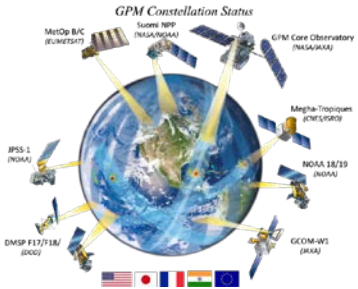
Impact of Microwave Sounder *(and Imager)* Calibration on Precipitation for the Global Precipitation Measurement (GPM) Mission



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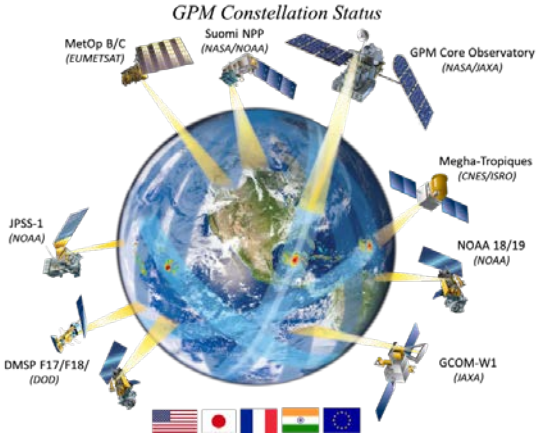
[2]NASA Goddard Space Flight Center

GPM Constellation: Current and Past

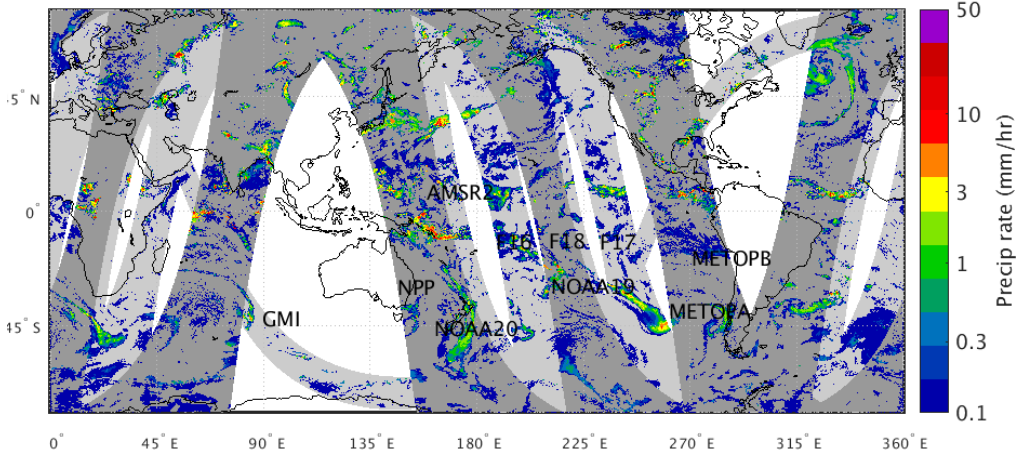


Imagers (Conical scanners)

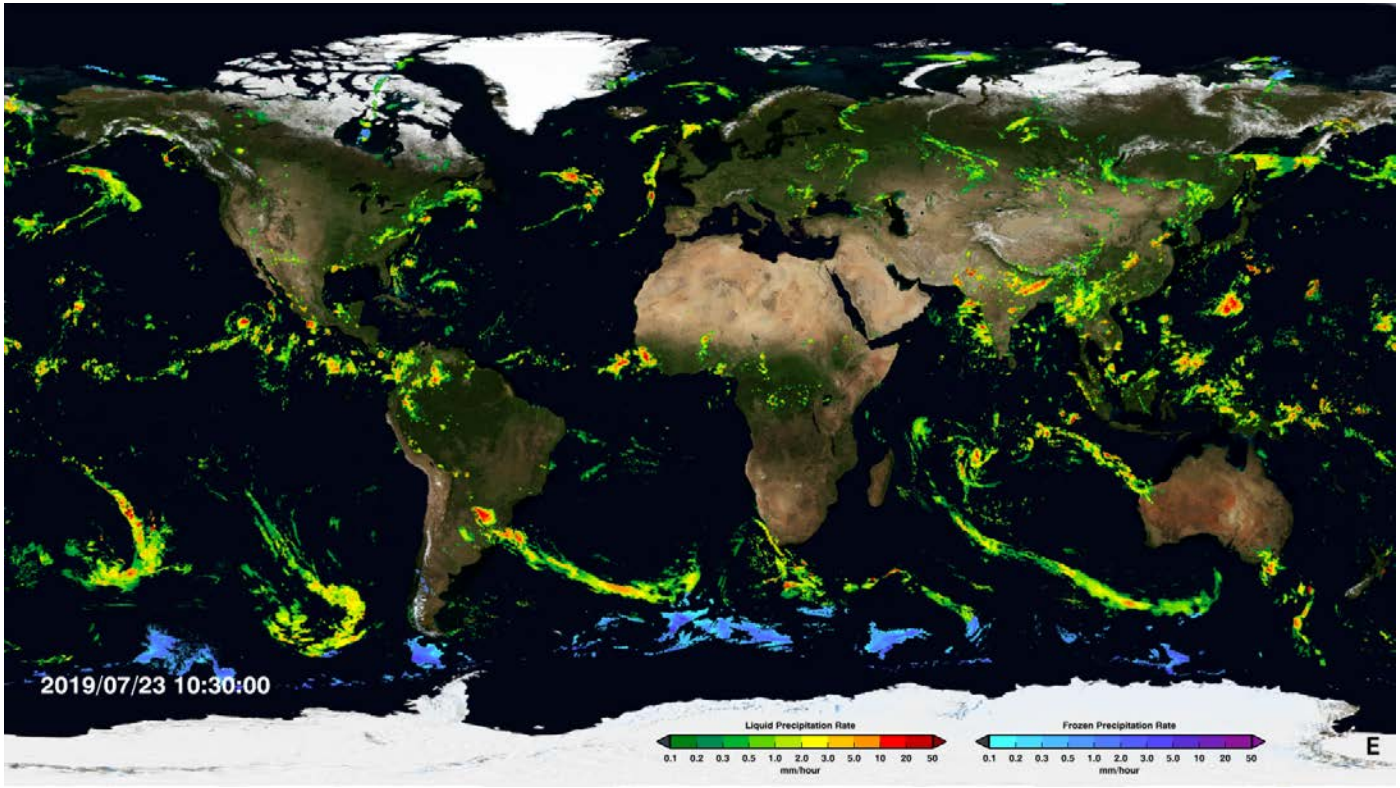
AMSR2 (GCOM-W1)
SSMIS (DMSP F16, F17, F18, F19)
GMI (GPM Core)
AMSRE (Aqua)
SSMI (DMSP F11, F13, F14, F15)
TMI (TRMM)

Sounders (Cross-track scanners)

MHS (NOAA18, NOAA19, METOP-A, METOP-B)
ATMS (NPP, NOAA20)
SAPHIR (Megha-Tropiques)
AMSU-B (NOAA15, NOAA16, NOAA17)



IMERG (Level 3 Precipitation)



https://pmm.nasa.gov/gpm/imerg-global-image

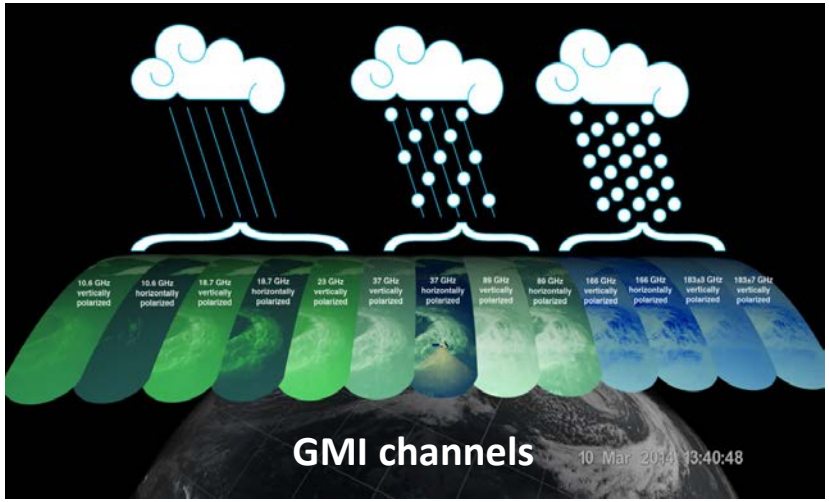
Background

The XCAL team is responsible for the Level 1C intercalibrated brightness temperature files used as input to the GPM operational precipitation retrieval algorithm (GPROF).

- New constellation radiometers first analyzed individually for potential calibration issues
  - If possible, correct any issues
- Constellation radiometers intercalibrated to calibration standard: GMI on GPM Core Observatory
  - Similar channels intercalibrated
  - Double Difference method using a radiative transfer model to simulate the observations to account for differences in instrument characteristics (frequency, EIA, etc.)
    - Potential for RTM to introduce errors into the intercalibration

Motivation

- XCAL intercalibrates the GPM radiometers so that the precipitation rates derived from the constellation are consistent
  - But how well do the precipitation rates really agree?
  - Could there be calibration errors that propagate into the precipitation?
- This study will compare precip rates from the constellation radiometers
  - Attempt to determine if any of the differences could be due to calibration
  - Go back and re-analyze the calibration, correct any errors, re-run GPROF and observe any differences



Channels have different sensitivities to precip

10-23 GHz: Rain, Ocean

36-89 GHz: Mix, Ocean and Land

166-183 GHz: Snow, Land

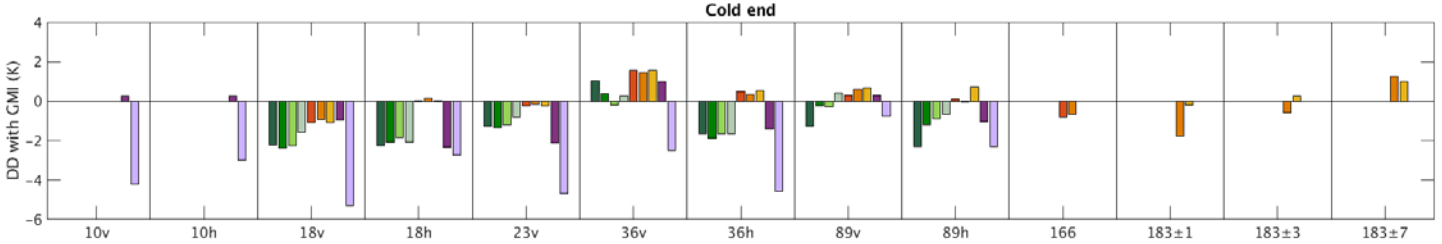
GPROF Channel Usage

	6-7 GHz	10 GHz	19 GHz	23 GHz	31-37 GHz	80-92 GHz	150-190 GHz
GMI		10.65 v/h	18.7 v/h	23.8 v	36.64 v/h	89 v/h	166 v/h, 183.31 ± 3, 7 v
SSMIS			19.35 v/h	22.235 v	37 v/h	91.655 v/h	150 h, 183.3 ± 1, 3, 6.6 h
AMSR2	6.9/7.3 v/h	10.65 v/h	18.7 v/h	23.8 v	36.5 v/h	89 v/h	
ATMS				23.8 v	31.4 v	88.2 v	165.5 h, 183.31 ± 1, 1.8, 3, 4.5, 7 h
MHS						89 v	157 v, 183.31 ± 1 & 3 h, 190.31 v

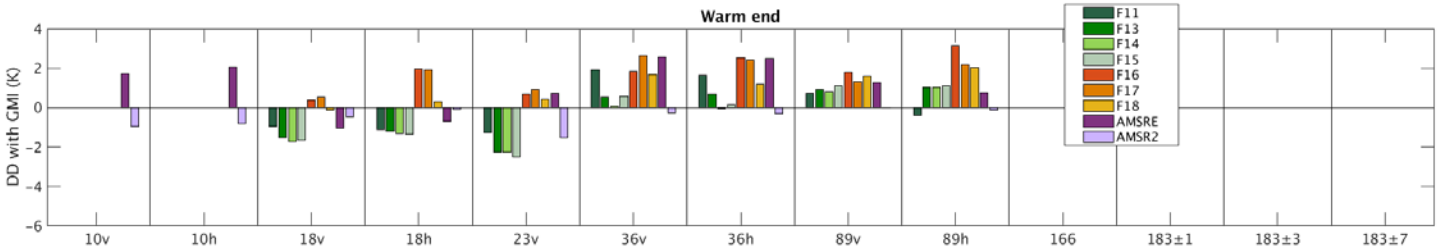
Black = not used, **Green** = land only, **Orange** = land and ocean

Imager and Sounder Intercalibration Tables

Imager (Cold end)

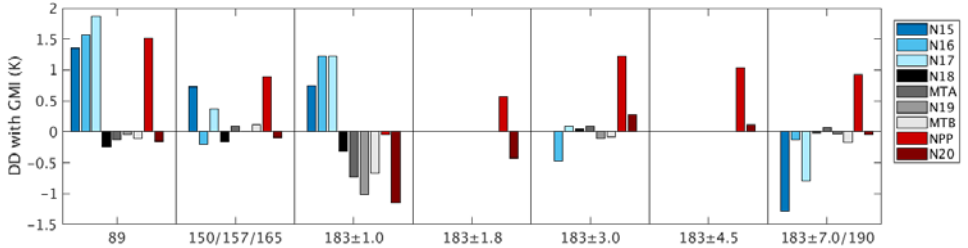


Imager (Warm end)



Values are added to the radiometer brightness temperatures to make them similar to GMI

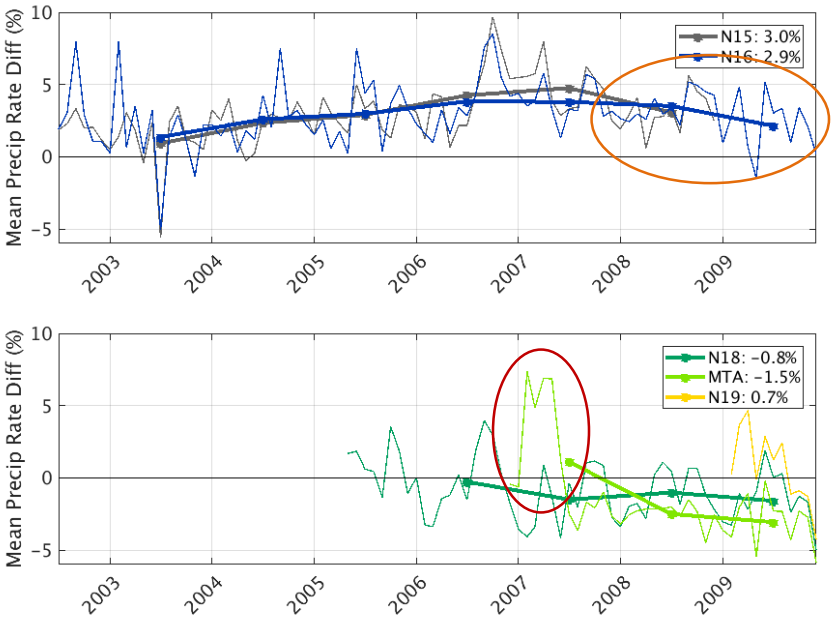
Sounder



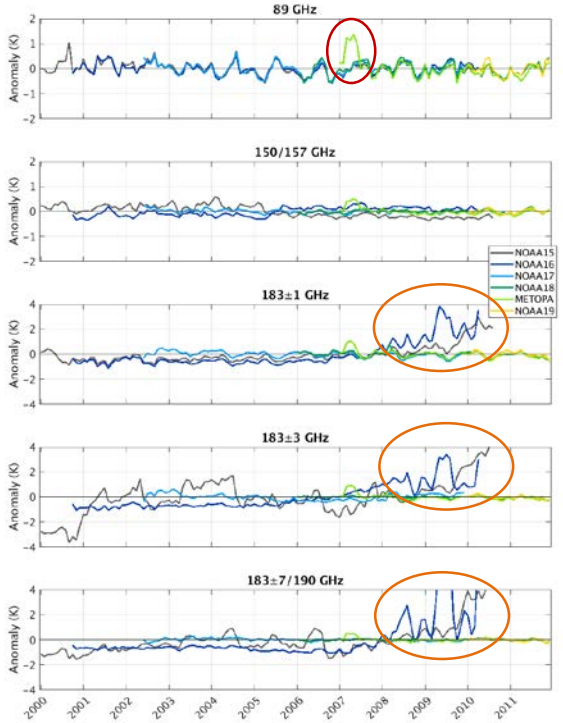
AMSU-B and MHS Analysis

Precip Rate Difference (Ocean only)

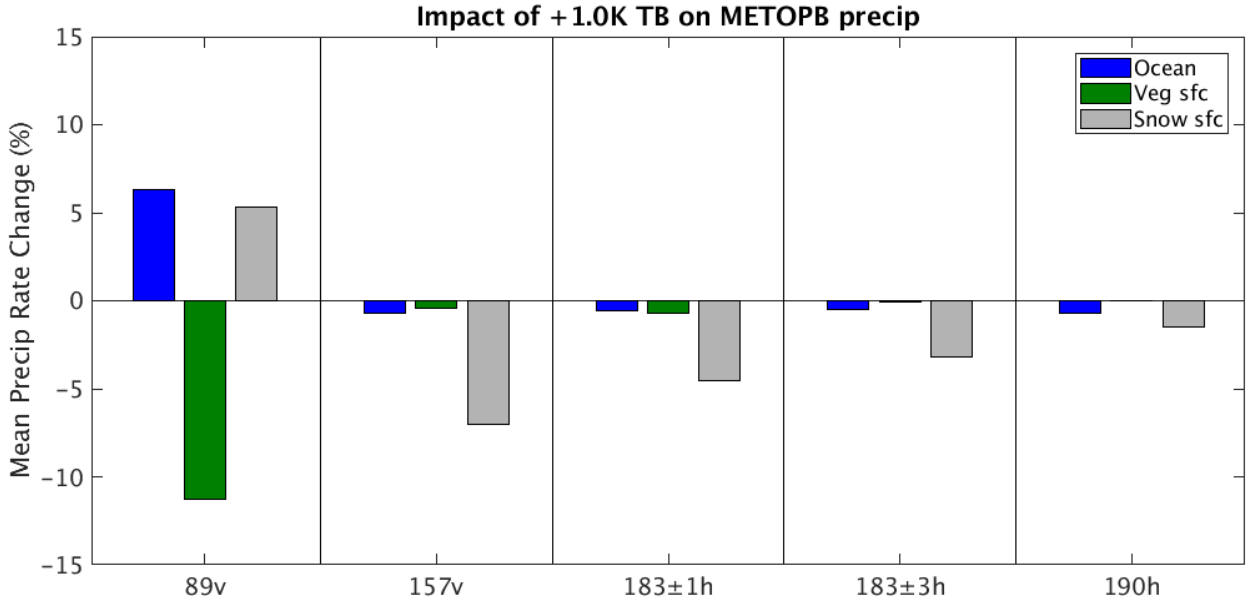
(compared with NOAA17 AMSU-B)



Single Difference Anomalies (K)



Which channels impact the precip for MHS/AMSU-B?



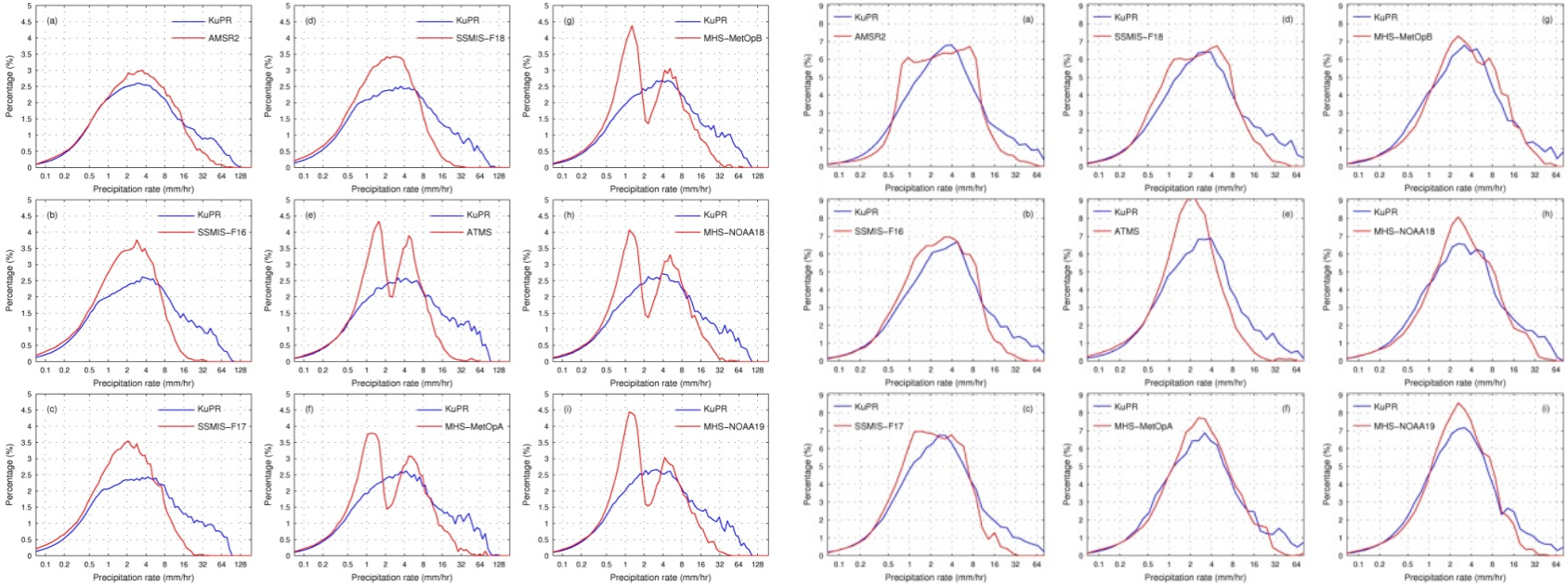
Precipitation over ocean and land is much more sensitive to errors in 89 GHz TB than the other channels

Comparison with GPM PR: Precip histograms

Comparison of GPROF precipitation with GPM PR (Ku-band) over match-up locations

Ocean

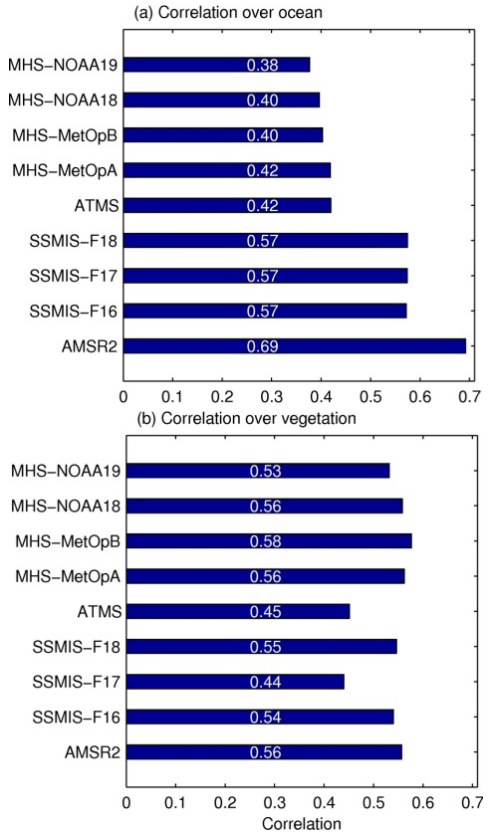
Vegetation



Correlation of Imagers and Sounders with PR

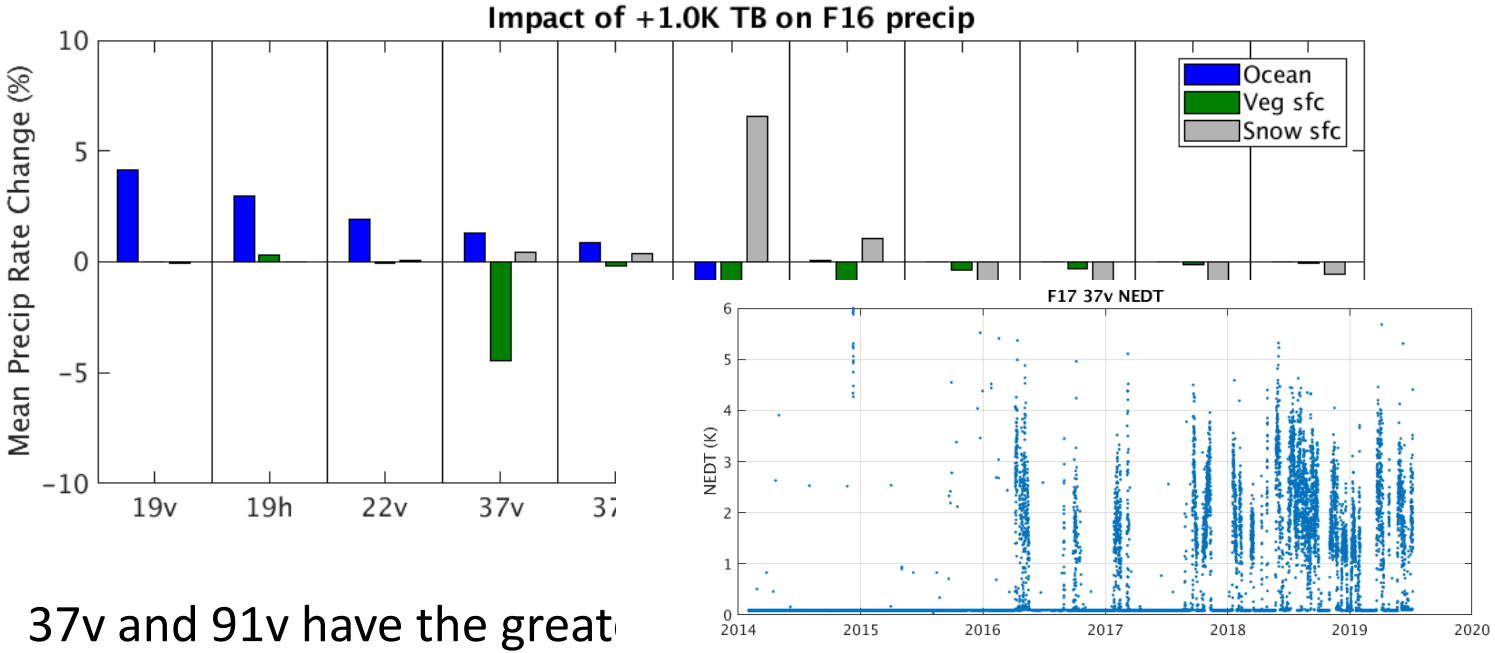
Ocean

Vegetation



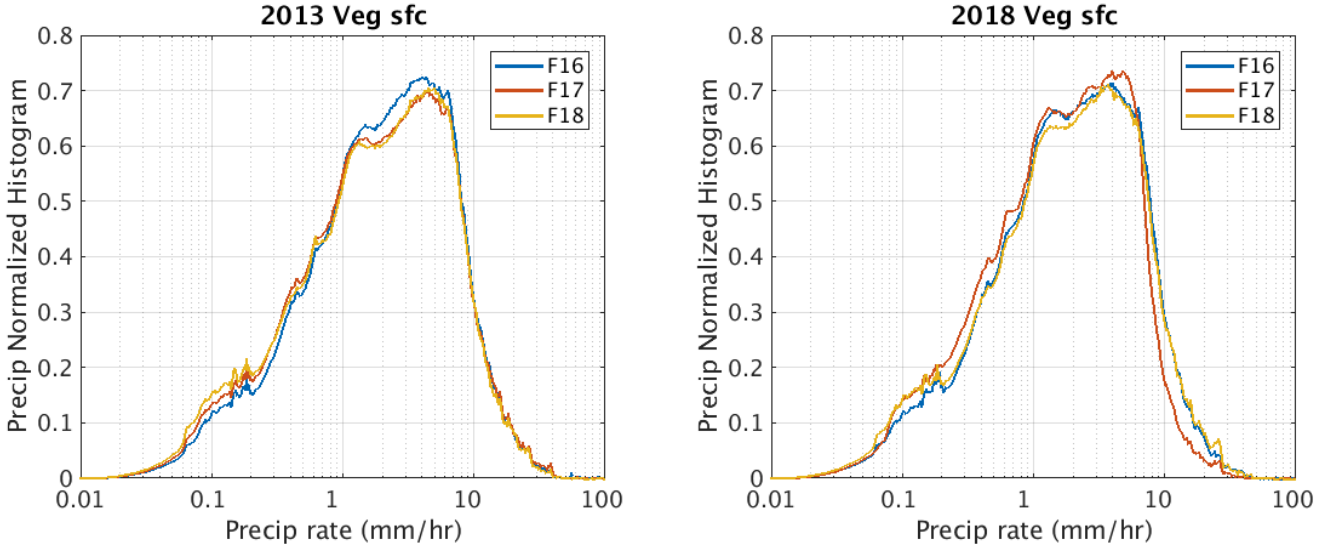
- Imagers perform better over ocean than sounders
  - Lack of low frequency channels on sounders
  - AMSR2 gives best performance
- Sounders and imagers perform similarly over vegetation
  - Notable exceptions: ATMS and SSMIS F17
  - Why is F17 so different from F16 and F18?

Which channels impact the precip for SSMIS?



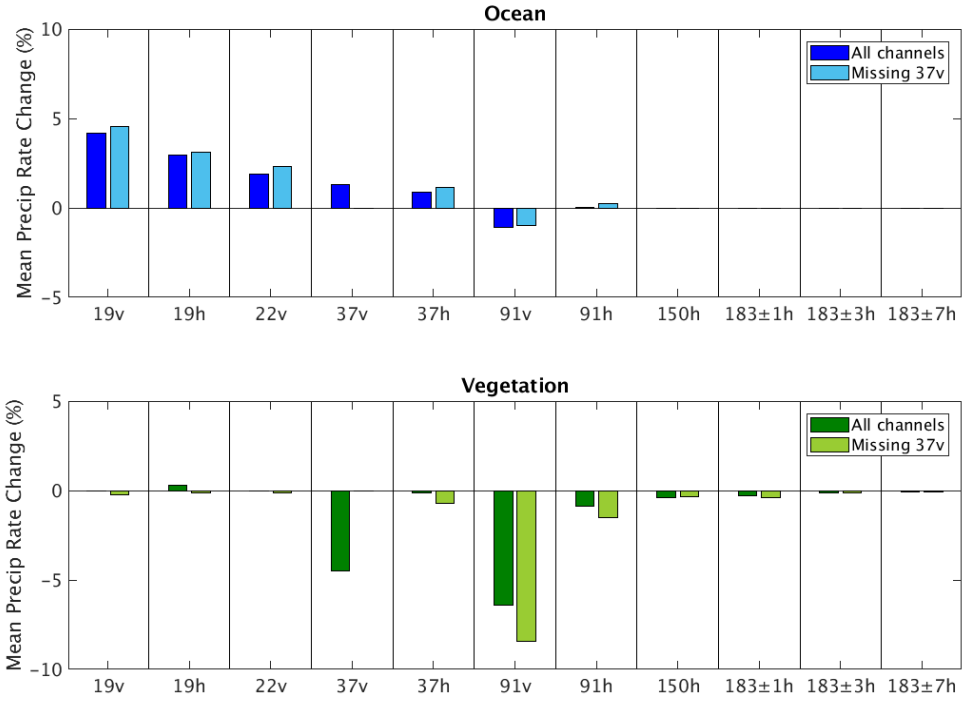
- 37v and 91v have the great
- F17 37v channel was set to missing in mid-2016 due to high NEΔT

F17 Precip Histogram Comparison: 2013 vs 2018



- Histograms look similar for all SSMIS sensors over vegetation in 2013
- Clear difference in 2018 for F17 when 37v is set to missing for the whole year

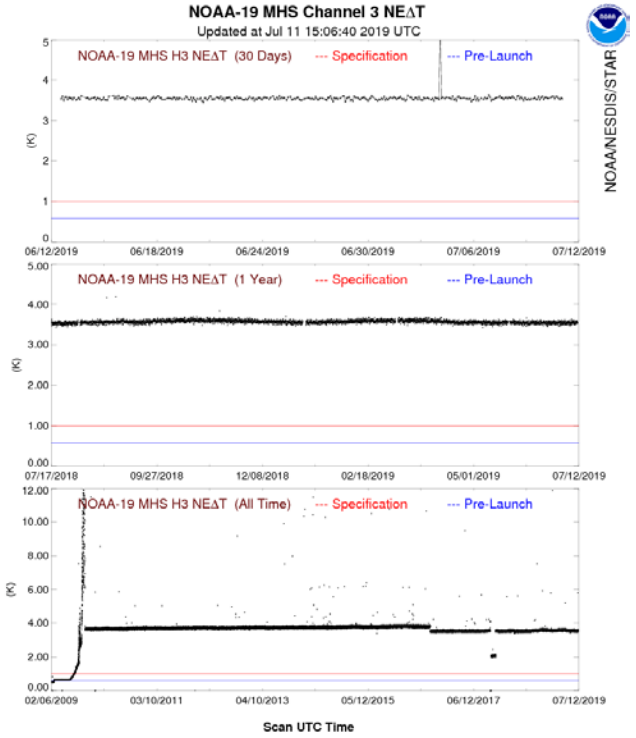
What is the impact of missing 37v on the other channels?

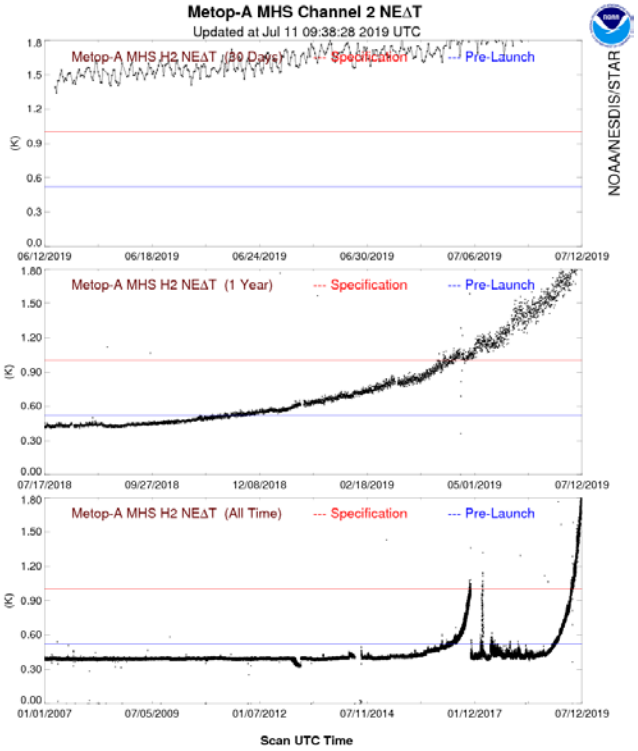


- Missing the 37v channel means other channels have a greater impact due to a 1 K calibration offset
  - Over vegetation, 37h, 91v, and 91h have greater impact
- We currently do not have a full answer to the difference noticed in F17
  - Missing the 37v channel seems to only be part of the problem
  - Study is ongoing

Potential issue to watch for MHS: High NEΔT

- High NEΔT on NOAA19 183±1 most of the mission (left) and recently on MetopA 157 (right)
- Need to monitor to observe any impact on the precipitation
- Do we set the channel to missing like with F17?



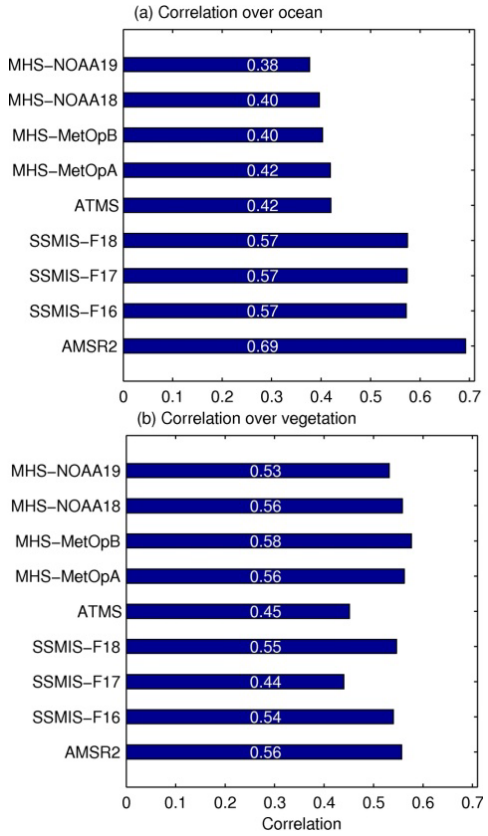


NOAA/NESDIS/STAR: https://www.star.nesdis.noaa.gov/icvs

Summary

- Comparing and contrasting the GPROF precipitation rates among the GPM constellation radiometers is important
  - May give insight into how the calibration impacts the precip
  - Helps the XCAL team determine which instruments and/or channels to focus on for improving the calibration
- Calibration changes in the instruments while on-orbit can have large impacts
  - Need to monitor things like NEΔT that could impact precip
  - Setting channels to missing (like F17 37v) can have major implications for the retrieval, depending on which channel is missing
  - As the current instruments age past their lifetimes, this type of analysis becomes even more important

Next Steps



Ocean

Vegetation

- Focus on improving the SSMIS F17 retrieval to attempt to make it similar to F16 and F18
  - Create a psuedo-37v channel and re-run GPROF
  - Re-assess the 91v channel calibration since that channel has greatest impact on vegetated surfaces
- Derive uncertainties for intercalibration and work on improving our calibration algorithms
  - 89-91 GHz is an important channel over land and very important for sounder precip retrieval
  - 89-91 GHz has some of the highest uncertainties for our intercalibration due to high geophysical variability and uncertainty in the radiative transfer model