Evaluation of CrIS/ATMS Proxy Data Generation Algorithms with Observed Radiances and Retrieval Products

By

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Evaluate Proxy SDRs/EDRs Resemble Real SDR/EDR Products

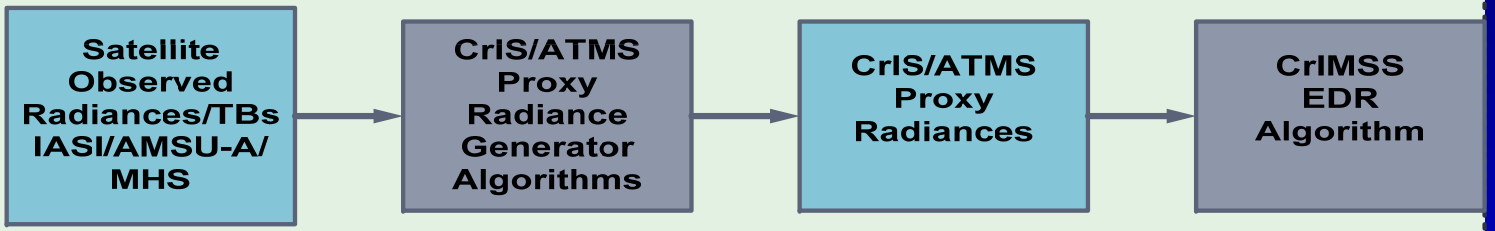
- Proxy Data Set Generation: Utilize Sensor Data Records (SDRs) from an existing satellite instrument suite (IASI/AMSU-A/MHS) to generate proxy SDRs for future satellite instruments (CrIS/ATMS, now in orbit).
- Pre-Launch use
  - Develop and test algorithms to produce retrieval products
  - Select channels for the physical retrieval algorithms
  - Define and test channel sub-sets for NWP assimilation
- Post-Launch use
  - Improve procedures developed with pre-launch proxy SDRs to optimize post-launch EDR algorithm (Research to Operations).
  - Time and effort in optimizing post-launch processes depends on the quality of proxy SDRs in resembling real observations.
- The attempt here is to present examples of duality between proxy EDRs derived using proxy SDRs, and EDRs derived with real CrIS/ATMS SDRs. One such example - effect of dust on two different retrieval algorithms – will be highlighted, showing the effect of dust on EDR products - how dust effect was perceived with proxy data, and how it is seen with real observations.

Proxy Data Algorithms for CrIS/ATMS

CrIS Proxy from LaRC (Liu and Kizer, 2010)
ATMS Proxy from MIT (Bill Blackwell et al., MIT)

Proxy Data Generation Algorithms for CrIMSS EDR Retrievals

Concept of Proxy Data Generation



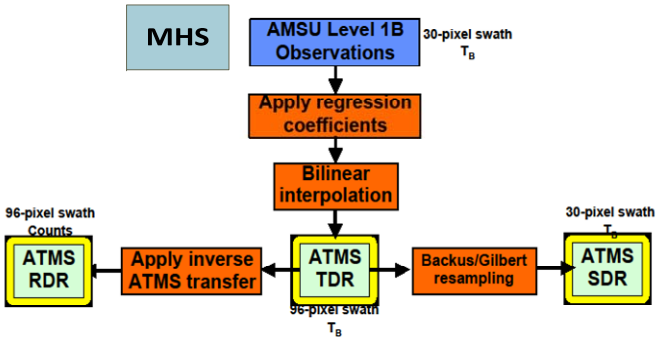
- Real Observations, Real Scenes (Atmosphere, Surface, Cloud), Sub-Pixel Variability
- Test Robustness of the Operational Code for Different QCs
- Check CrIMSS EDR Performance With Retrievals from Other Algorithms, and the Truth
- Truth is not known perfectly as like real data
- RTA Differences: Proxy Data Generation (e.g. ATMS LBL) vs. EDR Alg. RTA (OSS)

CrIS/ATMS Proxy Data Algorithms (Xu Liu and Kizer, 2010; Blackwell et al., 2010)

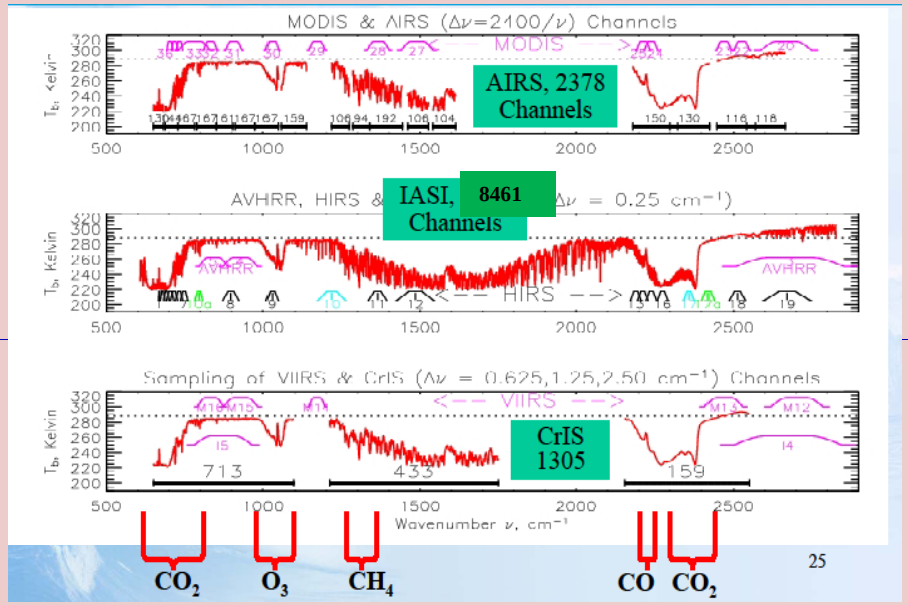
Steps for Generating CrIS proxy data from IASI

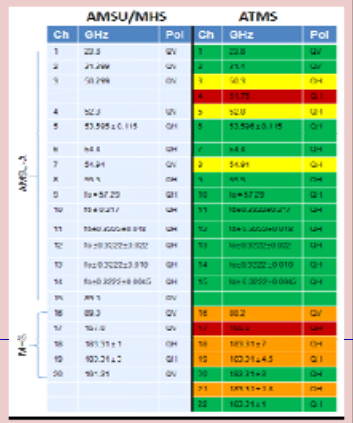
- Matching spectral resolution between two FTS instruments are easy and exact
  1. Transform the IASI spectrum into interferogram via FFT
  2. Truncate the interferogram according to the maximum OPD of the lower-resolution FTS instrument
  3. Divide the interferogram by the IASI apodization function
  4. Multiply the interferogram by the CrIS apodization function
  5. Perform inverse FTT to convert the modified interferogram into spectral domain
  6. Interpolate 4 IASI FOV to 9 CrIS FOV
- Use can choose from three apdization functions for CrIS
  - Unapodised, Hamming, and Blackmam
- Can include local angle adjustment before step 6

ATMS Proxy Data Generation Flow Chart



Availability of Hyper Spectral Infrared Sounders and Advanced Microwave Sounder Observations Enable Generation of CrIS/ATMS Proxy Data Sets





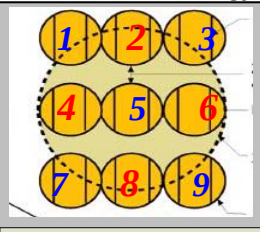
Exact match to AMSU/MHS
Only Polarization different
Unique Passband
Unique Passband, and Pol. different from closest AMSU/MHS channels

QV = Quasi-vertical; polarization vector is parallel to the scan plane at nadir

QH = Quasi-horizontal; polarization vector is perpendicular to the scan plane at nadir

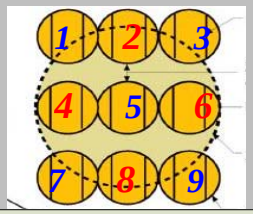
Broad Spectral Coverage, Thousands of Spectral Channels, High Spectral Resolution, High Information Content

Aqua-AIRS/AMSU-A	1:30 AM/PM Atmospheric Infrared Sounder (AIRS) – 2378 IR Channels
MetOp-IASI/AMSU-A/MHS	9:30 PM/AM Infrared Atmospheric Sounder Interferometer (IASI) – 8461 IR Channels
NPP-C1 & C3: CrIS/ATMS	1:30 AM/PM Cross-track Infrared Sounder (CrIS) 1317 IR Channels
Advanced Microwave Sounding Unit (AMSU-A15 CH MW temperature sounder - 55 GHz Oxygen band)	
Microwave Humidity Sounder (MHS 5 CH ~ 183 GHz)	
Advanced Technology Microwave Sounder (ATMS – 22 CH Temperature and Moisture sounder)	

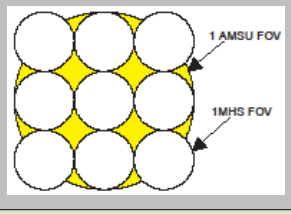


AIRS 9 FOVs

IASI 4 FOVs

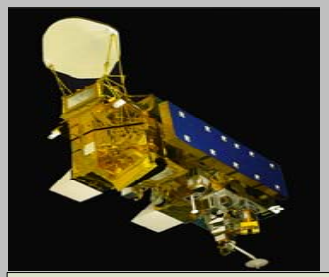


CrIS 9 FOVs



AMSU (1FOV) and MHS (9 FOVs)

Aqua - 2002

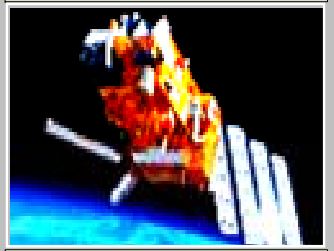


AIRS-2378 IR Channels

S-NPP - 2011

CrIS 1305 IR Channels

IASI- 8461 IR Channels)



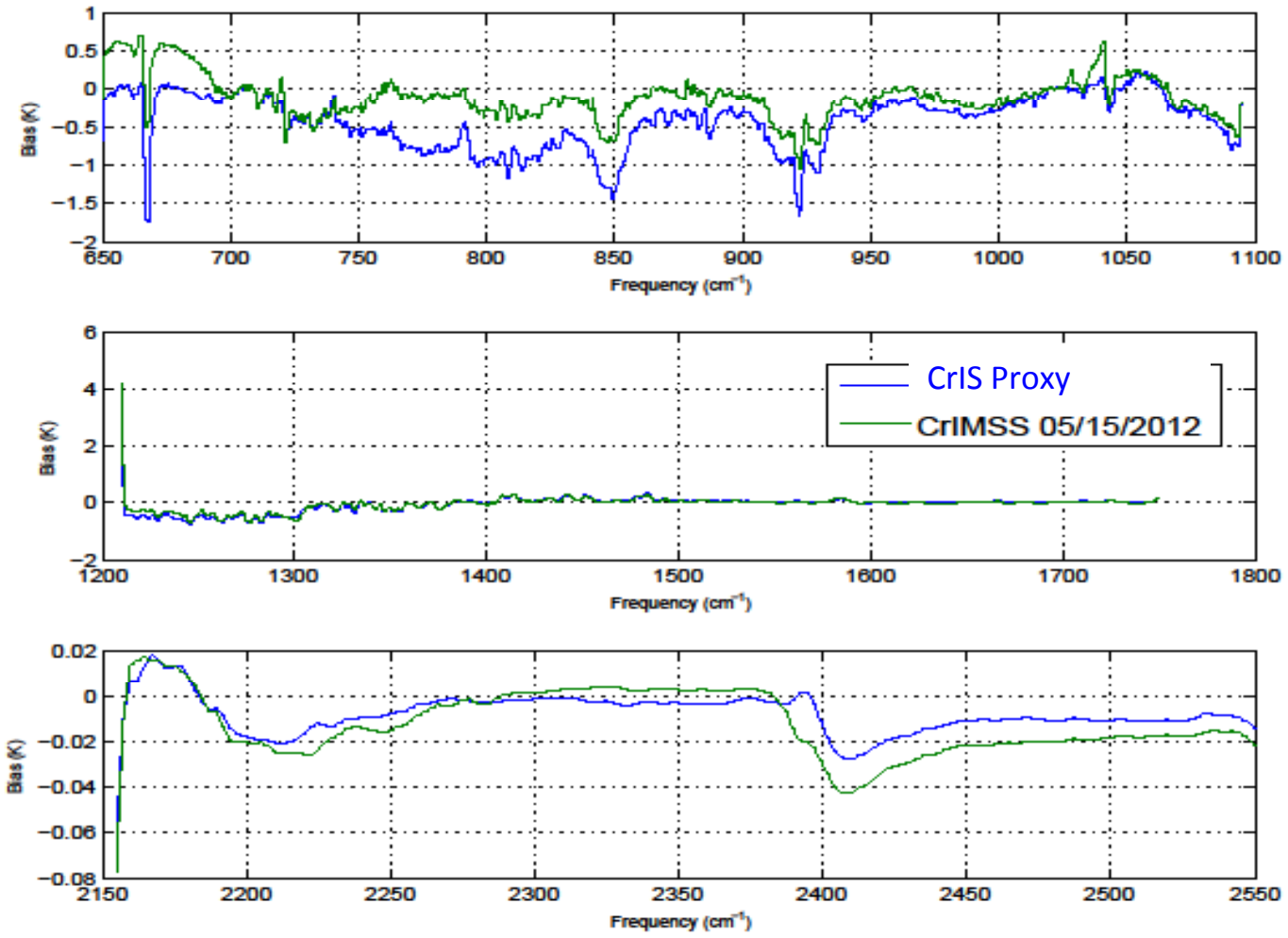
MetOp – 2007

Post-Launch exercises with Pre-Launch proxy data

- Verification of CrIMSS EDR Algorithm - Science Code (from NGAS), IDPS-EDRs and Off-Line Ported Code (from LaRC).
- Verification of OSS forward model implementations at coordinating agencies (STAR, LaRC, NGAS) using ECMWF analysis Fields.
- Development of Reader/Writer Routines; Interfaces towards generation of correlative data sets (ECMWF/RAOBs) for post-launch evaluation of CrIMSS EDR products; Unification of statistical routines and testing with common data sets.
- Development of bias-tuning procedures for CrIS and ATMS (CrIMSS) EDR Algorithm.
  - The CrIMSS EDR 'Day-1' algorithm (IDPS version MX5.3) used empirical bias-tuning LUTs generated from pre-launch proxy SDRs. The LUTs were replaced with LUTs generated from real observations after post-launch (MX6.3).

Empirical Bias Tuning for CrIS: Proxy CrIS (Derived from IASI) *vs.* Real Observations (05/15/2012)

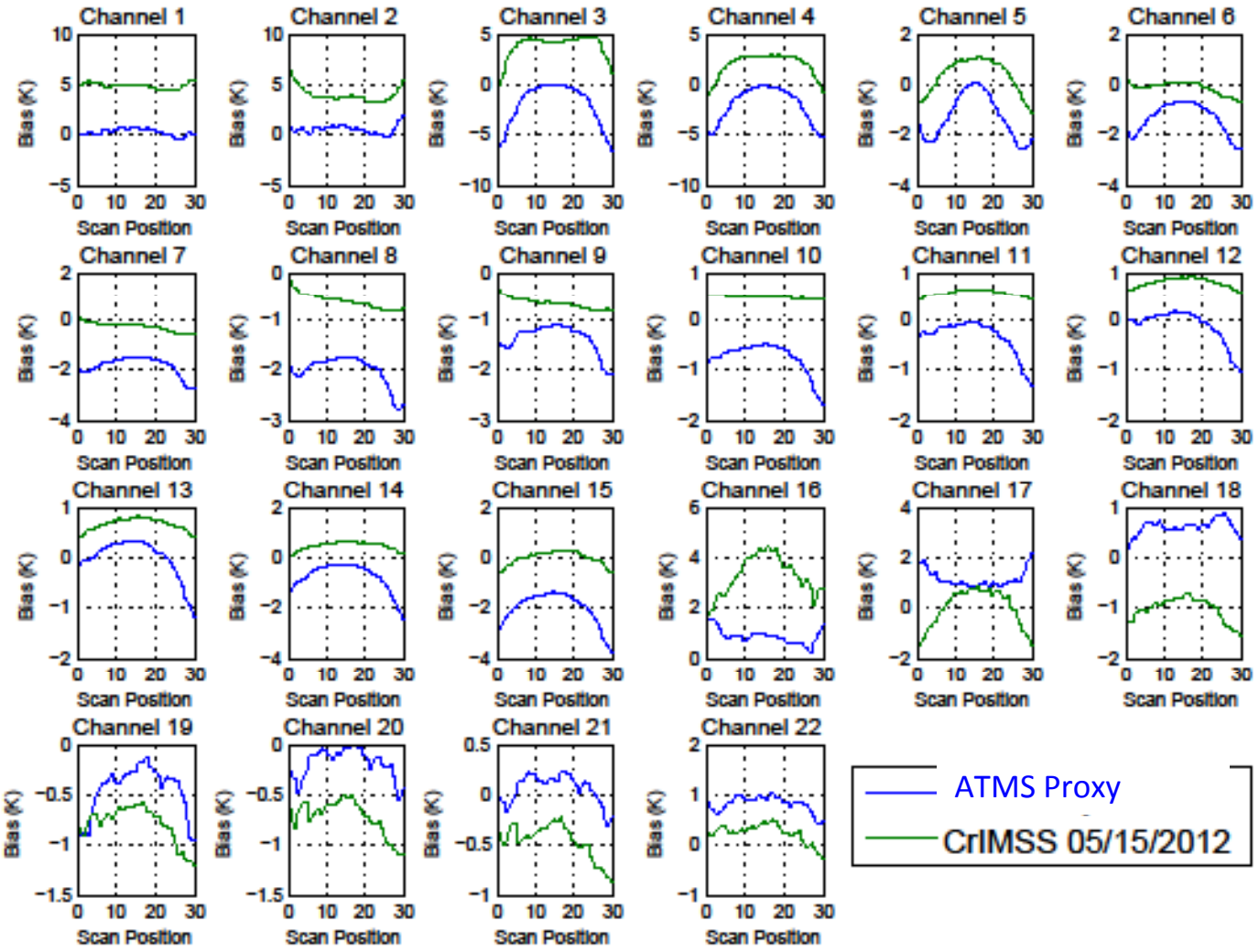
"Moving from Pre-Launch to Post-Launch"



Slide Courtesy: Xu Liu and Kizer, LaRC

Empirical Bias Tuning for ATMS:
Proxy ATMS (Derived from AMSU-A/MHS) vs. Real Observations (ATMS – 05/15/2012)

"Moving from Pre-Launch to Post-Launch"



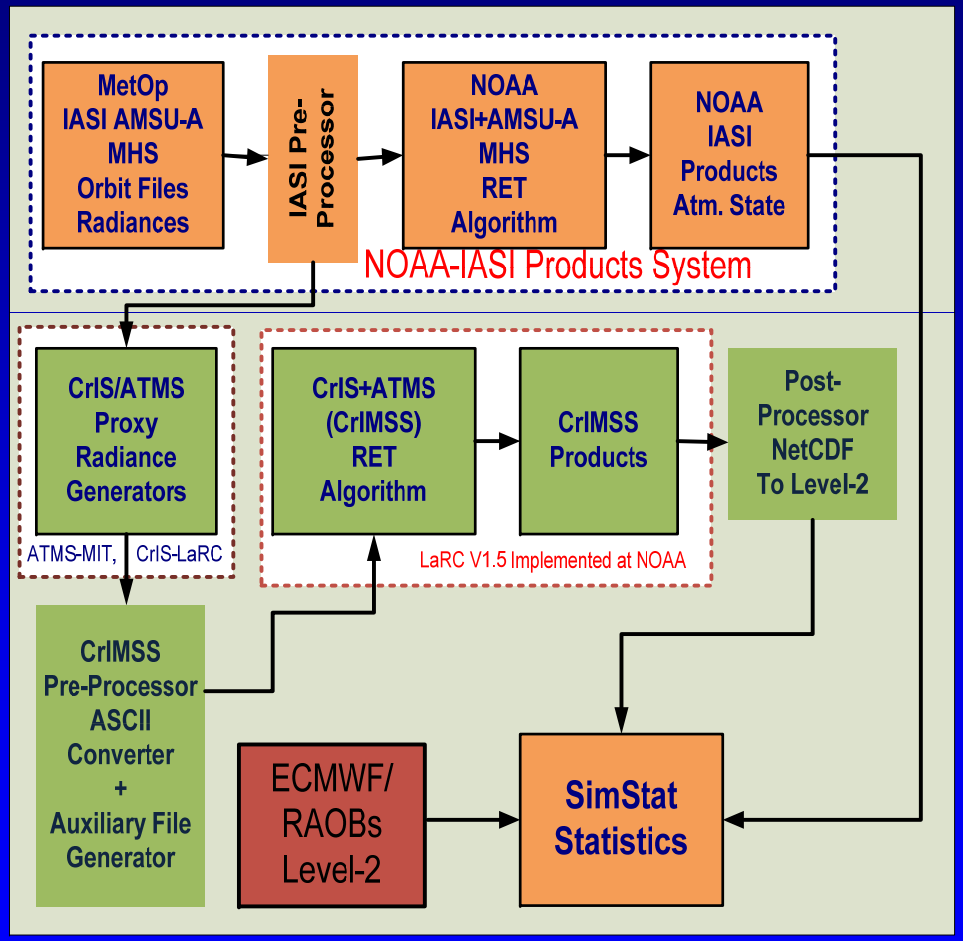
Slide Courtesy: Xu Liu and Kizer, LaRC

Pre-launch efforts to evaluate CrIMSS EDR products
CrIS/ATMS Proxy SDRs from IASI/AMSU-A/MHS Observations

- NOAA-IASI Retrieval Algorithm
  - A replica of AIRS Science Team algorithm
  - Implemented as a part of STAR-IASI (IASI/AMSU-A/MHS) EDR Product System.
  - Generated T(p), q(p) EDR products with real observations

  IASI/AMSU-A/MHS SDRs
- CrIMSS (CrIS/ATMS) official retrieval algorithm
  - NOAA/STAR implemented Off-line CrIMSS EDR algorithm for CrIMSS EDR products
  - Generated T(p), q(p) proxy EDR Products with proxy observations

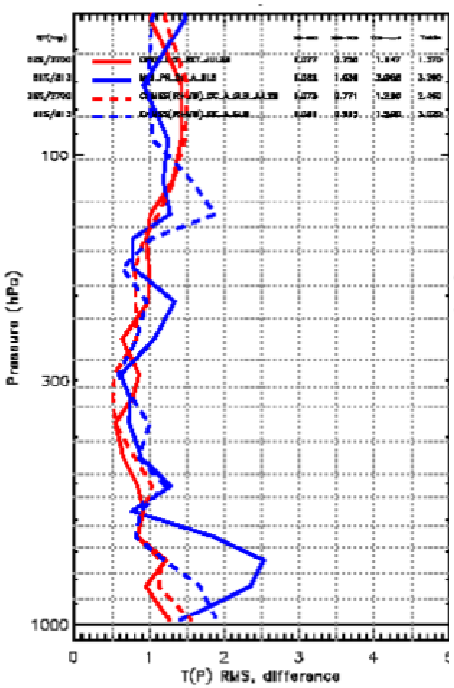
  CrIS/ATMS SDRs.
- Matched ECMWF analysis fields as a proxy to the truth.

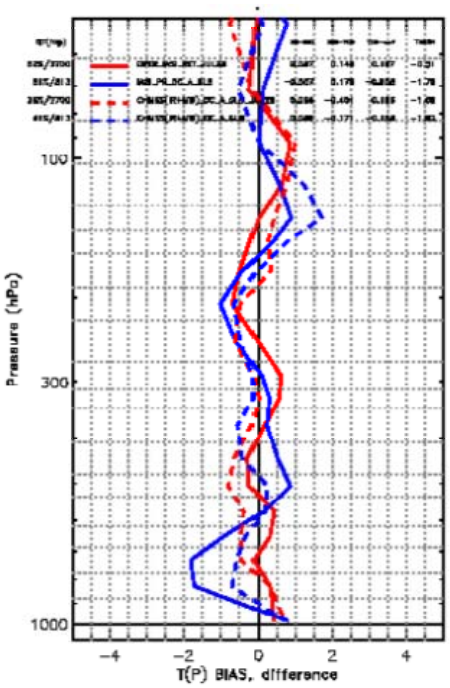


‘Dust-Free ’ vs. ‘Dusty’ Granule Proxy Retrievals 07/28/2011, 08/01/2011 IASI and CrIMSS

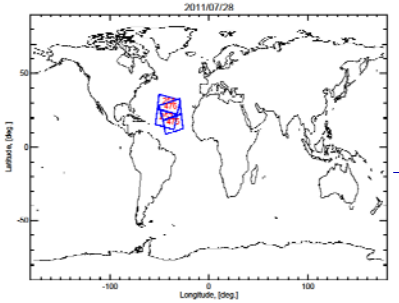
AEROSE-2011 Matched IASI(RET), ECMWF and CrIMSS (RET) - T(p) Dust-Free/Dusty

NOAA- AEROSE-2011 IASI-TRET vs. ECMWF; CrIMSS-TRET vs. ECMWF

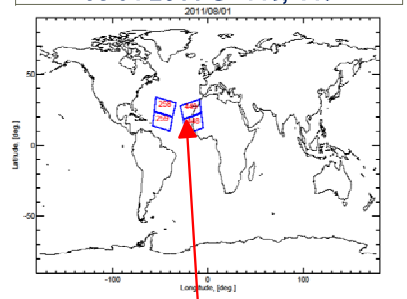


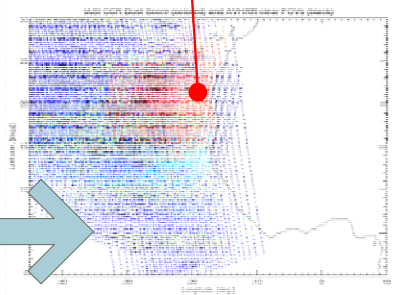


07/28/2011 G- 251, 252, 475, 476



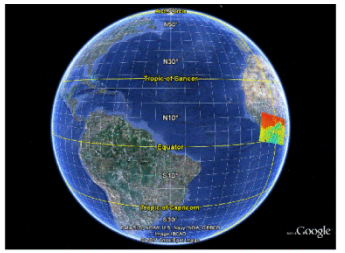
08/01/2011 G- 448, 449





Date	IASI Retrievals (NOAA)	CrIMSS Retrievals (NGAS)
07/28/2011 Dust-Free	Solid Red _____ (82%)	Dotted Red ---------- (36%)
08/01/2011 Dusty	Solid Blue _____ (81%)	Dotted Blue --------- (41%)

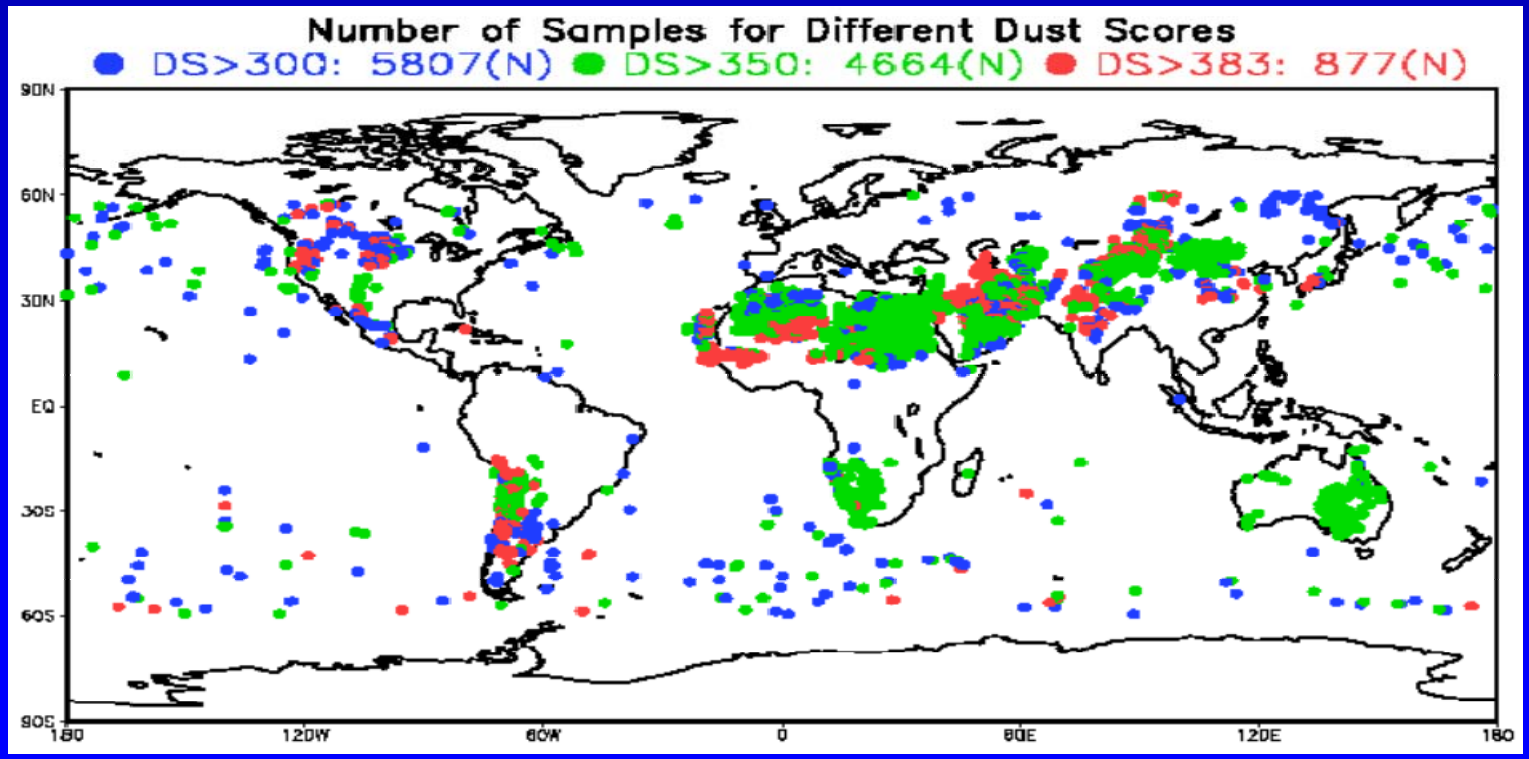
- From Eric Maddy’s findings and IASI Research Team at NOAA
- IASI dust score is based on S. De-Souza Machado’s recipe of channel differences for AIRS (GSFC, JPL, UMBC, personal communication) for similar IASI channels.
- Score is calculated using IASI CCRs (operational version + new regressions) and can range between 0. and 511.
- Warmer colors implies higher probability of contamination
- Side note: AVHRR clear scenes can be dust contaminated (see black circles surrounding red dots).



As a part of CrIMSS pre-launch efforts NOAA participated in Aerosols and Ocean Science Expedition (AEROSE) to test CrIMSS EDR algorithm (with CrIS/ATMS proxy SDRs) and compare EDR products with ECMWF and dedicated RAOBs

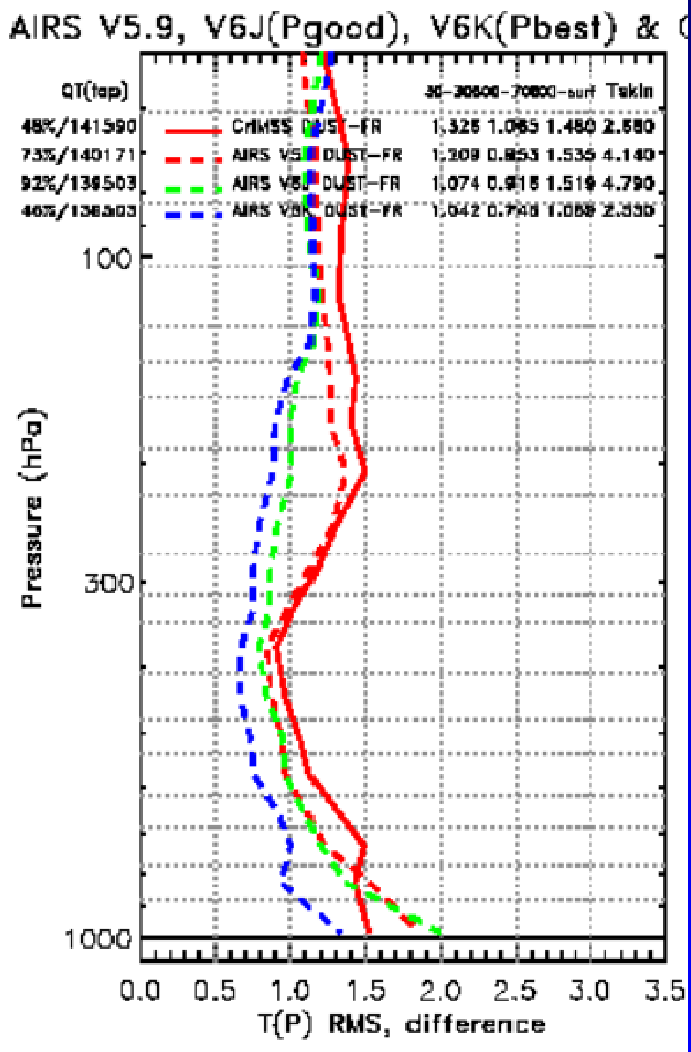
Post-Launch Verification of Pre-Launch Results
Focus Day: 05/15/2012

- **AIRS Heritage Algorithm**
  - **AIRS T(p), q(p) retrievals for 05/15/2012 (Version 5.9, Version 6 - pbest, pgood)**
  - **Dust Scores as obtained from the AIRS retrieval algorithm**
- **CrIMSS (CrIS/ATMS) official retrieval algorithm (MX7.1 Emulation)**
- **Matched ECMWF analysis fields as a proxy to the truth.**

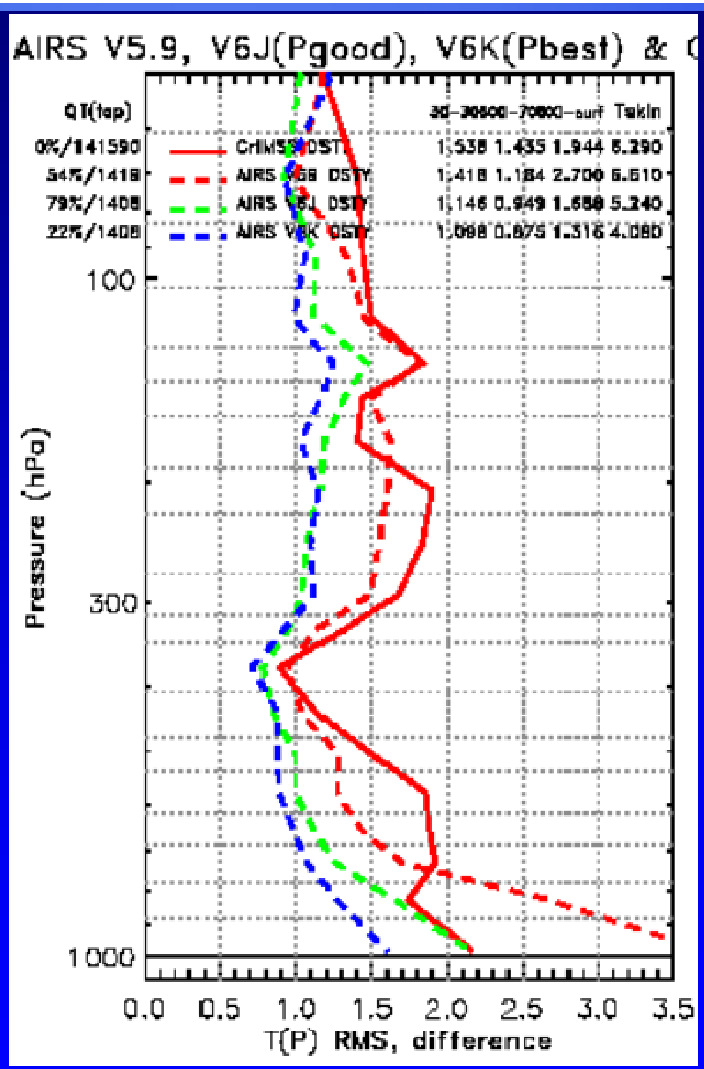


Matched AIRS/CrIMSS Retrievals ±60 LAT, GLOBAL (L+S+C; D +N)

Dust-Free (Left Panel) and Dusty (Right Panel)



T(p) RMS (K) Dust Free



T(p) RMS (Dusty Cases)

Solid Lines
CrIMSS IR+MW
Dashed Lines
AIRS V5.9 RET
AIRS V6 Pgood
AIRS V6 Pbest

N= 140171
Dust-Free Matches
AIRS:73% dashed
AIRS: 92% dashed
AIRS: 46% dashed
CrIMSS:48% solid

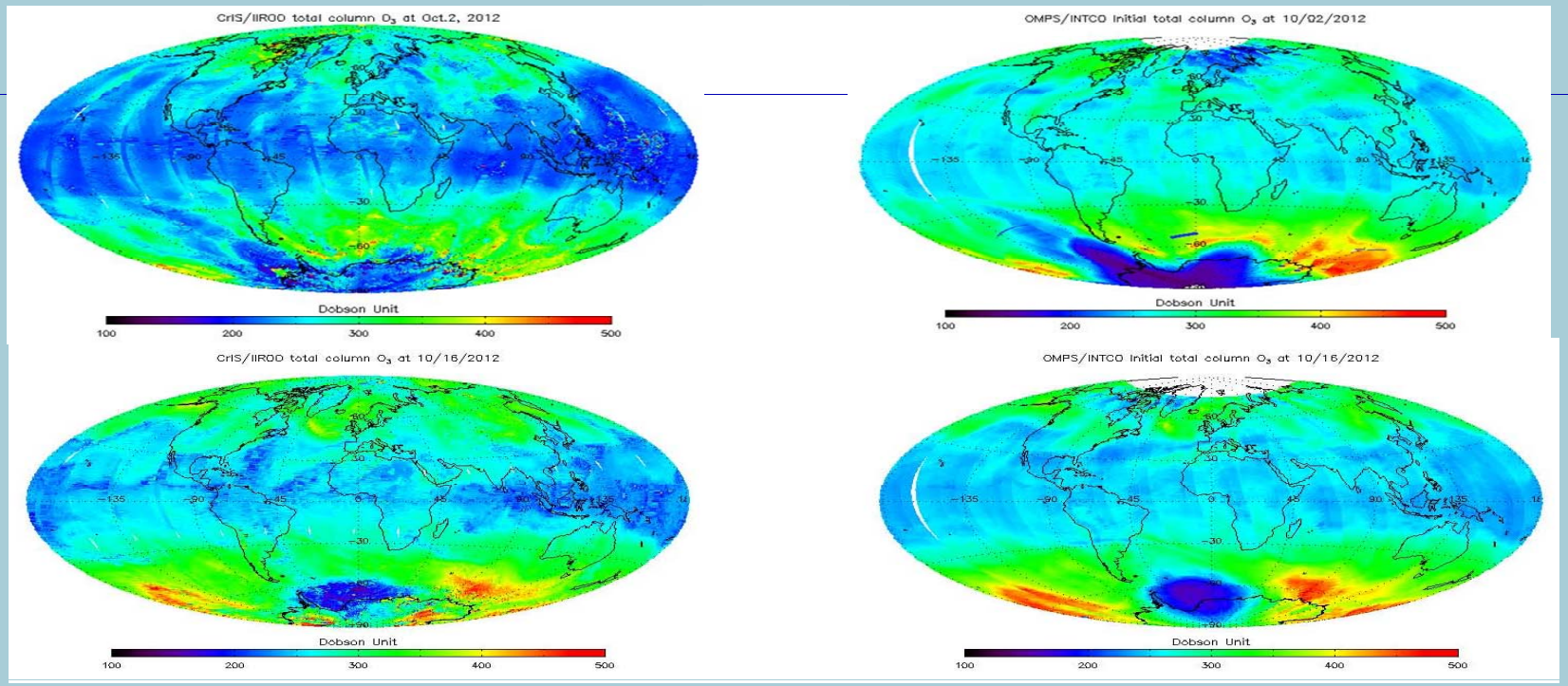
N= 1400
Dusty Matches
AIRS:54% dashed
AIRS: 79% dashed
AIRS: 22% dashed
CrIMSS:24% solid

Empirical Bias Tuning with Proxy SDRs Provide Reasonable Results with Real CrIS Observations

CrIMSS IR Ozone Plots:
Slide Courtesy: Jianguo Niu (ERT, Inc.)

CrIMSS IR Ozone for 10/02/2012
Source: IDPS MX5.3
CrIS Bias Tuning LUT: Based on Proxy CrIS SDRs Generated from IASI

OMPS total Column Ozone 10/02/2012



CrIMSS IR Ozone for 10/16/2012
Source: IDPS MX6.3
CrIS Bias Tuning LUT: Based on real CrIS observations of 05/15/2012)

OMPS total Column Ozone 10/16/2012

Results of Evaluation
Proxy SDRs/EDRs vis-à-vis Real SDRs/EDRs

- CrIS/ATMS Proxy data algorithms produced very reliable SDRs/EDRs that closely resemble real NPP-CrIS/ATMS SDR/EDR Products. These SDRs and EDRs helped in the following ways:
  - Bias-tuning procedures developed with proxy SDRs provided 'near-to-real' estimates, provided necessary place holders in the CrIMSS EDR operational package, and saved a lot of time during post-launch bias-tuning efforts with real CrIS/ATMS observations.
  - CrIMSS EDRs produced with proxy SDRs realistically predicted EDR product acceptance and rejections over land/sea boundaries and high latitude regions as evidenced with Day-1 CrIMSS IDPS-MX5.3 operational EDRs. This has helped to improve and optimize follow-up EDR algorithm updates (MX6.3, MX7.1).
  - EDR product statistics generated for proxy EDRs with reference to ECMWF gave a close estimate of Day-1 EDR product statistics (IDPS MX5.3) .
  - The perception that "CrIMSS-EDR products are resilient to dust" as seen with CrIMSS proxy EDRs has been validated with EDR products generated with real CrIS/ATMS SDRs, and comparison with matched Aqua-AIRS retrieval products, and the ECMWF analysis fields.

- With the availability of three Hyper-Spectral IR and MW sounder Instruments, and reliable proxy data generation algorithms, it is possible to perform many post-launch evaluations with pre-launch proxy data for NPP-J1 and subsequent satellite Instruments.

Backup Slides

Thank You for Your Attention