Validation of AMSR-E Ocean Precipitation Retrievals

Grant Petty

Longtao Wu

Atmospheric and Oceanic Sciences

University of Wisconsin-Madison

Algorithm Validation Milestones
SSM/I version

- Participation in AIP-3 and PIP-3
  - In AIP-3: Achieved *highest* overall linear correlation with 0.25 degree radar rain rates (out of approx. 27 SSM/I algos.)
    - Validates approach to high resolution horizontal structure
    - Vindicates neglect of vertical structure?
  - In PIP-3: Only algorithm to yield *all* of the following
    - Reasonable mid- and high-latitude precipitation *fractional-time-precipitating* as compared with ship-based climatology
    - Reasonable correlation *and* bias relative to tropical atolls
    - Reasonable reproduction of annual cycle

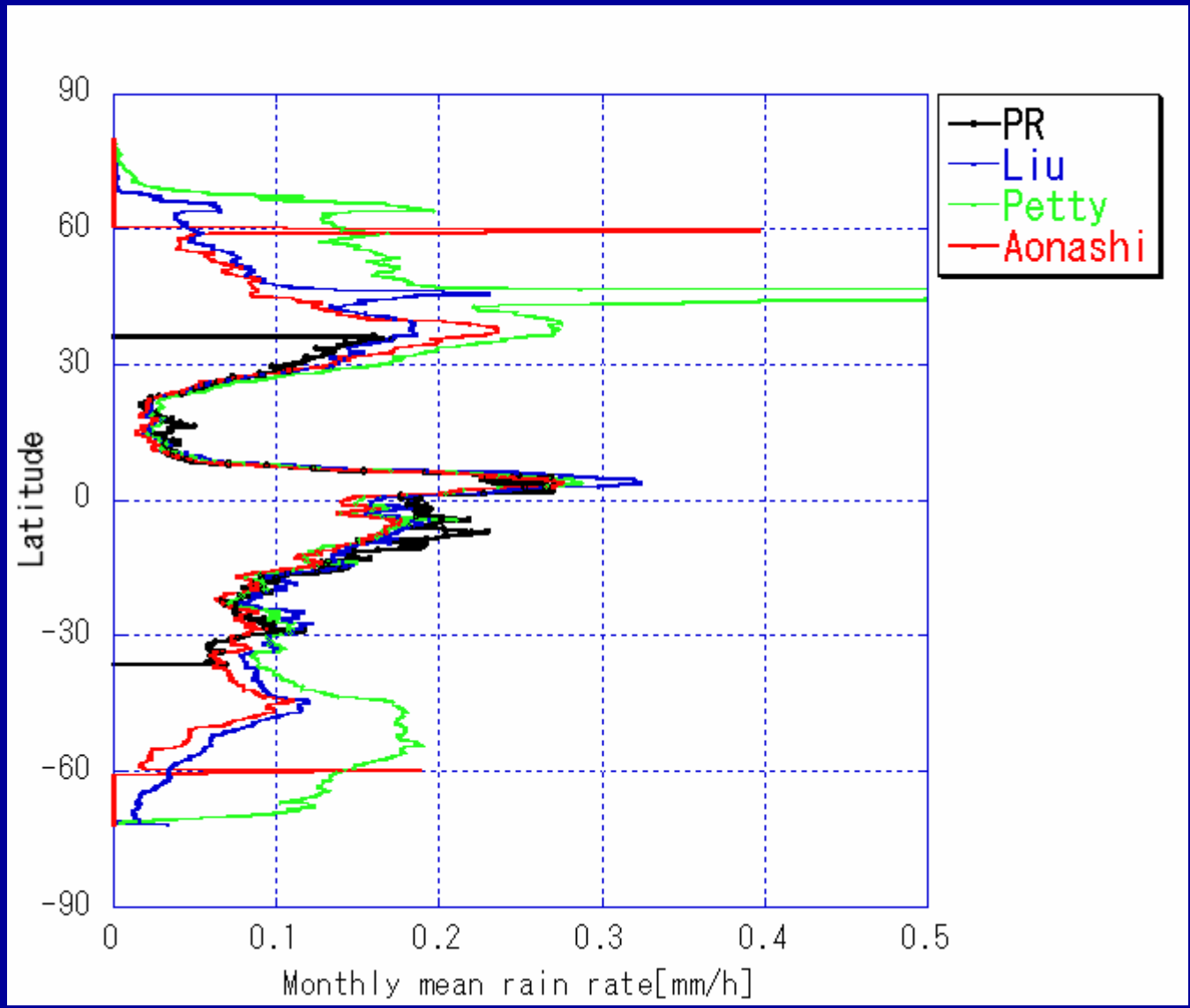
Algorithm Validation Milestones
AMSR-E Version

- Participation in JAXA internal intercomparisons (initial AMSR version)
  - Pronounced low bias in tropical areas
    - Apparent role of 10.65 GHz channels (there is no large bias in SSM/I version!)
  - Apparent high bias in high latitudes
    - Too many pixels classified as precipitating
    - Scattering-based precip rate estimate too high in those pixels.
    - Related to AMSR calibration?

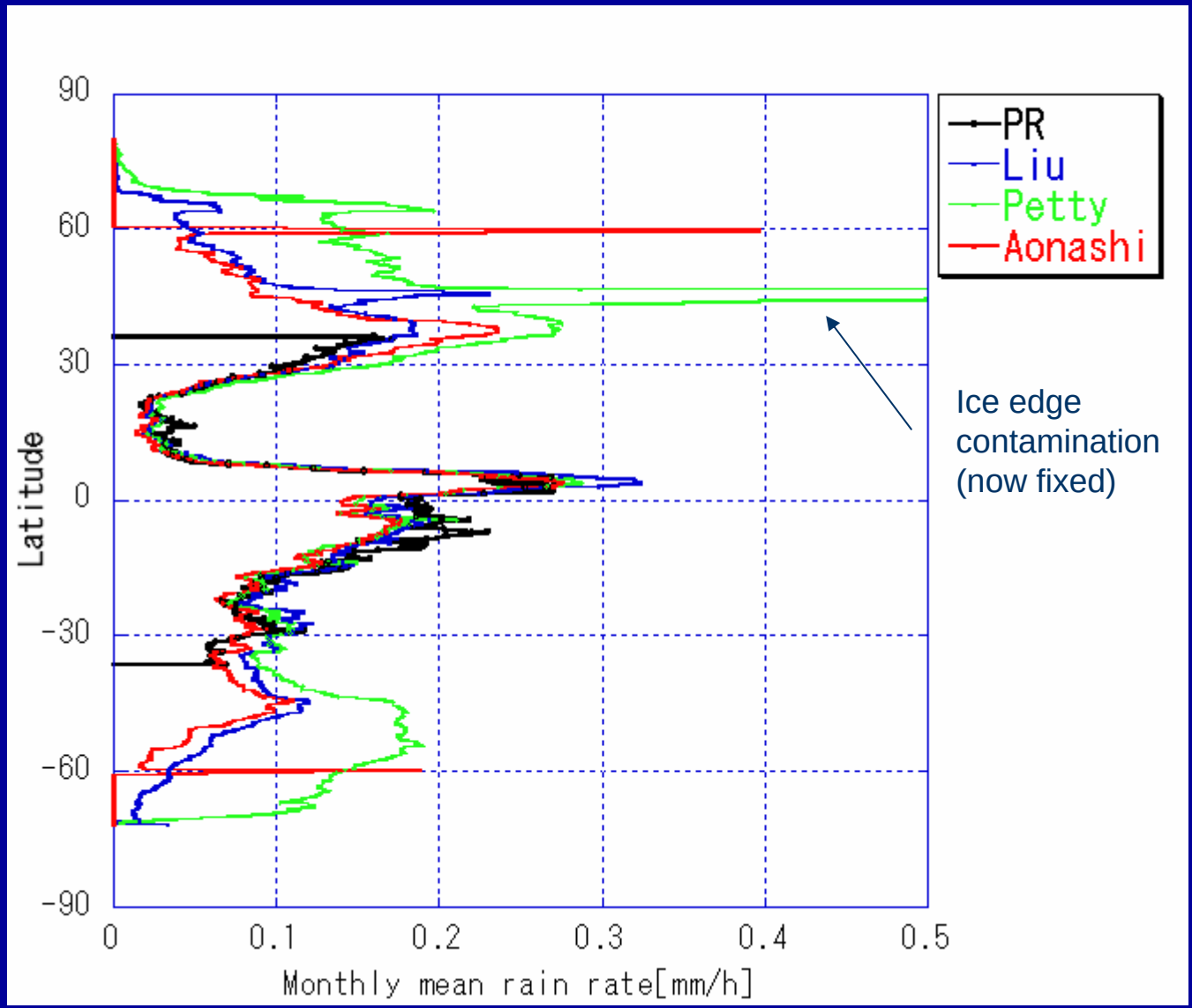
Algorithm Validation Milestones

- *First* major in-house cal/val effort in progress as of Fall 2004(student Longtao Wu)
  - Radar-AMSR matchups from JAXA (esp. winter)
  - Precipitation frequency from ship climatology
  - Tropical atoll monthly rainfall
  - PR matchups *NOT* used to validate or adjust algorithm!
- Empirical tuning:
  - increased liquid water thresholds for precip "maybe/no" screen
  - modified first-guess S_{89}-R relationship
  - reduced "effective" rain layer depth (75% of freezing level).

Evaluation of zonal mean : Jan.2003

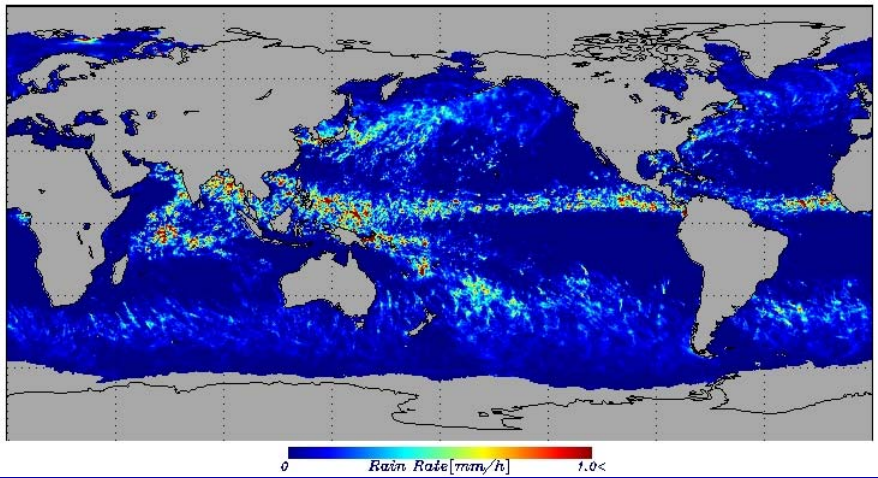


Evaluation of zonal mean : Jan.2003

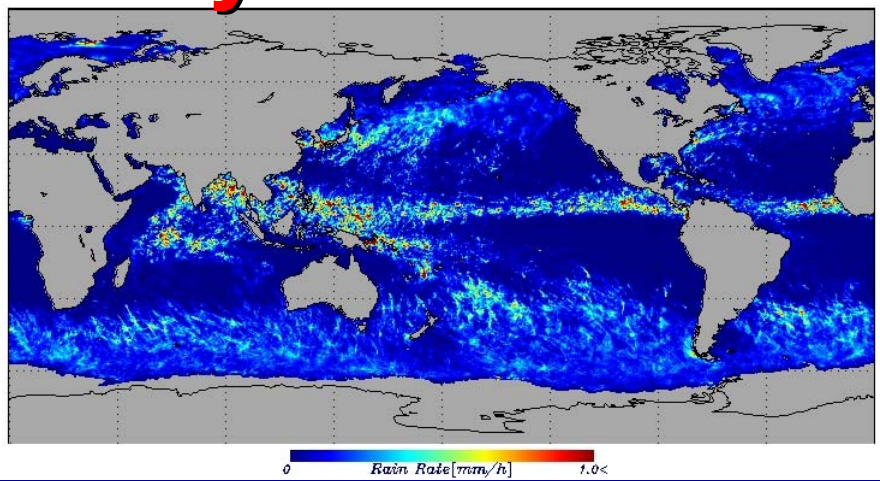


Evaluation of zonal mean : Jul.2003

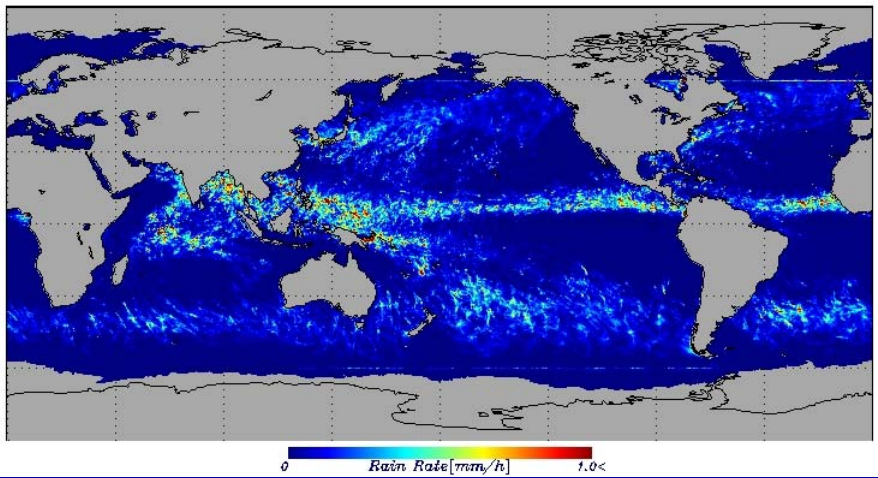
Liu



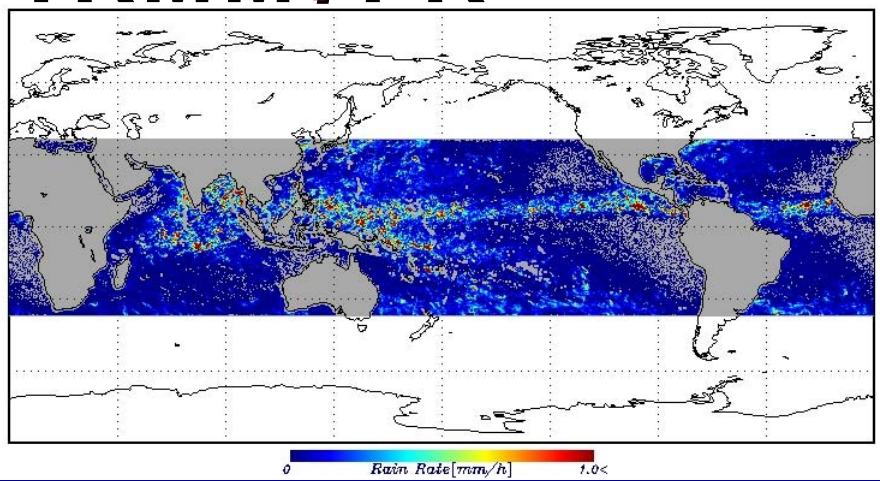
Petty



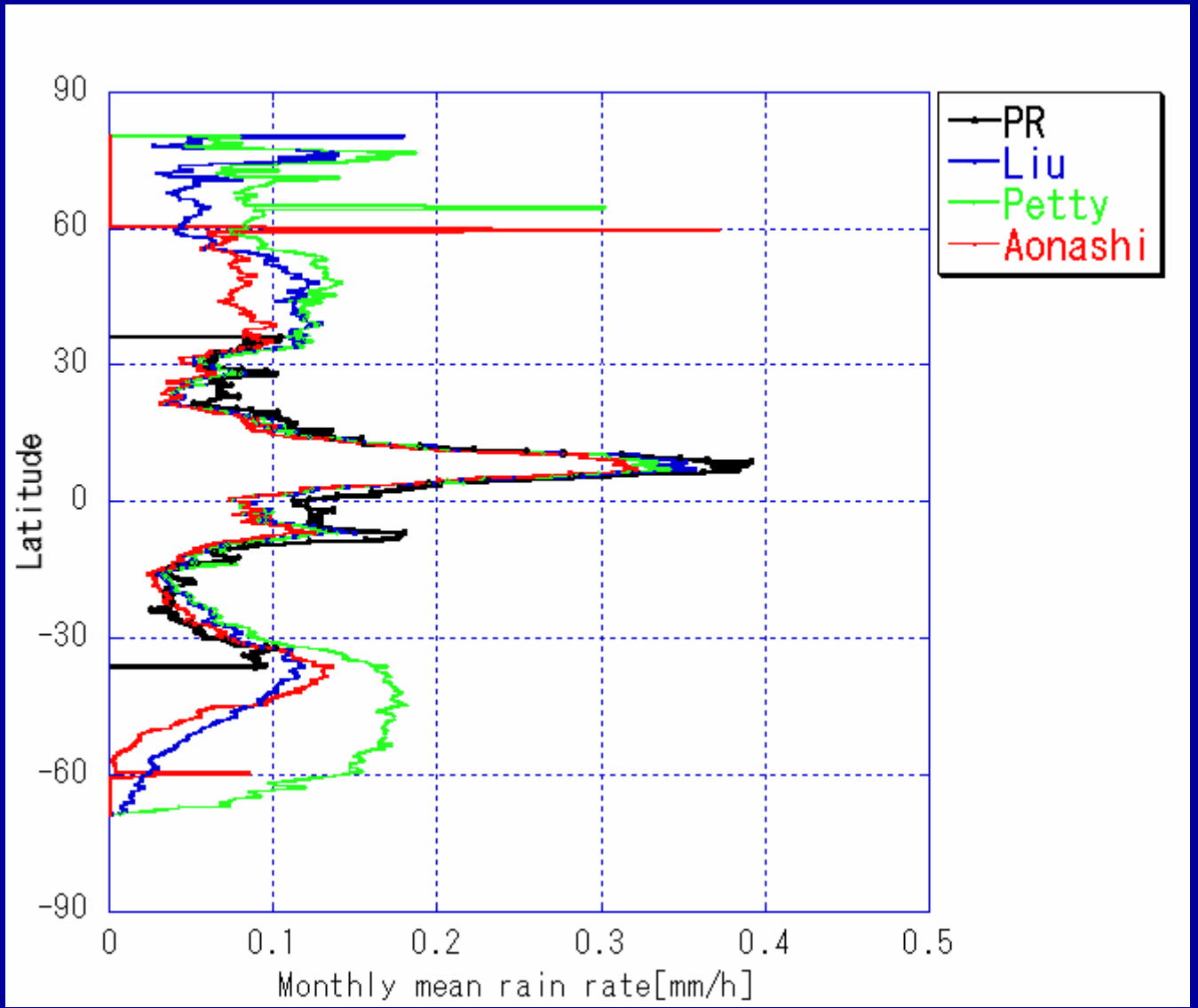
Aonashi



TRMM / PR



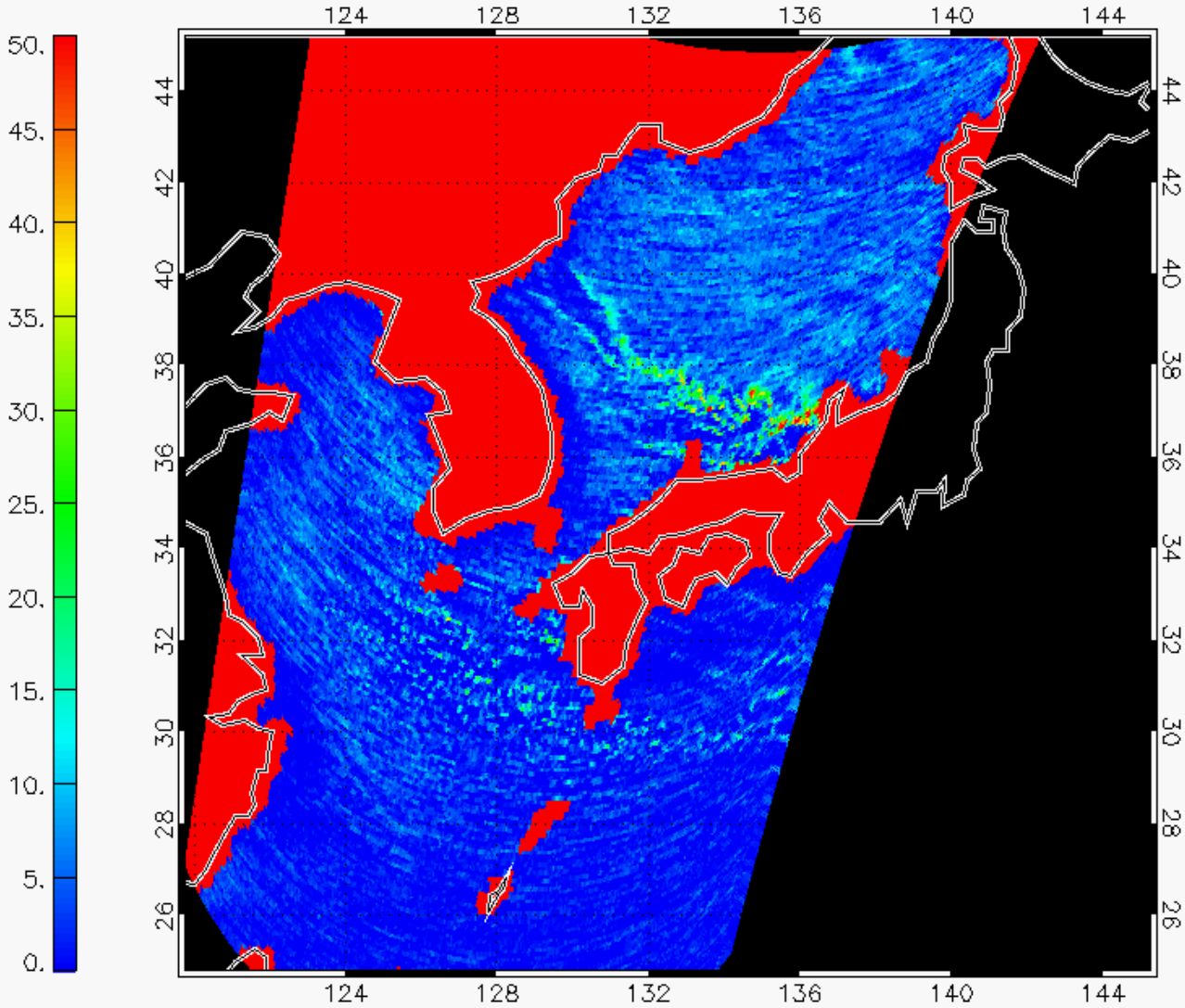
Evaluation of zonal mean : Jul.2003



Interpretation

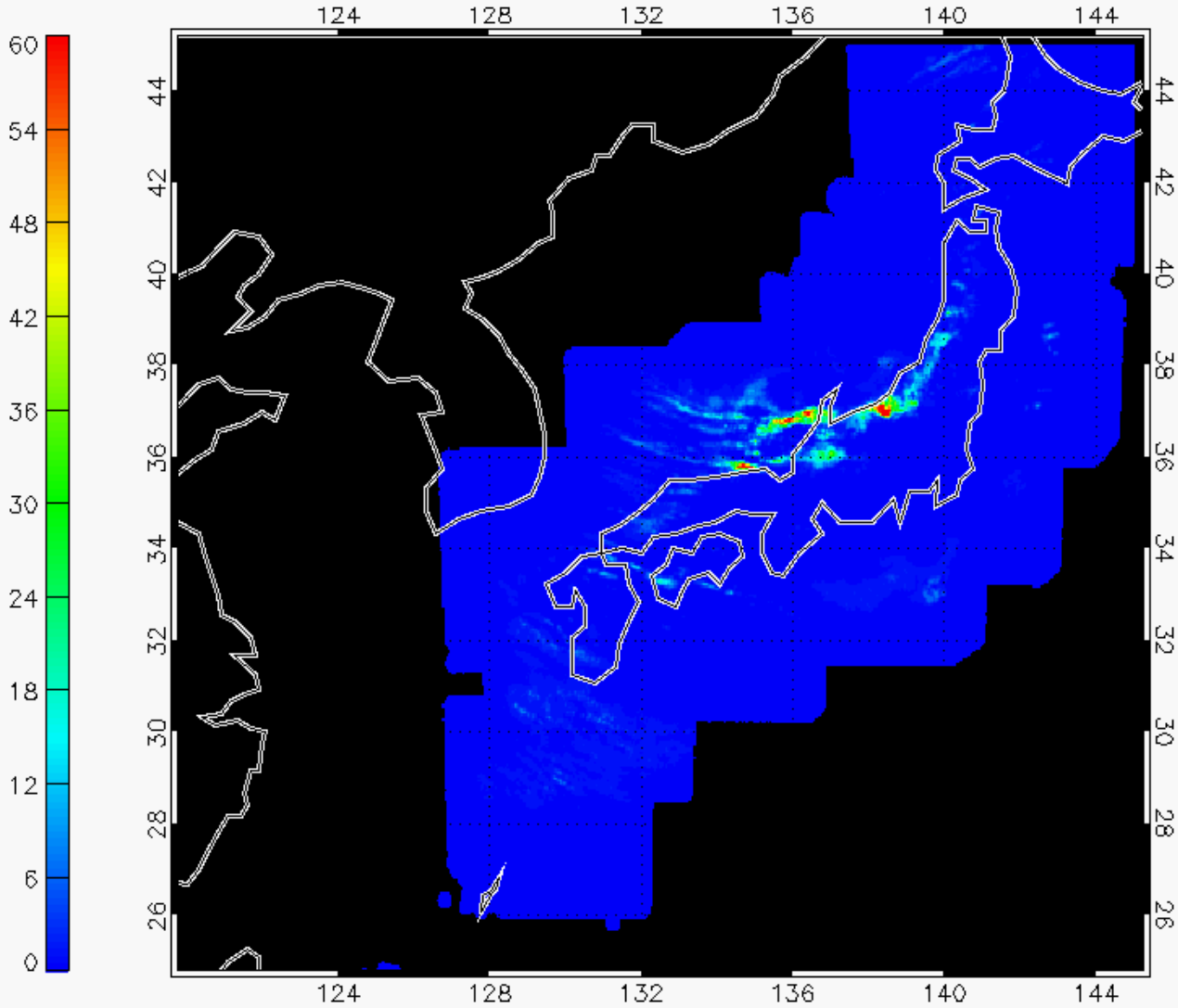
- Differences between all three algorithms are relatively **UNIMPORTANT** in region covered by PR.
  - Differences in apparent bias, RMS difference, etc., are small and *might even be smaller* than uncertainty in PR-derived rain rates.
- But differences are **IMPORTANT** at higher latitudes not covered by PR.
  - Aonashi and Liu algorithms (like many others) are similar in showing dramatic “fading” of precip amounts toward highest latitudes.
  - Petty algorithm yields substantially larger amounts at high latitudes.

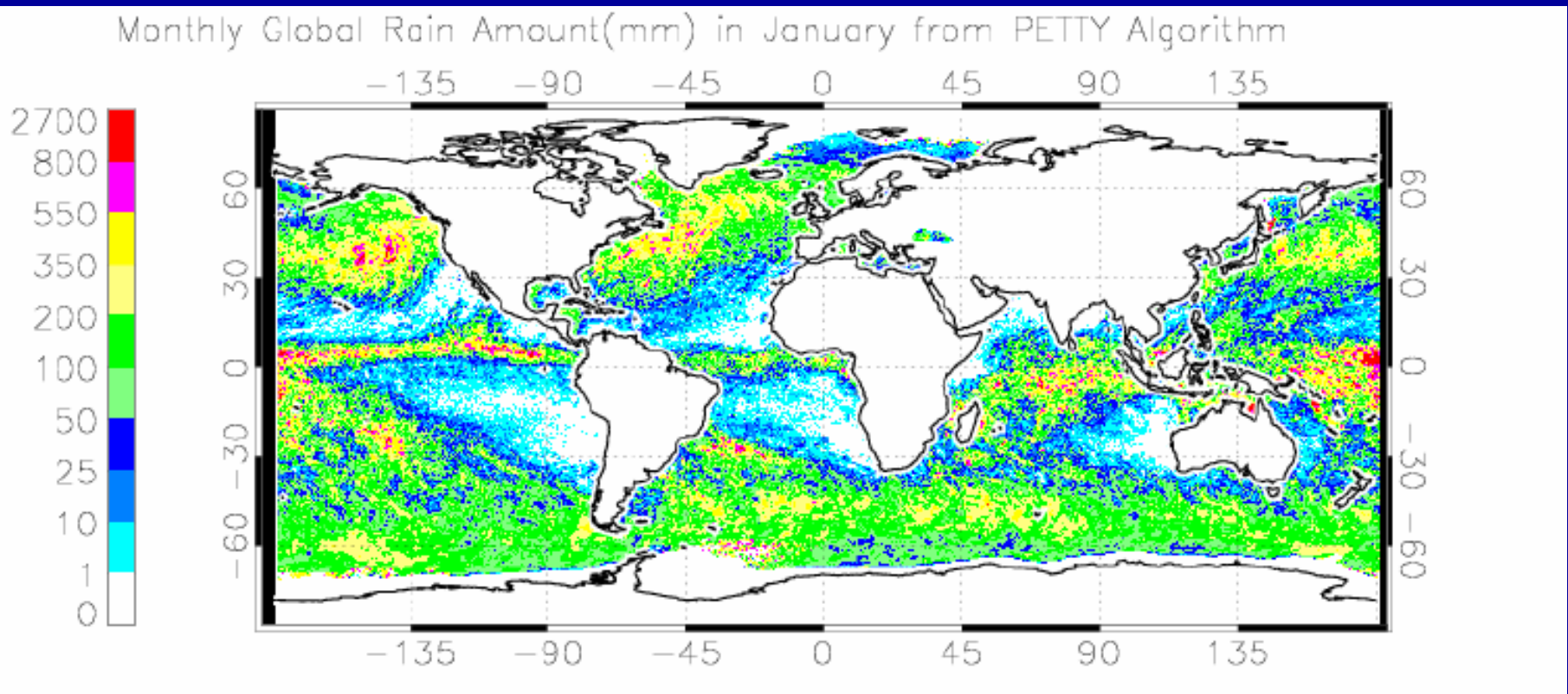
Scattering Index S at 89.0 GHz (K)

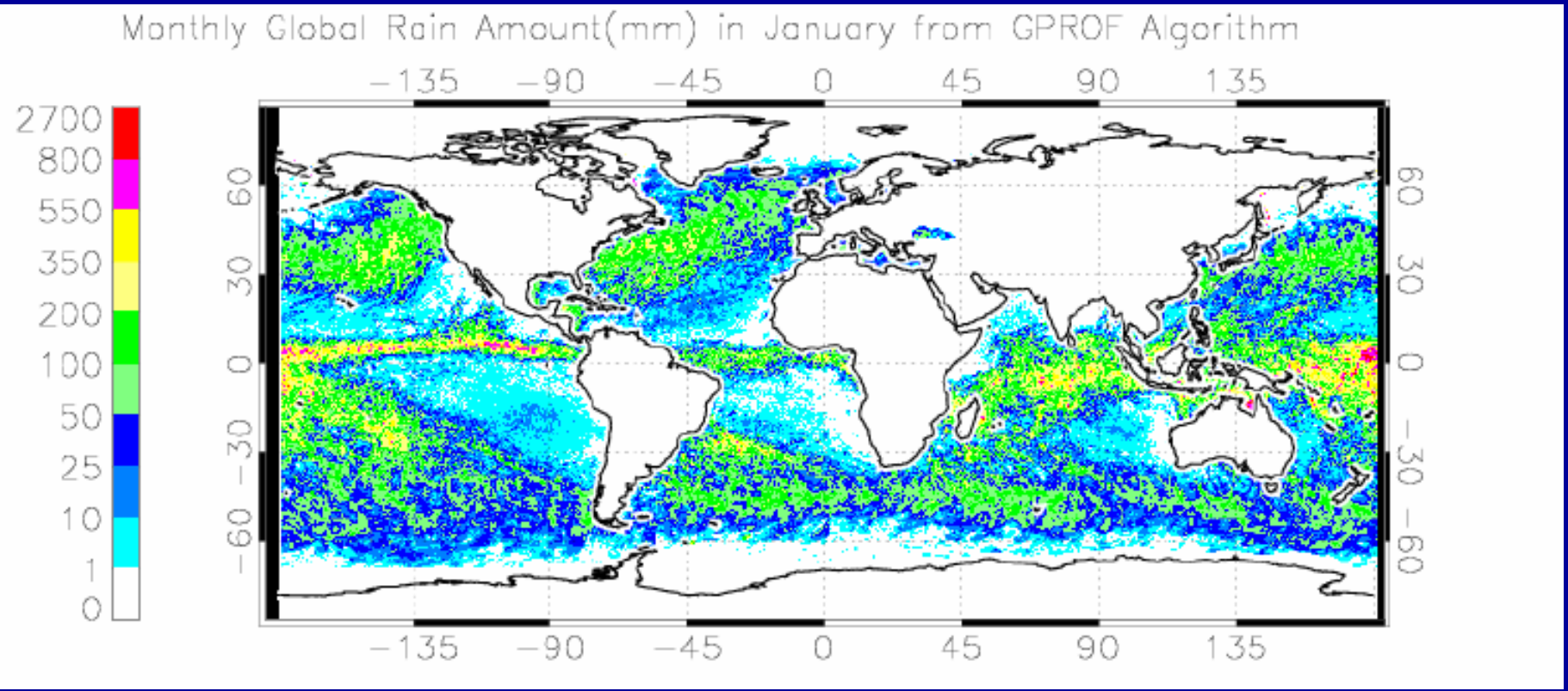


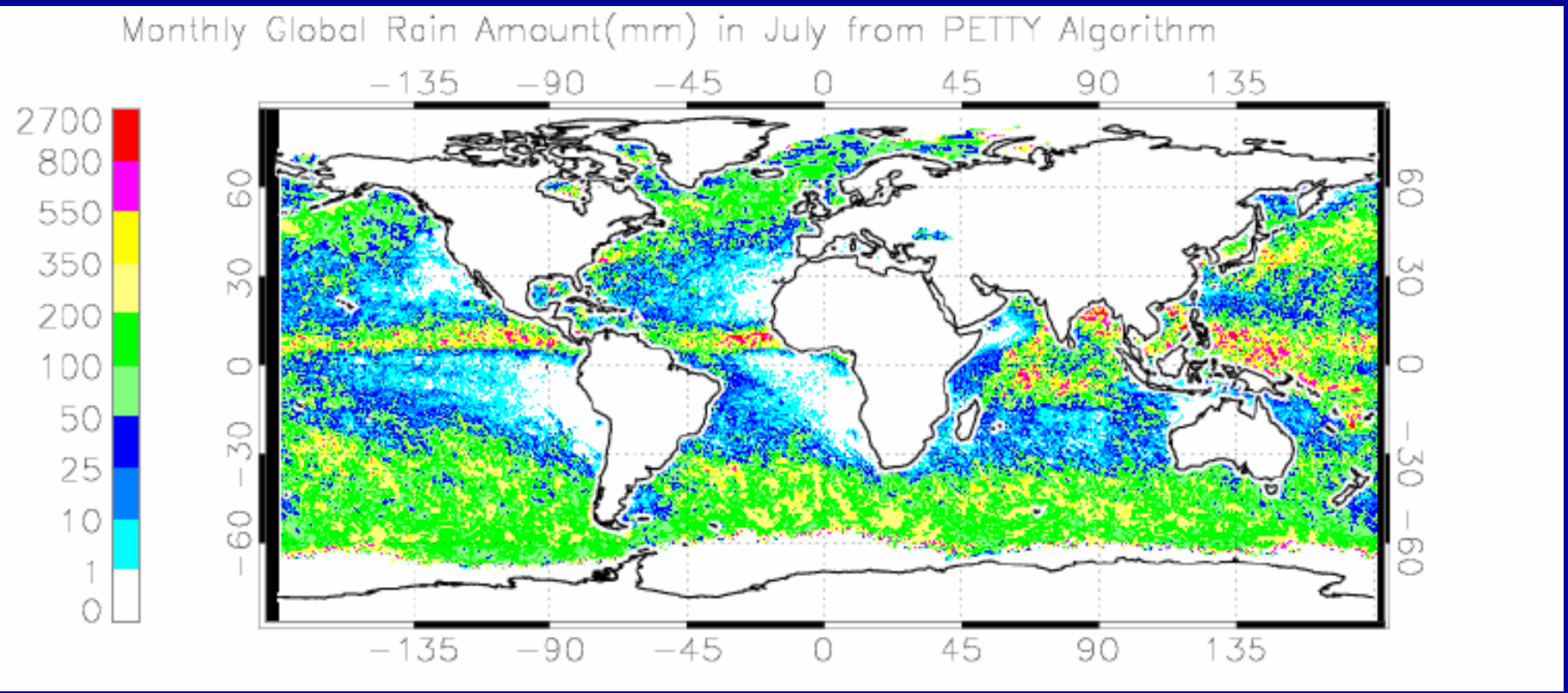
(03/01/04)

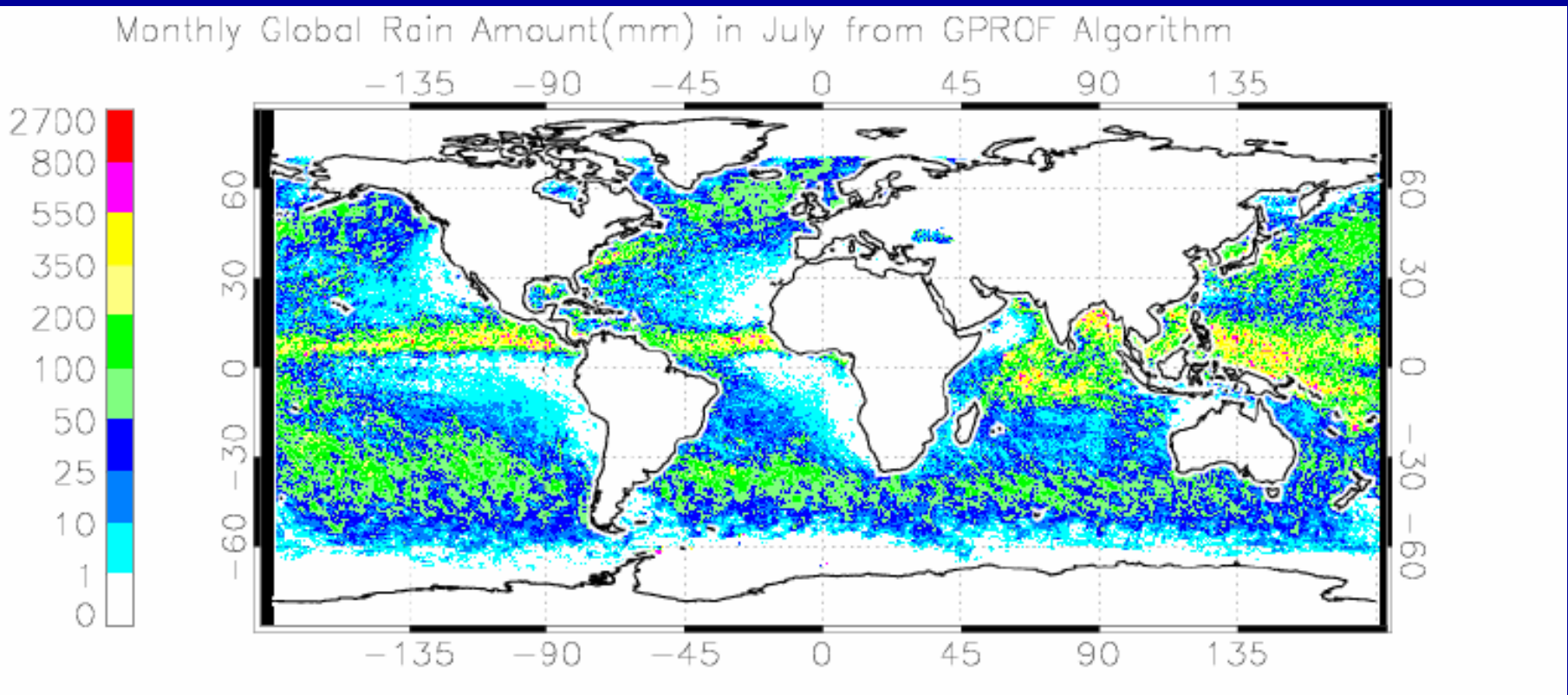
RadarAMeDAS Rain Rate (0.1mm/hr) (2003/01/04)

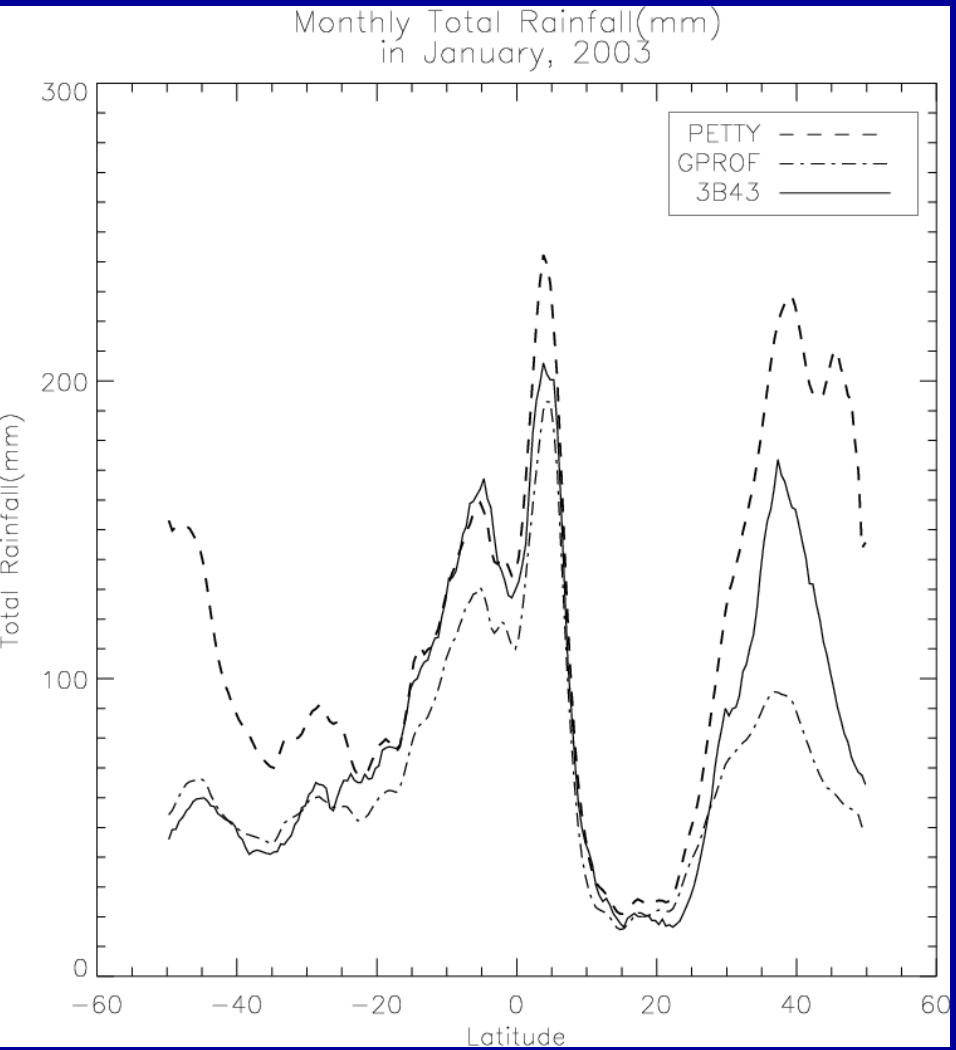


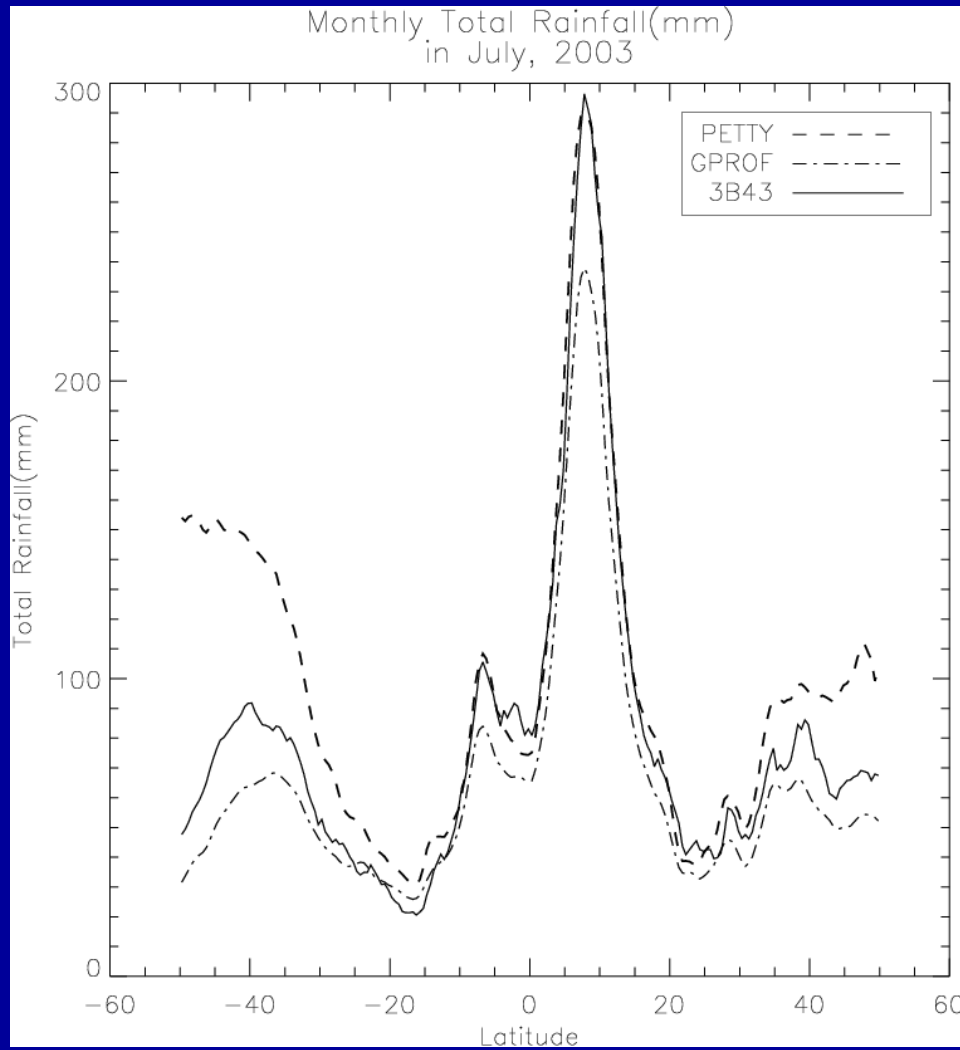

Monthly Global Rain Amount(mm) in January from PETTY Algorithm
2700
800
550
350
200
100
50
25
10
1
0
−135
−90
−45
0
45
90
135
60
30
0
−30
−60


Monthly Global Rain Amount(mm) in January from GPROF Algorithm
2700
800
550
350
200
100
50
25
10
1
0
−135
−90
−45
0
45
90
135
60
30
0
−30
−60


Monthly Global Rain Amount(mm) in July from PETTY Algorithm
2700
800
550
350
200
100
50
25
10
1
0
−135
−90
−45
0
45
90
135
60
30
0
−30
−60


Monthly Global Rain Amount(mm) in July from GPROF Algorithm
2700
800
550
350
200
100
50
25
10
1
0
−135
−90
−45
0
45
90
135
60
30
0
−30
−60


Monthly Total Rainfall(mm)
in January, 2003
PETTY
GPROF
3B43
Total Rainfall(mm)
300
200
100
0
−60
−40
−20
0
20
40
60
Latitude


Monthly Total Rainfall(mm)
in July, 2003
PETTY
GPROF
3B43
Total Rainfall(mm)
300
200
100
0
−60
−40
−20
0
20
40
60
Latitude

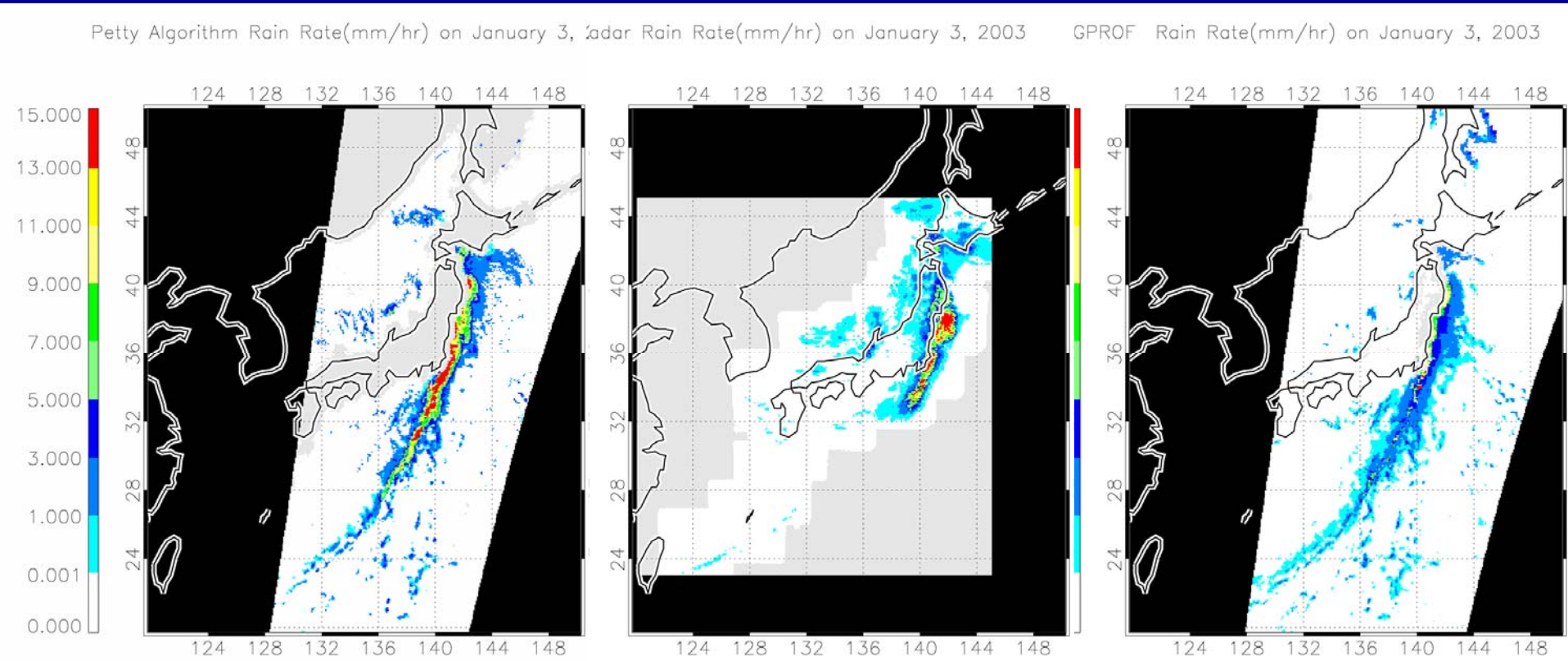
Preliminary Assessment of Monthly Totals

- Results for Petty and GPROF similar at low and middle latitudes (similar to comparison with Liu and Aonashi algorithms).
- Comparisons with tropical atolls (not shown) yield fairly comparable results for Petty and GPROF algorithms
- *Much higher totals at high latitudes for Petty.*
- *KEY POINT: Differences between all algorithms are most important where validation has historically been almost nonexistent!*

High Latitude / Cold Season Precipitation

- Direct comparisons of AMSR-E retrievals with AMeDAS radar, especially during wintertime.
  - *Skill* at delineating very lightest precip rates
  - AMeDAS averages during wintertime fall sharply with distance from radar sites over water, suggesting systematic bias.
- Comparison of fractional time precipitating (FTP) with ship-based climatology (Petty 1995)
- **NEW:** Preliminary evaluation of high latitude monthly precip totals using *island gauges*.
  - No correction yet for possible orographic effects.

Comparisons with Japanese AMeDAS Radar Network

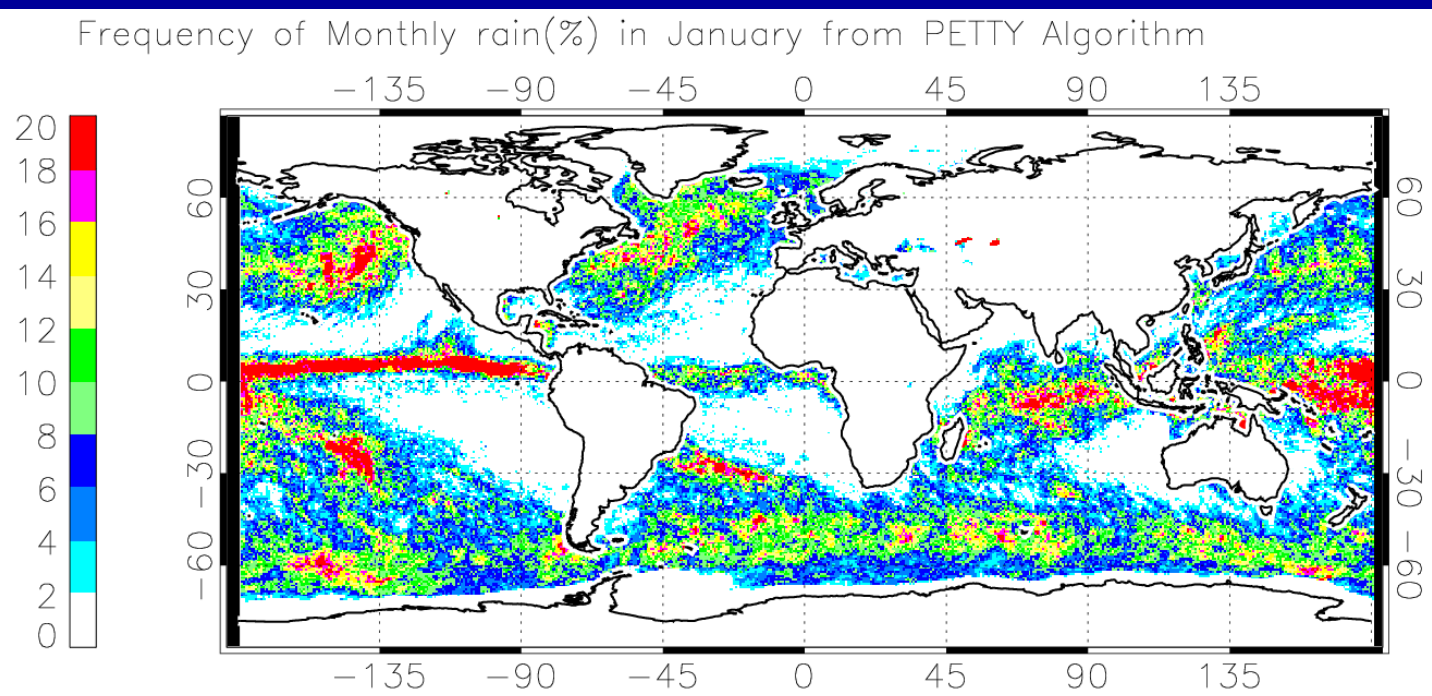


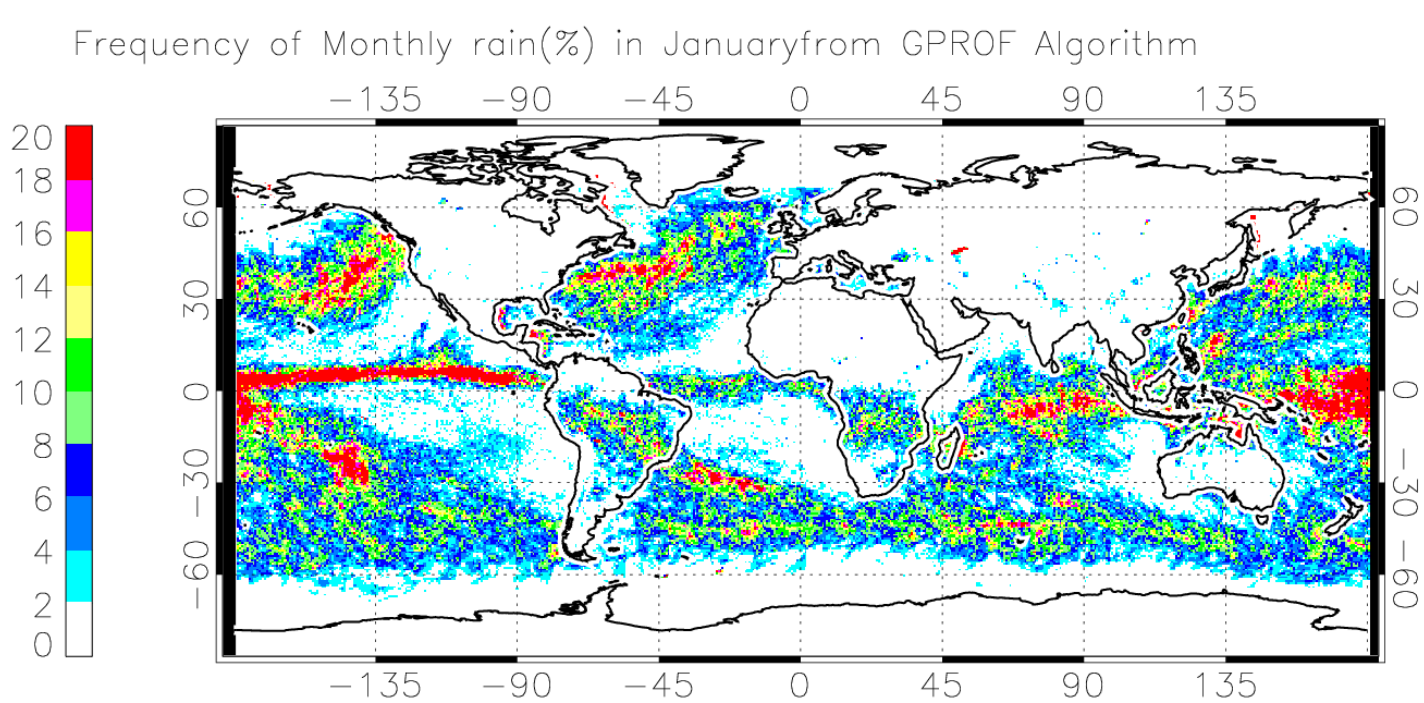
Result #1

- For all of 2003, Petty algorithm demonstrates significantly greater *skill* at delineating AMeDAS radar rain rates of a given intensity, except at very high (rare) rain rates.
- *This result is independent of any calibration bias in either radar or algorithm rain rates.*

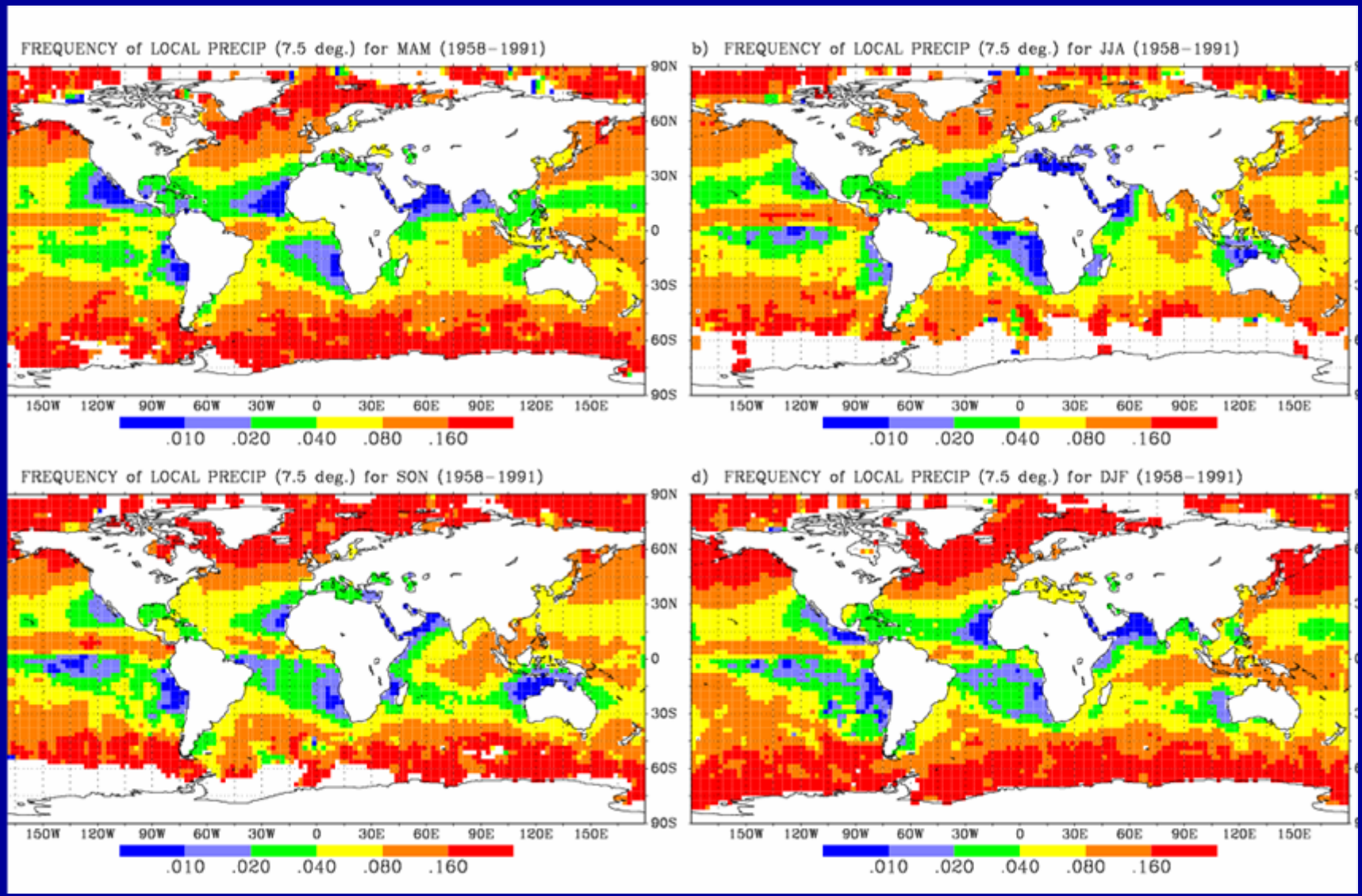
Validation of *Fractional Time Precipitating* (FTP)

- For given month and lat/lon grid box, tabulate fraction of pixels (at native resolution) with R>0 (similar to PIP-3).
- Assess “reasonableness” of results in light of surface ship-based climatology of FTP (Petty, 1995).
- Special focus on high latitudes in light of large disparities between algorithms.


Frequency of Monthly rain(%) in January from PETTY Algorithm
20
18
16
14
12
10
8
6
4
2
0
−135
−90
−45
0
45
90
135
60
30
0
−30
−60


Frequency of Monthly rain(%) in Januaryfrom GPROF Algorithm
20
18
16
14
12
10
8
6
4
2
0
−135
−90
−45
0
45
90
135
60
30
0
−30
−60

Ship-based climatology (Petty 1995)

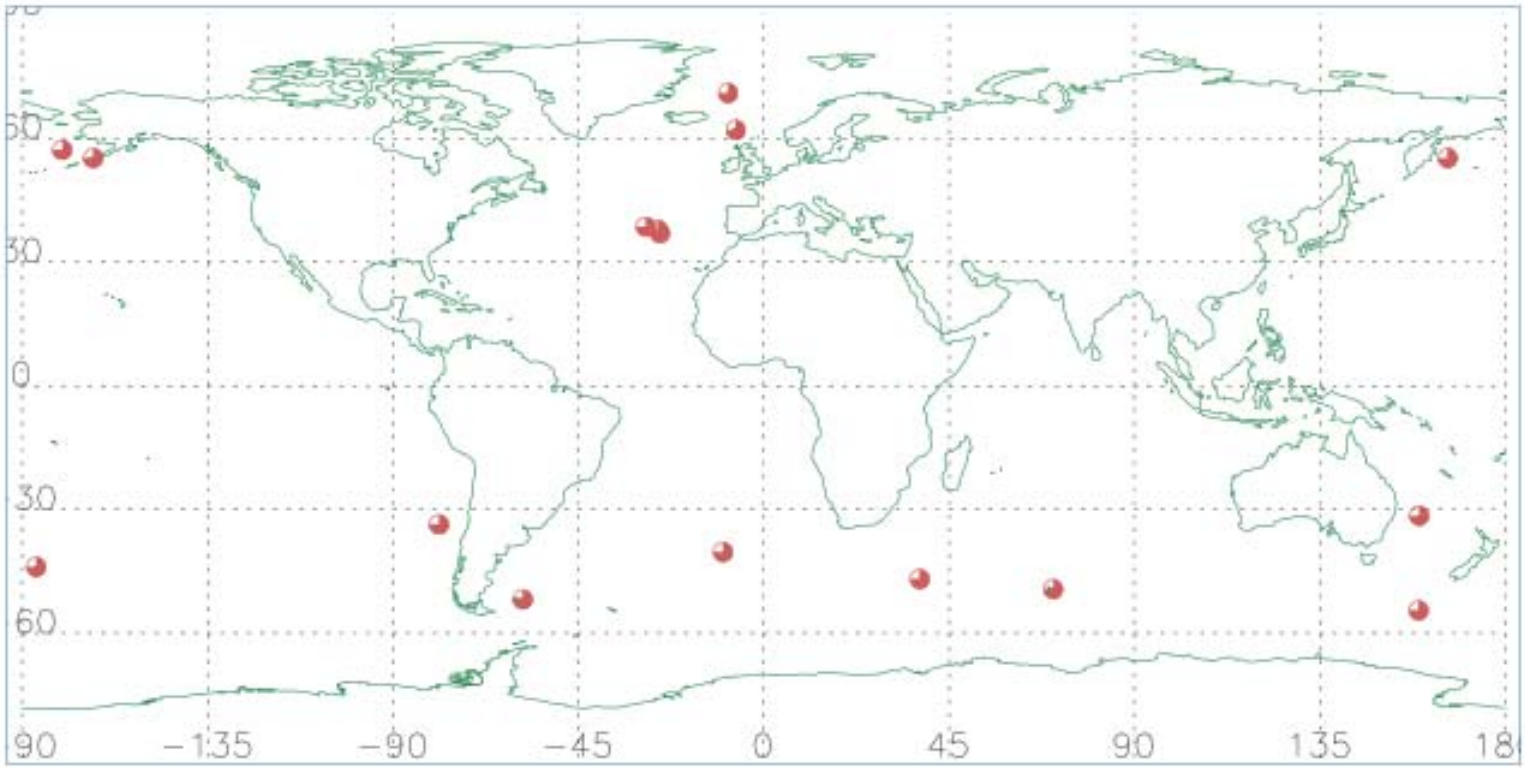


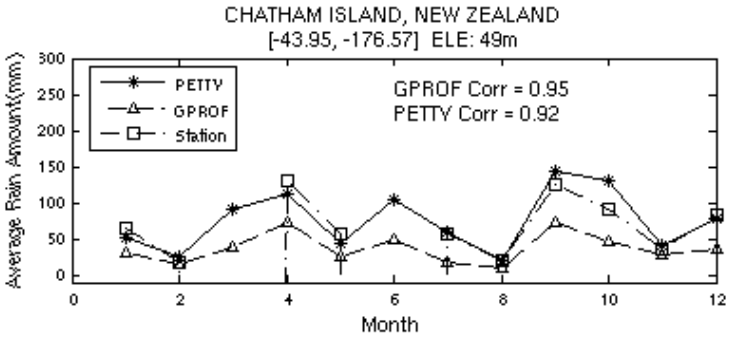
Result #2

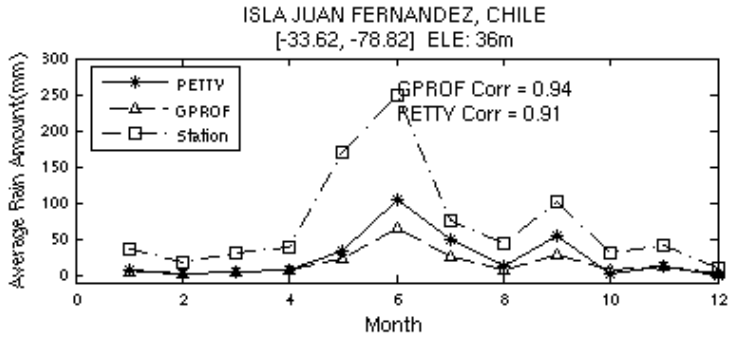
- UW-Madison FTP results are very similar to GPROF in low- to mid-latitudes.
- Substantially higher FTP for Petty poleward of extratropical storm tracks, relative to GPROF.
- High FTP at high latitudes is broadly consistent with ship-based climatology.

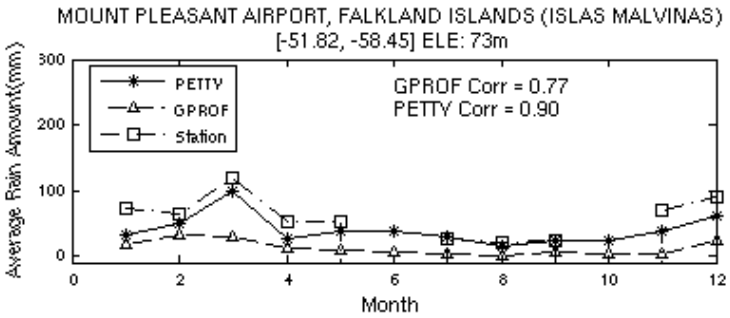
Mid- and High-Latitude Islands

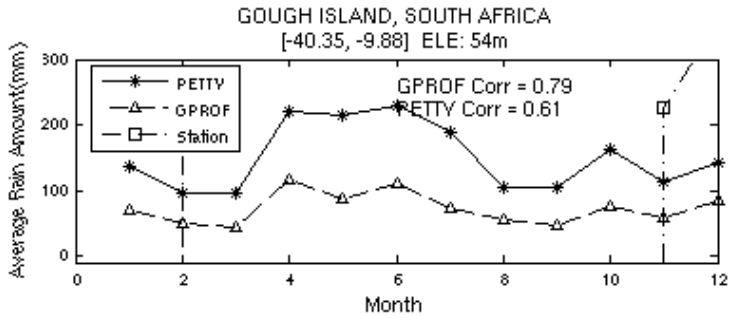
WMO ID	STATION NAME	COUNTRY	LAT	LON	ELE(m)
93987	CHATHAM ISLAND	NEW ZEALAND	-43.95	-176.57	49
85585	ISLA JUAN FERNANDEZ	CHILE	-33.62	-78.82	30
88889	MOUNT PLEASANT AIRPT	FALKLAND ISL.	-51.82	-58.45	73
68906	GOUGH ISLAND	SOUTH AFRICA	-40.35	-9.88	54
68994	MARION ISLAND	SOUTH AFRICA	-46.88	37.87	21
61998	PORT-AUX-FRANCE	FRANCE	-49.35	70.25	30
94998	MACQUARIE ISLAND	AUSTRALIA	-54.48	158.93	6
94995	LORD HOWE ISLAND	AUSTRALIA	-31.53	159.07	6
70308	ST PAUL ISLAND	UNITED STATES	57.17	-170.22	6.7
70316	COLD BAY	UNITED STATES	55.2	-162.72	29.3
8506	HORTA(ACORES)	PORTUGAL	38.52	-28.63	62
8515	SANTA MARIA (ACORES)	PORTUGAL	36.97	-25.17	100
8513	PONTA DELGADA	PORTUGAL	37.75	-25.67	36
6011	THORSHAVN	DENMARK	62.02	-6.77	55
1001	JAN MAYEN	NORWAY	70.93	-8.67	9
32618	NIKOL'SKOE	RUSSIA	55.2	165.98	18

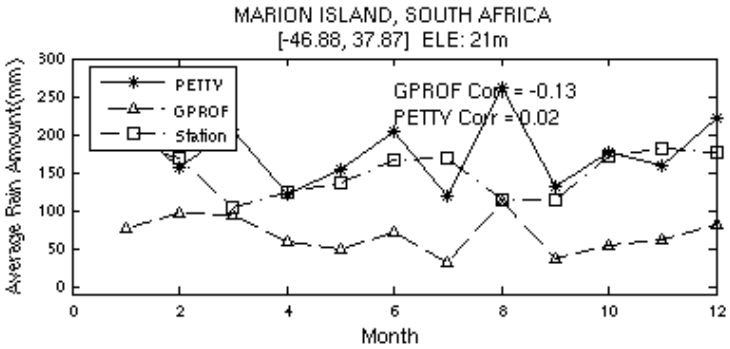

60
30
0
30
60
90
−135
−90
−45
0
45
90
135
18

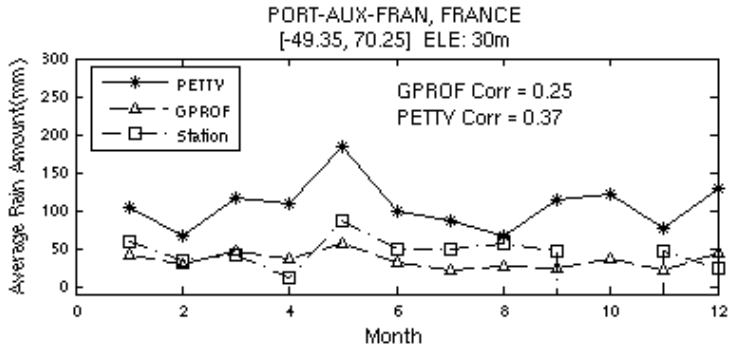

CHATHAM ISLAND, NEW ZEALAND
[-43.95, -176.57] ELE: 49m
PETTY
GPROF
Station
GPROF Corr = 0.95
PETTY Corr = 0.92
Average Rain Amount(mm)
Month

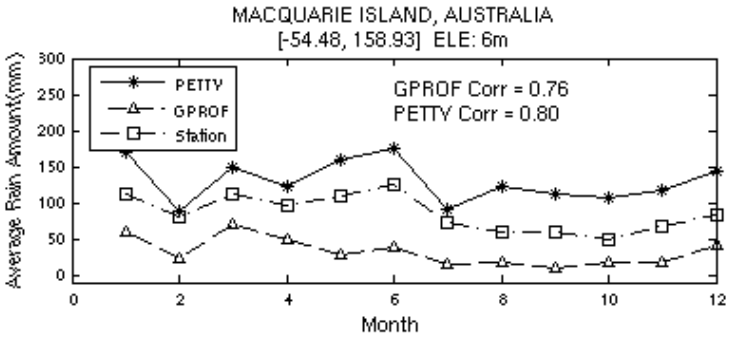

ISLA JUAN FERNANDEZ, CHILE
[-33.62, -78.82] ELE: 36m
PETTY
GPROF
Station
GPROF Corr = 0.94
PETTY Corr = 0.91
Average Rain Amount(mm)
Month

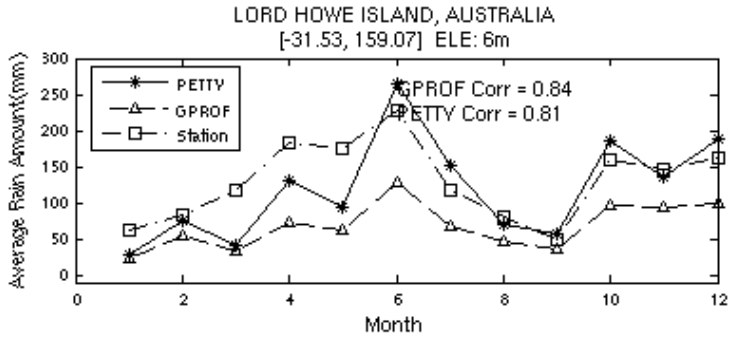

MOUNT PLEASANT AIRPORT, FALKLAND ISLANDS (ISLAS MALVINAS)
[-51.82, -58.45] ELE: 73m
PETTY
GPROF
Station
GPROF Corr = 0.77
PETTY Corr = 0.90
Average Rain Amount(mm)
Month

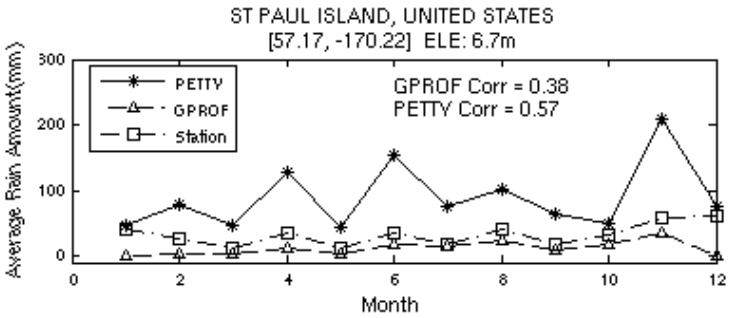

GOUGH ISLAND, SOUTH AFRICA
[-40.35, -9.88] ELE: 54m
PETTY
GPROF
Station
GPROF Corr = 0.79
PETTY Corr = 0.61
Average Rain Amount(mm)
Month

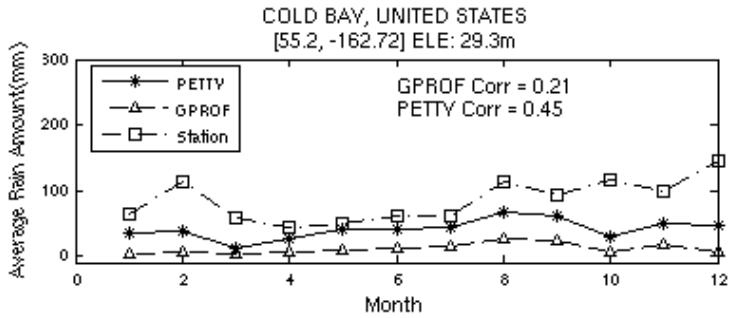

MARION ISLAND, SOUTH AFRICA
[-46.88, 37.87] ELE: 21m
PETTY
GPROF
Station
GPROF Corr = -0.13
PETTY Corr = 0.02
Average Rain Amount(mm)
Month

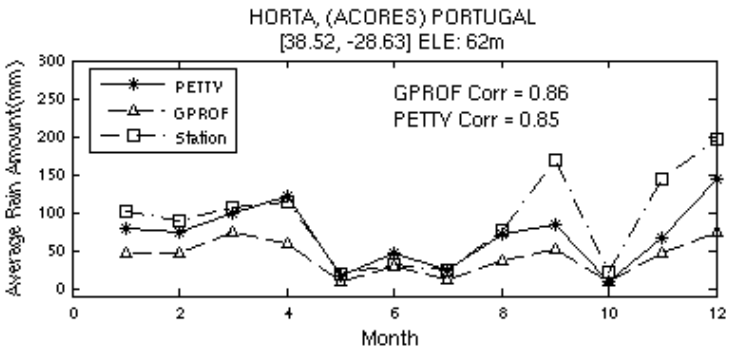

PORT-AUX-FRAN, FRANCE
[-49.35, 70.25] ELE: 30m
PETTY
GPROF
Station
GPROF Corr = 0.25
PETTY Corr = 0.37
Average Rain Amount(mm)
Month

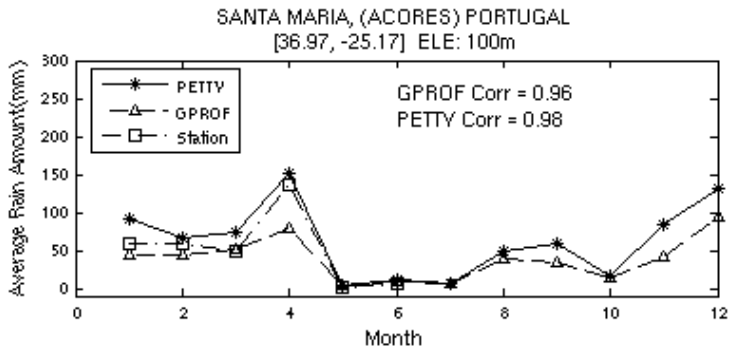

MACQUARIE ISLAND, AUSTRALIA
[-54.48, 158.93] ELE: 6m
PETTY
GPROF
Station
GPROF Corr = 0.76
PETTY Corr = 0.80
Average Rain Amount(mm)
Month

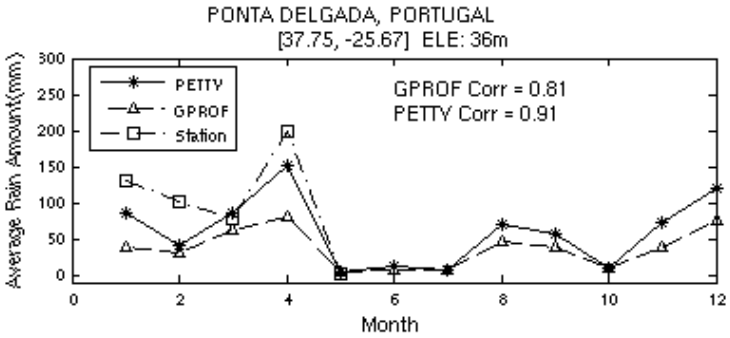

LORD HOWE ISLAND, AUSTRALIA
[-31.53, 159.07] ELE: 6m
PETTY
GPROF
Station
GPROF Corr = 0.84
PETTY Corr = 0.81
Average Rain Amount(mm)
Month

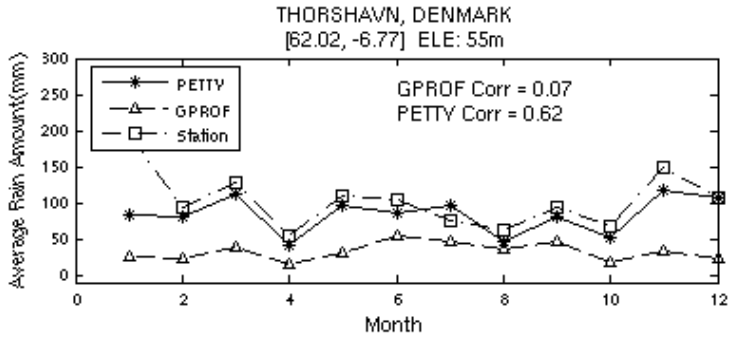

ST PAUL ISLAND, UNITED STATES
[57.17, -170.22] ELE: 6.7m
PETTY
GPROF
Station
GPROF Corr = 0.38
PETTY Corr = 0.57
Average Rain Amount(mm)
Month

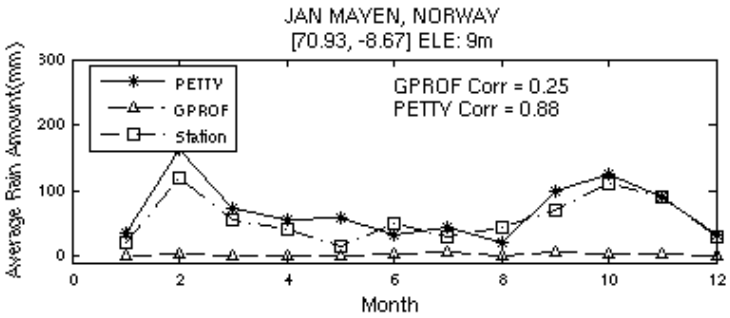

COLD BAY, UNITED STATES
[55.2, -162.72] ELE: 29.3m
PETTY
GPROF
Station
GPROF Corr = 0.21
PETTY Corr = 0.45
Average Rain Amount(mm)
Month

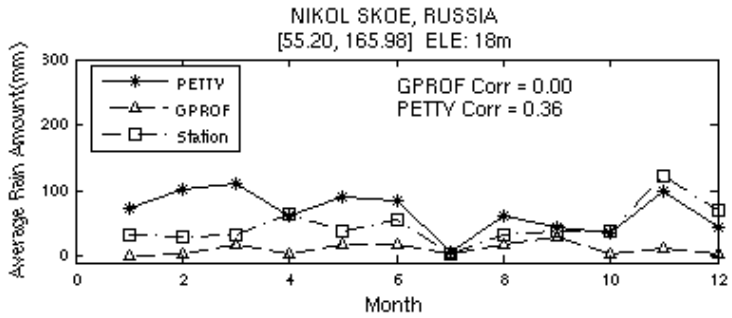

HORTA, (ACORES) PORTUGAL
[38.52, -28.63] ELE: 62m
PETTY
GPROF
Station
GPROF Corr = 0.86
PETTY Corr = 0.85
Average Rain Amount(mm)
Month


SANTA MARIA, (ACORES) PORTUGAL
[36.97, -25.17] ELE: 100m
PETTY
GPROF
Station
GPROF Corr = 0.96
PETTY Corr = 0.98
Average Rain Amount(mm)
Month


PONTA DELGADA, PORTUGAL
[37.75, -25.67] ELE: 36m
PETTY
GPROF
Station
GPROF Corr = 0.81
PETTY Corr = 0.91
Average Rain Amount(mm)
Month

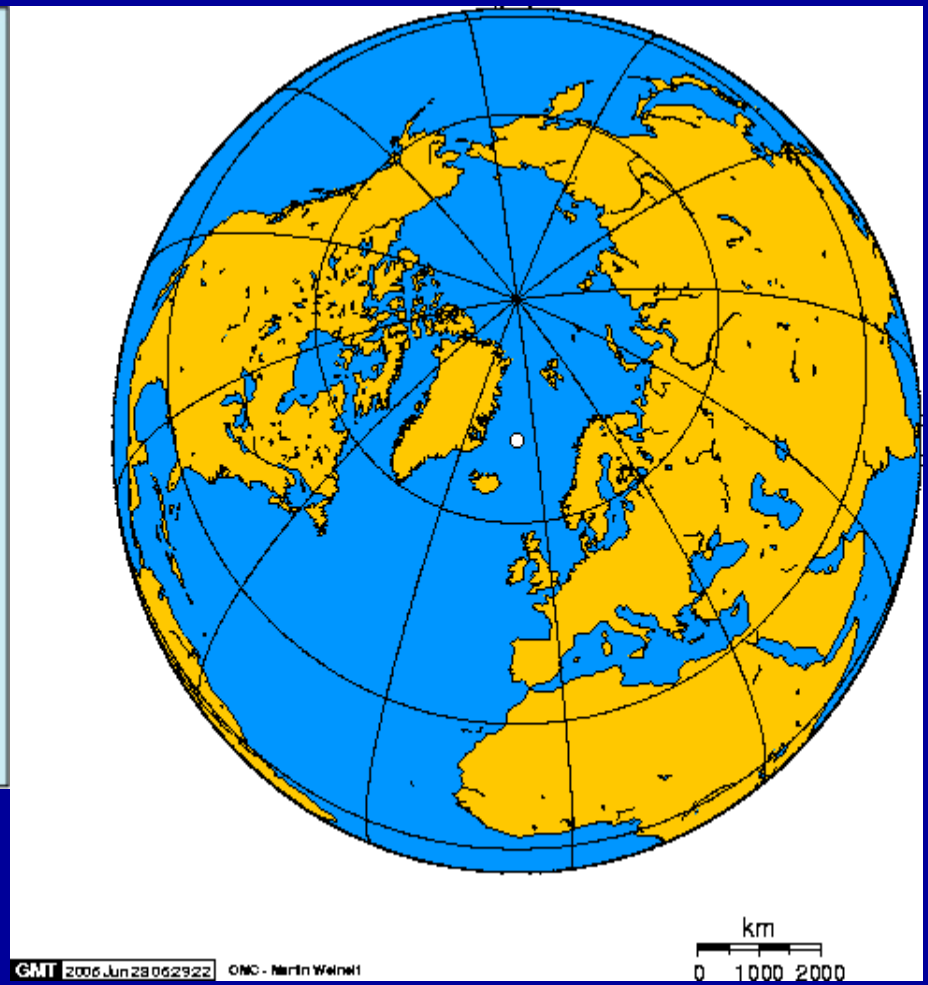

THORSHAVN, DENMARK
[62.02, -6.77] ELE: 55m
PETTY
GPROF
Station
GPROF Corr = 0.07
PETTY Corr = 0.62
Average Rain Amount(mm)
Month


JAN MAYEN, NORWAY
[70.93, -8.67] ELE: 9m
PETTY
GPROF
Station
GPROF Corr = 0.25
PETTY Corr = 0.88
Average Rain Amount(mm)
Month


NIKOL SKOE, RUSSIA
[55.20, 165.98] ELE: 18m
PETTY
GPROF
Station
GPROF Corr = 0.00
PETTY Corr = 0.36
Average Rain Amount(mm)
Month

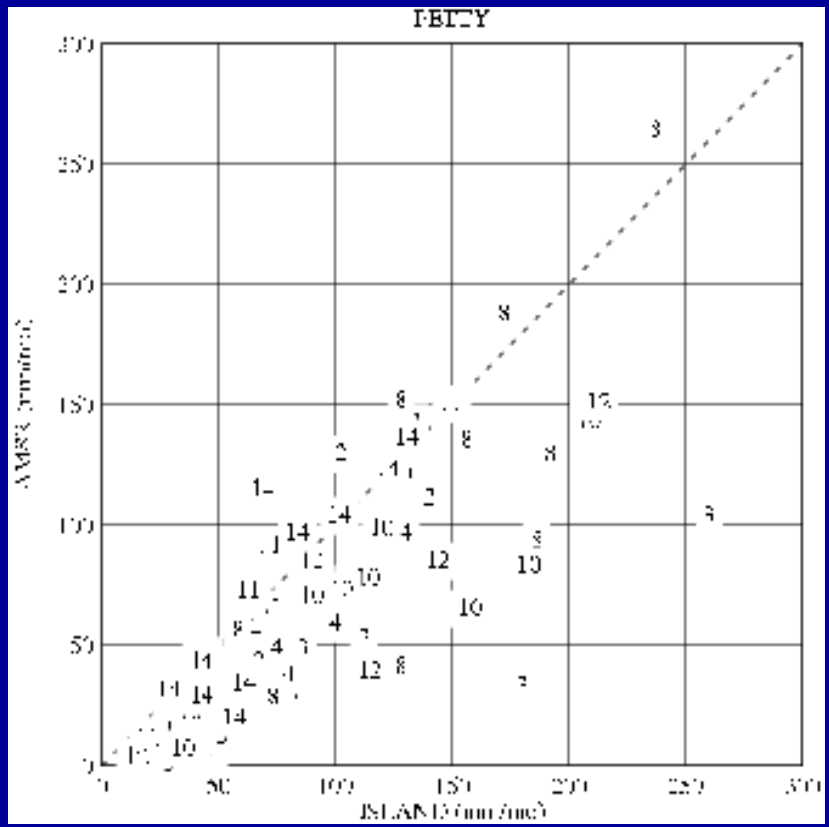
	CORR. COEFF.			RATIO	
	PETTY	GPROF	N	PETTY	GPROF
Marion Island	0.02	-0.13	12	1.17	0.45
St. Paul Island, AK	0.60	0.38	12	2.81	0.36
Chatham Island	0.92	0.95	10	1.04	0.53
Isla Juan Fernandez	0.91	0.94	12	0.34	0.22
Mt. Pleasant Airport (Falkland	0.90	0.77	10	0.69	0.22
Gough Island	0.61	0.79	4	0.52	0.28
Port-Aux-France	0.37	0.25	11	2.29	0.75
Macquarie Island	0.80	0.76	12	1.51	0.38
Lord Howe Island	0.81	0.84	12	0.91	0.52
Cold Bay, AK	0.49	0.21	12	0.48	0.12
Horta (Azores)	0.85	0.86	12	0.76	0.45
Santa Maria (Azores)	0.98	0.96	6	1.26	0.73
Ponta Delgada (Azores)	0.91	0.81	5	0.72	0.42
Thorshavn	0.62	0.07	12	0.80	0.31
Jan Mayen	0.88	0.25	12	1.20	0.04
Nikolskoe	0.44	0.00	12	1.38	0.21

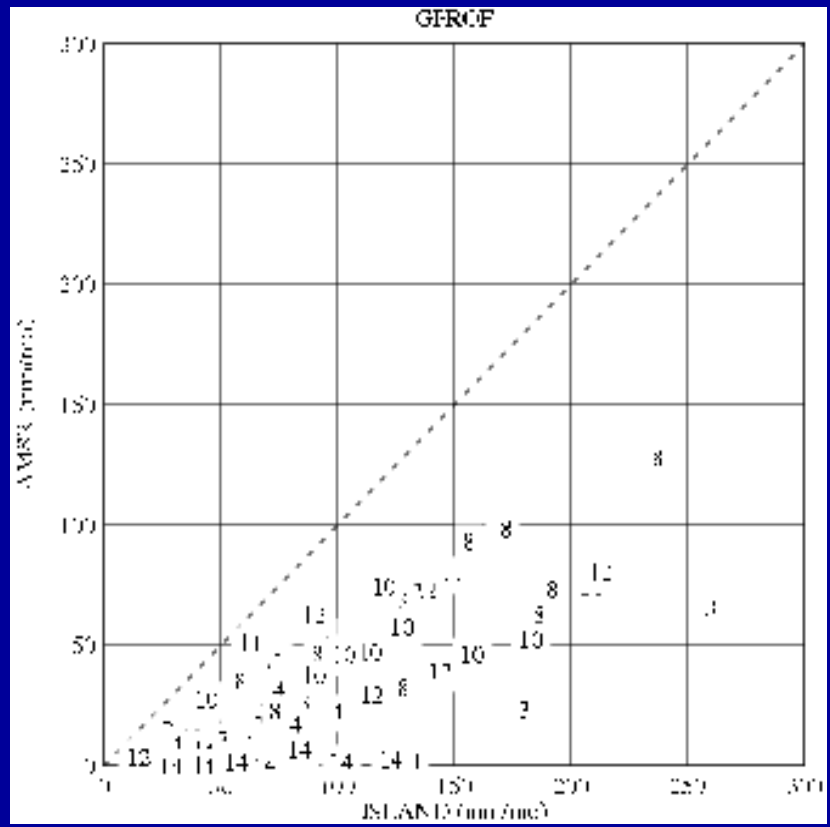
Jan Mayen (Norway)



Jan Mayen

Limit comparison to islands for which AT LEAST one of the two algorithms has correlation > 0.8 with island (eliminates islands wth severe orographic influences).
Overall correlation identical (0.76) for both algorithms!
PETTY ratio: 0.83 GPROF ratio: 0.39





Conclusions

- Middle and high latitude island stations exist that appear to have excellent potential for directly validating open-ocean precip amounts.
- Considerable work will be required in order to determine whether biases are present and, if so, whether they are correctable.

Future Work

- Use high-resolution cloud model simulations to evaluate mean orographic enhancement factor and variability on each island.
- Conduct site visits to assess placement and quality of operational gauges.
- Place logging rain gauges at strategic locations on key islands to evaluate topographically induced variability.
- Identify island stations that prove capable of providing unbiased estimates of open-ocean precip (possibly after empirical corrections).