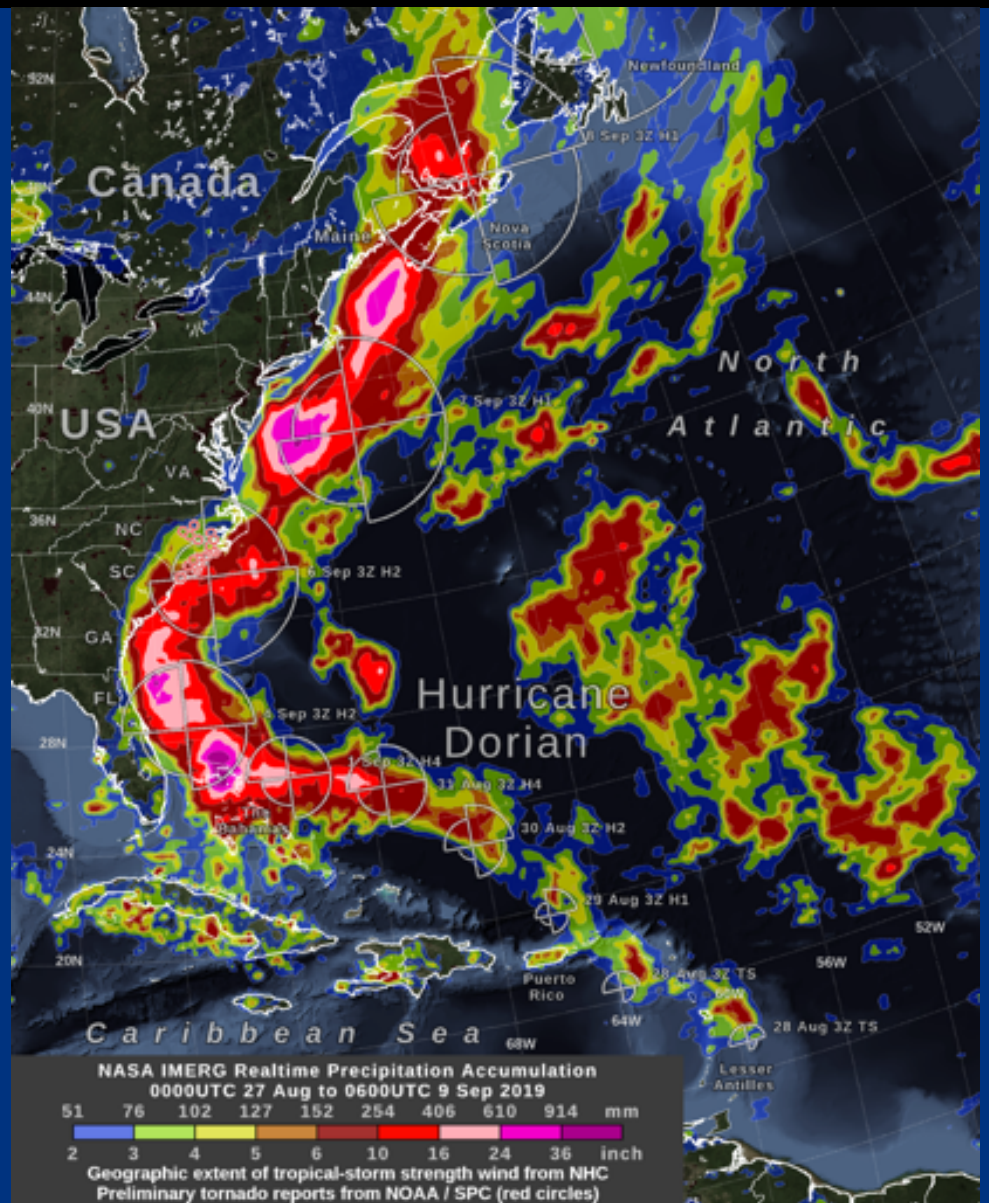
GPM Status and Science



Scott Braun
GPM Project Scientist

NASA Goddard Space Flight Center

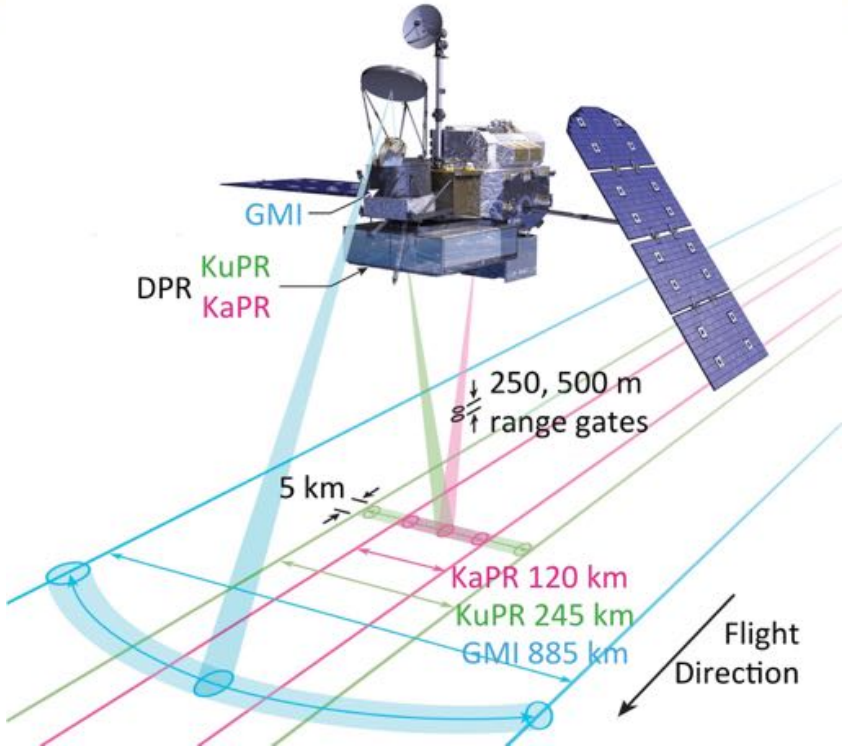
Precipitation Measurement Missions Science Team Meeting
November 5, 2019

www.nasa.gov/gpm
Twitter: NASARain
Facebook: NASARain

The GPM Core Observatory

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)

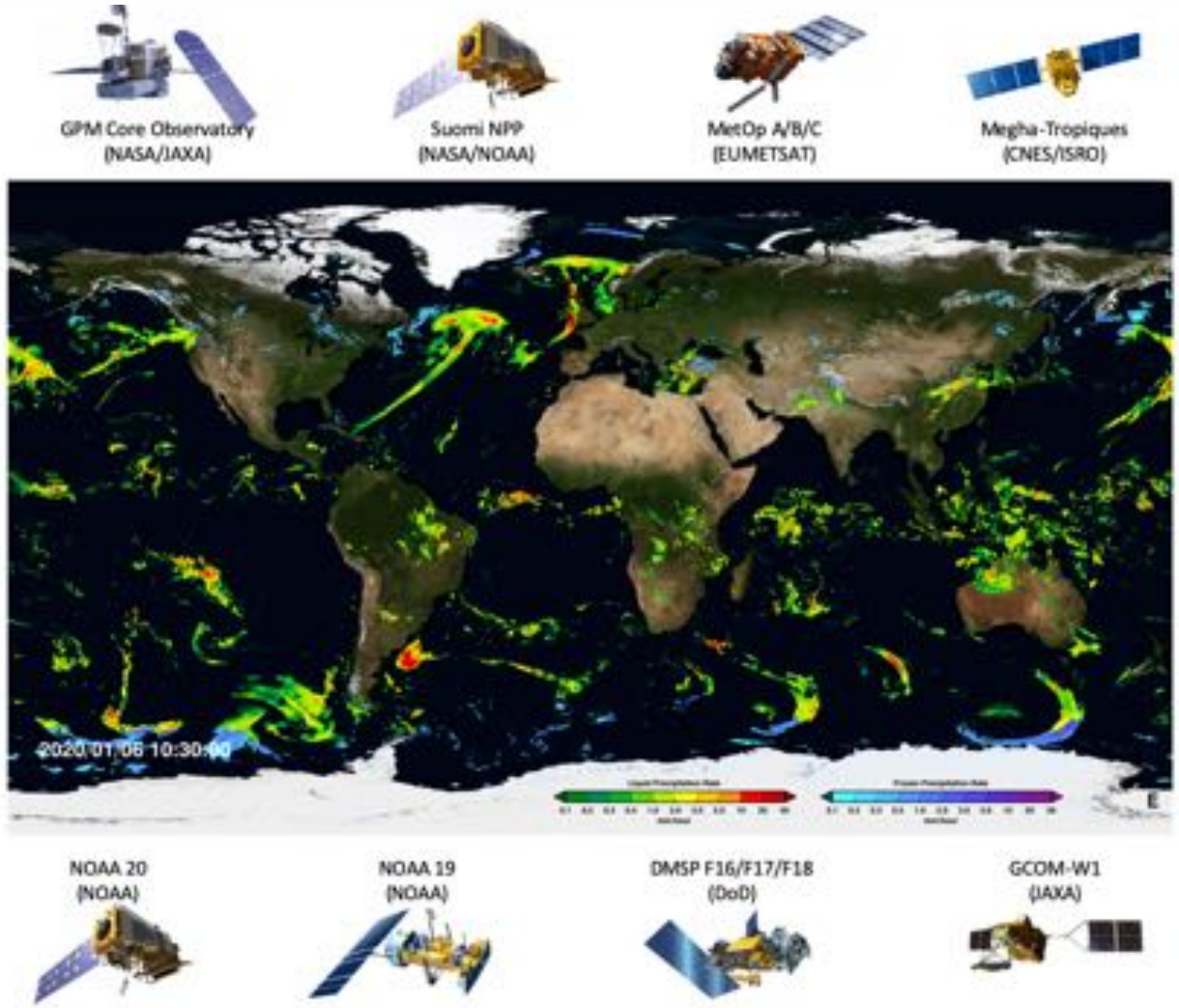
- Passive radiometer with excellent calibration
- 10VH, 19VH, 23, 36VH, 89VH, 166VH, 183±3, ±7
- Provides measurements of precipitation (rain and snow) intensity and distribution over 885 km swath
- High spatial resolution (down to ~5km footprints)

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

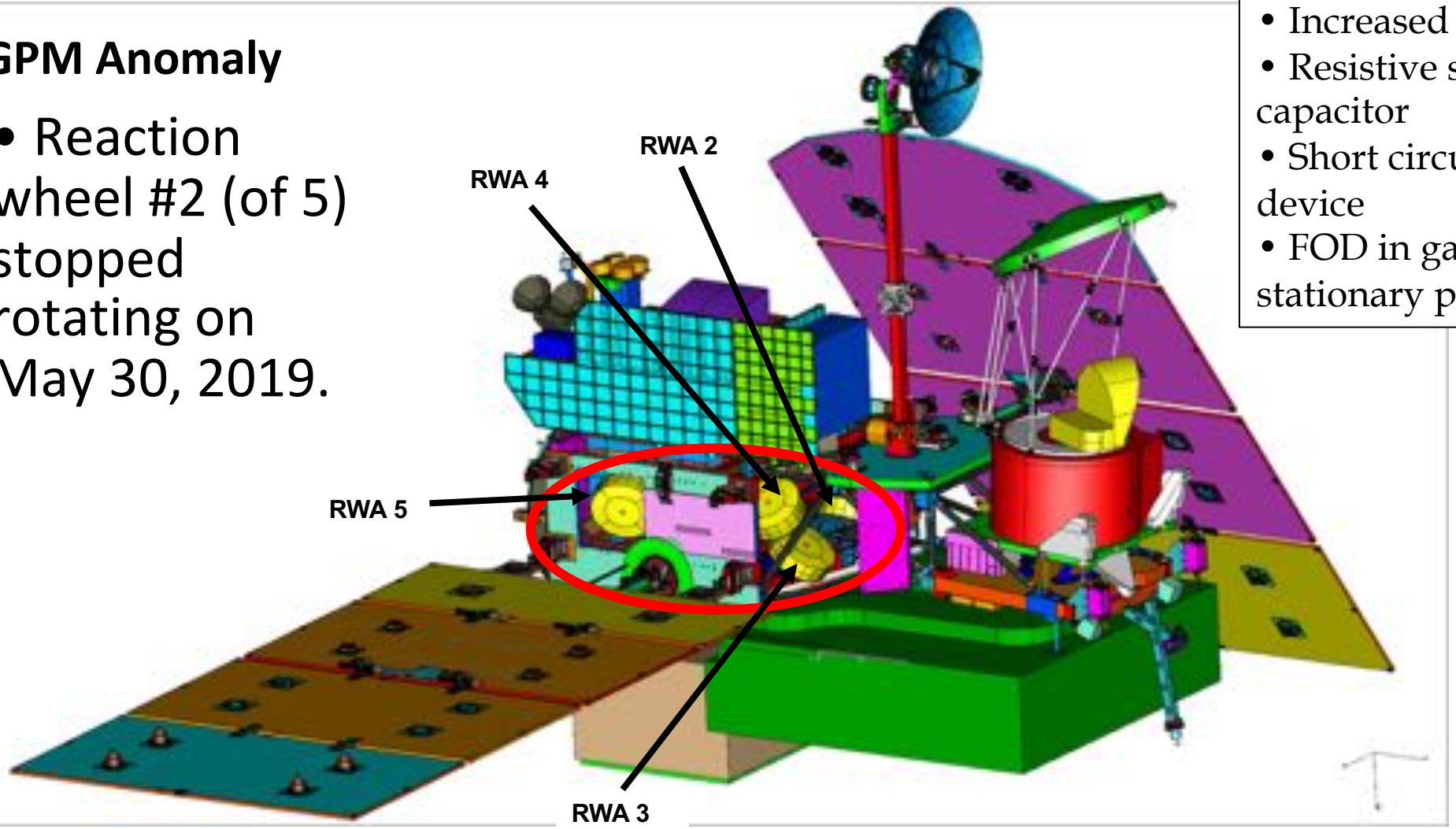


11 sensors in current constellation

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

Algorithm Updates

- 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

Notional V07 Timeline

- 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

GPM Applications

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

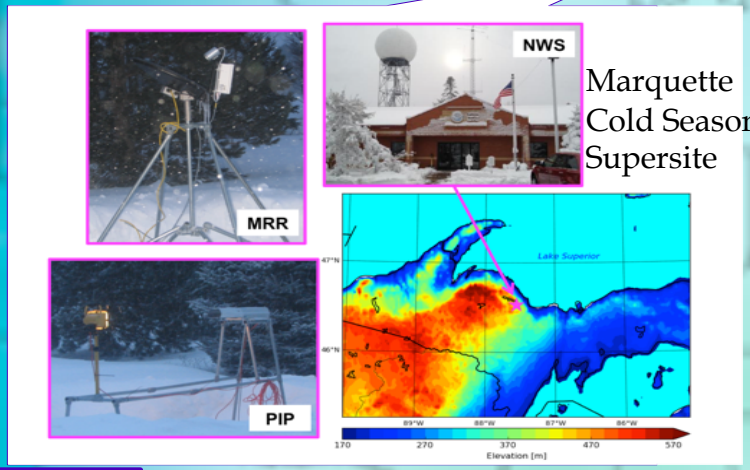
GMI Tbs are assimilated into the forecasting models for improved estimates of initial conditions

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

Ongoing GPM GV Activities

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



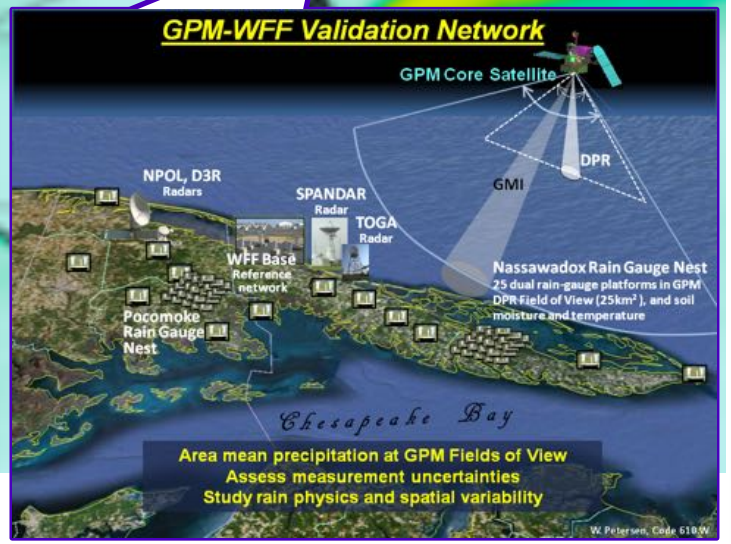
Marquette Cold Season Supersite

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

Tracking Aerosol Convection Interactions Experiment (TRACER)

Summer 2021 Houston, TX

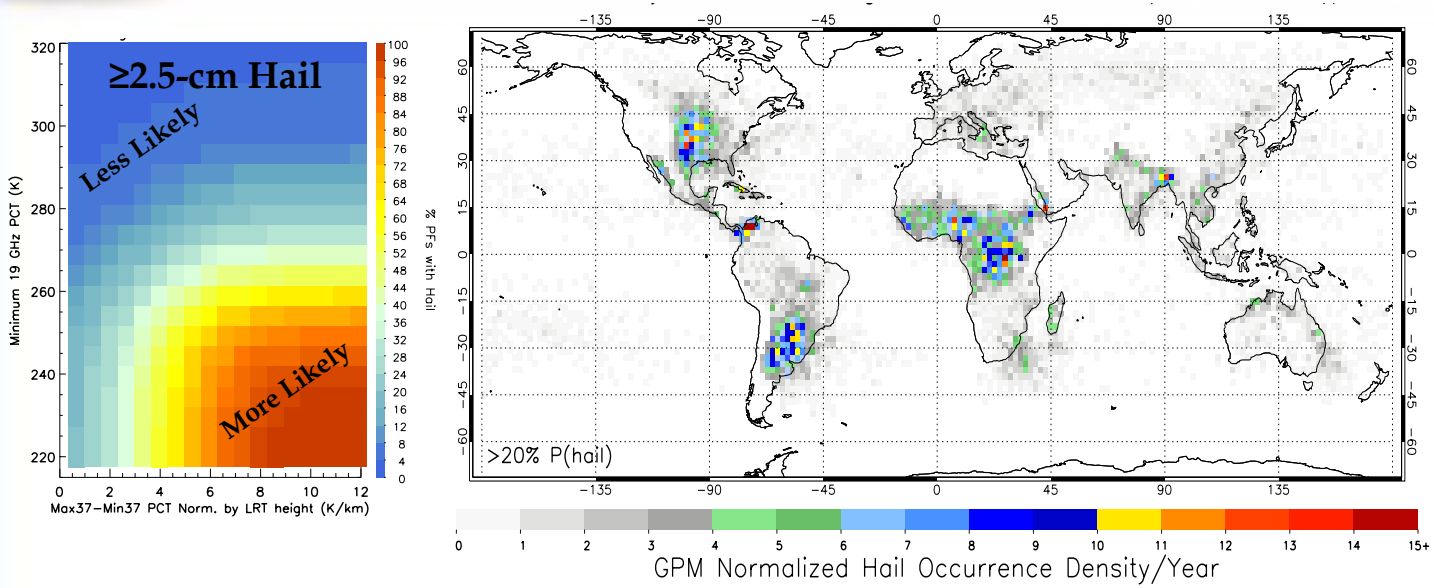
Primary Sponsor: DOE/ARM
NASA providing NPOL radar



https://www.colorado.edu/event/calval2020/

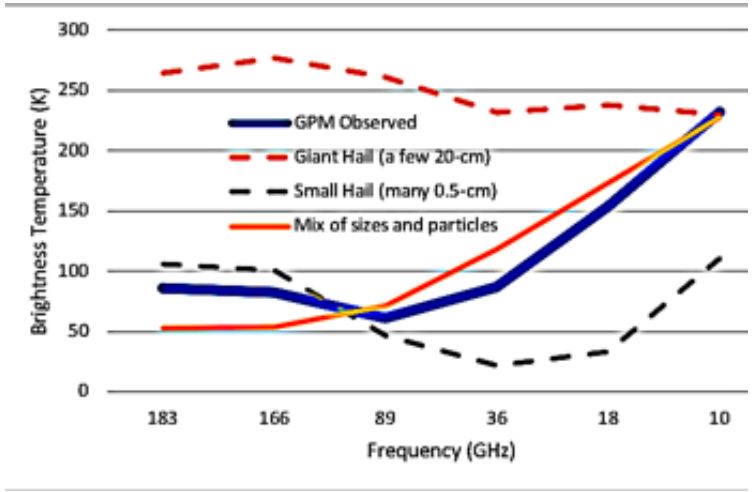
- 2020 Senior Review Proposal
- Should highlight recent accomplishments toward mission objectives:
  - Advancing precipitation measurements from space (including microphysical properties and vertical structure information)
  - Improving knowledge of precipitation systems, water cycle variability, and 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

Hail Retrieval and Climatology from GPM



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.

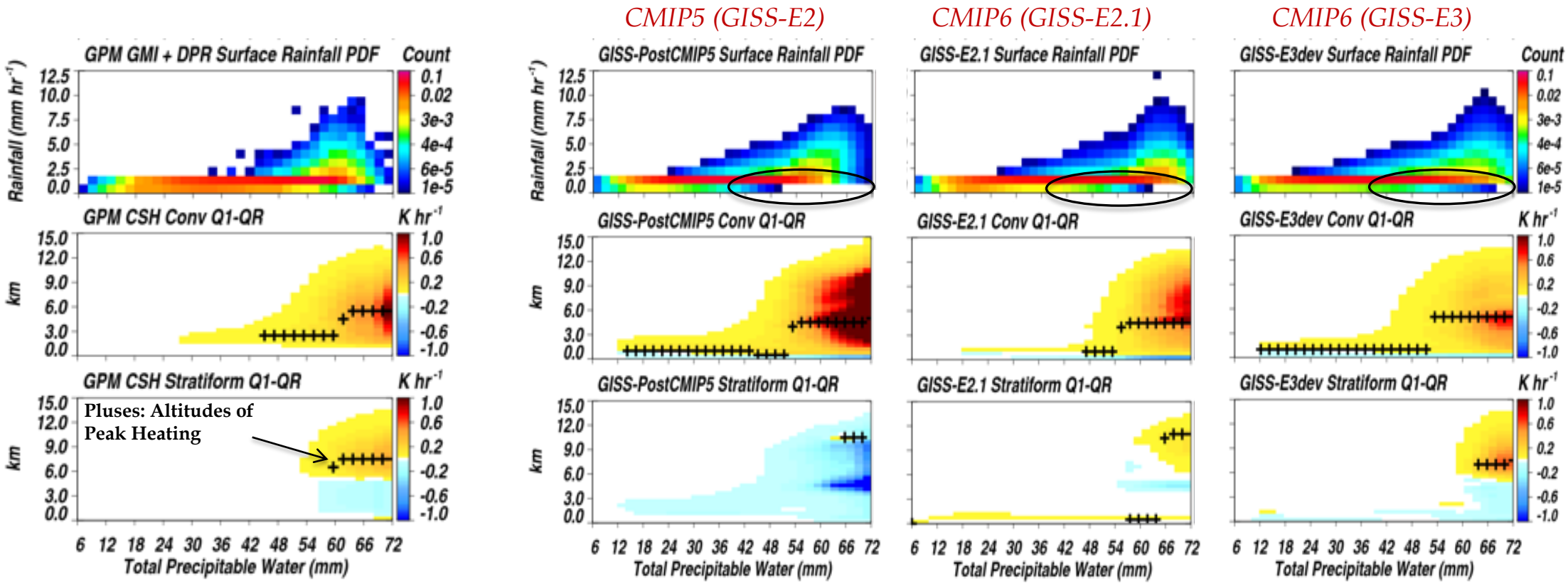
Right:
Measured (thick blue) and simulated GPM brightness temperatures for a Texas hailstorm. Adapted from Leppert and Cecil 2019.



- 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.

- 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*)

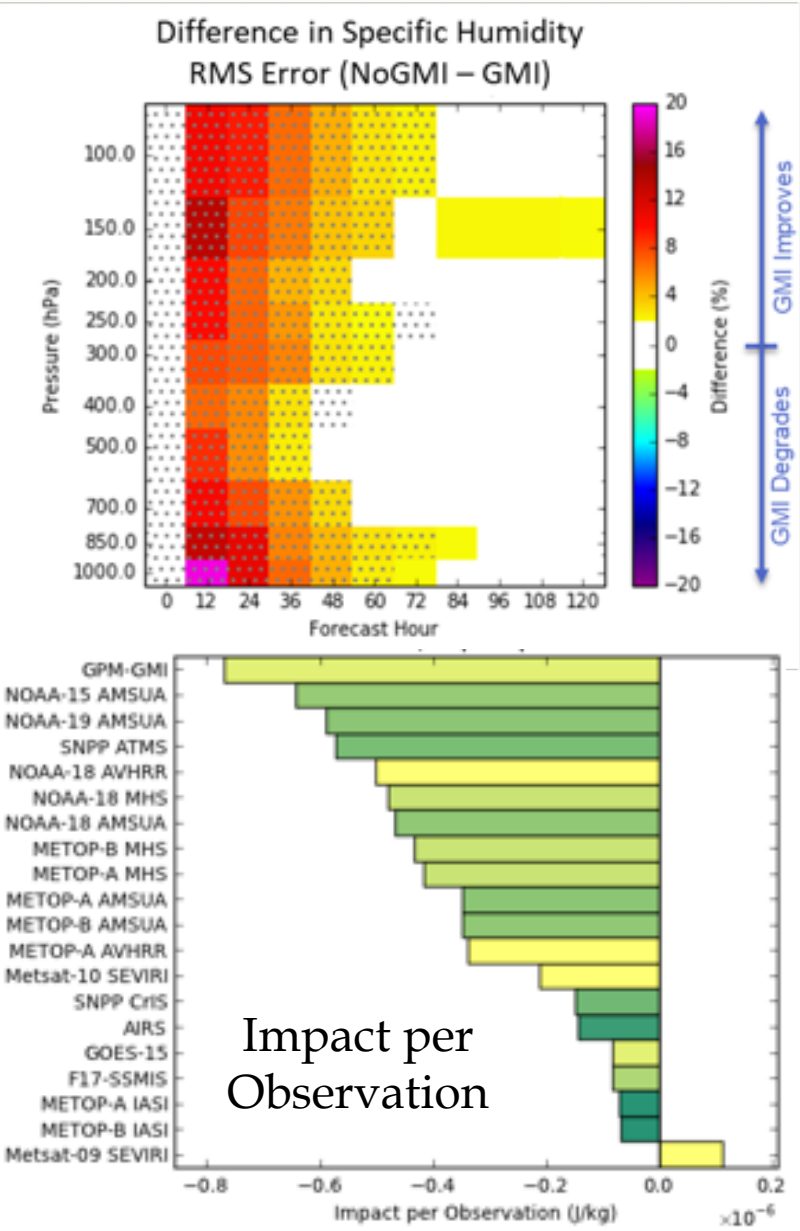


All-Sky GPM Data in GEOS Weather Forecasts

- 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)



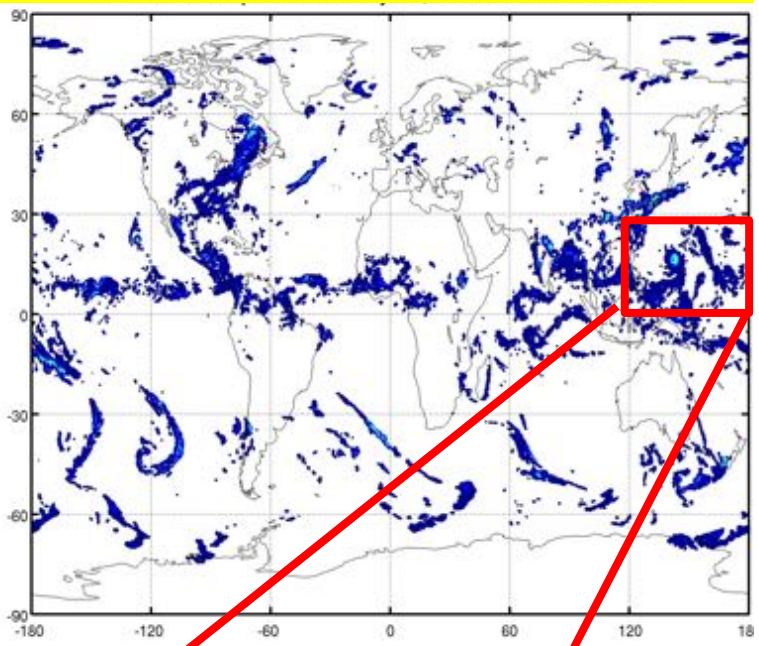
Min-Jeong Kim (GMAO/GESTAR)

GEOS-5 Assimilation Development and Products

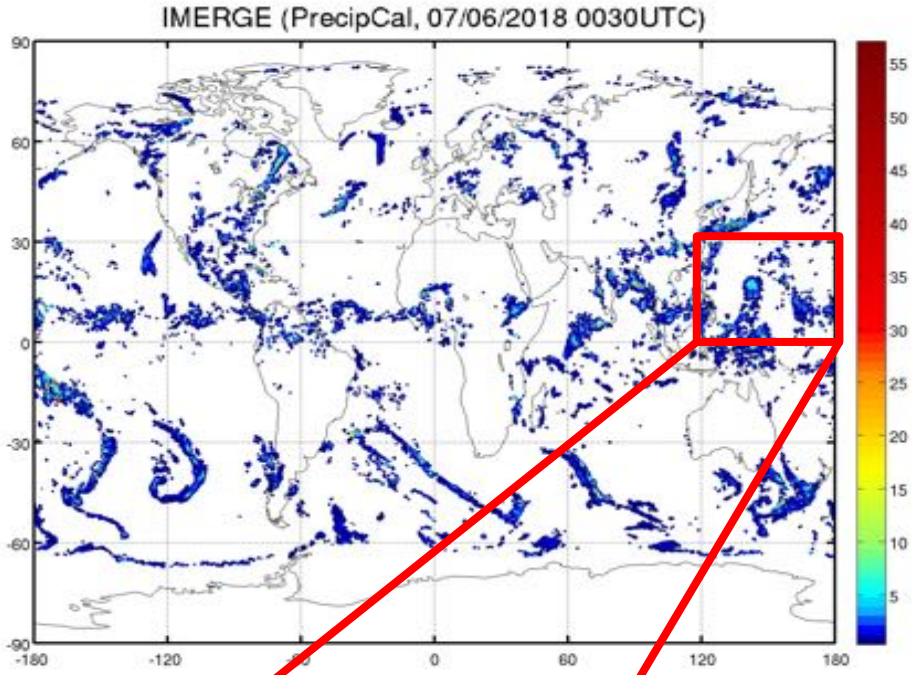
- GEOS-5 assimilation of all-sky radiances from constellation members
  - AMSU-A, MHS, ATMS
  - SSMIS, AMSR2 in progress
- GPM Project at GSFC is investigating the potential for a future Level-4 product (model assimilated rainfall product)
  - Horizontal resolution as low as 12.5 km, temporal resolution 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

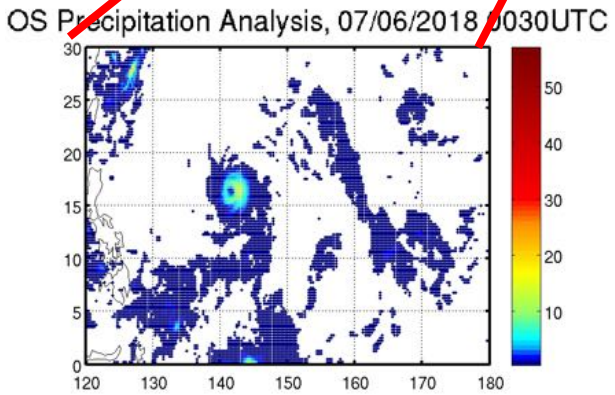
IMERG Versus GEOS

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

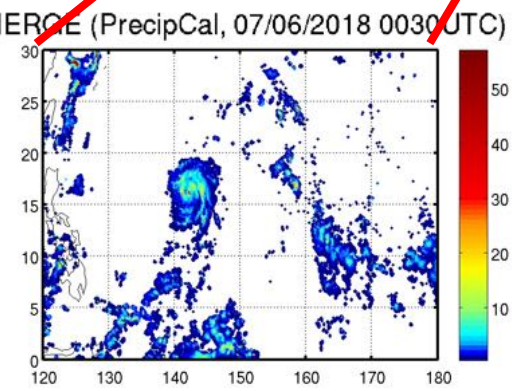


IMERG
precipCal (mm/hr)



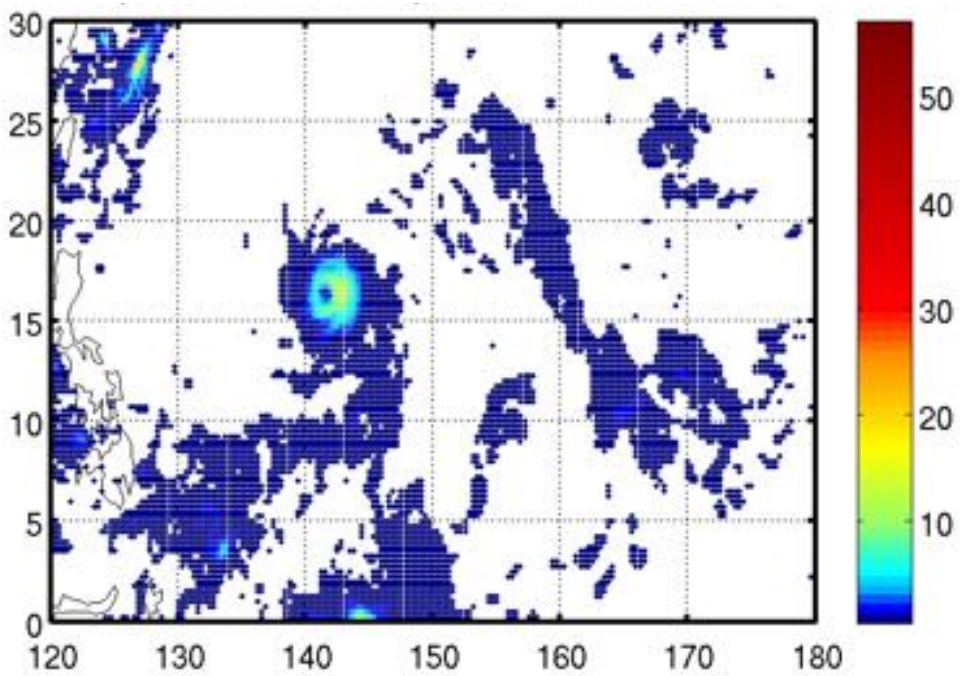


2018
Typhoon
Maria

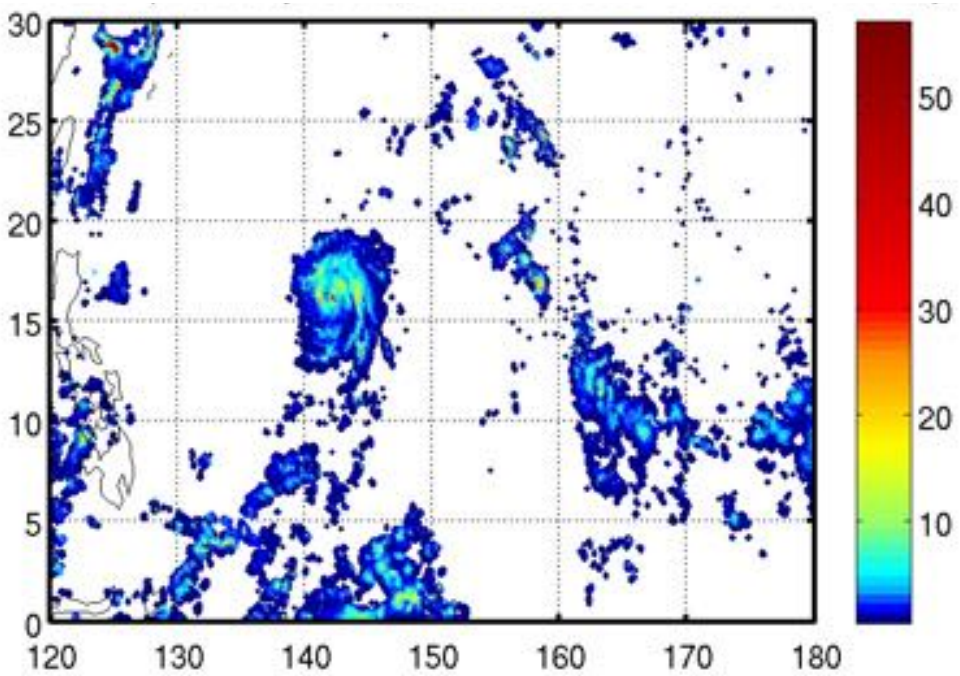


IMERG Versus GEOS

GEOS Precipitation Analysis
0030 UTC July 06, 2018

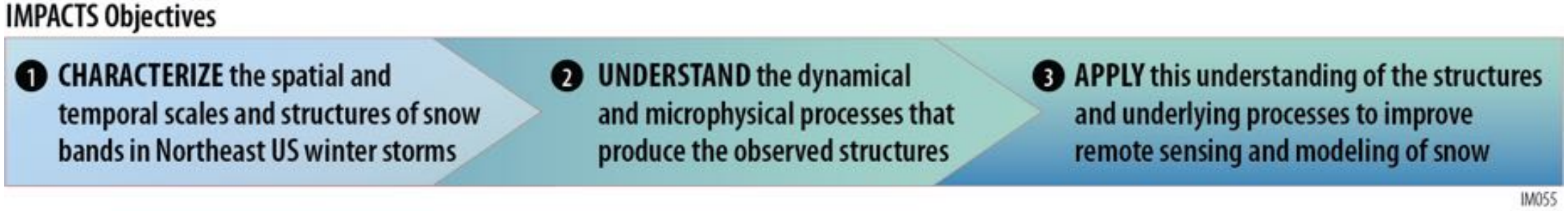


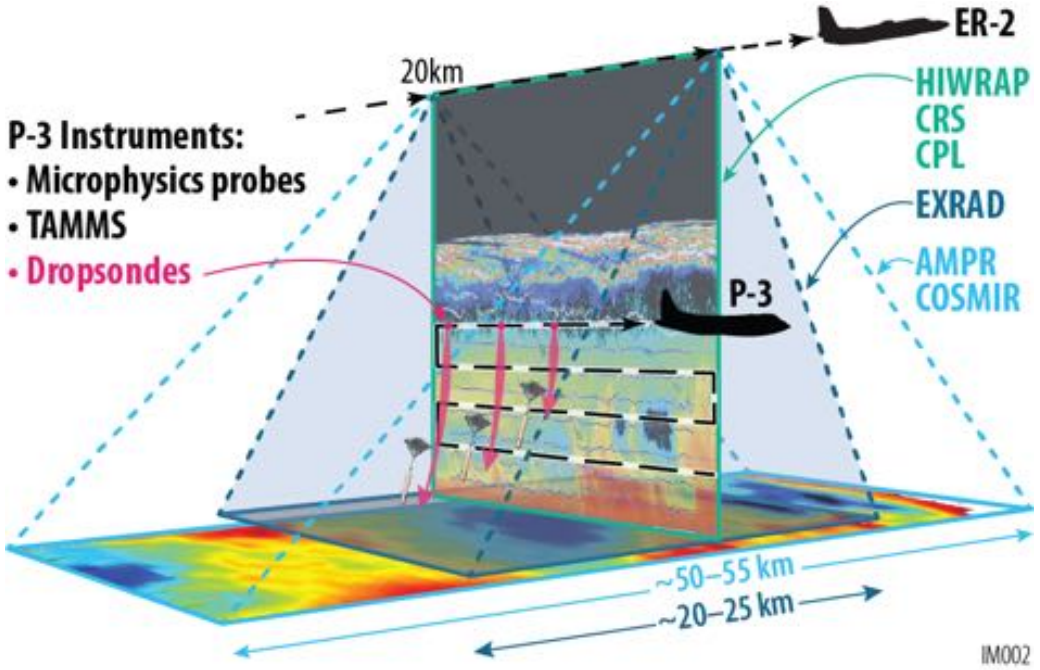
IMERG Precipitation Analysis
0030 UTC July 06, 2018



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





GPM funded additions:

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

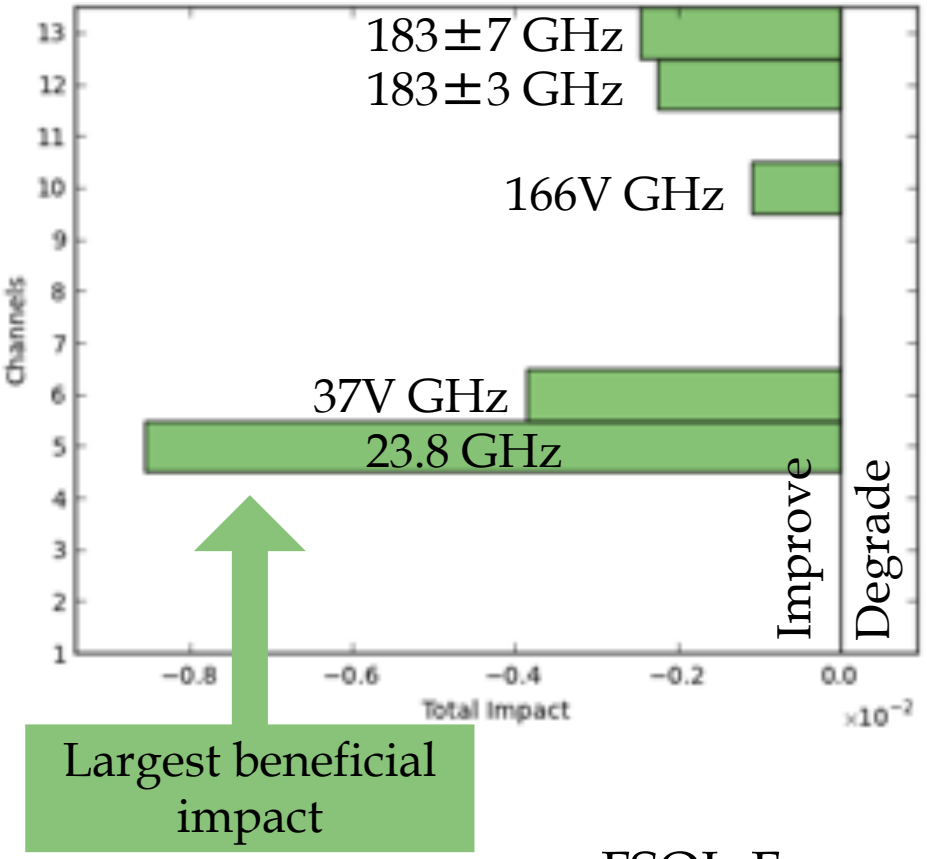
Summary

- 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

Impact of 23.8 GHz on 24 Hour Forecasts

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

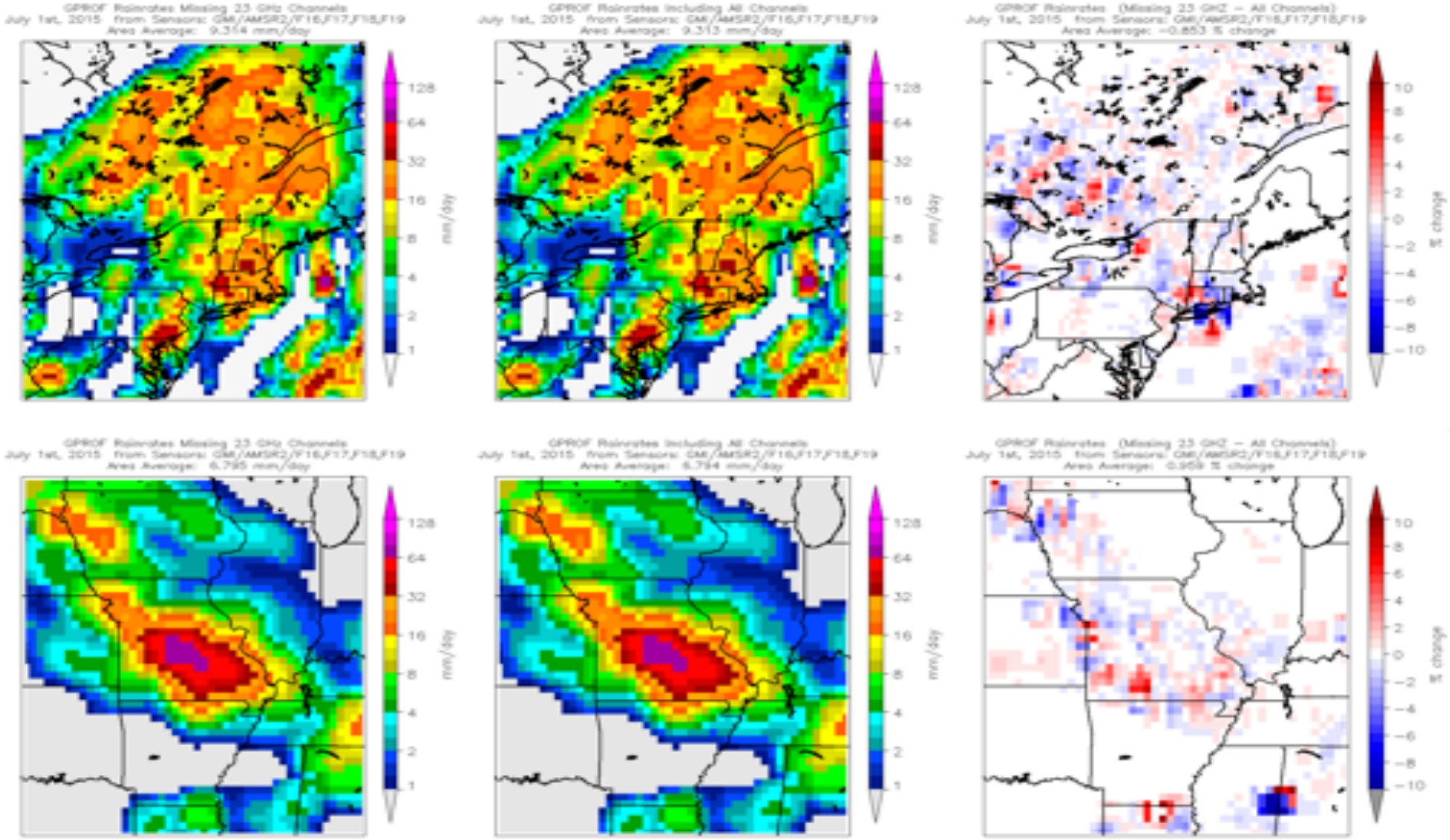
Courtesy of W. McCarty

Two Heavy Rain Events

Derived rain rate
No 23.8 GHz data

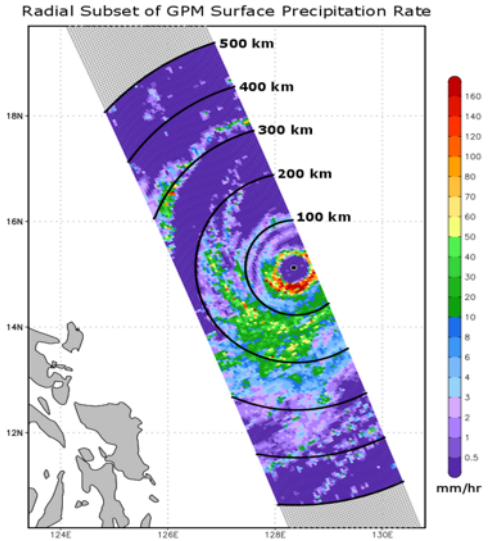
Derived rain rate
Includes 23.8 GHz data

Percentage differences between
the two estimates



GES DISC support to PMM

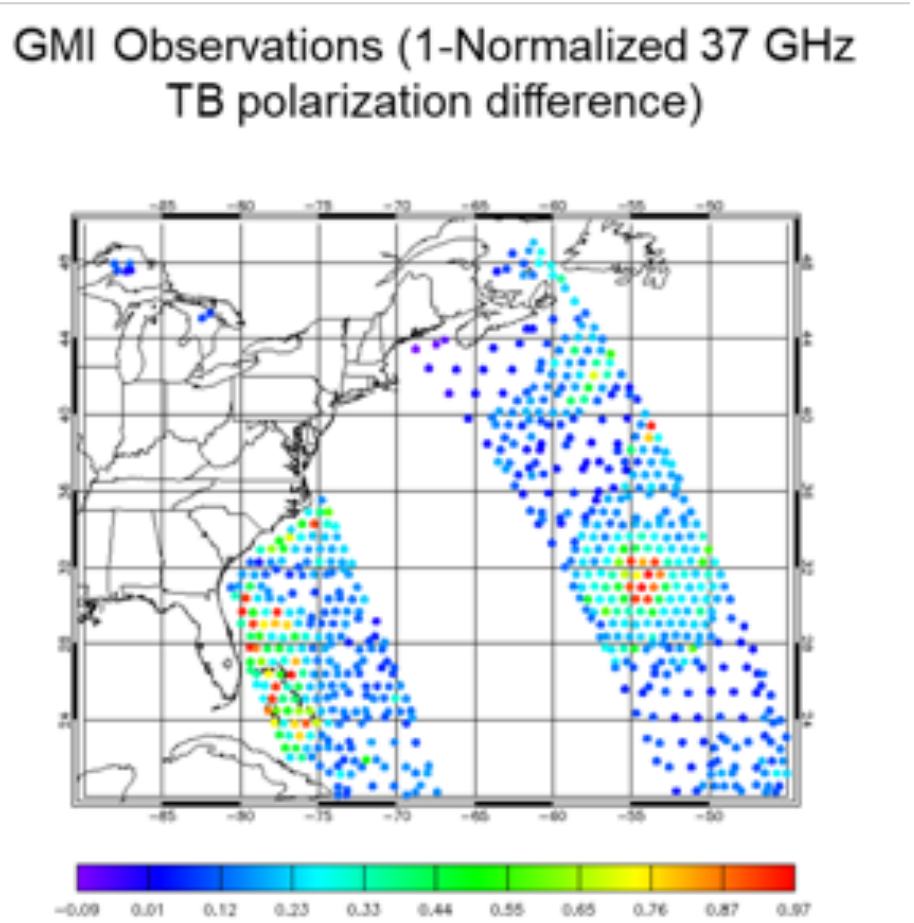
- Services updates:
  - V06B IMERG in Giovanni for visual and analysis exploration
  - Level 2 GPM sub-setter (average download **volume reduction >90%**)
  - Level 3 re-gridder (re-grids to 33 different gridding schemes)
- Services available:
  - OPeNDAP: Hyrax, THREDDS, GDS; OGC WMS
- User assistance 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.

All-Sky GPM Data in GEOS Weather Forecasts

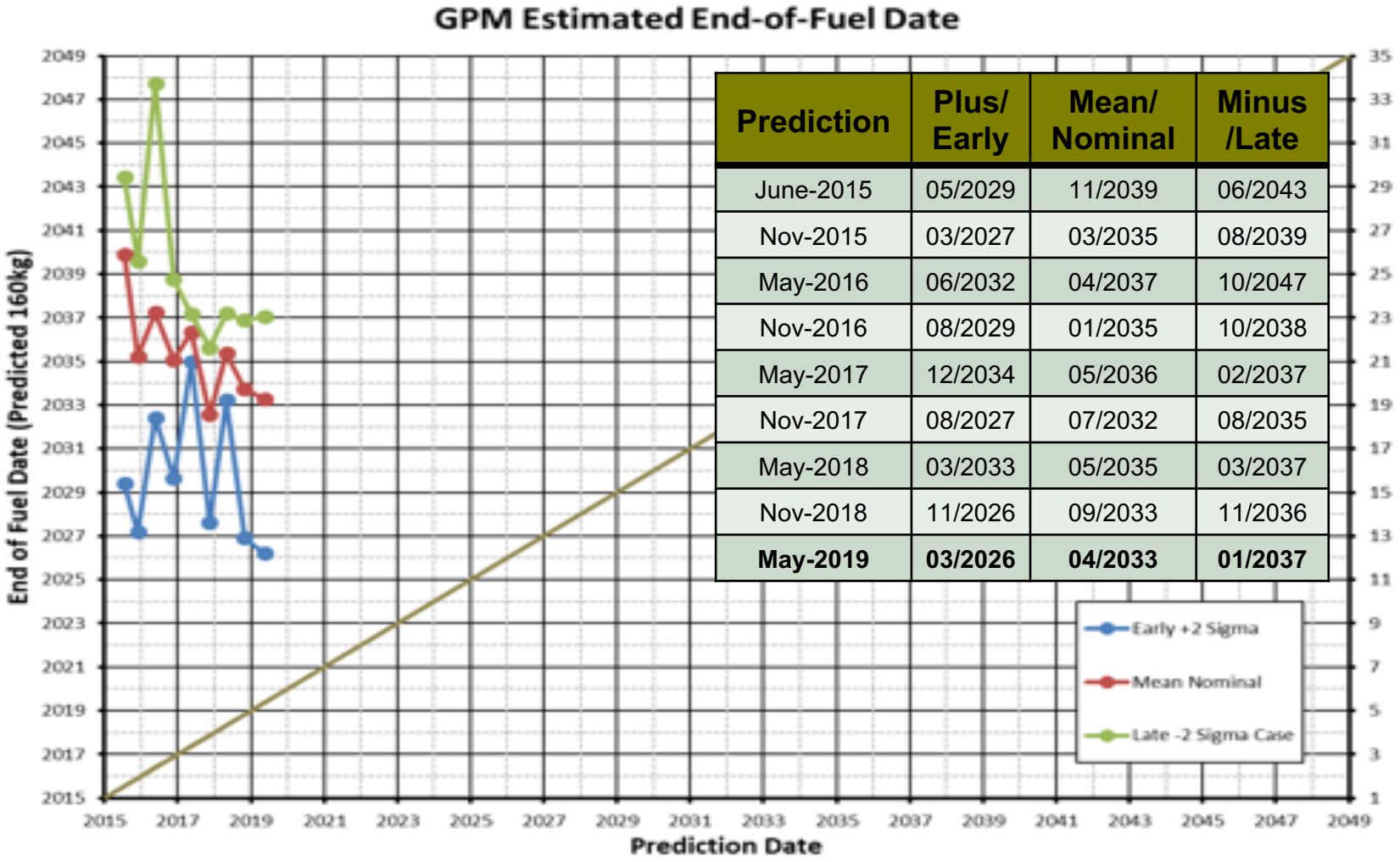
- On 11 July 2018, the GMAO began assimilating GMI observations
  - Assimilation of GMI radiances in real-time
  - Active assimilation under all-sky situations
- Advanced methods were incorporated to optimize the use of these observations
  - Adaptive thinning in the presence of clouds and precipitation (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



Min-Jeong Kim (GMAO/GESTAR)

Fuel Predictions to Date

Current end-of-fuel date is April 2033



Prediction	Plus/ Early	Mean/ Nominal	Minus /Late
June-2015	05/2029	11/2039	06/2043
Nov-2015	03/2027	03/2035	08/2039
May-2016	06/2032	04/2037	10/2047
Nov-2016	08/2029	01/2035	10/2038
May-2017	12/2034	05/2036	02/2037
Nov-2017	08/2027	07/2032	08/2035
May-2018	03/2033	05/2035	03/2037
Nov-2018	11/2026	09/2033	11/2036
May-2019	**03/2026**	**04/2033**	**01/2037**