MiRS Science Improvements and ATMS Sounding Products

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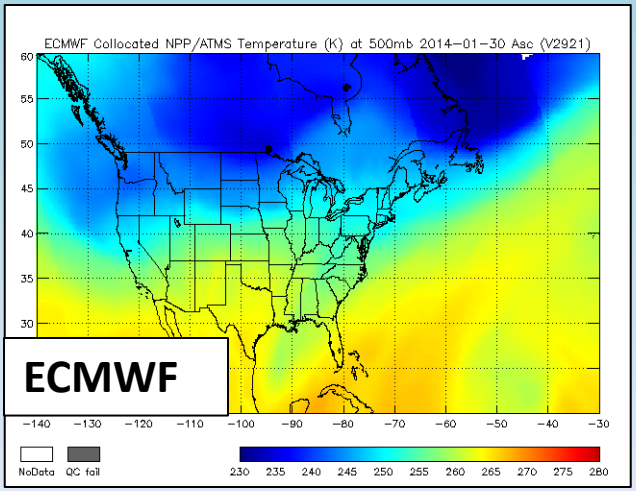
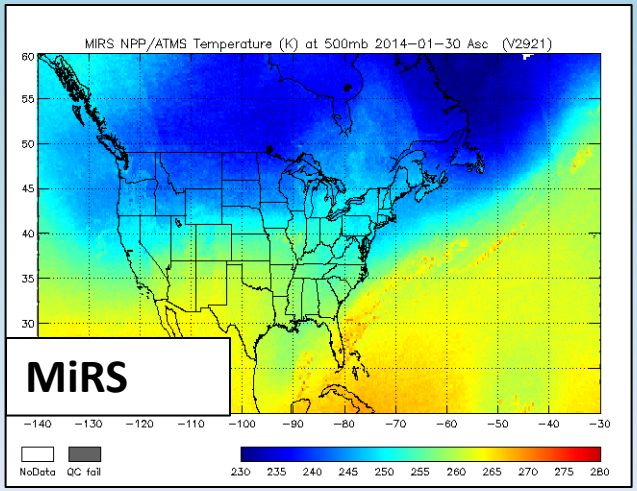
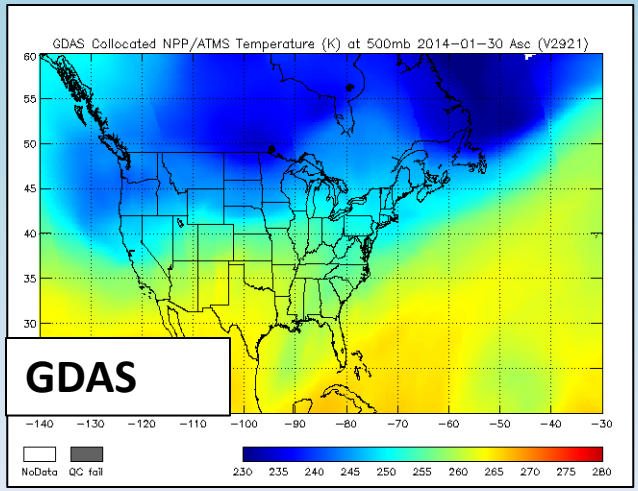






Outline

- MiRS Description
- Technical/Science Improvements
- Performance Comparisons (SNPP/ATMS)
- Applications
- Summary/Plans

MiRS Description

MiRS Key Features:

- 1D-Variational Approach; consistent across sensors
- Cost Function measures fit to observations, and departure from a priori background
- All elements of state vector retrieved simultaneously (T(p), q(p), clw(p), rwp(p), iwp(p), Tskin, emissivity(freq)
- Derived products from core retrieval: TPW, RR, cryospheric products
- Retrieval in reduced EOF space
- Uses CRTM for forward and Jacobian computation
- SW architecture: same common set of underlying modules; facilitates extension to new sensors

MiRS Sensors

- Running operationally at NOAA (OSPO):
  - o N-18, N-19, [Metop-A], Metop-B (hr) AMSU/MHS, [F16], F18 SSMI/S,
  - o S-NPP ATMS (delivered to NDE/OSPO late 2012, operational Feb 2014),
  - o Megha-Tropiques SAPHIR (delivered in March 2014)
- Experimentally run at STAR:
  - o TRMM TMI, GCOM-W1 AMSR2, planned GPM GMI
- Currently being extended to F17, (eventually F19)

MiRS Assessments

- In STAR, all operational satellites/sensors run daily
- Routine monitoring and assessments include comparisons with:
  - o GDAS, ECMWF, raobs (T, q, LST)
  - o Surface rain gauges, TMI 2A12, CPC daily (RR)
  - o F17 NRT (NASA Team) and NIC/IMS, OSI-SAF (sea ice)
  - o SNODAS, GlobSnow, JAXA/AMSR2 (SWE)
- Results posted to website
  - o http://www.star.nesdis.noaa.gov/smcd/mirs
- Retrieval product files available via website and ftp
  - o Last 7 days: N18, N19, MetopA, MetopB, SNPP, F18

MiRS Science and Technical Improvements: **CRTM**

- **All prior MiRS DAPs used an early version of CRTM (pCRTM)**
  - Good performance generally, but
  - Extension to new sensors was cumbersome (coefficient file format differences)
  - Leveraging improvements and fixes to CRTM difficult
- **New CRTM (2.1.1) implemented in MiRS for all sensors in STAR test environment; evaluation and tuning ongoing (may go to 2.1.3)**
- **Testing nearly compete and will be part of next official MiRS release in Summer 2014**
- **CRTM 2.1.x:**
  - Complete overhaul of interface
  - More sophisticated representation of hydrometeor data structures (rain, ice, graupel, snow) and the simulation of scattering effects, ocean surface reflection
- **Incorporating improvements, fixes, new sensors within MiRS will be much simpler**

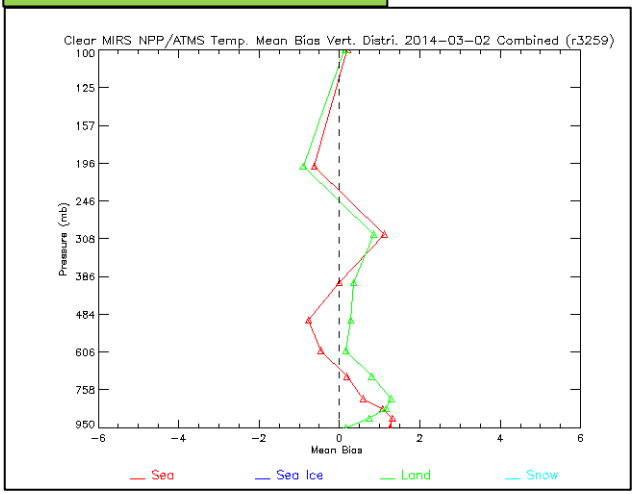
MiRS Science and Technical Improvements: **Background Constraint**

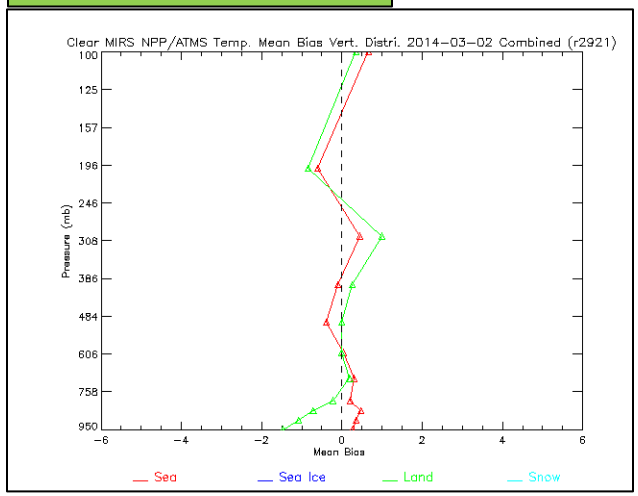
- MiRS (operational) currently utilizes a priori state vectors and error covariances based on a global climatologies tied to surface types
- New “dynamic” background developed
- Based on 1 year of ECMWF analyses (2012)
- Atmospheric Background (**mean T, q, clw**) stored on a smoothed 5 x 5 deg grid, with temporal variation by month, and diurnally (**covariances** still global)
- Additional smoothness within MiRS (interpolation to FOV location in space and time)
- Already part of the operational MiRS for MT/SAPHIR (v10.0); will be operational for all sensors in next release

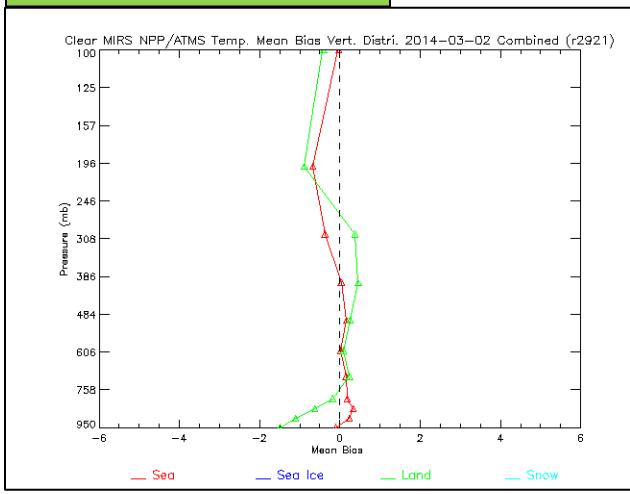
MiRS Sounding Performance Assessments:
Temperature Profile

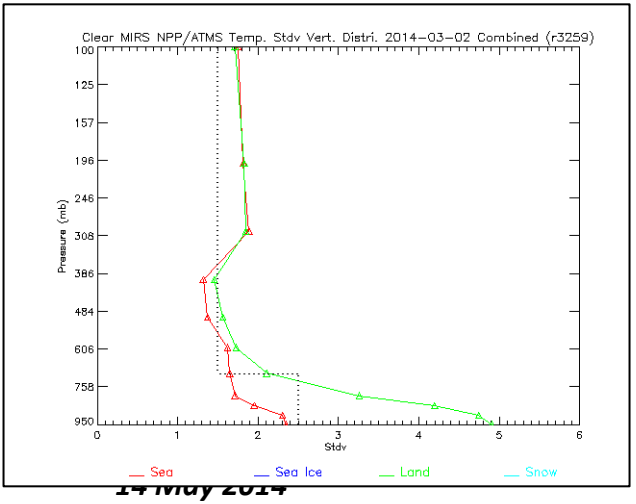
2014-03-02: Global

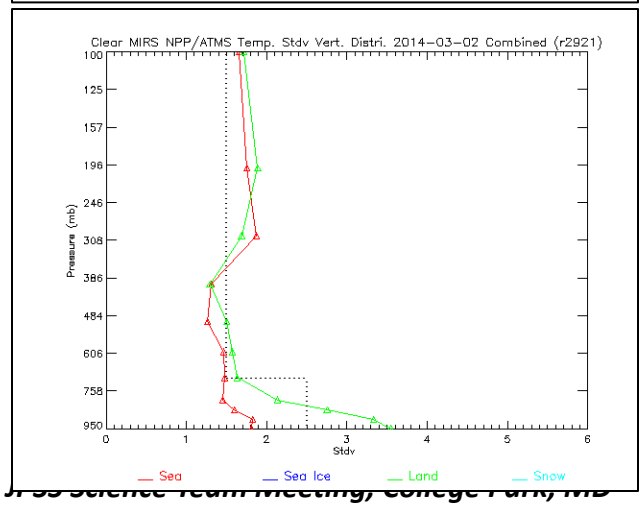
Operational MiRS	Test MiRS	Test MiRS
MIRS- ECMWF	MIRS- ECMWF	MIRS- GDAS

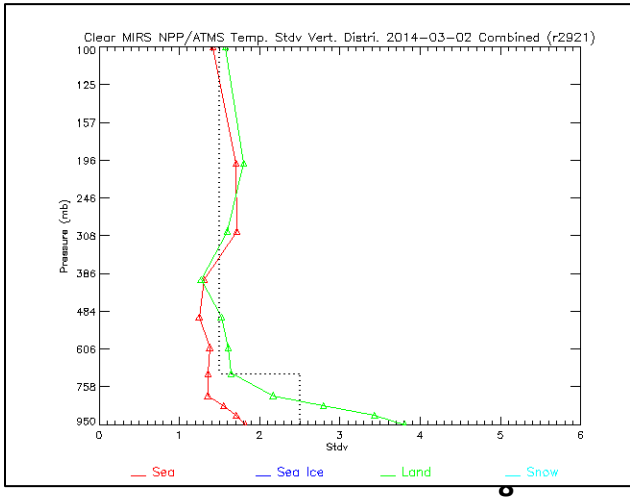








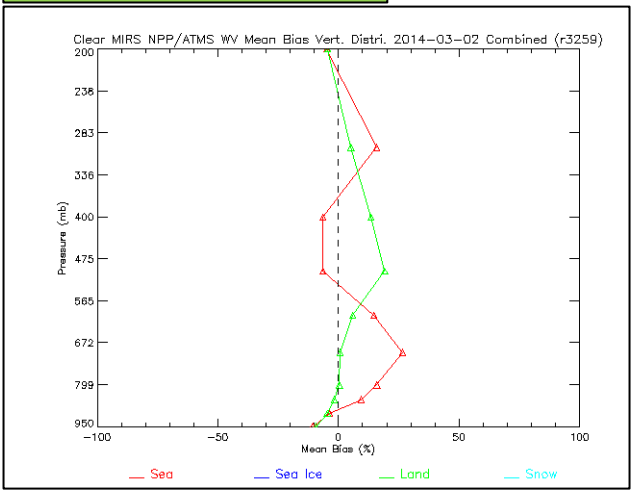


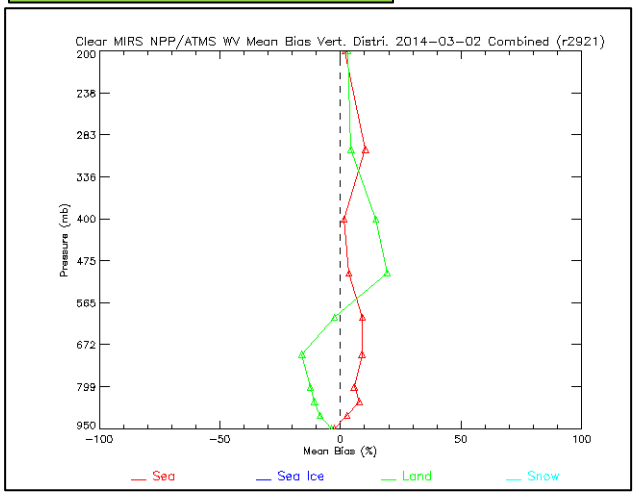


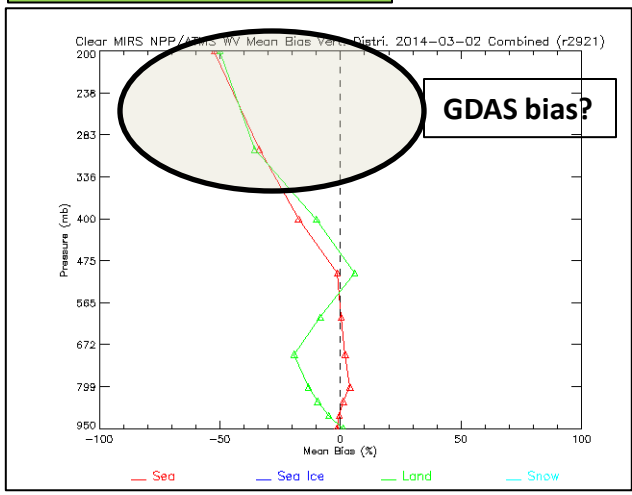
MiRS Sounding Performance Assessments:
Water Vapor Profile

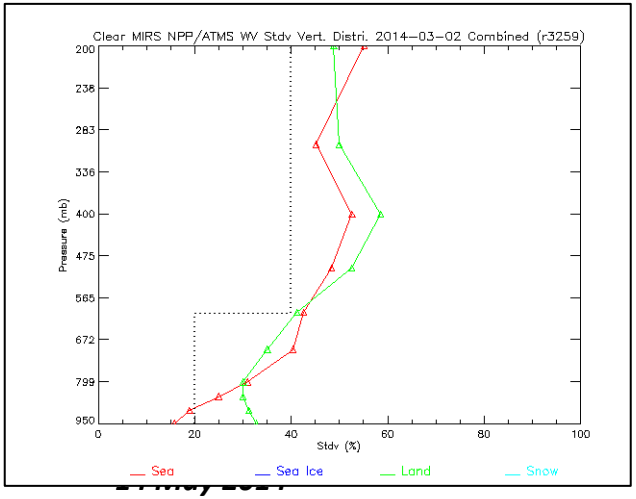
2014-03-02: Global

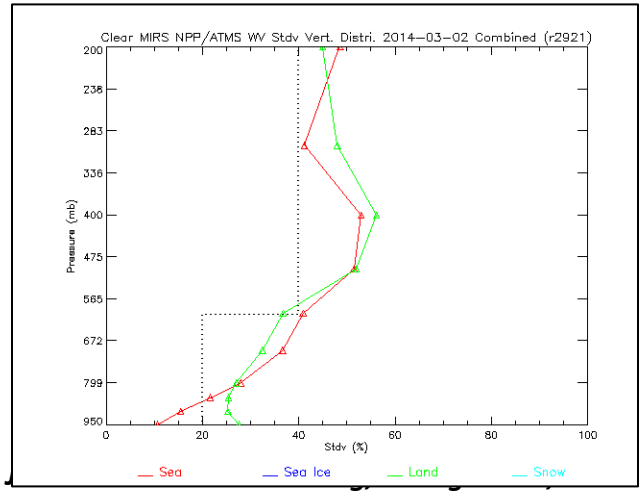
Operational MiRS	Test MiRS	Test MiRS
MIRS- ECMWF	MIRS- ECMWF	MIRS- GDAS

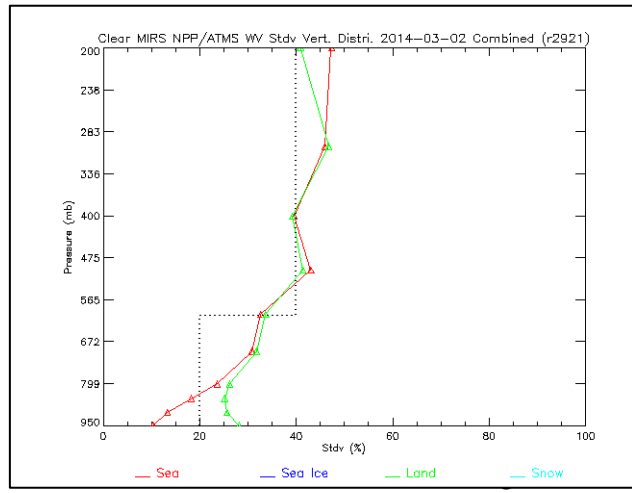




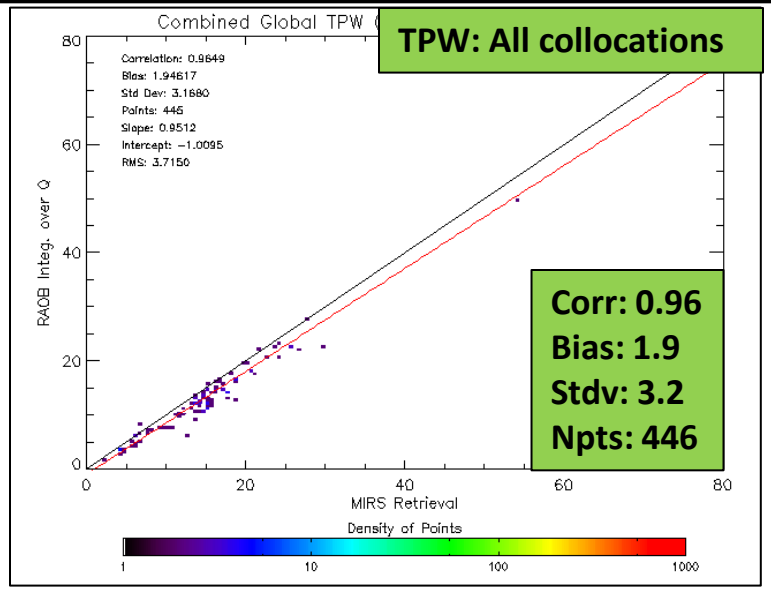








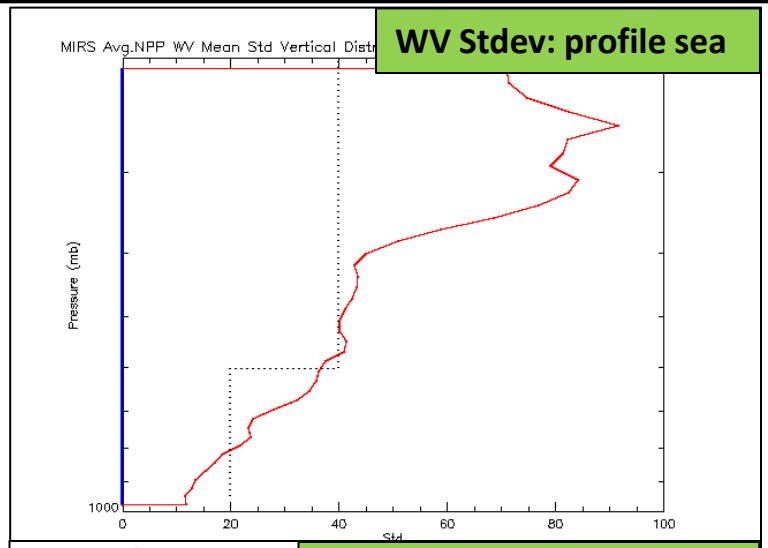
Raob vs. GDAS Analysis:
TPW, WV, Temperature



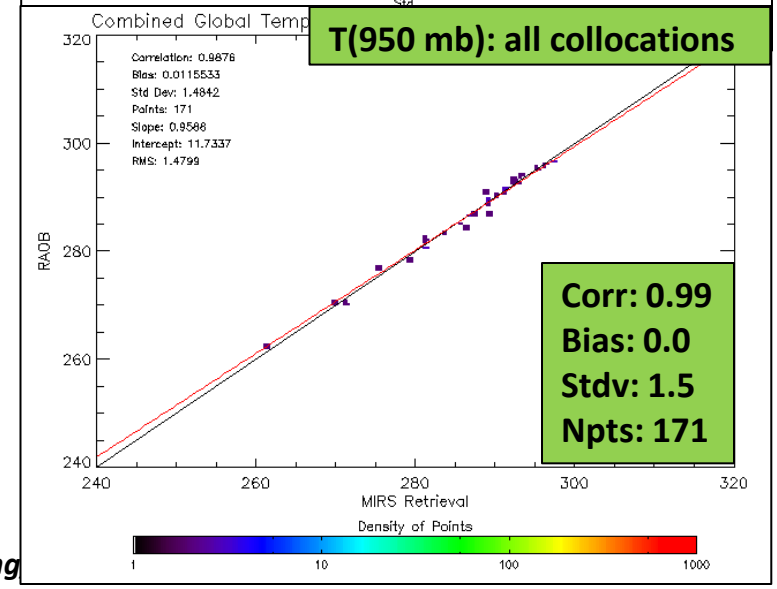
TPW: All collocations

Corr: 0.96
Bias: 1.9
Stdv: 3.2
Npts: 446

Collocations on 2014-05-10



WV Stdev: profile sea



T(950 mb): all collocations

Corr: 0.99
Bias: 0.0
Stdv: 1.5
Npts: 171

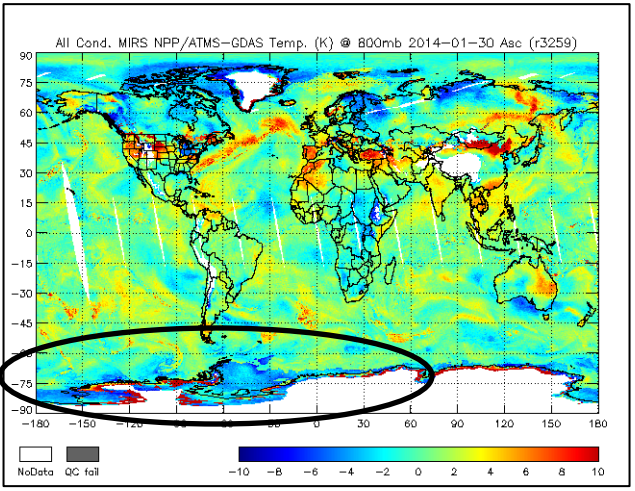
MiRS Sounding Performance Assessments:

800 hPa Temperature

2014-01-30: Global

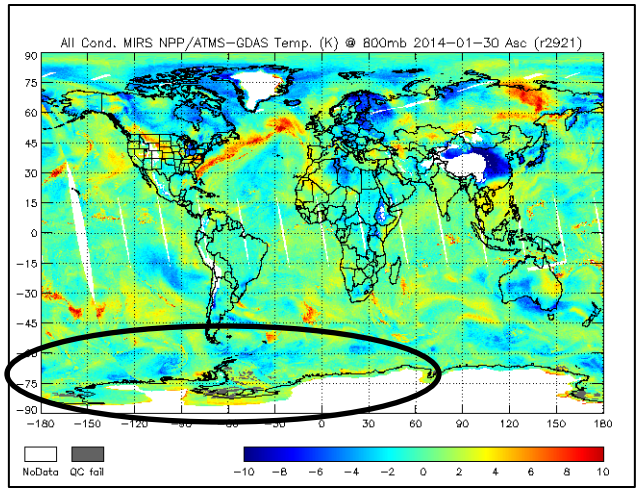
Operational MiRS

MIRS- GDAS

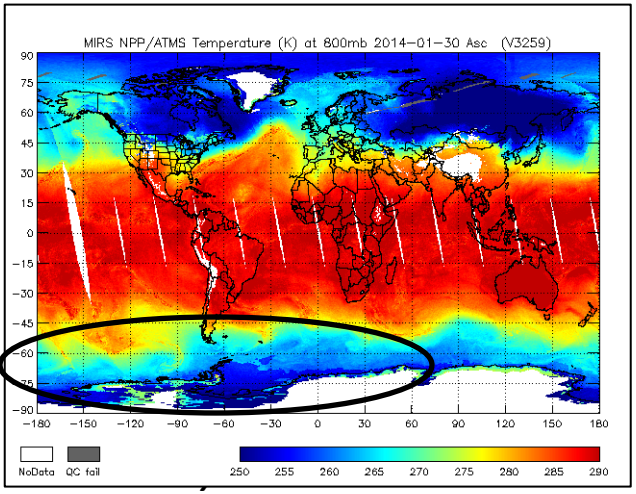


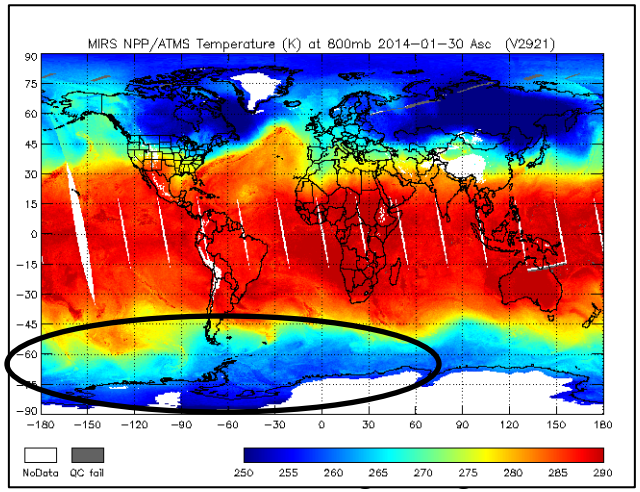
Test MiRS

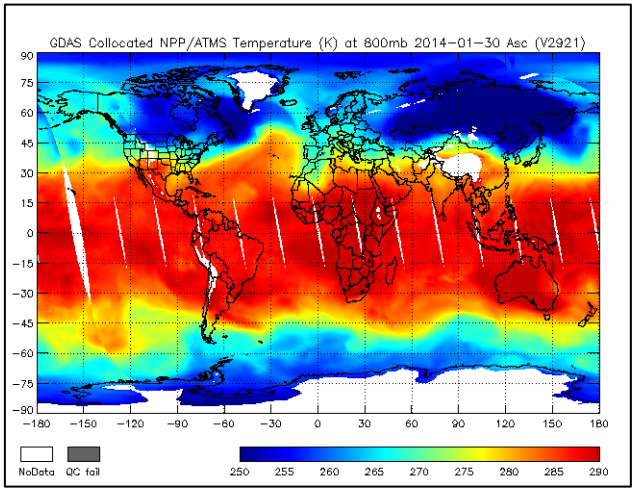
MIRS- GDAS



- Reduction in bias over all surface types
- Better consistency near Antarctic sea ice



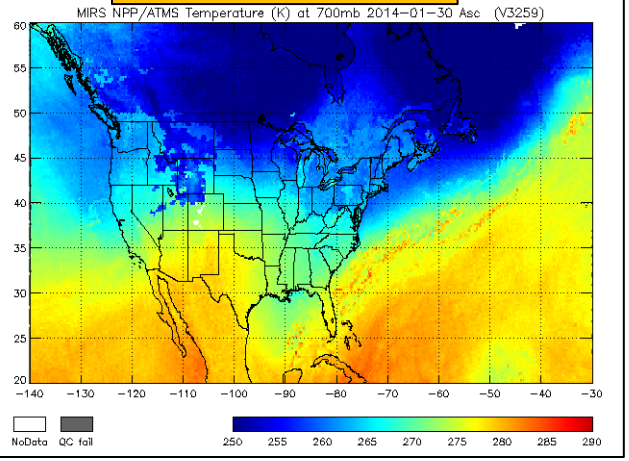




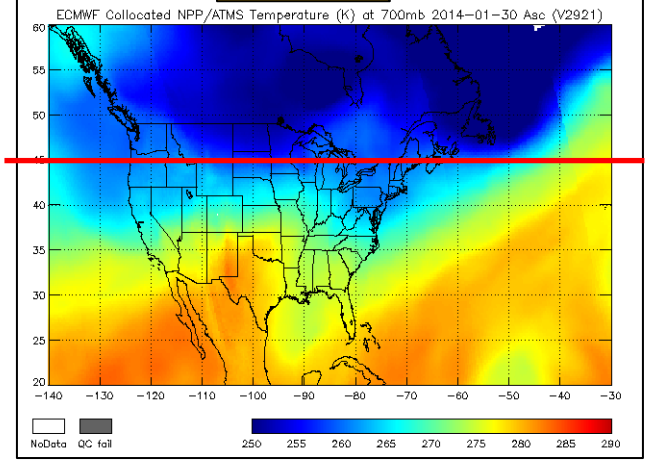
MiRS Sounding Performance Assessments:
700 hPa Temp, and Cross-sections

2014-01-30

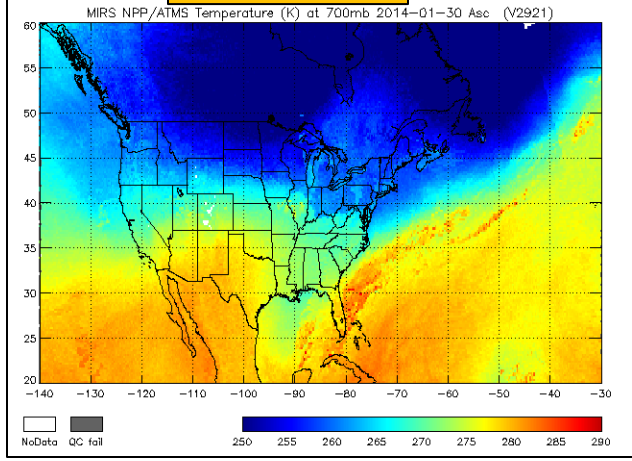
Operational MiRS

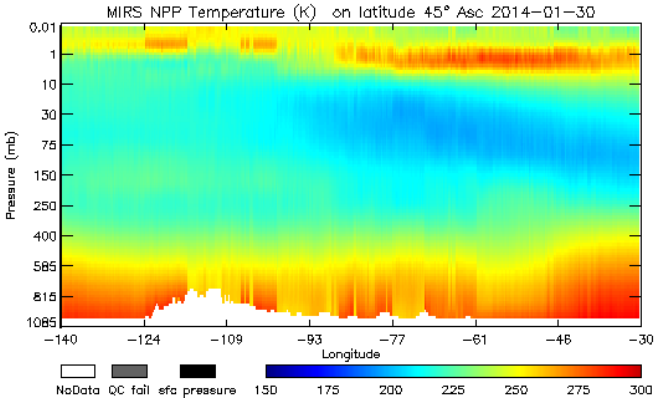


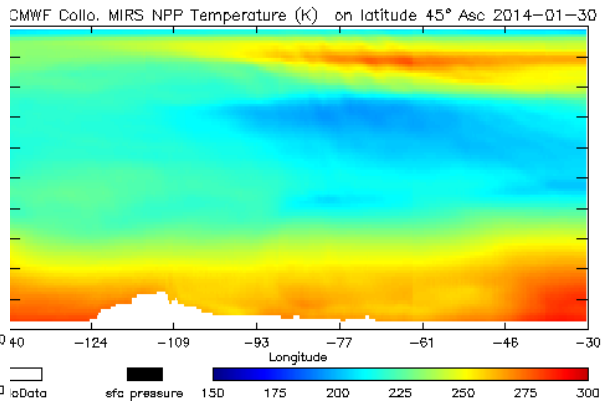
ECMWF

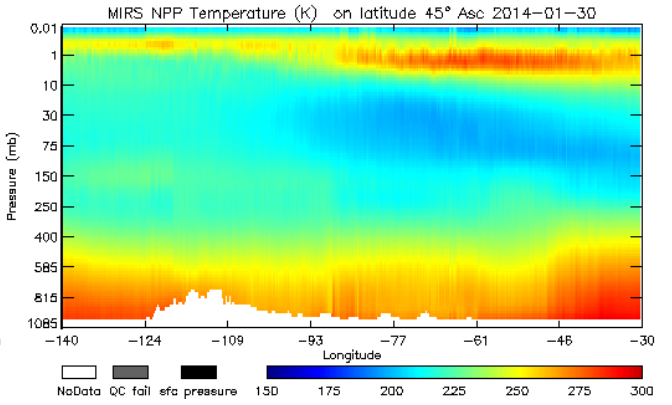


Test MiRS





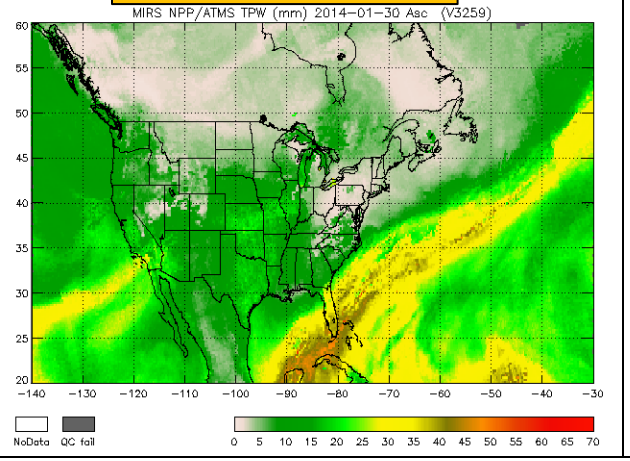




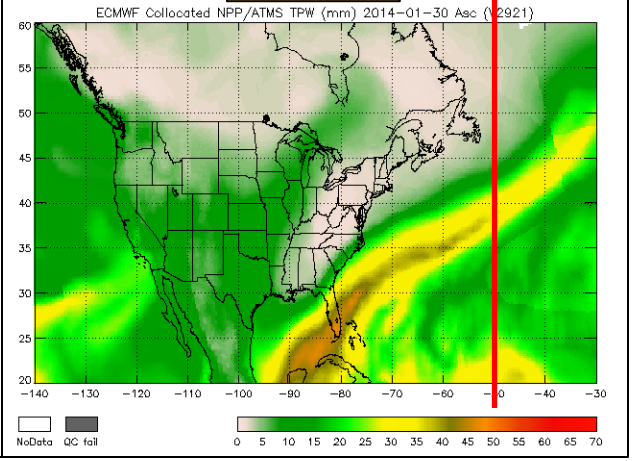
MiRS Sounding Performance Assessments: TPW, and Cross-sections

2014-01-30

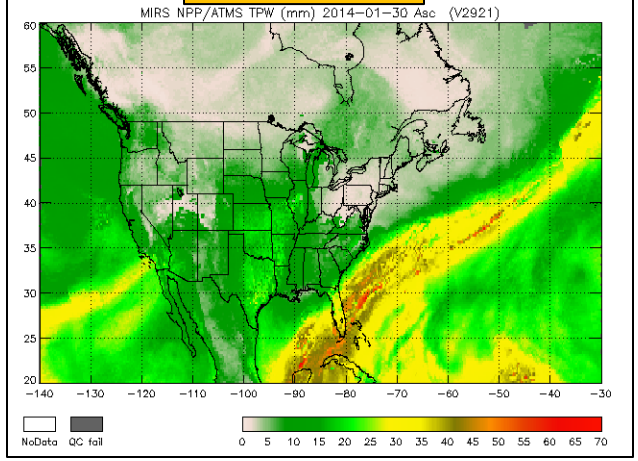
Operational MiRS

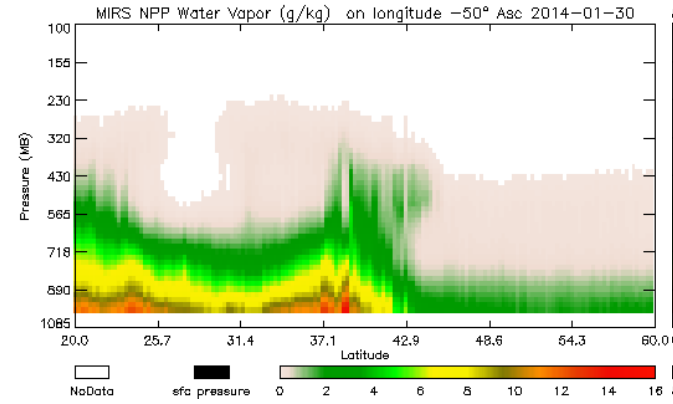


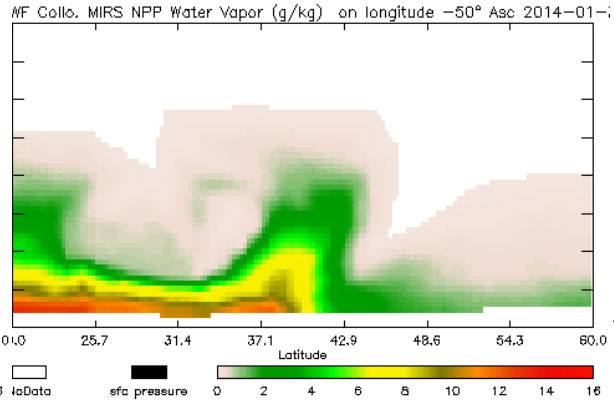
ECMWF

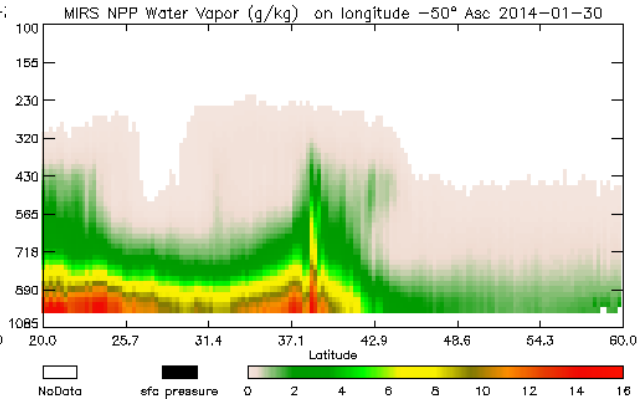


Test MiRS







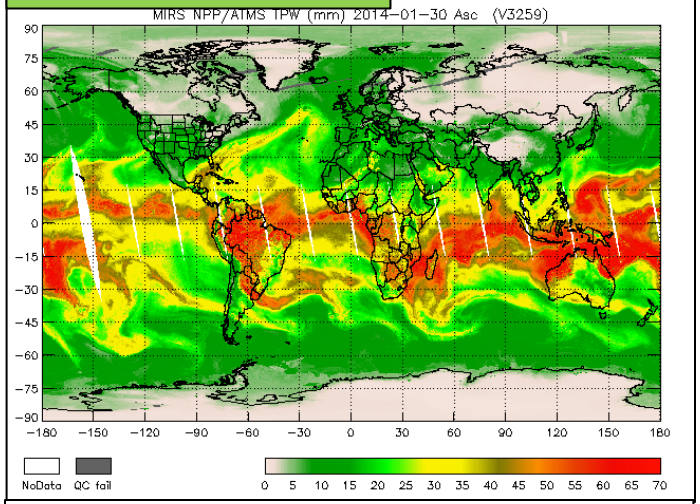


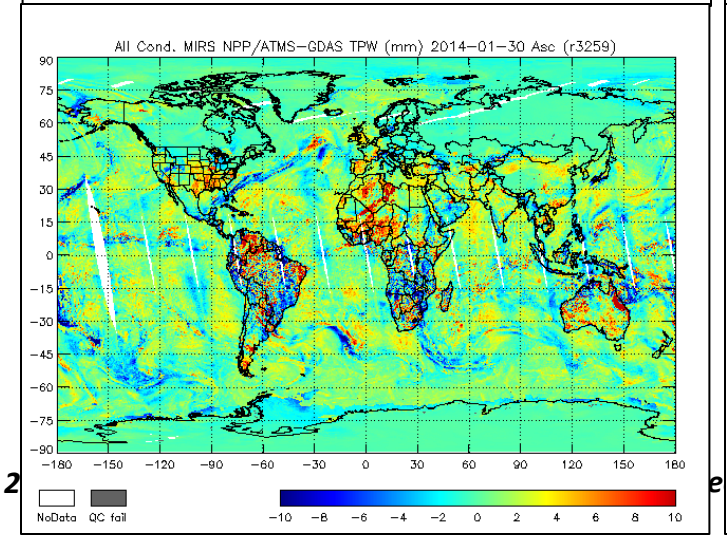
MiRS Sounding Performance Assessments:
Total Precipitable Water

2014-01-30: Global

Operational MiRS

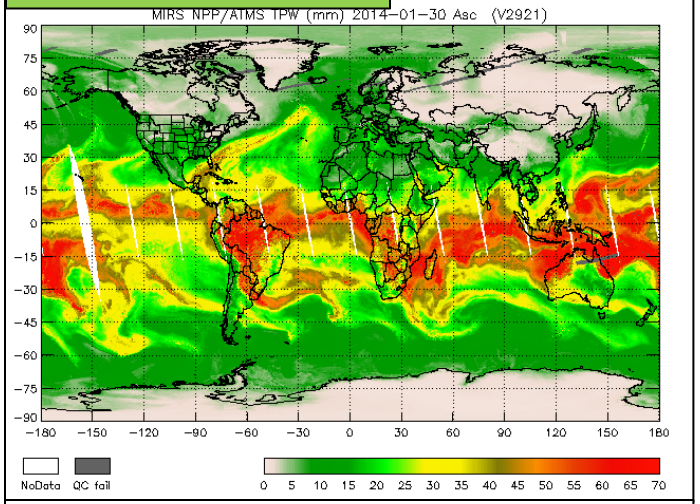
MIRS- GDAS

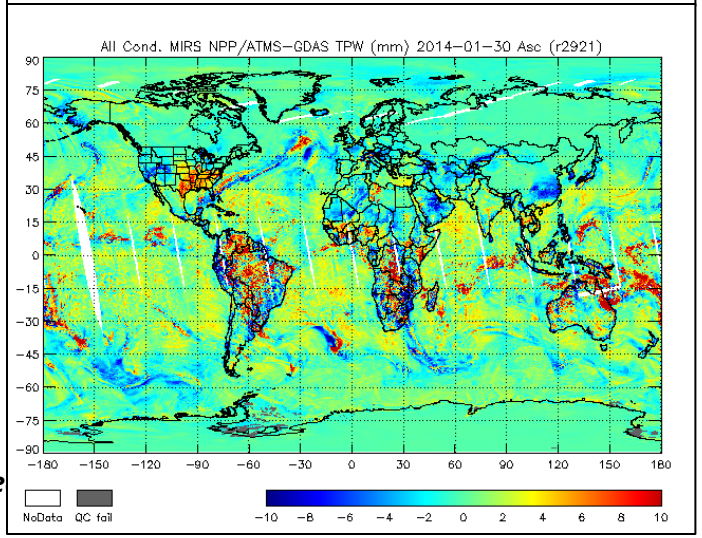




Test MiRS

MIRS- GDAS



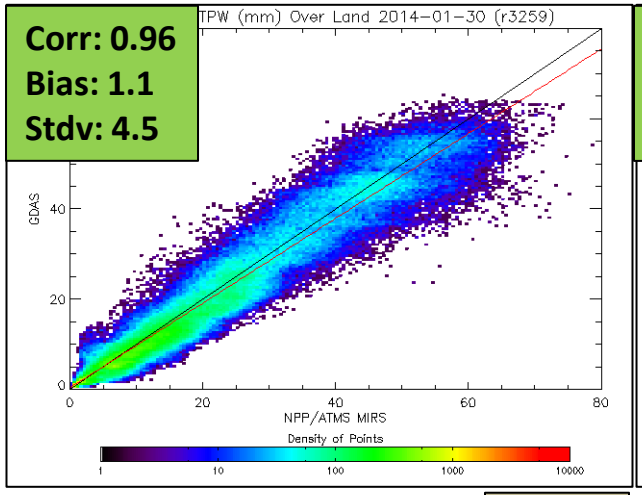


MiRS Sounding Performance Assessments:
Total Precipitable Water

MIRS- GDAS

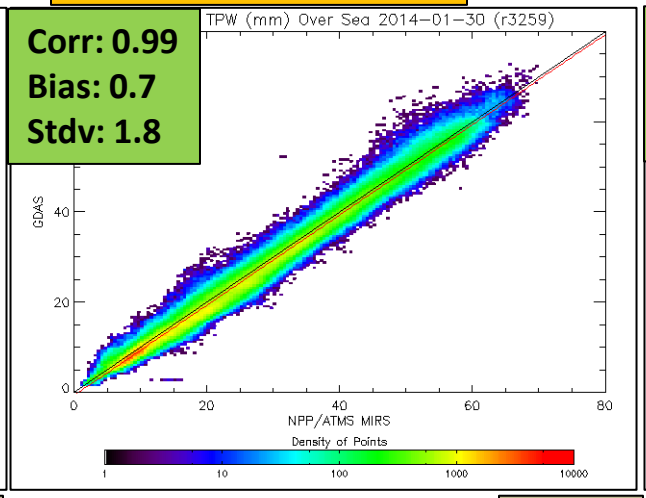
2014-01-30: Global

Operational MiRS



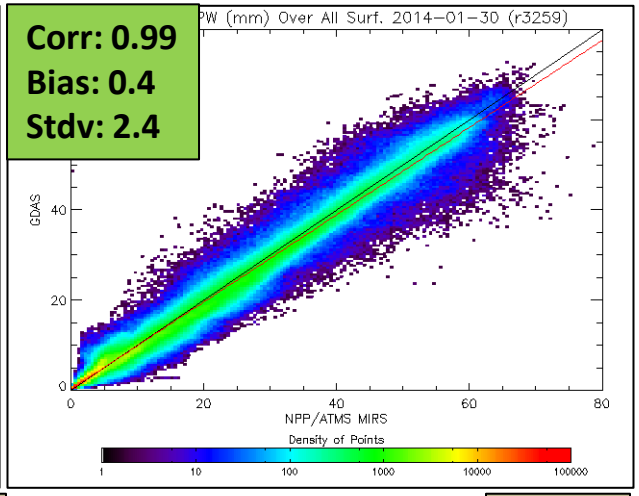
Corr: 0.96
Bias: 1.1
Stdv: 4.5

Land



Corr: 0.99
Bias: 0.7
Stdv: 1.8

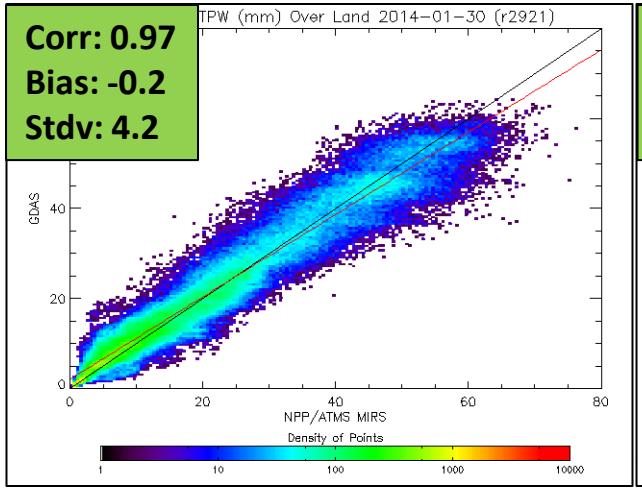
Sea



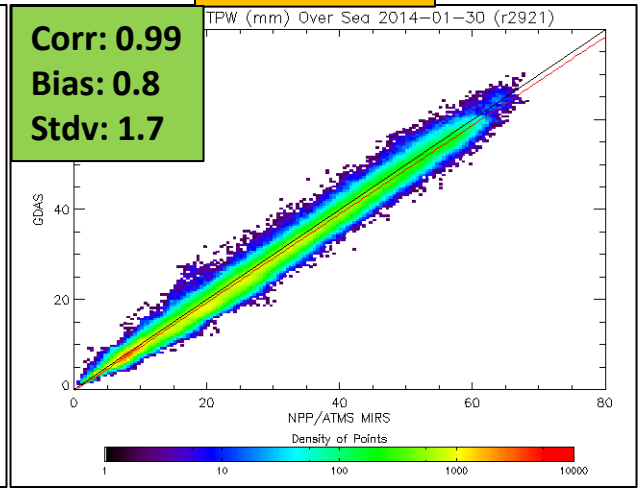
Corr: 0.99
Bias: 0.4
Stdv: 2.4

All

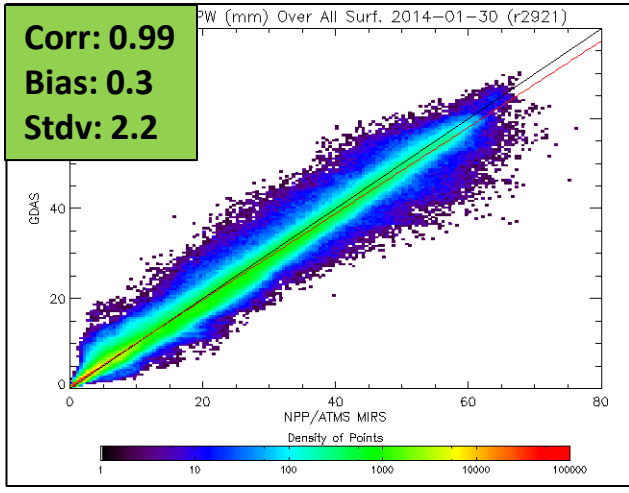
Test MiRS



Corr: 0.97
Bias: -0.2
Stdv: 4.2



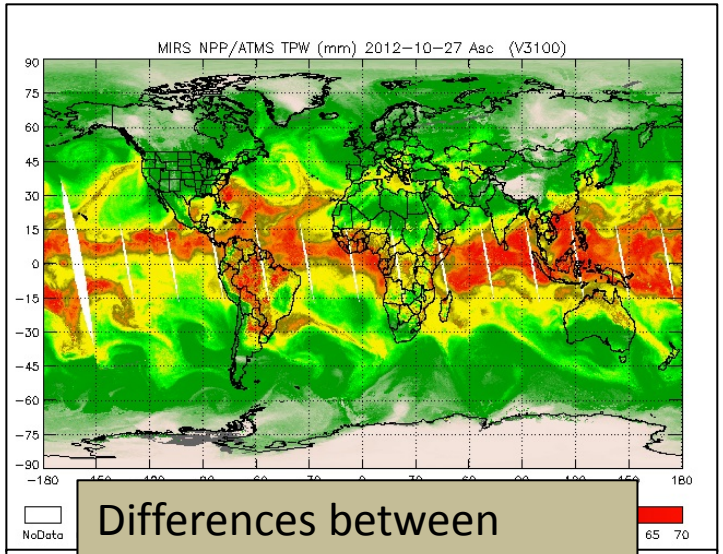
Corr: 0.99
Bias: 0.8
Stdv: 1.7



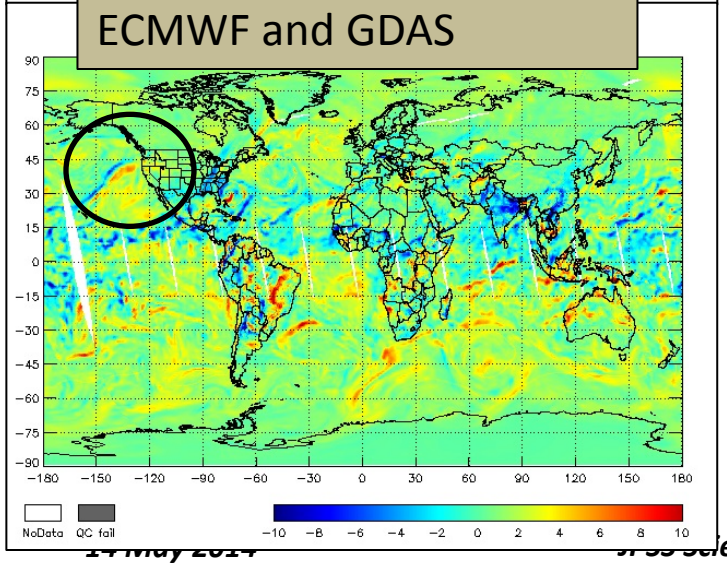
Corr: 0.99
Bias: 0.3
Stdv: 2.2

MiRS Sounding Performance: TPW

Test MiRS



Differences between ECMWF and GDAS



Summary of TPW Performance

Compared to ECMWF: 2012-10-27

	Bias (mm)	*Stdv (mm)*	*Corr.*	*RMSE (mm)*
Ocean	0.46	2.55	0.98	2.59
Land	0.48	4.47	0.95	4.50
Sea-Ice	0.42	1.28	0.82	1.35
Snow	0.25	0.89	0.93	0.92

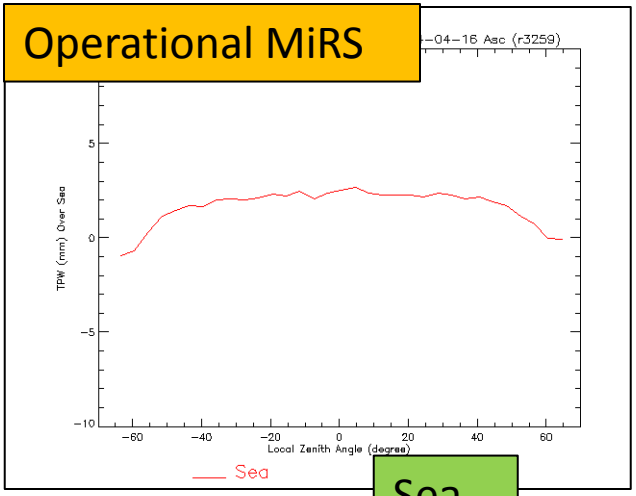
Compared to Raobs: Jul – Sep 2013

	SNPP bias/stdv (mm)	*NOAA-19 bias/stdv (mm)*	*Metop-A bias/stdv (mm)*
Ocean	7.25/15.40 (%)	8.26/15.69 (%)	8.89/13.7 (%)
Land	2.39/23.65 (%)	5.68/23.76 (%)	2.57/22.11 (%)

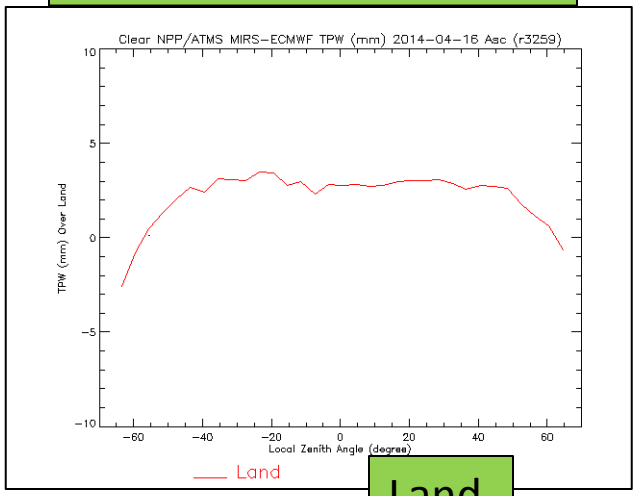
MiRS Sounding Performance Assessments: TPW Scan-dependent Bias

2014-04-16: vs. ECMWF

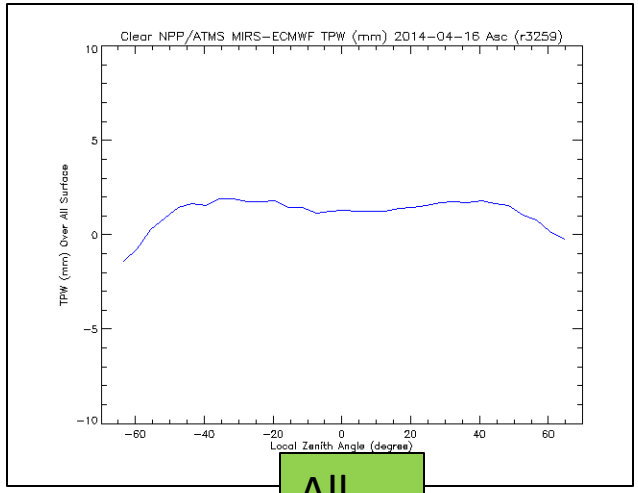
Operational MiRS



Sea

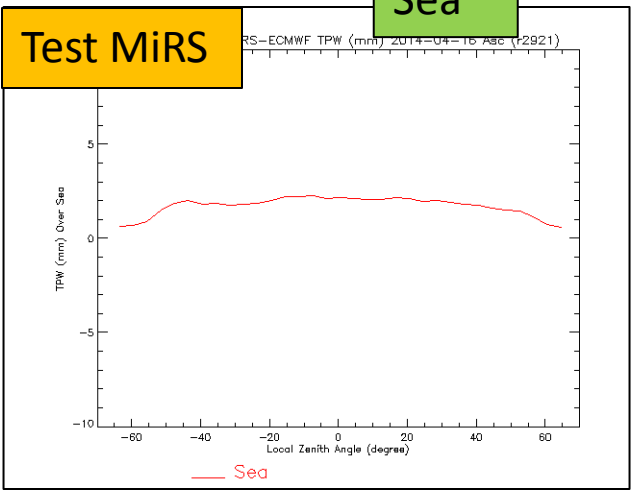


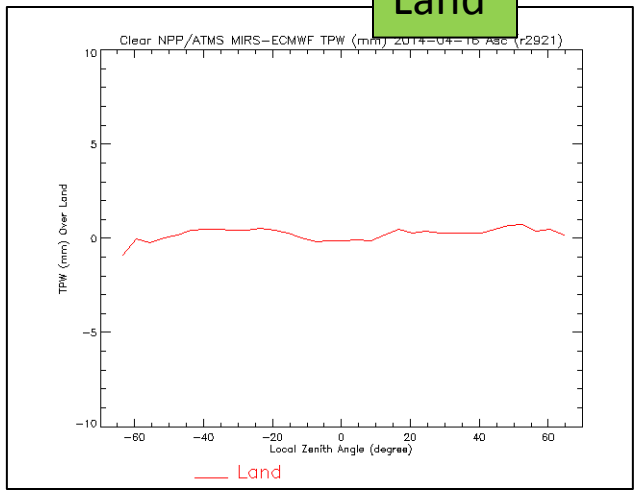
Land

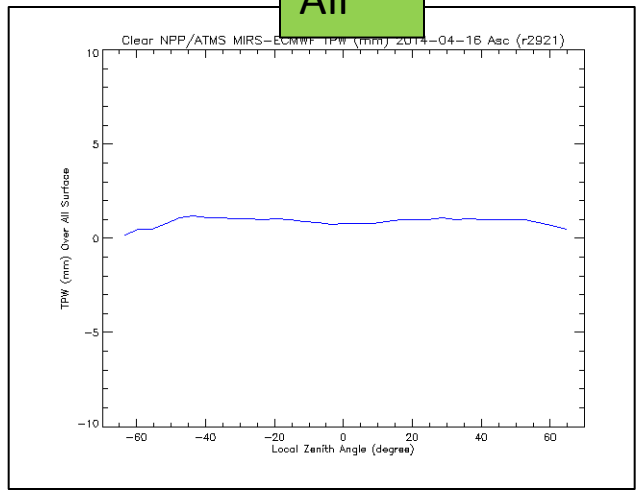


All

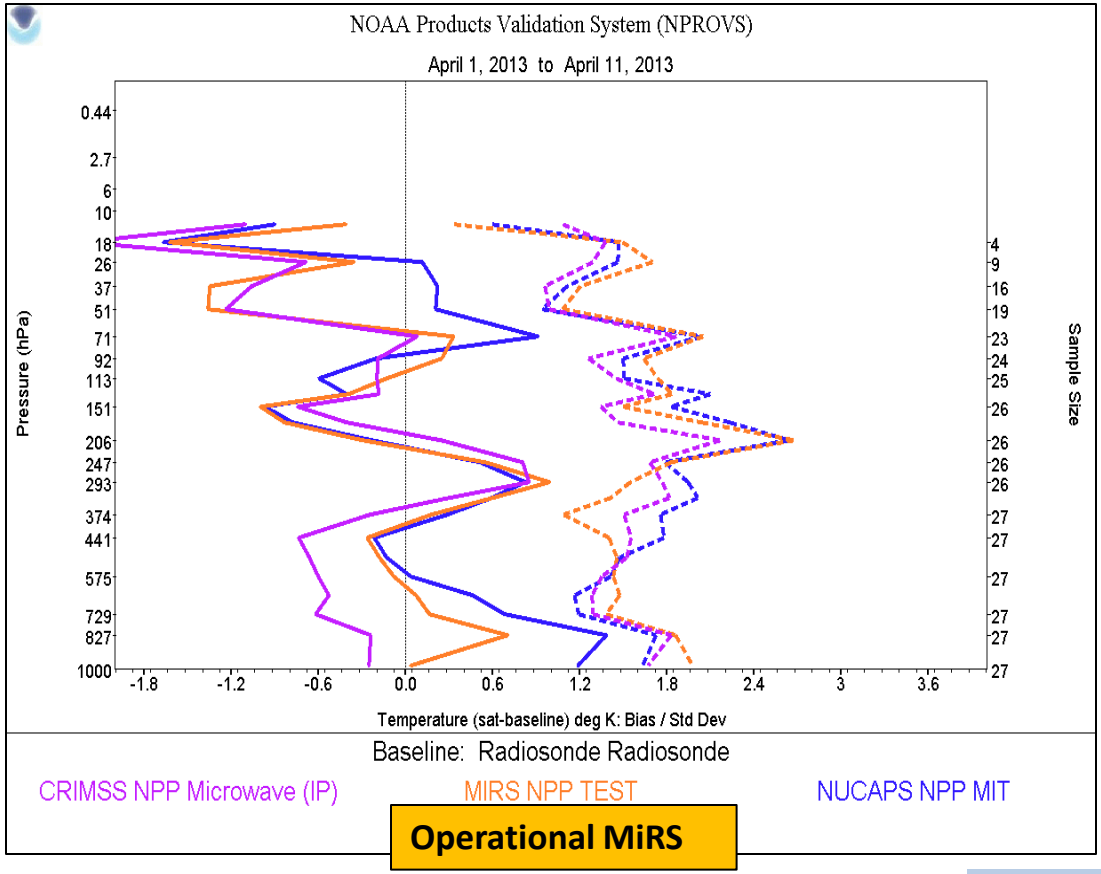
Test MiRS







Sounding Assessment via NPROVS



NPROVS performs assessment and intercomparisons by comparing several algorithms/ several sensors to common reference of radiosondes

Provided by T. Reale

MiRS Application: Rapid Hurricane Intensification (1)

MiRS/ATMS T,RH profiles used to compute ***(case of Hurricane Leslie, 2012)*****:**

-Radial-height cross section

- Temperature Anomaly

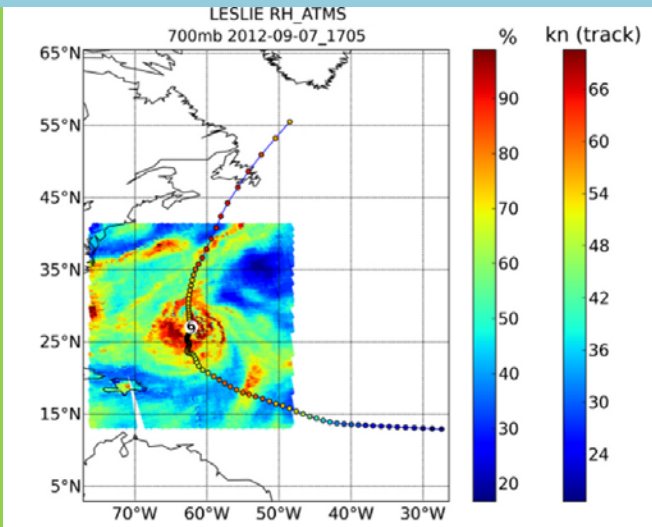
-500-800mb averaged values

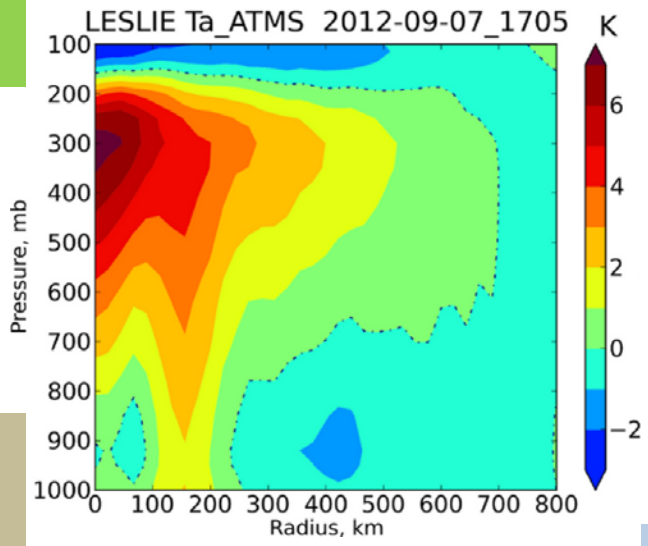
These are fed to :

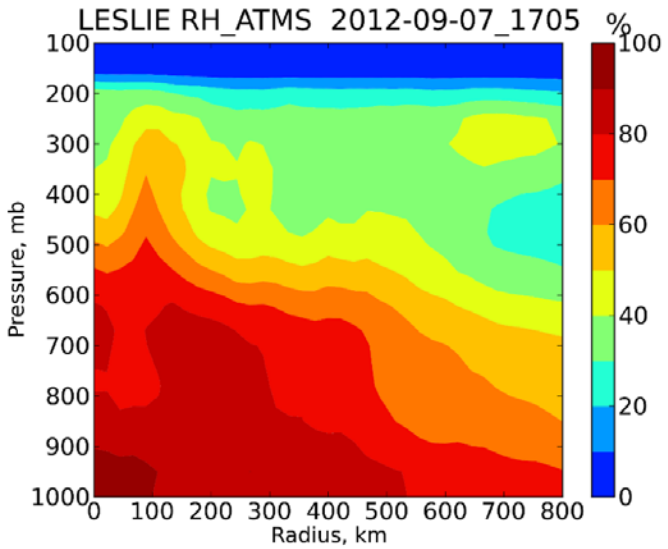
- Maximum Potential Intensity (**MPI**) algor.

MPI is then fed to :

- Rapid Intensification Index (**RII**) algor.





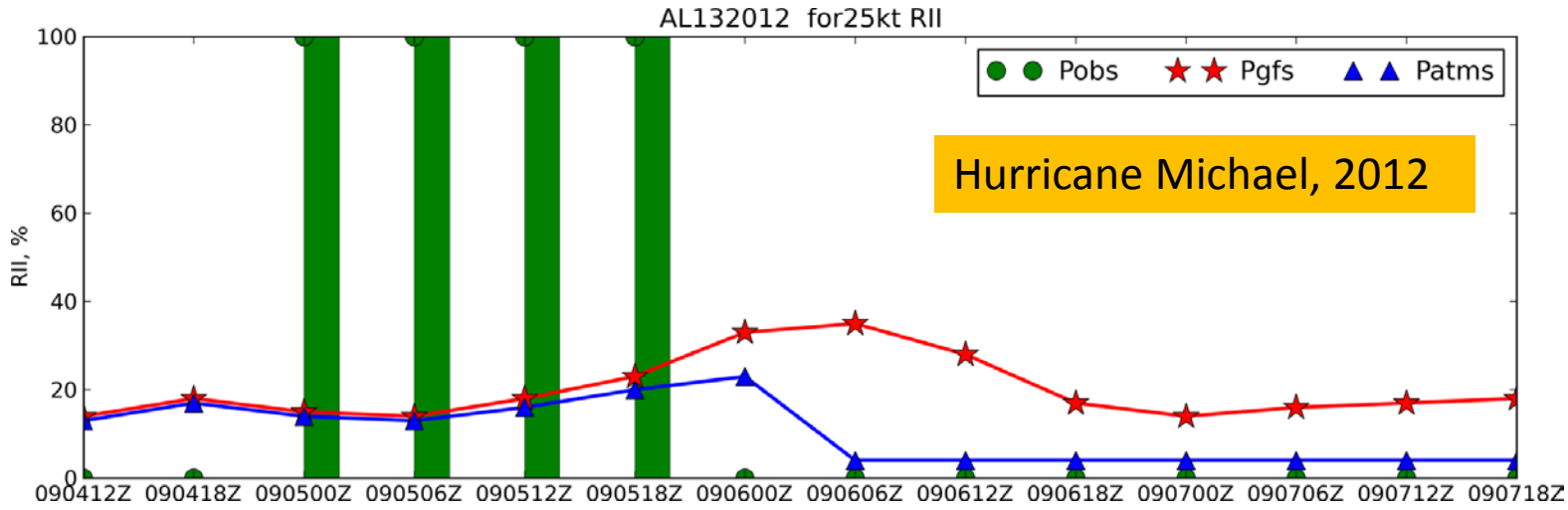


1. Average T, RH between r = 500 to 800 km to get $\overline{T}(p)$, $\overline{RH}(p)$
2. Input $\overline{T}(p)$, $\overline{RH}(p)$ environmental profiles to Emanuel (1988) MPI algorithm
3. Replace empirical MPI with ATMS MPI in RII and models

Slide courtesy of Galina Chirokova and Mark DeMaria

Rapid Intensification Forecast (2): GFS vs. MIRS/ATMS Inputs

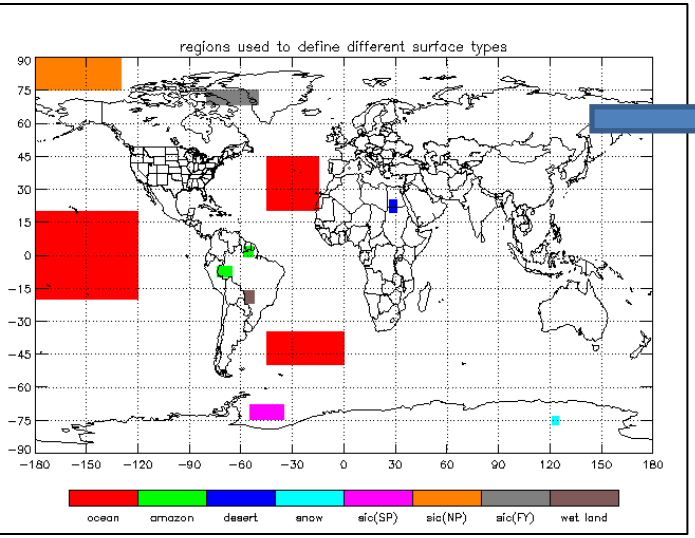
Atlantic Basin: The bias of RI index (between obs. and RII algorithm output) is 1.67 when MiRS/ATMS data is used as inputs and 1.87 when GFS I is used.

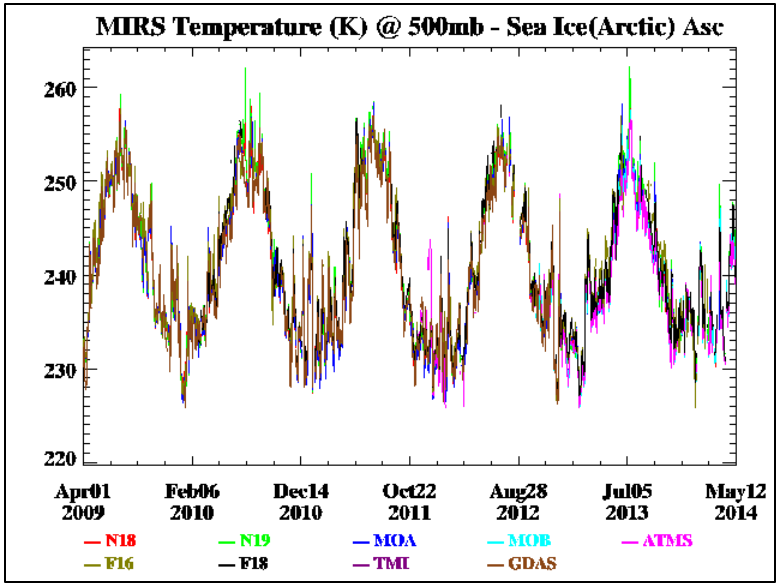


Atlantic Basin: Preliminary results for the RII forecast show up to 3.1% increase in Brier Skill Score with the use of MiRS/ATMS data, and for the center-fix algorithm up to 10% better center location as compared to the first guess position from the NHC real-time forecast positions.

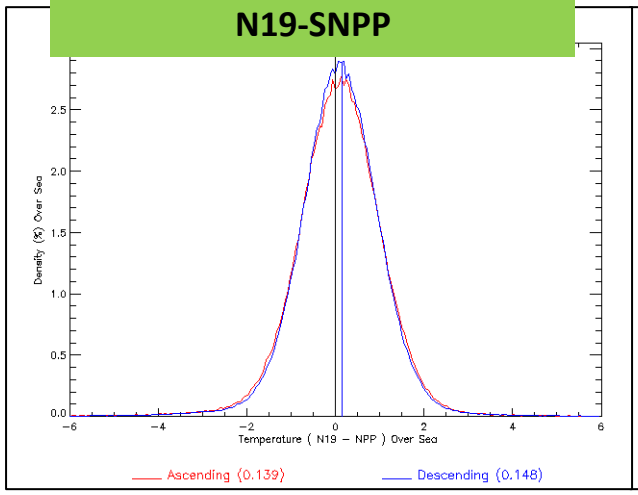
Slide courtesy of Galina Chirokova and Mark DeMaria

MiRS-Derived Products: Time Series, Inter-sensor consistency

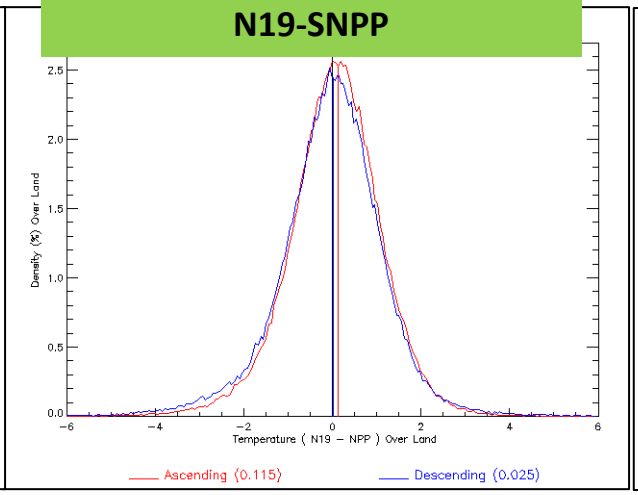




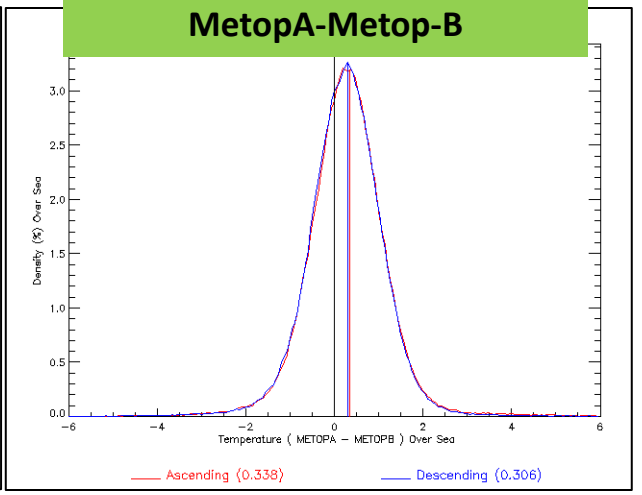
T(p) at 500mb over sea (global) N19-SNPP



T(p) at 500mb over land (global) N19-SNPP



T(p) at 500mb over sea (global) MetopA-Metop-B



MiRS Science Improvement Activities

Improvement Area	Integration Status	Work remaining	Expected completion	Included in next major DAP delivery (Summer 2014)
New Dynamic Mean Background/A Priori (T, WV, Tskin, CLW)	**Fully integrated**	None	Complete	**Yes**
New CRTM (v2.1.x)	**Fully integrated**	None	Complete	**Yes**
Hydrometeors/rain rate	**Fully integrated**	• RWP over land • Update RR=f(RWP, IWP, CLW) relationship	June 2014	**Yes**
Extend MiRS to high-resolution for all current operational sensors, and for F17/SSMIS	**Fully integrated**	• Hydrometeor validation with CRTM 2.1.1 • Validation for F17	June 2014	**Yes**
New Dynamic Emissivity Background/A Priori	**Initial testing**	• Testing ROIs • Temporal dependence • Global implementation and assessment	December 2014	No
New radiometric bias correction approach (e.g. air mass, rainy, etc.)	**Not started**	Most work still TBD	TBD	No
Integration with GPROF hydrometeors (e.g. FG,BG, Covariances, RR=f(RWP,IWP)…)	**D. Duncan (Kummerow PhD student), In progress**	Started November 2013	Early 2015	No

Summary

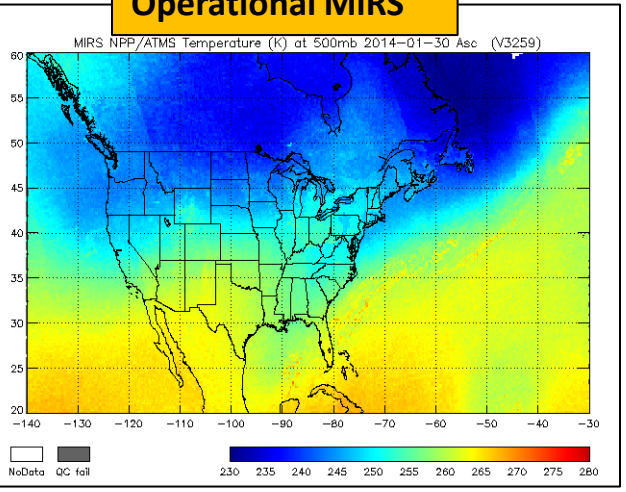
- Significant updates to MiRS algorithm: improved sounding performances for SNPP/ATMS (and other sensors).
  - o T and wv biases reduced, although some increase seen in low level T bias (negative) over land
  - o T and wv std dev reduced, especially over land
  - o TPW bias and std dev reduced over land
  - o Soundings more horizontally consistent due to updated a priori background
- Improvements seen across seasons/years
- These updates will be contained in next major release of MiRS scheduled for summer 2014 (v11.0)
  - o Extension of all sensors to high resolution (N18, N19, F18)
  - o Extension to F17 SSMIS
- Extension of MiRS to JPSS-1 will be simplified based on experience and software development with SNPP

Backup Slides

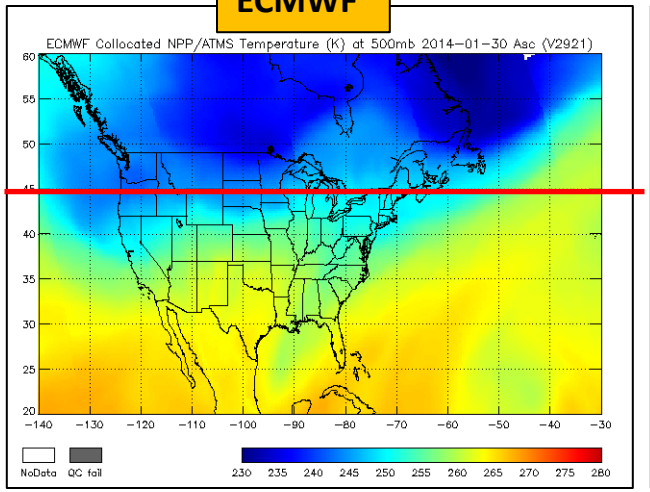
MiRS Sounding Performance Assessments:
500 hPa Temp, and Cross-sections

2014-01-30

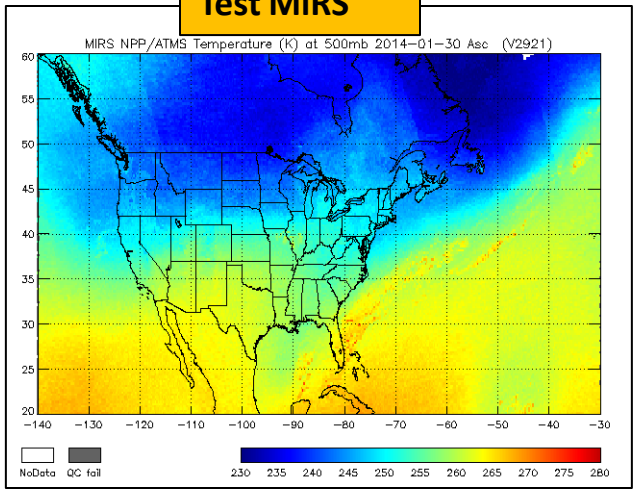
Operational MiRS

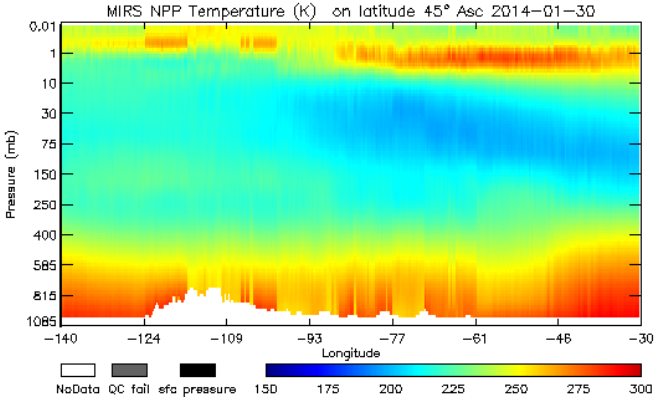


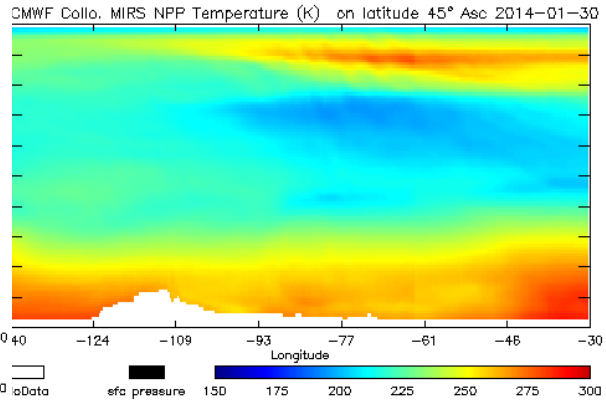
ECMWF

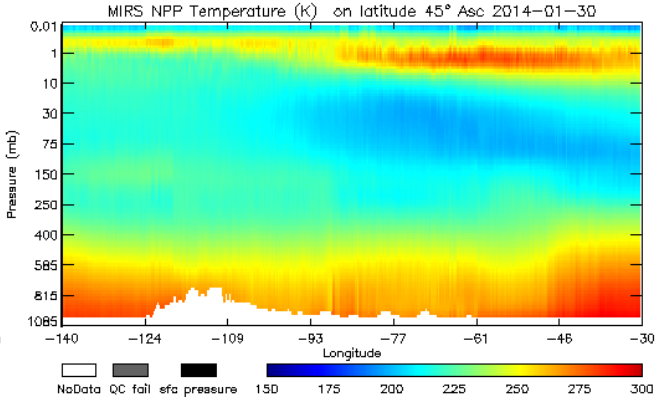


Test MiRS



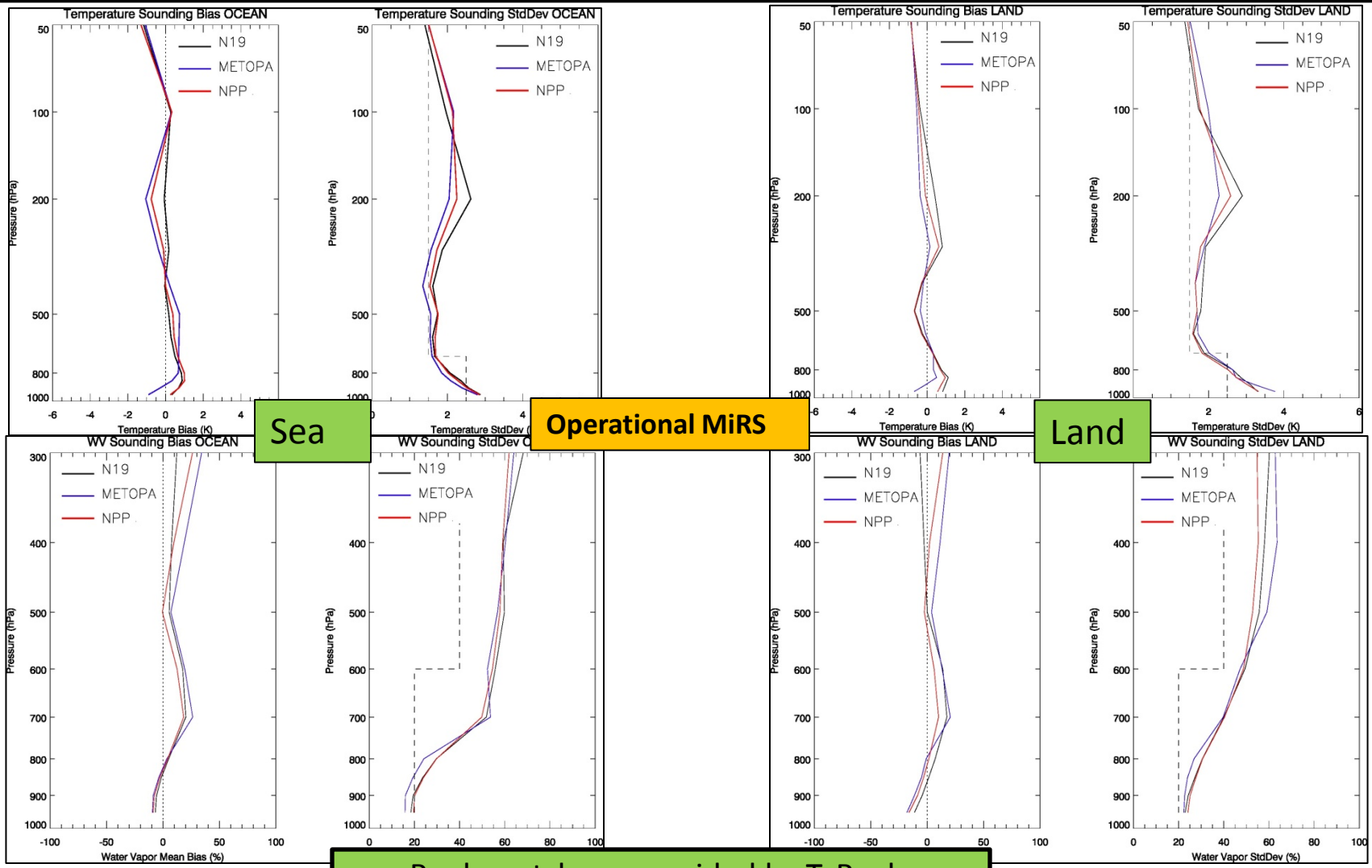






MiRS Sounding Performance Assessments: Radiosonde Comparison

Collocations July – September 2013 (~25,000 pts)



Sea

Operational MiRS

Land

Raob matchups provided by T. Reale