The CrIMSS EDR algorithm: Provisional Maturity and Beyond

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Questions/Comments/Suggestions – Please email to Murty.Divakarla@noaa.gov

CrIMSS EDR Product Assessment Steps

CrIMSS EDR Product Maturity Levels

Atmospheric Vertical Temperature Profiles(AVTP) ; Atmospheric Vertical Moisture Profiles(AVMP)

- Product Quality may not be optimal
- Incremental product improvements are still occurring
- Version control is in effect
- General research community is encouraged to participate in the QA and validation but need to be aware that product validation and QA are ongoing
- May be replaced in the archive when the validated product becomes available
- Ready for operational evaluation

Stage 1, Stage 2, Stage 3 Validations (June 2013)
Dedicated RAOBs (ARM/CART)
Special Campaigns (AEROSE)
Global RAOB Network
Focus Day Data Sets

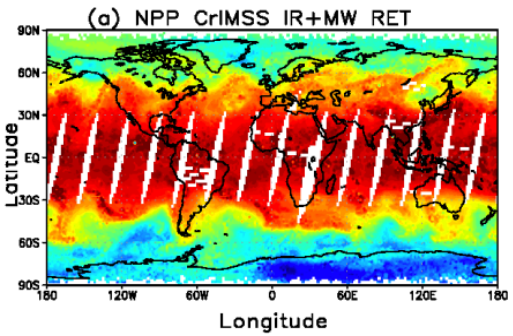
CrIMSS EDR Provisional Maturity (Jan 2013)
Optimization of CrIMSS EDR Algorithm
Baseline IDPS Version - MX5.3 (Past)
Current IDPS Version - MX6.3 (Current)
Upcoming IDPS Version – MX 7.1 (June 2013)
Off-line <-> ADL4.1 Synchronization -> DPE
Assessment with Matched ECMWF/Dedicated RAOBs
Focus Days 05/15/2012; 09/20/2012; PMRF RAOBs

CrIMSS EDR Beta Maturity (July 2012)
CrIMSS IDPS Version Emulation
Assessment with Matched ECMWF
Focus Days 02/25/2012; 05/15/2012

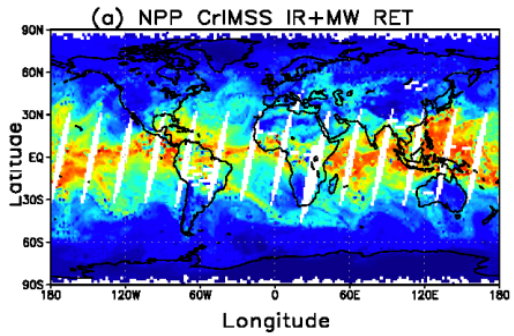
Pre-Launch to Post-Launch
November 11, 2011, ATMS
February 24, 24, 2012
Divakarla et al., AMS-2012

- Early release product; Minimally validated; May still contain significant errors.
- Versioning not established until a baseline is determined.
- Available to allow users to gain familiarity with data formats and parameters.
- Product is not appropriate as the basis for quantitative scientific publication studies and applications.

AVTP Product
Example: 500 hPa Temp
May 15, 2012



AVMP Product
Shown as
Total Precipitable Water
May 15, 2012



Evaluation Scheme Implemented

1. **Global evaluation of CrIMSS EDR products (STAR)**
   - Focus Day matches of correlative data sets
     - 05/15/2012, 09/20/2012, 02/03/2013, 03/12/2013
     - with ECMWF model/forecast analysis fields
     - Aqua-AIRS EDR products
2. **Global RAOB collocations (STAR)**
   - Typically ~300 co-located matches for a given day (± 3 hours, 100 km radius)
   - Representative highly sampled geographic locations (RAOBs predominant in NH-Midlatitudes) and the instrument types used in the RAOB Ascents
   - Many Sources (STAR-AIRS/IASI Testbed -> NPROVS, NG Sounder SDR/RAOB matchup PGEs on NSIPS, NCEP/PREPBUFR)
3. **GPS Radio occultation profiles from the COSMIC Network (SSEC, Bob Knuteson)**
   - Global sampling and long-term stability of GPS RO makes it a good candidate as a validation reference.
   - ~ 200-300 matches/day
4. **Dedicated Sondes**
   - ARM/CART Sites (Dave Tobin, SSEC)
   - Campaigns of Opportunity (AEROSE, Nick Nalli)
   - Aerospace PMRF RAOBs (Andrew Mollner)
   - *Some of these data sets have been acquired and currently undergoing analysis to generate best estimates as was done by David Tobin for the AIRS Validations*

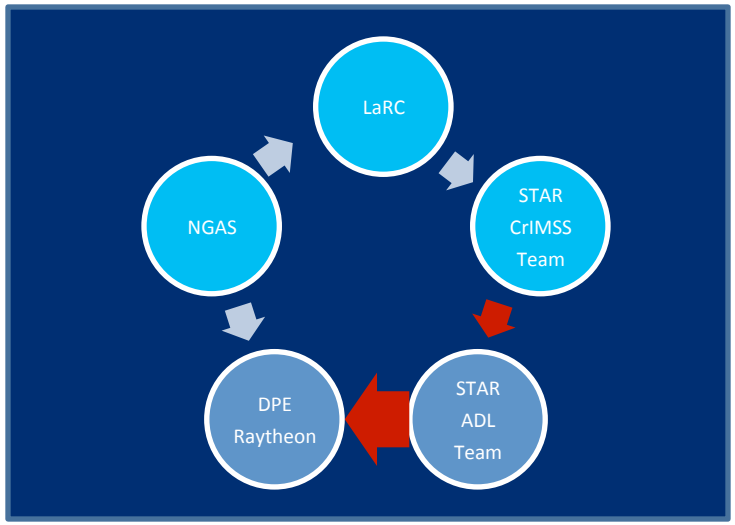
Focus Day Correlative Data Sets For CrIMSS EDR Evaluation

Focus Days	IDPS versions	Off-line Emulations	Correlative Data Sets
05-15-2012	MX5.3	MX5.3, MX6.3, MX7.1, MX8.1 (upcoming)	ECMWF/GFS (NOAA-STAR) Aqua-AIRS V6 SDR/EDRs (JPL- NASA) IASI SDR/EDR Products (NOAA-STAR) NUCAPS SDR/EDR Products (NOAA-STAR) GPSRO Measurements (SSEC: Bob Knuteson)
09-20-2012	MX5.3		
02-03-2013	MX6.3		
03-12-2013	MX6.6		
Global RAOB Matches	MX6.3 MX6.6	MX5.3, MX6.3, MX7.1, MX8.1 (upcoming)	NPROVS Other sources: NCEP/PREPBUFR STAR-Matchups
Dedicated RAOB Ascents	MX5.3 MX6.3	MX5.3, MX6.3, MX7.1, MX8.1 (upcoming)	• Aerospace PMRF RAOBs Kauai, Hawaii, May-Sept, 2012 (Andrew Mollner) • ARM/CART Dedicated RAOBs (Lori Borg, Dave Tobin) • Special Campaigns of Opportunity (Nick Nalli)

CrIMSS SDRs/EDRs for these focus days are available on STAR FTP Site

Contact: Changyi.Tan@noaa.gov and Murty.Divakarla@noaa.gov,

Realization of IDPS MX7.1



Series of 'CrIMSS' Algorithm telecons between STAR, NGAS, and LaRC from 'pre-launch proxy' era to 'present time'.

-- Discussed results of investigations and fixes among all cal/val groups.

-- Decided which changes should become MX7.1.

Offline CrIMSS EDR, ADL, and G-ADA were all used synergistically to mimic current IDPS operations and generate code change requests (CCRs) and Algorithm Change Packages (ACPs) to realize MX7.1 Operational implementation (June 2013)

Degui Gu, Xia L Ma, and Denise Hagan, Northrop Grumman Aerospace Systems
Xu Liu and Susan Kizer, Langley Research Center
Murty Divakarla, Mike Wilson, C.D. Barnet, Xiaozhen Xiong and Changyi Tan, Flavio Iturbide, STAR, NOAA/NESDIS
Wael Ibrahim, Richard Cember, Raytheon

MX6.3 Emulation (Operated Until Oct. 2012)	MX6.6 Emulation (Currently in Operations)
New Climatology, Microwave Bias, and IR Bias LUTs	Fix indexing for non-LTE and ozone cases.
MX7.1 Emulation (Expected OPS, June 2013)	**Other Variations**
Fix bug to add RTM error to total radiance error. Fix a bug that calls partly cloudy skies clear in fovsel.f Loosen a constraint between skin temperature and air temperature for daytime land. Change threshold for warm ocean vs. cold ocean. Loosen microwave chisq requirement for combined retrieval from 2 to 4. New IR-NOISE-LUT and New IR-ATM-NOISE-LUT	Fix surface pressure in IDPS product. Turn off climatology stratification. Alternative LUTs (IR-ATM-NOISE-LUT, IR-NOISE-LUT). Multiply devnoise by 1.8. Modifications to clear/partly cloudy/cloudy skies.

Yields for Three Versions of CrIMSS EDRs

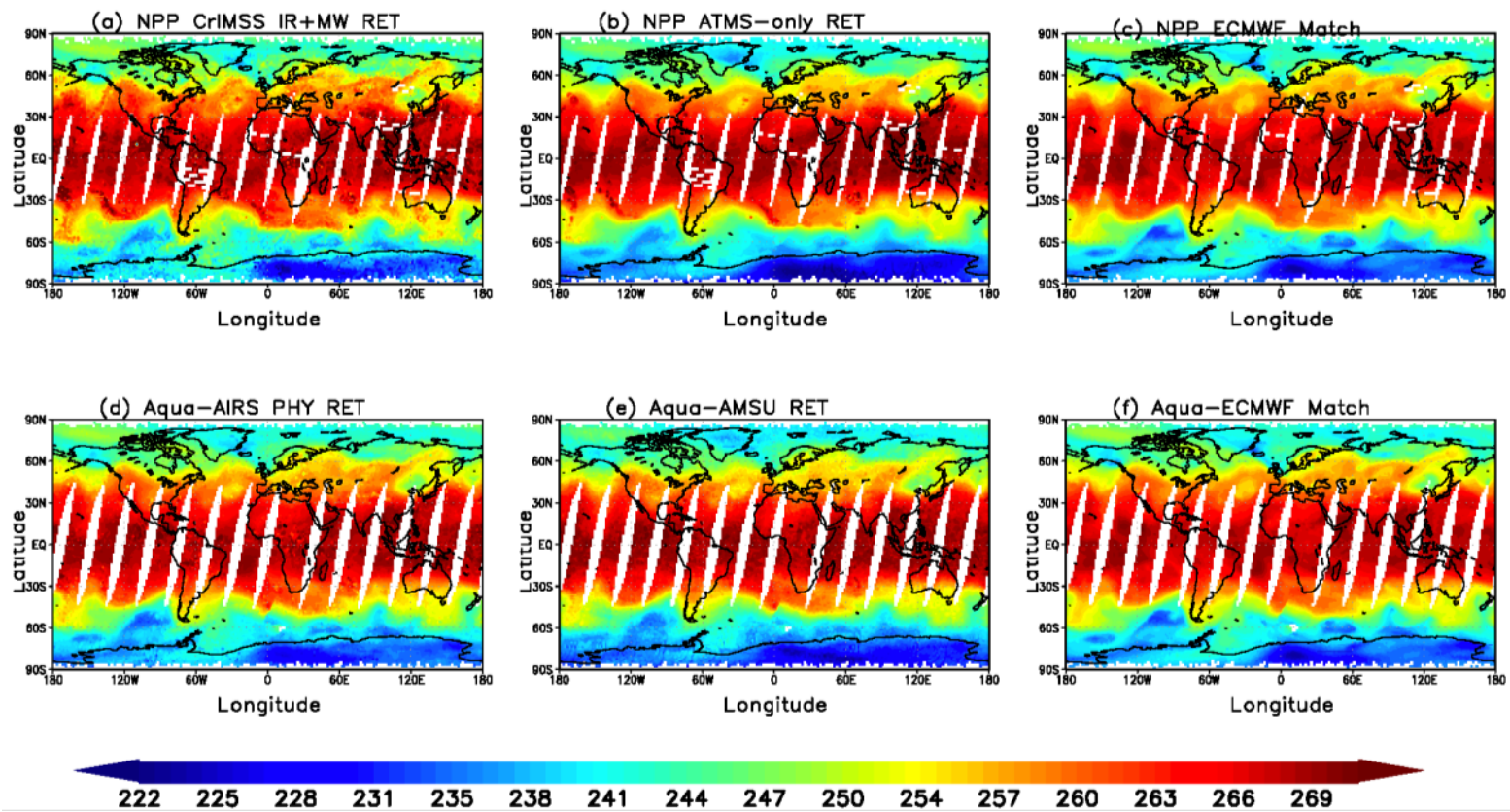
MX Version	Date	Combined Yield Percentage	MW-Only Percentage	Poor Yield
MX5.3	May 15, 2012 Sept. 20, 2012 Feb. 3, 2013 Mar 12, 2013	4.76% 4.15% 3.37% 3.74%	66.34% 70.72% 61.72% 61.89%	28.90% 25.14% 34.91% 34.37%
MX6.3	May 15, 2012 Sept. 20, 2012 Feb. 3, 2013 Mar 12, 2013	22.09% 20.17% 19.86% 20.73%	66.47% 68.23% 65.21% 65.91%	11.44% 11.60% 14.94% 13.37%
MX7.1	May 15, 2012 Sept. 20, 2012 Feb. 3, 2013 Mar 12, 2013	47.36% 47.62% 47.73% 49.41%	43.47% 43.56% 40.22% 39.84%	9.17% 8.82% 12.05% 10.75%

- **CrIMSS EDR algorithm reports 2nd stage 'IR+MW' retrieval as the final product.**
- **If the 2nd Stage fails to produce a better EDR Product, the 1st MW-only Product is reported as final product**
- **MX7.1 (IR+MW) yield and results of evaluations with ECMWF for different focus-day are very similar. Results presented in next set of slides are for the focus-day: 05/15/2012**

CrIMSS EDRs - MW-only (1st Stage), IR+MW (2nd Stage), Aqua-AIRS Retrievals, and ECMWF Matches

- AVTP (850 hPa-surface) temperature product for May 15, 2012
  - CrIMSS IR+MW (upper left) and MW-only (upper middle)
  - AIRS IR+MW (lower left) and AMSU-only (lower middle)
  - Co-located ECMWF for CrIS (upper right) and AIRS (lower right)

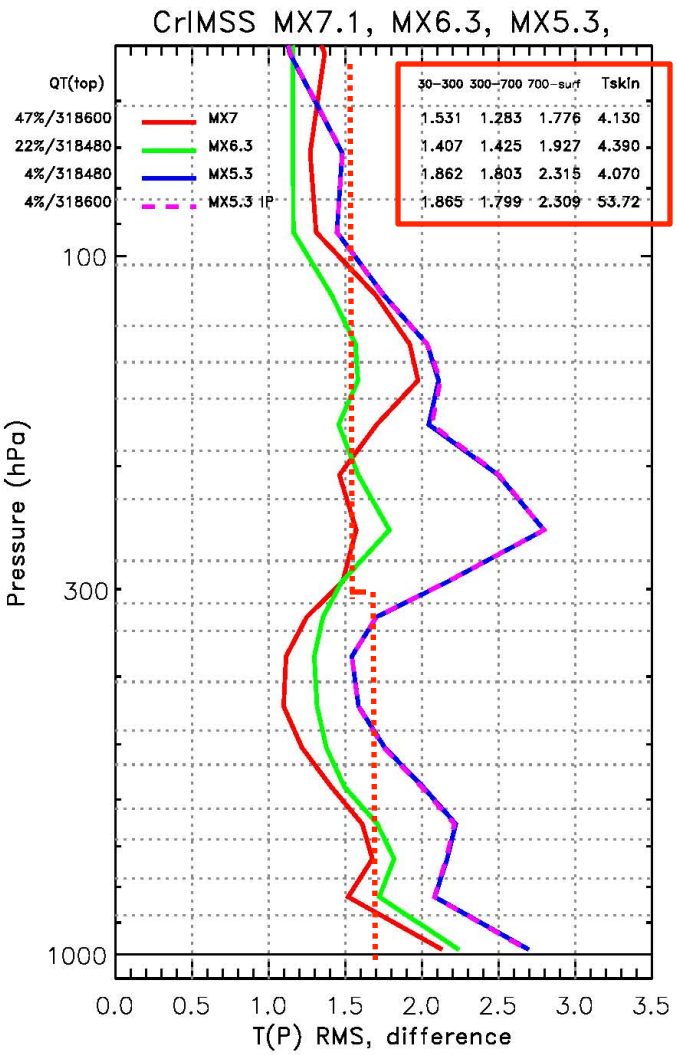
T(p) RET:25 478.0–535.2 hPa 2012/05/15 DESC CL2002_UPD



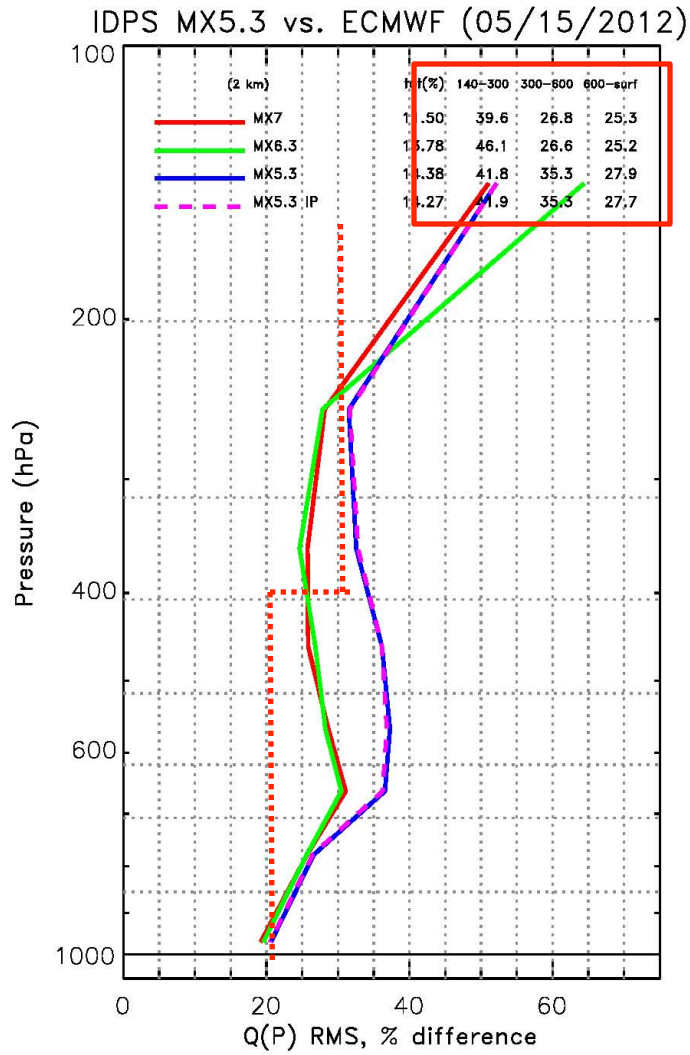
CrIMSS Combined 'IR+MW' AVTP, AVMP RMS Differences wrt ECMWF

MX 5.3 (Day1), MX 6.3 (Present) and MX 7.1 (June 2013)

Data: Global (Focus Day: 05/15/2012)



T(p) RMS (K)

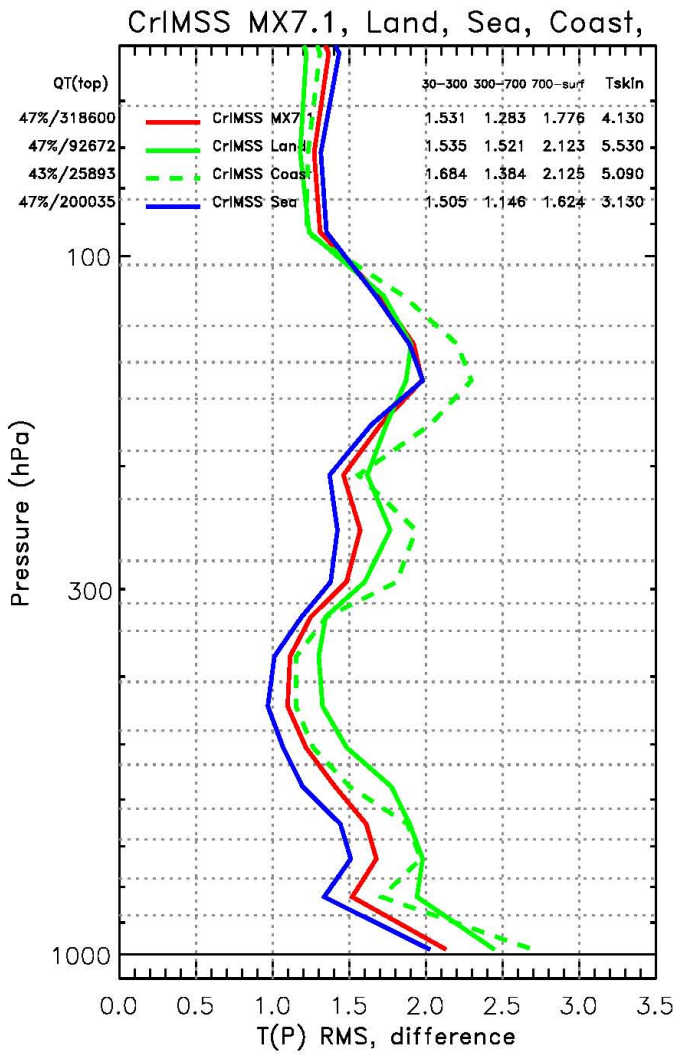


q(p) RMS (%)

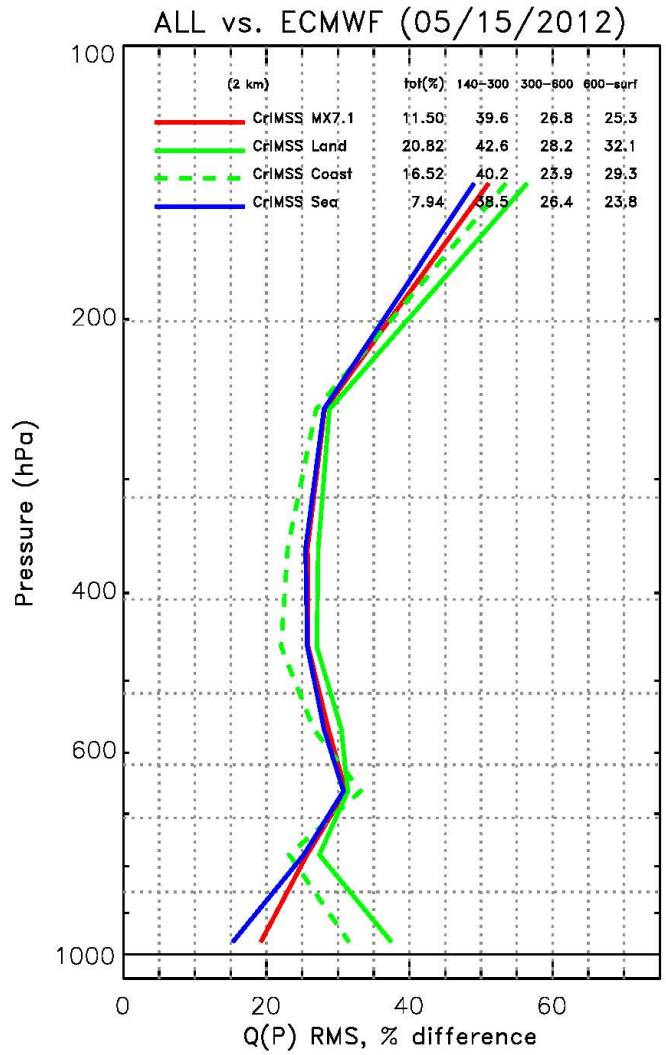
CrIMSS 'IR+MW'
MX7.1 (47%)
MX6.3 (22%)
MX5.3 (4%)
MX5.3 IDPS (4%)

Global ALL
N=318,600

CrIMSS Combined 'IR+MW' AVTP, AVMP MX7.1 RMS Differences wrt ECMWF Global, Land, Sea, Coast, ALL(05/15/2012)



T(p) RMS (K)



q(p) RMS (%)

CrIMSS IR+MW MX7.1

Global ALL N=318,000

Yield:

ALL: 47%

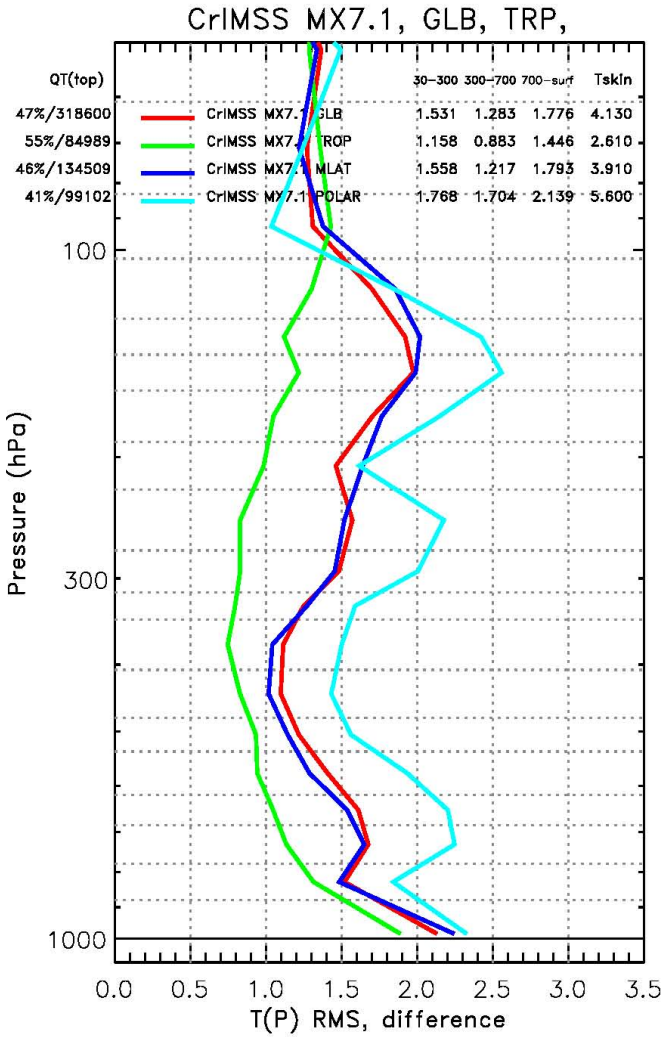
Land: 47%

Sea:47%

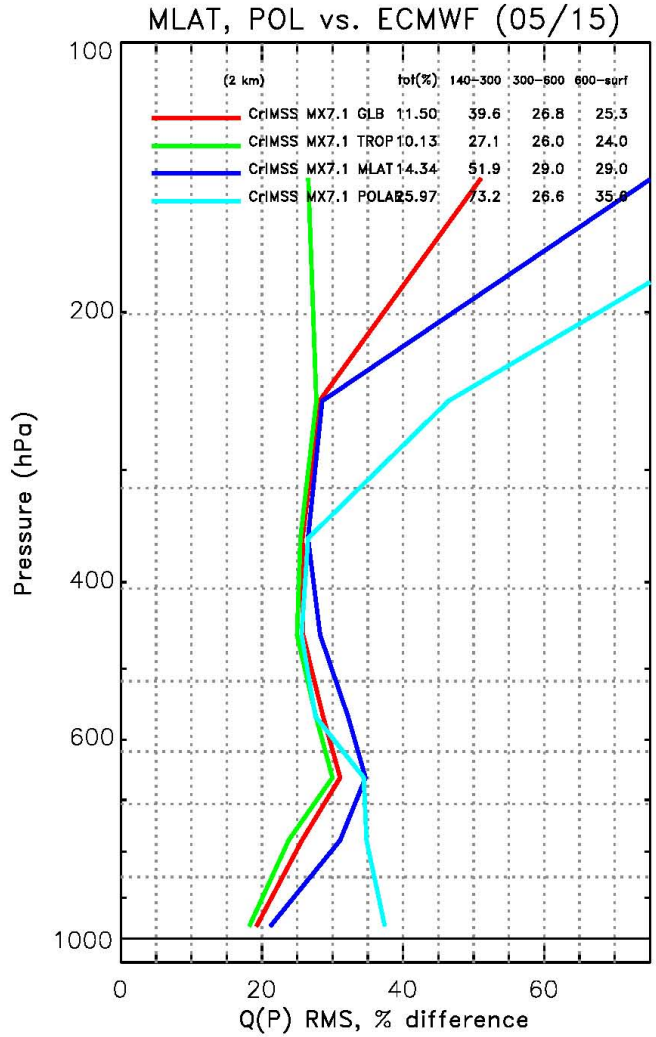
Coast(--):43%

Difficulties over land cases are causing CrIMSS Global EDR stats exceeding the requirements at sfc-700 hPa (Improvements Planned are in Summary)

MX7.1 T(p), q(p) RMS Differences wrt ECMWF
Tropics, Midlat, Polar, Global



T(p) RMS (K)



q(p) RMS (%)

CrIMSS IR+MW MX7.1

Global ALL N=318,000

Yield:

ALL: 47%

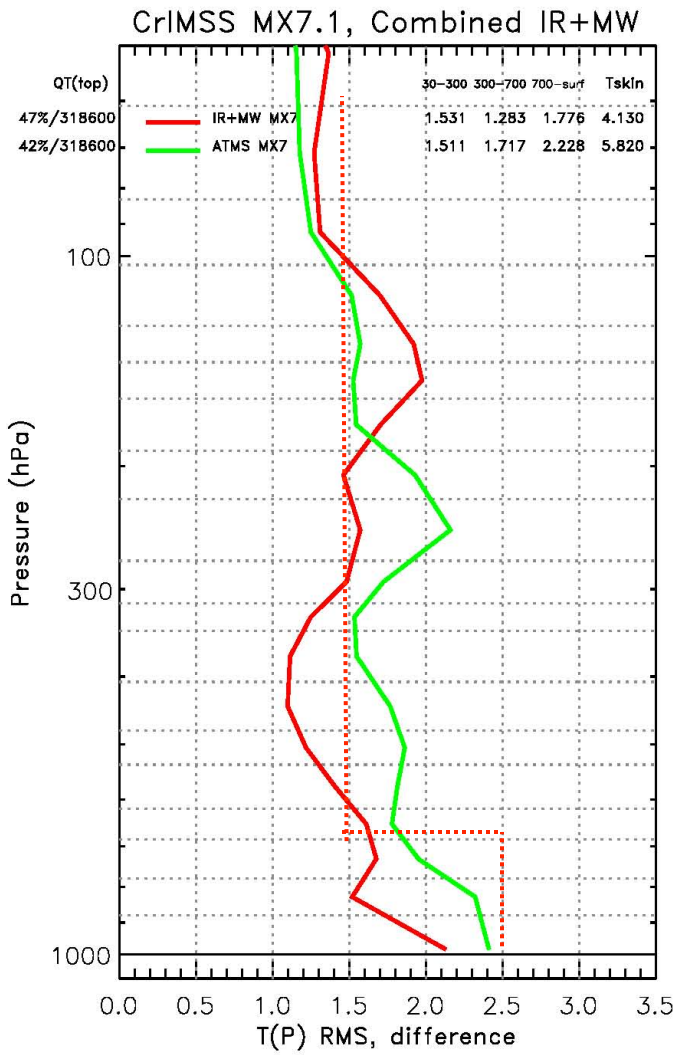
Tropics: 55%

Midlat: 46%

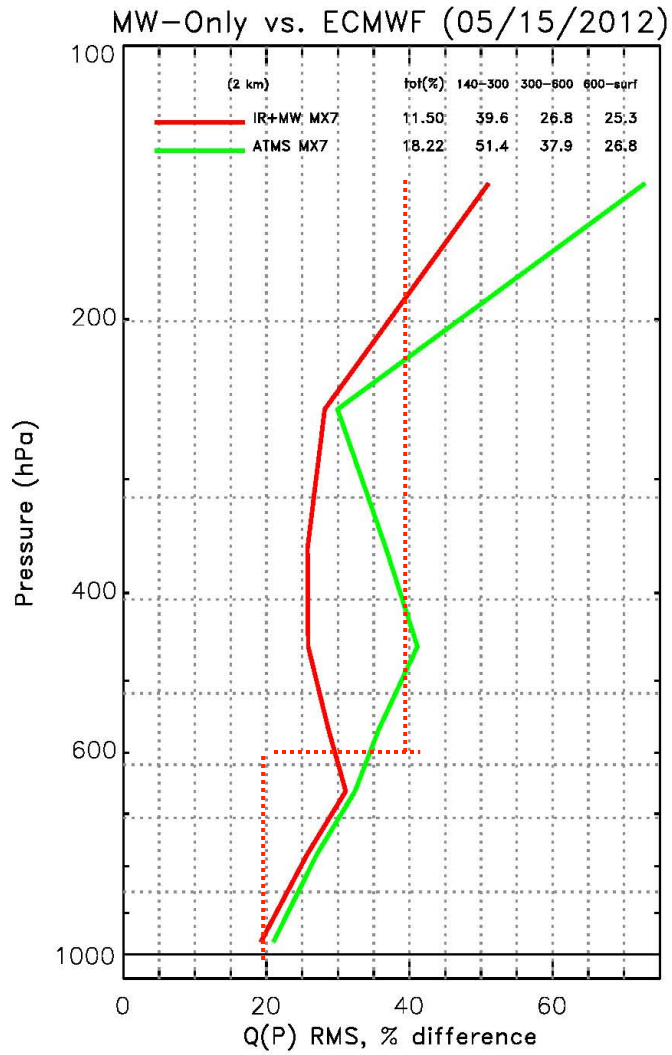
Polar:41%

Difficulties over polar regions are affecting Global EDR stats (see Improvements Planned in Summary)

MX7.1 AVTP and AVMP RMS Differences wrt ECMWF
Global, Combined IR+MW, MW-Only



T(p) RMS (K)

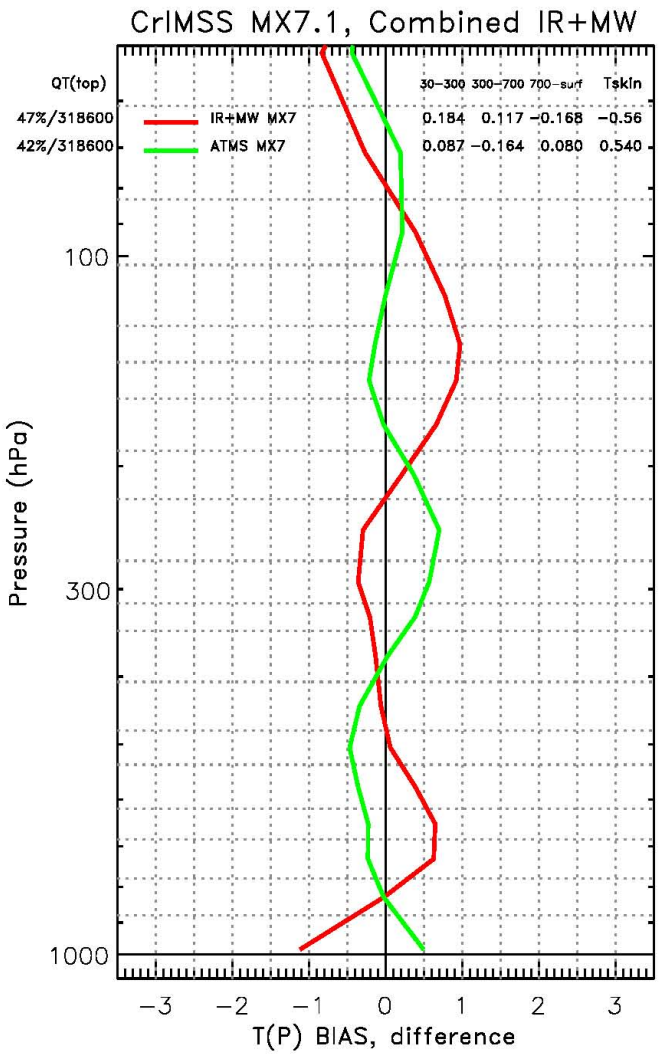


q(p) RMS (%)

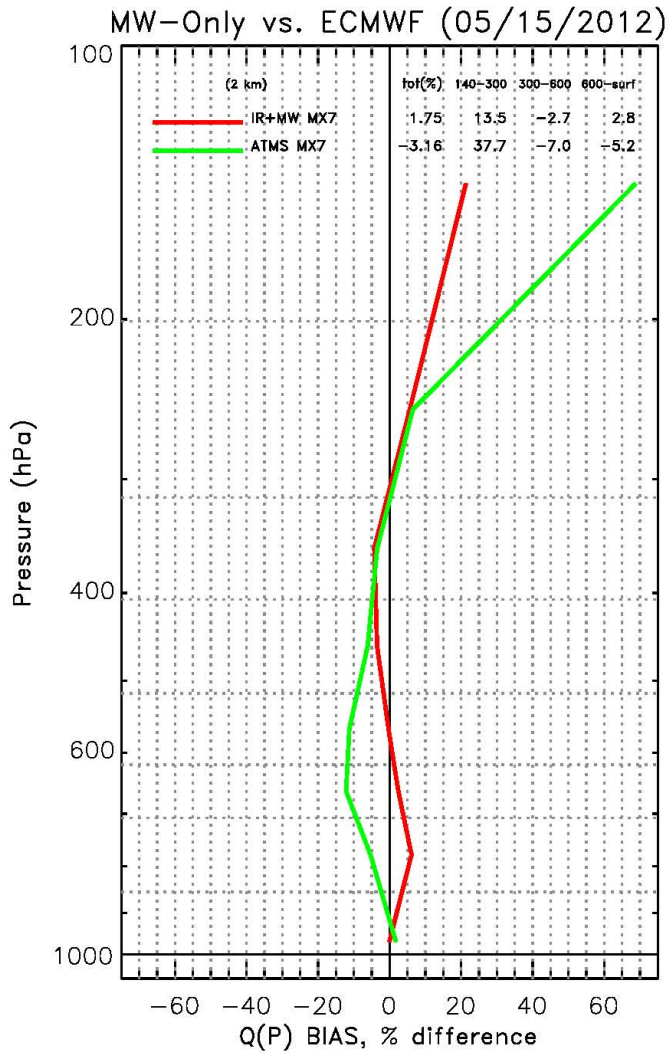
CrIMSS IR+MW
CrIMSS MW-only
MX7.1

Global ALL
N=318,000
Yield:
IR+MW: 47%
MW-only:42%

MX7.1 AVTP and AVMP Biases wrt ECMWF
Global, Combined IR+MW, MW-Only



T(p) Bias (K)

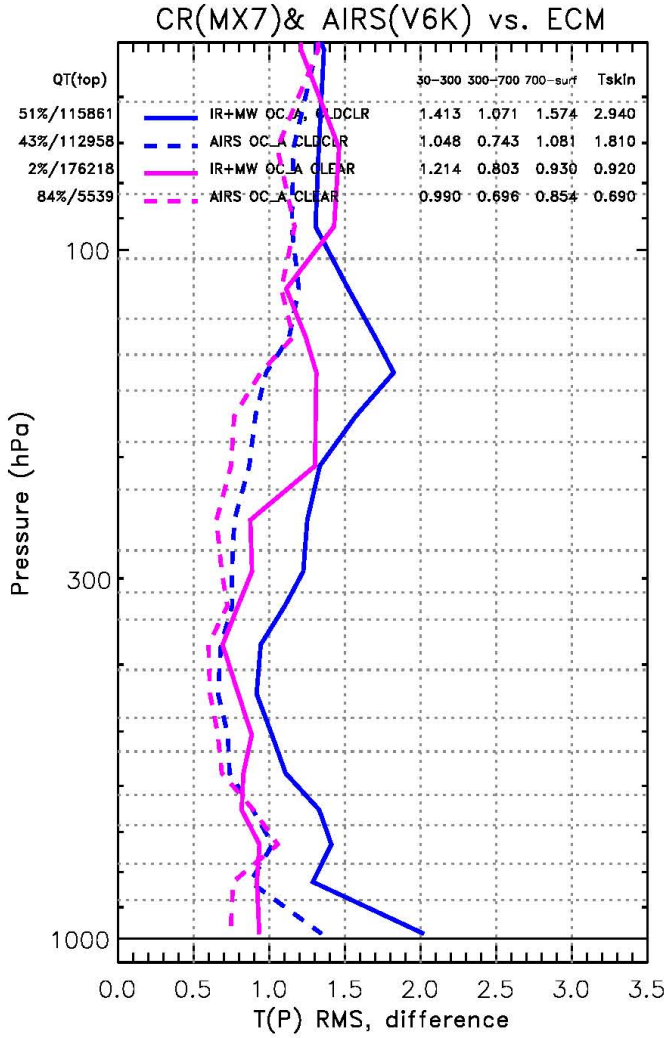


q(p) Bias (%)

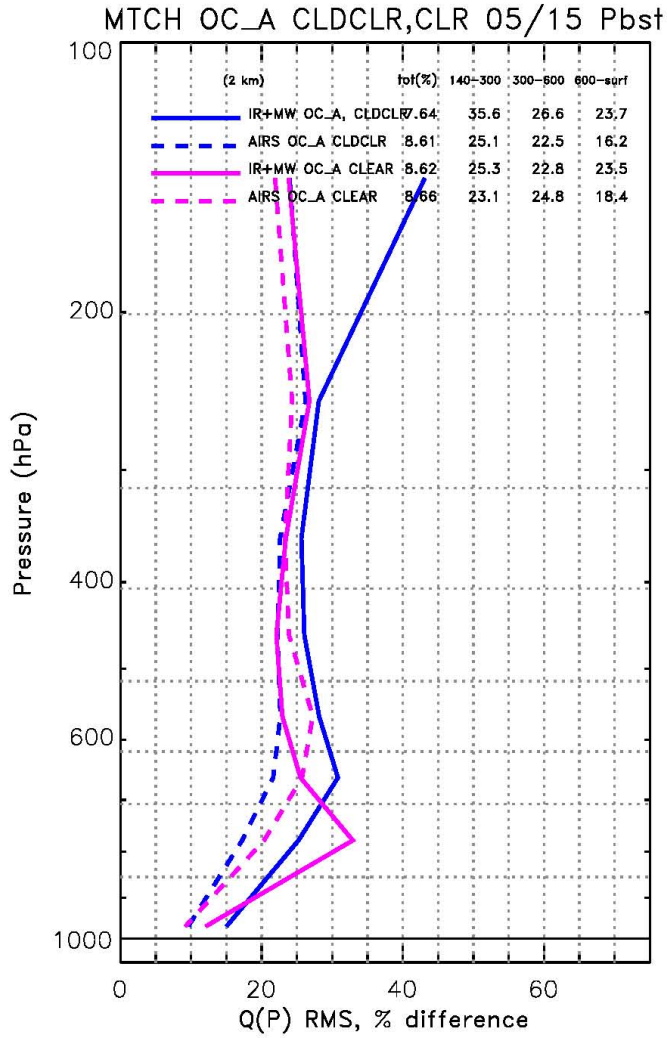
CrIMSS IR+MW
CrIMSS MW-only
MX7.1

Global ALL
N=318,000
Yield:
IR+MW: 47%
MW-only:42%

CrIMSS vs. ECMWF; AIRS V6 vs. ECMWF
Matched EDRs - Global Ocean – Cloud-Cleared, and Cloud-free



T(p) RMS (K)



q(p) RMS (%)

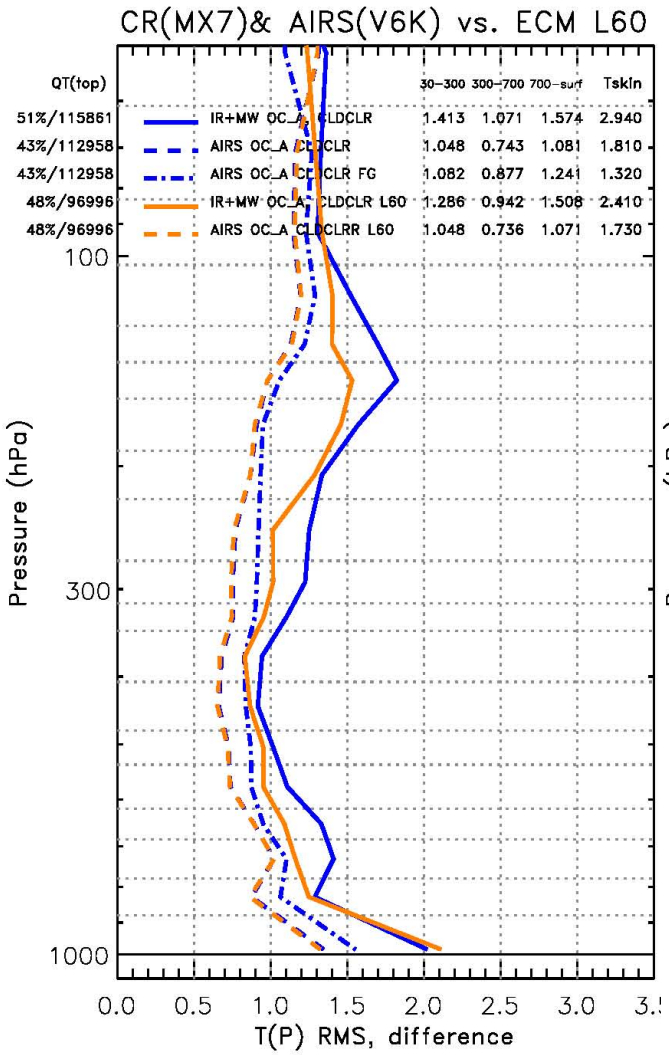
Solid Lines
CrIMSS IR+MW

Dashed Lines
AIRS V6 RET
pbest

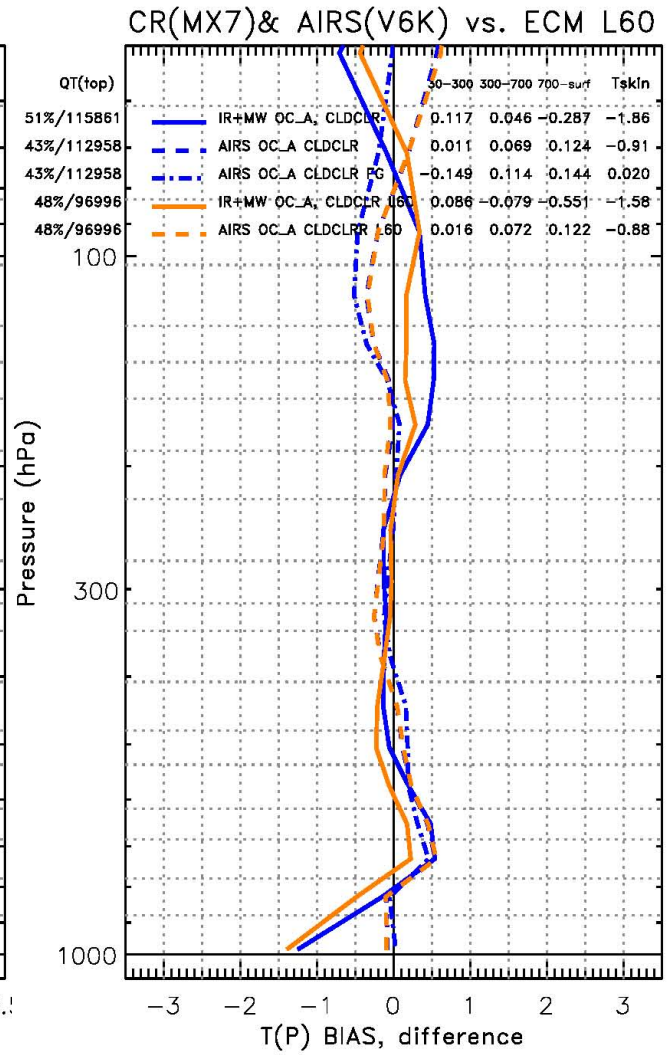
N= 116,000 -CLDCLR
AIRS:43% dashed
CrIMSS:51% solid

Clear
N= 5,538
AIRS: 5% dashed
CrIMSS solid

CrIMSS vs. ECMWF; AIRS V6 vs. ECMWF
Using Matched AIRS-V6 and CrIMSS EDRs
Matched EDRs - Cloud-Cleared: Global Ocean and Ocean ±Lat60



T(p) RMS (K)



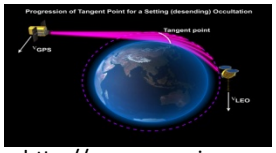
T(p) Bias

Solid Lines
CrIMSS IR+MW

Dashed Lines
AIRS V6 RET
pbest

Matched EDRs-
Global:N= 116,000
AIRS PR :43% dashed
AIRS FG:43% dash-dot
CrIMSS:51% solid

Matched EDRs
N=97000 ±Lat60
AIRS:48% dashed
AIRS FG:48% dash-dot
CrIMSS:48% solid



http://www.cosmic.ucar.edu/launch/GPS_RO_cartoon.jpg

CrIMSS EDRs-GPS RO Occultation Data Comparisons for 05/15/2012

(Slide Courtesy: Bob Knuteson, SSEC, Madison, WI)

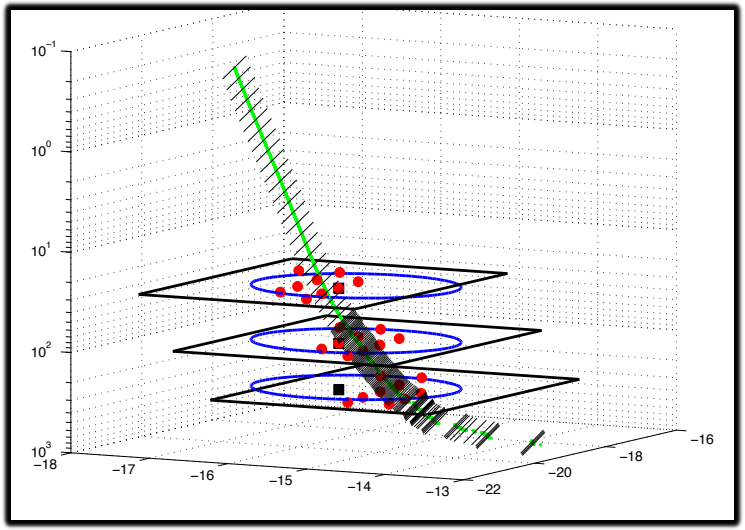
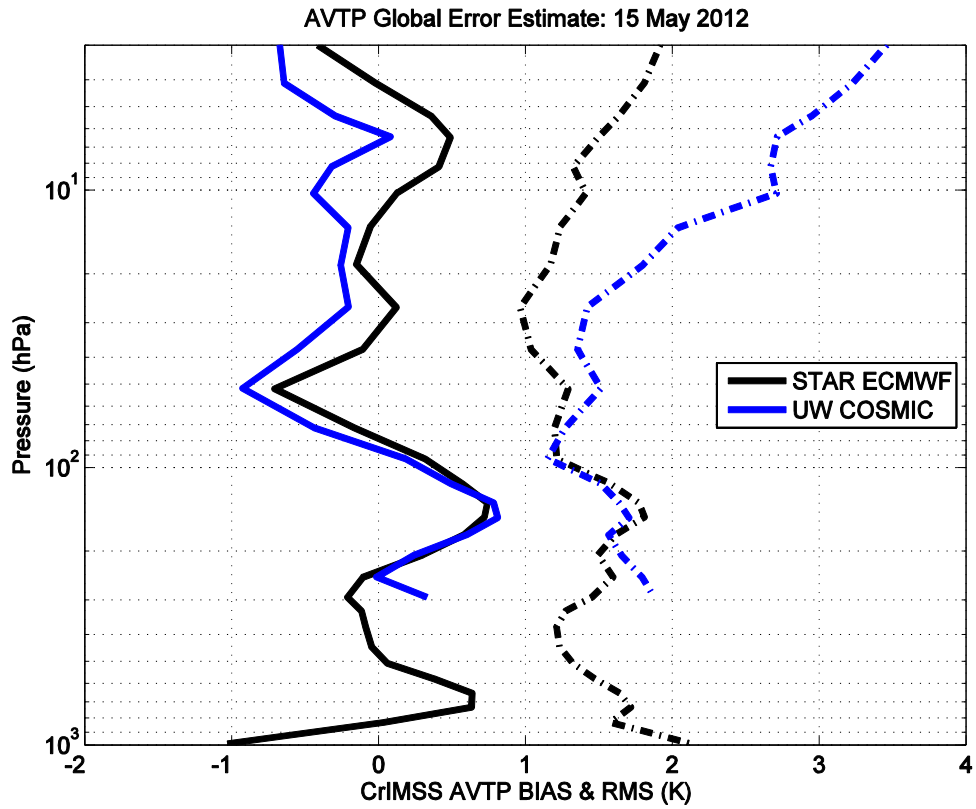


Illustration of the closest (black square), circular (blue circle), and ray path (red dots) methods for a single GPS profile (green) for the circle centered at the GPS RO level of 100 hPa



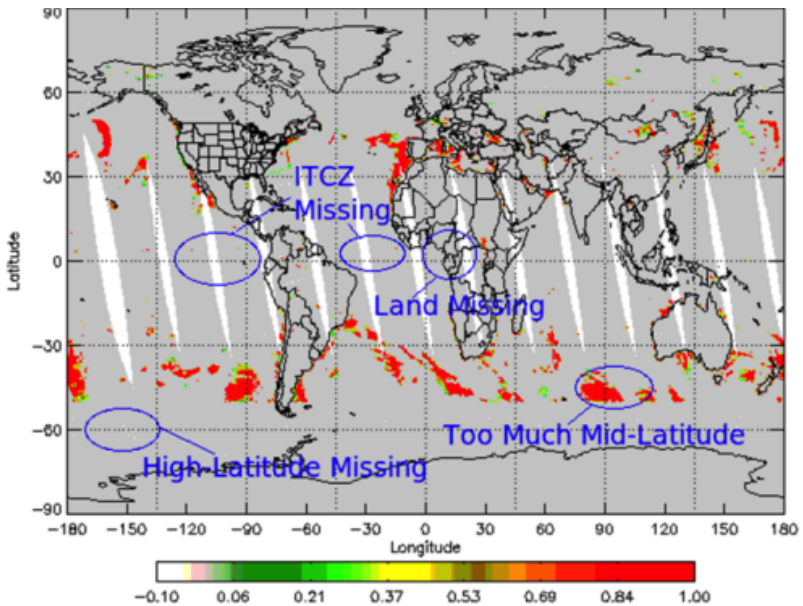
Comparison of CrIMSS AVTP bias and RMS difference relative coincident ECMWF and COSMIC GPS radio occultation data for the focus day 05/15/2012. The bias trend with altitudes observed between CrIMSS and COSMIC, and between the CrIMSS and ECMWF for the focus day complement each other thus making this data set viable source of independent verification. Evaluations with longer validation time period is in progress.

Identified and Tested Fixes - CrIMSS EDR Precipitation Flag

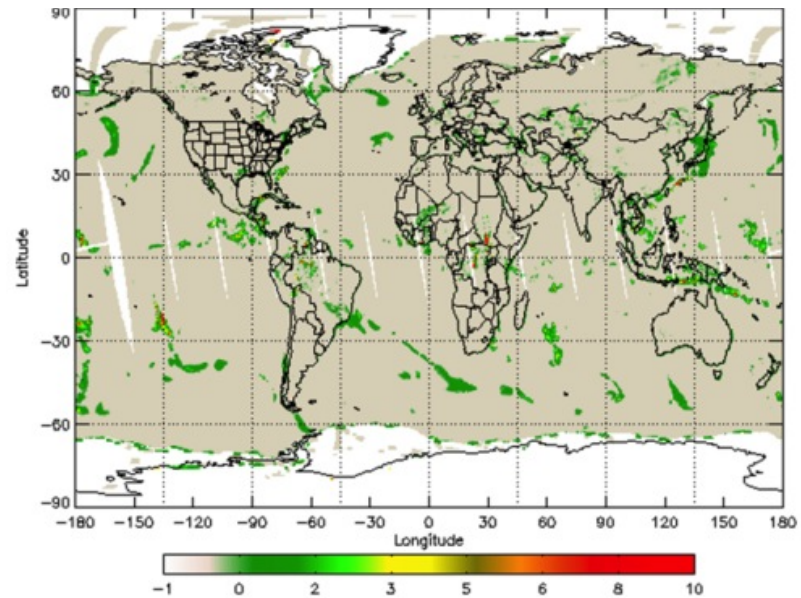
Expected to be in Operations November 2013

Slide Courtesy: Ralph Ferrao and Wenze Yang (AMS-2013)

(a) Current Precip Flag (05/15)



(b) Improved Precip Flag (05/15)



Improvements to CrIMSS EDR algorithm - Precipitation Flag. (a) Precipitation detection flag as depicted from the current CrIMSS EDR algorithm. (b) Updated precipitation flag using MSPPS 'Day-2' like algorithm. The updated algorithm shows increased rain occurrences in the ITCZ, and much more rain over land and compares well with MIRS and other MW-only systems.

Intensive Cal/Val Dedicated RAOB Campaign(s)More Details:

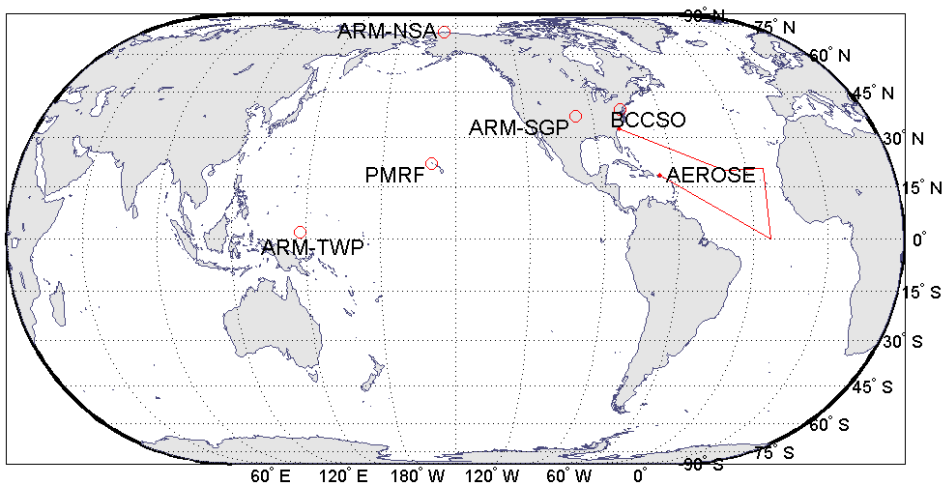
Lori Borg, Dave Tobin et al., Status of ARM Best Estimate :

ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/nnalli/telecons/2013-05-07/

Nalli et al., ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/nnalli/telecons/2013-05-07/

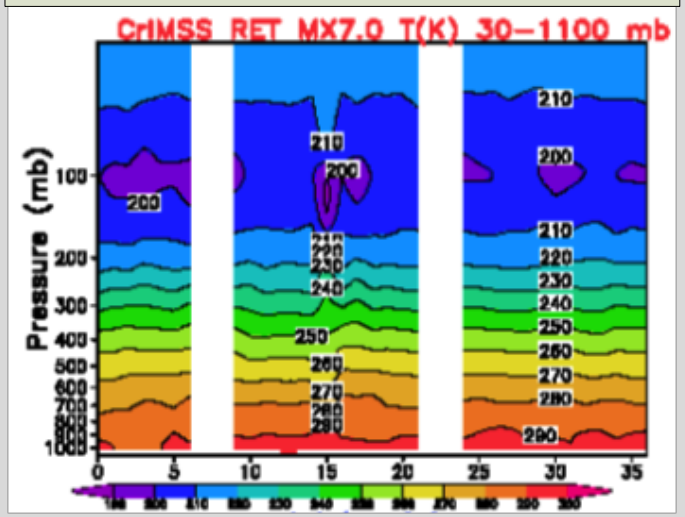
	ARM-TWP	ARM-SGP	ARM-NSA	PMRF	BCCSO	NOAA AEROSE
Location	Manus Island, Papua New Guinea	Ponca City, Oklahoma, USA	Barrow, Alaska, USA	Kauai, Hawaii, USA	Beltsville, Maryland, USA	Tropical North Atlantic Ocean
Regime	Tropical Pacific Warm Pool, Island	Midlatitude Continent, Rural	Polar Continent	Tropical Pacific, Island	Midlatitude Continent, Urban	Tropical Atlantic, Ship
Planned *N*	90	180	180	40	—	≈ 60–120
Launched n_1	**82**	**100**	**93**	**40**	**23**	**69**
Launched n_2	—	**96**	**90**	—	—	—
Time Frame	Aug–present	Jul–Dec	Jul–Dec	May, Sep	Jun–Jul, Sep–Oct	Sep 2012 Jan–Feb 2013

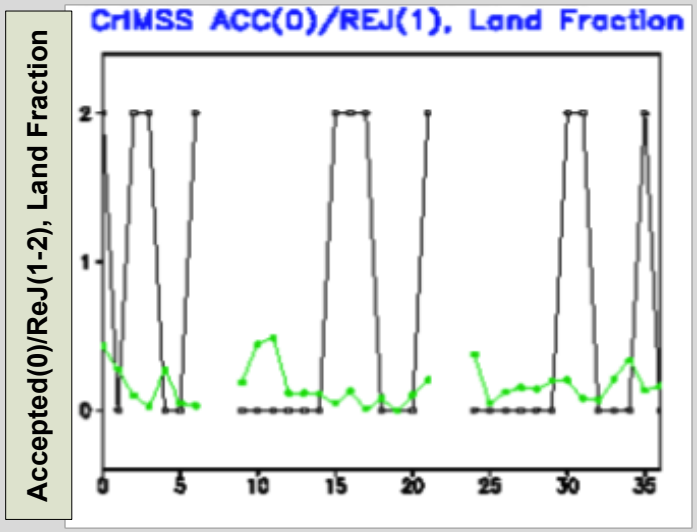
NPP CrIMSS EDR ICV Dedicated RAOB Sites

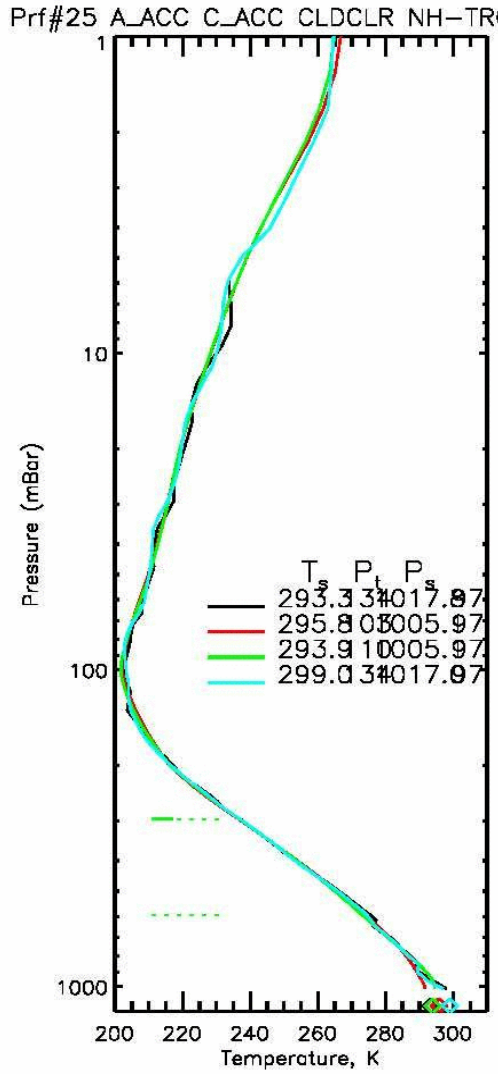


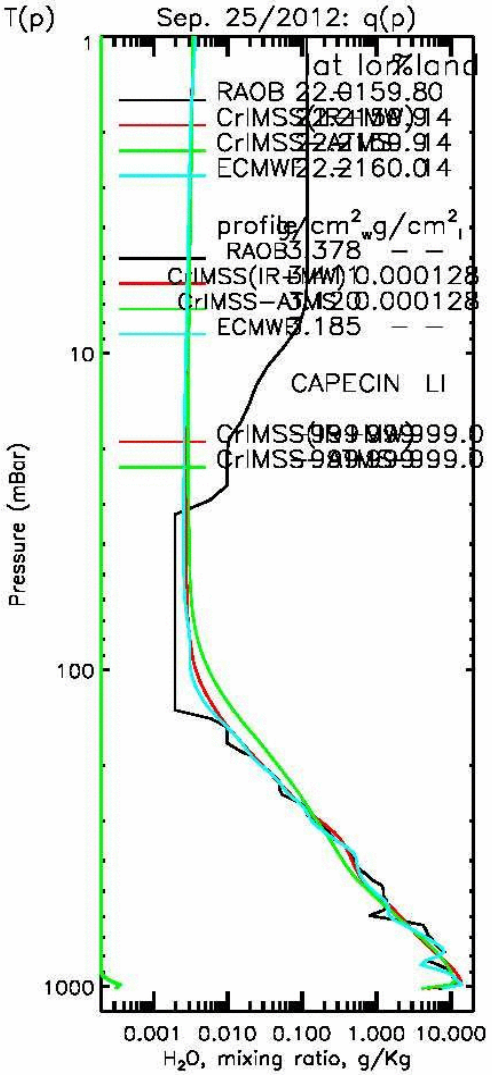
The Aerospace RAOB (Kauai, 22.05N, 159.78W, Hawaii)
Dedicated RAOB, ECMWF, CrIMSS Versions (MX5.3, MX6.3, MX7.0)

PMRF- Kauai, 37 Matches, May-Sep, 2012



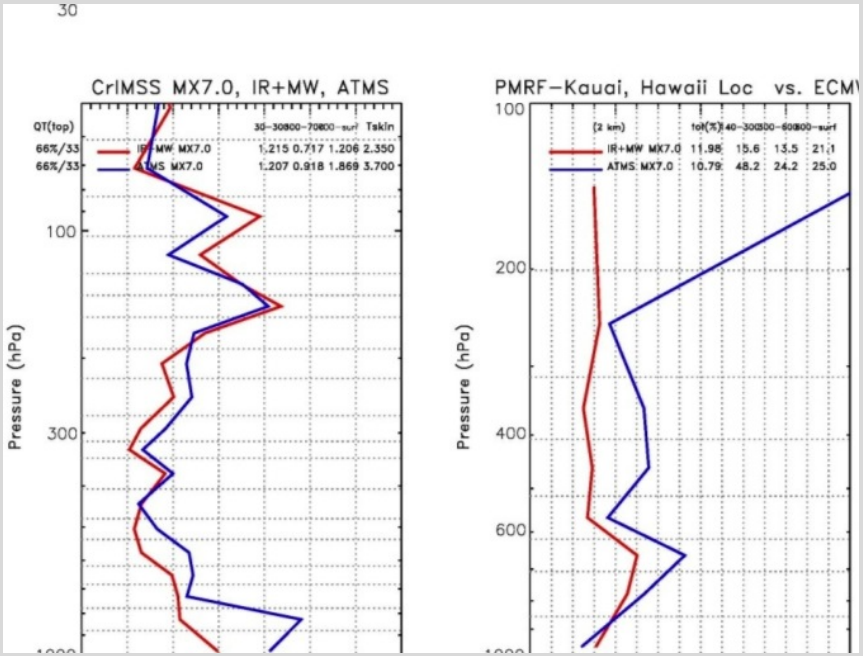




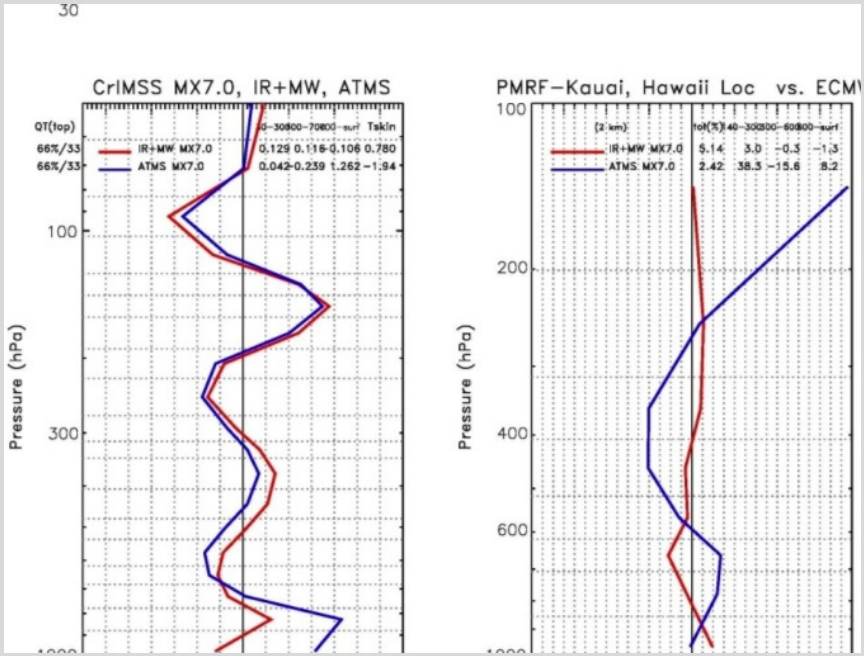


Black: RAOB; Red: 2nd Stage IR+MW; Green: 1st Stage MW; Cyan: ECMWF

PMRF- Kauai, CrIMSS vs. ECMWF T(p), q(p) RMS
Red: 2nd Stage IR+MW; Blue: ATMS-only



PMRF- Kauai, CrIMSS vs. ECMWF T(p), q(p) Bias
Red: 2nd Stage IR+MW; Blue: ATMS-only



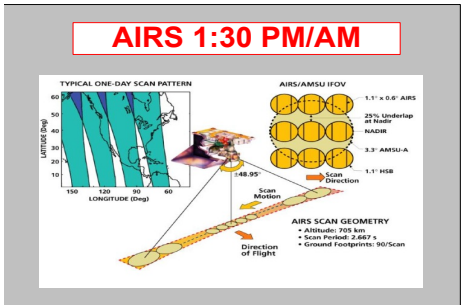
T(p) RMS (K) **q(p) RMS (%)** **T(p) Bias (K)** **q(p) Bias (%)**

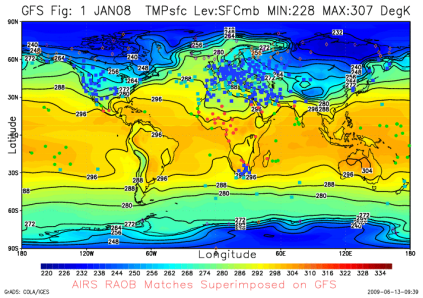
- **The 1st stage MW-only retrievals get affected by the land fraction (ATMS surface sensitive channels), and the retrievals may not represent a 'sea-only' CrIMSS EDR as we anticipate.**
- **The Aerospace Corporation (POI: Andrew Mollner) supported launching of 40 RS-92 from the Pacific Missile Range Facility (PMRF), Barking Sands, Hawaii during May-September 2012. We are currently evaluating CrIMSS EDRs vs. matched RAOBs.**

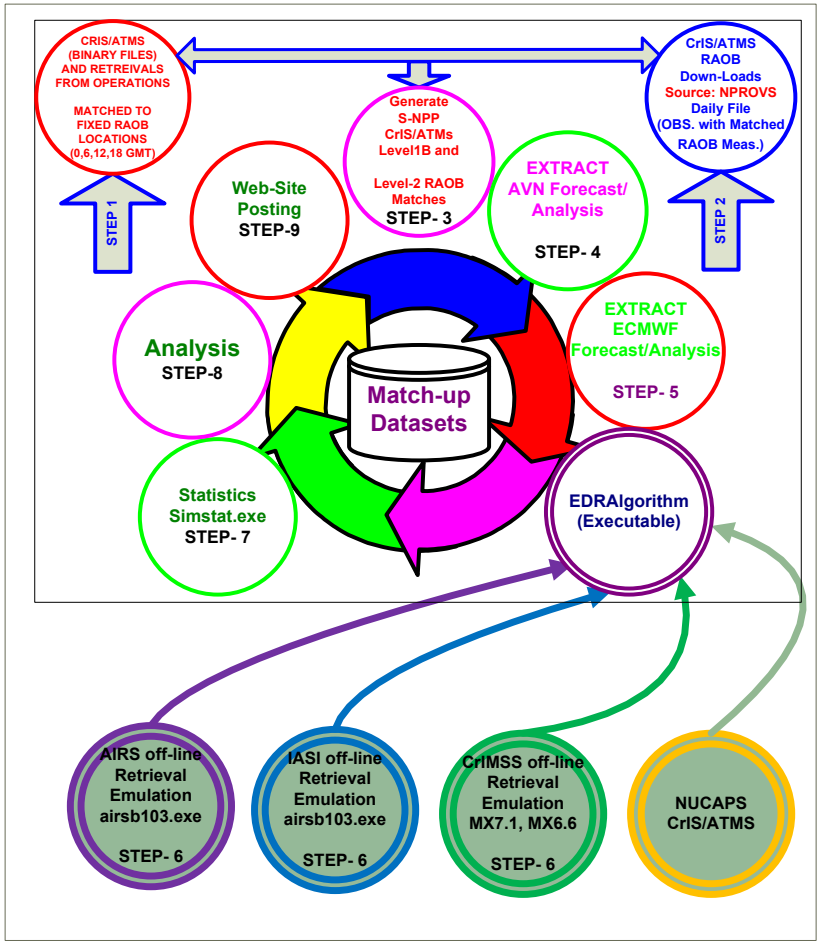
The AIRS/IASI Validation Testbed

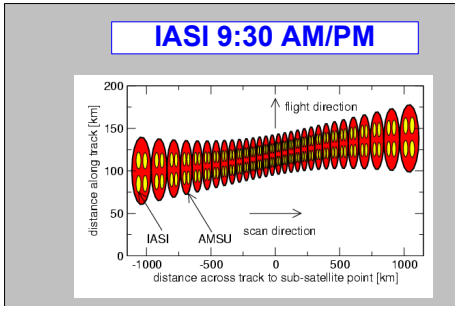
Using Global RAOB/ECMWF/GFS Matchups → S-NPP

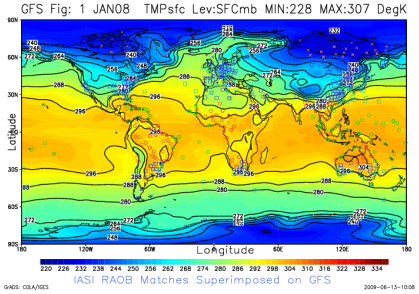
Divakarla et. al., JGR-2006; 2008; HISE-2011a,b











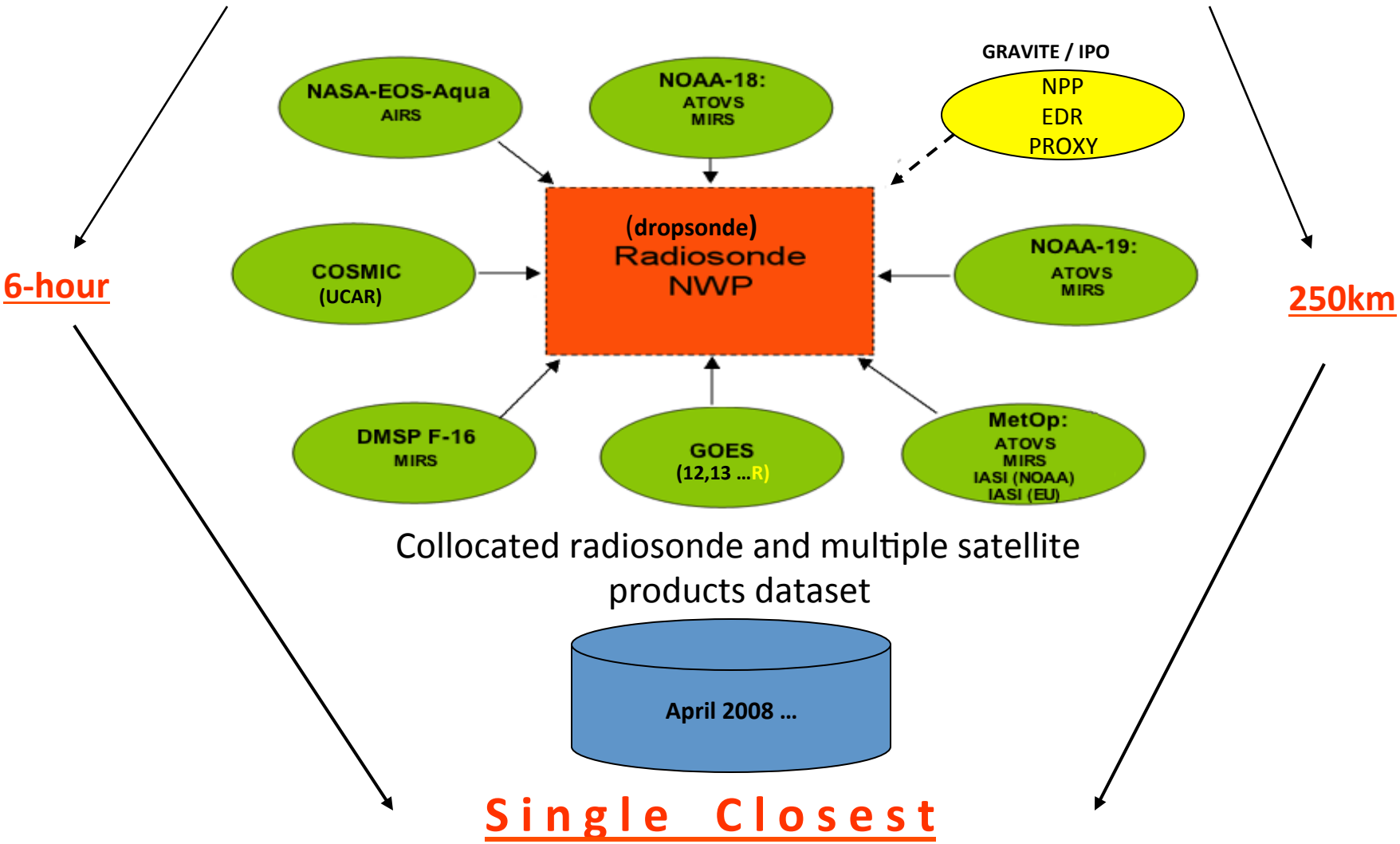
NOAA STAR In-house Capability with Reprocessing Options

Adaptable to S-NPP Validations with Global RAOBs from NPROVS and other Sources

NOAA Products Validation System (NPROVS)

Contact: Tony.Reale@noaa.gov (JTECH, 2011)

Centralized Radiosonde and Collocation Processing



MX7.1 to MX8 (in Operations – Nov. 2013) Pathway Beyond MX8

- MX7.1 to MX8 Changes include the following:
  - DR 3193: Fixes a small error in the noise threshold. This is used to determine whether a scene is variable enough for cloud clearing.
  - DR 7116: The noise amplification factor is reported as fill when it is not used.
  - DR 7119: Makes definitions of clear, partly cloudy, and cloudy consistent with the ATBD.
  - DR 7197: Fixes a bug in the quality flags for overcast skies and failed 2nd-stage runs.
- MX8 and Beyond – On-Going Improvements with Off-line EDR algorithm for implementation into Operations
  - New surface emissivity maps will improve the first guess.
  - Additional hinge points will improve resolution in ozone-sensitive spectra
  - A new, improved precipitation algorithm will replace the primitive model in the EDR.
  - Fixes for overcast skies will remove unrealistic ozone profiles (currently flagged as bad, but should not be present at all).

Summary

1. The CrIMSS EDR algorithm is a baseline operational product utilizing physical only approach available to user community.
2. The Algorithm has been in operations for only 18 months, and with very minor changes to the code and LUT updates from the pre-launch version, the algorithm has shown a remarkably improved performance.
3. The global yield of the algorithm is about 91%. The combined 'IR+MW' EDR product performance (yield ~47-50%) and the MW-only only product performance with a (reminder yield of 43%) are meeting the AVTP and AVMP Global requirements for most of the atmosphere.
4. The algorithm is performing as expected for different categories (land, sea, and coast), and different regimes (tropics, midlatitudes, high-latitudes). **A slightly larger global RMS difference exceeding the requirement at sfc-700 hPa is due to larger RMS differences over the land cases, and polar regions impacting the global RMS difference. Temperature RMS differences with ECMWF are very close to reaching the requirements. Water vapor retrievals may require a little more algorithm optimization. Proposed improvements are expected to improve the performance.**
5. The precipitation detection routines in the current operational version have issues with false positives and false negatives. Analysis performed with improved precipitation detection are expected to produce improved EDR performance.
6. Further improvements planned for various LUTs such as ATMS and CrIS bias corrections, emissivity improvements for the MW and IR land surface are expected to produce better EDR performance. Details on planned improvements and Discrepancy Report Discussions are available on STAR Website under CrIMSS EDR Algorithm Telecons.
   - ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/murtyd/telecons/CrIMSS_ALG/2013-04-25/
7. Focus-Day SDR/EDR products are available on NOAA/STAR FTP site
8. The CrIMSS EDR team will be happy to select any future focus-day in concurrence with AIRS Science Team for inter-comparison of Aqua-AIRS V6 and CrIMSS EDR evaluations using a common ensemble of matched EDR products, ECMWF and other truth data sets.
9. **Questions/Comments/Queries – Email To: Murty.Divakarla@noaa.gov**

CrIMSS EDR Algorithm Evaluations, Improvements and Validation Plans Series of Telecon Presentations on STAR FTP Site

- Emissivity Databases (SSEC, LaRC)
  - ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/murtyd/telecons/CrIMSS_ALG/2013-04-19/
- CrIMSS Planned Improvements
  - ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/murtyd/telecons/CrIMSS_ALG/2013-03-21/
  - ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/murtyd/telecons/CrIMSS_ALG/2013-04-04/
  - ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/murtyd/telecons/CrIMSS_ALG/2013-04-25
- **Status of ARM Best Estimate Product (Lori Borg et al.)**
- ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/nnalli/telecons/2013-05-07/

Backup Slides

- Thank You for your Attention