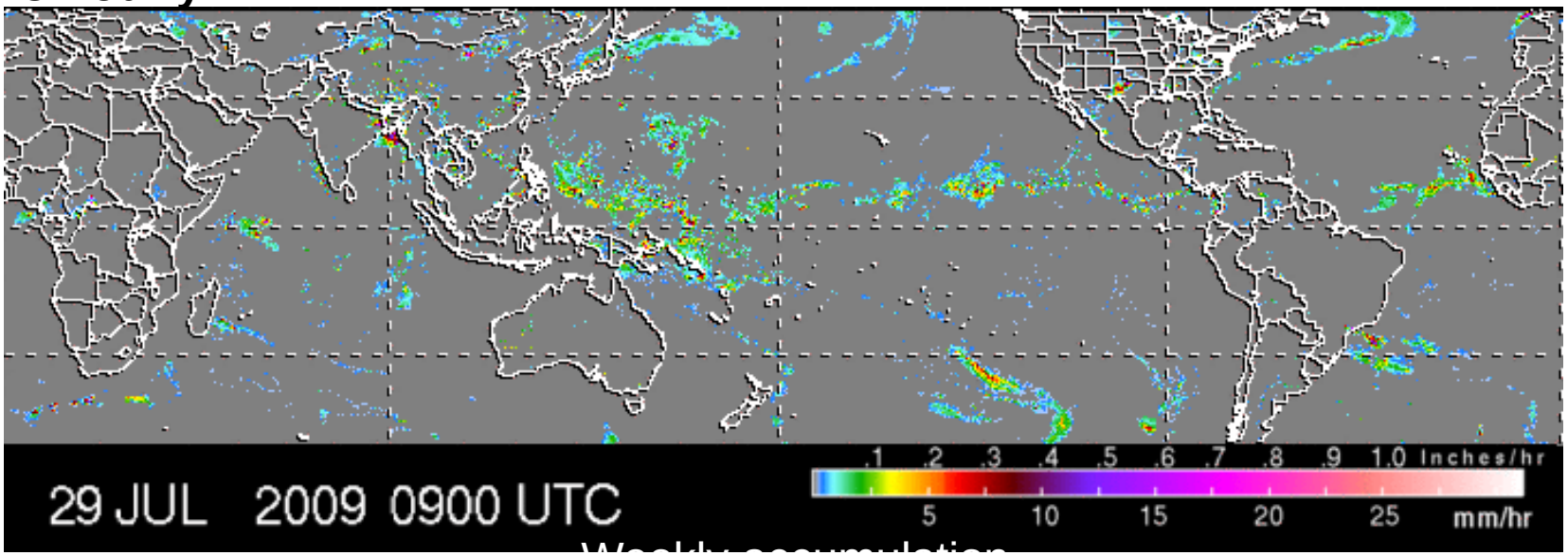
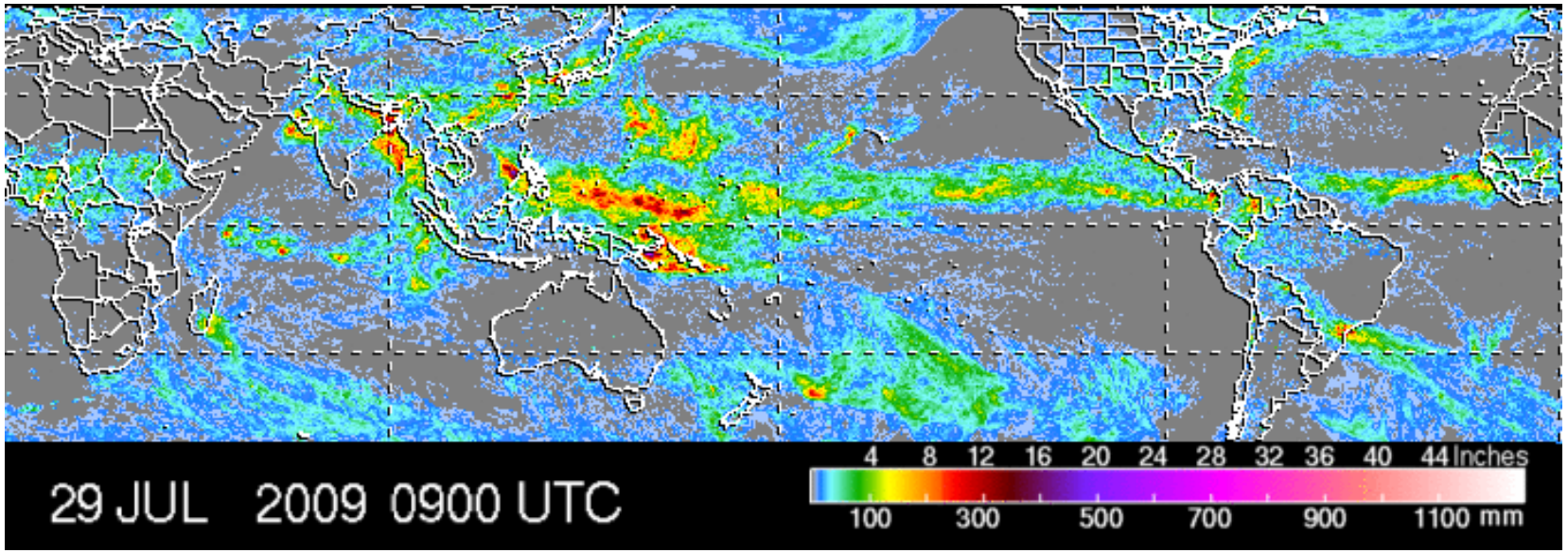
Rhythms of Rain

A Snapshot of Tropical Rain

3-hourly

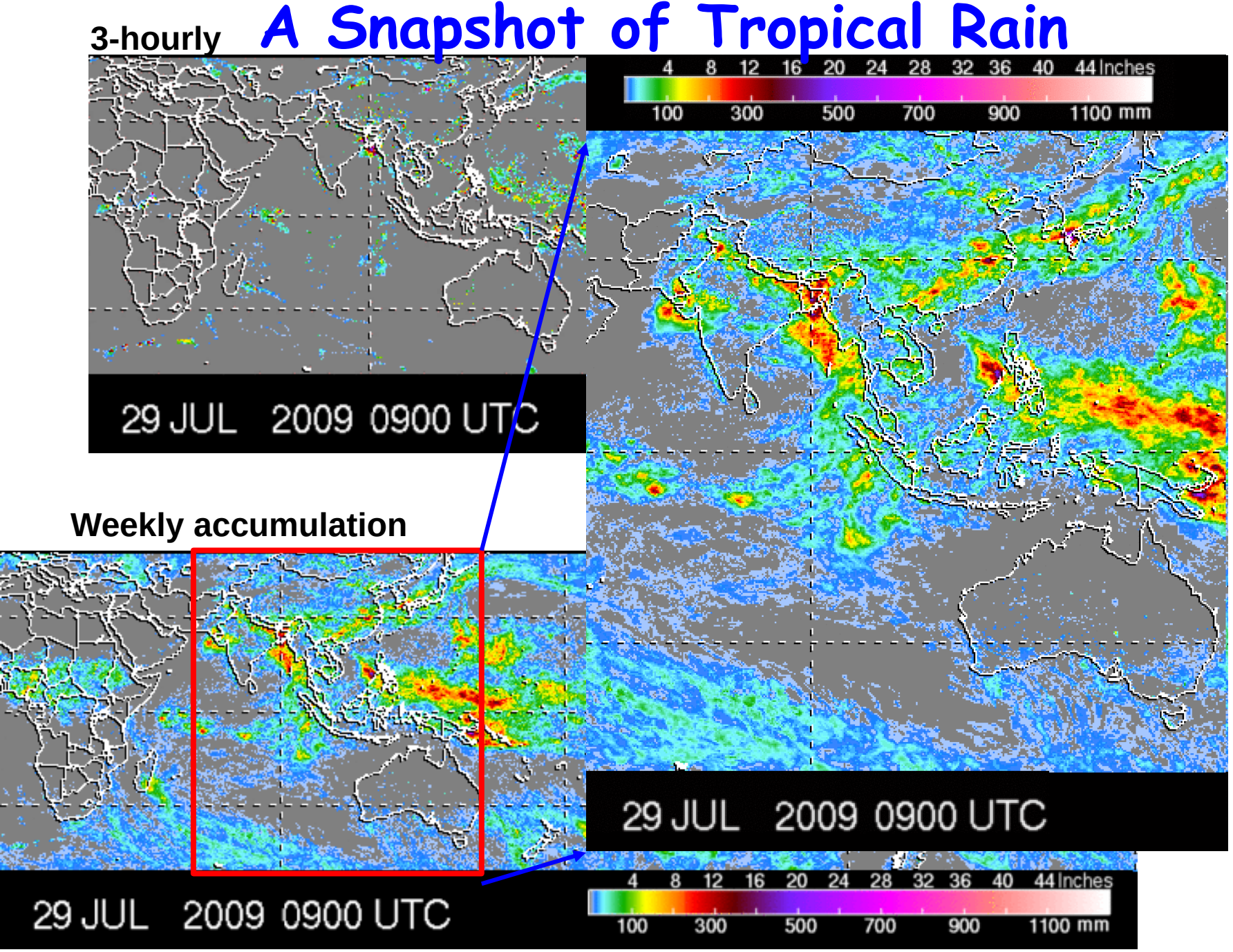


Weekly accumulation



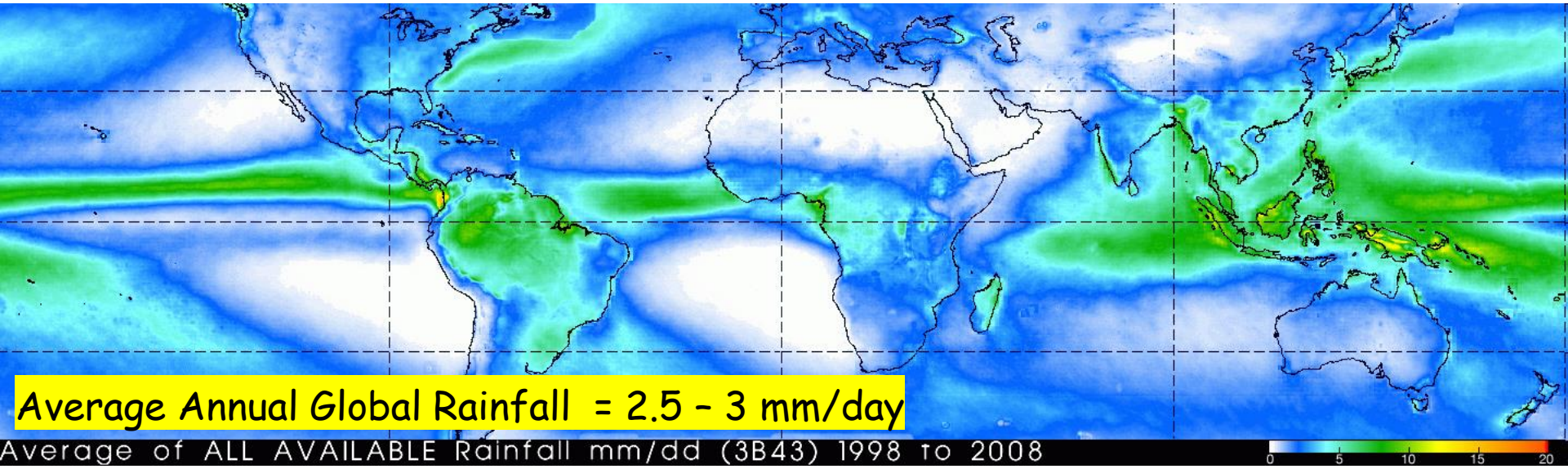
http://trmm.gsfc.nasa.gov

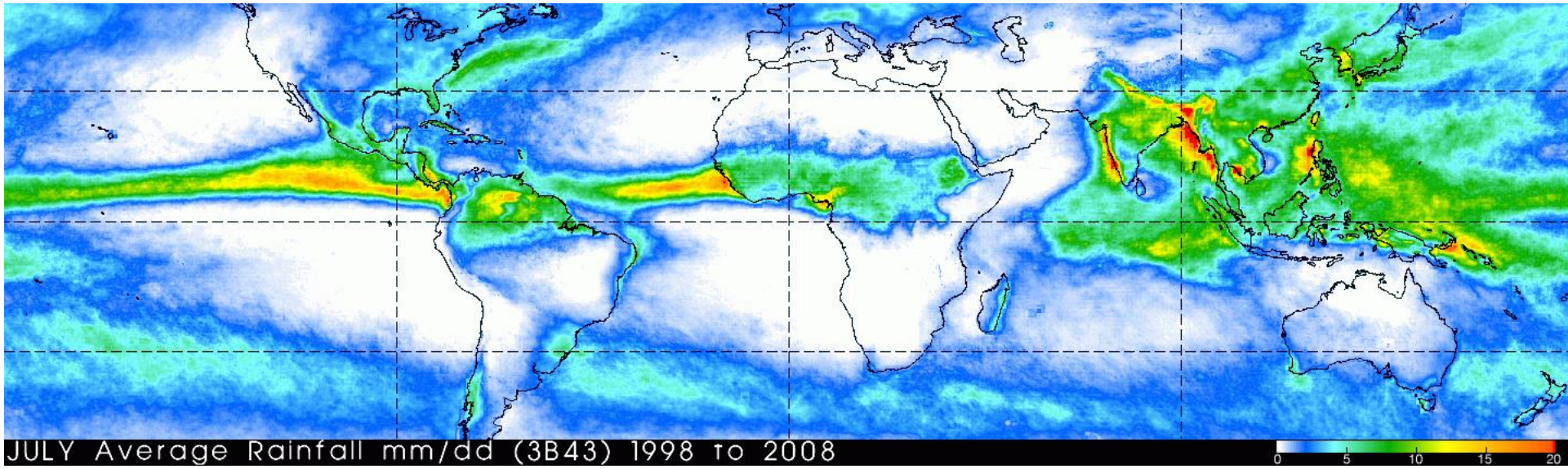
A Snapshot of Tropical Rain



http://trmm.gsfc.nasa.gov

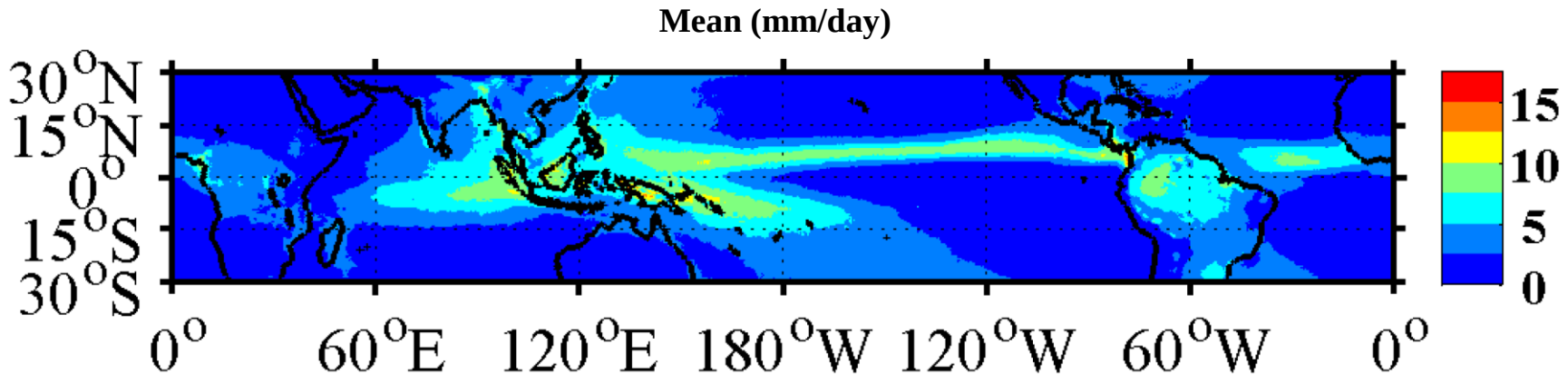
Magnitude of Rain



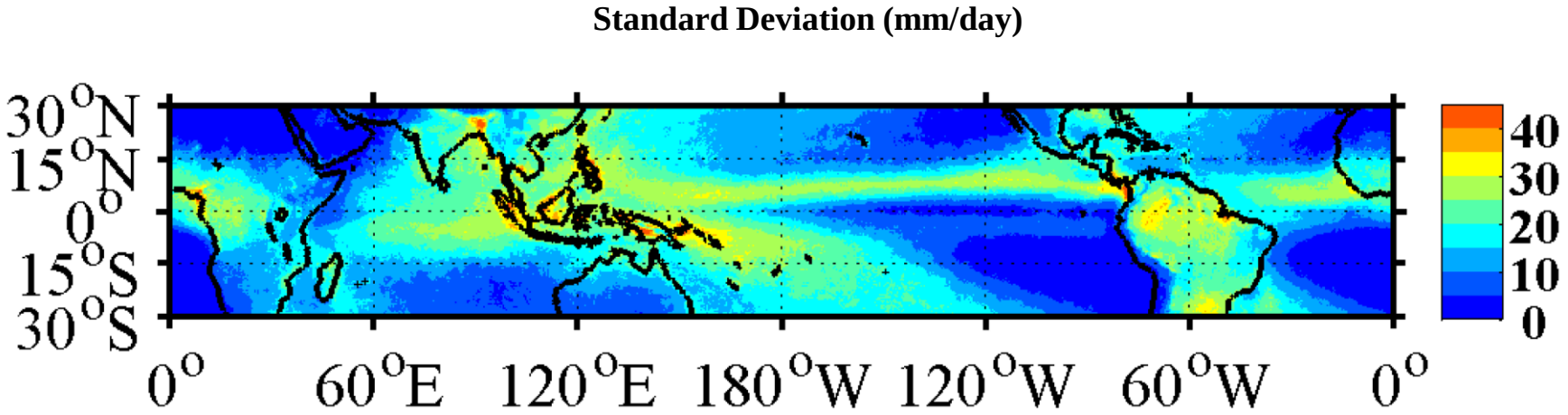


http://trmm.gsfc.nasa.gov

Annual Mean Rainfall Climatology (Tropics)



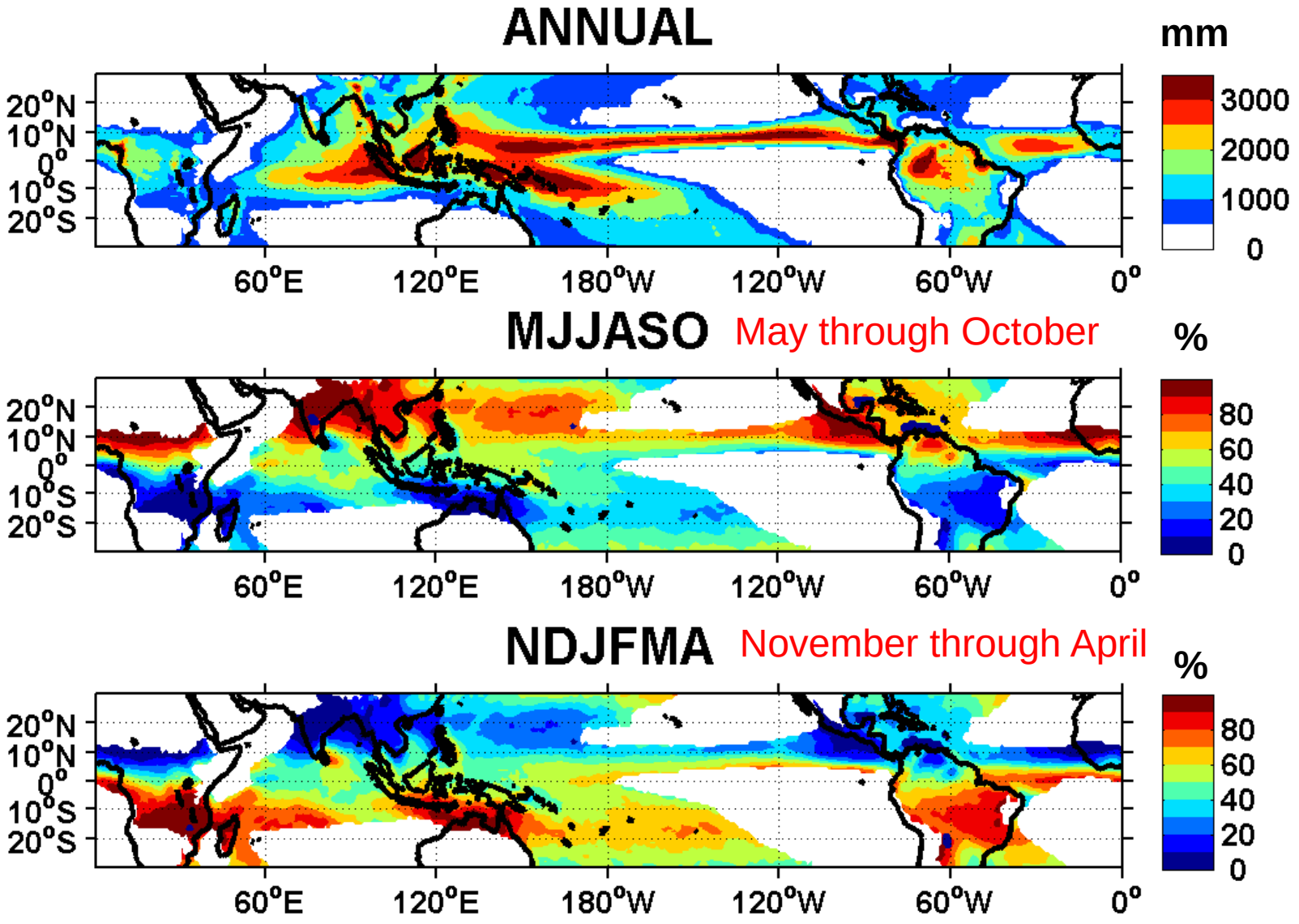
Climatology: average across all years



With R. Ratan

TRMM climatology (1998-2012)

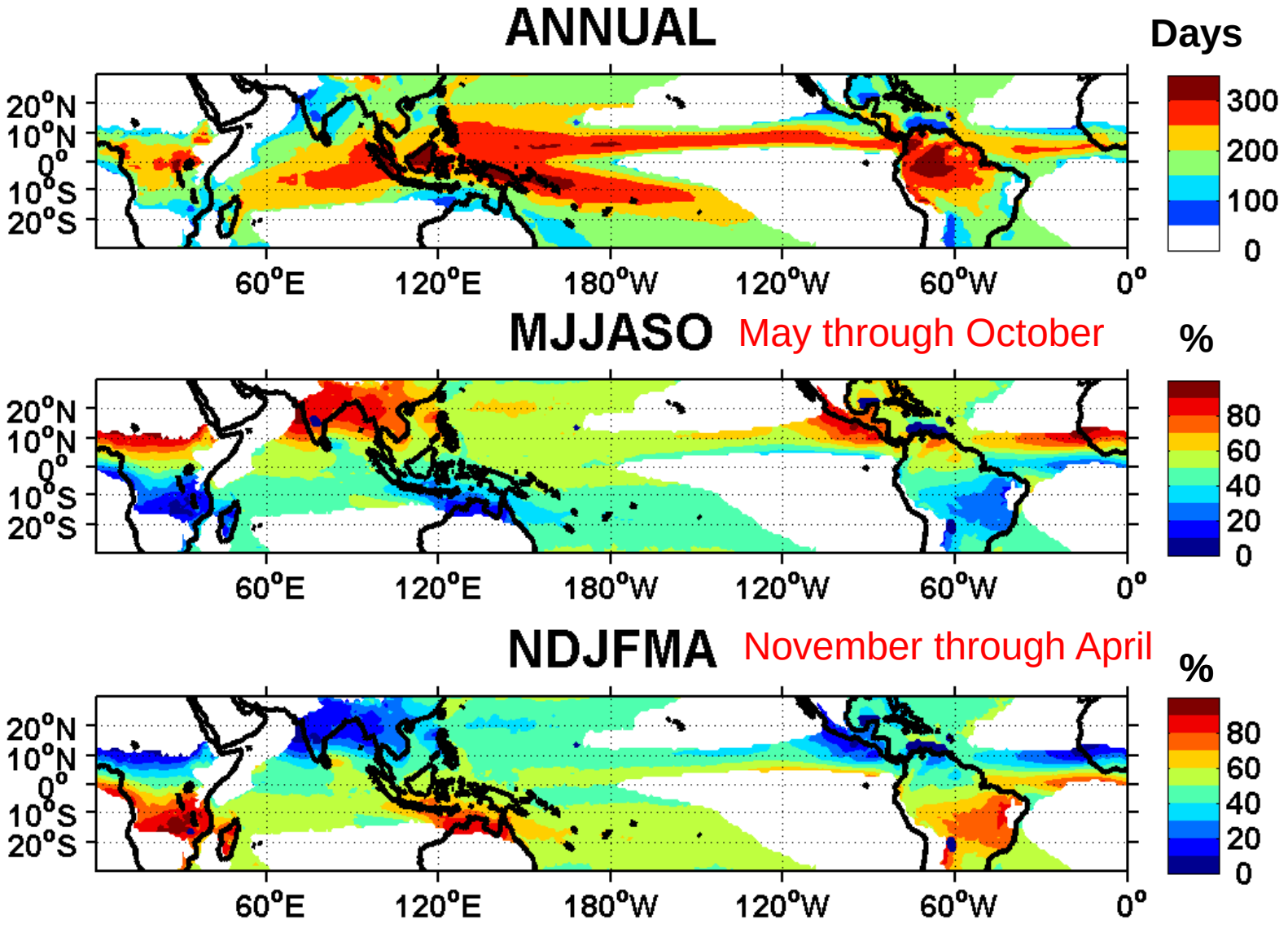
Rainfall Accumulation



With R. Ratan

Climatology (1998-2012) , TRMM 1-degree, daily rainfall

Number of "Rainy" days

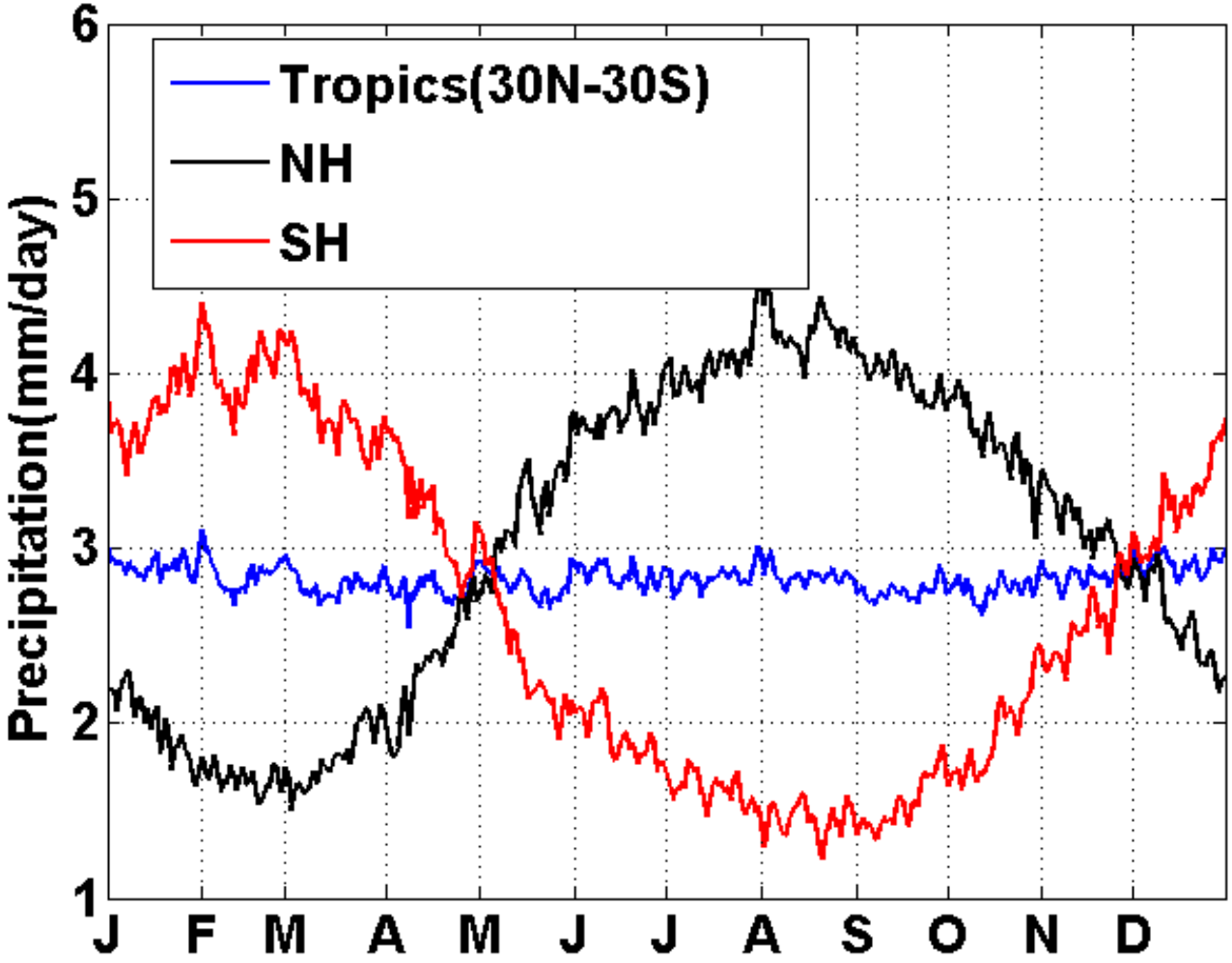


using min. measurable amount of precipitation

With R. Ratan

Climatology (1998-2012) , TRMM 1-degree, daily rainfall

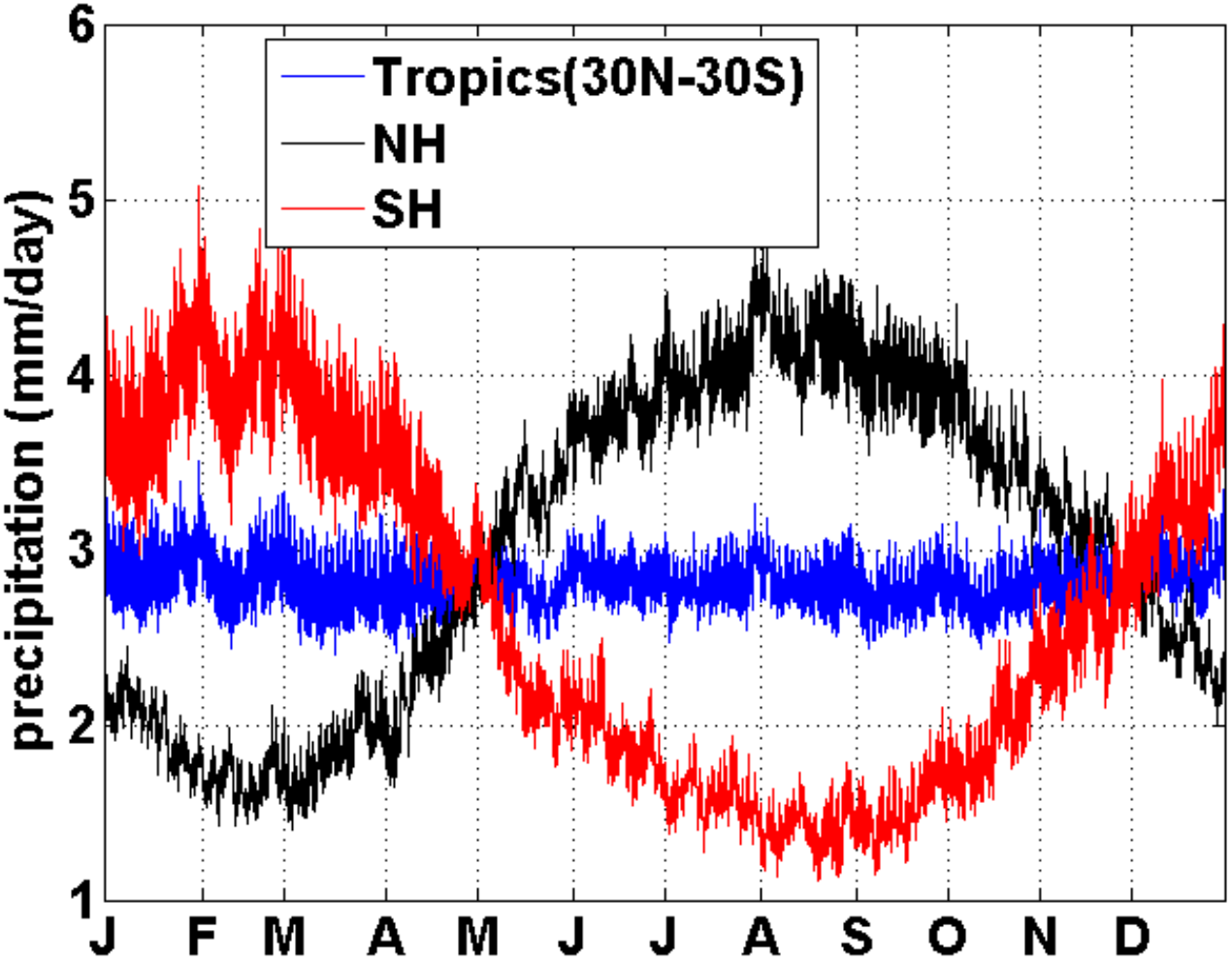
Spatially Averaged Daily Rainfall



TRMM 3B42 climatology (1998-2012)

With B. Chattopadhyay and J. Sukhatme

Spatially Averaged 3-hourly Rainfall

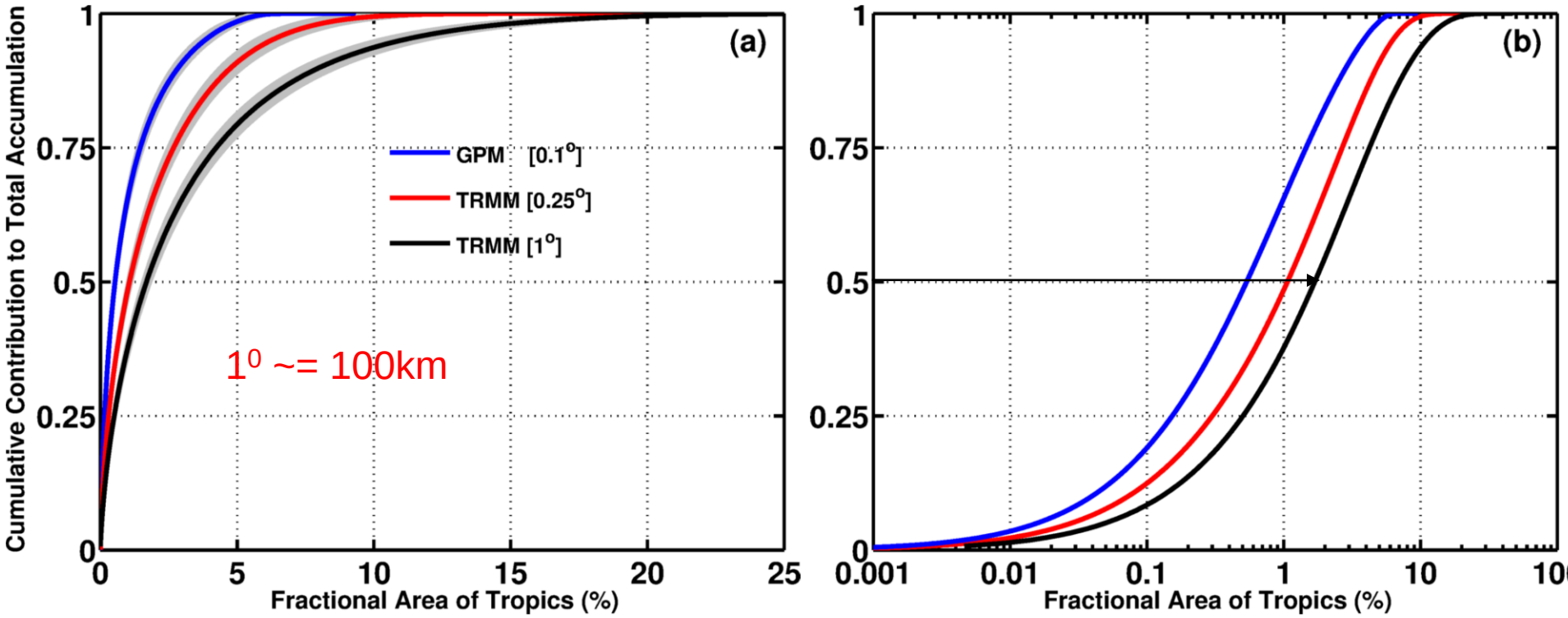


TRMM 3B42 climatology (1998-2012)

With B. Chattopadhyay and J. Sukhatme

At any given "instant", how much of the tropics (30S-30N) is raining?

At any given "instant", how much of the tropics (30S-30N) is raining?



N - total number of tropical grids boxes per snapshot (~300000 for 0.25°)

p - specified percentage of the total tropical rainfall

n(p) - number of grid boxes in the ranking (starting from the heaviest rain occurrence) required to account for *p* percent of the rainfall in that particular snapshot.

n(p)/N is equivalent to the areal fraction of the tropics that accounts for ***p*** percent of the accumulation in that particular snapshot.

With J.M. Wallace

Conditional Rain Rate / Intensity

✓Mean rain rate (mm/h) *when it is raining.*

✓Mean rain rate when it is raining harder than some specified threshold

✓Mean rain rate in events that account for x% of the total accumulated rainfall

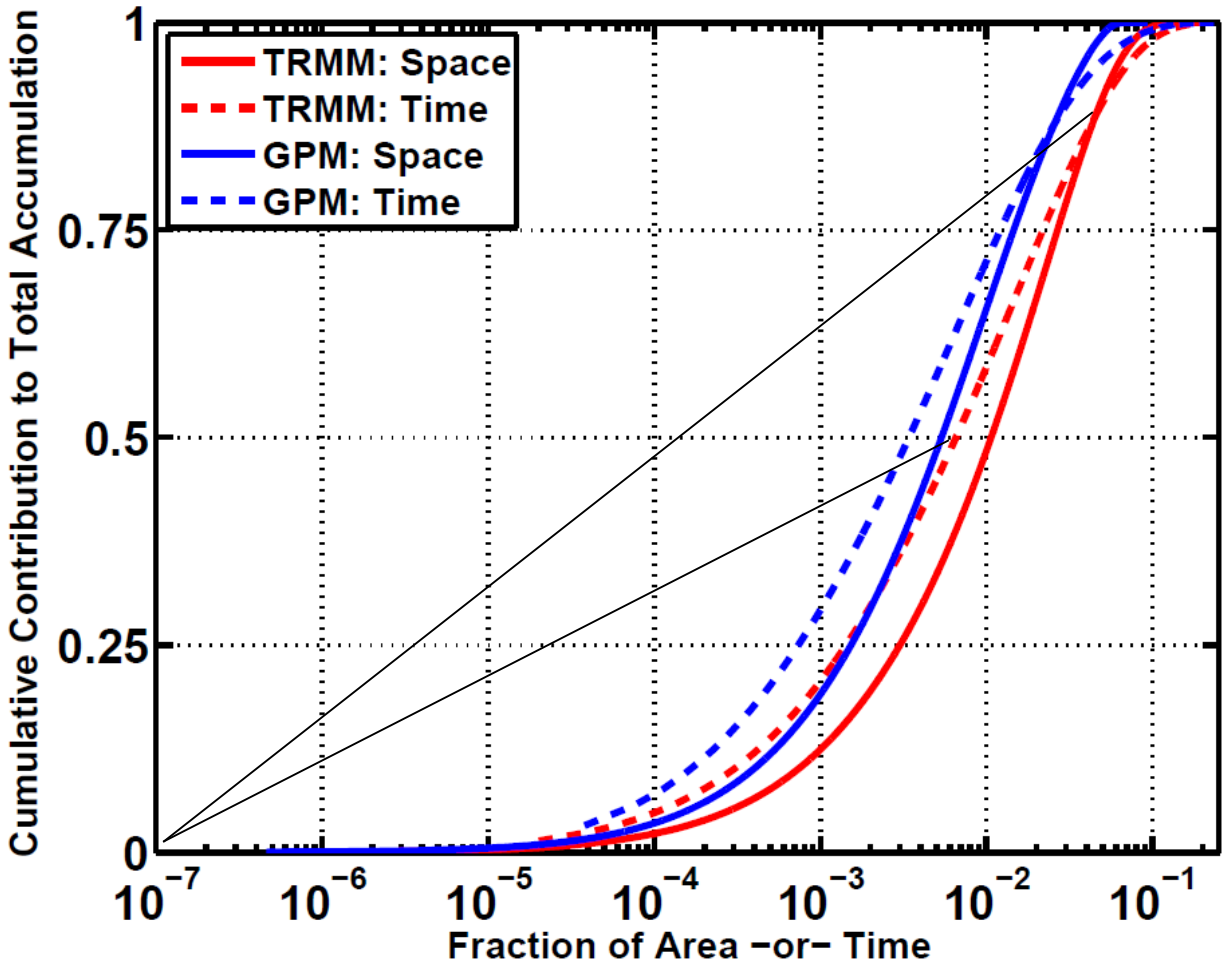
Conditional Frequency

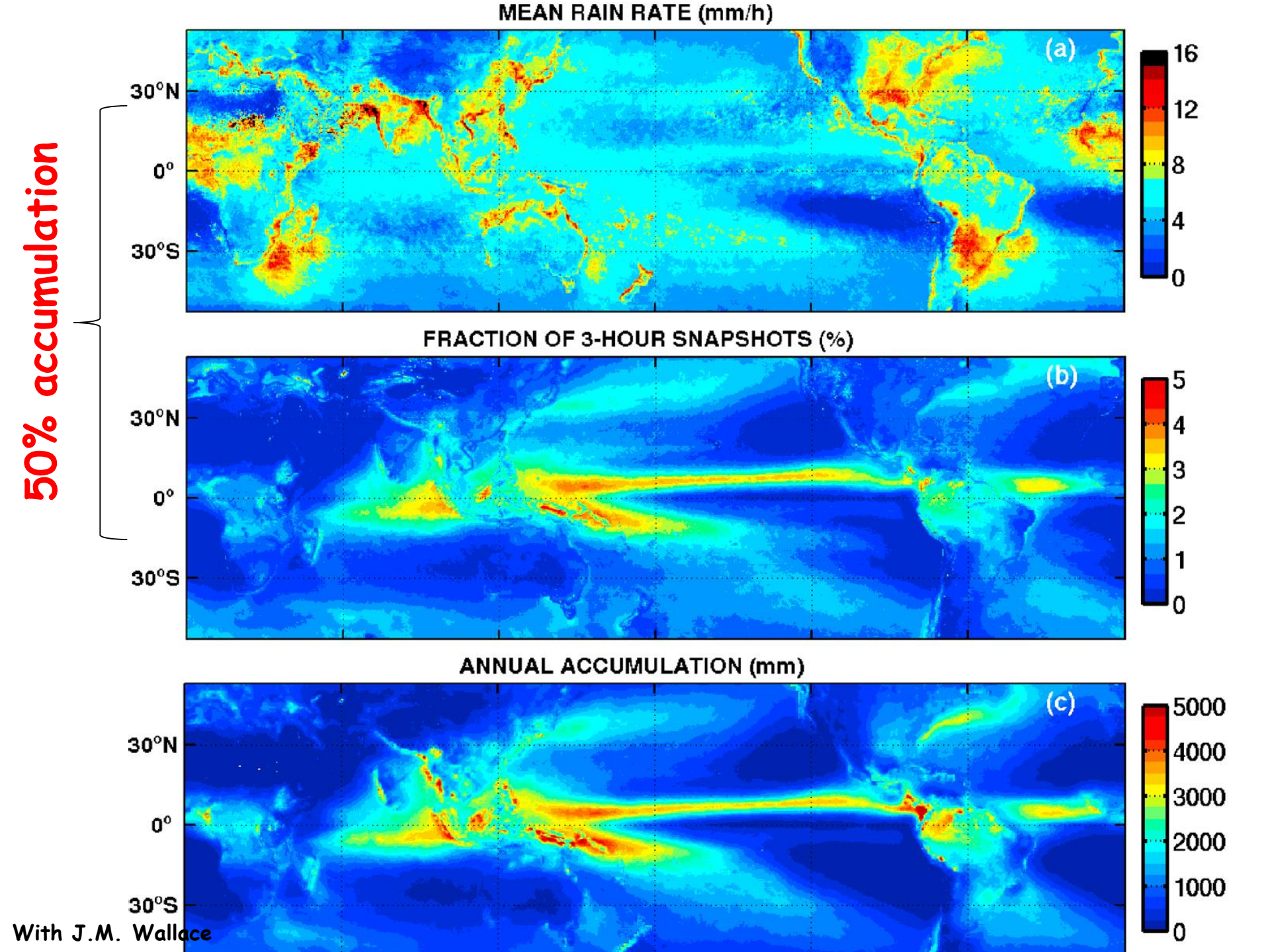
✓Fraction of the time it is raining harder than some specified threshold

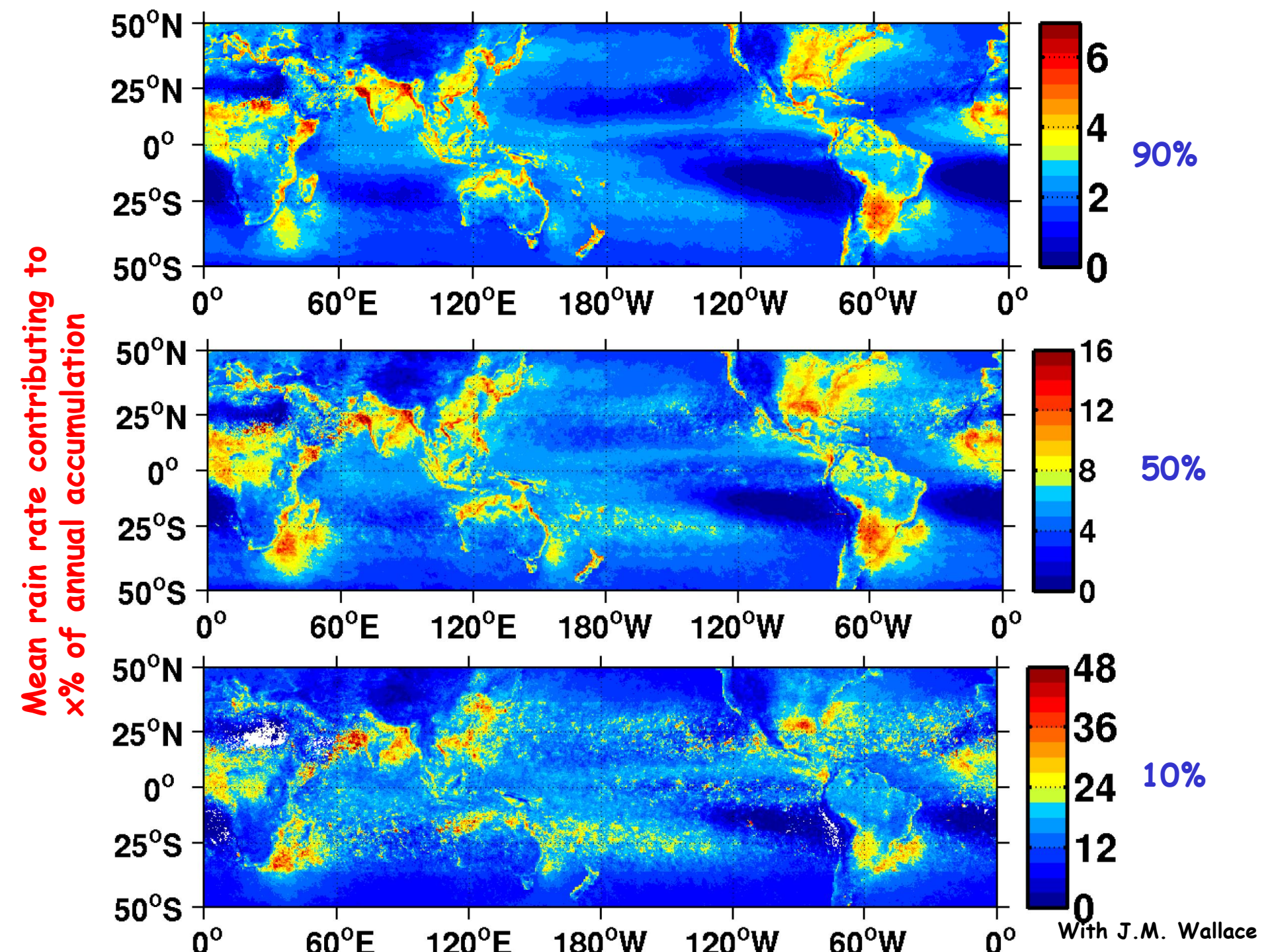
✓Fraction of the time in events that account for x% of the total accumulated rainfall

Intensity X Frequency = Rainfall Accumulation

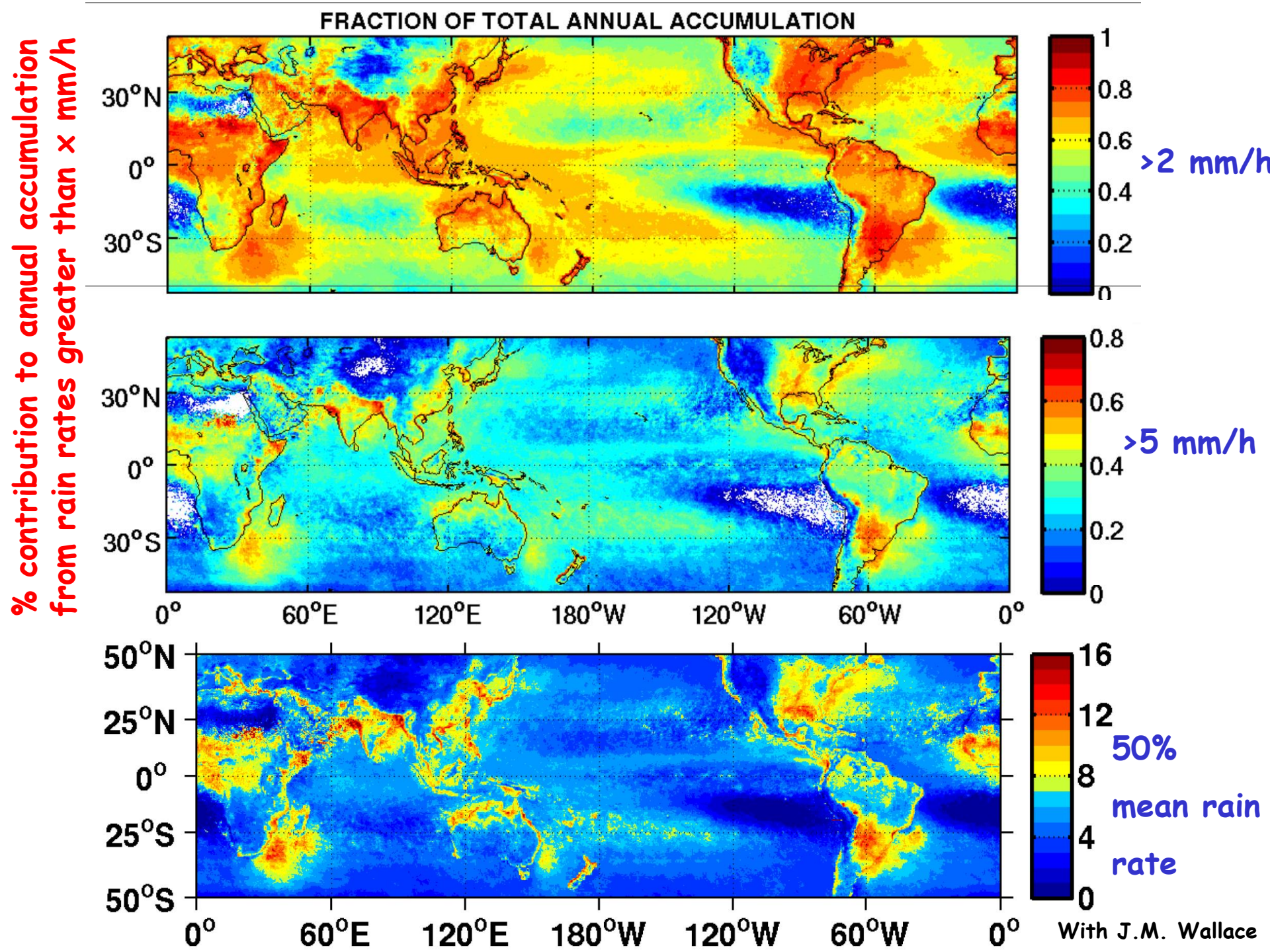
Mean rain rate contributing to x% of the annual accumulation

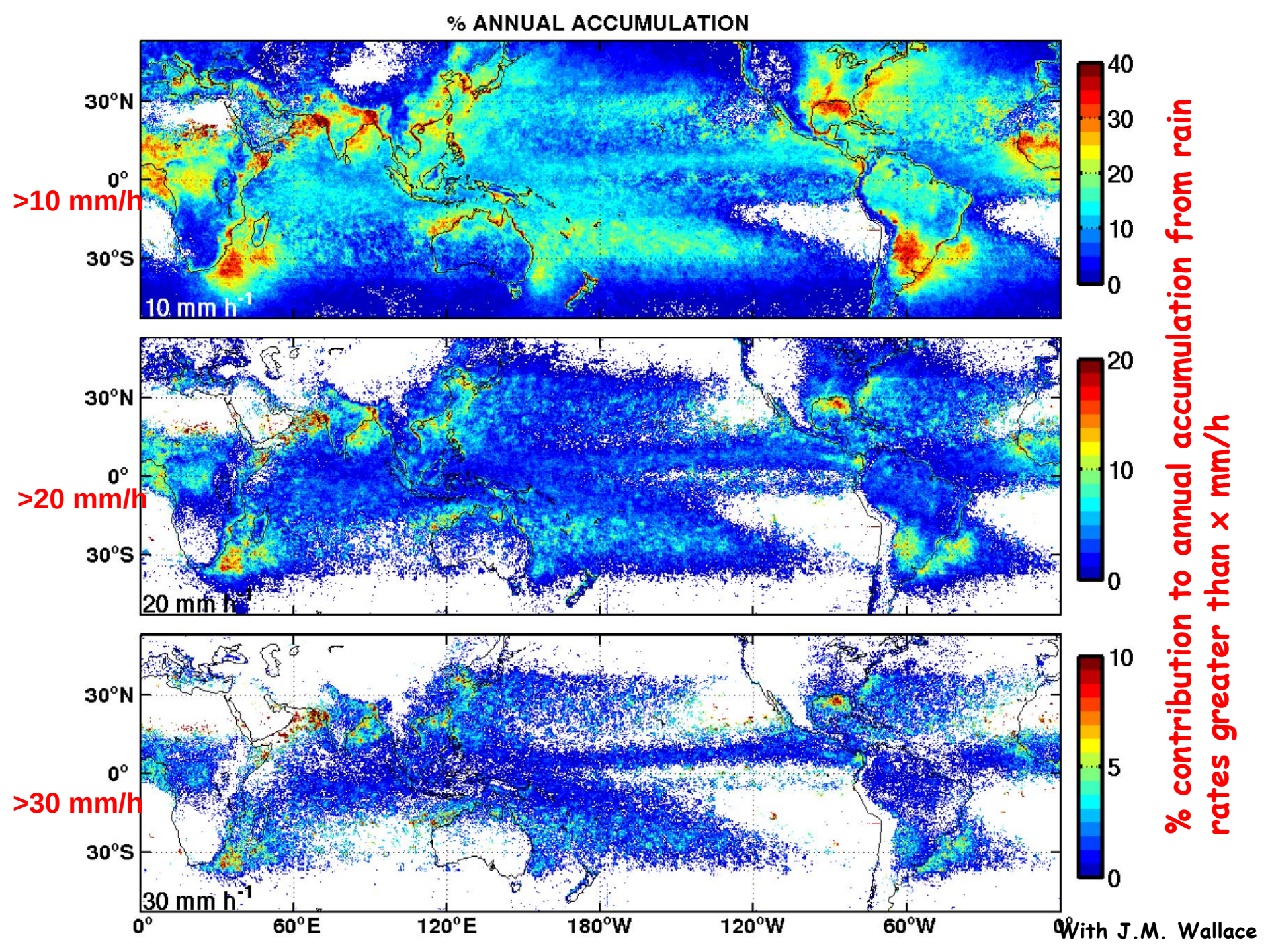

TRMM: Space
TRMM: Time
GPM: Space
GPM: Time
Cumulative Contribution to Total Accumulation
1
0.75
0.5
0.25
0
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
Fraction of Area −or− Time

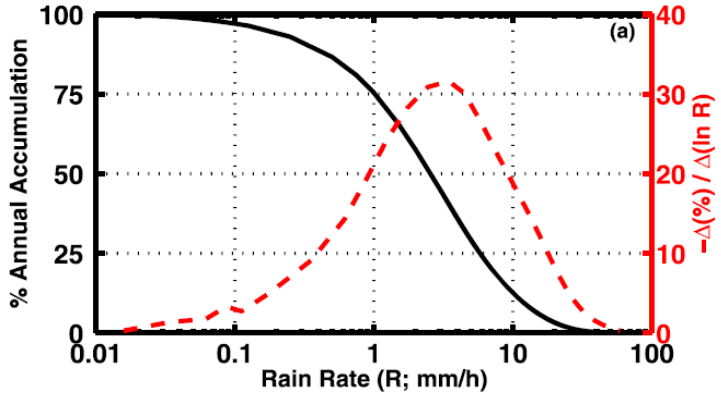

MEAN RAIN RATE (mm/h)
(a)
30°N
0°
30°S
16
12
8
4
0
50% accumulation
FRACTION OF 3-HOUR SNAPSHOTS (%)
(b)
30°N
0°
30°S
5
4
3
2
1
0
ANNUAL ACCUMULATION (mm)
(c)
30°N
0°
30°S
5000
4000
3000
2000
1000
0
With J.M. Wallace


Mean rain rate contributing to x% of annual accumulation
50°N
25°N
0°
25°S
50°S
0°
60°E
120°E
180°W
120°W
60°W
0°
6
4
2
0
90%
16
12
8
4
0
50%
48
36
24
12
0
10%
With J.M. Wallace

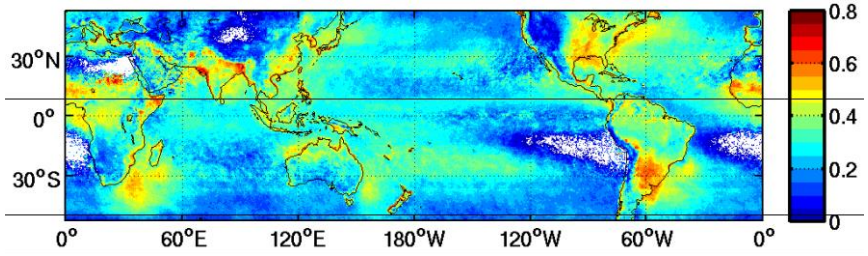
Fraction of annual accumulation from rain rates higher than x mm/h

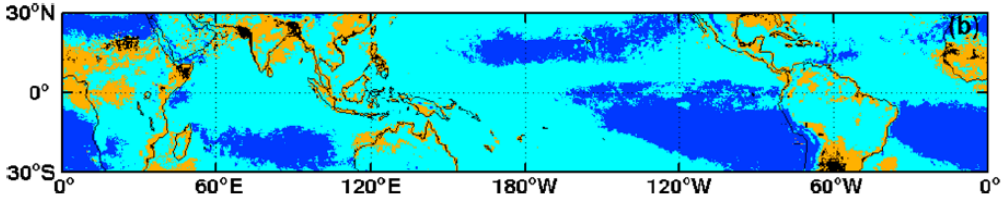

% contribution to annual accumulation from rain rates greater than x mm/h
FRACTION OF TOTAL ANNUAL ACCUMULATION
30°N
0°
30°S
1
0.8
0.6
0.4
0.2
0
>2 mm/h
30°N
0°
30°S
0.8
0.6
0.4
0.2
0
>5 mm/h
0°
60°E
120°E
180°W
120°W
60°W
0°
50°N
25°N
0°
25°S
50°S
16
12
8
4
0
50% mean rain rate
0°
60°E
120°E
180°W
120°W
60°W
0°
With J.M. Wallace

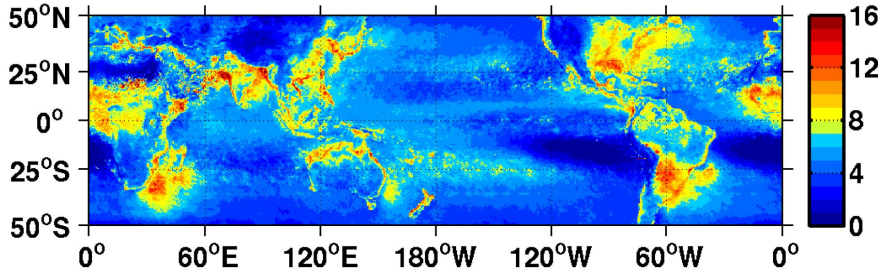

% ANNUAL ACCUMULATION
>10 mm/h
>20 mm/h
>30 mm/h
10 mm h-1
20 mm h-1
30 mm h-1
30°N
0°
30°S
0°
60°E
120°E
180°W
120°W
60°W
0°
40
30
20
10
0
20
10
0
10
5
0
% contribution to annual accumulation from rain rates greater than x mm/h
With J.M. Wallace

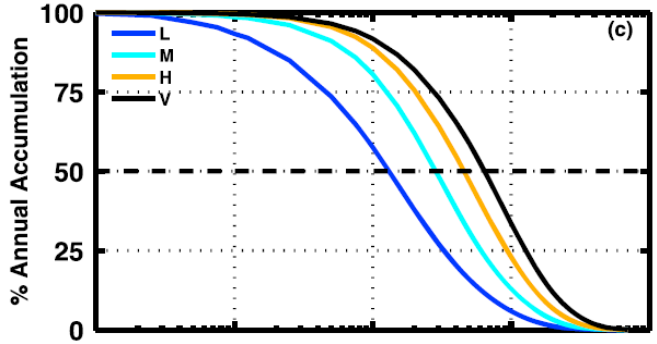


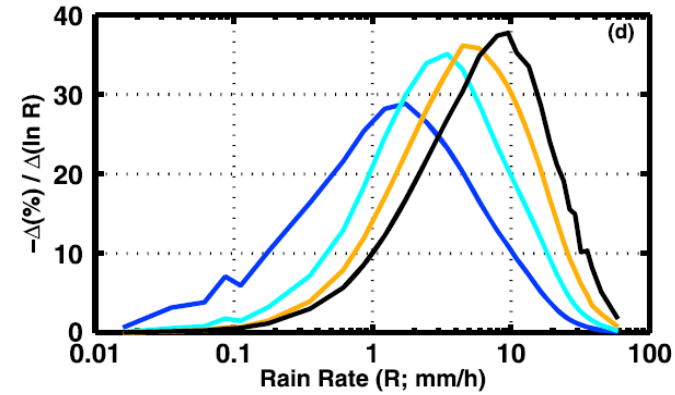
>5 mm/h











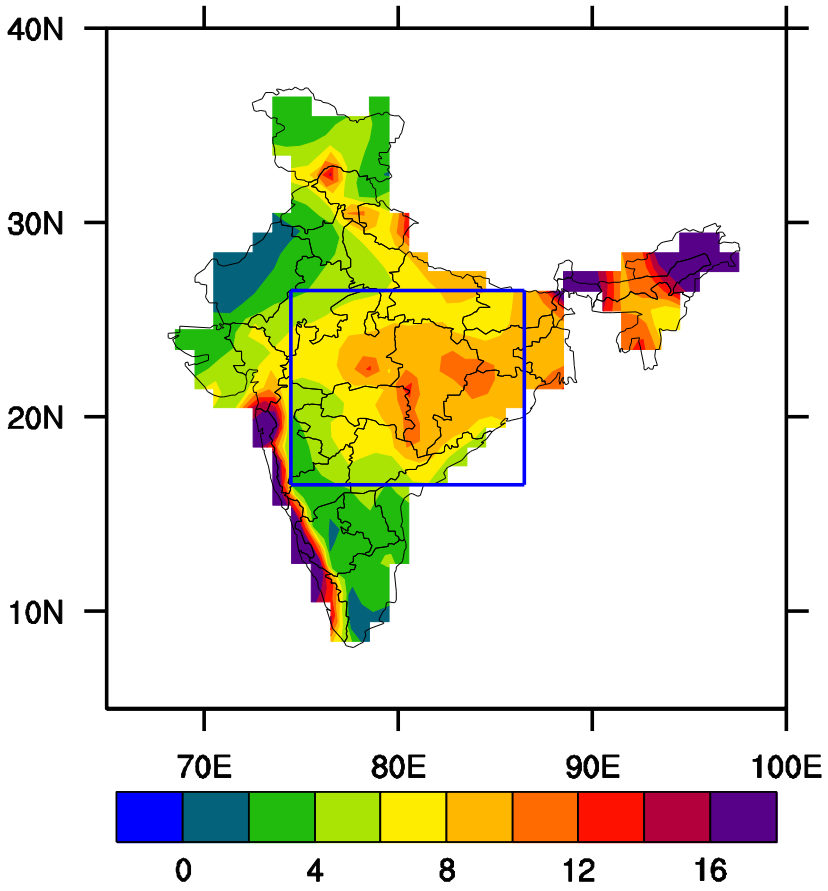
50% accumulation

mean rain rate

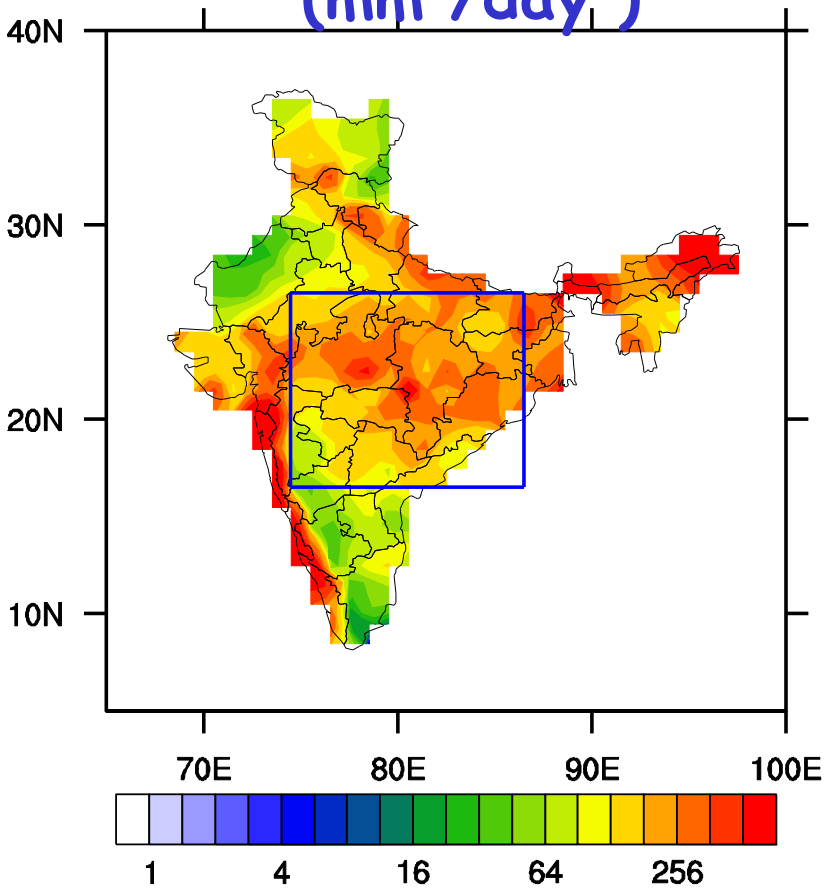
Closer Home…

June through September Rainfall

Climatological Mean (mm/day)



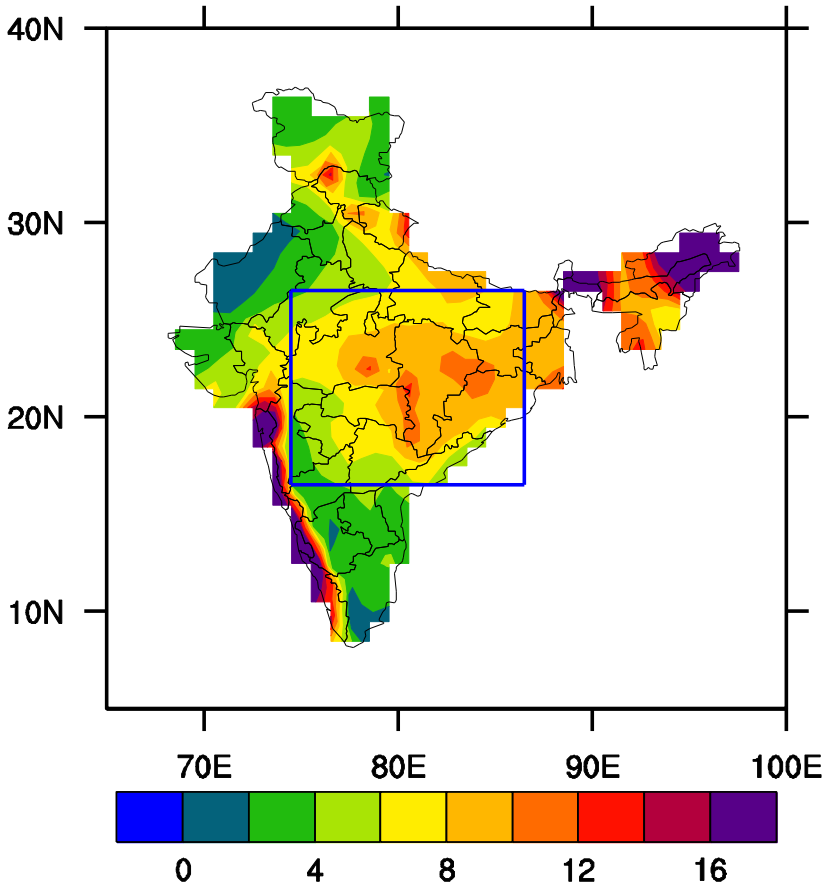
Climatological Variance of Daily Anomalies (mm^2/day^2)



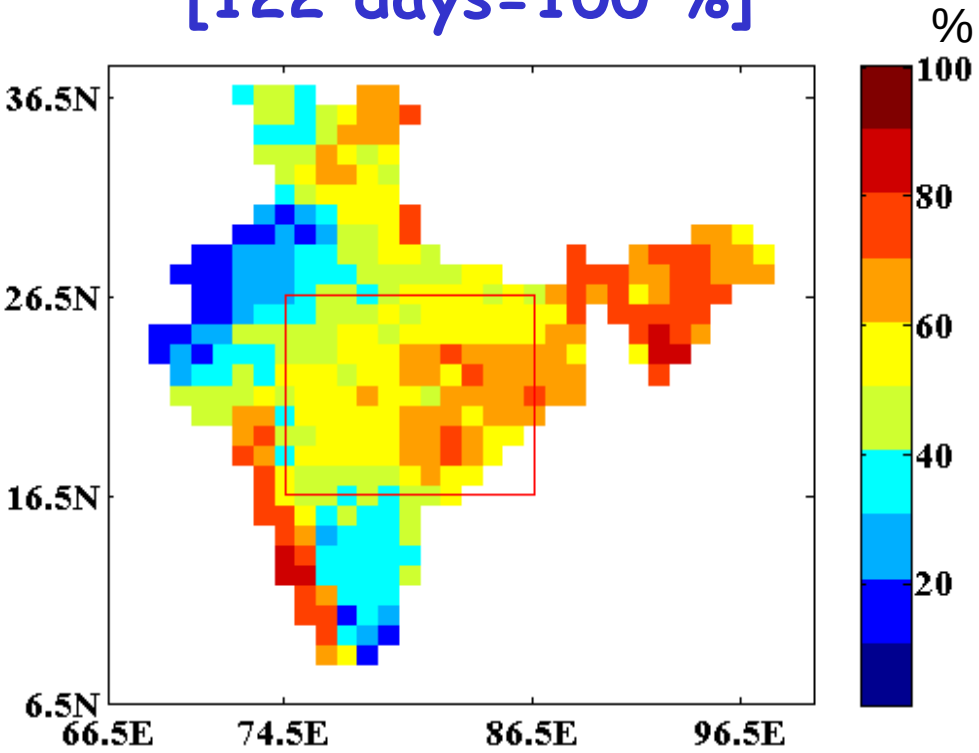
With B.N. Goswami, D. Sengupta, P. Xavier, M. Madhusoodanan

June through September Rainfall

Climatological Mean (mm/day)

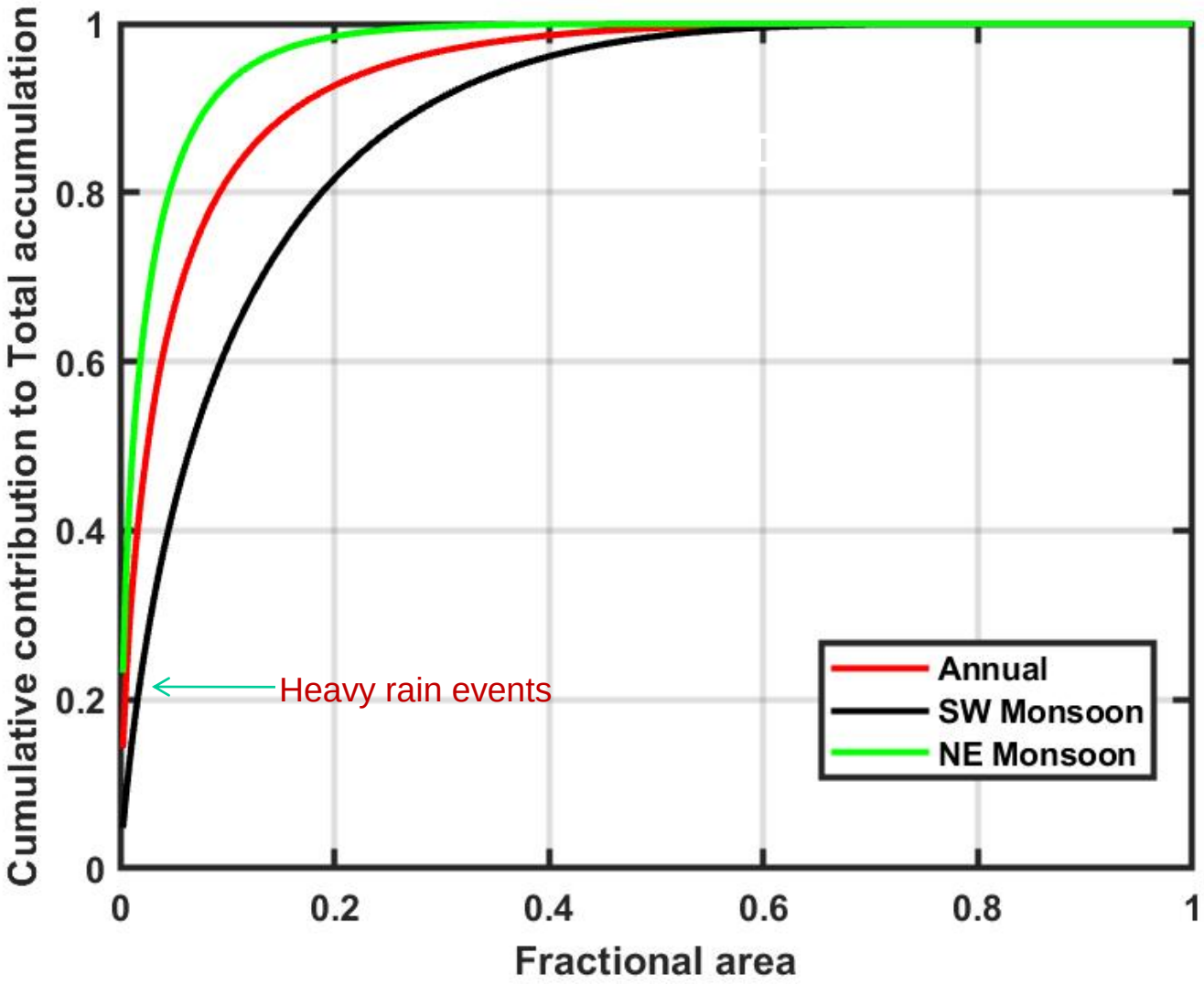


Average number of rainy days in JJAS [122 days=100 %]



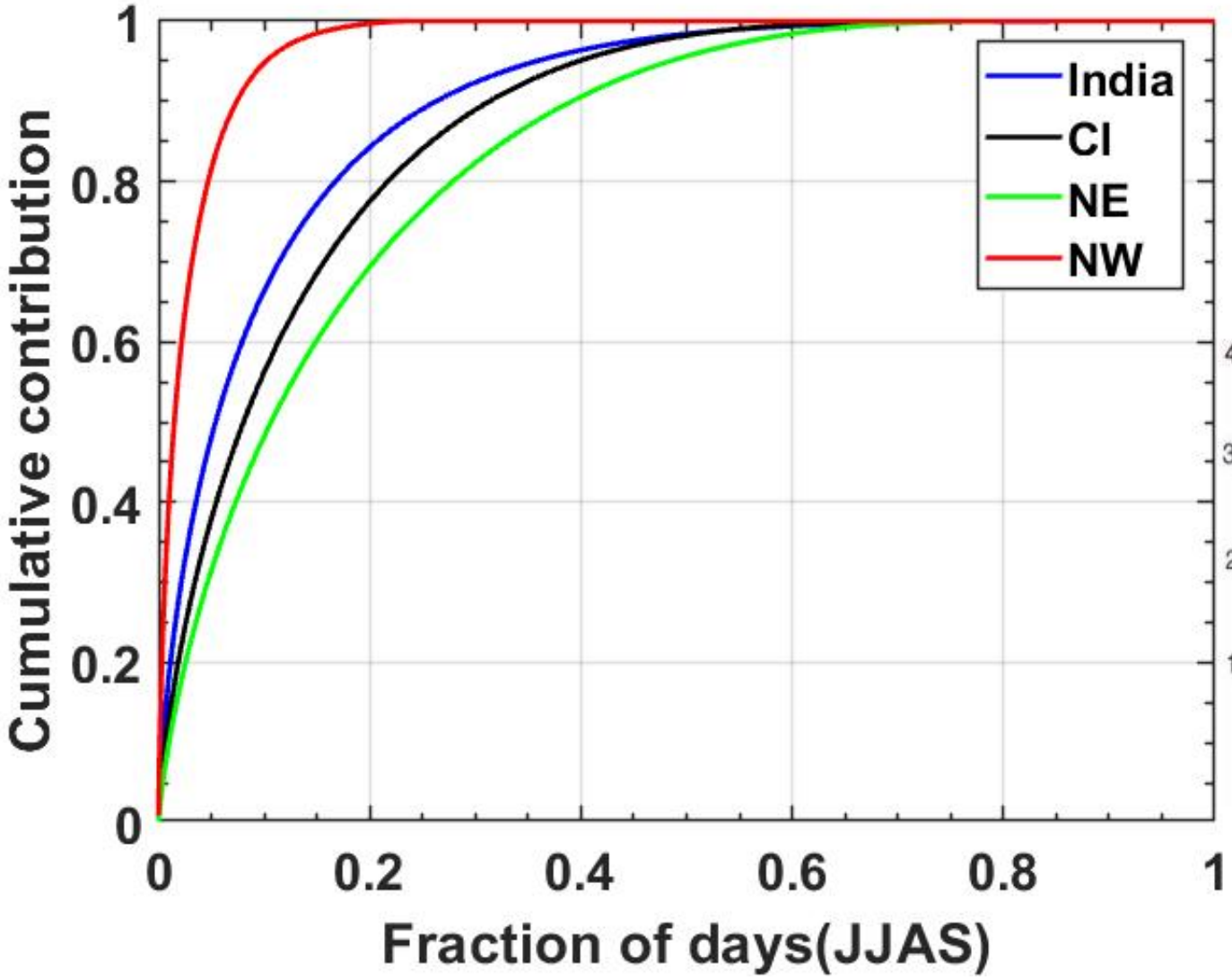
With R. Ratan

Climatology of Cumulative Contribution to Daily Accumulation (in Space)

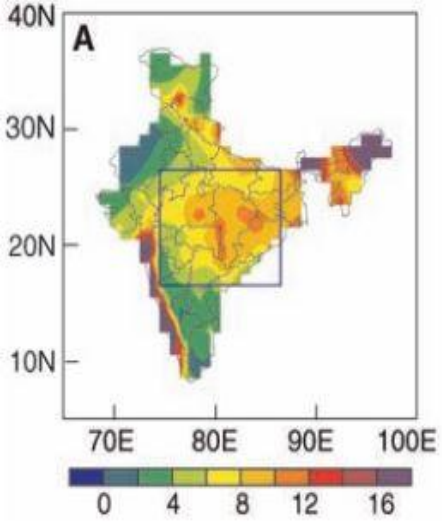


With V. Bathri

Climatology of Cumulative Contribution to Accumulation (in Time)



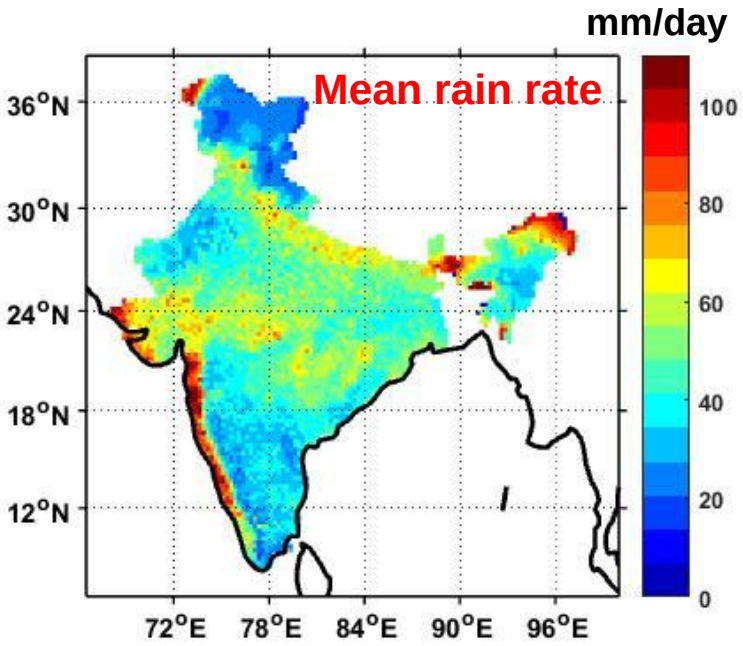
Central India
North East
North West

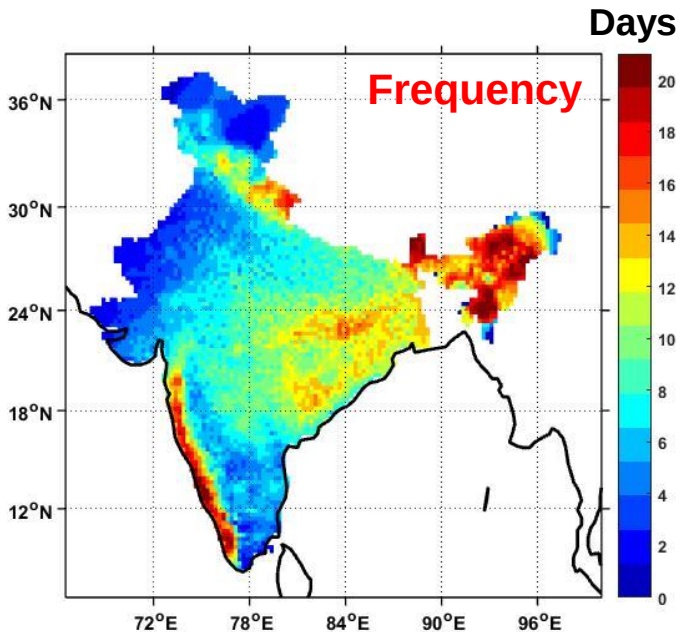


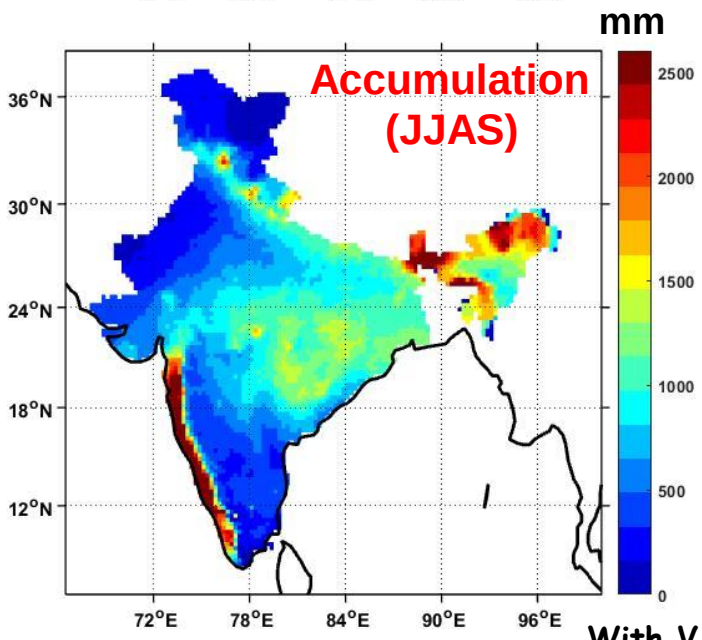
With V. Bathri

IMD, 0.25° daily rain data (1901-2014)

50% Accumulation (JJAS)



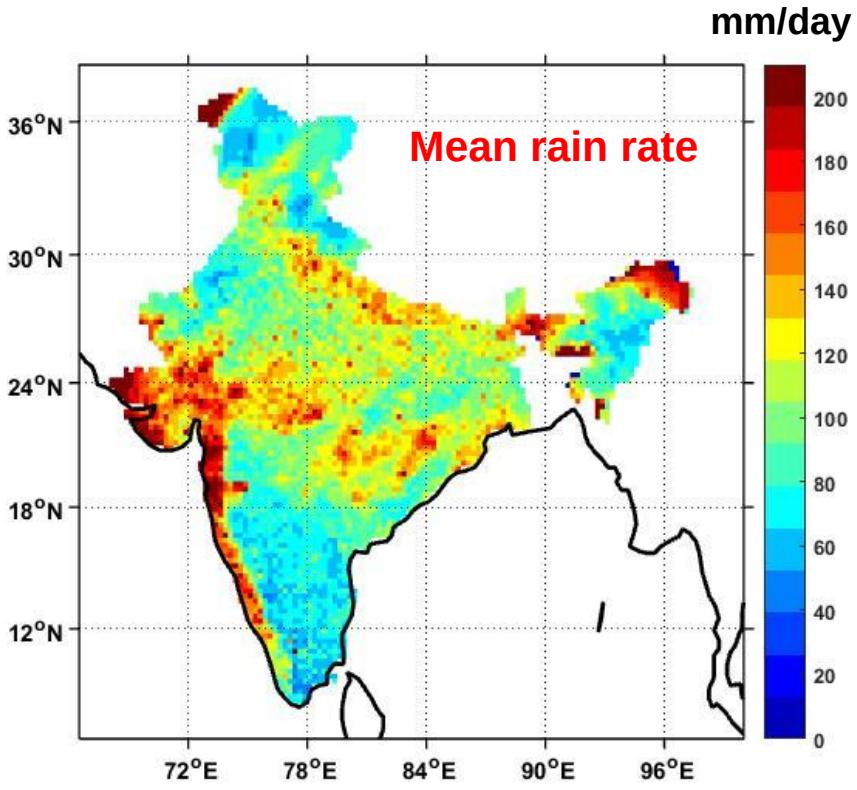


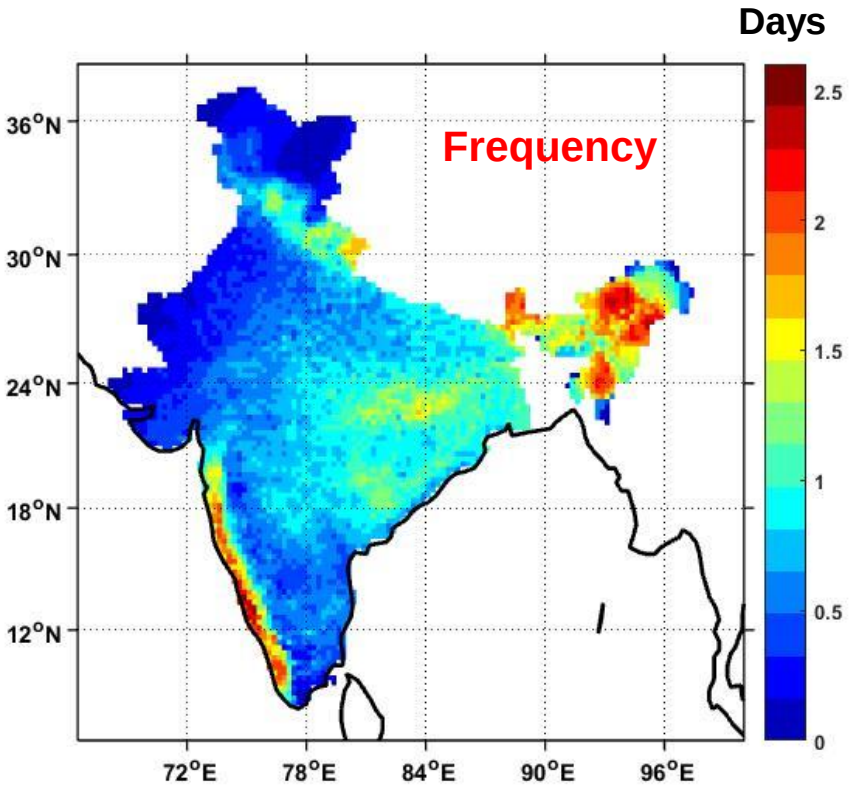


IMD, 0.25° daily rain data (1901-2014)

With V. Bathri

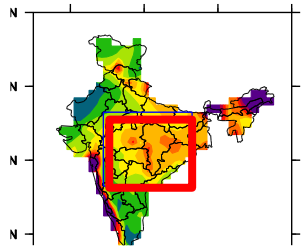
10% Accumulation (JJAS)



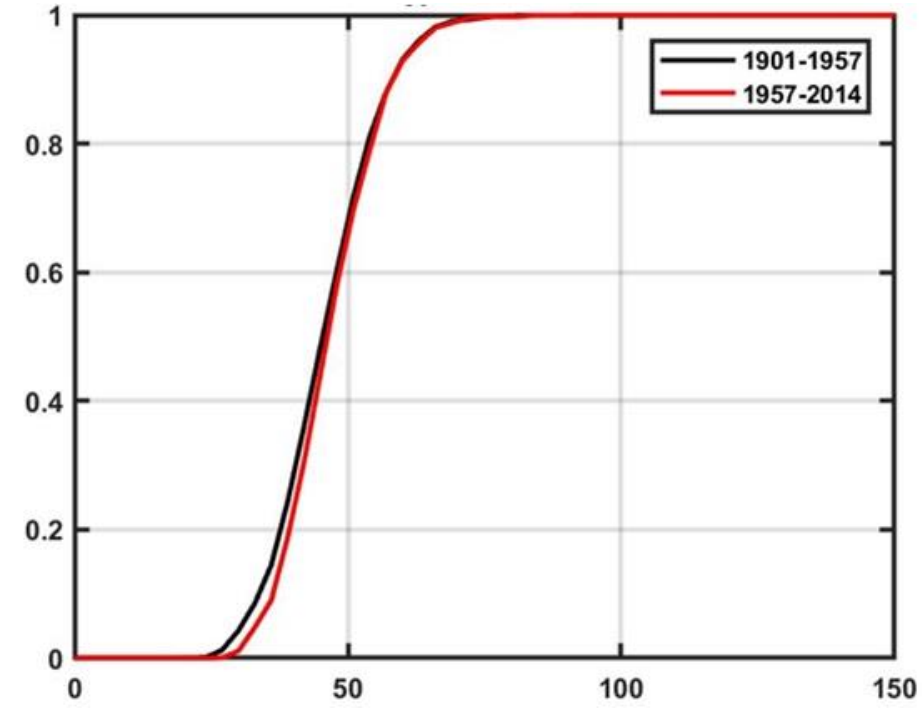


IMD, 0.25° daily rain data (1901-2014)

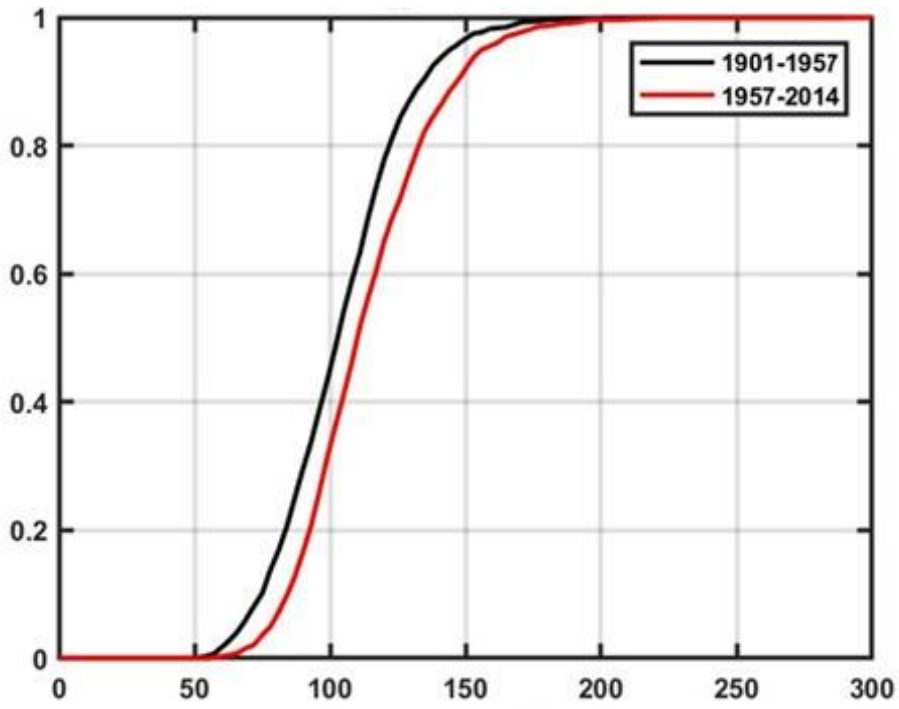
With V. Bathri



CDF of Rain Rates accounting 50% and 10% accumulation over Central India



CDF of R_{50}

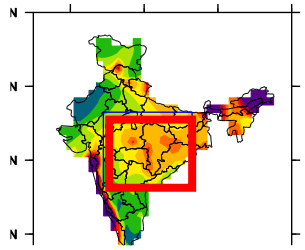


CDF of R_{10}

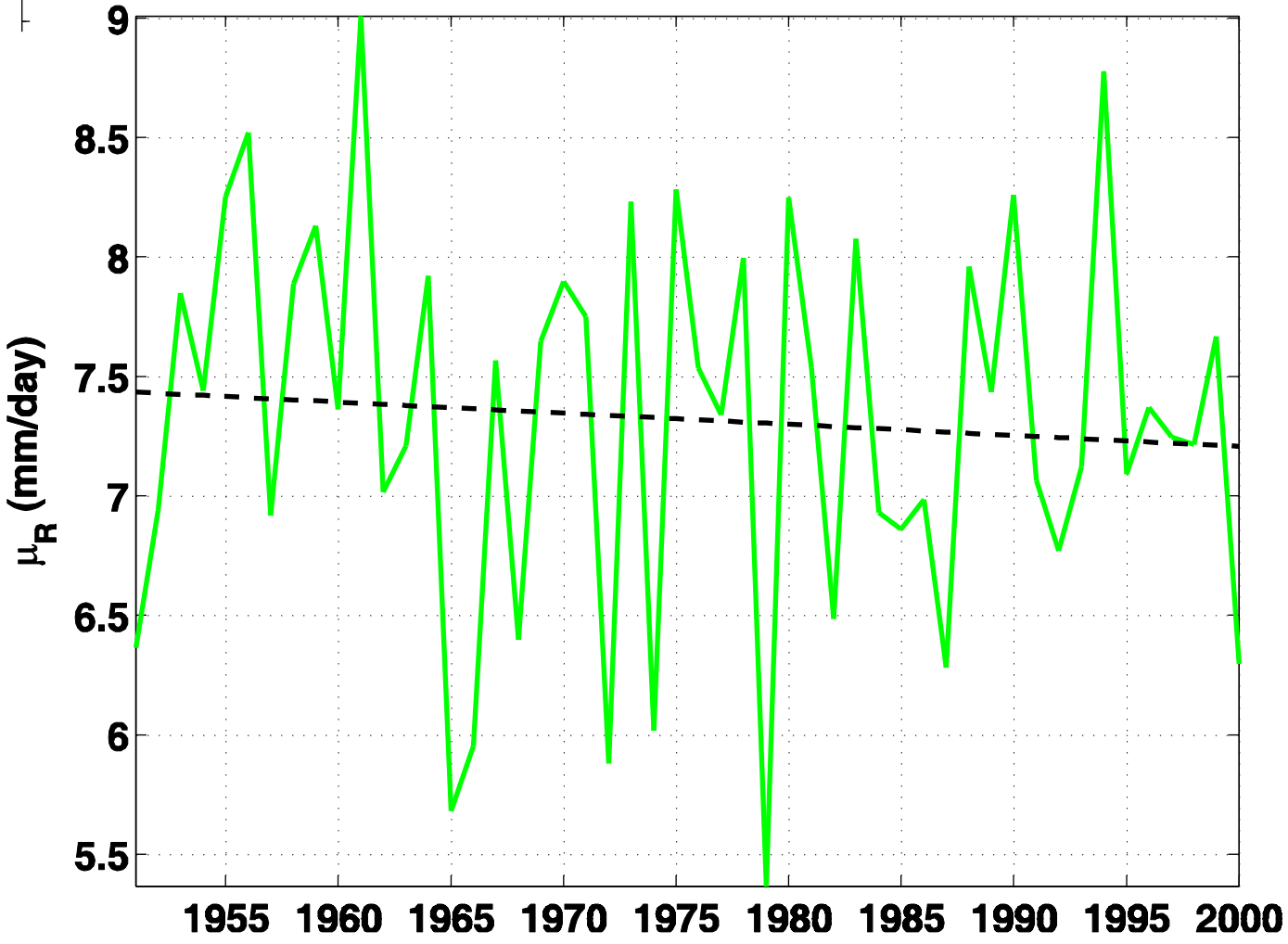
Kolmogorov-Smirnov test for H_0: 2 CDFs come from the same distribution, fails at 5 % significance level

With V. Bathri

IMD, 0.25° daily rain data (JJAS; 1901-2014) **Sample: [1600(grid boxes)]x2 eras**



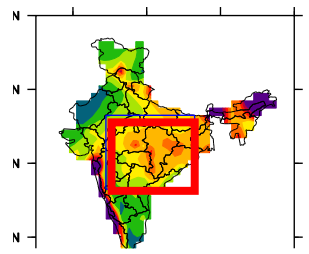
Seasonal Mean Rainfall over Central India

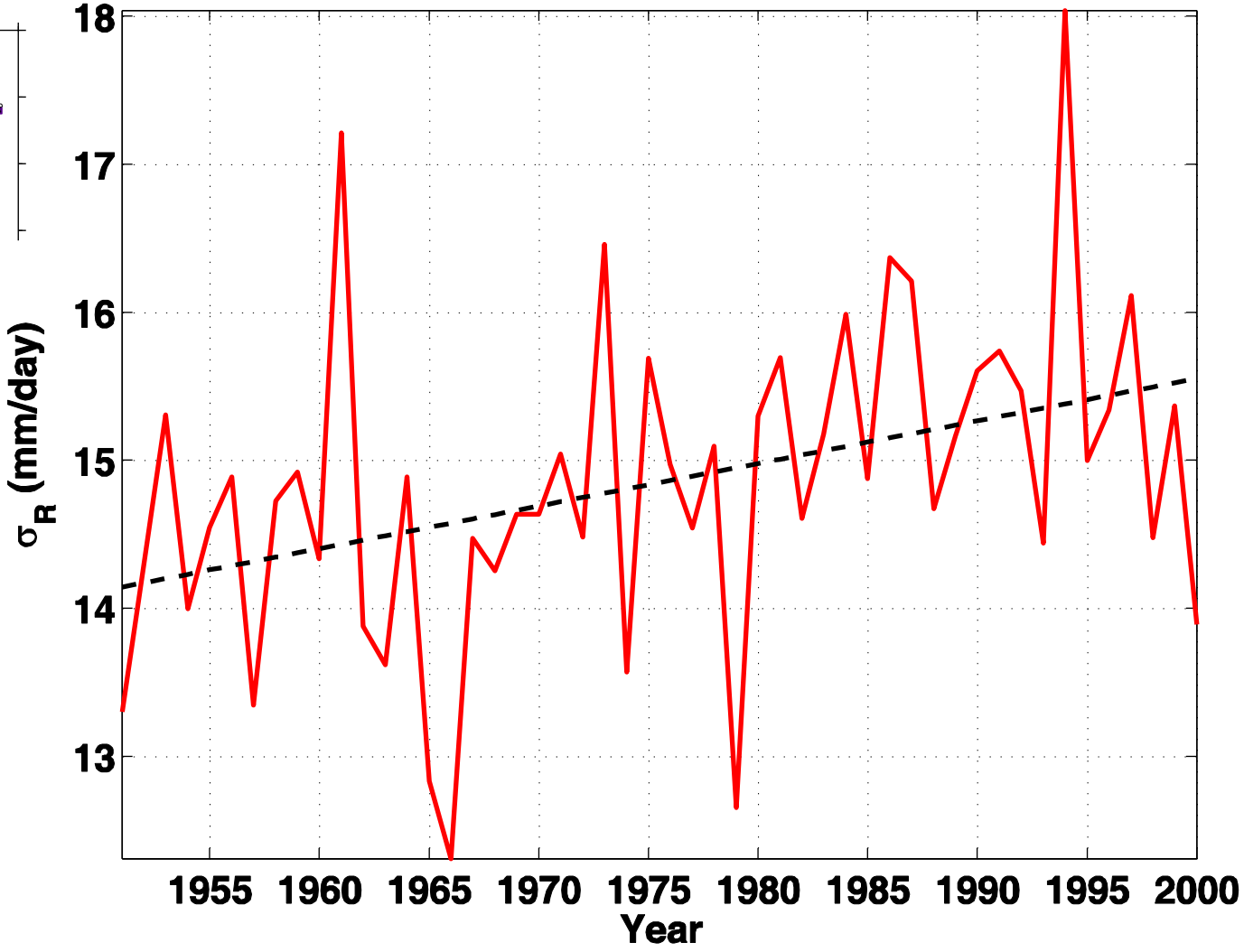


No Significant Trend

With B.N. Goswami, D. Sengupta, P. Xavier, M. Madhusoodanan

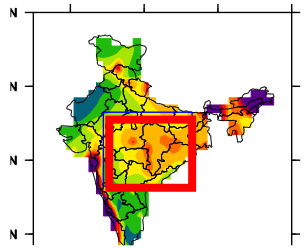
Standard Deviation of Rainfall over Central India



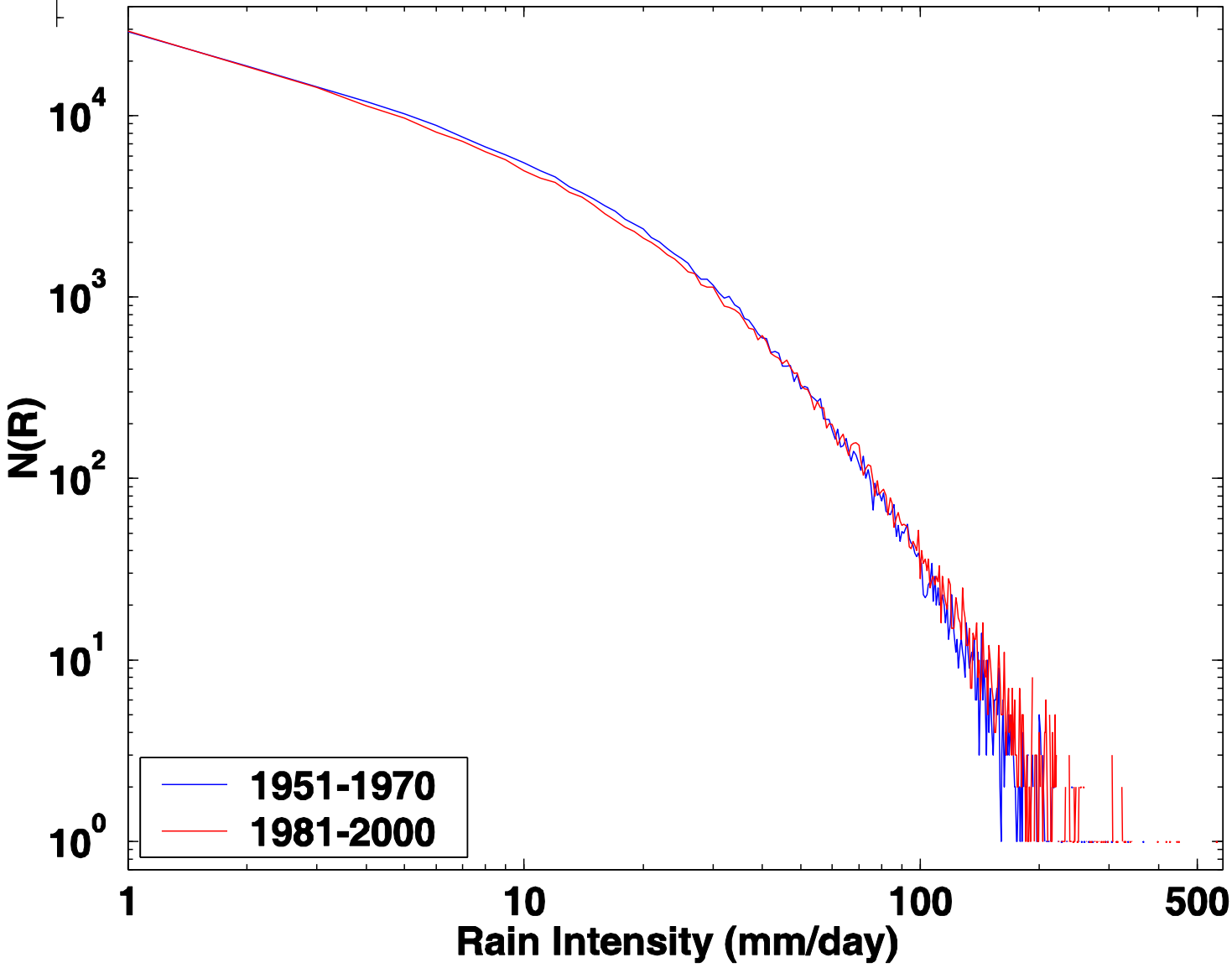


Trend significant at 5% significance level

With B.N. Goswami, D. Sengupta, P. Xavier, M. Madhusoodanan

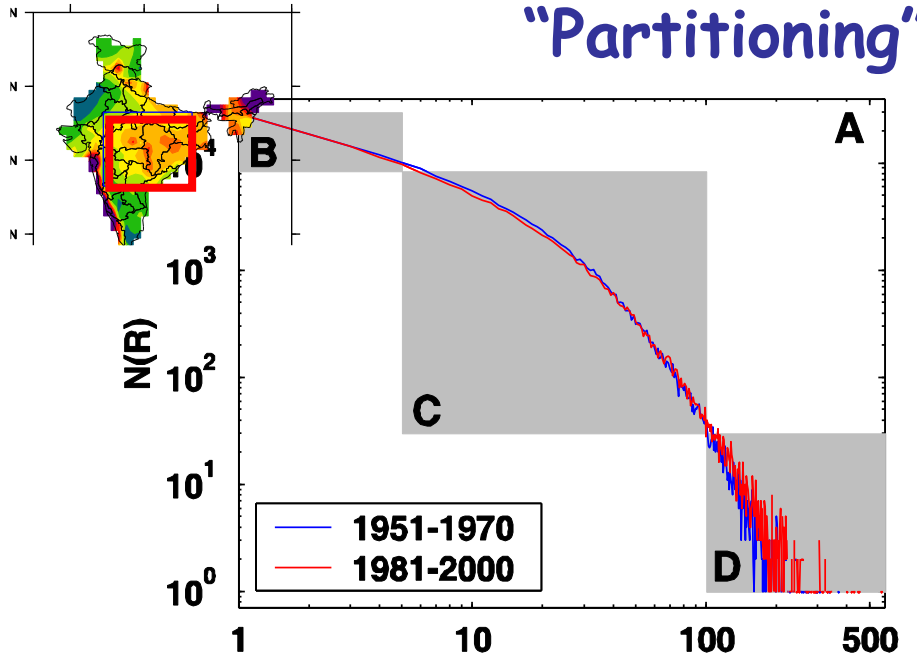


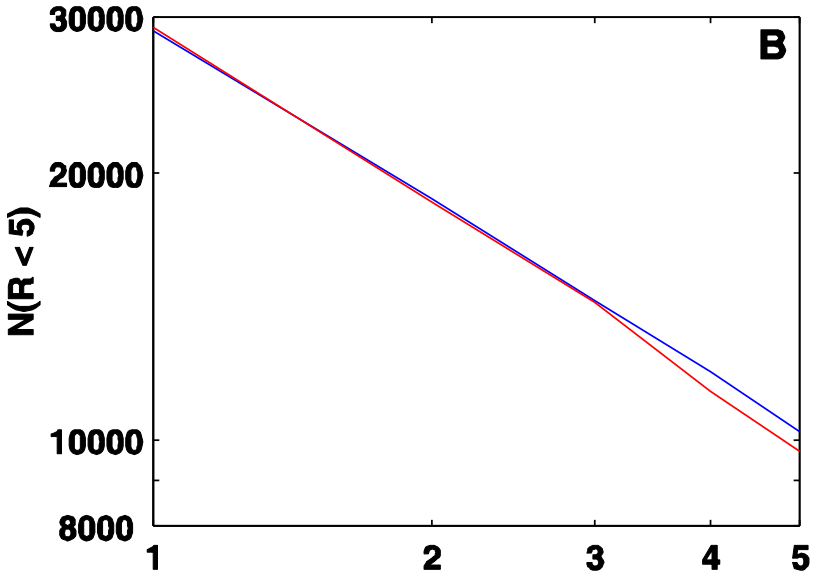
Histogram of Rainfall

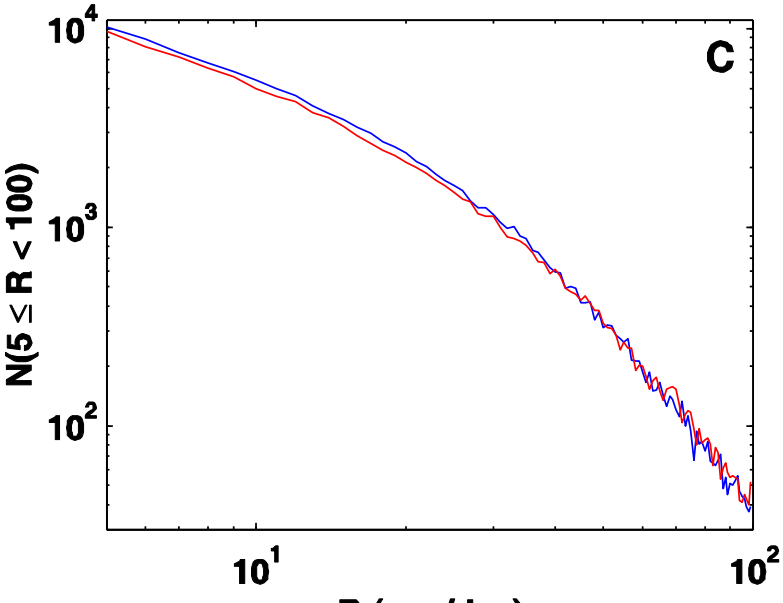


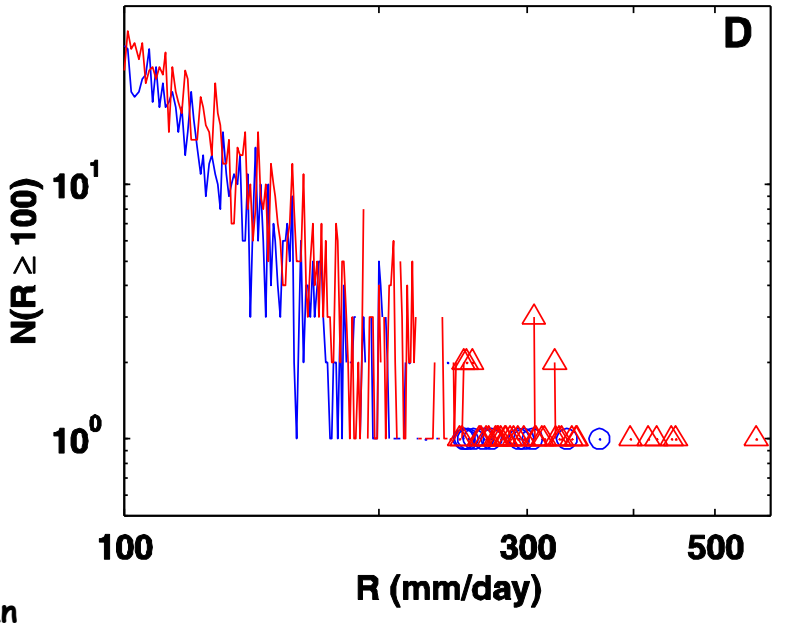
With B.N. Goswami, D. Sengupta, P. Xavier, M. Madhusoodanan

"Partitioning" the Histogram









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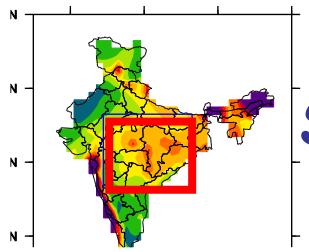
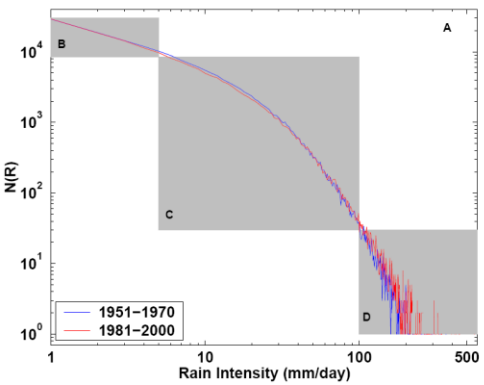


Seasonal Distribution of "Extreme" Events



$N_{R\geq100}(T,t)$

10
5
0

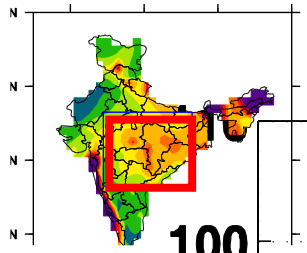
Sep
Aug
Jul
Jun

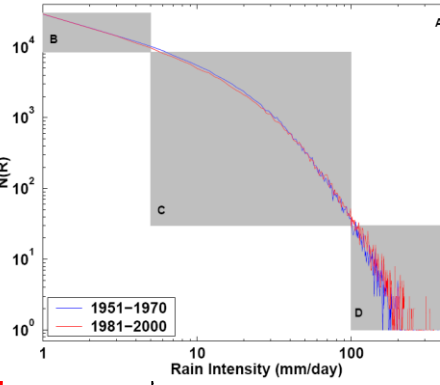
1960
1970
1980
1990
2

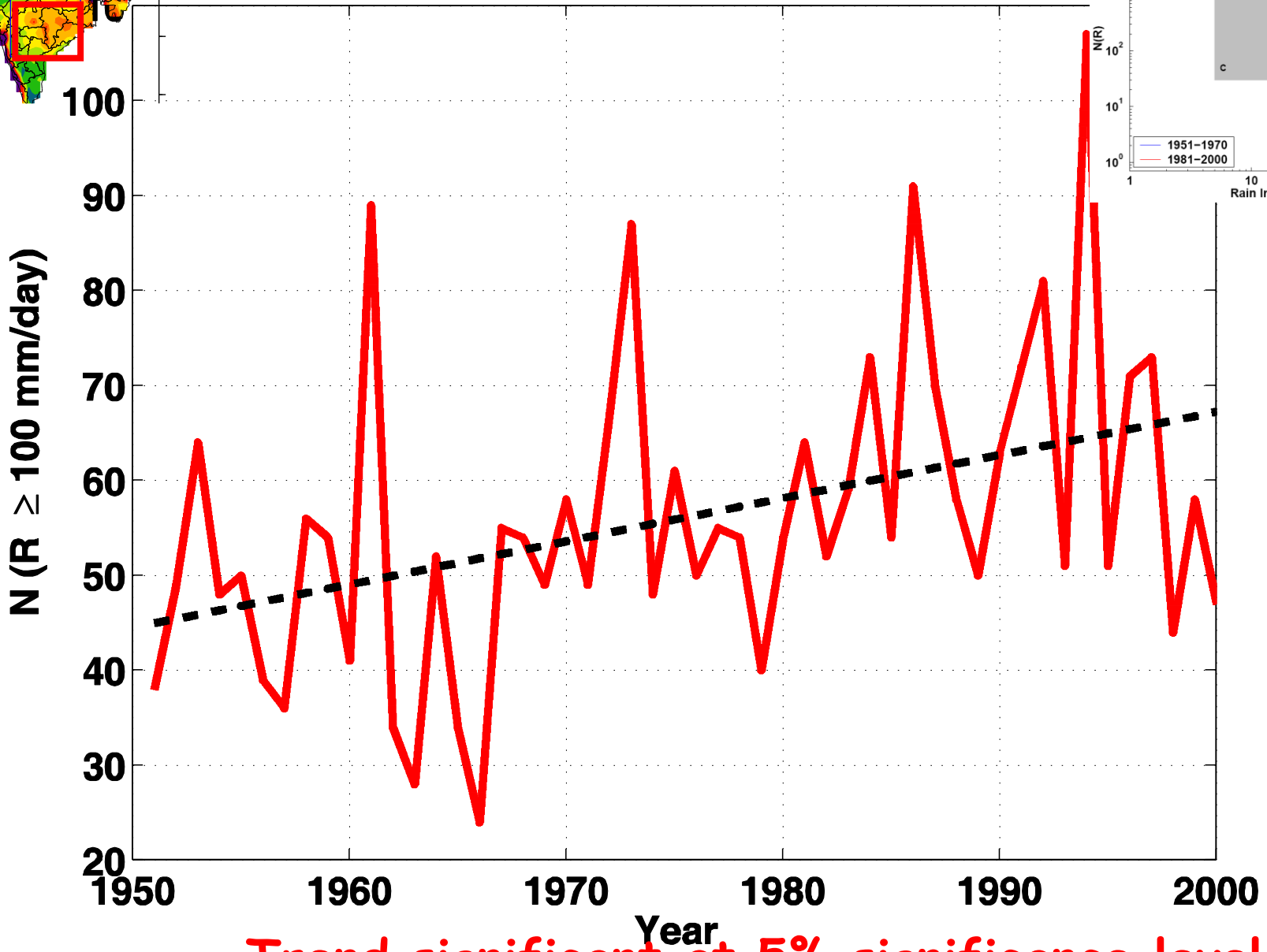
T (year)

12
10
8
6
4
2
0

Trends in "Extreme" Events







Trend significant at 5% significance level

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