MiRS Algorithm for the SNPP/JPSS/GCOM-W

-Science and Products Overview-

Presented by

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Chair, MiRS Oversight Board

MiRS Oversight Board

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With Contributions from:

K. Garrett (JCSDA)

Acknowledgements

- ***Main sponsor of MiRS project over the years: U.S. NOAA/NESDIS Product System Development and Implementation (PSDI) program***

- **Support was also provided over the years from:**
  - *NDE program*
  - *JPSS Program*
  - *JCSDA*

- **Instrumental Feedback from Users (of package and products) over the years helped in shaping the project**
  - *CIRA team*
  - *OSPO team*
  - *NPROVS team*
  - *JPL team*
  - *IPWG/UMD team*
  - *CPTEC team/Brazil*
- **Past team members:** K. Garrett, F. Iturbide-Sanchez, W. Chen, T. Clough, R. Chen, Q. Liu, V. Zubko, Z. Jiang, A. Mims, L. Moy, Etc

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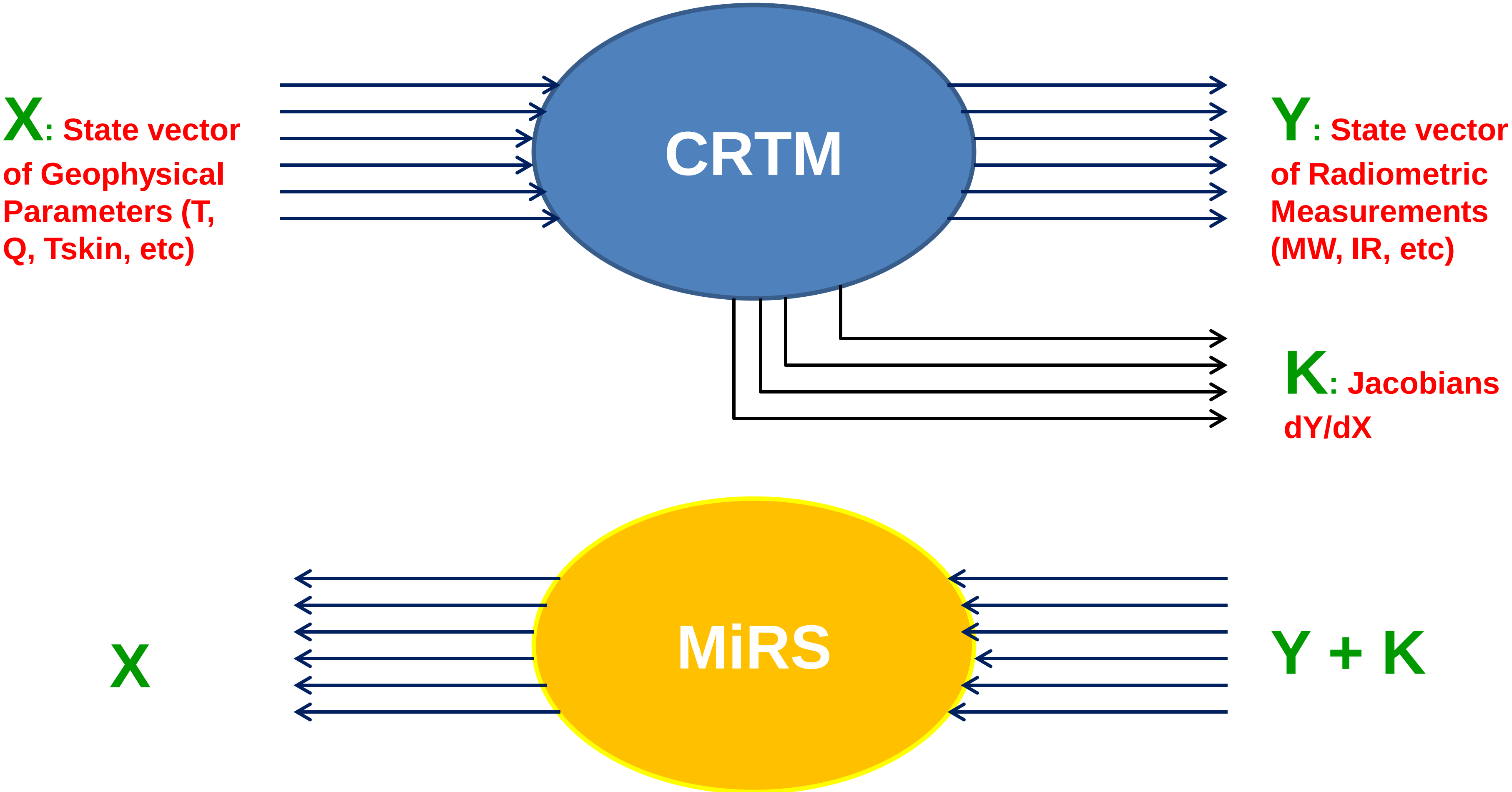
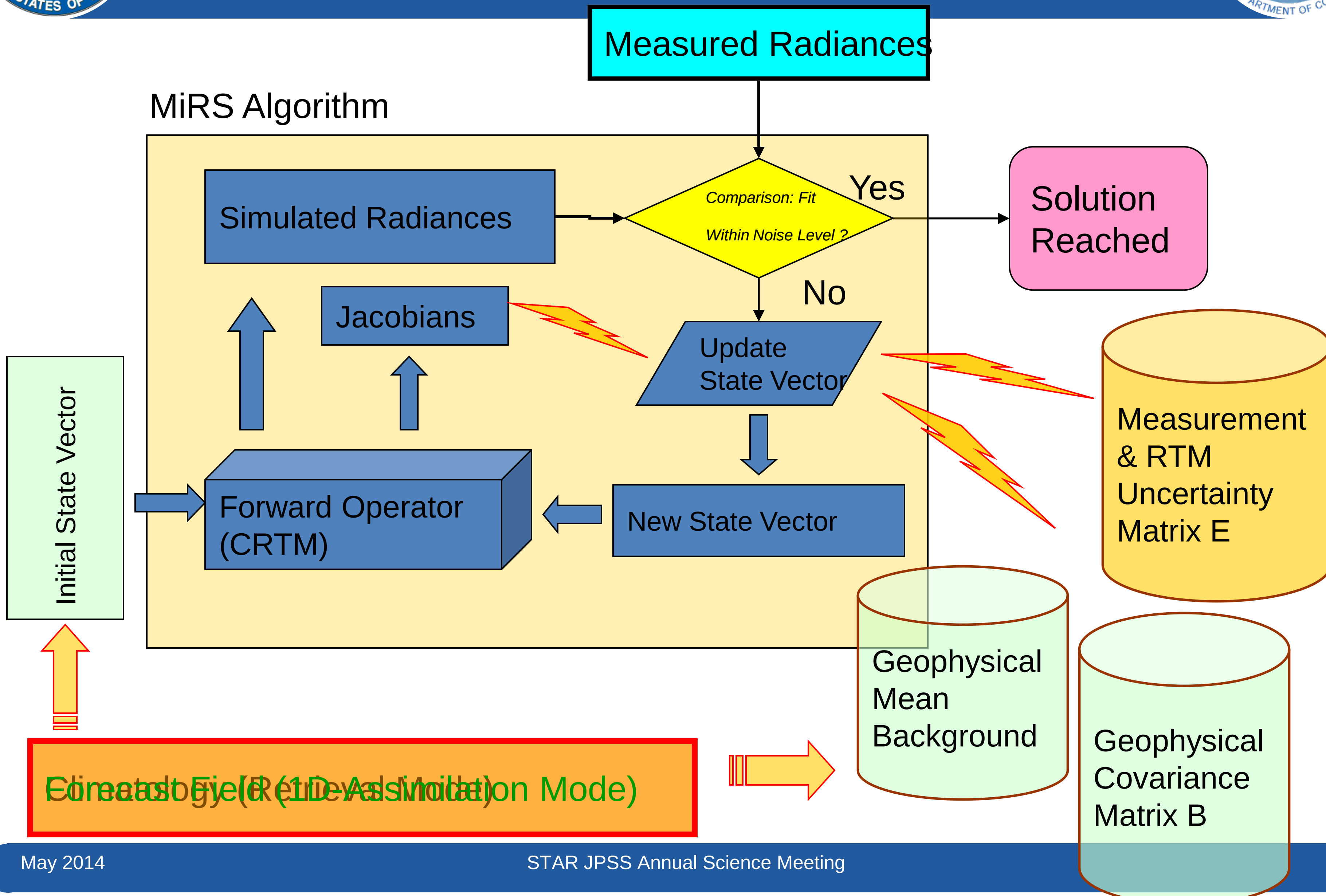
MiRS Concept

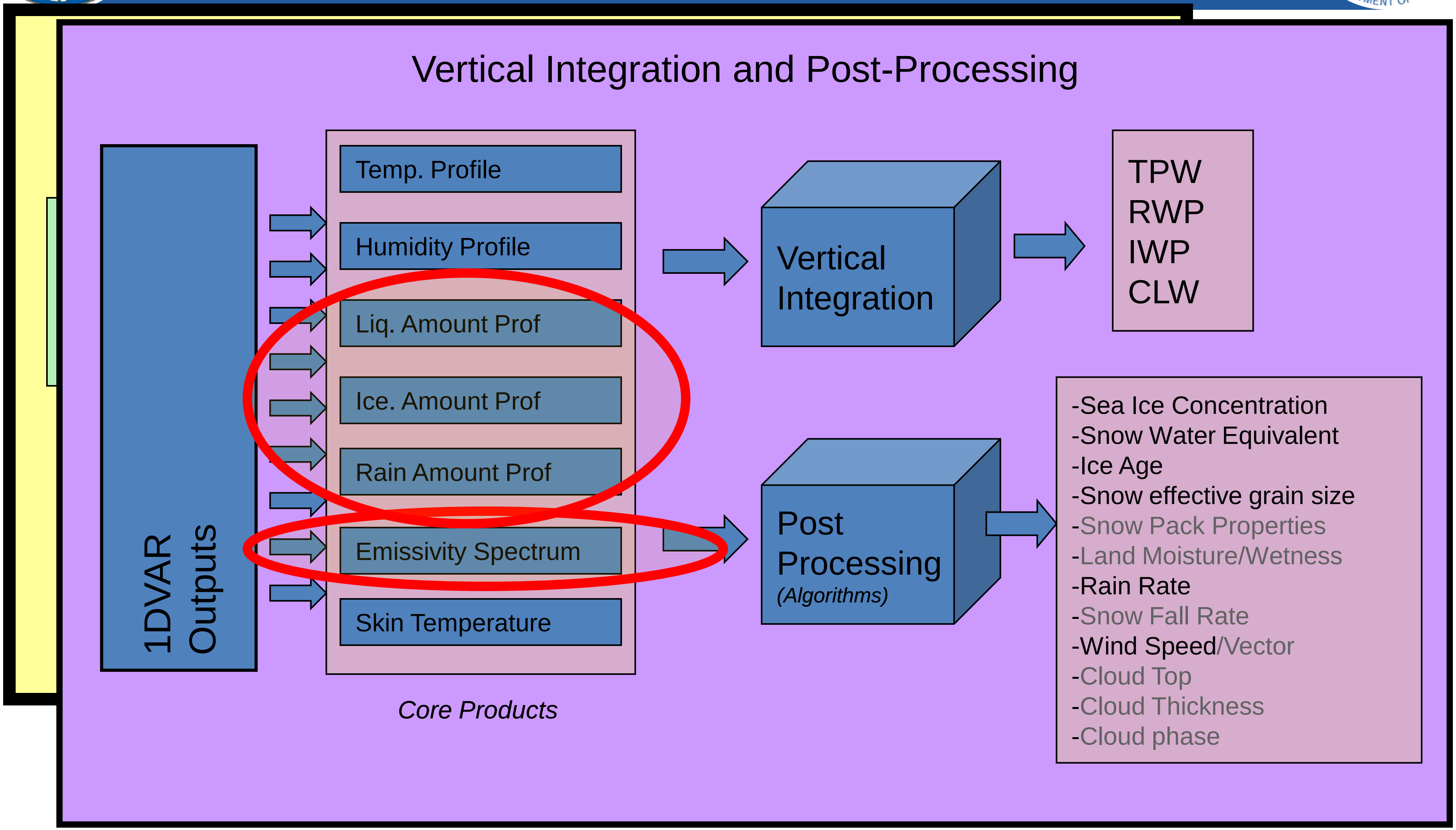


Conceptually, MiRS is the mirror image of CRTM

1D-Variational Retrieval/Assimilation



MiRS General Overview



Main Characteristics

- **Significant leverage of RT science (and Jacobians) by using CRTM**
- **Resiliency to noise increases, channel failures.**
- **Valid for sensors for which CRTM is valid**
- **Trivial to extend to new sensors *(main effort is validation)***
- **Valid in cloudy/precipitating conditions *(as long as CRTM is valid)***
- **Valid over all surfaces *(thanks to emissivity part of the state vector)***
- **Most important:**
  - ***Scientifically:* Consistent retrieval of parameters (atmos., cryosph., surface, hydrometeors) fitting channels simultaneously**
  - ***Programmatically*: Cost effective approach (~ 7-13 products depending on sensor, ~10 sensors, sustained with a team of ~4-5)**

Applicability of MiRS –Products-

Official Products

1. **Temperature profile**
2. **Moisture profile**
3. **TPW (global coverage)**
4. **Surface Temperature**
5. **Emissivity Spectrum**
6. **Surface Type**
7. **Snow Water Equivalent (SWE)**
8. **Snow Cover Extent (SCE)**
9. **Sea Ice Concentration (SIC)**
10. **Cloud Liquid Water (CLW)**
11. **Ice Water Path (IWP)**
12. **Rain Water Path (RWP)**
13. **Rainfall rate**

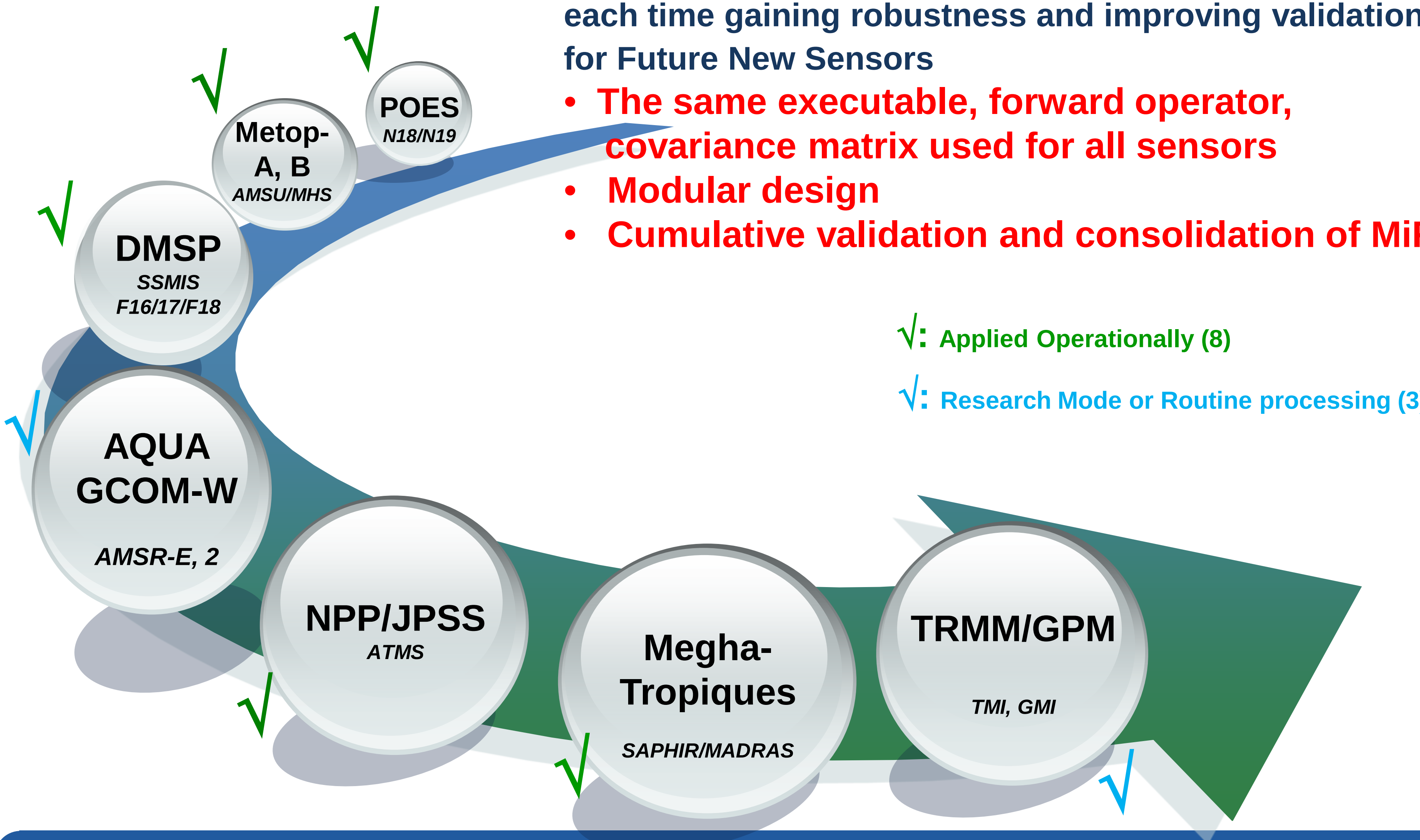
Products being investigated

1. Cloud Profile
2. Rain Profile
3. Atmospheric Ice Profile
4. Snow Temperature (skin)
5. Sea Surface Temperature
6. **Effective Snow grain size**
7. **Multi-Year (MY) Type SIC**
8. **First-Year (FY) Type SIC**
9. **Wind Speed**
10. Soil Wetness Index

Applicability of MiRS – Sensors-

MiRS is applied to a number of microwave sensors, each time gaining robustness and improving validation for Future New Sensors

- **The same executable, forward operator, covariance matrix used for all sensors**
- **Modular design**
- **Cumulative validation and consolidation of MiRS**



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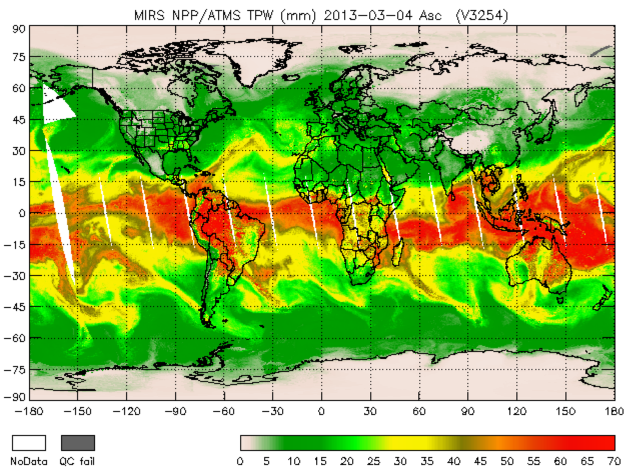
BACKUP SLIDES

SNPP/ATMS

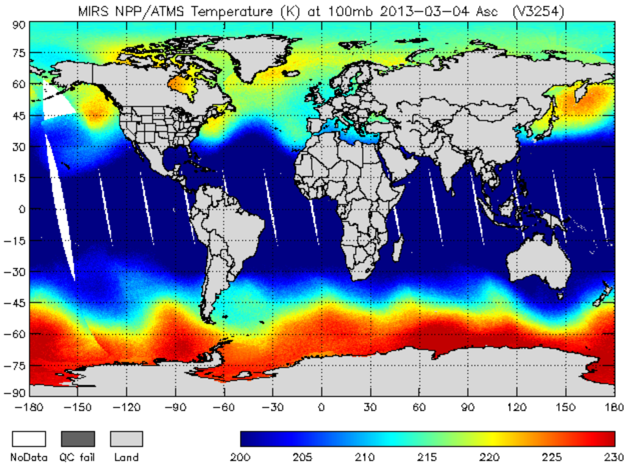
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

MiRS/ATMS Imagery & Sounding

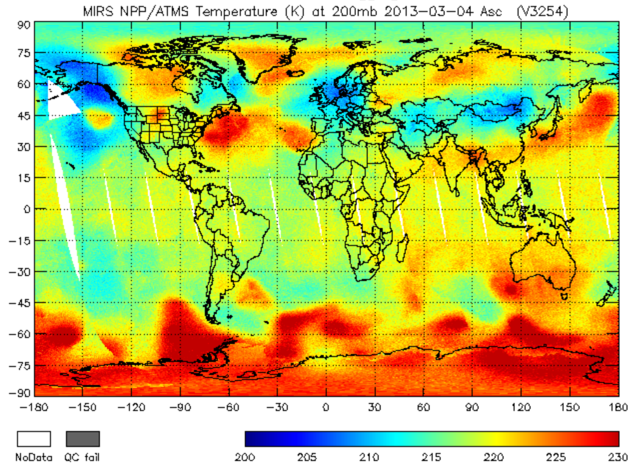
MiRS/ATMS TPW



MiRS/ATMS T(p) -100mb-

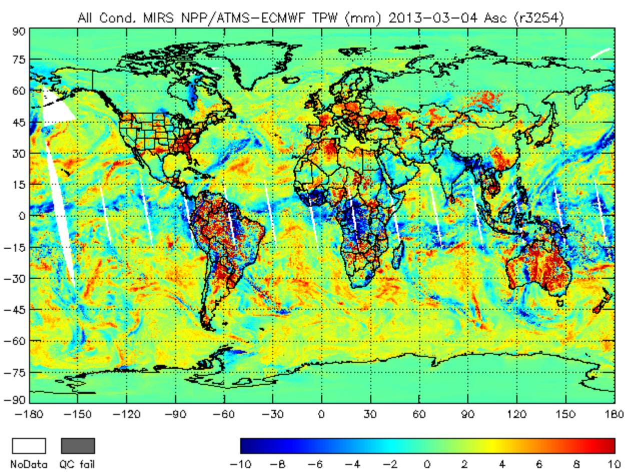


MiRS/ATMS T(p) -200mb-

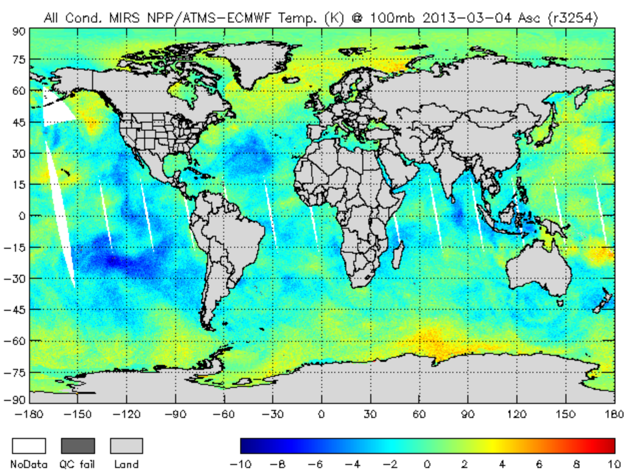


Presentation dedicated to MiRS-based Soundings will be given by C. Grassotti

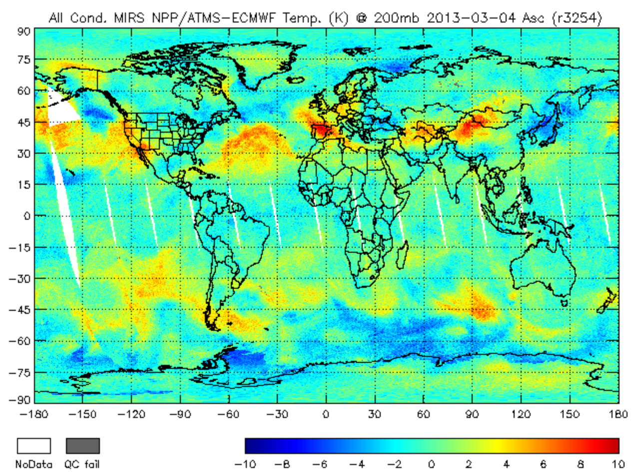
TPW Diff. wrt ECMWF



100mb T(p) Diff. wrt ECMWF



200mb T(p) Diff. wrt ECMWF

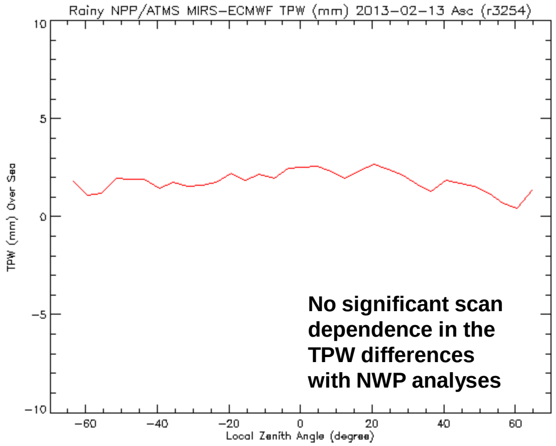


NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

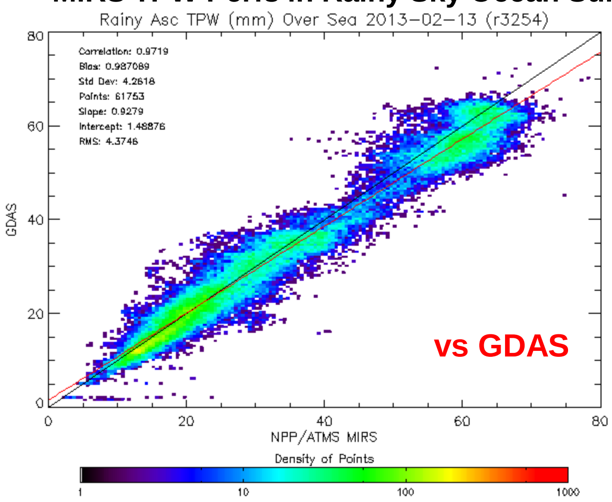
TPW in Exclusively Rainy Conditions
(ATMS)

Performances of MiRS TPW in e[...] surfaces present a good correla[...]

Angle dependence of MiRS TPW Perfs in Rainy Sky - Ocean Surfaces



MiRS TPW Perfs in Rainy Sky Ocean Surfaces



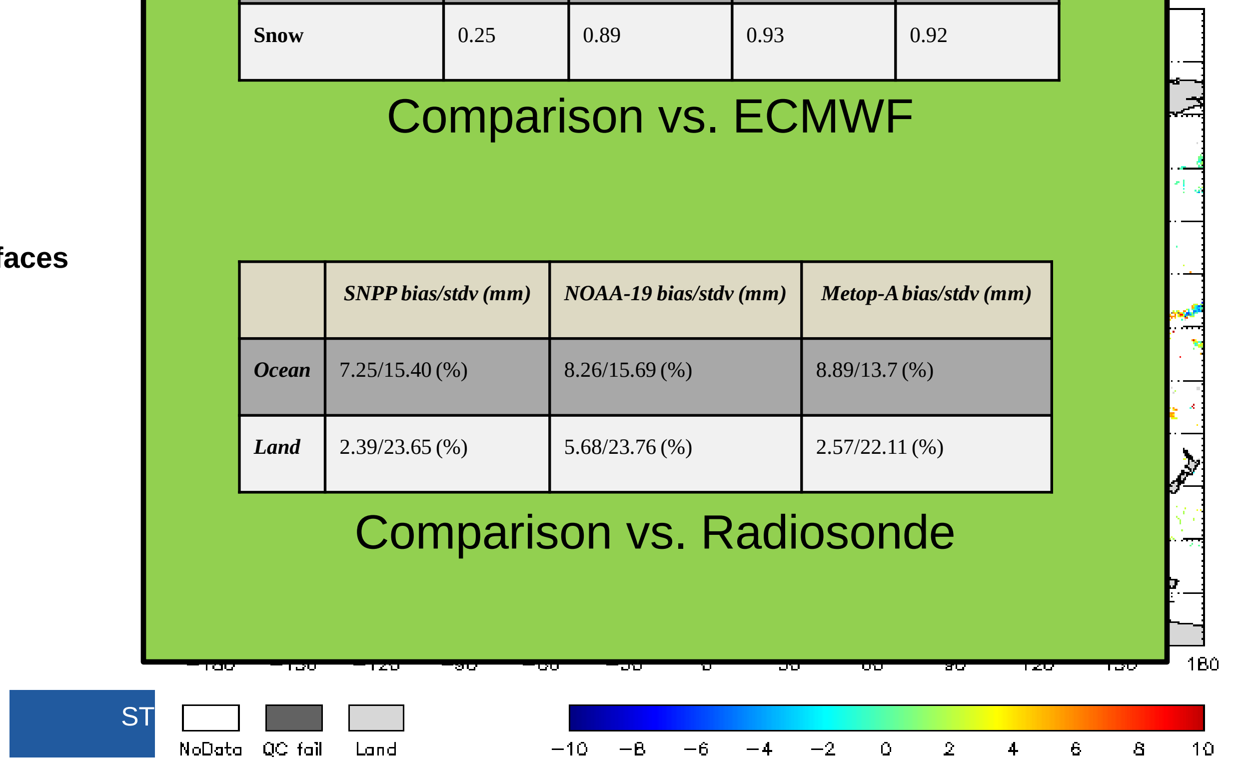
Summary of TPW Performance

	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

Comparison vs. ECMWF

	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 (%)

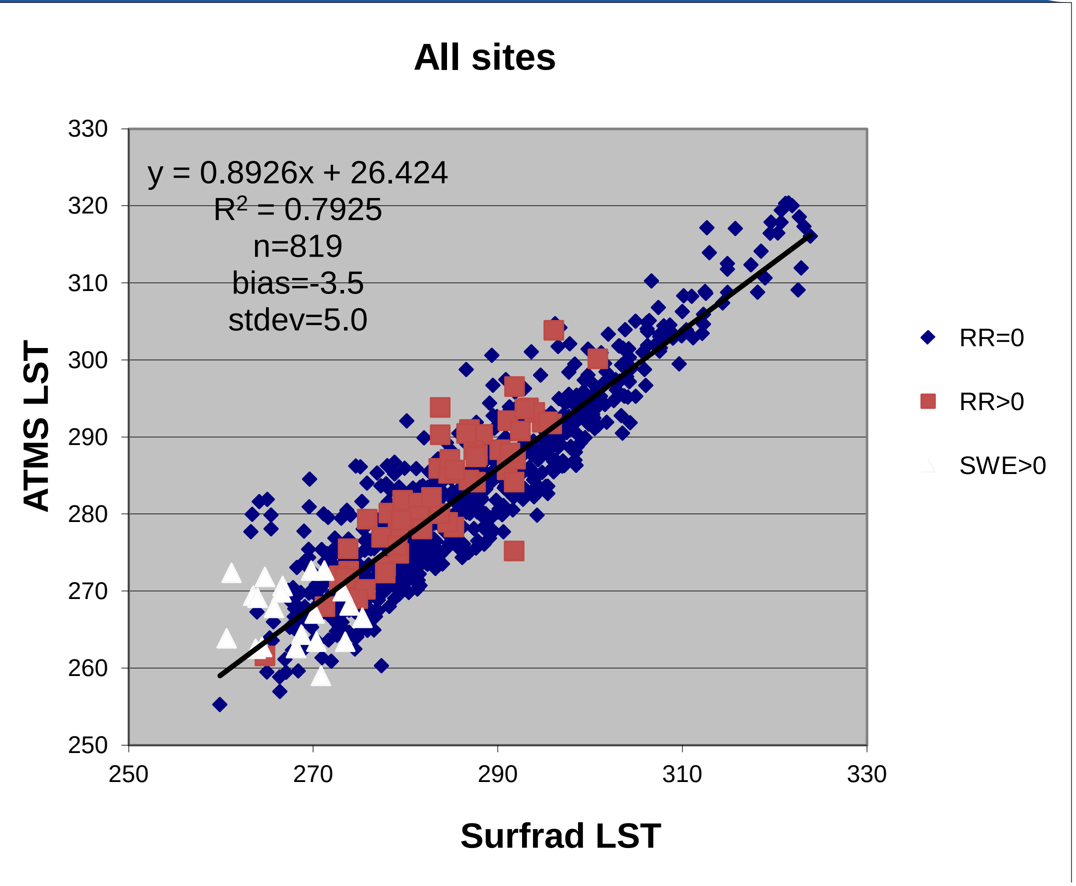
Comparison vs. Radiosonde



MiRS/ATMS LST Assessment

-Good performances of MiRS/ATMS wrt SURFARD ground measurements (correlation of 0.79)

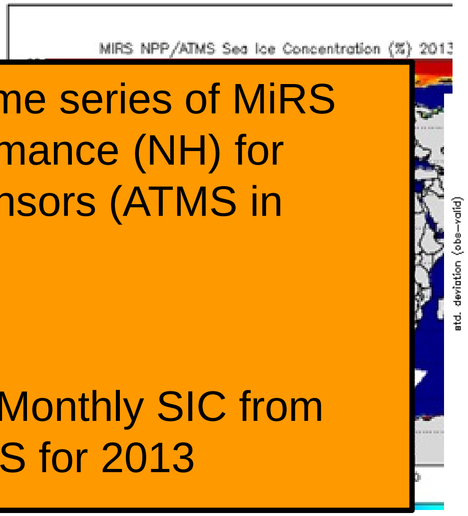
- Performances are also consistent when snow is detected over the surface (green dots)



GEOLOCATION AND SURFACE TYPE OF THE SIX SURFRAD STATIONS

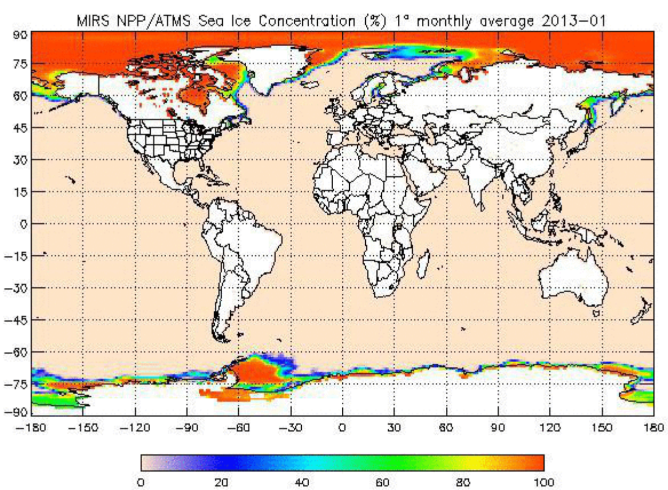
No.	Site Location	Lat(N)/Lon(W)	Surface Type*
1	Bondville, IL	40.05/88.37	Crop Land
2	Fort Peck, MT	48.31/105.10	Grass Land
3	Goodwin Creek, MS	34.25/89.87	Deciduous Forest
4	Table Mountain, CO	40.13/105.24	Crop Land
5	Desert Rock, NV	36.63/116.02	Open Shrub Land
6	Pennsylvania State University, PA	40.72/77.93	Mixed Forest

MiRS Sea-ice Concentration Assessment – NASA Team

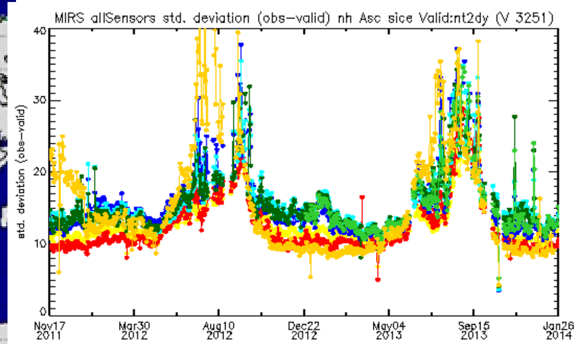


Right – Time series of MiRS SIC performance (NH) for various sensors (ATMS in Orange)

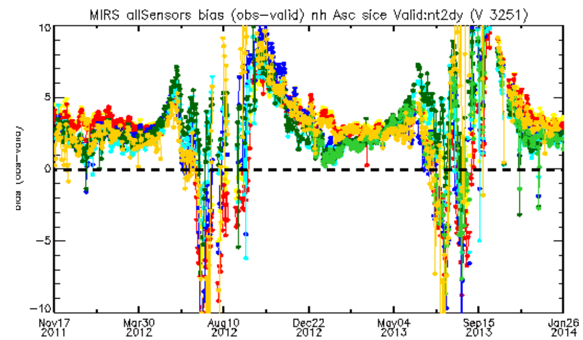
Bottom – Monthly SIC from MiRS ATMS for 2013



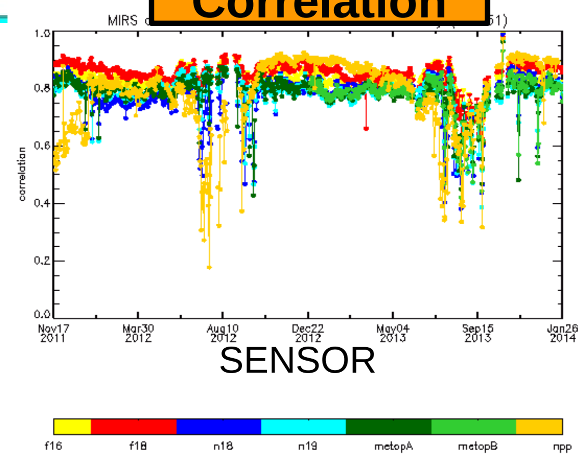
Stdv



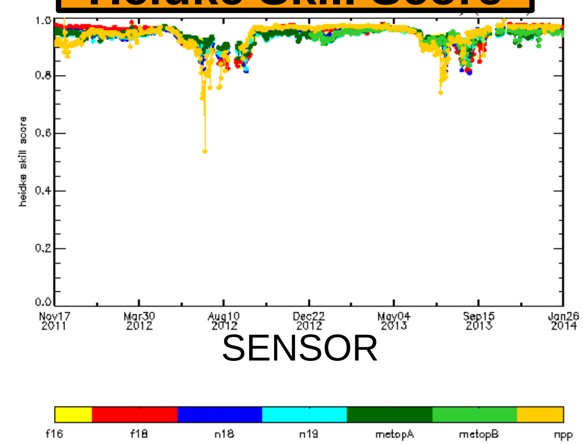
Bias



Correlation

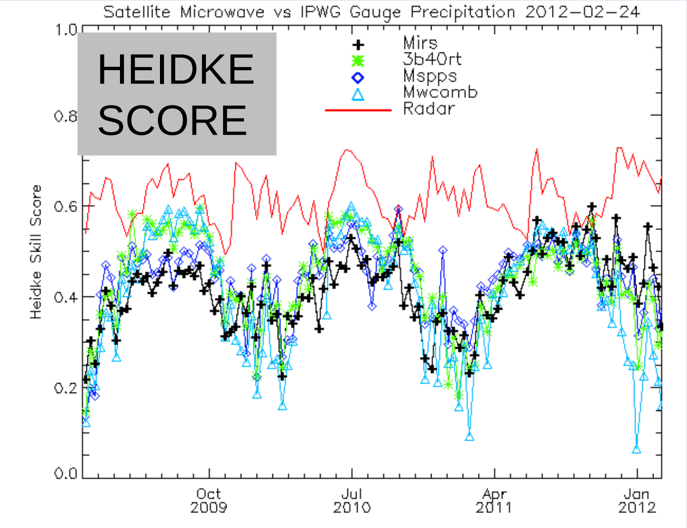


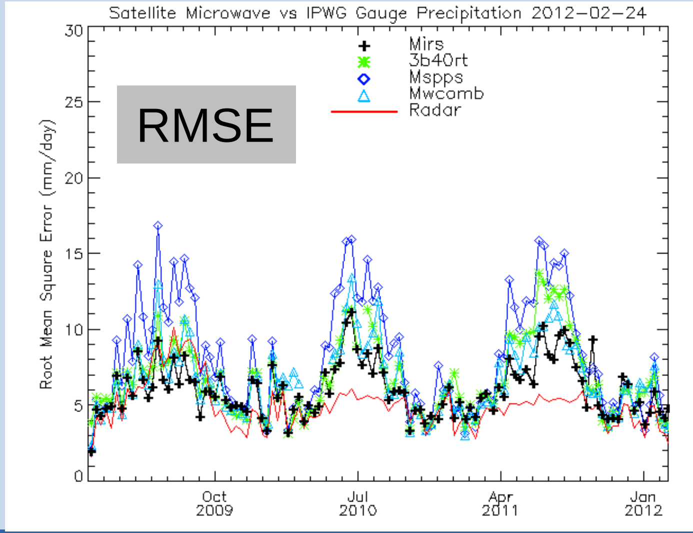
Heidke Skill Score

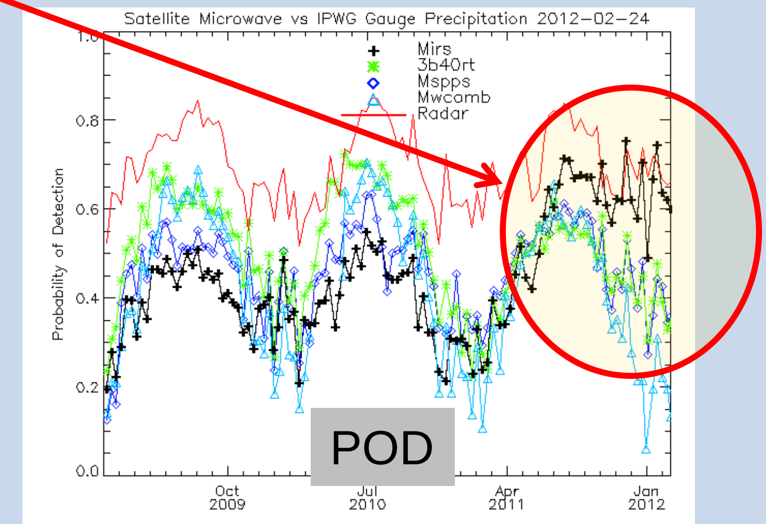


Independent RR Validation (IPWG)

- Monitor a running time series of statistics relative to rain gauges
- Intercomparison with other PE algorithms and radar
- MiRS composite uses all microwave sensors
- Tightening of RTM uncertainty in June 2011 improves POD & Heidke



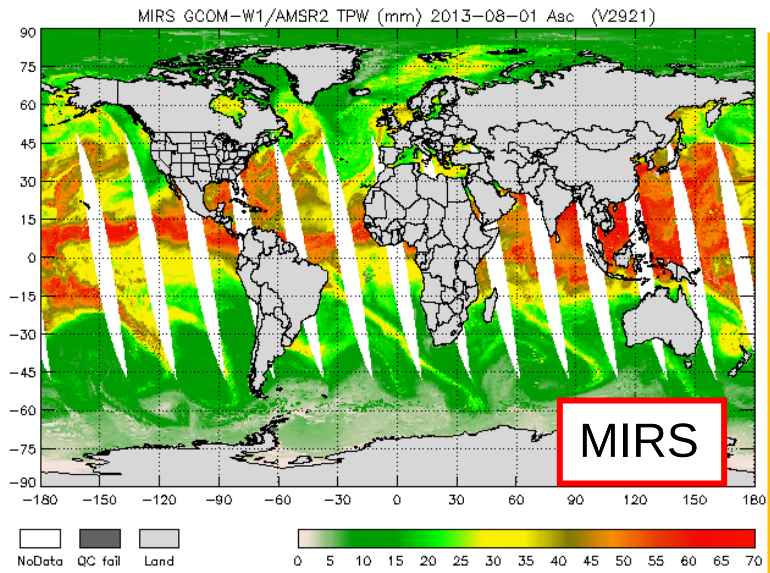




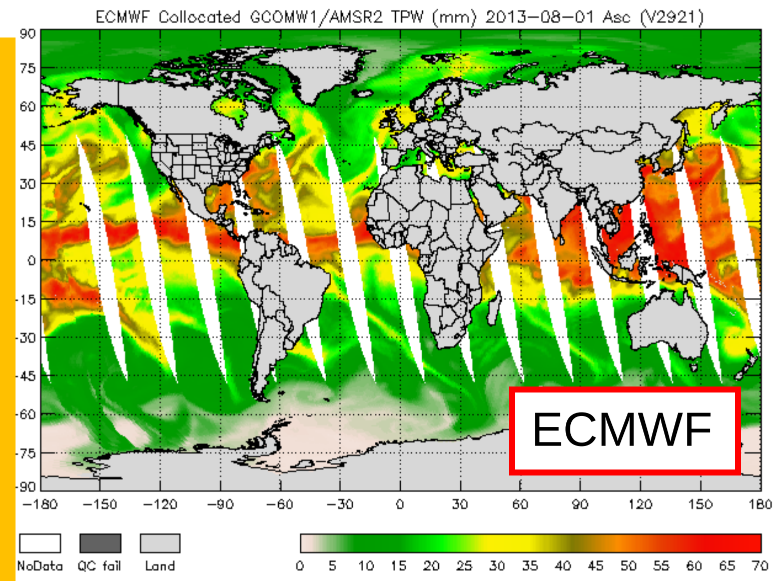
BACKUP SLIDES

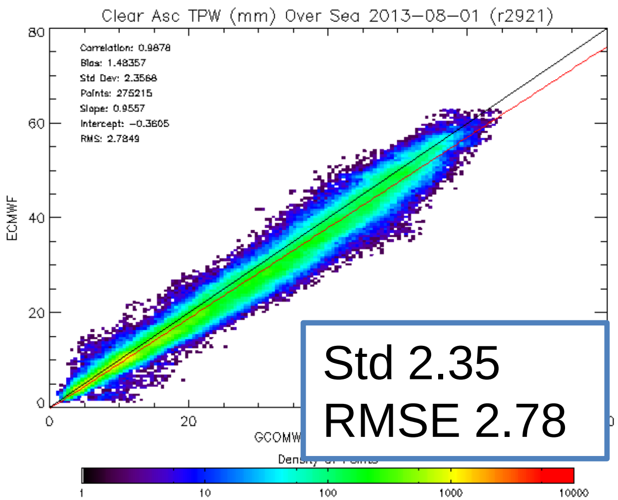
GCOM-W AMSR-2

GCOM-W1/AMSR2 TPW



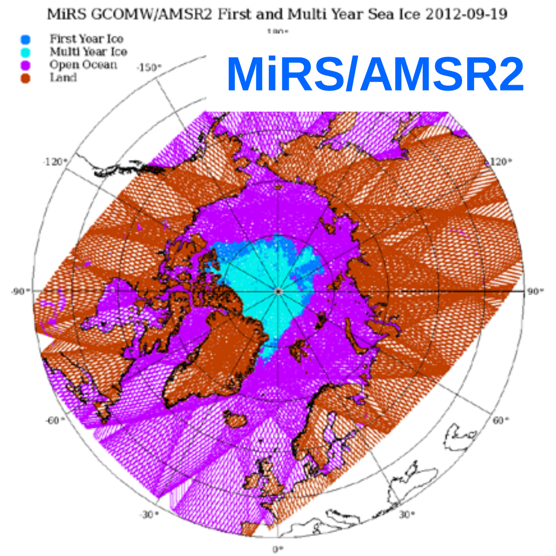
Products from MiRS/AMSR2 include TPW, Cloud, SST, Emissivity, SIC, Age, Snow, LST, RR, and lower tropospheric sounding

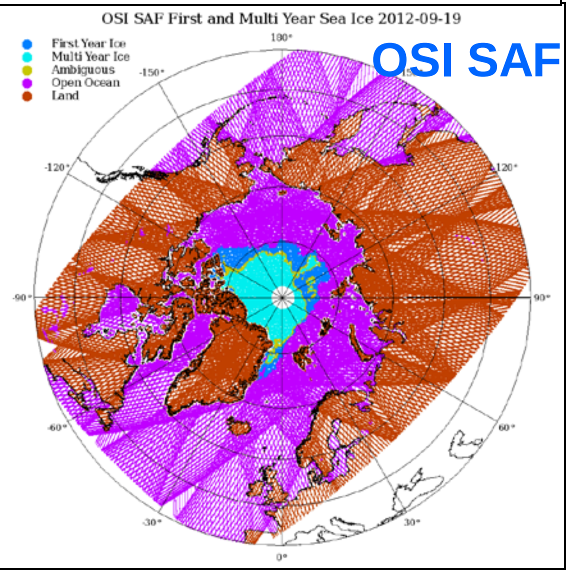




✓Good agreement with ECMWF.
✓Performances (2.35 mm std deviation) are similar to AMSU/MHS & SSMI/S instruments (global coverage).

Sea Ice Type (MY & FY): MiRS / OSI SAF



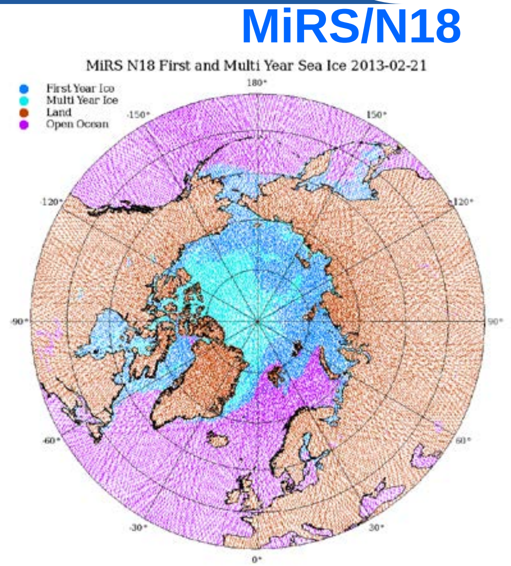


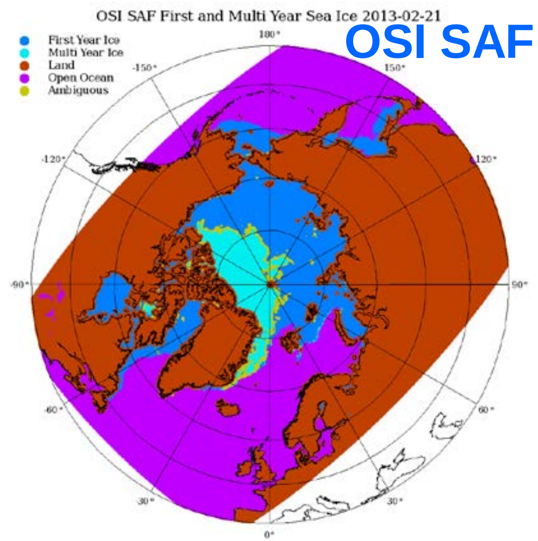
Late summer/Fall 2012

Qualitative assessment of the sea-ice type from MiRS (based on AMSR2 and POES data) by comparing it to EUMETSAT OSI SAF

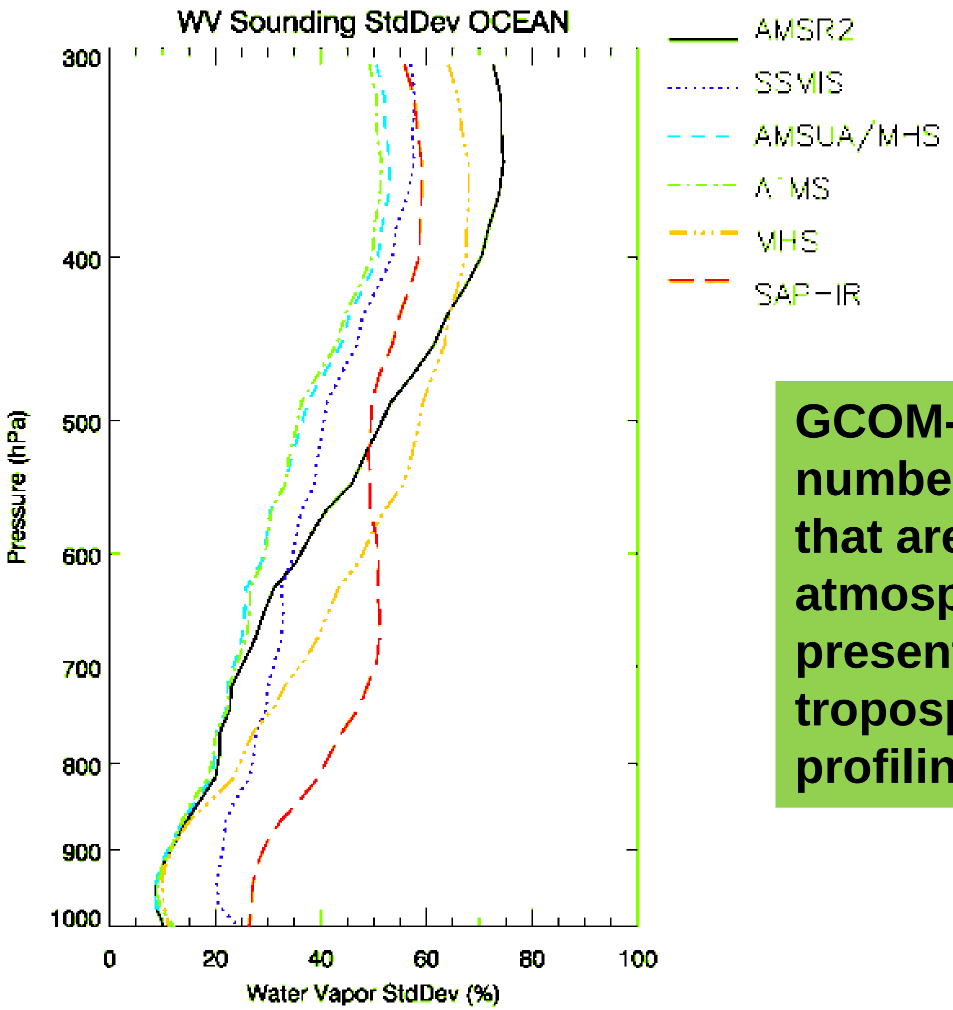
The OSI SAF algorithm uses a Bayesian method, SSMIS + ASCAT.
It also uses estimates of uncertainty to weight the observations.

Winter 2013





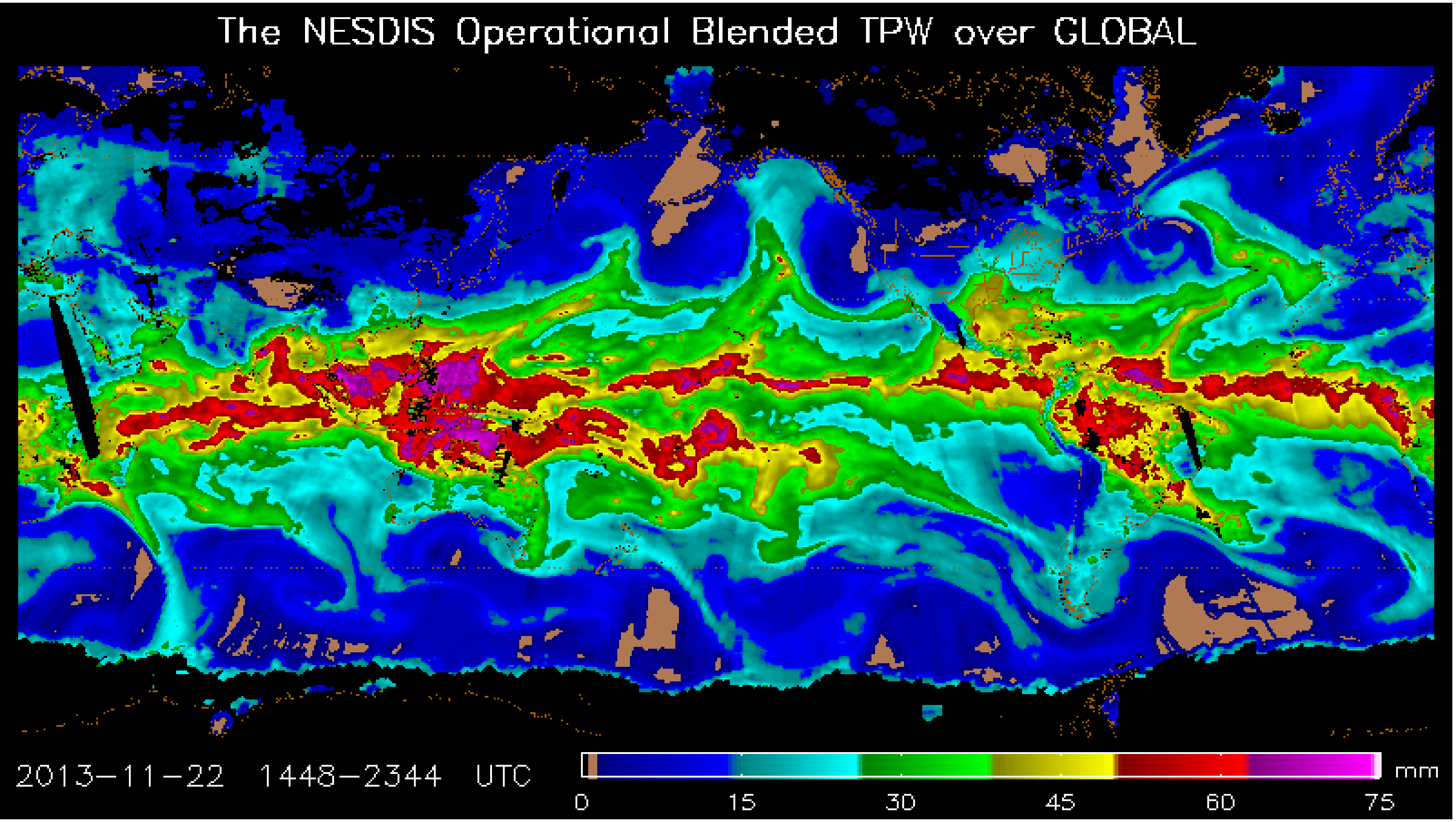
Tropospheric Moisture Sounding from AMSR2



GCOM-W AMSR-2 has a number of window channels that are sensitive to different atmospheric column depths, presenting a potential for lower tropospheric moisture profiling.

Contents

Blended TPW



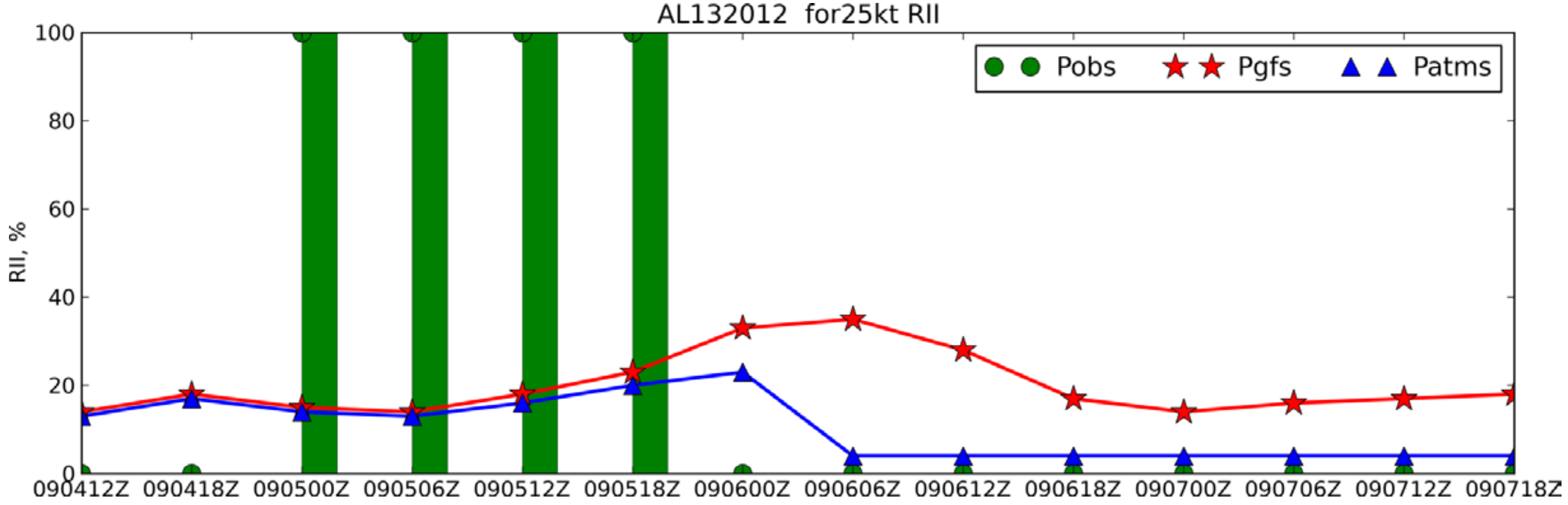
The blended TPW is available through AWIPS sectors that NWS forecasters use

MiRS from microwave sensors are included in the blended TPW. Extension in progress (for more sensors, over sea-ice, snow, etc)

Slide courtesy of the OSPO website: Effort led by CIRA: S. Kidder, J. Forsyth, L. Zhao and R. Ferraro

RI Forecast: GFS vs MiRS/ATMS Inputs

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 sused.

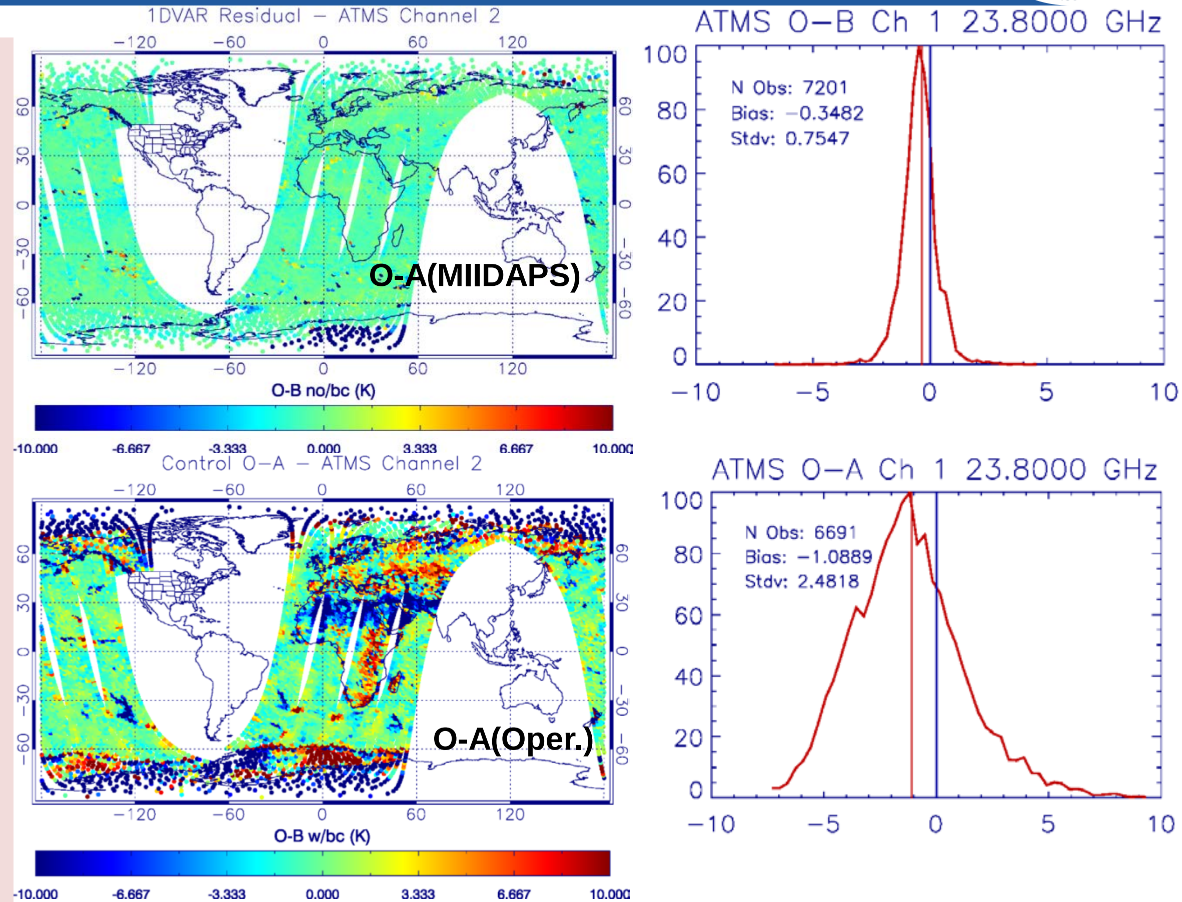


Preliminary results for the RII forecast show up to 3.1% increase in Brier Skill Score with the use of MiRS/ATMS data, and for the center-fix algorithm up to 10% better center location as compared to the first guess position from the NHC real-time forecast positions.

Slide courtesy of Galina Chirokova and Mark DeMaria

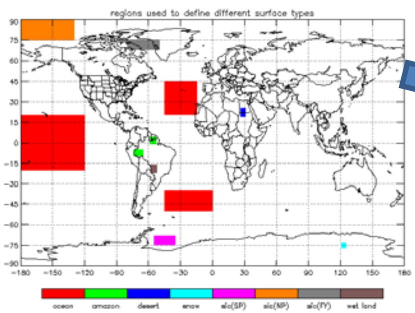
Data Assimilation Applications (MIIDAPS)

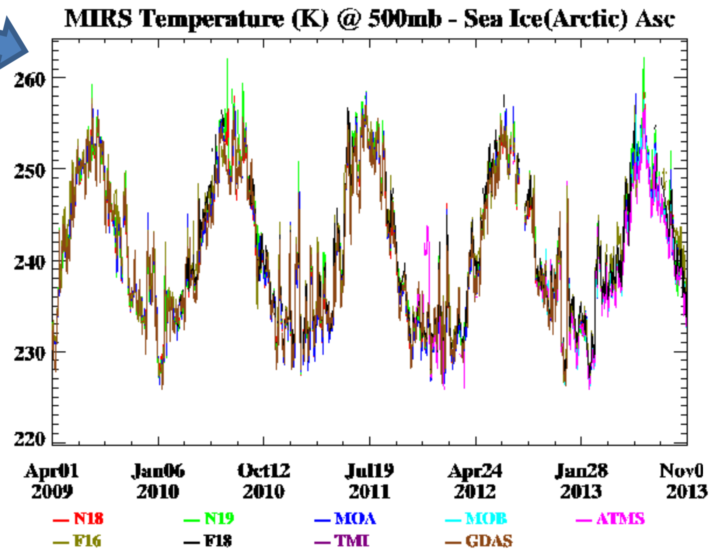
- **Efforts are on going to:**
  - Use MiRS technology (1DVAR) as a pre-processor to NWP
  - Allows uniform quality control of satellite data, rain and ice detection, coast contamination, RFI for imagers, etc
  - Implement dynamically-retrieved emissivity in the NWP
  - Assess assimilating sounding products in cloudy/rainy conditions



Goal is to have a community QC tool for satellite data assimilation pre-processing:
extend the MIIDAPS to all Sensors (IR & MW, geo/Pol)

Time series of MiRS-derived Products



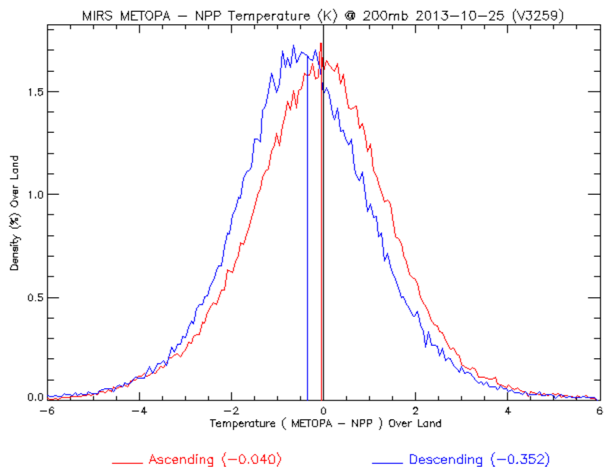


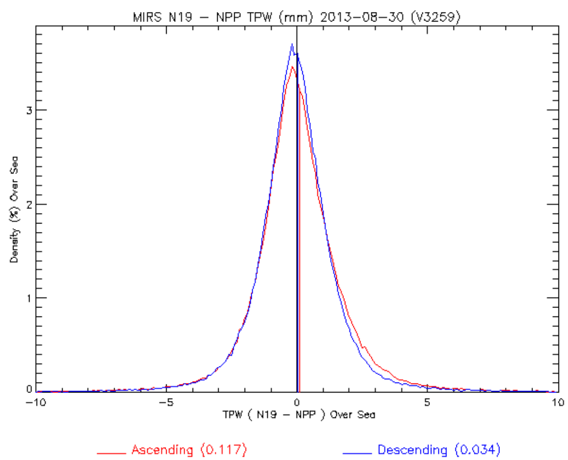
One algorithm approach
One radiative transfer
One set of assumptions,

Applied to all sensors, in all areas

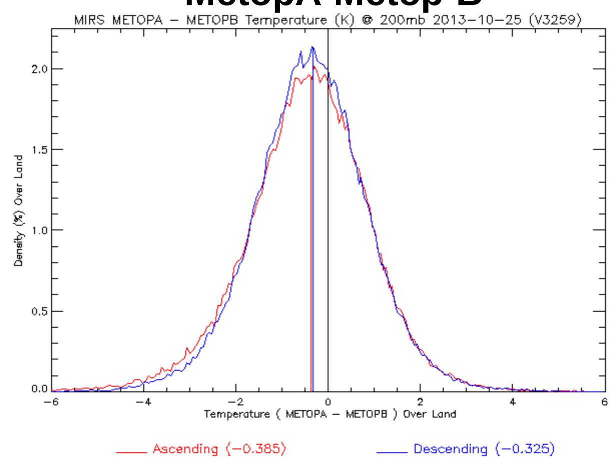
In theory should make interpretation easier

T(p) at 200mb over land (global) MetopA-SNPP





T(p) at 200mb over land (global) MetopA-Metop-B



Contents

Recommendation & Future Plans

- ***On-Going & Planned:***
  - Megha-Tropiques SAPHIR
  - GCOM-W AMSR-2
  - High spatial Resolution for existing sensors
  - To new Products: Sea Ice Age, Snow grain size
  - New Science: Dynamic Background (emissivity, sounding etc)
  - Extended validation using independent evaluations (RR, Soundings, SIC, IWP, Emiss, etc)

- ***Leveraging NOAA Activities in Support of JCSDA:***
  - Strong coordination with JCSDA activities (MIIDAPS)
  - CRTM constant improvements
  - Cloudy& rainy radiance assimilation
  - Extension of MIIDAPS to IR sensors could benefit MiRS
  - Access to S4 supercomputer

- ***Conclusions & Recommendations:***
  - MiRS is the consolidated algorithm at NOAA, for processing microwave sensors
  - It is applicable to ~10 sensors, to produce ~7-13 products for each sensor
  - It is expected it will be applied to JPSS ATMS sensors and GCOM-W AMSR2
  - Extension to IR, done in the context of MIIDAPS, could extend applicability

BACKUP SLIDES

BACKUP

Hurricane Rapid Intensification

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

-Radial-height cross section

- Temperature Anomaly

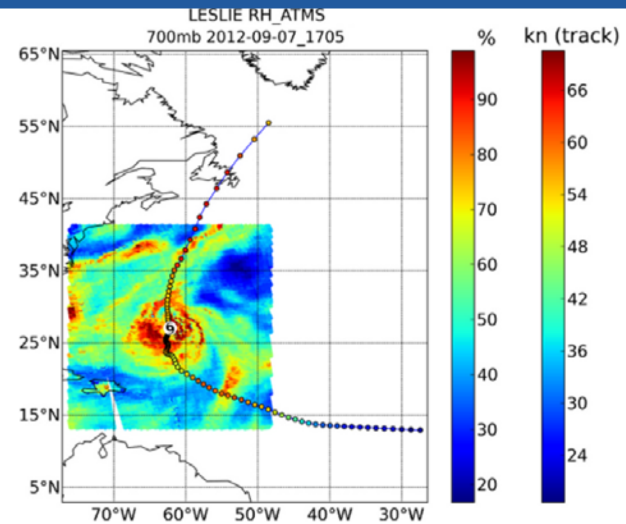
-500-800mb averaged values

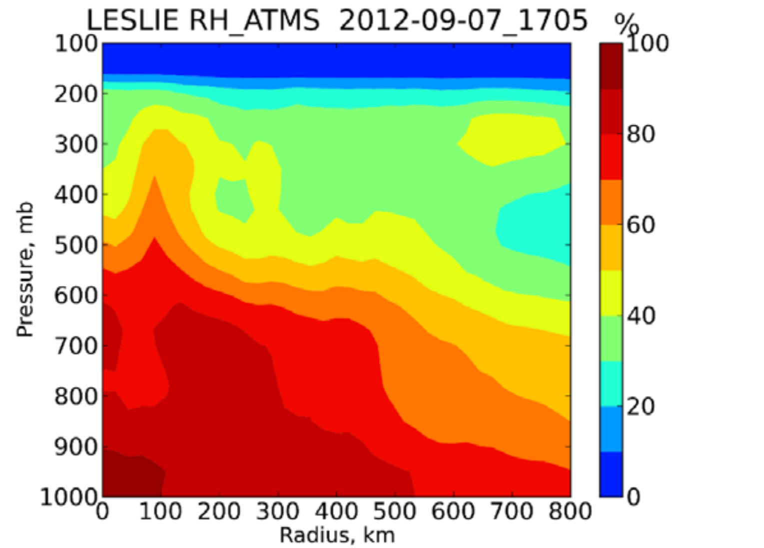
These are fed to :

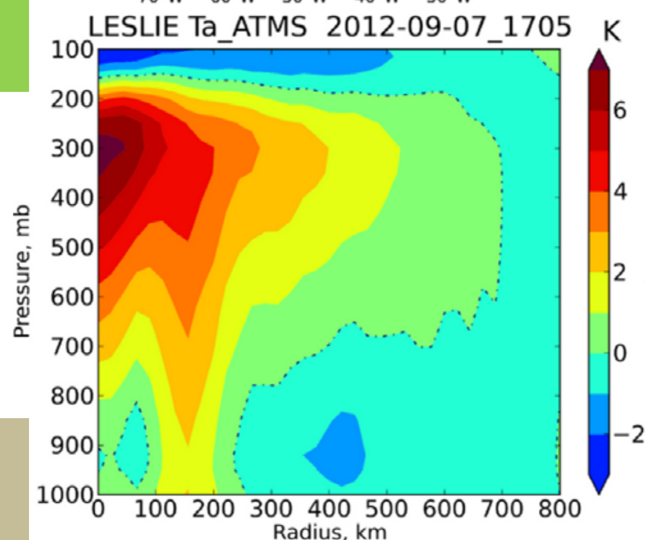
- Maximum Potential Intensity (**MPI**) algor.

MPI is then fed to :

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



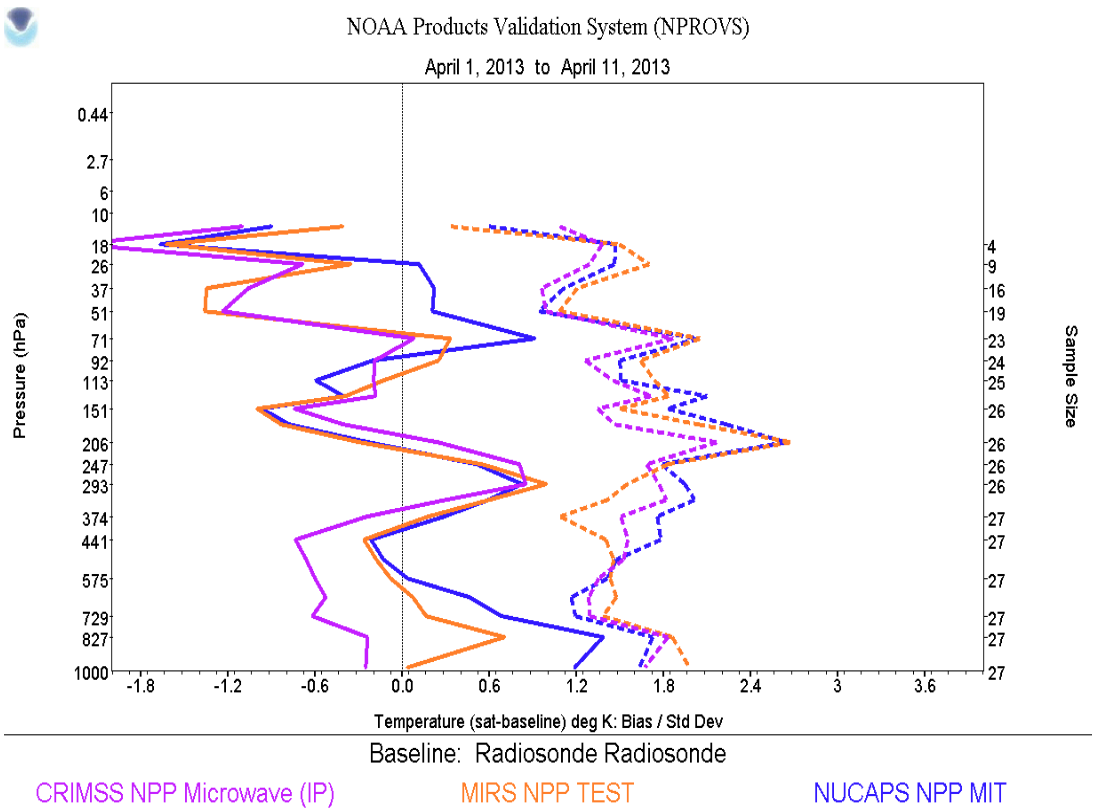




1. Average T, RH between r = 500 to 800 km to get $\overline{T}(p)$, $\overline{RH}(p)$
2. Input $\overline{T}(p)$, $\overline{RH}(p)$ environmental profiles to Emanuel (1988) MPI algorithm
3. Replace empirical MPI with ATMS MPI in RII and models

Slide courtesy of Galina Chirokova and Mark DeMaria

MiRS sounding assessment via NPROVS

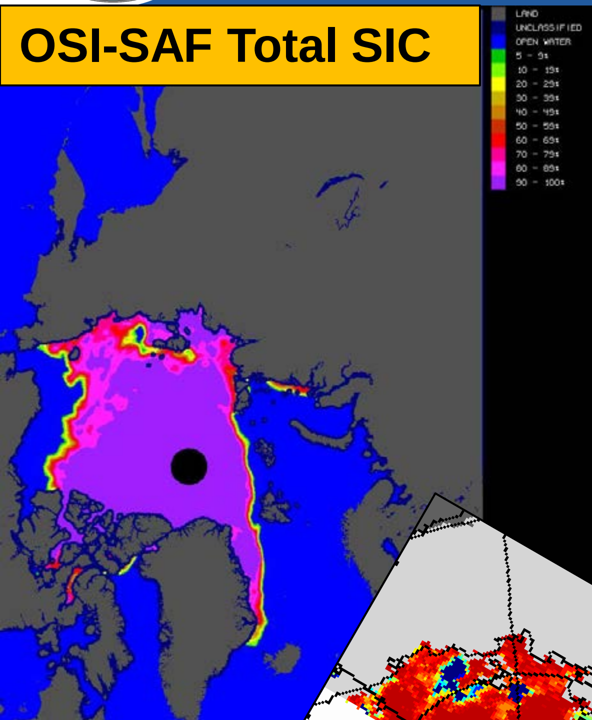


NPROVS performs assessment and intercomparisons by comparing several algorithms/ sevaral sensors to common reference of radiosondes

Slide courtesy of the Bomin Sun and Tony Reale (NPROVS project)

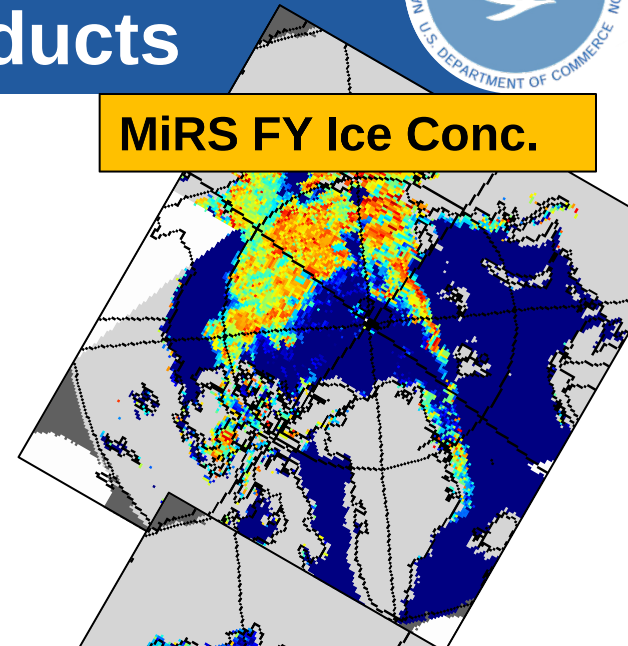
AMSR-2 Cryospheric Products

OSI-SAF Total SIC

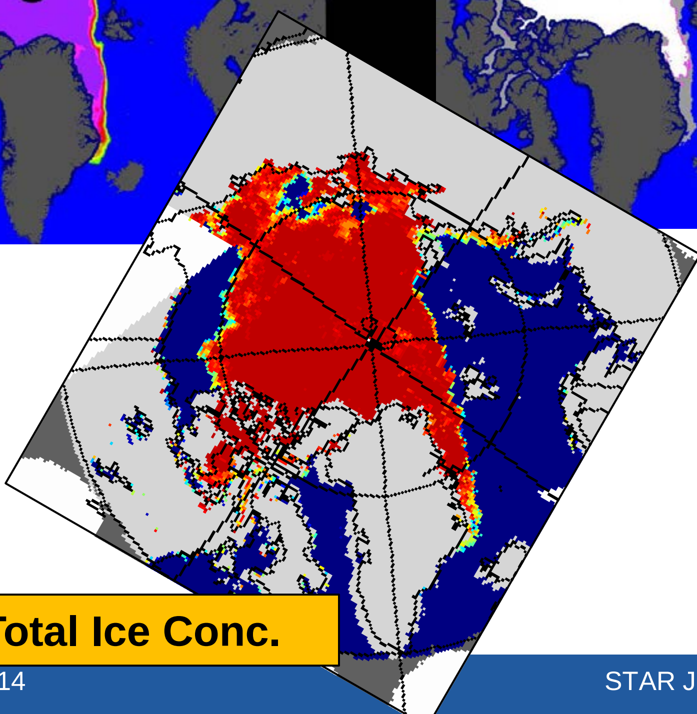


OSI-SAF Total Ice Type

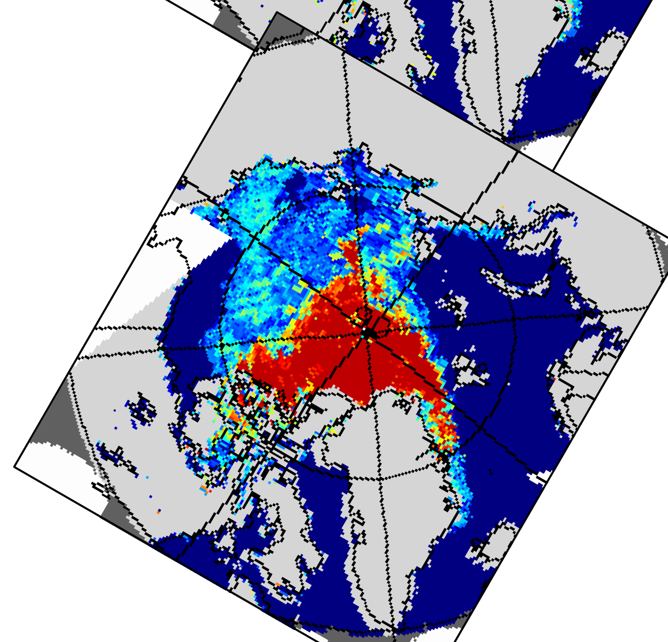
MiRS FY Ice Conc.



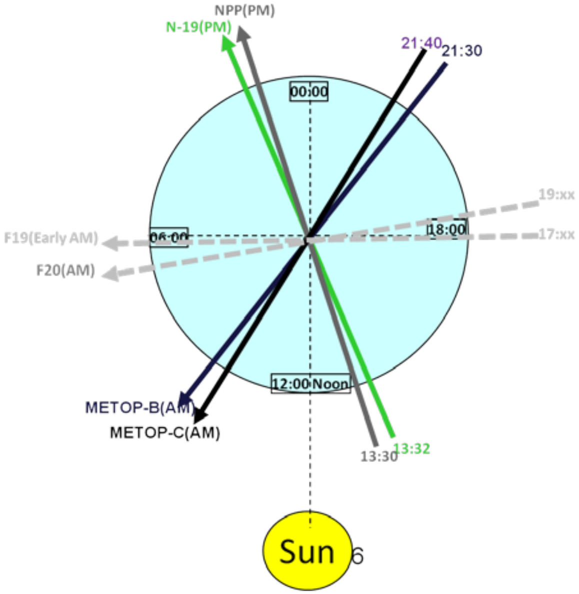
MiRS Total Ice Conc.



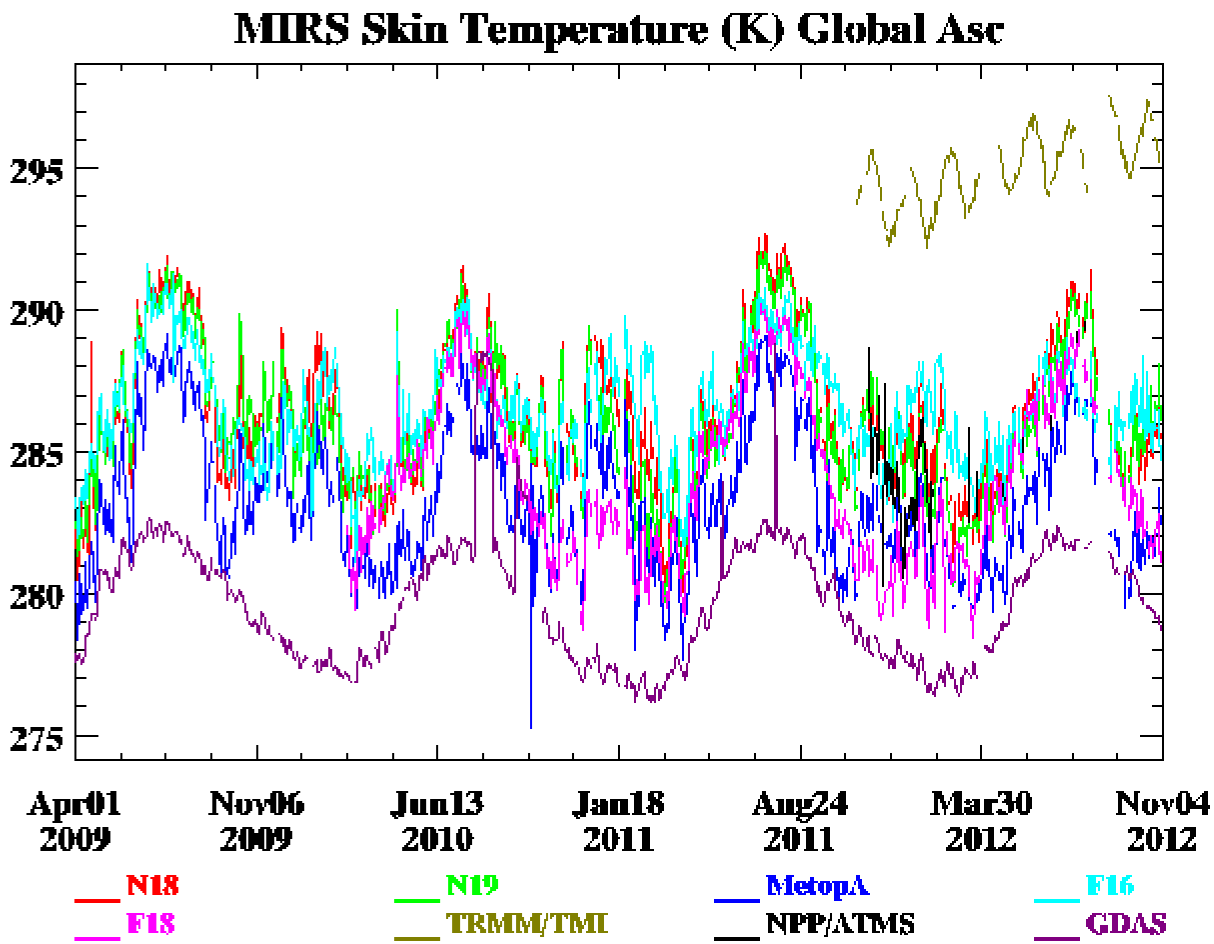
MiRS MY Ice Conc.



Inter Consistency in MiRS Retrievals for Climate Applications



Example of Tskin



Importance of the diurnal cycle and sensor measurement sampling in time and space

Advantages & Disadvantages of MiRS

- **Pros:**
  - Flexible and physical approach
  - Highly cost-effective: Cost to extend to new sensors greatly reduced (avoids stove-piping on both the sensors side and the products side).
  - MiRS can be consistently applied to sounders, imagers and combinations
  - MiRS uses the CRTM as forward operator (leverage of resources and science)
  - Applicable consistently on all surfaces and runs in all-weather conditions
  - Dual application for inversion and satellite data assimilation
- **Cons:**
  - Computationally expensive, although highly parallelizable (1D processing)
  - Cost effective approach, but need to sustain expertise in sounding, cryosphere, hydrometeors, surface emission, radiative transfer, calibration, etc in a single team (requires an efficient and strongly multi-disciplinary team)
  - Heavy constraints on the science approach: MiRS expected performances are the same as the single-product, single-sensor type algorithms, but with the significant added constraint that all parameters should fit all measurements simultaneously (keeps all results in check)