MICROWAVE INTEGRATED RETRIEVAL SYSTEM (MIRS):
Scientific Activities, Project Milestones, Future Plans

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28 August 2018
MiRS N20/ATMS Validation/Delivery Status

• **Beta Maturity** since 29 Nov 2017 (L+11 days)
• **Provisional Maturity** declared on 29 March 2018
• **V11.3 Preliminary DAP delivered to NDE/OSPO on** 8 June
• Possibly operational in September
• Additional validation ongoing, e.g. RR, cryosphere, T and WV vs. raobs, LST, and LSE, etc.
• An updated DAP will be delivered in late 2018/early 2019
• Also delivered to CSPP/DB in July (CSPP_MIRS 2.1)
MiRS Version 11.3 Changes

- Extension to NOAA-20/ATMS
- Addition of snowfall rate (SFR) to SNPP and N20 (not fully validated); SFR already implemented for AMSU-MHS
- Implementation of forest fraction emissivity correction in SWE algorithm for ATMS and AMSU-MHS (improved estimation in forested regions, e.g. eastern CONUS)
- Incorporation of cloud liquid water over land in RR algorithm for all satellites (improved detection/estimation of light rain)
- Miscellaneous fixes, changes to nc metadata, modifications to output nc file names
Algorithm Overview

**MiRS Components**

- **MiRS Forward RT Model (CRTM):**
  1. \( TB = F(Geophysical \ State \ Vector) \)
  2. Jacobians \( (dTB/dX) \)

- **A Priori Background:**
  Mean and Covariance of Geophysical State (Dyn Climatol)

- **Basis Functions for State Vector:**
  Reduce degrees of freedom in geophysical profile (~20 EOFs)

- **Uncertainty of satellite radiances:** Instrument NEDT + Fwd Model uncertainty

**Geophysical State Vector (OUTPUTS)**

- Temp. Profile (100 layers)
- Water Vapor Profile (100)
- Cloud Water Profile (100)
- Graupel Water Profile (100)
- Rain Water Profile (100)
- Emissivity Spectrum (~20 channels)
- Skin Temperature (1)

**MiRS 1D Variational Retrieval**

**MiRS Postprocessing**

**Derived Products (OUTPUTS)**

- TPW
- CLW
- RWP
- GWP
- RR
- SFR
- SIC/SIA
- SWE/GS

**Satellite Microwave (TB) Measurements (INPUTS)**

- ~ 20 channels (multispectral)
  - TB (Channel 1)
  - TB (Channel 2)
  - TB (Channel 3)
  - TB (Channel Ntot)
  - Sensor Noise


- **MW Only, 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.

- **“Enterprise” Algorithm:** Same core software runs on all satellites/sensors; facilitates science improvements and extension to new sensors.

- Initial capability delivered in 2007. Running v11.2 since Jan 2017 on SNPP/ATMS, N18, N19, MetopA, MetopB, F17, F18, GPM/GMI, Megha-Tropiques/SAPHIR. (eventually MetopC...)

- Delivery of v11.3 (extended to NOAA-20/ATMS) to operations on 8 June.

- External Users/Applications: TC Analysis/Forecasting at NHC, Blended Total/Layer PW Animations at NHC and WPC Animations (CSU/CIRA, U. Wisconsin/CIMSS), CSPP Direct Broadcast (U. Wisconsin), NFLUX model (NRL, Stennis), Global blended precipitation analysis at NOAA/CPC (CMORPH),...

- All N20 results here are generated with MiRS v11.3 (offline processing in STAR), and TDR data generated in IDPS (Block 2 processing).
Retrieval Convergence Rate

**N20**

MIRS N20 Convergence Rate

29 Nov 2017 – 22 Aug 2018

**SNPP**

MIRS NPP Convergence Rate

1 Jan 2016 – 22 Aug 2018

STAR JPSS Annual Science Team Meeting, 27-30 August 2018
Radiometric Biases: Time Series
TDR Obs-Sim (29 Nov – 20 Aug)

- Chan 6 (53.6 ± 0.12 GHz)
- Chan 7 (54.4 GHz)
- Chan 9 (55.5 GHz)
- Chan 11 (57.29 ± 0.22 GHz)
- Chan 20 (183.31 ± 3 GHz)

Simulated TBs: ECMWF + CRTM (v2.1.1), clear ocean
Temperature and WV Bias and Std Dev: Global (Land+Ocean) Comparison with Raobs

8-18 Jan 2018

Temperature (sat - baseline) deg K
January 8, 2018 to January 18, 2018

Water Vapor (sat - baseline) % error
January 8, 2018 to January 18, 2018

9-19 Jul 2018

Temperature (sat - baseline) deg K
July 9, 2018 to July 19, 2018

Water Vapor (sat - baseline) % error
July 9, 2018 to July 19, 2018

Courtesy of Bomin Sun

Baseline: SONDE
MIRS NPP v11
MIRS NOAA-20 Test

Courtesy of Bomin Sun

Baseline: SONDE
MIRS NPP v11
MIRS NOAA-20 Test

Courtesy of Bomin Sun

Baseline: SONDE
MIRS NPP v11
MIRS NOAA-20 Test

Courtesy of Bomin Sun

Baseline: SONDE
MIRS NPP v11
MIRS NOAA-20 Test
Temperature Bias and Std Dev: Time Series (29 Nov – 20 Aug)

Global collocation w/ ECMWF
Water Vapor Bias and Std Dev: Time Series (29 Nov – 20 Aug)

Global collocation w/ ECMWF

Sea

Land

Bias

StDv
Application Using MiRS Data: Hurricane Intensity and Structure Algorithm (HISA)

HISA provides MW-based TC Intensity estimates:
- Global
- Objective
- Independent of Dvorak

Input:
- Temperature profile, CLW from **AMSU/ATMS-MiRS** or statistical retrievals
- GFS boundary conditions
- ATCF TC track data

Output:
1) Intensity estimates, provided via f-deck
   - Maximum sustained wind (Vmax, kt)
   - Minimum Sea Level Pressure (MSLP, hPa)
2) Surface Wind Radii Estimates (nmi), provided via f-deck
   - R34, R50, R64 for NE, NW, SE, and SW TC quadrants
3) Azimuthally-averaged gradient winds as a function of geopotential height and distance from TC center.
4) Horizontal 2-D balanced winds (kt) for the local TC environment

Operational on ATMS and AMSU on 7 satellites, is upgraded to work with NOAA20 ATMS

Users: NHC, CPHC, JTWC

Galina Chirokova (CIRA), John Knaff (NOAA/NESDIS), Scott Longmore (CIRA), Mark DeMaria (NOAA/NWS/NHC), Jack Dostalek (CIRA)
Application Using MiRS Data:
Moisture In-Flux Storm Tool (MIST) (under development)

Dry-air intrusions:
- adversely affect TCs: inhibit convection, enhance cold downdrafts, contribute to storm asymmetry
- detected with TPW, LPW, WV imagery which do not provide quantitative information and do not always reflect moisture changes at mid-levels

MIST:
- detects and quantifies dry-air intrusions
- potential predictor for statistical TC intensity forecast models (SHIPS, LGEM, RII)

MIST shows moisture flux at R = 220 km from the storm center as a function of azimuth

Galina Chirokova (CIRA), Mark DeMaria (NOAA/NWS/NHC), John Knaff (NOAA/NESDIS)
Application: Blended Layer Precipitable Water Combines MiRS WV from up to 7 Polar Satellites for Rapid Refresh and Advection (NWP-based winds)

To be implemented at NHC and WPC

Gitro et al., 2018: Using the multisensor advected layered precipitable water product in the operational forecast environment. J. Operational Meteor., 6 (6), 59-73, doi: https://doi.org/10.15191/nwajom.2018.0606

Courtesy of John Forsythe
Future Development: Surface Classifier Using Machine Learning

- Current MiRS surface type classifier is categorical (no mixed types): ocean, land, snow, ice
- Using TensorFlow to train a neural network to probabilistically classify surface types with IMS operational analyses as truth data
- Probabilistic surface type can be used to condition the a priori conditions for mixed surface types (e.g. emissivity) with potential impact on retrievals (e.g. ice concentration, snow water, T, WV profiles)

IMS (Observed)

Neural Net (Predicted) Probability of Ice

Snow

Ice

1 km res

ATMS res

9 Jan 2016
SNPP/ATMS Sea Ice Concentration and Age: Comparisons with VIIRS

- Collocations of VIIRS pixels that fall within each ATMS FOV
- Example from one day of global data: 29 Jan 2018

### Ice Concentration difference VIIRS–ATMS all

- **bias:** 1.73
- **std:** 8.36
- **rmse:** 8.54
- **num:** 84005

### Ice Concentration difference VIIRS–ATMS 20–30%

- **bias:** -54.76
- **std:** 23.32
- **rmse:** 59.53
- **num:** 339

### Ice Concentration difference VIIRS–ATMS 30–50%

- **bias:** -34.79
- **std:** 21.05
- **rmse:** 40.65
- **num:** 743

### Ice Concentration difference VIIRS–ATMS 50–70%

- **bias:** -24.55
- **std:** 17.58
- **rmse:** 30.19
- **num:** 1003

### Ice Concentration difference VIIRS–ATMS 70–90%

- **bias:** -10.14
- **std:** 11.53
- **rmse:** 15.35
- **num:** 2783

### Ice Concentration difference VIIRS–ATMS 90–100%

- **bias:** 3.07
- **std:** 4.18
- **rmse:** 5.19
- **num:** 79137
RR validation: N20 and SNPP vs. Stage IV (Dec 2017 – Jul 2018)

5-Day CONUS Averages
Two Operational ATMS Better Than One: MiRS Rain Rate for Hurricane Hector

Doubling the number of ATMS overpasses increases odds that TCs fall within the (near nadir) “sweet spot” of swath.
Summary

- Continued N20 validation indicates **extremely good agreement** with SNPP, and performance against external references very similar to SNPP; additional validation necessary
- Validation maturity status: Provisional maturity
- MiRS v11.3: Extension to N20 ATMS processing, delivered to OSPO/NDE on 8 June
- Path Forward
  - Continued validation, e.g. rain rate, CLW, cryosphere, T, WV,...
  - Additional DAP delivery in late 2018 (updated radiometric bias corrections, possible science improvements)
  - Extend to MetopC in 2019, JPSS-2, etc.
  - Science improvements (e.g. surface classification, bias correction, rainy sounding)
  - Longer term: EON-MW (SmallSats), Metop-SG (sounding, surface, and ice cloud missions)
  - Stakeholders/user needs; continue collaboration with applications developers and users...
- MiRS data available at CLASS, and STAR ftp (S-NPP/ATMS, NOAA-20/ATMS, GPM/GMI)
- Software package available for download [https://www.star.nesdis.noaa.gov/mirs](https://www.star.nesdis.noaa.gov/mirs)
Temperature and Water Vapor Profile (2017-12-07)

Global collocation w/ECMWF

Bias

Temperature

N20 T profile slightly colder than SNPP due to colder TBs in T sounding channels

Sea:

Land:

Water Vapor

Sea

Land

Solid:N20

Dashed:NPP

Bias

StDv

Sea

Land

Solid:N20

Dashed:NPP