JPSS-1 ATMS implementation and surface emissivity improvement in NOAA Microwave Integrated Retrieval System (MIRS)

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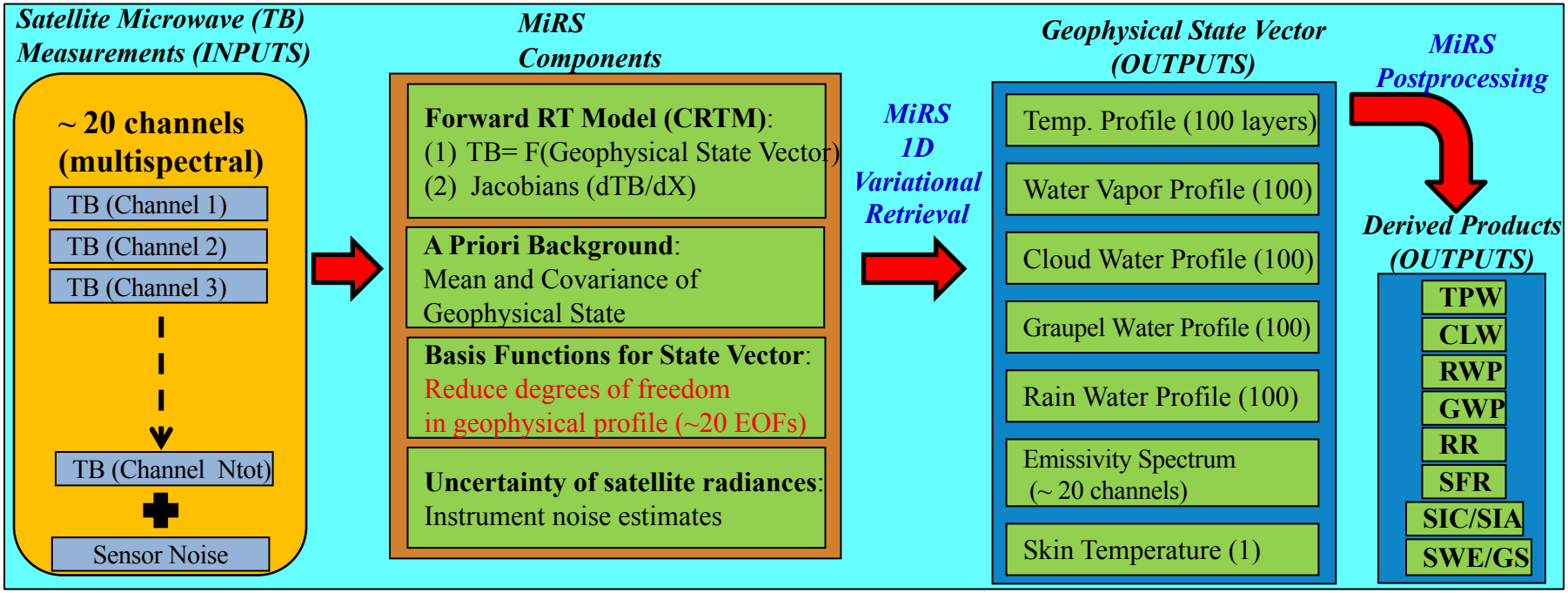
Outline

- MiRS algorithm
- MiRS readiness for JPSS-1 launch
- Land surface emissivity improvement and validation

MiRS Algorithm

MiRS is a 1DVAR retrieval system based on CRTM as the forward operator.
The column profile of T, WV, clouds and surface characters are simultaneously retrieved by minimizing below cost function:

$$J(X) = \left[\frac{1}{2}(X - X_0)^T \times B^{-1} \times (X - X_0)\right] + \left[\frac{1}{2}(Y^m - Y(X))^T \times E^{-1} \times (Y^m - Y(X))\right]$$



MiRS readiness for JPSS-1 launch

- The MiRS software is modified thoroughly to cooperate with the JPSS-1 (NOAA-20) ATMS data. Modification was done in MiRS GUI, shell scripts, Fortran, C++, IDL codes, end to end in 23 processing steps.

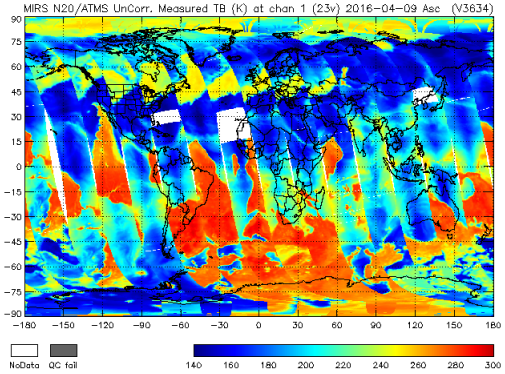
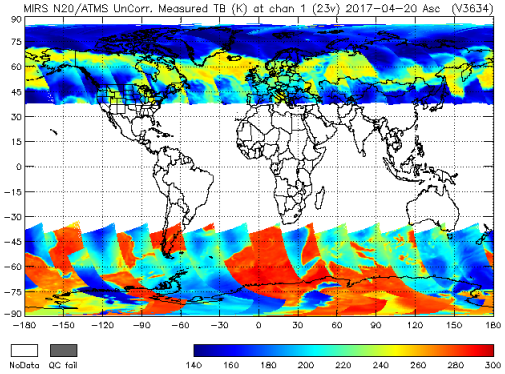
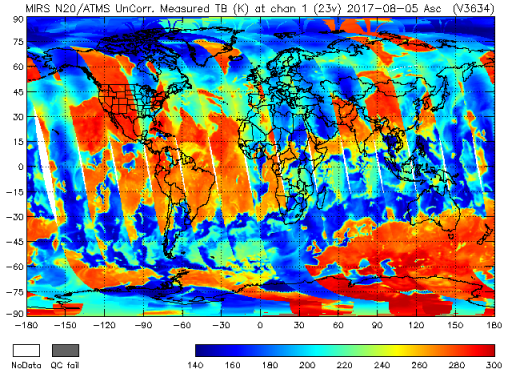
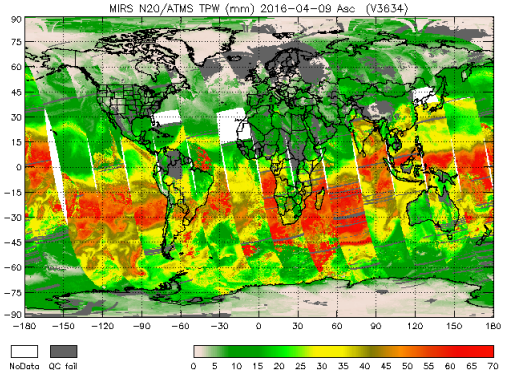
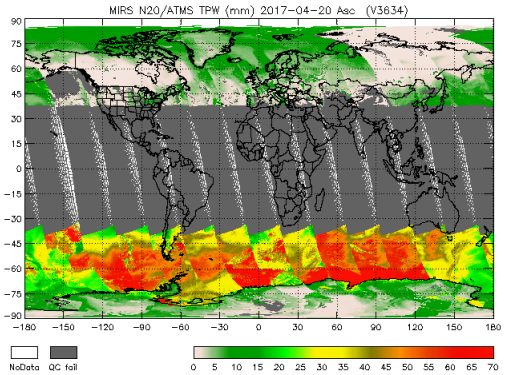
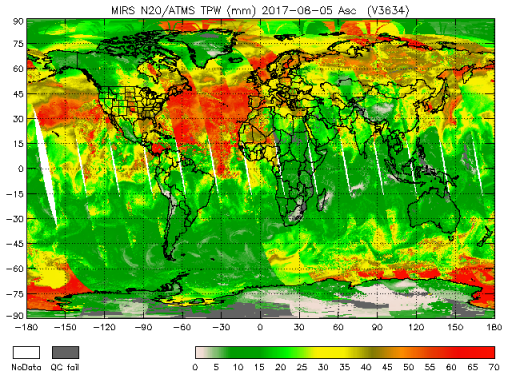
- Special treatments:
  - Satellite short name, J01 or N20?
  - Withhold the missing skyline solution, which is set to solve the missing skyline issue in NPP ATMS retrieval.

- The updated MiRS software was successfully tested with two kinds of proxy datasets, proxy data from Raytheon and in-house proxy data based on NPP ATMS data.

MiRS readiness for JPSS-1 launch

Testing with Raytheon proxy data

Raytheon provided a few versions of proxy data for algorithm testing. They are OK for code plumbing, but with blocks of misplaced or unrealistic values.

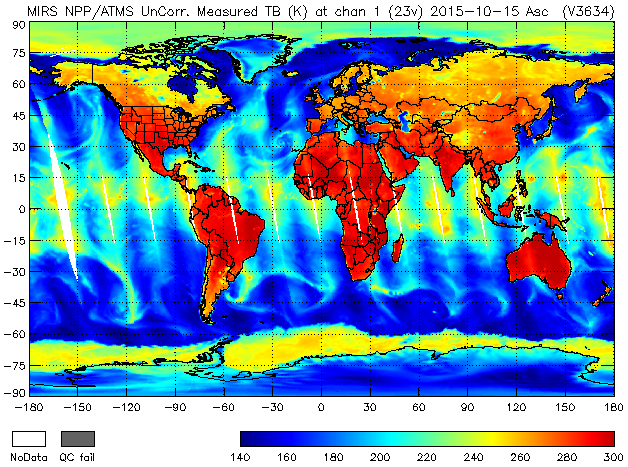
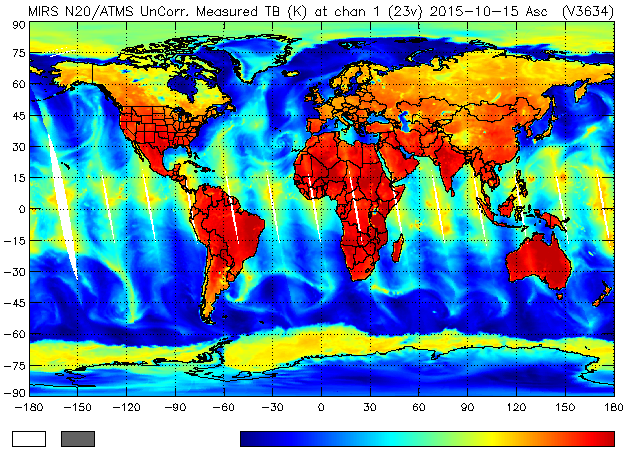
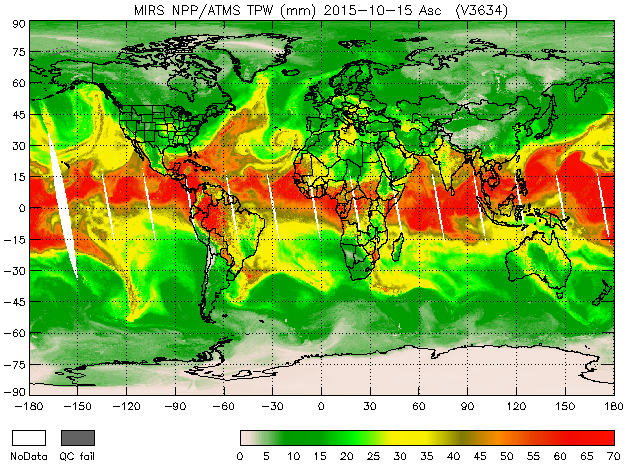
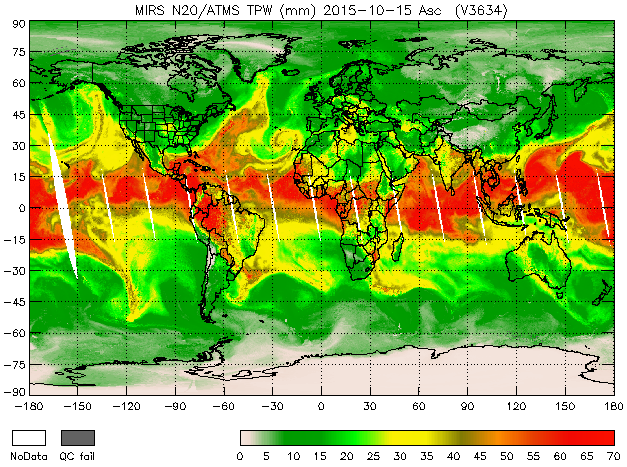
	2016-04-09	2017-04-20	2017-06-05
23V TB			
TPW			

MiRS readiness for JPSS-1 launch

Testing with in-house proxy data

We produced in-house JPSS-1 ATMS proxy dataset based on NPP ATMS data. The in-house hdf5 proxy data has the same data attributes and user blocks as Raytheon proxy data, but the datasets in hdf5 are filled with real NPP ATMS observations.

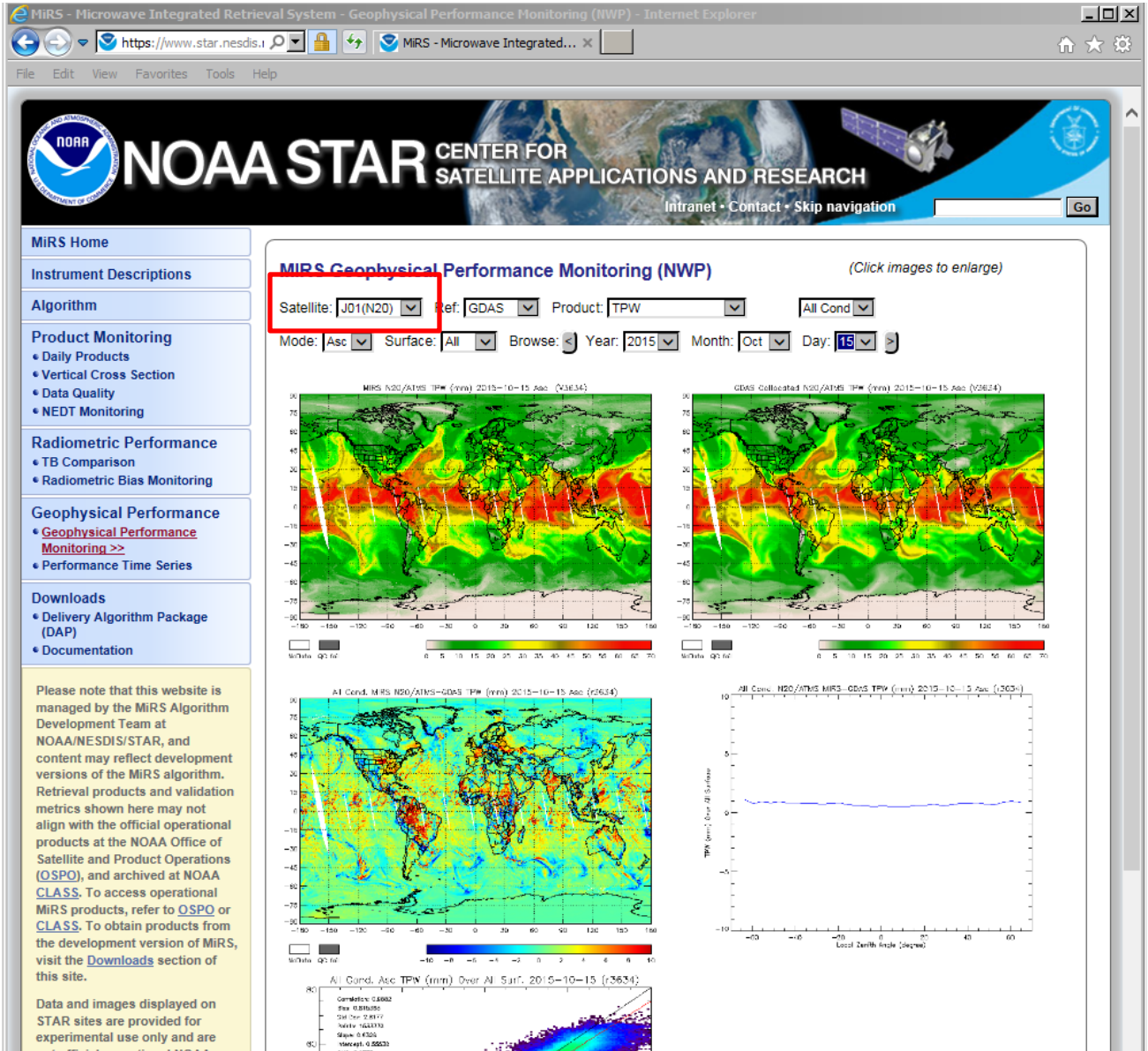
We tested the MiRS JPSS-1 implementation with both kinds of proxy data.

	2015-10-15 NPP/ATMS	2015-10-15 J01(N20)/ATMS
23V TB		
TPW		

MiRS readiness for JPSS-1 launch

Website is ready

MiRS website has also been updated, and is ready to intake and show the retrieval result based on JPSS-1 ATMS data.



Improve the land surface emissivity spectrum retrieval

How to validate the retrieved land surface emissivity?
Analytic emissivity based on ECMWF profiles and observed radiance

- 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:

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

The MiRS NPP ATMS emissivity retrieval could not meet the NOAA JPSS Algorithm Validation Requirement

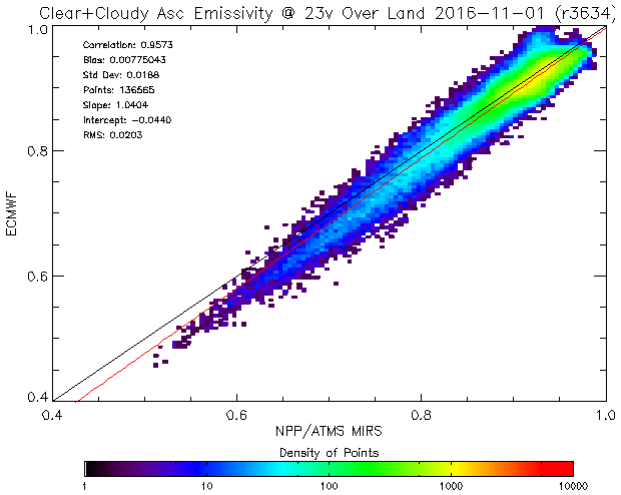
Product	Sfc	Condition	Freq (GHz)	Bias (%) (Accuracy)			StDv (%) (Precision)		
				MiRS	Thresh	Obj	MiRS	Thresh	Obj
Emissivity	Land	Clear+ Cloudy	23.8	**~0.009**	**0.020**	**0.013**	**~0.019**	**0.030**	**0.020**
			50.3	**~0.020**	**0.015**	**0.010**	**~0.030**	**0.030**	**0.020**
			165.5	**~0.041**	**0.015**	**0.010**	**~0.046**	**0.040**	**0.030**

Improve the land surface emissivity spectrum retrieval

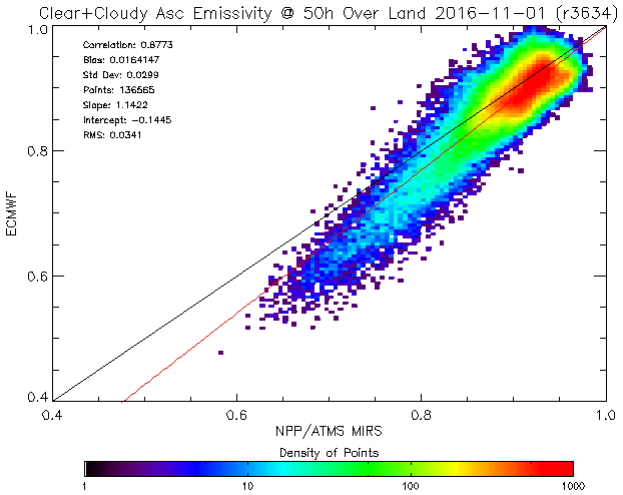
High biases in water vapor channels.

There are blank areas because low transmittance for water vapor channels makes it is hard to derive analytic emissivity.

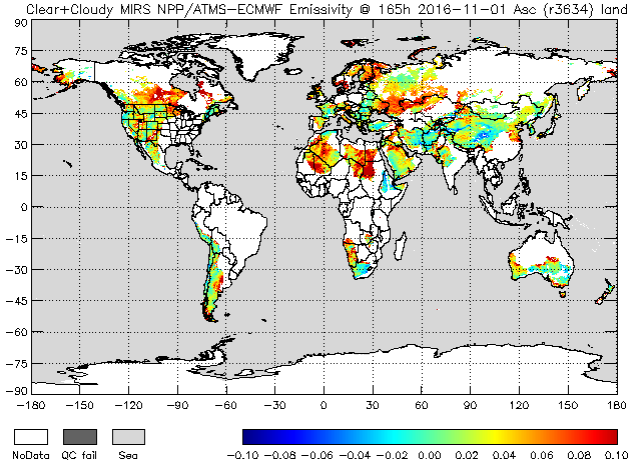
23V P2P



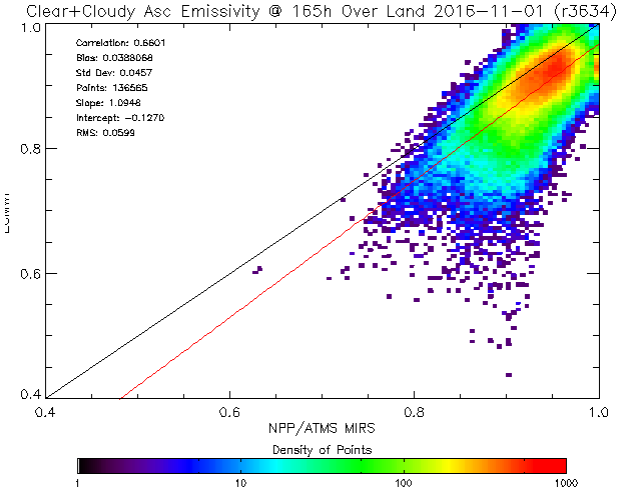
50H P2P



165H Bias



165H P2P



Improve the land surface emissivity spectrum retrieval

We noticed that the land surface emissivity background covariance has not been updated for a long time. It is worth to see if an update could improve the emissivity retrieval.

New surface covariance matrices: ECMWF analysis data in four dates, one in each season (2015-01-03, 2015-04-01, 2015-07-20, 2015-10-01), are used to generate an analytic emissivity dataset. Then **new surface covariance matrices** are generated based on the analytic emissivity data.

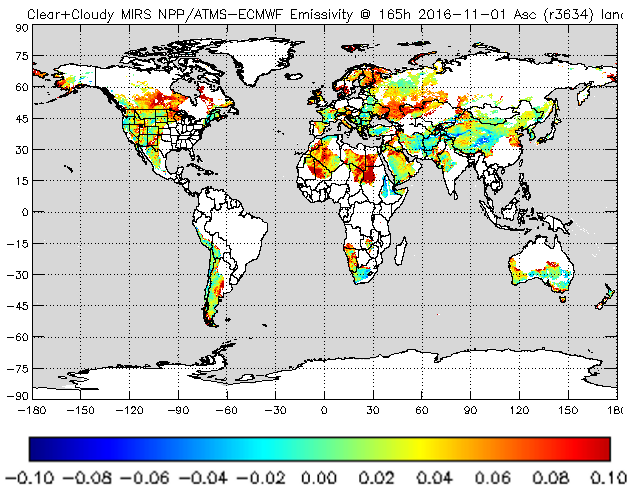
Extrapolation is applied to extend the analytic emissivity from low frequency channels to high frequency channels in case the high frequency emissivity could not be obtained because transmittance issue.

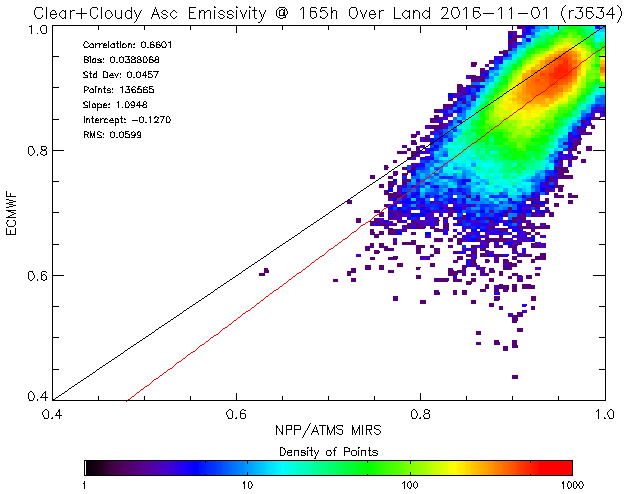
After the new surface covariance matrices are applied, the bias between MiRS retrieved emissivity and ECMWF analytic emissivity is largely removed.

165H Bias

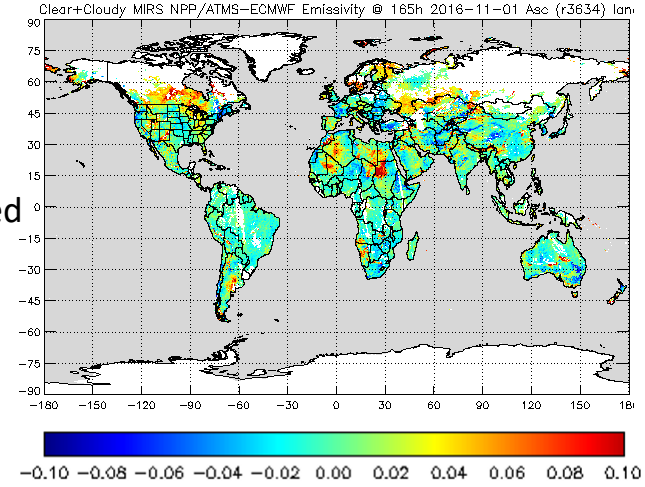
165H P2P

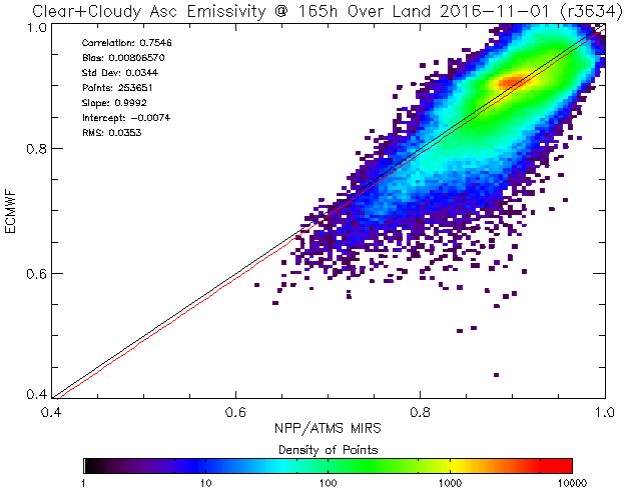
Before updated





After updated



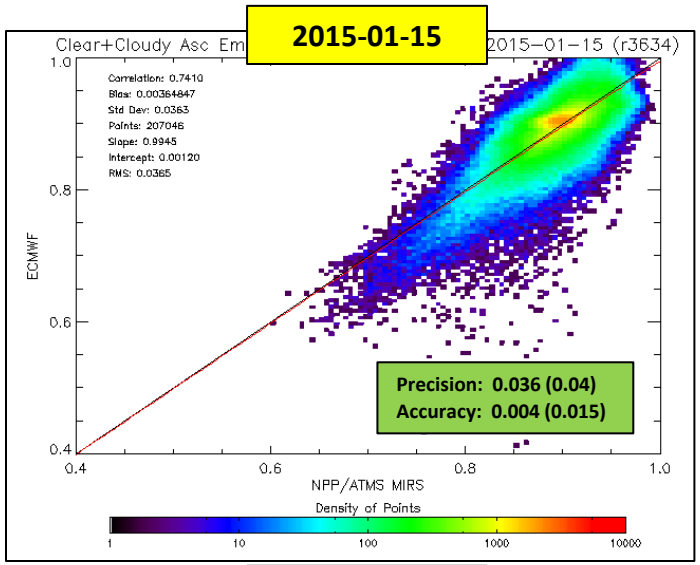


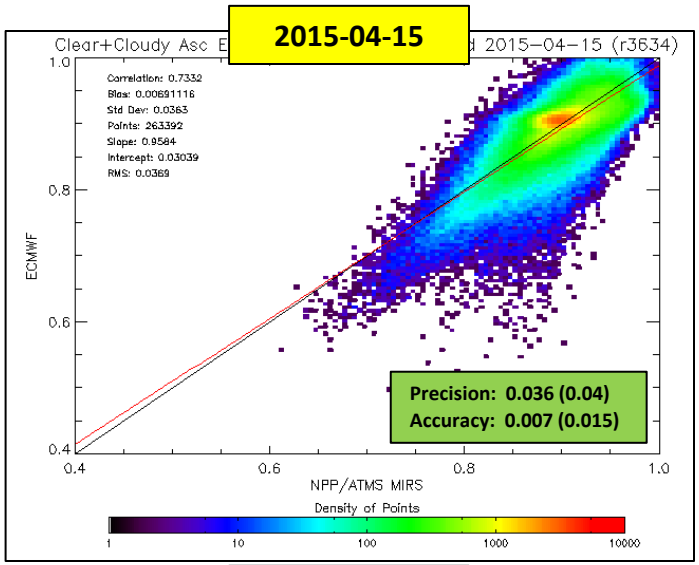
Improve the land surface emissivity spectrum retrieval

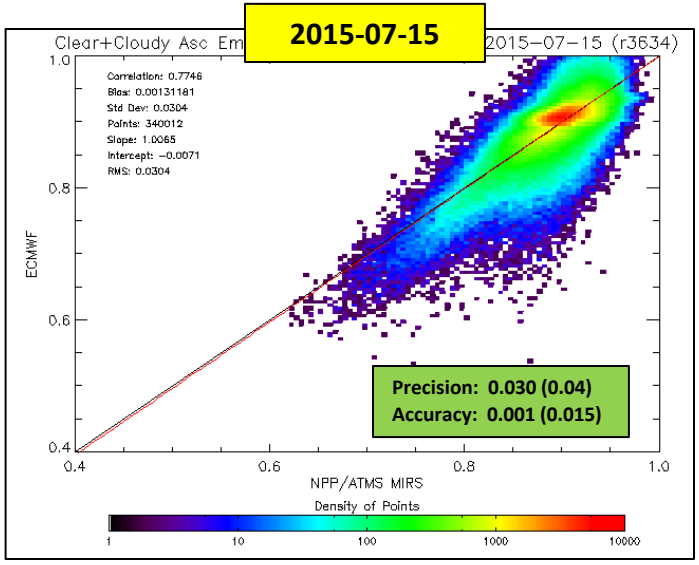
Systematic evaluation based on ECMWF analytic

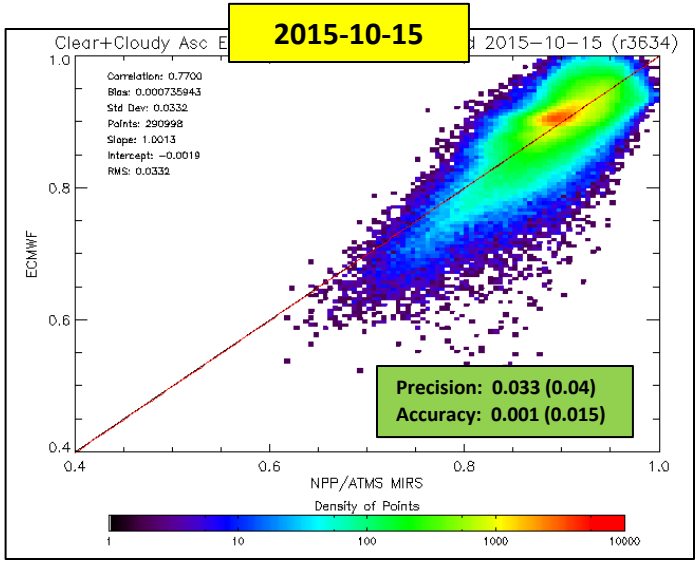
165H

Asc









Improve the land surface emissivity spectrum retrieval

Systematic evaluation based on ECMWF analytic

MiRS LSE Performance relative to analytic emissivity based on ECMWF

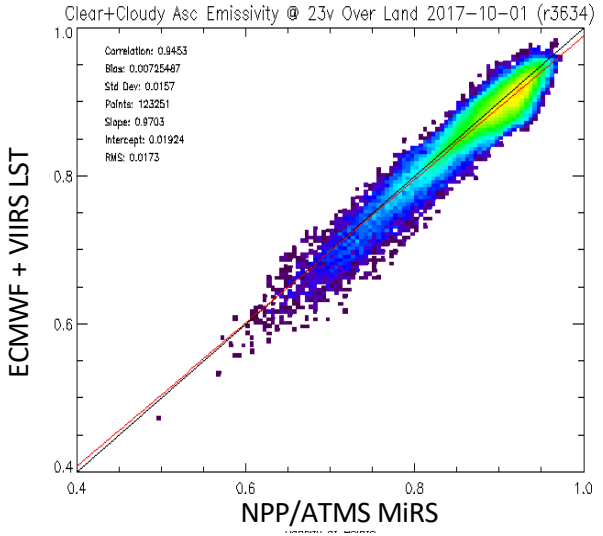
- Stable performance in different months/seasons.
- All threshold requirements met for all 3 channels; Accuracy objective requirements met.

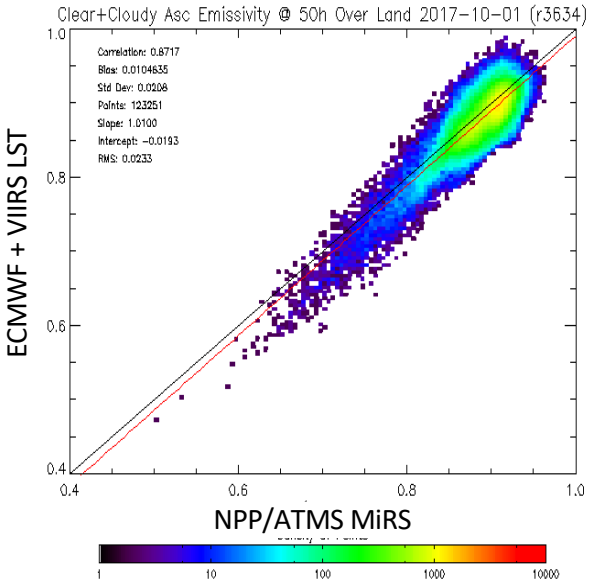
Date	Sfc	Condition	Freq (GHz)	Bias (%) (Accuracy)			StDv (%) (Precision)		
				MiRS	Thresh	Obj	MiRS	Thresh	Obj
2015-01-15	Land	Clear+ Cloudy	23.8	**0.002**	**0.020**	**0.013**	**0.023**	**0.030**	**0.020**
			50.3	**0.002**	**0.015**	**0.010**	**0.030**	**0.030**	**0.020**
			165.5	**0.005**	**0.015**	**0.010**	**0.037**	**0.040**	**0.030**
2015-04-15	Land	Clear+ Cloudy	23.8	**0.002**	**0.020**	**0.013**	**0.022**	**0.030**	**0.020**
			50.3	**0.003**	**0.015**	**0.010**	**0.030**	**0.030**	**0.020**
			165.5	**0.007**	**0.015**	**0.010**	**0.037**	**0.040**	**0.030**
2015-07-15	Land	Clear+ Cloudy	23.8	**0.003**	**0.020**	**0.013**	**0.021**	**0.030**	**0.020**
			50.3	**0.006**	**0.015**	**0.010**	**0.028**	**0.030**	**0.020**
			165.5	**0.003**	**0.015**	**0.010**	**0.031**	**0.040**	**0.030**
2015-10-15	Land	Clear+ Cloudy	23.8	**0.003**	**0.020**	**0.013**	**0.022**	**0.030**	**0.020**
			50.3	**0.005**	**0.015**	**0.010**	**0.029**	**0.030**	**0.020**
			165.5	**0.003**	**0.015**	**0.010**	**0.034**	**0.040**	**0.030**

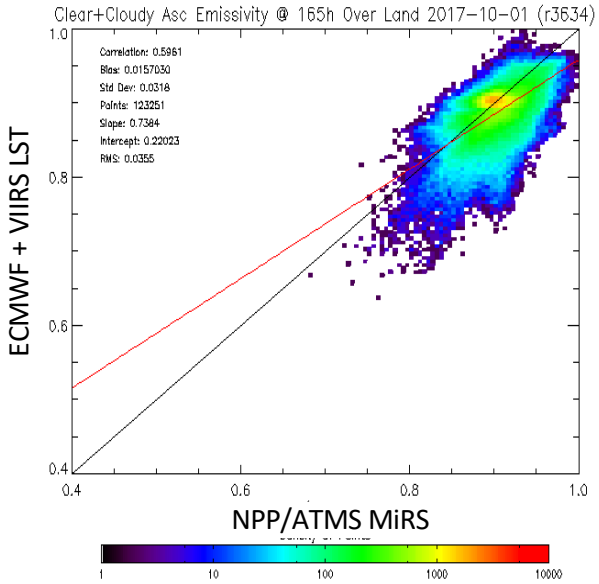
Improve the land surface emissivity spectrum retrieval

Systematic validation based on ECMWF + VIIRS LST analytic emissivity

In order to get another validation reference dataset, the ECMWF land skin temperature (model derived) is replaced with VIIRS observed land skin temperature in the calculation of analytic emissivity. The results are comparable in different channels with those based on ECMWF only analytic emissivity.







Improve the land surface emissivity spectrum retrieval

Systematic validation based on ECMWF + VIIRS LST analytic emissivity

Date	Sfc	Condition	Freq (GHz)	Bias (%) (Accuracy)			StDv (%) (Precision)		
				MiRS	Thresh	Obj	MiRS	Thresh	Obj
2017-01—01	Land	Clear+ Cloudy	23.8	**0.008**	**0.020**	**0.013**	**0.017**	**0.030**	**0.020**
			50.3	**0.012**	**0.015**	**0.010**	**0.023**	**0.030**	**0.020**
			165.5	**0.022**	**0.015**	**0.010**	**0.033**	**0.040**	**0.030**
2017-04-01	Land	Clear+ Cloudy	23.8	**0.007**	**0.020**	**0.013**	**0.017**	**0.030**	**0.020**
			50.3	**0.008**	**0.015**	**0.010**	**0.023**	**0.030**	**0.020**
			165.5	**0.019**	**0.015**	**0.010**	**0.031**	**0.040**	**0.030**
2017-07-01	Land	Clear+ Cloudy	23.8	**0.004**	**0.020**	**0.013**	**0.018**	**0.030**	**0.020**
			50.3	**0.006**	**0.015**	**0.010**	**0.024**	**0.030**	**0.020**
			165.5	**0.016**	**0.015**	**0.010**	**0.035**	**0.040**	**0.030**
2017-10-01	Land	Clear+ Cloudy	23.8	**0.007**	**0.020**	**0.013**	**0.016**	**0.030**	**0.020**
			50.3	**0.01**	**0.015**	**0.010**	**0.022**	**0.030**	**0.020**
			165.5	**0.015**	**0.015**	**0.010**	**0.030**	**0.040**	**0.030**

MiRS LSE Performance relative to ECMWF + VIIRS LST analytic emissivity

- Stable performance in different months/seasons.
- Except 165H bias marginally exceed the requirement, all other channels meet the requirement in both Bias and STDV, some meet the objective.

Summary

MiRS is ready for the launch of JPSS-1. Once the J01 (N20) ATMS data is available, the retrieval system will begin to work and the result will be shown on MiRS website without delay.

By updating the surface background covariance, the retrieved surface emissivity spectrum is largely improved. Systematical validations are done with two kind of references, ECMWF based analytic emissivity and ECMWF + VIIRS LST based analytic emissivity.