Review of Microwave Integrated Retrieval System (MiRS) Improvements and Integration within CSPP

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2015 CSPP/IMAPP Users' Group Meeting
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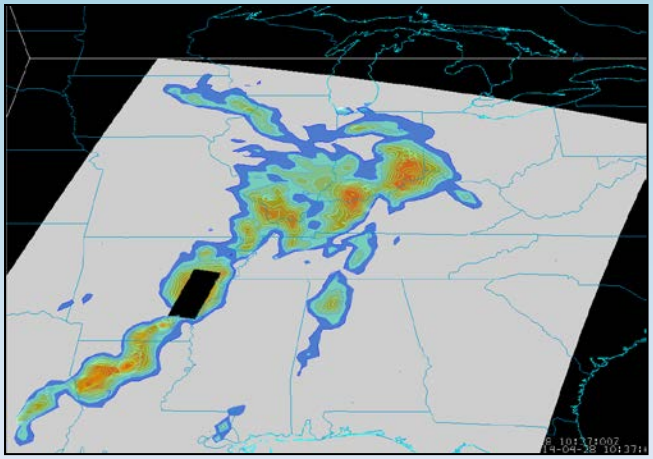
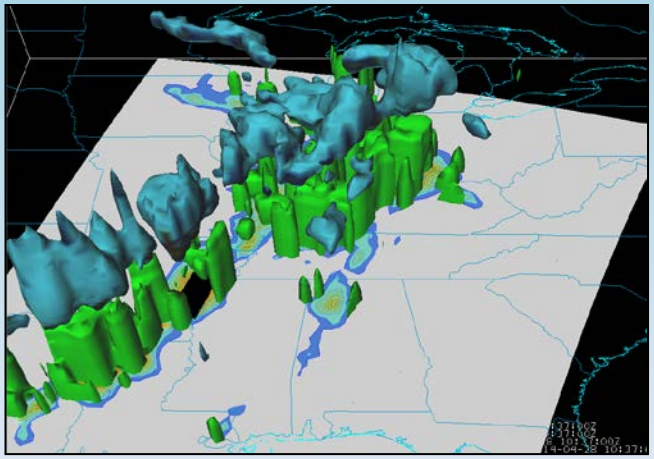
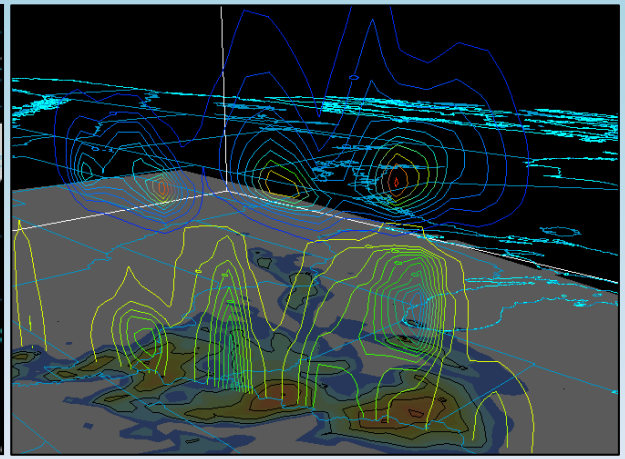




Outline

- MiRS Overview and Integration within CSPP
  - o Description, Products
  - o Satellites/sensors, resolution
  - o Changes from v9.2 and v11 (coming attractions)
- Performance impacts (v9.2 vs. v11)
  - o Global T, WV sounding
  - o Rain rate
  - o Sea ice concentration/age
  - o Snow grain size
- Examples of V11 using McIDAS-V
  - o Severe weather event, 28 April 2014
  - o Hurricane Arthur
- Summary/Future Plans

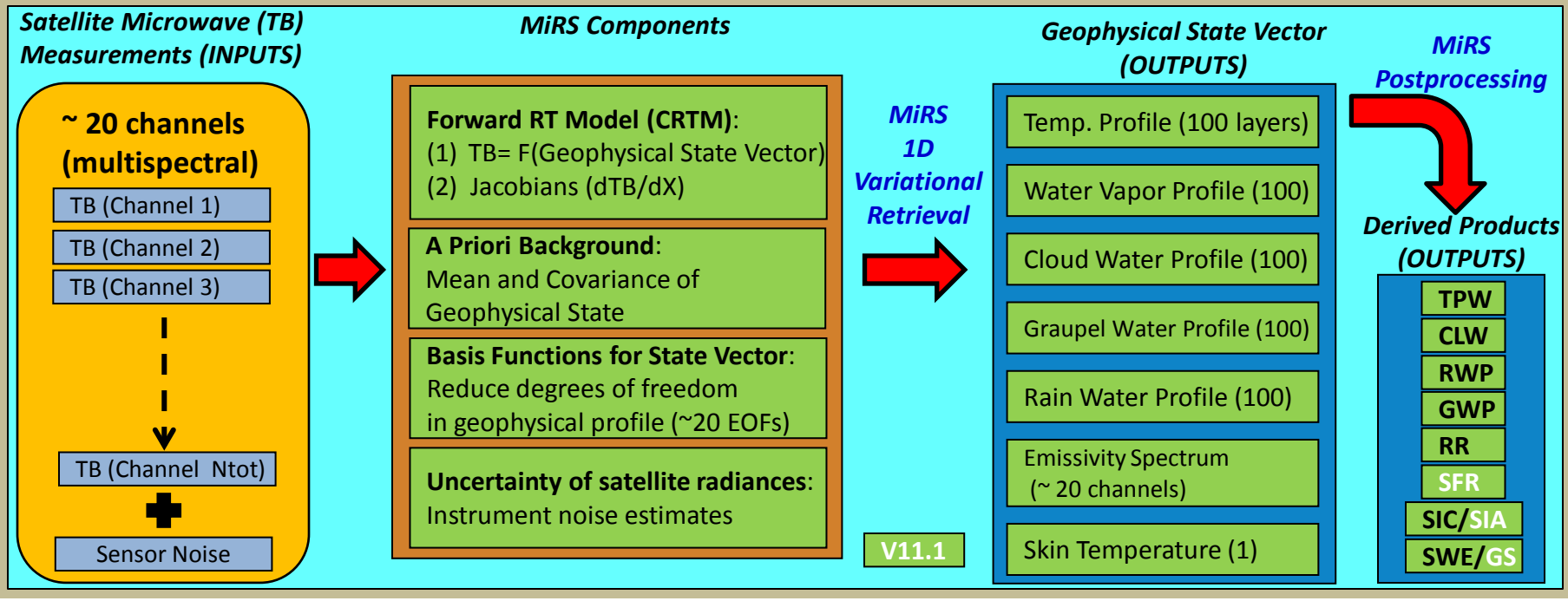
MiRS and CSPP

• **Official NOAA passive microwave retrieval algorithm**: Phased implementation starting in 2007, currently processing 7 different satellites, with more planned. (Additional satellites processed in research mode: TRMM/TMI, GCOM-W1/AMSR2).
• **Variational approach**: ensures that final estimate of atmosphere/surface is physically consistent with measurements and statistically "likely".
• **Modular software design**: most underlying codes are shared; extending to new satellites/sensors simplified. Simplified CSPP integration.

• **CSPP Integration**: MiRS V9.2 integrated in late 2013. (CSPP_MIRS V1.0) Satellites processed: N18, N19, MetopA, MetopB, SNPP. SNPP at high resolution, all others at low (AMSUA) resolution.
• **MiRS V11**: released in Sept 2014; significant number of changes to algorithm, resolution.
• **MiRS V11.1**: to be released in 2015; new products (snow grain size, sea ice age, snowfall rate).

MiRS General Description

- **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?
  - o **State vector can have 100+ elements**
  - o **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



MiRS Retrieved Parameters

Currently Produced (v9.2/v11)
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

Planned in 2015 (v11.1)
Snowfall Rate
Sea Ice Age (FY, MY)
Snow Grain Size

MiRS: Updates to V11

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 already using CRTM 2.1.1)	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
Extension to high (MHS) resolution for AMSUA-MHS (LR=30 FOVs/scan, HR=90FOVs/scan)	N18, N19, MetopA/AMSUA-MHS, (MetopB, SNPP/ATMS already high-res)	Improved depiction of small-scale features: CLW, RR, WV, ice edge
Extension to high (ENV) resolution for SSMIS (+extension to F17) (LR=30 FOVs/scan, HR=90FOVs/scan)	F17/SSMIS (and F18, to be delivered in 2015)	Better depiction of small-scale features: CLW, RR, WV, ice edge
New bias corrections for all sensors	All	Needed for consistency with CRTM 2.1.1
Dynamic channel selection near sea ice boundary	N18, N19, MetopA, MetopB/AMSUA-MHS, SNPP/ATMS	Better convergence behavior for cross-track instruments
Updated surface type preclassifier	F17, F18 SSMIS	Improved snow detection for conical scan instruments
Miscellaneous changes to improve code efficiency, bug fixes	All	Matrix preparation time reduced from 40% to 5% of 1dvar computation time

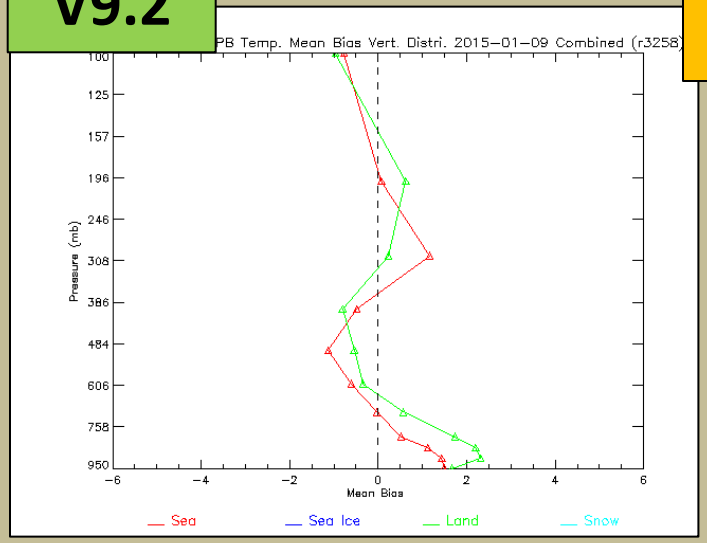
MiRS V9.2 and V11 Global Performance

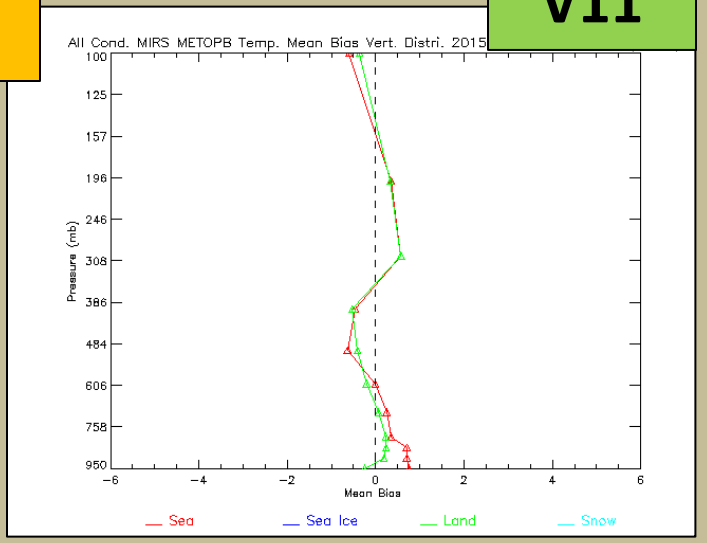
MetopB Temperature Bias and Std Dev (vs. ECMWF)

V9.2

All conditions

V11

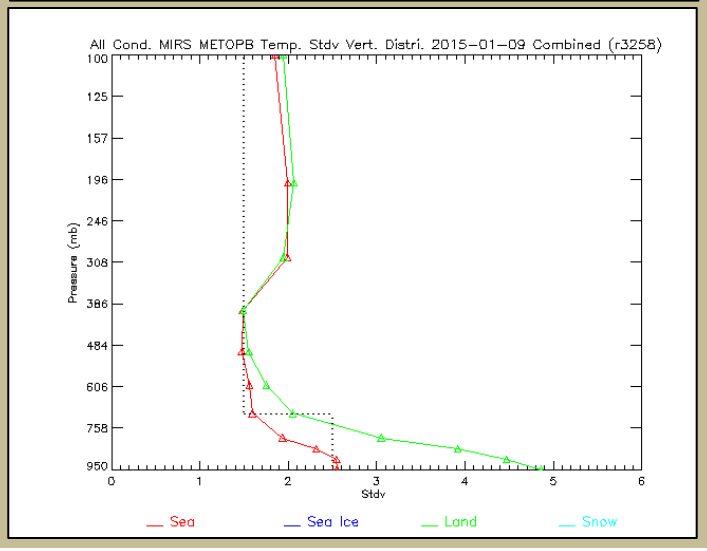


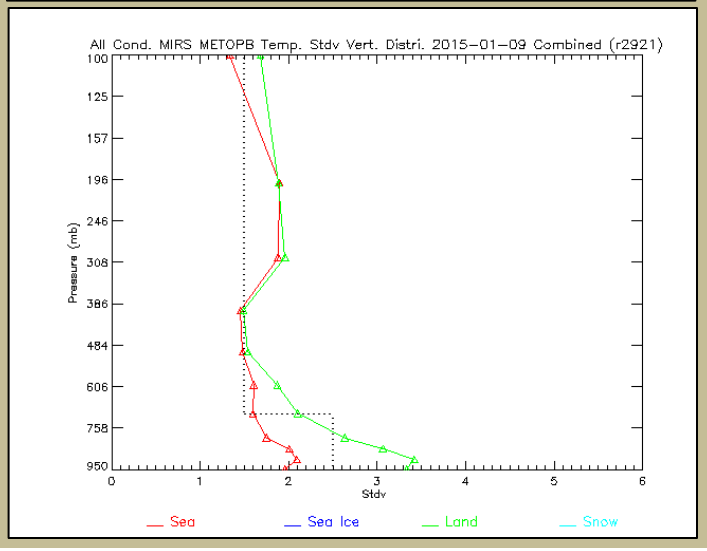


Land
Ocean

2015-01-09

V11 Reduction in both bias and std dev at most layers





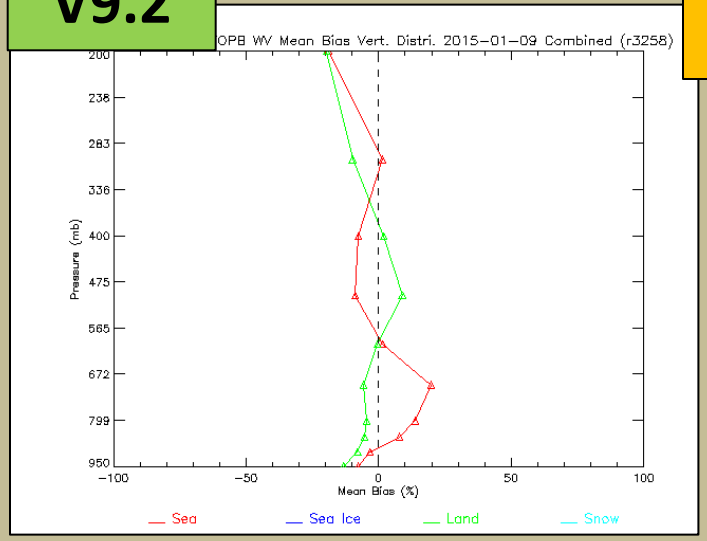
MiRS V9.2 and V11 Global Performance

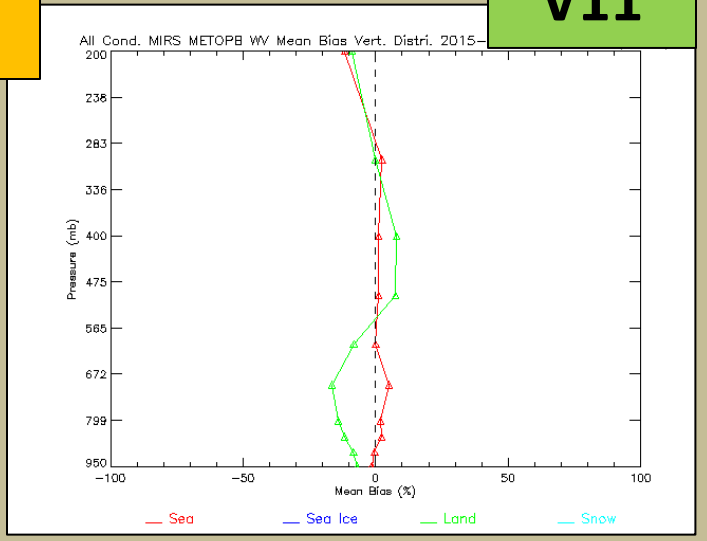
MetopB Water vapor Bias and Std Dev (vs. ECMWF)

V9.2

All conditions

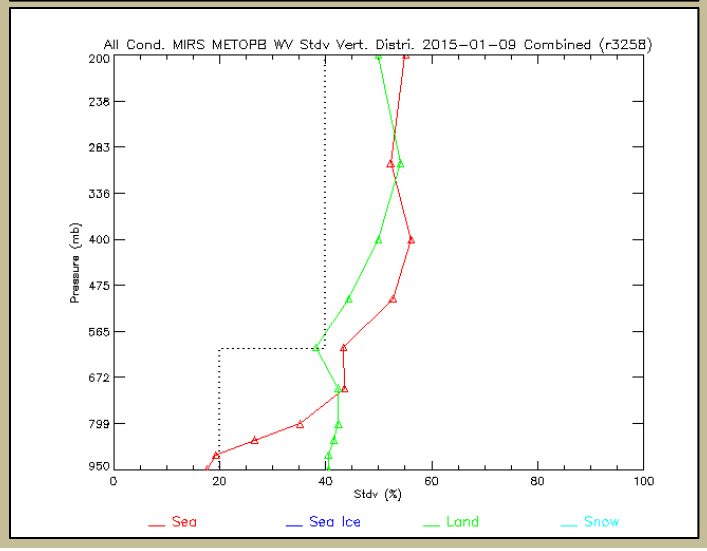
V11



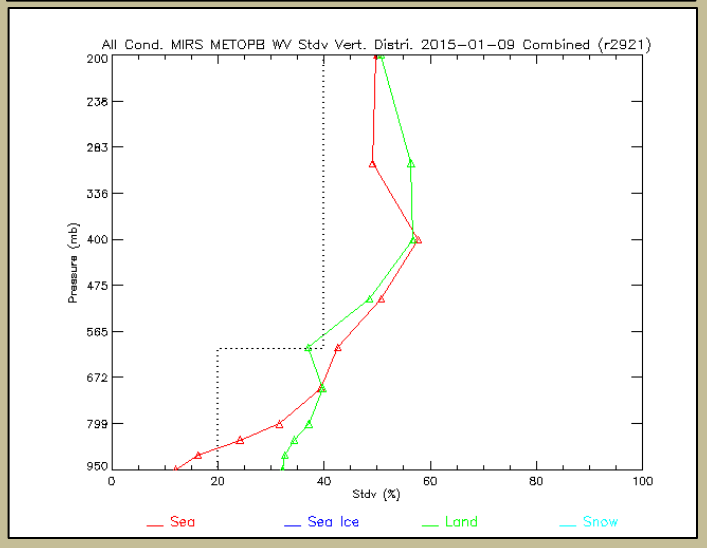


Land
Ocean

2015-01-09



V11 Reduction in both bias and std dev at most layers

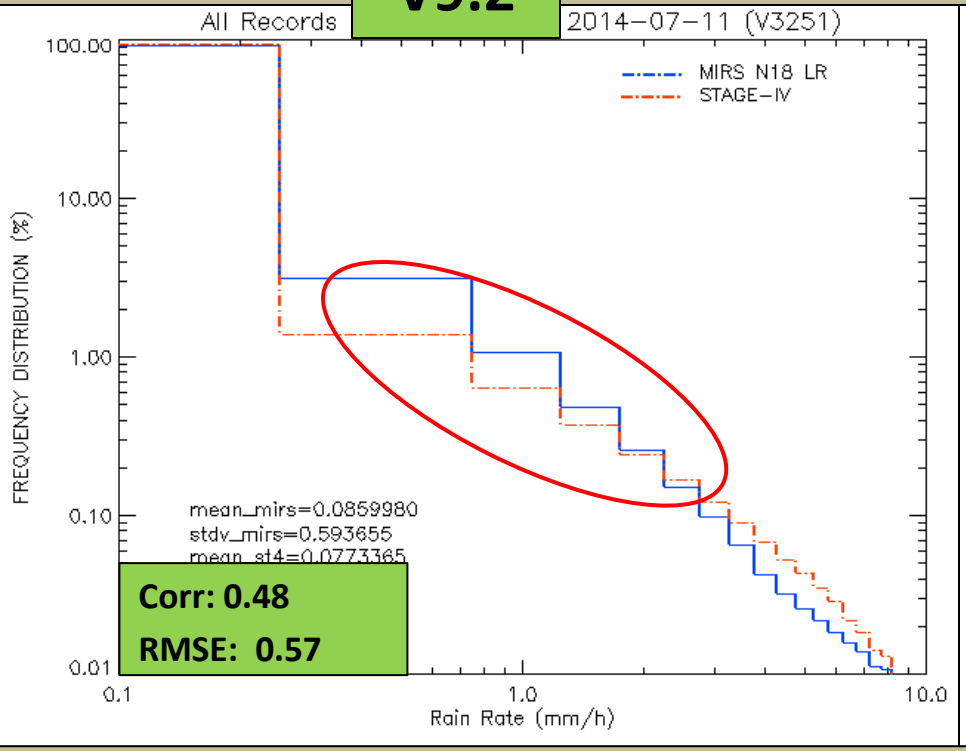


MiRS V9.2 and V11 Performance

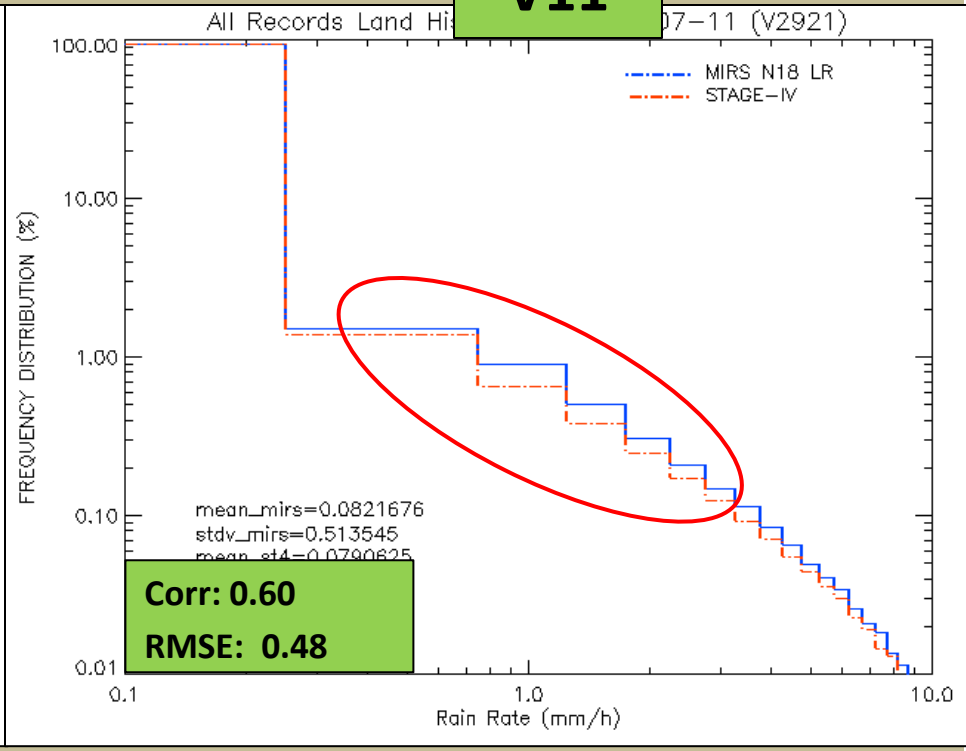
N18 Rain Rate (vs. Stage IV)

Assessment period (2009-2014)

V9.2



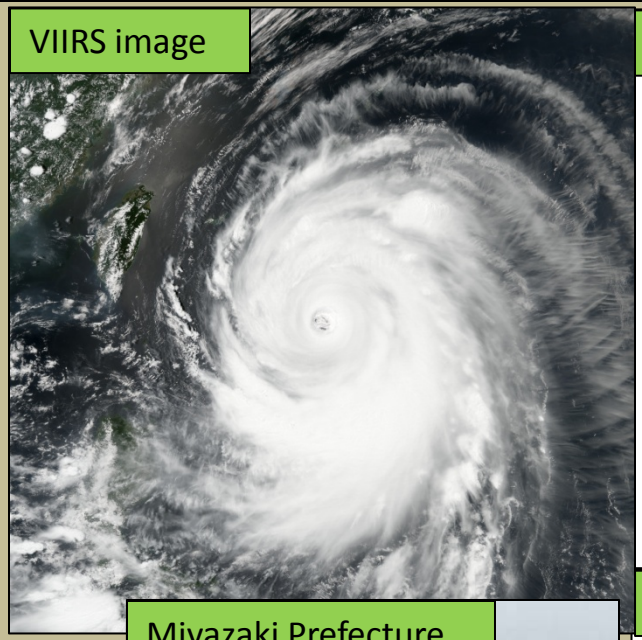
V11



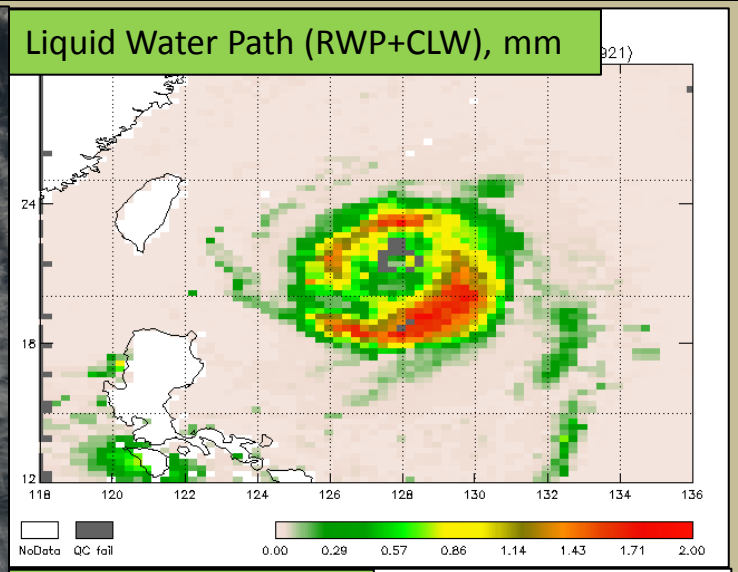
- Better agreement in low intensities
- More consistent at higher intensities (> 3 mm/h)
- Improved correlation and lower RMSE

MiRS V11 Rainfall: Typhoon Neoguri on 7 July 2014

VIIRS image



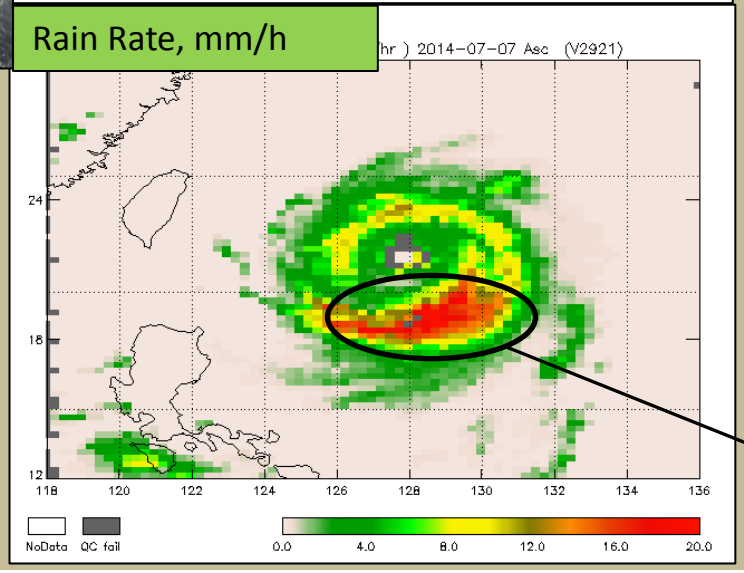
Liquid Water Path (RWP+CLW), mm



- SNPP/ATMS data
- Cyclone impacted Okinawa on 8 July

Miyazaki Prefecture

Rain Rate, mm/h

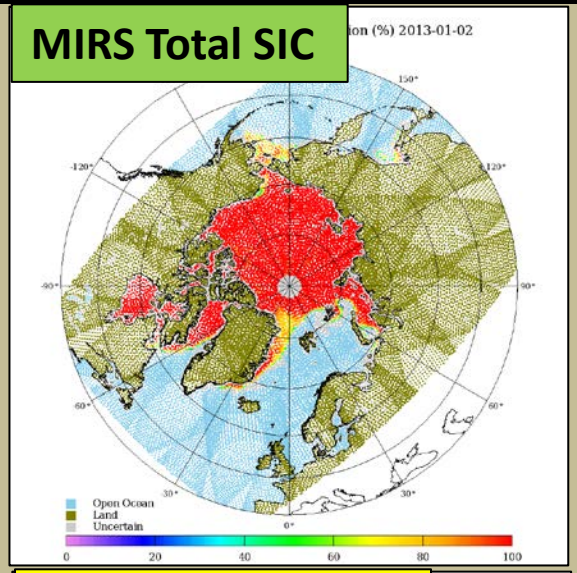


RR > 20 mm/h consistent with reports post-landfall (e.g. 340 mm in 24 h)

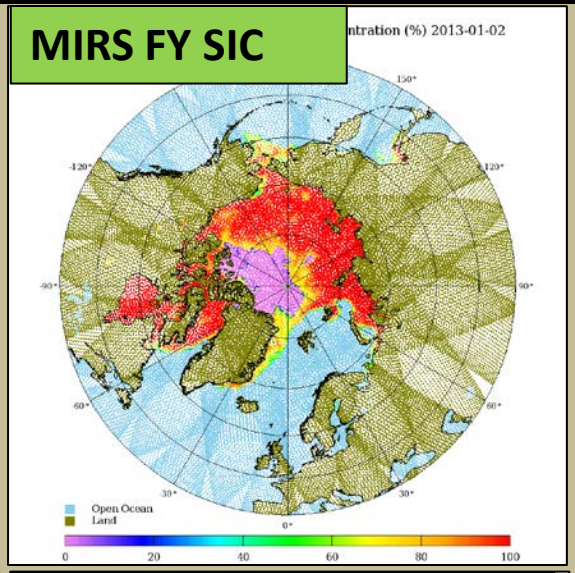
MiRS V11 Sea Ice Concentration/Age

F18 SSMI/S

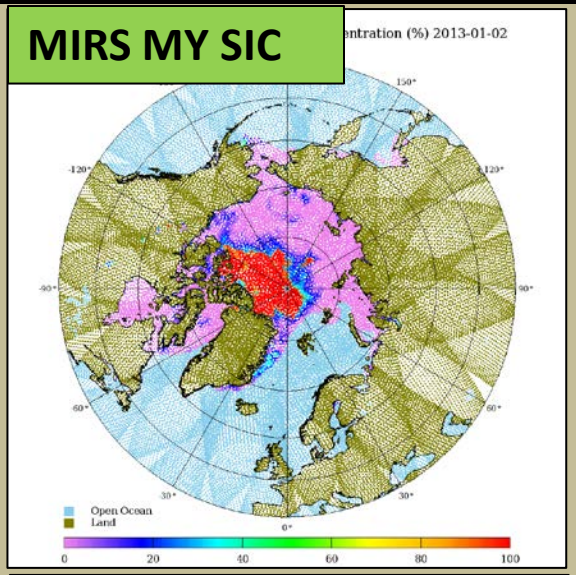
MIRS Total SIC



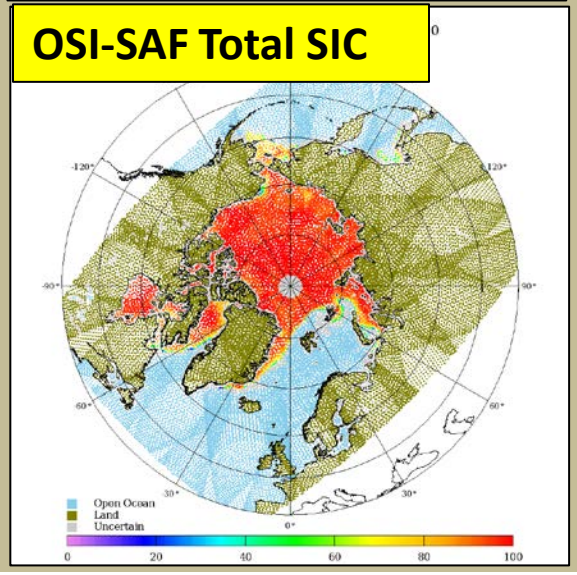
MIRS FY SIC



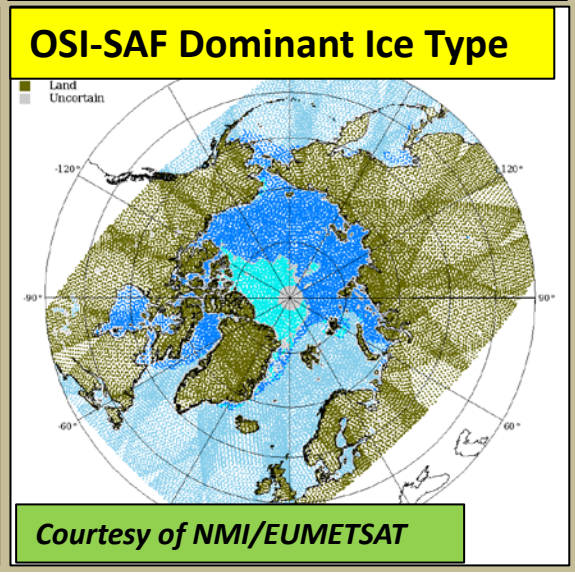
MIRS MY SIC



OSI-SAF Total SIC

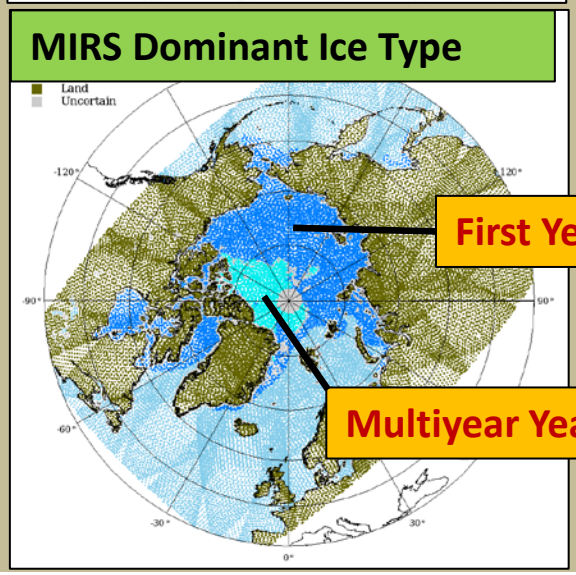


OSI-SAF Dominant Ice Type



Courtesy of NMI/EUMETSAT

MIRS Dominant Ice Type



First Year Ice

Multiyear Year Ice

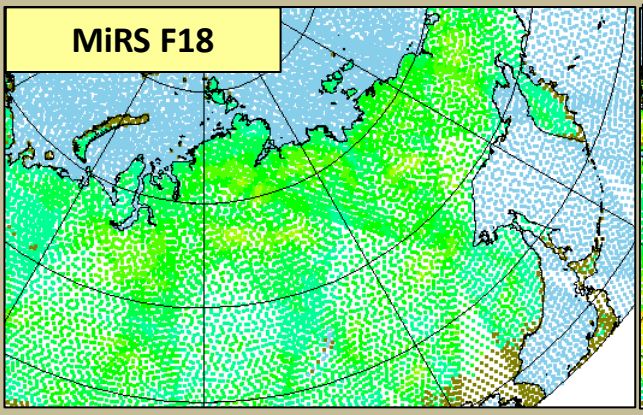
MiRS V11.1 Snow Grain Size

V9.2

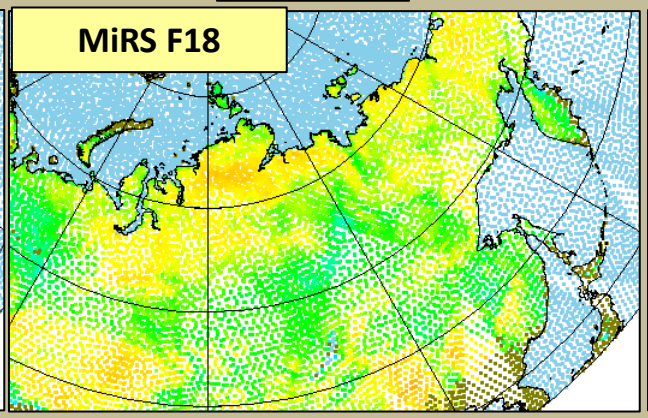
V11.1

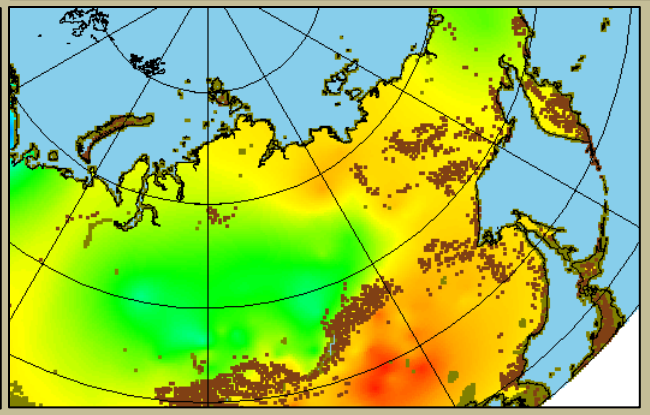
GlobSnow SGS (not operational)

MiRS F18



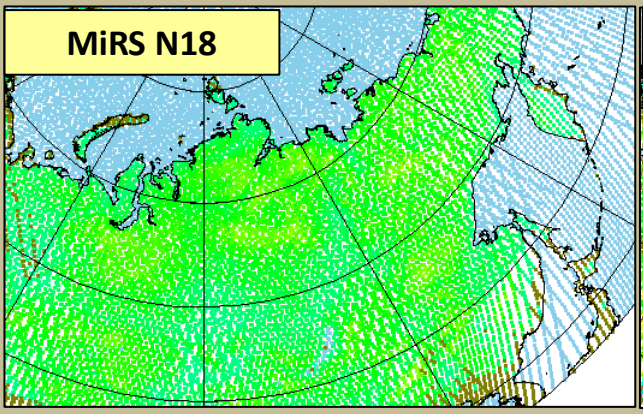
MiRS F18



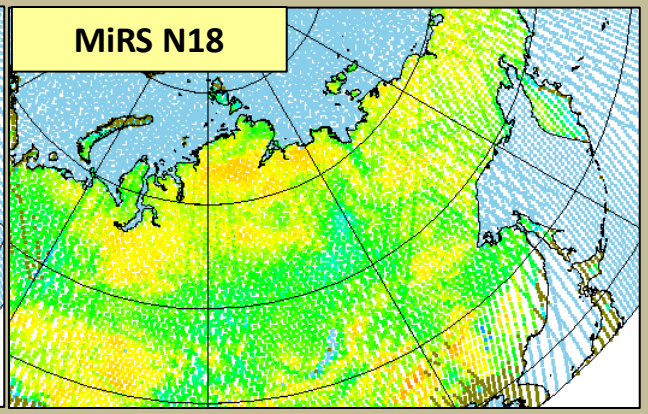


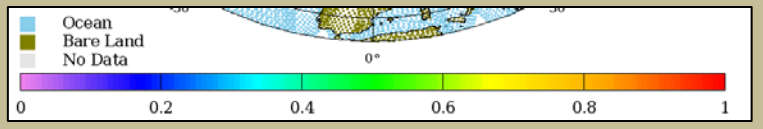
Courtesy of FMI/ESA

MiRS N18



MiRS N18





Grain Size Radius (mm)

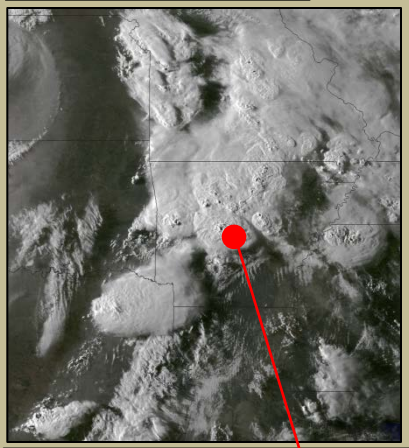
- **Comparison with independent analysis (GlobSnow) shows V11.1 better agreement than v9.2**

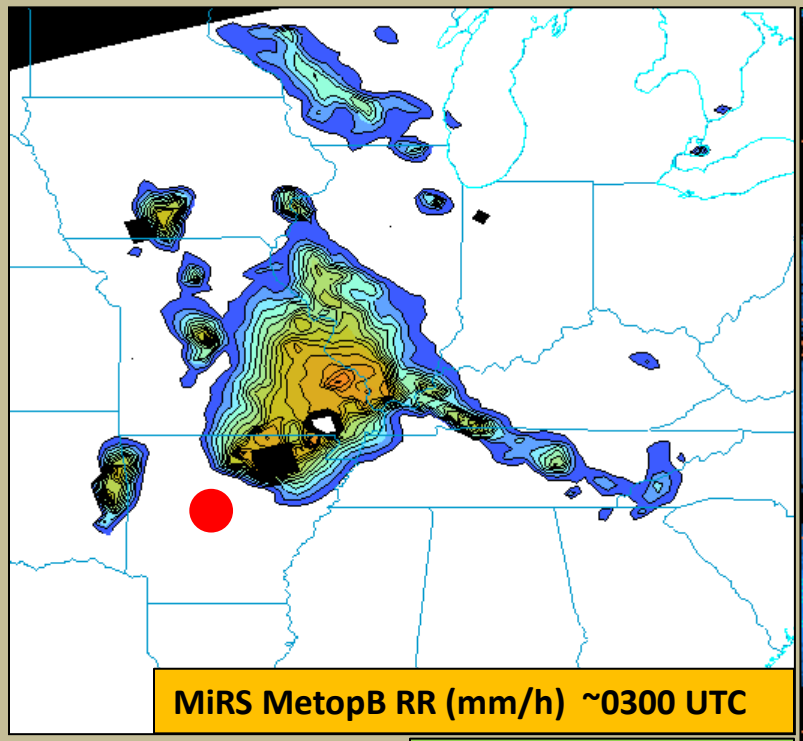
2013-01-30

MiRS V11* Examples: Severe Weather, 28 April 2014

** CSPP_MIRS is V9.2*

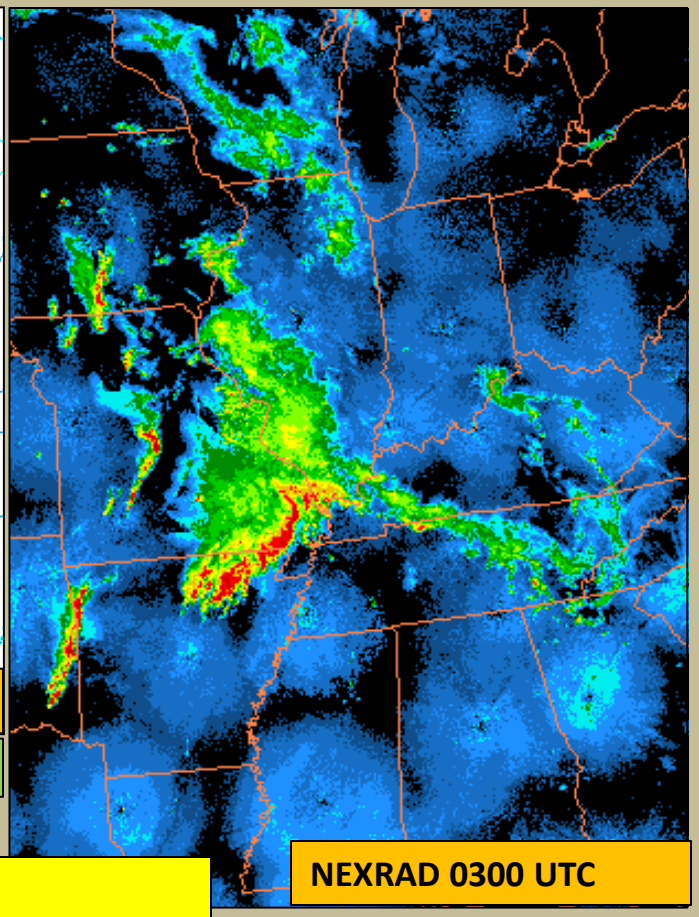
GOES-13
2345 UTC 27APR



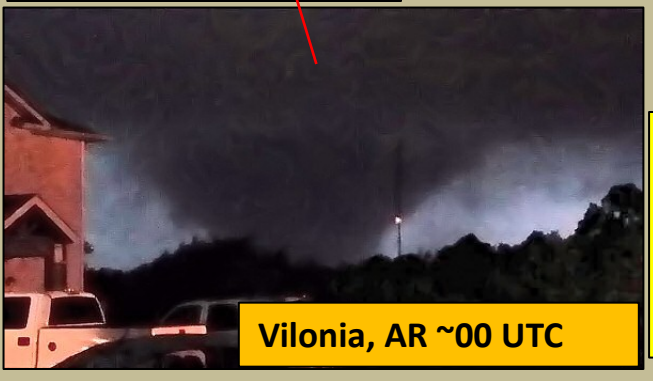


MiRS MetopB RR (mm/h) ~0300 UTC

Produced with McIDAS-V



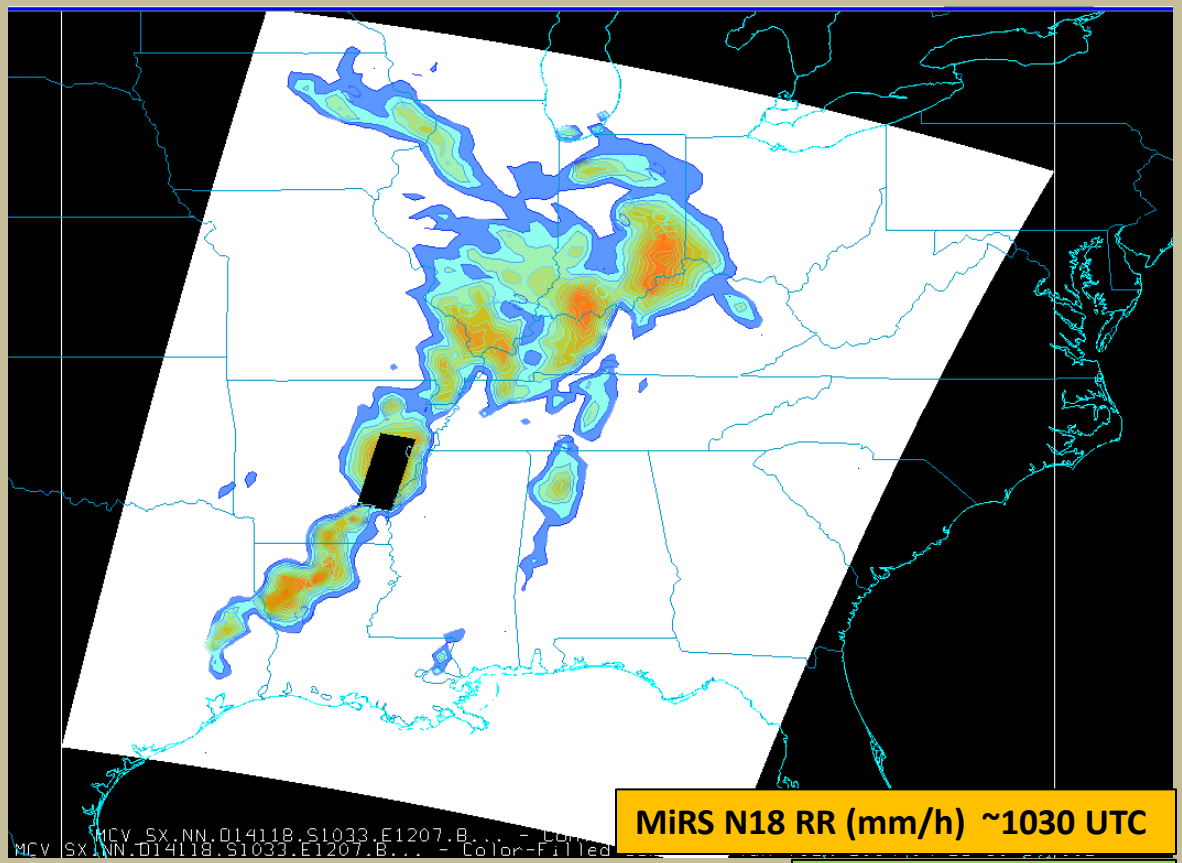
NEXRAD 0300 UTC



Vilonia, AR ~00 UTC

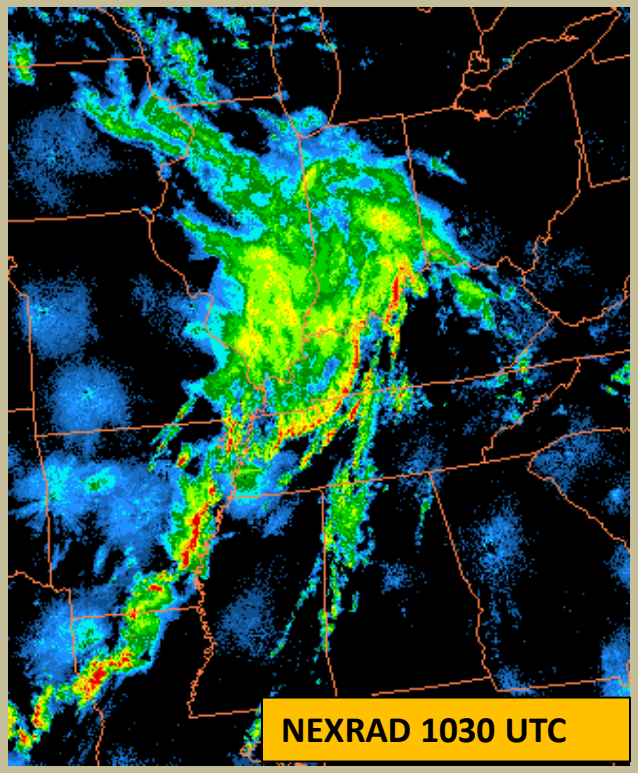
27-30 Apr 2014 Severe Weather
- **84 tornadoes, 35 fatalities**
- **Vilonia EF4 tornado 28 Apr 2014 ~0000 UTC**
- **MetopB valid ~0300 UTC**
- **N18 vaild ~1030 UTC**

MiRS V11 Examples: Severe Weather, 28 April 2014



MiRS N18 RR (mm/h) ~1030 UTC

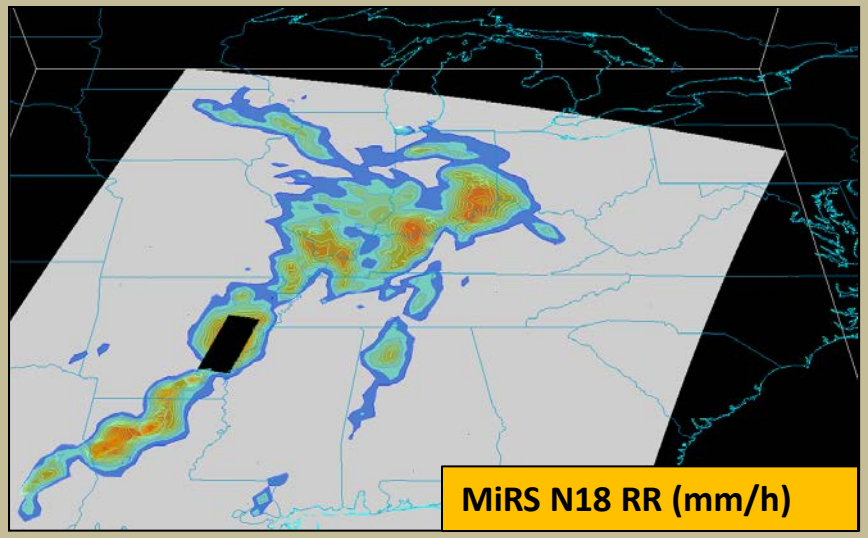
Produced with McIDAS-V

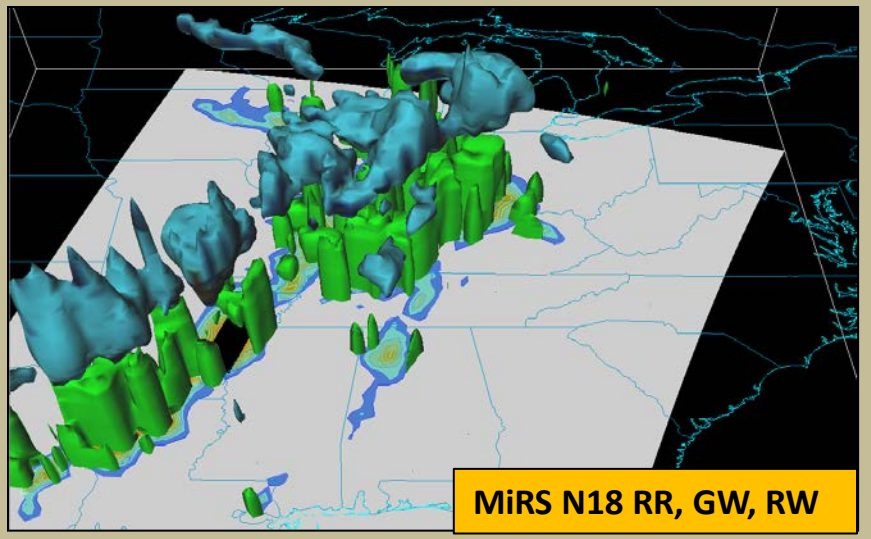


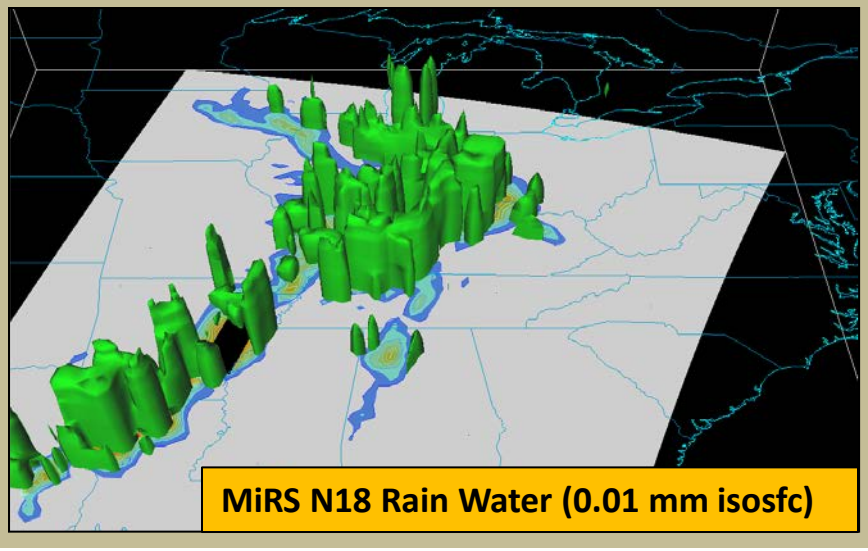
NEXRAD 1030 UTC

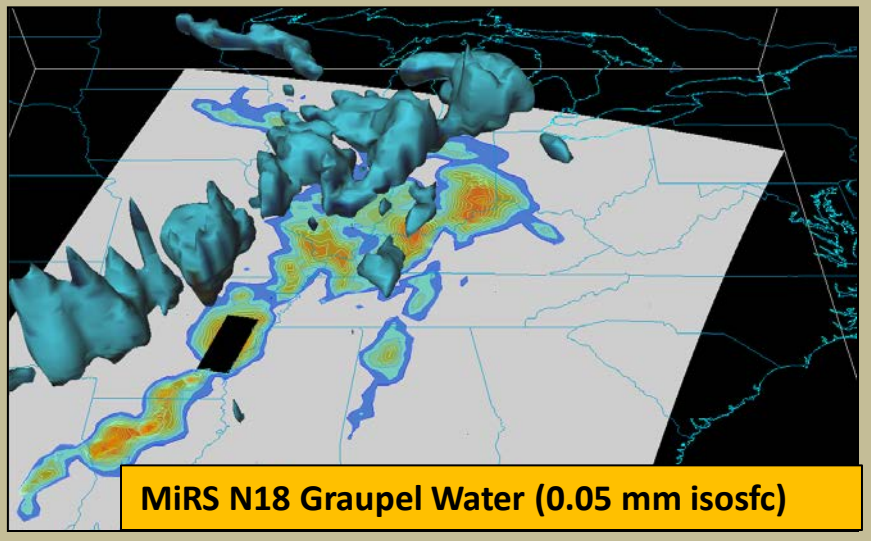
28 Apr 2014 Severe Weather
- **Vilonia tornado ~0000 UTC**
- **MetopB valid ~0300 UTC**
- **N18 vaild ~1030 UTC**

MiRS V11 Examples: Severe Weather, 28 April 2014





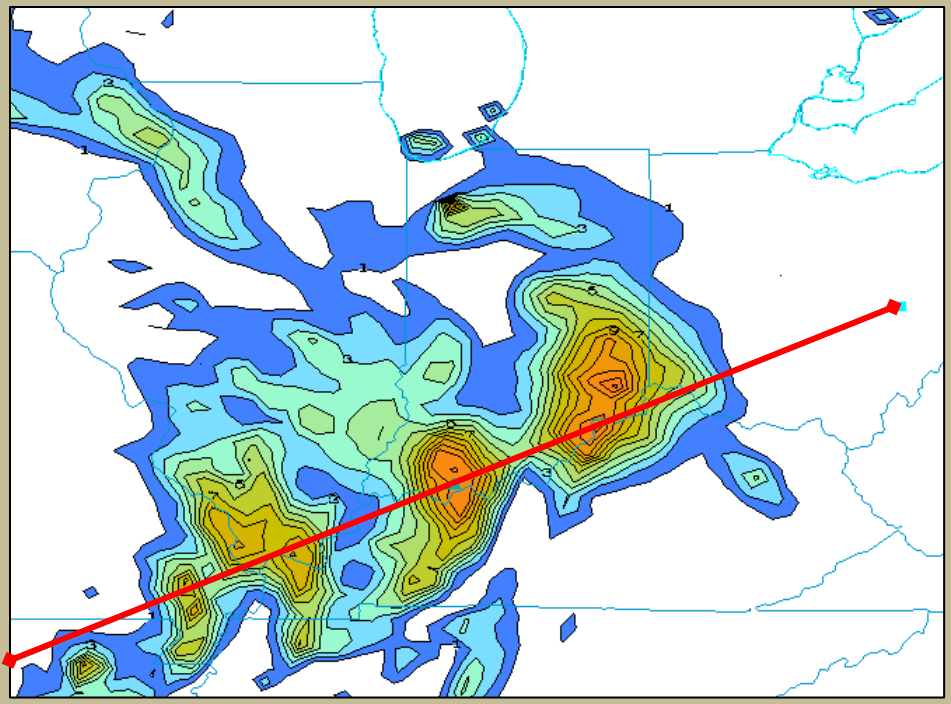


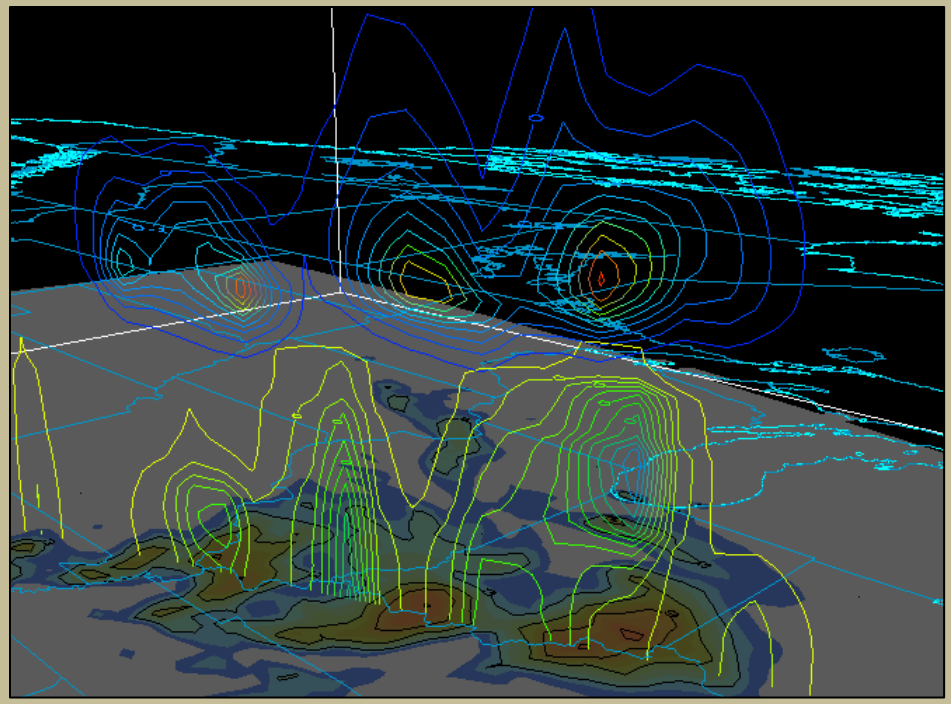


MiRS V11 Examples: Severe Weather, 28 April 2014

Cross-section View From Southeast

MiRS N18 RR, GW, RW



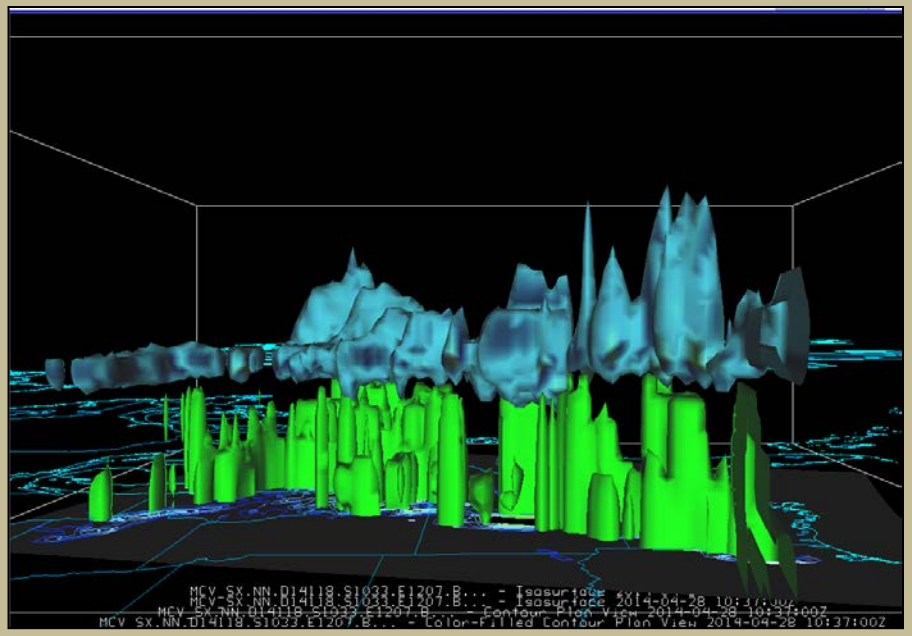


Vertical structure shows complexity (GW vs. RW distribution)

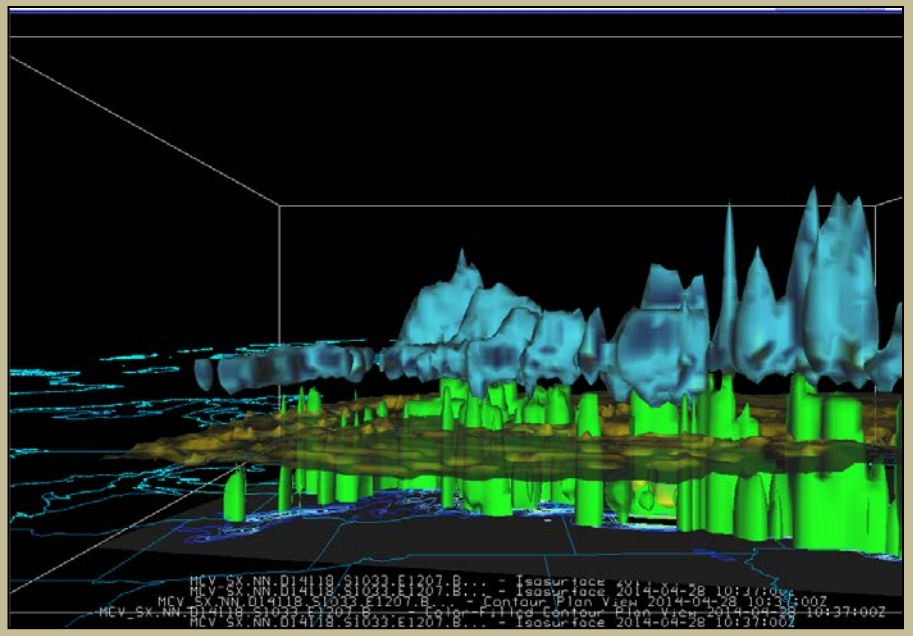
MiRS V11 Examples: Severe Weather, 28 April 2014

View From West

MiRS N18 RR, GW, RW

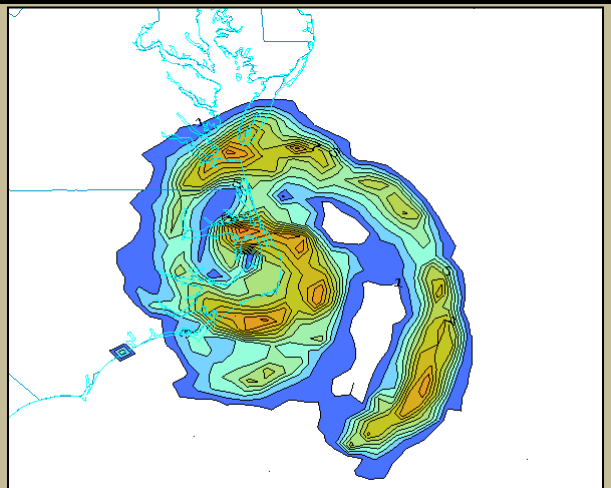


MiRS N18 RR, GW, RW + Freezing Level

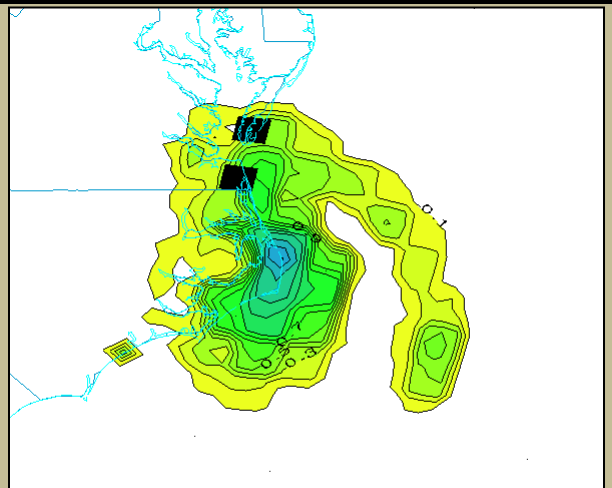


Most RW below 273K isotherm

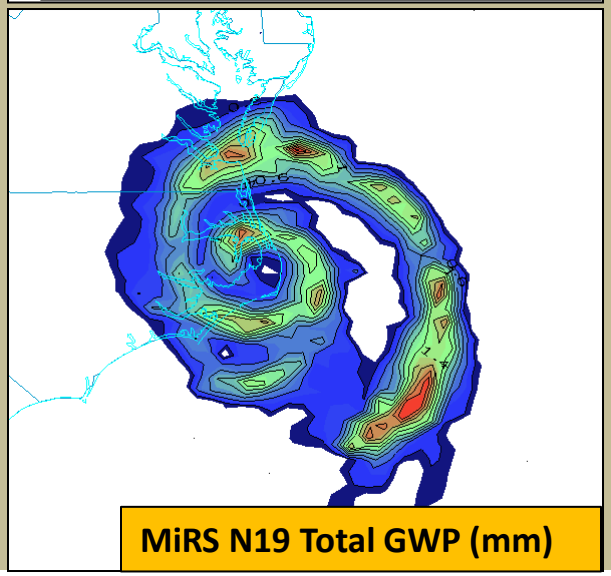
MiRS V11 Examples: Hurricane Arthur, 4 July 2014



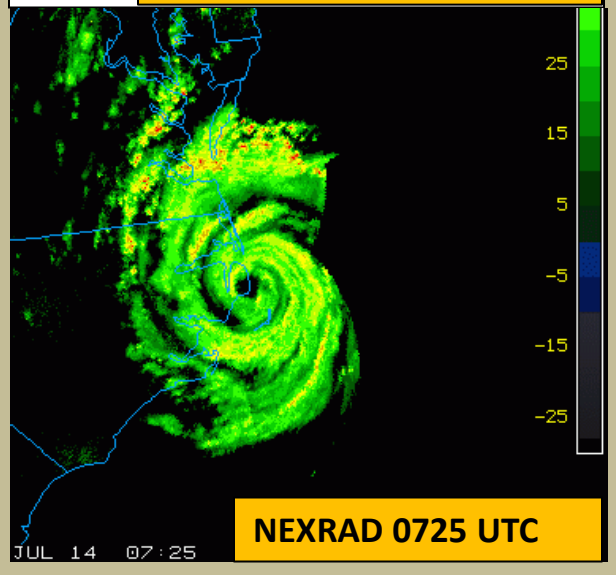
MiRS N19 RR (mm/h) ~0700 UTC



MiRS N19 Total RWP (mm)



MiRS N19 Total GWP (mm)



NEXRAD 0725 UTC

Distinct eye structure in GWP

Summary

- MiRS is a robust, flexible satellite retrieval system designed for rapid, physically-based atmospheric and surface property retrievals from passive microwave measurements.
- Phased into NOAA operations starting in 2007; now processing 7 different satellites.
- MiRS v9.2 integrated into CSPP late 2013.
- **MiRS v11 released in September 2014, contains numerous changes, leading to improved performance for T, WV sounding, rainfall. New products to be added in v11.1: snowfall rate, snow grain size, sea ice age.**
- **Q:** When will v11.1 be available in CSPP?
- **A:** Integration planned for summer 2015? (integration of v11.1 should be faster than v9.2!)
- User feedback

- Future: Planned extension to new satellites: GPM, JPSS-1, F19,…

Thank You

Questions?

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