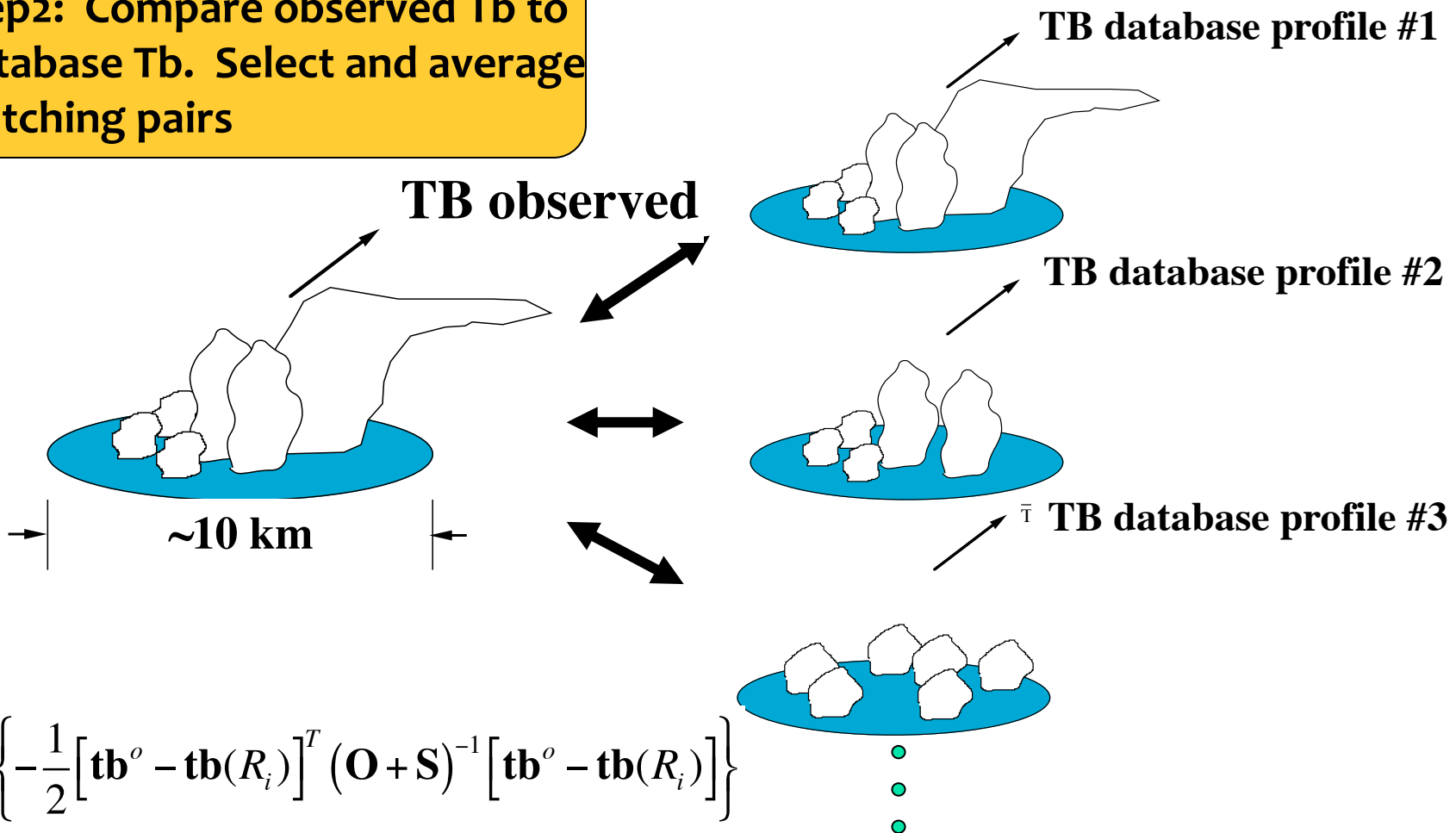
The GPM radiometer algorithm – GPROF

Step 1: Use GPM Satellite to derive set of "Observed" profiles that define an a-priori database of possible rain structures.

Step2: Compare observed Tb to Database Tb. Select and average matching pairs



$$J_i = \exp\left\{-\frac{1}{2}\left[\mathbf{tb}^o - \mathbf{tb}(R_i)\right]^T \left(\mathbf{O}+\mathbf{S}\right)^{-1}\left[\mathbf{tb}^o - \mathbf{tb}(R_i)\right]\right\}$$

GMI Versions

V5 – Over oceans, uses “GPM CMB V04” rainfall + additional hydrometeor adjustments to get better Tb match at higher GMI frequencies.

Uses GMI to extend rain rates to lower thresholds than detectable by DPR. Cloud Water is converted to drizzle to match CloudSat rain occurrence.

Over land, uses “DPR Ku V04” rainfall + additional hydrometeor adjustments to get better Tb match at higher GMI frequencies. Used DPR Ku because GPM CMB showed poor results vs MRMS

Uses “MRMS matchups with individual satellites” for a-priori databases over snow covered surfaces.

Sets precipitation threshold to match rain occurrence in a-priori database.

Version 5 Feedback

High Latitude precipitation not enough to match CloudSat or Reanalyses. This is both a radar sensitivity issue but also due to shallow precipitation occurring below the clutter bin of the radars

Overall precipitation on the low end of the radiation budget estimates that require more LE to balance sfc energy.

Overall precipitation balances Evaporation and reanalysis Water Vapor divergence over tropical oceans.

Orographic precipitation not enough to match gauge analyses (e.g. GPCC). True for rainfall as well as snow.

Produced almost no precipitation over sea ice (due largely to CMB product having nearly no precipitation)

Still had some local coastline contamination (particularly for thick clouds), and almost never any precipitation over sea ice.

Version 7 changes (there is no V6)

High Latitude precipitation not enough to match CloudSat or Reanalyses. This is both a radar sensitivity issue but also due to shallow precipitation occurring below the clutter bin of the radars

Added more precipitation form radiometer (up to 0.2 mm/hr) if radiometer had precipitation but radars showed no echo.

Overall precipitation on the low end of the radiation budget estimates that require more LE to balance sfc energy.

CMB increased precipitation by roughly 9%. GPROF follows that increase but 0.2 mm/hr threshold for additional precipitation increases total adjustment by an additional 3% over CMB.

Version 7 changes

Orographic precipitation not enough to match gauges analyses (e.g. GPCC). True for rainfall as well as snow.

Added a mountain class to land that enhances precipitation on windward side.

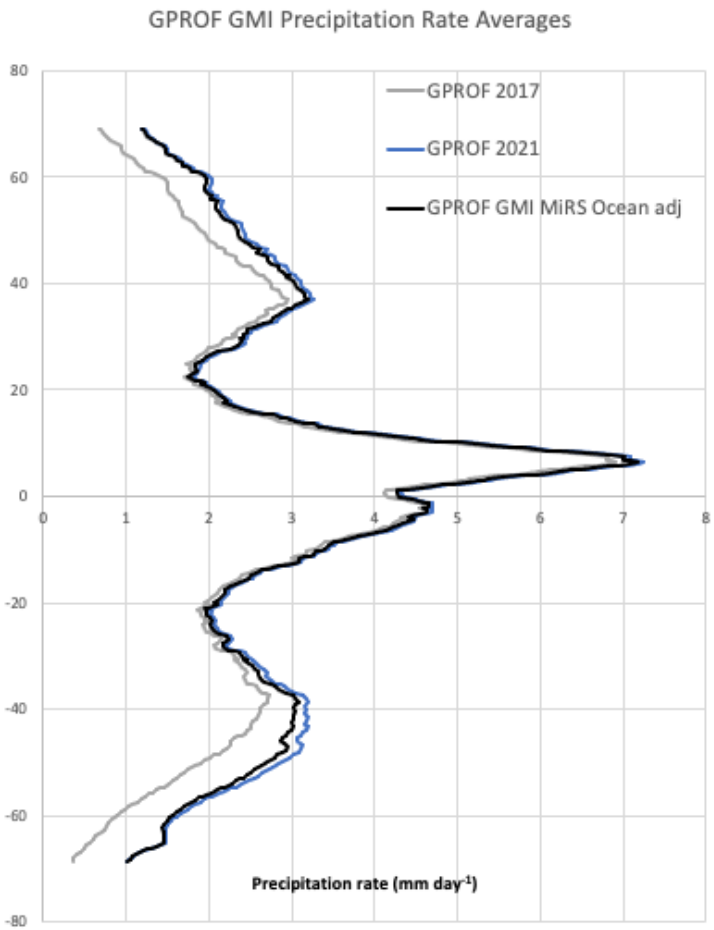
Produced almost no precipitation over sea ice (due largely to CMB product having nearly no precipitation)

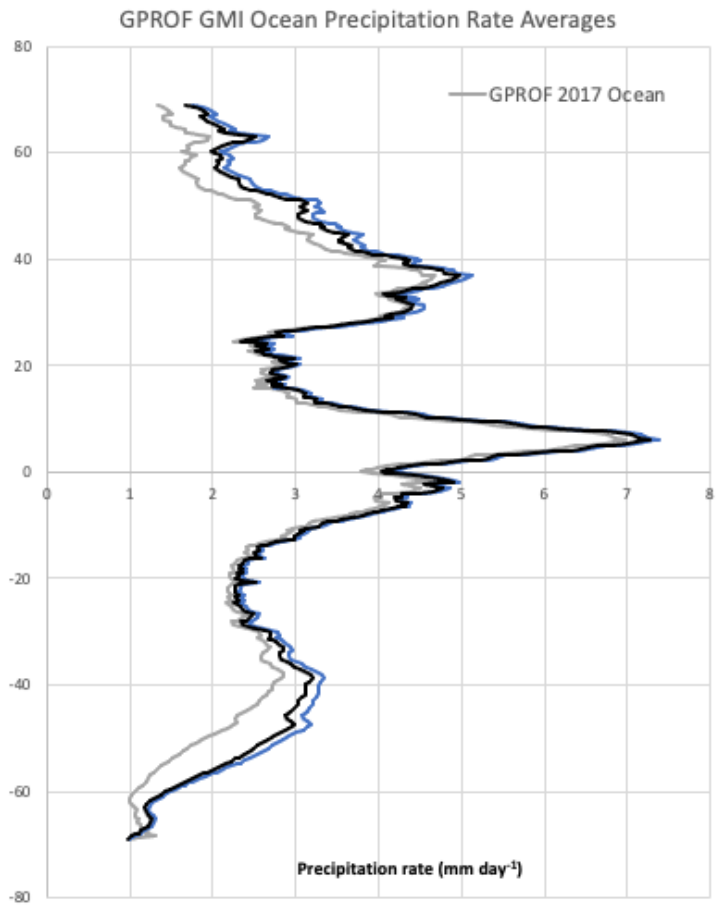
Used ERA-5 for a-priori precipitation over sea ice

Still had some local coastline contamination (particularly for thick clouds), and almost never any precipitation over sea ice.

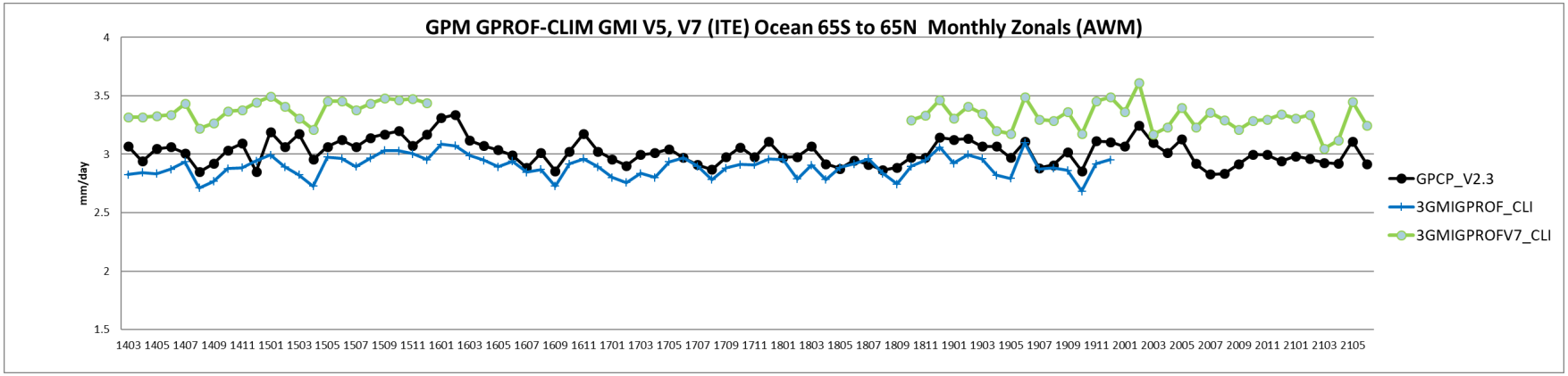
Divided coastline into ”mostly ocean”, “50/50”, and “mostly land”. We see fewer erroneous pixels with new coastline classes.

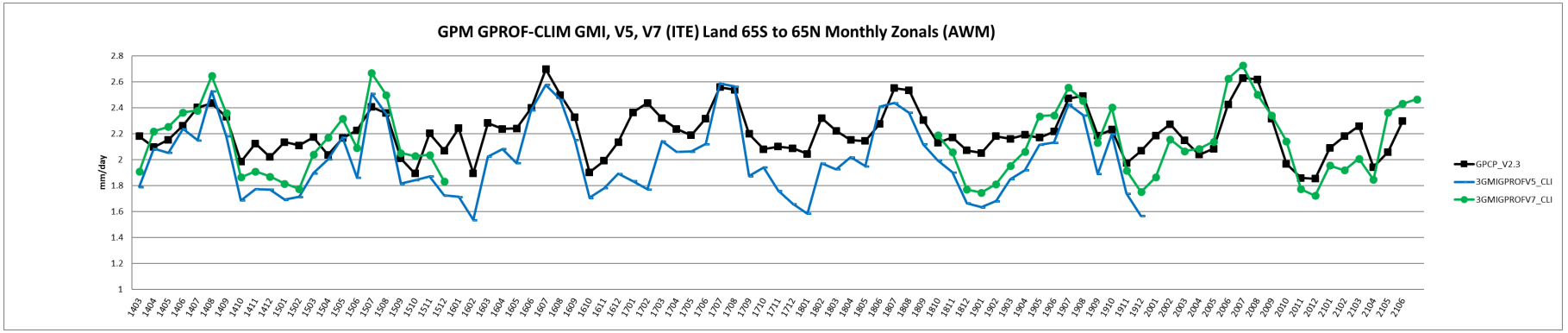
Precipitation Zonal means



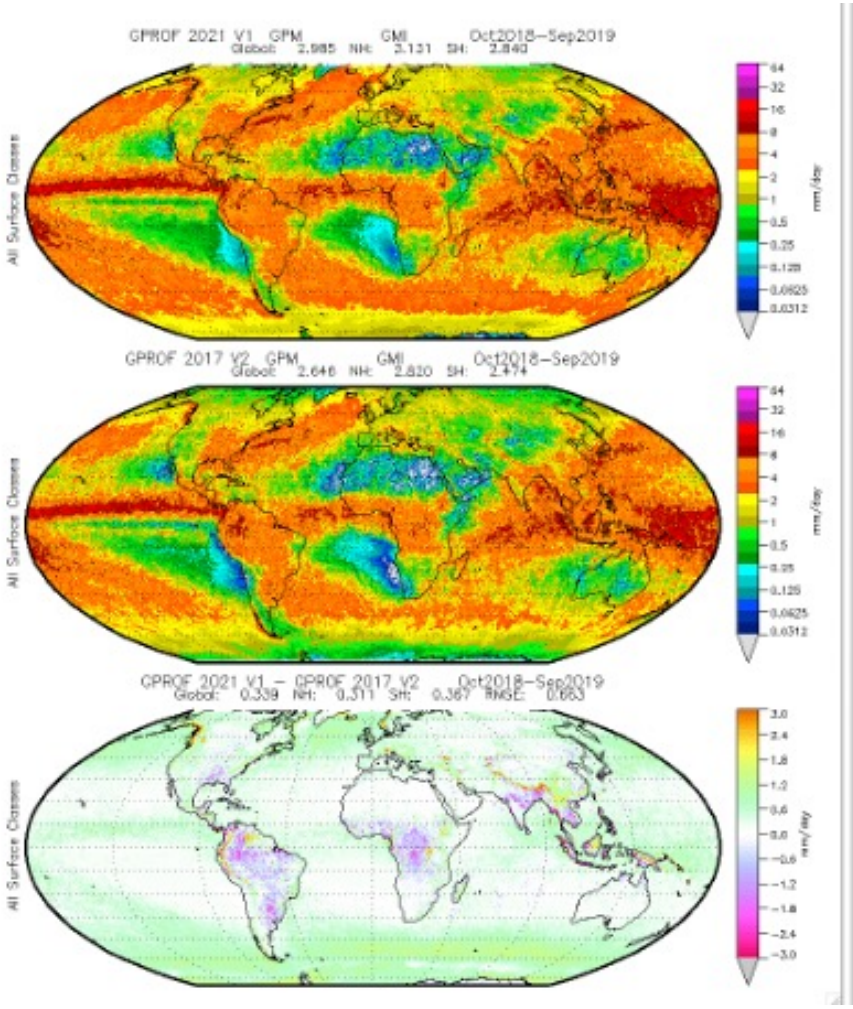


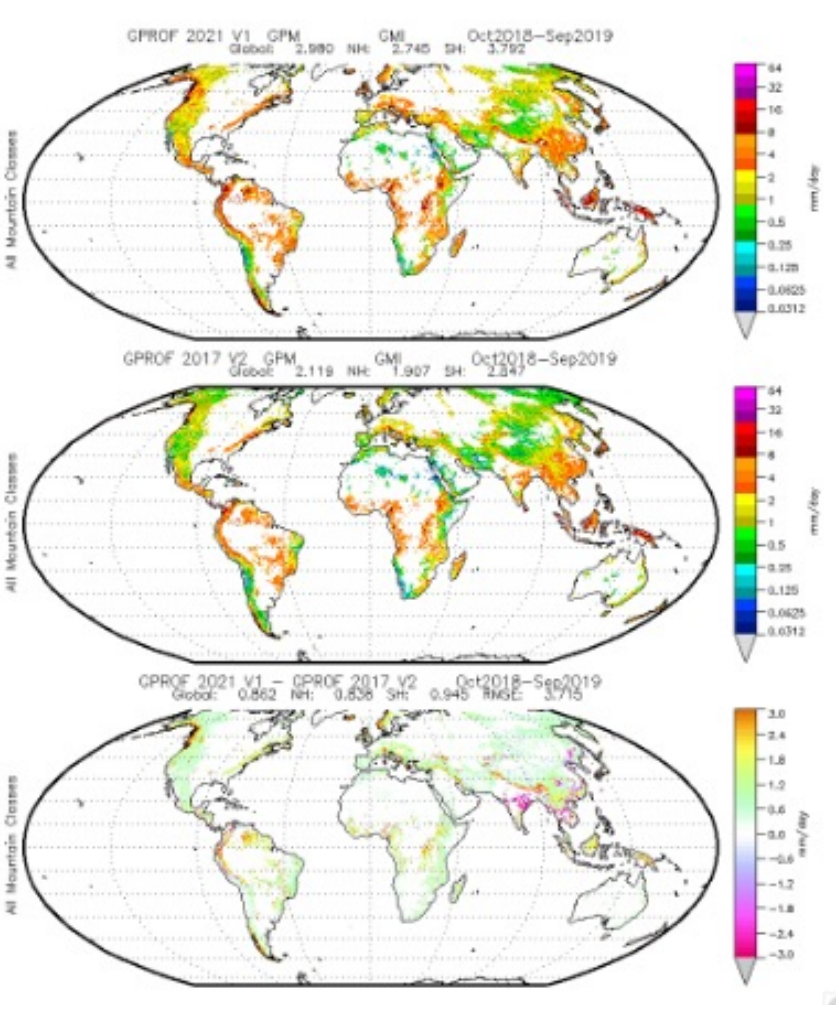
Precipitation Trends



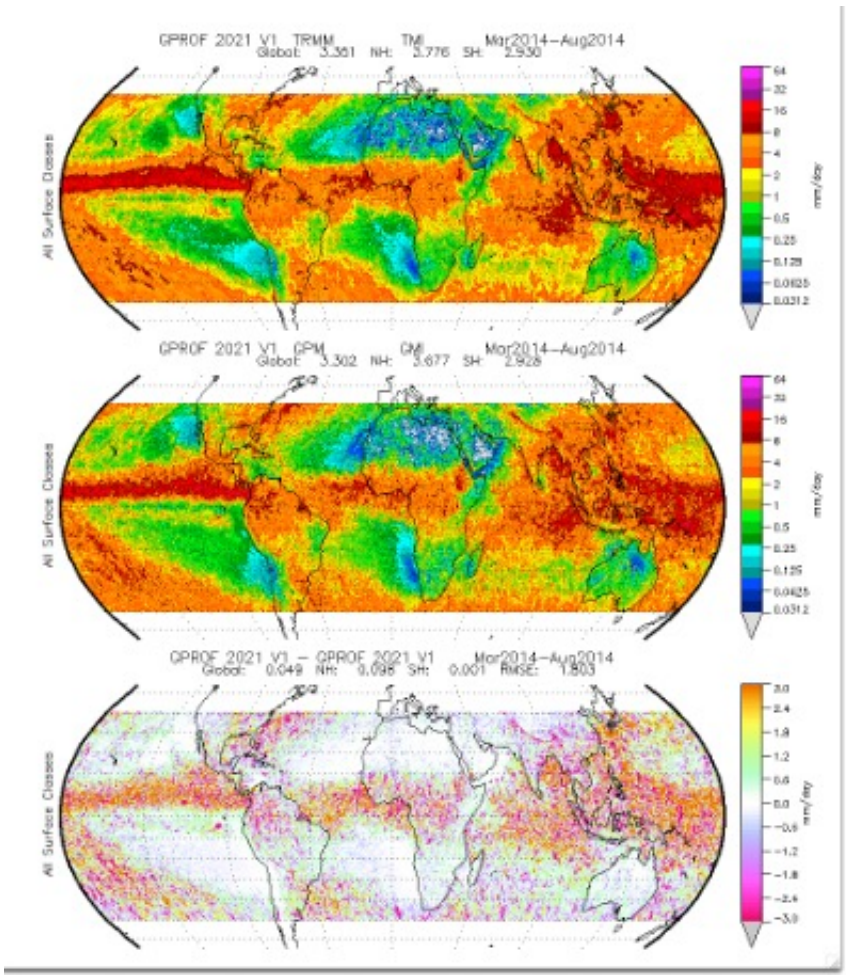


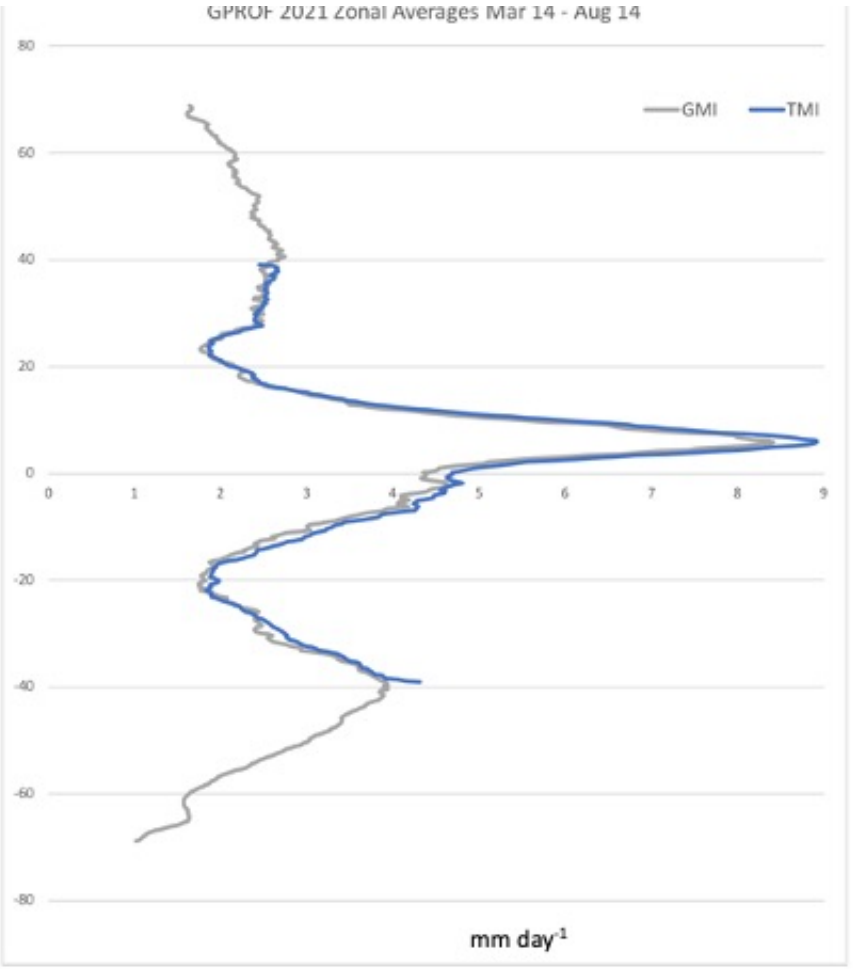
Impact from new Mountain Class



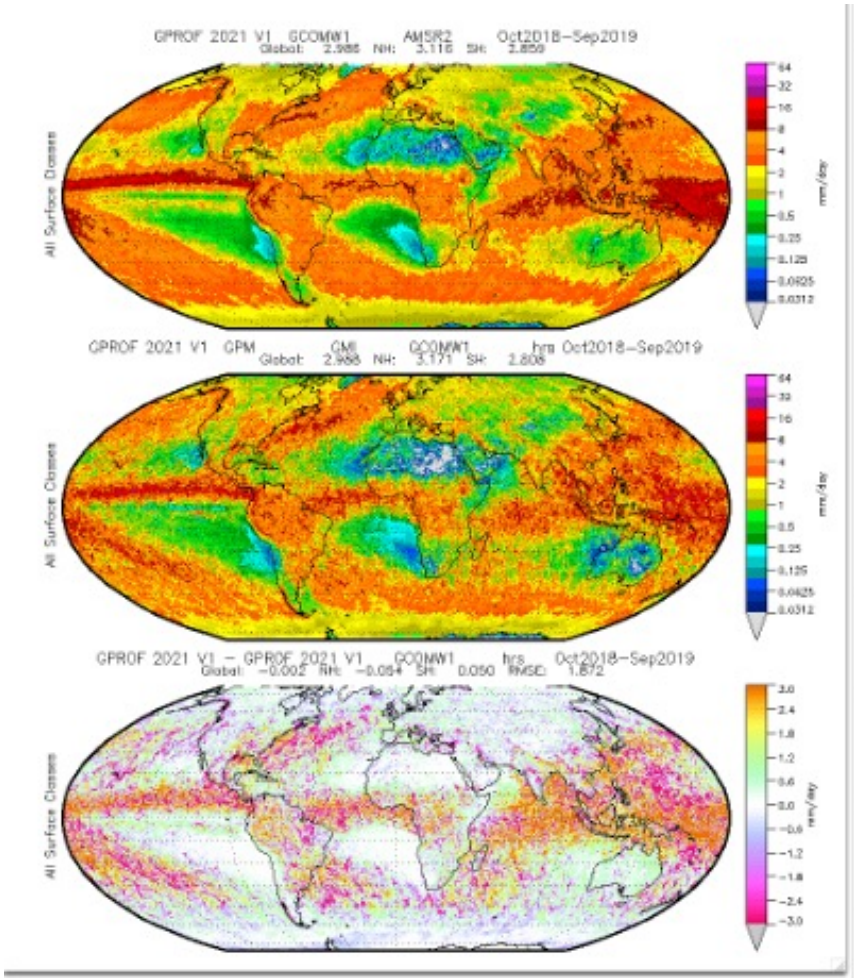


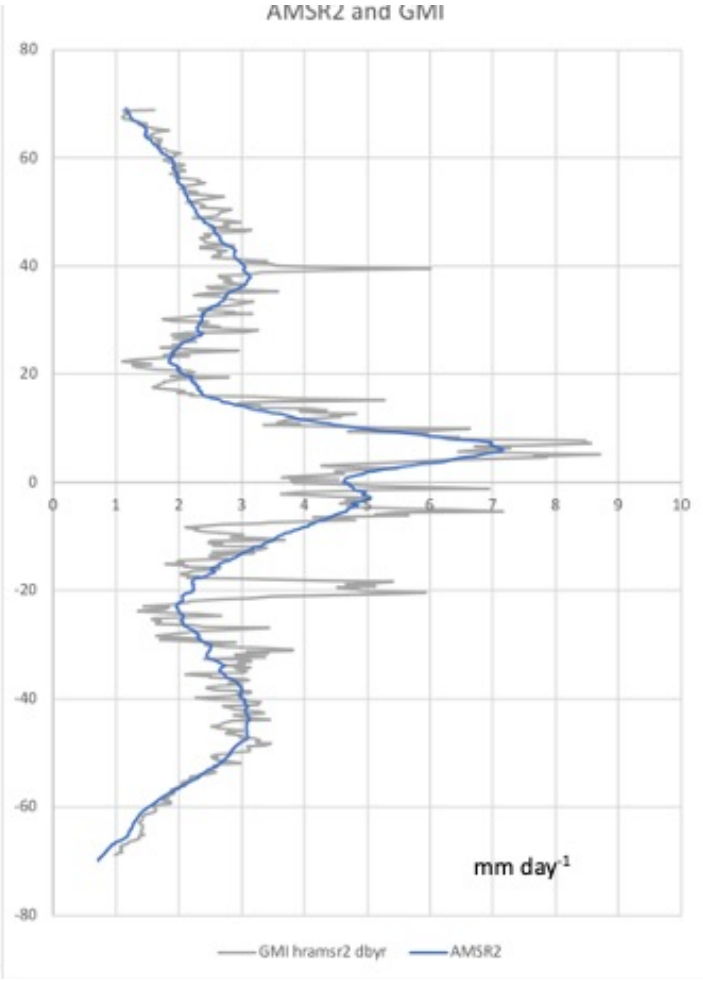
GMI vs TMI


GPROF 2021 V1 TRMM TMI Mar2014–Aug2014
Global: 3.351 NH: 3.776 SH: 2.930
All Surface Classes
mm/day
GPROF 2021 V1 GPM GMI Mar2014–Aug2014
Global: 3.302 NH: 3.677 SH: 2.928
All Surface Classes
mm/day
GPROF 2021 V1 – GPROF 2021 V1 Mar2014–Aug2014
Global: 0.049 NH: 0.098 SH: 0.001 RMSE: 1.803
All Surface Classes
mm/day

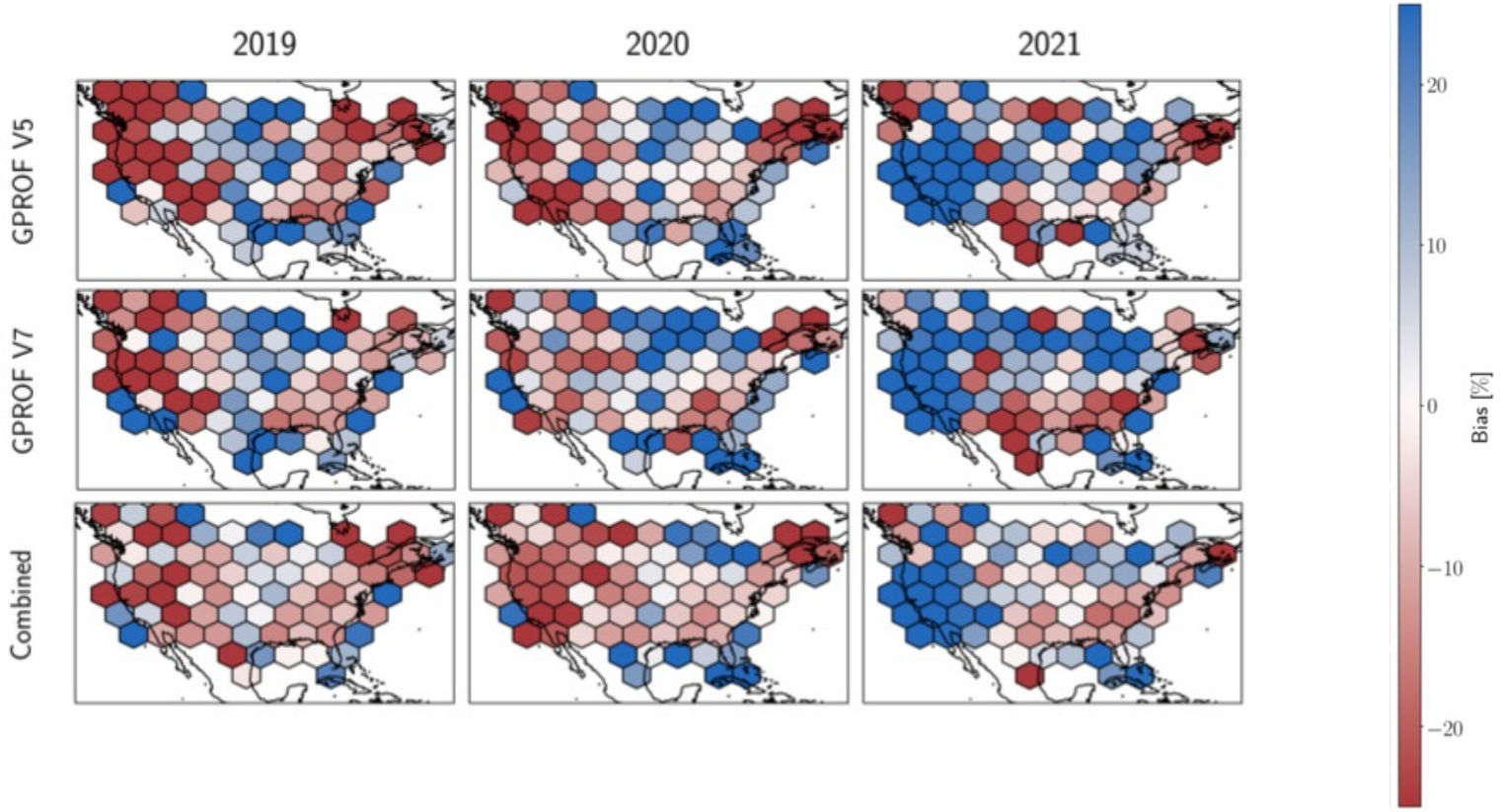

GPROF 2021 Zonal Averages Mar 14 - Aug 14
GMI
TMI
80
60
40
20
0
-20
-40
-60
-80
0
1
2
3
4
5
6
7
8
9
mm day-1

GMI vs AMSR2 vs GMI

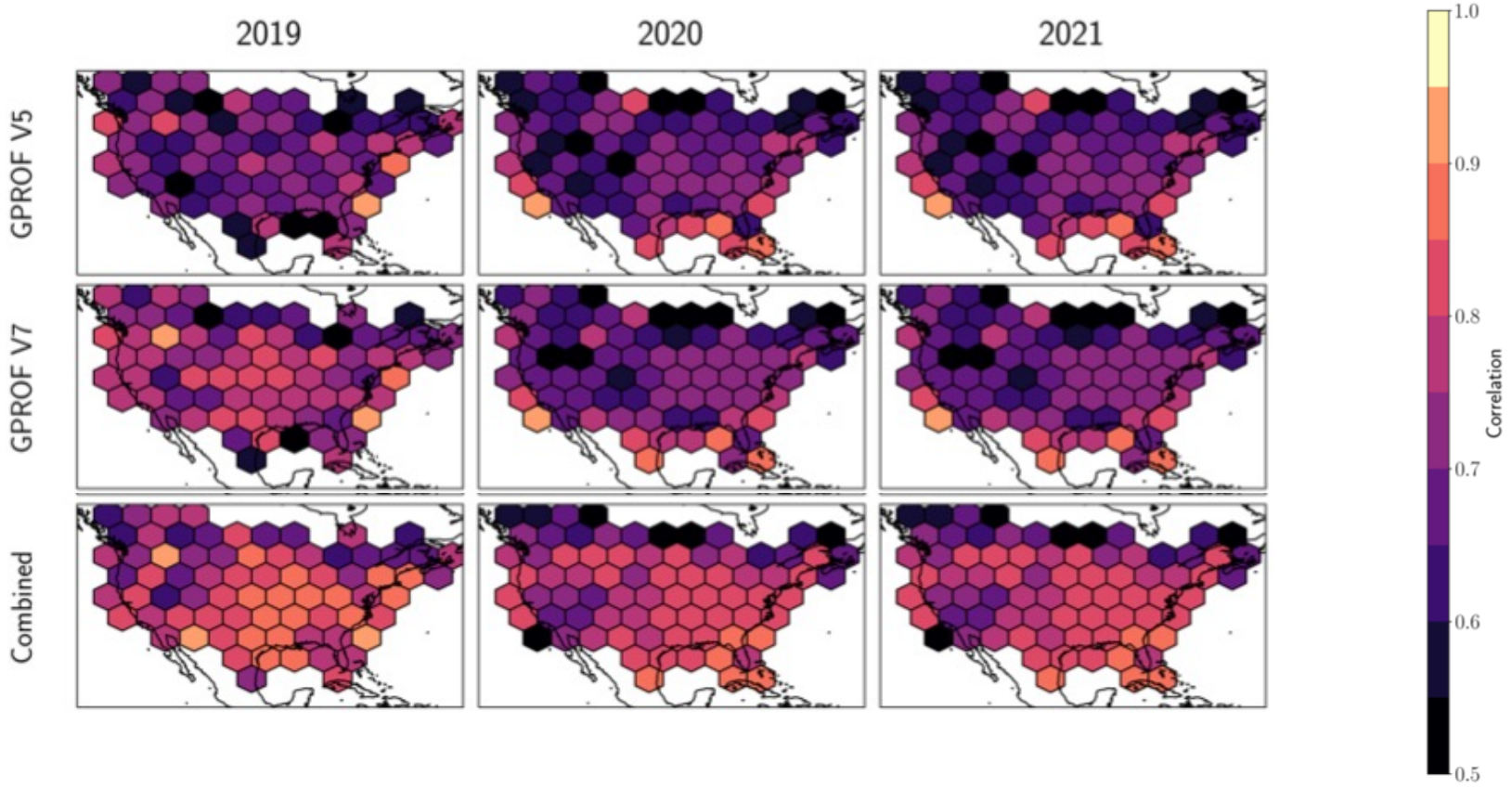




Regional Bias vs RMS

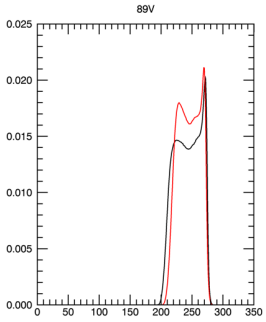


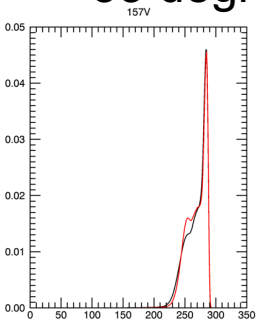
Regional Correlation vs RMS

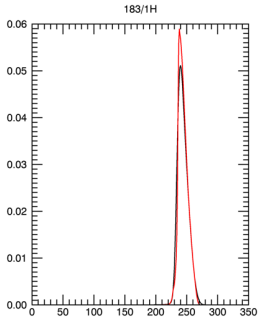


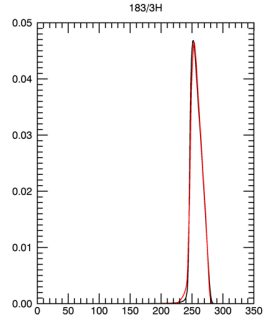
Simulations of Cross-Track Scanners (Oceans)

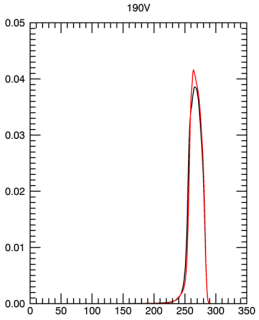
53 degrees











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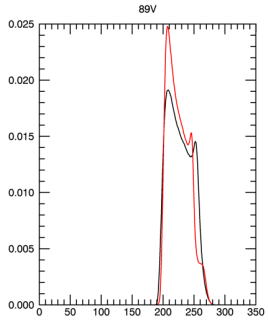
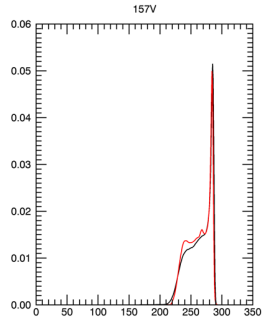
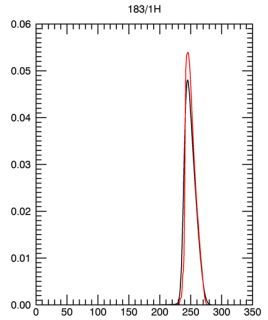
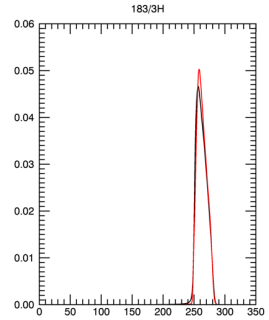
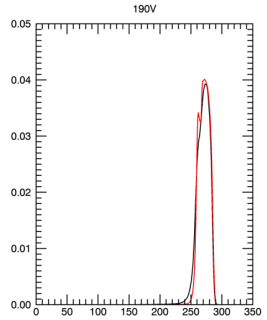




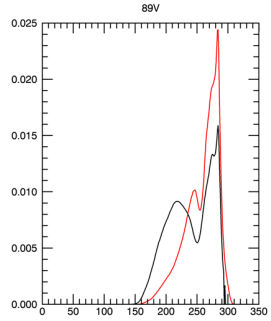


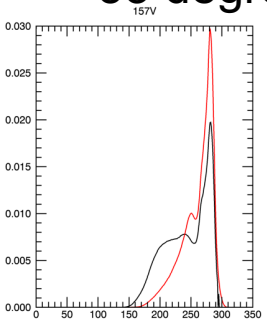


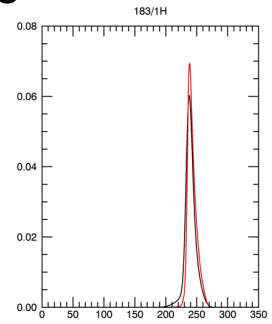


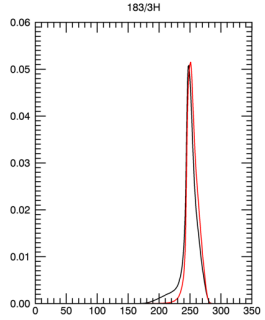
Simulations of Cross-Track Scanners (Non-oceans)

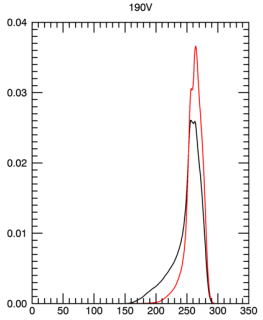
53 degrees



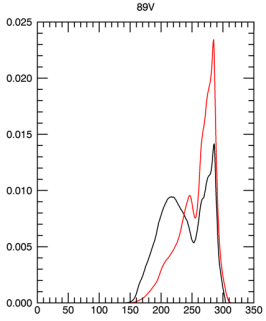


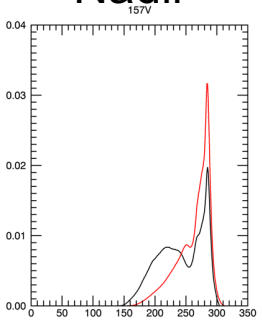


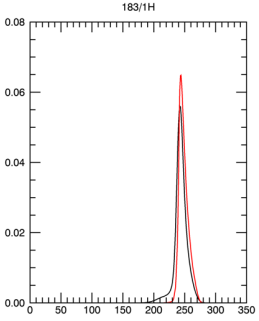


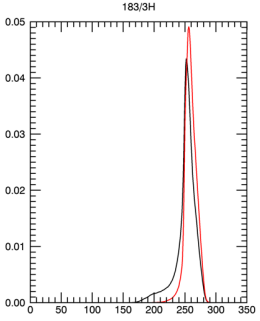


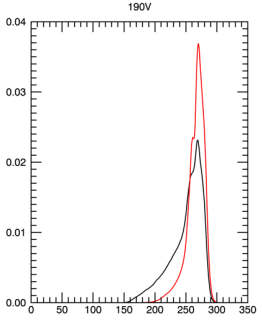
Nadir



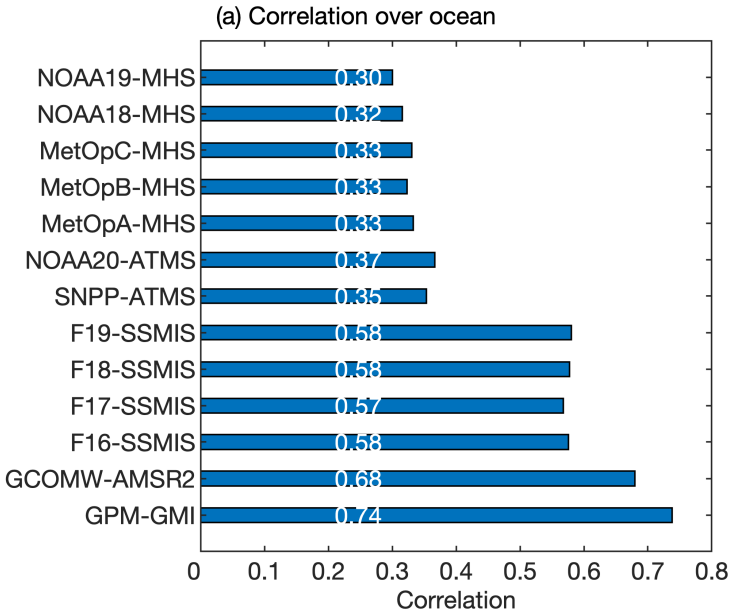


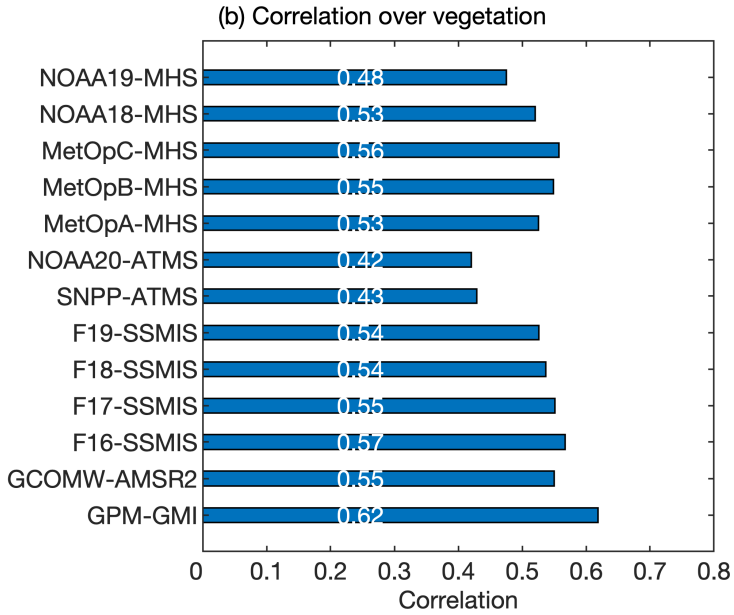






GPROF V07 vs. KuPR V07



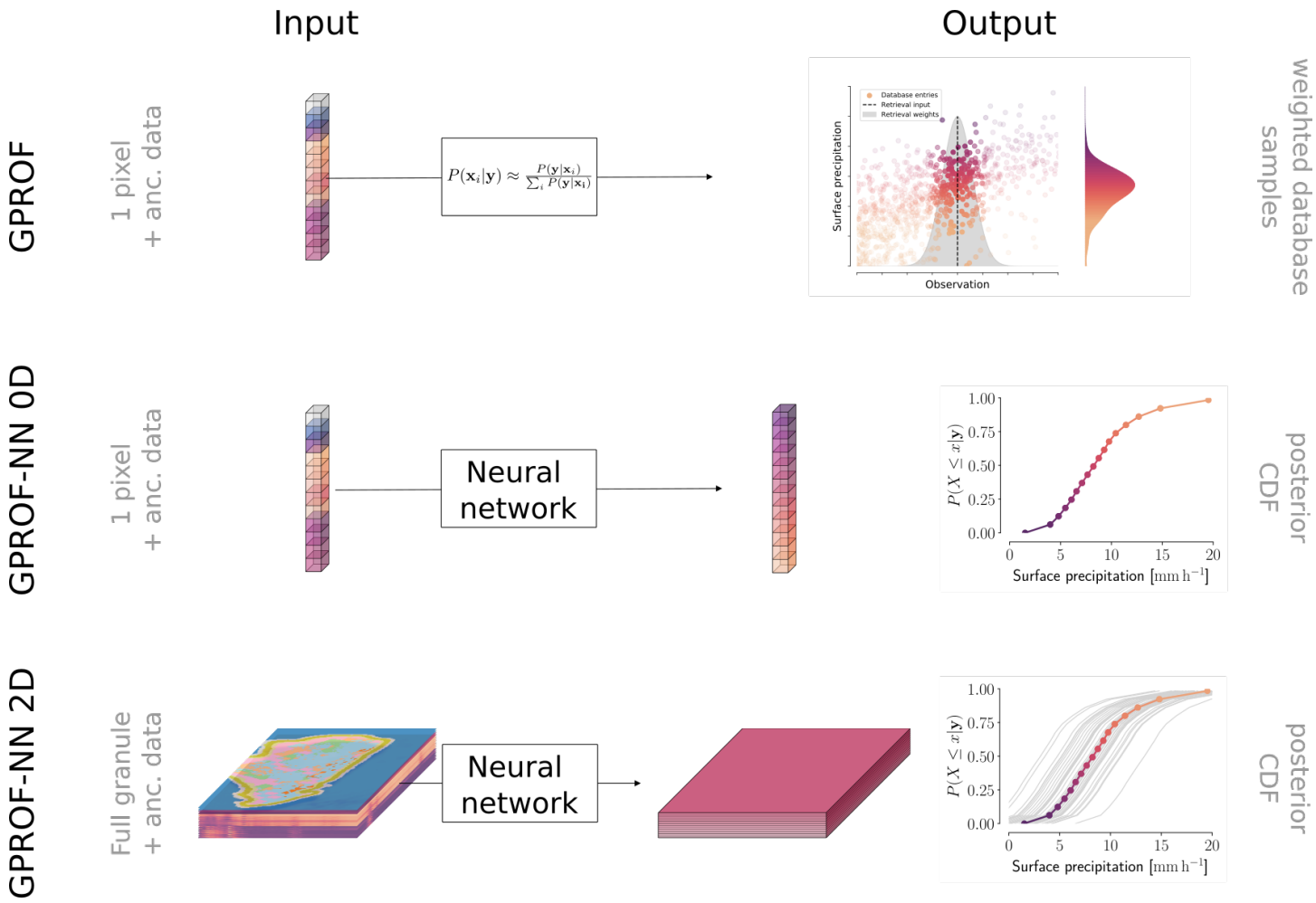


- Correlations between each sensor and KuPR when they meet (5 km and 5 minutes)
- In GPROF V07: **All four SSMIs perform similarly relative to KuPR V07.**

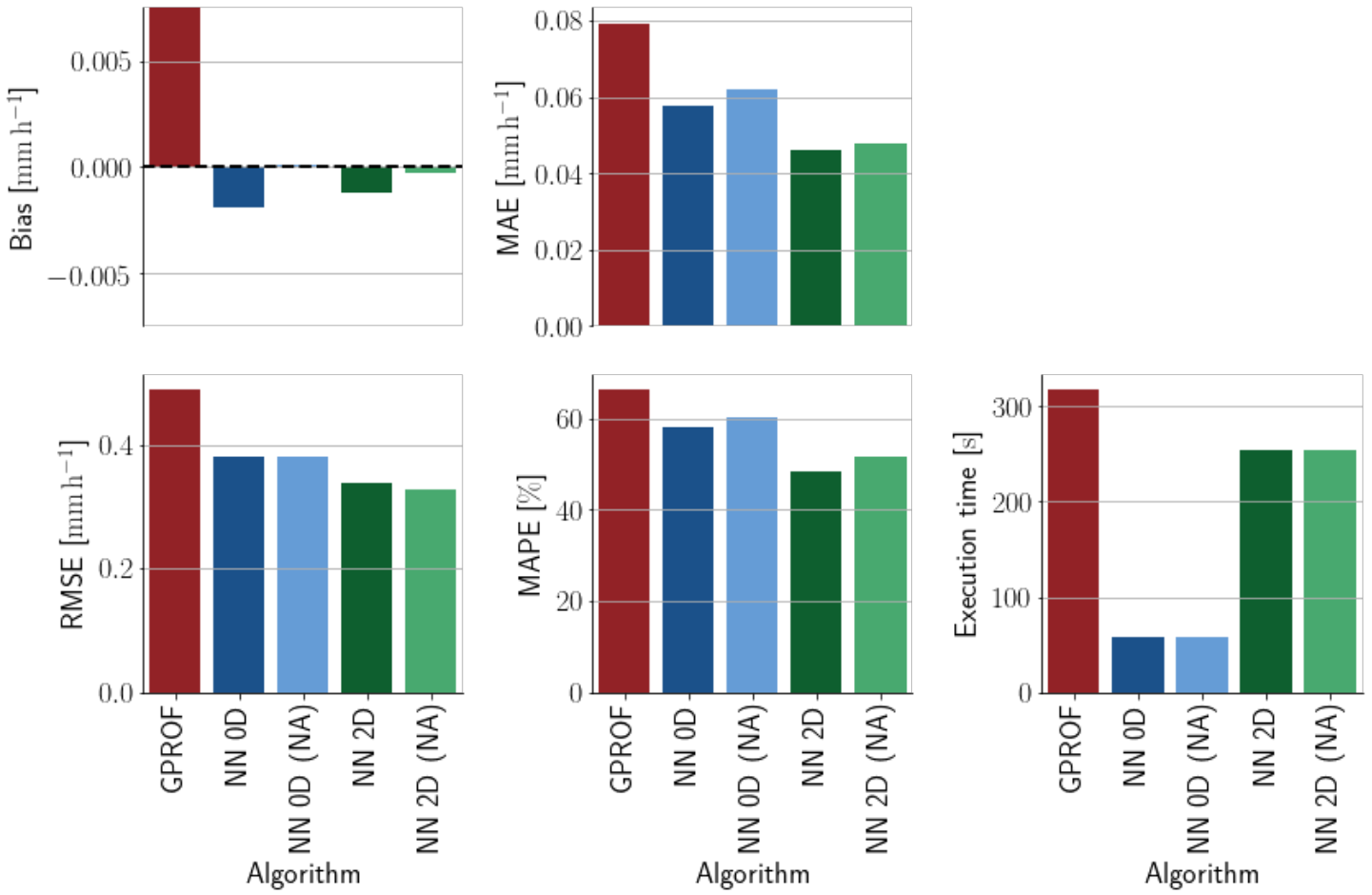
From Yalei You

GPROF-NN

Two new, neural network based implementations of GPROF



Retrieval performance (surface precipitation)



GPROF vs GPROF-NN

NN algorithms are functionally equivalent: Output is identical to GPROF

1) Neural network versions improve accuracy consistently across all retrieved quantities (GPROF-NN 0D)
2) Further, substantial improvements through incorporation of spatial information.
3) **BUT**: No capabilities for introspection, need operational testing. Will submit to PPS once new processing is calmed down.

Code is public (github.com/simonpf/gprof_nn).

Summary

- *Database creation using standard, agency supported products adds standardization and continuous improvement but CMB and MIRS are not created as a-priori database products.*
- *Tackling orographic enhancement by adding ancillary flow data with Bayesian scheme. New Surface "Mountain" class introduced*
- *Minor changes that were implemented*
  - *Back to probability of precipitation but w. yes/no flag*
  - *3 coastline classes – mostly ocean, mixed, mostly land*
  - *2 new mountain classes (snow cover determined by ancillary data)*
- *AI version of GPROF likely for V8 but largely transparent to the User. Lots of testing between now and then.*
- *Working on better a-priori (coupled to, but with different goals than CMB) as well as establishing validation metrics away from GV sites.*