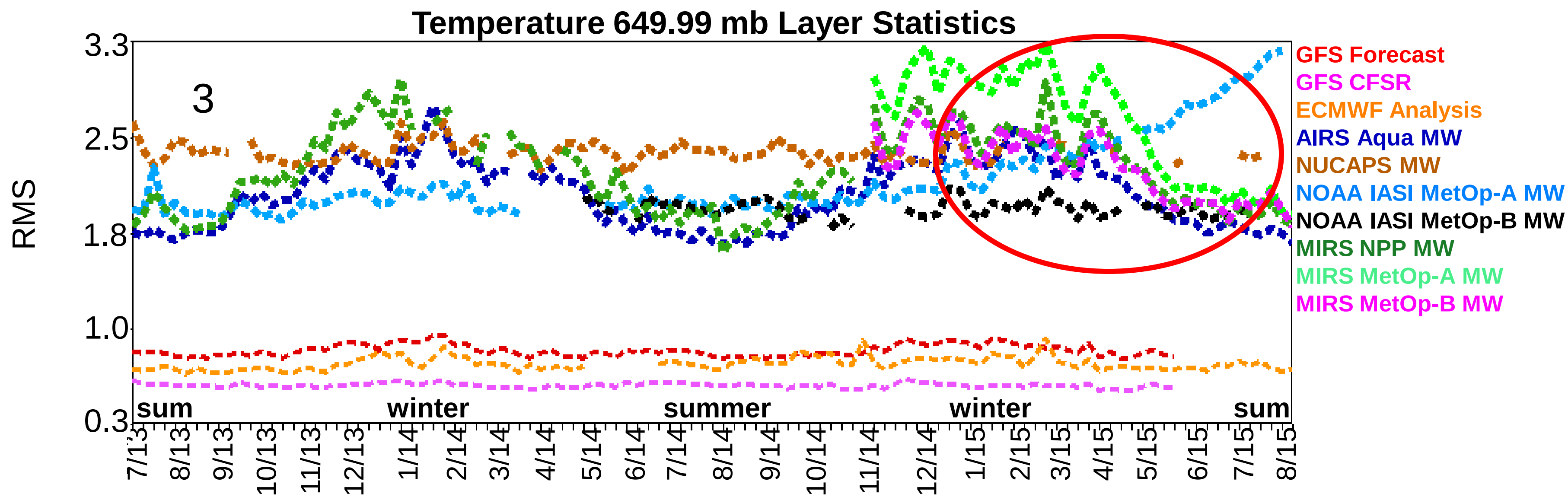
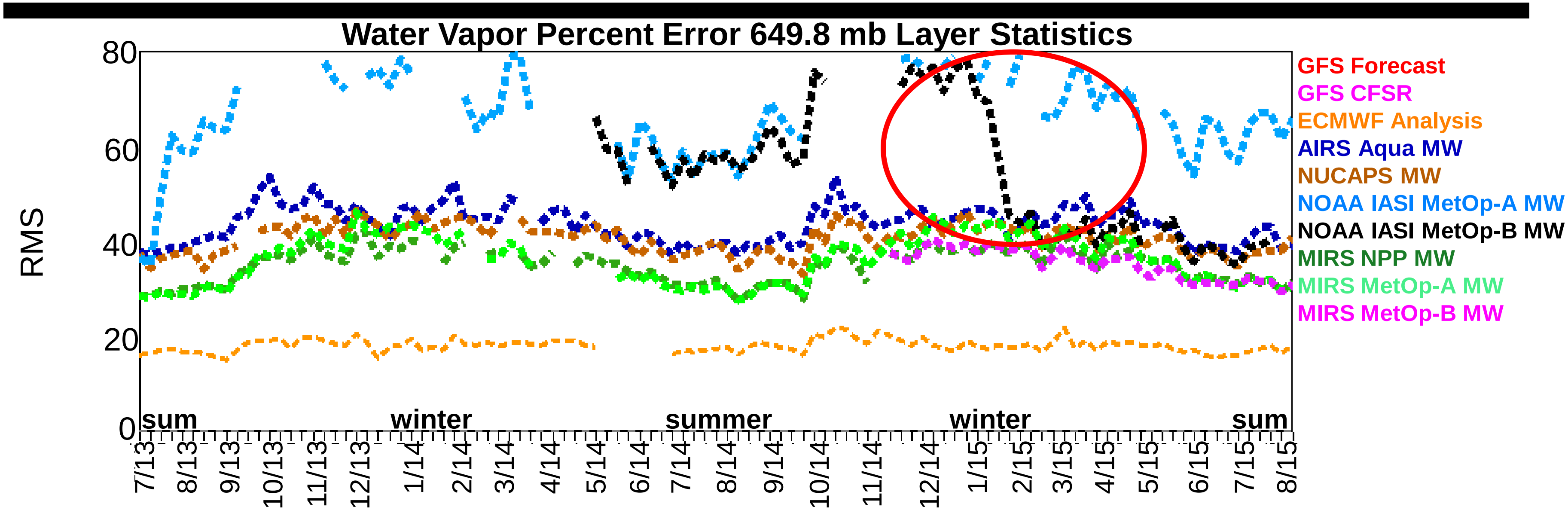
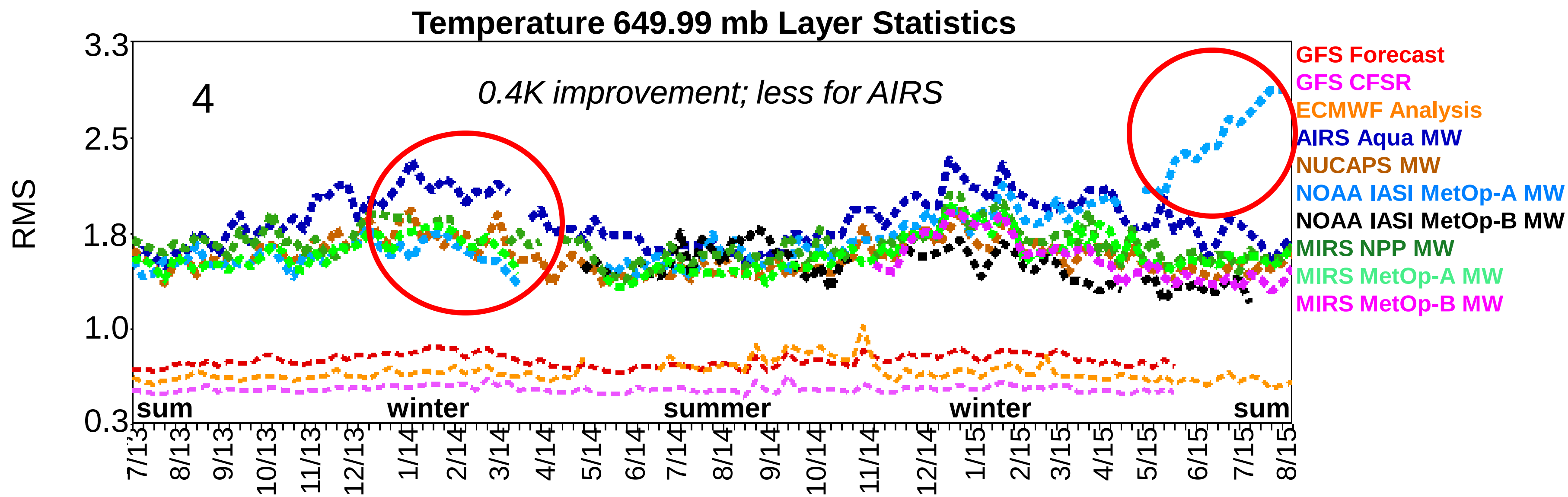




Continental MW


Temperature 649.99 mb Layer Statistics
4
0.4K improvement; less for AIRS
RMS
3.3
2.5
1.8
1.0
0.3
sum
winter
summer
winter
sum
7/13
8/13
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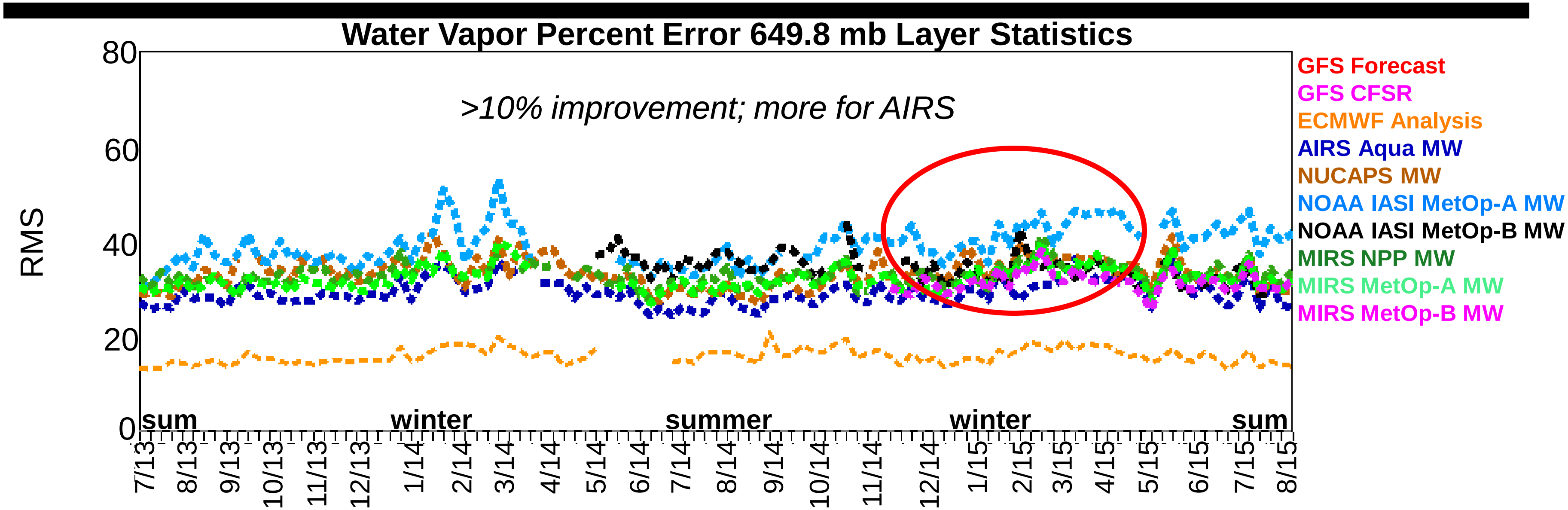
8/15
GFS Forecast
GFS CFSR
ECMWF Analysis
AIRS Aqua MW
NUCAPS MW
NOAA IASI MetOp-A MW
NOAA IASI MetOp-B MW
MIRS NPP MW
MIRS MetOp-A MW
MIRS MetOp-B MW


Water Vapor Percent Error 649.8 mb Layer Statistics
>10% improvement; more for AIRS
RMS
80
60
40
20
0
sum
winter
summer
winter
sum
7/13
8/13
9/13
10/13
11/13
12/13
1/14
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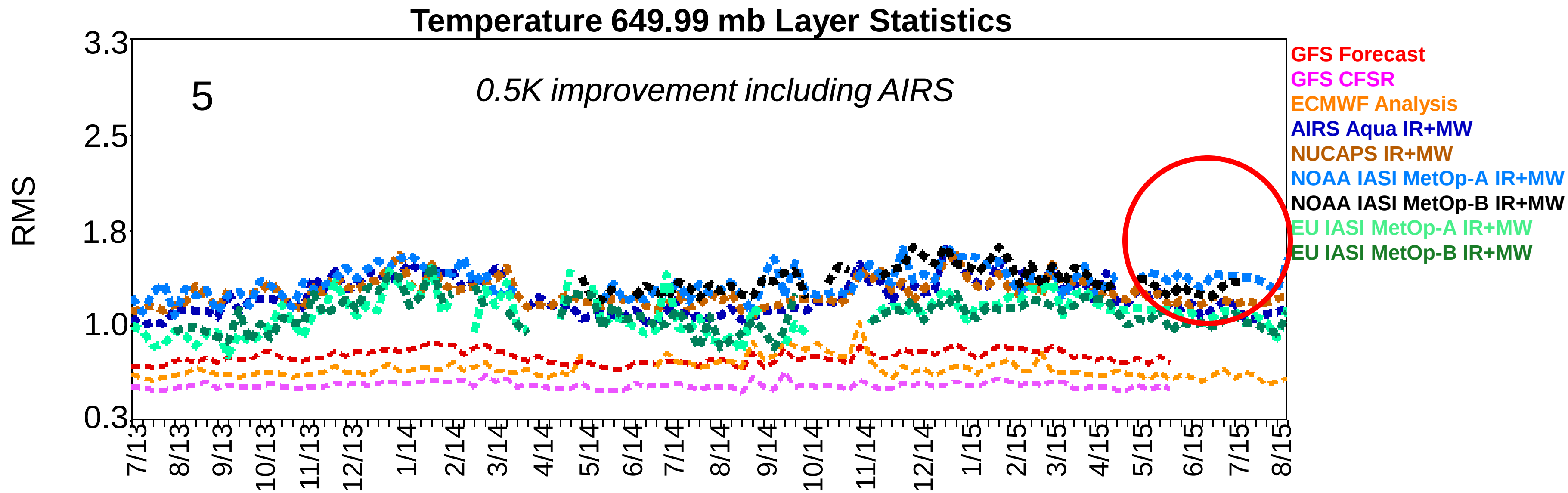
GFS Forecast
GFS CFSR
ECMWF Analysis
AIRS Aqua MW
NUCAPS MW
NOAA IASI MetOp-A MW
NOAA IASI MetOp-B MW
MIRS NPP MW
MIRS MetOp-A MW
MIRS MetOp-B MW

Maritime MW


Temperature 649.99 mb Layer Statistics
5
0.5K improvement including AIRS
RMS
3.3
2.5
1.8
1.0
0.3
7/13
8/13
9/13
10/13
11/13
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AIRS Aqua IR+MW
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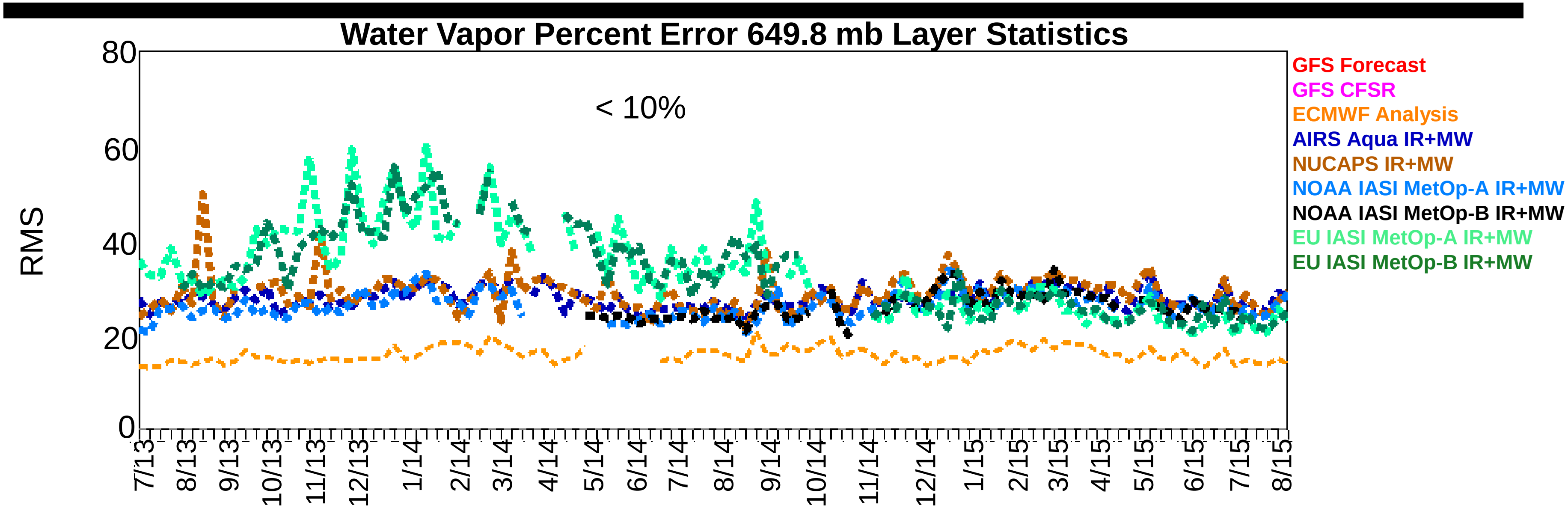
NOAA IASI MetOp-B IR+MW
EU IASI MetOp-A IR+MW
EU IASI MetOp-B IR+MW


Water Vapor Percent Error 649.8 mb Layer Statistics
< 10%
RMS
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12/13
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GFS Forecast
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AIRS Aqua IR+MW
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EU IASI MetOp-A IR+MW
EU IASI MetOp-B IR+MW

Maritime IR

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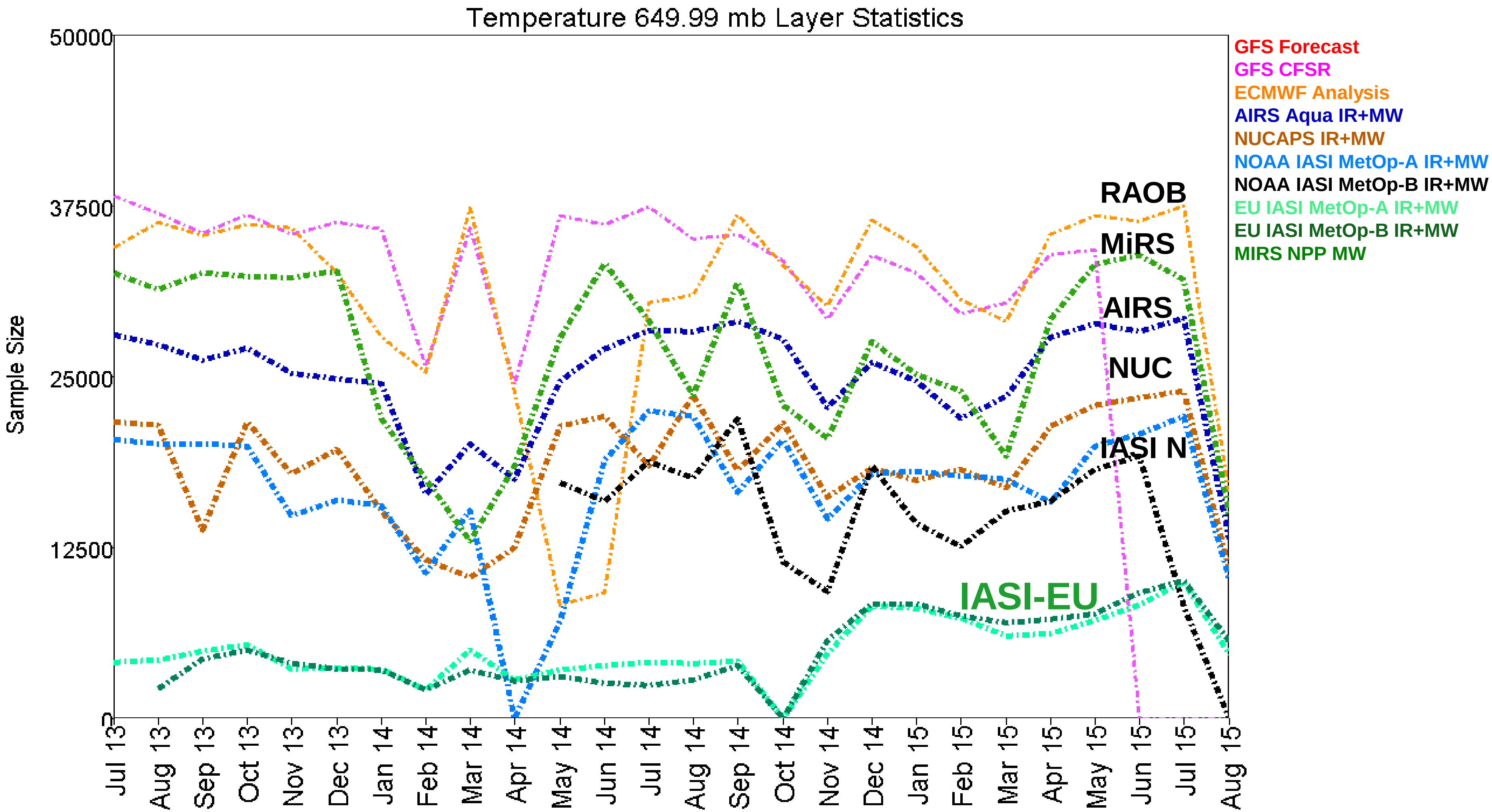

Monthly Global Collocation Sample Size Yields Reflect Global Product Yields

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WEB Site

NOAA STAR CENTER FOR SATELLITE APPLICATIONS AND RESEARCH

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- » NOAA PROducts Validation System (NPROVS) >>
- » Summary Plots
- » User Interface
- » Daily Data Monitoring
- » Documentation
- » Links
- » Personnel
- » OPDB Polar Products

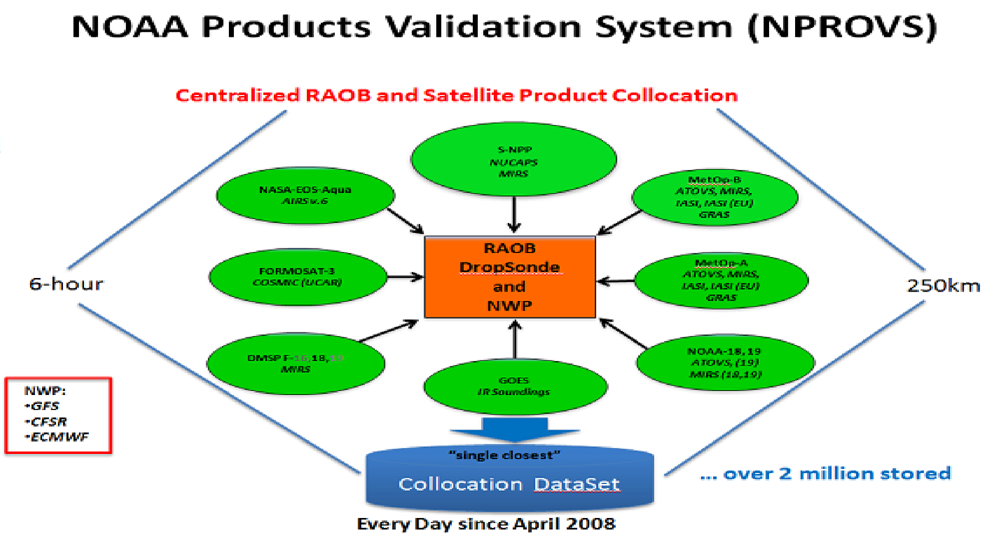
Data and images displayed on STAR sites are provided for experimental use only and are not official operational NOAA products. More information>>

STAR / SMCD / OPDB - NOAA Products Validation System (NPROVS)

NPROVS Overview

NPROVS routinely (daily) compiles datasets of collocated radiosonde, dropsonde and numerical weather prediction (NWP) collocated with the following satellites and sounding product suites:

- Suomi-NPP (S-NPP)
  - NOAA Unique CrIS and ATMS Processing System (NUCAPS)
  - Microwave Integrated Retrieval System (MIRS)
- MetOp A and B
  - Infrared Atmospheric Sounding Interferometer (IASI)
  - IASI from EUMETSAT
  - MIRS
  - ATOVS
- NOAA-18,19
  - MIRS
  - ATOVS
- Defense Meteorological Satellite Program (DMSP) F-16, F-18 , F18
  - MIRS
- NASA-Earth Observing System (EOS)-Aqua
  - Advanced InfraRed Sounder (AIRS) (NASA v6 beginning April, 2013)
- GOES 11 and 13 (clear sky only)
- Constellation Observing System for Meteorology Ionosphere and Climate (COSMIC) Global Positioning System Radio Occultation (GPSRO) from University Corporation for Atmospheric Research (UCAR) Infrared Atmospheric Sounding Interferometer (IASI)



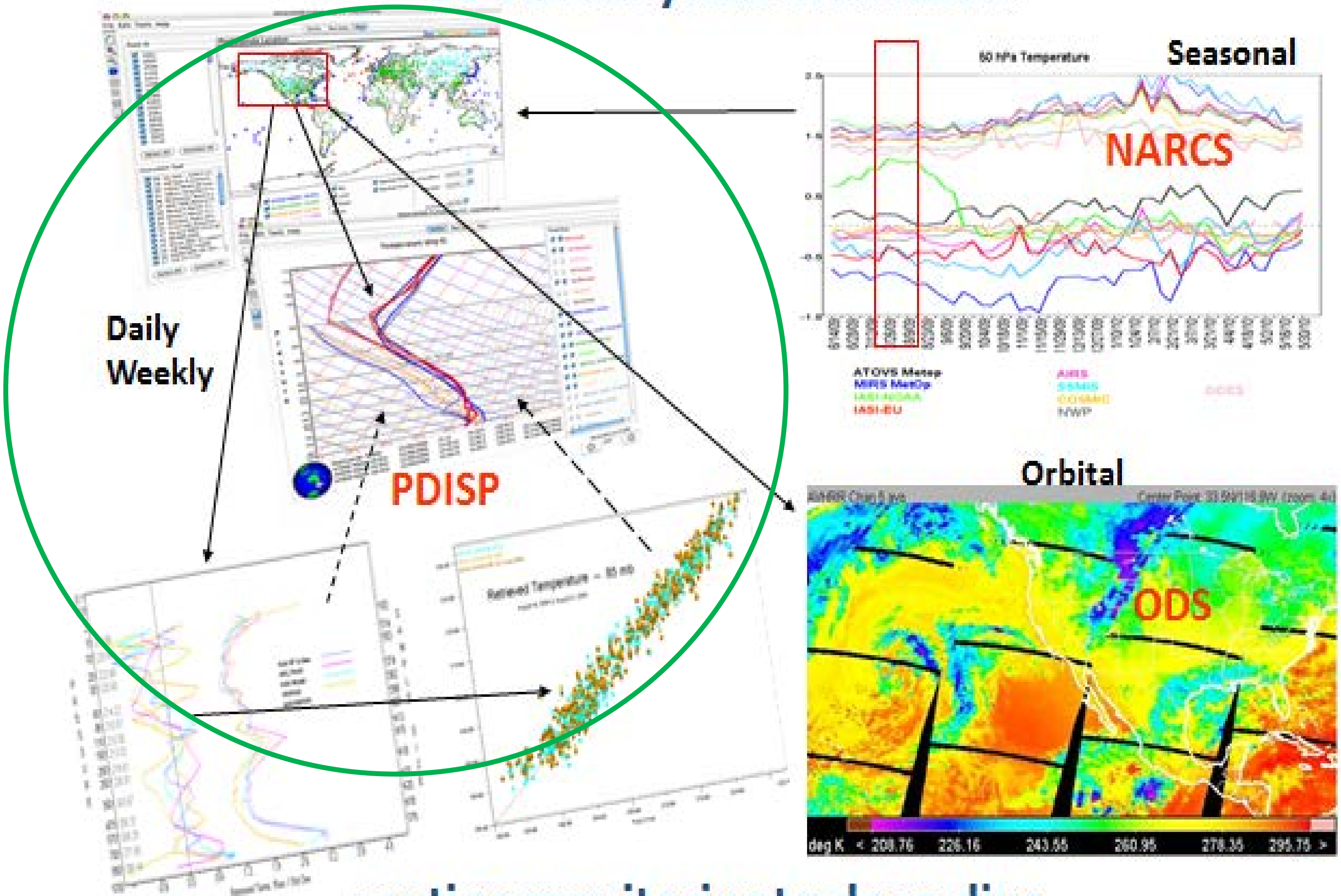
Collocation datasets are used for product monitoring and support of scientific algorithm development.

The website is broken into 3 major sections:

- Summary Plots of product monitoring for selected product suite combinations
- Graphical Interface (JAVA applications) for user analysis of collocation datatsets (i.e., weekly) and longer term trends (seasonal) are available.
- Daily Data Monitoring Images on this page show 24 hour data coverage for each system that is input into NPROVS.

http://www.star.nesdis.noaa.gov/smcd/opdb/nprovs/index.php

EDGE Analytical Interface ...



... routine monitoring to deep dive

Profile Display (PDISP):

(Monitoring/Analysis of (10-day) NPROVS collocation datasets)

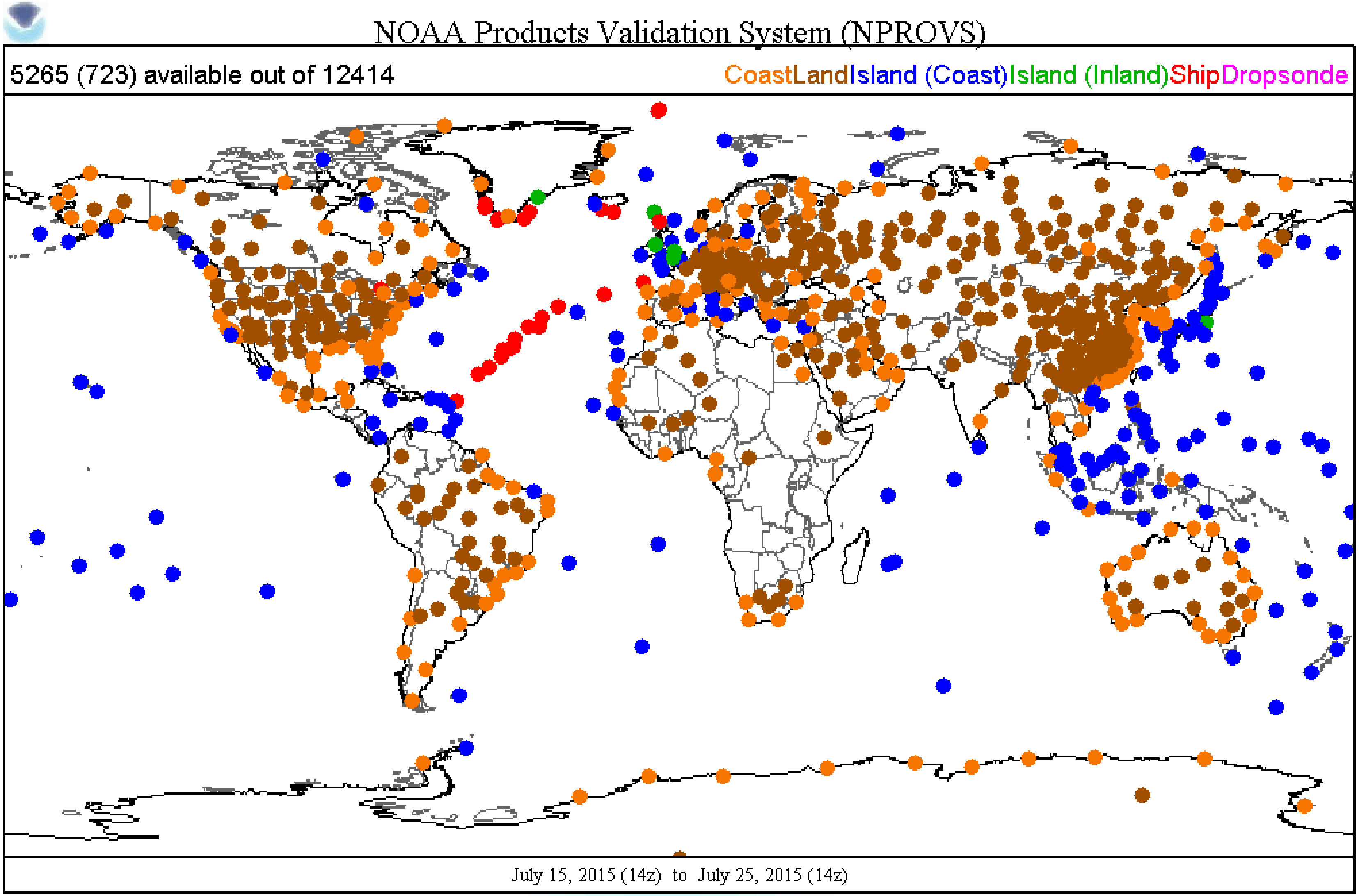
Common Samples

Analytical options:

- Collocated profile display and statistics
- Sampling options (space / time windows, region, weather, satellites, instruments, day/nite, qc …)

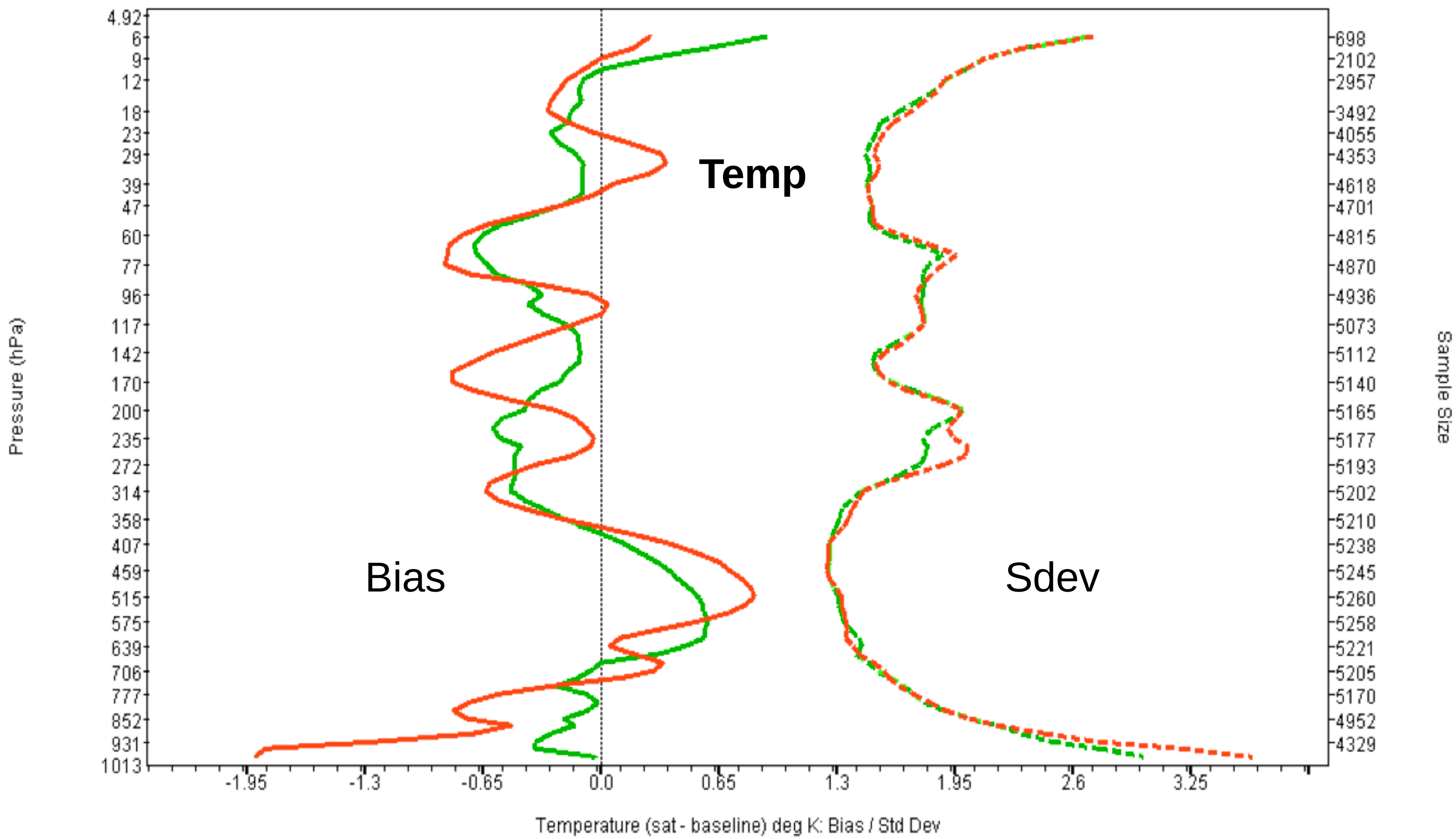
Assessments:

- *NUCAPS upgrade (oper vs parallel test)*
- *MiRS upgrade (oper vs parallel test)*
- *Retrieval vs First Guess Convergence*
- *Moisture Statistics Weighting*



10-day sample of collocations containing NUCAPS test and Oper IR+MW soundings which pass QC

NOAA Products Validation System (NPROVS)



Baseline: Radiosonde Radiosonde

NUCAPS NUCAPS Test

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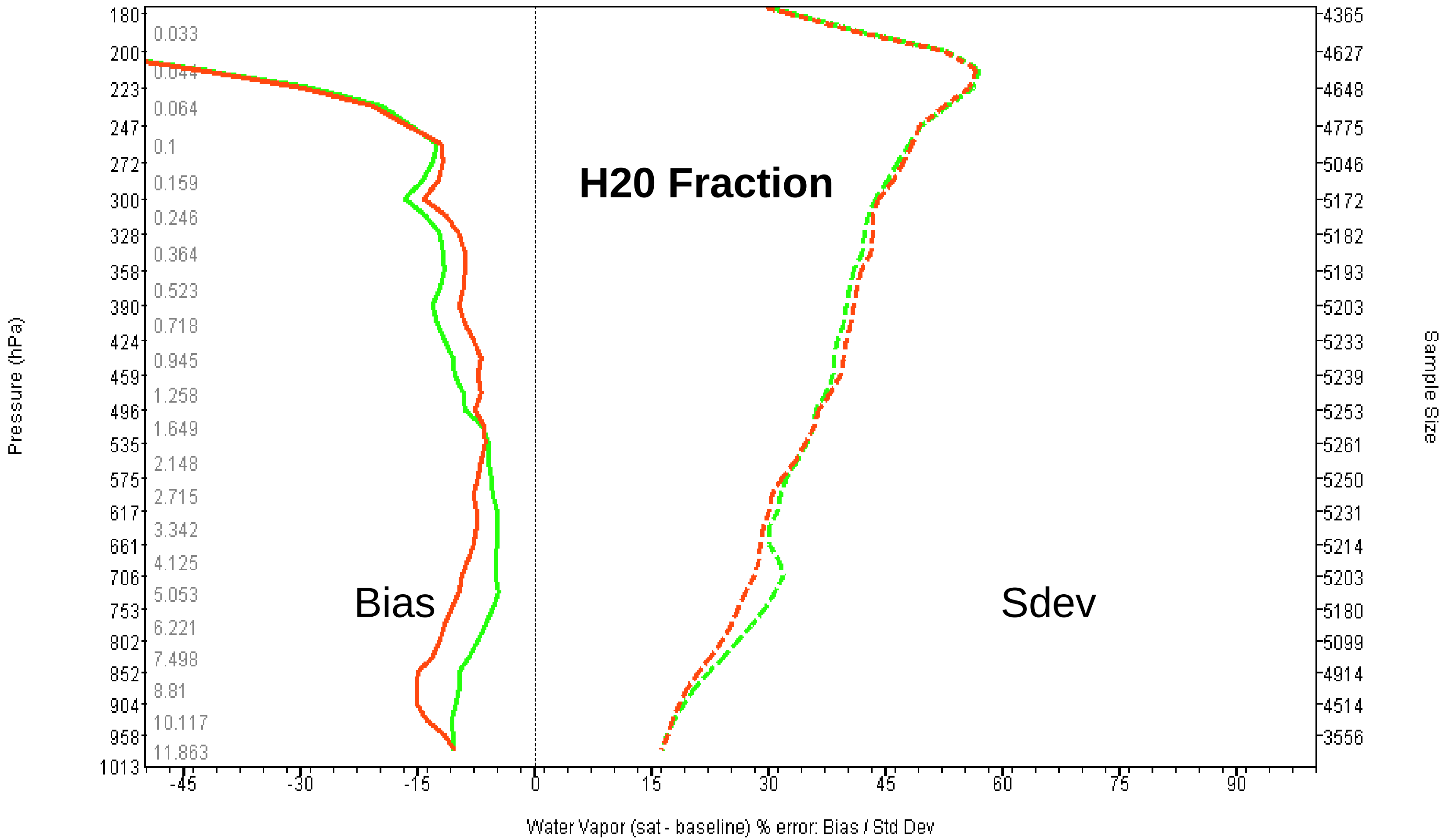
NOAA Products Validation System (NPROVS)

July 15, 2015 to July 25, 2015

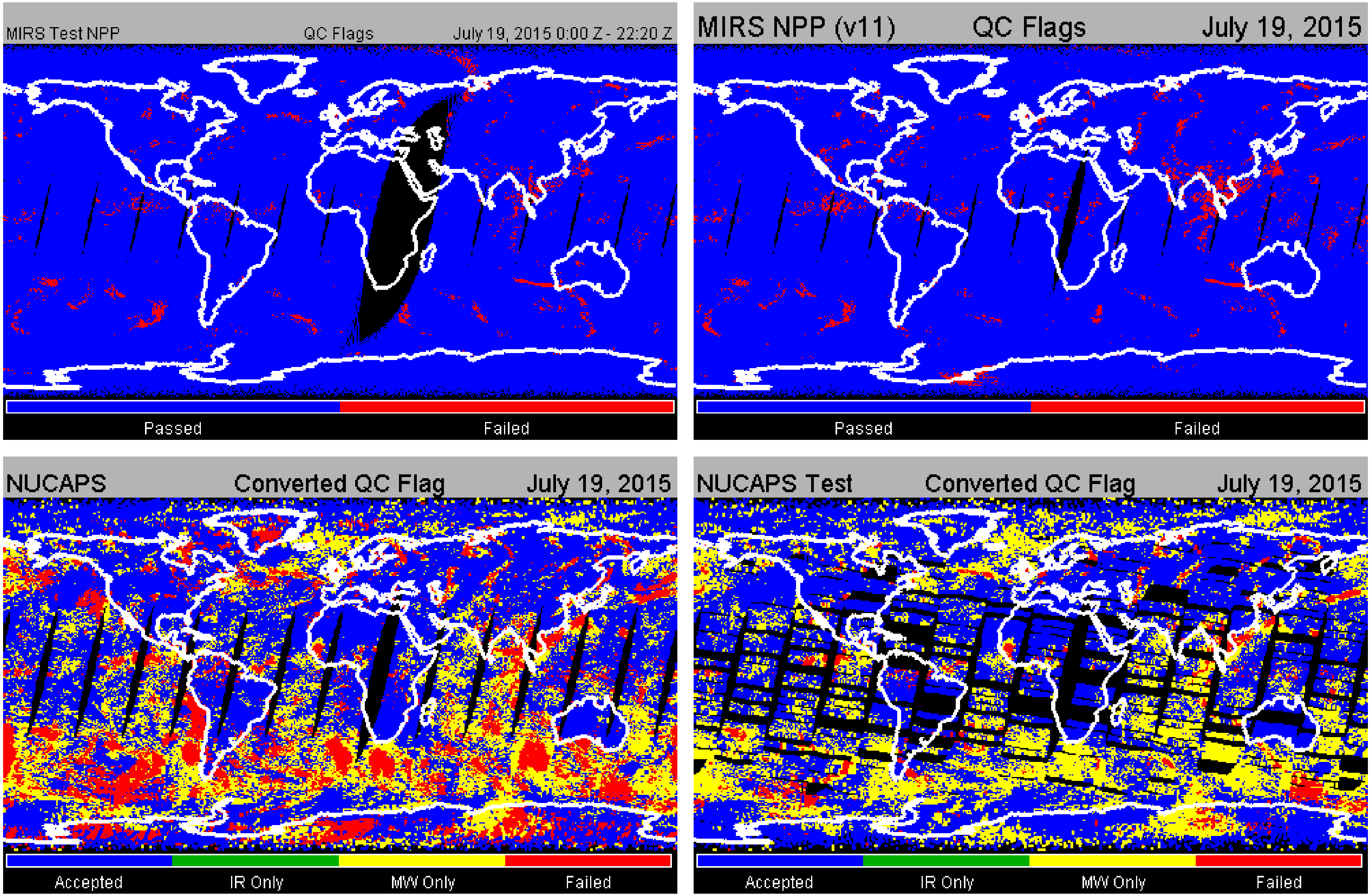


Baseline: Radiosonde Radiosonde

NUCAPS

NUCAPS Test

ODS



QC flags … red means MiRS (upper) and both NUCAPS (lower) failed

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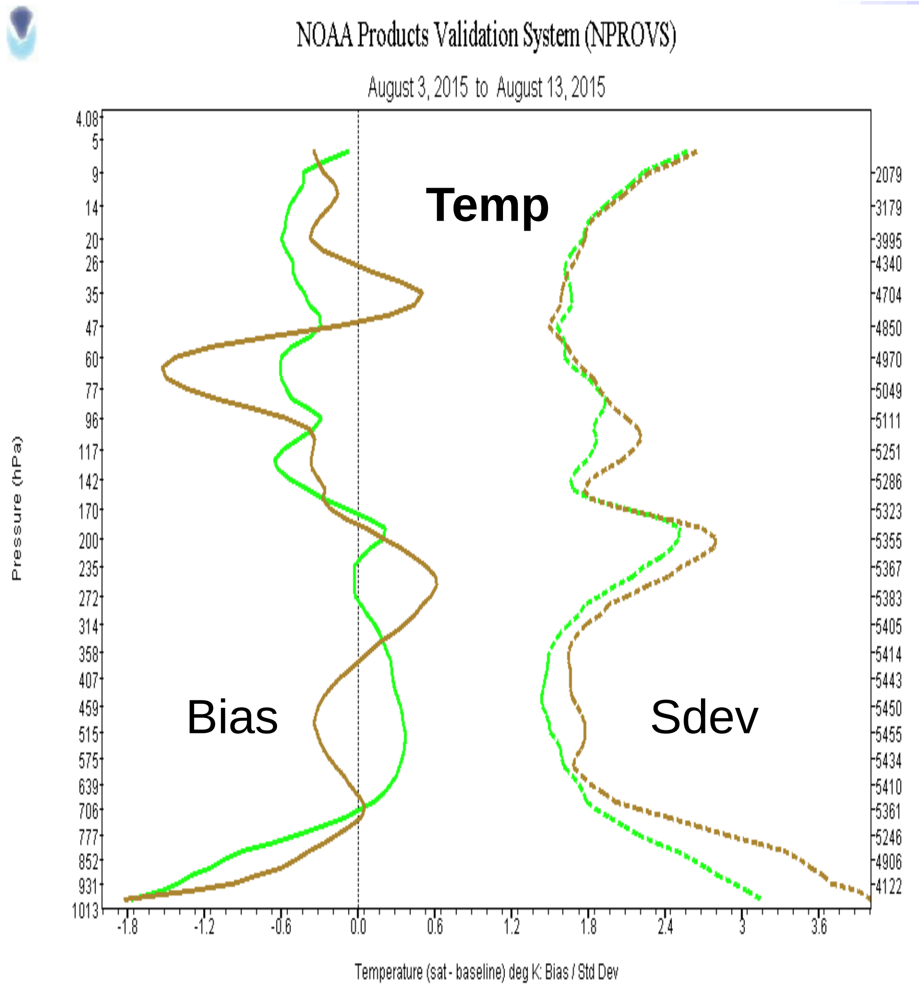
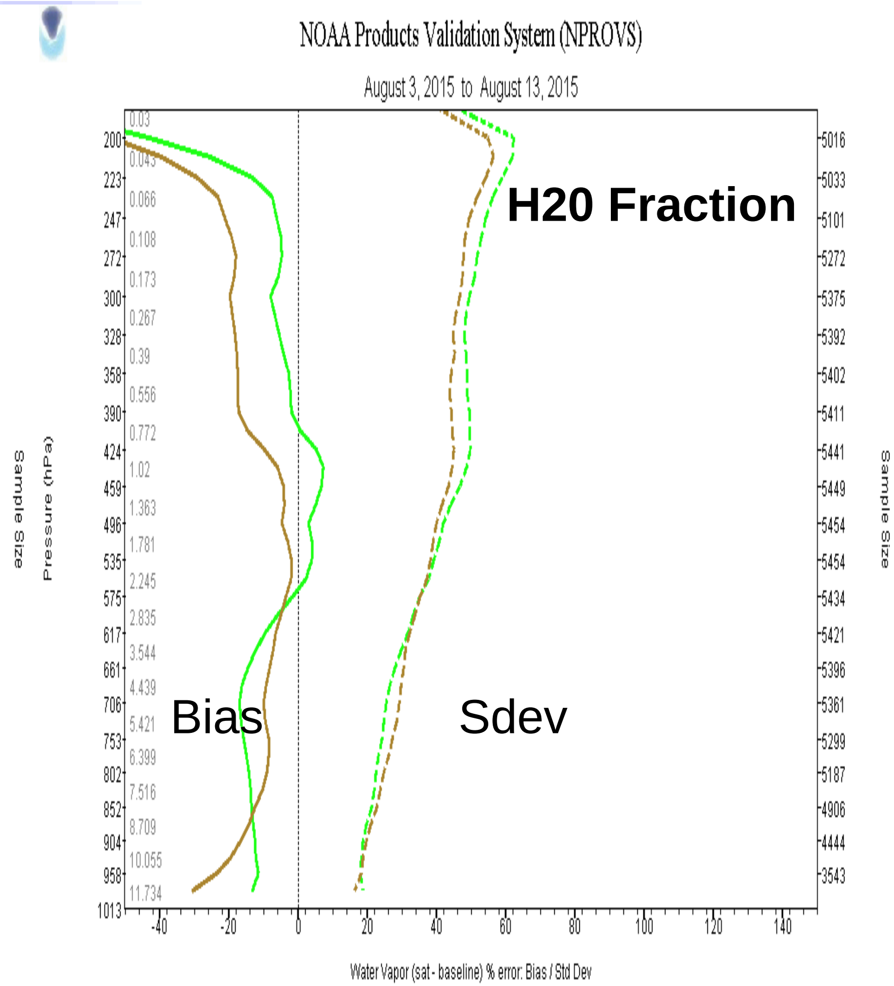




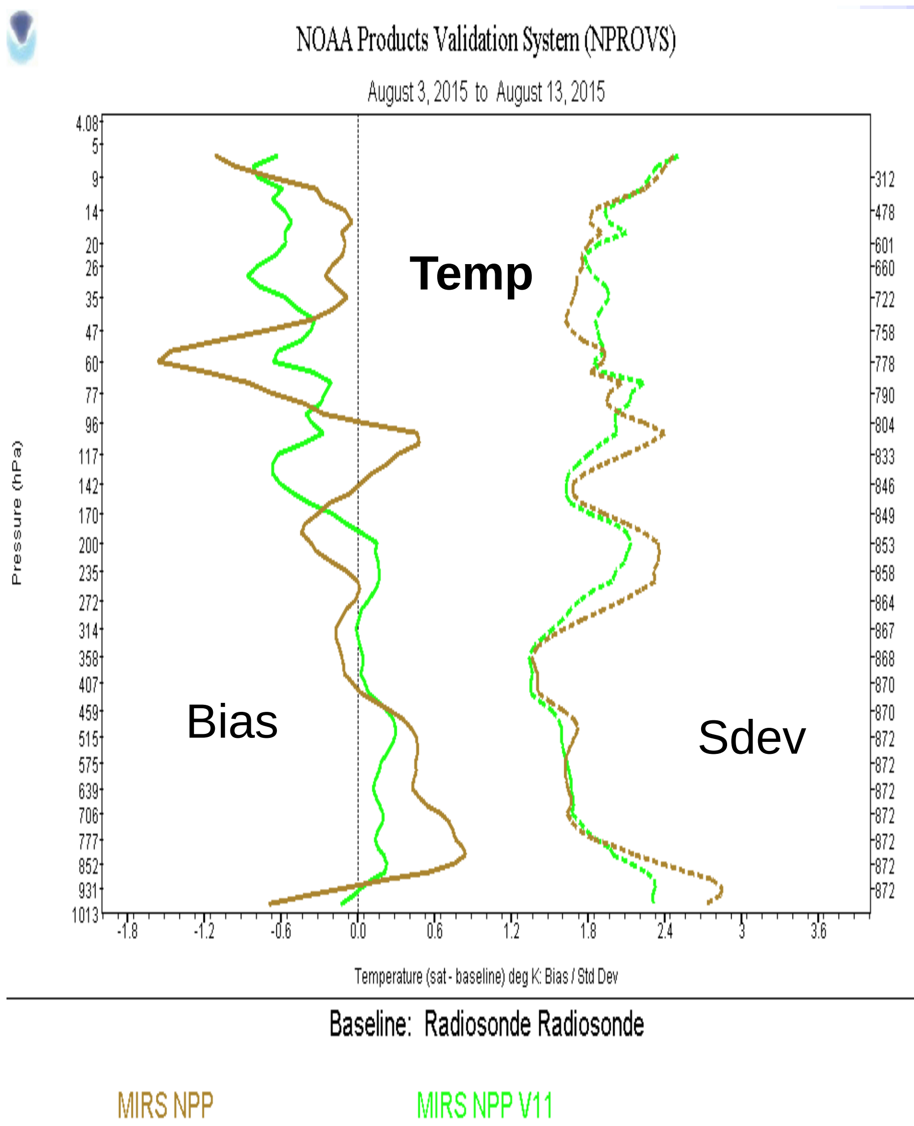
Baseline: Radiosonde Radiosonde

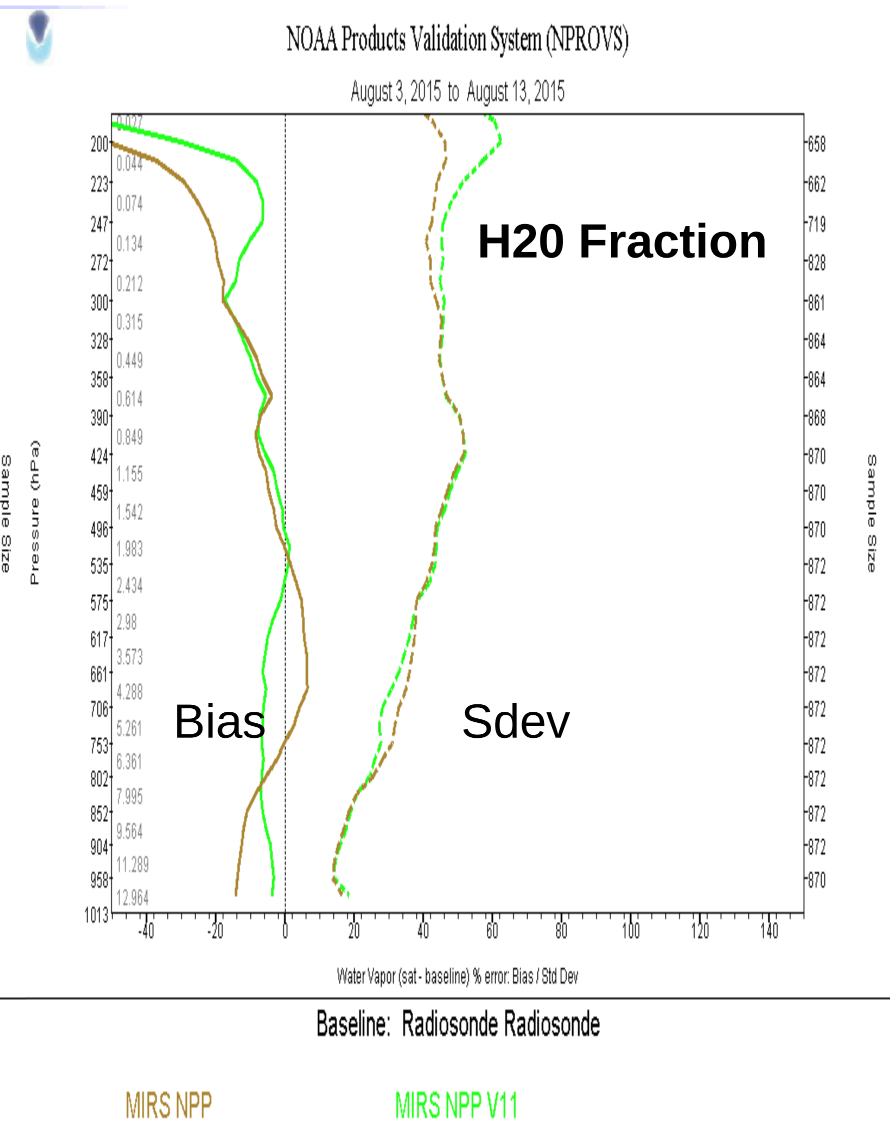
MIRS NPP MIRS NPP V11

Baseline: Radiosonde Radiosonde

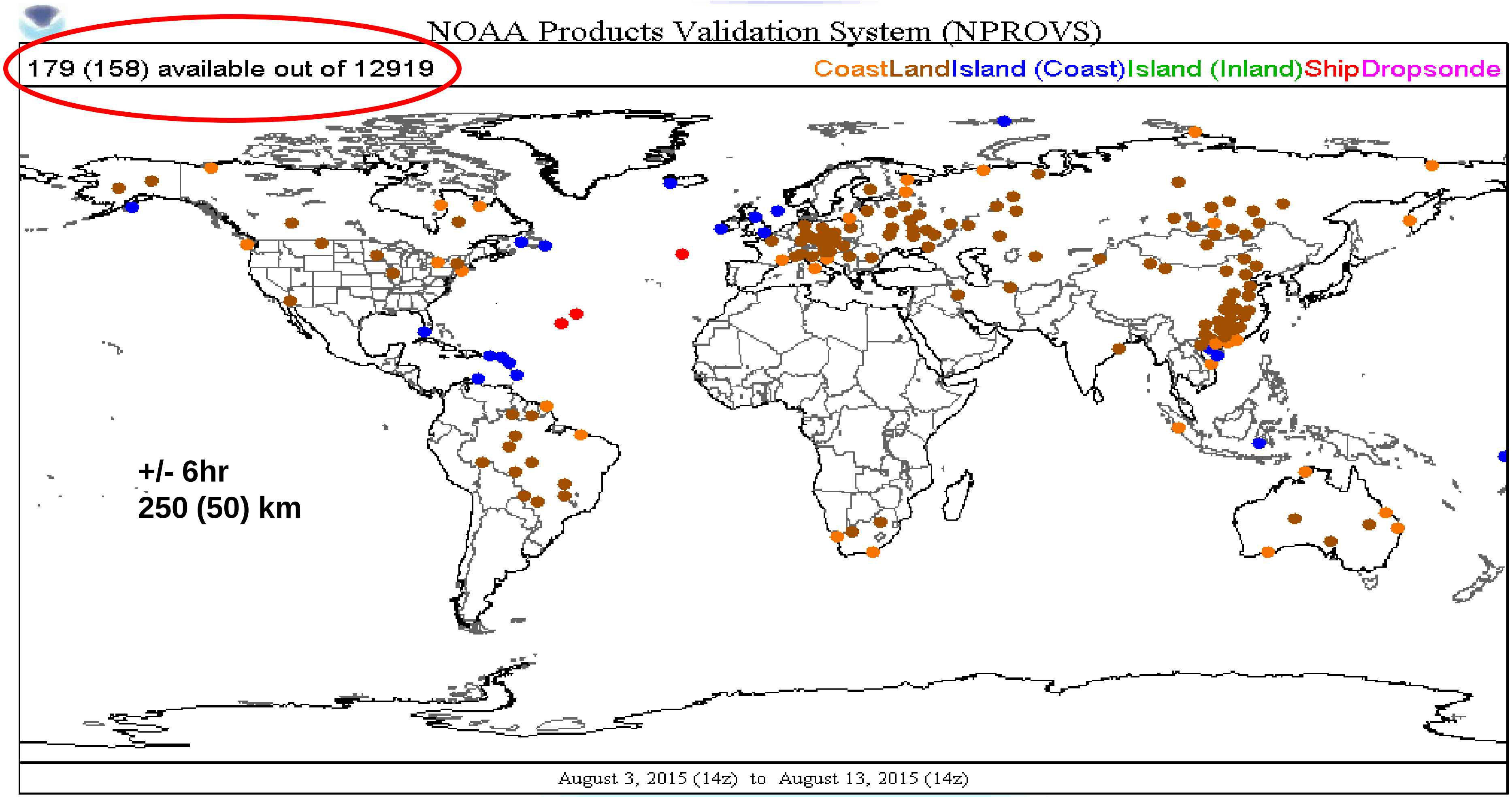
MIRS NPP MIRS NPP V11

Land


NOAA Products Validation System (NPROVS)
August 3, 2015 to August 13, 2015
Temp
Bias
Sdev
Pressure (hPa)
Sample Size
Temperature (sat - baseline) deg K: Bias / Std Dev
Baseline: Radiosonde Radiosonde
MIRS NPP
MIRS NPP V11


NOAA Products Validation System (NPROVS)
August 3, 2015 to August 13, 2015
H20 Fraction
Bias
Sdev
Pressure (hPa)
Sample Size
Water Vapor (sat - baseline) % error: Bias / Std Dev
Baseline: Radiosonde Radiosonde
MIRS NPP
MIRS NPP V11

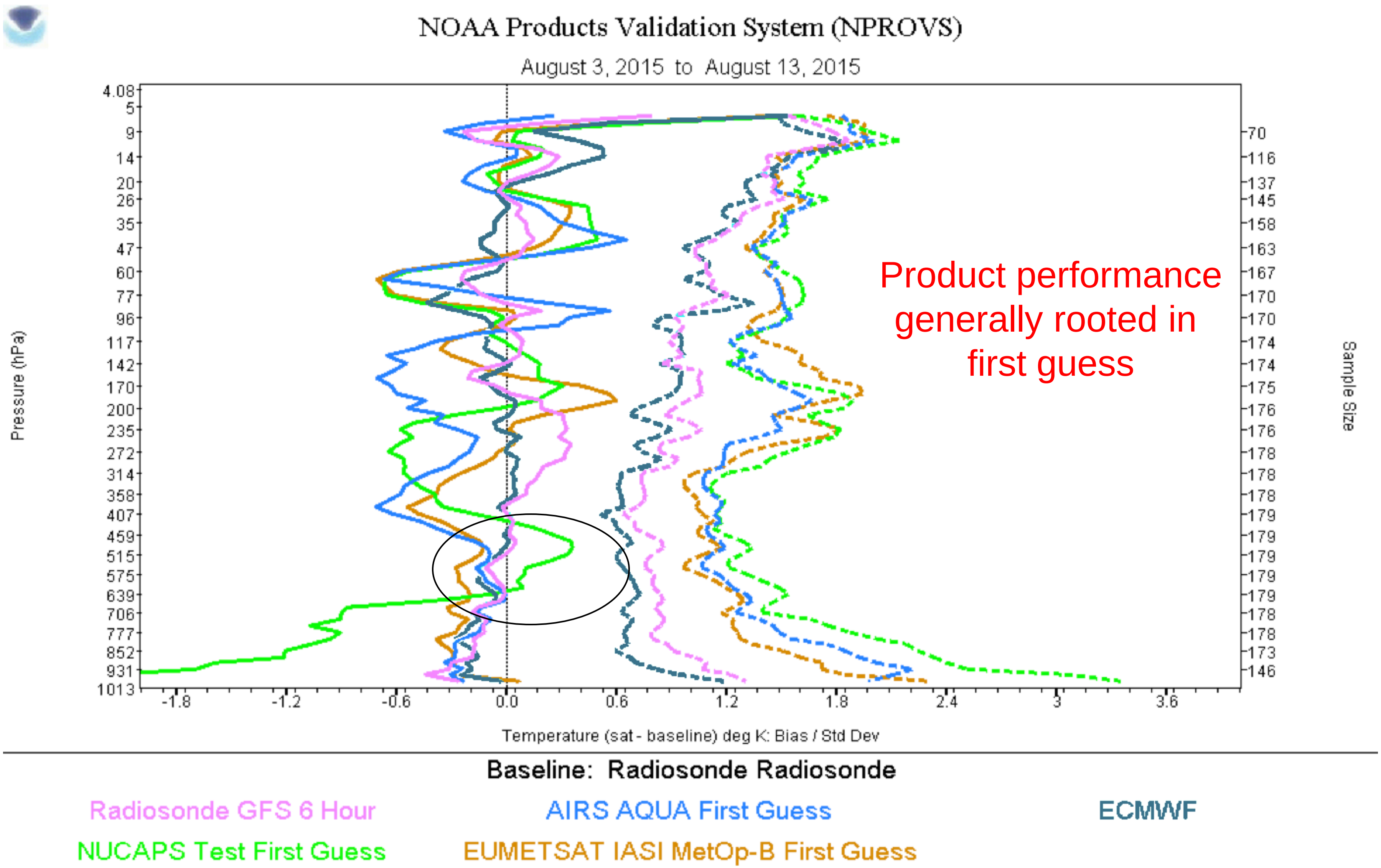
Sea



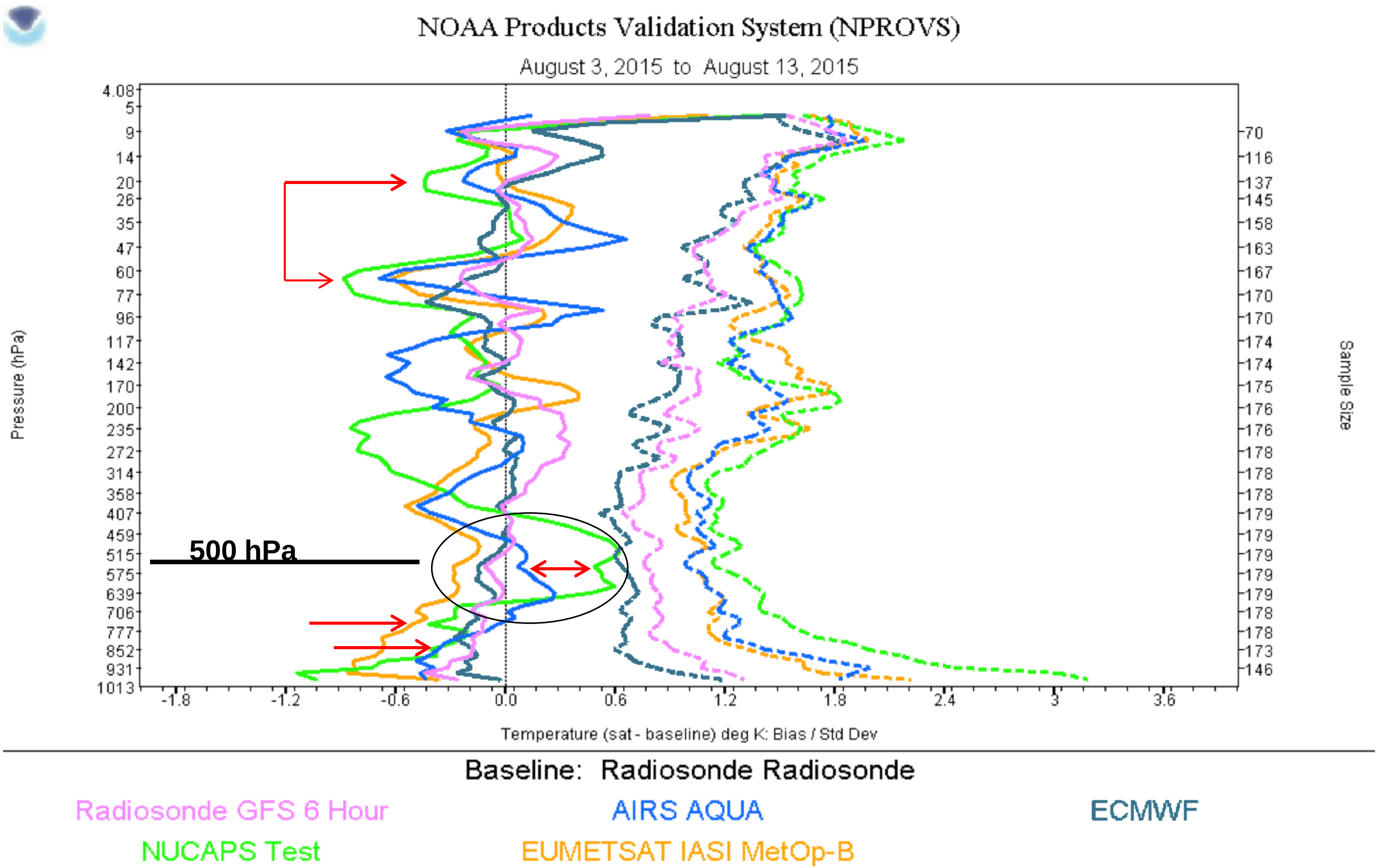
10-day sample of collocations containing:

1) NUCAPS Test 2) AIRS 3) IASI-EU … all pass respective QC

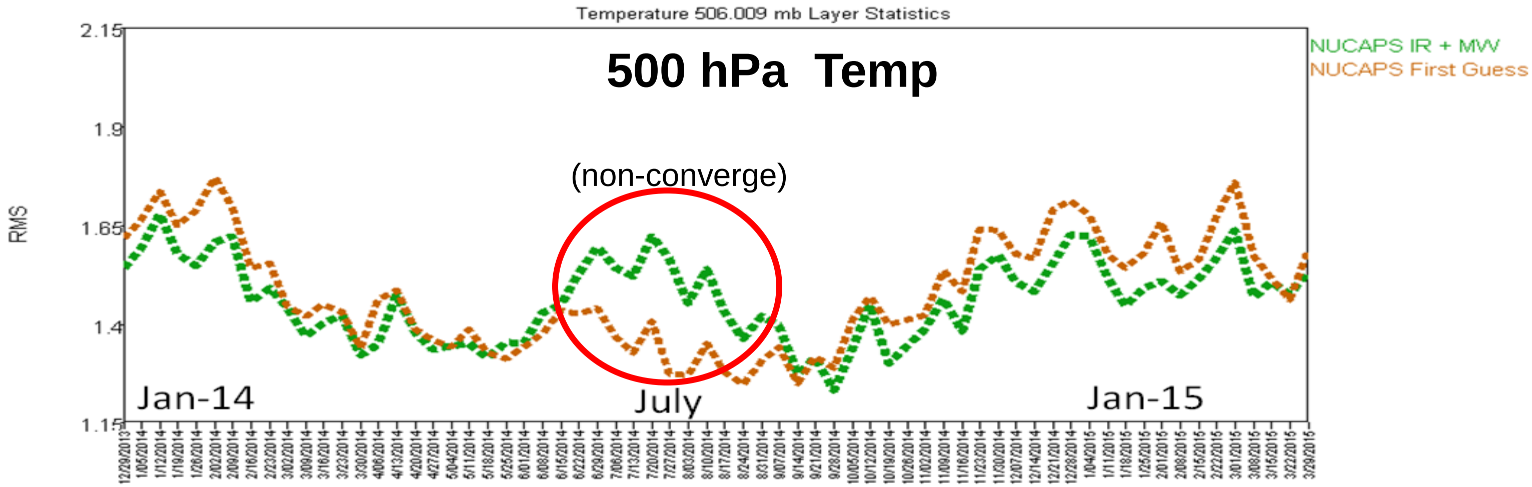
4) ECMWF

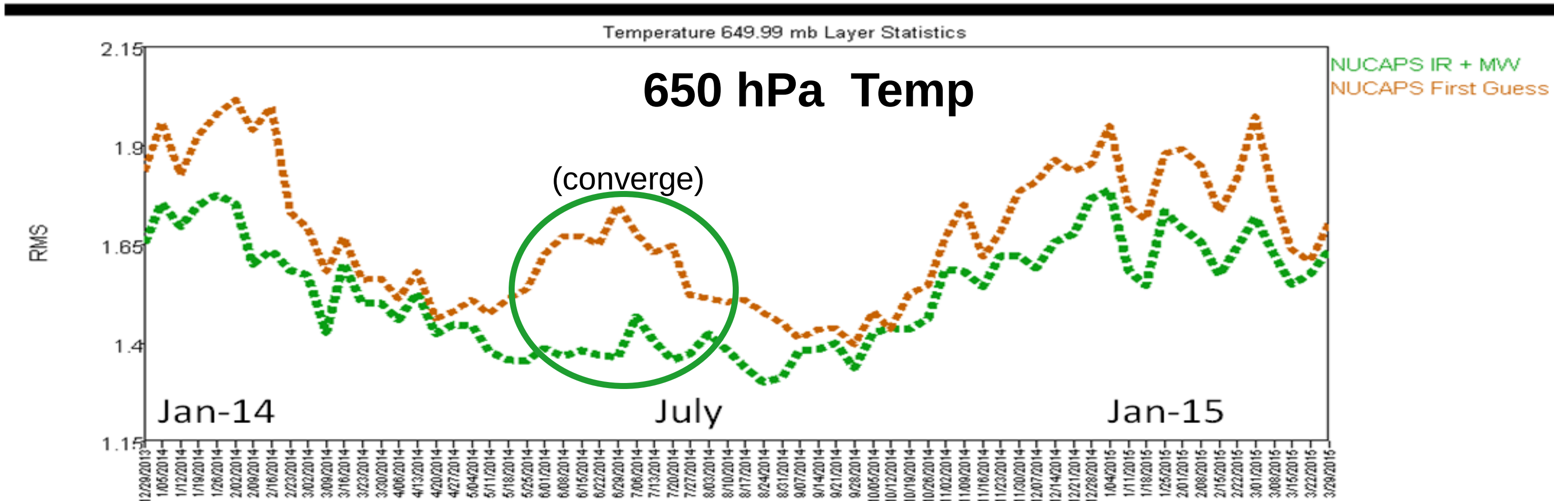


First Guess Temp



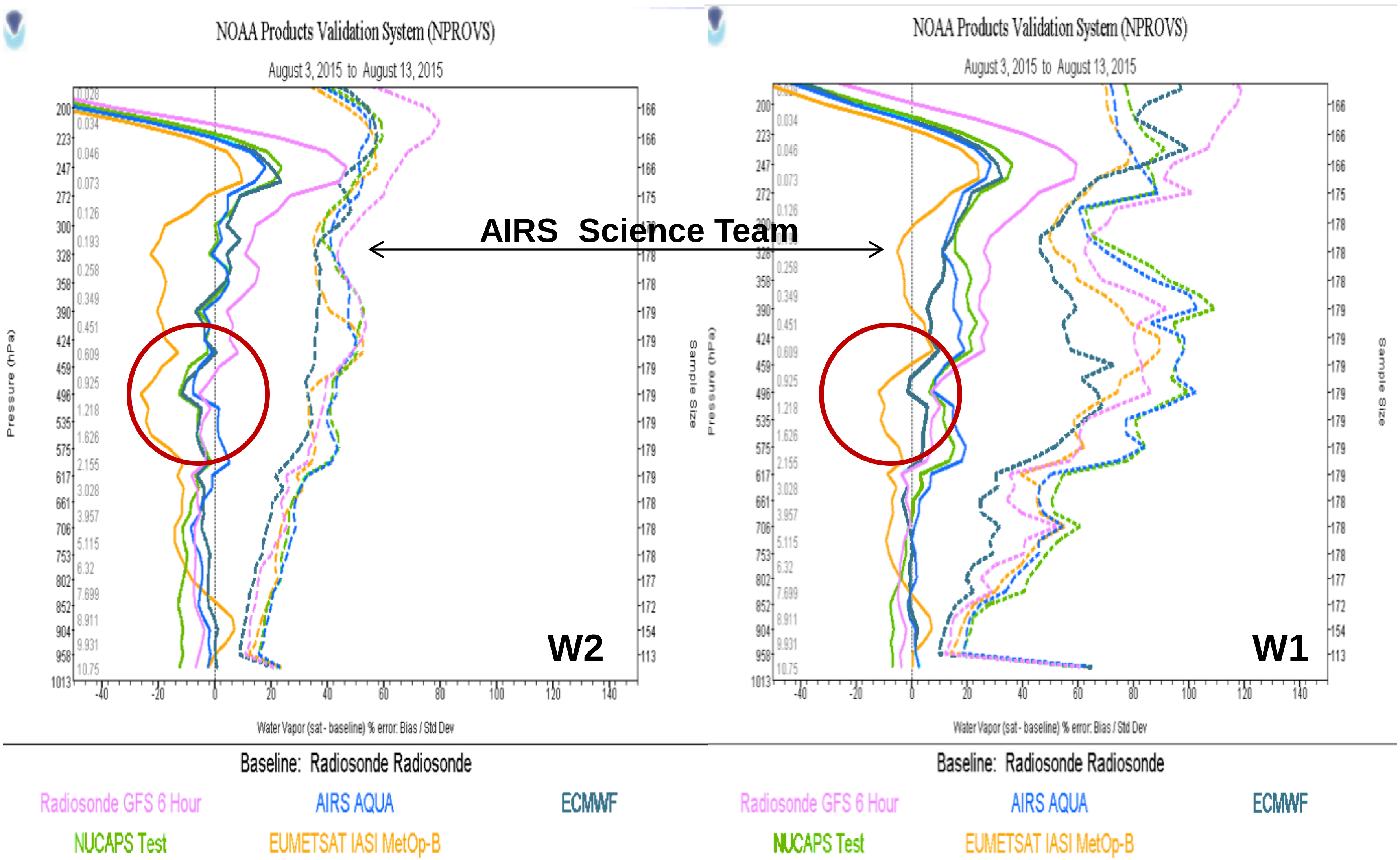
Retrieval Temp





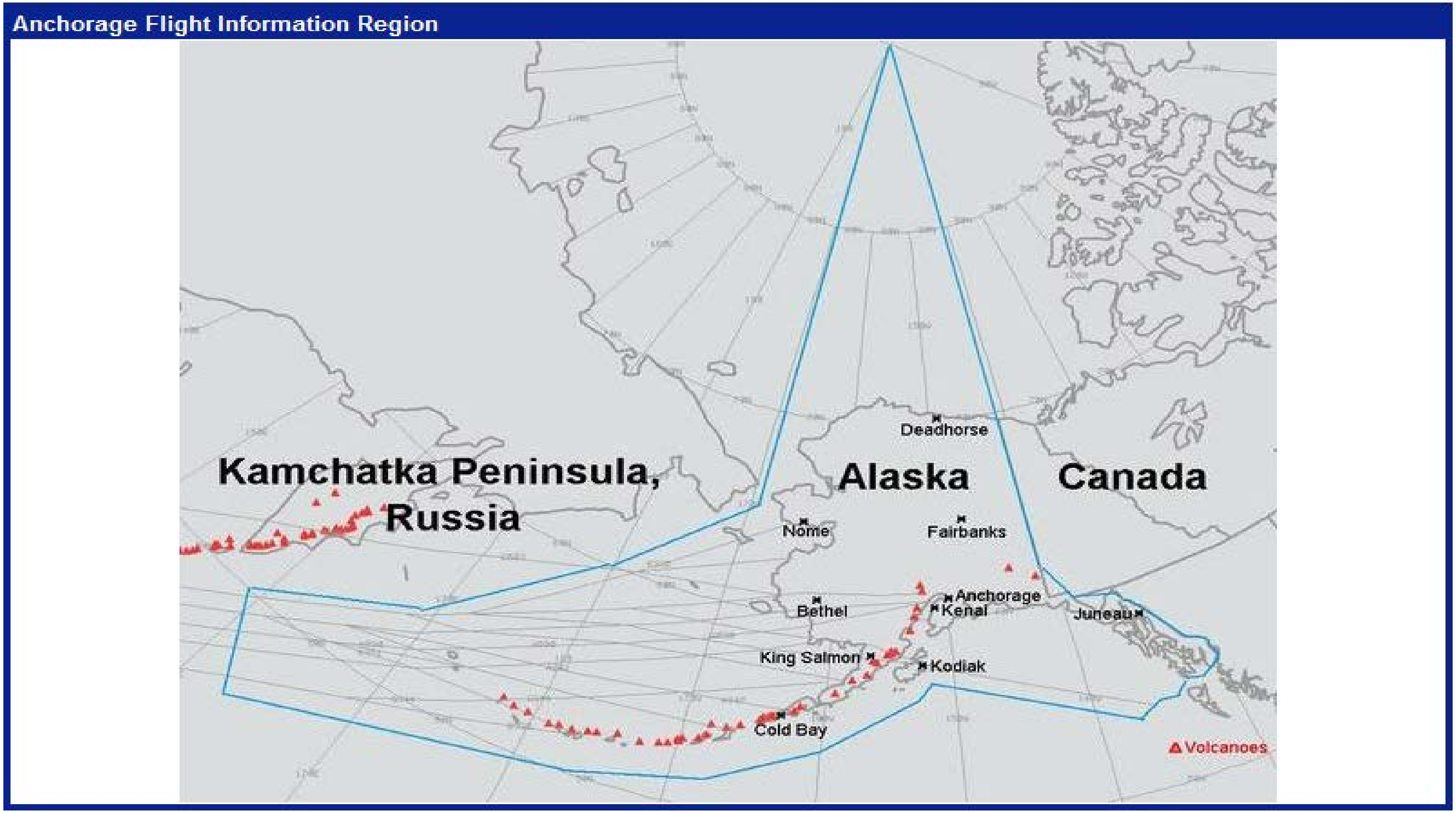
NARCS LTM of NUCAPS (Oper) retrieval vs 1st guess:

(NUCAPS IR+MW show seasonal (summer) non-convergence vicinity 500 hPa mainly continental cases; not evident at 650 hPa)



Moisture weighting makes a difference

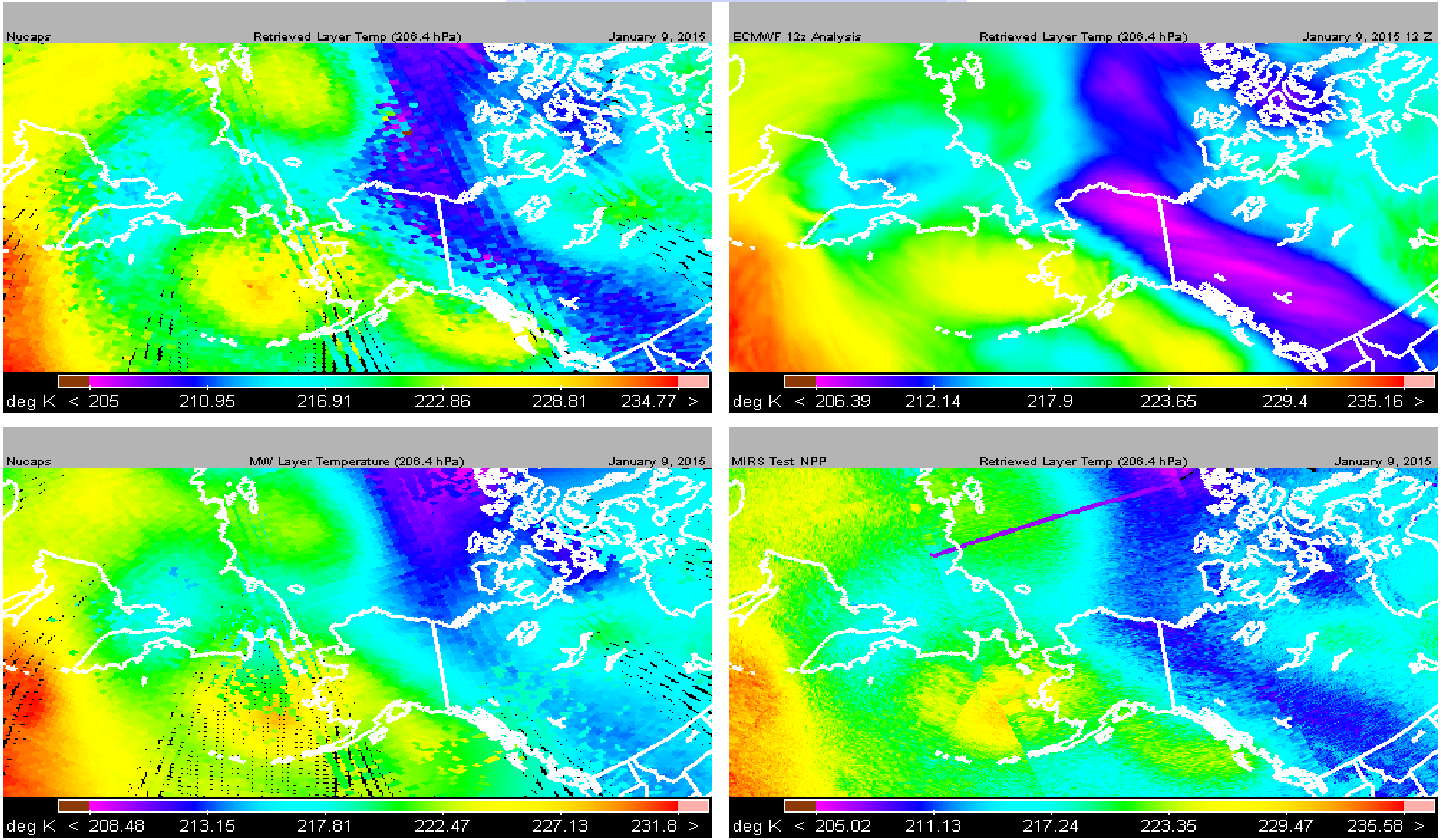
See Poster



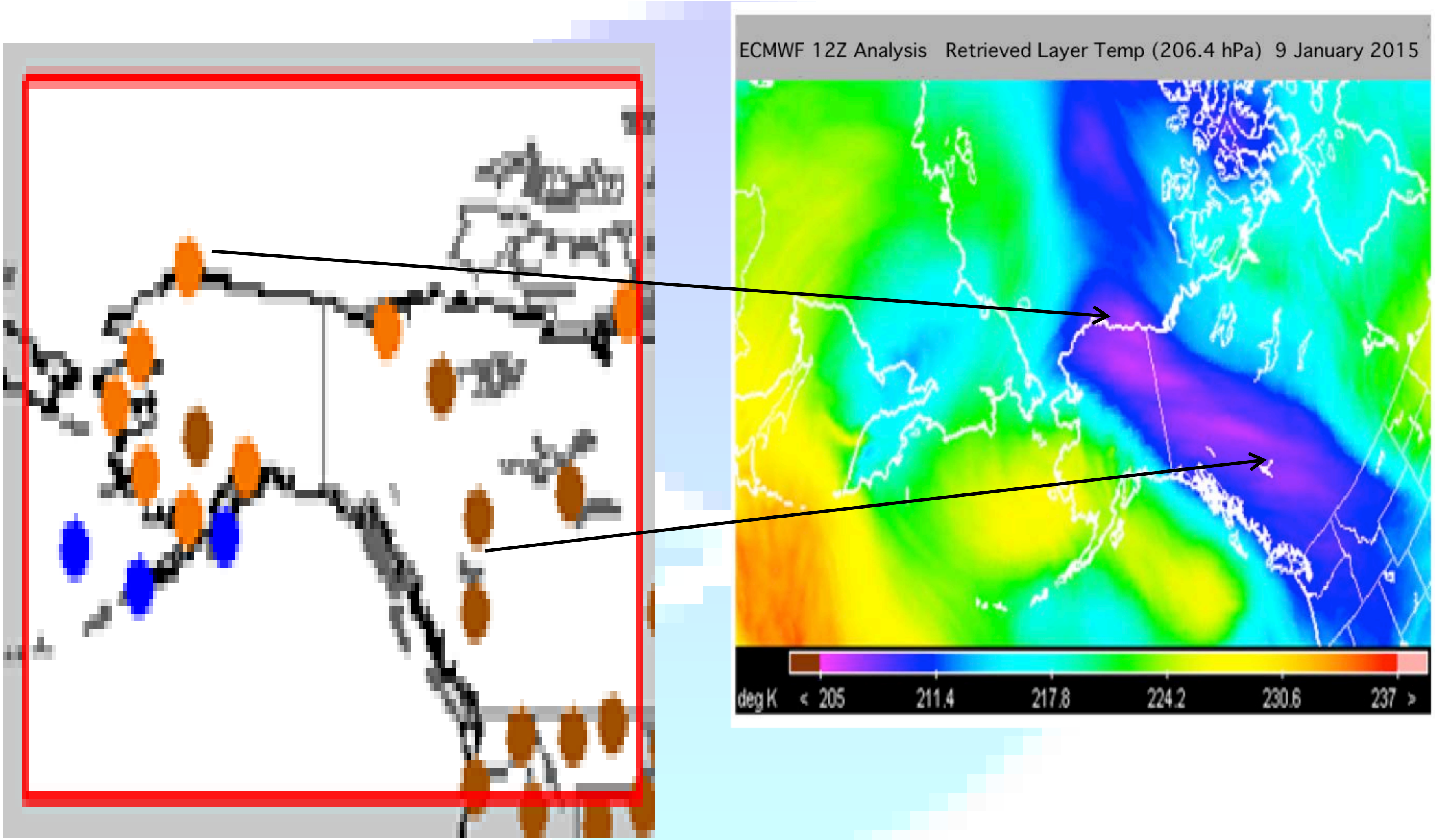
AWIPS-2 WG Cold Core Analysis

(fuel freezes below -60C)

NUCAPS IR+MW **206 hPa (35000 ft)** ECMWF



NUCAPS MW **Temp** MiRS NPP


ECMWF 12Z Analysis
Retrieved Layer Temp (206.4 hPa) 9 January 2015
deg K
< 205
211.4
217.8
224.2
230.6
237 >

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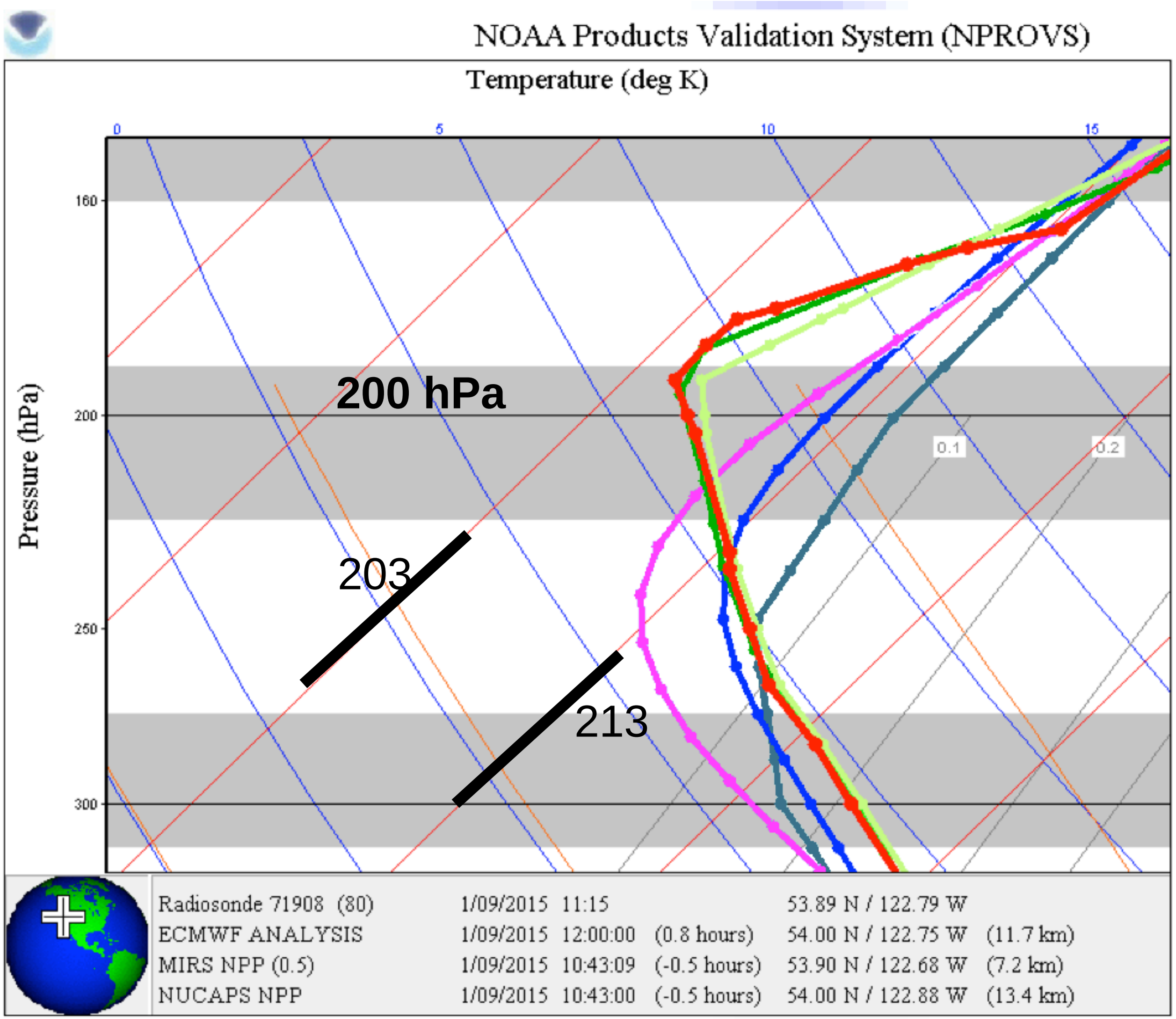
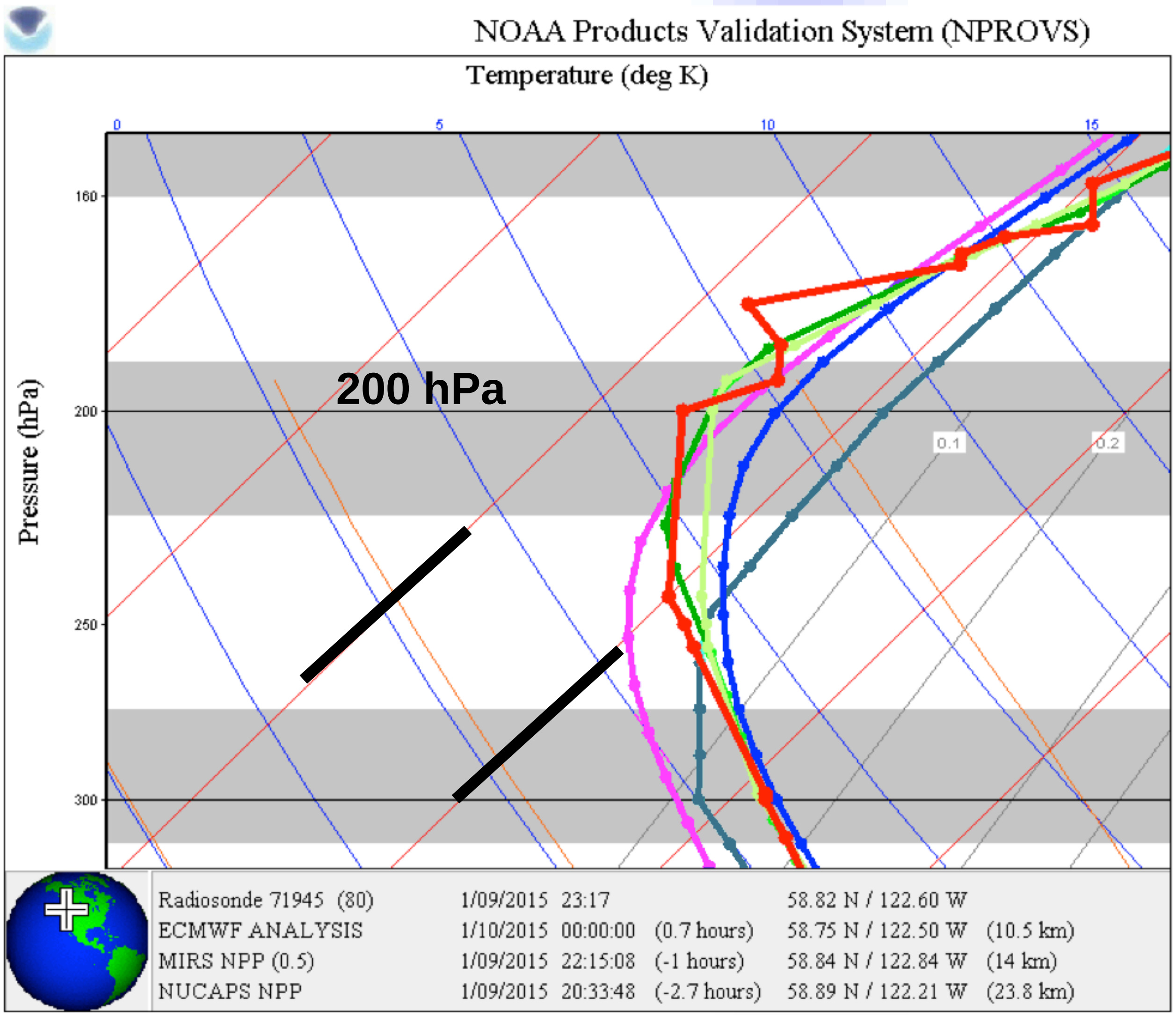


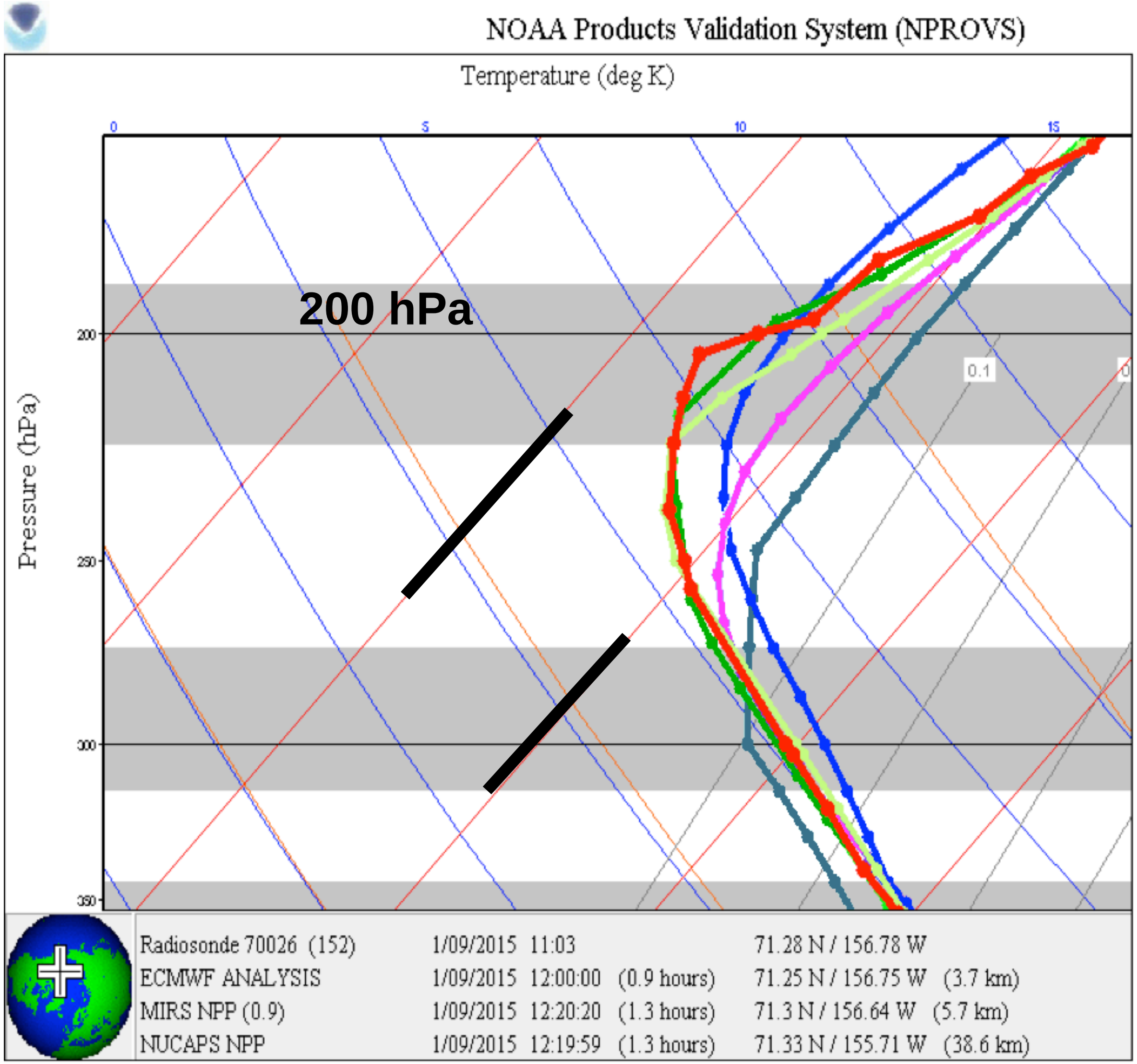
Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

Canada (S)
IR+MW pass QC



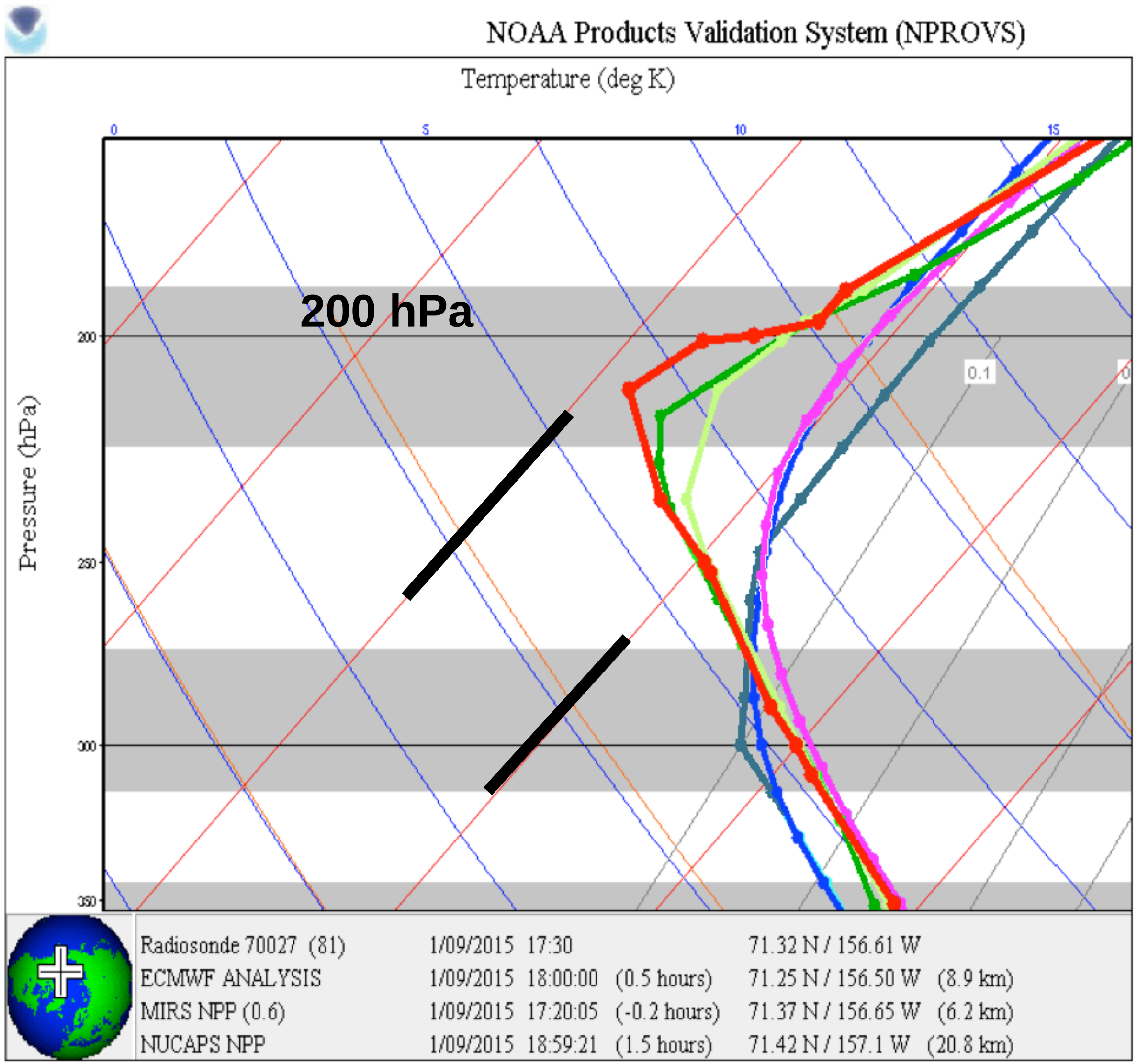
Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

Canada (N)
IR+MW pass QC



Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

NSA
IR+MW pass QC



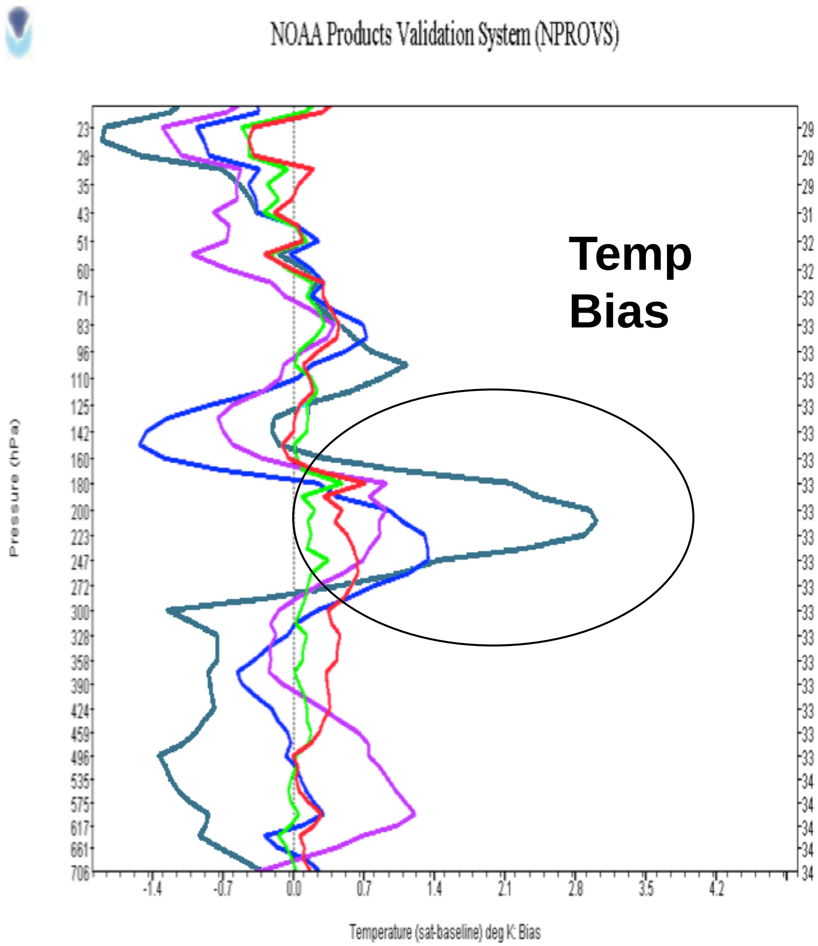
Radiosonde
GFS 6 Hour
ECMWF Analysis
MIRS NPP
NUCAP NPP
MIT

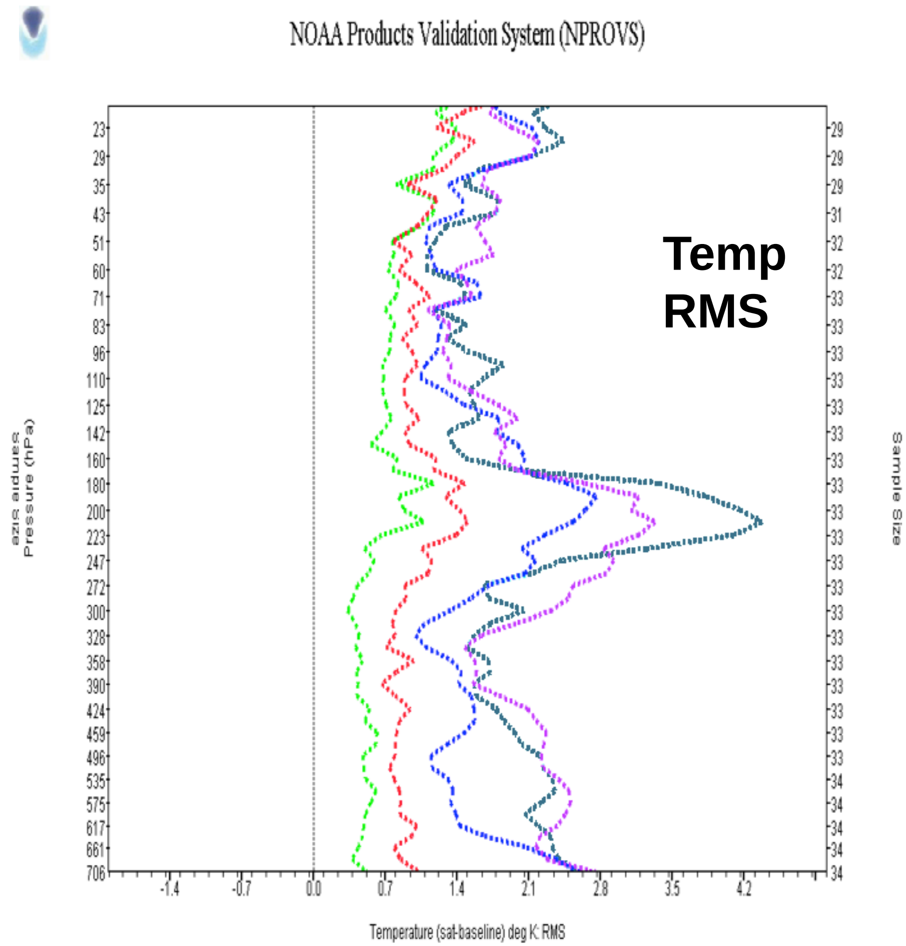
NSA

IR+MW pass QC

SAT-minus-RAOB Statistics

1. Case Study Day Jan 9 (Alaska Region)
2. Case Study Period Jan 5-15 (Alaska Region)
3. Case Study Period Jan 5-15 (CONUS)





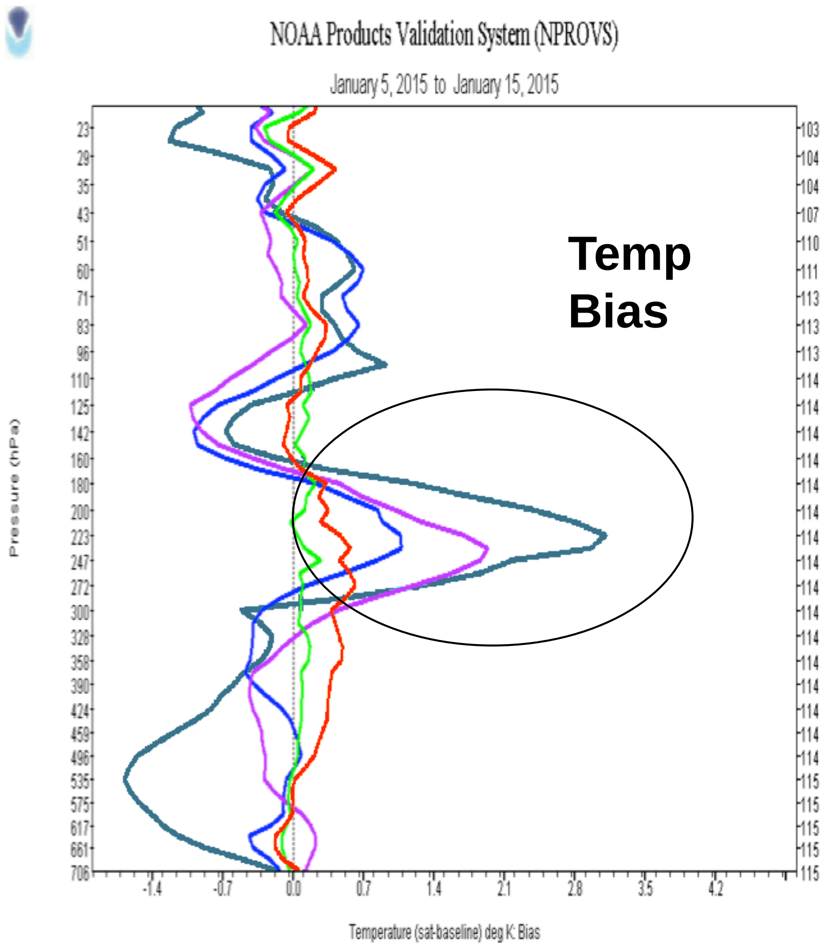
Baseline: Radiosonde

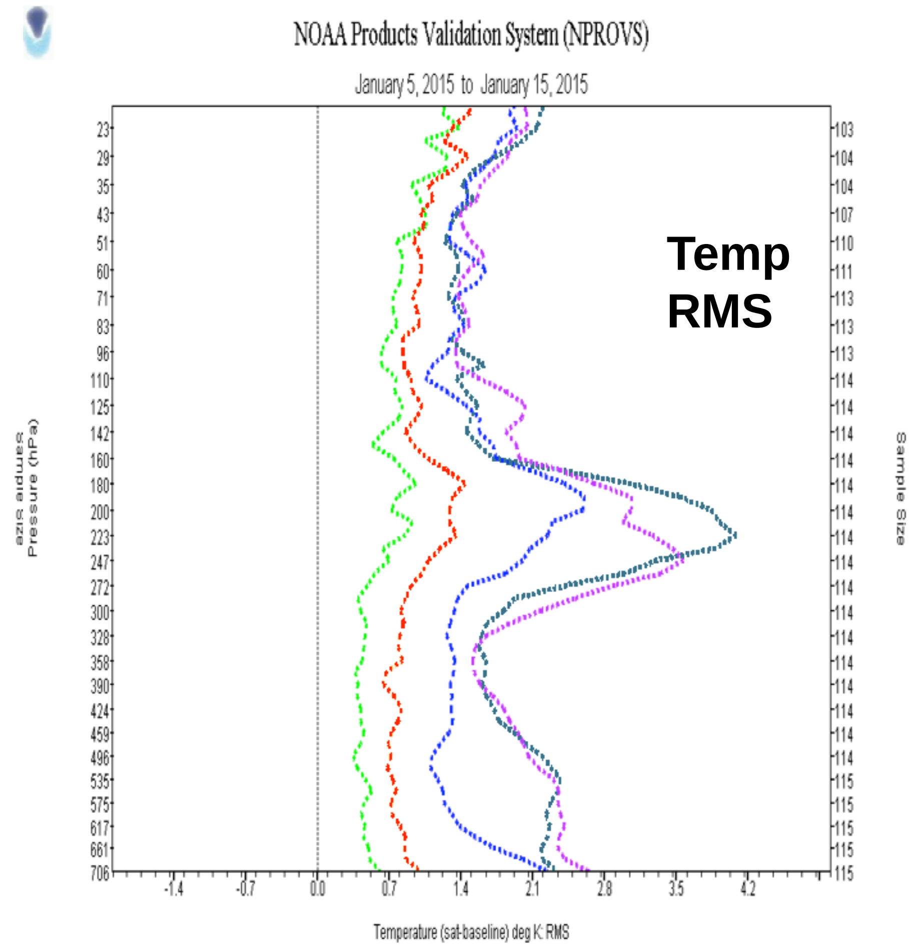
*

Radiosonde GFS 6 Hour **ECMWF Analysis** **MIRS NPP** *

NUCAPS NPP **NUCAPS NPP MIT**

SAT-minus-RAOB for Jan 9, 2015: Alaska Region (NUCAPS IR+MW and MiRS pass QC)

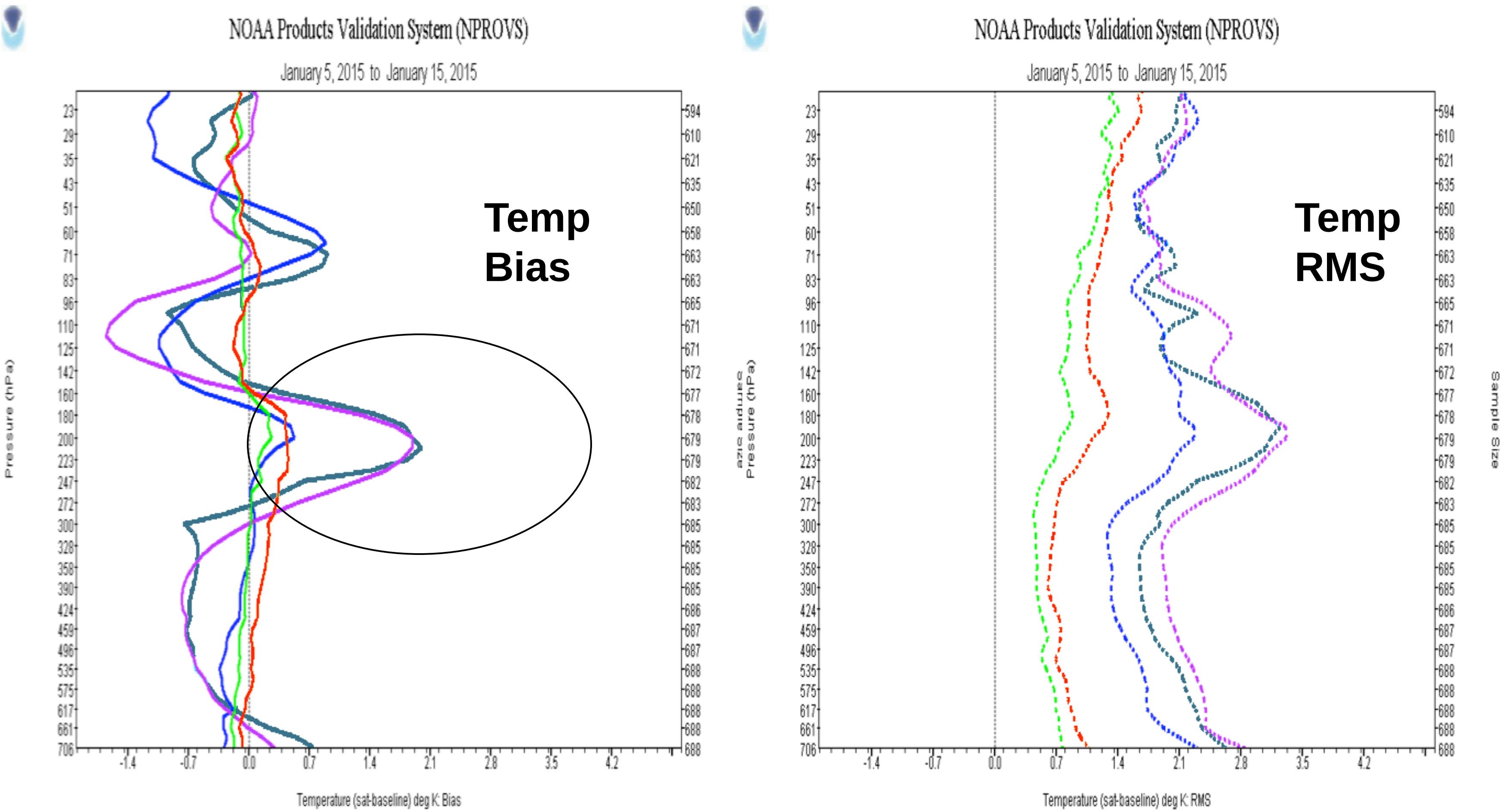




Baseline: Radiosonde

Radiosonde GFS 6 Hour   ECMWF Analysis   MIRS NPP *
NUCAPS NPP   NUCAPS NPP MIT

SAT-minus-RAOB for Jan 5-15, 2015: Alaska Region (NUCAPS IR+MW and MiRS pass QC)



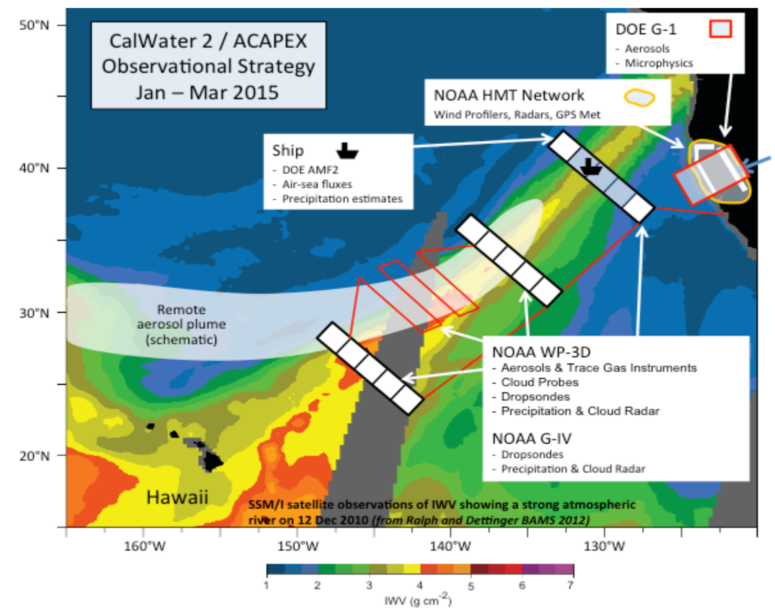
Baseline: Radiosonde

Radiosonde GFS 6 Hour * ECMWF Analysis MIRS NPP *
NUCAPS NPP NUCAPS NPP MIT

SAT-minus-RAOB for Jan 5-15, 2015: CONUS (NUCAPS IR+MW and MiRS pass QC)

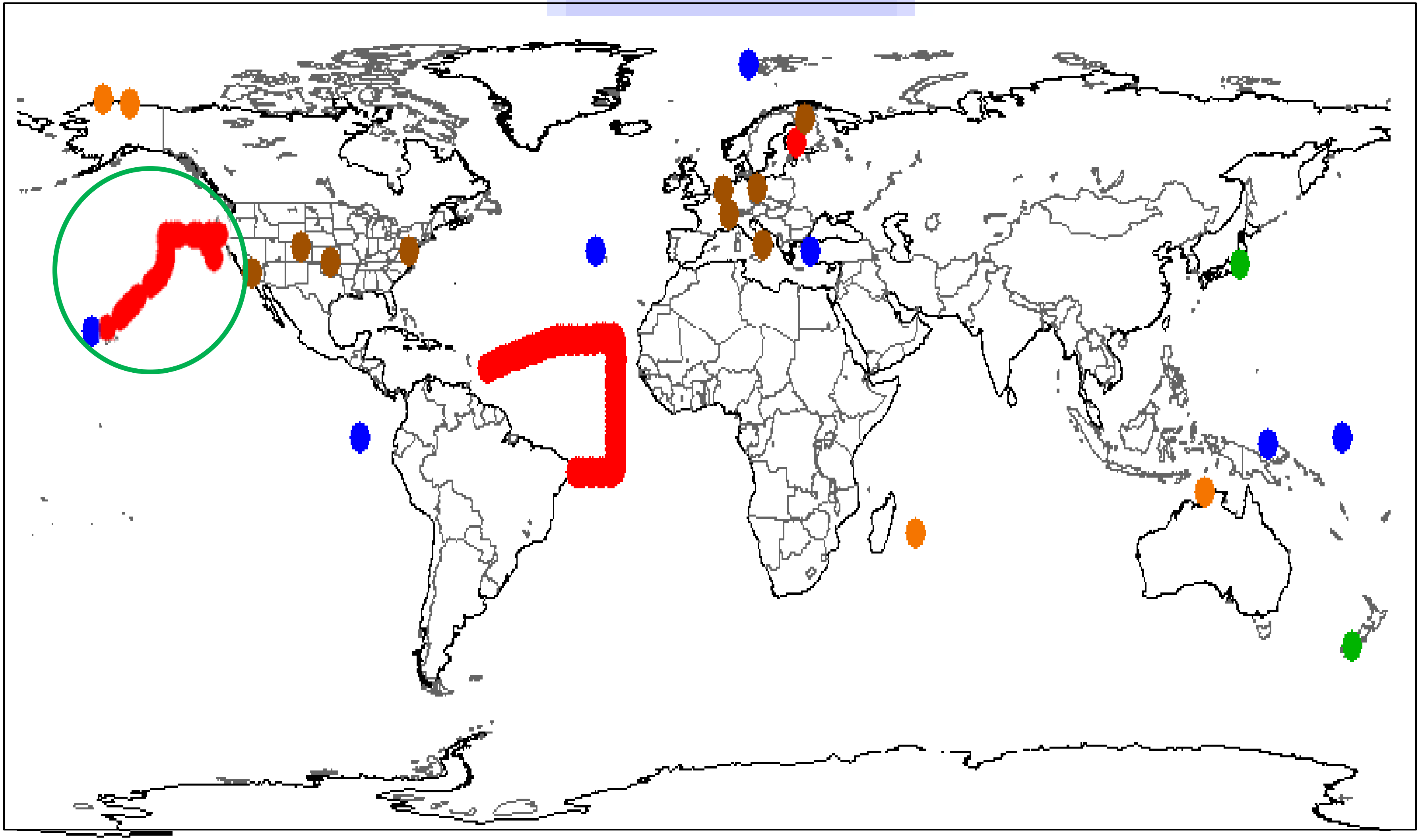
CalWater 2/ACAPEX Field Campaign

- 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

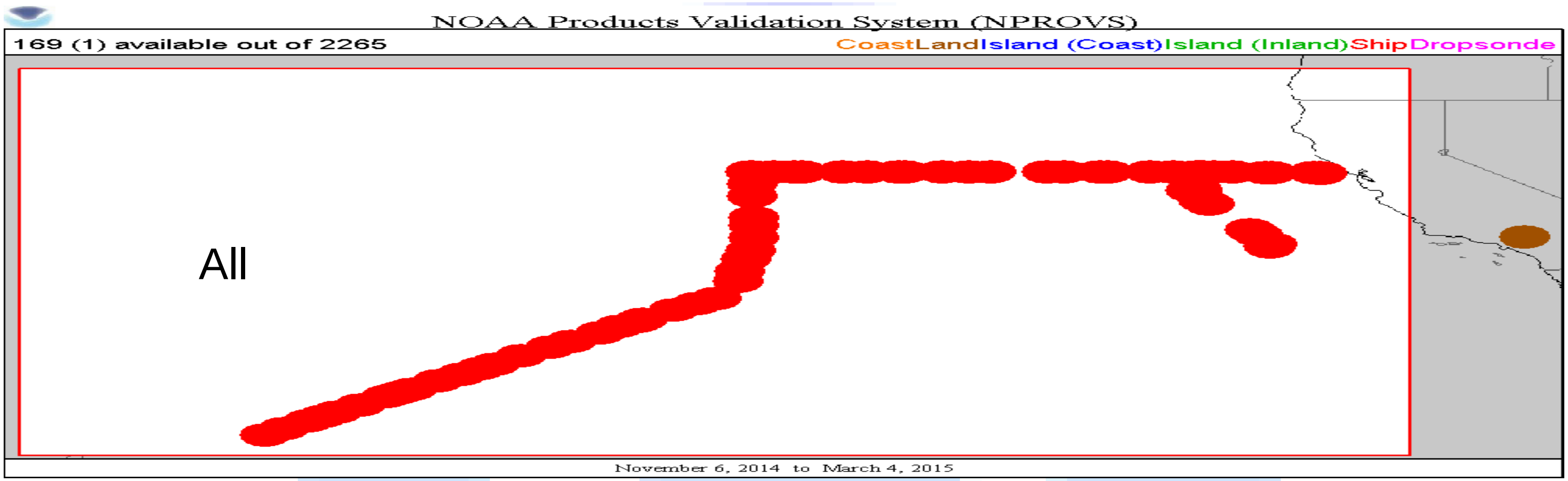


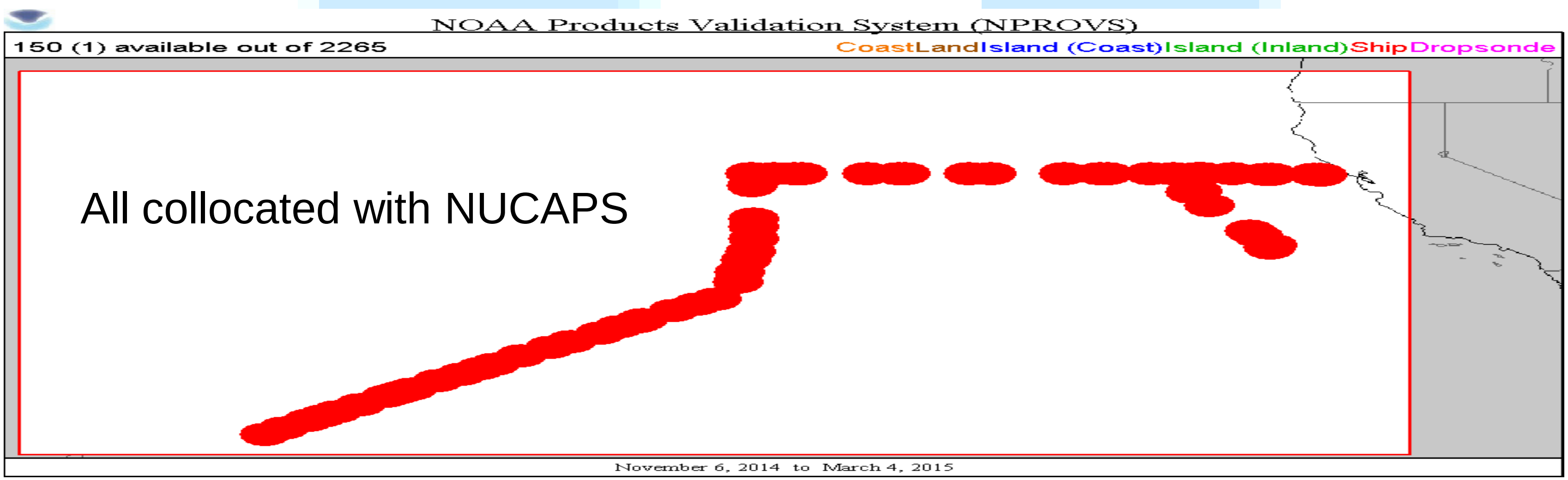
Platform	Range of Obs	Duration	Types of sensors
AR Observatories and Hydro-Met Testbed	ARO sites: CA(4), OR(2), WA(1)	Full campaign	Snow level radar (S-band), 449 MHz wind profilers, soil moisture, 10 meter surface tower
NOAA WP-3D	1-22 kft, 4000 km range	80h over 4 weeks	~150 dropsondes, W-band radar (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)

NPROVS+

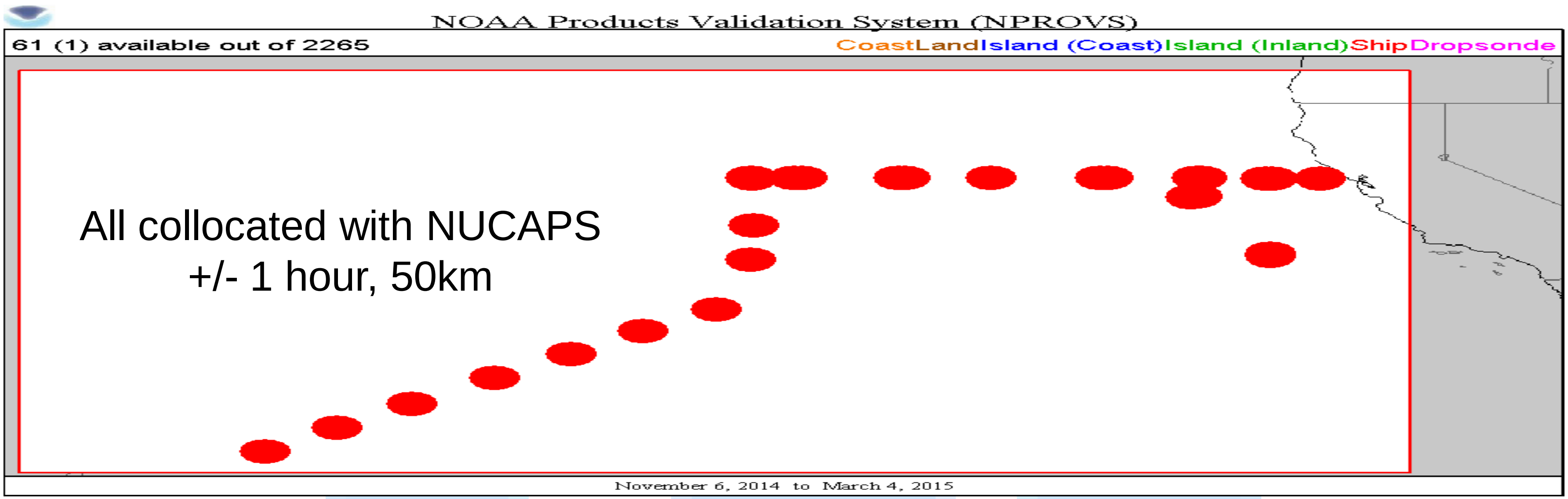


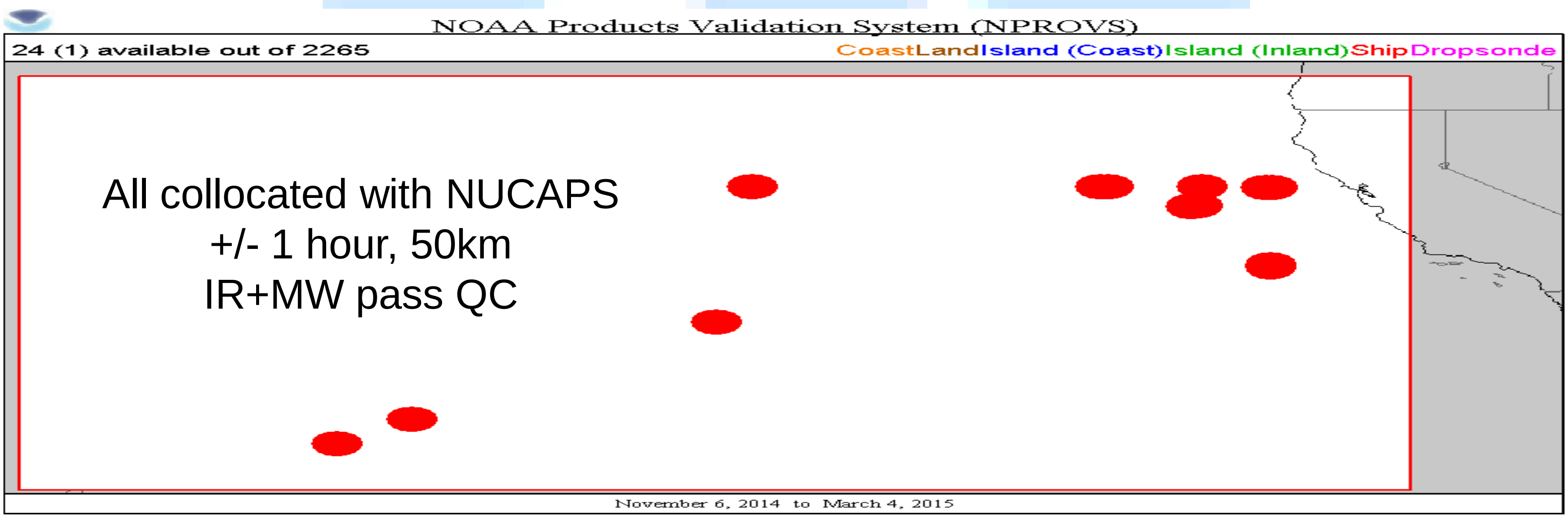
GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 10,000 RAOBS (1000 dedicated) available since July 2013



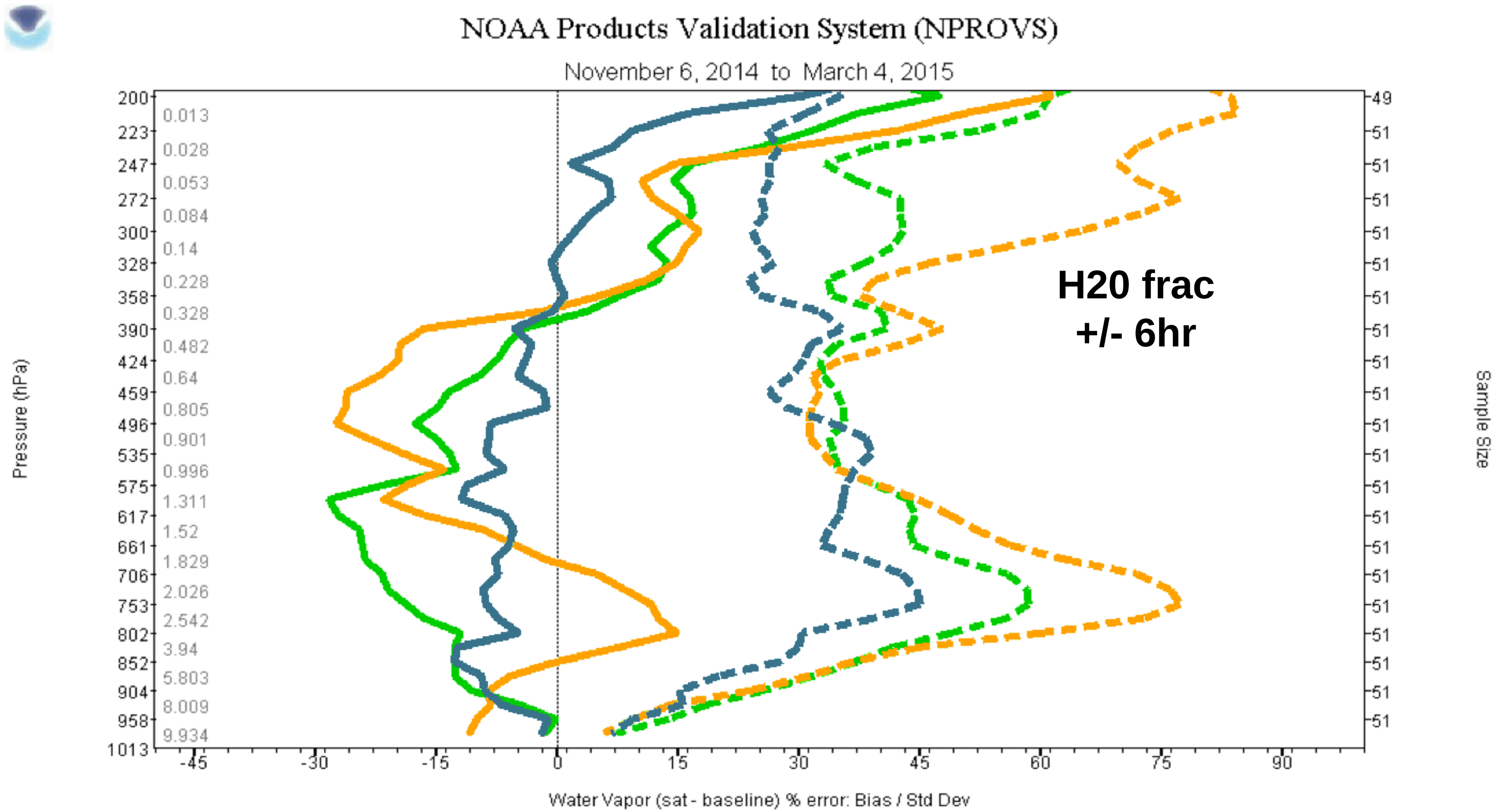


CALWATER RAOB collocated with NUCAPS





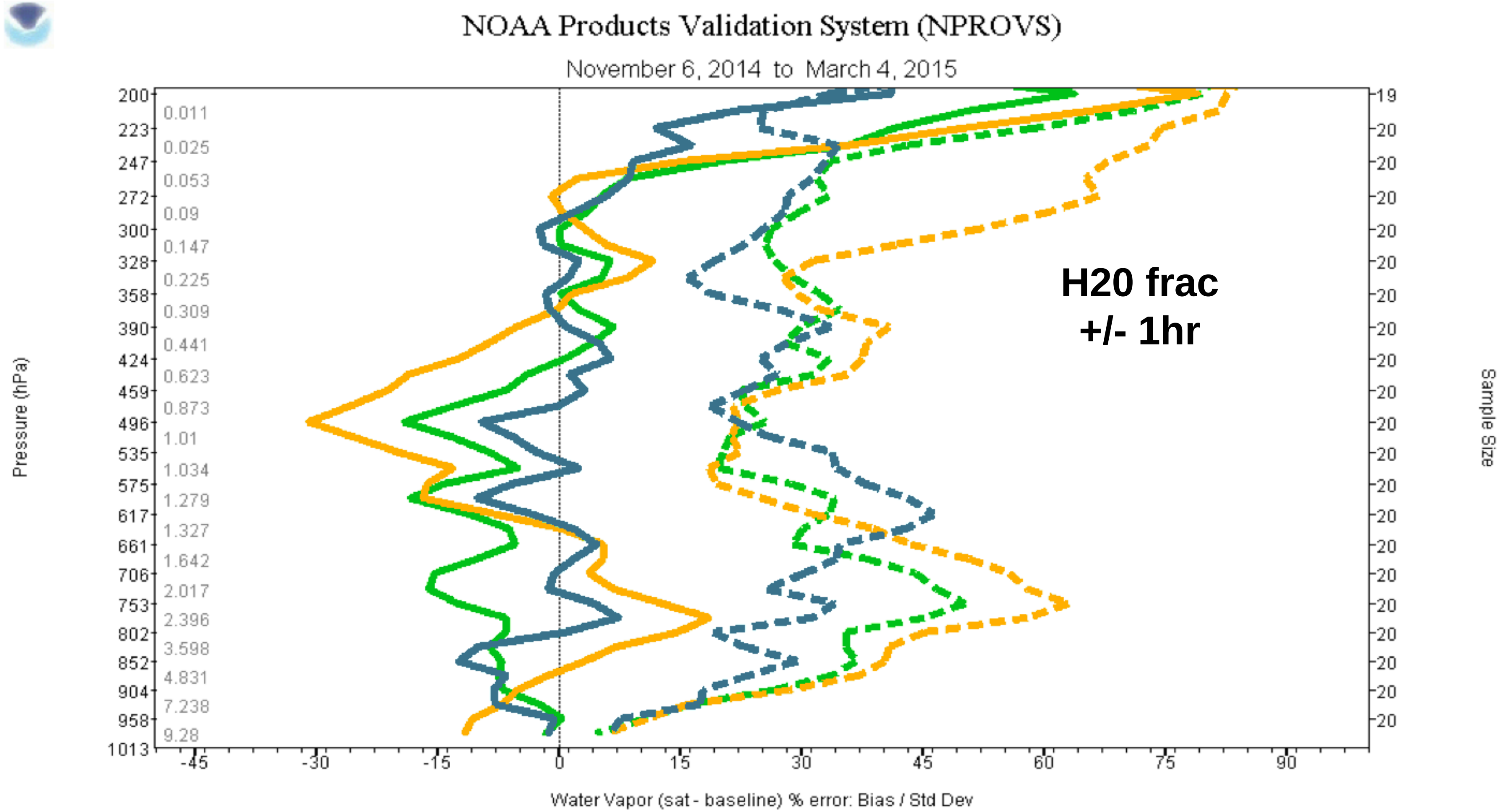
CALWATER RAOB collocated with NUCAPS



Baseline: Reference Sonde GRUAN RAOB

ECMWF Analysis **MIRS NPP Test** **NUCAPS NPP**

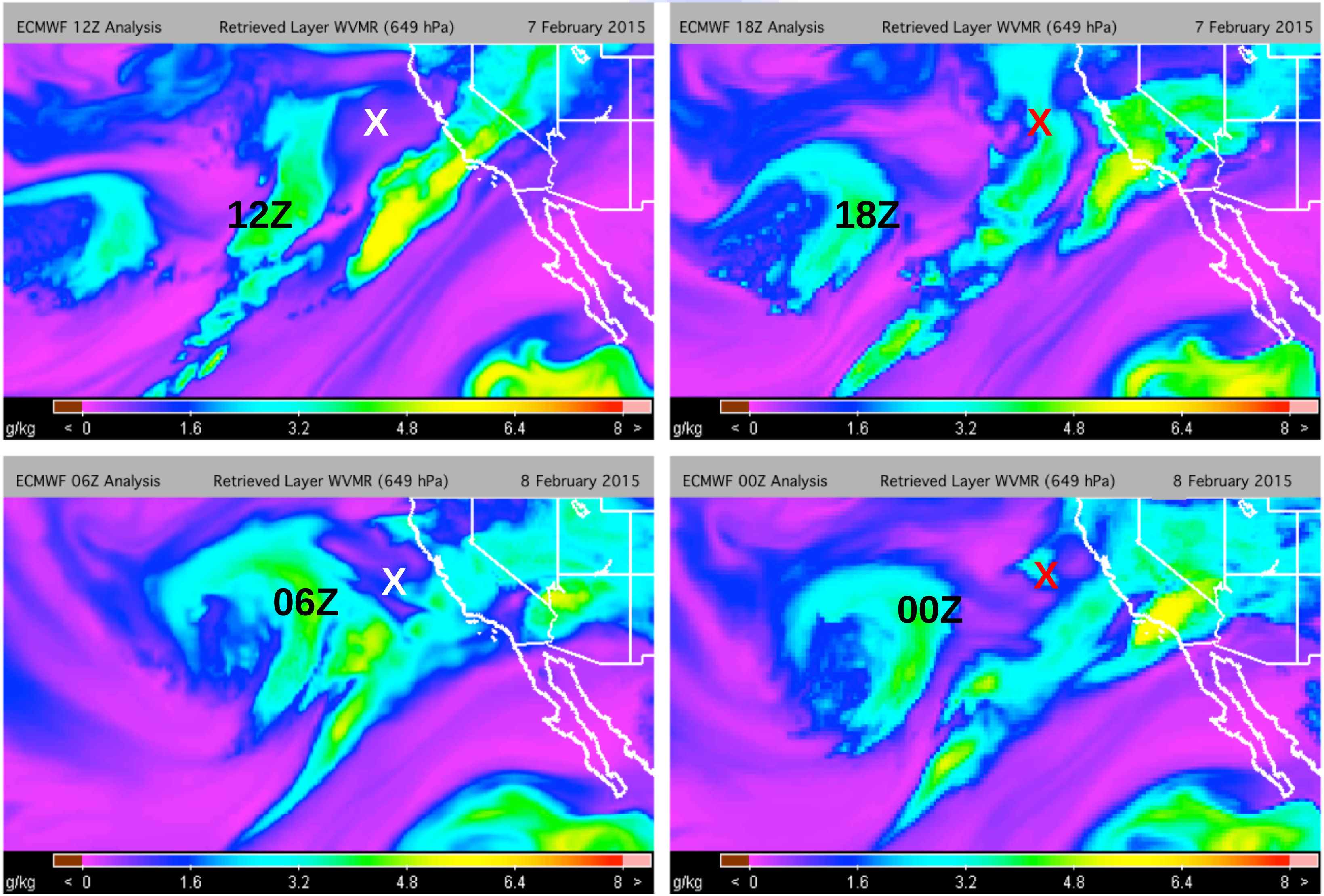
Sample of NUCAPS IR which pass QC



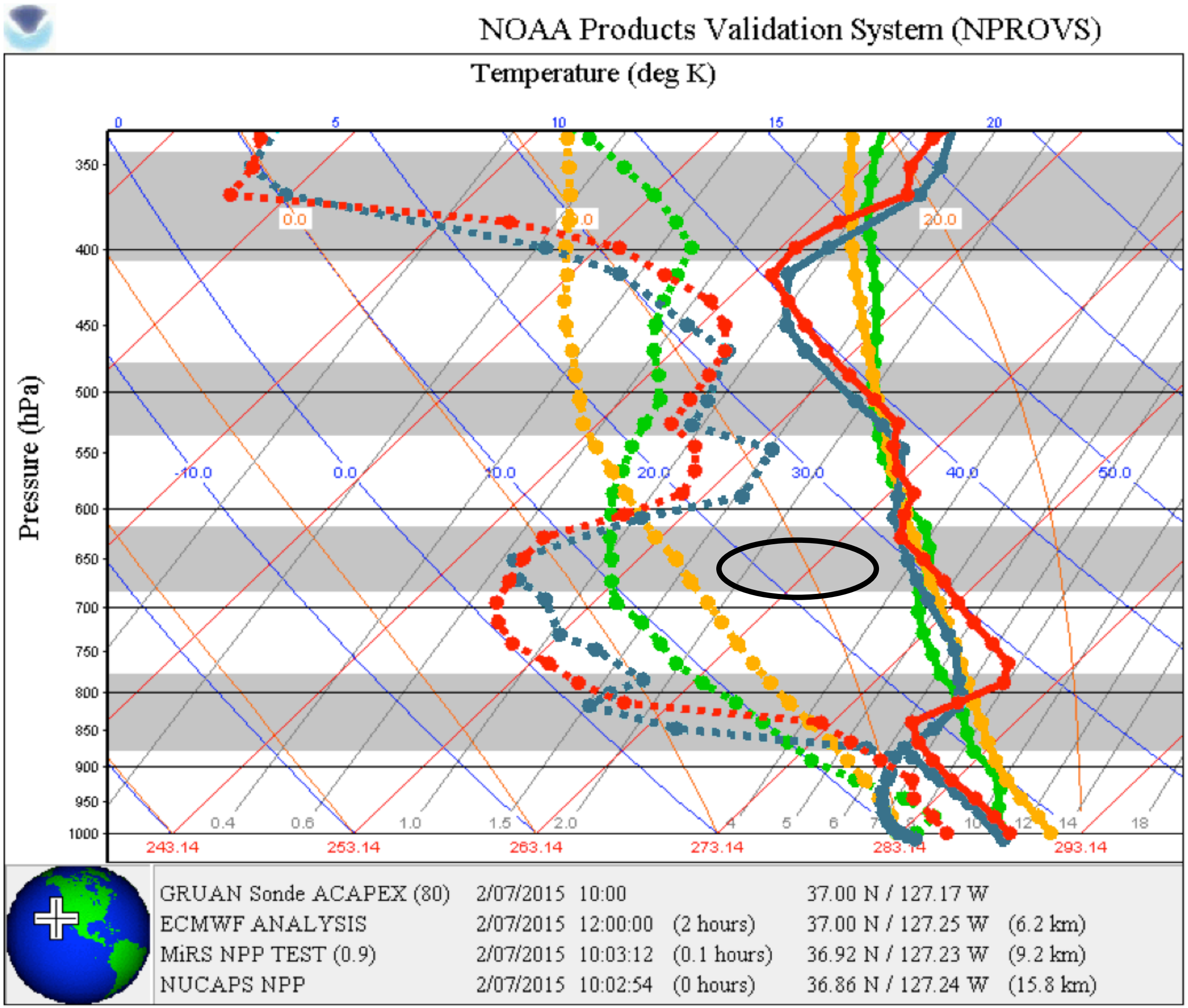
Baseline: Reference Sonde GRUAN RAOB

ECMWF Analysis MIRS NPP Test NUCAPS NPP

Sample of NUCAPS IR which pass QC

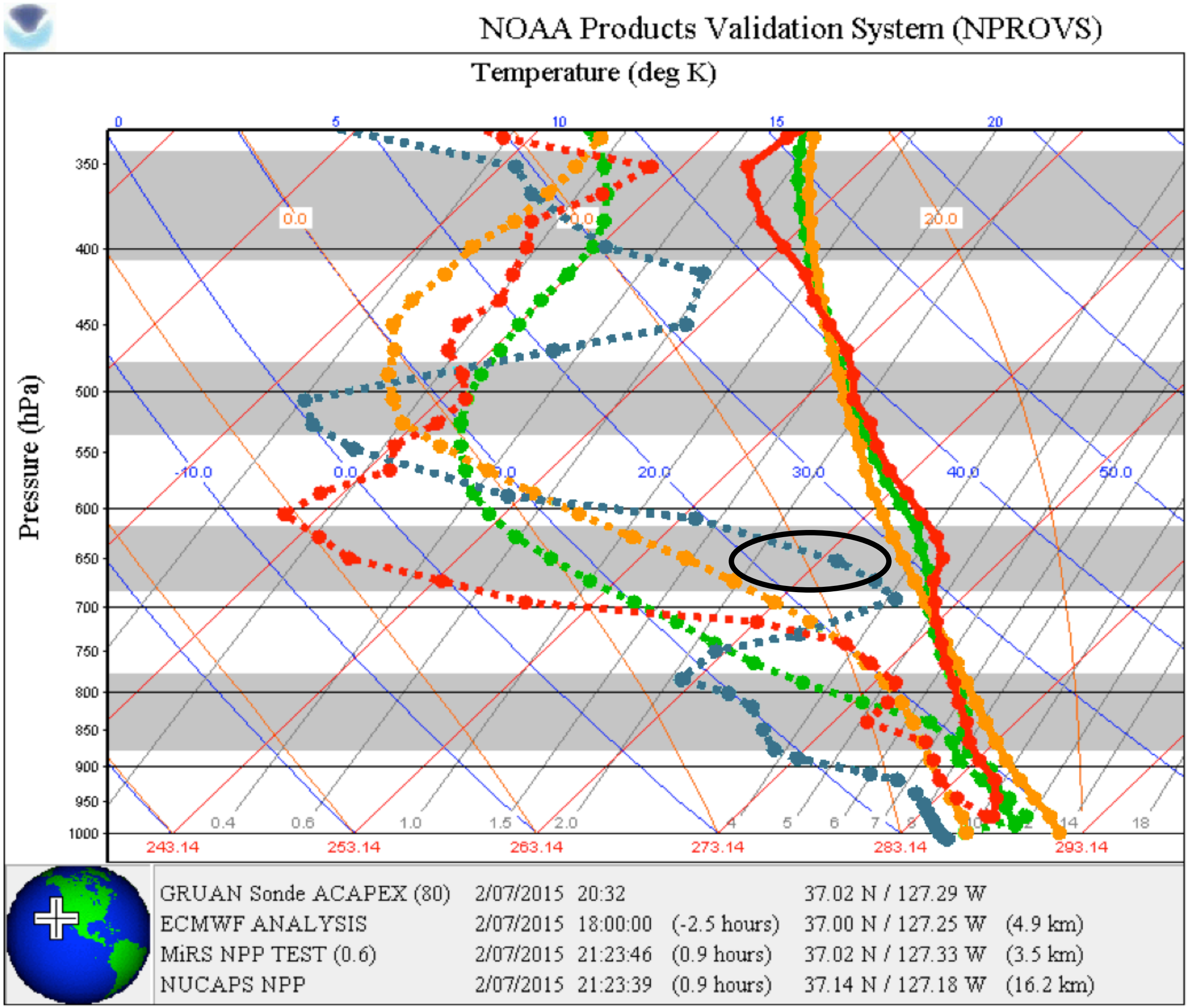


ECMWF 12Z (Feb 7th) to 6Z (Feb 8th)



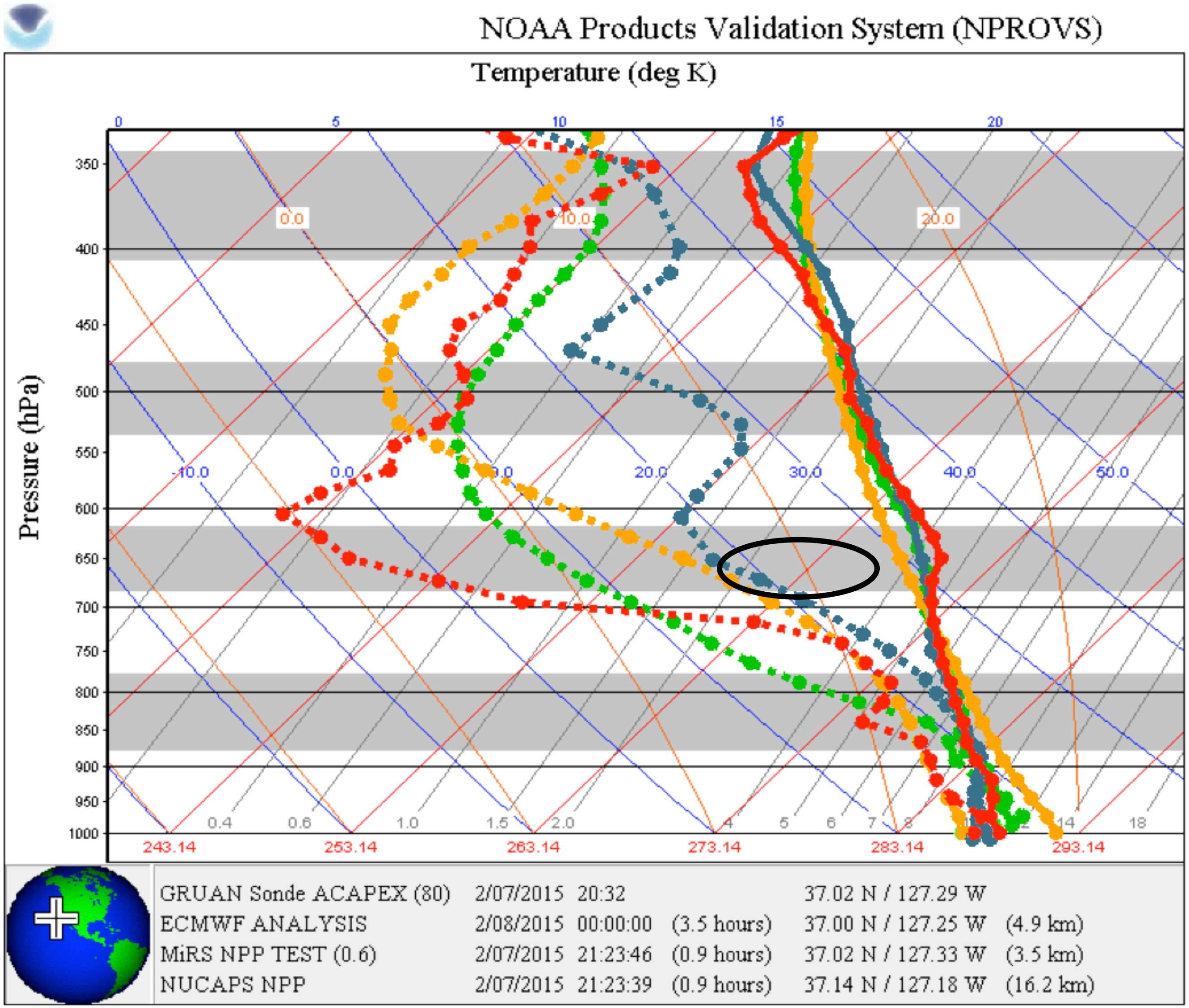
Reference Sonde
ECMWF Analysis
MIRS NPP Test
NUCAPS NPP

SAT @ 1003Z … ECMWF @ 12Z … RAOB @ 1000Z



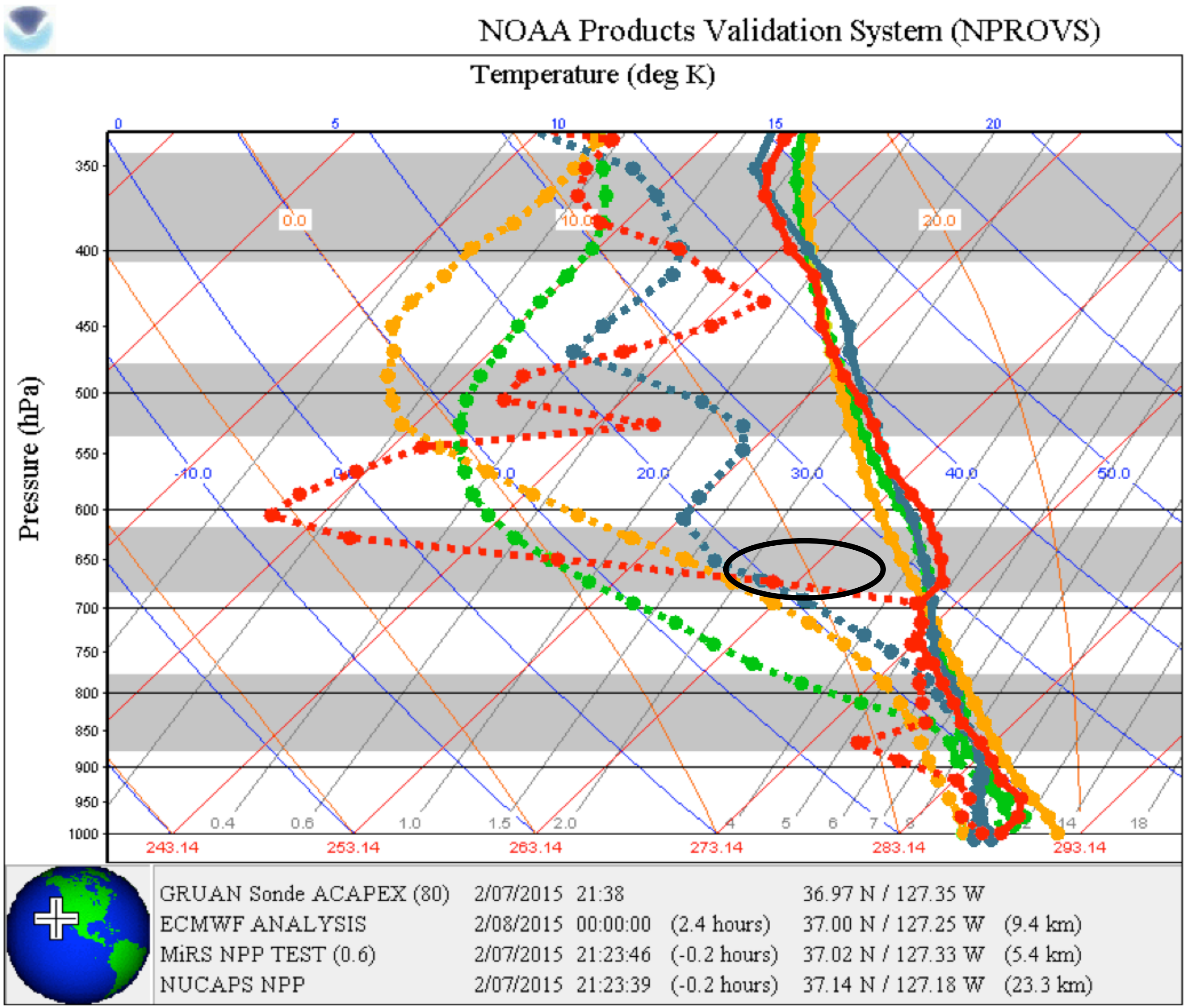
Reference Sonde
ECMWF Analysis
MIRS NPP Test
NUCAPS NPP

SAT @ 2123Z … ECMWF @ 18Z … RAOB @ 2032Z



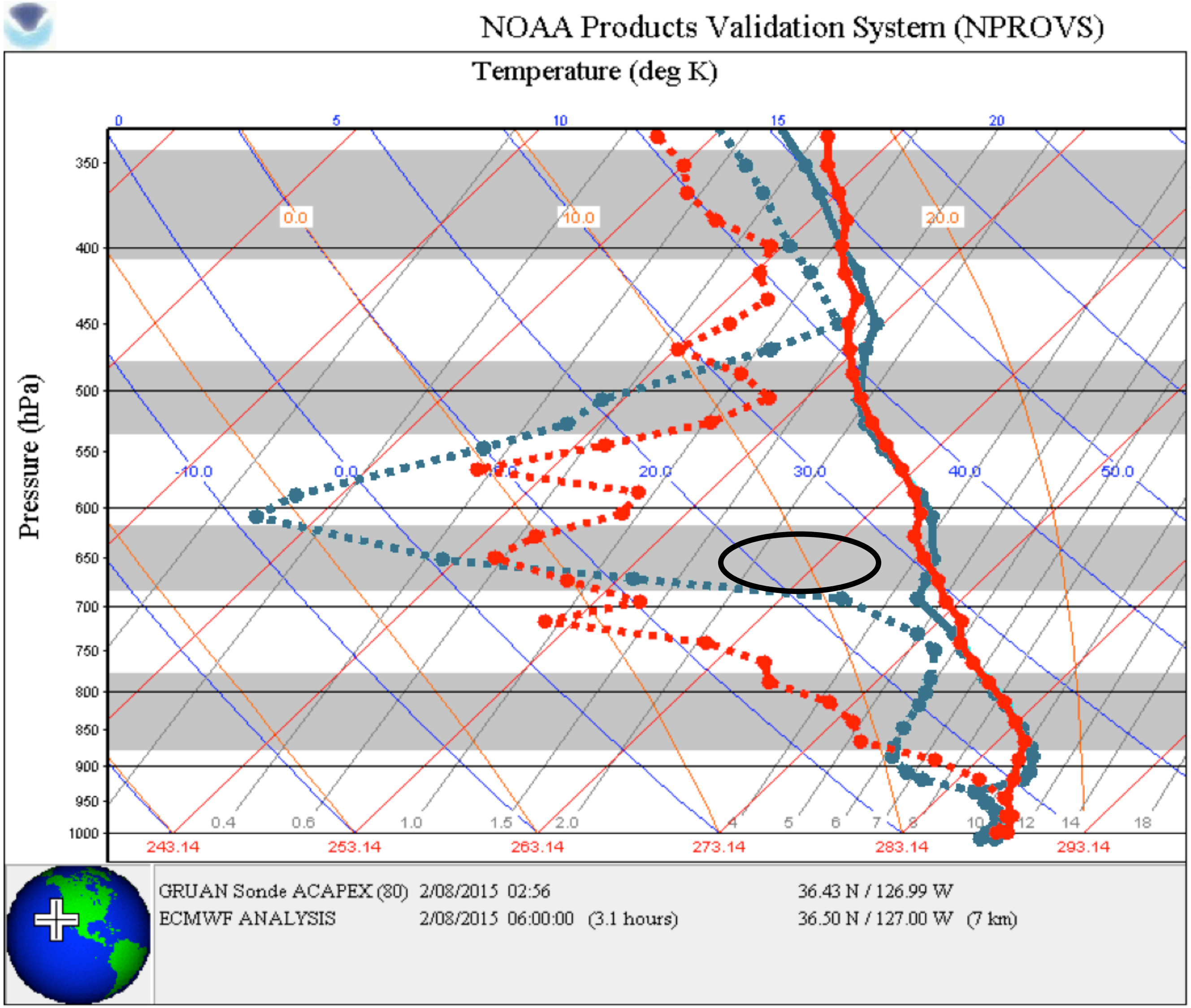
Reference Sonde
ECMWF Analysis
MIRS NPP Test
NUCAPS NPP

SAT @ 2123Z … ECMWF @ 00Z … RAOB @ 2032Z



Reference Sonde
ECMWF Analysis
MIRS NPP Test
NUCAPS NPP

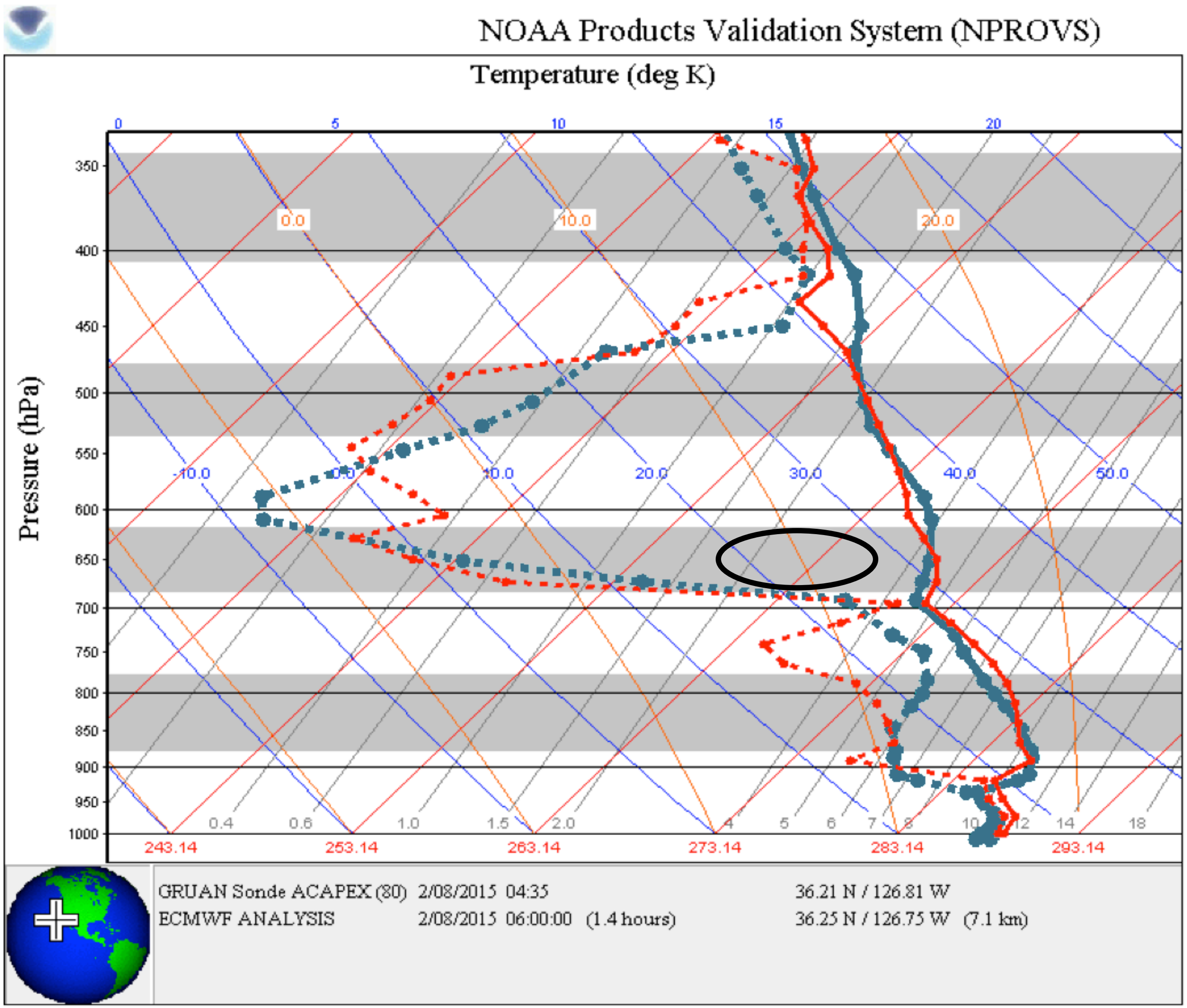
SAT @ 2123Z … ECMWF @ 00Z … RAOB @ 2138Z



Reference Sonde

ECMWF Analysis

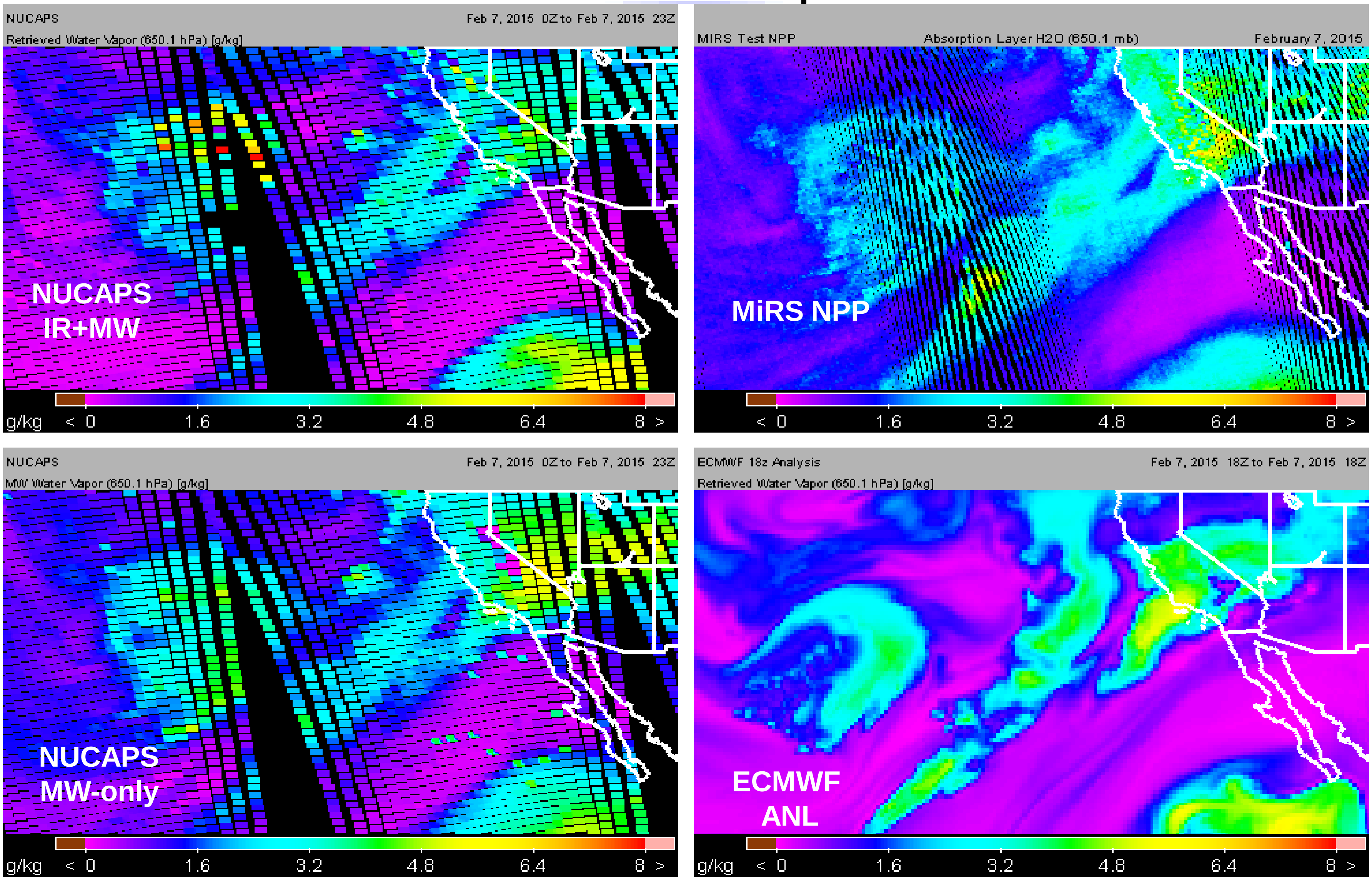
SAT @ … ECMWF @ 06Z … RAOB @ 0256Z



Reference Sonde
ECMWF Analysis

SAT @ … ECMWF @ 06Z … RAOB @ 0435Z

650 hPa H20 Vapor



SAT @ 21Z Feb 7th … ECMWF @ 18Z

Special session on users

featuring

ongoing AWIPS-2 activities

top utilize NUCAPS (etc) sounding

at

at NWS field office

Thursday

10:30

GRUAN Reference Measurement Principles (see Poster)

Given two measurement (m1, m2), their uncertainty (u_1, u_2) and variability (σ), then two observations are **consistent** if k .le. 2:

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

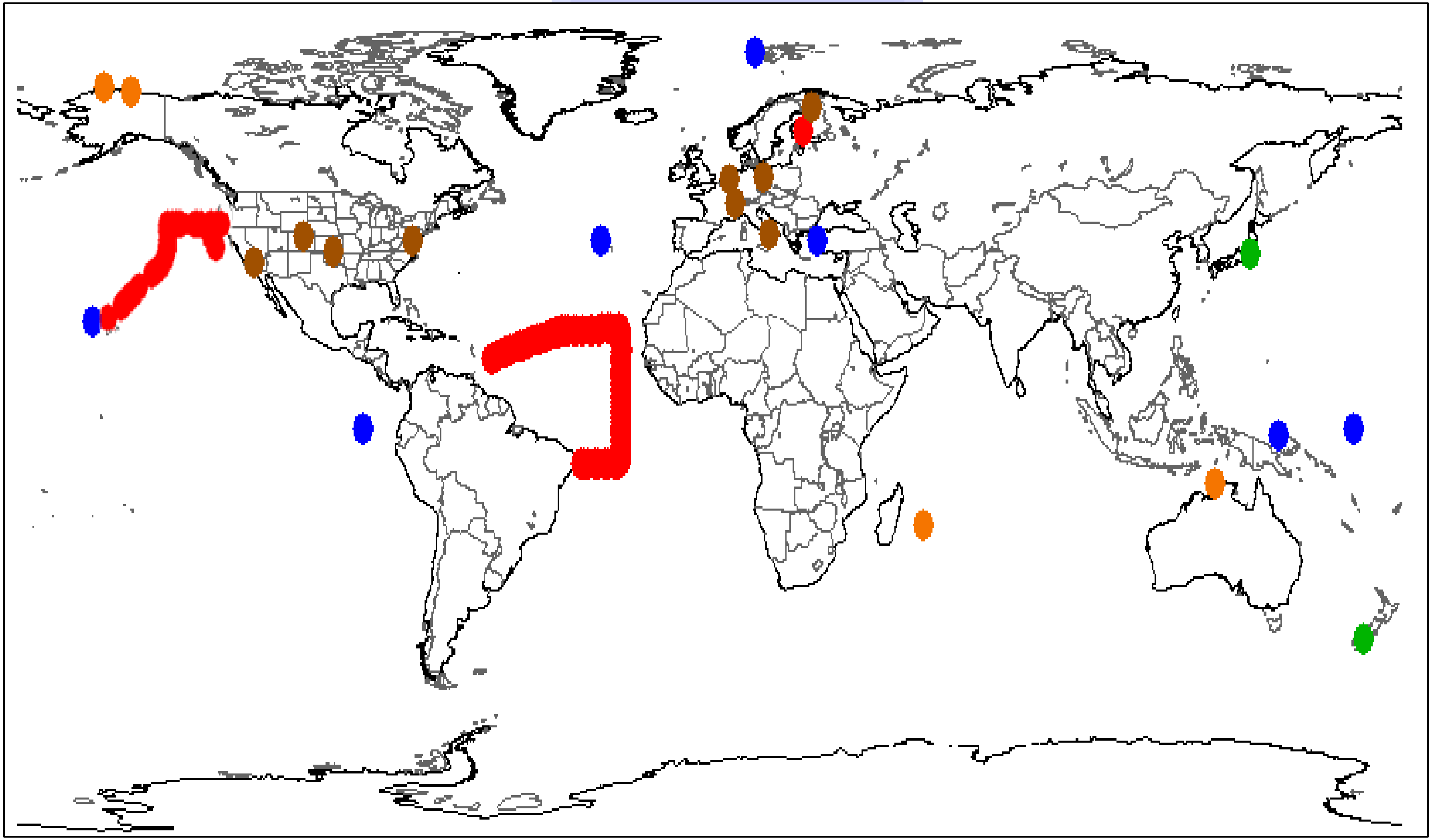
... in following plots :

K = ABS(X – GRUAN) / u

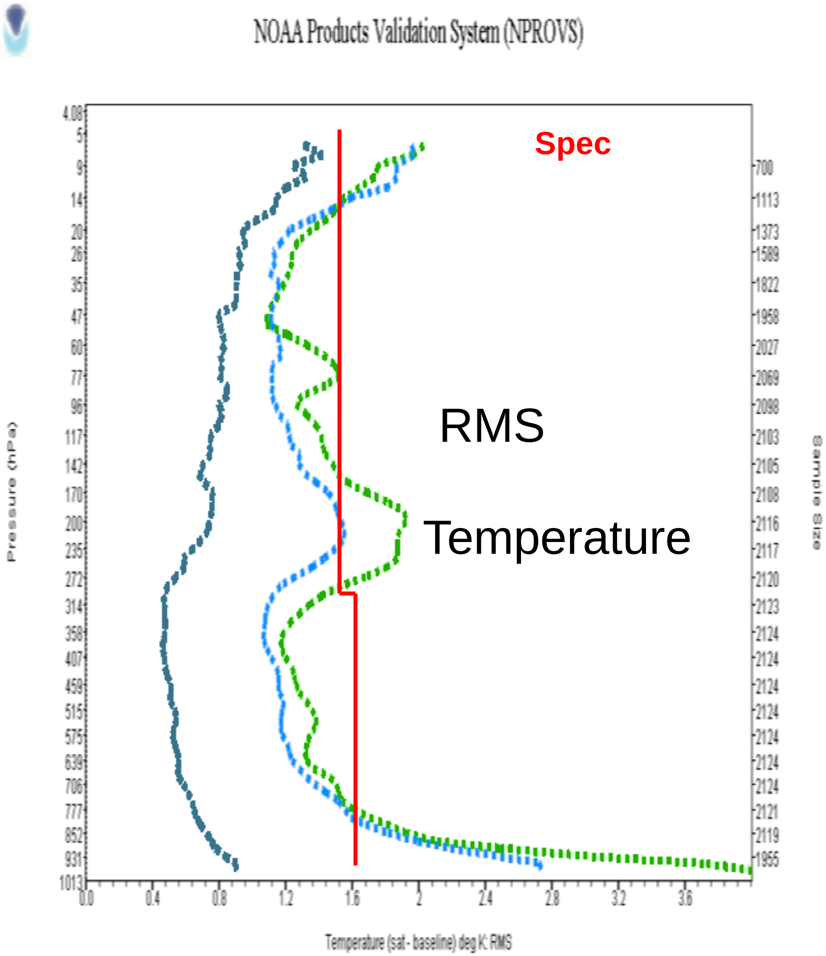
where u is GRUAN or NASA v6 uncertainty

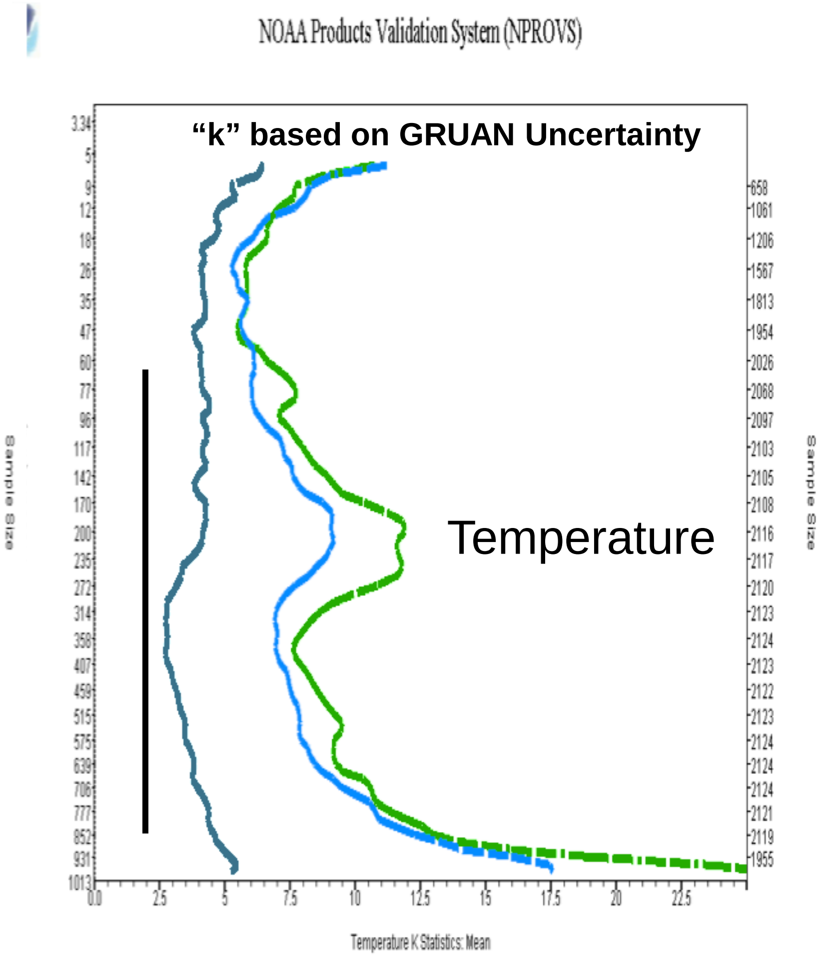
"need uncertainty estimates for EDR" !!

NPROVS+



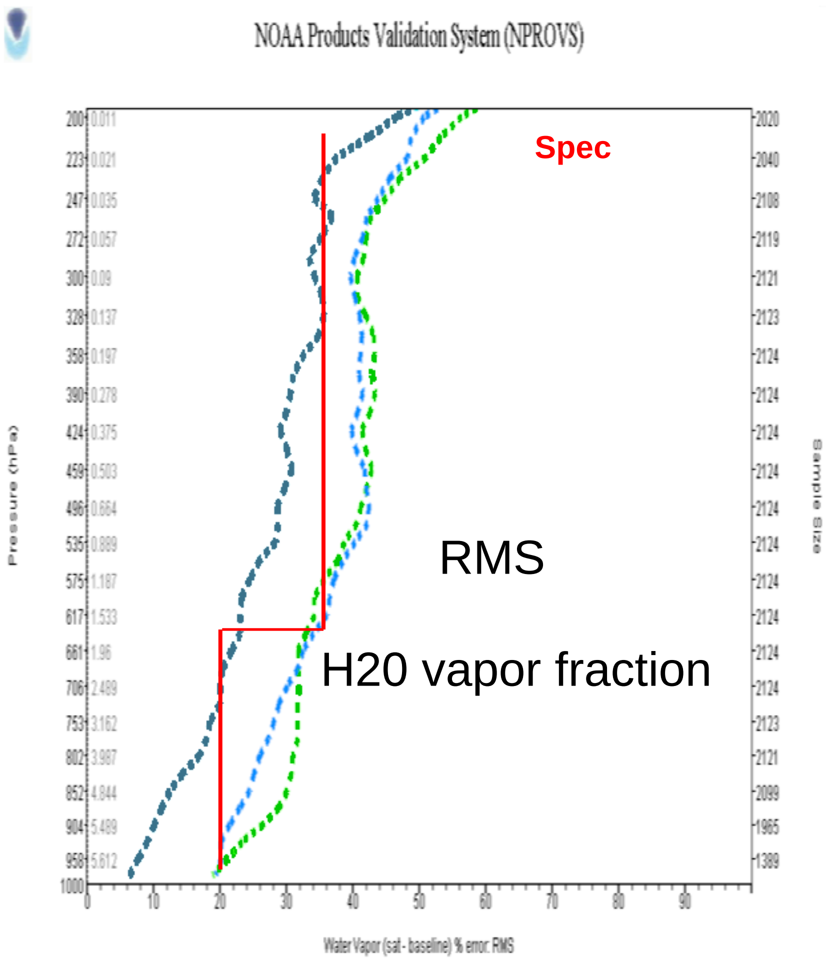
GRUAN and JPSS funded Dedicated (S-NPP) RAOB Sites
Over 10,000 RAOBS (1000 Dedicated) available since July 2013

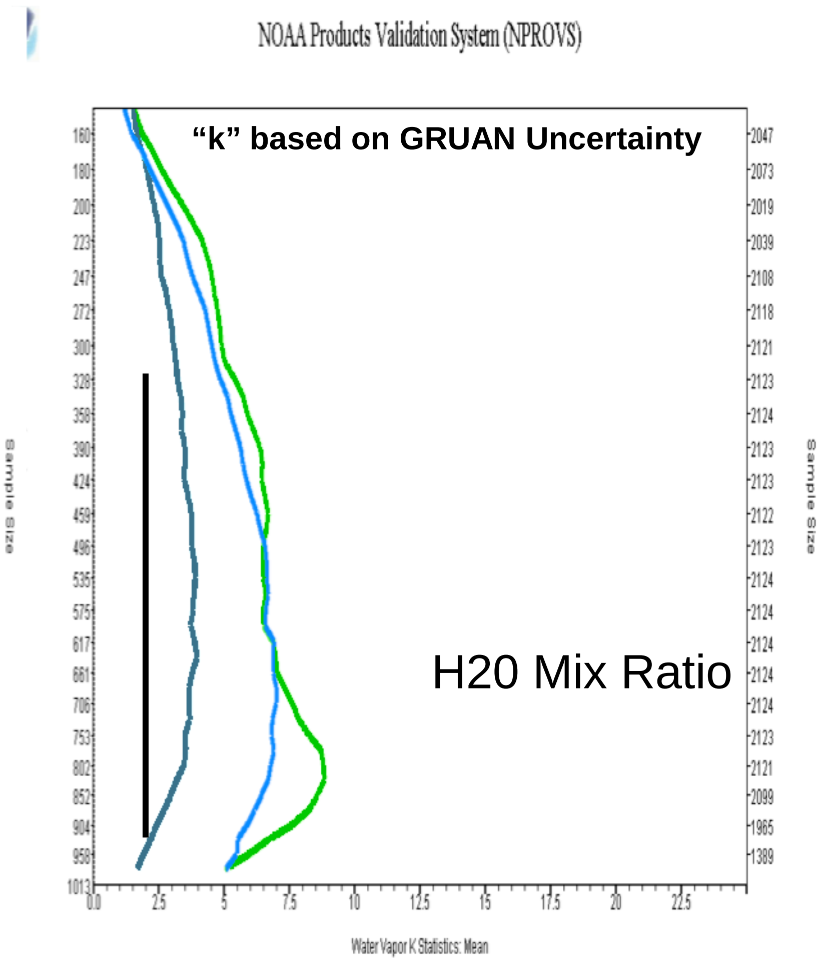




Baseline: GRUAN Radiosonde

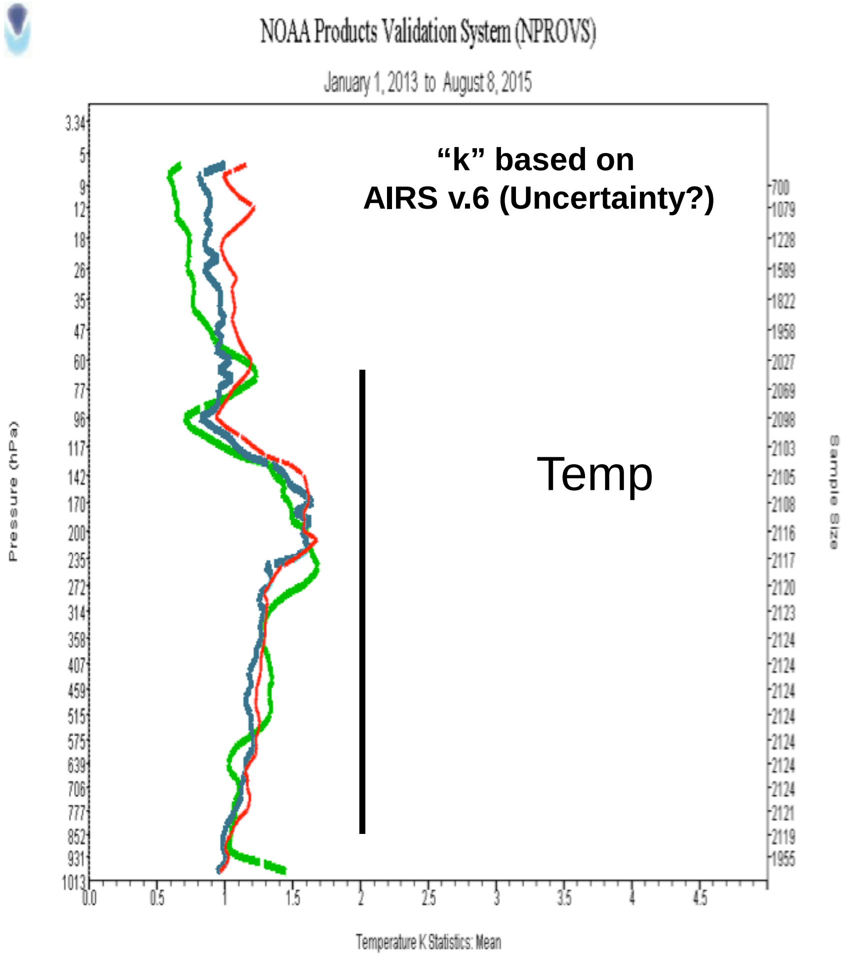
AIRS AQUA **ECMWF** **NUCAPS NPP**

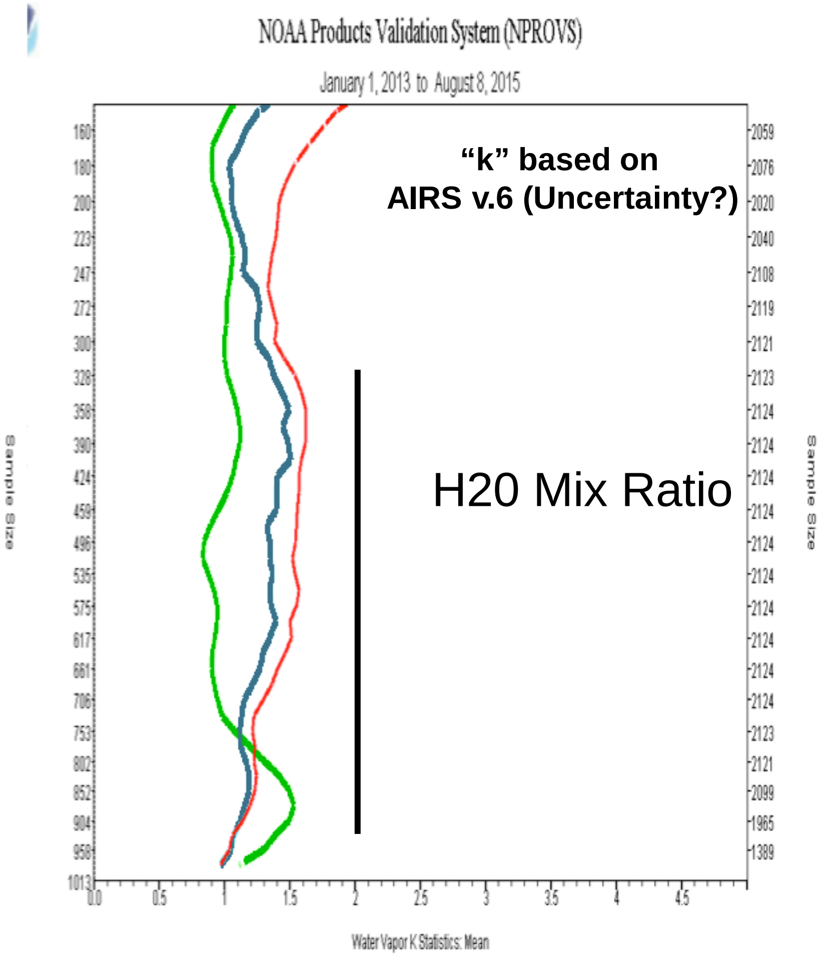




Baseline: GRUAN Radiosonde

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





Baseline: AIRS AQUA

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

"k" based on AIRS v.6 (Uncertainty?)

SUMMARY

- Independent validation of multiple product system performance provided by NPROVS/NPROVS+ (see Poster; Pettey)

- LTM tracks overall characteristic performance and targets areas of improvement for respective systems

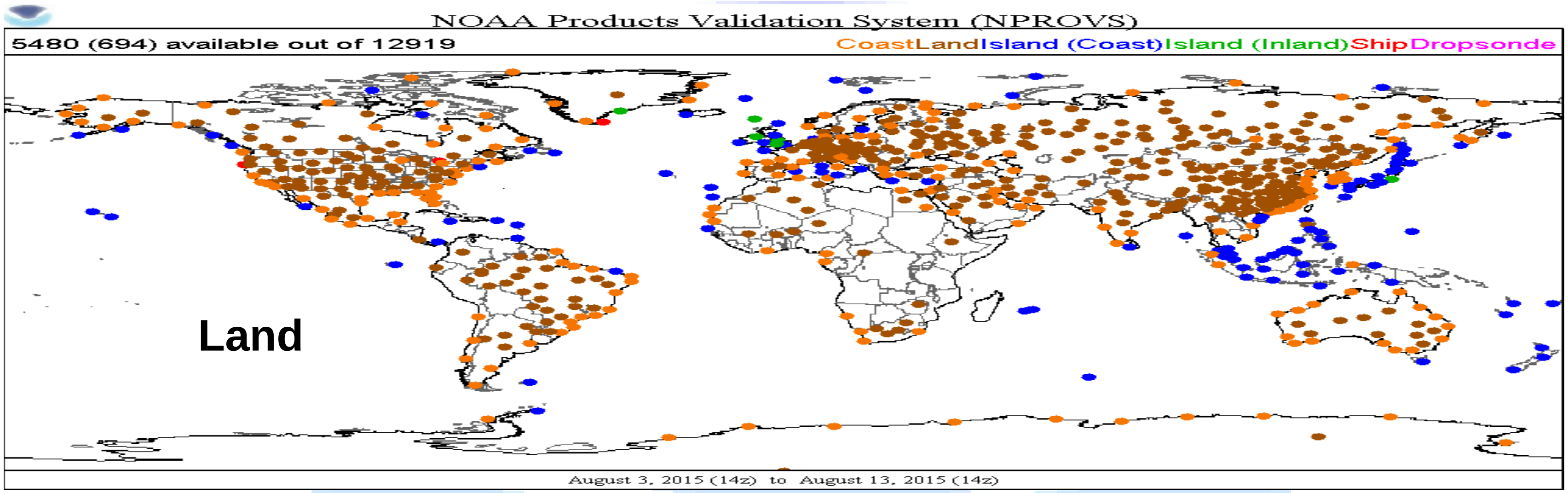
- Analysis of collocations with conventional and reference/dedicated RAOB provides more detailed assessments down to "deep dive" (see Poster; Sun)

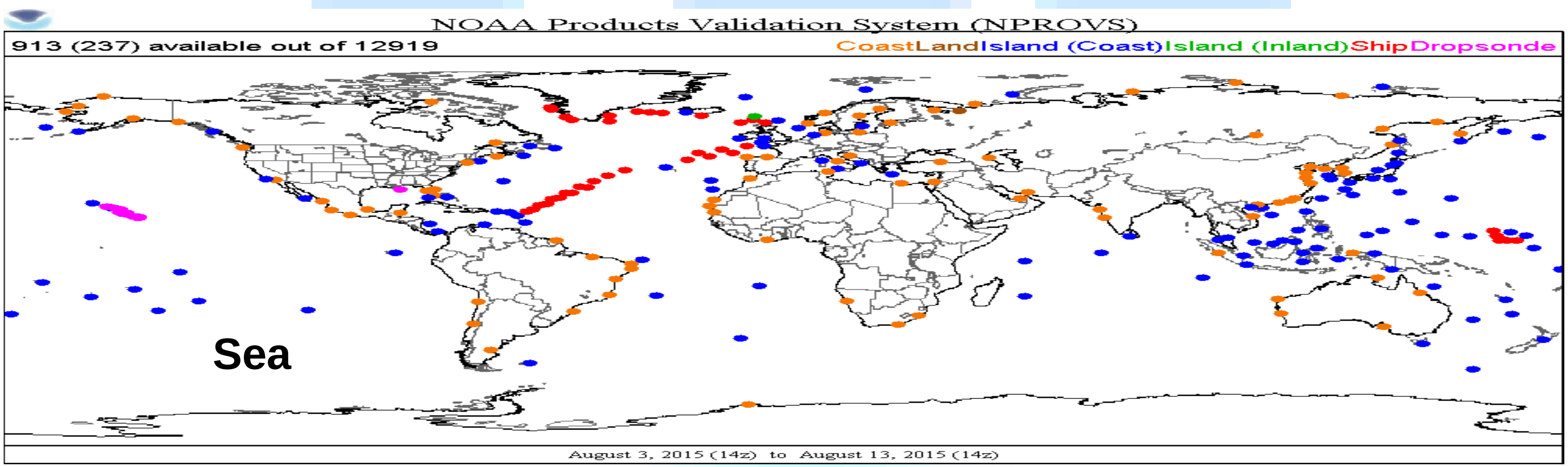
- NUCAPS and MiRS test products appear better than respective operations

- Product performance generally rooted in first guess; moisture weighting

- Performance in unique weather environments (Cold core and CALWATER) justifies ongoing *AWIPS-2* efforts to disseminate (NUCAPS) soundings to NWS field offices (See Poster; Sounding user session Thursday)

- Providing uncertainty estimates for soundings opens door to more robust validation against GRUAN RAOB (see Poster)





10-day sample of collocations containing MiRS v.11 and Oper MW soundings which pass QC

Recent Enhancements to the NOAA Unique CrIS ATMS Processing System (NUCAPS)

Antonia Gambacorta [1], Chris Barnet [1], Mitch Goldberg [2], Mark Liu [3], Nick Nalli [4], Changyi Tan [4], Kexin Zhang [4], Flavio Iturbide Sanchez [4], Tony Reale [3], Bomin Sun [3]

JPSS meeting, August 26, 2015

1. Science and Technology Corporation (STC)
2. NOAA JPSS Science Lead
3. NOAA NESDIS STAR
4. IM System Group (IMSG)

Objectives

- **Introduction on the NUCAPS System**
  - General outline, algorithm characteristics
- **Recent enhancements to the system**
  - MW-only retrieval module
  - MW+IR retrieval module
  - New system has been delivered to NOAA on July 8th 2015 and is currently running in operations.
- **Ongoing research**
- **Future work**

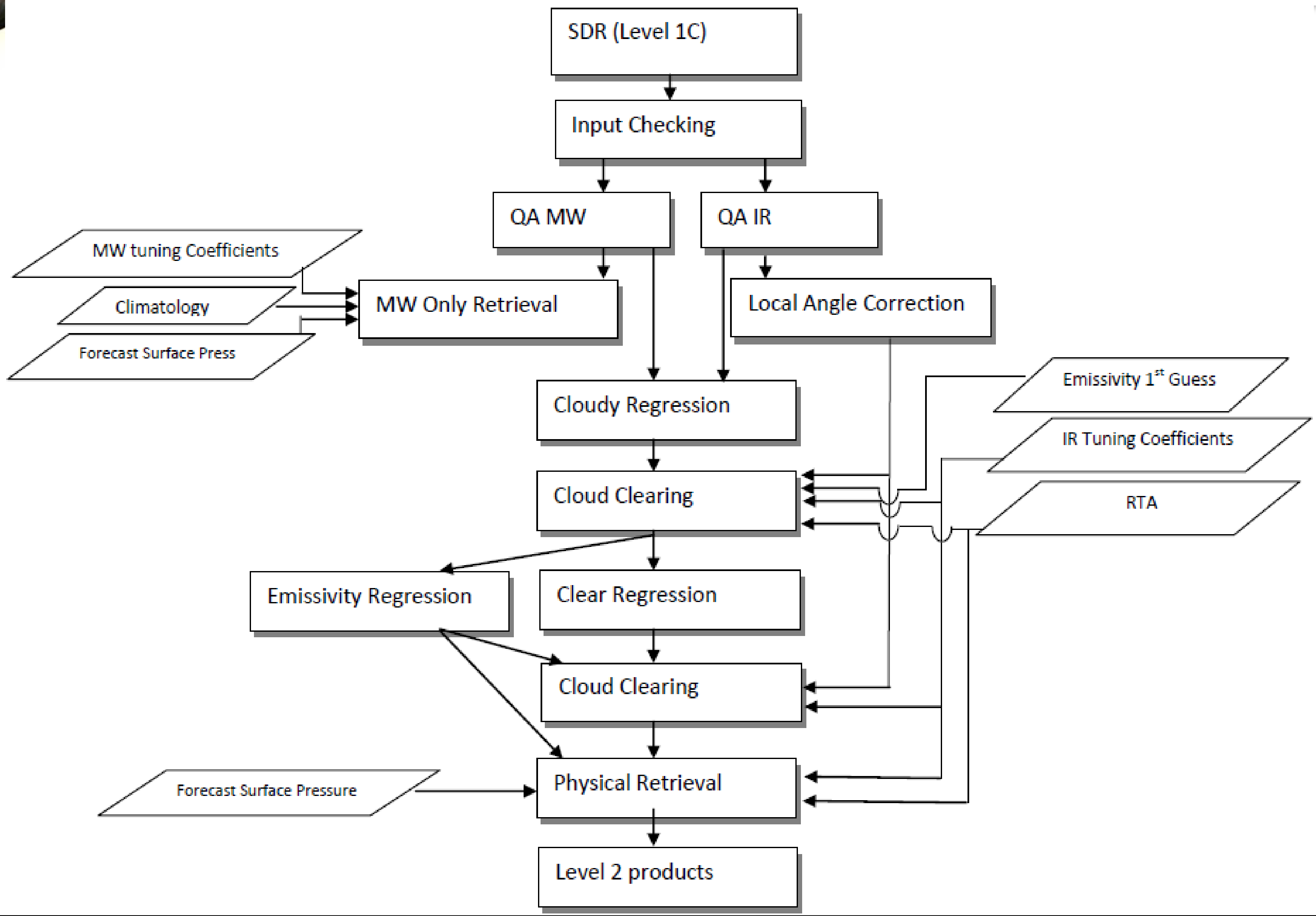
The NOAA Unique CrIS ATMS Processing System (NUCAPS)

- **A multi-step retrieval algorithm, heritage of the AIRS Science Team Retrieval Algorithm**

- **Current operational system (same retrieval code, same spectroscopy) run by NOAA to process:**
  - AIRS/AMSU (since 2003); IASI/AMSU/MHS (since 2006); CrIS/ATMS (since 2011)

- **Retrieval Steps**
  - 1) a microwave retrieval module which computes Temperature, water vapor and cloud liquid water (Rosenkranz, 2000)
  - 2) a fast eigenvector regression retrieval that is trained against the European Center for Medium-Range Weather Forecasts (ECMWF) analysis and CrIS all sky radiances which computes temperature and water vapor (Goldberg et al., 2003)
  - 3) a cloud clearing module (Chahine, 1974)
  - 4) a second fast eigenvector regression retrieval that is trained against ECMWF analysis and CrIS cloud cleared radiances (Temperature and water vapor)
  - 5) 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)

The NOAA Unique CrIS ATMS Processing System (NUCAPS)



What's Unique about NUCAPS?

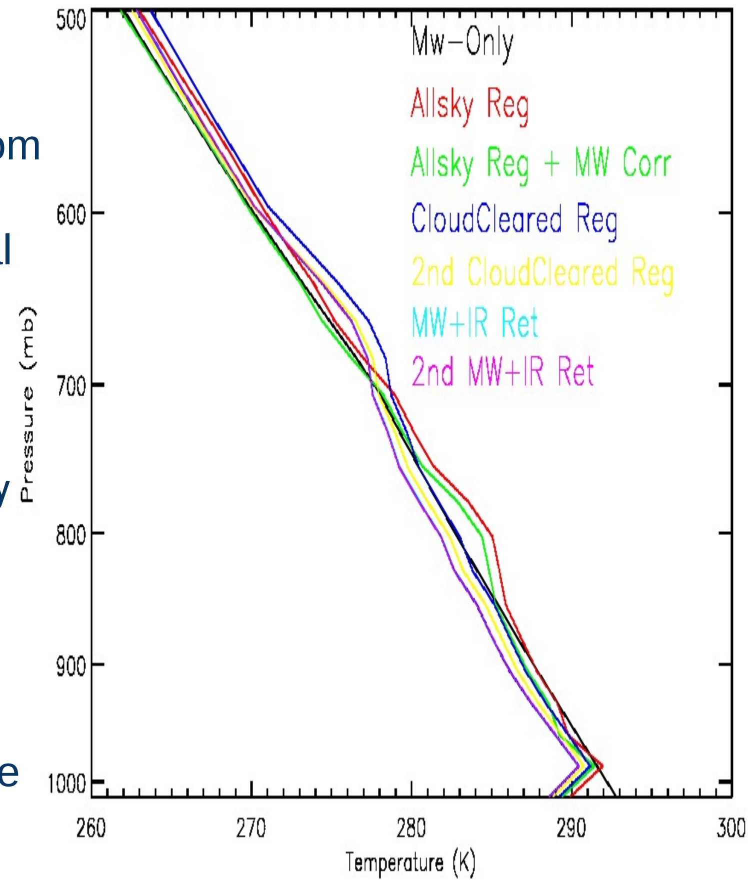
Designed to use all available *sounding* instruments.

- Climatological startup.
- Only ancillary information used is surface pressure from GFS model
- Microwave radiances used in microwave-only physical retrieval, "allsky" regression solution, "cloud cleared" regression and downstream physical T(p) and q(p) steps.

Uses a comparison of 4 independent retrieval steps for quality control (QC) in addition to traditional QC (residuals, etc.).

Utilizes the high-information content of the hyper-spectral infrared – both radiances and physics.

- All channels used in linear regression first guesses.
- Utilizes forward model derivatives to help constrain the solution.
  - Physical steps use full off-diagonal covariance of (obs-calc) errors.
  - Minimizes arbitrary *a-priori* constraints.



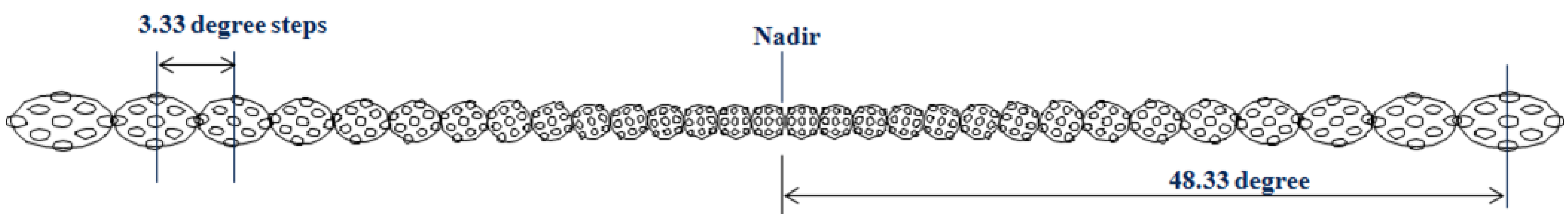
Goal of NUCAPS is to sound as close to surface as possible

We use a cluster of 9 infrared footprints and co-located microwave to eliminate the effects of clouds

- Cloud clearing sacrifices spatial resolution for coverage
- Cloud clearing works in ~70% of cases (~225,000 / 324,000 per day)

For all 3 hyperspectral infrared instruments (AIRS, IASI, and CrIS) we have 30 retrieval fields-of-regard per 2200 km-wide swath (a "scan-set")

- Nadir retrieval field of regard is ~50 km, Edge of scan is ~70x135 km
- At this scale ~95% of all retrievals are impacted by clouds

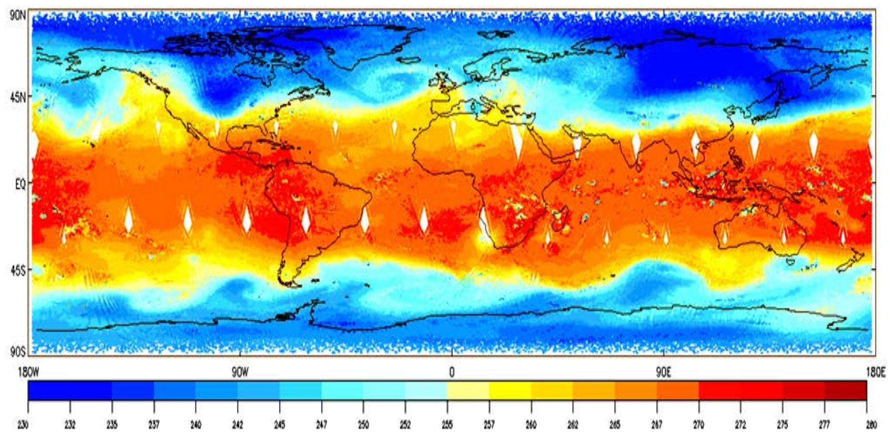


List of operational retrieval products

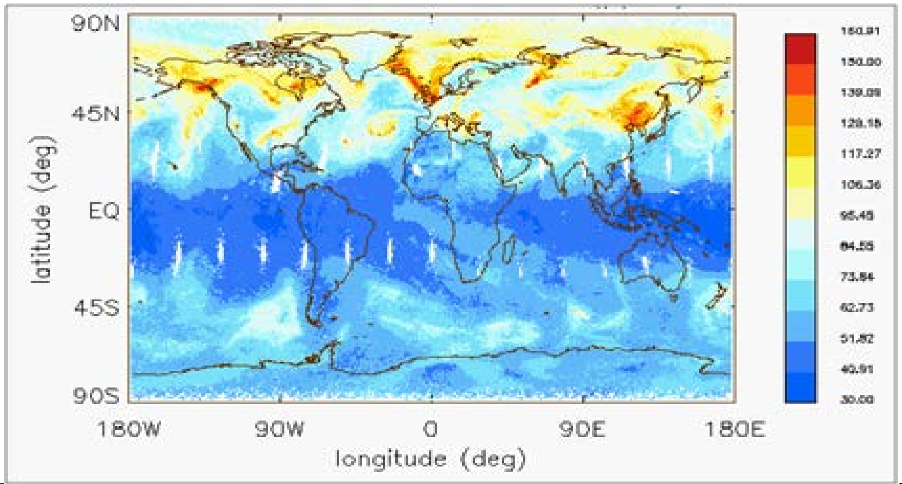
Retrieval Products

Cloud Cleared Radiances	660-750 cm-1 2200-2400 cm-1
Cloud fraction and Top Pressure	660-750 cm-1
Surface temperature	window
Temperature	660-750 cm-1 2200-2400 cm-1
Water Vapor	780 – 1090 cm-1 1200-1750 cm-1
O3	990 – 1070 cm-1
CO	2155 – 2220 cm-1
CH4	1220-1350 cm-1
CO2	660-760 cm-1
N2O	1290-1300cm-1 2190-2240cm-1
HNO3	760-1320cm-1
SO2	1343-1383cm-1

NUCAPS Temperature retrieval @ 500mb



NUCAPS Ozone retrieval @ 500mb

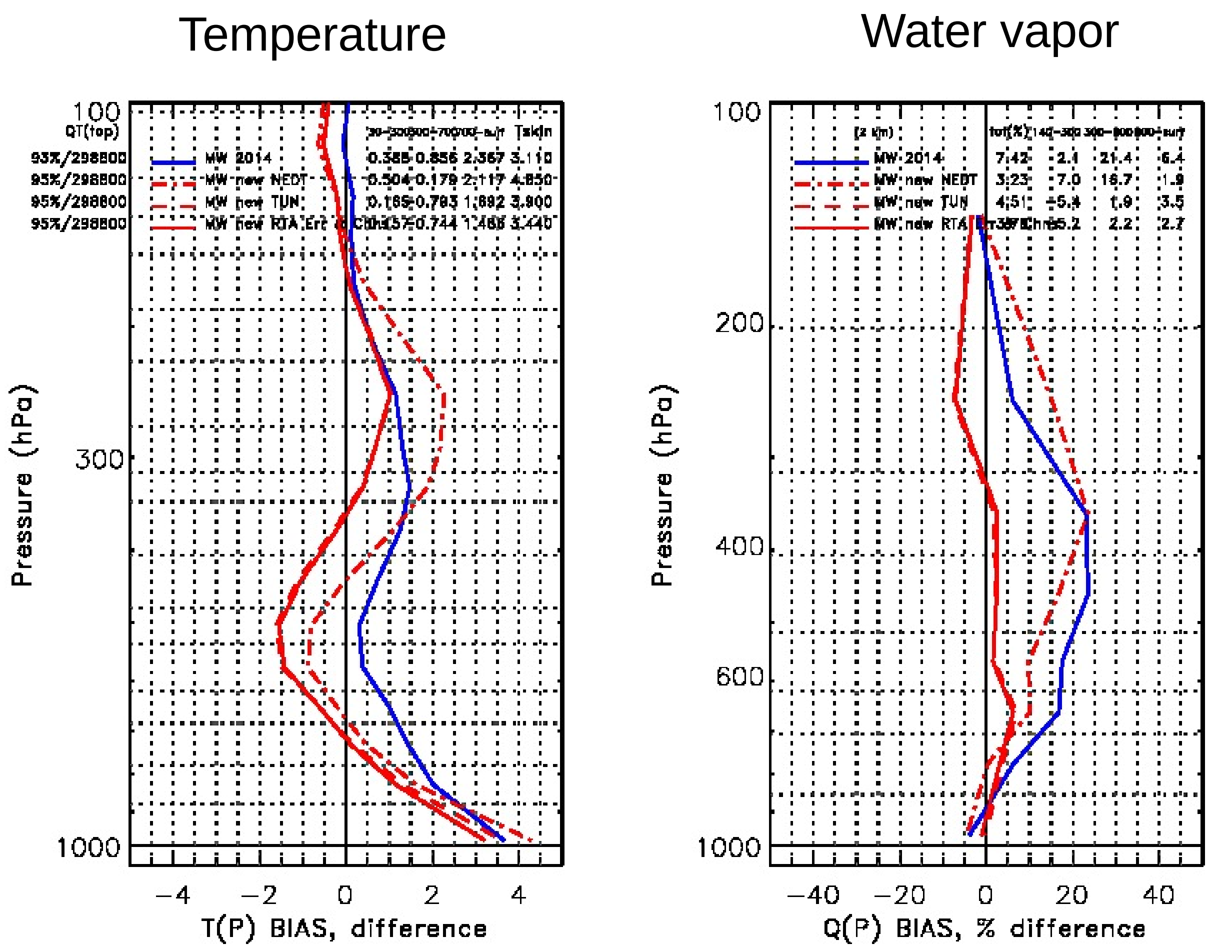


Recent Algorithm Enhancements - MW Only Retrieval

MW-Only Module

- 2014 MW Only System
- Updated Instrument NEDT file (dash dot red)
- New Forward Model Bias Tuning (dash ret)
- and Error file and optimized Channel Selection (solid ret)
- Bug fixes

FOCUS DAY 2015-02-17 GLOBAL BIAS



Recent Algorithm Enhancements - MW Only Retrieval

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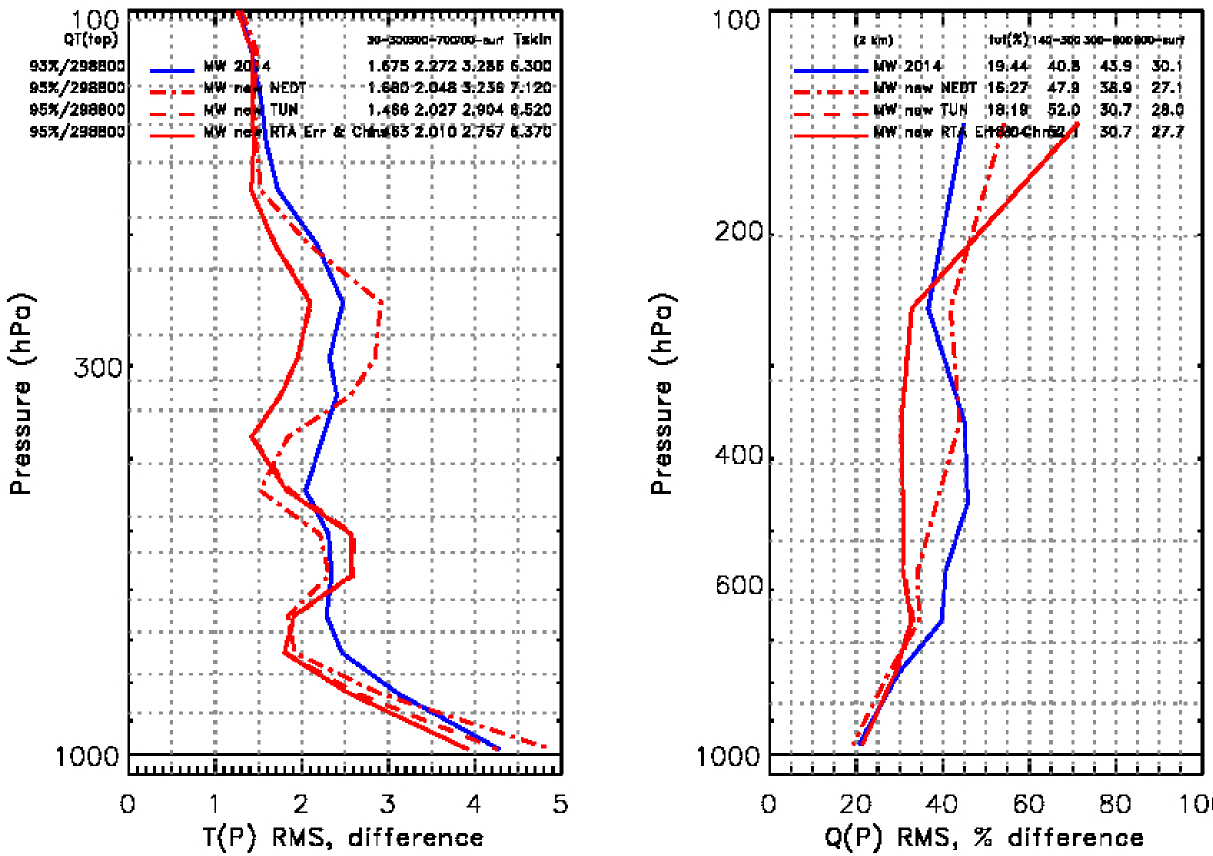
- Bug fixes

FOCUS DAY 2015-02-17 GLOBAL RMS

Temperature

Water vapor

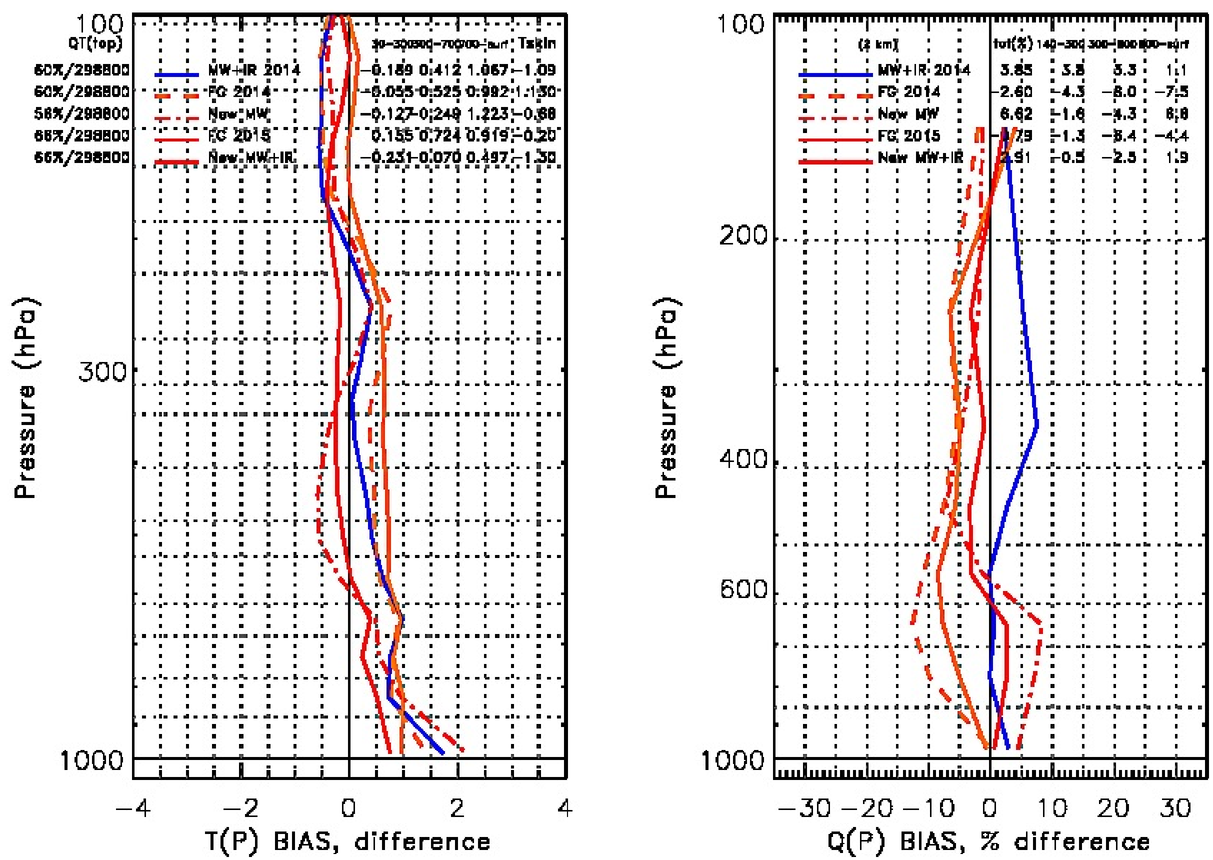


Recent Algorithm Enhancements - MW+IR Retrieval

MW+IR Module

- 2014 MW+IR System
- OLD FG (dash blue)
- New MW-Only System
- New first guess (STAR)
- Optimized QC (on going)
- New first guess experiment (on going)

FOCUS DAY 2015-02-17 GLOBAL BIAS



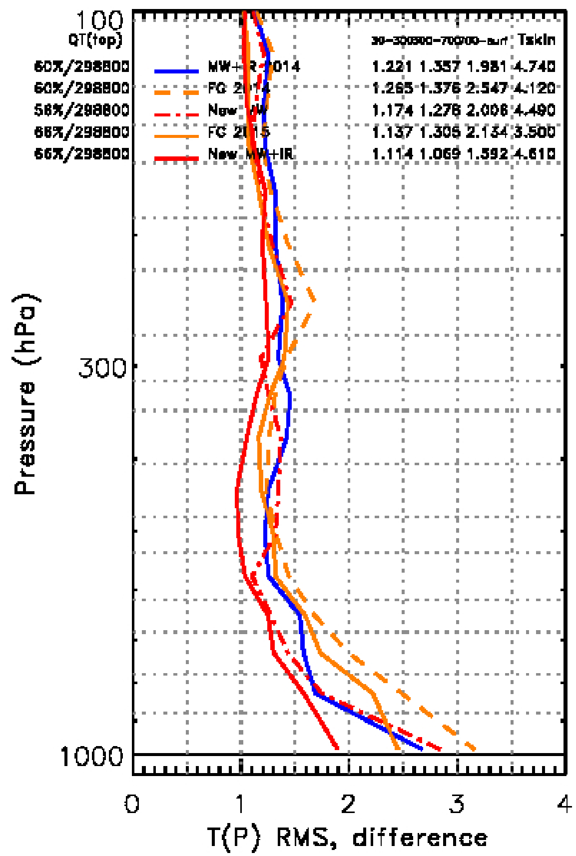
Recent Algorithm Enhancements - MW+IR Retrieval

MW+IR Module

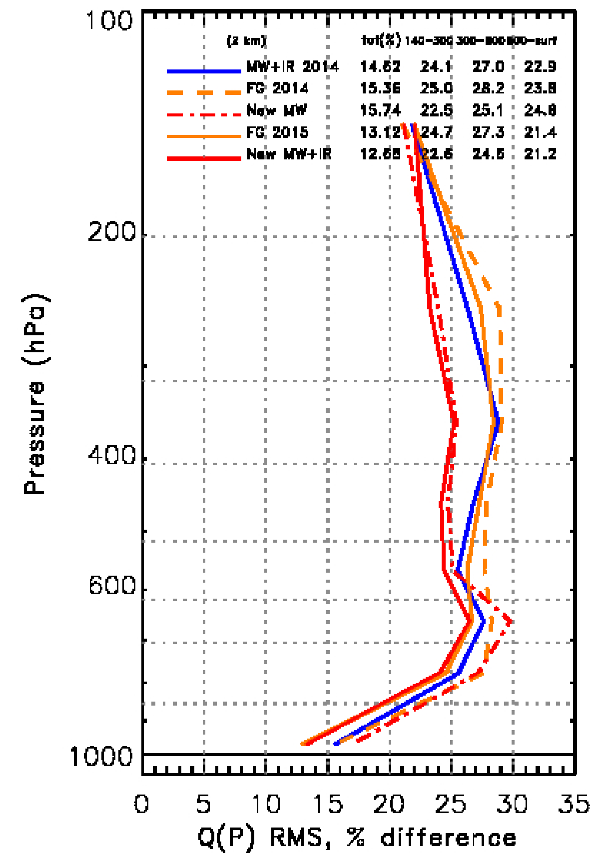
- 2014 MW+IR System
- OLD FG (dash blue)
- New MW-Only System
- New first guess (STAR)
- Optimized QC (on going)
- New first guess experiment (on going)

FOCUS DAY 2015-02-17 GLOBAL RMS

Temperature



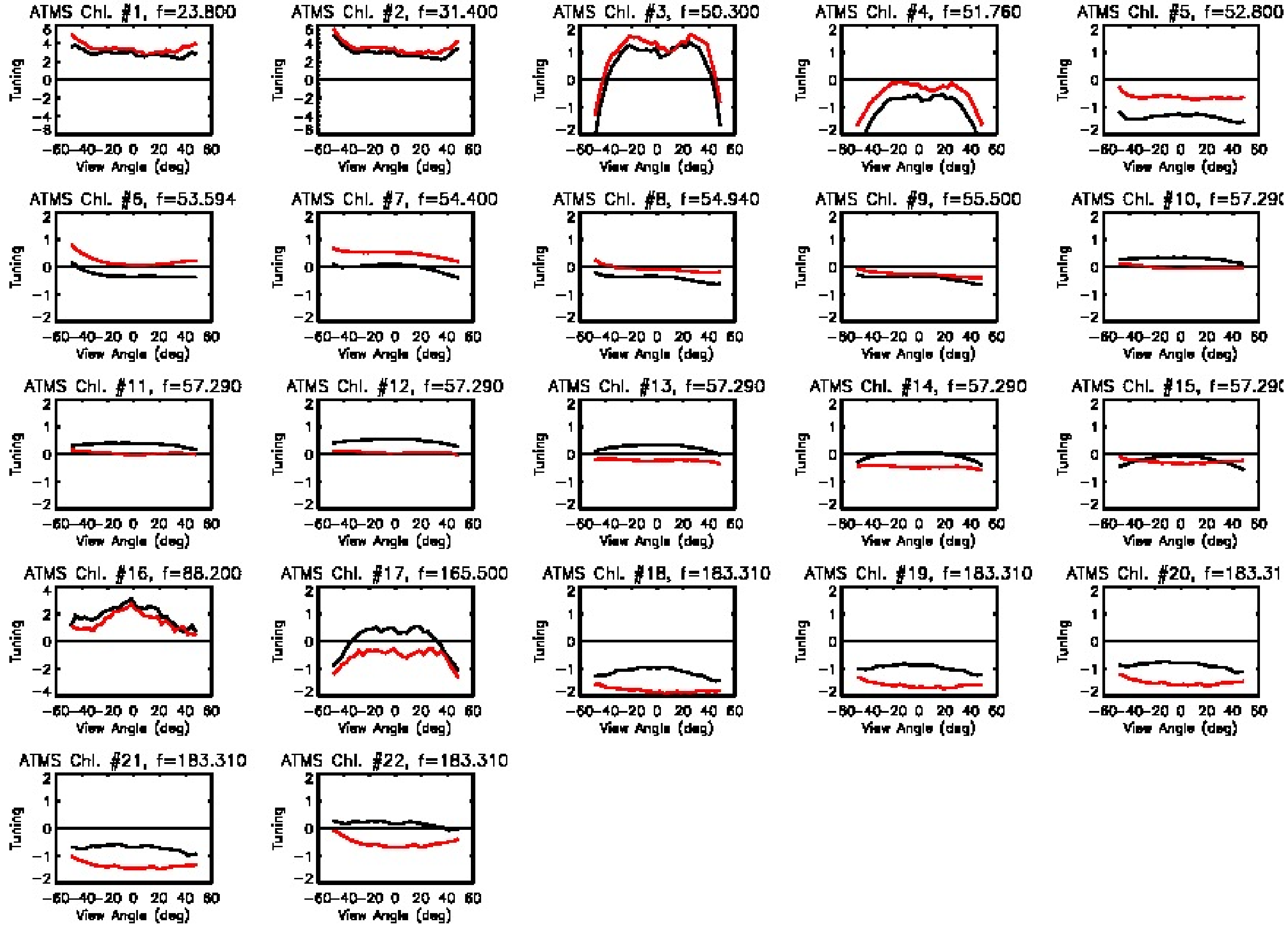
Water vapor



Ongoing research

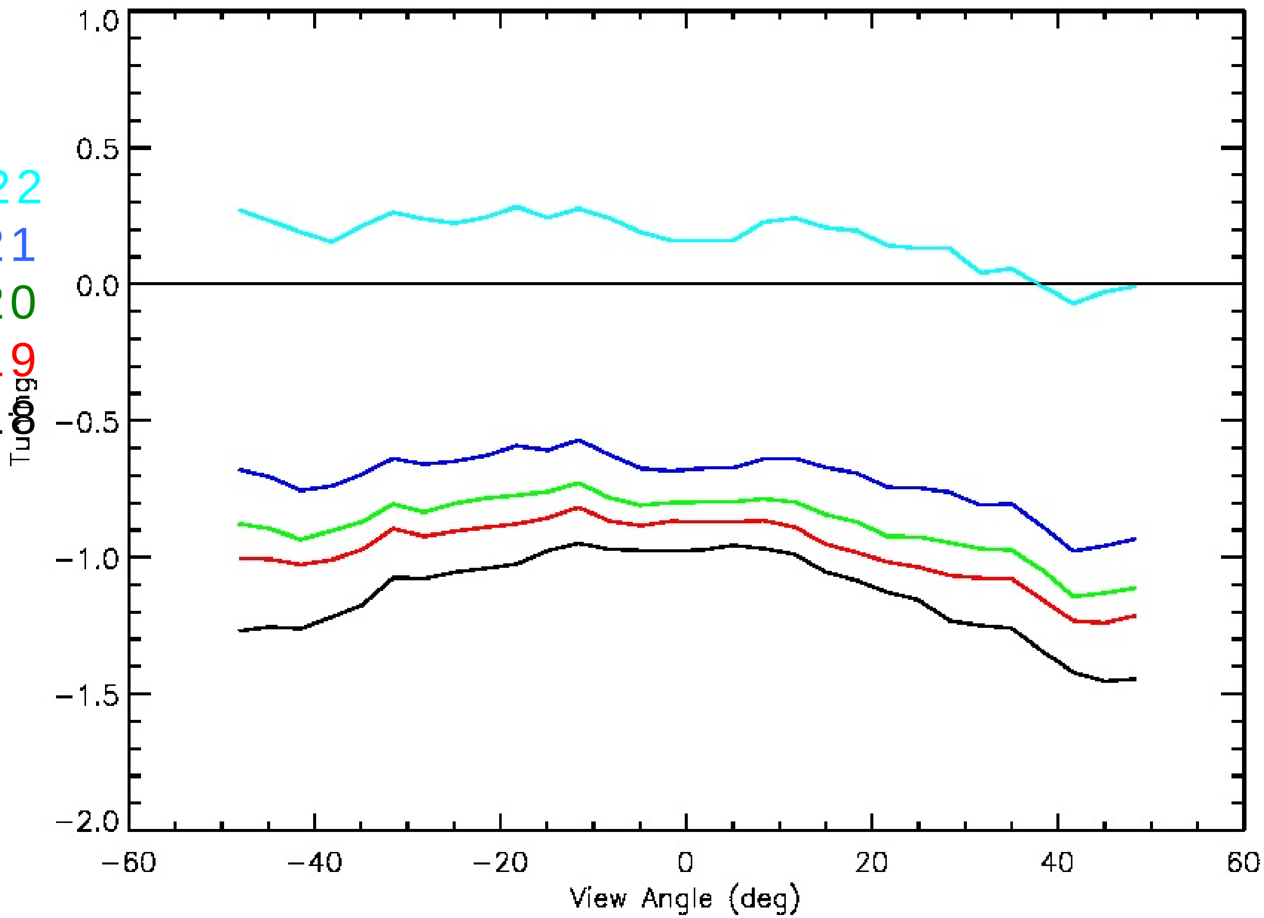
- **Ongoing discussion on the sensitivity peak height dependent bias in the 183GHz band**
  - OBS-CALC bias computation is observed to increase with lower peaking 183GHz channels
  - Problem is observed across all current forward models and MW instruments (AMSU, SAPHIR, ATMS)
  - Problem is observed on both ATMS TDR and SDR files (next 2 slides)
  - June 2015: a dedicated workshop to study the issue
  - Possible sources: surface, precipitation contamination, water vapor continuum. Workshop outcome summary is going to be distrubuted soon.
  - We are in contact with Phil Rosenkranz who has an updated forward model with improved water vapor transmittance.

ATMS tuning TDR (black) & SDR (red)



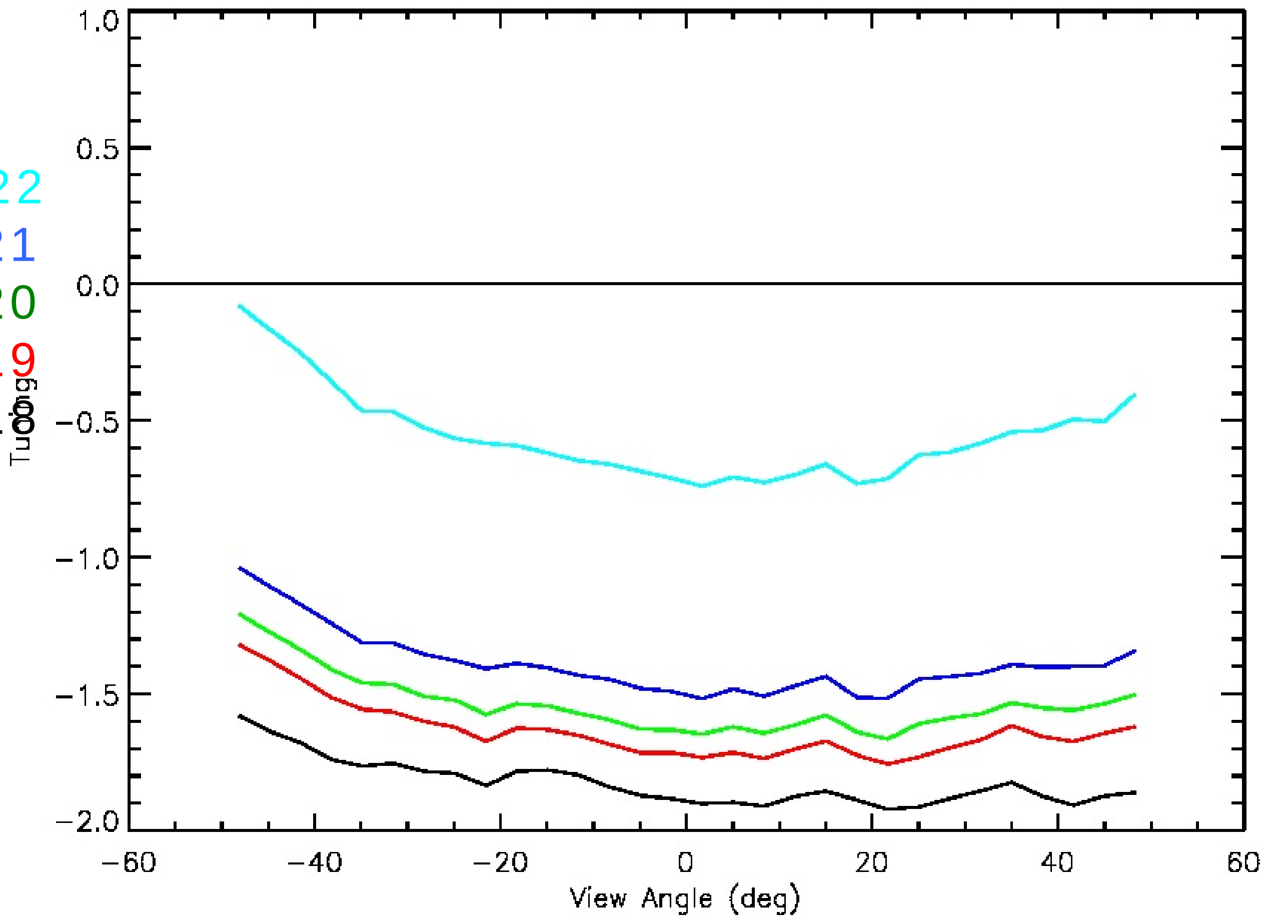
183 GHz bias (OBS-CALC): TDR cases

ATMS Chn. 22
ATMS chn. 21
ATMS chn. 20
ATMS chn. 19
ATMS chn. 18



183 GHz bias (OBS-CALC): SDR cases

ATMS Chn. 22
ATMS chn. 21
ATMS chn. 20
ATMS chn. 19
ATMS chn. 18



Summary and future work

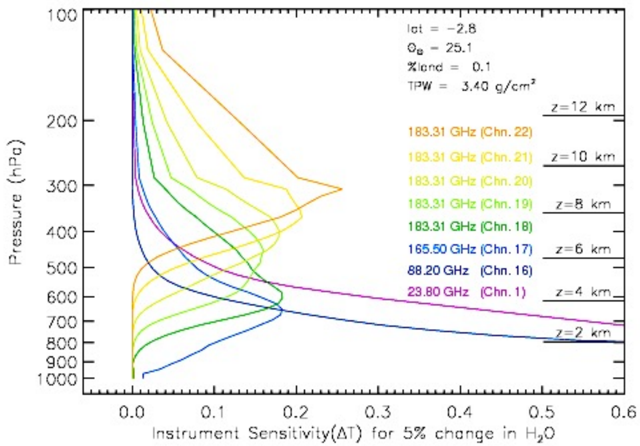
- **NUCAPS is showing an improved accuracy, yield and stability.**
  - Upgrades shown have been delivered to NOAA on July 8th 2015 and is currently running in operations.

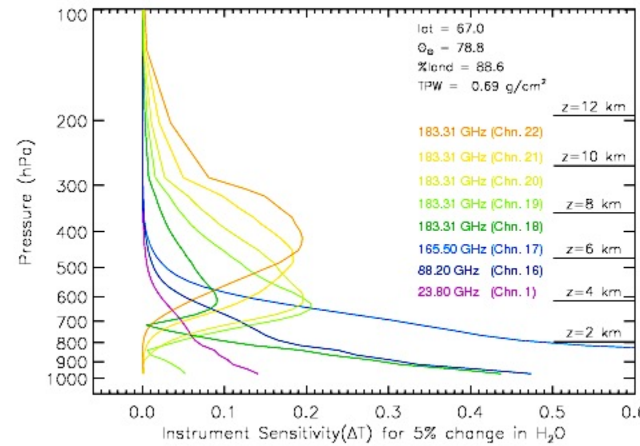
- **Ongoing research towards solving existing issues in both MW and MW+IR retrieval module**
  - 183GHz bias issue
  - Experimenting with alternative first guess and improved QC

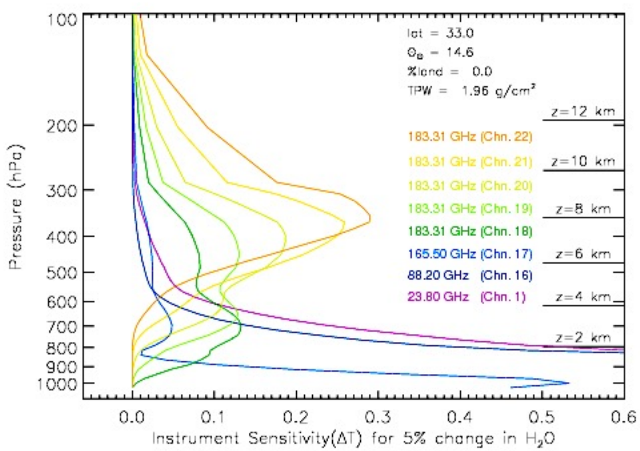
- **Approved 2014 PSDI project plan has the SARTA CrIS full-spectral resolution delivery scheduled early next year.**
  - We are currently funded to compute high res CrIS channel selection and IR bias tuning. Delivery is scheduled for April 2016.

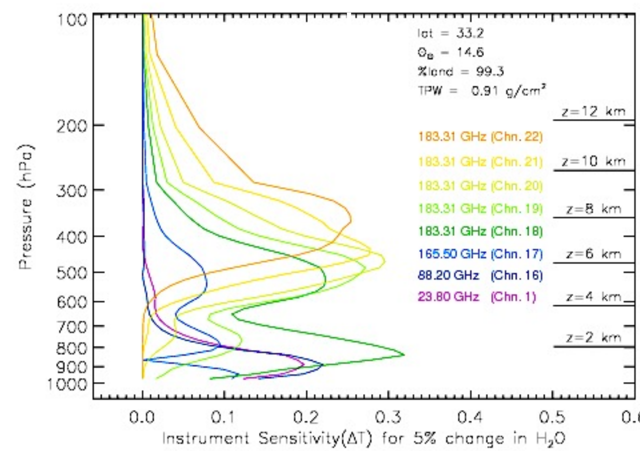
Back-Up Slides

ATMS q(p) Sensitivity









MiRS ATMS Retrievals: Algorithm Updates, Product Assessment, and Preparations for JPSS-1

Product/Algorithm: ***MiRS (Microwave Integrated Retrieval System)***

Contributors: ***X. Zhan, C. Grassotti, M. Chattopadhyay, J. Davies***

Date: August 26, 2015

MiRS Cal/Val Team Members

Team Member	Organization	Roles and Responsibilities
X. Zhan (Task Lead)	NESDIS/STAR/SMCD	Project management
C. Grassotti (Contractor, Technical Lead)	NESDIS/STAR/SMCD (U. MD./ESSIC)	Coordination of technical activities; review/deliverable planning
M. Chattopadhyay (Contractor, 50%)	NESDIS/STAR/SMCD (AER, Inc.)	DAP preparation, EDR generation/validation

MiRS S-NPP Product Overview: Product List

- **MiRS V9.2 Currently running on S-NPP/ATMS operationally at NDE (since 2013), also running at OSPO on 8 different satellites/sensors**
- **V11.0 delivered Sept 2014 (for N18, N19, MetopA, MetopB, F17 HR)**
- **V11.1 delivered August 2015 to OSPO (for N18, N19, MetopA, MetopB, F17, F18) and NDE for ATMS (pre-DAP for V11.2)**
- **Numerous algorithm updates/improvements in V11.0 and V11.1**

V9.2/V11.0
Atmospheric Temperature profile
Atmospheric Water Vapor profile
Total Precipitable Water
Land Surface Temperature
Surface Emissivity Spectrum
Sea-Ice Concentration
Snow Cover Extent
Snow-Water Equivalent
Integrated Cloud Liquid Water
Integrated Ice Water Path
Integrated Rain Water Path
Rainfall Rate

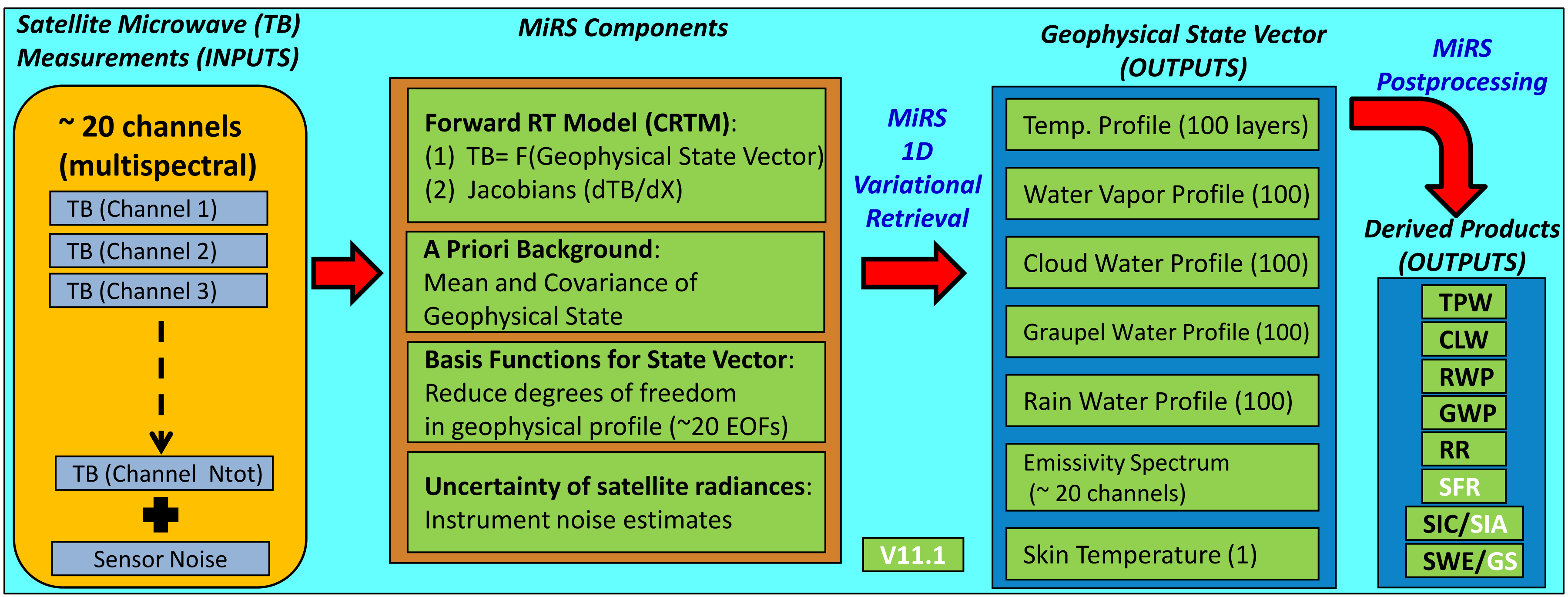
Added V11.1
Snowfall Rate (MSPPS, AMSU/MHS currently)
Sea Ice Age (FY, MY)
Snow Grain Size

MiRS S-NPP Product Overview: Cal/Val Status

- **All official EDRs are compared/validated against appropriate reference data:**
  - T and WV profiles and TPW: ECMWF and GDAS analyses, radiosondes
  - RR: Stage IV over CONUS, TRMM 2A12 (when operational), IPWG, CDC daily rainfall (new plans for this year to incorporate GPM official RR in comparisons)
  - Tskin: daily comparison with NWP, limited comparison with SURFRAD (more intensive comparisons planned starting March 2017 as per project plan)
  - Sea Ice Concentration: AMSRE, AMSR2, SSMIS NRT, European OSI-SAF
  - SWE: NOHRSC/SNOWDAS, European GlobSnow, AMSRE, AMSR2
- **V9.2 deficiencies included:**
  - WV, TPW moist bias in extreme cold/dry air outbreaks
  - Larger T profile std dev over land surfaces
  - Some underestimation of SWE in Siberia.
  - These have largely been addressed in the upgrade to V11.1
- **Long-term monitoring: MiRS website contains product maps, comparisons with reference data, and radiometric monitoring; plan to work with STAR webmaster (L. Brown) to update website to accommodate JPSS-1 requirements.**
  - http://www.star.nesdis.noaa.gov/smcd/mirs/

JPSS-1 Readiness: MiRS Algorithm Overview

- **Basic Retrieval Problem**: Given a limited set of satellite-based microwave radiometric measurements, which are related to the Earth atmospheric and surface conditions (state vector) in a linear or non-linear way, how does one determine the elements of this state vector?
  - State vector can have 100+ elements
  - Problem is underdetermined: many more variables to retrieve than measurements; more than one combination of atm/sfc conditions can "fit" the measurements
- **Variational Approach**: Find the "most likely" atm/sfc state that: (1) best matches the satellite measurements, and (2) is still close to an a priori estimate of the atm/sfc conditions

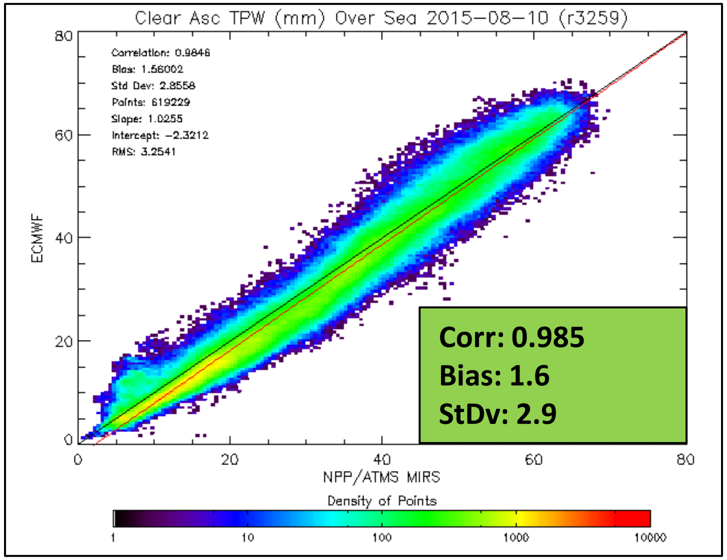


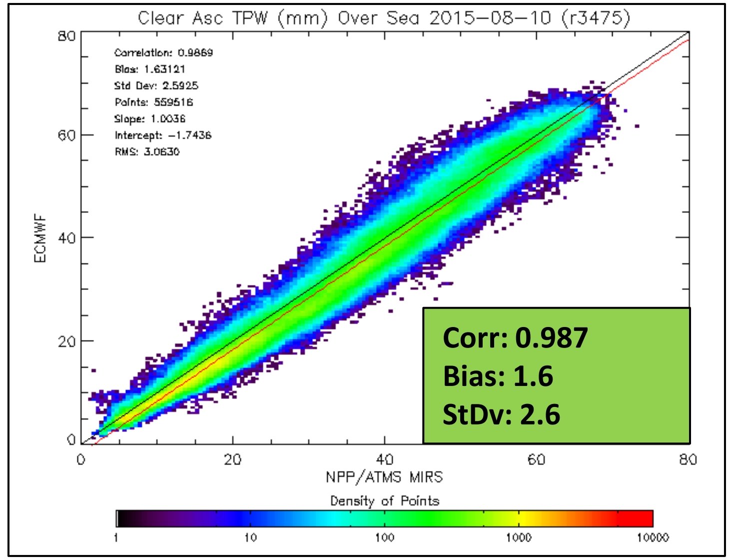
JPSS-1 Readiness: MiRS
Algorithm Changes in V11.1 (compared with v9.2)

Description	Satellites/Sensors Affected	Benefit
Integration of CRTM 2.1.1 (previously using pCRTM)	All: N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS, F17, F18/SSMIS , MT/SAPHIR	Better sync with CRTM development cycle; more realistic ice water retrievals (Jacobians)
Integration of new dynamic a priori atmospheric background	All	Large improvement in T, WV sounding; reduction in average number of iterations; increase in conv rate
Updated hydrometeor/rain rate relationships	All	Improved RR over land and ocean
Updated hydrometeor a priori background profiles	All	Improved RR over land and ocean; improved sounding products in rainy conditions
New bias corrections for all sensors	All	Needed for consistency with CRTM 2.1.1
Snow Water Equivalent (SWE) spatially-temporally variable climatology background	All	Better spatial and temporal constraint on SWE; also improved SGS retrieval
Snow Grain Size (SGS) and Sea Ice Age (SIA)	All	Preliminary Product, satisfies user request
Updated all Snow Emissivity Catalogs: finer SGS discretization and larger physical ranges	All	Smoother distributions for SGS, SWE, larger dynamic range for SGS.
Dynamic channel selection near sea ice boundary	N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS	Better convergence behavior for cross-track instruments
Miscellaneous changes to improve code efficiency, bug fixes	All	Matrix preparation time reduced from 40% to 5% of 1dvar computation time

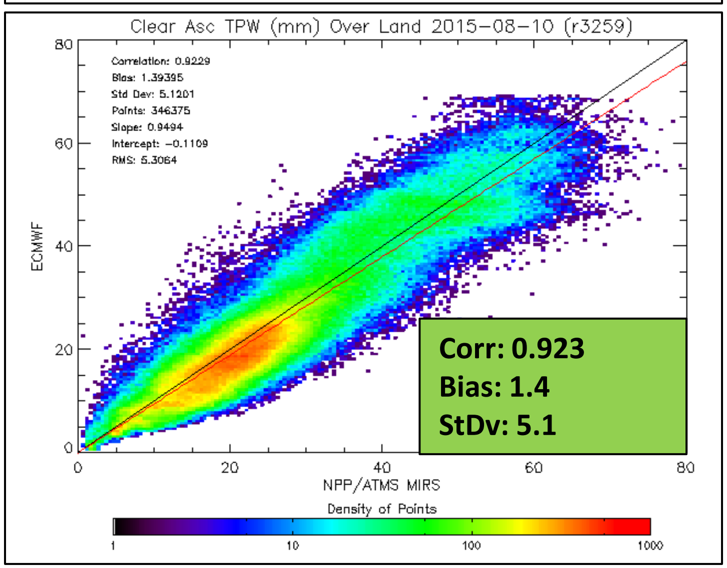
JPSS-1 Readiness: MiRS
S-NPP/ATMS TPW (mm) Performance vs. ECMWF

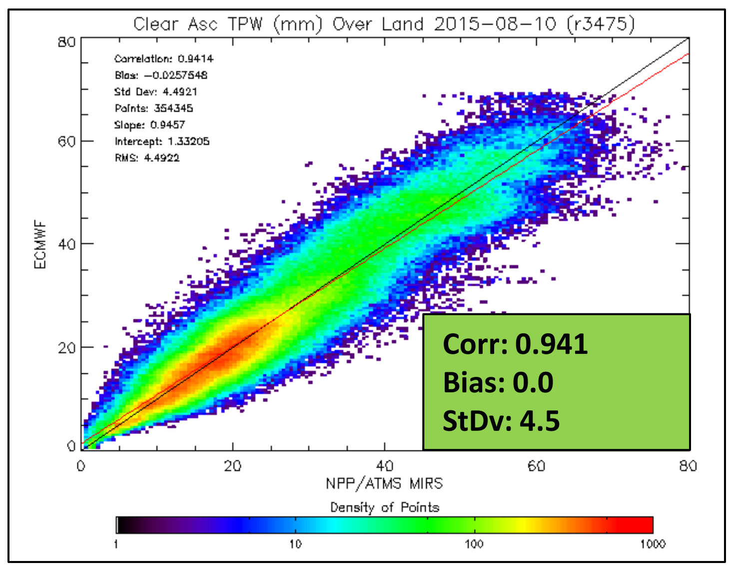
V9.2 | **2015-08-10** | **V11.1**





Ocean





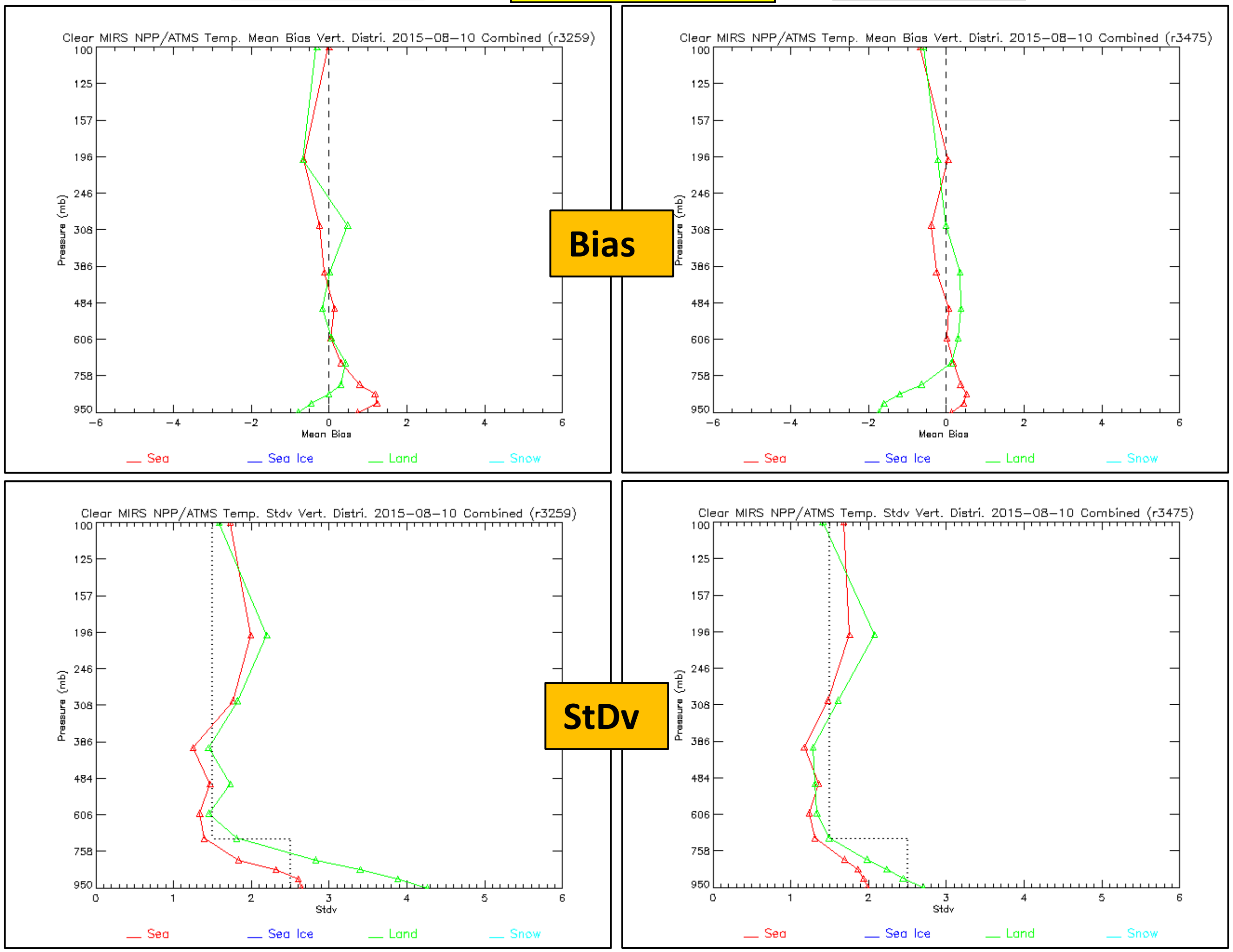
Land

Produced daily on STAR website

JPSS-1 Readiness: MiRS
S-NPP/ATMS Temp Sounding Performance vs. GDAS

V9.2 **2015-08-10** **V11.1**

vs. GDAS



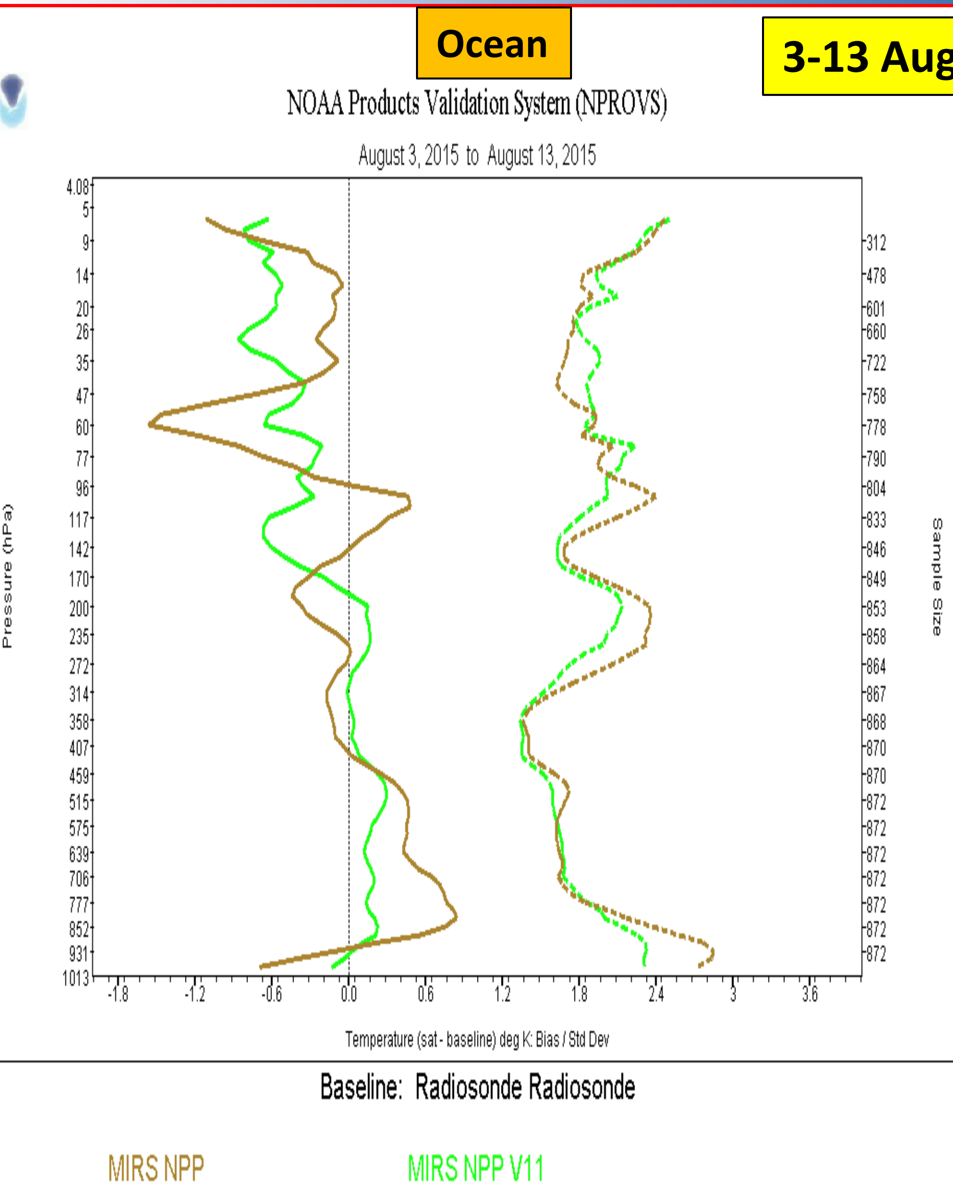
Land
Ocean

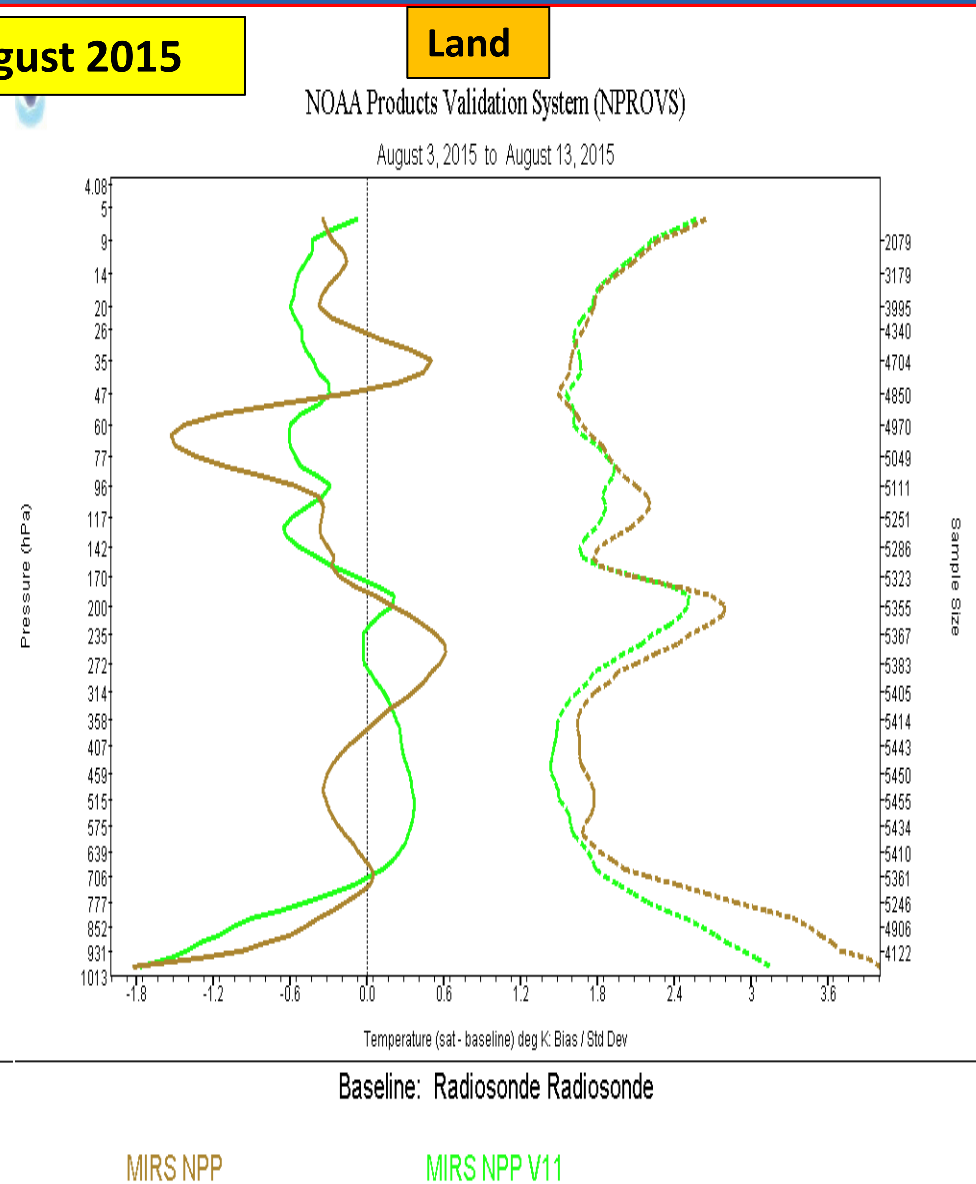
- V11.1 Reduction in both bias and std dev at most layers
- Low level cold bias over land

Produced daily on STAR website

JPSS-1 Readiness: MiRS
S-NPP/ATMS Temp Sounding Performance: RAOBs

3-13 August 2015



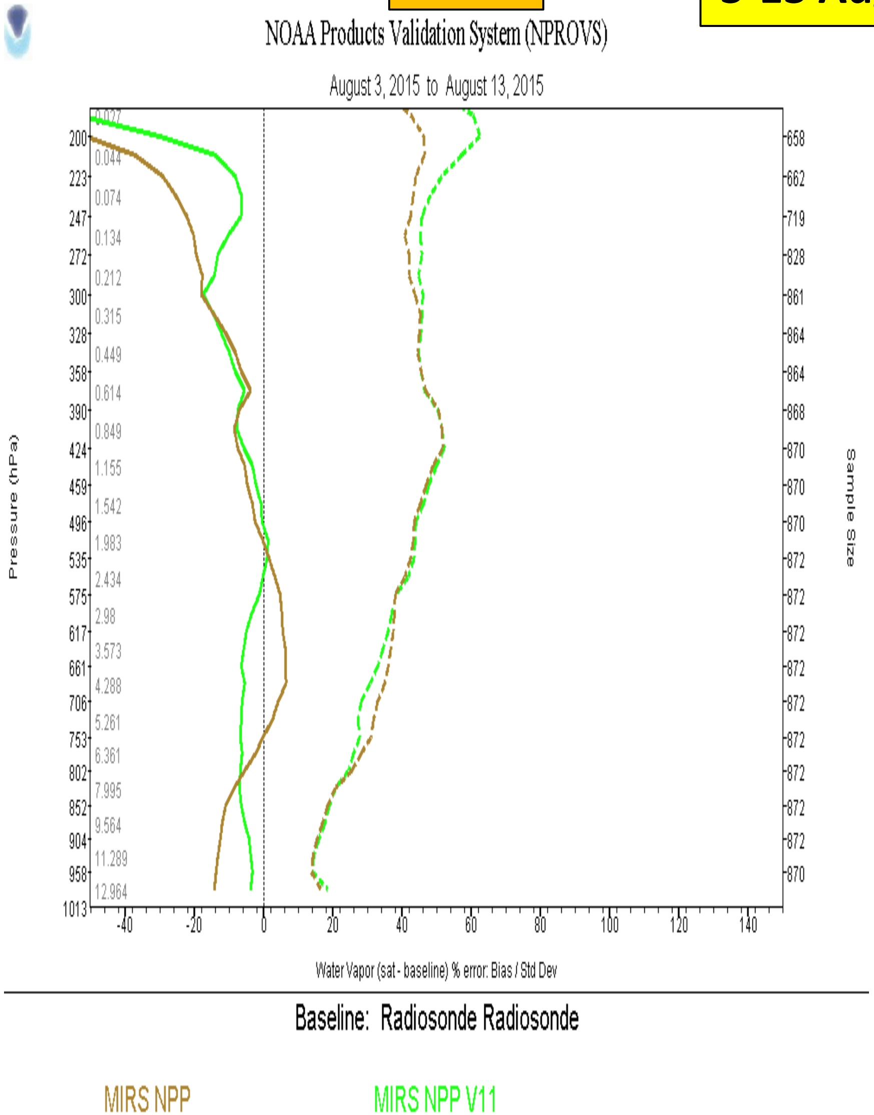


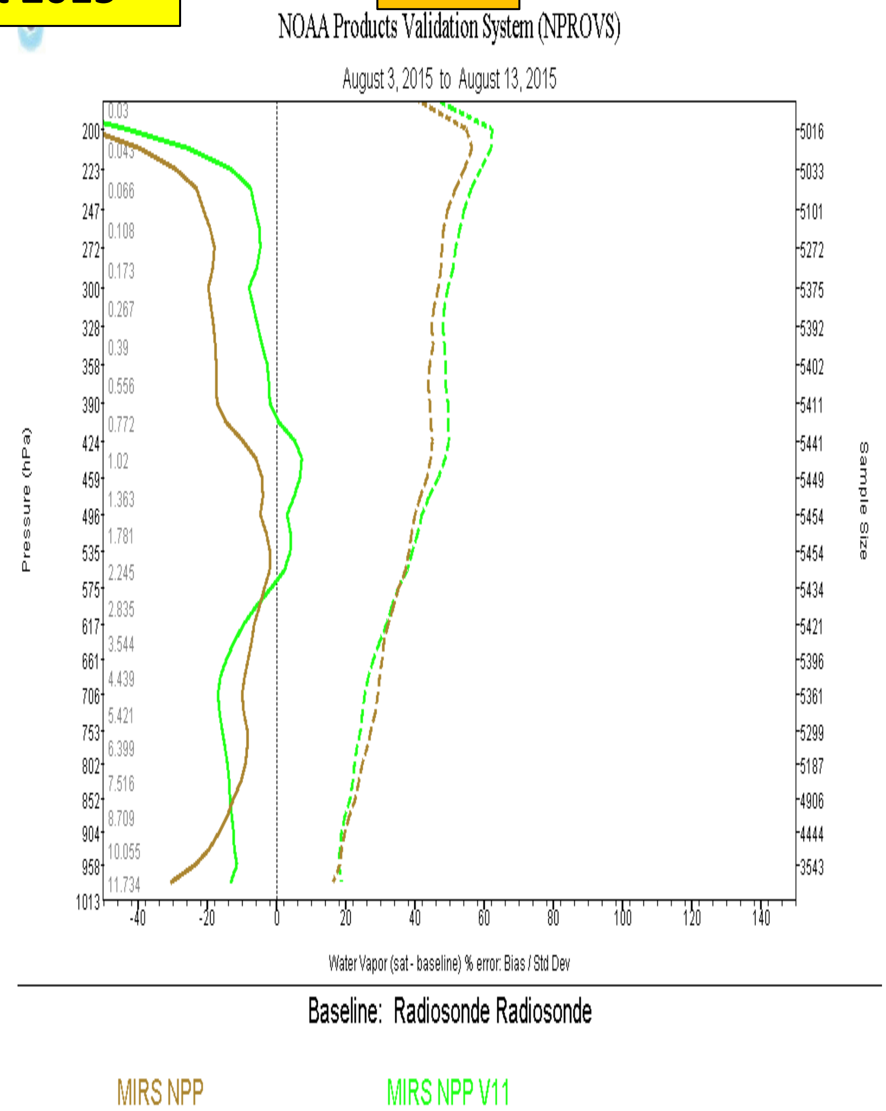
JPSS-1 Readiness: MiRS
S-NPP/ATMS WV Sounding Performance: RAOBs

Ocean

3-13 August 2015

Land

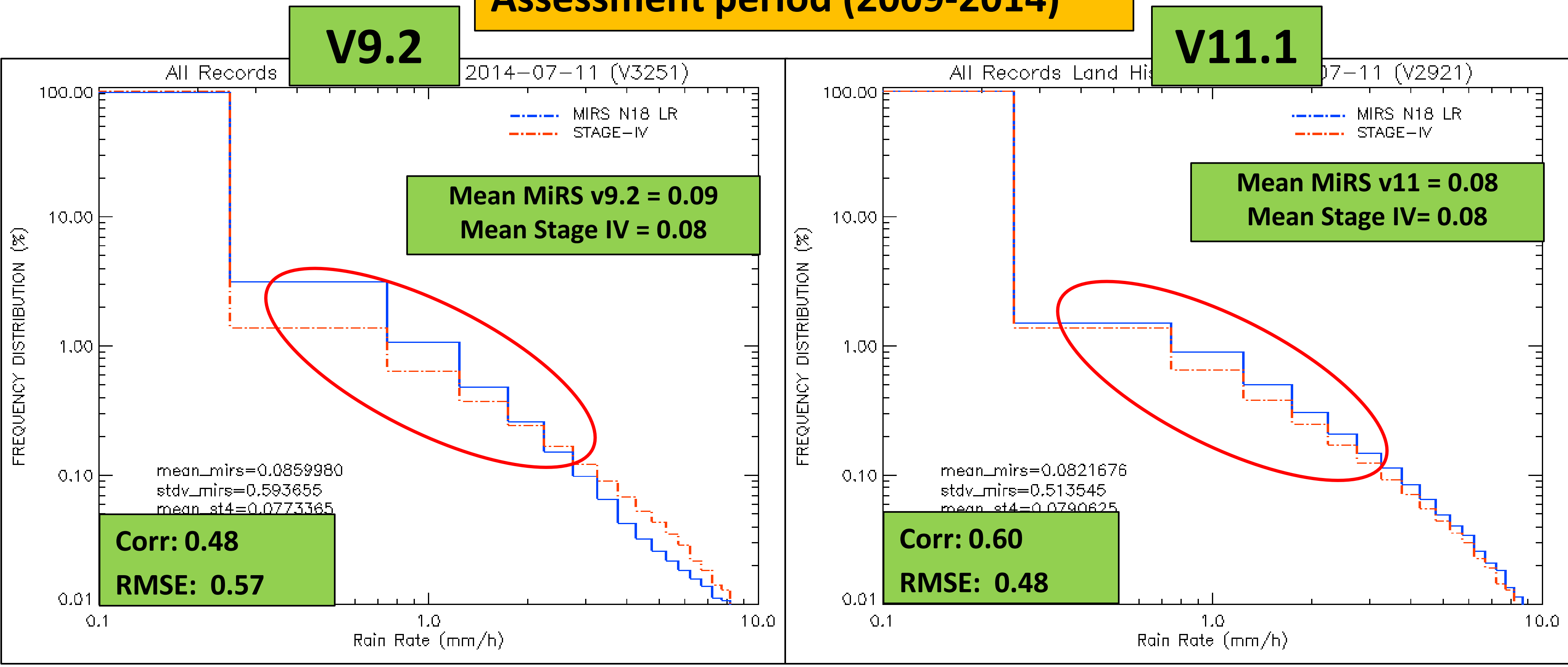




JPSS-1 Readiness: MiRS
Rain Rate Performance (AMSU/MHS)

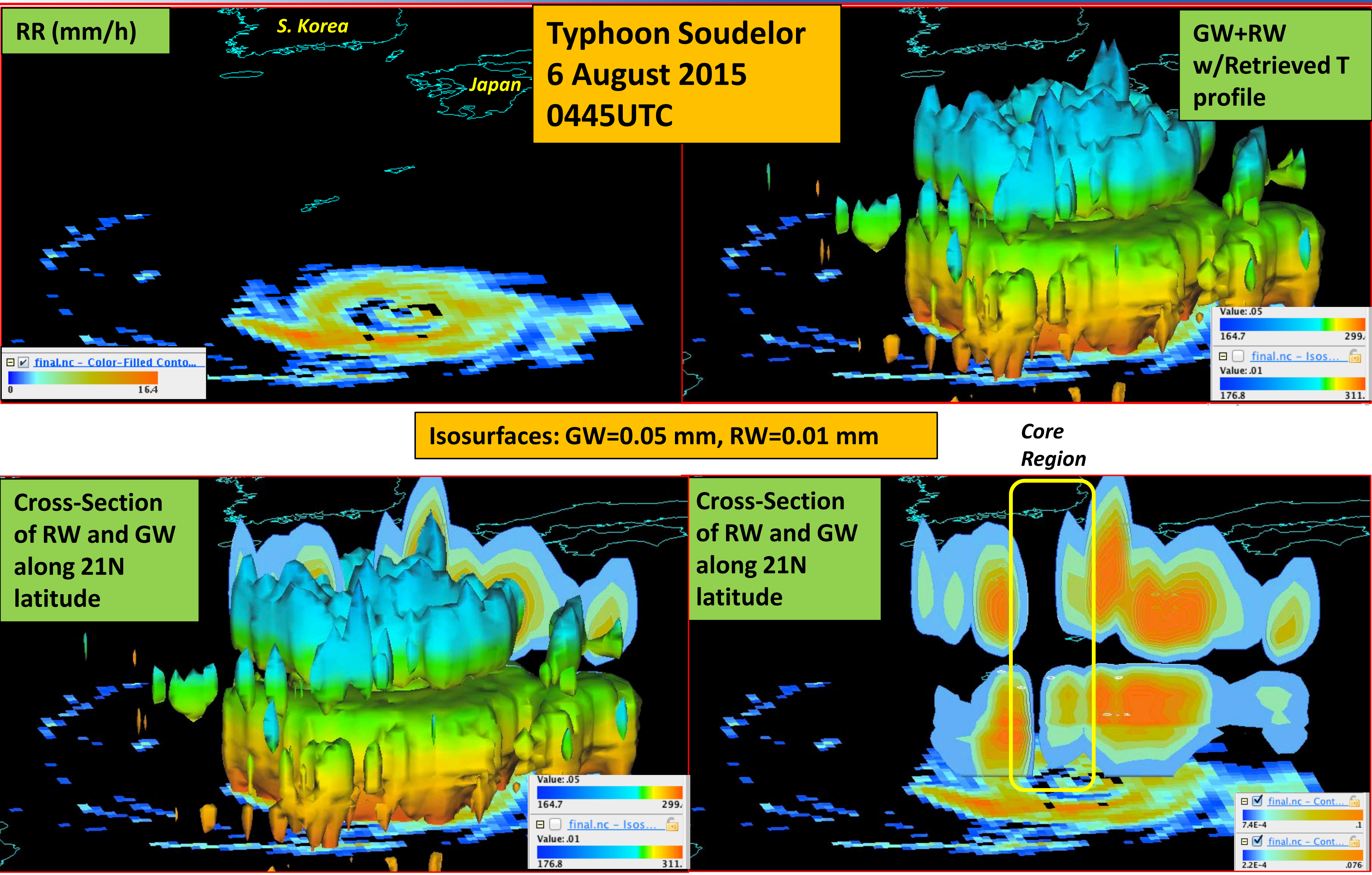
N18 Rain Rate (vs. Stage IV)

Assessment period (2009-2014)



- Better agreement in low intensities
- More consistent at higher intensities (> 3 mm/h)
- Improved correlation and lower RMSE

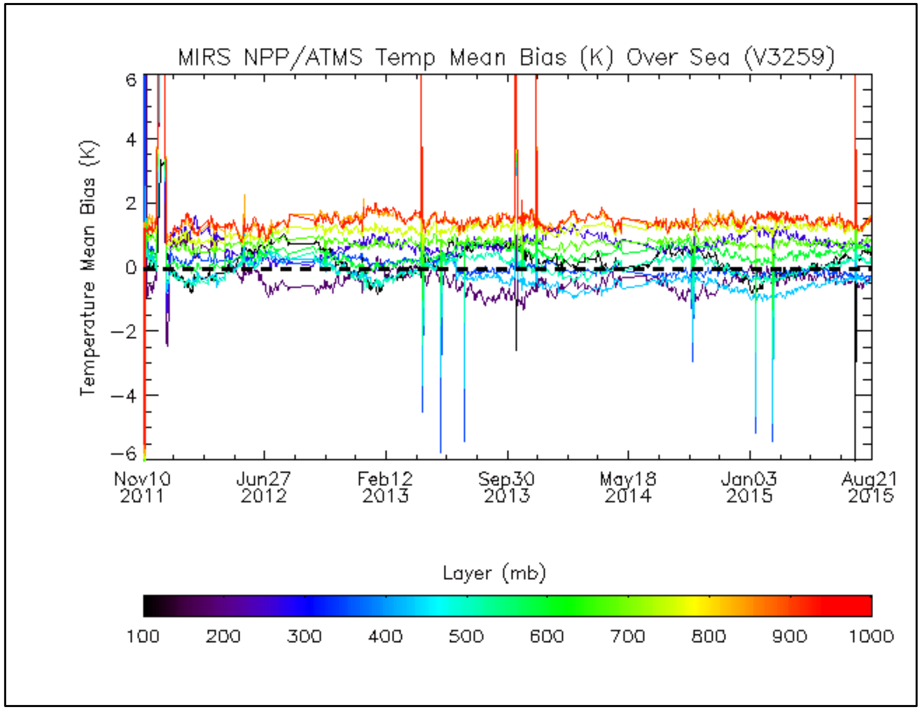
JPSS-1 Readiness: MiRS Hydrometeor Retrievals (ATMS)



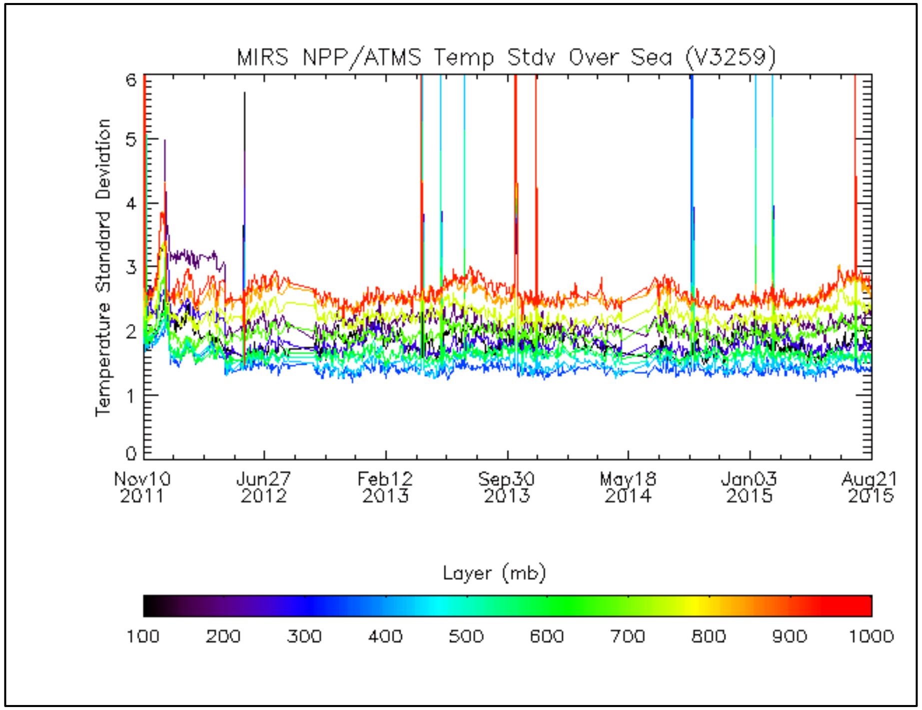
JPSS-1 Readiness: MiRS Long-Term Monitoring

- **S-NPP/ATMS MiRS v9.2 Temperature Retrieval Bias and Std Dev vs. ECMWF since Nov 2011 (Ocean)**

Bias



StDv



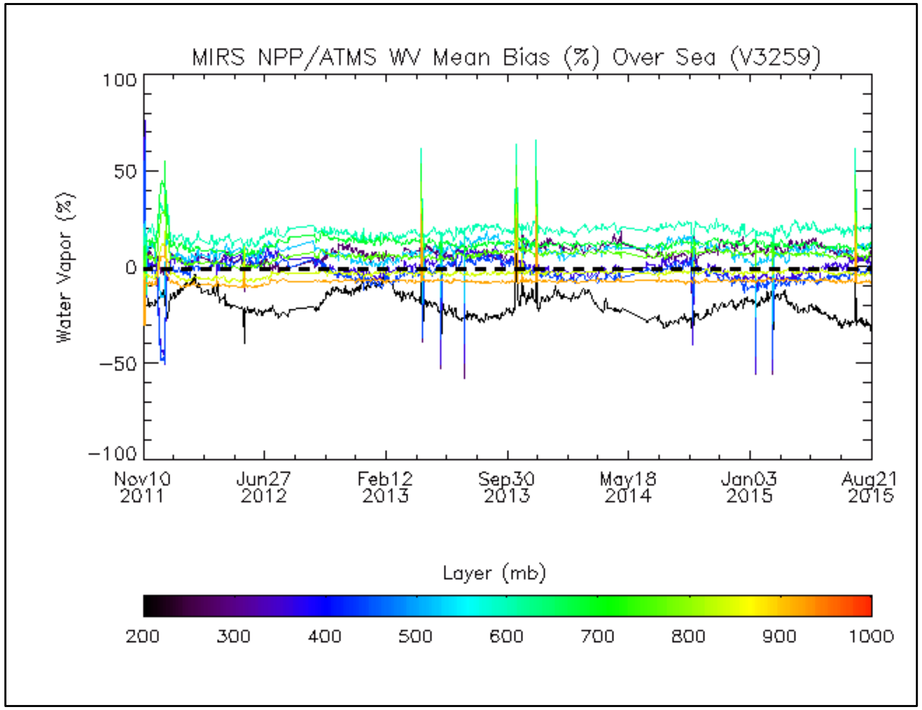
Outliers are processing anomalies, not retrievals

Produced daily on STAR website

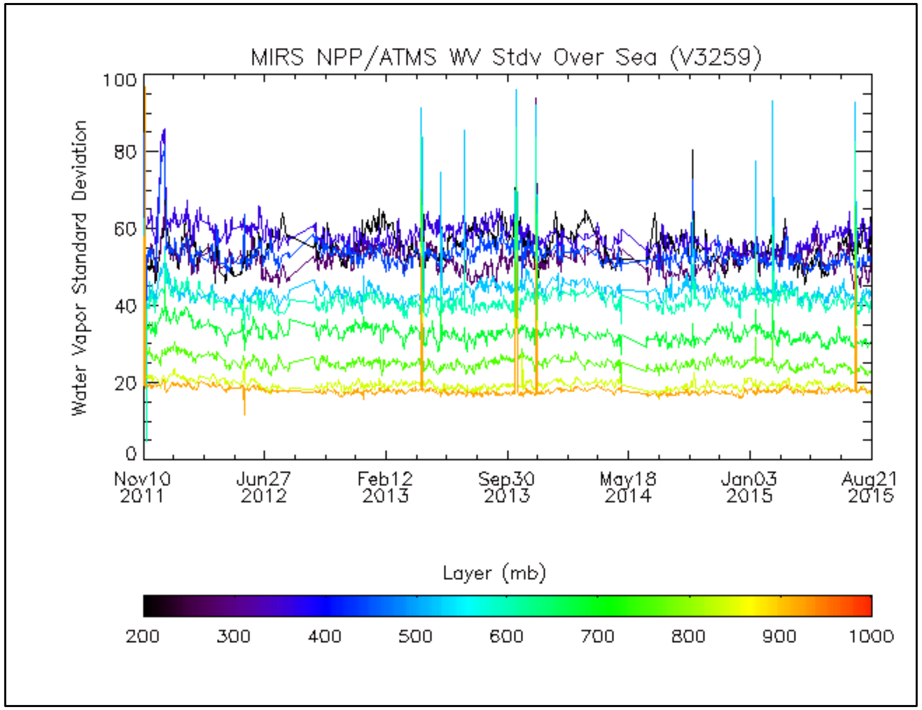
JPSS-1 Readiness: MiRS Long-Term Monitoring

- **S-NPP/ATMS MiRS v9.2 Water Vapor Retrieval Bias and Std Dev vs. ECMWF since Nov 2011 (Ocean)**

Bias



StDv



Outliers are processing anomalies, not retrievals

Produced daily on STAR website

JPSS-1 Readiness: MiRS Plans/Deliverables in FY16 and Beyond

- **Good working relationship with POCs at NDE, facilitates delivery and integration.**
- **No major changes to basic MiRS software architecture anticipated**

Date(s)	Activities	Comment/Deliveries
Jul - Oct 2016	Code + data extension to JPSS-1/ATMS	****Need CRTM sensor coefficient files for J-1/ATMS and sample data****
Oct 2016	Critical Design Review	**CDR Docs**
Oct 2016 - Apr 2017	MiRS algorithm testing with sample/proxy data	
Apr 2017	**JPSS-1 Launch**	
May 2017	Preliminary DAP delivery to NDE	**pDAP (radiometric bias corrections based on limited post-launch data)**
Apr 2017 - Mar 2018	Algorithm Verification and Validation with real data	
Mar/Apr 2018	Algorithm Readiness Review + Final DAP delivery to NDE	**ARR Docs + DAP**
Oct 2017 - Sep 2018	MiRS JPSS-1/ATMS products validated to Stage 1	
Oct 2018 - Sep 2019	MiRS JPSS-1/ATMS products validated to Stage 2	

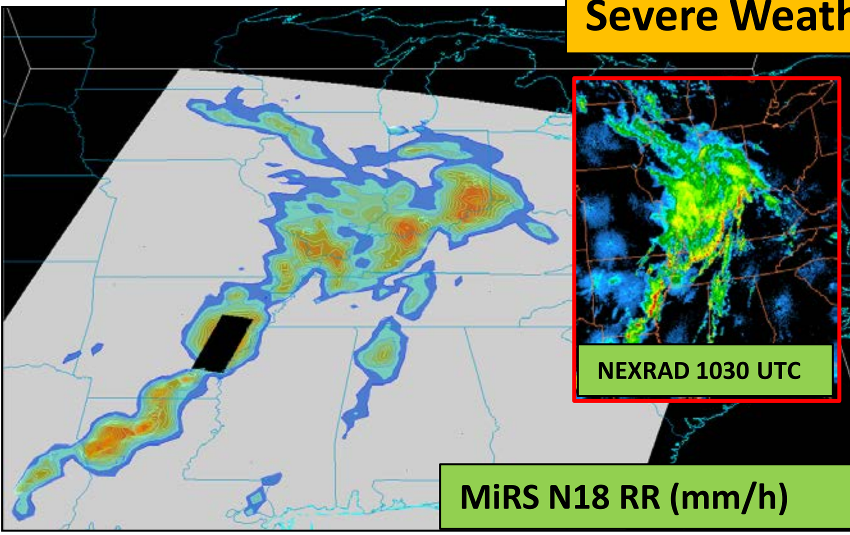
Summary & Path Forward

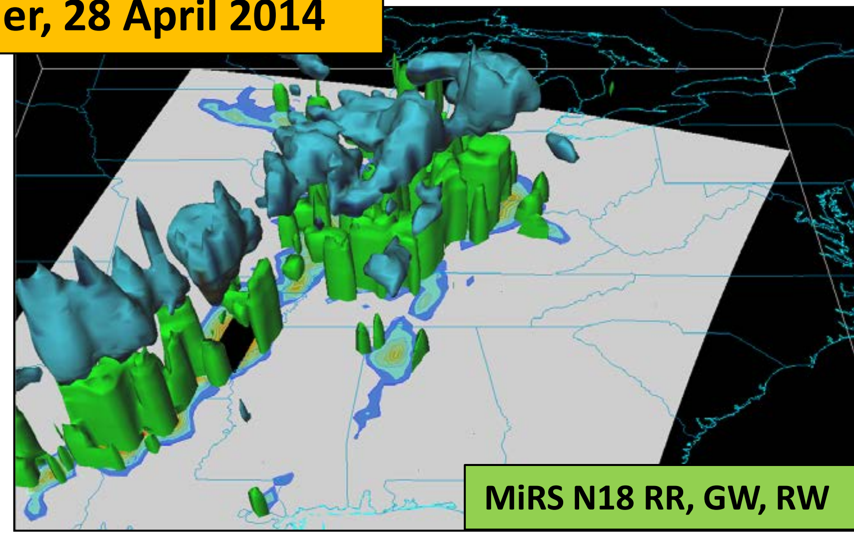
- MiRS is a robust, flexible satellite retrieval system designed for rapid, physically-based atmospheric and surface property retrievals from passive microwave measurements.
- MiRS v9.2 running at NDE since 2013.
- MiRS v11 released in September 2014, V11.1 released in this month, and V11.2 expected delivery to NDE in near future: contains numerous changes, leading to improved performance for T, WV sounding, hydrometeor, cryospheric products.
- MiRS software package already contains features designed to facilitate validation of certain EDRs (T and WV soundings). Additional off-line software exists in STAR for additional assessment and validation of RR, surface and cryospheric parameters.
- **Future Improvements:**
  - Bias corrections (air mass dependence, rainy conditions)
  - Precipitation: hydrometeor size, and distribution parameters, stratiform/convective
  - Background constraint in rainy conditions: Impacts on T and WV sounding through rain
  - Surface emissivity: project plan 2017-2018 S-NPP/ATMS emissivity product cal/val
  - Surface type: currently 4 types, move toward mixed types with unique emissivity characteristics (e.g. fuzzy clustering)

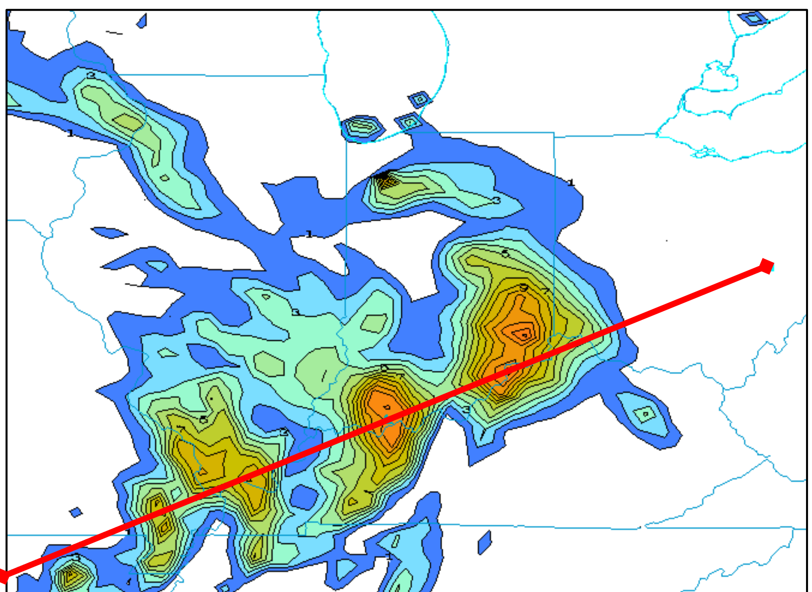
Backup Slides

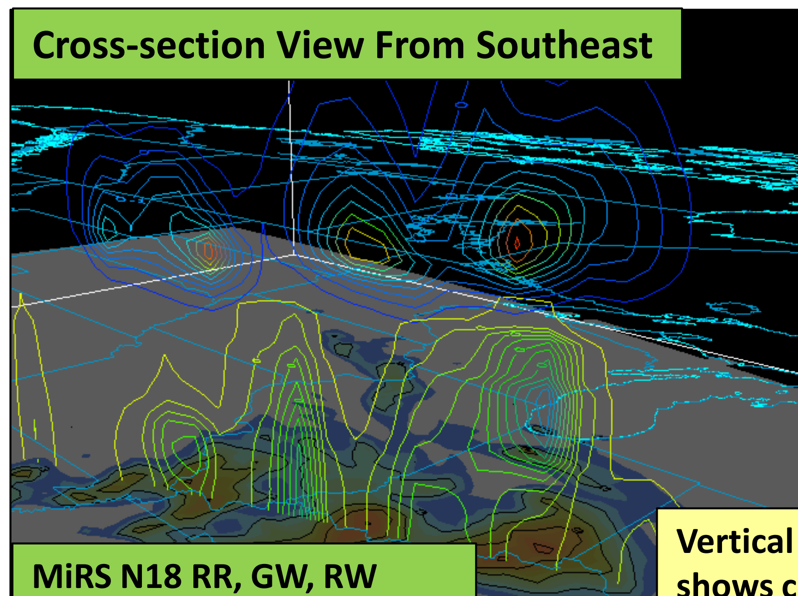
JPSS-1 Readiness: MiRS Hydrometeor Retrievals (AMSU/MHS)

Severe Weather, 28 April 2014



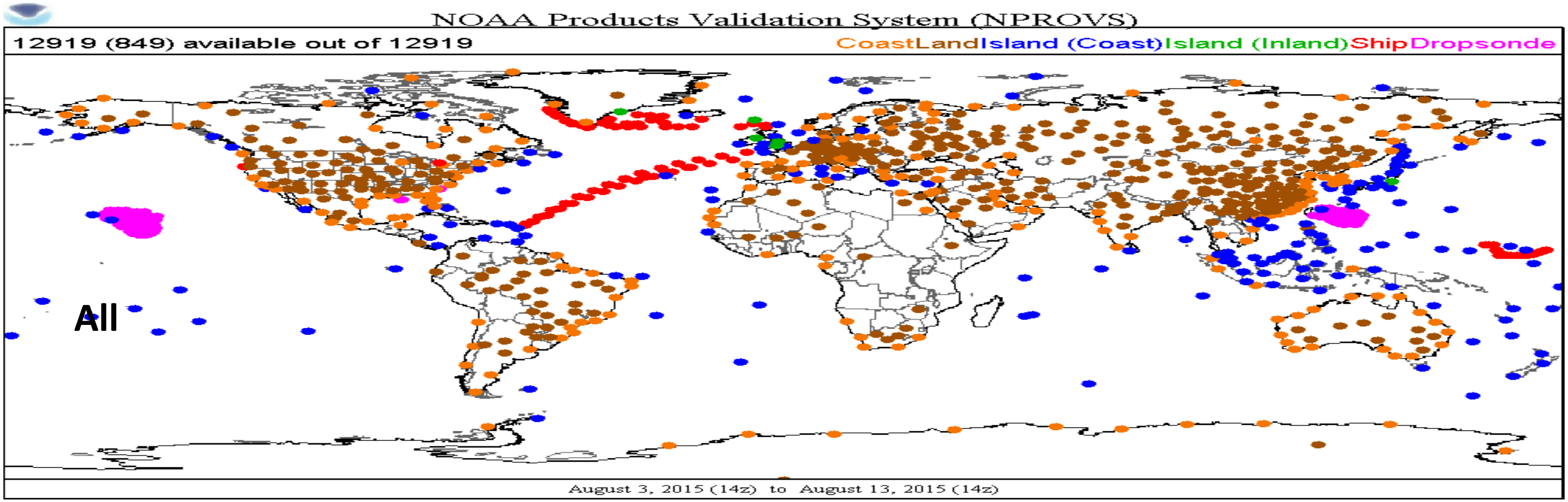


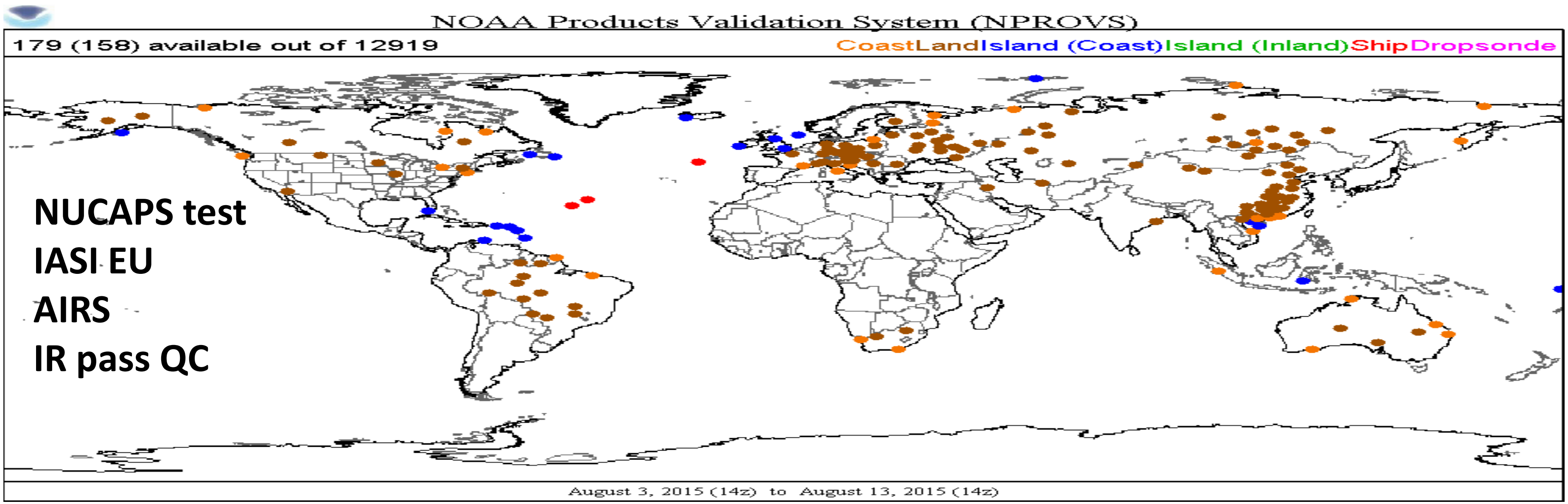




Vertical structure shows complexity (GW vs. RW distribution)

Radiosonde Locations

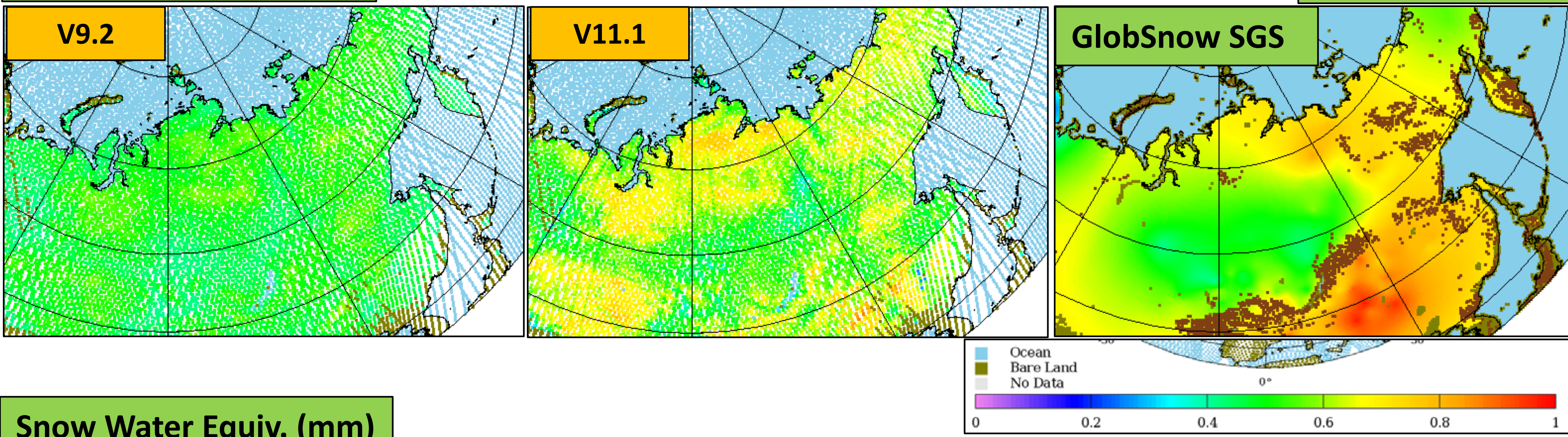




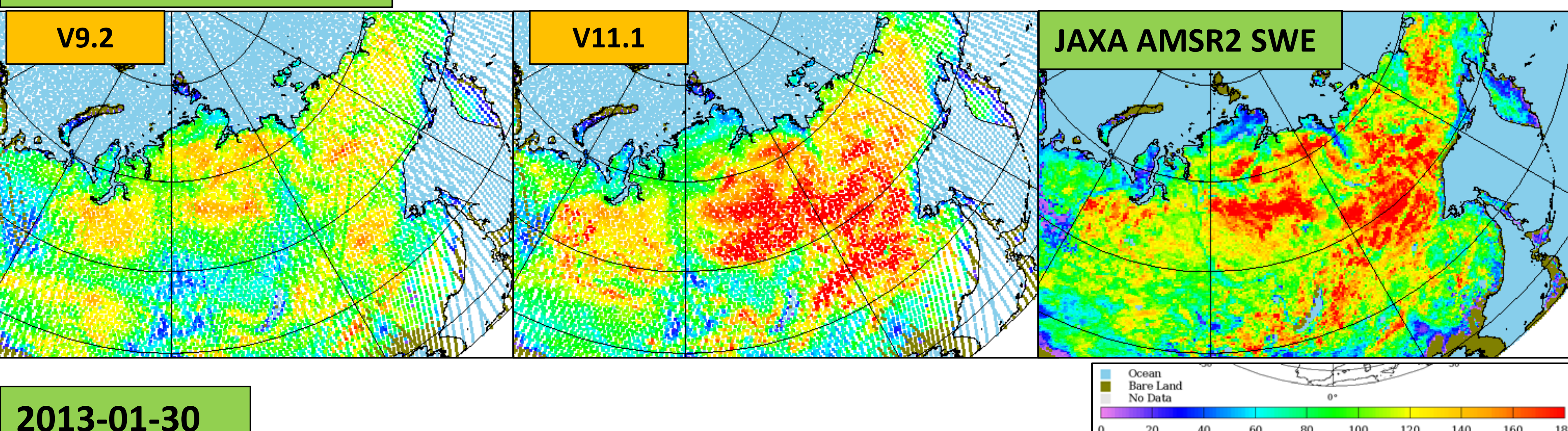
JPSS-1 Readiness:
MiRS Snow Grain Size and SWE (AMSU/MHS)

Snow Grain Size (mm)

Courtesy of FMI/ESA



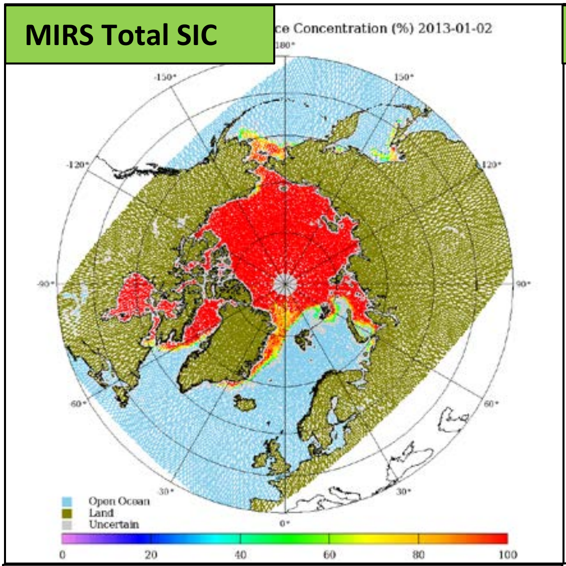
Snow Water Equiv. (mm)



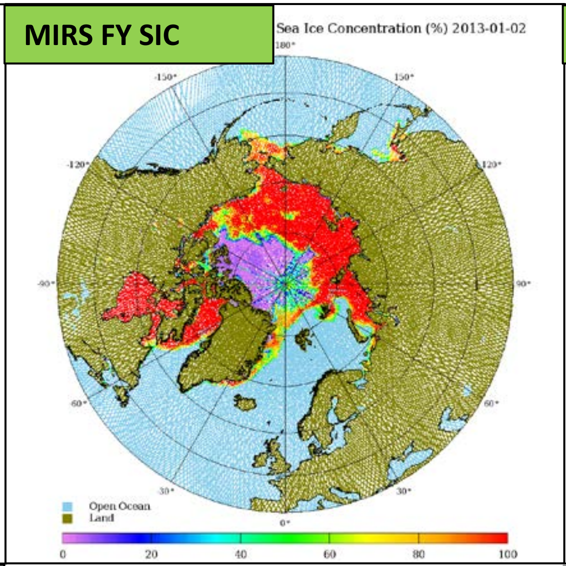
2013-01-30

JPSS-1 Readiness: MiRS Sea Ice Conc and Ice Age (AMSU/MHS)

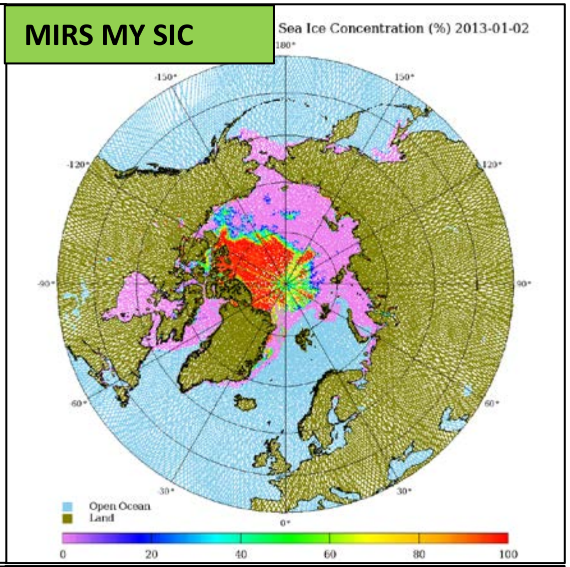
MIRS Total SIC



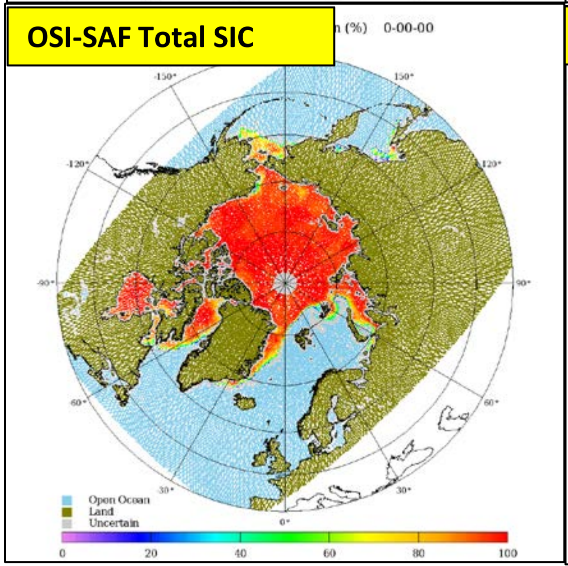
MIRS FY SIC



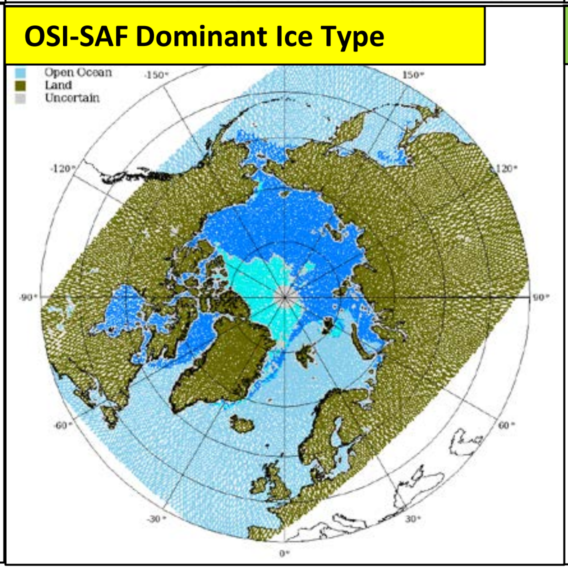
MIRS MY SIC



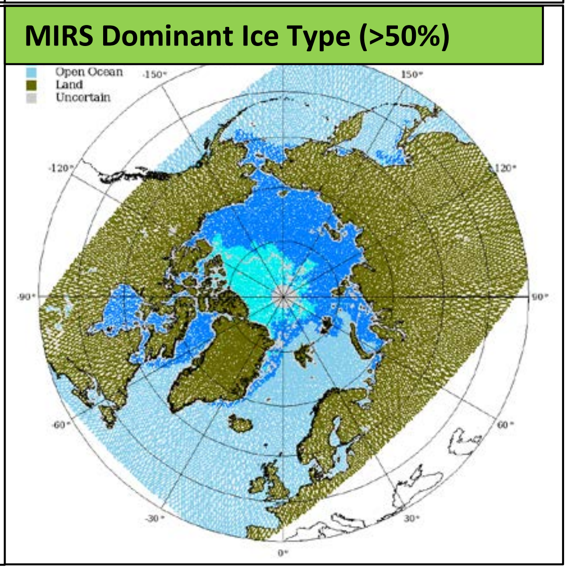
OSI-SAF Total SIC



OSI-SAF Dominant Ice Type



MIRS Dominant Ice Type (>50%)



2013-01-02

Current SNPP Sounding Products from the Operational System and Way Forward for the JPSS-1 CrIS/ATMS Products

A.K. Sharma,
OSPO, Sounding Products Area Lead

August 26, 2015

Outline

- NUCAPS Team Members
- NUCAPS System Requirements
- Unique CrIS ATMS Processing System (NUCAPS) - Operational Products
- JPSS Specification Performance Requirements
- NUCAPS Products on the OSPO Website (External Users)
- NUCAPS Online Product Monitoring (Internal Users)
- NUCAPS Data Distribution and Access (NDE/PDA)
- NUCAPS Users
- NUCAPS Major Accomplishments
- SNPP Looking Ahead
- Summary / NUCAPS Future Plans

NUCAPS Team Members

Team Members:

STAR: Mark Liu, Tony Reale, Walter Wolf, Thomas King, Nicholas Nalli, Bomin Sun, Letitia Soulliard, Mike Wilson, Kexin Zhang

STC: Chris Barnet, Antonia Gambacorta

OSPO: A.K. Sharma, Antonio Irving, Chris Sisko, Donna McNamara, Zhaohui Cheng, Jing Han, Oleg Roytburd, William OConnor, Sterling Spangler

OSGS (NDE project): Tom Schott, Geoff Goodrum, Dylan Powell

NUCAPS System Requirements

- The NUCAPS shall provide:
  - CrIS thinned radiance products for NWP center users. (product, functional)
  - CrIS full spatial resolution granule files containing all CrIS FOVs and FORs for all 1305 channels.
  - Trace gas profile products for U.S. users. (product, functional)
  - Atmospheric temperature and moisture profiles for AWIPS derived from CrIS/ATMS radiances.
  - Retrieval products for AWIPS in netCDF4 format.
  - CrIS Cloud-clear Radiance (CCR) products for NWP centers and CLASS. (product, operational)
  - Daily global products for system validation, maintenance, and development. (product, operational)
  - Data files for science quality monitoring of SDR and EDR data.
  - Granules available within 103 minutes of observation

Unique CrIS ATMS Processing System (NUCAPS) Operational Products

Objectives

Provide Products within 16 to 23 minutes of data receipt from IDPS to NWS and DOD.

Operational Products:

>> Spectrally and spatially thinned Radiances,

>> Retrieved products such as Temperature, moisture, pressure profiles

>> Cloud cleared radiances

>> Atmospheric trace gas products

>> Principal components

>>QA/QC Science products for Operational Monitoring

>>EDR Validation Products: Global Grids, Matchups, and Binaries

++ Not Validated

** Currently not yet declared operational

Retrieval Products

Cloud Cleared Radiances	660-750 cm-1 2200-2400 cm-1
Cloud fraction and Top Pressure **	660-750 cm-1
Surface temperature **	window
Temperature	660-750 cm-1 2200-2400 cm-1
Water Vapor	780 – 1090 cm-1 1200-1750 cm-1
O3 ++	990 – 1070 cm-1
CO ++	2155 – 2220 cm-1
CH4 ++	1220-1350 cm-1
N2O++	1290-1300cm-1 2190-2240cm-1
HNO3 **	760-1320cm-1
SO2 **	1343-1383cm-1

NUCAPS AWIPS Products

The retrieval product for AWIPS includes the following variables.

CrIS FOR	Time
Latitude	Longitude
View Angle	Ascending/Descending Status
Topography	Surface Pressure
Skin Temperature	Quality Flag
Pressure (at 100 levels)	Effective Pressure (at 100 levels)
Temperature (Kelvin at 100 levels)	H2O (g/Kg at 100 levels)
O3 (ppb at 100 levels)	Liquid H2O (g/Kg at 100 levels)
Ice/Liquid Flag (at 100 levels)	SO2 (ppb at 100 levels)
Stability parameters	

- *See Session 7b on Thursday morning for AWIPS User Presentations.*

JPSS Specification Performance Requirements

- **NUCAPS Algorithm:** Unified **(**AIRS/IASI/CrIS) approach, multi-step iterative method, front-end regression
  NUCAPS science code (100 layer)
  – Operational product in Sept 2013

"Clear to Partly Cloudy" – ≤50% cloudiness

"Cloudy" – >50% cloudiness

- *"Cloudy"* – IR fails converge, MW-only retrieval
- *"Clear to Partly Cloudy"* – IR convergence

- L1RD Supp– Table 5.2.3.1, 5.2.3.2, 5.2.4.1, 5.2.4.2, 5.2.5, 5.2.6, 5.2.7, and 5.2.8

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

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

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

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

NUCAPS - OSPO Websites (External/Internal)

- OSPO NUCAPS Sounding Products Webpages (Internet) for **external users**:
- NUCAPS Sounding Products

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/

- NUCAPS/SNPP Global Granules Composite Images

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_composite.html

- NUCAPS/SNPP Global Gridded Products

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_gridded.html

- NUCAPS/SNPP Retrieval Statistics

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_stats.html

- NUCAPS Product Monitor Web links (Intranet) for **internal users**:

http://nucaps.espc.nesdis.noaa.gov/cgi-bin/NUCAPS/nucapsMonitor.pl (OSPO Oper)

http://nucaps.espc.nesdis.noaa.gov/cgi-bin/NUCAPS/nucapsPSmonitor.pl

http://nucaps.espc.nesdis.noaa.gov/cgi-bin/NUCAPS/globeStats.pl

http://nucaps.espc.nesdis.noaa.gov/cgi-bin/NUCAPS/yieldStats.pl

http://nucaps.espc.nesdis.noaa.gov/cgi-bin/NUCAPS/RetrStats.pl

http://nucaps.espc.nesdis.noaa.gov/cgi-bin/NUCAPS_DIFF/nucapsMonitor.pl

http://prodmonp.espc.nesdis.noaa.gov/mtool (NDE)

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_gridded.html

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NUCAPS Sounding Products

SNPP Global Gridded 0.5 deg lat x 2 deg lon Images

Archives: Select a Date Go

Wednesday, August 19, 2015

	NUCAPS / SNPP
Temperature	0-24 Z
Mixing Ratio of Water Vapor (H2O)	0-24 Z
Mixing Ratio of Liquid H20	0-24 Z
Mixing Ratio of Ozone (O3)	0-24 Z
Mixing Ratio of Methane (CH4)	0-24 Z
Mixing Ratio of Carbon Dioxide (CO2)	0-24 Z
Mixing Ratio of Carbon Monoxide (CO)	0-24 Z
Mixing Ratio of Sulfur Dioxide (SO2)	0-24 Z
Mixing Ratio of Nitric Acid (HNO3)	0-24 Z
Mixing Ratio of Nitrous Oxide (N2O)	0-24 Z

NUCAPS Links
NUCAPS Overview
Global Gridded Images
Granule Composite Images
Retrieval Statistics

GOES Soundings
GGCP
GOES Skew-T
Satellite Cloud Product
Sounder DPI

POES Soundings
ATOVS: Profiles | vstats
IASI
MIRS
NUCAPS
POES skew-T

Related Soundings Links
Comprehensive Large Array-data Stewardship System
National Climatic Data Center
Polar Orbiter Data and NOAA KLM User's Guides
Satellite Health
Soundings Overview
Additional Product Information
2005 Workshop Presentations
Product List

NUCAPS Gridded Temperature

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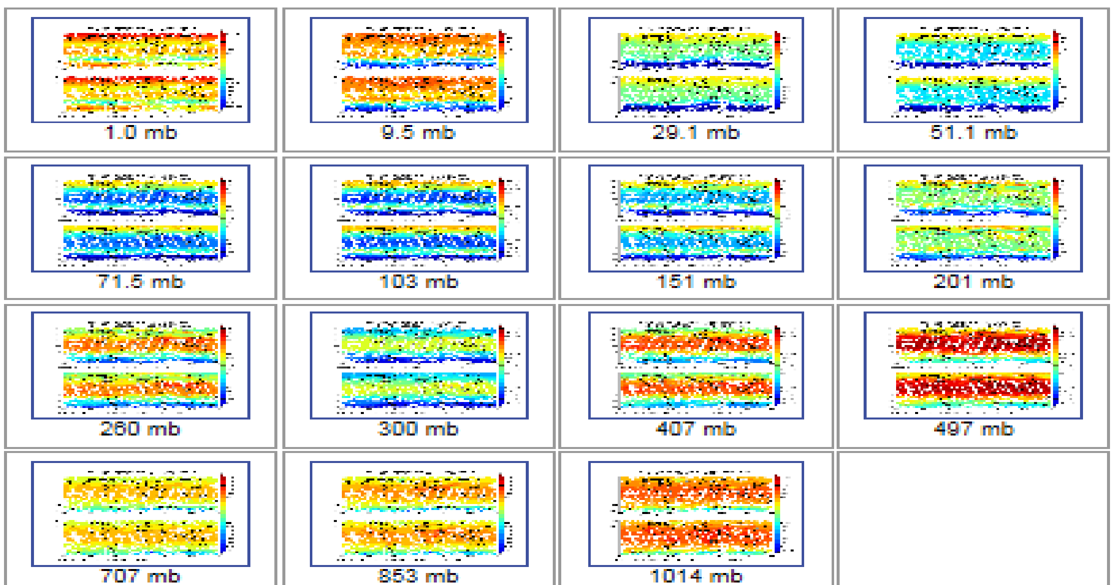
NUCAPS: Temperature

SNPP Global Gridded 0.5 deg lat x 2 deg lon Images

Archives: Select a Date Go

Wednesday, August 19, 2015 0-24Z



NUCAPS Links

- NUCAPS Overview
- Global Gridded Images
- Granule Composite Images
- Retrieval Statistics

GOES Soundings

- GGCP
- GOES Skew-T
- Satellite Cloud Product
- Sounder DPI

POES Soundings

- ATOVS: Profiles | vstats
- IASI
- MIRS
- NUCAPS
- POES skew-T

Related Soundings Links

- Comprehensive Large Array-data Stewardship System
- National Climatic Data Center
- Polar Orbiter Data and NOAA KLM User's Guides
- Satellite Health
- Soundings Overview
- Additional Product Information
- 2005 Workshop Presentations
- Product List

http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/gg/gg_temp.html http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_composite.html

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NUCAPS/SNPP Granule Composite Images

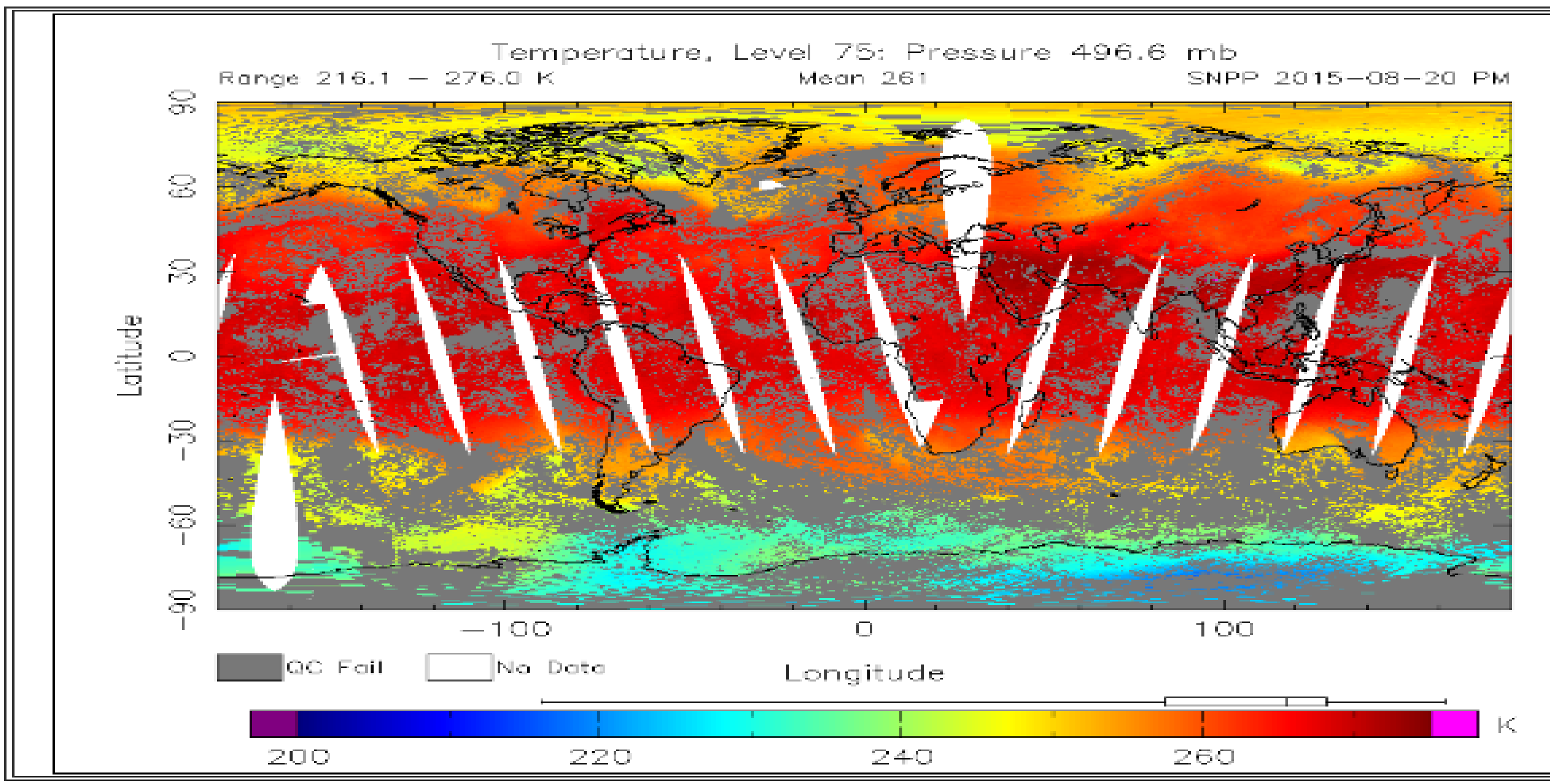
Product: Temperature

Pressure Level: 497 mb

Day and Time D1 T1

Day 1, T1, 497 mb

Start Stop << Prev Next >>



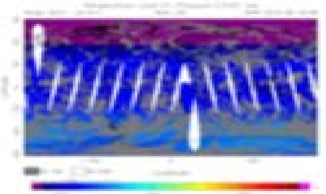
Temperature (deg K), Water Vapor Mixing Ratio (g/Kg), Liquid Water Mixing Ratio (g/Kg), Ozone Mixing Ratio (ppb), Methane Mixing Ratio (ppb), Carbon Dioxide dry mixing ratio (ppm), Carbon Monoxide Mixing Ratio (ppb), Sulfur Dioxide mixing ratio (ppb), Nitric Acid Mixing Ratio (ppb), and Nitrous Oxide Mixing Ratio (ppb) at 15 fixed air pressure levels/layers twice a day

NUCAPS Level Temperatures

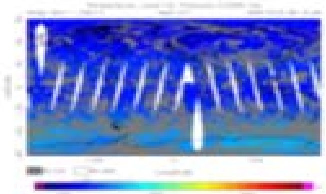
Temperature Images for 2015-08-18 AM - SNPP

Temperature

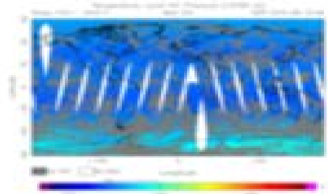
L01: 0.0161 mb



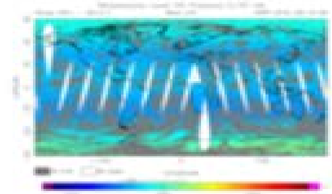
L02: 0.0384 mb



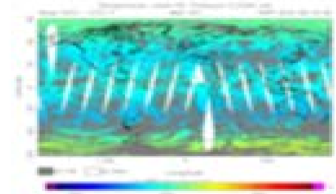
L03: 0.0769 mb



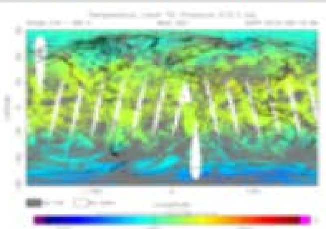
L04: 0.137 mb



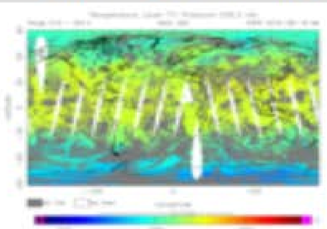
L05: 0.2244 mb



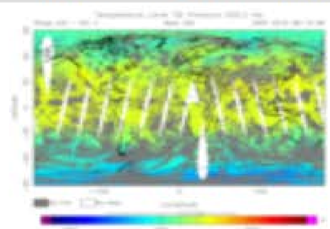
L76: 515.7 mb



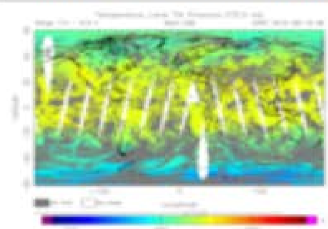
L77: 535.2 mb



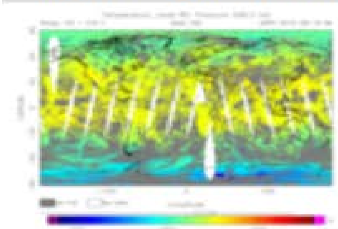
L78: 555.2 mb



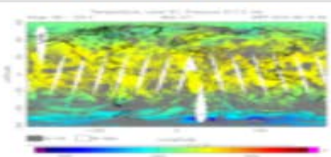
L79: 575.5 mb



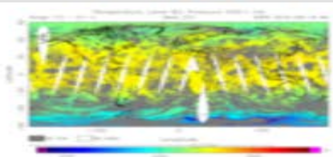
L80: 596.3 mb



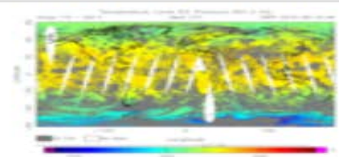
L81: 617.5 mb



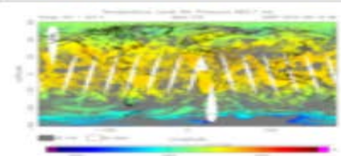
L82: 639.1 mb



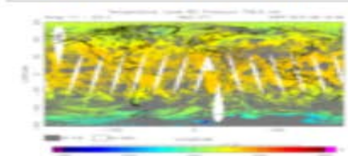
L83: 661.2 mb



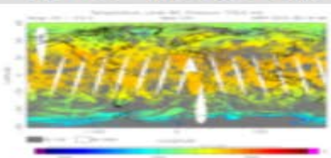
L84: 683.7 mb



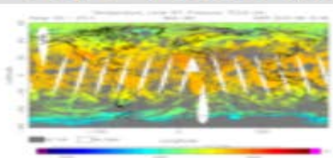
L85: 706.6 mb



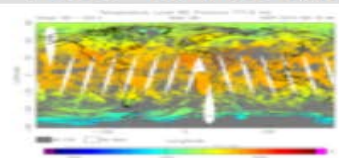
L86: 729.9 mb



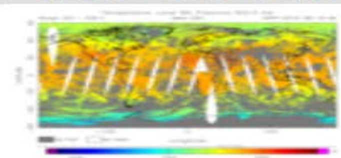
L87: 753.6 mb



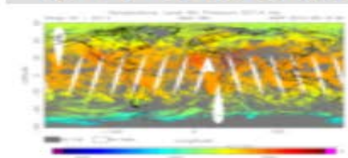
L88: 777.8 mb



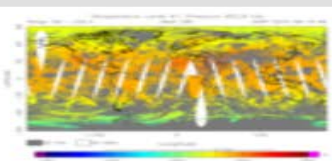
L89: 802.4 mb



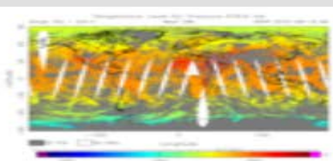
L90: 827.4 mb



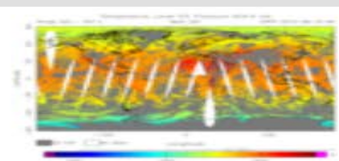
L91: 852.8 mb



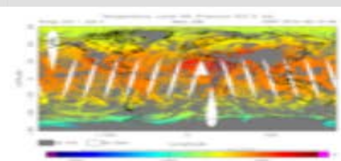
L92: 878.6 mb



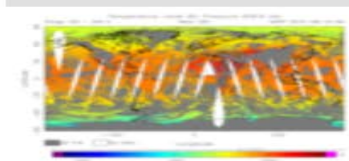
L93: 904.9 mb



L94: 931.5 mb



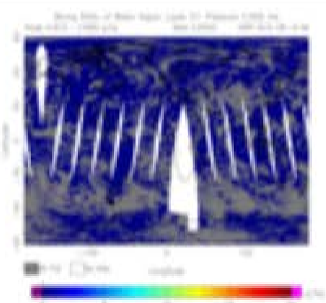
L95: 958.6 mb



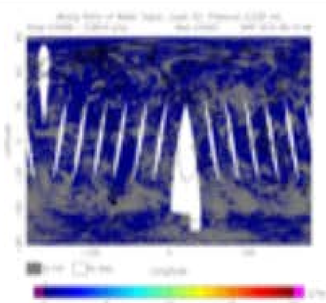
Mixing Ratio of Water Vapor Images for 2015-08-19 AM - SNPP

Mixing Ratio of Water Vapor

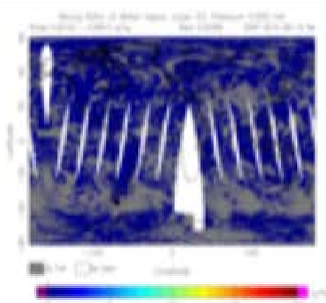
L01: 0.009 mb



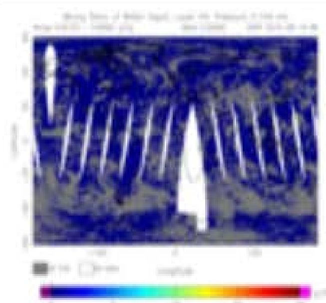
L02: 0.026 mb



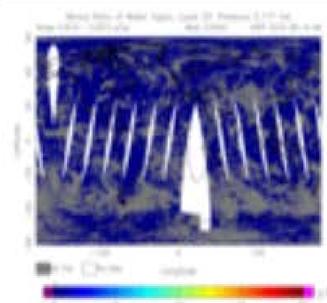
L03: 0.055 mb



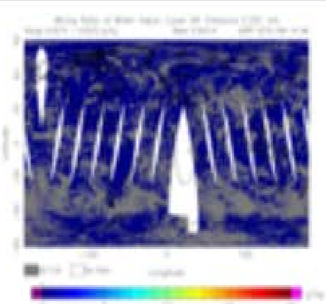
L04: 0.104 mb



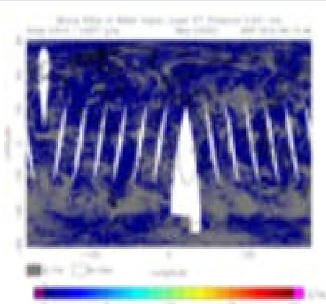
L05: 0.177 mb



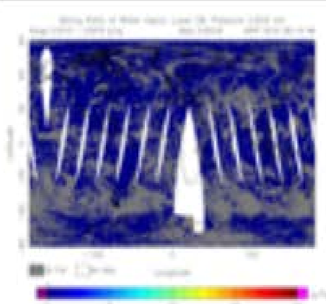
L06: 0.281 mb



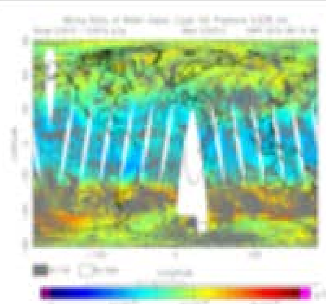
L07: 0.421 mb



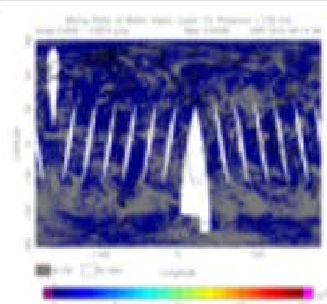
L08: 0.604 mb



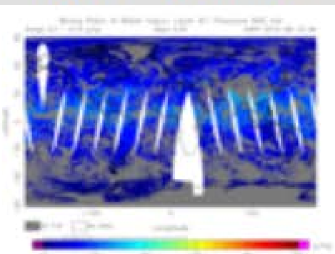
L09: 0.838 mb



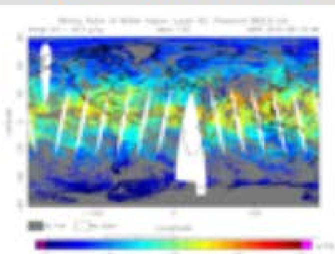
L10: 1.129 mb



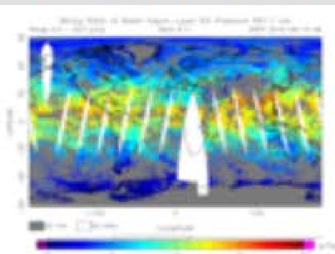
L91: 840 mb



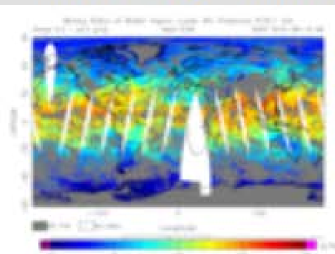
L92: 865.6 mb



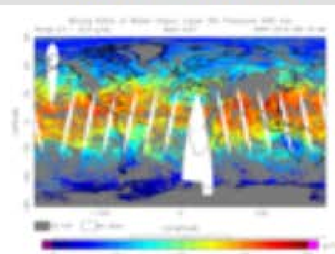
L93: 891.7 mb



L94: 918.1 mb



L95: 945 mb



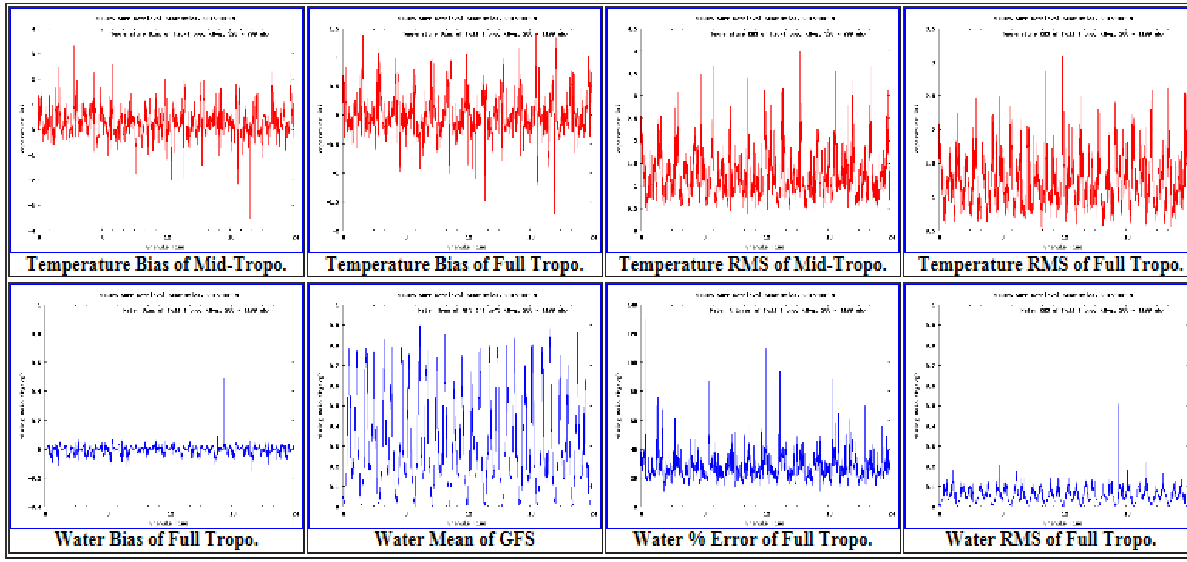
http://www.ospo.noaa.gov/Products/atmosphere/soundings/nucaps/NUCAPS_stats.html

ORGANIZATION | SERVICES | PRODUCTS | OPERATIONS

NUCAPS/SNPP Retrieval Statistics

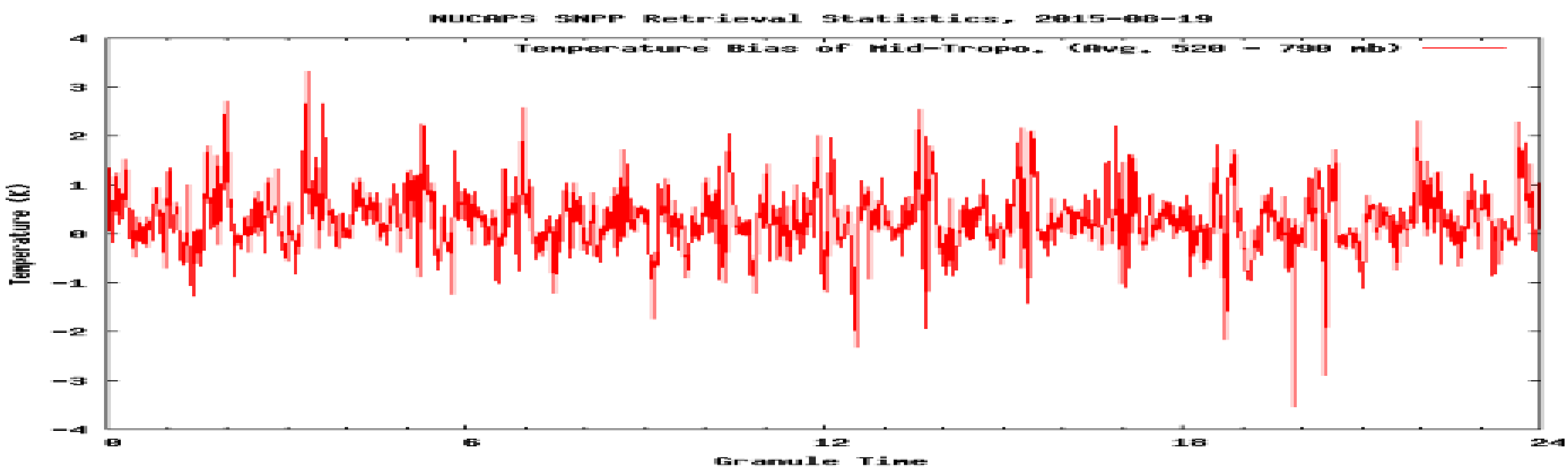
2015-08-19	2015-08-18	2015-08-17	2015-08-16	2015-08-15
2015-08-14	2015-08-13	2015-08-12	2015-08-11	2015-08-10
2015-08-09	2015-08-08	2015-08-07	2015-08-06	2015-08-05
2015-08-04	2015-08-03	2015-08-02	2015-08-01	2015-07-31
2015-07-30	2015-07-29	2015-07-28	2015-07-27	2015-07-26
2015-07-25	2015-07-24	2015-07-23	2015-07-22	2015-07-21

NUCAPS Retrieval Statistics - SNPP 2015-08-19



Temperature Bias of Mid-Tropo. | Temperature Bias of Full Tropo. | Temperature RMS of Mid-Tropo. | Temperature RMS of Full Tropo.

Water Bias of Full Tropo. | Water Mean of GFS | Water % Error of Full Tropo. | Water RMS of Full Tropo.



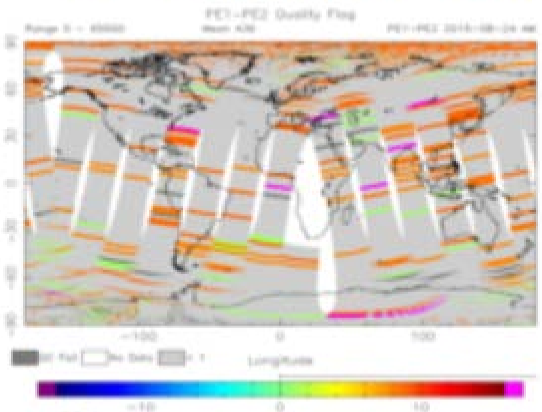
NUCAPS Phase 3

- The NUCAPS Phase 3 has the following updates:
- New retreival regression
- CrIS OLR (granules and global grids)
- CrIS/VIIRS collocation (for CrIS SDR BUFR)
- Major preprocessor updates
- Bug fixes to retrieval and preprocessor codes
- CF-compliance updates for netCDF4 output files
- Port to GNU compiler
- Update to handle VIIRS CM IP or EDR (for IDPS 2.0 testing)
- Turned off many of the NUCAPS global products (only running L2 and OLR grids)
- SNPP hardcoding is removed from scripts (for using J1 filenames)
- NUCAPS Phase 3 ARR planned on Sept 3, 2015

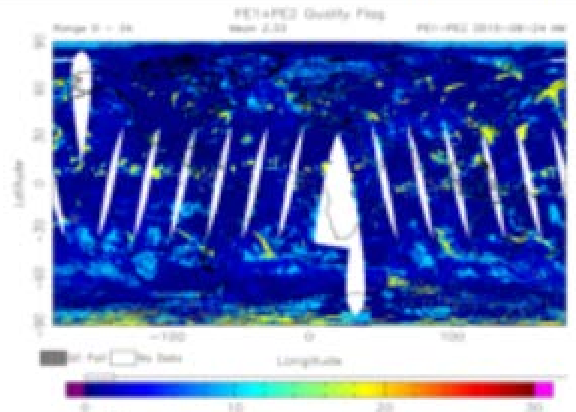
NUCAPS EDR Images for 2015-08-24 AM - PE1-PE2

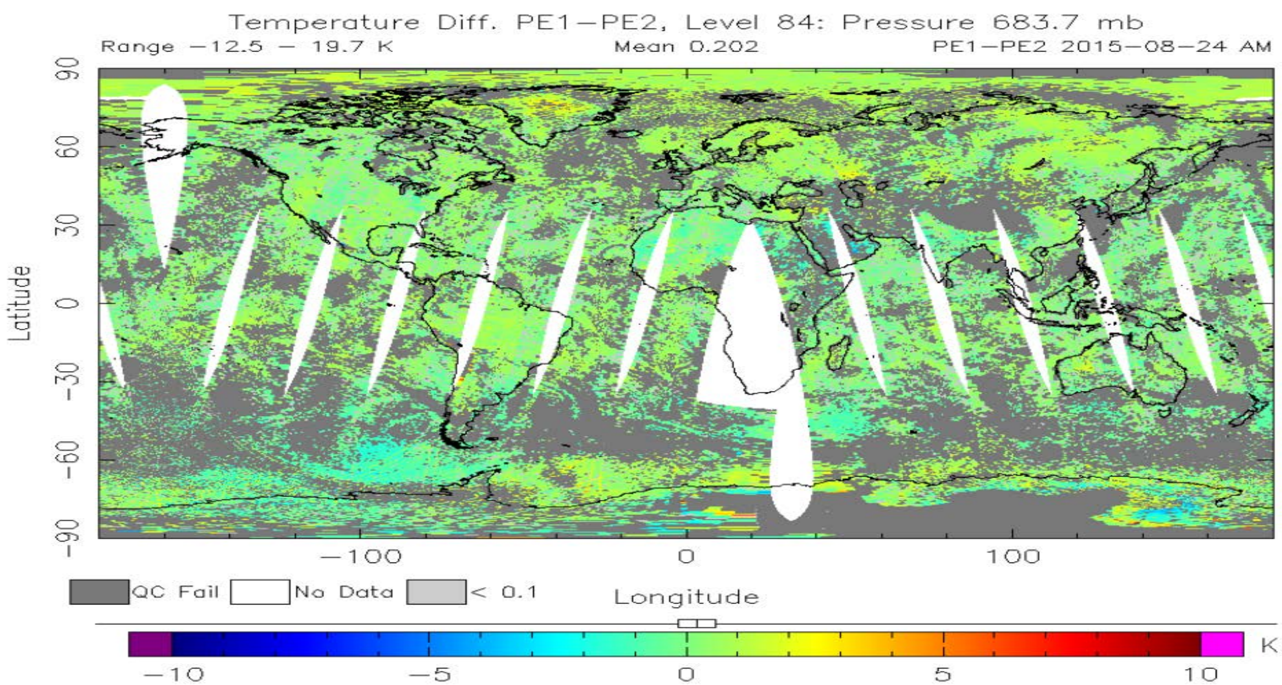
Internal links: [Single Level Parameters] [MR of Water Vapor Diff. PE1-PE2] [Temperature Diff. PE1-PE2]

PE1-PE2 Quality Flag

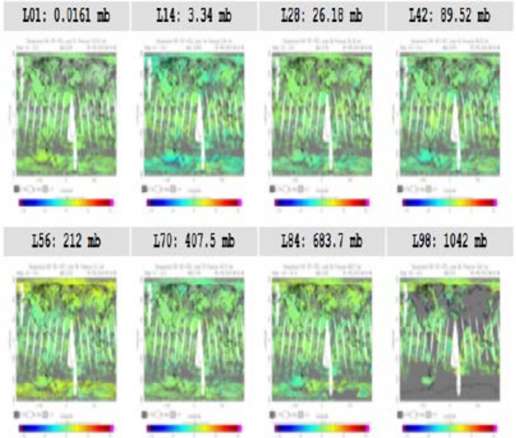


PE1+PE2 Quality Flag

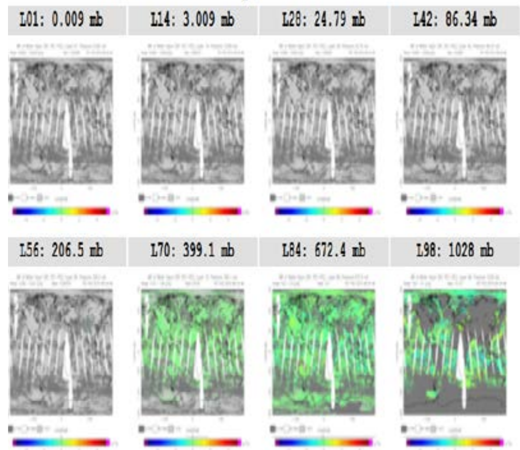




Temperature Diff. PE1-PE2



MR of Water Vapor Diff. PE1-PE2



NUCAPS SNPP Global Statistics – Dynamically Generated

Time		Start			End		
	○ Absolute	Year	Month	Day	Year	Month	Day
		2015	Aug	20	2015	Aug	20
	◉ Relative	Week ending yesterday					
Granularity	○ Half Day ◉ Day ○ Week						
Output	◉ Bar chart (PNG) ○ HTML table ○ Comma-separated values ○ Tab-separated values						
Quality	Discard periods whose statistics cover an average of less than 0 % of Earth's surface every 12 hours.						
Statistic	☑ Mean ☐ Variance ☐ Maximum ☐ Minimum ☐ Median* ☐ Lower quartile* ☐ Upper quartile* * Only available for half-day granularity						

NUCAPS EDR

- ☐ Bottom Level Index
- ☐ Ice Liquid Flag, Layer 01: Pressure 0.009 mb
- ☐ Ice Liquid Flag, Layer 14: Pressure 3.009 mb
- ☐ Ice Liquid Flag, Layer 28: Pressure 24.79 mb
- ☐ Ice Liquid Flag, Layer 42: Pressure 86.34 mb
- ☐ Ice Liquid Flag, Layer 56: Pressure 206.5 mb
- ☐ Ice Liquid Flag, Layer 70: Pressure 399.1 mb
- ☐ Ice Liquid Flag, Layer 84: Pressure 672.4 mb
- ☐ Ice Liquid Flag, Layer 98: Pressure 1028 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 01: Pressure 0.009 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 14: Pressure 3.009 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 28: Pressure 24.79 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 42: Pressure 86.34 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 56: Pressure 206.5 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 70: Pressure 399.1 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 84: Pressure 672.4 mb
- ☐ Mixing Ratio of Carbon Dioxide, Layer 98: Pressure 1028 mb

- ☐ Mixing Ratio of Liquid Water, Layer 01: Pressure 0.009 mb
- ☐ Mixing Ratio of Liquid Water, Layer 14: Pressure 3.009 mb
- ☐ Mixing Ratio of Liquid Water, Layer 28: Pressure 24.79 mb
- ☐ Mixing Ratio of Liquid Water, Layer 42: Pressure 86.34 mb
- ☐ Mixing Ratio of Liquid Water, Layer 56: Pressure 206.5 mb
- ☐ Mixing Ratio of Liquid Water, Layer 70: Pressure 399.1 mb
- ☐ Mixing Ratio of Liquid Water, Layer 84: Pressure 672.4 mb
- ☐ Mixing Ratio of Liquid Water, Layer 98: Pressure 1028 mb
- ☐ Mixing Ratio of Methane, Layer 01: Pressure 0.009 mb
- ☐ Mixing Ratio of Methane, Layer 14: Pressure 3.009 mb
- ☐ Mixing Ratio of Methane, Layer 28: Pressure 24.79 mb
- ☐ Mixing Ratio of Methane, Layer 42: Pressure 86.34 mb
- ☐ Mixing Ratio of Methane, Layer 56: Pressure 206.5 mb
- ☐ Mixing Ratio of Methane, Layer 70: Pressure 399.1 mb
- ☐ Mixing Ratio of Methane, Layer 84: Pressure 672.4 mb
- ☐ Mixing Ratio of Methane, Layer 98: Pressure 1028 mb

- ☐ Quality Flag
- ☐ Surface Height
- ☐ Temperature, Level 01: Pressure 0.0161 mb
- ☐ Temperature, Level 14: Pressure 3.34 mb
- ☐ Temperature, Level 28: Pressure 26.18 mb
- ☐ Temperature, Level 42: Pressure 89.52 mb
- ☐ Temperature, Level 56: Pressure 212 mb
- ☐ Temperature, Level 70: Pressure 407.5 mb
- ☐ Temperature, Level 84: Pressure 683.7 mb
- ☐ Temperature, Level 98: Pressure 1042 mb

FOR ALL NUCAPS Products and Parameters

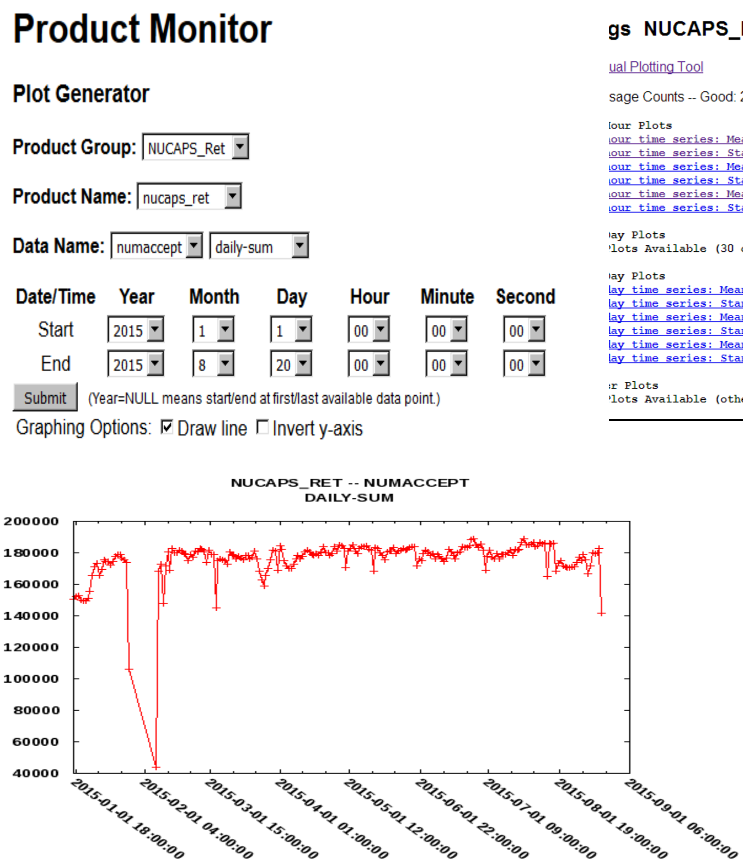
NUCAPS SNPP Granule Monthly Processing Statistics for 2015

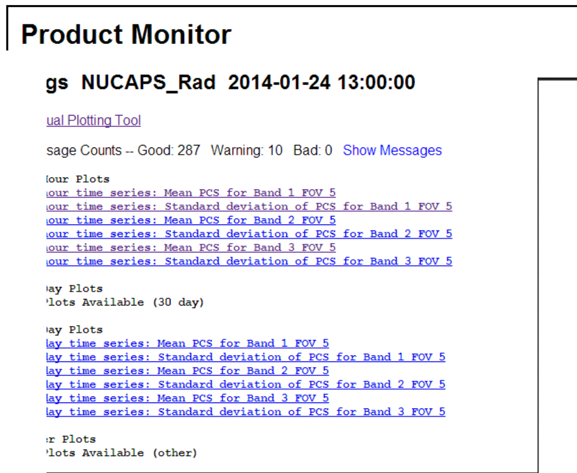
Date	TD#	SD#	Avg. EDR Delay	RGsdr#	EPsdr%	TPsdr%	RGedr#	SGedr#	APedr%	EPedr%	Tfov#	Sfov#	Yield%
201501	31	31	01:15:26	83607	99.89	99.89	83607	83204	99.52	99.41	10032840	9984480	99.52
201502	28	28	01:14:28	75516	99.89	99.89	75488	75488	99.96	99.85	9058560	9058560	100.00
201503	31	31	01:18:35	83607	99.89	99.89	83607	83607	100.00	99.89	10032840	10032840	100.00
201504	30	30	01:19:36	80880	99.85	99.85	80730	80730	99.81	99.67	9694800	9687600	99.93
201505	31	31	01:16:16	83514	99.78	99.78	83514	83514	100.00	99.78	10021680	10021680	100.00
201506	30	30	01:15:56	80850	99.81	99.81	80850	80790	99.93	99.74	9702000	9694800	99.93
201507	31	31	01:14:03	83483	99.74	99.74	83483	83483	100.00	99.74	10017960	10017960	100.00

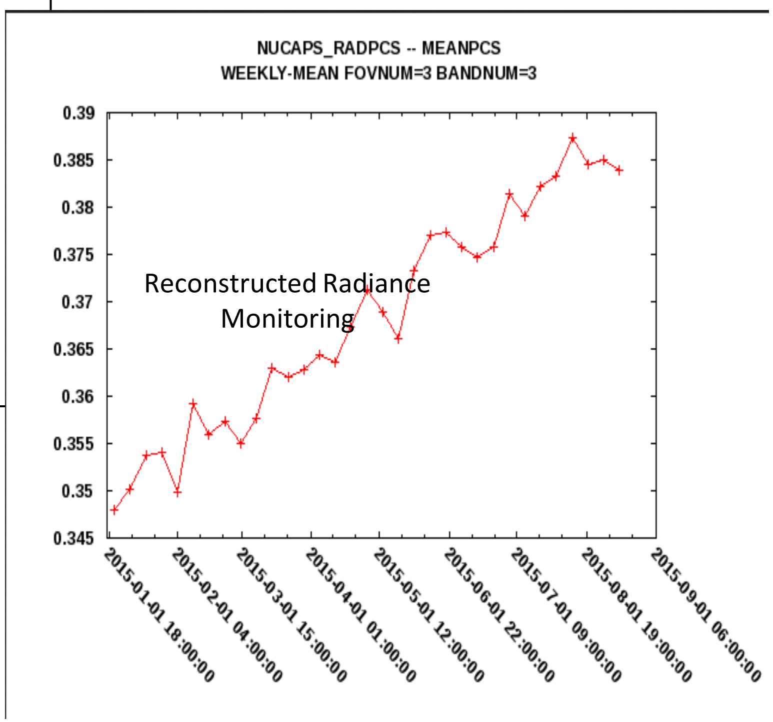
- Date: The date, year/month
- TD#: Number of days in this month
- SD#: Number of days with good retrievals in this month
- Avg. EDR Delay: Avg. EDR processing delay (latency), hh:mm:ss
- RGsdr#: Number of SDR granules received
- EPsdr%: SDR expected percentage: RGsdr# / (SD# * (Max gran. per day))
- TPsdr%: SDR total percentage: RGsdr# / (TD# * (Max gran. per day))
- RGedr#: Number of EDR granules received
- SGedr#: Number of EDR granules marked as good retrievals
- APedr%: Actual percentage for EDR/SDR: SGedr#/RGsdr#
- EPedr%: EDR expected percentage: SGedr# / (SD# * (Max gran. per day))
- Tfov#: Total FOVs: (FOV per gran.) * (Tot. number of retrievals)
- Sfov#: Total FOVs marked as good retrievals
- Yield%: Yield percentage: Sfov#/Tfov#

NDE Product Monitoring

Products	Variables to Monitor
NUCAPS	Mean & Std PCS of each FOV and each band, number of accepted cases, Bias and RMS of water vapor profiles, mean GFS water vapor (truth), % water vapor error, Layer Bias and RMS of temperature profile







http://prodmonp.espc.nesdis.noaa.gov/mtool

NUCAPS Data Distribution and Access (NDE/PDA)

NDE 1.0 (PE1) Summary – Today's Operations

- NDE system has been operational for 23 months and the system is performing as expected. Production Generation is > 99.9 %
- Oversubscription is causing significant strain on the infrastructure.
- Over 80% of the current NDE system will be utilized in NDE 2.0; therefore, from a support and system perspective we expect the product generation portion to be very stable going into the ground segment upgrade (NDE 2.0, PDA and JPSS Block 2.0).

	Sep 2013 (initial operations)	**Today** (July 2015)
Number of users (subscriptions)	3 (12)	29 (310)
Average Data Ingest*	~70 TB	~109 TB
Production Success*	> 99.9%	> 99.9%
Distribution Success*	> 99.5%	> 99.9%
Average Data Distributed*	~10 TB	~27 TB

NUCAPS Data Distribution and Access (NDE/PDA)

- JPSS NDE / PDA Transition
  - Today, NDE does product generation and provides its own distribution mechanism.
  - After JPSS Block 2.0 goes operational (in the 2016 time frame), JPSS products (S-NPP, JPSS-1, JPSS-2 and GCOM-W1) will be provided to users via the PDA interface.
  - For 30-45 days, NDE 1.0 (current operational NDE system) will remain online to facilitate an orderly transition to PDA – NASA's Network Adapter Box will permit both NDE 1.0 and NDE 2.0 to serve out the same content.
  - Under the PDA paradigm, the top priority will be given to the operational users with a demonstrated real-time data need.
- Other sources of data for research groups:
  - GRAVITE (in near real-time under Block 2.0)
  - CLASS

NUCAPS Data Distribution and Access (PDA)

- Future Contingency Operations Note
  - In the event of an outage at the primary Facility (NSOF in Suitland, MD), PDA access is transferred to the Consolidated Back-up in Fairmont, West Virginia, to support only the JPSS/S-NPP mission.
  - Fail-over requirement (JPSS/S-NPP) is under 12 hours
  - Just the JPSS primary mission sensor data will be available - the backup system is smaller scale than the operational system at NSOF.
  - Supports a full failover to CBU and a split failover scenario:
    - i.e. GOES-R can be nominal at NSOF while JPSS is failed over to CBU
    - This backup flexibility requires different network addresses at both NSOF and CBU; therefore, pull users will need to change to CBU or incorporate smart logic into their scripts.

NUCAPS Users

- **U.S. Users:**
  - NOAA NCEP (John Deber, Andrew Collard, Dennis Keyser)
  - NOAA CPC (OLR)
  - NASA GMAO (Emily Liu)
  - NOAA AWIPS II [Atmospheric stability condition for severe storms, Nowcasting, Alaska (cold core)]
  - NOAA STAR (Tony Reale, Mark Liu, Nicholas Nalli, Kexin Zhang, Jonathan Smith)
  - NOAA CLASS (Phil Jones)
- **International Users:**
  - EUMETSAT (Simon Elliott)
    - UK Met Office (Nigel Atkinson)
    - ECMWF (Tony McNally)
    - DWD (Reinhold Hess)
    - Meteo-France (Lydie Lavanant)
    - Plus other EUMETSAT members states
  - CMC (Louis Garand)
  - EC (Sylvain Heilliette)
  - JMA (Hidehiko Murata)
  - BOM (John Le Marshall)

NUCAPS Accomplishments

- NUCAPS QA/QC Near-Real-Time Tools were developed and used for monitoring the products (EDRs and SDRs)
- STAR Enterprise Product Lifecycle (EPL) process was used for NUCAPS system Development
- NUCAPS code met the Satellite Product and Services Review Board (SPSRB) software standards and OSPO security standards
- NUCAPS system successfully transition to ESPC operation

SNPP Looking Ahead

- NUCAPS Phase 3.0 implementation
  - Operationalize Outgoing long-wave radiation (OLR) EDR
  - CrIS ozone algorithm improvement
- NUCAPS upgrades including CrIS full-spectral data
- Improvement of Trace gas EDRs (CO, CO2, CH4)
- Participation in the Aircraft, satellite, dedicated radiosonde campaign for NUCAPS validation

SUMMARY
NUCAPS Future Plans

• **Ongoing optimization study includes channels, perturbation functions, first guess and damping parameter.**

• **Use dedicated cal/val field campaign in situ measurements to fully assess NUCAPS retrieval performance of temperature, water vapor, cloud cleared radiance, cloud parameters and trace gases.**

•**Leverage ongoing scientific collaborations (low cost activities for NOAA) to perform trace gas validation.**

•**CrIS OLR development and implementation for ESPC operation.**

•**Full Resolution RDR's for CrIS SW and MW bands to support carbon products.**

•**Improve the Quality of CO, CO2, and CH4 by employing the full-resolution.**

• **Enhancement of real time NUCAPS Quality Monitoring System for JPSS-1 products validation.**

•**NPROVS can be operationalized for JPSS-1 for validating the products.**

•**Plan for JPSS-1 Algorithm Updates and Validation using existing tools developed at OSPO**

•**PDA Future Activities for JPSS –**

- Continue Integration users & Testing of PDA systems.
- Determine the optimal method for supporting the PDA OGC / AWIPS DD interface for AWIPS2 users (169 sites) given resource constraints – KPP/critical products are supported 24x7 and all other data is best effort.
- Conduct Operational Readiness Review (ORR) currently scheduled for Mar 2016 time frame.
- Conduct Operations at NSOF (all missions*) and CBU (limited to JPSS).

BACKUP

NUCAPS Retrieved Products

NUCAPS Cloud Cleared Radiances	NUCAPS Principal Components
NUCAPS Methane CH_4 Profile	NUCAPS Convective Available Potential Energy
NUCAPS Cloud Fraction	NUCAPS Level 1 Radiances
NUCAPS Clear Sky OLR	NUCAPS Reconstructed Radiances
NUCAPS Carbon Monoxide CO Profile	NUCAPS Surface Emissivity
NUCAPS Carbon Dioxide CO_2 Profile	NUCAPS Sulfur Dioxide SO_2 Profile
NUCAPS Cloud Top Pressure	NUCAPS Sea Surface Temperature
NUCAPS Water Vapor Profile	NUCAPS Atmospheric Temperature Profile
NUCAPS Nitric Acid HNO_3 Profile	NUCAPS Thinned Radiances
NUCAPS Nitrous Oxide N_2O Profile	NUCAPS Total Ozone
NUCAPS Ozone Profile	NUCAPS Cloud Cleared Radiances - for archiving
NUCAPS Outgoing Longwave Radiation	

NUCAPS SNPP System Monitoring

[Granule Processing Status] [Global statistics] [Yield Statistics] [Retrieval Stats]

NUCAPS EDR, SNPP

Globe Images

[2015-08-20 AM*] [2015-08-19 AM PM] [2015-08-18 AM PM] [2015-08-17 AM PM]
[2015-08-16 AM PM] [2015-08-15 AM PM] [2015-08-14 AM PM] [2015-08-13 AM PM]
[2015-08-12 AM PM] [2015-08-11 AM PM] [2015-08-10 AM PM] [2015-08-09 AM PM]
[2015-08-08 AM PM] [2015-08-07 AM PM] [2015-08-06 AM PM] [2015-08-05 AM PM]
[2015-08-04 AM PM] [2015-08-03 AM PM] [2015-08-02 AM PM] [2015-08-01 AM PM]
[2015-07-31 AM PM] [2015-07-30 AM PM] [2015-07-29 AM PM] [2015-07-28 AM PM]

NUCAPS_DIFF PE1-PE2 System Monitoring

[Global statistics] [Retrieval Stats Differences]

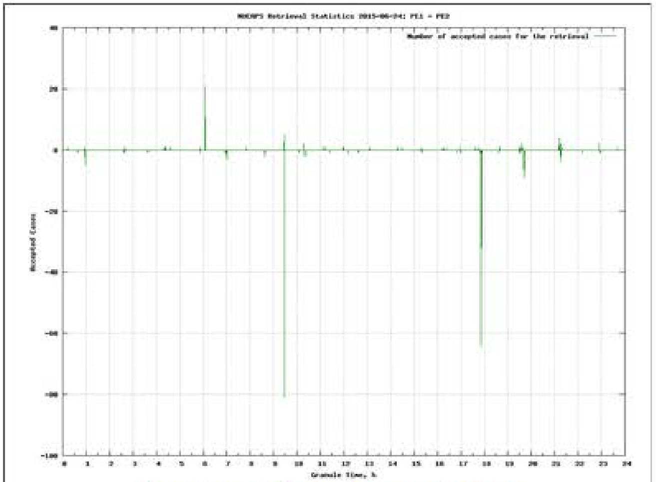
NUCAPS EDR, PE1-PE2

Globe Images

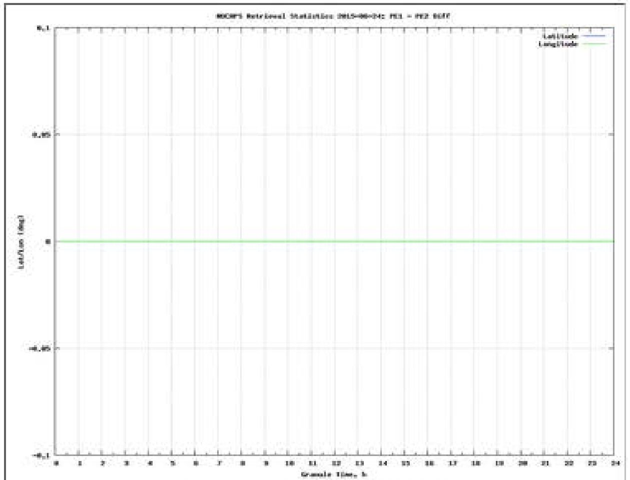
[2015-06-25 AM*] [2015-06-24 AM] [2015-06-23 AM PM] [2015-06-22 AM PM] [2015-06-21 AM PM]
[2015-06-10 AM] [2015-06-09 AM PM] [2015-06-08 AM PM] [2015-06-07 AM PM] [2015-06-06 AM PM]

* Some or all images may not be ready yet.

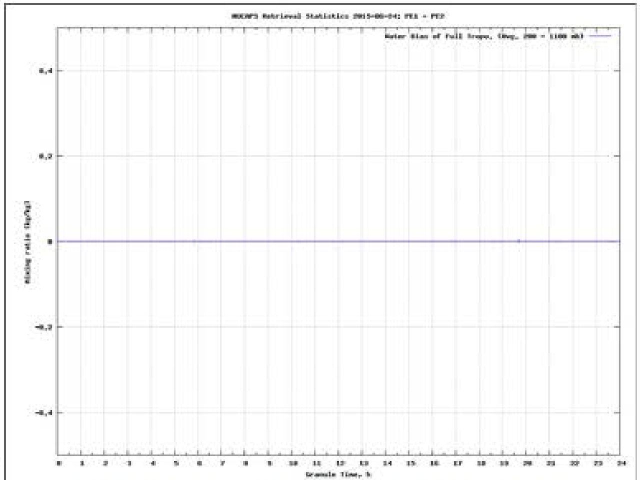
NUCAPS_DIFF PE1-PE2 Retrieval Statistics Graphics: 2015-06-24



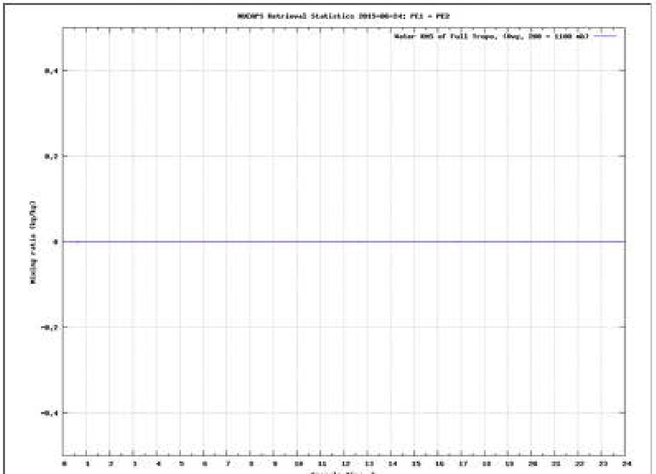
Acceptable Cases Diff.



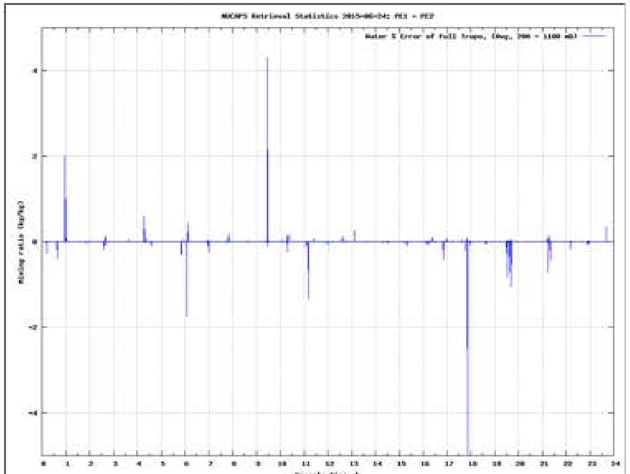
Coordinate Diff.



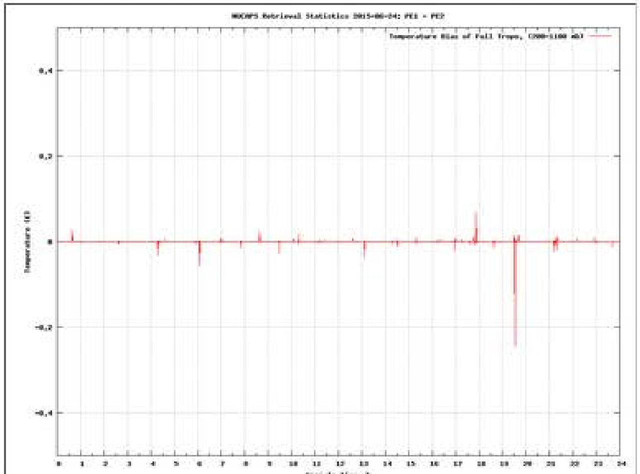
Water Bias of Full Tropo. Diff.



Water RMS of Full Tropo. Diff.

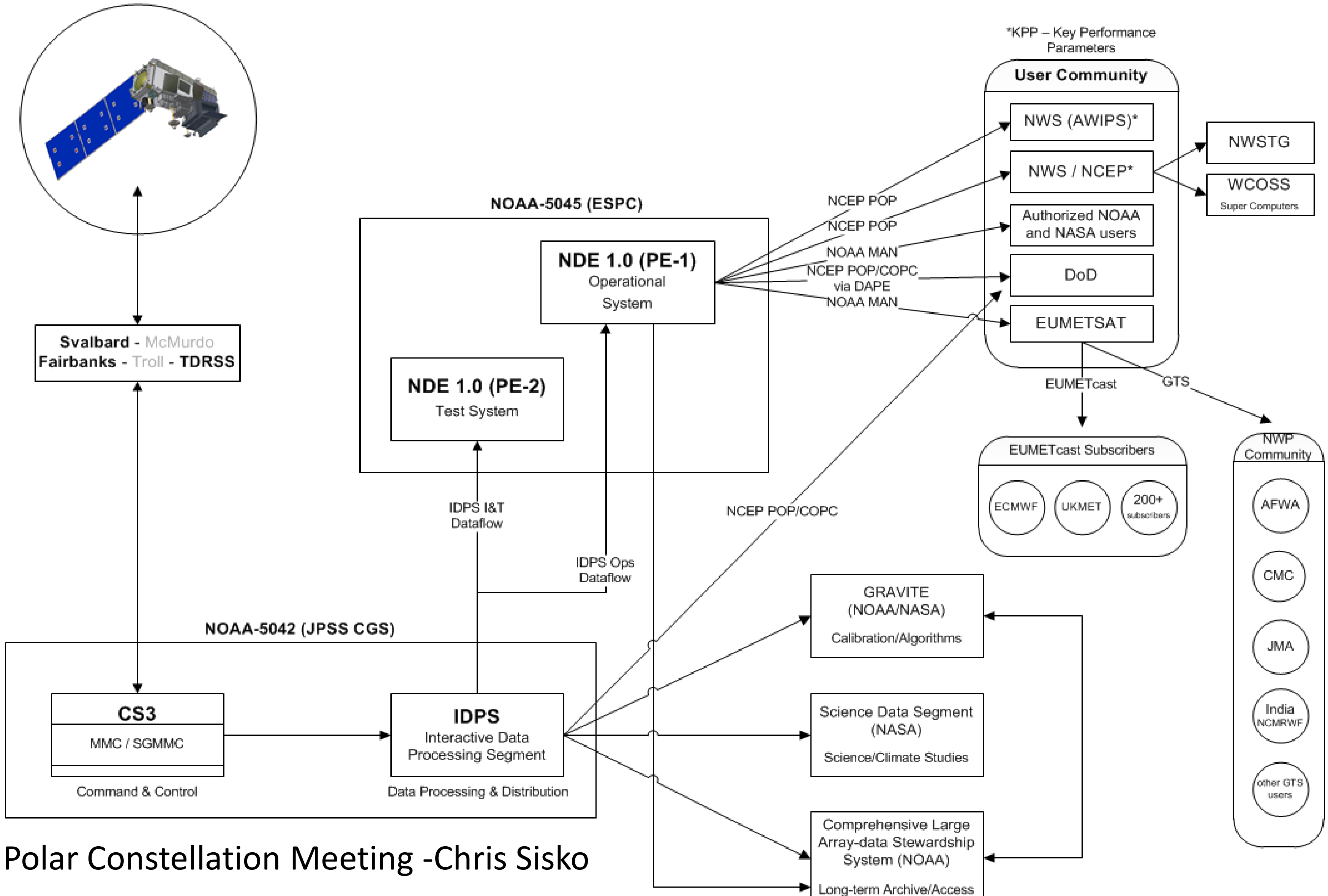


Water % Error of Full Tropo. Diff.



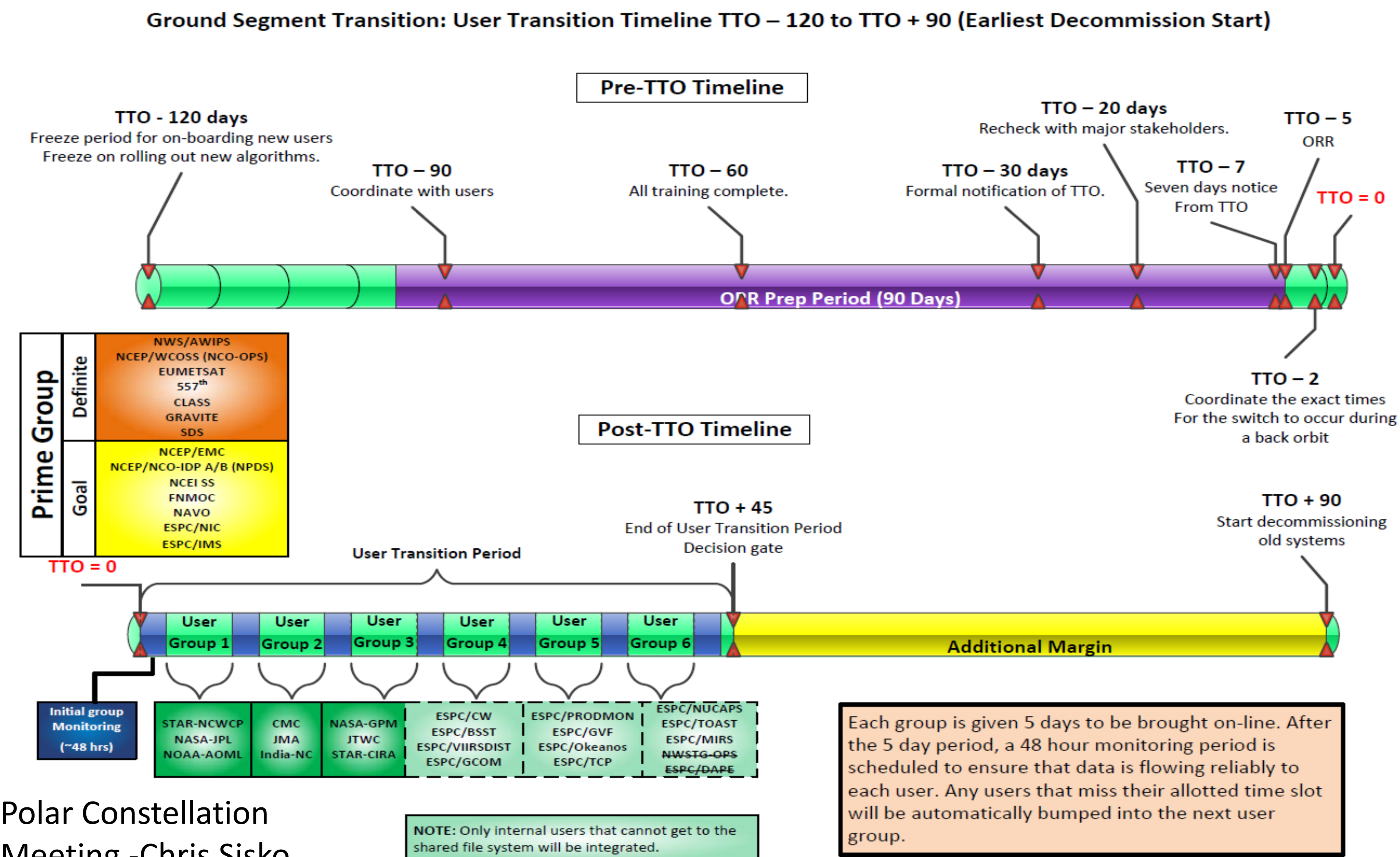
Temperature Bias of Full Tropo. Diff.

NUCAPS Data Distribution and Access (NDE)



Polar Constellation Meeting -Chris Sisko

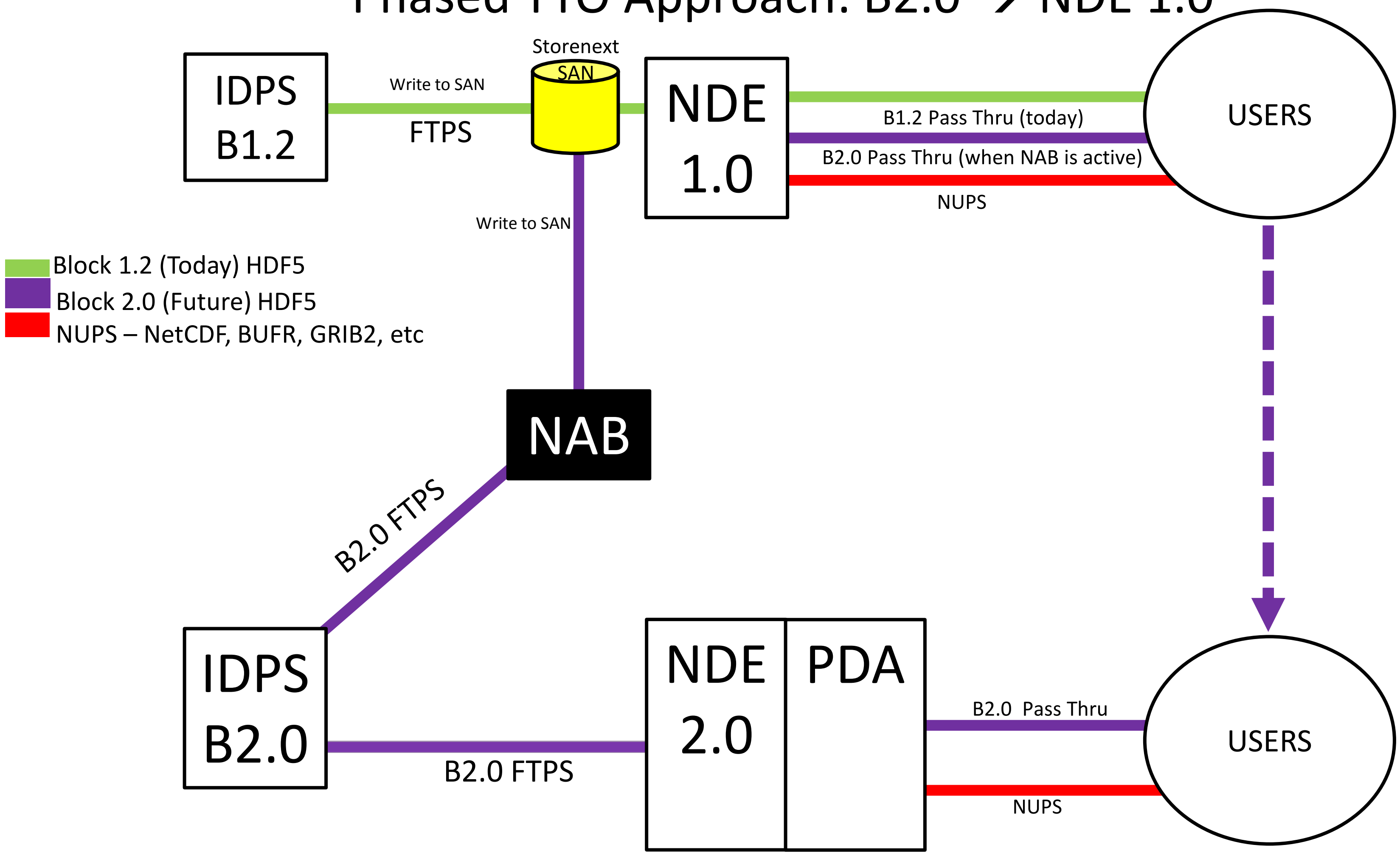
Ground Segment Transition - PDA



Polar Constellation Meeting -Chris Sisko

Phase Transition to Operation - PDA

Phased TTO Approach: B2.0 → NDE 1.0



Polar Constellation Meeting -Chris Sisko

Processing and Distribution (near Future) - PDA

Purpose of the **Production Distribution and Access (PDA)** system is to serve as the NESDIS enterprise distribution system for our near real-time users.

- All near real-time distribution except for McIDAS will be migrated to PDA – phased approach (new missions and then current missions).
- McIDAS ADDE access will remain on GEODIST systems for the foreseeable future.
- GOES-R products will be provided to AWIPS2/Satellite Broadcast Network (SBN), GOES Re-Broadcast (GRB) and the primary PDA system at NSOF.
- S-NPP/JPSS products will be provided via PDA.
- PDA is being developed for OSPO by the Office of Satellite Ground Services (OSGS).

PDA Distribution Service Improvements:

- User managed subscriptions
- User managed search and tailoring
- Enhanced security controls / transfer protocols
- Enhanced reporting and control for system optimization
- Ability to handle large data volumes

Atmospheric Soundings from JPSS - Retrievals for NWP Data Assimilation

William L. Smith Sr., Elisabeth Weisz, Nadia Smith

University of Wisconsin Space Science and Engineering Center - Madison

THE UNIVERSITY of WISCONSIN MADISON

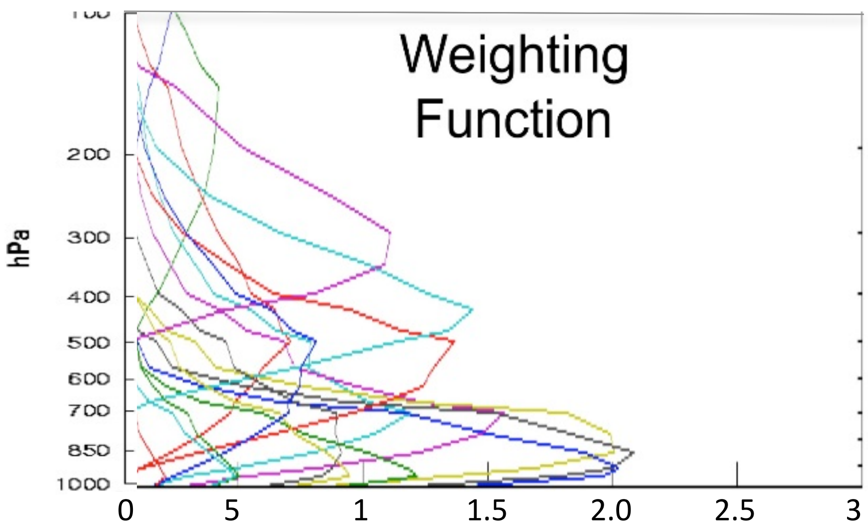
STAR JPSS 2015 Annual Science Team Meeting
24 – 28 August 2015
NCWP College Park, MD

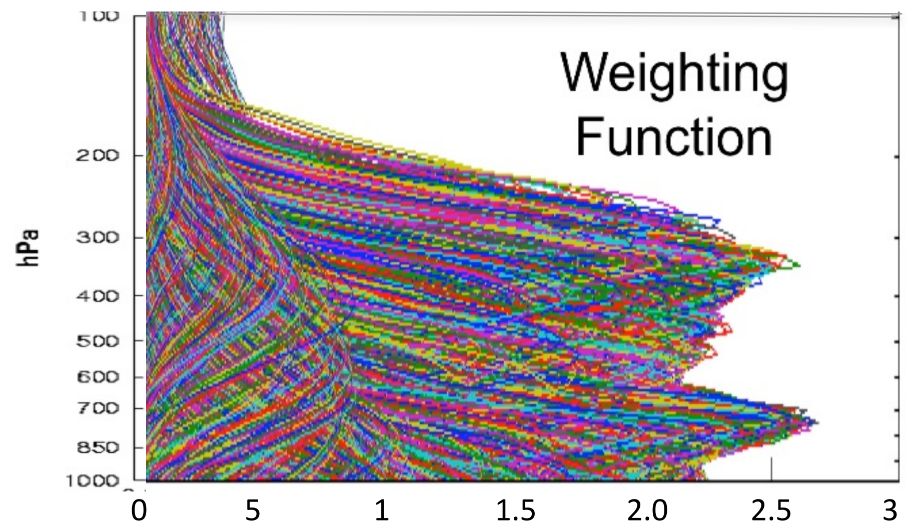
SSEC

Poor Sounding Vertical Resolution Causes Problem with Direct Assimilation of Satellite Profiles

Filter Sounders (e.g., HIRS)

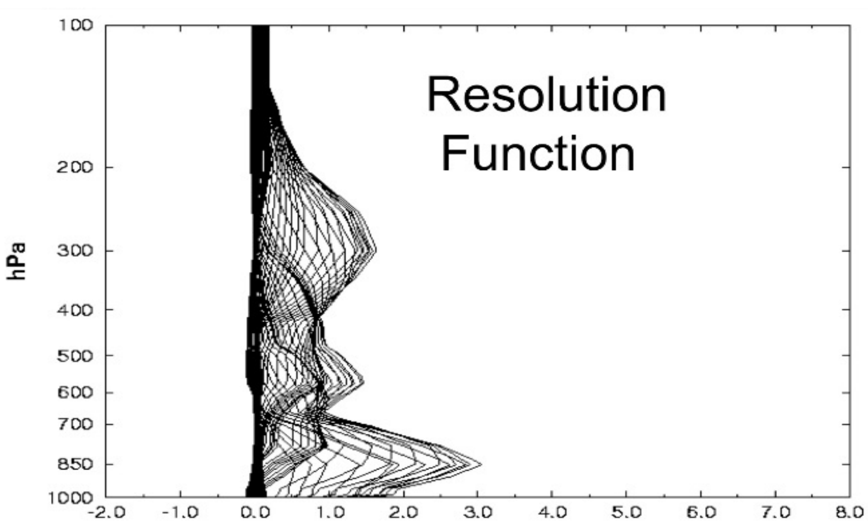
Interferometer Sounders (e.g.CrIS)

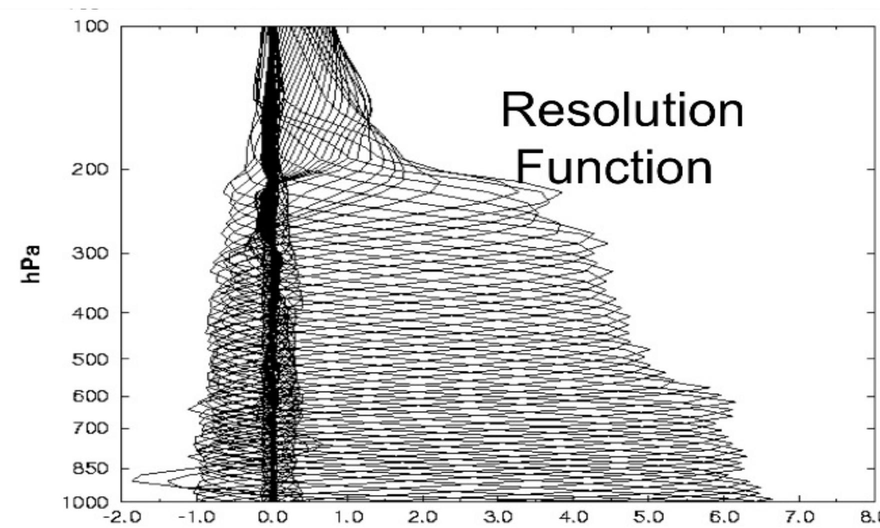




$\Delta\nu = 15.0\ cm^{-1}$

$\Delta\nu = 0.5\ cm^{-1}$





The Problem

- Satellite profile retrievals exhibit vertical structure biases toward the a-prior profile (i.e., either the initial guess profile or the mean of the statistics used for regression) due to the low vertical resolution (i.e., "null space") of the radiance observations
- This bias was large for retrievals from low spectral resolution filter radiometers (e.g., HIRS) causing vertical resolution aliasing when assimilated into NWP models causing negative impact.
- Direct assimilation of the radiances, rather than retrievals, was employed to avoid vertical resolution aliasing and to achieve positive impact.
- However, for hyperspectral sounding instruments, which contain thousands of spectral channels, radiance assimilation of all the spectral radiances is currently too time consuming for operational use. As a result, only a small subset of spectral channel radiances are assimilated limiting the vertical resolution, which is maximized by utilizing "ALL" the spectral channels in the retrieval process.
- Here, a simple and time efficient method for de-aliasing full spectral resolution hyperspectral sounding retrievals is presented

"Dual-Regression" Retrieval Algorithm* Overview

Global clear soundings

Radiances (clear FM)

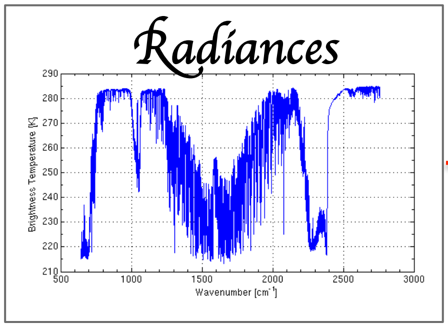
Clear-trained regression coefficients

Global cloudy soundings

Radiances (cloudy FM)
Cloud height classes

Cloud-trained regression coefficients

Theoretical Statistics



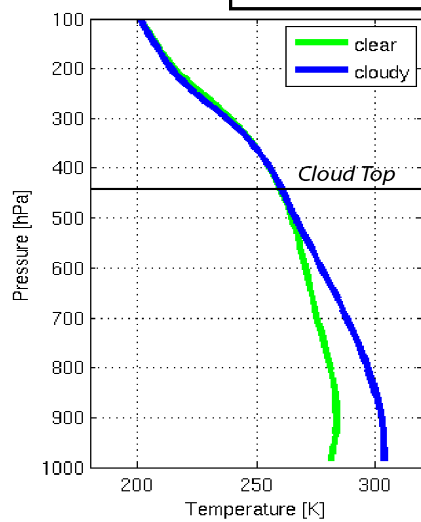
Radiance Observations

Clear-trained EOF regression retrieval

Cloud-trained EOF regression retrieval

Cloud Top Altitude
Level where $T_{cloudy} > T_{clear}$ for $p > p_{cld}$

Final Profile
from cloudy and/or clear retrievals



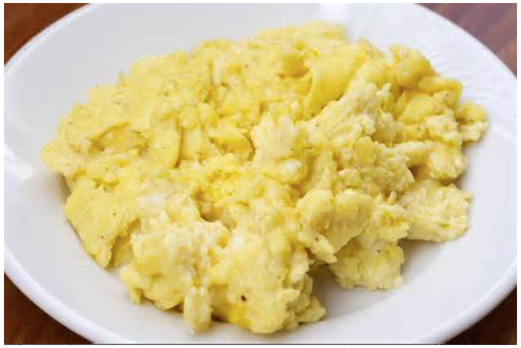
Temperature, Humidity and Ozone profiles, Surface and Cloud parameter at single FOV (0-2-km) resolution

* Smith, W. L., E. Weisz, S. Kirev, D. K. Zhou, Z. Li, and E. E. Borbas (2012), Dual-Regression Retrieval Algorithm for Real-Time Processing of Satellite Ultraspectral Radiances. *J. Appl. Meteor. Clim., 51*, Issue 8, 1455-1476.

How Can We Transform Radiances to Vertical Profiles?

Prof. Suomi provided the answer many years ago. He said the problem of satellite profile retrieval is similar to trying to separate the Yolk from the White in a scrambled egg.

The answer: Feed the scrambled egg back to the chicken


→

→

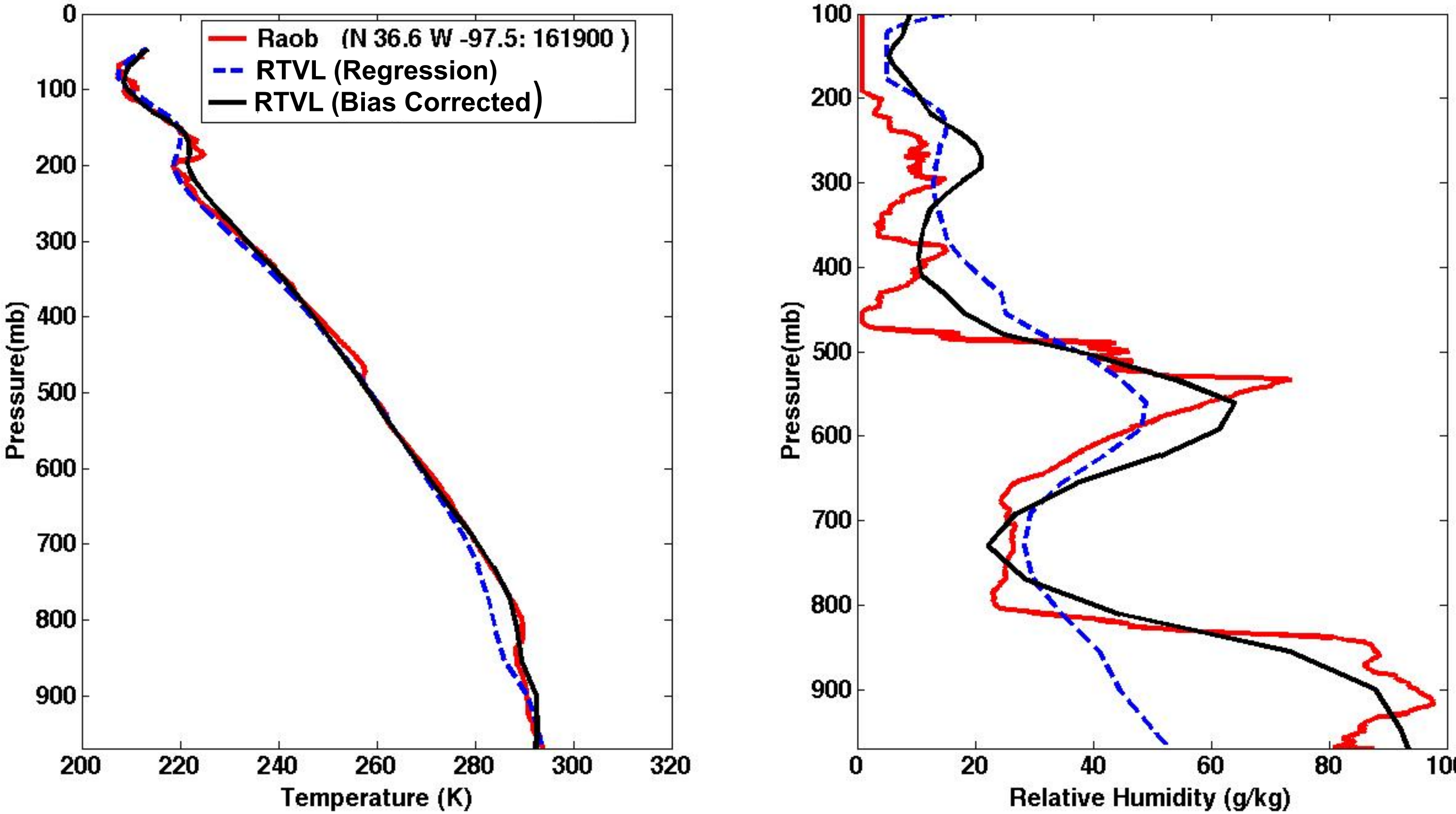

Spectral Radiances → Models → Vertical Profiles

De-aliasing Using Forecast Model Profile

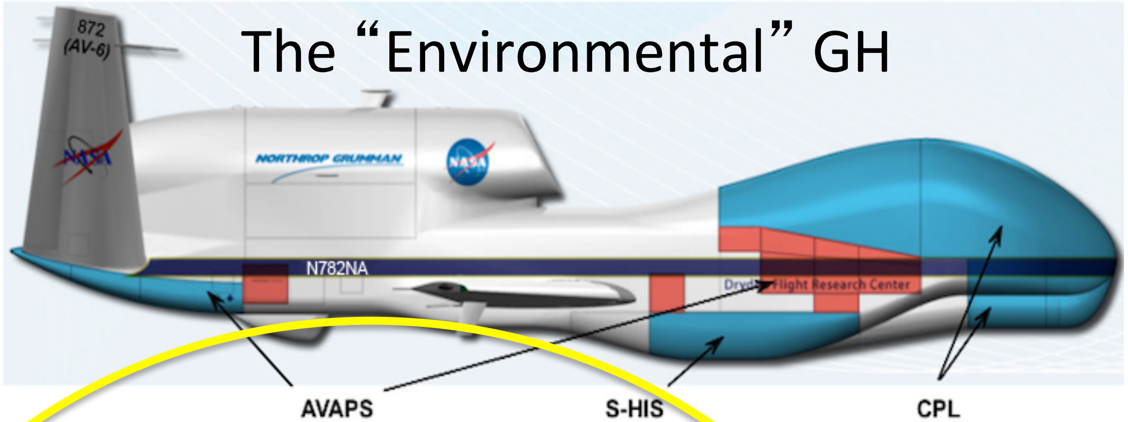
Problem: DR method uses a statistical training data set. Imperfect skill, due to lack of vertical resolution in radiances, leads to a vertical resolution alias.

Solution: Calculate radiances from a Forecast Profile (FP) and perform DR retrieval using simulated radiances. Simulated Retrieval Error = Vertical Alias.

Vertical Alias= FP radiance Retrieval - FP



The “Environmental” GH

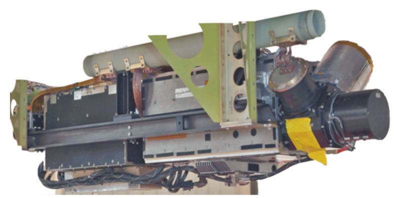


Airborne Vertical Atmospheric Profiling System (AVAPS)

89 Dropsondes / flight

Temperature, Pressure, wind, humidity vertical profiles

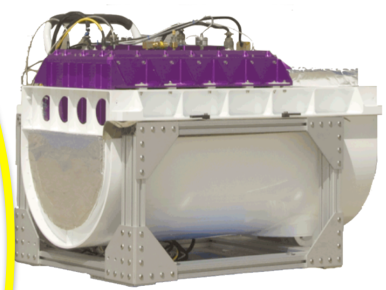
Scanning High Resolution Infrared Sounder (S-HIS)



Upwelling thermal radiation at high spectral resolution between 3.3 and 18 microns.

Temperature, water vapor vertical profiles

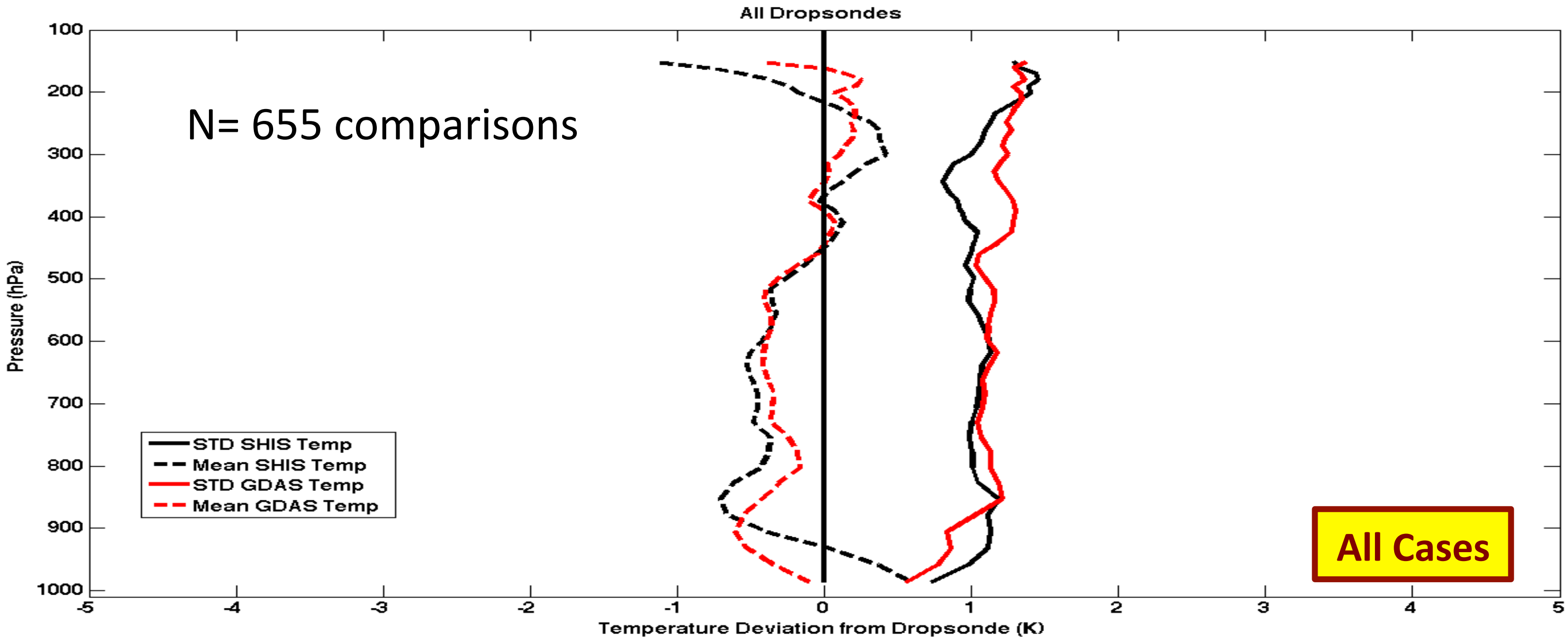
Cloud Physics Lidar (CPL)

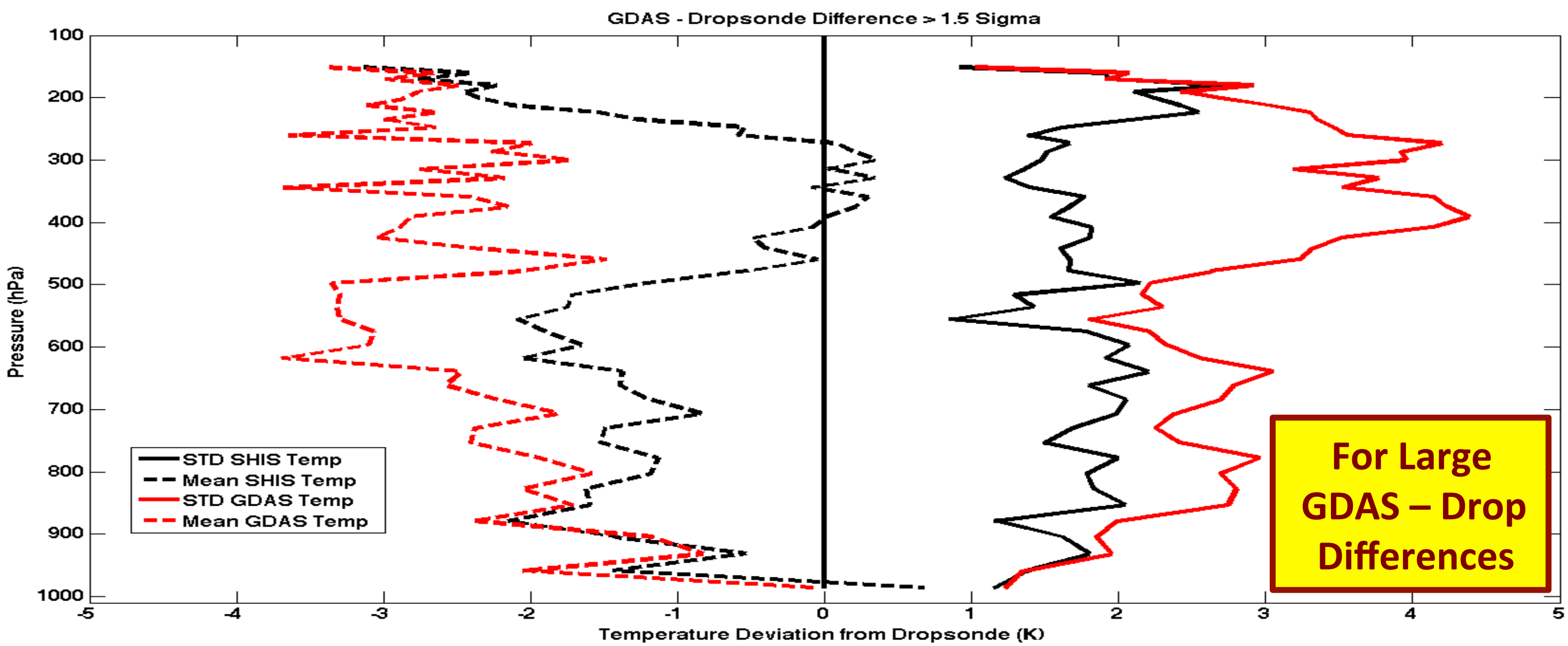


532/1064 nm Lidar Reflection

Cloud structure and depth

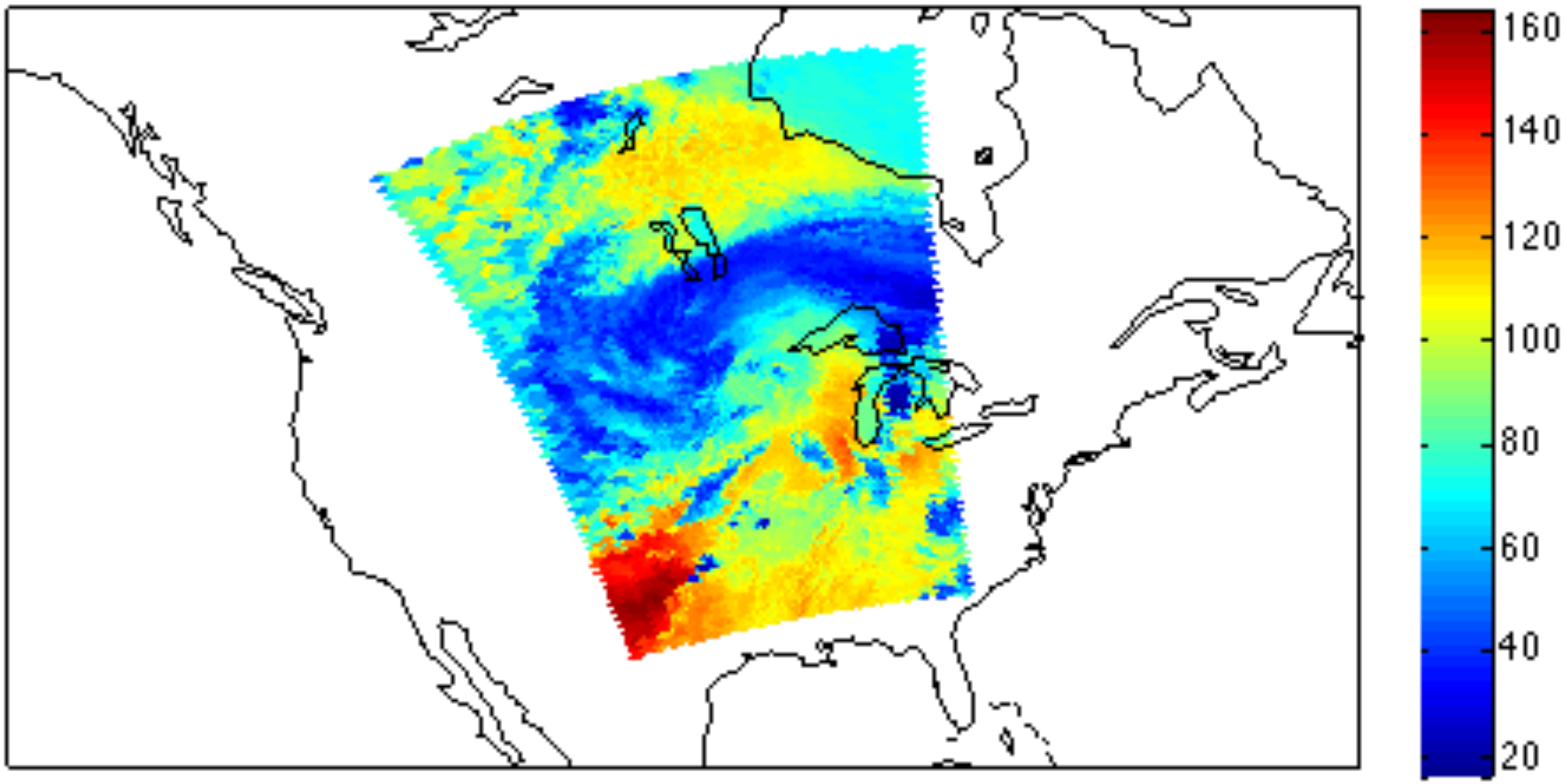
DA S-HIS Vs. Dropsonde Statistics (HS3-2014)



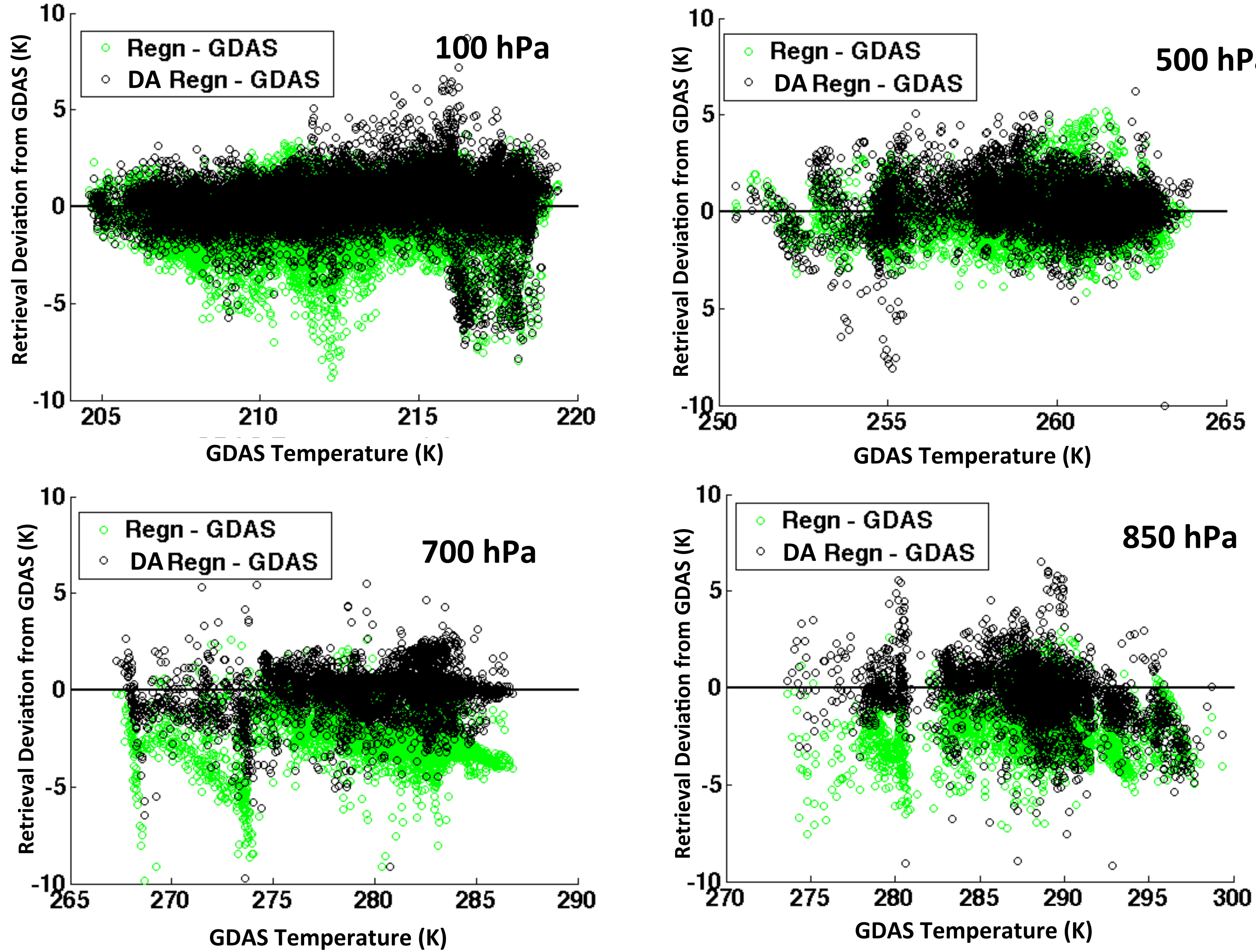


CrIS Coverage 19:08 UTC
S-NPP Cal/Val May 20 2013

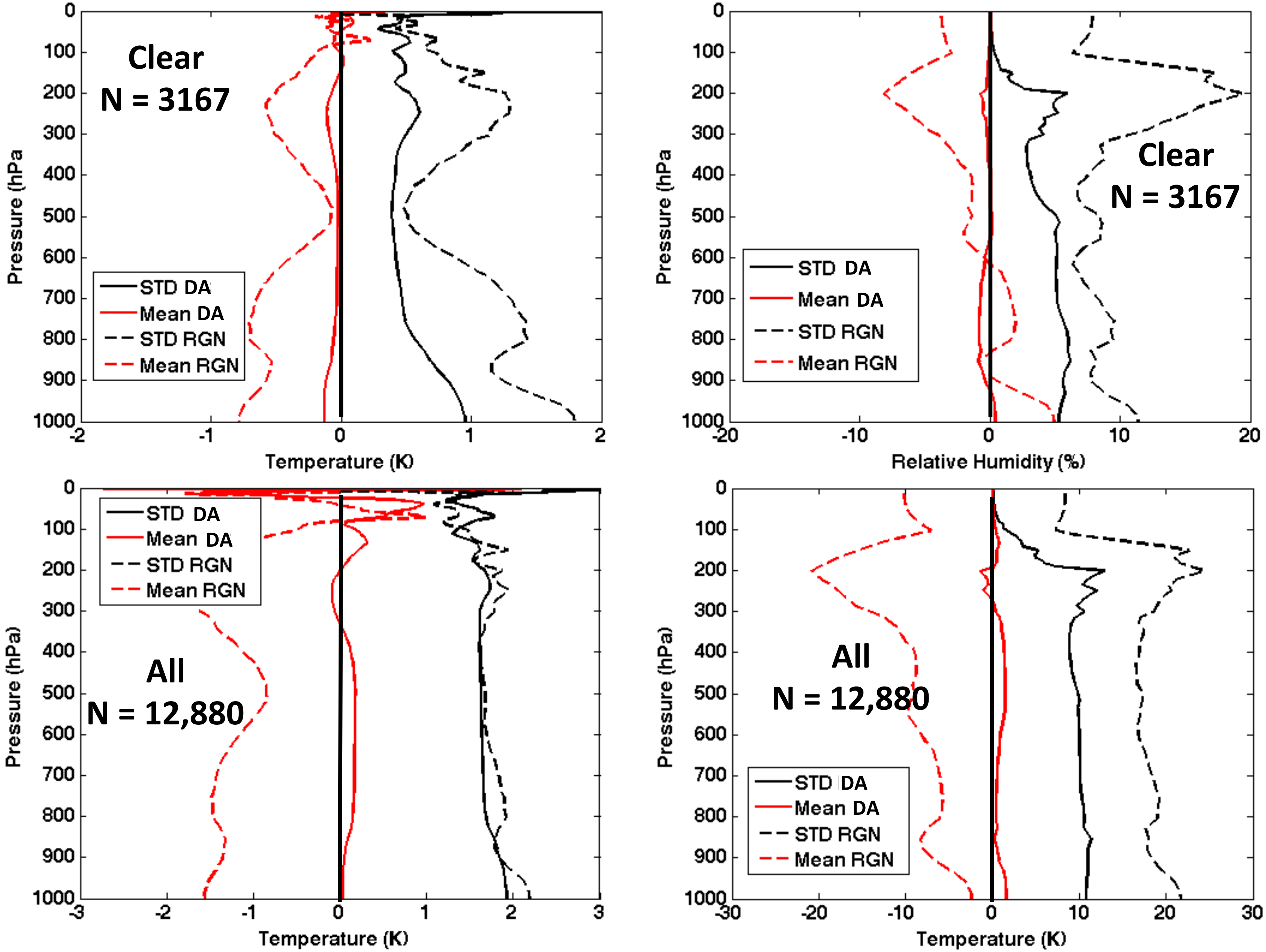
11 micron (i.e., 900 cm^{-1}) Radiance



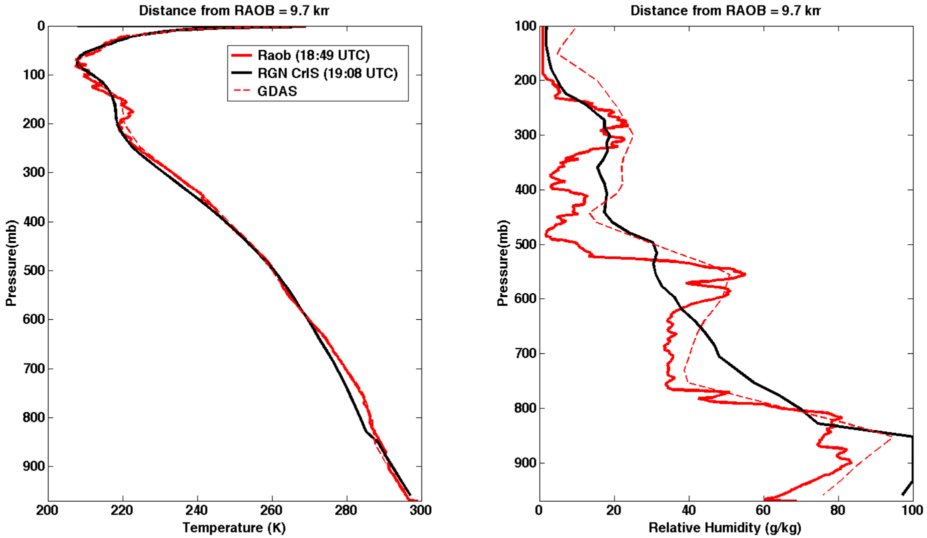
Deviation from GDAS (All, N = 12,880)

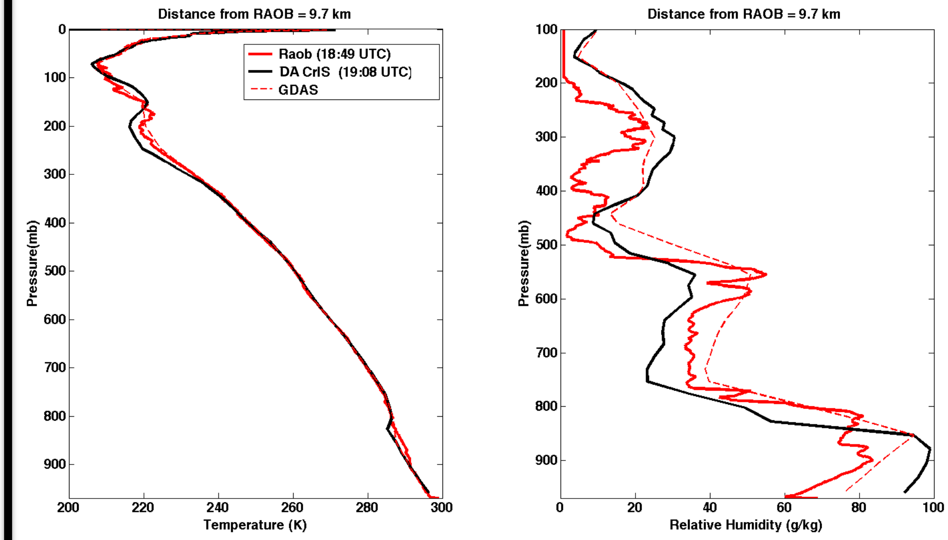


Mean and Standard Deviation from GDAS



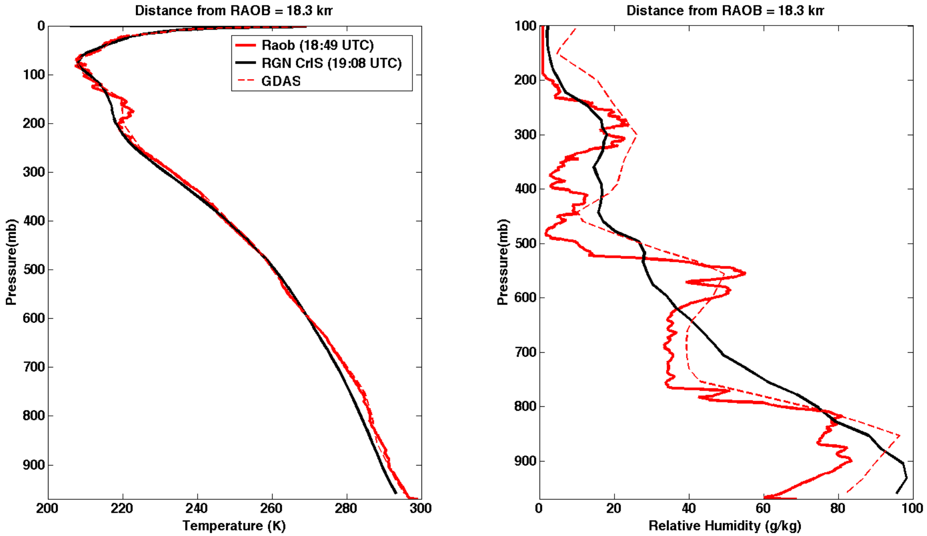
Regression and De-Aliased CrIS Retrievals Vs. ARM-site Radiosonde (May 20, 2013)

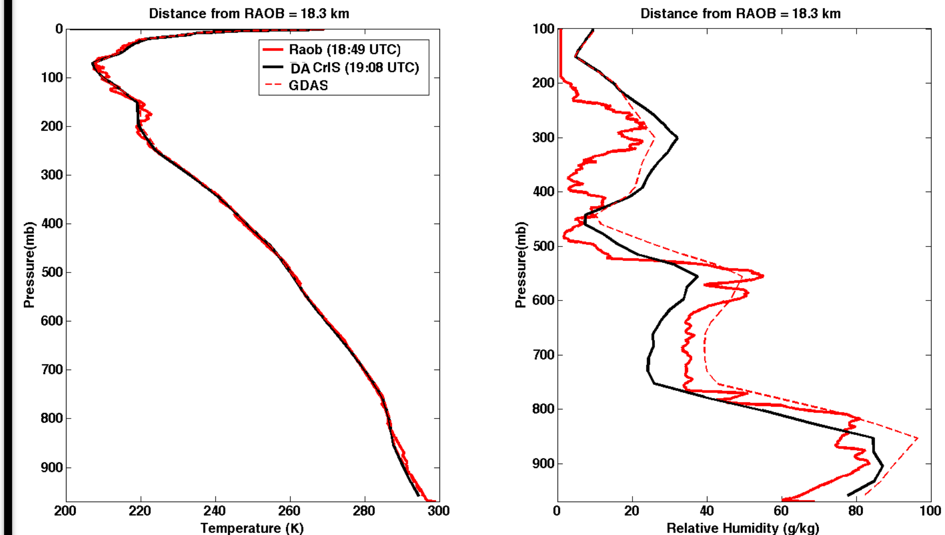




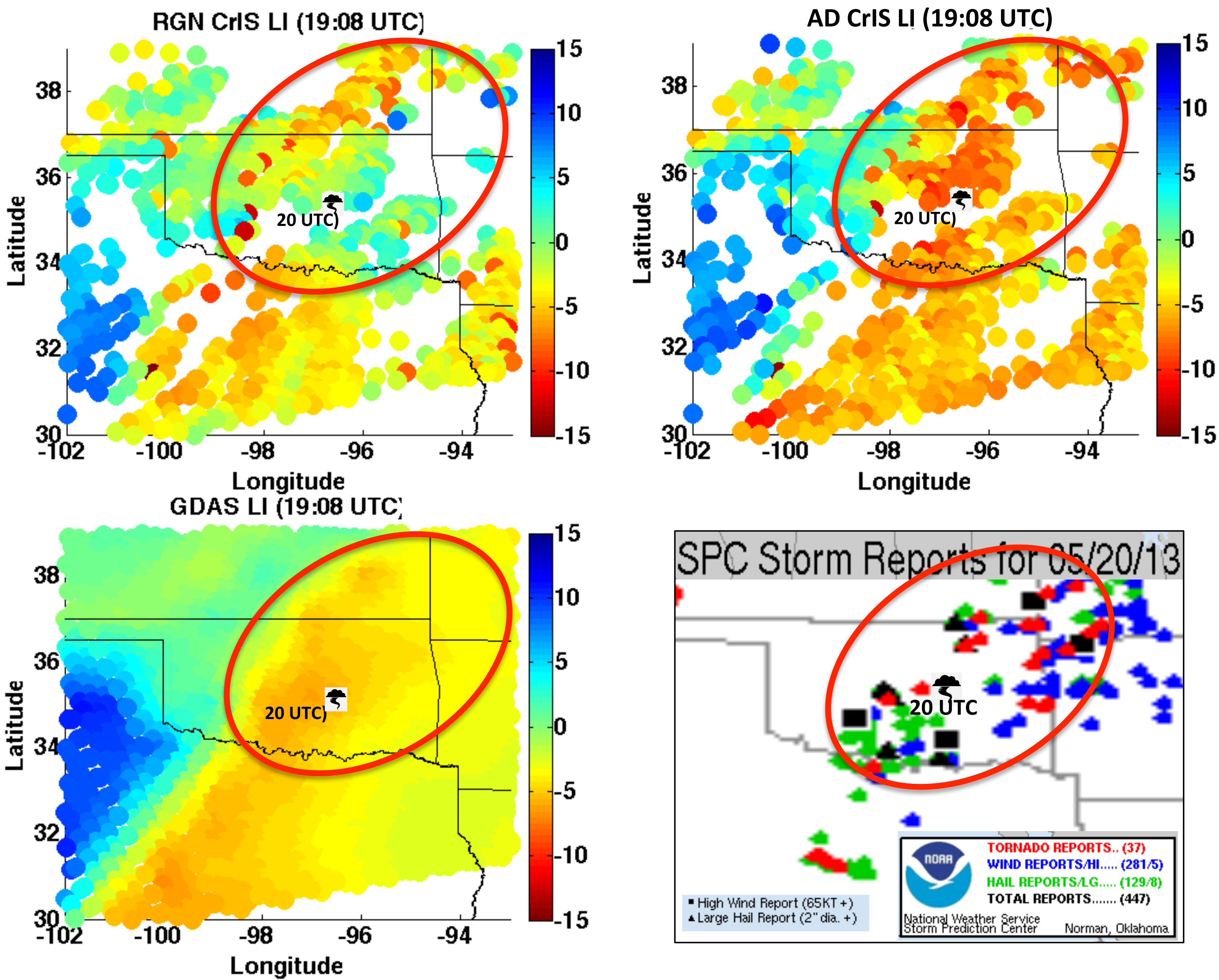
Regression Retrievals

De-aliased Retrievals

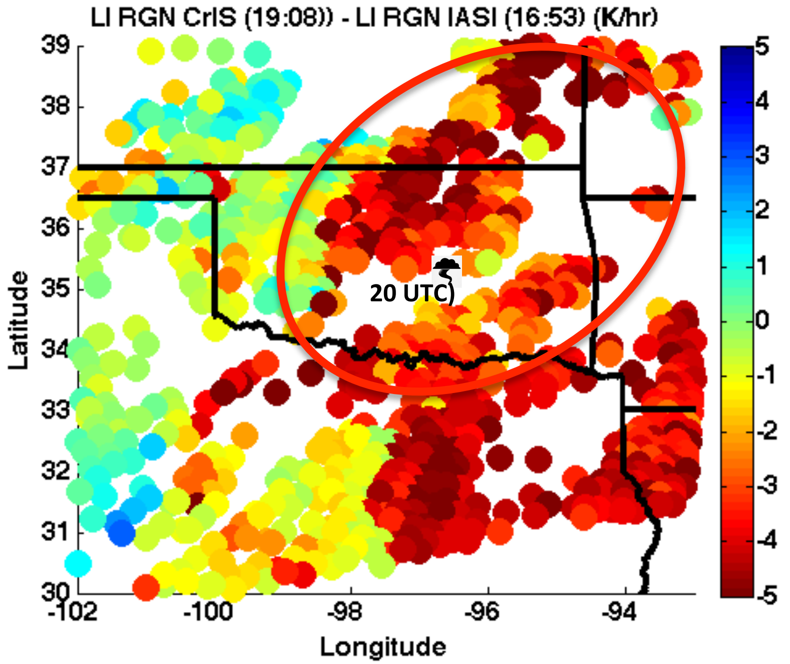


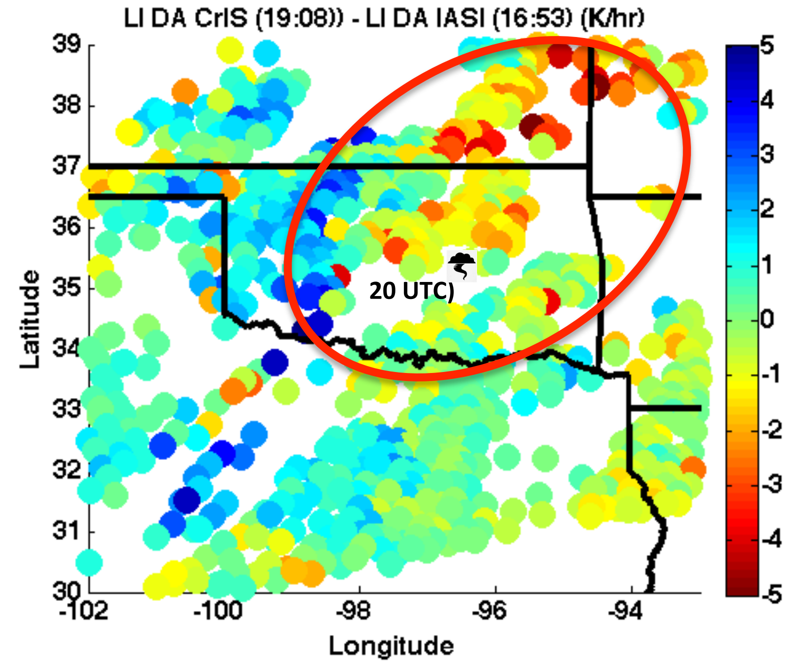


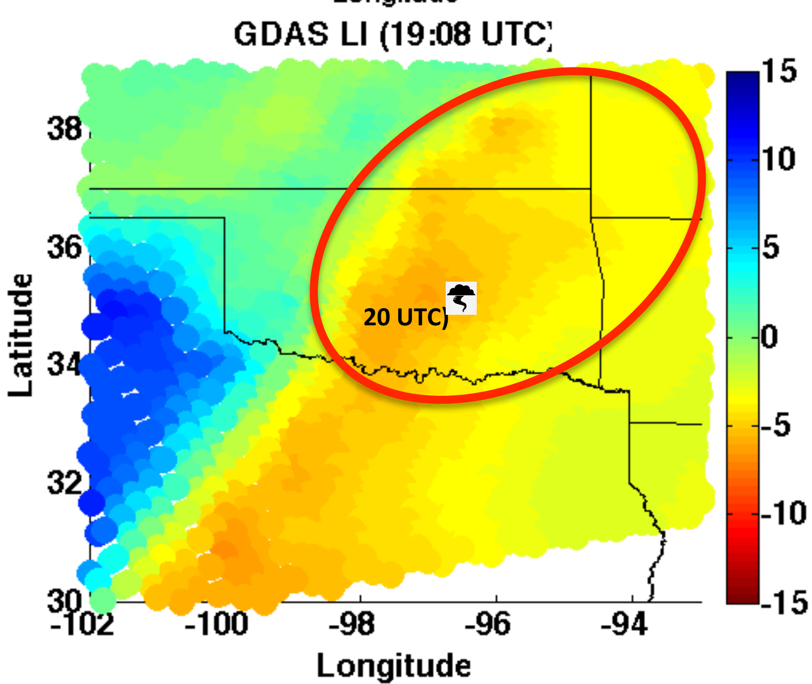
Regression Vs. De-aliased Vs. GDAS Lifted Index (May 20 2013)

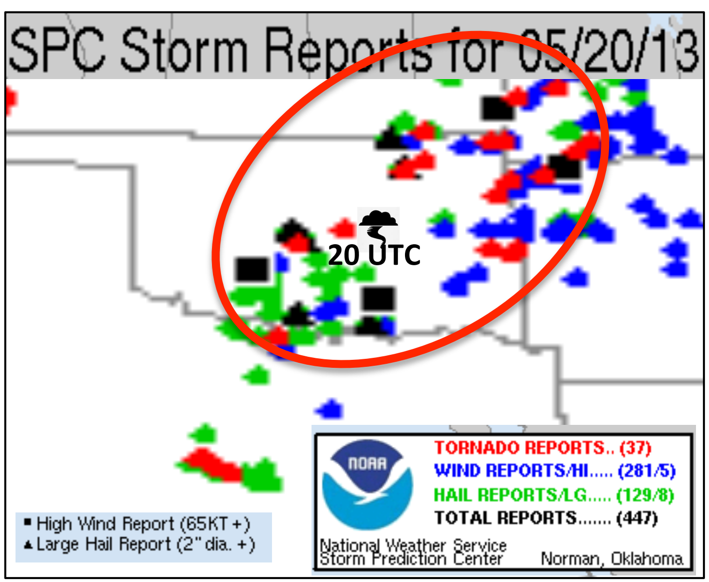


Time Tendencies of Lifted Index (May 20 2013)









Summary

- **Poor vertical resolution of satellite soundings can cause a vertical alias within the NWP models that assimilate them**
- **The vertical alias can be determined using NWP simulated radiances and removed from the real radiance retrieval**
- **It is shown that the de-aliased profile retrieval is an improvement of the model profile that was used for the de-aliasing process**
- **Analyses of time consecutive (2-hr interval) satellite retrievals (i.e., from Metop-B IASI and S-NPP CrIS), antecedent to a Tornadic storm outbreak, indicates that the assimilation of de-aliased satellite profile retrievals will improve the forecast of the location and timing of severe weather events.**
- **This hypotheses now needs to be proven through the time assimilation of de-aliased hyperspectral soundings obtained from the system of Metop-A, Metop-B, S-NPP, and Aqua satellites.**

Results from CrIS/ATMS Obtained Using an AIRS "Version-6 like" Retrieval Algorithm

Joel Susskind, Louis Kouvaris, and Lena Iredell
NASA GSFC
Earth Sciences Division - Atmospheres, Code 610

NOAA JPSS Meeting
Session 7b: Soundings Breakout
College Park, MD

August 27, 2015

Background

The AIRS Science Team Version 6 retrieval algorithm is currently producing very high quality level-3 Climate Data Records (CDRs) from AIRS that will be critical for understanding climate processes. CDRs are gridded level-3 products which include all cases passing AIRS Climate QC

AIRS CDRs should eventually cover the period September 2002 through at least 2020

CrIS/ATMS is the only scheduled follow on to AIRS/AMSU

The objective of this research is to generate a long term CrIS/ATMS level-3 data set that is consistent with that of AIRS/AMSU Version-6, or an improved version of it.

Research Plan

The AIRS Science Team has made significant improvements to AIRS Version-6 and plans to reprocess all AIRS data with AIRS Version-7 in the relatively near future. Research is continuing toward the development of AIRS Version-7. The current version is called AIRS Version-6.22. We have adapted AIRS Version-6.22 to run with CrIS/ATMS. AIRS Version-6.22 and CrIS Version-6.22 both run now at JPL. JPL plans to generate, in the relatively near future, many months in common of AIRS Version-6.22 and CrIS 6.22 data products, or possibly products using improved versions of each retrieval system. We will evaluate the results by comparison of monthly mean AIRS and CrIS products, and more significantly, their inter-annual differences and, eventually, anomaly time series.

Overview of AIRS/AMSU Version-6 Retrieval Methodology

AIRS Version 6 is a physically based retrieval system

Uses cloud cleared radiances $\widehat{R}_i$ to determine the state vector X

$\widehat{R}_i$ represents what AIRS would have seen in the absence of clouds

<u>Basic steps</u>

1) Generate a Neural-Net based initial guess X^0 using AIRS/AMSU observations R_i
2) Generate cloud clearing coefficients that provide $\widehat{R}_i$ for all channels
3) Sequentially determine: T_s, $T(p)$, $q(p)$, $O_3(p)$, $CO(p)$, and $CH_4(p)$ using $\widehat{R}_i$ in subsets of channels i selected for each step

   Finds state X such that $R_i(X)$ best match $\widehat{R}_i$ where $R_i(X)$ is the computed radiance for state X
4) Derive cloud parameters such that R_i (X^{CLD}) best matches observed radiances R_i where X^{CLD} is the final state vector including cloud parameters
5) Compute Outgoing Longwave Radiation (OLR) using an OLR Radiative Transfer Algorithm in conjunction with X^{CLD}
6) Generate QC flags for all parameters

   QC=0 passes Data Assimilation QC; QC=1 passes Climate QC

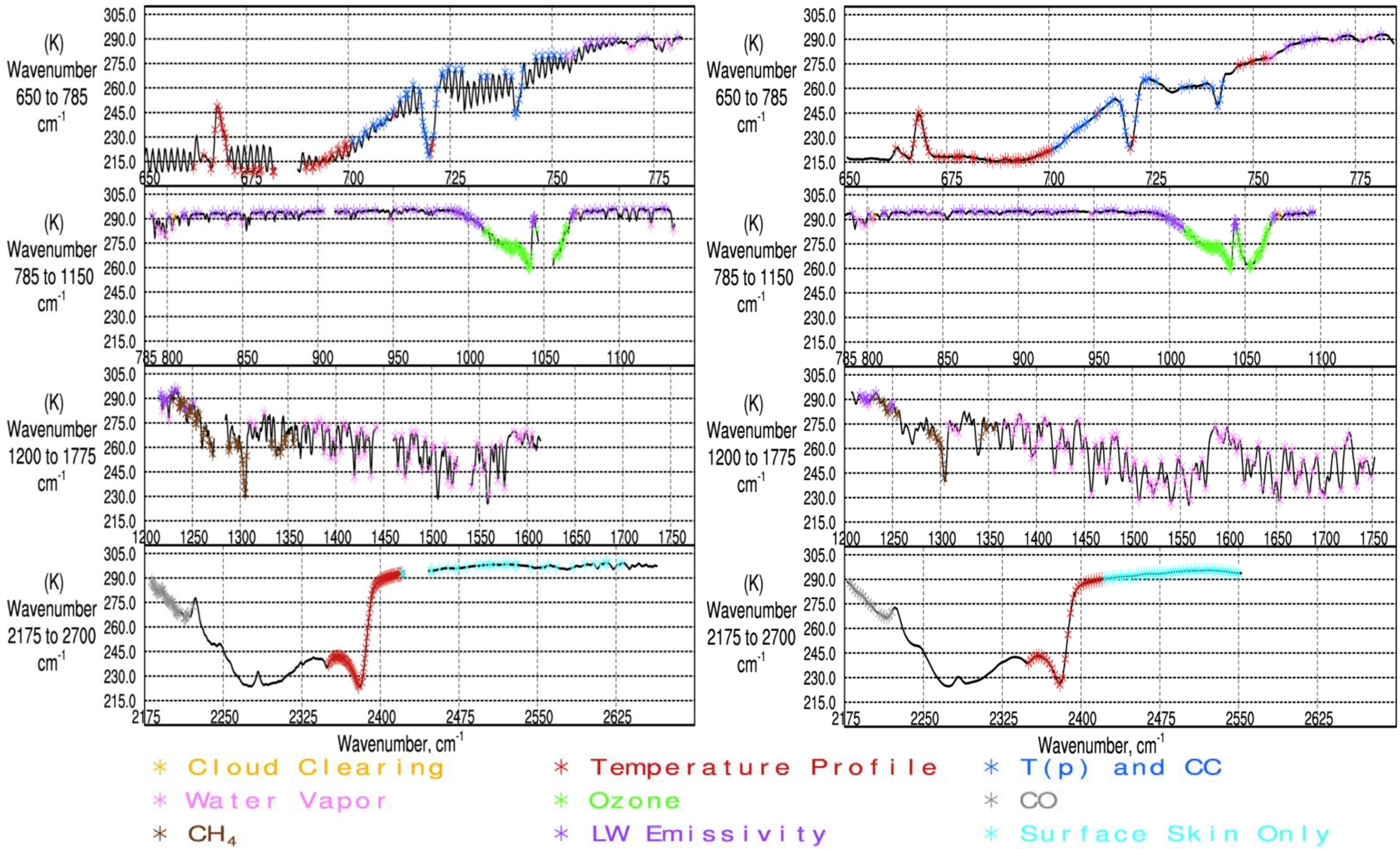
Major Improvements in Version-6.22 Over Version-6

Version-6.22 is very much like Version-6 with some modifications in details. The major changes are given below.

- *$O_3(p)$* retrieval step uses many more channels and also simultaneously solves for surface spectral emissivity in the vicinity of the O_3 absorption band near 1000 cm^{-1}. Version-6.22 retrievals of $O_3(p)$ have improved considerably compared to Version-6.
- *q(p)* retrieval step uses many more channels in Version-6.22 compared to Version-6 and also allows for changes from the *q(p)* first guess which have more vertical structure than Version-6, especially in the boundary layer. Version-6.22 retrievals of *q(p)* have improved considerably compared to Version-6.
- *T(p)* retrieval step now includes all tropospheric sounding CO_2 channels, but only if the cloud corrections made to the brightness temperatures of those channels are less than 5K. We also loosened the *T(p)* Data Assimilation (DA) QC thresholds to allow for more cases, while still keeping RMS errors of *T(p)* with QC=0 on the order of 1K or less.

Sample Cloud Free Brightness Temperature Spectrum

AIRS Version-6.22 Channels | CrIS Version-6.22 Channels



Sample AIRS and CrIS brightness temperature computed for cloud free scenes. The AIRS and CrIS channels we use in different steps in the retrieval process are indicated in the figures by different colored stars. AIRS is sampled twice as densely as CrIS.

CrIS/ATMS Neural-Net Coefficients

Like in AIRS Version-6, Version-6.22 uses Neural-Net methodology to generate the first guess $T^o(p)$, $q^o(p)$, and T^o_{surf} for each AIRS/AMSU or CrIS/ATMS (Field of Regard) FOR. The CrIS/ATMS Neural-Net coefficients were trained by Bill Blackwell and co-workers at Lincoln Labs using data on select time periods. These coefficients are then used on all time periods.

The CrIS Neural-Net coefficients were trained using CrIS/ATMS observations early in the NPP mission. CrIS and ATMS calibration procedures were modified in November 2013. The quality of CrIS/ATMS retrievals improved after this change, even though the Neural-Net coefficients began to produce a biased first guess. They will need retraining.

Bill Blackwell has indicated that he will generate new CrIS/ATMS Neural-Net coefficients trained on radiances using the newest CrIS/ATMS calibration procedures when they are finalized. In the meantime, we are using and evaluating results using the old Neural-Net coefficients.

Comparison of AIRS Version-6, AIRS Version-6.22, and CrIS Version-6.22 Results

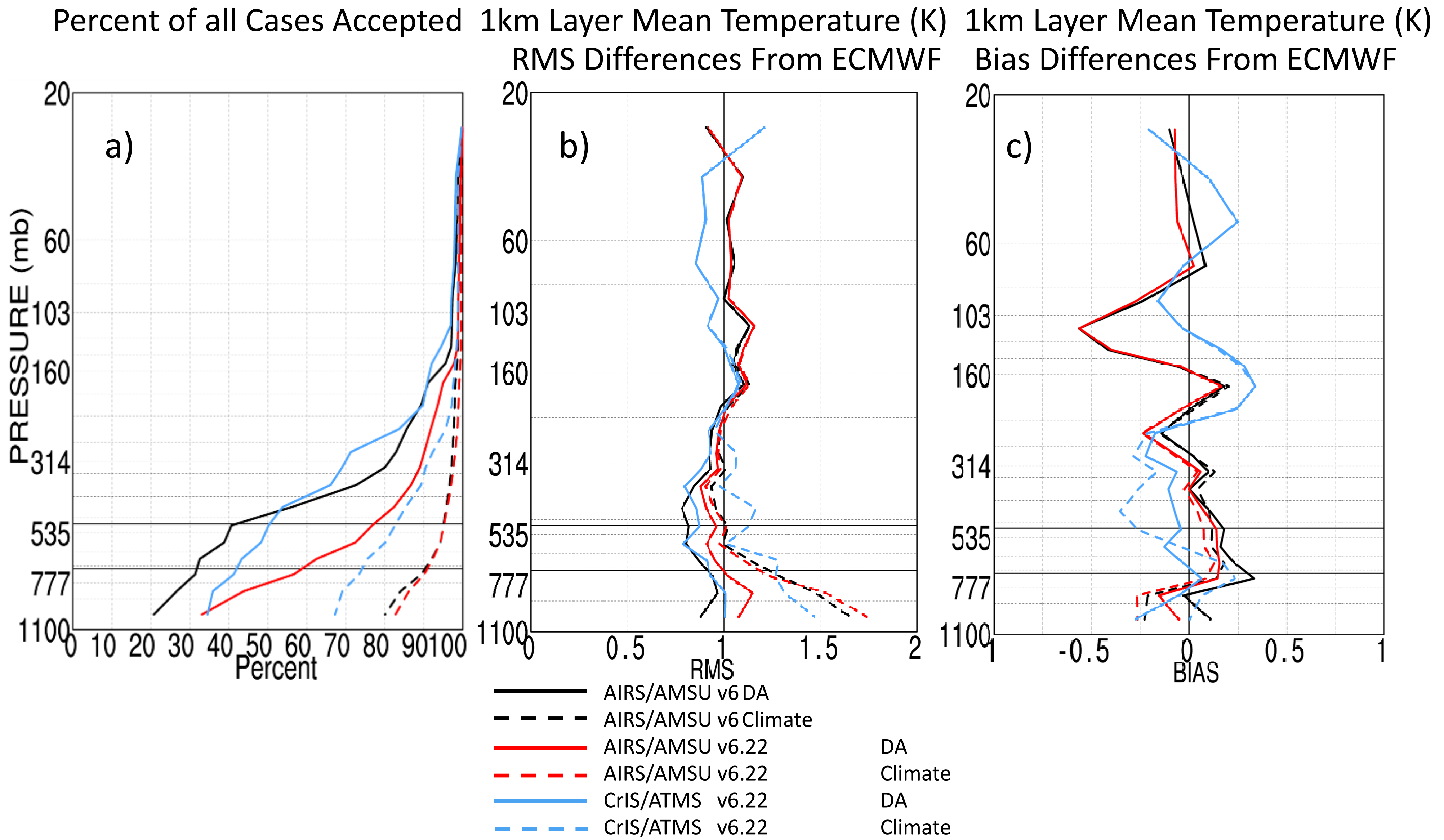
The following results are shown for the single day, December 4, 2013. EOS Aqua and NPP orbits overlap closely on this day. This is important for comparison purposes to minimize time-of-day sampling differences. This day also occurs after the major upgrade in ATMS calibration procedures.

QC'd level-2 results are shown for all experiments in terms of yields, RMS errors, and biases compared to ECMWF for *T(p)*, *q(p),* and ocean surface skin temperature T_s.

In addition, AIRS Version-6, AIRS Version-6.22, and CrIS/ATMS Version-6.22 level-3 gridded fields are shown and compared to measures of truth for total O_3 burden and total precipitable water W_{tot}. AIRS and CrIS results using Version-6.22 are significantly improved compared to Version-6 for both water vapor and ozone products.

Finally, daily fields of other select products of Version-6.22 AIRS and Version-6.22 CrIS are compared and show good agreement with each other, especially over ocean.

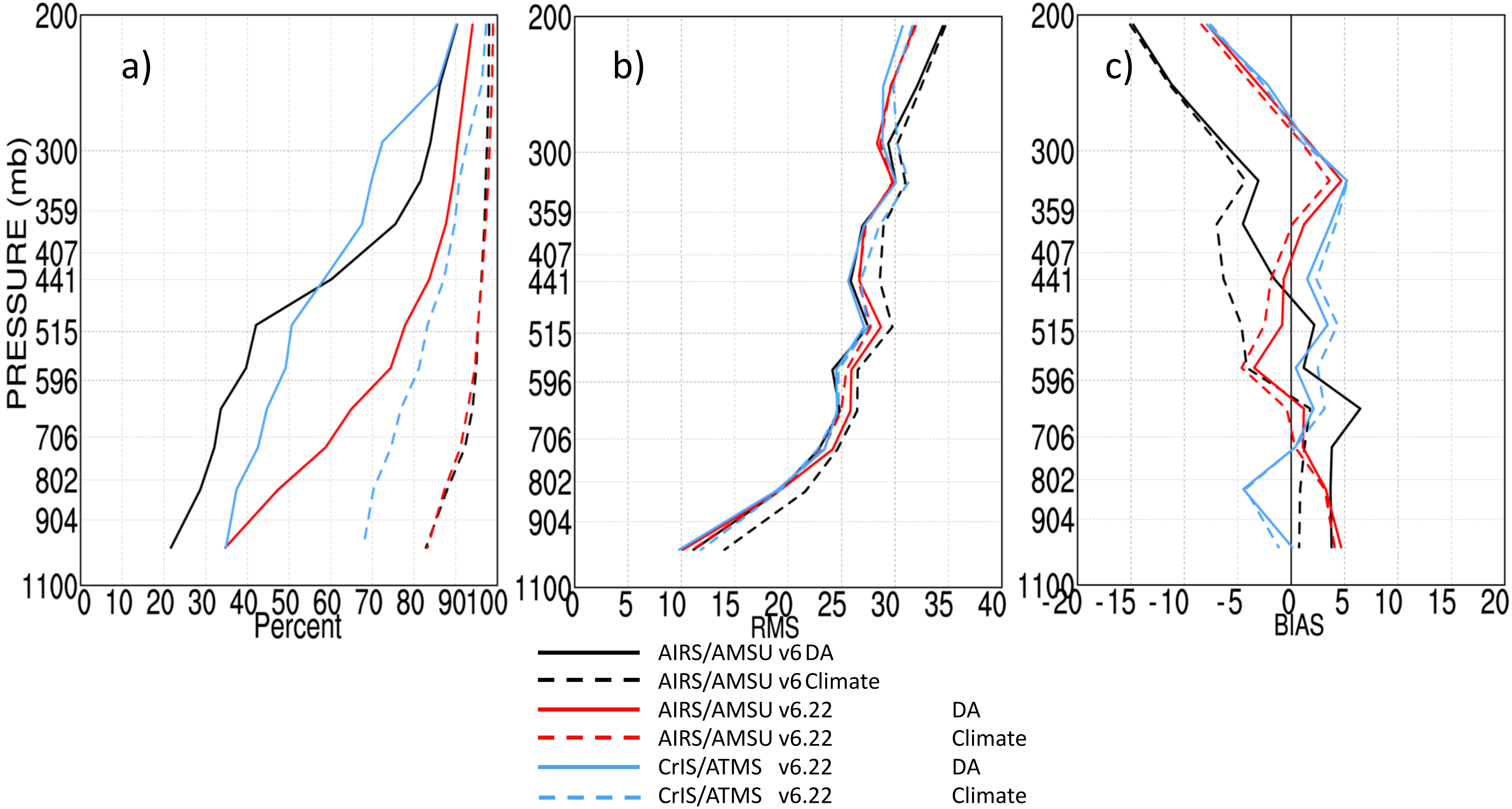
December 4, 2013 Global Statistics



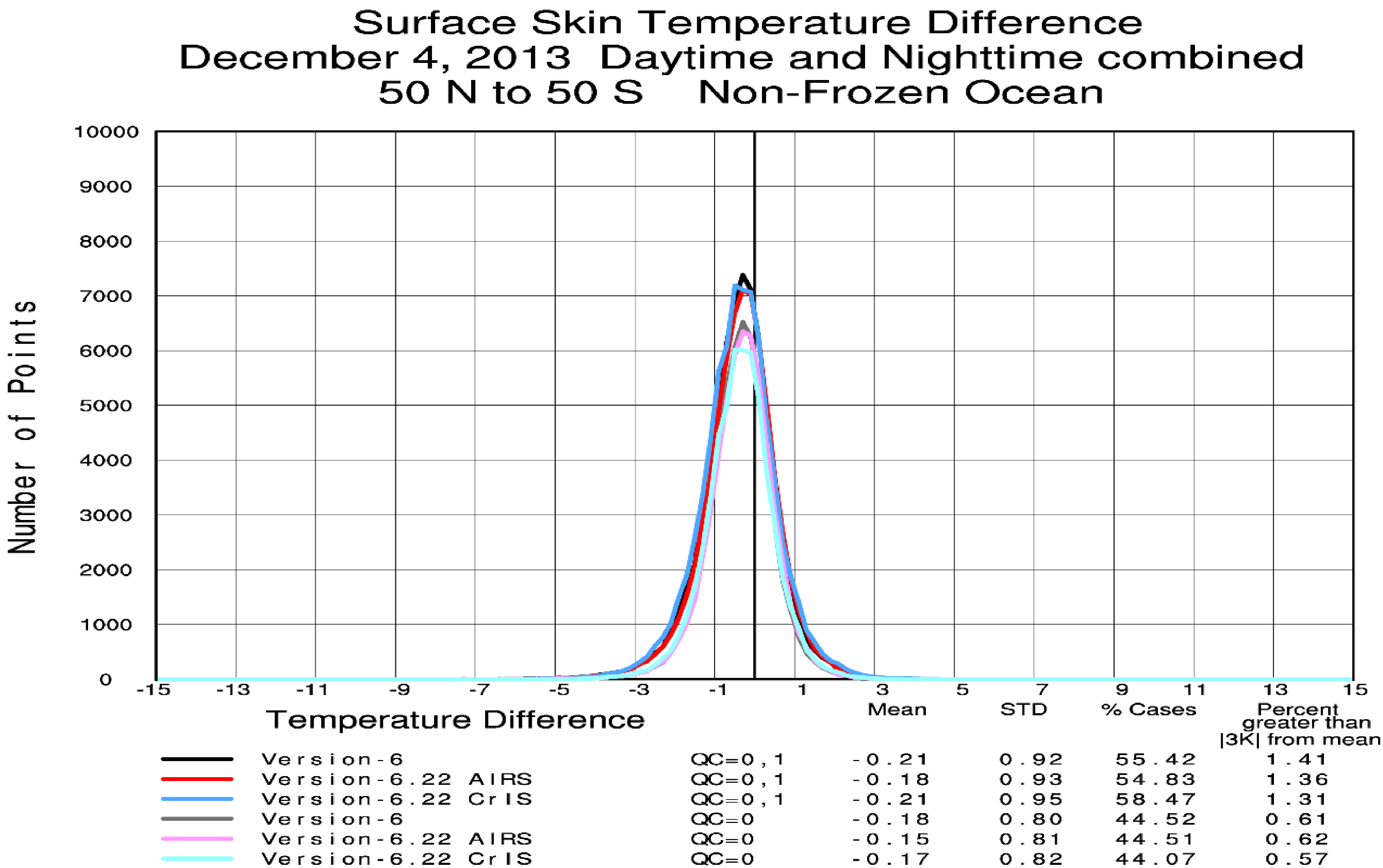
Global QC'd 1 km layer mean temperature profile statistics for December 4, 2013 for different retrievals and different QC thresholds. CrIS results use both the AIRS Version-6.22 DA and Climate thresholds. CrIS results using DA QC has a lower yield than AIRS Version-6.22 with smaller errors, as expected. CrIS results with Climate QC has a lower yield and larger errors than AIRS, possibly indicative of poorer performance in cloudier scenes than AIRS.

December 4, 2013 Global Statistics

Percent of all Cases Accepted | 1km Layer Precipitable Water RMS % Differences From ECMWF | 1km Layer Precipitable Water Bias % Differences From ECMWF

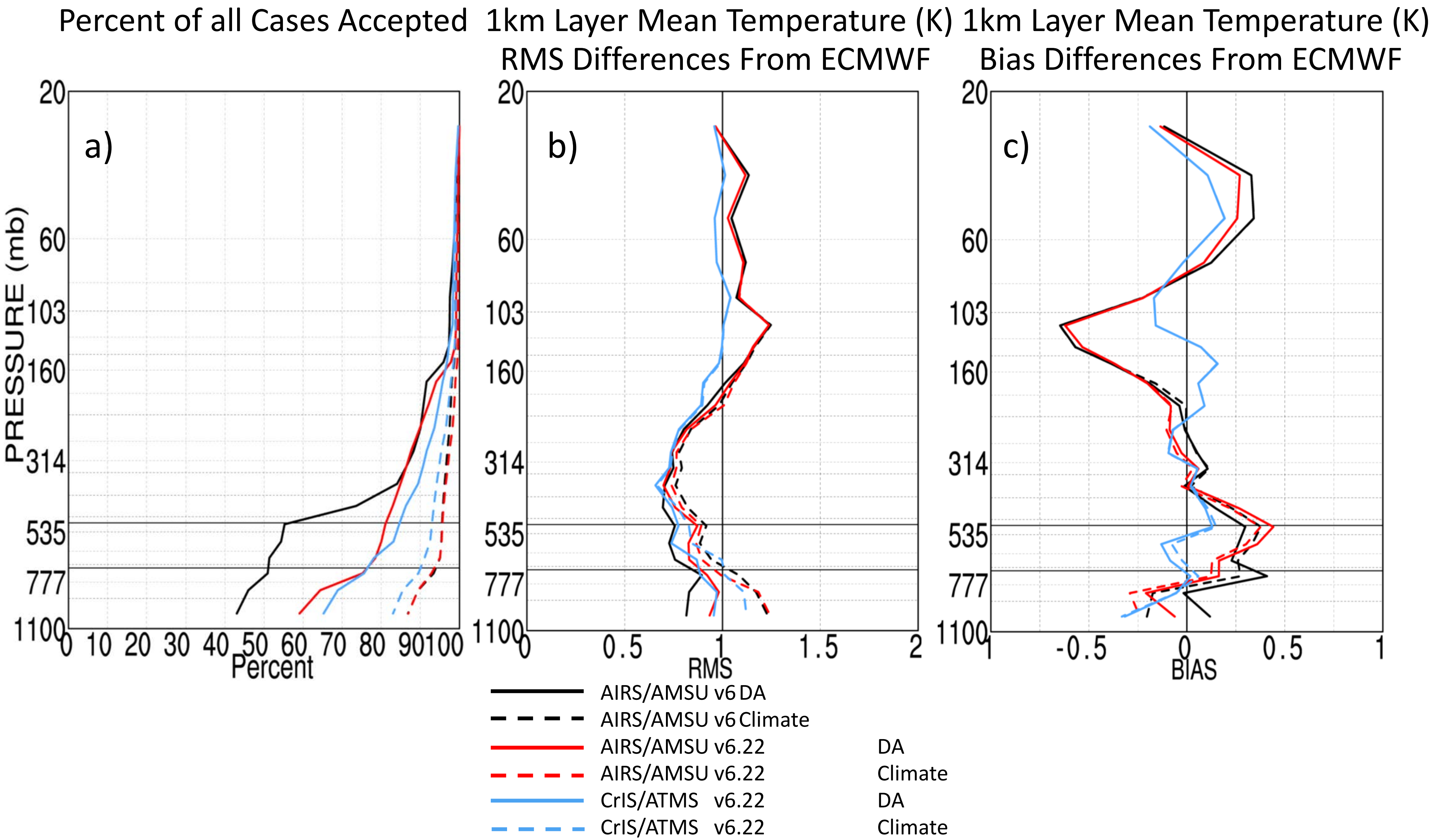


Global QC'd 1 km layer precipitable water profile statistics for December 4, 2013 for different retrievals and different QC thresholds. AIRS and CrIS Version-6.22 results are both superior to those of AIRS Version-6 with regard to both RMS errors and biases, especially with Climate QC.



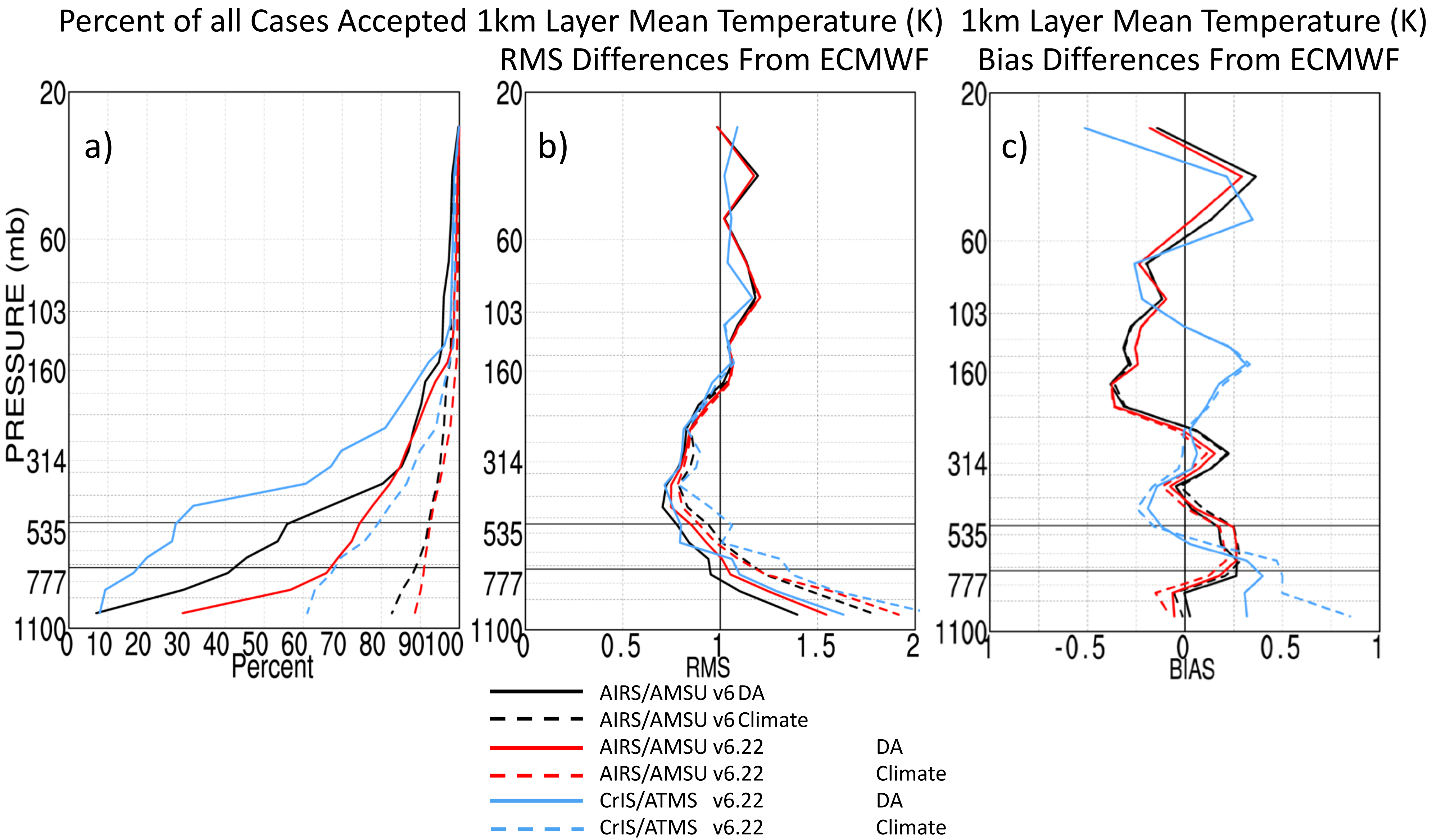
Counts of QC'd values as a function of errors of AIRS Version-6, AIRS Version-6.22 and CrIS Version-6.22 sea surface temperatures using both DA (QC=0) and Climate (QC=0,1) QC thresholds. All three sets of results are excellent and are comparable quality with each other. CrIS SW spectral coverage truncated at 2550 cm^{-1} does not degrade ocean SST.

December 4, 2013 50°N to 50°S Ocean

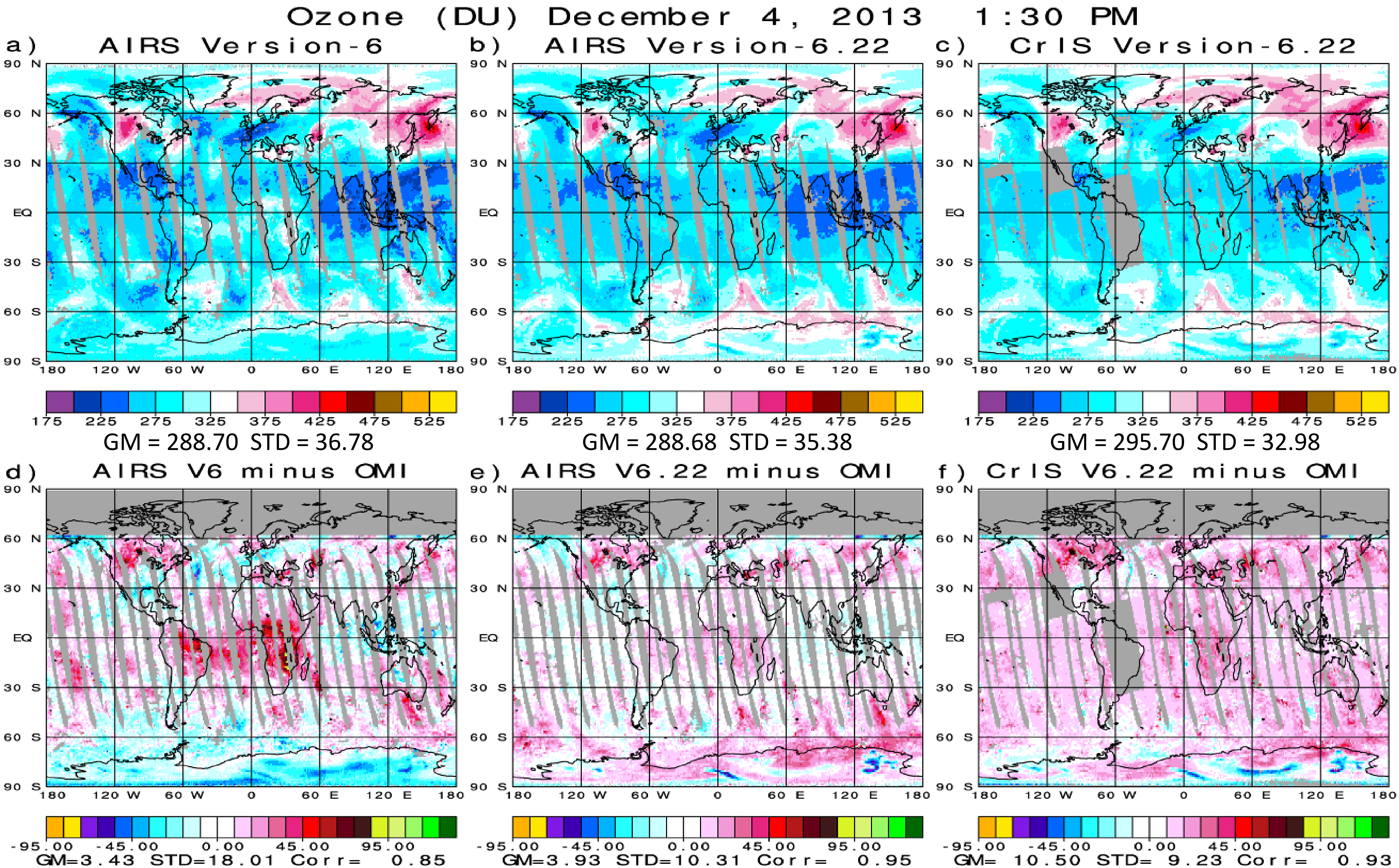


CrIS/ATMS statistics for *T(p)* are similar to those of AIRS/AMSU over mid-latitude ocean using each of DA and Climate QC thresholds.

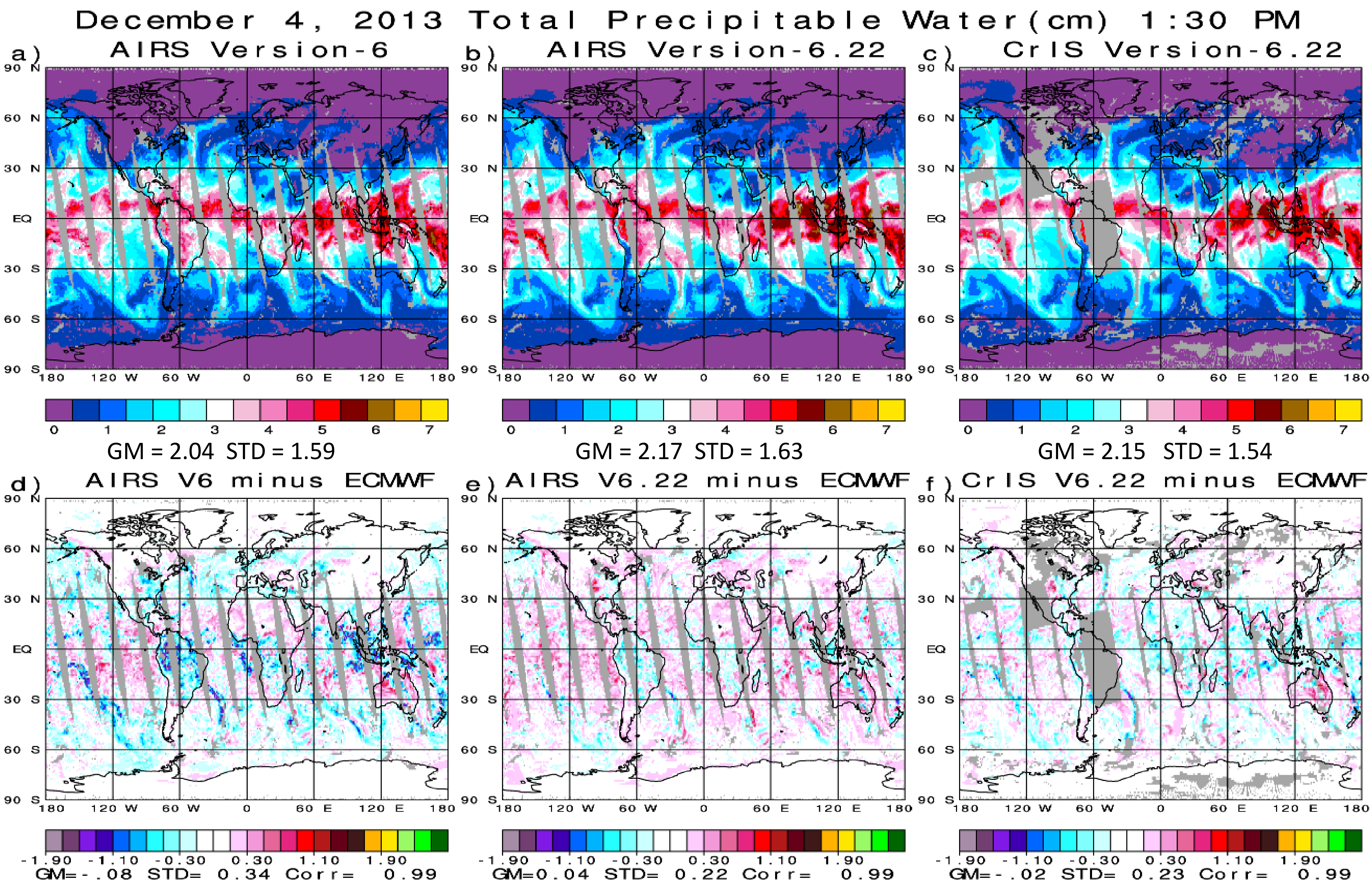
December 4, 2013 50°N to 50°S Non-Ocean



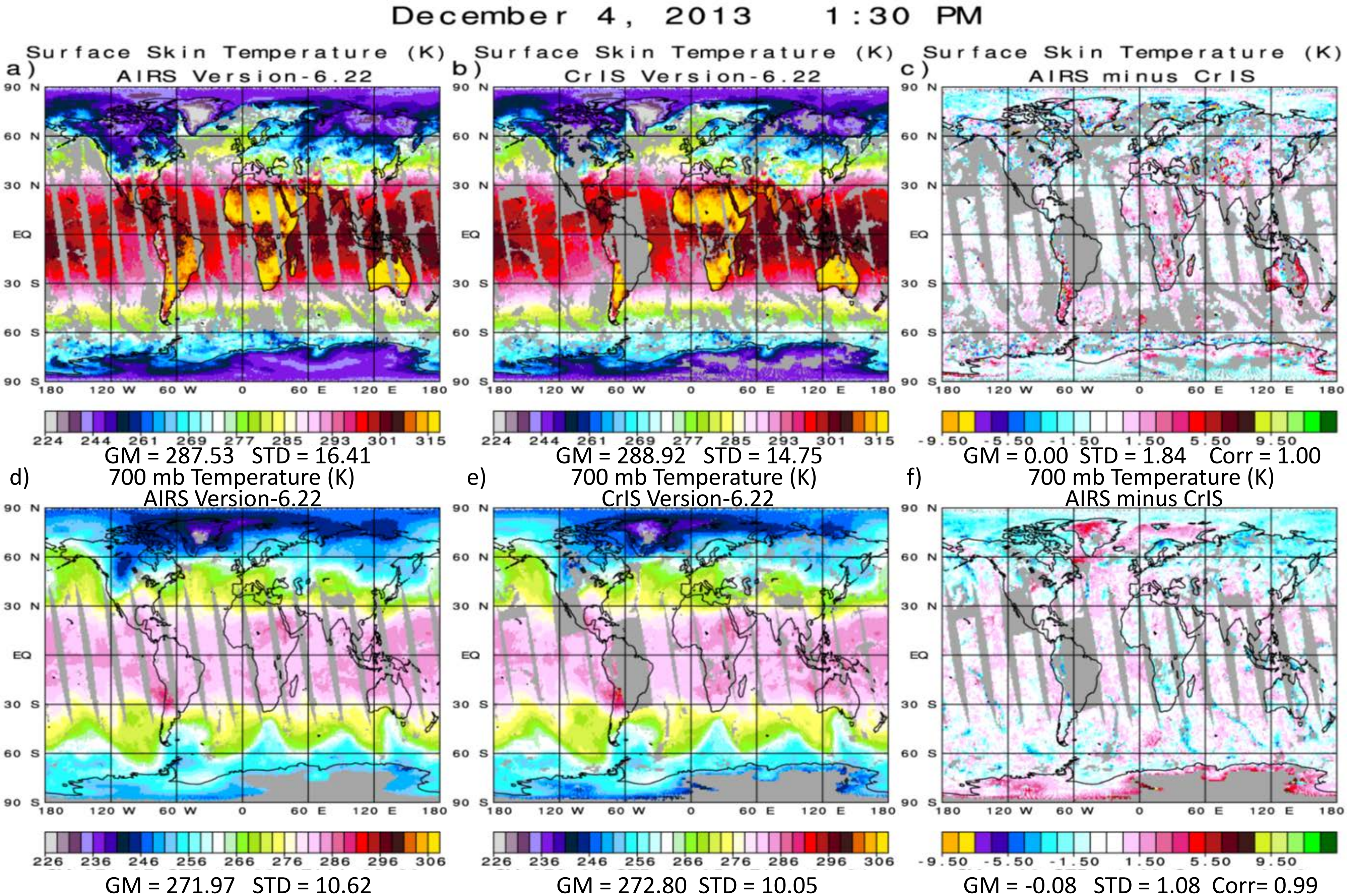
CrIS/ATMS statistics for *T(p)* are poorer over land than those of AIRS/AMSU, with regard to % yield, RMS differences from ECMWF, and bias structure, especially for the more cloudy cases included using Climate QC. This could be a consequence of poorer CrIS/ATMS land surface skin temperatures than those of AIRS/AMSU resulting from truncated SW CrIS spectral coverage.



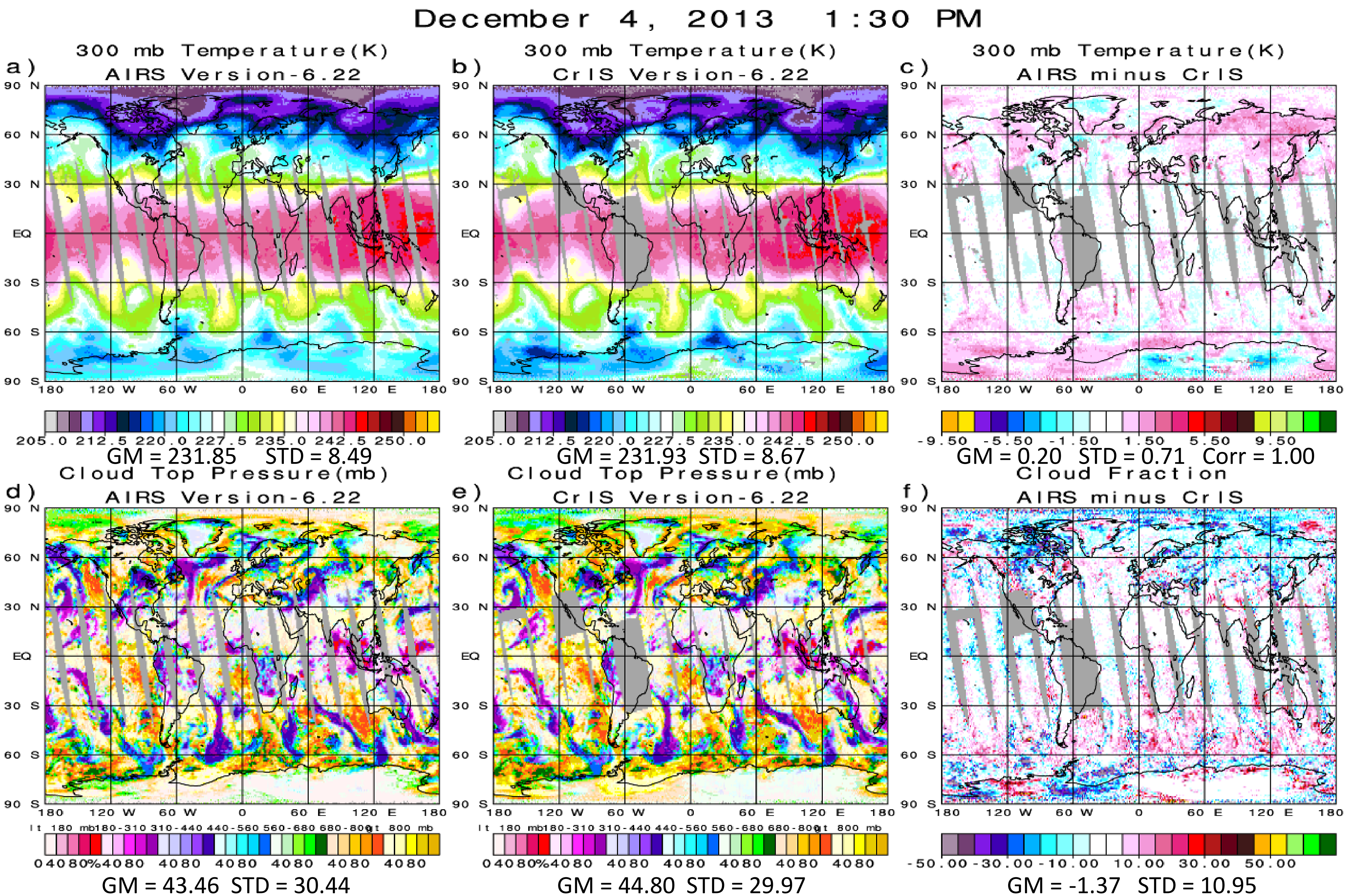
AIRS Version-6, AIRS Version-6.22, and CrIS Version-6.22 QC'd fields of total O_3 for ascending orbits on December 4, 2013, and their differences from OMI. CrIS is missing parts of some orbits. AIRS V6.22 agrees much better with OMI than AIRS V6 with regard to both STD and spatial correlation. CrIS V6.22 statistics are comparable to AIRS V6.22 but CrIS is biased high.



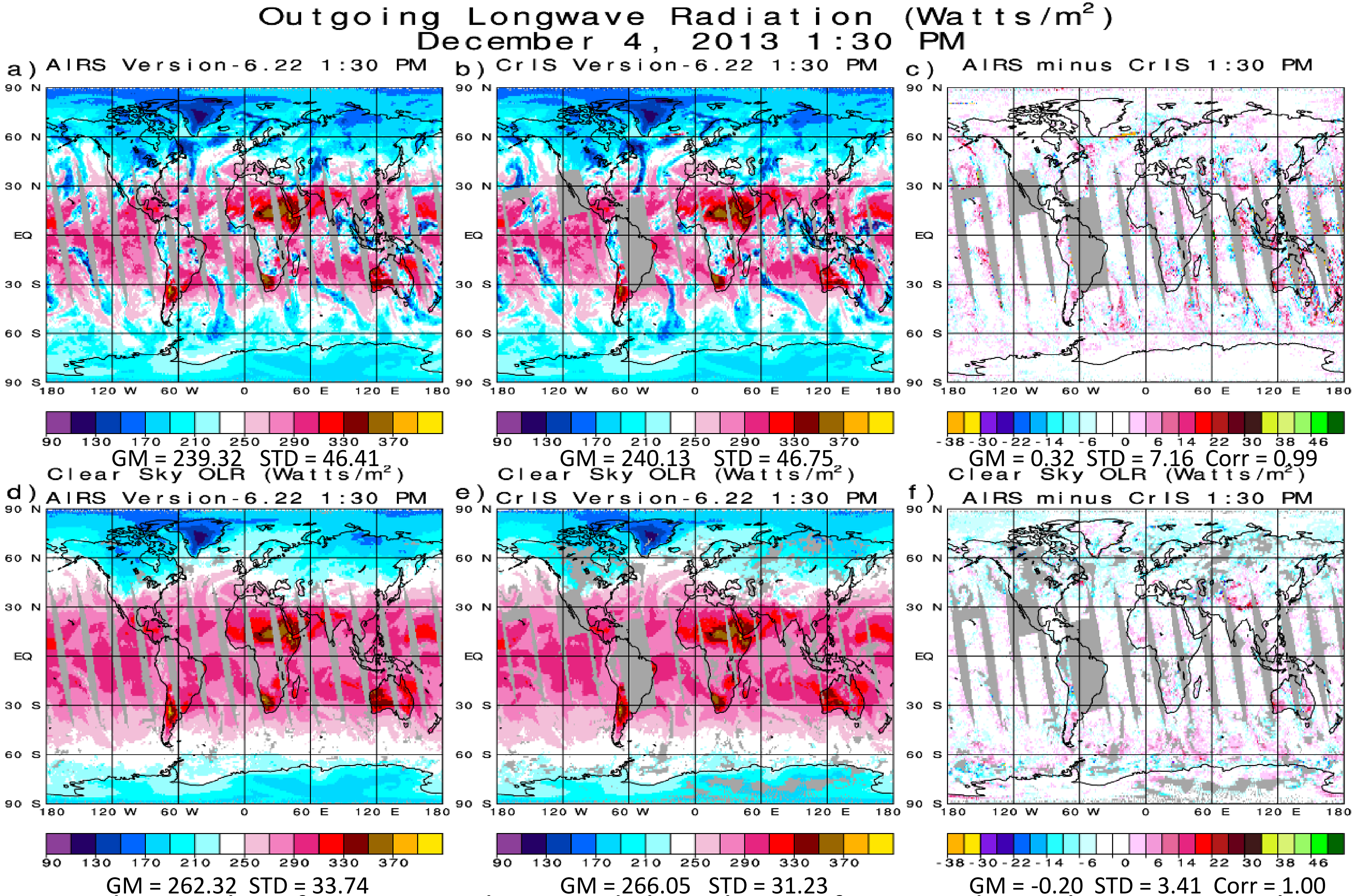
Derived QC'd fields of Total Precipitable Water (W_{TOT}) for the ascending (1:30 PM) orbits of AIRS and CrIS, and their differences from the ECMWF 3-hour forecast for this time period, which we take as truth. AIRS V6.22 W_{tot} is much more accurate than V6, especially in areas of high cloud cover. CrIS W_{tot} is very good as well.



Comparison of AIRS and CrIS retrieved values of surface skin temperature and 700 mb temperature for ascending orbits on December 4, 2013. Results agree very well over the tropical oceans. There are some differences over land, especially at high latitudes.



Comparison of AIRS and CrIS retrieved values of 300 mb temperatures and cloud parameters from December 4, 2013. Cloud fields show both p_c (color) and α (intensity). Agreement over tropical ocean is excellent in both fields. Again, some differences occur at high latitudes.



AIRS and CrIS values for computed OLR and clear sky OLR for ascending orbits on December 4, 2013. Agreement of both fields is excellent with regard to global mean and spatial correlation. Some of the differences in OLR are a result of EOS Aqua and NPP orbits not aligning up as well East of 90 E.

Summary

We tested and evaluated Version-6.22 AIRS and Version-6.22 CrIS products on a single day, December 4, 2013, and compared results to those derived using AIRS Version-6.

- AIRS and CrIS Version-6.22 $O_3(p)$ and *q(p)* products are both superior to those of AIRS Version-6
- All AIRS and CrIS products agree reasonably well with each other
- CrIS Version-6.22 *T(p)* and *q(p)* results are slightly poorer than AIRS over land, especially under very cloudy conditions.

Both AIRS and CrIS Version-6.22 run now at JPL. Our short term plans are to analyze many common months at JPL in the near future using Version-6.22 or a further improved algorithm to assess the compatibility of AIRS and CrIS monthly mean products and their interannual differences

Updates to the calibration of both CrIS and ATMS are still being finalized. JPL plans, in collaboration with the Goddard DISC, to reprocess all AIRS data using a still to be finalized Version-7 retrieval algorithm, and to reprocess all recalibrated CrIS/ATMS data using Version-7 as well.

NASA

The MTG-IRS level 2 processor: physical basis, selected results and planned evolution

Stephen Tjemkes, Stefano Gigli
and Rolf Stuhlmann

EUMETSAT

Overview

- MTG-IRS: mission and instrument
- Level 2 processor: overview
- Demonstration projects
- Outlook

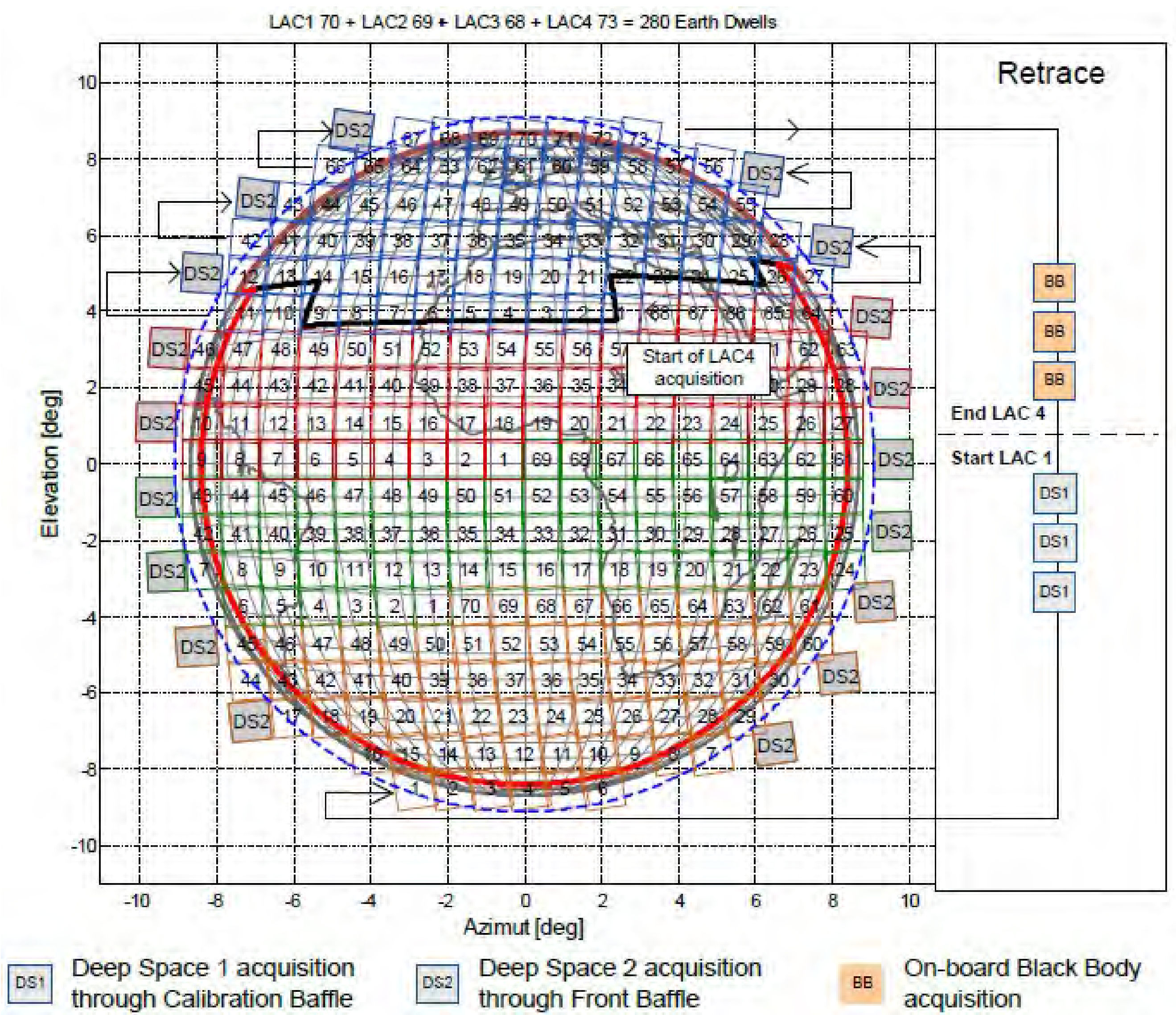
MTG-IRS: Mission and instrument

- Meteosat Third Generation:
  - Constellation of 3 EUMETSAT instruments and 1 EU/ESA instrument on two separate platforms:
    - MTG-I: FCI and LI
    - MTG-S: IRS and Sentinel 4
- IRS is developed to provide high spatial and temporal information on specific humidity and temperature especially for pre-convective situations as requested by operational user community

MTG-IRS: instrument

- Step and stare mode: one stare in 10 sec
- Two large detector arrays (160x160 elements), each detector consists of 9 sub-detectors.
- Spatial sampling of 4 km at SSP
- Temporal sampling: 4 x ¼ Full Disc in 1 hour
- Spectral Domain: LWIR: 700 – 1210 cm-1, MWIR: 1600 – 2175 cm-1
- Sampling: 0.625 cm-1
- There is **no** build in imager

MTG-IRS: Acquisition



EUMETSAT

MTG-IRS: Data volume

- MTG-IRS: 1 Dwell = 25600 fov in 10 sec
- Comparison (fov/sampling time)
  - IASI 1-PDU = 2760 fov / 180 sec:
  - CrIS 1 Granula = 1080 fov / 32 sec
- Substantial increase in data volume

MTG-IRS level 2 processor

- EUMETSAT decided to develop a new Level 2 processor for MTG-IRS because
  - MTG-IRS is a radical new instrument with new challenges and problems
  - the main application is regional scale forecast
- The processor
  - grounds on the fundamental radiative transfer equation,
  - is physically based and
  - can potentially use the full spectral coverage of the instrument

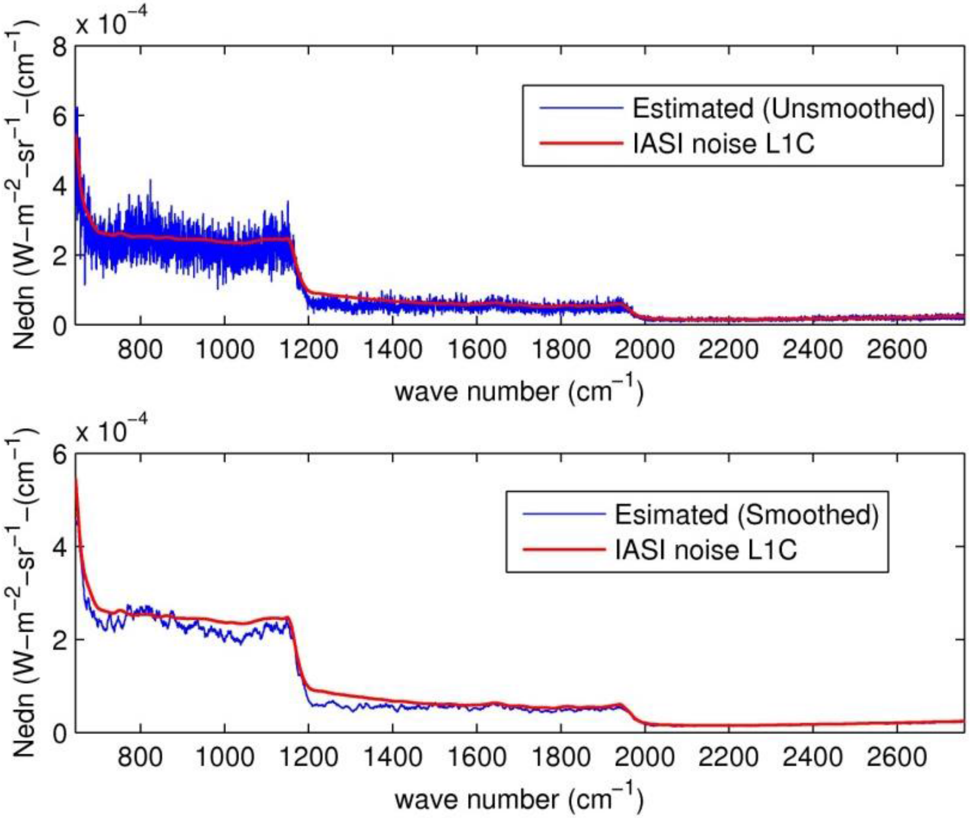
MTG-IRS Level 2 processor

- End-To-End processor
  - Scene analysis using information contained in spectra
  - retrieval only over clear sky area at Day-1
  - 1D-VAR with
    - T, q, O3, surface emissivity and temperature as state vector
    - OSS as RTM
    - ECMWF forecast state and flow dependent error covariance for a-priori
  - Post-processing for data assimilation applications

1DVAR

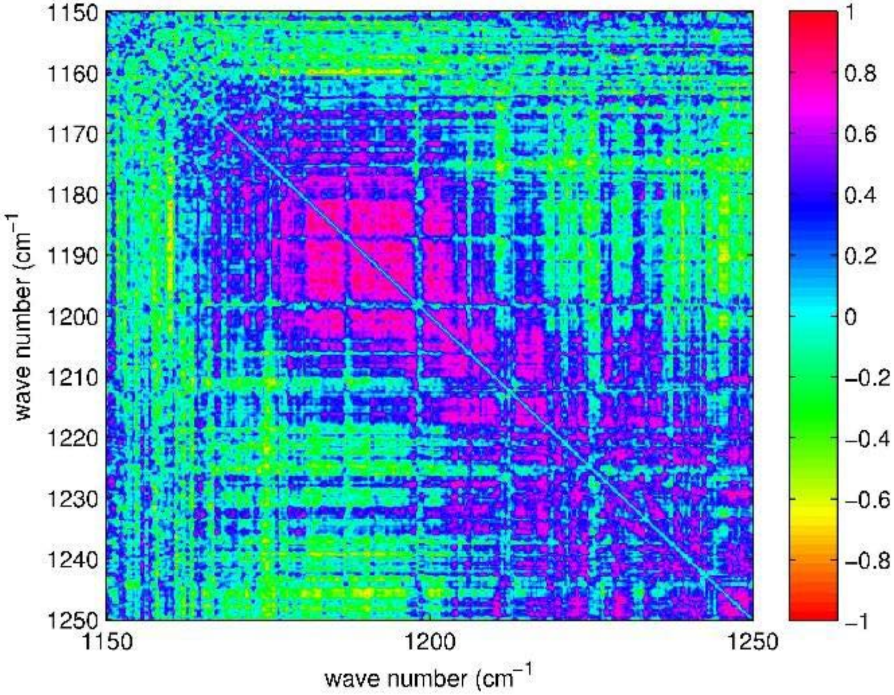
- Critical components
  - Radiometric error covariance, in particular any correlation
    - Normally provided by characterisation of instrument but now we have a method to derive this from in-flight earth observations
  - Background error covariance
    - Generated twice per day from ECMWF ensemble forecast system and adopted for 1DVAR (Holm and Kral, 2011)

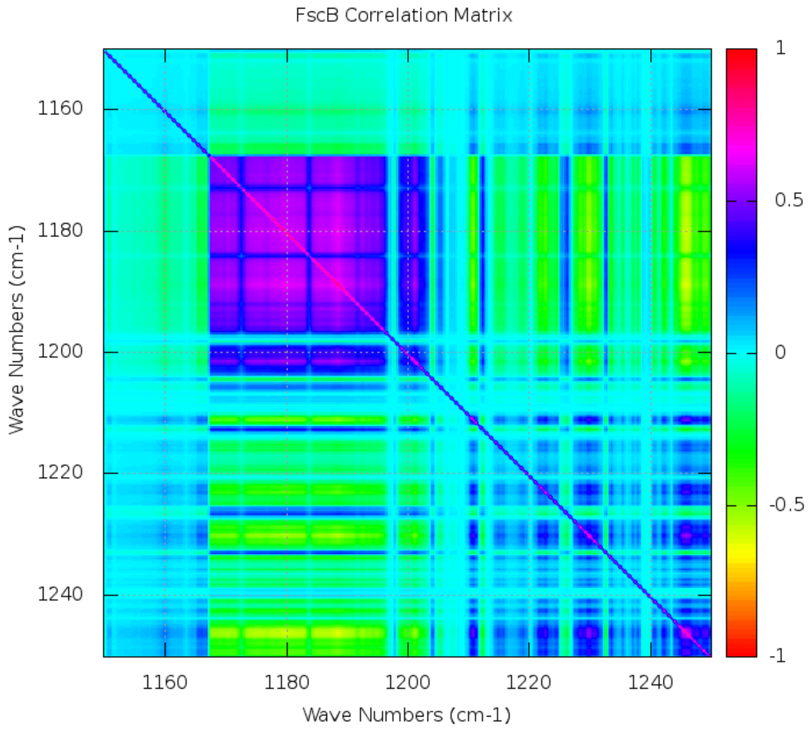
Example: IASI radiometric error covariance



- Serio et al: Appl Optics 2015

IASI example II





- The error covariance matrix for the IASI level 1C data for spectral channels between 1150 and 1250 cm^{-1}, derived from actual Earth observations (left) compared to a theoretical model which depicts correlated errors induced by realistic micro-vibrations (right). In both cases the correlated errors due to apodisation which affect the neighbouring spectral channels are removed

Post process

- Mainly a transformation of level 2 products from physical space to feature space

$$S_s = S_o^{-1/2} K S_a^{1/2} = U \Lambda V^t$$

- Solution is linear combination of true state and background state
- For dominant eigenvectors the effect of background is minimal.

Validation

- Validation suffers from a significant inconsistency in the time/space sampling of atmosphere between satellite and in-situ measurement.
  - This can be corrected for by inflating error covariance matrix (if known), but this is ignored in general (Pougatchev et al, 2009).
- Ultimately: if the user is (un) happy we are (un) happy
  - This implies to embrace/involve the users during the development of the processor
- In mean time: intercomparison study and demonstration projects

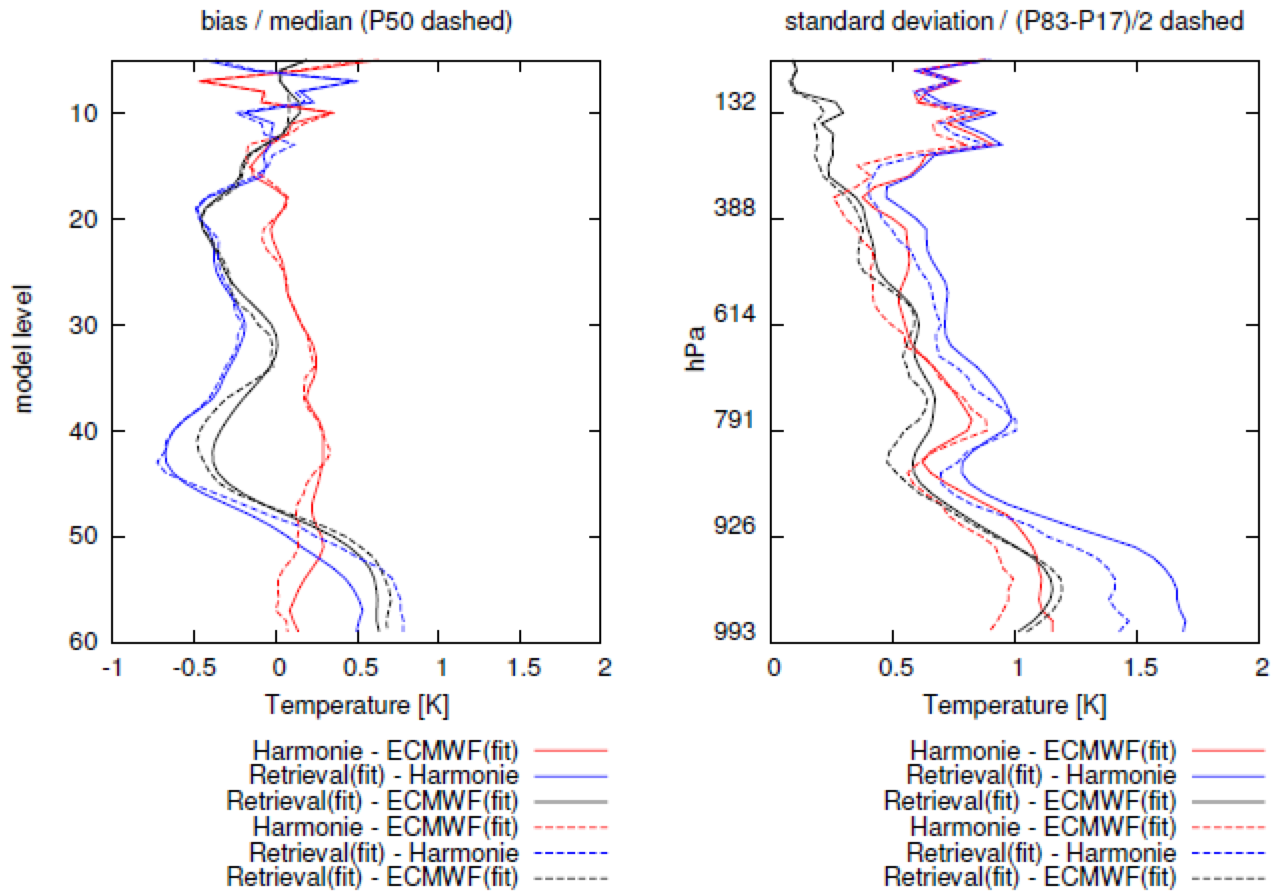
Retrieval intercomparison

- To identify strength and weakness of different approaches
- To identify way forward of open issues (e.g. Bias correction, Forward Model Errors)
- Objective is to do detailed analysis using a small set of carefully chosen cases
- Established a reference dataset
  - RS taken from GRUAN site manu, with collocated clear IASI observations
- Multi phase approach
  - First limited comparison of RTM
  - Comparison of retrievals using synthetic data
  - Comparison of retrievals using real data
- Participants: NASA (D. Zhou, X. Liu), NOAA (A. Gambacorta, Q. Liu), Met Office (S. Havemann), SSEC (B. Smith, N. Smith, P. Antonelli), KIT (M. Schneider), SI (C. Serio), EUMETSAT (T. August, S. Tjemkes)

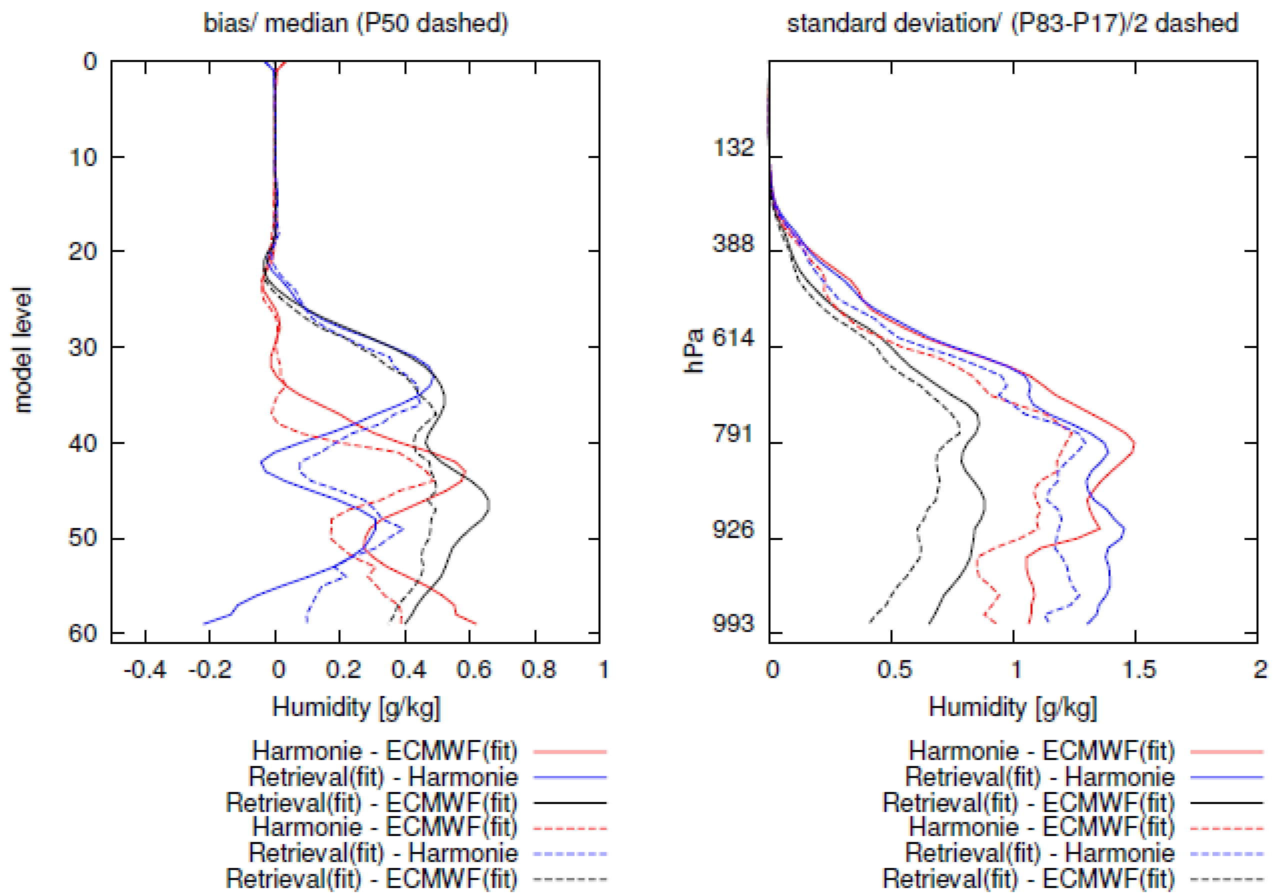
Demonstration projects: example

- Assimilation in regional scale NWP by KNMI over Europe and P. Antonelli over Hawaii
  - Validation of the level 2 products to determine if assimilation is feasible
  - Setup the technical infrastructure to assimilate the transformed retrievals
  - Perform retrieval over limited time period

Sample results: T-profile compared to Harmonie

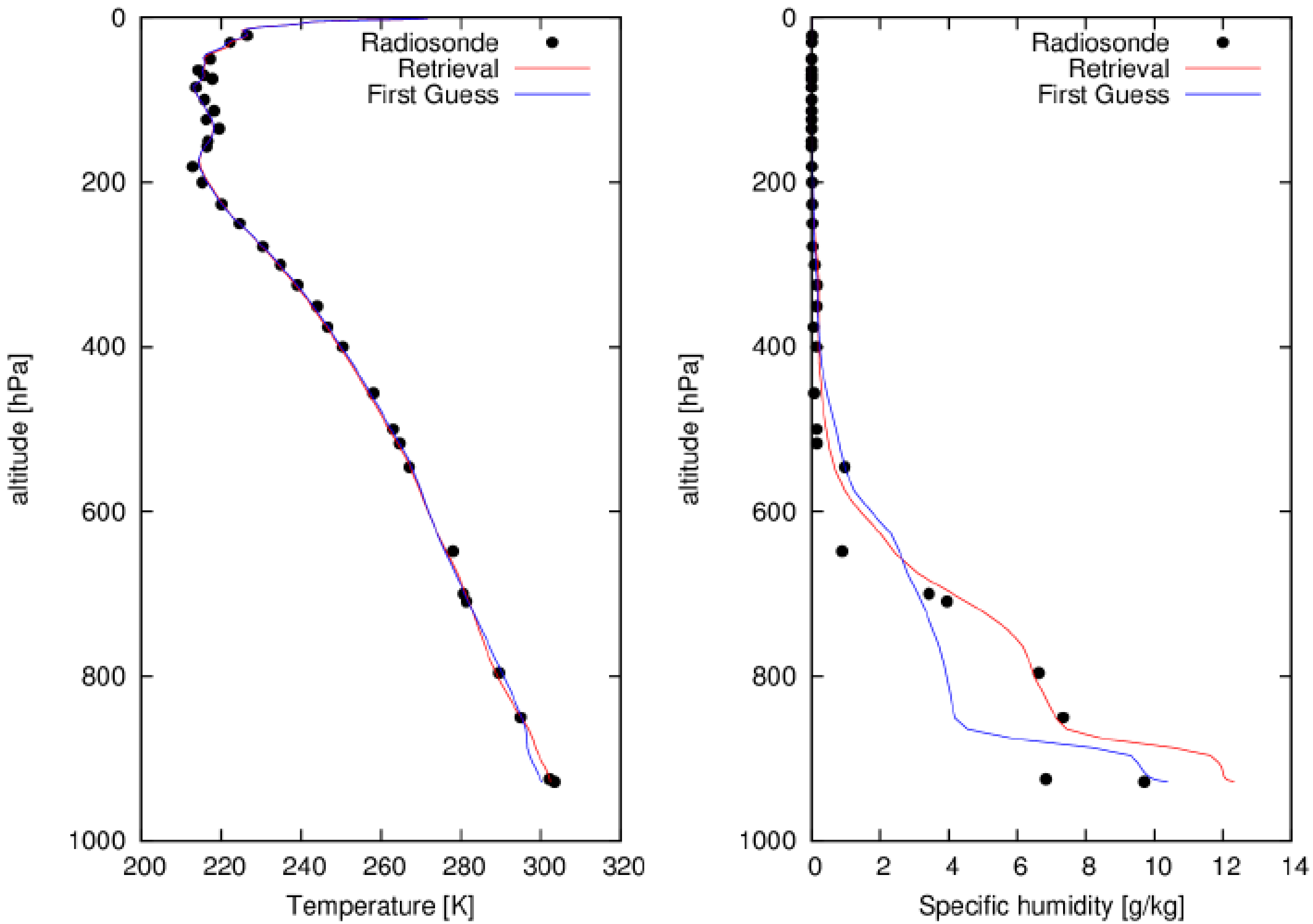


Sample results: q-profile compared to Harmonie



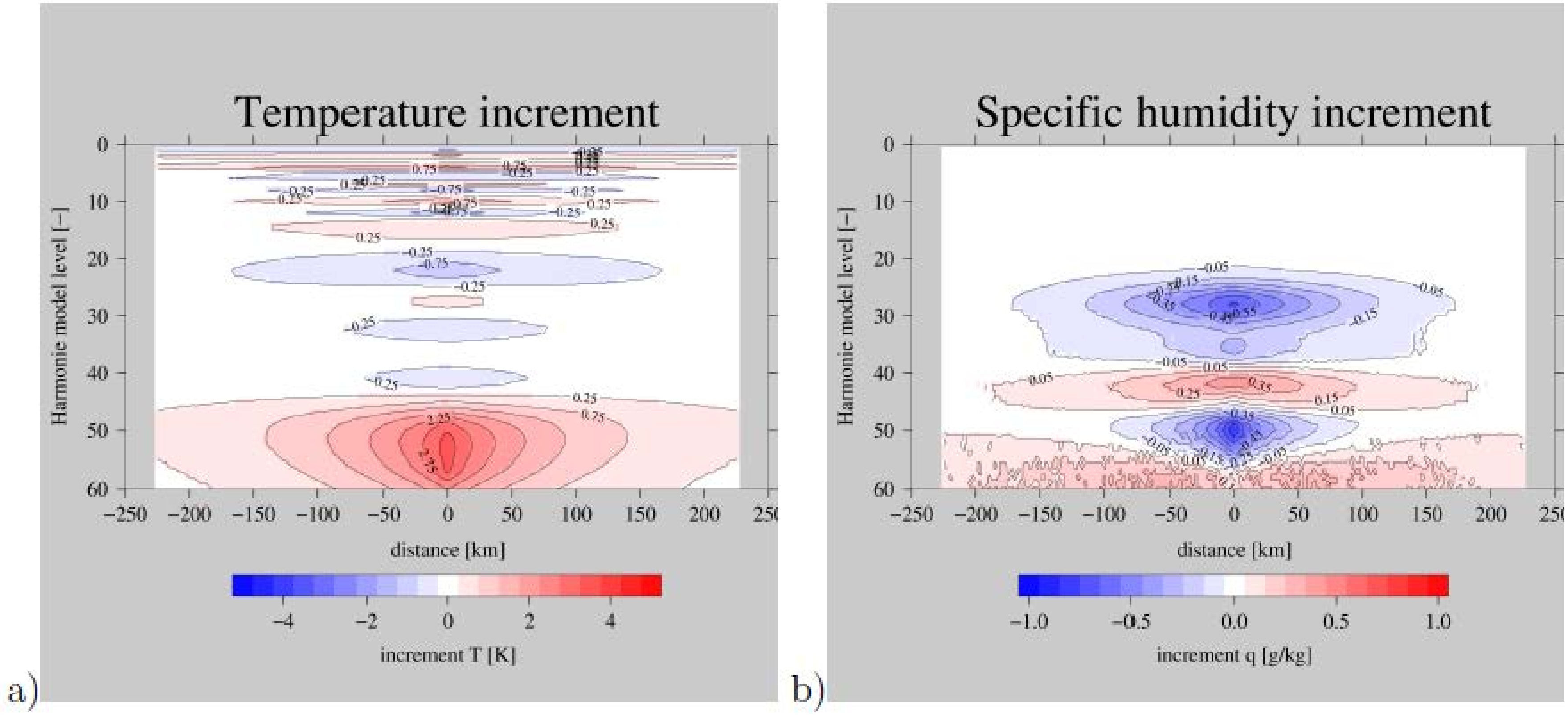
EUMETSAT

Single profile assimilation: Comparison to RS

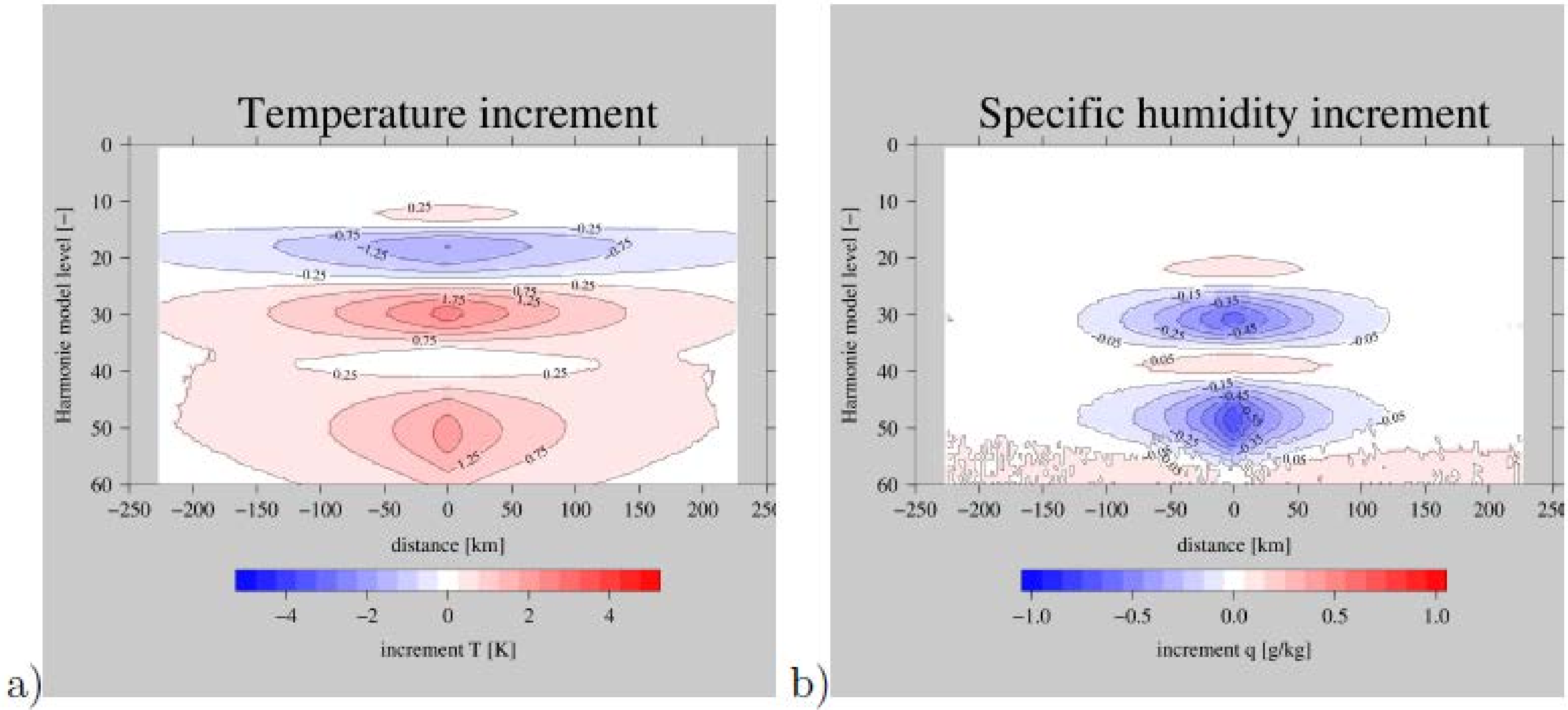


EUMETSAT

Single profile retrieval: direct assimilation of T/Q profile



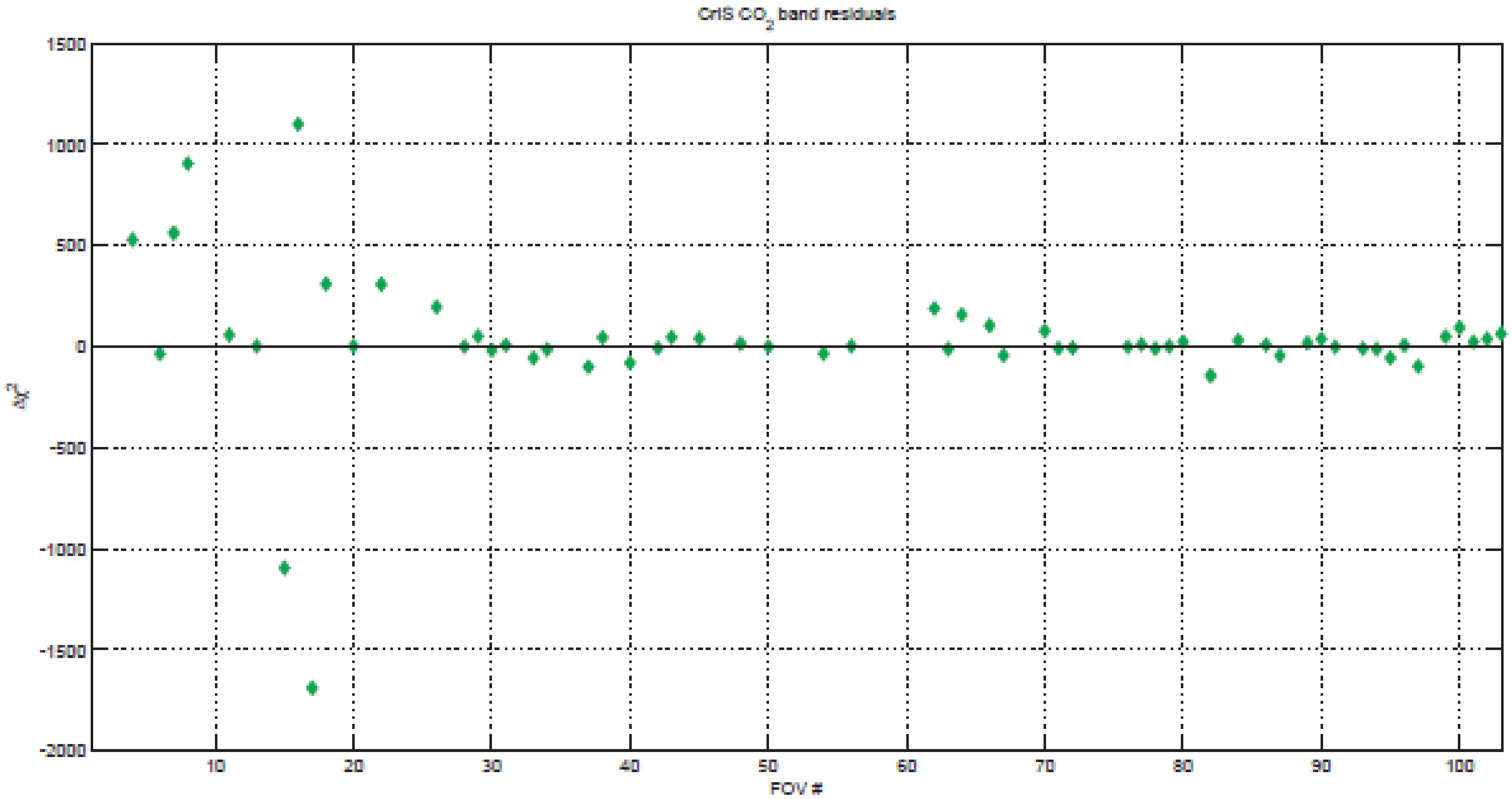
Single profile retrieval: assimilation of transformed product



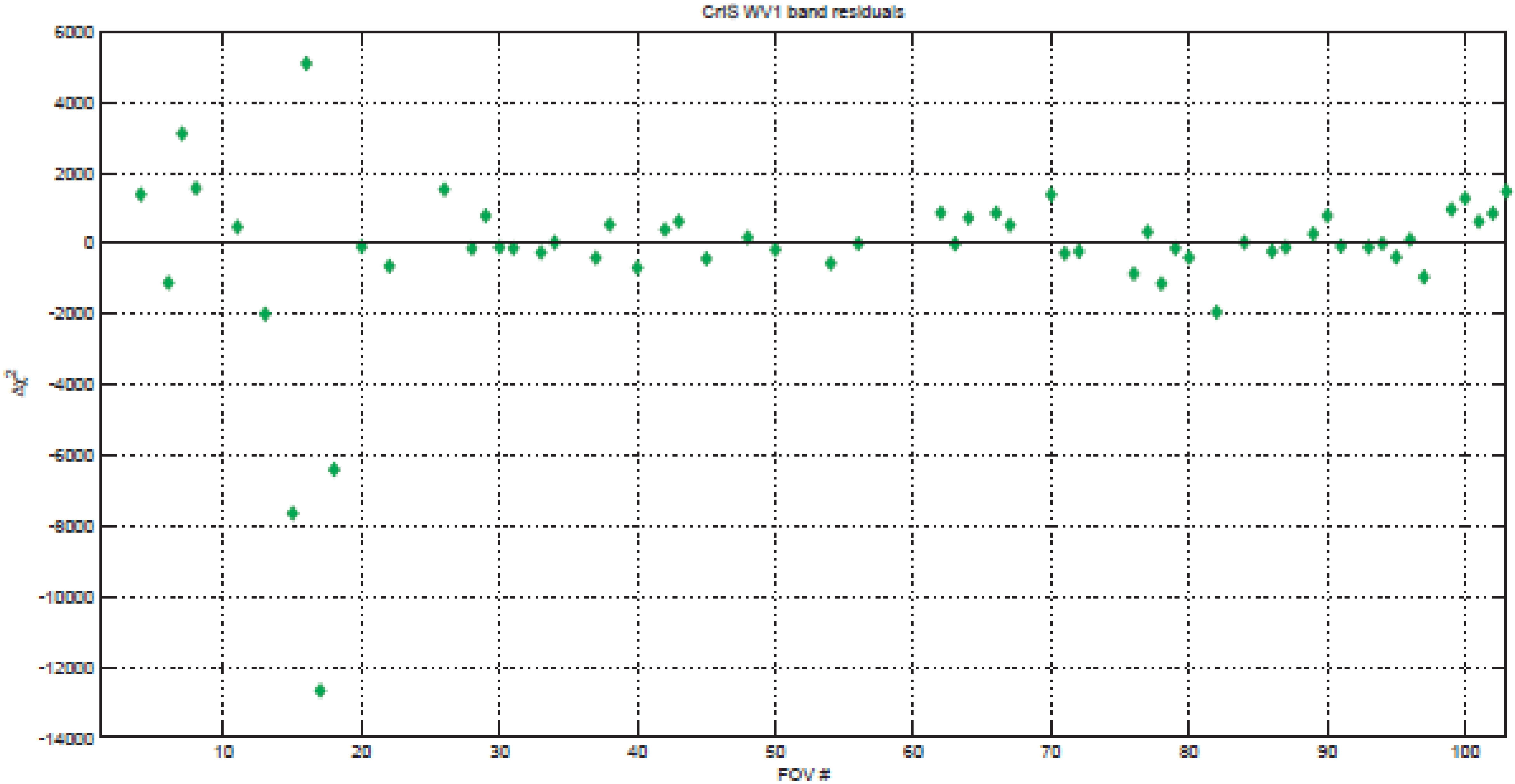
Impact on forecast

- Period of 3 weeks is too short to say anything conclusive.
- On next slides show illustration from Antonelli et al where impact is documented through comparison with CrIS observations.

CO2 domain: 650 - 780



WV: 1088 - 1261


CrIS WV1 band residuals
6000
4000
2000
0
-2000
-4000
-6000
-8000
-10000
-12000
-14000
10
20
30
40
50
60
70
80
90
100
FOV #

Demonstration Projects

- Projects considered so far:
  - DA in regional scale NWP, will be continued with DA in global scale NWP
  - 2D Analysis using LAPS (FMI), NiNjo (DWD) and MESAN (SHMI)
  - 3D analysis for NWC (KNMI)
    - Mixed results (positive FMI, DWD, neutral SHMI, KNMI) mainly because of the small datasets considered.

Evolution of Demonstration Projects

- Move from historical case studies to a NRT demonstration context:
  - running the processor over a long period (many months) using all available observations (IASI, CrIS) and provide the data in NRT to users

Evolution of processor

- Change minimisation method to make the method robust using the information matrix

$$-\Lambda^t \Delta y + \Delta x^a + \left(\Gamma + \Lambda^t \Lambda\right) \Delta x = 0$$

- Above equation is in feature space and represents a set of 30 equations
- Evaluate possibilities to perform retrievals in OSS node space
- Critically evaluate the a-priori error covariance with respect to
  - Representation errors, i.e. sampling at different scales by NWP and satellite
  - Representation of small scale variability

Summary

- Introduced MTG-IRS mission and level 2 processing,
  - To validate the processor
    - Comparison to independent observations/model data
    - Involve the users especially nwc
    - the intercomparison study
- Presented the current evolution plans
  - L2 processor
    - To explore retrievals in OSS node space and minimisation in feature space
  - Validation
    - NRT demonstration
- Further information:
  - http://www.eumetsat.int/website/home/Satellites/FutureSatellites/MeteosatThirdGeneration/MTGResources/index.html
  - select the “MTG Reports from EUMETSAT Scientific Studies”

Last slide

- Thank IRS Mission Advisory Group for continuous support:
  - Antonelli, Paolo (SSEC), Clerbaux, Cathy (Latmos, France), De Haan, Siebren (KNMI, The Netherlands), Fontan, Anne-Claire (Météo-France, France), Friedl-Vallon, Felix (KIT, Germany), Gregow, Erik (FMI, Finland), Holm, Elias (ECMWF, UK), Iršič-Žibert, Mateja (ARSO, Slovenia), Koepken-Watts, Christina (DWD, Germany), Lavanant, Lydie (Météo-France, France), Martinez, Miguel (AEMET, Spain), Pavelin, Edward (Met Office, United Kingdom), Serio, Carmine (DIFA, Italy), Strelec Mahović, Nataja (DHMZ, Croatia), Vocino, Antonio (CNMCA, Italy)
- Contact: Stephen.tjemkes@eumetsat.int
- Questions?

The Orbiting Carbon Observatory-2 (OCO-2) Mission

Watching The Earth Breathe… Mapping CO_2 From Space

An Overview of NASA's Orbiting Carbon Observatory-2 (OCO-2)

Prepared by

David Crisp, Annmarie Eldering, and Michael Gunson

Jet Propulsion Laboratory, California Institute of Technology

*Lesley Ott, NASA Goddard Space Flight Center

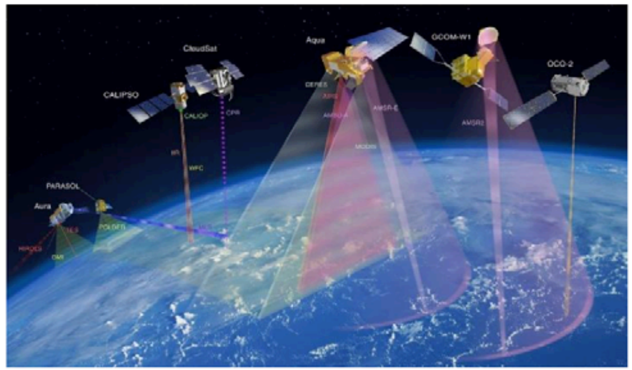
presenting for the OCO-2 Science Team

August 27, 2015

A Perfect Launch

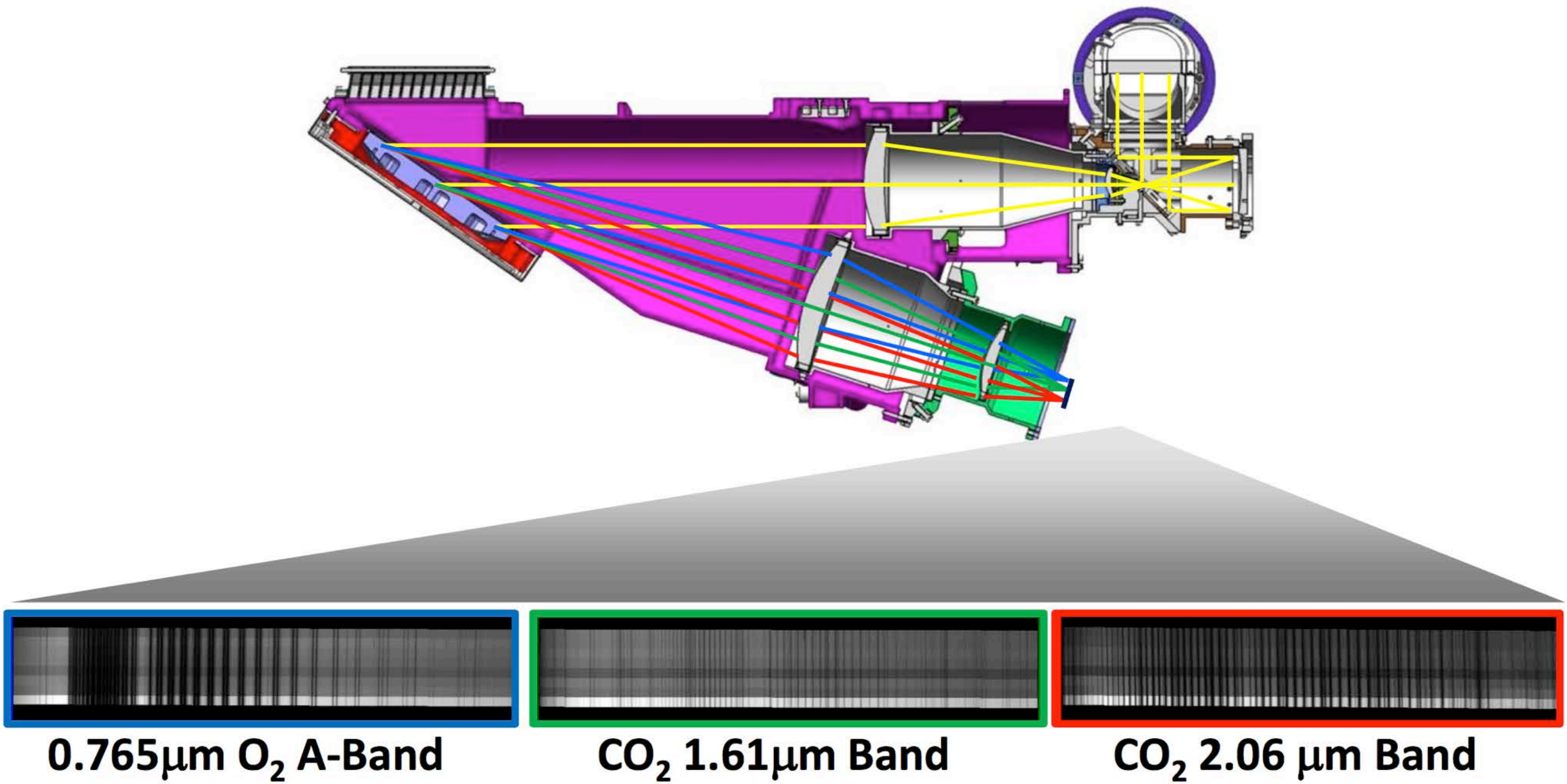
Lift-off at 2:56 am PDT, 02 July 2014

Separation!



Joining the A-Train
3 August 2014

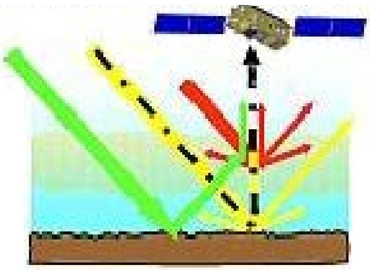
The OCO Instrument – Optimized for Sensitivity

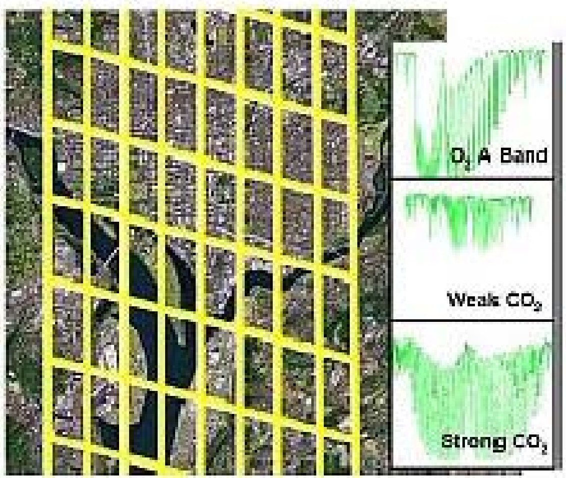


OCO-2 Observing Strategy

Nadir Observations:

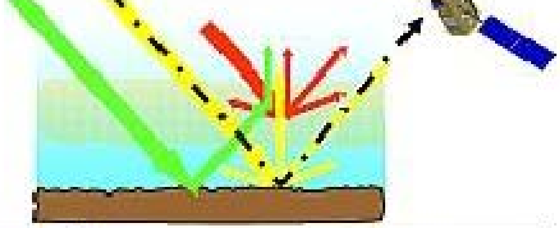
+ Small footprint (< 3 km^2)
- Low signal/noise over dark surfaces (ocean, ice)

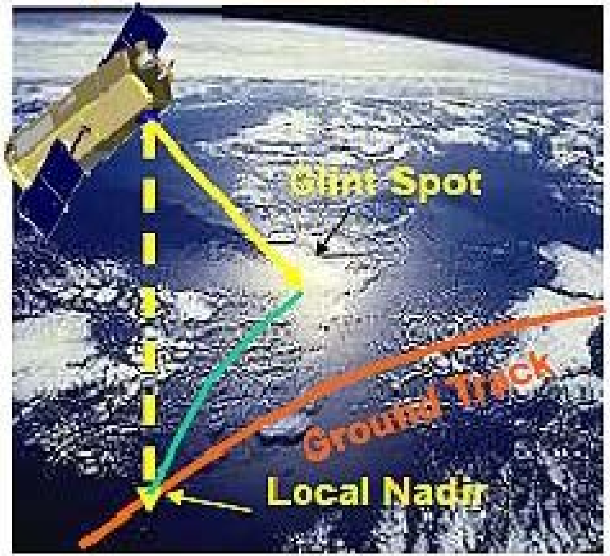




Glint Observations:

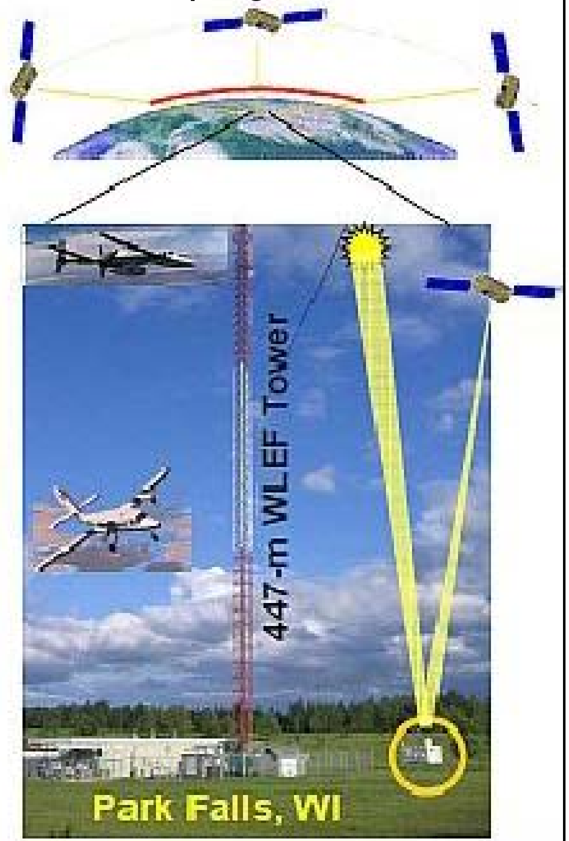
+ Improves signal/noise over oceans
- Potential for larger bias due to longer path



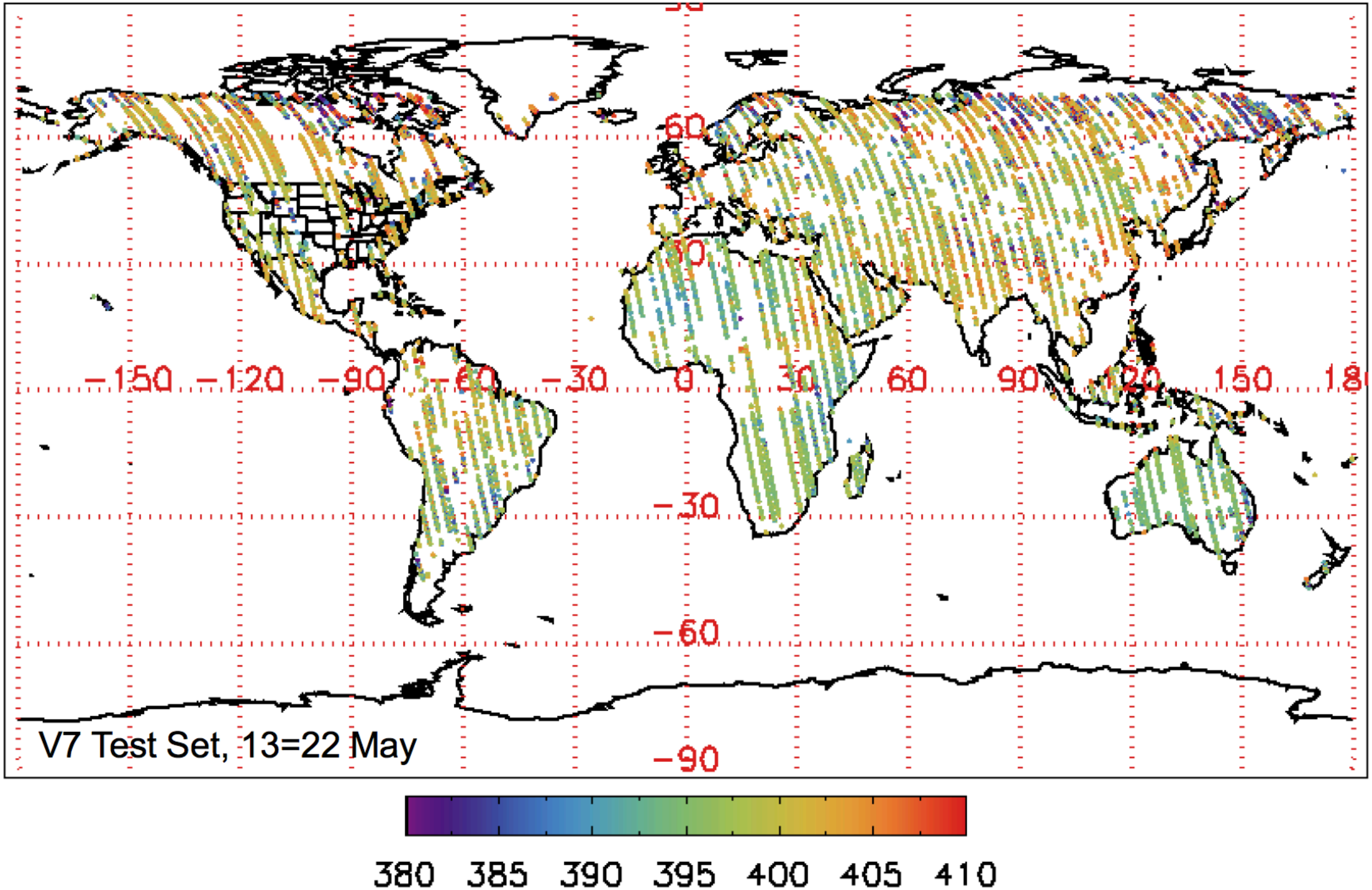


Target Observations:

Validation over ground-based FTS sites (TCCON), field campaigns

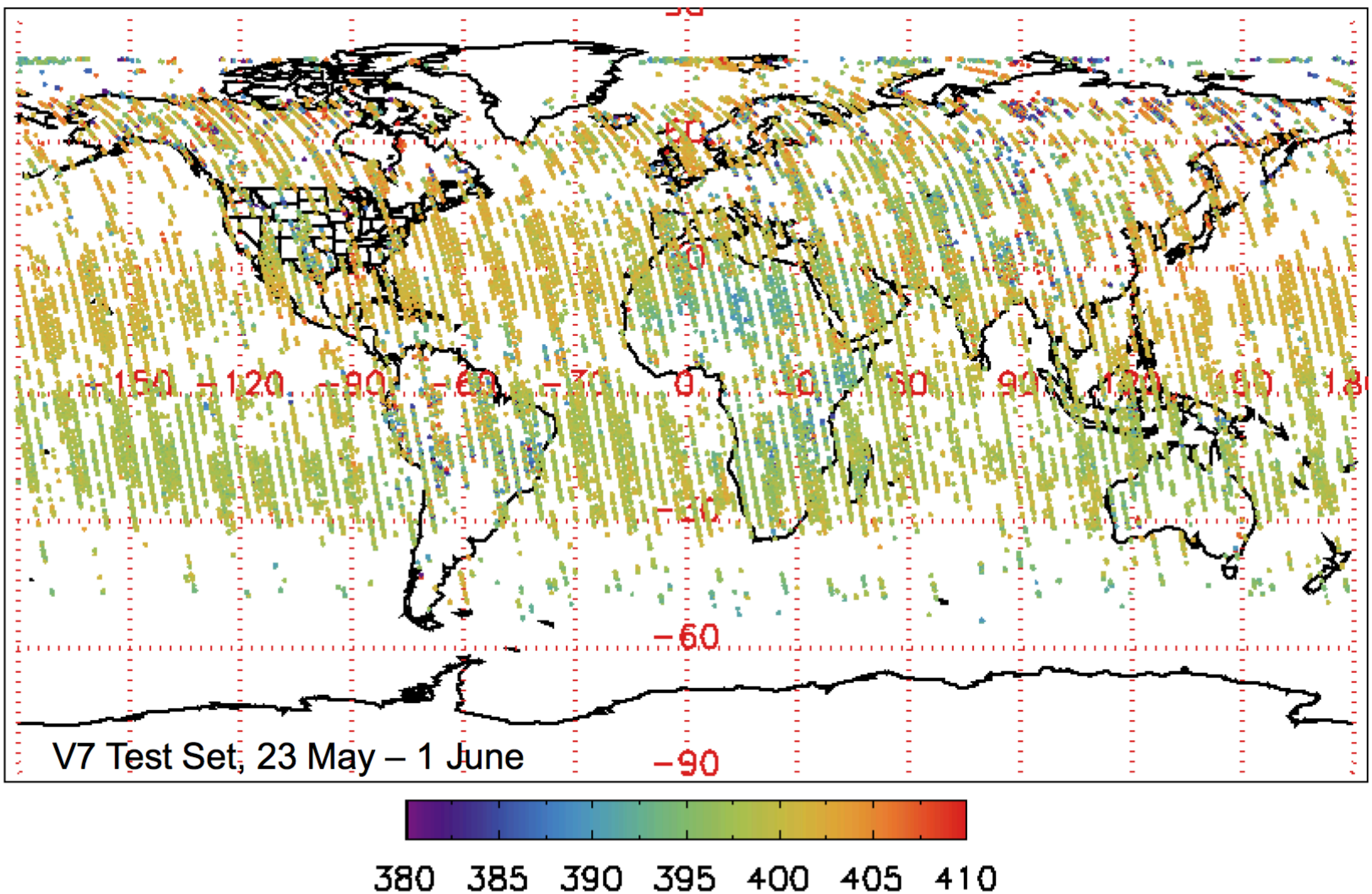


Preliminary Nadir Land XCO_2 Estimates



Nadir observations provide good coverage over land, but no coverage of ocean.

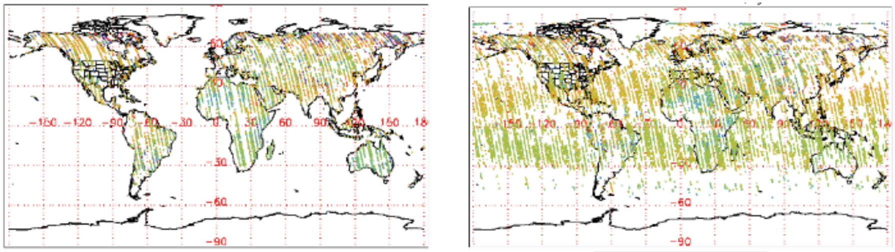
Preliminary Glint XCO_2 Estimates



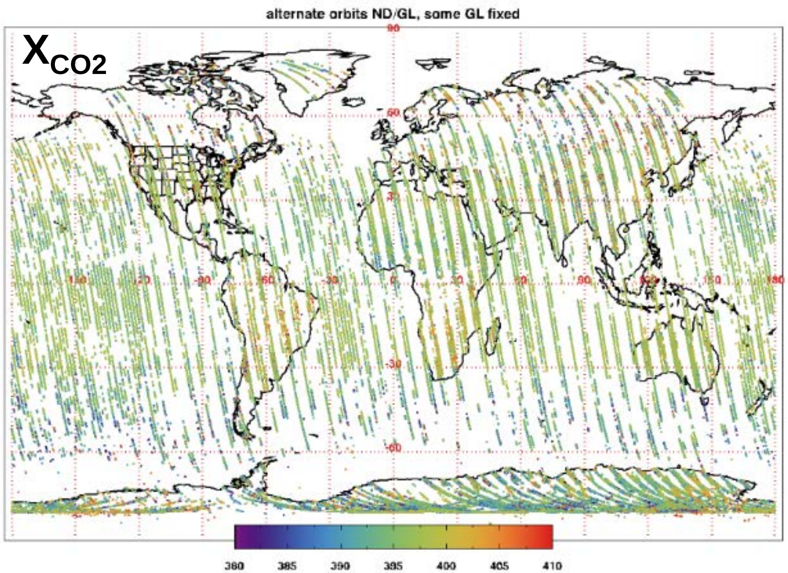
Glint observations provide better coverage of the ocean, but less coverage of high latitude land.

Changes in the Glint/Nadir Scheduling

Original Approach



Revised Approach

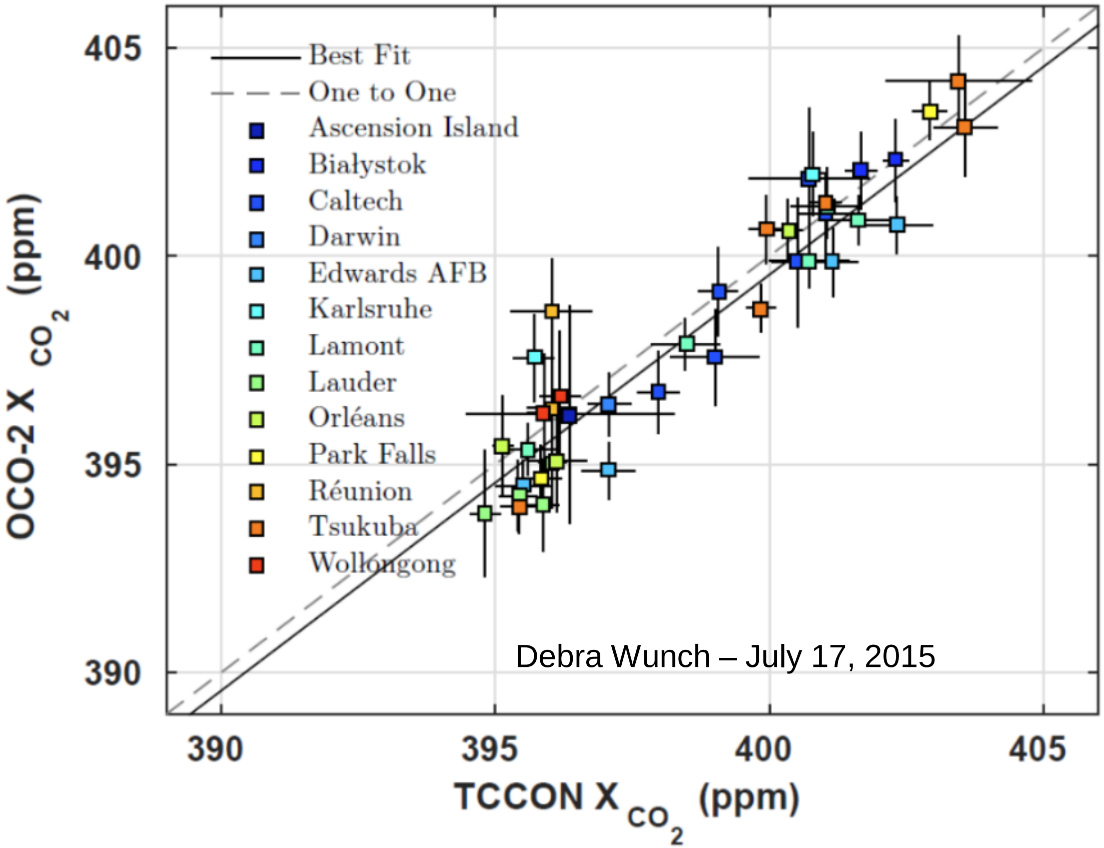


- Original sampling approach
  - Alternates between glint and nadir on successive 16-day ground repeat cycles
  - Precludes observations of oceans and high latitude continents for 16-day periods
- Revised glint/nadir strategy:
  - Step 1: Alternate between glint and nadir on successive orbits that include both land & ocean
  - Step 2: For orbits that are predominately over ocean, always stay in glint
- Changes implemented in early summer 2015

Target Observations – Validation of GOSAT and OCO-2 with TCCON

The Total Carbon Column Observing Network (TCCON) provides the primary means of validating GOSAT and OCO-2 products against WMO standards.

Comparison of TCCON and OCO-2 X_{CO2}

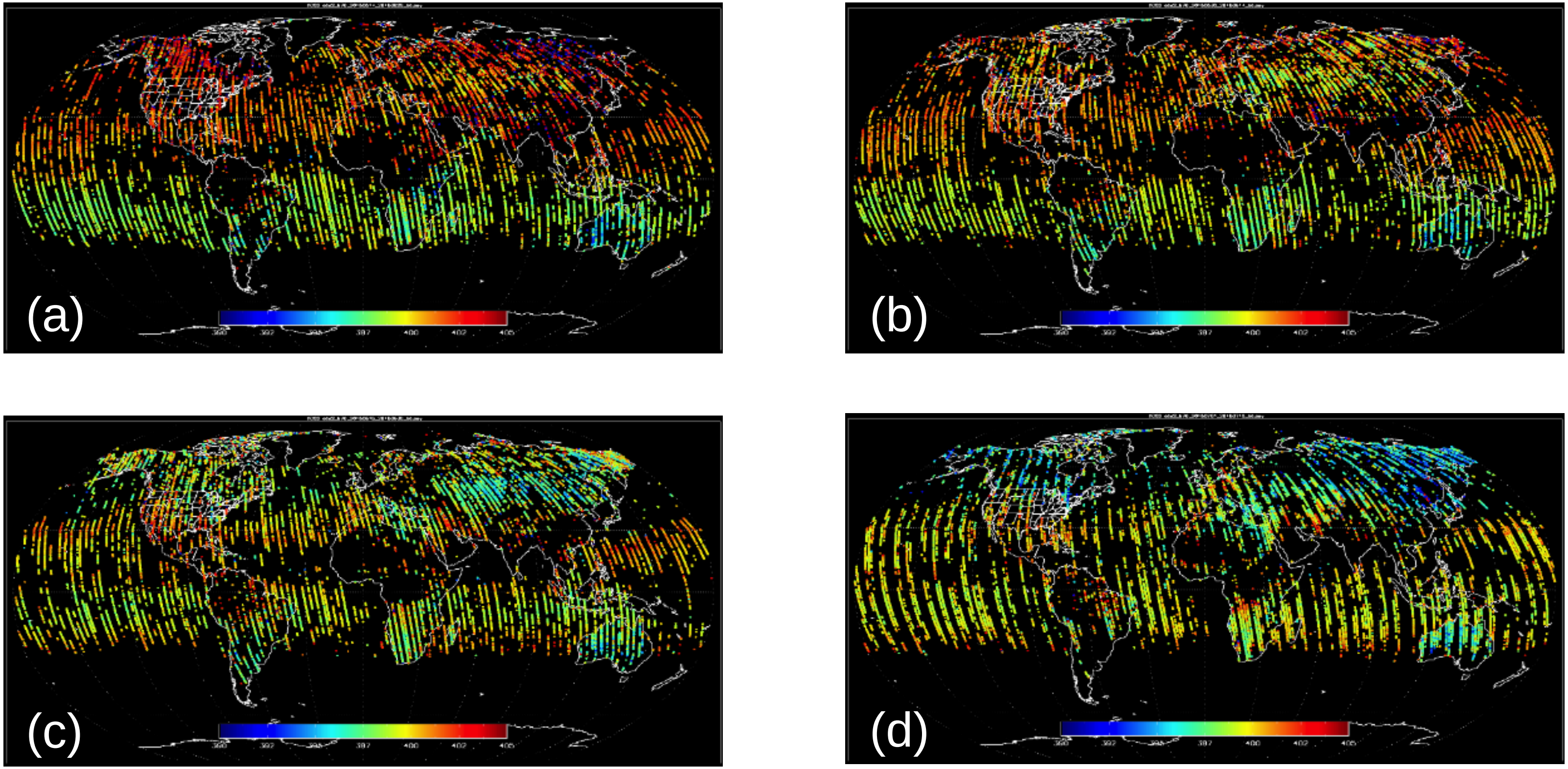


Comparisons with Total Carbon Column Observing Network (TCCON) stations are being used to identify and correct biases in target observations.

Initial differences between OCO-2 and TCCON X_{CO2} estimates were smaller than ~2 ppm (0.5%).

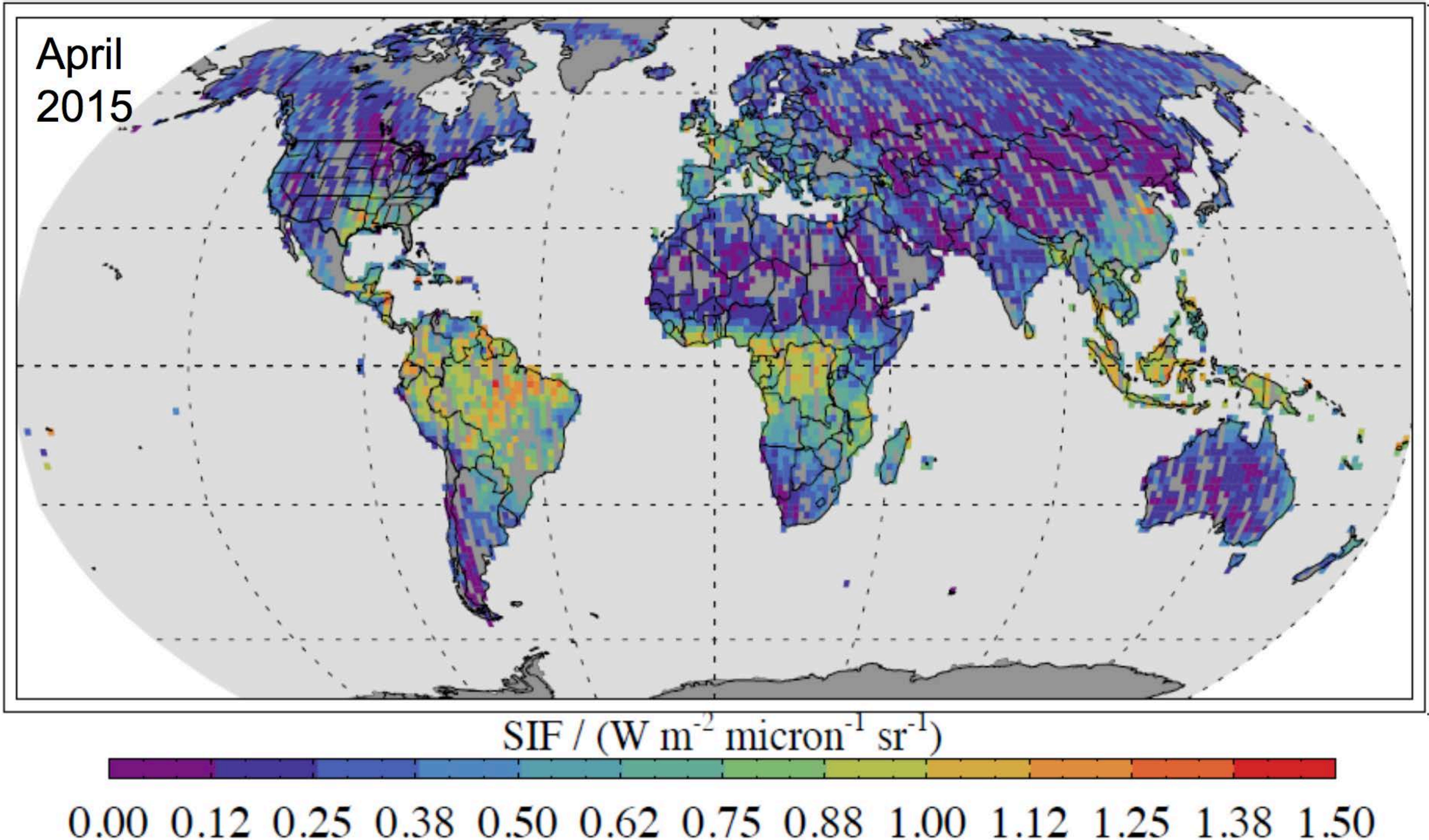
A preliminary bias correction further reduces these differences.

OCO-2 Observes the Spring Drawdown

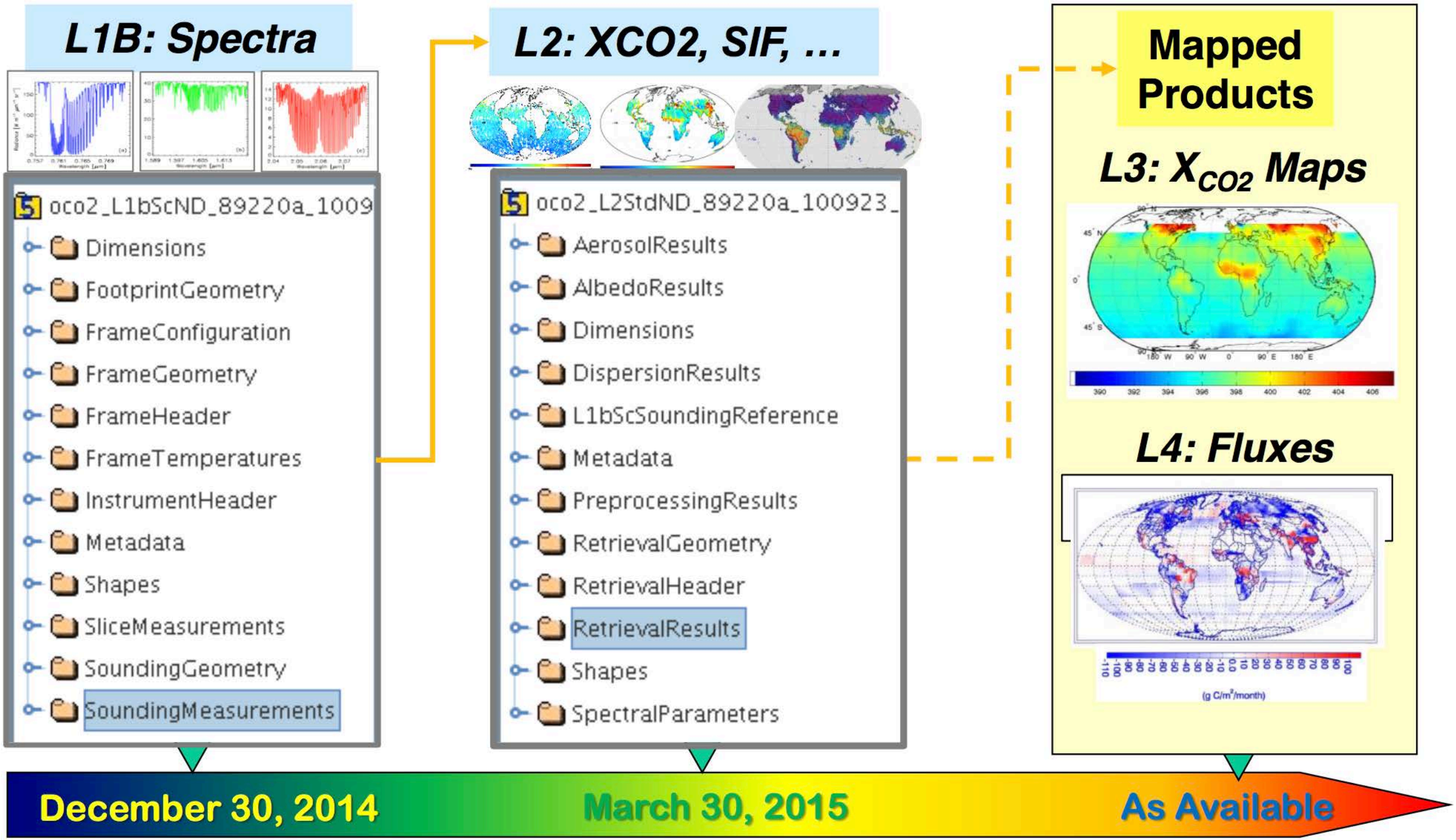


Global maps of the column-average CO_2 dry air mole fraction (X_{CO2}) for (a) 14-29 May, (b) 30 May to 14 June, (c) 15-30 June and (d) 1-15 July, produced from OCO-2 observations. The range of latitudes in the southern hemisphere is limited during this season because the sun is near it northernmost latitude. Large-scale reductions in X_{CO2} are clearly seen in the northern hemisphere, as the land biosphere becomes active and rapidly absorbs CO_2.

A New Product: Solar-Induced Chlorophyll Fluorescence (SIF)



Initial OCO-2 Data Product Deliveries



http://disc.sci.gsfc.nasa.gov/OCO-2/data-holdings/oco-2-v7

Summary

- OCO-2 was successfully launched on July 2, 2014 and began routine operations in early September 2014
  - Now returning about 1 million observations per day over the sunlit hemisphere
  - Between 10% (nadir) and 25% (glint) of these measurements are sufficiently cloud-free to yield accurate estimates of XCO_2
- The Build 7/7r data products are being delivered to the GES-DISC
  - Reprocessing back to September 6 2014 completed
  - V7 has no sounding (down)selection, warn levels, or bias correction
  - Bias corrections and warn levels currently under development
    - An airmass bias in glint is currently receiving most of the attention
- An intermediate product (B7.1) that includes warn levels and a recommended bias correction will be delivered before the end of September, along with a “Lite” product

Validation and Long-Term Monitoring of the NOAA Unique CrIS/ATMS Processing System (NUCAPS) Operational Retrieval Products

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College Park, Maryland, USA
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- **SNPP Sounder EDR Validation Dataset collection**
  - **NOAA AEROSE:** E. Joseph, V. R. Morris, M. Oyola (HU/NCAS); P. J. Minnett (UM/RSMAS); D. Wolfe (NOAA/ESRL); J. W. Smith (STAR, NRC)
    - AEROSE works in collaboration with the NOAA PIRATA Northeast Extension (PNE) project (R. Lumpkin, G. Foltz and C. Schmid), and is supported by the NOAA Educational Partnership Program (EPP) grant NA17AE1625, NOAA grant NA17AE1623, JPSS and STAR
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    - L. Borg, D. Tobin (UW/CIMSS)
    - D. Holdridge and J. Mather (ARM Climate Research Facility)
  - **CalWater:** R. Spackman (STC); C. Fairall, J. Intrieri (NOAA)
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  - **PMRF Site:** A. K. Mollner, J. E. Wessel (Aerospace)
  - **BCCSO Site:** R. Sakai, B. Demoz, M. Oyola (HU/NCAS)
  - **GRUAN Lead Center:** Ruud Dirksen
  - **NASA Sounder Science Team:** T. Pagano, E. Fetzer (NASA/JPL)

- **NUCAPS/CrIMSS validation effort (past and present)**: M. Wilson, T. King, W. W. Wolf, AK Sharma, M. Divakarla, E. S. Maddy, H. Xie (STAR); R. O. Knuteson and M. Feltz (UW/CIMSS); X. Liu (NASA/LaRC); M. Pettey, C. Brown (NPROVS team).

Outline

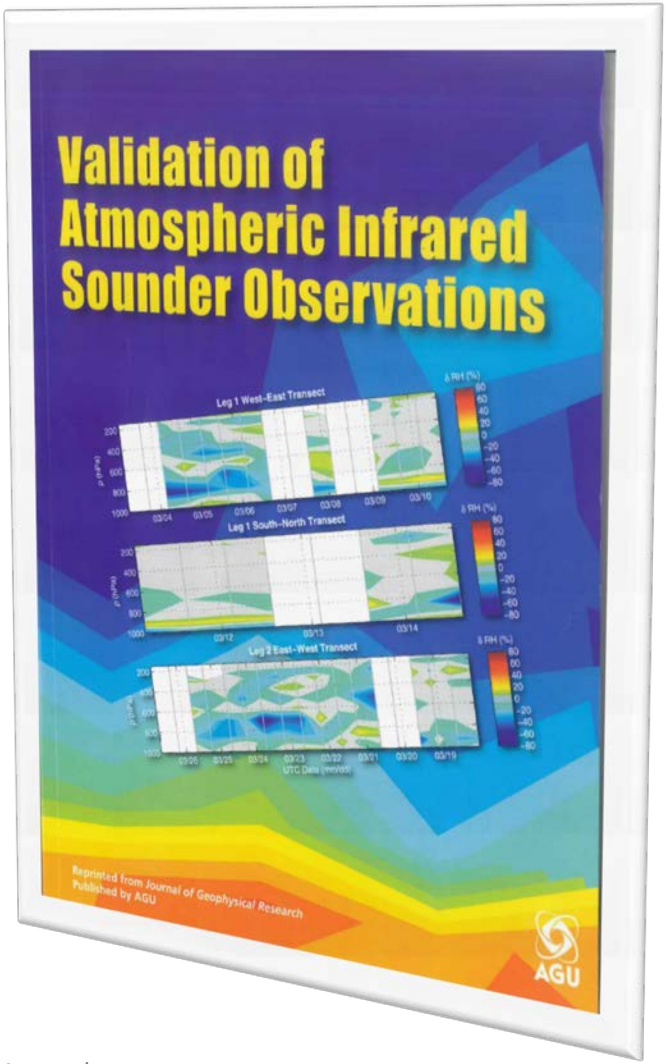
- **JPSS Sounder EDR Cal/Val Overview**
  - JPSS EDR validation
    - NOAA-Unique CrIS/ATMS Processing System (NUCAPS)
    - JPSS Level 1 Requirements
  - Validation Methodology
    - Validation Hierarchy
    - Statistical Metrics
  - JPSS SNPP Validation Datasets
    - STAR Validation Archive (VALAR)
    - NOAA Products Validation System (NPROVS/NPROVS+)
- **NUCAPS EDR Product Validation**
  - Temperature and Moisture (AVTP and AVMP) EDR
  - Trace Gas
    - Ozone profile EDR
  - Long-Term Monitoring (LTM)
- **Future Work**
  - SNPP ICV and LTM

Validation of NOAA-Unique Operational Sounder EDR

JPSS SOUNDER EDR CAL/VAL OVERVIEW

Intro: JPSS Sounder EDR Validation

- **Validation** is "the process of ascribing uncertainties to… radiances and retrieved quantities through comparison with correlative observations" (*Fetzer et al.,* 2003).
  - Sounder EDR validation supports validation of sounder SDRs and cloud-cleared radiances (a Level 2 product shown to have positive impact on NWP; e.g., *Le Marshall et al.,* 2008)
  - EDR validation enables development/improvement of algorithms



SNPP/JPSS Program Cal/Val

- **JPSS Cal/Val Phases**
  - Pre-Launch
  - Early Orbit Checkout (EOC)
  - **Intensive Cal/Val (ICV)**
    - Validation of EDRs against multiple correlative datasets
  - **Long-Term Monitoring (LTM)**
    - Routine characterization of all EDR products and long-term demonstration of performance

- In accordance with the JPSS phased schedule, the **SNPP CrIS/ATMS EDR Cal/Val Plan** was devised to ensure the EDR would meet the mission **Level 1 requirements** (*Barnet,* 2009)

- The **EDR validation methodology** draws upon previous work with AIRS and IASI (*Nalli et al.,* 2013, *JGR Special Section on SNPP Cal/Val*)
  - Classification of various approaches into a "Validation Methodology Hierarchy"

- The **J-1 CrIS/ATMS EDR Cal/Val Plan** was drafted during Jul–Aug 2015 and v1.0 was submitted on 20 August 2015

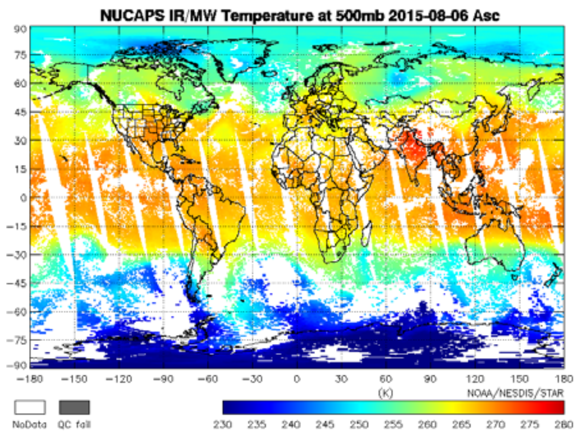
CrIS/ATMS Sounder Operational EDR: NOAA Unique CrIS/ATMS Processing System (NUCAPS)

NUCAPS Algorithm

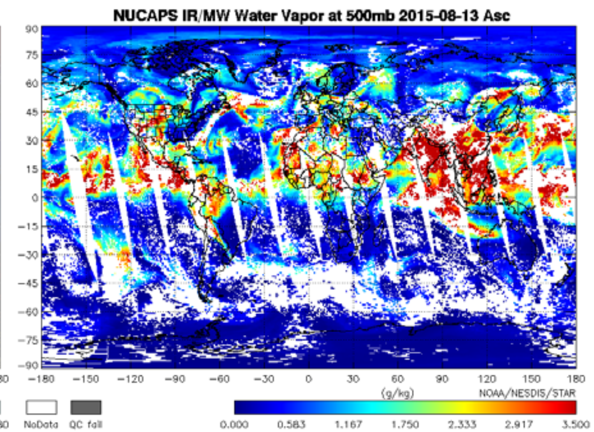
(*Susskind, Barnet and Blaisdell,* IEEE 2003; *Gambacorta et al.,* 2014)

- **Operational algorithm**
  - Superseded original IDPS CrIMSS algorithm in Sep 2013
  - Unified Sounder Science Team (AIRS/IASI/CrIS) retrieval algorithm
  - Non-precipitating conditions (cloudy, partly cloudy, clear)
  - Atmospheric Vertical Temperature , Moisture (AVTP, AVMP) and trace gas profiles (O_3, CO, CO_2, CH_4)
- **Stage-1 Validated Maturity achieved in Sep 2014**
  - Original IDPS CrIMSS EDR was validated through Beta and Provisional Maturities (*Divakarla et al.,* 2014)
- **Users** (Mark Liu's presentation, Thursday morning Users Session)
  - Weather Forecast Offices (AWIPS)
    - Nowcasting / severe weather
    - Alaska (cold core)
  - NOAA/CPC (OLR)
  - NOAA/ARL (IR ozone and trace gases)
  - TOAST (IR ozone)
  - Basic and applied science research (e.g., *Pagano et al.,* 2014)
    - Via NOAA Data Centers (e.g., NGDC, CLASS)
    - Universities, peer-reviewed pubs

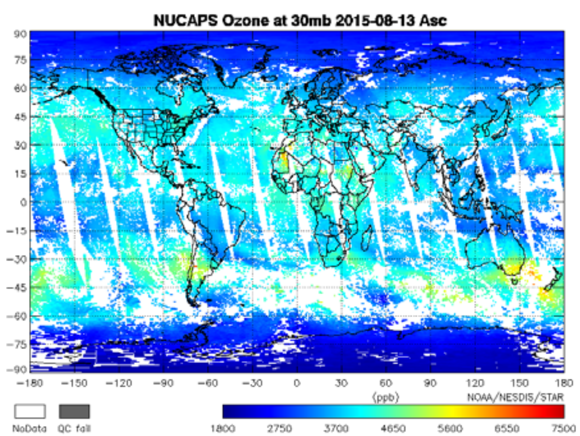
NUCAPS AVTP



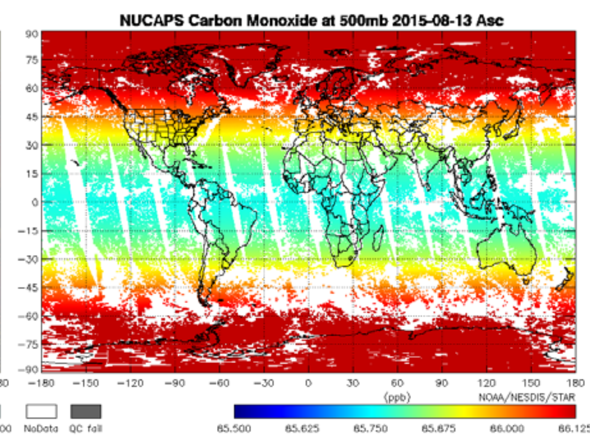
NUCAPS AVMP



NUCAPS O_3



NUCAPS CO



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

CrIS/ATMS Sounder EDR L1 Requirements

AVTP and AVMP EDR

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

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

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

Trace Gas EDR

CrIS Infrared Trace Gases Specification Performance Requirements	
PARAMETER	THRESHOLD
CO (Carbon Monoxide) Total Column Precision	35%, or full res mode 15%
CO (Carbon Monoxide) Total Column Accuracy	±25%, or full res mode ±5%
CO_2 (Carbon Dioxide Total Column Precision	0.5% (2 ppmv)
CO_2 (Carbon Dioxide) Total Column Accuracy	±1% (4 ppmv)
CH_4 (Methane) Total Column Precision	1% (≈20 ppbv)
CH_4 (Methane) Total Column Accuracy	±4% (≈80 ppmv)
O_3 (Ozone) Profile Precision, 4–260 hPa (6 statistic layers)	20%
O_3 (Ozone) Profile Precision, 260 hPa to sfc (1 statistic layer)	20%
O_3 (Ozone) Profile Accuracy, 4–260 hPa (6 statistic layers)	±10%
O_3 (Ozone) Profile Accuracy, 260 hPa to sfc (1 statistic layer)	±10%
O_3 (Ozone) Profile Uncertainty, 4–260 hPa (6 statistic layers)	25%
O_3 (Ozone) Profile Uncertainty, 260 hPa to sfc (1 statistic layer)	25%

Source: L1RD (2014), pp. 45-49

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

"Clear to Partly-Cloudy" (Cloud Fraction < 50%) ↔ **IR retrieval**
"Cloudy" (Cloud Fraction >= 50%) ↔ **MW-only retrieval**

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 early sanity checks, bias tuning and regression
   - However, not independent truth data

2. **Satellite EDR (e.g., AIRS, ATOVS, COSMIC) *Intercomparisons***
   - Global samples acquired from Focus Days (e.g., AIRS)
   - Consistency checks; merits of different retrieval algorithms
   - However, IR sounders have 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
   - Useful for representation of global zones and long-term monitoring
   - Large statistical samples acquired after a couple months' accumulation (e.g., *Divakarla et al.,* 2006)
   - **NOAA Products Validation System (NPROVS)** (*Reale et al.,* 2012)
   - Limitations:
     - Skewed distribution toward NH-continental sites
     - Mismatch errors, potentially systematic at individual sites
     - Non-uniform, less-accurate and poorly characterized radiosondes
     - RAOBs assimilated , by definition, into numerical models

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

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; EDR "dissections"
   - E.g., **AEROSE**, **CalWater/ACAPEX**, **SNAP**, JAIVEX, WAVES, AWEX-G, EAQUATE

Assessment Methodology: Statistical Metrics

- Level 1 AVTP and AVMP accuracy requirements are defined over **coarse layers**, roughly 1–5 km for tropospheric AVTP and 2 km for AVMP (Table, Slide 6).
- We have recently introduced rigorous **zonal/land/sea surface area weighting** capabilities to these schemes for dedicated/reference RAOB samples

AVTP

$$\mathrm{RMS}(\Delta T_{\mathfrak{L}}) = \sqrt{\frac{1}{n_j}\sum_{j=1}^{n_j}(\Delta T_{\mathfrak{L},j})^2} \qquad \mathrm{BIAS}(\Delta T_{\mathfrak{L}}) \equiv \overline{\Delta T}_{\mathfrak{L}} = \frac{1}{n_j}\sum_{j=1}^{n_j}\Delta T_{\mathfrak{L},j}$$

$$\mathrm{STD}(\Delta T_{\mathfrak{L}}) \equiv \sigma(\Delta T_{\mathfrak{L}}) = \sqrt{[\mathrm{RMS}(\Delta T_{\mathfrak{L}})]^2 - [\mathrm{BIAS}(\Delta T_{\mathfrak{L}})]^2}$$

AVMP and O_3

- W2 weighting was used in determining Level 1 Requirements
- To allow compatible STD calculation, W2 weighting should be consistently used for both RMS and BIAS

$$\Delta q_{\mathfrak{L},j} \equiv \frac{\hat{q}_{\mathfrak{L},j} - q_{\mathfrak{L},j}}{q_{\mathfrak{L},j}} \qquad \mathrm{RMS}(\Delta q_{\mathfrak{L}}) = \sqrt{\frac{\sum_{j=1}^{n_j} W_{\mathfrak{L},j}(\Delta q_{\mathfrak{L},j})^2}{\sum_{j=1}^{n_j} W_{\mathfrak{L},j}}},$$

water vapor weighting factor, $W_{\mathfrak{L},j}$,

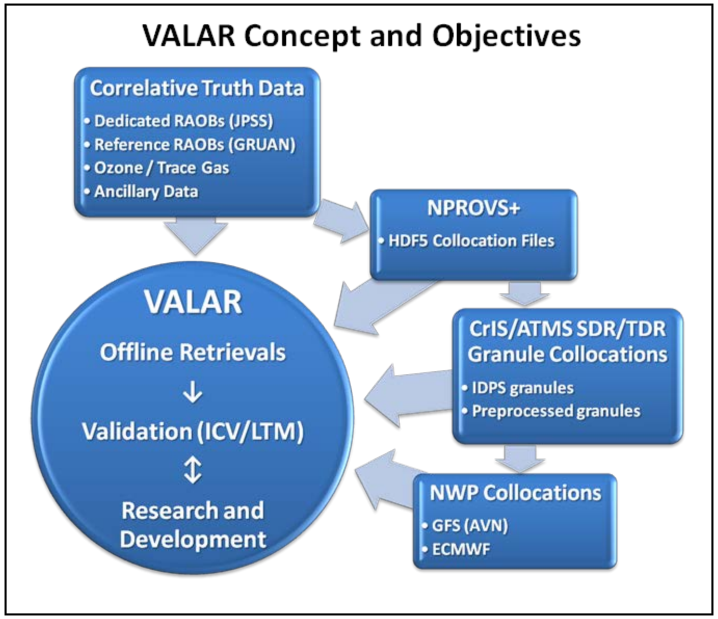
$$\mathrm{BIAS}(\Delta q_{\mathfrak{L}}) = \frac{\sum_{j=1}^{n_j} W_{\mathfrak{L},j}\,\Delta q_{\mathfrak{L},j}}{\sum_{j=1}^{n_j} W_{\mathfrak{L},j}}, \qquad W_{\mathfrak{L},j} = \begin{cases} 1 & , \mathrm{W}^0 \\ q_{\mathfrak{L},j} & , \mathrm{W}^1 \\ (q_{\mathfrak{L},j})^2 & , \mathrm{W}^2 \end{cases}$$

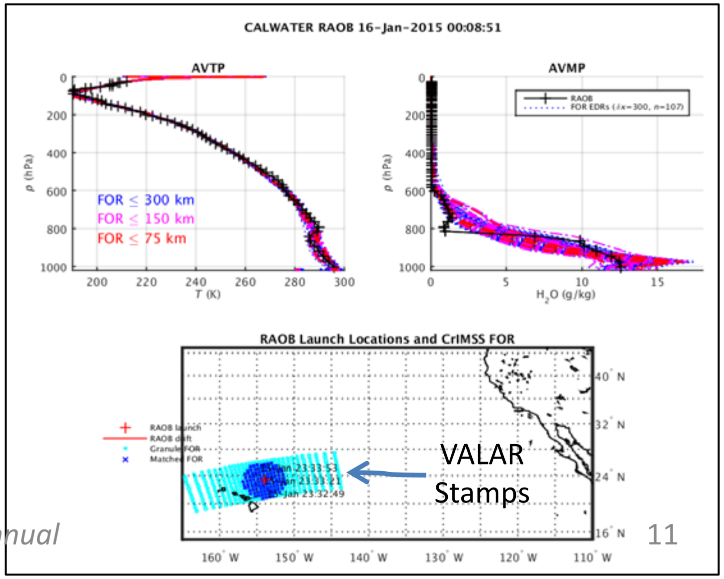
$$\mathrm{STD}(\Delta q_{\mathfrak{L}}) = \sqrt{[\mathrm{RMS}(\Delta q_{\mathfrak{L}})]^2 - [\mathrm{BIAS}(\Delta q_{\mathfrak{L}})]^2}$$

JPSS SNPP Validation Datasets and Tools

- **STAR Validation Archive (VALAR)** (*Nalli et al.*, 2014)
  - Low-level research data archive designed to meet needs of Cal/Val Plan
  - Dedicated/reference and intensive campaign RAOBs
  - SDR/TDR granule-based collocations ("stamps") within 500 km radius acquired off SCDR (past 90 days) or CLASS (older than 90 days)
  - Trace Gas EDR validation
  - Offline retrievals / retrospective reprocessing
  - MATLAB and IDL statistical codes and visualization software tools for monitoring
  - Rigorous coarse-layer (1-km, 2-km) product performance measures based on statistical metrics corresponding to Level 1 Requirements detailed in *Nalli et al.* (2013)

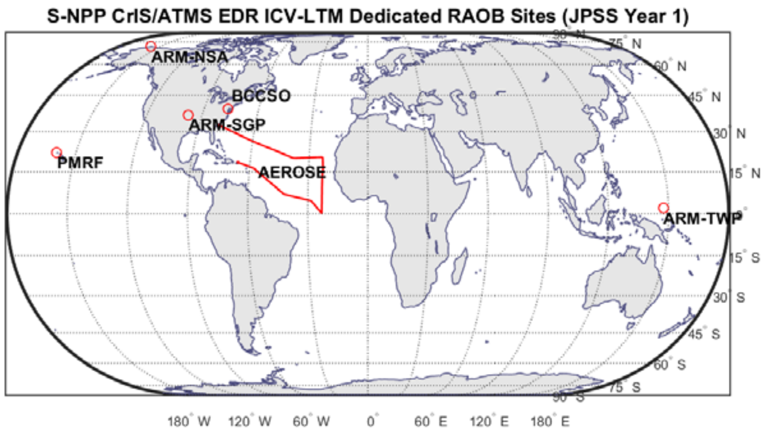
- **NOAA Products Validation System (NPROVS)** (*Reale et al.*, 2012)
  - Conventional RAOBs (NPROVS+ dedicated/reference), "single closest FOR" collocations
  - HDF5-formatted Collocation Files facilitates GRUAN RAOB matchups within VALAR
  - NRT monitoring capability
  - Satellite EDR intercomparison capability
  - Java based graphical user interface tools for monitoring
    - Profile Display (PDISP)
    - NPROVS Archive Summary (NARCS)

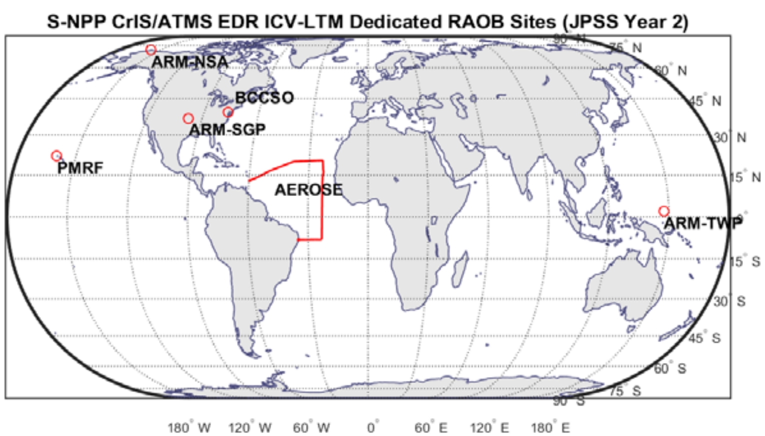




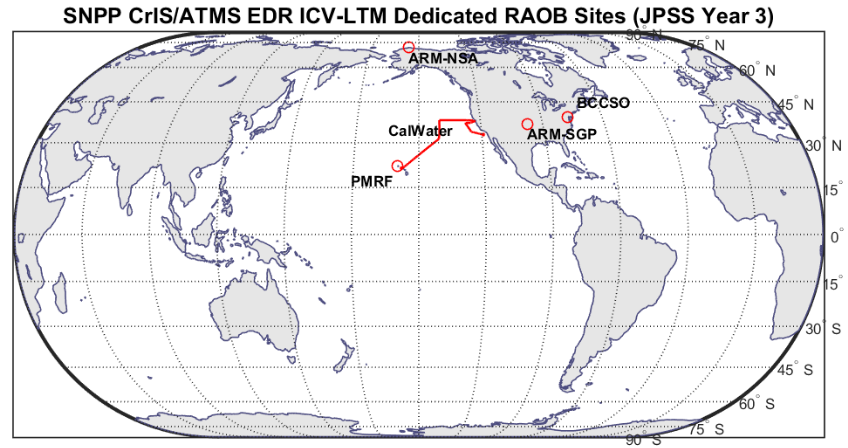
VALAR/NPROVS+ Dedicated and Reference RAOBs

JPSS SNPP Dedicated Years 1 and 2 (2012-2014)

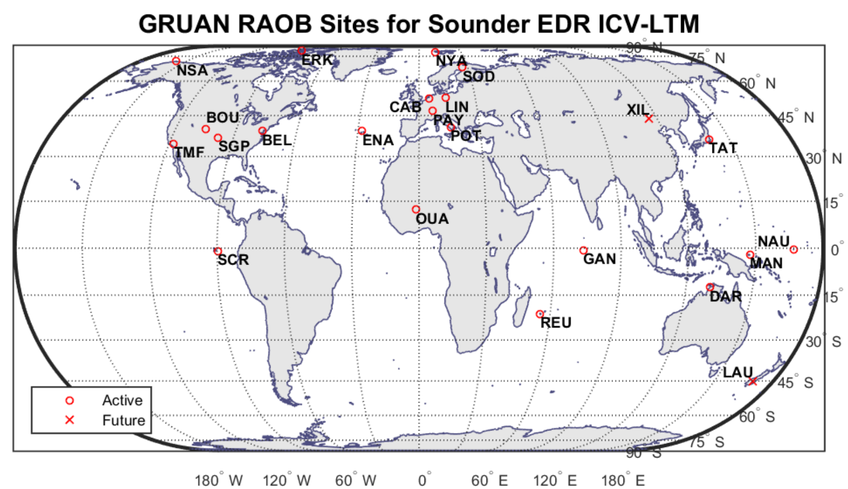




JPSS SNPP Dedicated Year 3 (2014-2015)



GRUAN Reference Sites

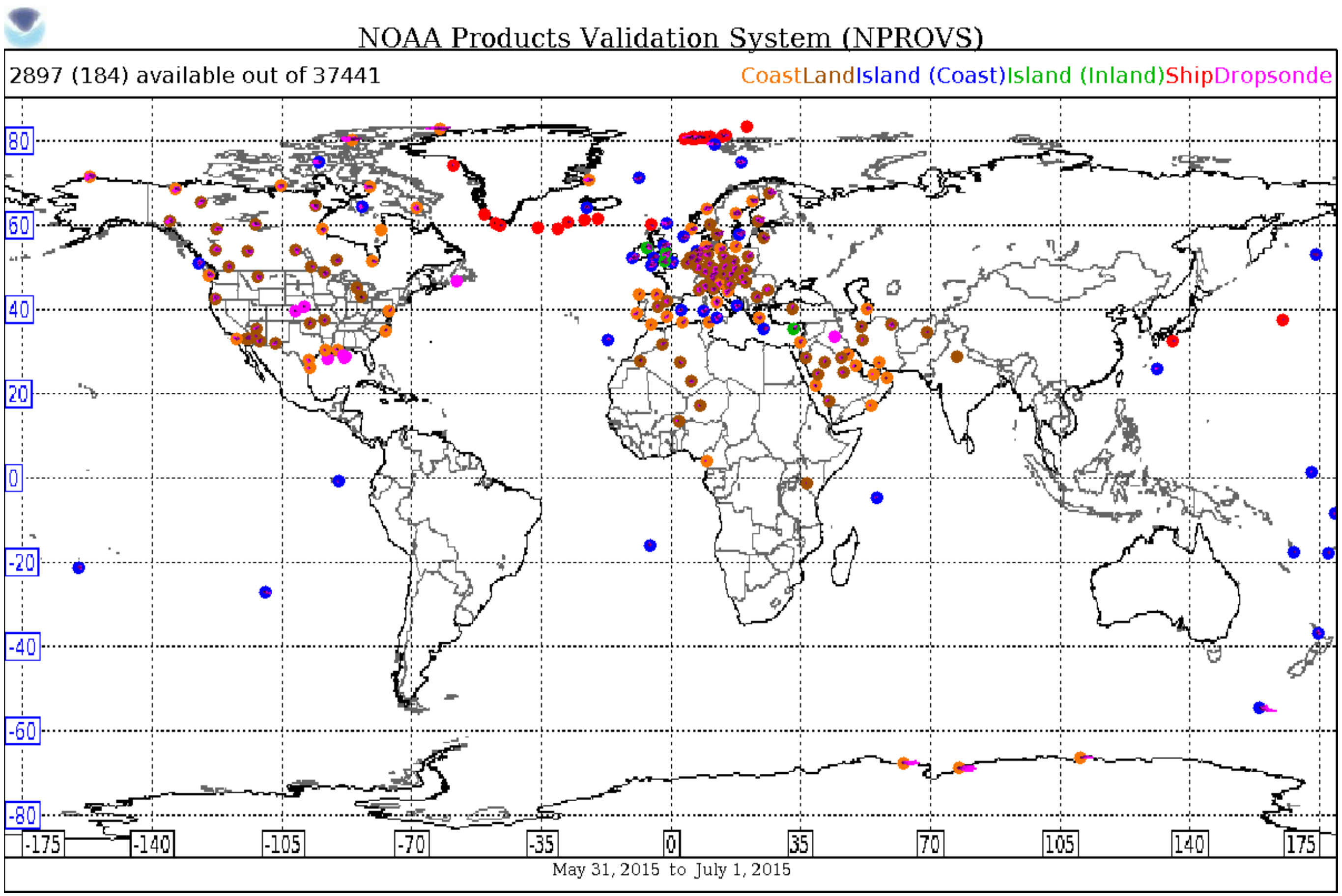


Validation of NOAA-Unique Operational Sounder EDR

NUCAPS EDR PRODUCT VALIDATION

NPROVS Conventional RAOB Collocations

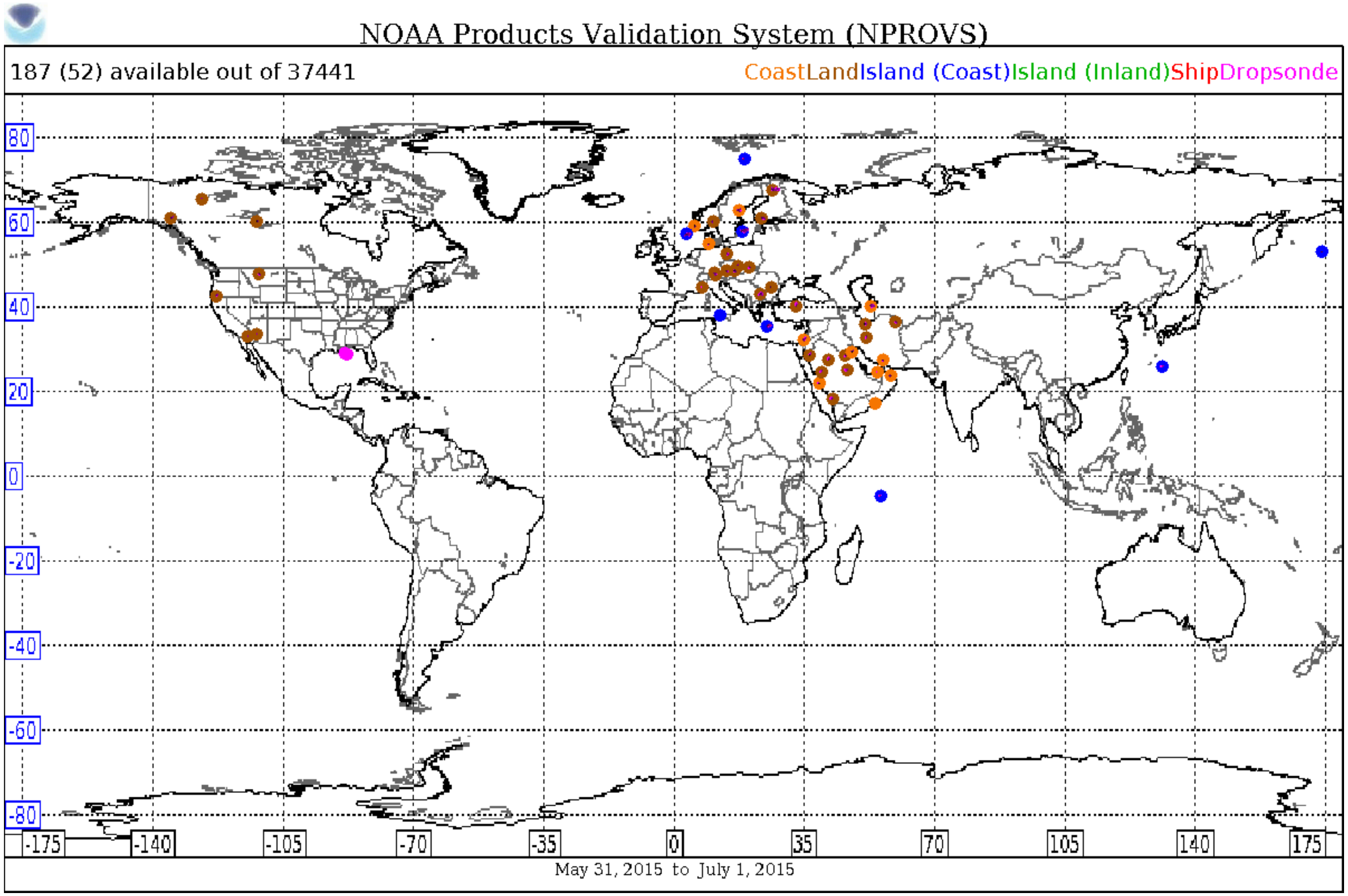
Single Closest FOR



- June 2015
- **RS92 and RS41 sondes**
- Single-closest FOR
- **Space-time window [1]**
  - **±3 h before/after overpass**
  - **75 km**
- **Sample size [1]** ***N*** **= 2897**

NPROVS Conventional RAOB Collocations

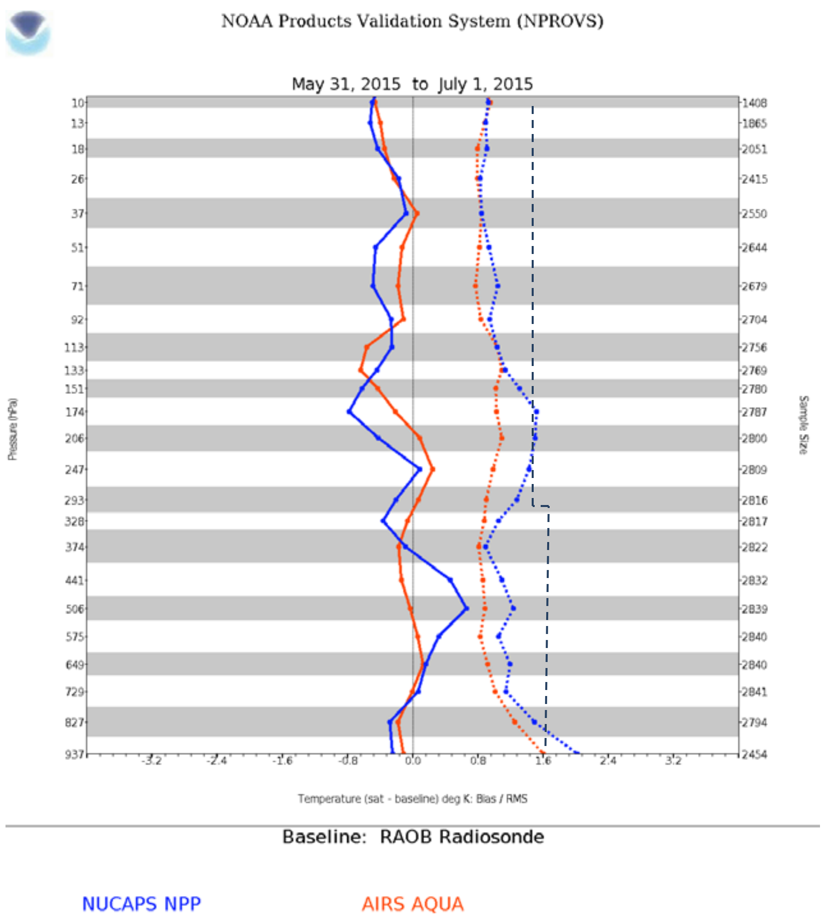
Single Closest FOR



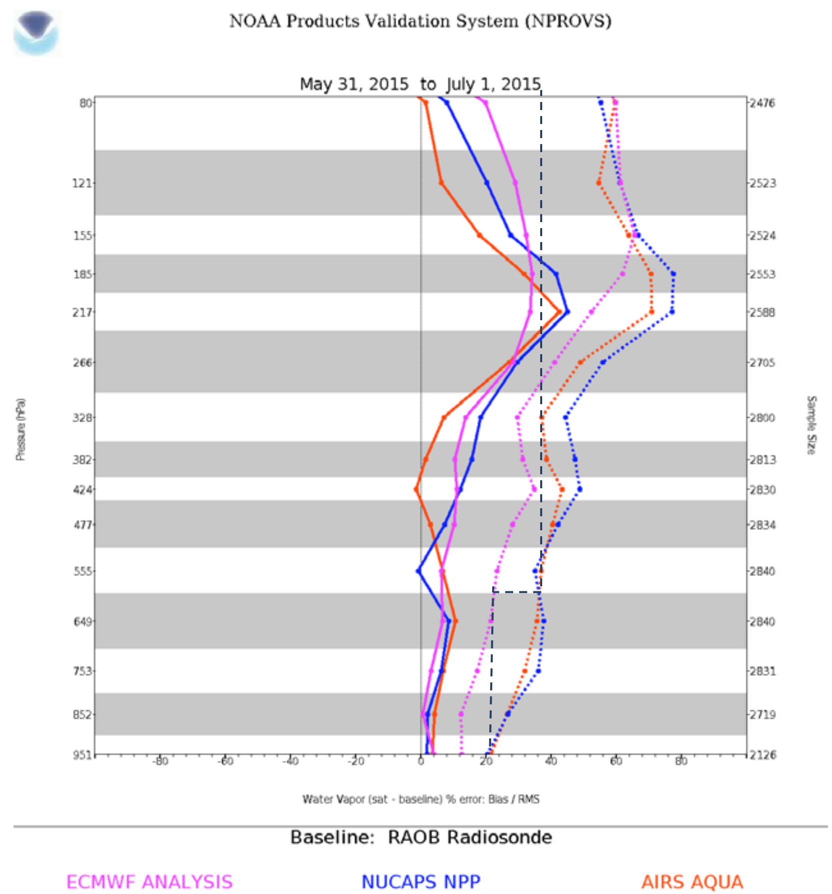
- June 2015
- **RS92 and RS41 sondes**
- Single-closest FOR
- **Space-time window [2]**
  - **−2 to +0.5 h before/after overpass**
  - **75 km**
- **Sample size [2] *N* = 187**

NUCAPS OPS-EDR and AIRS versus NPROVS Collocated Conventional RAOB: Sample [1]

AVTP (BIAS and RMS)

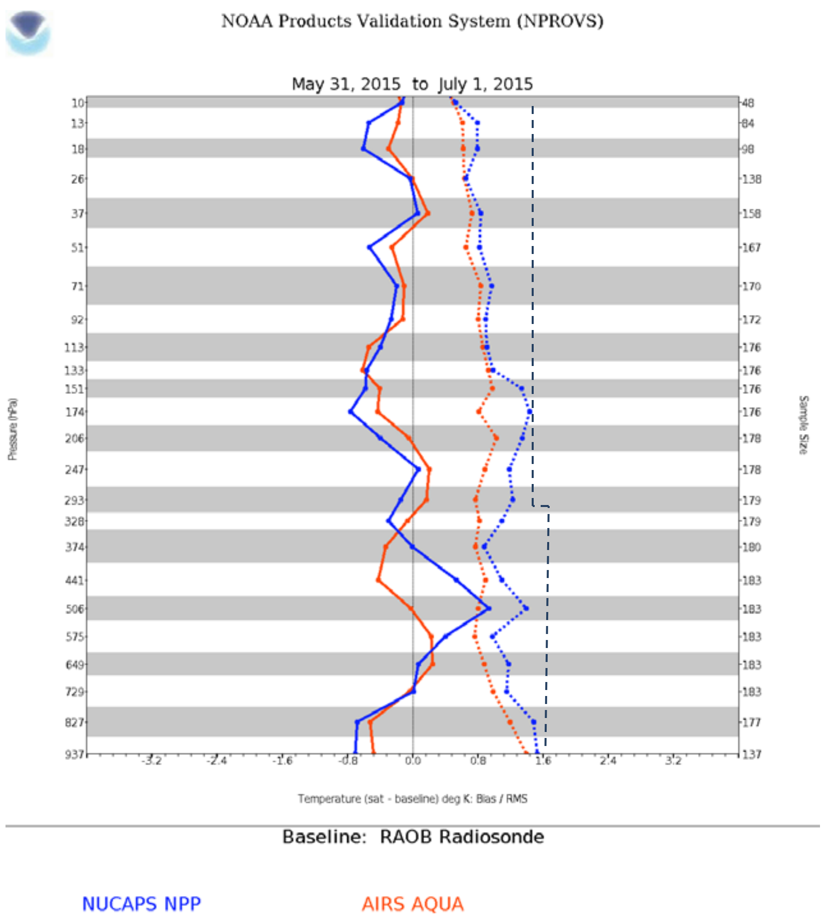


AVMP (BIAS and RMS)

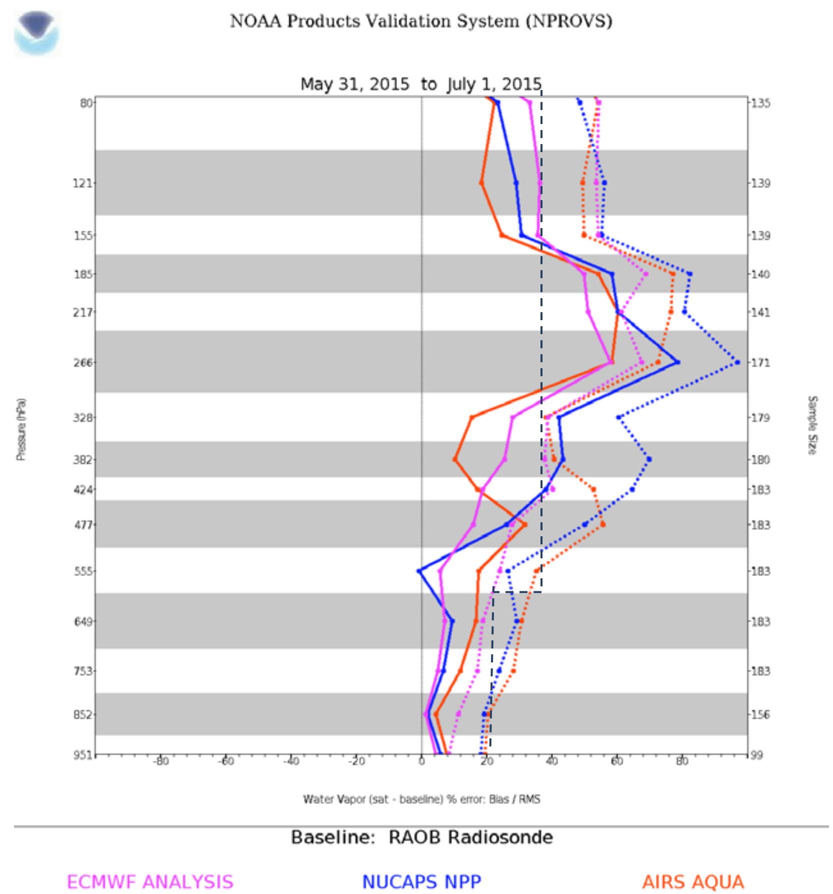


NUCAPS OPS-EDR and AIRS versus NPROVS Collocated Conventional RAOB: Sample [2]

AVTP (BIAS and RMS)

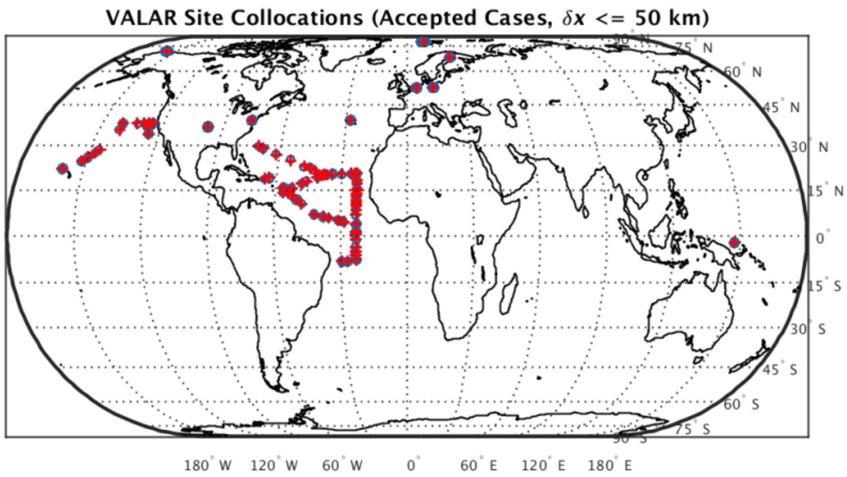


AVMP (BIAS and RMS)

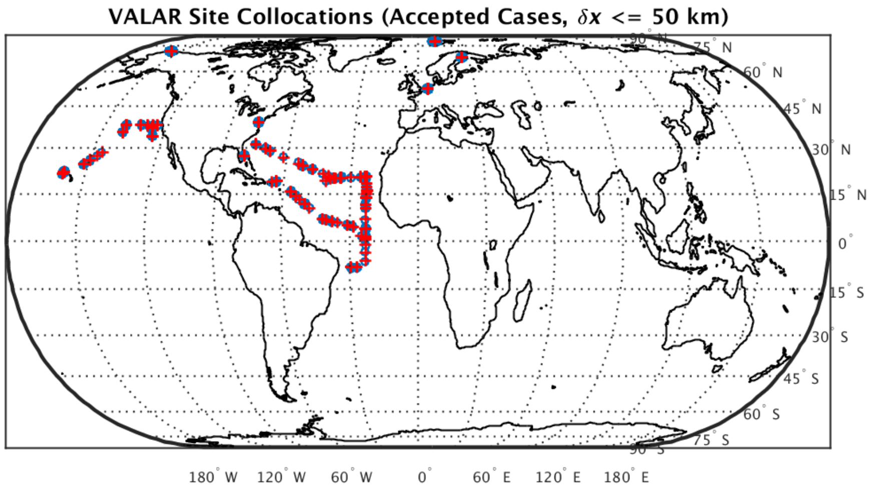


VALAR Dedicated/Reference RAOB Collocations
50 km radius

NUCAPS OPS-EDR Sample

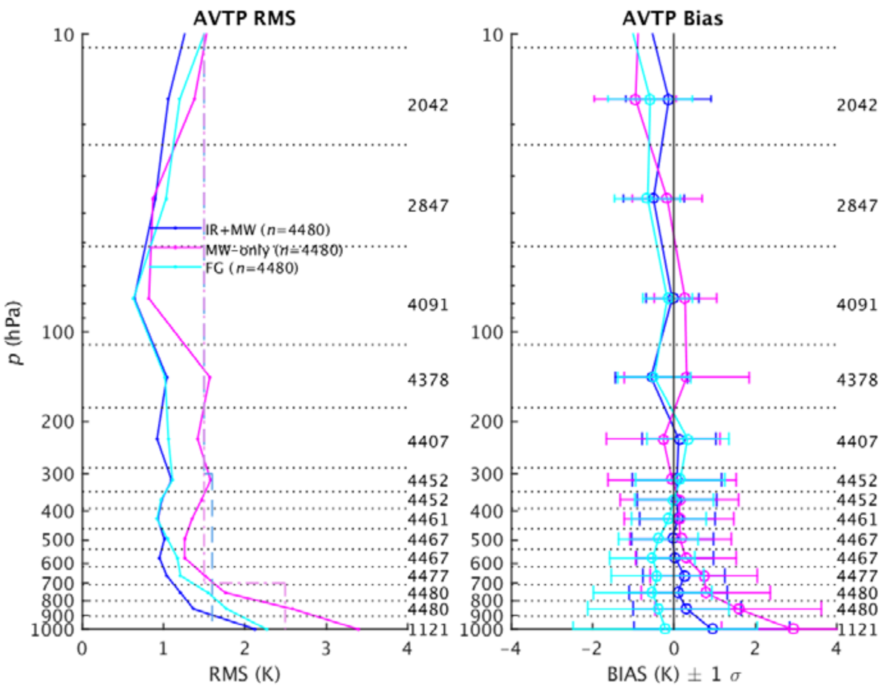


NUCAPS Offline (v1.5) Prelim Sample

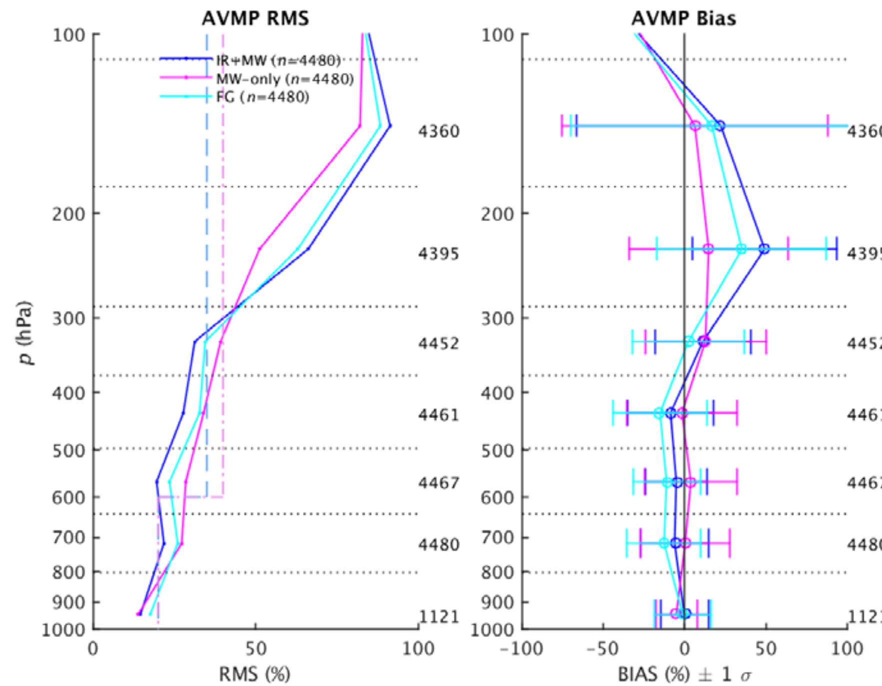


NUCAPS OPS-EDR
VALAR Dedicated/Reference RAOB Sample

AVTP

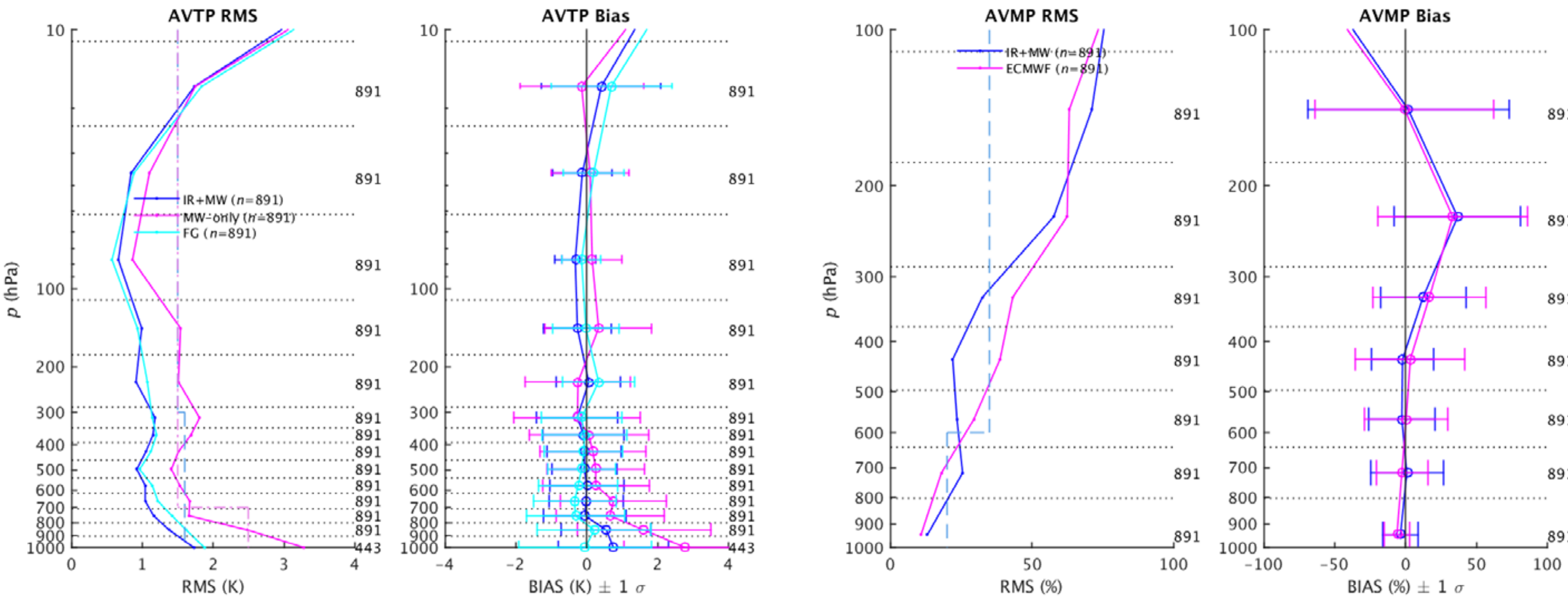


AVMP



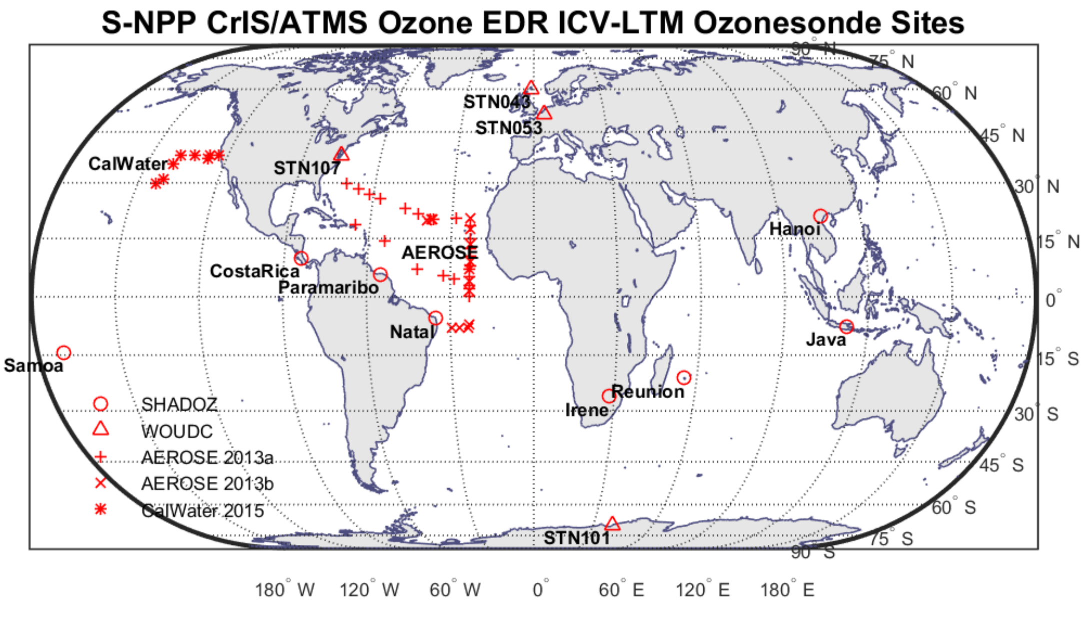
NUCAPS Offline (v1.5) EDR
VALAR Dedicated/Reference RAOB Prelim Sample

AVTP **AVMP**



NUCAPS Trace Gas Validation *In Situ* Truth Datasets

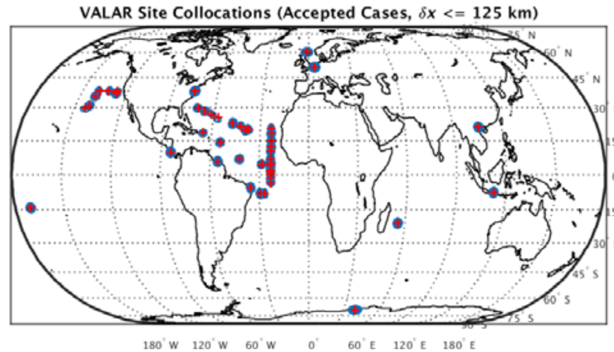
- **Collocated ozonesondes** for **O_3 (ozone) profile EDR**
  - **Dedicated Ozonesondes**
    - **NOAA AEROSE** (*Nalli et al.* 2011)
    - **CalWater/ACAPEX 2015**
  - **Sites of Opportunity**
    - **SHADOZ**
      - Costa Rica
      - Hanoi
      - Irene
      - Java
      - Natal
      - Paramaribo
      - Reunion
      - American Samoa
    - **WOUDC**
      - STN043
      - STN053
      - STN107
      - STN101
- Data suitable for carbon product CO, CO_2, CH_4 are currently being identified
  - MOZAIC aircraft (CO)
  - NOAA ESRL flask data (CO)
  - Satellite data (MLS, OCO-2, etc.)
  - Additional data currently being sought



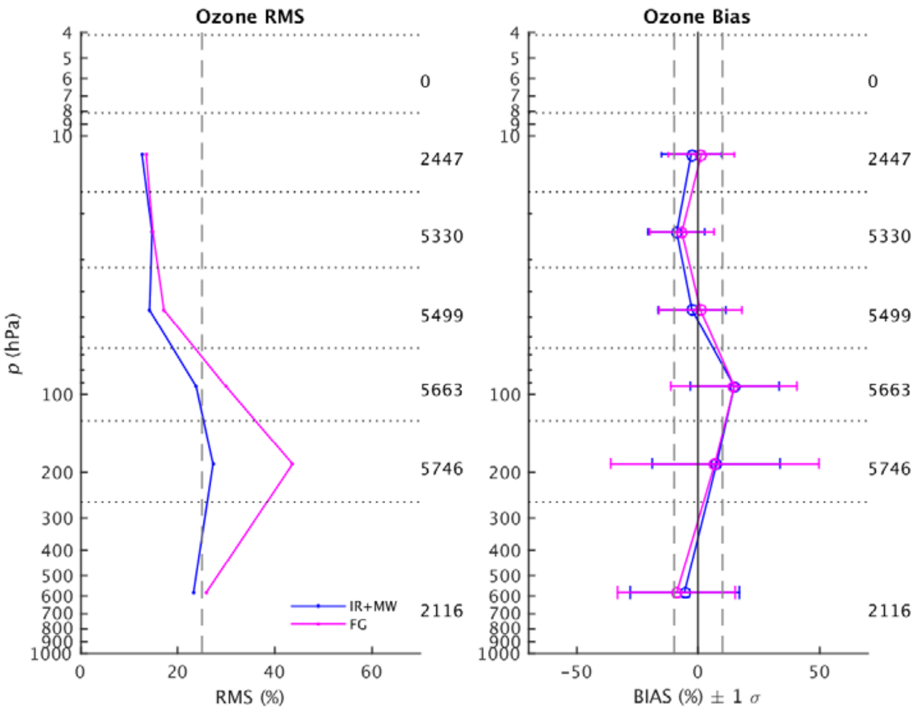
Stage-2 Ozone Profile Validation

NUCAPS Offline (v1.5) EDR versus Global Ozonesondes

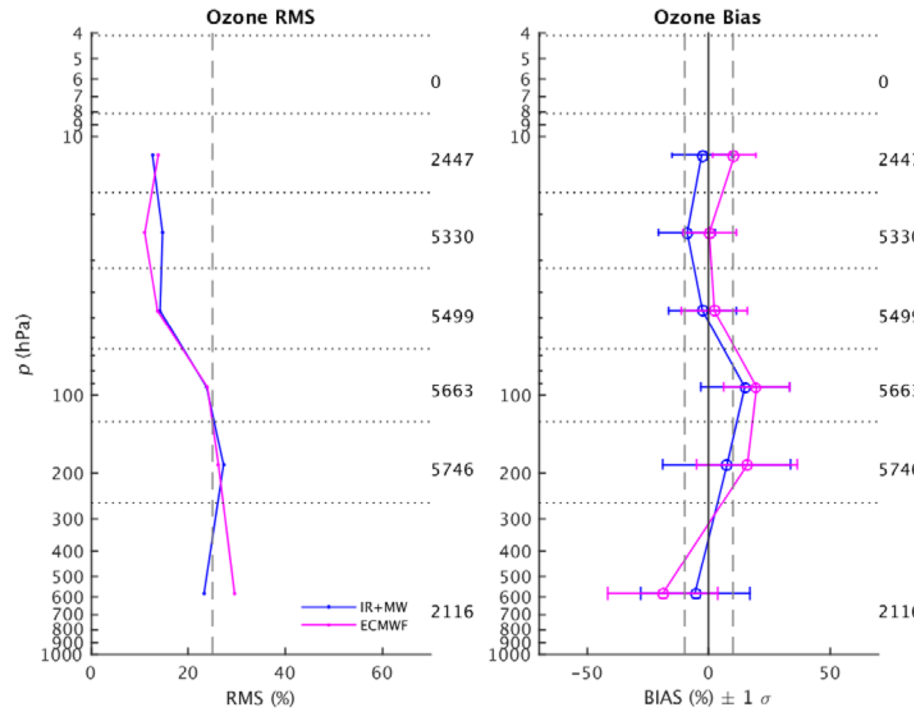
VALAR Dedicated, SHADOZ and WOUDC Ozonesonde Sample



Retrieval and ***A Priori* First Guess**

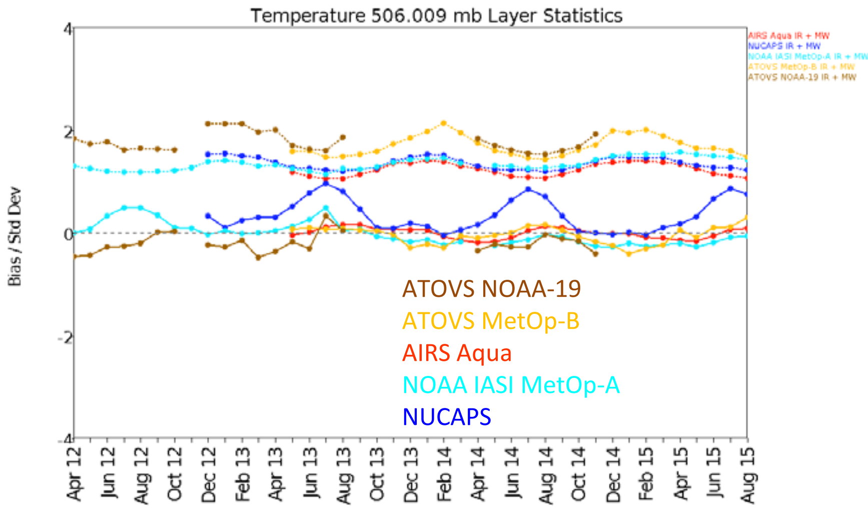


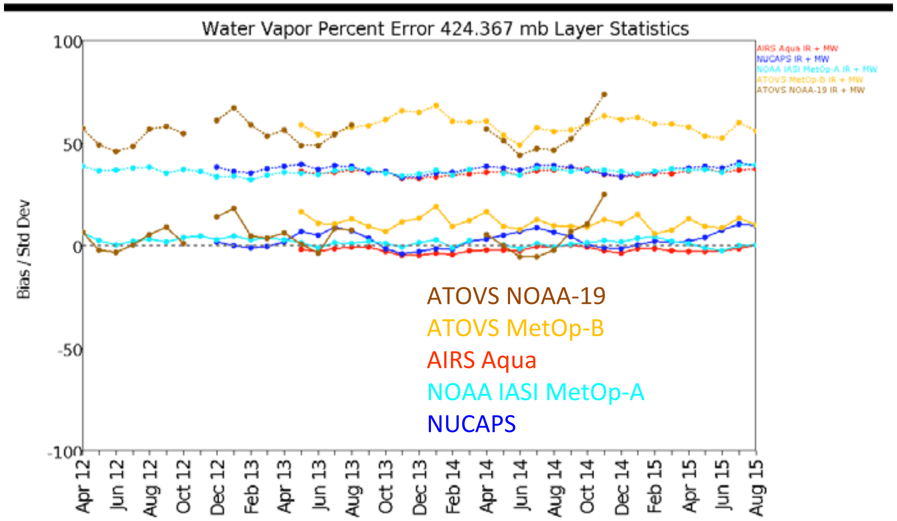
Retrieval and **ECMWF**



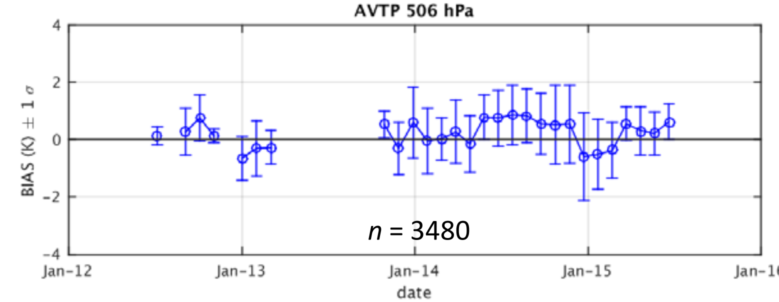
Long-Term Monitoring (LTM)

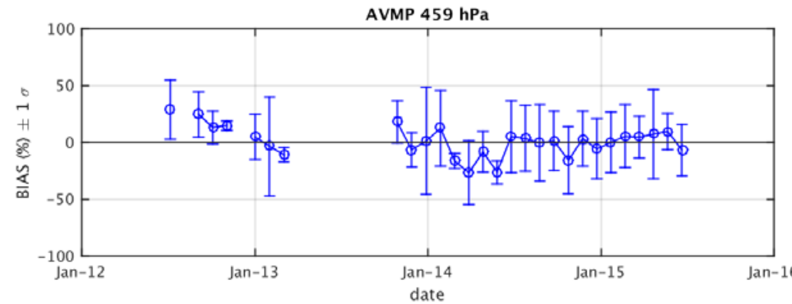
NPROVS NARCS Conventional RAOB Collocation (OPS-EDR)



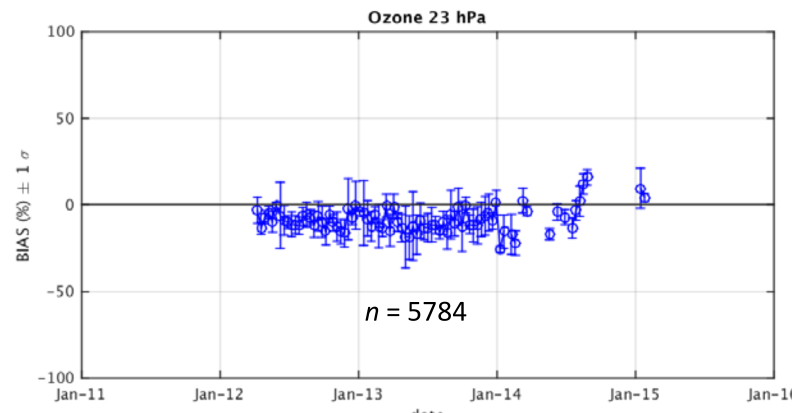


VALAR Dedicated/GRUAN Collocation (OPS-EDR)





VALAR Ozonesonde Collocation (Offline v1.5)



Future Work: SNPP ICV and LTM

- **NUCAPS Stages 2-3 Validated Maturities**
  - **AVTP/AVMP, Trace Gas validation** for operational and offline code versions
    - Global coarse-layer ensemble statistical analyses versus dedicated, reference and conventional RAOB truth
    - Geographic surface area weighting
    - **Apply averaging kernels** in NUCAPS error analyses, including ozone profile EDR
  - **VALAR expansion, development and enhancements**
    - Support **AEROSE-X campaign (Atlantic Ocean, Nov-Dec 2015)**
    - Continue support of ARM dedicated RAOBs (including dual-launches, “best estimates”)
    - Continue leveraging GRUAN reference RAOBs
    - Acquire carbon trace gas (CO, CO_2) truth datasets
    - **GRUAN reprocessing** of RS92 RAOB data (viz., entire AEROSE data record)
  - Support short- and long-term NUCAPS EDR algorithm development, updates, improvements

- **Other Related Work**
  - Collocation uncertainty estimates
  - calc – obs analyses (CRTM, LBLRTM, SARTA, etc.)
  - Support skin SST EDR validation
  - Support EDR applications (AWIPS, AR/SAL, atmospheric chemistry users)

EXTRA SLIDES

Assessment Methodology: Reducing Truth to Correlative Layers

- The **measurement equation** (e.g., *Taylor and Kuyatt,* 1994) for retrieval includes forward and inverse operators (*Rodgers*, 1990) to estimate the measurand, $\mathbf{x}$, on forward model layers:

$$\hat{\mathbf{x}} = I[F(\mathbf{x},\mathbf{b}),\mathbf{b},\mathbf{c}]$$

- **Rigorous validation** therefore requires high-resolution truth measurements (e.g., dedicated RAOB) be **reduced to correlative RTA layers** (*Nalli et al.,* 2013, *JGR Special Section on SNPP Cal/Val*)
- **Radiative transfer approach** is to integrate quantities over the atmospheric path (e.g., number densities → column abundances), interpolate to RTA (arbitrary) levels, then compute RTA layer quantities, e.g.,

$$\sum\nolimits_x(z) = \int_{z_t}^{z} N_x(z')\,dz'$$

NUCAPS Offline (v1.5) EDR
VALAR Merged Dedicated/Reference RAOB + ECMWF

AVTP **AVMP**

Evaluation of NUCAPS within high impact mesoscale events: overview of the CalWater 2015 field campaign.

Chris Barnet, Antonia Gambacorta, and Mitch Goldberg

STAR/JPSS Annual Meeting

Thursday, Aug. 26, 2015

Discussion Points

- A few additional comments about the NOAA-Unique CrIS/ATMS Processing System (NUCAPS)
- NOAA Sounding Initiative Activities
  1. CalWater 2 Campaign, Jan/Feb 2015
  2. Cold Air Aloft Initiative
  3. AWIPS-II Implementation and Training
  4. Hazardous Weather 2015 Spring Experiment
  5. Trace Gas Product Evaluation
- Future Plans

Availability of NUCAPS (with latency)

- Apr. 18, 2014 NUCAPS operational at OSPO
  - Via DDS subscription in near real time (≤ 3h)
  - Via CLASS interactive webpage (~ 6h)
  - Via CLASS ftp site (~48h)
- Sep. 2014 AWIPS-II implementation begins
  - NUCAPS T(p) and H_2O(p) products can be displayed as skew-T and manipulated (≤ 3h)
- Feb. 24, 2015 NUCAPS operational at CSPP direct broadcast stations
  - Much better latency (~30 minute)
  - CSPP = Community Satellite Processing Package
  - Support field campaigns and science evaluations
- Reprocessing of full mission CrIS+ATMS SDRs and NUCAPS at Univ. Wisconsin (JPSS funded)
  - V1.0 completed in Aug. 2015
  - V1.5 will be run in near future (Oct. timeframe) and available via CLASS

Why Study Retrievals?

- Data assimilation (DA) ingests many instruments
  - Microwave (*e.g.*, ATMS) is easier (more linear) to assimilate
  - Infrared (*e.g.*, CrIS) is under-utilized in all NWP models
    - Avoid clouds , so must sub-sample FOVs and channels
  - Therefore, CrIS/ATMS obs. are sparse and have low weight w.r.t. model
    - Assumes obs. will nudge model in the right direction over many cycles
- Retrievals operate on single satellite field of regard
  - Can afford to do detailed calculations
    - More channels, including trace gas state and covariance
    - off-diagonal covariance can be used
  - CrIS+ATMS can provide soundings in ~70% of scenes
    - Use of cloud clearing significantly increases the number of scenes and the number of channels used
    - Cloudy scenes are more likely to include interesting weather
  - Many lessons learned can be incorporated into global models
- But there are other applications where profiles have value.

NOAA/JPSS Application Team Initiatives for Sounding

- Sounding applications team
  - Primary goal is to promote new applications.
  - Secondary goal is to encourage interaction between developers and users to tailor NUCAPS to applications
- We currently have 5 active initiatives for sounding
  1. Hydrometeorology Testbed (HMT): Atmospheric Rivers
  2. Aviation Weather Testbed (AWT): Cold Air Aloft
  3. AWIPS-II NUCAPS and training module & improvements
  4. Hazardous Weather Testbed (HWT): Convective Initiation
  5. NUCAPS Trace Gas Product Evaluation

Initiative #1 / 5

Hydrometeorology Testbed: CalWater-2015

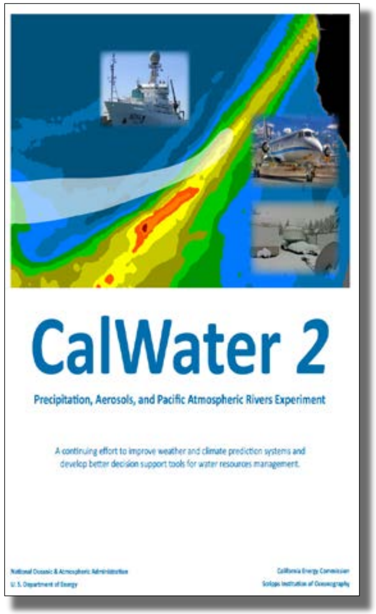
POCs: Chris Barnet (JPSS) & Ryan Spackman (NOAA/ESRL/PSD)

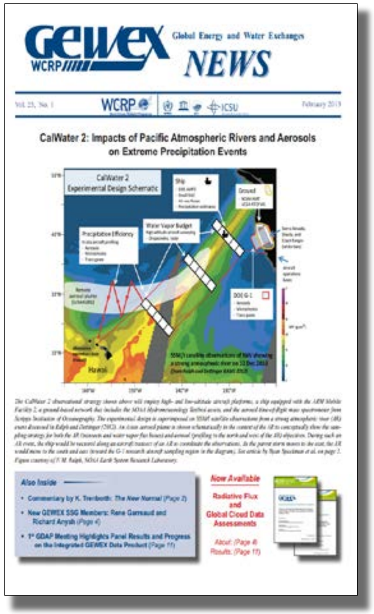
Hydrometeorology Testbed Initiative – CalWater-2015

Science focus of this campaign is to improve forecasting of Atmospheric Rivers (ARs)

- CalWater 2 white paper is at http://esrl.noaa.gov/psd/calwater
  PI is Marty Ralph, Scripps

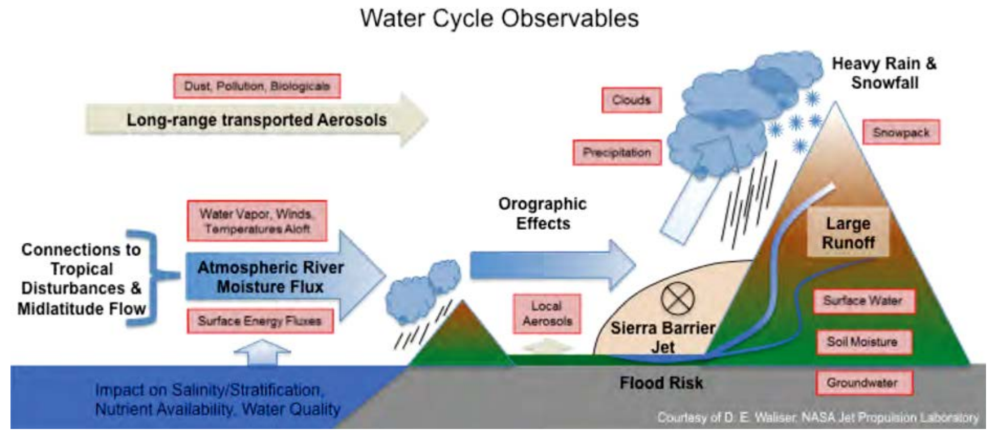
- Coordinated with DOE ACAPEX (ARM Cloud Aerosol Precipitation Experiment)
  PI is L. Ruby Leung, DOE





Understanding Atmospheric Rivers (ARs) has national and societal value

- ARs are narrow filaments of enhanced WV transport
  - responsible for ≈ 90% of mid-latitude transport (Zhu 1998 MWR)
  - 75% is below 2.25 km altitude



30-50% of annual precipitation on USA west coast is associated with ARs

- Typically within a few extreme precipitation events
  - Jan. 6-8, 2009 a strong event damaged the Hansen Dam (White 2012 BAMS)
  - Warm moist conditions in ARs can accelerate snowmelt
- Northwest USA snowfall tends to come in a few powerful winter ARs
  - Winter snowpack provides 70-90% of water supply for western USA
- AR events end ~40% of Northern California droughts (Dettinger 2013 J.Hydro.)
- Large ARs transport 13-26 km^3/day, ~7.5-15 times the average discharge of the Mississippi River (Ralph 2011 Eos)

CalWater-2015 was topic in recent JPSS focus article

- In JPSS Quarterly Newsletter (Issue 2, Apr-June 2015)
- On JPSS webpage:
  http://www.jpss.noaa.gov/media.html?story=news-61

NUCAPS sees domain of the entire field campaign (backup)

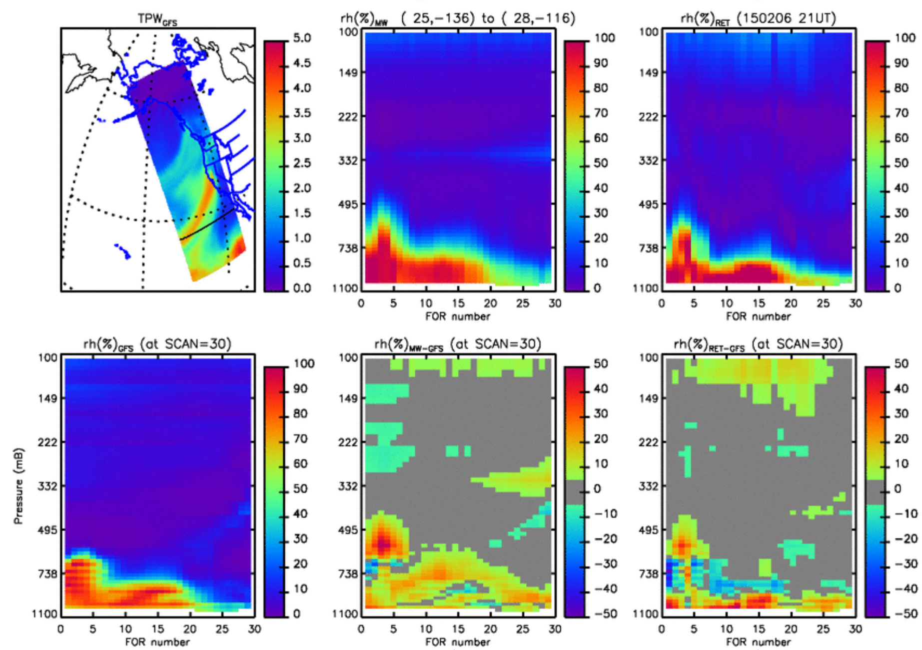
- NUCAPS 2200 km wide “scanset” is acquired in 8 seconds
- 30 retrievals with spatial resolution of ~50 km at nadir and ~70x134 km at edges of scan
- In many cases these retrievals reveal structures many hours in advance of a model analysis (i.e., CrIS/ATMS have not been ingested)
- Differences shown at in lower panels could be due to retrieval errors or GFS errors

NUCAPS Microwave RH Retrieval cross section along scanset shown as black-line in top left figure. Insensitive to non-precipitating clouds

NUCAPS Microwave + Infrared RH retrieval along same scanset. More sensitive to clouds but higher vertical resolution

GFS TPW
Feb. 6, 2015

GFS RH cross section (along scanset indicated on top left



NUCAPS Microwave retrieval – GFS

NUCAPS Microwave + Infrared retrieval – GFS

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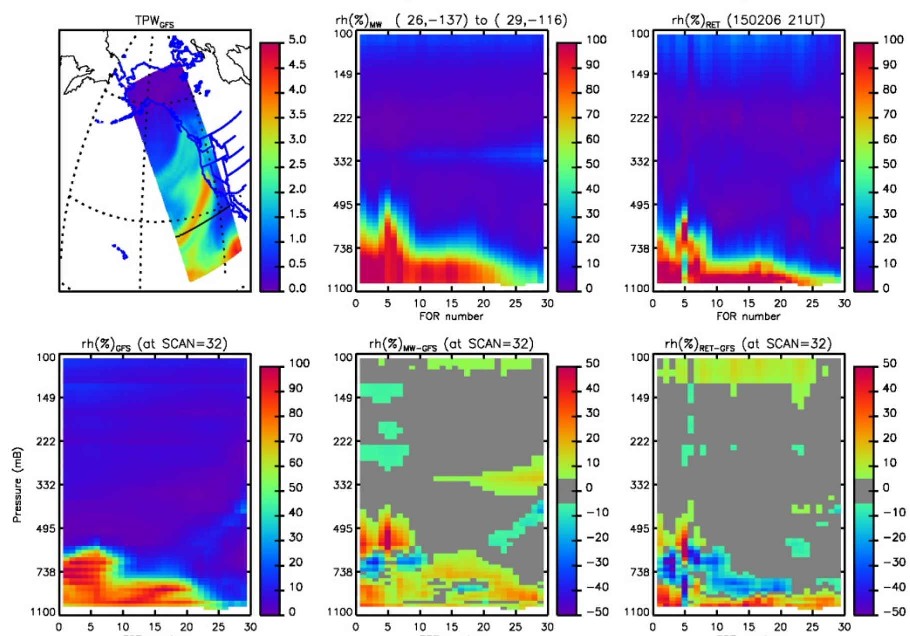


NUCAPS Microwave retrieval – GFS

NUCAPS Microwave + Infrared retrieval – GFS

CalWater-2015 time line

- Campaign began Jan. 12
- Jan. 12 to Feb. 12 we used Corvallis Oregon DB data
  - Processing with NUCAPS science code
  - Provided forecasters the Pacific west coast overpass (10:00 UT ≅ 2 am PST = 5 am EST) in real time
    - Considered in 7 am PST flight planning meeting
  - Provided 22:00 UT (14:00 PST = 5 pm EST) overpass while field campaign aircraft were in the air
- Feb. 14, 2015 we used Univ. of Hawaii DB data
  - Field campaign is winding down
    - G-IV ferried to Hawaii
    - R.H. Brown departed 2/13
    - NOAA P-3 departed 2/15
  - Provided forecasters the Hawaii overpass in real time (24 UT) while G-IV was in the air.

What JPSS program gained from CalWater 2015

NOAA • NESDIS JPSS Joint Polar Satellite System

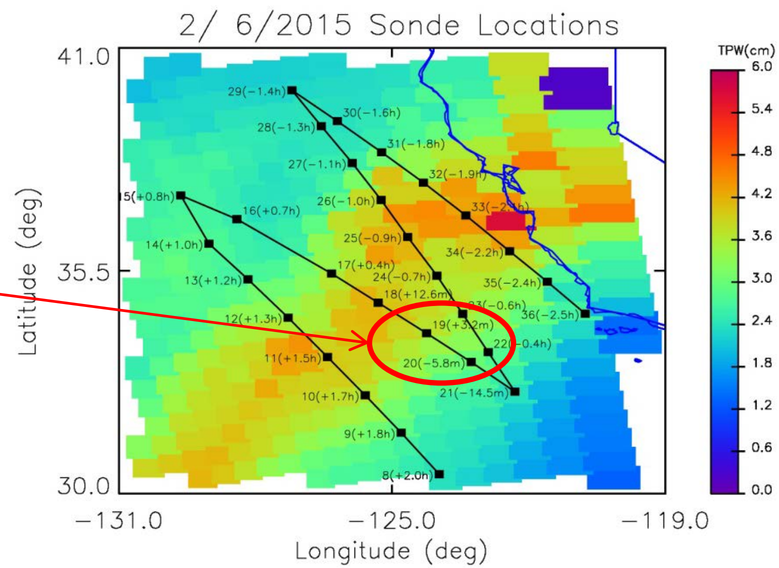
- CalWater-2015 was an opportunity for NUCAPS product validation
  - Over 435 dropsondes were acquired
  - Test NUCAPS in extreme weather that is of national and societal interest
- As algorithm developers, we need these kinds of scenes to improve the retrieval skill and tailor the quality control.
  - Can test experimental versions of NUCAPS
  - Gain the expertise of the entire CalWater science team to characterize the underlying science and meteorology.
  - Other *in-situ* measurements (CO, O_3, CO_2, aerosols) will help the NPP validation,
  - Demonstrate the value and shortcomings of NUCAPS in the field

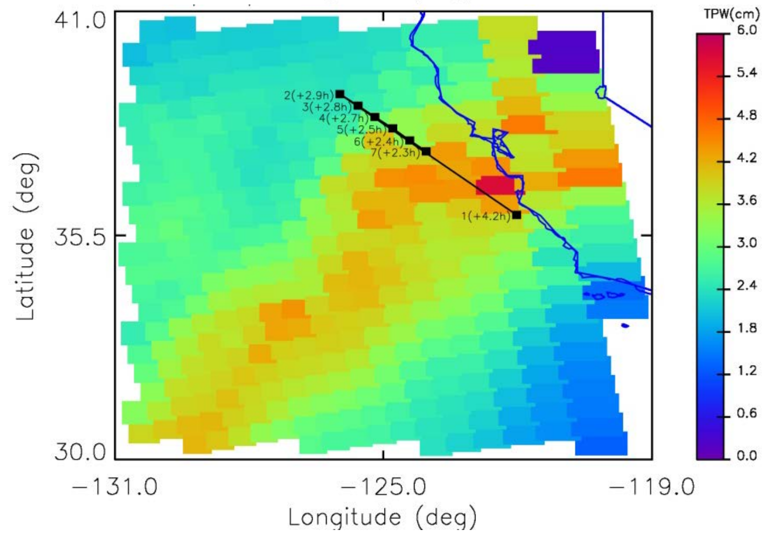
Date	G-IV	P-3
1/15	25	
1/17	29	
1/22	13	
1/24	23	
1/27		22
1/31		24
2/5	35	
2/6	30	7
2/7		9
2/8	32	
2/9		16
2/14	41	
2/19	37	
2/20	35	
2/22	30	
2/24	35	
total	365	78

Example of Feb. 6 dropsondes

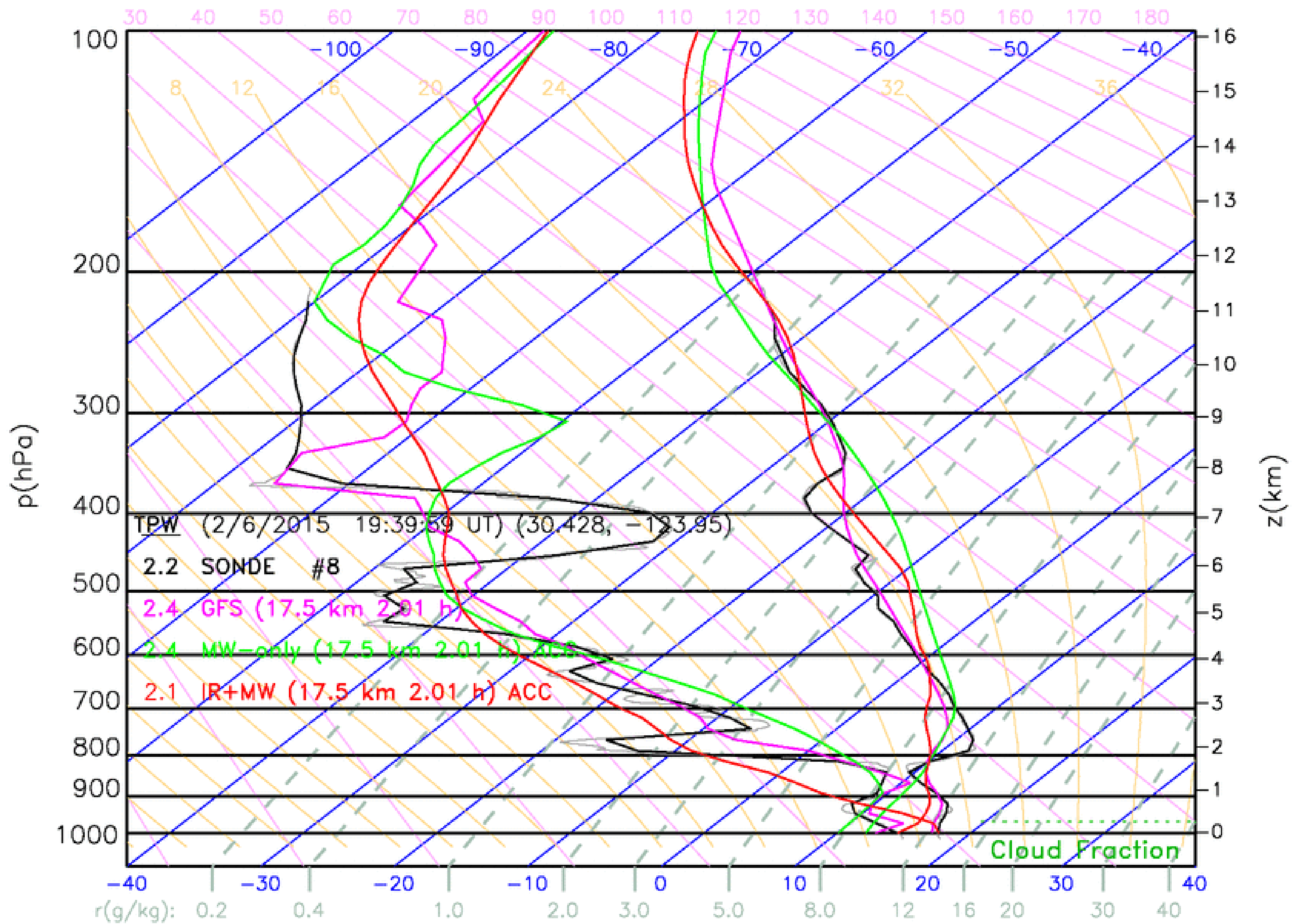
- NOAA G-IV did a saw-tooth pattern across the AR
  - NPP Overpass occurred between sondes #19 and #20
  - Capture pre-AR, AR, and post-AR regimes on 4 crossings
  - Pre-AR is relatively warm and dry
  - AR is wet, cloudy, warm, and most likely raining
  - Post-AR is wet and cooler

- NOAA P-3 was flying at 800 mb
  - Sampling same region as G-IV
  - ~4 hours later





wide range of pre-AR, AR, and post-AR conditions

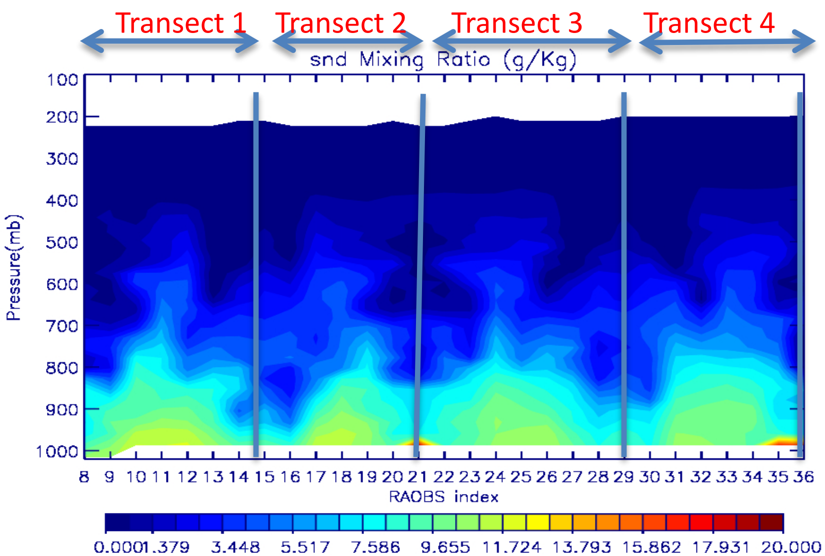


Pre-AR:
#8, 9, 20, 21, 22

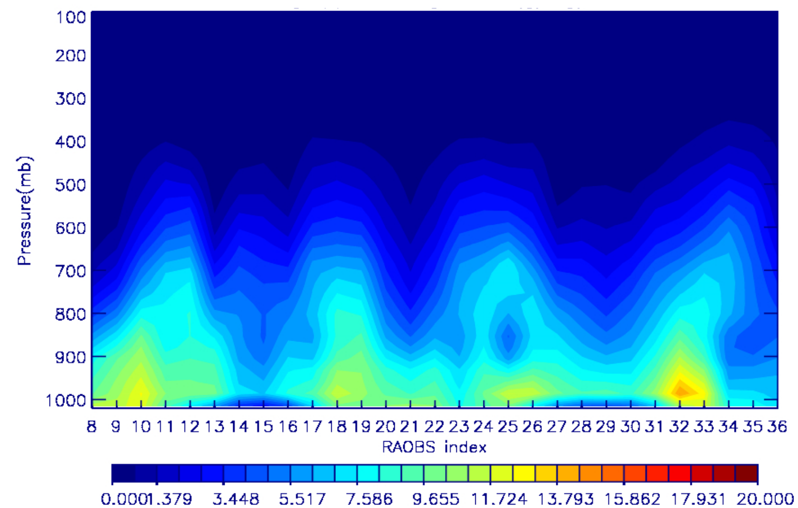
AR:
#10, 19

Post-AR:
#13, 27,28,29,30

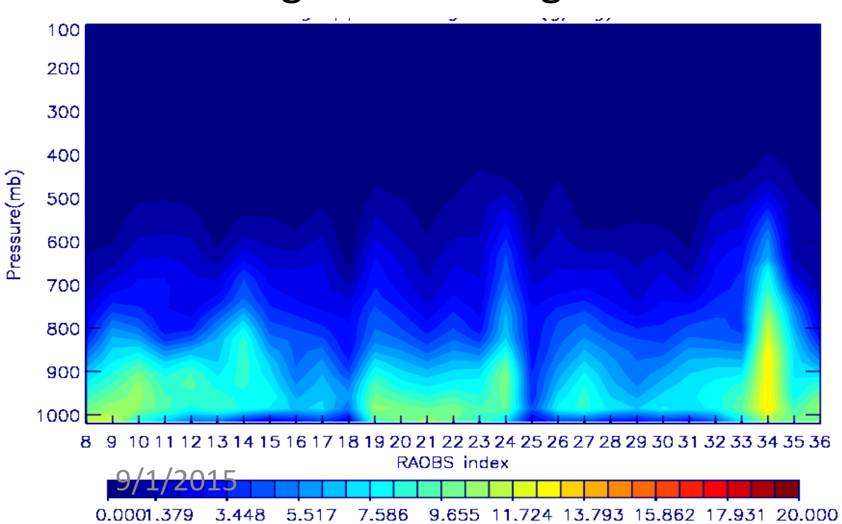
Dropsonde and retrieval cross section along flight



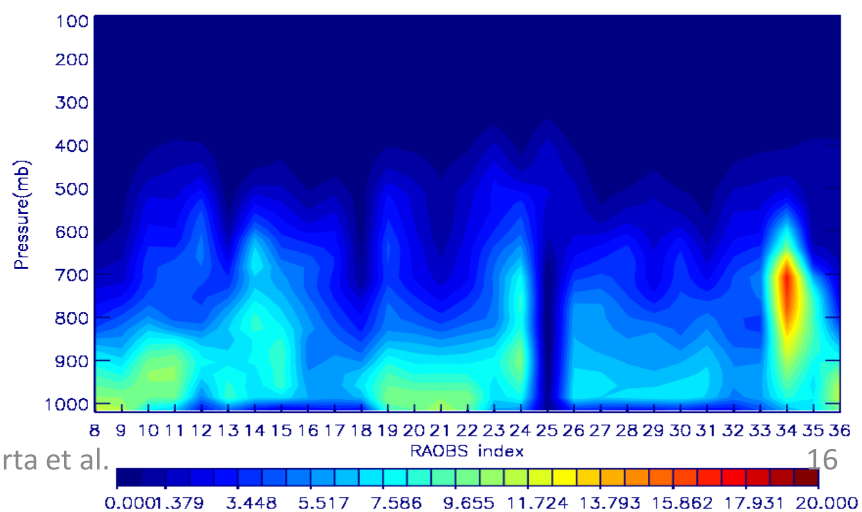
Micro-wave only



Regression first guess



MW+IR retrieval



Summary of CalWater-2015

- We demonstrated the value of NUCAPS soundings in defining crucial moisture structure (position, water vapor content, amplitude) in the vicinity of sparsely sampled but high impact mesoscale events.
  - Low latency (direct broadcast) access is valuable for field campaign logistical support and understanding context of *in-situ* data
  - Synergistic validation yields a large sample of *in-situ* data (~150 RS-92 radiosonde and ~450 dropsondes from CalWater-2015 alone) in regimes that are traditionally difficult to validate
- Ongoing and future work:
  - We are using these dropsondes to improve performance (better radiance bias tuning, first guess, etc.)
    - Retrieval can be re-run with proposed changes and compared to original retrieval and in-situ data before promoting to operations
  - Will publish an analysis of NUCAPS capabilities in AR environments

Initiative #2 / 5

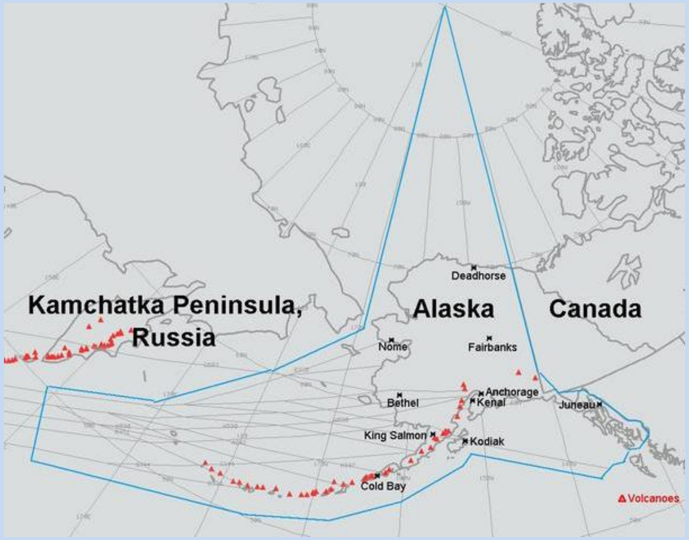
Aviation Weather Testbed:
Cold Air Aloft

POC: Brad Zavodsky (NASA/SPoRT), Kristine Nelson (NWS/AR/ARS/CWSU/ANCHORAGE AK)

Aviation Weather Testbed
Cold Air Aloft

In Alaska, forecasters must rely on analysis and model fields and limited radiosonde observations (~4/day) to determine the 3D extent of the cold air aloft

- Airline fuel begins to freeze below -65 degC, need to issue pilot advisories
- Forecasters need to know spatial and vertical location of “bubble” of cold air aloft



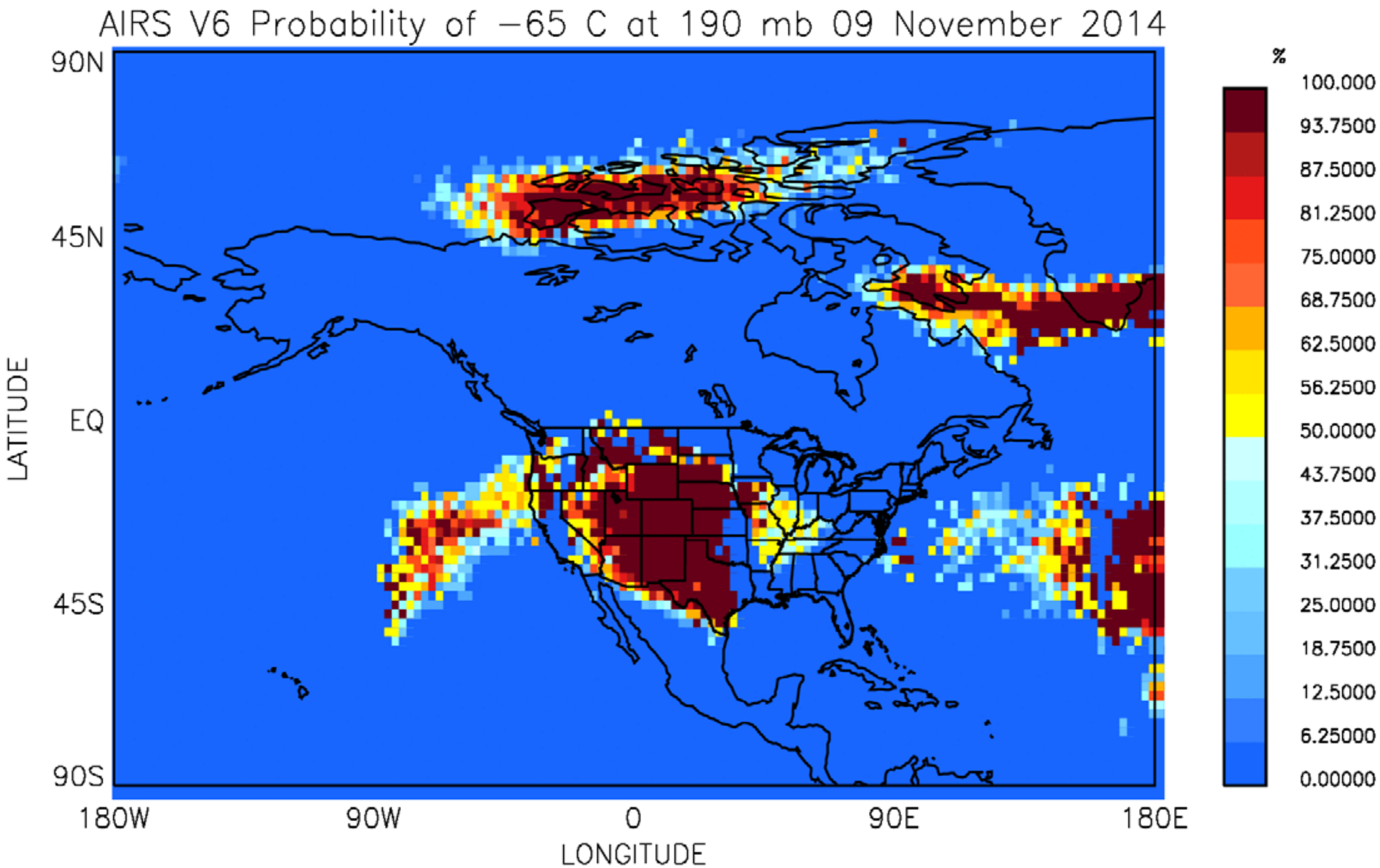
- Anchorage Flight Information Area (FIR) encompasses 2.4 square million miles
- Anchorage Airport was ranked 3rd worldwide for throughput cargo (90% of China to USA) and 1st in the USA for cargo poundage (5.9 Billion lbs)

Daily Cold Air Loft frequency of occurrence at 190 mbar

Used AIRS Level.2 Support Product

Counted occurrences of T(190mb) ≤ -65 degC in a 1x1 deg grid

Anchorage Center Weather Service Unit (CWSU) issues warnings on Nov. 11th to 14th



Analysis and graphics by C. Francoeur, STC

Daily Cold Air Loft frequency of occurrence (backup)

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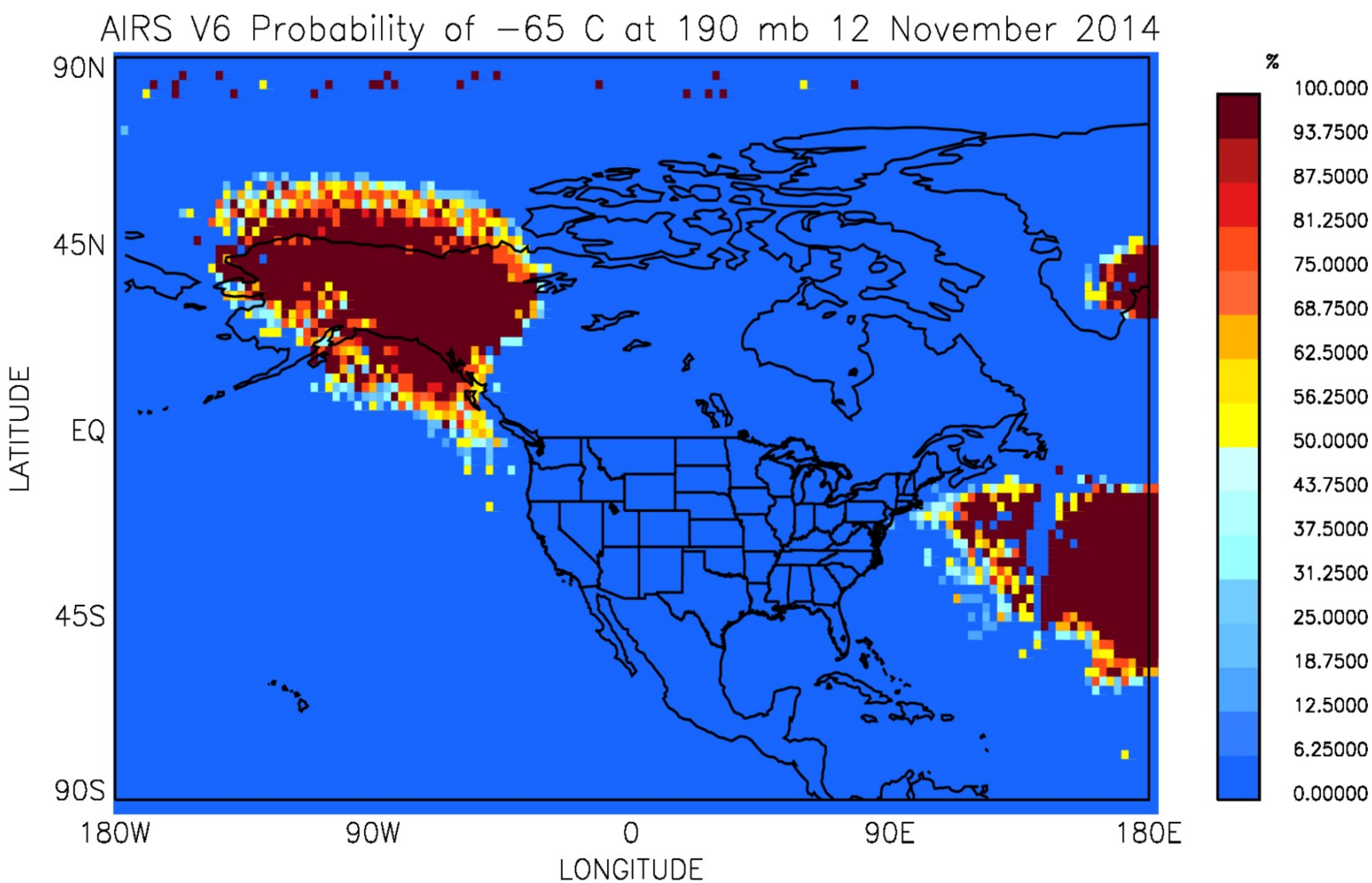


Analysis and graphics by C. Francoeur, STC

Summary of Aviation Weather initiative

- CrIS/ATMS easily sees the cold air aloft in our cross-sections and skew-T plots
  - Product has +/- 4 K differences f/GFS and is smoother
    - Vertical location is different
  - Goal is to work with Alaska AWT/CWSU to develop better visualization of cold air aloft and to evaluate Suomi-NPP soundings in this context.
- GFS ingests CrIS and ATMS, is it good enough?
  - At 200 mbar many CrIS channels are used
  - Real time NUCAPS (8, 9.5, 11 and 20, 21.5, 23 Z) adds information between the model analysis times (0, 6, 12, 18Z) and gives forecaster more confidence

Initiative # 3 / 5

AWIPS-II NUCAPS training module & AWIPS improvements

POCs: Brian Motta (NWS), Scott Lindstrom (CIMSS)

AWIPS-NUCAPS training module and improvements

- Articulate Presenter modules are available at:
  - V1: https://www.youtube.com/watch?v=91ORWNreXLI
  - V2: https://www.youtube.com/watch?v=U-w6EBnOzb0
- NUCAPS was installed without QC
  - QC exists in NUCAPS file ingested by AWIPS
  - DR submitted to fix the problem
- Recent upgrades to AWIPS-II causes NUCAPS data to be deleted
  - WFO installed patch until problem can be fixed
- Improved Visualization
  - Plan View displays

Initiative #4 / 5

Hazardous Weather Testbed: 2015 Spring Experiment

Will be discussed in next 2 presentations by the POCs: Bill Line (OU/CIMMS & NOAA/NWS/SPC) and Dan Nietfeld (SOO at Omaha WFO)

Initiative #5 / 5

NUCAPS Trace Gas Product Evaluation

POCs: Greg Frost (NOAA/ESRL/GSD), Brad Pierce (NOAA/STAR)

NUCAPS Trace Gas Product Evaluation

- This initiative is based on two recent JPSS funded proposals.
  1. Greg Frost: “Understanding emissions and tropospheric chemistry using NUCAPS and VIIRS”
  2. Brad Pierce: “High Resolution Trajectory-Based Smoke Forecasts using VIIRS Aerosol Optical Depth and NUCAPS Carbon Monoxide Retrievals “
- Using modeling and in-situ aircraft observations
  – Models are used to interpolate the sparse field observations to the satellite temporal, spatial, and vertical sampling characteristics

NUCAPS Trace Gas Product Evaluation

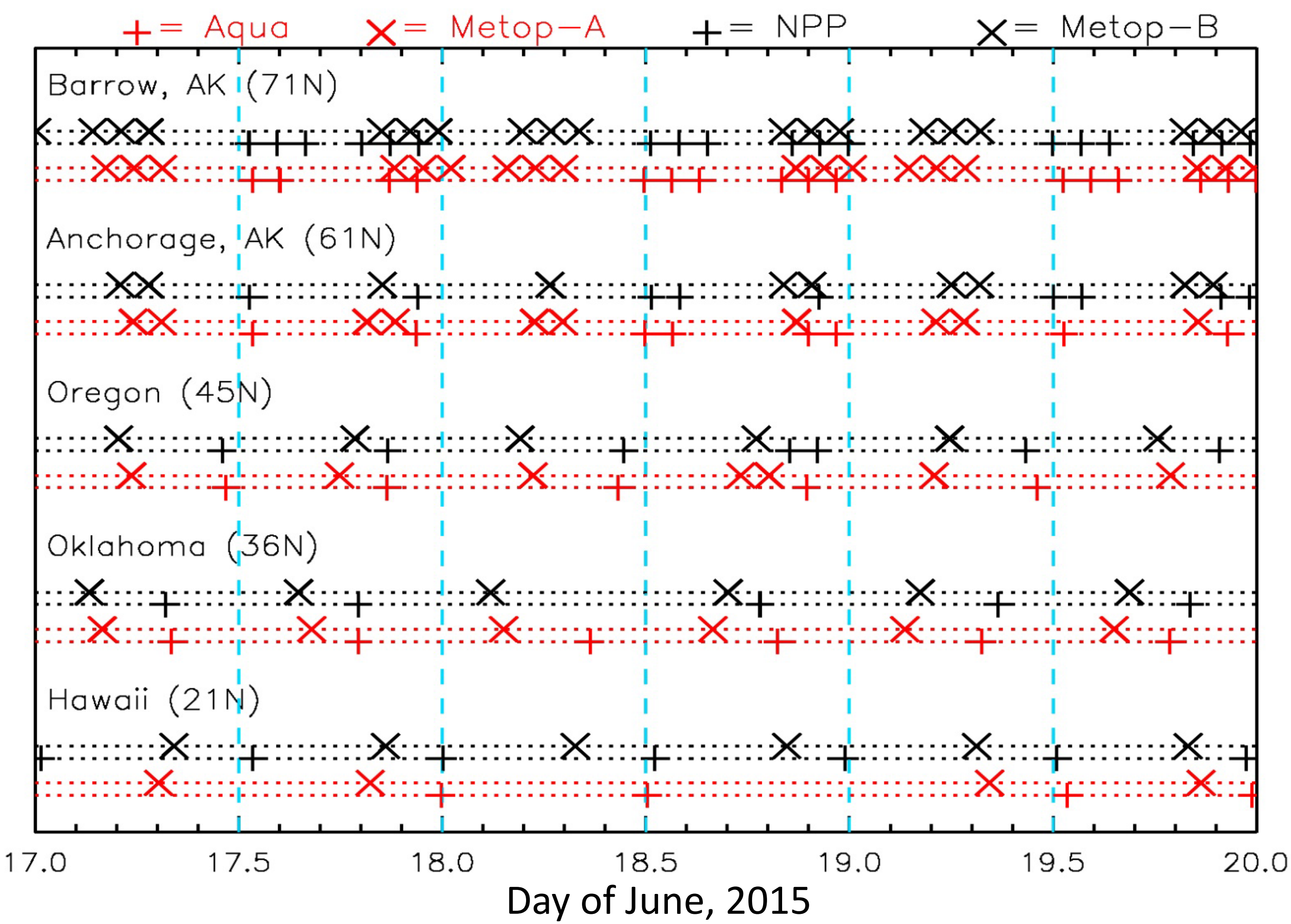
- We selected two field campaigns for initial study
  - Senex: http://www.esrl.noaa.gov/csd/projects/senex
    - Senex ≡ Southeast Nexus, Summer 2013, SE USA
    - Look at methane emissions associated with fires.
  - Songex: http://esrl.noaa.gov/csd/projects/songnex/
    - Songex ≡ Shale Oil and Natural Gas Nexus, Spring 2014, Western USA
    - Will begin with NUCAPS Carbon Monoxide product
      - Requires full spectral resolution CrIS data
      - Will use experimental version of NUCAPS
    - Also look at methane emissions from oil and gas

Future Plans for NUCAPS
and
The Path Forward

Future Plans
The way forward

- Improve AWIPS implementation
  - Better training
  - Automate profile modification (funded, Dan Lindsey)
  - Spatial and/or cross-section visualization
- Metop-A & B retrievals into AWIPS-II
  - Same as NUCAPS, but 4 hours earlier
  - NOAA/STAR can provide file now.
  - Need user request to make it happen within AWIPS.
- Metop-A & B retrievals into CSPP direct broadcast
  - In work, should be operational in early 2016

Constellation of satellites allows more observations between 0Z & 12Z RAOBS



NPP/J-1 will be phased similar to Metop-A/B approx. 6 months after launch of J-1

If we included NOAA AMSU/HIRS there would be even more soundings

These are overpasses with satellite elevation > 32 deg (all FOR's)

Also looking for ways to take lessons learned back to NWS

- Much of the NUCAPS retrieval skill comes from use of cloud cleared radiances
  - Jun Li (CIMSS) is doing a study of using NUCAPS cloud cleared radiances within a NWP regional model
    - WRF model
    - focused on H. Sandy (2012) and Typhoon Haiyan (2013)
- Emily Berndt (SPoRT) will investigate the use of NUCAPS T(p), q(p), and O3(p) to study extratropical transition of hurricanes
  - create an enhanced stratospheric depth product
  - conduct a product demonstration and assessment with the NHC, WPC, OPC forecasters

QUESTIONS?

Acronyms

- AIRS = Atmospheric Infrared Sounder
- AMSU = Advanced Microwave Sounding Unit
- AR = Atmospheric River
- ATMS = Advanced Technology Microwave Sounder
- AVHRR = Advanced Very High Resolution Radiometer
- AWIPS = Advanced Weather Interactive Processing System
- AWT = Aviation Weather Testbed
- CrIS = Cross-track Infrared Sounder
- CIMMS = Cooperative Institute for Mesoscale Meteorological Studies
- CIMSS = Cooperative Institute for Meteorological Satellite Studies
- CSPP = (CIMSS) Community Satellite Processing Package
- CWA = (NWS) County Warning Area
- CWSU = (FAA) Center Weather Service Unit
- EUMETSAT = EUropean organization for exploitation of METeorological SATellites
- FOV/FOR = Field Of View/Regard
- GFS = (NCEP) Global Forecast System
- GSFC = (NASA) Goddard Space Flight Center
- HMT = Hydrometeorology Testbed
- HSB = Humidity Sounder Brazil
- HWT = Hazardous Weather Testbed
- IASI = Infrared Atmospheric Sounding Interferometer
- JPSS = Joint Polar Satellite System
- METOP = METeorological Observing Platform
- MHS = Microwave Humidity Sensor
- MODIS = MODerate resolution Imaging Spectroradiometer
- NASA = National Aeronautics and Space Administration
- NCEP = National Centers for Environmental Prediction
- NESDIS = National Environmental Satellite, Data, and Information Service
- NHC = (NCEP) National Hurricane Center
- NOAA = National Oceanographic and Atmospheric Administration
- NPP = National Polar-orbiting Partnership
- NWP = Numerical Weather Prediction
- NWS = National Weather Service
- NUCAPS = NOAA Unique CrIS/ATMS Processing System
- OPC = (NCEP) Ocean Prediction Center
- OSPO = (NESDIS) Office of Satellite and Product Operations
- SPC = (NCEP) Storm Prediction Center
- SPoRT = (NASA) Short-term Prediction and Research Transition Center
- STAR = (NESDIS) SaTellite Applications and Research
- STC = Science and Technology Corporation
- UMBC = University of Maryland, Baltimore County
- VIIRS = Visible Infrared Imaging Radiometer Suite
- WFO = (NWS) Weather Forecast Office
- WPC = (NCEP) Weather Prediction Center

Summary of products from NUCAPS (and AWIPS-II)

gas	Precision	d.o.f.	Interfering Parameters	Sensitivity
Temperature Profile, T(p), SST, LST	1.5K/km	6-10	Emissivity, H_2O, O3, N2O	surface to ~1 mb
Water Profile, H_2O(p)	15%	4-6	CH4, HNO3	surface to ~300 mb
Cloud Top Pressure Cloud fraction	25 mbar, 1.5K, 5%	2 18	CO2, H2O	surface to tropopause
Ozone, O_3	10%	1+	H2O, emissivity	Lower stratosphere
Carbon Monoxide, CO	15%	≈ 1	H_2O, N2O	Mid-troposphere
Methane, CH_4	1.5%	≈ 1	H2O, HNO3, N2O	Mid-troposphere
Carbon Dioxide, CO_2	0.5%	≈ 1	H2O, O3, T(p)	Mid-troposphere
Sulfur Dioxide, SO_2	≈ 50%	< 1	H2O, HNO3	Volcanic flag
Nitric Acid, HNO_3	≈ 50%	< 1	emissivity H2O, CH4, N2O	Upper troposphere
Nitrous Oxide, N_2O	≈ 5%	< 1	H2O, CO	Mid-troposphere

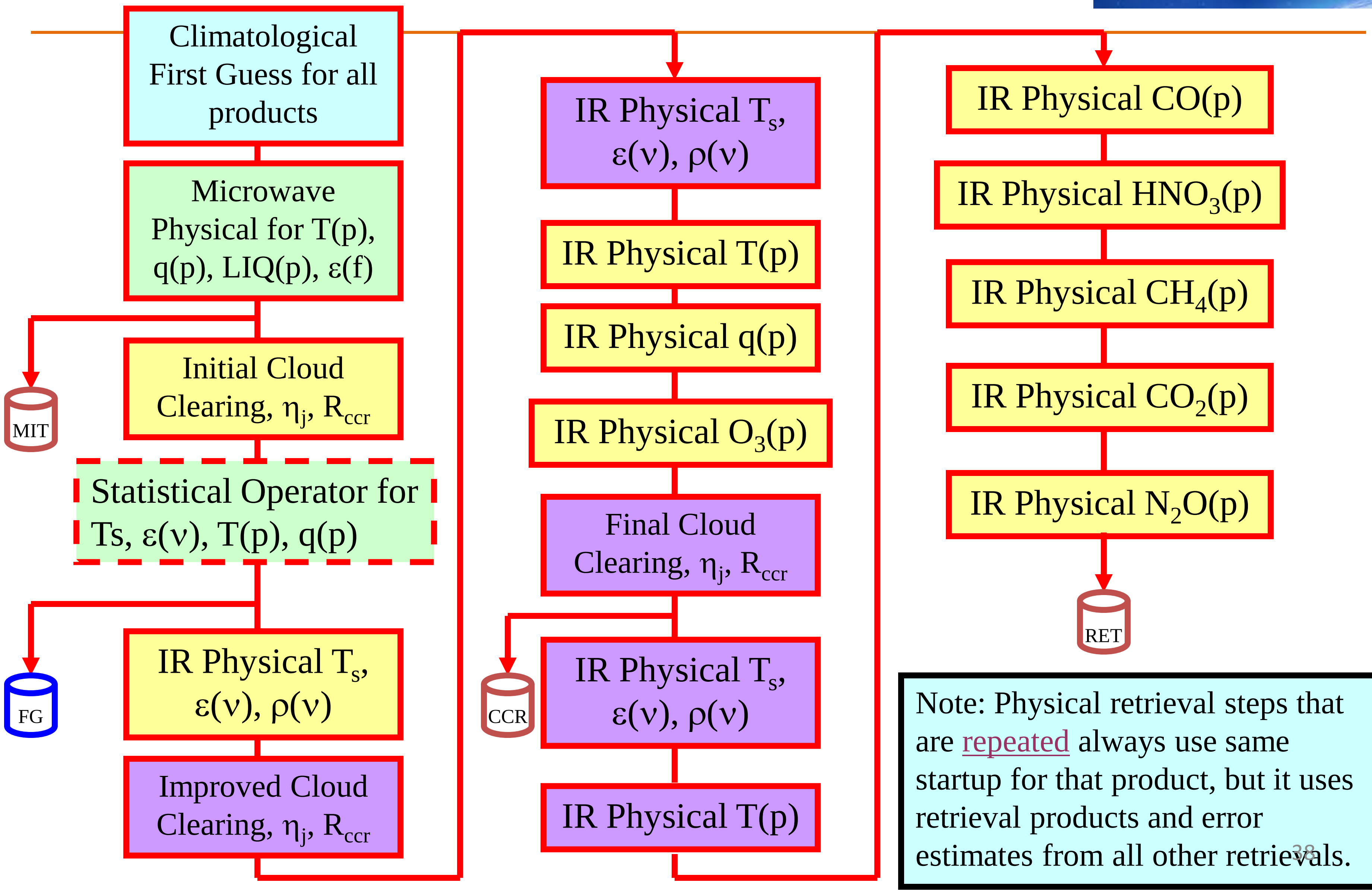
NUCAPS Retrieval File Variables for AWIPS

Variable	Type	Dim	Description	Units
Dice	Long	120	Field of Regard (FOR) number 1-120	NA
Time	Doub	120	UTC Milliseconds since Jan 1, 1970	Millisec
Latitude	Float	120	Latitude of the center of the FOR	Degrees
Longitude	Float	120	Longitude of the center of the FOR	Degrees
View_Angle	Float	120	Instrument view angle	Degrees
Ascend/Descend	Short	120	Ascending /Descending flag (0=Descending, 1=Ascending) for ea FOV	NA
Topography	Float	120	Surface elevation in meters above sea level	m
Surface_Pressure	Float	120	Surface pressure	mb
Skin_Temperature	Float	120	Skin temperature from the final retrieval step	K
Quality_Flag	Long	120	Quality flag for the retrieval (0=good, non zero = bad)	NA
Pressure	Float	120,100	Pressure at each of the 100 retrieval levels	mb
Effective_Pressure	Float	120,100	Effective pressure	mb
Temperature	Float	120,100	Temperature from the final retrieval	K

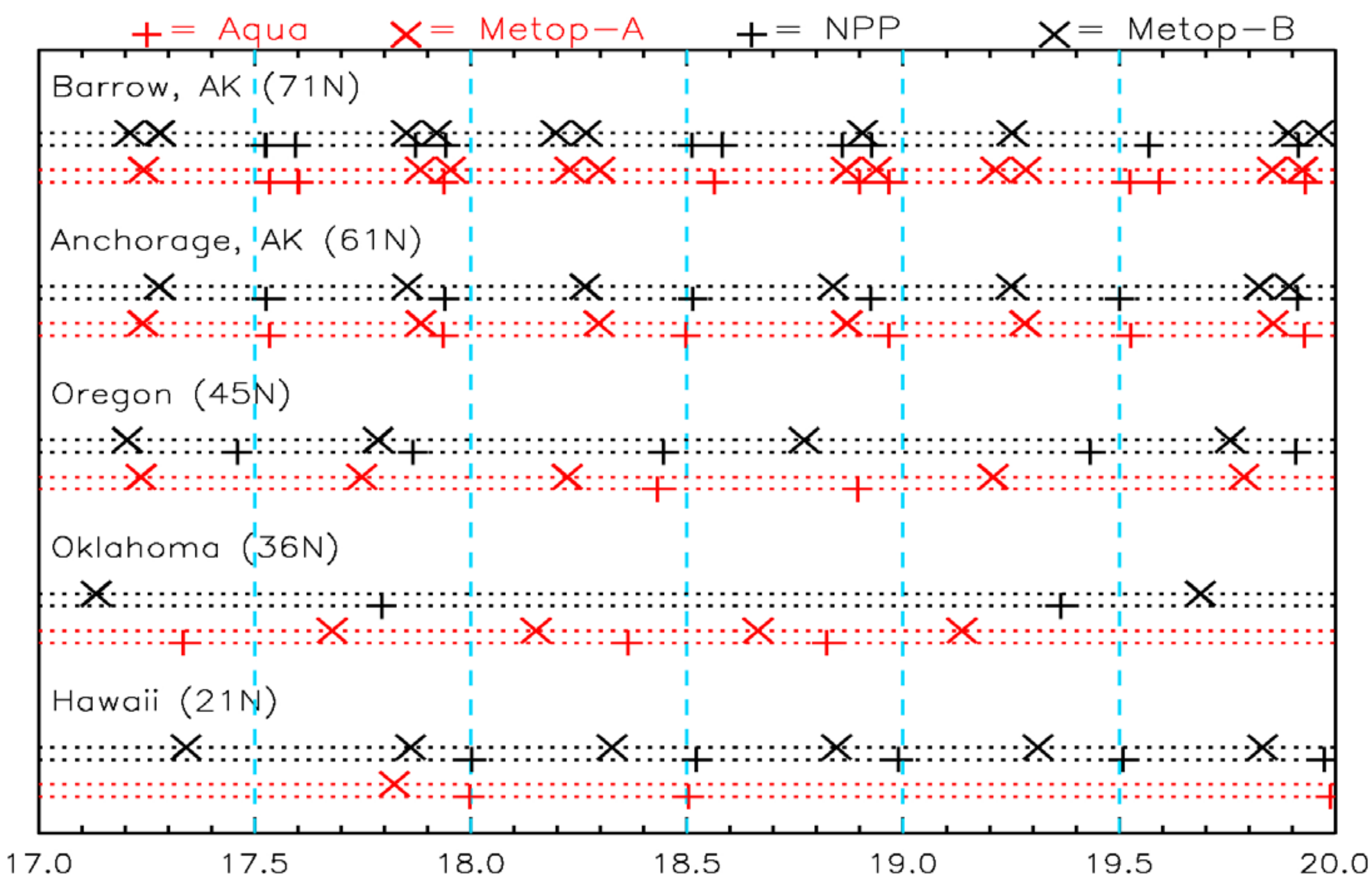
NUCAPS Retrieval File Variables for AWIPS

Variable	Type	Dim	Description	Units
H2O_MR	Float	120,100	Water vapor mixing ratio from the final retrieval	g/g
O3_MR	Float	120,100	Ozone mixing ratio from the final retrieval	ppb
Liquid_H2O_MR	Float	120,100	Liquid water mixing ratio from the final retrieval	g/g
Ice_Liquid_Flag	Short	120,100	Ice liquid flag 0=water, 1=ice	NA
SO2_MR	Float	120,100	Sulfur Dioxide mixing ratio from the final retrieval	g/g
Stability	Float	120,16	Stability parameters	Varying

Simplified Flow Diagram of the AIRS Science Team Algorithm



Constellation of satellites allows more observations between RAOBS



Day of June, 2015

NPP/J-1 will be phased similar to Metop-A/B approx. 6 months after launch of J-1

If we included NOAA AMSU/HIRS there would be even more soundings

These are overpasses with satellite elevation > 45 deg (FOR 4-27)

Applications using Satellite Sounder Products at the NASA SPoRT Center

Emily Berndt[1] and Bradley Zavodsky[2]

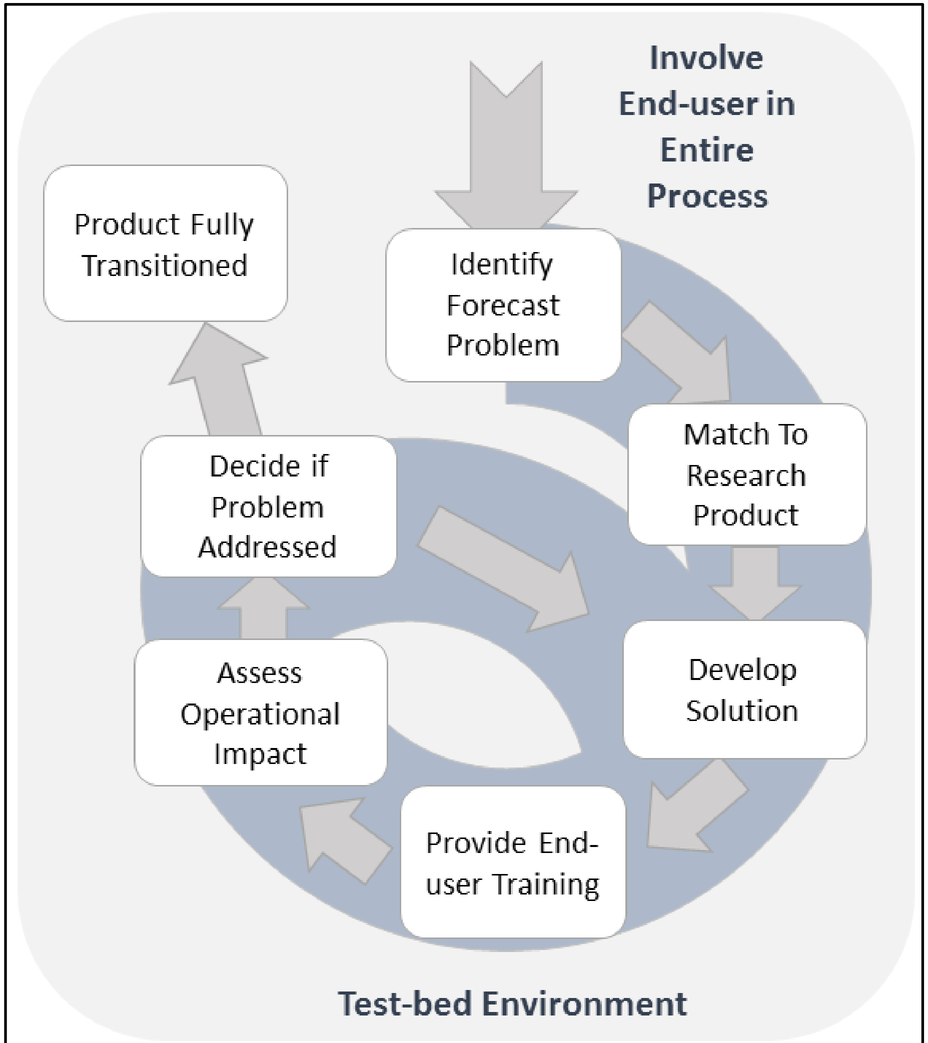
[1]University of Alabama in Huntsville/NASA SPoRT, Huntsville, Alabama
[2]Short-term Prediction Research and Transition Center NASA/MSFC, Huntsville, Alabama

STAR JPSS Annual Science Team Meeting
Soundings Breakout Session 7b
27 August 2015

Outline

- SPoRT Paradigm/Overview
- Situational Awareness Activities
- Data Assimilation Activities

SPoRT Mission and Paradigm



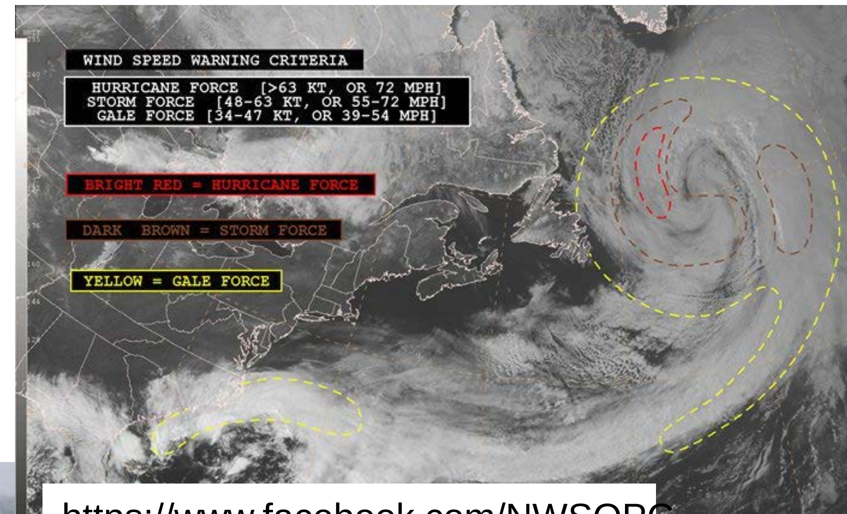
- ***Apply satellite measurement systems and unique Earth science research to improve the accuracy of short-term weather prediction at the regional and local scale***
- Bridge the "Valley of Death"
- Can't just "throw data over the fence"
  - Maintain interactive partnerships with help of specific advocates or "satellite champions"
  - Integrate into user decision support tools
  - Create forecaster training on product utility
  - Perform targeted product assessments with close collaborating partners
- Concept has been used to successfully transition a variety of satellite datasets to operational users for nearly 10 years

Outline

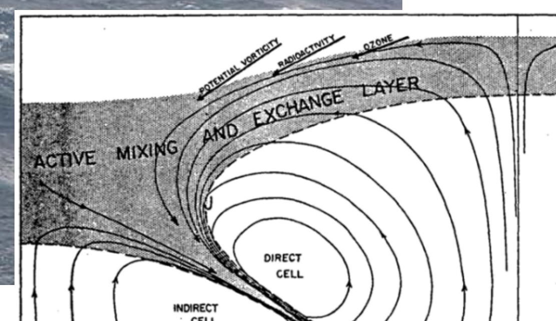
- SPoRT Paradigm/Overview
- Situational Awareness Activities
- Data Assimilation Activities

The Forecast Challenge and Ozone Retrievals

- The National Centers (WPC/OPC/SAB) are tasked with providing outlooks that involve forecasting the development of synoptic scale systems and associated severe weather
- OPC especially focuses on forecasting cyclogenesis and the development of hurricane-force winds in the North Pacific and Atlantic oceans
- Identifying regions of stratospheric air and the potential for tropopause folding can enhance forecaster situational awareness of impending cyclogenesis and high wind events
- Stratospheric air can be identified by potential vorticity and warm, dry, ozone rich air

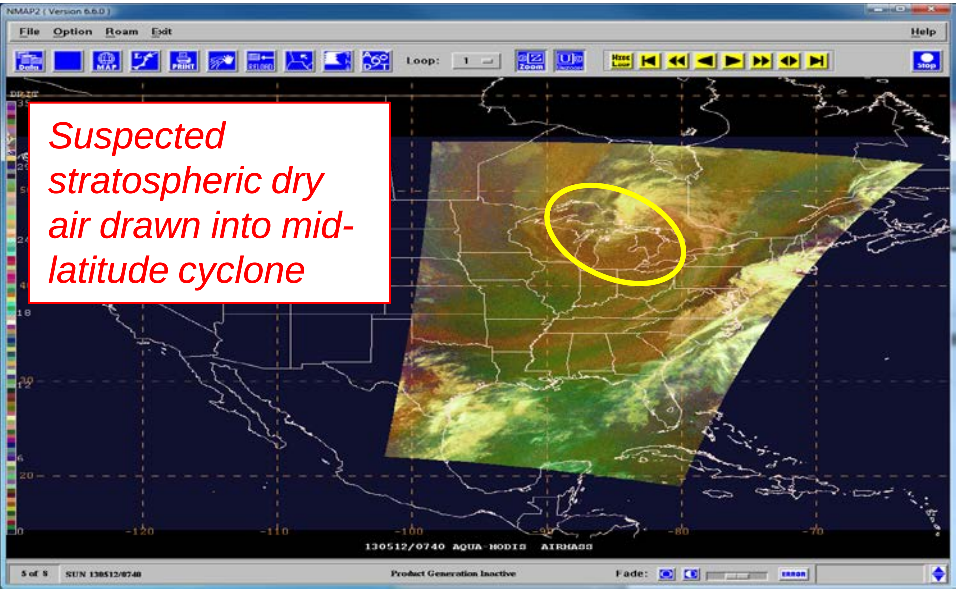


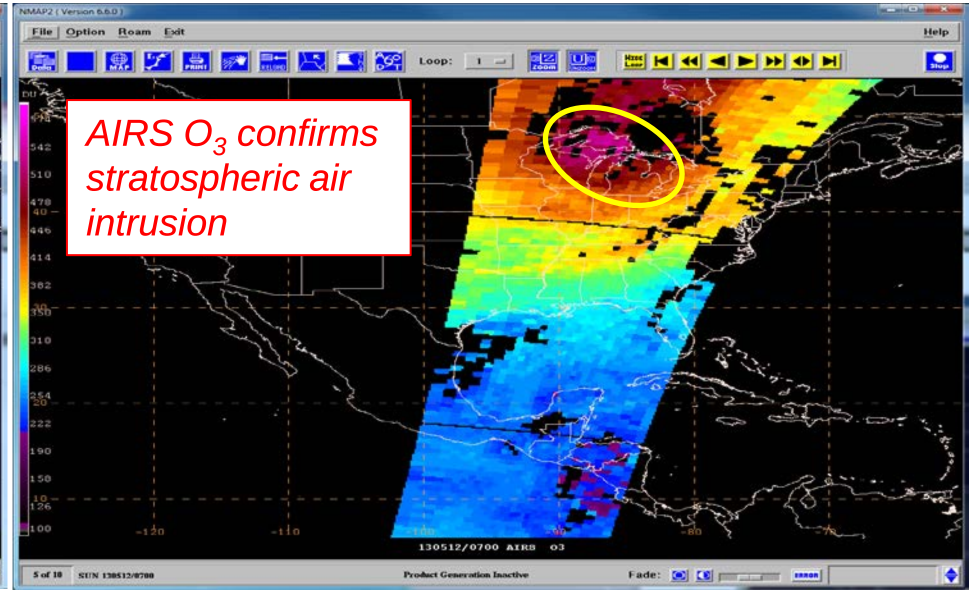
https://www.facebook.com/NWSOPC



(Danielson 1968)

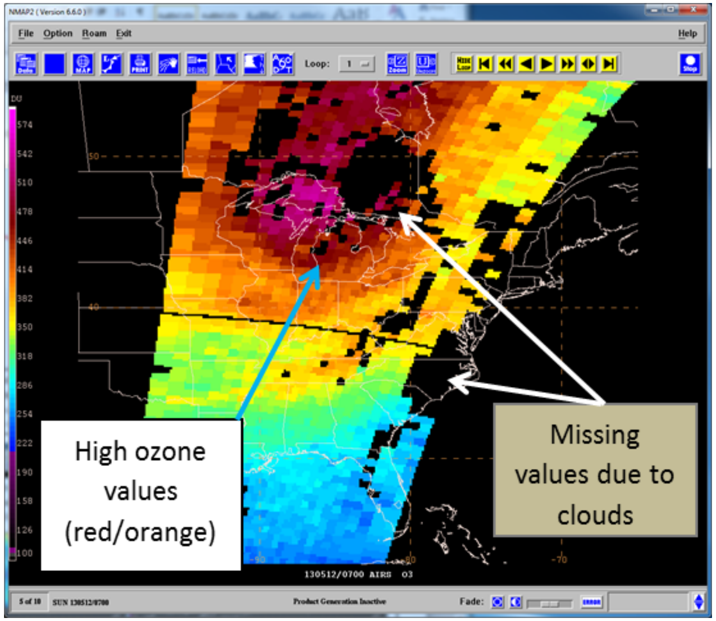
AIRS Total Ozone at WPC/OPC

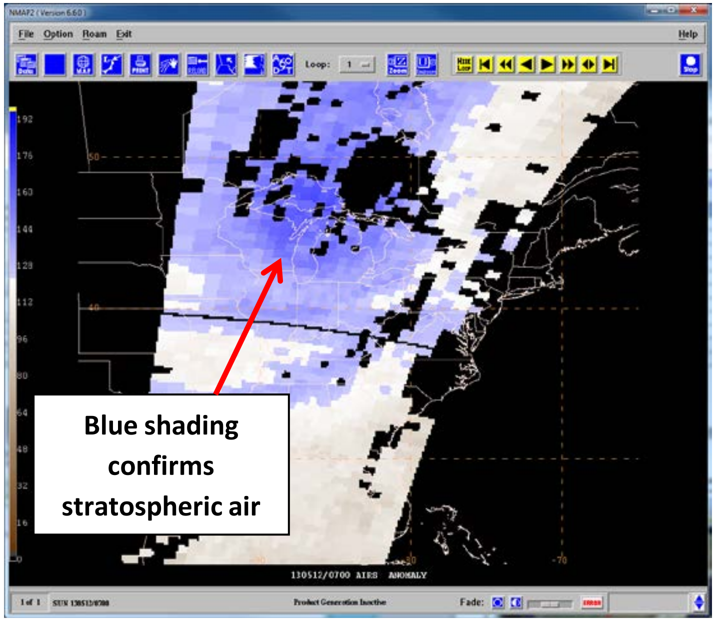




- AIRS helps determine stratospheric intrusions associated with mid-latitude and extratropical cyclone strengthening and damaging non-convective winds
- Enhances interpretation of RGB products
- Full transition of product to Weather Predication Center (WPC) and Ocean Prediction Center (OPC) in N-AWIPS decision support system

AIRS Total Ozone at WPC/OPC

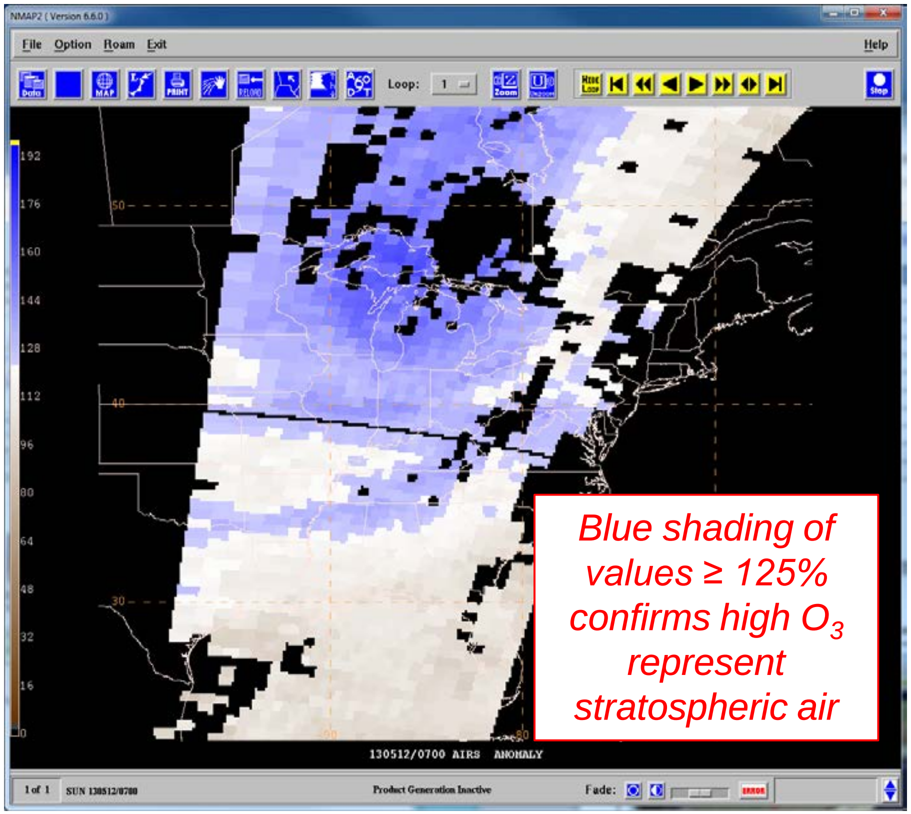




- Numerous posts on SPoRT and NOAA Proving Ground blogs related to product
- Journal of Operational Meteorology paper on use at WPC/OPC
- Paper on development, application, and transition of SPoRT ozone products in publication for IEEE Transactions in Geoscience and Remote Sensing
- Anomaly product developed to confirm high ozone values are stratospheric and not just within the climatological range

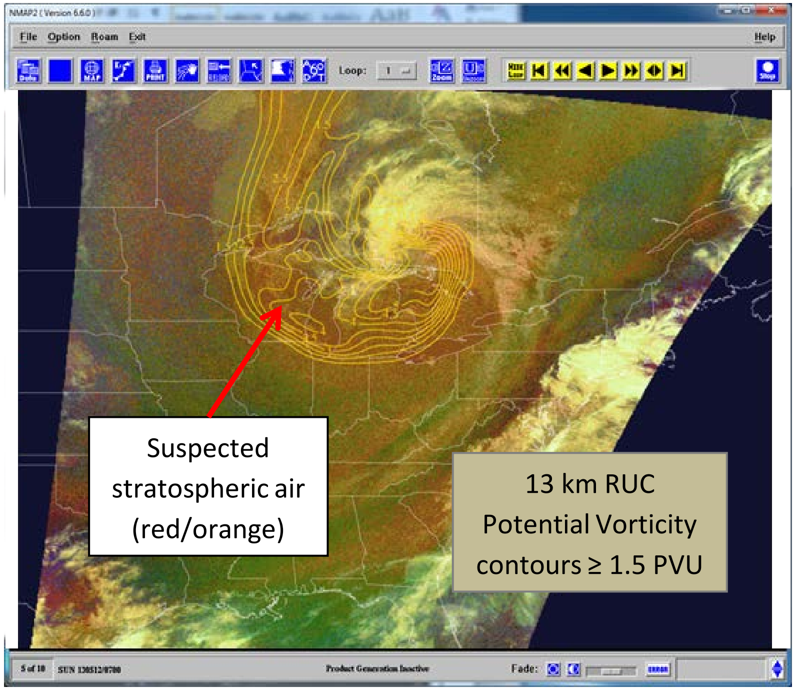
Ozone Anomaly Product

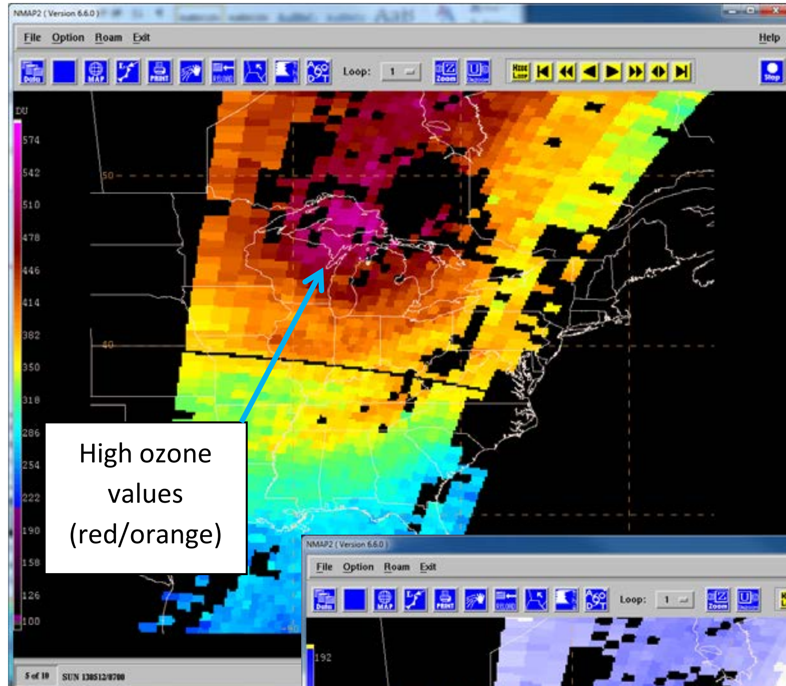
- Identification of stratospheric air based on high ozone values could lead to misinterpretation if the values actually range within climatology since the mean varies seasonally and spatially

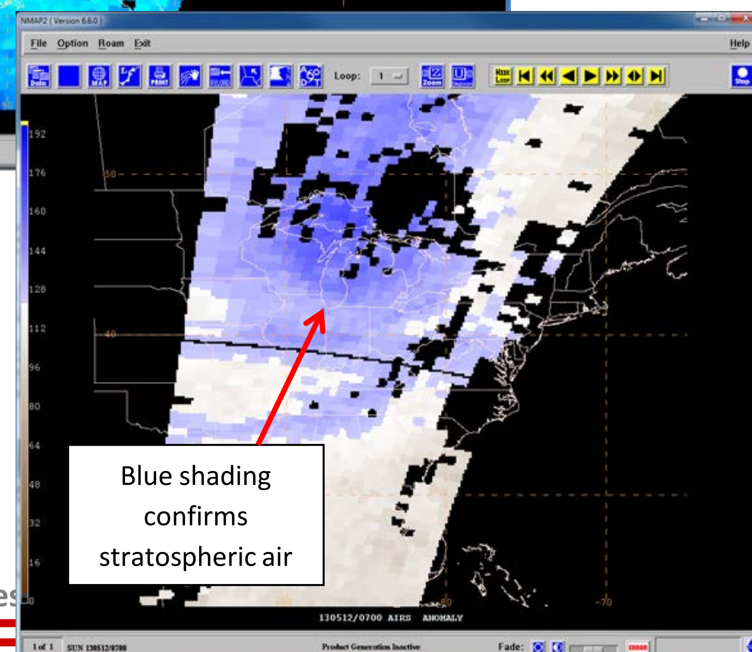


- The AIRS Ozone Anomaly product clarifies the presence of stratospheric air based on:
  - Stratospheric air has ozone values at least 25% larger than the climatological mean (Van Haver et al. 1996)
  - Global and zonal monthly mean climatology of stratospheric ozone derived from the NASA Microwave Limb Sounder (Ziemke et al. 2011)

Example 12 May 2013







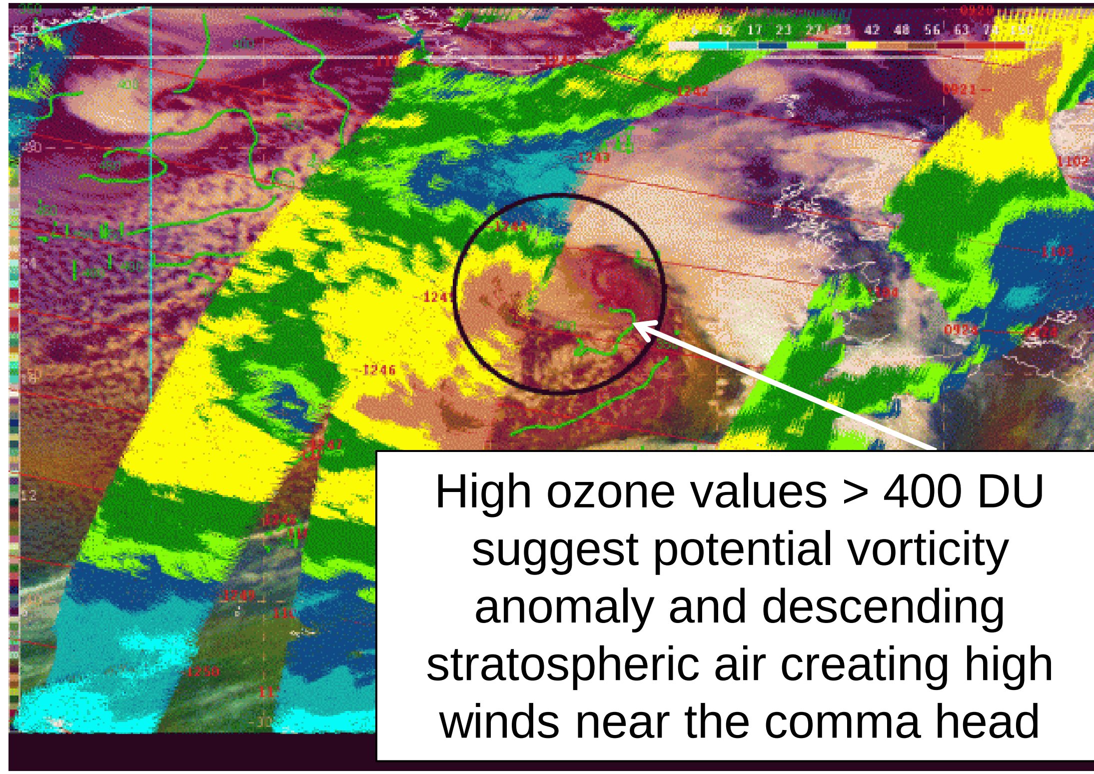
- SPoRT AIRS Ozone Anomaly product created as a percent of normal (0-200%)

$$PON = \frac{TCO}{climo}\ x\ 100$$

- Shades of blue represent stratospheric air (ozone values $\geq$ 125%)

Demonstration at National Centers

- AIRS ozone products evaluated at OPC, WPC, SAB winter 2013-2014
- Forecaster Feedback
  - "**Reinforce the evidence from RGB** of the descent of stratospheric air with tropopause folding."
  - "This has allowed me to **have confidence in assessing the RGB Airmass product** and also in conjunction with gridded GFS output that a perceived PV anomaly is real or not."



SEVIRI RGB Air Mass image, AIRS Total Column Ozone (green contours), and ASCAT winds valid at 1400 UTC on 12/18/13. The black circle highlights the descending stratospheric intrusion near the comma-head/bent back front. Image courtesy of Michael Folmer
Satellite Liaison at NOAA/NWS WPC/OPC/TAFB and NOAA/NESDIS SAB

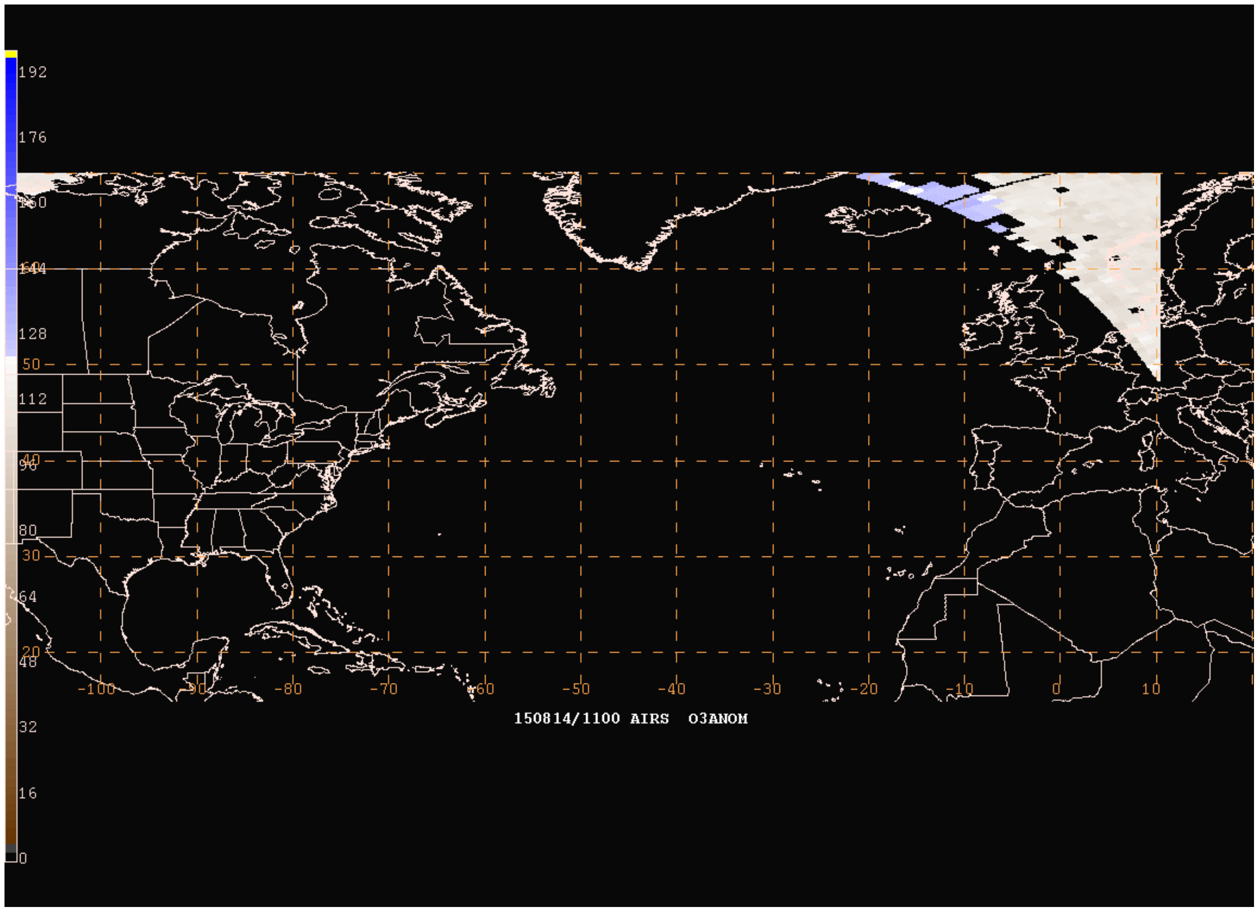
New Product Development

- Adjust product according to forecaster feedback from the winter 2014 product demonstration at OPC
- Expand the ozone products to other instruments
  - Increase temporal & spatial coverage by developing products from IASI and CrIS retrievals

"There may have been 1 occasion where 1 pass did line up over the US with the spot I was interested in. In that case, it was helpful in reaffirming my suspicions on whether stratospheric air was present. Otherwise, the passes were few and far between and not particularly timely. If there was greater coverage of passes and not as much of a lag, it would certainly be useful."

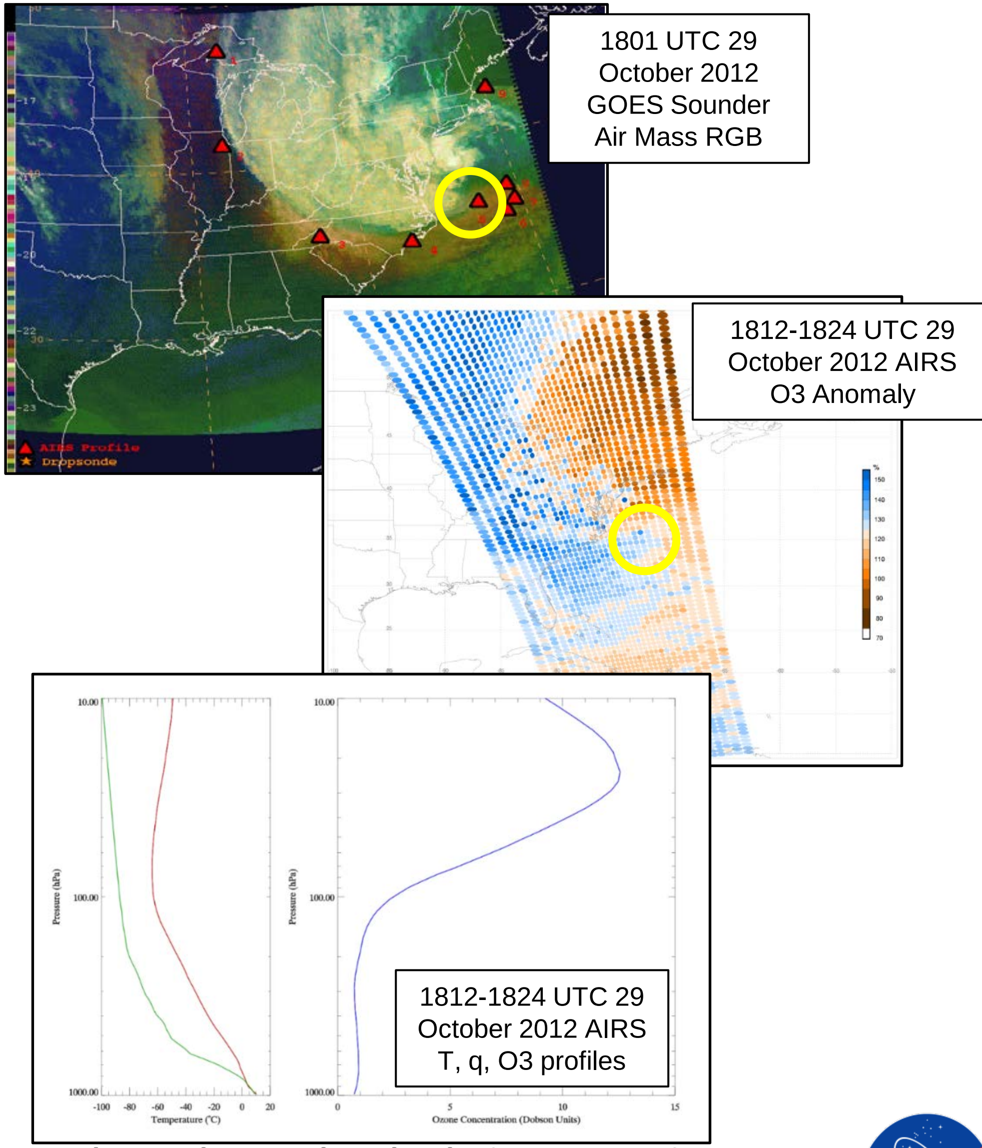
New Product Development

- Products from NUCAPS and IASI were develop in early 2015
- National Centers are receiving products from AIRS, IASI, and NUCAPS



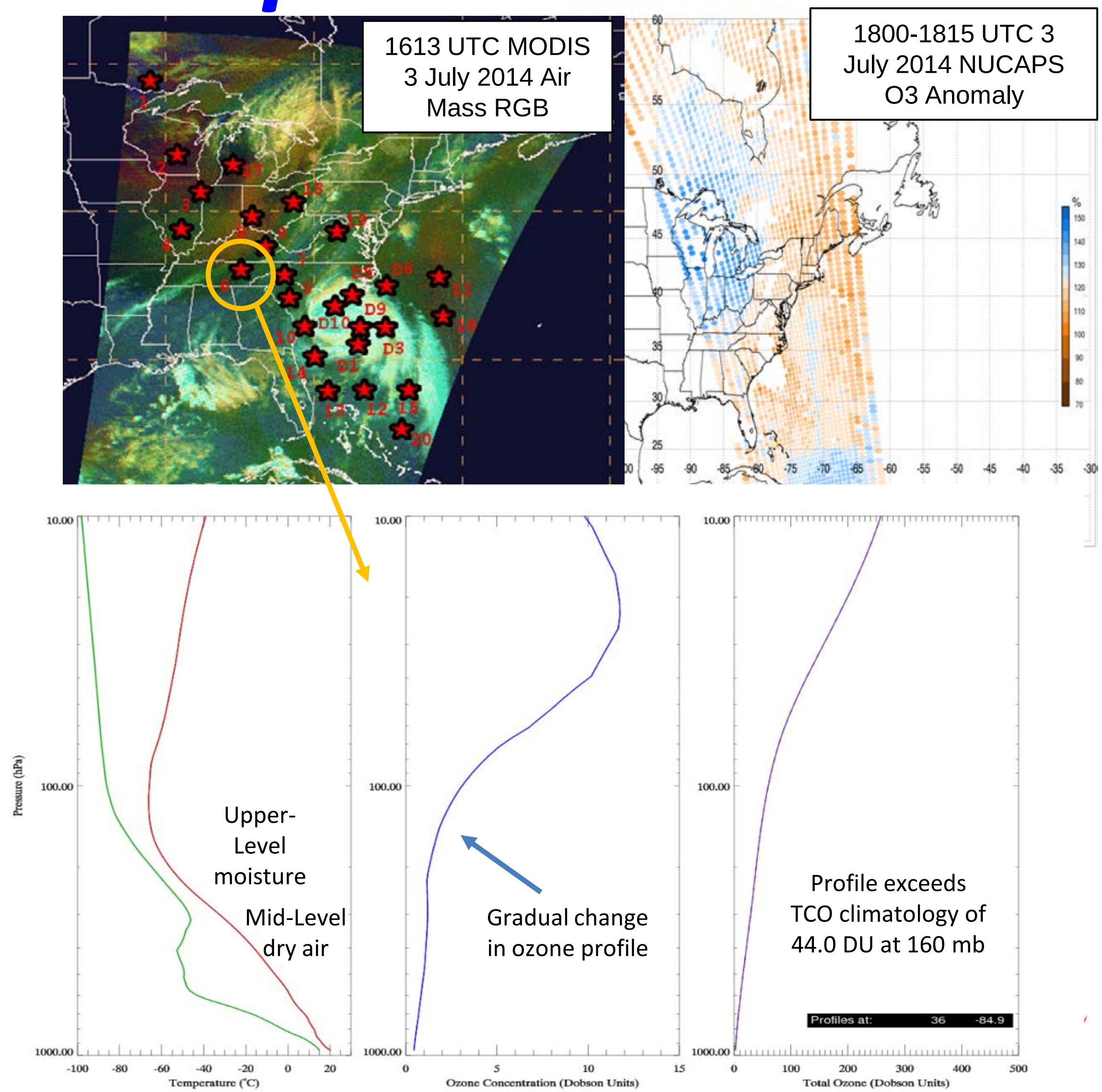
Hurricane Extratropical Transition

- National Centers' forecasters have GOES-R/JPSS Proving Ground proxy products, such as the Air Mass RGB, to assist in monitoring extratropical transition of hurricanes
- Air Mass RGB product provides an enhanced view of various air masses in one complete image to help differentiate between possible stratospheric/tropospheric interactions
- NUCAPS soundings can compliment the Air Mass RGB by providing insight about the vertical structure of the atmosphere
- Since NUCAPS sounding are already in AWIPS-II this projects investigates the utility of NUCAPS soundings for another unique forecasting challenge



Hurricane Extratropical Transition

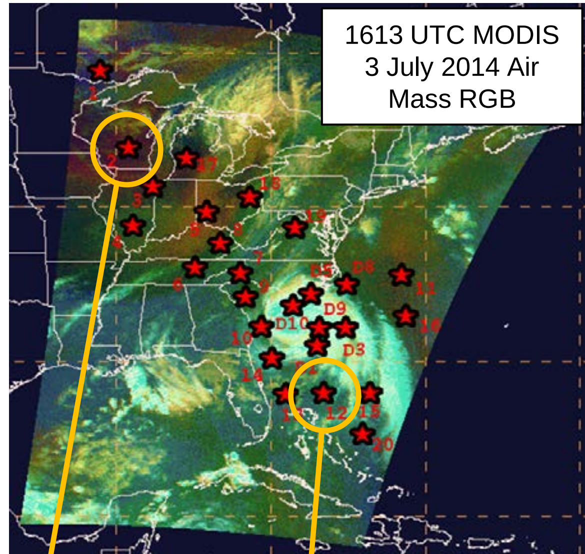
- Project will investigate 3 extratropical transition case studies
  - Arthur 2014
  - Sandy 2012
  - Nadine 2012
- Create a stratospheric depth product
- Create tailored training
- Conduct a product demonstration of NUCAPS soundings and stratospheric depth product with NHC, WPC, and OPC during 2016 hurricane season

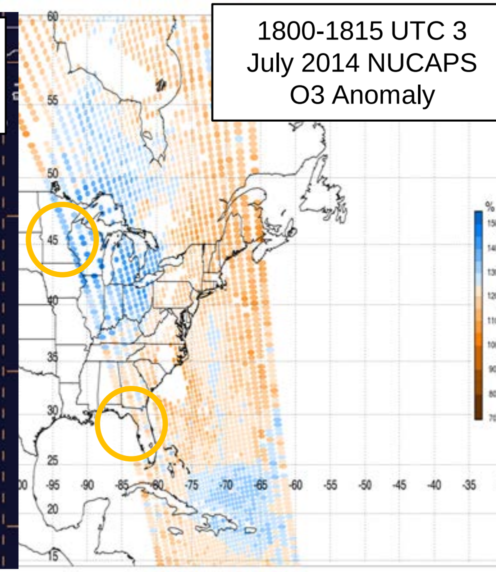


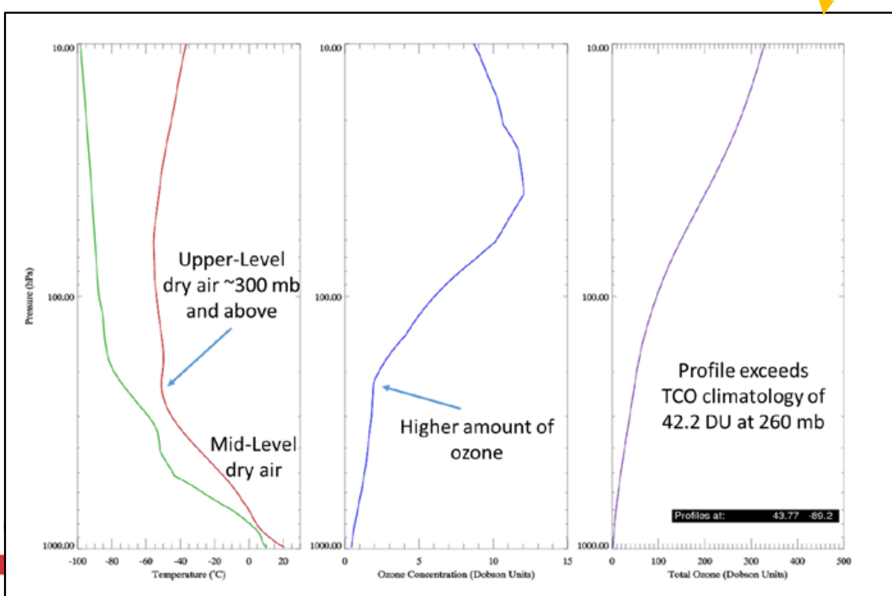
transitioning

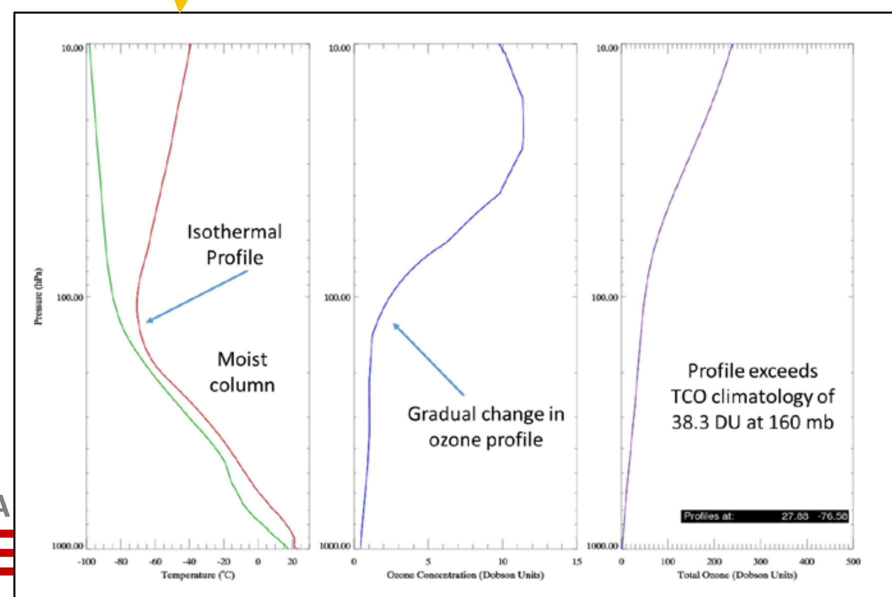
Hurricane Extratropical Transition

- Profiles in red/orange regions confirm mid- and upper-level dry air and lower tropopause
- Profile near the storm in blue/green regions confirm a moist column, a gradual change in the ozone profile, and a higher tropopause







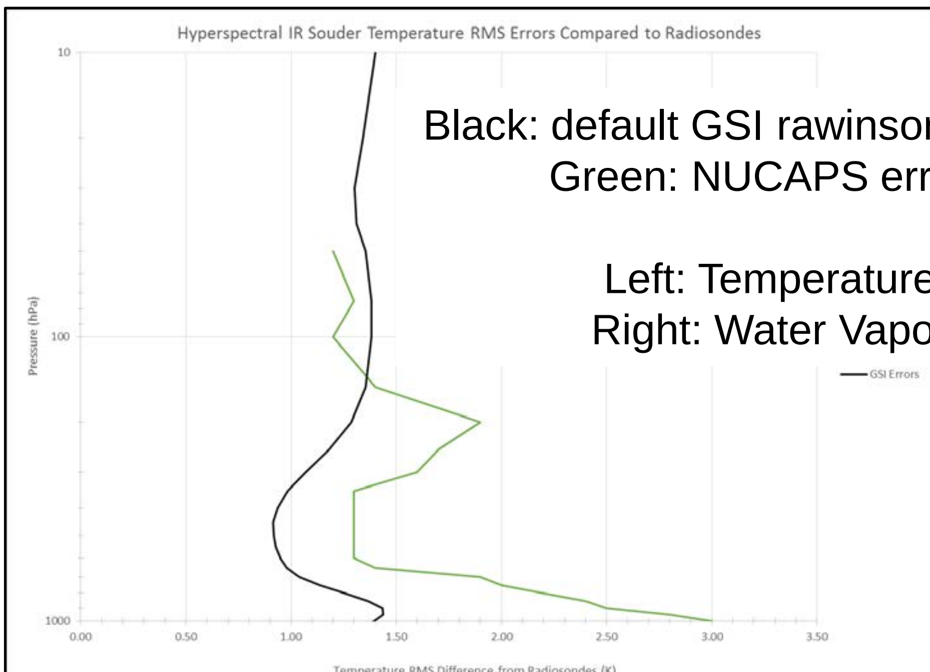


Outline

- SPoRT Paradigm/Overview
- Situational Awareness Activities
- Data Assimilation Activities

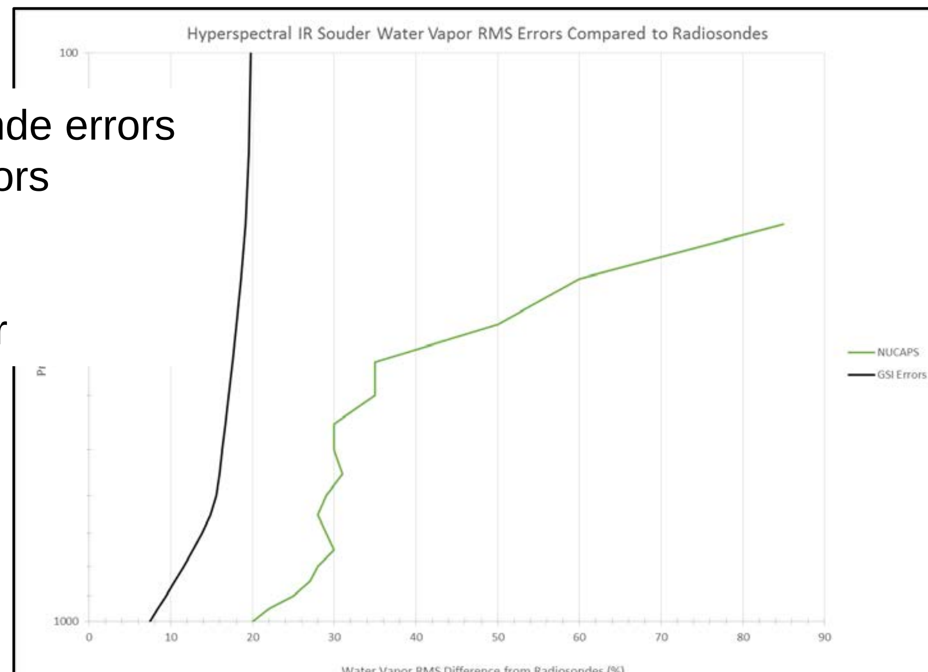
Assimilation of NUCAPS Profiles

- Satellite profiles are traditionally assimilated as rawinsonde observations and assigned rawinsonde errors which are unrepresentative for satellite profiles
- Experiments were conducted to compare model runs
  - No profile assimilation + conventional observations
  - Profile assimilation with rawinsonde errors + conventional observations
  - Profile assimilation with NUCAPS errors from Nalli et al. (2013) + conventional observations



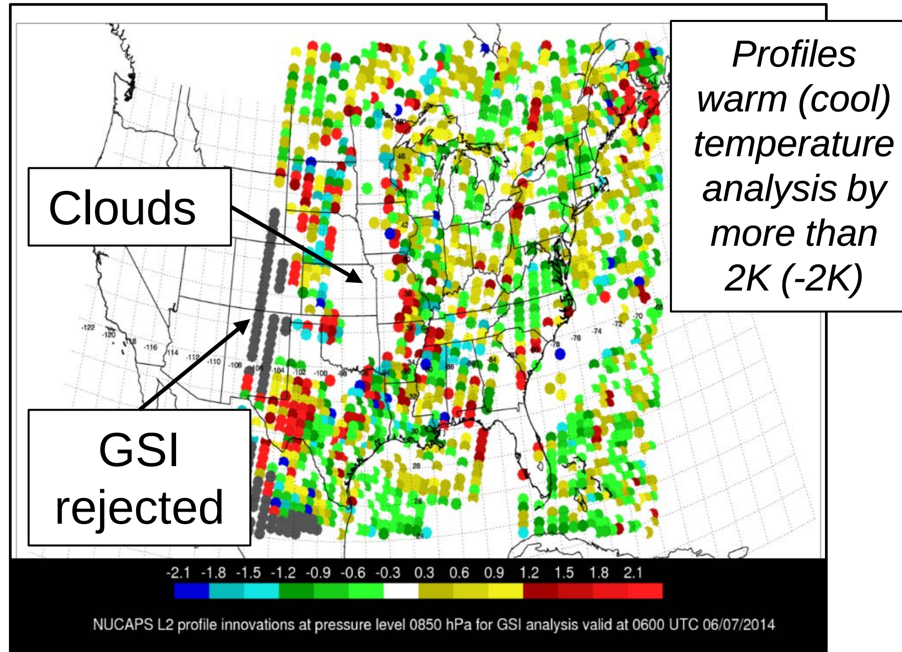
Black: default GSI rawinsonde errors
Green: NUCAPS errors

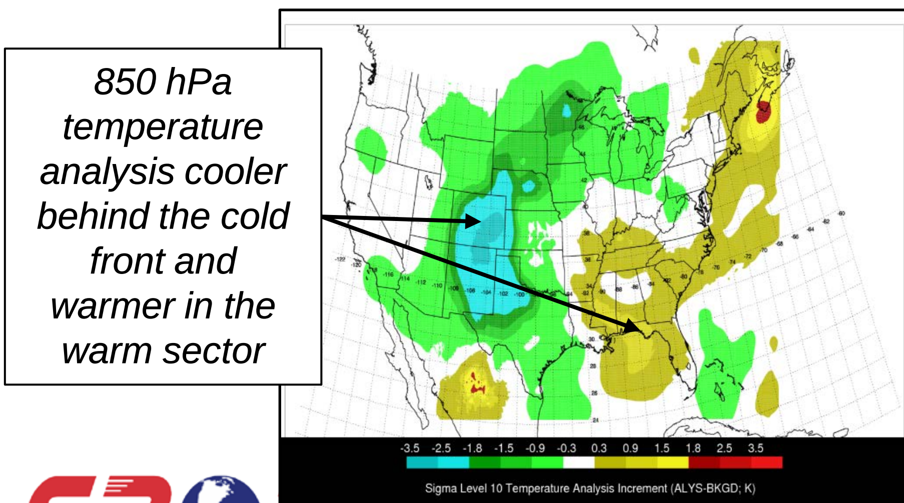
Left: Temperature
Right: Water Vapor

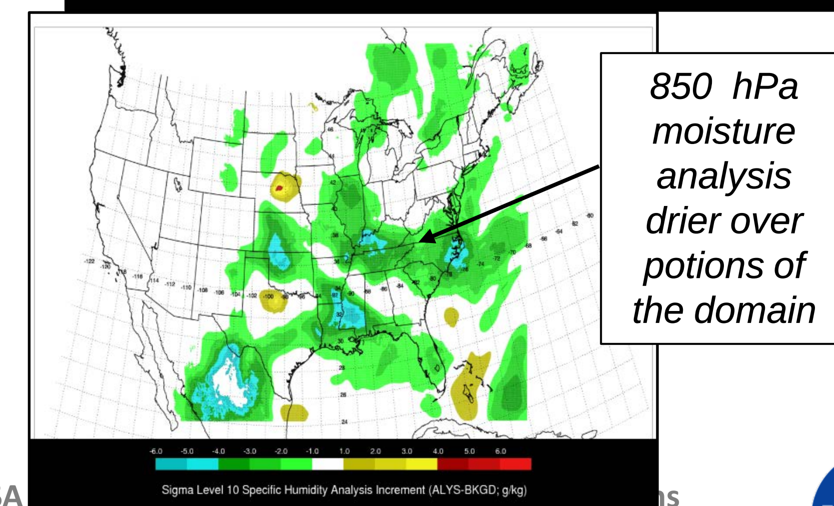


Assimilation of NUCAPS Profiles

- Location and color coded innovations where NUCAPS profiles were assimilated at 850 hpa
- Yellow/red (green/blue) regions represent locations where individual profiles are warmer (cooler) than the final temperature analysis, gray locations were rejected by GSI
- Analysis increments show how much and where the background fields have been modified by assimilating observations



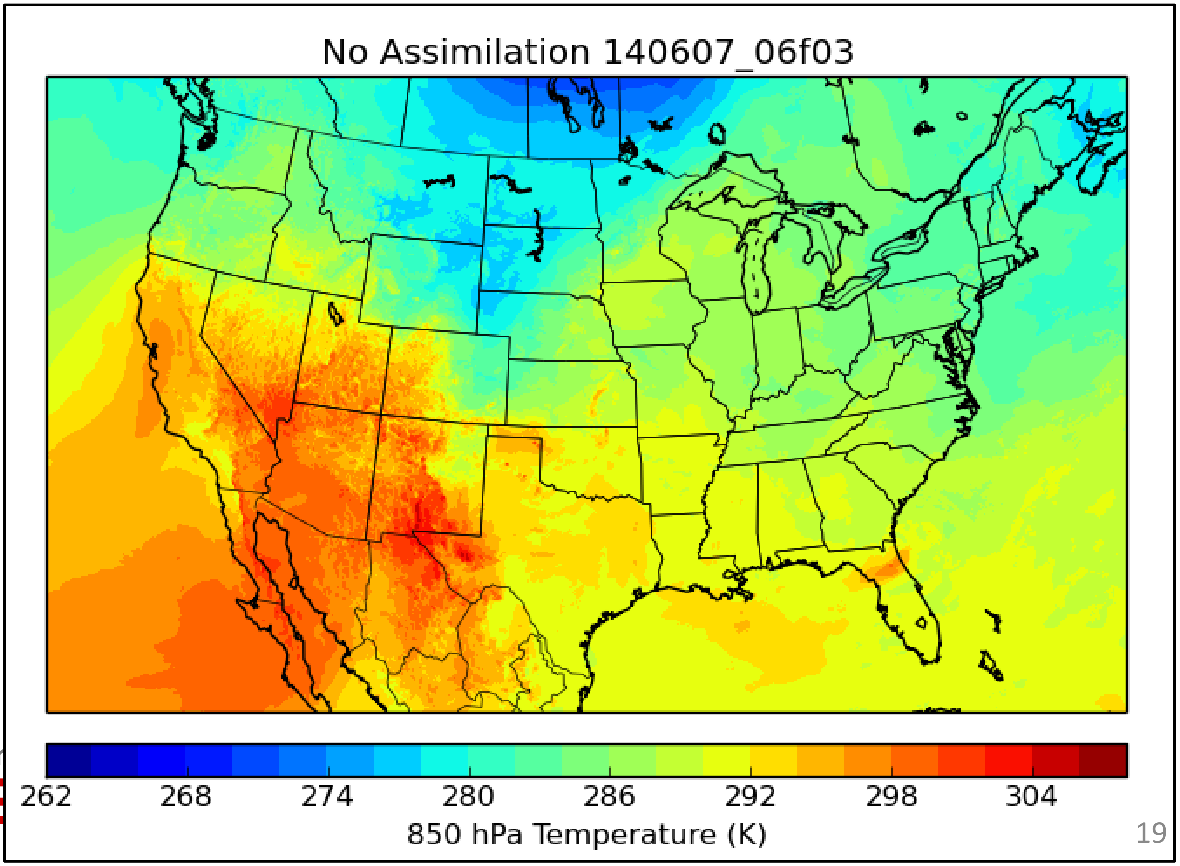




Assimilation of NUCAPS Profiles

- Comparison of experiments show colder 850 hPa temperatures in the Upper Midwest and subtle warming in the Midwest and Southeast when NUCAPS profiles are assimilated

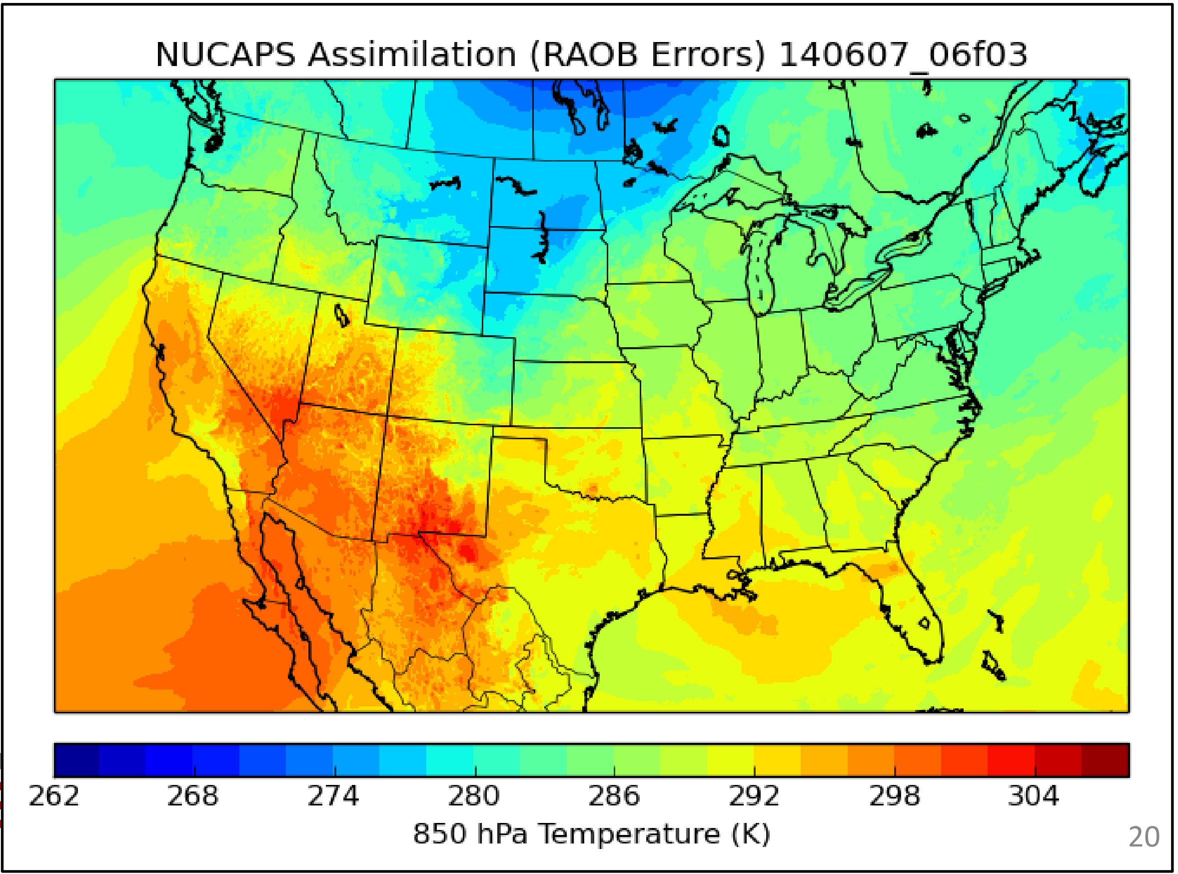
Only subtle changes are apparent in 850 hPa temperature between experiments that assimilate NUCAPS profiles with RAOB error and NUCAPS errors



SPORT transitionin

Assimilation of NUCAPS Profiles

Only subtle changes are apparent in 850 hPa temperature between experiments that assimilate NUCAPS profiles with RAOB error and NUCAPS errors



transitionin

Assimilation of NUCAPS Profiles

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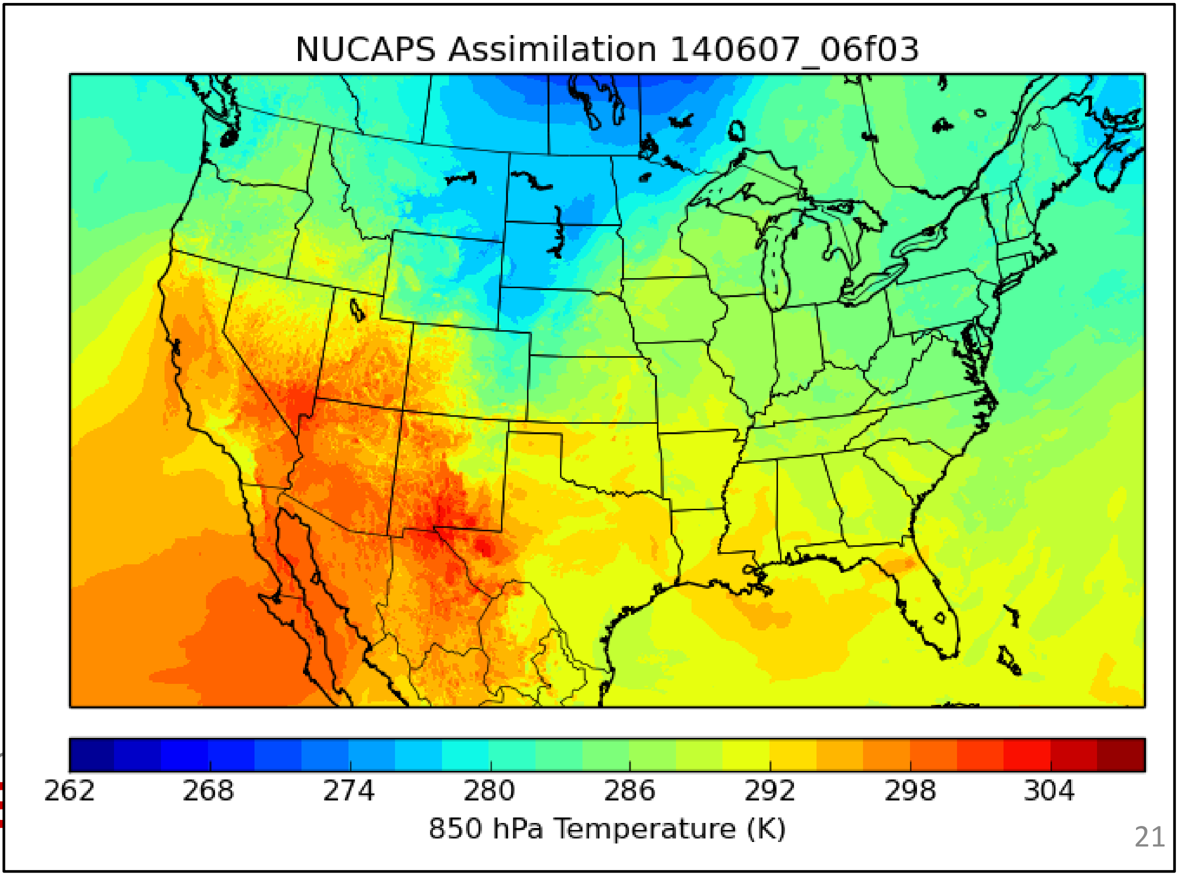
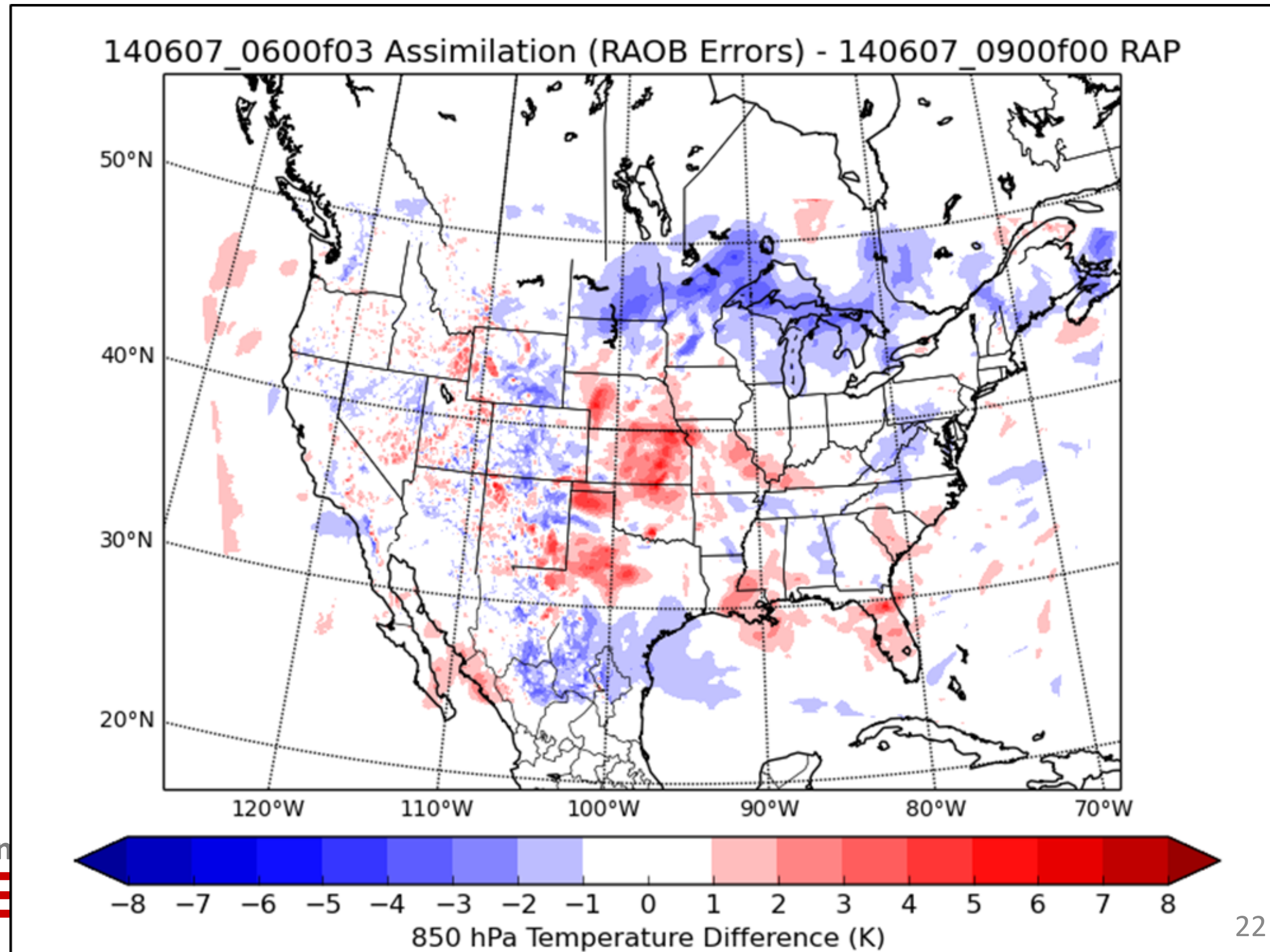


SPORT transitioni

Assimilation of NUCAPS Profiles

- Model output was re-gridded to 13-km and compared to the RAP analysis

Differences are smaller and the forecasted field is closer to the RAP analysis when assimilating profiles with NUCAPS errors



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Assimilation of NUCAPS Profiles

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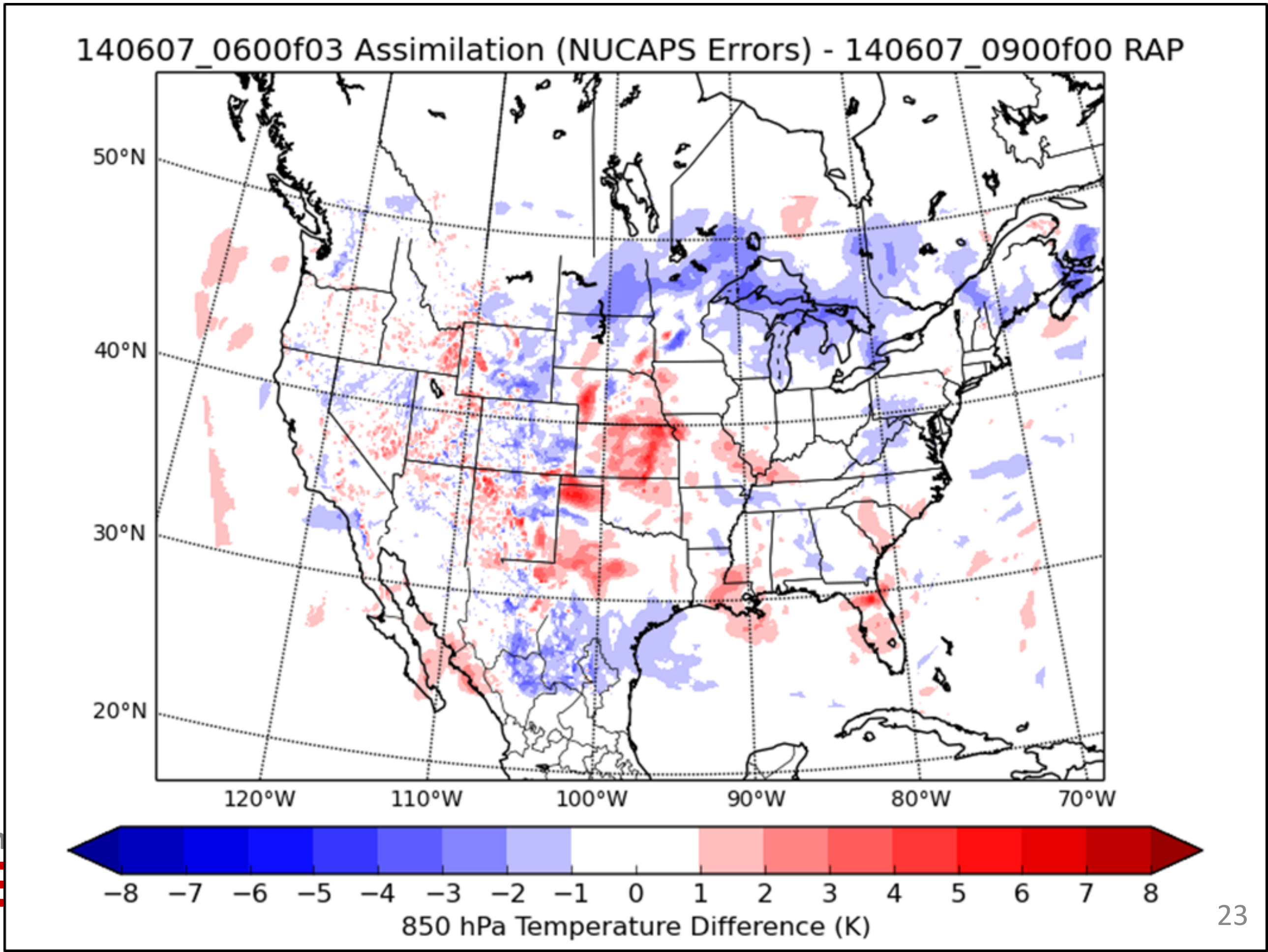

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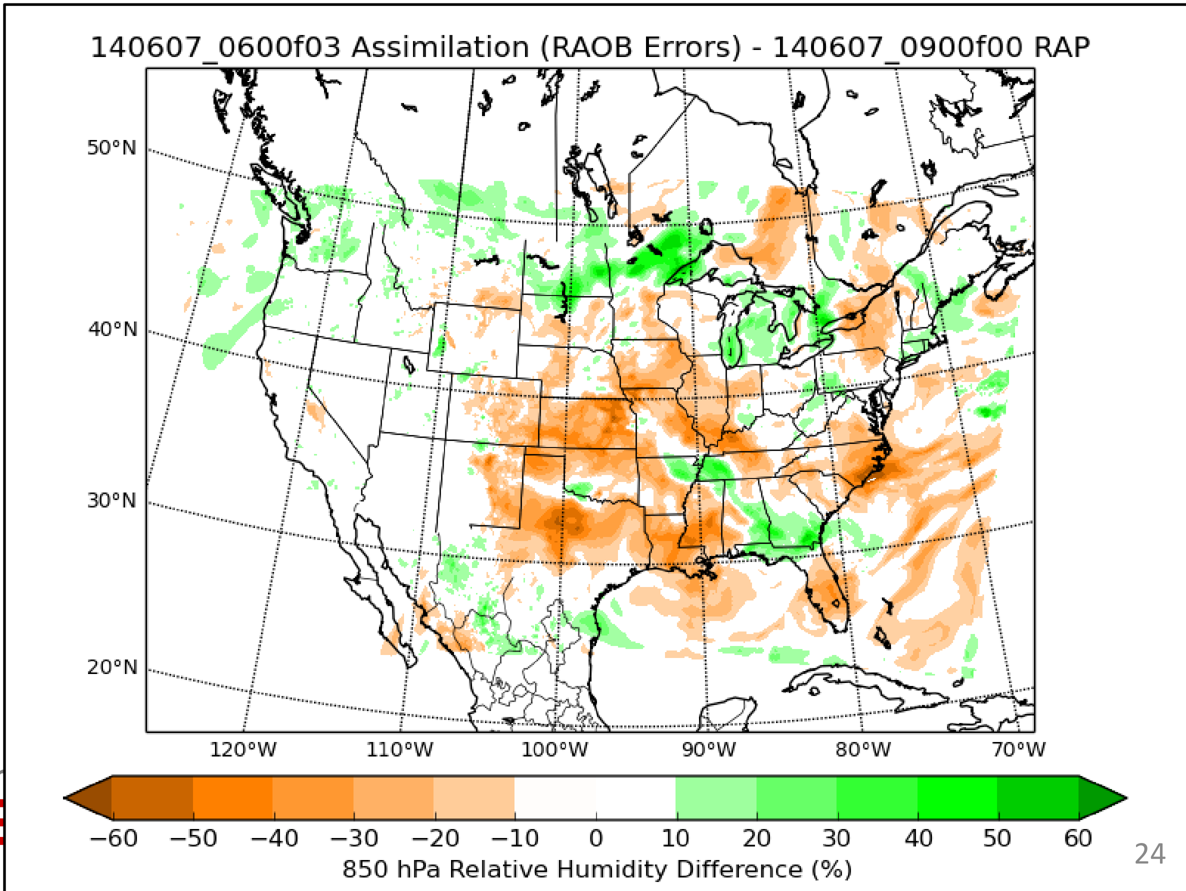
Assimilation of NUCAPS Profiles

- 850 hPa Relative Humidity Figures are not shown, but more drying occurs at low levels when assimilating NUCAPS profiles with subtle differences between assimilating profiles with RAOB and NUCAPS Errors

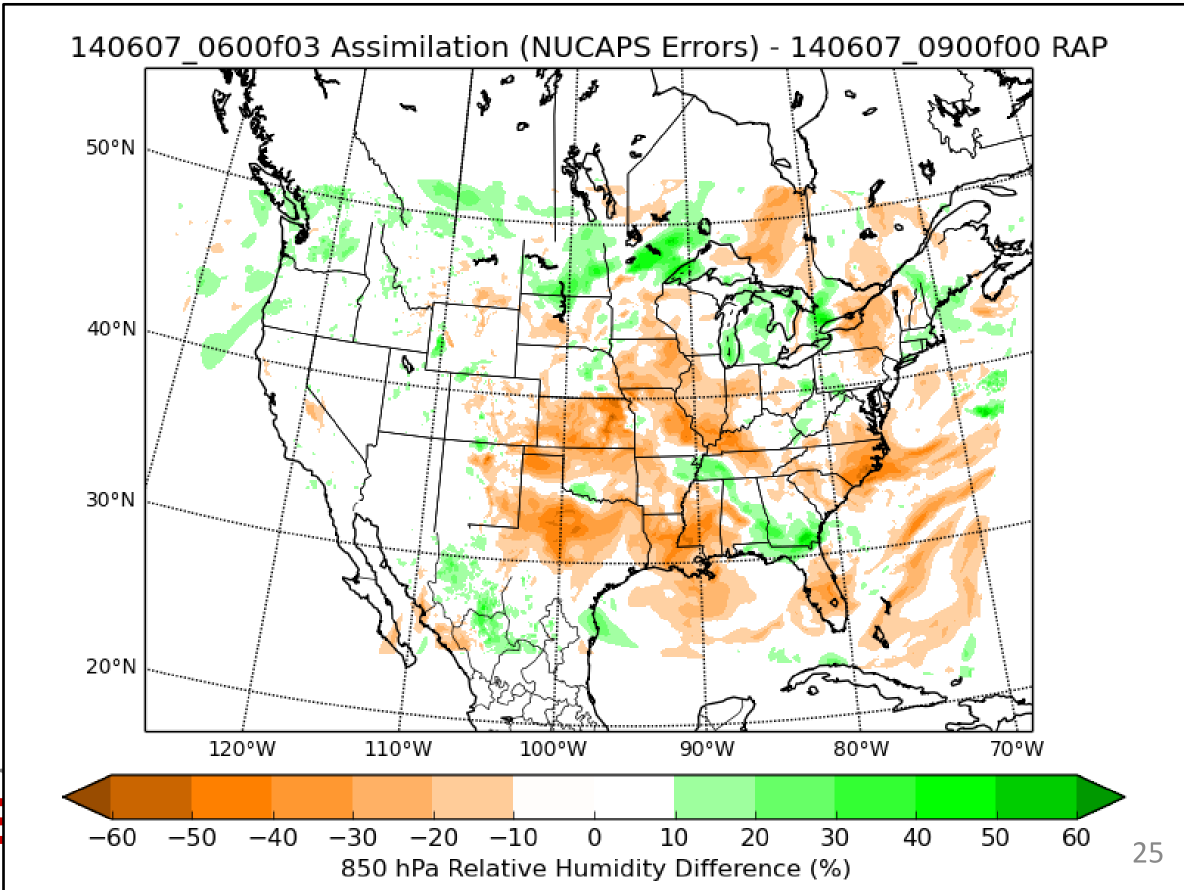
Less drying occurs (relative to 13-km RAP analysis) when profiles are assimilated with NUCAPS errors.



SPORT transitionin

Assimilation of NUCAPS Profiles

Less drying occurs (relative to 13-km RAP analysis) when profiles are assimilated with NUCAPS errors.



SPORT transitionin

Assimilation of NUCAPS Profiles

- NUCAPS profiles can be assimilated in GSI as a separate observation other than rawinsondes with only changes to tables in the fix directory
- Assimilation of profiles does produce changes to analysis fields and evidenced by:
  - Innovations larger than +/- 2.0 K are present and represent where individual profiles impact the final temperature analysis
  - The updated temperature analysis is colder behind the cold front and warmer in the warm sector
  - The updated moisture analysis is modified more in the low levels and tends to be drier than the original model background
- Differences relative to 13-km RAP analyses are smaller when profiles are assimilated with NUCAPS errors
- Next steps include assimilating profiles over a longer period of time and assessing the impact on the forecast

Summary

- SPoRT is a proven community leader for transitioning satellite products to operational end users and is working to bring data from hyperspectral infrared sounders to forecasters
- SPoRT products using AIRS, IASI, and NUCAPS data are currently available at National Centers: WPC, OPC, SAB
- SPoRT is continuing to investigate the utility of NUCAPS profiles for other applications such as Extratropical Transition
- SPoRT also assimilates NUCAPS profiles into regional models and is investigating the influence on summer-time convection forecasts

NUCAPS demonstration at the HWT 2015 Spring Experiment

William Line

University of Oklahoma - CIMMS

NOAA/NWS/Storm Prediction Center, Norman, OK

bill.line@noaa.gov

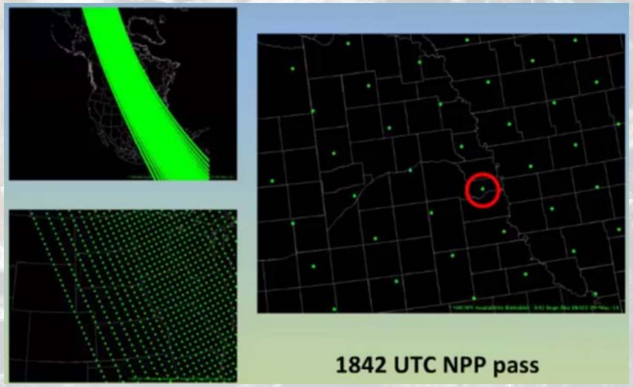
Dan Nietfeld, Scott Lindstrom, Brian Motta, Chris Barnet, others …

NUCAPS

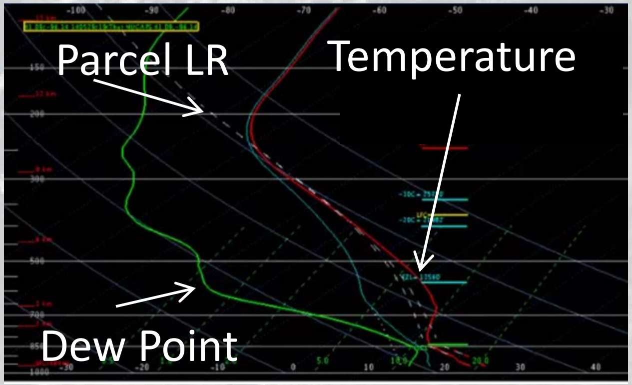
- NOAA Unique CrIS ATMS Processing System
  - Operational CrIS+ATMS physical retrieval algorithm
- NUCAPS vertical temperature and moisture profiles are available from NPP operationally in AWIPS-II
- Can NUCAPS data provide unique value to the severe weather nowcast and warning process?

Observed Radiosondes (12z and 18z)

Example NUCAPS Coverage



Example NUCAPS Skew-T Profile in AWIPS-II NSHARP

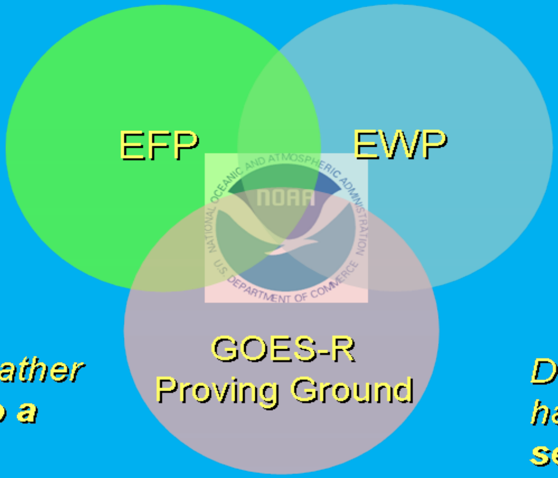


Hazardous Weather Testbed

- Facility <u>and</u> organization
- Jointly managed by NSSL, SPC, WFO-Norman
- Annual Spring Experiment

Experimental Forecast Program

*Prediction of hazardous weather events from **a few hours to a week in advance***



Experimental Warning Program

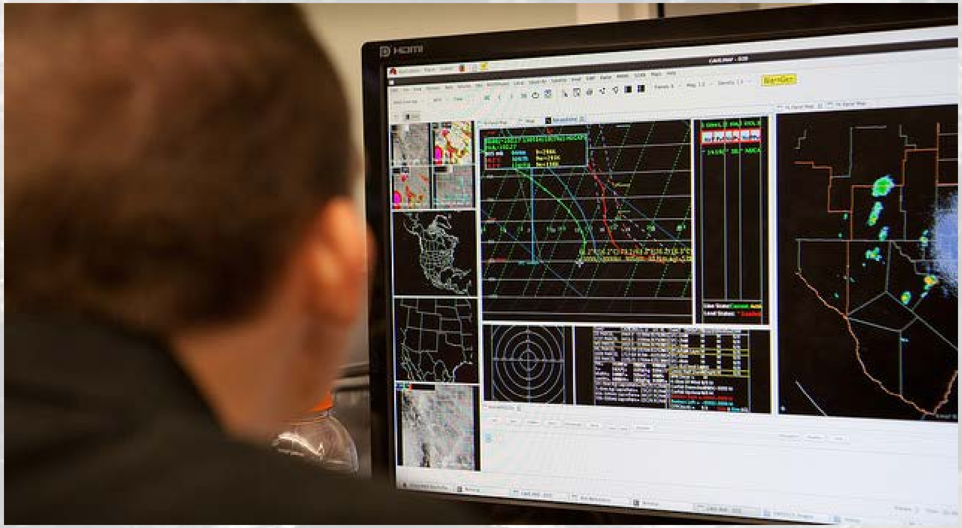
*Detection and prediction of hazardous weather events **up to several hours in advance***

2015 Hazardous Weather Testbed (HWT) Experimental Warning Program (EWP) Spring Warning Project

- Real-time, simulated nowcast/warning environment using AWIPS-II.
  - “mesoscale forecast updates” (via live blog posts)
  - experimental severe t-storm and tornado warnings (in AWIPS-II).
- Weeks of May 4, 11, 18, June 1, 8 (5 weeks)
  - Mon: 11a-7p, Tues-Thurs: Flex (start b/t 11a and 3p), Fri: 9a-1p
- 5 NWS forecasters, 1 broadcaster per week (30 total; and PI’s)
- GOES-R/JPSS and ENI demonstration's (including NUCAPS)
- Training: 10-30 min Articulate PowerPoint Presentations
- Feedback: Daily and weekly debriefs, daily surveys, blog posts, TFTT Webinar
- **Final Report available shortly**

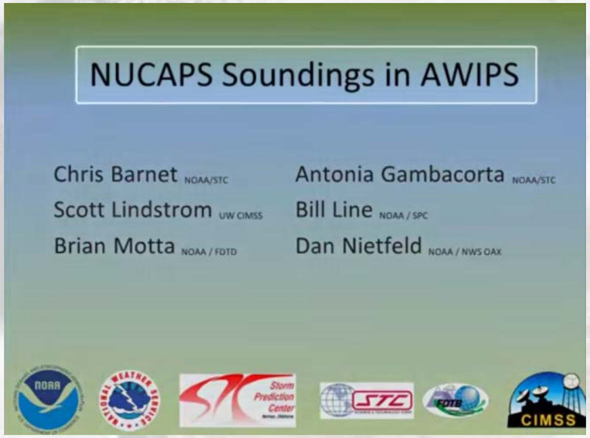
NUCAPS HWT-EWP 2015 Demonstration

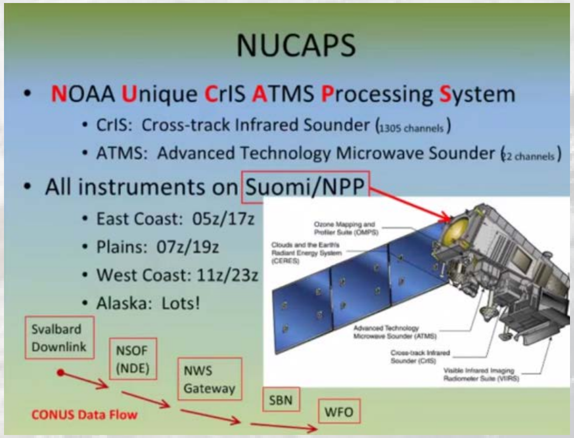
- Capture the value added by NUCAPS to the severe weather nowcast and warning process
- Learn what adjustments could be made to enhance operational usefulness of NUCAPS in AWIPS-II
- Enlighten participants to the existence of NUCAPS in AWIPS-II

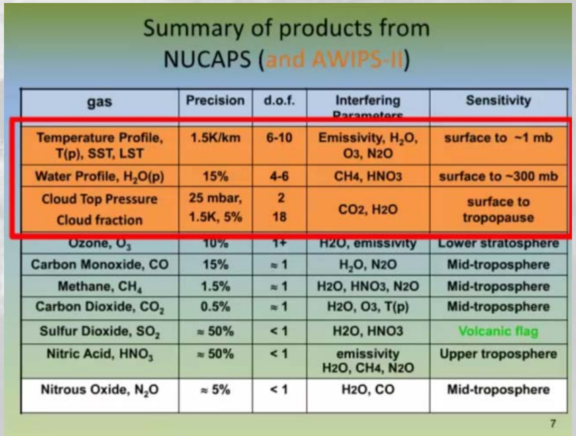


NUCAPS HWT 2015 Training

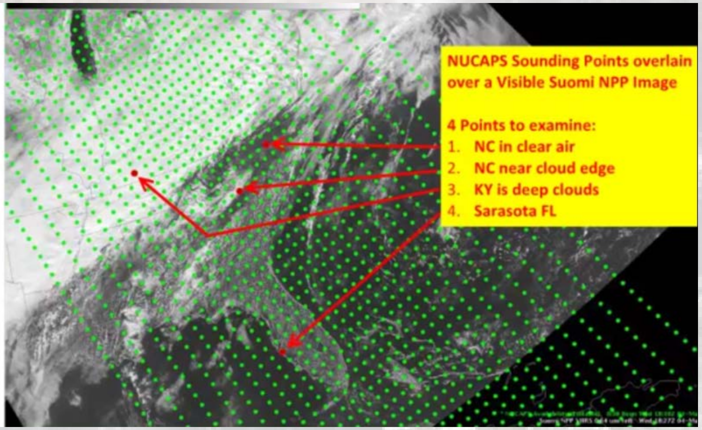
- 13 minute Articulate PowerPoint
  - http://rammb.cira.colostate.edu/training/visit/training_sessions/nucaps_soundings_in_awips/

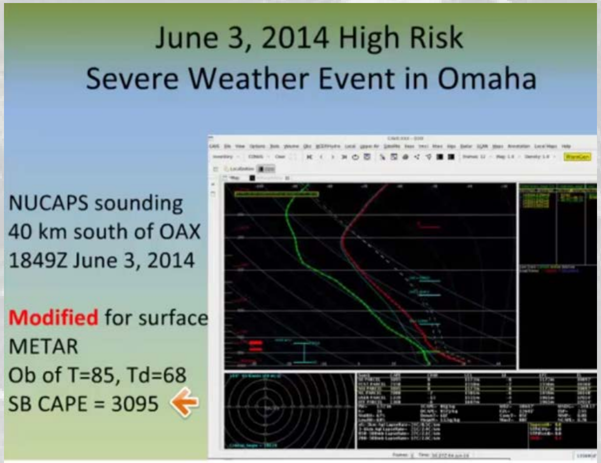






gas	Precision	d.o.f.	Interfering Parameters	Sensitivity
Temperature Profile, T(p), SST, LST	1.5K/km	6-10	Emissivity, H_2O, O3, N2O	surface to ~1 mb
Water Profile, H_2O(p)	15%	4-6	CH4, HNO3	surface to ~300 mb
Cloud Top Pressure Cloud fraction	25 mbar, 1.5K, 5%	2 18	CO2, H2O	surface to tropopause
Ozone, O_3	10%	1+	H2O, emissivity	Lower stratosphere
Carbon Monoxide, CO	15%	≈ 1	H_2O, N2O	Mid-troposphere
Methane, CH_4	1.5%	≈ 1	H2O, HNO3, N2O	Mid-troposphere
Carbon Dioxide, CO_2	0.5%	≈ 1	H2O, O3, T(p)	Mid-troposphere
Sulfur Dioxide, SO_2	≈ 50%	< 1	H2O, HNO3	Volcanic flag
Nitric Acid, HNO_3	≈ 50%	< 1	emissivity H2O, CH4, N2O	Upper troposphere
Nitrous Oxide, N_2O	≈ 5%	< 1	H2O, CO	Mid-troposphere





- Participants across all weeks felt the training articulate adequately prepared them for the NUCAPS evaluation.

NUCAPS in 2015 HWT

- Timing of profiles
  - East: ~1730-1800
  - Central: ~1900-1930Z
  - West: 2030-2100Z

Plus ~75 minute latency to AWIPS-II

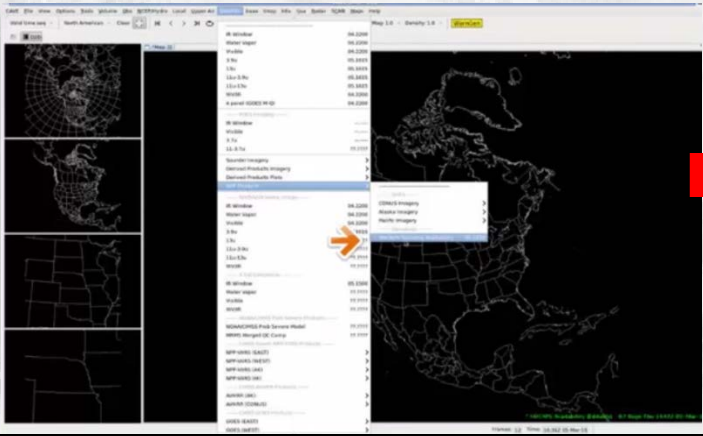
- Most common uses in HWT
  - Analysis of pre-convective environment
    - Asses instability, boundaries, etc
  - Analysis of near-storm environment
  - Comparisons with NWP, RAOBS

❖ Sfc/near-surface modifications to profiles necessary in most cases
❖ Clear-sky selections recommended

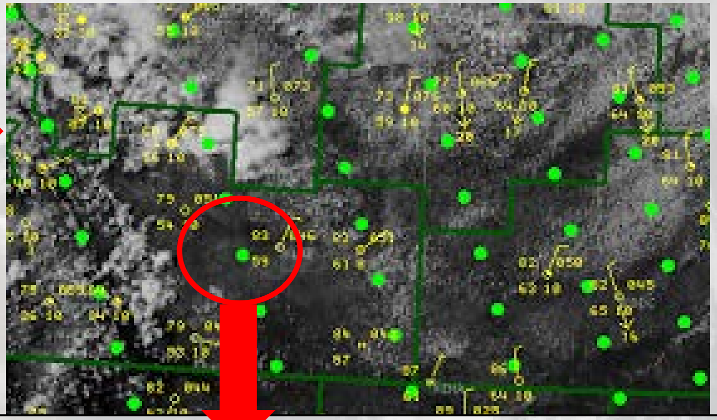
In general, forecasters felt that, when modified, the profiles provide an adequate and useful representation of the current state of the atmosphere …
… leading them to see the value in having this information to fill the spatiotemporal gaps that exist in observed sounding information.

NUCAPS Selection in AWIPS-II

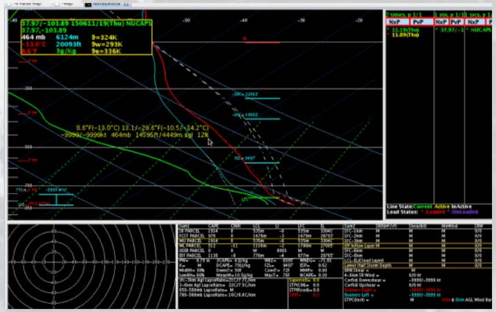
1. Load "NUCAPS Sounding Availability" with satellite imagery and sfc obs from AWIPS-II menu.



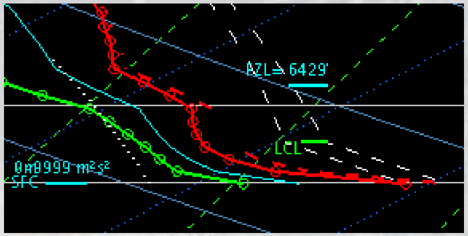
2. Sounding locations appear in AWIPS-II D2D. Select sounding in relatively clear-sky

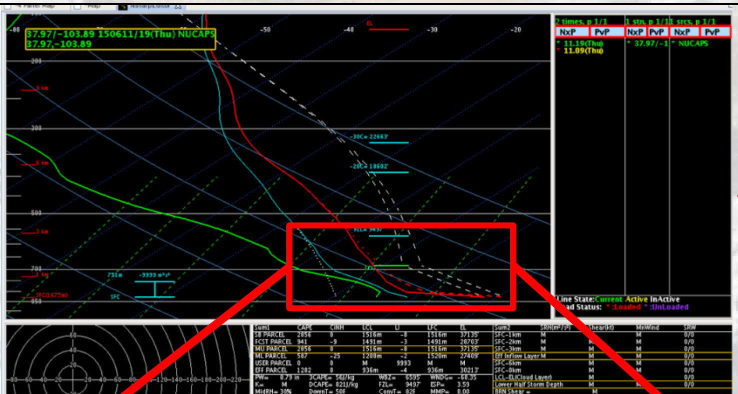


3. Temperature and Moisture profile load in AWIPS-II NSHARP skew-T application. Modify sfc if needed.

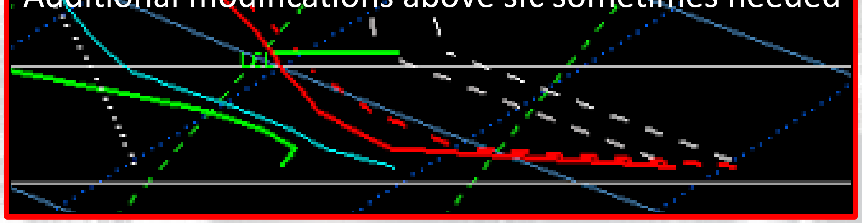


OR

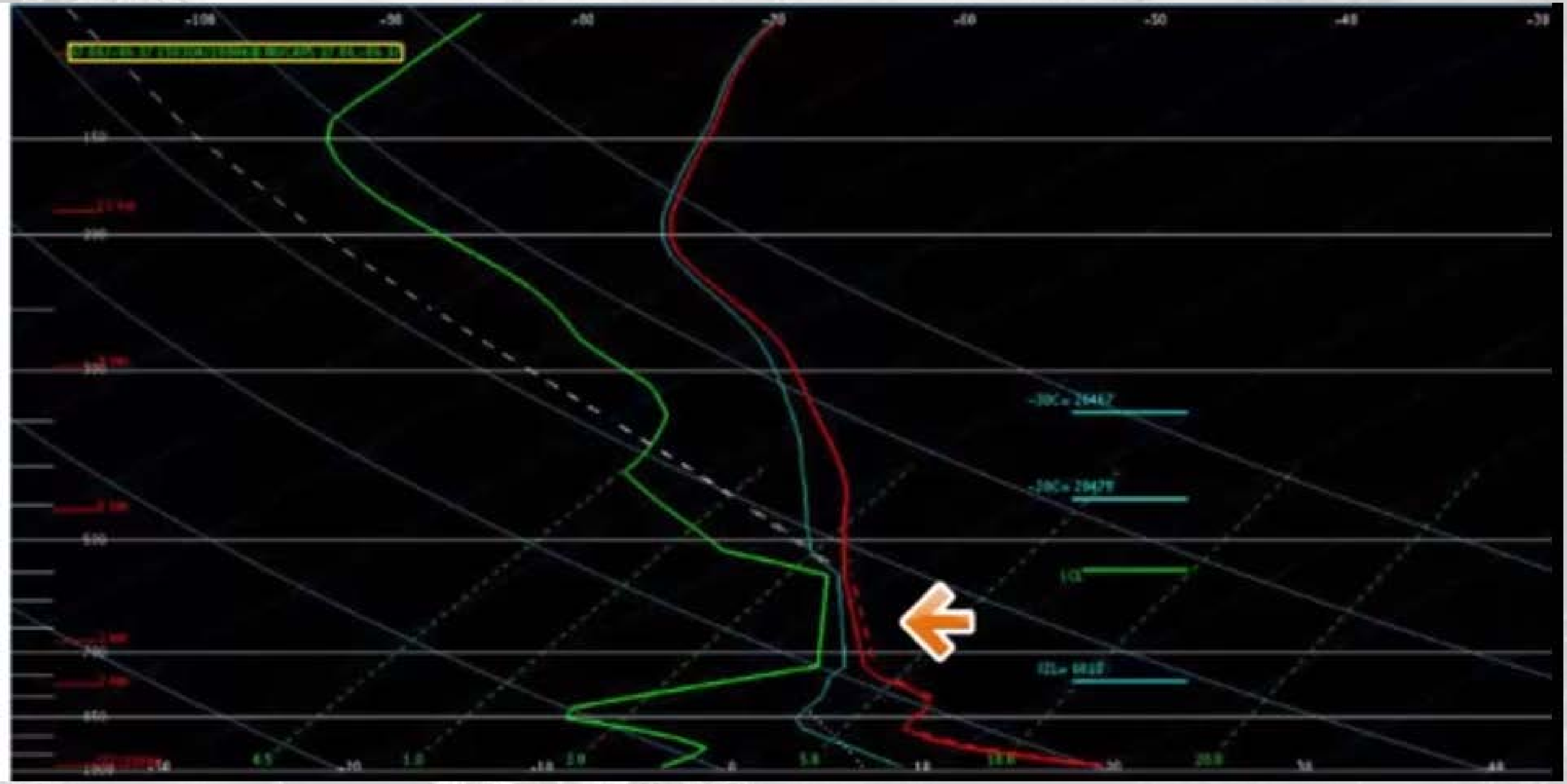




Additional modifications above sfc sometimes needed



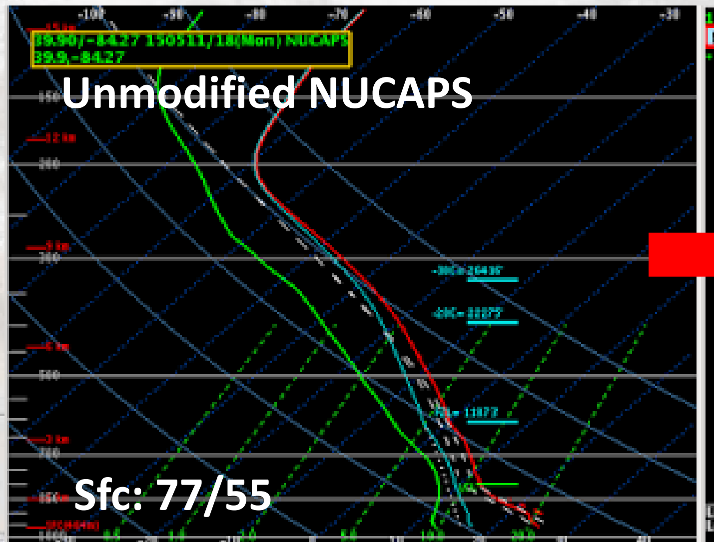
NUCAPS in Thick Clouds

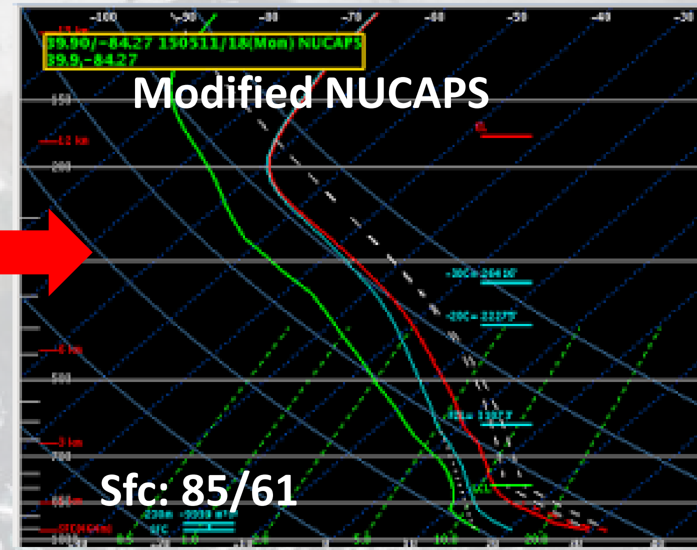


Blog Post: “Observed Radiosonde Data/NUCAPS Comparison”

May 11 - Wilmington, OH

“However, if the boundary layer temperature and dew point profile is modified using nearby METAR observations (85/61), the SBCAPE is more representative to the observed sounding (1761 vs. 1688 J/kg):”

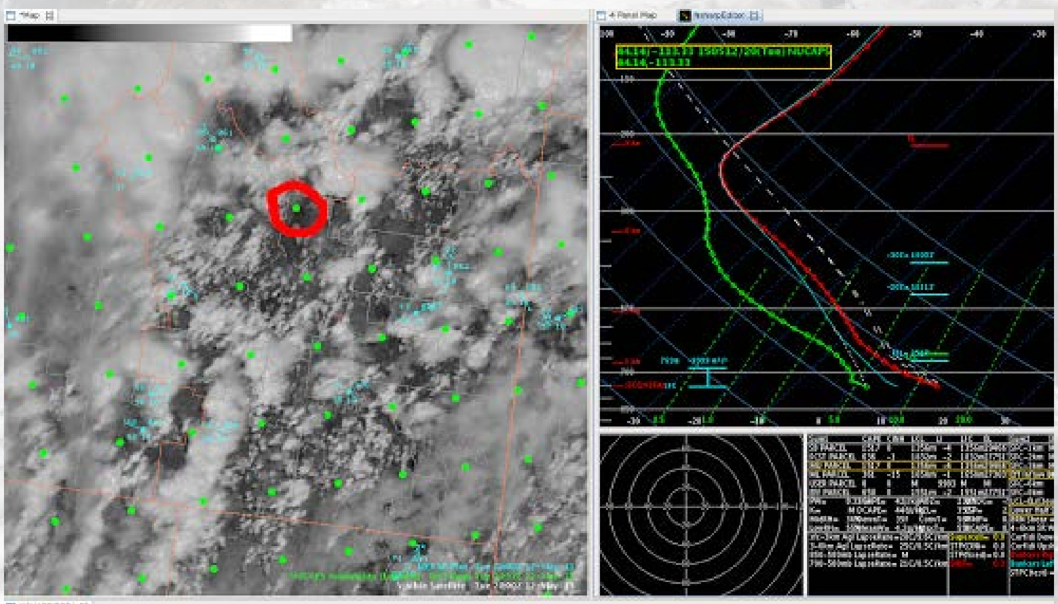




“You can't just modify the surface values, you must modify the whole mixed layer, otherwise you get unrealistic lapse rates”

Blog Post: “NUCAPS Sample”
May 12 - Pocatello, ID

- “The instability seems a little high, but it could be localized. Will see how the thunderstorms in the area develop over the next few hours….. “

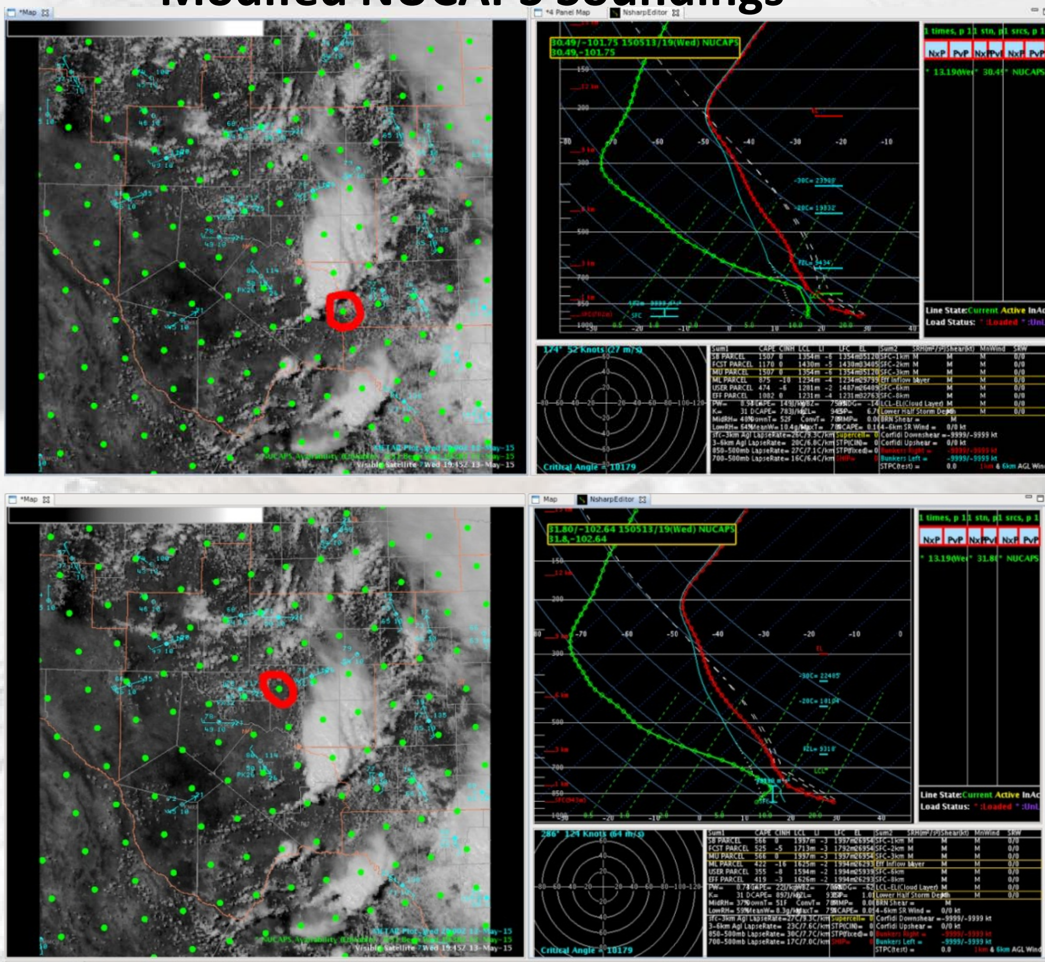


- “This thunderstorm moved over the sampled area about two hours later. It peaked at about 55-60 dBZ Composite Refl ”

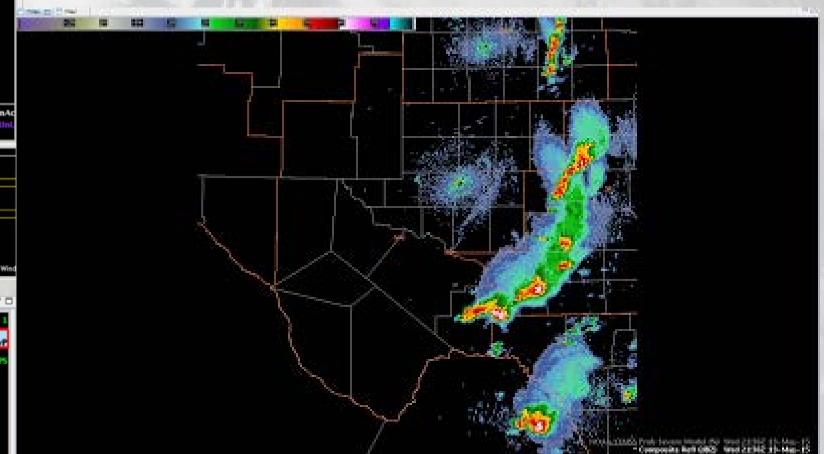
“With our office between ROAB sites, having the NUCAPS soundings will be a good way for us to get a handle on the conditions in our area.”

Blog Post: “NUCAPS Sample”
May 13 - Midland, TX

Modifed NUCAPS Soundings



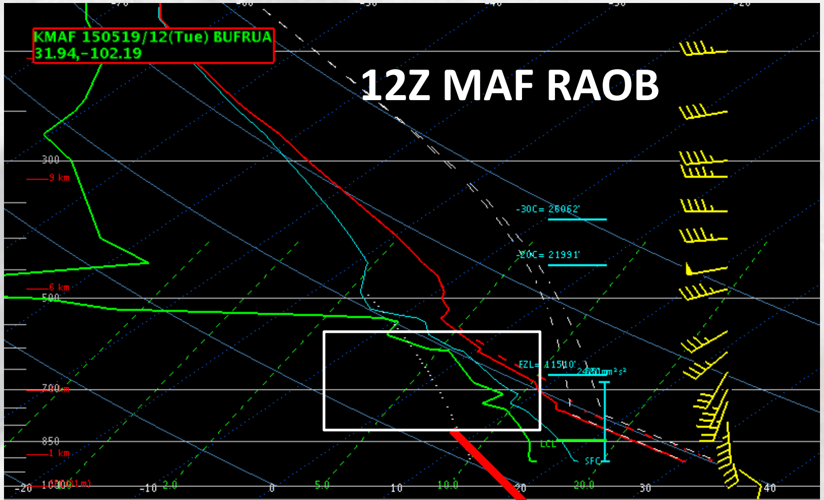
Storms moving east into this environment continued to develop and strengthen

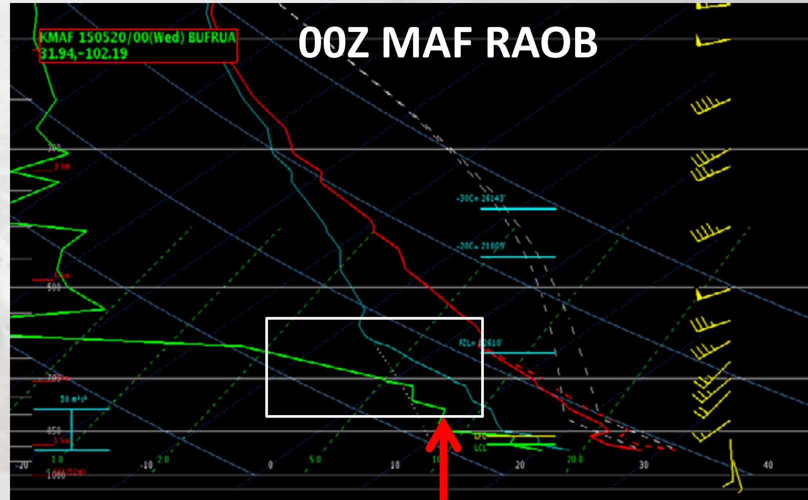


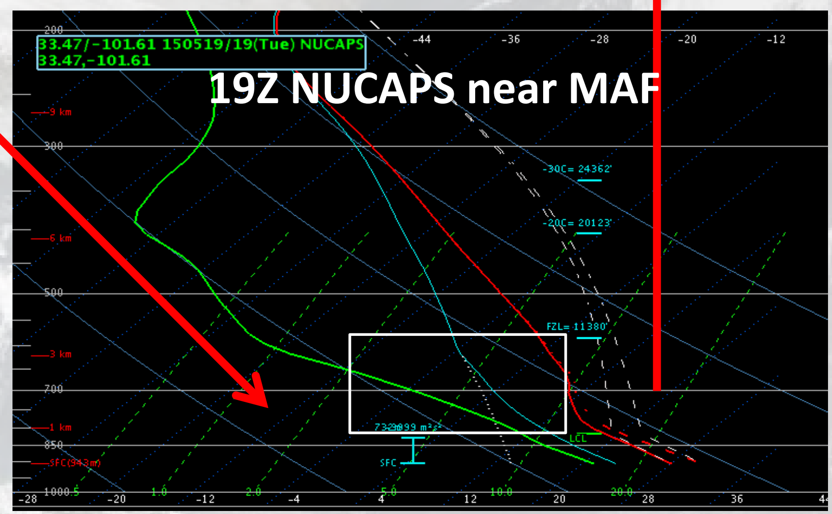
Back west, no new development in environment characterized by weaker instability and less moisture

“I liked it and thought it was useful to have today. My office is in between RAOB sites, so it would be nice to have this additional environmental information.”

Blog Post: "West Texas Soundings"
May 19 – Midland, TX







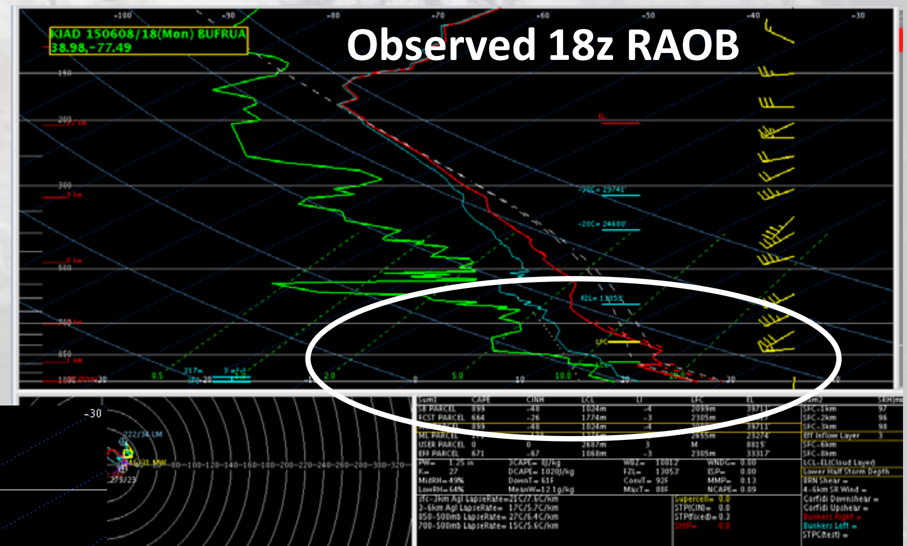
"The drying of the air at 600-800 mb since 12Z is reflected by intermediate NUCAPS soundings."

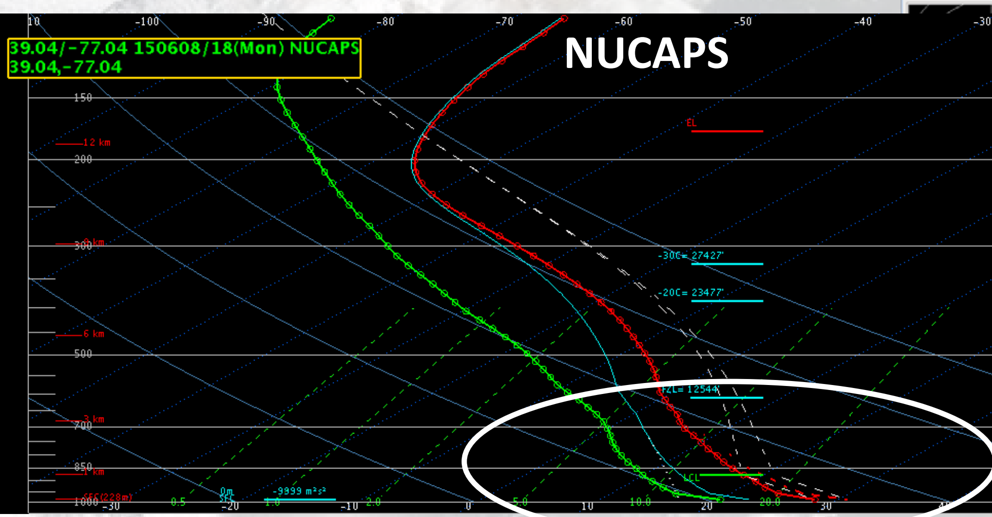
"The NUCAPS soundings are a good way to see changes in the airmass since the RAOB soundings have been taken."

Blog Post: "NUCAPS compared to Observed IAD sounding"
June 8 - Sterling, VA

- "18 UTC NUCAPS sounding near IAD, modified for IAD surface data showing 2200 J/kg when compared to 900 J/kg in the observed IAD 18 UTC sounding. The observed sounding also shows an elevated mixed layer and capping near 825 mb which is not seen in the NUCAPS sounding.

"I'm still a little suspect of the NUCAPS data as it doesn't show the fine scale detail that is so valuable in a standard RAOB."

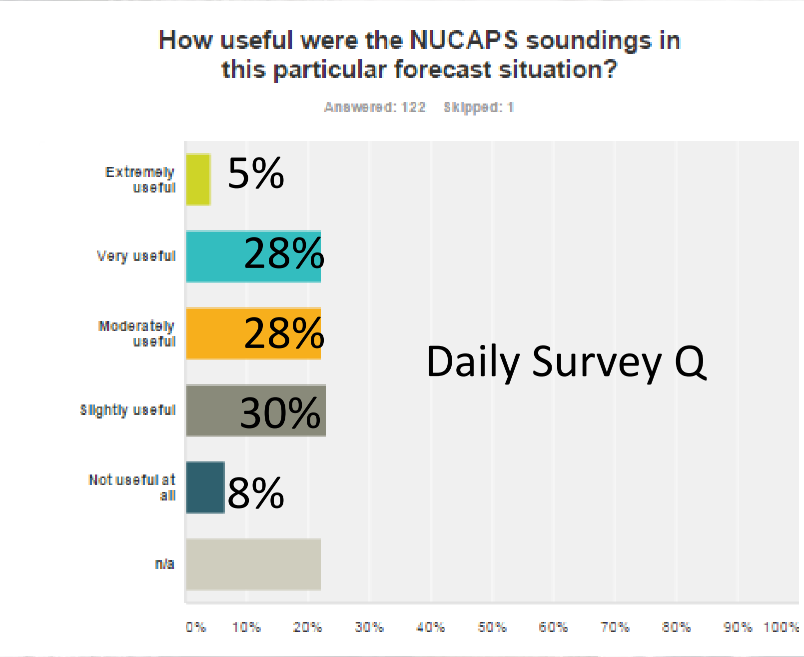


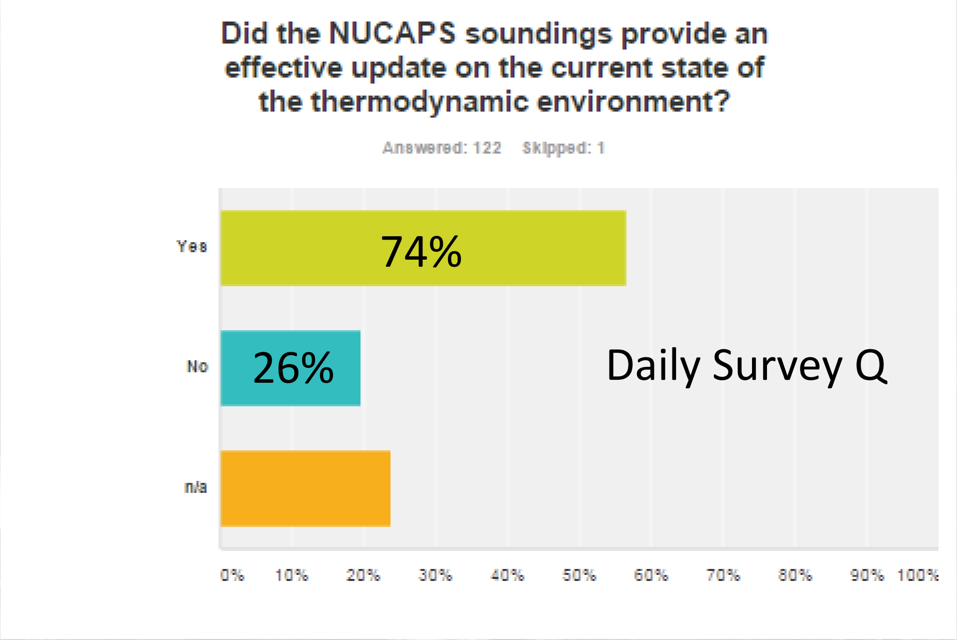


"Fusing of all the sources is really the way to go, they should all be blended together, instead of having to use them all (NWP, NUCAPS, etc)"

NUCAPS Feedback

- All participants answered that they understand the differences between space-based soundings and RAOBs
- Only 1 NWS participant already uses NUCAPS at home office (Alaska)
    - 20/23 say they will





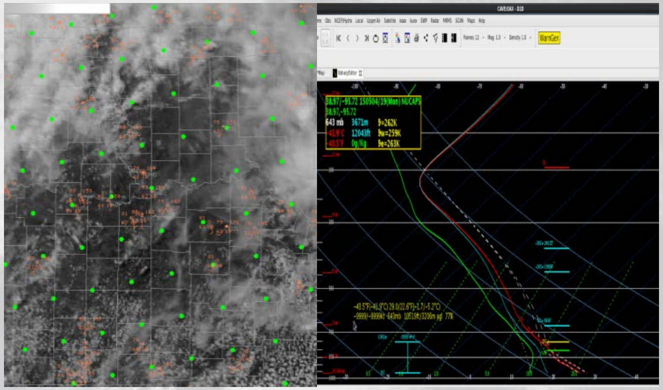
"In its current state, I would probably not use NUCAPS. It is cumbersome to modify the sounding by hand and try to determine the amount of mixing required…I would probably use it more when it automatically uses surface observations and mixes it for you."

NUCAPS Feedback

- General shape and stability/moisture parameter values seemed realistic
  - Comparable to observed soundings
- Important features and details such as capping inversions not depicted well (or at all) in the soundings
  - Stable layer sometimes apparent (bump); how to interpret this was unknown
- Surface/ML modification often necessary, too cumbersome
  - “Automating the modifications would be great, including the low-level mixing”
- QC Flags a must
  - “QC flags would give me more confidence in the soundings, as it is difficult to judge with just the cloud data.”
- Various AWIPS-II requests
- Training requests
  - More severe app examples
  - Verification statistics

- Feedback available online
  - Blog: http://goesrhwt.blogspot.com/search/label/NUCAPS
  - “Tales” webinars: http://hwt.nssl.noaa.gov/ewp/
  - Final Report: Coming soon

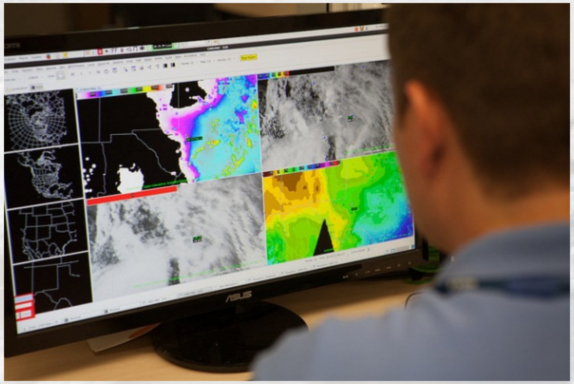
Future of NUCAPS in the HWT

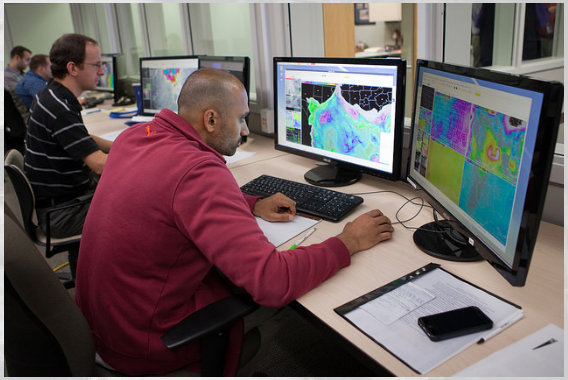


- 2016 Spring Experiment
  - Code upgrade
  - Additional satellites
  - QC flags
  - Additional visualization options
- 2017 Spring Experiment
  - Evaluate automated sfc modification NUCAPS project

BACKUP

Satellite Product Demonstrations in the HWT





- Forecaster feedback is abundant
  - Ideas for improving algorithm, enhancing display, best practices, etc.
- Test algorithms in operational systems
- Prepare/train various users for /current satellite systems
  - NWS forecasters (WFO, CWSU, SPC, etc.), broadcasters, researchers
- Foster interaction b/t research and operational communities
- Enhance/promote use of satellite data in forecast/warning ops

Some Forecaster Quotes

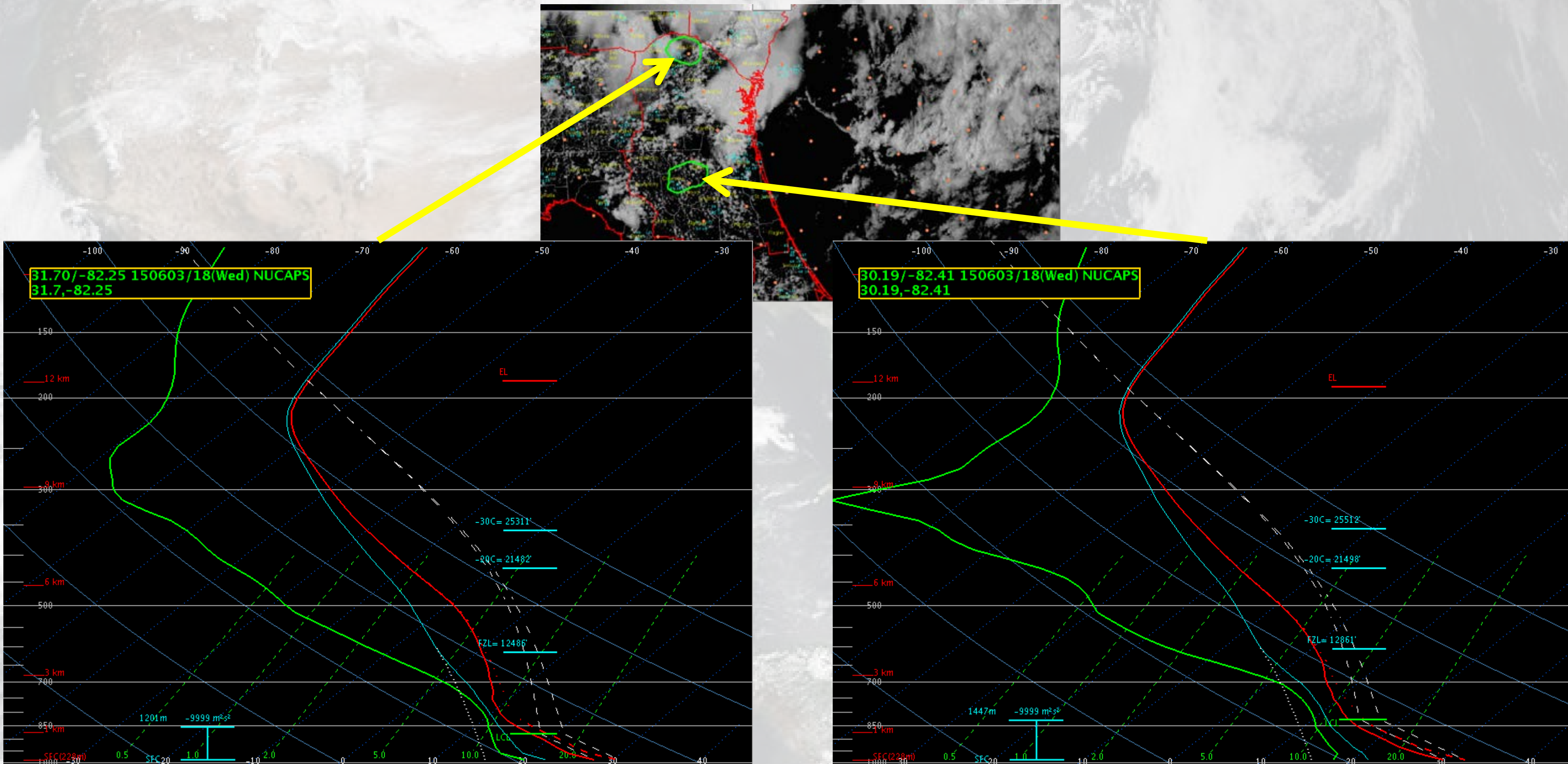
- "In San Diego, it will benefit us during the summer monsoon. Also, the San Diego RAOB is not representative of the mountains in our CWA"
- "I can see myself using this a lot in the winter."
- "Drawbacks are they are only 2x day and seem to lack the vertical resolution and critical details of inversions and moisture compared to the RAP/HRRR/RAOB."
- "I may not use it every day, but getting additional experience will help me understand the environments and situations where it will provide the most critical value."
- "Presence of a cold pocket aloft and relatively low precipitable water values around a half an inch confirm elevated convection along with the scattered reports of severe hail in eastern Idaho"
- "With our office between ROAB sites, having the NUCAPS soundings will be a good way for us to get a handle on the conditions in our area."
- "It would be helpful because the climate within our CWA varies so greatly. Our sounding is not representative of the environment over the deserts, and the nearest soundings are a bit too far and not consistent."
- "This will be great for WR where observations are more scarce."

Initial Requests (many are NSHARP-related)

- Quality control flags into AWIPS-II
- Automated correction of surface/ML conditions
- Ability to sample sounding locations "dots" for environmental information
- Provide nearest city after clicking on sounding and/or include map in sounding window with location marked
- Indicator in display after a sounding has been clicked
- Undo button when editing profile
- Overlay NUCAPS soundings with others (NWP, RAOB, etc)
- Make sure the AWIPS fix is implemented
  - Many requests for this code already have been fulfilled.

Blog Post: "Comparing NUCAPS Soundings at Two Locations in the FA"
June 03 – Jacksonville, FL

- "Having the NUCAPS soundings available was important to my situational awareness in this particular case… At my office in Columbia, SC, we do not have upper air and there really aren't any upper air sites close by, so having these available would be extremely beneficial."



The Utility of NUCAPS in Operational Forecasting

2015 STAR JPSS Annual Science Team Meeting

Daniel Nietfeld
Science and Operations Officer (SOO) NWS-WFO Omaha
Branch Chief (Acting) NCEP-WPC Development and Training Branch

Hopeful Takeaways

- The Appeal of NUCAPS
- Issues for Forecasters to be aware of
- Forecasters’ sense of understanding “error”
- Ultimately…foster user-developer collaboration
  - R2O
  - O2R

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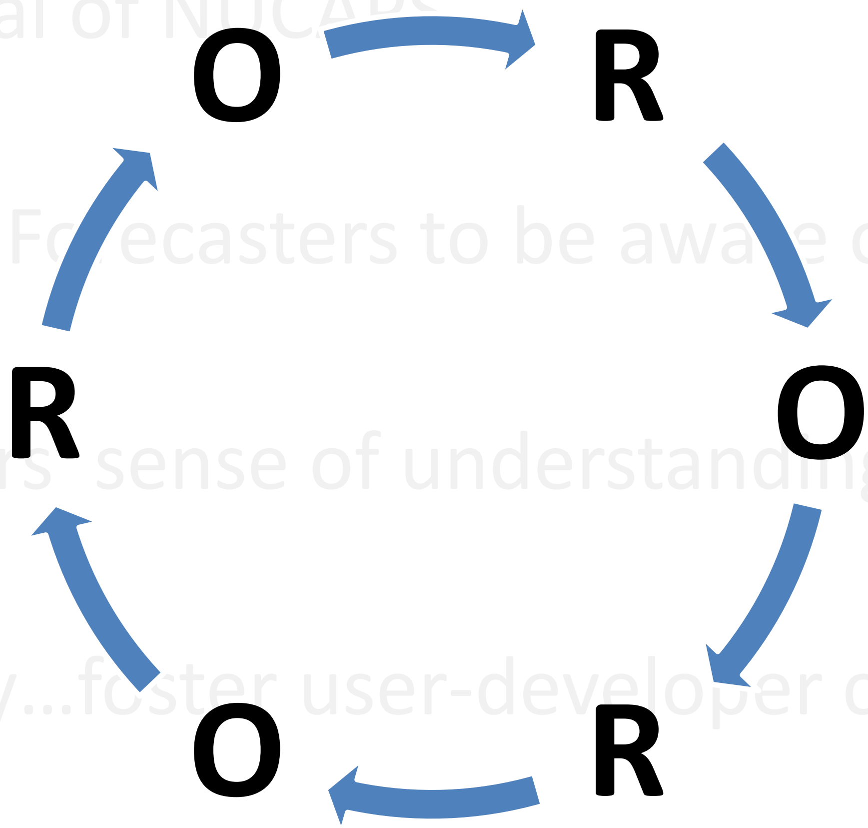
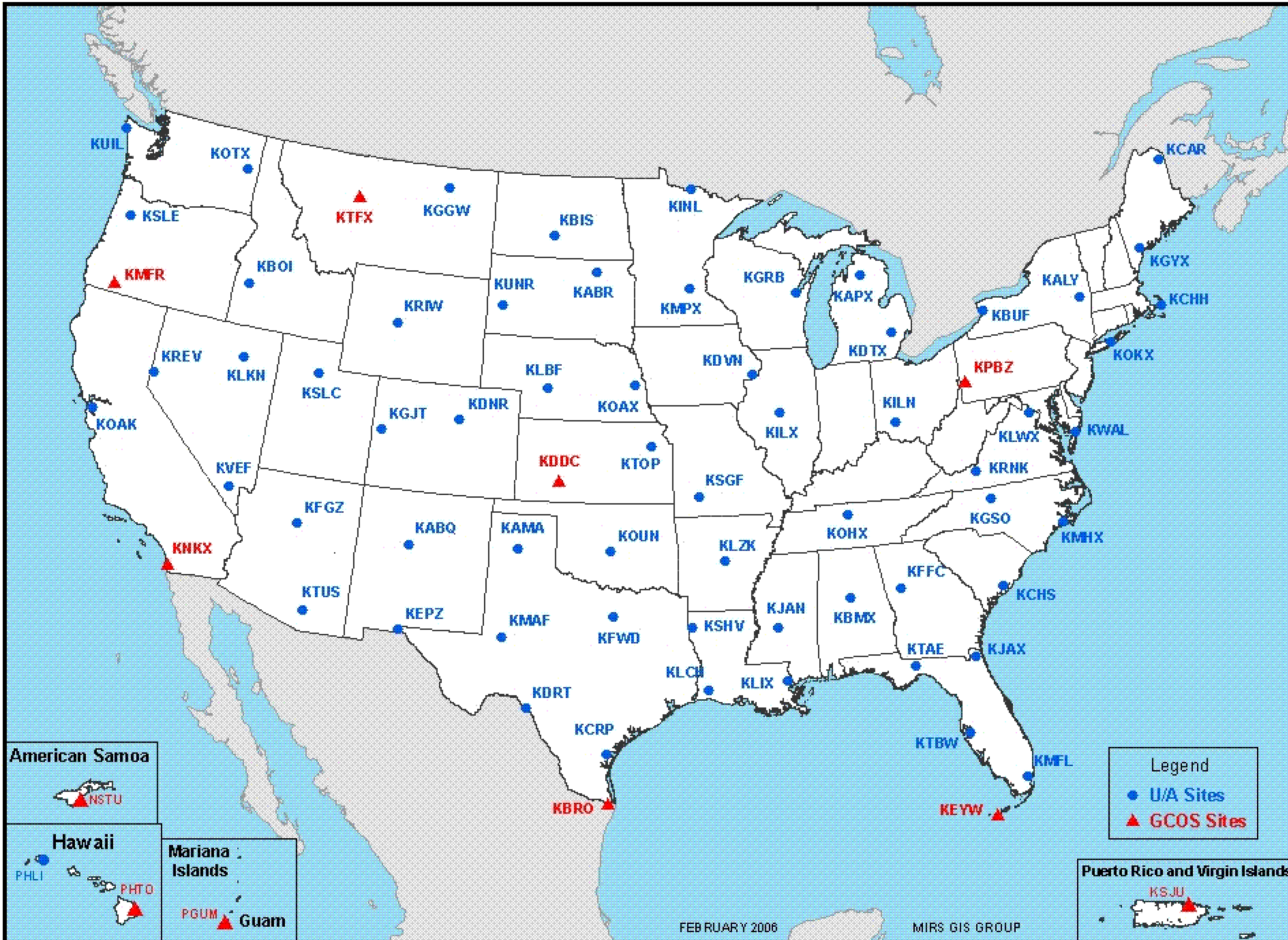


Day in the Life of a Forecaster in a Midwest WFO

- Convection is a common forecast problem
- Accustomed to looking at the 12Z RAOB, with density of ~ 2 per state


KUIL
KOTX
KTFX
KGGW
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KINL
KCAR
KSLE
KMFR
KBOI
KUNR
KABR
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KAPX
KGYX
KALY
KCHH
KRIW
KMPX
KBUF
KDTX
KOKX
KREV
KLKN
KSLC
KLBF
KDVN
KPBZ
KOAK
KGJT
KDNR
KOAX
KILX
KILN
KWAL
KLWX
KVEF
KDDC
KTOP
KSGF
KRNK
KFGZ
KABQ
KAMA
KOUN
KLZK
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KCHS
KTUS
KEPZ
KMAF
KFWD
KSHV
KJAN
KBMX
KTAE
KJAX
KLCH
KLIX
KDRT
KCRP
KTBW
KMFL
KBRO
KEYW
Legend
U/A Sites
GCOS Sites
American Samoa
NSTU
Hawaii
PHLI
PHTO
Mariana Islands
PGUM
Guam
Puerto Rico and Virgin Islands
KSJU
FEBRUARY 2006
MIRS GIS GROUP

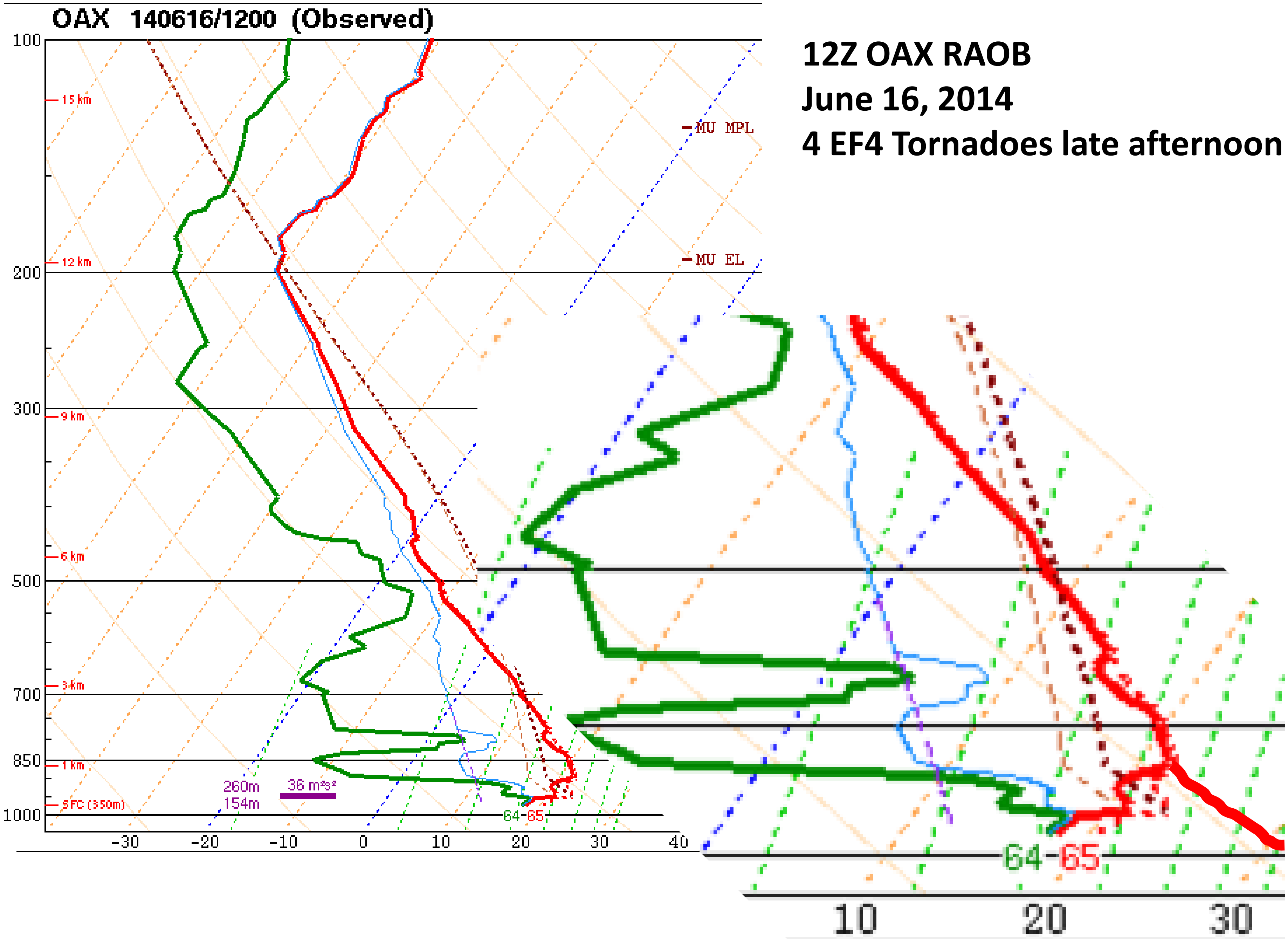
Day in the Life of a Forecaster in a Midwest WFO

- Convection is a common forecast problem

- Accustomed to looking at the 12Z RAOB, with density of ~ 2 per state

- During the pre-convective, early afternoon, I modify the 12Z RAOB for current surface conditions, and try to modify it for any changes in the airmass (from upstream)

12Z OAX RAOB
June 16, 2014
4 EF4 Tornadoes late afternoon

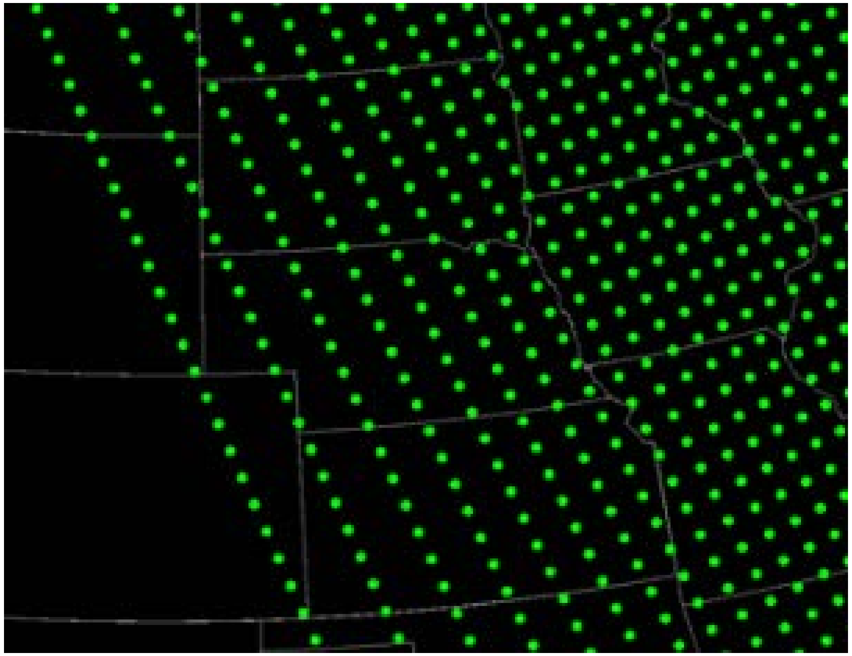


Day in the Life of a Forecaster in a Midwest WFO

- 18Z Special RAOB is a ***rare*** luxury (a few per year)
  - I don't have to guess about the airmass changes
  - I typically still need to tweak the surface conditions due to the sensitivity to dewpoint
- We occasionally get an Aircraft observation
- I look at all of my data with some sense of the margin of error *(and I try to learn what that margin of error is).*
  - Observations from instrumentation
  - NWP

Quote from a Forecaster:

- "Last year some really smart people gave me 23 satellite sounding retrievals over my area in the 18Z-19Z timeframe!"
  - Using a new polar orbiter satellite
  - With a hyperspectral IR sounder and microwave sounder



June 2014 Proving Ground/Readiness Meeting
NUCAPS on AWIPS2 at WFO OAX

How can we take advantage of these observations??? *(Over one year later…)*

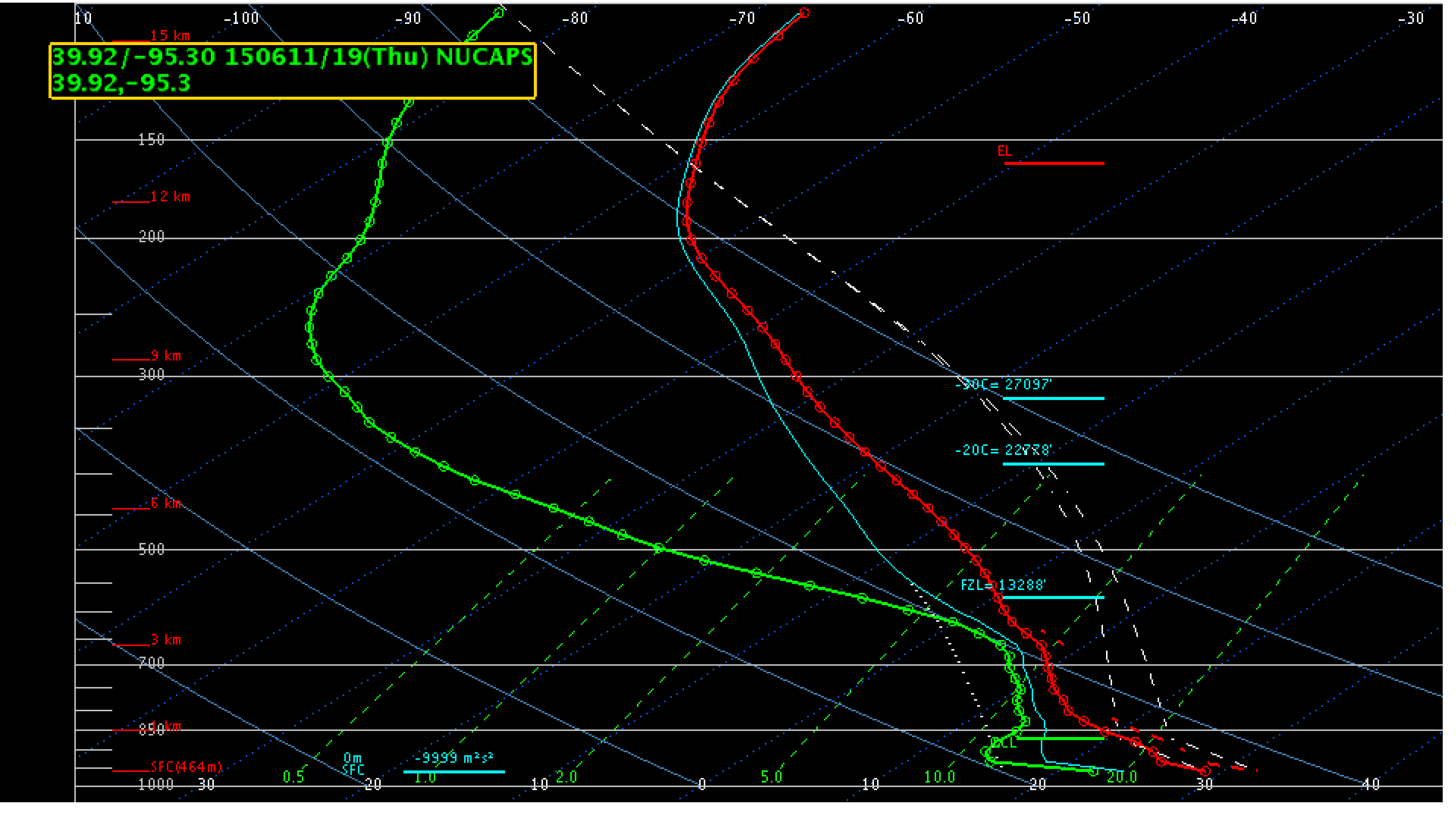
- Learned a lot from Chris Barnet and Antonia Gambocorta about the details of how the retrievals are obtained/created
  - Strengths (benefits)
  - Weaknesses (limitations)

- Beneficial training material has been developed

- Great interaction between developers and field forecasters *(and through the Hazardous Weather Testbed…)*

Issue #1: Smoothing

- Vertical resolution is a bit course
  - ~20 temperature layers
  - ~10 moisture layers
- Significant smoothing
- Identification of warm capping layers
- Identification of dry layers aloft (downburst potential)

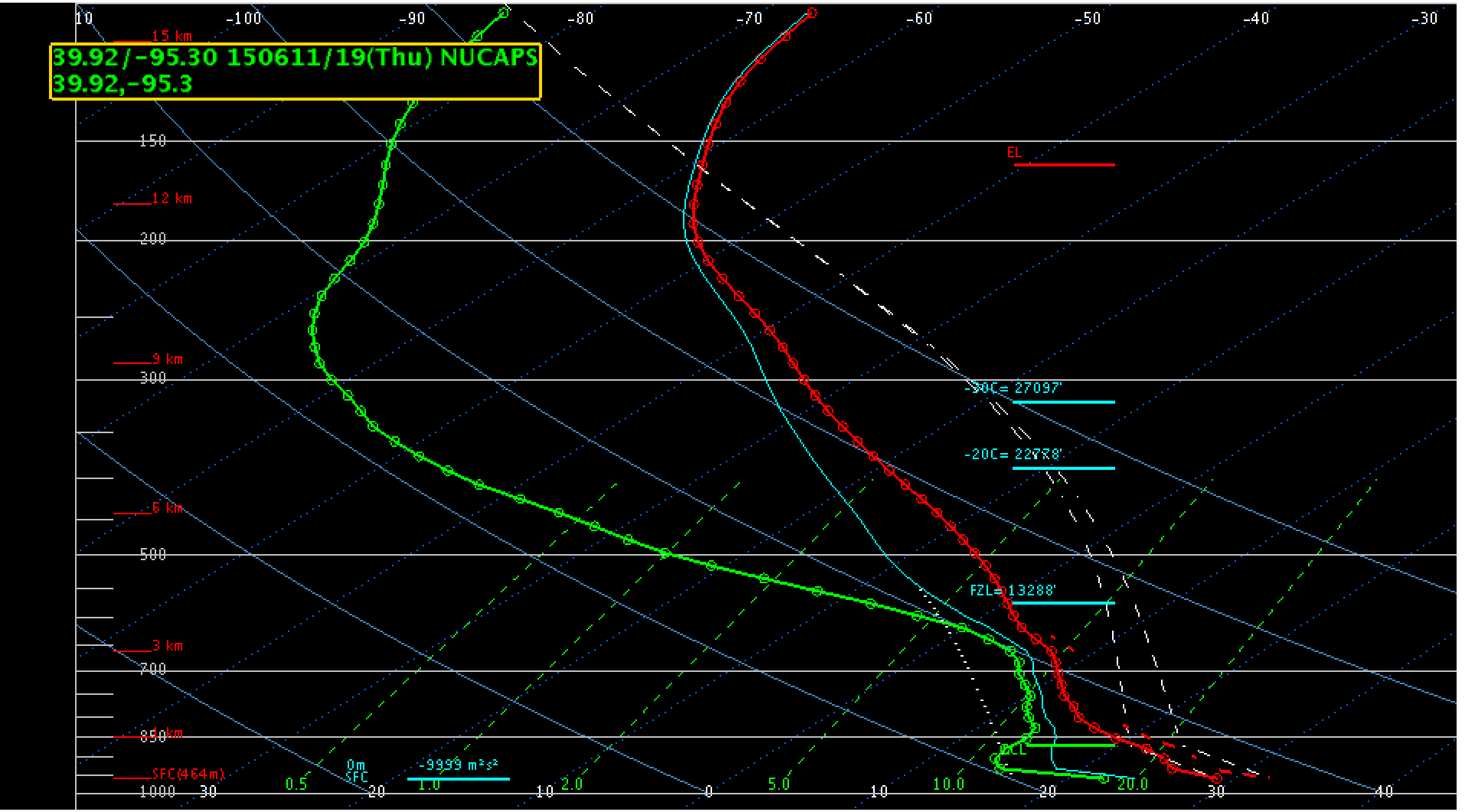


39.92/-95.30 150611/19(Thu) NUCAPS
39.92,-95.3
-100
-90
-80
-70
-60
-50
-40
-30
15 km
12 km
9 km
6 km
3 km
SFC(464m)
150
200
300
500
700
850
1000
EL
-30C= 27097'
-20C= 22778'
FZL= 13288'
0m
SFC
-9999 m²s²
0.5
1.0
2.0
5.0
10.0
20.0
30
20
10
0
10
20
30
40

Issue #2: Surface/BL Modification

- Modification is necessary 99+% of the time due to errors in surface T and Td
- Techniques, such as SPC's SFCOA, have been used to objectively modifying the low levels of a sounding (RAP) using METARs
- Automation of Sounding Modification at the Surface and in the BL

"**Improving NUCAPS Soundings for CONUS Severe Weather Applications via Data Fusion**"
- Dan Lindsey PI

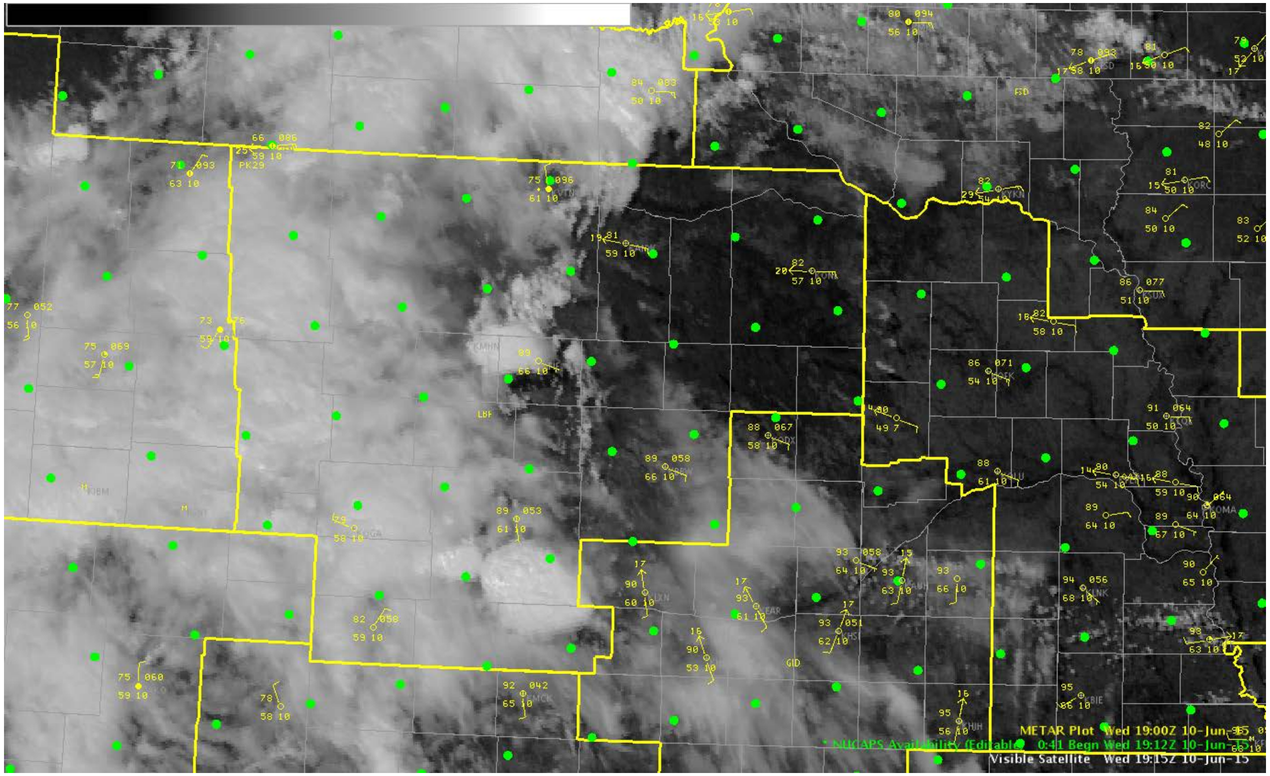


39.92/-95.30 150611/19(Thu) NUCAPS
39.92,-95.3
15 km
12 km
9 km
6 km
3 km
SFC(464m)
150
200
300
500
700
850
1000
-100
-90
-80
-70
-60
-50
-40
-30
EL
-30C= 27097'
-20C= 22778'
FZL= 13288'
LCL
0m
SFC
-9999 m²s²
0.5
1.0
2.0
5.0
10.0
20.0
30
20
10
0
10
20
30
40

Issue #3: Clouds/Rain Errors

- Extra caution/scrutiny is needed

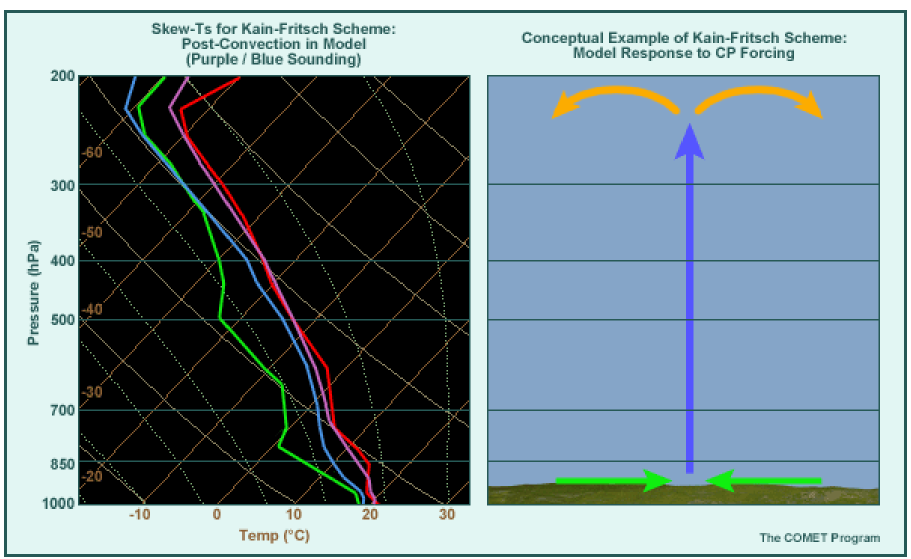
Excited about the recent improvements!

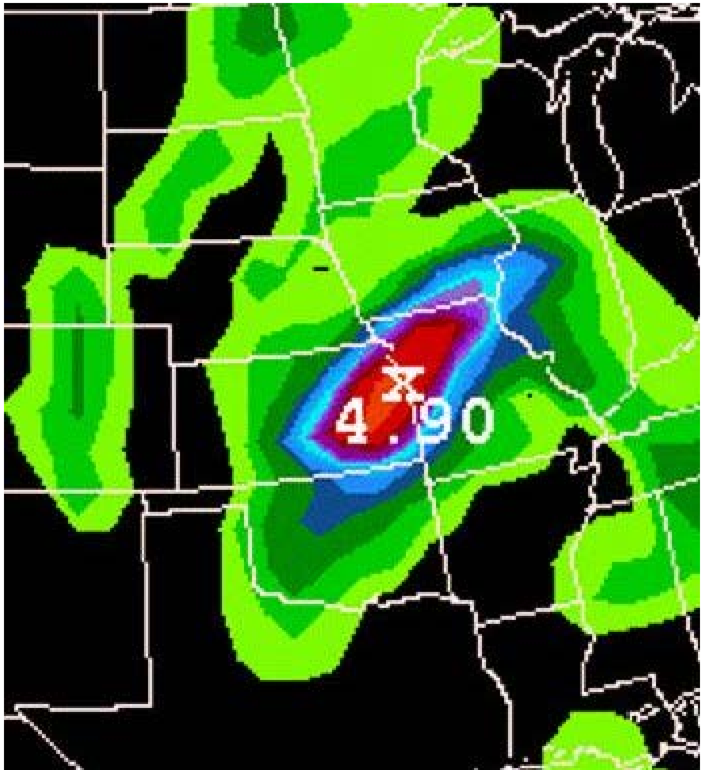


Why not use the NWP sounding?

- Sometimes do, but subject to NWP issues/errors
- Soundings within model convection

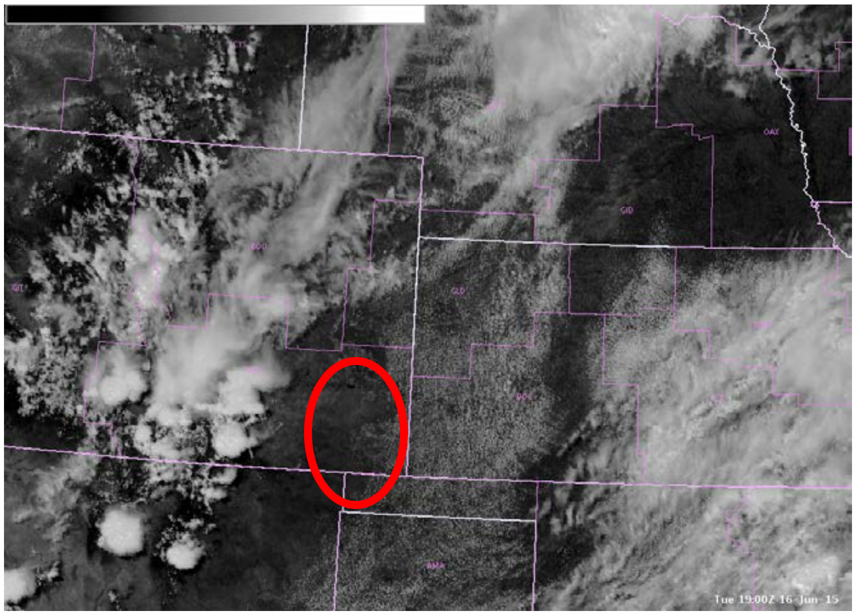
Convective Parameterization Schemes result in unrealistic profiles





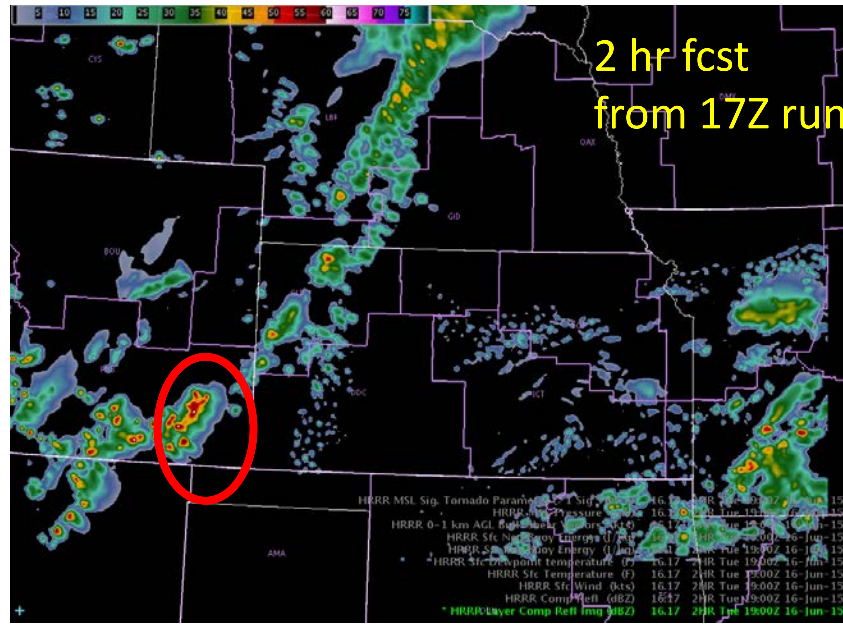
Real vs. Modeled

Observed GOES Visible

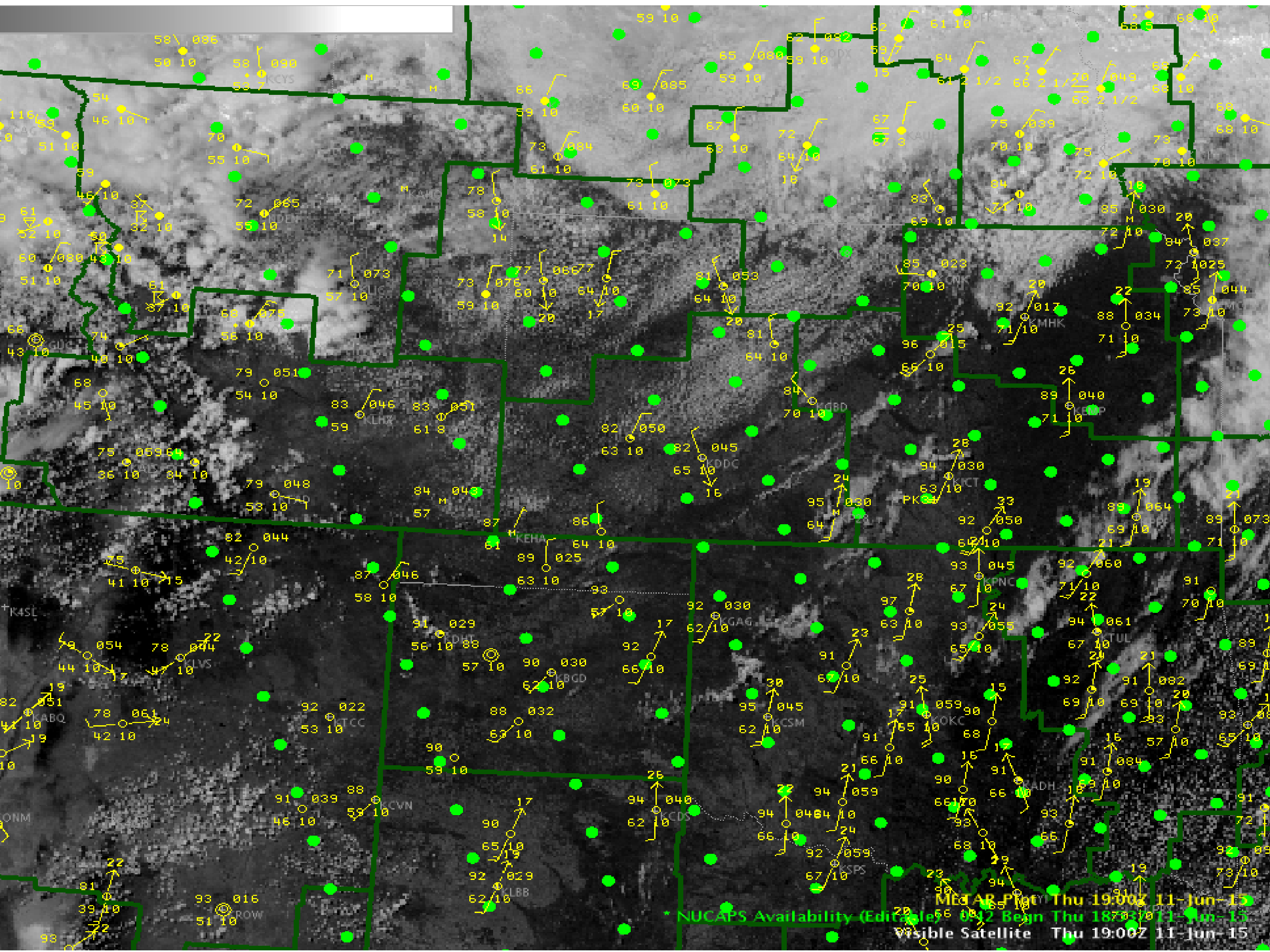


1900 UTC June 16, 2015
Atmosphere with clear, blue sky

HRRR 2-hr forecast

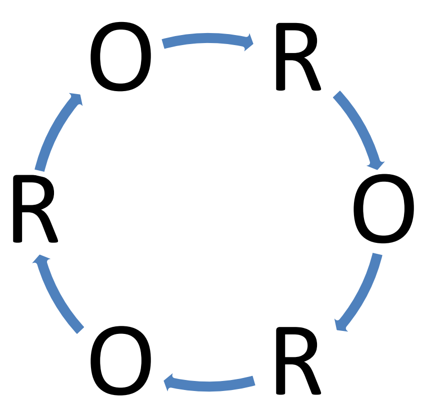


1900 UTC June 16, 2015
Atmosphere with deep convection


METAR Plot Thu 19:00Z 11-Jun-15
* NUCAPS Availability (Editable)
Visible Satellite Thu 19:00Z 11-Jun-15

A Case for O2R/R2O

- Forecasters are difficult to predict
- Generally, good things come from interaction between forecasters and researchers/developers
  - What the users' needs are
  - What the developers can provide
    - Bias Tuning
    - Sources of error and improvements
- We won't know if we can't explore

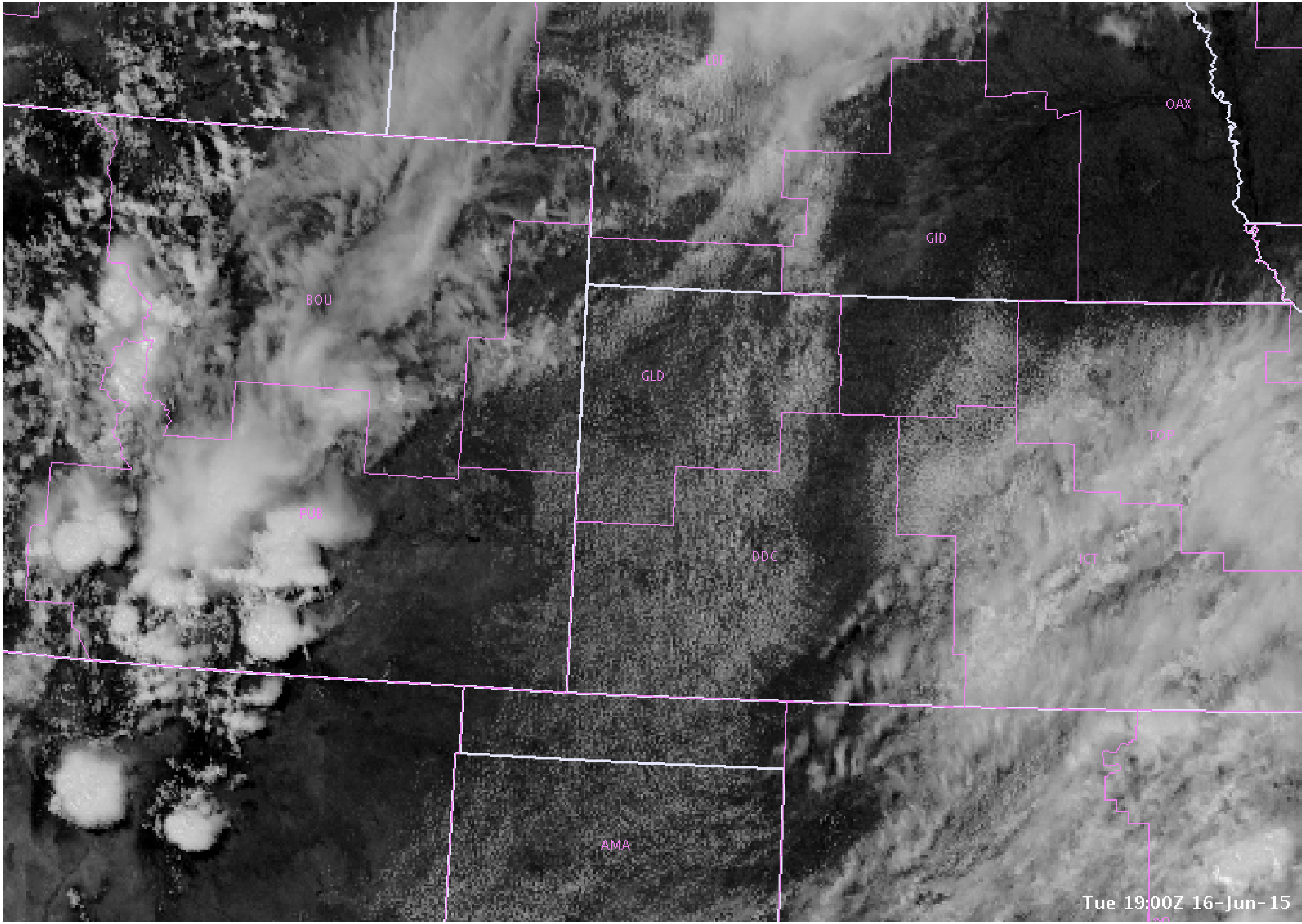


THANK YOU for this opportunity and for this technology!

The Utility of NUCAPS in Operational Forecasting

2015 STAR JPSS Annual Science Team Meeting

Daniel Nietfeld
Science and Operations Officer (SOO) NWS-WFO Omaha
Branch Chief (Acting) NCEP-WPC Development and Training Branch


LBF
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DDC
ICT
AMA
Tue 19:00Z 16-Jun-15

Hyperspectral OLR for Improved Climate Applications

P. Xie

Acknowledgements:
F. Sun, A. Vintzileos, C. Long, S.-K. Yang, J. Gottschalck, Mark Liu,T. Schott, and M. Glodberg

2015.08.27.

Presented at
2015 JPSS Science Team Meeting

Background

1) OLR is an important component of climate

- Outgoing longwave radiation (OLR) is a primary component of the global and regional energy budget and transfer
- Estimation of OLR made from satellite measurements has been widely used for nearly 40 years:
  - Quantifying energy budget of the earth system
  - documenting the state and variations of the atmospheric system;
  - *monitoring and assessments of climate variability*
  - *estimating precipitation over the tropical and sub-tropical regions*

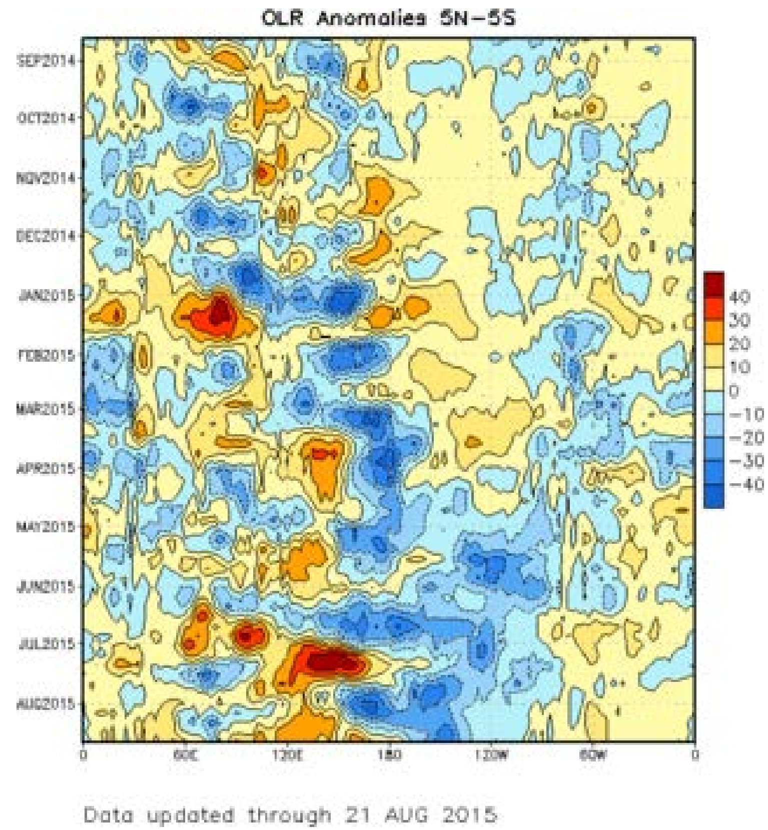


Figure 1: Time-longitude section of pentad OLR anomaly over the tropics (5^{o}S-5^{o}N), used by NOAA Climate Prediction Center for the monitoring of Madden – Julian Oscillation (MJO). (copied from NOAA/CPC Official Webpage: (http: //www.cpc.ncep.noaa.gov /products /precip/CWlink/MJO/mjo.shtml)

Background

2) Current CPC Operational OLR data has problems

- Poor estimation accuracy restricted by the narrow band observations from the AVHRR;
- Insufficient use of observations from all available satellites due to the strategy to use the OLR data only from the afternoon satellites to reduce the impacts of the OLR diurnal cycle to the definition of the daily mean;
- Artificial trends and discontinuities caused by orbit shifts of the NOAA polar satellites and the imperfect instrument inter-calibration (figure 2); and
- Coarse time and space resolution (monthly – pentad : 2.5^{o}lat/lon) to resolve individual weather systems associated with MJO and other climate variability.

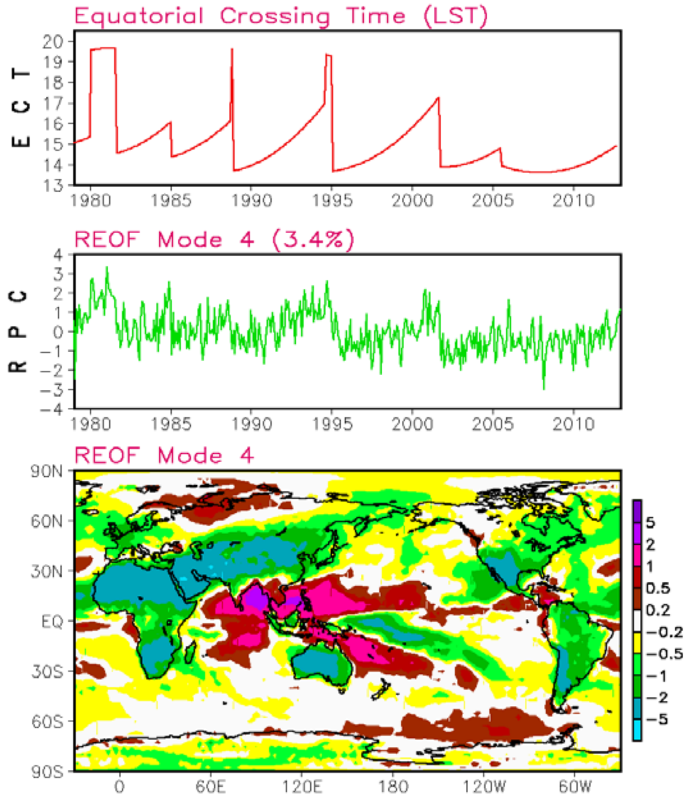


Figure 2: Time series (middle) of the principal component (PC) and the spatial loading (bottom) of the forth mode of the rotated EOF analysis of the CPC AVHRR OLR monthly anomaly, together with (top) the time series of the equator crossing time (ECT) of the NOAA polar orbiting satellites from which the AVHRR data are utilized to construct the NOAA OLR. Correlation between the satellite ECT and the OLR time series, together with the land/ocean contrast in the EOF spatial loading, indicate that the ECT changes have produced artificial variability of OLR due to the sampling different phases of the diurnal cycle.

Background

3) Hyperspectral OLR for improved climate monitoring

- Broadband OLR not available on a real-time (<1day) basis
- Techniques developed to derive OLR from **the hyperspectral** measurements of infrared radiance from advanced sensors:
  - *The Atmospheric Infrared Sounder (AIRS)*
  - *The Infrared Atmospheric Sounding Interfermeter (IASI), and*
  - *The Cross-track Infrared Sounder (CrIS)*
- NESDIS Operations has started the routine production of the level-2 OLR orbit data from the IASI hyperspectral measurements onboard the MetOp-A satellite

Goal and Objectives:

- **Long-term goal**

Developing next generation NOAA OLR data capitalizing the technology advances in the satellite OLR achieved in recent years

  - *Combined use of OLR measurements from multi-platform / multi-sensors*
  - *substantially improved quantitative accuracy*
  - *refined spatial/ temporal resolution (at least 0.25^{o}lat/lon; daily)*
  - *reduced temporal in-homogeneities*
  - *covering an extended period from 1979*
  - *updated on a quasi real-time basis*

- **First step**
  - *Examining strategy to transition the newly available high-resolution, high-quality **IASI OLR** for enhanced operational climate monitoring, climate analysis, and climate model verifications at CPC.*

IASI OLR

1) What we have achieved

- Reprocessing

  Generated Level 2 hyperspectral OLR data from both the MetOp A and B satellites for the entire time periods

- Adjusting the IASI OLR against AVHRR climatology

  The raw IASI OLR is adjusted against the AVHRR long-term climatology

- Real-time system

  Established real-time processing system at CPC to receive the L1 data from NESDIS, generate L2 IASI OLR, adjust the IASI OLR against AVHRR and produce gridded fields for climate applications

IASI OLR

2) Comparison with operational AVHRR OLR

- Operational OLR (top)
  - *The operational CPC OLR is derived from infrared window channel measurements of AVHRR using empirical relationships;*
  - *Only OLR data from one single satellite (afternoon satellite) are used;*
  - *Currently the AVHRR OLR is from NOAA 18, with an orbit time of ~03-04PM*
- IASI OLR (middle)
  - *Derived from hyperspectral measurements aboard a satellite with a different orbit time (~09AM);*
- Their differences (bottom)
  - *The differences are quite large, at 5-10 W/m2*
  - *Especially, large differences are observed over tropics and over oceanic dry zones (e.g. SE Pacific, SE Atlantic), water vapor over where Is detected by IASI but not the AVHRR;*

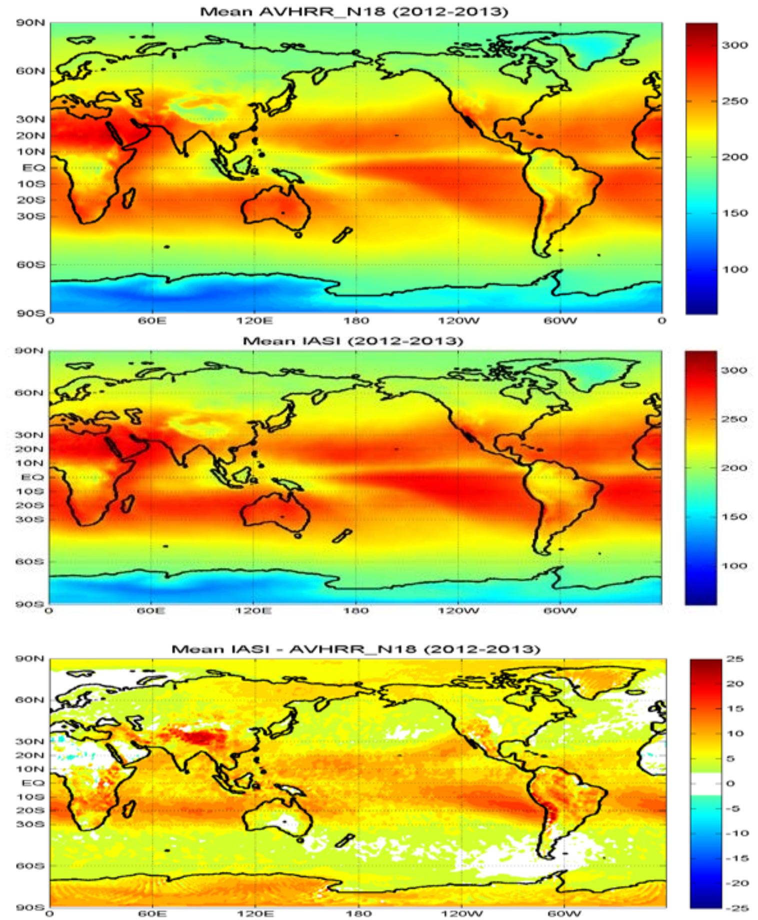
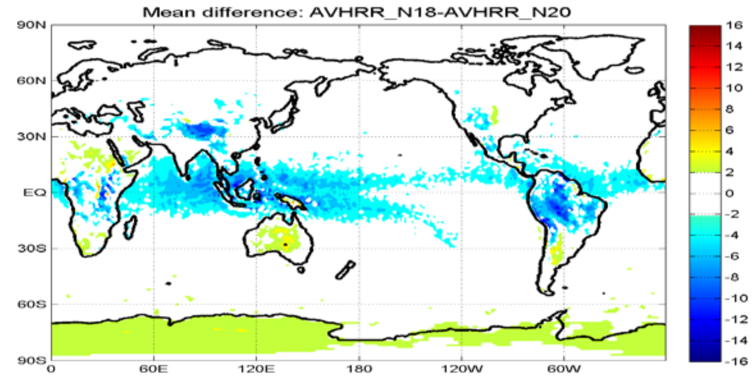


Figure 5: 2012-2013 annual mean OLR (W/m^2) Derived from (top) AVHRR aboard NOAA18 and (middle) IASI aboard MetOP A, as well as (bottom) the differences between the two OLR data sets.

IASI OLR

3) Attributions of the IASI/AVHRR OLR differences

- Total OLR differences
  - *The differences shown in figure 5 are attributable to two factors: observation time and sensor/algorithm differences*
- Effects of different observation times (top)
  - Overall, quite small;
  - Relatively larger over tropics, especially over tropical land where diurnal cycle presents large magnitude
- Differences caused by different sensor /algorithm
  - *Dominating factor of the IASI/AVHRR OLR differences*
  - *Throughout the globe*
- ***Inter-calibration is needed between IASI and AVHRR OLR.***



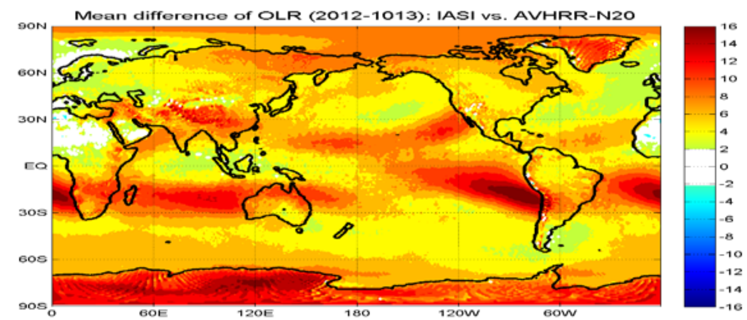


Figure 6: 2012-2013 mean OLR differences (W/m^2) between AVHRR OLR from NOAA 18 and MetOP A; and (bottom) AVHRR and IASI OLR from the same satellite (MetOP A).

IASI OLR

4) Inter-calibration between IASI and AVHRR OLR

- Differences between IASI and AVHRR OLR
  - *Further inter-comparison between the IASI and AVHRR OLR shows the differences present regional / seasonal variations and perform as a function of OLR magnitude*
- Inter-calibration through PDF matching
  - *A prototype algorithm is developed to perform inter-calibration between the IASI and AVHRR OLR through matching the probability density function (PDF) of the two OLR data sets;*
  - *PDF tables are established for each grid box of 1°lat/lon and for each calendar month using the col-located IASI and AVHRR OLR data over 3-month sliding window centering at the target calendar month and over a 3°lat/lon square centering at the target grid box;*
- ***The Differences in OLR are largely vanished after the PDF***

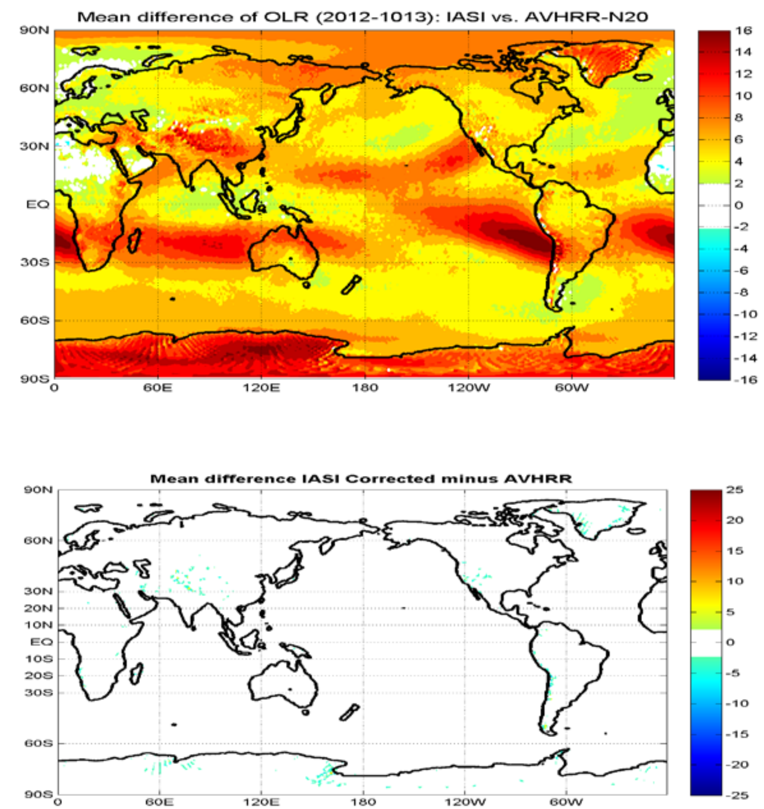


Figure 7: 2012-2013 mean OLR differences (W/m^2) between the IASI and AVHRR aboard MetOP A (top) before and (bottom) after the PDF calibration.

Applications of IASI OLR

1) Improved capacity to detect strong convection

- With a refined spatial resolution of 0.25^{o}lat/lon, the IASI OLR is capable of quantifying the intensity of convection at a meso-scale cloud systems scale;
- Standard deviation of OLR inside a 1^{o}lat/lon grid is very large, especially over ITCZ and land areas of strong convection where the standard deviation may reach 15W/m^2 or greater;
- Climate monitoring using OLR data on a 1^{o}lat/lon grid, like the current operational AVHRR OLR, may substantially under-estimate the intensity of convective activities.

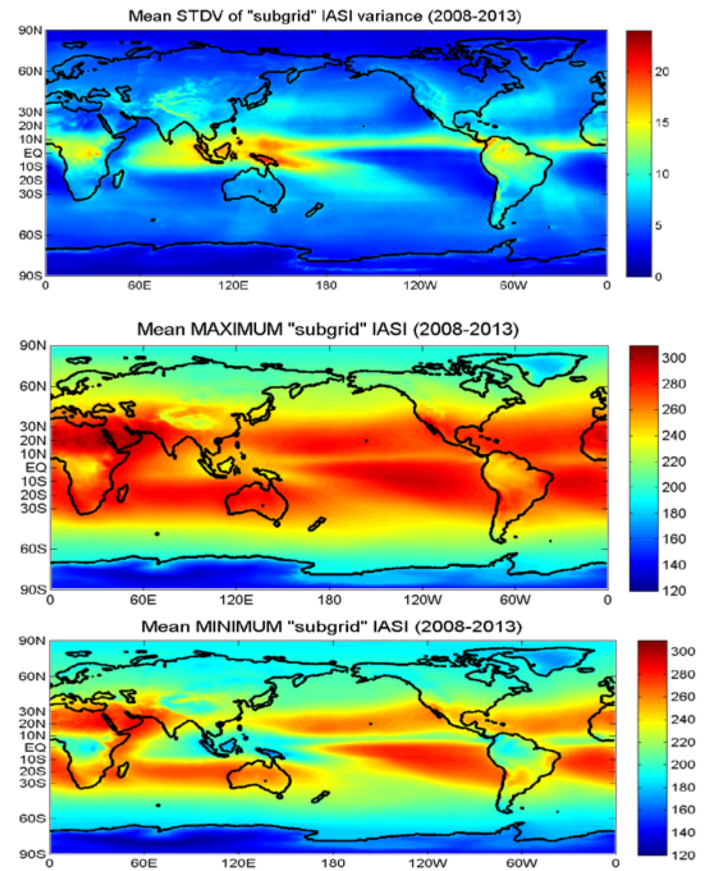


Figure 8: (Top) standard deviation, (middle) maximum, and (bottom) minimum of OLR values over 16 0.25^{o}lat/lon grid boxes with a 1^{o}lat/lon grid box. Statistics are averaged over 6 year period from 2008 to 2013. Units are all in W/m^2.

Applications of IASI OLR

2) Enhancing the tropical monitoring

- With refined spatial resolution and improved capacity to detect strong convection, the IASI OLR provides a powerful mean to monitor tropical convection and its evolution;

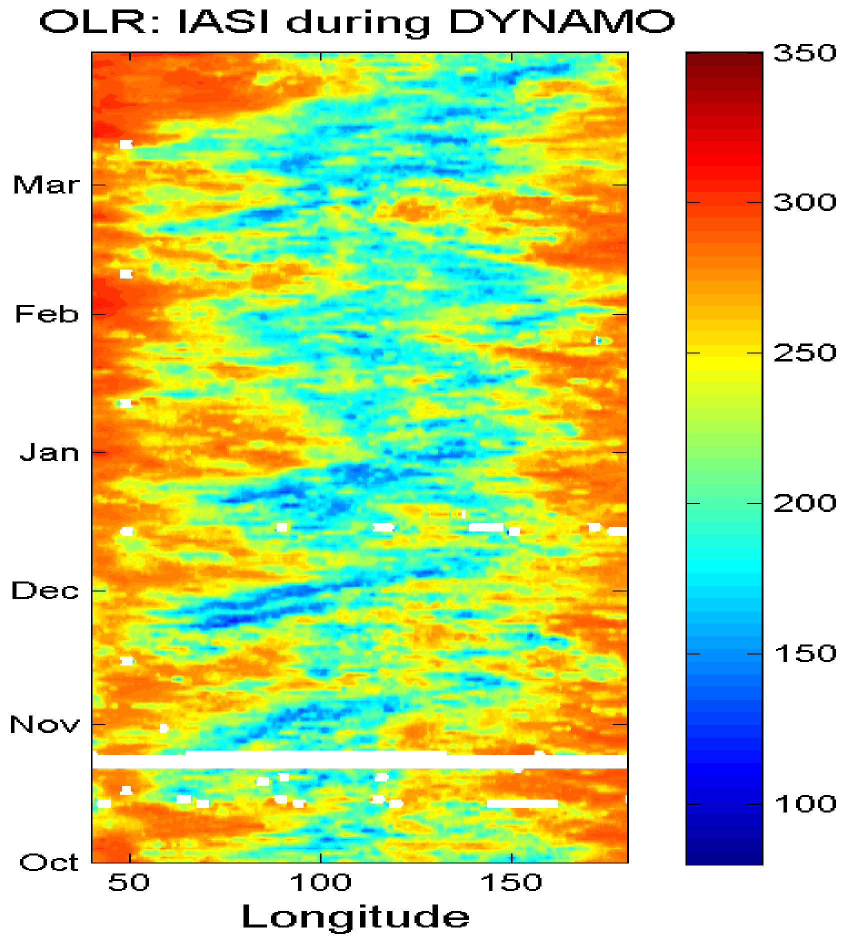


Figure 9: Time-longitude section of equatorial (5°S-5°N) mean IASI OLR during the DYNAMO experiment (Oct.2009 – Mar.2010).

Applications of IASI OLR

3) Accurate quantification on MJO evolution

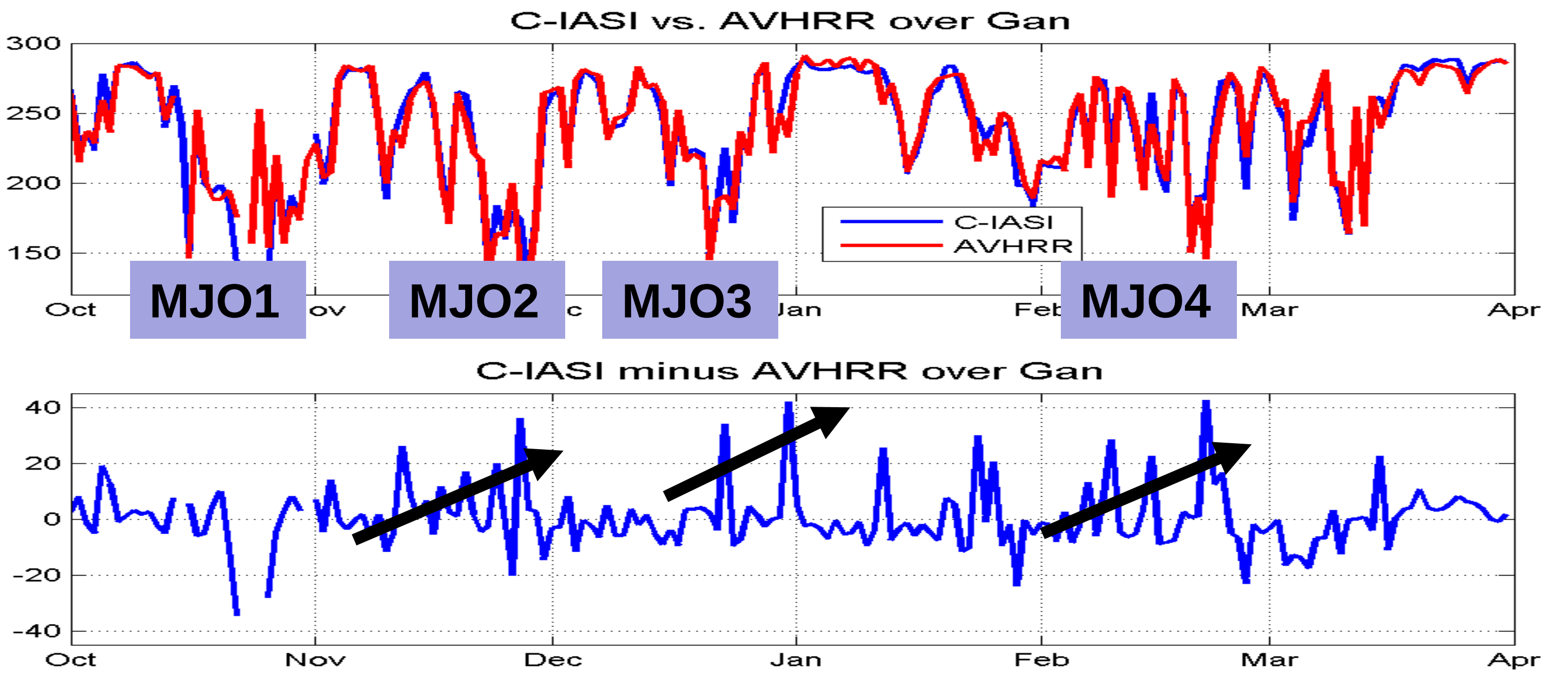


Figure 10: Time series of OLR derived from the operational AVHRR (top, red) and the calibrated IASI OLR (top, blue), as well as the difference between them (bottom), at a grid box over Gan Island during the DYNAMO field experiment period (Oct.2009 – Mar.2010).

- While both the IASI and AVHRR capture the MJO quite well, differences between them present a tendency in association with the evolution of MJO, suggesting possibility of aliased OLR quantification by the AVHRR OLR;
- Further work is underway to examine the causes of this difference and how we may improve the MJO monitoring taking advantage of the IASI OLR;

Applications of IASI OLR

4) Improved heat wave detection and quantification

- (top) Based on a 30+ year technology and derived from AVHRR infrared window channel measurements blind of water vapor variations, capacity of the operational OLR data to detect and quantify heat waves is compromised;

- (bottom) The IASI OLR presents better skills in capturing and quantifying the heat wave.

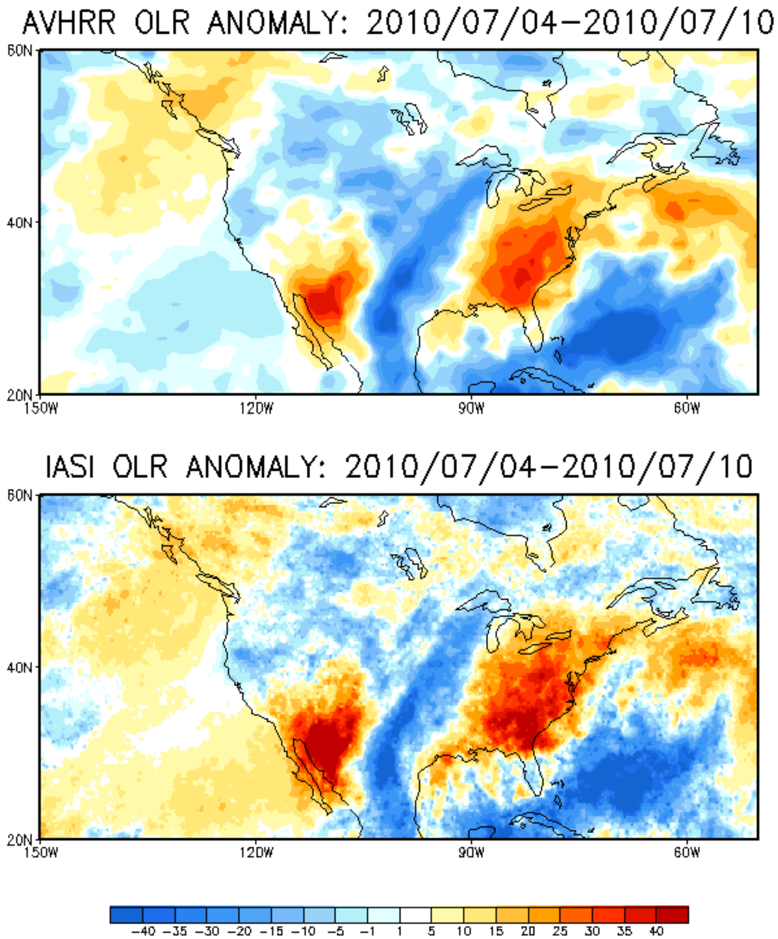


Figure 11: OLR anomaly (W/m2) associated with the heat wave of Jul. 4-10, 2010, derived from the operational AVHRR (top) and the IASI (bottom) data sets.

Summary and Future Work

- IASI OLR transition project show important improvements of the hyperspectral OLR for climate applications
- Further work is needed to repeat the work for hyperspectral OLR from other satellites and to combine the data from individual satellites into a consistent long-term time series
- We appreciate it very much JPSS's support for the reprocessing of hyperspectral OLR from CrIS and other sensors

Trace gas applications for air quality

Pius Lee[1], Youhua Tang[1], Jeff McQueen[2], Mark Liu[3], Li Pan[1], Daniel Tong[1], Hyun Kim[1], Shobha Kondragunta[3], Sarah Lu[4], Jun Wang[5], Min Huang[1], Chuanyu Xu[5], Ho-Chun Huang[5], Matthew Alvarado[6]

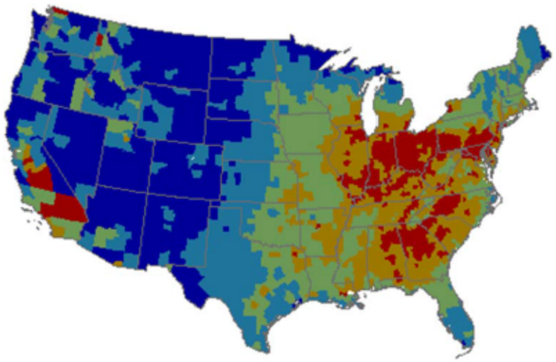
[1]Air Resources Lab. (ARL), NOAA Center for Weather and Climate Prediction (NCWCP), College Park, MD
[2] Environmental Modeling Center (EMC), NCEP, NCWCP, College Park, MD
[3] NOAA/NESDIS/STAR, College Park, MD
[4] State University of New York, Albany, NY
[5] I.M. Systems Group Inc. Rockville, MD
[6] AER Inc. Lexington, MA

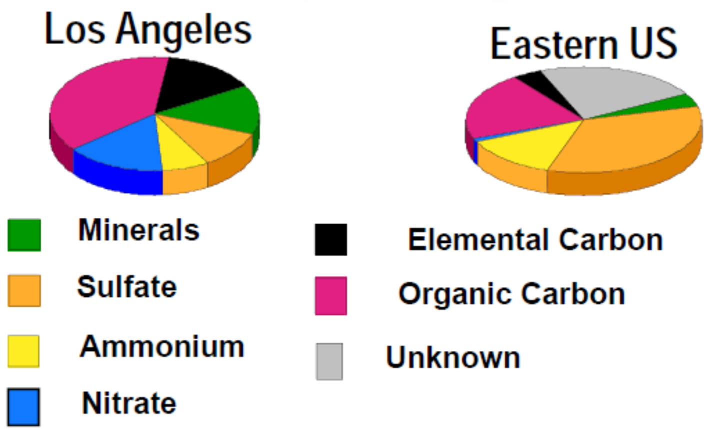
Courtesy: Dan Costa
“New Directions in Air Quality Research at the US EPA”

Public Health Burden of $PM_{2.5}$

(Fann et al., 2011)

Percentage of $PM_{2.5}$ related deaths due to 2005 air quality levels by county

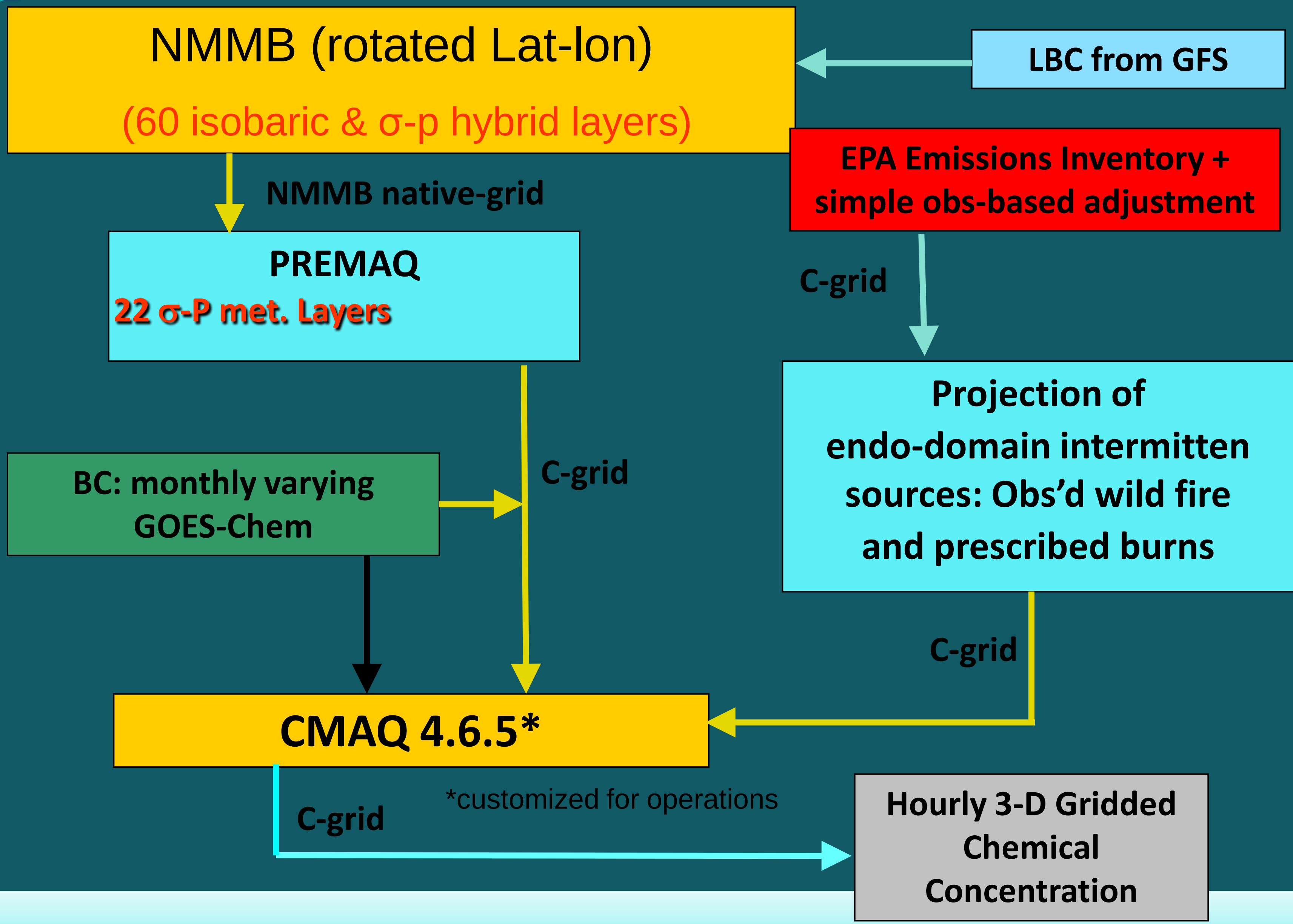




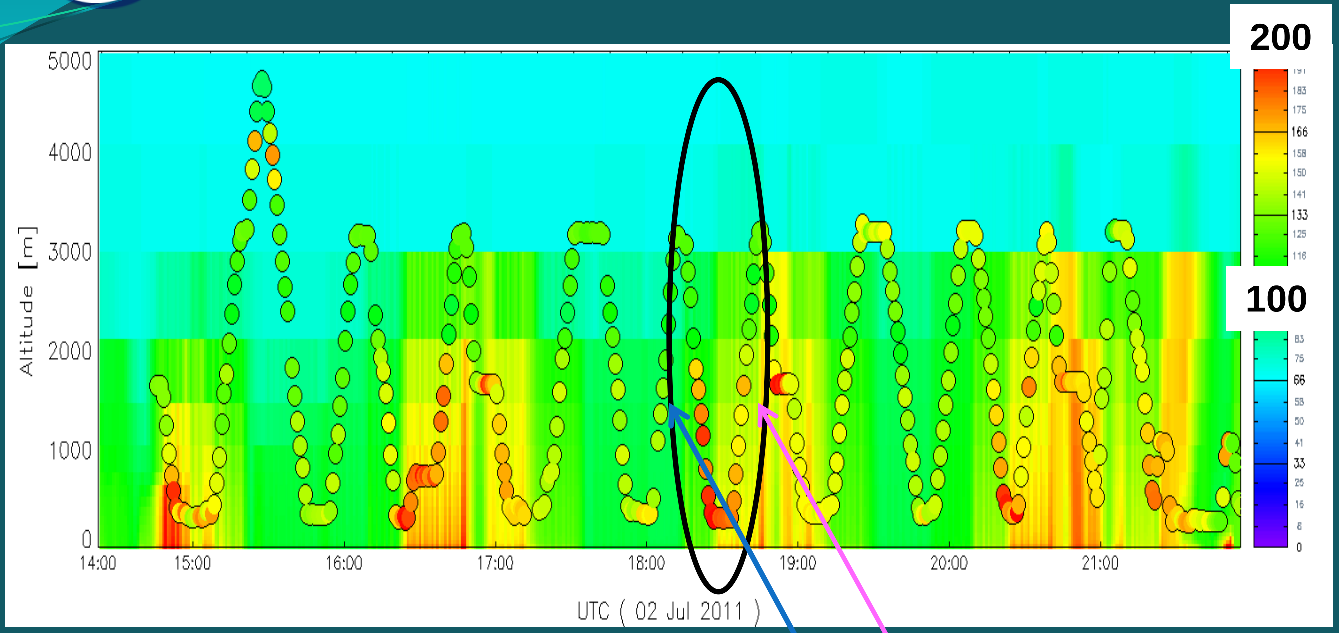
Summary of National $PM_{2.5}$ impacts due to 2005 air quality	
Excess mortalities (adults)[A]	130 to 320,000
Percentage of all deaths due to $PM_{2.5}$[B]	5.4%
Impacts among Children	
ER visits for asthma (<18 yr)	110,000
Acute bronchitis (age 8-12)	200,000
Exacerbation of asthma (age 6-18)	2,500,000

[A] Range reflects use of alternate PM mortality estimates
[B] Population-weighted value using Krewski et al. (2009) PM mortality estimates

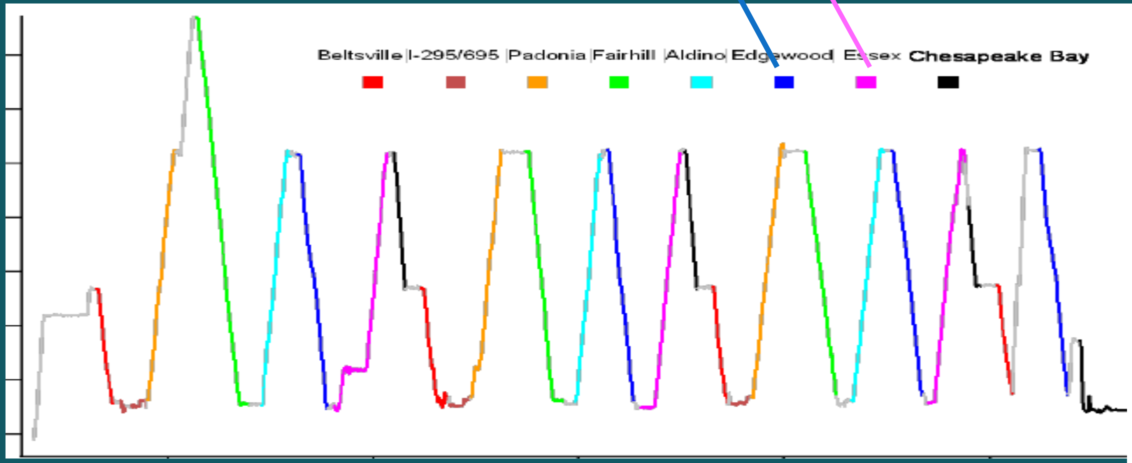
NAQFC: NMMB-CMAQ

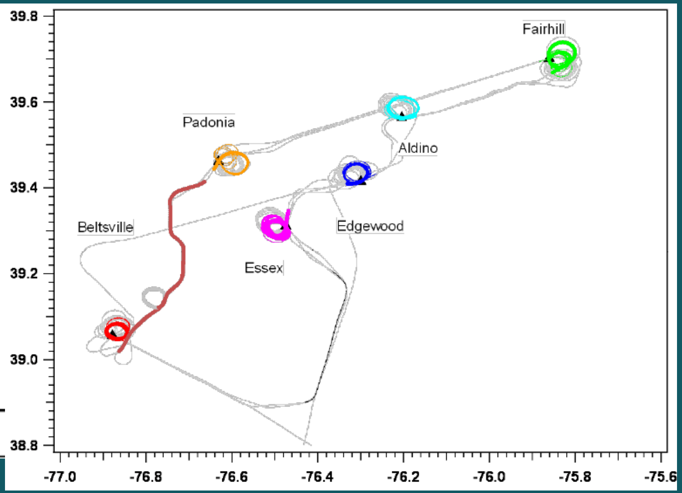


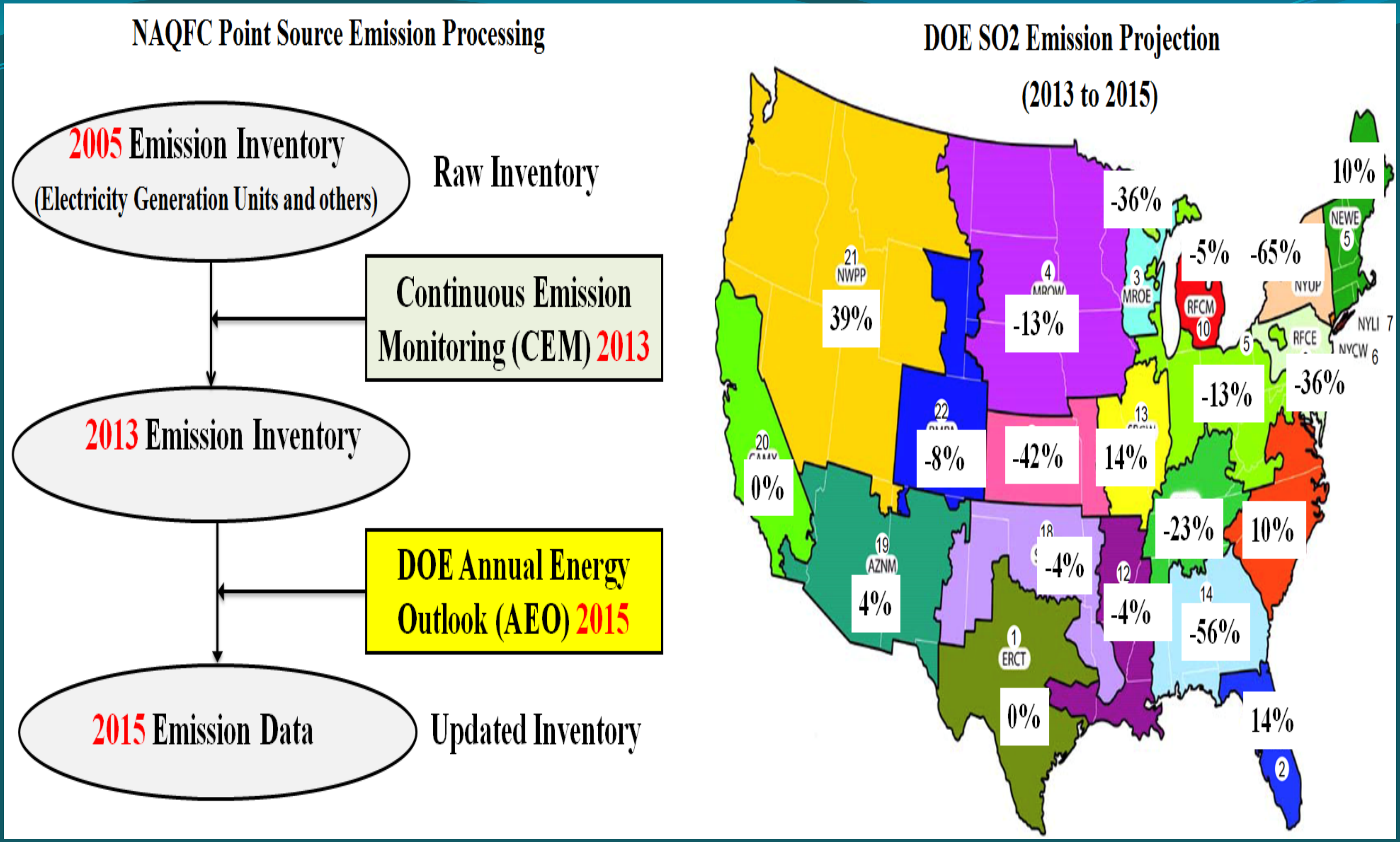
CO (ppb) along the P3 Flight – July 2 2011: AOD_DA case vs. Obs



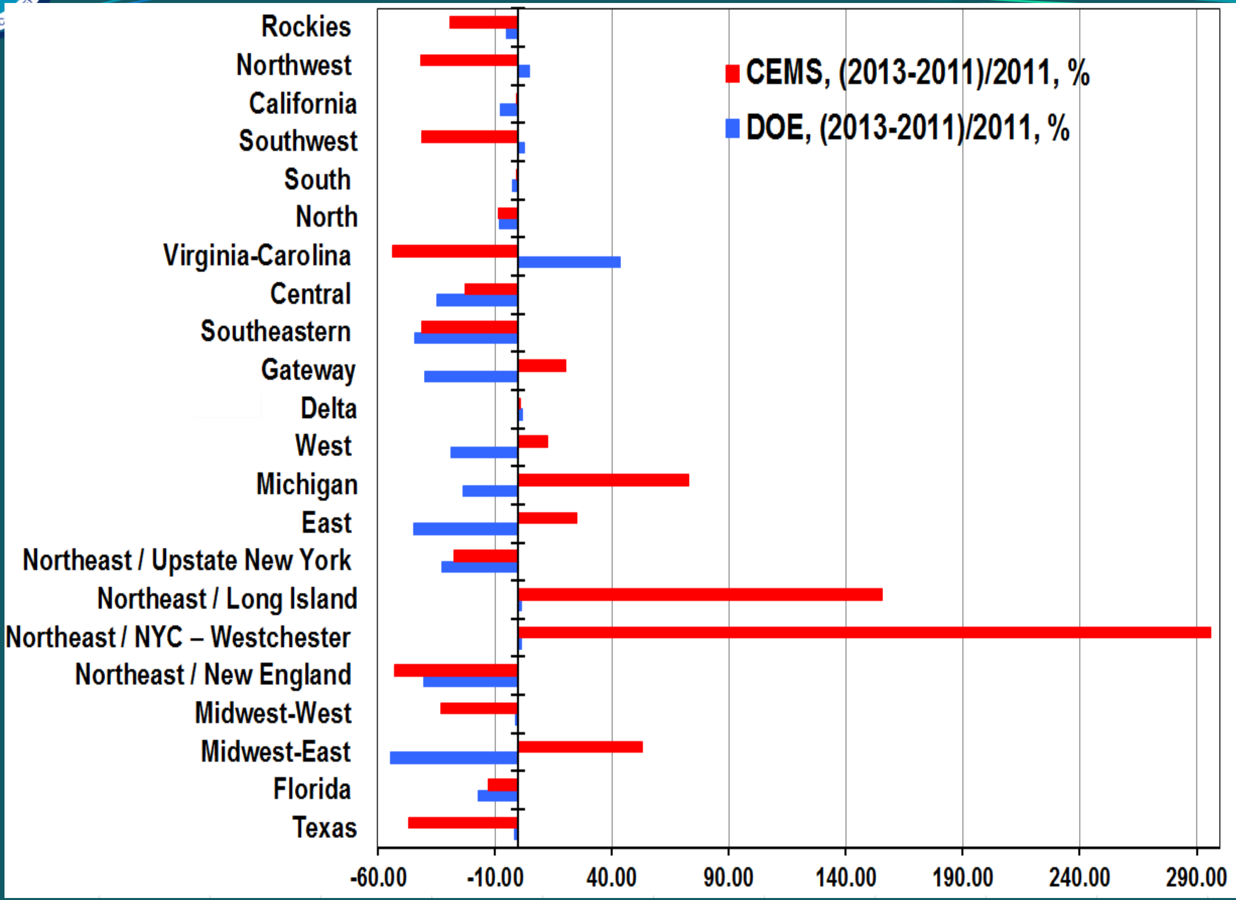
P3 Three and a half loops:
Beltsville
Padonia
Fairhill
Aldino
Edgewood
Essex
Chesapeake Bay



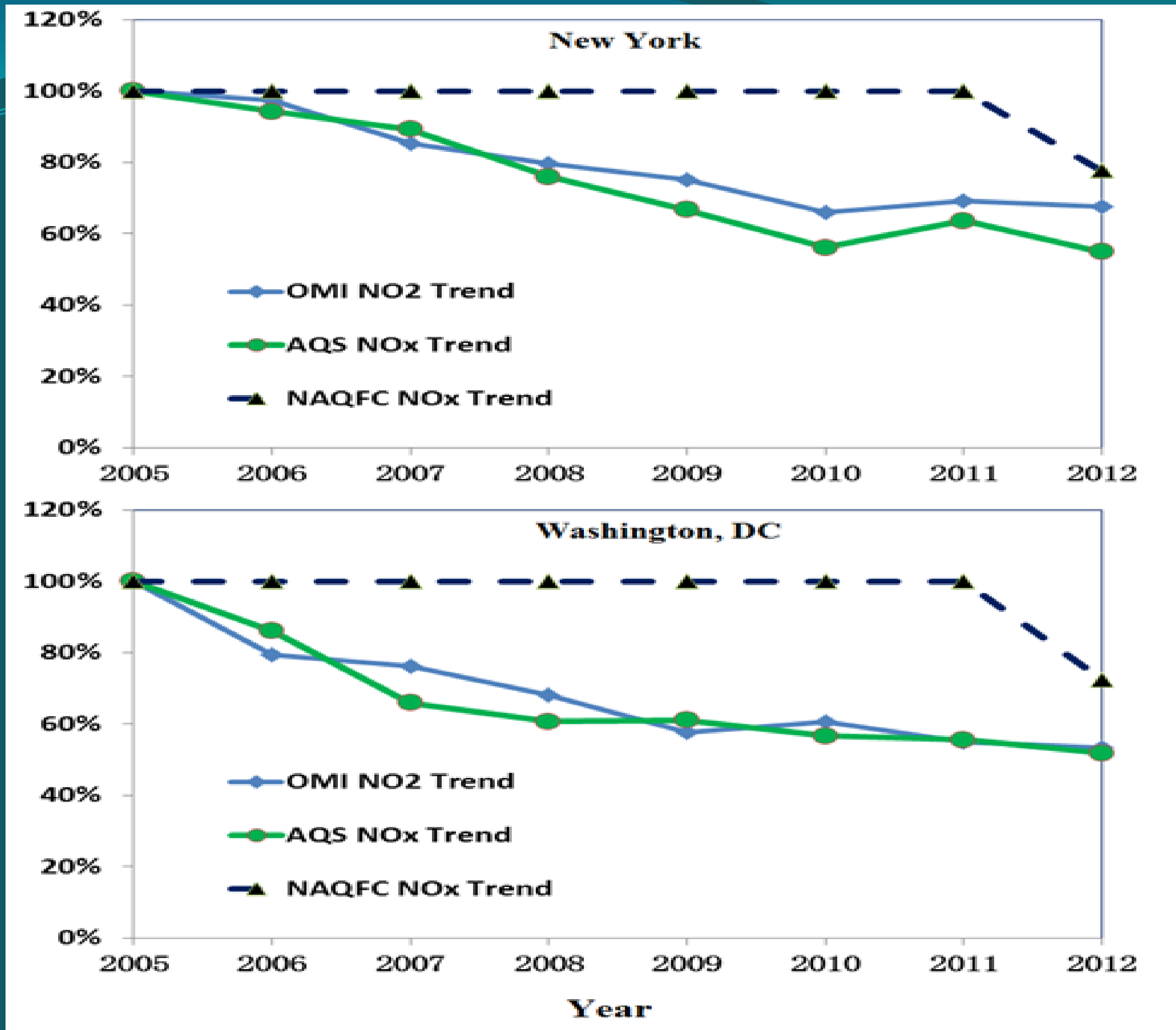




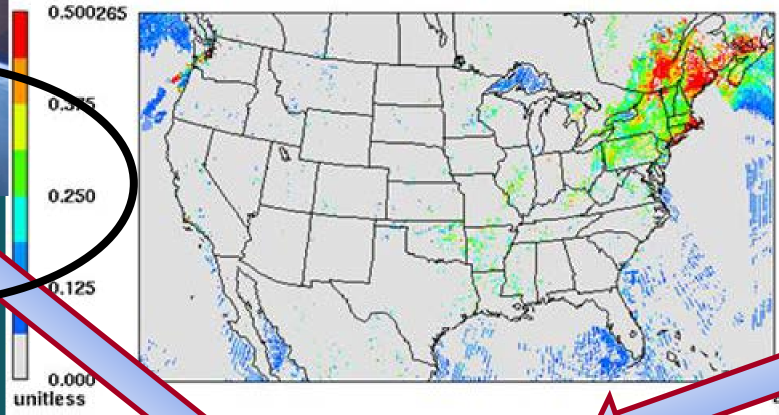
Current approach useed by NAQFC to update power plant emissions (left) and DOE projection factors for FY 2015 operation (right).



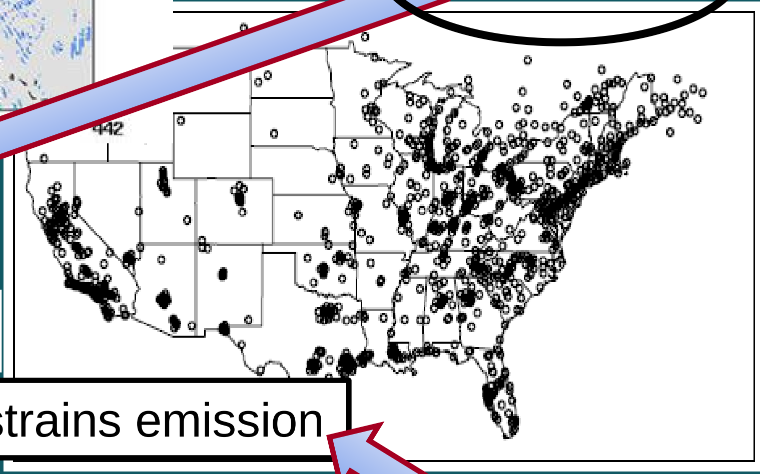
Comparison of DOE projected changes and CEM observations from 2011 to 2013 in 22 EMMs



Rapid refresh of NOx emission projection in NAQFC
Comparison of satellite (OMI), ground (AQS) and NAQFC model NOx emissions in New York and Washington, DC from 2005 to 2012 (Tong et al., 2015).



AIRNow



Constrain Chemical fields

Constrains Cloud-obs Photolysis rates

Constrains emission

GOES-MCIP INTERFACE

Cloud transmissivity (calculated from satellite retrieved cloud albedo), cloud top pressure, and cloud fraction are prepared for input to MCIP

MODIFIED MCIP

GOES retrievals replaces MM5 cloud information being passed to CMAQ. Cloud fraction, transmissivity, cloud base and top heights are passed to CMAQ.

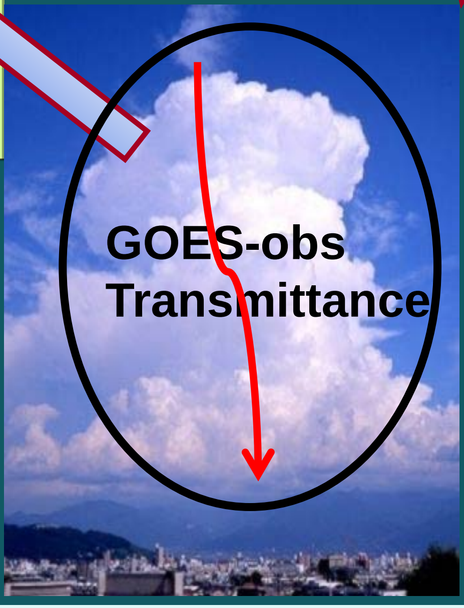
PHOT in CMAQ

In subroutine PHOT, clear sky photolysis rates will be adjusted for cloud cover based on GOES cloud fraction and cloud transmissivity information.

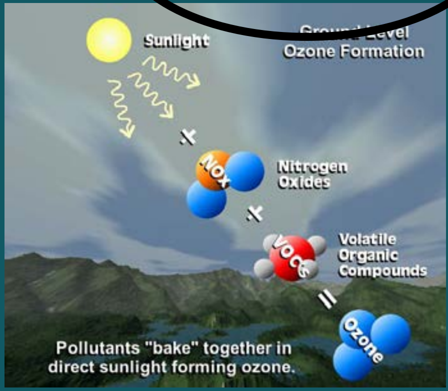
Interpolated in between.

Cloud Base According to Lifting Condensation Level

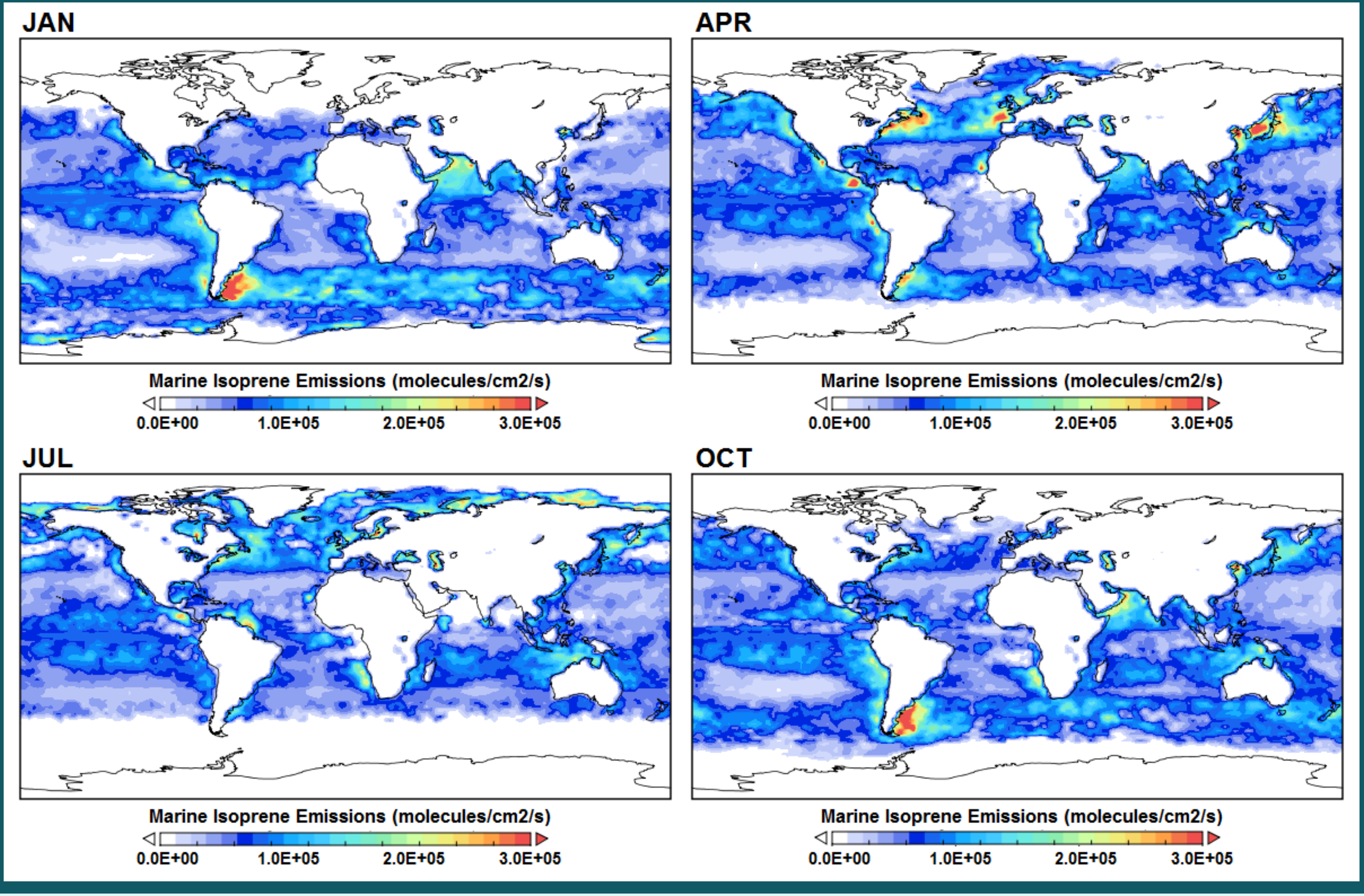
$$T_c = B / \ln\left[\frac{A\varepsilon}{wp_0}\left(\frac{T_0}{T_c}\right)^{1/k}\right]$$

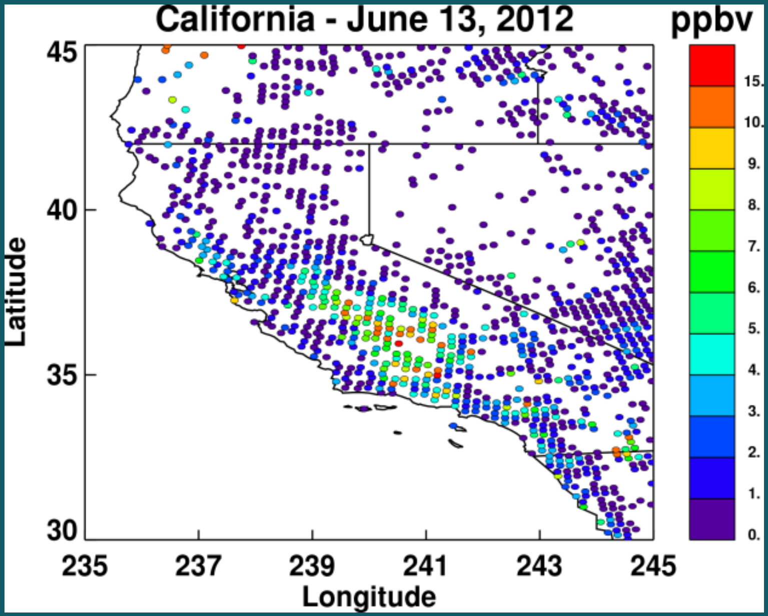


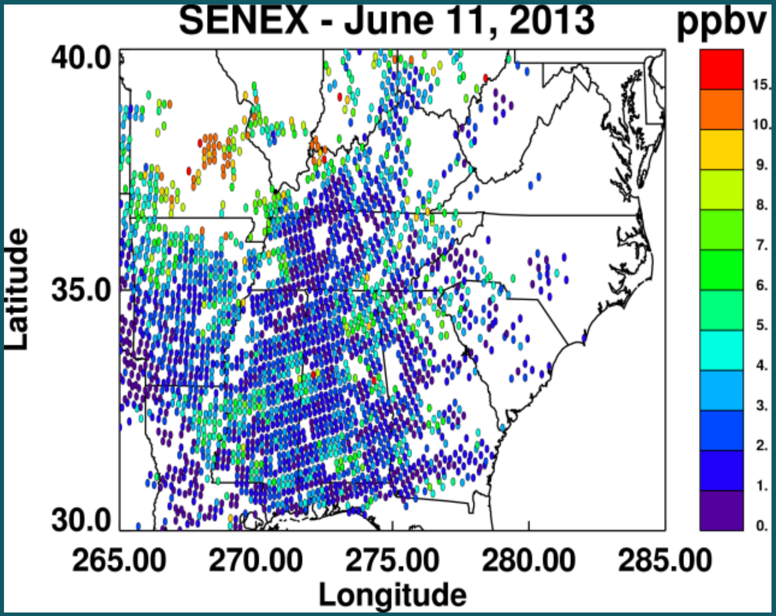
Biogenic emissions



Global Distribution of Marine Isoprene

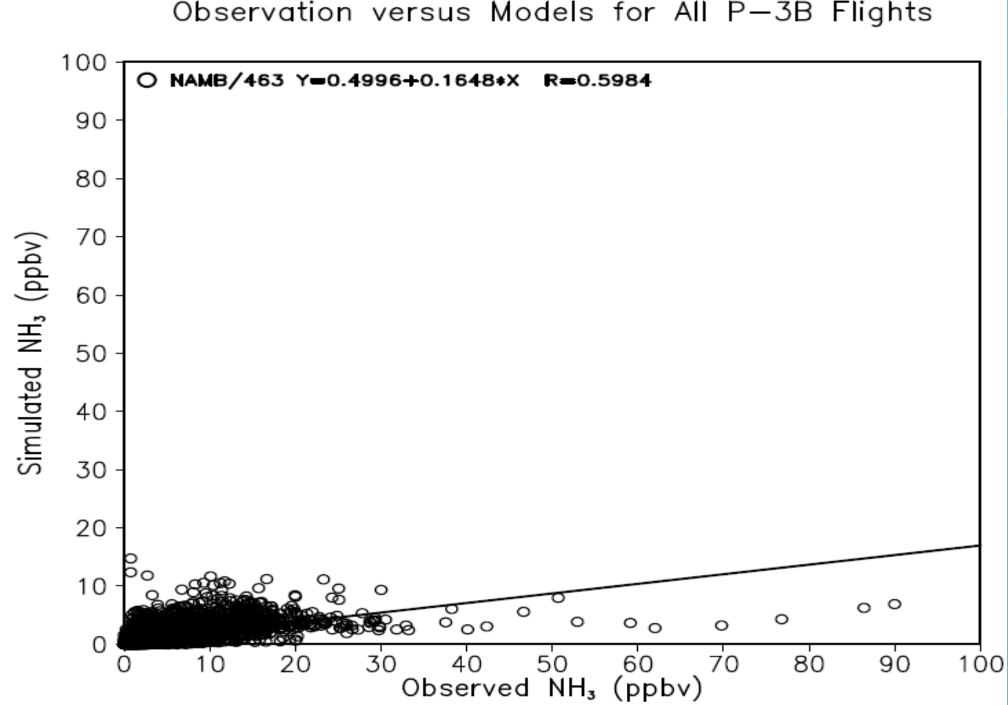


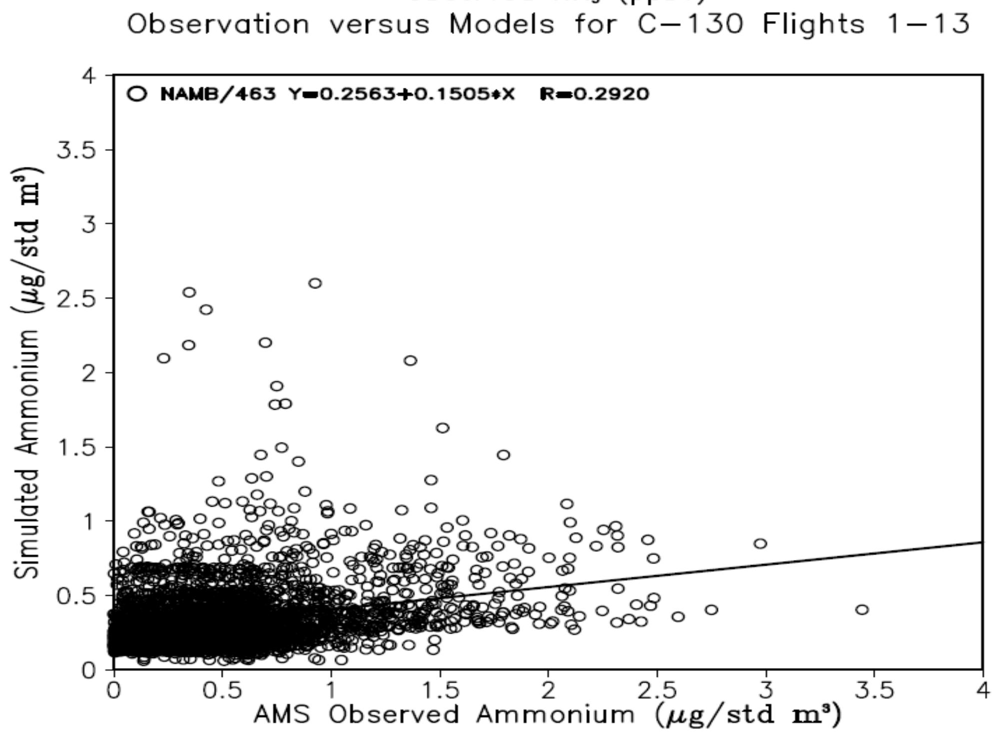


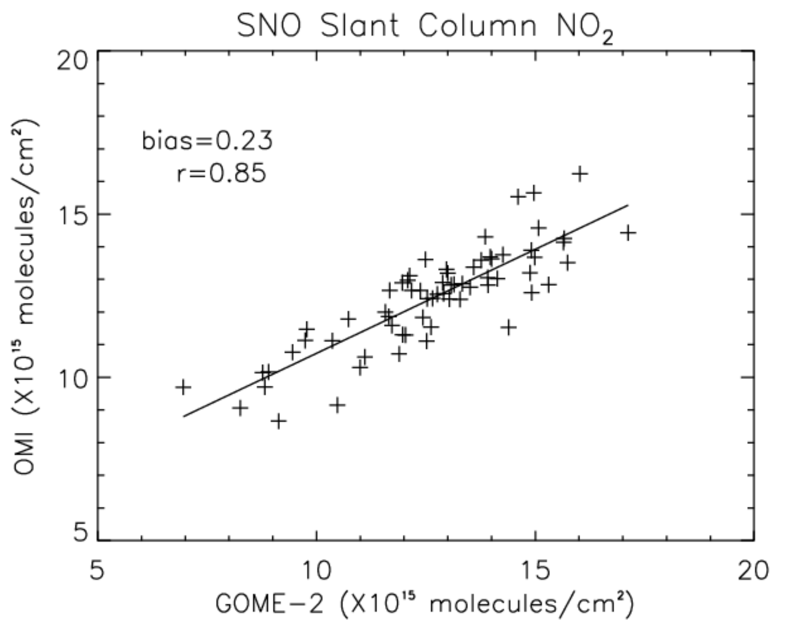


(left) CrIS NH_3 retrieval results over California plotted using the NH_3 representative volume mixing ratio (RVMR), which is approximately the retrieved value at the height of peak sensitivity of CrIS to NH_3. Most missing data is due to the presence of clouds. (right) The same but for the Southeast US during the NOAA SENEX campaign.

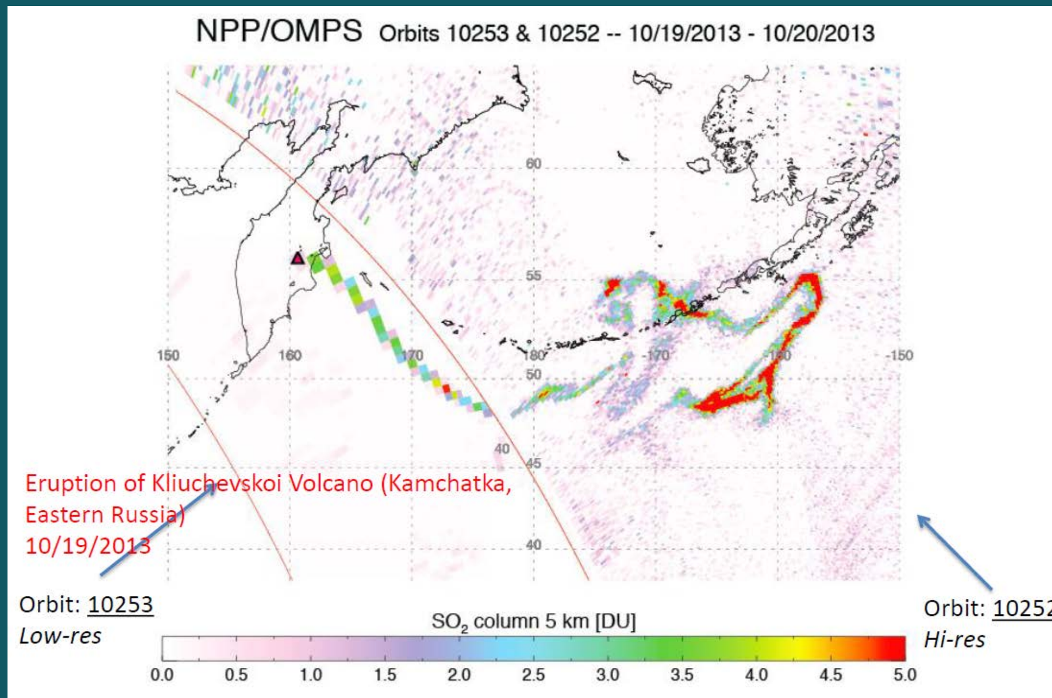
We systematically underestimated ammonia concentrations as well as ammonium.



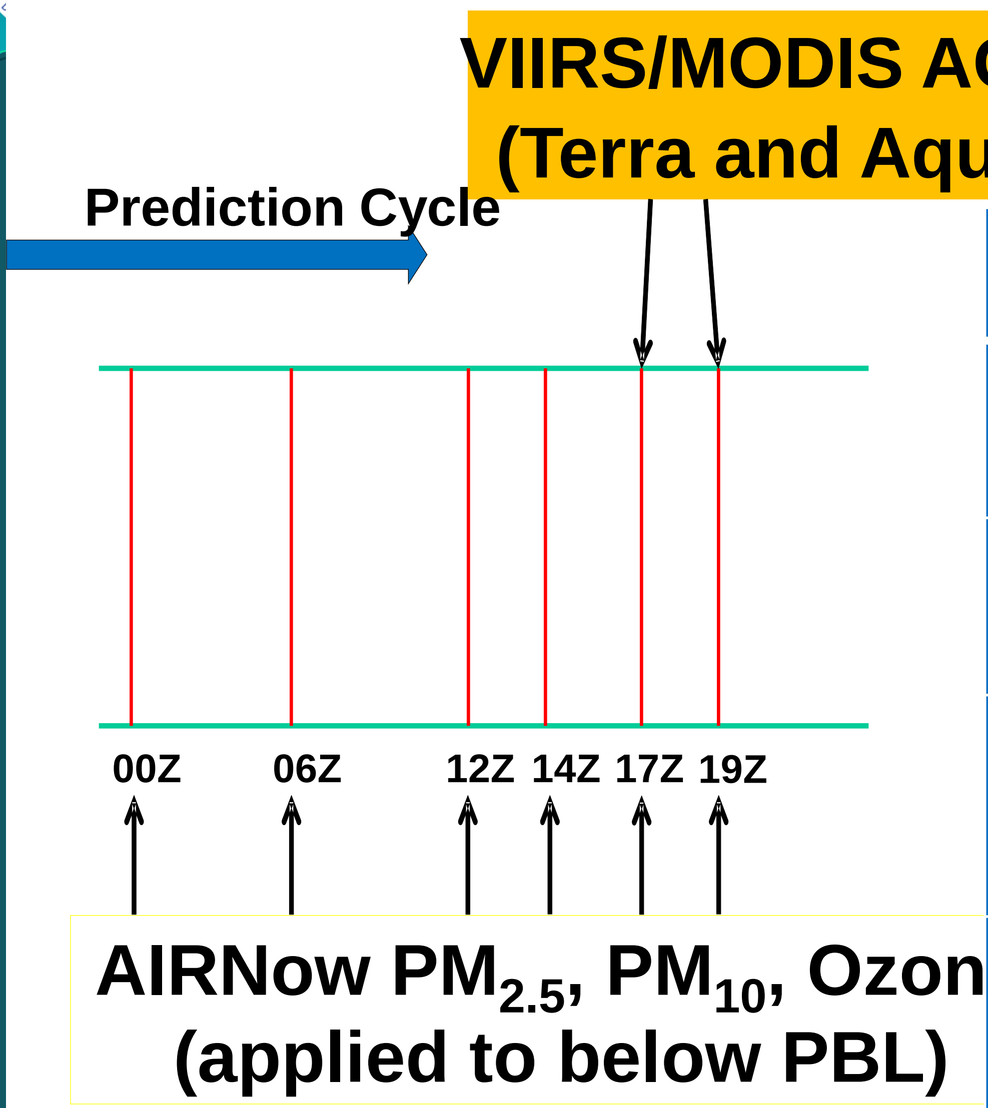




Simultaneous nadir overpass analysis comparisons of GOME-2 and OMI. The top left figure shows an example overpass of two satellites. We restricted data to less than 80° solar zenith angle, nadir only. Results are shown in the scatter plot on the right with GOME-2 on x-axis and OMI on y-axis. Both agree well with a correlation coefficient of 0.85 and a mean bias of about 2%. This agreement gives us confidence that we can now use OMI and GOME-2 tropospheric retrievals to study the diurnal variations at other latitudes.



SO_2 products from processing by K. Yang, NASA OMPS Science Team Member. The data for the low-resolution orbit has 35 cross-track FOVs 50x50 KM^2 at nadir. The high-resolution orbit has 175 cross track FOVs 10x10 KM^2 at nadir. Lower resolution data will be obtained starting with OMPS on JPSS01. The data shows the volcanic SO_2 plume from Kliuchecevskoi (located at the red triangle) as observed by S-NPP OMPS for October 19-20 2013.



CMAQ: cb05_ae4

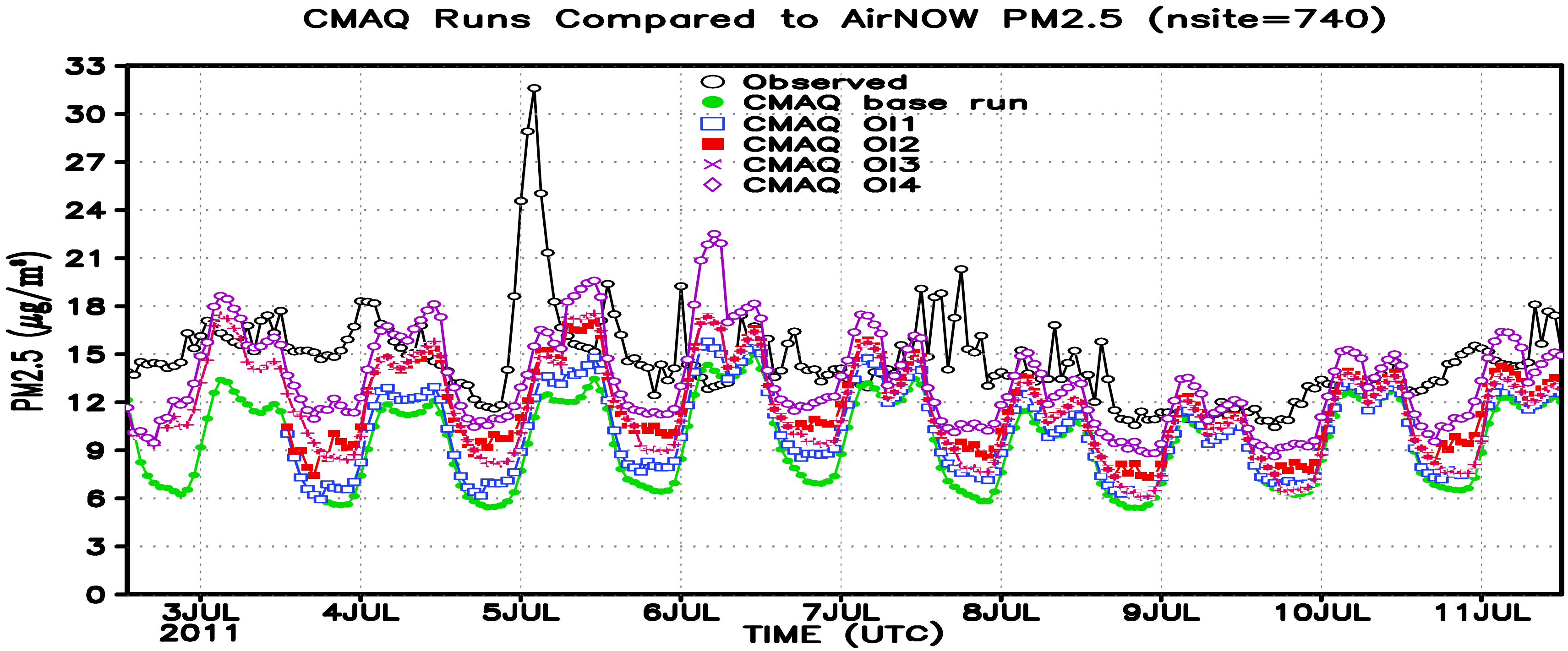
2008 anthropogenic emission inventory projected to 2015

NOAA HMS (hazard mapping system) fire emission with Bluesky algorithm

Cases of Studies	Assimilation Times	Settings of U Settings of Uncertainties
OI1 (7×7 OI)	00z, 06Z, 12Z, 18Z for AIRNow data 18Z for MODIS AOD (+/- one hour)	0.6 for modeled aerosols and 0.4 for modeled O_3.
OI2 (7×7 OI)	00Z, 06Z, 12Z, 14Z, 17Z, 19Z for AIRNow 17Z and 19Z for MODIS (+/- two hours)	2.0 for modeled aerosols and 0.4 for modeled O_3.
OI3 (7×7 OI)	00Z, 06Z, 12Z, 14Z for AIRNow 17Z and 19Z for MODIS (+/- two hours)	Dynamic uncertainties up to 5.0 for modeled PM2.5, and up to 0.6 for modeled O_3.
OI4 (11×11 OI)	00Z, 06Z, 12Z, 14Z, 17Z, 19Z for AIRNow 17Z and 19Z for MODIS (+/- two hours)	Dynamic uncertainties up to 10.0 for modeled PM2.5, and up to 1.0 for modeled O_3.

Hourly Statistic Results for CONUS 12Z, 07/06/2011- 12Z, 07/07/2011

Cases	O_3	PM2.5
Base case	R=0.53 MB=2.54	R=0.23 MB= -7.14
OI1	R=0.56 MB=2.36	R=0.24 MB= -2.63
OI2	R=0.58 MB=1.06	R=0.39 MB= -1.33
OI3	R=0.52 MB=2.08	R=0.36 MB= -1.89
OI4	R=0.56 MB=1.55	R=0.40 MB= -0.11



	Aqua-MODIS	Suomi NPP-VIIRS
Orbit altitude	705 km	824 km
Equator crossing time	13:30 LT	13:30 LT
Granule size	5 minutes	86 seconds
Swath	2330 km	3040 km
Sensor zenith angle range	±64°	±70°
Valid solar zenith angle (for high quality)	< 82°	≤ 65°
Sensor bands used for aerosol retrieval	0.412, 0.466, 0.554, 0.646, 0.856, 1.24, 1.63, 2.11 μm	0.412, 0.445, 0.488, 0.555, 0.672, 0.746, 0.865, 1.24, 1.61, 2.25 μm
Pixel size, nadir	0.25, 0.5, and 1 km	0.375 and 0.75 km
Bow-tie effects	Yes	No
Product resolution, nadir	10 km	6 km (AOT and Angstrom exponent) 0.75 km (Suspended matter)
Product resolution, edge	40 km	10 km (AOT and Angstrom exponent) 1.2 km (Suspended matter)
Products, land (vegetated regions)	AOT (Dark Target Approach)	AOT, Angstrom exponent, Suspended matter
Product, land (deserts, urban regions)	AOT, Angstrom exponent, Dust single scattering albedo (Deep Blue Approach)	None
Products, ocean	AOT (7 wavelengths), Size (fine mode fraction)	AOT (11 wavelengths), Angstrom exponent, Suspended matter
Global gridded product	Level 3 daily, 8-day, monthly mean	None

Courtesy: C. Hsu et al.

Summary

- NH3
- *SO2*
- *Constraints for emission projection, photolytic rates, initialization adjustment of chemical fields*
- *VIIRS should give NAQFC further advantages due to finer temporal and spatial resolution of the retrieved data*

EXTRA SLIDES

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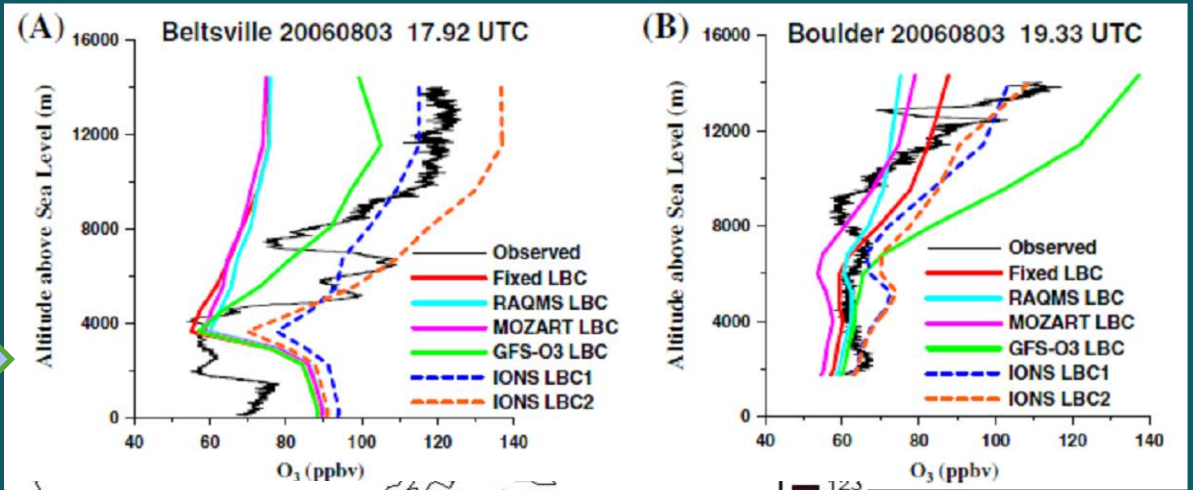
September 1-3 2015 NOAA NCWCP, College Park, MD

Next data set
To be include
In data assimilation?

MLS & MODIS
AOD from global
Model: e.g., RAQMS



Exo-domain as well as endo-domain wild fires & prescribed burns