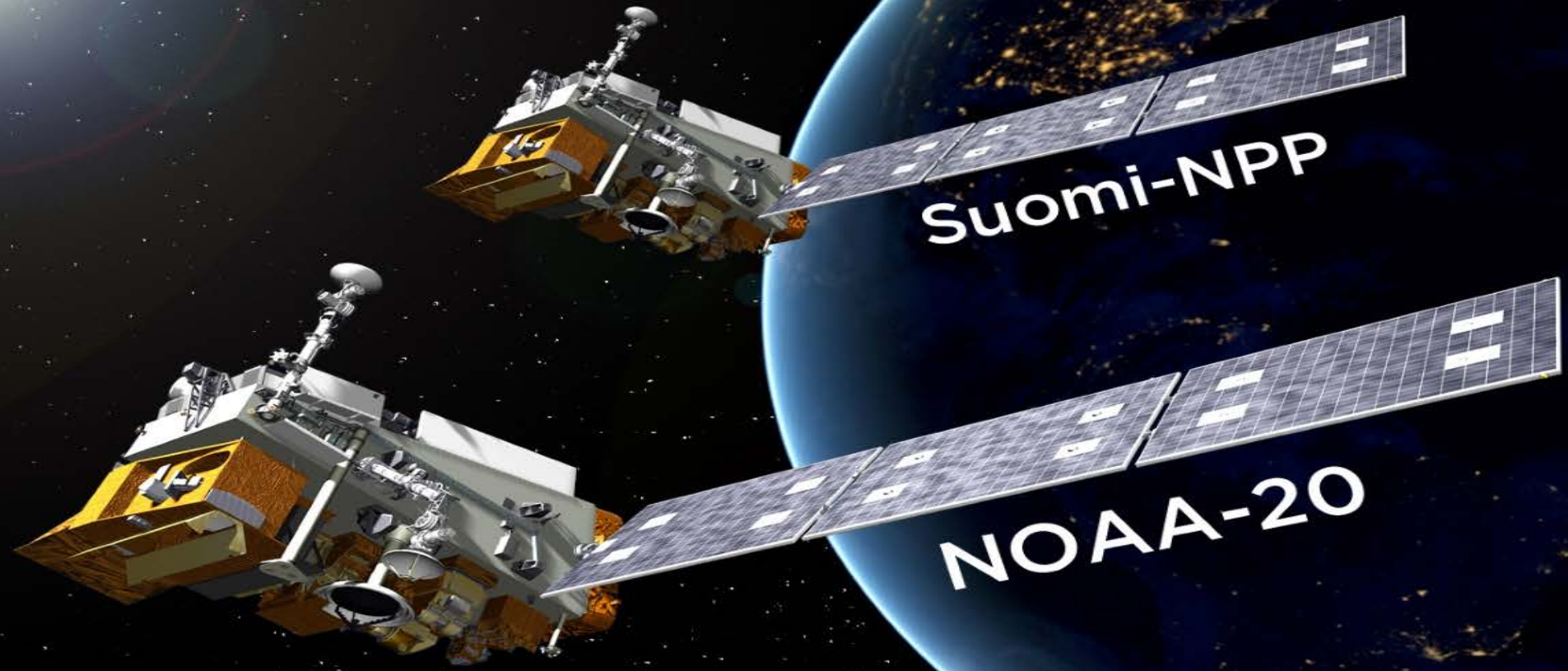
Validated Maturity Science Review For MiRS NOAA-20/ATMS Algorithm



Presented by C. Grassotti, Y.-K. Lee, S. Liu, M. Liu

Date: 2019/09/19

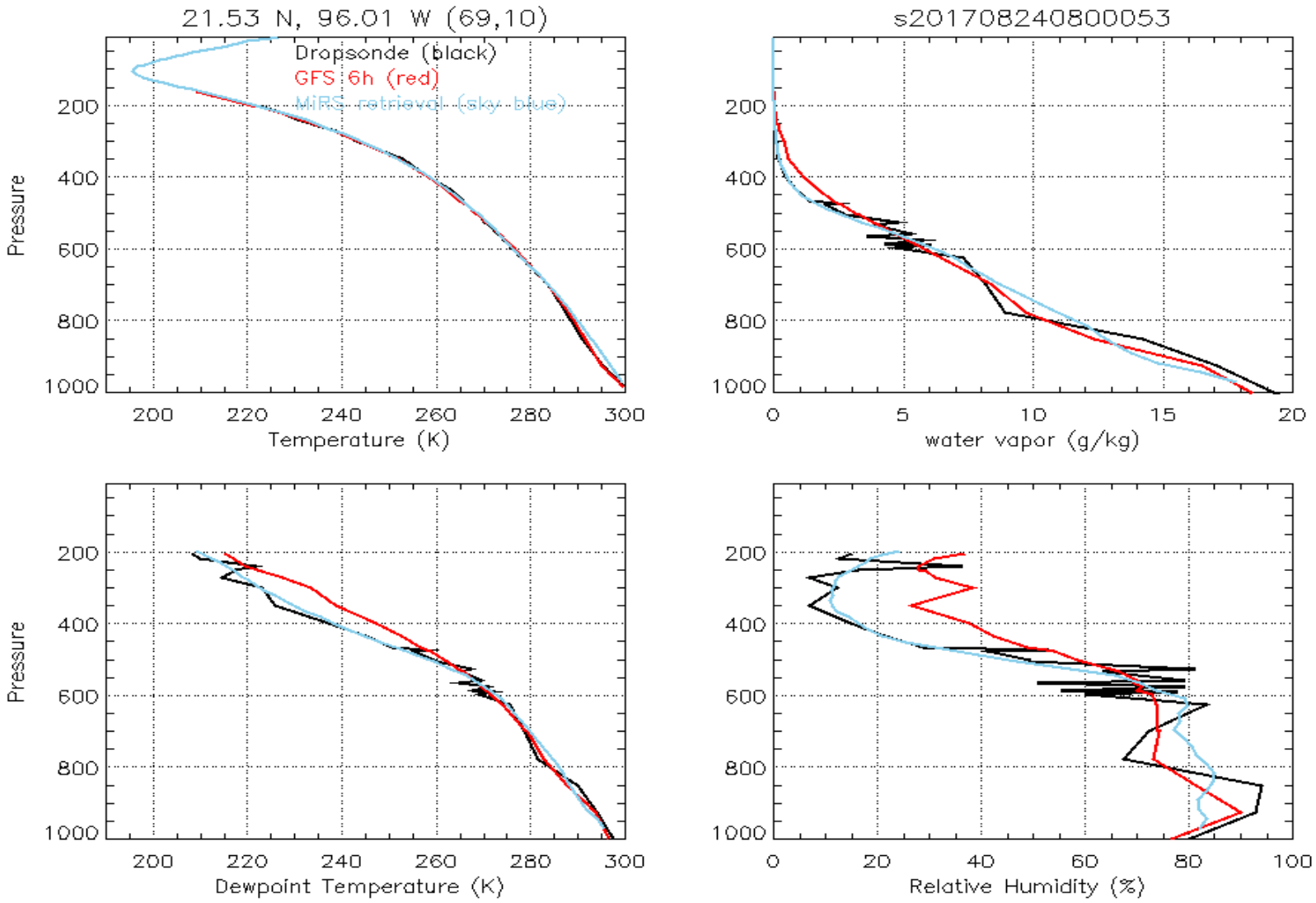
JPSS NOAA NASA

MiRS Team

Algorithm 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/CISSES)	Coordination of technical activities; review/deliverable planning
S. Liu	NESDIS/STAR/SMCD (CSU/CIRA)	Precipitation product val, SFR integration, DAP preparation
Y.-K. Lee	NESDIS/STAR/SMCD (U. MD./ESSIC/CISSES)	Sounding, emissivity, and cryosphere product val, Sounding improvements
Ming Fang	NESDIS/STAR/SMCD (IMSG)	IT optimization, MiRS build system improvement
L. Zhao	NESDIS/OSPO	Operational Product Area Lead

Dropsonde, GFS 6h Forecast, and MiRS Retrieval



MiRS Users

- Many users use MiRS products for operational applications and research.
- Operational users, who have subscriptions on PDA, are:
  - NWS NHC, NESDIS_VIZLAB, CLASS, STAR, NASA GPM, NAVO, FNMOC, 557TH, NASA JPL, GNC-A, NWC, CHINA CMA, NWS AWIPS, NWS NCO, CIRA, NASA SPORT, SSEC/CIMMS, NESDIS operational applications: eTRaP, blended TPW, blended RR, IMS and TC,
  - NHC TC intensity (POC: Galina Chirokova (CIRA))
  - International Arctic Research Center, Alaska (POC: Carl Dierking, NOAA Liaison)
  - NOAA Climate Prediction Center (POC: Pingping Xie)
  - National Ice Center
  - NWS Weather Forecast Offices
- CSPP generates MiRS products for direct broadcasting
- Users also download MiRS from CSPP and generate MiRS products at their own machines

MiRS Downstream Products

- Ensemble Tropical Rainfall Potential (**eTRaP**)
- blended TPW, and blended layer PW
- blended Rain Rate
- Snow and Ice Cover Analysis (**IMS**)
- NESDIS Microwave Sounder-based Tropical Cyclone (**TC**) Products

JPSS Data Products Maturity Definition

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Validated Maturity Review - Entry Criteria

- Product Requirements **(presented with each EDR)**
- Pre-launch Performance Matrix/Waivers **(None)**
- Validated Maturity Performance Validation
  - On-orbit instrument performance assessment
    - Identify all of the instrument and product characteristics you have verified/validated as individual bullets **(presented with each EDR)**
    - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data **(None)**
- Users/EDRs feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward
- Summary

Validated Maturity Review - Exit Criteria

- Validated Maturity Performance is well characterized and meets/exceeds the requirements:
  - On-orbit instrument performance assessment
    - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria **(presented with each EDR)**
    - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk. **(None)**
- Updated Validated Maturity Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Validated Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward

VALIDATED MATURITY REVIEW MATERIAL

Outline

- Algorithm Team Members
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - **Product requirements/Validation results (supplemental slides at end of presentation)**
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward
- Supplemental Slides

Identification of Processing Environment

- Algorithm version: v11.4 (delivered March 2019)
- 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

Evaluation of algorithm performance to specification requirements

- MiRS initial operational processing at NDE was v9.2 in June 2013. NOAA-20 ATMS capability was delivered with v11.3 in Dec 2018, and TTO in March 2019. MiRS v11.4 was delivered in March 2019, and TTO in July. Most validation results shown here reflect v11.3.
  - Primary change in v11.3 ➔ v11.4 was update of radiometric bias correction (minor impact on T profile bias, example shown).

- Cal/Val Activities for evaluating algorithm performance:
  - **T, WV**: Regular comparisons with radiosondes (NPROVS system). NPROVS group has been monitoring MiRS products. MiRS group has NPROVS software and is also analyzing performance, globally, regionally, and seasonally.
  - Daily comparisons to both ECMWF and GDAS: global maps and statistics. Results automatically posted to MiRS website each day. (T, WV, TPW). Other parameters such as LSE, LST, CLW are compared qualitatively with ECMWF and GDAS.
  - **LSE**: Analytic emissivity using CRTM, VIIRS LST (not ECMWF) and ECMWF atmospheric T, WV profiles with global coverage in 4 different seasons
  - **LST**: SURFRAD ground-based measurements for 7 sites over CONUS for the period Nov 2017- Mar 2019
  - **Sea Ice Concentration**: Regular comparisons with NASA SSMIS (F17/F18) NRT 25-km product (NASA Team Algorithm), supplemented with 4-km NIC/IMS analyses.
  - **SWE/SC**: Regular comparisons with JAXA Algorithm (AMSR2) 25-km product, supplemented with NIC/IMS analyses.
  - **Rain Rate**: Regular comparisons with surface radar-gauge analyses (Stage IV and MRMS) over CONUS and nearby waters.
  - **CLW**: Regular comparisons with JAXA AMSR2 CLW. Qualitative comparisons with ECMWF CLW.
  - External Users: provide feedback, identify issues, algorithm team has issued several bug fixes/patches in past few years.
  - **NOTE:** SFR already at Validated maturity, so not validated here.

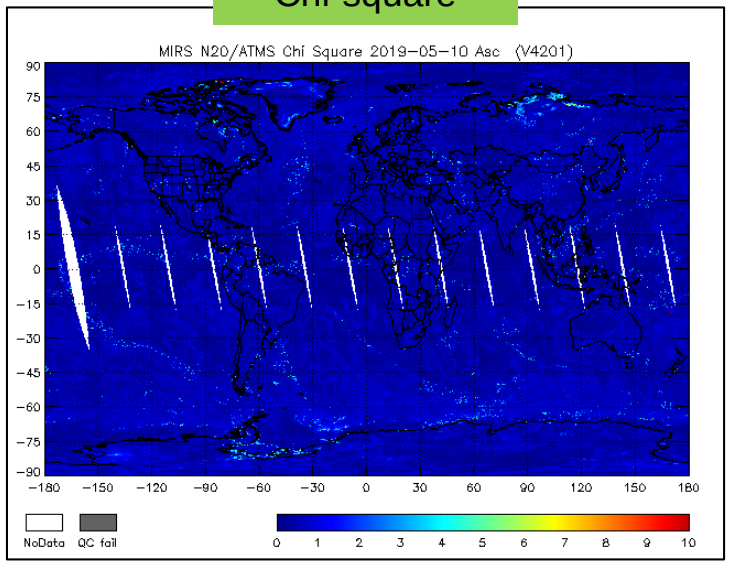
Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data: MiRS requires (1) TDRs (for retrieval), (2) SDRs (for NEDTs), and (3) geolocation
  - Ancillary Data: GFS (0.5 deg) data for SFR procedure (not validated in this review)
  - Upstream algorithms: None (if/when TDR/SDR processing changes, we evaluate impacts and update bias corrections if needed)
  - 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.
  - Only change has been the update to the radiometric bias correction in v11.4. Only impact is on temperature profile bias and this is minor (example shown).
  - 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

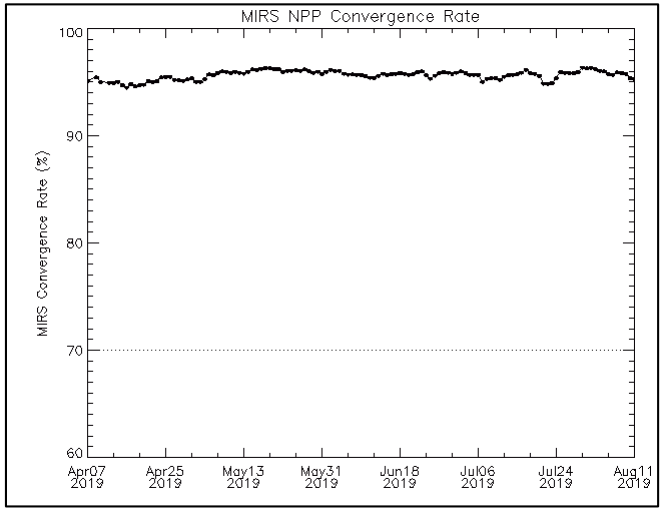
Quality flag analysis/validation

- 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.

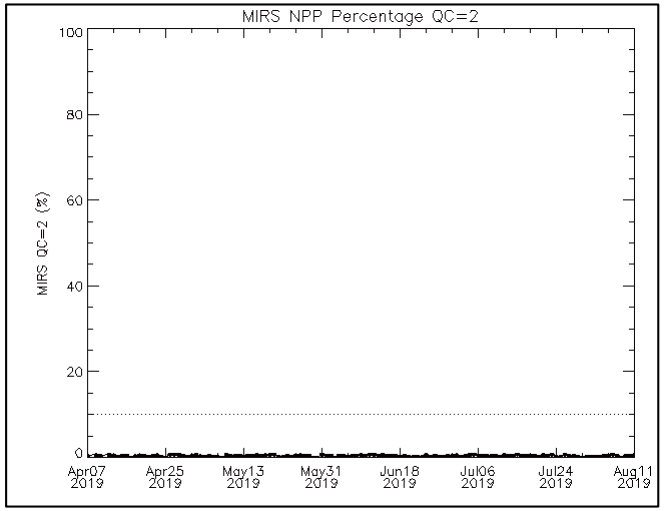
Chi-square



Convergence Rate: 2019-04-03 to 2019-08-11



Percent QC=bad: 2019-04-03 to 2019-08-11



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, 2=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	Bit 16	Bit 17	Bit 18	Bit 19
QC (1)	0 = GOOD, 1= SOME EVENT/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		SFR			
				LIGHT	MEDIUM	HEAVY	TSKIN	TEMP	Q	EMISS	TPW	ICLW	RWP	GWP			RTM CONVERGENCE	SFR LOW/UNDETERMINED		
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				

New flags added for SFR in v11.4

Validation Data Sets: EDRs, Reference data, Time Periods

- **Temperature, and Water vapor profiles**: Radiosonde
  : 6 ten-day periods (2018.01.09-20, 2018.04.09-20, 2018.07.09-20, 2018.10.09-20, 2019.01.09-20, 2019.04.09-20)
- **Temperature, Water vapor profiles, and TPW**: ECMWF AND GDAS
  : 6 days (2018.01.15, 2018.04.15, 2018.07.15, 2018.10.15, 2019.01.15, 2019.04.15) and daily time series since launch (T and WV)
- **Land Surface Temperature**: SURFRAD ground based measurements
  : 14 months (2017.11.29-2019.03.04)
- **Land Surface Temperature**: VIIRS LST
  : 7 days (2019.03.17, 2019.04.01, 2019.04.14, 2019.05.11, 2019.05.29, 2019.06.04, 2019.06.12)
- **Land Surface Emissivity**: VIIRS LST and ECMWF as input to CRTM (Analytic emissivity eqn.), also ECMWF LST as input
  : 7 days VIIRS (2019.03.17, 2019.04.01, 2019.04.14, 2019.05.11, 2019.05.29, 2019.06.04, 2019.06.12)
  : 7 days ECMWF (2018.01.15, 2018.04.15, 2018.07.15, 2018.10.15, 2019.01.15, 2019.04.15, 2019.07.15)
- **Sea Ice Concentration**: SSMIS NRT (F18)
  : 2019.01.19 – 2019.07.09 daily time series
- **Sea Ice Concentration**: IMS
  : 4 days (2018.01.15, 2018.12.15, 2019.01.15, and 2019.02.15)
- **Snow Water Equivalent and Snow Cover**: JAXA AMSR2 and IMS
  : 4 days (2018.01.15, 2018.12.15, 2019.01.15, and 2019.02.15)
- **Rain Rate**: Stage IV and MRMS
  : 4 ~3-month periods (seasons) during 2018-2019
- **Cloud Liquid Water**: JAXA AMSR2 and ECMWF
  : 4 days (2019-01-09, 2019-04-09, 2019-06-21, 2018-09-09)

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
- All accuracy and precision requirements are met

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	

Data collected:

ECMWF and GDAS: 2018.01.15, 2018.04.15 2018.07.15, 2018.10.15, 2019.01.15, and 2019.04.15

Radiosonde: 6 ten-day periods 2018.01.09-01.20, 2018.04.09-04.20, 2018.07.09-07.09, 2018.10.09-10.20, 2019.01.09-01.20, and 2019.04.09-04.20

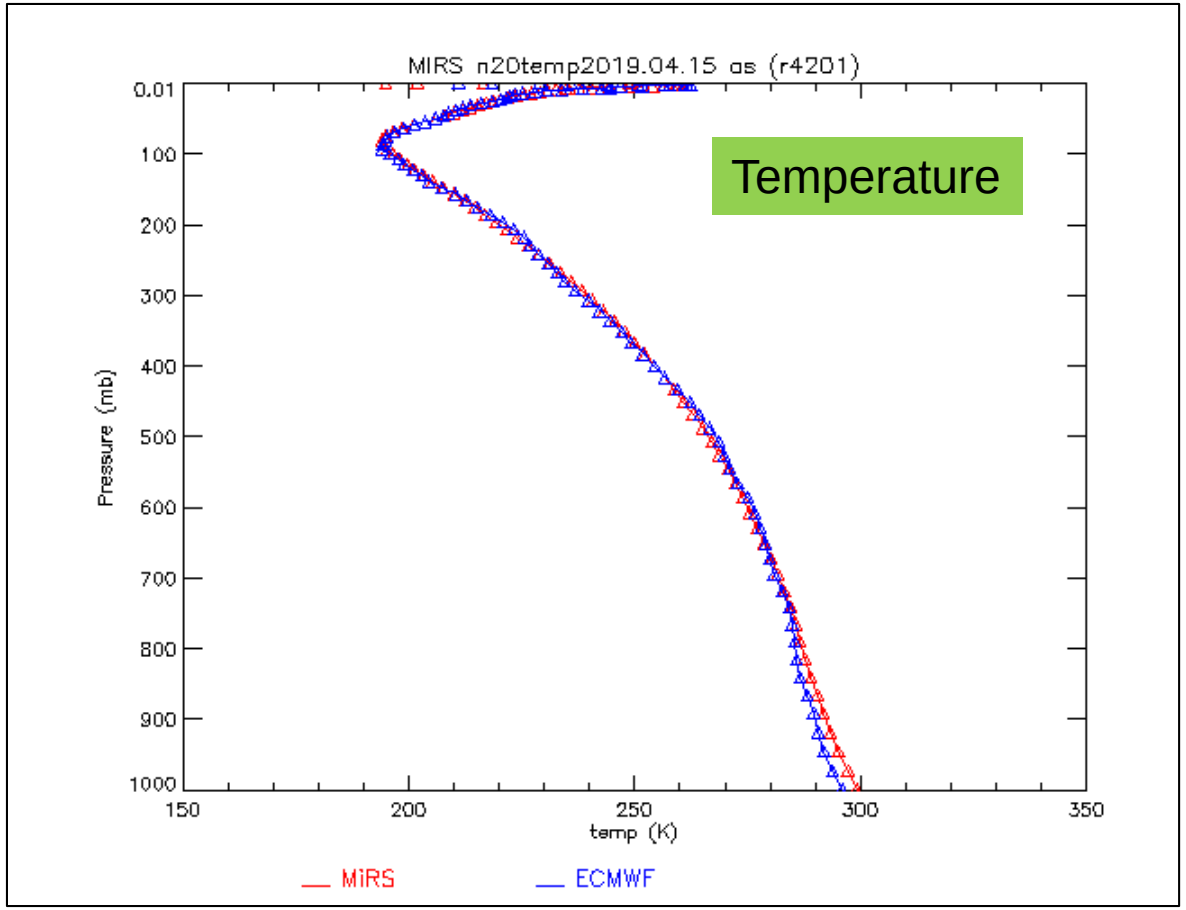
Collocation details:

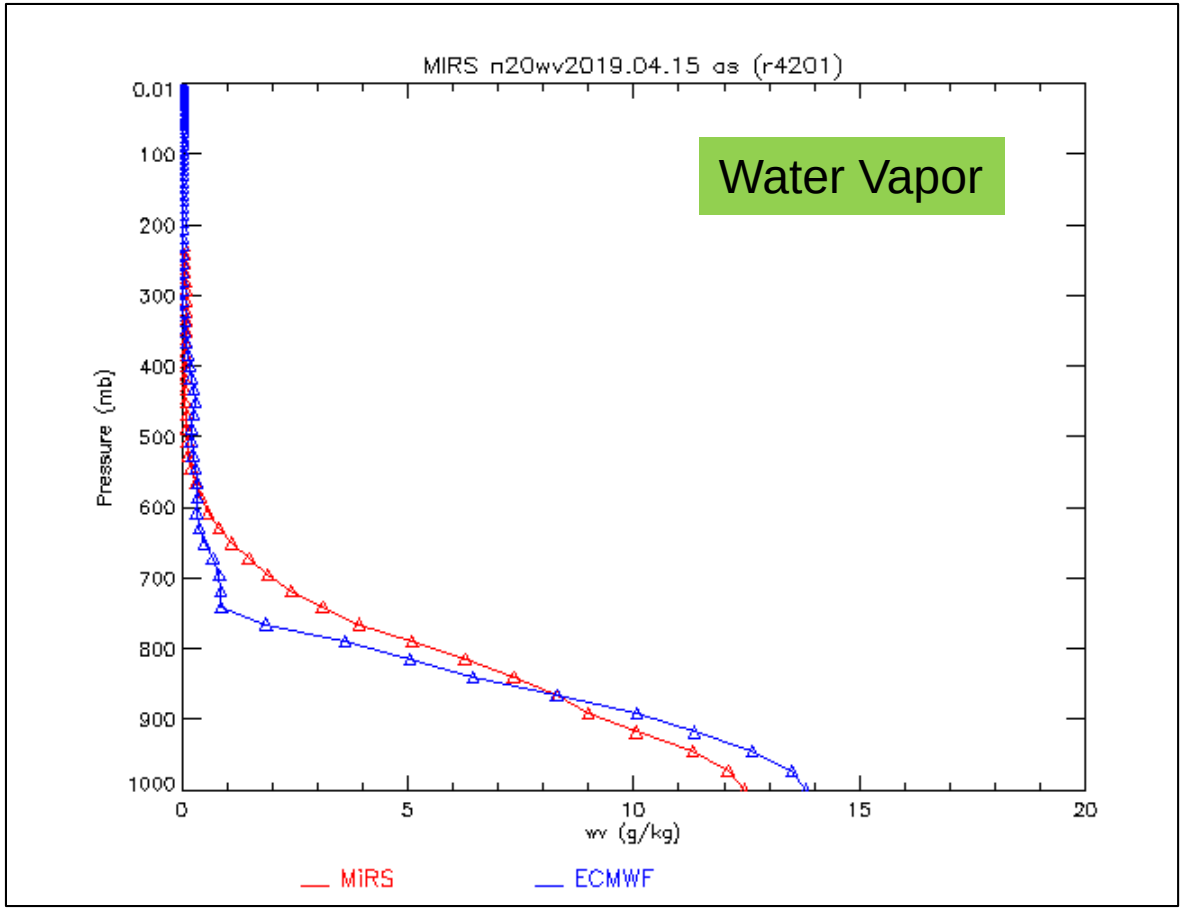
- ECMWF and GDAS: bilinear interpolation in space and time from 1 deg lat/lon, 6-hour analyses
- Radiosonde (NPROVS): radius: 250 km & time: 6 hour

Original retrieval on 100 Layers from 0.01 to 1100 hPa

Date: 2019-04-15
Lat: 20.16 N
Lon: 170.23 W
Psfc: 1008.5

Symbols plotted at every p layer





Requirements and Validation Results: Temperature Profile Compared to radiosondes

Sea

Scene	Layer (hPa)	Accuracy (K)		Precision (K)	
		MiRS	Req	MiRS	Req
Clear	100	**-0.19 (-0.06)**	**0.5**	**1.90 (1.92)**	**2.0**
	300	**-0.35 (0.10)**	**0.5**	**1.43 (1.50)**	**2.0**
	500	**-0.14 (0.05)**	**0.5**	**1.38 (1.37)**	**2.0**
	900	**0.05 (0.10)**	**1.5**	**2.00 (1.98)**	**3.0**
Cloudy	100	**-0.07 (0.03)**	**0.8**	**2.09 (2.10)**	**2.0**
	300	**-0.43 (0.08)**	**0.8**	**1.50 (1.51)**	**2.5**
	500	**0.23 (0.39)**	**0.8**	**1.37 (1.38)**	**2.0**
	900	**0.39 (0.40)**	**2.0**	**2.03 (2.02)**	**3.0**

Land

Scene	Layer (hPa)	Accuracy (K)		Precision (K)	
		MiRS	Req	MiRS	Req
Clear	100	**-0.23 (-0.19)**	**1.0**	**2.07 (2.10)**	**2.0**
	300	**-0.26 (0.35)**	**0.8**	**1.83 (1.83)**	**2.0**
	500	**-0.36 (0.13)**	**0.5**	**1.59 (1.60)**	**2.5**
	900	**0.13 (-0.32)**	**2.5**	**2.93 (2.93)**	**5.5**
Cloudy	100	**-0.08 (0.02)**	**1.0**	**1.99 (2.19)**	**2.0**
	300	**-0.25 (0.35)**	**0.8**	**1.99 (2.02)**	**2.0**
	500	**0.00 (0.50)**	**0.5**	**1.70 (1.73)**	**2.5**
	900	**0.02 (-0.39)**	**2.5**	**3.06 (3.08)**	**5.5**

Values in ( ) indicates NPP

Meets requirement

Marginal (± 20%)

Requirements and Validation Results: Temperature Profile Compared to GDAS

Sea

Scene	Layer (hPa)	Accuracy (K)		Precision (K)	
		MiRS	Req	MiRS	Req
Clear	100	**-0.82 (-0.63)**	**0.5**	**1.46 (1.50)**	**2.0**
	300	**-0.32 (0.07)**	**0.5**	**1.43 (1.47)**	**2.0**
	500	**0.16 (0.34)**	**0.5**	**1.24 (1.25)**	**2.0**
	900	**0.50 (0.63)**	**1.5**	**1.78 (1.83)**	**3.0**
Cloudy	100	**-0.54 (-0.37)**	**0.8**	**1.46 (1.53)**	**2.0**
	300	**-0.42 (-0.15)**	**0.8**	**1.72 (1.76)**	**2.5**
	500	**0.02 (-0.37)**	**0.8**	**1.45 (1.48)**	**2.0**
	900	**0.58 (0.25)**	**2.0**	**2.13 (2.12)**	**3.0**
Rainy	100	**-1.23 (-1.13)**	**1.5**	**1.46 (1.49)**	**2.5**
	300	**-0.32 (0.07)**	**1.5**	**1.43 (1.47)**	**2.5**
	500	**1.26 (1.46)**	**2.0**	**2.02 (1.97)**	**2.5**
	900	**0.50 (0.63)**	**2.0**	**1.78 (1.83)**	**3.5**

Land

Scene	Layer (hPa)	Accuracy (K)		Precision (K)	
		MiRS	Req	MiRS	Req
Clear	100	**-1.03 (-0.85)**	**1.0**	**1.60 (1.63)**	**2.0**
	300	**-0.07 (0.31)**	**0.8**	**1.52 (1.56)**	**2.0**
	500	**0.04 (0.29)**	**0.5**	**1.46 (1.49)**	**2.5**
	900	**-0.59 (-0.56)**	**2.5**	**2.94 (3.01)**	**5.5**
Cloudy	100	**-0.78 (-0.67)**	**1.0**	**1.68 (1.66)**	**2.0**
	300	**-0.14 (0.31)**	**0.8**	**1.53 (1.55)**	**2.0**
	500	**0.14 (0.50)**	**0.5**	**1.36 (1.40)**	**2.5**
	900	**-0.02 (-0.20)**	**2.5**	**3.17 (3.26)**	**5.5**
Rainy	100	**-1.81 (-1.60)**	**1.5**	**1.72 (1.71)**	**2.5**
	300	**-0.27 (0.13)**	**1.5**	**1.79 (1.82)**	**2.5**
	500	**0.85 (1.09)**	**1.0**	**1.85 (1.85)**	**3.0**
	900	**0.35 (0.26)**	**2.5**	**3.71 (3.76)**	**5.5**

Values in ( ) indicates NPP

Meets requirement

Marginal (± 20%)

Requirements and Validation Results: Temperature Profile Compared to ECMWF

Sea

Scene	Layer (hPa)	Accuracy (K)		Precision (K)	
		MiRS	Req	MiRS	Req
Clear	100	**-0.12 (0.07)**	**0.5**	**1.55 (1.58)**	**2.0**
	300	**0.23 (0.62)**	**0.5**	**1.54 (1.59)**	**2.0**
	500	**-0.49 (-0.30)**	**0.5**	**1.28 (1.29)**	**2.0**
	900	**0.52 (0.65)**	**1.5**	**1.84 (1.88)**	**3.0**
Cloudy	100	**-0.16 (0.01)**	**0.8**	**1.56 (1.63)**	**2.0**
	300	**0.06 (0.33)**	**0.8**	**1.87 (1.82)**	**2.5**
	500	**-0.62 (-0.37)**	**0.8**	**1.50 (1.52)**	**2.0**
	900	**0.99 (1.10)**	**2.0**	**2.26 (2.25)**	**3.0**
Rainy	100	**-0.56 (-0.41)**	**1.5**	**1.59 (1.65)**	**2.5**
	300	**0.23 (0.62)**	**1.5**	**1.54 (1.59)**	**2.5**
	500	**0.50 (0.70)**	**2.0**	**2.03 (1.98)**	**2.5**
	900	**0.52 (0.65)**	**2.0**	**1.84 (1.88)**	**3.5**

Land

Scene	Layer (hPa)	Accuracy (K)		Precision (K)	
		MiRS	Req	MiRS	Req
Clear	100	**-0.29 (-0.11)**	**1.0**	**1.67 (1.70)**	**2.0**
	300	**0.24 (0.62)**	**0.8**	**1.60 (1.64)**	**2.0**
	500	**-0.29 (-0.04)**	**0.5**	**1.51 (1.53)**	**2.5**
	900	**-0.40 (-0.40)**	**2.5**	**2.83 (2.88)**	**5.5**
Cloudy	100	**0.03 (0.12)**	**1.0**	**1.59 (1.73)**	**2.0**
	300	**0.11 (0.64)**	**0.8**	**1.63 (1.65)**	**2.0**
	500	**-0.30 (0.04)**	**0.5**	**1.46 (1.50)**	**2.5**
	900	**0.00 (-0.18)**	**2.5**	**3.02 (3.09)**	**5.5**
Rainy	100	**-0.90 (-0.66)**	**1.5**	**1.81 (1.80)**	**2.5**
	300	**0.05 (0.45)**	**1.5**	**1.84 (1.86)**	**2.5**
	500	**0.39 (0.65)**	**1.0**	**1.89 (1.86)**	**3.0**
	900	**0.33 (0.29)**	**2.5**	**3.41 (3.50)**	**5.5**

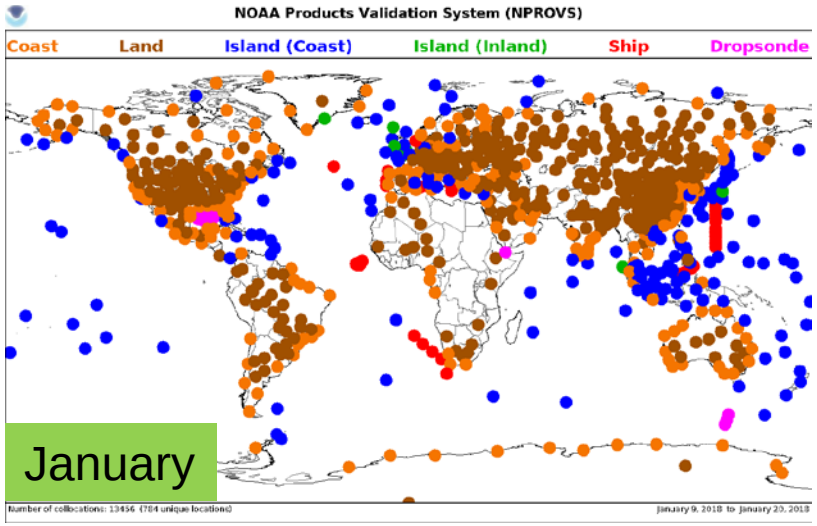
Values in ( ) indicates NPP

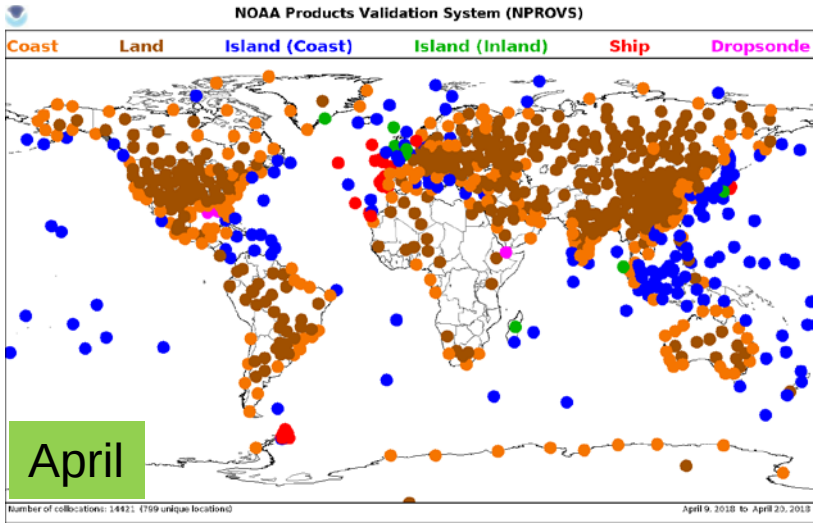
Meets requirement

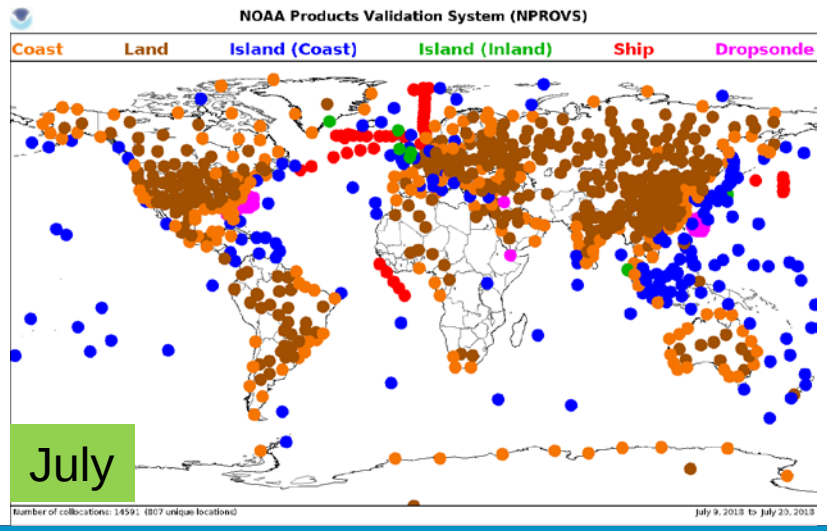
Validate MiRS Temp and WV retrieval based on collocated sonde data

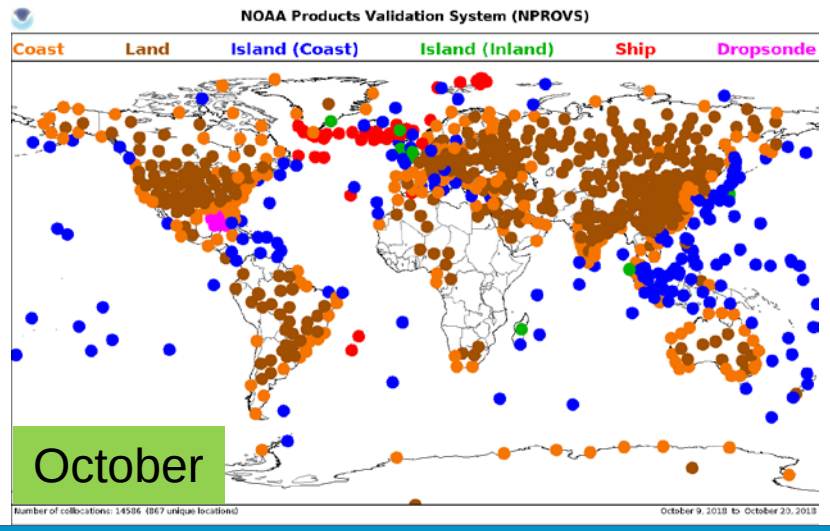
Validation data are from 6 ten day periods in January, April, July and October 2018, and January and April 2019. Collocation criteria: +/- 6 hour, 250km radius

Locations of collocated sonde observation 2018



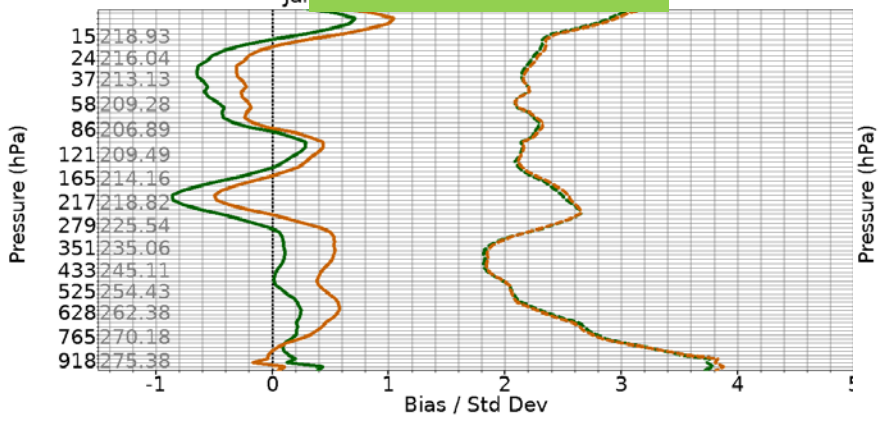




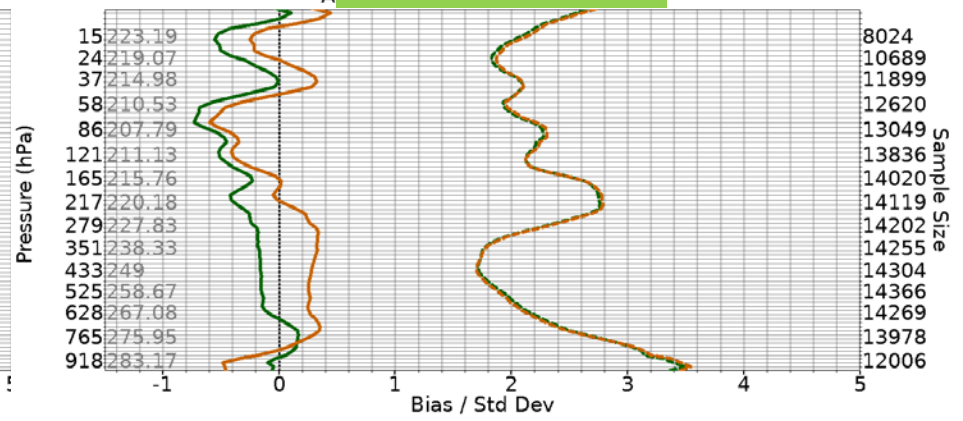


Temperature Profile Validation based on sonde data

9-20 Jan 2018



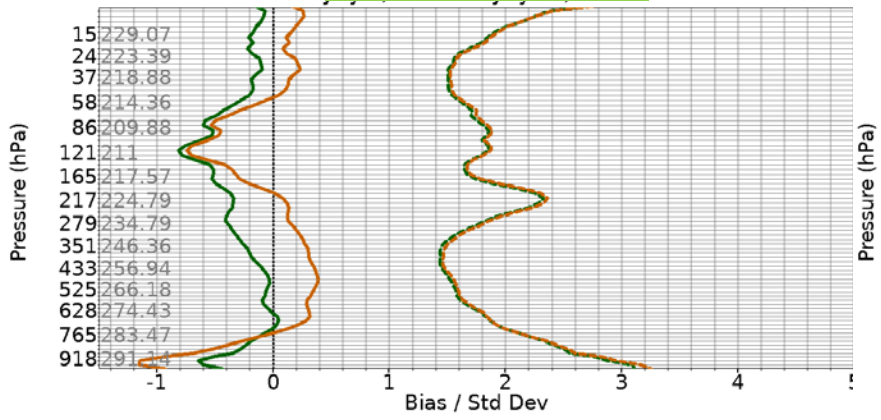
9-20 Apr 2018



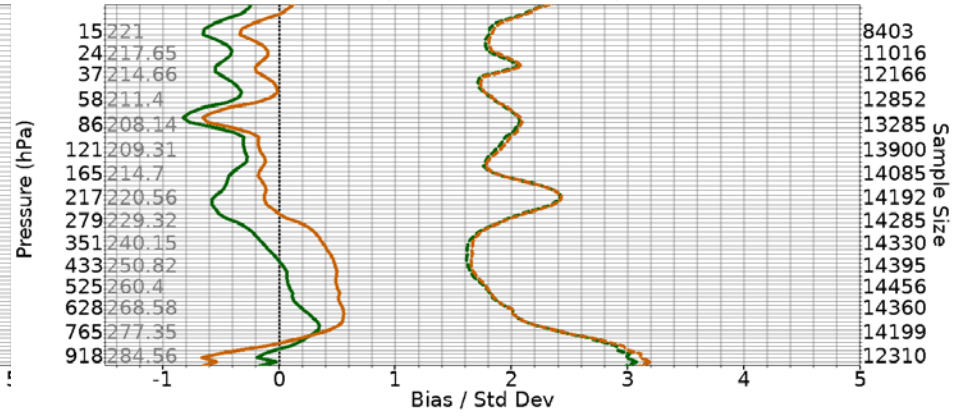
Baseline: SONDE

MIRS NPP MIRS NOAA-20

9-20 Jul 2018



9-20 Oct 2018



Baseline: SONDE

MIRS NPP MIRS NOAA-20

Temperature (K) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods

Land Clear

N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.32	-0.23	-0.23	-0.31	2.18	1.94	1.63	3.28
2018.04.15	-0.15	-0.62	-0.46	0.37	2.43	2.05	1.64	3.27
2018.07.15	-0.22	-0.45	-0.16	-0.29	1.73	1.58	1.53	2.45
2018.10.15	0.13	-0.40	-0.27	-0.40	1.73	1.65	1.48	2.90
2019.01.15	-1.23	0.41	-0.66	0.49	2.28	1.93	1.67	2.77
2019.04.15	-0.31	-0.47	-0.51	0.89	2.08	1.84	1.55	3.38

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.42	0.33	0.21	-0.45	2.21	1.94	1.69	3.23
2018.04.15	-0.06	-0.01	0.03	-0.02	2.47	2.03	1.62	3.23
2018.07.15	-0.18	0.21	0.38	-0.66	1.74	1.57	1.54	2.47
2018.10.15	-0.00	0.21	0.25	-0.71	1.79	1.66	1.48	2.95
2019.01.15	-1.11	1.01	-0.20	0.24	2.30	1.95	1.69	2.76
2019.04.15	-0.12	-0.09	-0.27	0.91	2.10	1.85	1.58	3.38

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Temperature (K) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods; sea statistics based on ~ 100 samples per 10-day period

Sea Clear

N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	100 hPa (0.5 K)	300 hPa (0.5 K)	500 hPa (0.5 K)	900 hPa (1.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	0.18	-0.53	0.22	-0.31	2.00	1.56	1.47	2.30
2018.04.15	0.29	-0.30	-0.20	-0.29	2.04	1.64	1.43	1.87
2018.07.15	-0.35	-0.42	0.05	-0.04	1.85	1.23	1.47	1.95
2018.10.15	0.44	-0.45	0.23	0.13	1.74	1.30	1.26	2.12
2019.01.15	-1.50	-0.06	-1.00	0.74	1.85	1.41	1.26	1.75
2019.04.15	-0.96	-0.44	-0.20	1.03	1.85	1.32	1.37	2.40

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	100 hPa (0.5 K)	300 hPa (0.5 K)	500 hPa (0.5 K)	900 hPa (1.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	0.26	0.14	0.55	-0.38	1.98	1.60	1.29	2.19
2018.04.15	0.34	0.14	-0.05	-0.09	2.08	1.68	1.45	2.08
2018.07.15	-0.14	-0.18	0.19	0.24	1.89	1.37	1.52	1.76
2018.10.15	0.61	0.03	0.34	-0.14	1.89	1.34	1.23	2.03
2019.01.15	-1.36	0.37	-0.77	0.87	1.78	1.61	1.37	1.86
2019.04.15	-0.96	0.28	-0.21	0.62	1.88	1.45	1.30	2.53

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Temperature (K) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods

Land Cloudy

N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.40	-0.28	0.18	-0.19	2.25	1.96	1.77	3.22
2018.04.15	-0.05	-0.39	-0.00	-0.01	2.32	2.19	1.77	3.26
2018.07.15	-0.18	-0.36	-0.07	-0.52	1.75	1.72	1.39	2.62
2018.10.15	-0.01	-0.31	0.06	0.18	1.20	1.99	1.80	2.97
2019.01.15	-0.58	0.08	-0.17	0.62	2.42	2.09	1.78	3.24
2019.04.15	-0.38	-0.23	-0.29	0.77	2.04	2.04	1.76	3.35

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.52	0.31	0.64	-0.63	2.32	2.00	1.83	3.23
2018.04.15	0.04	0.21	0.52	-0.37	2.38	2.23	1.80	3.25
2018.07.15	-0.14	0.27	0.46	-0.90	1.77	1.76	1.42	2.65
2018.10.15	0.11	0.30	0.56	-0.28	2.03	2.00	1.82	3.03
2019.01.15	-0.43	0.67	0.30	0.23	2.45	2.12	1.80	3.26
2019.04.15	-0.23	0.19	-0.02	0.68	2.07	2.09	1.77	3.43

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Temperature (K) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods; sea statistics based on ~ 100 samples per 10-day period

Sea Cloudy

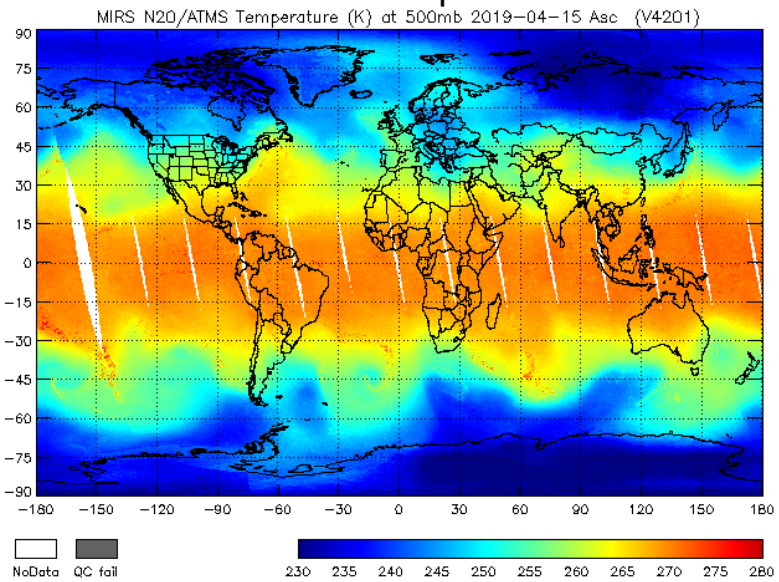
N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	100 hPa (0.8 K)	300 hPa (0.8 K)	500 hPa (0.8 K)	900 hPa (2.0 K)	100 hPa (2.0 K)	300 hPa (2.5 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	0.25	-0.56	0.52	0.28	2.10	1.43	1.45	2.09
2018.04.15	0.22	-0.63	0.12	0.25	2.12	1.56	1.33	1.86
2018.07.15	-0.18	-0.52	-0.06	0.59	2.06	1.48	1.31	2.11
2018.10.15	0.27	-0.35	0.39	0.31	1.87	1.47	1.29	2.02
2019.01.15	-0.92	-0.07	0.19	0.54	2.26	1.54	1.48	2.05
2019.04.15	-0.21	-0.38	0.30	0.86	2.02	1.30	1.39	2.00

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	100 hPa (0.8 K)	300 hPa (0.8 K)	500 hPa (0.8 K)	900 hPa (2.0 K)	100 hPa (2.0 K)	300 hPa (2.5 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	0.37	-0.09	0.67	0.36	2.11	1.43	1.53	2.05
2018.04.15	0.33	-0.17	0.26	0.26	2.08	1.66	1.31	1.95
2018.07.15	-0.15	0.05	0.19	0.52	2.09	1.45	1.30	2.12
2018.10.15	0.36	0.16	0.49	0.30	1.98	1.43	1.27	2.00
2019.01.15	-0.78	0.47	0.36	0.56	2.23	1.60	1.48	2.00
2019.04.15	-0.13	0.09	0.40	0.77	2.09	1.38	1.44	2.12

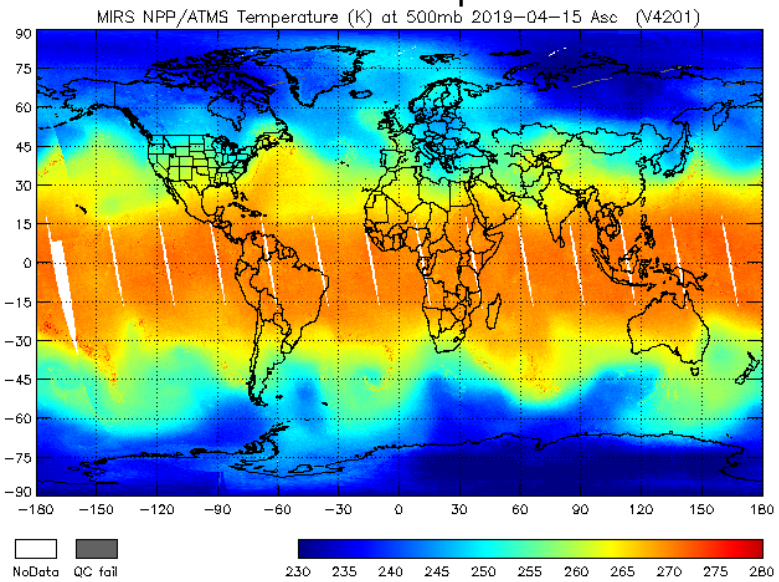
Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Temperature Profile Validation based on ECMWF data

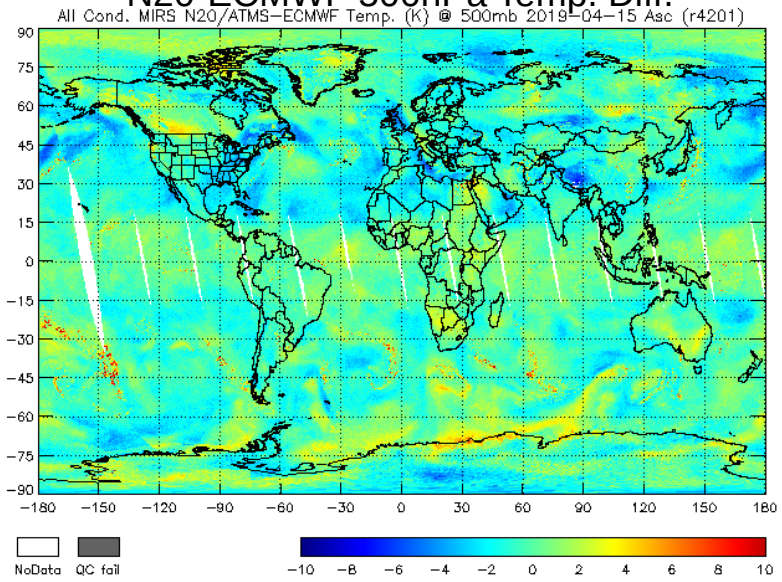
N20 500hPa Temperature



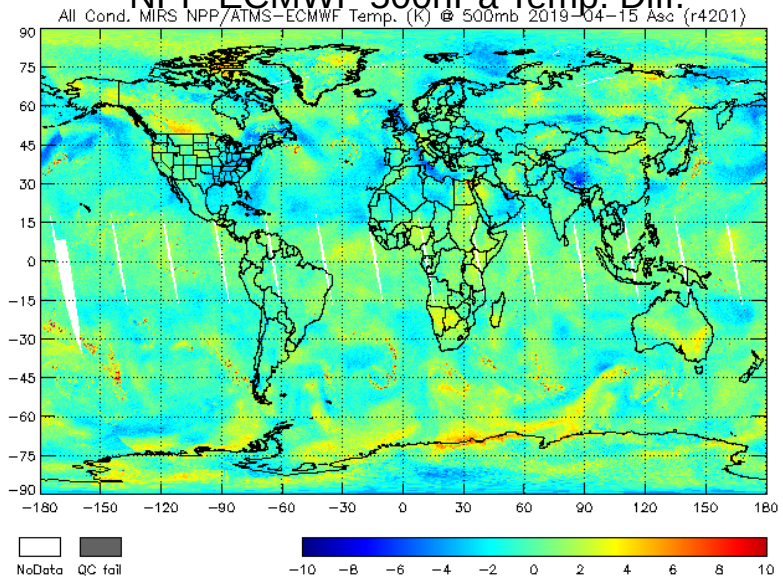
NPP 500hPa Temperature



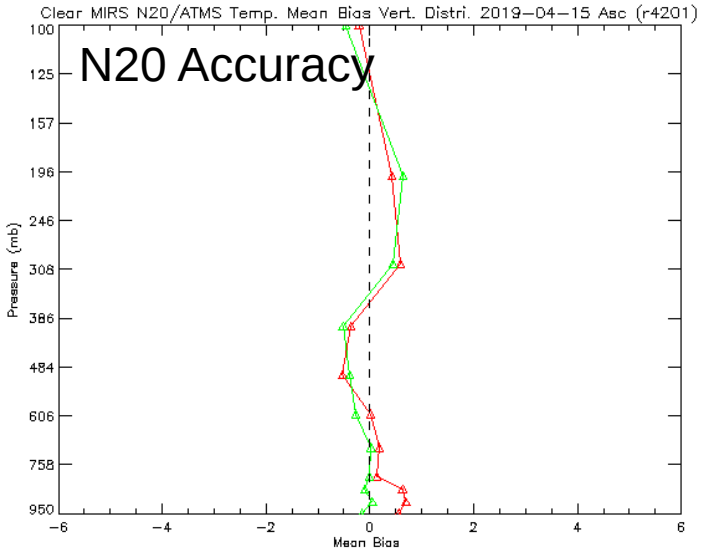
N20-ECMWF 500hPa Temp. Diff.

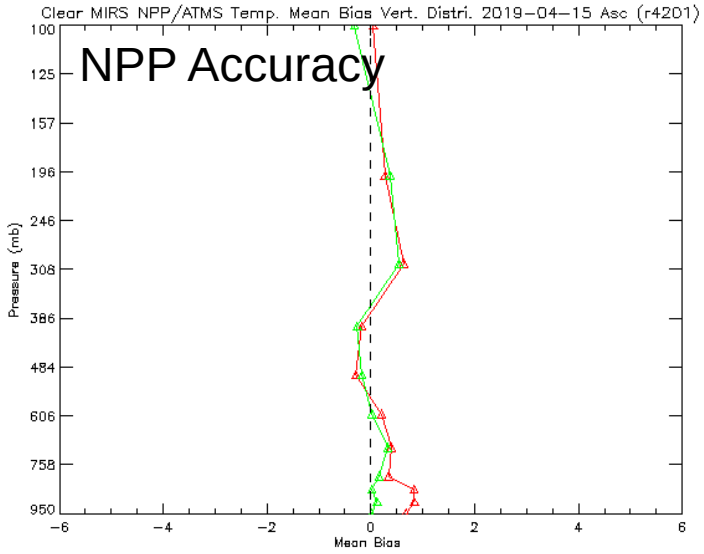


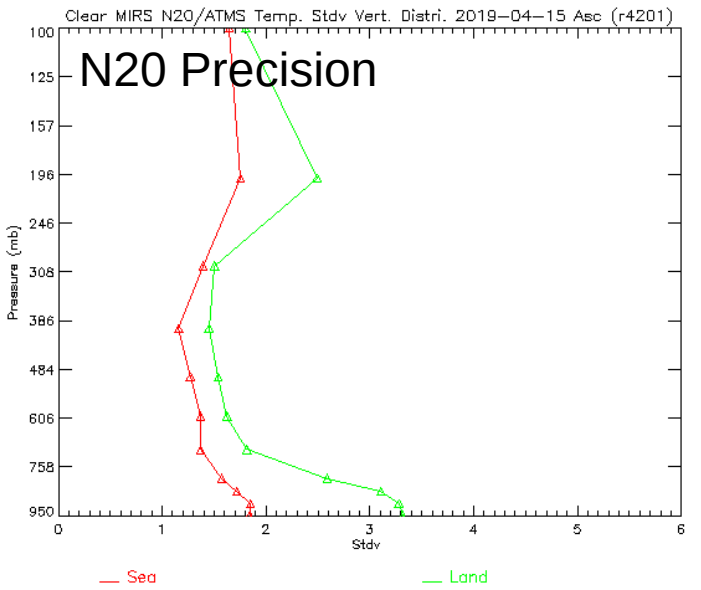
NPP-ECMWF 500hPa Temp. Diff.

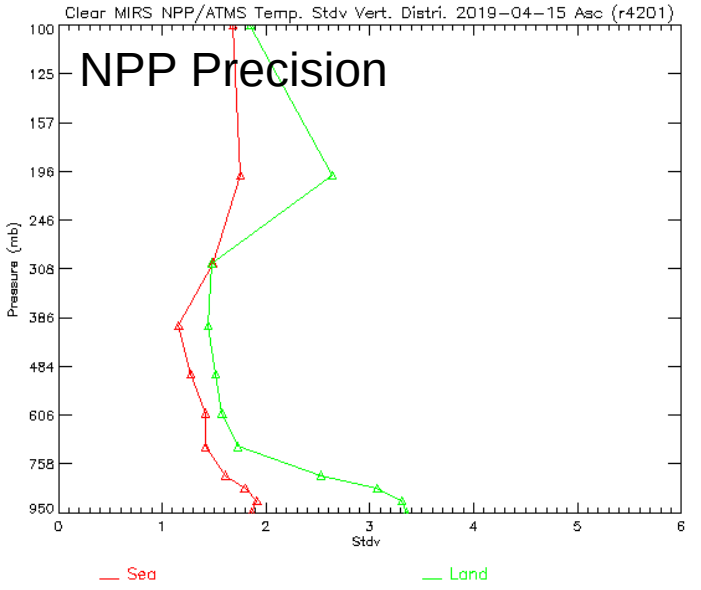


Temperature Profile Validation based on ECMWF data

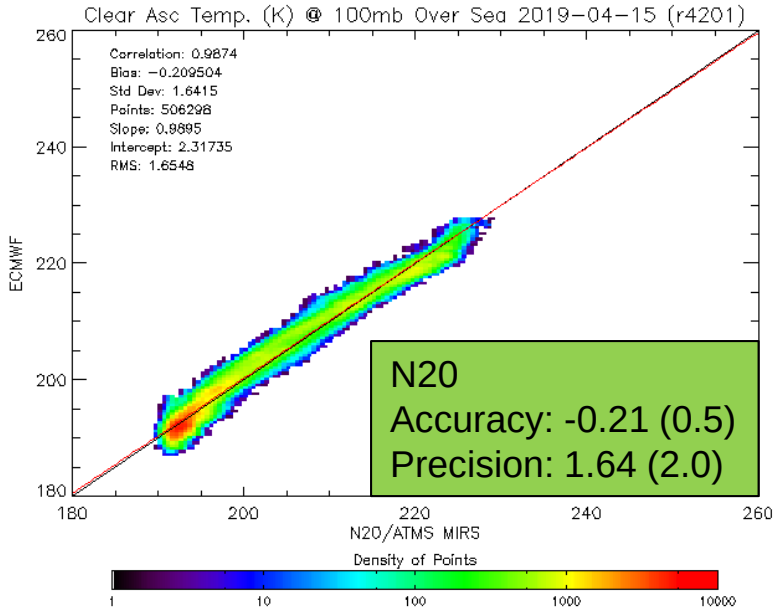


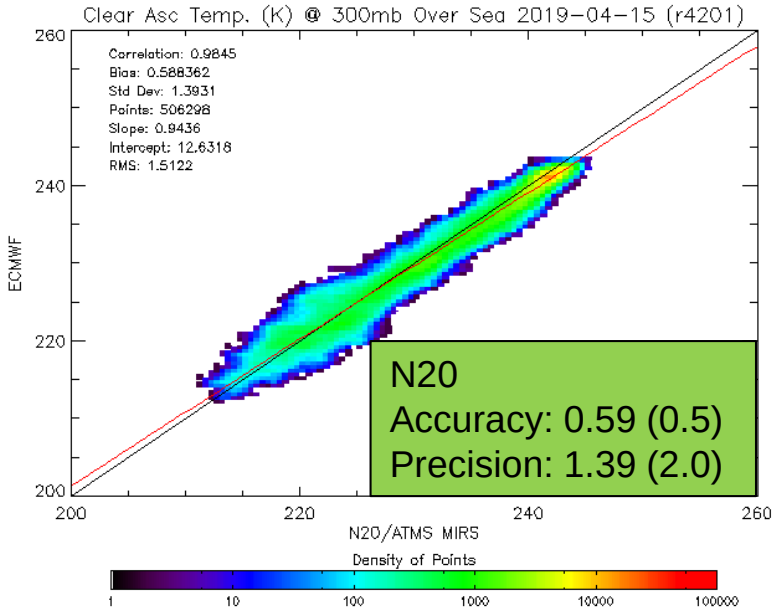


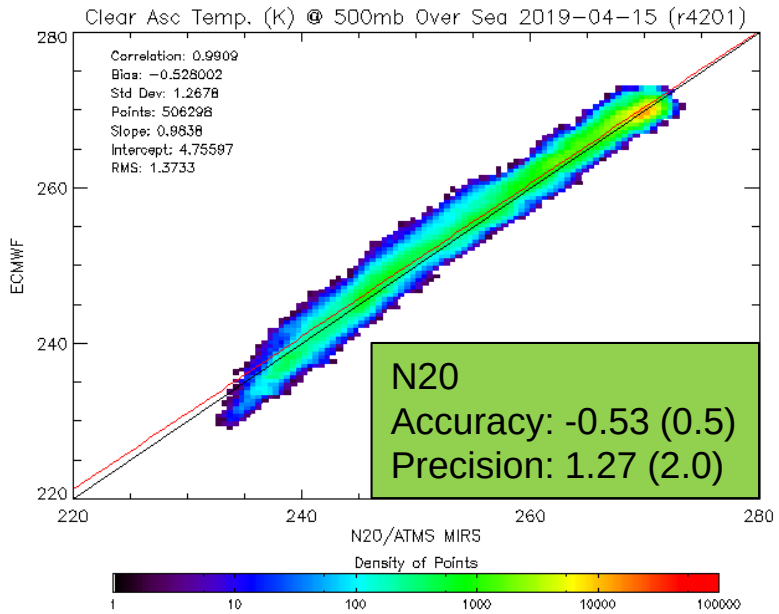


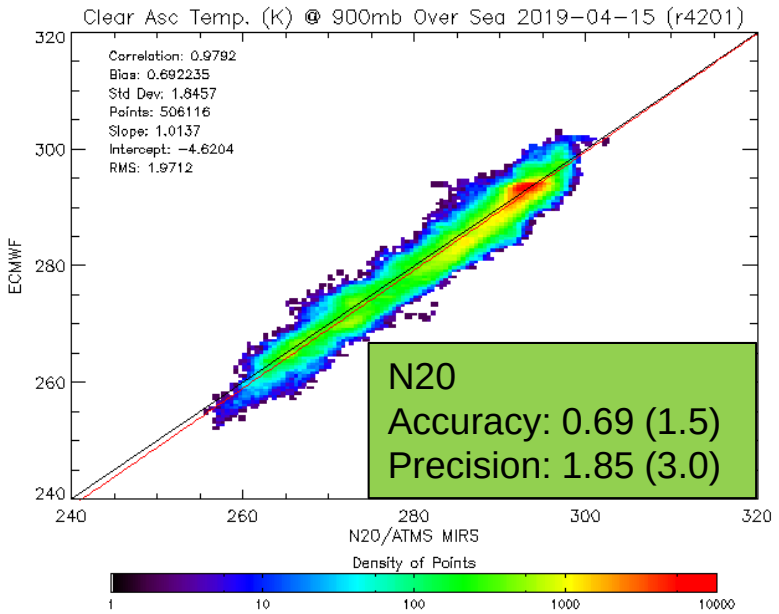


Temperature Profile Validation based on ECMWF data

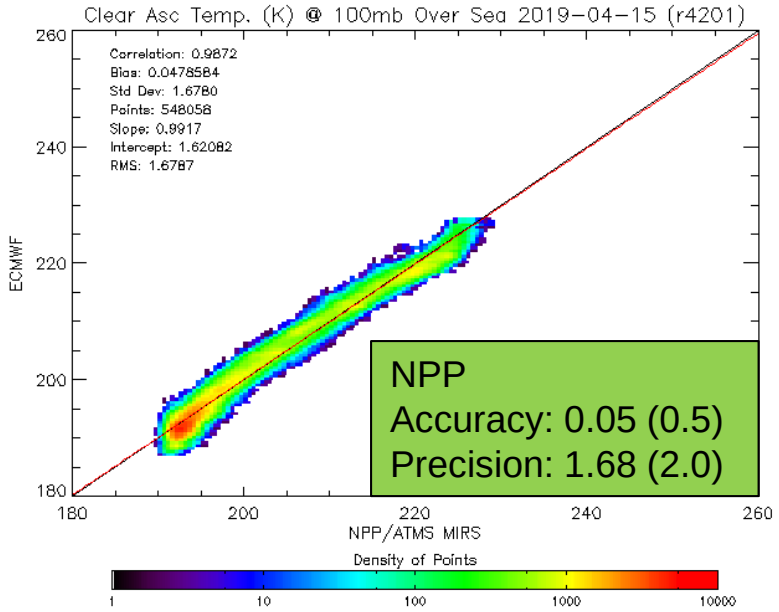


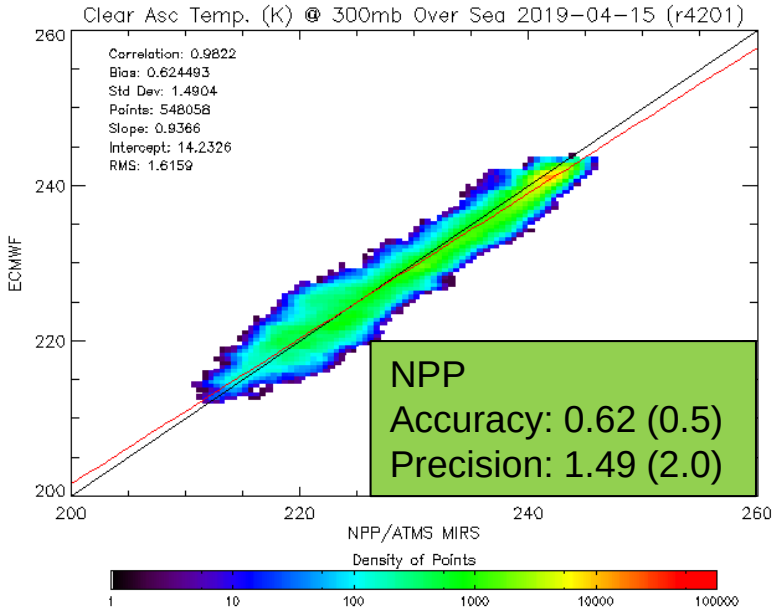


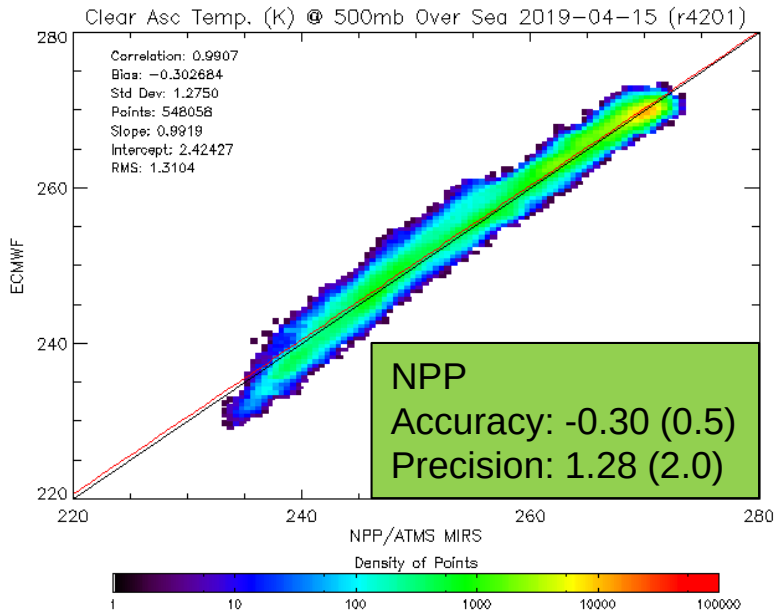


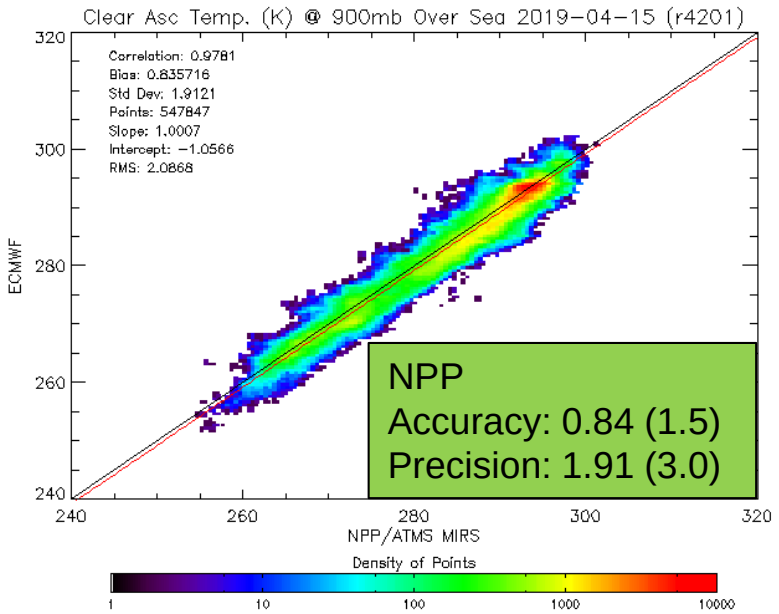


Temperature Profile Validation based on ECMWF data

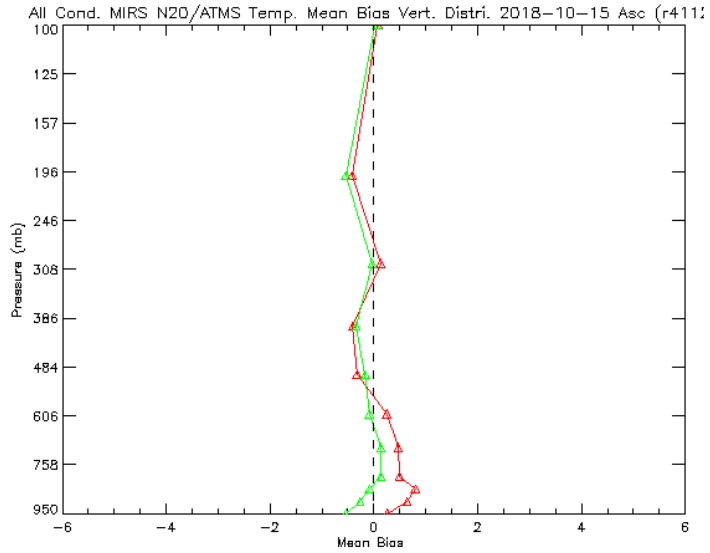


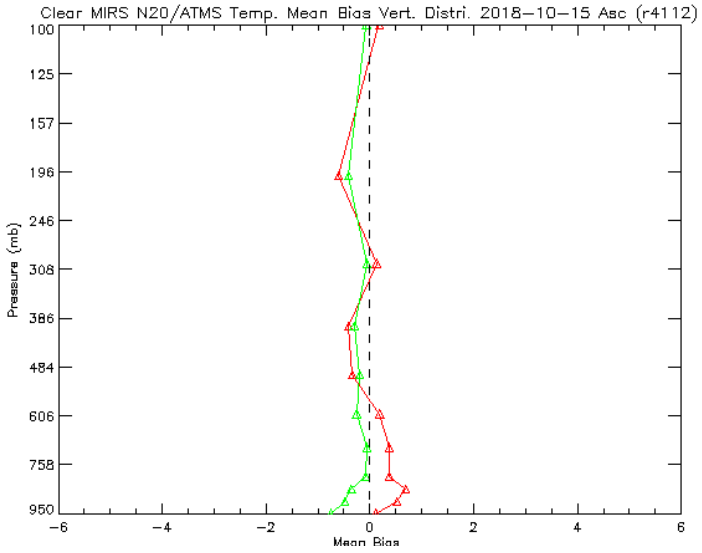


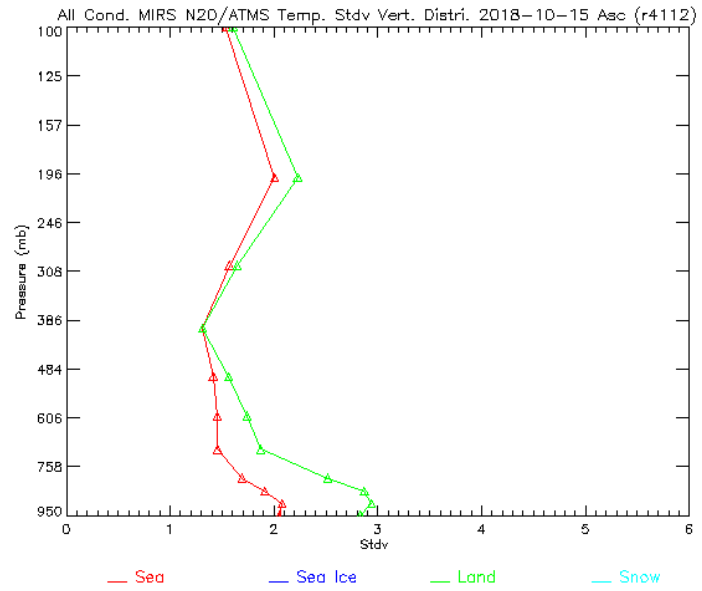


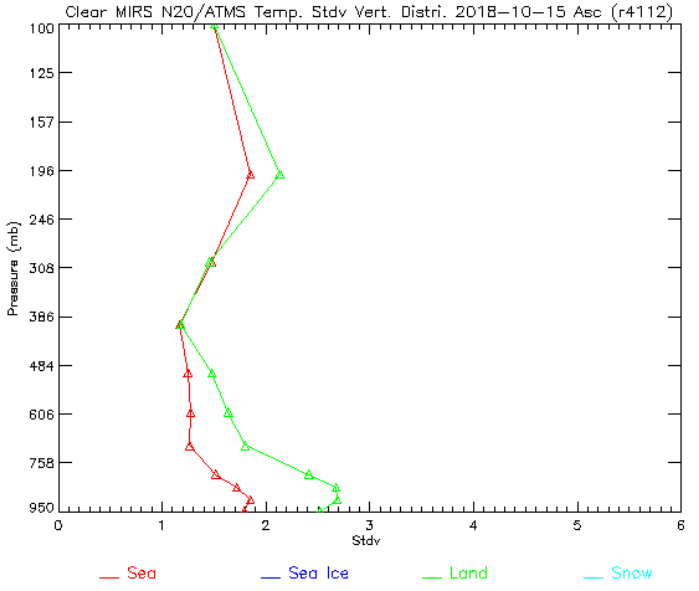


Bias Correction Effect on Temperature Profile
V11.3 2018.10.15

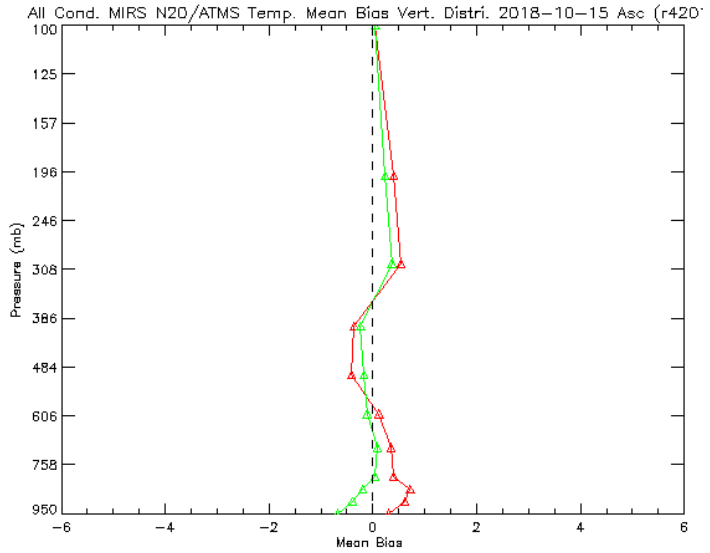


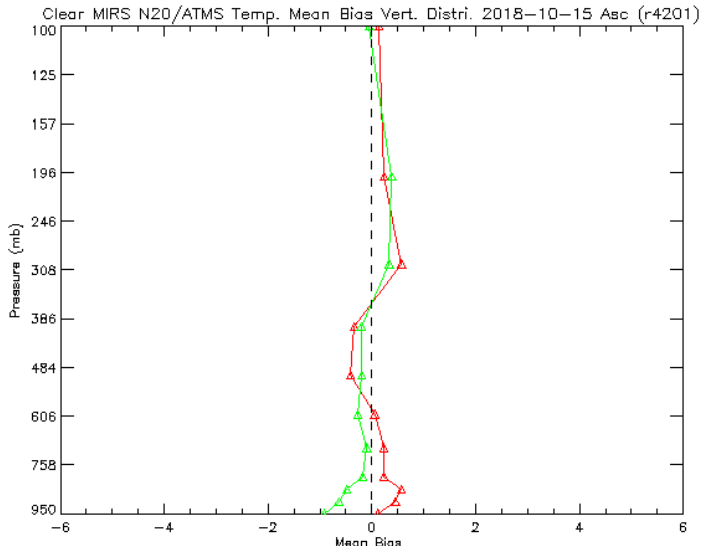


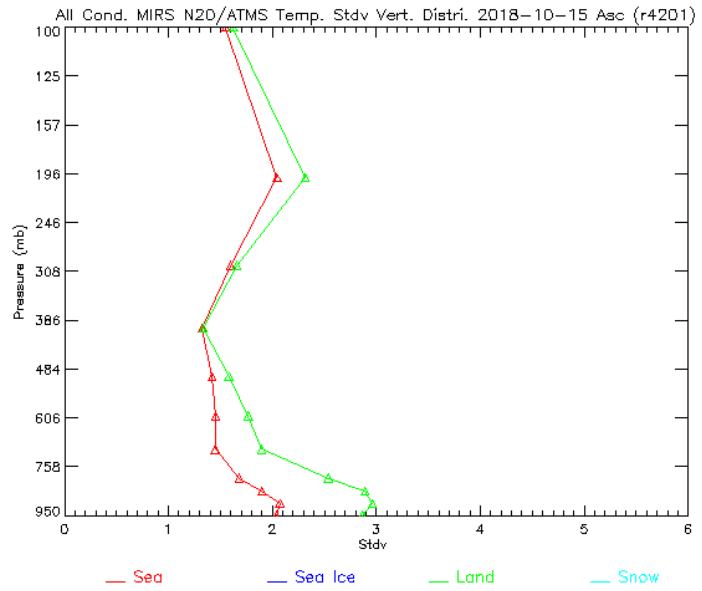


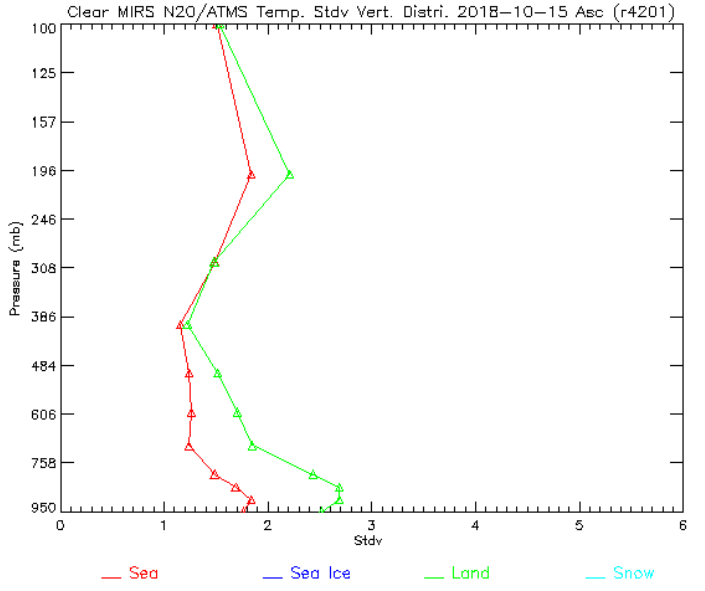


Bias Correction Effect on Temperature Profile
V11.4 2018.10.15







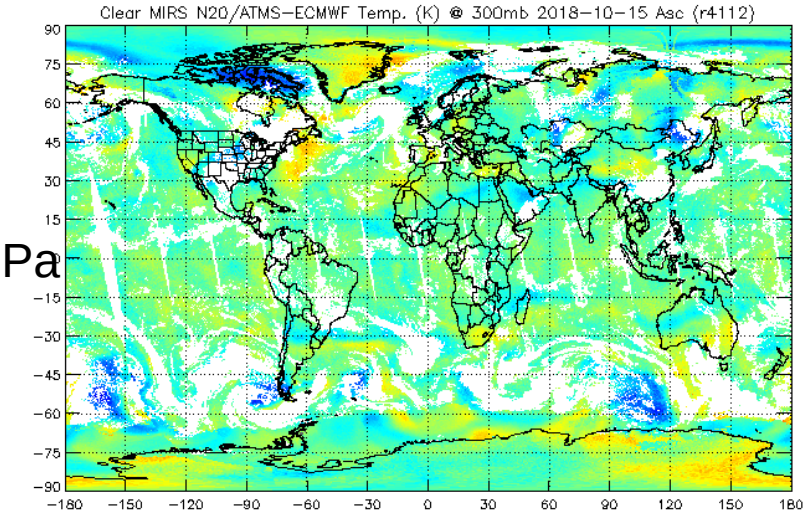


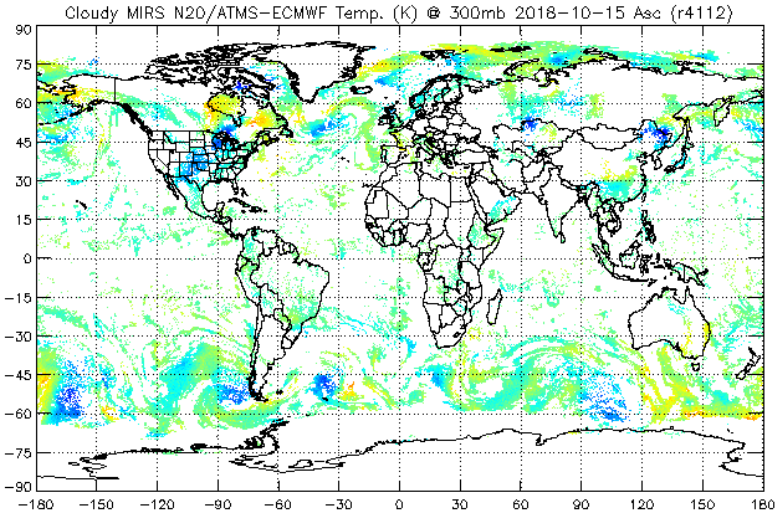
Bias correction effect on temperature profile
V11.3 2018.10.15

Clear

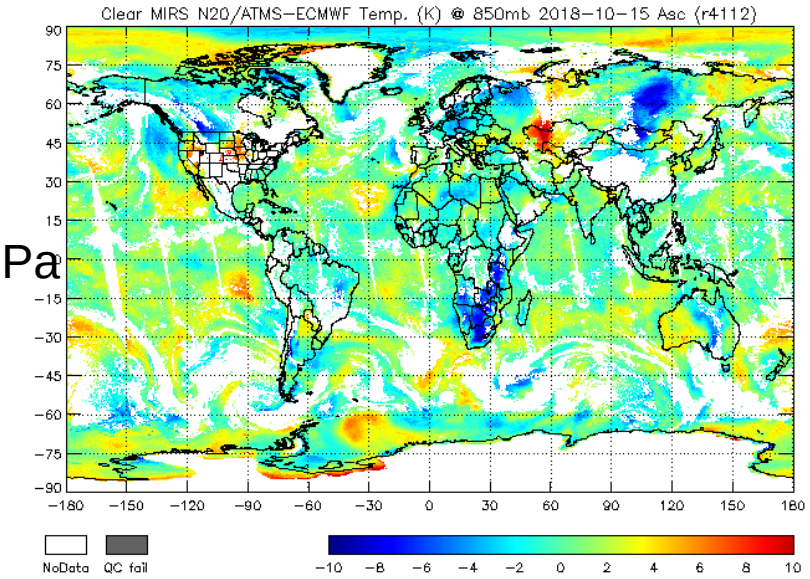
Cloudy

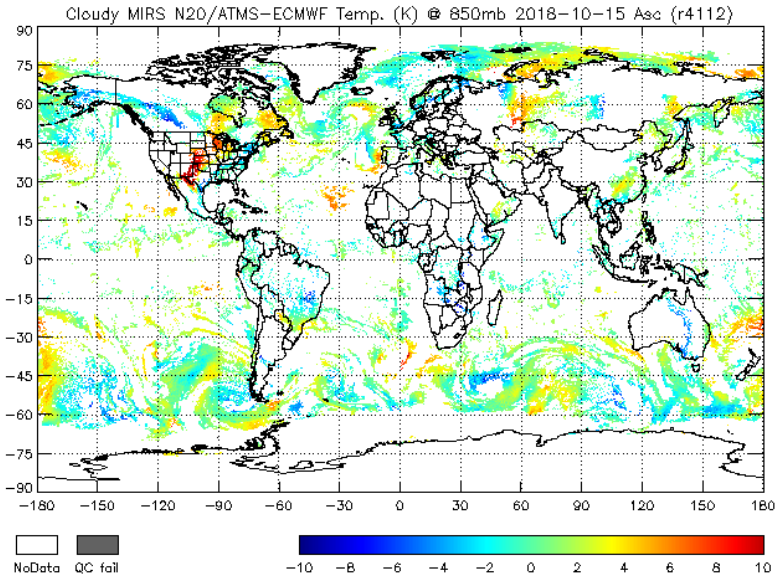
300hPa





850hPa



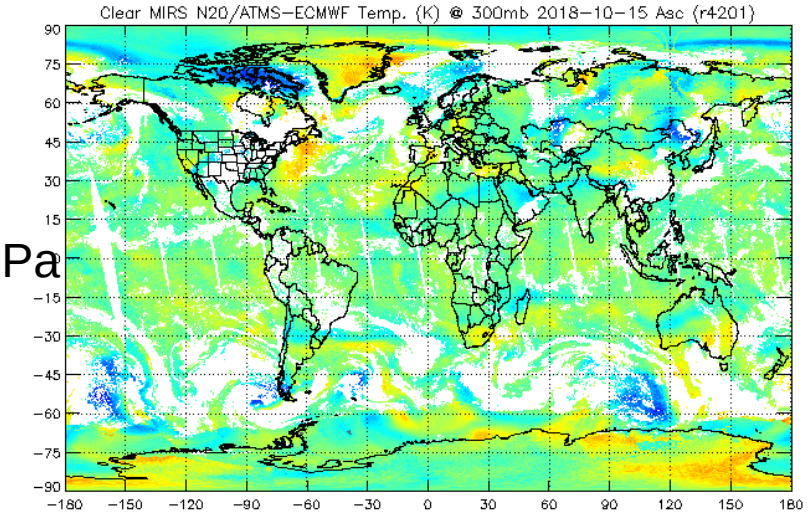


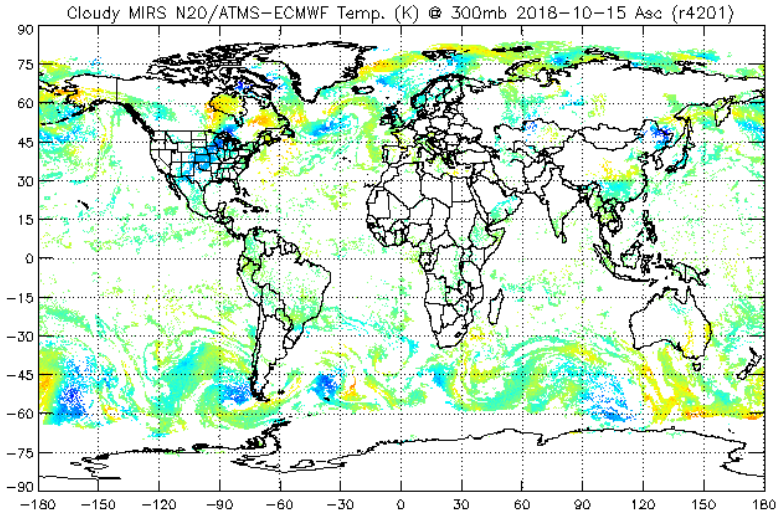
Bias correction effect on temperature profile
V11.4 2018.10.15

Clear

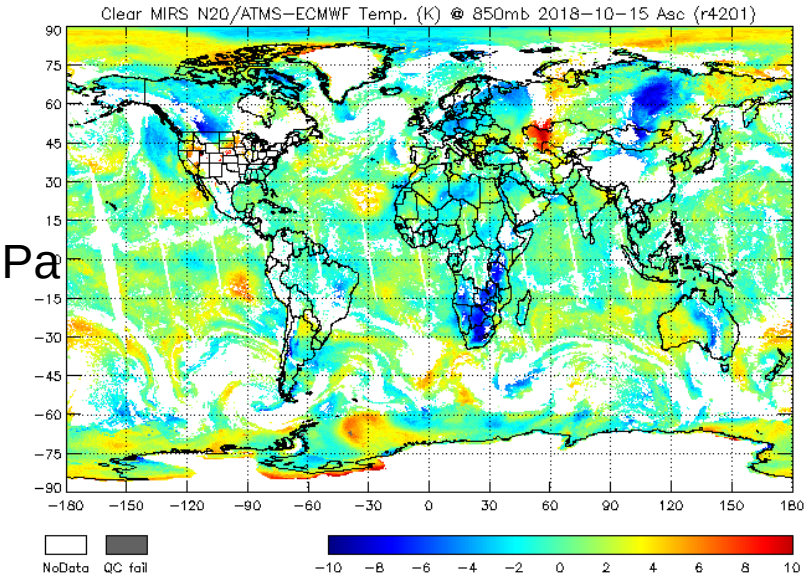
Cloudy

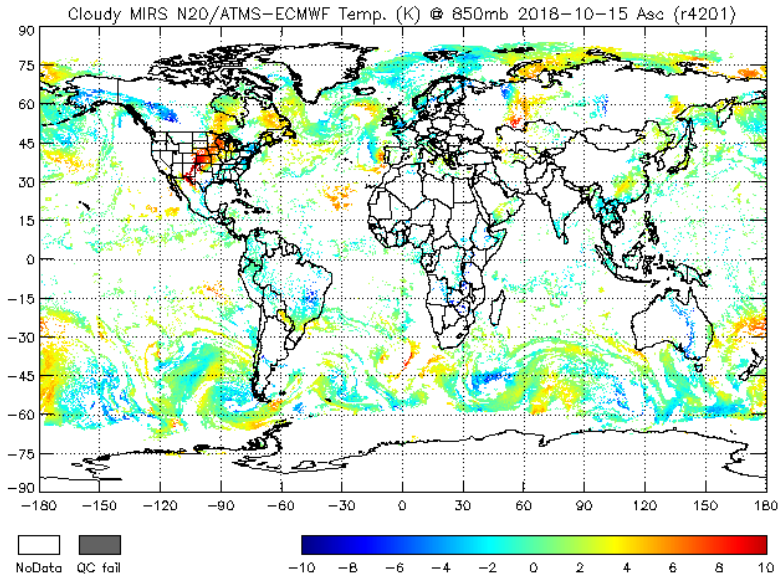
300hPa





850hPa





Temperature Profile Validation based on GDAS data

Clear Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.5 K)	300 hPa (0.5 K)	500 hPa (0.5 K)	900 hPa (1.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	-0.56 / -0.52	-0.53 / -0.52	0.21 / 0.24	0.51 / 0.52	1.46 / 1.47	1.57 / 1.51	1.28 / 1.21	1.76 / 1.75
2018.04.15	-0.63 / -0.58	-0.56 / -0.52	0.20 / 0.26	0.52 / 0.39	1.49 / 1.51	1.50 / 1.43	1.17 / 1.16	1.81 / 1.76
2018.07.15	-0.89 / -0.91	-0.42 / -0.43	0.06 / 0.13	0.50 / 0.35	1.27 / 1.31	1.35 / 1.45	1.28 / 1.33	1.89 / 1.79
2018.10.15	-0.58 / -0.59	-0.50 / -0.59	0.27 / 0.40	0.38 / 0.34	1.34 / 1.26	1.35 / 1.35	1.19 /1.18	1.77 / 1.71
2019.01.15	-1.39 / -1.47	0.06 / 0.09	-0.09 / -0.03	0.68 / 0.58	1.77 / 1.80	1.47 / 1.45	1.33 / 1.32	1.79 / 1.79
2019.04.15	-0.86 / -0.91	0.04 / 0.03	0.13 / 0.17	0.68 / 0.58	1.44 / 1.43	1.31 / 1.39	1.20 / 1.23	1.80 / 1.76

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.5 K)	300 hPa (0.5 K)	500 hPa (0.5 K)	900 hPa (1.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	-0.35 / -0.36	-0.05 / -0.05	0.34 / 0.45	0.75 / 0.65	1.42 / 1.46	1.54 / 1.48	1.25 / 1.21	1.77 / 1.77
2018.04.15	-0.44 / -0.39	-0.08 / -0.06	0.31 / 0.42	0.70 / 0.50	1.55 / 1.55	1.55 / 1.51	1.19 / 1.20	1.81 / 1.78
2018.07.15	-0.71 / -0.75	0.04 / 0.11	0.24 / 0.27	0.57 / 0.45	1.33 / 1.38	1.38 / 1.49	1.33 / 1.35	1.94 / 1.90
2018.10.15	-0.40 / -0.41	-0.10 / -0.17	0.46 / 0.57	0.54 / 0.43	1.38 / 1.31	1.41 / 1.44	1.22 / 1.21	1.77 / 1.76
2019.01.15	-1.20 / -1.22	0.53 / 0.50	0.03 / 0.18	0.76 / 0.67	1.77 / 1.89	1.51 / 1.48	1.32 / 1.32	1.86 / 1.86
2019.04.15	-0.62 / -0.73	0.07 / 0.07	0.36 / 0.45	0.83 / 0.68	1.47 / 1.47	1.40 / 1.45	1.21 / 1.19	1.87 / 1.82

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on GDAS data

Cloudy Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.8 K)	300 hPa (0.8 K)	500 hPa (0.8 K)	900 hPa (2.0 K)	100 hPa (2.0 K)	300 hPa (2.5 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	-0.52 / -0.46	-0.77 / -0.68	0.14 / 0.16	0.34 / 0.37	1.40 / 1.38	1.79 / 1.76	1.50 / 1.42	2.11 / 2.15
2018.04.15	-0.53 / -0.53	-0.46 / -0.47	-0.10 / -0.01	0.68 / 0.67	1.49 / 1.51	1.98 / 1.78	1.54 / 1.54	2.20 / 2.26
2018.07.15	-0.49 / -0.63	-0.56 / -0.50	0.01 / 0.03	0.81 / 0.73	1.47 / 1.44	1.51 / 1.50	1.34 / 1.40	2.17 / 2.20
2018.10.15	-0.48 / -0.52	-0.43 / -0.35	0.04 / 0.15	0.36 / 0.32	1.48 / 1.36	1.63 / 1.55	1.51 / 1.40	2.21 / 2.09
2019.01.15	-0.56 / -0.59	-0.16 / -0.15	-0.26 / -0.23	0.59 / 0.65	1.67 / 1.62	1.82 / 1.81	1.50 / 1.47	1.98 / 1.98
2019.04.15	-0.56 / -0.71	-0.28 / -0.21	0.13 / 0.12	0.73 / 0.75	1.37 / 1.34	1.70 / 1.80	1.38 / 1.35	2.09 / 2.07

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.8 K)	300 hPa (0.8 K)	500 hPa (0.8 K)	900 hPa (2.0 K)	100 hPa (2.0 K)	300 hPa (2.5 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	-0.36 / -0.29	-0.53 / -0.40	0.43 / 0.39	0.46 / 0.55	1.49 / 1.41	1.75 / 1.78	1.50 / 1.47	2.15 / 2.14
2018.04.15	-0.34 / -0.37	-0.13 / -0.12	0.09 / 0.18	0.78 / 0.74	1.56 / 1.53	2.07 / 1.83	1.60 / 1.53	2.21 / 2.20
2018.07.15	-0.26 / -0.44	-0.19 / -0.13	0.28 / 0.26	0.85 / 0.76	1.58 / 1.54	1.56 / 1.55	1.49 / 1.40	2.19 / 2.16
2018.10.15	-0.34 / -0.36	-0.08 / -0.02	0.29 / 0.35	0.44 / 0.46	1.55 / 1.43	1.66 / 1.62	1.52 / 1.42	2.20 / 2.12
2019.01.15	-0.40 / -0.42	0.11 / 0.16	-0.04 / -0.02	0.69 / 0.78	1.73 / 1.71	1.84 / 1.84	1.50 / 1.50	1.94 / 1.99
2019.04.15	-0.35 / -0.49	-0.25 / -0.17	0.43 / 0.40	0.77 / 0.79	1.45 / 1.42	1.79 / 1.86	1.42 / 1.37	2.12 / 2.06

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on GDAS data

Rainy Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.5 K)	500 hPa (2.0 K)	900 hPa (2.0 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (2.5 K)	900 hPa (3.5 K)
2018.01.15	-1.07 / -0.80	-0.97 / -0.89	1.58 / 1.35	0.76 / 0.76	1.38 / 1.40	1.90 / 1.79	2.09 / 2.07	2.43 / 2.57
2018.04.15	-1.16 / -1.10	-0.78 / -0.73	1.33 / 1.17	1.14 / 0.91	1.58 / 1.72	1.70 / 1.62	2.13 / 2.14	2.86 / 2.96
2018.07.15	-1.30 / -1.30	-0.61 / -0.45	1.13 / 1.15	0.79 / 0.65	1.38 / 1.33	1.53 / 1.57	1.88 / 1.96	2.22 / 2.24
2018.10.15	-1.24 / -1.34	-0.64 / -0.62	1.21 / 1.13	0.94 / 0.55	1.33 / 1.34	1.52 / 1.57	2.04 / 2.01	2.86 / 2.67
2019.01.15	-1.85 / -1.71	-0.32 / -0.14	1.33 / 1.15	0.25 / 0.15	1.67 / 1.79	1.68 / 1.60	1.87 / 1.95	2.51 / 2.73
2019.04.15	-0.96 / -0.89	-0.46 / -0.27	1.37 / 1.28	1.07 / 0.72	1.26 / 1.31	1.77 / 1.81	2.06 / 1.98	2.81 / 2.48

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.5 K)	500 hPa (2.0 K)	900 hPa (2.0 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (2.5 K)	900 hPa (3.5 K)
2018.01.15	-1.01 / -0.79	-0.65 / -0.54	1.81 / 1.57	1.04 / 0.82	1.57 / 1.57	1.79 / 1.94	2.09 / 1.99	2.61 / 2.40
2018.04.15	-1.10 / -0.87	-0.51 / -0.39	1.36 / 1.36	1.38 / 1.06	1.61 / 1.65	1.73 / 1.63	2.04 / 2.13	2.82 / 2.88
2018.07.15	-1.25 / -1.10	-0.33 / -0.16	1.32 / 1.26	0.90 / 0.73	1.38 / 1.39	1.52 / 1.56	1.79 / 1.94	2.01 / 2.16
2018.10.15	-1.19 / -1.26	-0.34 / -0.31	1.46 / 1.36	1.03 / 0.85	1.32 / 1.36	1.58 / 1.63	1.98 / 1.99	2.68 / 2.61
2019.01.15	-1.72 / -1.65	0.06 / 0.14	1.49 / 1.43	0.25 / 0.39	1.67 / 1.80	1.60 / 1.59	1.80 / 1.84	2.29 / 2.54
2019.04.15	-0.87 / -0.78	-0.37 / -0.18	1.54 / 1.56	1.14 / 0.82	1.28 / 1.31	1.79 / 1.79	2.06 / 1.98	2.72 / 2.38

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on GDAS data

Clear Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	-0.57 / -0.74	0.04 / 0.04	-0.07 / 0.03	-0.19 / -0.25	1.61 / 1.66	1.78 / 1.74	1.33 / 1.25	2.72 / 2.52
2018.04.15	-0.82 / -1.04	-0.24 / -0.23	0.05 / 0.08	-0.07 / -0.32	1.89 / 1.84	1.78 / 1.60	1.64 / 1.63	3.40 / 2.83
2018.07.15	-0.60 / -0.66	-0.50 / -0.31	0.10 / 0.06	-0.75 / -0.88	1.24 / 1.26	1.33 / 1.26	1.39 / 1.55	2.71 / 2.51
2018.10.15	-0.75 / -0.69	-0.42 / -0.35	0.11 / 0.08	-0.91 / -0.69	1.41 / 1.36	1.38 / 1.22	1.40 / 1.32	2.72 / 2.62
2019.01.15	-1.95 / -2.08	0.36 / 0.38	-0.02 / 0.06	-1.07 / -1.16	1.73 / 1.69	1.56 / 1.62	1.60 / 1.58	3.22 / 3.23
2019.04.15	-1.09 / -1.35	0.15 / 0.24	-0.00 / -0.05	-0.29 / -0.47	1.77 / 1.73	1.48 / 1.48	1.50 / 1.35	3.49 / 3.37

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	-0.36 / -0.45	0.34 / 0.41	0.34 / 0.28	-0.50 / -0.33	1.45 / 1.55	1.75 / 1.74	1.64 / 1.41	2.87 / 2.76
2018.04.15	-0.64 / -0.88	0.24 / 0.26	0.28 / 0.22	0.07 / -0.24	1.96 / 1.93	1.77 / 1.62	1.60 / 1.56	3.48 / 2.91
2018.07.15	-0.50 / -0.62	0.06 / 0.16	0.38 / 0.21	-0.97 / -0.78	1.25 / 1.34	1.41 / 1.33	1.45 / 1.39	2.85 / 2.52
2018.10.15	-0.44 / -0.50	-0.02 / 0.05	0.43 / 0.36	-0.89 / -0.73	1.49 / 1.49	1.47 / 1.33	1.48 / 1.44	2.96 / 2.70
2019.01.15	-1.81 / -1.88	0.82 / 0.81	0.24 / 0.29	-0.95 / -0.91	1.80 / 1.74	1.61 / 1.68	1.51 / 1.54	3.00 / 3.05
2019.04.15	-0.95 / -1.12	0.25 / 0.37	0.25 / 0.19	-0.21 / -0.32	1.82 / 1.79	1.47 / 1.50	1.51 / 1.35	3.55 / 3.52

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on GDAS data

Cloudy Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	-0.15 / -0.12	-0.55 / -0.35	0.41 / 0.45	-0.31 / -0.21	1.81 / 1.78	1.68 / 1.64	1.37 / 1.33	3.09 / 2.81
2018.04.15	-1.06 / -1.37	-0.21 / -0.18	0.24 / 0.17	0.34 / 0.52	2.19 / 2.04	1.60 / 1.43	1.33 / 1.25	3.67 / 3.69
2018.07.15	-0.40 / -0.47	-0.43 / -0.30	0.05 / -0.02	-0.46 / -0.01	1.30 / 1.32	1.50 / 1.52	1.19 / 1.24	2.59 / 2.76
2018.10.15	-0.31 / -0.24	-0.46 / -0.34	0.15 / 0.14	0.13 / 0.65	1.63 / 1.62	1.84 / 1.82	1.52 / 1.46	3.44 / 3.33
2019.01.15	-1.45 / -1.83	0.22 / 0.11	-0.11 / 0.19	-0.74 / -0.63	1.47 / 1.50	1.30 / 1.29	1.49 / 1.35	2.67 / 3.15
2019.04.15	-1.08 / -0.94	0.31 / 0.46	0.11 / -0.04	-0.12 / 0.69	1.73 / 1.79	1.40 / 1.35	1.40 / 1.35	3.41 / 3.46

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.10 / -0.01	-0.08 / 0.21	1.11 / 1.04	-1.27 / -0.98	1.55 / 1.50	1.48 / 1.70	1.52 / 1.37	3.62 / 2.84
2018.04.15	-1.15 / -1.19	0.21 / 0.34	0.53 / 0.41	0.15 / 0.56	2.12 / 2.16	1.67 / 1.48	1.36 / 1.32	3.51 / 3.51
2018.07.15	-0.22 / -0.29	0.13 / 0.10	0.40 / 0.24	-0.47 / -0.02	1.29 / 1.36	1.55 / 1.64	1.24 / 1.26	2.66 / 2.74
2018.10.15	-0.17 / -0.08	0.16 / 0.09	0.38 / 0.40	-0.03 / 0.72	1.67 / 1.77	1.80 / 1.84	1.50 / 1.52	3.59 / 3.69
2019.01.15	-1.44 / -1.53	0.72 / 0.76	0.34 / 0.57	-0.95 / -0.90	1.45 / 1.49	1.26 / 1.41	1.48 / 1.46	2.66 / 3.03
2019.04.15	-1.08 / -0.95	0.49 / 0.62	0.35 / 0.27	0.02 / 0.80	1.71 / 1.83	1.36 / 1.40	1.41 / 1.37	3.65 / 3.67

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on GDAS data

Rainy Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.0 K)	500 hPa (1.0 K)	900 hPa (2.5 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (3.0 K)	900 hPa (5.5 K)
2018.01.15	-1.01 / -1.14	-0.75 / -0.53	1.38 / 1.52	0.40 / 0.01	1.81 / 1.51	1.74 / 1.56	1.66 / 1.82	4.72 / 2.94
2018.04.15	-2.05 / -2.70	-0.39 / -0.58	0.64 / 0.66	1.08 / 1.35	2.34 / 2.42	1.93 / 1.71	2.01 / 1.81	4.17 / 4.05
2018.07.15	-1.16 / -1.70	-0.16 / -0.23	0.85 / 0.92	-0.46 / -0.10	1.29 / 1.44	1.80 / 1.84	1.73 / 1.68	2.90 / 3.06
2018.10.15	-0.94 / -1.15	0.07 / -0.17	1.18 / 0.83	0.52 / 1.09	1.73 / 1.78	2.05 / 1.82	2.08 / 2.02	3.87 / 4.39
2019.01.15	-2.43 / -2.72	-0.06 / -0.08	0.61 / 1.28	-0.85 / -1.07	1.41 / 1.43	1.56 / 1.47	1.83 / 1.87	3.09 / 3.49
2019.04.15	-2.08 / -2.63	-0.04 / -0.27	0.31 / 0.06	0.67 / 1.57	1.71 / 1.79	2.01 / 1.98	1.99 / 1.67	3.92 / 3.87

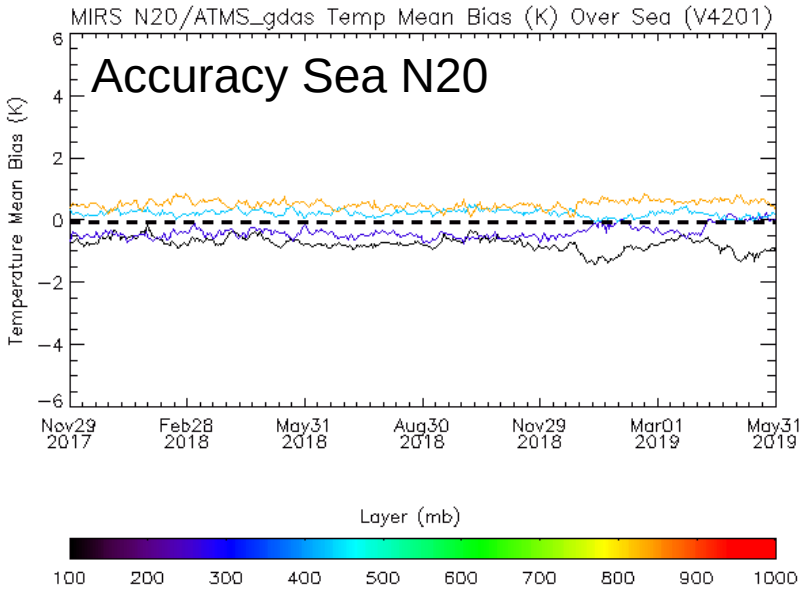
NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.0 K)	500 hPa (1.0 K)	900 hPa (2.5 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (3.0 K)	900 hPa (5.5 K)
2018.01.15	-0.34 / -0.80	-0.72 / -0.01	1.73 / 1.50	0.18 / 0.42	1.82 / 1.62	1.92 / 1.85	1.85 / 1.93	5.44 / 4.54
2018.04.15	-2.08 / -2.37	0.12 / 0.09	0.93 / 0.78	0.83 / 1.20	2.42 / 2.35	1.89 / 1.75	2.00 / 1.78	3.82 / 4.11
2018.07.15	-1.10 / -1.53	0.22 / 0.15	1.00 / 1.00	-0.35 / -0.02	1.33 / 1.44	1.82 / 1.84	1.83 / 1.75	2.81 / 2.97
2018.10.15	-0.77 / -0.99	0.55 / 0.35	1.40 / 1.19	0.11 / 0.68	1.64 / 1.88	1.93 / 1.85	1.99 / 1.96	3.52 / 3.92
2019.01.15	-2.27 / -2.54	0.21 / 0.27	1.15 / 1.47	-0.77 / -1.09	1.28 / 1.47	1.58 / 1.53	1.72 / 1.77	2.94 / 3.35
2019.04.15	-2.04 / -2.37	0.19 / 0.14	0.58 / 0.39	0.52 / 1.41	1.59 / 1.62	1.90 / 1.92	1.97 / 1.69	4.04 / 3.64

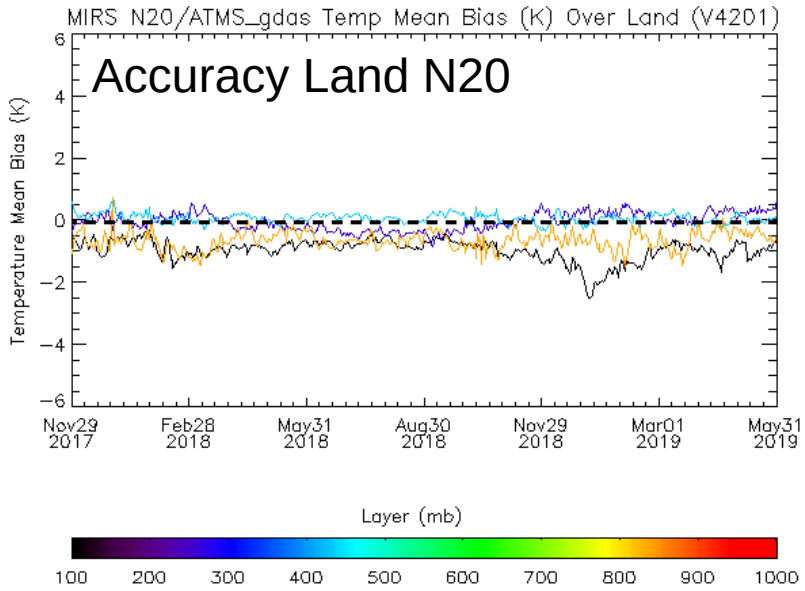
Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

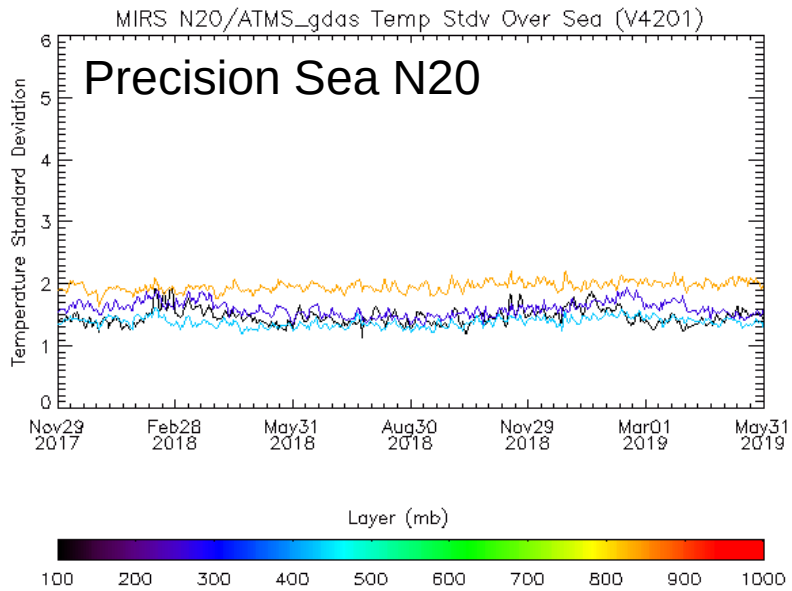
Note: results stratified by asc/des, but requirements are for combined passes

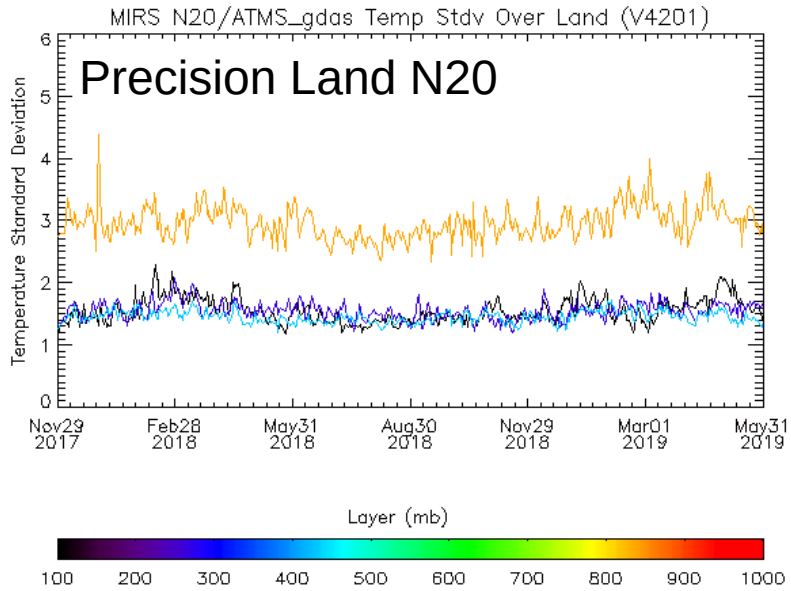
Additional comparisons with ECMWF located in Supplemental Slides

Temperature Profile Validation based on GDAS data: Time Series (Nov 2017 – May 2019)

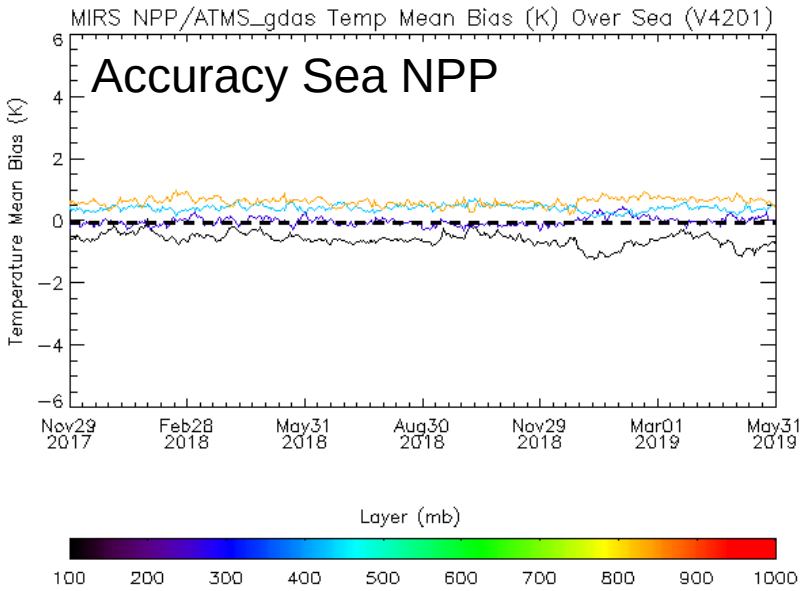


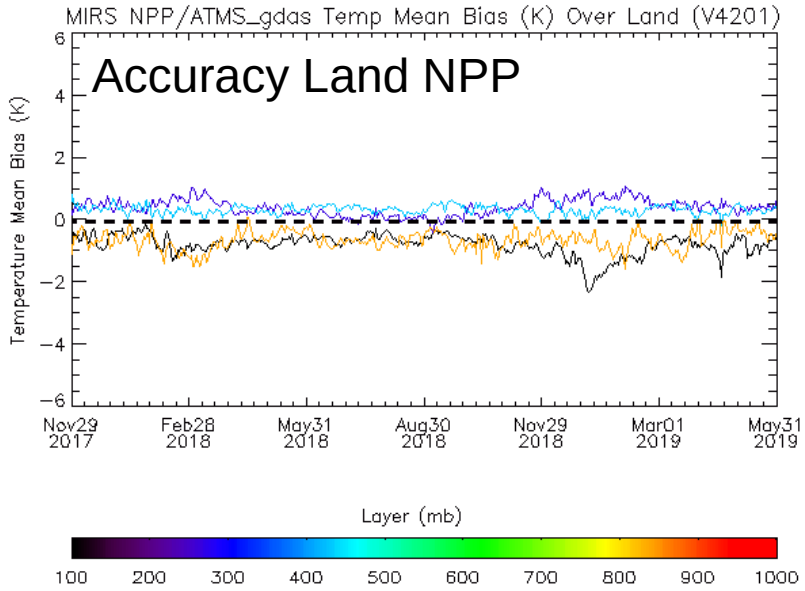


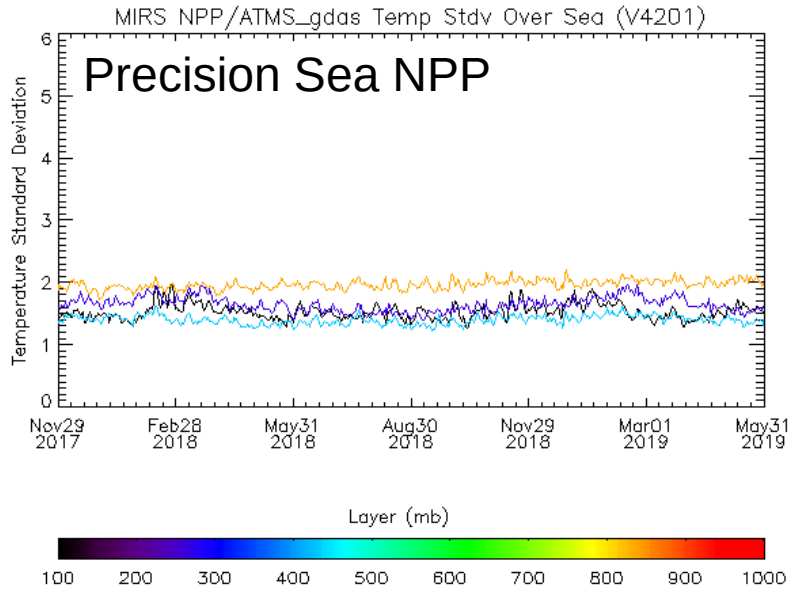


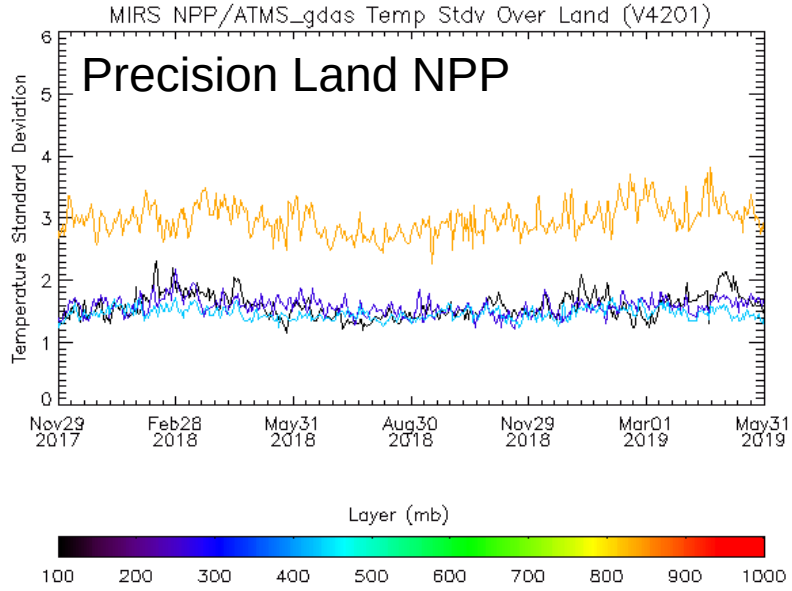


Temperature Profile Validation based on GDAS data: Time Series (Nov 2017 – May 2019)

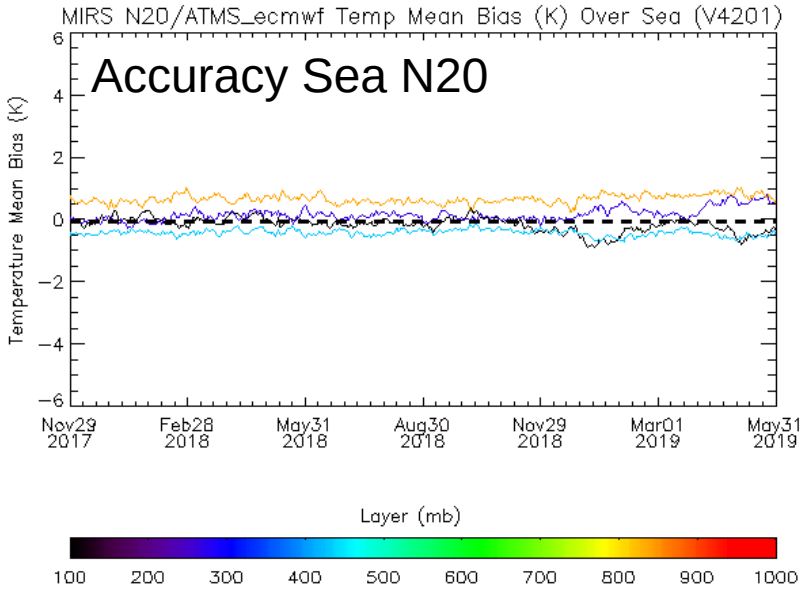


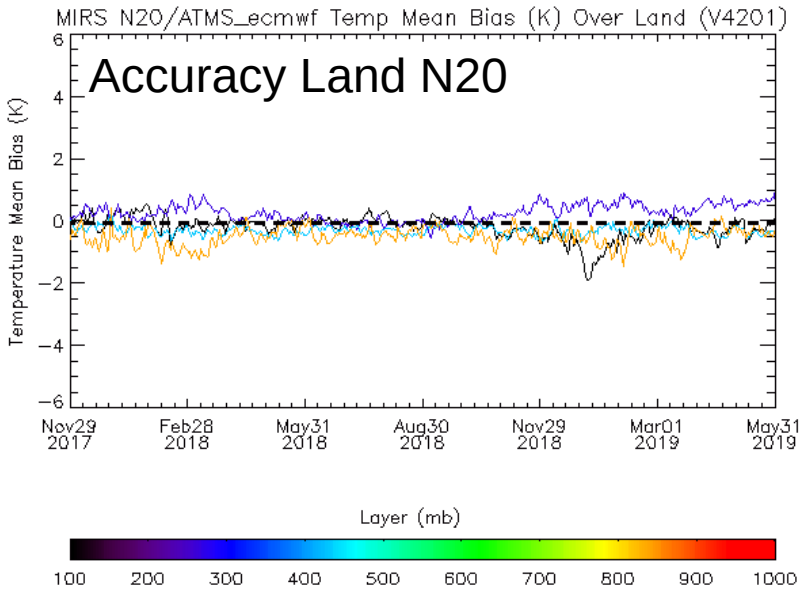


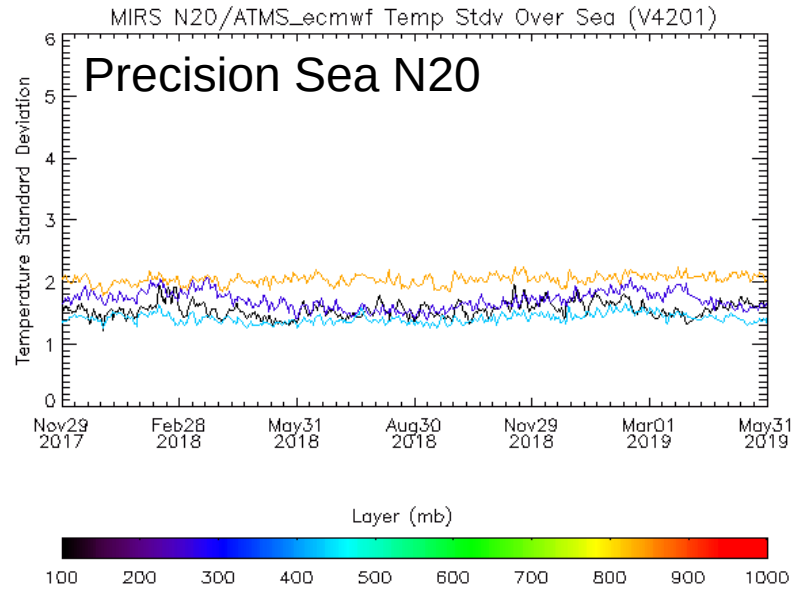


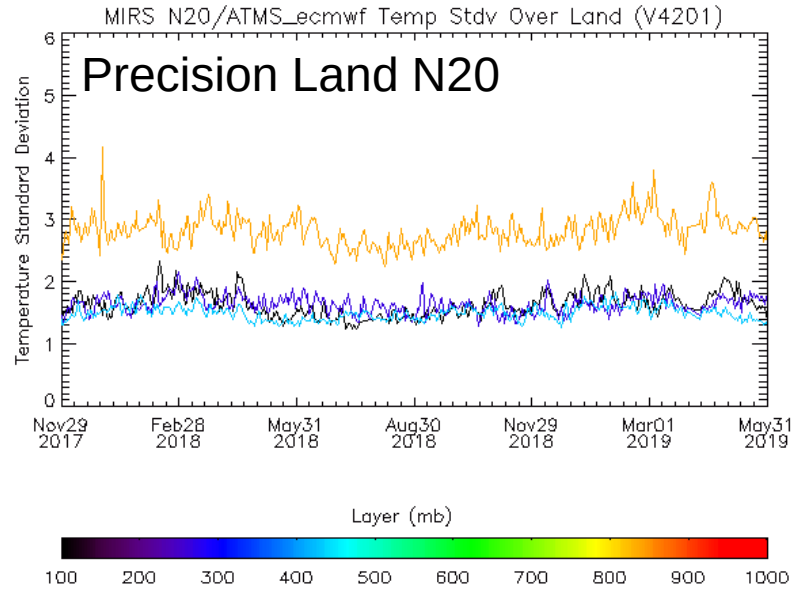


Temperature Profile Validation based on ECMWF data: Time Series (Nov 2017 – May 2019)

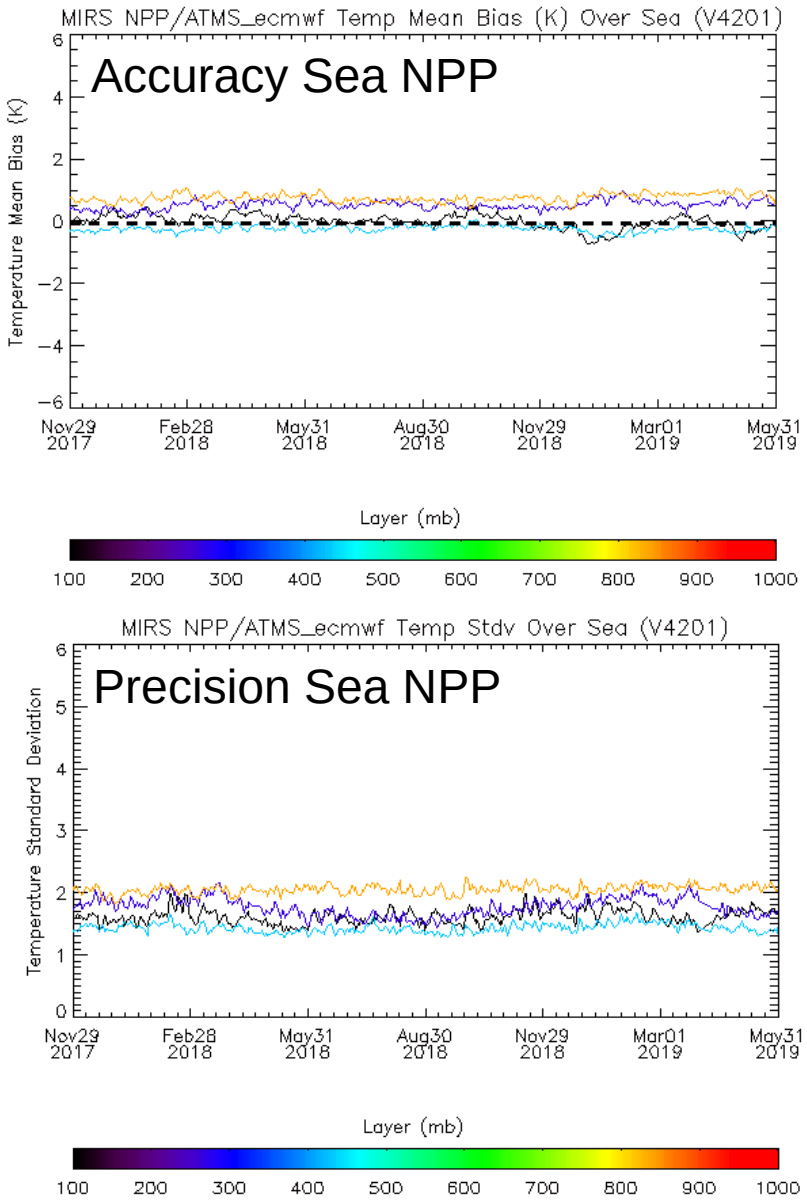


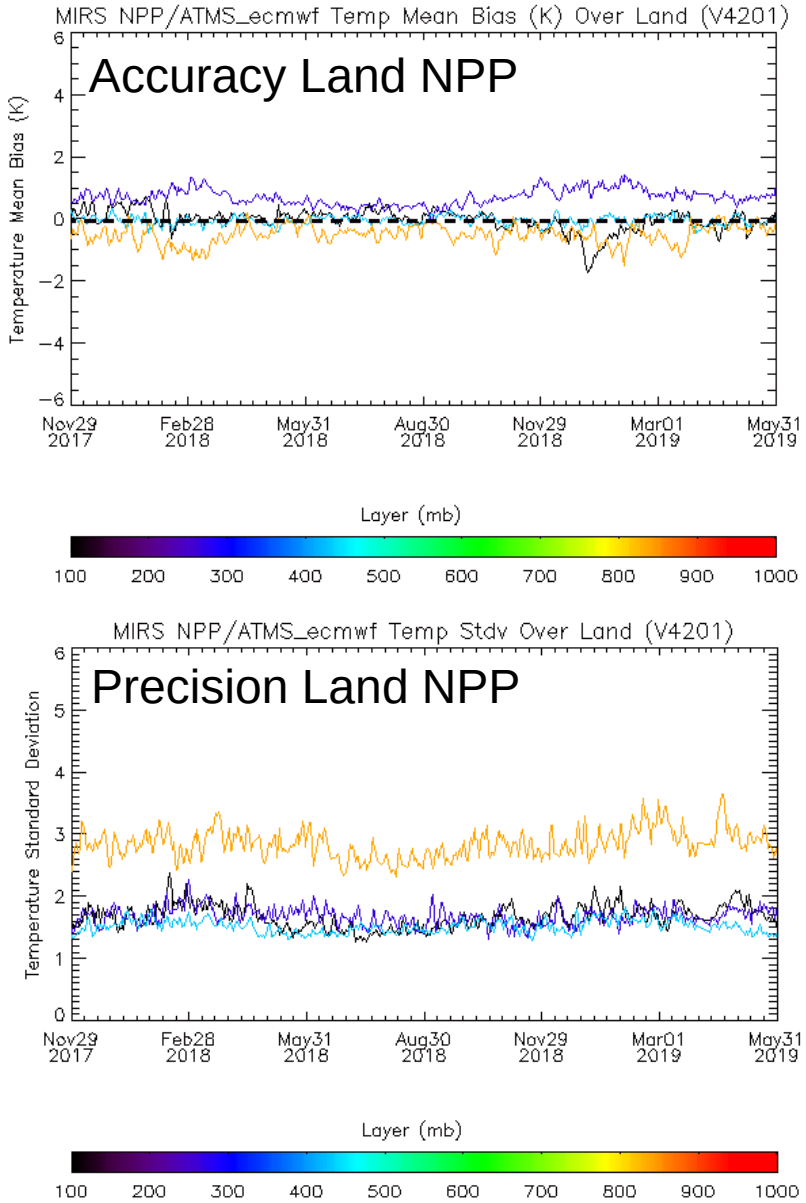






Temperature Profile Validation based on ECMWF data: Time Series (Nov 2017 – May 2019)





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
- All accuracy and precision requirements are met

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	

Data collected:

ECMWF and GDAS: 2018.01.15, 2018.04.15 2018.07.15, 2018.10.15, 2019.01.15, and 2019.04.15

Radiosonde: 6 ten-day periods 2018.01.09-01.20, 2018.04.09-04.20, 2018.07.09-07.09, 2018.10.09-10.20, 2019.01.09-01.20. and 2019.04.09-04.20

Collocation details:

- ECMWF and GDAS: bilinear interpolation in space and time from 1 deg lat/lon, 6-hour analyses
- Radiosonde (NPROVS): radius: 250 km & time: 6 hour

Requirements and Validation Results: Water Vapor Profile Compared to radiosonde

Sea

Scene	Layer (hPa)	Accuracy (%)		Precision (%)	
		MiRS	Req	MiRS	Req
Clear	400	**4.0 (3.5)**	**30**	**47.7 (46.5)**	**60**
	500	**12.6 (11.1)**	**20**	**42.5 (44.6)**	**60**
	700	**5.3 (5.5)**	**20**	**34.6 (35.5)**	**50**
	900	**0.5 (0.8)**	**20**	**17.4 (17.8)**	**30**
Cloudy	400	**9.3 (8.5)**	**30**	**41.9 (42.6)**	**70**
	500	**11.1 (8.4)**	**20**	**39.2 (40.3)**	**65**
	700	**-2.6 (-2.9)**	**10**	**27.4 (27.2)**	**60**
	900	**-4.3 (-3.9)**	**20**	**12.9 (12.8)**	**30**

Land

Sene	Layer (hPa)	Accuracy (%)		Precision (%)	
		MiRS	Req	MiRS	Req
Clear	400	**3.6 (8.3)**	**30**	**48.9 (51.9)**	**60**
	500	**5.9 (5.6)**	**20**	**46.6 (47.9)**	**60**
	700	**2.8 (-3.7)**	**20**	**34.1 (32.3)**	**50**
	900	**7.1 (0.9)**	**20**	**28.1 (26.9)**	**50**
Cloudy	400	**8.7 (15.6)**	**30**	**44.0 (48.3)**	**60**
	500	**10.0 (12.7)**	**20**	**40.0 (41.3)**	**60**
	700	**-9.7 (-7.7)**	**20**	**26.2 (25.7)**	**50**
	900	**-3.2 (-7.3)**	**20**	**19.9 (19.8)**	**50**

Values in ( ) indicates NPP

Meets requirement

Requirements and Validation Results: Water vapor Profile Compared to GDAS

Sea

Scene	Layer (hPa)	Accuracy (%)		Precision (%)	
		MiRS	Req	MiRS	Req
Clear	400	**-15.5 (-14.8)**	**30**	**37.9 (39.7)**	**60**
	500	**2.7 (0.3)**	**20**	**40.2 (41.7)**	**60**
	700	**7.1 (6.3)**	**20**	**32.0 (31.8)**	**50**
	900	**-0.3 (-0.2)**	**20**	**12.8 (12.8)**	**30**
Cloudy	400	**-18.4 (7.2)**	**30**	**44.3 (62.1)**	**70**
	500	**-6.3 (2.8)**	**20**	**50.1 (58.2)**	**65**
	700	**-1.8 (8.0)**	**10**	**36.0 (36.5)**	**60**
	900	**-6.3 (-2.2)**	**20**	**15.3 (16.3)**	**30**

Land

Scene	Layer (hPa)	Accuracy (%)		Precision (%)	
		MiRS	Req	MiRS	Req
Clear	400	**-12.4 (-11.6)**	**30**	**43.1 (45.0)**	**60**
	500	**5.9 (4.8)**	**20**	**44.4 (46.1)**	**60**
	700	**-4.3 (-4.9)**	**20**	**31.7 (31.0)**	**50**
	900	**6.2 (4.8)**	**20**	**24.1 (24.9)**	**50**
Cloudy	400	**-7.8 (-4.1)**	**30**	**37.3 (38.6)**	**60**
	500	**8.6 (9.8)**	**20**	**37.9 (38.4)**	**60**
	700	**-9.5 (-8.8)**	**20**	**27.0 (26.7)**	**50**
	900	**7.7 (7.3)**	**20**	**20.8 (20.8)**	**50**

Values in ( ) indicates NPP

Meets requirement

Requirements and Validation Results: Water vapor Profile Compared to ECMWF

Sea

Scene	Layer (hPa)	Accuracy (%)		Precision (%)	
		MiRS	Req	MiRS	Req
Clear	400	**3.7 (3.0)**	**30**	**49.0 (51.0)**	**60**
	500	**6.8 (3.8)**	**20**	**45.3 (47.4)**	**60**
	700	**10.4 (9.9)**	**20**	**33.1 (33.6)**	**50**
	900	**-0.8 (-0.3)**	**20**	**13.4 (13.5)**	**30**
Cloudy	400	**7.8 (7.2)**	**30**	**62.9 (62.1)**	**70**
	500	**4.4 (2.8)**	**20**	**57.3 (58.2)**	**65**
	700	**7.7 (8.0)**	**10**	**37.8 (36.5)**	**60**
	900	**-2.7 (-2.2)**	**20**	**16.8 (16.3)**	**30**

Land

Scene	Layer (hPa)	Accuracy (%)		Precision (%)	
		MiRS	Req	MiRS	Req
Clear	400	**8.2 (8.4)**	**30**	**49.8 (53.1)**	**60**
	500	**11.8 (11.5)**	**20**	**45.6 (46.8)**	**60**
	700	**-2.7 (-3.9)**	**20**	**29.5 (30.5)**	**50**
	900	**0.3 (-0.7)**	**20**	**24.1 (25.2)**	**50**
Cloudy	400	**14.6 (16.3)**	**30**	**46.7 (48.3)**	**60**
	500	**16.0 (18.1)**	**20**	**40.1 (41.2)**	**60**
	700	**-7.0 (-6.2)**	**20**	**25.9 (26.8)**	**50**
	900	**2.7 (2.8)**	**20**	**21.1 (20.9)**	**50**

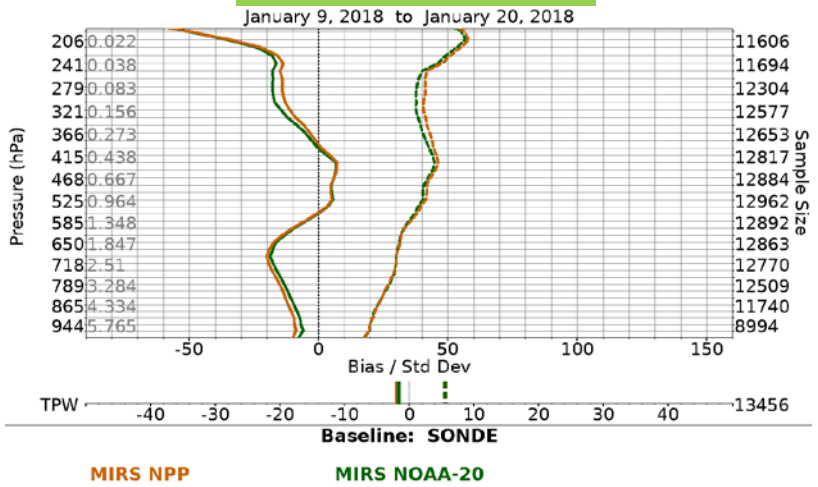
Values in ( ) indicates NPP

Meets requirement

Water Vapor Profile Validation based on sonde data

All conditions and surface types

9-20 Jan 2018



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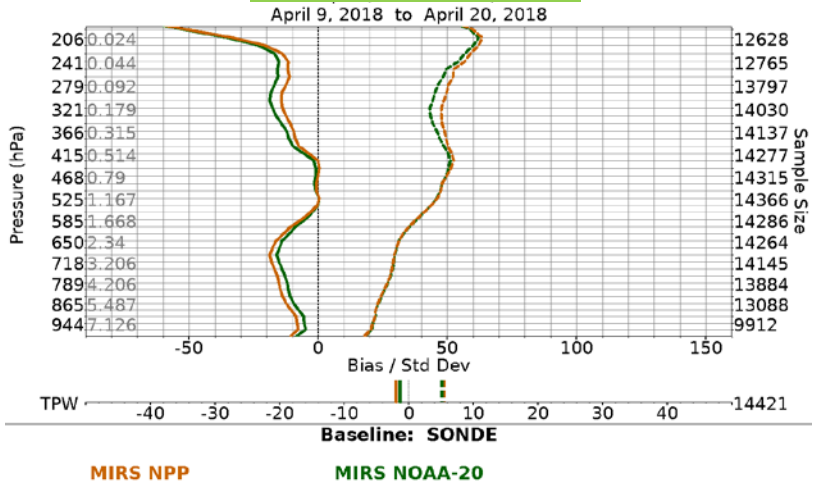

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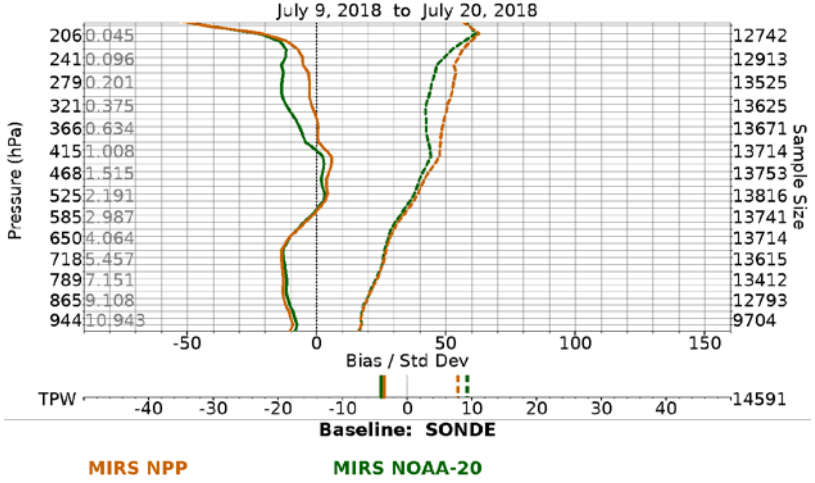

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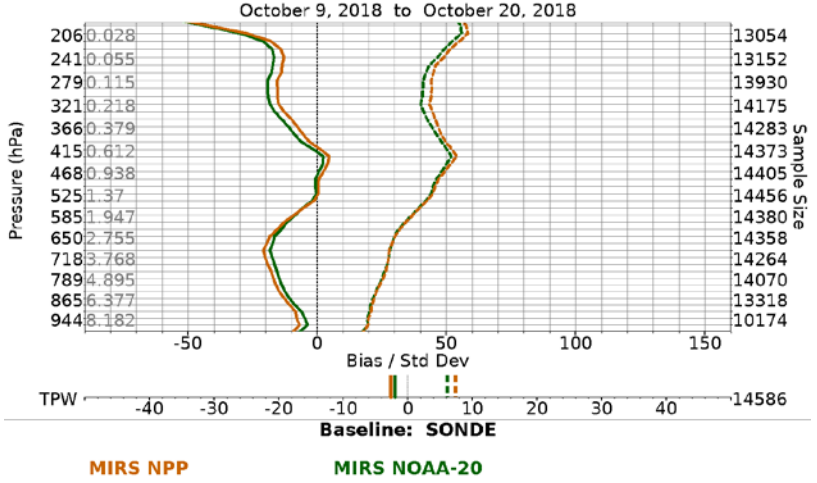


Water Vapor (%) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods

Land Clear

N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	10.04	10.89	-0.90	14.97	51.49	48.18	34.13	31.85
2018.04.15	-1.13	8.59	11.35	6.94	47.42	50.70	38.53	29.39
2018.07.15	6.80	7.94	1.99	-0.40	50.82	42.27	30.97	21.36
2018.10.15	-1.65	1.31	-0.48	5.11	47.71	43.03	32.37	28.24
2019.01.15	3.83	0.61	2.24	8.97	47.12	48.77	34.37	29.77
2019.04.15	0.48	11.97	11.66	8.75	51.07	51.30	37.34	30.97

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	14.39	10.06	-6.58	8.22	54.76	48.74	32.10	30.62
2018.04.15	2.97	7.85	3.00	-0.04	47.62	50.67	36.38	28.26
2018.07.15	13.77	10.68	-1.61	-4.01	56.75	44.89	30.37	21.34
2018.10.15	2.98	1.58	-7.03	-0.61	51.34	46.24	30.93	26.57
2019.01.15	7.29	-1.98	-6.04	1.14	49.05	48.93	31.63	27.53
2019.04.15	-0.22	8.45	9.39	7.77	50.24	50.30	37.70	30.62

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Water Vapor (%) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods; sea statistics based on ~ 100 samples per 10-day period

Sea Clear

N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (30 %)
2018.01.15	0.73	8.19	6.05	-0.50	60.92	47.61	38.46	16.03
2018.04.15	-4.24	16.90	8.27	0.27	36.03	41.30	32.51	17.40
2018.07.15	10.30	18.15	1.39	1.11	29.69	27.23	30.29	17.36
2018.10.15	7.77	21.18	3.84	0.16	47.37	51.30	31.14	14.87
2019.01.15	5.23	-1.65	6.76	1.47	64.31	45.23	40.54	21.40
2019.04.15	-16.05	-1.10	22.24	-0.07	39.19	53.26	43.74	15.22

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (30 %)
2018.01.15	1.47	9.79	4.62	-1.55	54.07	46.15	39.57	17.06
2018.04.15	-4.68	13.01	8.14	1.07	34.46	47.98	33.86	17.83
2018.07.15	10.80	14.51	3.11	2.66	37.77	31.88	31.26	17.75
2018.10.15	7.51	19.01	4.25	0.30	43.88	48.12	30.74	14.48
2019.01.15	2.46	-0.96	7.30	1.74	62.31	48.99	42.18	21.83
2019.04.15	-17.32	-3.89	18.18	-0.78	43.04	51.70	44.93	16.14

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Water Vapor (%) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods

Land Cloudy

N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	13.23	10.99	-12.32	-6.04	38.79	33.33	25.01	17.63
2018.04.15	6.45	11.91	-6.94	-0.81	47.76	44.24	27.90	22.24
2018.07.15	6.84	9.25	-6.97	-3.07	40.47	36.92	23.51	19.01
2018.10.15	5.39	7.66	-12.46	-3.01	47.81	43.87	26.01	19.98
2019.01.15	11.43	10.18	-9.83	-2.95	45.10	39.40	28.37	20.48
2019.04.15	6.23	9.45	-3.17	-0.30	45.23	42.37	29.38	21.41

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	19.68	13.71	-15.77	-10.08	42.01	36.03	25.35	17.60
2018.04.15	12.16	14.15	-11.37	-5.12	52.42	46.01	27.10	22.06
2018.07.15	17.30	13.75	-9.04	-5.71	48.09	39.56	24.29	20.01
2018.10.15	11.73	10.91	-16.82	-7.68	51.11	45.41	24.99	19.56
2019.01.15	17.04	11.08	14.72	-7.88	48.02	39.35	26.85	19.62
2019.04.15	10.24	11.44	-3.38	-1.02	50.05	44.52	29.25	21.89

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Water Vapor (%) comparison NOAA-20 (NPP) vs. radiosonde

Note: statistics are for 10-day periods; sea statistics based on ~ 100 samples per 10-day period

Sea Cloudy

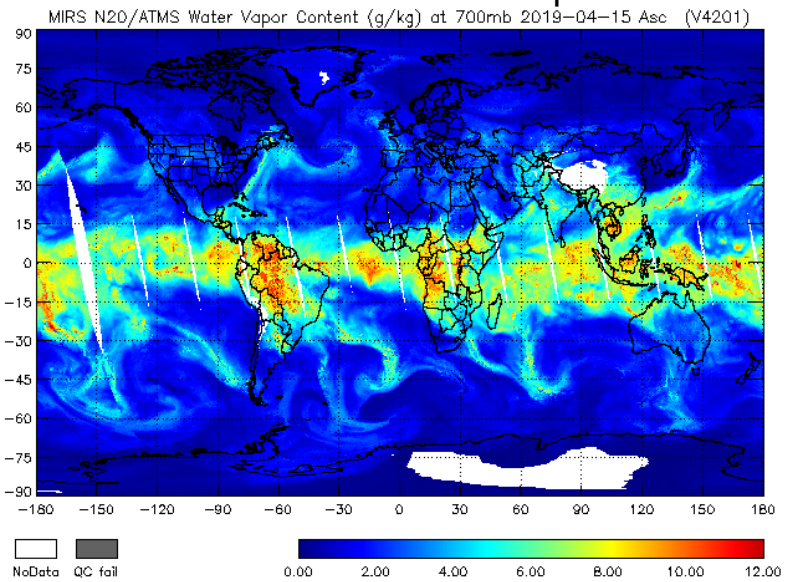
N20	Accuracy (N20)				Precision (N20)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (10 %)	900 hPa (20 %)	400 hPa (70 %)	500 hPa (65 %)	700 hPa (60 %)	900 hPa (30 %)
2018.01.15	15.08	12.46	-2.67	-4.62	41.64	43.50	31.06	12.77
2018.04.15	2.46	11.21	-4.77	-2.37	38.76	40.28	26.70	14.57
2018.07.15	1.82	10.25	-0.53	-5.92	34.84	34.85	27.23	12.09
2018.10.15	16.71	14.82	-0.49	-5.04	49.84	41.09	24.51	12.12
2019.01.15	10.52	6.75	-4.31	-3.54	44.66	36.16	27.59	12.93
2019.04.15	16.18	14.87	2.79	-3.15	53.15	44.89	36.74	13.83

NPP	Accuracy (NPP)				Precision (NPP)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (10 %)	900 hPa (20 %)	400 hPa (70 %)	500 hPa (65 %)	700 hPa (60 %)	900 hPa (30 %)
2018.01.15	14.61	10.13	-2.56	-3.94	43.61	44.28	29.40	12.71
2018.04.15	3.77	10.46	-5.48	-2.26	38.36	42.33	26.89	14.14
2018.07.15	1.85	7.05	-1.28	-5.24	36.77	36.88	27.80	12.13
2018.10.15	11.38	8.75	-0.18	-4.30	47.24	39.28	24.27	12.47
2019.01.15	10.69	5.85	-5.08	-3.60	47.20	38.80	27.82	12.46
2019.04.15	10.05	10.21	3.79	-2.61	48.96	46.81	36.61	14.21

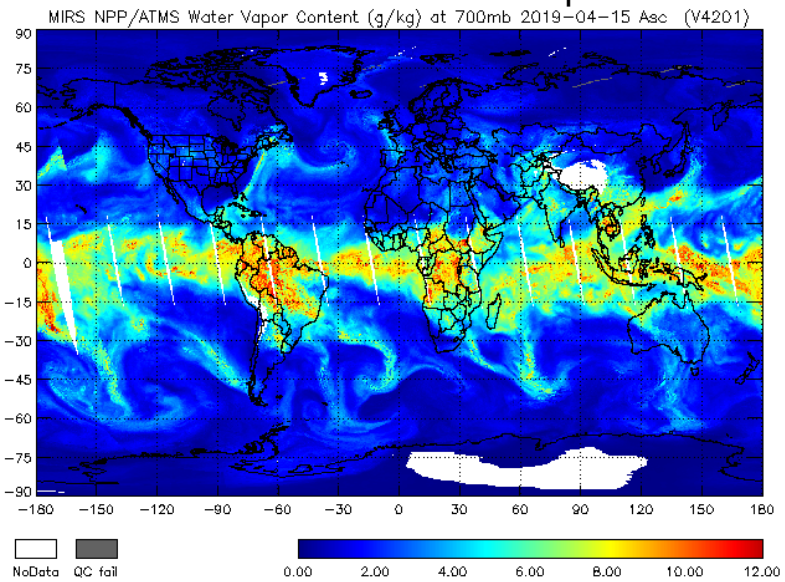
Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Water Vapor Profile Validation based on ECMWF data

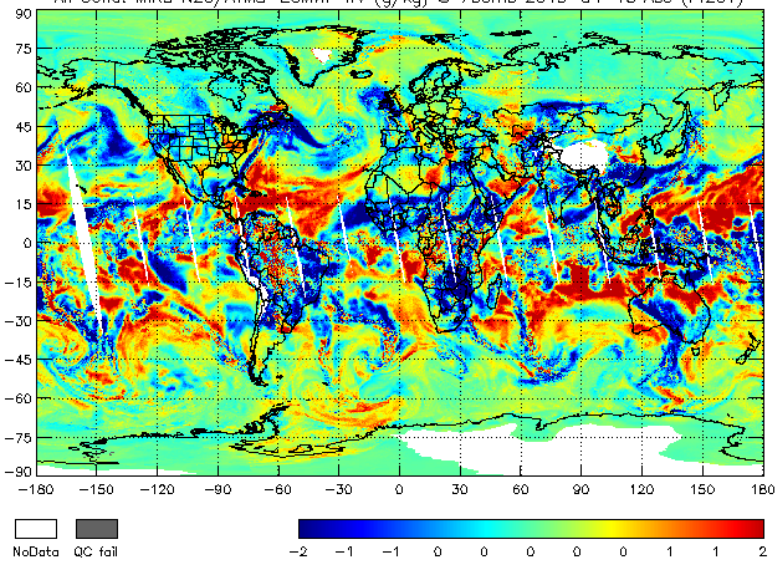
N20 700hPa Water Vapor



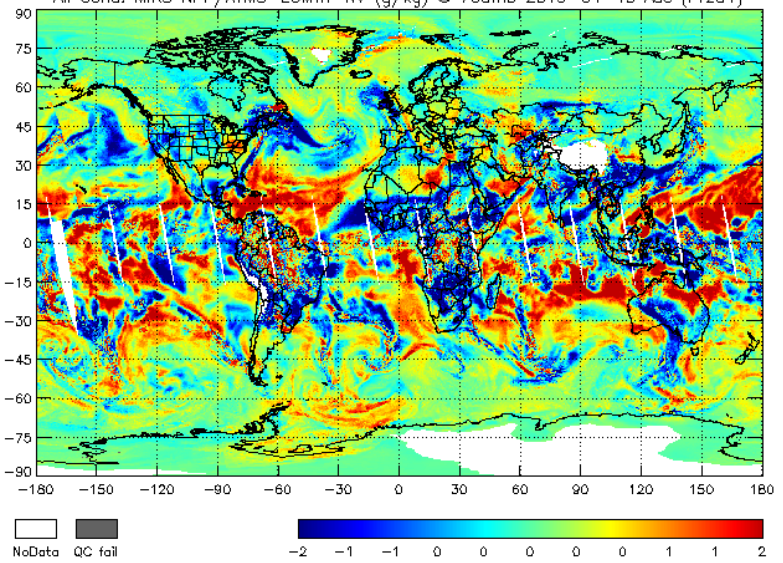
NPP 700hPa Water Vapor



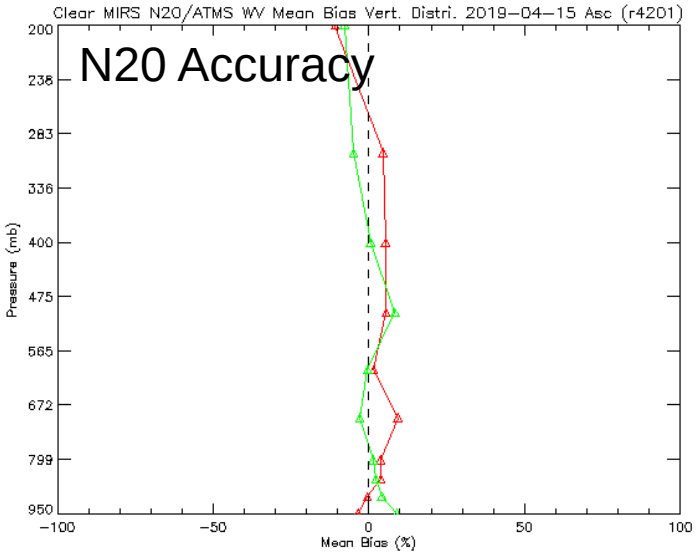
N20-ECMWF 700hPa WV Diff.

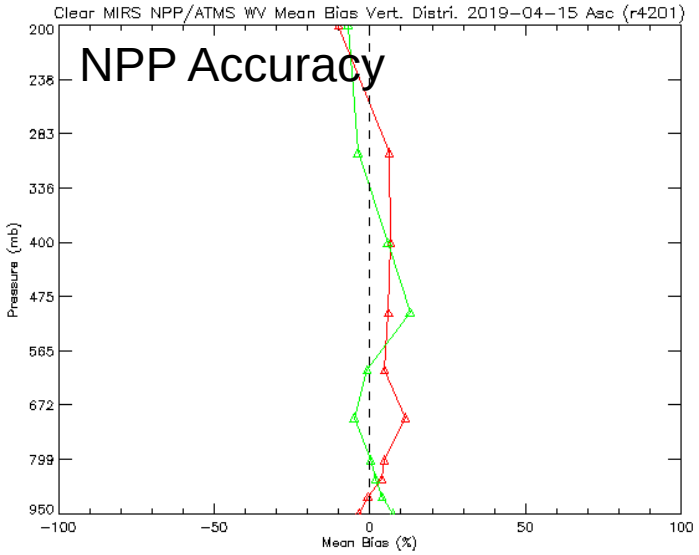


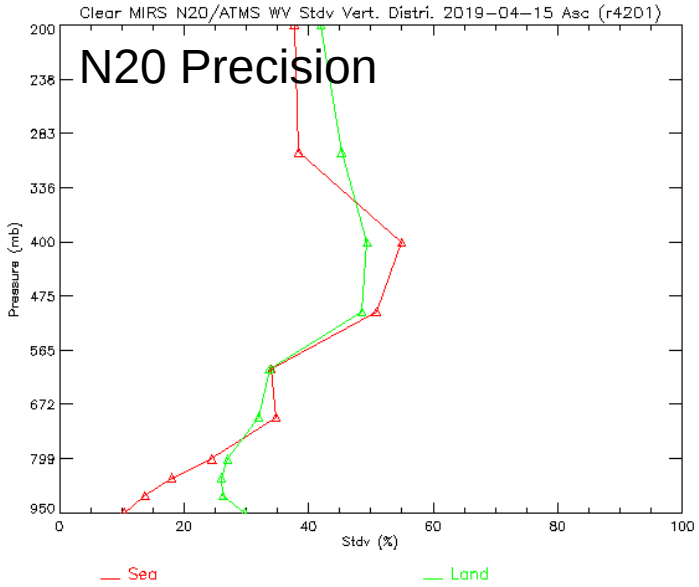
NPP-ECMWF 700hPa WV Diff.

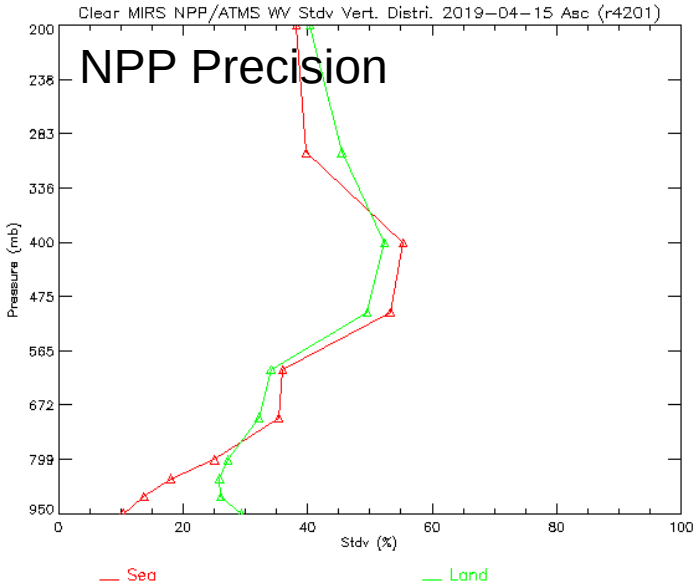


Water Vapor Profile Validation based on ECMWF data









Water Vapor Profile Validation based on GDAS data

Clear Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (30 %)
2018.01.15	-18.0 / -17.0	2.0 / 3.0	9.0 / 9.0	0.0 / 1.0	40.0 / 39.0	43.0 / 42.0	36.0 / 34.0	14.0 / 13.0
2018.04.15	-18.0 / -17.0	4.0 / 4.0	5.0 / 4.0	1.0 / 1.0	39.0 / 36.0	41.0 / 38.0	33.0 / 32.0	14.0 / 13.0
2018.07.15	-17.0 / -14.0	3.0 / 1.0	8.0 / 6.0	0.0 / 0.0	36.0 / 35.0	37.0 / 34.0	29.0 / 27.0	12.0 / 12.0
2018.10.15	-15.0 / -14.0	4.0 / 3.0	11.0 / 10.0	-2.0 / -1.0	37.0 / 35.0	42.0 / 38.0	32.0 / 32.0	12.0 / 12.0
2019.01.15	-19.0 / -15.0	2.0 / 2.0	5.0 / 6.0	-1.0 / 0.0	39.0 / 37.0	42.0 / 40.0	33.0 / 32.0	13.0 / 13.0
2019.04.15	-10.0 / -12.0	3.0 / 1.0	5.0 / 7.0	-1.0 / -1.0	42.0 / 40.0	44.0 / 41.0	32.0 / 32.0	13.0 / 12.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (30 %)
2018.01.15	-20.0 / -18.0	0.0 / 1.0	9.0 / 9.0	0.0 / 1.0	41.0 / 40.0	44.0 / 43.0	35.0 / 34.0	13.0 / 13.0
2018.04.15	-17.0 / -17.0	0.0 / 1.0	4.0 / 3.0	1.0 / 1.0	39.0 / 38.0	41.0 / 41.0	34.0 / 31.0	13.0 / 13.0
2018.07.15	-16.0 / -12.0	-1.0 / 0.0	5.0 / 6.0	0.0 / 0.0	37.0 / 39.0	38.0 / 37.0	28.0 / 28.0	12.0 / 11.0
2018.10.15	-14.0 / -12.0	-1.0 / -1.0	9.0 / 9.0	-1.0 / -2.0	39.0 / 38.0	41.0 / 39.0	32.0 / 31.0	12.0 / 13.0
2019.01.15	-18.0 / -14.0	0.0 / 1.0	4.0 / 3.0	0.0 / 0.0	40.0 / 39.0	44.0 / 43.0	32.0 / 31.0	14.0 / 13.0
2019.04.15	-11.0 / -9.0	2.0 / 1.0	7.0 / 8.0	-1.0 / -1.0	43.0 / 43.0	47.0 / 42.0	34.0 / 31.0	13.0 / 12.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Water Vapor Profile Validation based on GDAS data

Clear Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	-18.0 / -14.0	6.0 / 5.0	-1.0 / 4.0	9.0 / 7.0	40.0 / 42.0	49.0 / 47.0	38.0 / 39.0	27.0 / 26.0
2018.04.15	-19.0 / -11.0	6.0 / 10.0	-5.0 / -6.0	8.0 / 3.0	41.0 / 44.0	47.0 / 46.0	32.0 / 30.0	22.0 / 21.0
2018.07.15	-11.0 / -12.0	6.0 / 2.0	-3.0 / -1.0	7.0 / 2.0	43.0 / 41.0	41.0 / 42.0	27.0 / 26.0	23.0 / 21.0
2018.10.15	-15.0 / -12.0	5.0 / 10.0	-5.0 / -4.0	7.0 / 4.0	41.0 / 46.0	43.0 / 45.0	28.0 / 27.0	26.0 / 24.0
2019.01.15	-7.0 / -1.0	5.0 / 6.0	-8.0 / -8.0	10.0 / 3.0	42.0 / 46.0	41.0 / 40.0	33.0 / 35.0	27.0 / 26.0
2019.04.15	-19.0 / -10.0	1.0 / 9.0	-6.0 / -8.0	10.0 / 4.0	44.0 / 47.0	46.0 / 46.0	32.0 / 33.0	22.0 / 24.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	-16.0 / -15.0	3.0 / 8.0	0.0 / 0.0	9.0 / 4.0	43.0 / 41.0	48.0 / 48.0	35.0 / 37.0	27.0 / 27.0
2018.04.15	-17.0 / -14.0	6.0 / 10.0	-4.0 / -4.0	6.0 / 4.0	45.0 / 45.0	50.0 / 48.0	32.0 / 31.0	28.0 / 24.0
2018.07.15	-10.0 / -11.0	5.0 / 6.0	-2.0 / -5.0	5.0 / 0.0	48.0 / 46.0	44.0 / 45.0	26.0 / 26.0	23.0 / 22.0
2018.10.15	-14.0 / -9.0	1.0 / 5.0	-5.0 / -5.0	6.0 / 1.0	44.0 / 50.0	46.0 / 48.0	28.0 / 29.0	21.0 / 20.0
2019.01.15	-6.0 / -1.0	2.0 / 2.0	-8.0 / -8.0	8.0 / 3.0	44.0 / 47.0	45.0 / 42.0	31.0 / 30.0	28.0 / 27.0
2019.04.15	-15.0 / -11.0	3.0 / 7.0	-9.0 / -9.0	9.0 / 2.0	44.0 / 43.0	45.0 / 44.0	33.0 / 34.0	27.0 / 25.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Water Vapor Profile Validation based on GDAS data

Cloudy Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (10 %)	900 hPa (20 %)	400 hPa (70 %)	500 hPa (65 %)	700 hPa (60 %)	900 hPa (30 %)
2018.01.15	-15.0 / -17.0	-2.0 / -1.0	-6.0 / -5.0	-6.0 / -6.0	43.0 / 41.0	51.0 / 49.0	34.0 / 34.0	16.0 / 16.0
2018.04.15	-21.0 / -20.0	-6.0 / -8.0	-2.0 / 0.0	-6.0 / -6.0	44.0 / 41.0	52.0 / 48.0	37.0 / 38.0	16.0 / 16.0
2018.07.15	-22.0 / -18.0	-6.0 / -4.0	-1.0 / 0.0	-7.0 / -7.0	43.0 / 42.0	48.0 / 46.0	35.0 / 34.0	14.0 / 15.0
2018.10.15	-18.0 / -17.0	-7.0 / -4.0	-4.0 / 2.0	-6.0 / -7.0	50.0 / 43.0	54.0 / 49.0	36.0 / 37.0	14.0 / 14.0
2019.01.15	-18.0 / -16.0	-10.0 / -8.0	-4.0 / -1.0	-5.0 / -6.0	51.0 / 45.0	54.0 / 51.0	36.0 / 36.0	15.0 / 15.0
2019.04.15	-19.0 / -20.0	-11.0 / -9.0	-1.0 / 0.0	-7.0 / -7.0	45.0 / 43.0	51.0 / 48.0	37.0 / 38.0	16.0 / 16.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (10 %)	900 hPa (20 %)	400 hPa (70 %)	500 hPa (65 %)	700 hPa (60 %)	900 hPa (30 %)
2018.01.15	-13.0 / -12.0	-2.0 / -5.0	-6.0 / -3.0	-5.0 / -6.0	44.0 / 41.0	50.0 / 48.0	32.0 / 33.0	15.0 / 14.0
2018.04.15	-23.0 / -22.0	-11.0 / -7.0	-2.0 / 0.0	-6.0 / -5.0	43.0 / 42.0	49.0 / 48.0	36.0 / 36.0	16.0 / 16.0
2018.07.15	-18.0 / -18.0	-6.0 / -6.0	0.0 / 0.0	-7.0 / -7.0	45.0 / 43.0	48.0 / 46.0	33.0 / 33.0	14.0 / 14.0
2018.10.15	-13.0 / -17.0	-6.0 / -6.0	-2.0 / 1.0	-5.0 / -7.0	49.0 / 44.0	54.0 / 50.0	35.0 / 37.0	13.0 / 14.0
2019.01.15	-17.0 / -15.0	-11.0 / -9.0	-3.0 / -1.0	-4.0 / -6.0	49.0 / 47.0	55.0 / 52.0	34.0 / 34.0	15.0 / 15.0
2019.04.15	-18.0 / -18.0	-10.0 / -9.0	0.0 / 1.0	-6.0 / -7.0	43.0 / 42.0	51.0 / 48.0	36.0 / 38.0	17.0 / 16.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Water Vapor Profile Validation based on GDAS data

Cloudy Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	-2.0 / -1.0	18.0 / 16.0	-8.0 / -11.0	6.0 / 6.0	37.0 / 34.0	39.0 / 37.0	26.0 / 31.0	19.0 / 21.0
2018.04.15	-10.0 / -8.0	5.0 / 10.0	-10.0 / -12.0	8.0 / 9.0	36.0 / 38.0	36.0 / 37.0	24.0 / 25.0	21.0 / 19.0
2018.07.15	-11.0 / -9.0	8.0 / 6.0	-6.0 / -8.0	8.0 / 6.0	32.0 / 31.0	34.0 / 35.0	24.0 / 24.0	17.0 / 19.0
2018.10.15	-10.0 / -11.0	3.0 / 5.0	-10.0 / -10.0	8.0 / 11.0	44.0 / 45.0	45.0 / 44.0	30.0 / 32.0	26.0 / 28.0
2019.01.15	-7.0 / -3.0	12.0 / 11.0	-9.0 / -12.0	6.0 / 6.0	34.0 / 30.0	35.0 / 31.0	26.0 / 26.0	20.0 / 18.0
2019.04.15	-12.0 / -10.0	4.0 / 5.0	-10.0 / -8.0	8.0 / 10.0	41.0 / 45.0	40.0 / 42.0	26.0 / 30.0	20.0 / 21.0

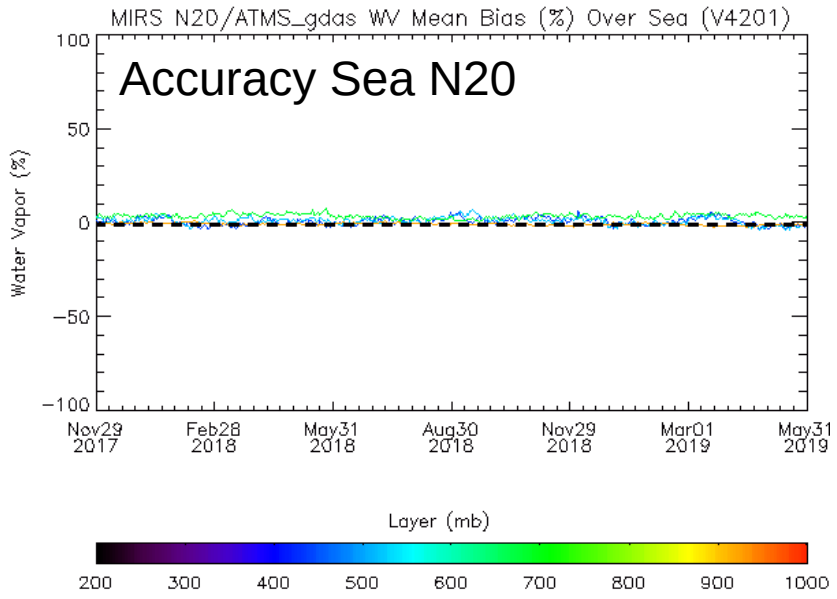
NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	-2.0 / 1.0	17.0 / 16.0	-4.0 / -12.0	9.0 / 4.0	35.0 / 31.0	36.0 / 33.0	23.0 / 24.0	20.0 / 18.0
2018.04.15	-8.0 / -6.0	7.0 / 11.0	-6.0 / -11.0	11.0 / 11.0	39.0 / 38.0	38.0 / 38.0	24.0 / 27.0	22.0 / 24.0
2018.07.15	-7.0 / -8.0	8.0 / 5.0	-5.0 / -9.0	2.0 / 2.0	39.0 / 37.0	38.0 / 38.0	26.0 / 26.0	19.0 / 21.0
2018.10.15	-7.0 / 8.0	3.0 / 4.0	-9.0 / -11.0	9.0 / 9.0	48.0 / 48.0	47.0 / 46.0	29.0 / 33.0	24.0 / 25.0
2019.01.15	-5.0 / 1.0	13.0 / 17.0	-7.0 / -12.0	6.0 / 6.0	32.0 / 31.0	33.0 / 32.0	26.0 / 27.0	18.0 / 17.0
2019.04.15	-10.0 / -6.0	9.0 / 8.0	-9.0 / -10.0	10.0 / 9.0	41.0 / 44.0	40.0 / 42.0	25.0 / 30.0	22.0 / 20.0

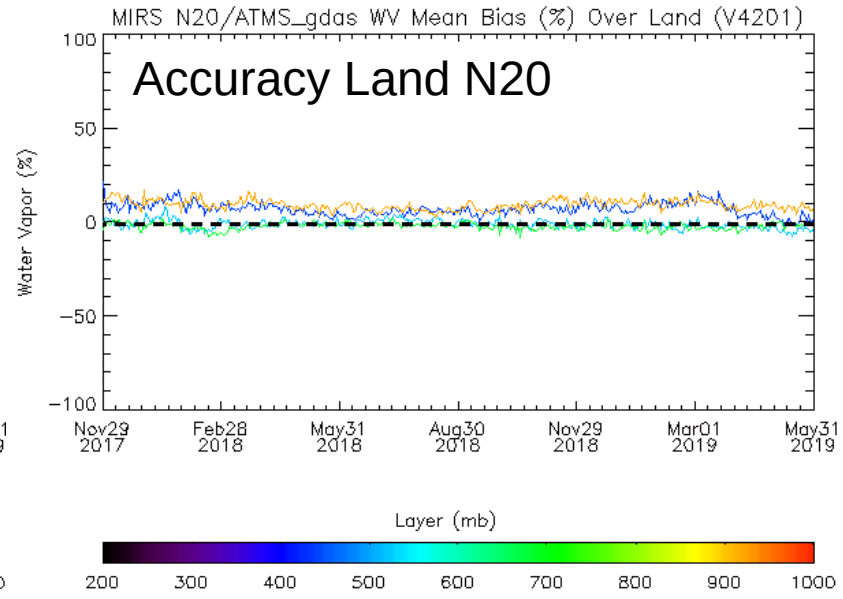
Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

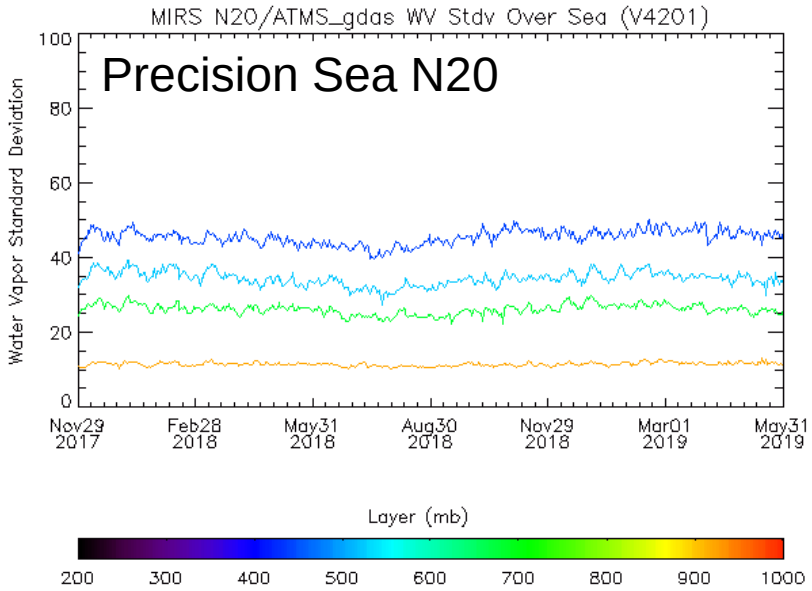
Note: results stratified by asc/des, but requirements are for combined passes

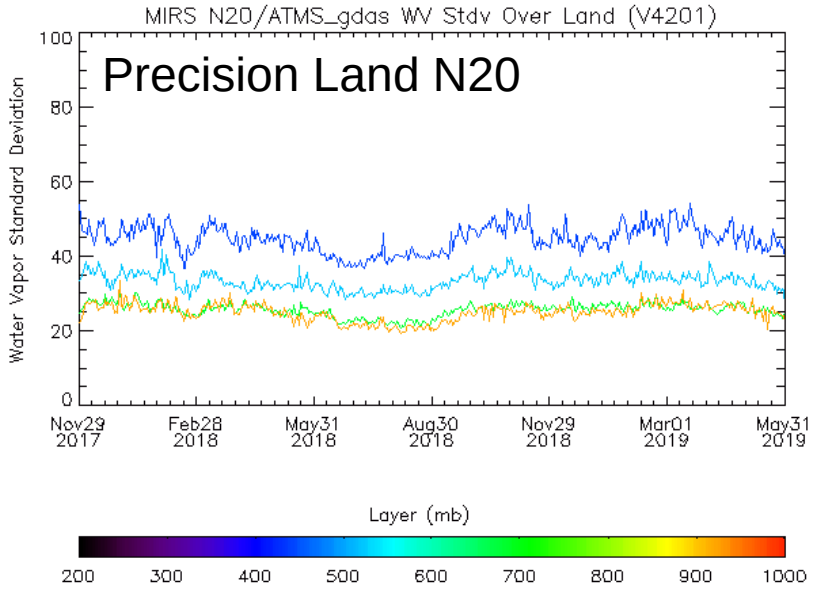
Additional comparisons with ECMWF located in Supplemental Slides

Water Vapor Profile Validation based on GDAS data: Time Series (Nov 2017 – May 2019)

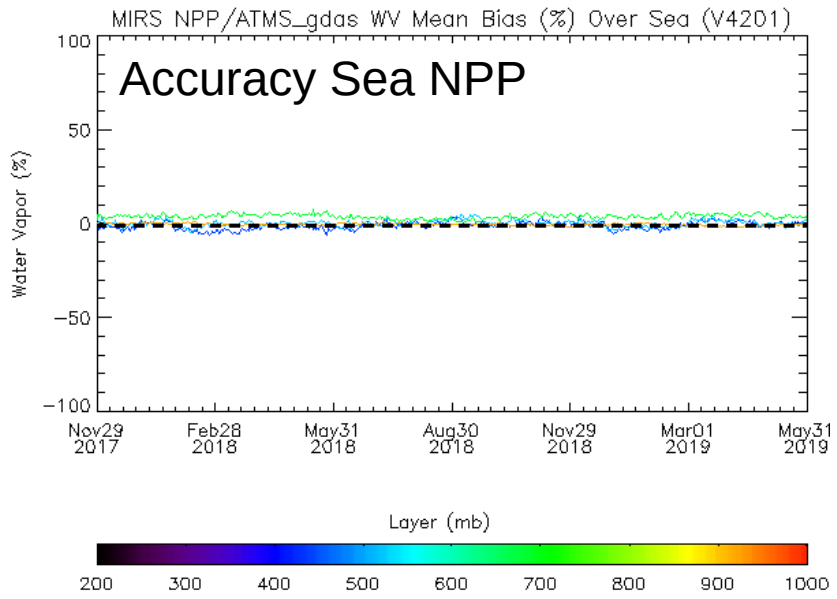


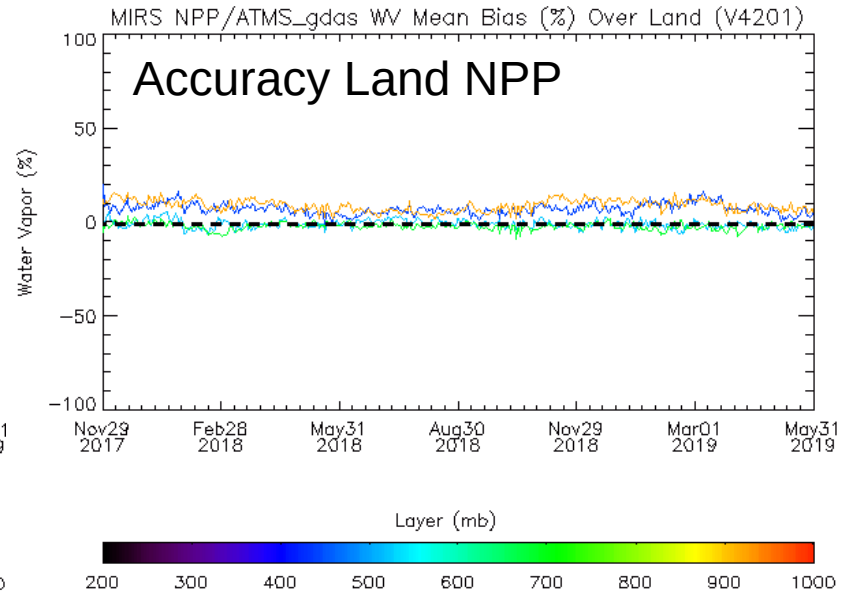


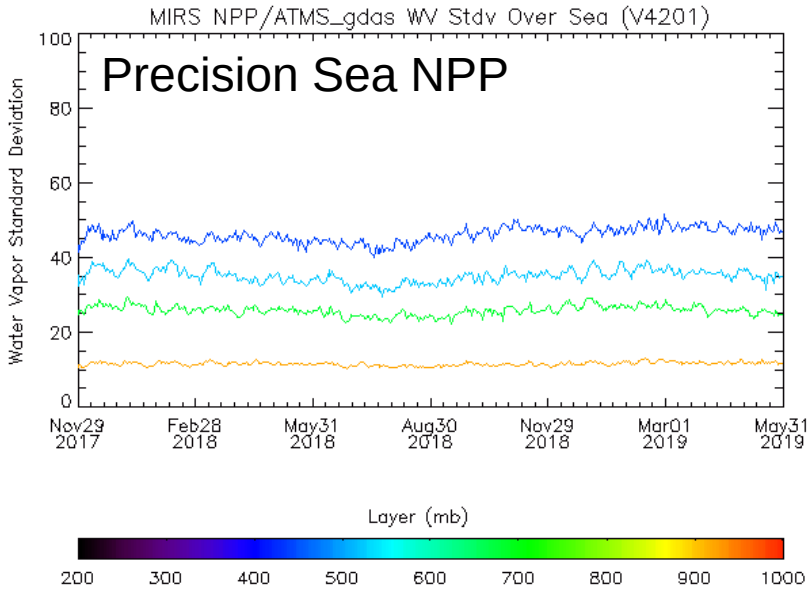


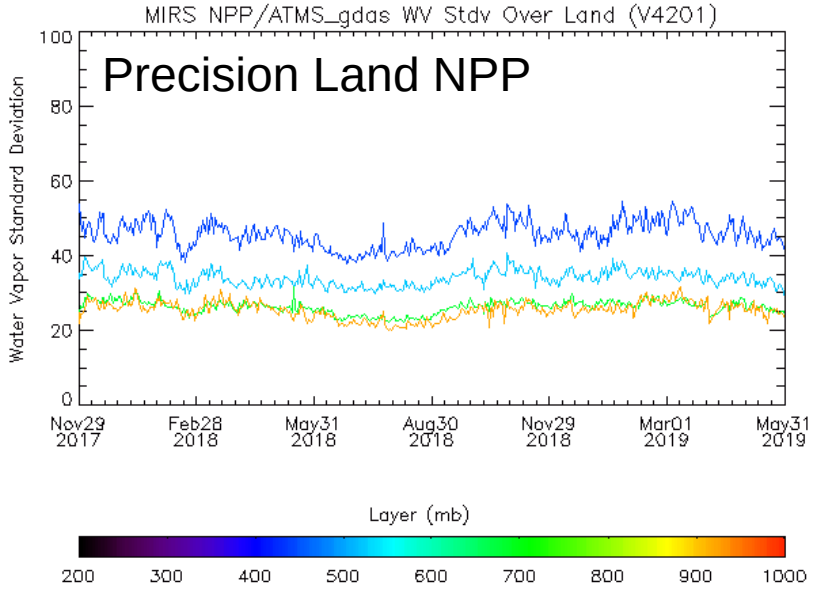


Water Vapor Profile Validation based on GDAS data: Time Series (Nov 2017 – May 2019)

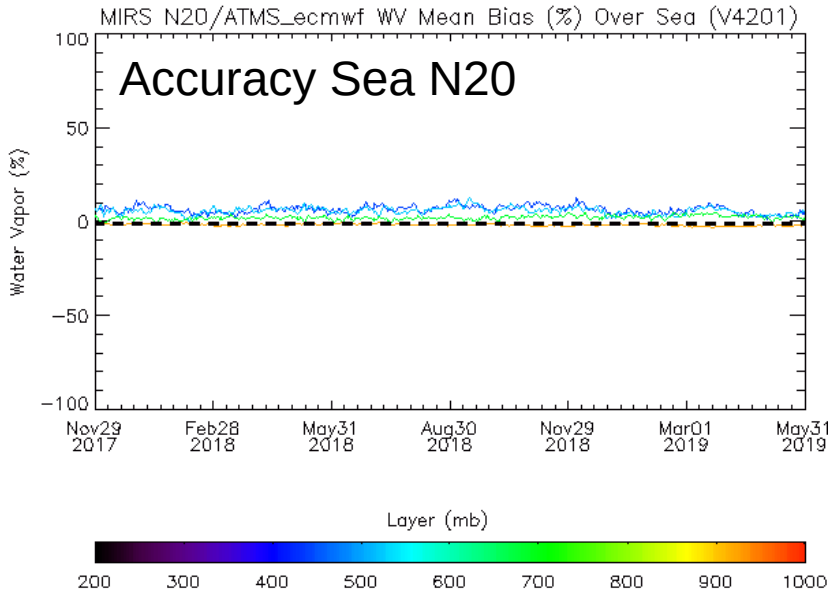


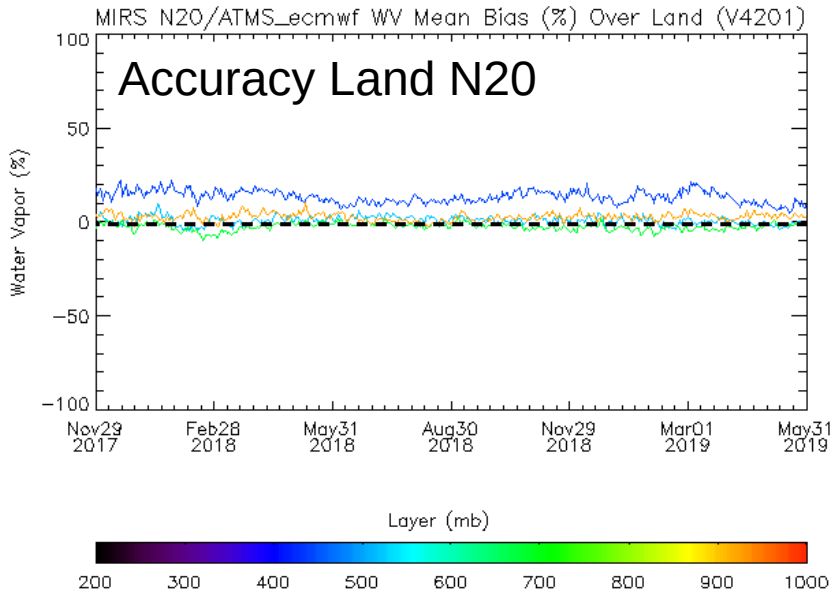


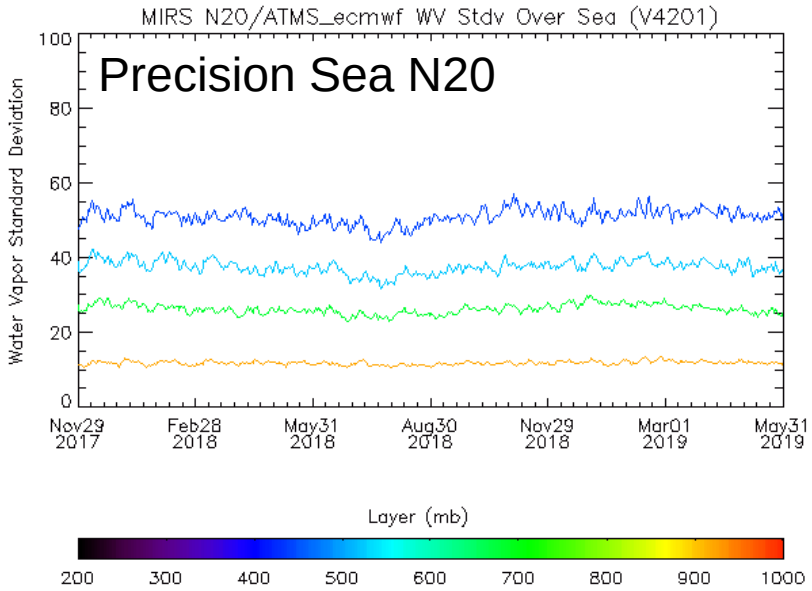


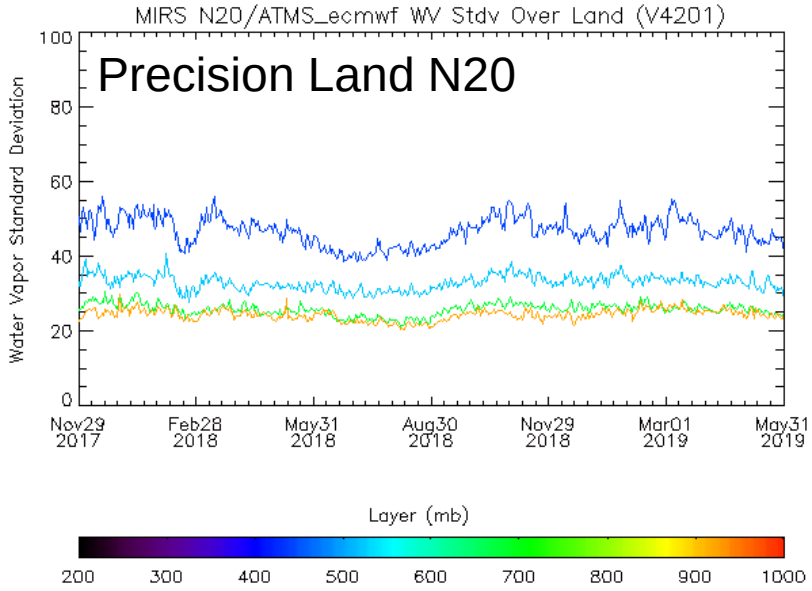


Water Vapor Profile Validation based on ECMWF data: Time Series (Nov 2017 – May 2019)

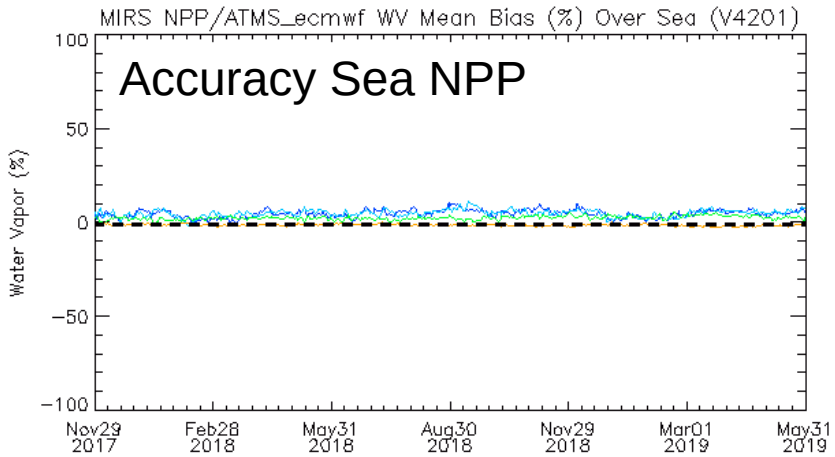


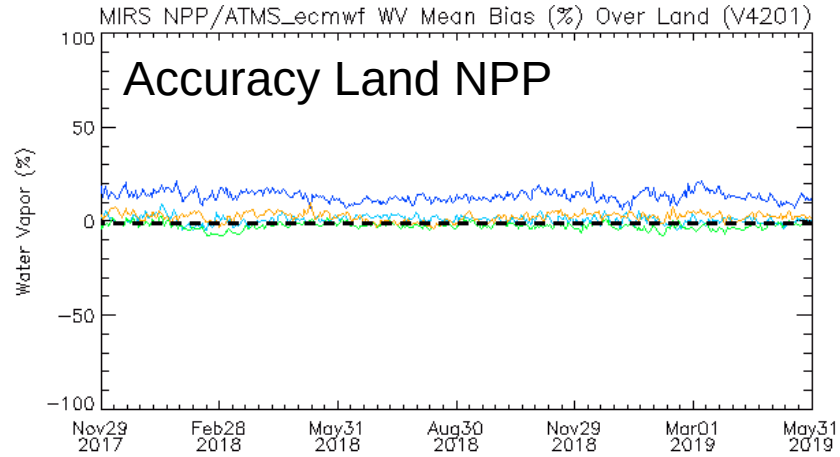


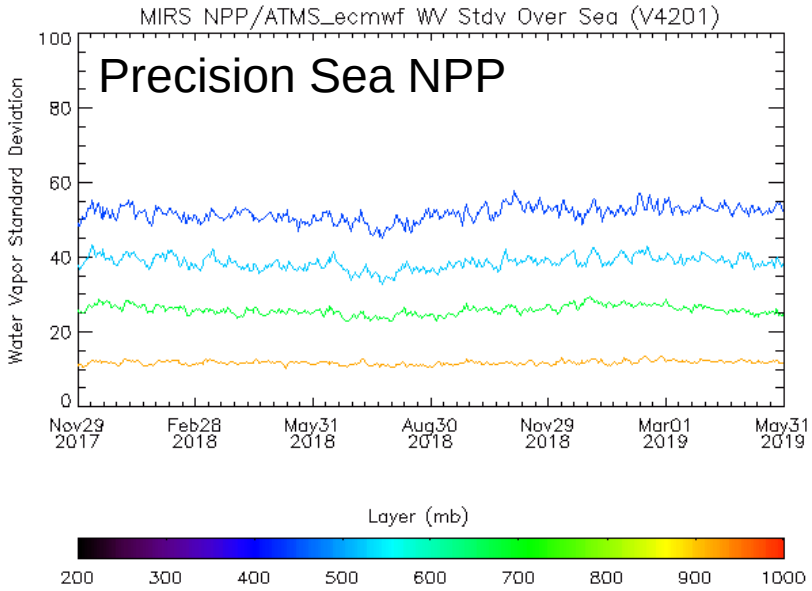


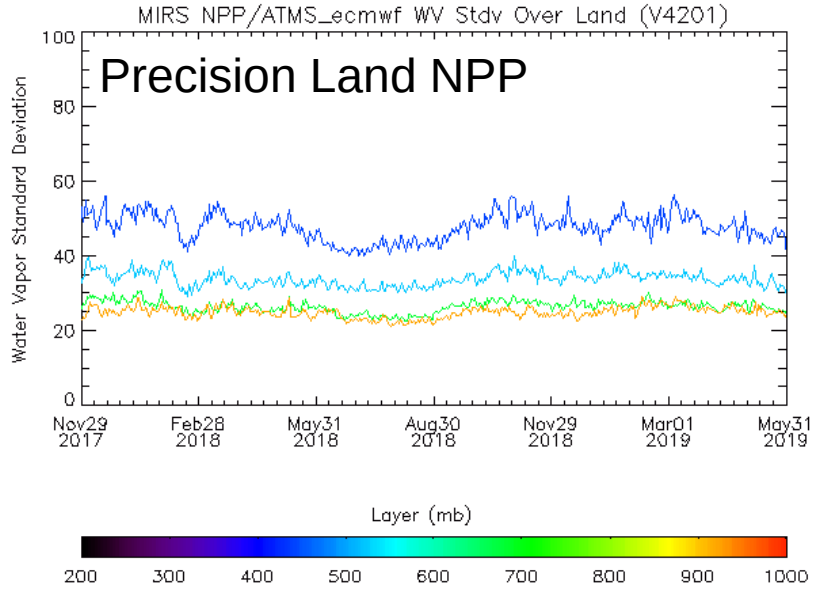


Water Vapor Profile Validation based on ECMWF data: Time Series (Nov 2017 – May 2019)









Requirements and Validation Results: Total Precipitable Water Compared to GDAS

- Daily, Global Collocations with ECMWF and GDAS.
- Stratified by clear/cloudy, and surface type
- Requirements from JPSS-REQ-1004
- All accuracy and precision requirements are met

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 (mm) (Accuracy)		StDv (mm) (Precision)	
			MiRS	Req	MiRS	Req
TPW	Sea	Clear	**1.47 (1.46)**	**1.5**	**1.91 (1.86)**	**2.5**
		Cloudy	**0.12 (0.17)**	**0.5**	**2.04 (2.01)**	**2.5**
	Ice	Clear	**-0.39 (-0.39)**	**2.0**	**1.12 (1.15)**	**2.0**
		Cloudy	**0.15 (0.16)**	**2.0**	**1.79 (1.89)**	**2.0**
	Land	Clear	**1.17 (0.96)**	**2.5**	**4.90 (3.97)**	**5.5**
		Cloudy	**1.23 (1.52)**	**2.5**	**4.86 (5.26)**	**5.5**
	Snow	Clear	**-0.22 (-0.20)**	**0.5**	**0.86 (0.86)**	**2.0**
		Cloudy	**0.26 (0.48)**	**0.5**	**1.95 (2.19)**	**2.0**

Values in ( ) indicates NPP

Meets requirement

Collocation details:

- ECMWF and GDAS: bilinear interpolation in space and time from 1 deg lat/lon, 6-hour analyses

Data collected:

ECMWF and GDAS: 2018.01.15, 2018.04.15 2018.07.15, 2018.10.15, 2019.01.15, and 2019.04.15

Requirements and Validation Results: Total Precipitable Water Compared to ECMWF

- Daily, Global Collocations with ECMWF and GDAS.
- Stratified by clear/cloudy, and surface type
- Requirements from JPSS-REQ-1004
- Most accuracy and precision requirements are met

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 (mm) (Accuracy)		StDv (mm) (Precision)	
			MiRS	Req	MiRS	Req
TPW	Sea	Clear	**1.66 (1.65)**	**1.5**	**2.16 (2.14)**	**2.5**
		Cloudy	**1.13 (1.21)**	**0.5**	**2.06 (2.02)**	**2.5**
	Ice	Clear	**0.22 (0.23)**	**2.0**	**1.12 (1.16)**	**2.0**
		Cloudy	**1.17 (1.16)**	**2.0**	**1.87 (1.97)**	**2.0**
	Land	Clear	**1.06 (0.84)**	**2.5**	**3.89 (4.11)**	**5.5**
		Cloudy	**1.23 (1.51)**	**2.5**	**5.07 (5.74)**	**5.5**
	Snow	Clear	**0.28 (0.31)**	**0.5**	**0.91 (0.93)**	**2.0**
		Cloudy	**0.97 (1.13)**	**0.5**	**2.13 (2.39)**	**2.0**

Values in ( ) indicates NPP

Meets requirement

Marginal

Collocation details:

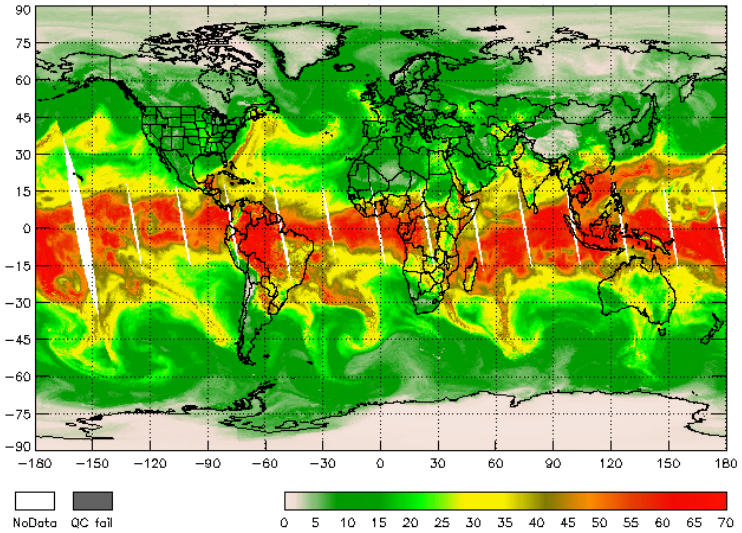
- ECMWF and GDAS: bilinear interpolation in space and time from 1 deg lat/lon, 6-hour analyses

Data collected:

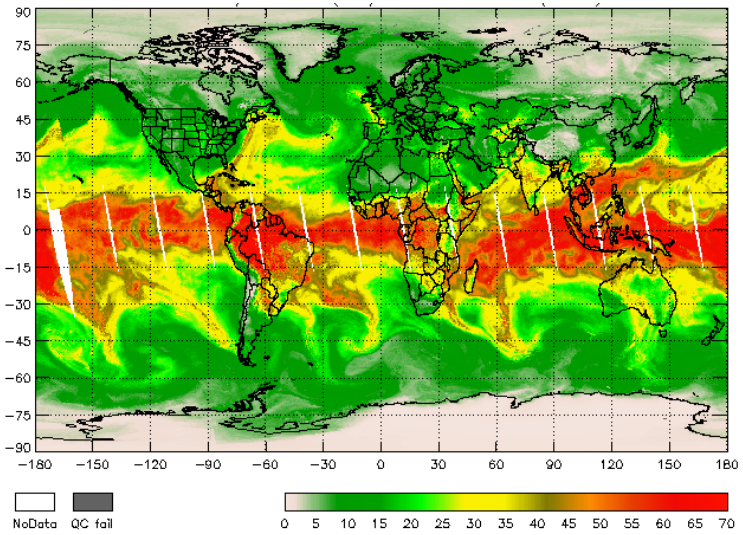
ECMWF and GDAS: 2018.01.15, 2018.04.15 2018.07.15, 2018.10.15, 2019.01.15, and 2019.04.15

Validation Results: Total Precipitable Water (TPW)

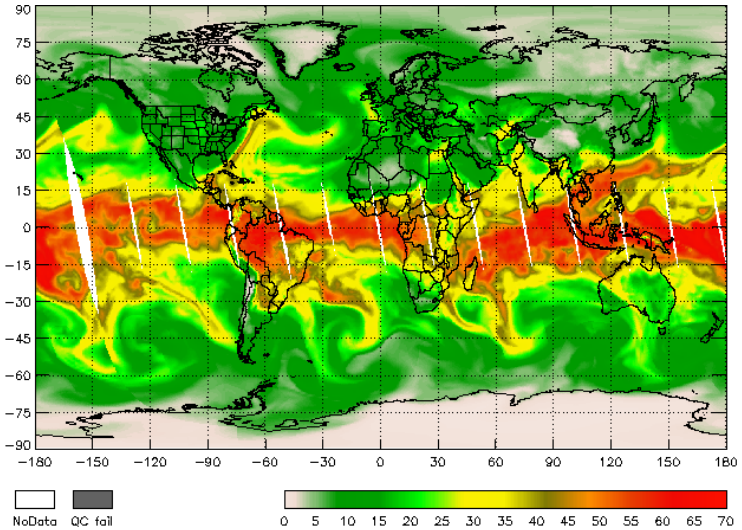
MiRS N20/ATMS TPW (mm) 2019-04-15 Asc



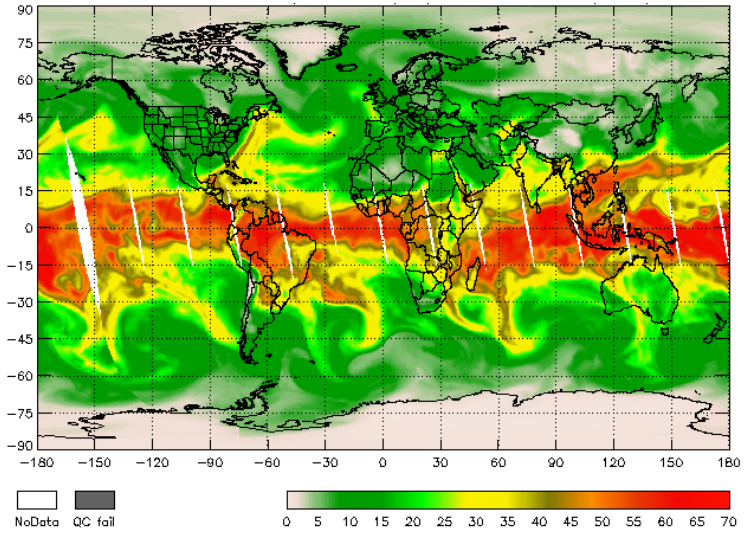
MiRS NPP/ATMS TPW(mm) 2019-04-15 Asc



GDAS TPW (mm) 2019-04-15 Asc

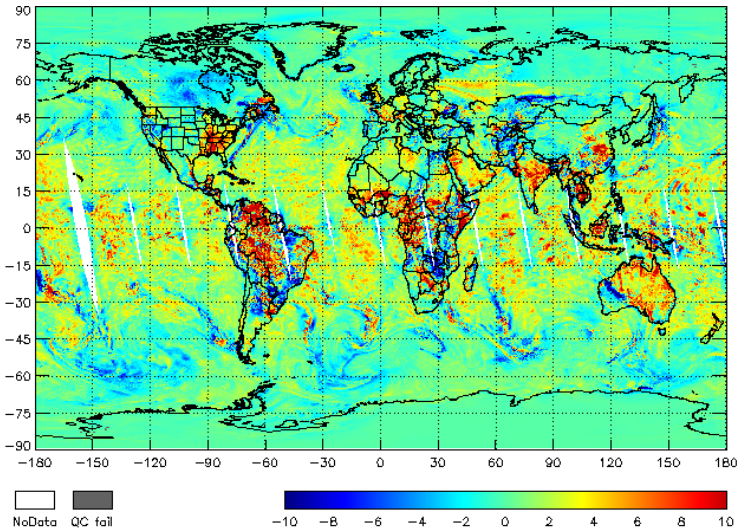


ECMWF TPW (mm) 2019-04-15 Asc

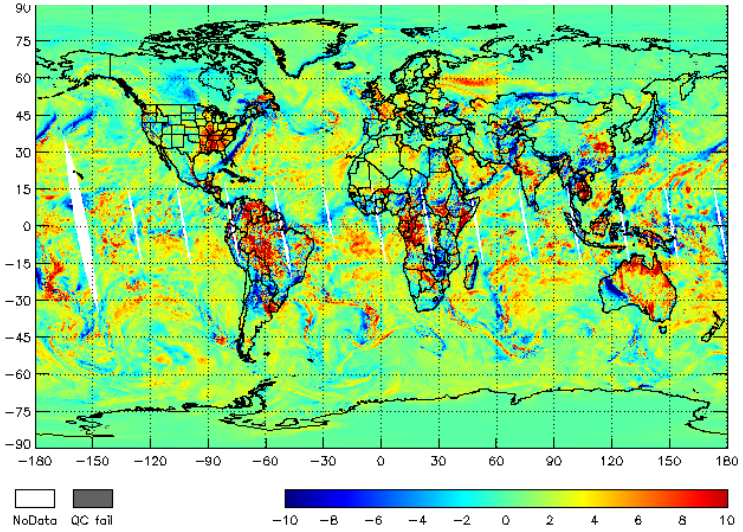


Validation Results: Total Precipitable Water (TPW)

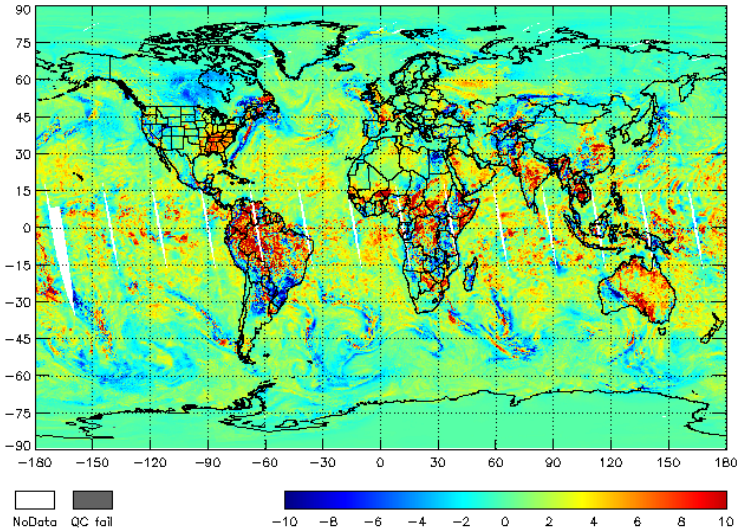
MiRS N20/ATMS -GDAS TPW (mm) 2019-04-15 Asc



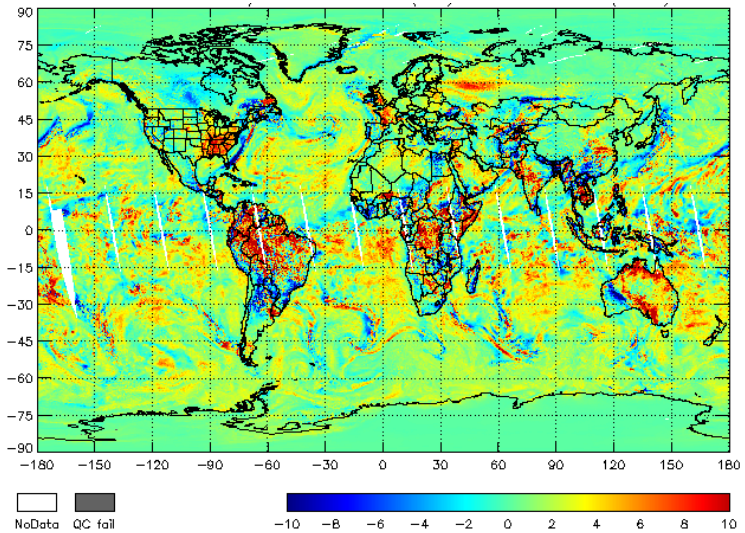
MiRS N20/ATMS -ECMWF TPW(mm) 2019-04-15 Asc



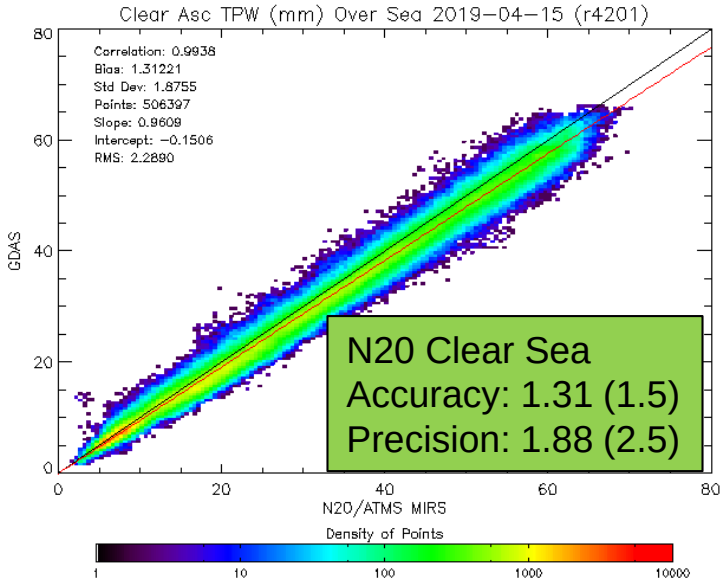
MiRS NPP/ATMS - GDAS TPW (mm) 2019-04-15 Asc

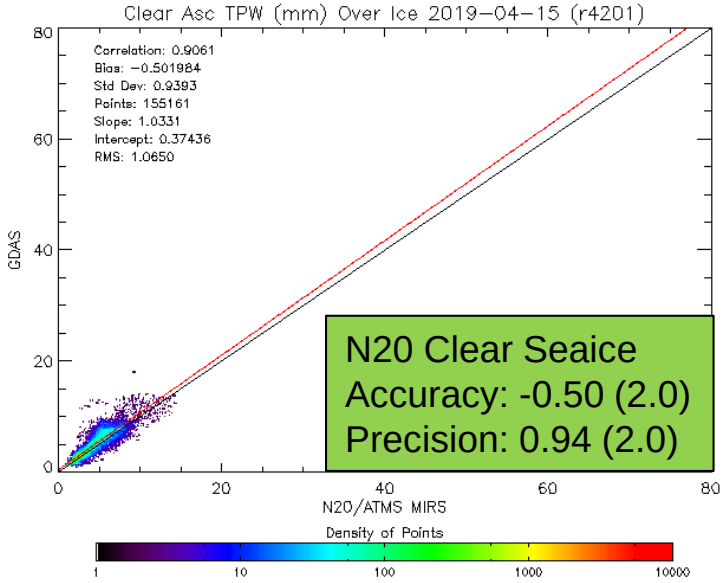


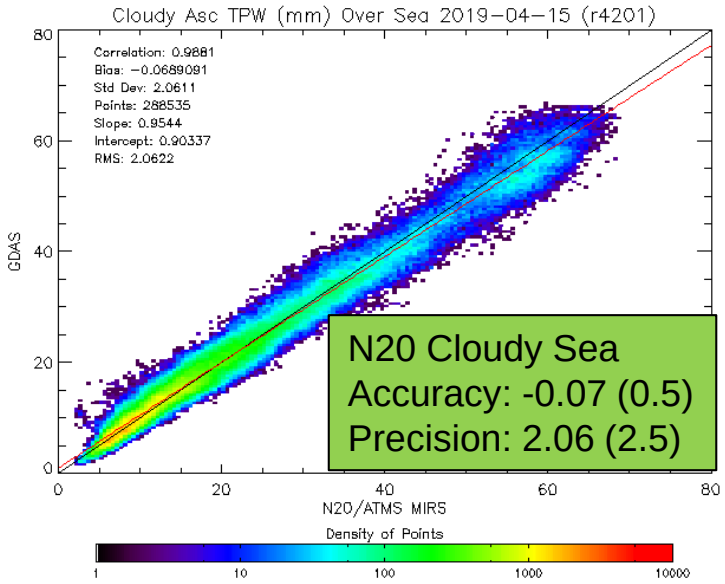
MiRS NPP/ATMS - ECMWF TPW (mm) 2019-04-15 Asc

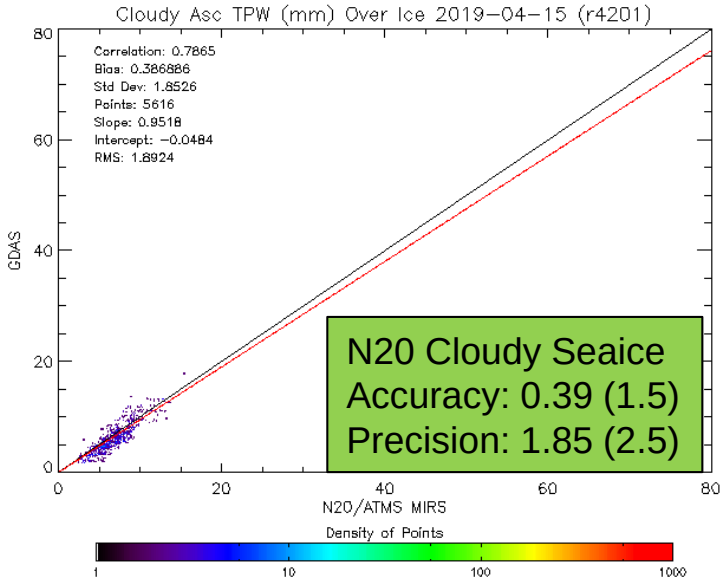


Validation Results: Total Precipitable Water (TPW) Compared to GDAS

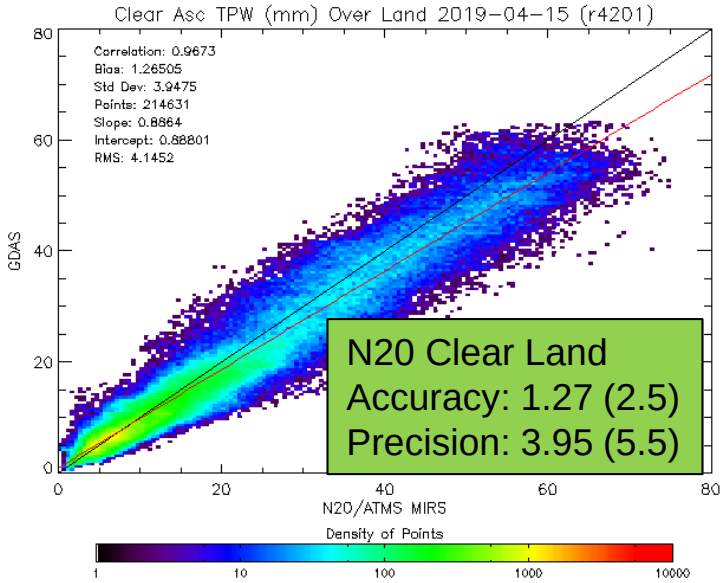


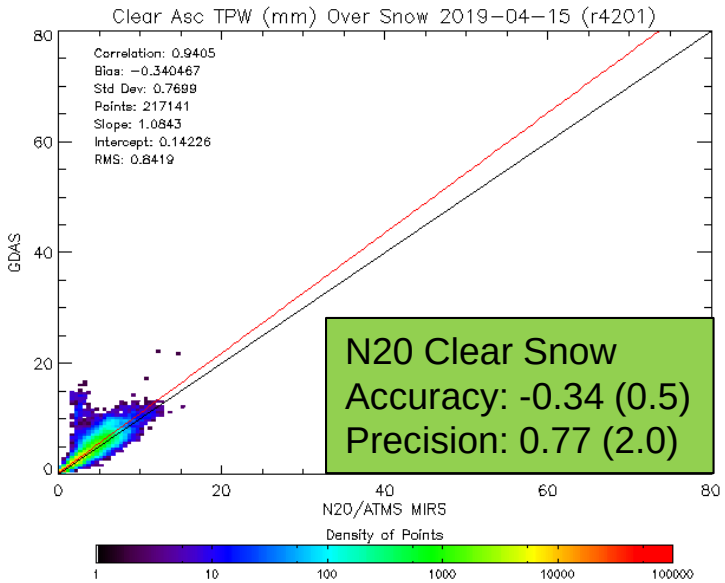


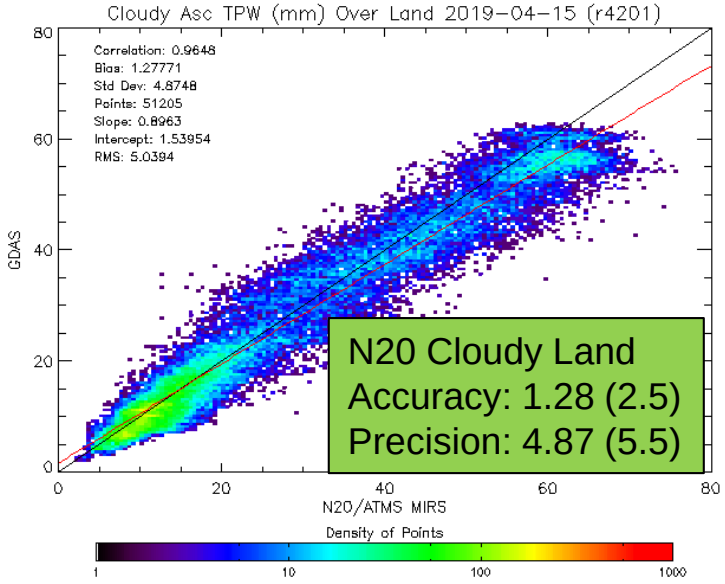


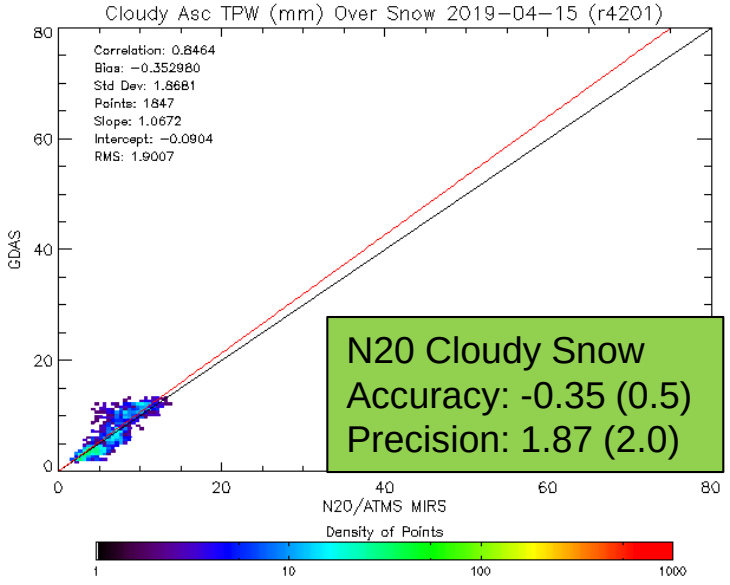


Validation Results: Total Precipitable Water (TPW) Compared to GDAS









TPW Validation based on GDAS data: Ocean

N20	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Sea (1.5 mm)	Cloudy Sea (0.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)	Clear Sea (2.5 mm)	Cloudy Sea (2.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)
2018.01.15	1.62 / 1.84	0.19 / 0.19	-0.35 / -0.26	0.49 / 0.40	1.93 / 1.99	2.20 / 2.18	0.99 / 1.03	1.67 / 1.55
2018.04.15	1.45 / 1.58	0.14 / 0.20	-0.67 / -0.62	0.22 / -0.58	1.94 / 1.93	2.00 / 2.00	1.40 / 1.25	1.88 / 2.65
2018.07.15	1.35 / 1.48	-0.02 / -0.05	-0.30 / -0.30	0.26 / 0.16	2.06 / 2.06	2.11 / 2.20	1.34 / 1.24	1.63 / 1.57
2018.10.15	1.36 / 1.44	0.15 / 0.22	-0.38 / -0.27	0.40 / 0.55	1.83 / 1.87	2.03 / 1.94	1.37 / 1.30	1.62 / 1.40
2019.01.15	1.35 / 1.52	0.24 / 0.26	-0.31 / -0.28	-0.09 / -0.53	1.77 / 1.82	1.88 / 1.82	0.86 / 0.86	1.82 / 2.14
2019.04.15	1.31 / 1.39	-0.07 / -0.05	-0.50 / -0.49	0.39 / 0.12	1.88 / 1.89	2.06 / 2.04	0.94 / 0.91	1.85 / 1.74

NPP	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Sea (1.5 mm)	Cloudy Sea (0.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)	Clear Sea (2.5 mm)	Cloudy Sea (2.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)
2018.01.15	1.62 / 1.80	0.21 / 0.23	-0.40 / -0.35	-0.23 / -0.62	1.88 / 1.85	2.20 / 2.13	1.04 / 0.98	2.01 / 1.98
2018.04.15	1.40 / 1.55	0.17 / 0.20	-0.66 / -0.64	0.20 / -0.46	1.87 / 1.89	1.96 / 2.00	1.41 / 1.28	2.03 / 2.77
2018.07.15	1.31 / 1.46	0.04 / -0.07	-0.21 / -0.25	0.37 / 0.34	2.02 / 2.02	2.05 / 2.12	1.29 / 1.32	1.67 / 1.79
2018.10.15	1.33 / 1.43	0.23 / 0.21	-0.36 / -0.28	0.69 / 0.58	1.78 / 1.79	2.02 / 1.98	1.48 / 1.36	1.63 / 1.43
2019.01.15	1.34 / 1.46	0.23 / 0.33	-0.34 / -0.29	0.03 / -0.41	1.76 / 1.76	1.83 / 1.77	0.92 / 0.87	1.85 / 1.99
2019.04.15	1.39 / 1.44	0.14 / 0.11	-0.47 / -0.47	0.83 / 0.56	1.84 / 1.80	2.03 / 2.00	0.96 / 0.92	1.80 / 1.74

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

TPW Validation based on GDAS data: Land

N20	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Land (2.5 mm)	Cloudy Land (2.5 mm)	Clear Snow (0.5 mm)	Cloudy Snow (0.5 mm)	Clear Land (5.5 mm)	Cloudy Land (5.5 mm)	Clear Snow (2.0 mm)	Cloudy Snow (2.0 mm)
2018.01.15	1.34 / 1.34	1.76 / 1.09	-0.25 / -0.23	1.37 / 1.79	3.34 / 3.51	4.86 / 4.58	0.81 / 0.81	1.91 / 1.91
2018.04.15	1.19 / 0.95	0.85 / 1.22	-0.32 / -0.27	0.06 / 0.47	3.84 / 3.92	5.16 / 4.85	0.98 / 1.04	2.19 / 2.22
2018.07.15	1.68 / 1.34	1.72 / 1.29	-0.01 / -0.01	-0.65 / -0.53	4.12 / 4.24	4.82 / 4.48	0.78 / 0.83	2.98 / 3.13
2018.10.15	1.15 / 0.95	0.82 / 0.96	-0.21 / -0.26	0.27 / 0.68	3.95 / 3.92	4.85 / 4.49	0.83 / 0.96	1.52 / 1.40
2019.01.15	1.18 / 0.74	1.34 / 0.89	-0.25 / -0.25	-0.05 / -0.07	3.85 / 3.92	5.43 / 5.32	0.84 / 0.78	1.43 / 1.11
2019.04.15	1.27 / 0.91	1.28 / 1.55	-0.34 / -0.28	-0.35 / 0.12	3.95 / 4.24	4.87 / 4.66	0.77 / 0.86	1.87 / 1.69

NPP	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Land (2.5 mm)	Cloudy Land (2.5 mm)	Clear Snow (0.5 mm)	Cloudy Snow (0.5 mm)	Clear Land (5.5 mm)	Cloudy Land (5.5 mm)	Clear Snow (2.0 mm)	Cloudy Snow (2.0 mm)
2018.01.15	1.32 / 1.13	2.44 / 1.20	-0.20 / -0.19	1.73 / 1.32	3.51 / 3.69	5.75 / 4.89	0.81 / 0.85	2.38 / 2.21
2018.04.15	1.14 / 1.08	2.17 / 1.72	-0.27 / -0.23	0.50 / 2.28	3.91 / 4.26	5.69 / 5.49	0.91 / 1.09	3.27 / 3.43
2018.07.15	1.43 / 0.87	1.41 / 0.89	-0.02 / -0.01	-0.64 / -0.60	4.23 / 4.18	5.20 / 4.77	0.74 / 0.82	2.73 / 3.02
2018.10.15	0.87 / 0.47	1.07 / 0.82	-0.19 / -0.26	0.20 / 0.74	3.83 / 4.16	5.43 / 4.71	0.82 / 1.02	1.57 / 1.49
2019.01.15	0.87 / 0.68	1.77 / 1.29	-0.25 / -0.20	-0.12 / 0.12	3.97 / 3.81	5.89 / 5.42	0.86 / 0.74	1.47 / 1.05
2019.04.15	1.04 / 0.68	1.83 / 1.67	-0.32 / -0.25	-0.30 / 0.49	3.82 / 4.25	5.20 / 4.68	0.78 / 0.91	2.00 / 1.72

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Additional comparisons with ECMWF located in Supplemental Slides

Requirements and Validation Results: Land Surface Emissivity

- Daily, Global Collocations with Analytic emissivity based on VIIRS LST, ECMWF and CRTM. VIIRS LST recommended at NPP Maturity Review.
- Analytic emissivity = See below
- Requirements from JPSS-REQ-1004
- All accuracy and precision requirements are met

Collocation details:

- ECMWF: bilinear interpolation in space and time from 1 deg lat/lon, 6-hour analyses
- LST: clear VIIRS pixels within ~30 km of ATMS FOV are averaged.

Attribute	Threshold	Validated
Geographic coverage	Global land(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	0.00001 – 1.0	
Measurement Accuracy	See table	
Measurement Precision	See table	

"Analytic" Emissivity Calculation

- Assume Simplified RT equation:

$$Tb(f) = [\epsilon(f) * B(Tskin) * \tau(f)] + T\uparrow(f) + [T\downarrow(f) * (1 - \varepsilon(f)) * \tau(f)]$$

- Analytic emissivity:

$$\epsilon(f) = \left[\left(\frac{Tb(f) - T\uparrow(f)}{\tau(f)}\right) - T\downarrow(f)\right] / (B(Tskin) - T\downarrow(f))$$

- Tb= measured radiance (corrected Tb), at frequency f
- Tskin=LST
- ε = emissivity
- τ = total transmittance (top of atmosphere)
- $T\uparrow$ = upwelling radiance
- $T\downarrow$ = downwelling radiance
- $Tskin, T(p), q(p)$ from collocated VIIRS LST; B the Planck function
- $\tau, T\uparrow, T\downarrow$ from CRTM using ECMWF inputs

Data Collected (VIIRS): 7 days
2019.03.17, 2019.04.01, 2019.04.14
2019.05.11, 2019.05.29, 2019.06.04,
2019.06.12

Data Collected (ECMWF): 7 days
2018.01.15, 2018.04.15, 2018.07.15
2018.10.15, 2019.01.15, 2019.04.15,
2019.07.15

Note: R-J approximation is used here and will be changed by using radiance.

Product	Sfc	Condition	Freq (GHz)	Accuracy (%)		Precision (%)	
				MiRS	Req.	MiRS	Req.
Emissivity	Land	Clear	23.8	**-0.23 (-0.35)**	**2.0**	**1.75 (1.78)**	**3.0**
			50.3	**-0.08 (-0.25)**	**1.5**	**1.36 (2.44)**	**3.0**
			165.5	**-1.22 (-1.55)**	**1.5**	**3.39 (3.44)**	**4.0**

Reference:
VIIRS LST-based emissivity

Values in ( ) indicates NPP

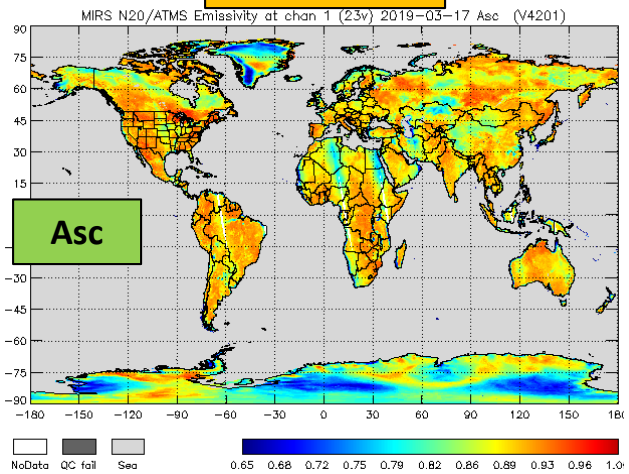
Meets requirement

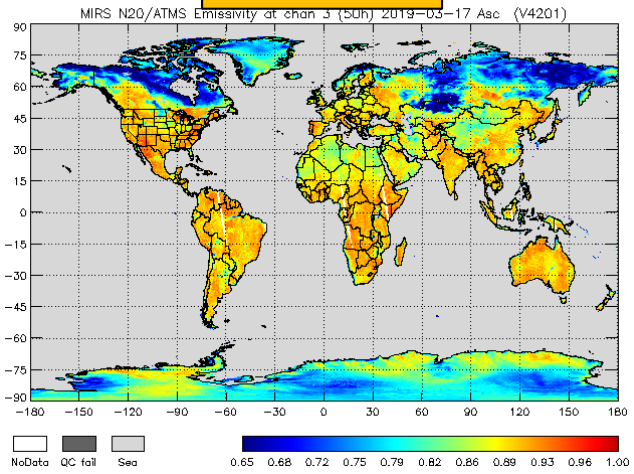
Validation Results: Land Surface Emissivity

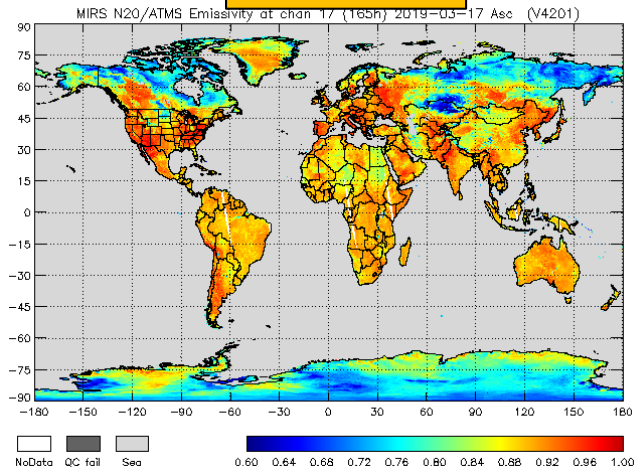
2019-03-17

23V | **50H** | **165H**

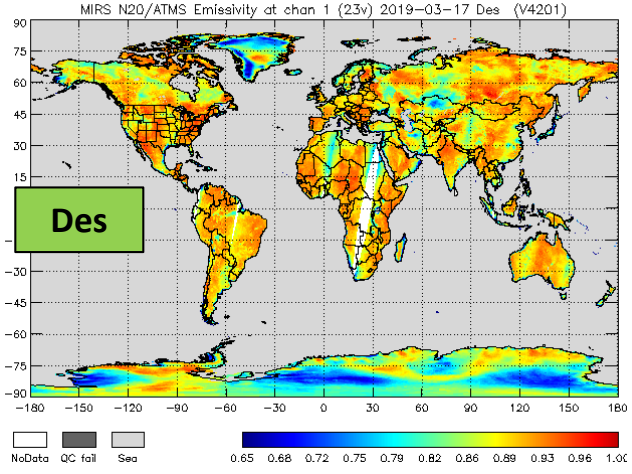
Asc

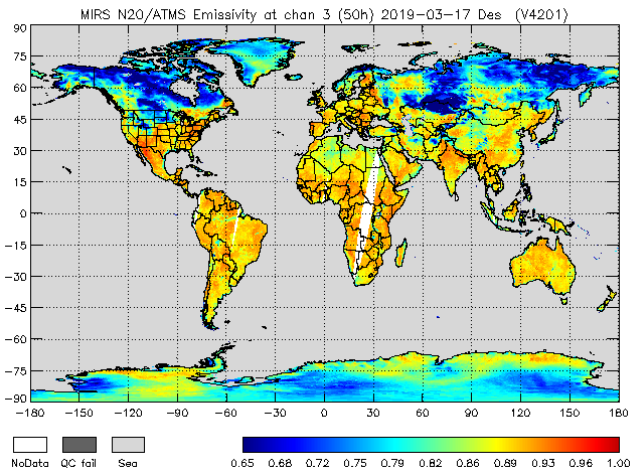


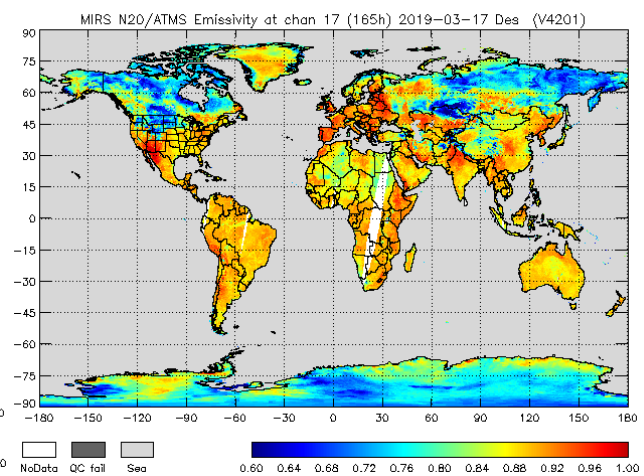




Des

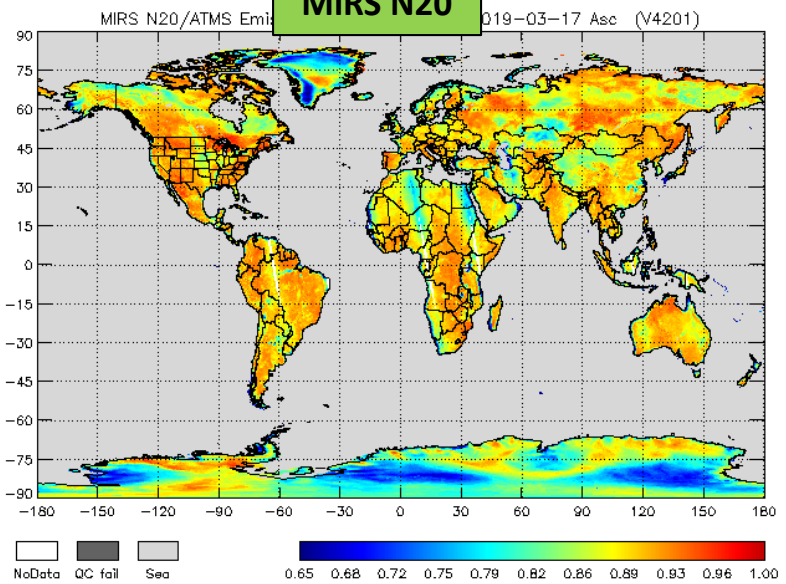




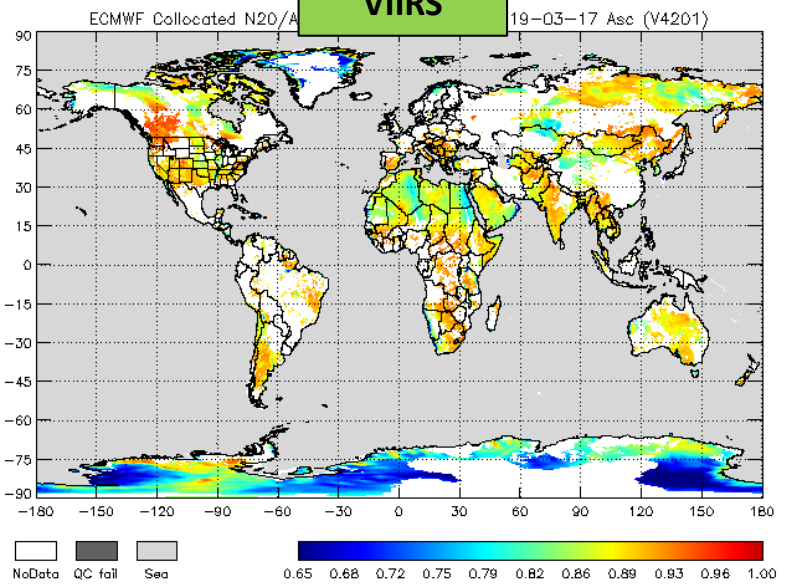


Validation Results: Land Surface Emissivity

MiRS N20



VIIRS

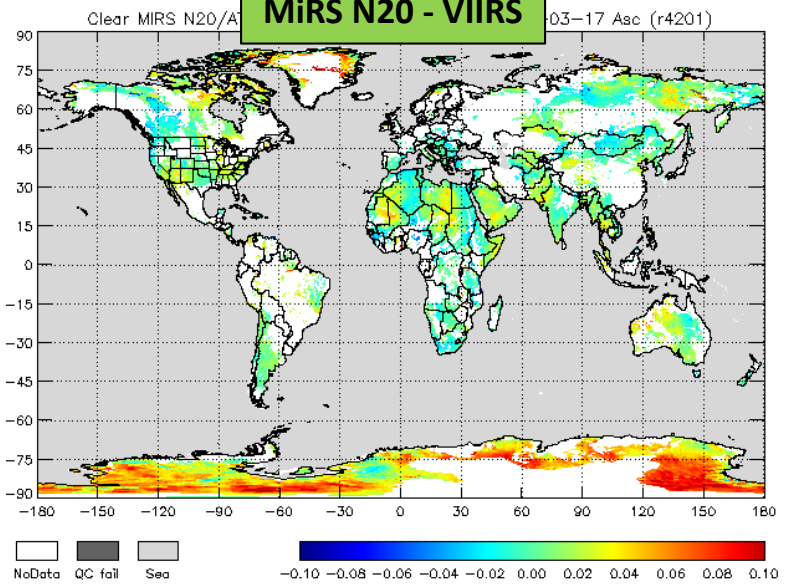


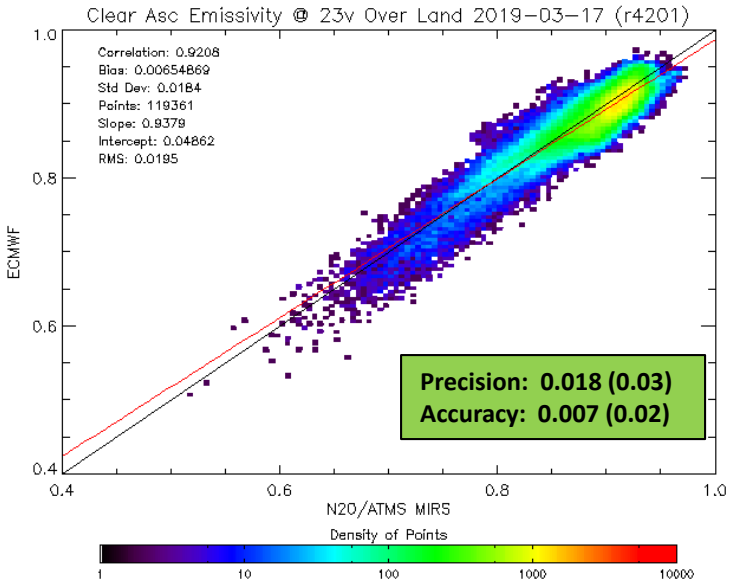
2019-03-17

23V

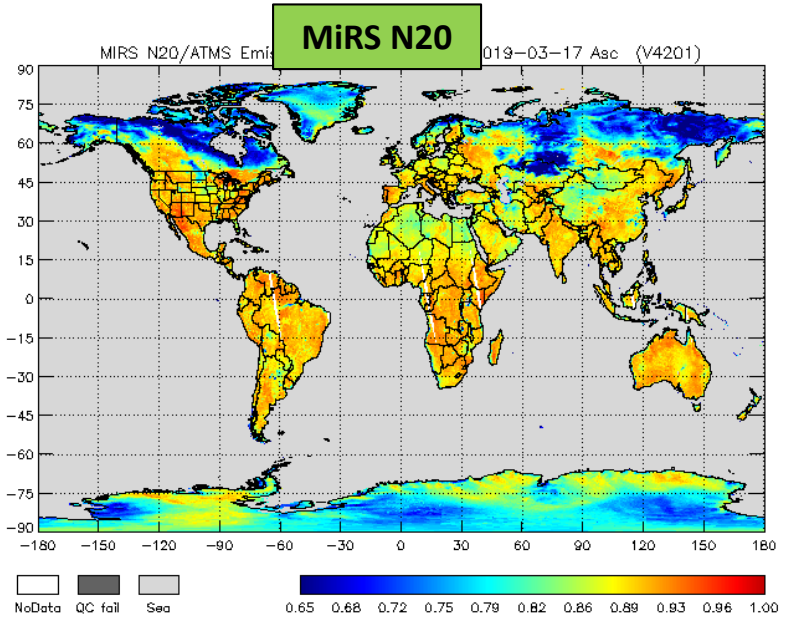
Asc

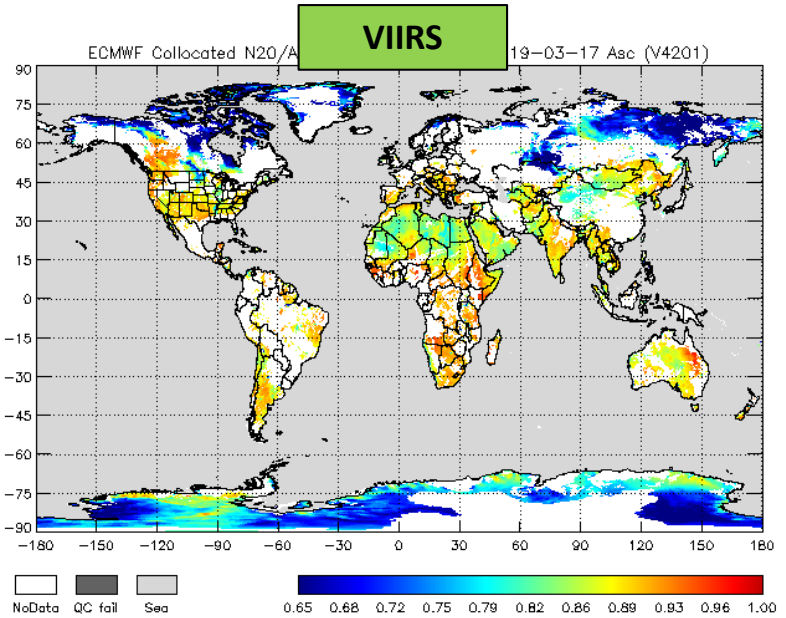
MiRS N20 - VIIRS





Validation Results: Land Surface Emissivity

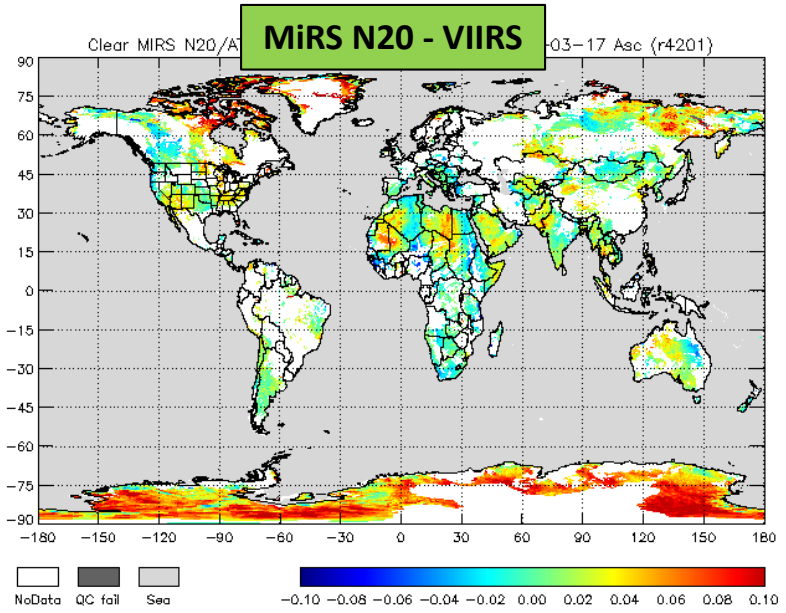


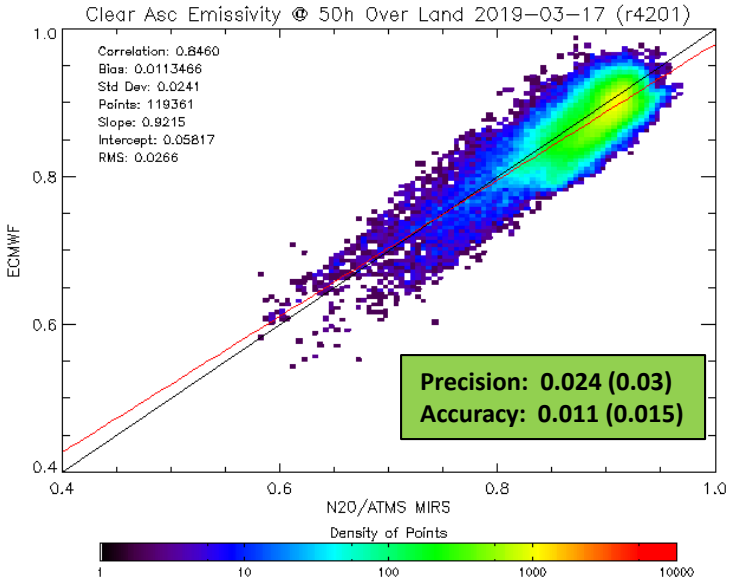


2019-03-17

50H

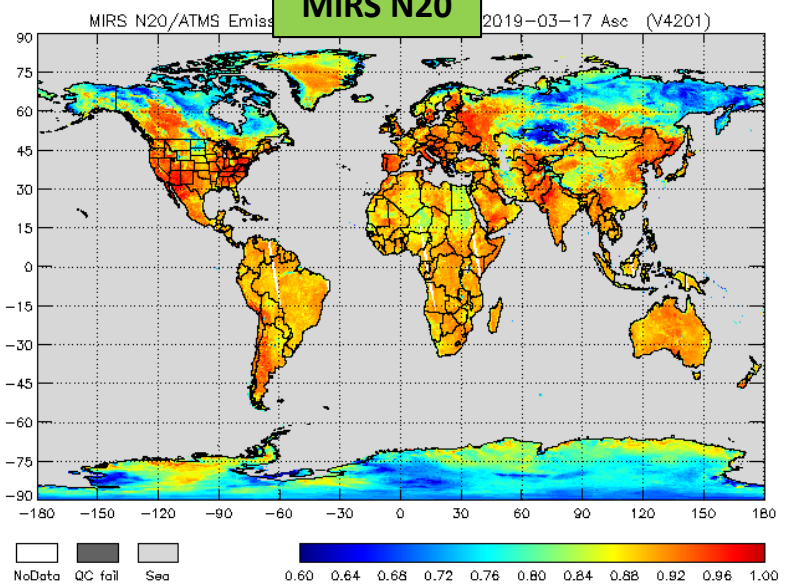
Asc



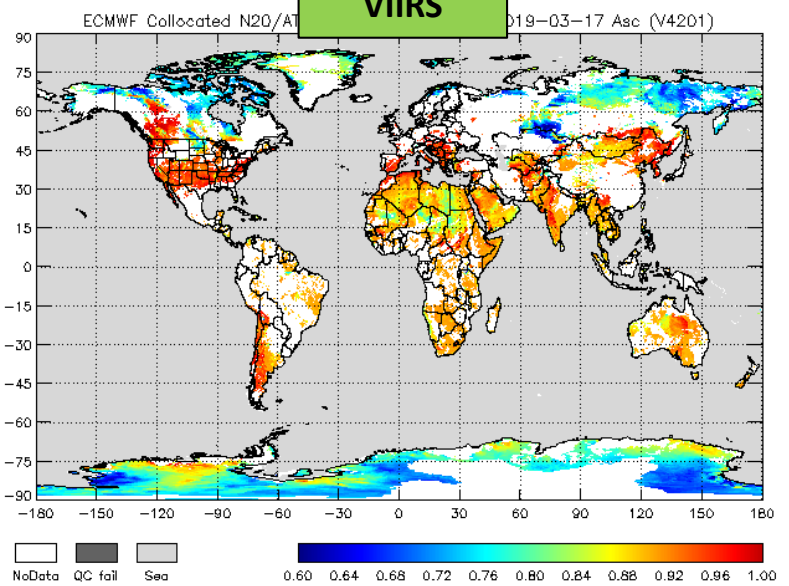


Validation Results: Land Surface Emissivity

MiRS N20



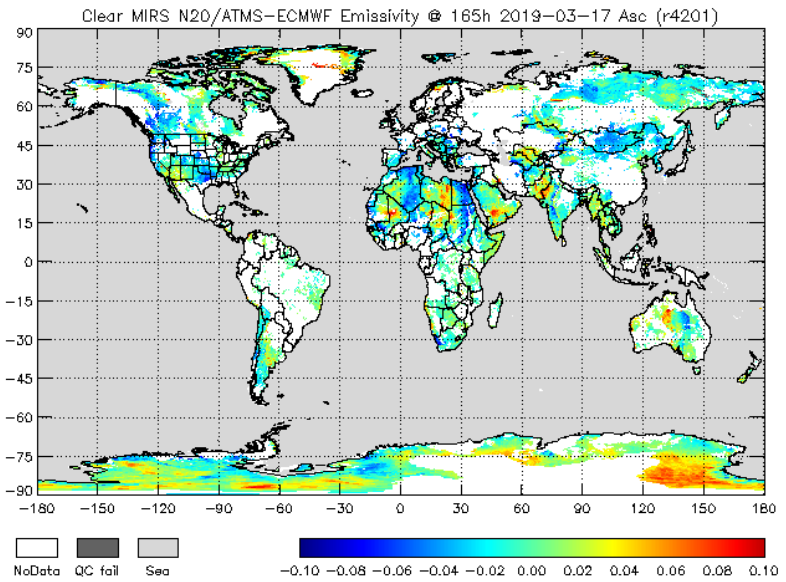
VIIRS

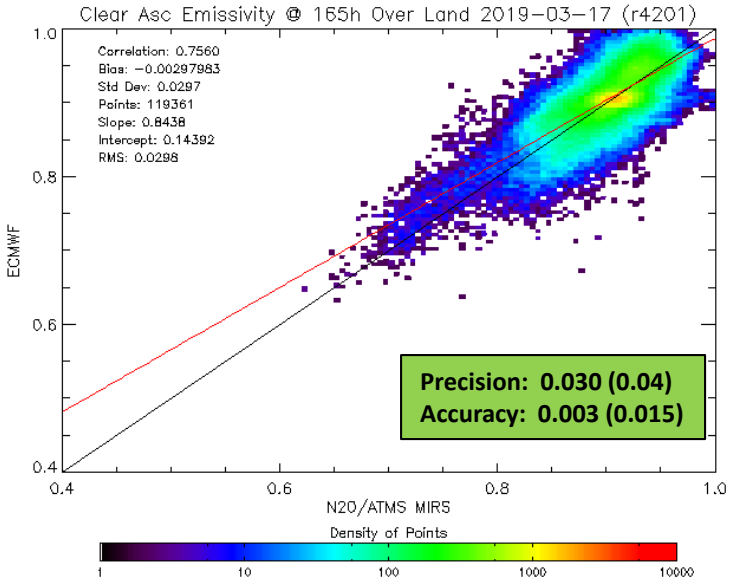


2019-03-17

165H

Asc





Precision: 0.030 (0.04)
Accuracy: 0.003 (0.015)

Validation Results: Land Surface Emissivity Compared with Em From VIIRS LST and ECMWF+CRTM

N20	Accuracy (asc/des)			Precision (asc/des)		
Threshold	23 H (2.0 %)	50 H (1.5%)	165 H (1.5%)	23 H (3.0%)	50 H (3.0%)	165 H (4.0%)
2019.03.17	0.65 / -0.82	1.13 / -0.73	-0.30 / -1.45	1.84 / 1.56	2.41 / 2.19	2.97 / 3.47
2019.04.01	0.46 / -0.85	0.85 / -0.76	-0.74 / -1.89	1.78 / 1.64	2.37 / 2.28	2.92 / 3.63
2019.04.14	0.64 / -0.53	1.06 / -0.39	-0.76 / -1.59	1.62 / 1.63	2.20 / 2.20	2.81 / 3.64
2019.05.11	-0.75 / -0.14	-0.89 / 0.10	-1.94 / -1.14	2.05 / 2.02	2.77 / 2.63	3.79 / 3.88
2019.05.29	0.25 / -0.91	0.46 / -0.94	-0.72 / -1.84	1.66 / 1.54	2.19 / 2.17	2.93 / 3.56
2019.06.04	0.12 / -0.89	0.29 / -0.87	-1.01 / -1.73	1.69 / 1.54	2.27 / 2.13	3.04 / 3.61
2019.06.12	-0.64 / 0.12	-0.83 / 0.39	-1.27 / -0.64	2.00 / 1.98	2.66 / 2.60	3.70 / 3.54

NPP	Accuracy (asc/des)			Precision (asc/des)		
Threshold	23 H (2.0 %)	50 H (1.5%)	165 H (1.5%)	23 H (3.0%)	50 H (3.0%)	165 H (4.0%)
2019.03.17	-0.56 / -0.81	-0.57 / -0.73	-1.69 / -1.72	2.07 / 1.81	2.79 / 2.46	3.71 / 3.62
2019.04.01	-0.40 / -0.53	-0.34 / -0.33	-1.86 / -1.59	2.05 / 1.64	2.82 / 2.22	3.52 / 3.60
2019.04.14	-0.37 / -0.62	-0.41 / -0.56	-1.89 / -2.12	2.12 / 1.69	2.85 / 2.41	3.45 / 3.75
2019.05.11	0.47 / -0.84	0.75 / -0.83	-0.90 / -2.15	1.82 / 1.81	2.45 / 2.55	3.15 / 3.92
2019.05.29	0.48 / -0.81	0.69 / -0.78	-0.63 / -1.94	1.73 / 1.60	2.32 / 2.26	2.99 / 3.52
2019.06.04	0.30 / -0.78	0.51 / -0.71	-0.85 / -2.11	1.69 / 1.62	2.24 / 2.27	3.01 / 3.50
2019.06.12	0.43 / -0.81	0.62 / -0.81	-0.54 / -1.68	1.73 / 1.57	2.30 / 2.23	2.89 / 3.52

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Validation Results: Land Surface Emissivity Compared with Em From ECMWF+CRTM

N20	Accuracy (asc/des)			Precision (asc/des)		
Threshold	23 H (2.0 %)	50 H (1.5%)	165 H (1.5%)	23 H (3.0%)	50 H (3.0%)	165 H (4.0%)
2018.01.15	-0.68 / -0.16	-0.51 / 0.42	-2.17 / -1.52	2.26 / 2.18	3.11 / 2.95	3.78 / 3.84
2018.04.15	-0.63 / -0.03	-0.58 / 0.39	-2.08 / -1.47	2.09 / 2.09	2.90 / 2.83	3.64 / 3.84
2018.07.15	-0.37 / 0.41	-0.46 / 0.82	-1.27 / -0.72	2.15 / 2.05	2.86 / 2.78	3.37 / 3.21
2018.10.15	-0.64 / -0.13	-0.65 / 0.22	-1.90 / -1.38	2.09 / 2.10	2.82 / 2.85	3.54 / 3.58
2019.01.15	-0.52 / -0.22	-0.40 / 0.12	-1.92 / -1.44	2.21 / 2.26	2.97 / 3.01	3.76 / 3.96
2019.04.15	-0.75 / 0.00	-0.87 / 0.26	-2.21 / -1.31	2.03 / 2.02	2.75 / 2.68	3.94 / 3.84
2019.07.15	-0.42 / 0.30	-0.68 / 0.48	-1.14 / -0.56	2.05 / 1.97	2.73 / 2.62	3.27 / 3.18

NPP	Accuracy (asc/des)			Precision (asc/des)		
Threshold	23 H (2.0 %)	50 H (1.5%)	165 H (1.5%)	23 H (3.0%)	50 H (3.0%)	165 H (4.0%)
2018.01.16	-0.39 / -0.13	-0.36 / 0.18	-1.79 / -1.43	2.21 / 2.23	3.05 / 3.04	3.72 / 4.13
2018.04.15	-0.41 / 0.25	-0.43 / 0.59	-1.81 / -1.08	2.01 / 2.26	2.78 / 2.98	3.54 / 3.91
2018.07.15	-0.12 / 0.55	-0.21 / 0.92	-1.00 / -0.35	2.04 / 2.00	2.73 / 2.70	3.12 / 3.29
2018.10.15	-0.32 / 0.08	-0.41 / 0.29	-1.64 / -1.01	2.10 / 2.12	2.85 / 2.85	3.54 / 3.84
2019.01.15	-0.22 / -0.00	-0.21 / 0.25	-1.67 / -1.36	2.17 / 2.14	2.88 / 2.77	3.99 / 3.92
2019.04.15	-0.42 / 0.18	-0.47 / 0.48	-2.10 / -1.35	2.16 / 2.08	2.90 / 2.75	3.60 / 4.17
2019.07.15	-0.22 / 0.42	-0.39 / 0.73	-1.04 / -0.42	2.08 / 2.02	2.74 / 2.67	3.23 / 3.40

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Requirements and Validation Results: Land Surface Temperature

- 14 months (Nov. 2017- Mar. 2019) of collocations with ground-based SURFRAD data
- Global comparisons with VIIRS LST
- Requirements from JPSS-REQ-1004
- All accuracy and precision requirements are met

Attribute	Threshold	Validated
Geographic coverage	Global (clear/cloudy)	See table/figs
Vertical Coverage	Surface	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	150-350K	
Measurement Accuracy	See table	
Measurement Precision	See table	

Product	SFC	EDR Attribute	MiRS clear	MiRS cloudy	Req	Reference
LST (K)	Land	Accuracy (K)	0.46 (0.00)		4.0	SURFRAD
		Precision (K)	5.34 (5.14)		7.0	SURFRAD
		Uncertainty (K)	5.36 (5.14)		8.0	SURFRAD
		Accuracy (K)	1.90 (2.14)	1.13 (1.53)	4.0	VIIRS
		Precision (K)	4.63 (4.77)	4.77 (5.39)	7.0	VIIRS
		Uncertainty (K)	5.01 (5.23)	4.90 (5.60)	8.0	VIIRS

Values in ( ) indicates NPP

Meets requirement

Data Collected:

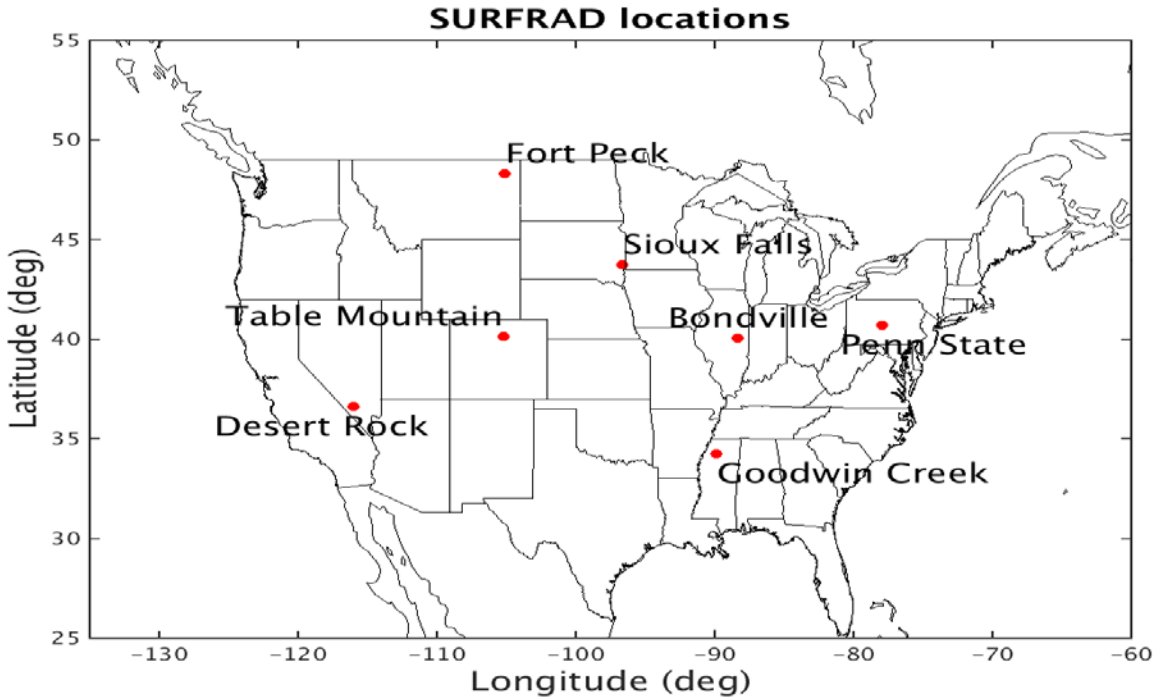
For SURFRAD: 2017.11.29-2019.03.04
For VIIRS: 7 days
2019.03.17, 2019.04.01, 2019.04.14
2019.05.11, 2019.05.29, 2019.06.04,
2019.06.12

Collocation details:

- SURFRAD: radius=25 km and time=180 seconds => find the closest ATMS pixel to each SURFRAD location
- VIIRS: clear VIIRS pixels within ~30 km of ATMS FOV are averaged.

Validation of Land Sfc Temperature: SURFRAD

- Targeted daily collocations with SURFRAD data:
  - Collocations with SURFRAD LST (IR Flux Based): Nov. 2017-Mar. 2019, 7 stations over the CONUS
  - Advantage: in situ, direct measurement (need to convert from flux to LST using Stefan-Boltzmann law), IR emissivity assumed=0.97
    - $$\mathrm{LST} = \left[\left(\mathrm{IR_{uw}} - (1-\varepsilon)\,\mathrm{IR_{dw}} \right) / (\varepsilon\sigma) \right]^{\frac{1}{4}}$$
  - Disadvantage: IR LST, not same as MW LST (vertical penetration/emission depth), representativeness error (point vs. IFOV average)
  - SURFRAD stations used:



LST Validation Using SURFRAD: Nov 2017- Mar 2019

Validation Parameter	MiRS vs. SURFRAD Station-by-station Comparison																				
	DRA, NV			BON, IL			FPK, MT			GWN, MS			PSU, PA			SXF, SD			TBL, CO		
	Dsc	Asc	A+D	Dsc	Asc	A+D	Dsc	Asc	A+D	Dsc	Asc	A+D	Dsc	Asc	A+D	Dsc	Asc	A+D	Dsc	Asc	A+D
R	0.93 /0.93	0.97 /0.96	0.96 /0.95	0.94 /0.93	0.95 /0.95	0.95 /0.95	0.84 /0.81	0.95 /0.96	0.94 /0.94	0.93 /0.92	0.86 /0.88	0.90 /0.89	0.91 /0.90	0.94 /0.93	0.92 /0.92	0.91 /0.92	0.94 /0.95	0.94 /0.94	0.92 /0.93	0.93 /0.94	0.93 /0.94
Bias (K)	-1.12 /-1.09	-5.40 /-6.25	-3.21 /-3.55	2.24 /1.41	1.54 /0.90	1.85 /1.13	4.84 /4.81	2.28 /1.44	3.42 /3.00	3.35 /2.41	-2.43 /-3.58	0.01 /-1.04	4.43 /3.64	0.71 /0.45	2.54 /2.04	3.42 /3.12	2.40 /1.80	2.88 /2.44	0.66 /-0.80	-3.73 /-3.02	-1.64 /-1.94
Std (K)	4.09 /3.95	3.41 /3.70	4.33 /4.62	3.78 /3.77	3.78 /3.47	3.79 /3.61	4.62 /4.86	5.02 /4.43	5.01 /4.93	3.79 /3.77	4.83 /4.50	5.26 /5.14	4.07 /4.04	3.92 /3.92	4.40 /4.28	4.61 /4.24	4.55 /4.03	4.60 /4.18	4.67 /4.33	5.48 /5.16	5.56 /4.90
RMSE (K)	4.24 /4.10	6.39 /7.26	5.40 /5.83	4.40 4.02	4.08 /3.59	4.22 /3.79	6.70 /6.84	5.51 /4.66	6.06 5.77	5.06 /4.47	5.41 /5.76	5.26 /5.25	6.01 /5.44	3.98 /3.94	5.08 /4.74	5.74 /5.26	5.14 /4.41	5.43 /4.84	4.71 /4.40	6.63 /5.98	5.79 /5.27

Note: N20/NPP

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc and des, but requirements are for combined passes

Product	SFC	EDR Attribute	Requirement
LST (K)	Land	Bias/Accuracy (K)	4.0
		STDV/Precision (K)	7.0
		RMS/Uncertainty (K)	8.0

- Performance roughly consistent between stations
- Ascending (daytime) negative bias larger than descending (nighttime).
- Ascending correlation higher for most stations
- Overall Bias (Accuracy) of 0.46 K, Standard Deviation (Precision) of 5.34 K, and RMSE (Uncertainty) of 5.36 K are within JPSS Requirements: 4 K, 7 K, and 8 K, respectively

Validation Results: Land Surface Temperature Compared to VIIRS

N20	Accuracy (asc/des)		Precision (asc/des)	
Threshold	Clear (4.0 K)	Cloudy (4.0 K)	Clear (7.0 K)	Cloudy (7.0 K)
2019.03.17	-0.89 / 3.33	-0.93 / 3.33	5.21 / 4.18	4.57 / 5.35
2019.04.01	-0.29 / 3.37	-0.96 / 2.24	5.03 / 4.36	4.52 / 5.74
2019.04.14	-0.90 / 2.62	-0.00 / 2.39	4.60 / 4.21	4.26 / 5.24
2019.05.11	4.00 / 1.88	0.79 / 0.38	5.33 / 4.85	4.71 / 4.52
2019.05.29	0.49 / 3.62	0.21 / 4.89	4.52 / 4.03	4.22 / 4.91
2019.06.04	0.91 / 3.60	0.20 / 3.90	4.65 / 4.04	4.00 / 5.31
2019.06.12	3.73 / 1.18	0.46 / -1.02	5.07 / 4.77	4.75 / 4.69

NPP	Accuracy (asc/des)		Precision (asc/des)	
Threshold	Clear (4.0 K)	Cloudy (4.0 K)	Clear (7.0 K)	Cloudy (7.0 K)
2019.03.17	3.15 / 3.40	-1.47 / 2.06	5.45 / 4.69	5.21 / 5.19
2019.04.01	2.67 / 2.45	-0.89 / 2.73	5.28 / 4.20	5.41 / 5.86
2019.04.14	2.61 / 2.72	-0.13 / 2.83	5.53 / 4.48	5.03 / 5.24
2019.05.11	-0.33 / 3.48	-0.51 / 5.39	5.23 / 4.72	5.28 / 6.82
2019.05.29	-0.24 / 3.24	-0.87 / 4.39	4.85 / 4.24	4.21 / 5.84
2019.06.04	0.30 / 3.20	-0.70 / 4.05	4.68 / 4.35	4.47 / 6.51
2019.06.12	0.00 / 3.32	-0.61 / 5.09	4.77 / 4.28	4.81 / 5.60

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Requirements and Validation Results: Sea Ice Concentration

- Regular collocations with SSMIS NRT (F18), NASA Team algorithm (also comparisons with NIC IMS analyses)
- Official reference is SSMIS NASA Team
- Period: 2019.01.19~2019.07.09 for F18 comparison, and 4 days for IMS comparison
- Requirements from JPSS-REQ-1004
- All accuracy and precision requirements are met

Attribute	Threshold	Validated
Geographic coverage	Global (Oct-May)	See table/figs
Vertical Coverage	Surface	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	20 – 100 %	
Measurement Accuracy	See tables	
Measurement Precision	See tables	

Product	SFC	EDR Attribute	MiRS	Requirement
SIC (%)	Ocean/ Ice	Accuracy (%)	**1.3 ~ 9.2 (2.6 ~ 9.4)**	**10.0**
		Precision (%)	**11.3 ~ 18.4 (11.4 ~ 18.2)**	**25.0**

Meets requirement

Reference: SSMIS NRT (F18)
Values in () indicates NPP

Collocation details:

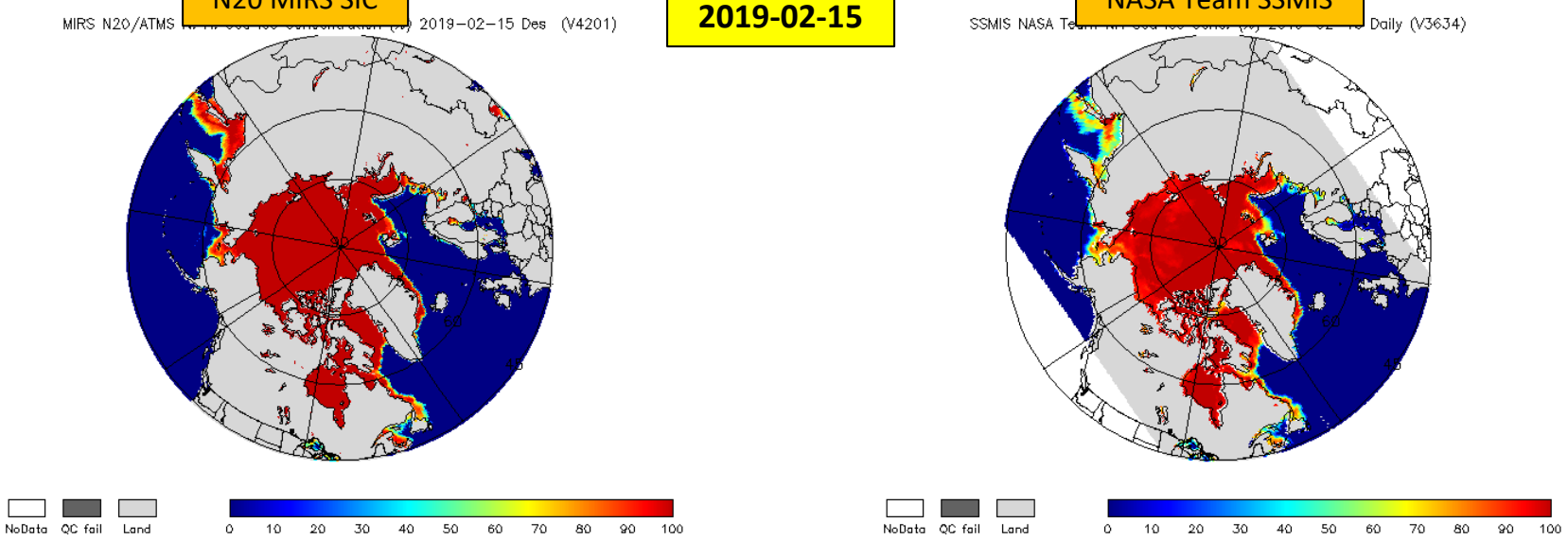
- SSMIS NRT (F18): remap both SSMIS and MiRS to 0.25 deg grid and compare.
- IMS: collocate to IMS on 4 km grid, average 13x13 grid window nearest to ATMS.

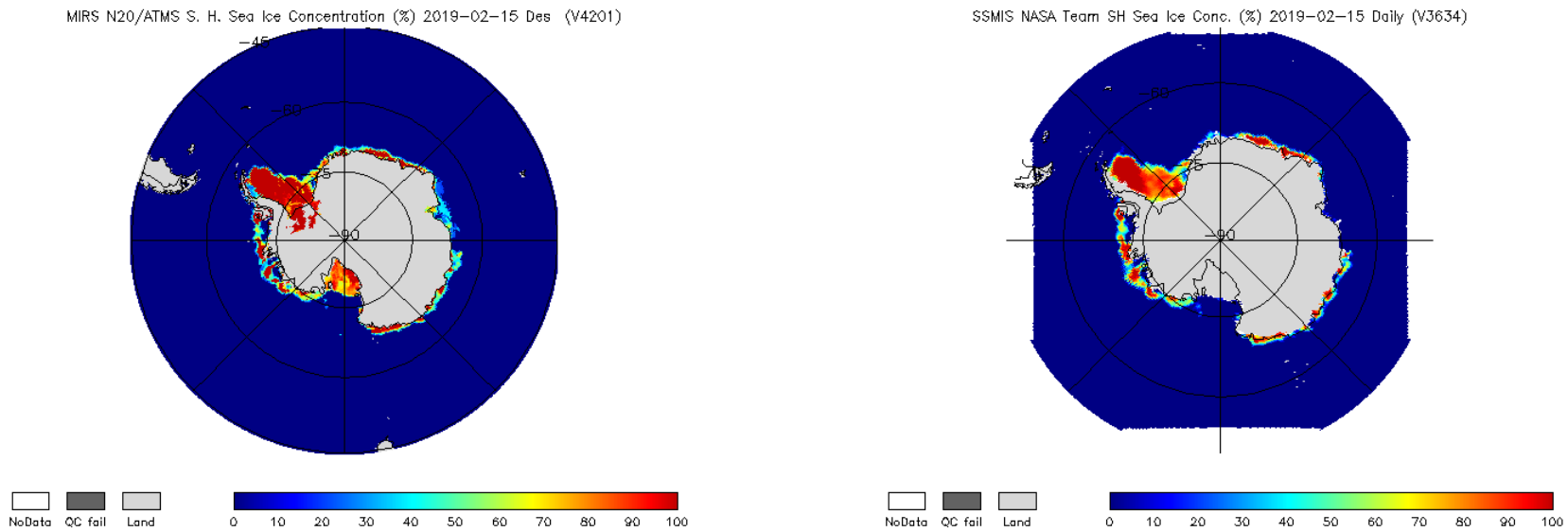
Sea Ice Concentration Performance: Comparison with NASA Team NRT SSMIS (F18)

N20 MiRS SIC

2019-02-15

NASA Team SSMIS



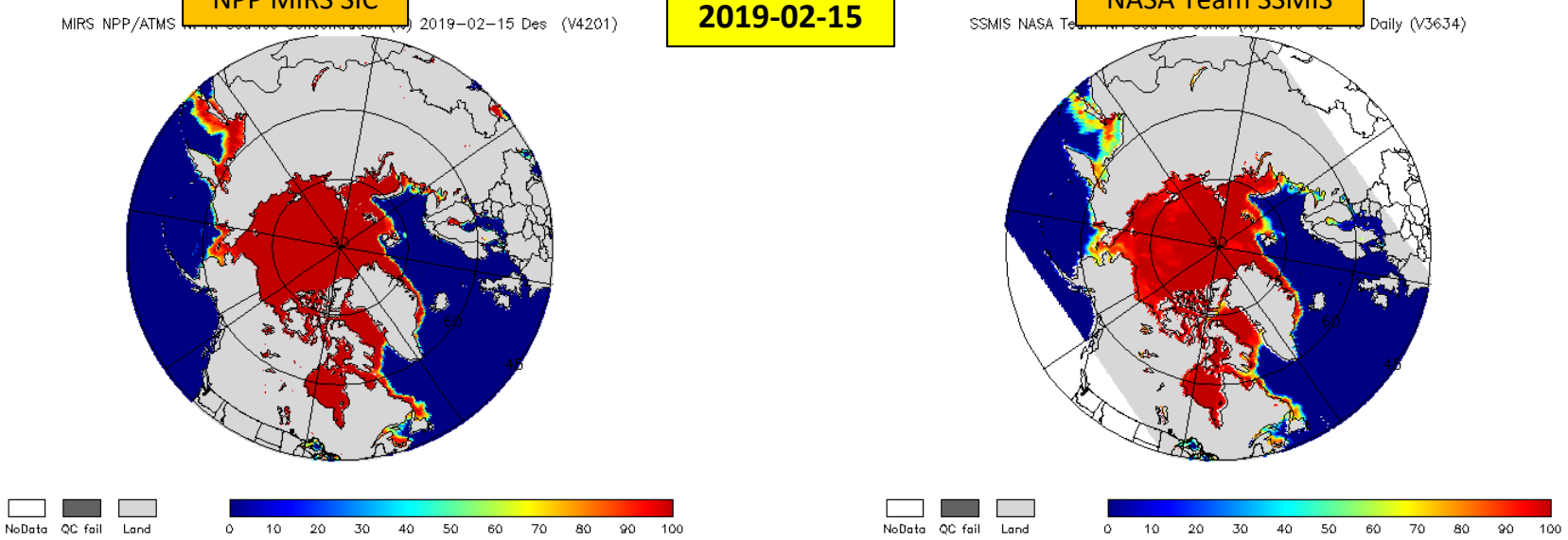


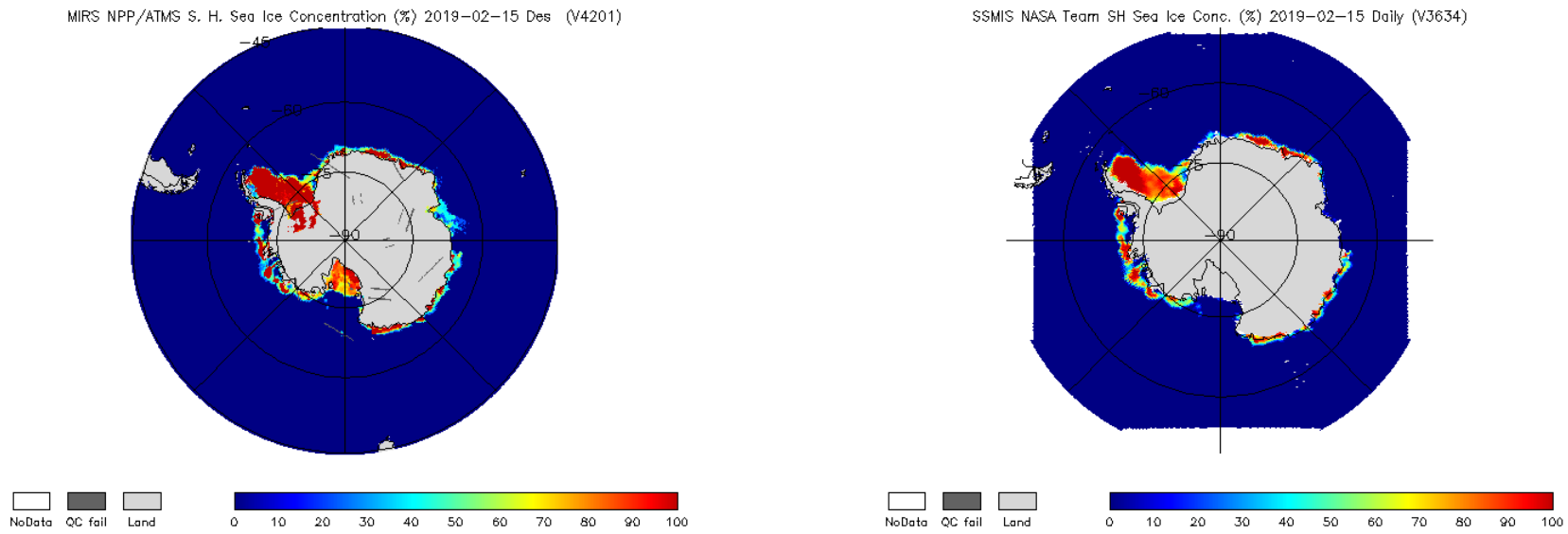
Sea Ice Concentration Performance: Comparison with NASA Team NRT SSMIS (F18)

NPP MiRS SIC

2019-02-15

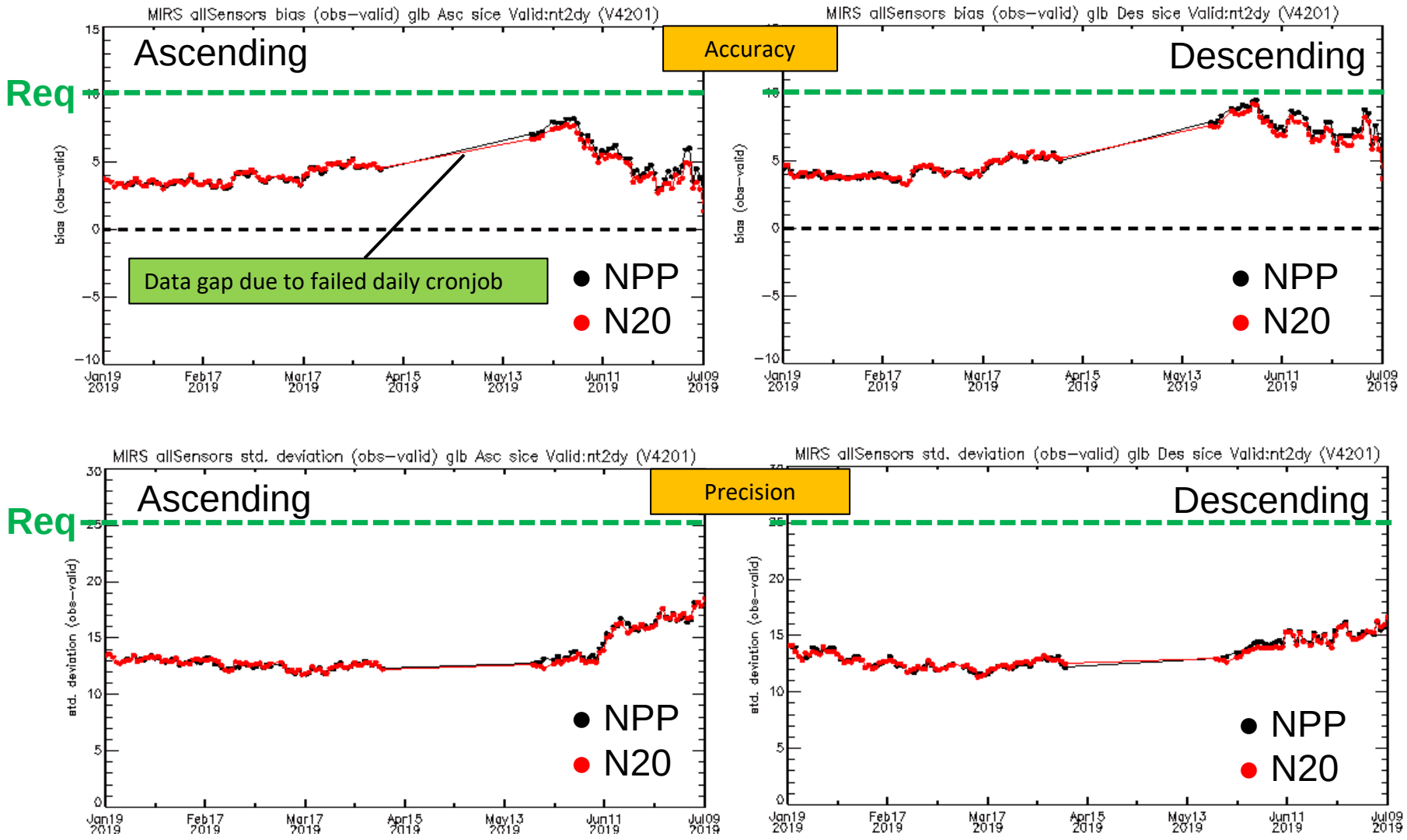
NASA Team SSMIS





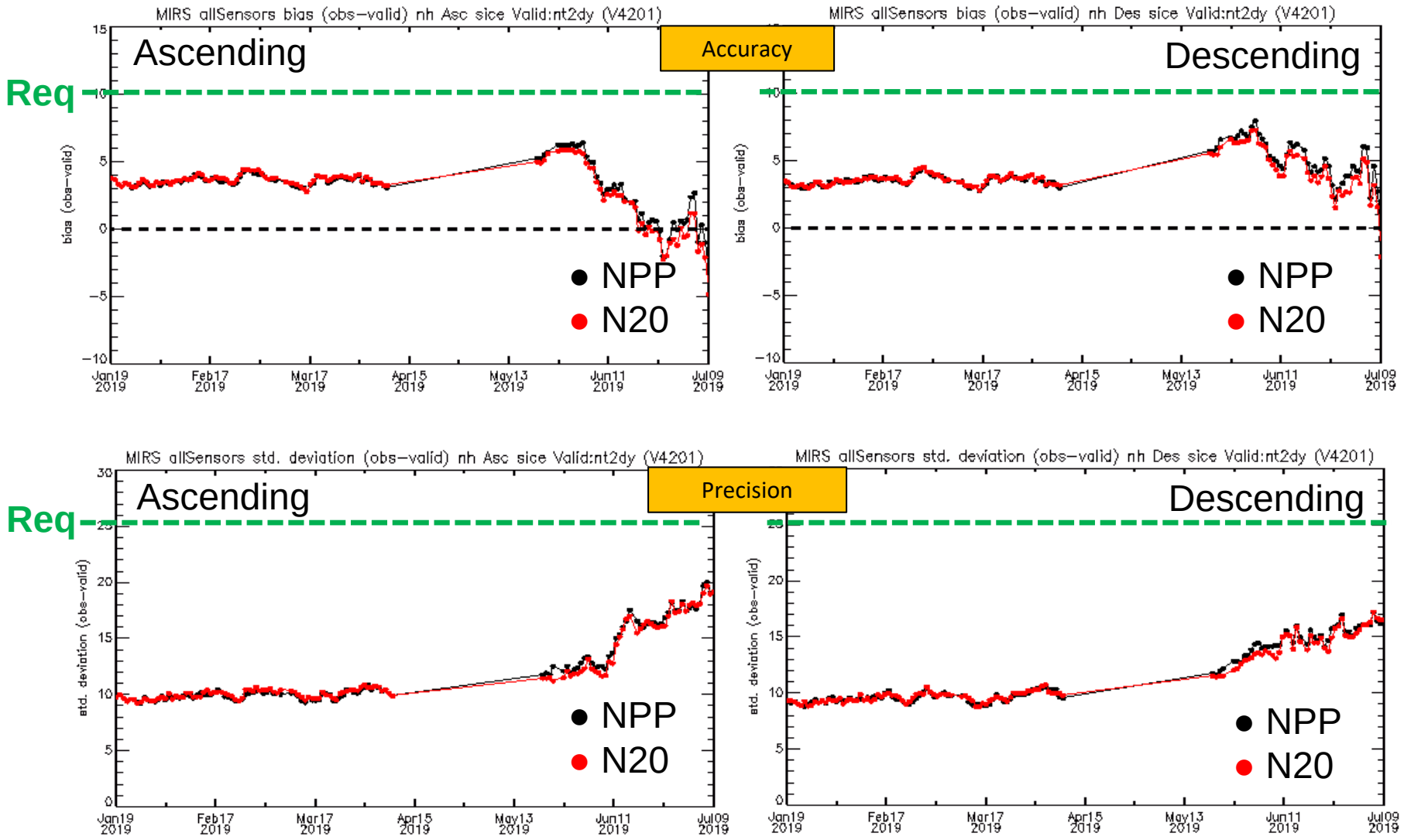
Sea Ice Concentration Performance (19 Jan – 9 Jul 2019): Daily Comparison with NASA Team NRT SSMIS (F18)

Globe



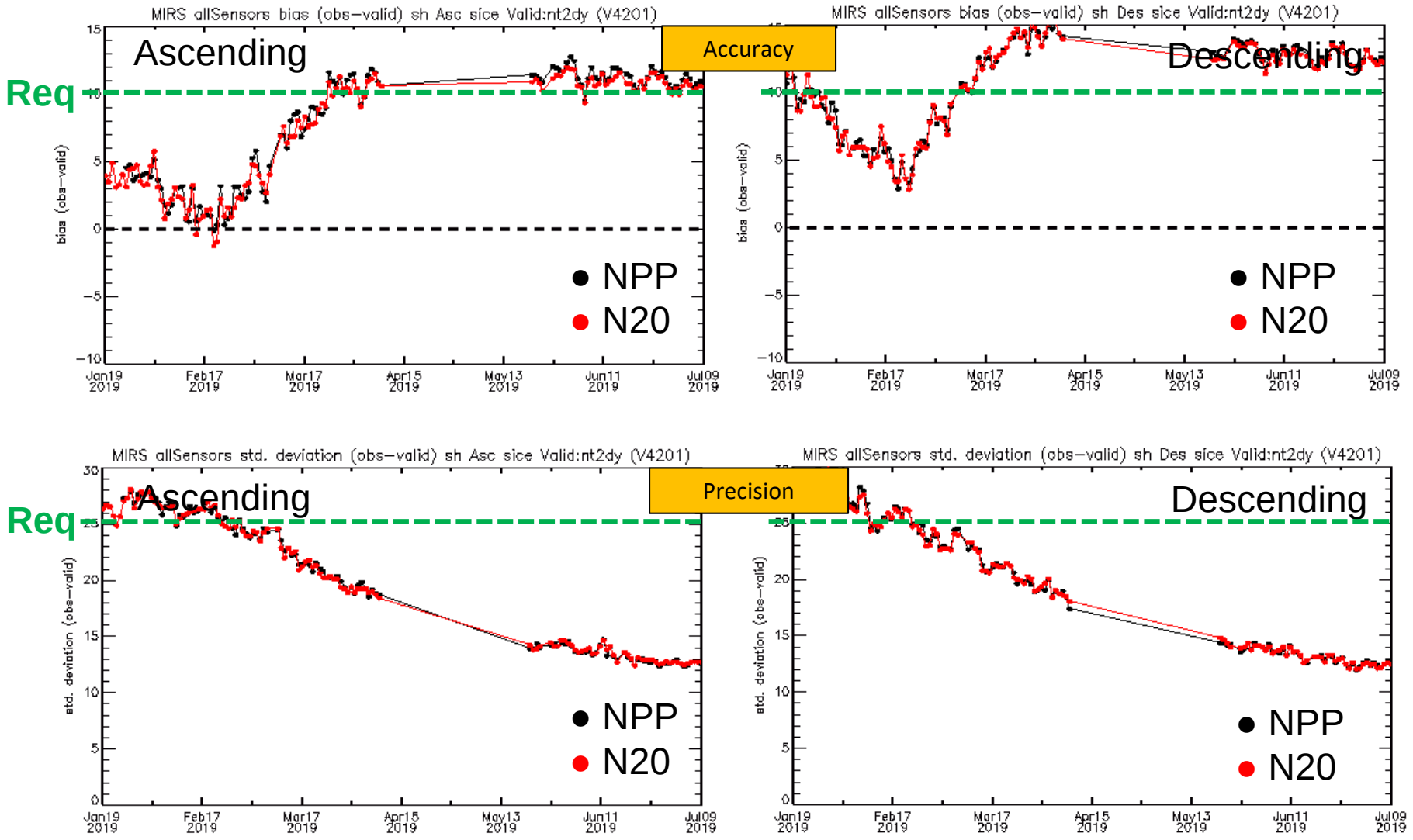
Sea Ice Concentration Performance (19 Jan – 9 Jul 2019): Daily Comparison with NASA Team NRT SSMIS (F18)

Northern Hemisphere



Sea Ice Concentration Performance (19 Jan – 9 Jul 2019): Daily Comparison with NASA Team NRT SSMIS (F18)

Southern Hemisphere

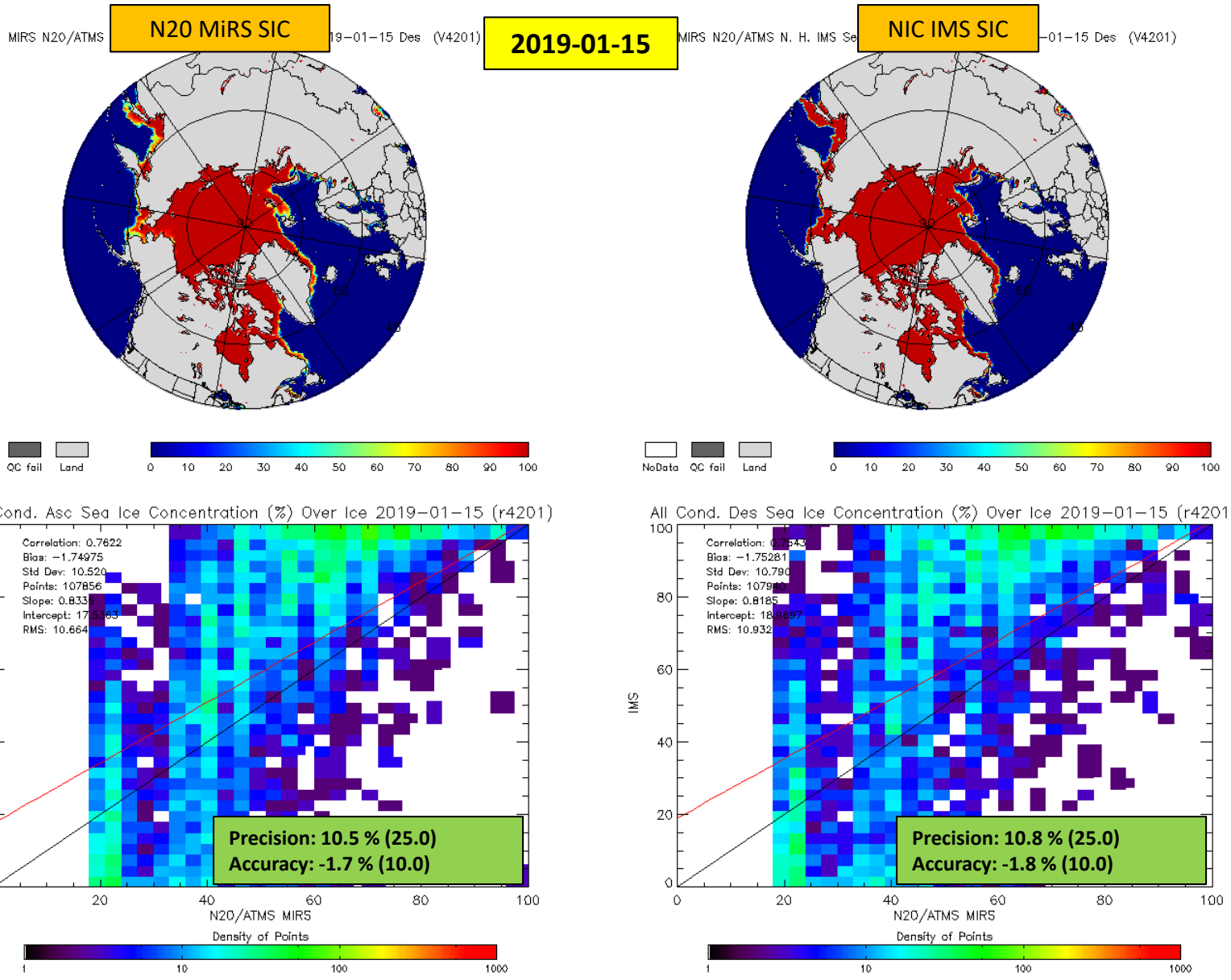


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

N20 MiRS SIC

2019-01-15

NIC IMS SIC

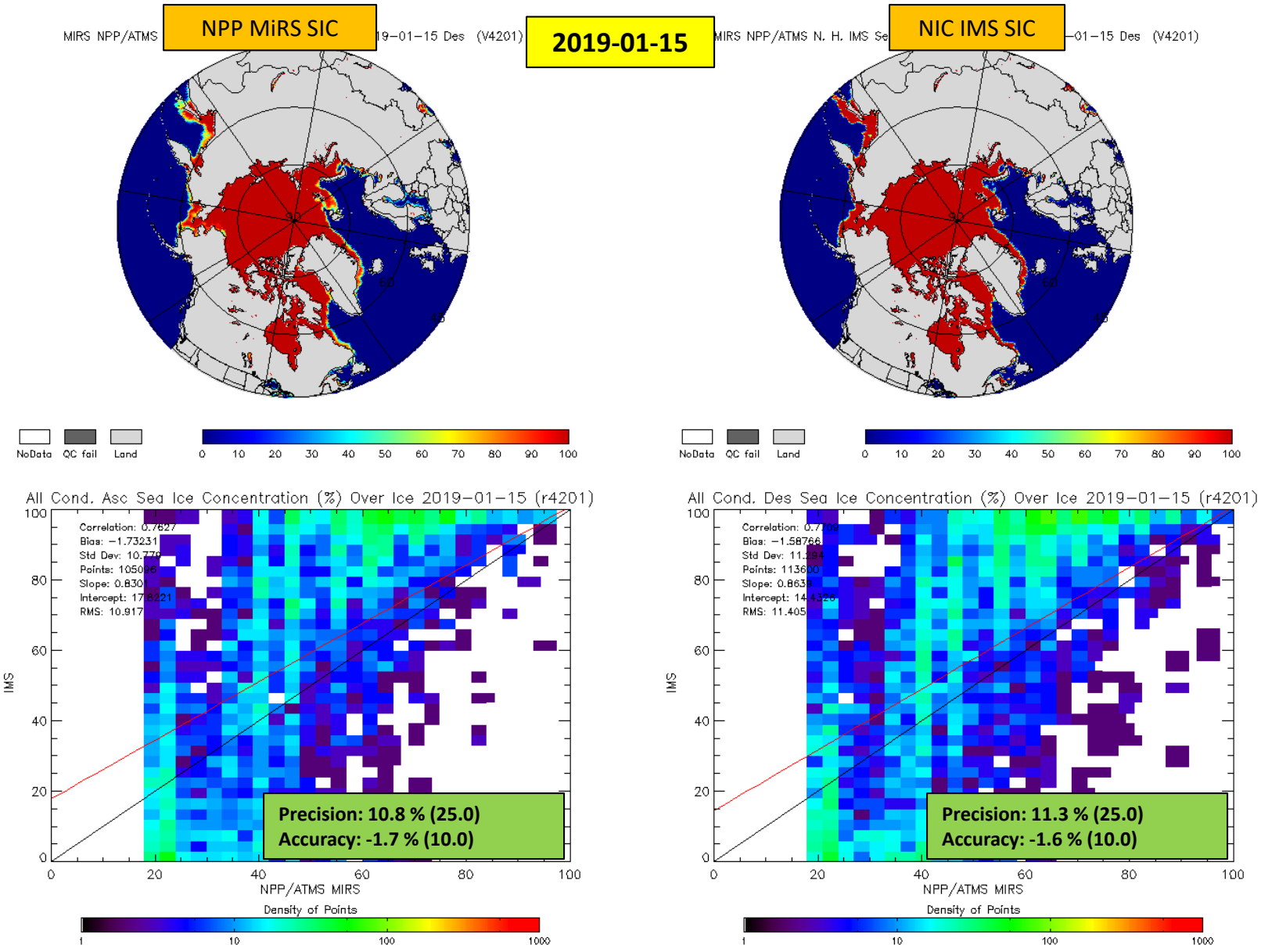


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

NPP MiRS SIC

2019-01-15

NIC IMS SIC



Additional comparisons with IMS located in Supplemental Slides

Validation Results Summary: Sea Ice Concentration

Date(s)	Accuracy (%)	Precision (%)	Reference	Comment
Requirement	**10.0**	**25.0**		
Jan 2019-Jul 2019 (Glb)	1.3 ~ 9.2 (2.6 ~ 9.4)	11.3 - 18.4 (11.4 ~ 18.2)	F18 SSMIS NASA Team (NRT)	Performance degraded June-July (NH ice melt)
Jan 2019-Jul 2019 (NH)	-4.9 ~ 7.2 (-3.0 ~ 7.9)	8.7 ~ 19.6 (8.8 ~ 19.9)	F18 SSMIS NASA Team (NRT)	NH warm season performance degraded (ice melt)
Jan 2019-Jul 2019 (SH)	-1.3 ~ 15.1 (-0.2 ~ 15.1)	12.0 ~ 30.4 (11.9 ~ 30.0)	F18 SSMIS NASA Team (NRT)	SH warm season performance degraded (ice melt)
2018-01-15 (NH)	2.1 / 2.2 (2.5 / 2.3)	10.7 / 11.7 (11.8 / 11.3)	NIC IMS	asc/des
2018-12.15 (NH)	-2.6 / -2.7 (-2.6 / -2.6)	10.9 / 11.4 (11.6 / 11.4)	NIC IMS	asc/des
2019-01-15 (NH)	-1.7 / -1.8 (-1.7 / -1.6)	10.5 / 10.8 (10.8 / 11.3)	NIC IMS	asc/des
2019-02-15 (NH)	-2.2 / -2.1 (-2.3 / -2.2)	10.7 / 10.6 (11.2 / 10.4)	NIC IMS	asc/des

Meets the requirement except during warm season (ice-melt)

Meets requirement

Values in () indicates NPP

MiRS SIC Performance vs. SSMIS NASA Team and NIC IMS
- Official reference is SSMIS NASA Team
- Most requirements are met (degraded performance in warm season due to ice melt)
- IMS used as secondary reference

Note: results stratified by asc/des, but requirements are for combined passes

Requirements and Validation Results: Snow Water Equivalent/Snow Cover

- Periodic collocations with JAXA AMSR2 (also comparisons with NIC IMS analyses)
- Official reference is JAXA AMSR2
- Period: 4 days (20180115, 20181215, 20190115, 20190215)
- Requirements from JPSS-REQ-1004
- Maturity Level: Validated
- All requirements are met except some individual cases for False Alarm Rate.

Attribute	Threshold	Validated
Geographic coverage	N. Hemisphere (cold season, Nov-Mar)	See table/figs
Vertical Coverage	Surface	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	1.2 – 26.5 cm	
Measurement Accuracy	See tables	
Measurement Precision	See tables	

Product	SFC	EDR Attribute	MiRS	requirement
SWE/SC (cm)	Land/ Snow	Accuracy (cm)	**1.27 ~ 1.41 (1.39 ~ 1.53)**	**3.0**
		Precision (cm)	**2.46 ~ 3.95 (2.43 ~ 3.93)**	**6.0**
		Probability of Detection (0-1)	**0.84 ~ 0.94 (0.84 ~ 0.94)**	**0.80**
		False Alarm Ratio (0-1)	**0.09 ~ 0.11 (0.09 ~ 0.11)**	**0.10**
		Heidke Skill Score (0-1)	**0.55 - 0.69 (0.57 ~ 0.71)**	**0.55**

Meets requirements except some cases

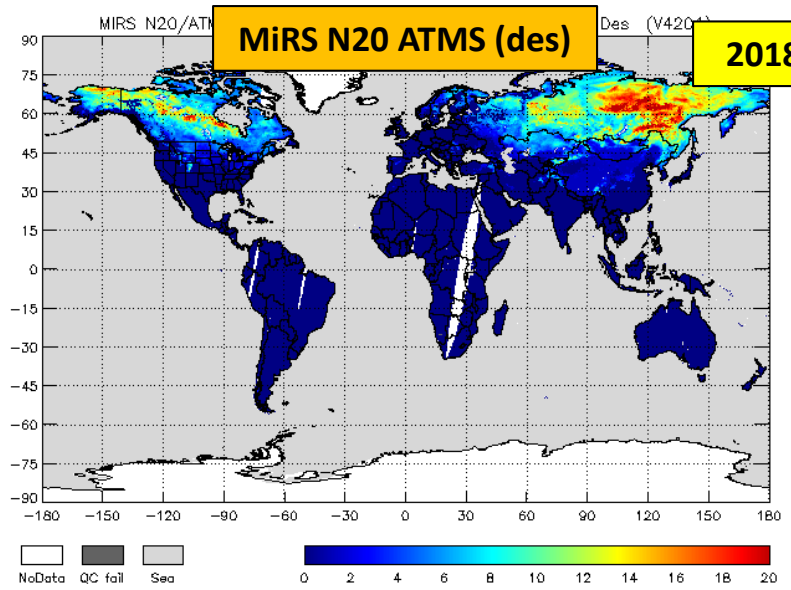
Meets requirements

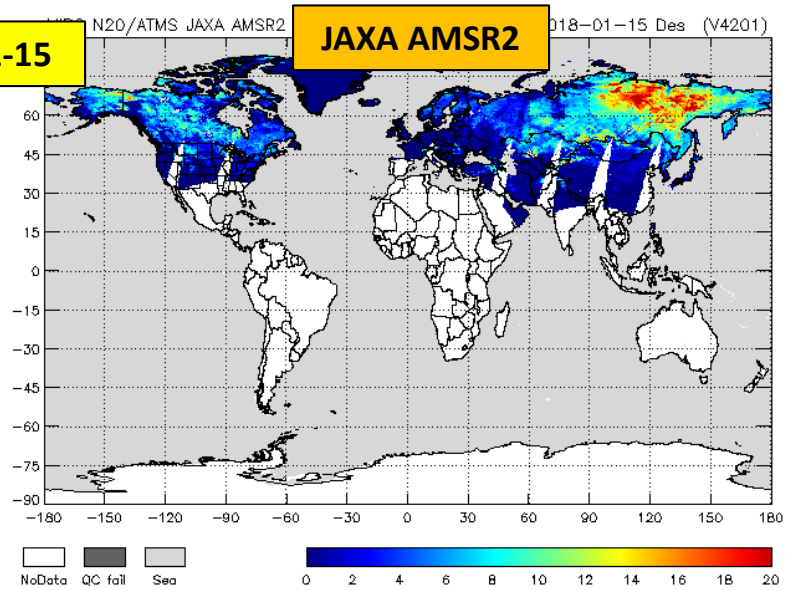
Reference: JAXA AMSR2
Values in () indicates NPP

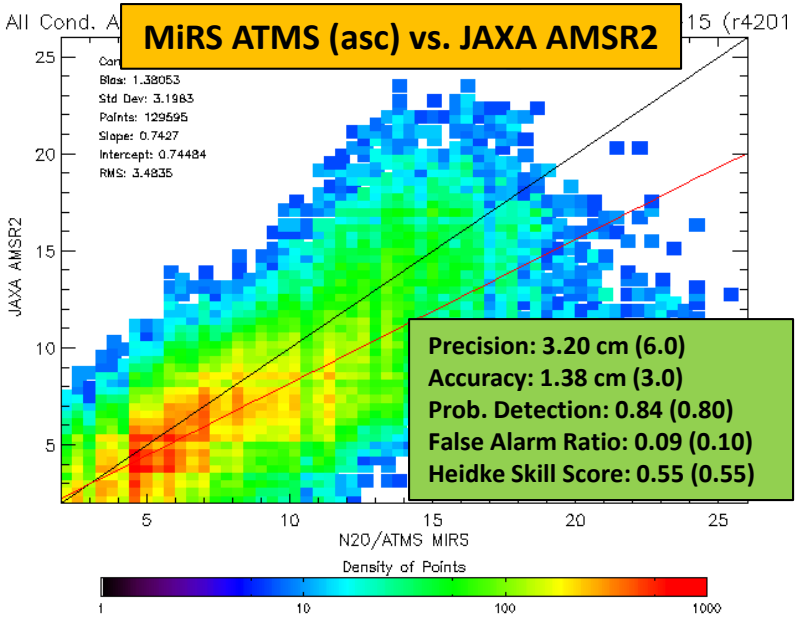
Collocation details:

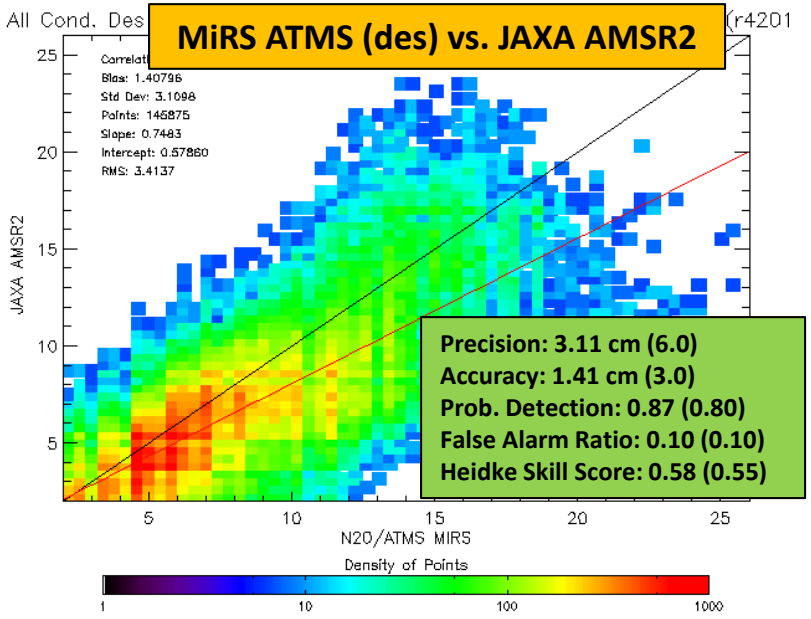
- JAXA AMSR2: collocate to AMSR2 on 25 km grid, choosing grid nearest to ATMS.
- IMS: collocate to IMS on 4 km grid, average 13x13 pixel window nearest to ATMS.

Validation Results Summary: Snow Water Equivalent/Snow Cover

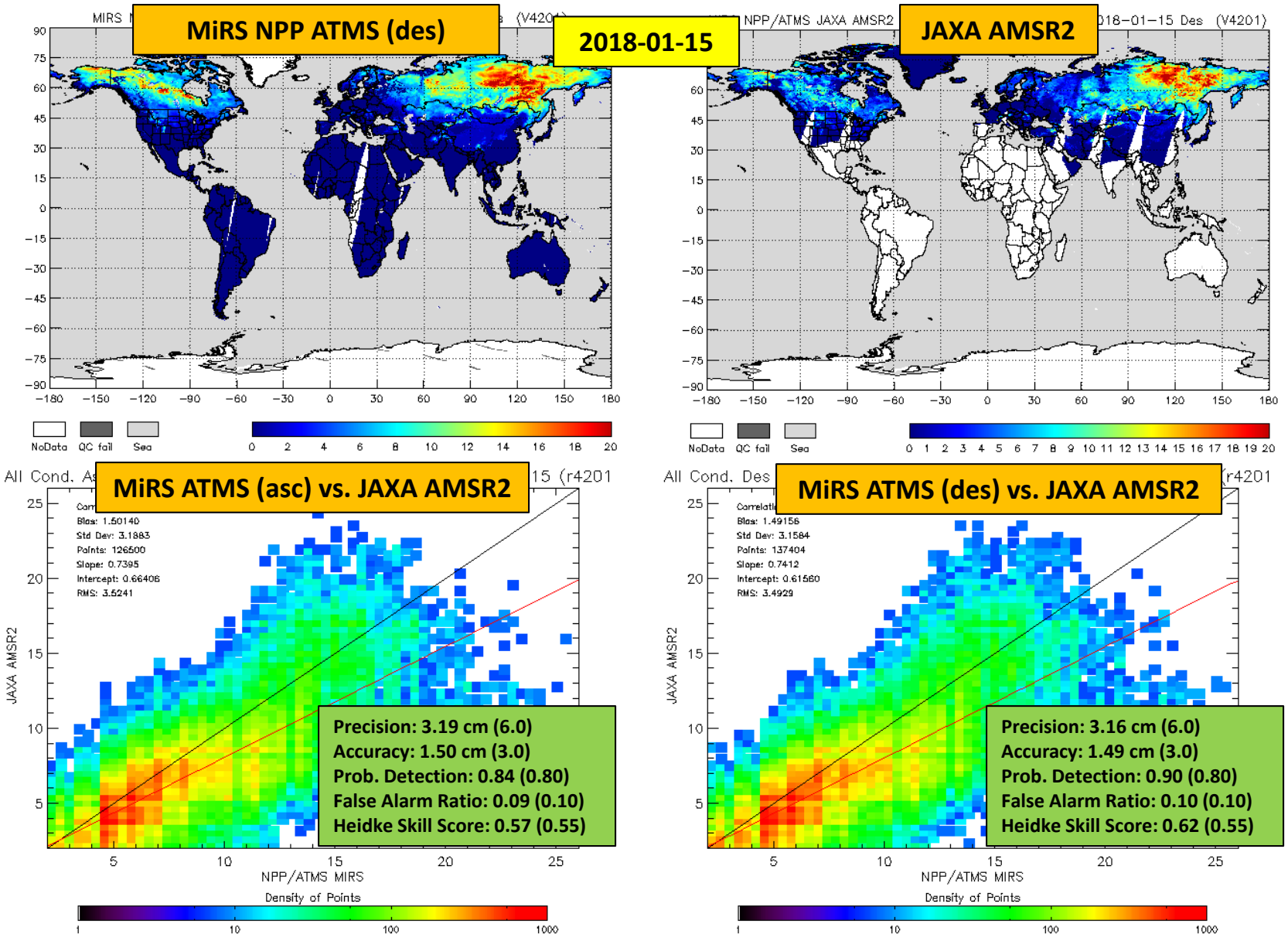




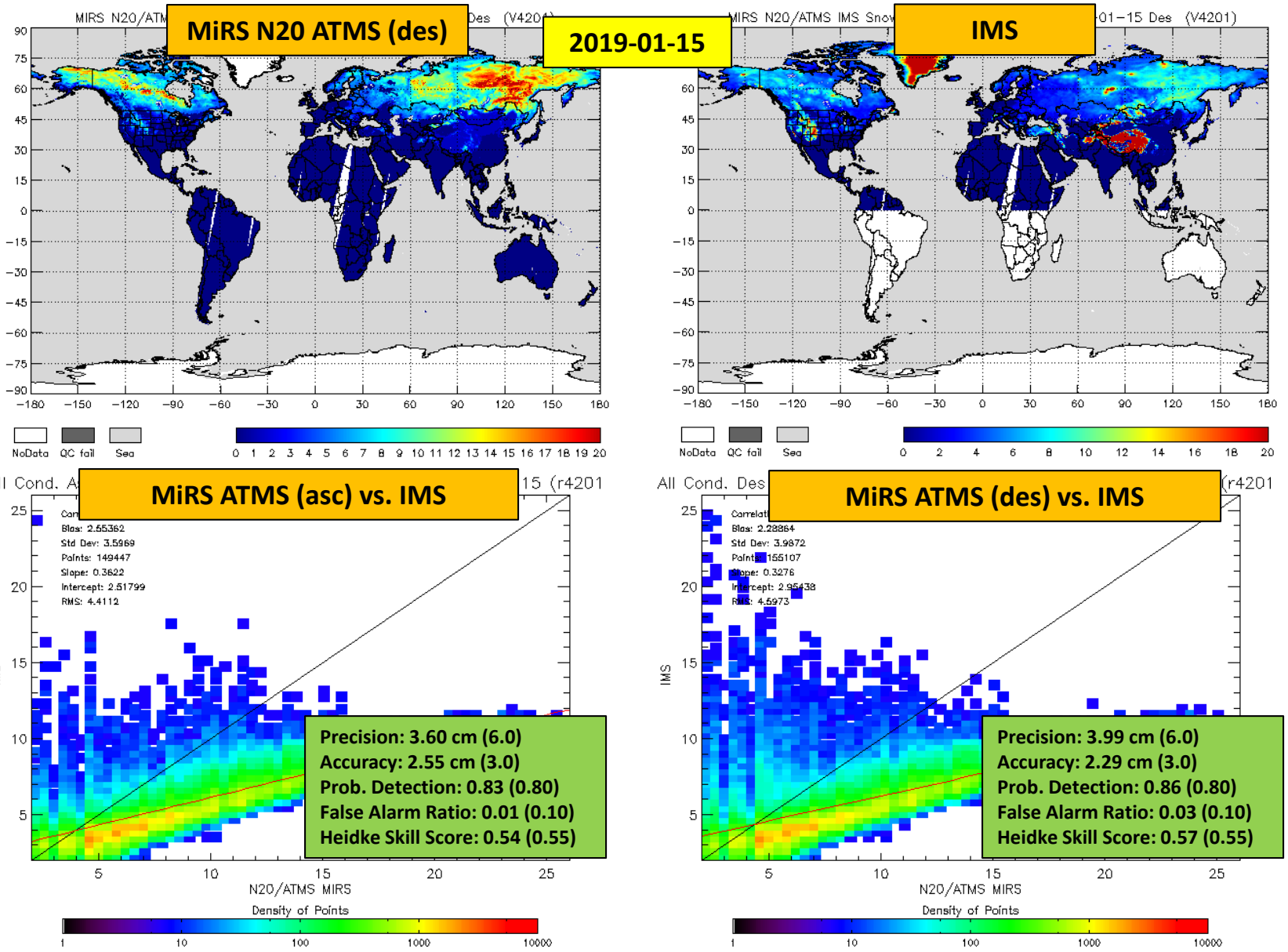




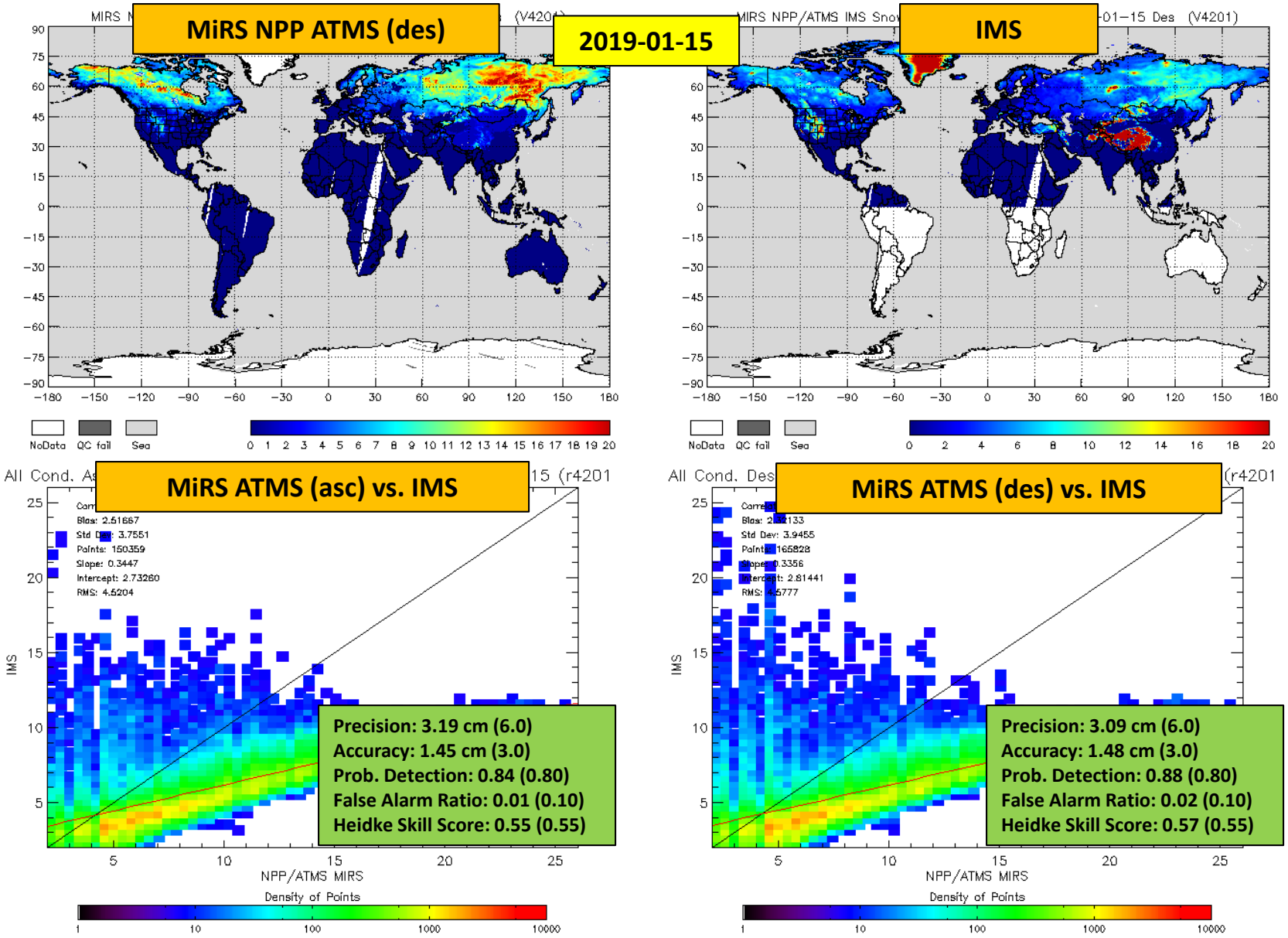
Validation Results Summary: Snow Water Equivalent/Snow Cover



Validation Results Summary: Snow Water Equivalent/Snow Cover



Validation Results Summary: Snow Water Equivalent/Snow Cover



Precision: 3.19 cm (6.0)
Accuracy: 1.45 cm (3.0)
Prob. Detection: 0.84 (0.80)
False Alarm Ratio: 0.01 (0.10)
Heidke Skill Score: 0.55 (0.55)

Precision: 3.09 cm (6.0)
Accuracy: 1.48 cm (3.0)
Prob. Detection: 0.88 (0.80)
False Alarm Ratio: 0.02 (0.10)
Heidke Skill Score: 0.57 (0.55)

Additional comparisons with AMSR2 located in Supplemental Slides

Validation Results Summary (N20): Snow Water Equivalent/Snow Cover

Date	SWE		Snow Cover			Reference
	Accuracy (asc/des)	Precision (asc/des)	POD (asc/des)	FAR (asc/des)	HSS (asc/des)	
Requirement	**3.0 cm**	**6.0 cm**	**0.80**	**0.10**	**0.55**	
2018-01-15	1.38/1.41	3.20/3.11	0.84/0.87	0.09/0.10	0.55/0.58	JAXA AMSR2
2018-12-15	1.30/1.27	2.49/2.46	0.85/0.92	0.09/0.10	0.62/0.69	JAXA AMSR2
2019-01-15	1.40/1.35	3.17/3.12	0.88/0.93	0.10/0.10	0.59/0.68	JAXA AMSR2
2019-02-15	1.40/1.36	3.95/3.86	0.87/0.94	0.11/0.11	0.61/0.68	JAXA AMSR2
2018-01-15	2.23/2.05	3.85/3.98	0.79/0.81	0.01/0.02	0.50/0.52	NIC IMS
2018-12-15	1.88/1.58	3.40/3.74	0.78/0.83	0.00/0.03	0.52/0.53	NIC IMS
2019-01-15	2.55/2.29	3.60/3.99	0.83/0.86	0.01/0.03	0.54/0.57	NIC IMS
2019-02-15	2.30/2.01	3.81/4.10	0.80/0.86	0.00/0.01	0.52/0.58	NIC IMS

Meets requirement

Marginal

MiRS SWE/Snow cover Performance vs. JAXA/AMSR2 and NIC IMS
- Official reference is JAXA/AMSR2
- Most threshold requirements are met (except FAR for select cases)
- IMS used as secondary reference

Note: results stratified by asc/des, but requirements are for combined passes

Validation Results Summary (NPP): Snow Water Equivalent/Snow Cover

Date	SWE		Snow Cover			Reference
	Accuracy (asc/des)	Precision (asc/des)	POD (asc/des)	FAR (asc/des)	HSS (asc/des)	
Requirement	**3.0 cm**	**6.0 cm**	**0.80**	**0.10**	**0.55**	
2018-01-15	1.50/1.49	3.19/3.16	0.84/0.90	0.09/0.10	0.57/0.62	JAXA AMSR2
2018-12-15	1.41/1.39	2.49/2.43	0.84/0.92	0.10/0.10	0.63/0.71	JAXA AMSR2
2019-01-15	1.45/1.48	3.19/3.09	0.88/0.94	0.09/0.10	0.60/0.65	JAXA AMSR2
2019-02-15	1.53/1.46	3.93/3.84	0.88/0.94	0.10/0.11	0.62/0.68	JAXA AMSR2
2018-01-15	2.39/2.13	3.75/4.05	0.79/0.85	0.01/0.02	0.52/0.56	NIC IMS
2018-12-15	1.85/1.79	3.66/3.51	0.77/0.81	0.01/0.03	0.52/0.54	NIC IMS
2019-01-15	2.52/2.32	3.76/3.95	0.84/0.88	0.01/0.02	0.55/0.57	NIC IMS
2019-02-15	2.38/2.07	3.85/4.18	0.80/0.86	0.00/0.01	0.52/0.59	NIC IMS

Meets requirement

Marginal

MiRS SWE/Snow cover Performance vs. JAXA/AMSR2 and NIC IMS
- Official reference is JAXA/AMSR2
- Most threshold requirements are met (except FAR for select cases)
- IMS used as secondary reference

Note: results stratified by asc/des, but requirements are for combined passes

Requirements and Validation Results: Rainfall Rate

- Periodic collocations with Stage-IV and MRMS
- Official reference is Stage-IV
- Stratified by surface type, but requirement is for land only
- Requirements from JPSS-REQ-1004
- All requirements are met except some individual cases for False Alarm Rate

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	

Data Collected: Fall 2018, Winter 2018-19, Spring 2019, Summer 2019

Meets requirements except some cases

Meets requirements

Reference: Stage IV
Values in () indicates NPP

Product	SFC	EDR Attribute	MiRS	Requirement
RR (mm/h)	Land	Accuracy (mm/h)	0.02 ~ 0.05 (0.02 ~ 0.05)	0.1
		Precision (mm/h)	0.5 ~ 0.8 (0.5 ~ 0.8)	1.0
		Probability of Detection (%)	66 ~ 80 (67 ~ 80)	50
		False Alarm Rate (%)	4.9 ~ 7.0 (4.8 ~ 6.3)	5
		Heidke Skill Score	0.44 ~ 0.51 (0.47 ~ 0.52)	0.3

Product	SFC	EDR Attribute	MiRS	Requirement
RR (mm/h)	Ocean	Accuracy (mm/h)	0.02 ~ 0.08 (0.03 ~ 0.08)	0.1
		Precision (mm/h)	0.62 ~ 0.95 (0.64 ~ 0.92)	1.0
		Probability of Detection (%)	75 ~ 80 (74 ~ 80)	50
		False Alarm Rate (%)	3.3 ~ 5.7 (3.2 ~ 5.5)	5
		Heidke Skill Score	0.47 ~ 0.61 (0.50 ~ 0.61)	0.3

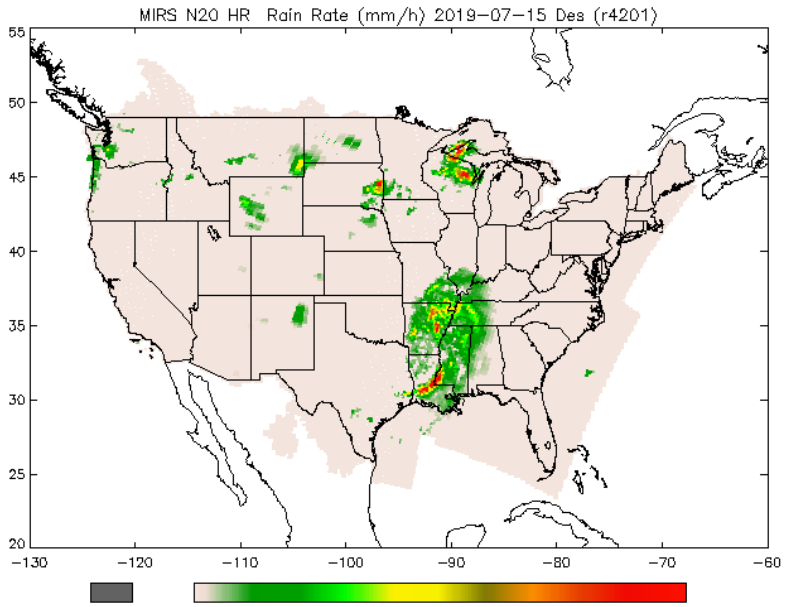
Collocation details:

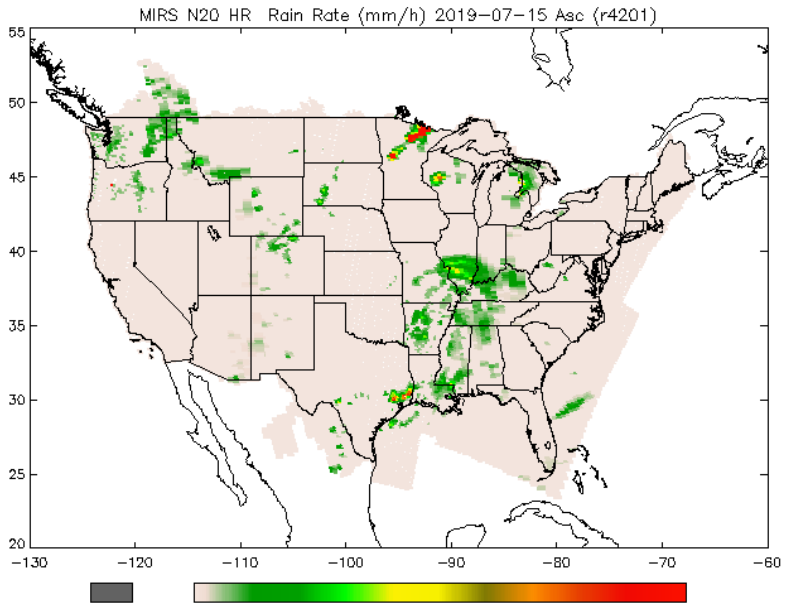
- Stage-IV:
  - NOAA NCEP Multisensor (radar + gauges) Precipitation Estimator (MPE) analyses, hourly over CONUS and adjacent near ocean, spatial resolution is 4 km.
  - Collocation spatial radius: ~4.55 km, average Stage-IV values within the range.
  - Collocation time window: ± 30 minutes.
- MRMS :
  - Multi-Radar Multi-Sensor (MRMS) Quantitative Precipitation Estimation (QPE), in situ gauge corrected radar QPE, hourly over CONUS and adjacent near ocean, spatial resolution 0.01 degree.
  - Collocation spatial radius: FOV size, average grid values fall within each FOV.
  - Collocation time window: ± 30 minutes

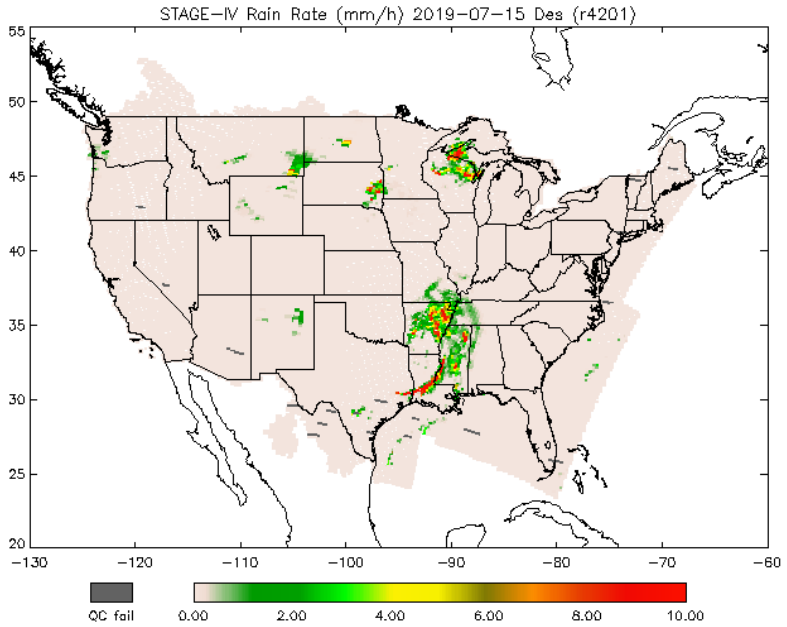
One day example: N20 MiRS vs. Stage-IV Rain Rate (mm/h)

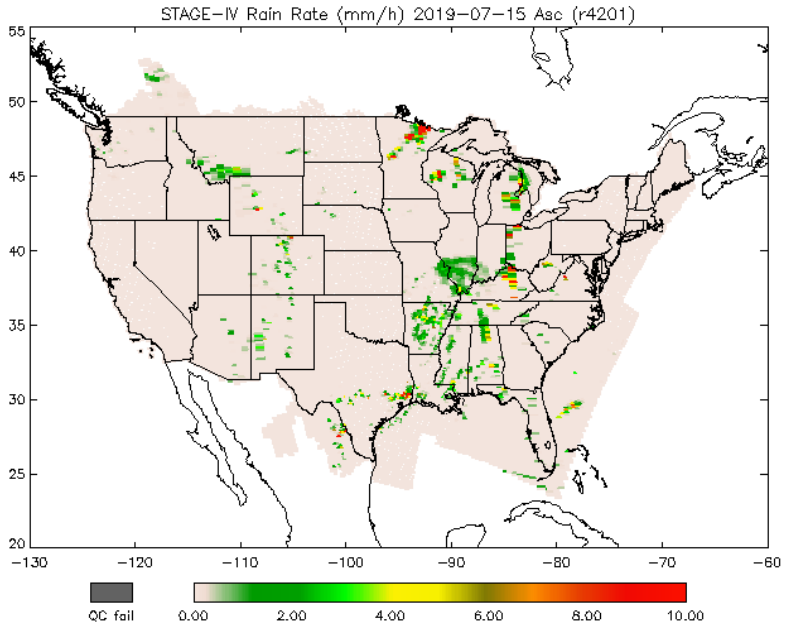
MiRS

Stage IV

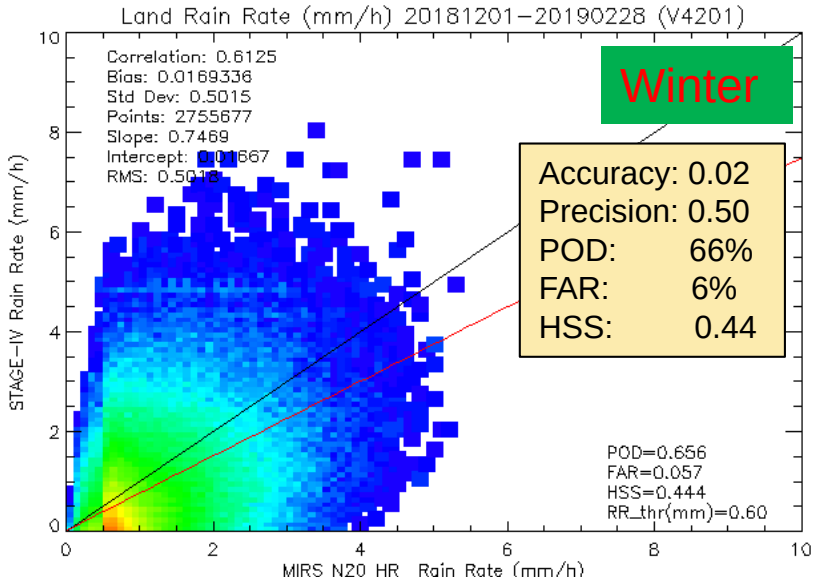


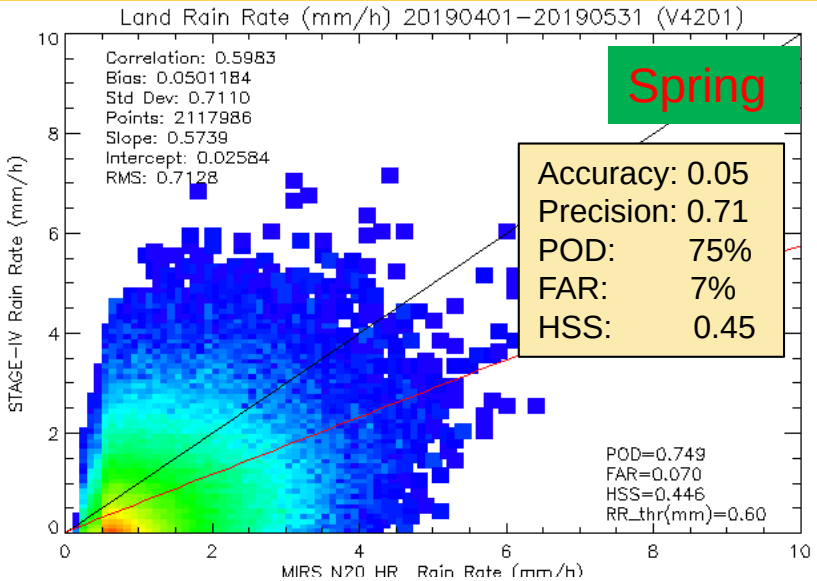


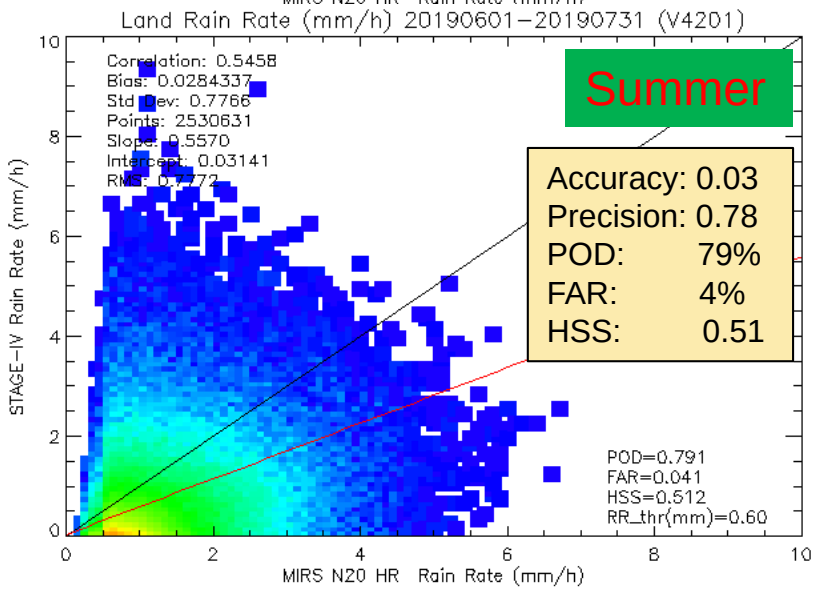


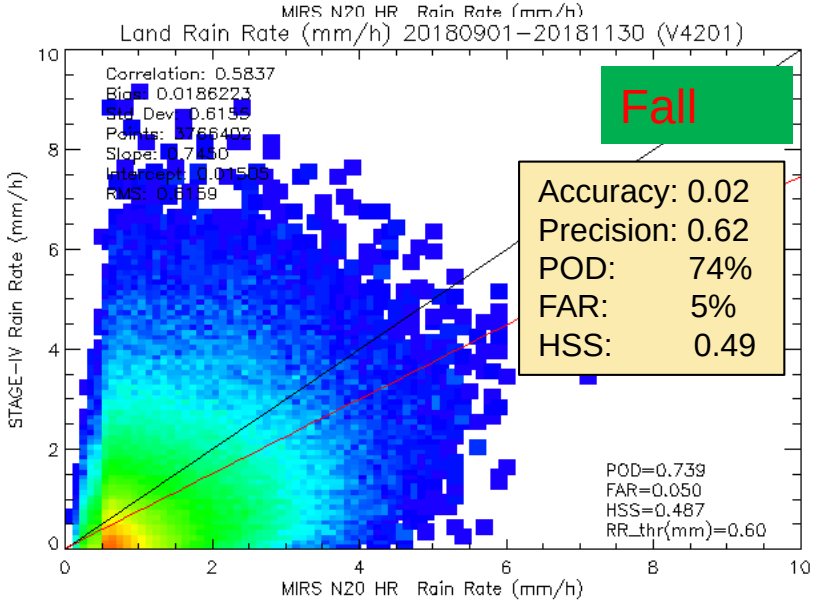


Rain Rate Validation Results: Stage-IV density plot LAND



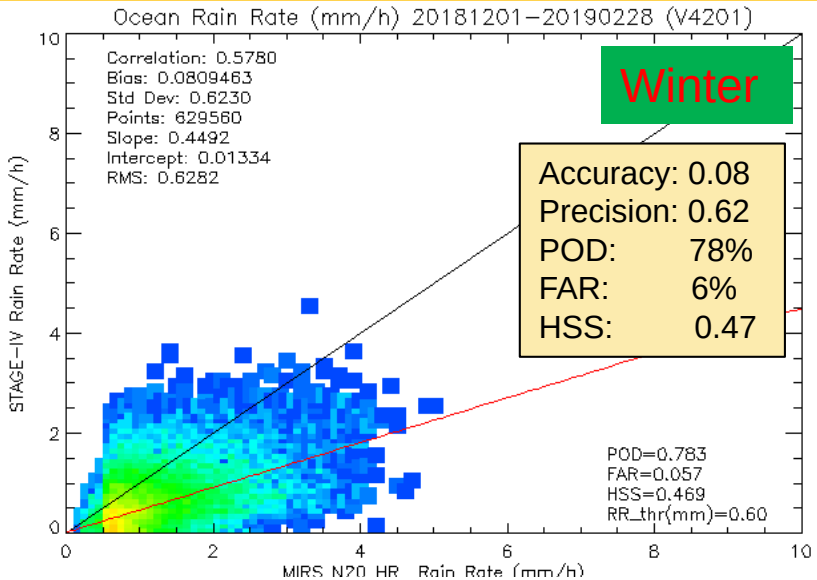


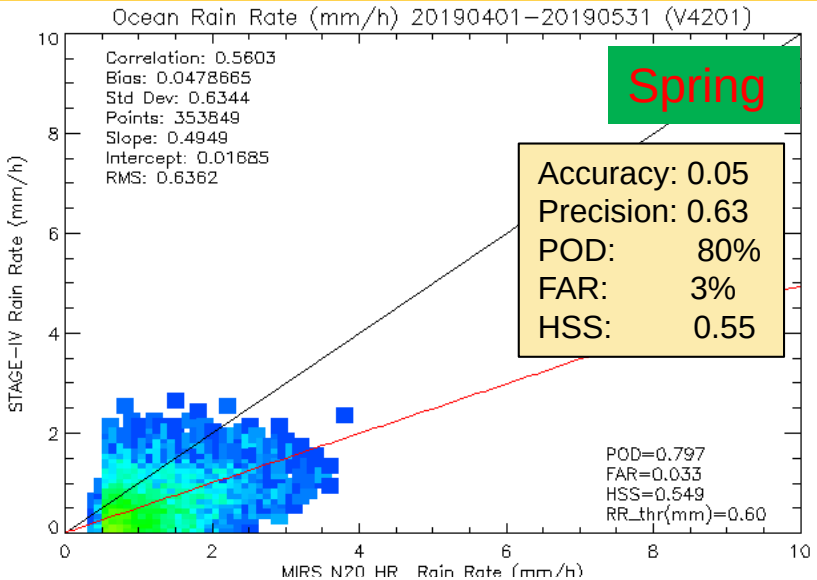


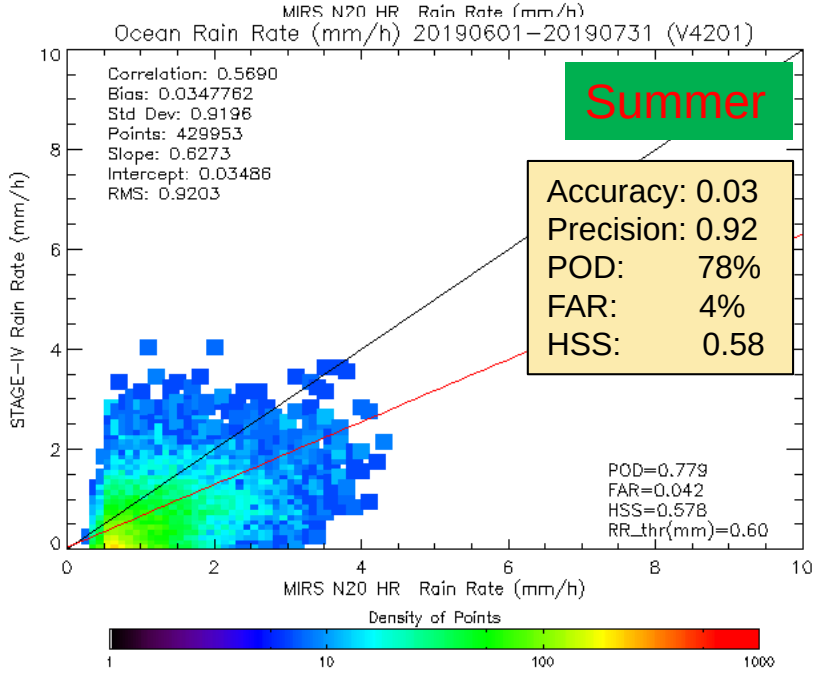


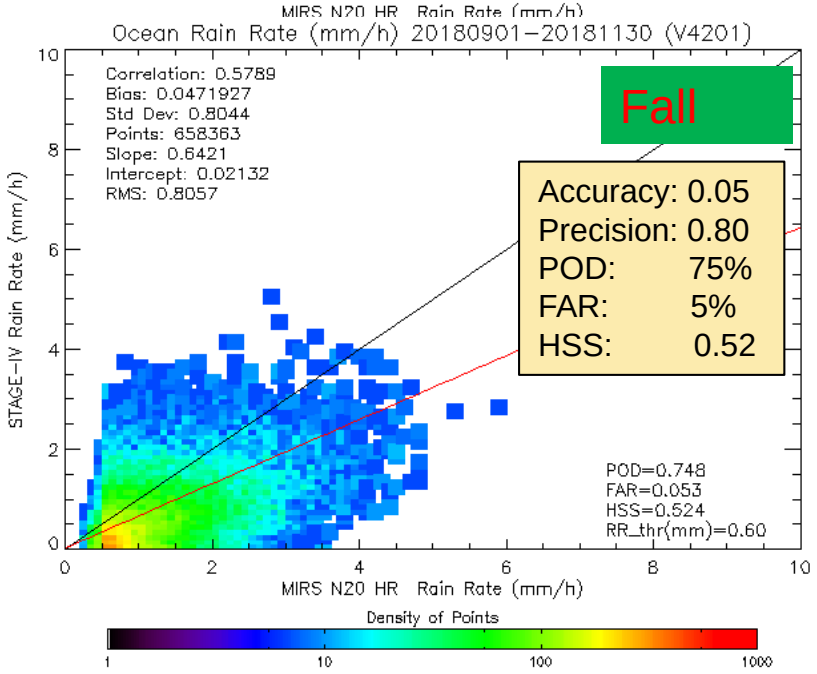
Requirement:
Accuracy: 0.1
Precision: 1.0
POD: 50
FAR: 5
HSS: 0.3

Rain Rate Validation Results: Stage-IV density plot OCEAN



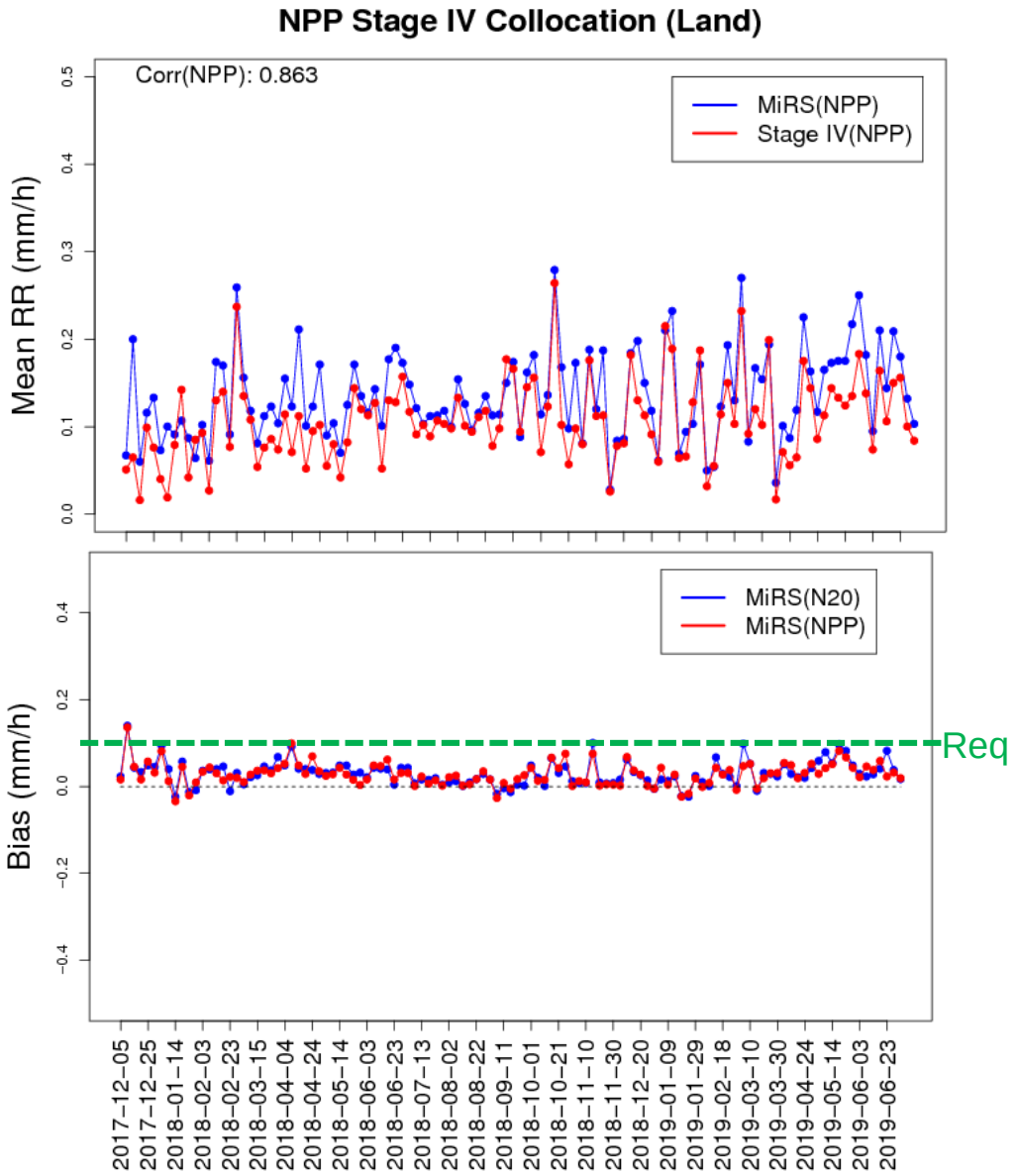


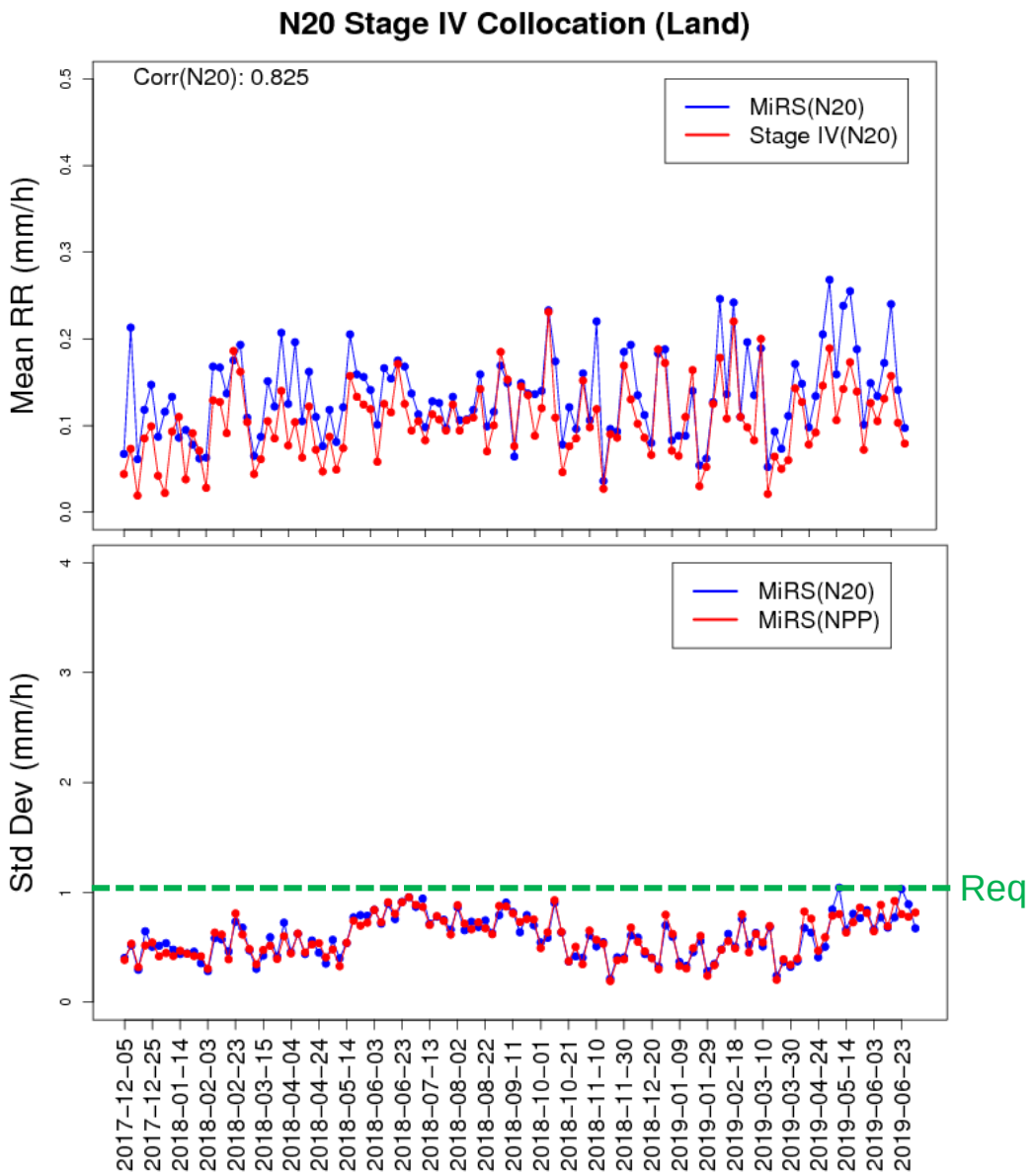




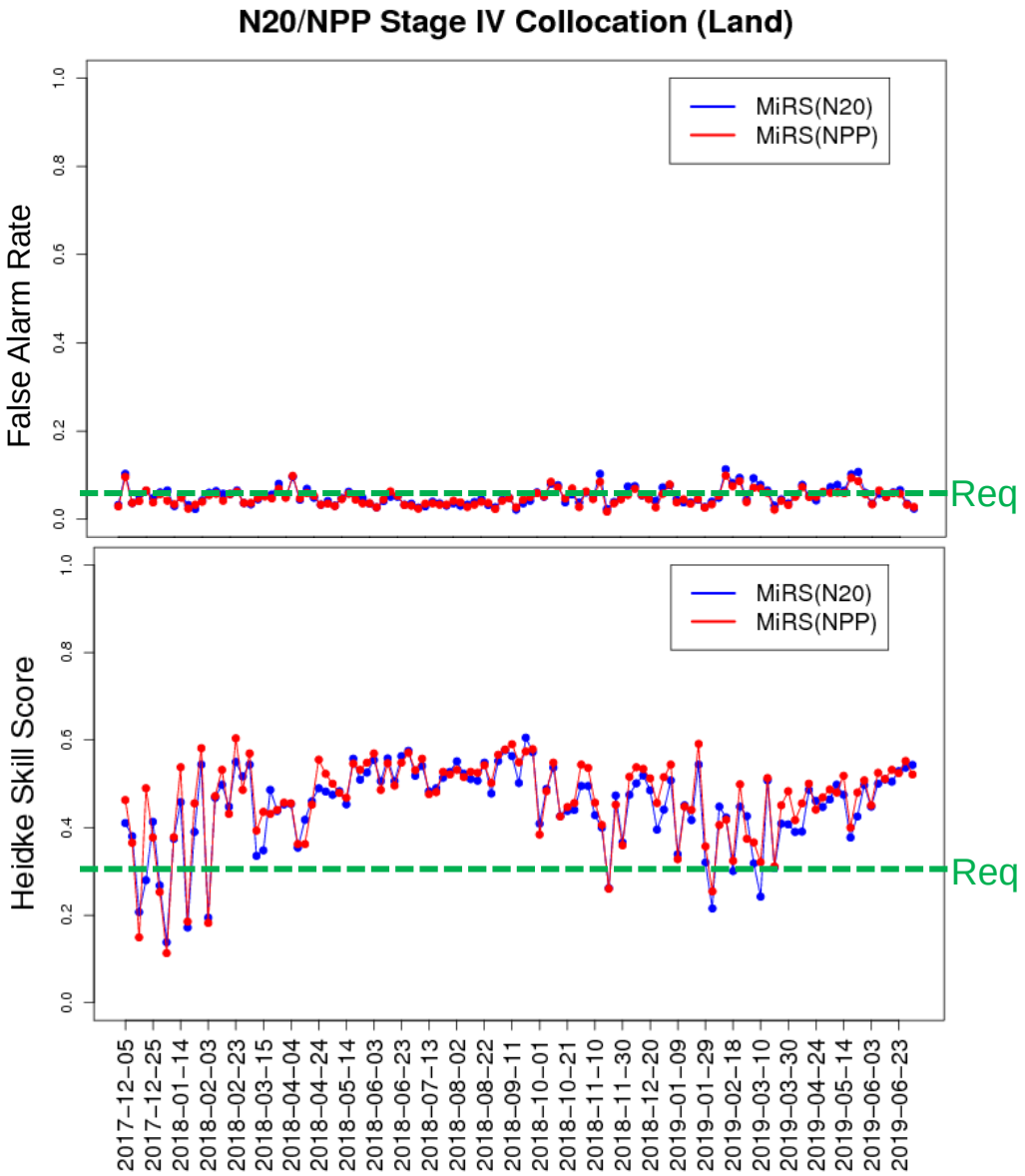
Requirement:
Accuracy: 0.1
Precision: 1.0
POD: 50
FAR: 5
HSS: 0.3

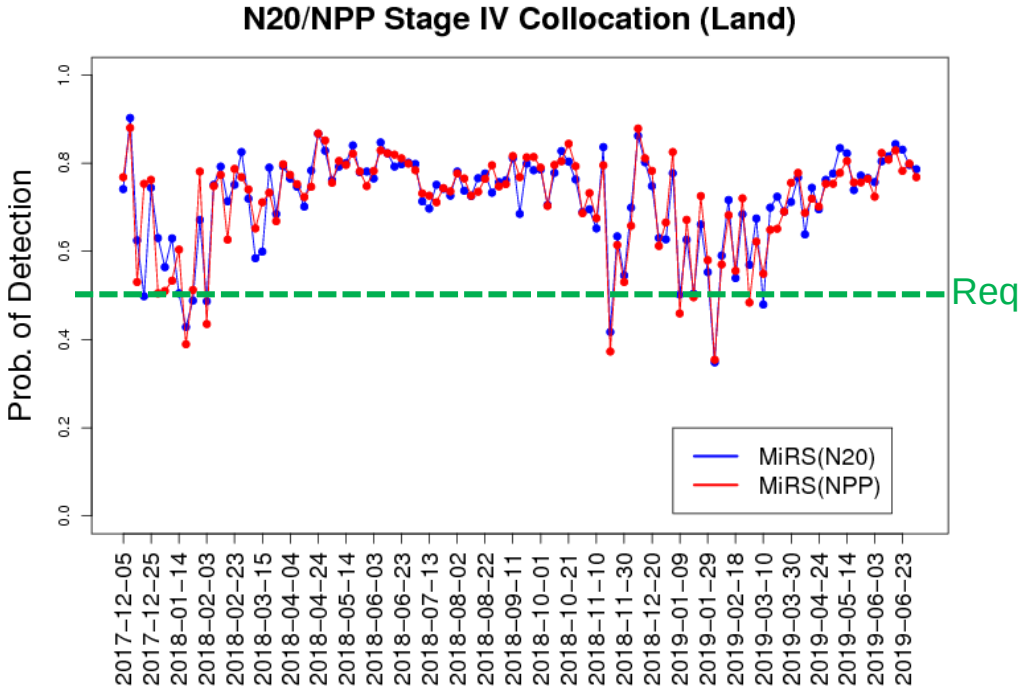
Time Series: N20 and NPP vs. Stage-IV
Dec 2017 – Jun 2019 (5-day average over CONUS)





Time Series: N20 and NPP vs. Stage-IV
Dec 2017 – Jun 2019 (5-day average over CONUS)

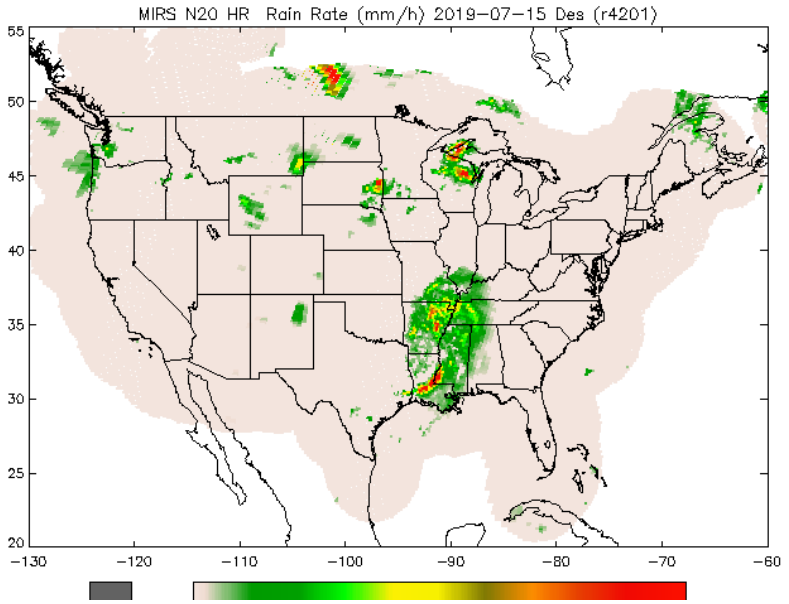


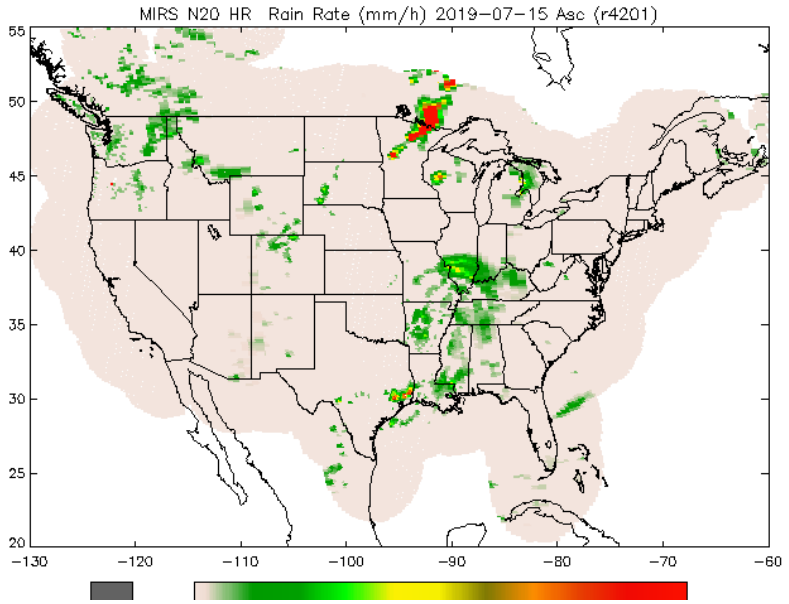


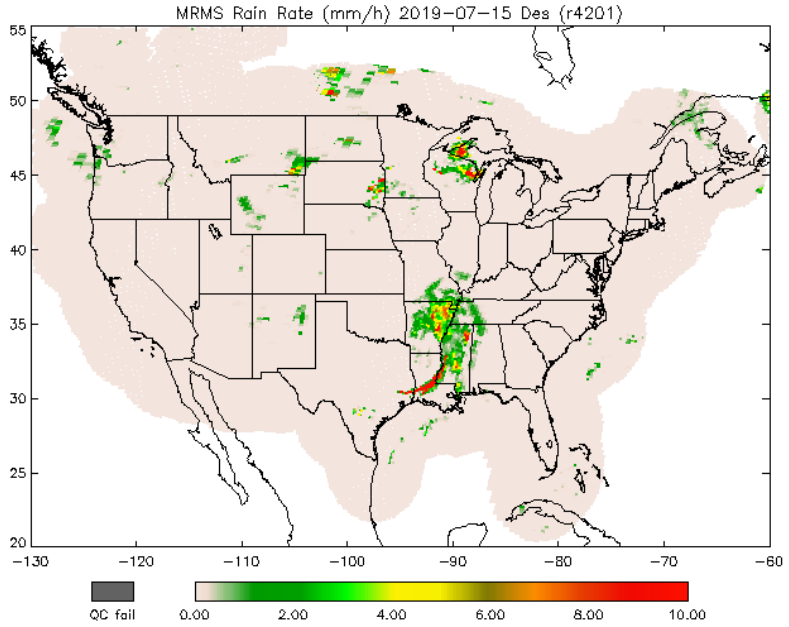
One day example: N20 MiRS vs. MRMS Rain Rate (mm/h)

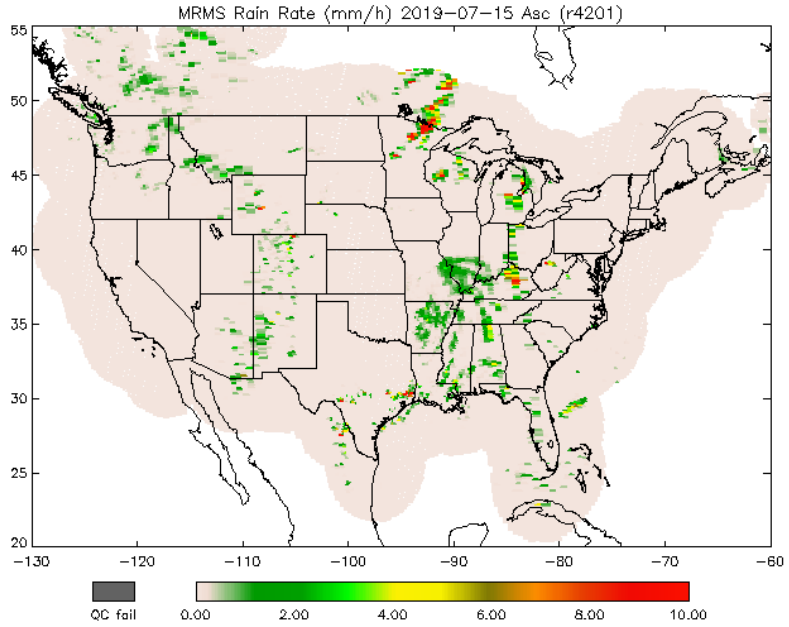
MiRS

MRMS

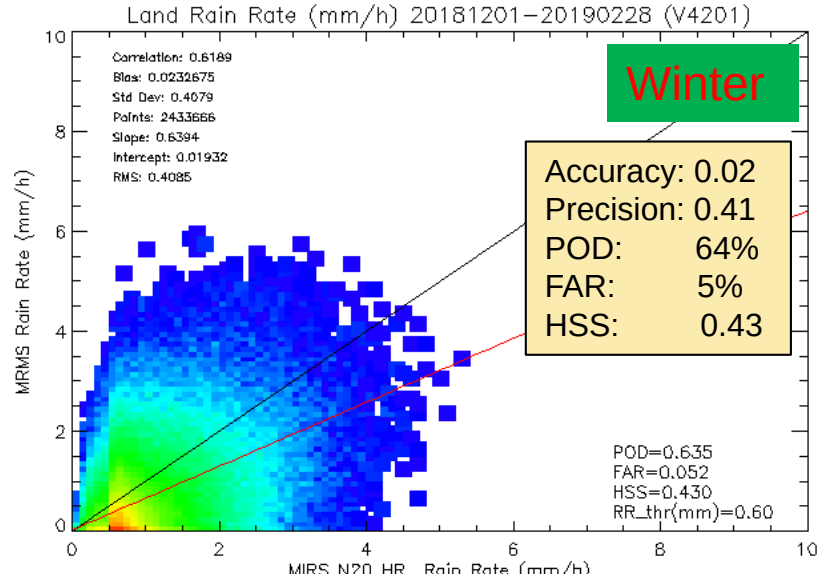


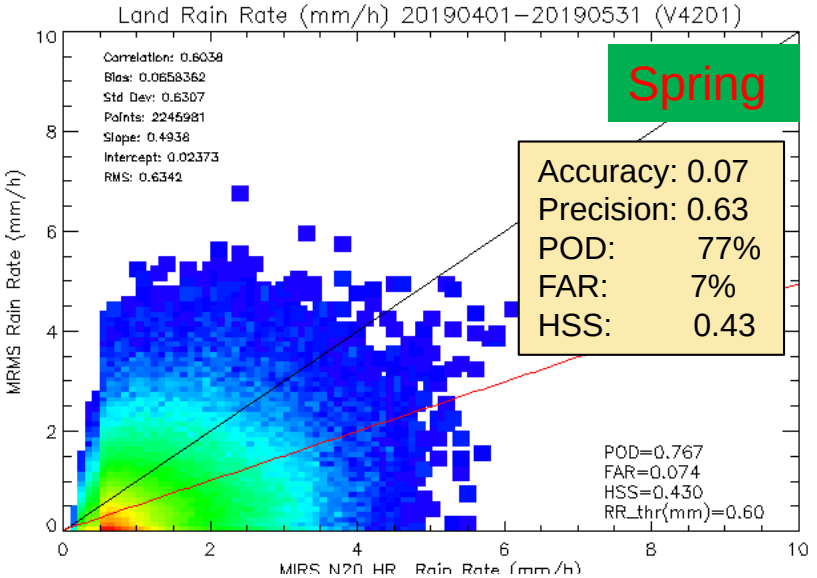


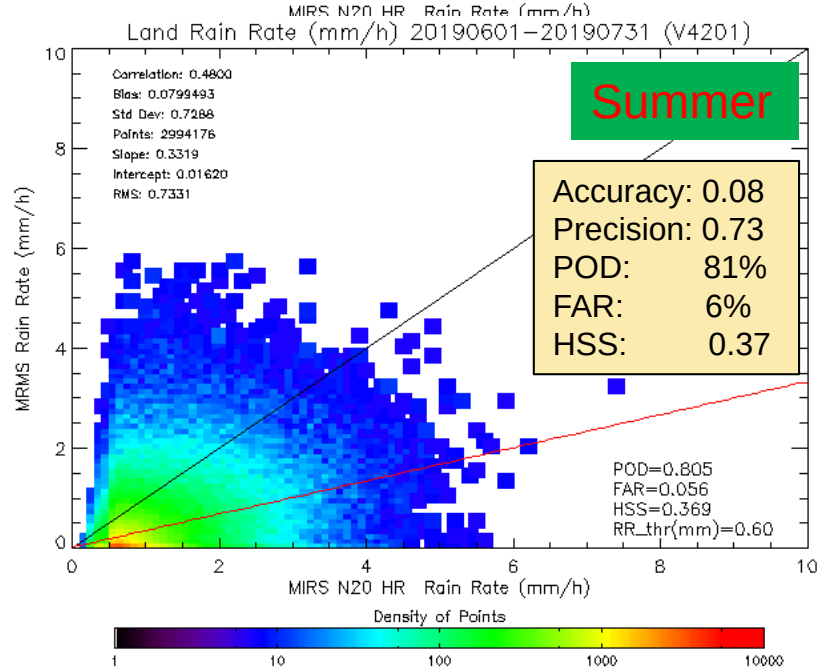


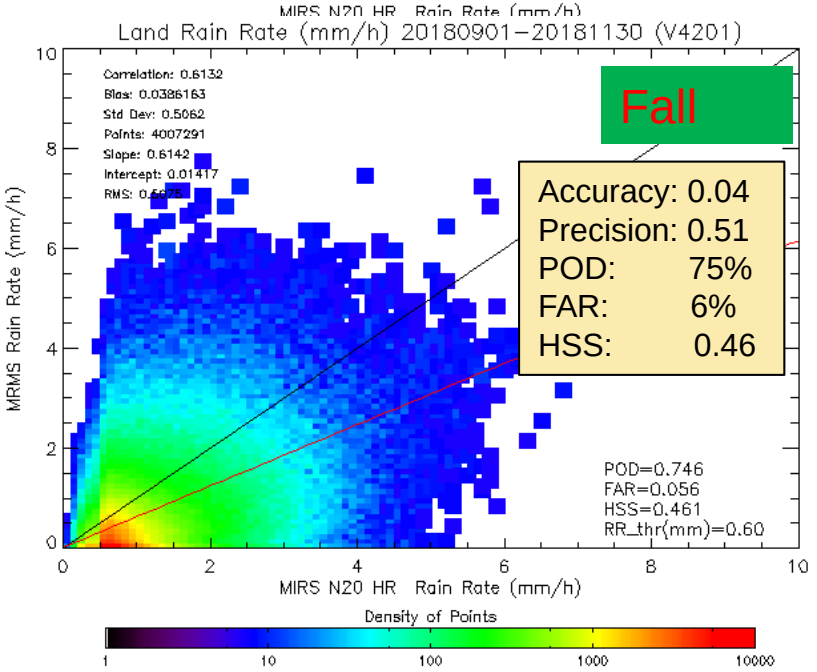


Rain Rate Validation Results: MRMS density plot LAND



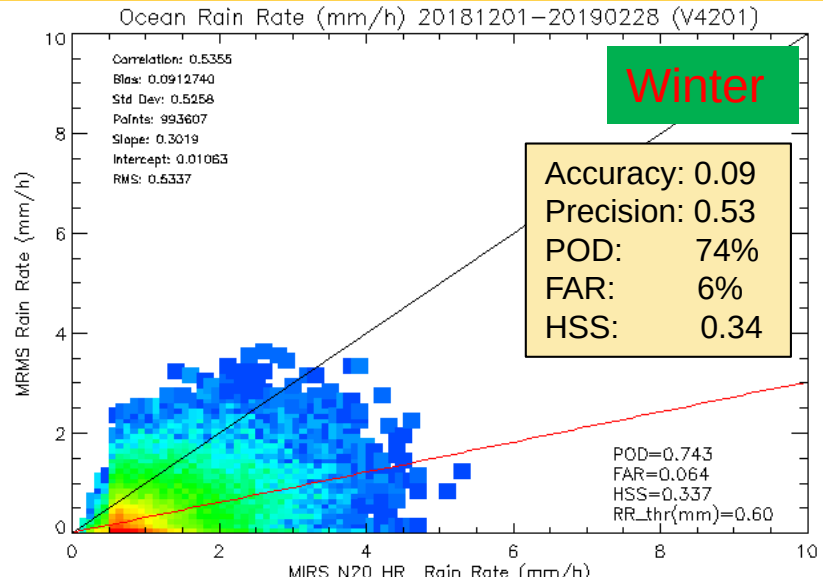


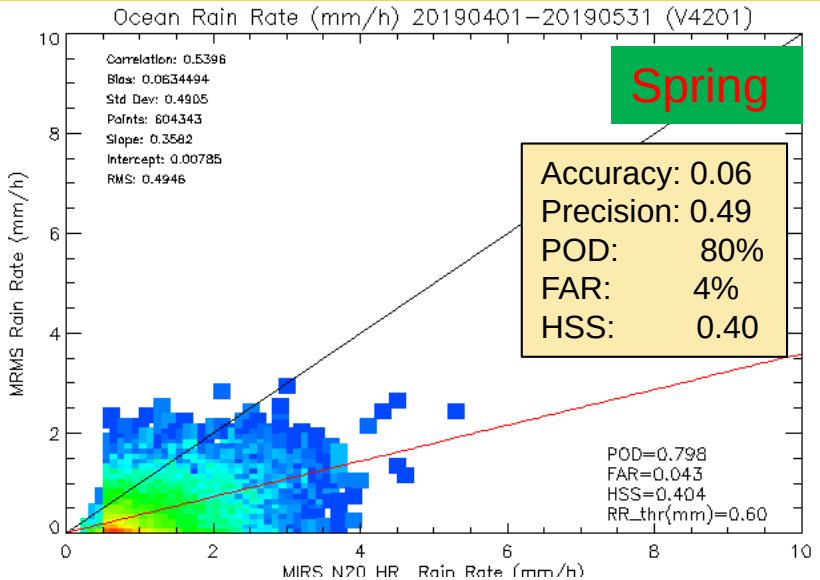


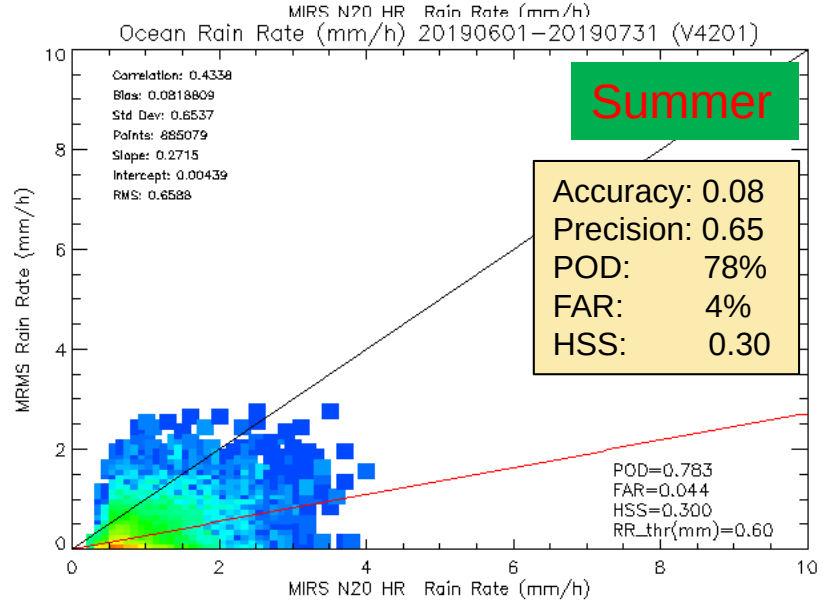


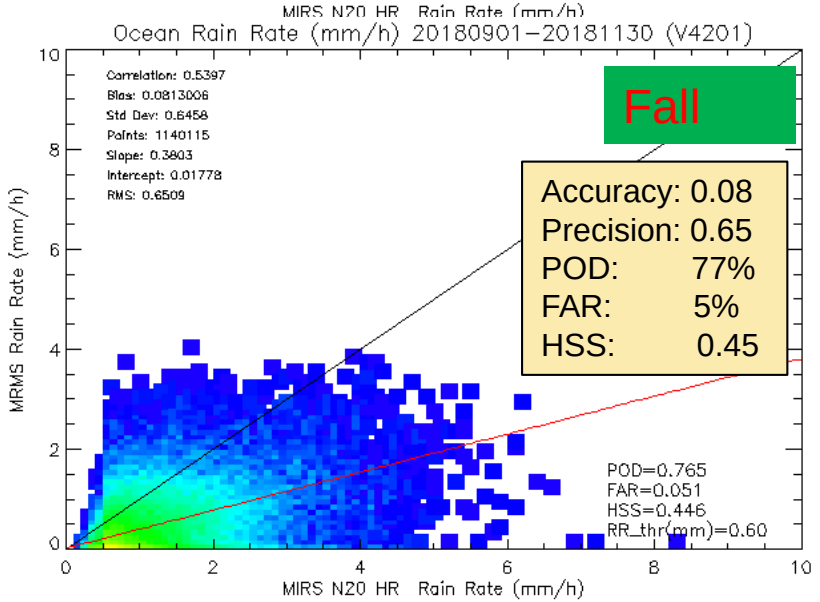
Requirement:
Accuracy: 0.1
Precision: 1.0
POD: 50
FAR: 5
HSS: 0.3

Rain Rate Validation Results: MRMS density plot OCEAN









Requirement:
Accuracy: 0.1
Precision: 1.0
POD: 50
FAR: 5
HSS: 0.3

Rainfall Rate Validation Based on Stage IV

NOAA-20

EDR Attribute	Requirements	Winter 18-19 (DJF)		Spring 19 (AM)		Summer 19 (JJ)		Fall 18 (SON)		Combined	
		Land	Sea	Land	Sea	Land	Sea	Land	Sea	Land	Sea
Bias (mm/h)	0.10	0.02	0.08	0.05	0.05	0.03	0.03	0.02	0.05	0.03	0.05
STDV (mm/h)	1.0	0.50	0.62	0.72	0.63	0.78	0.92	0.60	0.80	0.66	0.75
Prob. of Detection (%)	50	65.6	78.0	75.0	79.7	79.1	77.9	73.9	74.8	73.6	78.1
False Alarm Rate (%)	5.0	5.7	5.7	7.0	3.3	4.1	4.2	5.0	5.3	5.7	4.6
Heidke Skill Score	0.30	0.44	0.47	0.45	0.55	0.51	0.58	0.49	0.52	0.47	0.54

NPP

EDR Attribute	Requirements	Winter 18-19 (DJF)		Spring 19 (AM)		Summer 19 (JJ)		Fall 18 (SON)		Combined	
		Land	Sea	Land	Sea	Land	Sea	Land	Sea	Land	Sea
Bias (mm/h)	0.10	0.02	0.08	0.05	0.05	0.03	0.04	0.02	0.04	0.03	0.07
STDV (mm/h)	1.0	0.50	0.64	0.72	0.71	0.80	0.92	0.63	0.79	0.66	0.77
Prob. of Detection (%)	50	66.6	79.9	74.4	79.8	78.9	78.8	74.9	74.4	73.7	78.2
False Alarm Rate (%)	5.0	5.2	5.5	6.3	3.2	4.1	4.3	5.0	4.7	5.2	4.4
Heidke Skill Score	0.30	0.47	0.50	0.47	0.59	0.53	0.59	0.50	0.54	0.49	0.56

Meets requirement

Marginal

RR threshold for categorical scores: 0.6 mm/hr

Rainfall Rate Validation Based on MRMS

NOAA-20

EDR Attribute	Requirements	Winter 18-19 (DJF)		Spring 19 (AM)		Summer 19 (JJ)		Fall 18 (SON)		Combined	
		Land	Sea	Land	Sea	Land	Sea	Land	Sea	Land	Sea
Bias (mm/h)	0.10	0.02	0.09	0.07	0.06	0.08	0.08	0.04	0.08	0.05	0.08
STDV (mm/h)	1.0	0.41	0.53	0.63	0.49	0.73	0.65	0.51	0.65	0.57	0.58
Prob. of Detection (%)	50	63.5	74.3	76.7	79.8	80.5	78.3	74.6	76.5	73.8	77.2
False Alarm Rate (%)	5.0	5.2	6.4	7.4	4.3	5.6	4.4	5.6	5.1	5.6	5.1
Heidke Skill Score	0.30	0.43	0.34	0.43	0.40	0.37	0.30	0.46	0.45	0.42	0.37

NPP

EDR Attribute	Requirements	Winter 18-19 (DJF)		Spring 19 (AM)		Summer 19 (JJ)		Fall 18 (SON)		Combined	
		Land	Sea	Land	Sea	Land	Sea	Land	Sea	Land	Sea
Bias (mm/h)	0.10	0.03	0.10	0.06	0.07	0.11	0.1	0.04	0.07	0.06	0.09
STDV (mm/h)	1.0	0.43	0.56	0.64	0.58	0.77	0.69	0.53	0.60	0.59	0.61
Prob. of Detection (%)	50	65.8	77.1	76.7	80.1	84.4	80.5	75.1	76.0	75.5	78.4
False Alarm Rate (%)	5.0	4.9	6.2	6.8	4.2	6.2	4.9	5.6	4.7	5.9	5.0
Heidke Skill Score	0.30	0.46	0.36	0.46	0.43	0.27	0.22	0.47	0.46	0.42	0.37

Meets requirement

Marginal

RR threshold for categorical scores: 0.6 mm/hr

Requirements and Validation Results: Cloud Liquid Water

- Regular collocations with JAXA/GCOM-W AMSR2 (0.25 degree global)
- Also regular daily comparisons with ECMWF analyses.
- Four days of global collocations, ocean only, non-rainy conditons
- Days: 2019-01-09, 2019-04-09, 2019-06-21, 2018-09-09
- Requirements from JPSS-REQ-1004
- All accuracy and precision requirements are met

Attribute	Threshold	Validated
Geographic coverage	Ocean	See table/figs
Vertical Coverage	Single Layer	
Horizontal Cell Size	15 km at nadir	
Mapping Uncertainty	N/A (reflects SDR characteristics)	
Measurement Range	0.0 - 2.0 mm	
Measurement Accuracy	See table	
Measurement Precision	See table	

Date(s)	JAXA GCOMW/AMSR2		ECMWF	
	Bias/ Accuracy (mm)	**StDev/ Precision (mm)**	**Bias/ Accuracy (mm)**	**StDev/ Precision (mm)**
Requirement	**0.03**	**0.08**	**0.03**	**0.08**
2019-01-09	0.004 (0.002)	0.049 (0.040)	-0.010 (-0.010)	0.053 (0.052)
2019-04-09	0.012 (0.002)	0.048 (0.043)	-0.006 (-0.010)	0.054 (0.052)
2019-06-21	0.009 (0.005)	0.050 (0.043)	-0.007 (-0.012)	0.054 (0.053)
2018-09-09	-0.0001 (0.003)	0.049 (0.053)	-0.014 (-0.016)	0.053 (0.053)

Meets requirements except some cases

Meets requirements

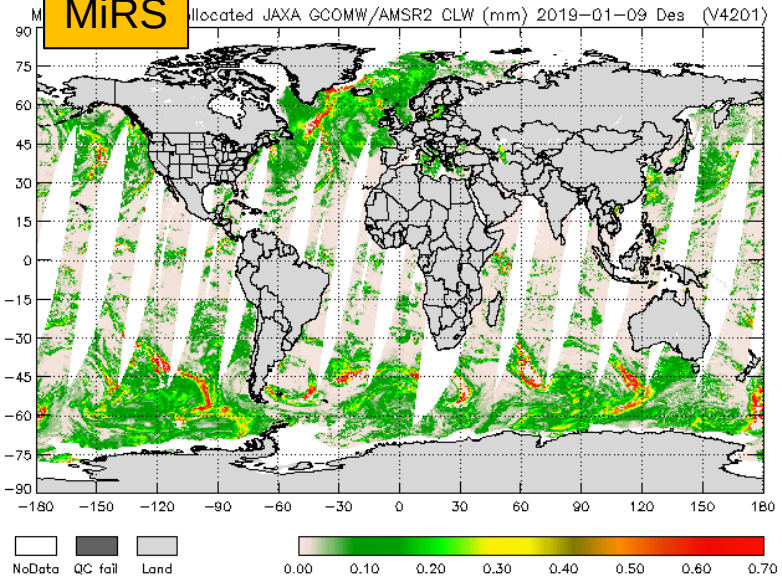
Values in () indicates NPP

Collocation details:

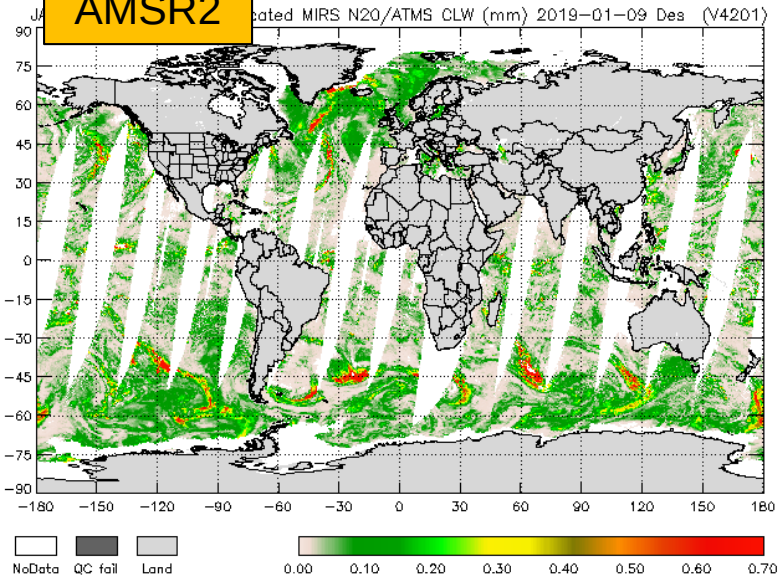
- JAXA AMSR2: collocate to AMSR2 on 25 km grid, weighted four point interpolation.
- ECMWF: bilinear interpolation in space and time from 1 deg lat/lon, 6-hour analyses

NOAA-20 example for one day: 2019-01-09 Descending

MiRS

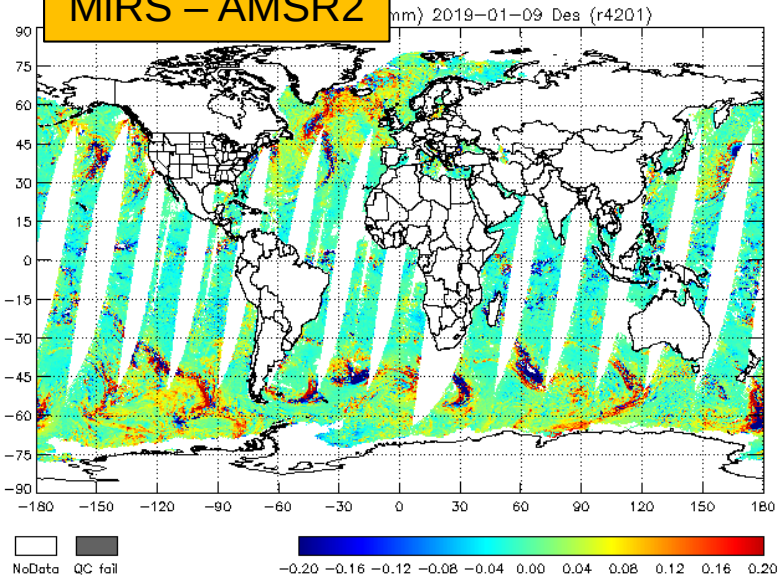


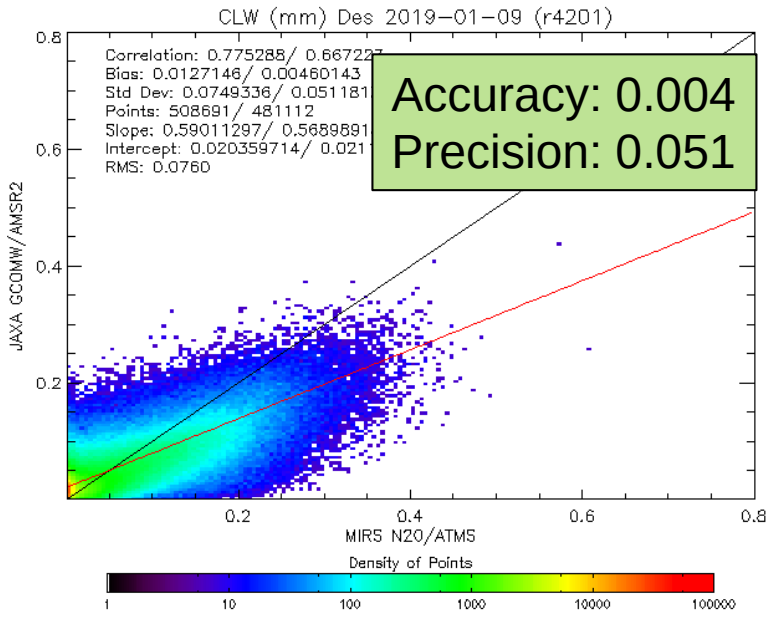
AMSR2



Requirement:
Accuracy: 0.03
Precision: 0.08

MiRS – AMSR2

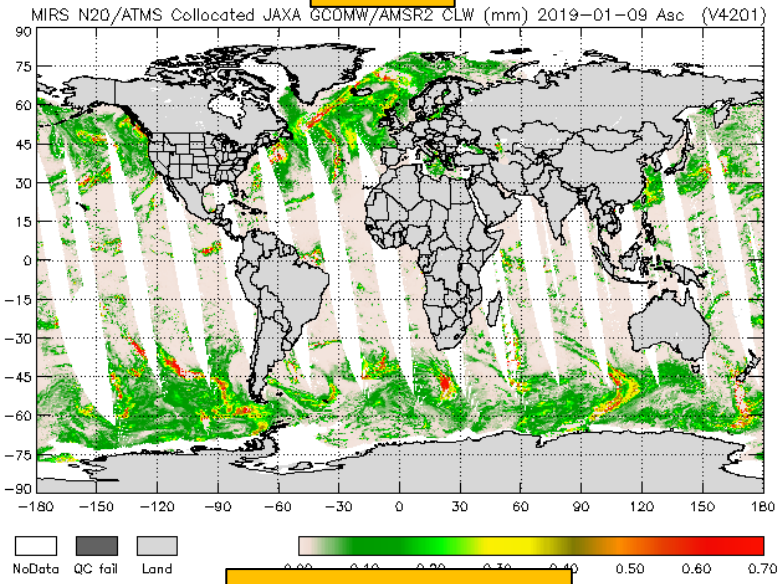




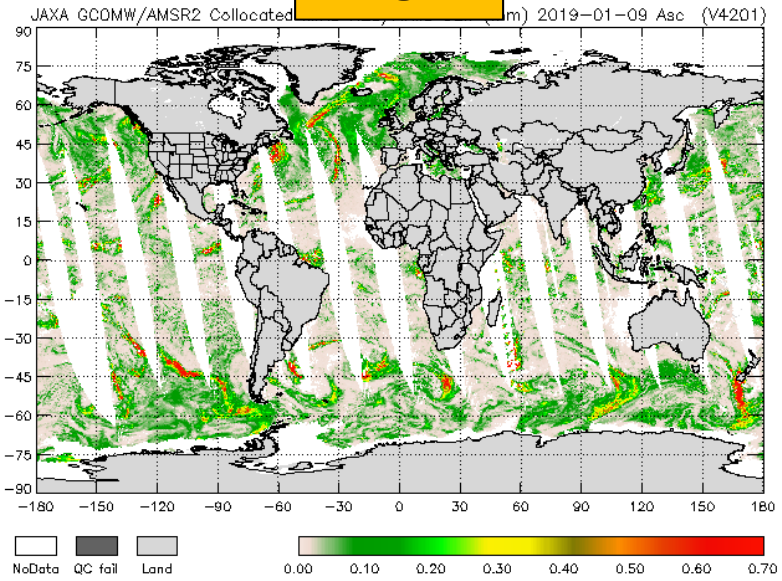
Accuracy: 0.004
Precision: 0.051

NOAA-20 example for one day: 2019-01-09 Ascending

MiRS

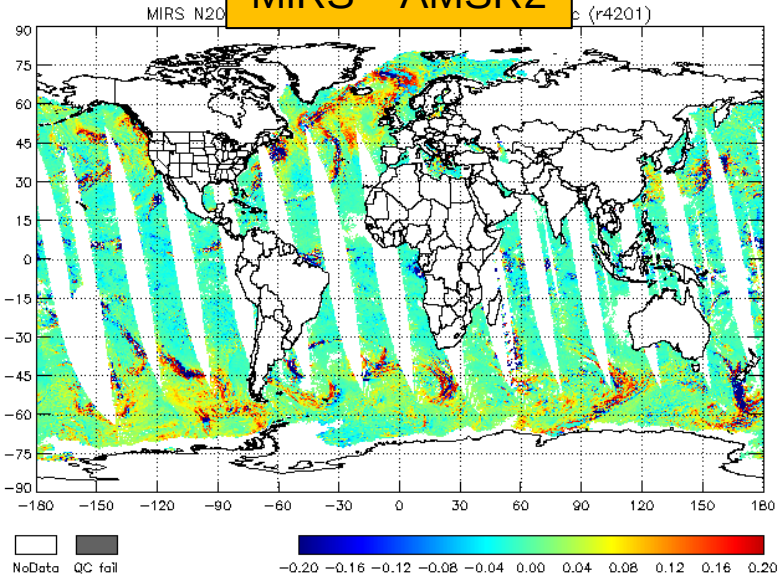


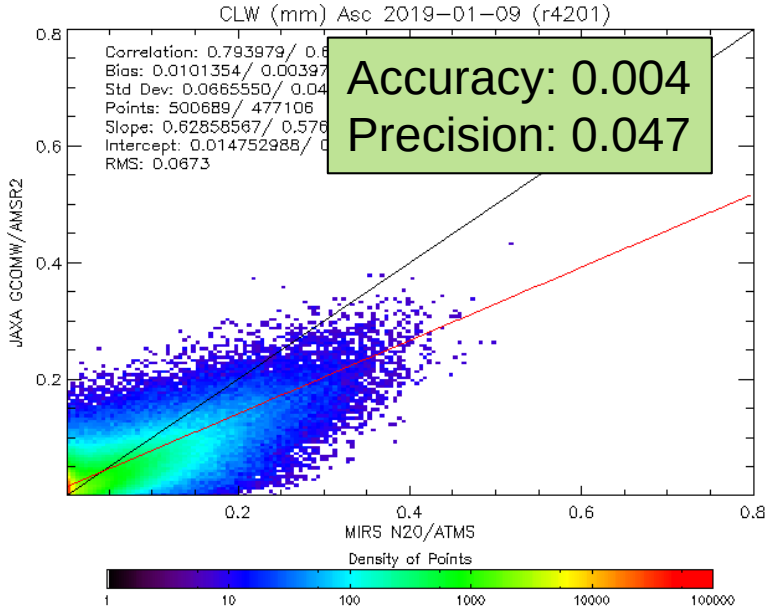
AMSR2



Requirement:
Accuracy: 0.03
Precision: 0.08

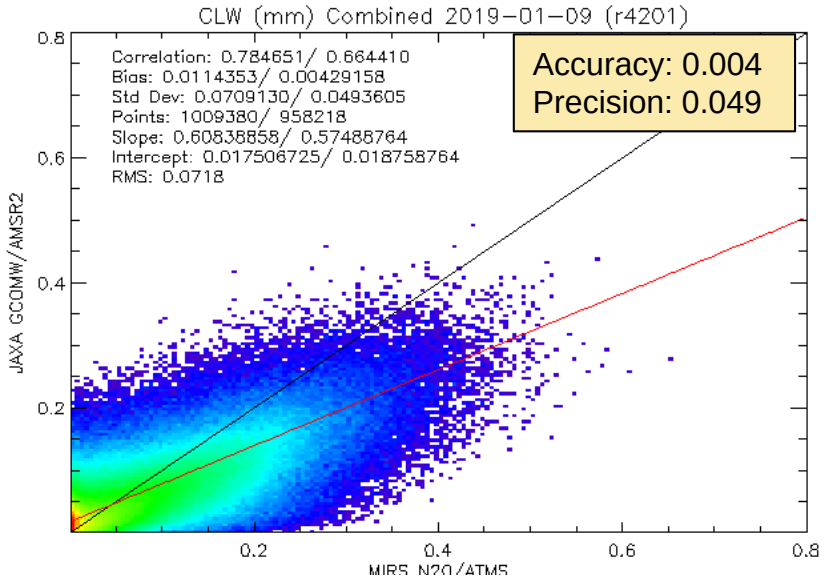
MiRS – AMSR2

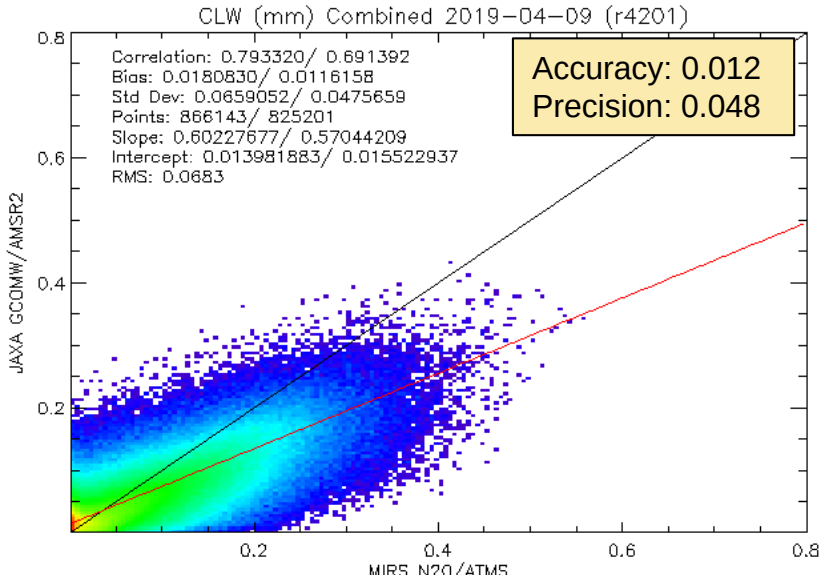


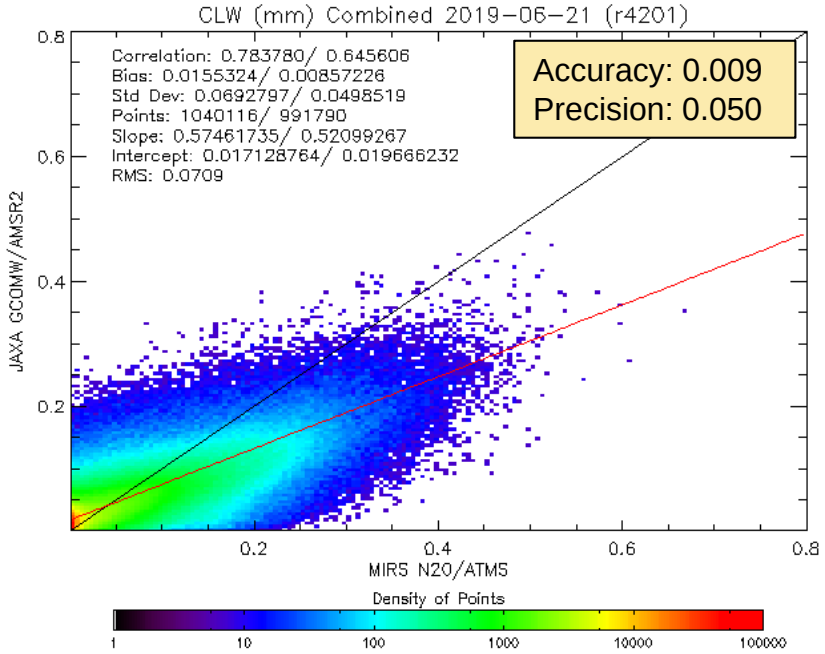


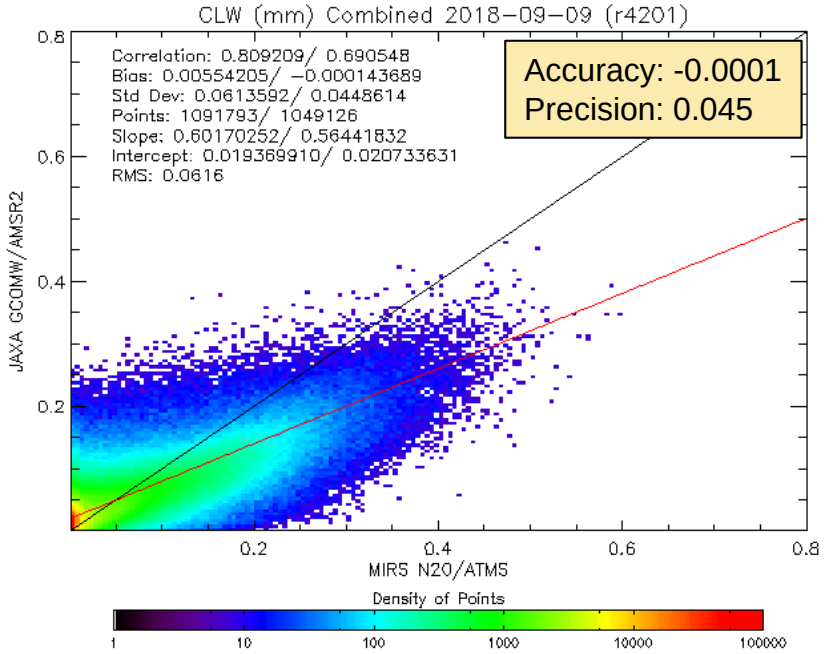
Accuracy: 0.004
Precision: 0.047

N20 CLW Validation Results: JAXA AMSR2 Comparison



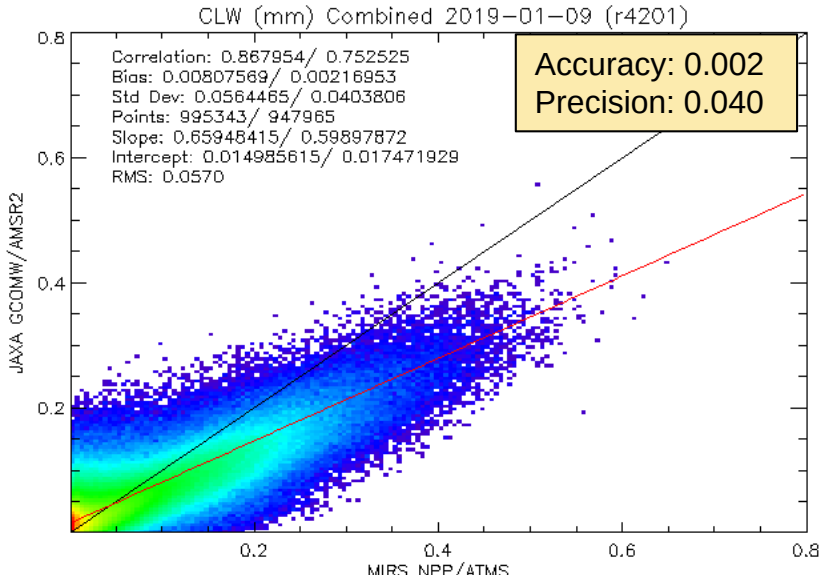


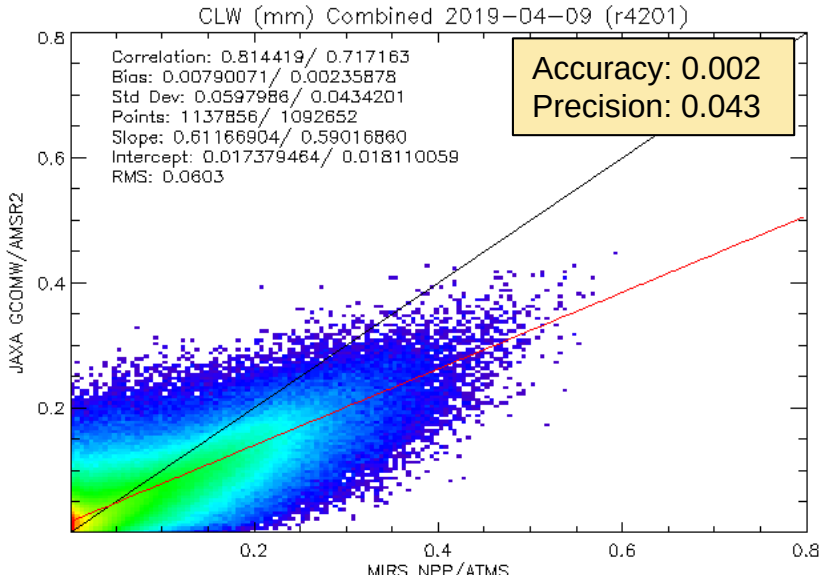


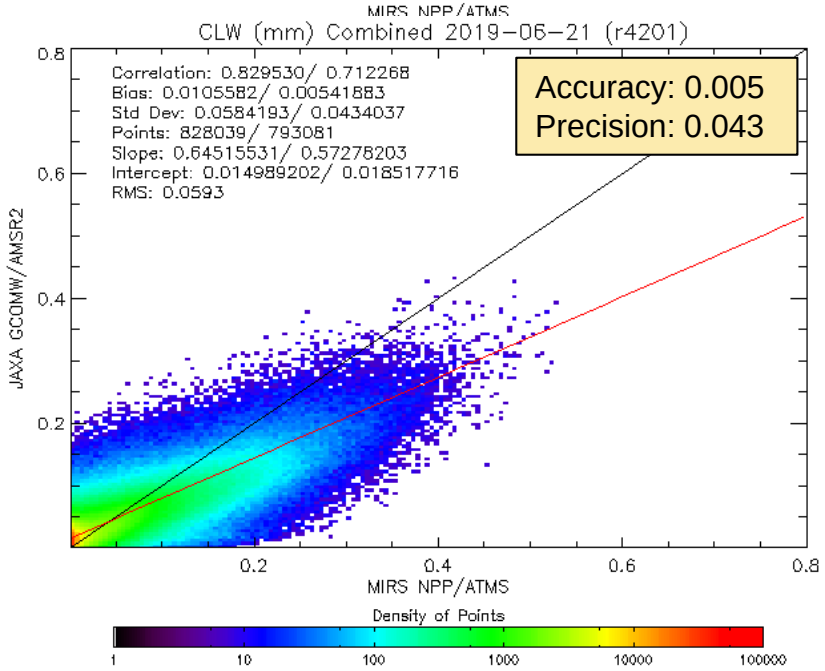


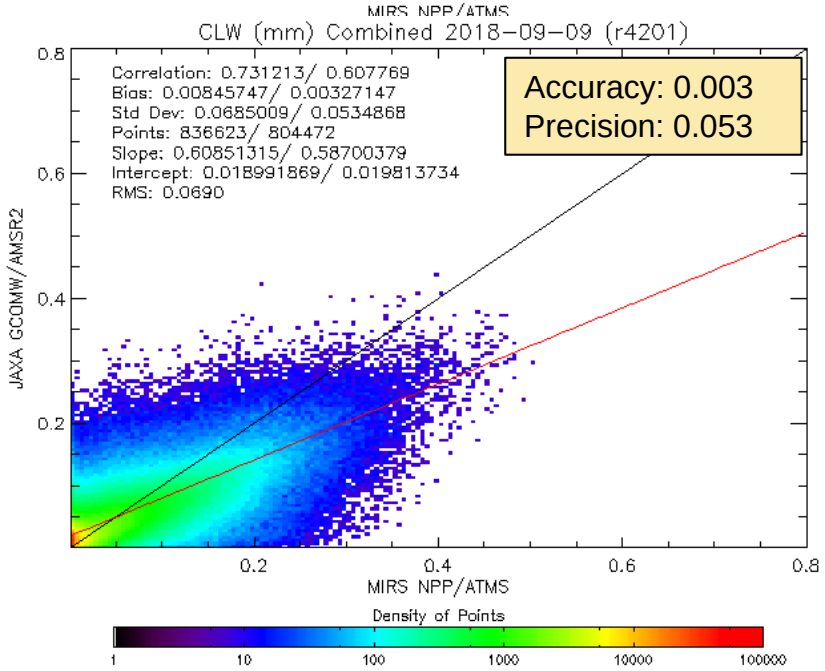
Requirement:
Accuracy: 0.03
Precision: 0.08

NPP CLW Validation Results: JAXA AMSR2 Comparison





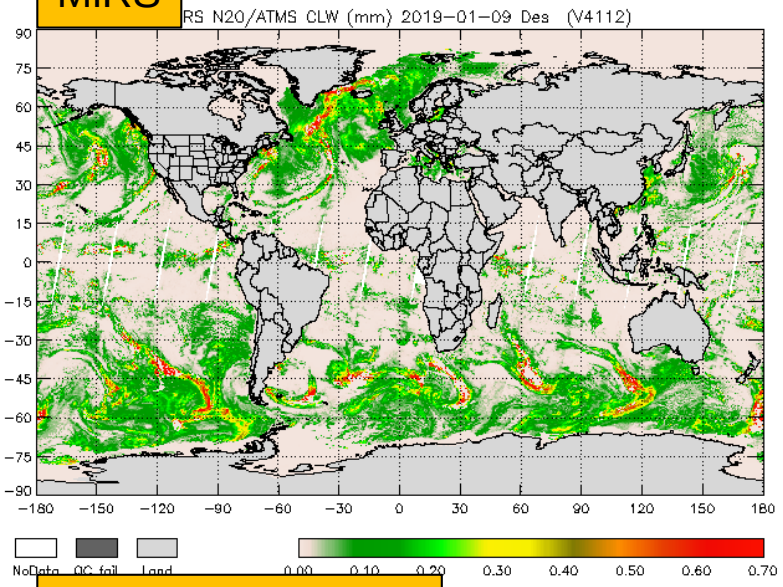




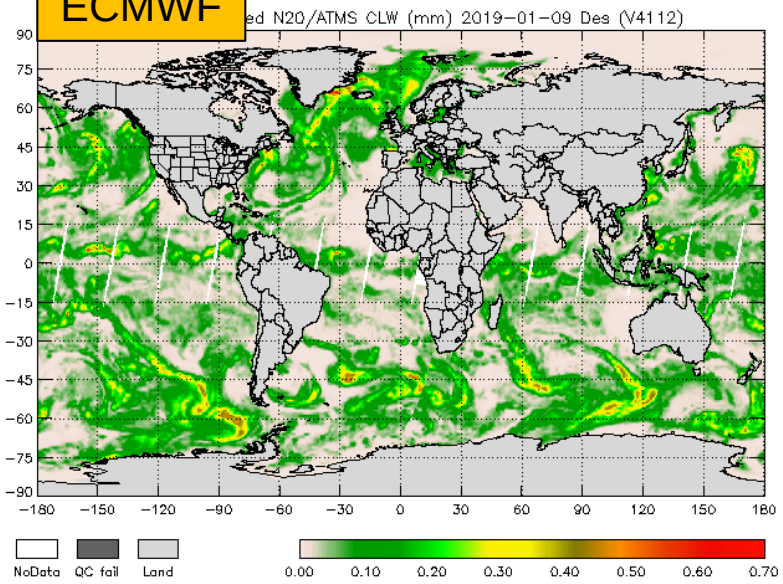
Requirement:
Accuracy: 0.03
Precision: 0.08

NOAA-20 example for one day: 2019-01-09 Descending

MiRS

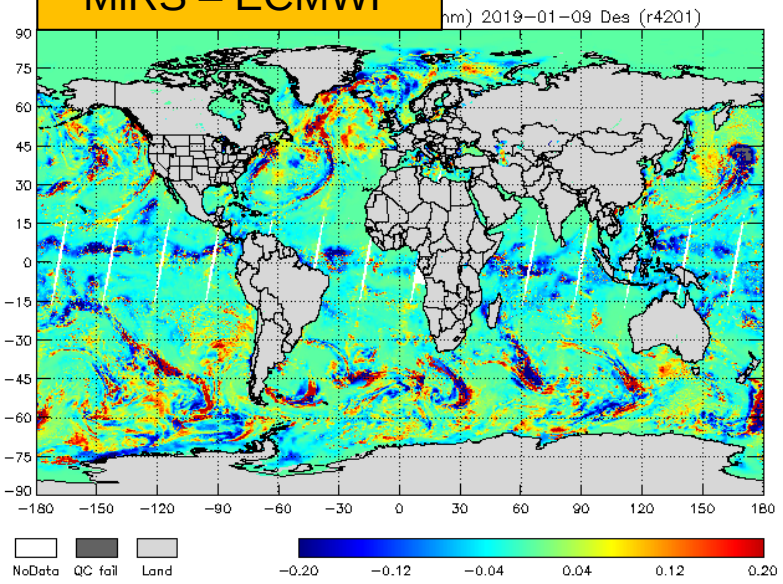


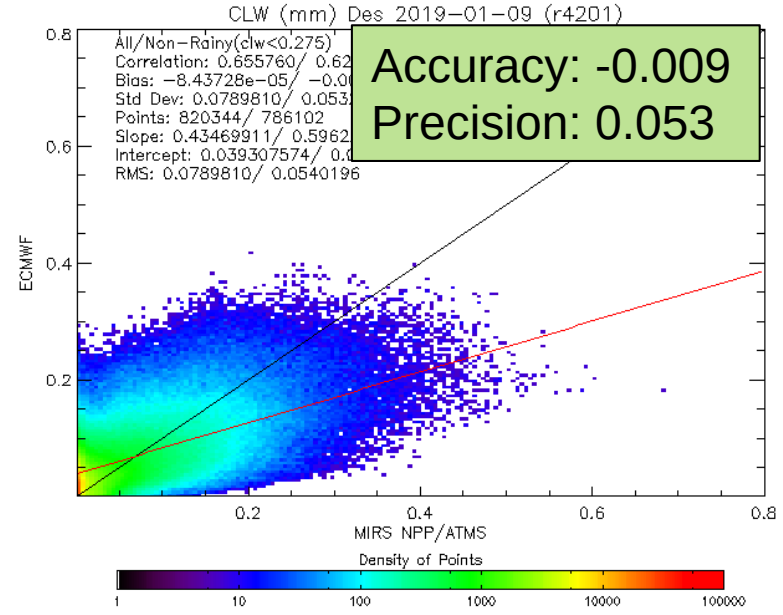
ECMWF



Requirement:
Accuracy: 0.03
Precision: 0.08

MiRS – ECMWF

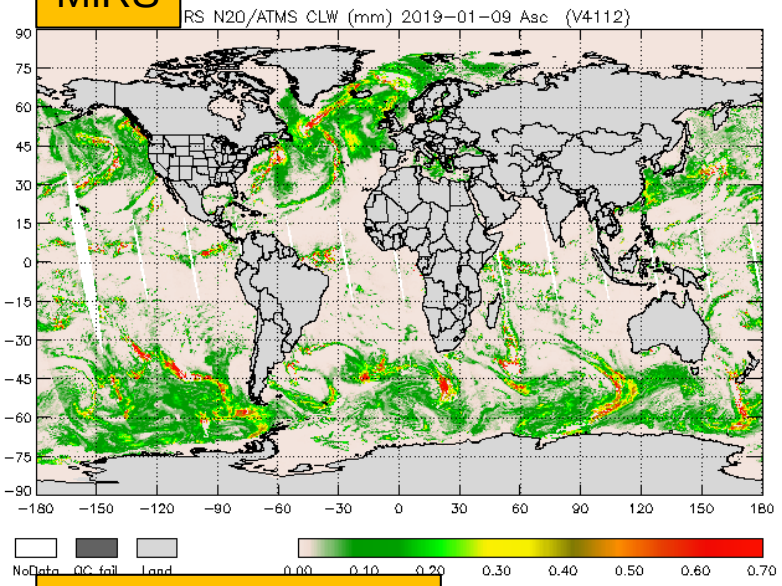




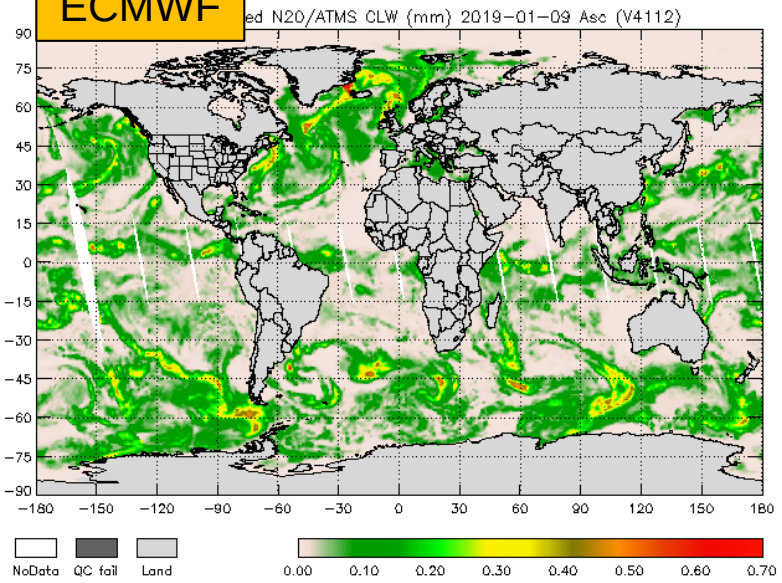
Accuracy: -0.009
Precision: 0.053

NOAA-20 example for one day: 2019-01-09 Ascending

MiRS

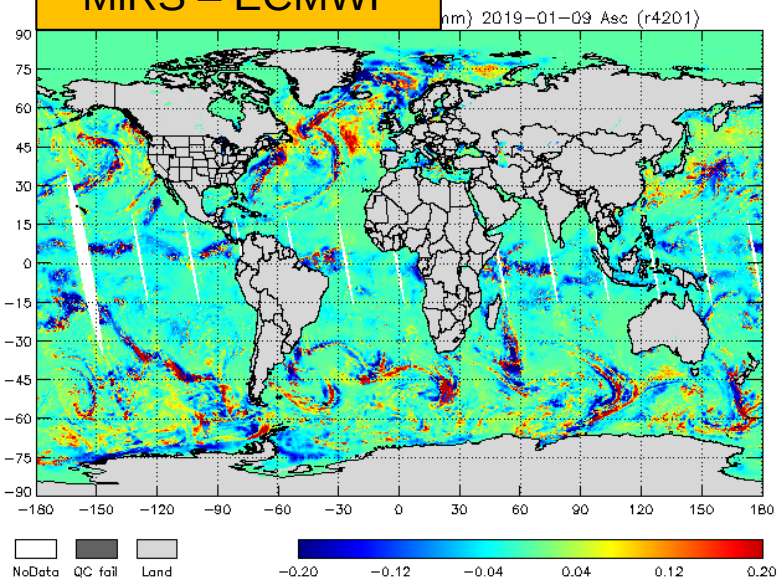


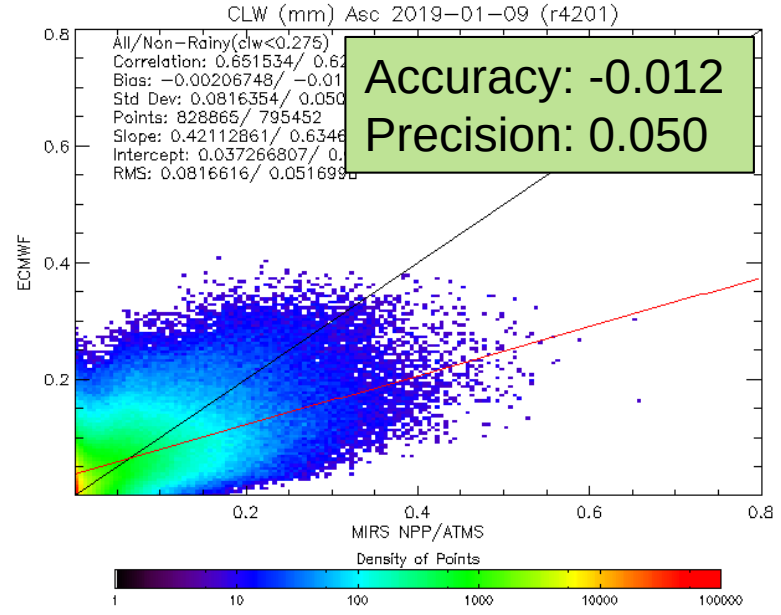
ECMWF



Requirement:
Accuracy: 0.03
Precision: 0.08

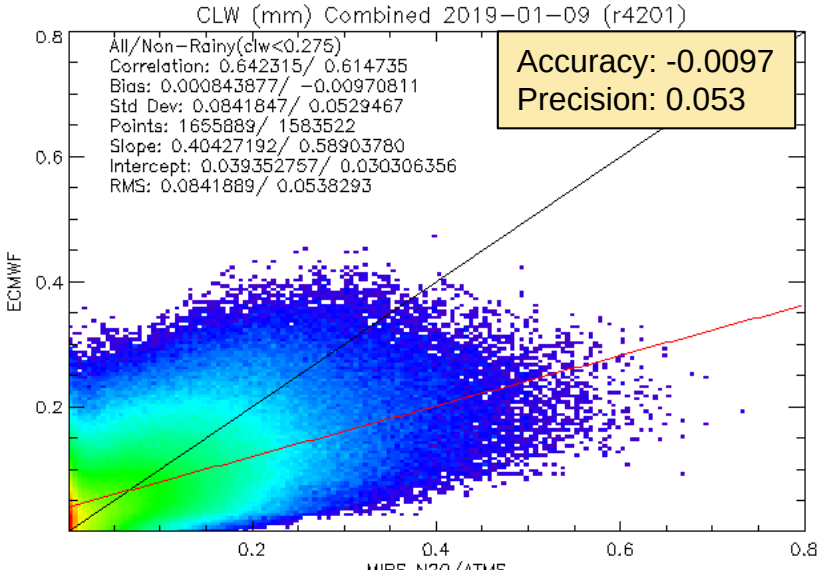
MiRS – ECMWF

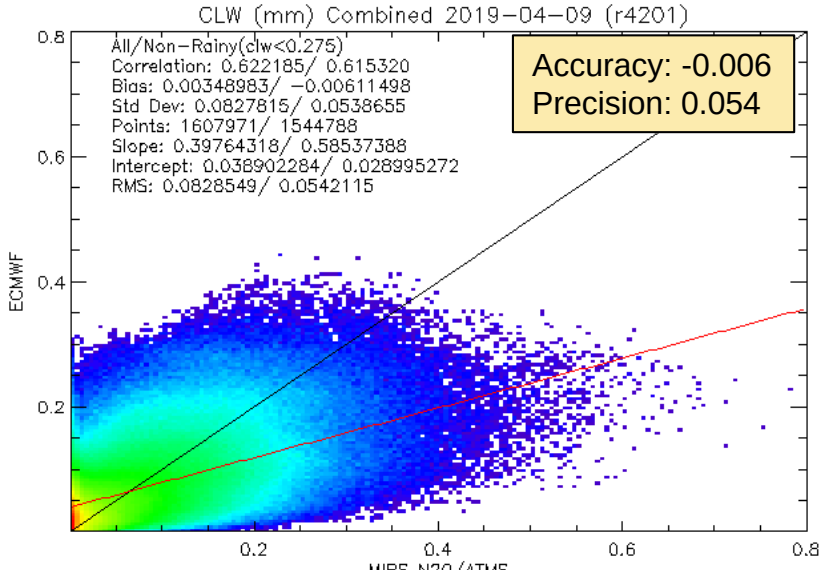


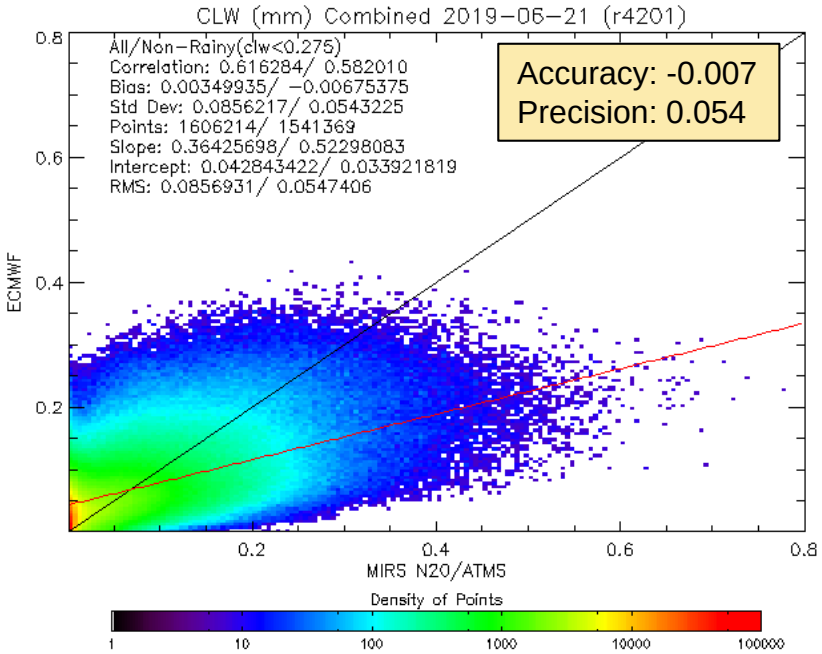


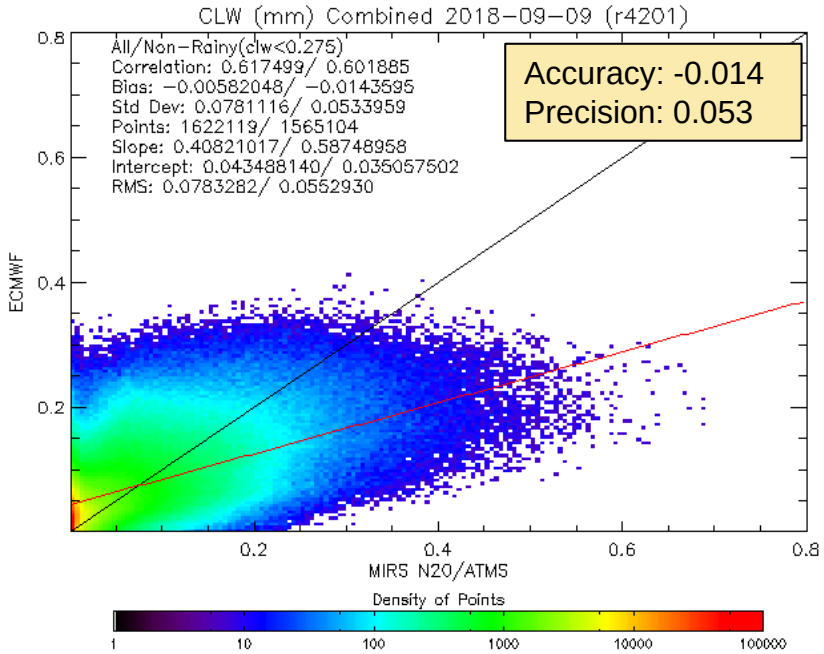
Accuracy: -0.012
Precision: 0.050

N20 CLW Validation Results: ECMWF Comparison



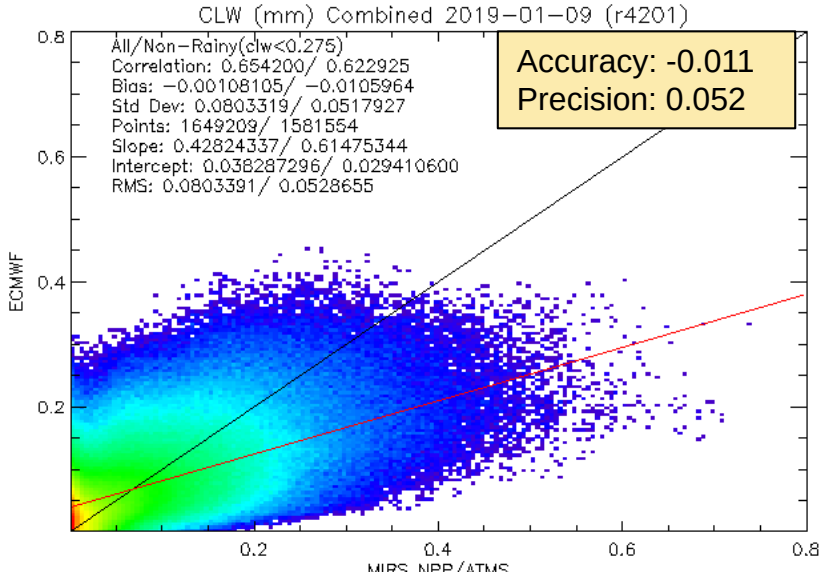


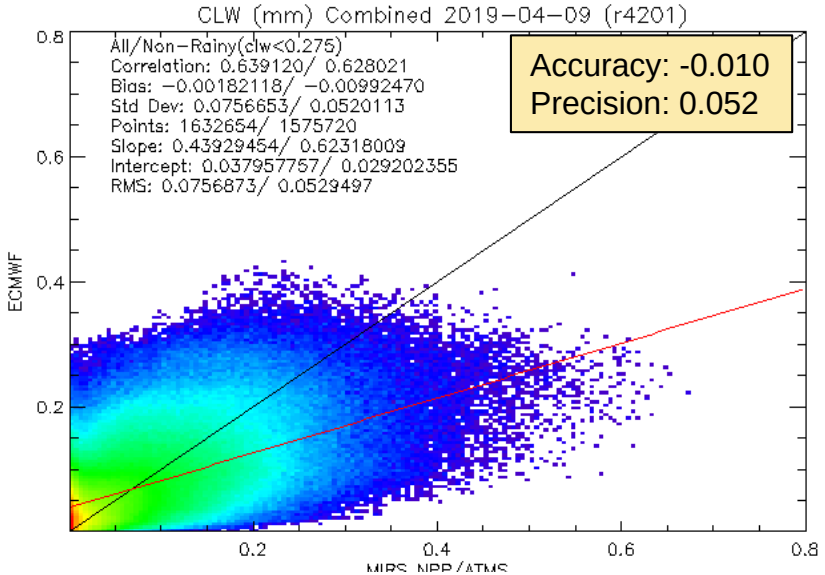


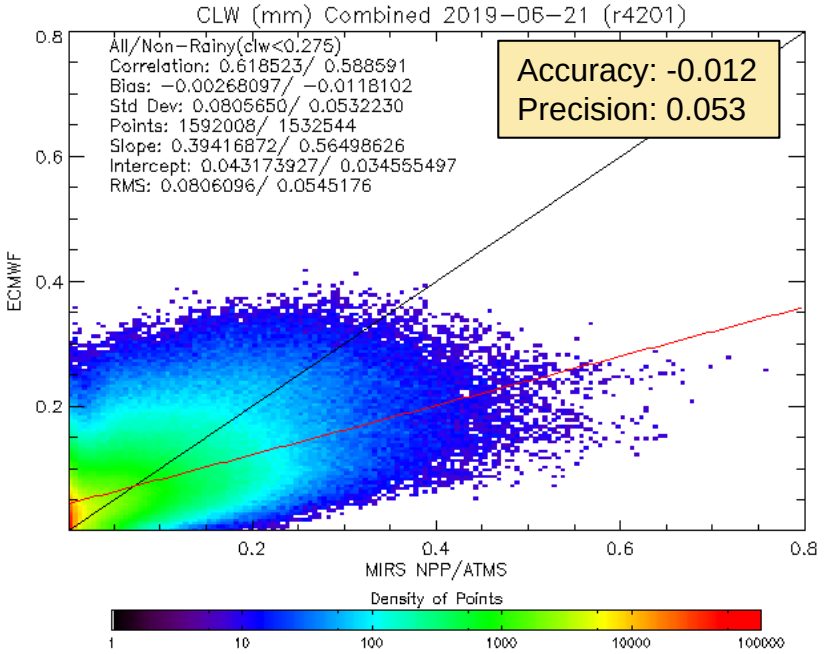


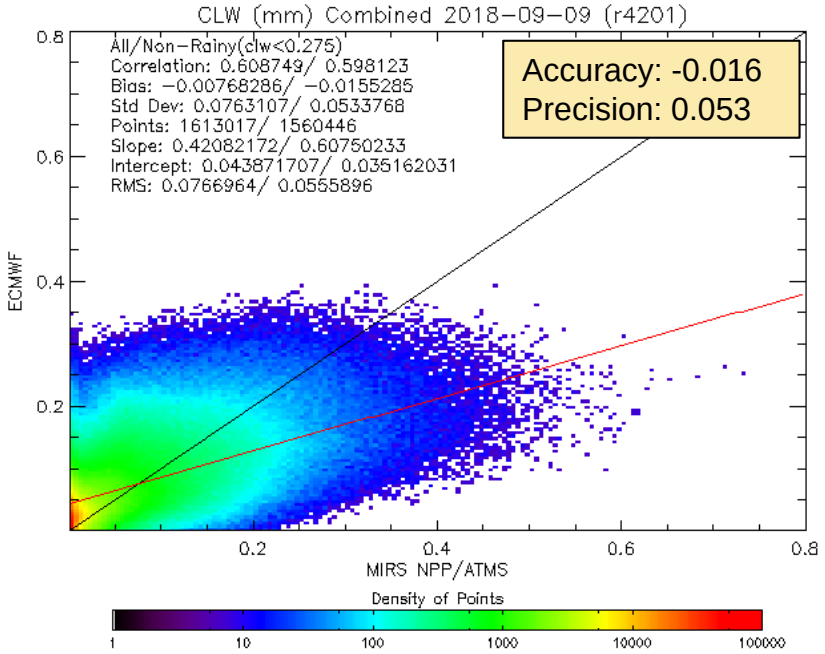
Requirement:
Accuracy: 0.03
Precision: 0.08

NPP CLW Validation Results: ECMWF Comparison









Requirement:
Accuracy: 0.03
Precision: 0.08

Error Budget: T, WV, TPW, LSE, LST, SIC, SWE, SCE, RR, CLW

Attribute Analyzed	L1RD Threshold Accuracy/Precision	Analysis/Validation Result	Error Summary	Support Artifacts
T Profile	See Slides 17-46	Meets all requirements	See Slides 17-46	
WV Profile	See Slides 47-66	Meets all requirements	See Slides 47-66	
TPW	See Slides 67-75	Meets all requirements	See Slides 67-75	
LSE	See Slides 76-82	Meets all requirements	See Slides 76-82	
LST	See Slides 83-87	Meets all requirements	See Slides 83-87	
SIC	See Slides 88-96	Meets all requirements	See Slides 88-96	
SWE/SCE	See Slides 97-104	Meets all requirements	See Slides 97-104	
RR	See Slides 105-115	Meets all requirements	See Slides 105-115	
CLW	See Slides 116-124	Meets all requirements	See Slides 116-124	

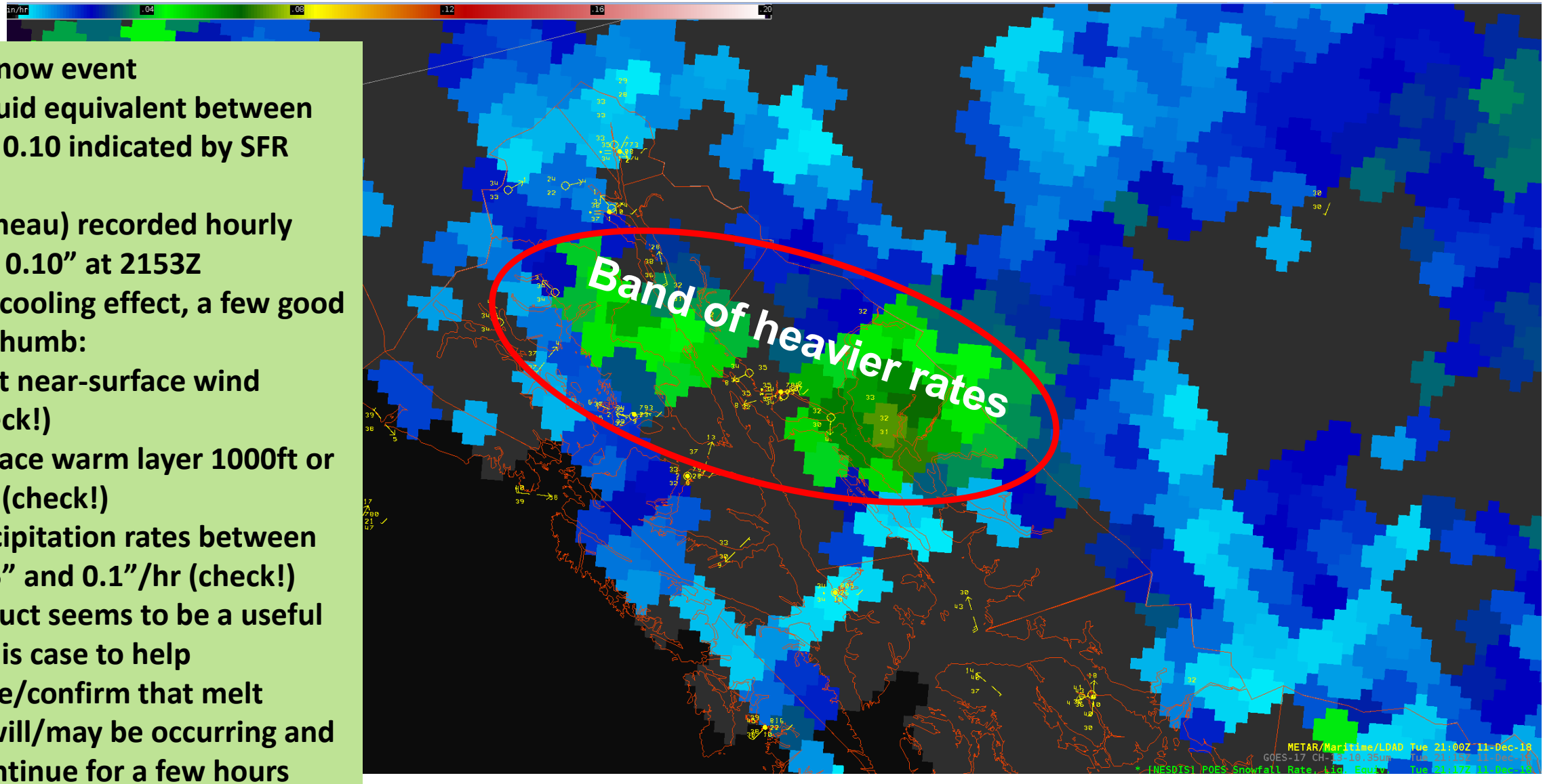
User Feedback:
RR, TPW, SFR (Bryan Caffrey, Juneau WFO)

Algorithm	Product	User Feedback
MiRS	Rain Rate	• Provides great situational awareness with good spatial scale, esp with approaching weather fronts over Pacific and radar void AK. • Used as assessment of model performance. • Many passes so good information on time evolution and how extreme rainfall is.
MiRS	TPW	• Provides much better high-res images of TPW for analysis of atmospheric rivers in tandem with other TPW products. Frequent passes a big plus.
MiRS	SFR	• Very helpful for snow vs. rain discrimination. • Has been used to generate and/or cancel storm warnings. • Identifying/predicting melt/evaporative cooling snow events. (example slide).

Note: Original comments collected by Carl Dierking at U. Alaska/GINA

User Feedback: SFR, Case of changeover from rain to snow due to falling snow melt/evaporative cooling on 11 Dec 2018

- Rain to snow event
- Snow liquid equivalent between 0.05 and 0.10 indicated by SFR product.
- PAJN (Juneau) recorded hourly precip of 0.10” at 2153Z
- For melt cooling effect, a few good rules of thumb:
  - Light near-surface wind (check!)
  - Surface warm layer 1000ft or less (check!)
  - Precipitation rates between 0.05” and 0.1”/hr (check!)
- SFR product seems to be a useful tool in this case to help anticipate/confirm that melt cooling will/may be occurring and could continue for a few hours



User Feedback:
RR (Dave Streubel, Alaska Pacific RFC, Anchorage)

Algorithm	Product	User Feedback
MiRS	Rain Rate	• Very useful especially where gauge measurements are sparse. • Better situational awareness on precipitation spatial extent in NW and interior AK. • Depiction of banded precipitation not seen in gauge analysis (Mountain Mapper QPE).

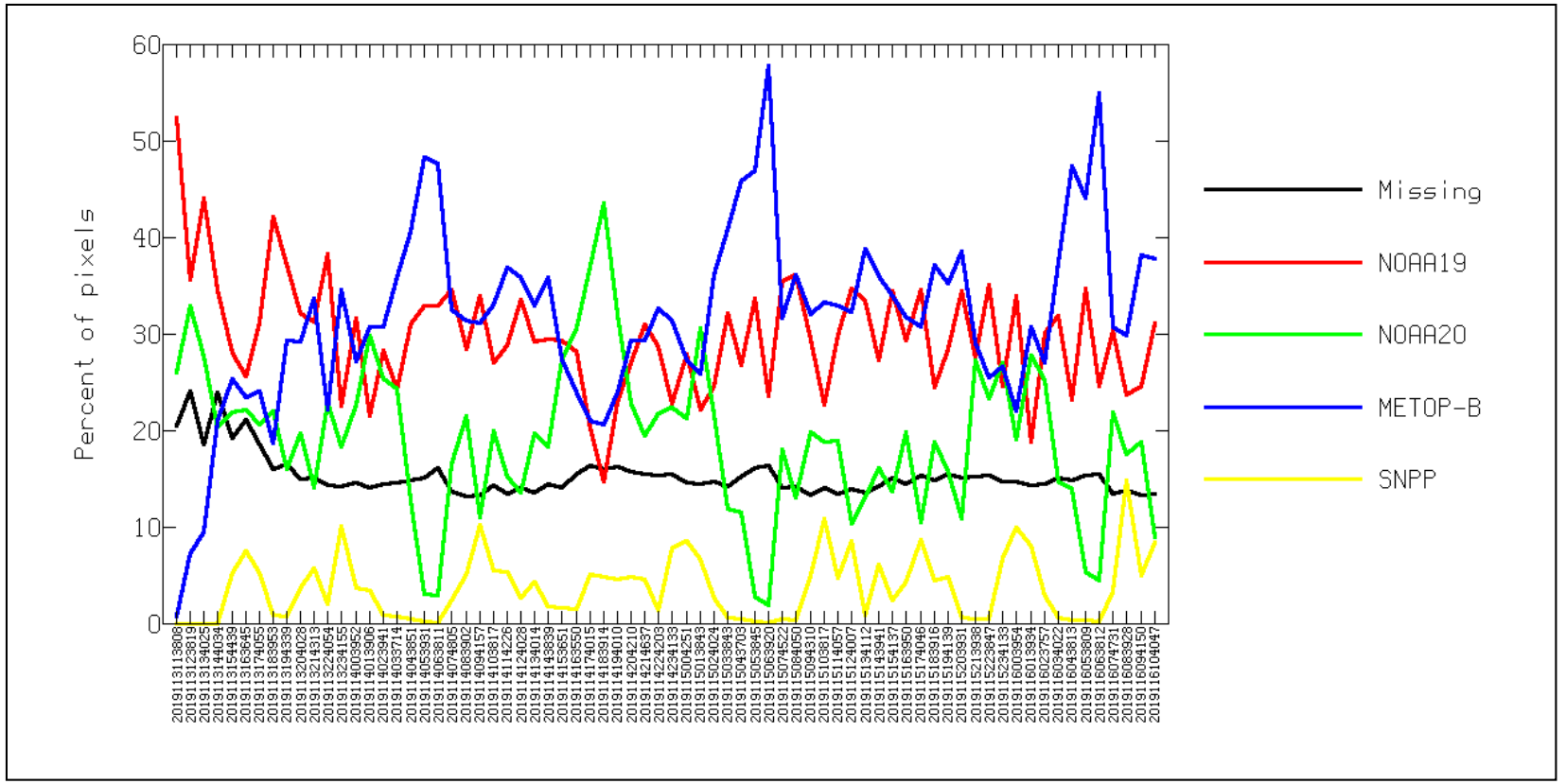
Note: Original comments collected by Carl Dierking at U. Alaska/GINA

Downstream Product Feedback: Blended TPW, RR, Advected LPW (J. Forsythe, CSU/CIRA)

Algorithm	Product	Downstream Product Feedback - Reports from downstream product teams on the dependencies and impacts
	Operational Blended TPW / Operational Blended Rain Rate	• NOAA-20 MiRS TPW retrieval performance comparable to S-NPP, results presented in May 2019 at N-20 ORR. N-20 included in operational products beginning June 2019 • N-20 reduces the overall latency of the product, and greatly reduces cases where the newest data in the blend is > 4 hours old. (example slide)
	Advected LPW (ALPW)* *Not operational, but NWS (WPC) has submitted the SPSRB request to make it operational.	• N-20 greatly helps fill missing data gaps which sometime occur over CONUS at 0 and 12 UTC. The wide ATMS swath helps. • Visual quality seems similar to the other spacecraft (N-19,SNPP, F17/18,Metop-A/B) • CIRA distributing hourly to WPC, NHC and 23 WFO's in AWIPS-2. Frequently used in discussions, especially for heavy precip.

Downstream Product Feedback: Blended TPW

23-26 April 2019



With improved product time latency, N20 is making more contribution to the blended-hydro products. The following figure shows that the percentage of N20 data used in the blended TPW is significantly higher than that of SNPP.

Risks, Actions, and Mitigations

Identified Risk	Description	Impact	Action/Mitigation and Schedule
	None Identified		

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 Gitro et al. (2018) Liu et al. (2017) Ferrraro et al. (2017) 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, and as part of DAP

Check List - Validated Maturity

Validated Maturity End State	Assessment
Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).	Yes. See slides 16-124.
Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.	Yes. See slide 132
Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.	Yes. See slides 16-130.
Product is ready for operational use based on documented validation findings and user feedback.	Yes. See User Feedback and Downstream Products Feedback slides 126-130.
Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument	Yes. See planned activities slide 135.

Conclusion

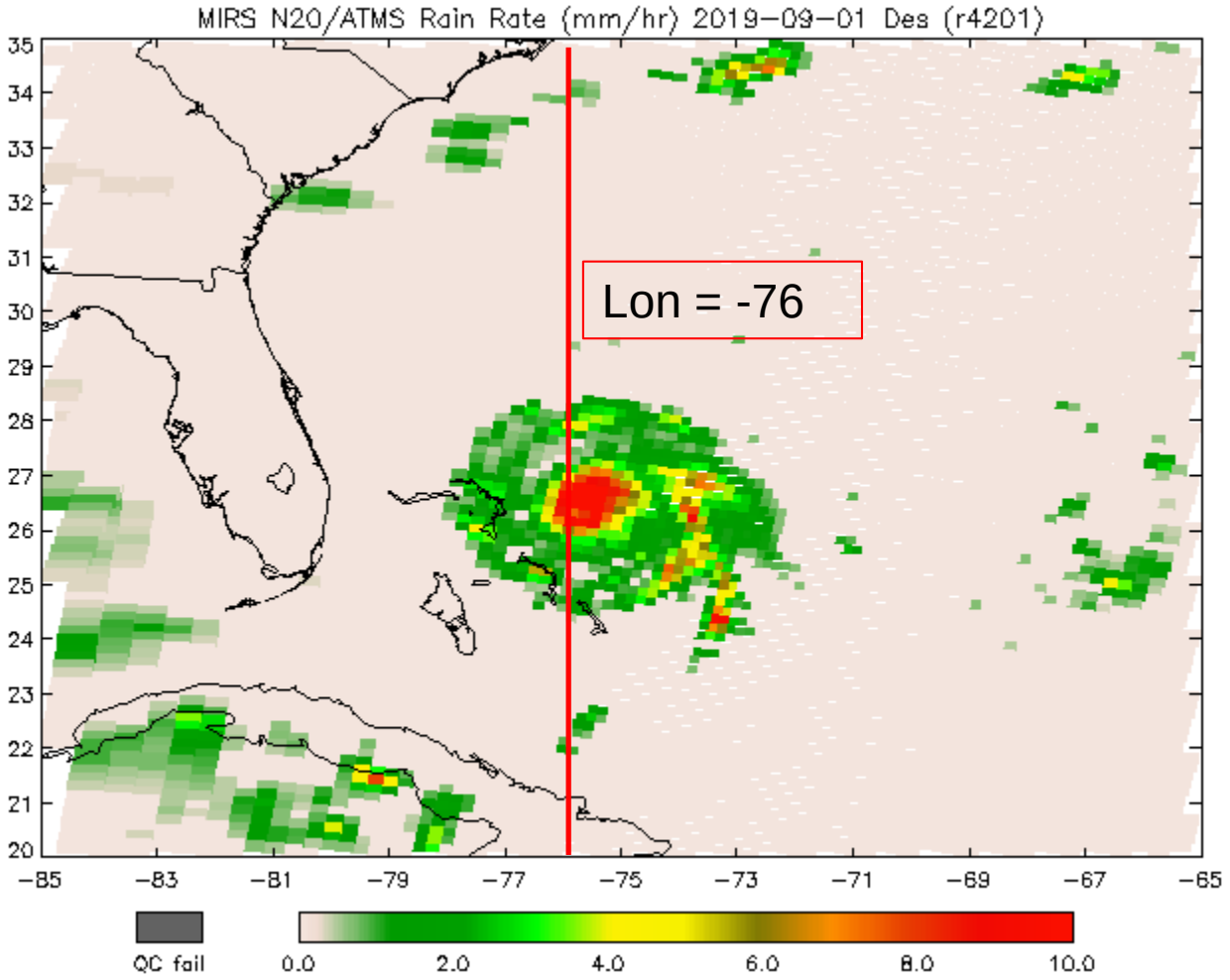
- Validation review results summary:
  - Temperature, Water Vapor, TPW, LST, LSE, Sea Ice Concentration, Snow Cover, SWE, Rain Rate, and CLW have been validated using in situ observations, independent satellite products, and global forecast model analyses.
  - Performance has been evaluated in STAR over more than one annual cycle, globally, over land and ocean, and in clear, cloudy, and rainy conditions.
  - EDRs generally meet all requirements for accuracy, precision and categorical scores (with a few exceptions).
  - Performance highly consistent with SNPP validation results for same time periods.

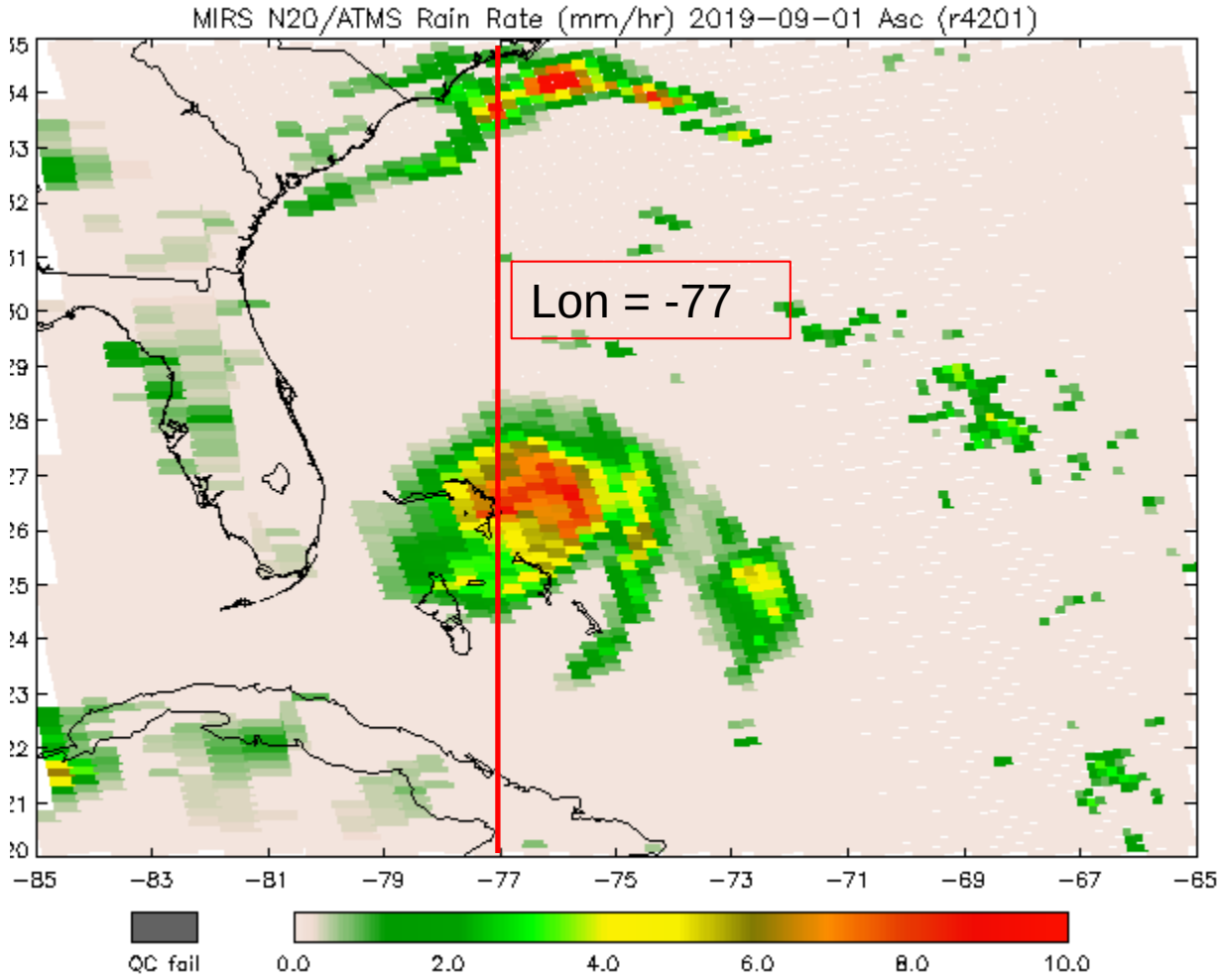
Path Forward

- Improvements implemented
  - Snowfall rate integration for N20
  - Hydrometeors (CLW over land for light rain detection)
  - Snow cover/amount (vegetation correction)
  - Updated sea ice climatology mask (finer temporal/spatial resolution) ➔ Great Lakes ice detection
- Planned further improvements
  - Air mass-dependent bias corrections (machine learning)
  - Rainy condition sounding (update a priori constraints)
  - Experimenting with MiRS version adapted for tropical cyclones (MiRS-TC)
  - Hydrometeors: precharacterization of precip type, improvements to CRTM i.e. scattering, particle size/shape distribution in CRTM)
  - Applications/user feedback
- Planned/ongoing validation activities
  - N20/ATMS: Continued daily assessments (as posted to MiRS website)
  - N20/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
  - Assessment of recalibrated SDRs: used 3 days to generate radiometric bias corrections, compared performance on single independent day of global data, no significant differences.
  - **Reprocessing of NPP and N20 mission data (Spring/Summer 2020)**
  - Plan for JPSS-2 (2020-2021), and EPS-SG (2019-2022)

Science Improvement Examples: TC Warm Core Structure

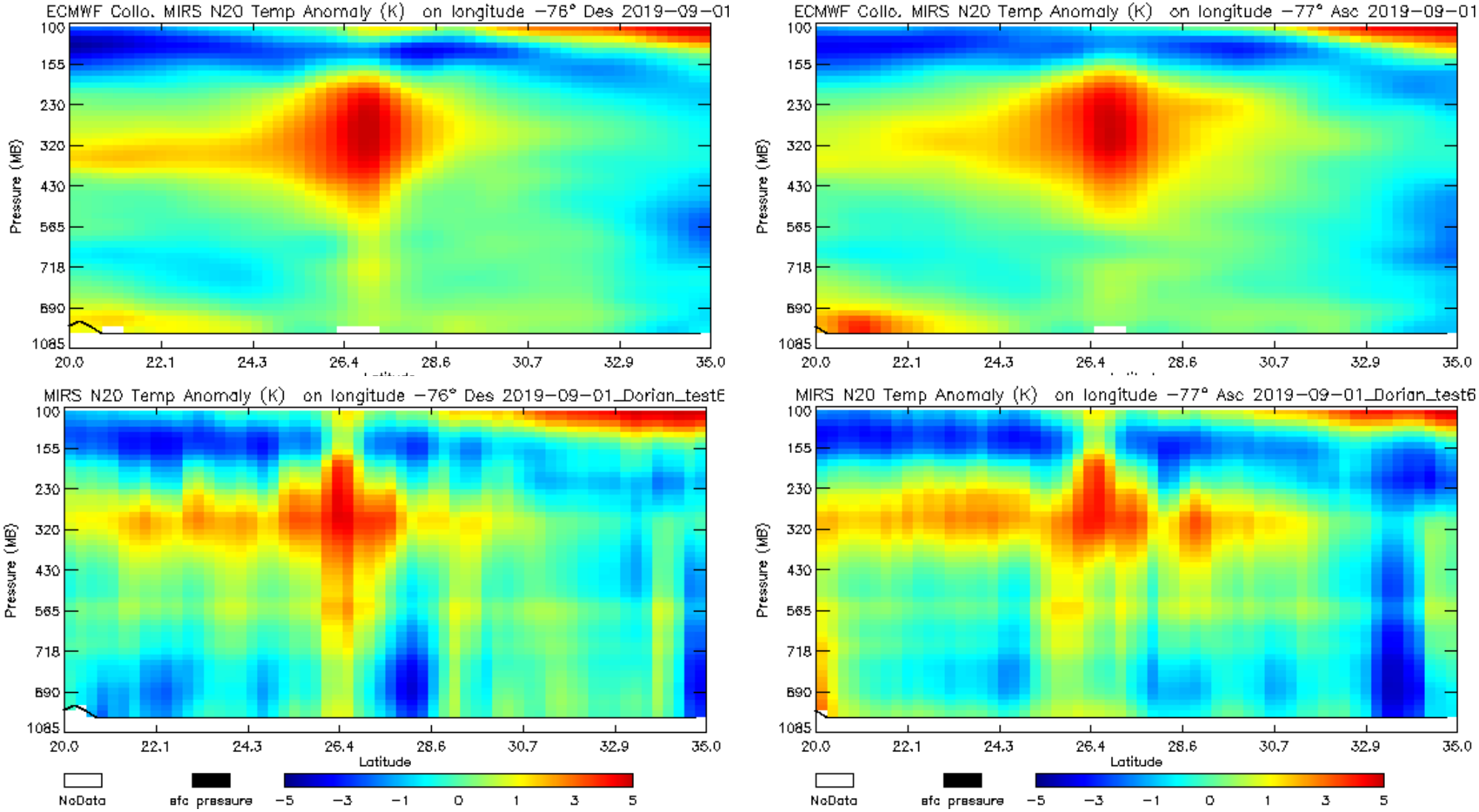
Hurricane Dorian, 1 September 2019





Science Improvement Examples: TC Warm Core Structure

Hurricane Dorian, 1 September 2019

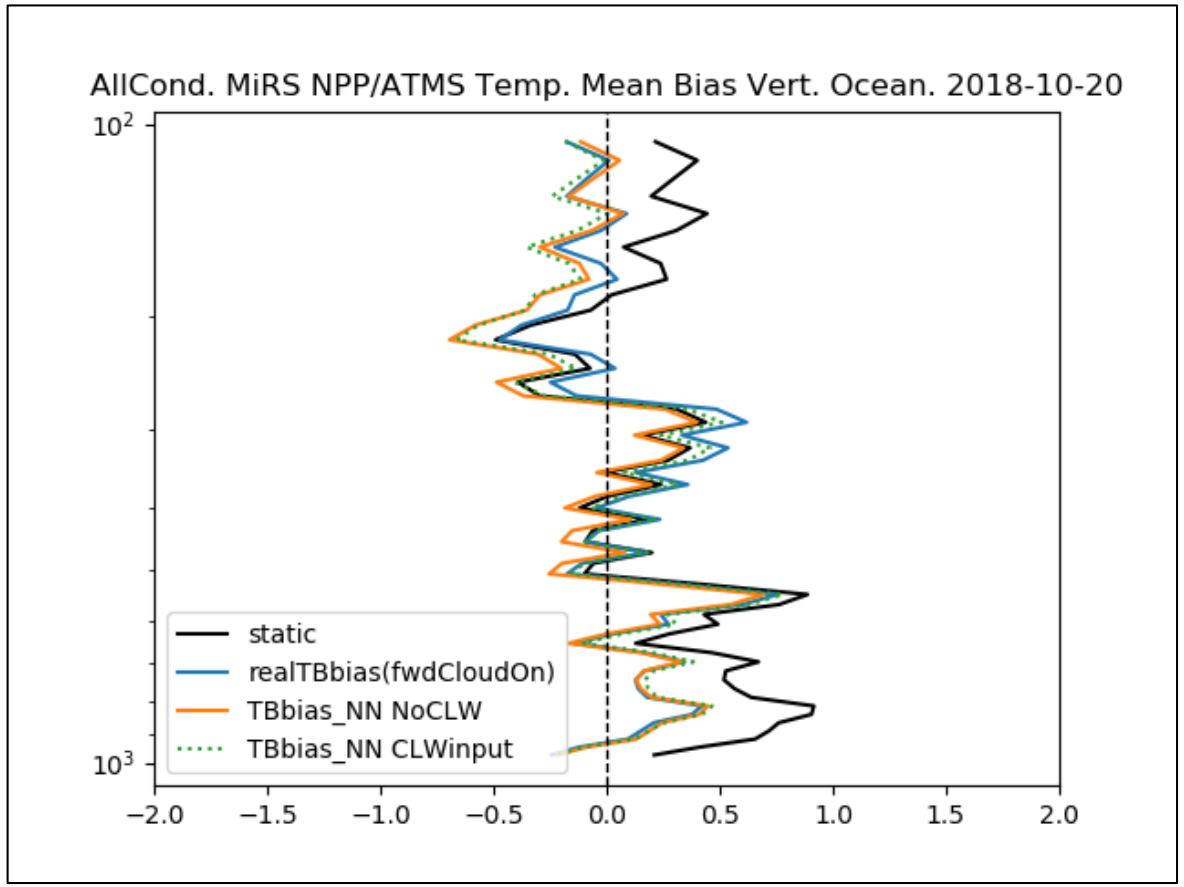


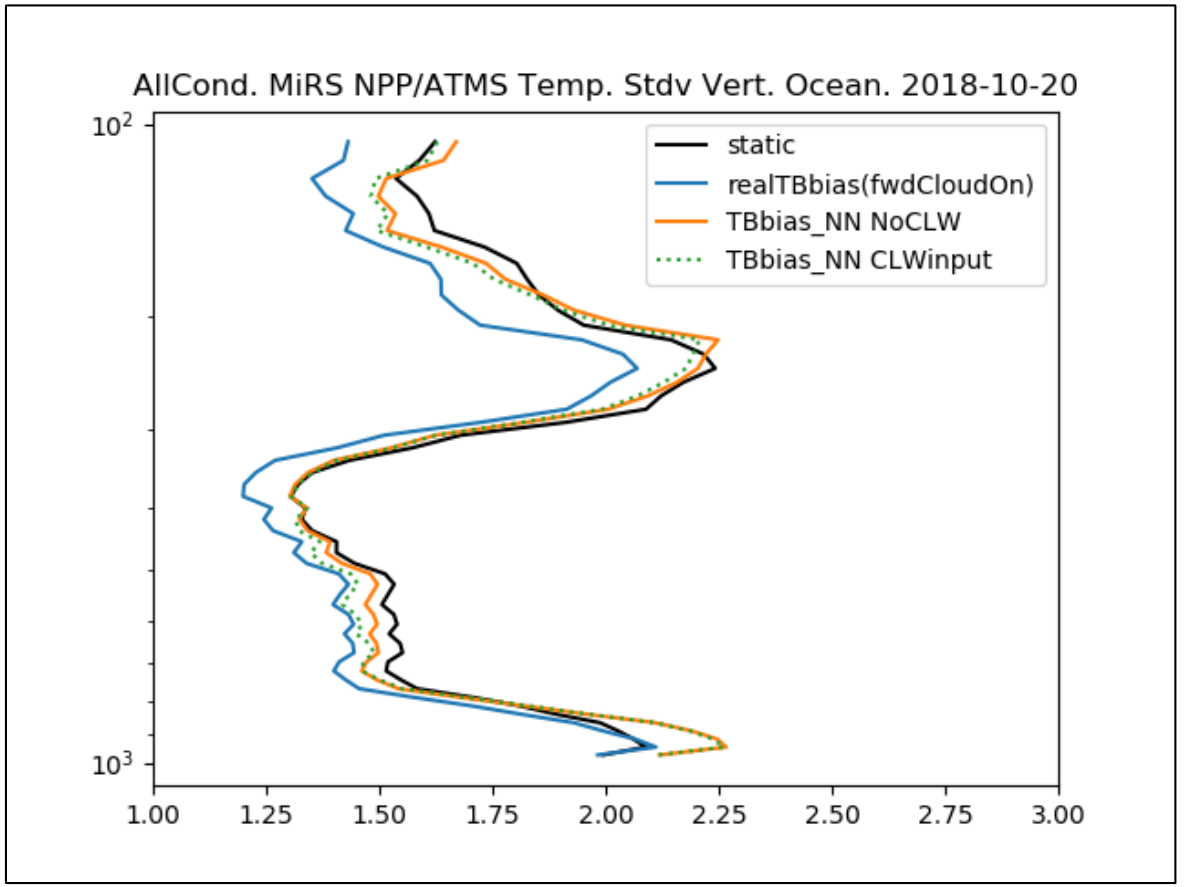
ECMWF

MiRS (experimental version)

Science Improvement Examples: Dynamic radiometric bias correction using AI

- Example of Temperature profile bias and standard deviation (difference with ECMWF)
- Blue and orange curves show potential for improvement when using an air mass bias-based bias correction using a machine learning (neural network) approach compared with the operational static bias correction (black curves)





Supplemental Slides

Temperature Profile Validation based on ECMWF data

Clear Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.5 K)	300 hPa (0.5 K)	500 hPa (0.5 K)	900 hPa (1.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	0.14 / 0.21	-0.12 / -0.10	-0.40 / -0.40	0.38 / 0.41	1.57 / 1.57	1.71 / 1.63	1.33 / 1.24	1.84 / 1.84
2018.04.15	0.08 / 0.18	-0.02 / 0.04	-0.45 / -0.39	0.59 / 0.46	1.55 / 1.57	1.64 / 1.57	1.21 / 1.17	1.88 / 1.80
2018.07.15	-0.18 / -0.15	0.16 / 0.18	-0.62 / -0.57	0.45 / 0.32	1.36 / 1.37	1.40 / 1.49	1.35 / 1.36	1.99 / 1.84
2018.10.15	0.18 / 0.18	0.13 / 0.03	-0.34 / -0.25	0.52 / 0.46	1.50 / 1.41	1.47 / 1.47	1.25 / 1.24	1.85 / 1.75
2019.01.15	-0.81 / -0.81	0.59 / 0.63	-0.71 / -0.68	0.75 / 0.64	1.71 / 1.70	1.61 / 1.58	1.35 / 1.35	1.85 / 1.85
2019.04.15	-0.21 / -0.21	0.59 / 0.60	-0.53 / -0.51	0.69 / 0.62	1.64 / 1.59	1.39 / 1.47	1.27 / 1.28	1.85 / 1.80

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.5 K)	300 hPa (0.5 K)	500 hPa (0.5 K)	900 hPa (1.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	0.34 / 0.38	0.35 / 0.37	-0.25 / -0.18	0.65 / 0.53	1.54 / 1.52	1.65 / 1.60	1.27 / 1.26	1.86 / 1.81
2018.04.15	0.26 / 0.36	0.46 / 0.49	-0.34 / -0.24	0.74 / 0.57	1.62 / 1.60	1.70 / 1.68	1.22 / 1.23	1.89 / 1.81
2018.07.15	0.01 / 0.02	0.63 / 0.71	-0.42 / -0.40	0.50 / 0.42	1.41 / 1.44	1.44 / 1.54	1.38 / 1.39	2.01 / 1.93
2018.10.15	0.37 / 0.32	0.53 / 0.46	-0.13 / -0.08	0.71 / 0.58	1.55 / 1.46	1.52 / 1.58	1.28 / 1.26	1.85 / 1.80
2019.01.15	-0.62 / -0.57	1.06 / 1.07	-0.59 / -0.48	0.84 / 0.74	1.72 / 1.82	1.67 / 1.62	1.37 / 1.34	1.92 / 1.91
2019.04.15	0.05 / -0.09	0.62 / 0.65	-0.30 / -0.24	0.84 / 0.72	1.68 / 1.60	1.49 / 1.53	1.28 / 1.24	1.91 / 1.86

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on ECMWF data

Cloudy Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.8 K)	300 hPa (0.8 K)	500 hPa (0.8 K)	900 hPa (2.0 K)	100 hPa (2.0 K)	300 hPa (2.5 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	-0.13 / -0.08	-0.47 / -0.38	-0.51 / -0.50	0.48 / 0.67	1.56 / 1.54	1.96 / 1.91	1.60 / 1.50	2.21 / 2.30
2018.04.15	-0.20 / -0.19	0.02 / 0.02	-0.71 / -0.63	1.13 / 1.20	1.57 / 1.61	2.15 / 1.96	1.56 / 1.55	2.36 / 2.35
2018.07.15	0.06 / -0.10	-0.02 / 0.10	-0.59 / -0.64	1.07 / 1.01	1.56 / 1.55	1.61 / 1.56	1.48 / 1.49	2.38 / 2.40
2018.10.15	0.00 / -0.01	0.13 / 0.24	-0.51 / -0.47	0.79 / 0.81	1.59 / 1.45	1.77 / 1.66	1.53 / 1.43	2.33 / 2.20
2019.01.15	-0.27 / -0.29	0.18 / 0.22	-0.94 / -0.92	1.10 / 1.24	1.70 / 1.60	2.07 / 2.06	1.52 / 1.50	2.14 / 2.09
2019.04.15	-0.30 / -0.43	0.26 / 0.38	-0.48 / -0.51	1.20 / 1.23	1.54 / 1.48	1.86 / 1.86	1.46 / 1.43	2.18 / 2.14

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (0.8 K)	300 hPa (0.8 K)	500 hPa (0.8 K)	900 hPa (2.0 K)	100 hPa (2.0 K)	300 hPa (2.5 K)	500 hPa (2.0 K)	900 hPa (3.0 K)
2018.01.15	-0.04 / 0.06	-0.30 / -0.15	-0.21 / -0.23	0.72 / 0.88	1.63 / 1.53	1.95 / 1.96	1.54 / 1.56	2.22 / 2.27
2018.04.15	-0.02 / -0.03	0.37 / 0.39	-0.50 / -0.42	1.25 / 1.29	1.63 / 1.63	2.25 / 2.02	1.62 / 1.55	2.34 / 2.32
2018.07.15	0.30 / 0.10	0.36 / 0.46	-0.29 / -0.39	1.11 / 1.05	1.67 / 1.65	1.65 / 1.62	1.54 / 1.49	2.38 / 2.36
2018.10.15	0.16 / 0.13	0.48 / 0.58	-0.27 / -0.27	0.86 / 0.96	1.63 / 1.51	0.48 / 1.74	1.53 / 1.45	2.31 / 2.26
2019.01.15	-0.12 / -0.11	0.46 / 0.56	-0.71 / -0.70	1.17 / 1.36	1.76 / 1.71	2.10 / 2.11	1.53 / 1.54	2.09 / 2.10
2019.04.15	-0.08 / -0.21	0.26 / 0.43	-0.20 / -0.23	1.26 / 1.26	1.60 / 1.54	1.95 / 1.95	1.51 / 1.43	2.20 / 2.16

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on ECMWF data

Rainy Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.5 K)	500 hPa (2.0 K)	900 hPa (2.0 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (2.5 K)	900 hPa (3.5 K)
2018.01.15	-0.33 / -0.21	-0.36 / -0.31	0.85 / 0.57	0.76 / 0.87	1.72 / 1.63	1.88 / 1.81	2.11 / 2.11	2.49 / 2.59
2018.04.15	-0.49 / -0.43	-0.16 / -0.11	0.56 / 0.40	1.33 / 1.17	1.68 / 1.78	1.70 / 1.56	2.10 / 2.13	2.88 / 2.85
2018.07.15	-0.50 / -0.52	0.09 / 0.22	0.41 / 0.36	0.78 / 0.80	1.53 / 1.50	1.56 / 1.59	1.91 / 1.96	2.18 / 2.23
2018.10.15	-0.58 / -0.65	0.08 / 0.09	0.48 / 0.38	1.10 / 0.80	1.48 / 1.47	1.56 / 1.56	2.05 / 2.01	2.85 / 2.62
2019.01.15	-1.19 / -1.03	0.27 / 0.45	0.58 / 0.37	0.30 / 0.30	1.62 / 1.60	1.69 / 1.61	1.91 / 1.98	2.47 / 2.59
2019.04.15	-0.42 / -0.36	0.24 / 0.48	0.60 / 0.47	1.21 / 0.99	1.58 / 1.52	1.72 / 1.78	2.09 / 2.01	2.81 / 2.50

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.5 K)	500 hPa (2.0 K)	900 hPa (2.0 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (2.5 K)	900 hPa (3.5 K)
2018.01.15	-0.33 / -0.13	-0.03 / 0.03	1.11 / 0.86	1.10 / 0.97	1.91 / 1.85	1.81 / 1.94	2.11 / 2.02	2.62 / 2.50
2018.04.15	-0.42 / -0.21	0.13 / 0.24	0.60 / 0.60	1.63 / 1.40	1.72 / 1.68	1.74 / 1.60	2.01 / 2.12	2.79 / 2.80
2018.07.15	-0.32 / -0.20	0.40 / 0.54	0.59 / 0.51	0.90 / 0.83	1.60 / 1.64	1.52 / 1.57	1.80 / 1.93	1.94 / 2.11
2018.10.15	-0.43 / -0.61	0.36 / 0.40	0.69 / 0.58	1.21 / 1.08	1.49 / 1.49	1.57 / 1.62	1.98 / 2.00	2.63 / 2.55
2019.01.15	-0.94 / -0.91	0.69 / 0.76	0.82 / 0.63	0.28 / 0.50	1.59 / 1.69	1.56 / 1.60	1.85 / 1.89	2.24 / 2.42
2019.04.15	-0.29 / -0.14	0.34 / 0.54	0.75 / 0.69	1.23 / 1.03	1.62 / 1.57	1.75 / 1.78	2.07 / 1.98	2.70 / 2.37

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on ECMWF data

Clear Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.28 / 0.06	0.26 / 0.27	-0.42 / -0.29	0.07 / -0.31	1.81 / 1.76	1.78 / 1.72	1.41 / 1.36	2.75 / 2.49
2018.04.15	-0.07 / -0.28	0.05 / 0.08	-0.38 / -0.27	0.15 / -0.25	2.10 / 2.04	1.90 / 1.76	1.56 / 1.58	3.25 / 2.68
2018.07.15	0.16 / 0.09	-0.15 / 0.09	-0.28 / -0.27	-0.25 / -0.80	1.25 / 1.24	1.38 / 1.32	1.51 / 1.52	2.50 / 2.40
2018.10.15	-0.07 / 0.05	-0.05 / 0.06	-0.21 / -0.18	-0.48 / -0.58	1.50 / 1.51	1.46 / 1.31	1.47 / 1.40	2.68 / 2.65
2019.01.15	-1.21 / -1.31	0.59 / 0.68	-0.31/ -0.20	-0.76 / -1.22	1.71 / 1.65	1.72 / 1.77	1.66 / 1.66	3.05 / 3.13
2019.04.15	-0.47 / -0.73	0.45 / 0.58	-0.39 / -0.26	0.05 / -0.40	1.80 / 1.72	1.51 / 1.53	1.54 / 1.44	3.28 / 3.15

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.53 / 0.38	0.55 / 0.70	-0.03 / -0.04	-0.21 / -0.49	1.59 / 1.67	1.72 / 1.74	1.62 / 1.50	2.63 / 2.65
2018.04.15	0.09 / -0.15	0.52 / 0.55	-0.15 / -0.04	0.28 / -0.17	2.14 / 2.09	1.89 / 1.79	1.55 / 1.56	3.32 / 2.70
2018.07.15	0.25 / 0.15	0.41 / 0.56	0.04 / -0.15	-0.47 / -0.69	1.29 / 1.30	1.45 / 1.38	1.54 / 1.46	2.65 / 2.42
2018.10.15	0.22 / 0.16	0.36 / 0.43	0.11 / 0.11	-0.50 / -0.65	1.58 / 1.57	1.56 / 1.45	1.53 / 1.53	2.88 / 2.75
2019.01.15	-1.07 / -1.09	1.03 / 1.09	-0.06 / 0.01	-0.67 / -1.00	1.77 / 1.73	1.79 / 1.85	1.61 / 1.61	2.89 / 2.97
2019.04.15	-0.32 / -0.46	0.55 / 0.68	-0.17 / -0.12	0.12 / -0.32	1.85 / 1.76	1.47 / 1.56	1.51 / 1.39	3.31 / 3.33

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on ECMWF data

Cloudy Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.61 / 0.51	-0.20 / 0.01	-0.09 / 0.07	-0.20 / -0.38	1.97 / 1.85	1.80 / 1.73	1.38 / 1.43	2.78 / 2.76
2018.04.15	-0.09 / 0.07	0.06 / 0.18	-0.26 / -0.23	0.31 / 0.38	1.38 / 1.43	1.73 / 1.57	1.36 / 1.29	3.45 / 3.46
2018.07.15	0.30 / 0.22	-0.09 / 0.07	-0.42 / -0.48	-0.18 / -0.13	1.26 / 1.25	1.59 / 1.56	1.28 / 1.34	2.52 / 2.80
2018.10.15	0.46 / 0.47	-0.15 / -0.03	-0.32 / -0.23	0.25 / 0.55	1.78 / 1.78	2.03 / 1.98	1.57 / 1.57	3.40 / 3.28
2019.01.15	-0.60 / -1.00	-0.53 / 0.54	-0.62 / -0.20	-0.47 / -0.74	1.40 / 1.48	1.46 / 1.34	1.69 / 1.65	2.43 / 2.99
2019.04.15	-0.36 / -0.26	0.61 / 0.81	-0.41 / -0.44	0.05 / 0.56	1.77 / 1.71	1.36 / 1.35	1.46 / 1.47	3.10 / 3.26

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.0 K)	300 hPa (0.8 K)	500 hPa (0.5 K)	900 hPa (2.5 K)	100 hPa (2.0 K)	300 hPa (2.0 K)	500 hPa (2.5 K)	900 hPa (5.5 K)
2018.01.15	0.93 / 0.86	0.23 / 0.59	0.51 / 0.62	-1.10 / -1.19	1.67 / 1.63	1.58 / 1.78	1.52 / 1.38	3.42 / 2.71
2018.04.15	-0.30 / -0.33	0.51 / 0.67	0.05 / 0.01	0.22 / 0.40	2.26 / 2.24	1.82 / 1.63	1.42 / 1.40	3.21 / 3.24
2018.07.15	0.48 / 0.37	0.44 / 0.48	-0.10 / -0.26	-0.24 / -0.12	1.27 / 1.32	1.64 / 1.69	1.32 / 1.36	2.60 / 2.80
2018.10.15	0.62 / 0.62	0.49 / 0.40	-0.10 / 0.03	0.08 / 0.61	1.84 / 1.91	1.99 / 2.02	1.56 / 1.62	3.52 / 3.63
2019.01.15	-0.54 / -0.66	0.98 / 1.22	-0.10 / 0.17	-0.66 / -0.96	1.46 / 1.51	1.40 / 1.50	1.69 / 1.70	2.40 / 2.88
2019.04.15	-0.40 / -0.26	0.75 / 0.92	-0.16 / -0.20	0.20 / 0.64	1.77 / 1.84	1.32 / 1.41	1.50 / 1.51	3.25 / 3.47

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Temperature Profile Validation based on ECMWF data

Rainy Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.0 K)	500 hPa (1.0 K)	900 hPa (2.5 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (3.0 K)	900 hPa (5.5 K)
2018.01.15	0.07 / -0.23	-0.42 / -0.12	0.85 / 1.06	0.62 / -0.04	2.15 / 1.66	1.81 / 1.61	1.68 / 1.93	4.34 / 2.74
2018.04.15	-1.14 / -1.82	-0.12 / -0.23	0.01 / 0.22	0.83 / 1.13	2.48 / 2.48	1.98 / 1.84	2.03 / 1.85	3.91 / 3.59
2018.07.15	-0.33 / -0.75	0.06 / 0.04	0.43 / 0.61	-0.26 / -0.20	1.26 / 1.31	1.87 / 1.90	1.70 / 1.70	2.71 / 2.86
2018.10.15	0.07 / -0.26	0.43 / 0.17	0.59 / 0.38	0.38 / 0.96	1.87 / 1.98	2.12 / 1.90	2.06 / 2.11	3.54 / 4.01
2019.01.15	-1.54 / -1.89	0.22 / 0.35	0.12 / 0.99	-0.72 / -0.91	1.52 / 1.36	1.63 / 1.54	1.90 / 2.03	2.80 / 3.48
2019.04.15	-1.21 / -1.72	0.19 / 0.01	-0.30 / -0.33	0.72 / 1.42	1.82 / 1.80	1.96 / 1.97	1.99 / 1.80	3.36 / 3.54

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	100 hPa (1.5 K)	300 hPa (1.0 K)	500 hPa (1.0 K)	900 hPa (2.5 K)	100 hPa (2.5 K)	300 hPa (2.5 K)	500 hPa (3.0 K)	900 hPa (5.5 K)
2018.01.15	0.66 / 0.30	-0.42 / 0.40	1.16 / 1.06	0.39 / 0.30	1.99 / 1.87	2.02 / 1.87	1.76 / 1.91	5.25 / 4.36
2018.04.15	-1.16 / -1.56	0.43 / 0.44	0.31 / 0.39	0.79 / 1.05	2.49 / 2.39	1.95 / 1.86	1.99 / 1.86	3.58 / 3.66
2018.07.15	-0.22 / -0.53	0.43 / 0.40	0.64 / 0.73	-0.15 / -0.10	1.29 / 1.34	1.89 / 1.92	1.71 / 1.70	2.66 / 2.77
2018.10.15	0.20 / -0.13	0.91 / 0.69	0.84 / 0.79	0.08 / 0.58	1.80 / 2.04	1.97 / 1.89	1.97 / 2.06	3.09 / 3.67
2019.01.15	-1.29 / -1.62	0.53 / 0.72	0.73 / 1.19	-0.51 / -0.78	1.42 / 1.49	1.62 / 1.59	1.76 / 1.86	2.73 / 3.41
2019.04.15	-1.24 / -1.32	0.44 / 0.39	0.05 / -0.07	0.58 / 1.23	1.71 / 1.77	1.85 / 1.92	1.97 / 1.77	3.51 / 3.28

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

TPW (mm) comparison NOAA-20/(NPP) vs. radiosonde

N20	Accuracy (mm)				Precision (mm)			
Requirement	Land clear (2.5 mm)	Land cloudy (2.5 mm)	Sea clear (1.5 mm)	Sea cloudy (0.5 mm)	Land clear (5.5 mm)	Land cloudy (5.5 mm)	Sea clear (2.5 mm)	Sea cloudy (2.5 mm)
2018.01.15	-0.90	-2.50	-1.90	-2.10	3.80	4.30	3.80	4.60
2018.04.15	-0.10	-1.70	-1.50	-2.20	3.80	5.20	3.90	4.60
2018.07.15	-1.80	-2.40	-1.50	-2.10	4.20	5.80	3.40	3.90
2018.10.15	-1.50	-2.50	-1.20	-2.10	3.80	5.10	3.00	4.00
2019.01.15	0.60	-2.00	-1.40	-1.80	3.80	4.30	3.90	4.30
2019.04.15								

NPP	Accuracy (mm)				Precision (mm)			
Requirement	Land clear (2.5 mm)	Land cloudy (2.5 mm)	Sea clear (1.5 mm)	Sea cloudy (0.5 mm)	Land clear (5.5 mm)	Land cloudy (5.5 mm)	Sea clear (2.5 mm)	Sea cloudy (2.5 mm)
2018.01.15	-1.00	-3.10	-1.20	-2.10	4.10	4.90	4.20	4.60
2018.04.15	-1.00	-2.20	-1.50	-2.20	3.80	5.50	4.10	4.30
2018.07.15	-2.20	-2.60	-1.20	-2.10	4.80	6.10	3.40	4.00
2018.10.15	2.20	-3.20	-1.20	-2.10	3.90	5.20	3.00	4.10
2019.01.15	1.80	-2.20	-1.30	-1.90	4.00	4.20	3.90	4.20
2019.04.15								

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Water Vapor Profile Validation based on ECMWF data

Clear Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (30 %)
2018.01.15	1.0 / 1.0	7.0 / 6.0	11.0 / 10.0	0.0 / 0.0	51.0 / 48.0	48.0 / 48.0	35.0 / 36.0	15.0 / 14.0
2018.04.15	4.0 / 2.0	9.0 / 9.0	8.0 / 8.0	0.0 / 1.0	50.0 / 44.0	46.0 / 44.0	34.0 / 32.0	13.0 / 14.0
2018.07.15	3.0 / 5.0	8.0 / 6.0	11.0 / 10.0	-1.0 / -1.0	46.0 / 47.0	40.0 / 41.0	31.0 / 29.0	13.0 / 12.0
2018.10.15	7.0 / 8.0	6.0 / 7.0	13.0 / 12.0	-2.0 / -1.0	50.0 / 48.0	44.0 / 43.0	33.0 / 32.0	13.0 / 13.0
2019.01.15	1.0 / 2.0	6.0 / 6.0	11.0 / 10.0	-2.0 / -1.0	49.0 / 47.0	47.0 / 45.0	34.0 / 32.0	13.0 / 14.0
2019.04.15	6.0 / 4.0	6.0 / 5.0	10.0 / 11.0	-1.0 / -1.0	56.0 / 52.0	51.0 / 47.0	35.0 / 34.0	14.0 / 13.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (30 %)
2018.01.15	-2.0 / 0.0	3.0 / 3.0	9.0 / 11.0	0.0 / 0.0	51.0 / 51.0	50.0 / 53.0	37.0 / 38.0	14.0 / 17.0
2018.04.15	-1.0 / 2.0	2.0 / 6.0	8.0 / 7.0	0.0 / 1.0	47.0 / 48.0	46.0 / 46.0	35.0 / 33.0	13.0 / 13.0
2018.07.15	3.0 / 5.0	2.0 / 3.0	9.0 / 9.0	0.0 / 0.0	49.0 / 50.0	43.0 / 41.0	30.0 / 30.0	13.0 / 12.0
2018.10.15	5.0 / 7.0	3.0 / 3.0	12.0 / 13.0	-1.0 / -1.0	51.0 / 51.0	46.0 / 43.0	33.0 / 32.0	13.0 / 13.0
2019.01.15	-1.0 / 4.0	3.0 / 7.0	8.0 / 9.0	-1.0 / -1.0	50.0 / 51.0	49.0 / 49.0	34.0 / 31.0	14.0 / 13.0
2019.04.15	7.0 / 7.0	6.0 / 4.0	12.0 / 12.0	0.0 / -1.0	56.0 / 57.0	54.0 / 49.0	36.0 / 34.0	14.0 / 13.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Water Vapor Profile Validation based on ECMWF data

Clear Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	6.0 / 8.0	13.0 / 9.0	2.0 / 6.0	3.0 / -2.0	52.0 / 51.0	56.0 / 48.0	38.0 / 38.0	28.0 / 24.0
2018.04.15	0.0 / 11.0	16.0 / 17.0	-3.0 / -7.0	3.0 / -2.0	51.0 / 53.0	50.0 / 49.0	31.0 / 29.0	25.0 / 20.0
2018.07.15	10.0 / 7.0	11.0 / 9.0	-2.0 / -2.0	1.0 / -3.0	47.0 / 48.0	40.0 / 40.0	26.0 / 25.0	23.0 / 21.0
2018.10.15	10.0 / 9.0	11.0 / 15.0	-1.0 / -2.0	1.0 / -1.0	52.0 / 51.0	44.0 / 45.0	26.0 / 27.0	24.0 / 22.0
2019.01.15	12.0 / 13.0	10.0 / 9.0	-3.0 / -9.0	2.0 / -2.0	46.0 / 48.0	42.0 / 40.0	32.0 / 28.0	27.0 / 26.0
2019.04.15	1.0 / 10.0	9.0 / 12.0	-3.0 / -8.0	4.0 / -1.0	49.0 / 50.0	48.0 / 45.0	22.0 / 32.0	26.0 / 23.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	5.0 / 8.0	11.0 / 12.0	2.0 / -1.0	1.0 / 0.0	55.0 / 52.0	54.0 / 53.0	37.0 / 37.0	27.0 / 27.0
2018.04.15	0.0 / 6.0	15.0 / 19.0	-2.0 / -6.0	3.0 / -2.0	52.0 / 51.0	53.0 / 49.0	31.0 / 28.0	26.0 / 21.0
2018.07.15	9.0 / 8.0	11.0 / 10.0	-2.0 / -5.0	-1.0 / -5.0	53.0 / 54.0	42.0 / 45.0	26.0 / 26.0	23.0 / 22.0
2018.10.15	9.0 / 12.0	10.0 / 11.0	-1.0 / -5.0	1.0 / -4.0	53.0 / 57.0	48.0 / 45.0	28.0 / 28.0	25.0 / 24.0
2019.01.15	13.0 / 18.0	8.0 / 6.0	-5.0 / -8.0	-1.0 / -1.0	54.0 / 57.0	37.0 / 43.0	30.0 / 29.0	29.0 / 27.0
2019.04.15	6.0 / 7.0	13.0 / 12.0	-5.0 / -9.0	3.0 / -2.0	52.0 / 47.0	49.0 / 43.0	32.0 / 34.0	26.0 / 25.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Water Vapor Profile Validation based on ECMWF data

Cloudy Sea Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (10 %)	900 hPa (20 %)	400 hPa (70 %)	500 hPa (65 %)	700 hPa (60 %)	900 hPa (30 %)
2018.01.15	8.0 / 7.0	7.0 / 7.0	2.0 / 4.0	-2.0 / -2.0	61.0 / 58.0	57.0 / 56.0	35.0 / 36.0	16.0 / 17.0
2018.04.15	6.0 / 5.0	6.0 / 5.0	8.0 / 10.0	-3.0 / -4.0	63.0 / 58.0	59.0 / 57.0	38.0 / 39.0	17.0 / 17.0
2018.07.15	5.0 / 8.0	4.0 / 6.0	7.0 / 8.0	-4.0 / -4.0	60.0 / 58.0	53.0 / 54.0	36.0 / 34.0	16.0 / 17.0
2018.10.15	11.0 / 10.0	5.0 / 6.0	8.0 / 11.0	-3.0 / -4.0	70.0 / 64.0	60.0 / 55.0	39.0 / 38.0	17.0 / 17.0
2019.01.15	10.0 / 10.0	2.0 / 3.0	8.0 / 10.0	-2.0 / -3.0	74.0 / 66.0	62.0 / 59.0	38.0 / 39.0	17.0 / 17.0
2019.04.15	8.0 / 6.0	1.0 / 1.0	7.0 / 9.0	-3.0 / -4.0	64.0 / 59.0	59.0 / 56.0	40.0 / 41.0	17.0 / 16.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (10 %)	900 hPa (20 %)	400 hPa (70 %)	500 hPa (65 %)	700 hPa (60 %)	900 hPa (30 %)
2018.01.15	9.0 / 9.0	8.0 / 5.0	2.0 / 5.0	-1.0 / -2.0	61.0 / 57.0	58.0 / 56.0	34.0 / 34.0	16.0 / 16.0
2018.04.15	2.0 / 5.0	2.0 / 4.0	8.0 / 9.0	-2.0 / -3.0	60.0 / 59.0	59.0 / 58.0	38.0 / 38.0	16.0 / 17.0
2018.07.15	4.0 / 4.0	1.0 / 3.0	7.0 / 7.0	-4.0 / -3.0	61.0 / 58.0	55.0 / 54.0	34.0 / 34.0	16.0 / 16.0
2018.10.15	10.0 / 9.0	4.0 / 3.0	7.0 / 11.0	-2.0 / -4.0	69.0 / 63.0	62.0 / 56.0	38.0 / 40.0	16.0 / 17.0
2019.01.15	9.0 / 10.0	0.0 / 2.0	8.0 / 10.0	-1.0 / -3.0	70.0 / 68.0	63.0 / 62.0	36.0 / 38.0	16.0 / 17.0
2019.04.15	7.0 / 8.0	1.0 / 1.0	11.0 / 11.0	-2.0 / -3.0	61.0 / 58.0	59.0 / 56.0	39.0 / 41.0	17.0 / 16.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Water Vapor Profile Validation based on ECMWF data

Cloudy Land Scenes

N20	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	21.0 / 22.0	24.0 / 21.0	-1.0 / -7.0	2.0 / -2.0	50.0 / 45.0	41.0 / 39.0	27.0 / 32.0	20.0 / 22.0
2018.04.15	13.0 / 20.0	15.0 / 18.0	-9.0 / -12.0	6.0 / 5.0	46.0 / 47.0	40.0 / 41.0	24.0 / 19.0	20.0 / 18.0
2018.07.15	12.0 / 11.0	15.0 / 13.0	-2.0 / -7.0	2.0 / 1.0	41.0 / 40.0	35.0 / 33.0	22.0 / 19.0	18.0 / 20.0
2018.10.15	14.0 / 12.0	13.0 / 14.0	-8.0 / -9.0	4.0 / 7.0	57.0 / 58.0	51.0 / 49.0	30.0 / 33.0	25.0 / 28.0
2019.01.15	15.0 / 12.0	19.0 / 17.0	-5.0 / -11.0	1.0 / -1.0	42.0 / 35.0	37.0 / 31.0	27.0 / 24.0	20.0 / 19.0
2019.04.15	11.0 / 12.0	12.0 / 11.0	-7.0 / -6.0	3.0 / 4.0	47.0 / 52.0	42.0 / 42.0	25.0 / 29.0	21.0 / 22.0

NPP	Accuracy (asc/des)				Precision (asc/des)			
Pressure level & Requirement	400 hPa (30 %)	500 hPa (20 %)	700 hPa (20 %)	900 hPa (20 %)	400 hPa (60 %)	500 hPa (60 %)	700 hPa (50 %)	900 hPa (50 %)
2018.01.15	20.0 / 21.0	28.0 / 22.0	1.0 / -9.0	4.0 / -1.0	45.0 / 40.0	43.0 / 36.0	25.0 / 24.0	21.0 /18.0
2018.04.15	12.0 / 16.0	17.0 / 18.0	-3.0 / -12.0	8.0 / 7.0	47.0 / 48.0	40.0 / 41.0	25.0 / 27.0	21.0 / 22.0
2018.07.15	13.0 / 14.0	16.0 / 12.0	-3.0 / -8.0	-1.0 / -1.0	48.0 / 46.0	40.0 / 39.0	24.0 / 26.0	19.0 / 23.0
2018.10.15	15.0 / 16.0	14.0 / 13.0	-7.0 / -9.0	4.0 / 4.0	61.0 / 60.0	52.0 / 48.0	31.0 / 33.0	24.0 / 26.0
2019.01.15	18.0 / 20.0	22.0 / 20.0	-2.0 / -9.0	1.0 / -1.0	41.0 / 42.0	38.0 / 34.0	26.0 / 26.0	17.0 / 18.0
2019.04.15	13.0 / 17.0	20.0 / 15.0	-4.0 / -9.0	6.0 / 3.0	46.0 / 55.0	42.0 / 41.0	26.0 / 29.0	21.0 / 21.0

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

Requirements and Validation Results: Total Precipitable Water Compared to ECMWF and radiosondes

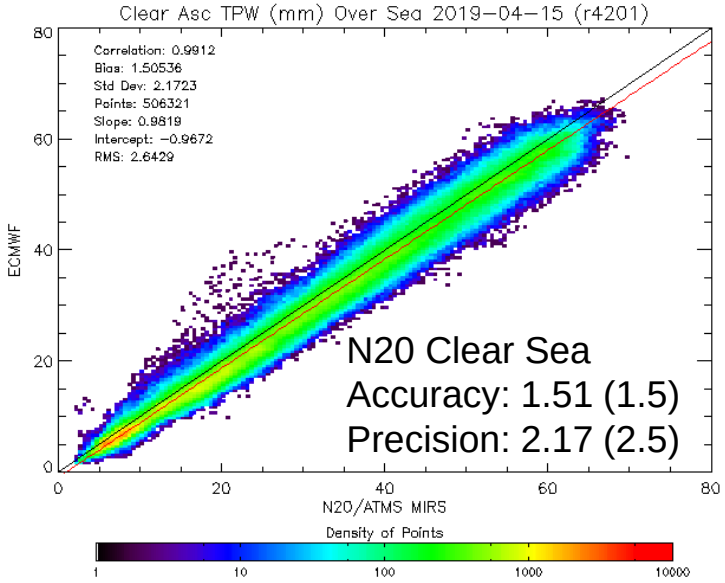
		ECMWF				Radiosonde			
Sfc	**Condition**	**Bias (mm) (Accuracy)**		**StDv (mm) (Precision)**		**Bias (mm) (Accuracy)**		**StDv (mm) (Precision)**	
		MiRS	Req	MiRS	Req	MiRS	Req	MiRS	Req
Sea	Clear	**1.66 (1.65)**	**1.5**	**2.16 (2.14)**	**2.5**	**-1.5 (-1.28)**	**1.5**	**3.6 (3.7)**	**2.5**
	Cloudy	**1.13 (1.21)**	**0.5**	**2.06 (2.02)**	**2.5**	**-2.1 (-2.1)**	**0.5**	**4.3 (4.2)**	**2.5**
Ice	Clear	**0.22 (0.23)**	**2.0**	**1.12 (1.16)**	**2.0**	**N/A**	**2.0**	**N/A**	**2.0**
	Cloudy	**1.17 (1.16)**	**2.0**	**1.87 (1.97)**	**2.0**	**N/A**	**2.0**	**N/A**	**2.0**
Land	Clear	**1.06 (0.84)**	**2.5**	**3.89 (4.11)**	**5.5**	**-0.7 (0.0)**	**2.5**	**3.9 (4.1)**	**5.5**
	Cloudy	**1.23 (1.51)**	**2.5**	**5.07 (5.74)**	**5.5**	**-2.2 (-2.7)**	**2.5**	**4.9 (5.2)**	**5.5**
Snow	Clear	**0.28 (0.31)**	**0.5**	**0.91 (0.93)**	**2.0**	**N/A**	**0.5**	**N/A**	**2.0**
	Cloudy	**0.97 (1.13)**	**0.5**	**2.13 (2.39)**	**2.0**	**N/A**	**0.5**	**N/A**	**2.0**

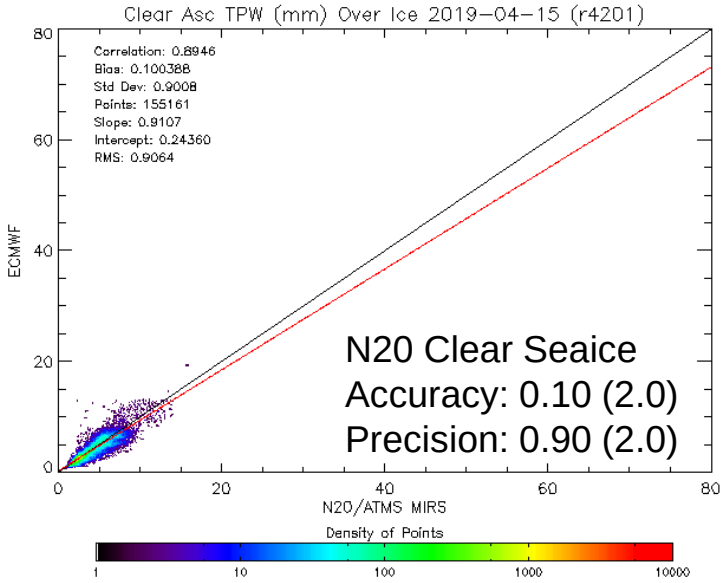
Values in ( ) indicates NPP

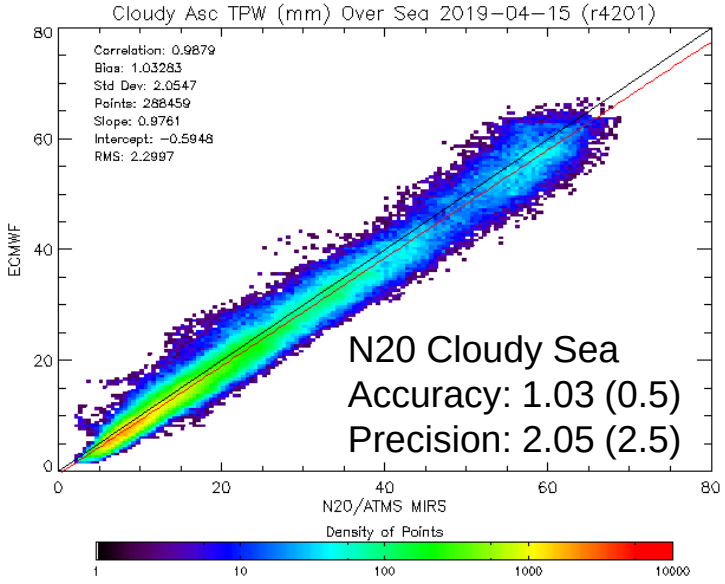
Meets requirement

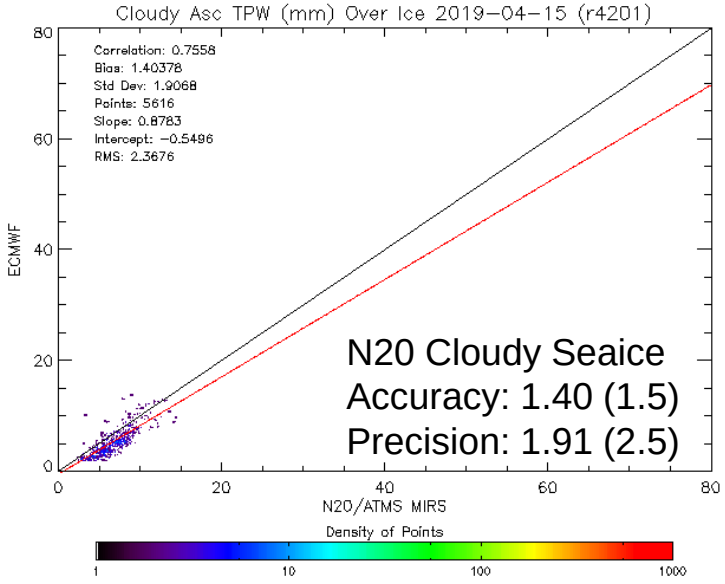
Marginal

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

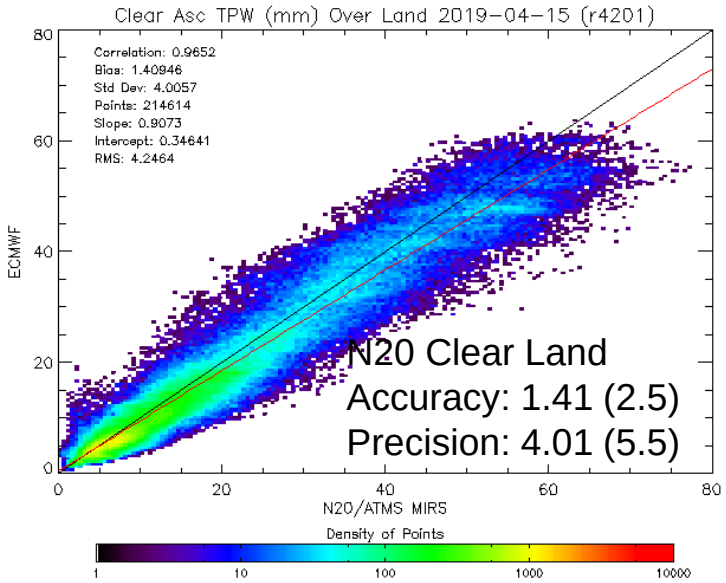


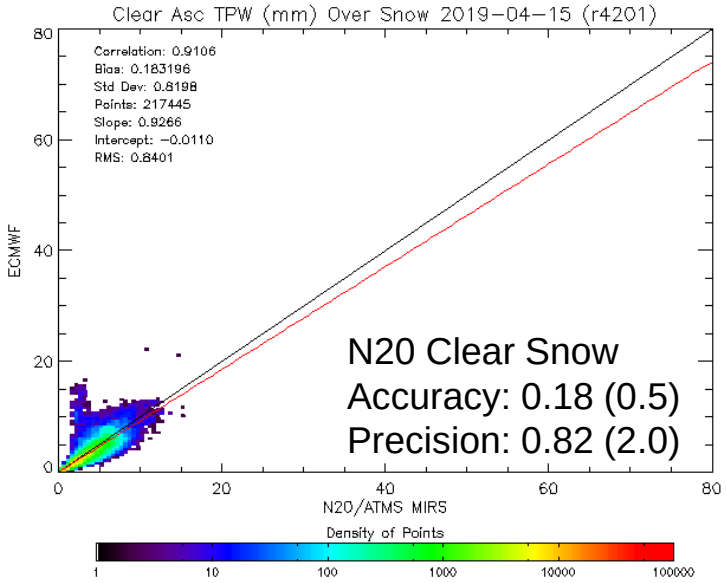


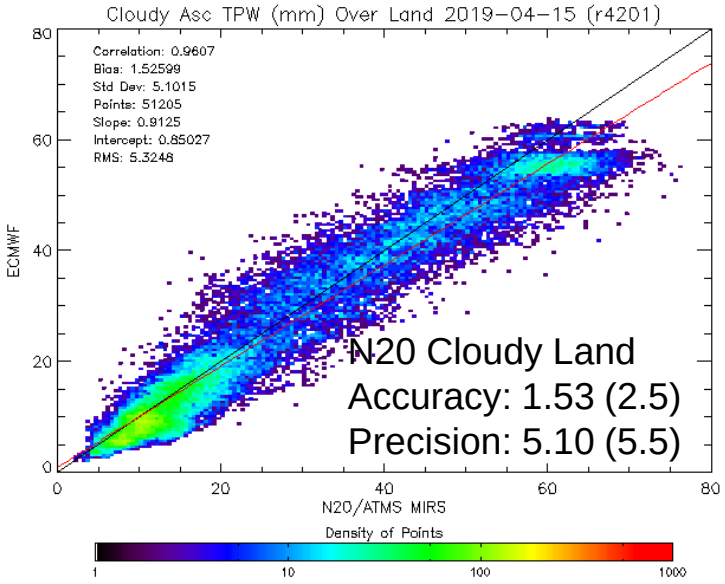


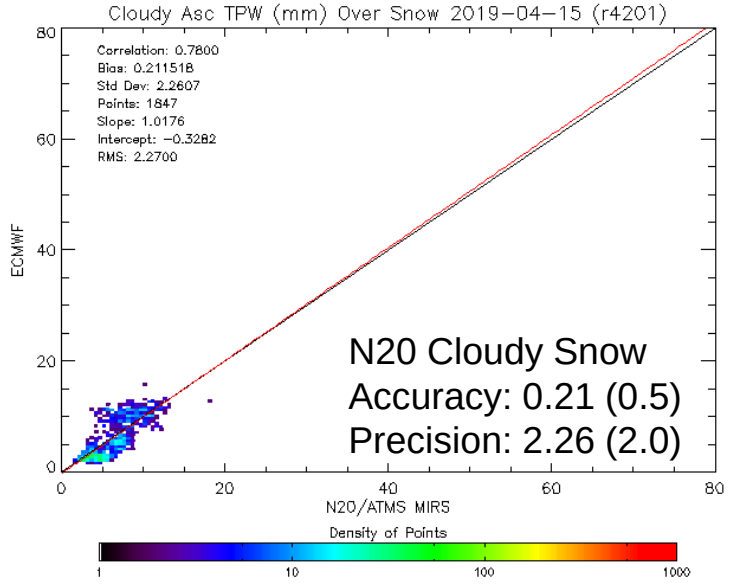


Validation Results: Total Precipitable Water (TPW) Compared to ECMWF









TPW Validation based on ECMWF data: Ocean

N20	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Sea (1.5 mm)	Cloudy Sea (0.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)	Clear Sea (2.5 mm)	Cloudy Sea (2.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)
2018.01.15	1.60 / 1.70	1.12 / 1.16	0.24 / 0.32	1.33 / 1.19	2.08 / 2.11	2.16 / 2.15	1.11 / 1.14	2.13 / 1.76
2018.04.15	1.64 / 1.75	1.25 / 1.27	-0.00 / 0.03	1.45 / 0.80	2.21 / 2.20	2.05 / 2.05	1.31 / 1.17	1.83 / 2.62
2018.07.15	1.57 / 1.64	0.87 / 0.92	0.41 / 0.32	1.29 / 1.11	2.40 / 2.35	2.20 / 2.21	1.39 / 1.35	1.76 / 1.76
2018.10.15	1.73 / 1.80	1.14 / 1.22	0.28 / 0.37	1.19 / 1.44	2.10 / 2.15	2.05 / 2.04	1.26 / 1.17	1.45 / 1.27
2019.01.15	1.64 / 1.78	1.29 / 1.31	0.20 / 0.24	0.97 / 0.45	2.04 / 2.03	1.88 / 1.84	0.89 / 0.88	1.96 / 2.20
2019.04.15	1.51 / 1.58	1.03 / 1.04	0.10 / 0.11	1.40 / 1.39	2.17 / 2.14	2.05 / 2.03	0.90 / 0.88	1.91 / 1.78

NPP	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Sea (1.5 mm)	Cloudy Sea (0.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)	Clear Sea (2.5 mm)	Cloudy Sea (2.5 mm)	Clear Ice (2.0 mm)	Cloudy Ice (2.0 mm)
2018.01.15	1.55 / 1.64	1.22 / 1.25	0.25 / 0.29	0.47 / 0.08	2.07 / 2.10	2.14 / 2.03	1.18 / 1.14	2.48 / 2.31
2018.04.15	1.58 / 1.71	1.29 / 1.31	0.04 / 0.02	1.49 / 0.95	2.16 / 2.23	1.99 / 2.03	1.32 / 1.20	1.96 / 2.74
2018.07.15	1.50 / 1.68	0.92 / 0.92	0.46 / 0.38	1.39 / 1.33	2.31 / 2.37	2.11 / 2.23	1.33 / 1.41	1.75 / 1.95
2018.10.15	1.74 / 1.76	1.21 / 1.20	0.29 / 0.38	1.43 / 1.47	2.08 / 2.08	2.07 / 2.05	1.36 / 1.26	1.45 / 1.31
2019.01.15	1.60 / 1.73	1.39 / 1.37	0.17 / 0.22	1.10 / 0.53	1.99 / 2.05	1.83 / 1.87	0.94 / 0.90	2.03 / 2.01
2019.04.15	1.64 / 1.62	1.25 / 1.20	0.14 / 0.11	1.82 / 1.83	2.14 / 2.10	1.99 / 1.95	0.94 / 0.91	1.81 / 1.80

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

Note: results stratified by asc/des, but requirements are for combined passes

TPW Validation based on ECMWF data: Land

N20	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Land (2.5 mm)	Cloudy Land (2.5 mm)	Clear Snow (0.5 mm)	Cloudy Snow (0.5 mm)	Clear Land (5.5 mm)	Cloudy Land (5.5 mm)	Clear Snow (2.0 mm)	Cloudy Snow (2.0 mm)
2018.01.15	1.32 / 0.93	2.02 / 1.04	0.36 / 0.33	1.73 / 2.06	3.50 / 3.44	5.29 / 4.85	0.88 / 0.88	1.71 / 1.87
2018.04.15	1.34 / 0.76	1.10 / 0.95	0.23 / 0.30	0.80 / 1.42	3.65 / 3.80	5.26 / 4.89	0.99 / 1.11	2.53 / 2.15
2018.07.15	1.58 / 1.00	1.81 / 1.14	0.38 / 0.37	0.23 / 0.30	4.37 / 4.31	5.00 / 4.65	0.90 / 0.93	3.43 / 3.45
2018.10.15	1.27 / 0.83	1.08 / 0.88	0.28 / 0.20	1.16 / 1.35	3.88 / 3.78	5.02 / 4.83	0.82 / 0.94	1.67 / 1.55
2019.01.15	1.15 / 0.41	1.48 / 0.39	0.29 / 0.26	0.84 / 0.56	3.78 / 3.90	5.67 / 5.38	0.89 / 0.85	1.63 / 1.24
2019.04.15	1.41 / 0.69	1.53 / 1.39	0.18 / 0.22	0.21 / 1.01	4.01 / 4.18	5.10 / 4.93	0.82 / 0.94	2.26 / 2.06

NPP	Accuracy (asc/des)				Precision (asc/des)			
Requirement	Clear Land (2.5 mm)	Cloudy Land (2.5 mm)	Clear Snow (0.5 mm)	Cloudy Snow (0.5 mm)	Clear Land (5.5 mm)	Cloudy Land (5.5 mm)	Clear Snow (2.0 mm)	Cloudy Snow (2.0 mm)
2018.01.15	1.27 / 0.84	2.94 / 1.04	0.38 / 0.31	1.83 / 1.68	3.84 / 3.83	6.27 / 5.04	0.89 / 0.94	2.34 / 2.32
2018.04.15	1.29 / 0.73	2.28 / 1.29	0.27 / 0.35	1.25 / 3.02	3.75 / 4.04	5.75 / 5.33	0.93 / 1.18	3.54 / 3.31
2018.07.15	1.25 / 0.58	1.38 / 0.73	0.38 / 0.38	0.24 / 0.28	4.37 / 4.42	5.36 / 5.08	0.86 / 0.94	3.09 / 3.32
2018.10.15	1.03 / 0.25	1.33 / 0.83	0.29 / 0.22	1.14 / 1.38	3.85 / 4.01	5.62 / 5.03	0.81 / 1.01	1.74 / 1.67
2019.01.15	0.80 / 0.36	1.99 / 0.81	0.29 / 0.31	0.74 / 0.61	3.98 / 3.89	6.11 / 5.53	0.91 / 0.82	1.61 / 1.17
2019.04.15	1.26 / 0.43	2.11 / 1.44	0.21 / 0.27	0.15 / 1.22	3.97 / 4.33	5.39 / 5.89	0.85 / 1.04	2.39 / 2.13

Green: meeting the requirement, Blue: within 20% from the req., Black: over 20%

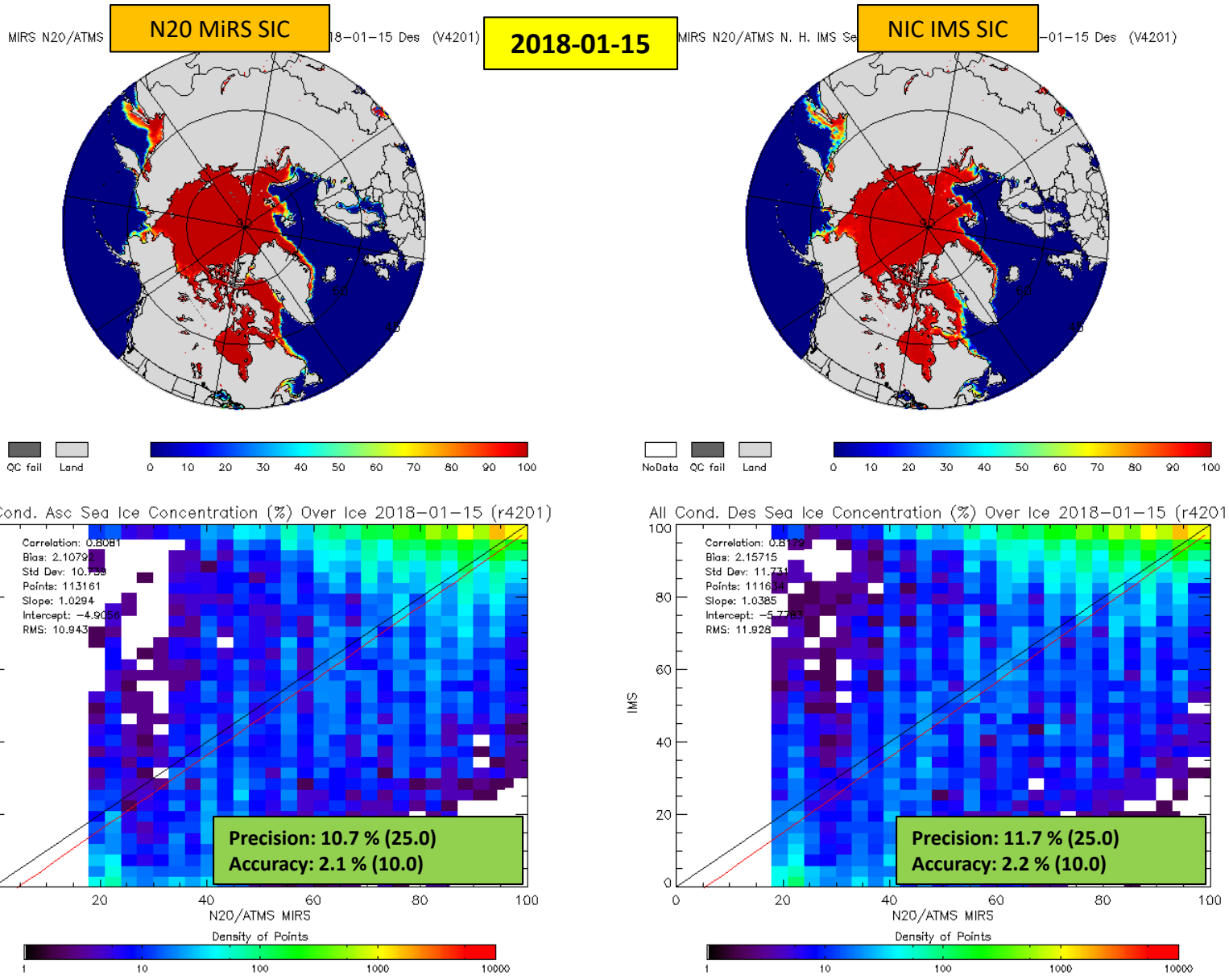
Note: results stratified by asc/des, but requirements are for combined passes

Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

N20 MiRS SIC

2018-01-15

NIC IMS SIC

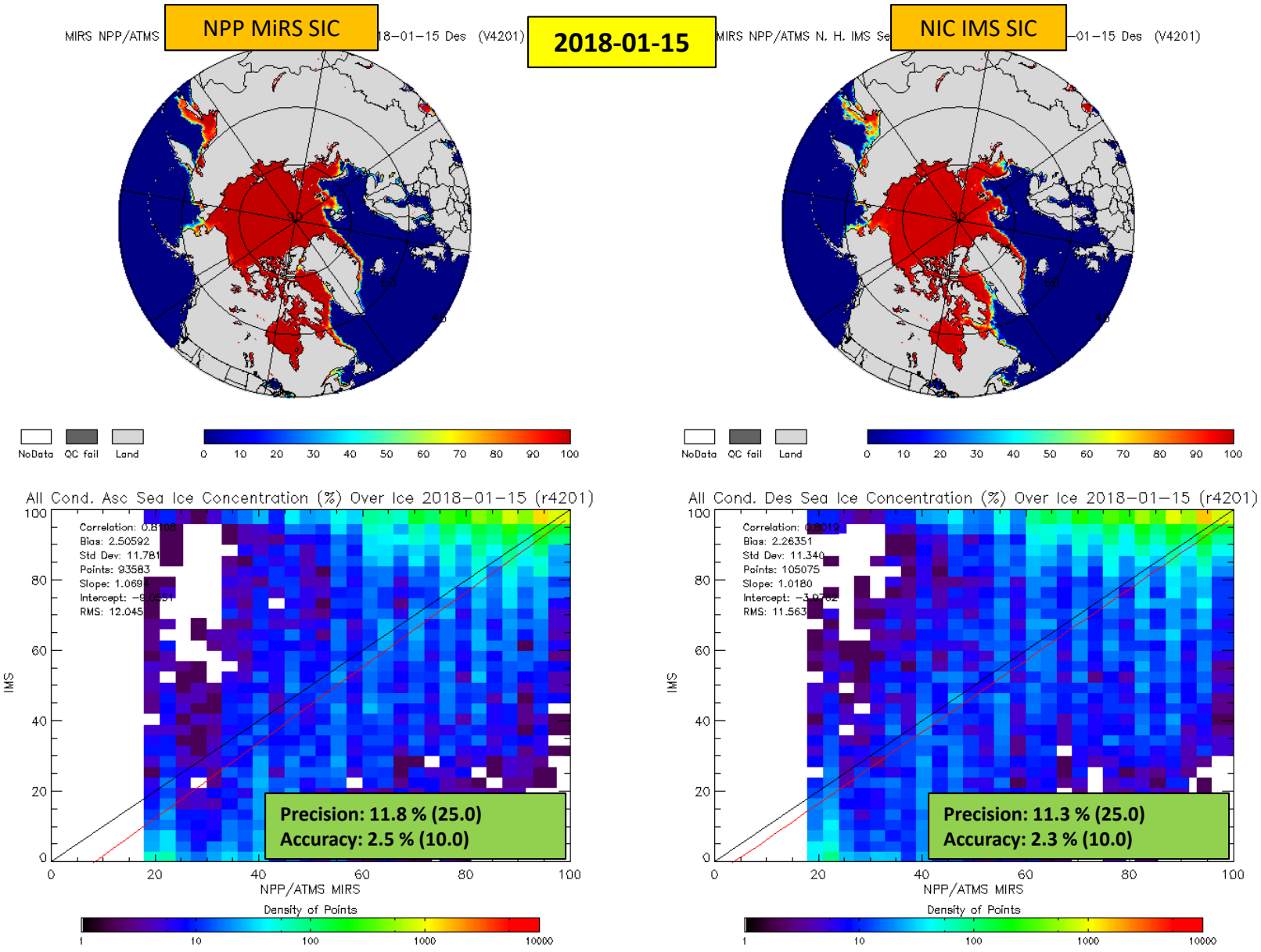


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

NPP MiRS SIC

2018-01-15

NIC IMS SIC

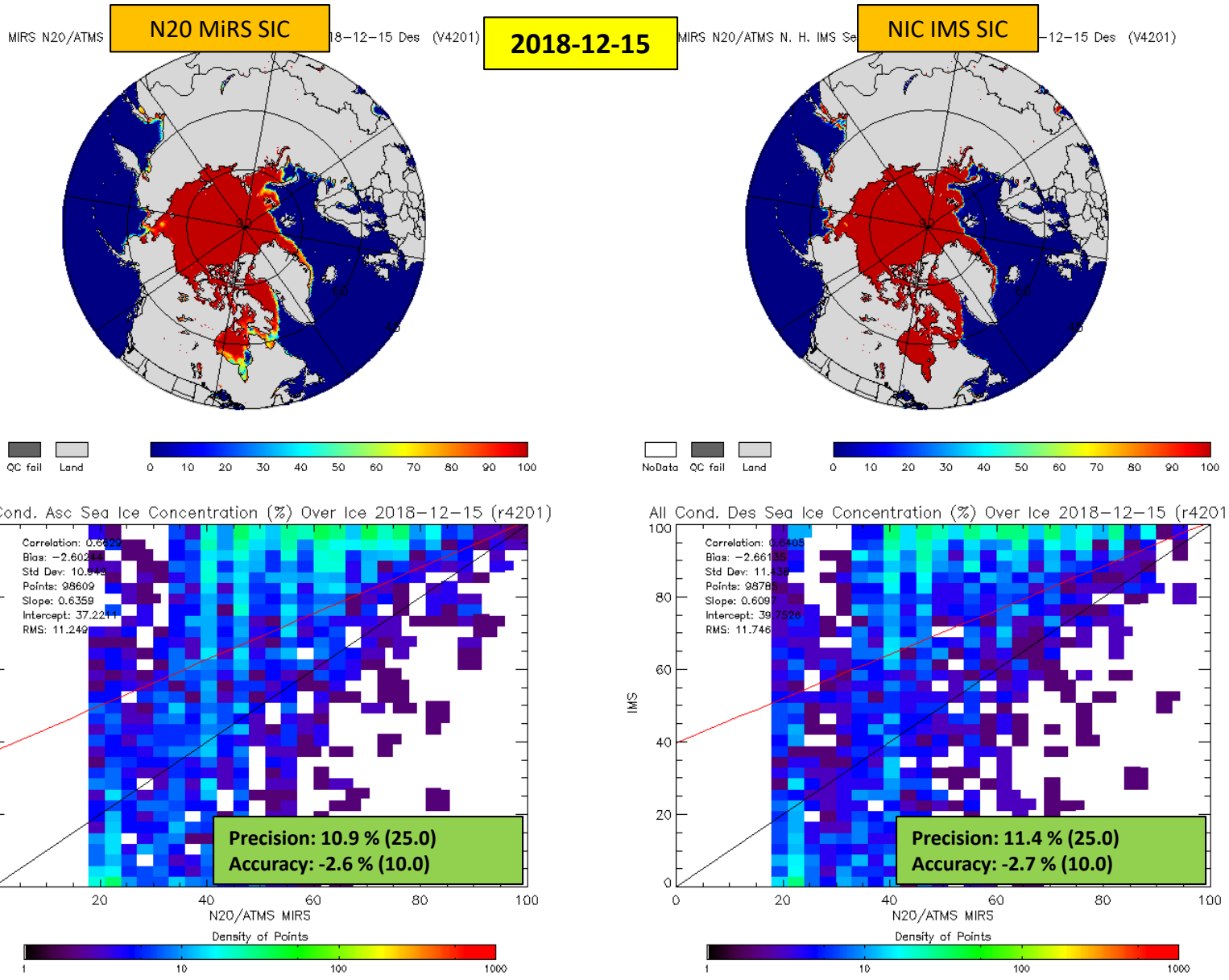


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

N20 MiRS SIC

2018-12-15

NIC IMS SIC

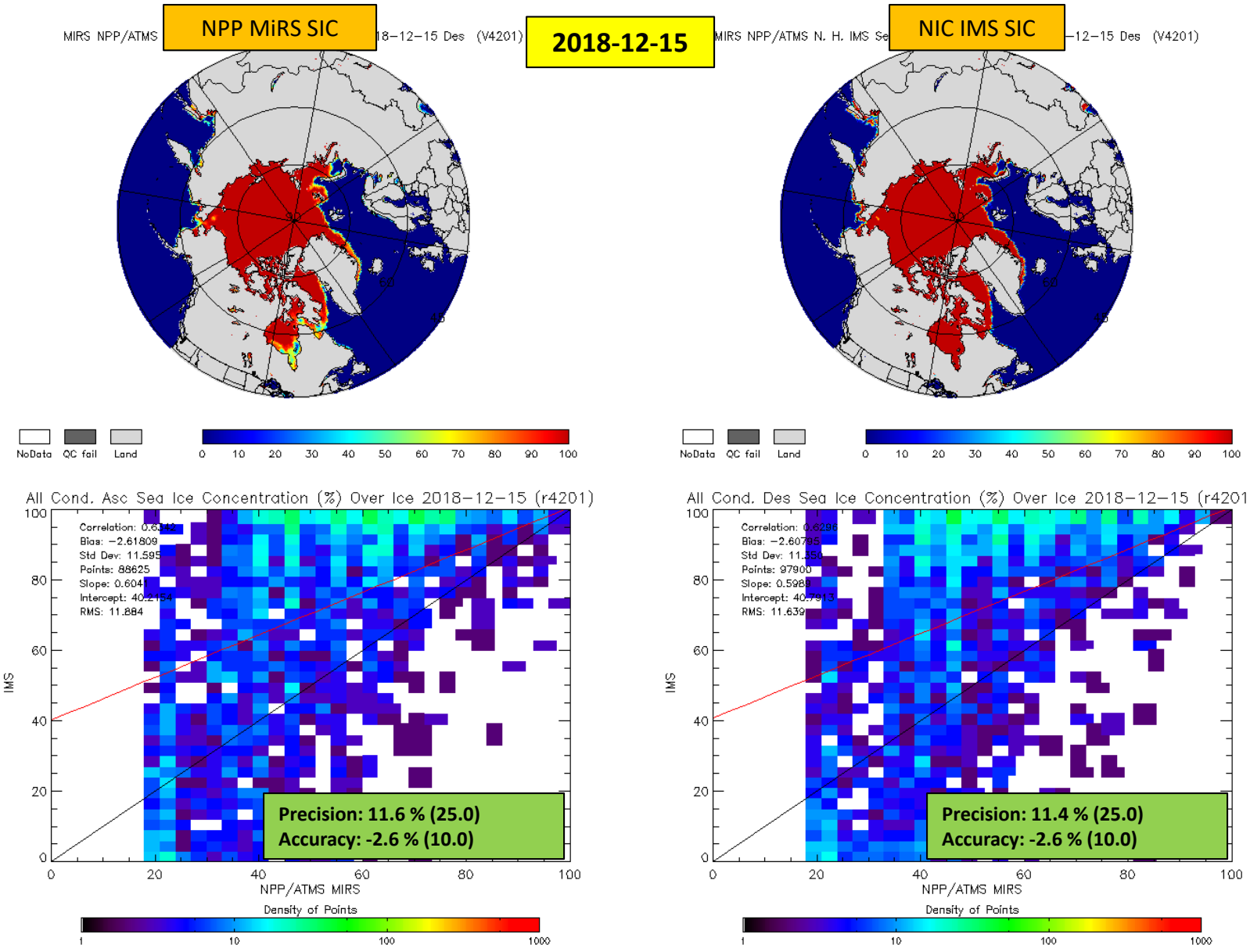


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

NPP MiRS SIC

2018-12-15

NIC IMS SIC

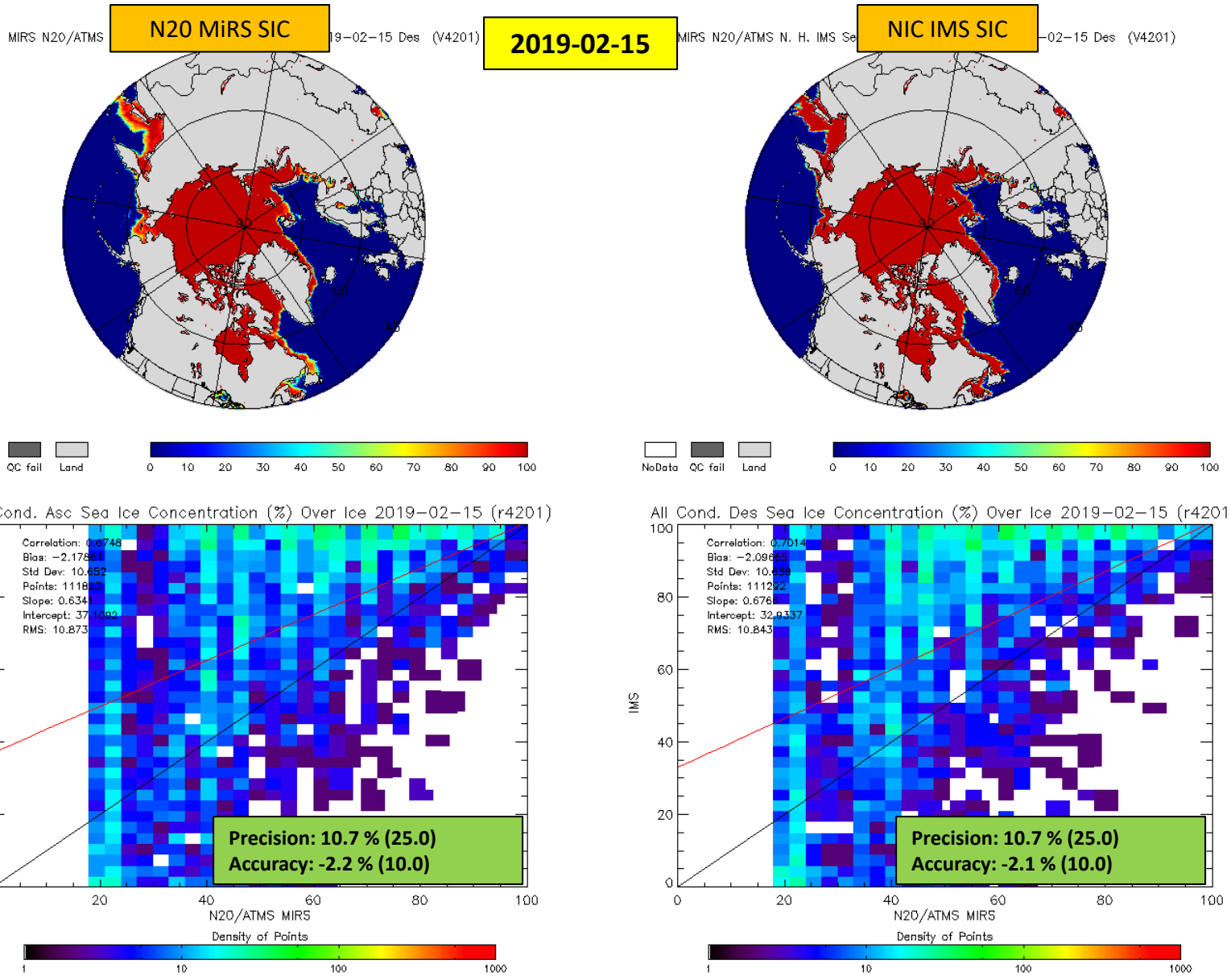


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

N20 MiRS SIC

2019-02-15

NIC IMS SIC

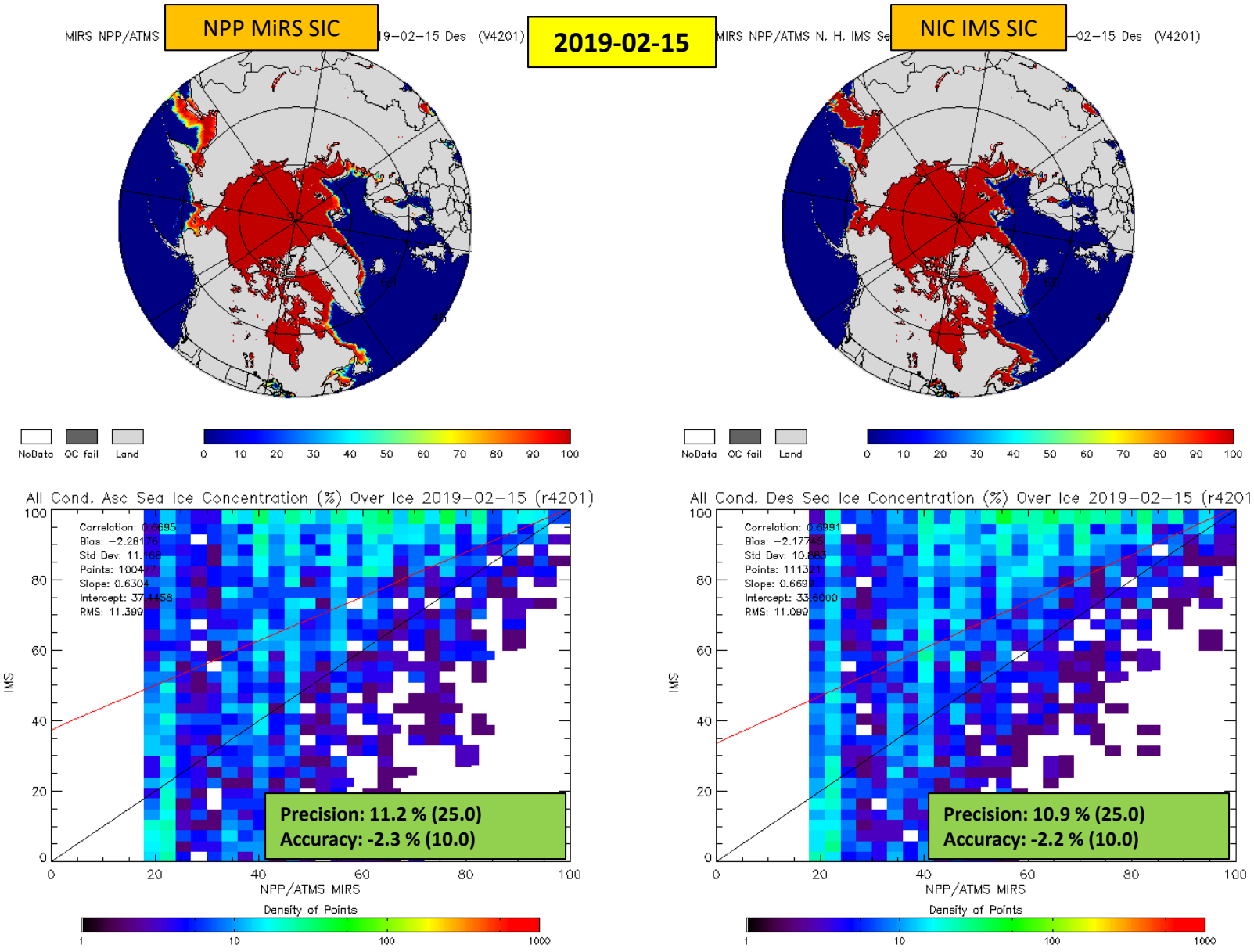


Sea Ice Concentration Performance: Comparison with IMS 4-km Analysis

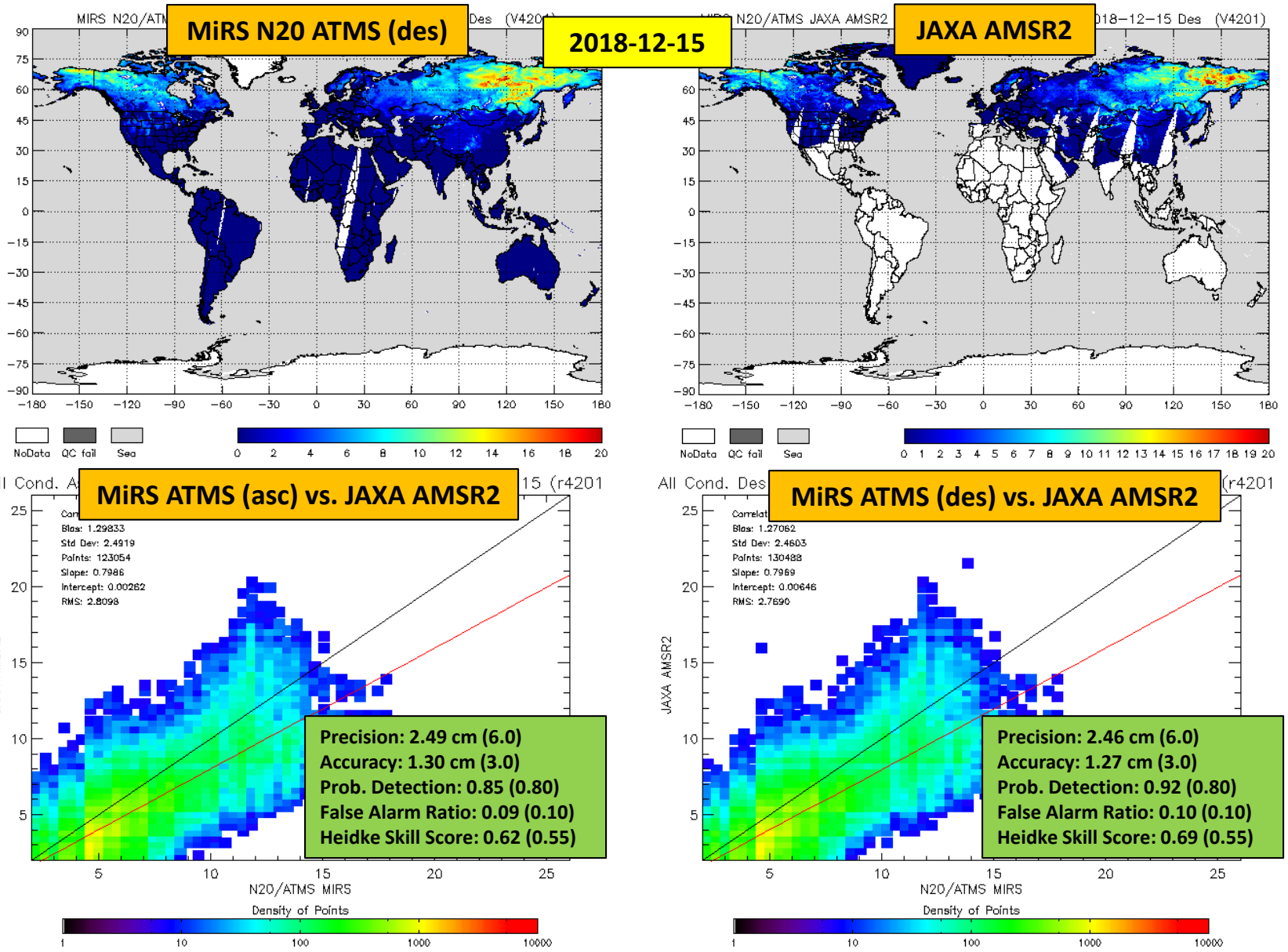
NPP MiRS SIC

2019-02-15

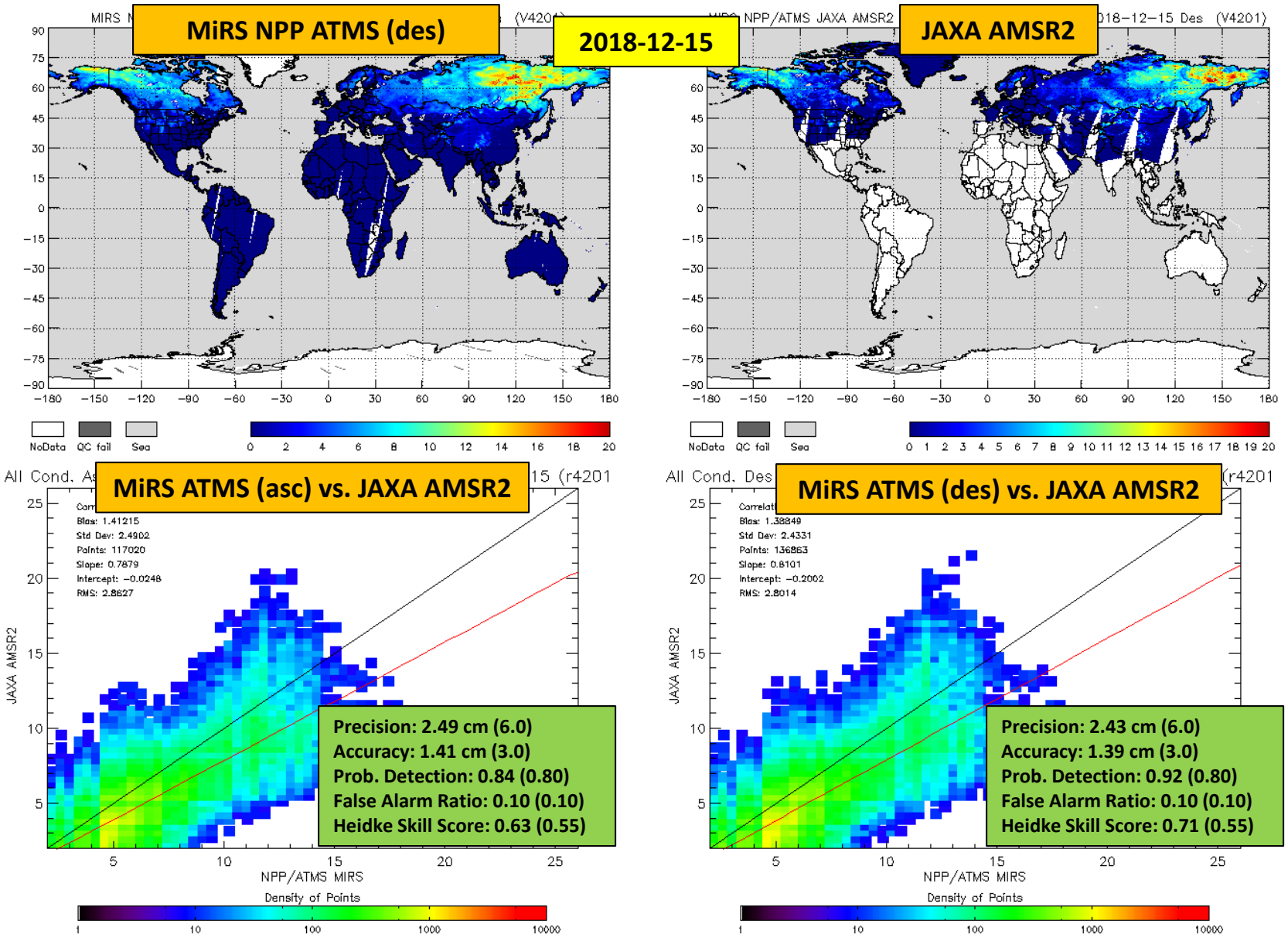
NIC IMS SIC



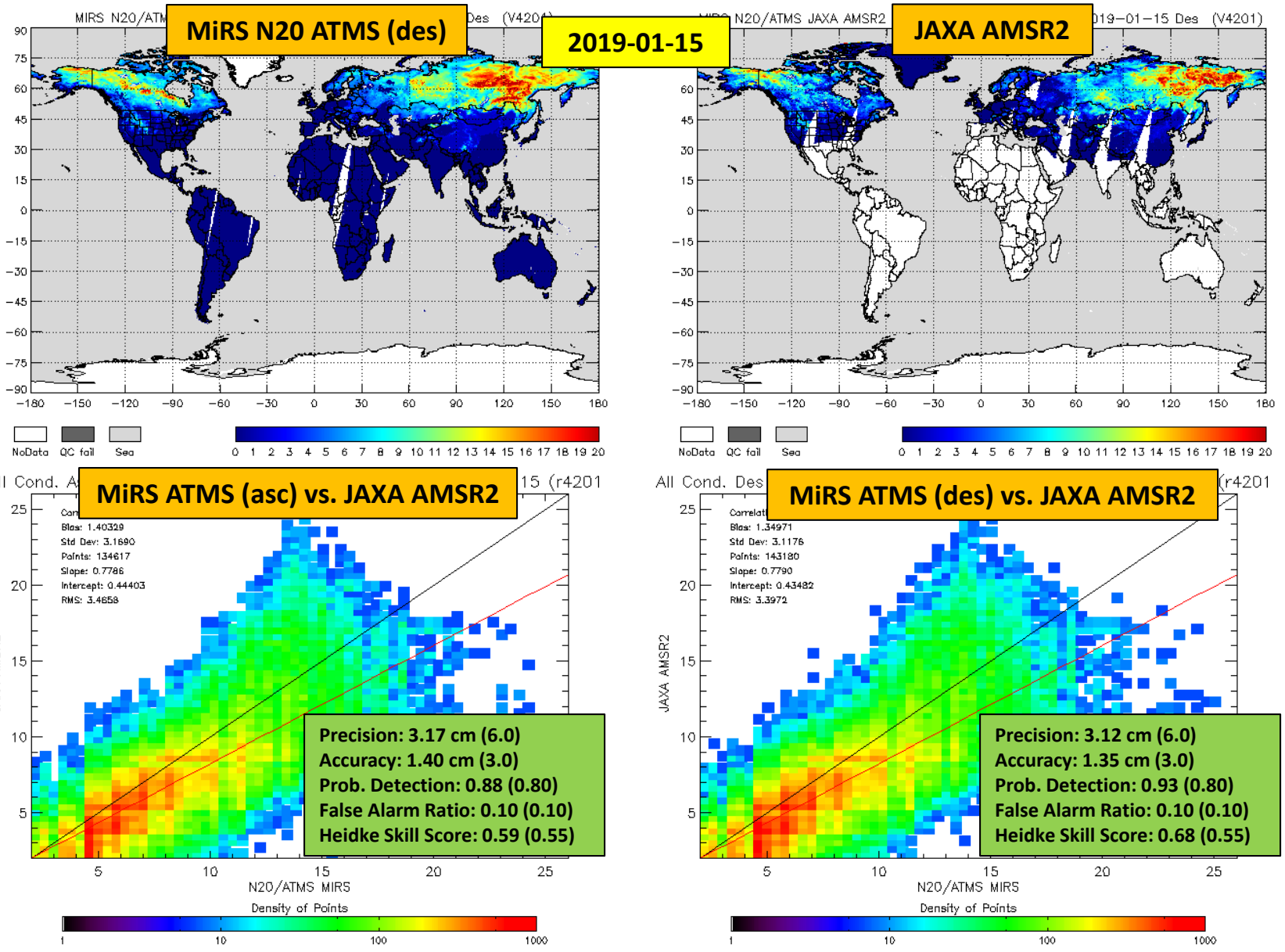
Validation Results Summary:
Snow Water Equivalent/Snow Cover



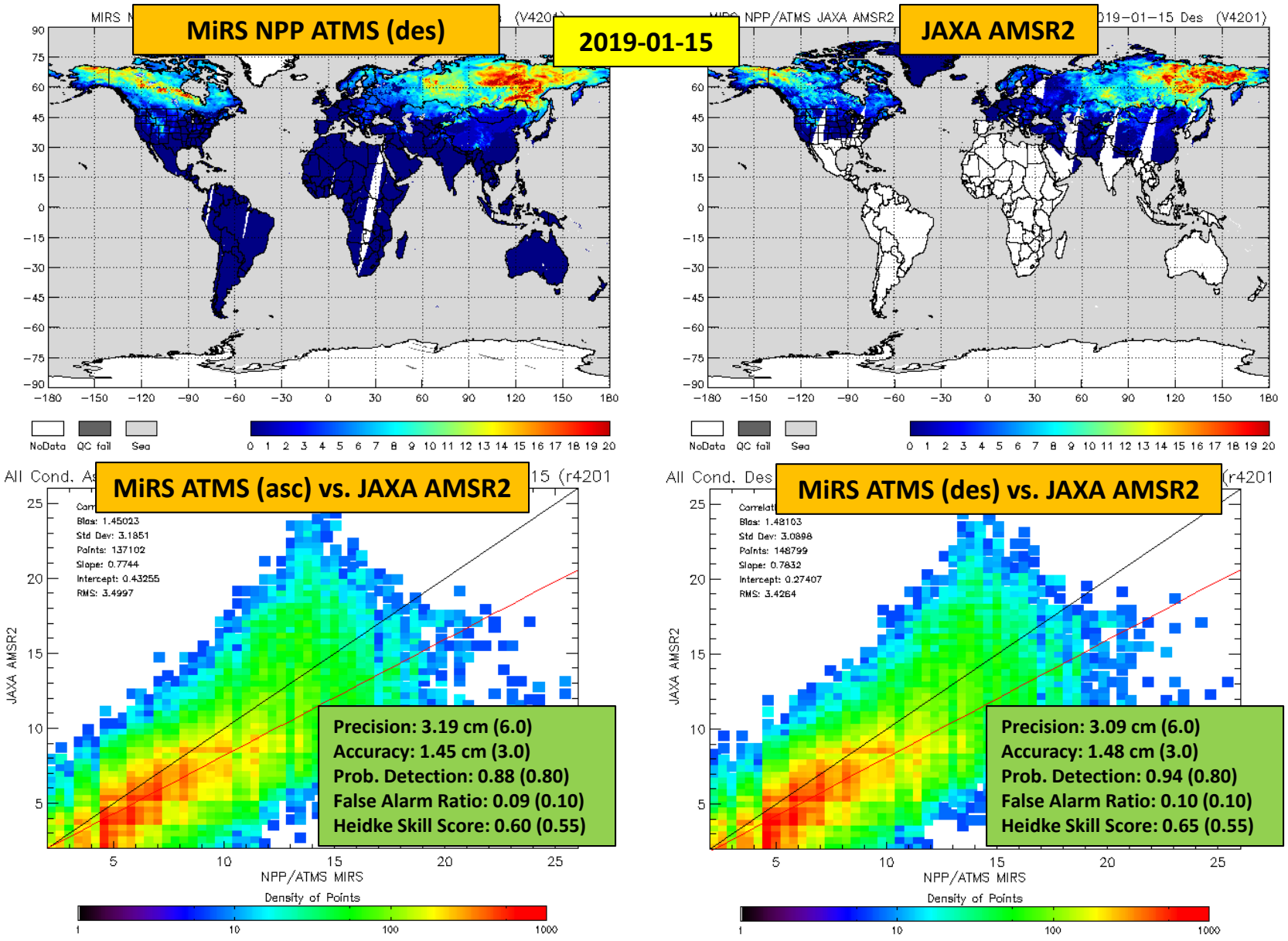
Validation Results Summary:
Snow Water Equivalent/Snow Cover



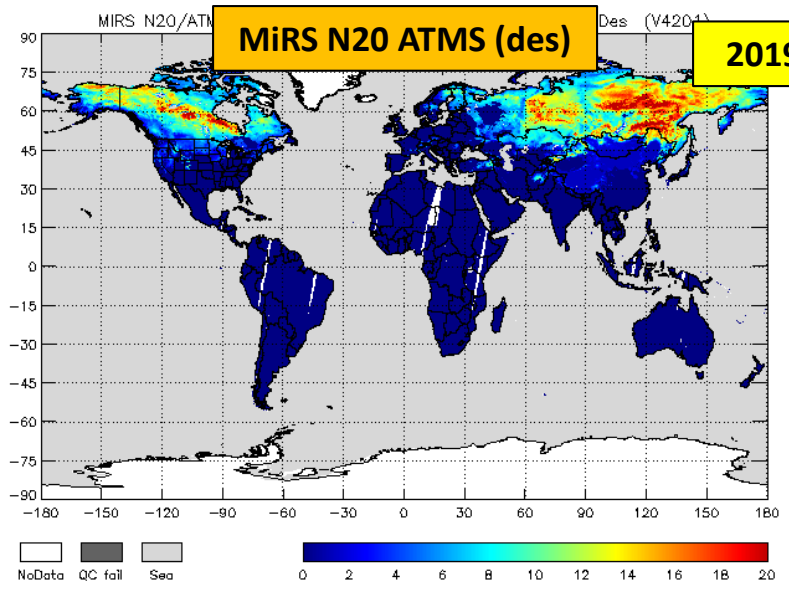
Validation Results Summary: Snow Water Equivalent/Snow Cover

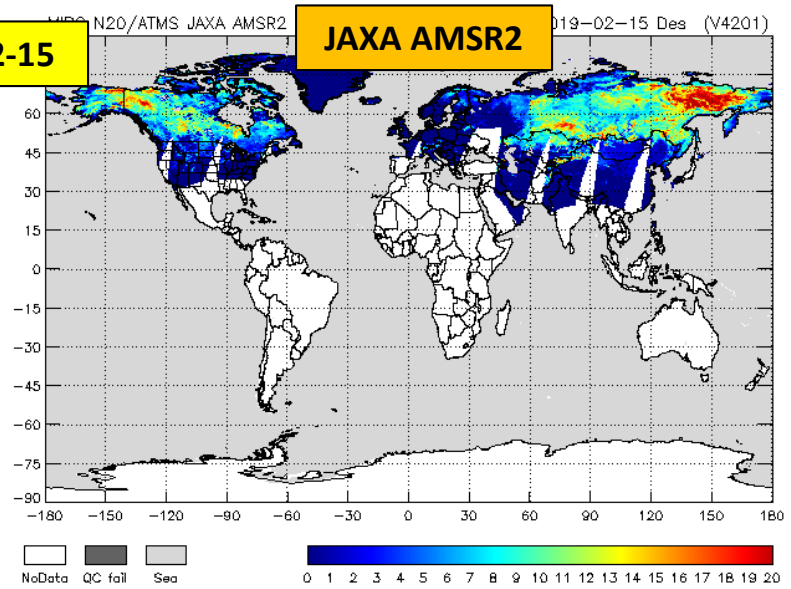


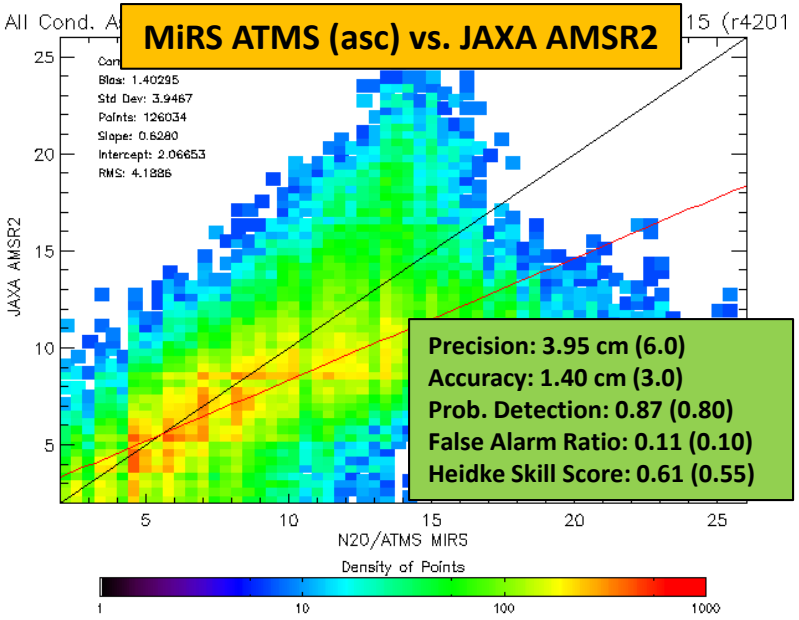
Validation Results Summary: Snow Water Equivalent/Snow Cover



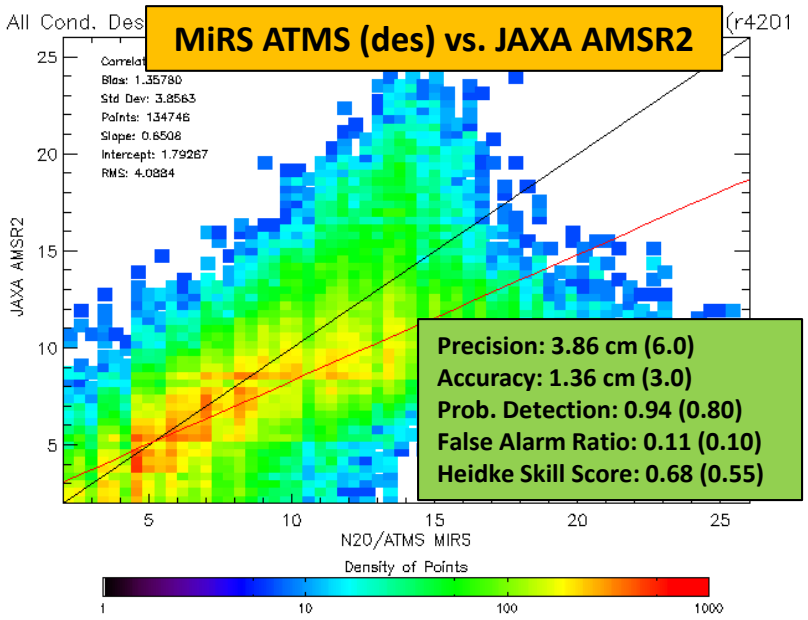
Validation Results Summary: Snow Water Equivalent/Snow Cover





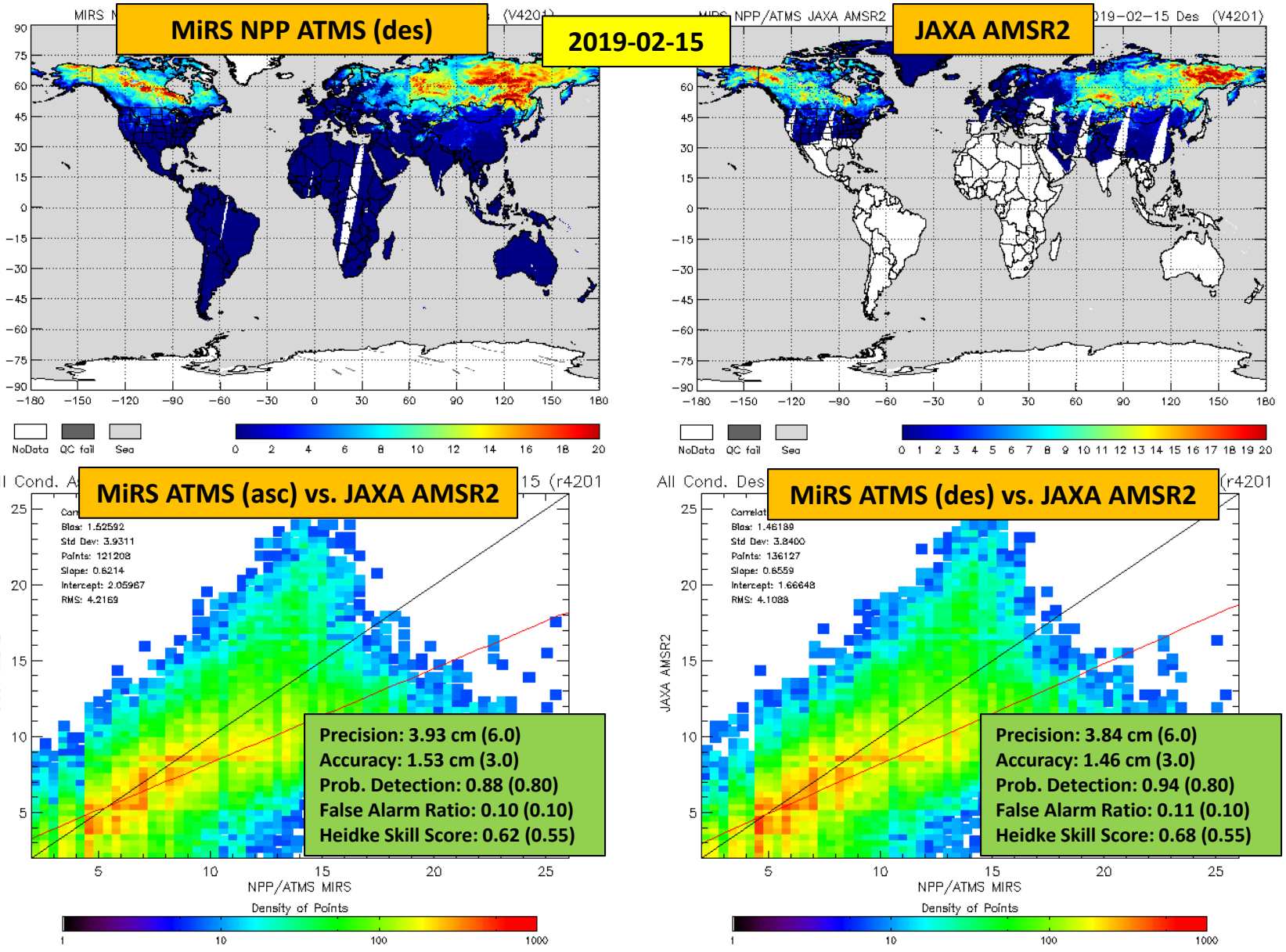


Precision: 3.95 cm (6.0)
Accuracy: 1.40 cm (3.0)
Prob. Detection: 0.87 (0.80)
False Alarm Ratio: 0.11 (0.10)
Heidke Skill Score: 0.61 (0.55)

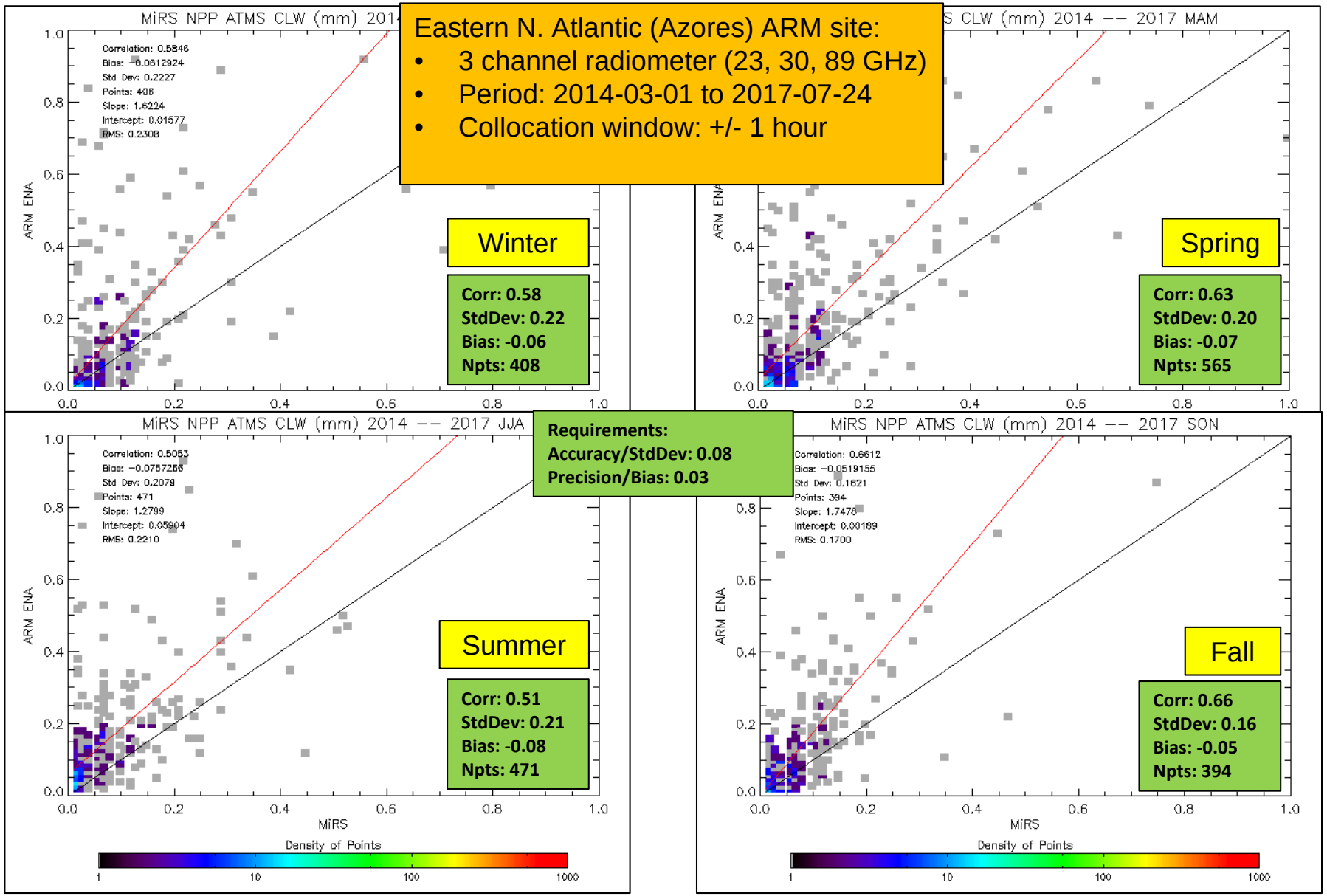


Precision: 3.86 cm (6.0)
Accuracy: 1.36 cm (3.0)
Prob. Detection: 0.94 (0.80)
False Alarm Ratio: 0.11 (0.10)
Heidke Skill Score: 0.68 (0.55)

Validation Results Summary: Snow Water Equivalent/Snow Cover



Example from NPP Validated maturity review: Validation of Oceanic Cloud Liquid Water: Collocation with ARM Ground-based Measurements



Snow cover and rain rate validation category

	Obs. Yes	Obs. No
MiRS Yes	a	b
MiRS No	c	d

Anna Ghelli, 2009: Verification of categorical predictands, The 4th International Verification Methods Workshop, 8-10 June 2009, Helsinki, Finland. (WMO/TD-No.1540 WWRP 2010-1)

- Probability of Detection (POD)
  POD = a / (a+c), range: 0~1, perfect score=1
- False Alarm Ratio
  FARatio = b / (a+b), range: 0~1, perfect score=0, for snow cover
- False Alarm Rate (Probability of False Detection)
  FARate = b / (b+d), range: 0~1, perfect score=0, for rain rate
- Heidke Skill Score (HSS)
  HSS = 2(ad-bc) / [(a+c)(c+d)+(a+b)(b+d)], range: -∞ ~ 1, perfect score=1