Evaluating and Improving TROPICS Millimeter-Wave Sounder's Precipitation Estimate over Ocean

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Acknowledgement: NASA Weather and Dynamics and NASA Global Precipitation Measurement Program

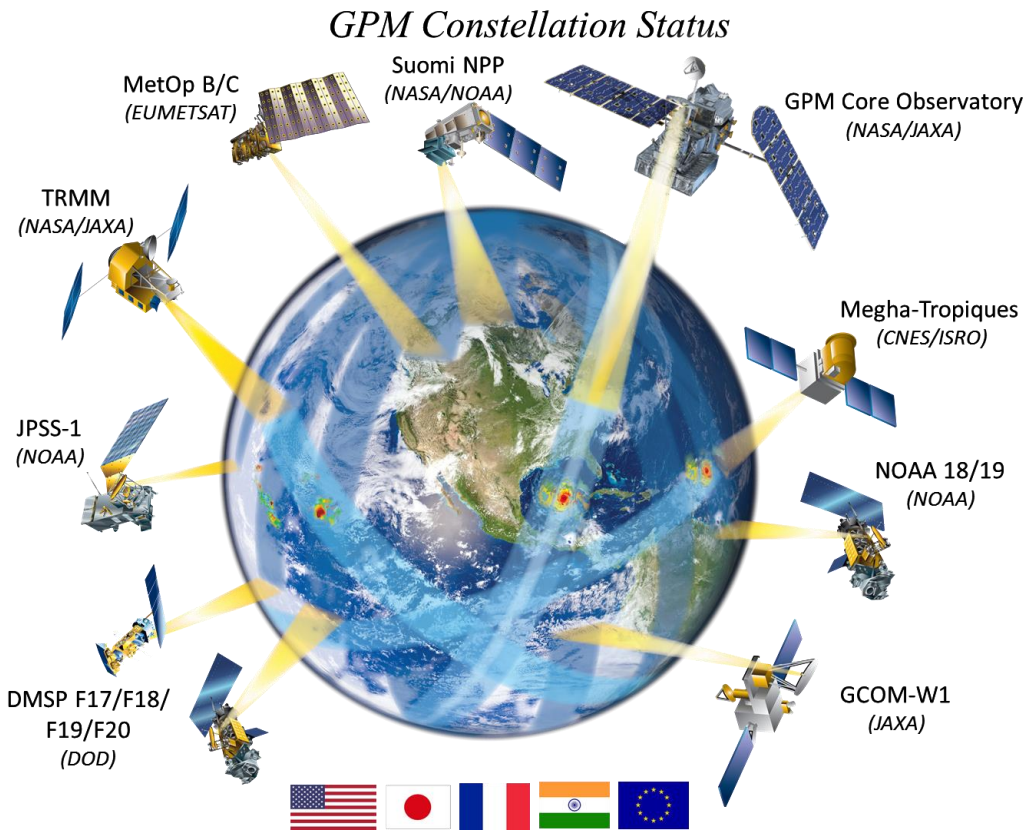
Objective: Improving TMS' retrievals by morphing conical scanning radiometers' retrieval

Motivation: Conical > Cross-track over ocean

Innovation:

- Compare TMS retrieval relative to results from other passive microwave sensors
- Improve TMS retrieval results by morphing technique
- Motion vector derived from precipitation rate directly, instead of IR or model variables

- CMORPH: Morphing Microwave to IR
- **Morphing among Microwave sensors**



- **Cross-track Scanning Radiometers (Sounder)** :

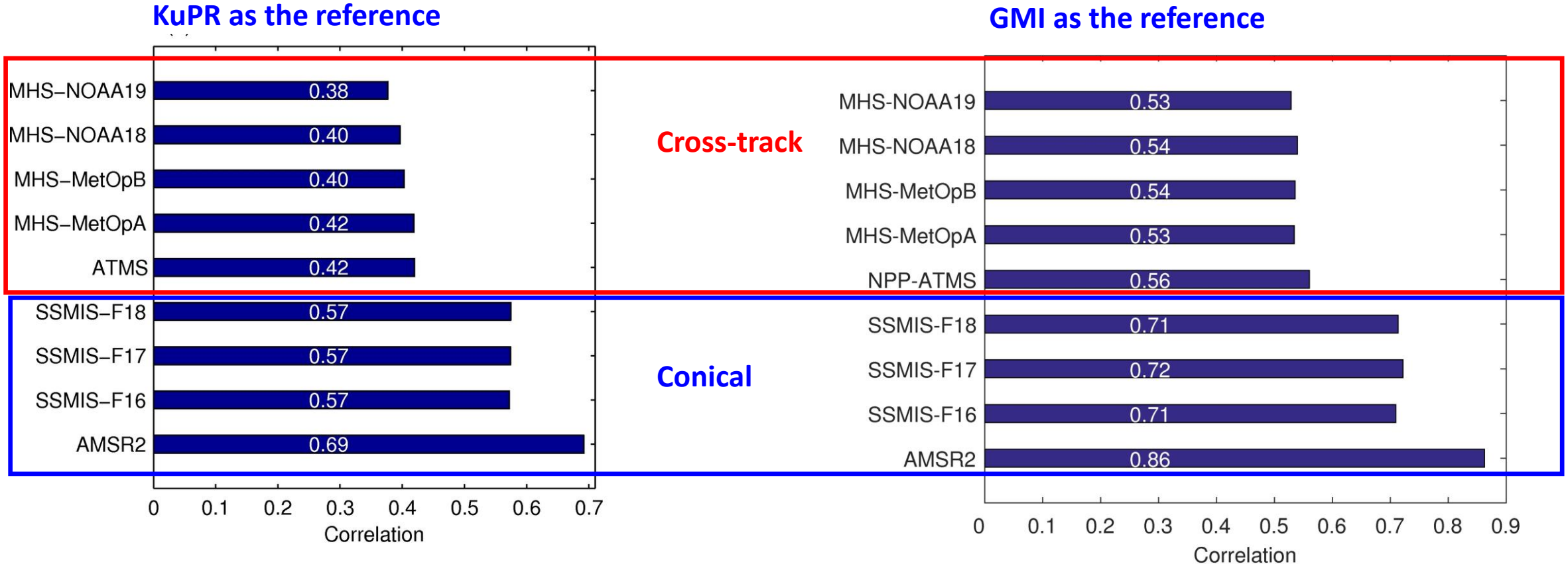
  FOV varies along the scan line, AMSU, MHS, ATMS, **TMS**

- **Conical Scanning Radiometers (Imager):**

  FOV remains constant along the scan line, AMSRE, AMSR2, TMI, GMI, SSMIS

- This study uses 9 radiometers:
  - **4 Cross track**: MHSs onboard NOAA19 and MetOp-B, ATMS onboard NPP, and TMS
  - **5 Conical**: SSMIS onboard F16, F17, and F18, AMSR2, and GMI

Motivation: **Conical** > **Cross-track** over ocean

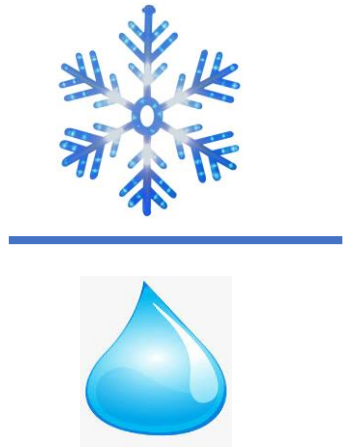


- **Coincident observations between KuPR (GMI) and each sensor**

You et al., JHM, 2020, 2021.

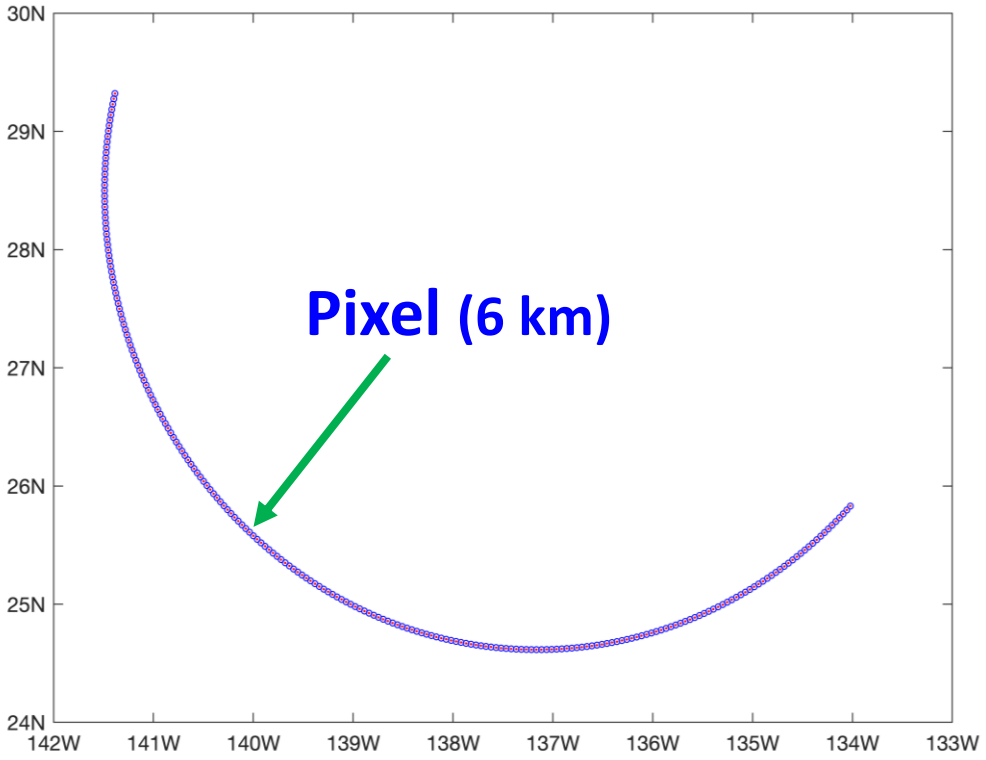
Physical reason: low-freq. channel availability

	GMI	MHS
High frequency (GHz)	89, 166, 183	89, 157, 183
Low frequency (GHz)	10, 19, 24, 37	



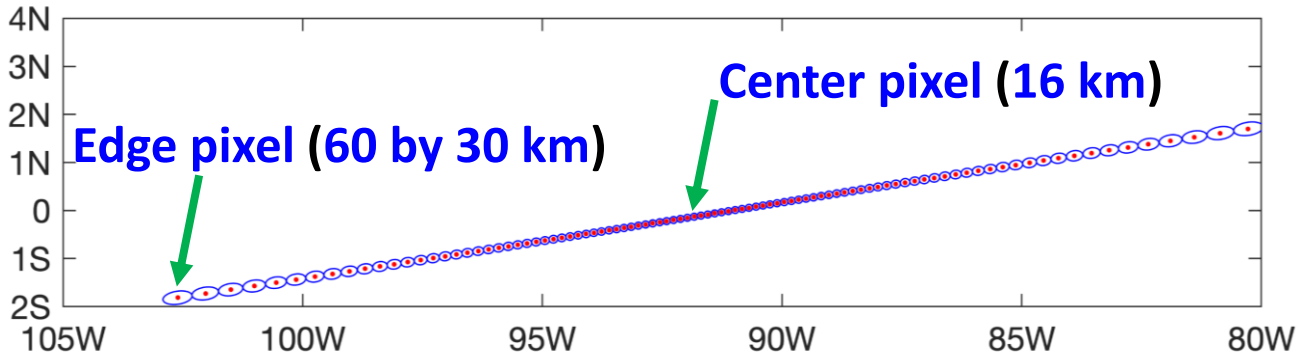
Freezing level height (0 C) at ~5km

Physical reason: spatial resolution

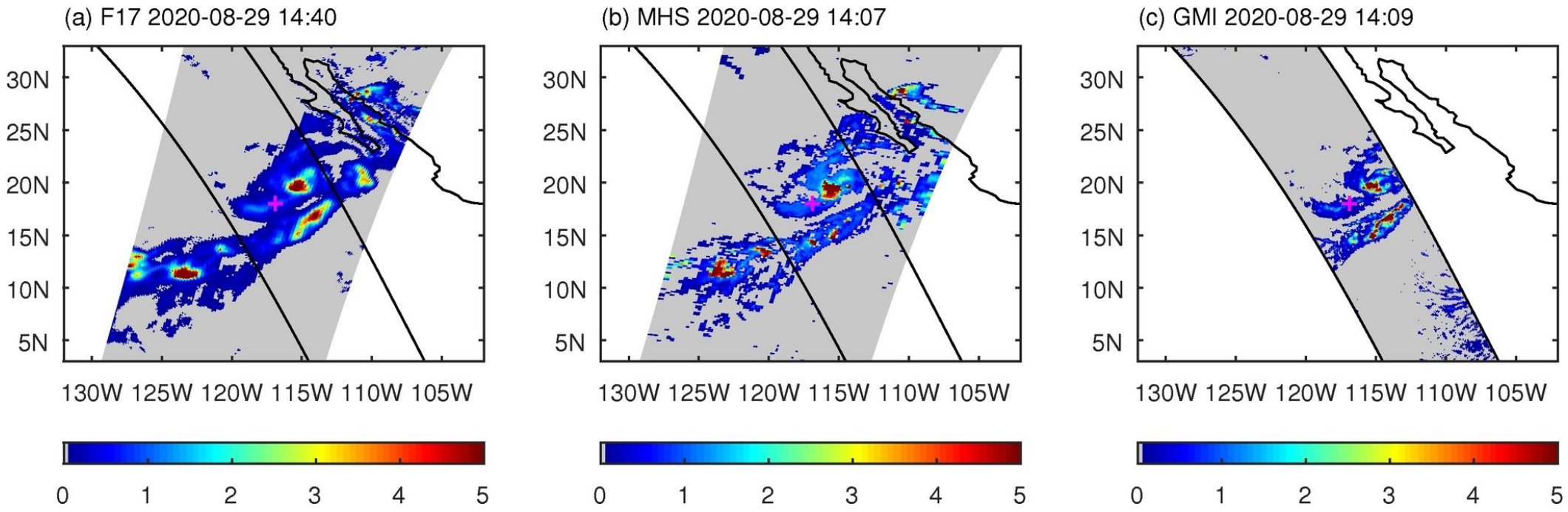


GMI (conical) scan line @ 183 GHz

ATMS (cross-track) scan line @ 183 GHz

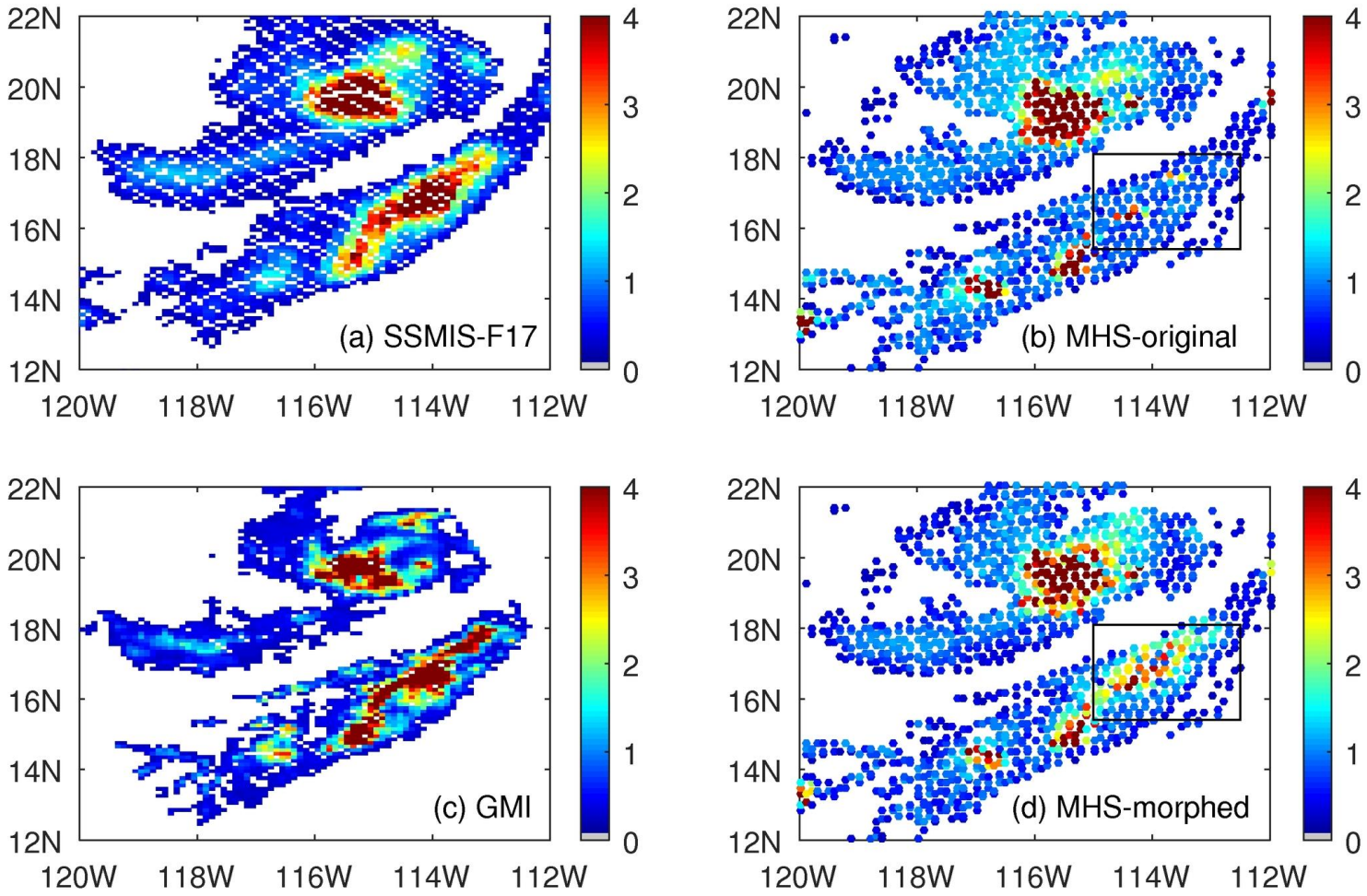


Case study: Morphing F17-SSMIS backward to NOAA19-MHS

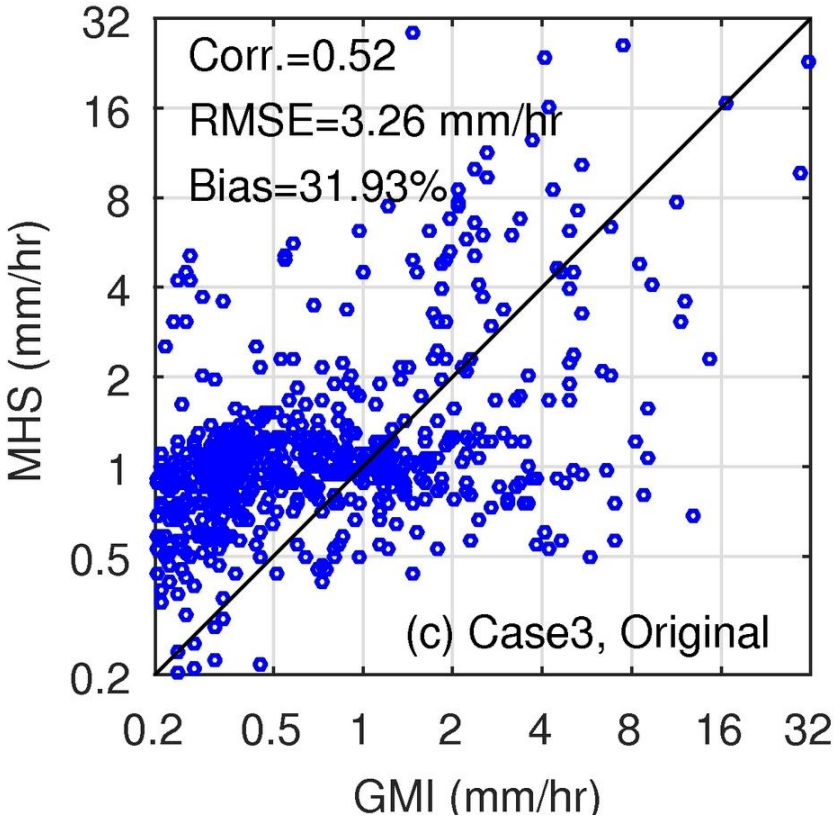


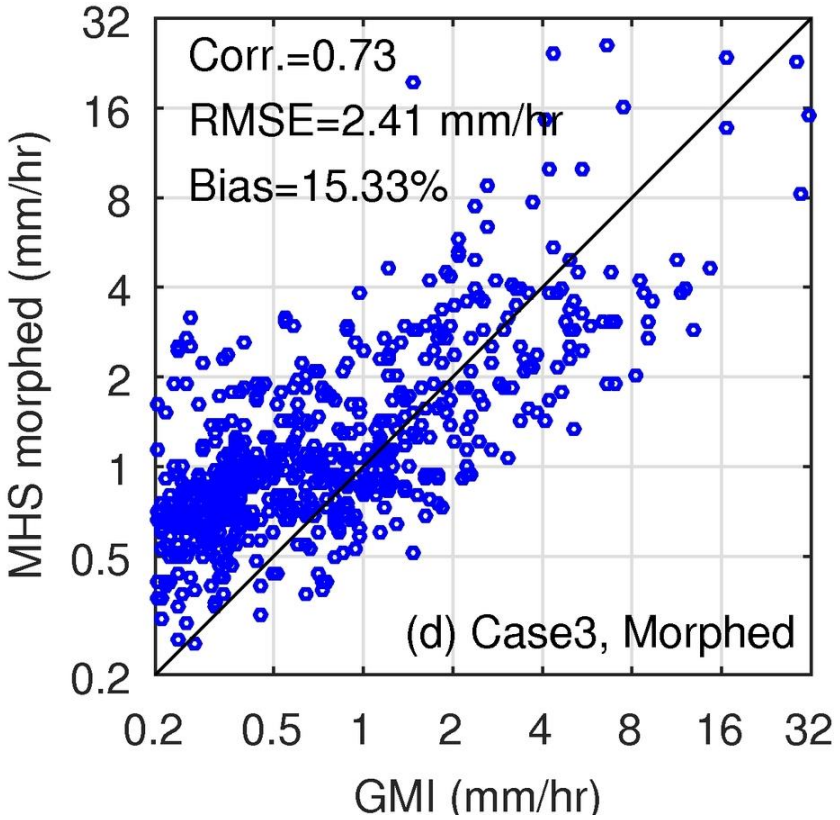
Tropical Strom Hernan on 2020-08-29

Case1: Morphing F17-SSMIS backward to NOAA19-MHS

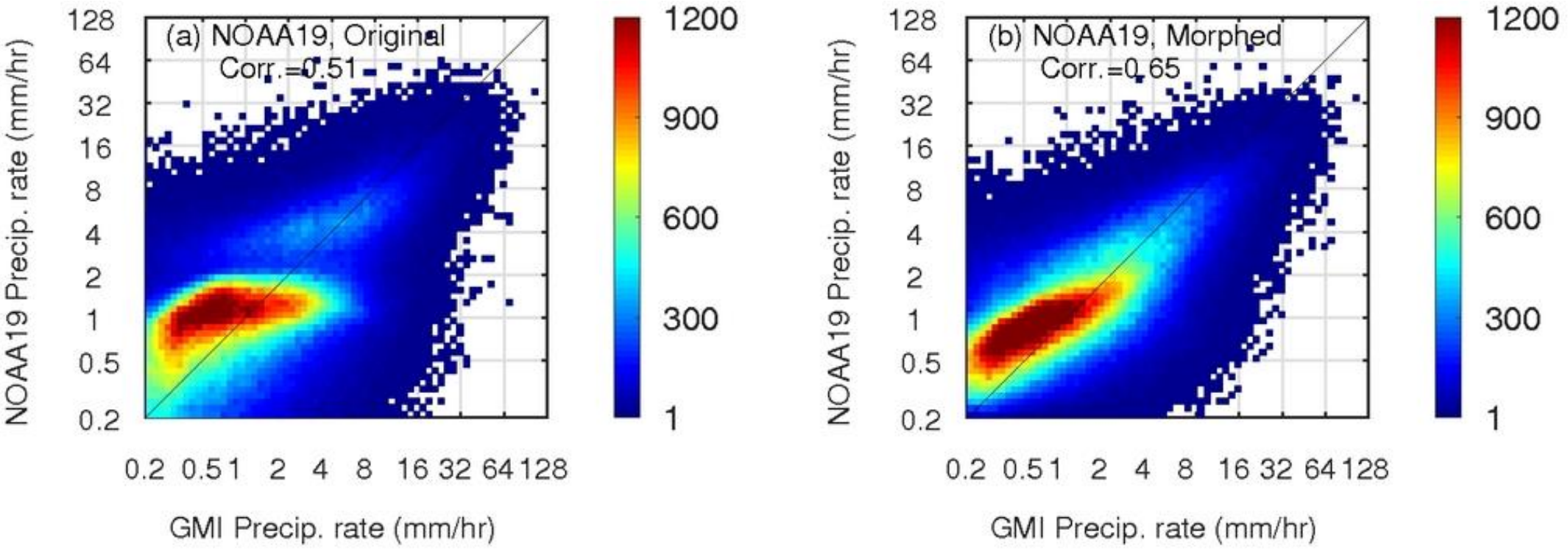


Case2: Morphing F17-SSMIS backward to NOAA19-MHS

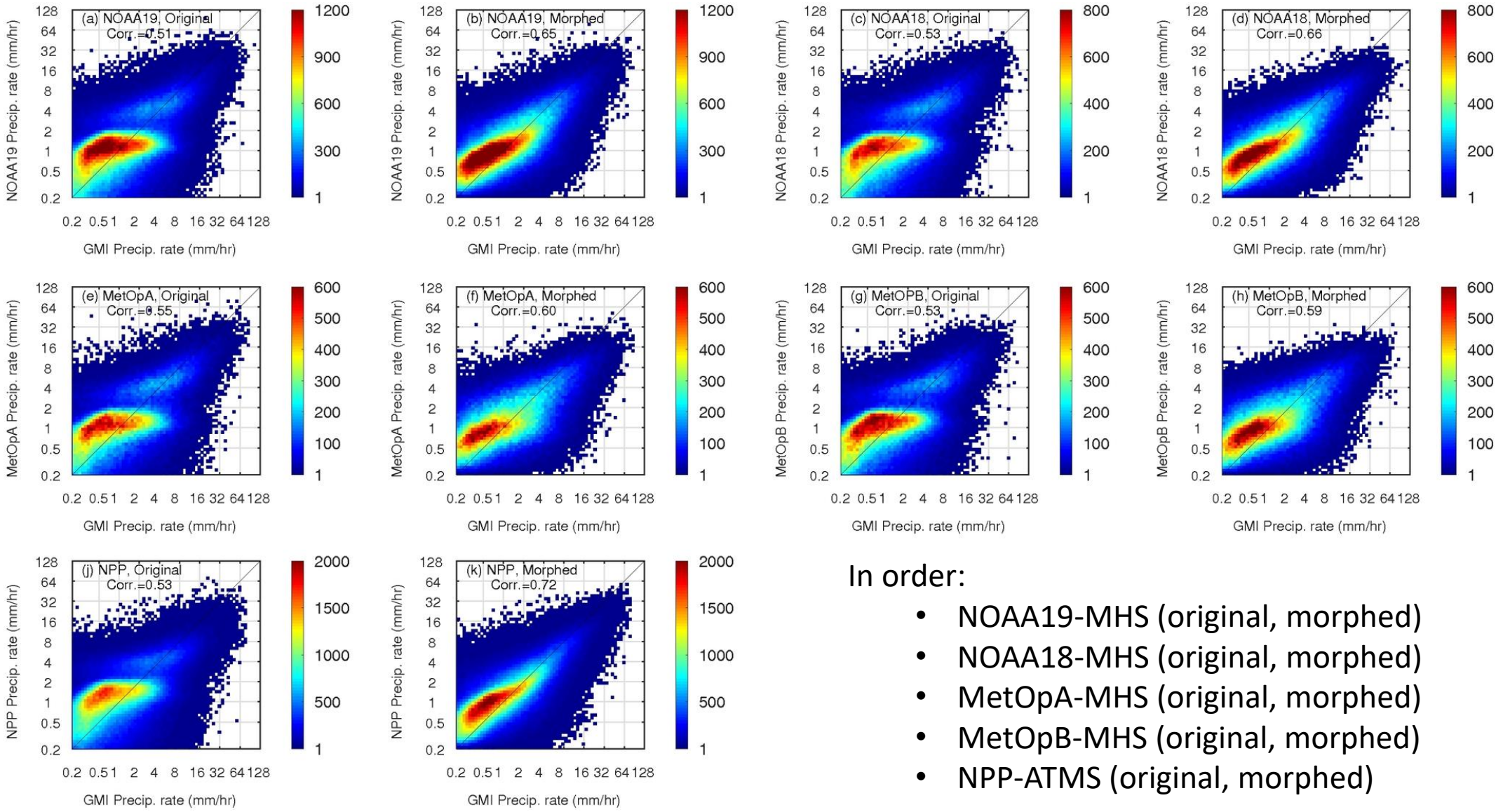




Overall performance for all sounders



Overall performance for all sounders (**GMI as the reference**)



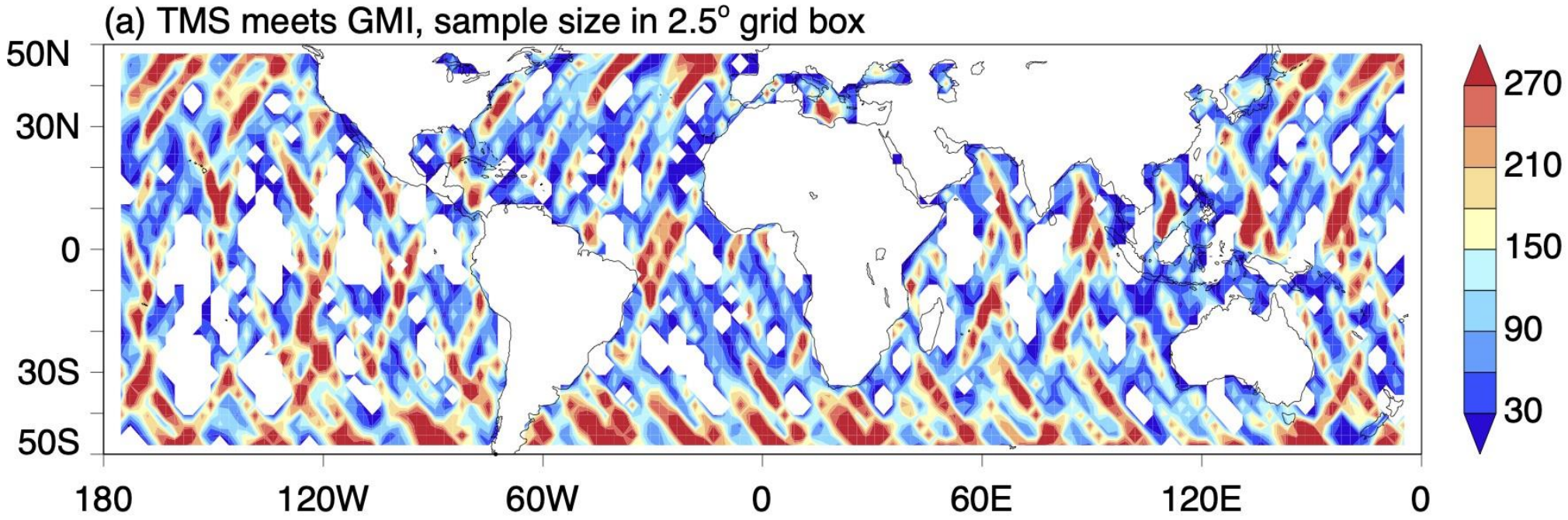
In order:

- NOAA19-MHS (original, morphed)
- NOAA18-MHS (original, morphed)
- MetOpA-MHS (original, morphed)
- MetOpB-MHS (original, morphed)
- NPP-ATMS (original, morphed)

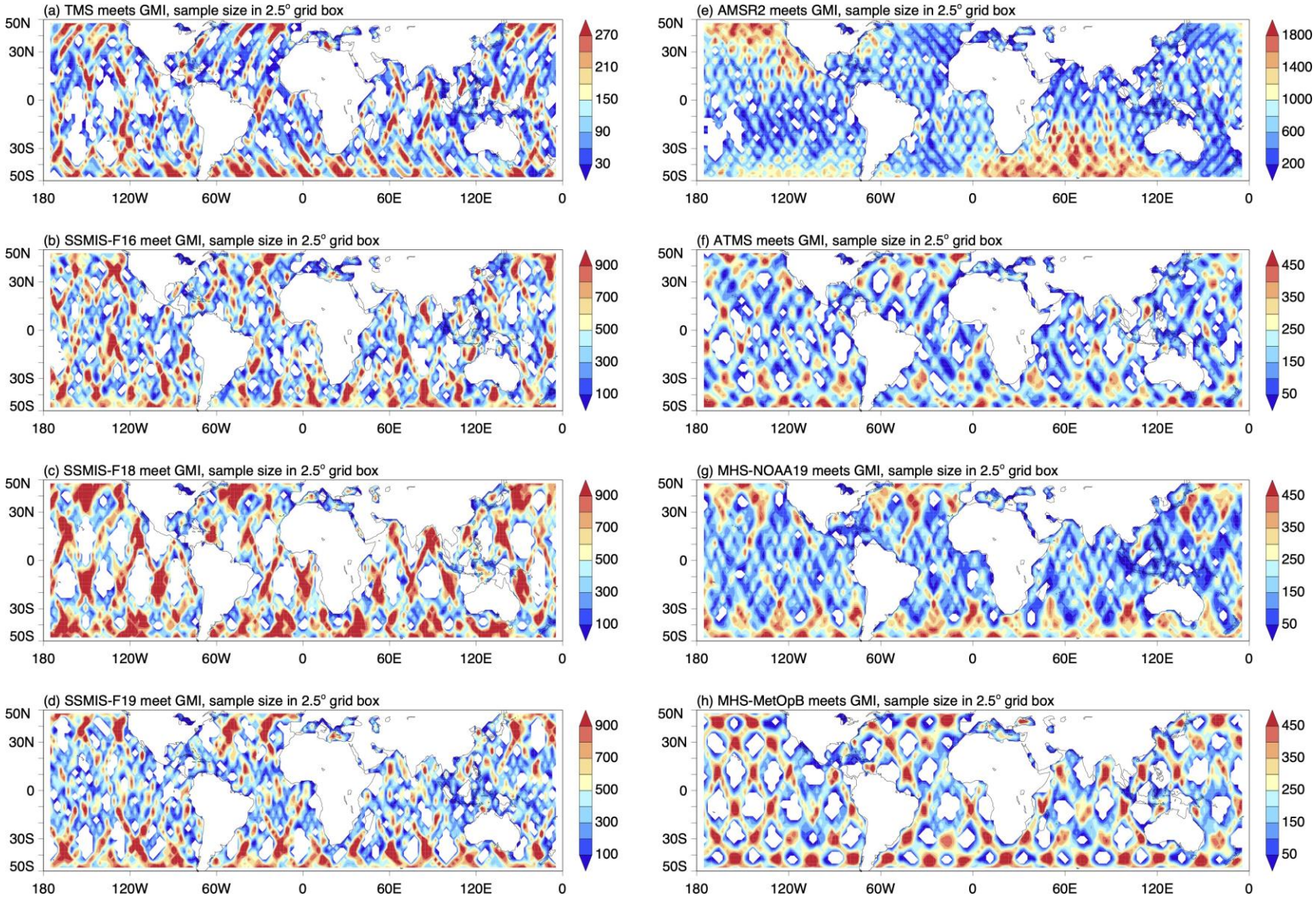
How TMS retrieval performs, relative to other passive microwave sensors (PMWs):

- **PMW Sensors**
  - 4 Cross track: 2 MHSs, ATMS onboard NPP, and TMS
  - 5 Conical: 3 SSMISs, AMSR2, and GMI
- **Temporal & spatial coverage**
  - June to November 2021
  - 50S to 50N
- **Algorithms**
  - PRPS for TMS
  - GPROF for other PMWs

TMS meets GMI

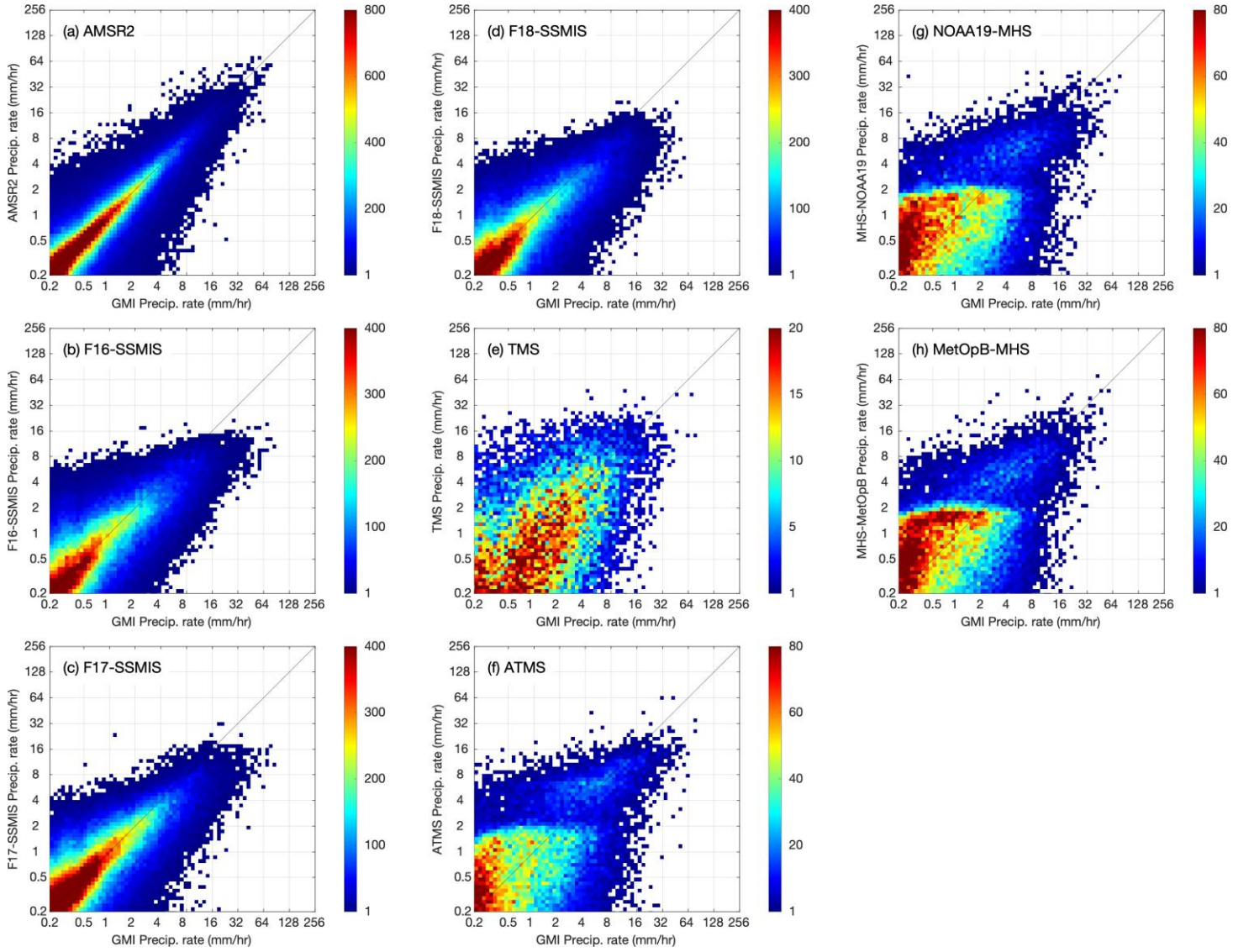


- **observations from GMI and TMS: < 15 minutes & < 15 km**



- **observations from GMI and other sensors: < 15 minutes & < 15 km**

Overall performance for **TMS** (**GMI as the reference**)



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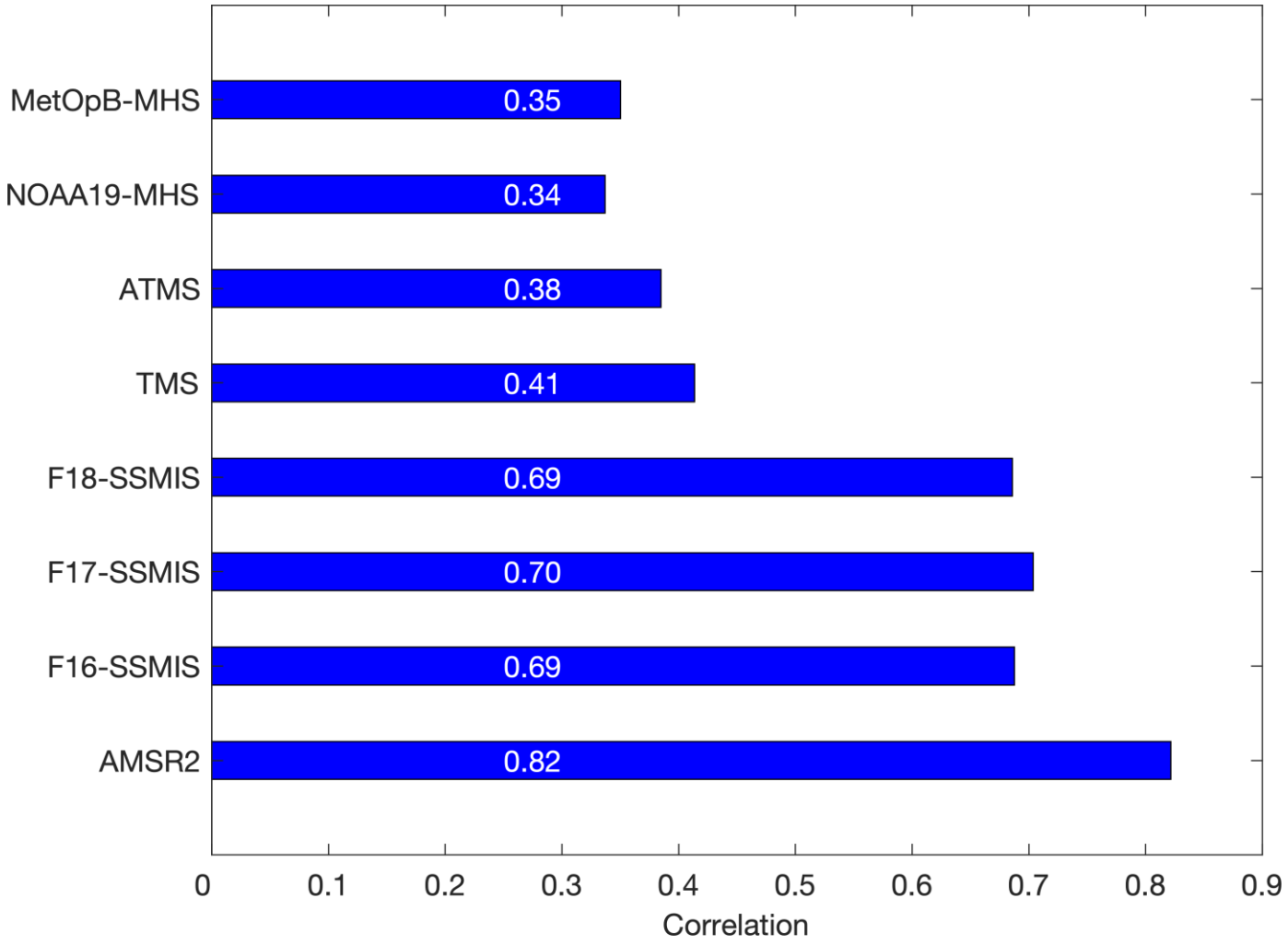
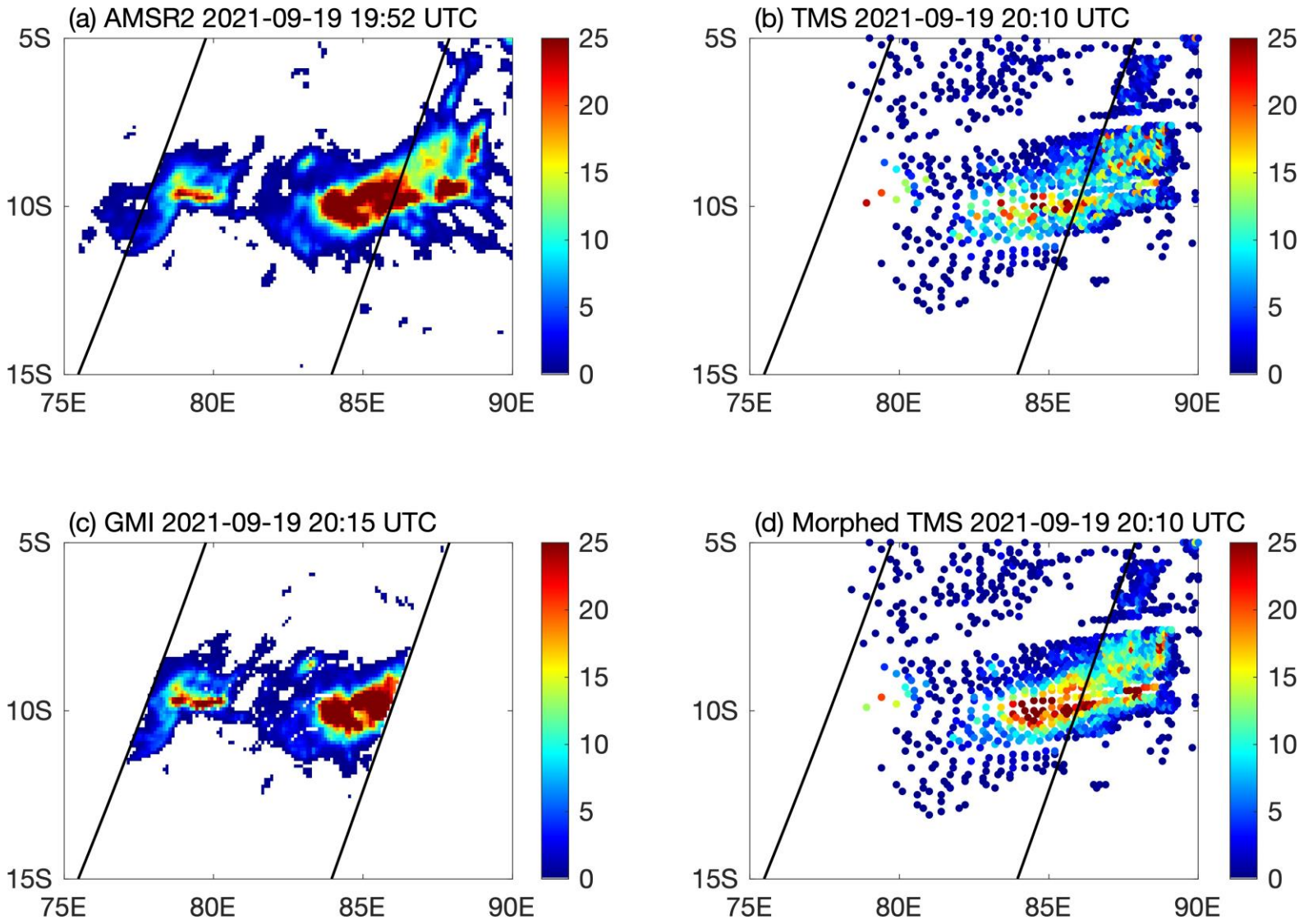


- **TMS retrieval results are comparable to other cross-track scanning radiometers**
- **TMS retrieval results perform worse than those from conical scanning radiometers**

Case study: Morphing AMSR2 forward to TMS



Black curves in each plot represent the GMI swath boundaries

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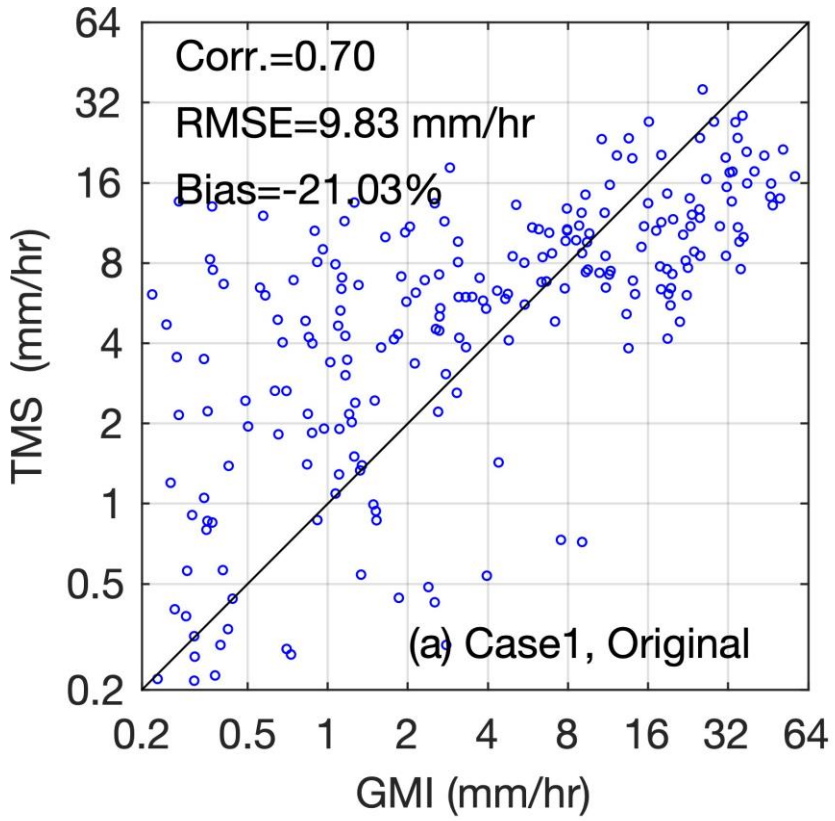
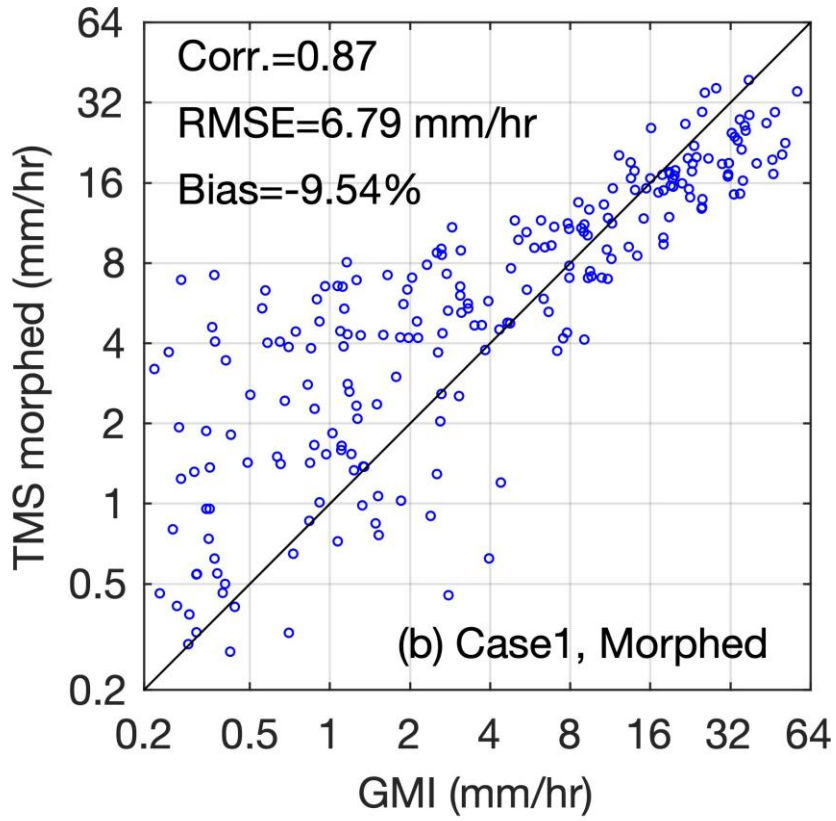
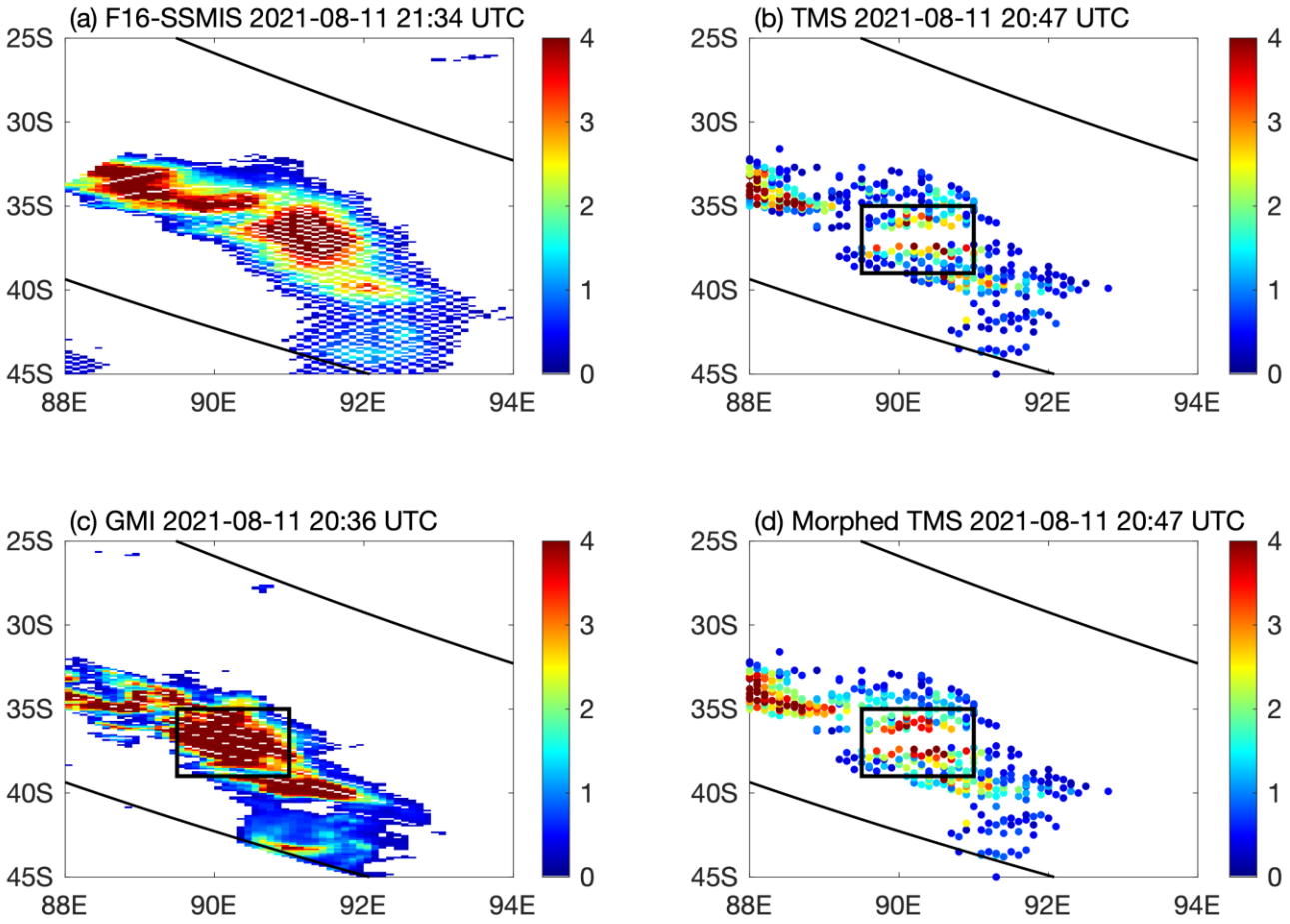




Case study: Morphing F16-SSMIS backward to TMS



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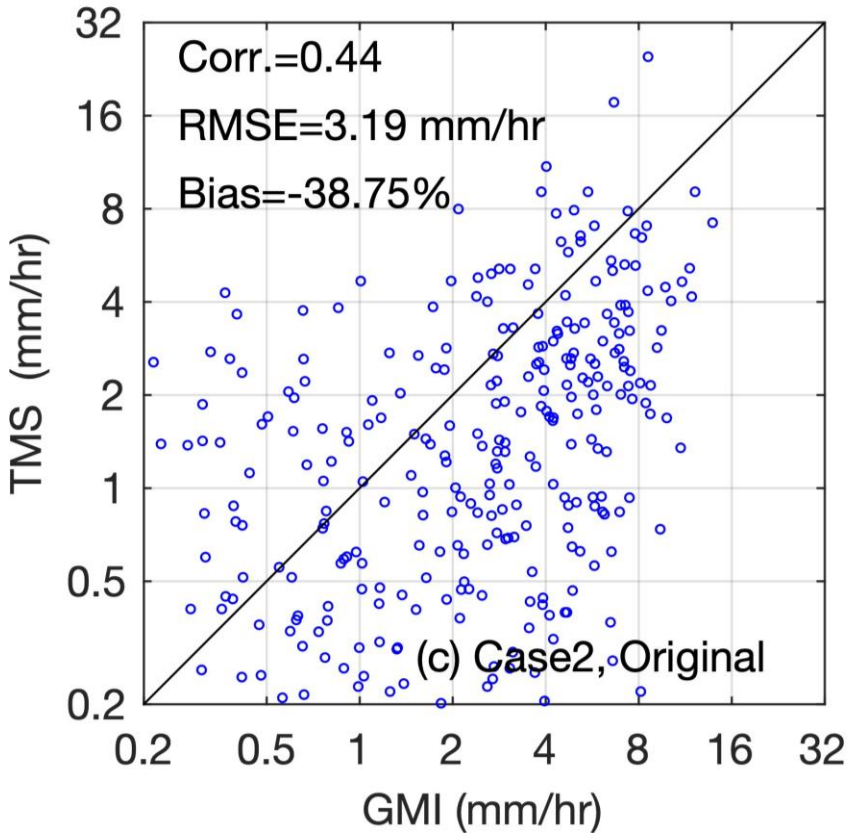
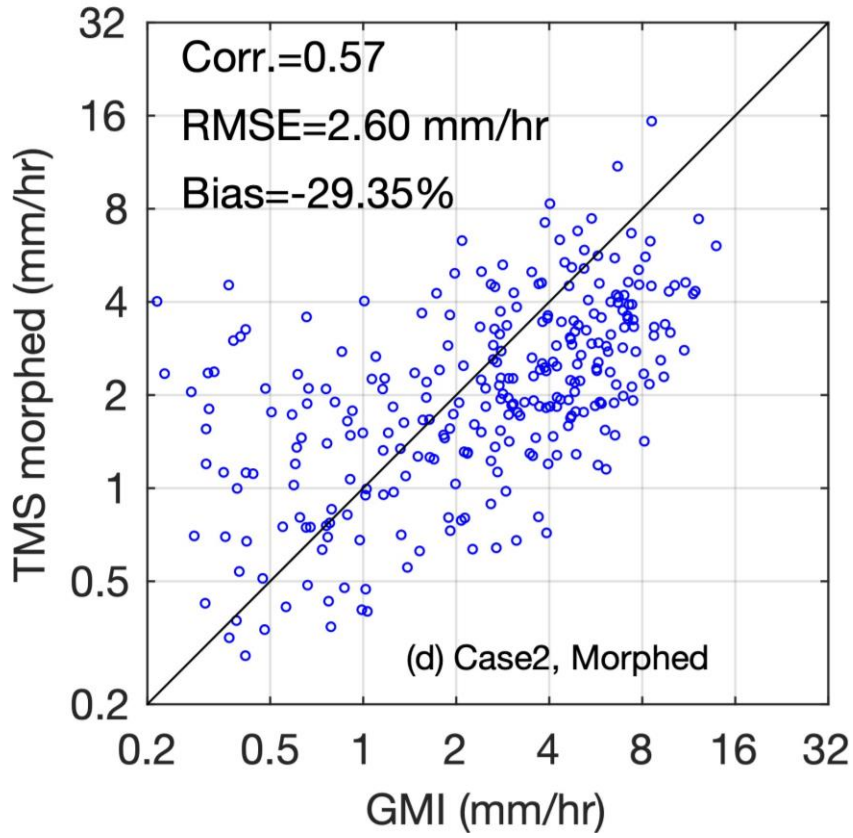
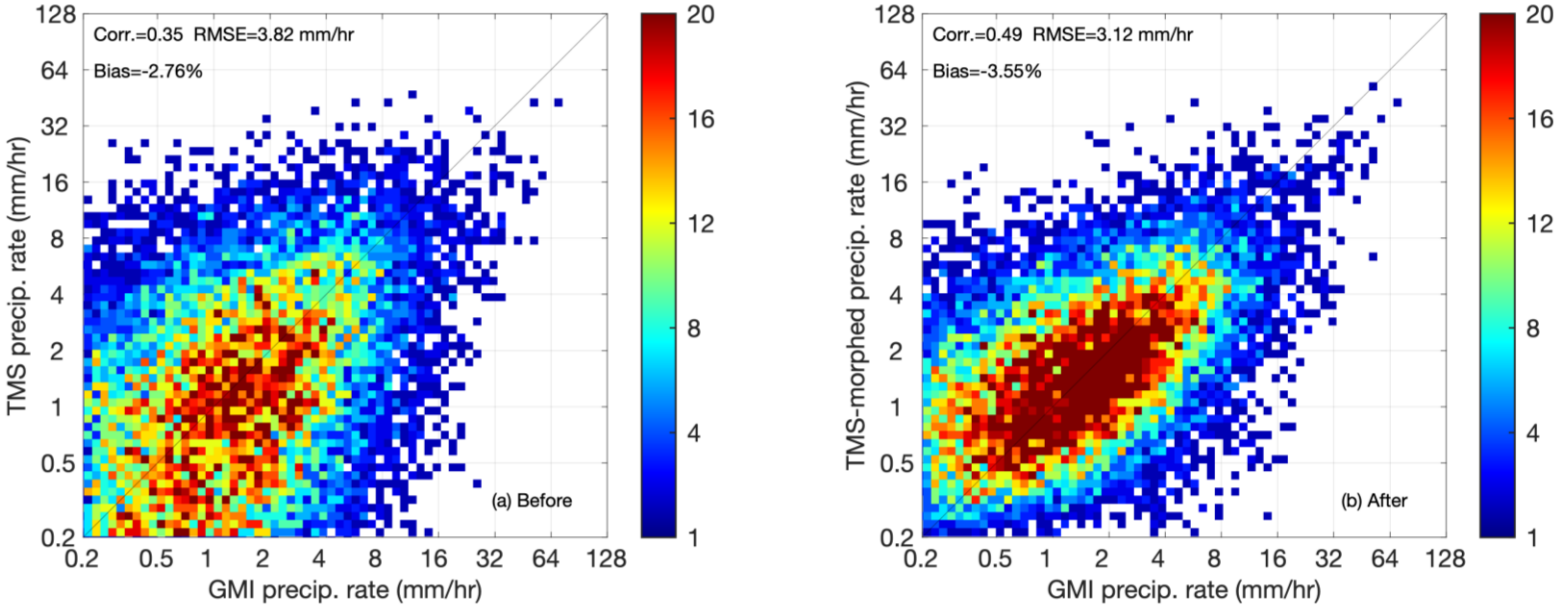


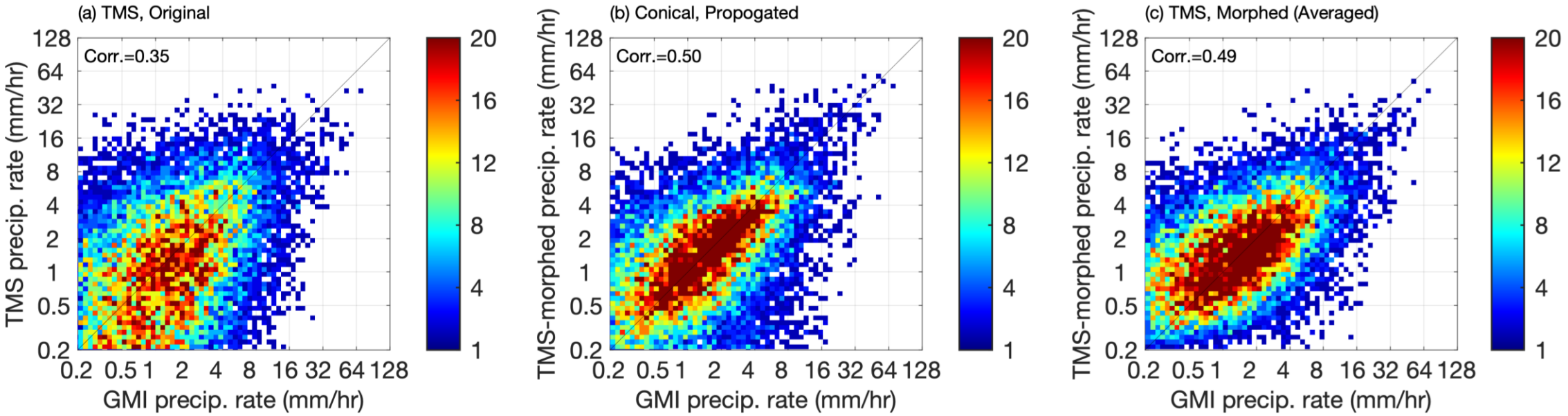


Overall performance for **TMS** (**GMI as the reference**)



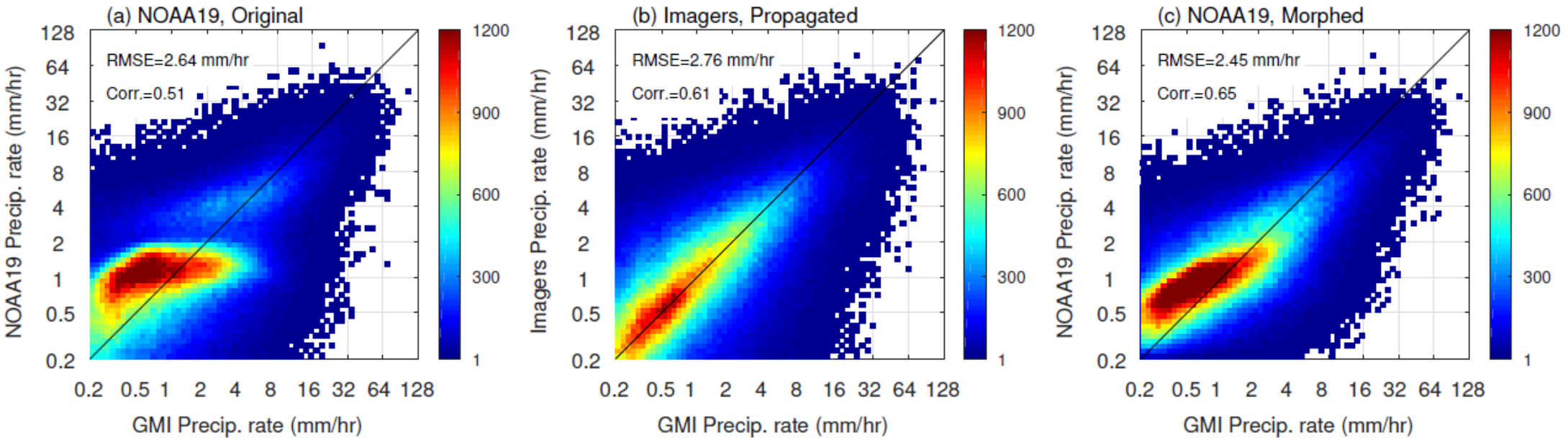
- **Correlation improves from 0.35 to 0.49**

The value of the sounder retrieval



	Correlation	RMSE (mm/hr)	Bias
TMS, Original	0.35	3.82	-2.76%
Conical, Propagated	0.50	3.21	-4.34%
TMS, Morphed	**0.49**	**3.12**	**-3.55%**

The value of the sounder retrieval



Conclusions and Discussions:

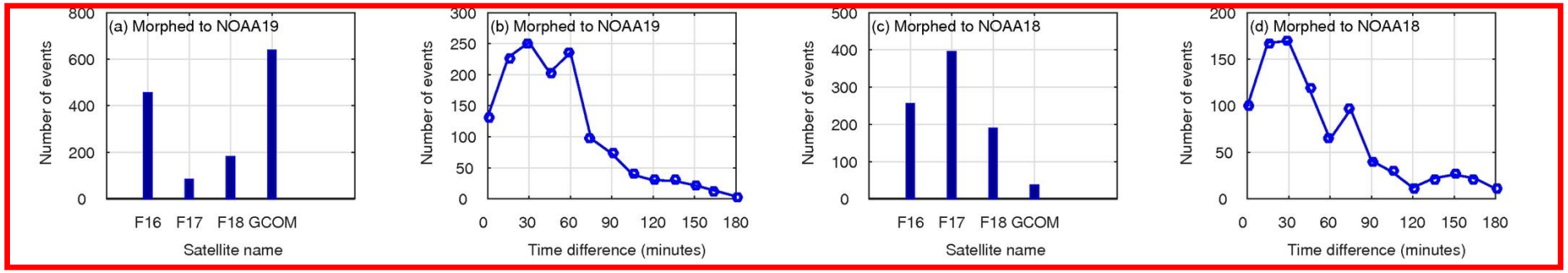
- **TMS retrieval results are comparable to other cross-track scanning radiometers**
- **TMS retrieval results perform worse than those from conical scanning radiometers**
- **Create a blended Level2 product**

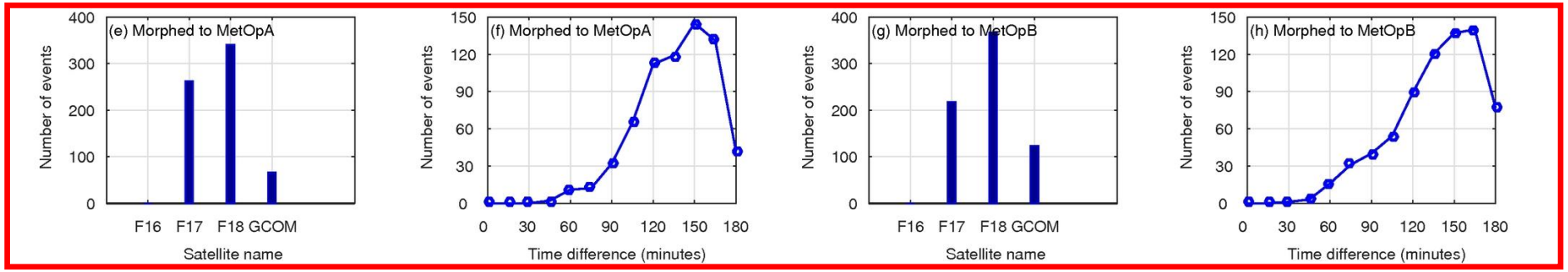
Acknowledgments:

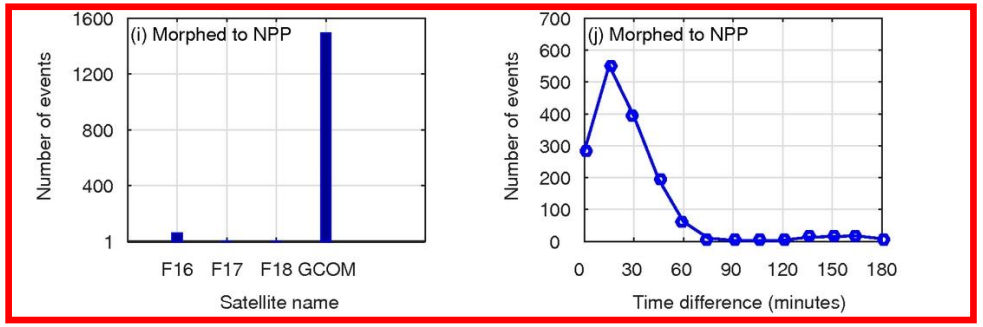
- NASA grant 80NSSC20K0903 from the Weather and Atmospheric Dynamics program
- NASA’s Precipitation Measurement Mission

Backup slides

Improvement degree differs:





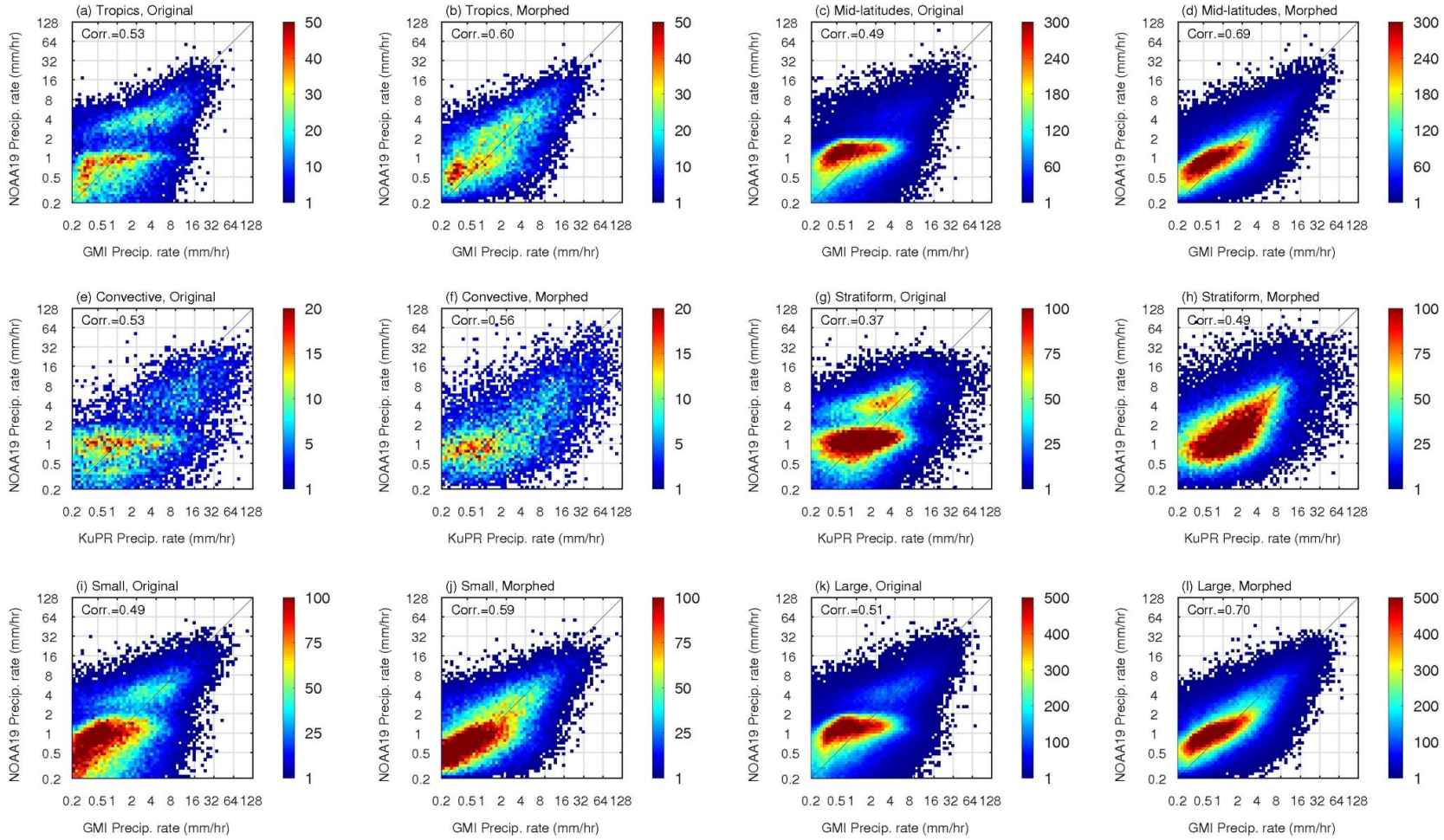


Compared with ATMS:
- More contributions from SSMISs
- Time differences are larger

Compared with ATMS:
- More contributions from SSMISs
- Time differences are much larger

Why ATMS improves the most:
- Almost all the morphed imagers results are from AMSR2
- Almost all the time differences between ATMS and AMSR2 < 60 minutes

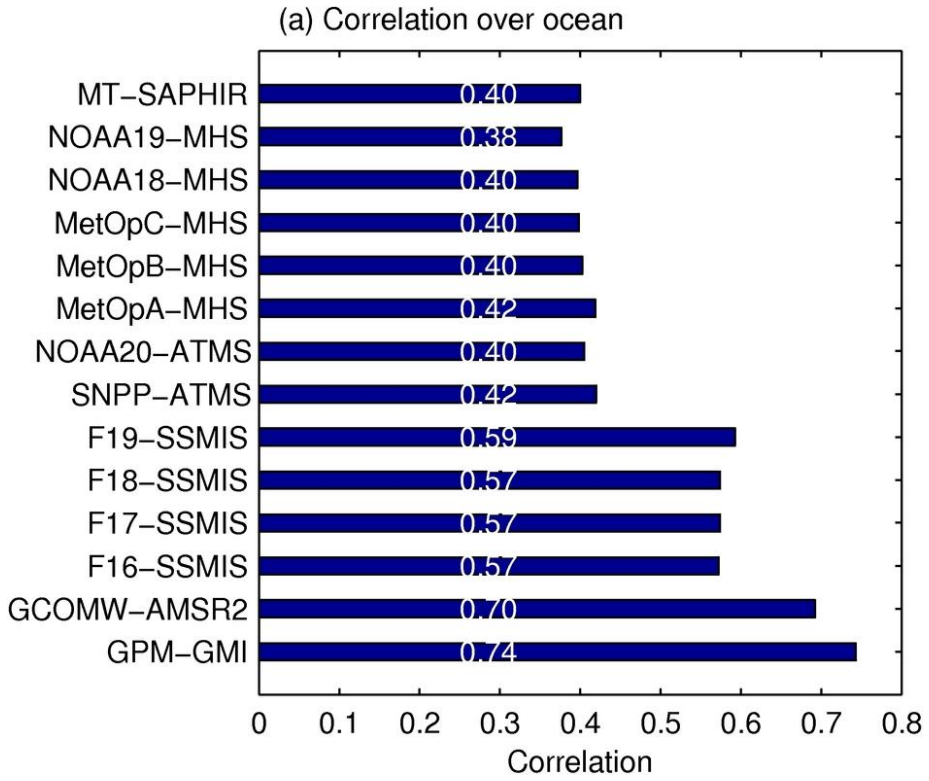
- **We also analyzed three other factors: precipitation type (convective vs. stratiform), precipitation event size (large vs. small), and region (tropics vs. subtropics)**

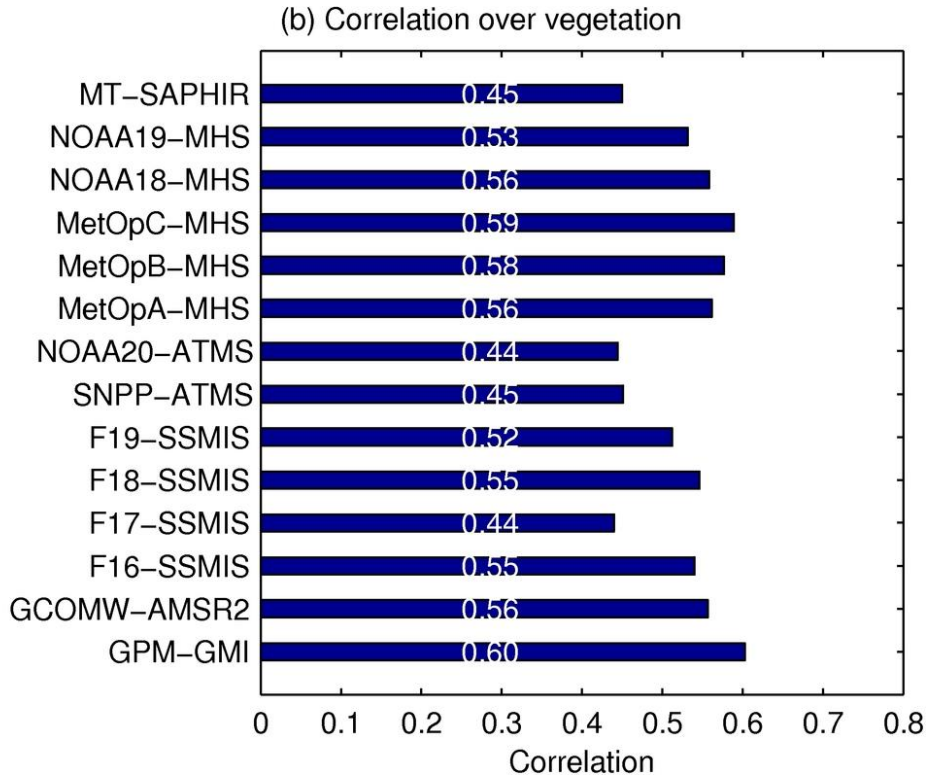


Tropics vs. Sub-tropics

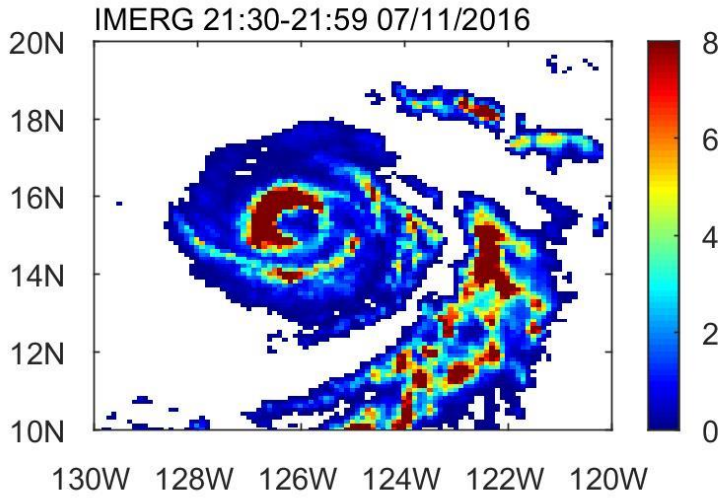
Convective vs. Stratiform

Small vs. Large





- **Coincident observations between KuPR (GMI) and each sensor**


IMERG 21:30-21:59 07/11/2016
20N
18N
16N
14N
12N
10N
130W 128W 126W 124W 122W 120W
8
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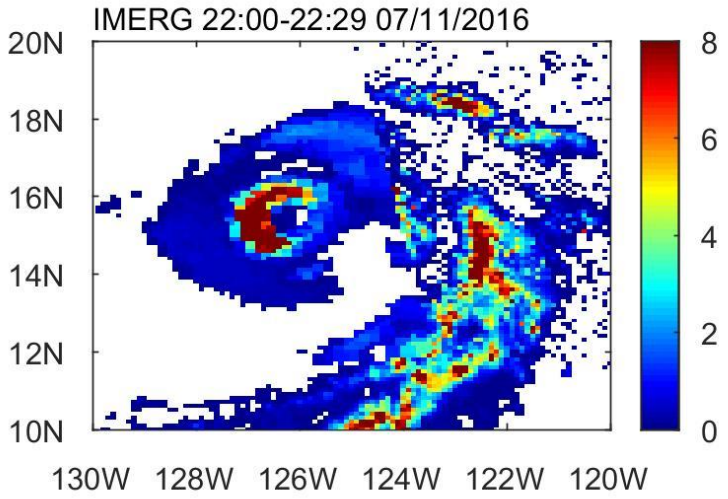
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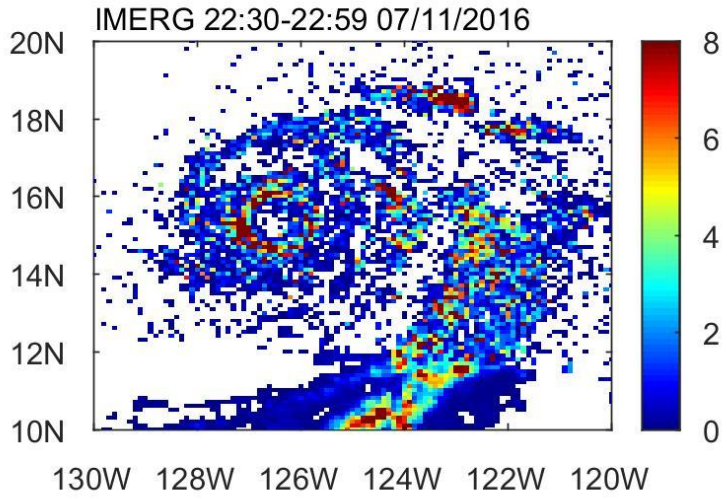
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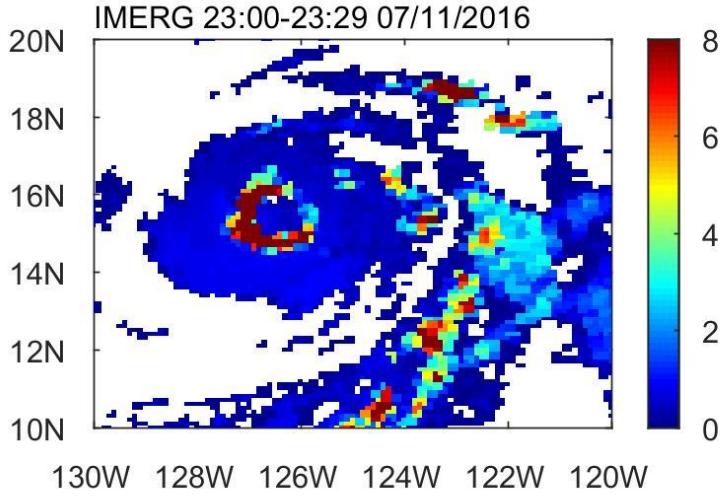
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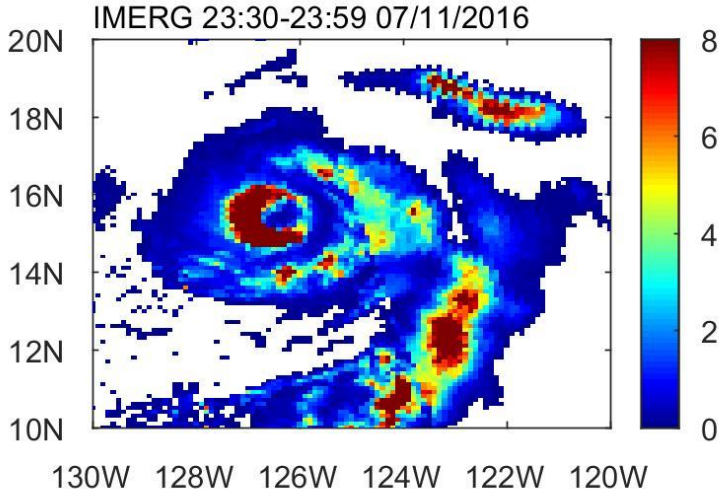
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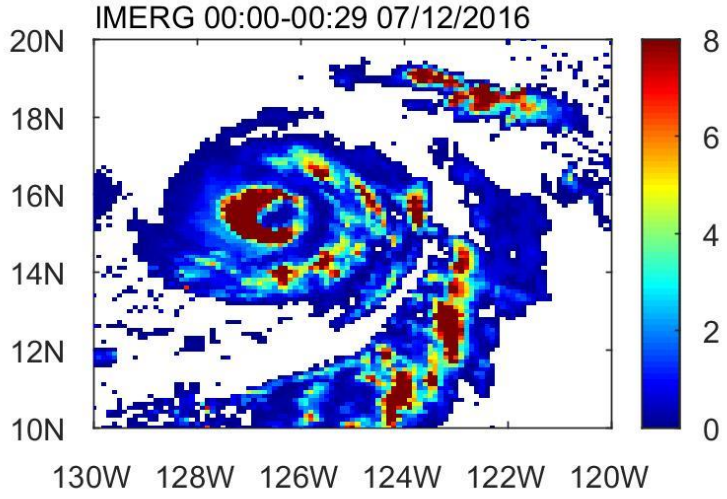
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20N
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14N
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130W 128W 126W 124W 122W 120W
8
6
4
2
0

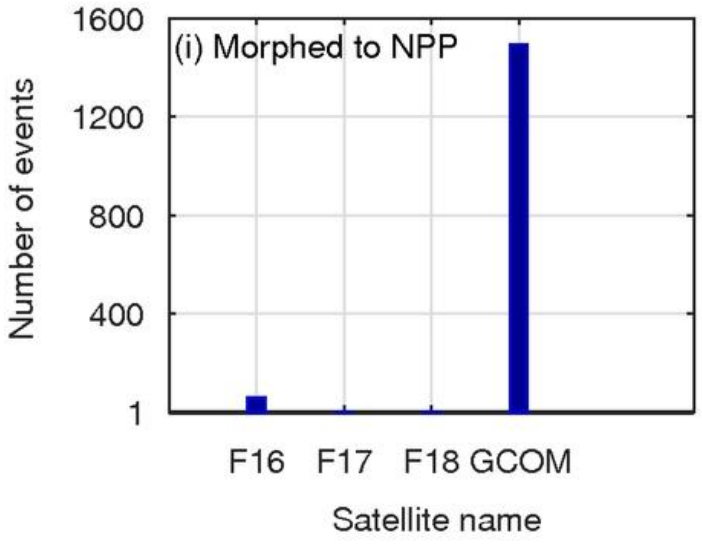
Improvement degree differs:

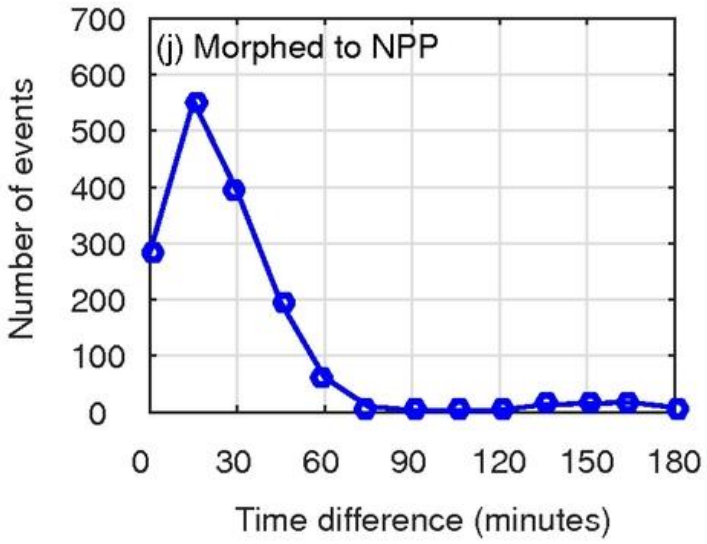
	Correlation	RMSE (mm/hr)	Bias (%)	Sample size
NOAA19-MHS original	0.51	2.64	-15.23	486,606
NOAA19-MHS morphed	0.65	2.45	-13.44	486,606
NOAA18-MHS original	0.53	2.82	-16.83	302,527
NOAA18-MHS morphed	0.66	2.66	-17.70	302,527
MetOpA-MHS original	0.55	2.96	-18.06	221,869
MetOpA-MHS morphed	0.60	3.04	-19.63	221,869
MetOpB-MHS original	0.53	2.71	-16.94	227,126
MetOpB-MHS morphed	0.59	2.81	-18.71	227,126
ATMS original	0.53	2.49	-12.27	613,913
ATMS morphed	0.72	2.08	-7.84	613,913

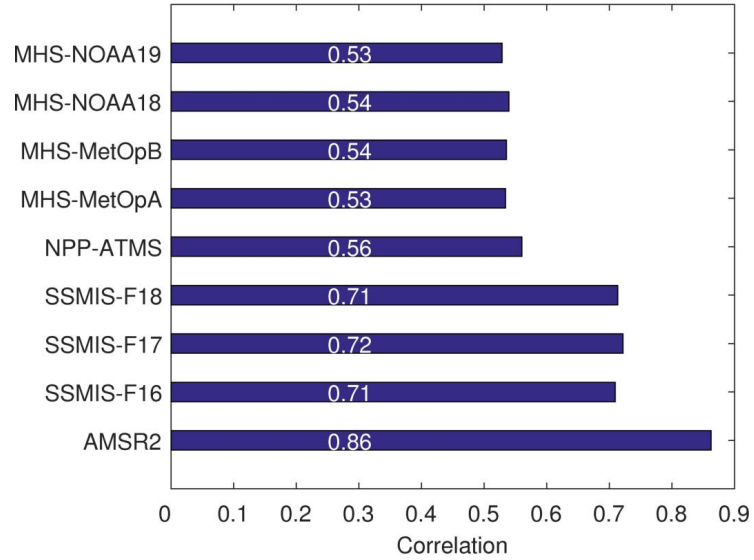
Degree of the improvement can be grouped into three categories:

1. **ATMS**
2. **MHSs from NOAA18 and NOAA19**
3. **MHSs from MetOpA and MetOpB**

Improvement degree differs:





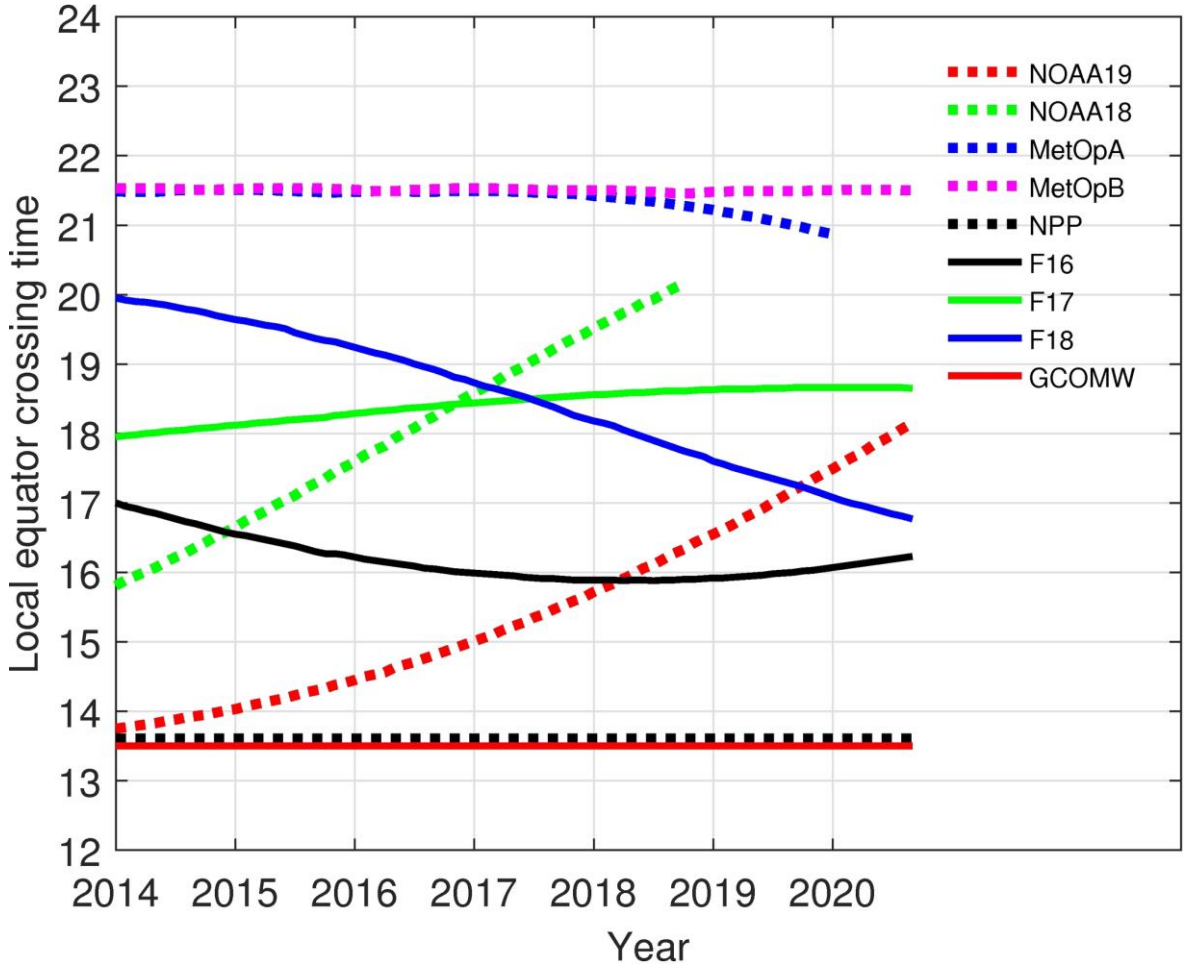


Why ATMS improves the most:

- Almost all the morphed precipitation rates are from AMSR2 (**precipitation sources**)
- Almost all the time differences between ATMS and AMSR2 < 60 minutes (**time interval**)

- We also analyzed three other factors: **precipitation type (convective vs. stratiform), precipitation event size (large vs. small), and region (tropics vs. subtropics)**

More sensors (conical), better performance: **possible connection with FY conical sensors**



Whether or not a cross-track scanning sensor can meet a conical scanning sensor depends on their orbital features

- ATMS and AMSR2 are close to each other
- MetOpA and B do not meet F16 in a +/- 3 hr window