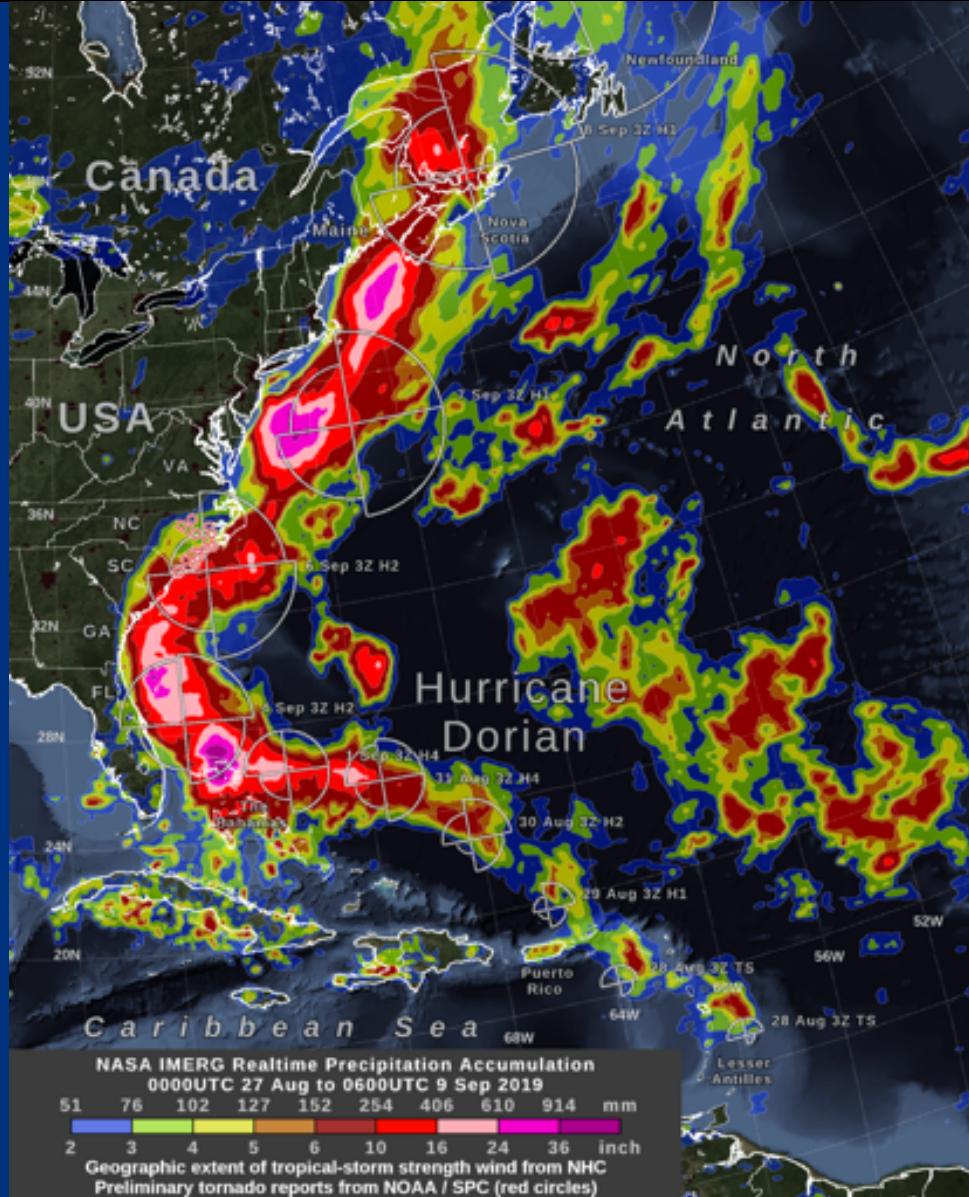




GPM Status and Science



Scott Braun
GPM Project Scientist

NASA Goddard Space Flight
Center

Precipitation Measurement
Missions Science Team Meeting
November 5, 2019

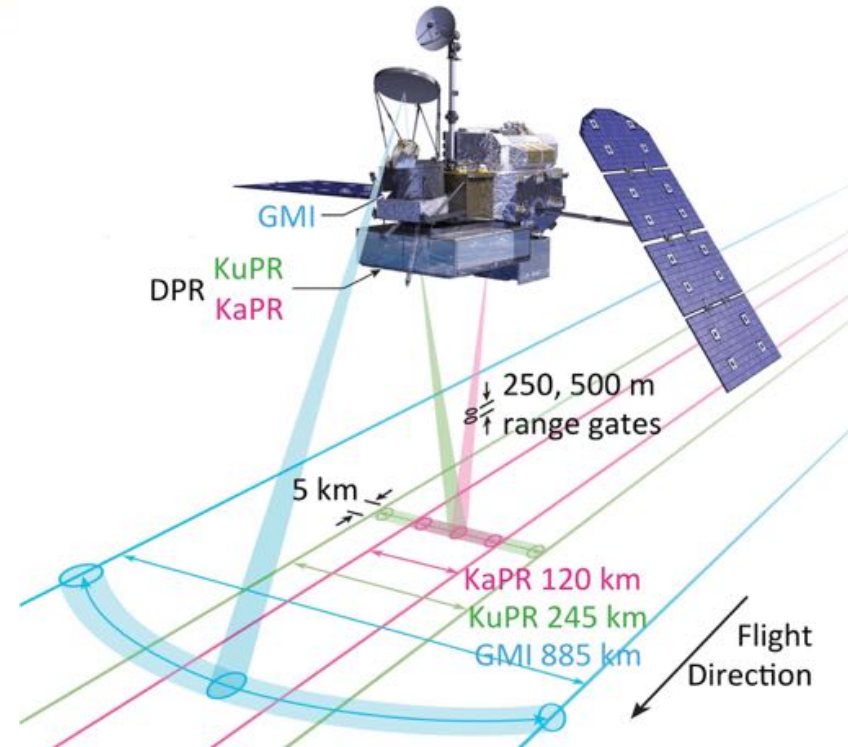
www.nasa.gov/gpm

Twitter: NASARain

Facebook: NASARain

GPM Core Observatory:

- Launched: Feb. 27, 2014
- 6 years of operations, with fuel to last to ~2033
- All systems operating nominally
 - Reaction wheel #2 failed in 2019



GPM Microwave Imager (GMI) 13 Channels, (Provided by NASA)

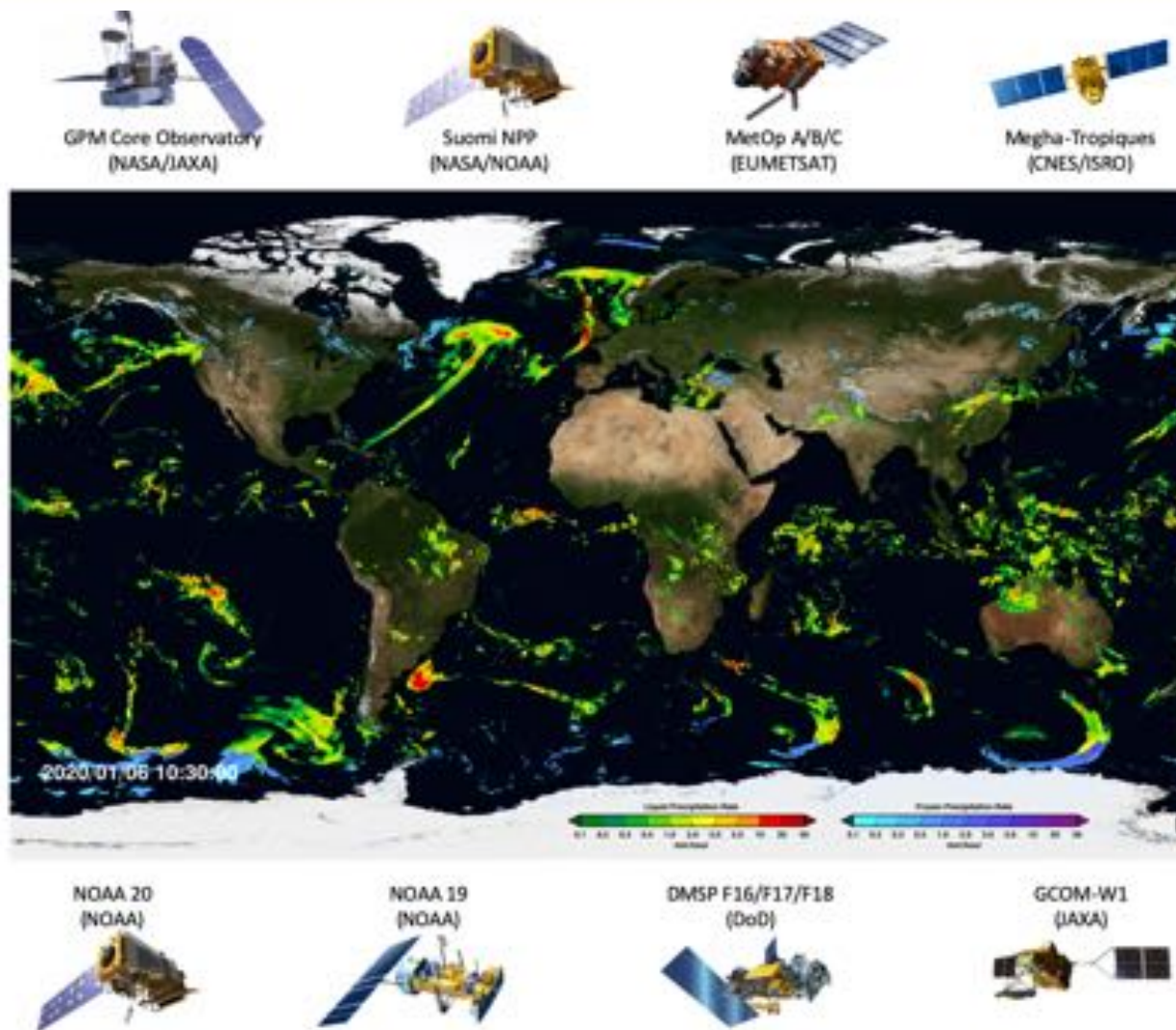
- Passive radiometer with excellent calibration
- 10VH, 19VH, 23, 36VH, 89VH, 166VH, 183 ± 3 , ± 7
- Provides measurements of precipitation (rain and snow) intensity and distribution over 885 km swath
- High spatial resolution (down to ~5km footprints)

Dual-frequency Precipitation Radar (DPR), (Provided by JAXA)

- KuPR similar to TRMM, KaPR added for GPM
- Provides 3D measurements of precipitation structure, precipitation particle size distribution
- High spatial resolution (5km horiz.; 250m vertical)

GPM Constellation:

- Intercalibrated brightness temperatures
- Merged satellite products
- Improved knowledge of water cycle variability
- Improved prediction of floods, landslides & freshwater resources

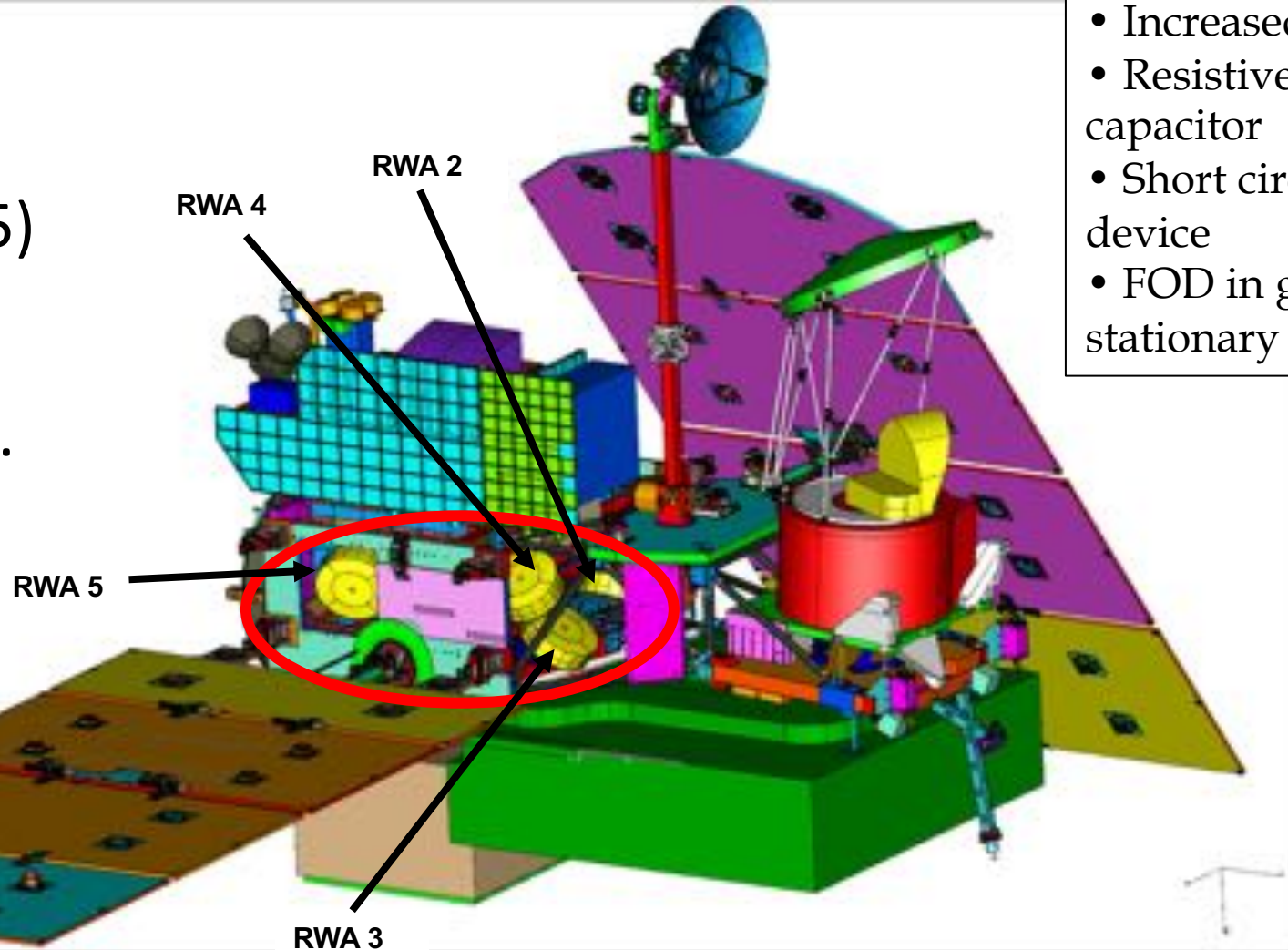


11 sensors in current constellation

Spacecraft and instrument status: **All systems are fully functional**

GPM Anomaly

- Reaction wheel #2 (of 5) stopped rotating on May 30, 2019.



Possible causes:

- Increased drag in ball bearings
- Resistive short in ceramic capacitor
- Short circuit in +5V logic device
- FOD in gap between rotor and stationary part of reaction wheel

- Current algorithms
 - All passive microwave products at Version 05 (V05)
 - All radar, combined, latent heating, and multi-satellite products at V06
 - Covers TRMM and GPM eras
- Radar team working with PPS on V06X radar products
 - Algorithms adjusted to account for Ka across full Ku swath
 - Will be released to as experimental product once ready
- Next algorithm reprocessing
 - PPS exploring use of NetCDF due to commercialization of HDF5. Desire for V07 toolkit to use NetCDF4.
 - V07 expected to begin in the 2021 time frame

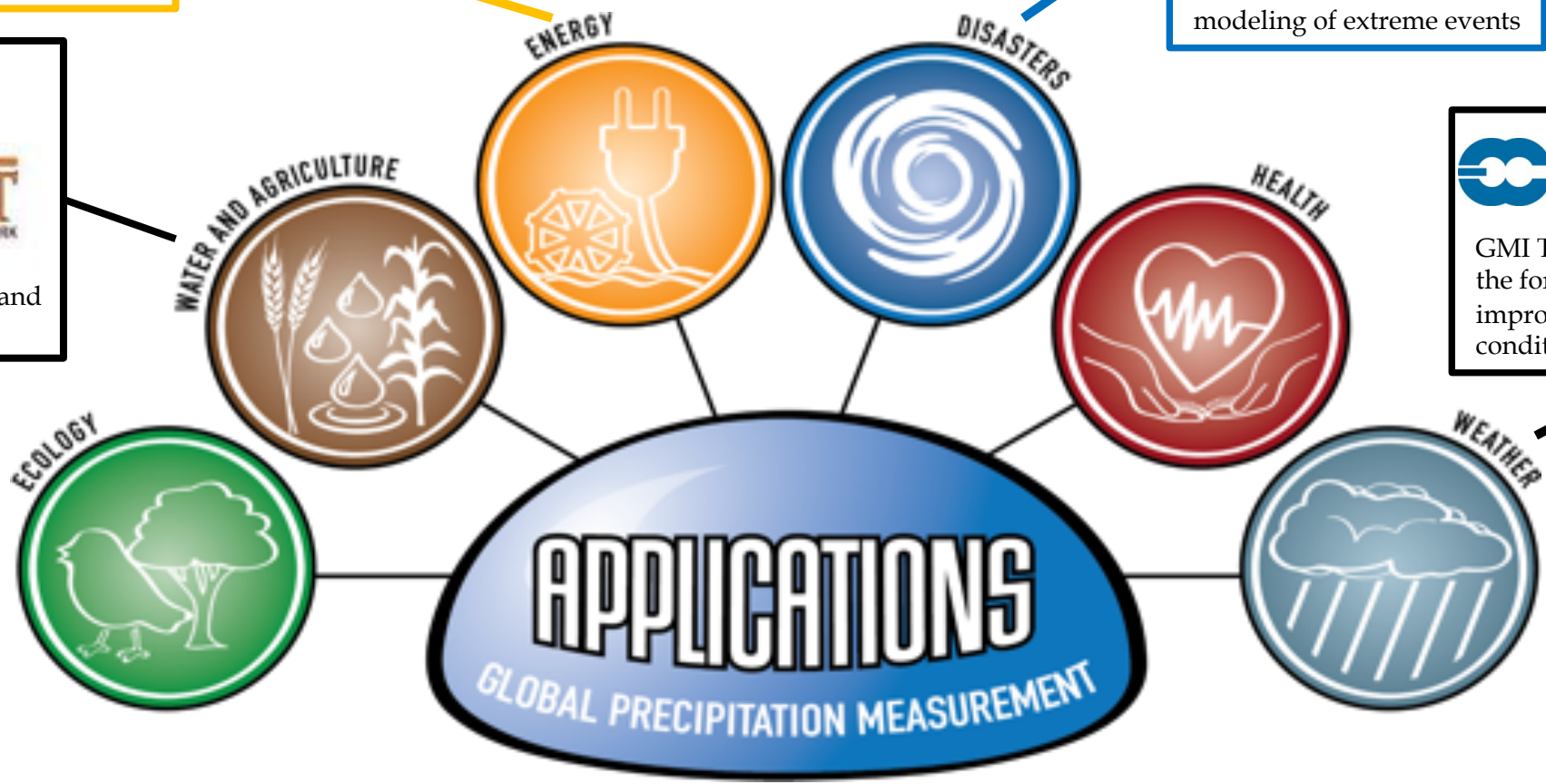
- Feb 2021 L1B Radar
L1B/Base/L1C GMI/TMI
- Mar 2021 L2/L3 GMI/TMI GPROF
- Apr 2021 L2/L3 TRMM/GPM Radar
L1C Partner radiometers
- May 2021 L2/L3 Combined
L2/L3 GPROF Partner radiometer
- **June 2021** **Begin GPM/TRMM V07 reprocessing**
- Aug 2021 SLH/CSH
- Sept 2021 Begin IMERG reprocessing

LM WIND POWER
Uses IMERG for estimating corrosion on wind turbines

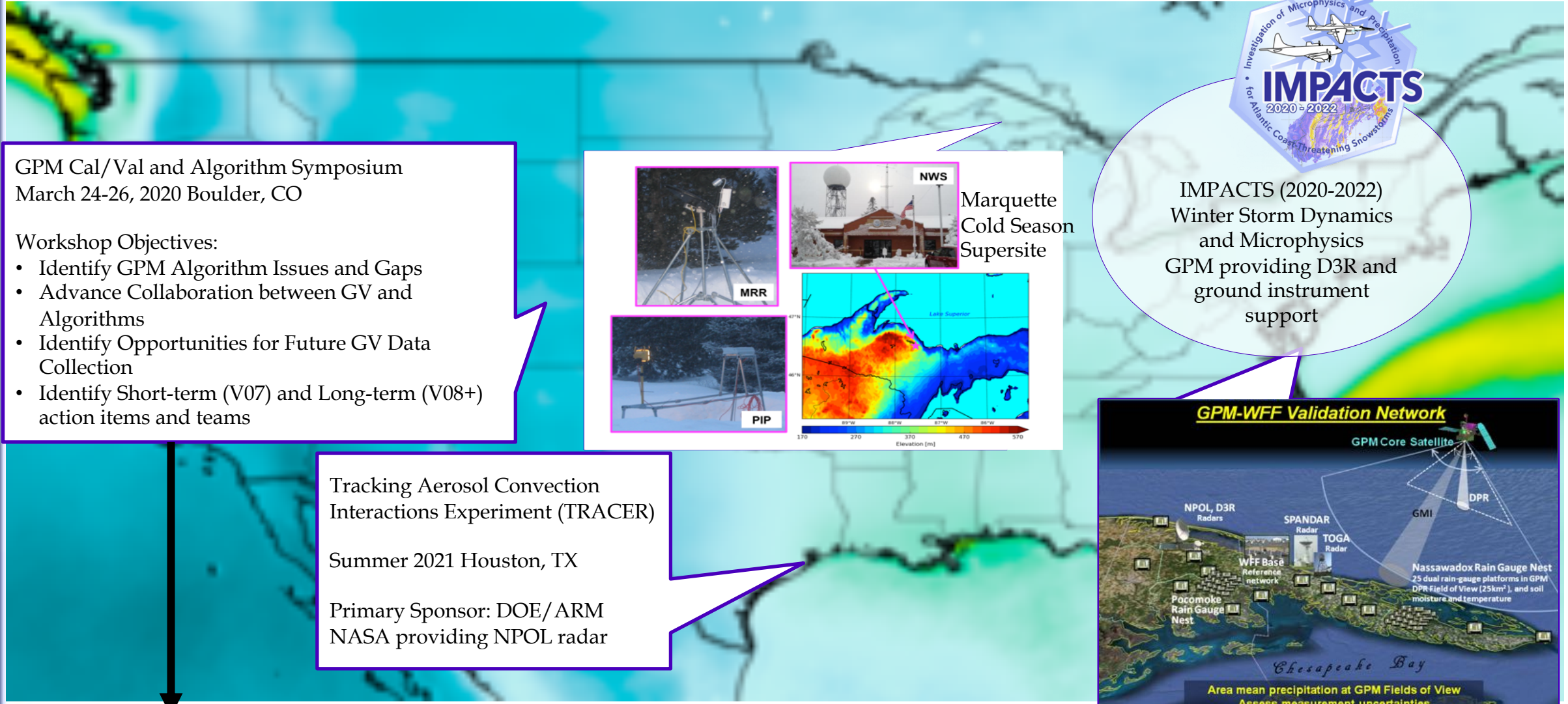
miCRO
Microinsurance Catastrophe Risk Organisation
Parametric insurance modeling of extreme events

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK
IMERG and other precip retrievals for agriculture and food security forecasting

ECMWF
GMI Tbs are assimilated into the forecasting models for improved estimates of initial conditions



Database of 8300 unique users highlight use of GPM data across six thematic application areas. Engagement with users through webinars, in person trainings, workshops, interviews, and reaching out through social media

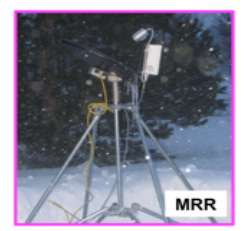


IMPACTS (2020-2022)
Winter Storm Dynamics
and Microphysics
GPM providing D3R and
ground instrument
support

GPM Cal/Val and Algorithm Symposium
March 24-26, 2020 Boulder, CO

Workshop Objectives:

- Identify GPM Algorithm Issues and Gaps
- Advance Collaboration between GV and Algorithms
- Identify Opportunities for Future GV Data Collection
- Identify Short-term (V07) and Long-term (V08+) action items and teams



MRR

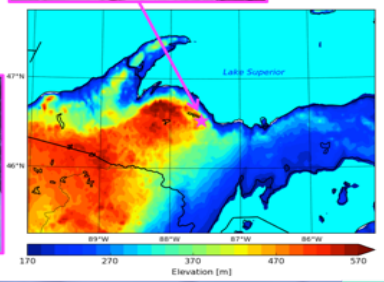


NWS

Marquette
Cold Season
Supersite



PIP

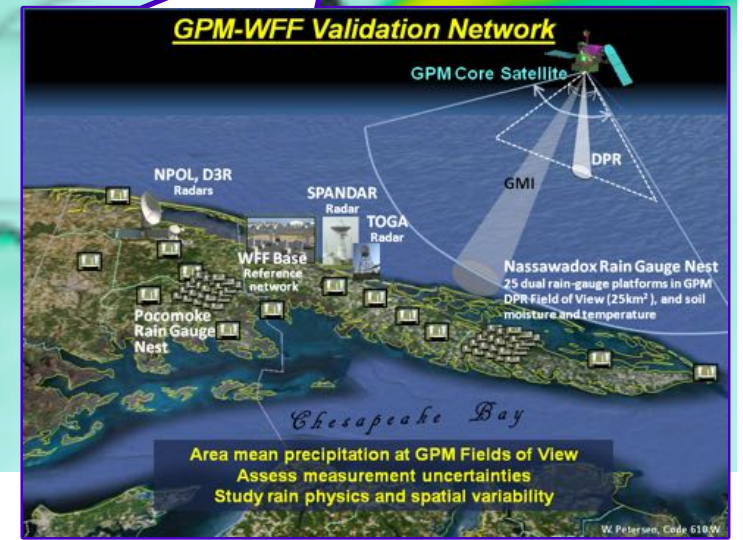


Elevation (m)

Tracking Aerosol Convection
Interactions Experiment (TRACER)

Summer 2021 Houston, TX

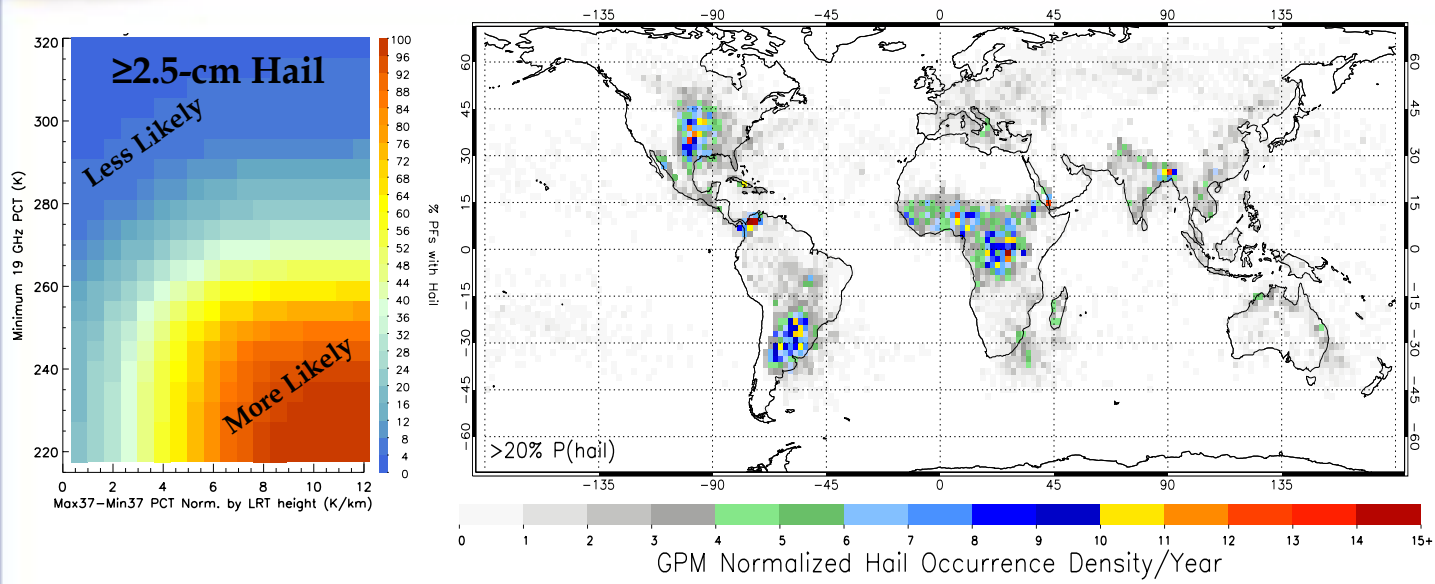
Primary Sponsor: DOE/ARM
NASA providing NPOL radar



GPM-WFF Validation Network

Area mean precipitation at GPM Fields of View
Assess measurement uncertainties
Study rain physics and spatial variability

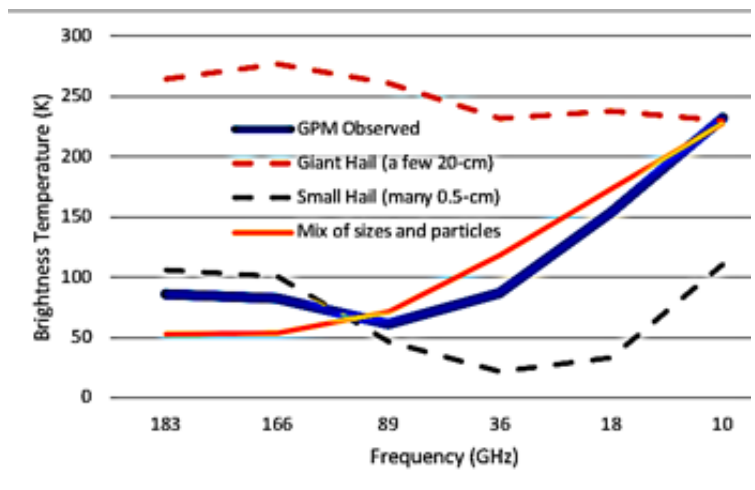
- 2020 Senior Review Proposal
- Should highlight recent accomplishments toward mission objectives:
 - Advancing precipitation measurements from space (including microphysical properties and vertical structure information)
 - Improving knowledge of precipitation systems, water cycle variability, and freshwater availability
 - Improving climate modeling and prediction
 - Improving weather forecasting and 4D reanalysis
 - Improving hydrological modeling and prediction
- Will identify top objectives for the next three years
 - Processing at V07 across full DPR swath for Ku and Ka
 - Evaluation of Level-4 (model assimilated) rainfall products
 - IMERG upgrades
 - Improved snowfall retrievals
 - New ground validation activities



- Bang and Cecil (2019) combine TRMM and GPM 19-GHz and 37-GHz measurements to estimate the likelihood a storm has large hail
- Determined the frequency of occurrence of those storms.
- Scaling by tropopause height used to mitigate overestimation of storms in the tropics.

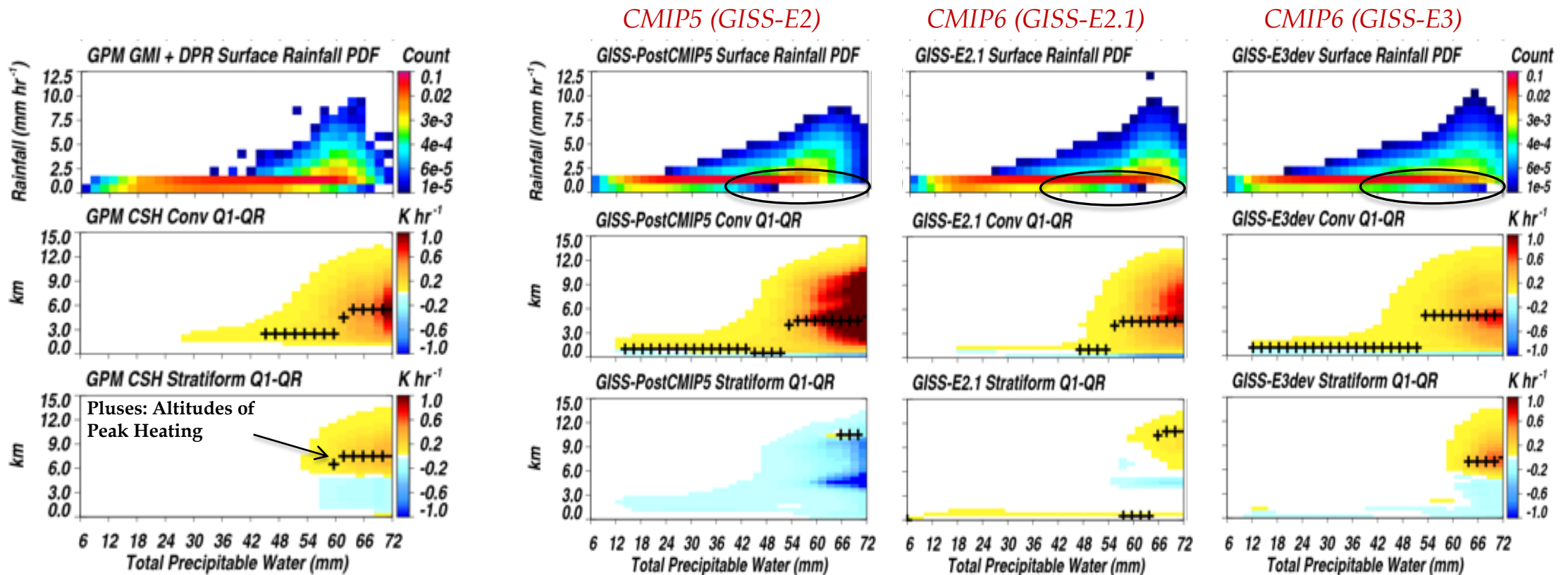
Above: (Right) Probability of hail as a function of 19- and 37-GHz measurements, normalized using tropopause height. From Bang and Cecil 2019. (Left) Map of estimated frequency of large (≥ 2.5 -cm) hail events using GPM 19 and 37 GHz channels, and tropopause height. From Bang and Cecil 2019.

Right: Measured (thick blue) and simulated GPM brightness temperatures for a Texas hailstorm. Adapted from Leppert and Cecil 2019.

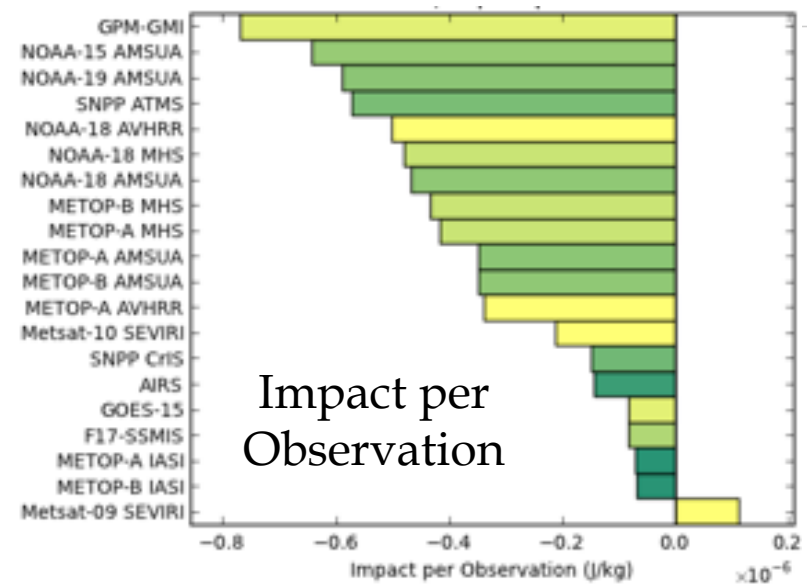
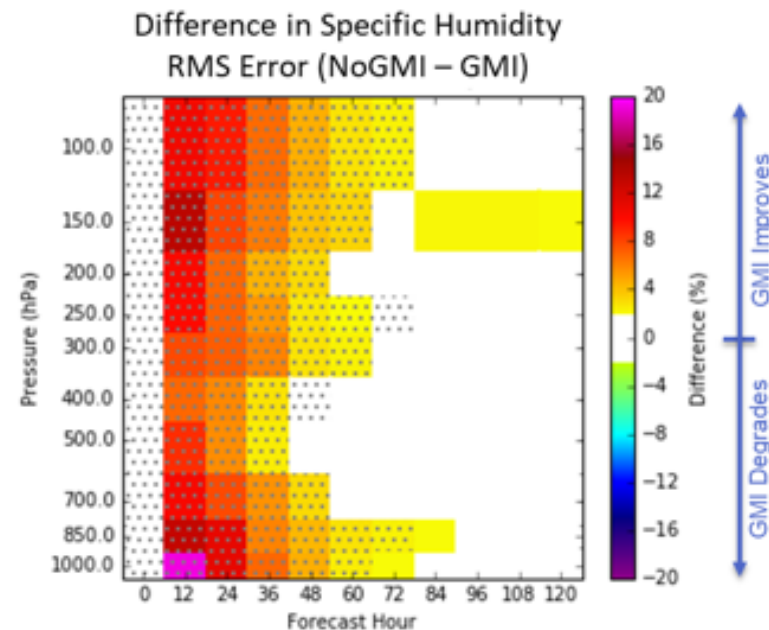


- Leppert and Cecil (2019) tested sensitivity to precipitation microphysics for a Texas hail storm with extremely low GPM-observed brightness temperatures.
- Explains why GPM measurements are not highly correlated with hail size – the number of hailstones is more important than their size.

Using GPM Rainfall and Latent Heating (LH) Data to Inform and Evaluate Deep Convection Simulation in the NASA GISS GCM (*Elsaesser et al., 2020*)

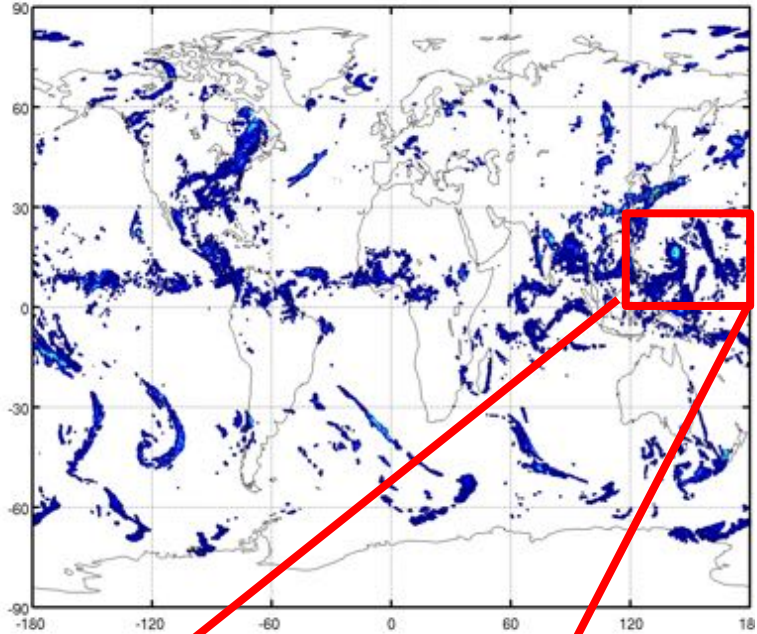


- Largest impact of GMI radiances in the Tropics
 - Specific humidity improved in short term (0-72 hour) forecasts (top, hatched indicates significance)
 - Similar improvements occur in tropical mid and lower tropospheric temperature and winds (not shown)
- Other modeling and initialization improvements included in the GEOS upgrade extend these improvements into the medium range
- **GMI is seen to have the highest impact per observation of all the radiance observation types**, and the total impact of GMI (bottom) is comparable to a single Microwave Humidity Sounder instrument (not shown)

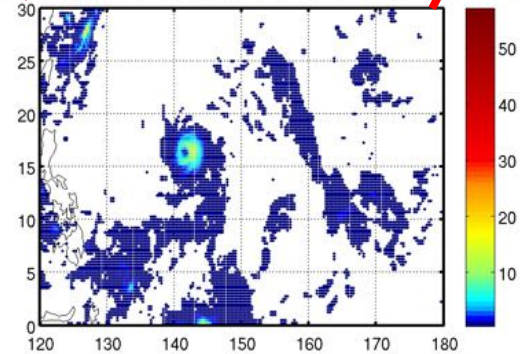


- GEOS-5 assimilation of all-sky radiances from constellation members
 - AMSU-A, MHS, ATMS
 - SSMIS, AMSR2 in progress
- GPM Project at GSFC is investigating the potential for a future Level-4 product (model assimilated rainfall product)
 - Horizontal resolution as low as 12.5 km, temporal resolution 30 minutes or better
 - Want to compare skill to IMERG, MRMS
 - Potential product could be released with one of two near-future retrospective reprocessings or eventual MERRA-3 product

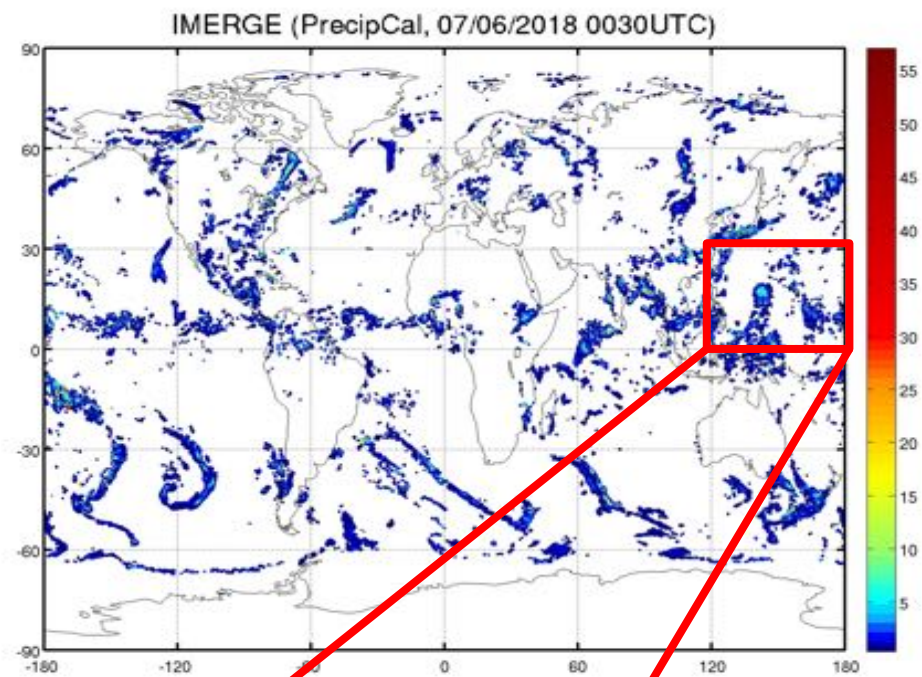
GEOS Analyzed Surface precip (mm/hr)
(Conventional, IR/MW clear sky data +
all-sky GMI and all-sky MHS data assimilated)



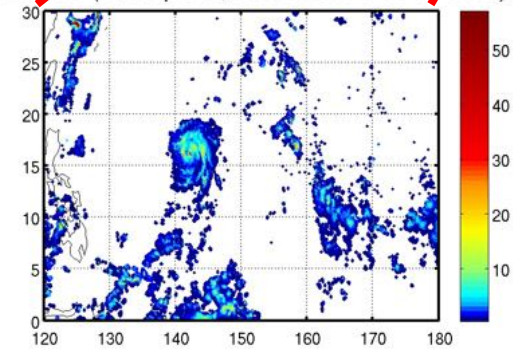
OS Precipitation Analysis, 07/06/2018 0030UTC



**IMERG
precipCal (mm/hr)**

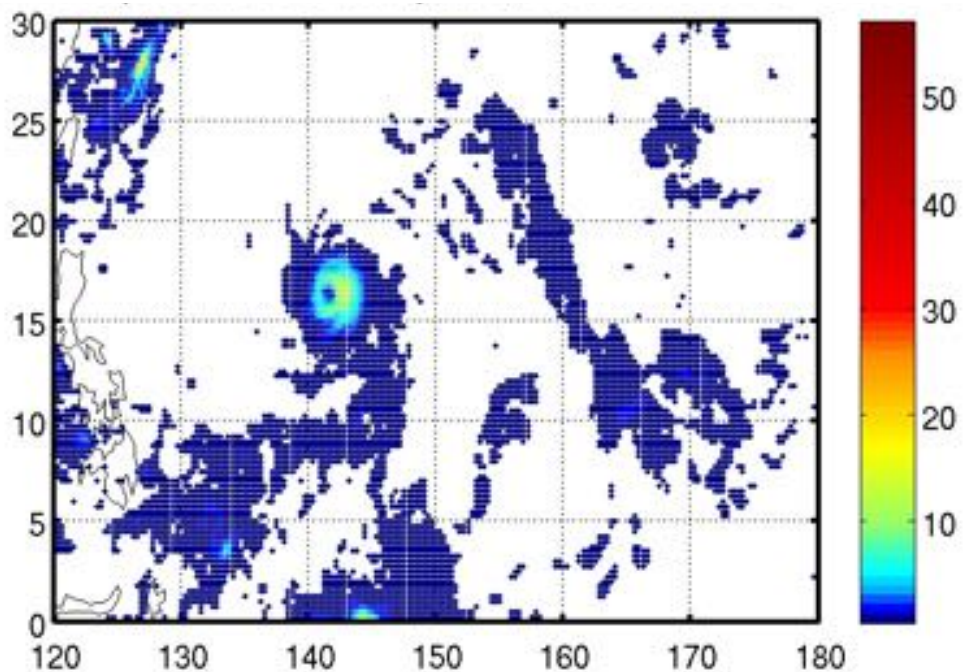


IMERG (PrecipCal, 07/06/2018 0030UTC)

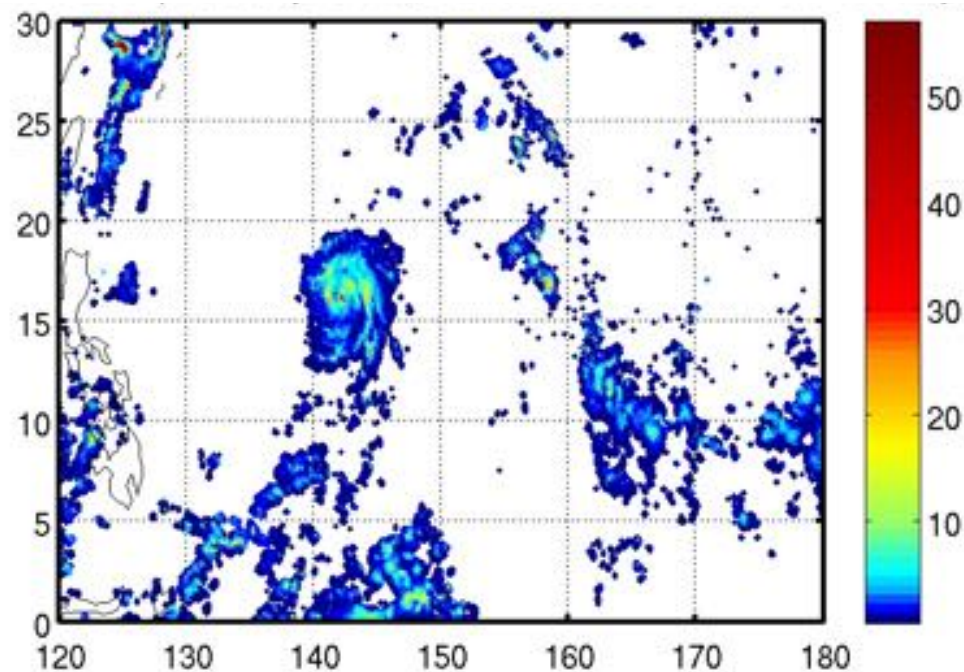


**2018
Typhoon
Maria**

GEOS Precipitation Analysis 0030 UTC July 06, 2018



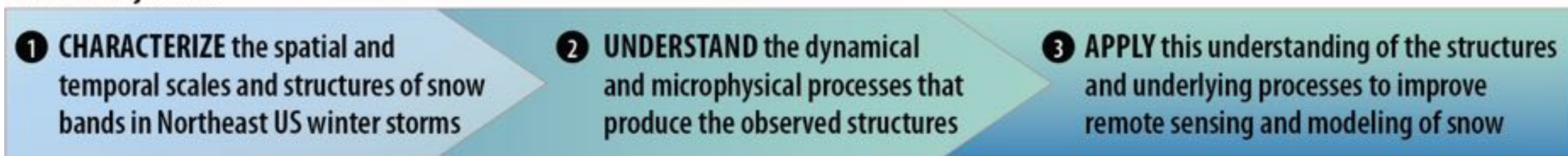
IMERG Precipitation Analysis 0030 UTC July 06, 2018



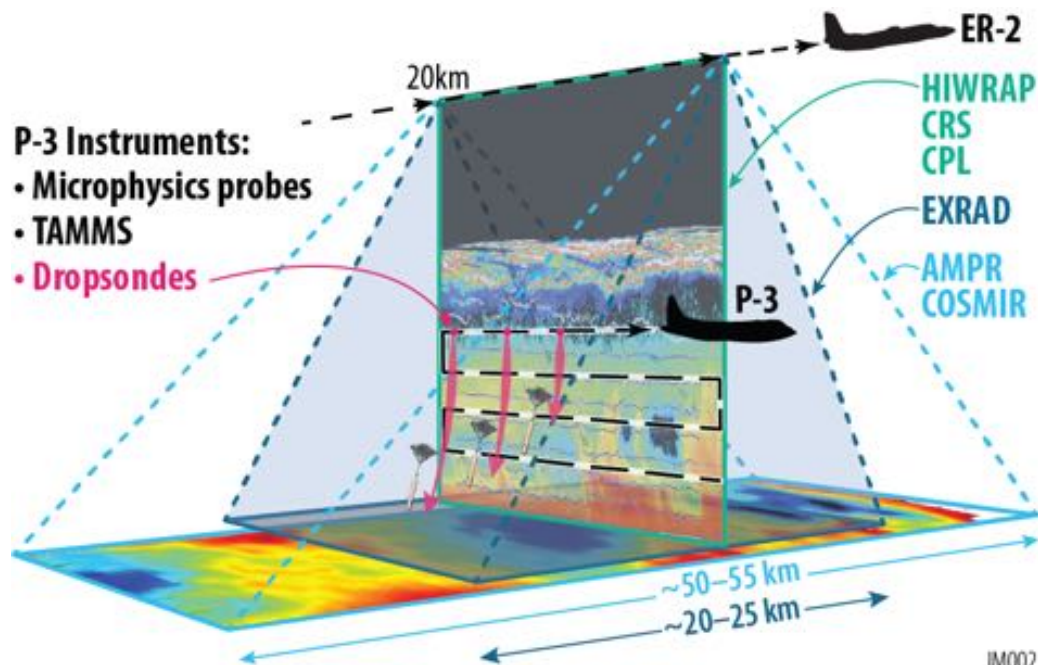
Investigation of Microphysics and Precipitation of Atlantic Coast-Threatening Snowstorms (IMPACTS)

- PI Lynn McMurdie, University of Washington, deputy PIs G. Heymsfield (GSFC), J. Yorks, and S. Braun

IMPACTS Objectives



IM055



IM002

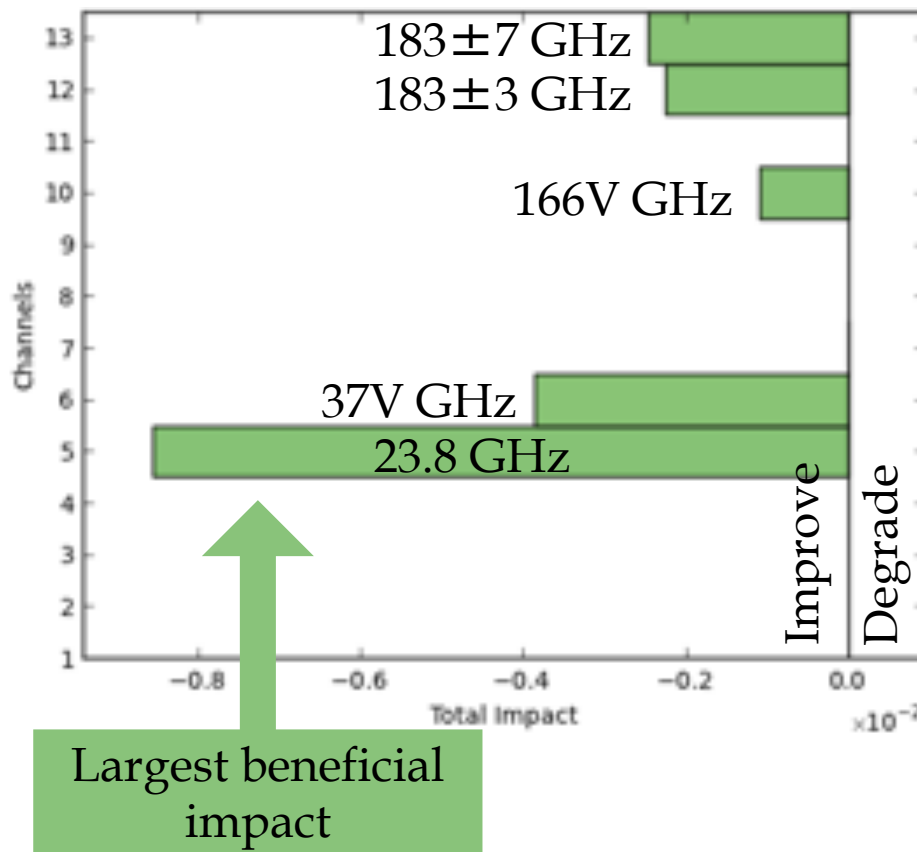
GPM funded additions:

- Dual-frequency, dual-polarized, Doppler radar (D3R) near UCONN
- Pluvio, disdrometer, other instruments

- GPM's systems are all fully functional, with fuel to potentially last until ~2033.
- V07 reprocessing nominally scheduled for mid 2021
- IMPACTS suborbital campaign ongoing
- GSFC exploring model assimilated level-4 rainfall products based on recent advancements in all-sky assimilation in GEOS model

- **EXTRA SLIDES**

GPM Microwave Imager FSOI by Band 1 Aug - 30 Nov 2018



The FSOI metric can be used to illustrate the importance of the 23.8 GHz band

- For FSOI, negative (positive) values indicate that the observations contributed to a forecast error reduction (increase)
 - *Negative is good*
- Of the six bands used in our weather forecasting system, the 23.8 GHz band accounts for 47% of the total forecast impact from GPM/GMI

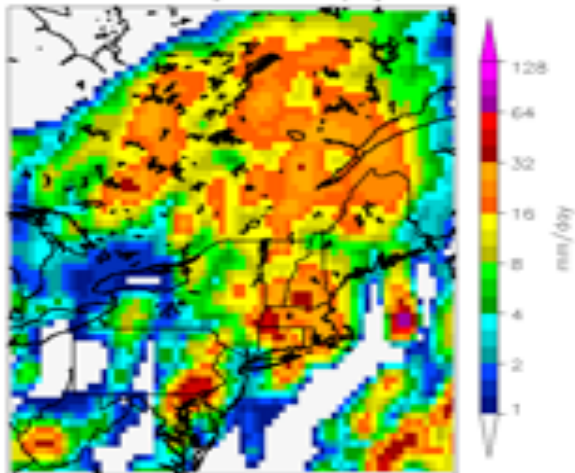
FSOI=Forecast Sensitivity-Observation Impact

Derived rain rate
No 23.8 GHz data

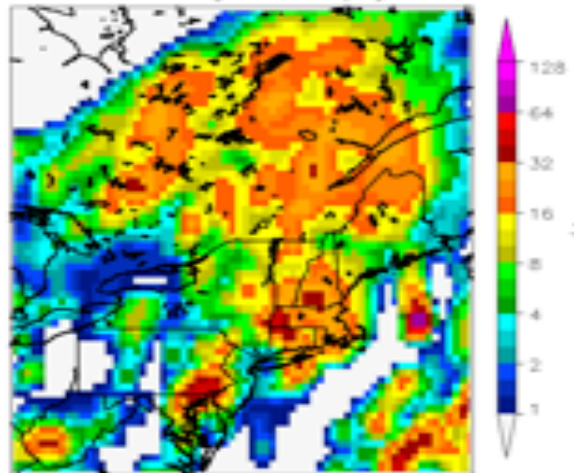
Derived rain rate
Includes 23.8 GHz data

Percentage differences between
the two estimates

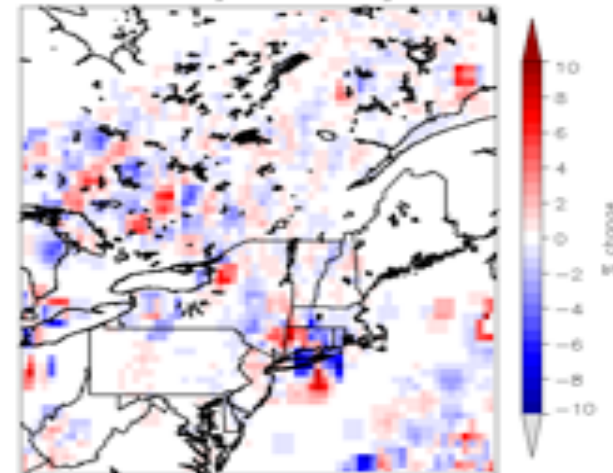
GPROF Rainrates Missing 23 GHz Channels
July 1st, 2015 from Sensors: GM/AMSR2/F16,F17,F18,F19
Area Average: 9.314 mm/day



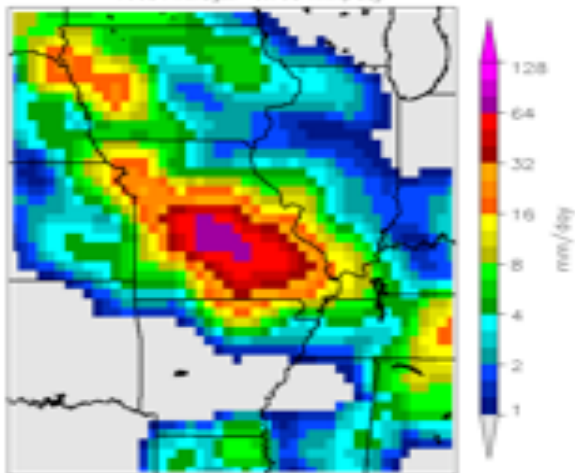
GPROF Rainrates Including All Channels
July 1st, 2015 from Sensors: GM/AMSR2/F16,F17,F18,F19
Area Average: 9.313 mm/day



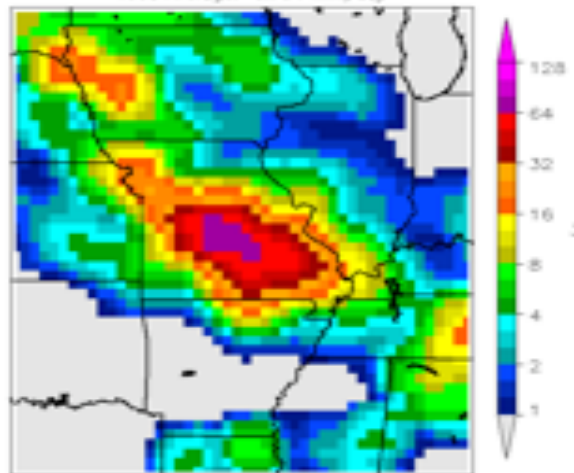
GPROF Rainrates (Missing 23 GHz - All Channels)
July 1st, 2015 from Sensors: GM/AMSR2/F16,F17,F18,F19
Area Average: -0.853 % change



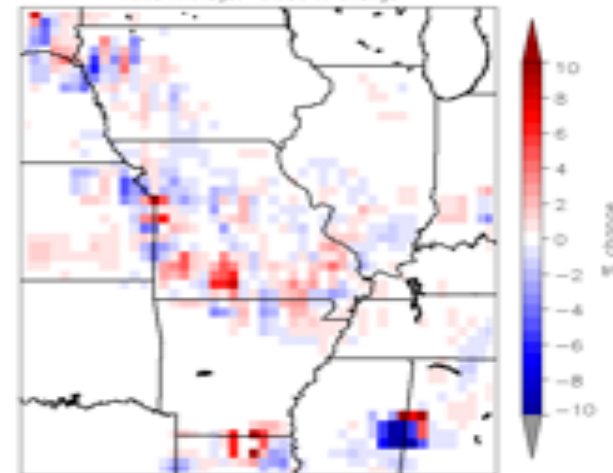
GPROF Rainrates Missing 23 GHz Channels
July 1st, 2015 from Sensors: GM/AMSR2/F16,F17,F18,F19
Area Average: 6.795 mm/day



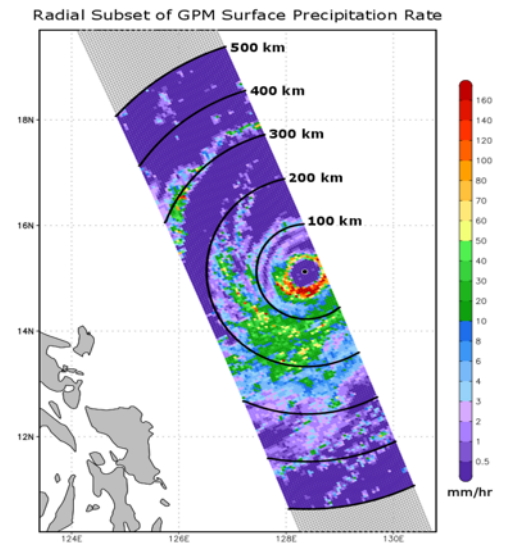
GPROF Rainrates Including All Channels
July 1st, 2015 from Sensors: GM/AMSR2/F16,F17,F18,F19
Area Average: 6.794 mm/day



GPROF Rainrates (Missing 23 GHz - All Channels)
July 1st, 2015 from Sensors: GM/AMSR2/F16,F17,F18,F19
Area Average: 0.959 % change



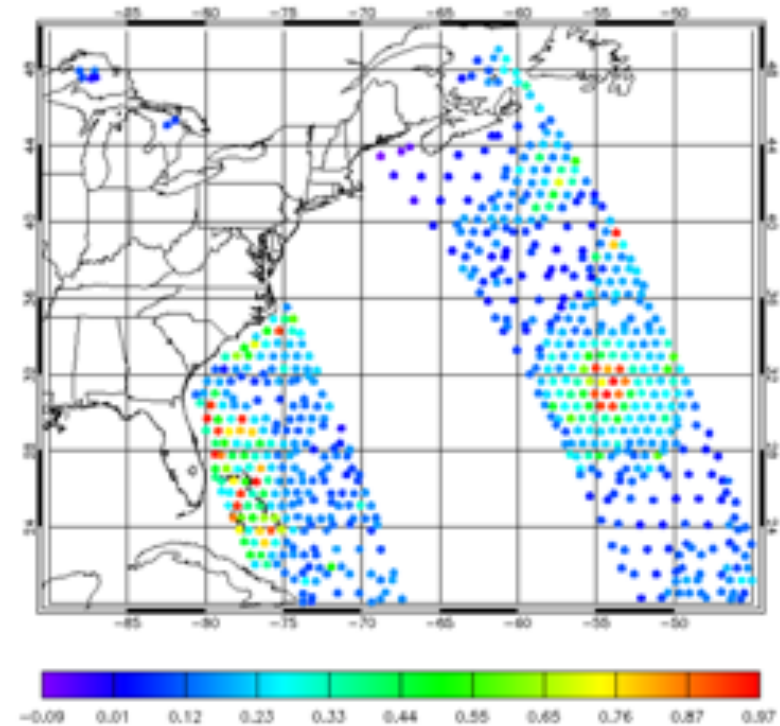
- Services updates:
 - V06B IMERG in Giovanni for visual and analysis exploration
 - Level 2 GPM sub-setter (average download **volume reduction >90%**)
 - Level 3 re-gridder (re-grids to 33 different gridding schemes)
- Services available:
 - OPeNDAP: Hyrax, THREDDS, GDS; OGC WMS
- User assistance and outreach
 - On-site science expertise providing personal assistance and numerous data recipes on how to understand and access PMM data.
 - User training including webinars, workshops
- IMERG in the Cloud (Cumulus)
 - Co-located with other DAACs data for integrated discovery, access, analysis in the Amazon cloud
 - MERRA-2, AIRS Level 2 as well in FY20.
- Giovanni in the Cloud
 - Analytics framework for next generation data systems
 - **> 500x performance improvements** for extraction and analysis of long time series (1000s of time steps)
 - Permits third parties to add data and services to Giovanni analysis framework.
- Other services in development:
 - Time aggregation services, geoTIFF format conversion for GIS users



Subset of L2 GPM-DPR within 500 km of Typhoon Mangkhut eye using GrADS.

- On 11 July 2018, the GMAO began assimilating GMI observations
 - Assimilation of GMI radiances in real-time
 - Active assimilation under all-sky situations
- Advanced methods were incorporated to optimize the use of these observations
 - Adaptive thinning in the presence of clouds and precipitation (left, where warm colors indicate increased convective activity)
 - Advances to underlying radiative transfer algorithm
 - Incorporations of cloud ice, cloud liquid, rain, and snow into the solution

GMI Observations (1-Normalized 37 GHz TB polarization difference)



Min-Jeong Kim (GMAO/GESTAR)

Current end-of-fuel date is April 2033

GPM Estimated End-of-Fuel Date

