HYDROLOGY PRODUCTS OVERVIEW

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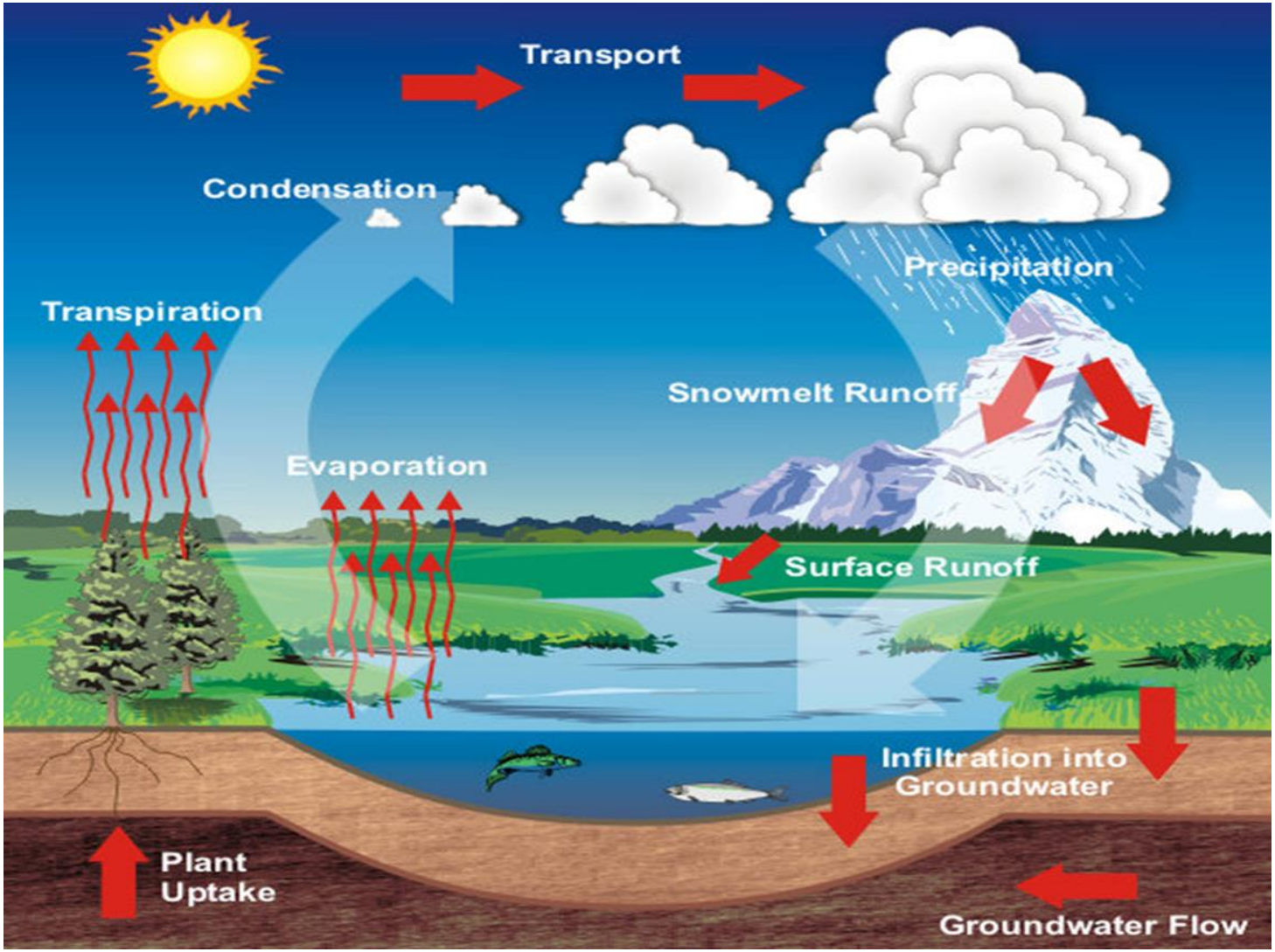
OUTLINE

- Why we want to monitor it

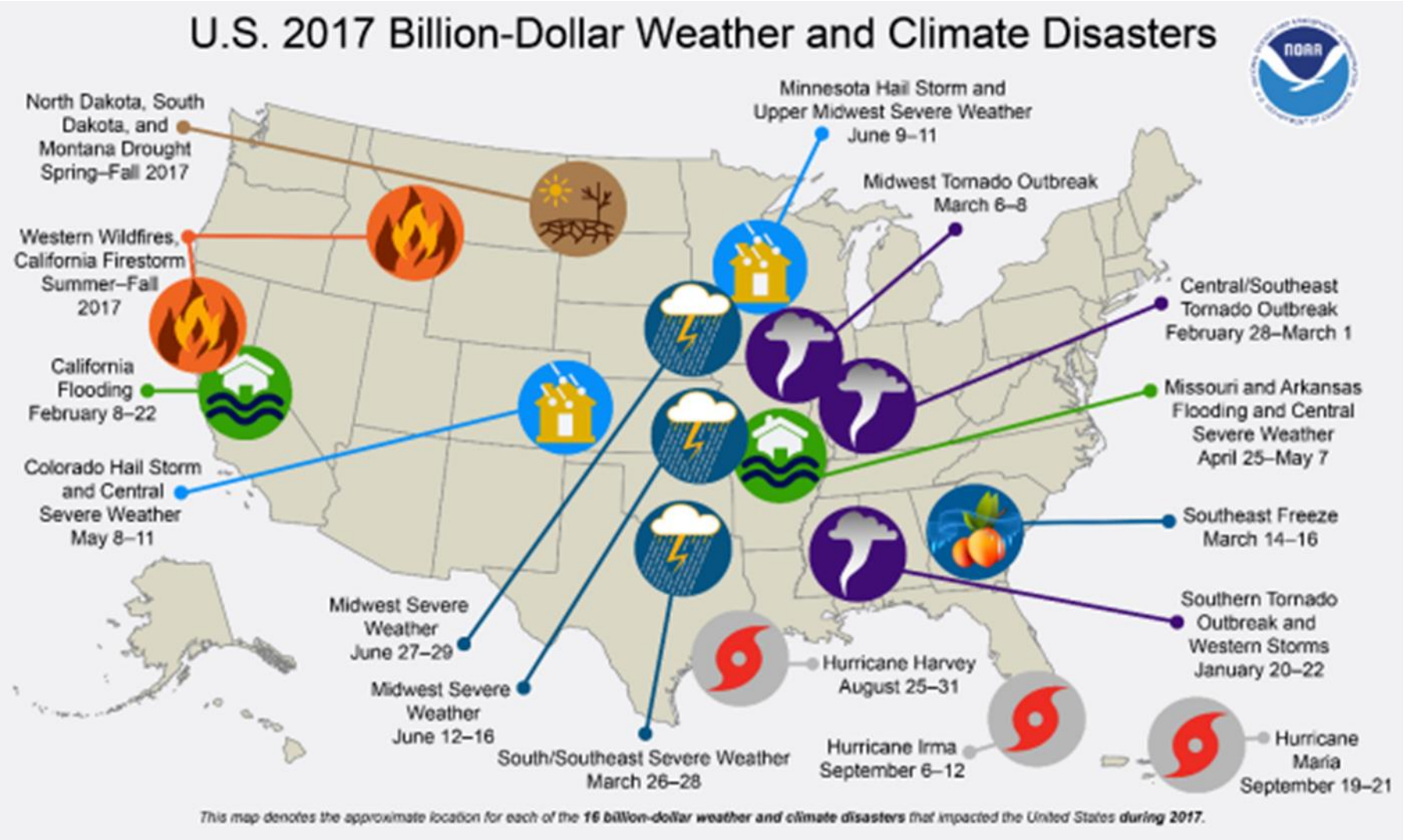
- What do we consider as “Hydrology” Products?
  - Operational products
    - JPSS Baseline
    - Legacy POES baseline
    - Blended products (fall under both categories)
  - Emerging JPSS PGRR Products

- What we will hear in this session

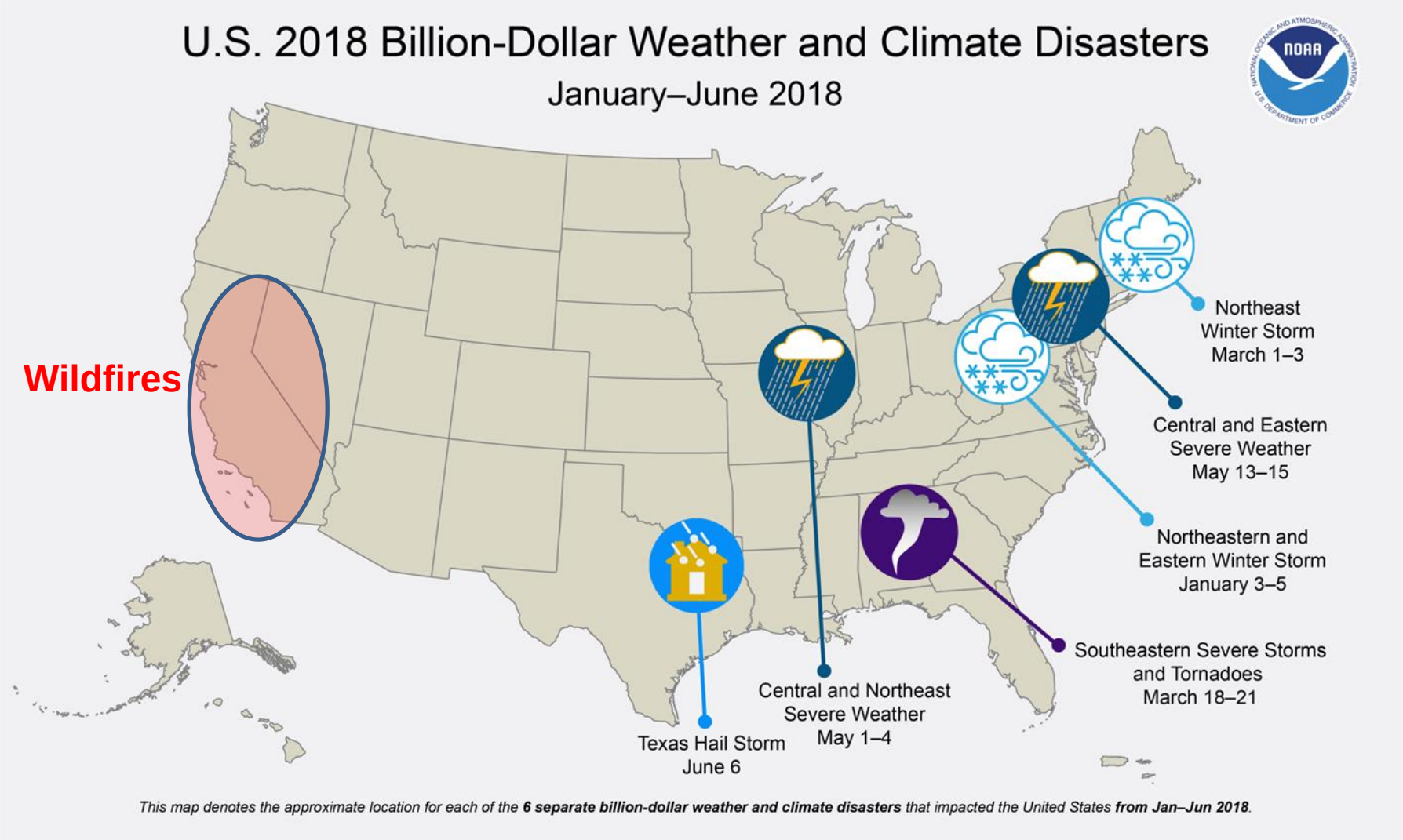
The Hydrological Cycle – Very Diverse!



Why We Need to Monitor and Understand it



Why We Need to Monitor and Understand it



Three Classes of Products

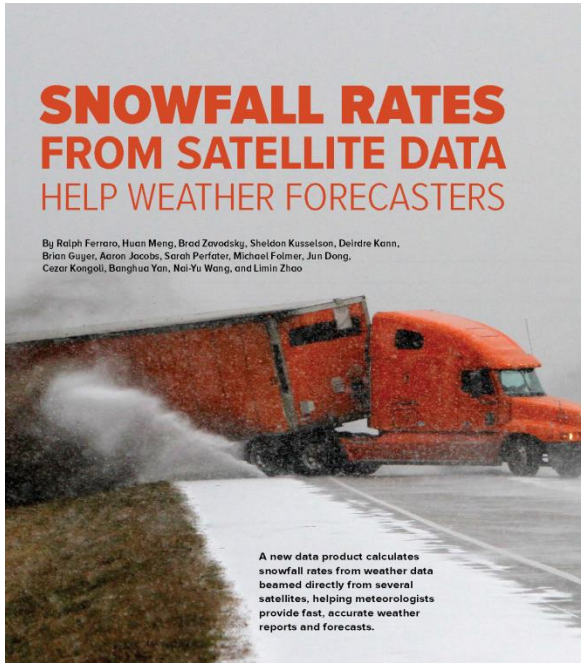
- JPSS Baseline products/systems
  - Primarily from ATMS, AMSR-2, VIIRS
- JPSS/Legacy POES “blended” products
  - Primarily MW driven, includes AMSU/MHS and non-NOAA satellites like GPM and DMSP
- JPSS Proving Ground Risk Reduction (PGRR) developmental products
  - Enhancements to baseline, could include data fusion with GOES and in-situ
  - Newer, pushing limits of sensor capabilities
- **NOTE – Many of the products are microwave sensor driven**

Primary Operational Product Systems

(Support S-NPP, NOAA-20, GCOM, POES, others…)

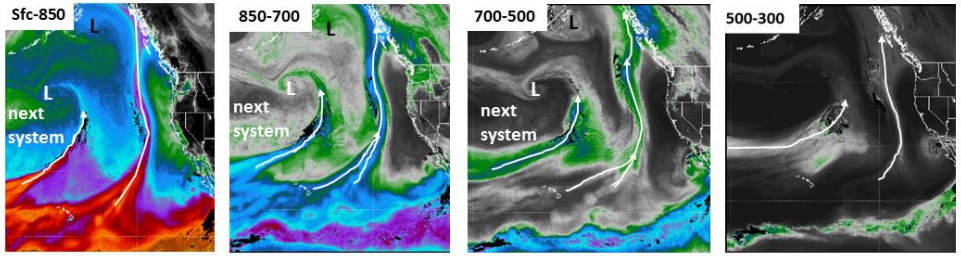
- Microwave Integrated Retrieval System (MiRS)
  - http://www.ospo.noaa.gov/Products/atmosphere/mirs/index.html
- Microwave Snowfall Rate (SFR)
  - http://www.ospo.noaa.gov/Products/atmosphere/mirs/index.html
  - Also available on AWIPS
- NOAA Operational GCOM-W1 AMSR2 Products System (NOGAPS)
  - http://www.ospo.noaa.gov/Products/atmosphere/gpds/
- NESDIS Operational Soil Moisture Products (SMOPS)
  - http://www.ospo.noaa.gov/Products/land/smops/index.html
- Blended TPW/RR
  - http://www.ospo.noaa.gov/Products/atmosphere/brr/
- VIIRS snow and ice products
  - https://www.star.nesdis.noaa.gov/jpss/EDRs/products_cryosphere.php
  - http://hippy.gina.alaska.edu/distro/ice_eval/
  - http://hippy.gina.alaska.edu/distro/ice_motion_eval/
- Interactive MultiSensor Snow & Ice Mapping System (IMS)
  - http://www.natice.noaa.gov/ims/index.html

Some Uses of the Products….

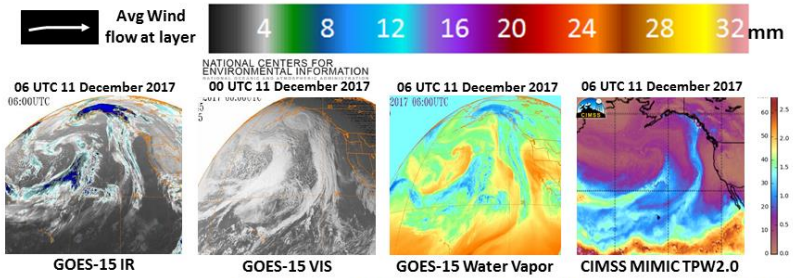


"Atmospheric Rivers" of High Concentrated Moisture into Alaska at 4 layers For a Week of Excessive Rainfall – Juneau, AK 11 & 13-14 December 2017

CIRA/Colorado State University Advected Layered Precipitable Water (ALPW) for 06 UTC 11 December 2017



Juneau*/Sitka, AK
Precipitation
11 December 2017
1.69"*/1.26"
*Record Precip

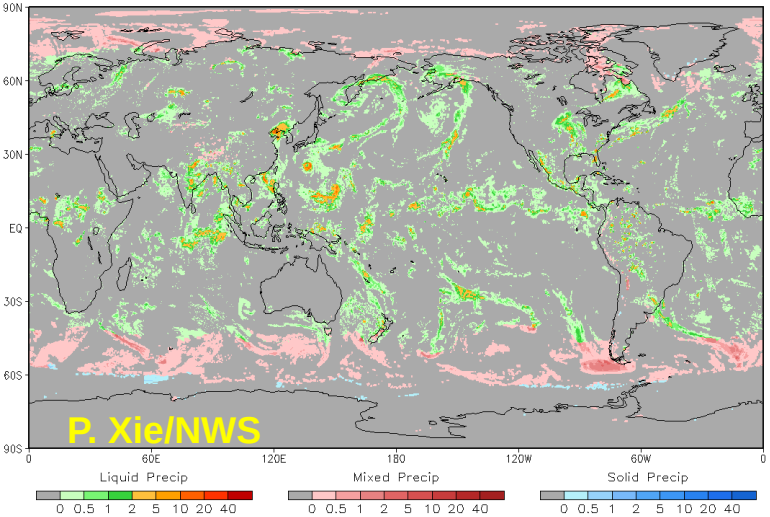


(Photo by Rashah McChesney/Alaska's Energy Desk)
https://www.ktoo.org/2017/12/11/southeast-alaska-sees-warm-temps-lots-rain/

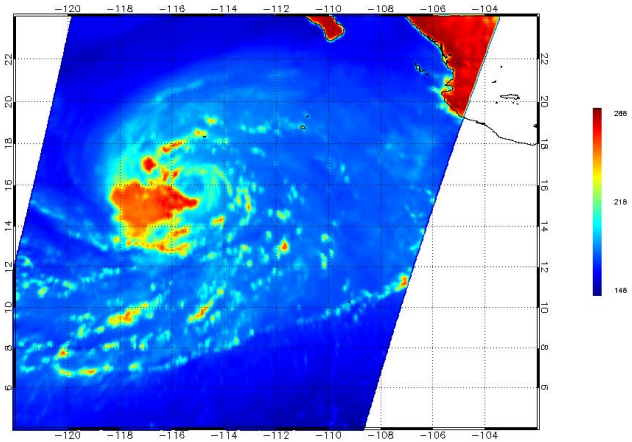
ftp://ftp.cira.colostate.edu/ftp/Forsythe/LPW/Anim_GIF/2017Dec1121Advect_LPW_ALT_anim.gif

Analysis Prepared by Sheldon Kusselson

CMORPH2 Precip Rate @ 2018.08.20 00:00Z (mm/hr)



AMSR-2 36.5GHz H-pol Date: 20180629-1218Z
Storm Name: EMILIA Region: Eastern_Pacific
AMSR2 L1B file: GW1AM2_201806290855_035B_L1SNBTBR_2220220.h5



JPSS PGRR Hydrology Initiative Projects/Participants FY15-FY17 (a few go into FY18)

Project PI	Project Title
Dave Gochis *(NCAR)*	Applying Snow Products from S-NPP JPSS and SNODAS to Seasonal Streamflow Forecasting at the NWS National Water Center
Huan Meng *(NESDIS/STAR)*	Continued expansion, enhancement and evolution of the NESDIS snowfall rate product to support weather forecasting
Pingping Xie *(NWS/NCEP)*	Reprocessing of JPSS precipitation and OLR products for improved operational climate applications
John Forsythe *(CSU/CIRA)*	Using JPSS Retrievals to Implement a Multisensor, Synoptic, Layered Water Vapor Product for Forecasters
Tony Wimmers *(UW/CIMSS)*	Strengthening TPW visualization in the OCONUS domain with JPSS data products
Tarendra Lakhankar *(CUNY/CREST)*	Validation and Application of JPSS/GCOM-W Soil Moisture Data Product for operational flood monitoring in Puerto Rico
Andi Walther *(UM/CIMSS)*	Further development of the VIIRS Nighttime Lunar Reflectance-derived Cloud Properties and the Demonstration for their use for Precipitation and Icing Applications

FY18 New Hydrology Project Selections

Project PI	Project Title
Huan Meng *(NESDIS/STAR)*	Development of Snowfall Rate over Ocean, Sea Ice, and Coast Product to Support Weather Forecasting
Pingping Xie *(NWS/NCEP)*	Improving and Reprocessing the CMORPH Satellite Precipitation Estimates and Global OLR Analysis with Retrievals from JPSS
John Forsythe *(CSU/CIRA)* and Tony Wimmers *(UW/CIMSS)*	Merged Water Vapor Products for Forecasters using Advanced Visualization Methods
Tarendra Lakhankar *(CUNY/CREST)*	Ensemble flood forecasting system coupling WRF-Hydro with Satellite Data (JPSS and GOES-R) for Puerto Rico
Xiwu Zhan *(NESDIS/STAR)* and Nai-Yu Wang *(UMD/CICS)*	Improving JPSS Soil Moisture Data Products for Use in Evaluation and Benchmarking of the National Water Model

Hydrology Initiative Accomplishments Past 3 years

- Moved the SFR product from a research product to a JPSS requirement
  - Allows for base funding to sustain the product for future sensors, perform routine validation, etc.
- Plans in place to get the LTPW into operational phase
- Matured engagement with NWS end users on several products
  - SFR – NWSFO product evaluations, use in WPC Winter Experiment
  - Layered and MIMIC TPW
  - National Water Center/National Water Model
- Developing synergies with River Flood/Ice and NUCAPS initiatives
- Expanded working group to include JPSS and GOES-R baseline projects
  - An outcome - enhancing bTPW product via L2 MiRS and GCOM TPW improvements
- Examining case studies of extreme events/product performance
  - CA Atmospheric Rivers past few winters
  - Hurricane rainfall, most recently, Harvey

The Remainder of the Session

Auditorium: Hydrology EDRs and Initiative - Trends and Drivers - Imagery EDRs and Visualization - Wrapup

Time	Presentations / Topics	Speaker	Affiliation
0830 - 0900	*Keynote Talk: Updates on CEOS/CGMS climate working group and how operational satellite programs can contribute to long term climate records*	Jörg Schulz	EUMETSAT
0900 - 1030	***Hydrology EDRs and Initiatives (GCOM-W included)*** ***Chairs: Ralph Ferraro and Huan Meng*** ***Auditorium***		
0900 - 0915	*Hydrology Products Overview - Operational and PGRR products and projects*	Ralph Ferraro	STAR
0915 - 0930	*MiRS Hydrological Products*	Chris Grassotti	CICS-MD
0930 - 0945	*Microwave Snowfall Rates*	Huan Meng	STAR
0945 - 1000	*GCOM Hydrological Products*	Paul Chang	STAR
1000 - 1015	*SMOPS Soil Moisture Products*	Jerry Zhan	STAR
1015 - 1030	*Satellite Hydrological Products Operational Applications in Alaska*	Jessica Cherry	NWS/APRFC
1030 - 1045	***Break***		

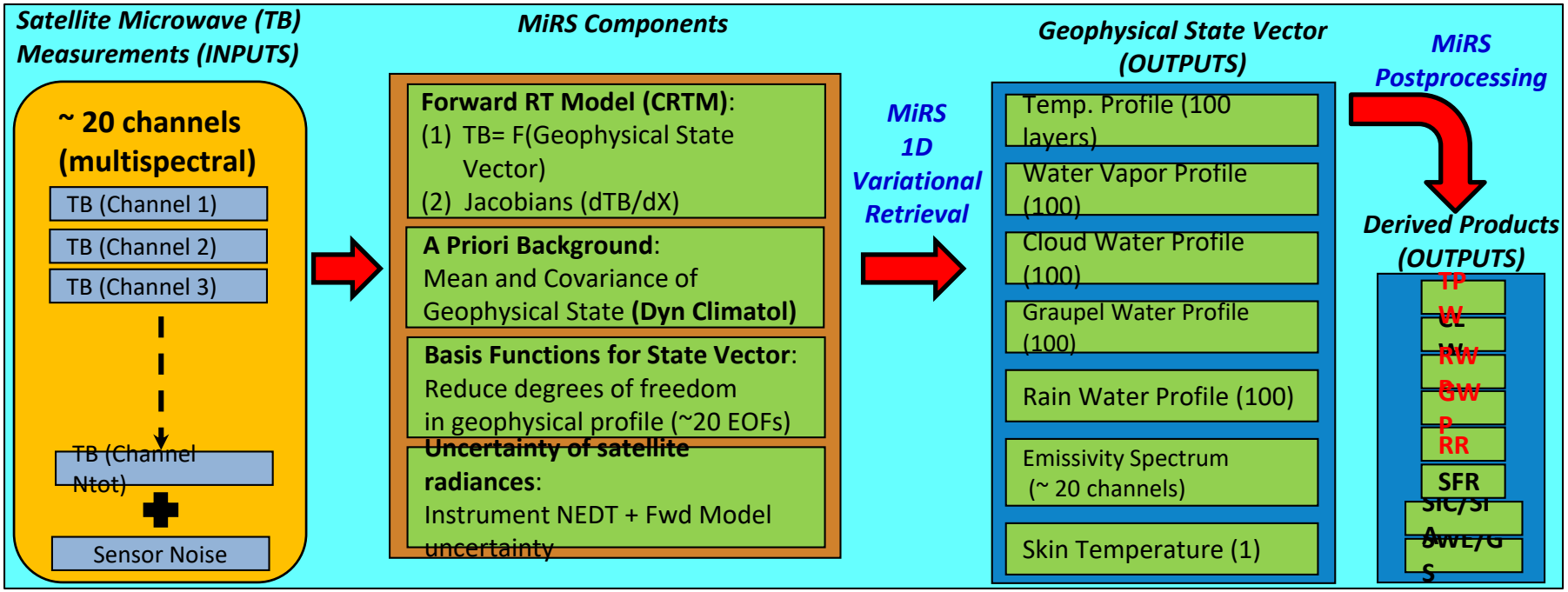
MICROWAVE INTEGRATED RETRIEVAL SYSTEM (MIRS): Hydrological Products and Applications

Chris Grassotti
CICS-MD and NOAA/NESDIS/STAR

MiRS Team: S. Liu, R. Honeyager, Y-K. Lee, Q. Liu
Help from: G. Chirokova, P. Meyers, H. Meng

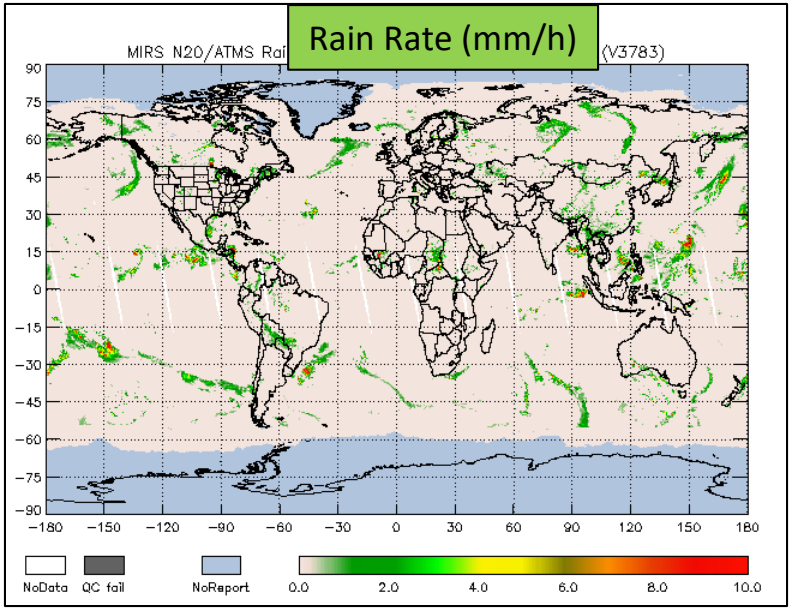
christopher.grassotti@noaa.gov
29 August 2018

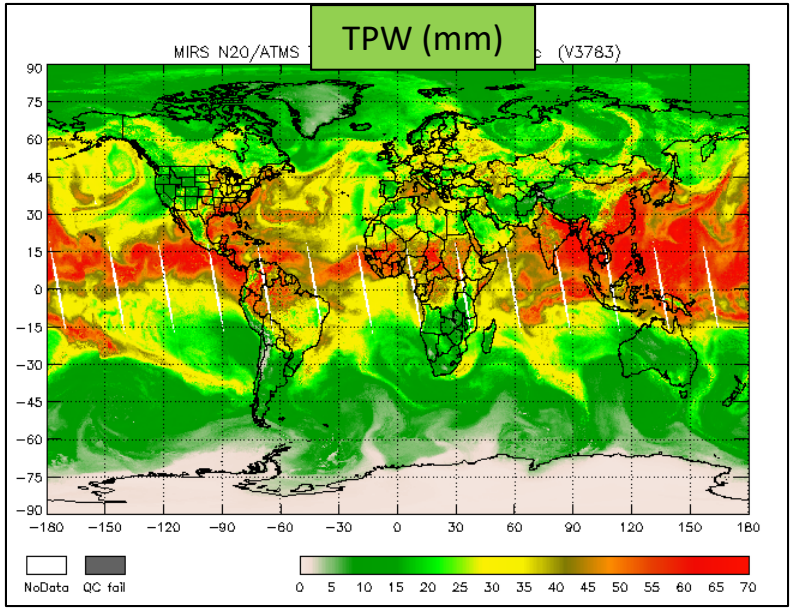
Algorithm Overview

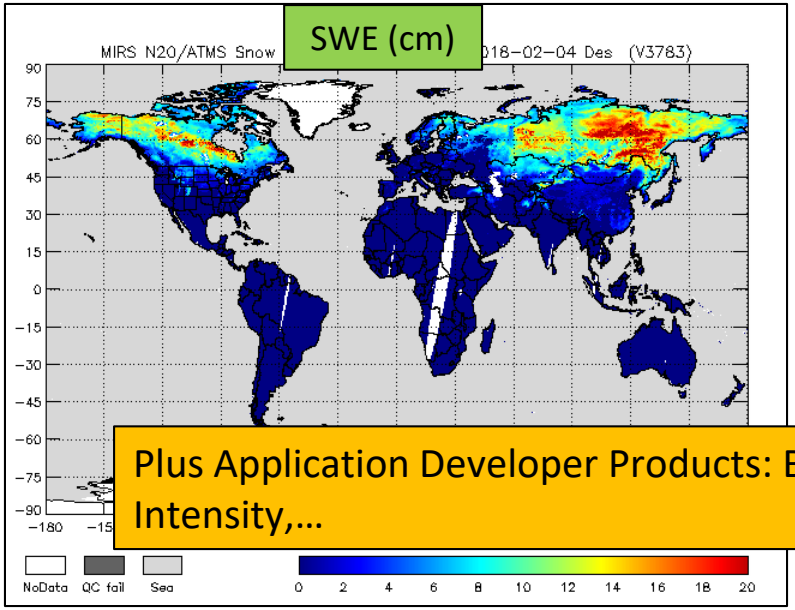


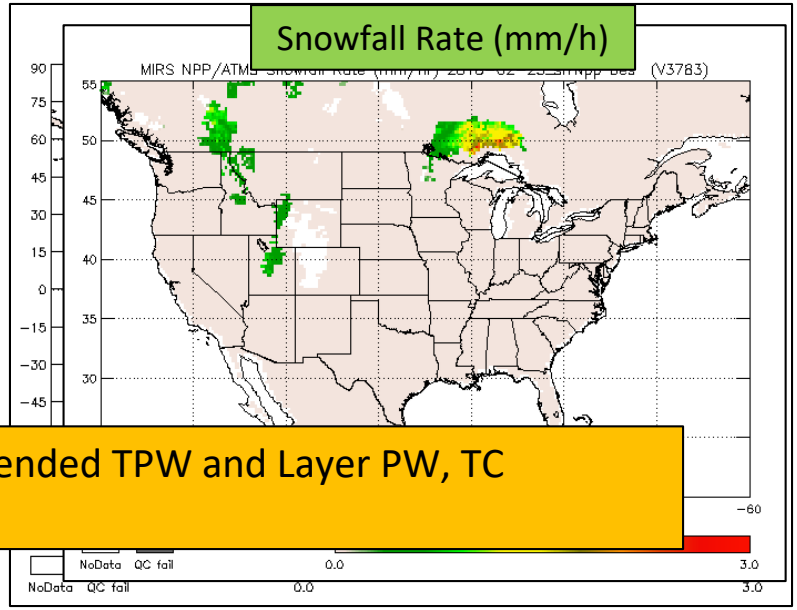
- MW Only, Variational Approach: Find the "most likely" atm/sfc state that: (1) best matches the satellite measurements, and (2) is still close to an a priori estimate of the atm/sfc conditions.
- **"Enterprise" Algorithm: Same core software runs on all satellites/sensors; facilitates science improvements 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 (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).**

Examples of MiRS Products with Hydrology Applications









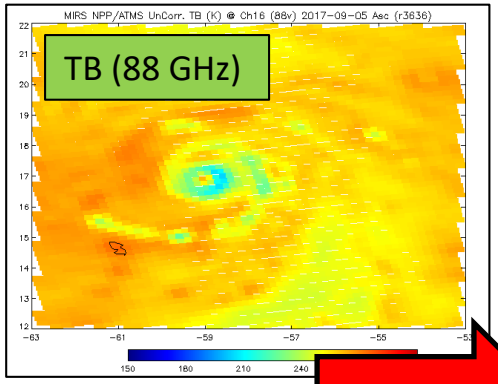
Plus Application Developer Products: Blended TPW and Layer PW, TC Intensity,…

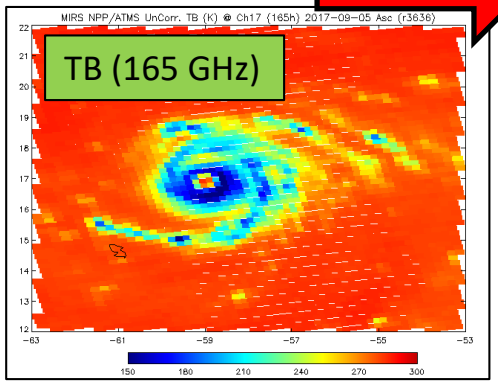
MiRS RR Algorithm

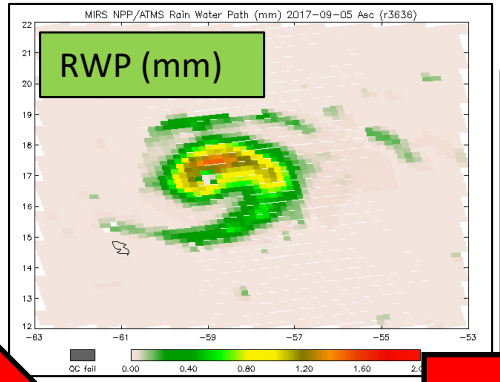
- 1DVAR retrieves pRWP and pGWP on 100 p layers
- Postprocessing:
  - Vertically integrate to obtain CLW, RWP GWP
  - Apply equation previously trained on mesoscale model simulations:

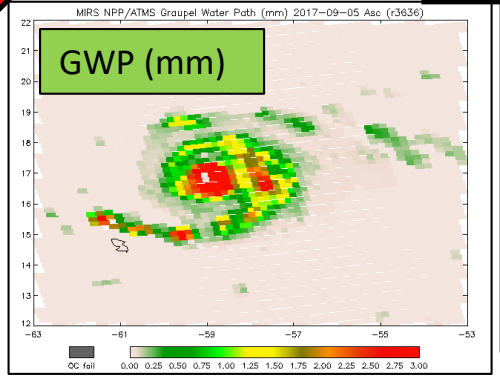
$$\text{[illegible]}, \text{[illegible]}, \text{[illegible]} = \text{[illegible]} + 3.879 \times \text{[illegible]} + \text{[illegible]}^{1.103}$$

$$\text{[illegible]} = 2.339 \times \text{[illegible]}^{1.156}$$

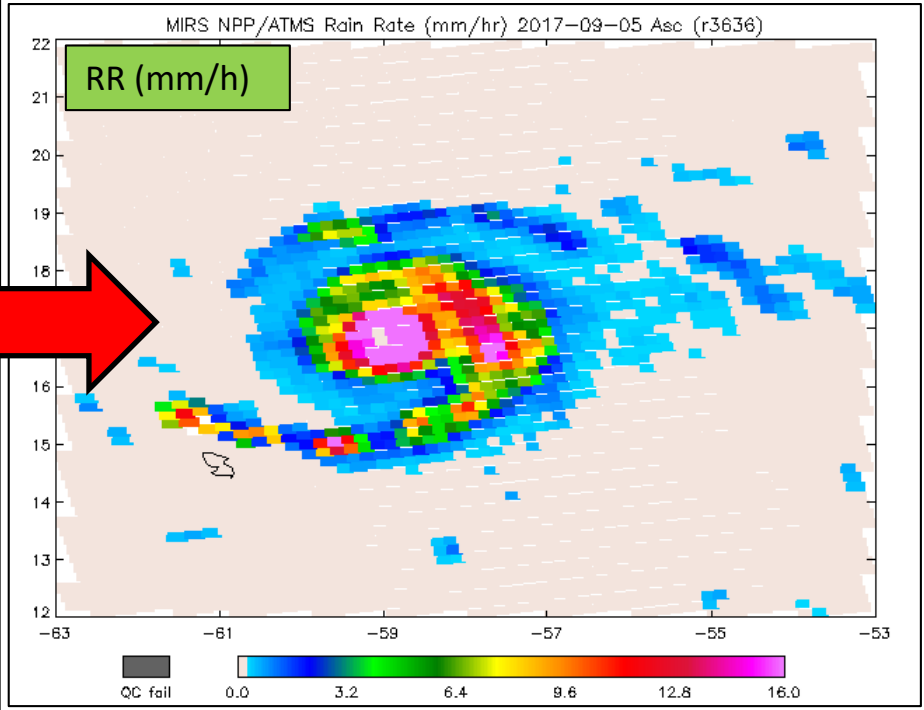






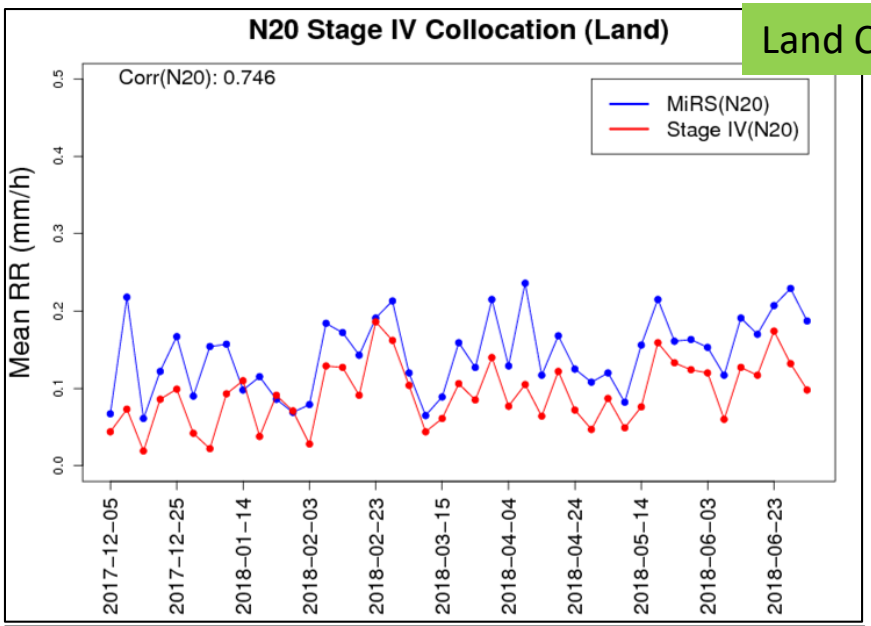


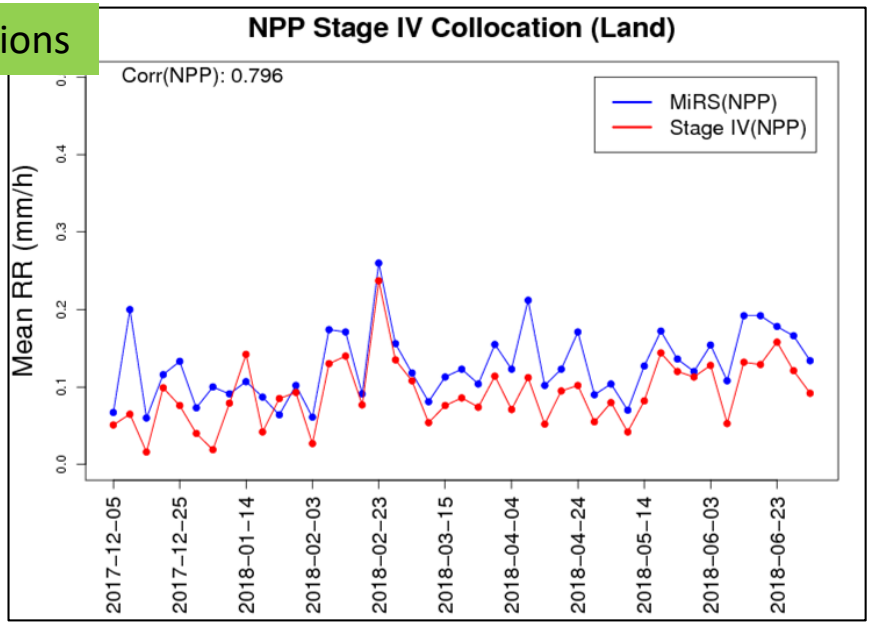
Hurricane Irma

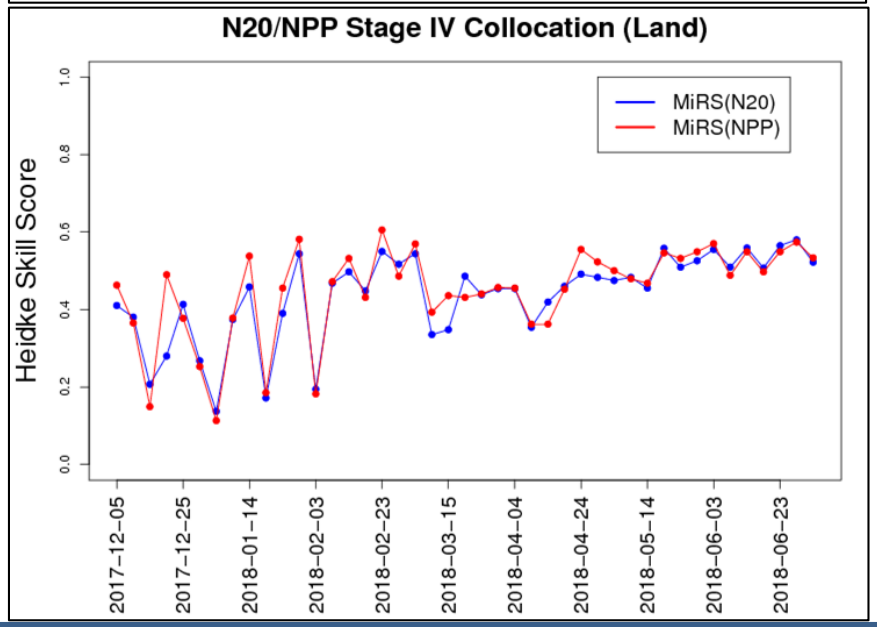


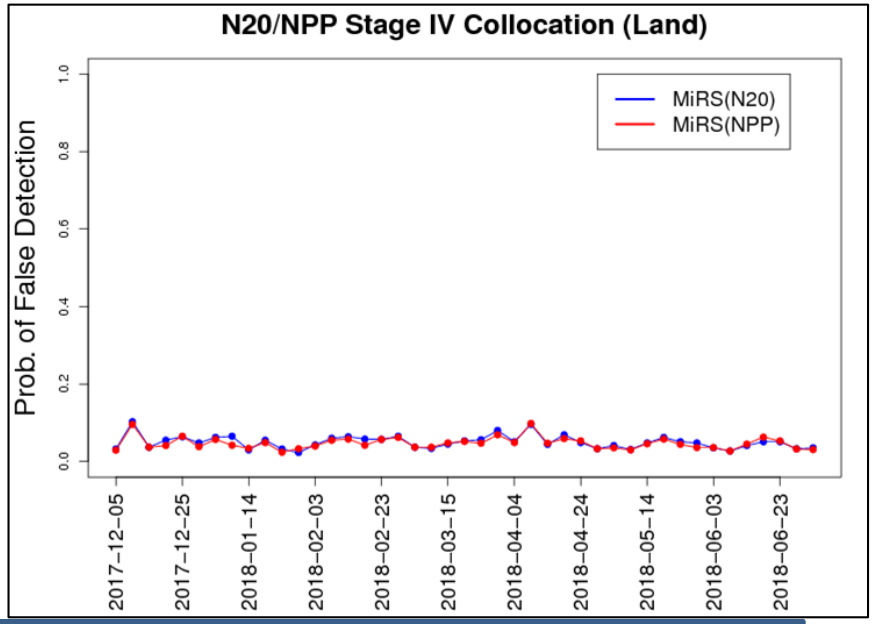
RR validation: N20 and SNPP vs. Stage IV 5-Day CONUS Averages (Dec 2017 – Jul 2018)

Land Collocations



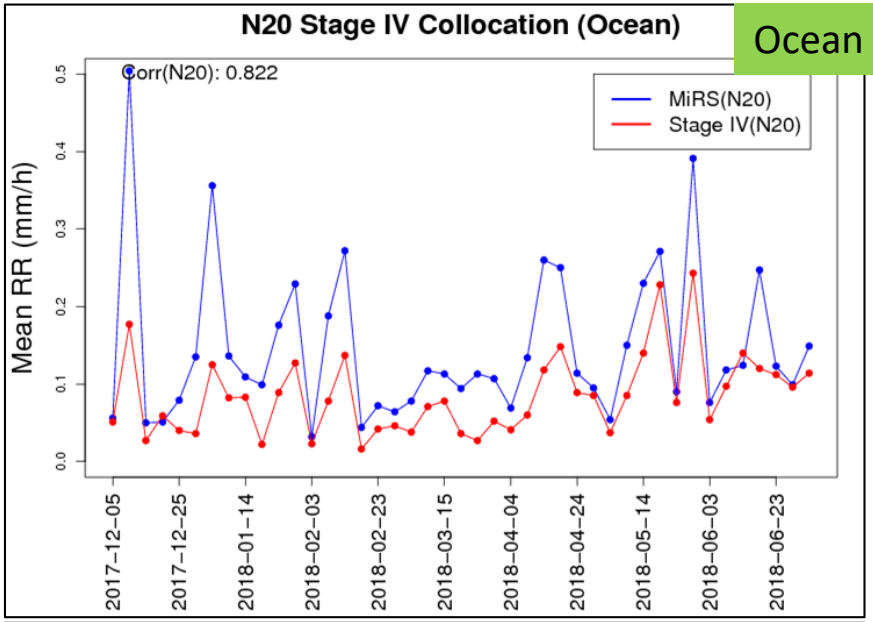


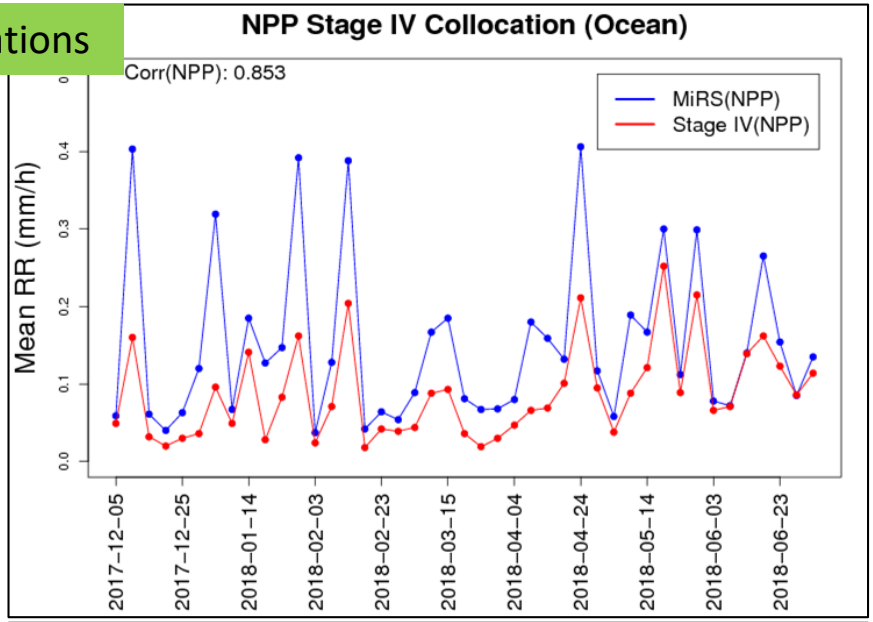


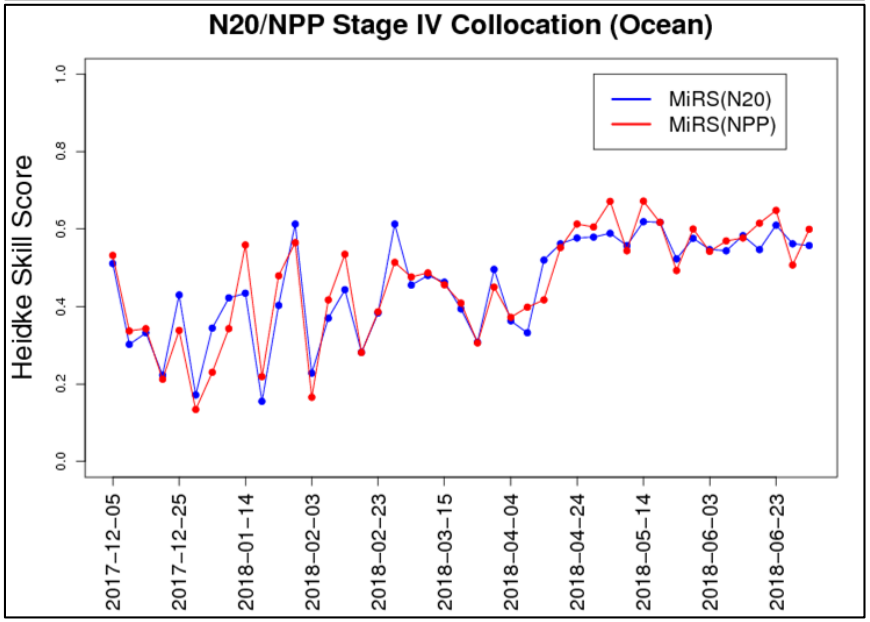


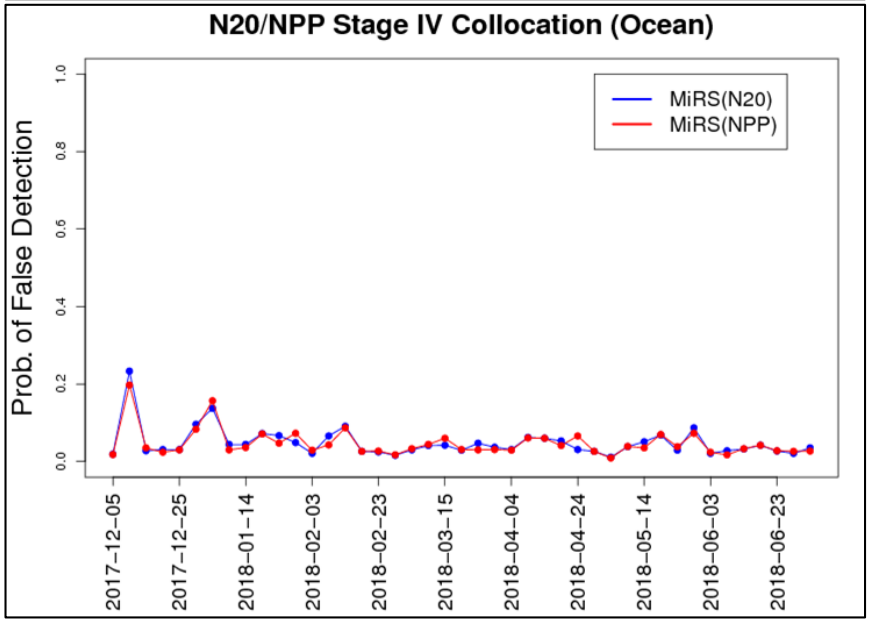
RR validation: N20 and SNPP vs. Stage IV 5-Day CONUS Averages (Dec 2017 – Jul 2018)

Ocean Collocations









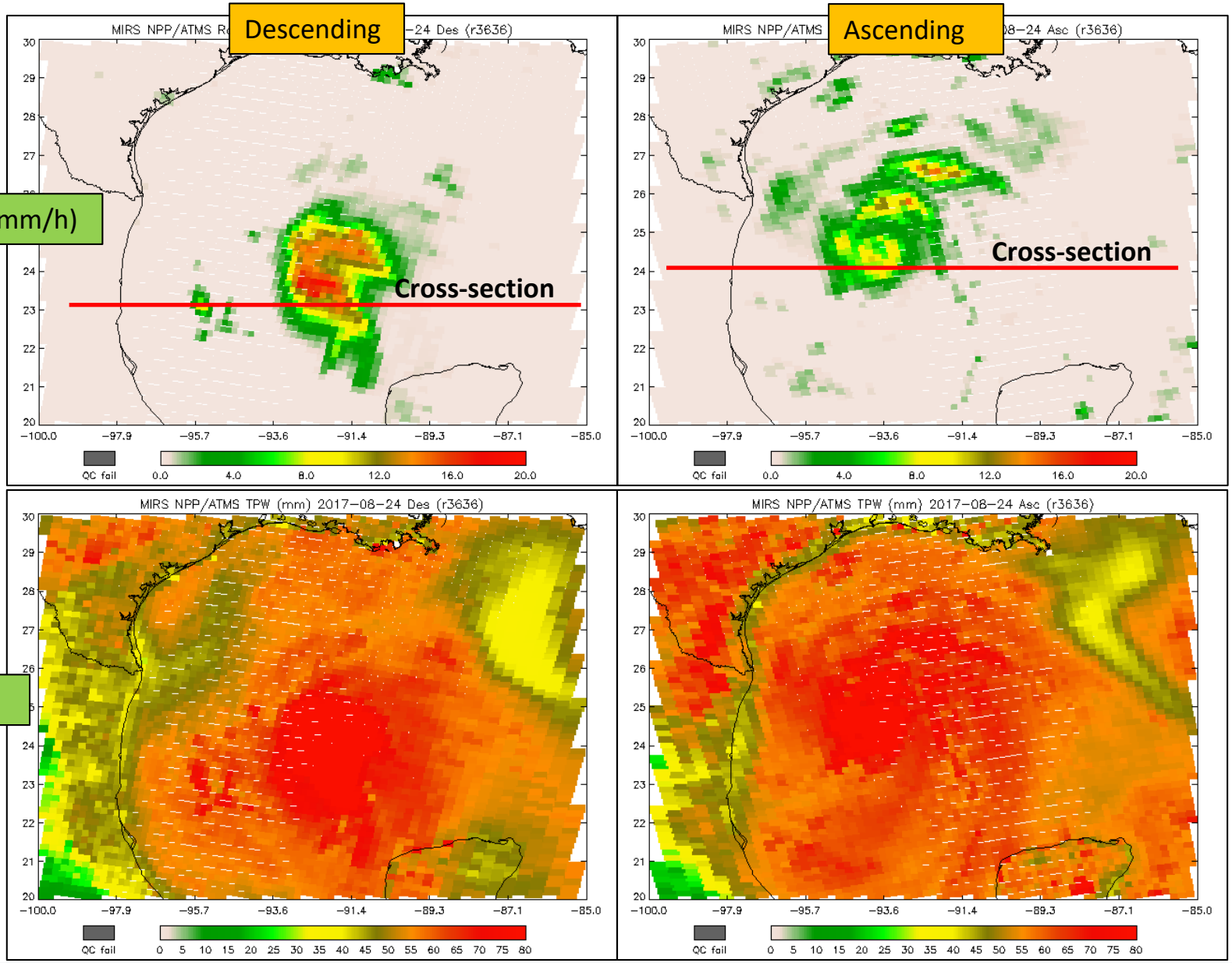
Hurricane Harvey:
MiRS ATMS Rain Rate and TPW, 24 August 2017

Descending

Ascending

Rain Rate (mm/h)

TPW (mm)



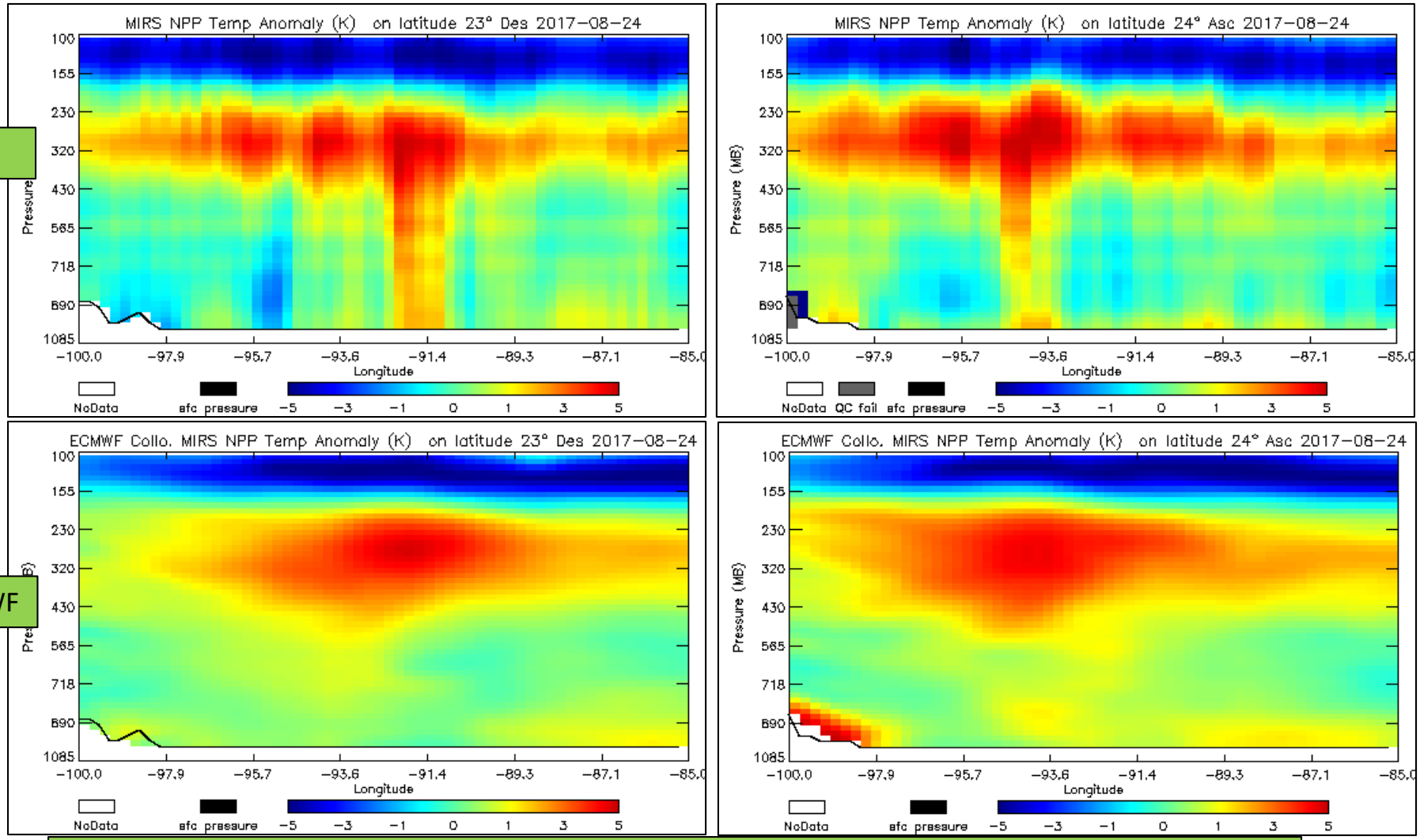
Hurricane Harvey: MiRS ATMS and ECMWF Temperature Anomaly Cross-sections, 24 August 2017

Descending

Ascending

MiRS

ECMWF

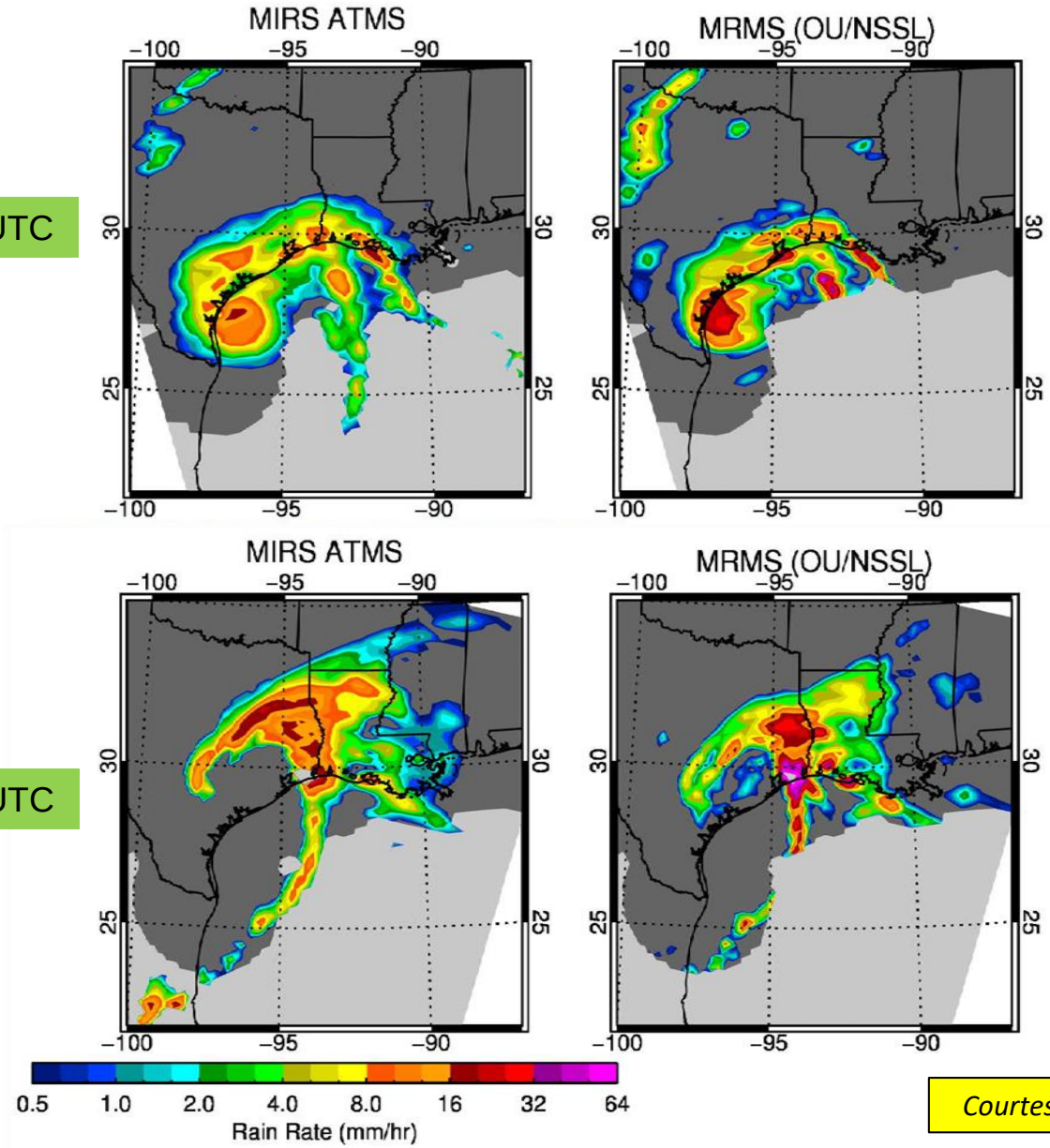


- Upper level T anomaly good agreement with ECMWF
- Lower level anomaly is artifact of rain contamination (see last year's presentation)

Hurricane Harvey: Comparison with MRMS

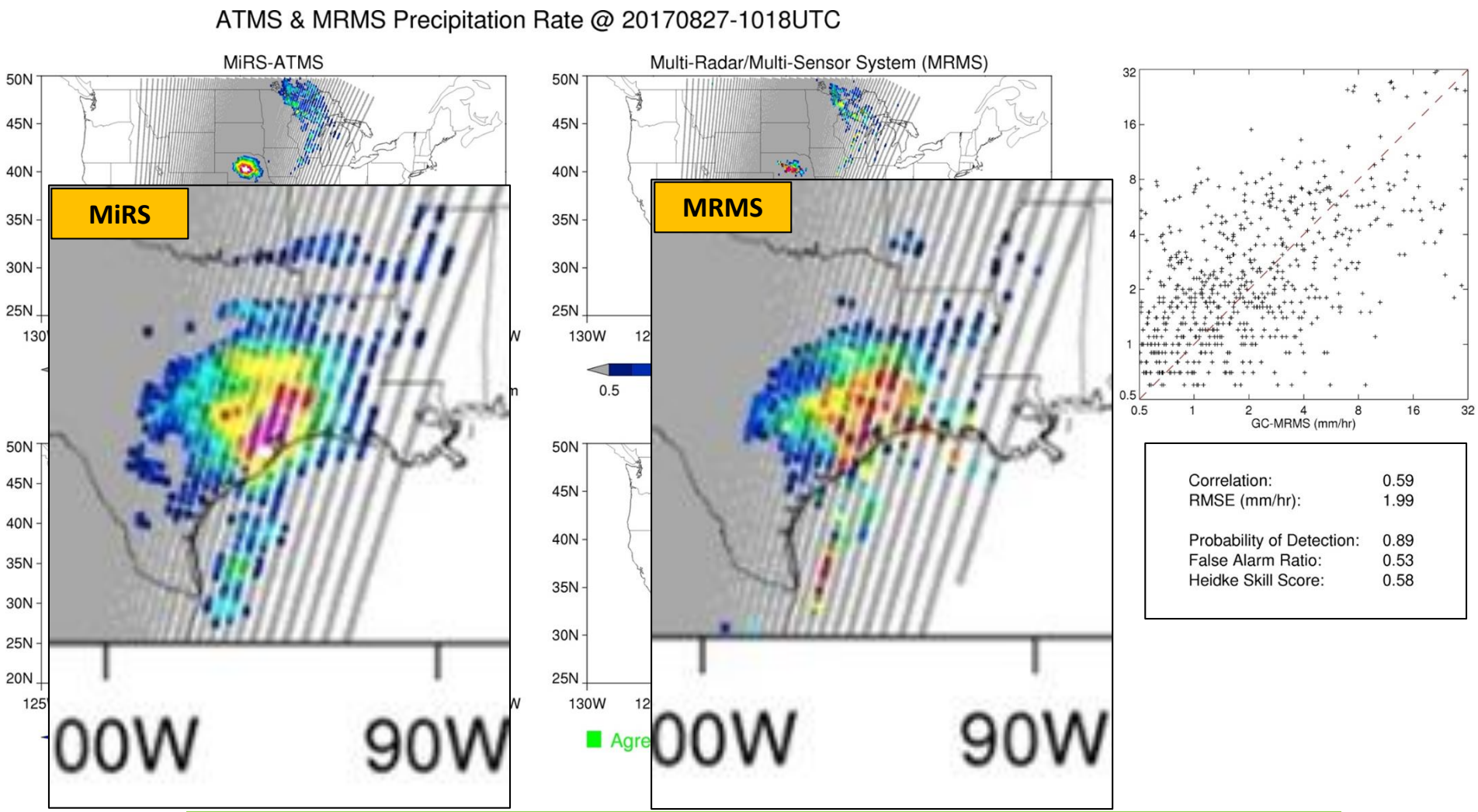
2017-08-25 1852 UTC

2017-08-28 0820 UTC



Courtesy of Pat Meyers (CICS-MD)

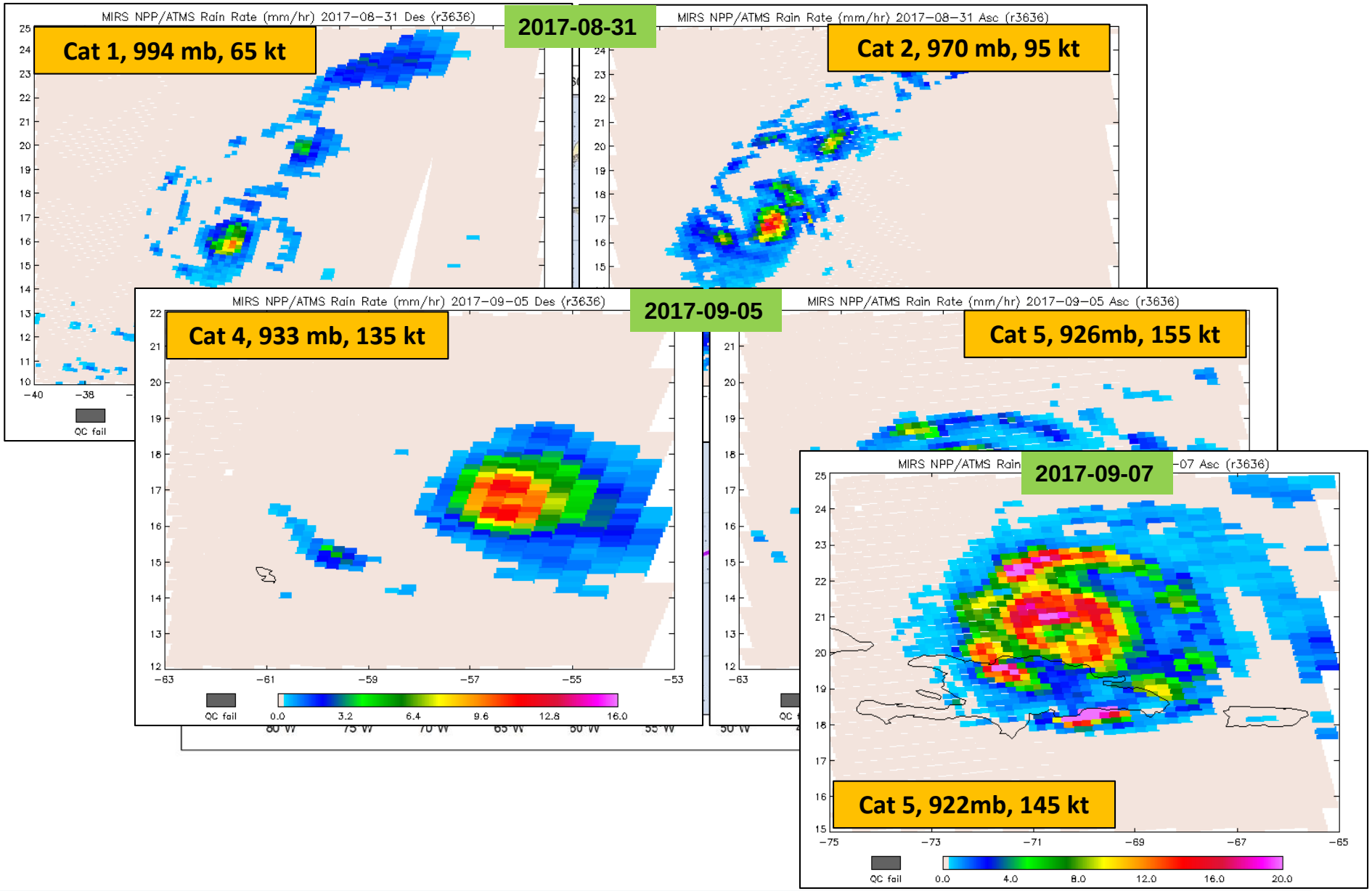
Hurricane Harvey:
27 August, Day of Extreme Flooding



- MRMS: Operational Blended Radar-Gauge Analysis, 1 km resolution
- Both satellite and MRMS detected rainfall rates > 25 mm/h

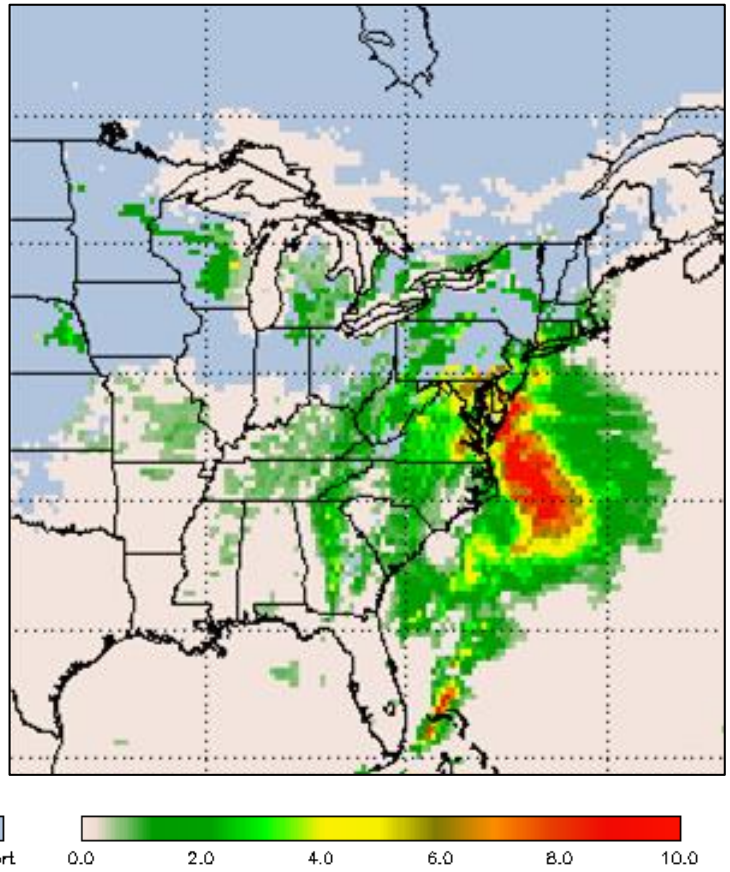
Courtesy of Pat Meyers (CICS-MD)

Hurricane Irma: Westward progression and Intensification

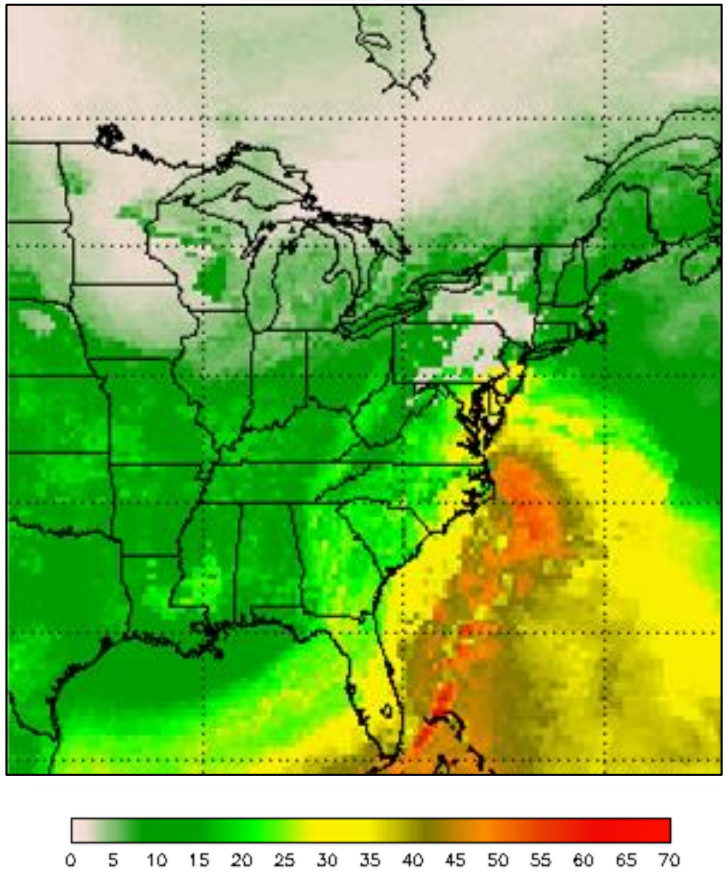


Northeastern Snowstorm: 14 March 2017

Rain rate (mm/h)



TPW (mm)

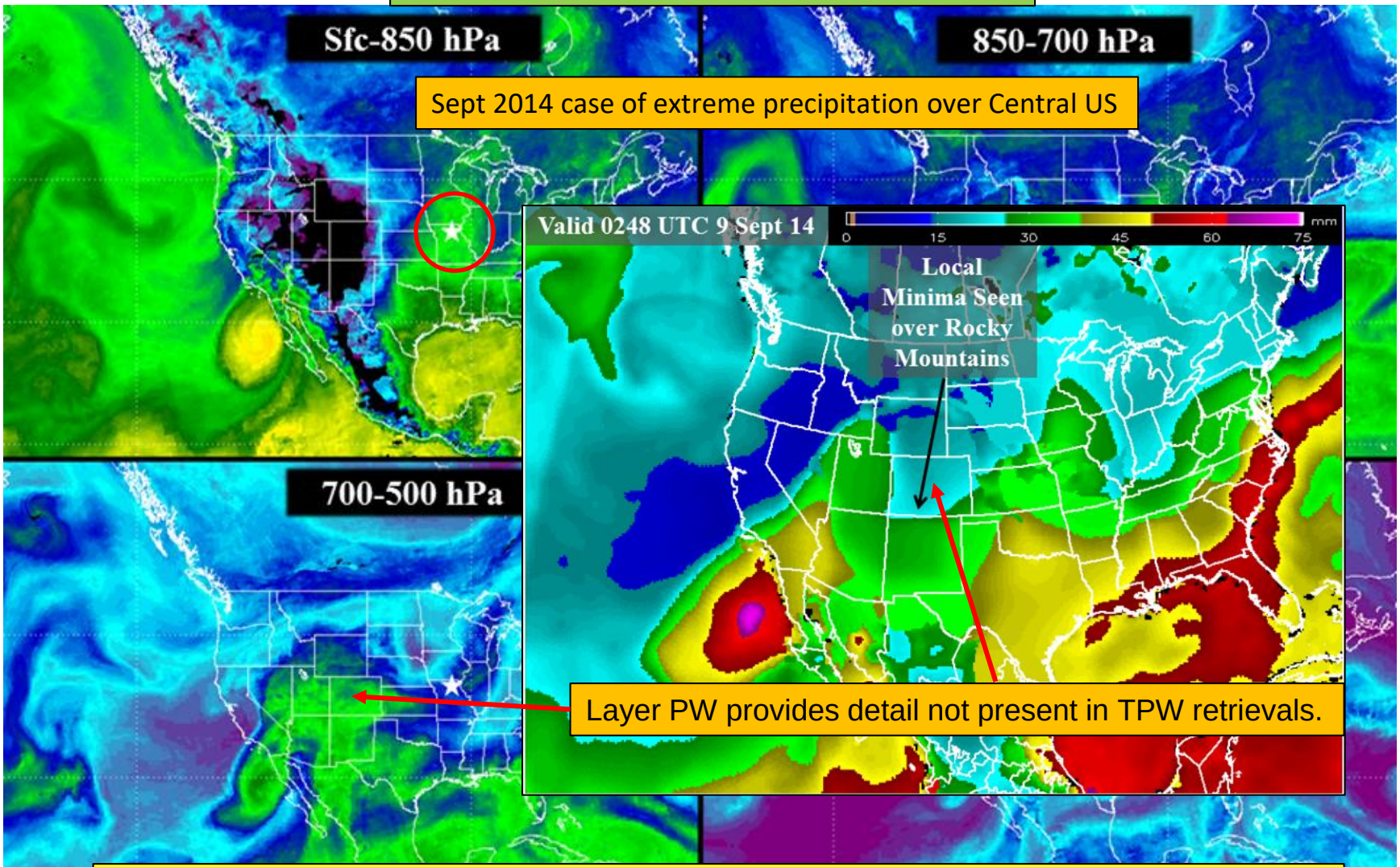


- High rain rates over ocean and southern areas (Caribbean moisture plume)
- Missing RR over snow covered land (algorithm does not retrieve precipitation when snow cover detected)
- Complementarity with SFR algorithm (retrieves over land only); see Huan Meng's presentation next.

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

Courtesy of John Forsythe



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*

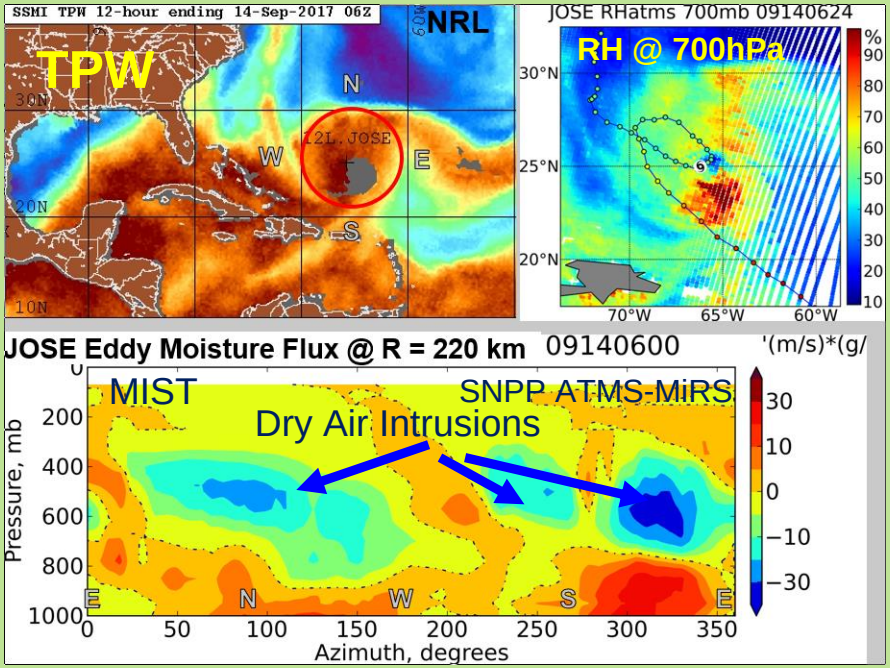
Application Using MiRS Data: Moisture In-Flux Storm Tool (MIST) (under development)

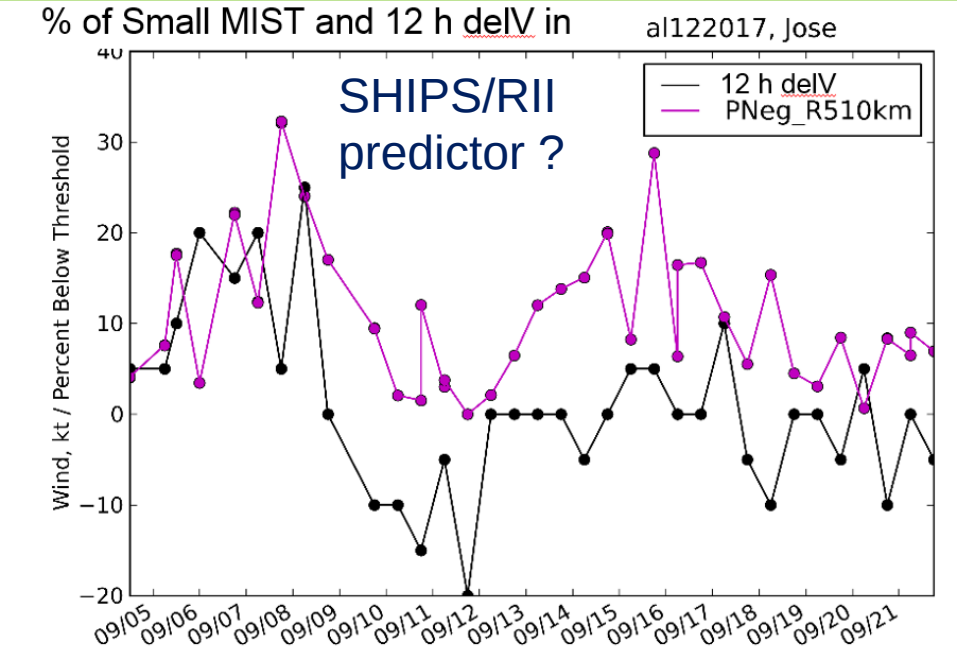
Dry-air intrusions:

- 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)

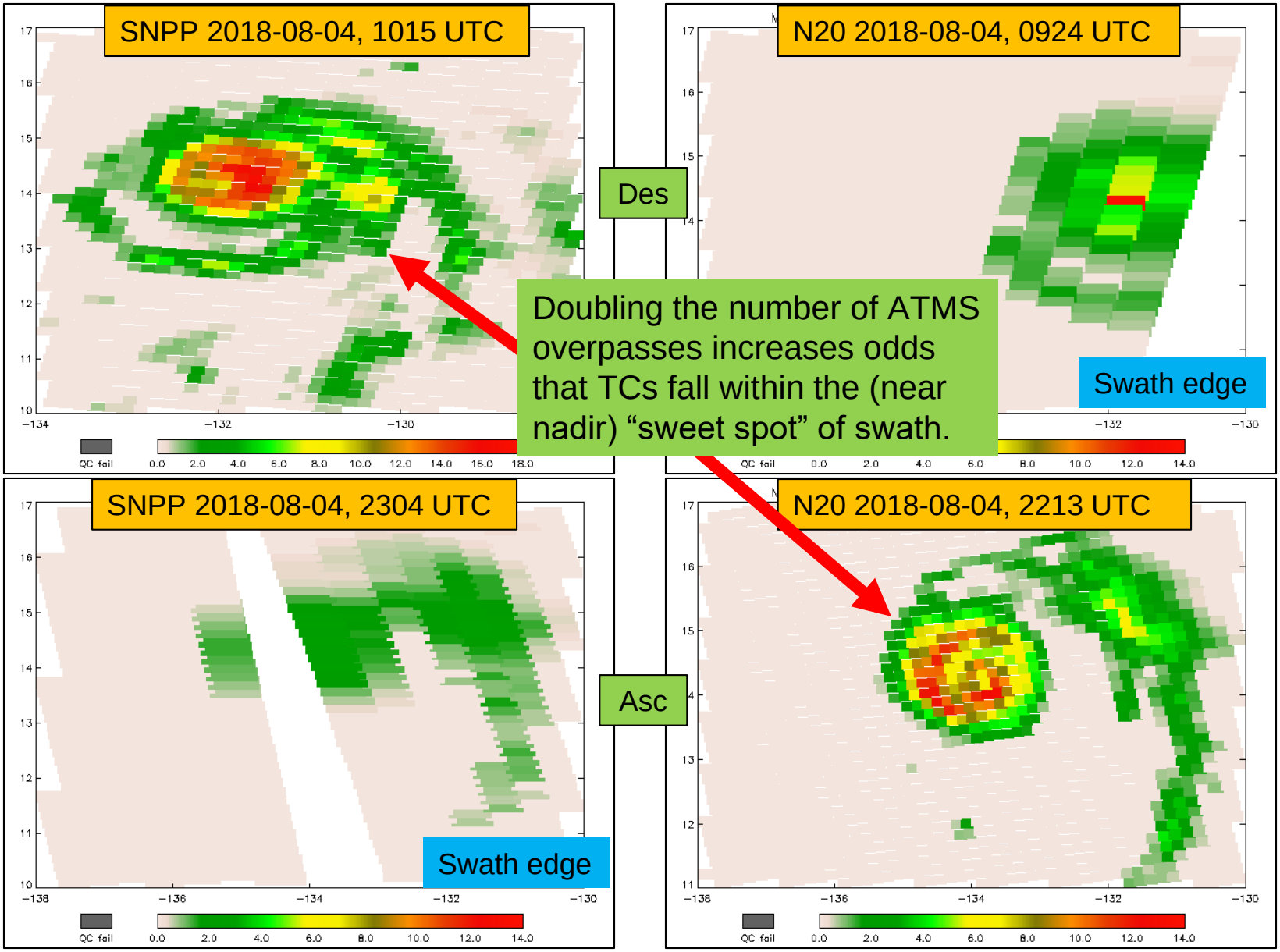




MIST shows moisture flux at R = 220 km from the storm center as a function of azimuth

Galina Chirokova (CIRA), Mark DeMaria (NOAA/NWS/NHC), John Knaff (NOAA/NESDIS)

Two Operational ATMS Better Than One: MiRS Rain Rate for Hurricane Hector



Summary

- MiRS products with hydrology applications: RR, RWP, GWP, CLW, TPW, Snowfall Rate, Sea Ice Concentration, Snow Water Equivalent
- Some products are used in downstream applications, e.g. Blended Layer and Total PW, TC Intensity
- Continued N20 validation (RR, TPW, SIC, SWE) indicates **extremely good agreement** with SNPP, and performance against external references very similar to SNPP
- Validation maturity status: Provisional maturity
- MiRS v11.3: Extension to N20 ATMS processing, delivered to OSPO/NDE on 8 June; operations possibly in September
- 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)
  - Stakeholders/user needs; <u>continue collaboration with applications developers and users</u>…
- MiRS data available at CLASS, and STAR ftp (S-NPP/ATMS, GPM/GMI, NOAA-20/ATMS)
- Software package available for download **https://www.star.nesdis.noaa.gov/mirs**

Extra Slides

Outline

- Algorithm Overview
- Rain rate validation
  - N20 and SNPP ATMS comparisons with Stage IV
- Case Studies
  - Hurricane Harvey (August 2017)
  - Hurricanes Irma and Jose (Sept 2017)
  - Northeastern Snowstorm (14 March 2017)
  - Advantage of 2 operational ATMS for TC monitoring
- Summary and Path Forward

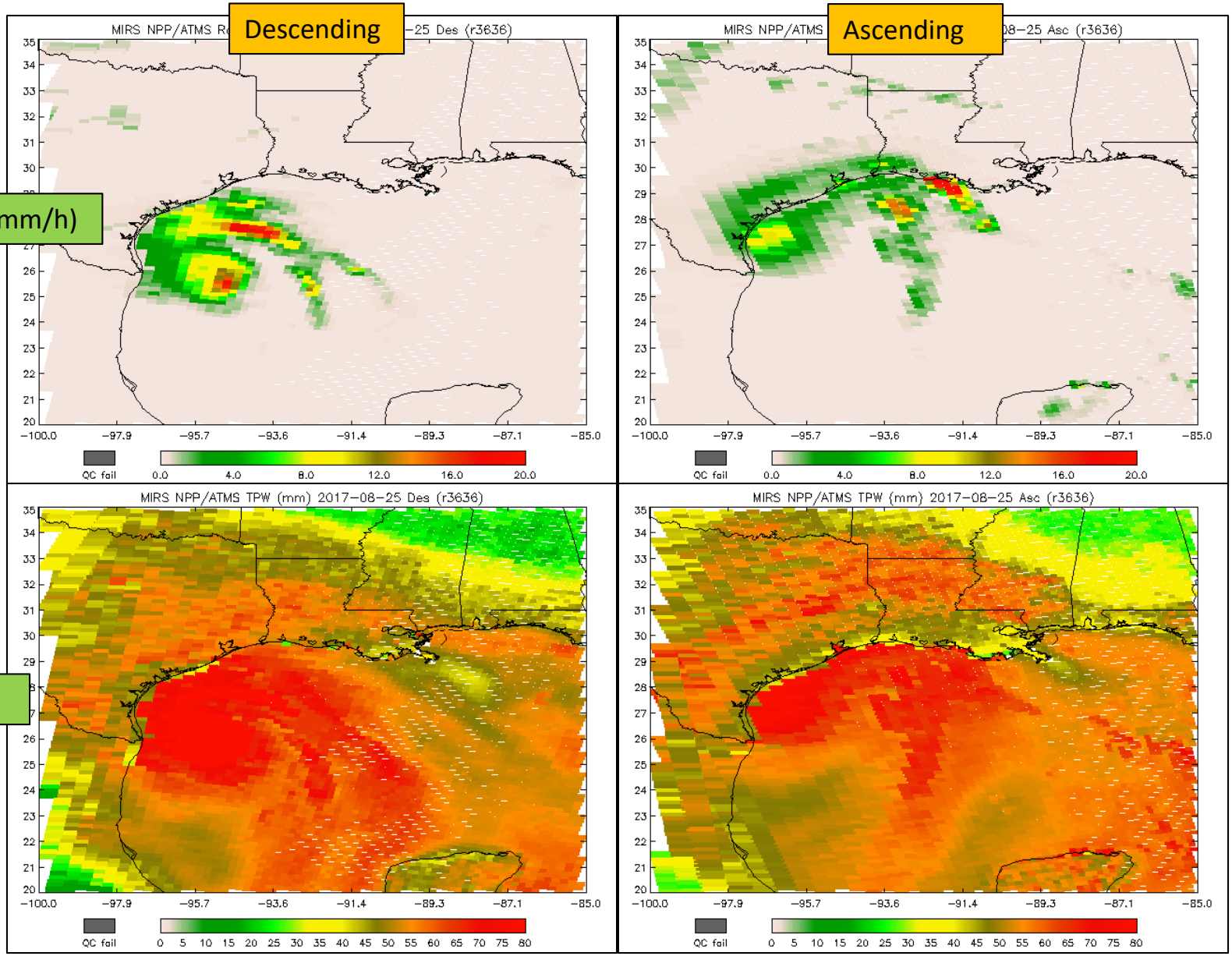
Hurricane Harvey:
MiRS ATMS Rain Rate and TPW, 25 August 2017

Descending

Ascending

Rain Rate (mm/h)

TPW (mm)



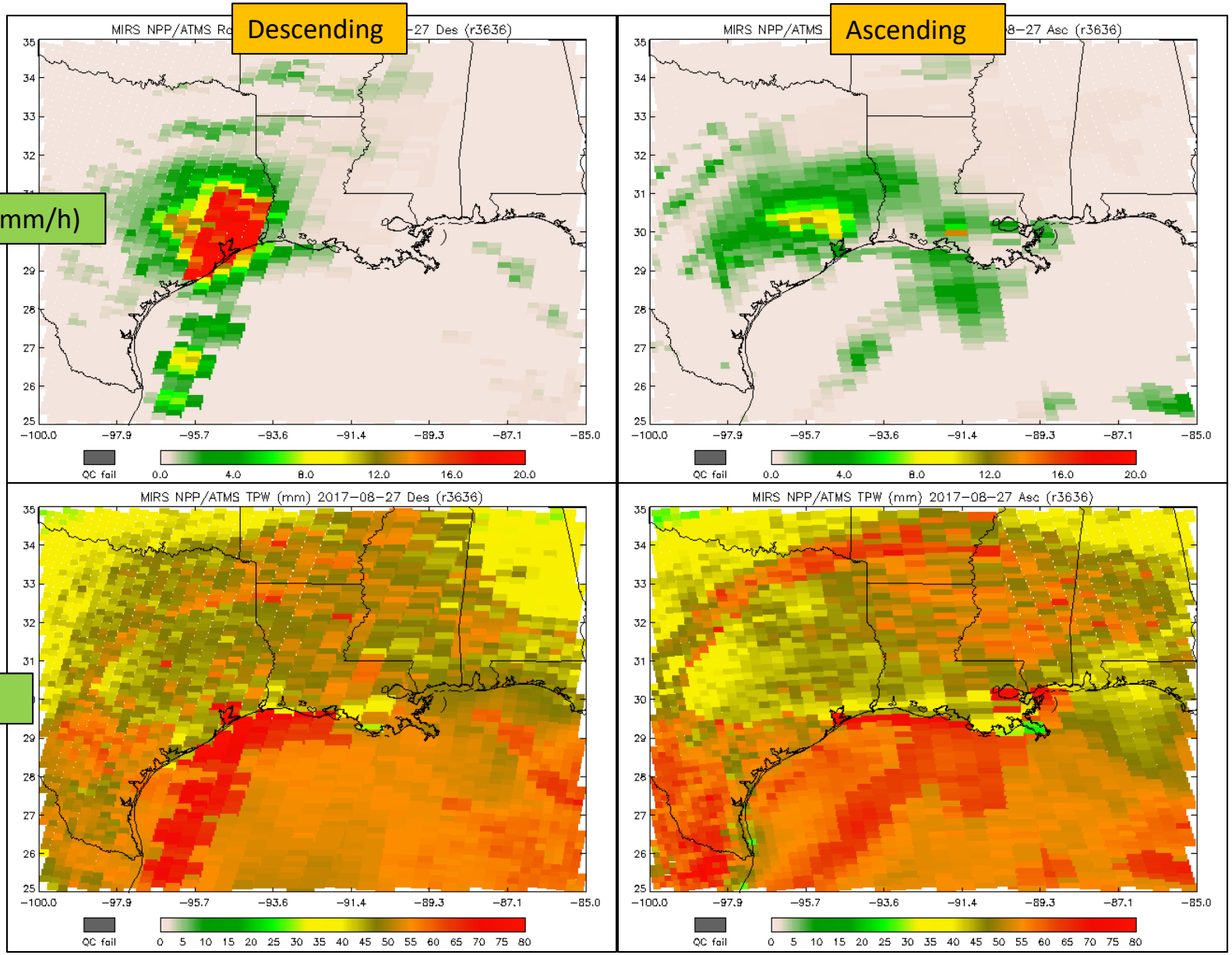
MiRS ATMS Rain Rate and TPW: 27 August 2017

Descending

Ascending

Rain Rate (mm/h)

TPW (mm)



ATMS SNOWFALL RATE

NOAA/NESDIS/STAR
University of Maryland/ESSIC/CICS
301-405-8799, huan.meng@noaa.gov
Huan Meng, Jun Dong, Cezar Kongoli, Ralph Ferraro

Outline

- Cal/Val Team Members (1 slide)
- Sensor/Algorithm Overview (1 slide)
- S-NPP/N-20 Product(s) Performance (1 slide)
- Major Risks/Issues and Mitigation (1 slide)
- Milestones and Deliverables (1 slide)
- Future Plans/Improvements (1 slide)
- Summary (1 slide)

Cal/Val Team Members

PI	Team Members	Organization	Roles and Responsibilities
Huan Meng		STAR	Develop project plan, manage project, develop algorithms, conduct cal/val, report progress
	Jun Dong	CICS-MD	Develop snowfall rate algorithm, conduct snowfall rate cal/val
	Cezar Kongoli	CICS-MD	Develop snowfall detection algorithm, conduct snowfall detection cal/val
	Ralph Ferraro	STAR	Provide overall supervision

Algorithm Overview

- The ATMS snowfall rate (SFR) algorithm consists of two components: snowfall detection and rate estimation
  - Snowfall detection (SD): statistical model trained using in-situ observations
  - Snowfall rate: 1DVAR-based physical model; calibrated with Stage IV radar and gauge combined precipitation analyses
- Channels used: 11 ATMS channels from 23.8 to 183±1 GHz, including window, temperature and water vapor sounding channels
- Data
  - Inputs: ATMS TDRs
  - Outputs: SFR, quality flag
  - Ancillary data: GFS

S-NPP/N-20 Product(s) Overview

- S-NPP SFR reaches provisional maturity; NOAA-20 SFR reaches beta maturity
- S-NPP SD Performance Summary (N20 SFR: visual comparisons with S-NPP)
  - Over CONUS

Metrics	L1RDS APU Thresholds	S-NPP Performance	N-20 Performance
Prob of Detection (%)	40 / 50 (obj)	51	
False Alarm Rate (%)	15 / 10 (obj)	8	

  - Over Alaska

Metrics	L1RDS APU Thresholds	S-NPP Performance	N-20 Performance
Prob of Detection (%)	40 / 50 (obj)	46	
False Alarm Rate (%)	15 / 10 (obj)	10	

- S-NPP SFR Performance Summary - CONUS

Metrics	L1RDS APU Thresholds	S-NPP Performance	N-20 Performance
Accuracy (mm/hr)	0.30 / 0.15 (obj)	0.06	
Precision (mm/hr)	1.00 / 0.70 (obj)	0.74	

Major Risks/Issues and Mitigation

- Provide updates for the status of the risks/actions identified

Risk/Issue	Description	Impact	Action/Mitigation
Complication with operational implementation	SFR is produced in MiRS. There might be potential complication caused by adding GFS ingestion to MiRS processing in NDE	Delayed MiRS DAP implementation	- Collaborations among NDE, MiRS team, and the algorithm developers to ensure the proper and timely implementation of the MiRS DAP (including SFR) - MiRS v11.3 has been successfully built, integrated, and tested in NDE Dev as of July 26, 2018 - MiRS v11.3 (including SFR) is scheduled for operational production in Sept/Oct 2018
Quality check flag	SFR quality check is not part of the MiRS quality flags	Quality uncertainty in application	Add SFR 1DVAR convergence status to MiRS quality flags in the next DAP scheduled for Dec 2018
Environmental impact on product quality	SD and SFR performance degrades with certain snowfall such as shallow cloud snowfall and snowfall along southern Alaska coastline	Quality degradation	Conduct focused study on these types of snowfall in the future

Milestones and Deliverables

- FY19 Milestones/Deliverables

Task	Description	Deliverables	Scheduled Date
Maturity	N20 SFR reaches provisional maturity; N20 MiRS/SFR ARR	Sept 2018	Sept 2018
Development	- Train N20 snowfall detection model - Update radiometric bias correction coefficients for N20 SFR	Aug 2018	Aug 2018
Integration & Testing	- Support MiRS N20 SFR integration/testing - Support NDE with N20 SFR implementation	Mar 2019	Mar 2019
Calibration & Validation	- N20 SD and SFR calibration and validation against in-situ, Stage IV, and MRMS data - S-NPP SD and SFR stratified validation	Jul 2019	Jul 2019

Future Plans/Improvements

- Algorithm Improvements
  - Advanced calibration (FY19~20)
  - Improved cloud microphysics (FY20~21)
- J2 and Beyond
  - Algorithm preparation (FY21)
  - Algorithm optimization (FY22)
- Reprocessing Plans/Status
  - SNPP SFR reprocessing (FY20)
  - N20 SFR reprocessing (FY21)
- Long Term Monitoring/Website links
  - ESPC web-based MiRS monitoring will be updated to include SFR
  - CICS: http://cics.umd.edu/sfr/index.php

User Feedback & Summary

- Summary
  - S-NPP ATMS SFR has reached provisional maturity
  - N20 ATMS SFR has reached beta maturity
  - ATMS SFR has been integrated in MiRS v11.3
  - MiRS v11.3 was successfully built, integrated, and tested in NDE Dev; scheduled for operational production in Sept/Oct 2018
  - N20 SFR will reach provisional maturity in FY19
- User Feedback
  - From NCEP CMORPH: The SFR product significantly enhances winter precipitation estimates and substantially expands the utilities of CMORPH2 (global blended precipitation analysis)
  - From assessment at NWS WFOs: The SFR product is useful in weather forecasting and improving forecasters situational awareness, especially in filling radar gaps

STAR GCOM-W1/AMSR2 PROJECT UPDATE AND STATUS

STAR GCOM-W1 Project Team
Presented by Paul Chang

Paul Chang, Zorana Jelenak, Ralph Ferraro, Suleiman Alsweiss, Joe Sapp, Patrick Meyers, Qi Zhu, Xiwu Zhan, Jicheng Liu, Eileen Maturi, Andy Harris, Jeff Key, Cezar Kongoli, Walt Meier, Yong-Keun Lee, Walter Wolf, Tom King, Letitia Soullaird, Peter Keehn, Mike Wilson …

STAR – GCOM-W1 AMSR2 ALGORITHM SOFTWARE PROCESSOR (GAASP)

Major Updates

- Converted Ocean and Precipitation algorithms to use CMC SST ancillary data files instead of Reynolds SST
- Updated Precipitation algorithm
  - TMI correction
  - Snow Flagging – new dynamic ancillary data file
  - Climatology Flagging
  - Clouds Screening Procedure
- Updated Ocean algorithm
  - Sea Surface Winds

DAP Deliveries

- GAASP_v2-4_20180117.tar.gz
  - Uses CMC SST instead of Reynolds SST
  - NDE on January 17, 2018
  - CSPP on January 17, 2018

Reprocessing and local NRT processing

- Rerun missing NRT data for STAR data repository
- Rerun data with new wind processor for Ocean algorithm development support
- Troubleshoot and Updated STAR local NRT processing scripts to be more robust with missing data
- Ran tests on the impacts of the new GFS FV3 ancillary data on the GCOM products

Future Plans

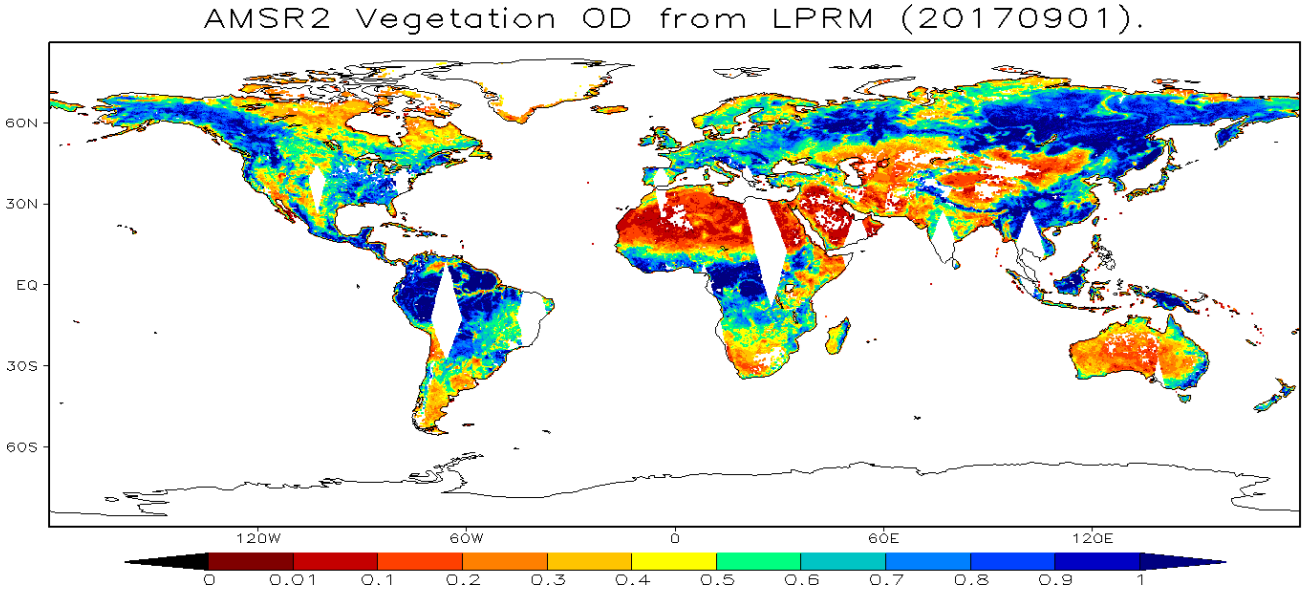
- Validate Ocean and Precipitation Updates
- Deliver Ocean and Precipitation Updates to NDE and CSPP
  - Also includes a minor update to netCDF metadata (production_site and production_environment added)
- Full GCOM life cycle local reprocessing with most up-to-date algorithms.

Land Products Update

JPSS GCOM-W1/AMSR2 Soil Moisture

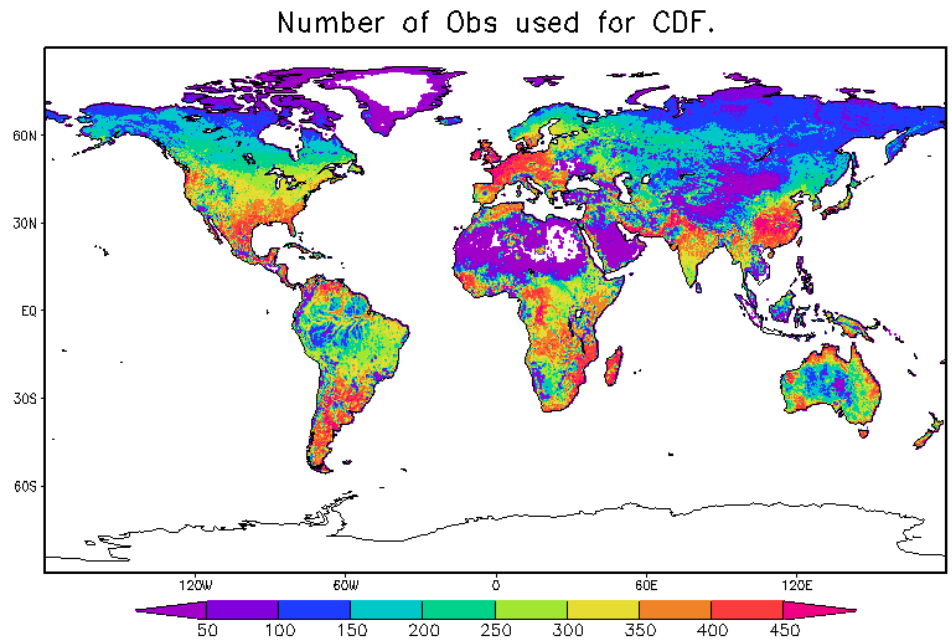
Algorithm and Refinement:

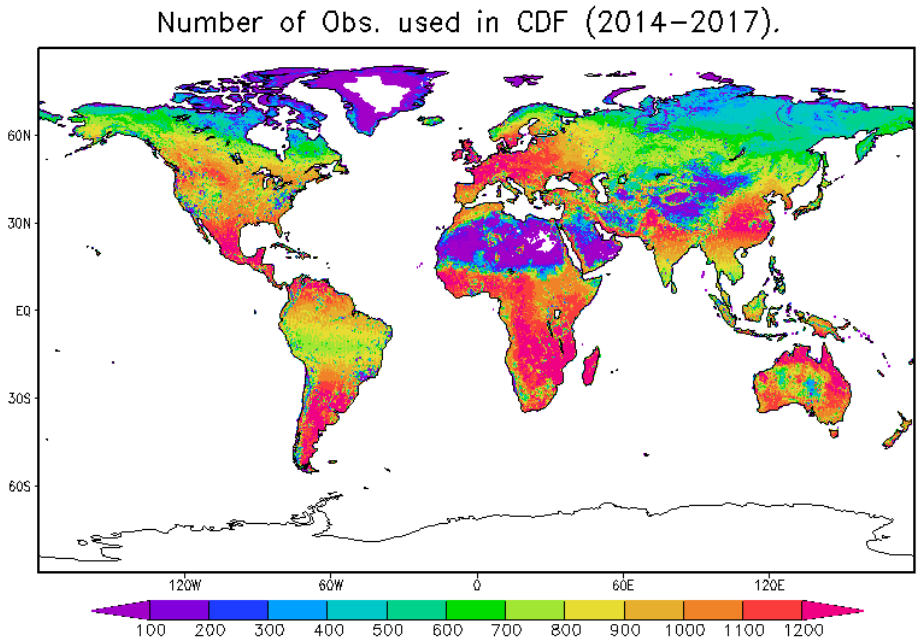
- The LPRM algorithm was used to retrieve Vegetation Optical Depth (VOD) from TBv and TBh
- Derive VOD climatology for Single Channel Algorithm (SCA) of soil moisture retrieval with historical AMSR2 data
- Inverse soil moisture from TBh using the VOD scaled to VOD climatology with CDF matching
- **Improved temporal dynamics and spatial coverage with improved LPRM vegetation Optical Depth retrieval algorithm (below) .**
- **Improved spatial coverage with longer period of historical data for generating Cumulative Distribution Function (CDF) data base.**
- **Validation with global in situ measurement data and other products are ongoing.**



JPSS GCOM-W1/AMSR2 Soil Moisture

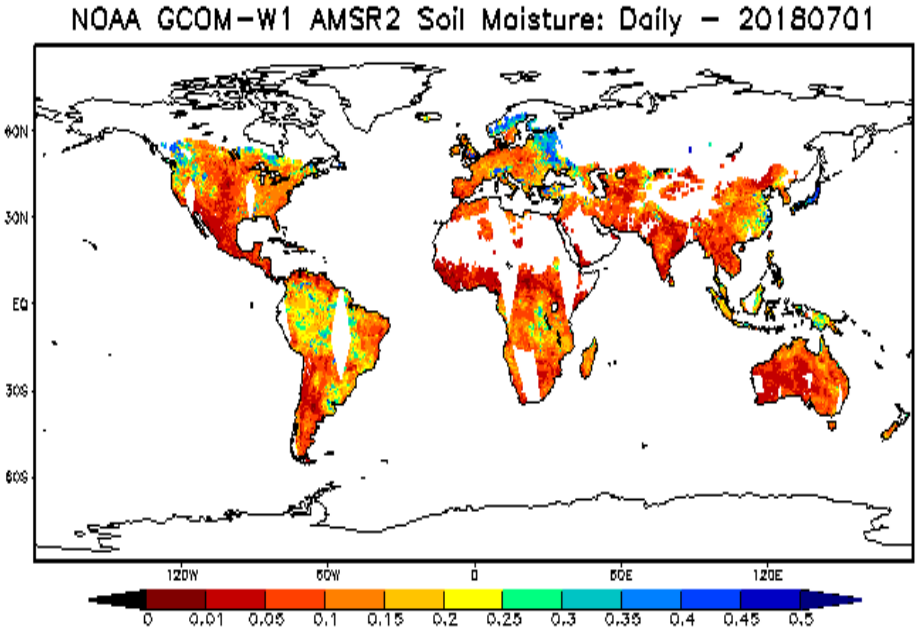
More reliable CDF with more historical AMSR2 data

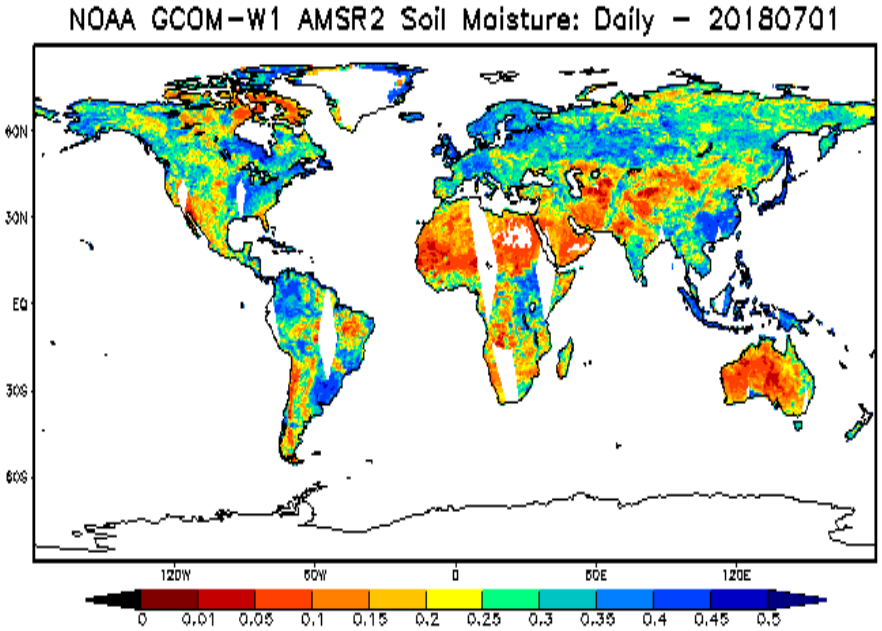




JPSS GCOM-W1/AMSR2 Soil Moisture

Better spatial coverage and the dynamic range of the final product.

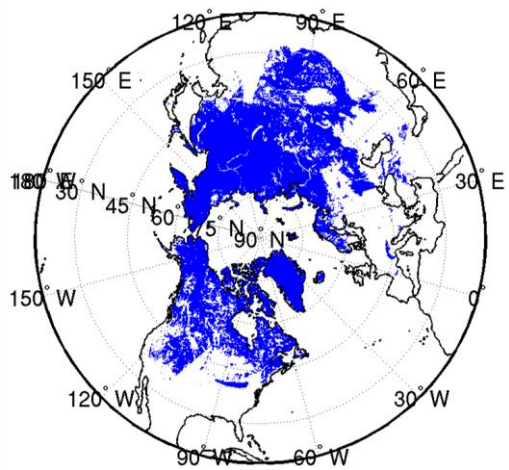




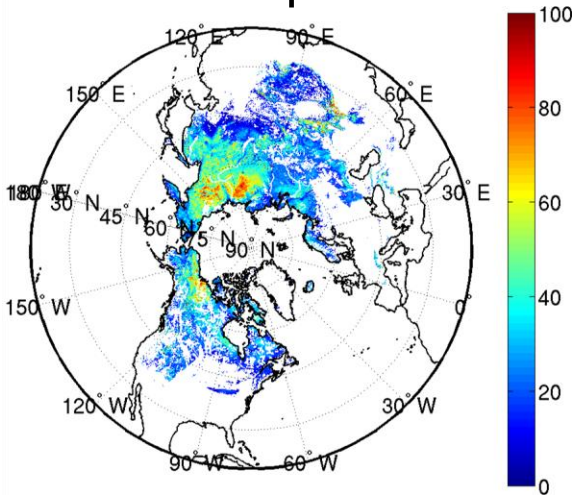
Snow Products Update

AMSR2 Snow and Ice Products

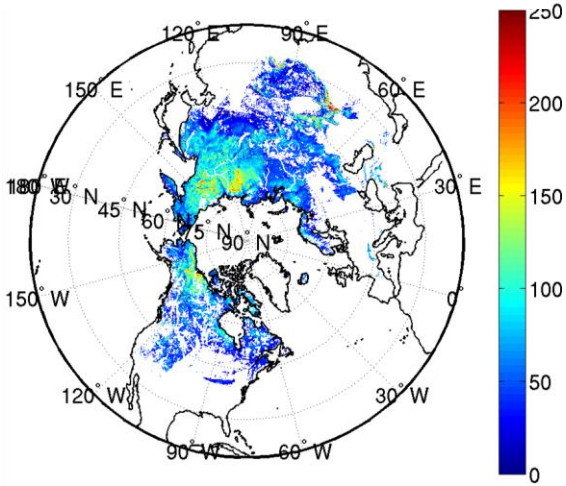
Snow Cover



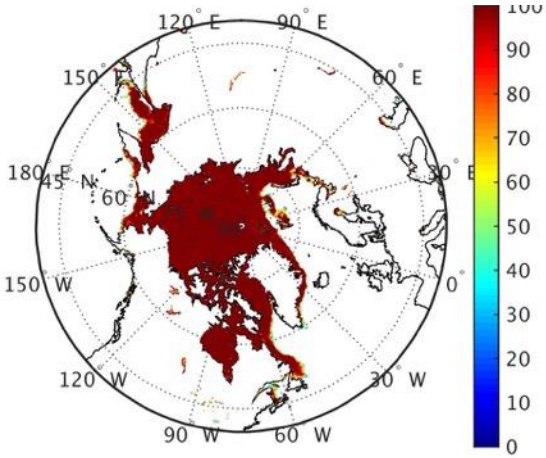
Snow Depth



Snow Water Equivalent

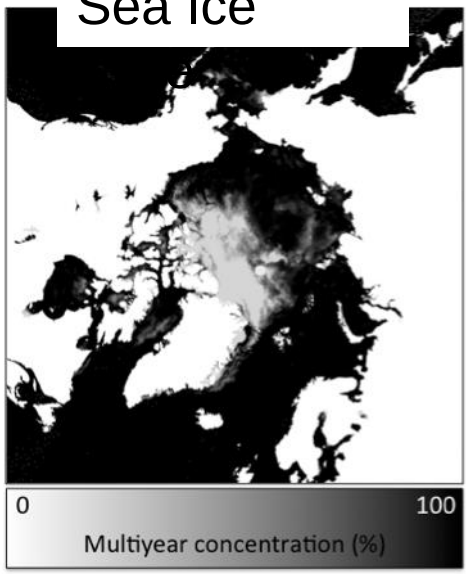


Sea Ice Concentration



Status: Operational, nominal, products meet requirements

Sea Ice



Product Performance – AMSR2

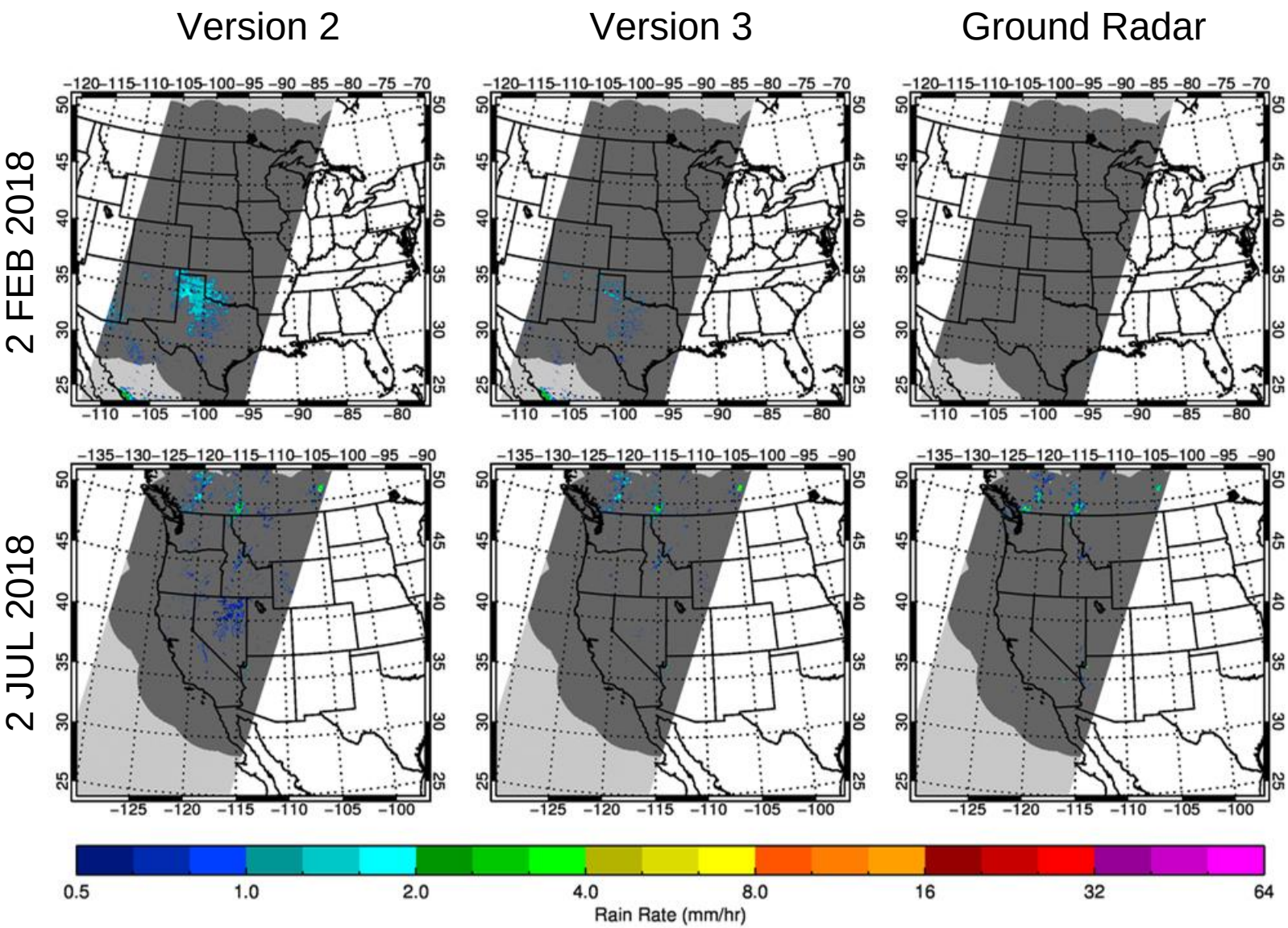
Product	L1RDS APU Thresholds	Performance	Meets Spec?
Snow cover (binary)	80% correct typing	72-97%	Y
Snow depth	20 cm uncertainty	15-22 cm	Y (marginal)
SWE	50-70% uncertainty (shallow to thick snowpacks)	~20-22%	Y
Ice concentration	10% uncertainty	3.9% NH; 4.4% SH	Y
Ice type	70% correct typing	80-90%, Arctic winter	Y

Precipitation Products Update

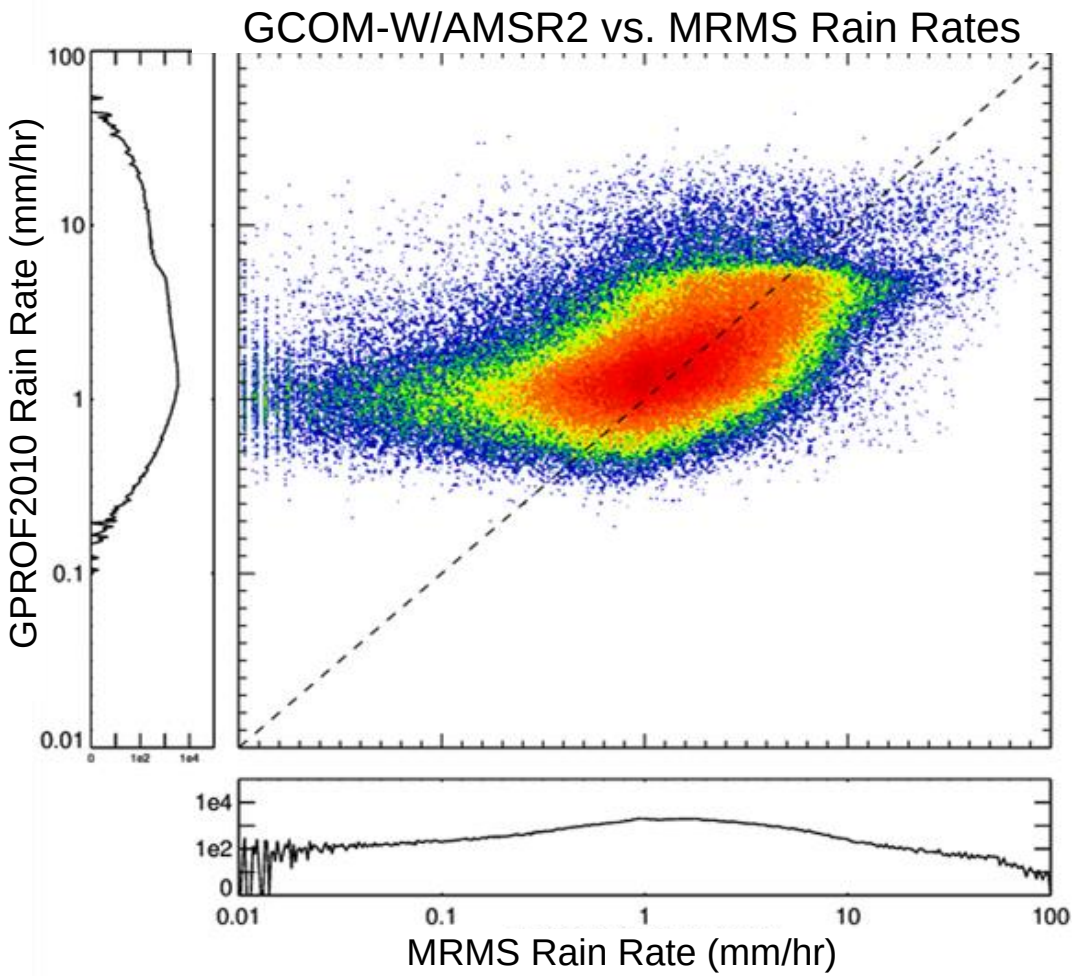
Precipitation Improvements
GPROF2010 – Version 3

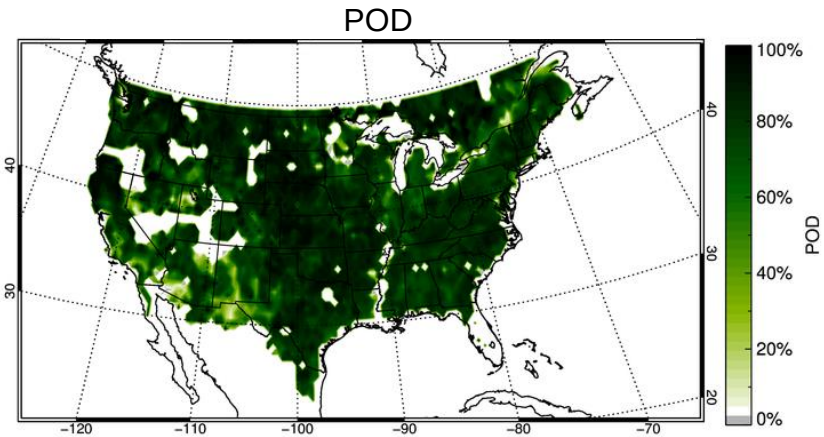
- Eliminates automatic flagging in climatological snowy areas
  - Use daily NOAA AutoSnow analysis for screening
- Applies no-cloud test to reduce false alarms
- Updated Tb-Rain Rate relationship
- Improved quality flags
  - Provide more valid retrievals (i.e. over snow)
- RMSE and rain detection improved by 10%

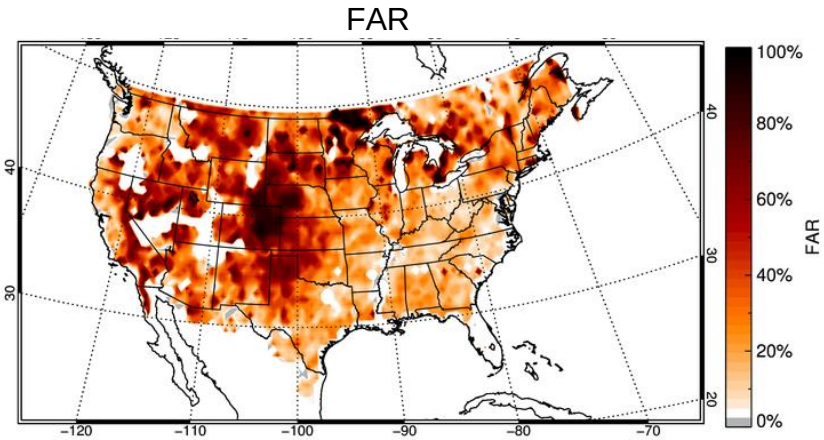
Screening Comparison



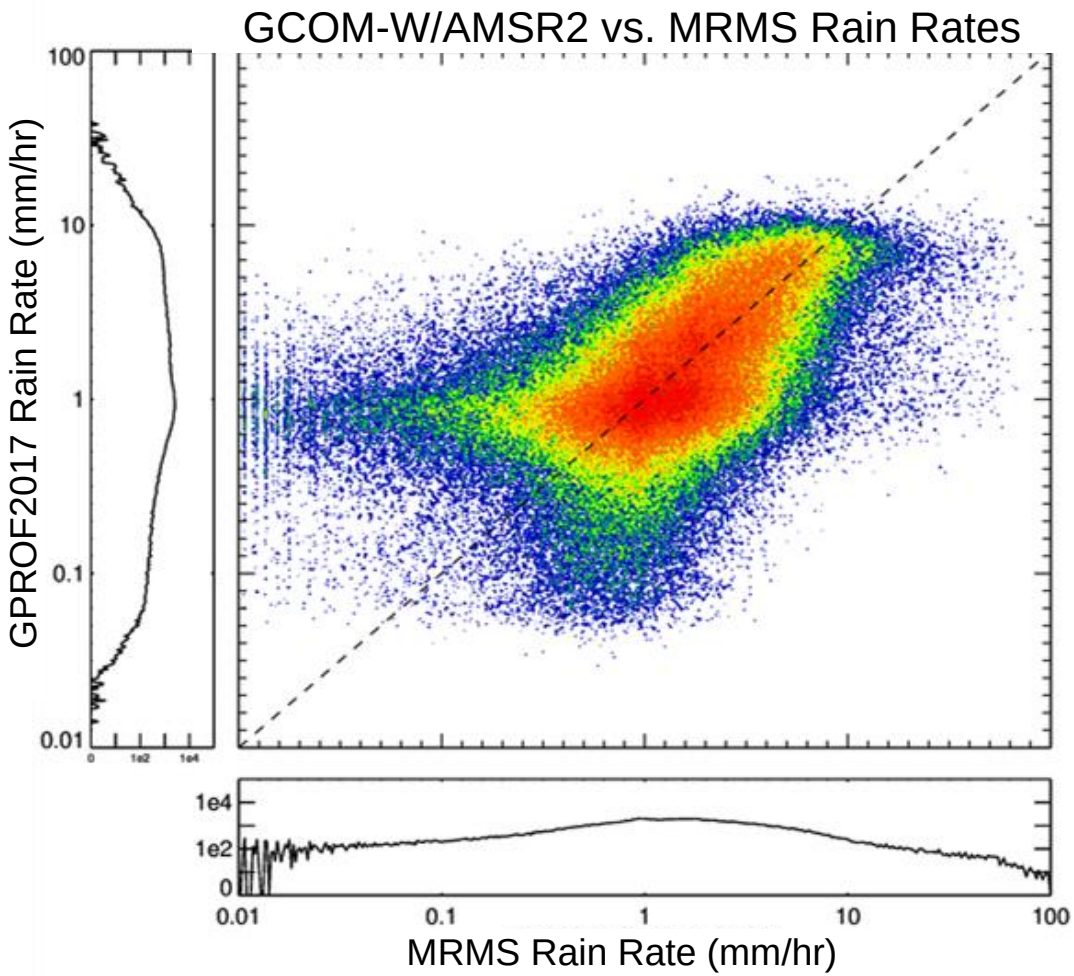
GPROF2010V3

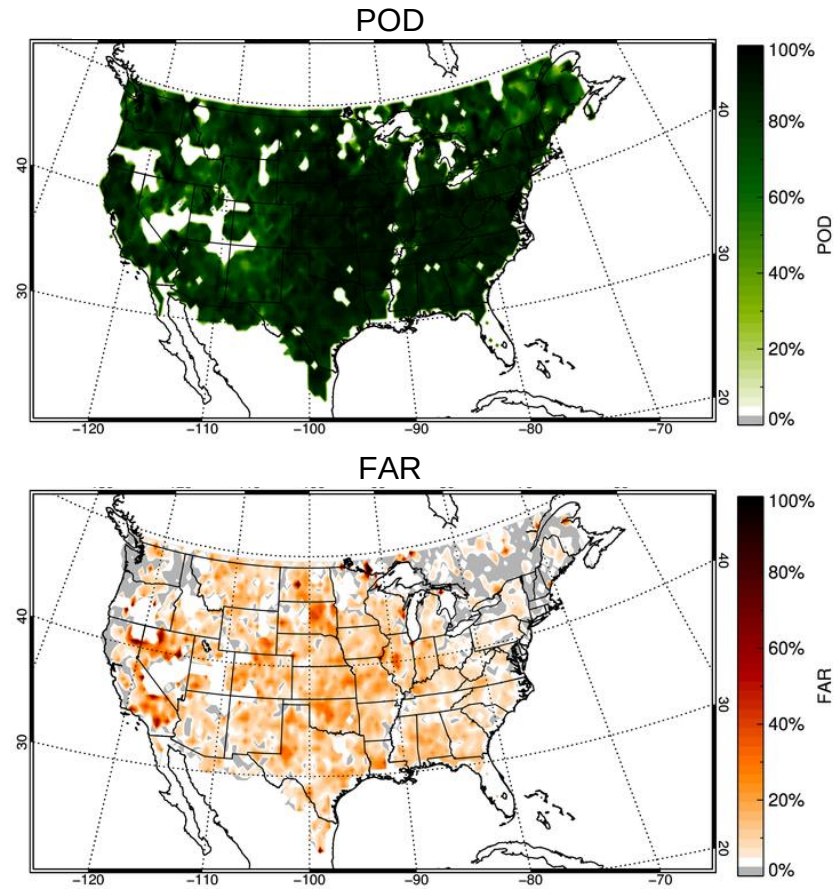






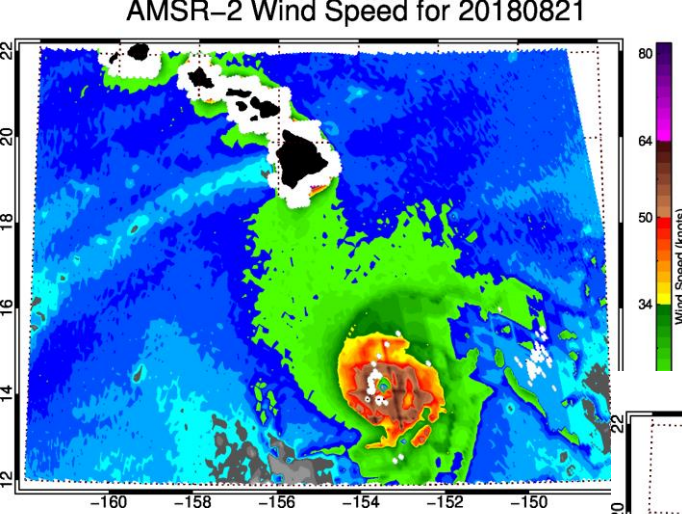
GPROF2017


GCOM-W/AMSR2 vs. MRMS Rain Rates
GPROF2017 Rain Rate (mm/hr)
MRMS Rain Rate (mm/hr)
100
10
1
0.1
0.01
1e4
1e2
0
0.01
0.1
1
10
100

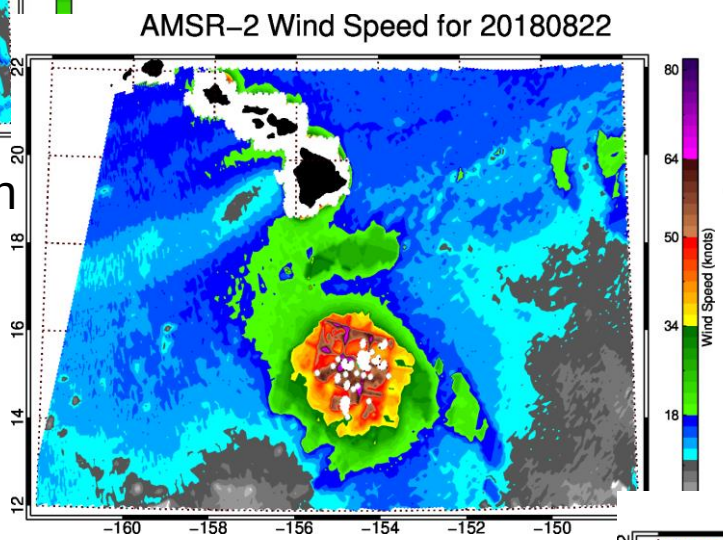

POD
FAR
100%
80%
60%
40%
20%
0%
POD
FAR
−120
−110
−100
−90
−80
−70
40
30
20

Ocean Products Update

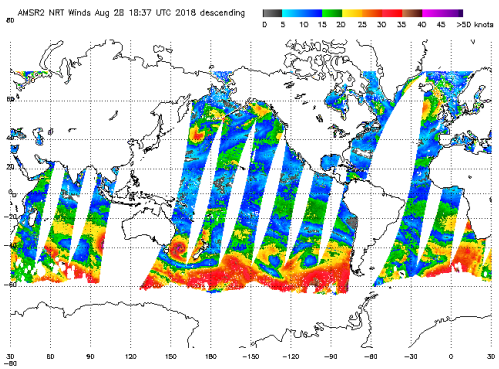
New Wind Speed Product

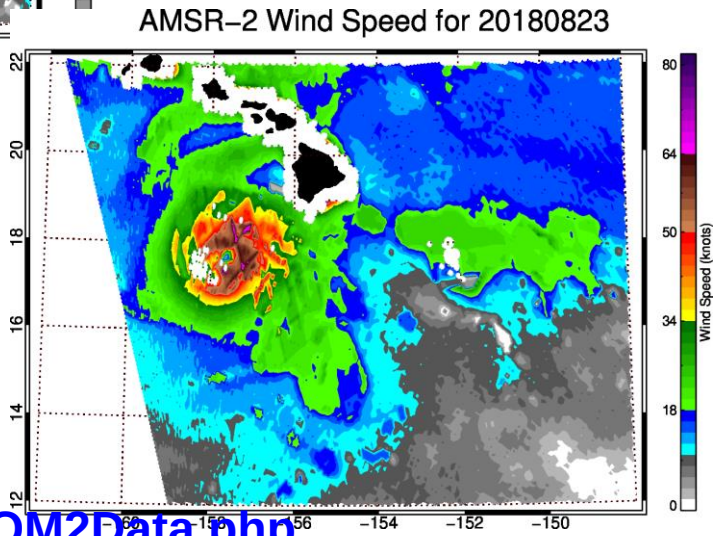


- New wind processor presented during last year JPSS Annual Science meeting has been transitioned from research to operational code



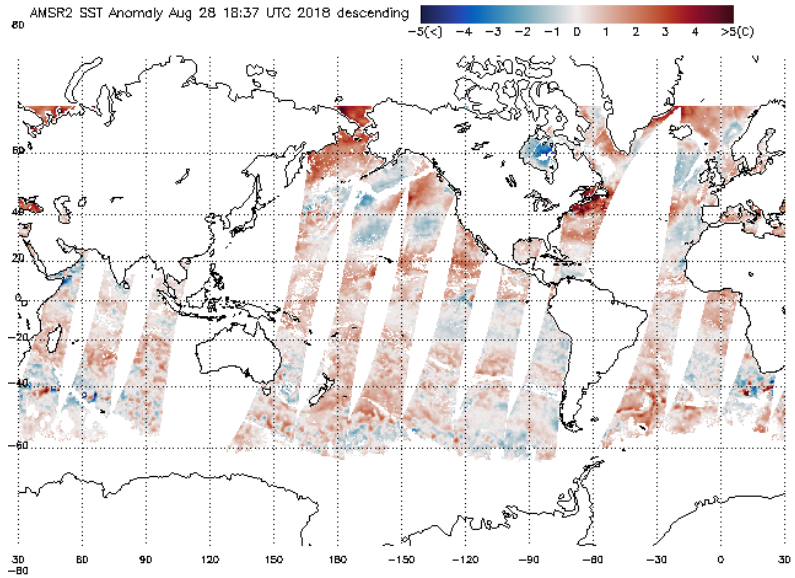
- Comprehensive validation analysis completed
  - Major improvements of high wind retrievals in rain and cloudy areas
  - Results to be published in a paper in J-STARS
  - New product has been publically available on the STAR GCOM web page (manati) since August 2018
  - Reprocessing of previous data in process

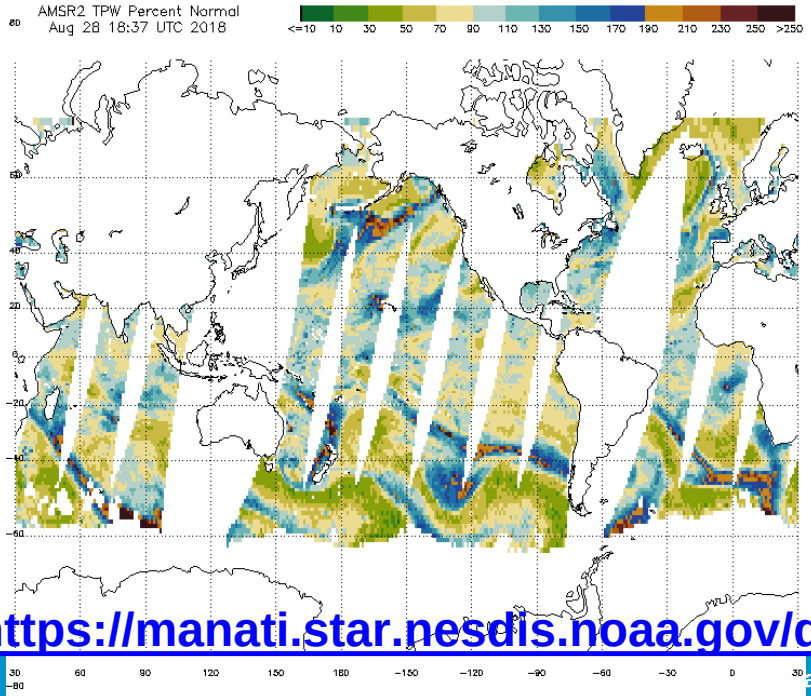




https://manati.star.nesdis.noaa.gov/datasets//GCOM2Data.php

New Products



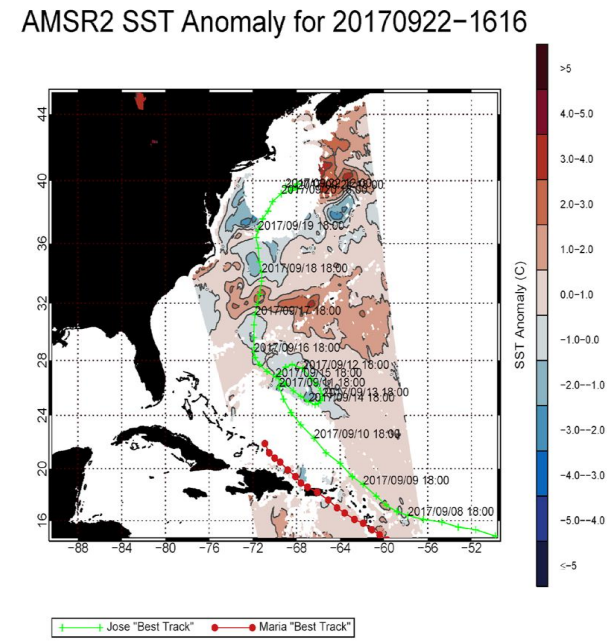


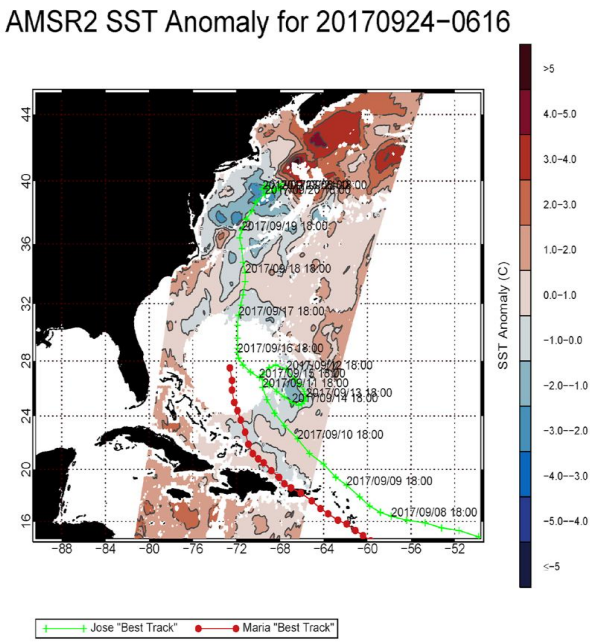
- **SST anomaly**
  - Calculated using the climatology from Banzon et al. (2014), available from NCEI
- **TPW anomaly – defined as TPW Percent Normal**
  - Calculated using NVAP-M daily level-3 dataset, which spans 1988 to 2009

https://manati.star.nesdis.noaa.gov/datasets//GCOM2Data.php

Hurricane Jose and Maria Sep, 2017
High Wind and SST Anomaly Example

Jose on Sep, 22nd 2017





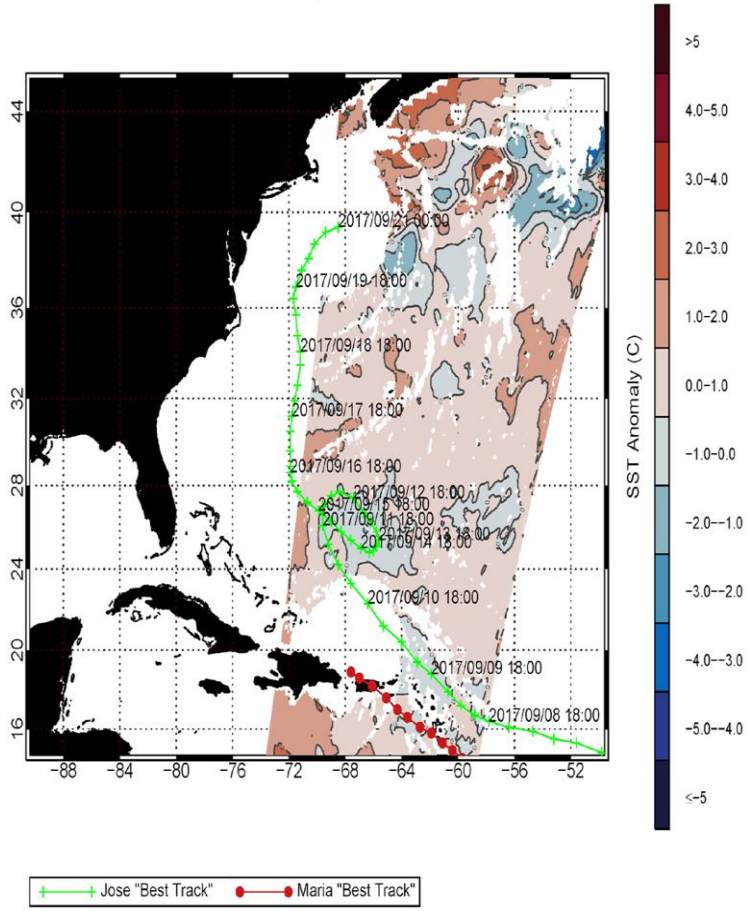

```
ZCZC MIATCDAT5 ALL
TTAA00 KNHC DDHHMM

Hurricane Maria Discussion Number  34
NWS National Hurricane Center Miami FL
AL152017
1100 AM EDT Sun Sep 24 2017

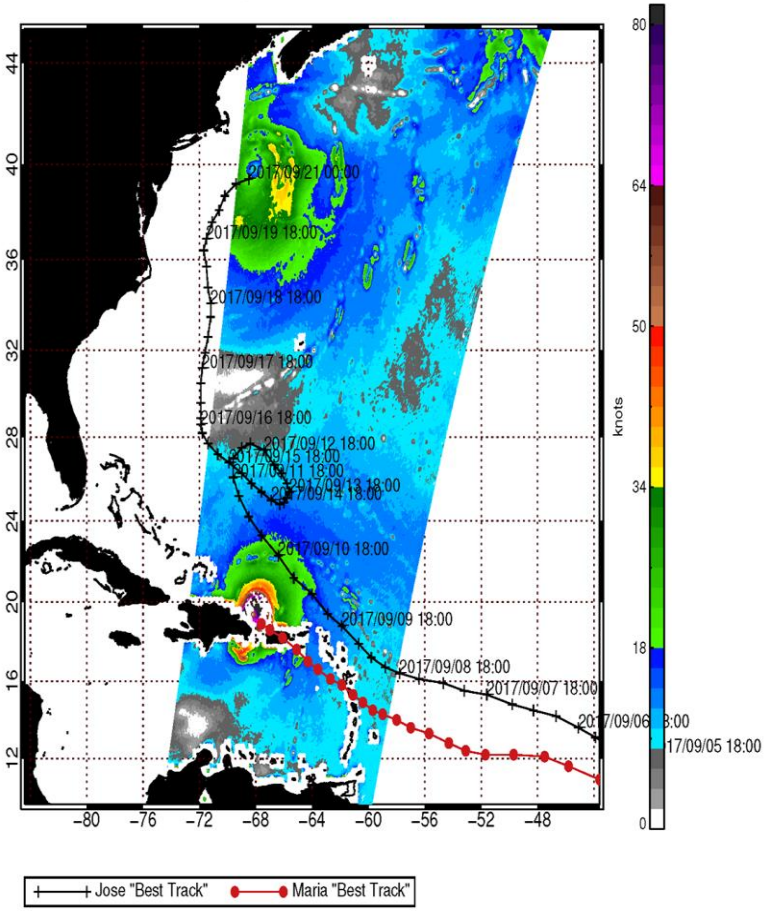
…

Some fluctuations in intensity could still occur
during the next day or so while Maria moves over
warm water and remains in a low shear environment.
Later in the forecast period, cooler waters from the
wake of Hurricane Jose that traversed the same area
last week will likely cause a gradual decrease in
intensity.
```

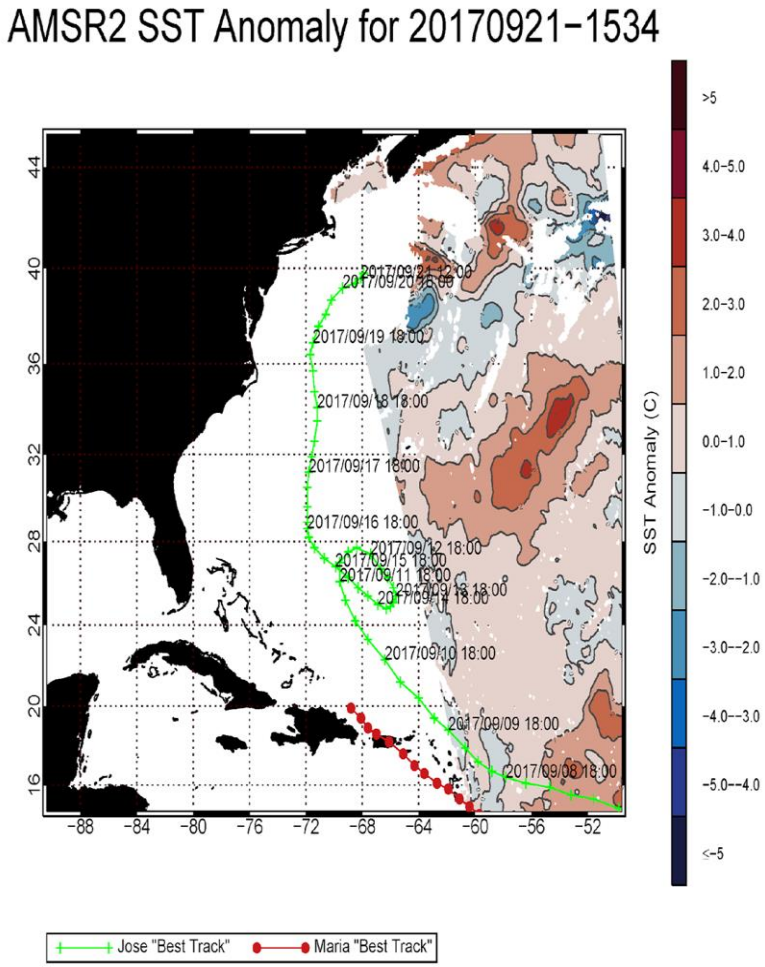
AMSR2 SST Anomaly for 20170921-0546

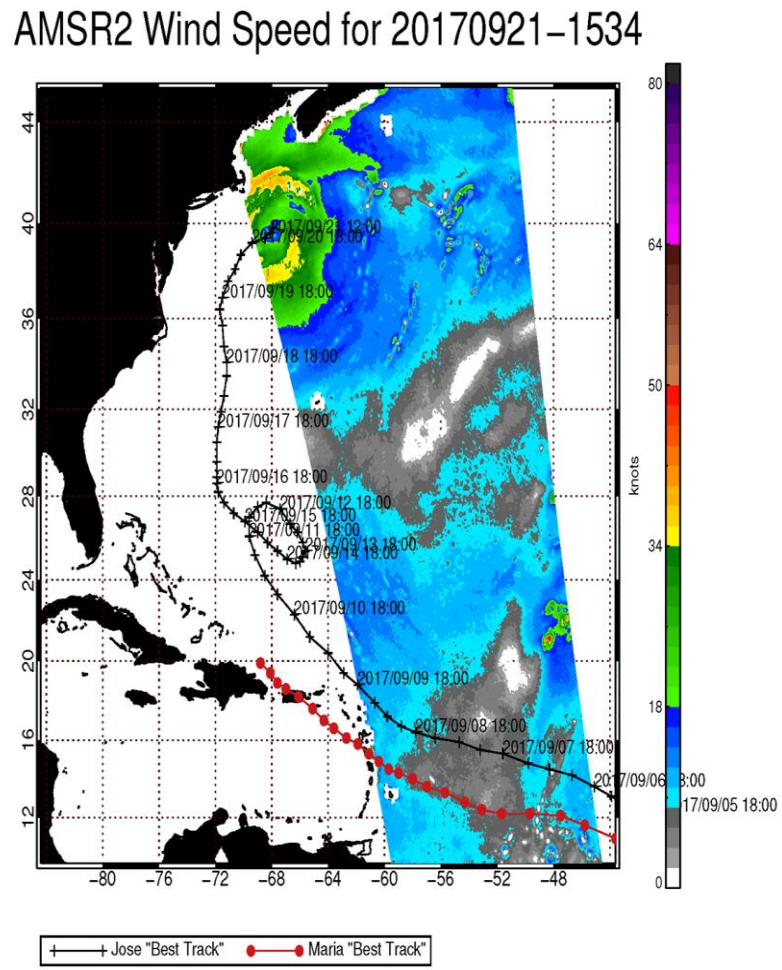


AMSR2 Wind Speed for 20170921-0546



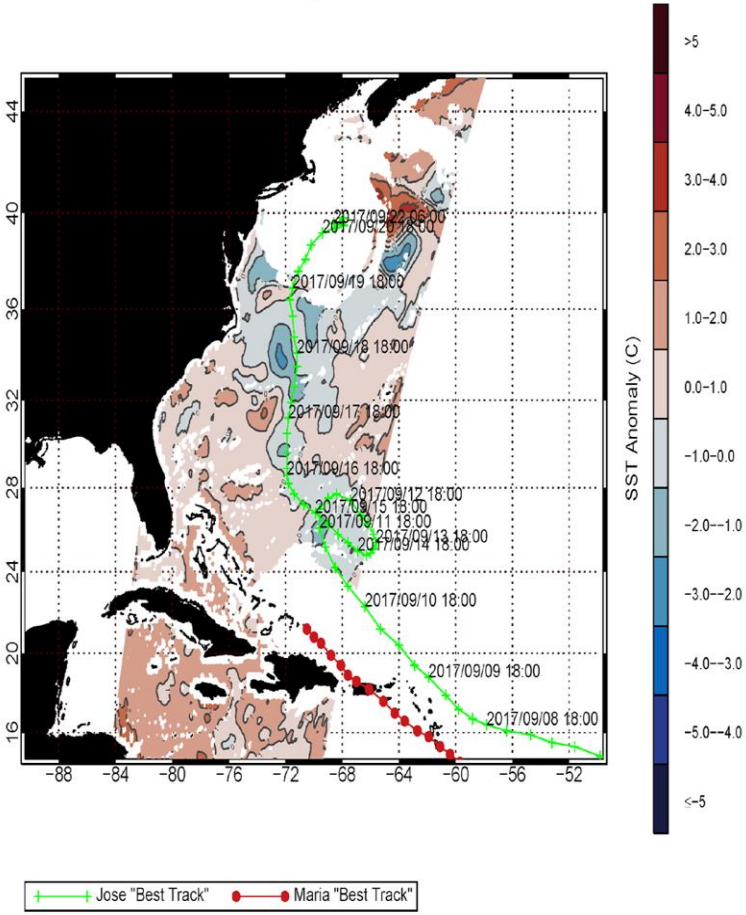
Max sustained winds 115mph



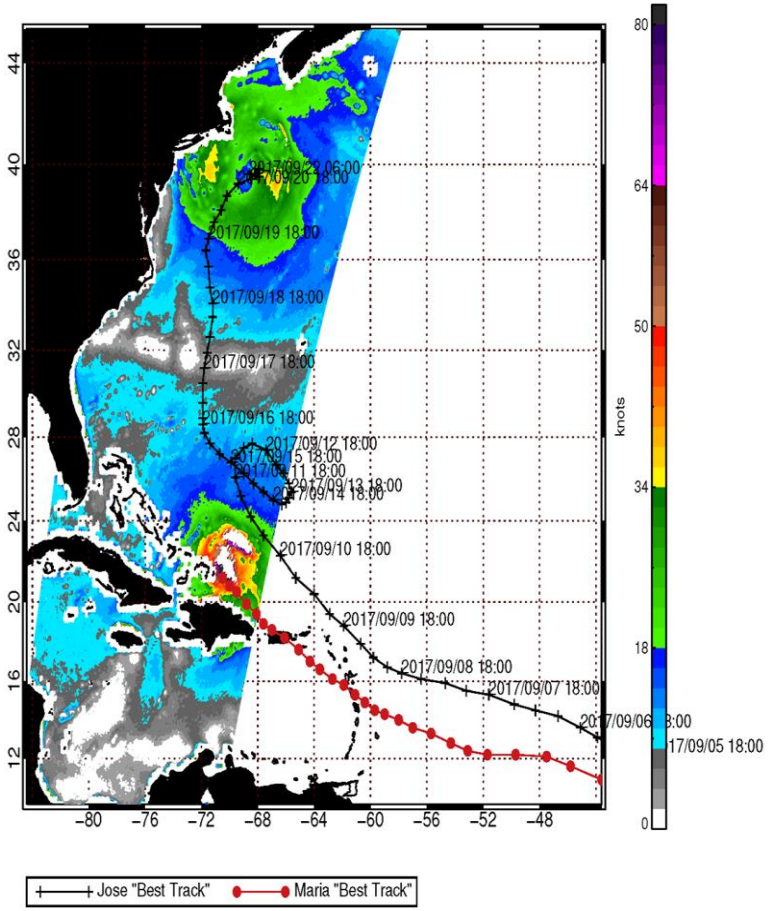


Max sustained winds 120mph

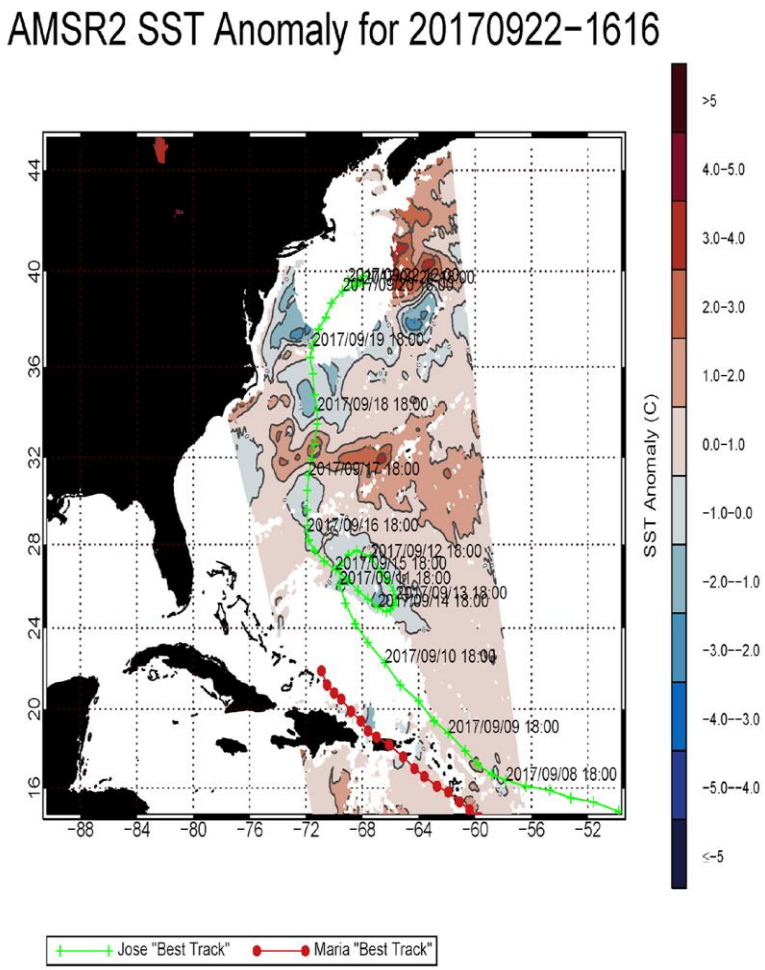
AMSR2 SST Anomaly for 20170922-0628

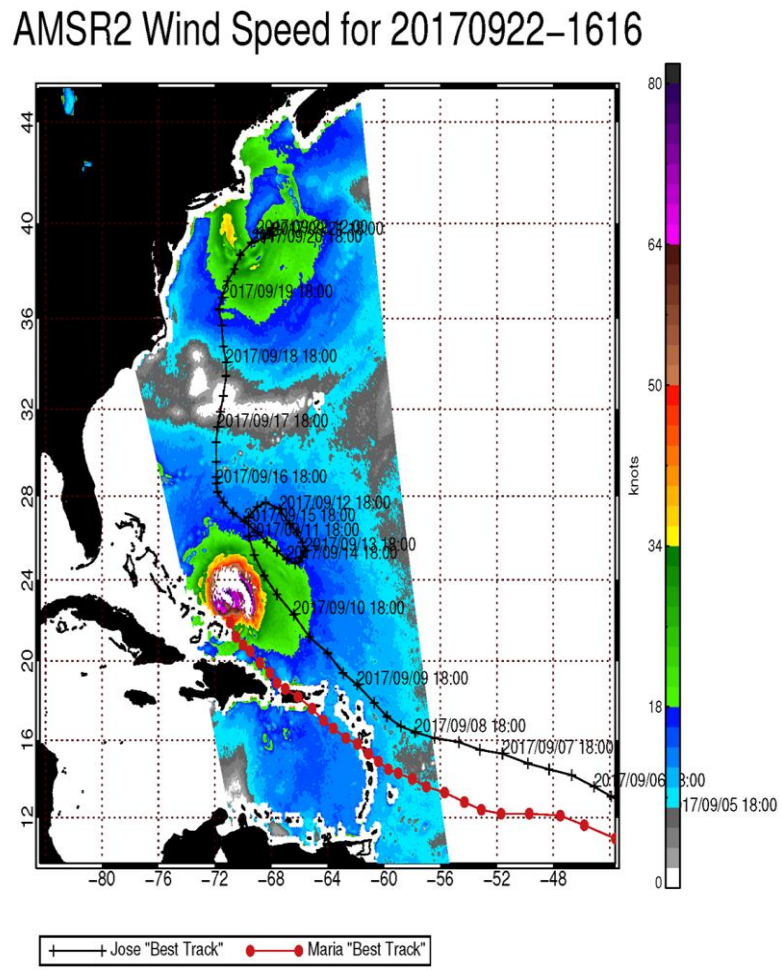


AMSR2 Wind Speed for 20170922-0628



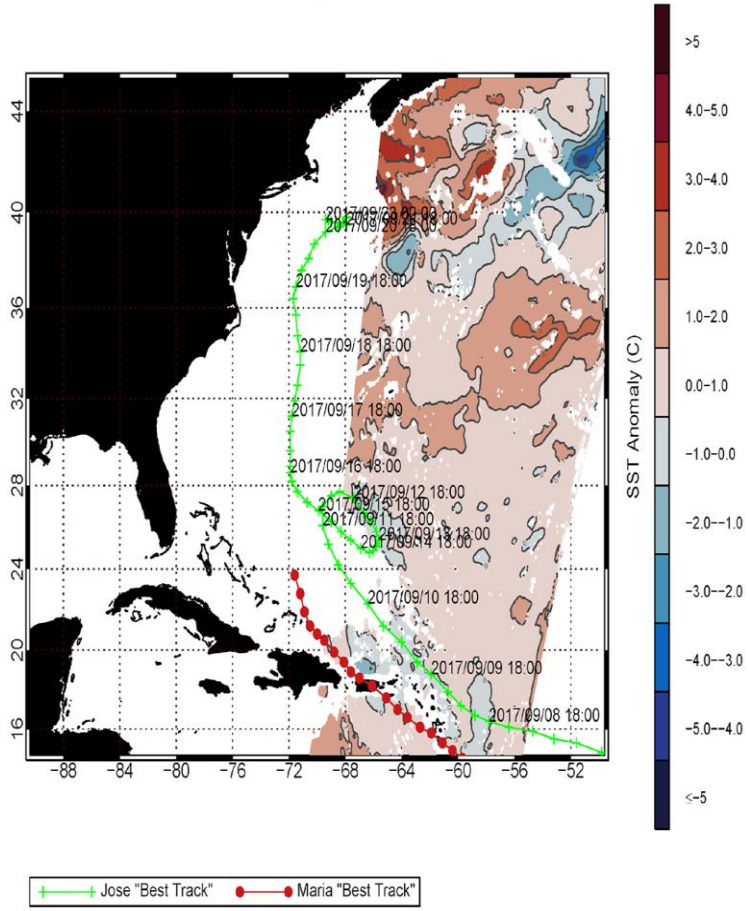
Max sustained winds 125mph



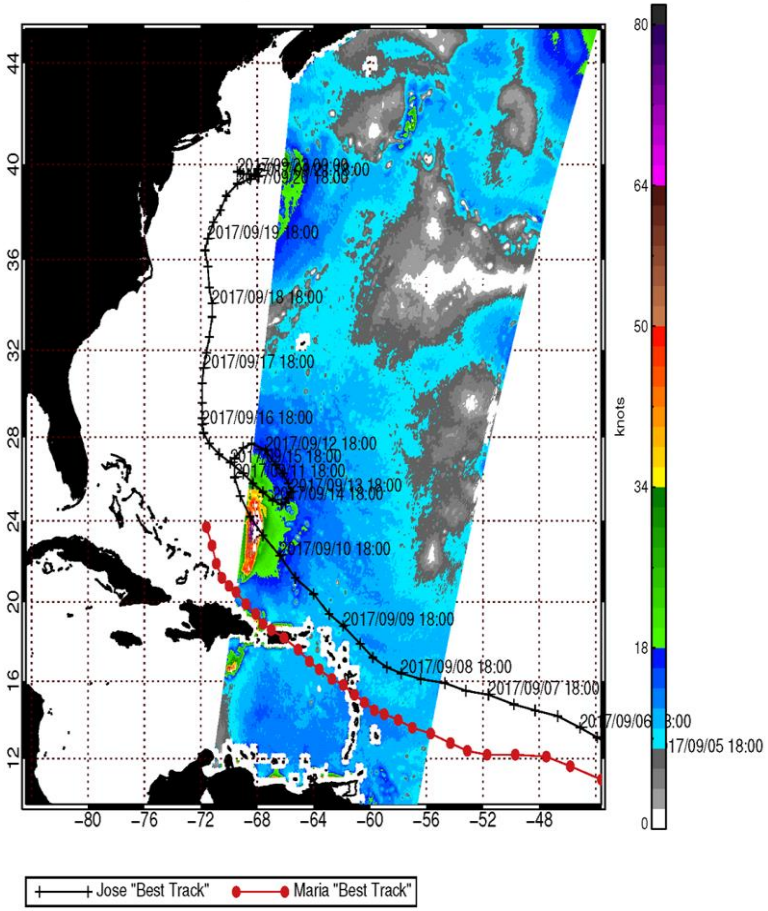


Max sustained winds 125mph

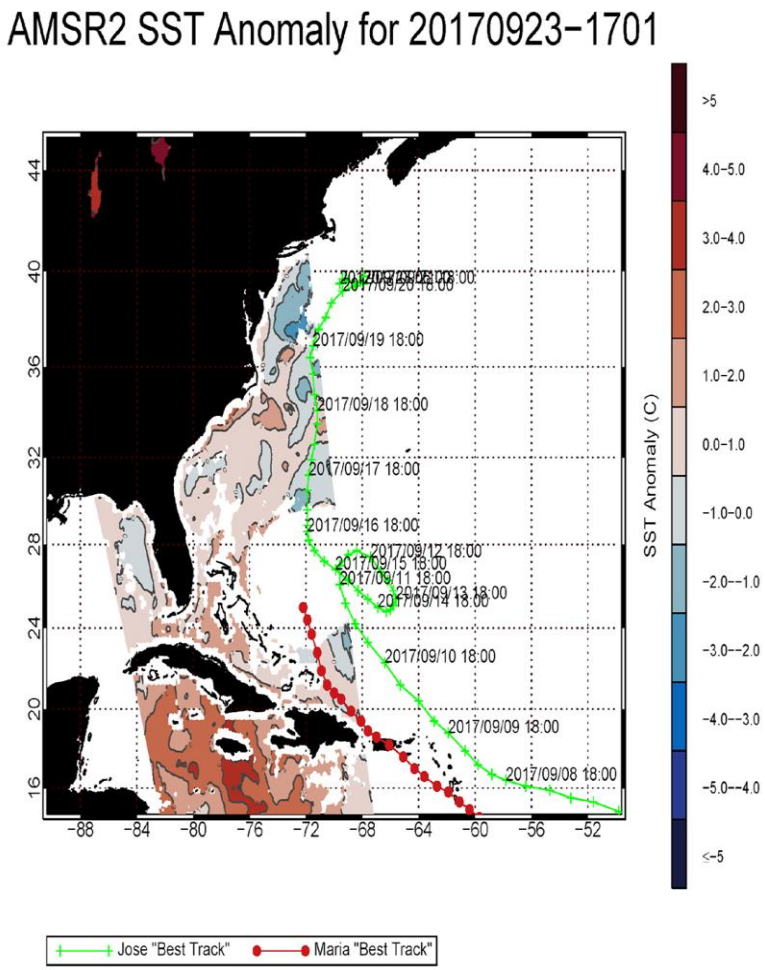
AMSR2 SST Anomaly for 20170923-0534

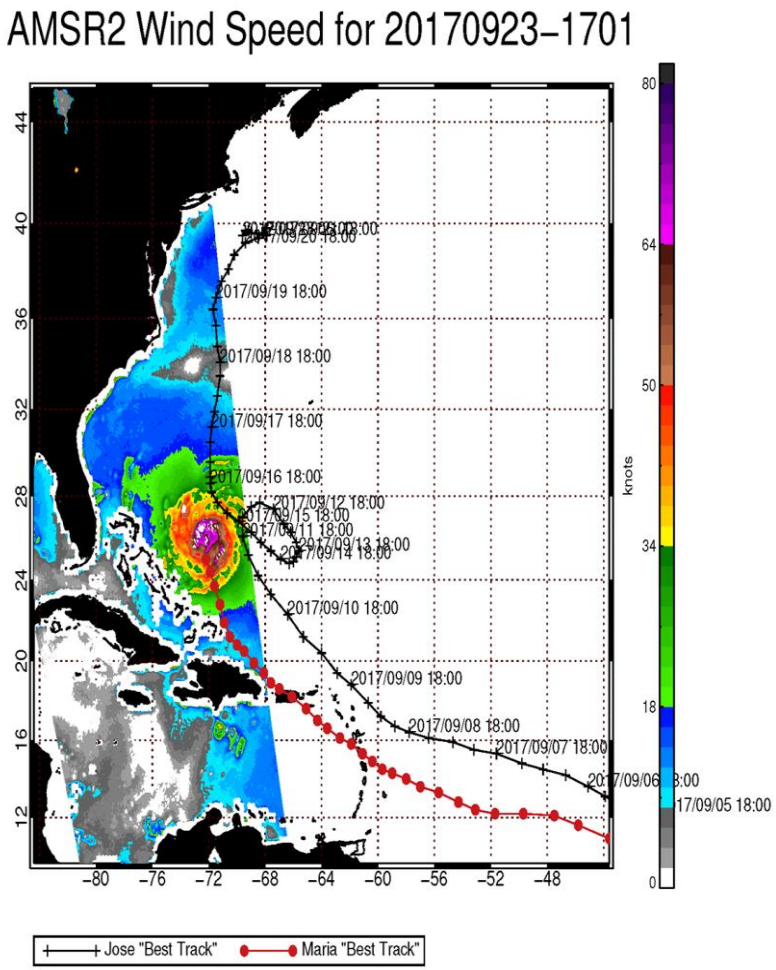


AMSR2 Wind Speed for 20170923-0534



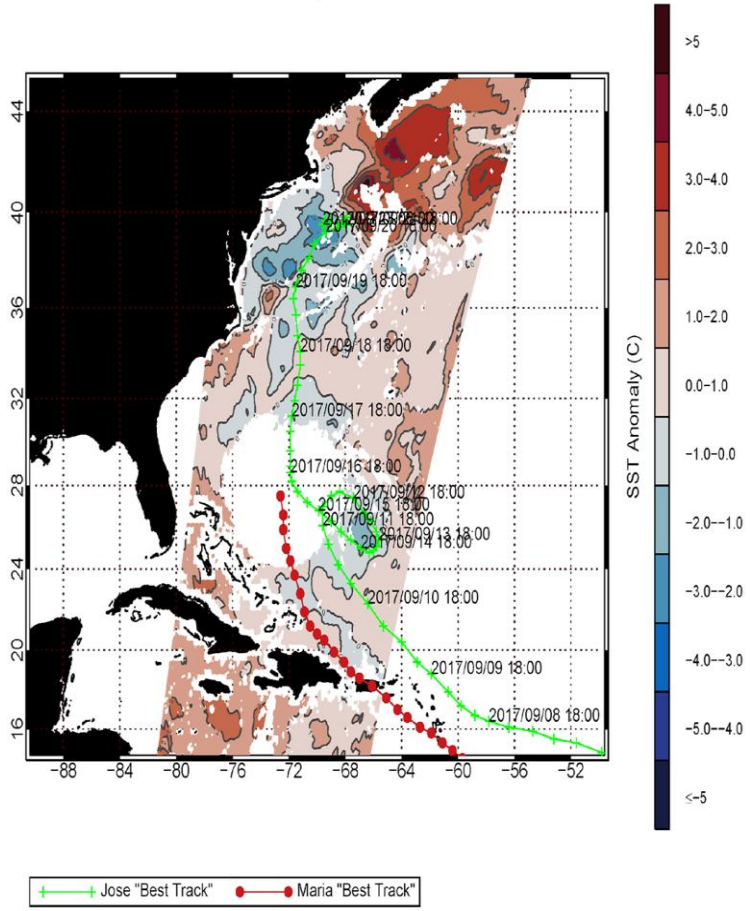
Max sustained winds 120mph



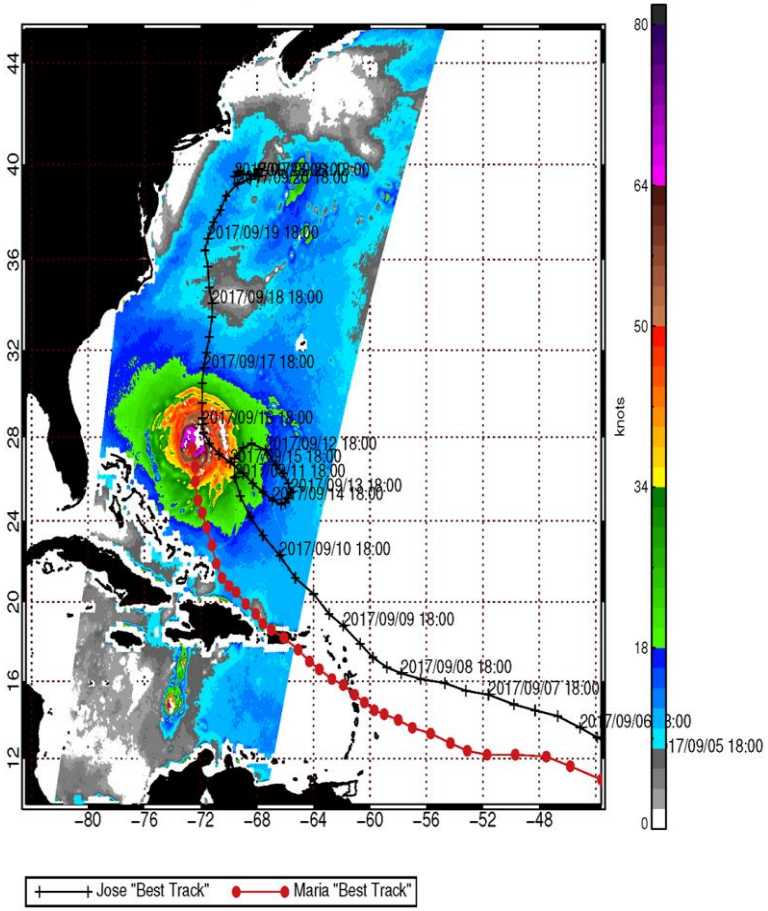


Max sustained winds 115mph

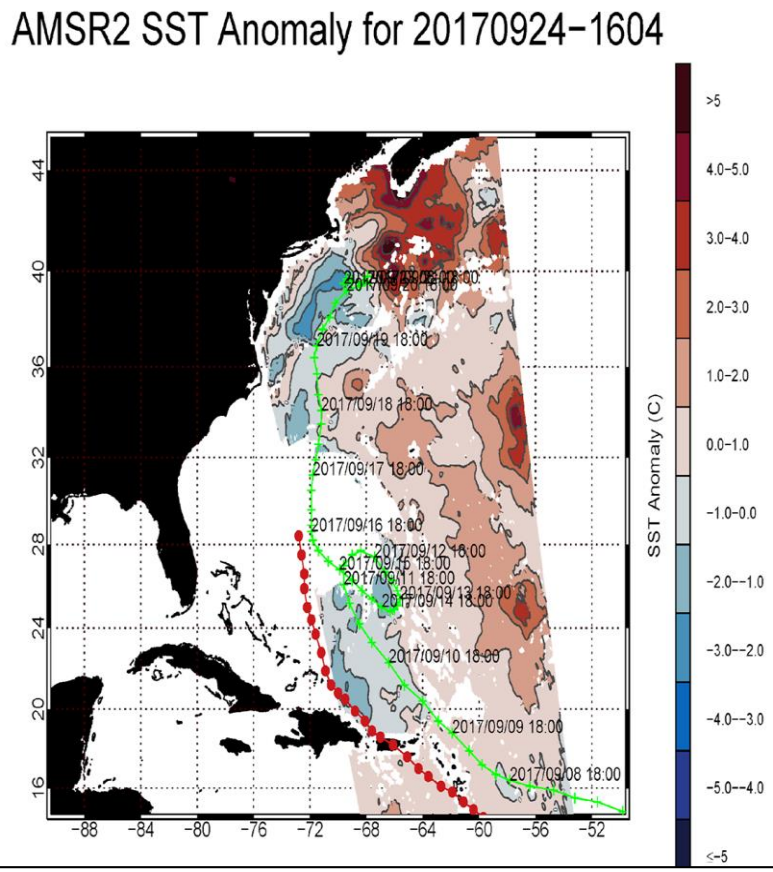
AMSR2 SST Anomaly for 20170924-0616

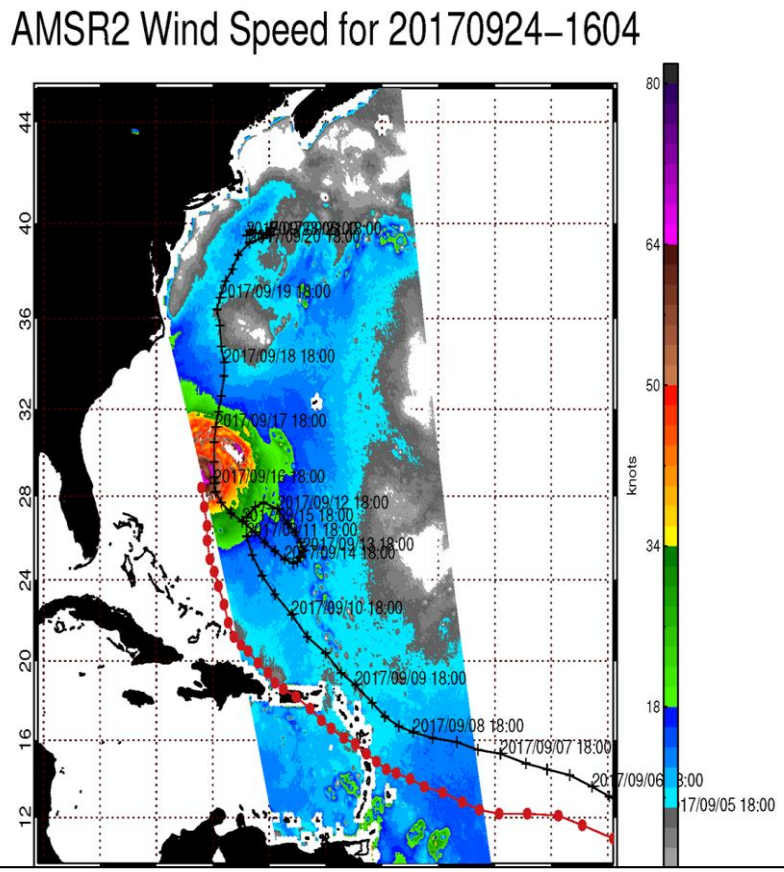


AMSR2 Wind Speed for 20170924-0616



Max sustained winds 110mph

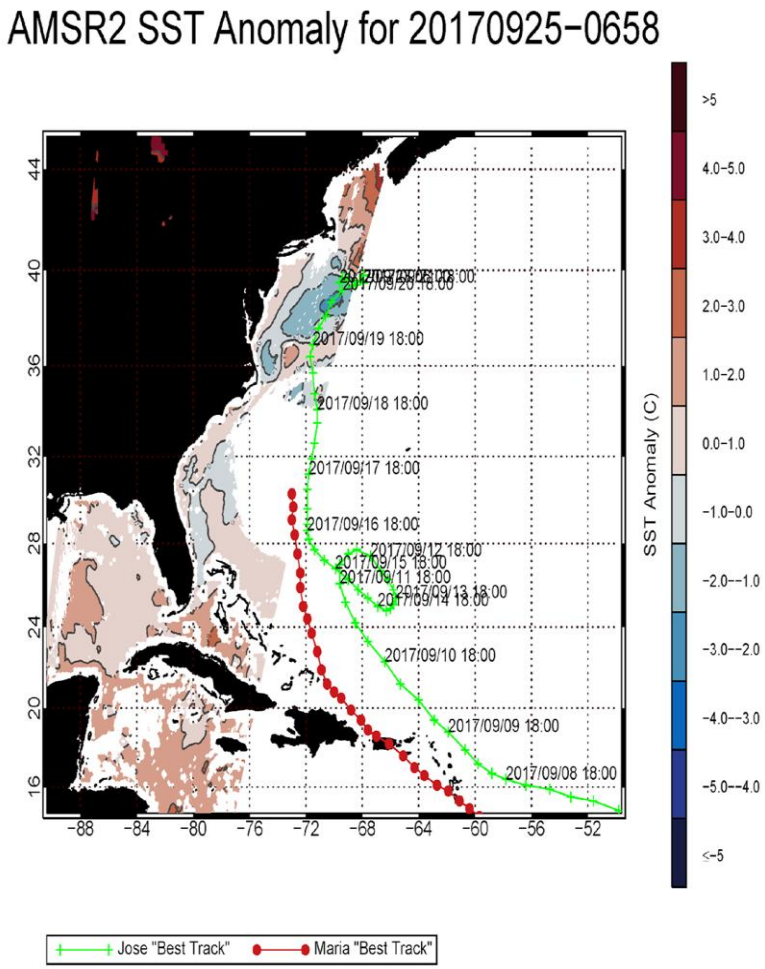


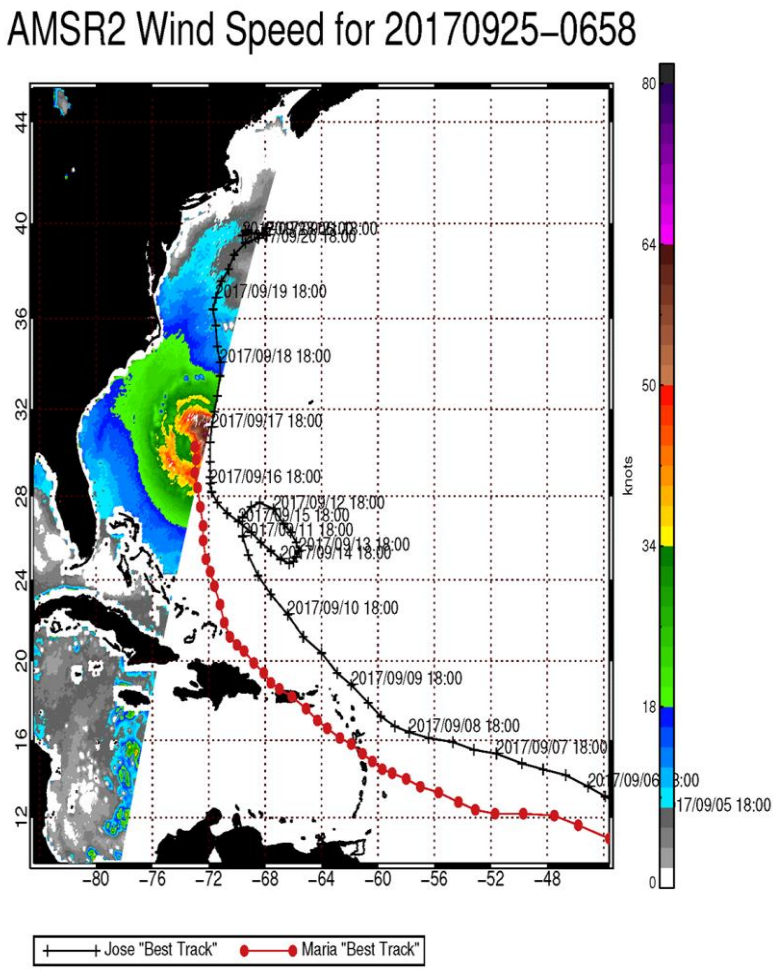


Max sustained winds 105mph

Hurricane Maria Discussion Number 36
NWS National Hurricane Center Miami FL AL152017
1100 PM EDT Sun Sep 24 2017

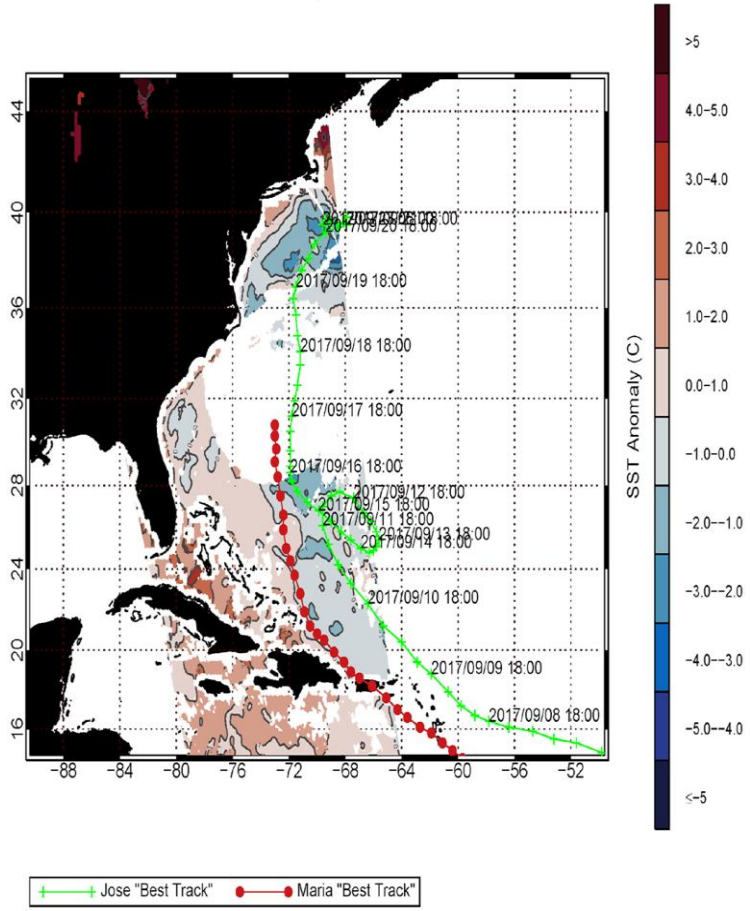
Observations from a NOAA aircraft indicate that the SSTs beneath Maria are on the order of 24-25 deg C, which has probably contributed to the decrease of intensity. **These relatively cool waters are likely due to mixing and upwelling from slow-moving Hurricane Jose, which traversed the area a little over a week ago.** Gradual weakening is anticipated for the next few days, and the official intensity forecast is near or above the latest model consensus. Maria is expected to remain a hurricane for at least the next few days, however.



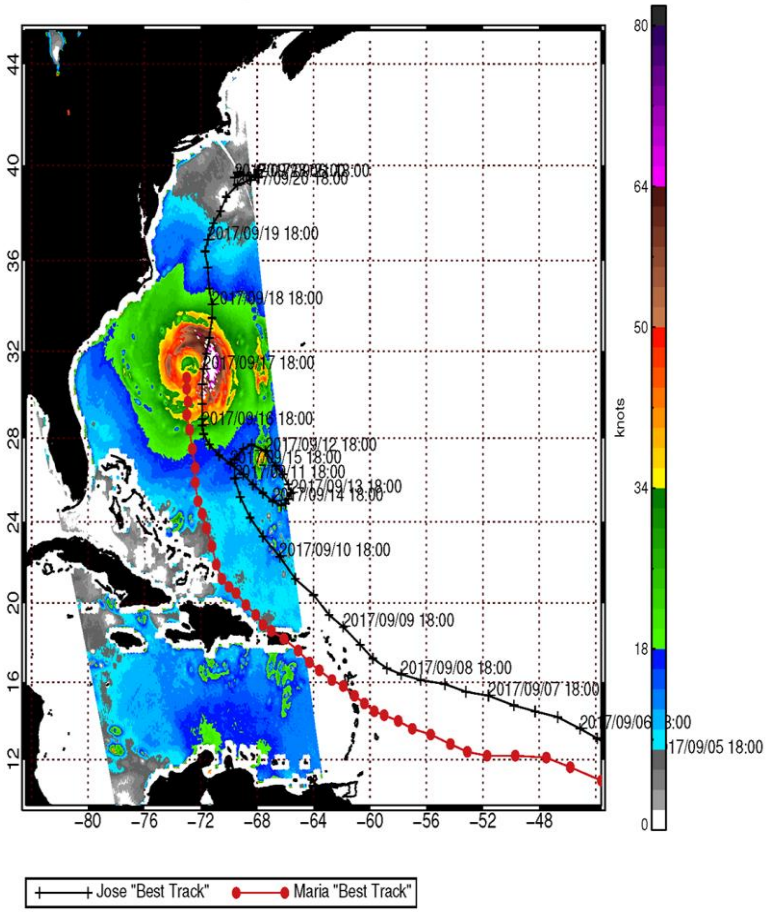


Max sustained winds 80mph

AMSR2 SST Anomaly for 20170925−1649

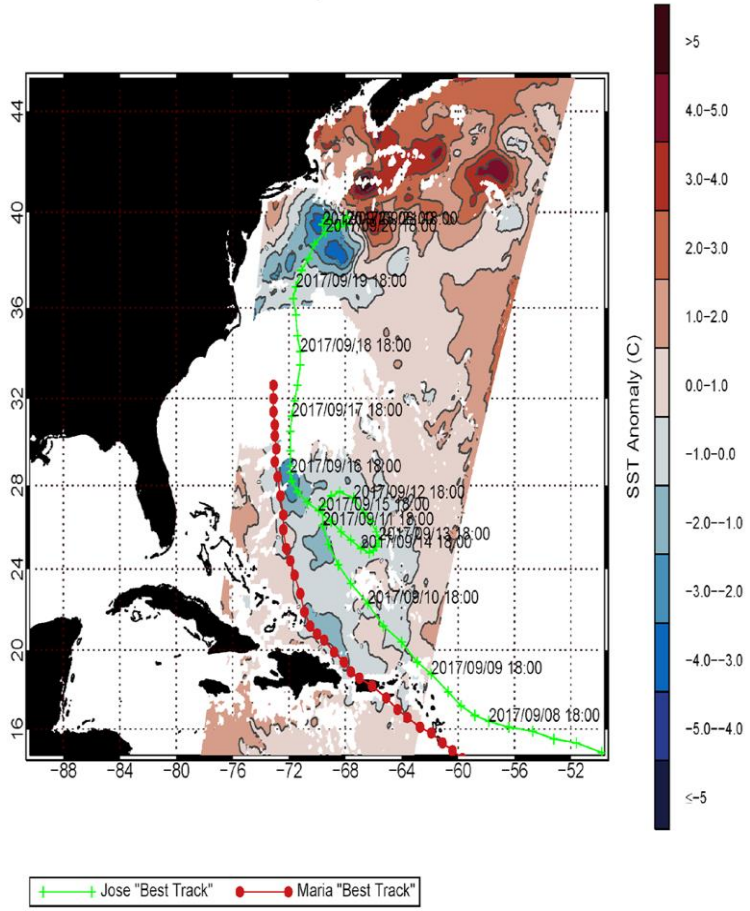


AMSR2 Wind Speed for 20170925−1649

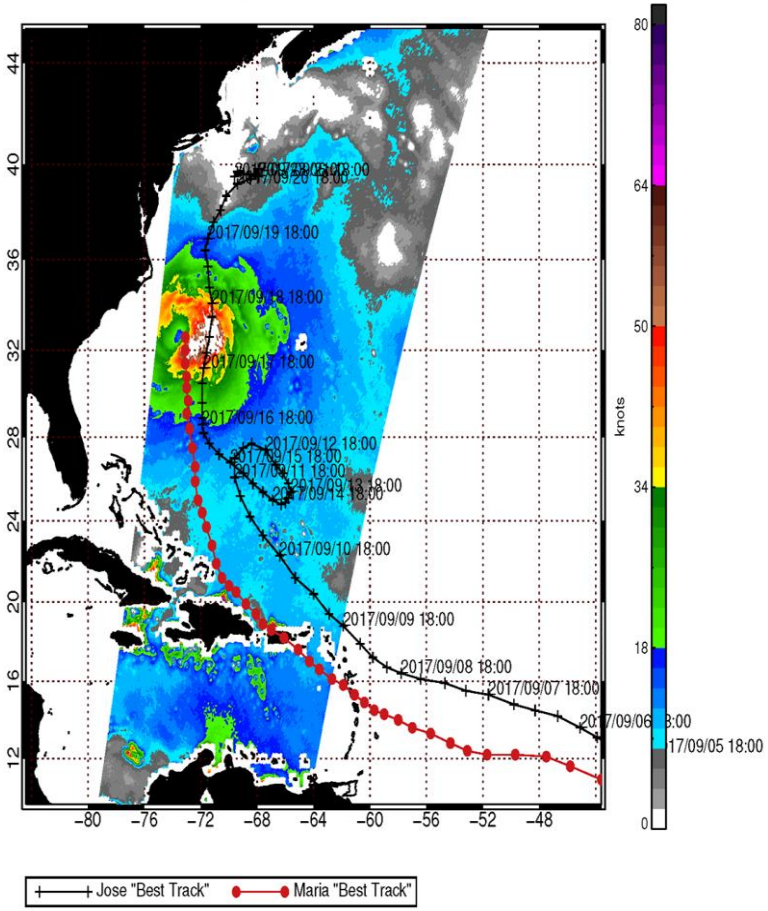


Max sustained winds 75mph

AMSR2 SST Anomaly for 20170926-0604



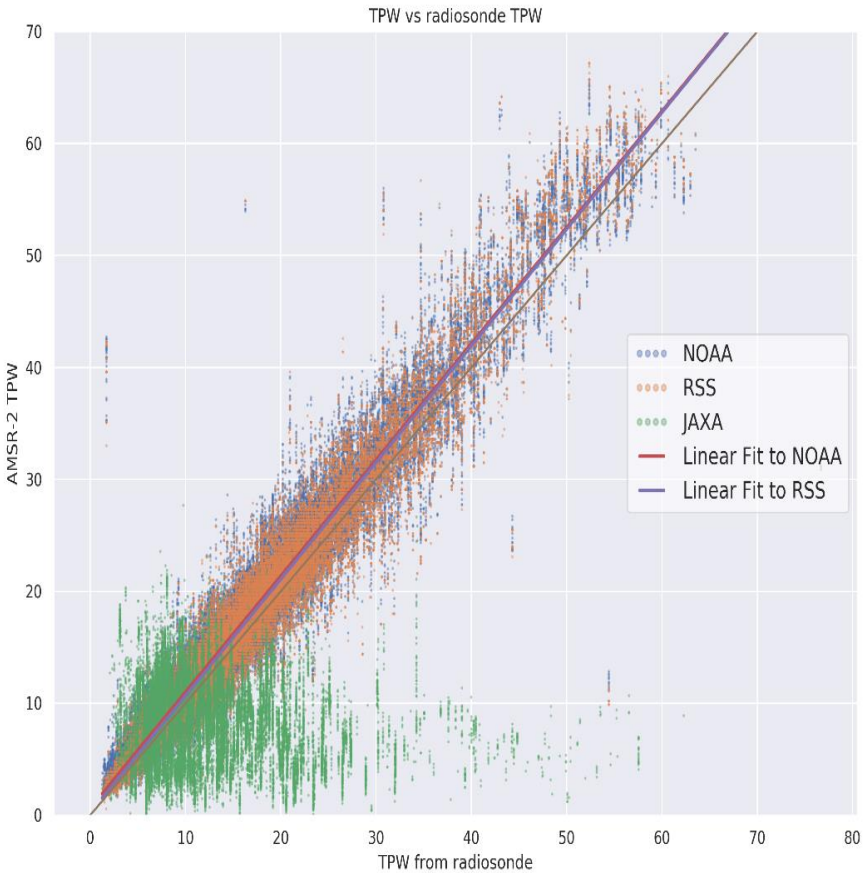
AMSR2 Wind Speed for 20170926-0604



Max sustained winds 65mph

TPW Validation

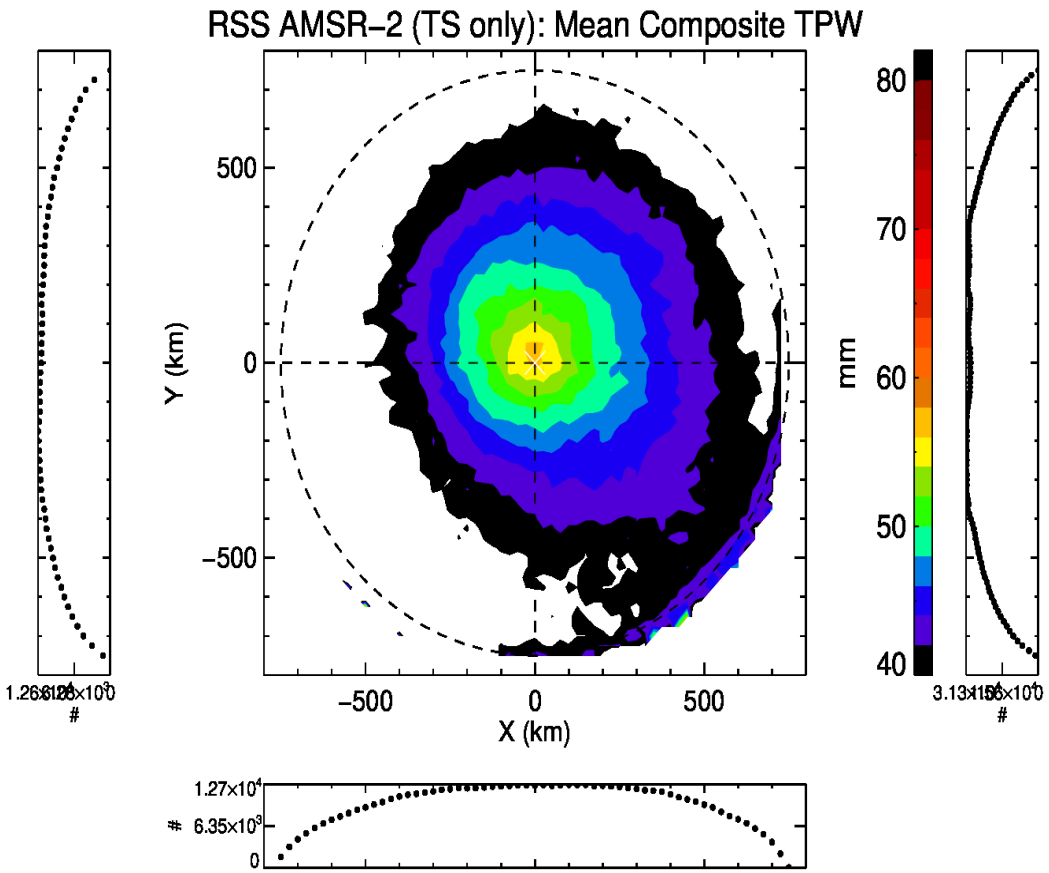
AMSR-2 TPW vs. Radiosonde TPW



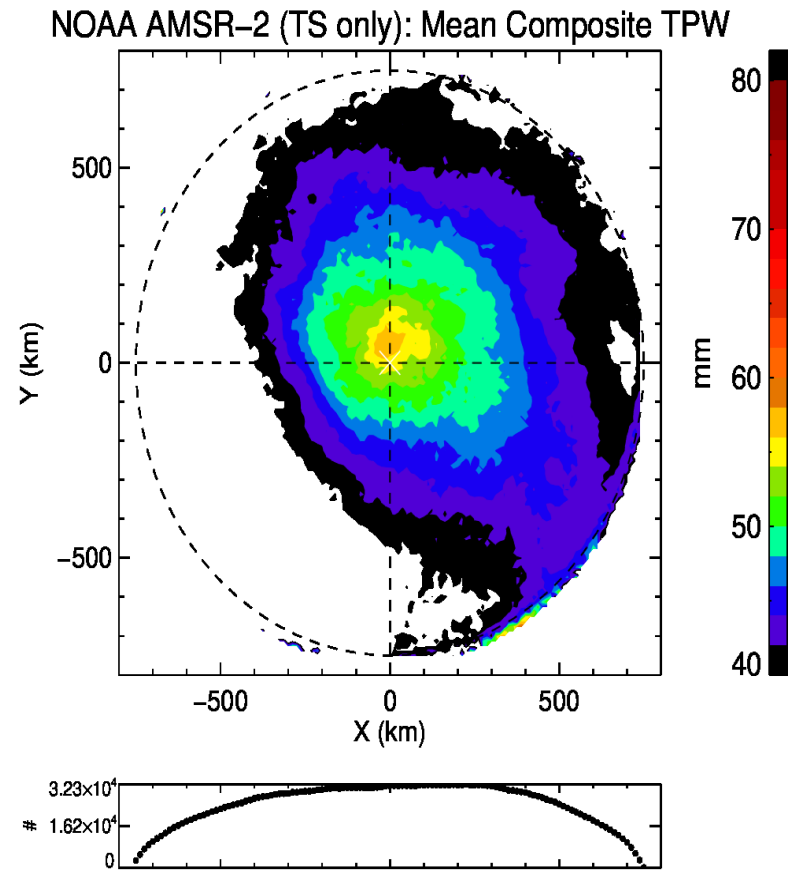
- NOAA, RSS, and JAXA TPW
- All data shown is from a collocation with radiosondes
  - < 50km
  - < 1 hour
  - No RFI, land mask (ours or RSS), no sunglint
- JAXA TPW is not very good
- Both RSS and NOAA slightly overestimate compared to radiosondes
  - Radiosonde “TPW” is actually “precipitable water below 500hPa”, so maybe not exactly “total”

Mean TPW Composites – Atlantic TS

- Comparison of RSS and NOAA TPW products assessed using TPW composite field within different stages of tropical cyclone
- NOAA product is showing higher resolution by resolving finer field structures then RSS product



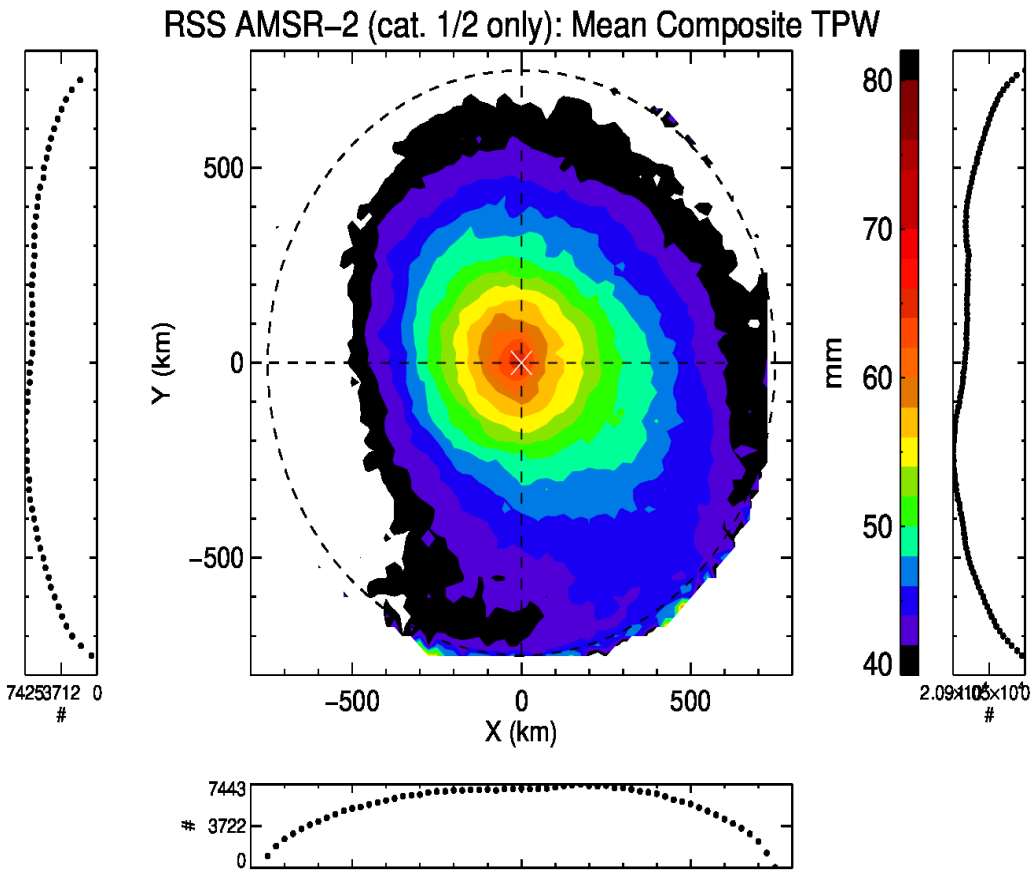
484 snapshots



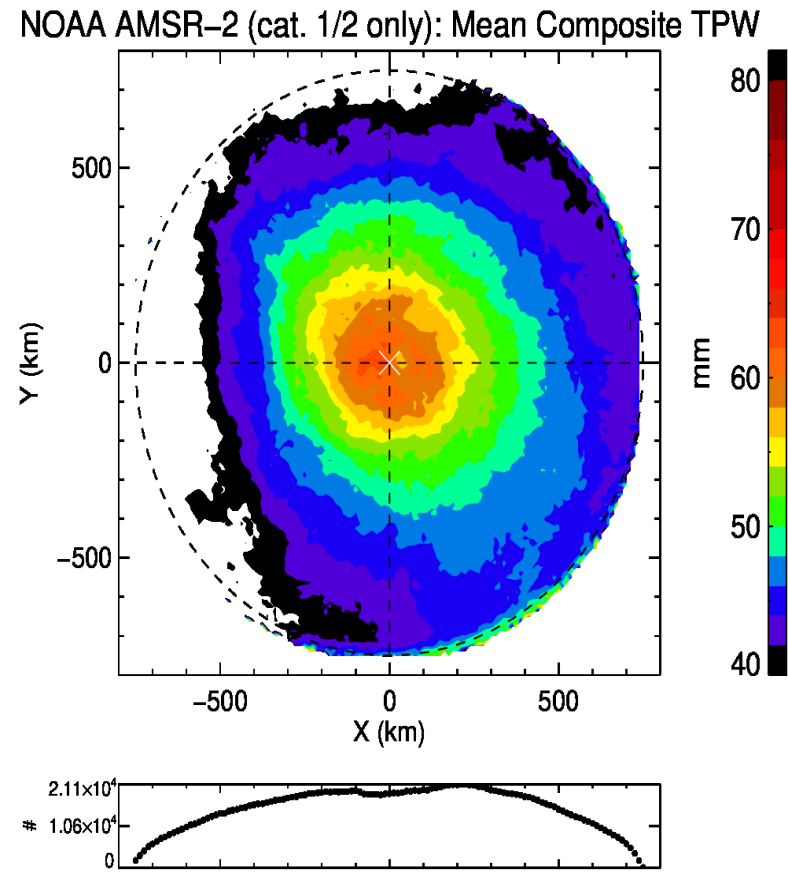
234 snapshots

Mean TPW Composites - Atlantic Hurricanes Cat. 1/2

- Overall mean TPW field within category 1 and 2 hurricanes is larger in NOAA product than RSS product
- In RSS product highest TPW values are produced within storm center while in NOAA product highest values are concentrated more on the west side of the storm



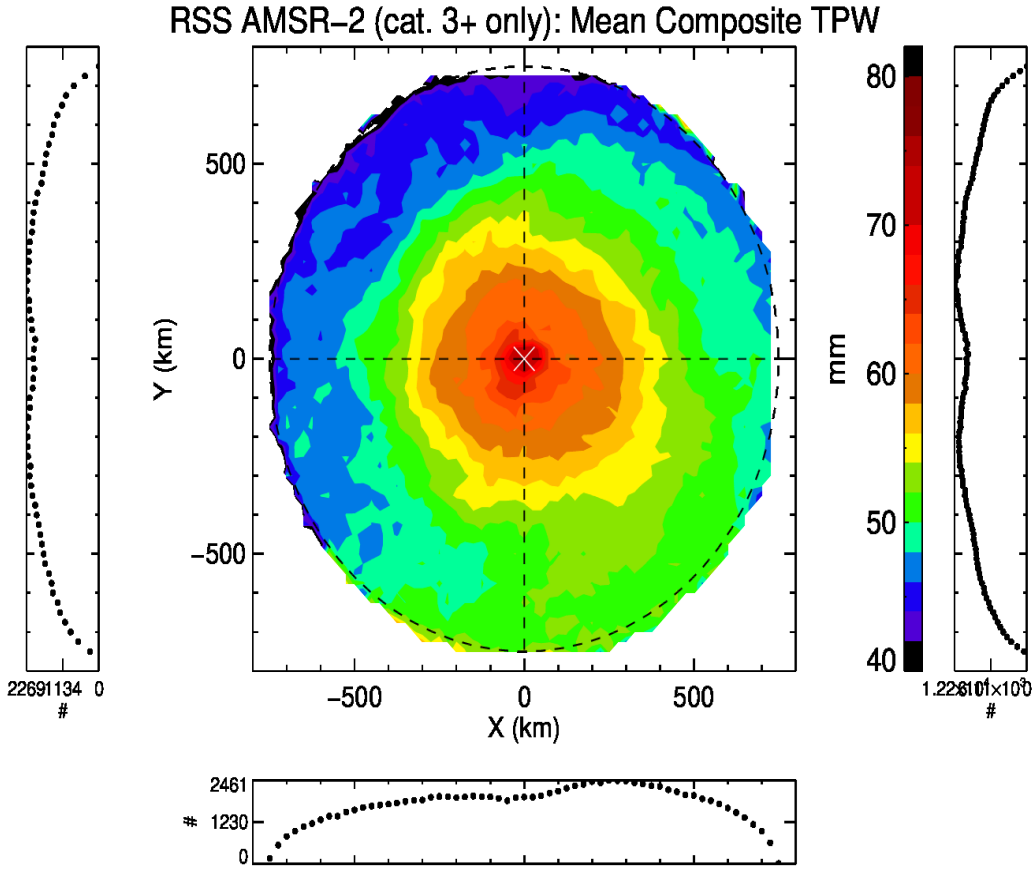
275 snapshots

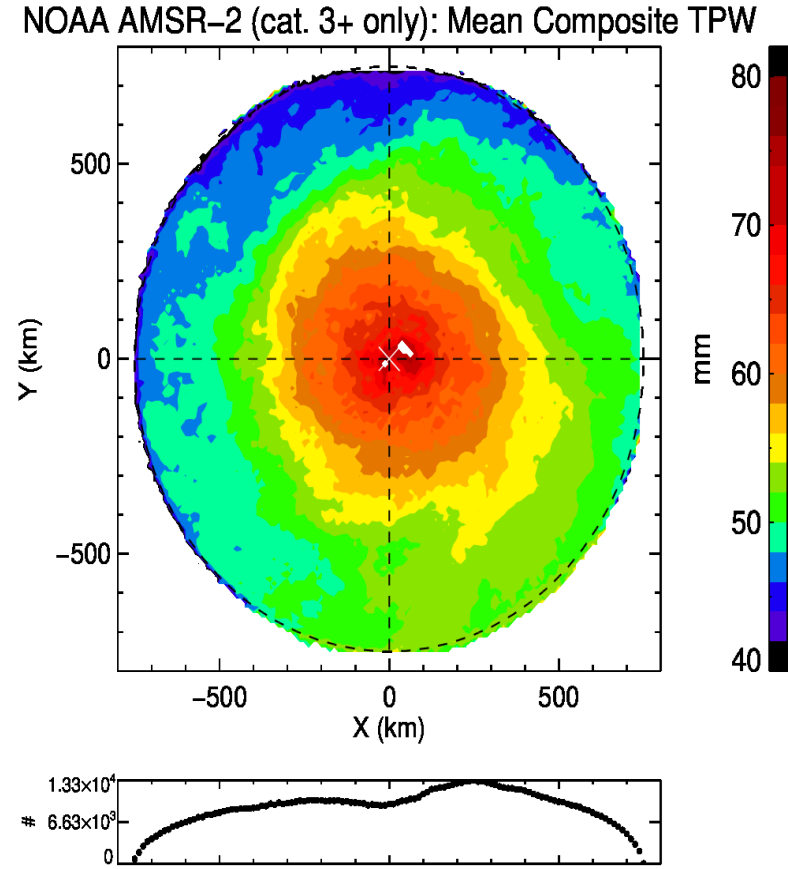


147 snapshots

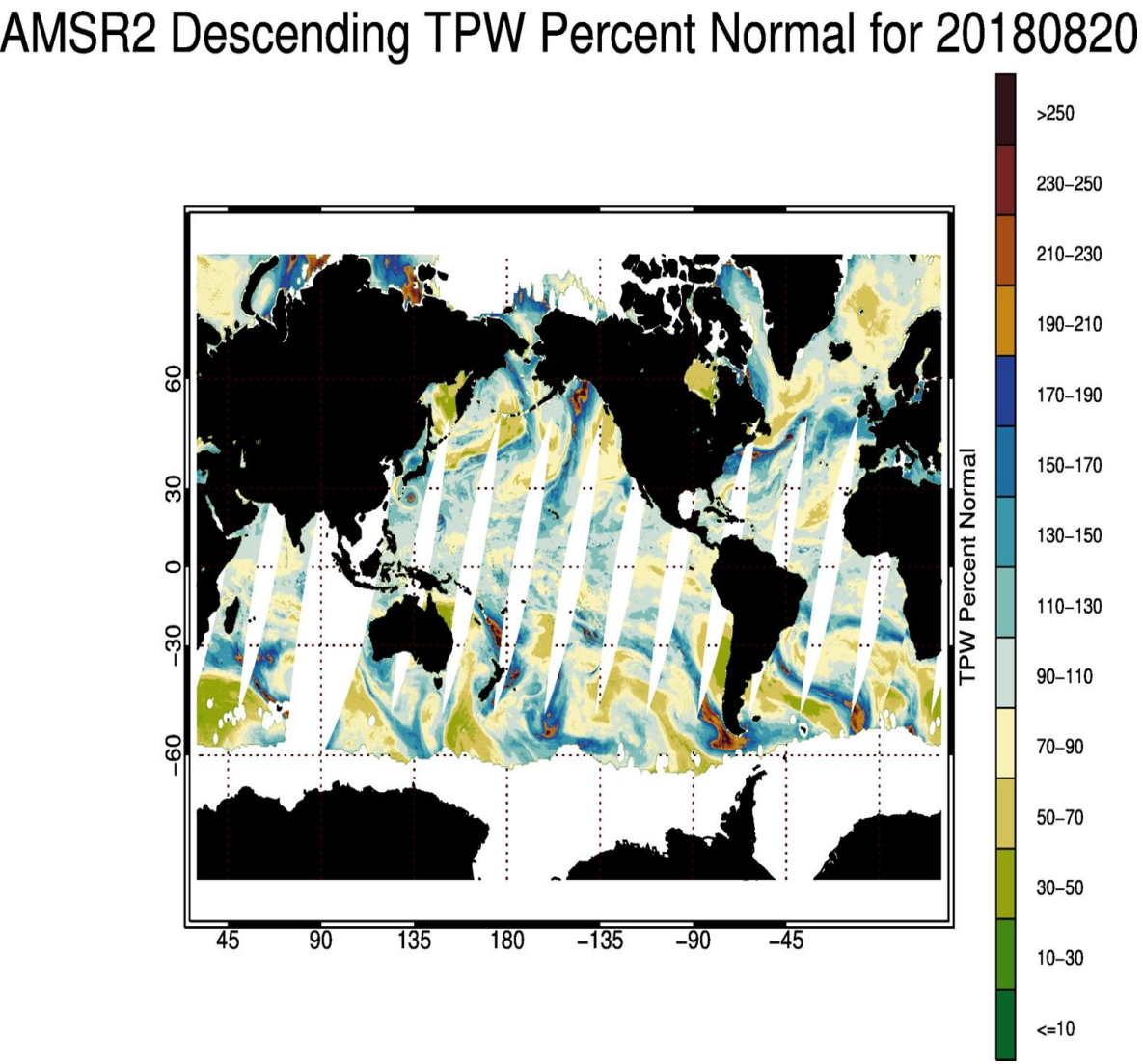
Mean TPW Composites – Atlantic Major Hurricanes

- Both NOAA and RSS products depicting double radius maxima TPW within major hurricanes however NOAA product is placing secondary maxima between 150-200km from the storm center while RSS product extends it up to 50-75km
- NOAA product is showing asymmetric nature of TPW field within first maxima while RSS product is not capable of resolving it





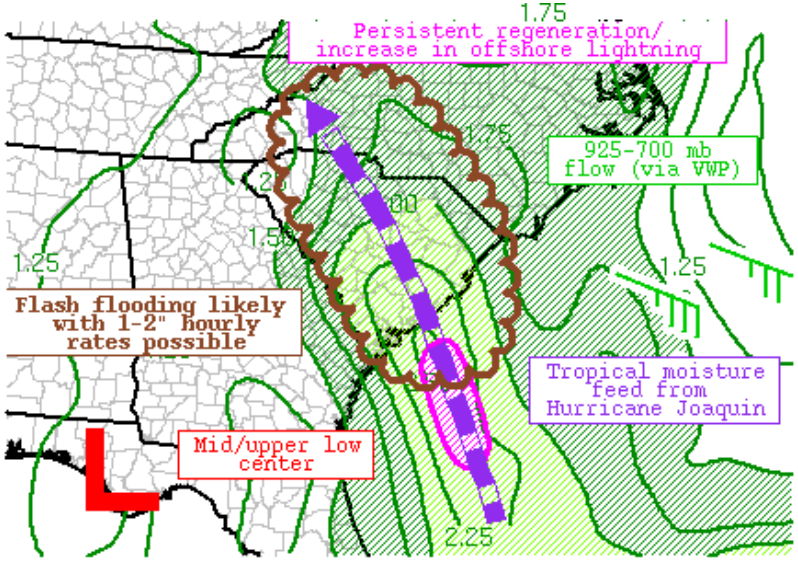
New Product
TPW Percent Normal



- Percent normal compared to NVAP-M daily climatology
- Very high percentage values (200% or more) indicate a strong flooding potential or a possible severe weather indicator, while low values indicate potential fire hazards.

Anomalous TPW Example: South Carolina Flooding Event Oct 3rd, 2015

Ferraro, R., et.al.,"Application of GCOM-W AMSR2 and S-NPP ATMS Hydrological Products to a Flooding Event in the United States" IEEE J-STARS, vol. 10, no. 9, pp. 3384-3891, Sept. 2017, DOI: 10.1109/JSTAR.2017.2696304



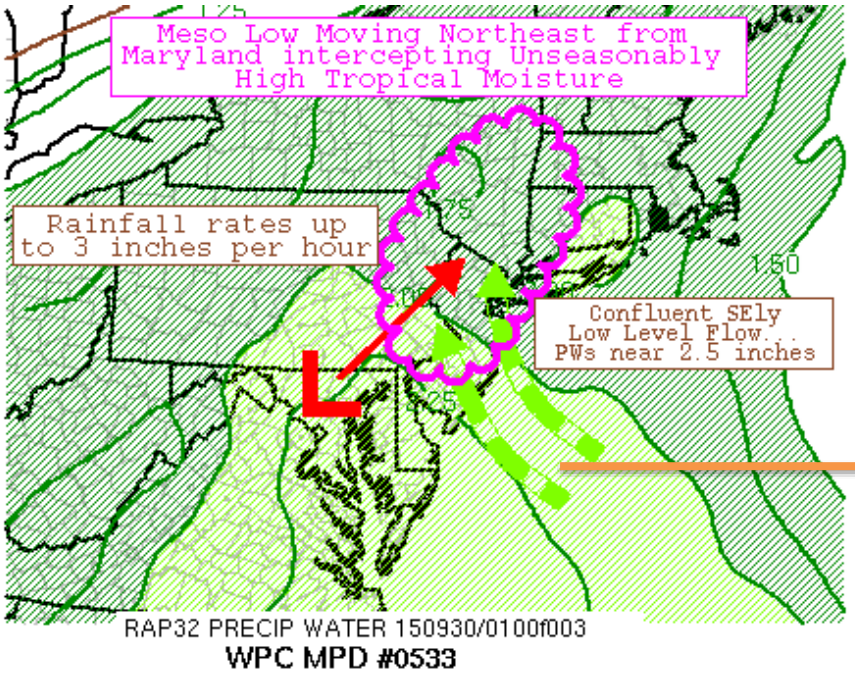
RAP32 PRECIP WATER 151003/0600f003
WPC MPD #0545

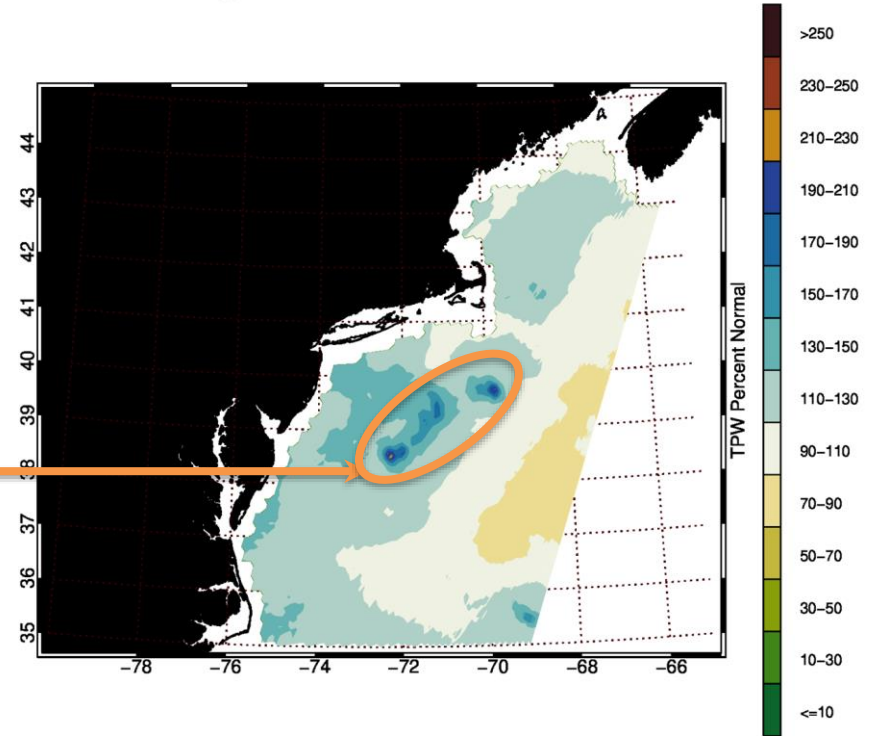
Hurricane Joaquin

DISCUSSION...WATER VAPOR IMAGERY EARLY THIS MORNING SHOWED AN UPPER LOW CIRCULATING OVER THE FL PANHANDLE WITH A BROAD RIDGE EXTENDING ACROSS THE WESTERN ATLANTIC. THESE **COMBINED CIRCULATIONS HAVE HELPED CHANNEL A NARROW PLUME OF MOISTURE FROM THE VICINITY OF HURRICANE JOAQUIN** AND EXTENDING NORTHWESTWARD INTO THE SOUTHEASTERN U.S. THE BLENDED-TPW PRODUCT SUGGESTED THE EXTENT OF THE 2" **PWAT WITHIN THE TROPICAL MOISTURE PLUME WAS APPROXIMATELY 175 MILES**.

Unseasonably High Tropical Moisture Bringing Floods to East Coast, Sep 30th, 2015

DISCUSSION...SFC/RADAR IMAGERY SHOWS A WELL DEFINED MESO LOW CIRCULATION OVER NORTHERN MARYLAND RIDING NORTHEASTWARD ALONG RIBBON OF WEAK INSTABILITY TOWARD SOUTHEAST PENNSYLVANIA. SATELLITE IMAGERY CONTINUES TO SHOW FAIRLY COLD TOP CONVECTION WITH AND TO THE NORTHEAST OF THIS SYSTEM. **THE LOW ITSELF IS HELPING PROVIDE INCREASING MOISTURE CONFLUENCE/LIFT IN AN OTHERWISE IMPRESSIVE TROPICAL MOISTURE REGIME WELL IN ADVANCE OF A SYNOPTIC COLD FRONT** ACROSS THE OH VALLEY. SATELLITE AND GPS PWS NDICATE PWS AS HIGH AS 2.5 INCHES EAST OF THE LOW CIRCULATION AND THE COMBINATION OF THE VERY HIGH MOISTURE...TALL SKINNY CAPES...AND ENHANCED CONVERGENCE WITH THE LOW WILL CONTINUE TO LEAD TO SOME VERY IMPRESSIVE LOCALIZED HEAVY RAINFALL RATES.

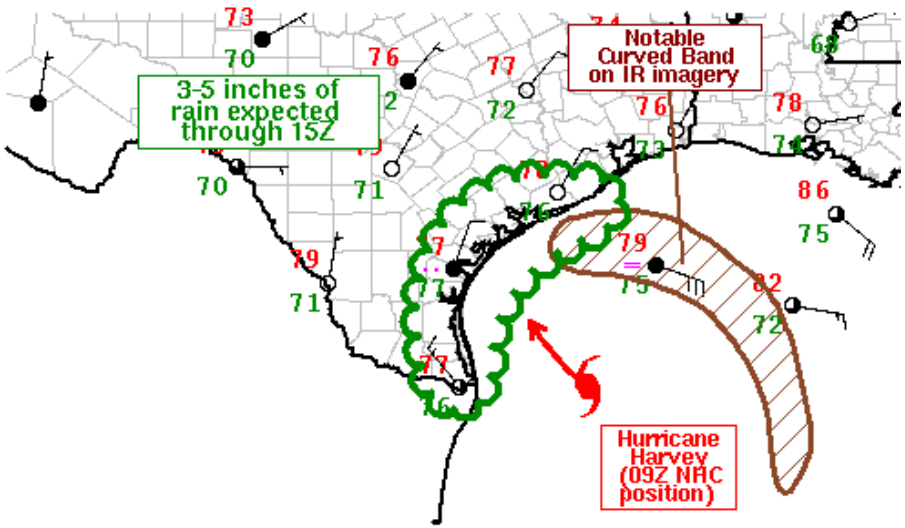




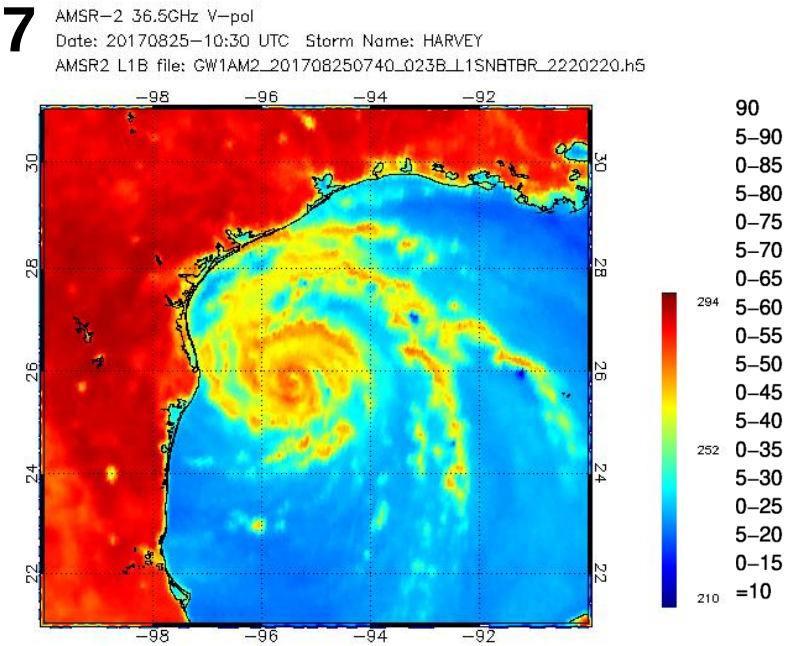
Hurricane Harvey Aug 25th, 2017

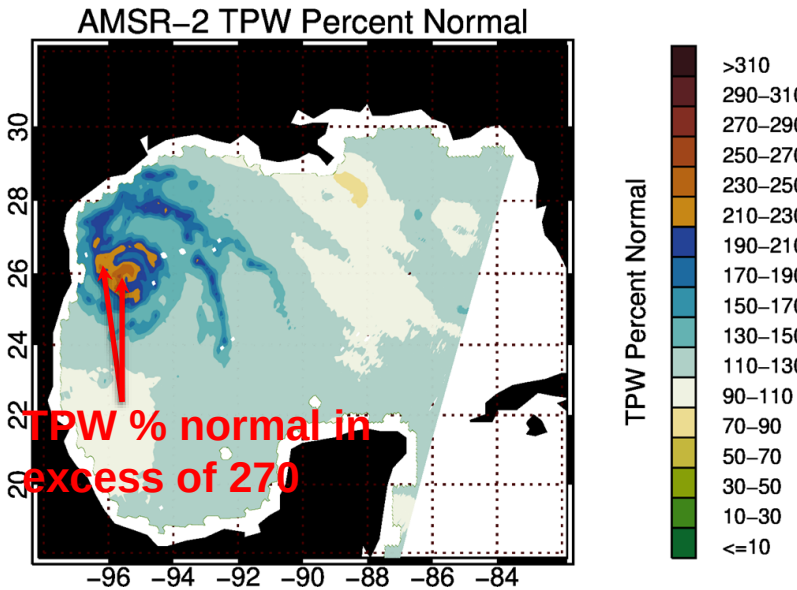
DISCUSSION...HURRICANE HARVEY CONTINUES MOVING NORTHWEST AT 10 MPH PER THE LATEST NHC ADVISORY. **THE SYSTEM HAS RECENTLY EXHIBITED A DOUBLE EYEWALL STRUCTURE WITH THIRD NEARBY INNER SPIRAL BANDEVIDENT**, AND THE LEADING EDGE OF ITS CDO LIES WITHIN AN HOUR OF THE COAST. **PRECIPITABLE WATER VALUES ARE ~2.5" PER RECENT GPS DATA**.

SHOULD THE SYSTEM NOT COMPLETE ITS EYEWALL REPLACEMENT CYCLE, THE OUTERMOST EYEWALL COULD REACH THE COAST AT THE END OF THE MPD HORIZON. HOURLY RAIN **TOTALS UP TO 3" WITH LOCAL AMOUNTS UP TO 6" ARE EXPECTED. THIS SHOULD LEAD TO FLASH FLOODING**, PARTICULARLY WITHIN URBAN AREAS.



METAR 170825/0900
WPC MPD #0722

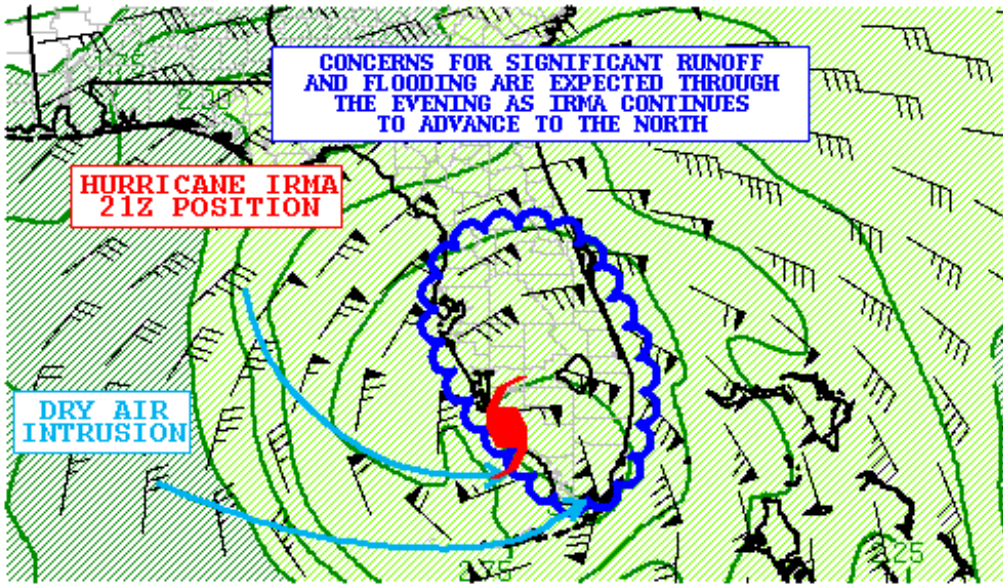




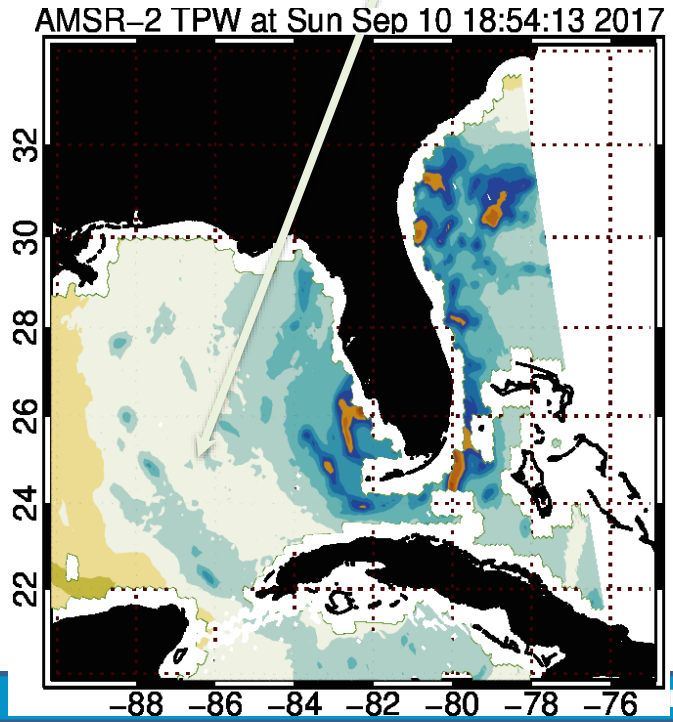
Hurricane Irma
Sep 10-11th, 2017

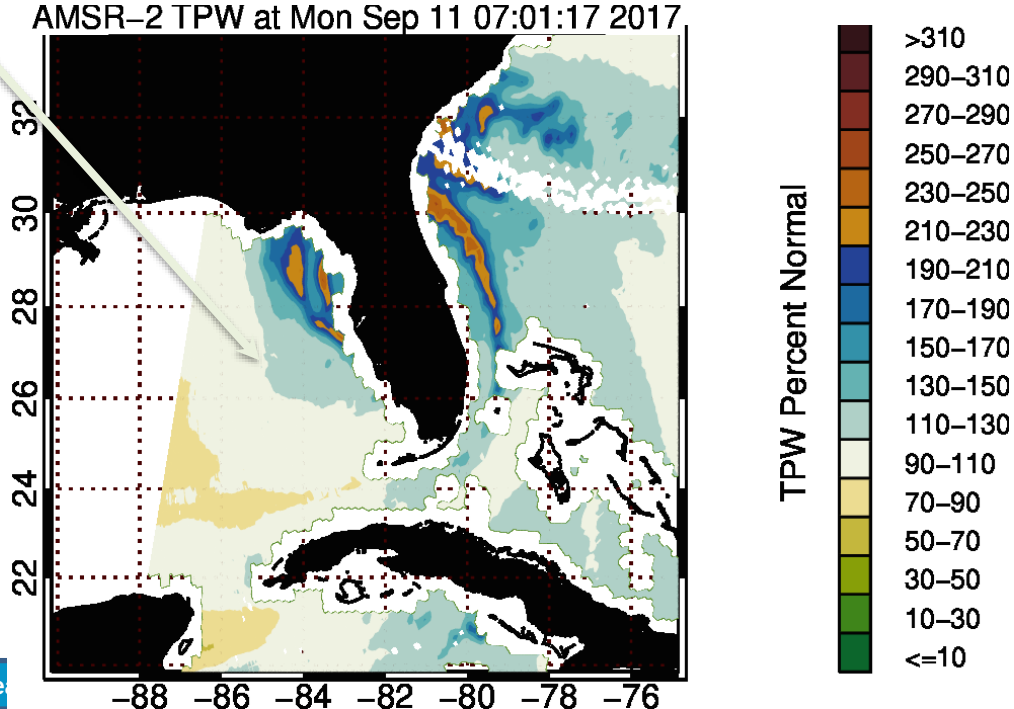
LATEST SPC/RAP MESOANALYSIS INDICATES PWAT VALUES OF 2.7-2.9 IN... LOW-LEVEL WATER

VAPOR IMAGERY SHOW VERY DRY AIR WRAPPING AROUND THE WESTERN SIDE OF IRMA, BUT AT THIS TIME THE DRY AIR IS **FAILING TO SIGNIFICANTLY PENETRATE THE STORM'S CORE, KEEPING PWATS HIGH.**

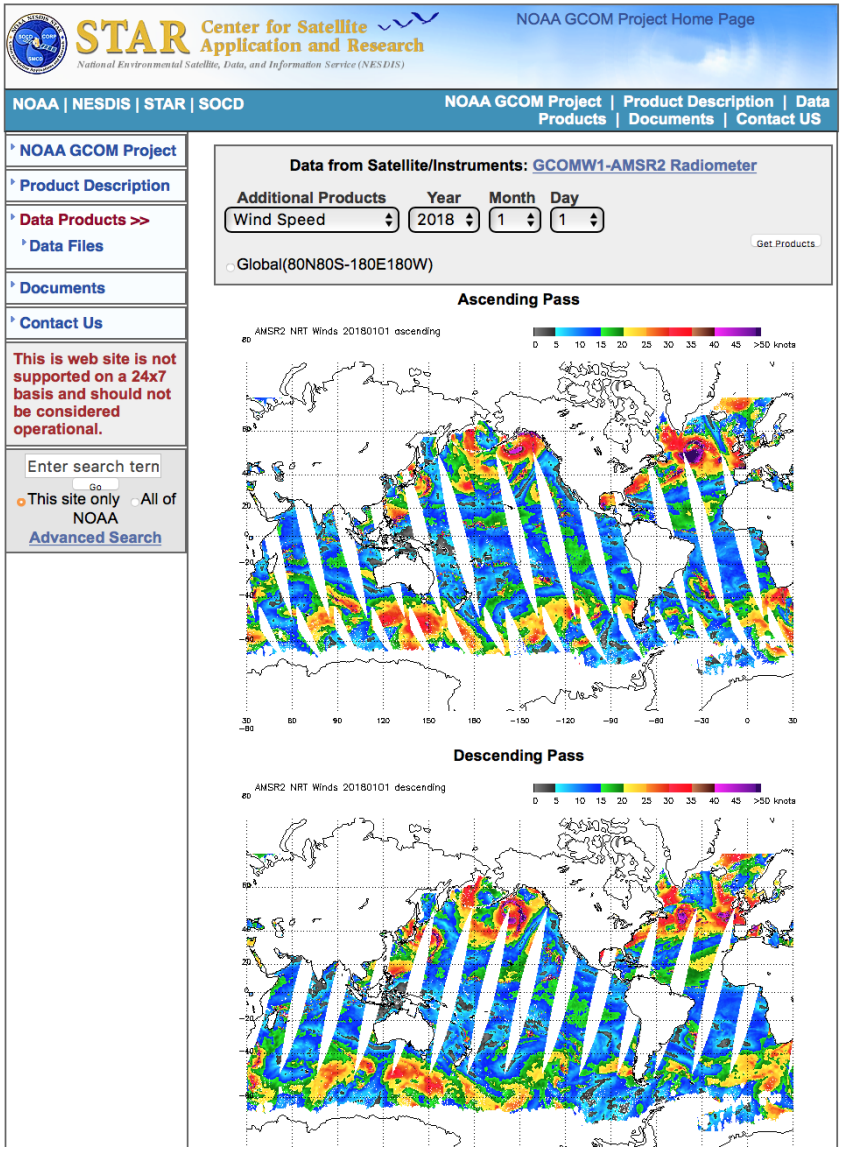


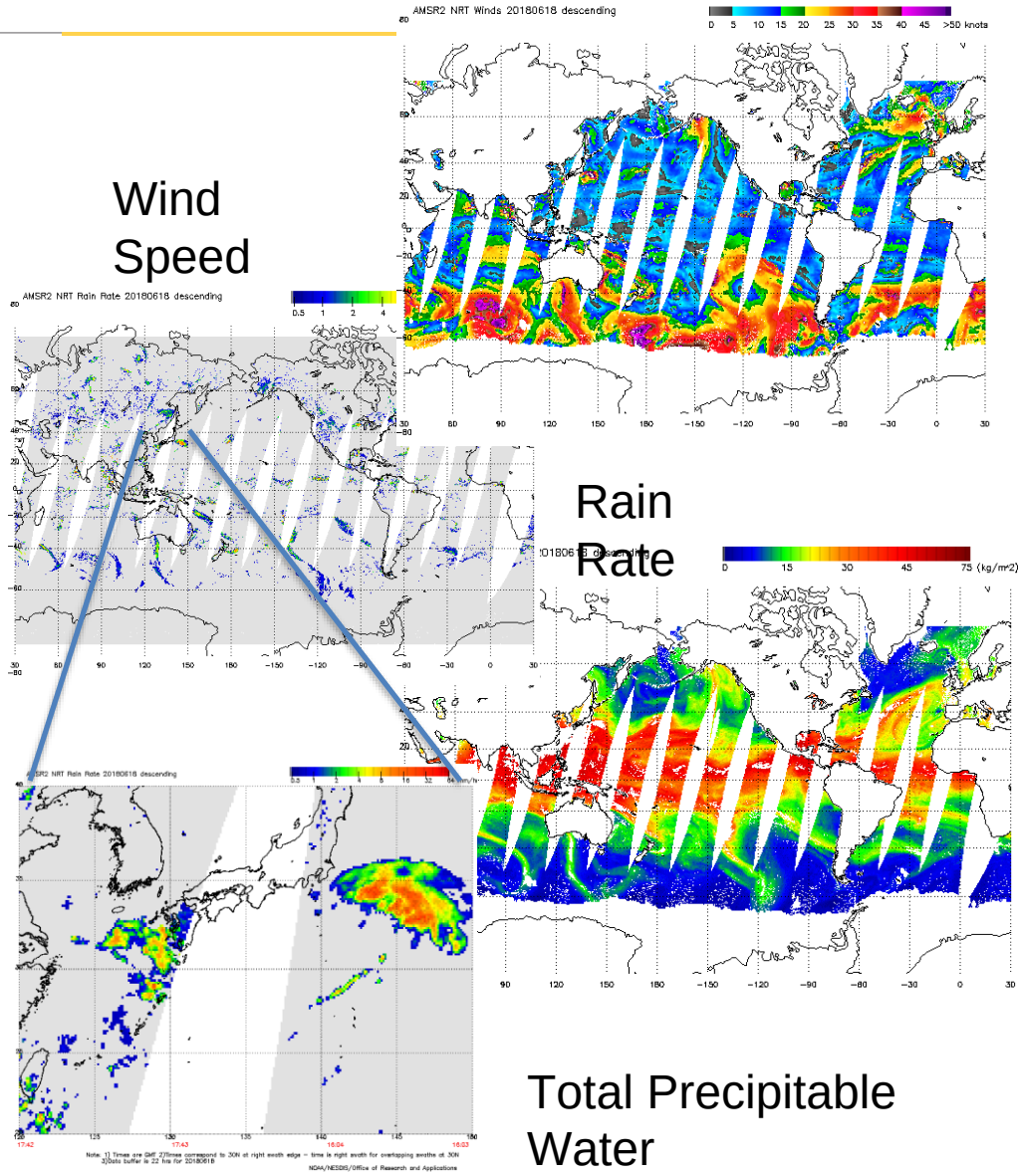
RAP32 PRECIP WATER 170910/2100f000
RAP32 850 MB WINDS 170910/2100f000
WPC MPD #0800





STAR AMSR-2 Product Monitoring and Data Portal

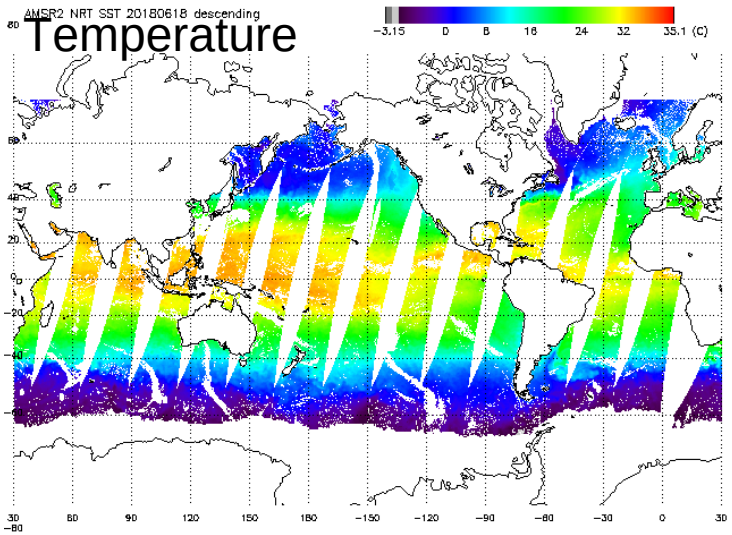




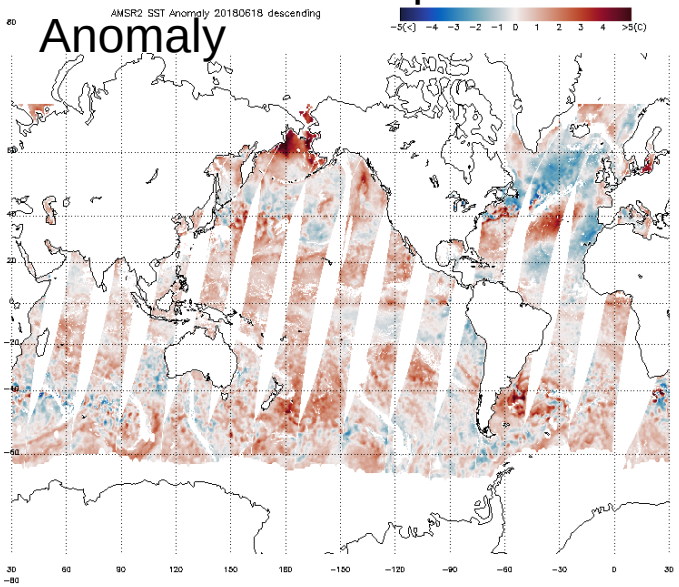
https://manati.star.nesdis.noaa.gov/gcom

STAR AMSR-2 Product Monitoring and Data Portal

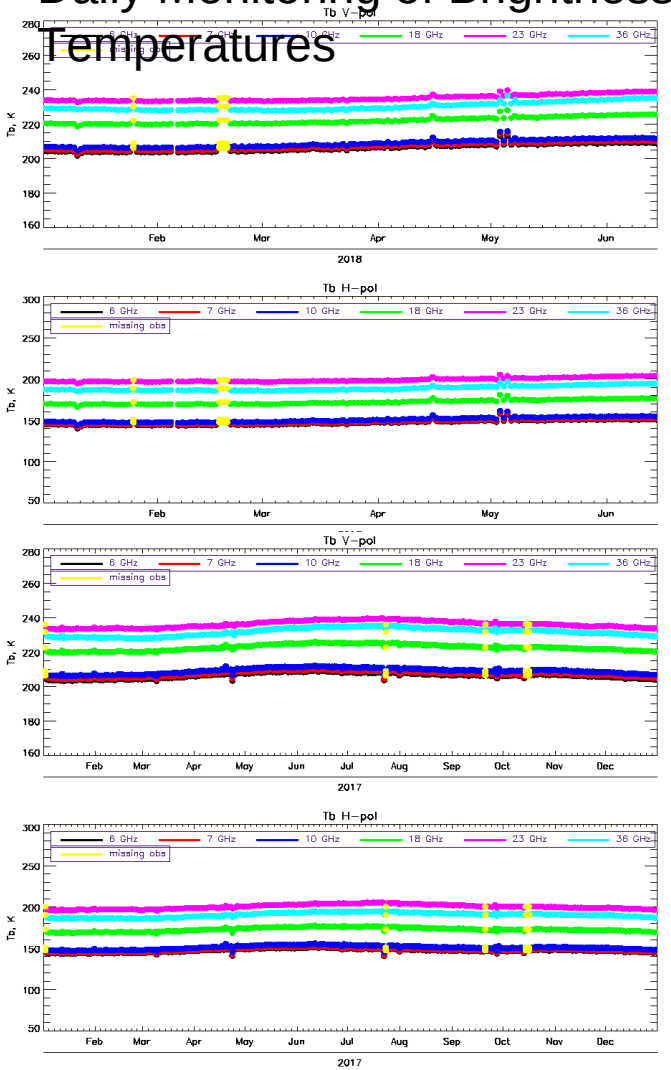
Sea Surface Temperature



Sea Surface Temperature Anomaly



Daily Monitoring of Brightness Temperatures



2018

2017

Thank You

SOIL MOISTURE FROM SMOPS

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Jicheng Liu, Jifu Yin, Li Fang, Nai-Yu Wang, Mitch Schull
UMD-CICS

Acknowledgment:* *Supports from JPSS PGRR and GCOM-W programs for soil moisture project are greatly appreciated

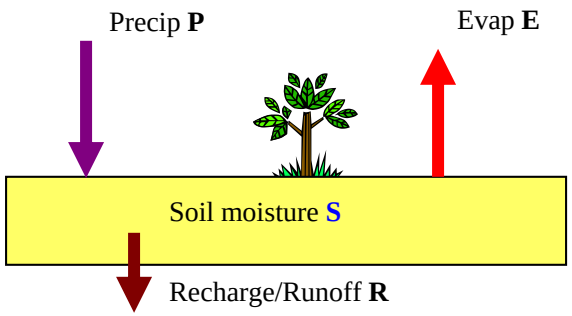
OUTLINE

- Why Soil Moisture
  - Sciences (water and energy cycle studies)
  - Applications (flood and drought monitoring/forecasts)
- Soil Moisture Operational Product System (SMOPS)
  - System Objectives and Architecture
  - Algorithms Updates for JPSS GCOM-W/AMSR2
- Supporting NWC NWM (JPSS PGRR)
- Summary and Path Forward

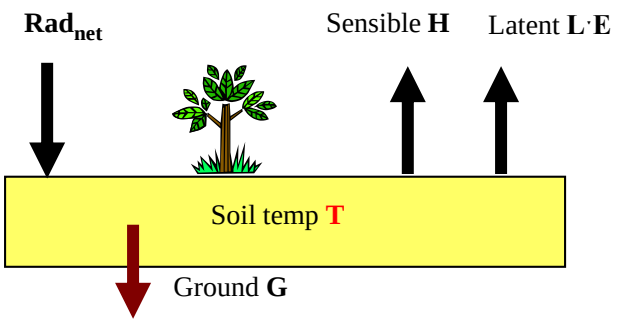
Why Soil Moisture

Soil moisture controls land surface **water** and **energy** partitioning through impacting **evapotranspiration** and is a critical component of both water and energy cycles

Mass balance



Energy balance



$$V \frac{dS}{dt} = P - E(T, S) - R(S)$$

$$c \frac{dT}{dt} = Rad_{net}(T) - H(T) - L \cdot E(T, S)$$

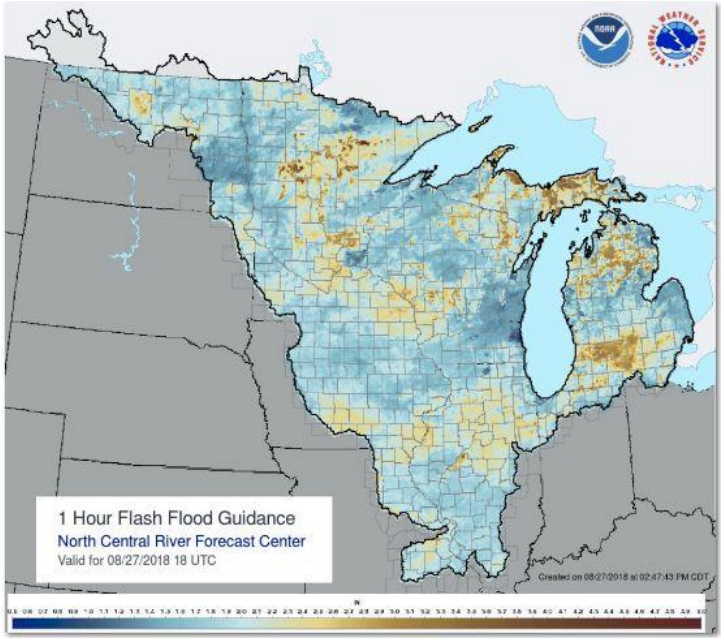
Evaporation & soil moisture **couple mass & energy balances** at land surface

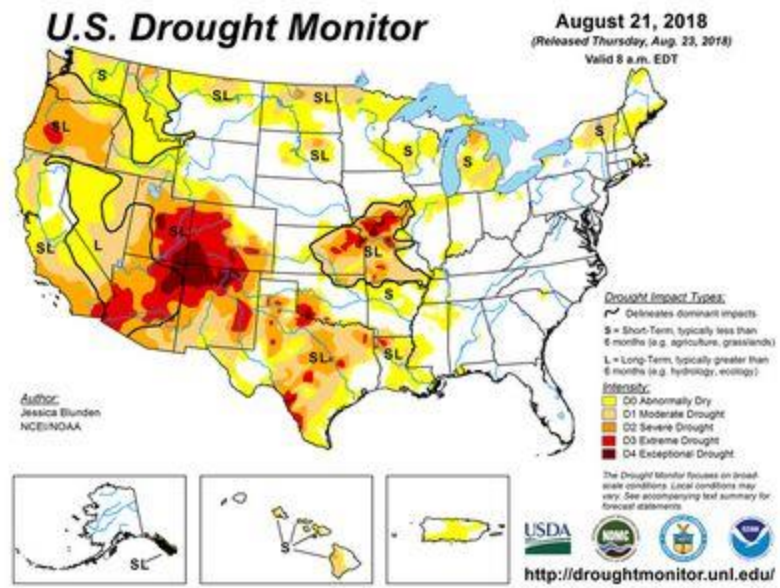
L is the latent heat of vaporization: 2.5×10^6 [J/kg]

Why Soil Moisture

Applications

NWS Operational Flash Flood Guidance (FFG) is Based on *Modeled* Soil Moisture Deficit

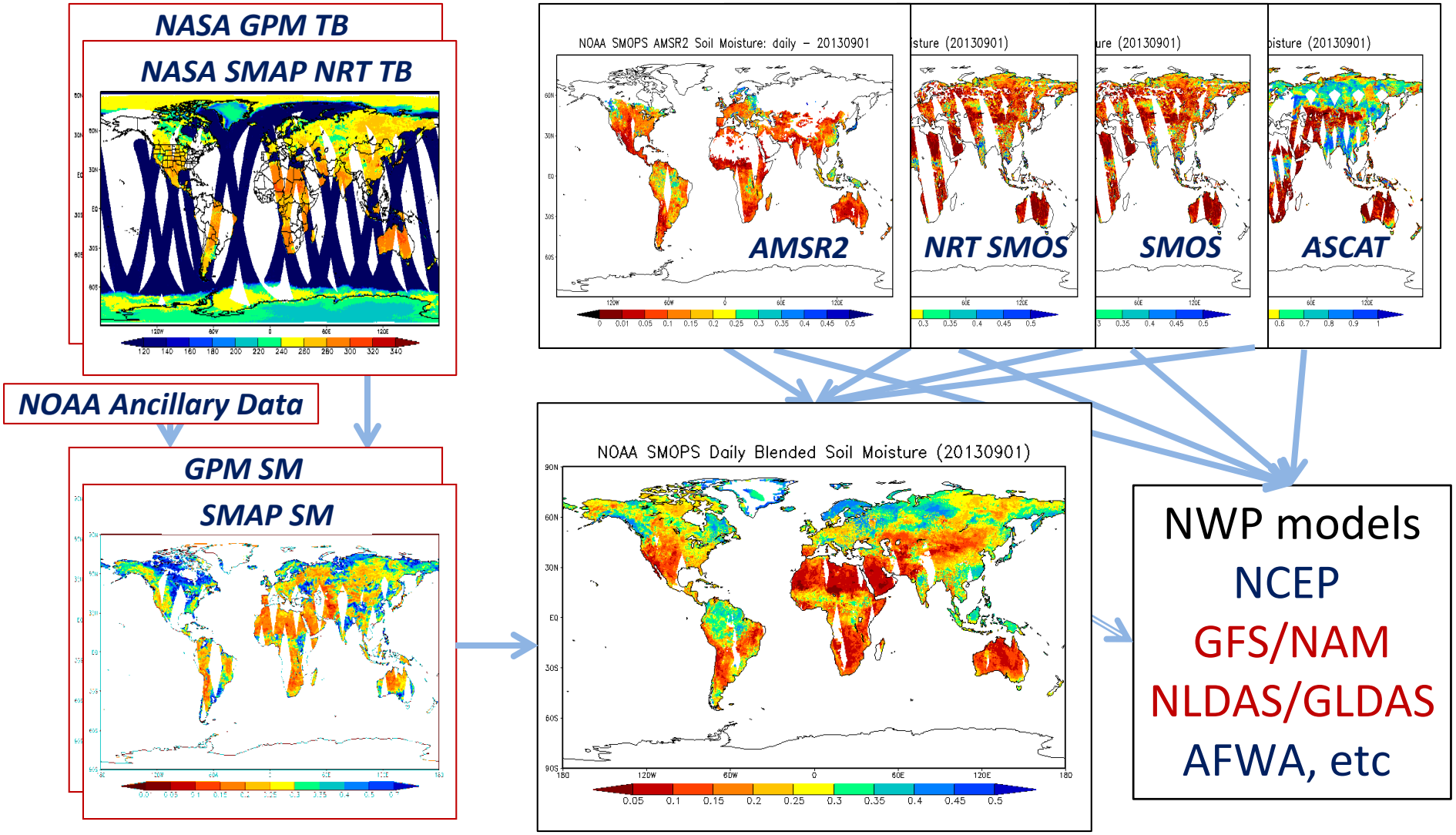




NOAA and National Drought Mitigation Center (NDMC) Operational Drought Indices are also based on *Modeled* Soil Moisture Data.

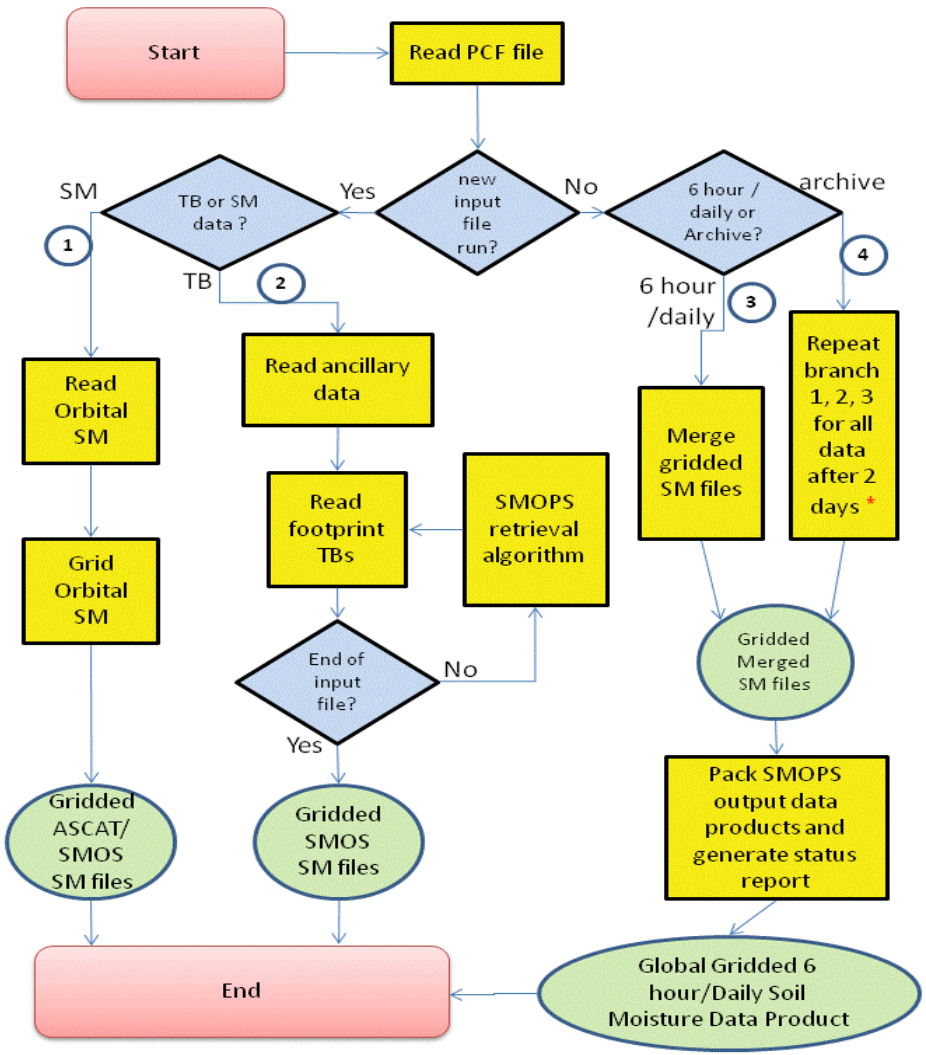
Soil moisture Observational data can replace model data or used to improve model estimates

Soil Moisture Operational Product System (SMOPS)



SMOPS ingests all currently available microwave satellite soil moisture observations and blends them into one data layer for NOAA and other users

Soil Moisture Operational Product System (SMOPS)



* *All data acquired within the 6 hour or whole day time period arrived in the past 48 hours*

1. **SM ingesting**
2. **SM retrieving**
3. **SM merging**
4. **Reprocessing for the archive product**

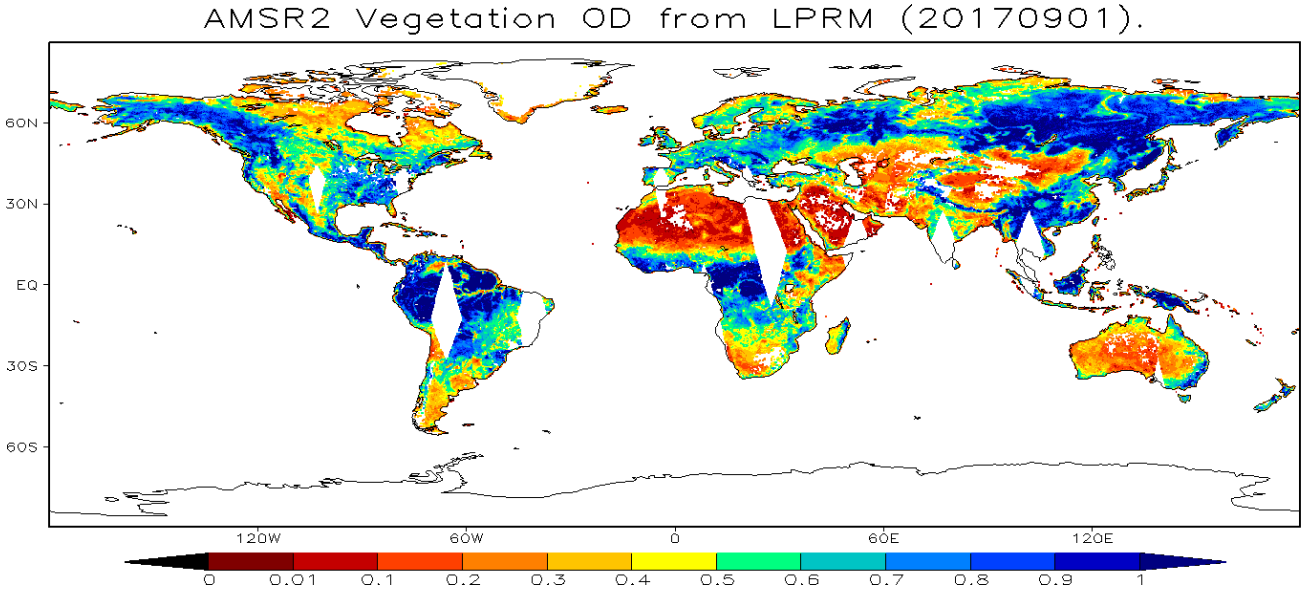
SMOPS Output Data layers

Soil Moisture Product	SMOPS Version 1.3	SMOPS Version 2.0	SMOPS Version 3.0
SMOPS Blended	√ (1)	√ (1)	√ (1)
NOAA AMSR-E	√ (2)	×	×
NOAA NRT SMOS	×	√ (2)	√ (2)
ESA SMOS	√ (3)	√ (3)	√ (3)
EUMETSAT ASCAT-A	√ (4)	√ (4)	√ (4)
EUMETSAT ASCAT-B	√ (5)	√ (5)	√ (5)
NOAA WindSat	√ (6)	×	×
NOAA AMSR2	×	√ (6)	√ (6)
NOAA GMI	×	×	√ (7)
NOAA NRT SMAP	×	×	√ (8)
NASA SMAP	×	×	√ (9)

JPSS GCOM-W1/AMSR2 Soil Moisture

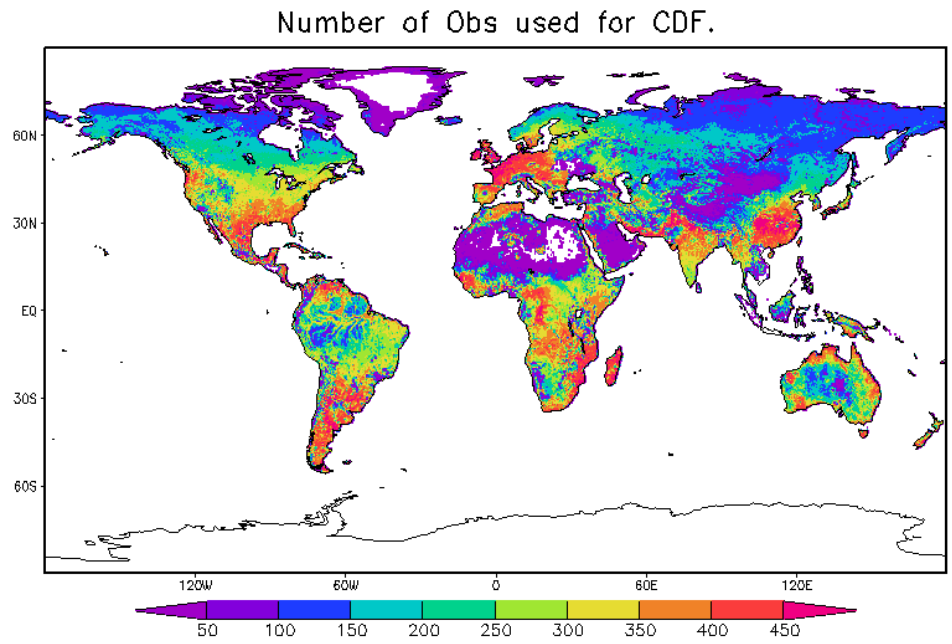
Algorithm and Refinement:

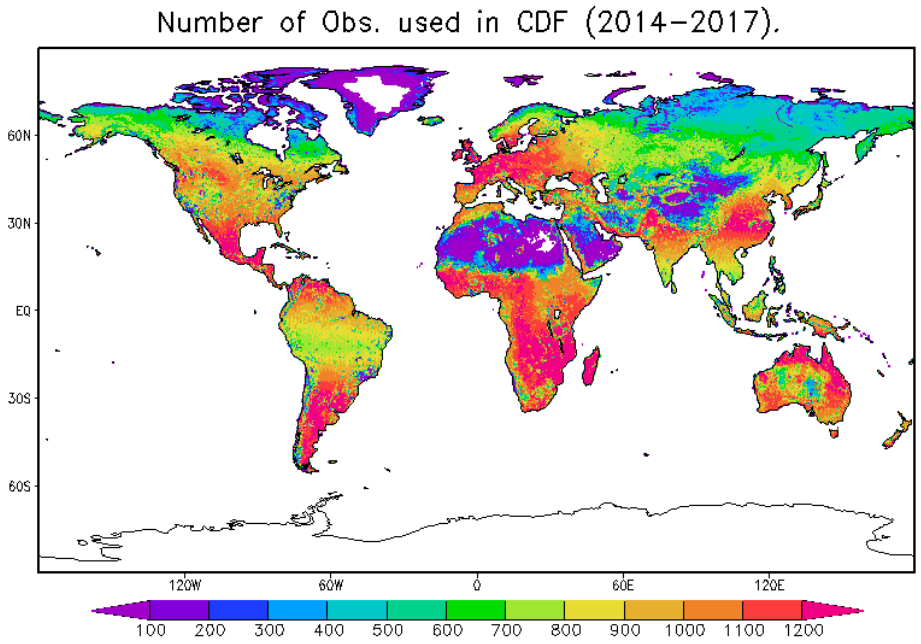
- The LPRM algorithm was used to retrieve Vegetation Optical Depth (VOD) from TBv and TBh
- Derive VOD climatology for Single Channel Algorithm (SCA) of soil moisture retrieval with historical AMSR2 data
- Inverse soil moisture from TBh using the VOD scaled to VOD climatology with CDF matching
- **Improved temporal dynamics and spatial coverage with improved LPRM vegetation Optical Depth retrieval algorithm (below) .**
- **Improved spatial coverage with longer period of historical data for generating Cumulative Distribution Function (CDF) data base.**
- **Validation with global in situ measurement data and other products are ongoing.**



JPSS GCOM-W1/AMSR2 Soil Moisture

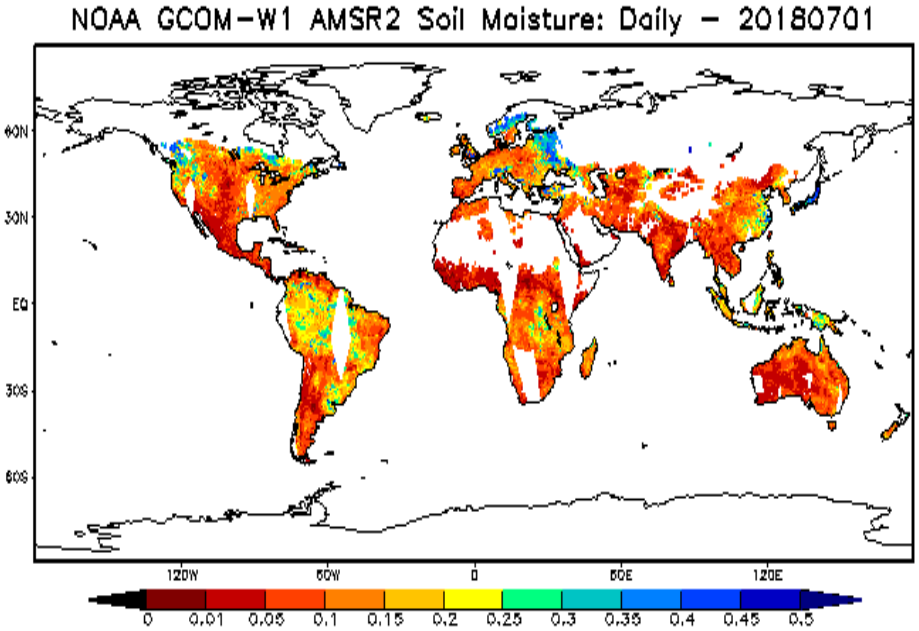
More reliable CDF with more historical AMSR2 data

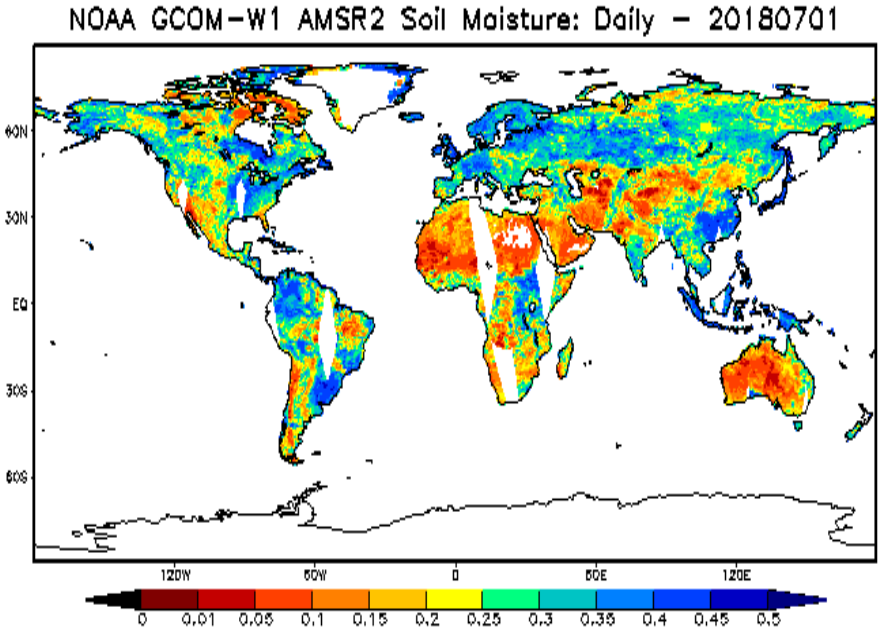




JPSS GCOM-W1/AMSR2 Soil Moisture

Better spatial coverage and the dynamic range of the final product.





JPSS PGRR Project: Sat SM for NWM

1) Comprehensive **evaluation of both NWM output and JPSS satellite retrievals of soil moisture** with independent data sets (e.g. **in situ** soil moisture measurement networks in **CONUS** and ground radar network **precipitation data**) for certain time periods and locations and for **some major hydrological events** (e.g. hurricane caused flooding);
2) Identification of **NWM needs/requirements** for JPSS soil moisture data products in terms of **spatial, temporal resolution, operational data formats, and accuracies**;
3) Development and validation of JPSS improved soil moisture data products that meet the NWM data needs through data mining approaches to **downscale AMSR2 C-band soil moisture retrievals (25km) to 375m** scale with VIIRS 375m Vegetation Index, 750m VIIRS land surface temperature, 9km AMSR2 Ka-band brightness temperature, and diurnal ABI observations as well as L-band observations from NASA SMAP and ESA SMOS and ancillary data (e.g. DEM, 30m land cover type);
4) **Streamline the production procedure** of these products for potential operational applications in NWM.

Ground SM Measurements for Validation

CREST-SMART Network

Millbrook, NY

M. Temimi, et al., 2011

Tibetan Plateau

Tibet, China; *K. Yang, et al., 2013*

USDA-ARS SM Networks

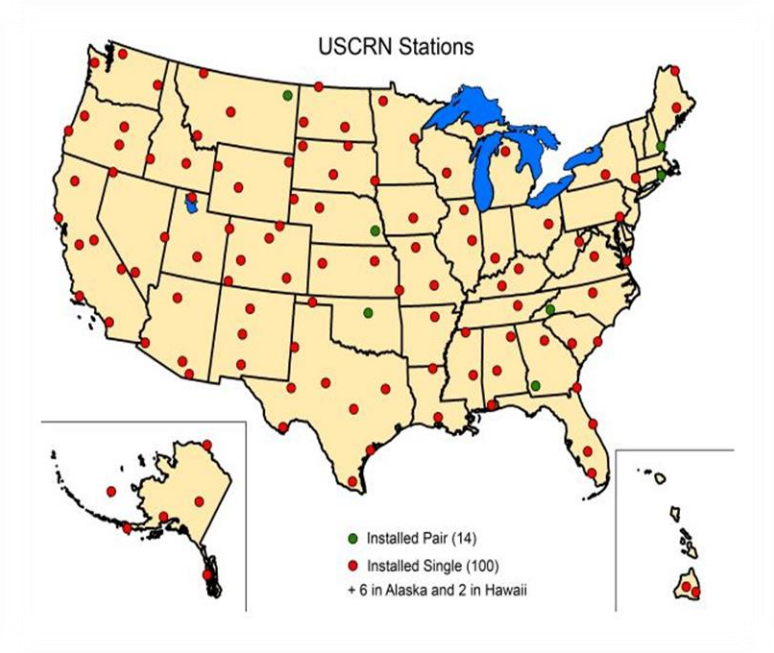
M. H. Cosh, et al. 2008

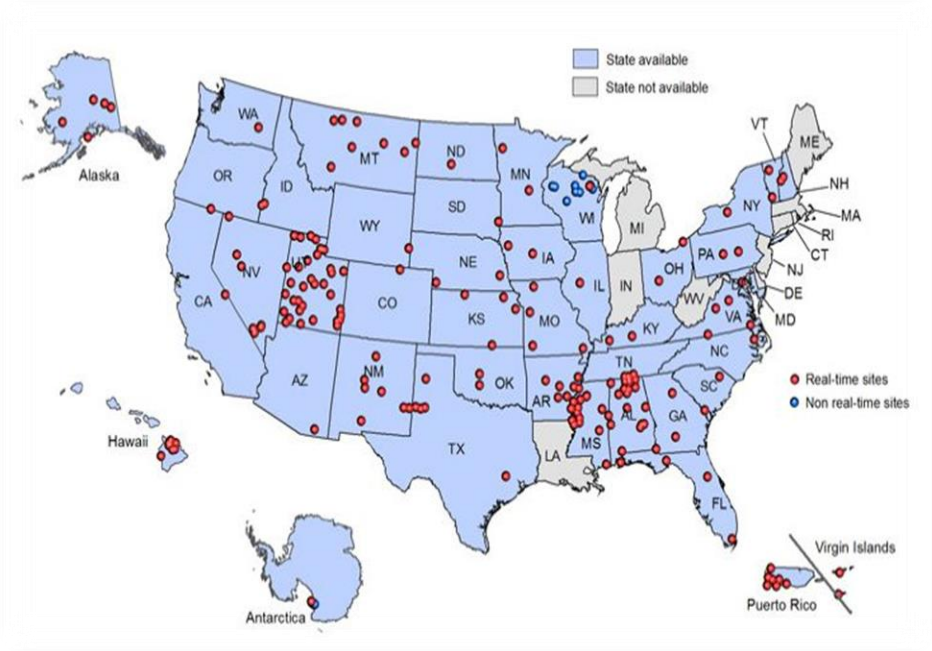
OzNet

Australia; *A. B. Smith, et al., 2012*

Ground SM Measurements for Validation

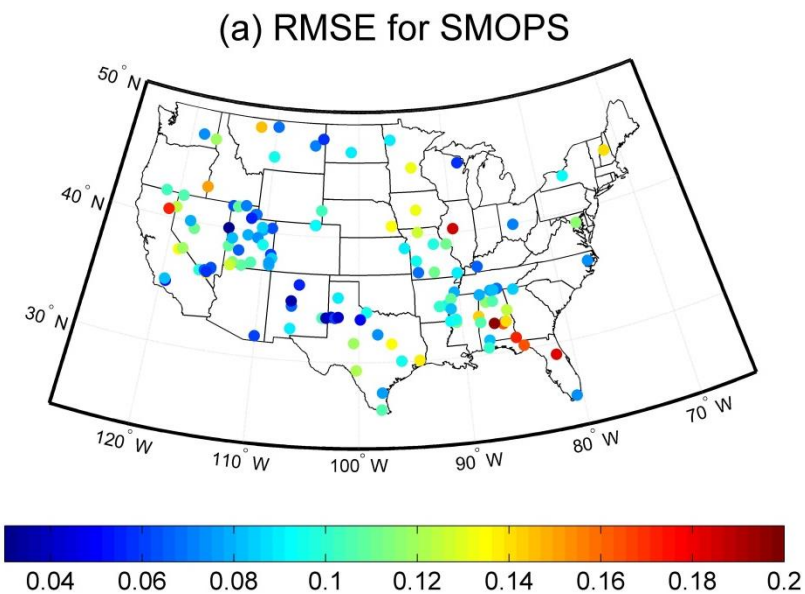
NOAA US Climate Reference Network

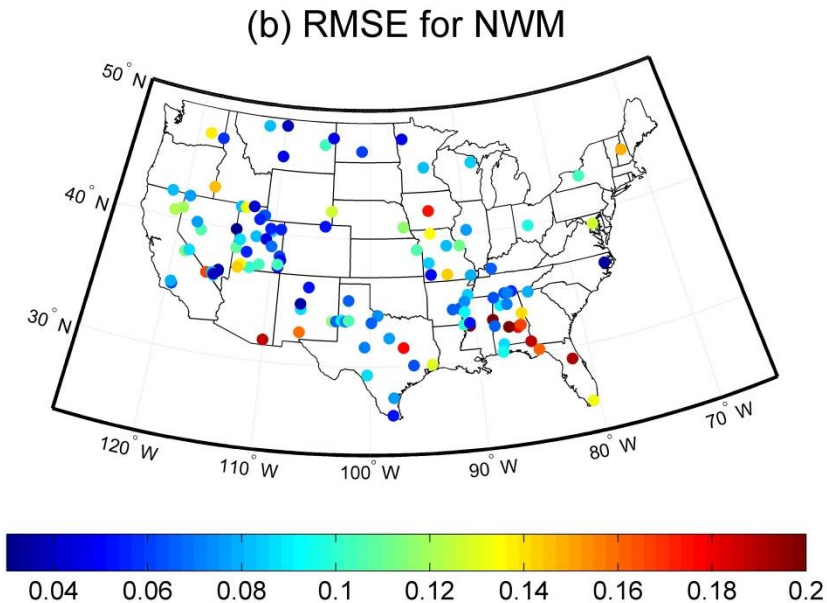


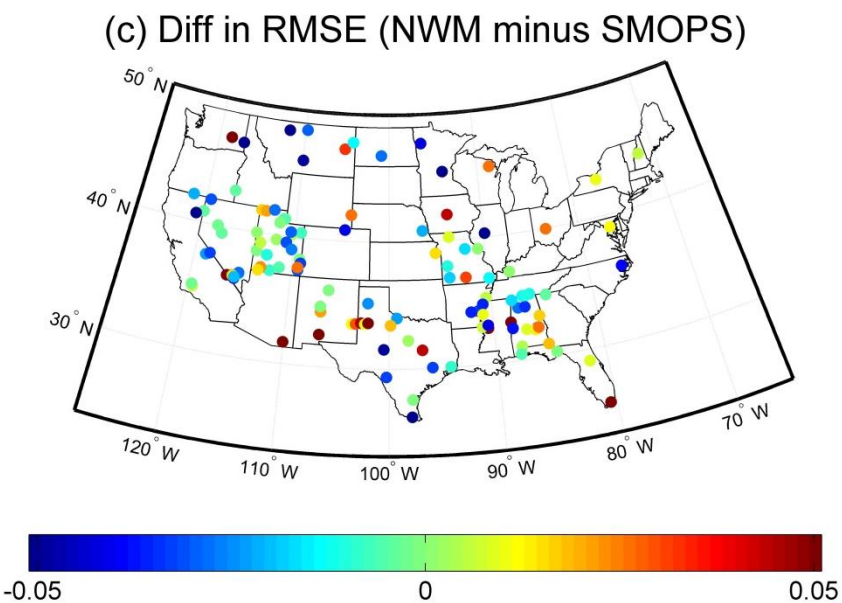


USDA Soil Climate Analysis Network (SCAN)

SMOPS SM Comparison with NWM SM







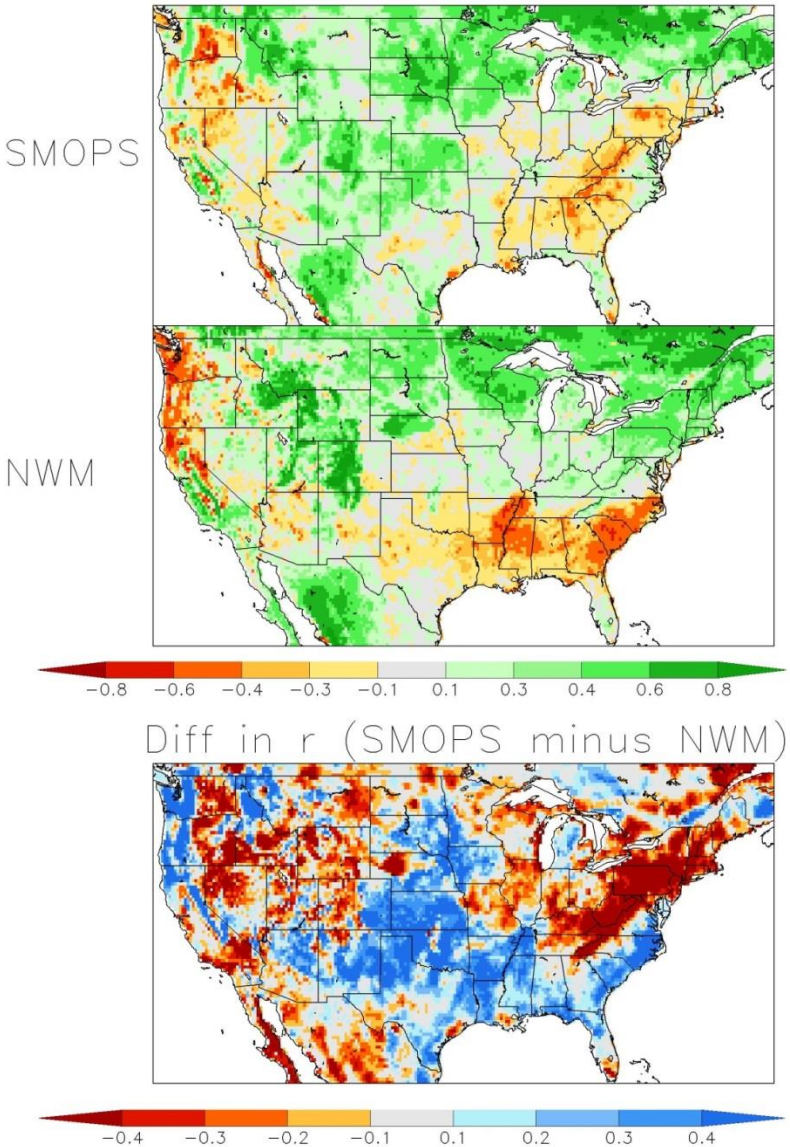
SCAN observations-based RMSE for

(a) SMOPS blended SM,

(b) NWM-based 0-10 cm SM,

(c) their differences.

SMOPS SM Comparison with NWM SM



From top to bottom:
r between 8-daily EVI and
(**Top**) 8-daily SMOPS blended SM,
(**Middle**) 8-daily NWM-based 0-10 cm SM estimations, as well as
(**Bottom**) their differences for a lag of SM preceding EVI by 8-day. The grey color shading indicates insignificant correlations (p>0.05).

The stronger correlations between SMOPS and EVI are observed **over the Great Plains and in the southeastern United States, where moisture-limiting (as opposed to energy limiting) was identified for vegetation growth** (Karnieli et al, 2010, JC; Anderson et al., 2011, JC.)

Downscaling for High Resolution for NWM

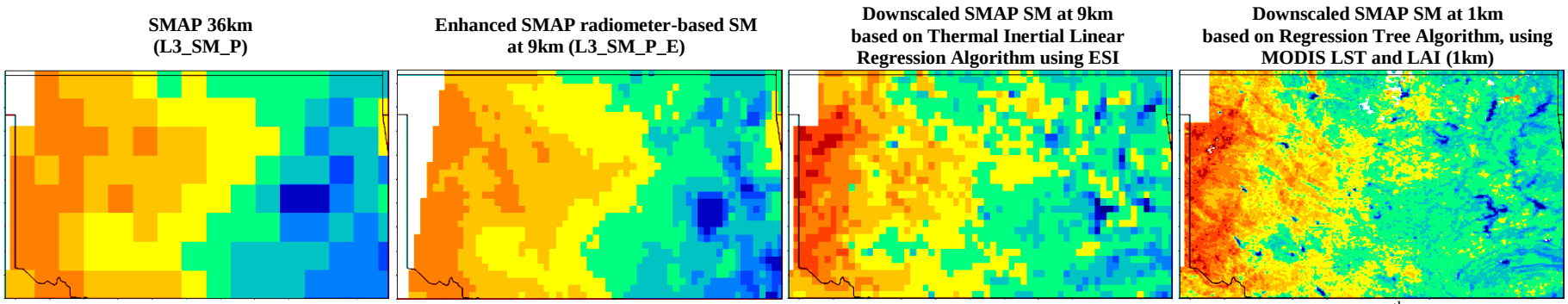


Figure 1. Comparison of SMAP SM data sets to be validated, over Oklahoma region (100.15W~ 94.53W, 34.2N~37.06N), on April 30th, 2015, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

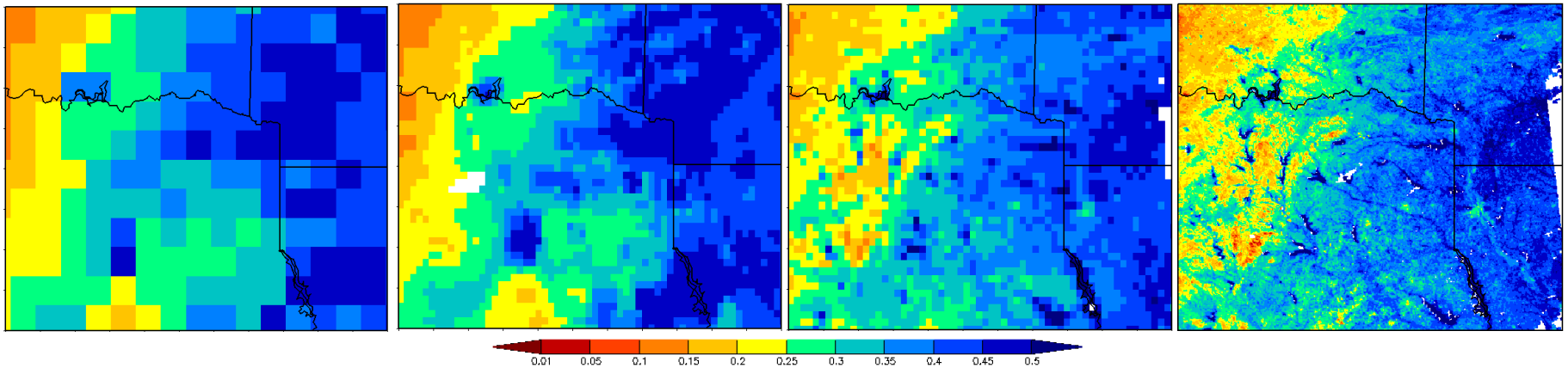
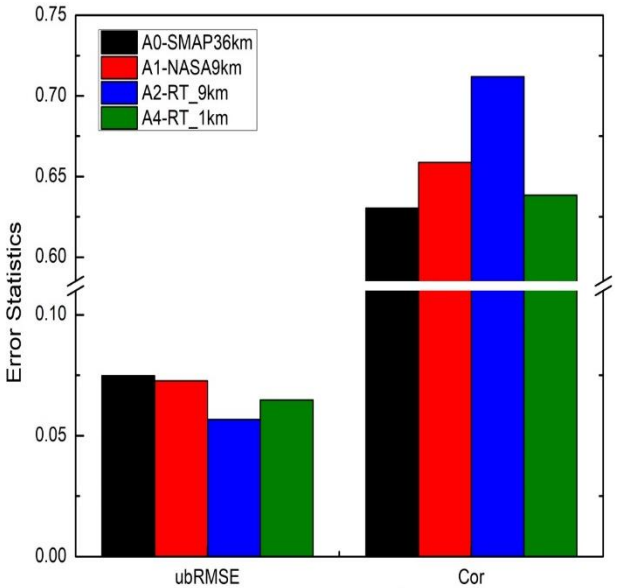
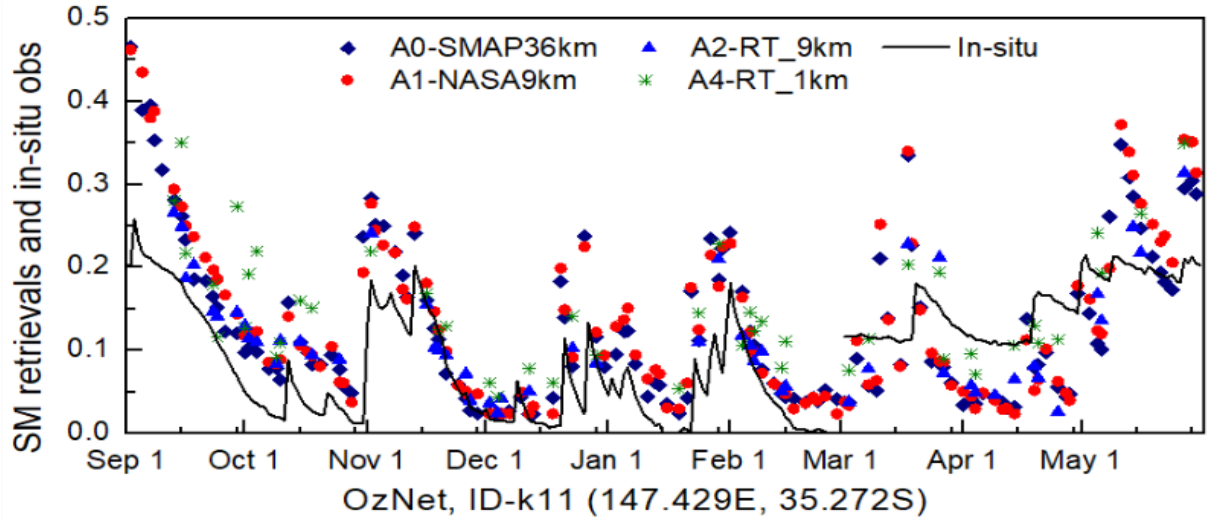


Figure 2. Comparison of SMAP SM data sets to be validated, over Texas region (98W~ 92.5W, 31N~35N), on April 2nd, 2016, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

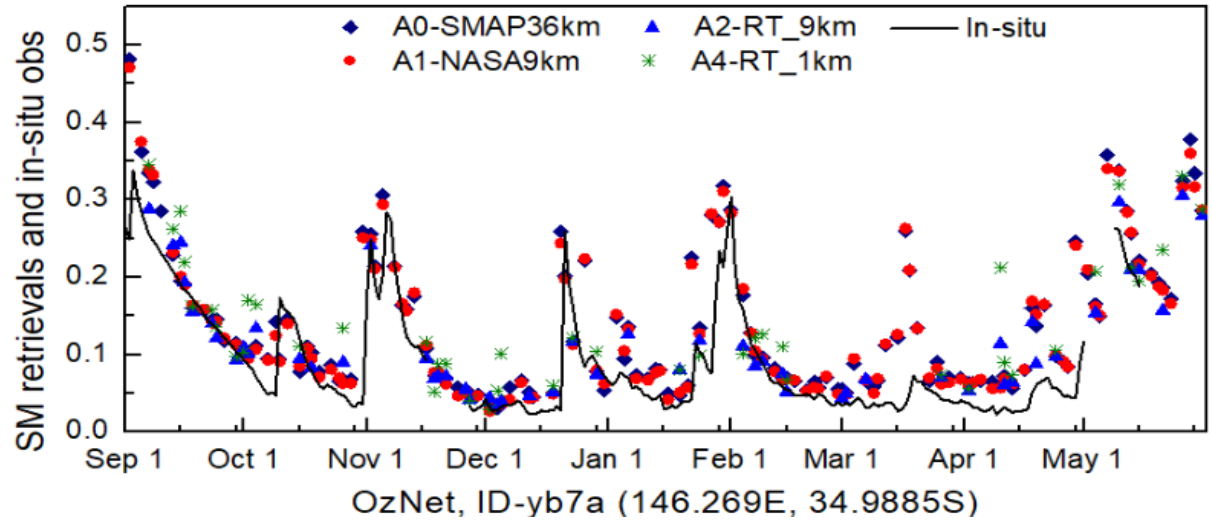
Downscaling for High Resolution for NWM



Validation against OzNet network, Australia. Sept. 2015 -- May 2016;
Averaged over total 38 in-situ sites ~(34.899S, 146.313E)



ubRMSE	A0-SMAP36	A1-NASA9	A2-RT_9km	A4-RT_1km
k11	0.0723	0.0748	0.0529	0.0621
yb7a	0.0556	0.0554	0.0434	0.0352



Summary and Path Forward

- *NESDIS SMOPS has been ingesting global soil moisture data products from available microwave satellite observations including the JPSS/GCOM-W project supported AMSR2*
- *With longer data record, AMSR2 soil moisture data product has larger spatial coverage and is expected to have higher accuracy*
- *JPSS PGRR program supported project on soil moisture for National Water Model has started to comprehensively evaluating both satellite retrievals and model estimates of SM*
- *Leveraging NASA SMAP project, SMOPS soil moisture is being downscaled to high spatial resolution to meet NWM needs*
- *SMOPS team plans to upgrade the software system in order to operationally generate high resolution soil moisture data products for NOAA and other users if supports will be available*

Alaska Hydrologic Remote Sensing: Current Capabilities and Needs

Alaska Pacific River Forecast Center

August 29, 2018

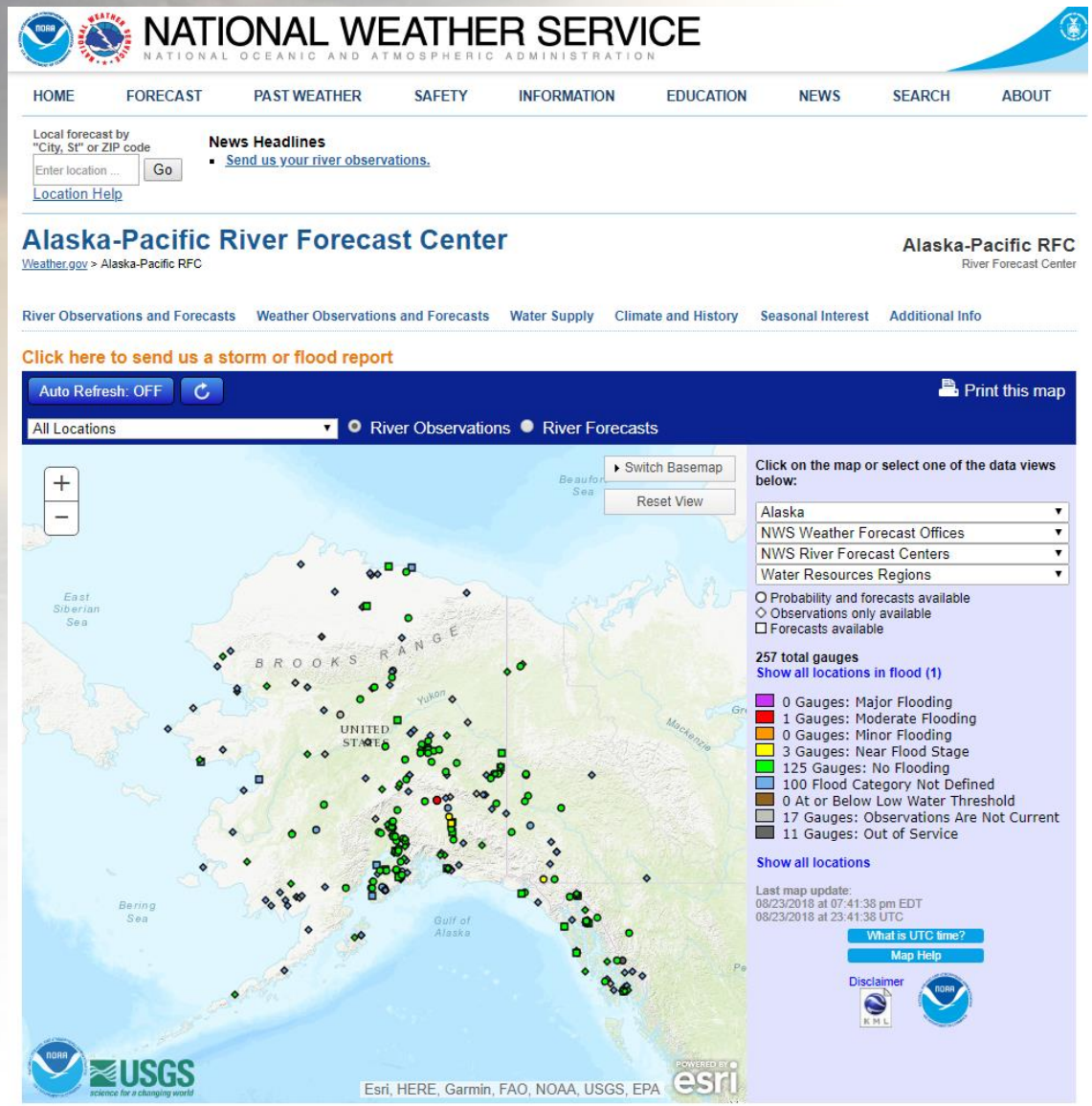
Outline

- NOAA's Hydrologic Endeavor in Alaska
- Current JPSS products used
- Gaps for future R&D

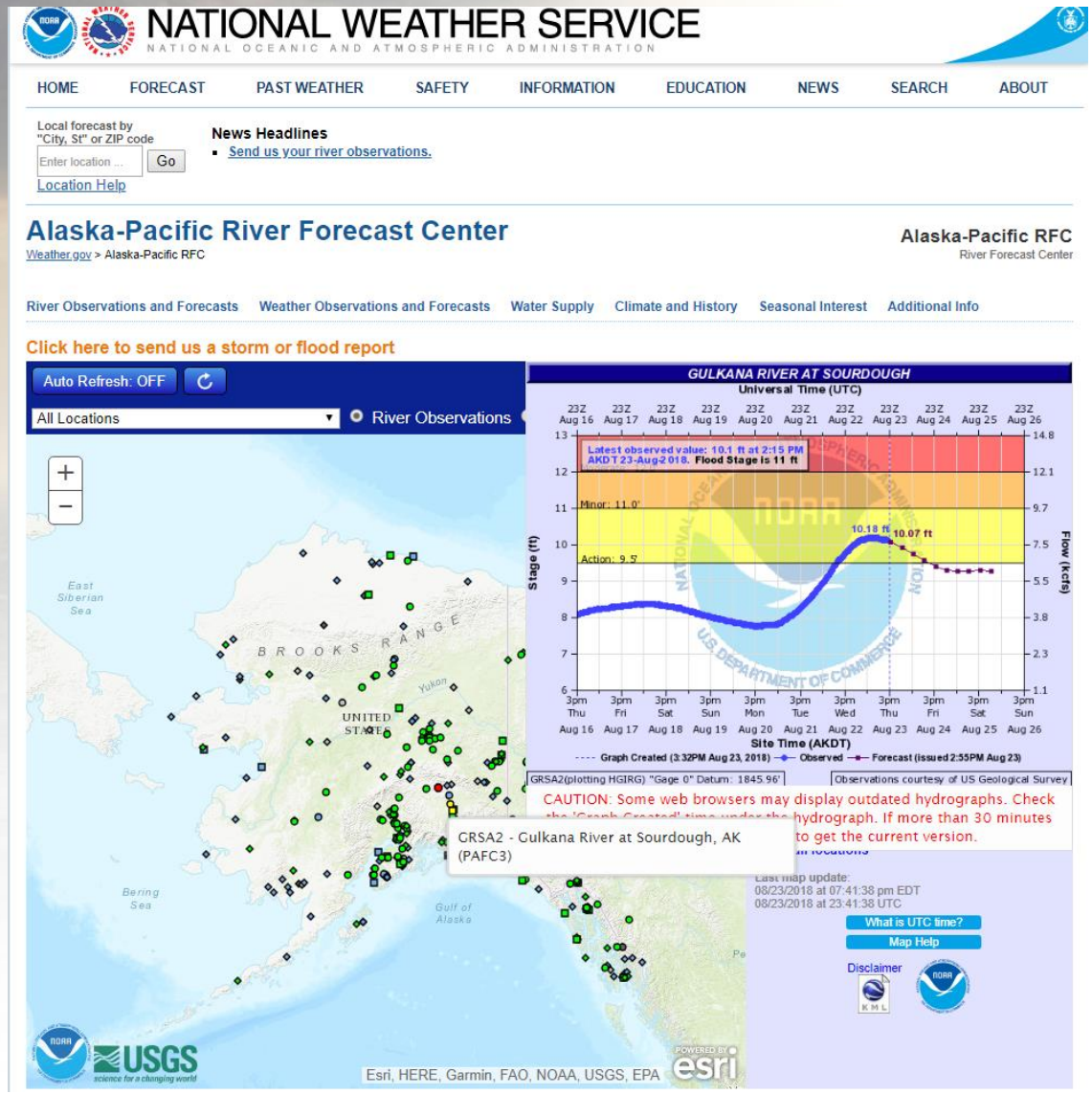
Outline

- NWS Hydrologic Endeavor in Alaska
- Current JPSS products used
- Gaps for future R&D

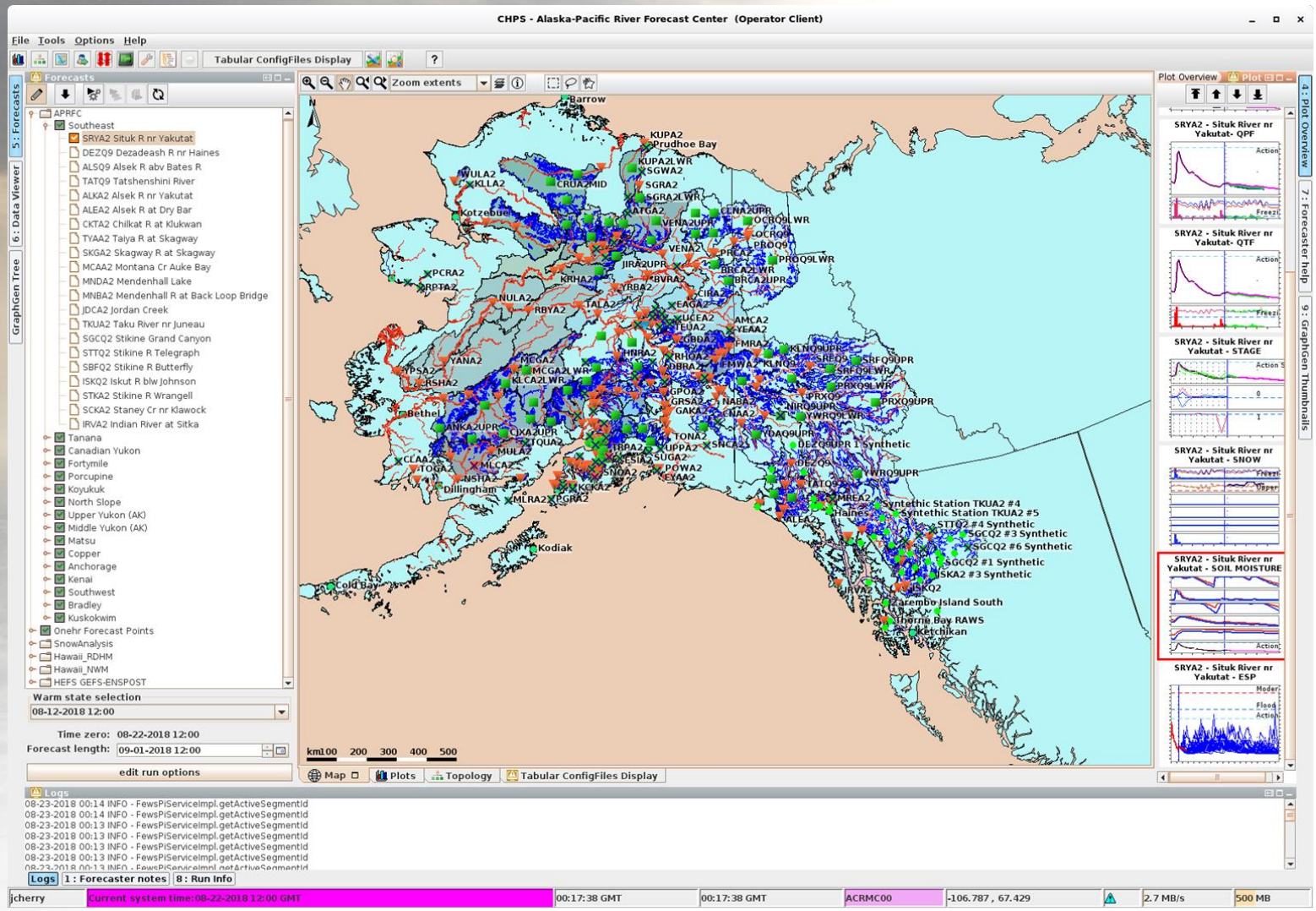
NWS Hydrology Mission in Alaska: Current Graphical Products



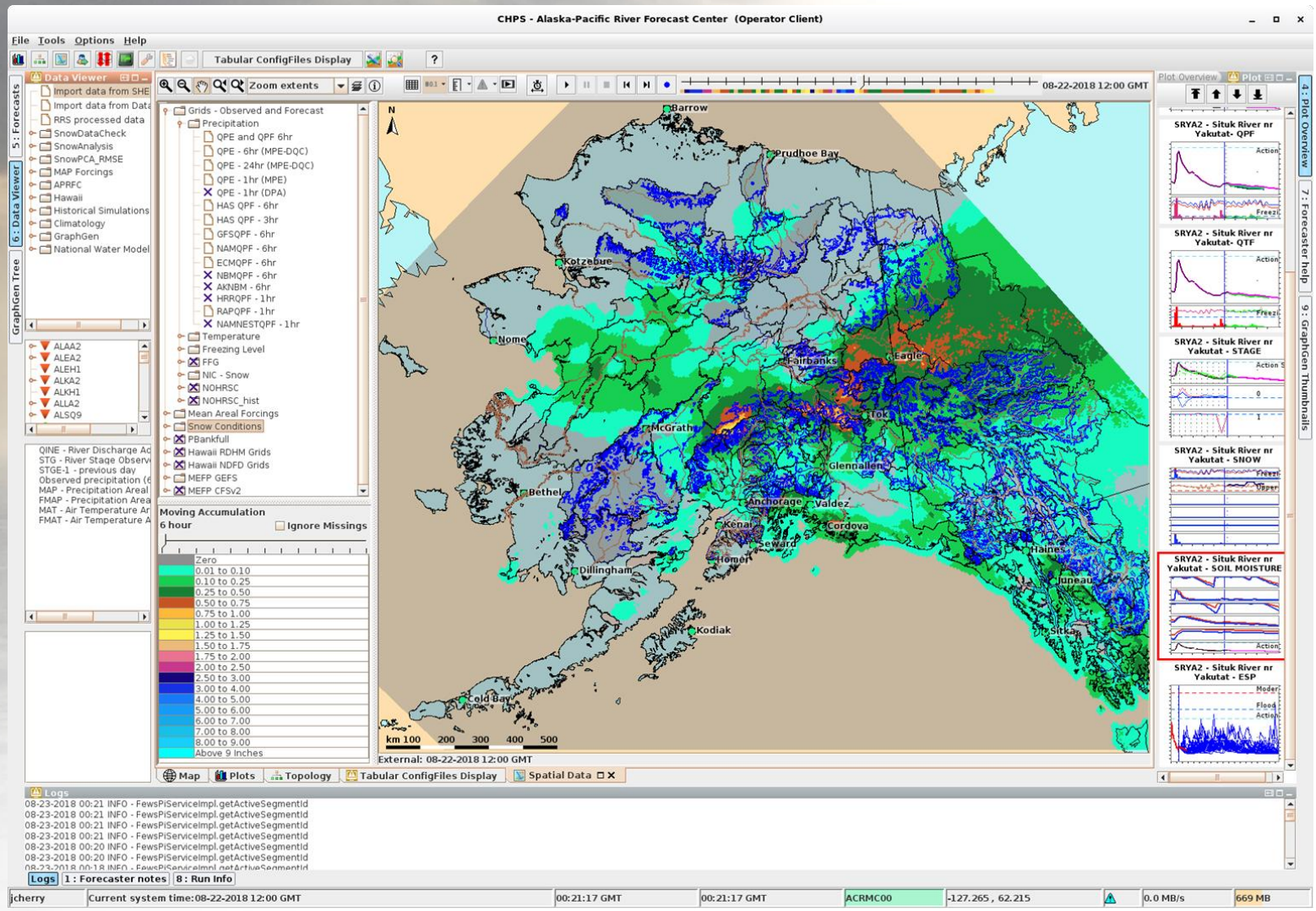
NWS Hydrology Mission in Alaska: Current Graphical Products



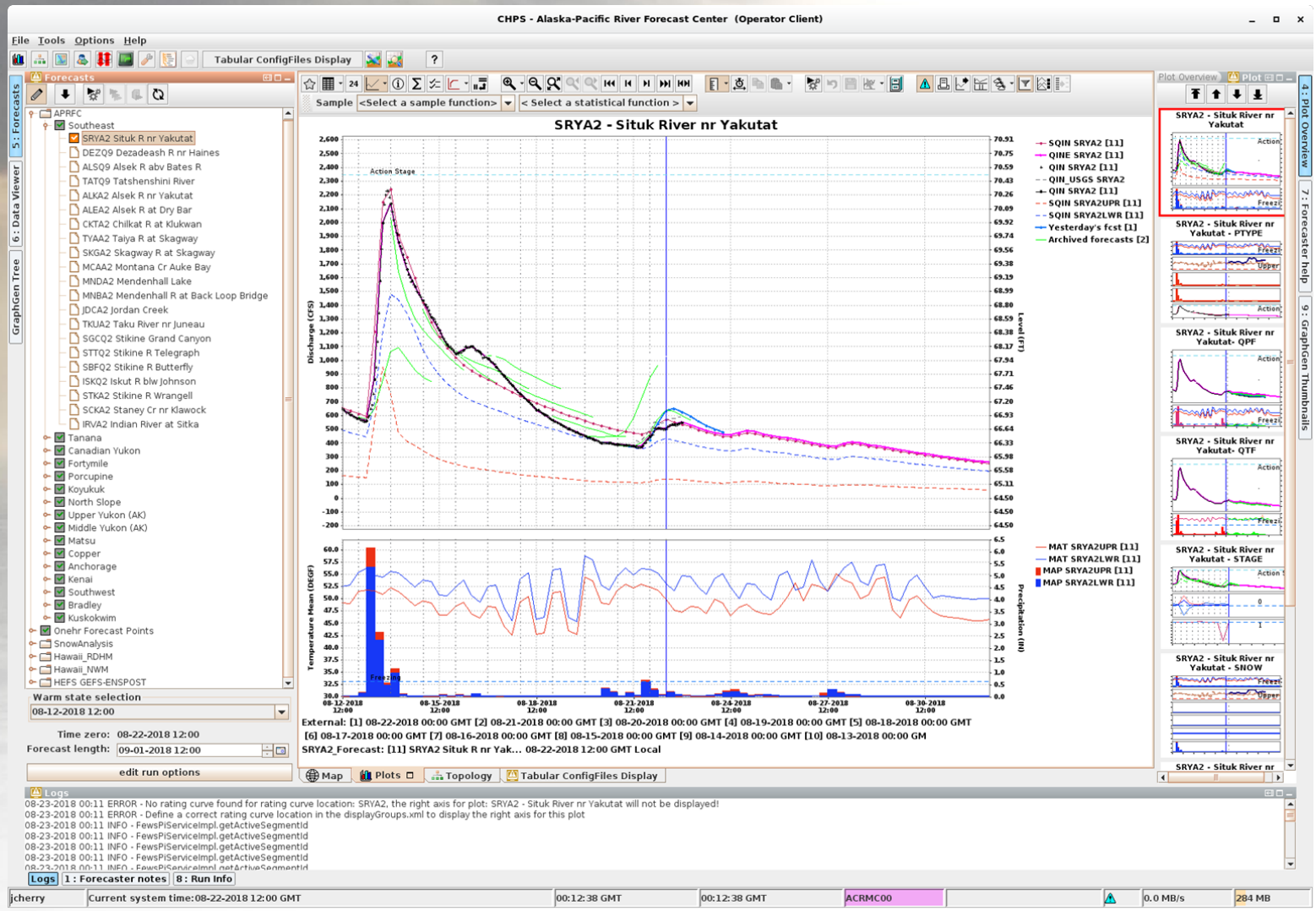
NWS Hydrology Mission in Alaska: Current Model Framework



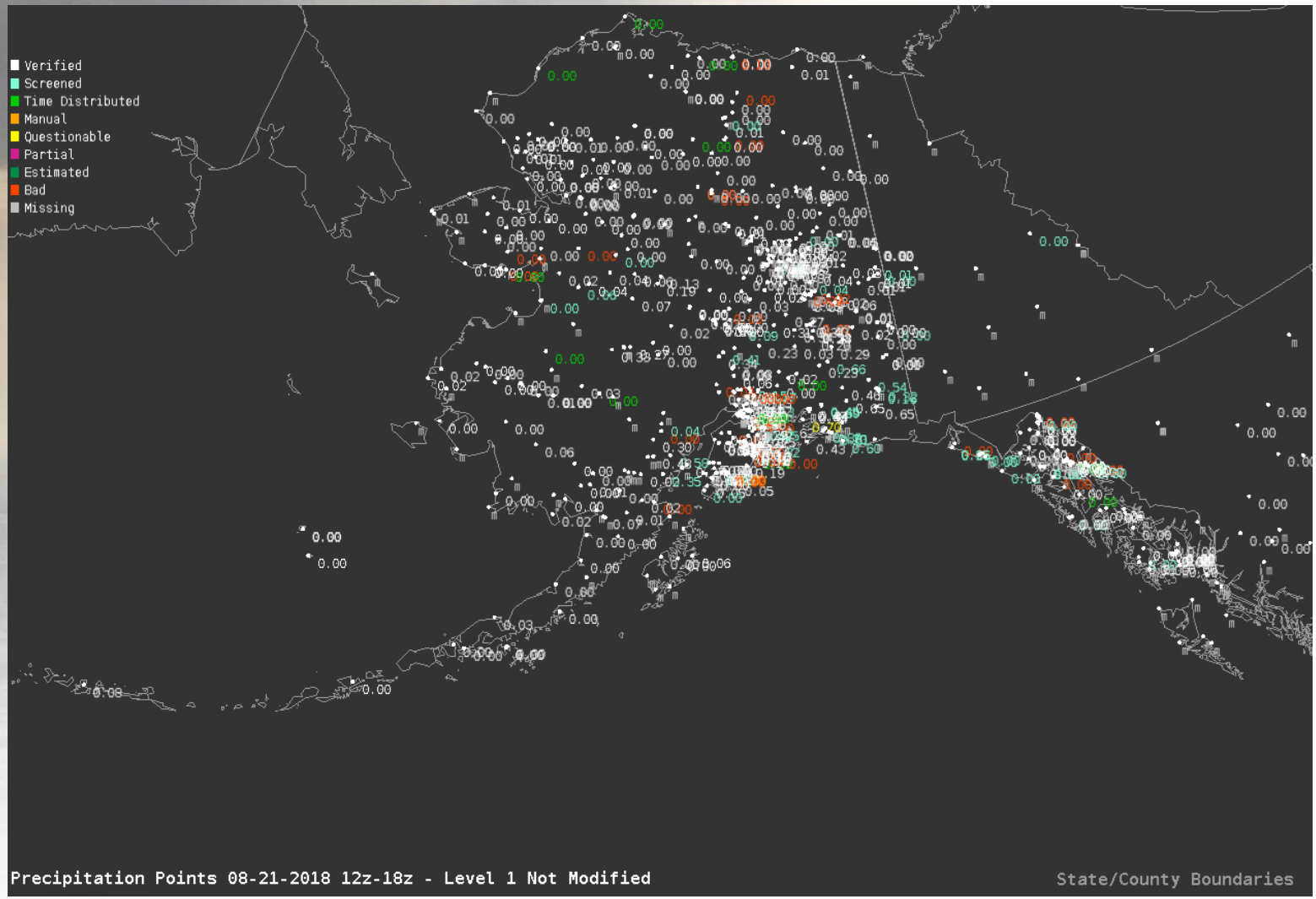
NWS Hydrology Mission in Alaska: Current Model Framework



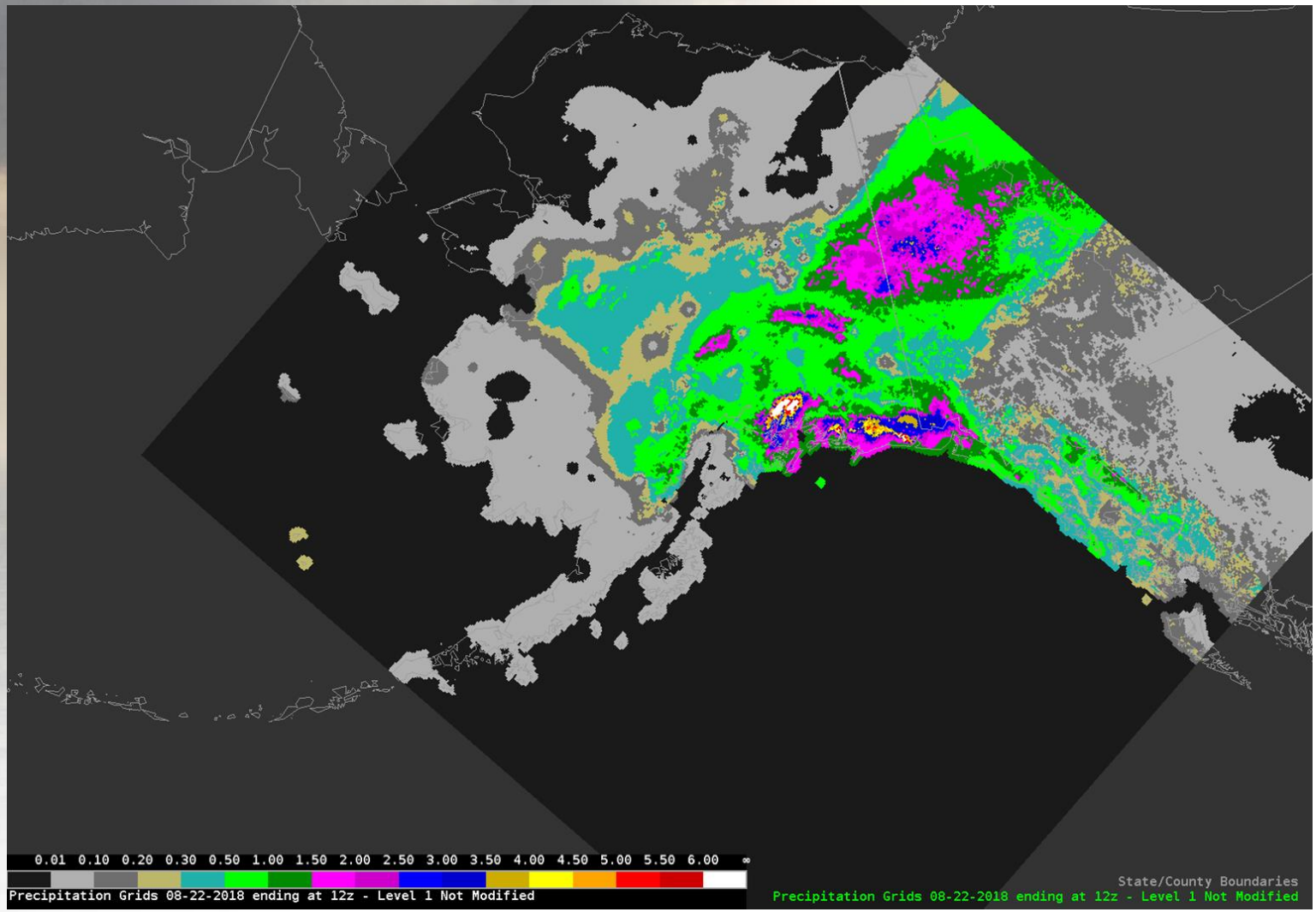
NWS Hydrology Mission in Alaska: Current Model Framework



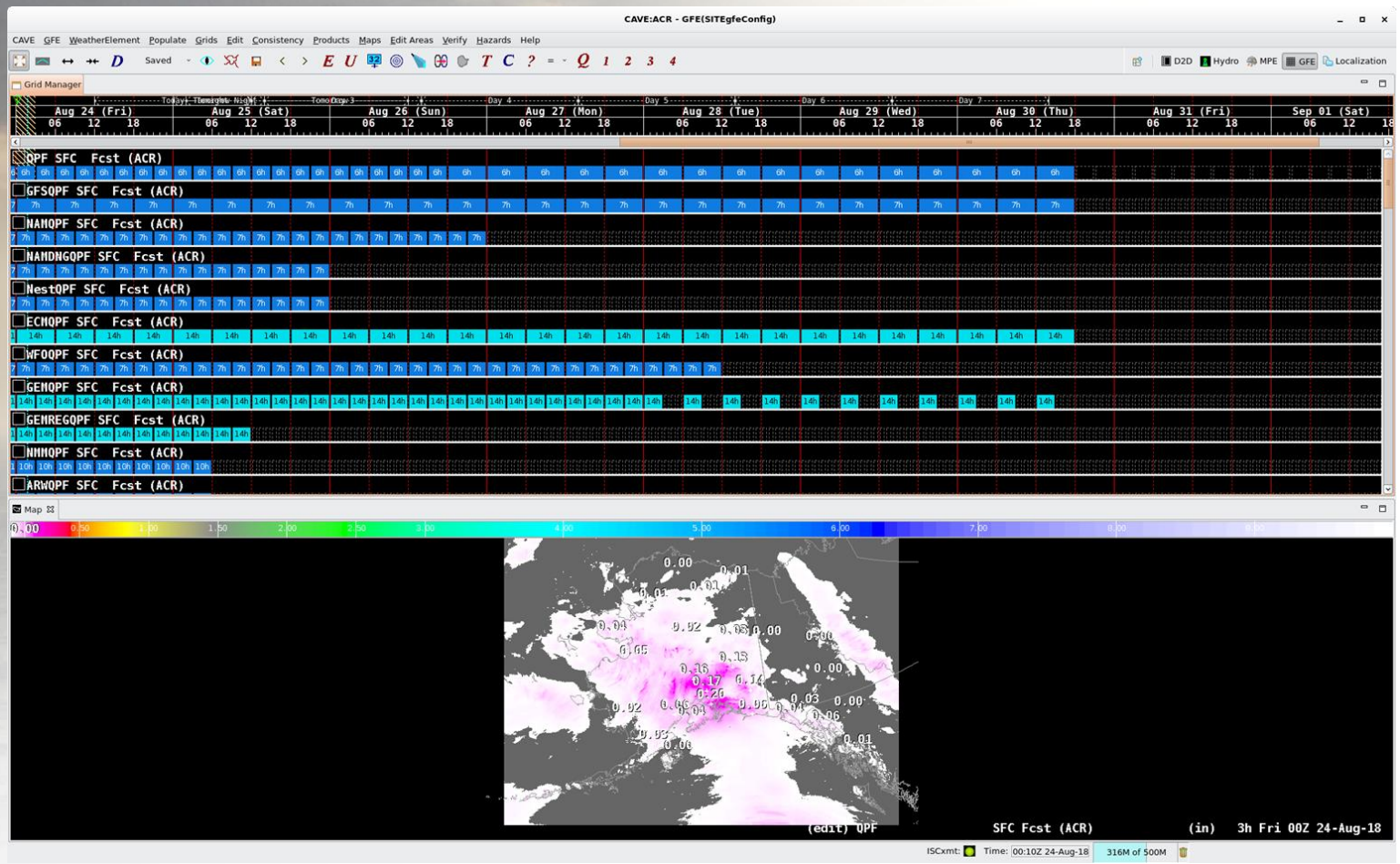
NWS Hydrology Mission in Alaska: Current Model Forcing



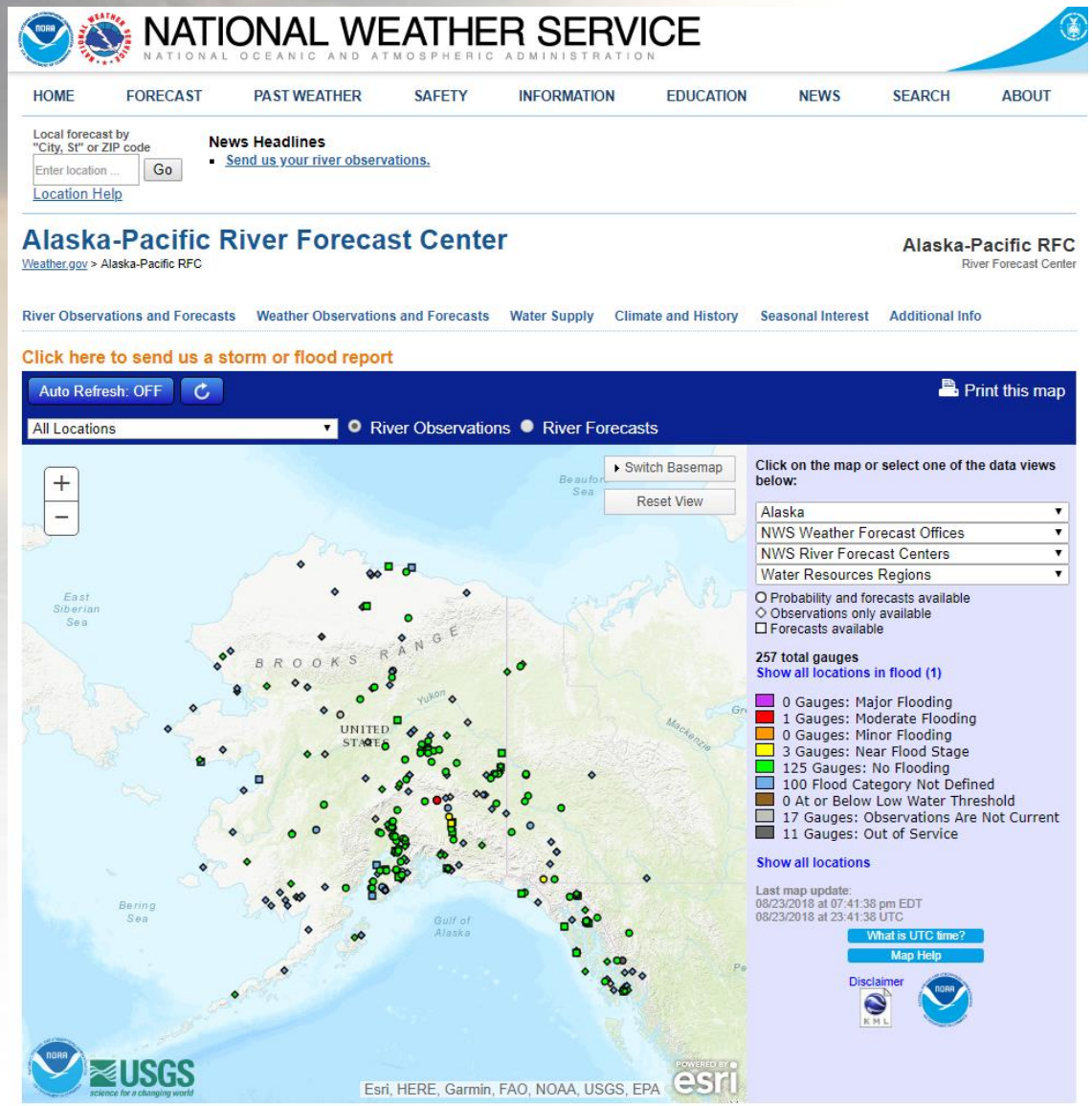
NWS Hydrology Mission in Alaska: Current Model Forcing



NWS Hydrology Mission in Alaska: Current Model Forcing



NWS Hydrology Mission in Alaska: Sparse Gage Network



NWS Hydrology Mission in Alaska: Current Text Products

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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Forecasts and Info

Weather.gov > Alaska-Pacific RFC > Forecasts and Info

Alaska-Pacific RFC
River Forecast Center

River Observations and Forecasts | Weather Observations and Forecasts | Water Supply | Climate and History | Seasonal Interest | Additional Info

Text Products

Name	Description	Last Updated
FLOOD	Flood Warnings, Watches or Statements	21 August 2018 10:42 AKDT
NOAK48PACR	Public Information Statement	unavailable
AGAK78PACR	HydroMeteorological Discussion	23 August 2018 14:55 AKDT
FGAK78PACR	Spring Breakup Outlook	14 June 2018 14:57 AKDT
SRAK48PACR	Breakup Summary	05 June 2018 12:47 AKDT
SRAK47PAJK	River Forecast for Southeast Alaska	23 August 2018 12:02 AKDT
SRAK49PAFG_AFG	River Forecast for Chena and Tanana Basins	23 August 2018 13:02 AKDT
SRAK49PAFG_YKN	River Forecast for Northern and Western Alaska	23 August 2018 13:42 AKDT
SRAK48PAFC	River Forecast for Southcentral and Southwest Alaska	23 August 2018 15:01 AKDT
FGAK88PACR	Recreational River Forecast	23 August 2018 15:07 AKDT
FGAK57PAJK	Daily River Summary - Juneau	23 August 2018 15:08 AKDT
FGAK59PAFG	Daily River Summary - Fairbanks	23 August 2018 15:09 AKDT
FGAK58PAFC	Daily River Summary - Anchorage	23 August 2018 15:13 AKDT
FGAK58PACR	Hourly River Forecast - Hawaii	23 August 2018 15:28 AKDT

Graphic Products

Name	Description
Graphical HydroMet Discussion	Current Hydro and Meteorological Conditions
Breakup Map	Daily Breakup Map (Issued Late April-June)
48hr Flood Potential Outlook	Flood Potential or Current Flooding
24 Hour QPE	Estimate of precipitation during the past 24 hours
0-24 Hour QPF	24 Hour Quantitative Precipitation Forecast for 0 to 24 hours
24-48 Hour QPF	24 Hour Quantitative Precipitation Forecast for 24 to 48 hours
Significant Flood Outlook	5 day Flood Potential Outlook for significant flooding

Select a product to view. It will display in a new tab.

NWS Hydrology Mission in Alaska: Current Text Products

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River Forecast for Southeast Alaska

Weather.gov > Alaska-Pacific RFC > River Forecast for Southeast Alaska

Alaska-Pacific RFC
River Forecast Center

River Observations and Forecasts | Weather Observations and Forecasts | Water Supply | Climate and History | Seasonal Interest | Additional Info

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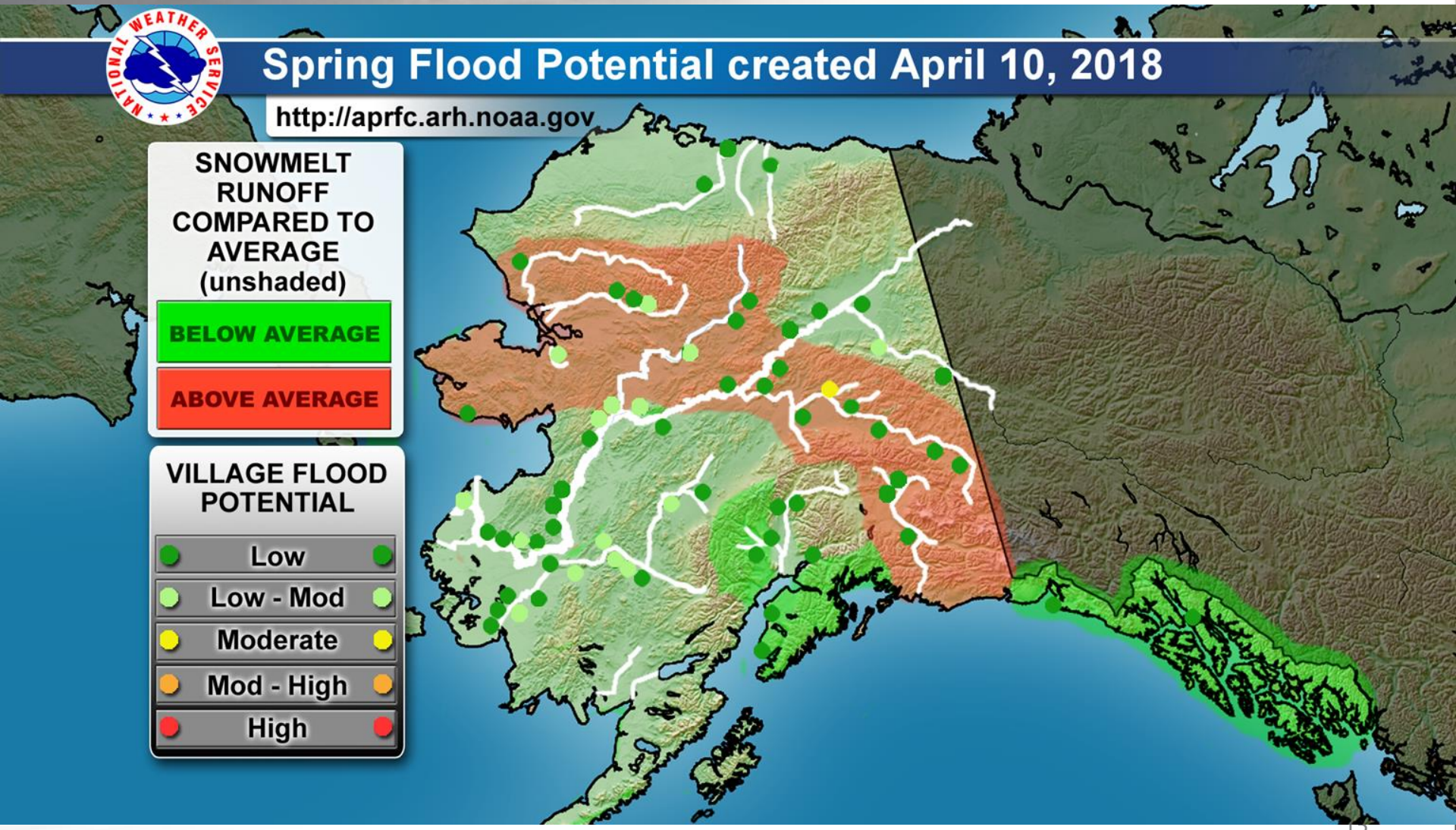
AKZ017>019-025>028--

RIVER SUMMARY AND FORECAST FOR SOUTHEAST ALASKA
NATIONAL WEATHER SERVICE JUNEAU AK
1200 PM AKDT Thu Aug 23 2018

Sites expected to be near or above flood stage: None


-----------------------------------------------------------------
|     10 AM OBSERVED STAGES          |FORECAST STAGE FOR |        |
|                                    |10PM  4AM 10AM  4PM| B-F  FLD|
|Location        Lst Wk  Wed   Thu   | Thu  Fri  Fri  Fri| Stg  Stg|
|---------------------------------------------------------------|
|Montana Creek                       |                   |        |
| at Back Lp Brg   11.3  11.2  11.3  |11.1 11.1 11.2 11.9|15.0 15.5|
|                                    |                   |        |
|Jordan Creek                        |                   |        |
| nr Juneau         7.6   7.6   7.6  | 7.6  7.6  7.9  8.1| 9.2  9.7|
|                                    |                   |        |
|Staney Creek                        |                   |        |
| nr Klawock        7.2   7.1   7.1  | 7.1  7.1  7.1  7.1|15.0 16.5|
-----------------------------------------------------------------
-----------------------------------------------------------------
|         10 AM OBSERVED STAGES      |10AM FORECAST STAGE| B-F  FLD|
|Location        Lst Wk  Wed   Thu   |  Fri   Sat    Sun | Stg  Stg|
|---------------------------------------------------------------|
|Situk River                         |                   |        |
| nr Yakutat       68.1  66.8  66.7  | 66.7  66.6    -   |70.5 71.5|
|                                    |                   |        |
|Alsek River                         |                   |        |
| abv Bates River  31.9  31.4  31.7  | 31.6  31.5    -   |31.5 32.5|
|                                    |                   |        |
|Tatshenshini River                  |                   |        |
| nr Dalton Post   16.4  16.4  16.2  | 16.1  16.1    -   |19.0 20.0|
|                                    |                   |        |
|Chilkat River                       |                   |        |
| at Klukwan      124.0 124.7 123.9  |123.8 123.8    -   |127.0 128|
|                                    |                   |        |
|Taiya River                         |                   |        |
| nr Skagway       14.9  15.1  14.7  | 14.6  14.7    -   |16.0 16.5|
|                                    |                   |        |
|Skagway River                       |                   |        |
| at Skagway       22.8  23.2  22.7  | 22.6  23.1    -   |26.5 26.5|
|                                    |                   |        |
|Mendenhall Lake                     |                   |        |
| Lake Level        5.2   5.3   5.7  |  5.7   6.0    -   | 8.0  9.0|
|                                    |                   |        |
|Taku River                          |                   |        |
| nr Juneau        34.7  34.9  35.0  | 35.2  35.0    -   |41.7 43.0|
|                                    |                   |        |
|Stikine River                       |                   |        |
| at Telegraph Cr   4.8   4.5   4.5  |  4.5   4.4    -   |20.0 23.0|
| nr Wrangell      15.3  16.4  16.4  | 15.4  14.4    -   |25.0 27.0|
|                                    |                   |        |
|Iskut River                         |                   |        |
| blw Johnson R     MSG   MSG   MSG  |  7.3   7.1    -   |14.0 17.0|
-----------------------------------------------------------------
-----------------------------------------------------------------
|OTHER RIVER AND LAKE 10 AM OBSERVED STAGES OVER THE PAST WEEK    |
|                                                                 |
|                                                     | B-F  FLD|
|Location             Fri  Sat  Sun  Mon  Tue  Wed  Thu | Stg  Stg|
```

Flood Outlook Potential



Ice Jam, Rainfall, and Jökulhlaup-Generated Flooding are all Common in Alaska

Photo: NWS

Galena Flooding May 28, 2013

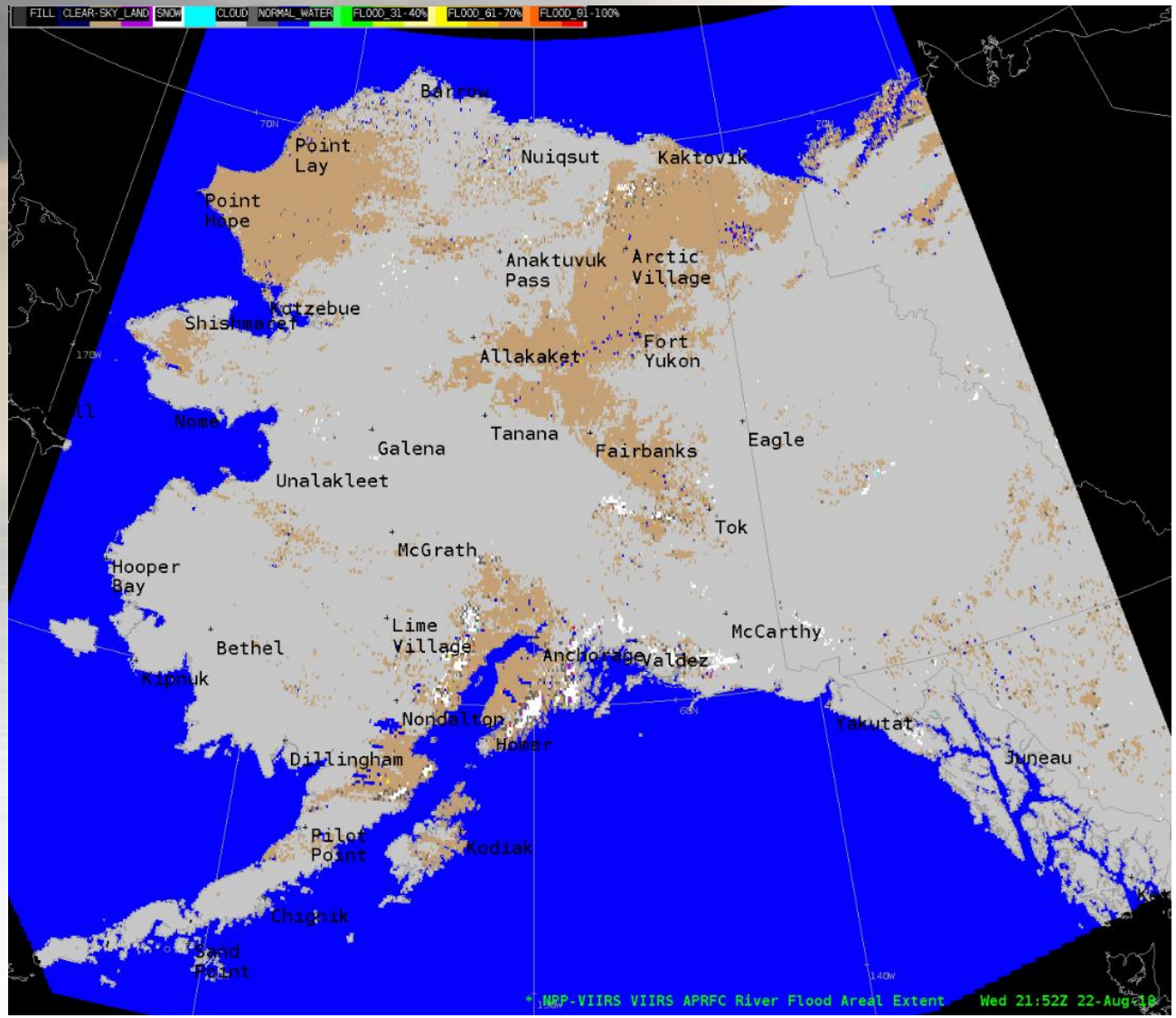
Juneau Flooding July 19, 2018

Video: KTOO Media

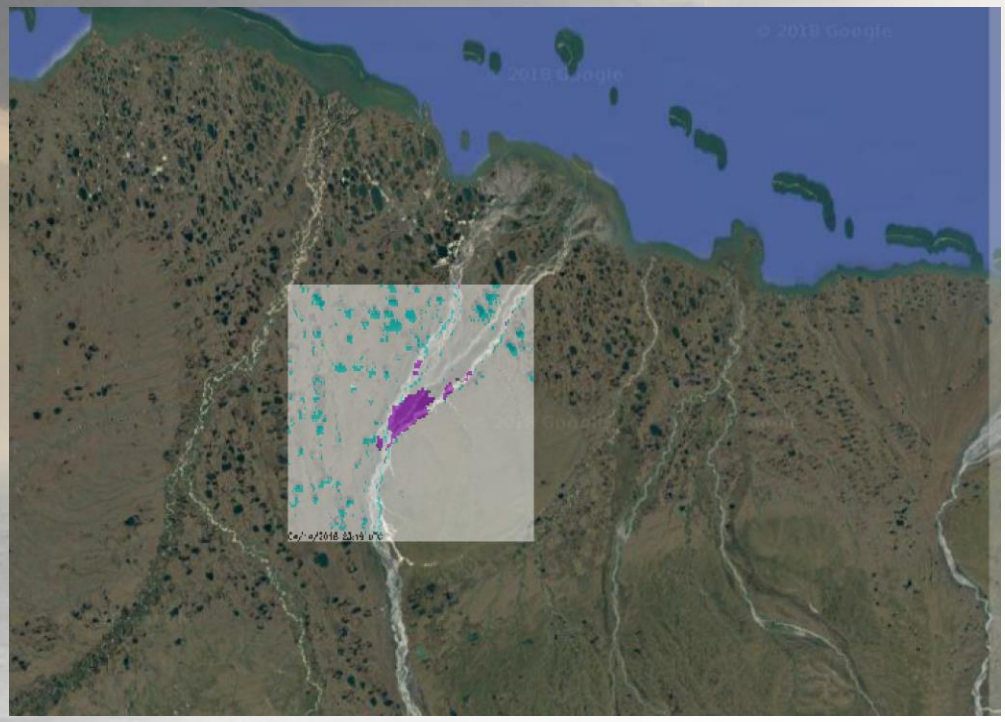
Outline

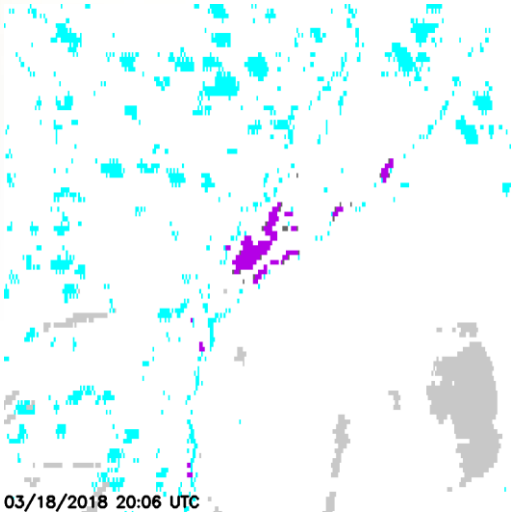
- NWS Hydrologic Endeavor in Alaska
- Current JPSS products used
- Gaps for future R&D

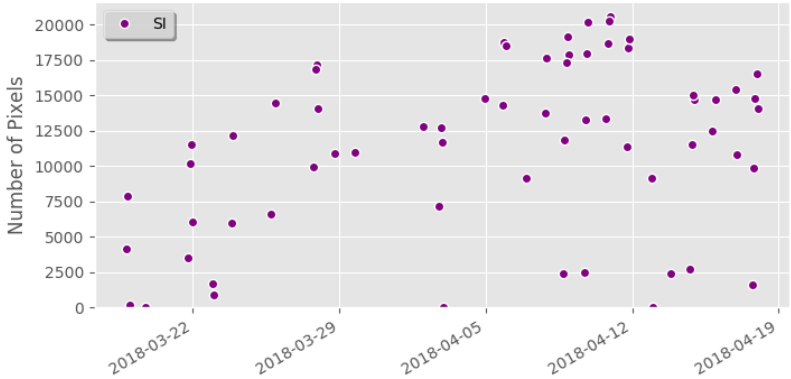
Current JPSS Workhorse for APRFC: GMU Flood and Ice Products



Sag River Aufeis







Outline

- NWS Hydrologic Endeavor in Alaska
- Current JPSS products used
- Gaps for future R&D

Gaps

- Perhaps our greatest need is a high quality QPE product
- Upcoming effort will be by the NSSL and focus on MRMS-like approach, despite radar deficiency in Alaska
- We need a satellite-derived QPE developed for Alaska conditions based on the strengths and weaknesses of data in our domain
- Also need satellite-derived Snow Water Equivalent that works in the boreal forest

Questions?

Jessica.Cherry@noaa.gov