Validation of CrIMSS AVTP and AVMP Retrievals with PMRF RAOBs, ECMWF Analysis Fields, and the Retrieval Products from Heritage Algorithms (Aqua-AIRS Science Team Algorithm; NUCAPS)

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AMS-2014, 94th Annual Meeting , February 2-6, Atlanta, GA
10th Annual Symposium on Future Operational Environmental Satellite Systems, Paper Number 10.4, Thur. 11:45AM
Also, look at JGR Special Issue on S-NPP Cal/Val Results, Divakarla et al., 2014

IDPS- Operational CrIMSS EDR Algorithm AVTP and AVMP Product Assessment

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 Sites)
Special Campaign Dedicated RAOBs(AEROSE)
PMRF RAOBs

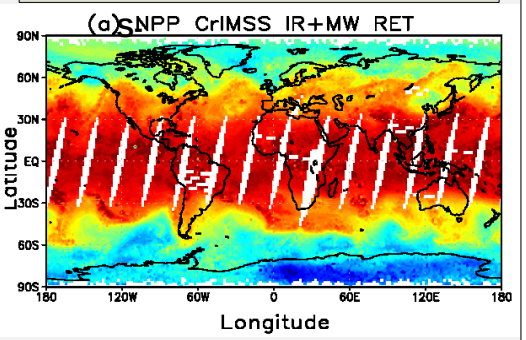
CrIMSS EDR Provisional Maturity (Jan 2013)
Optimization of CrIMSS EDR Algorithm
Baseline IDPS Version - MX5.3 (Past)
Current IDPS Version - MX6.6 (Until June 2013)
Upcoming IDPS Version – MX 7.1 (July 2013)
Off-line <-> ADL4.1 Synchronization -> DPE
Assessment with Matched ECMWF/Dedicated RAOBs
Focus Days 05/15; 09/20/2012; PMRF Dedicated RAOBs
Divakarla et al., AMS-2013

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

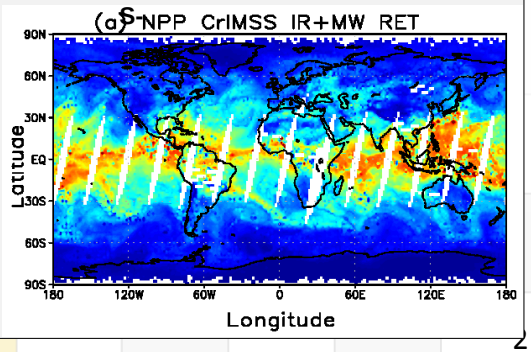
- Early release product; Minimally validated; May still contain significant errors.
- Versioning not established until a baseline is determined.
- Available to allow users to gain familiarity with data formats and parameters.
- Product is not appropriate as the basis for quantitative scientific publication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

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

AVTP Product
Example: 500 hPa Temp
May 15, 2012



AVMP Product
Shown as
Total Precipitable Water
May 15, 2012



Evaluation Scheme for AVTP and AVMP Products Provisional Maturity to Stage 1-3 Validations CrIMSS as well as NUCAPS/Aqua-AIRS/MetOp-IASI

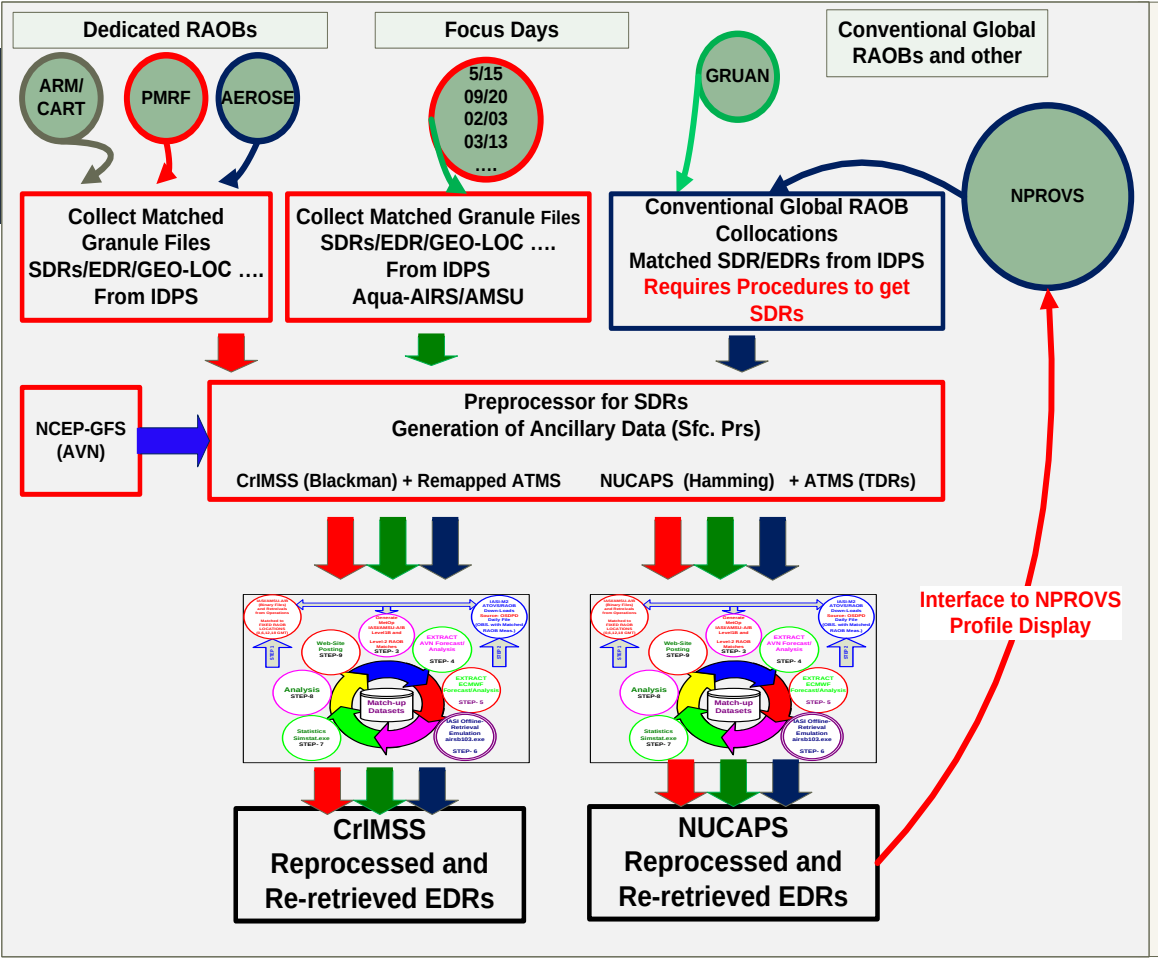
1. Global Evaluations with Focus Day Data Sets, CrIMSS/AIRS/ECMWF/NUCAPS/MiRS (05/15/, 09/20/2012; 02/03/, 03/12/2013)
2. Global RAOB collocations
   - Typically ~300 co-located matches for a given day (± 3 hr, 100 km)
3. GPS Radio occultation from COSMIC
   - Global sampling and long-term stability makes good reference
   - ~ 200-300 matches/day
4. Dedicated Sondes
   - ARM/CART Site (TWP SGP, NSA)
   - Campaigns of Opportunity (AEROSE)
   - Aerospace Pacific Missile Range Facility (PMRF), Hawaii, Launches

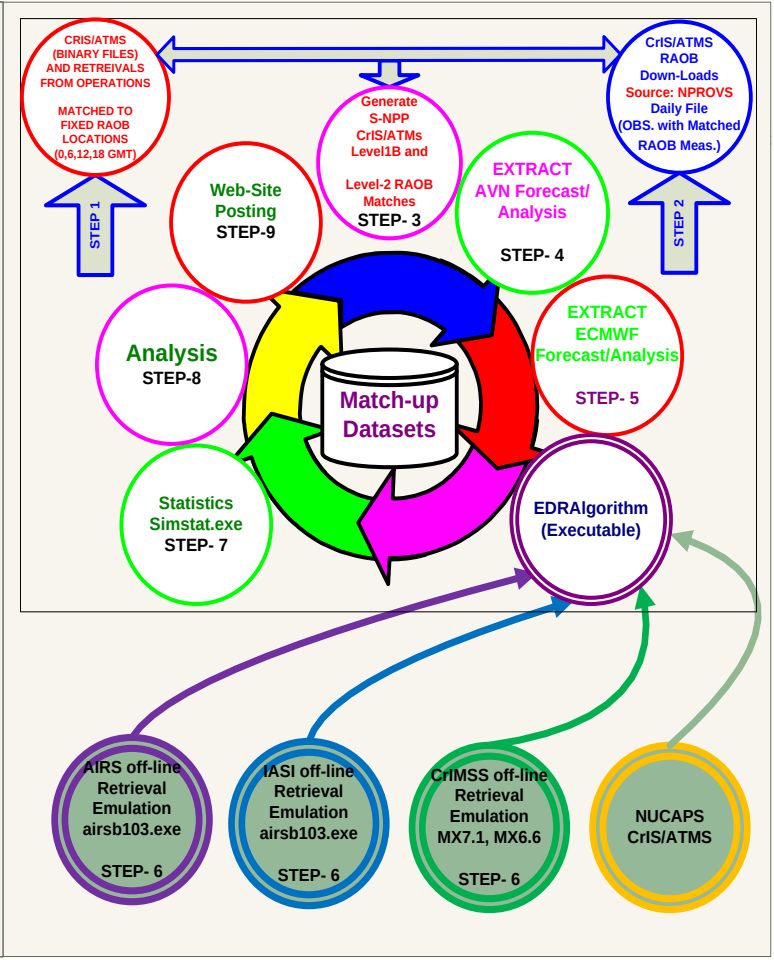
A. Stage-1: Product Validation performed using a small number of independent measurements obtained from selected locations and time periods and ground-truth/field program effort.

B. State 2: Product Validation performed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.

C. Stage 3: Product Validation performed and uncertainties were well established via independent measurements made in a systematic and statistically robust way that represents global conditions

Look for Divakarla *et al.*, JGR, 2014 for Results of Evaluation (1), (2), (3), (4)

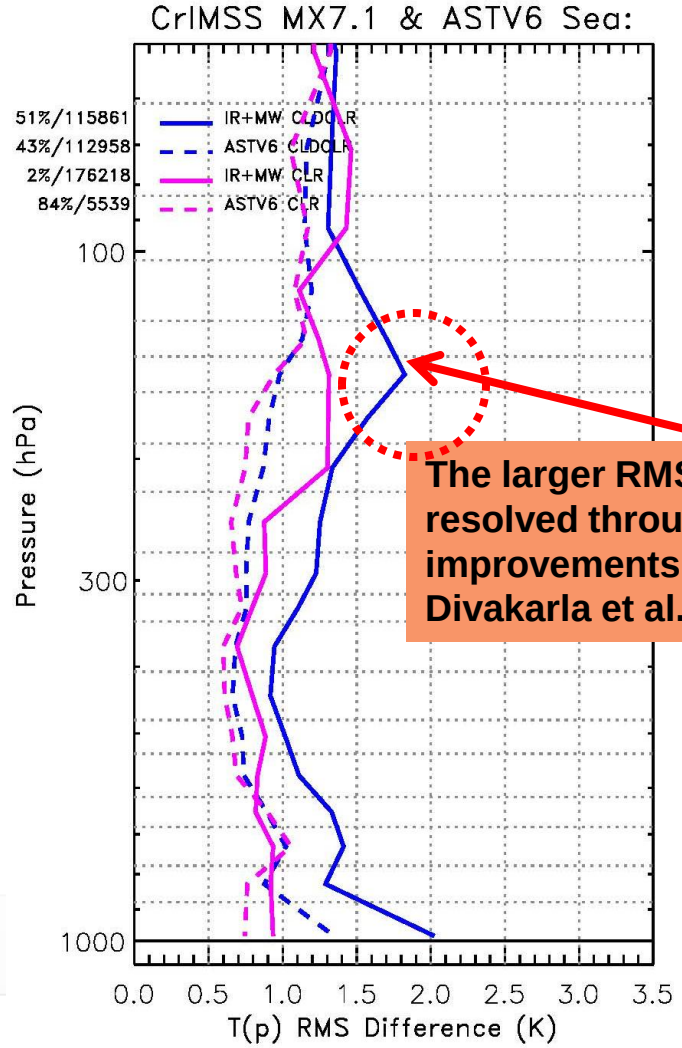




Utility of CrIS/AIRS/IASI Testbed

- ✓ Generating Focus Day Matches and Evaluations (Divakarla *et al.*,2011, 2014)
  - ✓ AIRS/IASI/S-NPP CrIMSS Ret.; ECMWF, NCEP-GFS, Proxy Data Sets for CrIS/ATMS
- ✓ Validation of AIRS/IASI Ret <-> Global RAOB matches (Divakarla et al., JGR 2006)
- ✓ Used for AIRS O3 Ret <->WOUDC O3SNDs/BD Matches (Divakarla *et al.*, JGR, 2008)
- ✓ Currently Interfaced with NPROVS PDISP (Pettey et al., Sun et al., AMS-2014, posters)

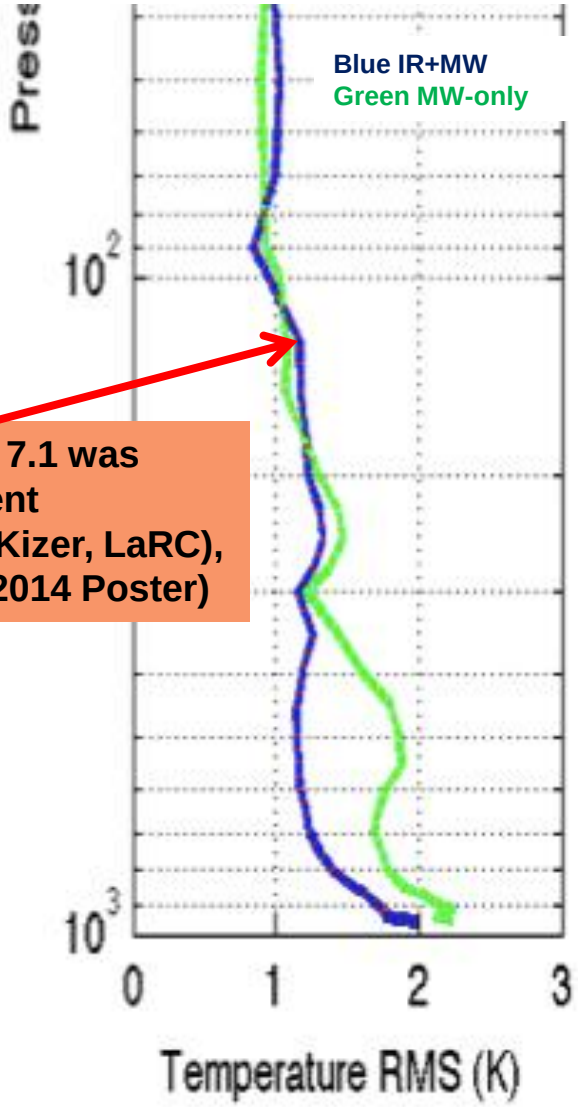
CrIMSS vs. ECMWF; AIRS V6 (Heritage Alg. pbest) vs. ECMWF Matched EDRs - Global Ocean – Cloud-Cleared, and Cloud-free



T(p) RMS (K)

Divakarla et al, JGR, 2014

The larger RMS in MX 7.1 was resolved through recent improvements (Liu & Kizer, LaRC), Divakarla et al., AMS-2014 Poster)

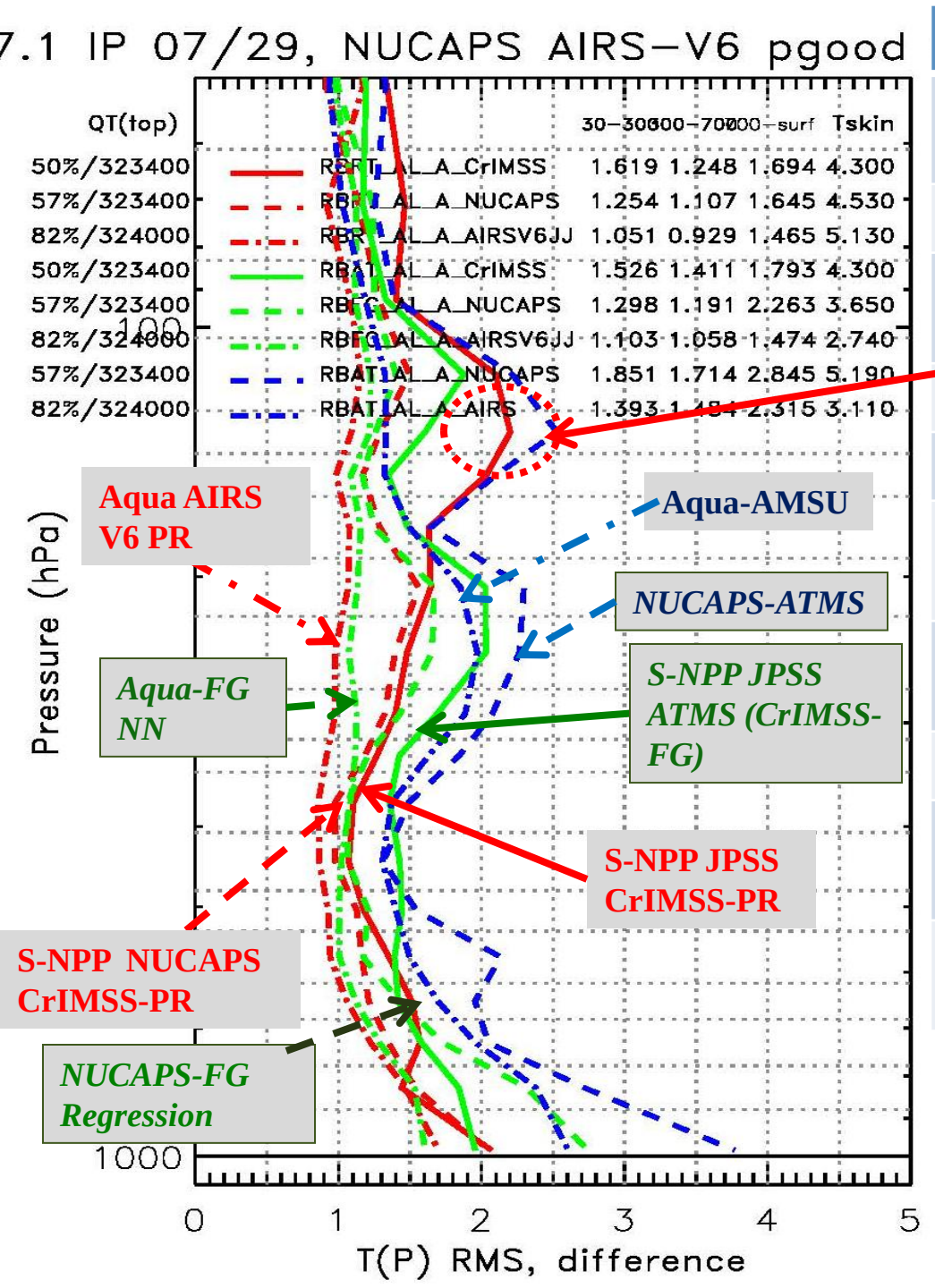


Solid Lines
CrIMSS IR+MW

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



Line Color, Style	Retrieval System
RED Dash-Dot-Dash	Aqua-AIRS V6 PR
RED Dashed	NUCAPS PR
RED Solid	JPSS-CrIMSS PR.
BLUE Dash-Dot-Dash	Aqua-AMSU RET
BLUE Dashed	NUCAPS ATMS RET
GREEN SOLID	CrIMSS ATMS RET (used as FG for CrIMSS PR)
GREEN Dash-Dot-Dash	Aqua-FG Using Neural Network
GREEN Dashed	NUCAPS FG (PC REG. with ECMWF Training)

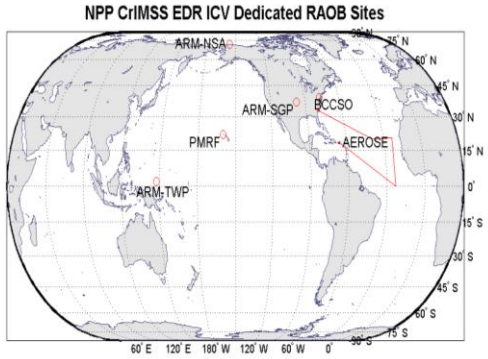
Recent improvements have helped to reduce this RMS difference (Liu and Kizer, LaRC)

Data is from the Focus Day 07/29/2013. All RET RMS are with ref. to ECMWF

CrIMSS: Intensive Cal/Val Dedicated RAOB Campaign(s)

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



Objective: Validate CrIMSS-EDRs with dedicated sondes, ECMWF analysis fields and evaluate against heritage algorithms (Aqua-AIRS) using collocated matches.

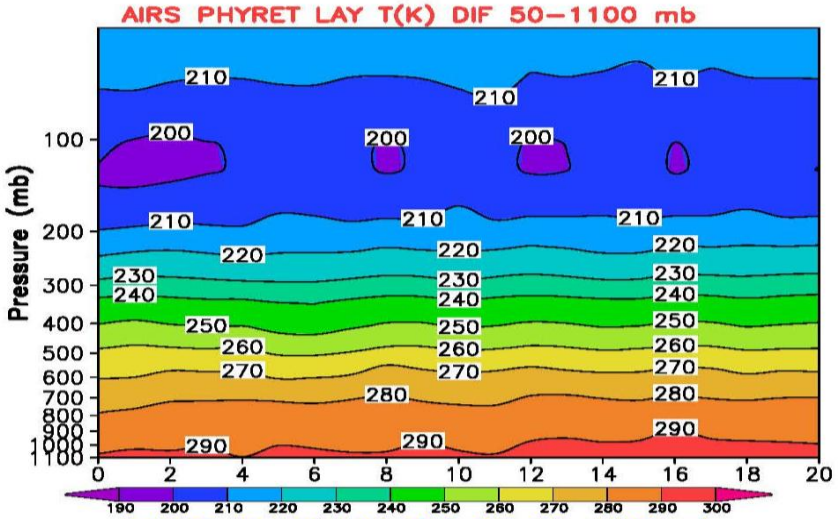
As a part of CrIMSS EDR validations, the Aerospace Corporation has provided 40 Vaisala RS92 from Pacific Missile Range Facility (PMRF), Barking Sands, Hawaii, in May and September 2012.

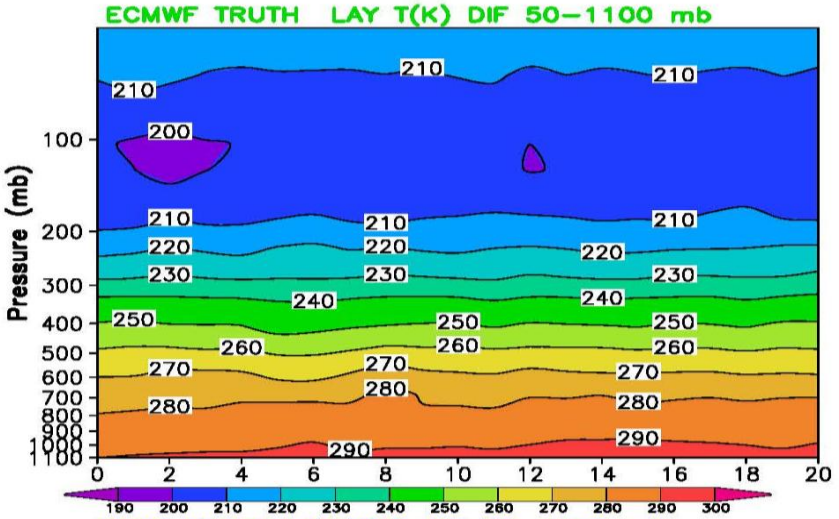
- **Evaluation of CrIMSS EDRs, Aqua-AIRS V6 pbest QC retrievals was carried out with reference to RAOBs, ECMWF**

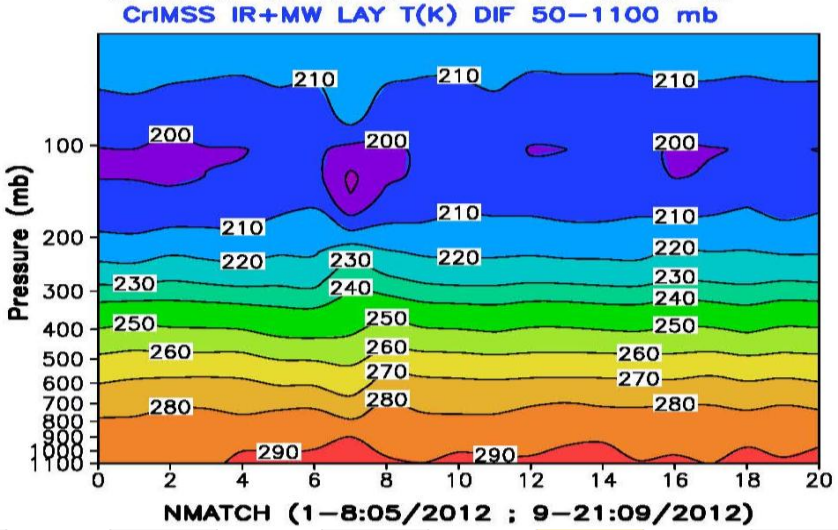
Lori Borg, *et al.*, ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/nnalli/telecons/2013-05-07/

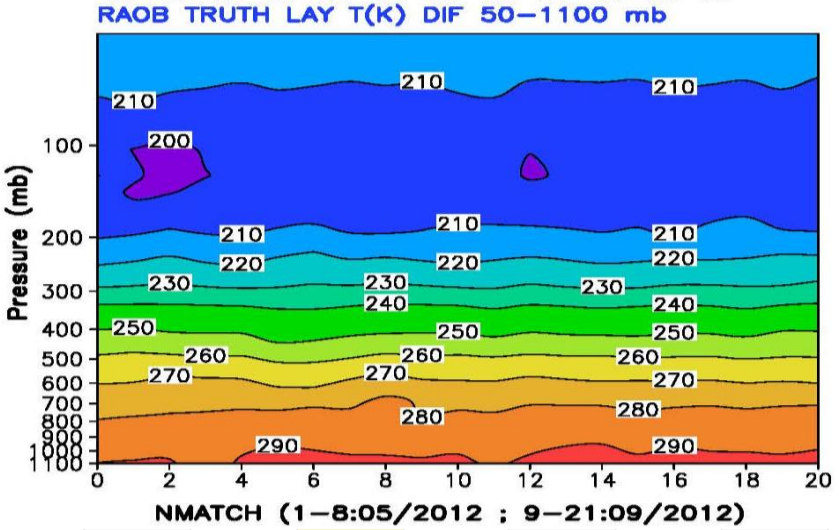
Nalli et al., ftp://www.star.nesdis.noaa.gov/pub/smcd/spb/nnalli/telecons/2013-05-07/

AVMP: PMRF RAOBs, ECMWF, CrIMSS and AIRS RET Matches
May 2012 (8, plotted as 0-7) , September (13, plotted as 8-21)
CrIMSS Yield: 61%, Aqua-AIRS Yield: 71% (pbest); 100%

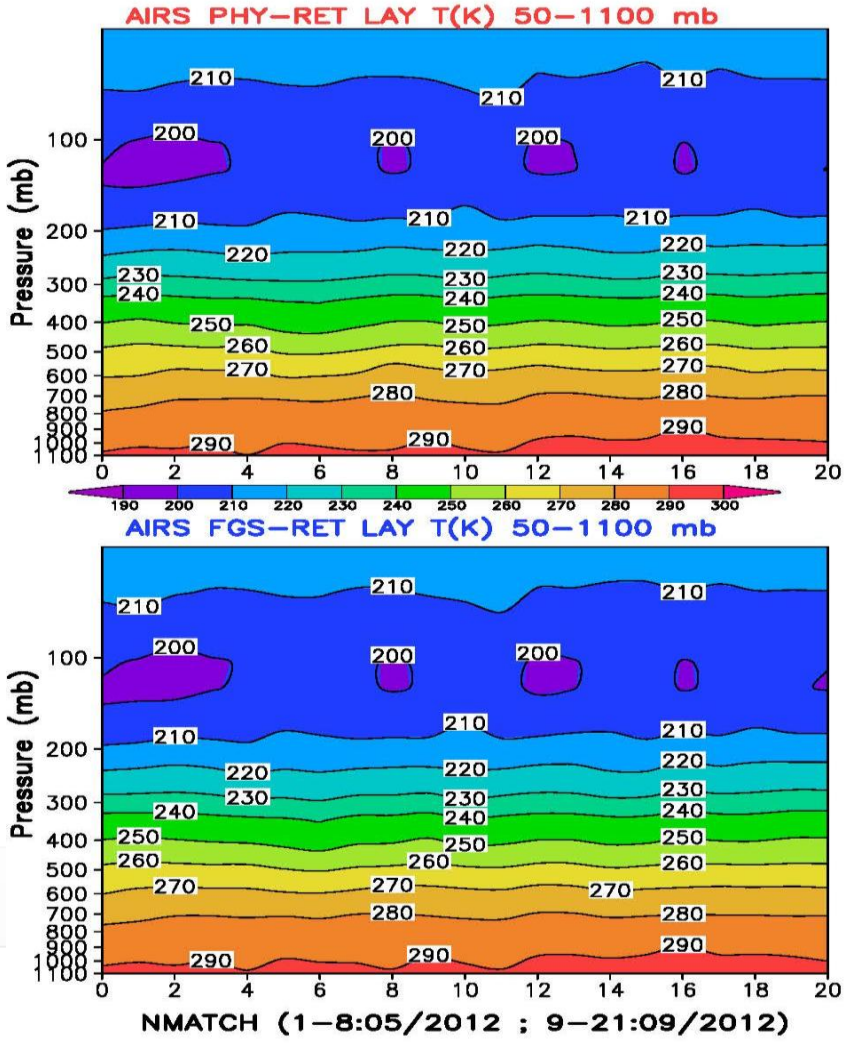


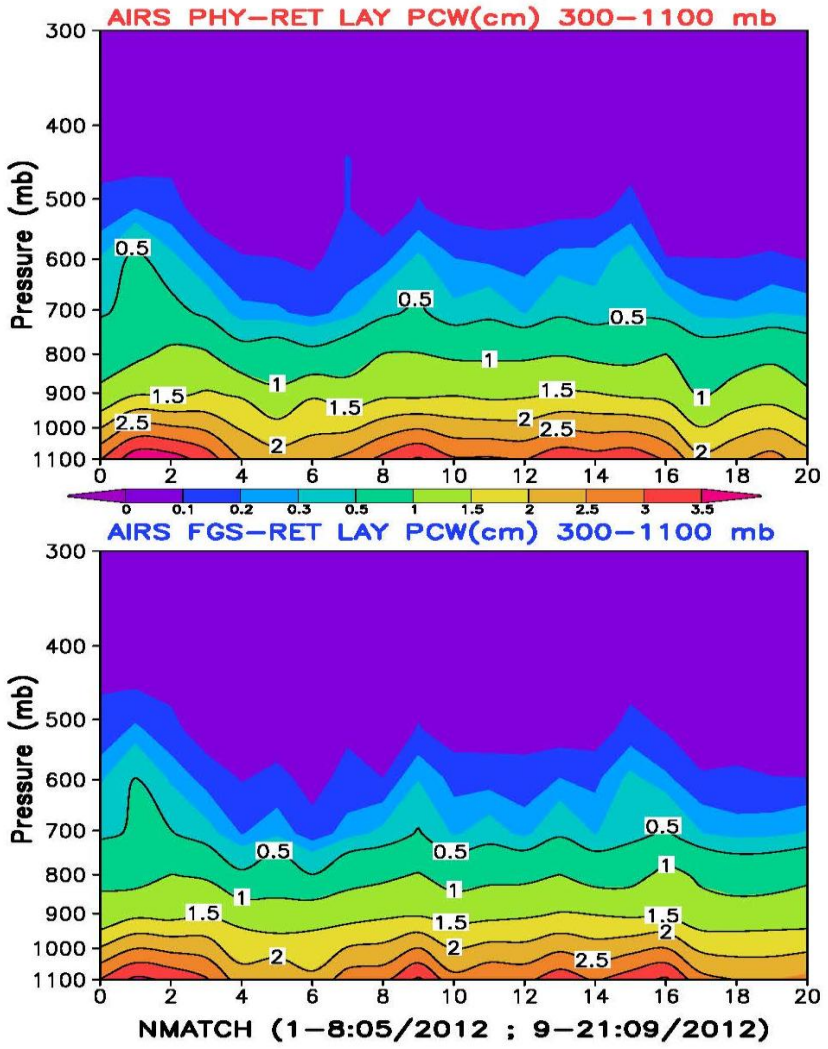




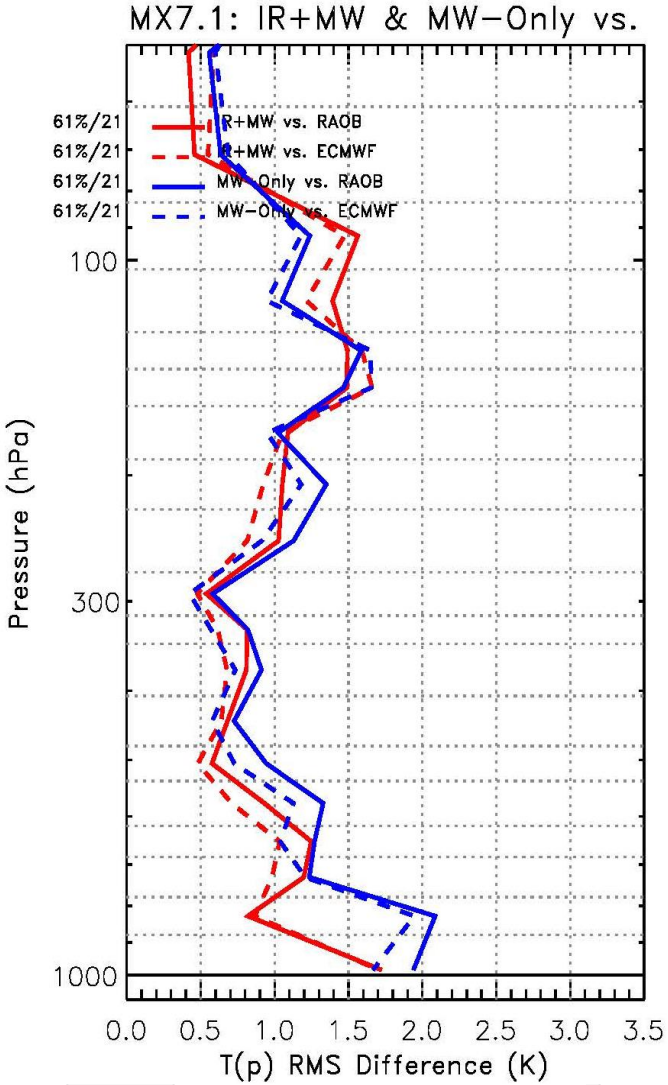


PMRF-Data Set – AVTP: AIRS-V6 (PRET, FG)
Yield: 71%

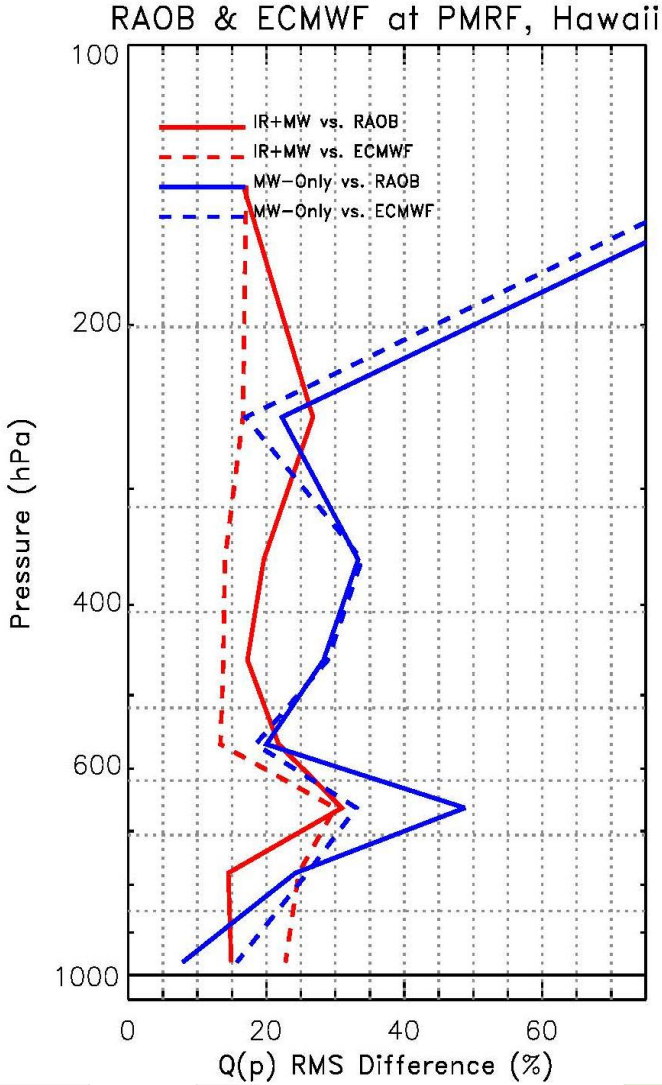




PMRF, Kauai, Hawaii (22.05°N, 159.78°W) Matches CrIMSS (IR+MW; MW-only) *vs.* RAOB; *vs.* ECMWF



T(p) RMS (K)



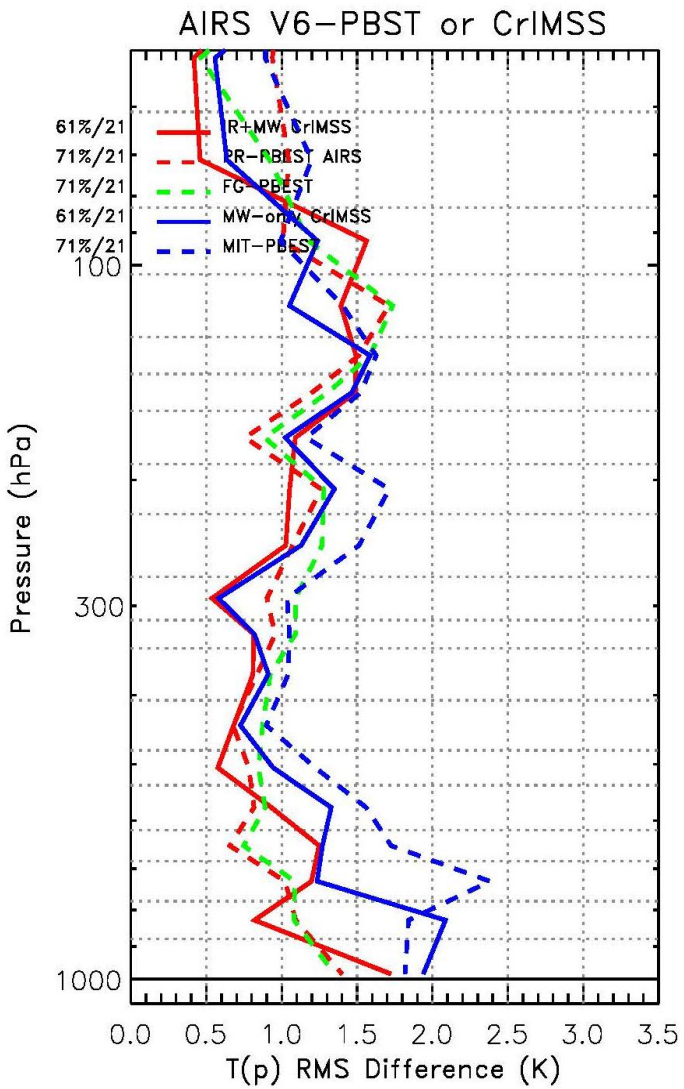
q(p) RMS (%)

RMS Differences with ref. to RAOB/ECMWF

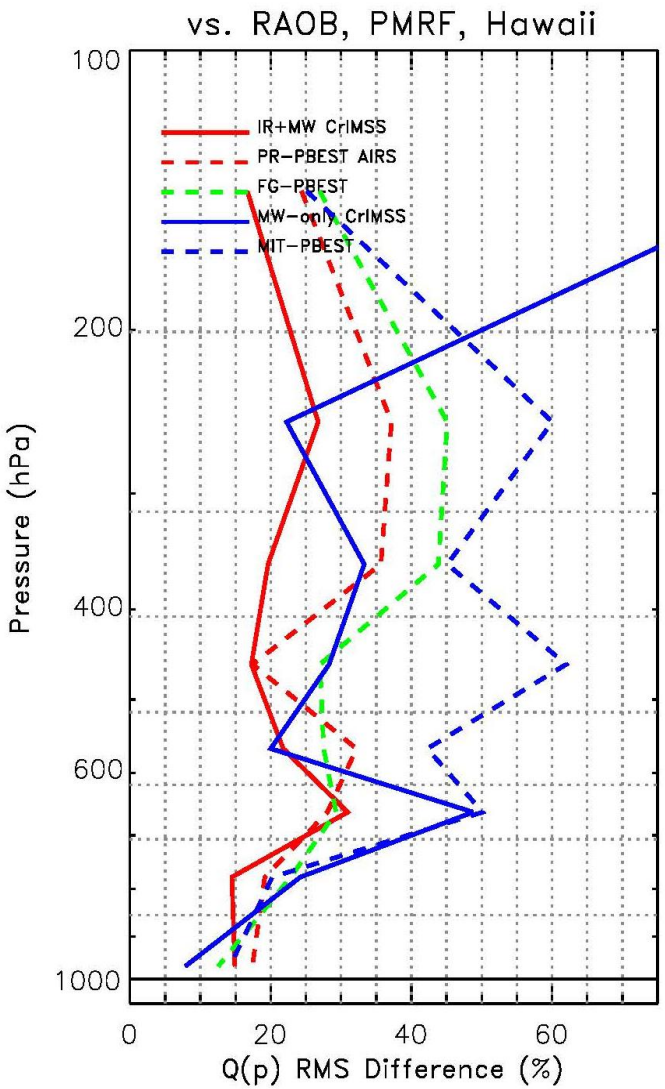
Solid Lines wrt RAOB
Dashed wrt ECMWF

Red: CrIMSS IR+MW
Blue: ATMS MW-Only

PMRF, Kauai, Hawaii (22.05°N, 159.78°W) Matches CrIMSS vs. RAOB; AIRS-V6 Pbest vs. RAOB



T(p) RMS (K)



q(p) RMS (%)

RMS Differences with RAOB

Solid Lines
CrIMSS IR+MW
ATMS MW-Only

Dashed Lines
AIRS V6 PR RET
AIRS FG (Neural N)
AMSU-A

Results and Discussion

1. Evaluation of the CrIMSS operational product (MX7.1) with PMRF-dedicated RAOBs, ECMWF and AIRS Ret.
   - Mainly Tropical (22.05N; 159.78W) and relatively 'cloud-free to lower percentage of cloud amounts'.
   - For low cloud amounts, and cloud-free samples the CrIMSS EDR algorithm is very robust and the algorithm performance is very similar to the AIRS-V6 heritage alg.

2. AVTP and AVMP RMS differences with RAOBs and ECMWF are very similar and the retrievals (CrIMSS as well as AIRS) tend to agree better with ECMWF. These dedicated RAOB matches are not assimilated into ECMWF assimilation system. Yet, the ECMWF analysis act as a good proxy-truth to evaluate algorithms performance around data sparse open ocean areas.

Results and Discussion

3

CrIMSS-ATMS MW-Only retrievals are more accurate than other MW-only algorithms (NUCAPS-ATMS, Aqua-AMSU retrievals)

- CrIMSS-MW-only represents about 50% of total number of retrievals and produce more realistic scene patterns than other algorithms. The algorithm currently defaults to MW-only when IR+MW fails retrieval criteria
- Procedures are in place in the CrIMSS EDR algorithm to output MW-only product if desired or perform CrIS Channel selection for IR+MW second stage retrieval.

4

CrIMSS IR+MW retrieval is very accurate in clear sky conditions. Cloud-clearing tends to be problematic for this algorithm as well as other similar algorithms. Clear sky retrievals represent a significant number of retrievals and use of clear sky retrievals over ocean and remote regions could be advantageous to NWP. The CrIMSS algorithms solves penalty function, and hence has necessary background covariance information for NWP data assimilation.

Retrieval Algorithms

Hyper-Spectral IR physical retrieval algorithms that use a statistical first guess tend to stick to the first guess.

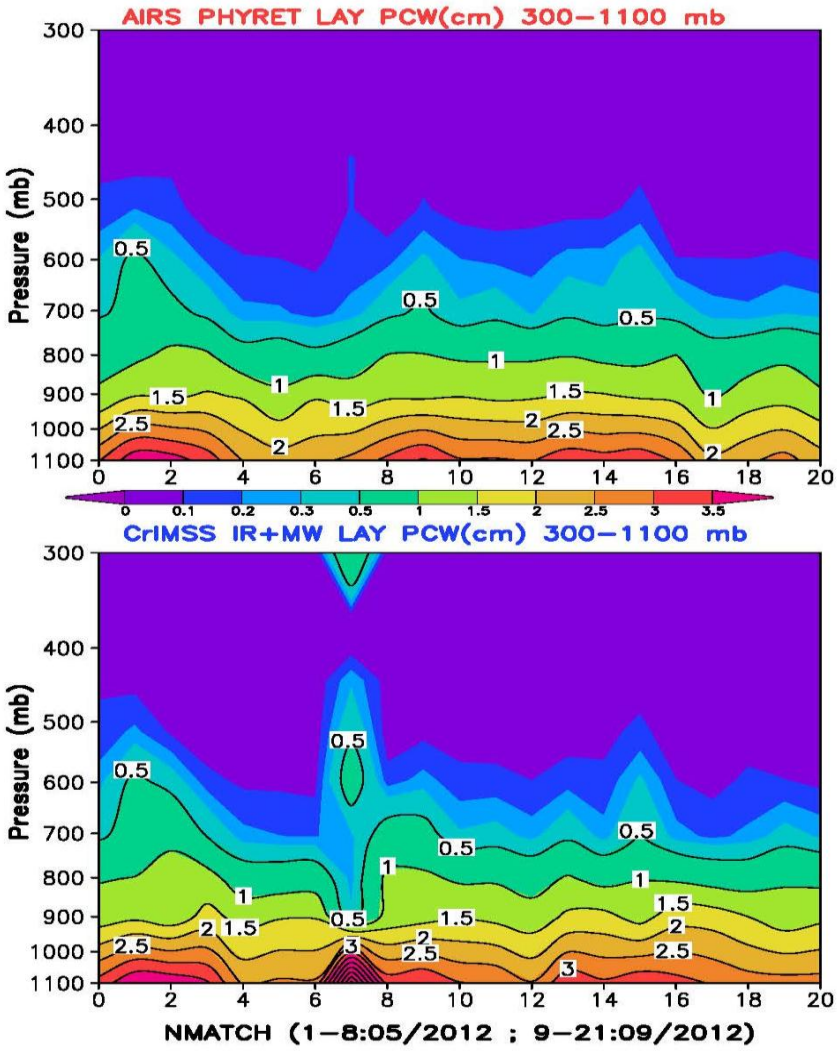
- **AIRS-V6 pbest is only marginally better than the AIRS-FG (NN regression operator.**
- **The first guess (statistical regression) although performs good in most cases, may not adequately represent all conditions (e.g. dust, etc.)**
  - **An algorithm that is entirely physical (CrIMSS EDR alg.) fares better in these situations (Divakarla, AMS-2013).**

The difference between AST-V6 and the CrIMSS EDR is that the CrIMSS EDR is physical-only and does not incorporate any knowledge of ECMWF with in the retrieval.

- **What type of RET. Products – Users (NCEP-GFS) wish to see?**
- **How can we utilize some of the improvements made in the CrIMSS algorithm to mitigate/improve NUCAPS or other algorithm(s) -- vice versa.**

Thank You for your Attention
Back up Slides

AVMP: PMRF RAOBs, ECMWF, CrIMSS and AIRS RET Matches
May 2012 (8) , September (13)
CrIMSS Yield: 61%, Aqua-AIRS Yield: 71% (pbest); 100%



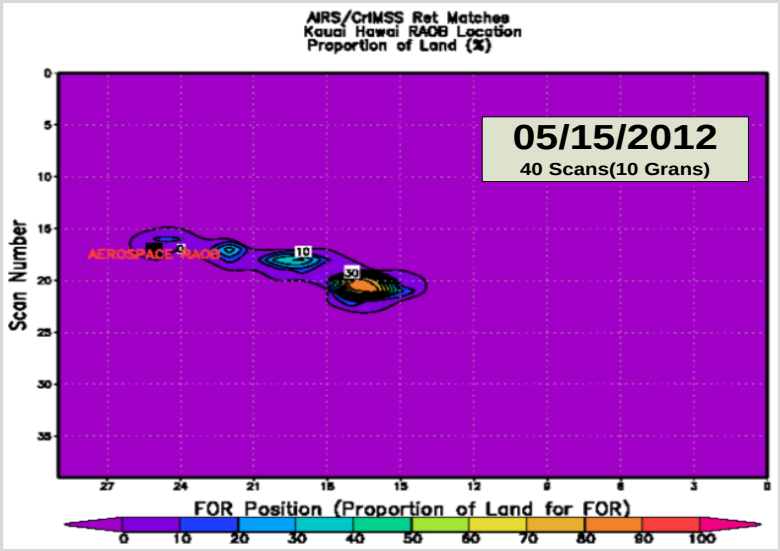
Need of the Day: Development of a Blended MW and Hyper Spectral IR Retrieval System

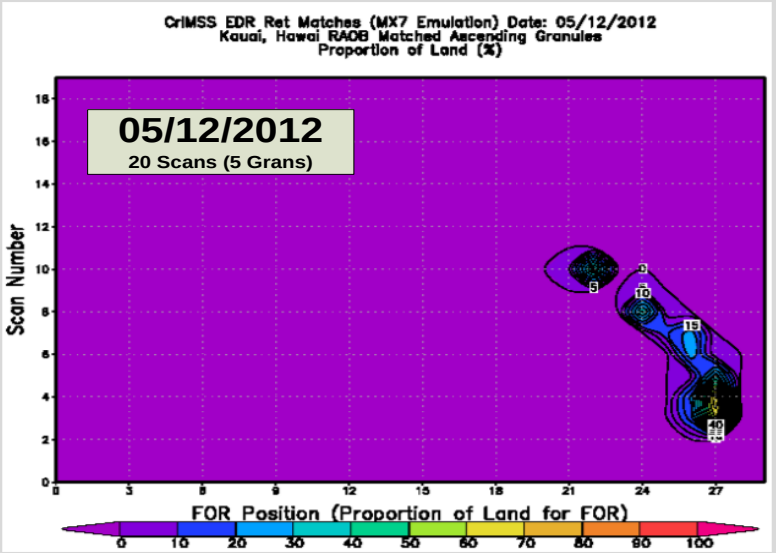
Look into Merits of the Existing MW and Hyper Spectral IR Retrieval Algorithm to come-up with a Common MW & Hyper Spectral IR Blended Algorithm

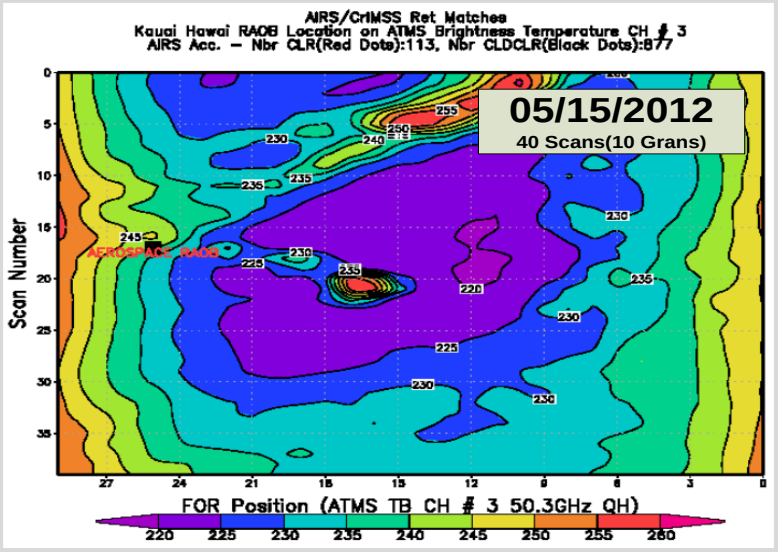
- MiRS MW 1D-VAR Retrieval Algorithm
- The Hyper-Spectral Heritage Algorithm: The NASA-AIRS V6 Algorithm
  - Uses Neural Network FG and a Sequential Retrieval Algorithm
  - NUCAPS (Adapted the AIRS Science Team V5 Algorithm (with FG regression based on ECMWF training)
- JPSS CrIMSS EDR Algorithm that uses a MW First Guess and a IR+MW Simultaneous Retrieval

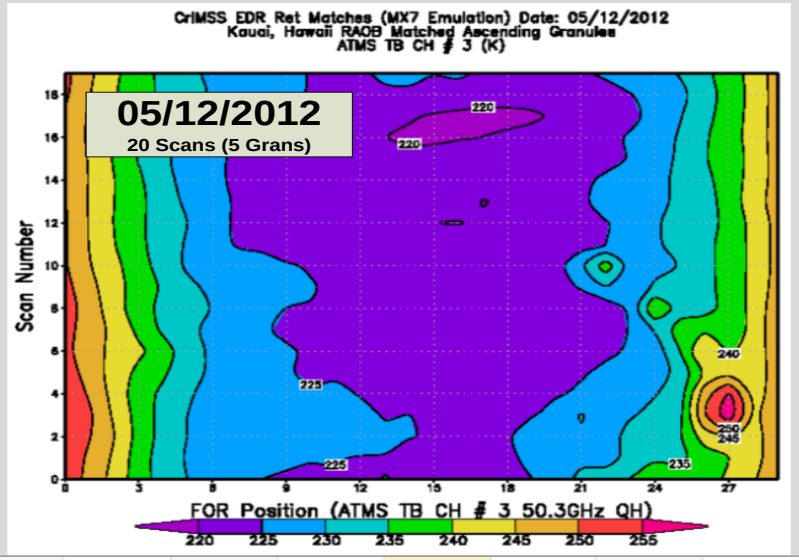
NOAA STAR has access to all these algorithms and the expertise, and provides an ideal ground for the development of a blended algorithm.

Aerospace RAOB (Kauai, Hawaii)
Land Fraction/ATMS TBs 05/15/2012, 05/12/2012
(Land fraction impacts MW BTs, and MW-only EDR Product

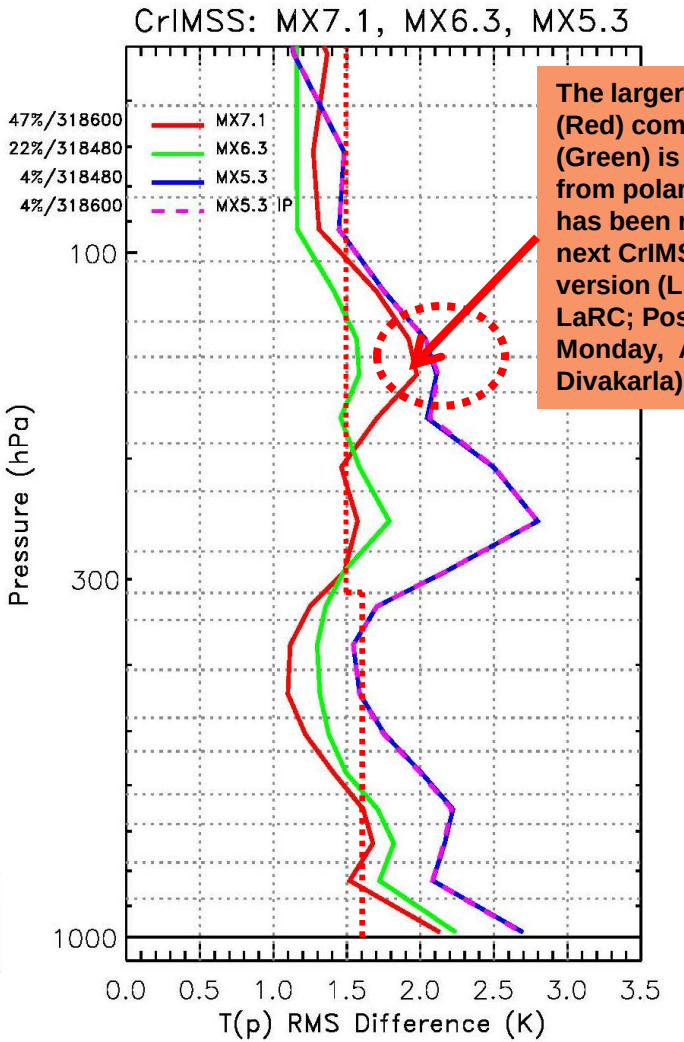




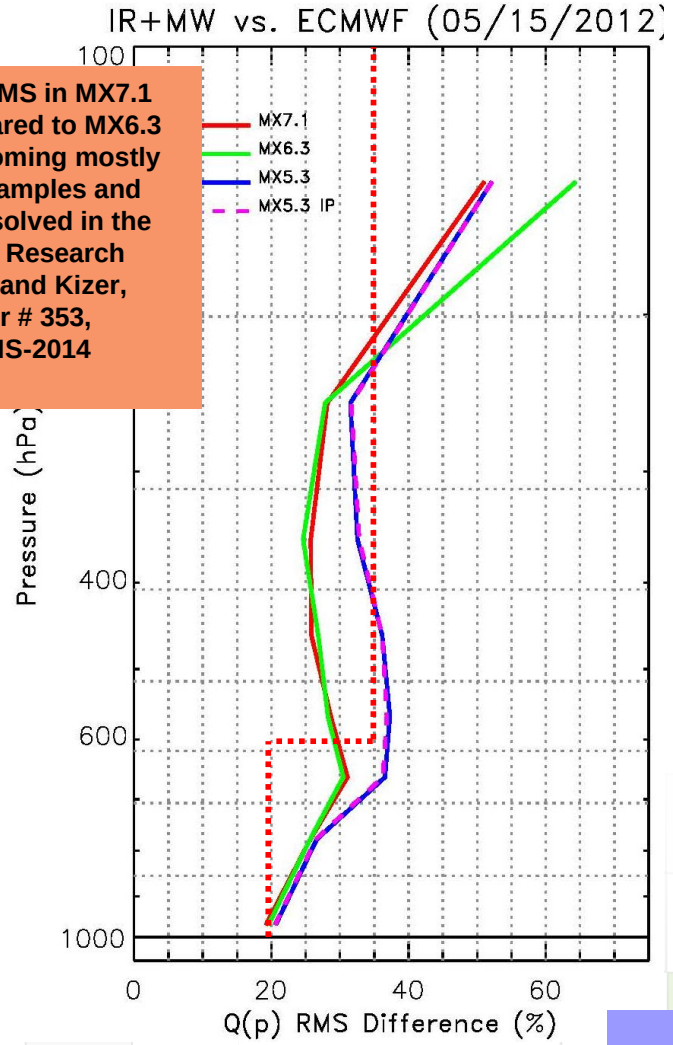




CrIMSS 'IR+MW' AVTP, AVMP RMS Differences wrt ECMWF
MX 5.3 (Day1), MX 6.3 (Present) and MX 7.1 (June 2013)
Data: Global (Focus Day: 05/15/2012)



The larger RMS in MX7.1 (Red) compared to MX6.3 (Green) is coming mostly from polar samples and has been resolved in the next CrIMSS Research version (Liu and Kizer, LaRC; Poster # 353, Monday, AMS-2014 Divakarla)



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

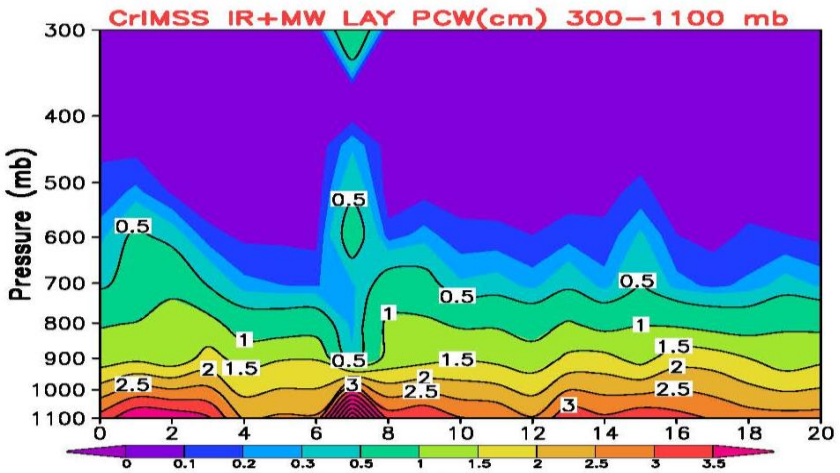
Global ALL
N=318,000

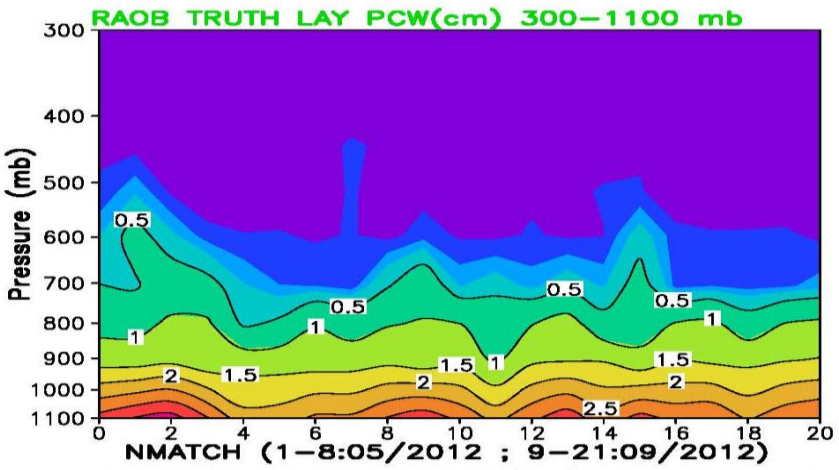
T(p) RMS (K)

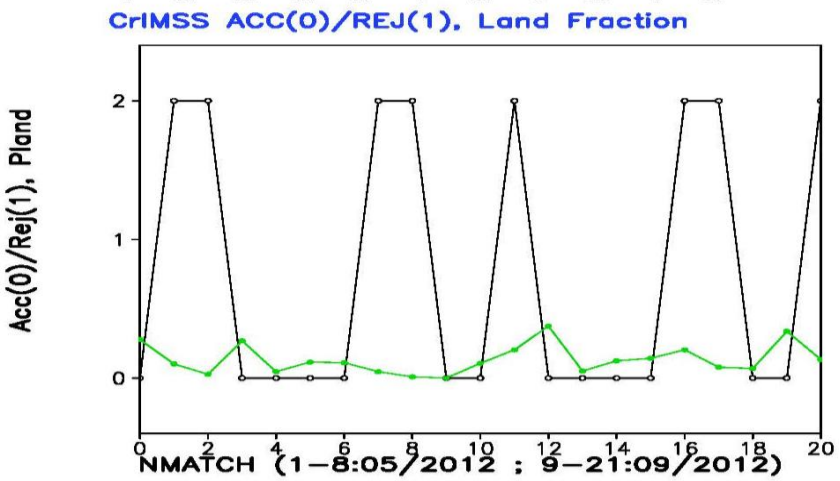
q(p) RMS (%)

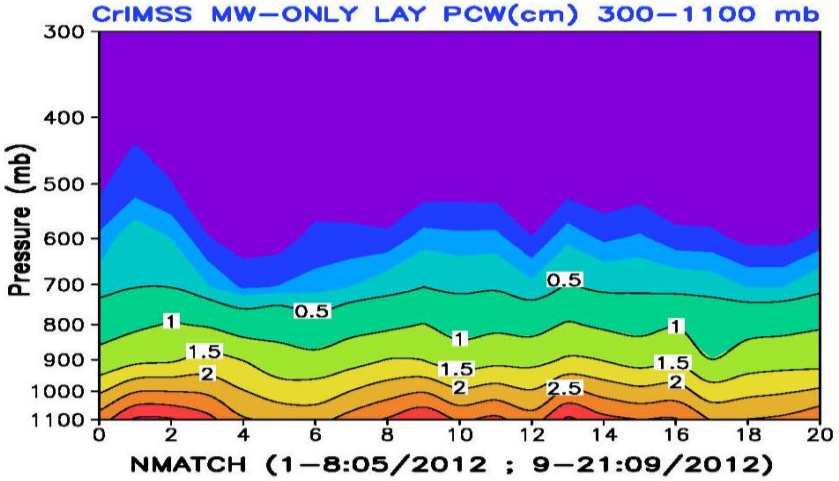
Divakarla et al, JGR, 2014

CrIMSS AVMP Validations with PMRF Dedicated RAOBs (22.05N; 159.78W), and ECMWF

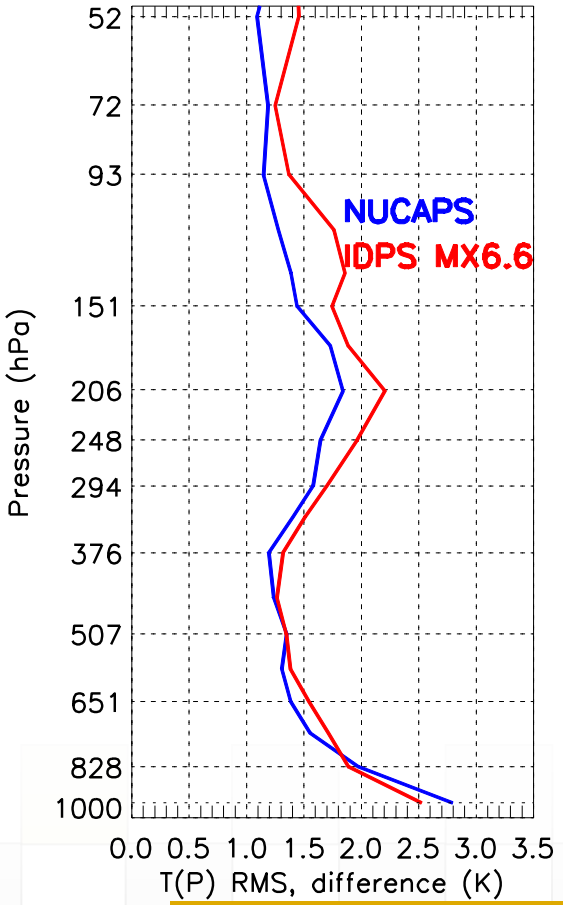


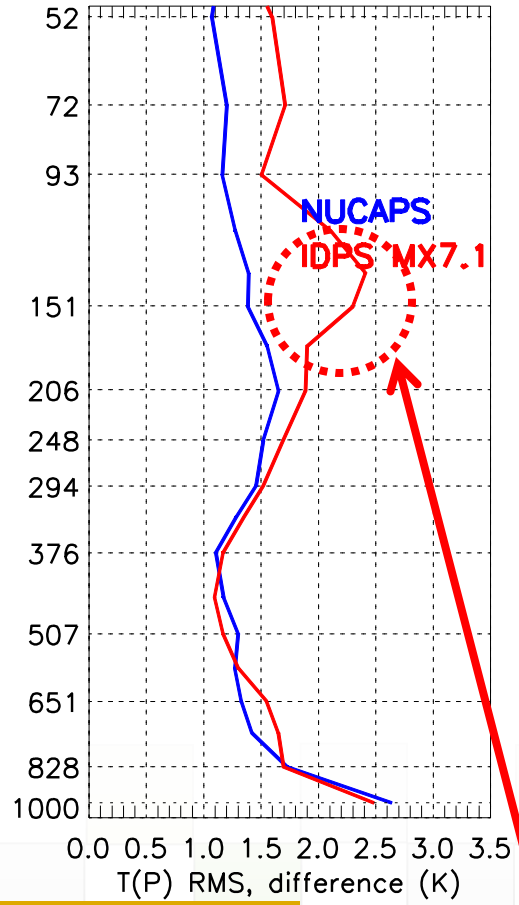


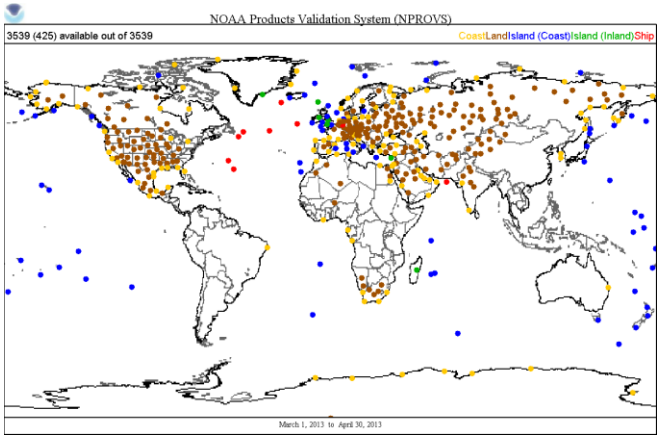




Evaluation with Global RAOB Matches using NPROVS







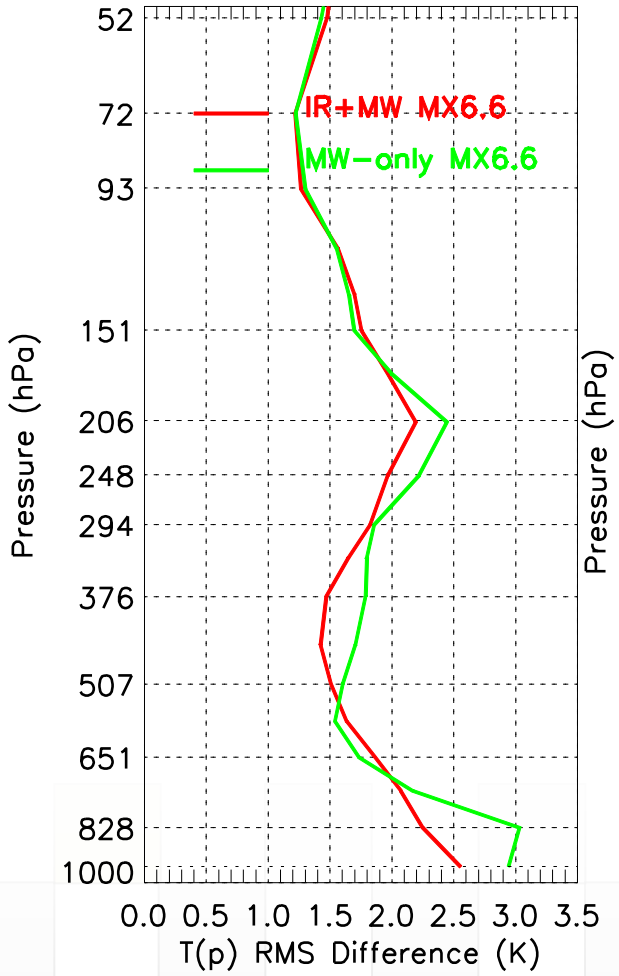
		Prof. number	Yield (%)
	IR+MW	17612	35
MX 6.6	MW-only	26986	53
	Poor	6436	12
	IR+MW	34234	48
MX 7.1	MW-only	28800	40
	Poor	8721	12

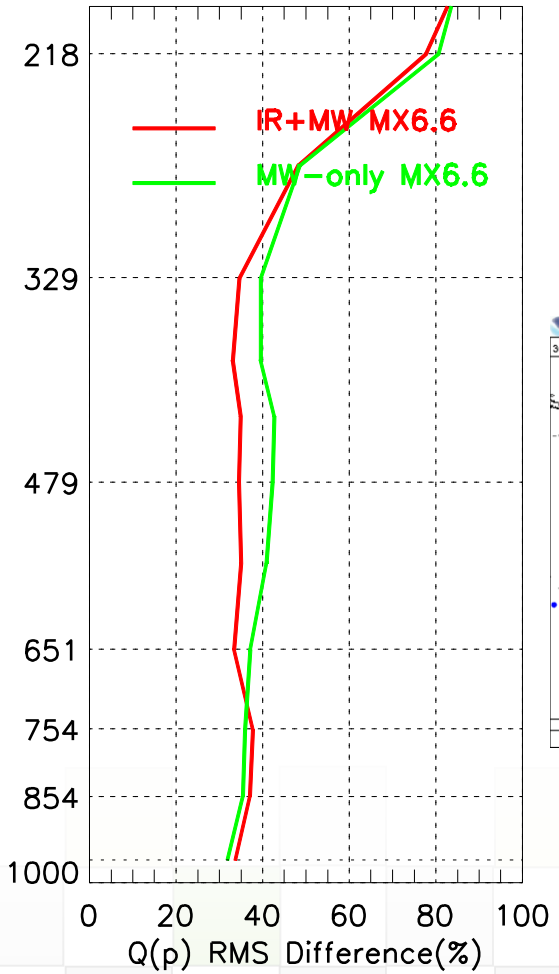
Poster – Sun *et al.*, AMS-2014 Poster

As discussed earlier, MX7.1 + Recent Improvements to Bias Tuning has helped to reduce the large RMS difference seen with MX7.1

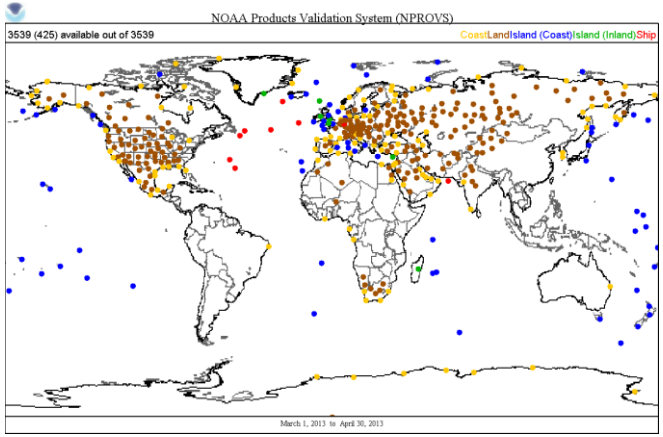
AVTP (left) and AVMP (right) RMS differences primarily reflect sounding performance over mid-latitude land areas where most of the global RAOB network stations are concentrated.

Evaluation with Global RAOB Matches (NPROVS)





CrIMSS MX6.6
N=25,000
Yield:
IR+MW: 34%
MW-Only: 51%



Divakarla et al, JGR, 2014

AVTP (left) and AVMP (right) RMS differences primarily reflect sounding performance over mid-latitude land areas where most of the global RAOB network stations are concentrated.