NOAA/NESDIS UPDATES FOR SOUNDING DATA PRODUCTS AND SERVICES

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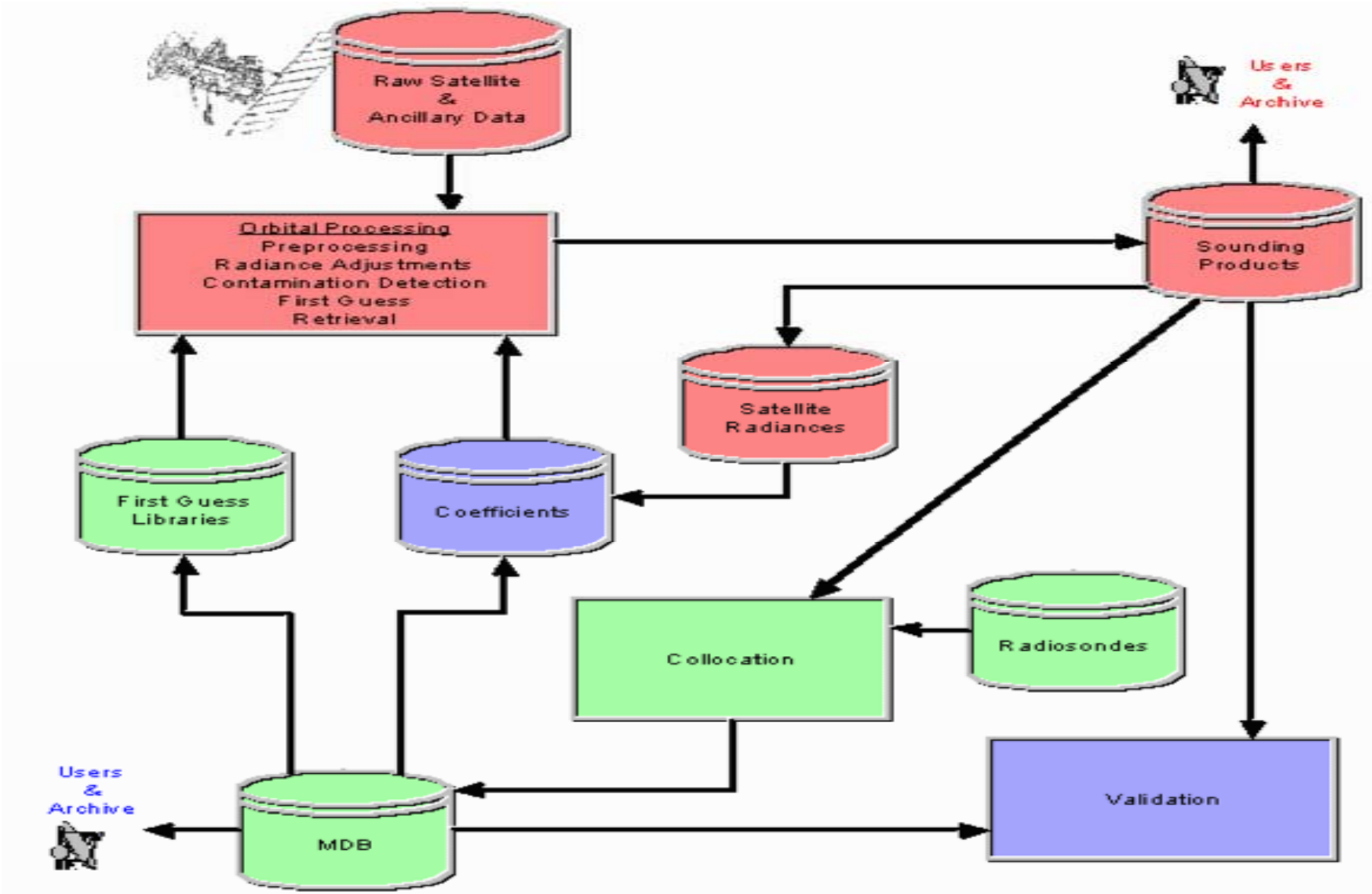
Raytheon-ITSS

Murty Divakarla, Walter Wolf
STG Inc.

International TOVS Study Conference-14
Beijing, China
May 25-31, 2005

ATOVS Processing Diagram … Orbital, Daily, Weekly



SOUNDING USERS (short list)

- NWP
  - DOD (NRL)
  - Germany (DWD)
  - Canada (AES)
  - Japan (JMA)
  - Brazil (INPE)

- Climate
  - NCEP (CDAS),
  - Germany (DWD)

- NOAA
  - AWIPS (NWS)
  - Cloud Products (NESDIS) …

- Others …

Daily Satellite Data Volume Ingest

- **NOAA Polar**
  - NOAA-15, 16 & 17 6.3GB
- **GOES**
  - GOES East/West 35.0GB
- **DMSP**
  - F13, 14 & 15 1.7GB

232.2 GB

- **Non-NOAA Satellites**
  - METEOSAT 5 (INDOEX) .4GB
  - TRMM 1.3GB
  - MODIS 175.0GB
  - AIRS .6GB
  - ERS 2 .2GB
  - QuikSCAT .4GB
  - GMS .1GB
  - METEOSAT 7 .8GB
  - RadarSat 5.0GB
  - Seawifs (not included in total, must be ordered)

Upcoming Launches

- NOAA-N
  - NOAA-N Launched: May 20, 2005
- METOP Launch Date: Summer 2007
- NPP Launch Date: ??
- NOAA-N' Launch Date: March 2008
- NPOESS Launch: 2009
- Second Metop Launch Date:August 2010

NOAA-N Instrument Schedule

• AMSU A1	5/24	17Z
• AMSU A2	5/24	19Z
• MHS	5/25	14Z
• SBUV	5/27	15Z
• DCS	5/27	17Z
• AVHRR	6/5	14Z
• HIRS	6/5	15Z
• SEM	6/6	15Z

NOAA-N/N' Changes

- MHS will replace AMSU-B
- Field of View Size Change for HIRS (17Km to 10Km)
- HIRS specify calibration and format changes
- AMSU-A specify calibration and format changes
- AVHRR specify format change
- Other 1b/1b* format changes
- New Telemetry data file

Initial Joint Polar System Products Overview

- Level 1 Products Created at NOAA
  - AVHRR
  - AMSU-A
  - HIRS
  - MHS
  - SBUV
  - SEM
  - [A]DCS
  - SAR
- Level 1 Products Obtained from EUMETSAT
  - ASCAT
  - IASI
  - GOME
  - GRAS

Product Processing Changes

Product Generation | Level 1 Data | Levels 2 and 3

SATEPS (SSD)

- **Snow/Ice** •AVHRR
- **Hazards Fire/Smoke Volcanic Ash** •AVHRR
- **Heavy Precip** •AMSU-A
- **Significant Event Imagery** •AVHRR
- **Tropical Cyclone Analysis** •AVHRR •AMSU-A

CEMSCS (IPD)

- **Aerosol** •AVHRR
- **Global Vegetation** •AVHRR
- **Cloud Imagery** •AVHRR
- **Global Sea Surface Temp** •AVHRR •HIRS/4
- **Local Sea Surface Temp** •AVHRR
- **MW Surface/Hydro** •AMSU-A •MHS
- **Radiation Budget** •AVHRR •HIRS/4
- **Soundings** •AVHRR •AMSU-A •HIRS/4 •MHS
- **Ozone** •SBUV/2 •GOME-2
- **Cloud Flags** •AVHRR
- **Advanced Soundings** •IASI
- **Ocean Surface Winds/Sea Ice** •ASCAT

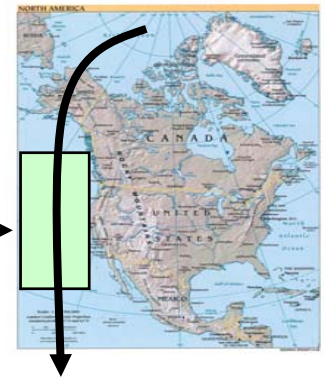
Other

- **Sea Ice (NIC)** •AVHRR
- **Space Environment (SEC)** •SEM-2
- **Data Collection** •DCS
- **Search and Rescue** •SAR

User Interfaces (Servers, Web Pages, GTS, NWS Gateway, etc.)

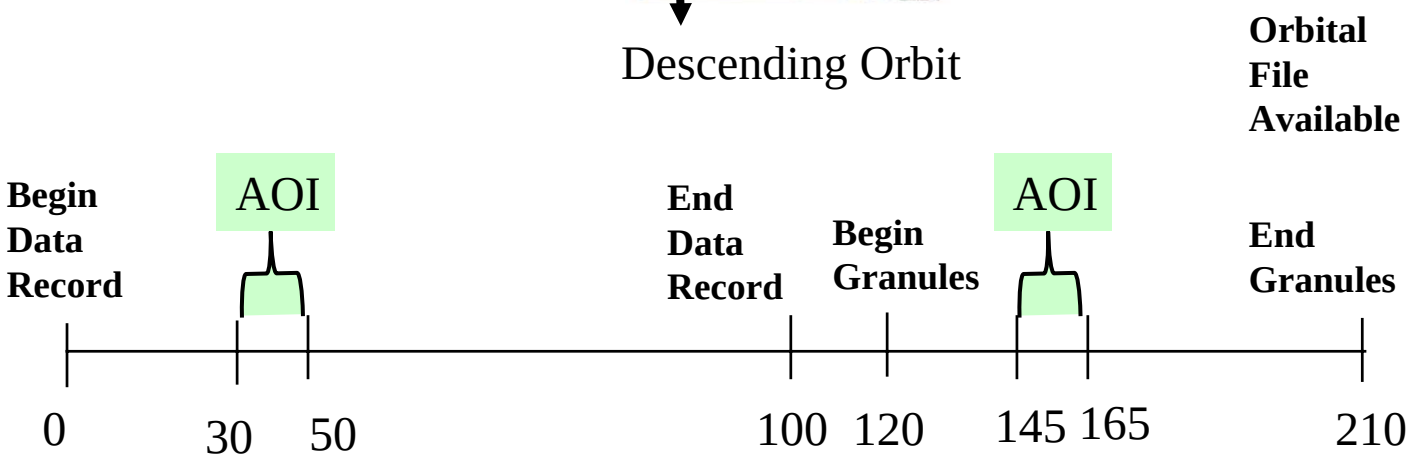
- Possible upgrades to use AVHRR global 1-km data from Metop
- New product systems
- Upgrade for pipeline processing

Pipeline Processing: Descending Pass Example



Area of Interest (AOI)

Descending Orbit



AOI product generation begins ~45 minutes sooner in pipeline vs orbital processing

Open Issues

User receipt of IJPS products

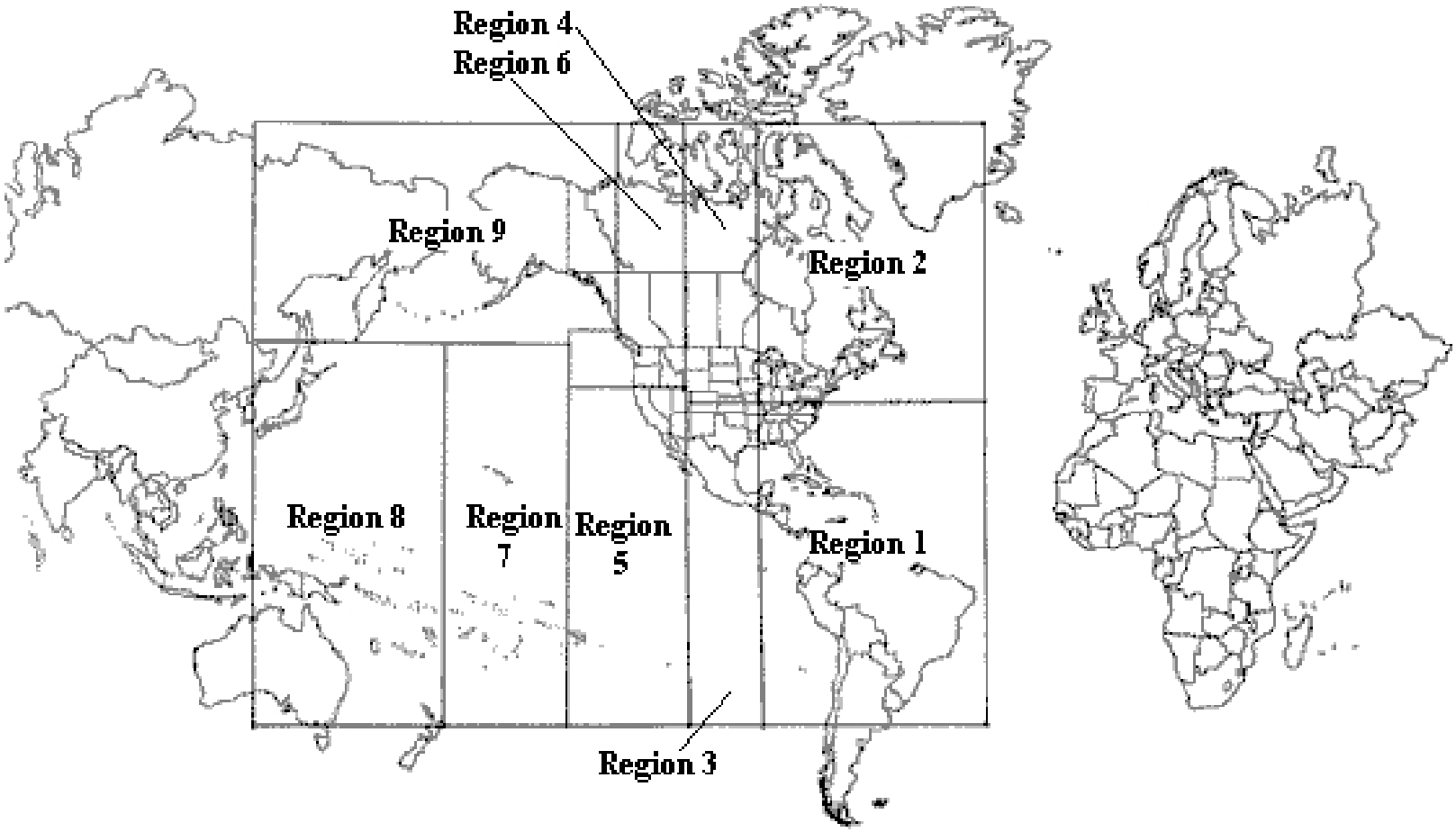
Shared Processing requirements

Dissemination of products generated in pipeline mode

Orbital to Granule Processing

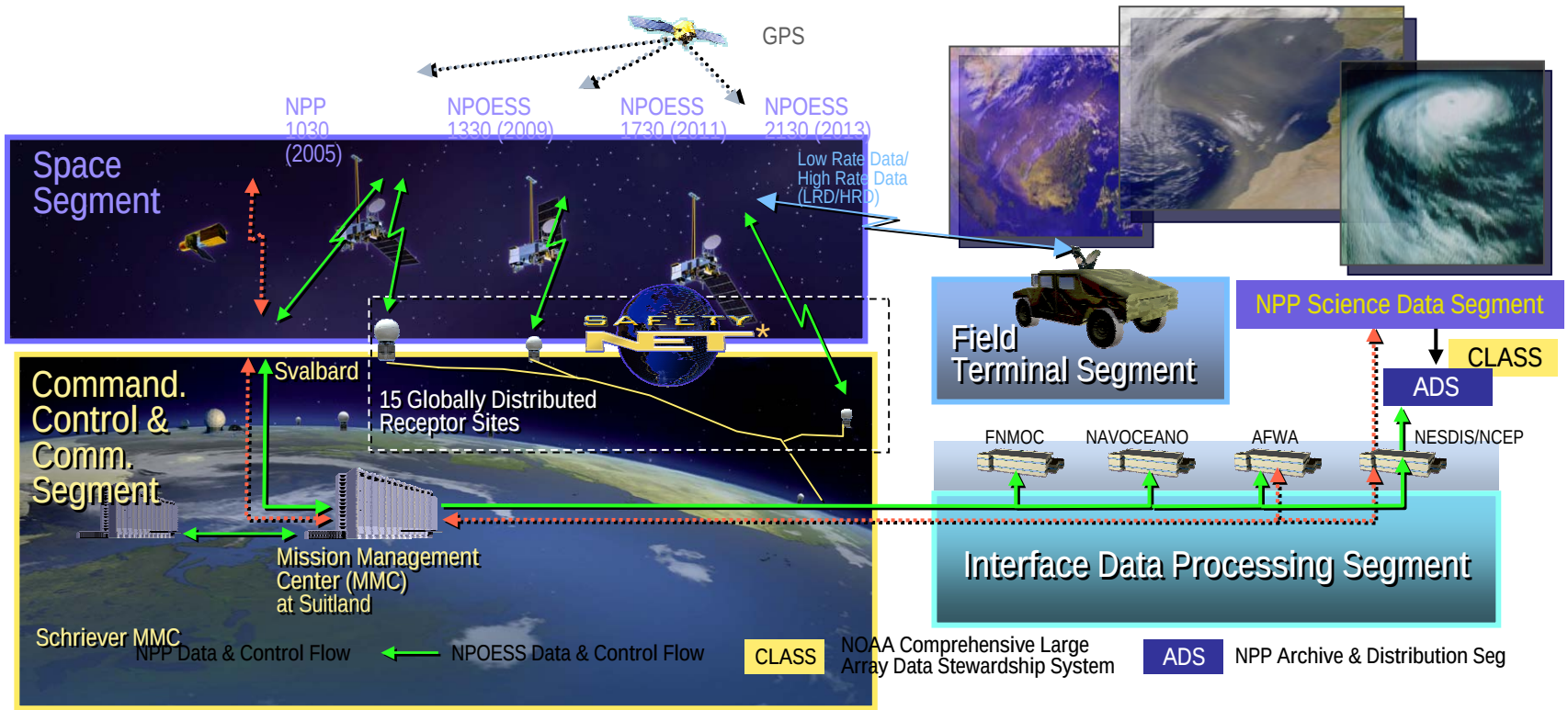
Granule Size, Granule Naming convention, Missing Granules, Multiple Strings for operational and backlog processing, Granule Reprocessing, and Data Transmission Problems.

AWIPS Regions



NPOESS Mission

- Provide a national, operational, polar-orbiting remote sensing capability



A Tri-agency Effort to Leverage and Combine Environmental Satellite Activities

* Patent Pending

OSDPD Product Access

http://www.osdpd.noaa.gov/IPD/IPD.html

http://satprod.osd.noaa.gov:8081/satprod/controlcenter.cfm

http://www.osdpd.noaa.gov/

http://www.oso.noaa.gov/

http://www.osd.noaa.gov/

http://www.saa.noaa.gov

http://www.ipo.noaa.gov/

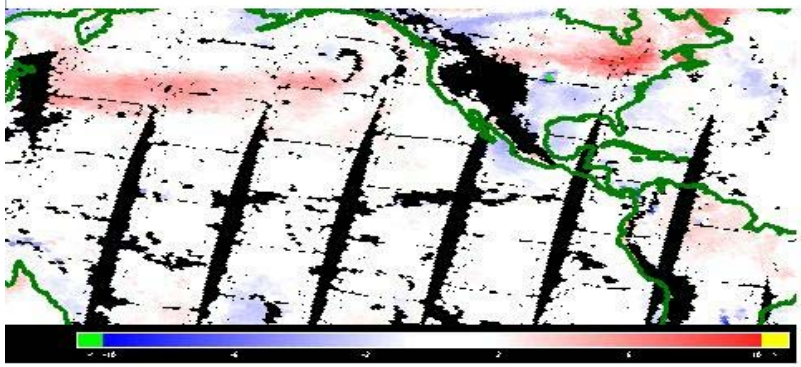
On the Science Side

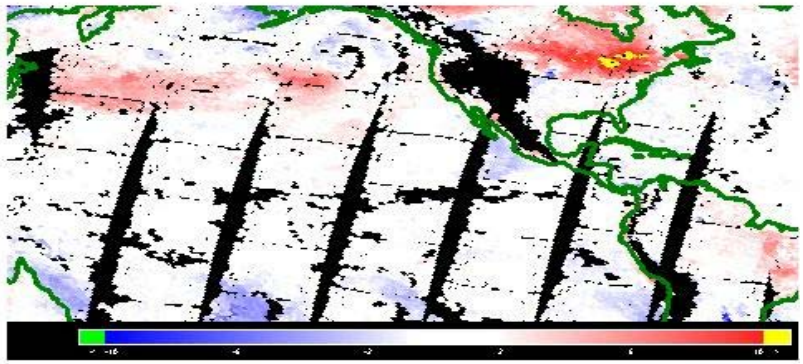
Environmental Data Graphic and Evaluation System (EDGE)

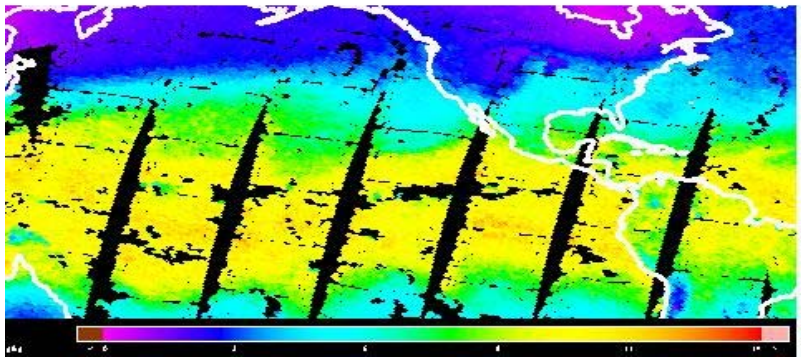
- **Three (3) Major Sub-systems:**
  - ***EDGEIS:*** Horizontal Fields of Orbital Products
  - ***Profile Display (PDISP):*** Collocated Radiosonde and Satellite Observations
  - ***Vertical Statistics (VSTAT):*** Collocations
- AQUA/AIRS vs. ATOVS Comparisons (Walter Wolf, Chris Barnet, Tom King and Murty Divakarla)
- ***Provided to EUMETSAT (Eamonn McKernan support of Collaborations for METOP …***

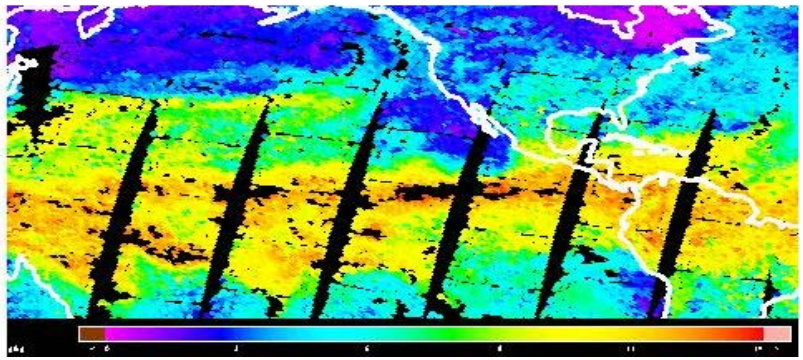
New ATOVS System-2005 Science

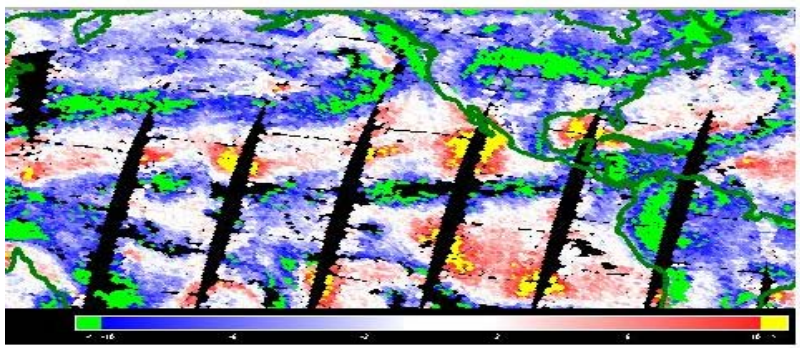
- ***Incorporate AMSU-B***
- Regression Guess replaces Library Search
  - Calculate First Guess Radiance (OPTRAN)
- Measurement (Radiance) Bias Adjustment
  - AMSU-A
  - AMSU-B
  - HIRS
- Analytical Retrieval Solution (OPTRAN-CRTM) per sounding (Paul Van-delst, Tom Kleespies, Yong Han)
  - based on Guess Temp and Moisture
- Peripheral Upgrades
  - Limb-adjustment
  - MSPPS Products… MIRS
  - Expanded Validation w/NWP

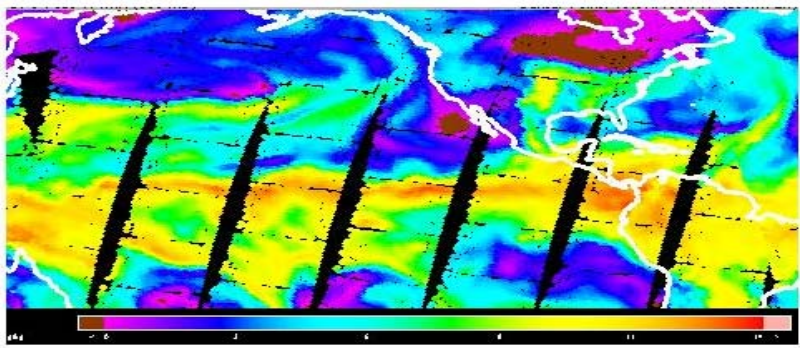


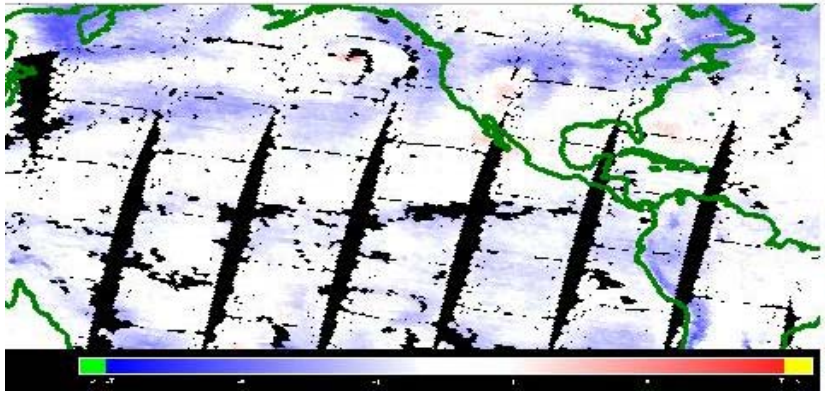


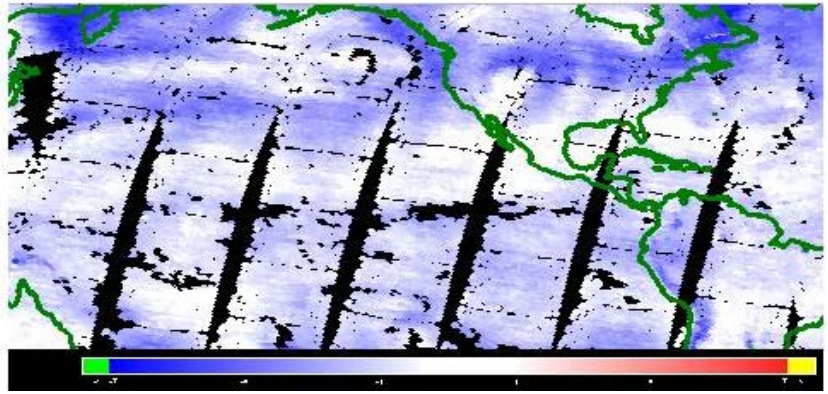


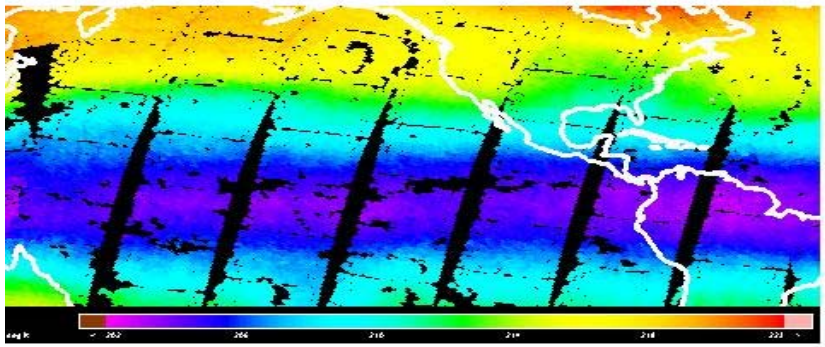


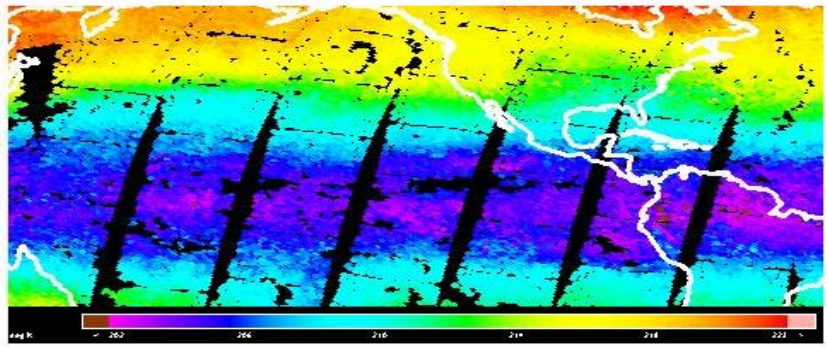


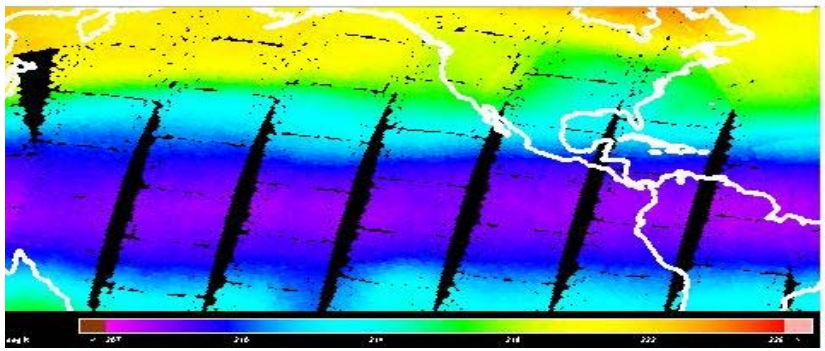


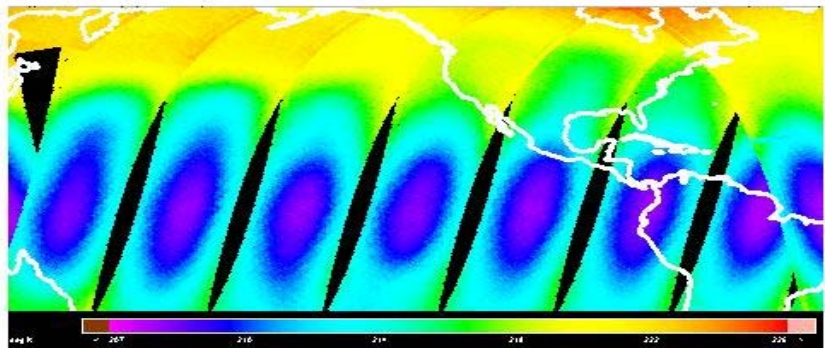


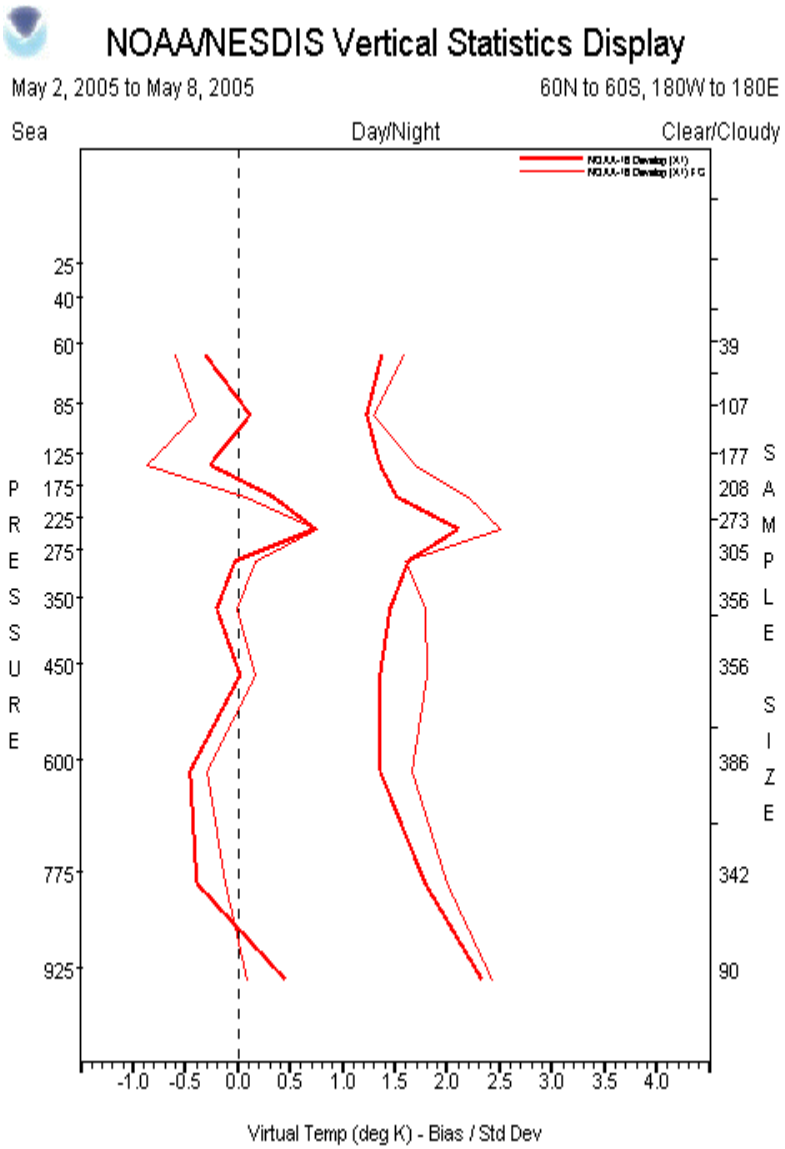


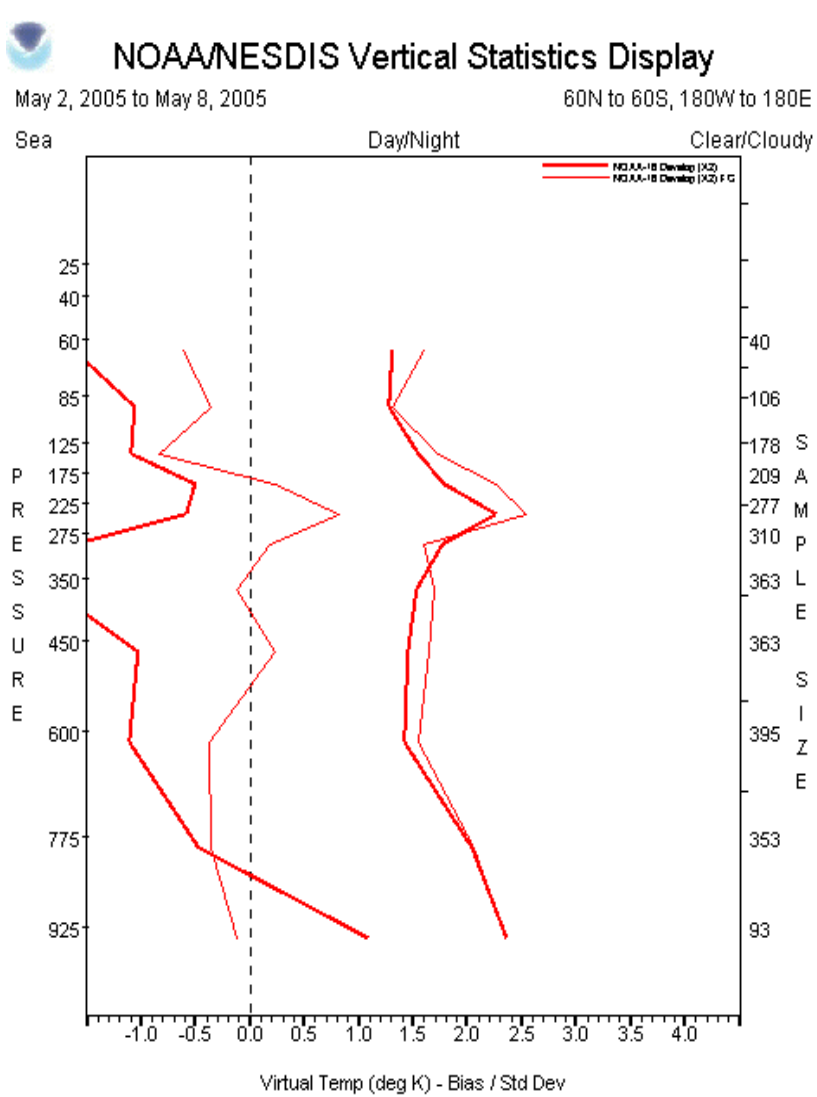






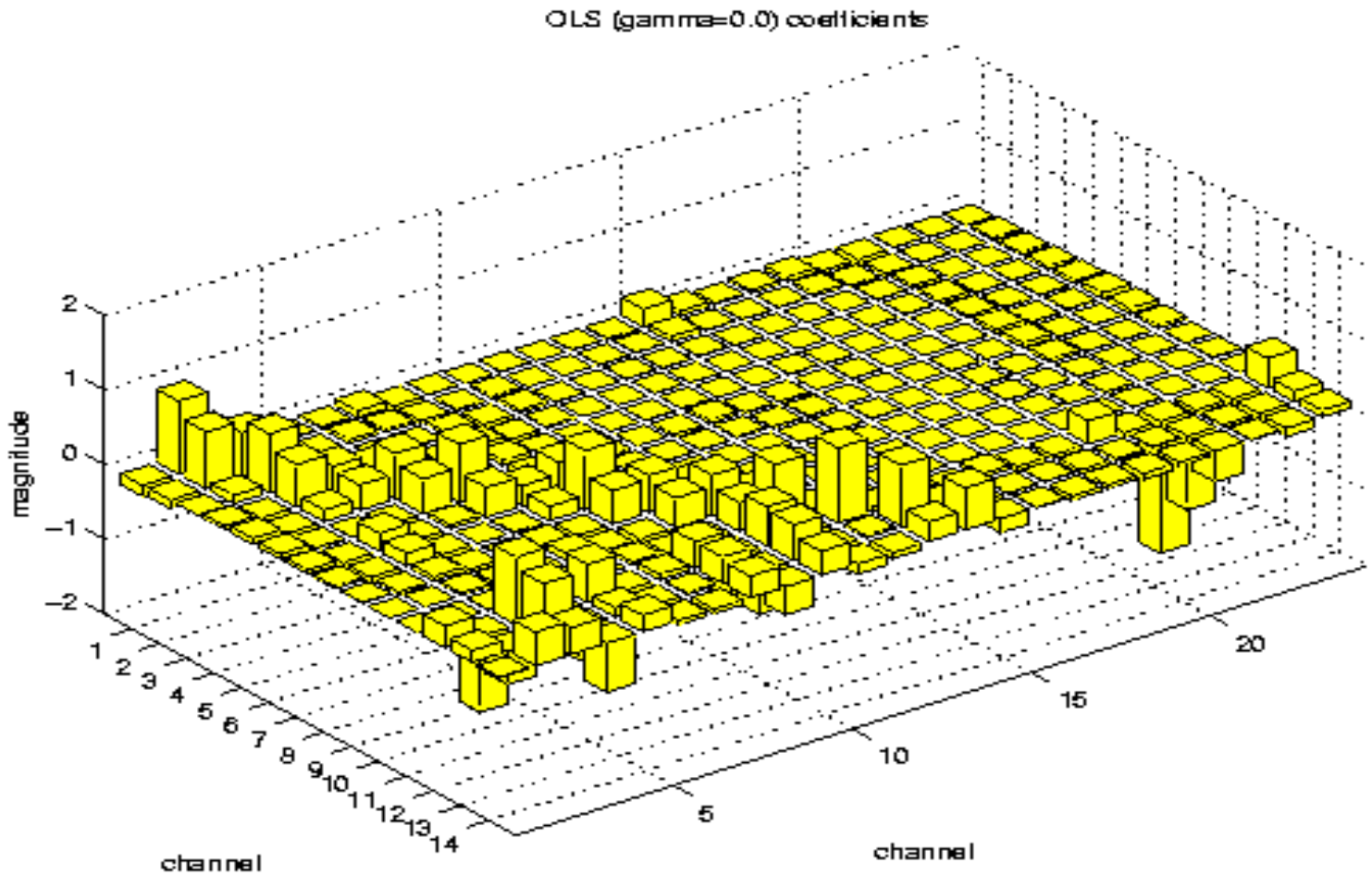



NOAA/NESDIS Vertical Statistics Display
May 2, 2005 to May 8, 2005
60N to 60S, 180W to 180E
Sea
Day/Night
Clear/Cloudy
NOAA-18 Develop (X1)
NOAA-18 Develop (X1) F G
PRESSURE
25
40
60
85
125
175
225
275
350
450
600
775
925
SAMPLE SIZE
39
107
177
208
273
305
356
356
386
342
90
-1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Virtual Temp (deg K) - Bias / Std Dev


NOAA/NESDIS Vertical Statistics Display
May 2, 2005 to May 8, 2005
60N to 60S, 180W to 180E
Sea
Day/Night
Clear/Cloudy
NOAA-18 Develop (X2)
NOAA-18 Develop (X2) F G
PRESSURE
25
40
60
85
125
175
225
275
350
450
600
775
925
SAMPLE SIZE
40
106
178
209
277
310
363
363
395
353
93
-1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
Virtual Temp (deg K) - Bias / Std Dev

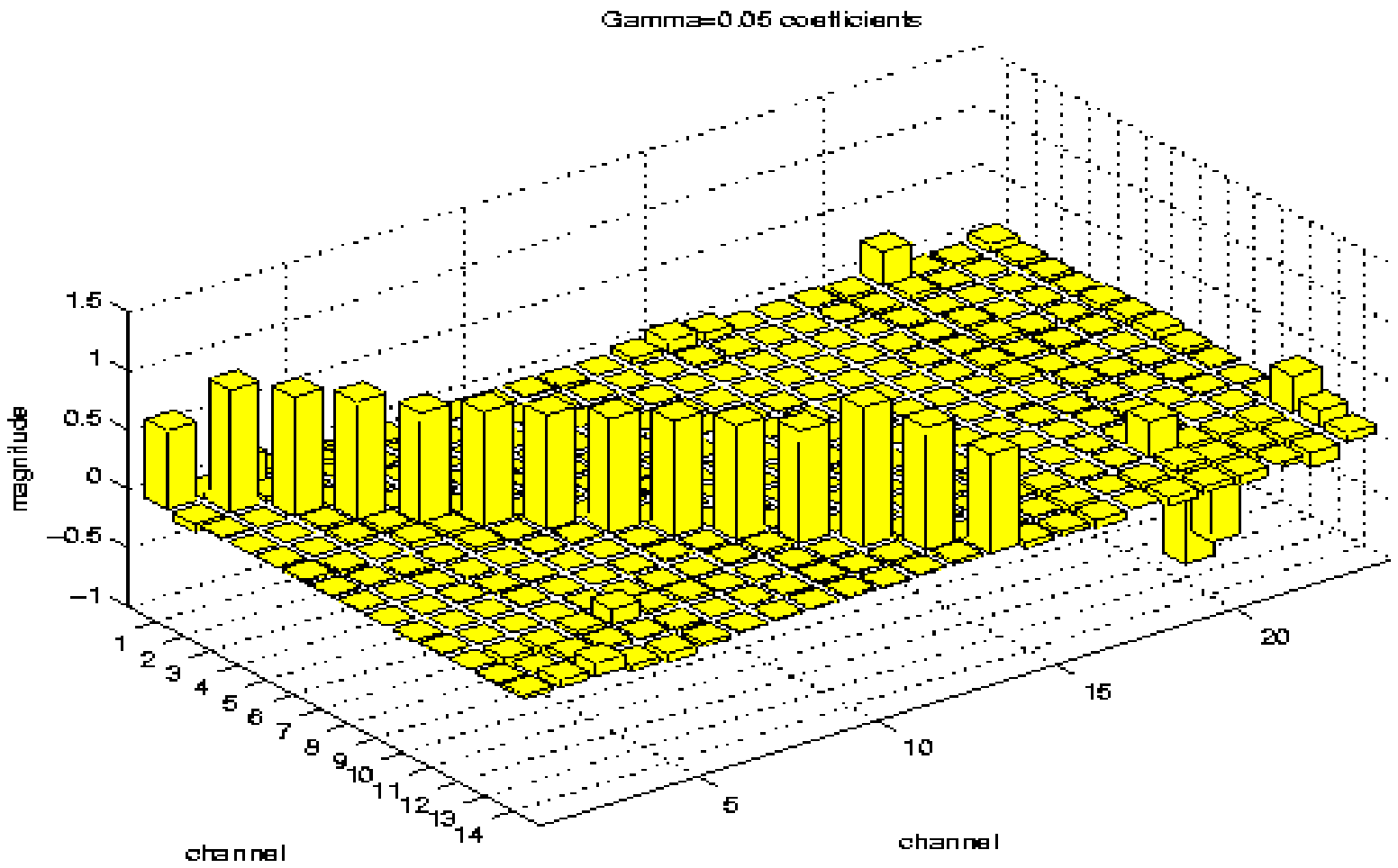
RT Bias Coefficients

(Gamma=0.0 ; AMSU-A ch 4-14; AMSU-B ch 3,4,and 5)



RT Bias Coefficients

(Gamma=0.05 ; AMSU-A ch 4-14; AMSU-B ch 3,4,and 5)



First Analytical Retrieval

$$(T - Tg)_j = S A^t (A S A^t + N)^{-1} (R - Rg)_i$$

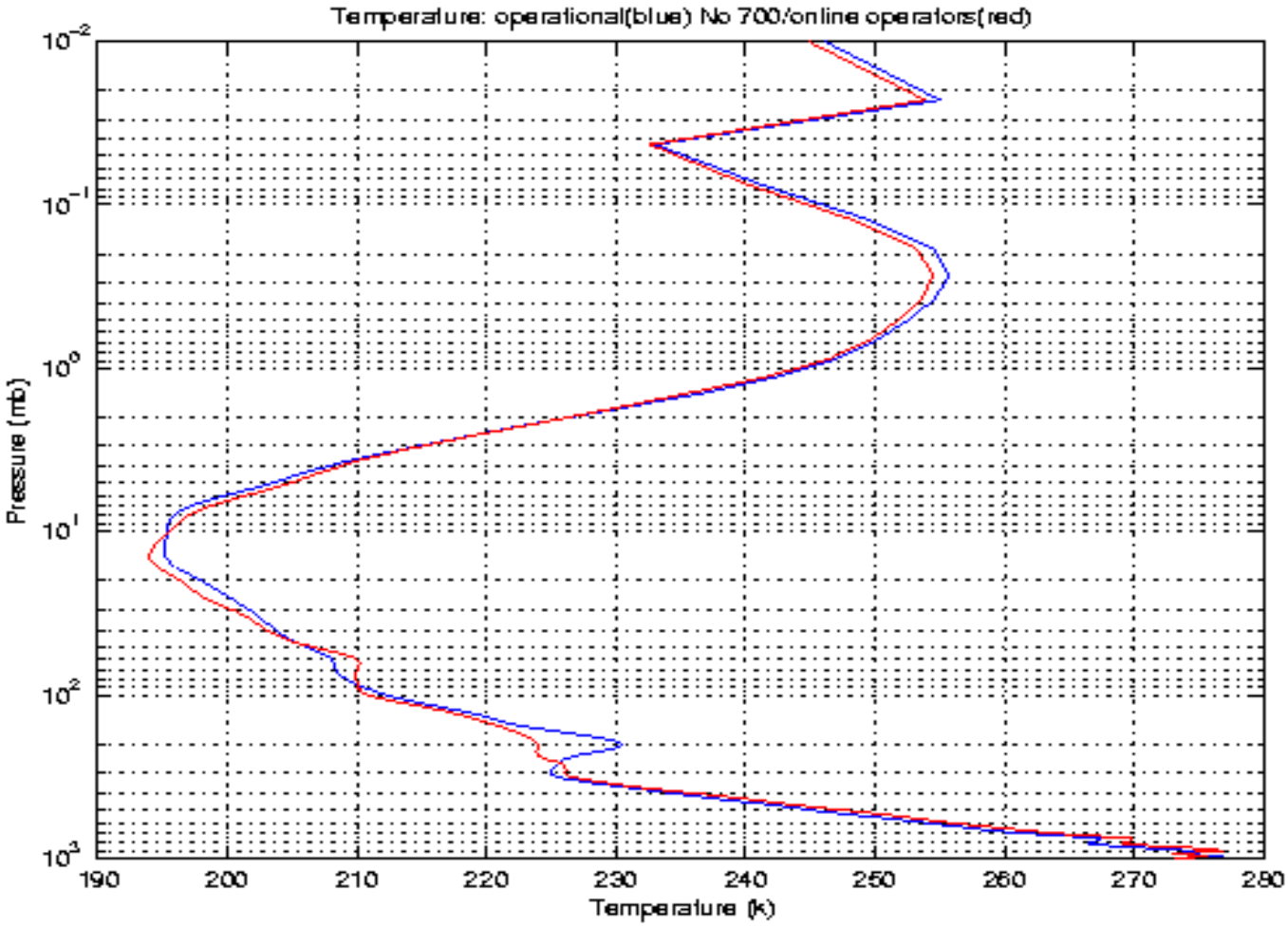
… *there are many questions and much potential for improvement* ***once the basic capability is installed and operating as designed:***

- MVS approach w/ CRTM - OPTRAN
- N matrix as scene dependent …
- Pressure levels versus layers (40 TOVS levels ???)
  - Also affects radiosonde interpolation
- Surface T, P, TPW and other boundary conditions (emissivity …)
- Others

- Retrieval on slant path
  - RT bias adjustment?
- Iteration
  - convergence testing?
  - S and N matrix adjustment?

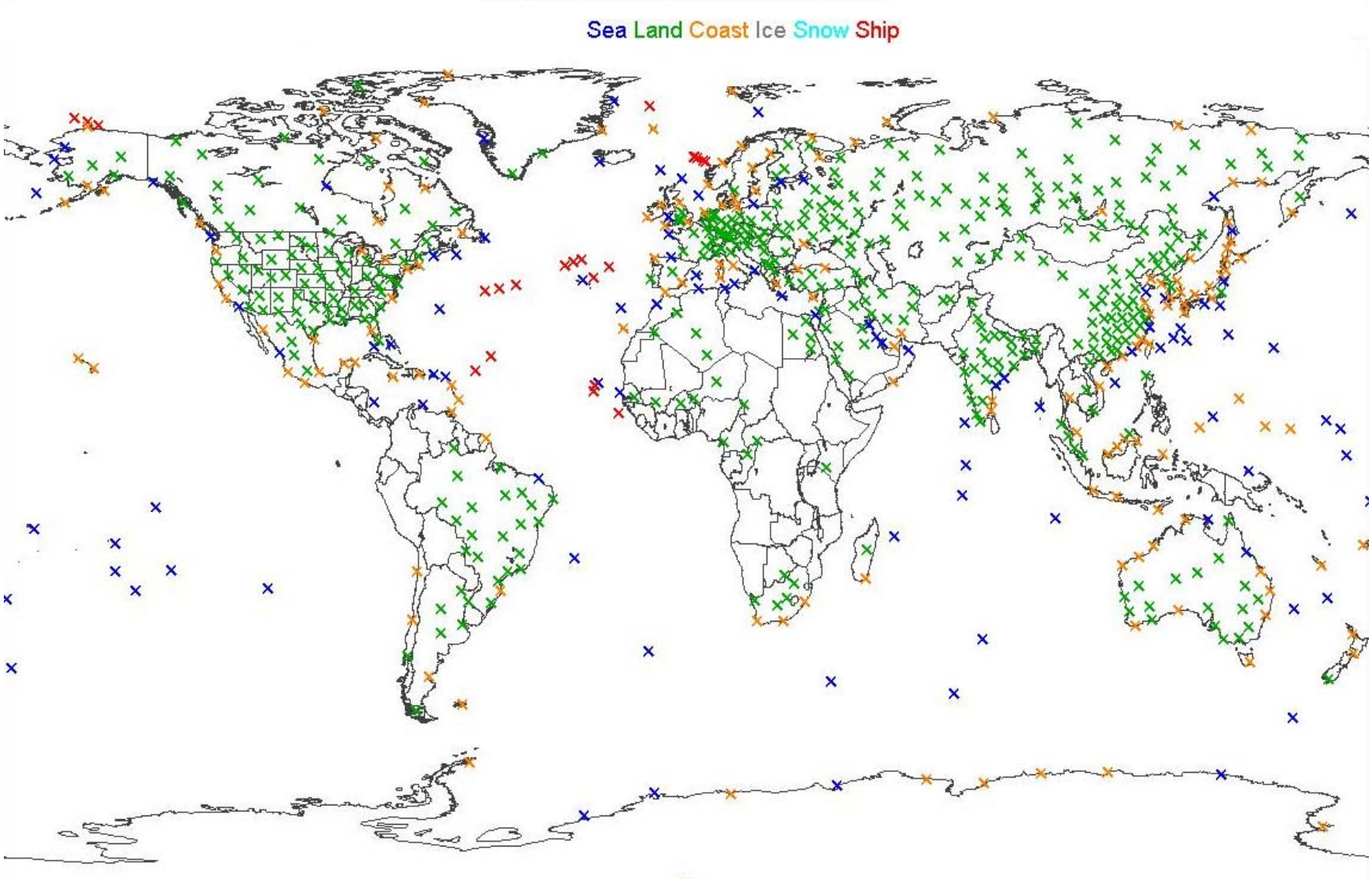
First Analytical Retrieval

(achieved in ATOVS operational environment)



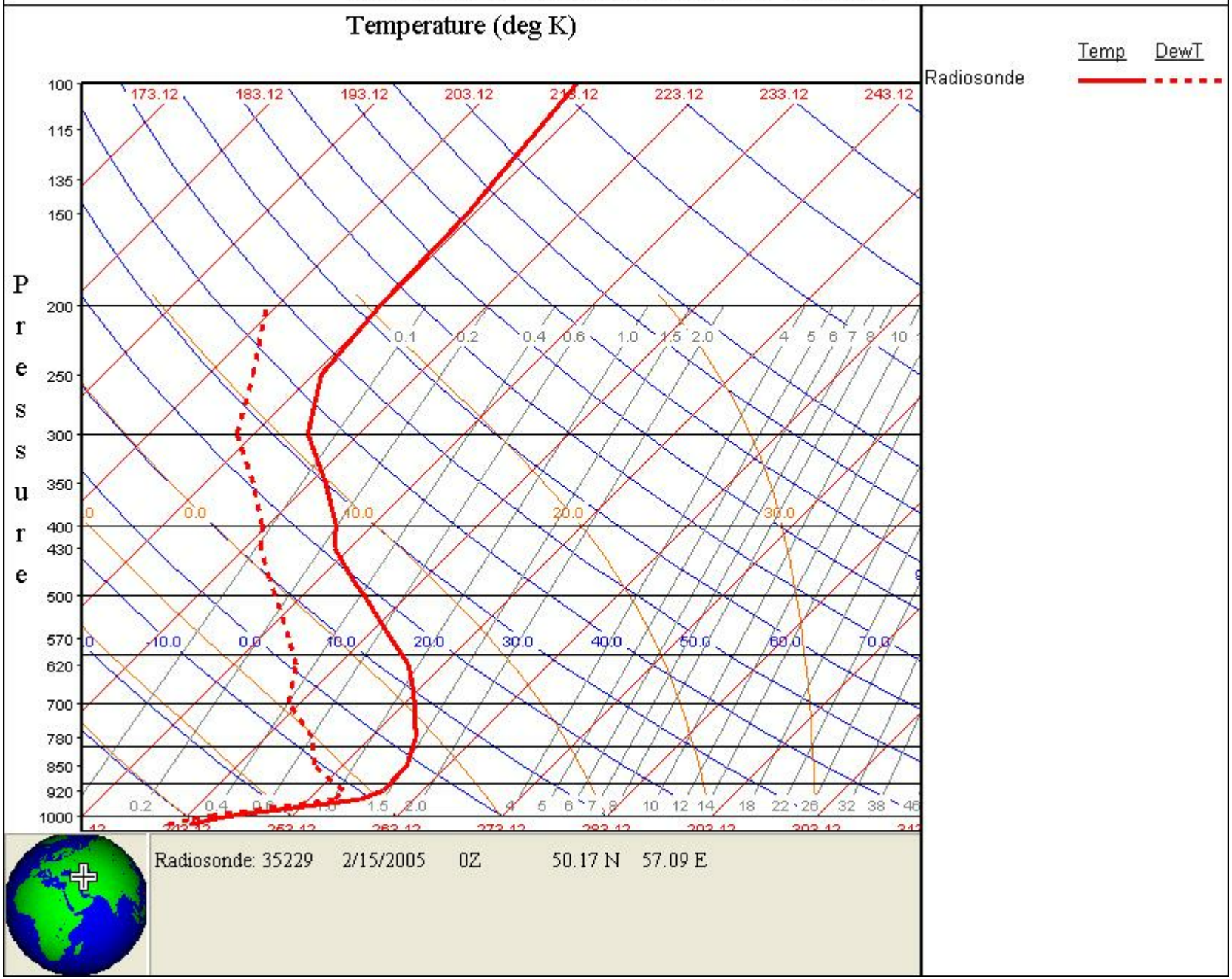
NESDIS Unified/Expanded Validation

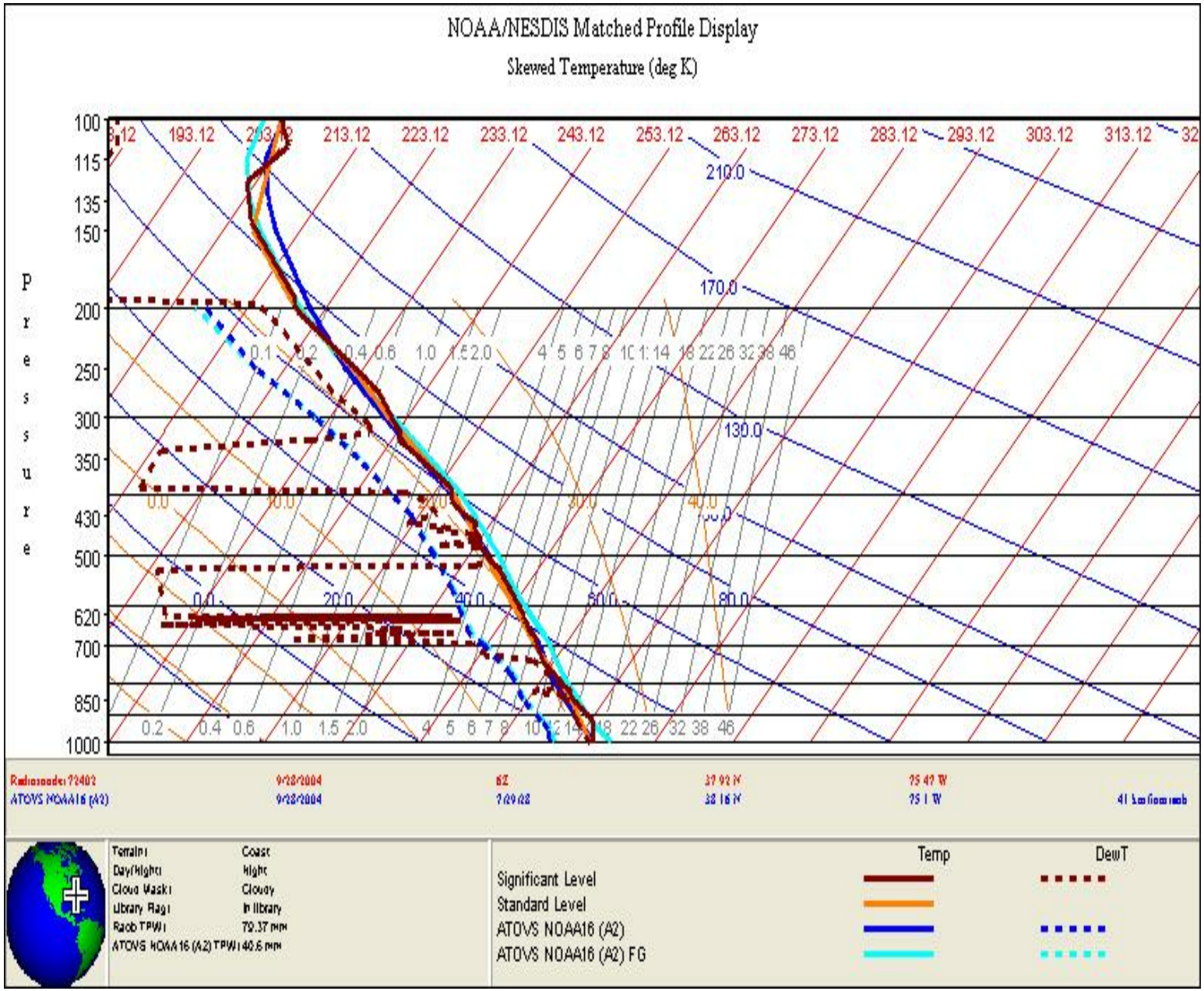
- Radiosonde Screening
- Radiance Comparisons
- Collocations with multiple satellite systems:
  - ATOVS Operation
  - Sys 2005 (NOAA-N)
  - AIRS (Goldberg, Barnet)
  - MSPPS (MIRS, F. Weng)
  - w/NWP
  - GOES



MDB … for all Radiosonde types

NOAA/NESDIS Matched Profile Display




NOAA/NESDIS Matched Profile Display
Skewed Temperature (deg K)
Pressure
100
115
135
150
200
250
300
350
430
500
620
700
850
1000
193.12
213.12
223.12
233.12
243.12
253.12
263.12
273.12
283.12
293.12
303.12
313.12
210.0
170.0
130.0
Terrain Coast
Day/Night Night
Cloud Mask Cloudy
Library Flag In library
Raob TPW 72.37 mm
ATOVS NOAA16 (A2) TPW 40.6 mm
Temp
DewT
Significant Level
Standard Level
ATOVS NOAA16 (A2)
ATOVS NOAA16 (A2) FG

Climate Requirements

"Real-time" Database Compilation Effort

…satellite data, ground truth collocations, NWP

…

(during satellite operational lifetime)

to serve as input for

"Retrospective" Processing Effort

…T, H2O, Clouds, Measurements ...

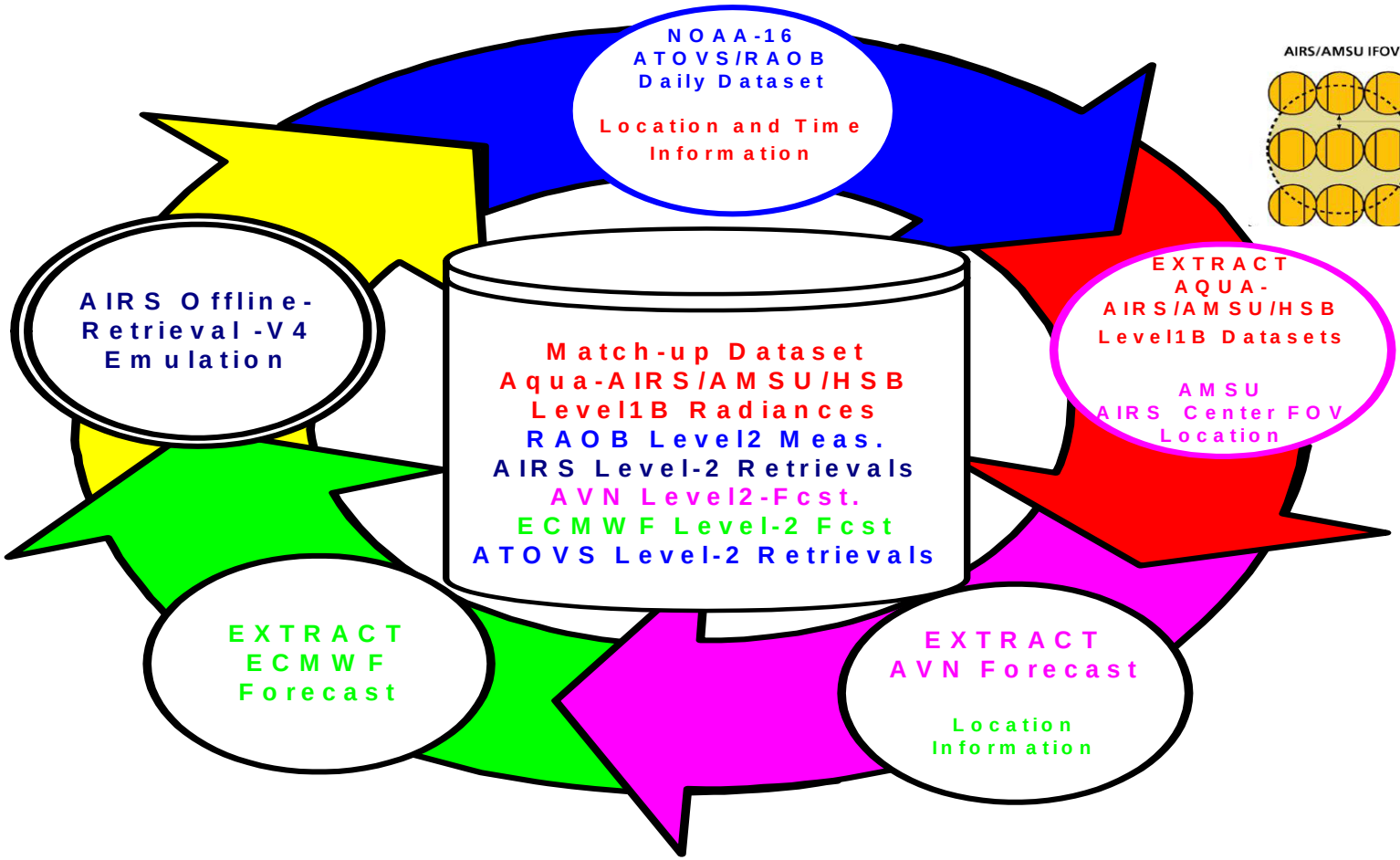
(at conclusion of satellite operational lifetime)

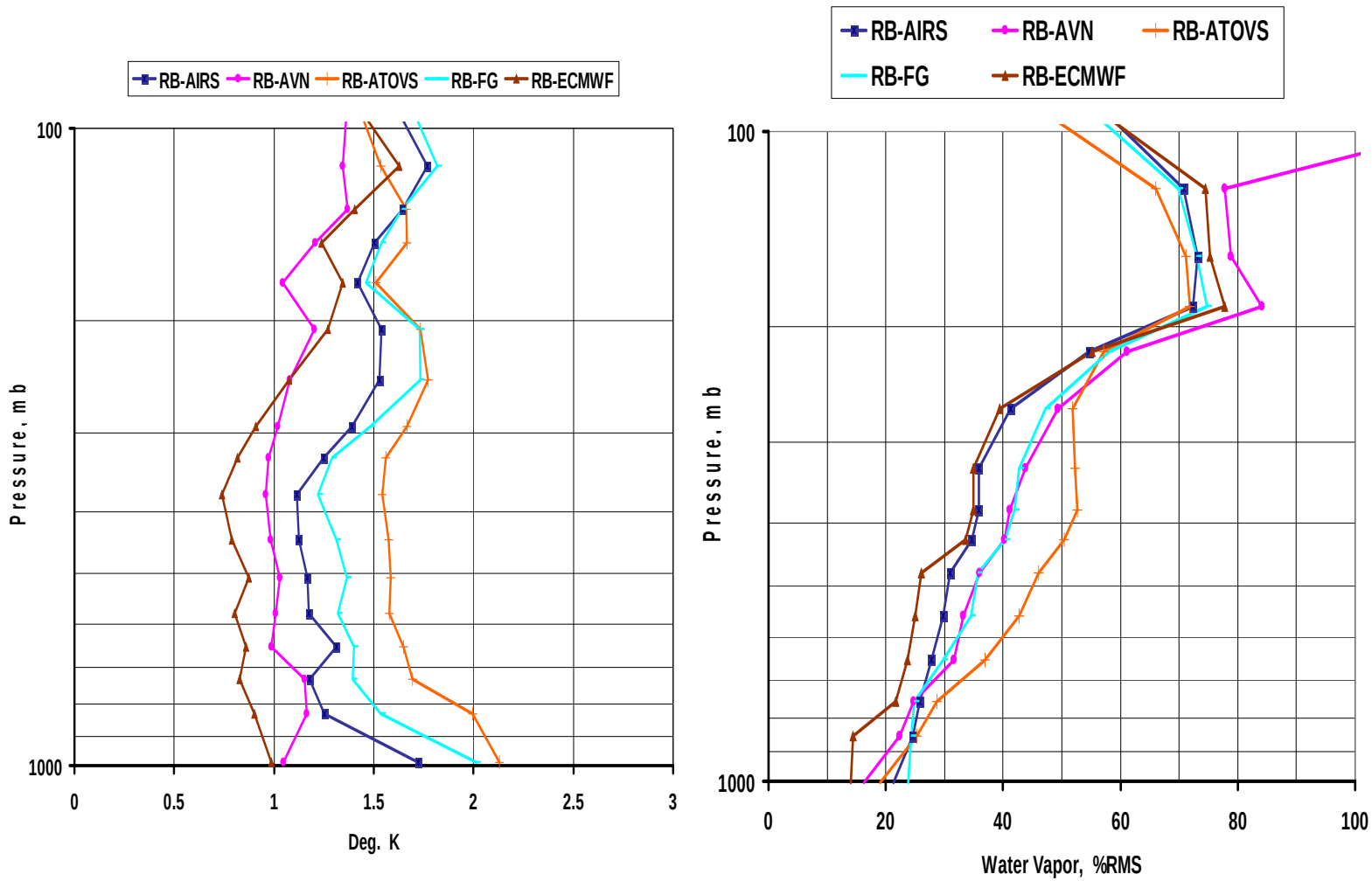
ORA Workshop Presentations
(held March 21-23, 2005

Temperature and Moisture Profile Retrievals from Current and Future Sensors

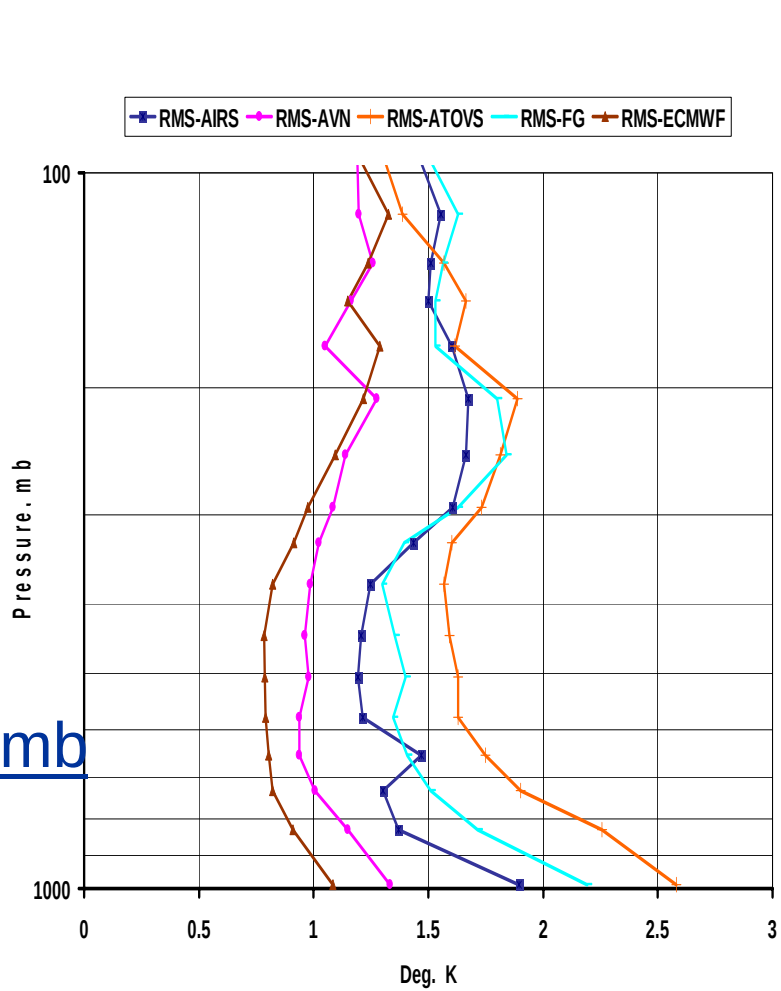
Retrieval Vision	Mitch Goldberg
Background and 1D-Var	Larry McMillin
AIRS Retrieval System	Chris Barnet
POES Retrieval System	Tony Reale
GOES System	Tim Schmit
Microwave Integrated Retrievals (MIR)	Fuzhong Weng

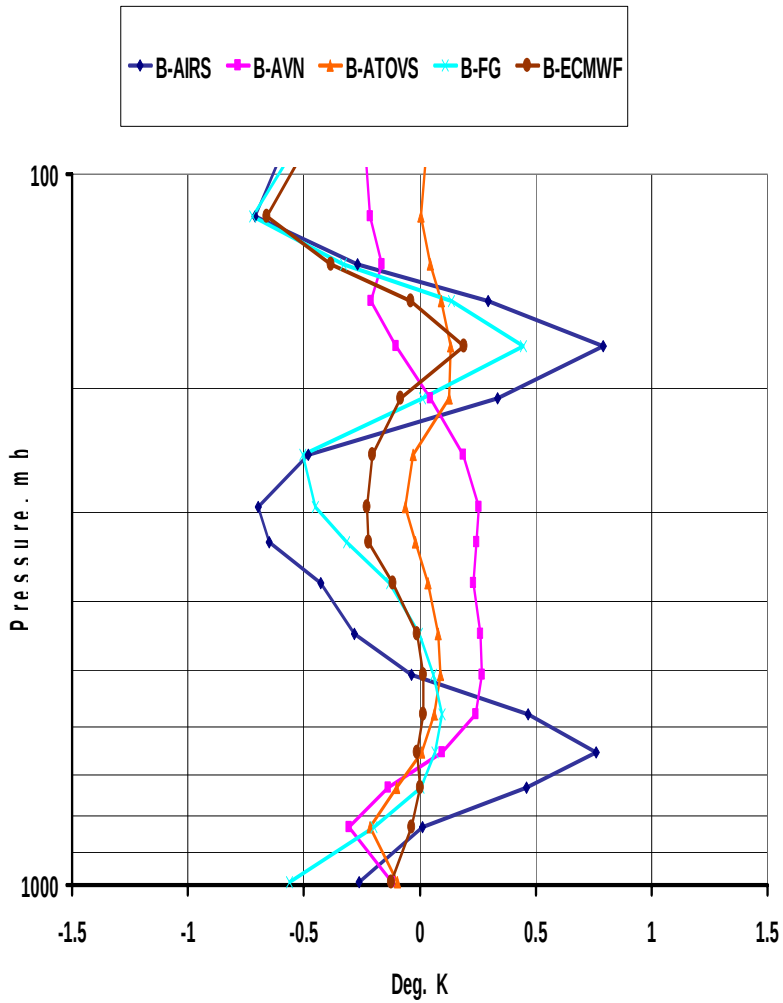
http://foehn-inter.nesdis.noaa.gov/PSB/SOUNDINGS/ORA/index.html


NOAA-16
ATOVS/RAOB
Daily Dataset
Location and Time
Information
AIRS Offline-
Retrieval-V4
Emulation
Match-up Dataset
Aqua-AIRS/AMSU/HSB
Level1B Radiances
RAOB Level2 Meas.
AIRS Level-2 Retrievals
AVN Level2-Fcst.
ECMWF Level-2 Fcst
ATOVS Level-2 Retrievals
EXTRACT
AQUA-
AIRS/AMSU/HSB
Level1B Datasets
AMSU
AIRS Center FOV
Location
EXTRACT
ECMWF
Forecast
EXTRACT
AVN Forecast
Location
Information
AIRS/AMSU IFOV
1.1° x 0.6° AIRS
25% Underlap
at Nadir
NADIR
3.3° AMSU-A



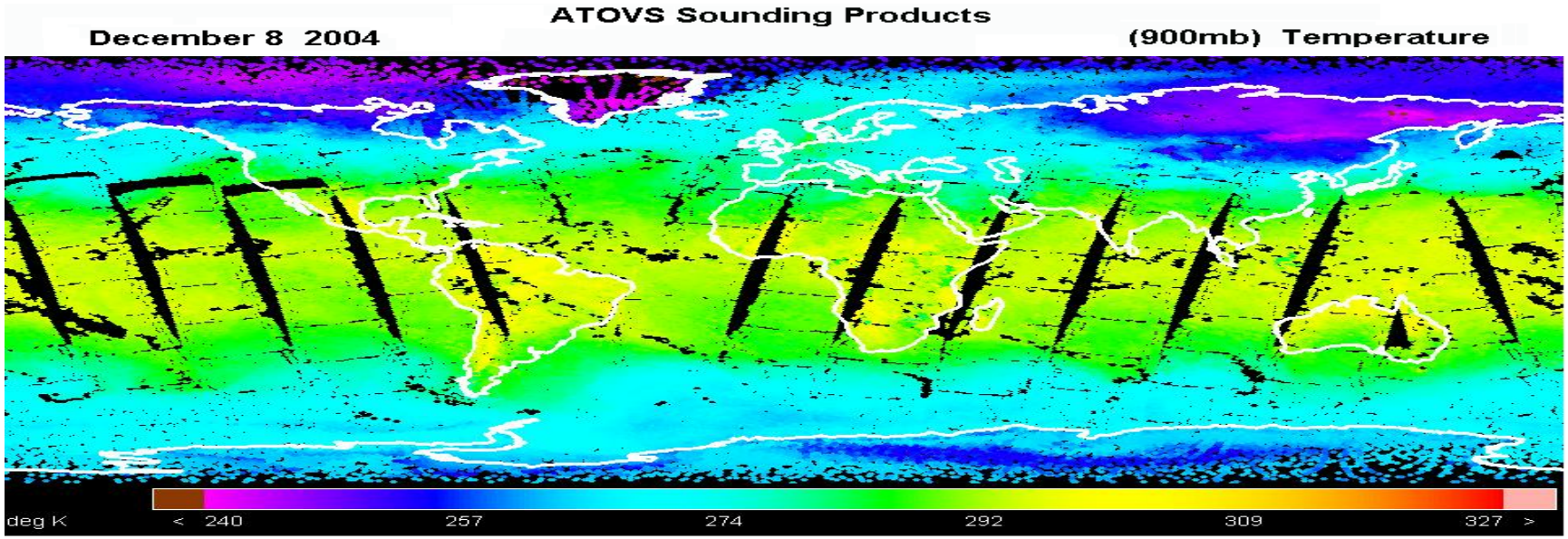
RAOB vs. AIRS AVN ATOVS FG ECMWF



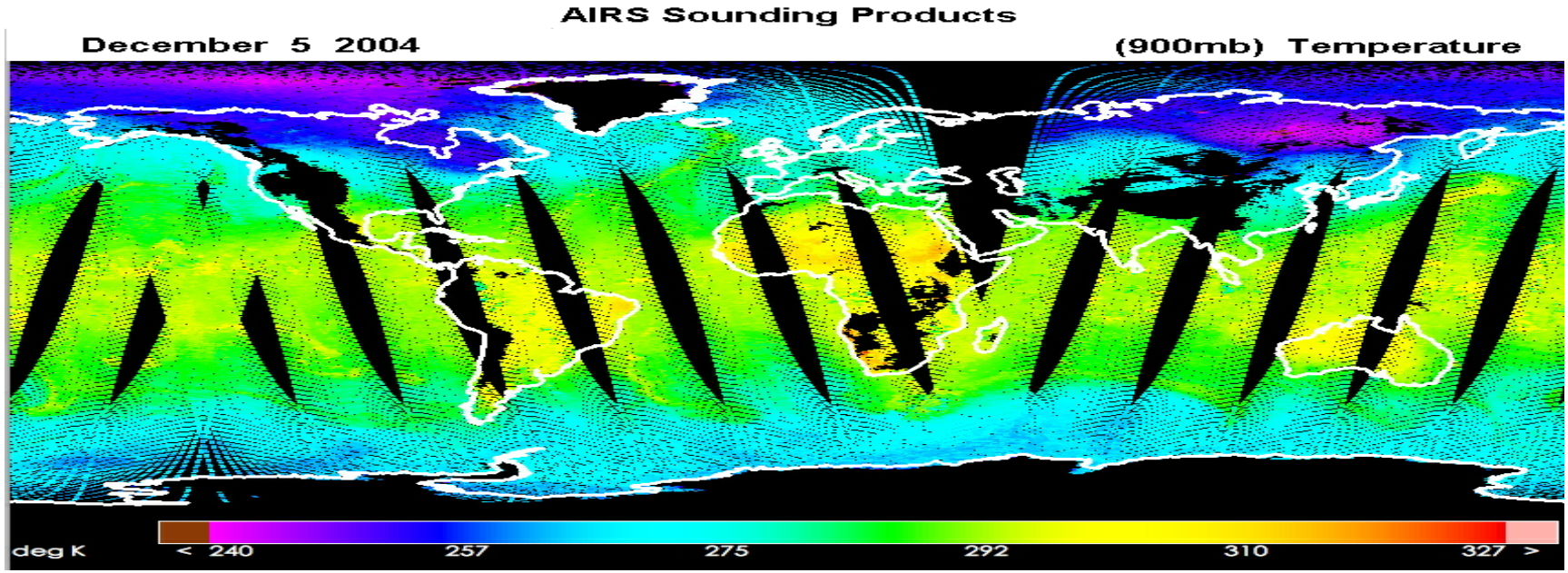


700mb

RAOB vs. AIRS AVN ATOVS FG ECMWF



ATOVS (top) as benchmark for AIRS (bottom)



Summary & Conclusions (AIRS Retrievals)

- **No Appreciable Difference in Day and Night Retrieval RMS**
- **No Appreciable difference in Time and Space Window Collocations - 3 HR vs 1 HR - An Improvement of 0.1K Temp Error, 4% difference at the Surface WV**
- **AIRS Biases Need to be addressed –**
  - **Using MODIS with AIRS Cloud Clearing**
  - **CO2 Climatology will Help ?**
- **Regression Using RAOB-AIRS Collocations shows Promise as a Fast Eigen Vector Regression Step.**

Support and interest for such work beckons the question “ *Why Soundings*?”

ITSC to address:

Operational products provide a rich environment for learning

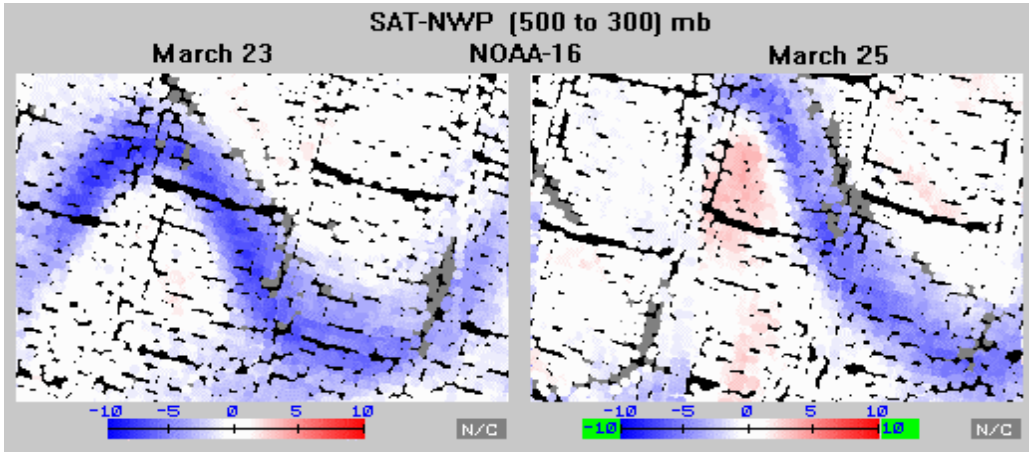
Importance of maintaining *“heritage”* Product systems,

Utility in weather/climate analyses/diagnostics,

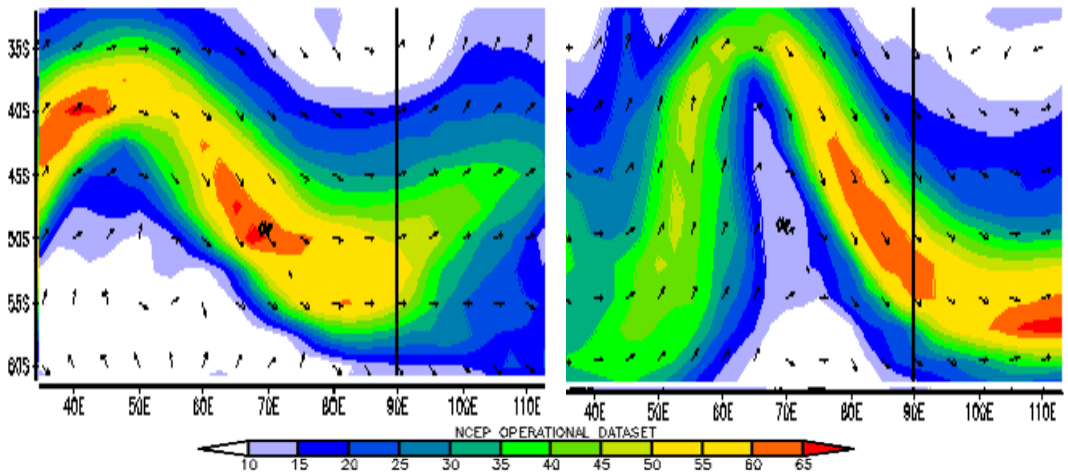
Data compression,

Demonstration of sounder capability to depict weather

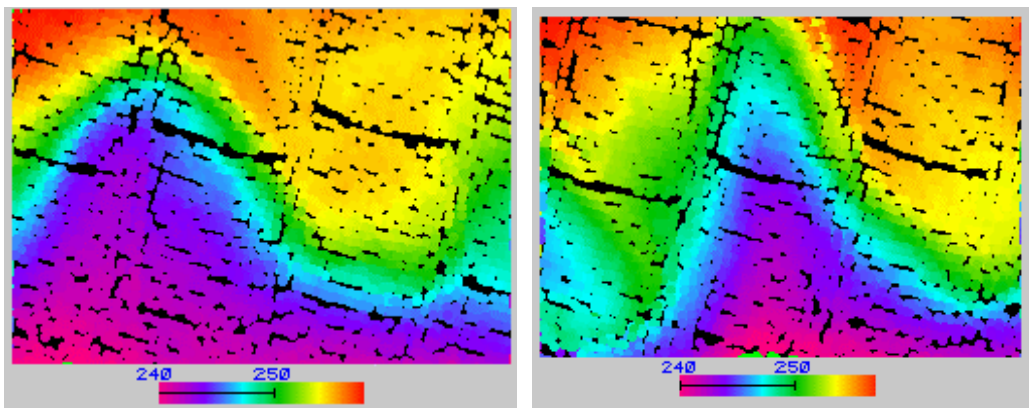
Global, regional and local (including direct readout) scales



< **DIFFERENCES**
between NESDIS
Satellite Soundings
and NWP



Pinpoint the Location
of the
JET STREAM
< (EMC 400mb Wind)



< (AMSU-A Ch 5)

extras

IJPS, IPS
Overview of Upgrades for Metop

- New Ingestor and Front End Processor (FEP)
  - Ingest of common instrument data, from the GDS as CCSDS VCDUs, in pipeline mode
  - Frame synchronizing and filtering of GDS data at Ingest
  - Receipt and distribution of ASCAT, GOME and GRAS Level 1b and IASI Level 1c products
  - Ingest blind orbit GAC, in pipeline mode
  - Produce instrument (NOAA) Level 1a's (i.e., for POES data - decommutate the TDM stream)

IJPS, IPS
Overview of Upgrades for Metop (Continue)

- New Preprocessor
  - IBM RS/6000 (development) and P570 (operations) AIX platform for parallel processing
  - Processing on a distributed (scalable processor) UNIX platform for parallel operations
  - Preprocessing of blind orbit GAC in pipeline mode
  - Producing common instrument Level 1b's from Metop in pipeline mode
  - Producing new Level 1b's for MHS and Full Resolution GAC (FRAC)

WHY SOUNDINGS

…. definitive statement ITSC

NOAA-N/N' Changes Continue

- MHS/MIU
  - MHS and AMSU-B Differences
    - Channels Frequency are Similar
      - Channels with different frequency
        - » H2 and 17 (change from 150 to 157)
        - » H5 and 20 (183 +/- 7 to 190 GHz)
    - Number of warm target PRTs
      - MHS has 5
      - AMSU-B has 7
    - Different Algorithms for Calibration
    - 1b/1b* format similar with minor changes

NOAA-N/N' Changes Continue

- MHS/MIU
  - Understanding different modes
    - Nominal modes
    - Non-nominal modes
    - MIU nominal modes
    - MIU non-nominal modes
  - Accommodating different modes
    - Set flag for Nominal and Non-Nominal modes
      - Operational nominal modes 99% of time

NOAA-N/N' Changes Continue

- HIRS
  - Field of View Size Change for HIRS
    - HIRS/4 10KM FOV compared to HIRS/3 20KM FOV
      - Users may need to change software, especially where co-location with other sensors such as AVHRR
  - Patch Temperature changed from 100 to 95K
  - Added a 5th Internal Warm Target temperature sensor and third telescope temperature sensor
  - Added extra bit to the electronic serial number in the Digital A data stream Element 63 Bits 40-44
    - Software change
    - Bits will be redefined in 1b

NOAA-N/N' Changes Continue

- HIRS Issues (Cont.)
  - Software Correction for the Operational HIRS Lunar Intrusion
  - HIRS Calibration Algorithm Version 4.0
    - New algorithm to be introduced as a supplement or replacement to current operational HIRS calibration algorithm

NOAA-N/N' Changes Continue

- AMSU-A
  - Correction of Lunar contamination
    - Will require minor change to 1b format
      - Header and Data record
  - Correction for sudden jumps in the calibration counts (NOAA-17 Channel 3 anomaly)
    - Minor changes to 1b format
      - Header and Data record

NOAA-N/N' Changes Continue

- AVHRR
  - Change to AVHRR Scaling Factors for some of the AVHRR nonlinear radiance coefficients
    - IR Operational/Test Cal Channel 4 coefficient 3
    - IR Operational/Test Cal channel 5 Coefficient 3

NOAA-N/N' Changes Continue

- Other 1b/1b* Format changes
  - Additional Headers added
    - Ancillary Data Set Names added
    - Quality Information added
      - Could be used to determine which data to keep

NOAA-N/N' Changes Continue

- New Telemetry File
  - File will contain telemetry that is not contained in instrument 1b
    - Will be useful for MIU data when in Non-nominal modes
    - All telemetry data will now be archived
  - May be similar to AIP 1a file
    - May also contain science data

Update Product Applications for Pipeline Processing

- **Atmospheric Soundings, Real-time Ozone, Hazards, Microwave Surface and Precipitation, CLAVR Cloud Flags**

- **Applications that plan to use 1-km AVHRR data from Metop are CLAVR cloud flags, Aerosol, Imagery, CoastWatch, Radiation Budget, Sea Surface Temperature, Vegetation, Hazards, Snow/Ice & Significant Event Imagery**

- **Pipeline concept: End to end test with preprocessor (initial test Sept/Oct 2004)**

Soundings System Upcoming Changes and Activities

AWIPS

- U.S. only system (current distribution)
- NOAA-16 ----NOAA-18 will be added
- Nine regions (shown on the next slide)
- Retrievals parsed by region
- Used by U.S. Forecast Offices on AWIPS-dedicated machines

ATOVS Porting

Porting ATOVS from Cray to IBM SP

- Old Cray (J90)
- New IBM SP P655 (4 nodes)
  - 2 nodes (called East and West) for parallel, pre-production testing
  - 2 nodes (called North and South) for production
  - ATOVS from all 3 polar orbiters (N15, 16, and 17)
  - Reduces orbital processing time by 17 minutes (From 20 minutes to 3 minutes)