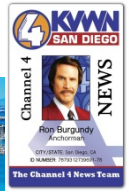
An Update on NOAA Operational Precipitation Products and NOAA's Contributions to the PMM Science Team

Ralph Ferraro[1] and Pingping Xie[2]

[1]NOAA/NESDIS/STAR; [2]NOAA/NWS/NCEP/CPC

College Park, MD

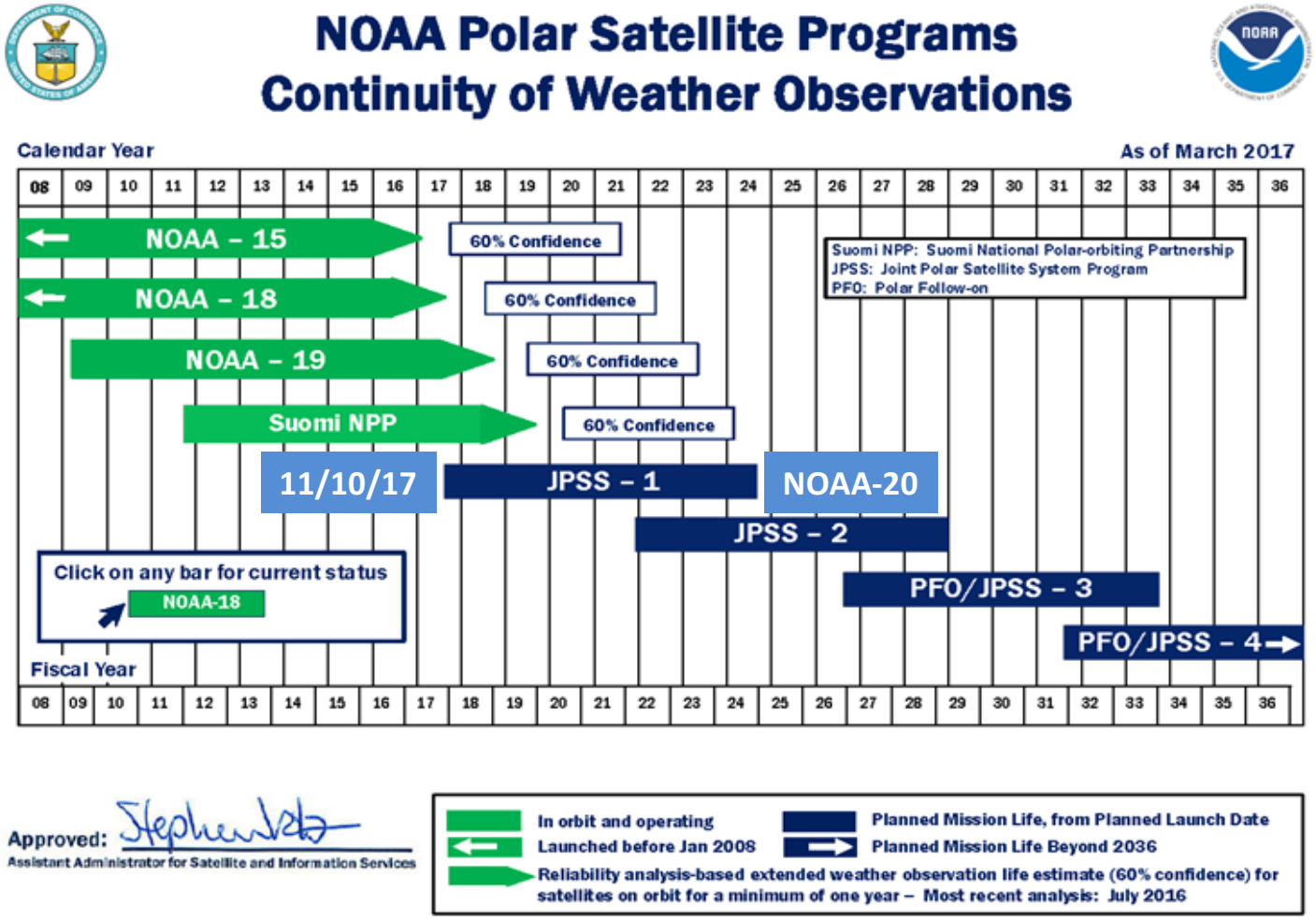
Includes contributions by other PI's and affiliates on the NOAA PMM Science Team



Outline

- Status of NOAA Satellites
- Status of NESDIS "Water" Products/use of GPM
- Examples of 2017 Hurricanes
  - GOES-16 ABI and GLM
  - S-NPP VIIRS and ATMS
- NOAA activities related to PMM Science Team and the GPM Program
- Summary

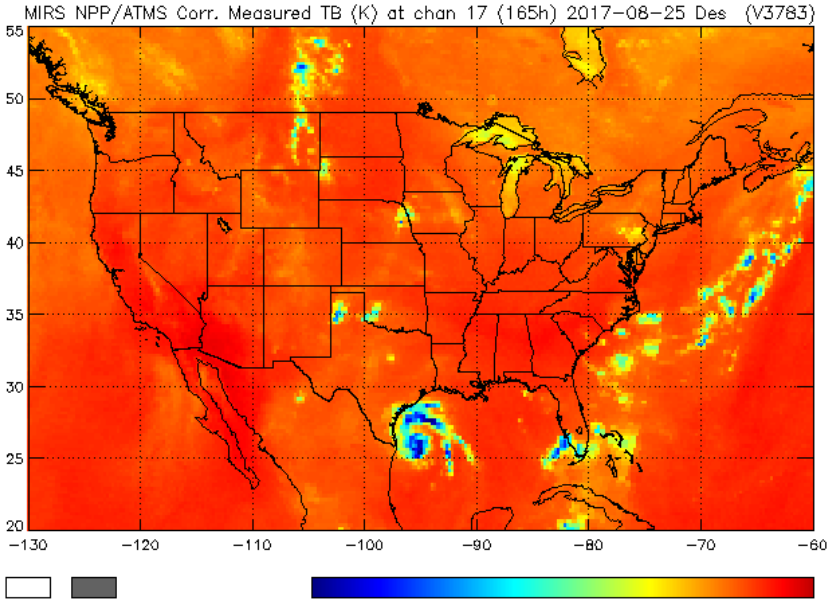
LEO Satellites

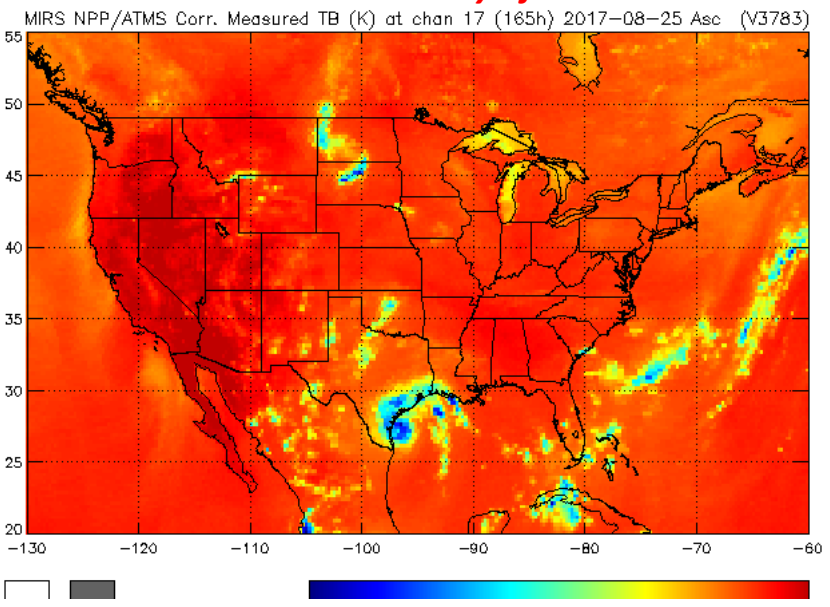


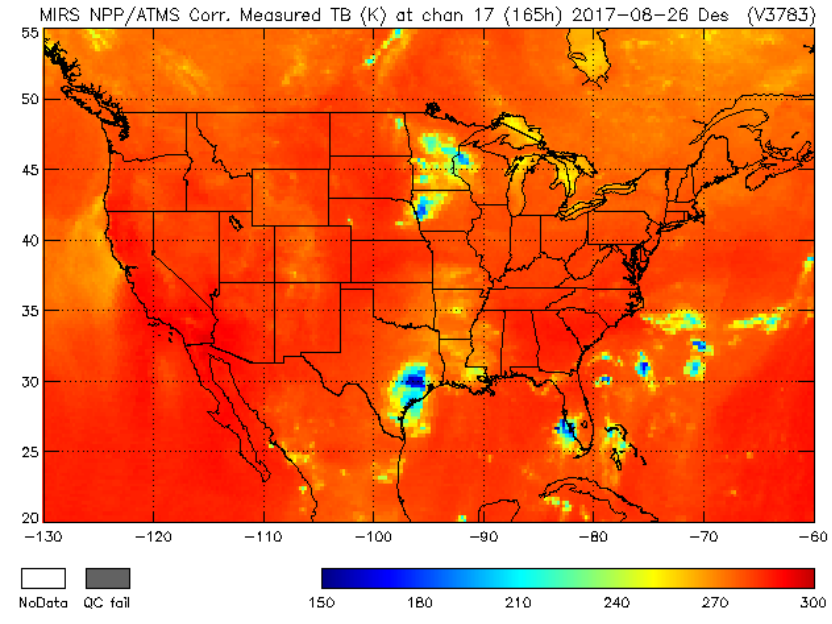
We also exploit MetOp-A, B; DMSP F-17, F-18; GPM; GCOM-W1; M-T

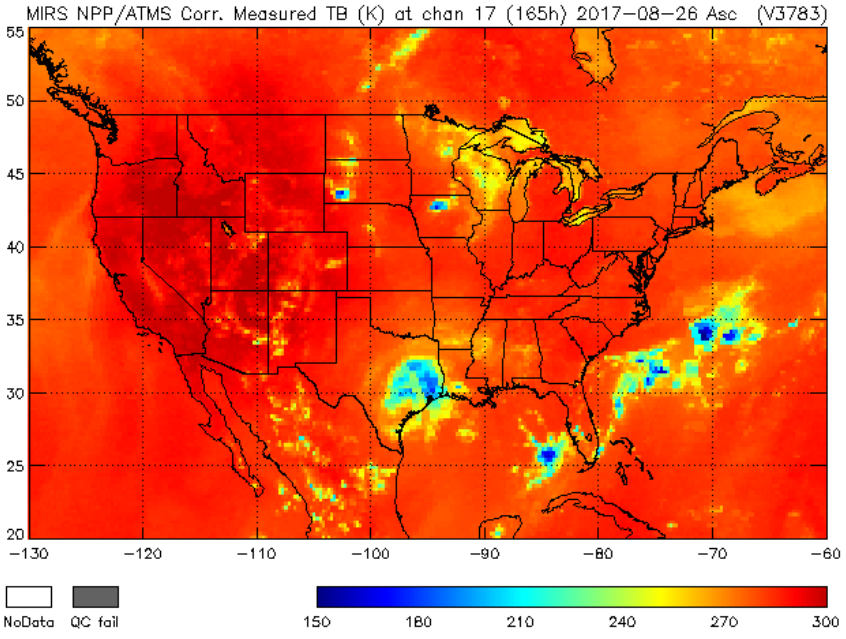
S-NPP ATMS Imagery – 165 GHz

Courtesy of STAR JPSS MiRS Team







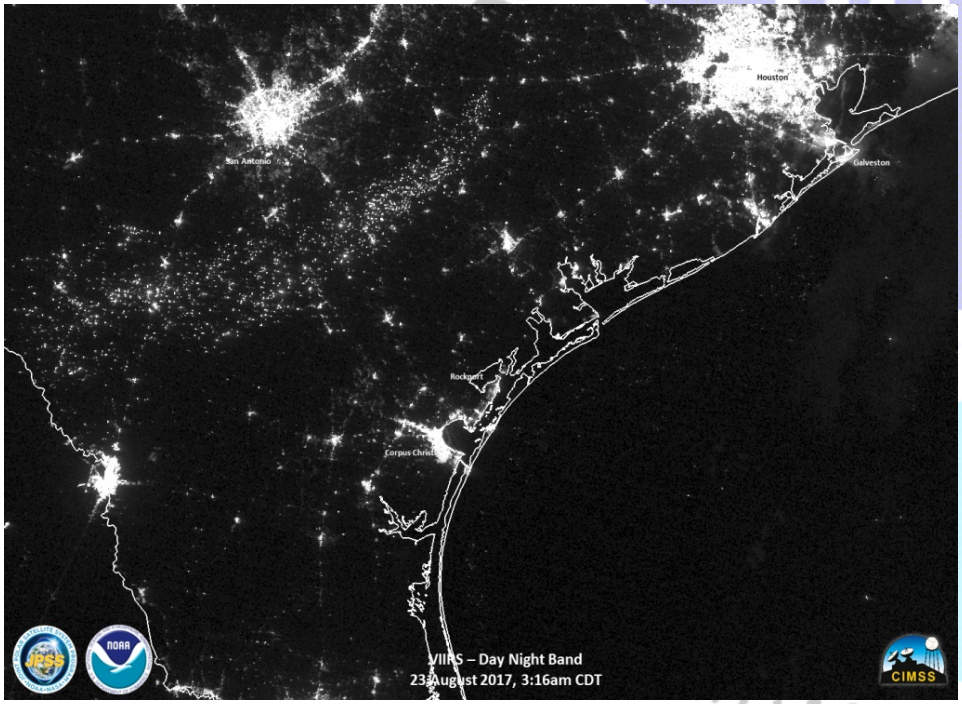


S-NPP VIIRS Day/Night Band

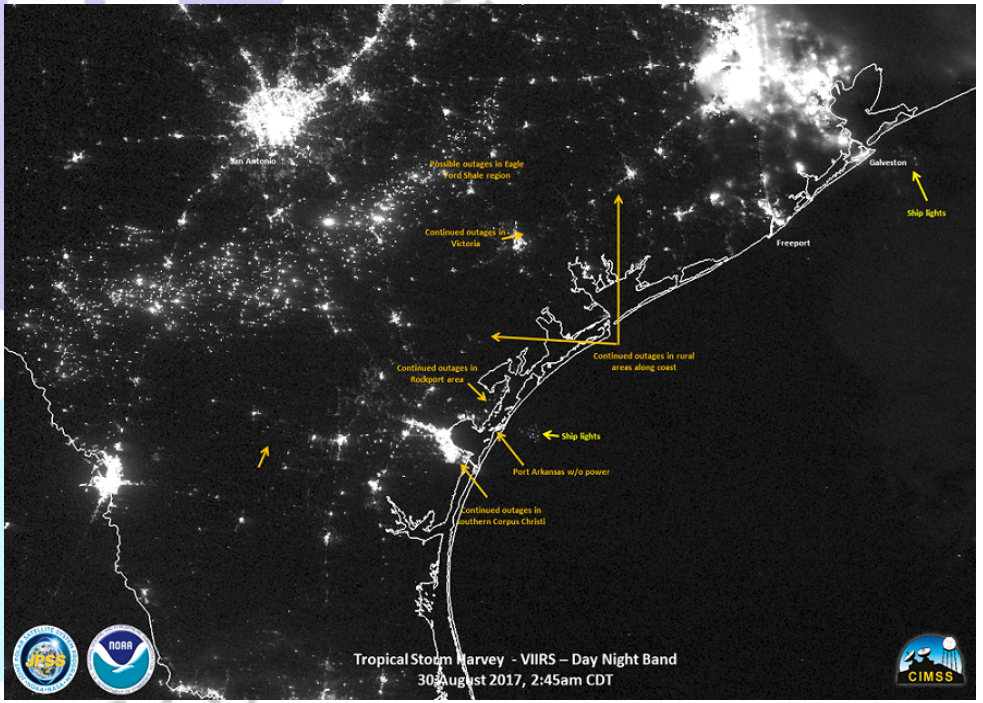
Impacts of Hurricane Harvey

Courtesy of STAR JPSS VIIRS Team

23 August 2017 - BEFORE

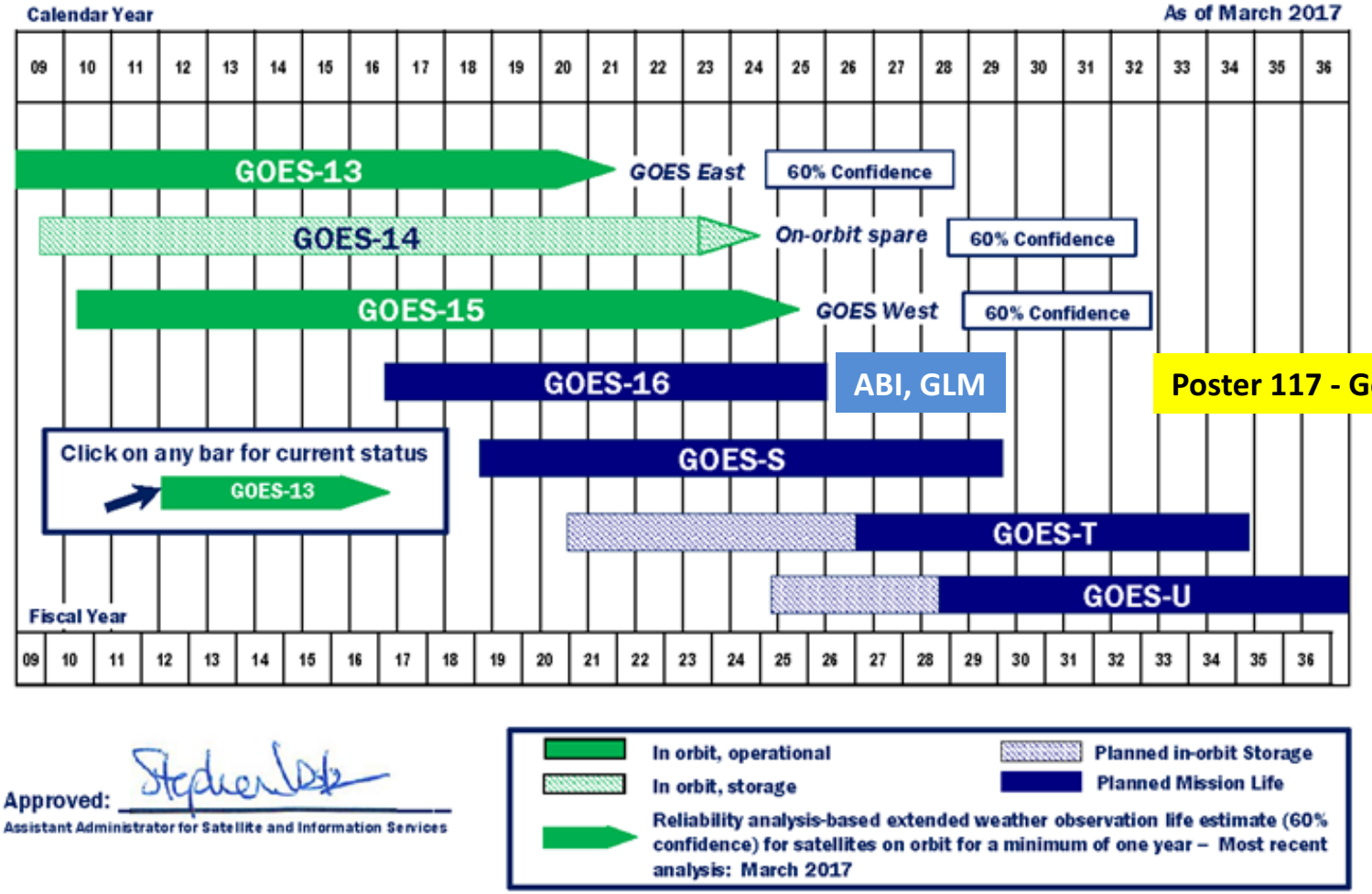


30 August 2017 - AFTER



GEO Satellites

NOAA Geostationary Satellite Programs
Continuity of Weather Observations



Poster 117 - Goodman

Approved: _____
Assistant Administrator for Satellite and Information Services

In orbit, operational
In orbit, storage
Planned in-orbit Storage
Planned Mission Life
Reliability analysis-based extended weather observation life estimate (60% confidence) for satellites on orbit for a minimum of one year – Most recent analysis: March 2017

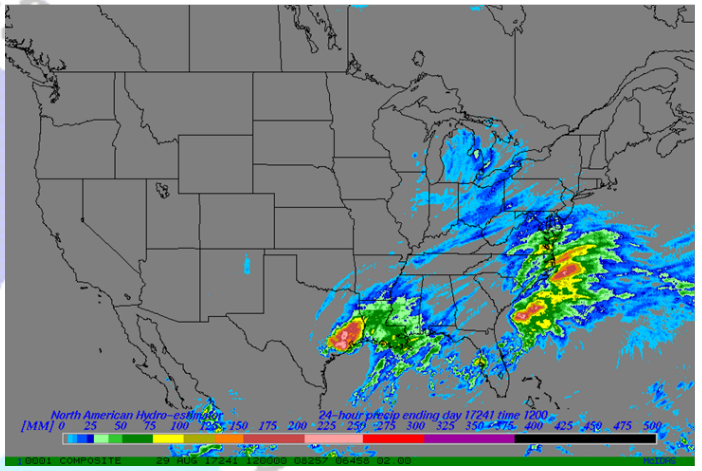
GOES-16 Drift to Operational Position

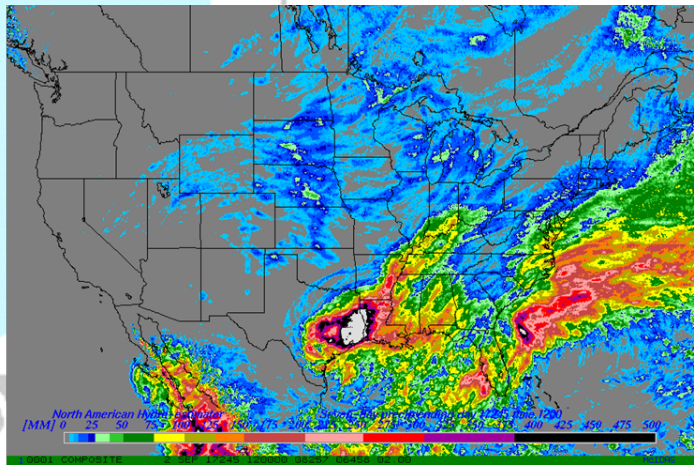
- Drift start: 89.3ºW at 1800 UTC 30 November 2017
- NO DATA during the drift period.
- Drift end: 75.2ºW on 11 December 2017
- GOES-16 resumes normal operations as GOES-East on 14 December (3 days of calibration activities)
- GOES-13 GVAR will begin parallel relay through GOES-14 (105ºW) on 7 December 2017; available ONLY through GOES-14 GVAR after 14 December.
- Three-week overlap of GOES-13 and -16 operations; GOES-13 deactivated on January 2 and will begin drift to 60ºW.

GOES-16 Operational Rainfall Rates

Courtesy of Bob Kuligowski, STAR

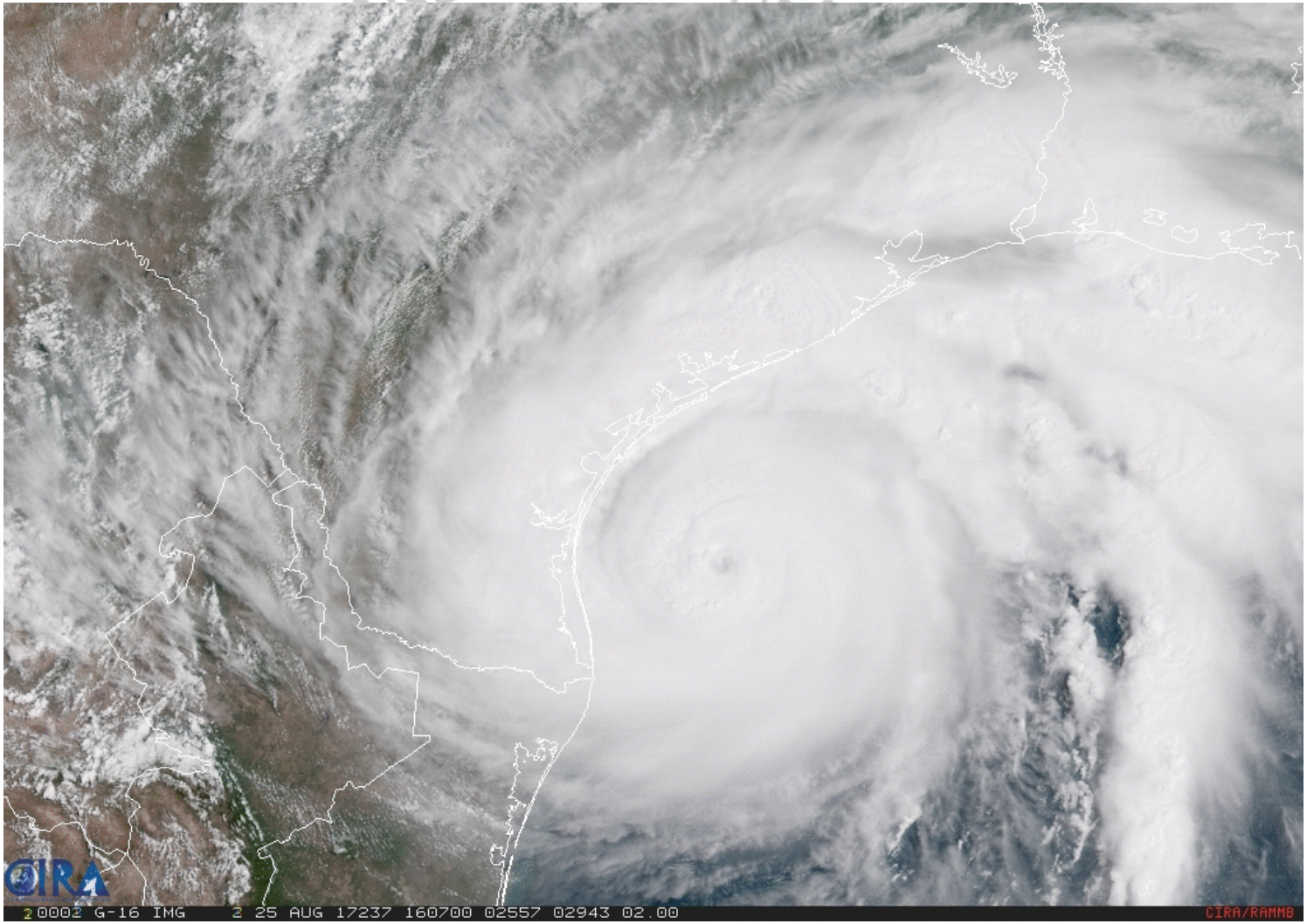
- **GOES-16 Rainfall Rate is currently at Beta maturity**
  - Accuracy and precision did not meet spec on limited data sets but remedial action has been taken
    - Impact of remediation is still being evaluated
  - Limited operational distribution with caveats
- **Stakeholder review for Provisional maturity: spring 2018**
  - Provisional=validated but not for all seasons
  - No operational GOES-16 rain rates during this time; continuity of the Hydro-Estimator as a gap-filler is being pursued until Provisional maturity is reached
  - Once Provisional maturity is reached, data will be openly distributed with caveats





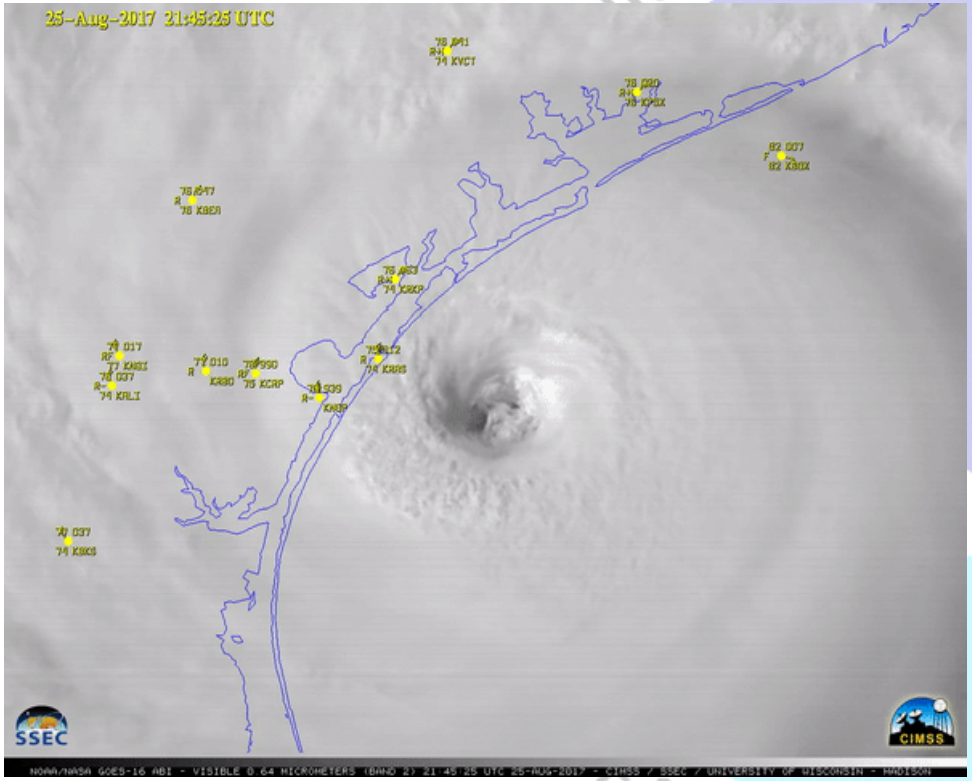
GOES-16 Visible & IR Imagery

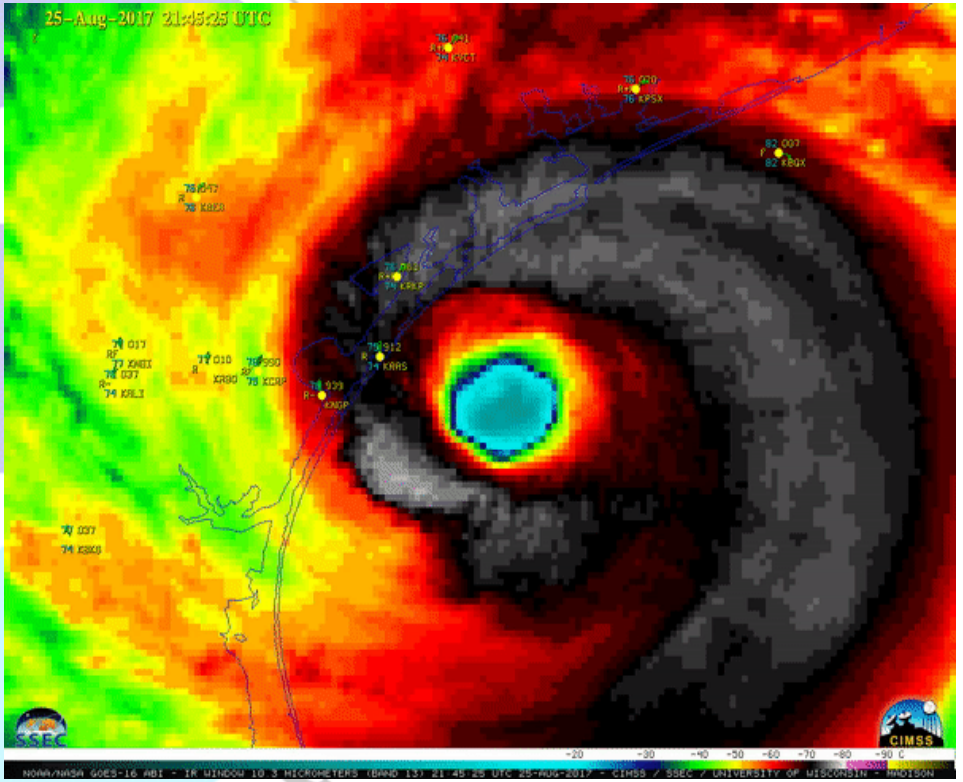
Courtesy of Dan Lindsey, NESDIS/STAR and CIRA



GOES-16 Visible & IR Imagery

Courtesy of Wayne Feltz, U. WI/CIMSS

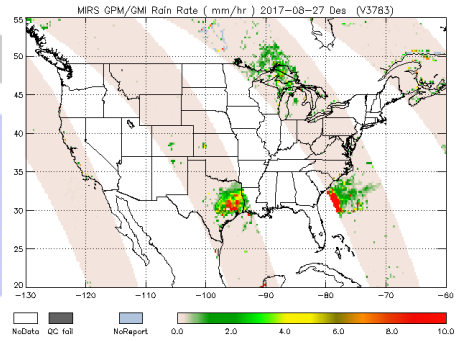


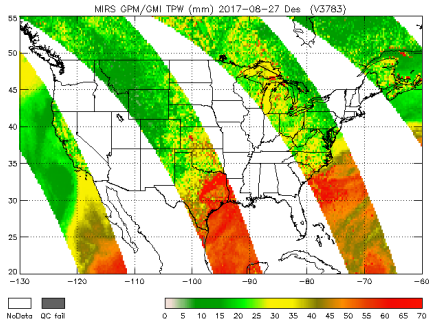


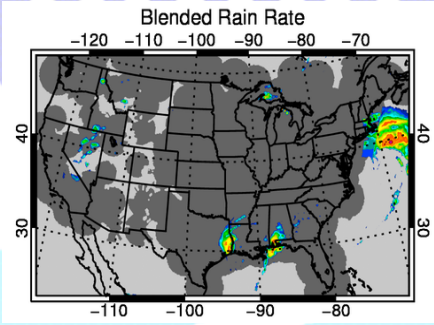
NESDIS Operational Products Update

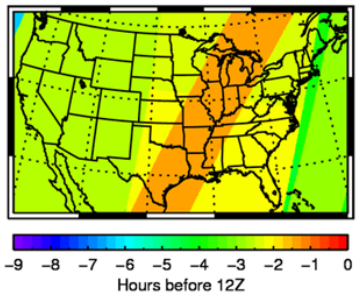
- ***NWS Use***
  - *GMI to BUFR for NWP*
  - *GMI TB's and some derived products available in AWIPS*
  - *GMI used in CMORPH*

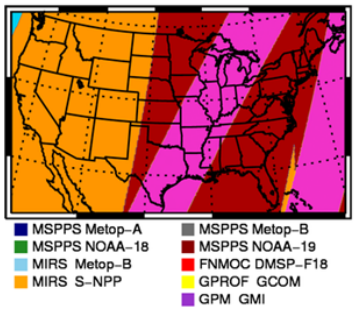
- ***NESDIS Use***
  - *MiRS High Resolution Hydrological Products*
  - *Advanced Dvorak Technique*
  - *eTRaP*
  - *Blended-Hydro (TPW, RR)*
  - *SMOPS (Soil moisture)*

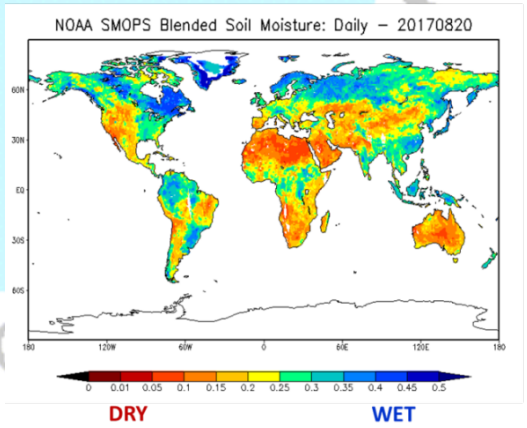


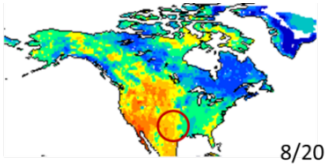


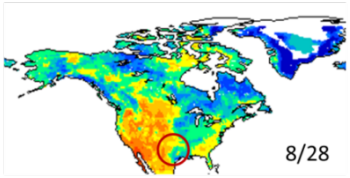












Ensemble TRaP (eTRaP) - Maria

14 individual estimates went into this forecast:

- RCLIPER (climatology)
- NOAA-18 and NOAA-19 MiRS rain rates
- NOAA AMSR-2 rain rates (GPROF2010V2)
- DMSP F-17 and F-18 MiRS rain rates
- GOES-E HydroEstimator
- GMI MiRS rain rates

/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.190800.RCLIPER.09190800
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/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.191447.AMSUM2.09191329
/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.191447.SSMISB.09191114
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/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.192000.RCLIPER.09192000
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/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.200200.RCLIPER.09200200
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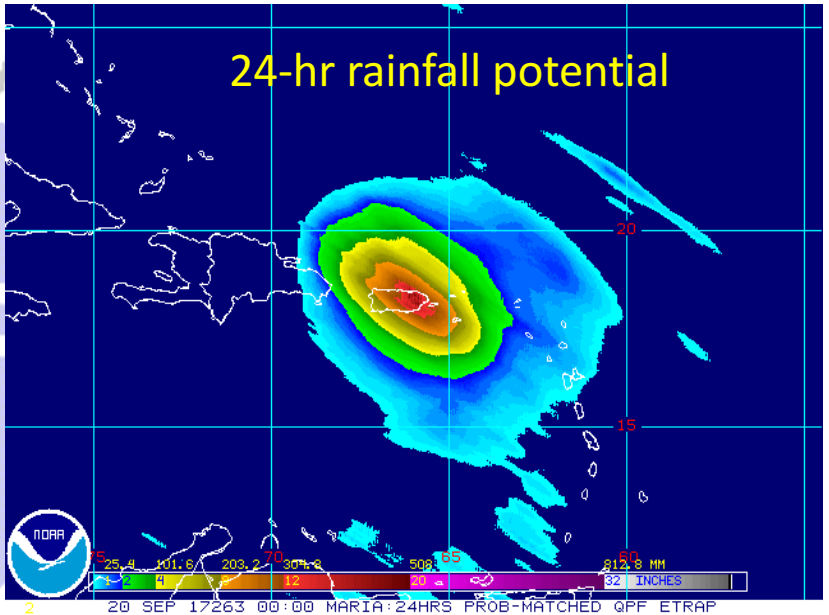
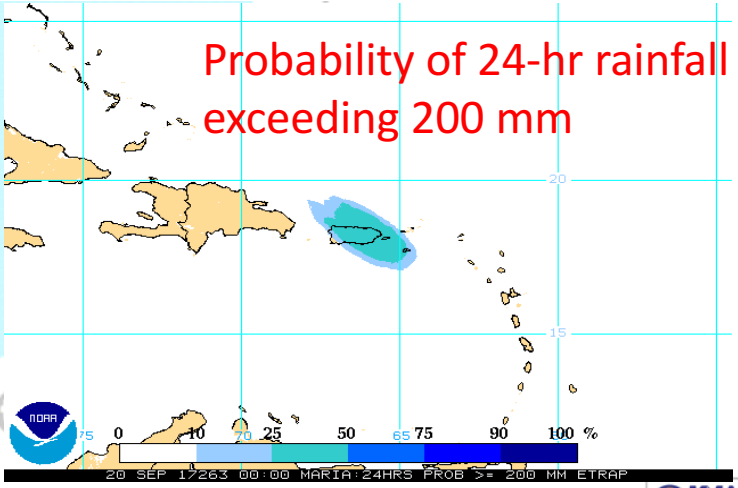
/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.200243.AMSUNN.09192342
/data/Petrap/2017/MARIA/2017MARIA.WTNT25.KNHC.200243.RRH_GPM.09200154
Grid information: nc,nr,clat,clon: 800 800 17.95 65.80
Total independent TRaPs used: 14
Ensemble members before cull to 200 : 4 x 6 x 11 x 14 = 3696
Total Ensemble TRaP members: 200





JCSDA Use of GMI

See https://www.jcsda.noaa.gov/documents/newsletters/2017_04JCSDAQuarterly.pdf

JOINT CENTER FOR SATELLITE DATA ASSIMILATION

NO. 57, FALL 2017

JCSDA Quarterly

NOAA | NASA | US NAVY | US AIR FORCE

https://doi.org/10.7289/V50P0X8R

Z. Pu and C. Yu, Dept. of Atm. Sci, Univ. of Utah

NEWS IN THIS QUARTER

SCIENCE UPDATE

Assimilation of GPM Microwave Imager Clear-Sky Radiance in Improving Hurricane Forecasts

The Global Precipitation Measurement (GPM) mission is a constellation-based satellite mission initiated by National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA). Building upon the success of its predecessor, the Tropical Rainfall Measurement Mission (TRMM), GPM aims to unify and advance the next-generation precipitation measurement from a constellation of both research and operational satellites (Hou et al. 2014).

Launched on February 28, 2014, the GPM core observatory is equipped with the first space-borne dual-frequency precipitation radar, the DPR, and a conical-scanning multichannel microwave imager, the GMI. Specifically, GMI not only inherits the nine channels of TRMM Microwave Imager (TMI) to detect heavy to light precipitation but also includes four additional high-frequency channels (166 GHz and 183 GHz) to improve sensitivity to snowfall detection.

GMI at least doubles the spatial resolution of the channels in TMI and is of the highest resolution among the group of GPM constellation satellites. Furthermore, the outstanding calibration of GMI also serves as the calibration reference for the inter-calibration of other microwave imagers in the GPM constellation to ensure a physically consistent brightness temperature. Through improved measurements of rain and snow, GPM provides new observations of hurricanes and typhoons as they transition from the tropics to mid-latitudes (Skofronick-Jackson et al. 2017).

(continued on page 2)

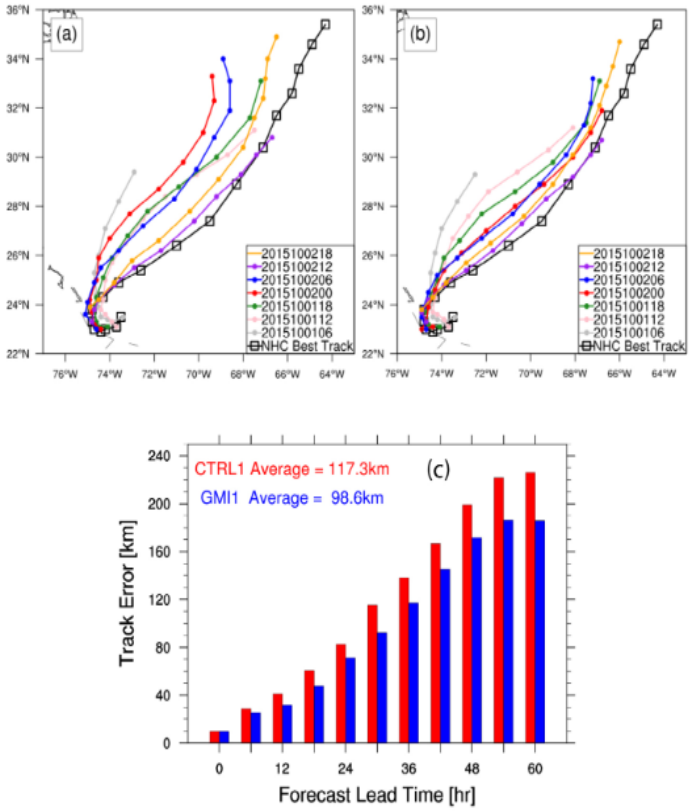


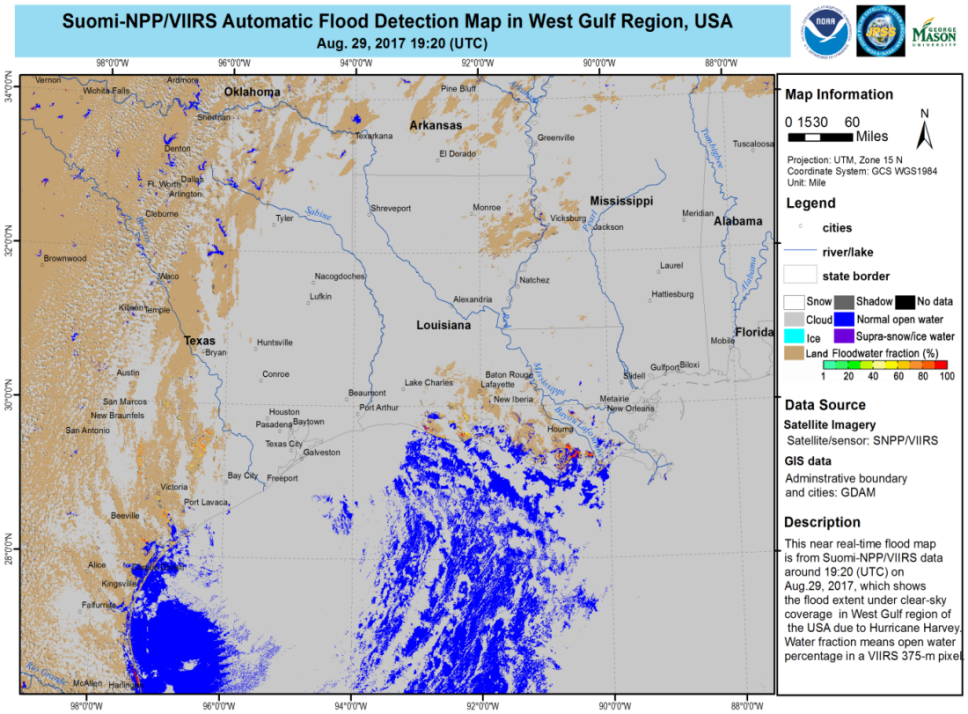
Figure 2: *Comparison between NHC best track (black curve) with track forecasts (colored lines) of Hurricane Joaquin from the seven 6-hourly analysis/forecast cycles for (a) CTRL1 (without GMI data assimilation) and (b) GMI1 (with GMI data assimilation) from different initial times (as listed in the legend). (c) is the 60-hour mean track error averaged over the forecasts started from seven analysis-forecast cycles during the mature phase of Joaquin (6-hourly from 0600 UTC October 1 to 1800 UTC October 2, 2015), for CTRL1 (red) and GMI1 (blue).*

Flood Detection and Inundation

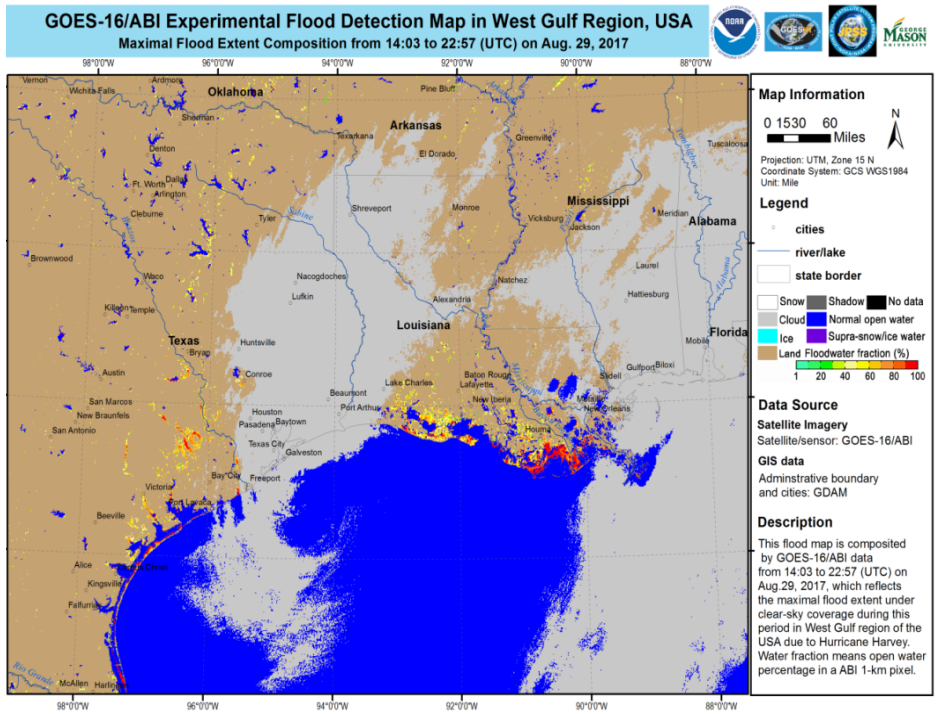
Courtesy of Sanmei Li, George Mason Univ.

Leveraging capabilities from both VIIRS and ABI

S-NPP VIIRS; high resolution, twice/day



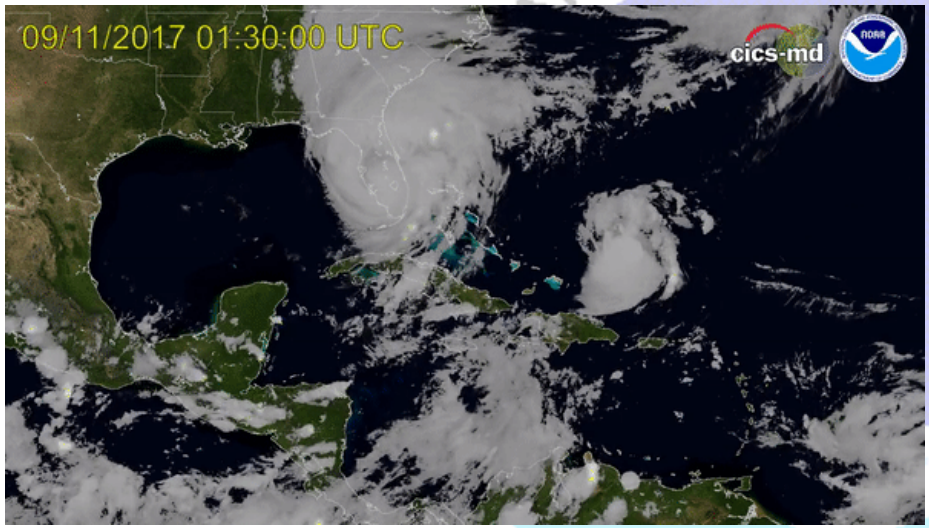
GOES-R ABI; lower resolution, rapid update



Emerging Opportunities – GLM!

Courtesy of S. Rudlosky (NESDIS), M. Peterson (CICS-MD)

GLM on GOES-16 ABI

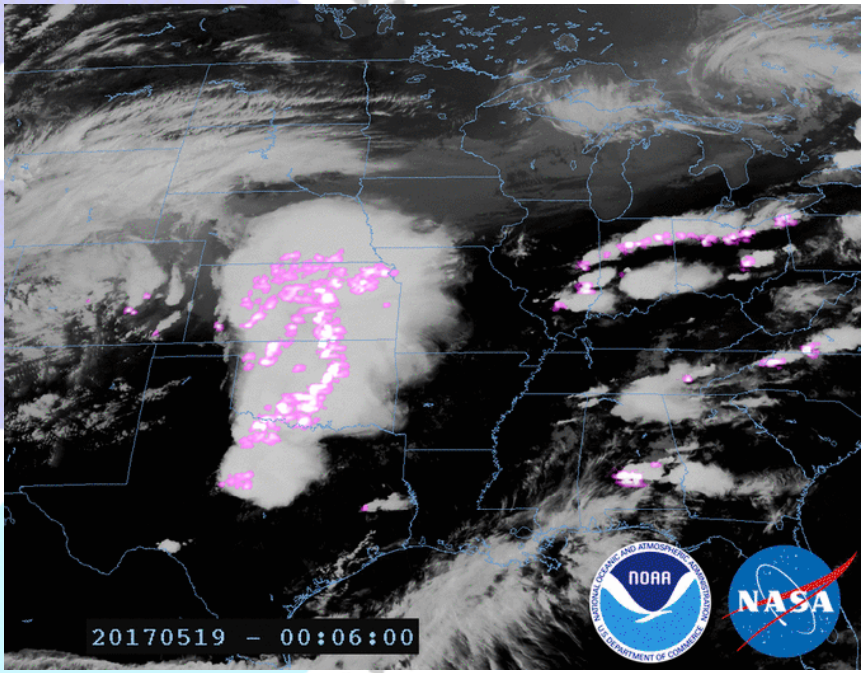


Lightning flare-ups associated with storm intensification.

Can lightning 'motion' be exploited in the IMERGE product?

Courtesy of P. Meyers (CICS-MD)

GLM overlaid with ABI and S-NPP ATMS MiRS Rain Rates



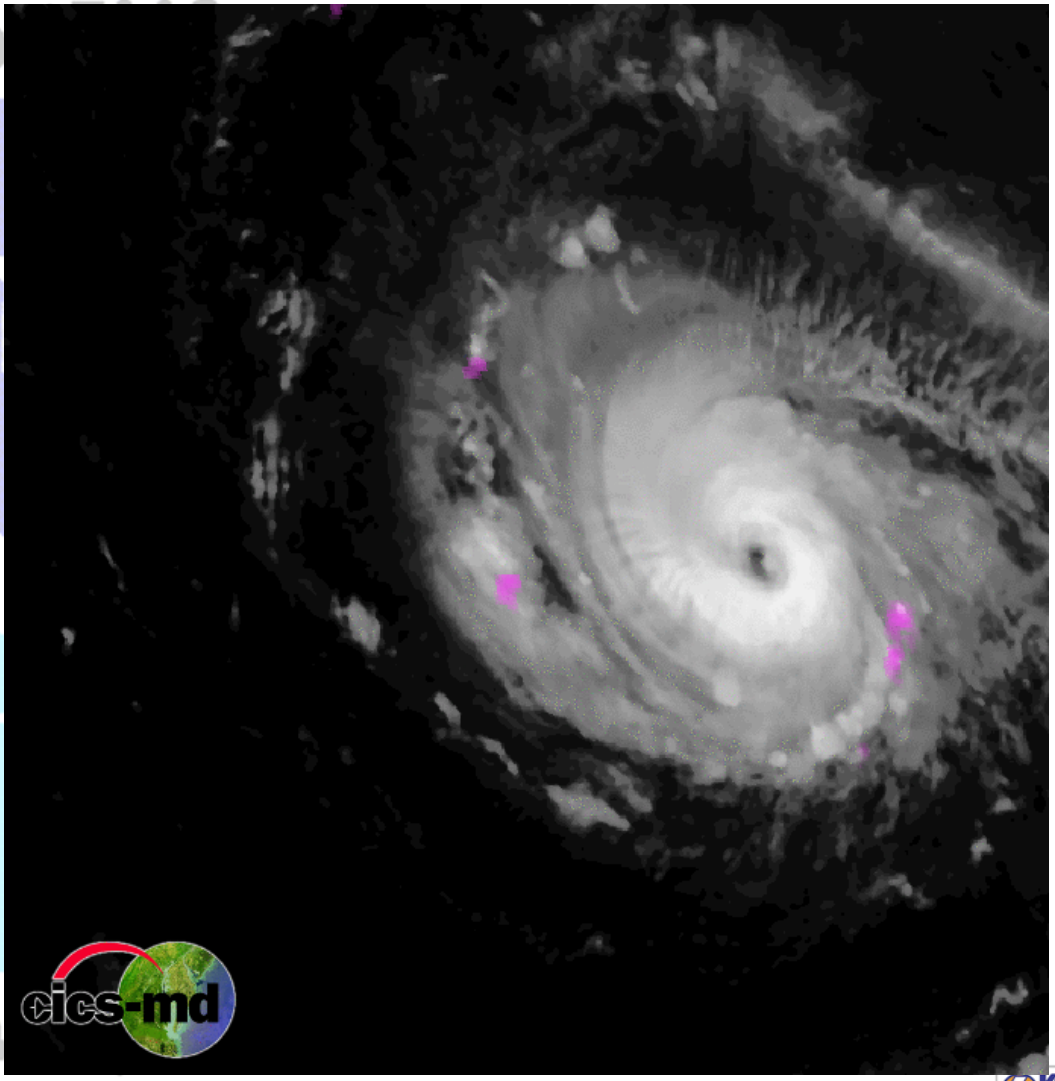
Can we prescribe databases for GPROF that exploit lightning information (proxy for updrafts/vertical velocity?)

GOES-R ABI+GLM & GPM GMI

Courtesy of Pat Meyers, CICS-MD/Unv. Of MD

Hurricane Irma

- Lightning associated with actively growing convective cells; note the feeder bands!
- Strong correspondence with GMI 89 GHz in some cases, but not all of them. Why?



NOAA Projects for PMM

Nine subtasks submitted as a single, no-cost to NASA, proposal

- **Contributions to the GPM GV Activities and Process Studies**
  - Characterization of Orographic Precipitation During IPHEX and HMT-SEPS (R. Cifelli)
  - Development of a ground radar-based snow database for satellite algorithms (J.J. Gourley)

- **Contributions to the Improvements of GPM Level 1, 2 and 3 Products**

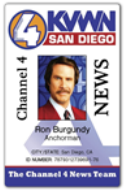
Posters 148 and 226

  - *Algorithm Enhancement for GPM Constellation Radiometers to Support NOAA/NWS Regions (R. Ferraro, N-Y. Wang, P. Meyers)*
  - *Enhancement of NOAA Operational Snowfall Rate (SFR) Product for GPM Constellation Satellites (H. Meng)*

Poster 231

  - *Development of 2nd generation pole-to-pole CMORPH (P. Xie and Joyce)*
  - *Enhancing regional CMORPH with gauge, radar and model data (P. Xie)*

- **Improving NOAA Operations and Climate Data Records with GPM Data**
  - A Rainfall Nowcaster Based on Multisensor Data (R. Kuligowski)
  - Development and Transition of Precipitation Climate Data Records (B. Nelson)
  - Changes in the hydrological cycle in the extratropics using GPM data (P. Groisman)

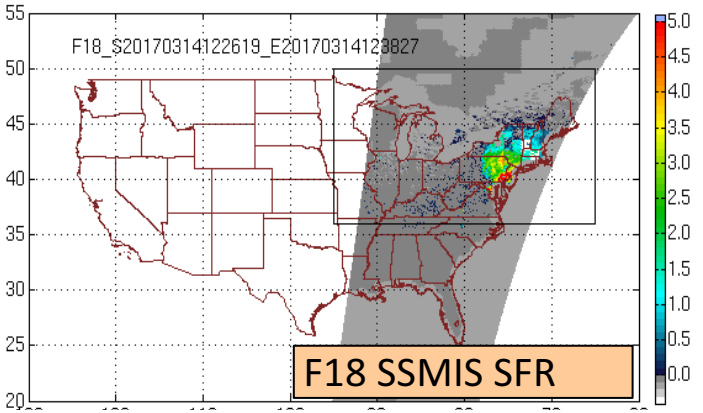


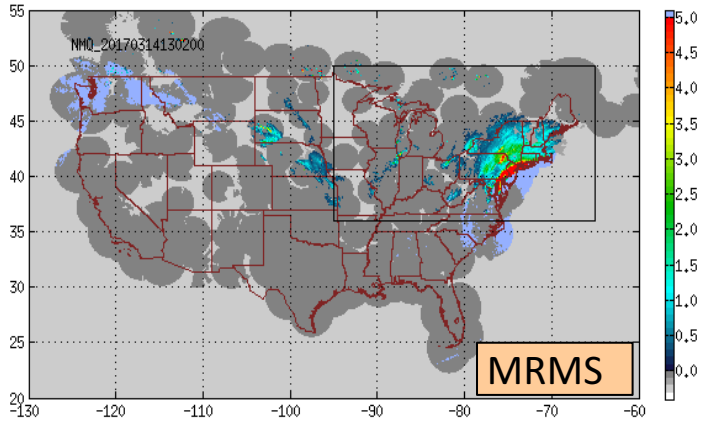
Enhancement of NOAA Operational Snowfall Rate (SFR) Product for GPM Constellation Satellites

Huan Meng, NESDIS/STAR

- **SSMIS Land SFR**
  - ✓ F16, F17, and F18; three satellites to improve SFR temporal resolution
  - ✓ Logistic regression snowfall detection (SD) model; under further development
  - ✓ 1DVAR-based snowfall rate algorithm
  - ✓ Separate algorithm for each satellite due to failed channels and different sensor characteristics
  - ✓ ATMS and MHS SFR outperform SSMIS SFR

	Corr Coeff	Bias (mm/hr)	RMS (mm/hr)
F16	0.44	0.01	0.94
F17	0.56	-0.11	0.88
F18	0.42	-0.06	0.91





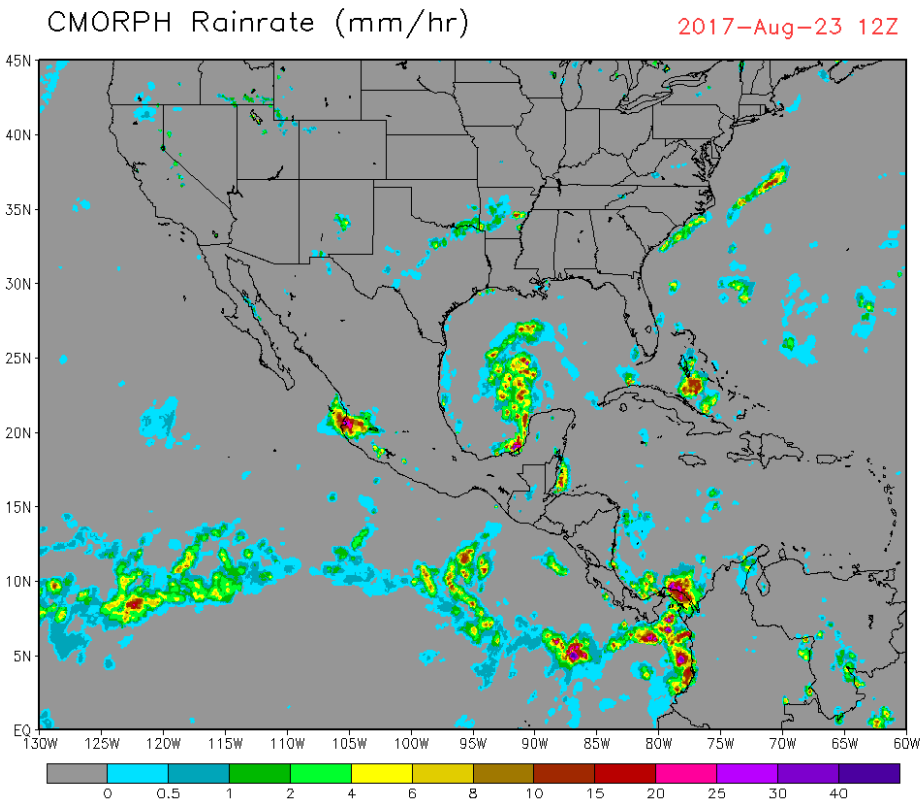
- **GMI Land SFR**
  - ✓ Same SD and SFR algorithm frameworks as SSMIS
  - ✓ SD statistics indicate very good performance against ground observations; comparable to ATMS
  - ✓ Algorithm completion by end of 2017

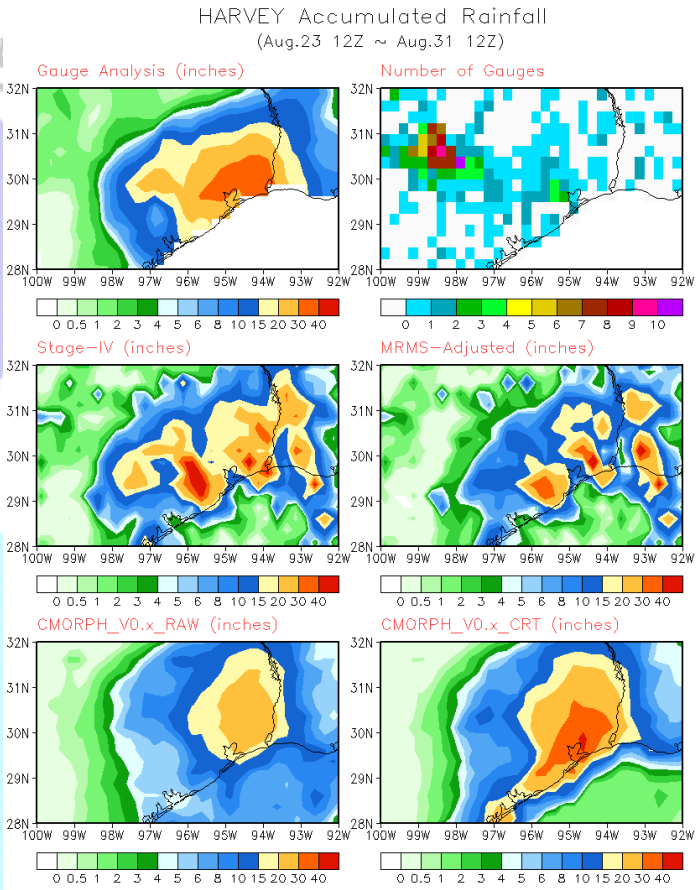
	POD (%)	FAR (%)	HSS
Warm Regime	67.1	15.3	0.49
Cold Regime	52.9	14.5	0.39

Operational CMORPH

Pingping Xie & Bob Joyce, NOAA/NWS/CPC

CMORPH hourly rain rates for Harvey

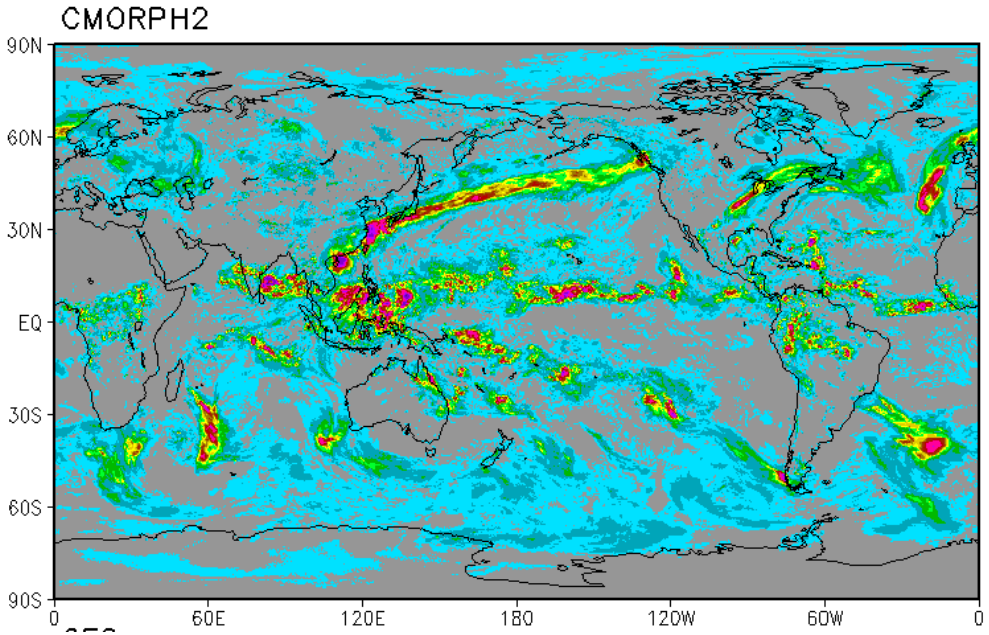


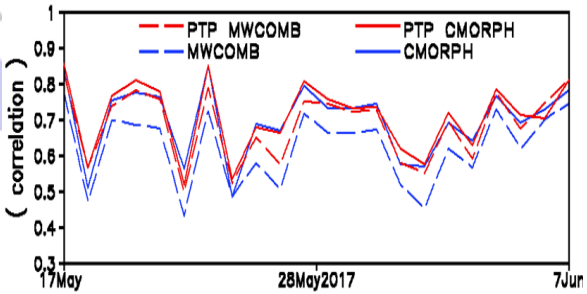


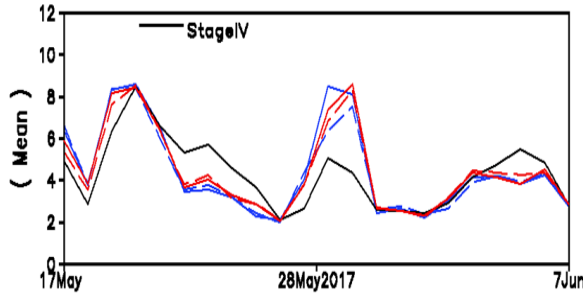
- Bias-corrected CMORPH generated at a 2-hour latency and updated every 3-min up to 6 hour-latency and then once an hour up to 12 hour – latency
- Evolution / spatial pattern / magnitude of the hurricane precip captured quite well

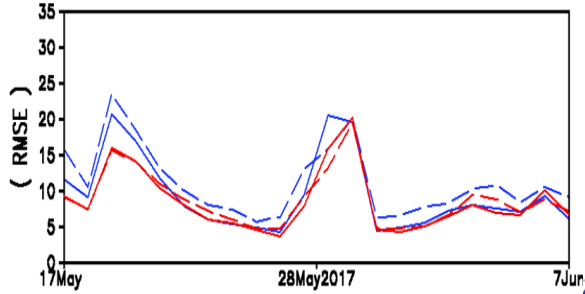
2nd Generation CMORPH

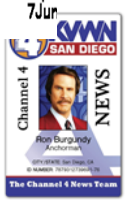
- Pole-to-Pole Complete Global Coverage
- Explicit snowfall representation
- Started real-time test production while fine-tuning algorithm piece by piece
- Focused on AVHRR IR precip estimates and preliminary examinations









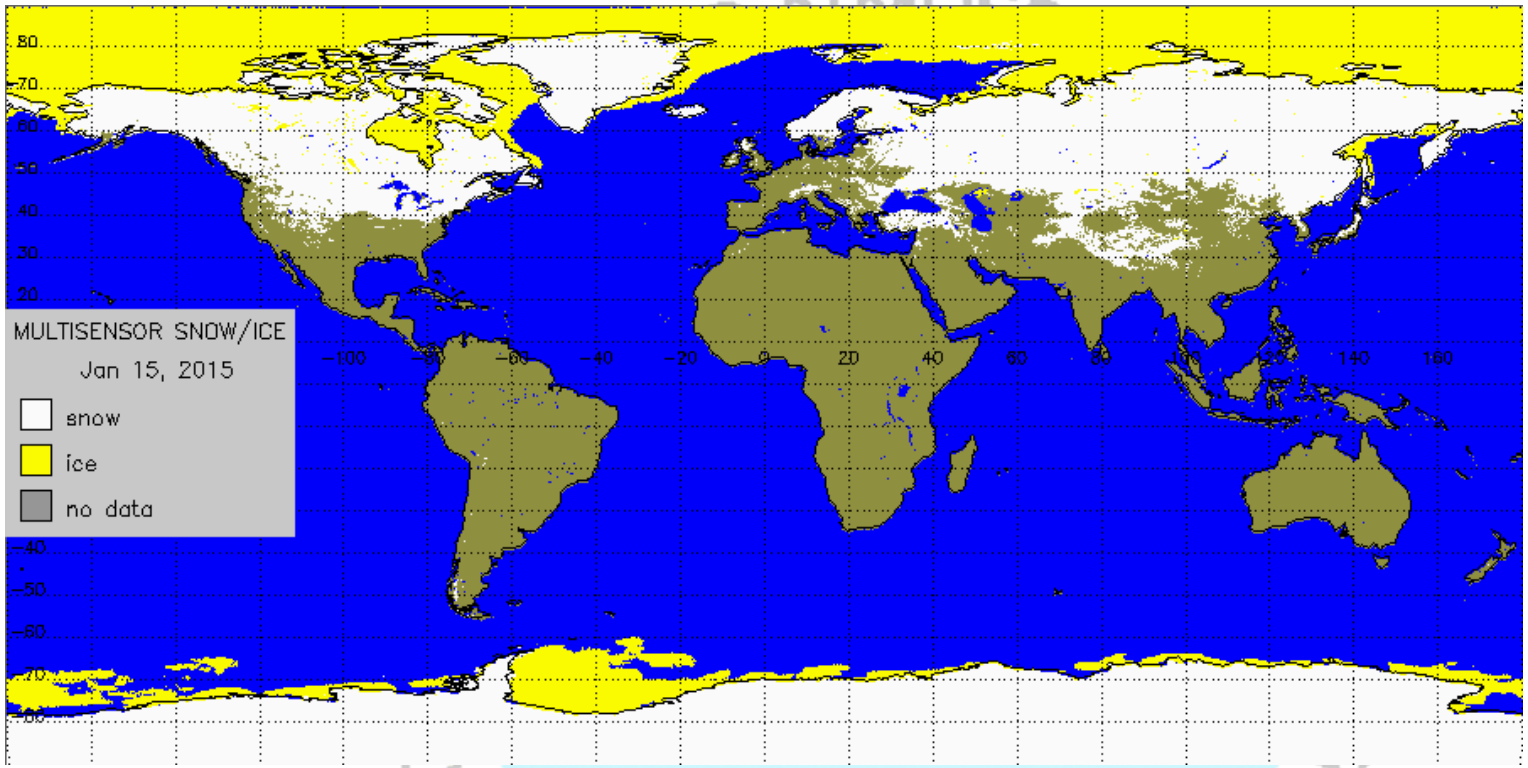


Other Relevant Activities

- MRMS/GPM GV
- Autosnow/TRMM and GPM reprocessing
- IPWG/Cal Val over CONUS
- CSI
  - V. Petkovic – CIRA visitor at CICS-MD
  - Joint activity with CICS-MD scientists – N-Y. Wang, Y. You, P. Meyers
- GPROF2017 evaluation/future use for NESDIS GCOM operational system

Global Multisensor Automated Snow/Ice (GMASI-Autosnow) Mapping System

Courtesy of Peter Romanov, City College of New York/NOAA CREST



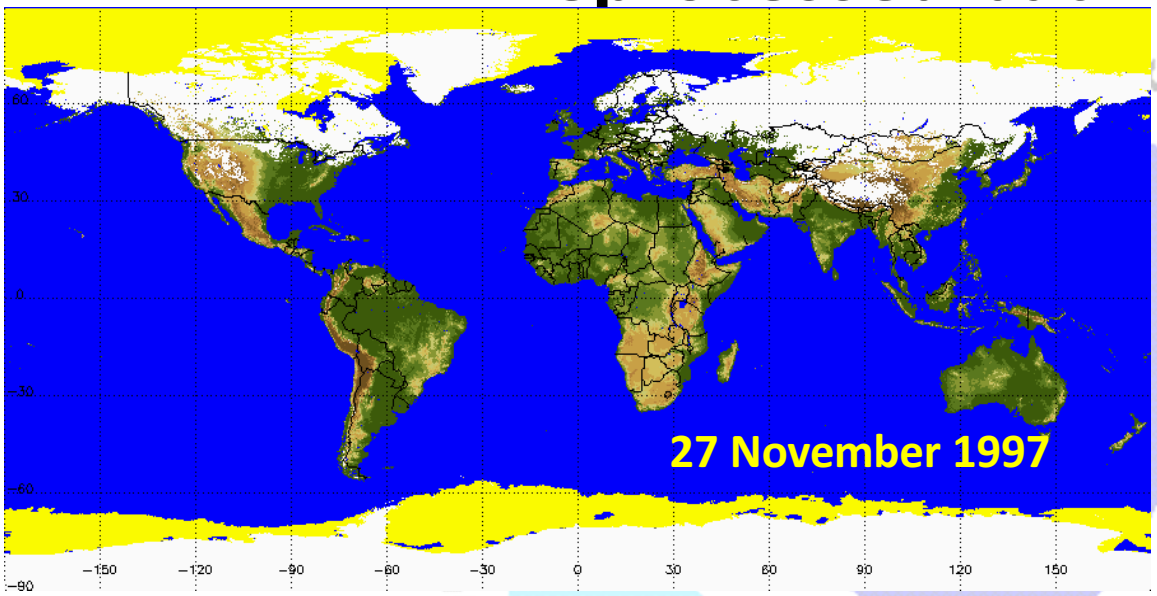
Categories: snow/no-snow, ice/no-ice,

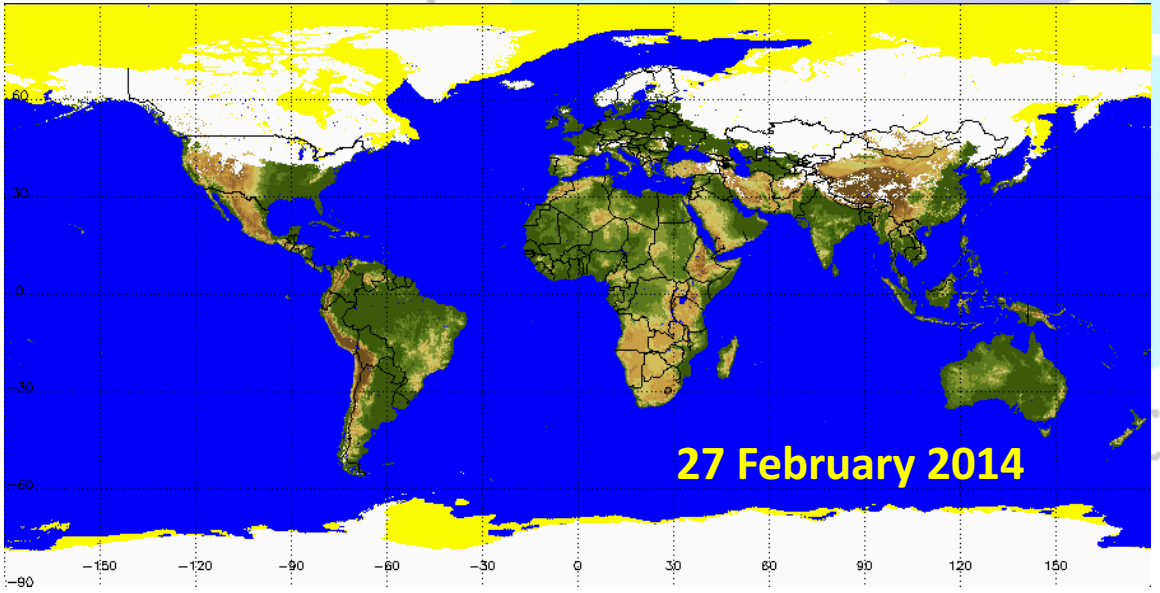
Projection: Plate Carree, 0.04^0 grid cell size (about 4km)

Sensors (current): METOP AVHRR + all DMSP SSMI/SSMIS

Operational since 2006

Autosnow – Reprocessed back to 1996





Year	Primary AVHRR carrier	Number of SSMI(S)	F11	F13	F14	F15	F16	F17	F18	F19
1998	NOAA-14	3								
1999		3								
2000		3								
2001	NOAA-16	3								
2002		3								
2003	NOAA-17	3								
2004		3								
2005		3								
2006		4								
2007	METOP-A	4								
2008		4								
2009		4								
2010		3								
2011		4								
2012		4								
2013		4								
2014		4								
2015		5								
2016		5								
2017		4								

Routine Validation/IPWG

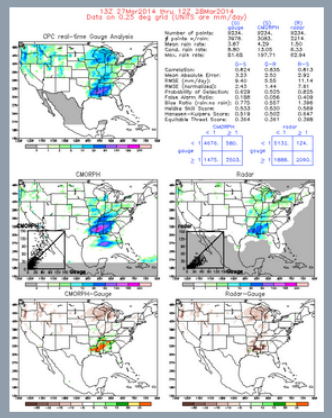
http://cics.umd.edu/ipwg/index.html

Y. You, P. Meyers, R. Smith

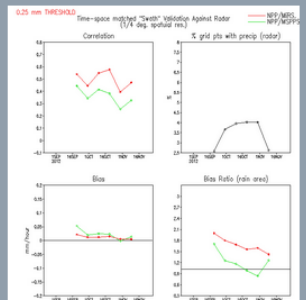
IPWG U.S. Validation Page

Daily Validation | Swath Validation | Seasonal Validation | External Links | Under Construction

Daily (IPWG) Validation



Swath Statistics



STAR Rainfall Product Cal/Val Center

Project Description

This website disseminates the results of both daily and seasonal validation of STAR rainfall products over the contiguous United States. Daily rainfall amounts are validated relative to the gauge-corrected Multi-Radar/Multi-Sensor System (MRMS), and MRMS radar-only data at 2-minute temporal resolution are used to validate the level-2 swath data (e.g., AMSR2 and ATMS).

Seasonal validation is performed for several NESDIS-generated operational rainfall products (i.e., SCaMPR, MiRS, MSPPS, and the HydroEstimator), which were originally developed by STAR scientists. For comparison, validation also was extended to CMORPH, Merged Microwave, GPI (CPC), TRMM (NASA), NRL Blended, PERSIANN (UC Irvine), and GSMAP (JAXA).

This research effort seeks to provide algorithm developers with feedback on the performance of their products, which will help guide decisions on whether to divert resources toward algorithm improvement or to investigate reasons for recent algorithm behavior (good or poor).

Recent Updates

The website has undergone a complete transformation to ease access and better serve the community. The main page now directly links our various validation activities. Navigation buttons accompany the daily validation images, allowing for easier analysis of consecutive days. Archives now provide access to daily imagery over 60 days old.

The validation procedures were modified to incorporate precipitation estimates from the ATMS instrument. In addition, considerable effort has been expended to streamline and document these procedures. The formatting and quality of the JPSS GCOM AMSR2 and ATMS images have been update. The new AMSR2 images are currently automated and the ATMS images will be automated in the near future.

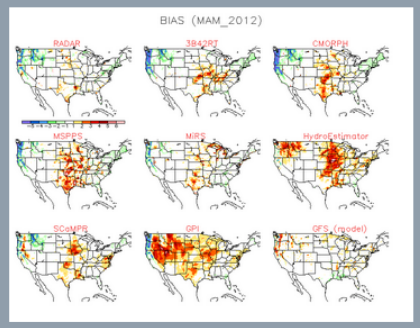
Times series and histograms were created to compare GPROF2014 rain rates with the Stage IV radar data for January and July 2013. This work was requested by Ralph Ferraro (STAR) to assist algorithm development by his group.

Future Tasks

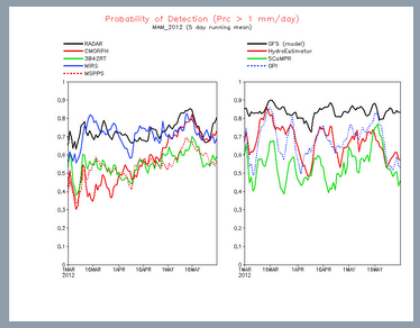
Seasonal rainfall validation for the ongoing 2016-2017 seasons is being conducted routinely and the new results are posted within one month following each season. The 2017 daily rainfall images will be archived and added to the Daily Validation seection. Work is also being conducted to update the daily validation images. Once these images are completed they will be phased into the "Most Recent" subsection in the Daily Validation Section.

Our Cal/Val efforts are expanding to incorporate several exciting new rainfall estimates, including the JPSS GCOM AMSR-2, MiRS ATMS, NESDIS bRR, Environmental Data Records (EDR) rain rate from SSMI/S, and NASA IMERG.

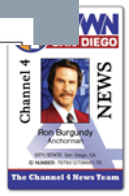
Statistical Maps



Time Series Plots



Precipitation Histograms

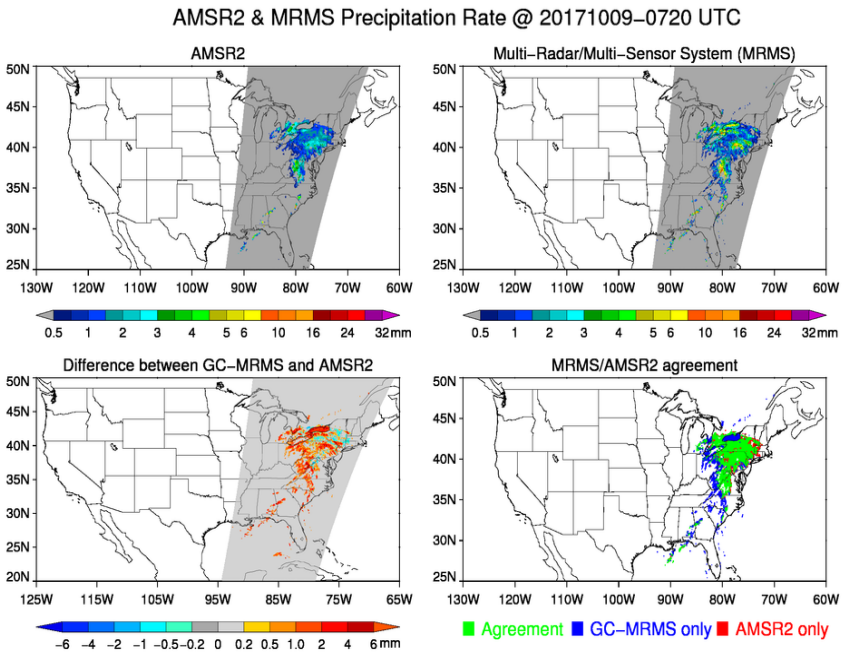


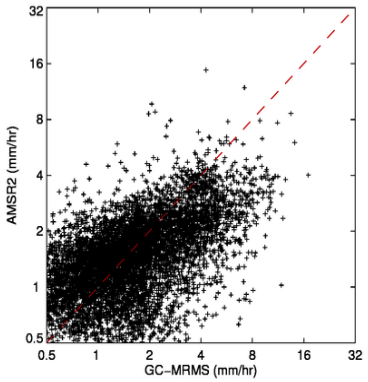
Routine Validation/IPWG

Y. You, P. Meyers, R. Smith – CICS-MD

Swath Validation with MRMS

NOAA GCOM-W1 AMSR-2 (GPROF2010V2)

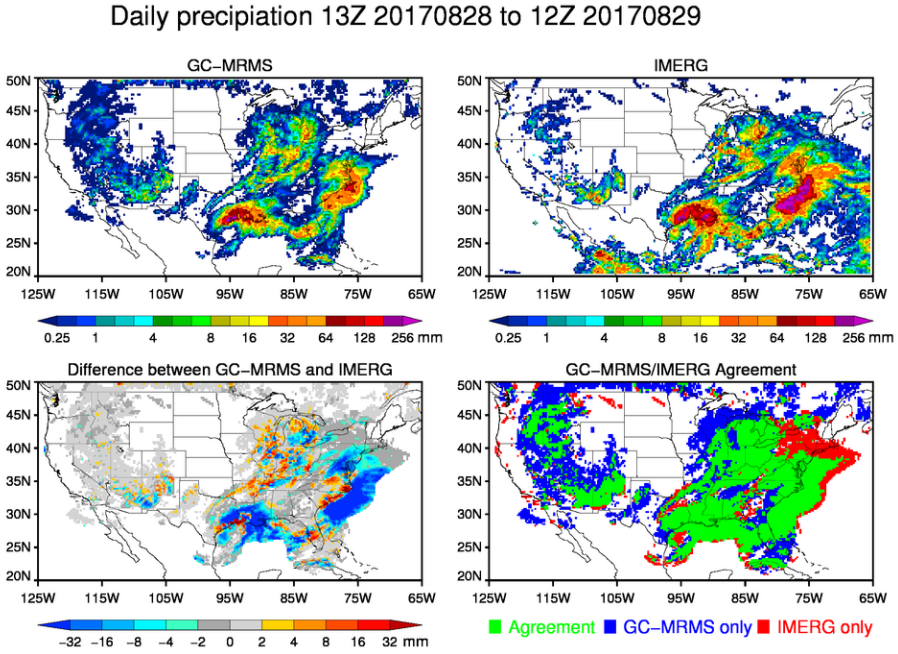


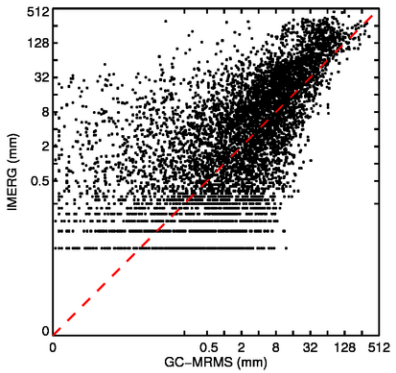


Correlation:	0.76
RMSE (mm/hr):	0.31
Probability of Detection:	0.74
False Alarm Ratio:	0.05
Heidke Skill Score:	0.82

24 Hour Validation – switch from Stage IV to MRMS

IMERGE





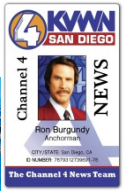
	GC–MRMS	IMERG
Number of points:	21240	21240
# points w/rain:	10536	7849
Mean rain rate:	3.14	7.17
Cond. rain rate:	6.33	19.40
Max rain rate:	341.70	448.43

Correlation:	0.71
Mean absolute error:	5.11
RMSE (mm/day):	22.11
RMSE (normalized):	3.08
Probability of Detection:	0.60
False Alarm Ratio:	0.19
Bias Ratio:	0.74
Heidke Skill Score:	0.46
Hanssen–Kuipers Score:	0.46
Equitable Threat Score:	0.30

Summary

- NOAA satellites continue to be a contributing element to the GPM program
  - S-NPP and soon, JPSS-1 – ATMS and VIIRS sensors
  - GOES-16 – ABI needed for IMERGE; GLM offers new potential to improve precipitation retrievals
- GPM products are now regularly used in a number of NOAA operational products (these would not have happened without NOAA's involvement with the PMM science team!)
  - "Hydrological" product suite; including use of GPROF
  - NWS/AWIPS, serving regions that rely on satellite products
  - NWP/DA – not regularly used; improving our synching with GPM/PPS L1C updates
- NOAA looks forward to our continued participation!
- Please see our posters during the next few days

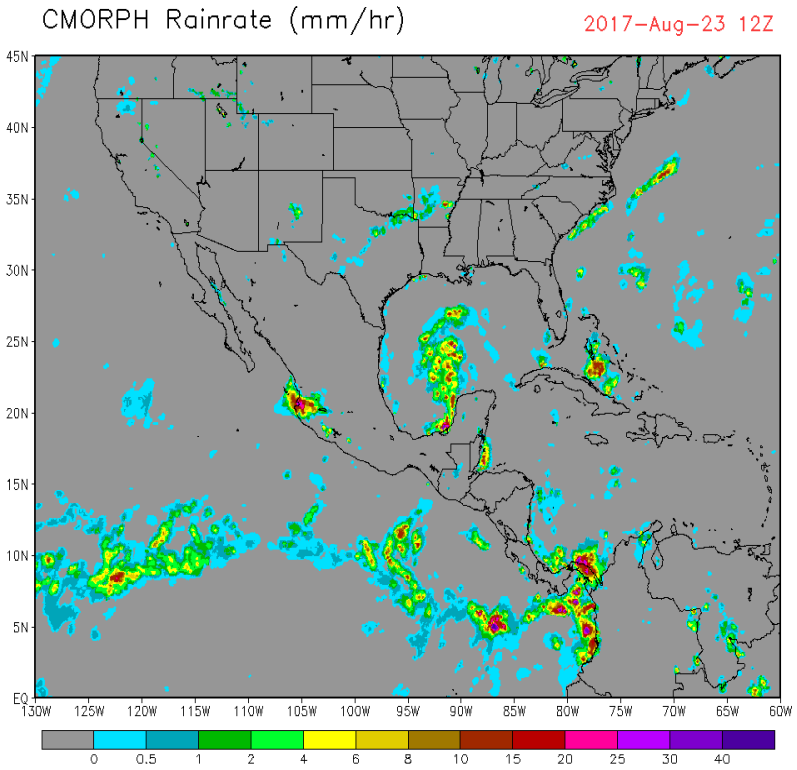
BACKUP


KWWN
SAN DIEGO
Channel 4
NEWS
Ron Burgundy
Anchorman
The Channel 4 News Team

CMORPH Update

Pingping Xie & Bob Joyce, NOAA/NWS/CPC

CMORPH hourly rain rates for Harvey



Evaluating CMORPH at multiple near real time production latencies. Daily correlation (top) with gauge corrected MRMS over CONUS; Mean precipitation [mm/day] (bottom)