



MiRS ATMS Retrievals: Algorithm Updates, Product Assessment, and Preparations for JPSS-1

Product/Algorithm: MiRS (Microwave Integrated Retrieval System)

*Contributors: X. Zhan, C. Grassotti, M. Chattopadhyay,
J. Davies*

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MiRS Cal/Val Team Members



Team Member	Organization	Roles and Responsibilities
X. Zhan (Task Lead)	NESDIS/STAR/SMCD	Project management
C. Grassotti (Contractor, Technical Lead)	NESDIS/STAR/SMCD (U. MD./ESSIC)	Coordination of technical activities; review/deliverable planning
M. Chattopadhyay (Contractor, 50%)	NESDIS/STAR/SMCD (AER, Inc.)	DAP preparation, EDR generation/validation



MiRS S-NPP Product Overview: Product List



- **MiRS V9.2** Currently running on S-NPP/ATMS operationally at NDE (since 2013), also running at OSPO on 8 different satellites/sensors
- **V11.0** delivered Sept 2014 (for N18, N19, MetopA, MetopB, F17 HR)
- **V11.1** delivered August 2015 to OSPO (for N18, N19, MetopA, MetopB, F17, F18) and NDE for ATMS (pre-DAP for V11.2)
- Numerous algorithm updates/improvements in V11.0 and V11.1

V9.2/V11.0
Atmospheric Temperature profile
Atmospheric Water Vapor profile
Total Precipitable Water
Land Surface Temperature
Surface Emissivity Spectrum
Sea-Ice Concentration
Snow Cover Extent
Snow-Water Equivalent
Integrated Cloud Liquid Water
Integrated Ice Water Path
Integrated Rain Water Path
Rainfall Rate

Added V11.1
Snowfall Rate (MSPPS, AMSU/MHS currently)
Sea Ice Age (FY, MY)
Snow Grain Size



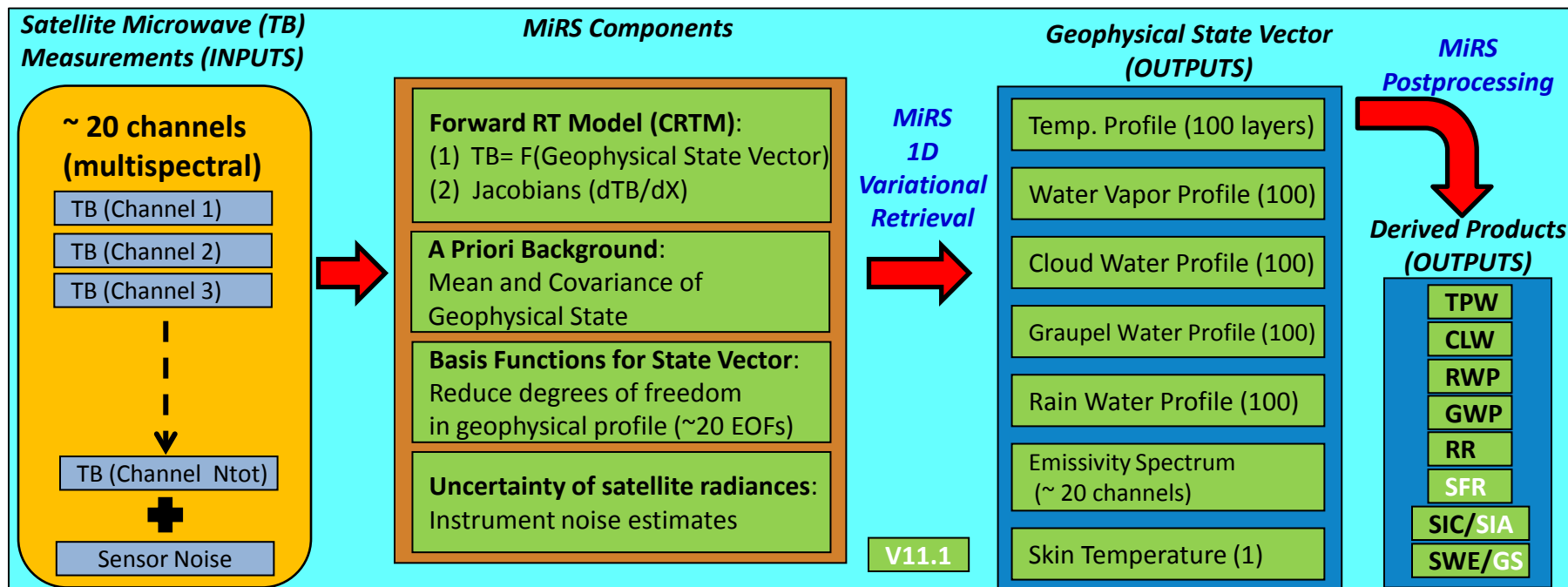
MiRS S-NPP Product Overview: Cal/Val Status



- **All official EDRs are compared/validated against appropriate reference data:**
 - T and WV profiles and TPW: ECMWF and GDAS analyses, radiosondes
 - RR: Stage IV over CONUS, TRMM 2A12 (when operational), IPWG, CDC daily rainfall (new plans for this year to incorporate GPM official RR in comparisons)
 - Tskin: daily comparison with NWP, limited comparison with SURFRAD (more intensive comparisons planned starting March 2017 as per project plan)
 - Sea Ice Concentration: AMSRE, AMSR2, SSMIS NRT, European OSI-SAF
 - SWE: NOHRSC/SNOWDAS, European GlobSnow, AMSRE, AMSR2
- **V9.2 deficiencies included:**
 - WV, TPW moist bias in extreme cold/dry air outbreaks
 - Larger T profile std dev over land surfaces
 - Some underestimation of SWE in Siberia.
 - These have largely been addressed in the upgrade to V11.1
- **Long-term monitoring: MiRS website contains product maps, comparisons with reference data, and radiometric monitoring; plan to work with STAR webmaster (L. Brown) to update website to accommodate JPSS-1 requirements.**
 - <http://www.star.nesdis.noaa.gov/smcd/mirs/>

JPSS-1 Readiness: MiRS Algorithm Overview

- **Basic Retrieval Problem:** Given a limited set of satellite-based microwave radiometric measurements, which are related to the Earth atmospheric and surface conditions (state vector) in a linear or non-linear way, how does one determine the elements of this state vector?
 - State vector can have 100+ elements
 - Problem is underdetermined: many more variables to retrieve than measurements; more than one combination of atm/sfc conditions can “fit” the measurements
- **Variational Approach:** Find the “most likely” atm/sfc state that: (1) best matches the satellite measurements, and (2) is still close to an a priori estimate of the atm/sfc conditions





JPSS-1 Readiness: MiRS

Algorithm Changes in V11.1 (compared with v9.2)



Description	Satellites/Sensors Affected	Benefit
Integration of CRTM 2.1.1 (previously using pCRTM)	All: N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS , F17, F18/SSMIS, MT/SAPHIR	Better sync with CRTM development cycle; more realistic ice water retrievals (Jacobians)
Integration of new dynamic a priori atmospheric background	All	Large improvement in T, WV sounding; reduction in average number of iterations; increase in conv rate
Updated hydrometeor/rain rate relationships	All	Improved RR over land and ocean
Updated hydrometeor a priori background profiles	All	Improved RR over land and ocean; improved sounding products in rainy conditions
New bias corrections for all sensors	All	Needed for consistency with CRTM 2.1.1
Snow Water Equivalent (SWE) spatially-temporally variable climatology background	All	Better spatial and temporal constraint on SWE; also improved SGS retrieval
Snow Grain Size (SGS) and Sea Ice Age (SIA)	All	Preliminary Product, satisfies user request
Updated all Snow Emissivity Catalogs: finer SGS discretization and larger physical ranges	All	Smoother distributions for SGS, SWE, larger dynamic range for SGS.
Dynamic channel selection near sea ice boundary	N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS	Better convergence behavior for cross-track instruments
Miscellaneous changes to improve code efficiency, bug fixes	All	Matrix preparation time reduced from 40% to 5% of 1dvar computation time

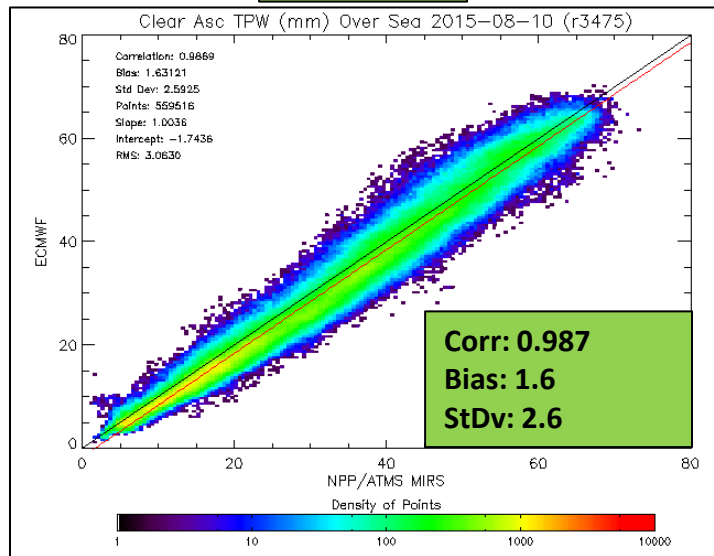
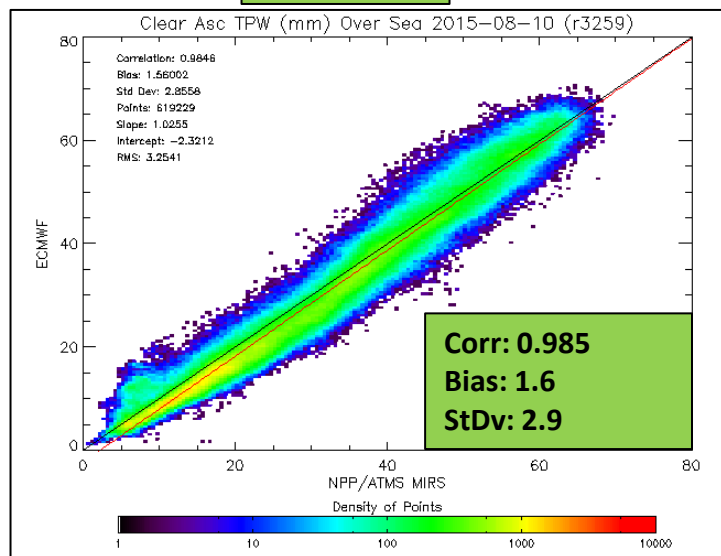
JPSS-1 Readiness: MiRS

S-NPP/ATMS TPW (mm) Performance vs. ECMWF

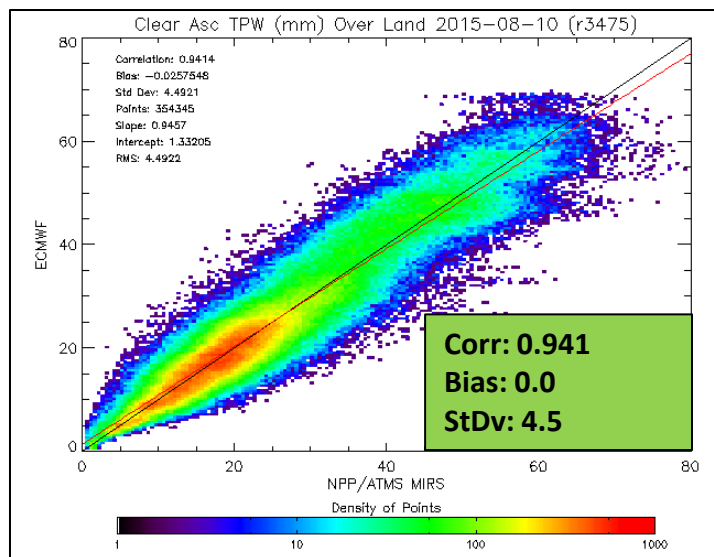
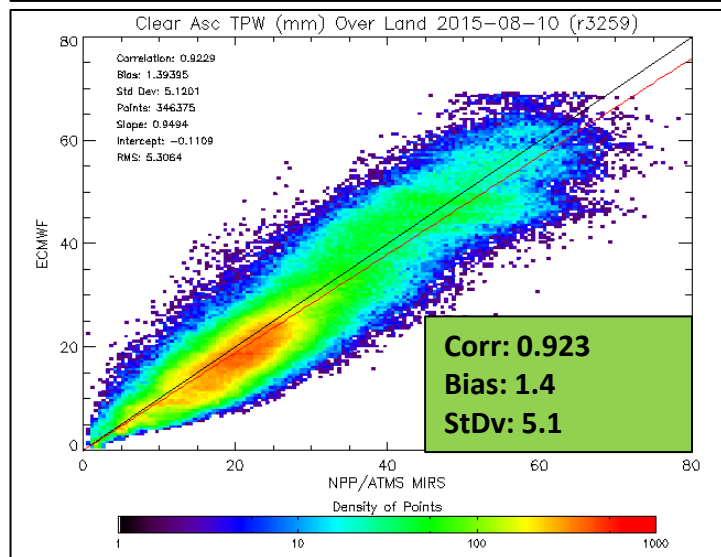
V9.2

2015-08-10

V11.1



Ocean



Land

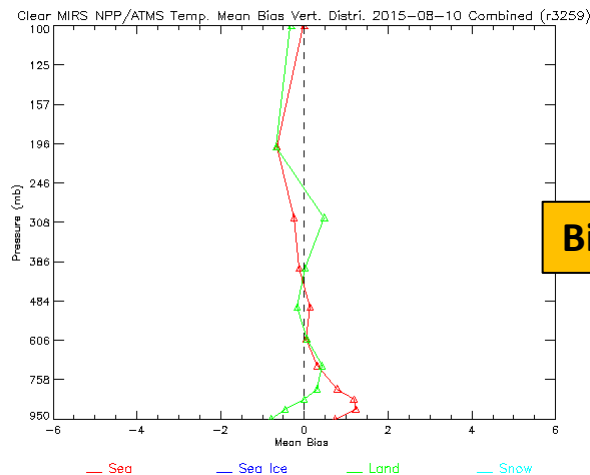
**Produced
daily on STAR
website**

V9.2

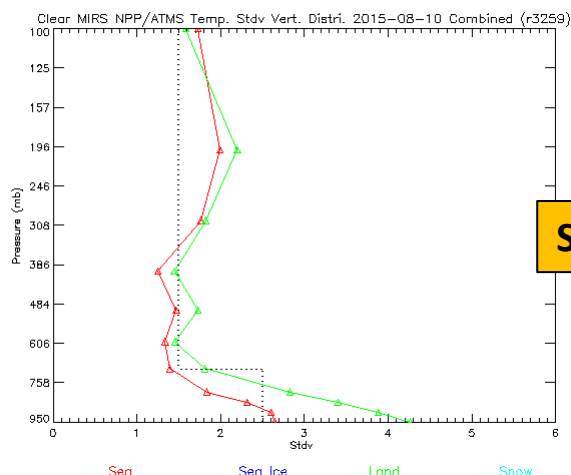
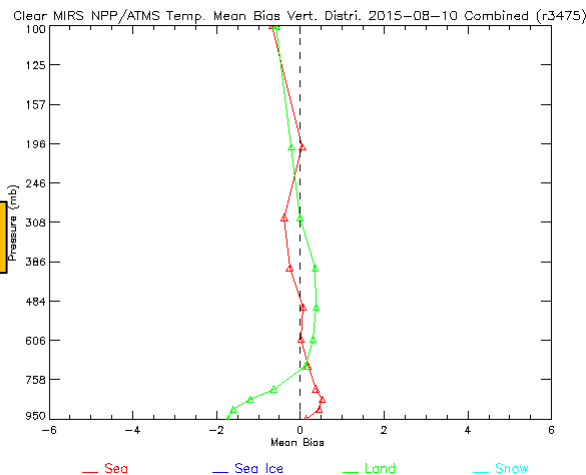
2015-08-10

V11.1

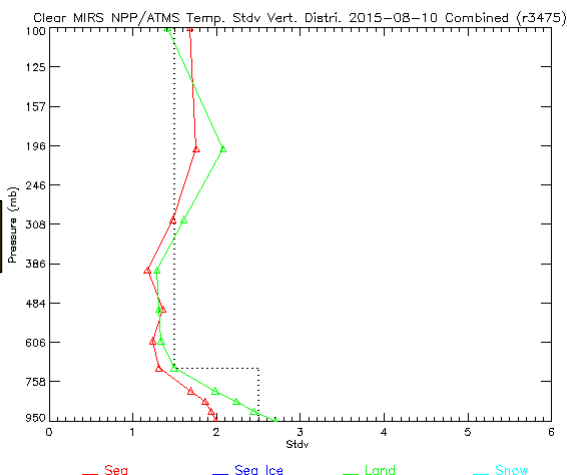
vs. GDAS



Bias



StdV



Land
Ocean



- V11.1 Reduction in both bias and std dev at most layers
- Low level cold bias over land

Produced daily
on STAR
website



JPSS-1 Readiness: MiRS



S-NPP/ATMS Temp Sounding Performance: RAOBs

Ocean

3-13 August 2015

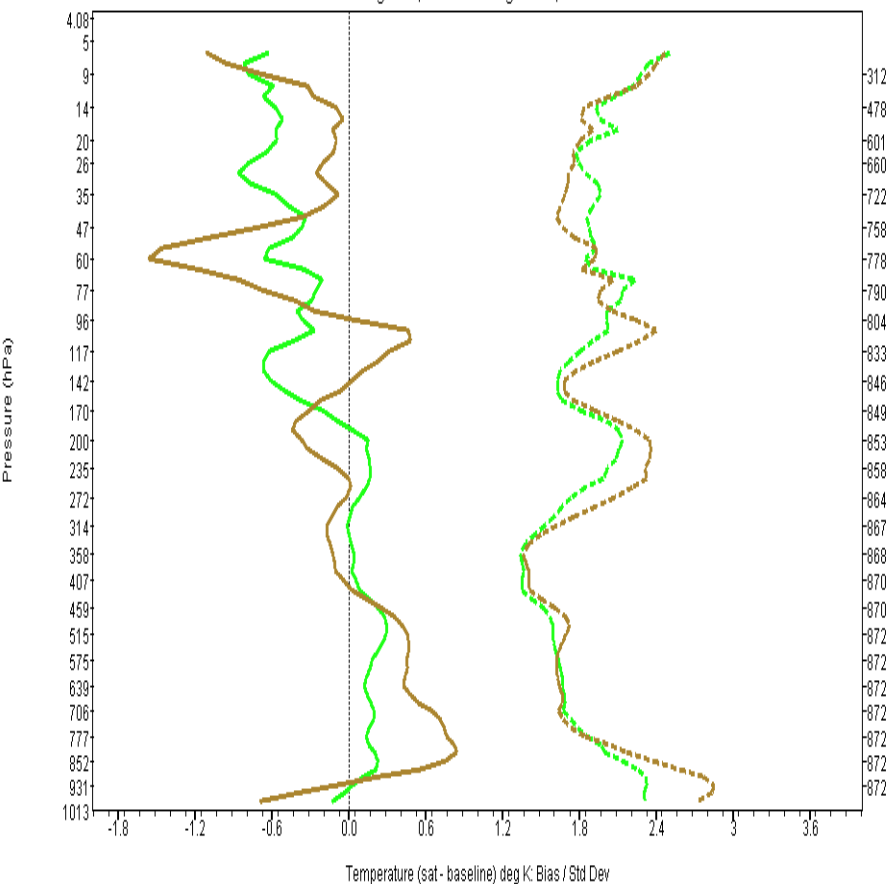
Land

NOAA Products Validation System (NPROVS)

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August 3, 2015 to August 13, 2015

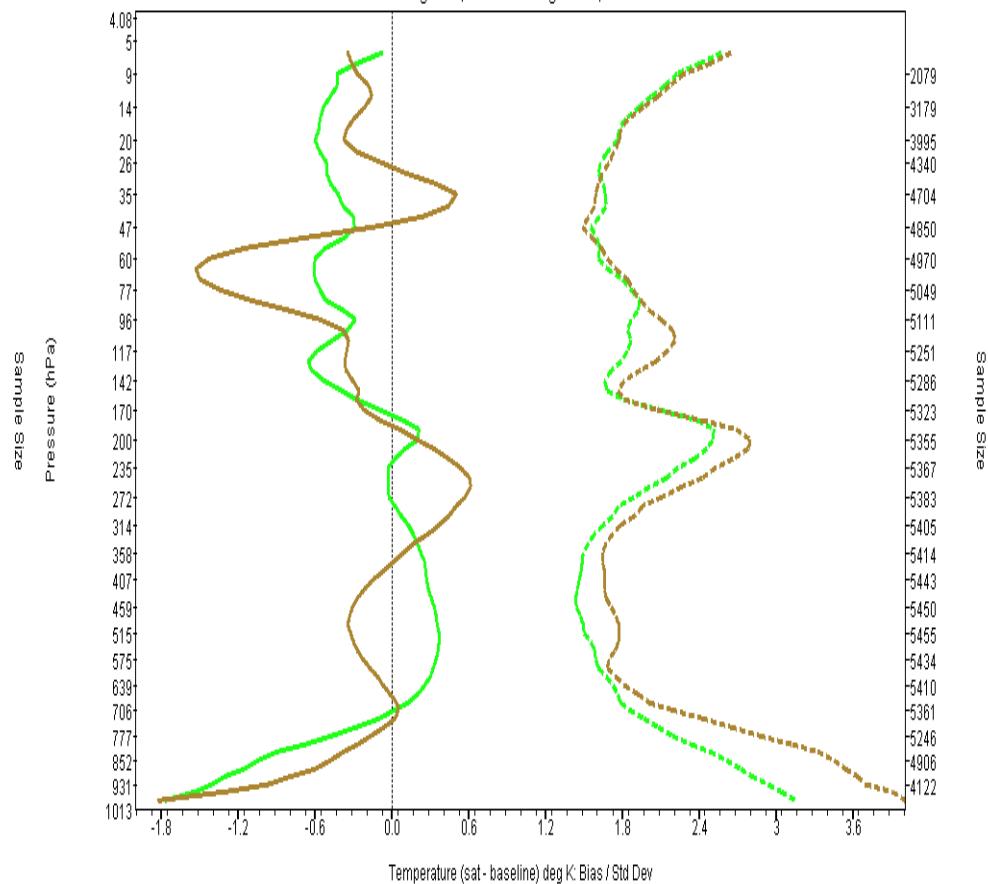
August 3, 2015 to August 13, 2015



Baseline: Radiosonde Radiosonde

MIRS NPP

MIRS NPP V11



Baseline: Radiosonde Radiosonde

MIRS NPP

MIRS NPP V11



JPSS-1 Readiness: MiRS

S-NPP/ATMS WV Sounding Performance: RAOBs



Ocean

3-13 August 2015

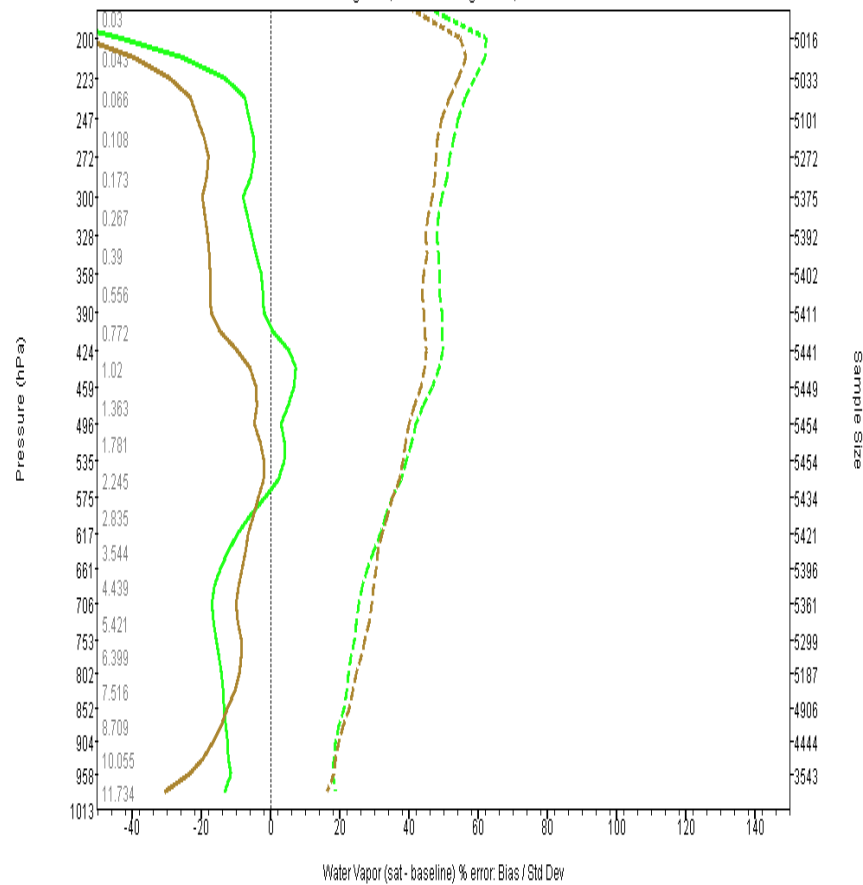
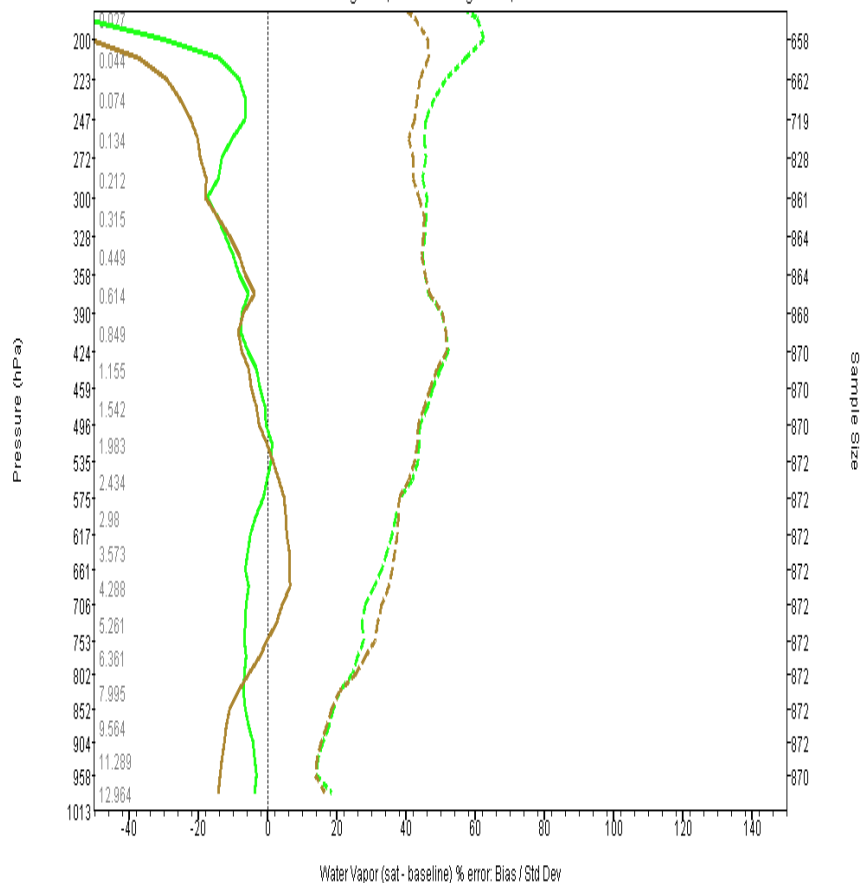
Land

NOAA Products Validation System (NPROVS)

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MIRS NPP

MIRS NPP V11

MIRS NPP

MIRS NPP V11

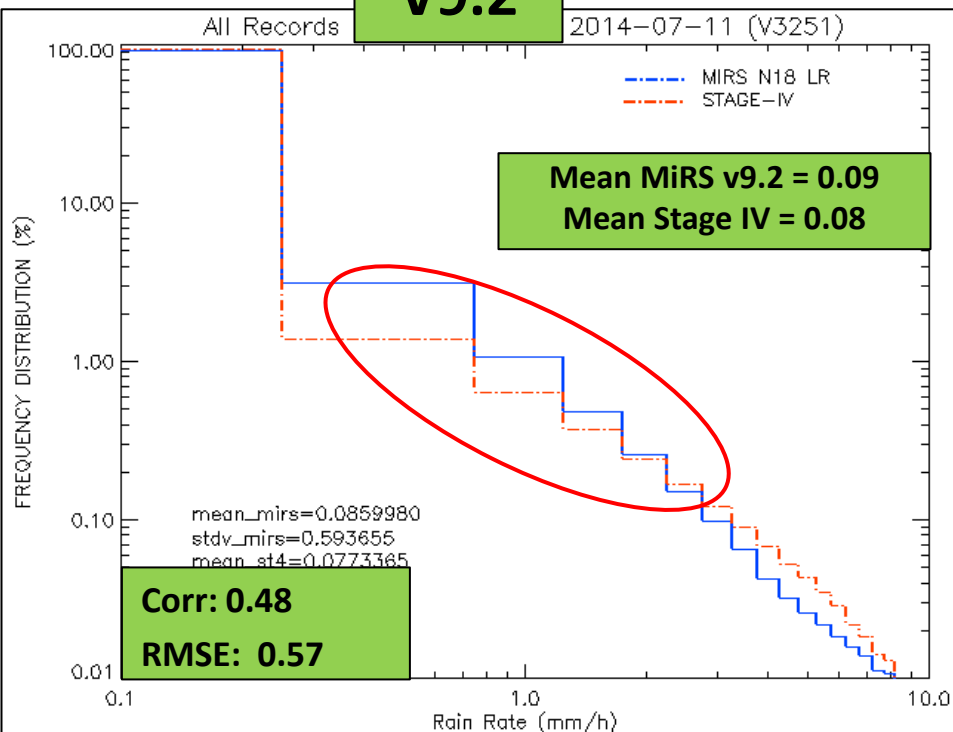
JPSS-1 Readiness: MiRS

Rain Rate Performance (AMSU/MHS)

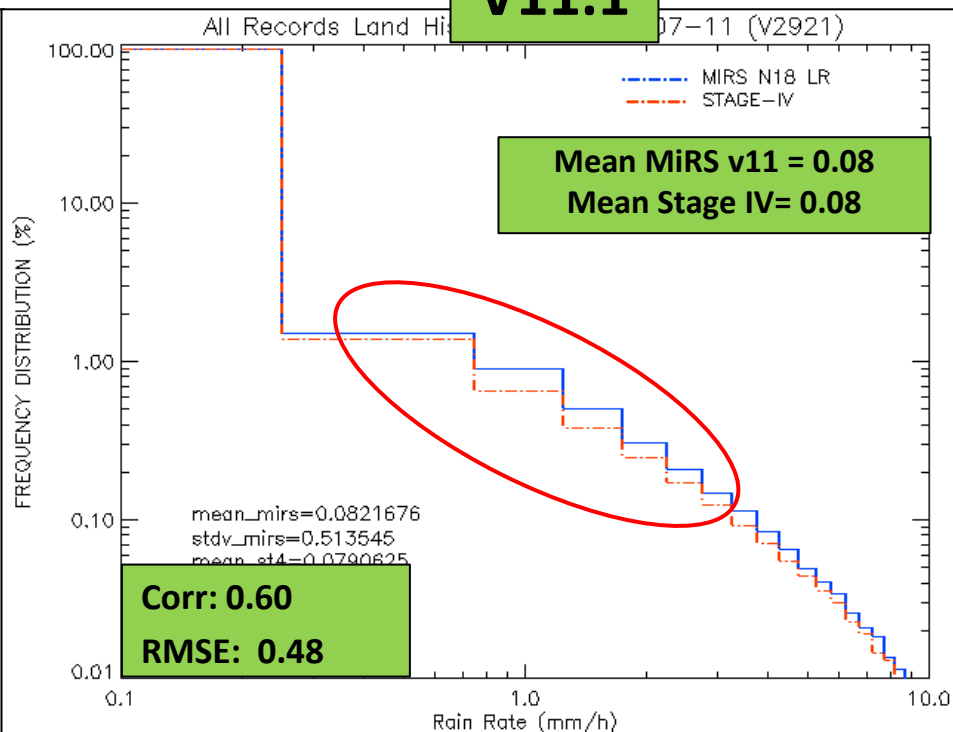
N18 Rain Rate (vs. Stage IV)

Assessment period (2009-2014)

V9.2

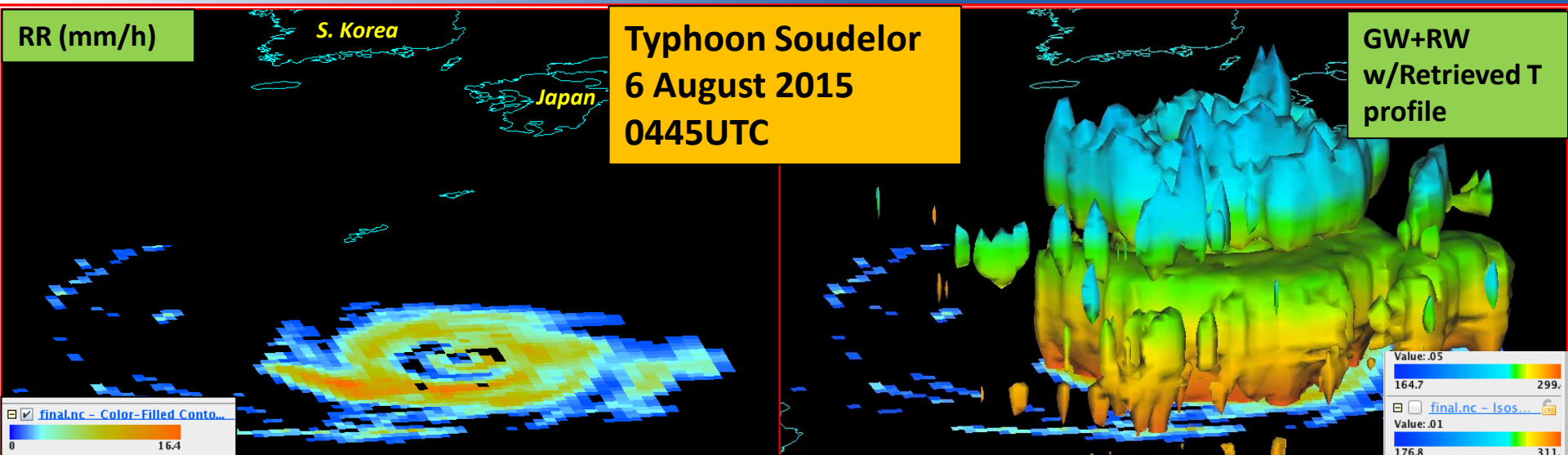


V11.1

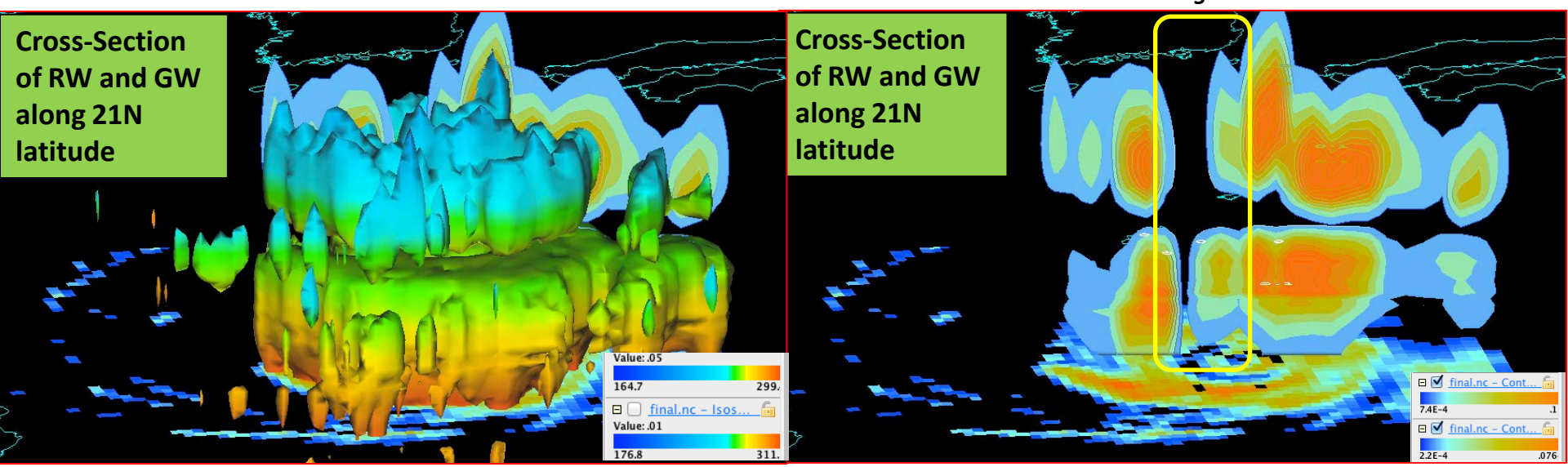


- Better agreement in low intensities
- More consistent at higher intensities (> 3 mm/h)
- Improved correlation and lower RMSE

JPSS-1 Readiness: MiRS Hydrometeor Retrievals (ATMS)



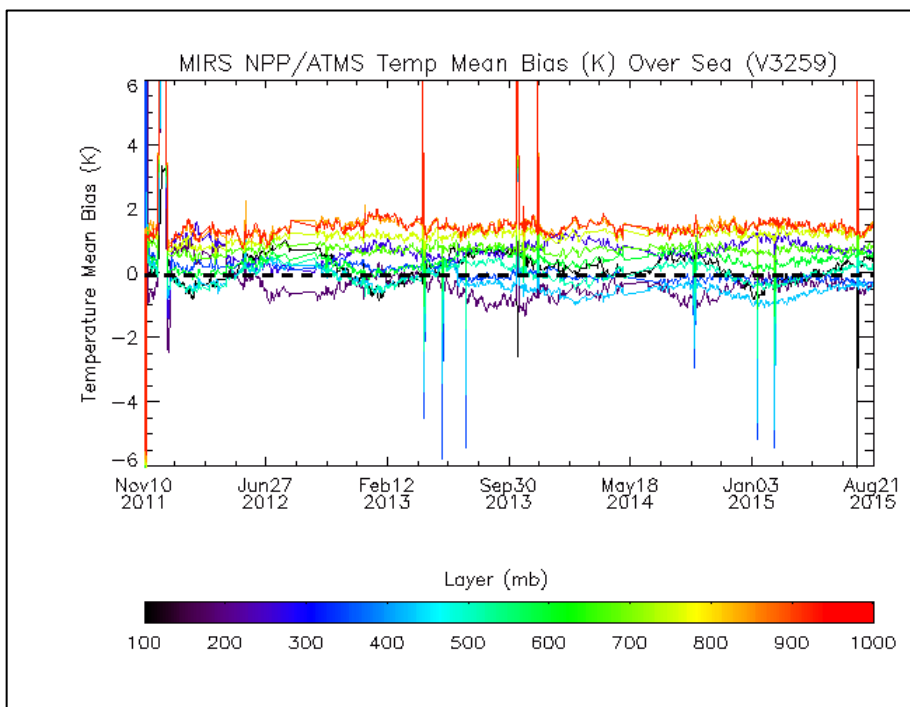
Isosurfaces: GW=0.05 mm, RW=0.01 mm



JPSS-1 Readiness: MiRS Long-Term Monitoring

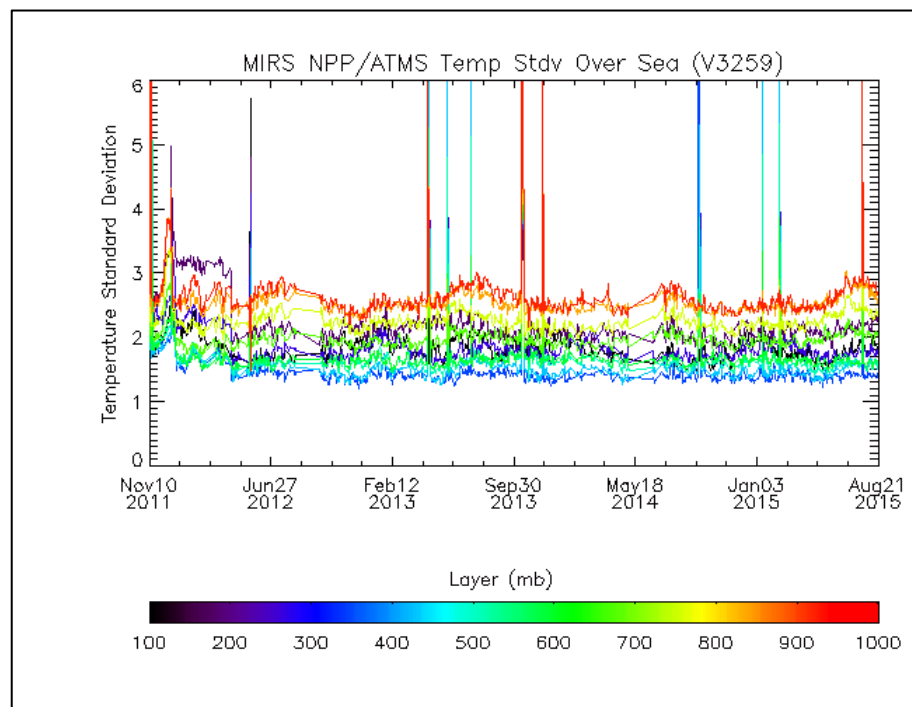
- **S-NPP/ATMS MiRS v9.2 Temperature Retrieval Bias and Std Dev vs. ECMWF since Nov 2011 (Ocean)**

Bias



Outliers are processing anomalies, not retrievals

Stdv

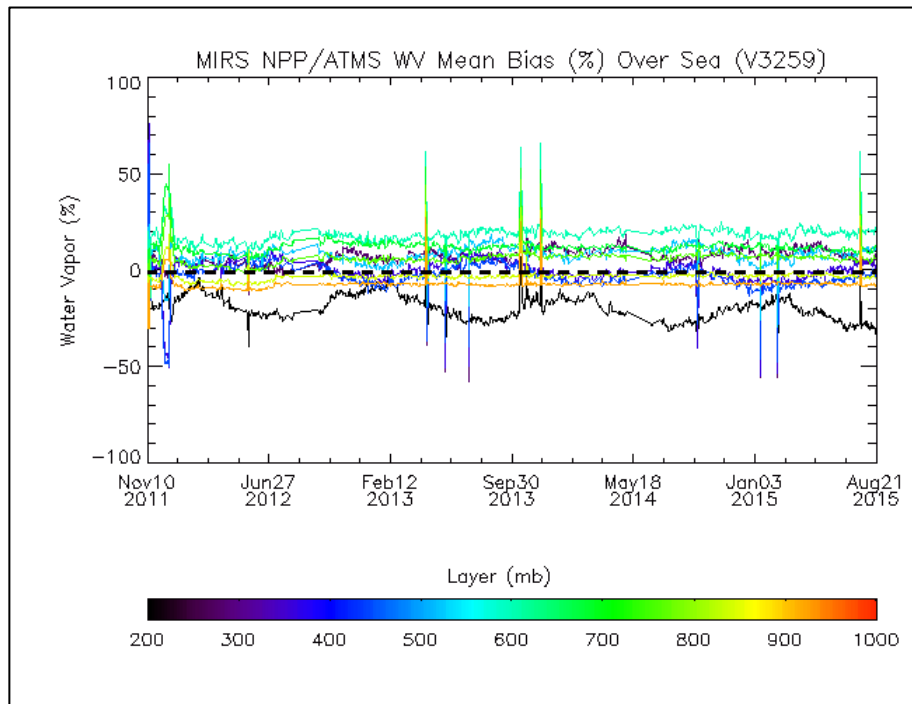


**Produced
daily on STAR
website**

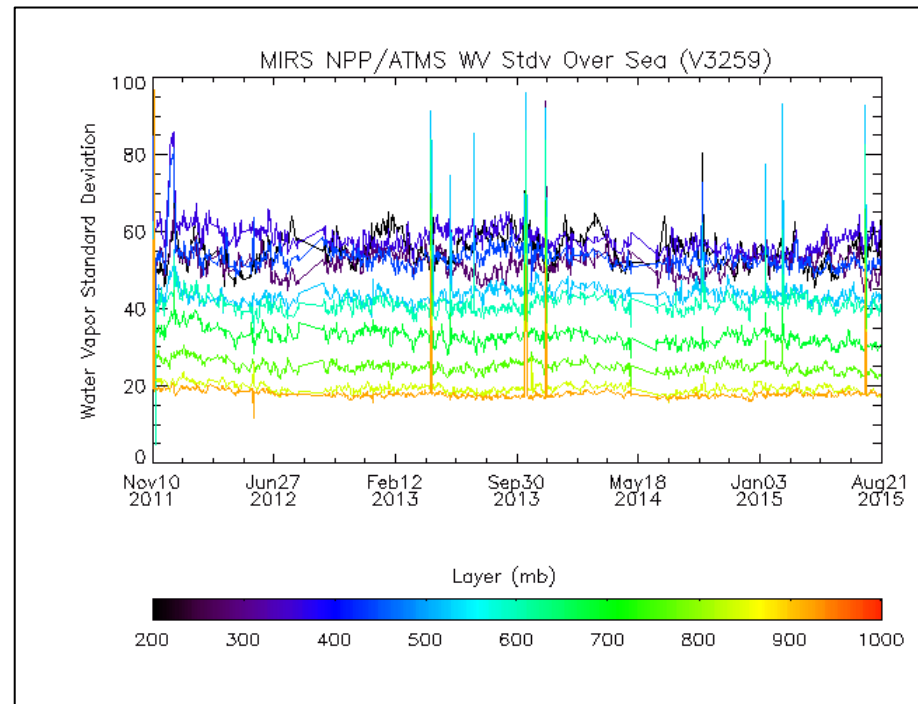
JPSS-1 Readiness: MiRS Long-Term Monitoring

- S-NPP/ATMS MiRS v9.2 Water Vapor Retrieval Bias and Std Dev vs. ECMWF since Nov 2011 (Ocean)**

Bias



Stdv



Outliers are processing anomalies, not retrievals

Produced daily on STAR website



JPSS-1 Readiness: MiRS Plans/Deliverables in FY16 and Beyond



- **Good working relationship with POCs at NDE, facilitates delivery and integration.**
- **No major changes to basic MiRS software architecture anticipated**

Date(s)	Activities	Comment/ Deliveries
Jul - Oct 2016	Code + data extension to JPSS-1/ATMS	**Need CRTM sensor coefficient files for J-1/ATMS and sample data**
Oct 2016	Critical Design Review	CDR Docs
Oct 2016 - Apr 2017	MiRS algorithm testing with sample/proxy data	
Apr 2017	JPSS-1 Launch	
May 2017	Preliminary DAP delivery to NDE	pDAP (radiometric bias corrections based on limited post-launch data)
Apr 2017 - Mar 2018	Algorithm Verification and Validation with real data	
Mar/Apr 2018	Algorithm Readiness Review + Final DAP delivery to NDE	ARR Docs + DAP
Oct 2017 - Sep 2018	MiRS JPSS-1/ATMS products validated to Stage 1	
Oct 2018 - Sep 2019	MiRS JPSS-1/ATMS products validated to Stage 2	



Summary & Path Forward



- MiRS is a robust, flexible satellite retrieval system designed for rapid, physically-based atmospheric and surface property retrievals from passive microwave measurements.
- MiRS v9.2 running at NDE since 2013.
- MiRS v11 released in September 2014, V11.1 released in this month, and V11.2 expected delivery to NDE in near future: contains numerous changes, leading to improved performance for T, WV sounding, hydrometeor, cryospheric products.
- MiRS software package already contains features designed to facilitate validation of certain EDRs (T and WV soundings). Additional off-line software exists in STAR for additional assessment and validation of RR, surface and cryospheric parameters.
- **Future Improvements:**
 - Bias corrections (air mass dependence, rainy conditions)
 - Precipitation: hydrometeor size, and distribution parameters, stratiform/convective
 - Background constraint in rainy conditions: Impacts on T and WV sounding through rain
 - Surface emissivity: project plan 2017-2018 S-NPP/ATMS emissivity product cal/val
 - Surface type: currently 4 types, move toward mixed types with unique emissivity characteristics (e.g. fuzzy clustering)

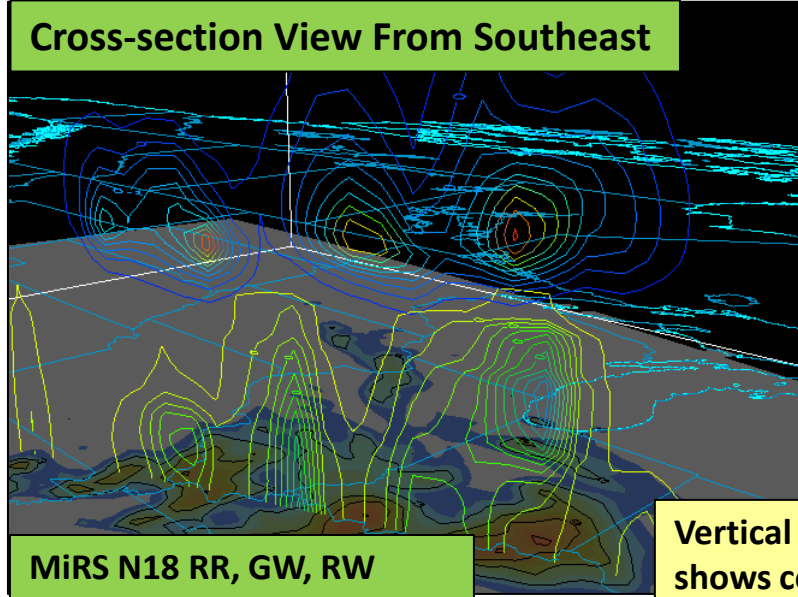
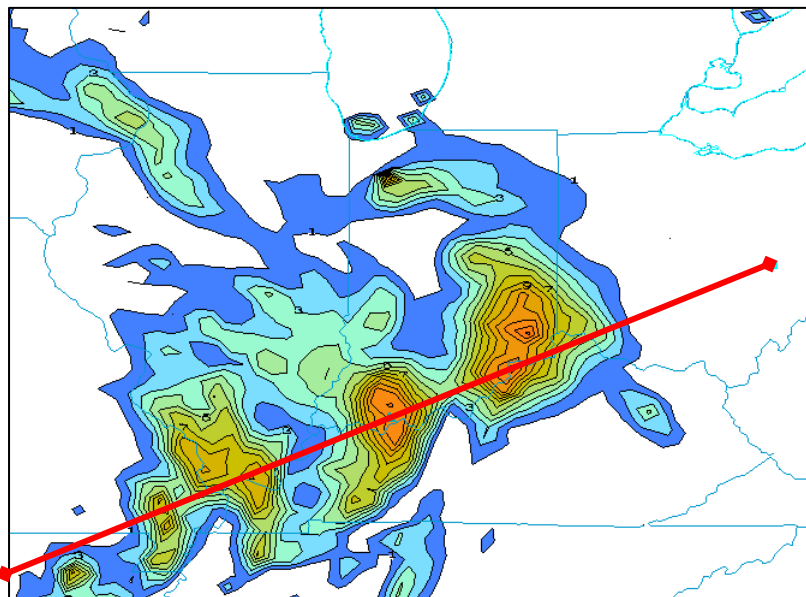
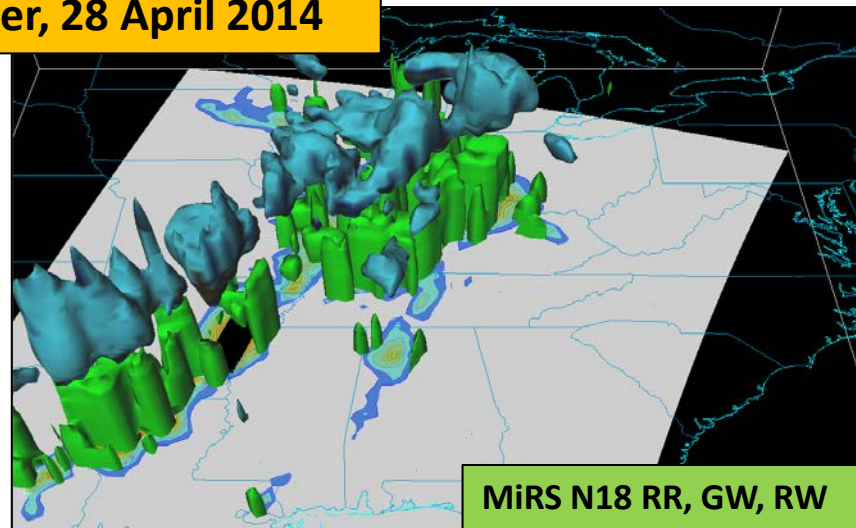
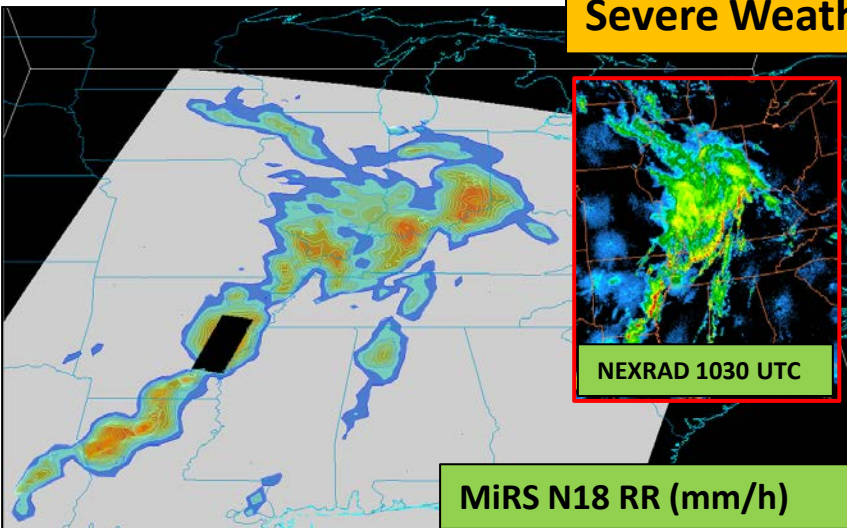


Backup Slides



JPSS-1 Readiness: MiRS Hydrometeor Retrievals (AMSU/MHS)

Severe Weather, 28 April 2014



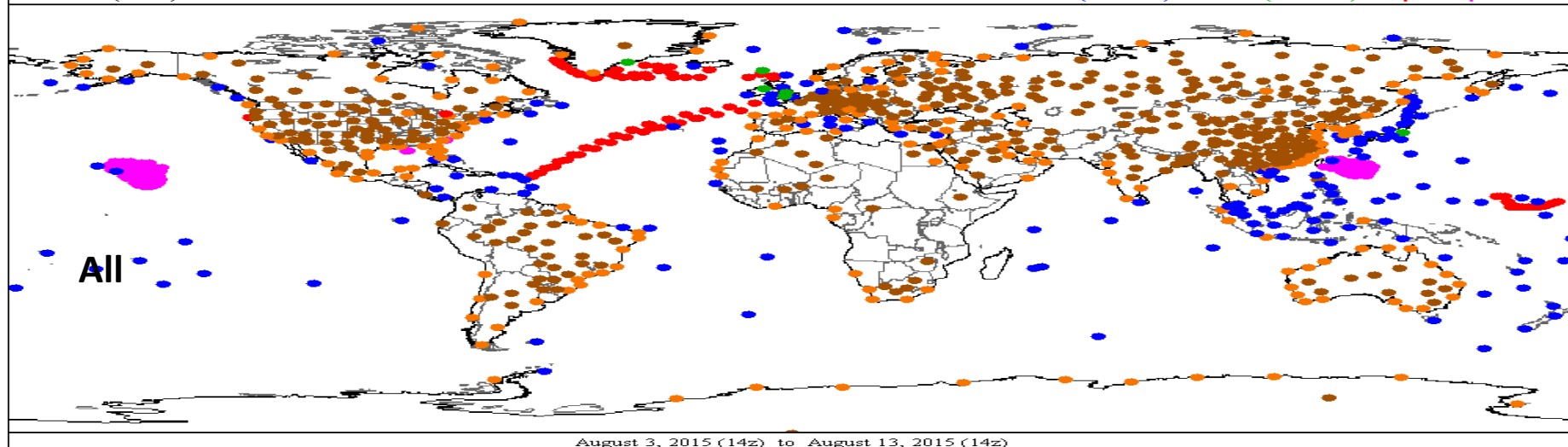
Vertical structure shows complexity (GW vs. RW distribution)

Radiosonde Locations

NOAA Products Validation System (NPROVS)

12919 (849) available out of 12919

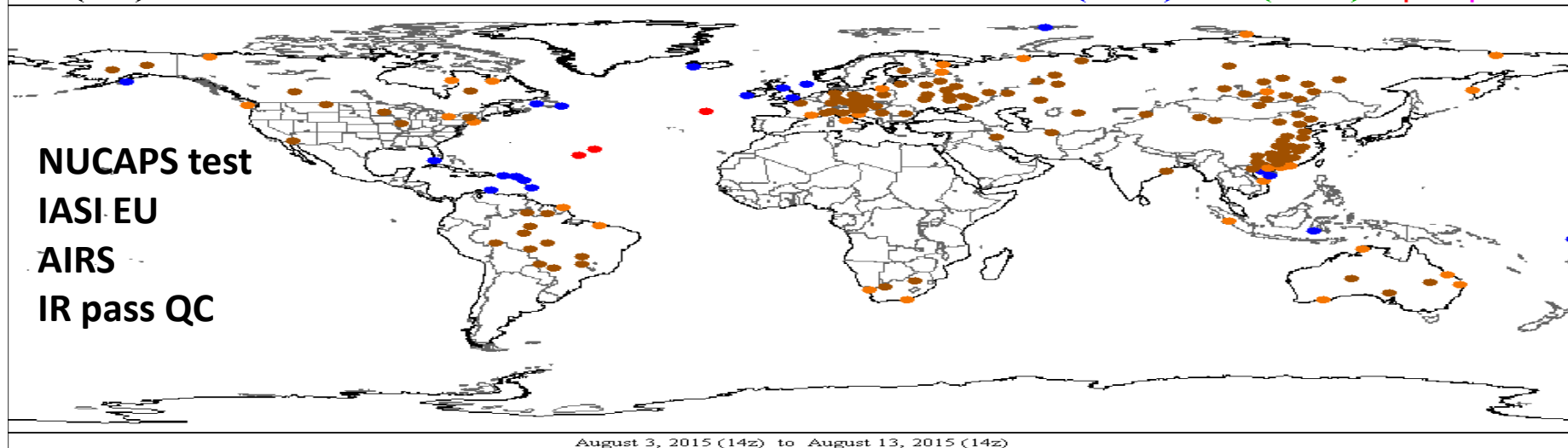
CoastLandIsland (Coast)Island(Inland)ShipDropsonde



NOAA Products Validation System (NPROVS)

179 (158) available out of 12919

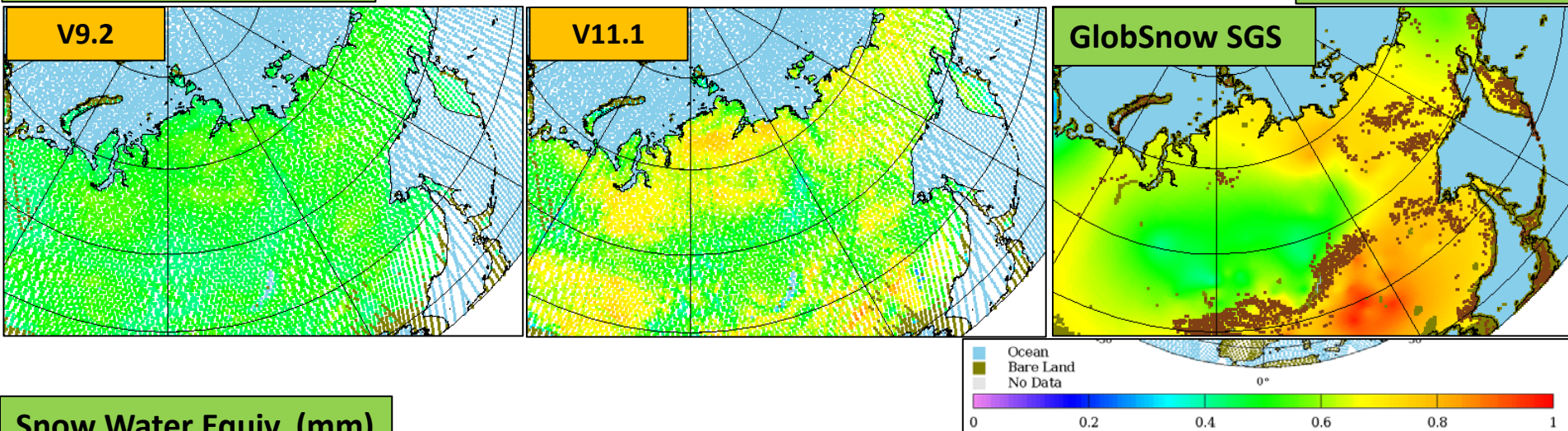
CoastLandIsland (Coast)Island(Inland)ShipDropsonde



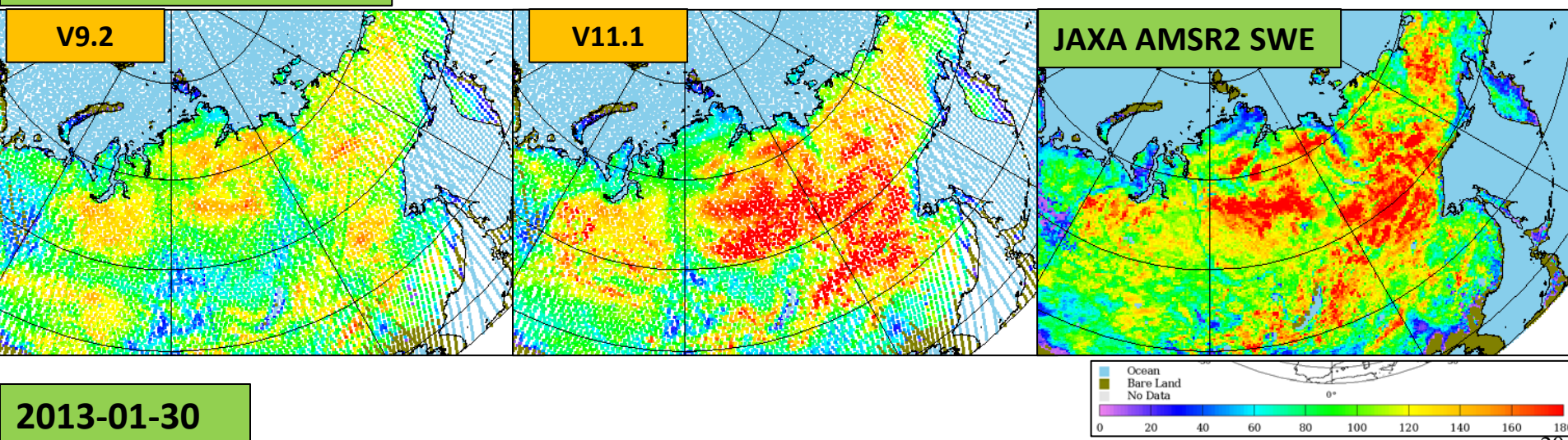
JPSS-1 Readiness: MiRS Snow Grain Size and SWE (AMSU/MHS)

Snow Grain Size (mm)

Courtesy of FMI/ESA



Snow Water Equiv. (mm)

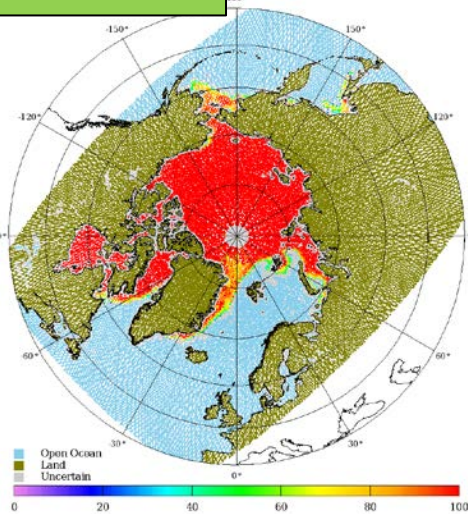


2013-01-30

JPSS-1 Readiness: MiRS Sea Ice Conc and Ice Age (AMSU/MHS)

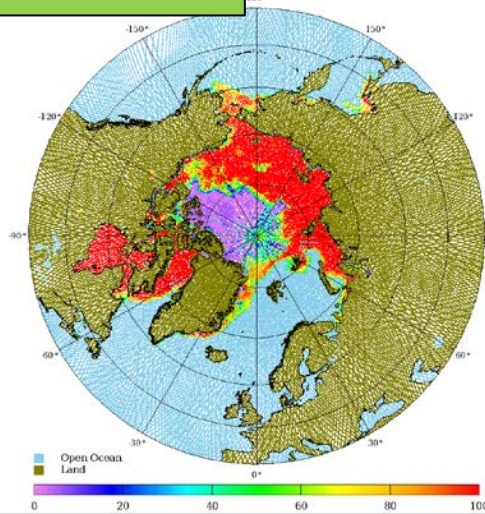
MIRS Total SIC

Sea Ice Concentration (%) 2013-01-02



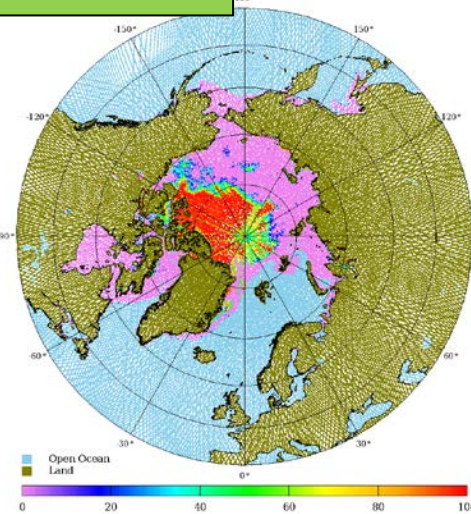
MIRS FY SIC

Sea Ice Concentration (%) 2013-01-02



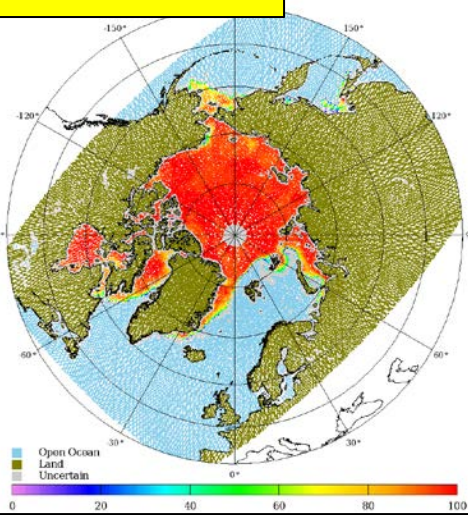
MIRS MY SIC

Sea Ice Concentration (%) 2013-01-02

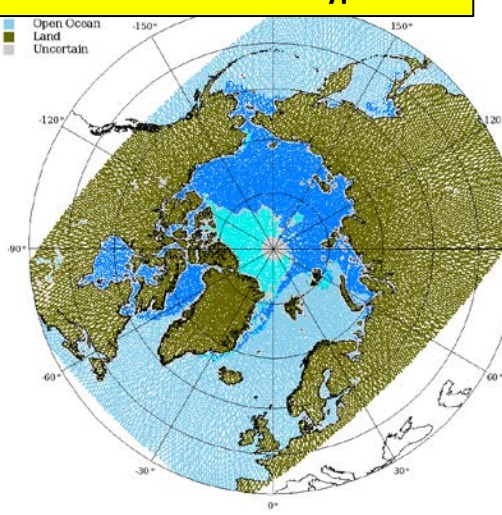


OSI-SAF Total SIC

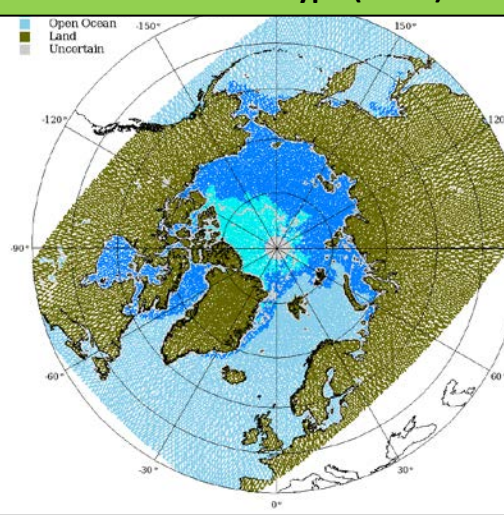
Sea Ice Concentration (%) 0-00-00



OSI-SAF Dominant Ice Type



MIRS Dominant Ice Type (>50%)



2013-01-02