Validated Maturity Science Review For Microwave Integrated Retrieval System (MiRS):

Temperature, Water Vapor Profile, TPW and Rain Rate

Presented by Chris Grassotti & Junye Chen

Date: 10/18/2016

Outline

- Algorithm Cal/Val Team Members
- Product Requirements
- Evaluation of algorithm performance to specification requirements
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- Identification of Processing Environment
- Users & User Feedback
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

MiRS Cal/Val Team

Algorithm Cal/Val Team Members

Team Member	Organization	Roles and Responsibilities
Q. Liu (Project Manager)	NESDIS/STAR/SMCD	Project management
C. Grassotti (Technical Lead)	NESDIS/STAR/SMCD (U. MD./ESSIC/CICS)	Coordination of technical activities; review/deliverable planning
S. Liu	NESDIS/STAR/SMCD (CSU/CIRA)	Precipitation cal/val, SFR integration, DAP preparation
J. Chen	NESDIS/STAR/SMCD (U. MD./ESSIC/CICS)	Sounding and emissivity cal/val, J1 extension, Sounding improvements
L. Zhao	NESDIS/OSPO	Operational Product Area Lead

Evaluation of algorithm performance to specification requirements

- MiRS initial operational processing at NDE was v9.2 in June 2013. Updated DAP v11.1 implemented in operations in October 2015. All validation results shown here reflect v11.1
  - Algorithm Improvements in v11.1: updated CRTM (v2.1.1), dynamic climatology background for T and WV (variable with location, season, time of day), plus other changes.
- Cal/Val Activities for evaluating algorithm performance:
  - Daily comparisons to both ECMWF and GDAS: global maps and statistics. Results automatically posted to MiRS website each day.
  - T, WV, TPW: Regular comparisons with radiosondes (NPROVS system). NPROVS group has been monitoring both v9.2 and v11.1 (v11.1 since June 2015). MiRS group has NPROVS software and is also analyzing performance, globally, regionally, and seasonally.
  - Rain Rate: Regular comparisons with surface radar-gauge analyses (Stage IV) over CONUS and nearby waters, supplemented with comparisons with GPROF globally.
  - External Users: provide feedback, identify issues, algorithm team has issued several bug fixes/patches in past 3 years.

Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data: MiRS requires (1) TDRs (for retrieval), (2) SDRs (for NEDTs), and (3) geolocation
  - Ancillary Data: No real-time ancillary data required.
  - Upstream algorithms: None
  - Static tables/files needed for: CRTM sensor coefficients, snow/ice retrieval, radiometric bias corrections, EOFs, background mean/covariance
- Evaluation of the effect of required algorithm inputs
  - None needed since only dynamic inputs are the TDR/SDR/GEO data. All other required data is static.
  - MiRS tools in STAR available to evaluate as needed to rapidly assess impacts of turning select channels on/off (e.g. if sensor shows signs of degradation, drift). This has been done for other operational satellites/sensors that MIRS runs on. To date, not required for ATMS

Quality flag analysis/validation

- MiRS Quality Flags
  - Top level QC: 0=good, 1="some event", 2=bad
  - Lower level QC: bitwise packed for multiple conditions (e.g. precipitation, RH saturation, T inversion, etc.)
  - Normally sufficient to utilize top level QC flag, along with geophysical situation for filtering (i.e. for valid T and WV in non-rainy conditions select all points where QC< 2 .and. RR=0)
- Quality flag analysis/validation
  - Daily maps indicate extremely low rate of QC=2 (bad), < 1%, normally caused by high chi-square (non-convergence), or extremely heavy precipitation
  - See maps and time series later in presentation

MiRS QC Flag Information

• Numerous checks made at various steps in retrieval process: TB values, chi-square, rain intensity, physical ranges, inversions, supersaturation, etc.

• Stored in 4-byte Integer array len=4.

• Individual QC checks are stored bitwise in QC(2-4). QC(1) contains top level summary QC: 0=good, 1=probably good, but some event triggered (e.g. rain, do not use T and WV), use with more caution, 3=bad

	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8	Bit 9	Bit 10	Bit 11	Bit 12	Bit 13	Bit 14	Bit 15
QC (1)	0 = GOOD, 1= SOME PROBLEM, 2=BAD															
QC (2)	CONVERGENCE I (ChiSq >= 10)	CONVERGENCE II (5<=ChiSq <10)	PRECIPITATION (YES/NO)	TYPE OF PRECIPITATION			OUT-OF-BOUND FLAGS								MEAS. QC	
				LIGHT	MEDIUM	HEAVY	TSKIN	TEMP	Q	EMISS	TPW	ICLW	RWP	GWP		
QC (3)	TEMPERATURE LAPSE RATE	TEMPERATURE INVERSION (Range:Psfc-200mb to Psfc)	SUPERSATURATION (RH > 99.9 %)	SUPERSATURATION 3 CONTIGUOUS LAYERS (RH > 99.9 %)	HUMIDITY INVERSION	CLOUD	VALIDITY FLAGS									
							TSKIN	TEMP	Q	EMISS	TPW	ICLW	RWP	GWP		
QC (4)	ALLOCATED FOR EACH ELEMENT OF MEASUREMENT QC												OCEAN	LAND		Calibration

Requirements and Validation Results: Temperature Profile

- Daily, Global Collocations with ECMWF and GDAS.
- Periodic, Global collocations with radiosondes (NPROVS)
- Stratified by clear/cloudy, and surface type
- Requirements from JPSS-REQ-1004
- Maturity Level: Validated, Stage 3

Attribute	Threshold	Validated
Geographic coverage	Global (non-frozen surfaces)	See table/figs
Vertical Coverage	Surface to 0.01 mb	
Vertical Cell Size	Individual layers (not averaged); based on CRTM 100 p layers	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	N/A	
Measurement Accuracy	See table	
Measurement Precision	See table	

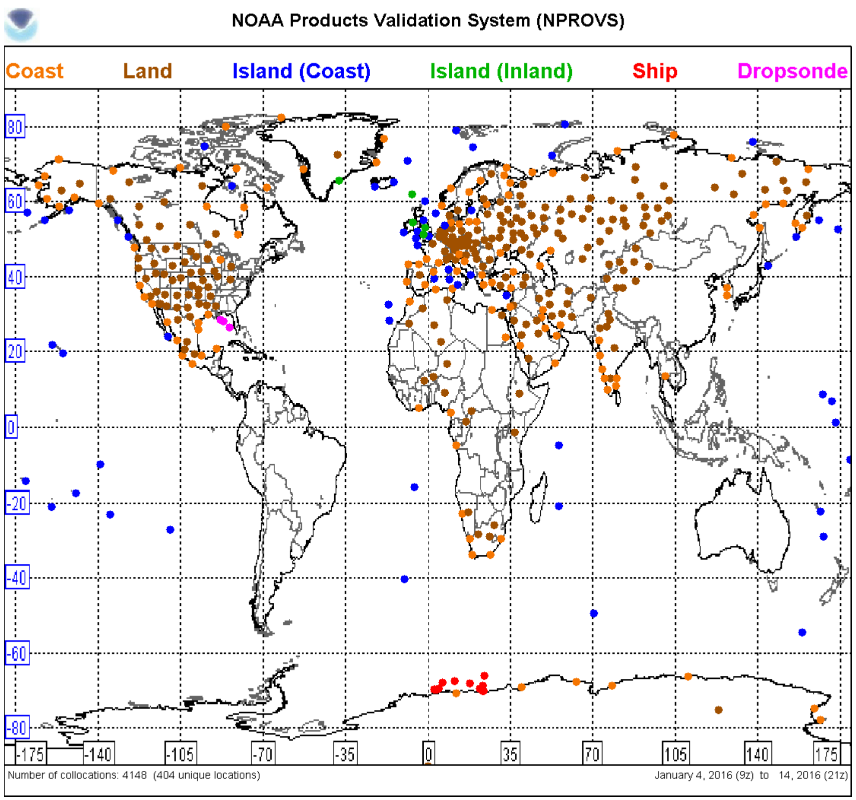
Product	Sfc	Condition	Layer (hPa)	Bias (K) (Accuracy)		StDv (K) (Precision)	
				MiRS	Req	MiRS	Req
Temperature	Sea	Clear	100	**-0.2**	**0.5**	**1.7**	**2.0**
			300	**0.6**	**0.5**	**1.5**	**2.0**
			500	**-0.5**	**0.5**	**1.1**	**2.0**
			900	**0.2**	**1.5**	**1.9**	**3.0**
		Cloudy	100	**-0.0**	**0.8**	**1.9**	**2.0**
			300	**0.4**	**0.8**	**1.9**	**2.5**
			500	**-0.5**	**0.8**	**1.4**	**2.0**
			900	**0.6**	**2.0**	**2.1**	**3.0**
	Land	Clear+ Cloudy	100	**-0.5**	**1.0**	**1.5**	**2.0**
			300	**0.8**	**0.8**	**1.7**	**2.0**
			500	**0.0**	**0.5**	**1.5**	**2.5**
			900	**-0.8**	**2.5**	**2.6**	**5.5**

Validate MiRS Temp and WV retrieval based on collocated sonde data

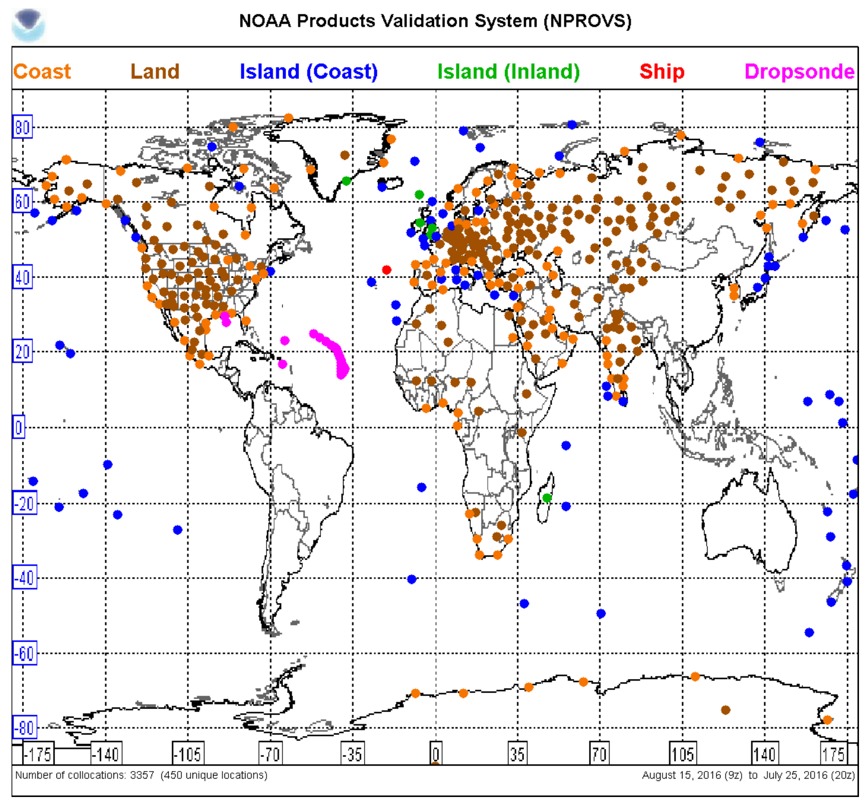
Validation data are from two ten day periods in January and August 2016
Collocation criteria: +/- 3 hour, 150km

Positions of collocated (MiRS NPP/ATMS, sonde, ECMWF analysis) data

January



August

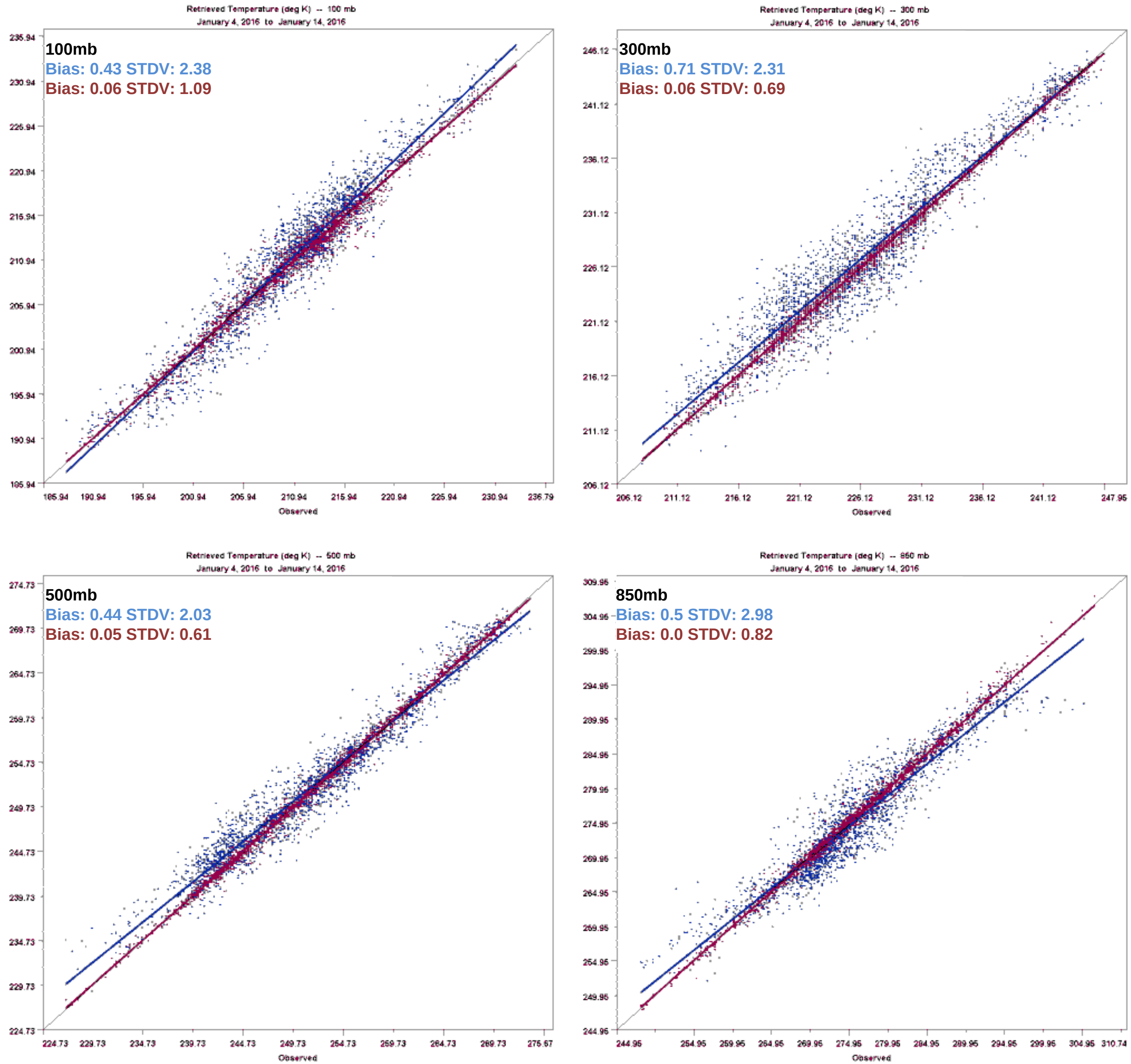


Temperature Profile Validation based on sonde data

Land January

MiRS vs Sonde

ECMWF vs Sonde

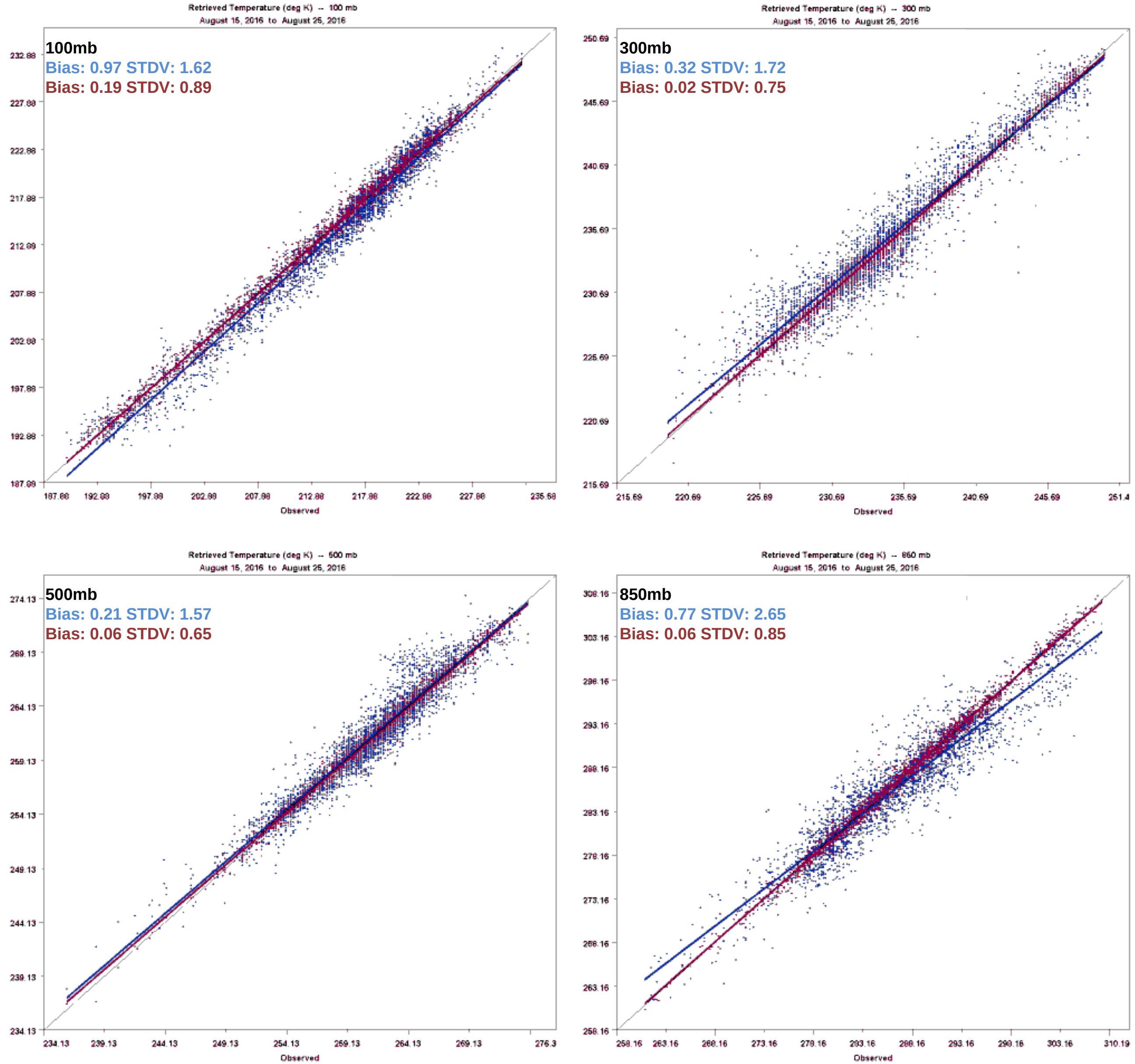


Temperature Profile Validation based on sonde data

Land August

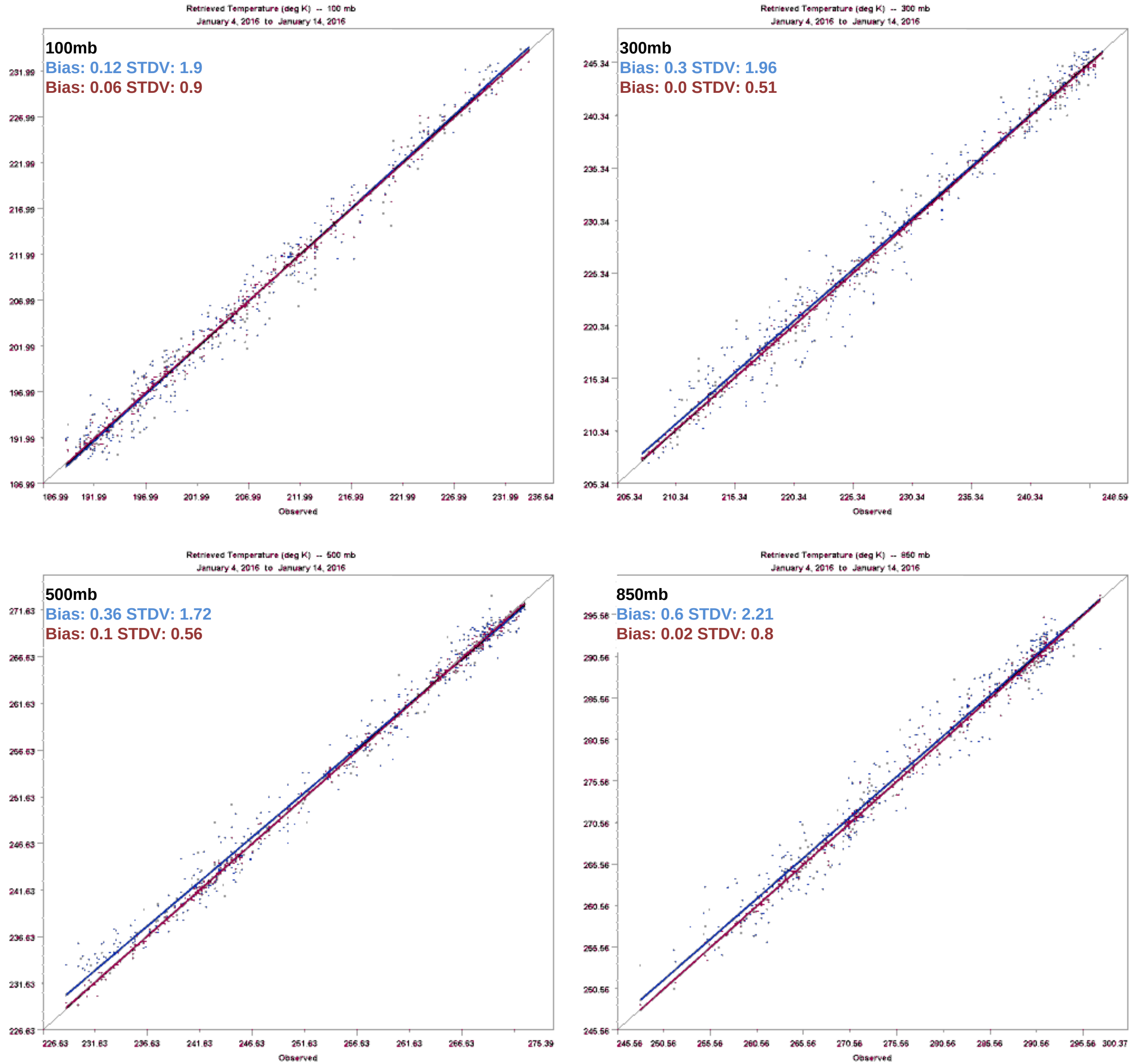
MiRS vs Sonde

ECMWF vs Sonde



Temperature Profile Validation based on sonde data

Sea January
MiRS vs Sonde
ECMWF vs Sonde

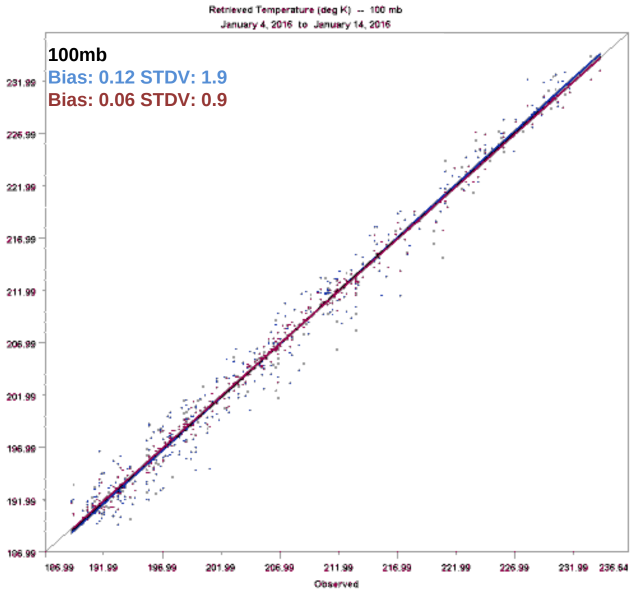


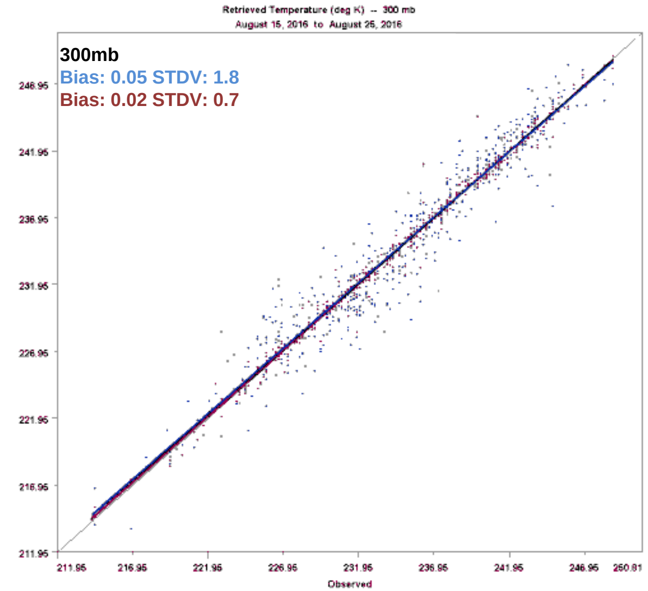
Temperature Profile Validation based on sonde data

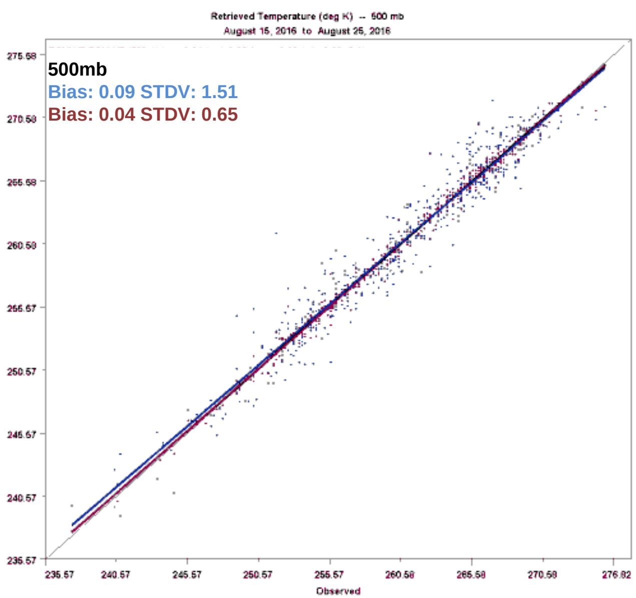
Sea August

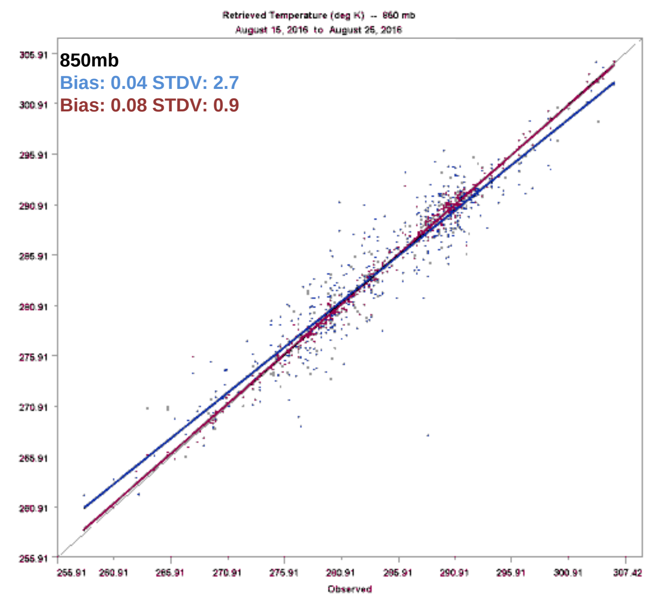
MiRS vs Sonde

ECMWF vs Sonde





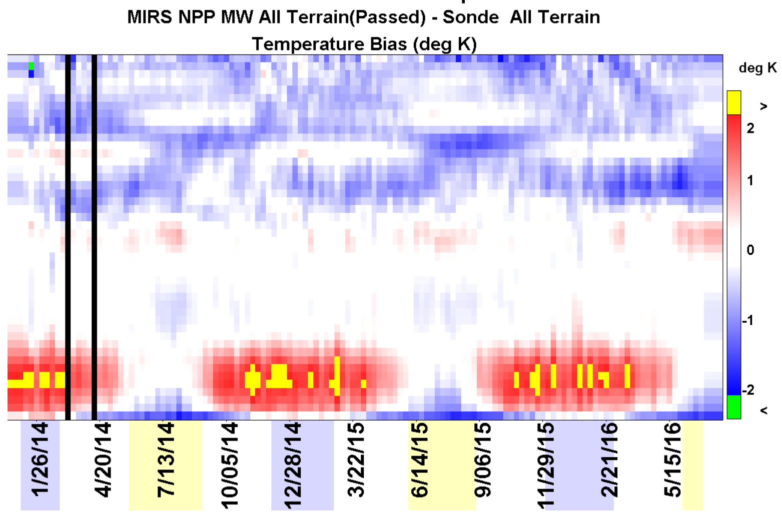




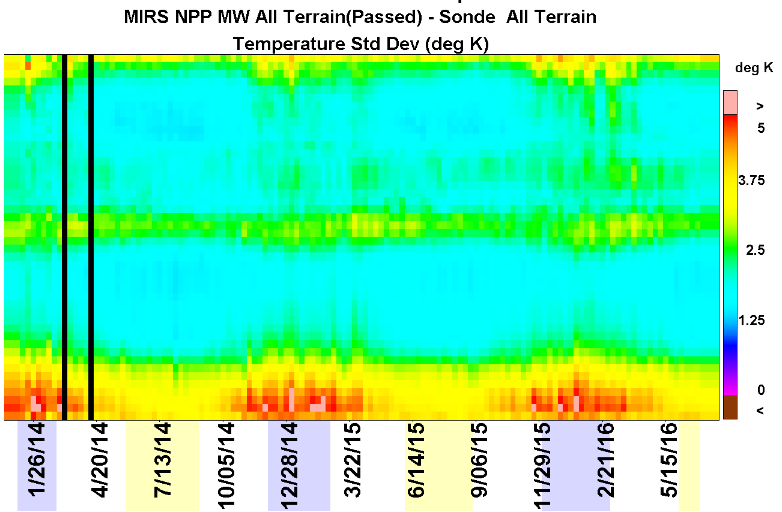
Temperature Profile Validation based on sonde data

The artificial seasonal cycle in Temperature bias and STDV are largely removed in MiRS version 11.1, probably could be attributed to the introduction of dynamic background

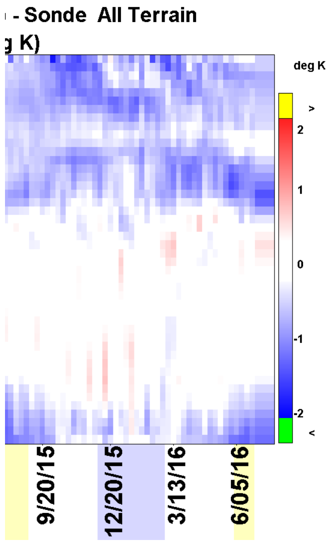
version 9.2 Temp Bias



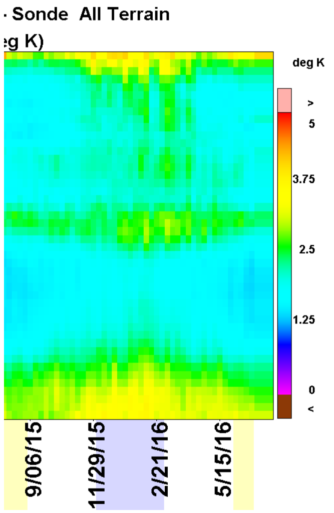
version 9.2 Temp STDV



V11 available from July 2015



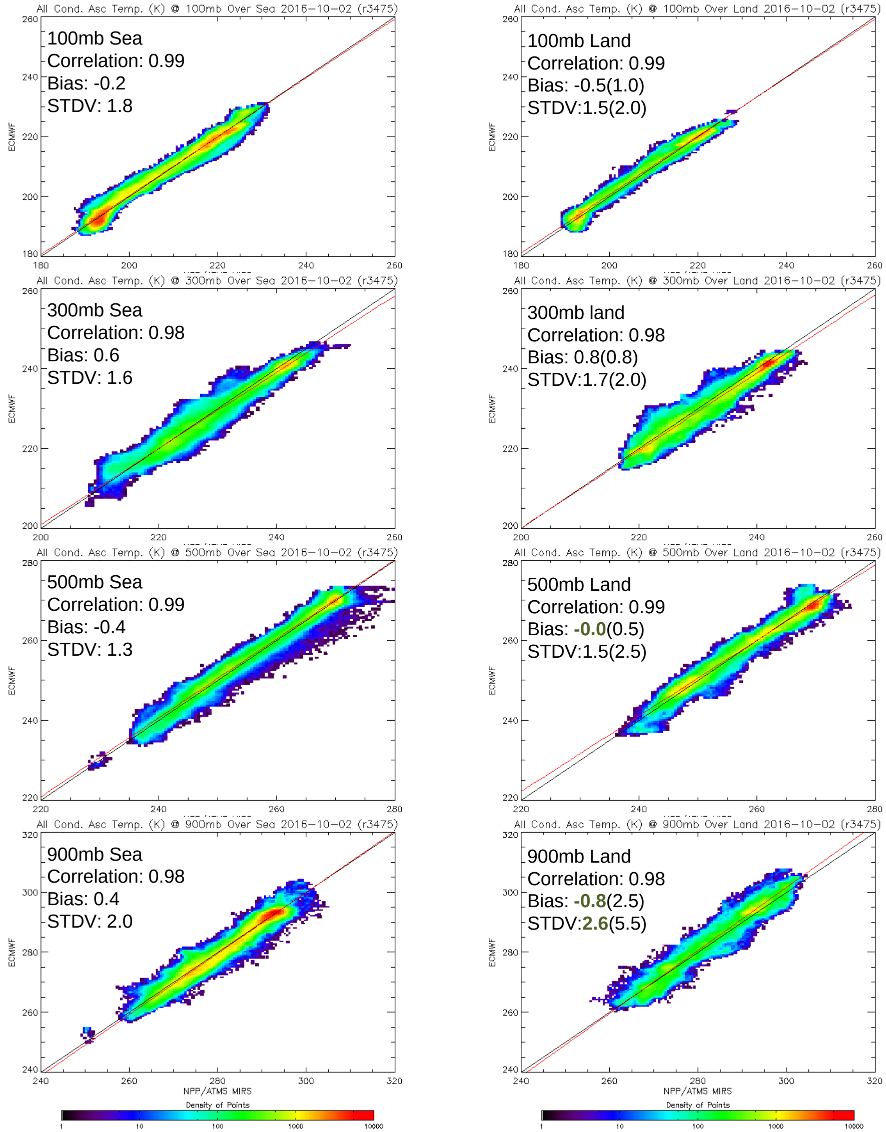
version 11.1 Temp Bias

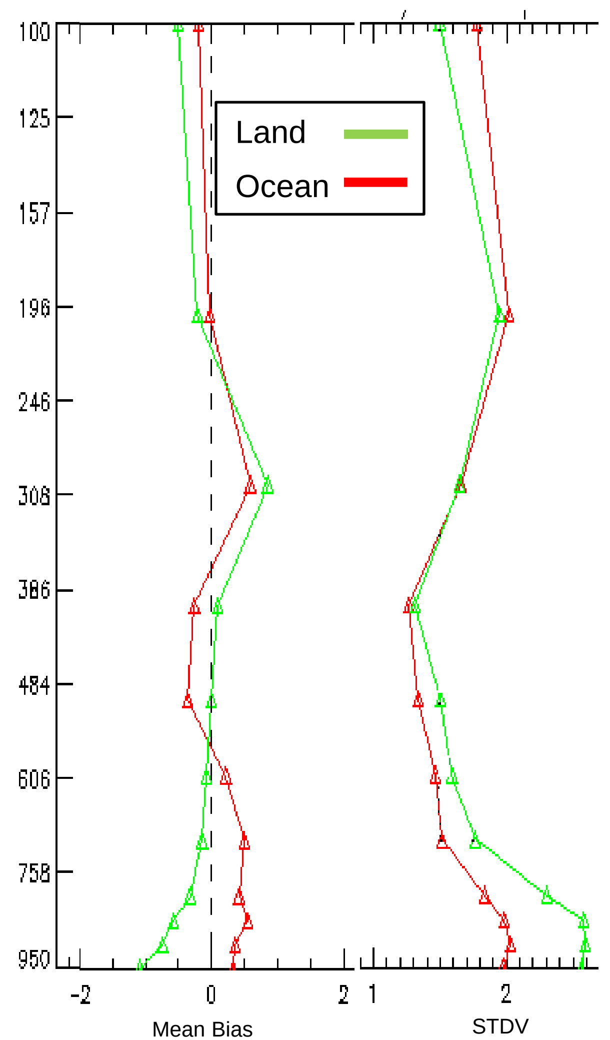


version 11.1 Temp STDV

Temperature Profile Validation based on ECMWF data

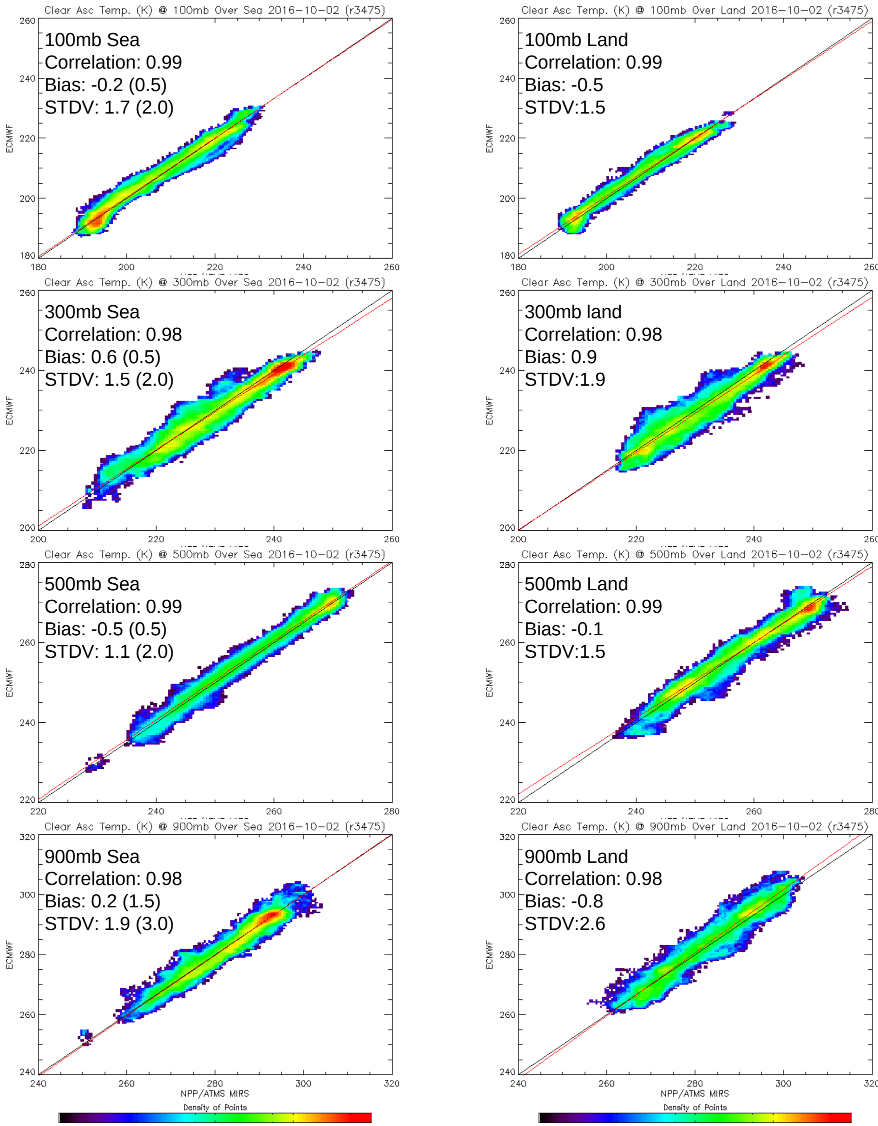
Global all Condition T Statistic refer to ECMWF

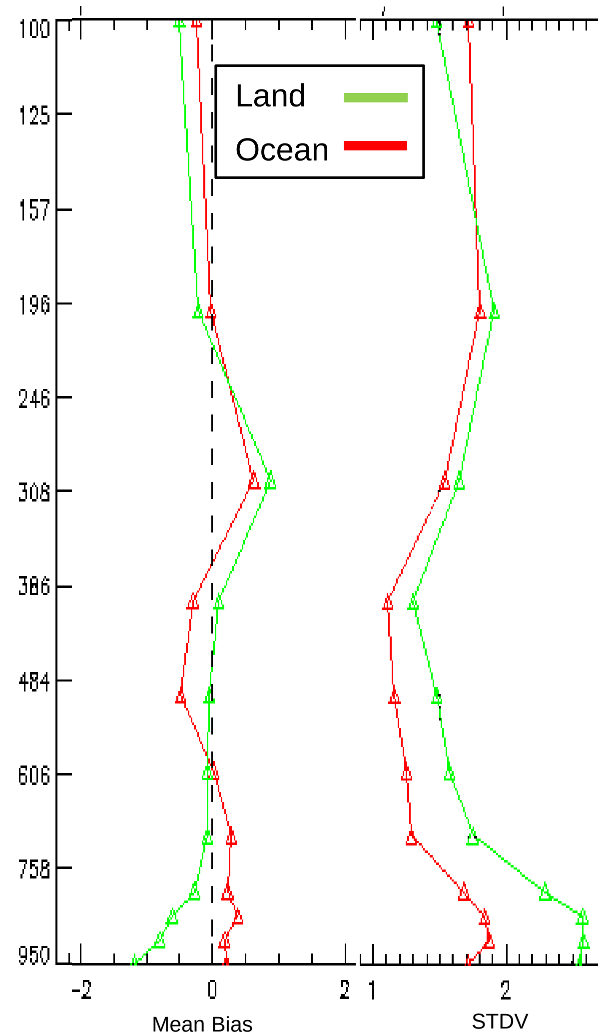




Temperature Profile Validation based on ECMWF data

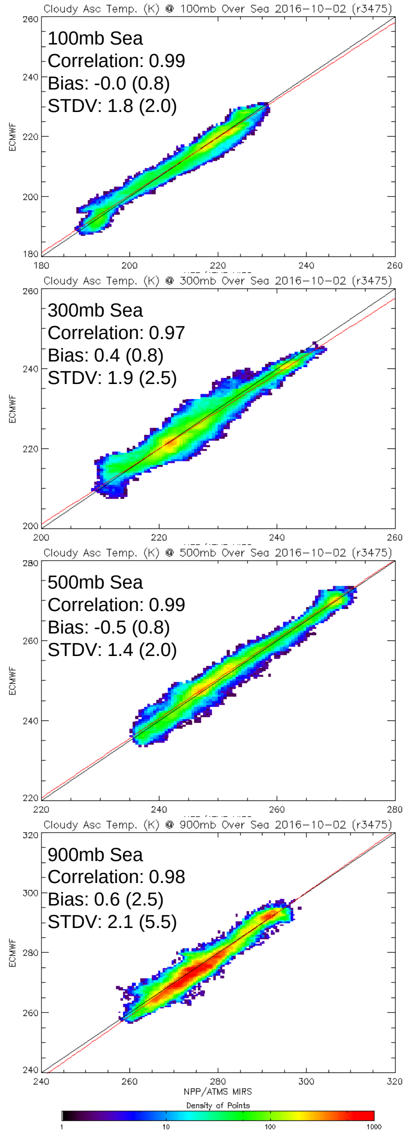
Global Clear Condition T Statistic refer to ECMWF

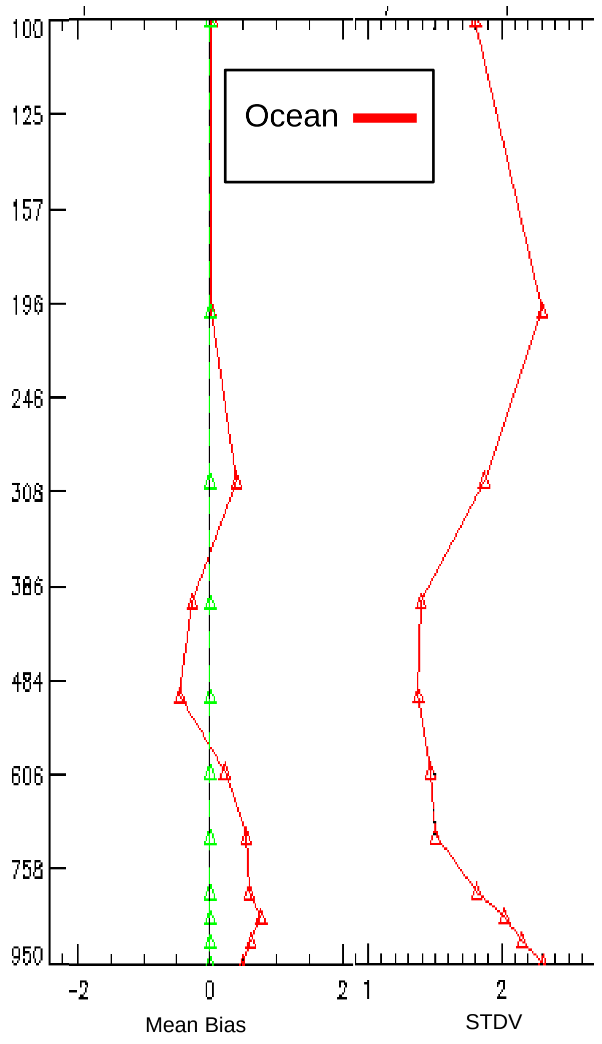




Temperature Profile Validation based on ECMWF data

Global Cloudy over Sea T Statistic refer to ECMWF





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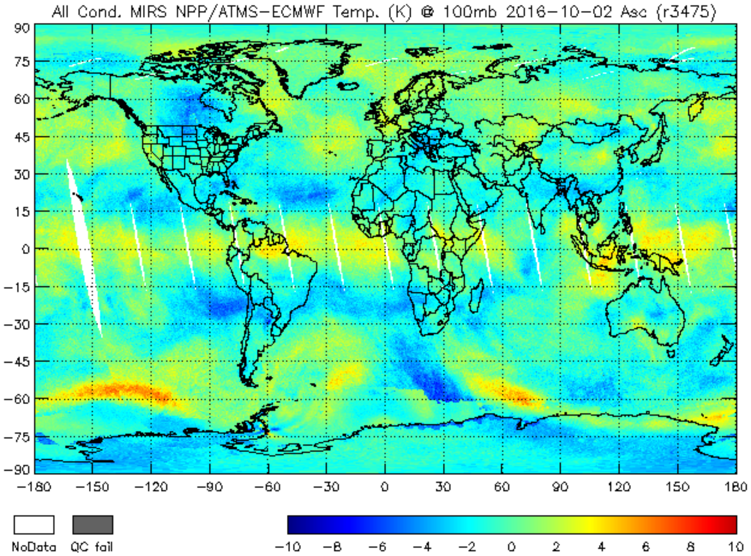

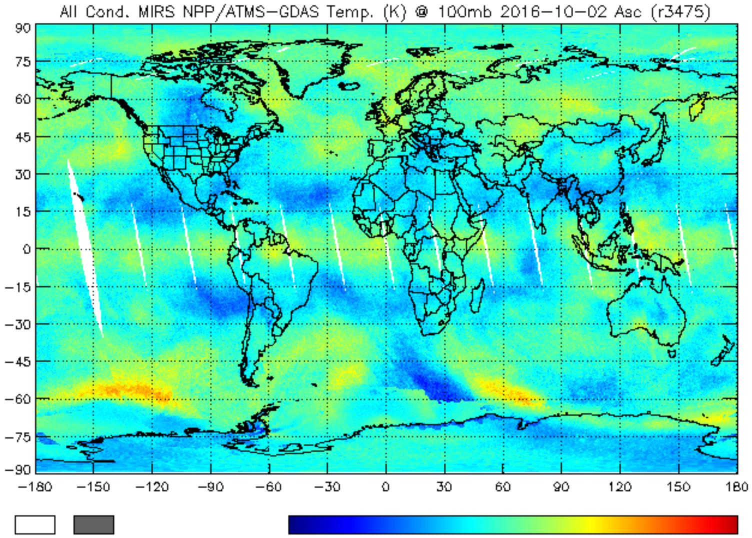

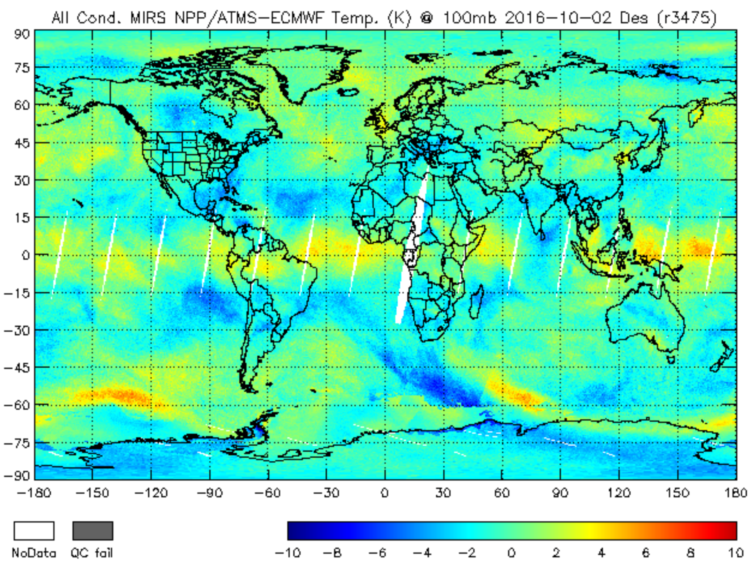

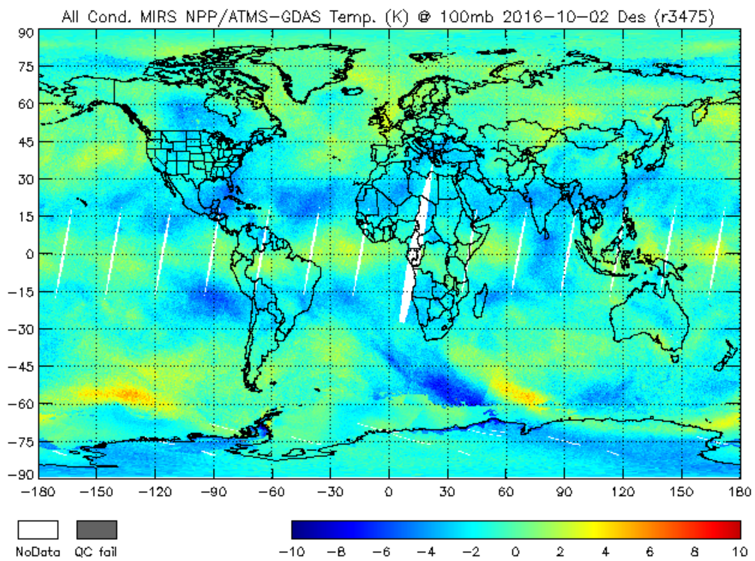

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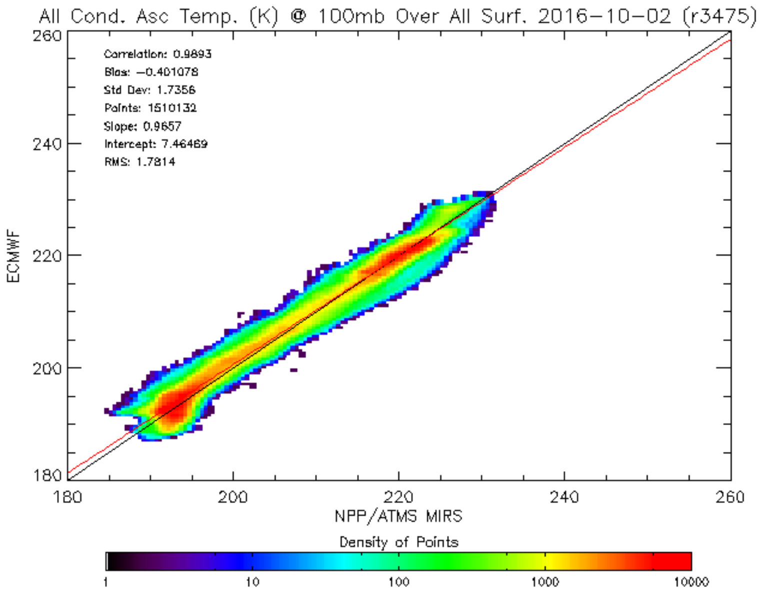

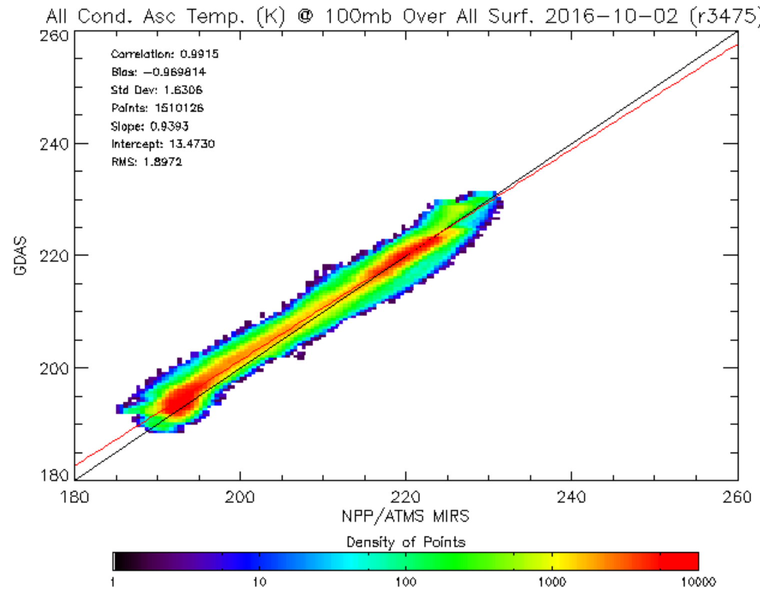

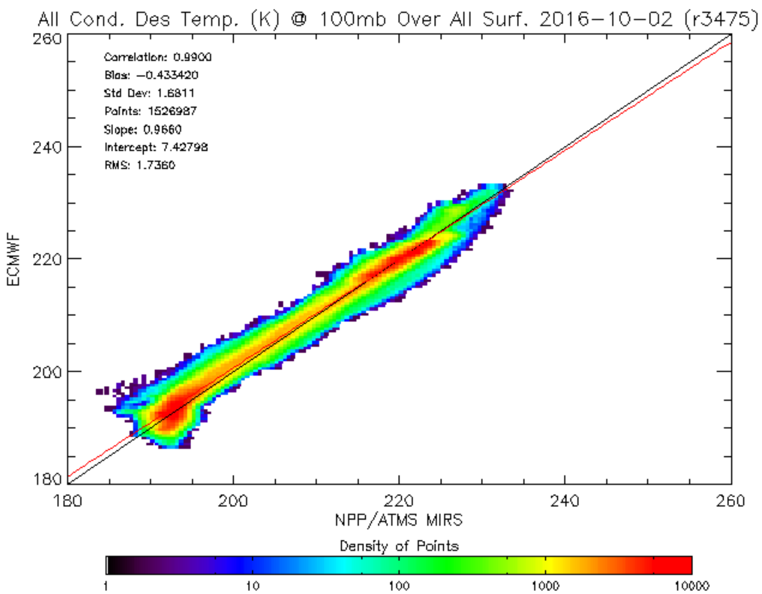

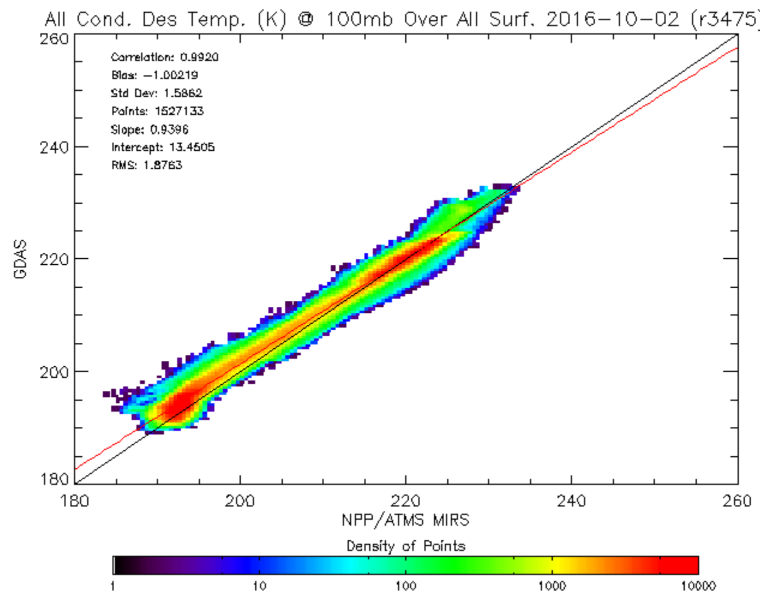

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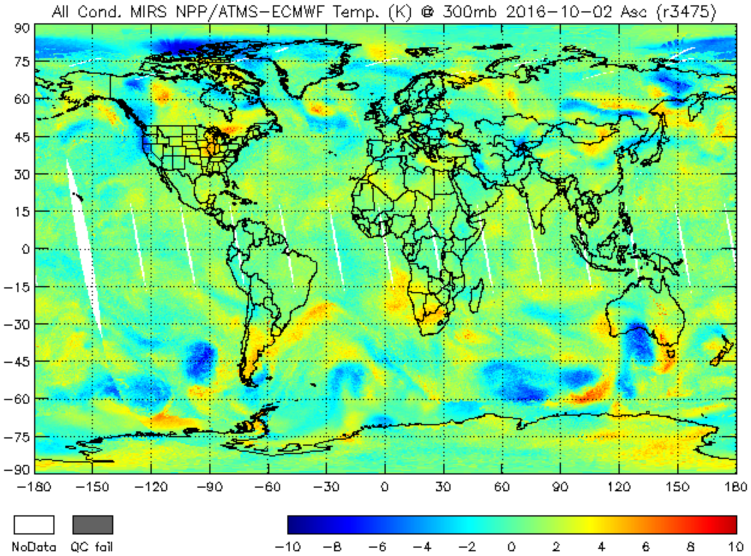
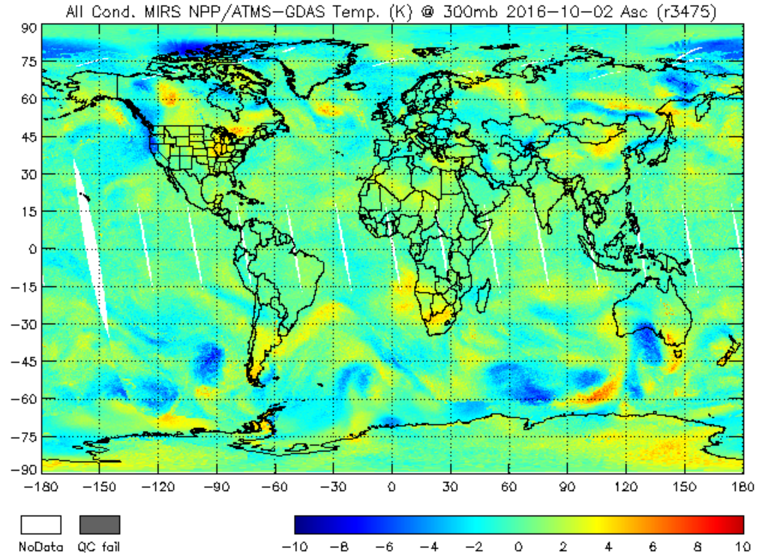
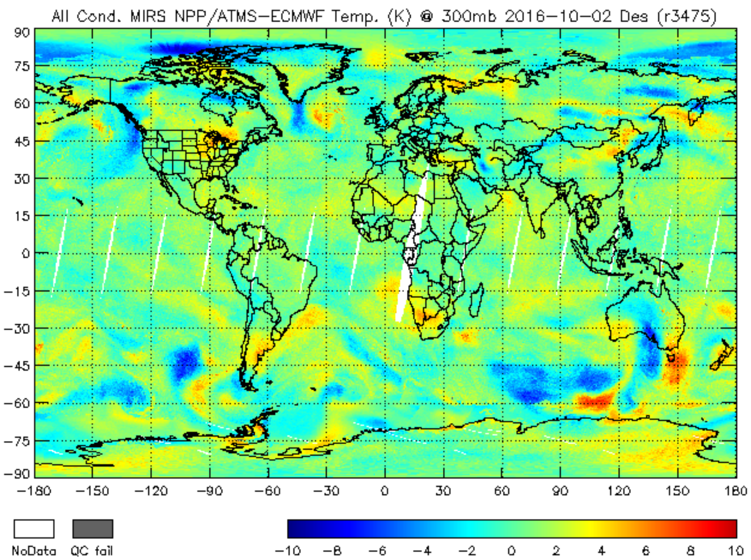
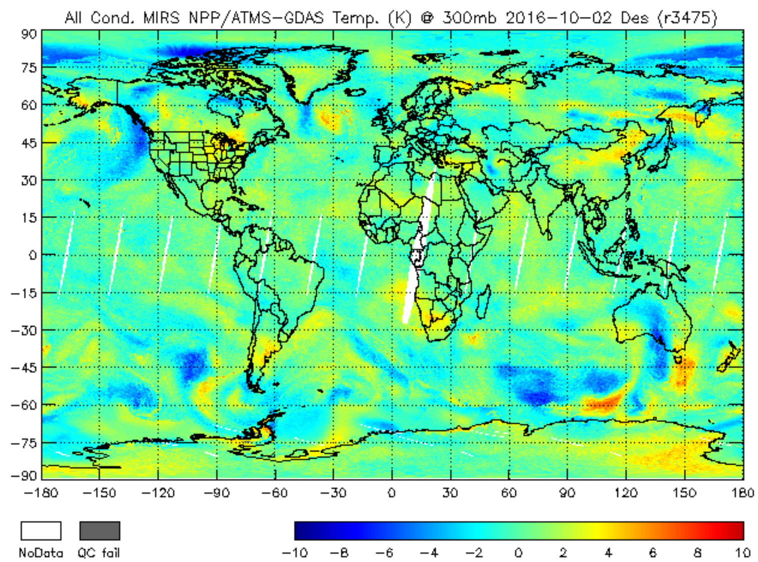
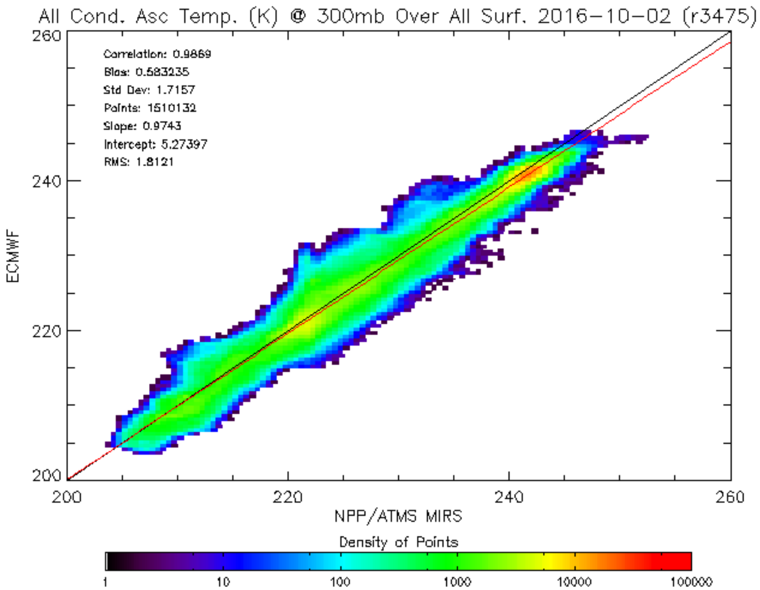


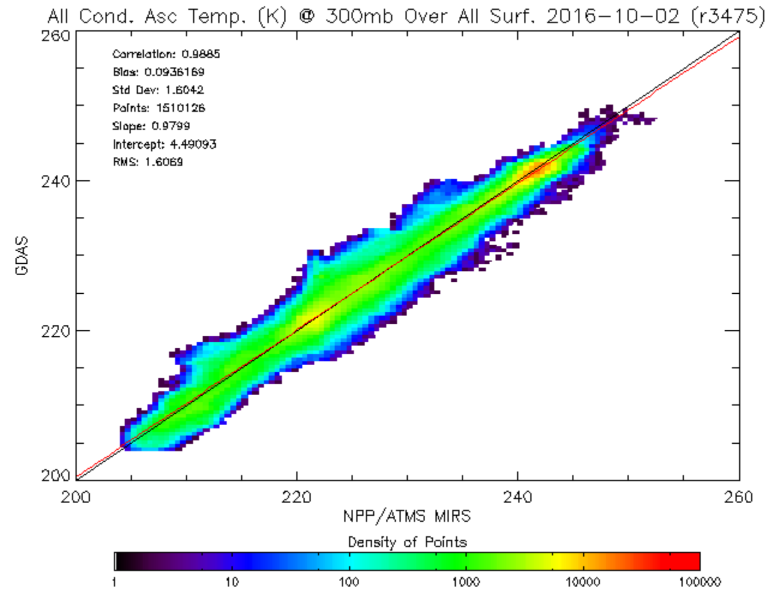


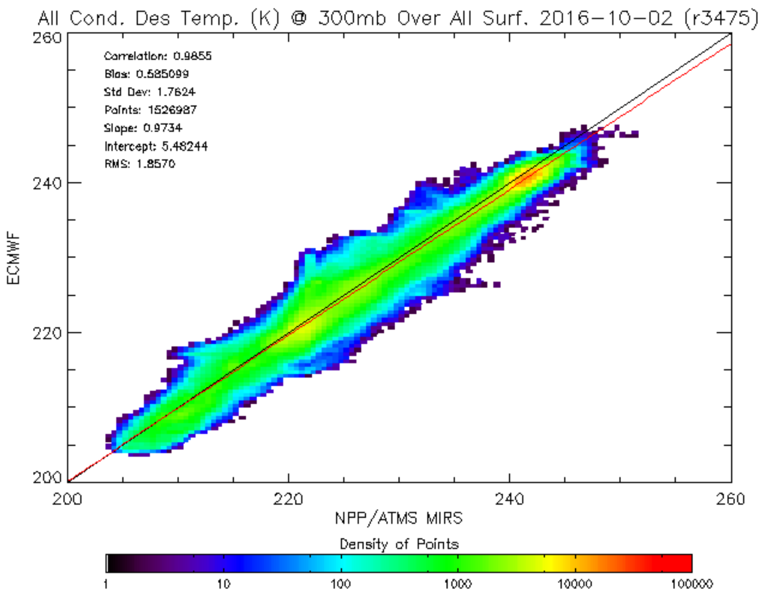


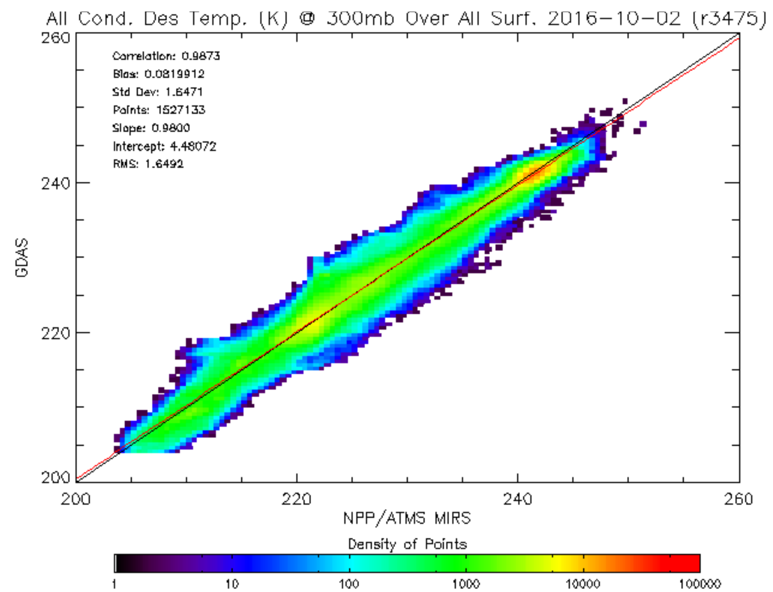


Temperature Profile Validation based on ECMWF data









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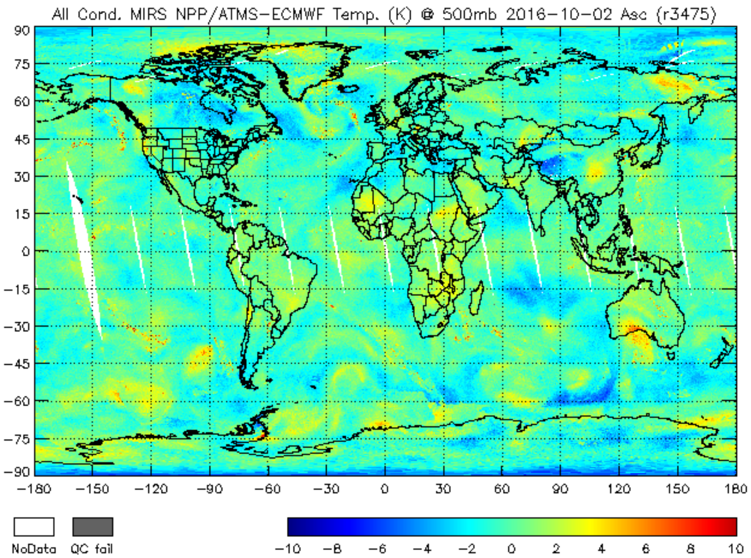

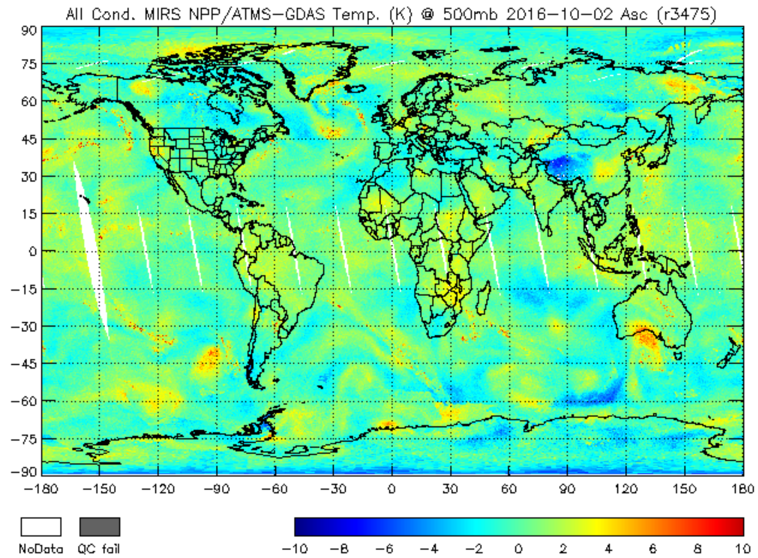

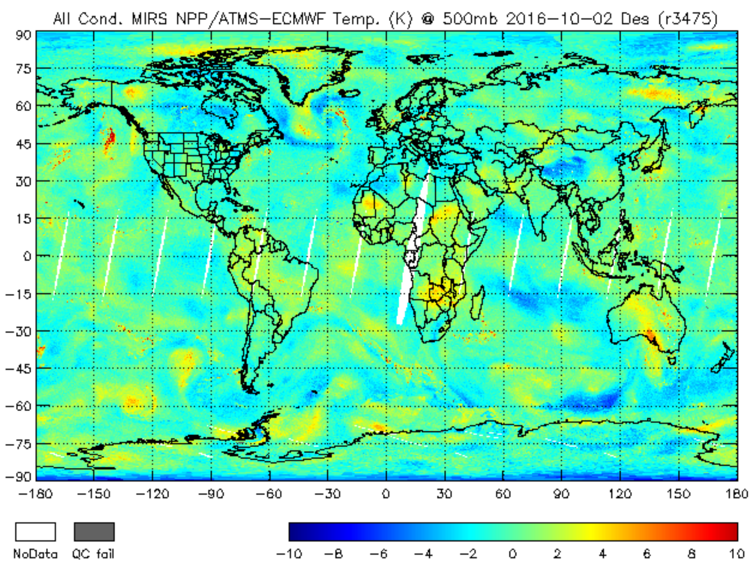

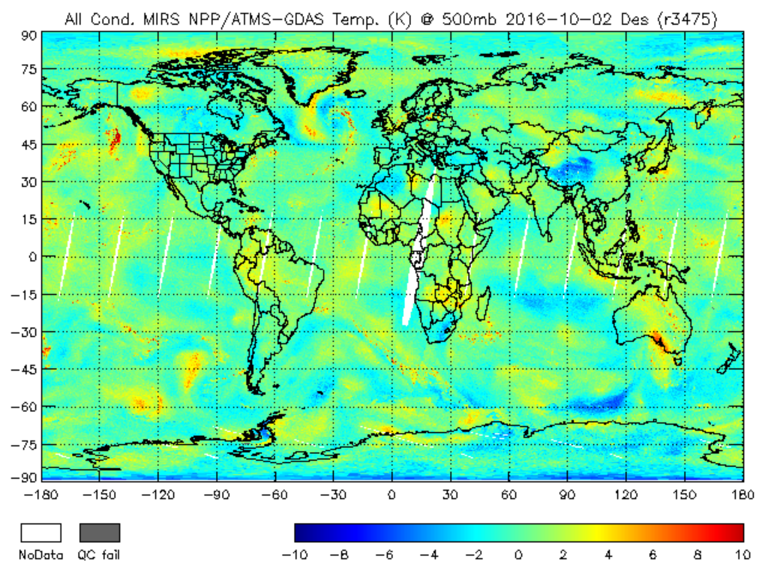

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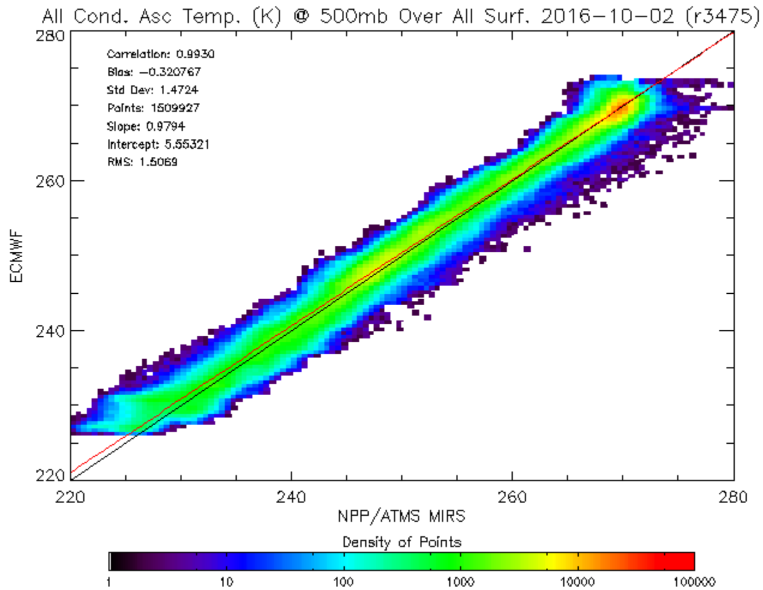

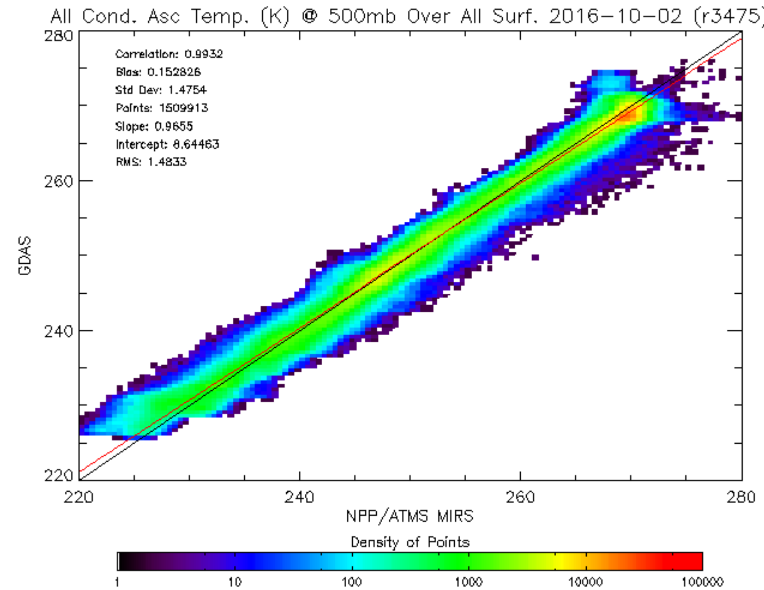

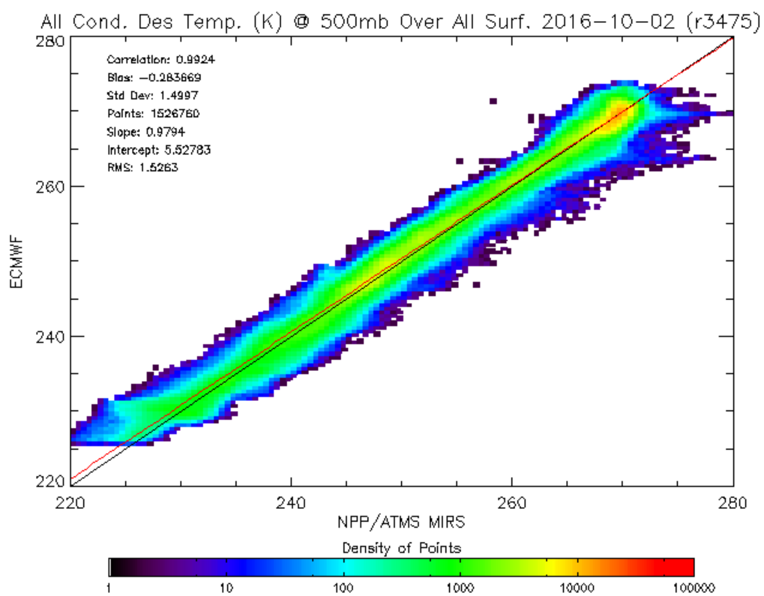

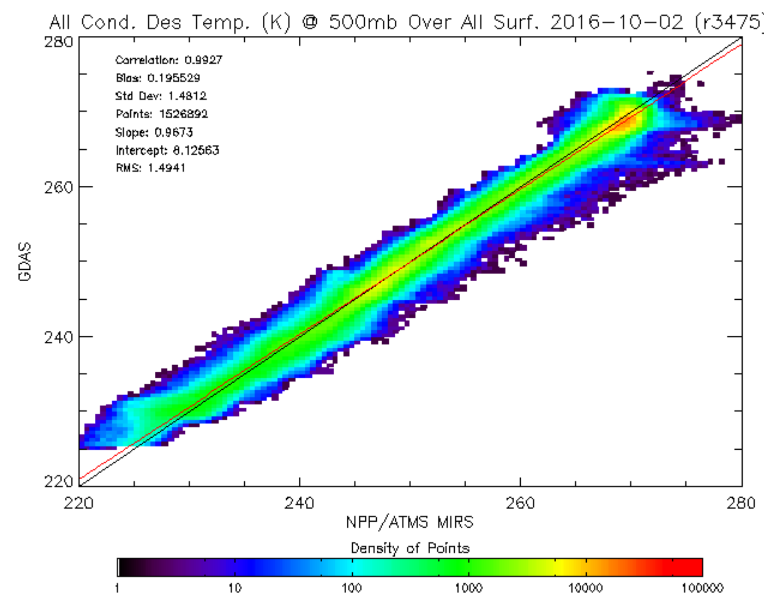

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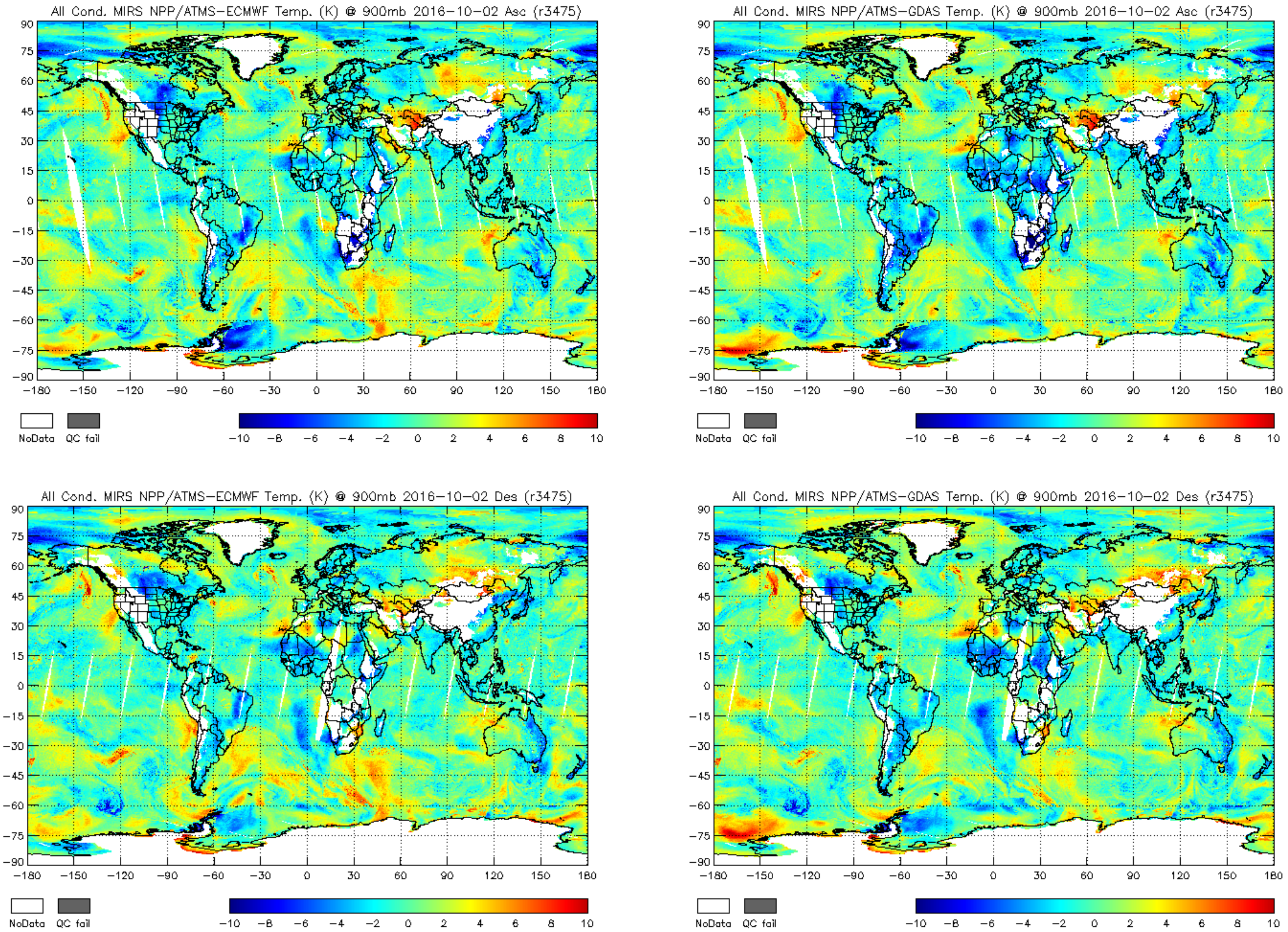

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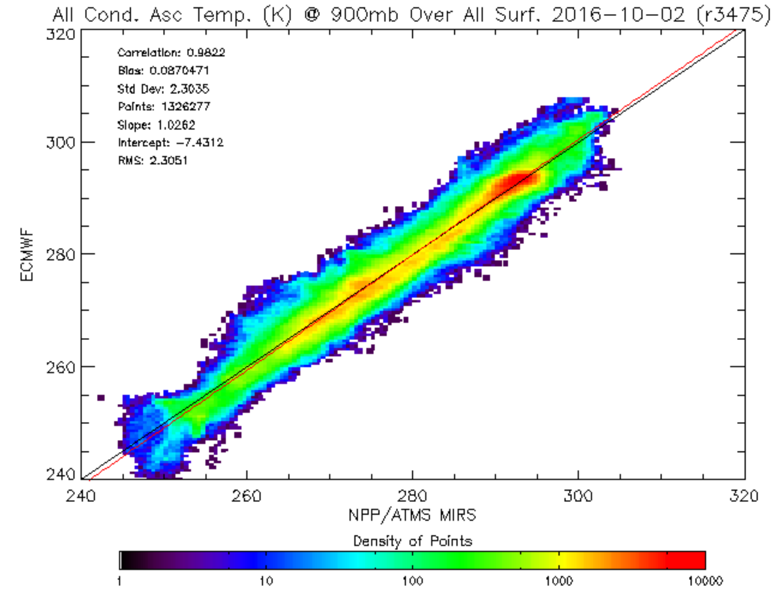

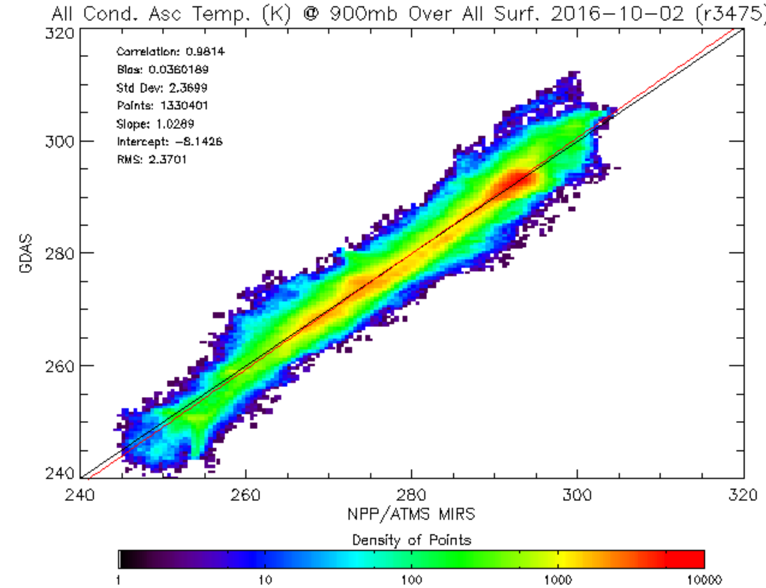

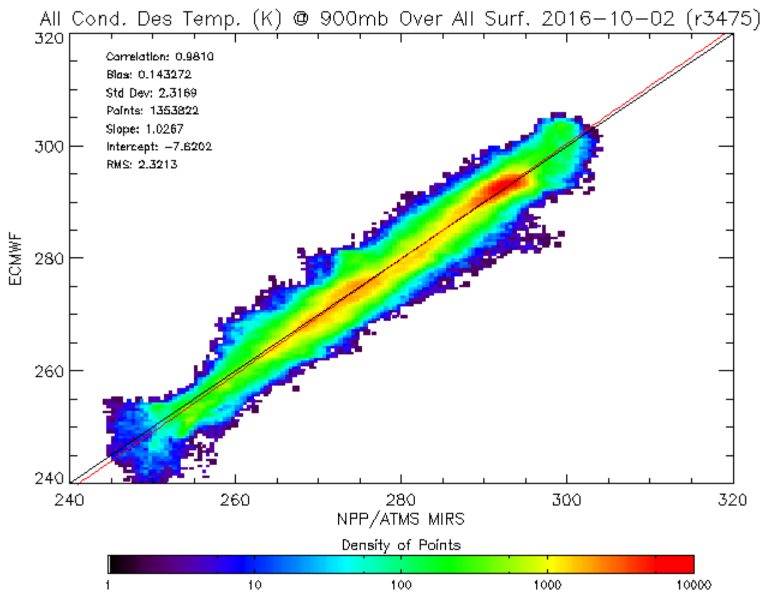

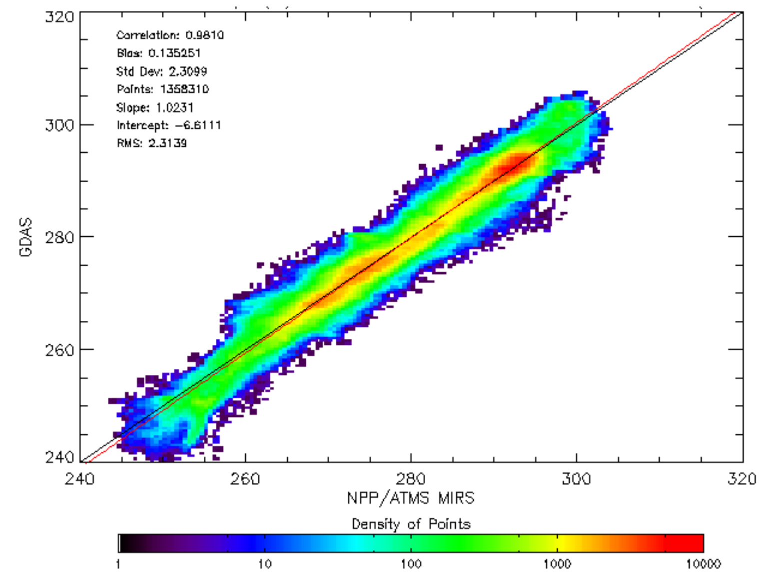

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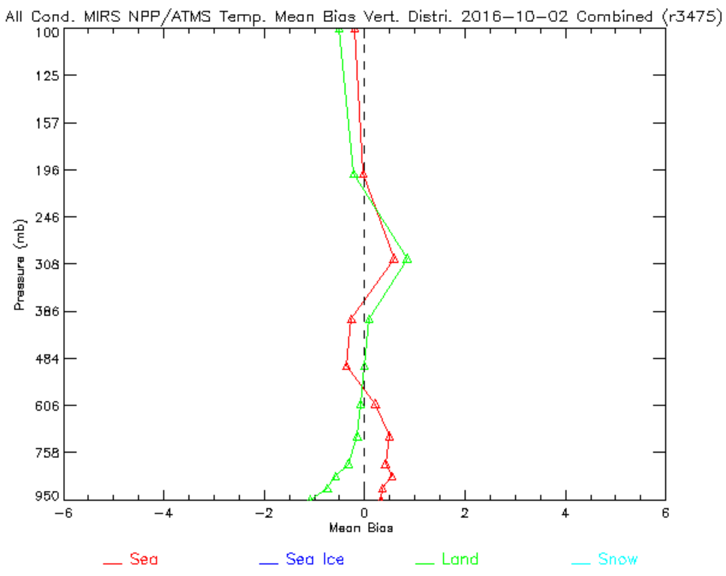
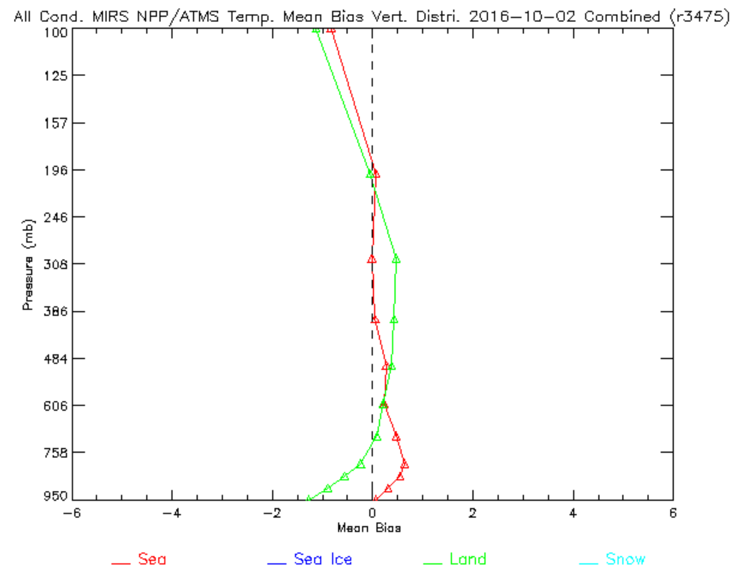
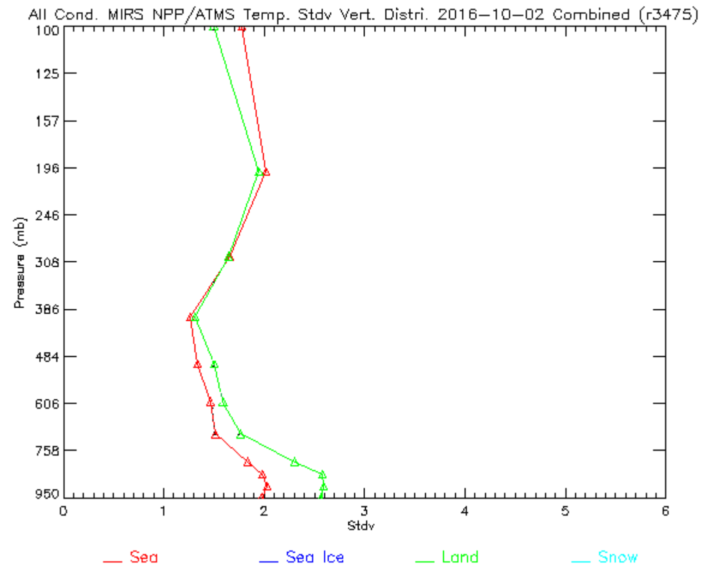
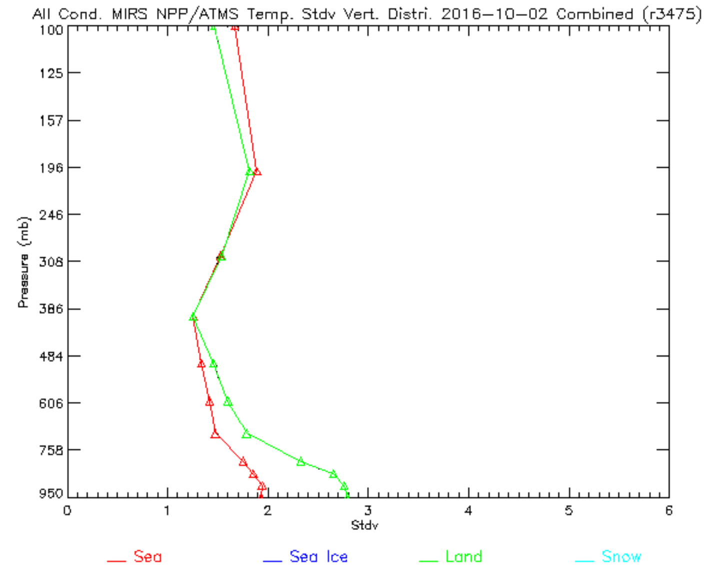


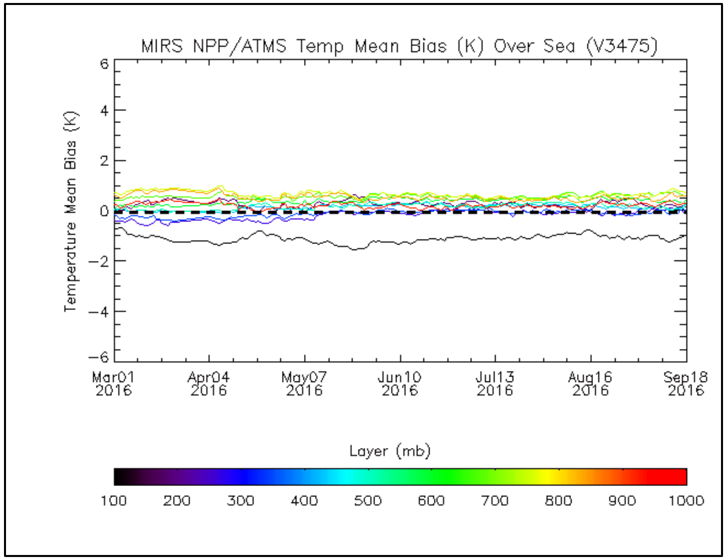


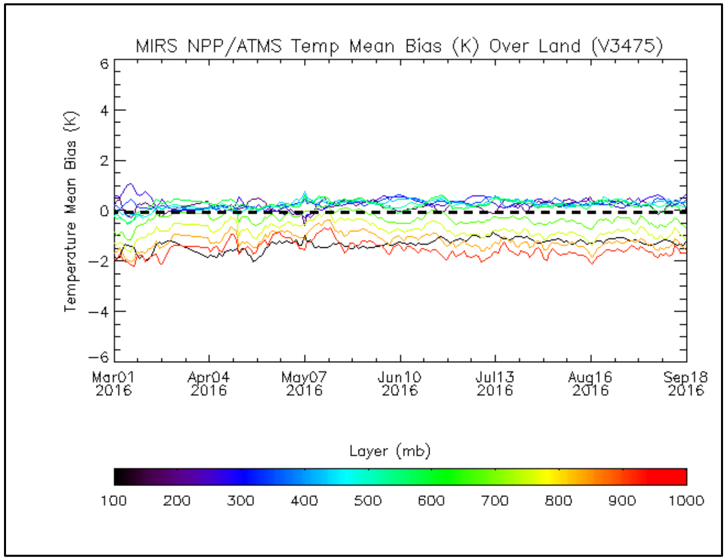


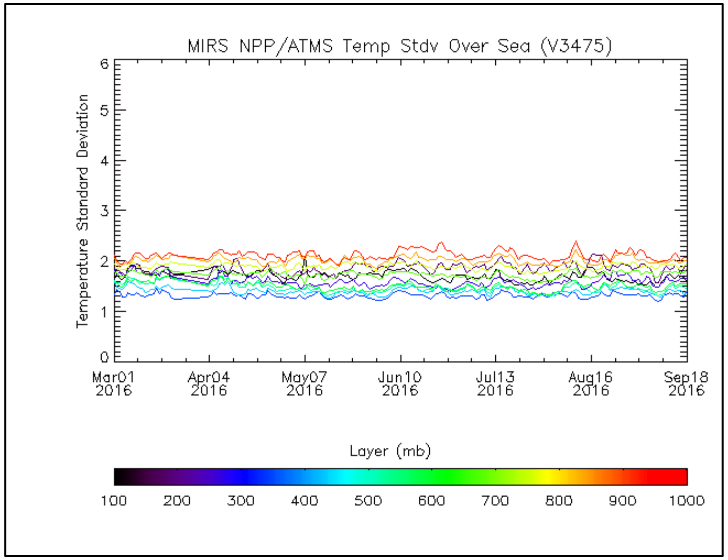


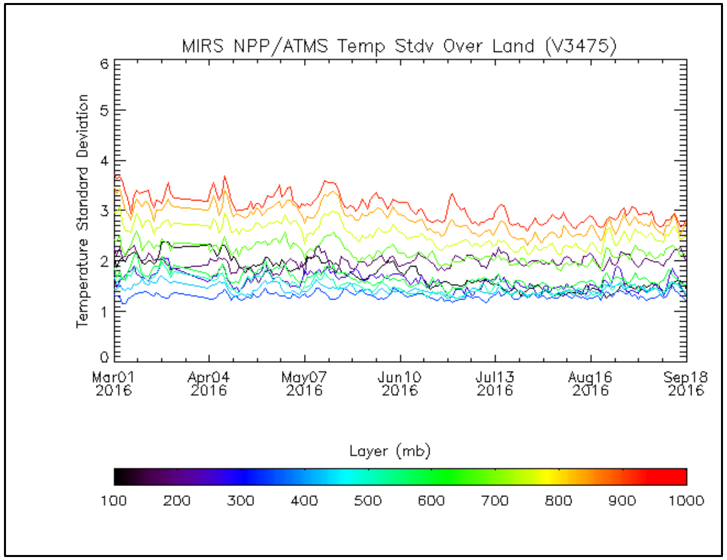
Temperature Profile Validation based on ECMWF data

- MiRS SNPP/ATMS Temperature Bias and Std Dev vs. GDAS: 1 March – 20 Sept 2016

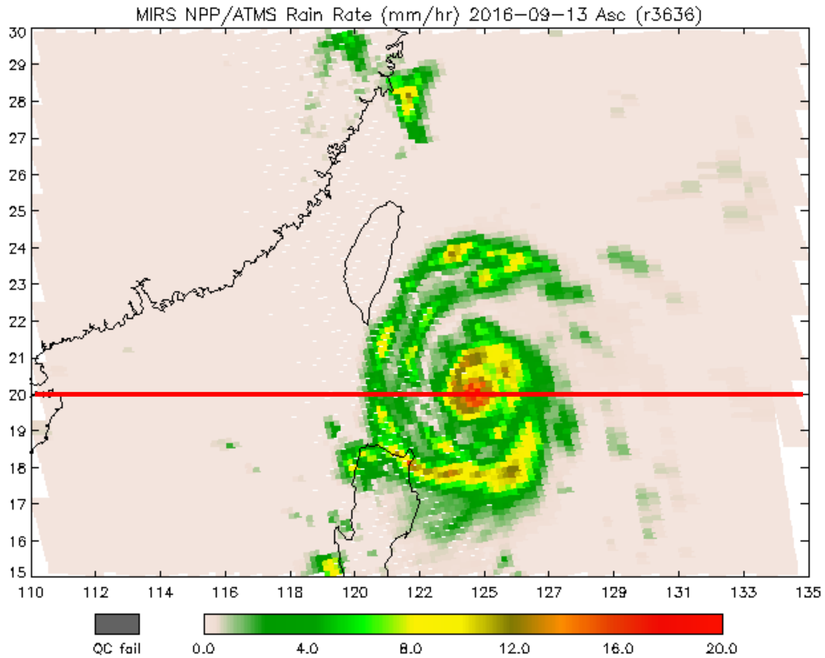




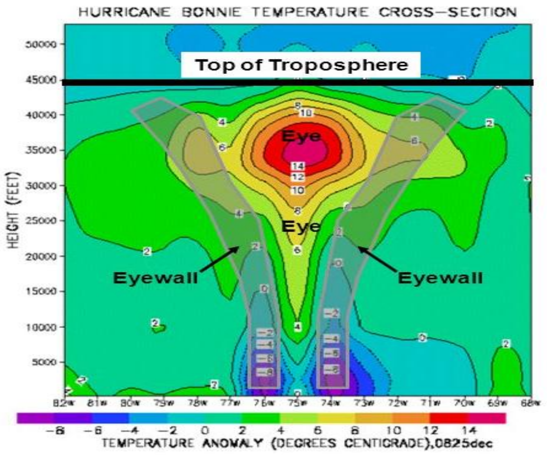


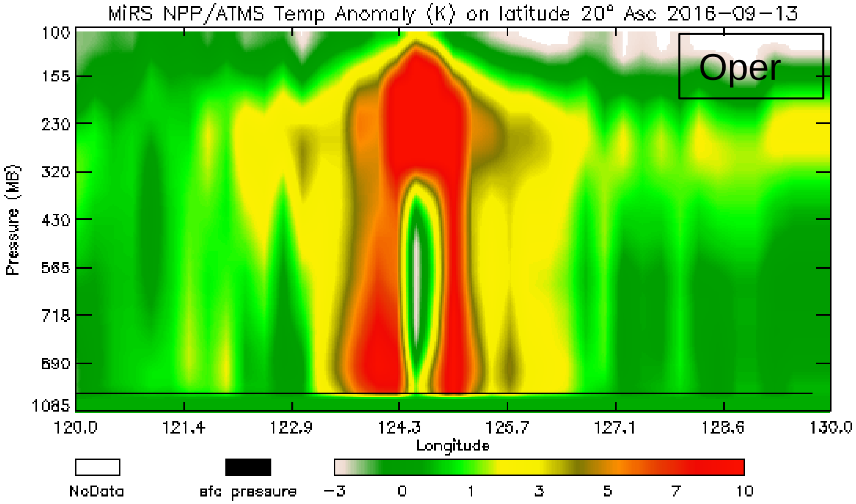


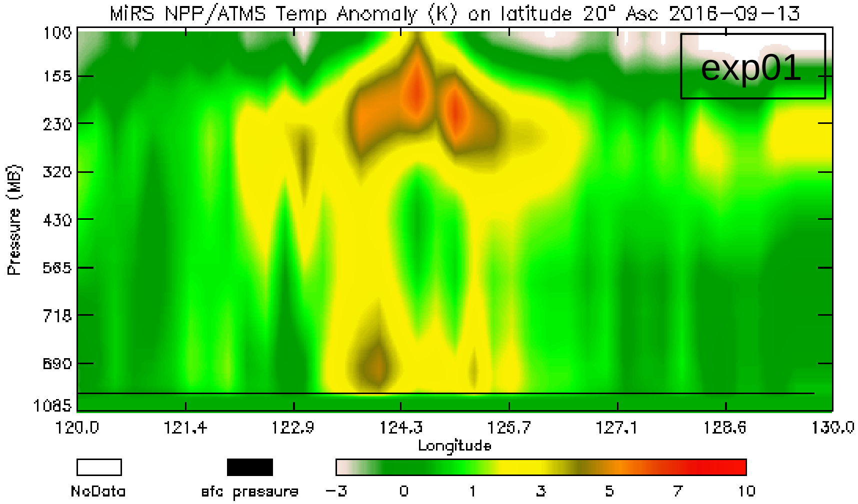
Temperature Profile Future Improvements: TC conditions



Typhoon Meranti Cross Section and Warm Core Anomaly:
- Improved depiction in experimental retrieval







Requirements and Validation Results: Water Vapor Profile

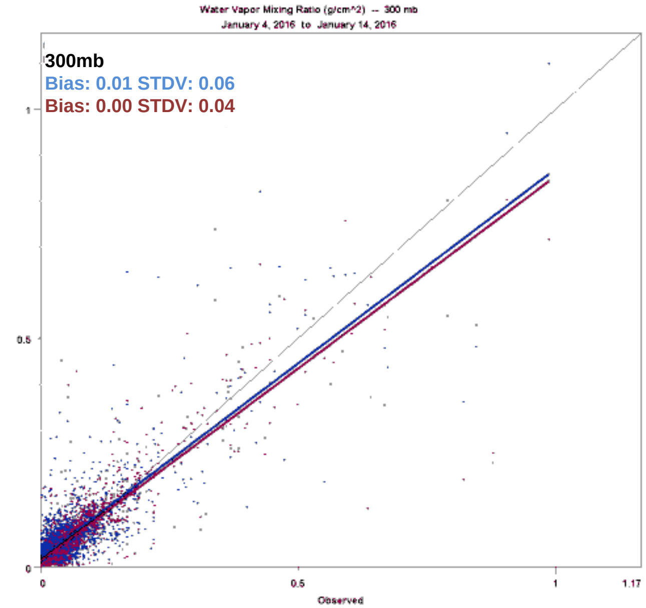
- Daily, Global Collocations with ECMWF and GDAS.
- Periodic, Global collocations with radiosondes (NPROVS)
- Stratified by clear/cloudy, and surface type
- Requirements from JPSS-REQ-1004
- Maturity Level: Validated, Stage 3

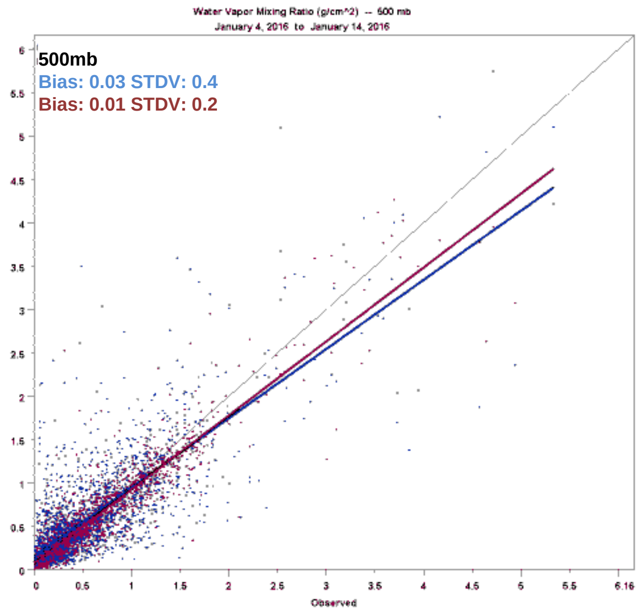
Attribute	Threshold	Validated
Geographic coverage	Global (non-frozen surfaces)	See table/figs
Vertical Coverage	Surface to 0.01 mb	
Vertical Cell Size	Individual layers (not averaged); based on CRTM 100 p layers	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	N/A	
Measurement Accuracy	See table	
Measurement Precision	See table	

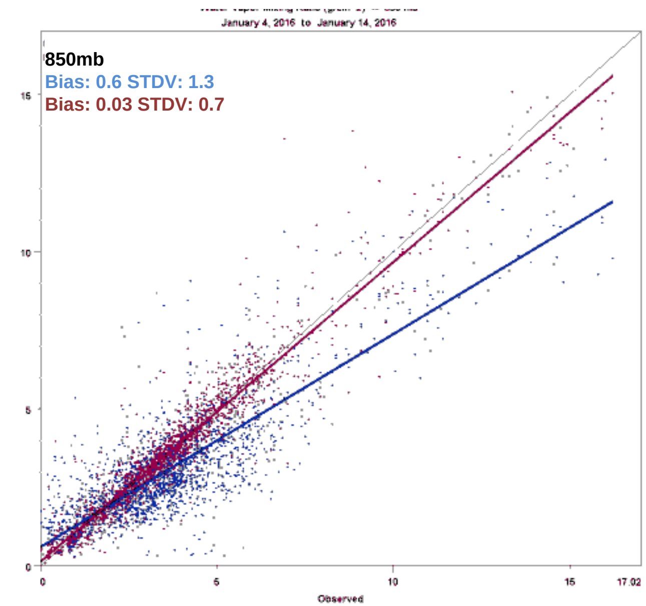
Product	Sfc	Condition	Layer (hPa)	Bias (%) (Accuracy)		StDv (%) (Precision)	
				MiRS	Req	MiRS	Req
Water Vapor	Sea	Clear	400	**0.**	**30.**	**45.**	**60.**
			500	**2.**	**20.**	**40.**	**60.**
			700	**4.**	**20.**	**30.**	**50.**
			900	**0.**	**20.**	**15.**	**30.**
		Cloudy	400	**0.**	**30.**	**55.**	**70.**
			500	**2.**	**20.**	**42.**	**65.**
			700	**2.**	**10.**	**32.**	**60.**
			900	**0.**	**20.**	**18.**	**30.**
	Land	Clear+ Cloudy	400	**7.**	**30.**	**45.**	**60.**
			500	**2.**	**20.**	**35.**	**60.**
			700	**5.**	**20.**	**30.**	**50.**
			900	**5.**	**20.**	**25.**	**50.**

Water Vapor Profile Validation based on Sonde data

Land January
MiRS vs Sonde
ECMWF vs Sonde

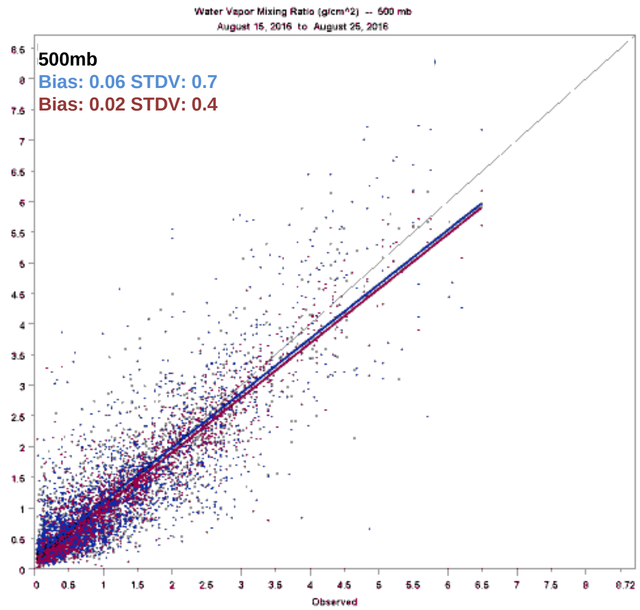


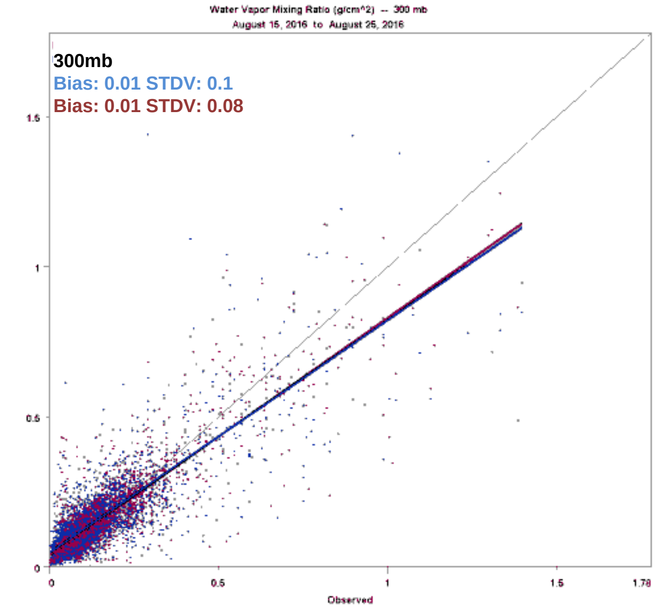


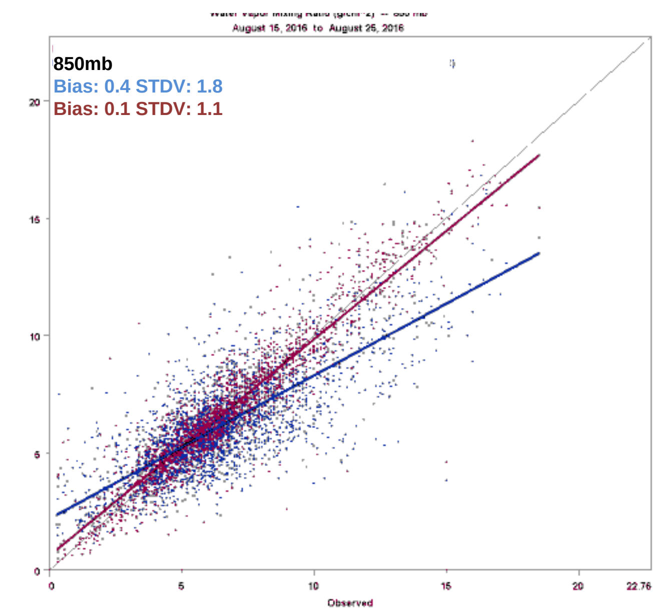


Water Vapor Profile Validation based on Sonde data

Land August
MiRS vs Sonde
ECMWF vs Sonde





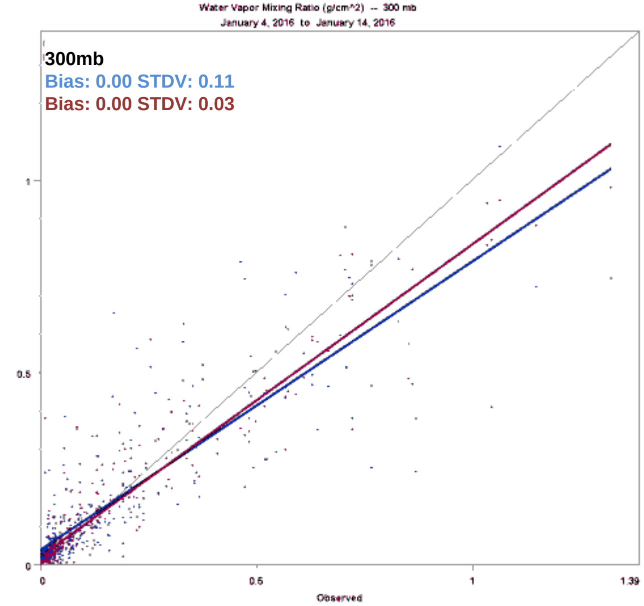


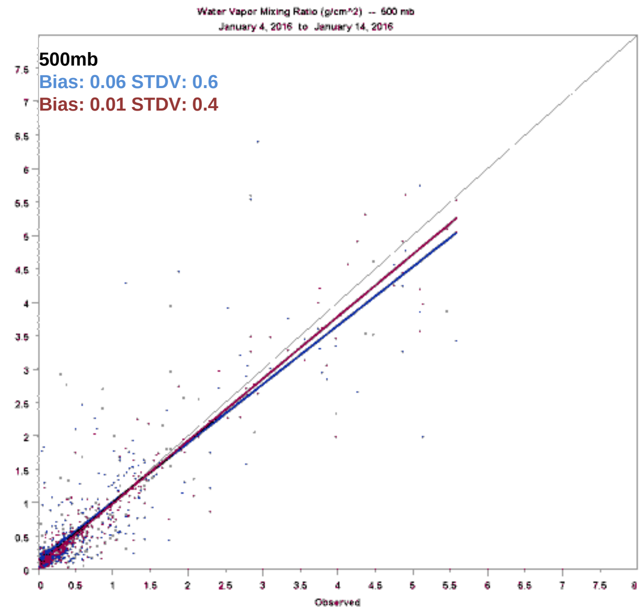
Validation Results: Water Vapor Profile

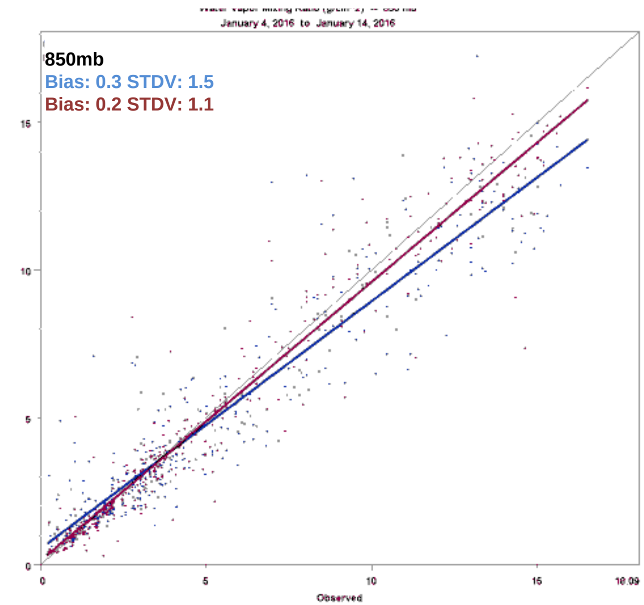
Sea January

MiRS vs Sonde

ECMWF vs Sonde





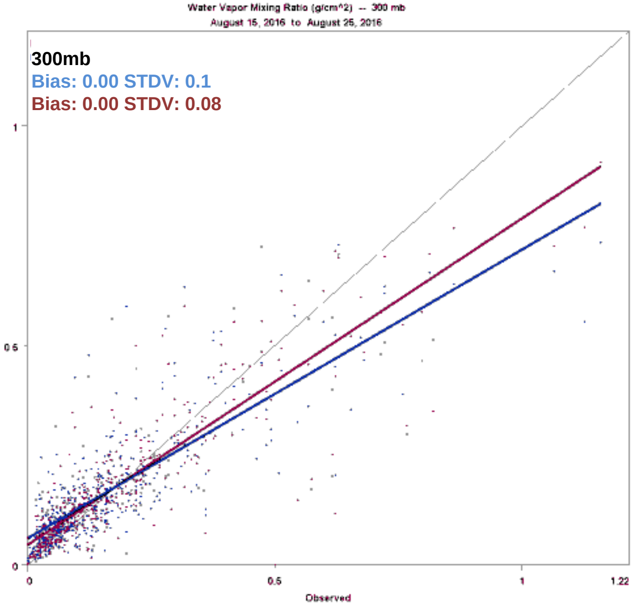


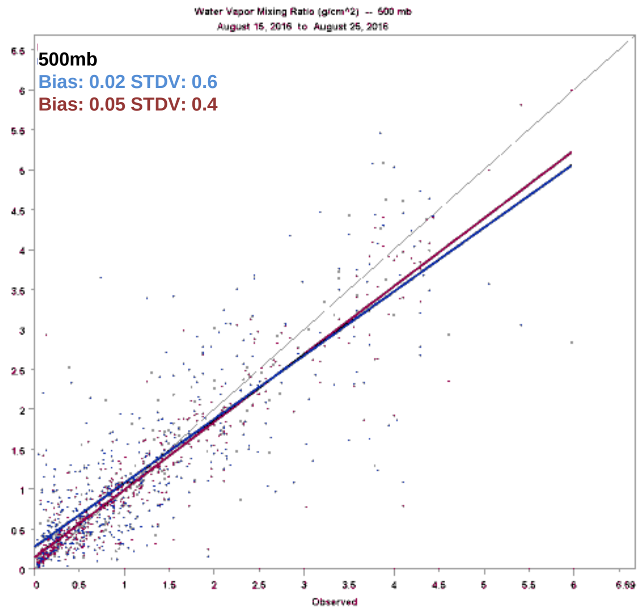
Water Vapor Profile Validation based on Sonde data

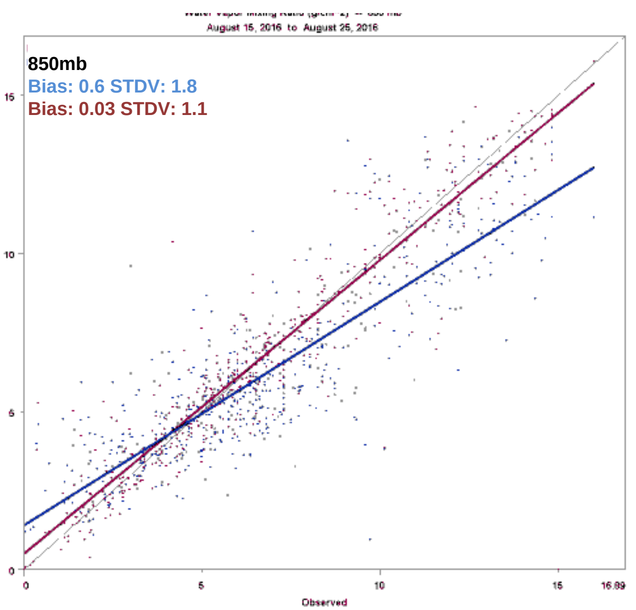
Sea August

MiRS vs Sonde

ECMWF vs Sonde

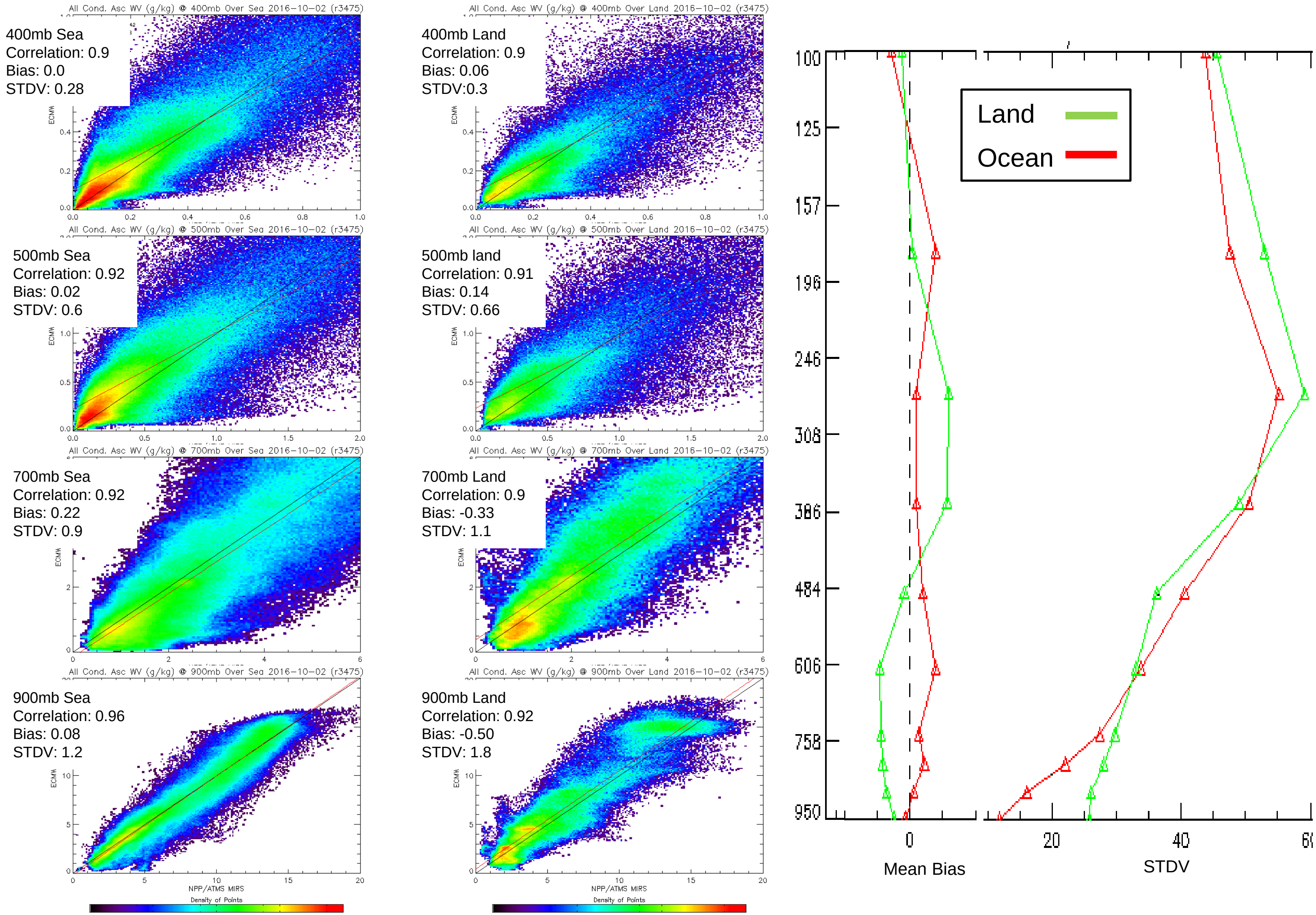






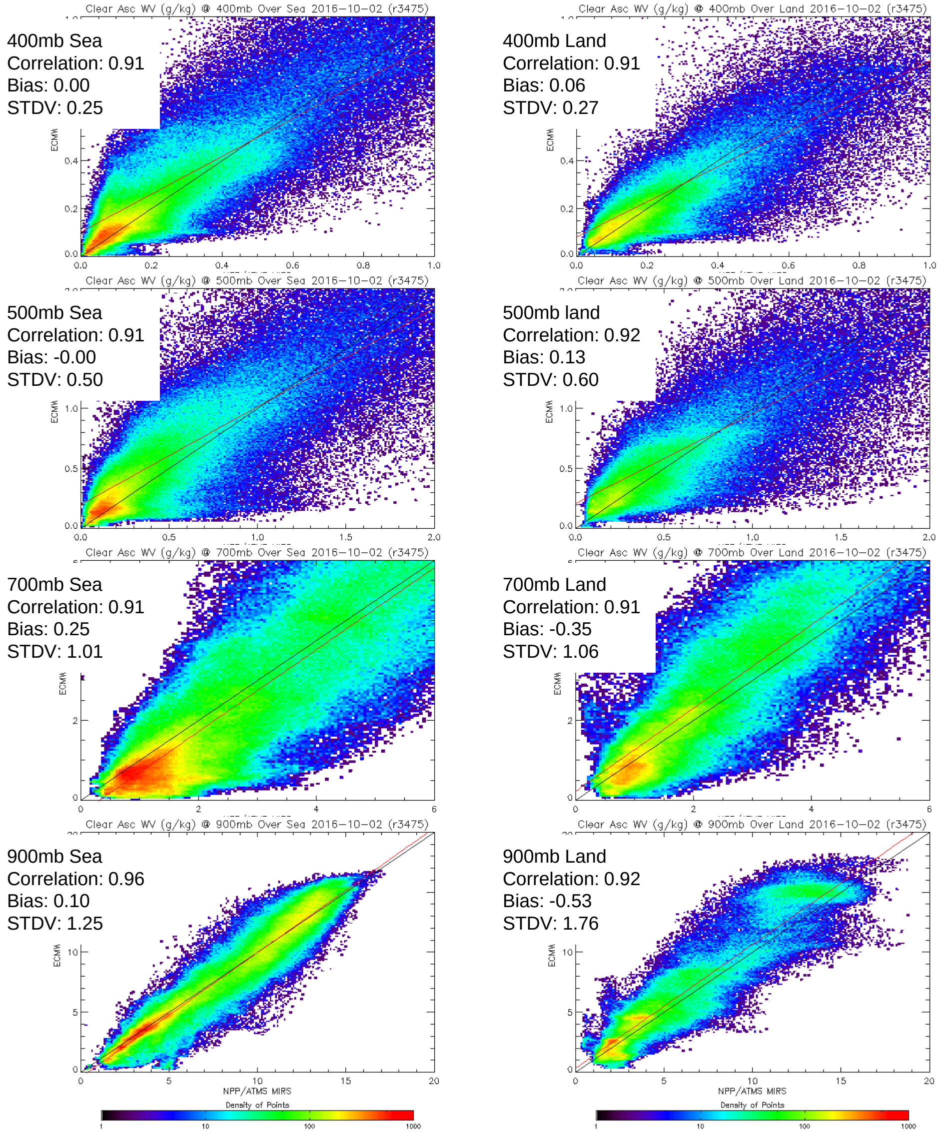
Water Vapor Profile Validation based on ECMWF data

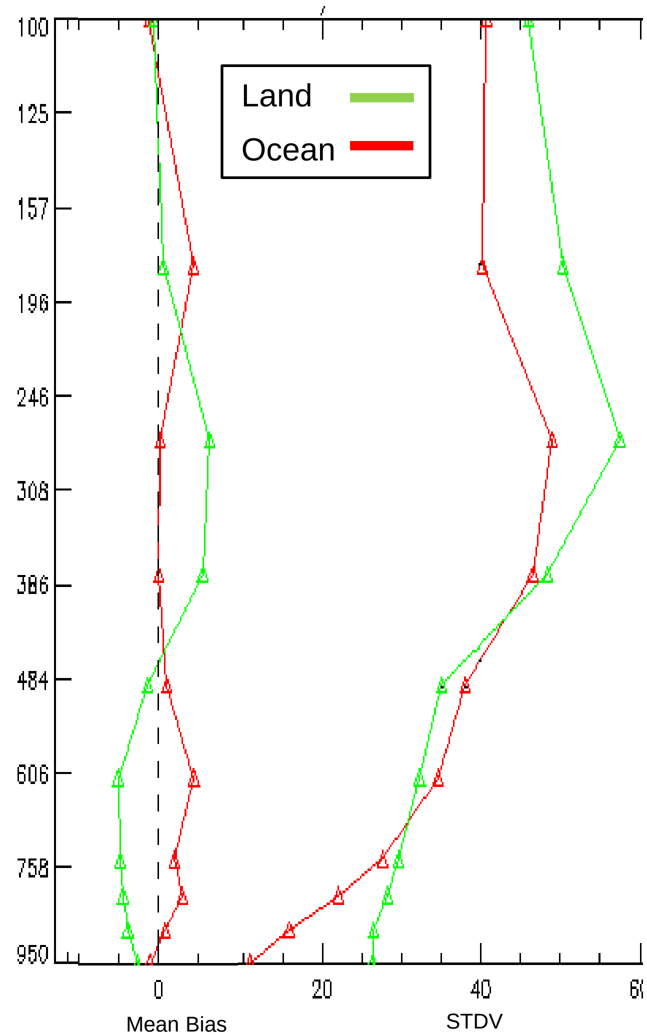
Global all Condition Water Vapor Statistic refer to ECMWF



Water Vapor Profile Validation based on ECMWF data

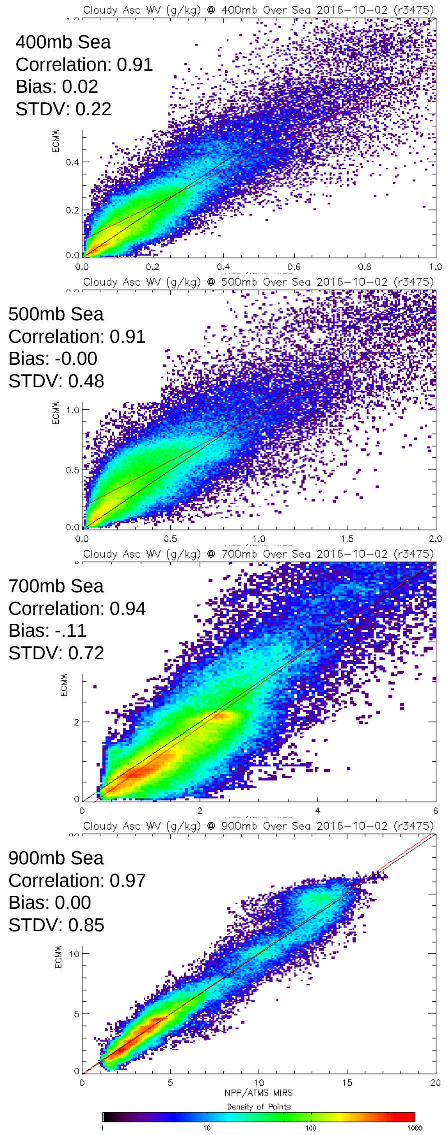
Global Clear Condition Water Vapor Statistic refer to ECMWF

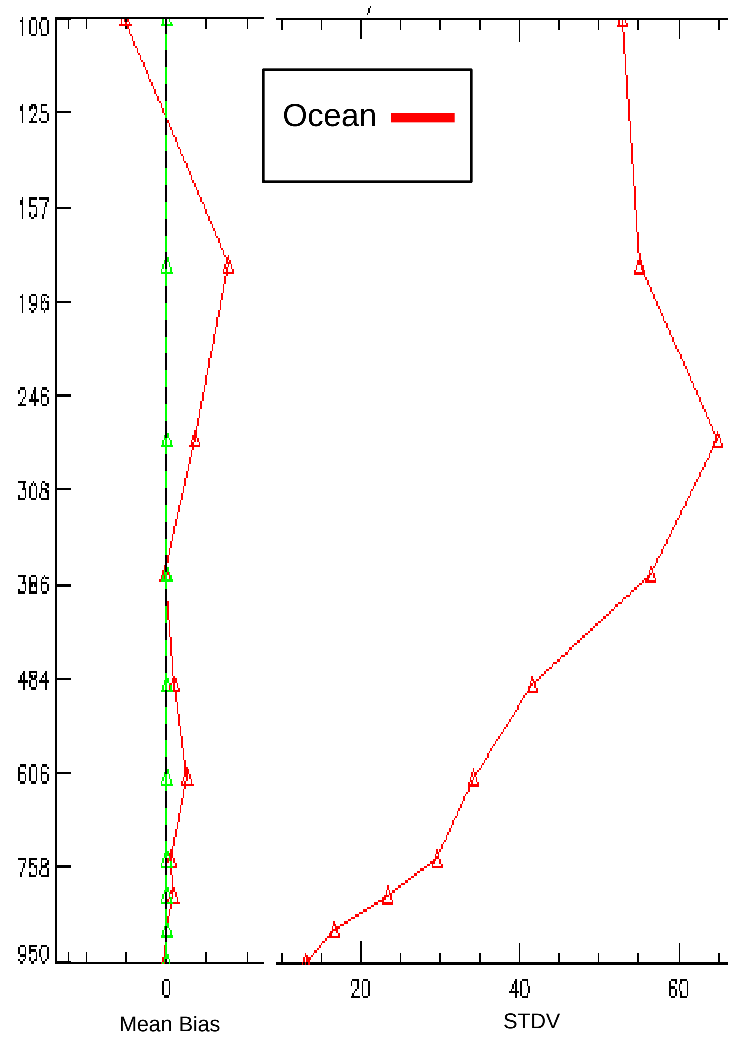




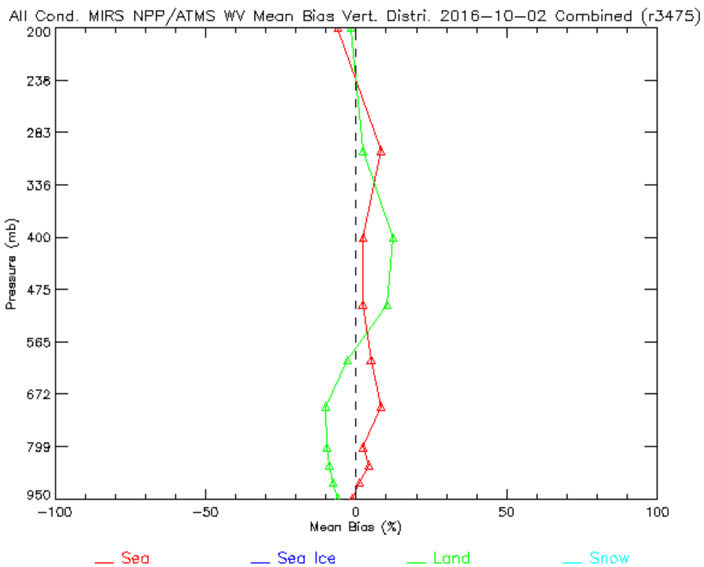
Water Vapor Profile Validation based on ECMWF data

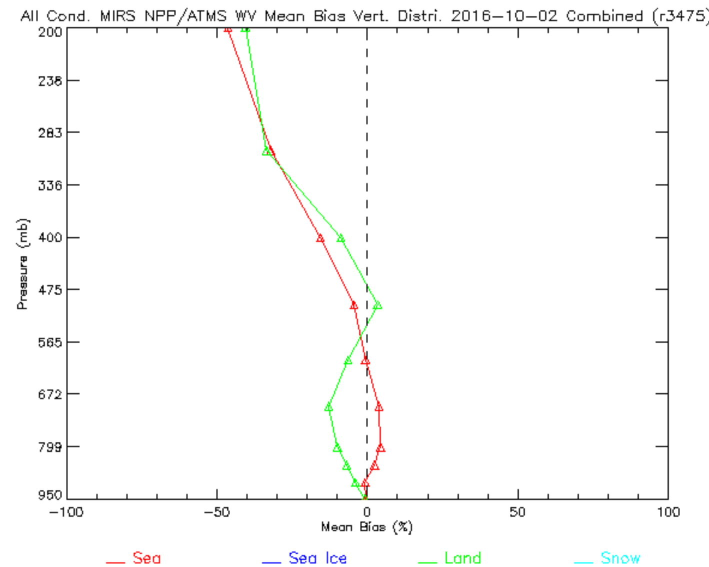
Global Cloudy Condition Water Vapor Statistic refer to ECMWF

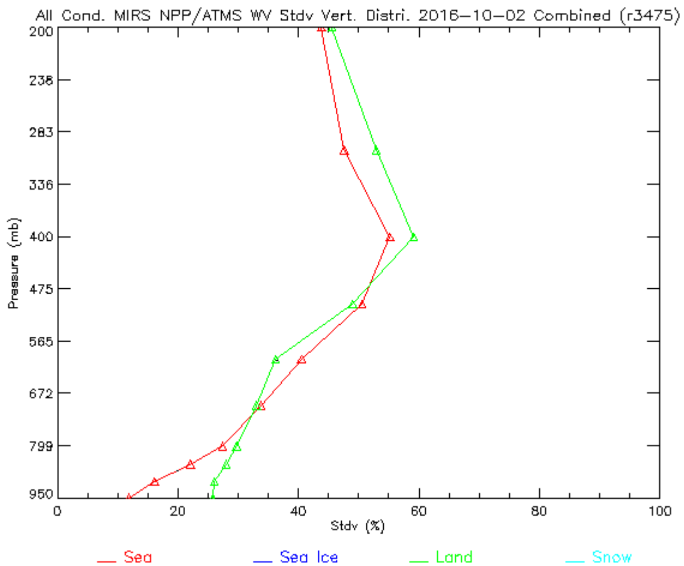


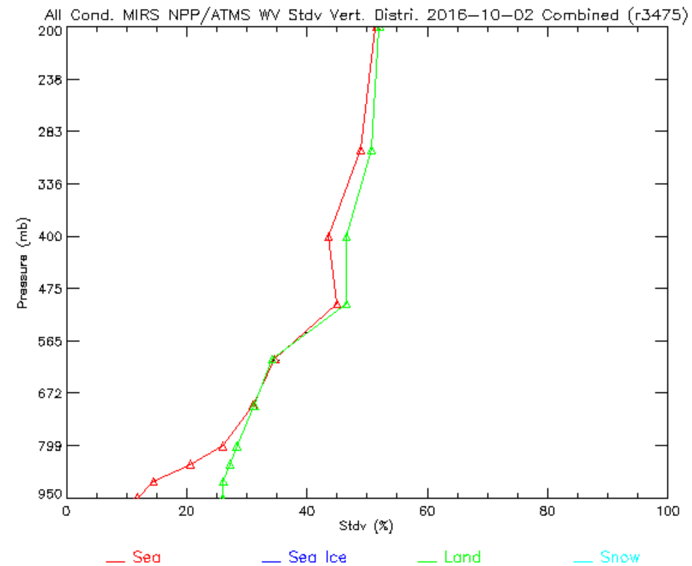


Water Vapor Profile Validation based on ECMWF data



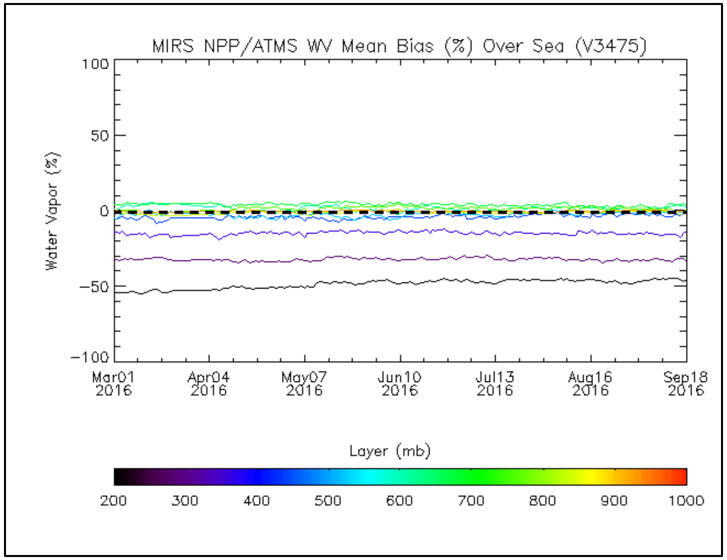


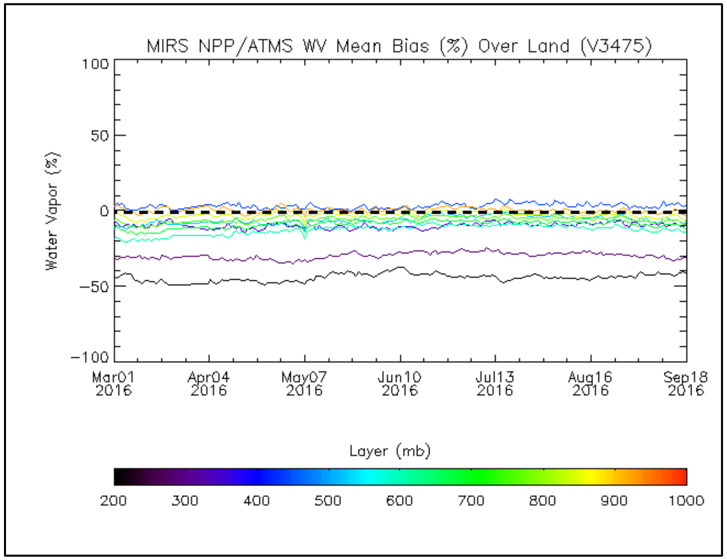


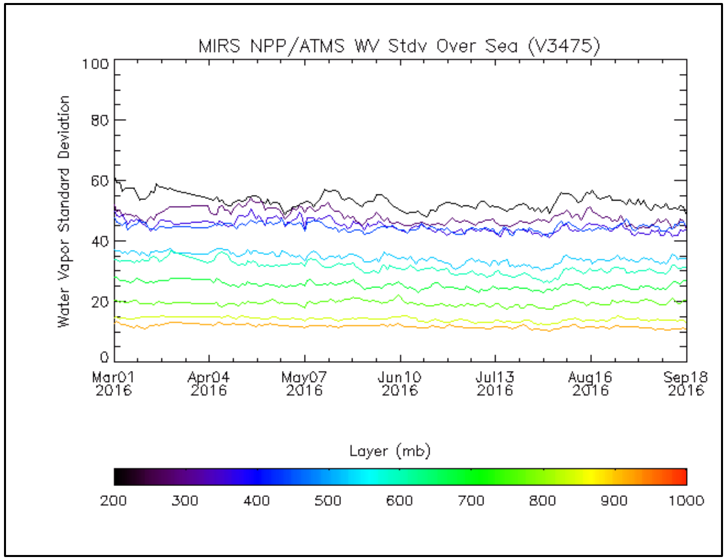


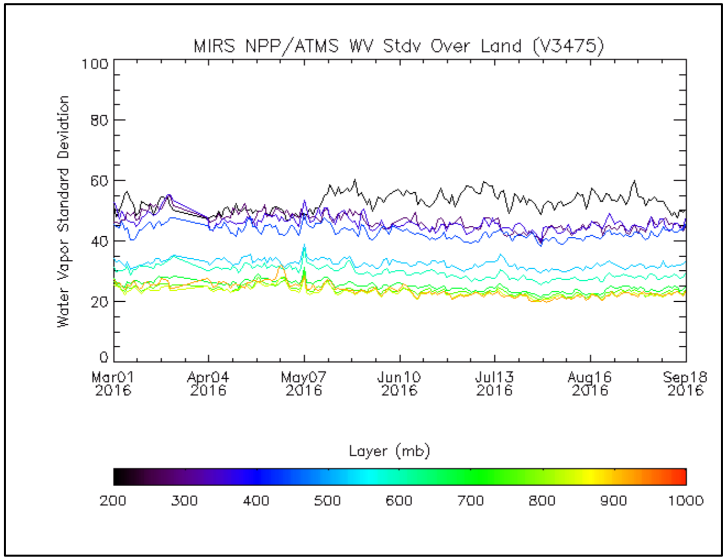
Water Vapor Profile Validation based on ECMWF data

- MiRS SNPP/ATMS Water Vapor Bias and Std Dev vs. GDAS: 1 March – 20 Sept 2016









Requirements and Validation Results: Total Precipitable Water

- Daily, Global Collocations with ECMWF and GDAS.
- Stratified by clear/cloudy, and surface type
- Requirements from JPSS-REQ-1002
- Maturity Level: Validated, Stage 3

Attribute	Threshold	Validated
Geographic coverage	Global	See table/figs
Vertical Coverage	Surface	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	N/A	
Measurement Accuracy	See table	
Measurement Precision	See table	

Product	Sfc	Condition	Bias (%) (Accuracy)			StDv (%) (Precision)		
			MiRS	Thr	Obj	MiRS	Thr	Obj
Water Vapor	Sea	Clear	**1.3**	**1.5**	**0.8**	**1.8**	**2.5**	**1.9**
		Cloudy	**0.2**	**0.5**	**0.1**	**1.9**	**2.5**	**1.7**
	Sea-Ice	Clear+ Cloudy	**-0.5**	**2.0**	**1.0**	**1.6**	**2.0**	**1.5**
	Land	Clear+ Cloudy	**-0.5**	**2.5**	**1.6**	**4.8**	**5.5**	**4.4**
	Snow	Clear+ Cloudy	**-0.2**	**0.5**	**0.2**	**0.8**	**2.0**	**1.2**

Green: achieve objective
White: meet Threshold

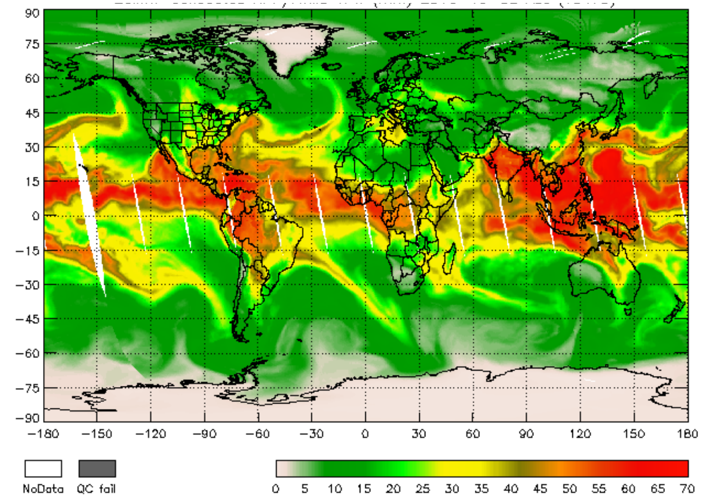
Validation Results: Total Precipitable Water (TPW)

Table 5.2.15 - Total Precipitable Water (ATMS)		
EDR Attribute	Threshold (1,2,3)	Objective
a. Horizontal Cell Size (4)	15 km @ nadir	
b. Vertical Reporting Interval	NS	NS
c. Mapping Uncertainty, 3 Sigma	NS	NS
d. Measurement Precision (mm)		
1. Sea		
a. Clear	2.5	1.9
b. Cloudy	2.5	1.7
2. Sea-Ice		
a. Clear/Cloudy	2.0	1.5
3. Land		
a. Clear/Cloudy	5.5	4.4
4. Snow		
a. Clear/Cloudy	2.0	1.2
e. Measurement Accuracy (mm)		
1. Sea		
a. Clear	1.5	0.8
b. Cloudy	0.5	0.1
2. Sea-Ice		
a. Clear/Cloudy	2.0	1.0
3. Land		
a. Clear/Cloudy	2.5	1.6
4. Snow-Land		
a. Clear/Cloudy	0.5	0.2
f. Measurement Uncertainty (mm)		
1. Sea		
a. Clear	2.5	2.0
b. Cloudy	2.5	1.7
2. Sea-Ice		
a. Clear/Cloudy	2.5	2.0
3. Land		
a. Clear/Cloudy	5.5	4.7
4. Snow		
a. Clear/Cloudy	2.0	1.2
g. Refresh (4)	At least 90% coverage of the globe every 18 hours (monthly average).	NS
		v2.5, 1/23/13

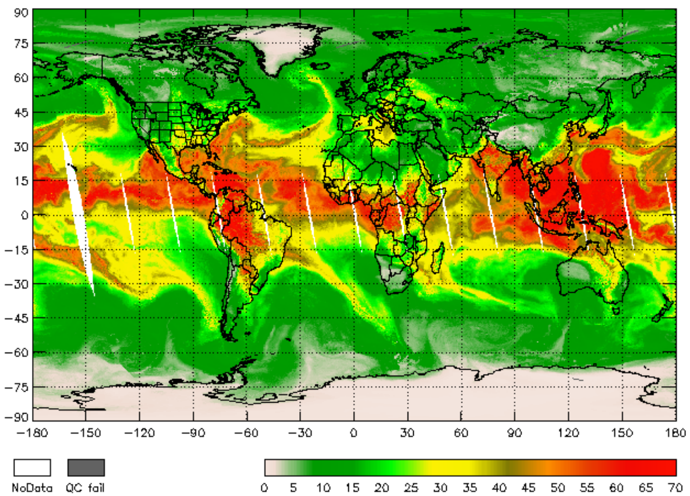
Notes:
1. Those performances are relative to the Global Data Assimilation System (GDAS).
2. The described performances include the Microwave Integrated Retrieval System (MiRS) algorithm performance, as well as the collocation error, the instrument noise and the errors inherent to the reference used to measure the performances.
3. The spatial distribution of the assessment data is global, encompassing the natural variability of the different geophysical conditions.
4. Refresh, coverage and horizontal size are all dependent on the refresh, coverage and horizontal size of the brightness temperatures measurements. The MiRS algorithm outputs characteristics will reproduce the TB characteristics of these factors.

Validation Results: Total Precipitable Water (TPW)

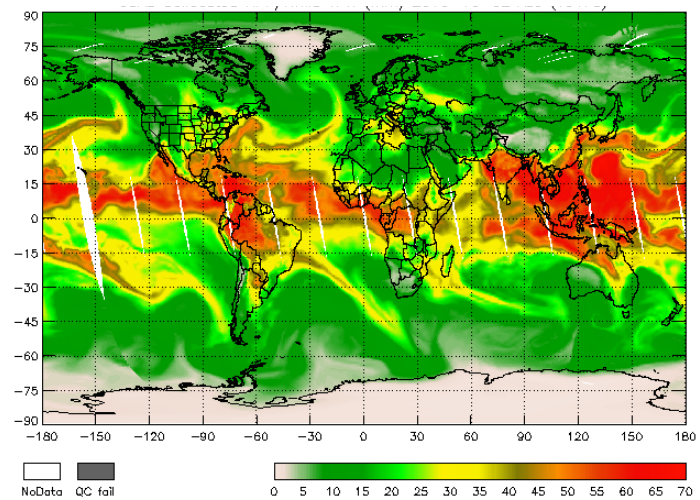
ECMWF Collocated NPP/ATMS TPW (mm) 2016-10-02 Asc



MiRS NPP/ATMS TPW (mm) 2016-10-02 Asc

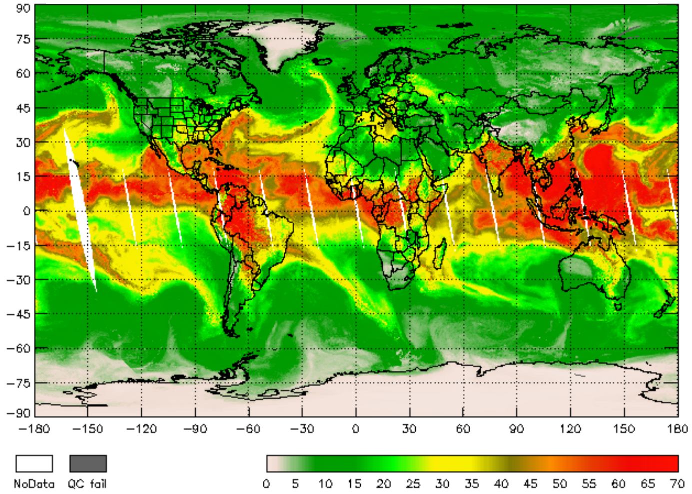


GDAS Collocated NPP/ATMS TPW (mm) 2016-10-02 Asc

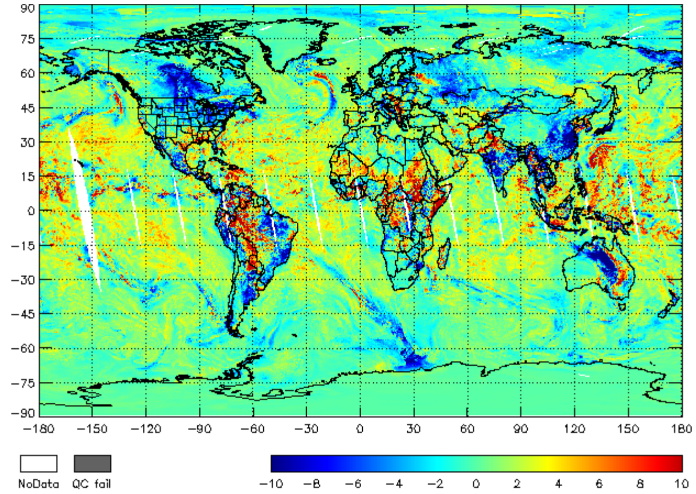


Validation Results: Total Precipitable Water (TPW)

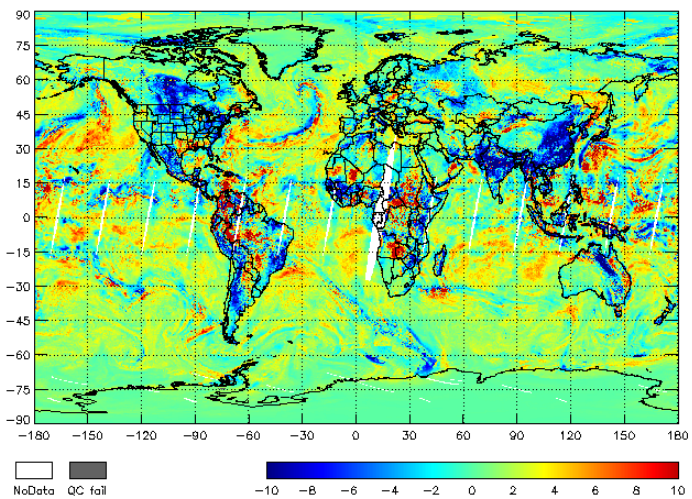
MiRS NPP/ATMS TPW (mm) 2016-10-02 Asc



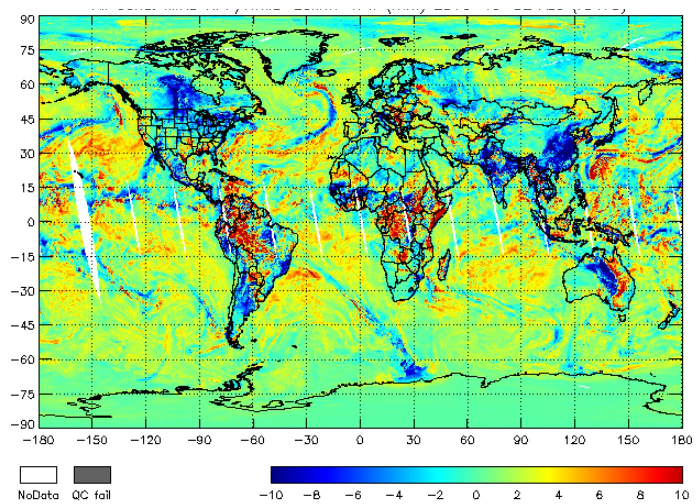
MiRS NPP/ATMS - GDAS TPW (mm) 2016-10-02 Asc



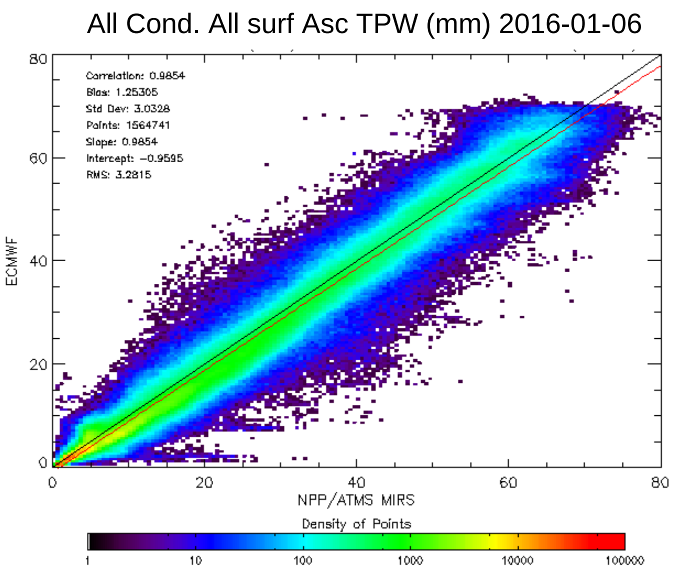
MiRS NPP/ATMS - ECMWF TPW (mm) 2016-10-02 Des

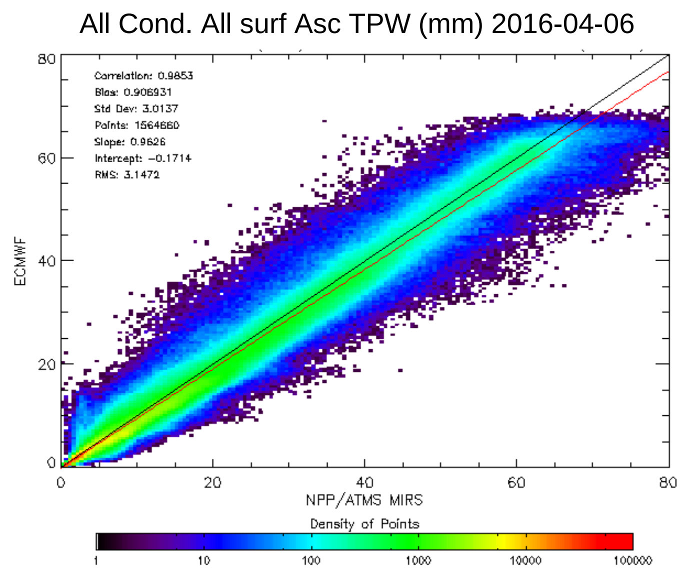


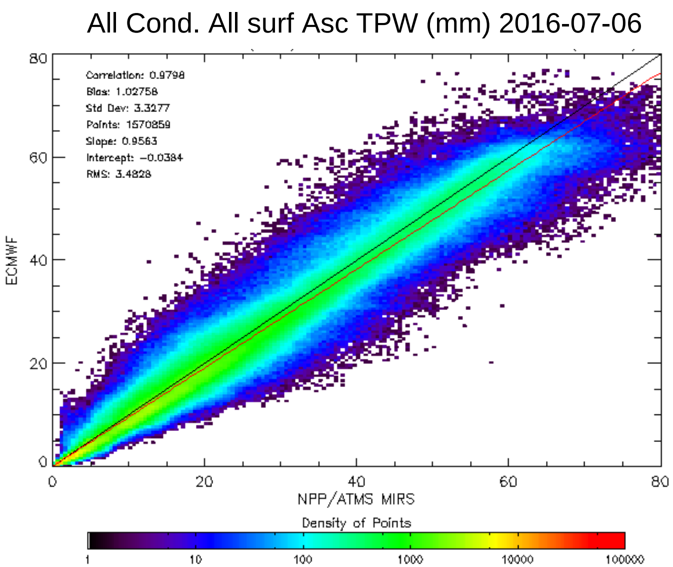
MiRS NPP/ATMS - ECMWF TPW (mm) 2016-10-02 Asc

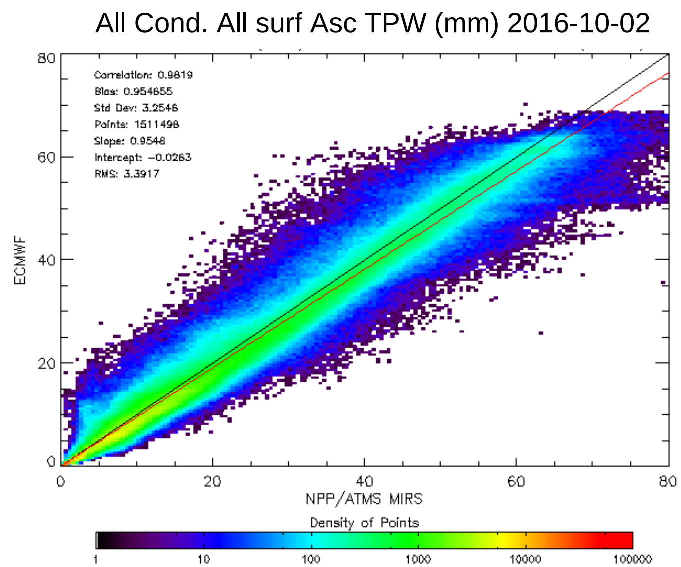


Validation Results: Total Precipitable Water (TPW) compared to ECMWF

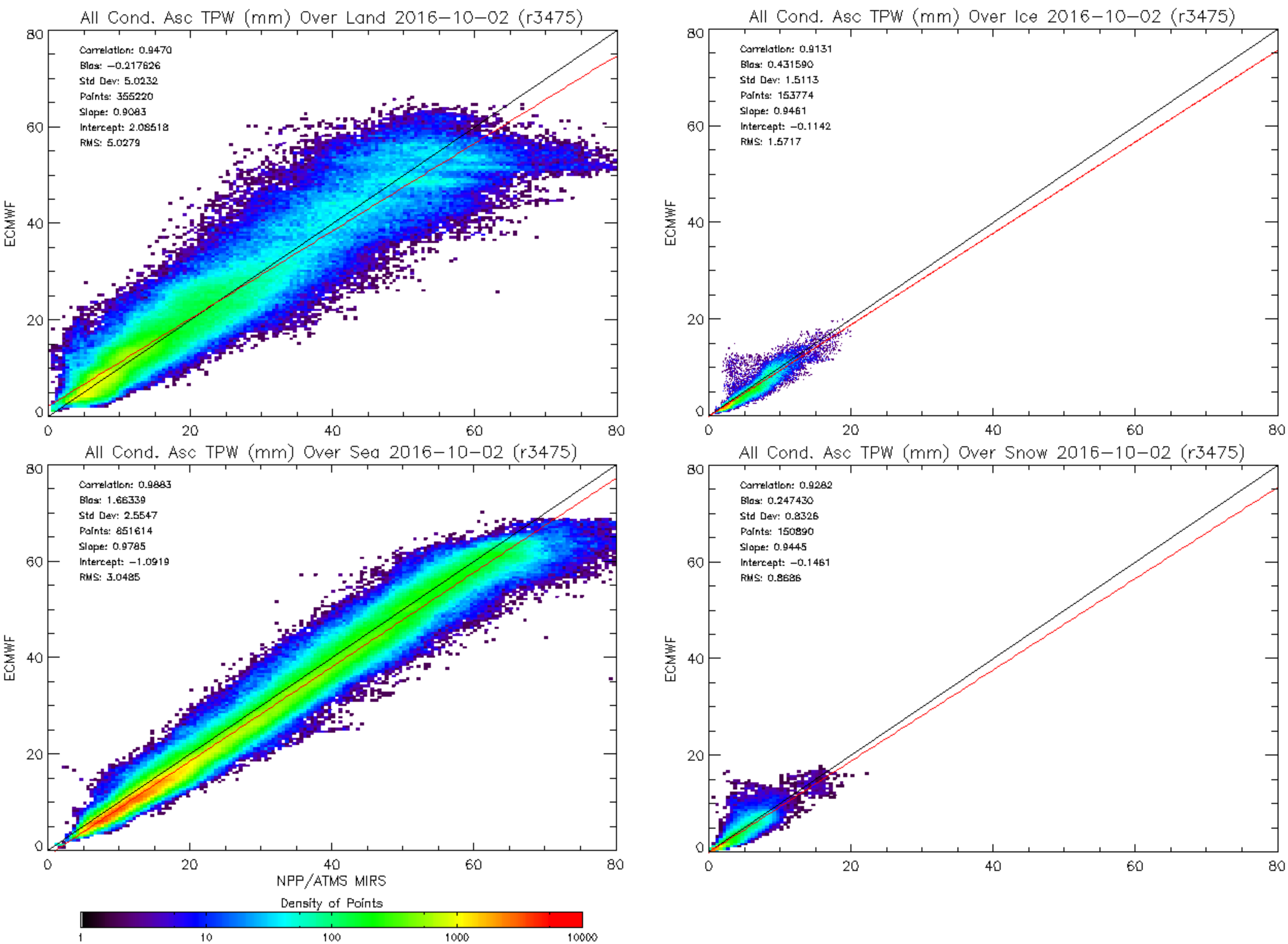




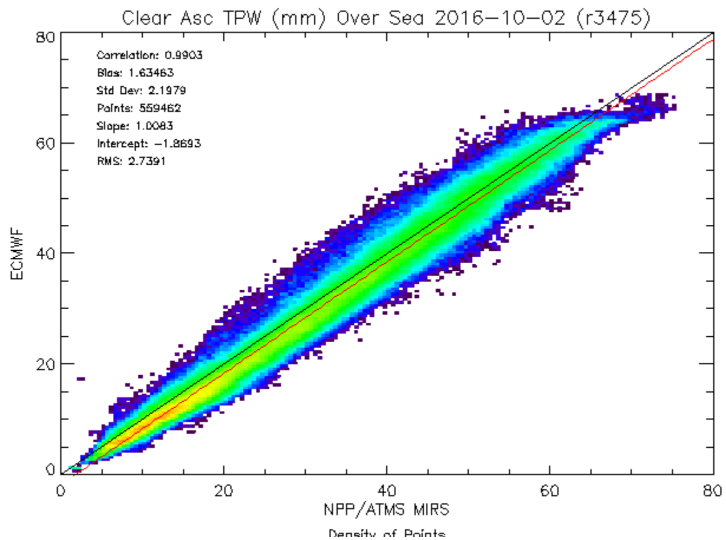


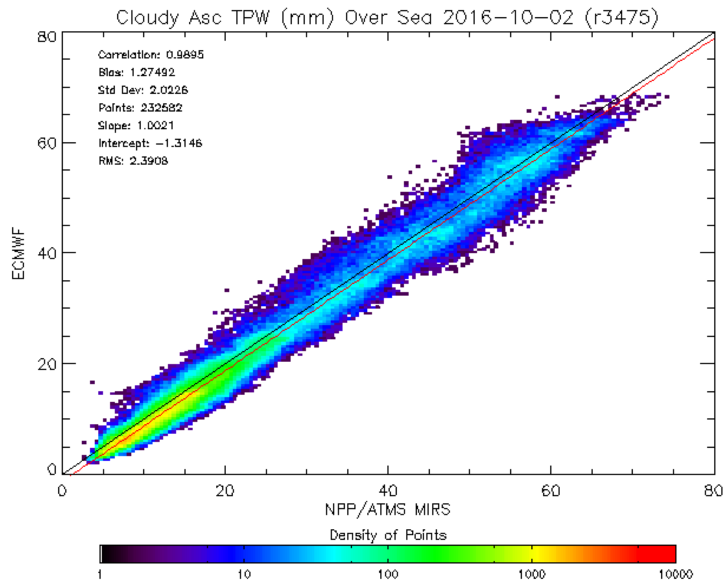


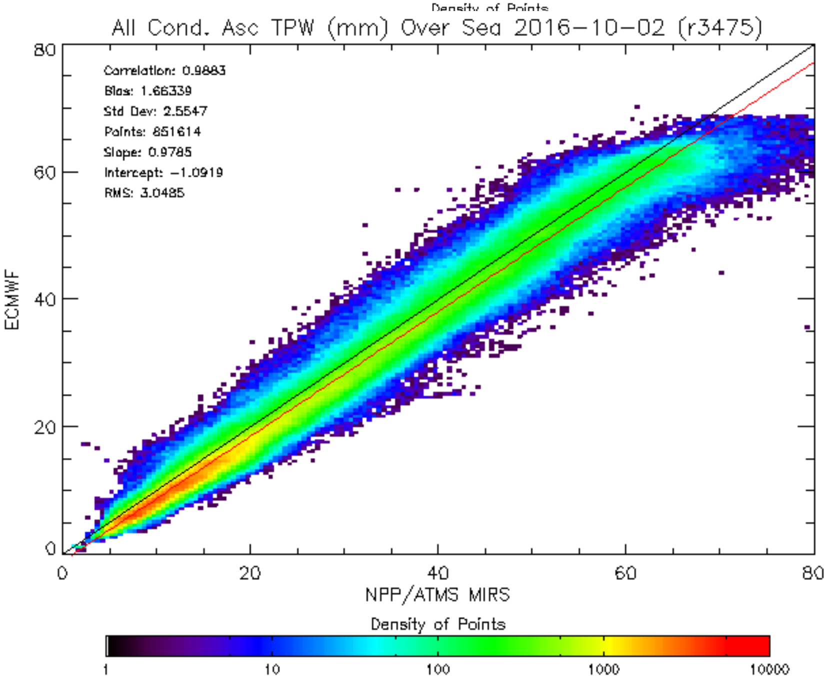
Validation Results: Total Precipitable Water (TPW) compared to ECMWF

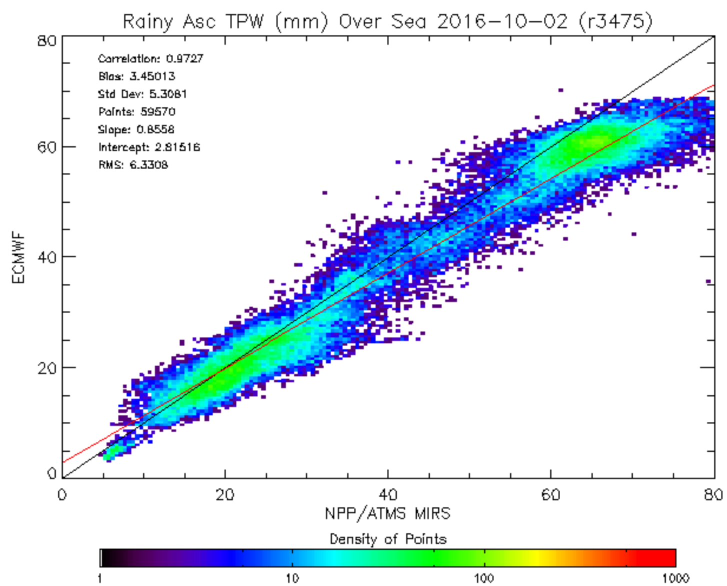


Validation Results: Ocean TPW for different weather conditions compared to ECMWF









Requirements and Validation Results: Rainfall Rate

Periodic collocations with Stage-IV
- Stratified by surface type
- Requirements from JPSS-REQ-1002
- Maturity Level: Validated, Stage 3

Attribute	Threshold	Validated
Geographic coverage	Global (non-frozen surfaces)	See table/figs
Vertical Coverage	Surface	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	N/A	
Measurement Accuracy	See table	
Measurement Precision	See table	

Product	SFC	EDR Attribute	MiRS	Threshold	Objective
Rainfall Rate (mm/h) (20160301-20160330)	Sea	Bias (mm/h)	0.07	0.10	0.05
		STDV (mm/h)	0.92	1.0	0.5
		Probability of Detection (%)	80	50	60
		False Alarm Rate (%)	4.0	5.0	3.0
		Heidke Skill Score	0.53	0.30	0.55
	Land	Bias (mm/h)	-0.01	0.05	0.02
		STDV (mm/h)	0.58	1.5	0.8
		Probability of Detection (%)	46	50	70
		False Alarm Rate (%)	1.0	6.0	4.0
		Heidke Skill Score	0.51	0.30	0.55
Rainfall Rate (mm/h) (20160701-20160731)	Sea	Bias (mm/h)	0.00	0.10	0.05
		STDV (mm/h)	0.78	1.0	0.5
		Probability of Detection (%)	69	50	60
		False Alarm Rate (%)	2.6	5.0	3.0
		Heidke Skill Score	0.55	0.30	0.55
	Land	Bias (mm/h)	0.02	0.05	0.02
		STDV (mm/h)	0.95	1.5	0.8
		Probability of Detection (%)	62	50	70
		False Alarm Rate (%)	2.6	6.0	4.0
		Heidke Skill Score	0.51	0.30	0.55

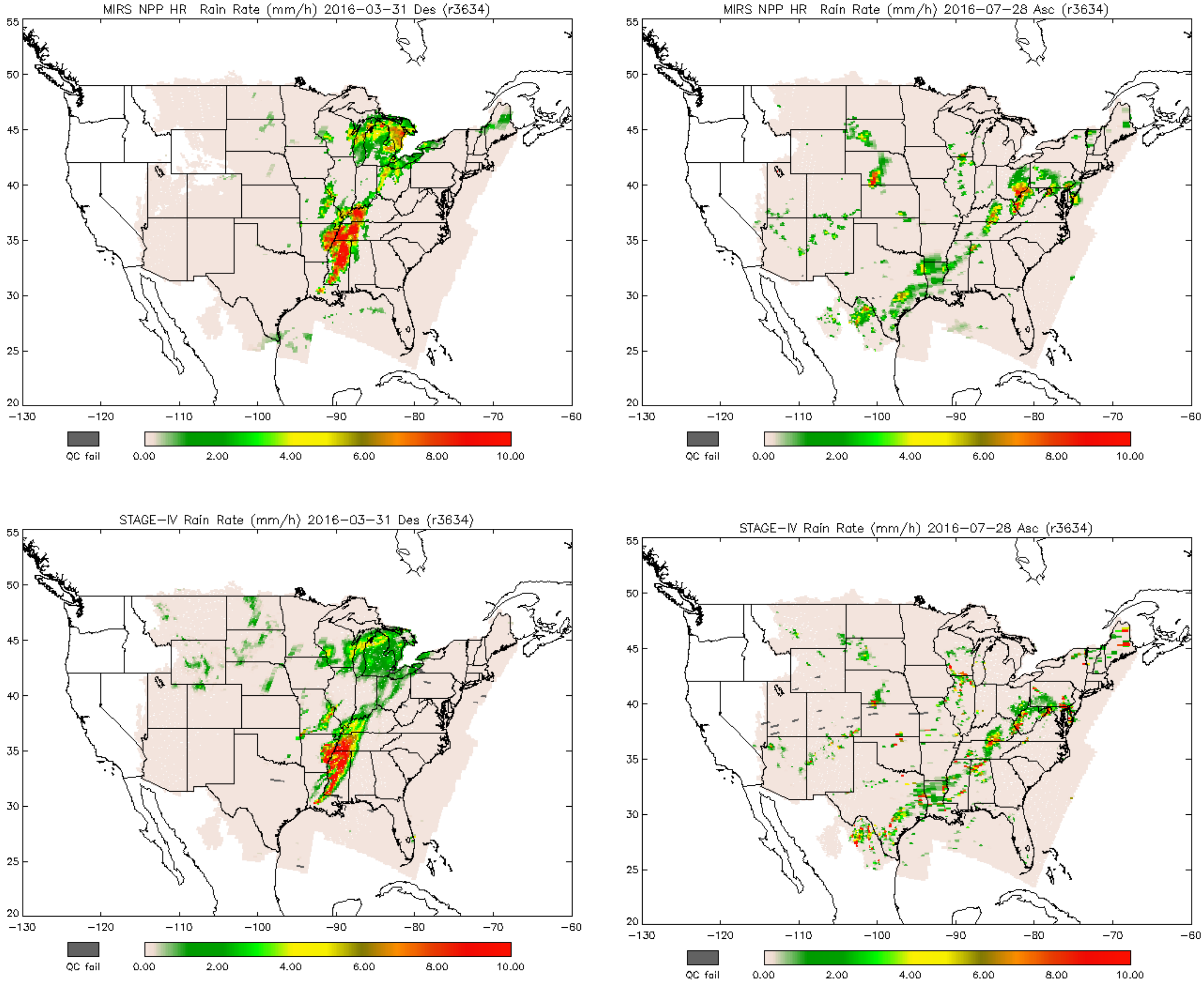
Validation Results: Rainfall Rate

Table 5.2.13 - Rainfall Rate (ATMS)		
EDR Attribute	**Threshold**	**Objective**
a. Horizontal Cell Size	15 km @ nadir	
b. Vertical Reporting Interval	NS	NS
c. Mapping Uncertainty, 3 Sigma	NS	NS
d. Measurement Precision (mm/h)		
1. Sea	1.0	0.5
2. Land	1.5	0.8
e. Measurement Accuracy (mm/h)		
1. Sea	0.10	0.05
2. Land	0.05	0.02
f. Measurement Uncertainty	NS	NS
g. Probability of Detection (%)		
1. Sea	50	60
2. Land	50	70
h. False Alarm Rate (%)		
1. Sea	5.0	3.0
2. Land	6.0	4.0
i. Heidke Skill Score (-1 - +1)		
1. Sea	0.30	0.55
2. Land	0.30	0.55
j. Refresh	At least 90% coverage of the globe every 18 hours (monthly average).	NS
		v2.5, 1/23/13

Notes:

1. The described performances include the Microwave Integrated Retrieval System (MiRS) algorithm performance, the collocation error, the instrument noise and the errors inherent to the reference used to measure the performances, as well as the errors due to differences in the footprint size of the collocated ATMS and the reference measurements (beam filling effect).
2. Over ocean performances are relative to the TRMM Microwave Imager (TMI) Level 2A Hydrometeor Profile Product Version 7. For the comparisons, 3 min and 7.5 km were used as the time and space collocation thresholds, respectively. This assesment is over the +/- 38 deg. latitudes.
3. Over land performances are relative to the hourly NCEP Stage IV precipitation analysis over the CONUS. The Stage IV precipitation analysis product is much more of an integrated hourly estimate, while the satellite-based MiRS precipitation estimation products represent an instantaneous observation. Because of that, during the comparison, it has been assumed that the Stage IV rainfall rate is a constant amount for an entire hour and is compared with the MiRS precipitation estimates that had occurred within that hour. Stage IV rainfall rate is approximately 4 km resolution. For the comparisons, 3 min and 7.5 km were used as the time and space collocation thresholds, respectively.
4. For the computation of precision and accuracy rainfall rate values equal to zero were included.
5. For the purpose of computing the POD, FAR and HSS the definition of rain is where the rainfall rate is greater than 0.6 mm/hr.
6. Refresh, coverage and horizontal size are all dependent on the refresh, coverage and horizontal size of the brightness temperatures measurements. The MiRS algorithm outputs characteristics will reproduce the TB characteristics of these factors.

Validation Results: Rainfall Rate

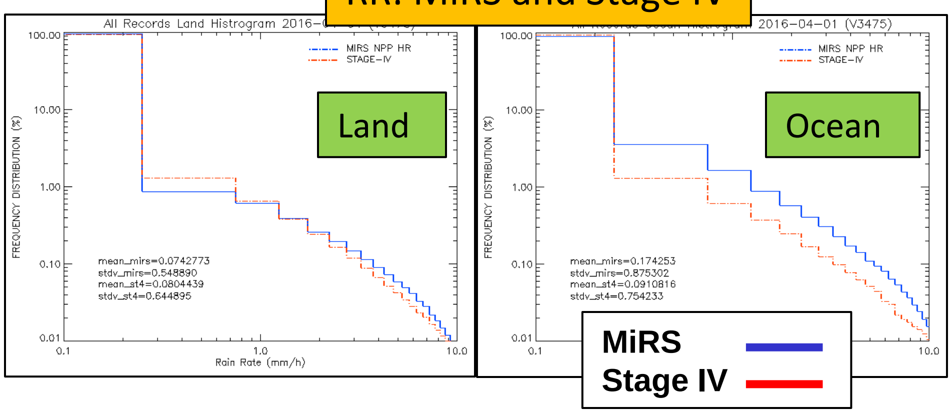


Validation Results: Rainfall Rate

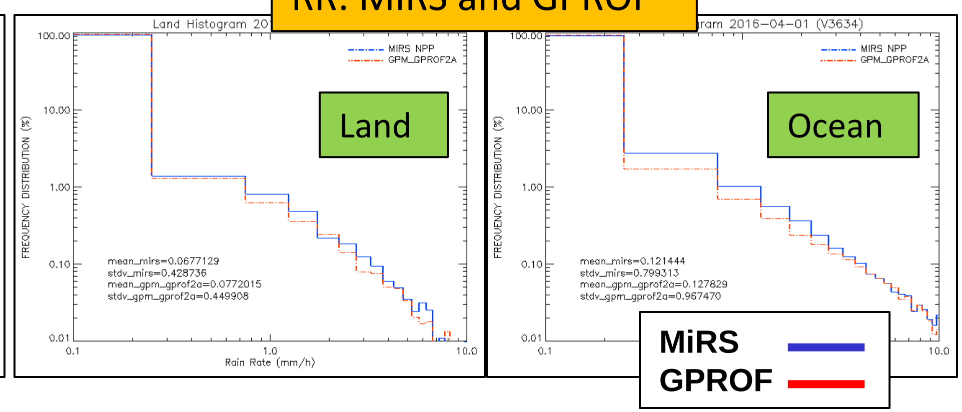
8 Month Collocation Period: August 2015- March 2016
- Rain Rate: MiRS ATMS collocation with Stage IV (CONUS and coastal ocean)
- Rain Rate: MiRS ATMS collocation with GPM GPROF 2A (global land and ocean)
- Maturity Level: Validated, Stage 3

Product	Units	Bias (Accuracy)		StDv (Precision)		Npts
		MiRS	Req	MiRS	Req	
Rain Rate (land, Stage IV)	mm/h	0.01	0.05	0.8	1.5	8.7E+06
Rain Rate (ocean, Stage IV)	mm/h	0.08	0.10	1.0	1.0	1.8E+06
Rain Rate (land, GPROF)	mm/h	-0.01	0.05	0.4	1.5	8.1E+04
Rain Rate (ocean, GPROF)	mm/h	-0.01	0.10	0.8	1.0	1.8E+05

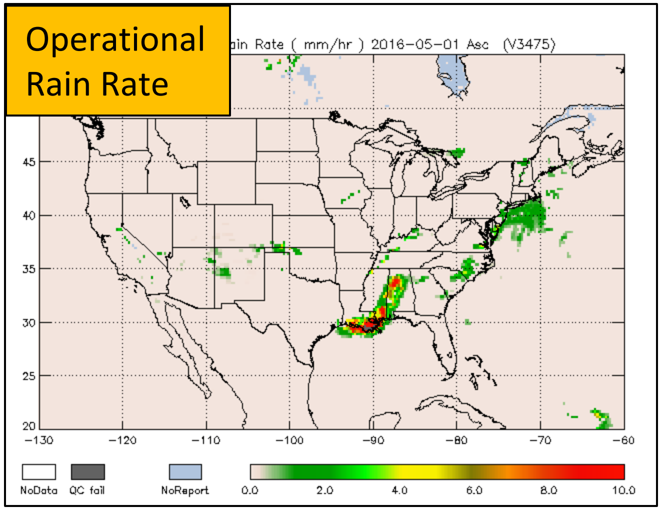
RR: MiRS and Stage IV

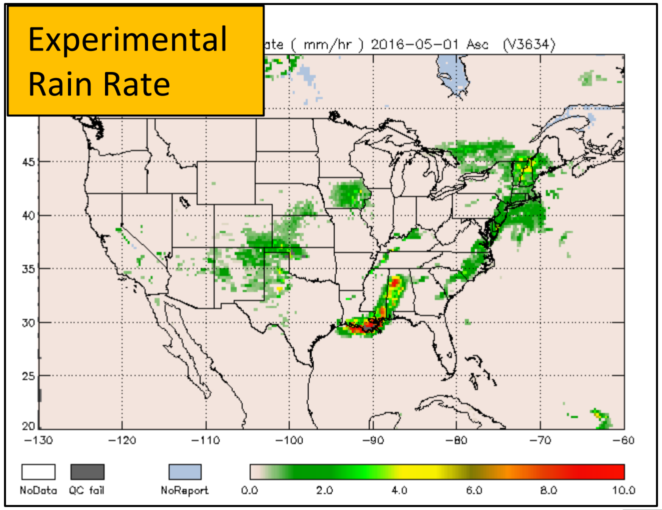


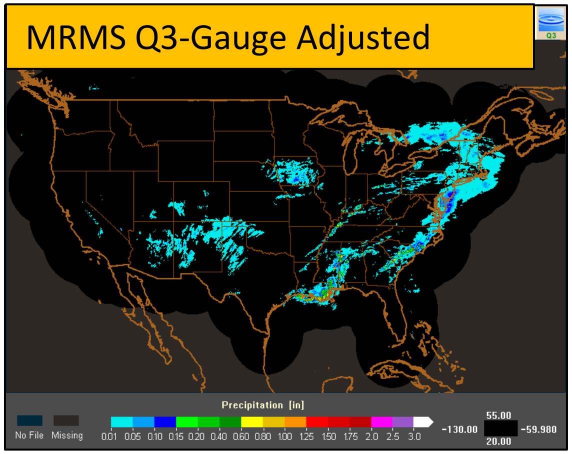
RR: MiRS and GPROF



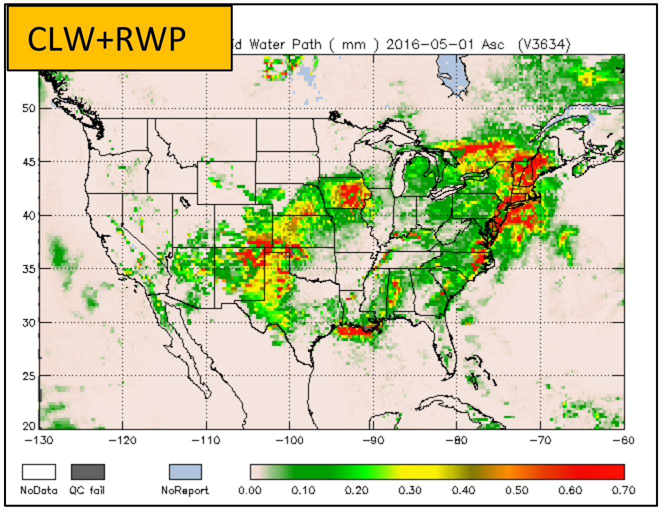
Path Forward: Rainfall Rate, Incorporating CLW over Land

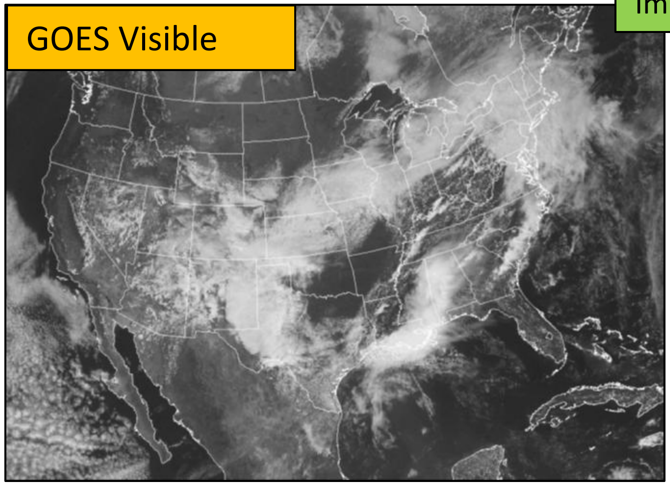






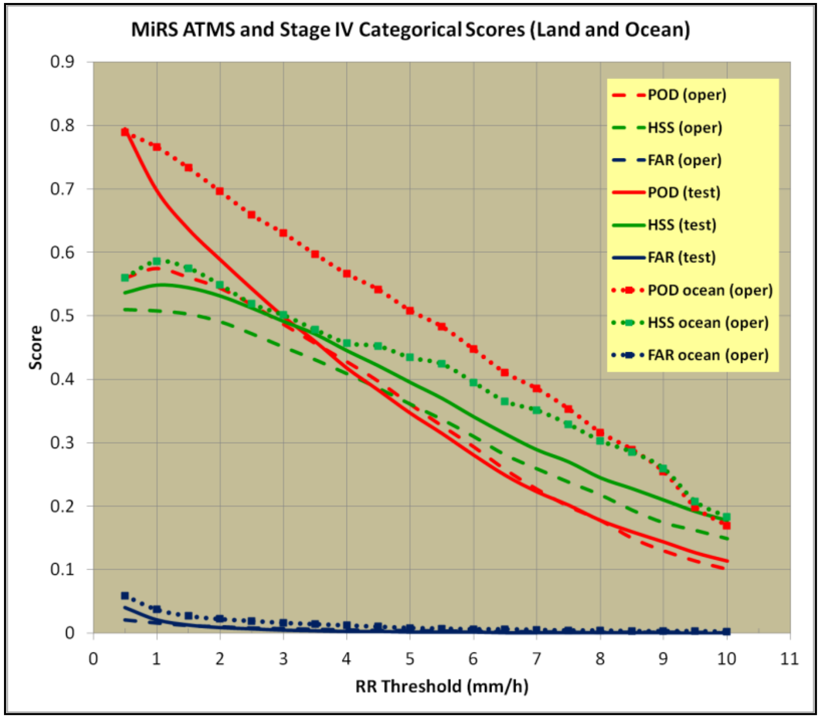
Improved detection of light rain (< 2 mm/h)

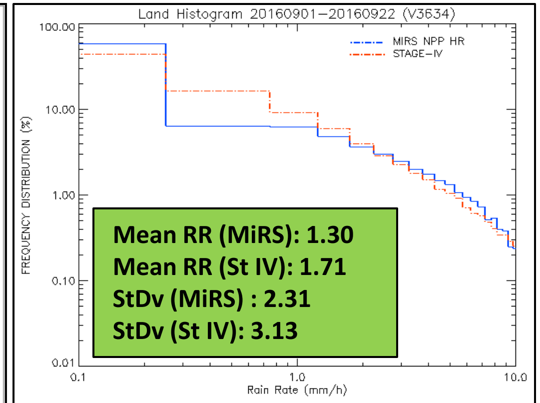


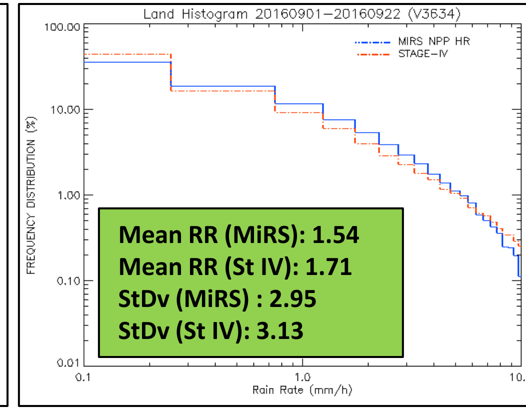


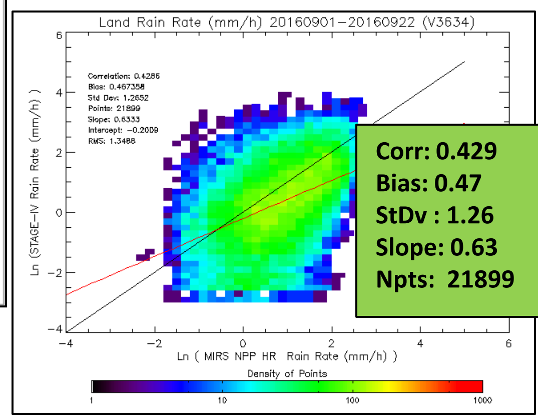
Path Forward: Rainfall Rate, Incorporating CLW over Land

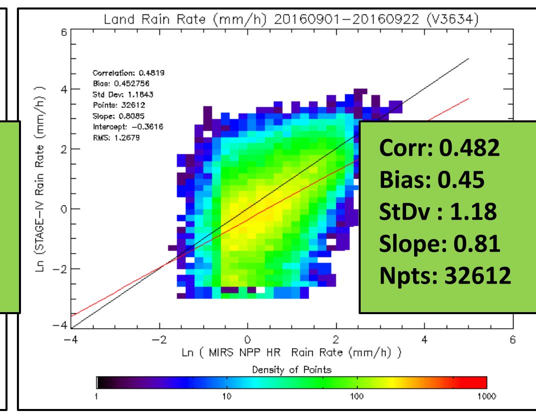
MiRS ATMS RR Performance Relative to Stage IV: 1-22 Sept 2016





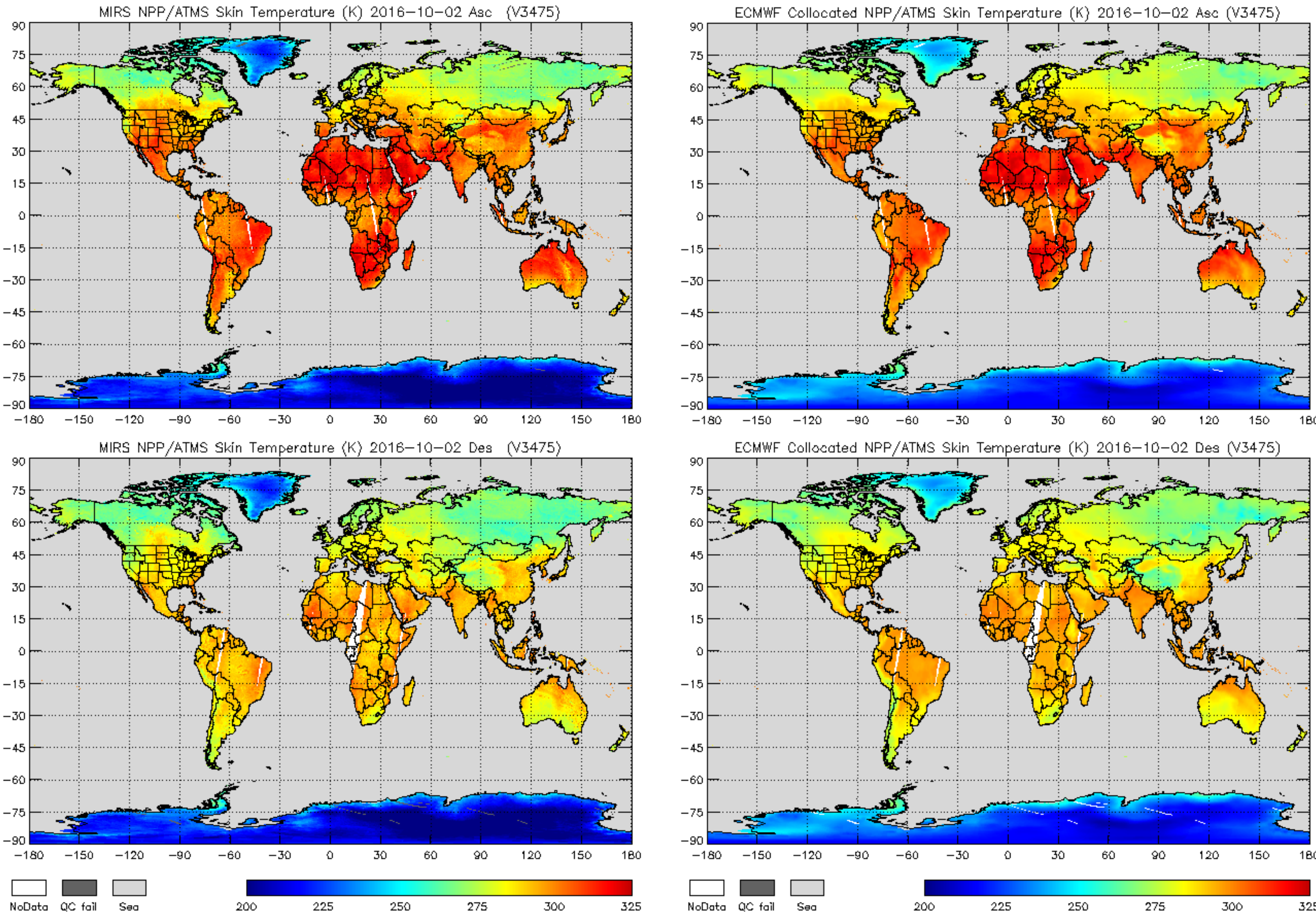




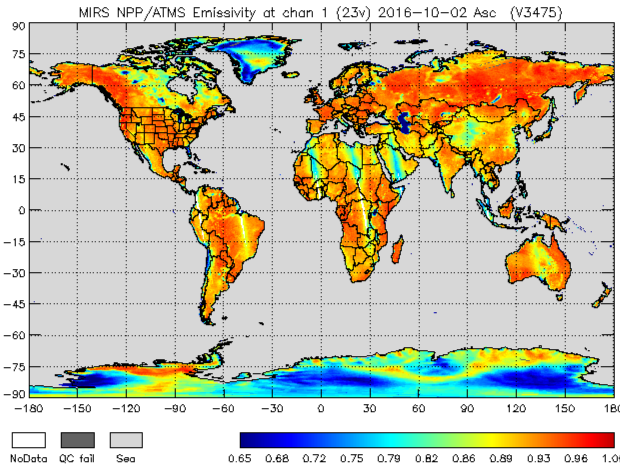


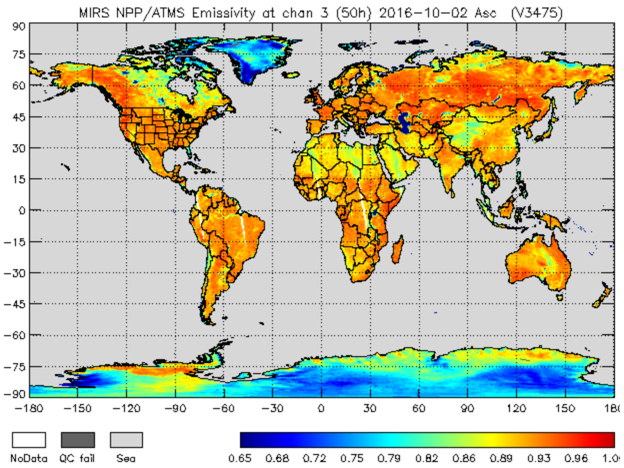
- Over land POD and Heidke Score significant increase
- Better PDF match with Stage IV for both low and high rain rates
- Increased correlation and slope closer to 1

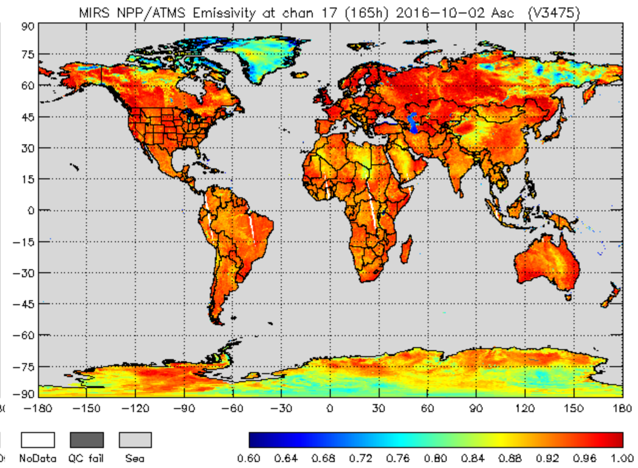
Requirements and Validation Results: Land Surface Temperature

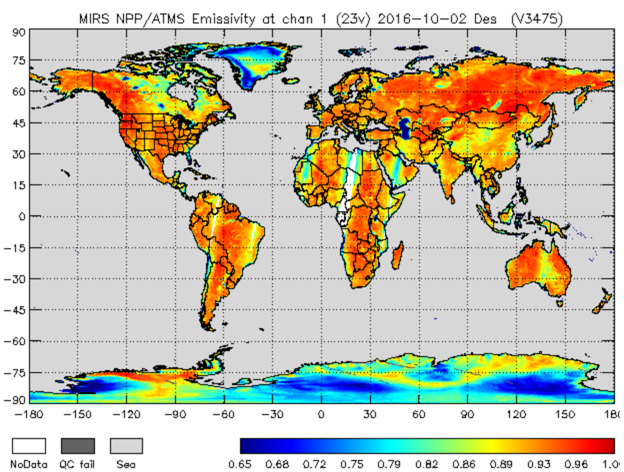


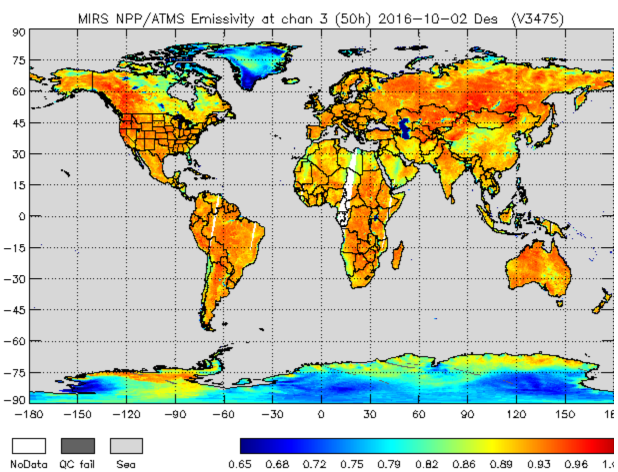
Requirements and Validation Results: Land Surface Emssivity

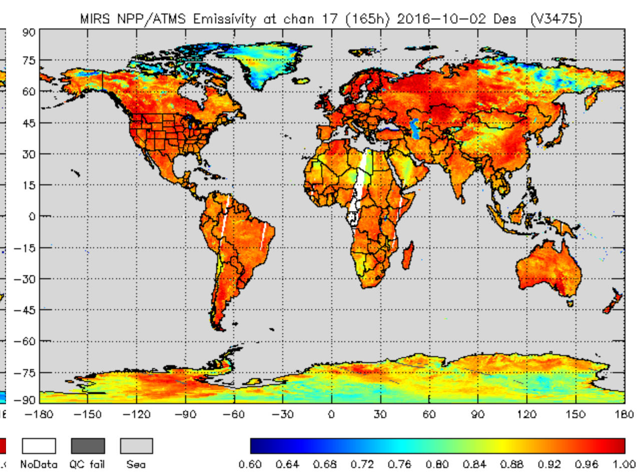




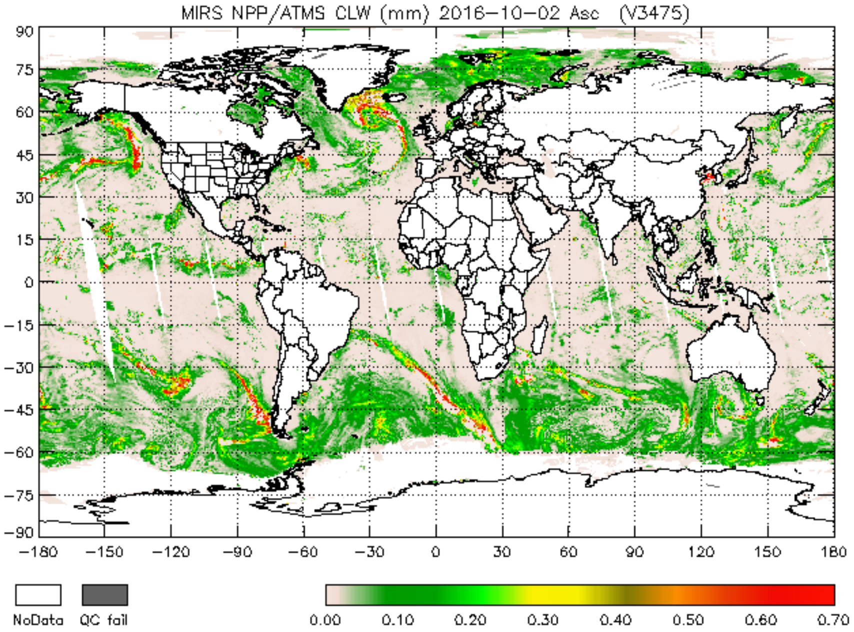


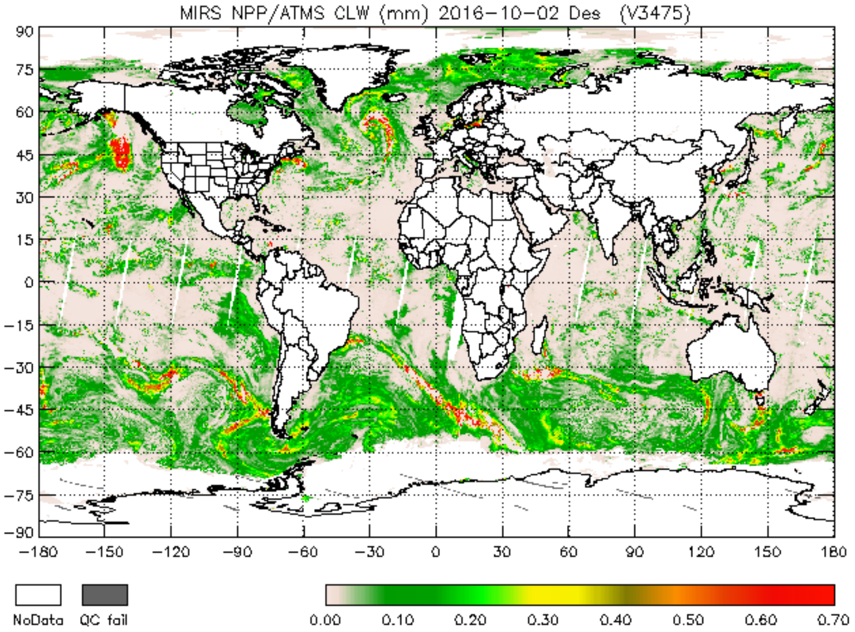




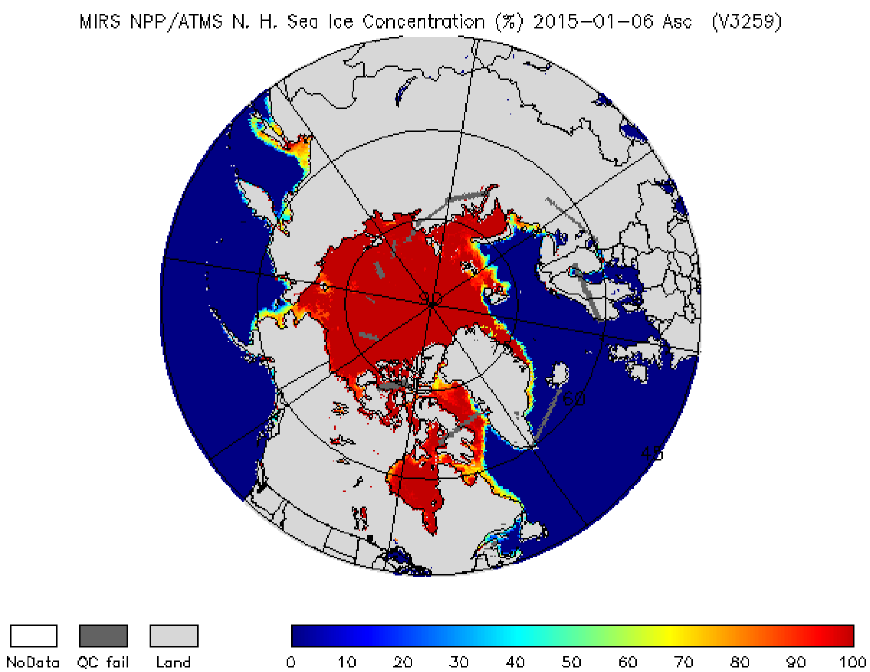


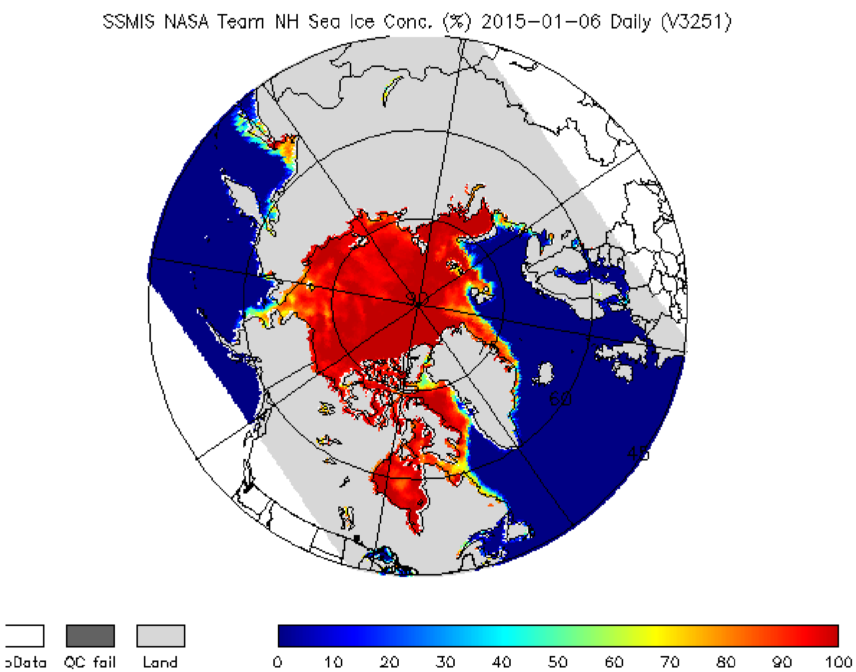
Validation Results: Cloud Liquid Water (CLW)





Validation Results: Sea Ice Concentration (SIC)

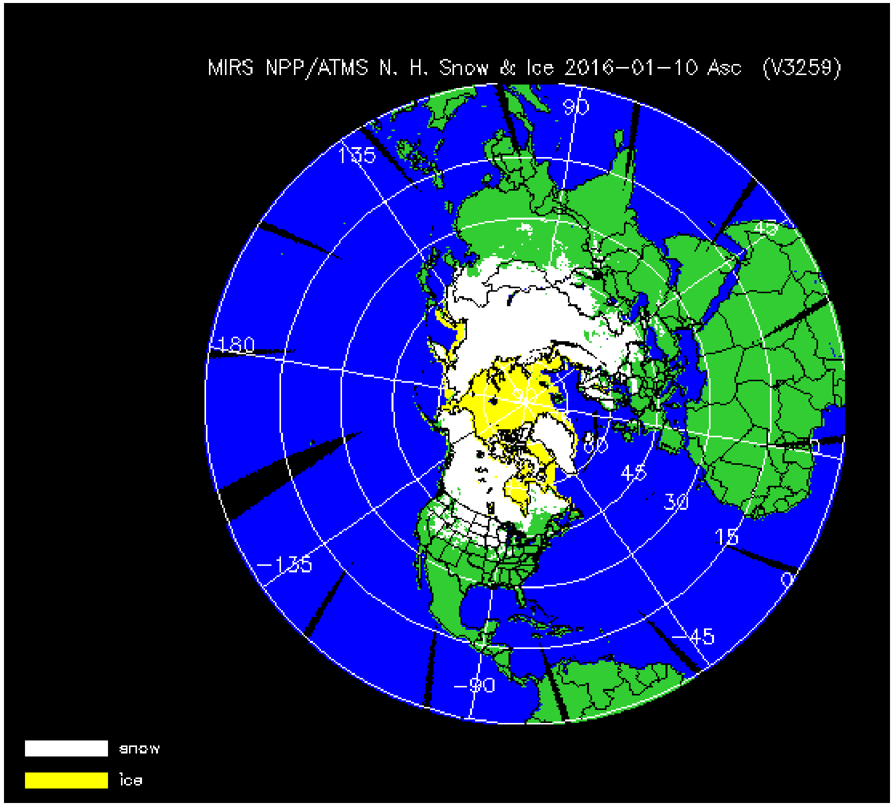


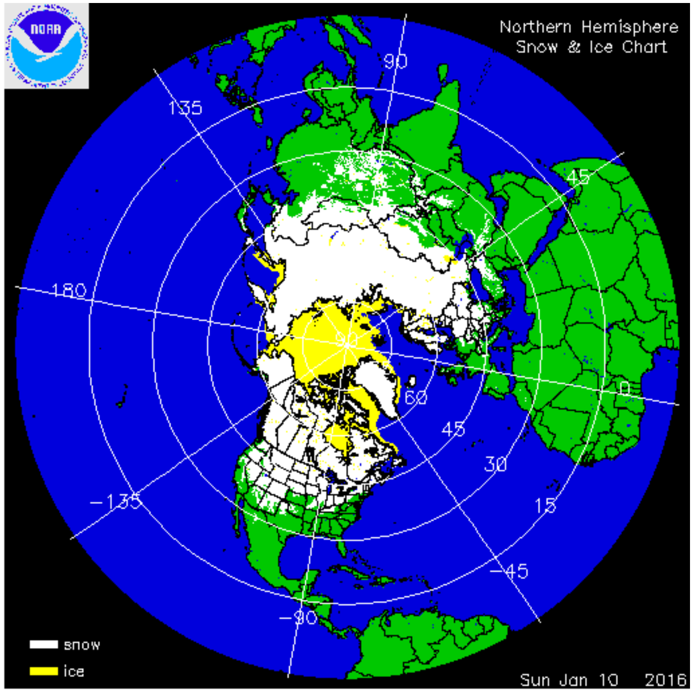


Validation Results: Snow Cover/Depth

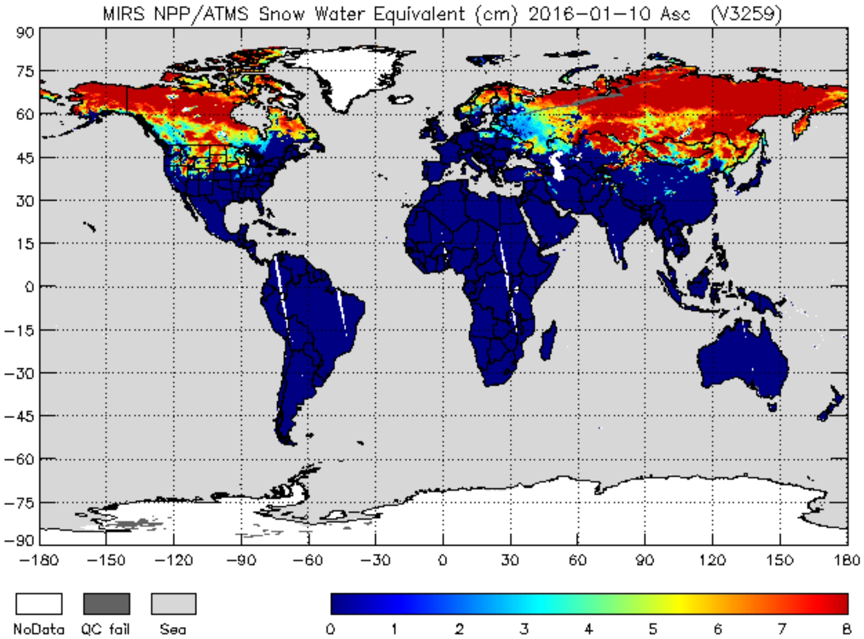
MiRS Sfc Type

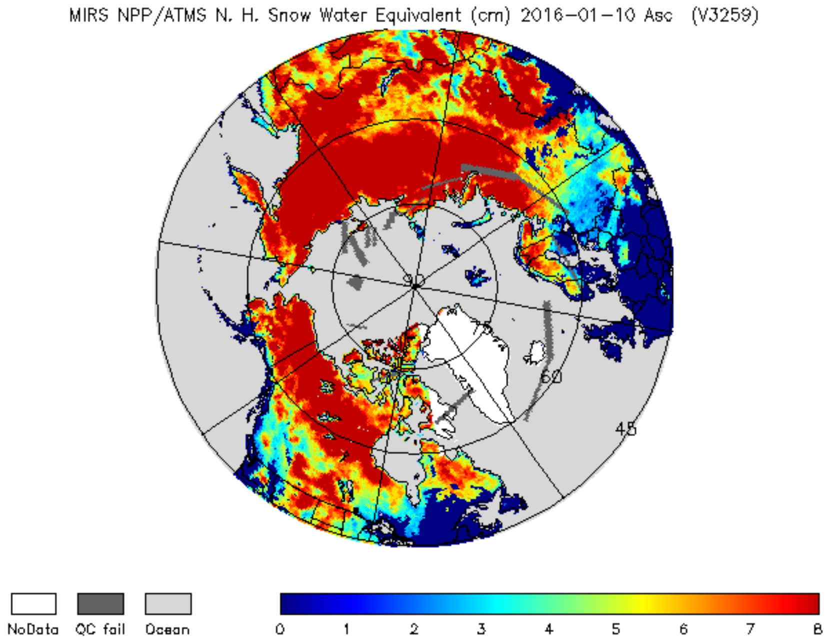
NIC IMS Sfc Type Analysis





Validation Results: Snow-Water Equivalent (SWE)

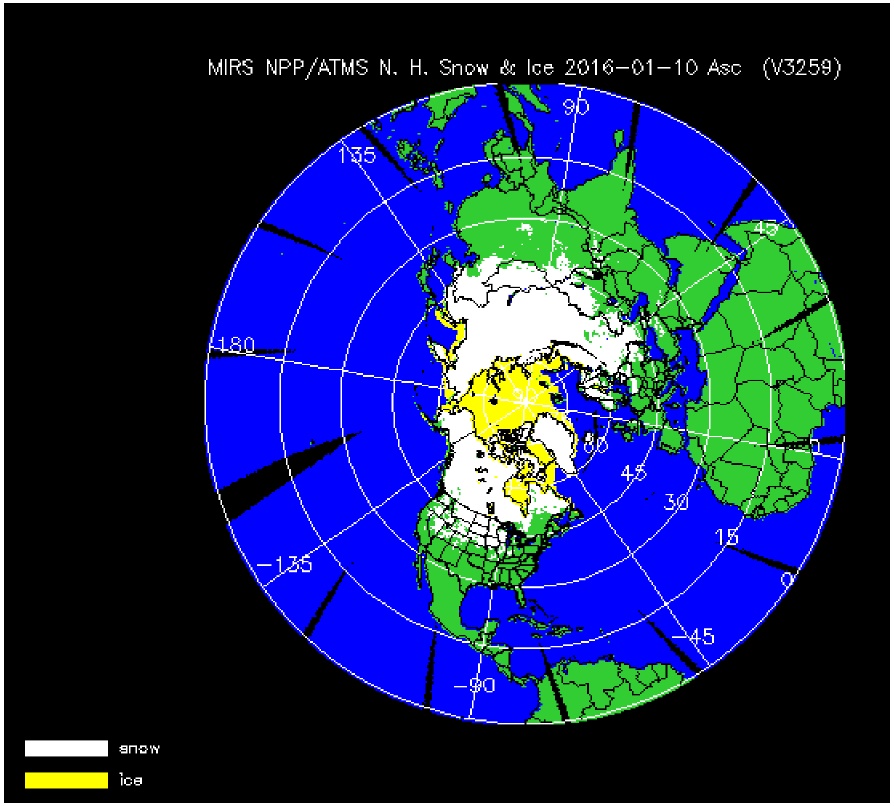


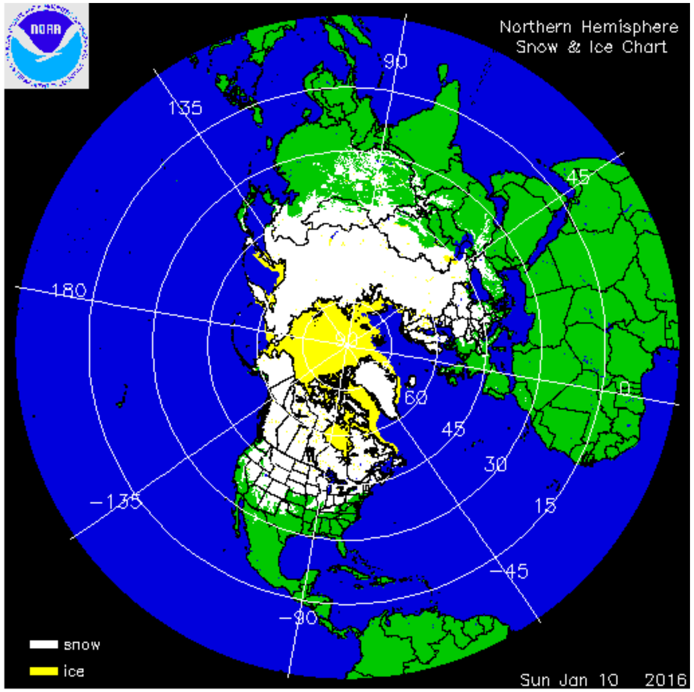


Validation Results: Snow-Water Equivalent (SWE)

MiRS Sfc Type

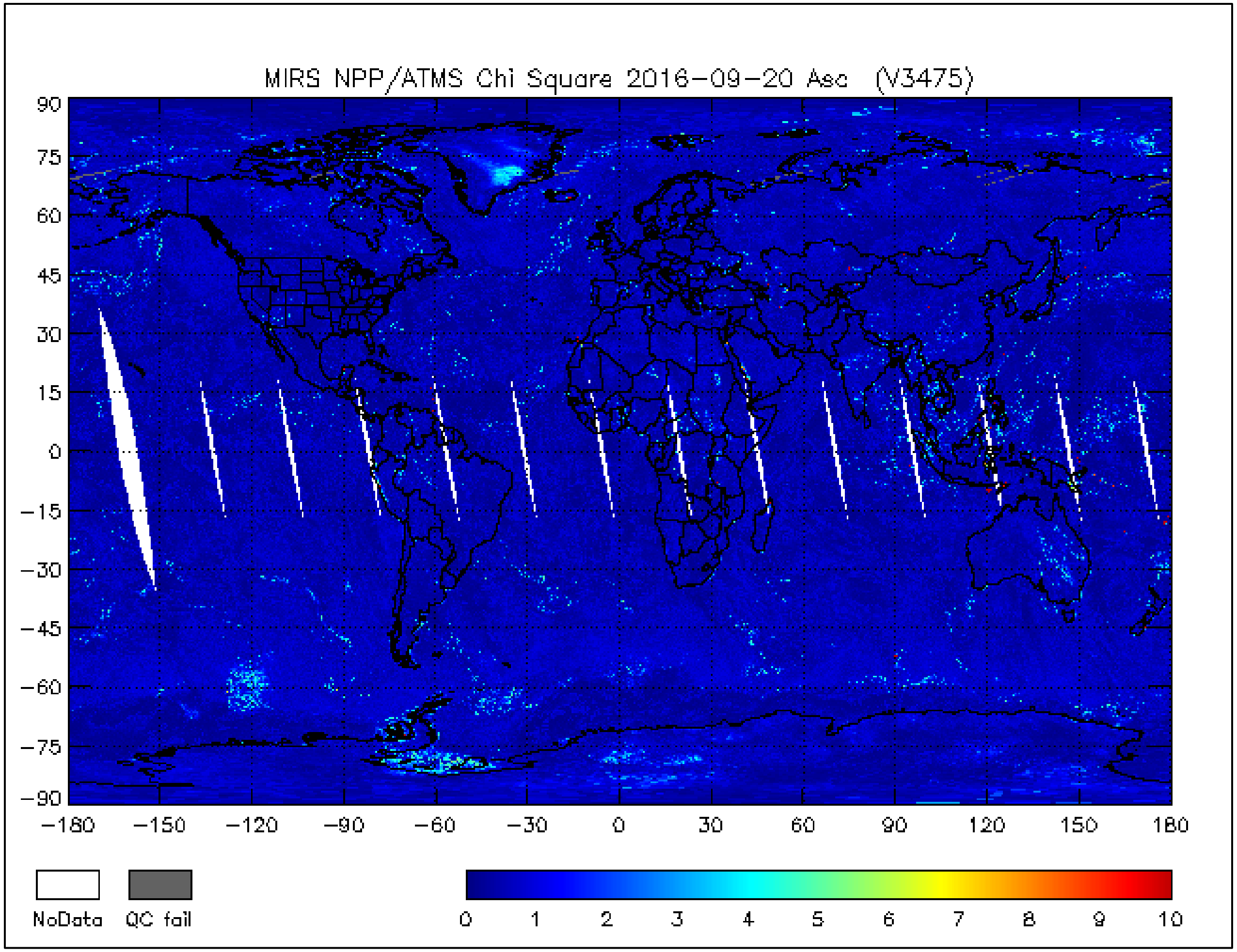
NIC IMS Sfc Type Analysis





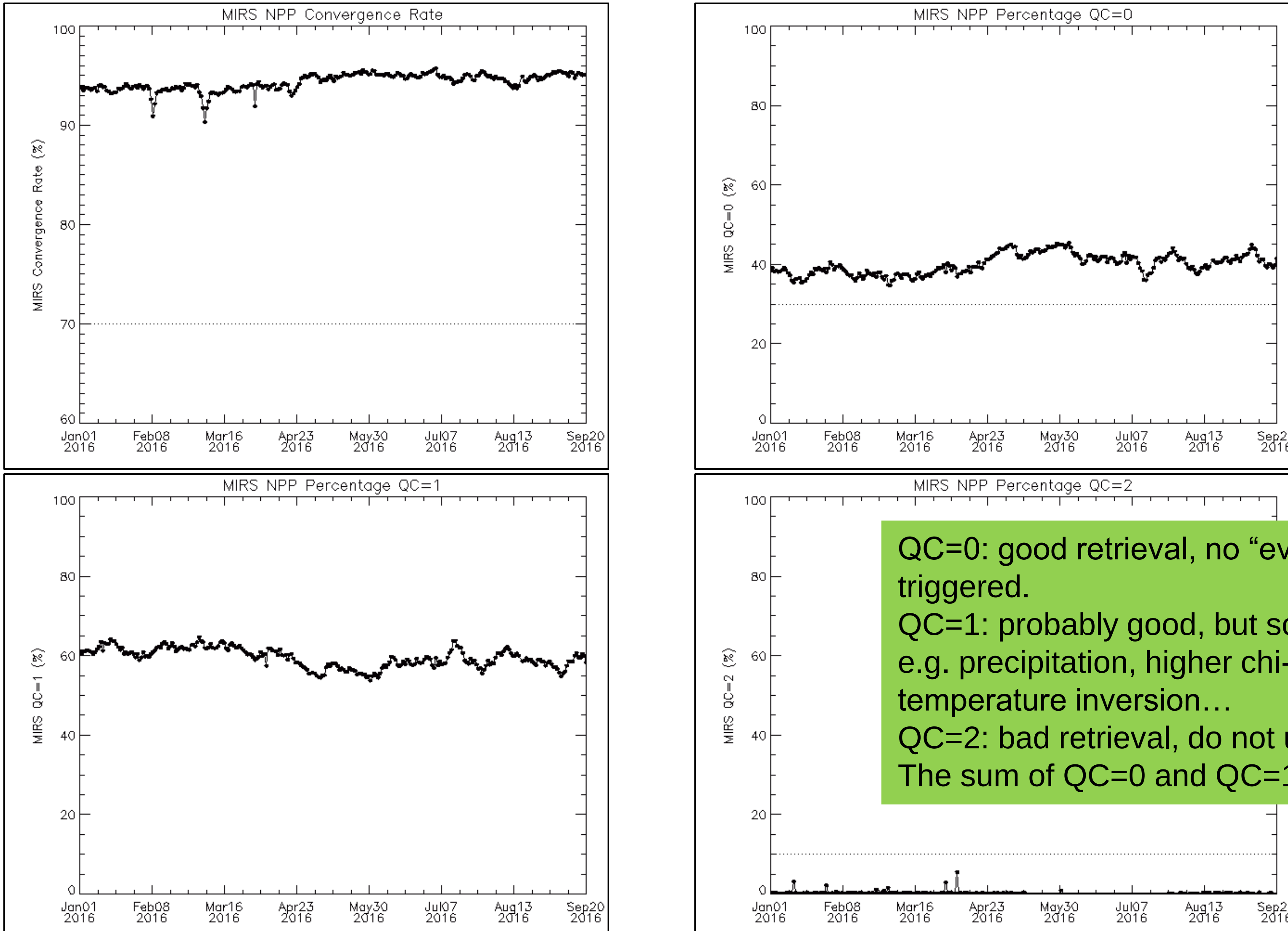
Validation Results: Chi-Square Convergence Metric

- MiRS SNPP/ATMS Chi-square (convergence) for 20 September 2016



Validation Results: QC flagging

MiRS SNPP/ATMS Convergence and QC flags: 1 Jan 2016 – 20 Sept 2016



QC=0: good retrieval, no “events” triggered.
QC=1: probably good, but some event, e.g. precipitation, higher chi-square, temperature inversion…
QC=2: bad retrieval, do not use.
The sum of QC=0 and QC=1 is > 90%

Error Budget: T, WV, TPW, RR

Compare analysis/validation results against requirements, present as a table. Error budget limitations should be explained. Describe prospects for overcoming error budget limitations with future improvement of the algorithm, test data, and error analysis methodology.

Attribute Analyzed	L1RD Threshold Accuracy/Precision	Analysis/Validation Result	Error Summary	Support Artifacts
T Profile	See Slide 8	Meets all requirements	See Slide 8	
WV Profile	See Slide 29	Meets all requirements	See Slide 29	
TPW	See Slide 39	Meets all requirements	See Slide 39	
RR	See Slides 46, 49	Meets all requirements	See Slides 46, 49	

Identification of Processing Environment

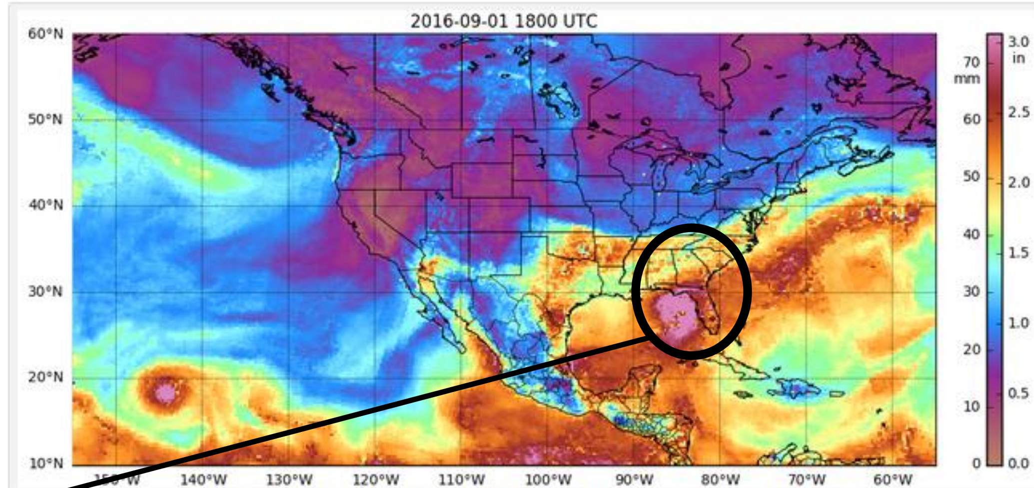
- Algorithm version: v11.1 (delivered September 2015)
- All static ancillary files needed by algorithm are contained within the DAP
- All validation conducted in STAR:
  - Linux servers running f90, IDL, bash, C/C++, libraries (hdf5 and netCDF4)
  - Many codes are run every day as part of regular validation and assessment

Users and User Feedback

- MIRS is mature algorithm. In operations since 2007 for many satellites, and since 2013 for SNPP/ATMS. Performance is very stable. Many users in research and operations:
  - NOAA NWS: CPC, NHC, TPC, SPC, WFOs
  - + more than 30 users (e.g. NASA/MSFC, JPL, CSU/CIRA, JMA, UKMO, UW/SSEC (e.g. MIMIC TPW), UMD, CMA, Taiwan Weather Bureau, CPTEC/Brazil, Max Planck Inst./Hamburg, U.Wisc/SSEC, ISRO,...)
- Examples: MIMIC-TPW, Blended TPW and Layer WV, Tropical Cyclone Intensity Monitoring
- Feedback from users
  - provide feedback, identify issues, algorithm team has issued several bug fixes/patches in past 3 years
- Downstream product list: e.g. Tailored products (OSPO can provide details), Blended TPW, TC Intensity Estimates (sent to NHC)
- No known issues in data dependencies for downstream products

User Feedback: MIMIC-TPW and CIMSS Satellite Blog

The high values of Total Precipitable Water (TPW) associated with Hermine were evident on hourly composites of **morphed TPW from MIRS sensors** ***(below)***. Rainfall amounts exceeded 22 inches in Florida (WPC storm summary)



Morphed Total Precipitable Water derived from MIRS sensors [click to play animation]

Morphed TPW animations using MiRS TPW from multiple satellites to flag flooding situations due to slow-moving tropical systems….

Tony Wimmers
to Scott, me

1:45 PM (24 minutes ago)

Hi Chris,

CIMSS has used Morphed MIRS TPW to draw attention to flooding potential from high-moisture, slow-moving tropical storms. And it verifies very well. Both events had significant flooding. Scott Lindstrom has two examples below. Is this the kind of thing you can use?

We're just beginning to get this shared with operational forecasters, so we don't have feedback from them yet. But it is coming…

Cheers,

Tony

User Feedback: Blended TPW and Layer WV

Blended TPW and Layer WV used at WPC and NHC ….

Forsythe,John
to me

5:55 PM (16 hours ago)

Hi Chris,

Hope you are doing well, happy to help. I might have sent too much but seeing as I wouldn't have a layered water vapor product without MiRS I've gathered quite a bit of this information.

I attended the National Weather Association annual meeting a few weeks ago and continued to publicize and gather support for the blended layer precipitable water. Michael Folmer has lots of anecdotes of forecasters using the product, particularly at the WPC and NHC, so if you get a chance to talk to him he can provide some more feedback. And don't forget the blended TPW (integration of the MiRS sounding, with a few other retrievals like AMSR-2 from JAXA) which has been operational throughout NWS since 2009. None of these would be possible without MiRS, as having MiRS running on several spacecraft allows time resolution we don't' get from just a single polar spacecraft. I think it speaks to the utility of the product and the need for the MiRS soundings in data-sparse regions that the product is being used operationally even with a mix of MiRS V7/V11 (SNPP only) retrievals, with attendant artifacts from having the two versions running (along track striping, SNPP sfc-850 moisture pulse).

I attached our recent paper with SPoRT on forecaster evaluations of the product from 2013. These were all MiRS except for some AIRS in clear skies, but the product wouldn't exist without MiRS. You might be able to use one of the evaluation figures from there.

I also attached some slides from the National Weather Association talk with some example uses.

For 28 days in July 2016, in the NHC Atlantic Tropical Weather Discussion (TWDAT), **CIRA LPW was mentioned 45 times** (out of 110 discussions). Widely used to assess the environment around tropical waves. Passive microwave retrievals perform around clouds, unlike GOES water vapor imagery or the Saharan Air Layer product.

Your meeting is probably not the venue but any advocacy to get everything running operationally on V11 (via the CHOPS system I believe) is worthwhile, I expect this is the single biggest quality improvement forecasters will see (higher resolution / better retrievals).

Please let me know if you need any more information. This is much more than a brief statement but there is a community of user support for these products.

Best Regards,

John

User Feedback: MiRS T and WV Profiles for TC Monitoring

CSU/CIRA Use in (1) TC Intensity Monitoring and Prediction, (2) Arctic Cold Air Aloft

Dostalek,Jack 3:13 PM (18 hours ago)
to me, quanhua.liu

Hi Chris,

We (CIRA) have been producing real-time estimates of tropical cyclone intensity and wind structure for well over a decade. The algorithm starts with microwave retrievals of temperature in and around tropical cyclones, and outputs estimates of the maximum wind, minimum pressure and the radius of the 34-, 50-, and 64-kt winds. At first we used a statistical microwave retrieval developed by Mitch Goldberg. As of last summer (2015) the version of the code which uses MiRS retrievals (from both AMSU and ATMS) has run operationally. The estimates of the TC structure (for systems in all basins) are sent out to the f-deck, where they are available to operational forecasters at the National Hurricane Center, the Central Pacific Hurricane Center, and the Joint Typhoon Warning Center.

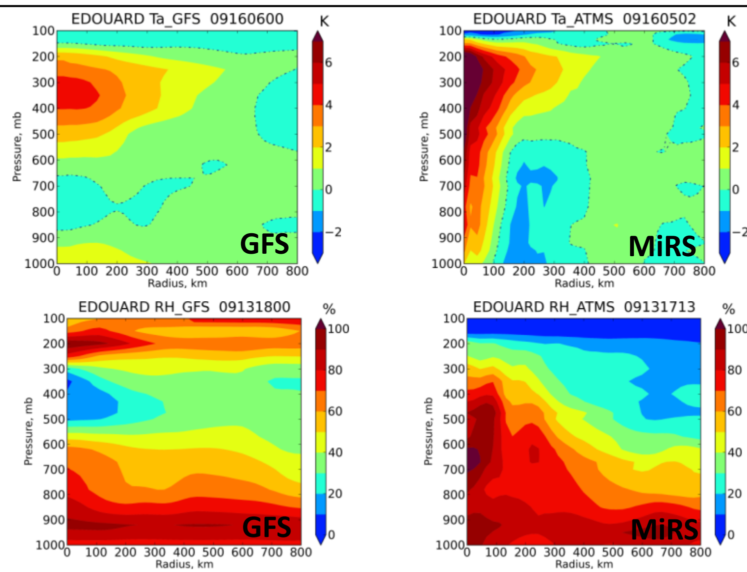
I also have been using MiRS retrievals for monitoring the Arctic Regions for areas of Cold Air Aloft. I've attached a poster outlining the work. One caveat on this application-we're having some data distribution problems, so as of Oct. 4, our AMSU-MiRS feed hasn't been working. But nevertheless, we have used MiRS in the past, and there is a chance that I will run the ATMS-MiRS eventually.

Hope this helps-let me know if you need any clarification,
Jack

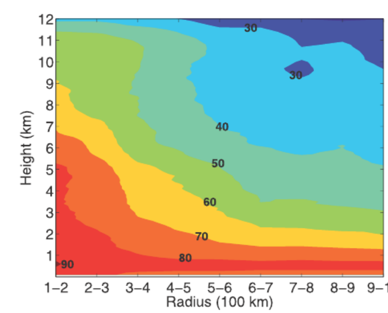
Hurricane Edouard 2014

Temp Anomaly

RH



Dropsonde Composite RH : 1997 -2005



Documentation

Science Maturity Check List	Yes ?
Readme for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes
System Maintenance Manual (for ESPC products)	Yes
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes Boukabara et al. (2011, 2013) Iturbide-Sanchez et al. (2011)
Regular Validation Reports (at least. annually) (Demonstrates long-term performance of the algorithm)	In progress

ATBD, External/Internal Users Manual, System Maintenance Manual available upon request, on Google Drive, and as part of DAP

Conclusion

- Cal/Val results summary:
  - Both Temperature, Water Vapor, TPW and Rain Rate are considered to be Validated, Level 3 Maturity
  - Performance in operations has been evaluated in STAR over more than one annual cycle, globally, over land and ocean, and in clear and cloudy conditions.
    - T and WV, TPW not operational in rainy conditions
    - RR: difficulty of validation over global oceans (ongoing issue at IPWG meeting, 3-7 Oct 2016, Bologna, Italy)

Path Forward

- Planned further improvements
  - Next 6-12 months: Extension to JPSS-1/ATMS and preliminary delivery prior to Spring 2017 launch (v11.3)
  - Future Improvements:
    - **Snowfall rate integration**
    - **Rainy condition sounding (update a priori constraints)**
    - **Hydrometeors (CLW over land for light rain detection**, precharacterization of precip type, improvements to CRTM i.e. scattering, particle size/shape distribution in CRTM)
    - **Snow cover/amount (vegetation correction)**
    - Air mass-dependent bias corrections
    - Applications/user feedback
- Planned Cal/Val activities
  - SNPP/ATMS: Continue to leverage NPROVS tool to characterize performance for specific surface, seasonal, regional, and/or atmospheric conditions. E.g. rainy sounding and methods for improving
  - Future and ongoing cal/val: Snow cover and snow water, sea ice concentration, Tskin, CLW