The impact of upgrading the background covariance matrices in NOAA Microwave Integrated Retrieval System (MiRS)

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Outline

- MiRS introduction
- Update the geophysical background covariance matrices based on EC-137 data set
- Validation based on dropsonde data and ECMWF analysis
- Conclusion

MiRS Introduction

The Microwave Integrated Retrieval System (MiRS) is the operational retieval system of NOAA/NESDIS. MiRS is a one-stop shop for retrieval products from various microwave instruments(AMSU/MHS, SSMI/S, ATMS, GMI) aboard different satellites (NOAA, MetOp, DMSP, S-NPP, JPSS, GPM) .

- The state vectors (Temp, Water Vapor, hydrometeor profiles, surface emissivity and skin Temp) are simultaneously retrieved by minimizing below cost function in a 1DVAR scheme with CRTM as the forward operator :

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

- Post processing generate derived surface products (TPW, CLW, RWP, IWP, RR, Sea Ice, SWE, SGS).

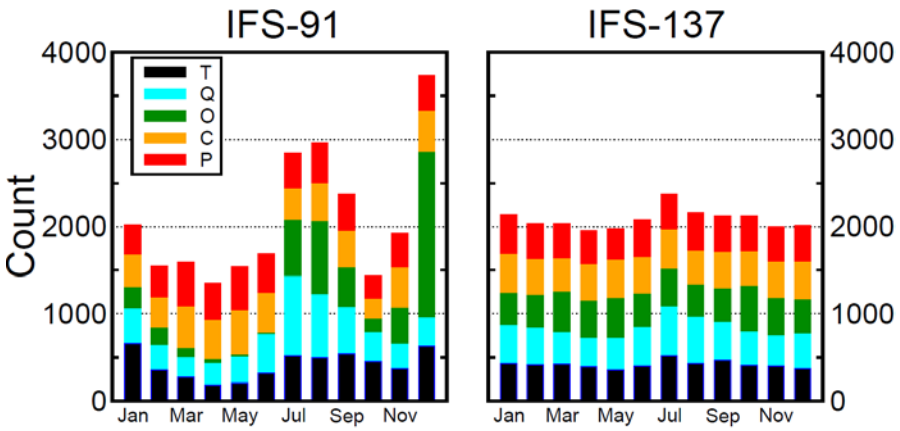
- Valid globally over all surface types in all weather conditions.

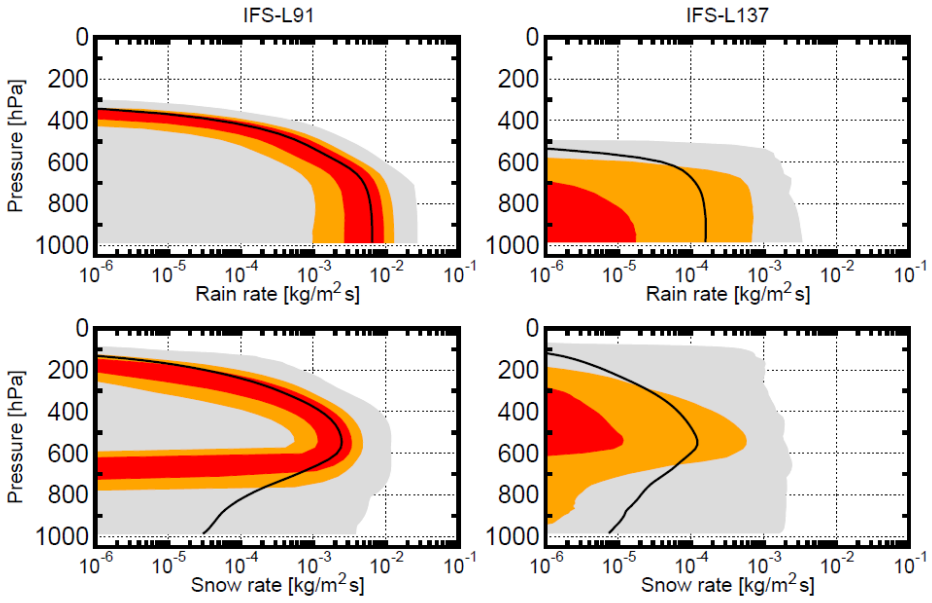
The Current Geophysical Background Covariance Matrix B is outdated

- Accurate background covariance matrices are essential in a variational retrieval system, like MiRS.
- The current covariance matrices were mainly built based on the ECMWF 60 layer sample data set (EC-60), Which was released in 2001 and based on the ECMWF analysis data at that time.
- In the recent decade or so, there are plenty of advances in global observation system, NWP model and data assimilation scheme to warrant ECMWF to produce two more generations of sample datasets, namely the 91-level (EC-91) and 137-level (EC-137) datasets.
- The newest dataset, EC-137, includes more parameters than its precedents, for example, the rain water content, which is an essential component of the MiRS background covariance matrix in rainy condition.

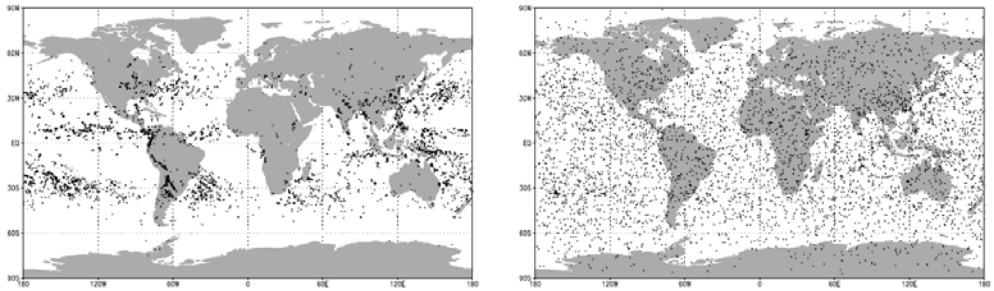
In the current MiRS background covariance matrix, the component of rain water content was generated based on MM5 simulation data, which is not necessarily consistent with the ECMWF analysis data for other parameters.

The characters of EC-137 dataset





The EC-137 dataset is more evenly distributed in both temporal and spatial domains. The vertical profiles has significant different distribution than its precedents.

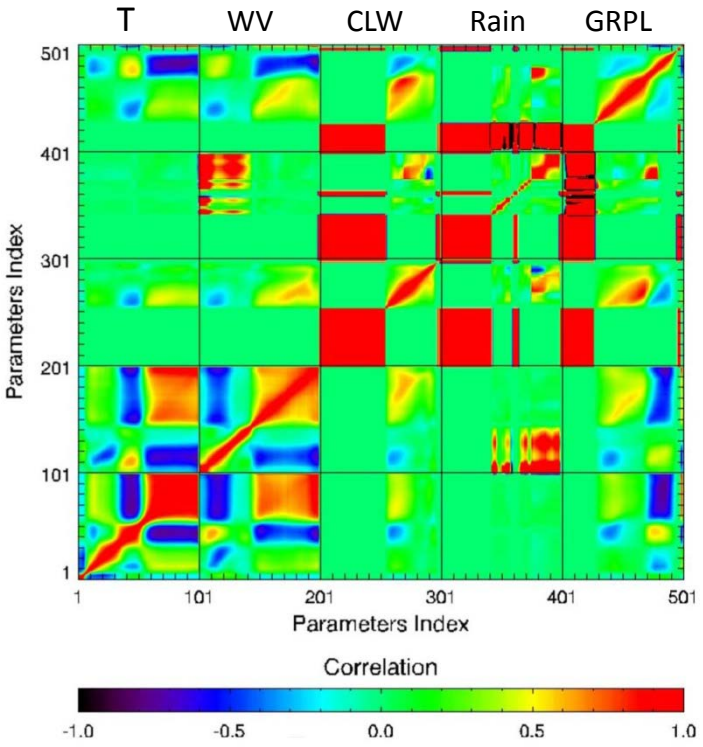


http://nwpsaf.eu/site/software/atmospheric-profile-data/

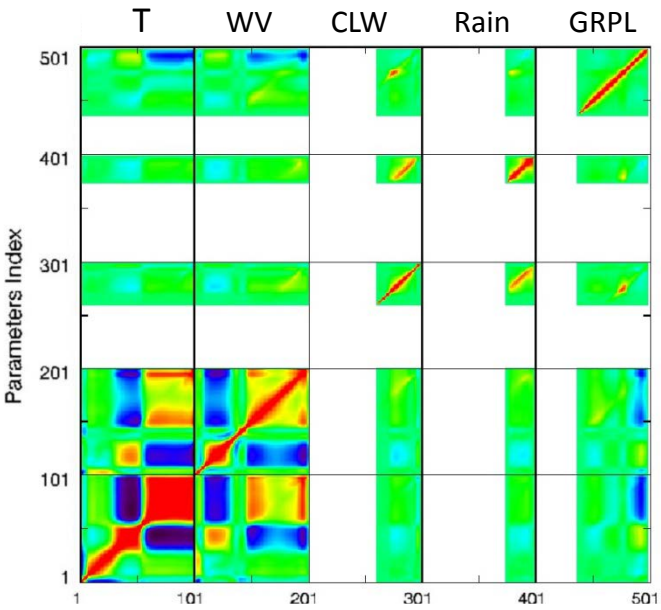
Courtesy of Reima Eresmaa and Anthony P. McNally, ECMWF, Shinfield Park, Reading, RG2 9AX, United Kingdom

Update Covariance Matrices

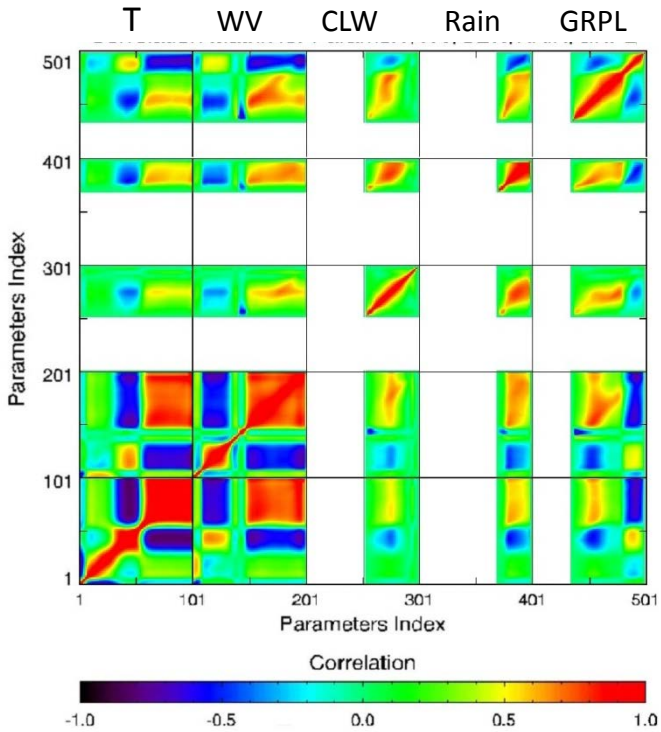
- Precip and Non-Precip conditions are separated
- In new matrices, the covariance between rain and other variables becomes meaningful.



Old over Sea



New non-precip over Sea

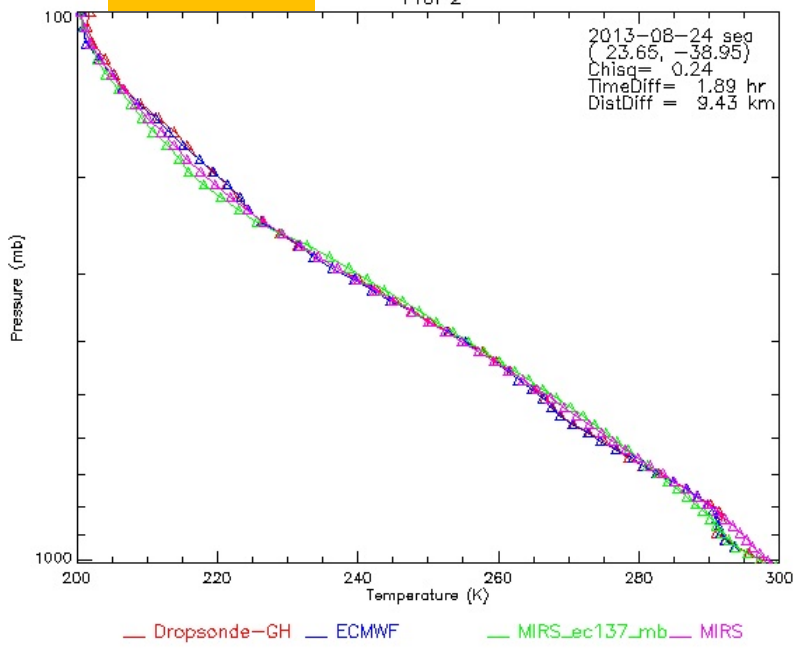


New precip over Sea

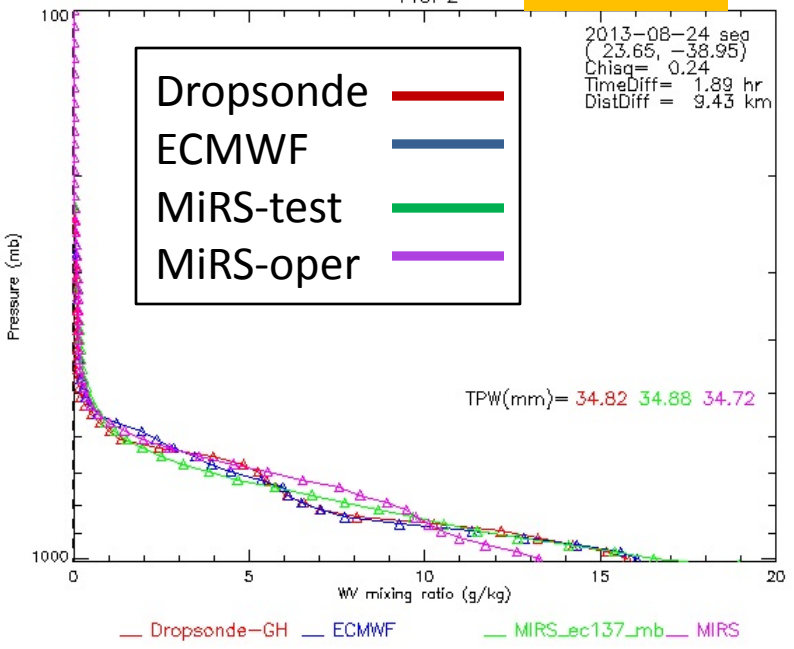
Validation after the new covariance matrices implemented

Validation is conducted by inter-comparing the MiRS NPP ATMS retrievals with the new/old covariance matrices, the collocated NASA/NOAA 2013-2014 HS3 Dropsonde data, and ECMWF analysis.

Temperature



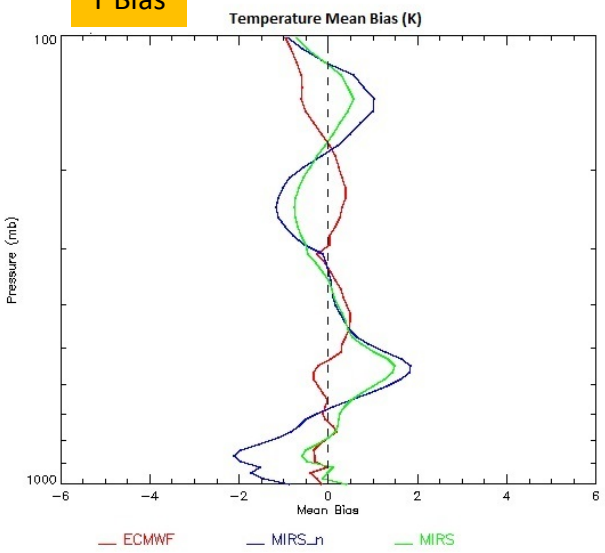
Water Vapor



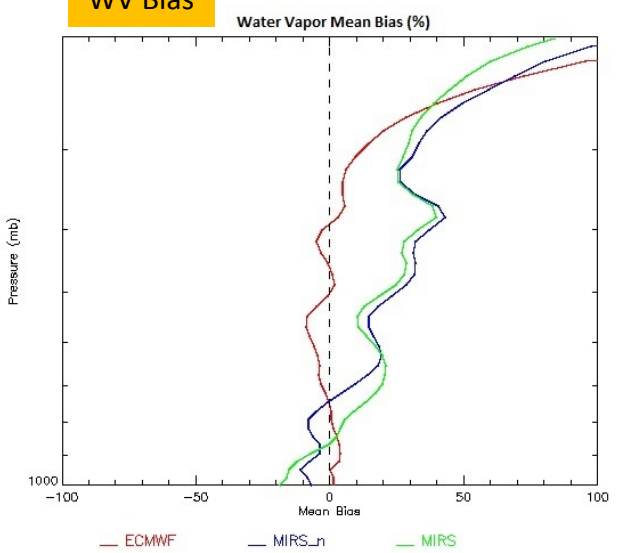
Statistic refer to dropsonde

Although only 38 collocated HS3 dropsonde profiles are identified in 2013-2014, the statistic still tell us: ECMWF is quite close to the HS3 dropsonde measurement, so could be used as an alternative reference.

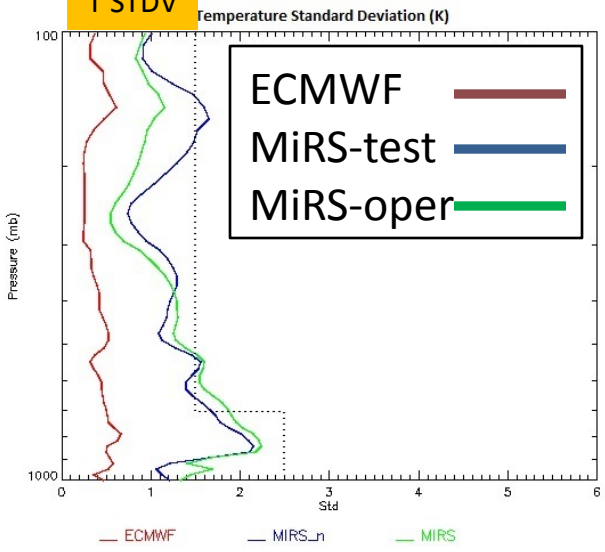
T Bias



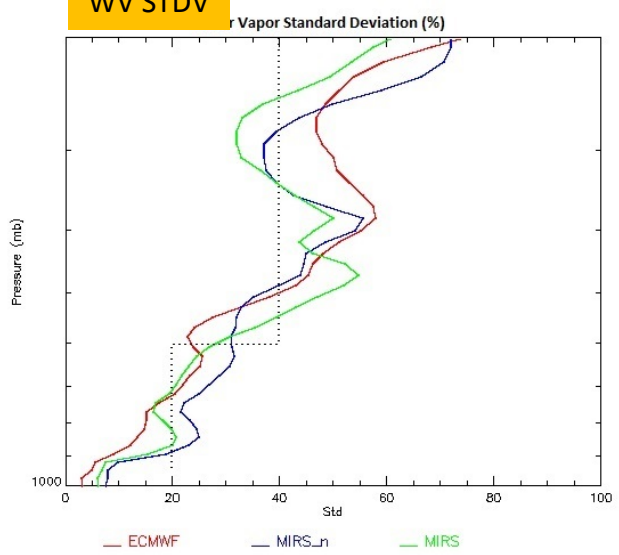
WV Bias



T STDV

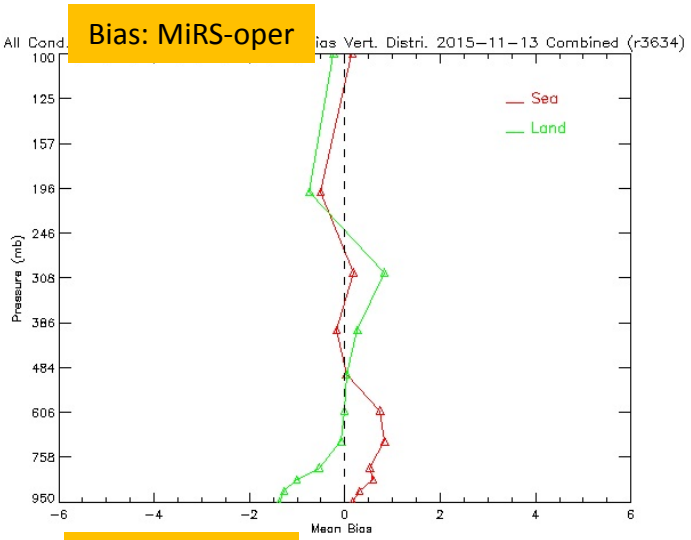


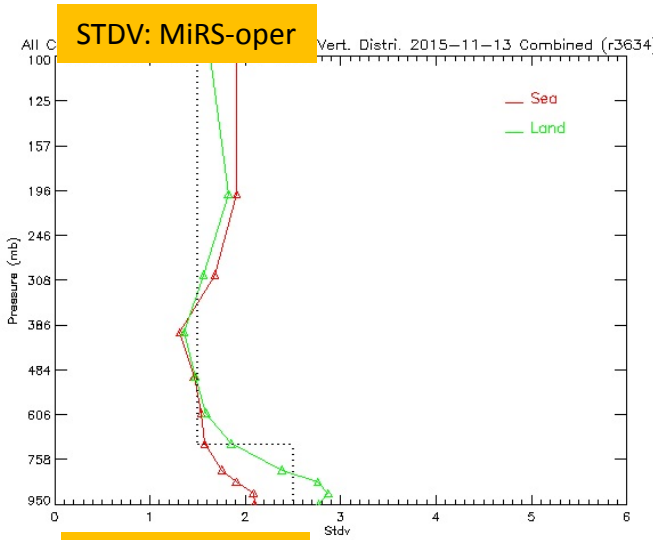
WV STDV

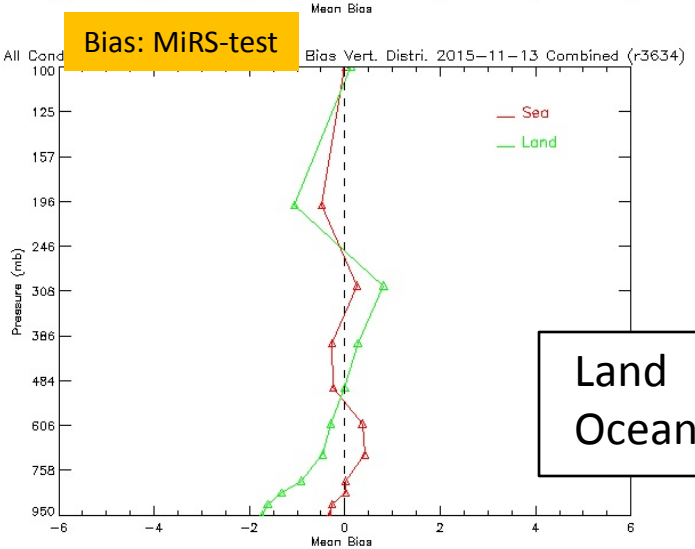


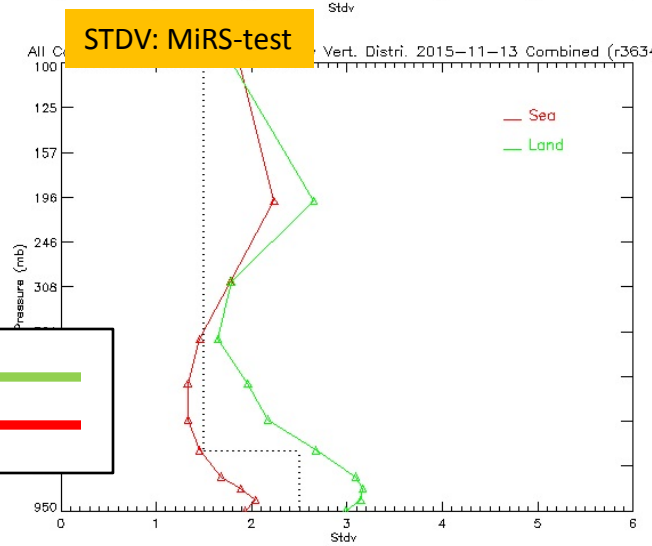
Global all Condition T Statistic refer to ECMWF

- One day global ATMS retrievals, comparison with ECMWF analysis on 11/13/2015.
- Noticeable improvement over ocean





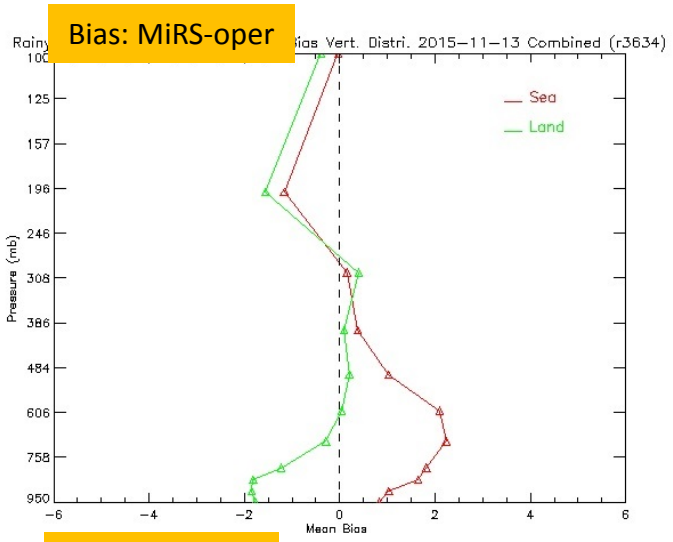


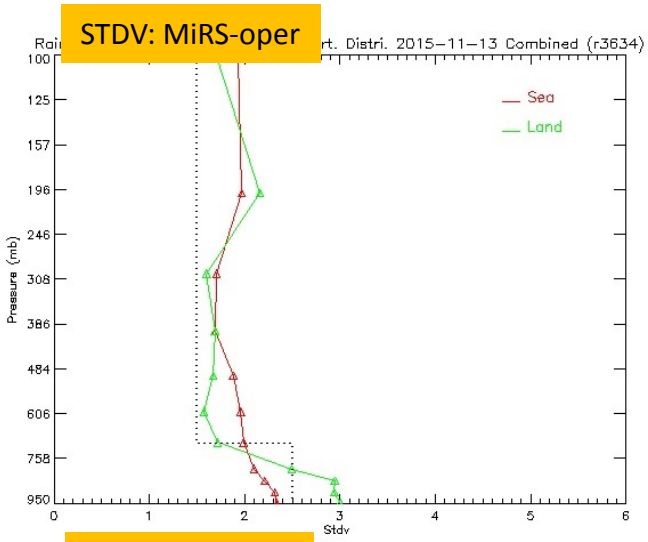


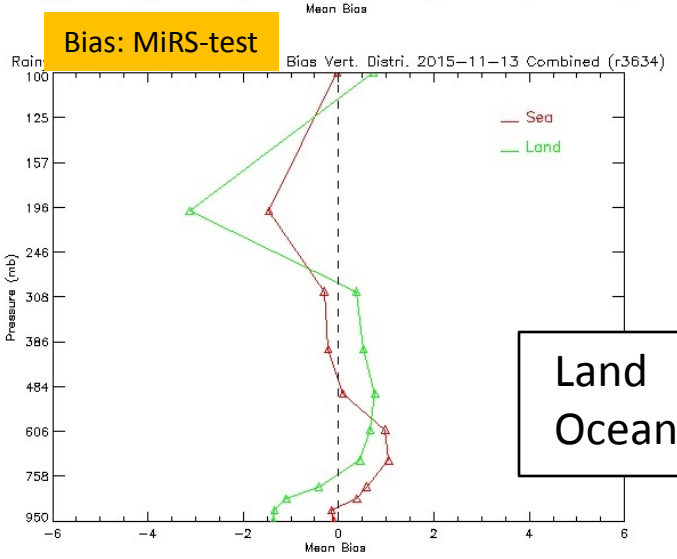
Land
Ocean

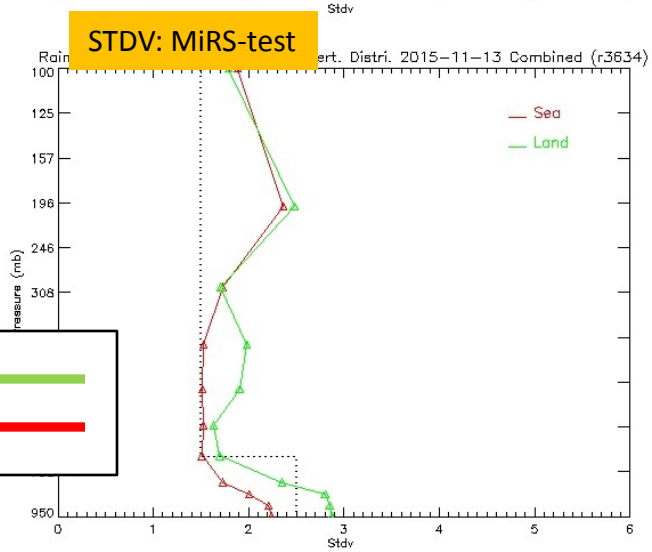
Global Rainy T Statistic refer to ECMWF

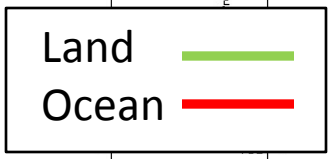
Significant improvement in Rainy condition over ocean in both T bias and STDV





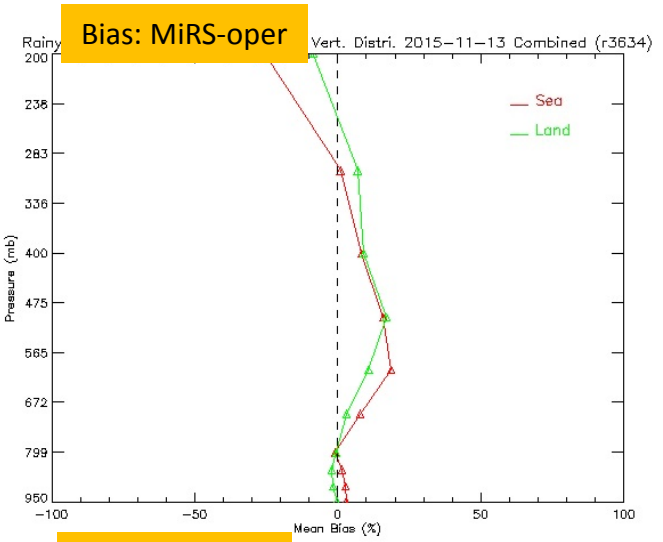


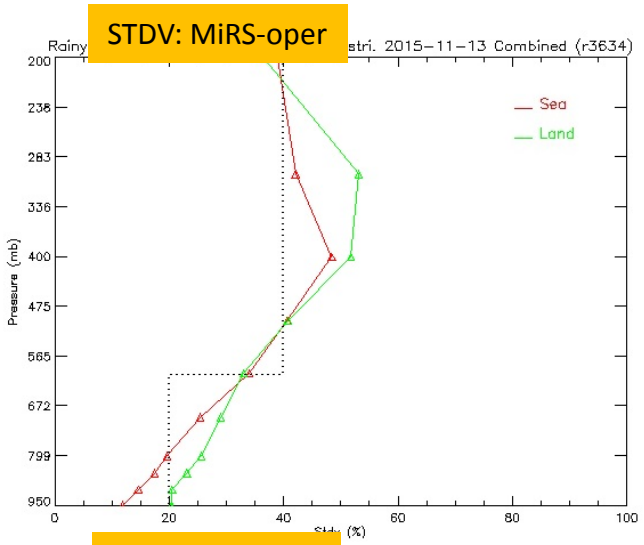


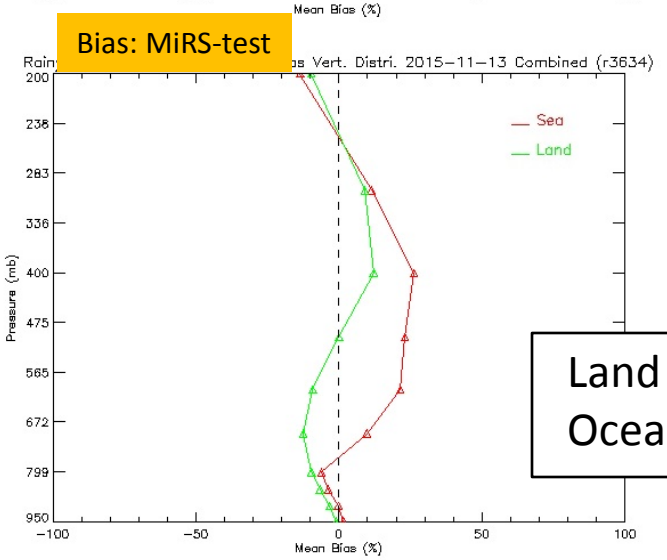


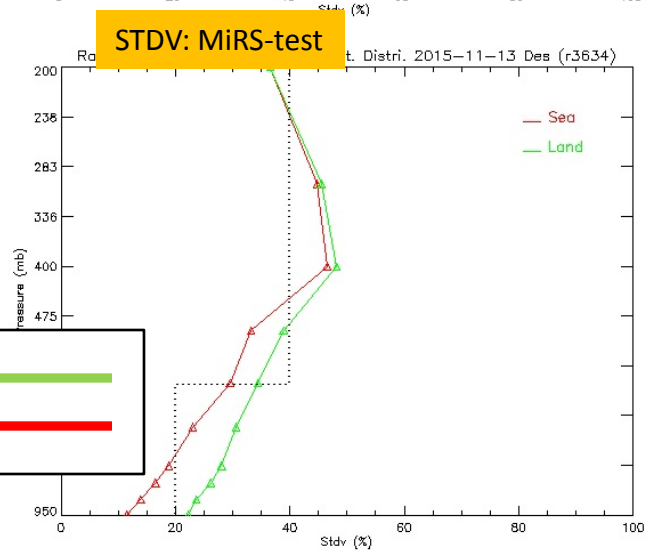
Global Rainy Over Sea WV Statistic refer to ECMWF

No significant improvement in Rainy condition over ocean in WV profile bias and STDV





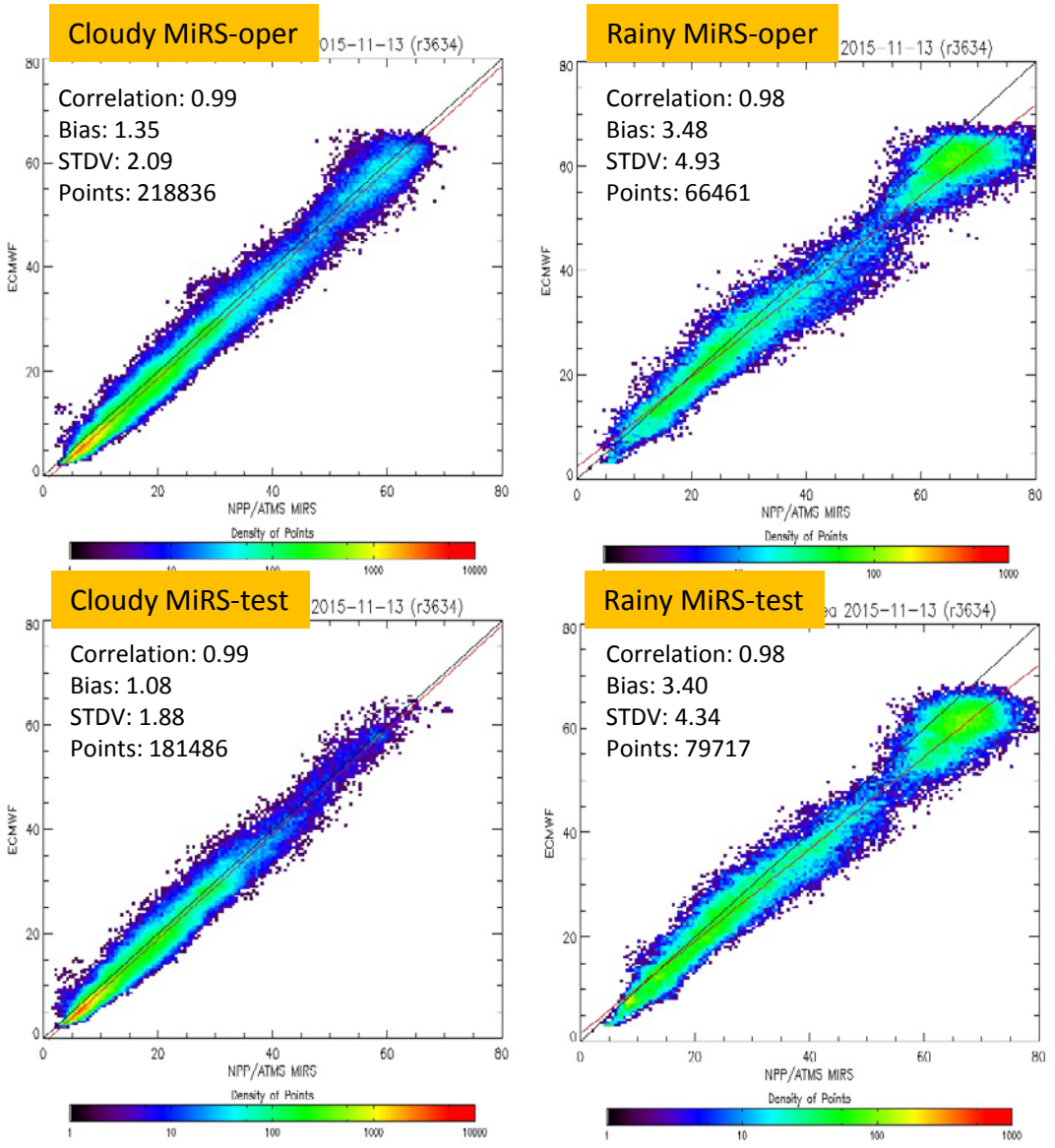




Land
Ocean

Over Ocean MiRS-ECMWF TPW scatter plots

- Significant improvement in TPW in both Cloudy and Rainy conditions over ocean
- Migrated some high TPW case from Cloudy to Rainy



Conclusion

- Upgrading the Geophysical Background Covariance Matrices based on the EC-137 dataset improves the atmospheric T and WV retrieval in MiRS.
- The most significant improvement is in rainy condition over sea.

Future work

- Tune the system with the new covariance matrices.
- Additional validation based on more sonde data.
- More comprehensive validation based on ECMWF analysis in different season and different climate zone.
- Apply the new background covariance matrices for other instruments.