AGU PUBLICATIONS

Reviews of Geophysics

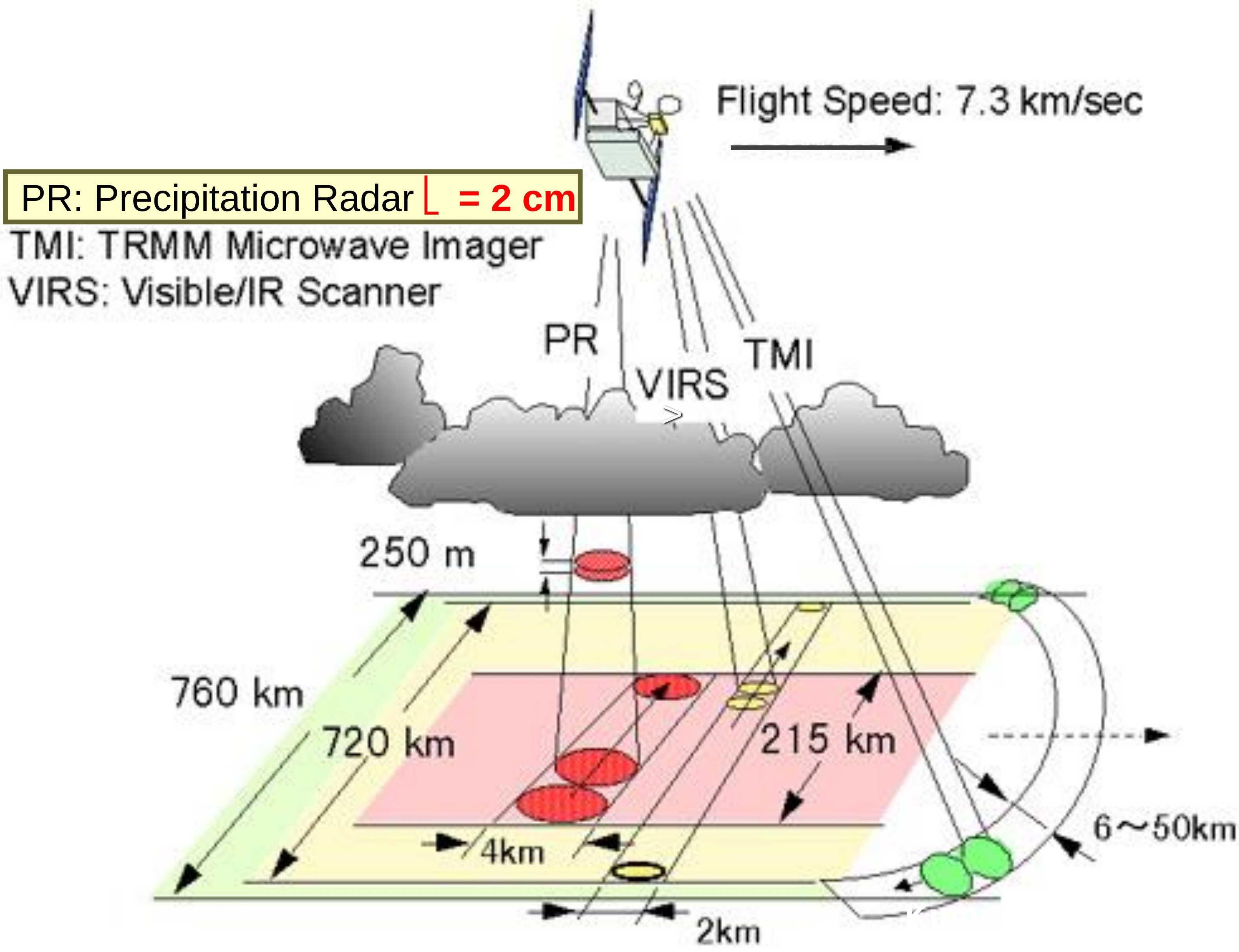
REVIEW ARTICLE

The variable nature of convection in the tropics and subtropics: A legacy of 16 years of the Tropical Rainfall Measuring Mission satellite

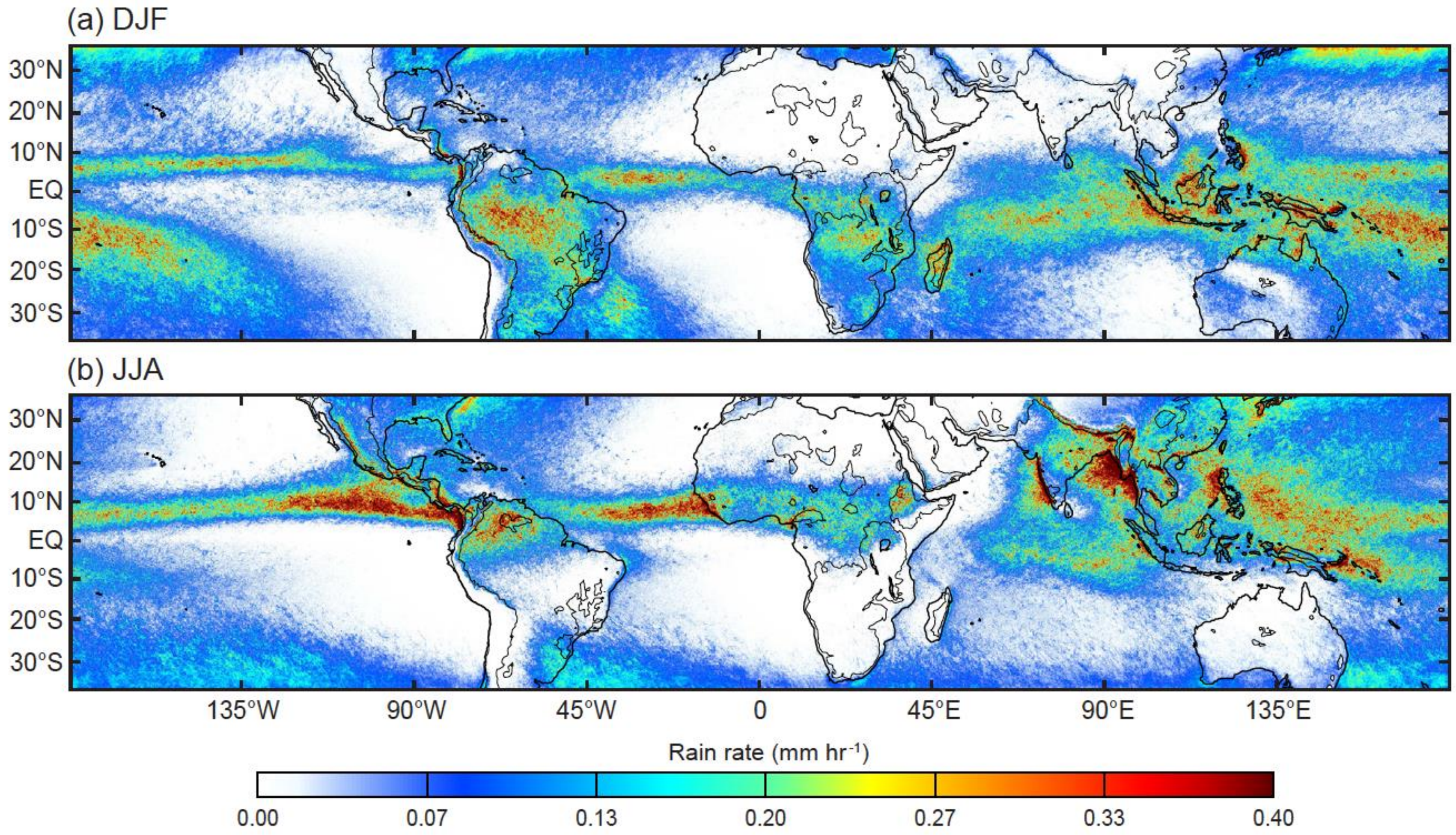
Robert A. Houze Jr.[1], Kristen L. Rasmussen[2], Manuel D. Zuluaga[3], and Stella R. Brodzik[1]

Presented at:
PNNL Seminar, 27 January 2016

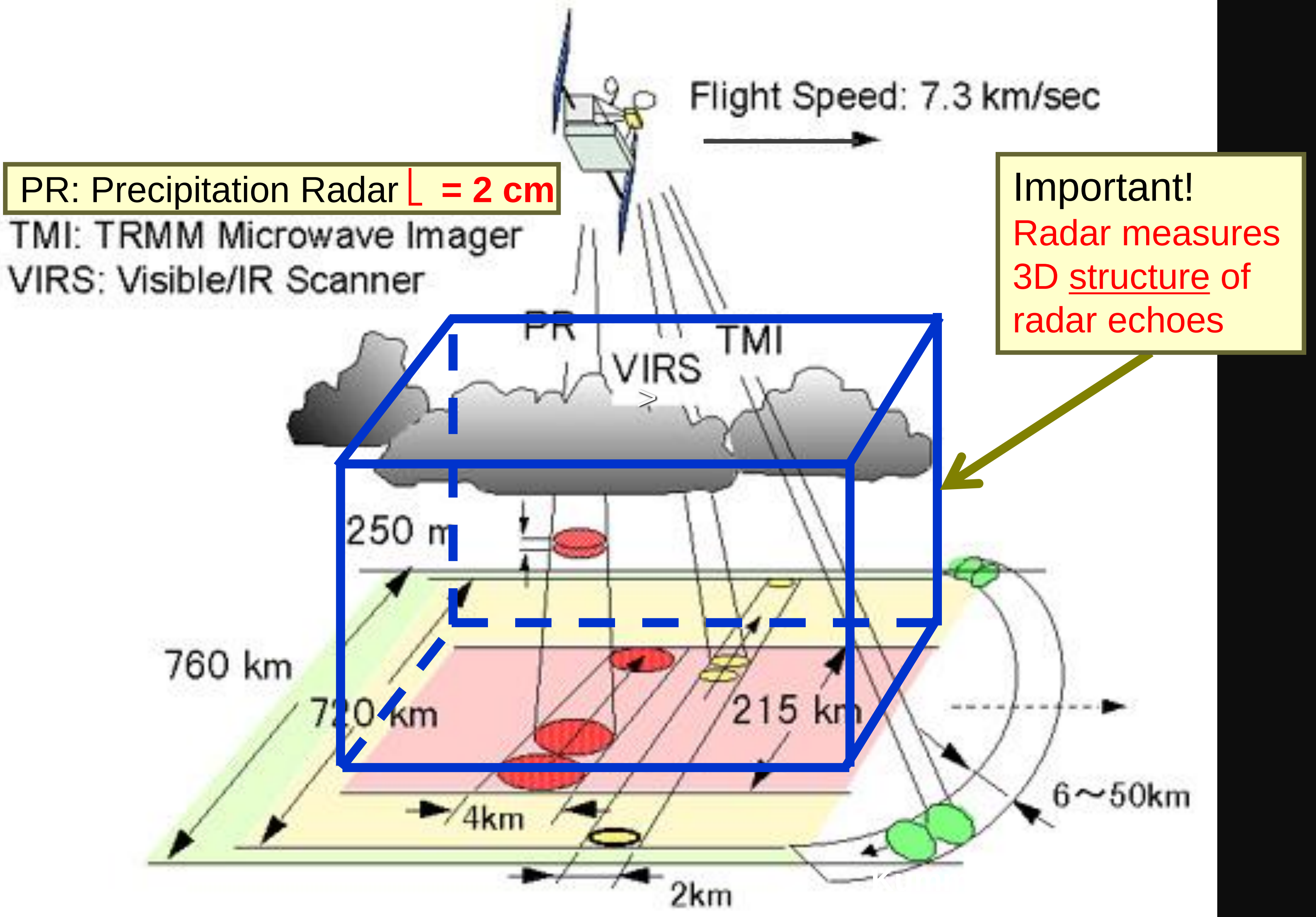
TRMM Instruments



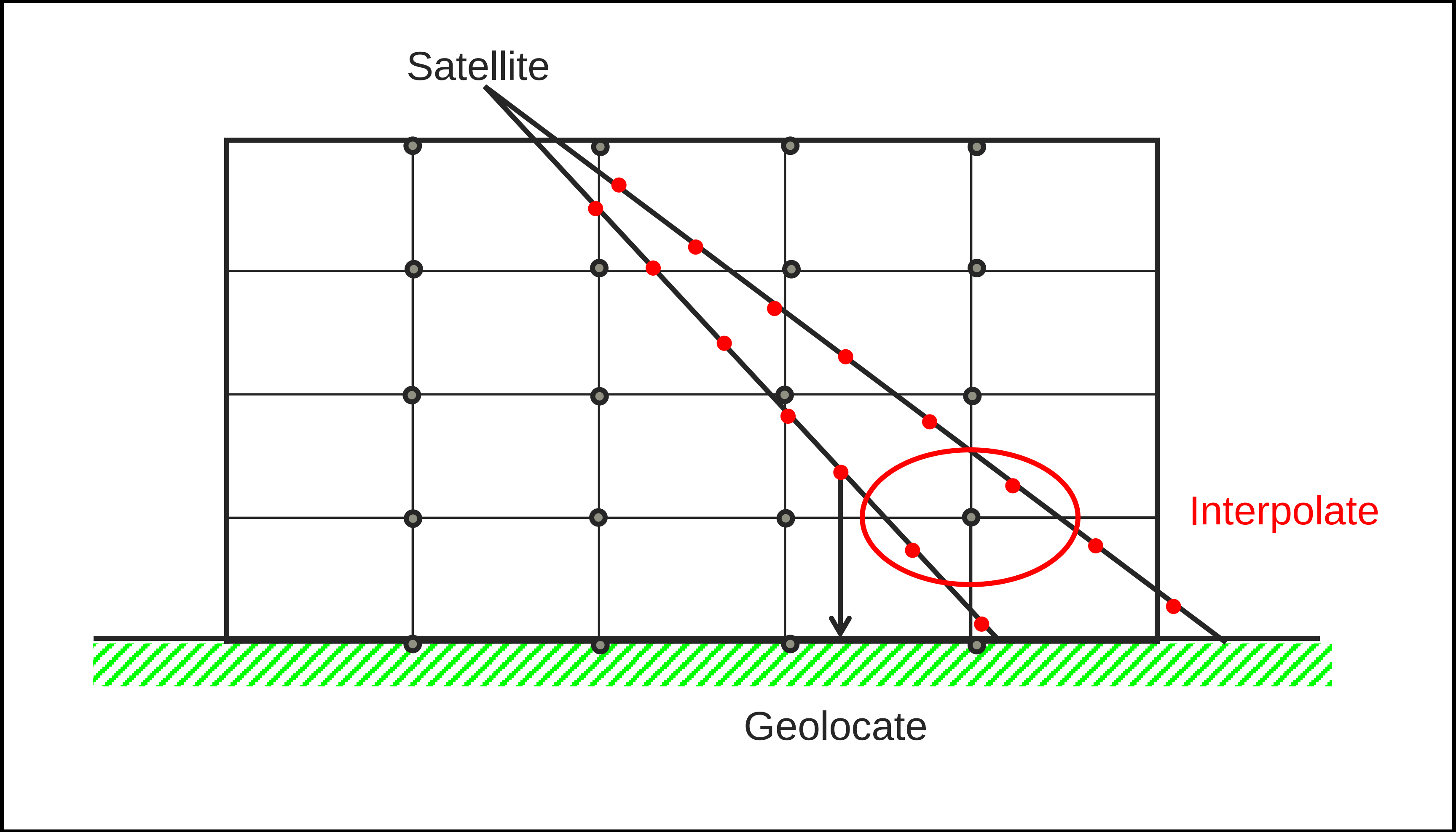
Rainfall from TRMM PR



TRMM Instruments

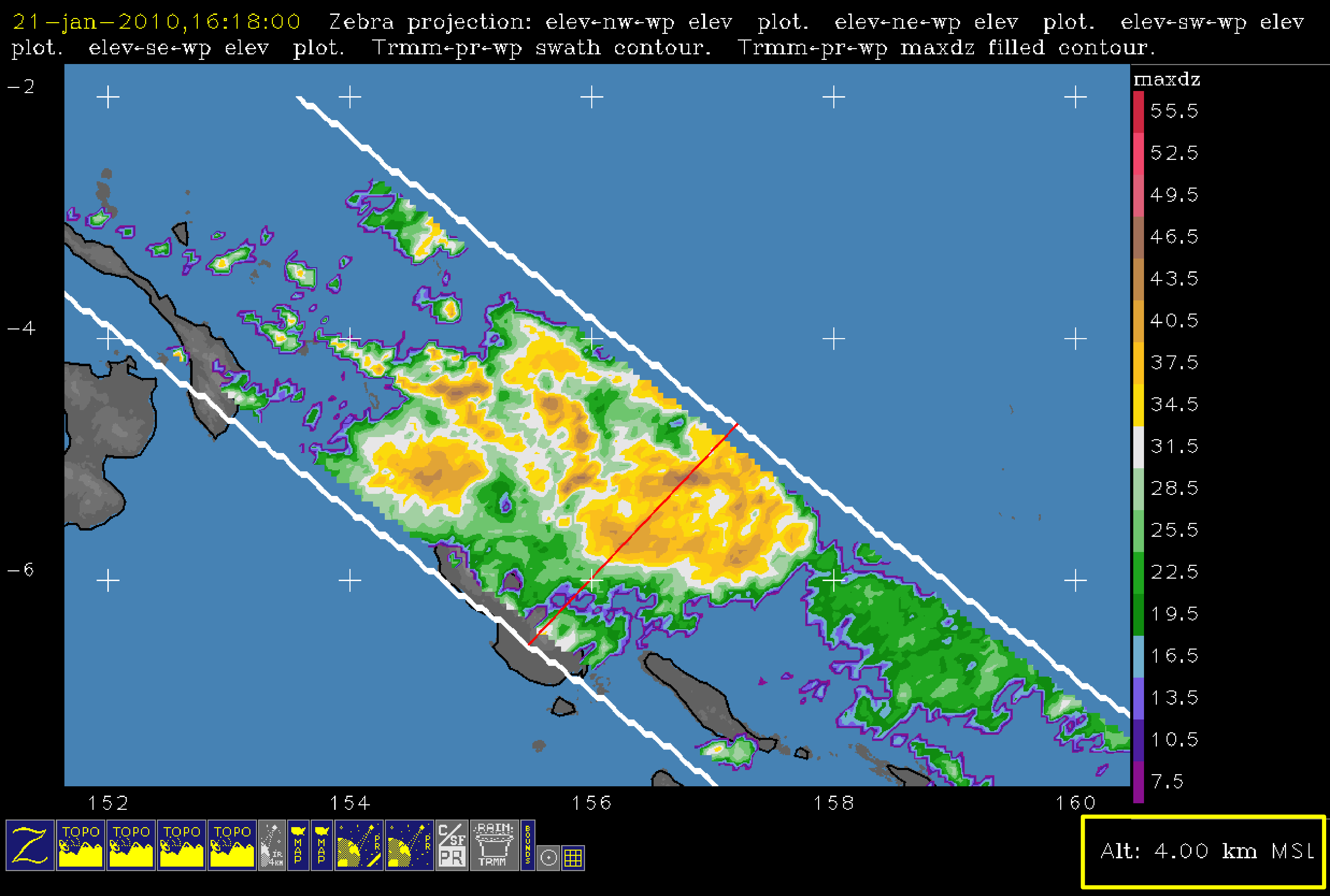


Re-map and interpolate the PR reflectivity field

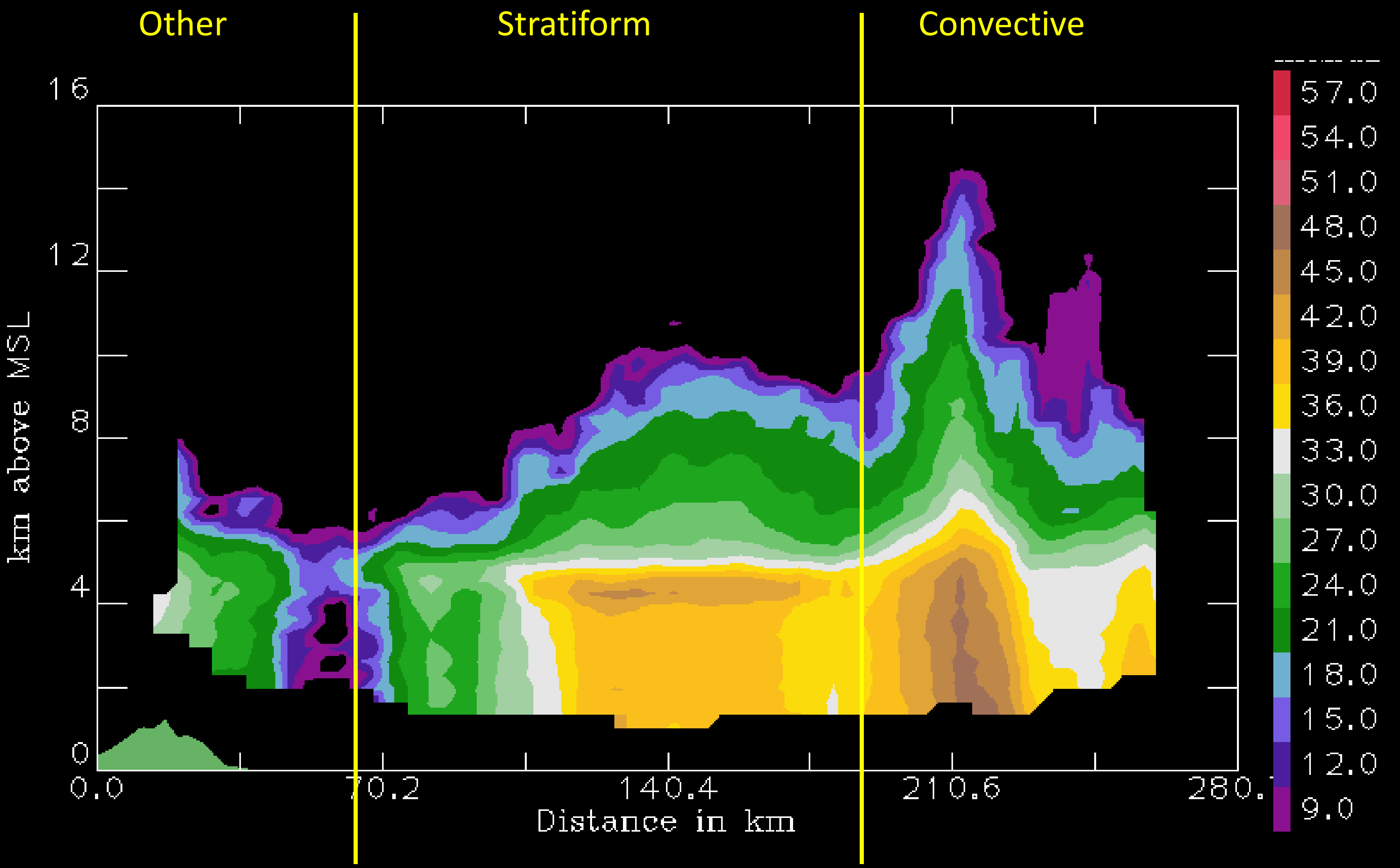


Use remapped & interpolated data to:

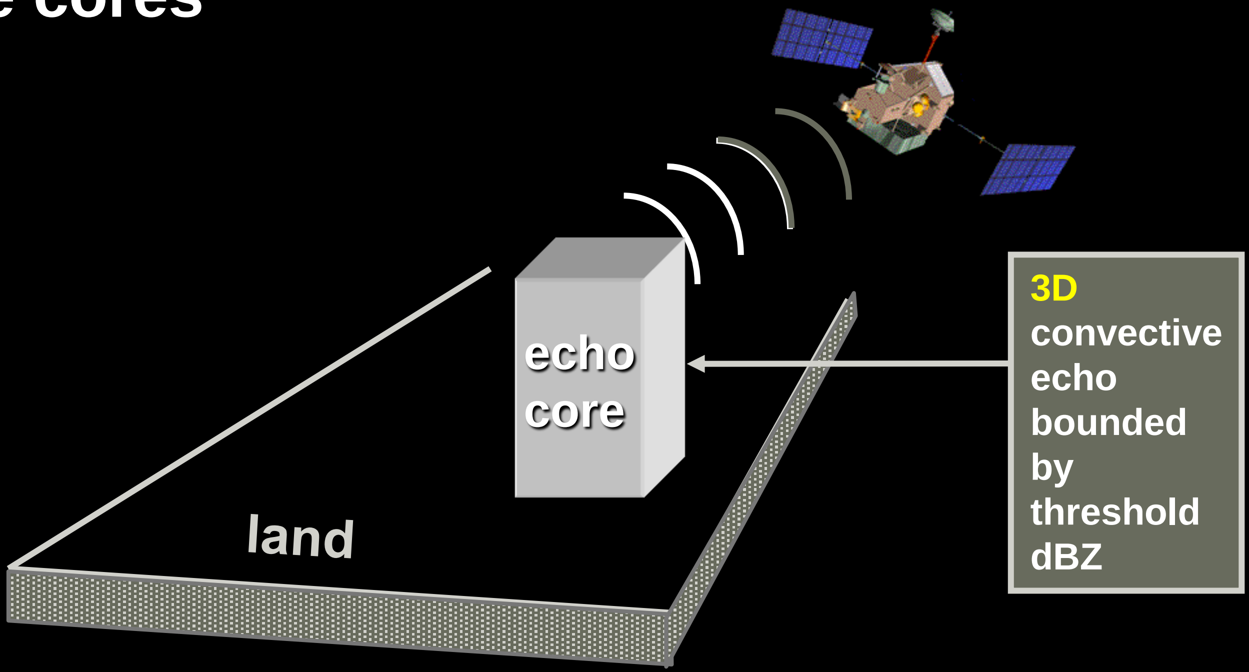
- View PR data in visualization software
- Objectively identify 3D echo objects indicative of convective lifecycle stage


21-jan-2010,16:18:00 Zebra projection: elev-nw-wp elev plot. elev-ne-wp elev plot. elev-sw-wp elev plot. elev-se-wp elev plot. Trmm-pr-wp swath contour. Trmm-pr-wp maxdz filled contour.
maxdz
55.5
52.5
49.5
46.5
43.5
40.5
37.5
34.5
31.5
28.5
25.5
22.5
19.5
16.5
13.5
10.5
7.5
-2
-4
-6
152
154
156
158
160
TOPO
TOPO
TOPO
TOPO
MAP
MAP
PR
PR
C/SF
PR
RAIN
TRMM
BOUNDS
Alt: 4.00 km MSL

TRMM algorithm subdivisions

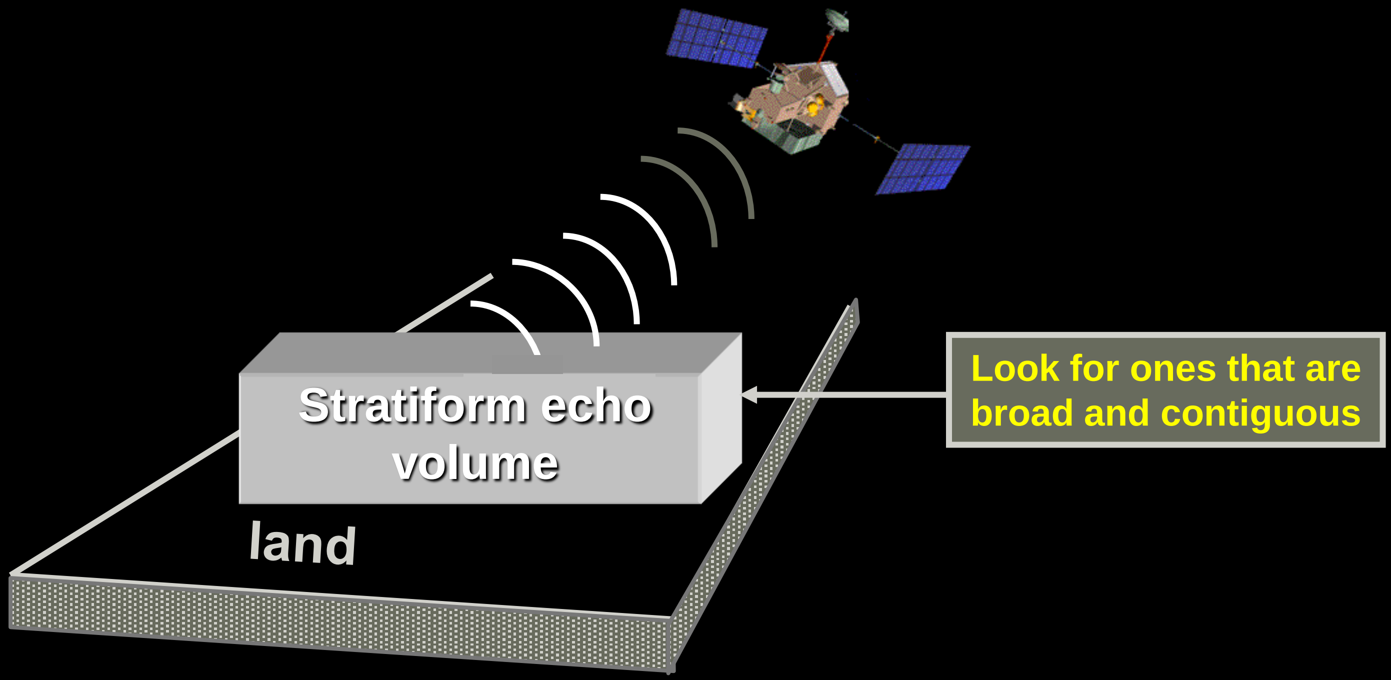


Convective cores



Type	Threshold	Width	Height
Shallow-isolated	17 dBZ	2 pixels	< 5 km
Deep-strong	40 dBZ		>10 km
Deep-moderate	30 dBZ		> 8 km
Wide-strong	40 dBZ	>1000 km^2	
Wide-moderate	30 dBZ	>800 km^2	

Broad stratiform regions



Type	Width
Strong	> 50,000 km^2
Moderate	> 30,000 km^2

Terminology:

ISE—isolated shallow echoes
DCC—deep convective cores
WCC—wide convective cores
BSR—broad stratiform regions

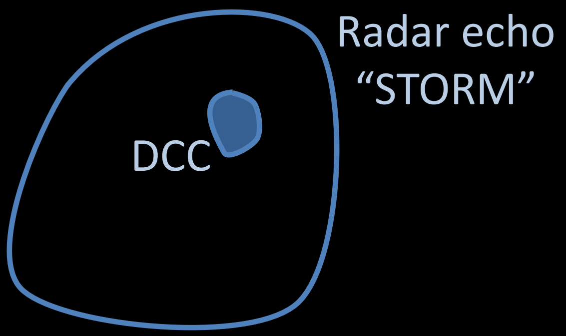
More terminology:

We call a contiguous radar echo a “storm”

Note:

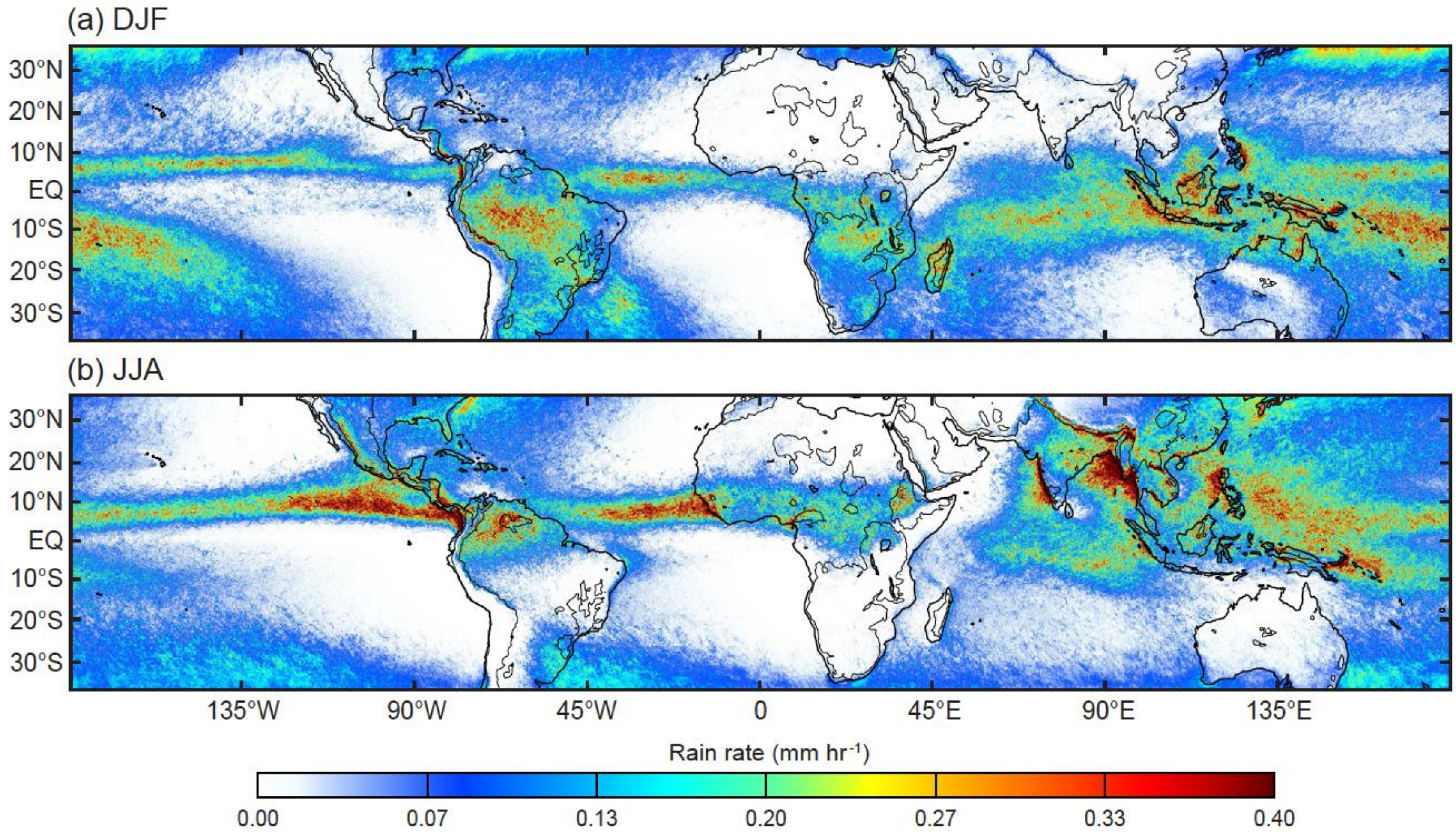
A storm may or may not contain a DCC, WCC, or BSR

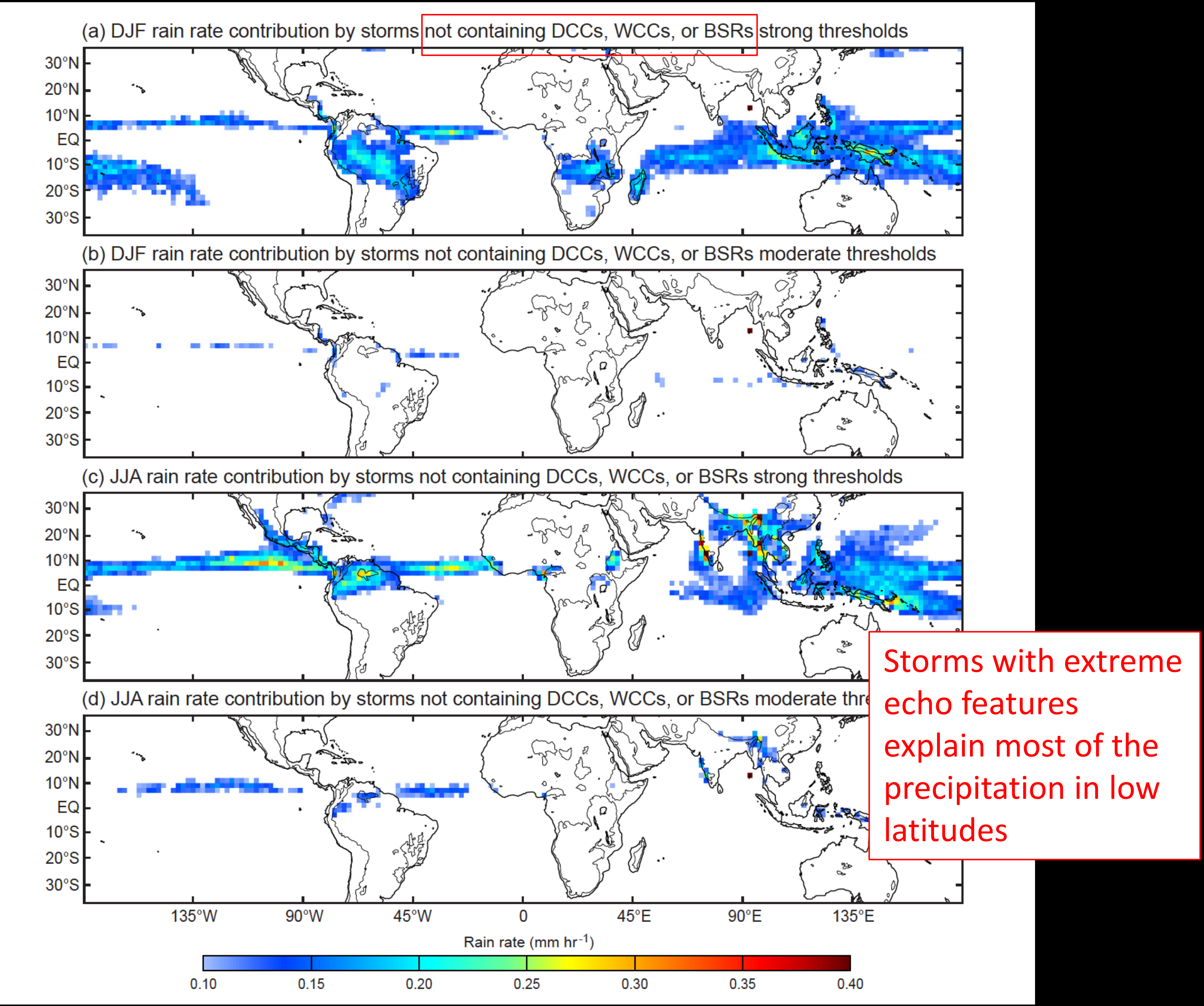
For example:



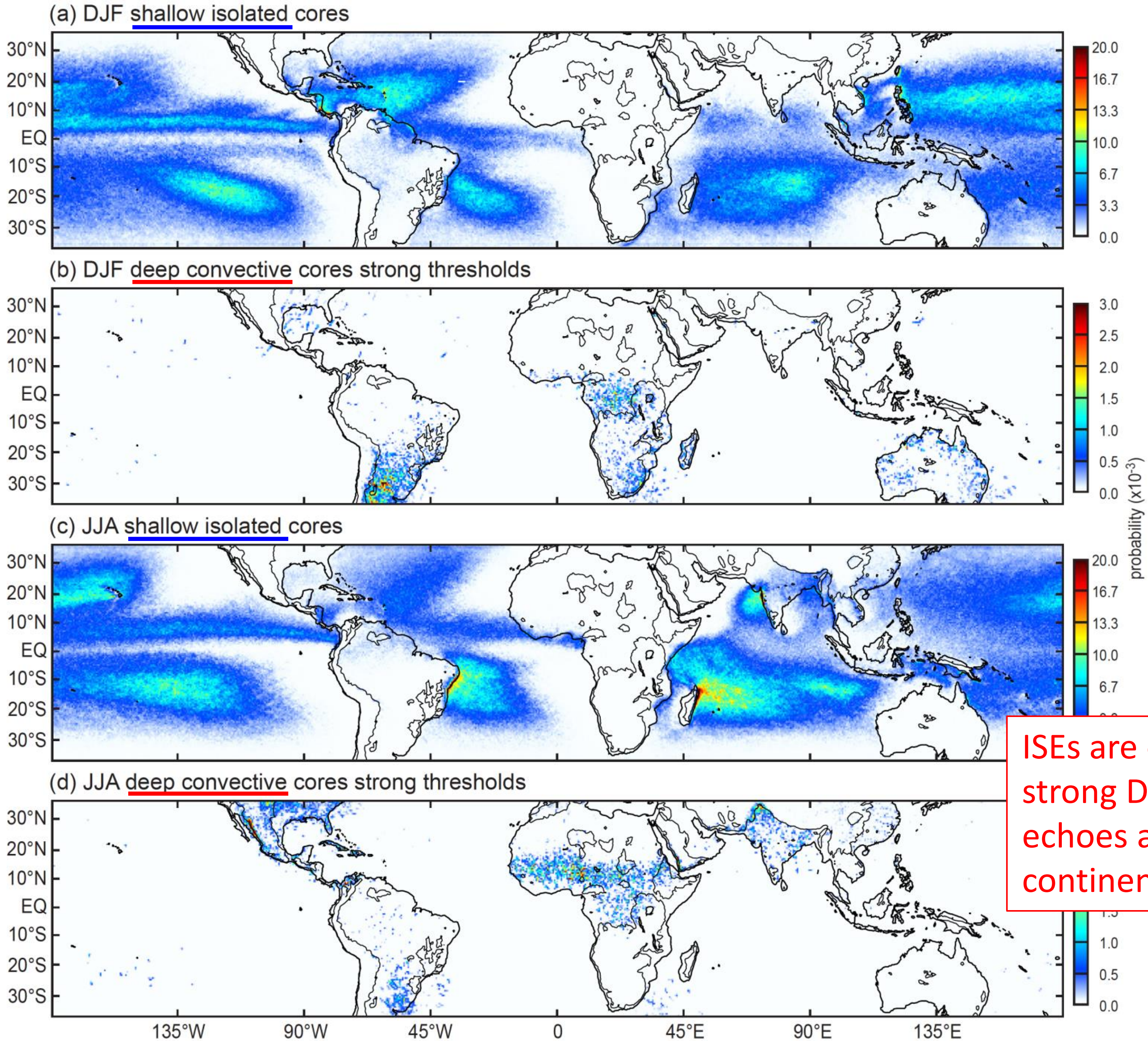
Recall

Rainfall from TRMM PR



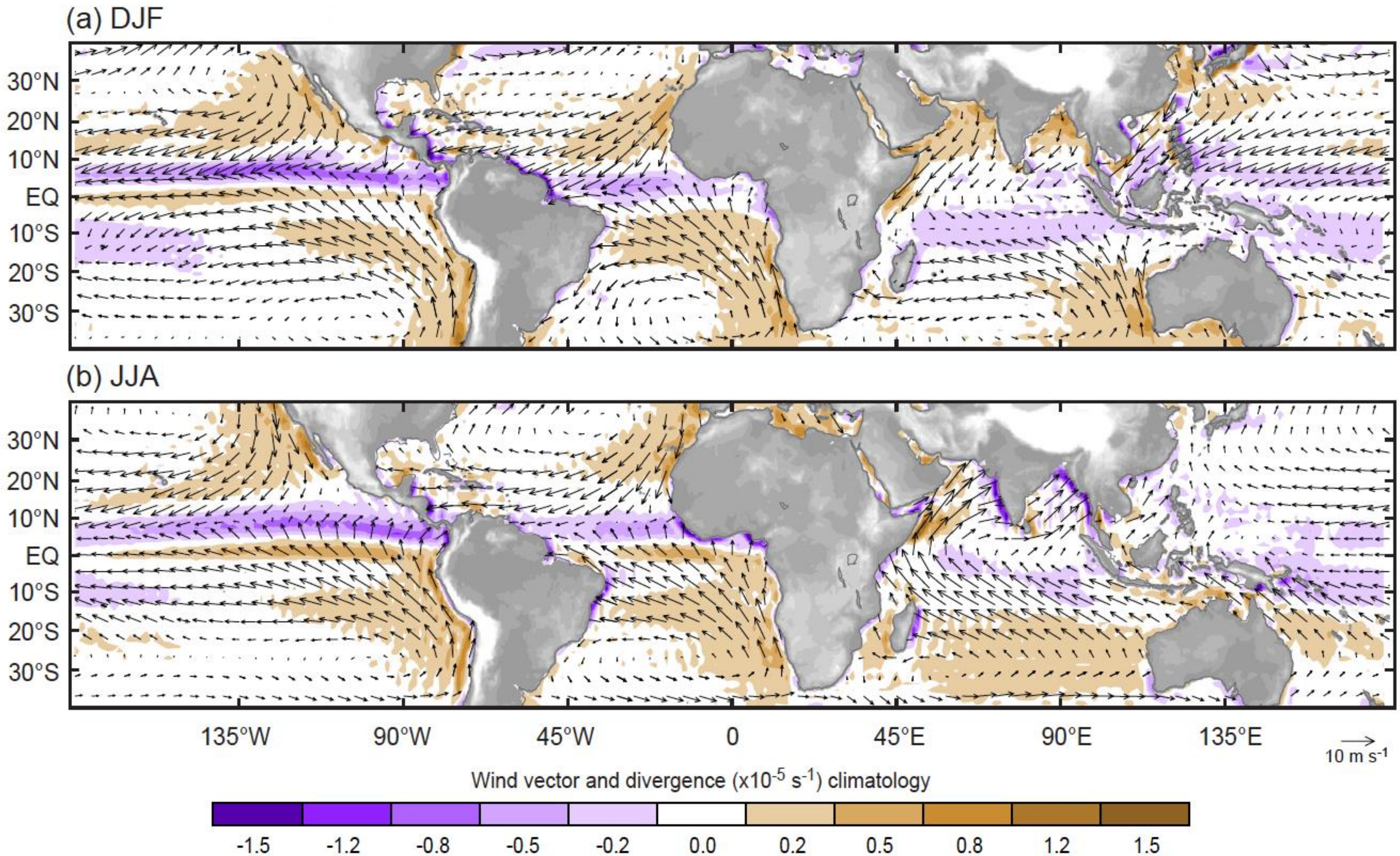

(a) DJF rain rate contribution by storms not containing DCCs, WCCs, or BSRs strong thresholds
(b) DJF rain rate contribution by storms not containing DCCs, WCCs, or BSRs moderate thresholds
(c) JJA rain rate contribution by storms not containing DCCs, WCCs, or BSRs strong thresholds
(d) JJA rain rate contribution by storms not containing DCCs, WCCs, or BSRs moderate thre
30°N
20°N
10°N
EQ
10°S
20°S
30°S
135°W
90°W
45°W
0
45°E
90°E
135°E
Rain rate (mm hr^{-1})
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Storms with extreme echo features explain most of the precipitation in low latitudes

The next few slides are maps of the frequency of occurrence of ISEs, DCCs, WCCs , and BSRs defined by both the strong and moderate thresholds



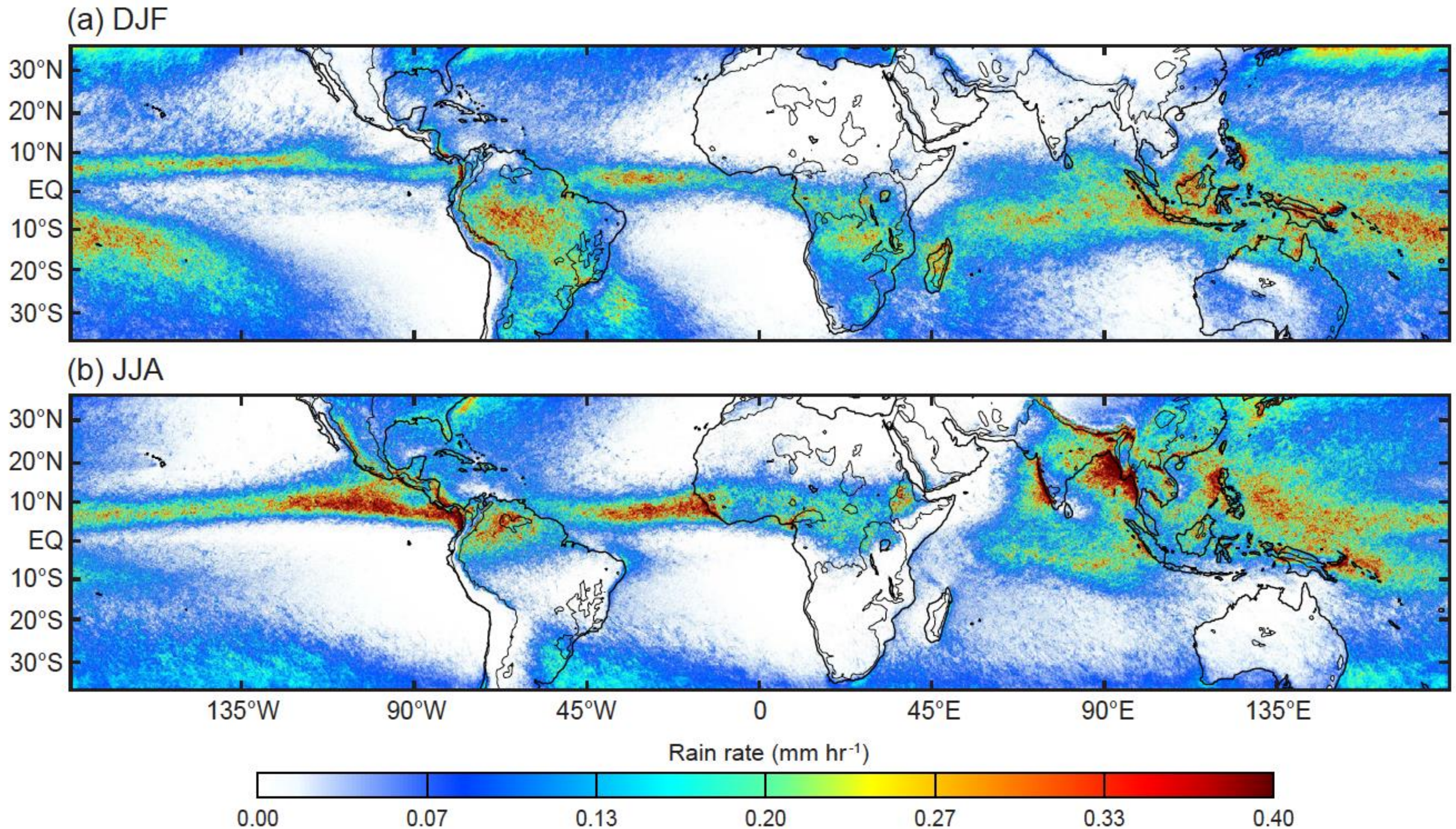
ISEs are oceanic; strong DCC echoes are continental

1000 hPa Climatology

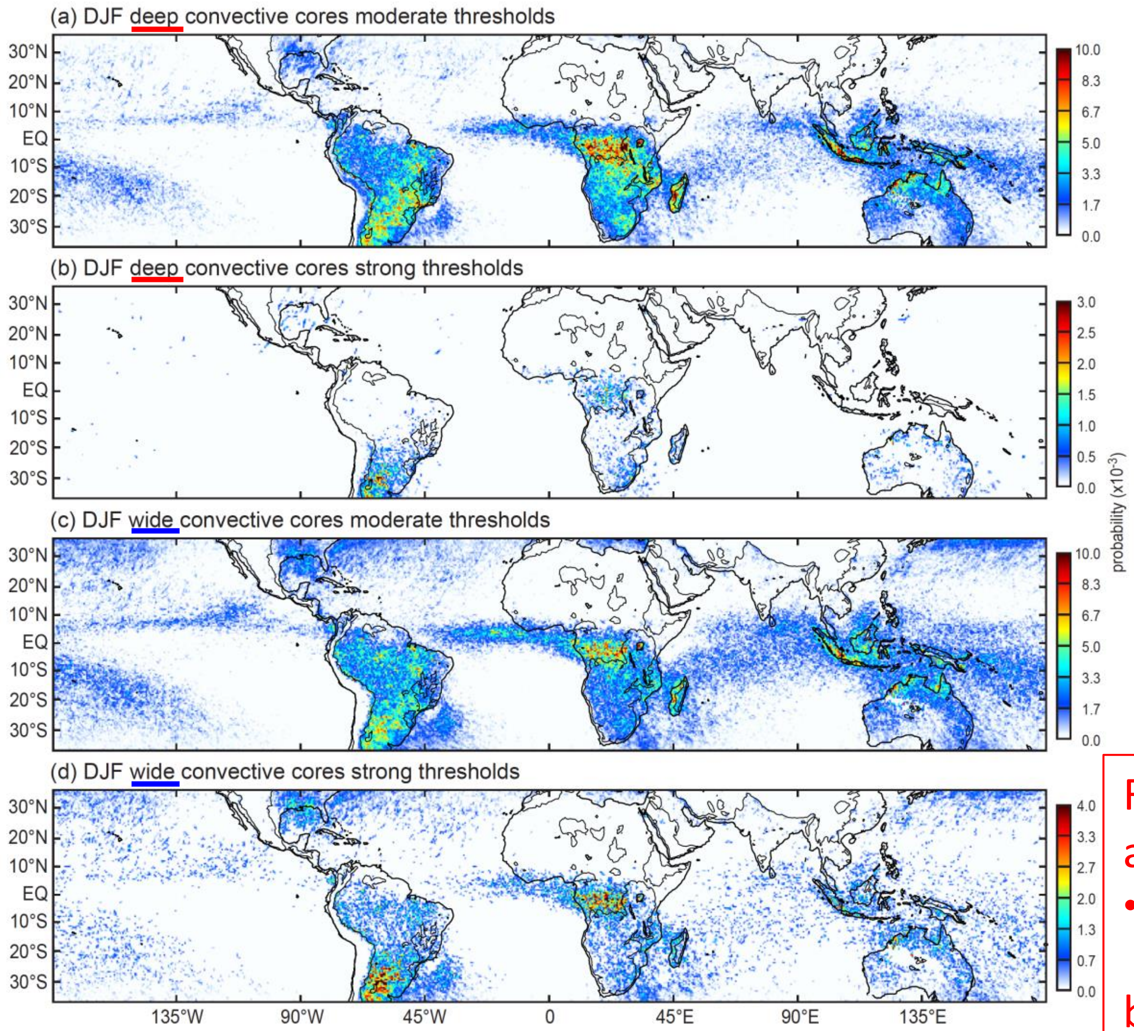


Recall

Rainfall from TRMM PR



Deep and wide convective cores in DJF



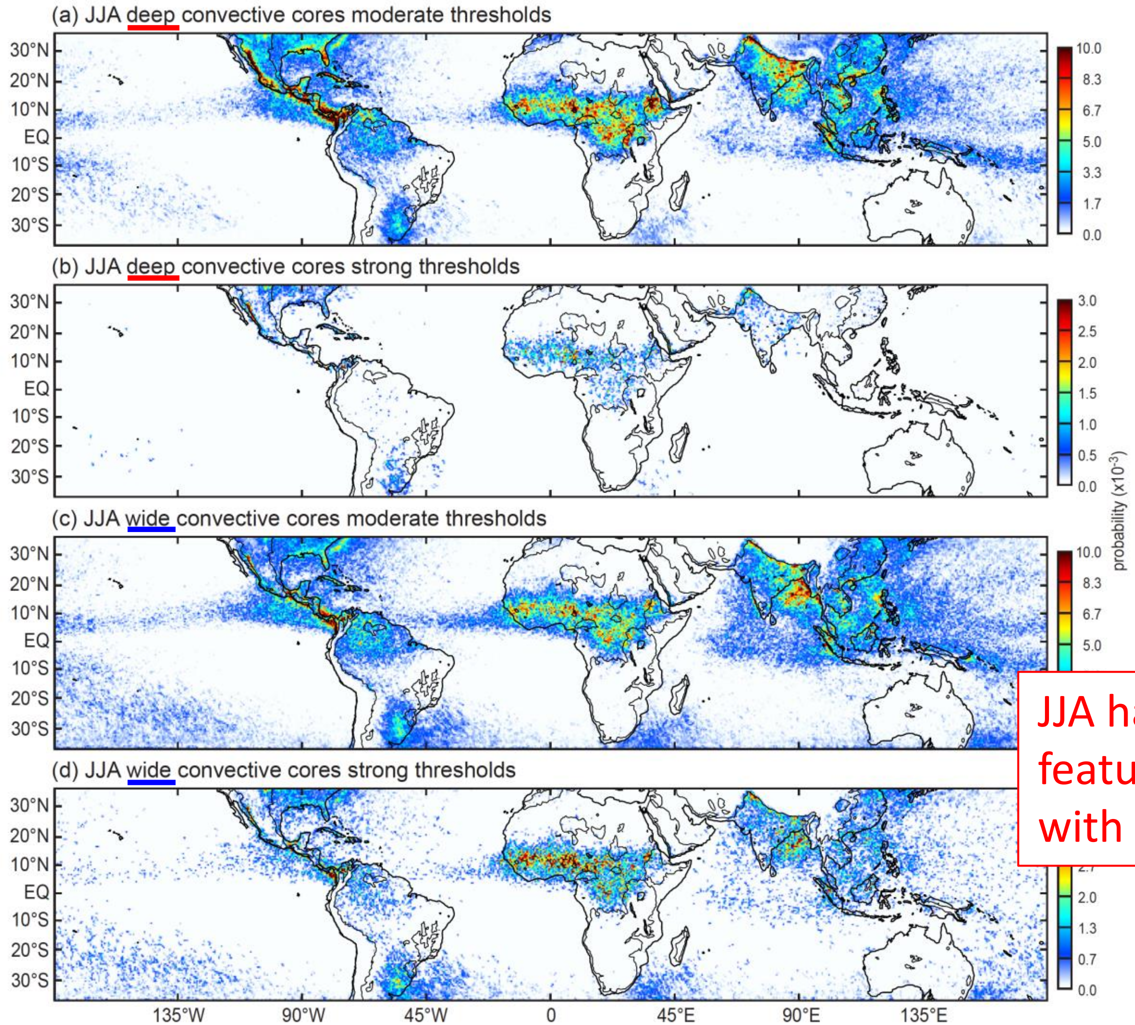
Raininess is associated with

- mesoscale organization

but not

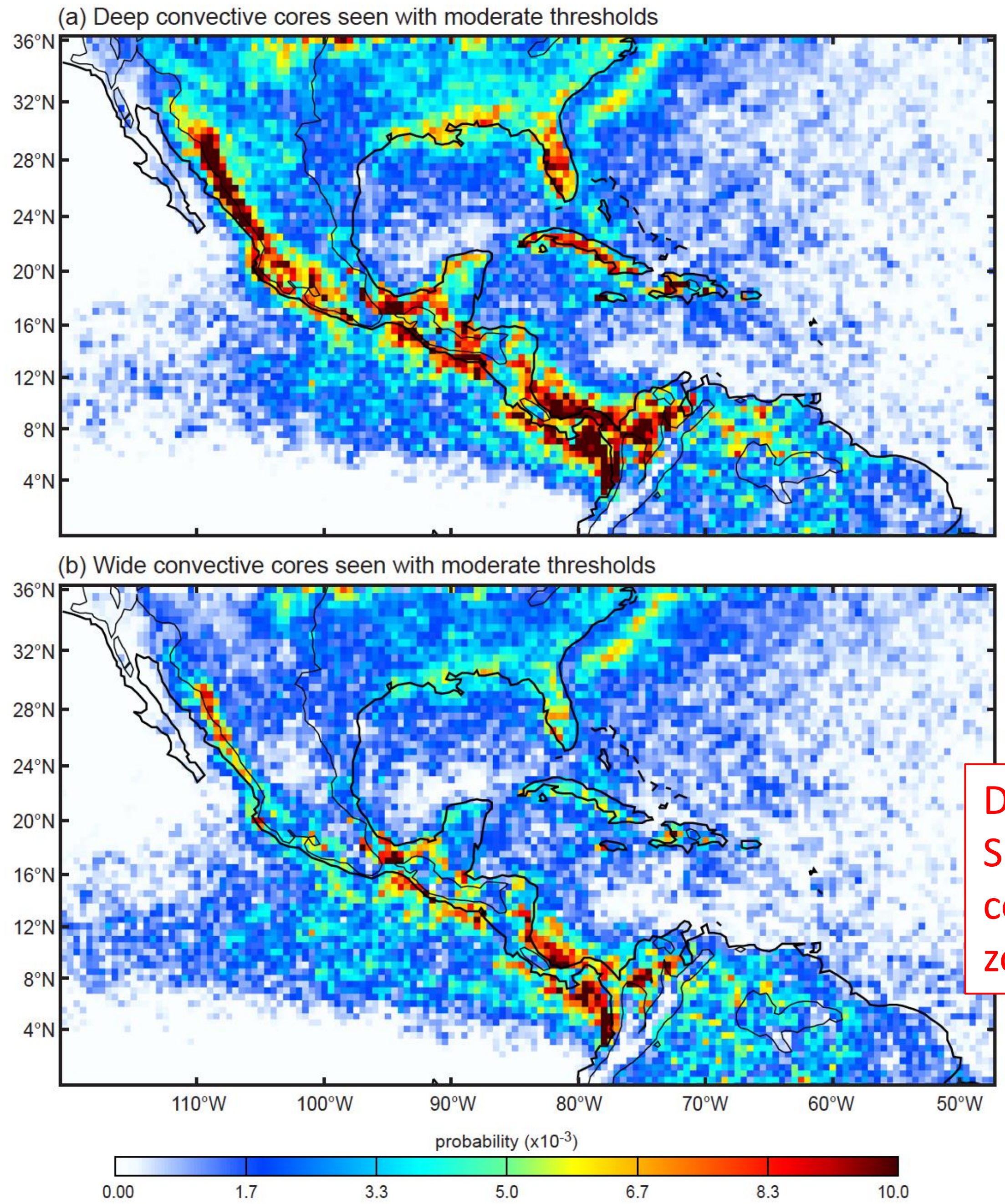
- intensity of convection

Deep and wide convective cores in JJA



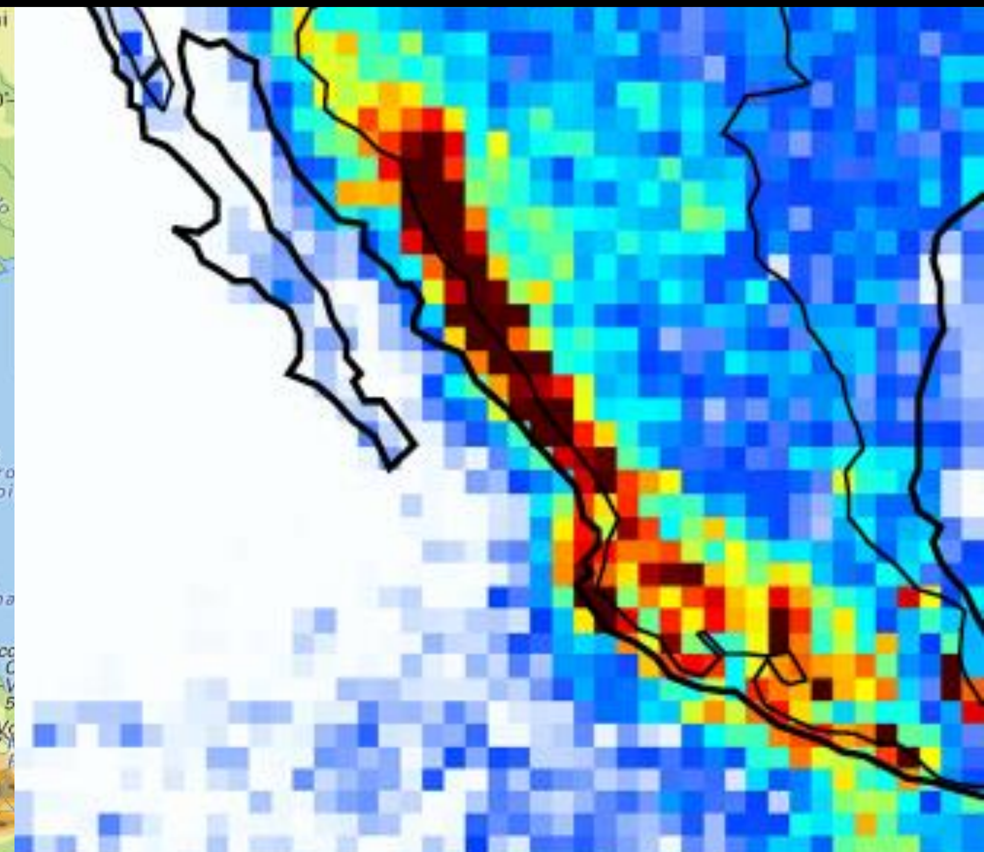
JJA has additional features associated with monsoons

American Monsoon

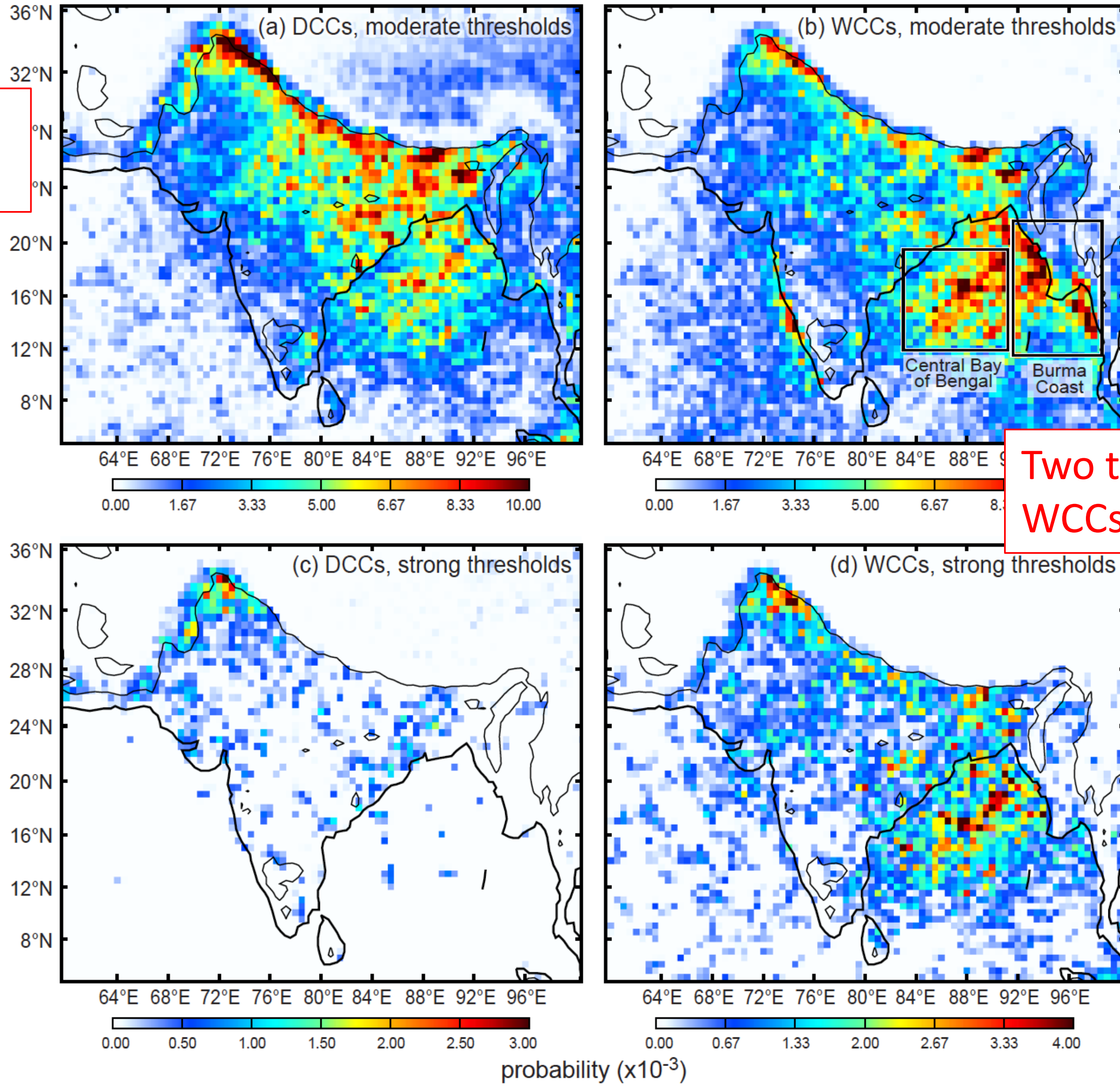


DCC & WCC over Sierra Madre and coastal convergence zones


SIERRA SAN PEDRO MARTIR
115°
110°
0 100 200 300 400 mi
0 200 400 600 km
30°
Ciudad Juárez
Pecos
Rio Grande
Carmen
UNITED STATES
Colorado
BAJA CALIFORNIA
Gulf of California
Conchos
Amistad Reservoir
San Antonio
Mayo
Fuerte
Sinaloa
COBRE CANYON
MAPIMÍ BASIN
Hidalgo del Parral
SIERRA
Culiacán
Nazas
MESA DEL NORTE
Falcon Reservoir
25°
Monterrey
MEXICO
MEXICAN PLATEAU
SIERRA
Durango
Mt. Peña Nevada 3660
Vicente Guerrero Reservoir
Mazatlán
MADRE
Fresnillo
PACIFIC OCEAN
San Luis Potosí
MADRE
OCCIDENTAL
Pánuco
León
Guanajuato
Moctezuma
Guadalajara
Mt. Colima 4240
Lake Chapala
ORIENTAL
20°
110°
Colima Volcano 3820
Paricutín 2808
Mexico City
Mt. Iztacc 5230
Mt. Toluca 4680
Puebla
Infiernillo Reservoir
Balsas
Popocatépetl 5465
SIERRA MADRE DEL SUR
SOUTHERN HIGHLANDS
OAXACA VALLEY
ELEVATION
metres feet
3000 9,843
2000 6,562
1000 3,281
500 1,640
200 656
0 0
International boundaries
State boundaries
Intermittent rivers
Dams
Spot elevations in metres
© 2011 Encyclopædia Britannica, Inc.
100°

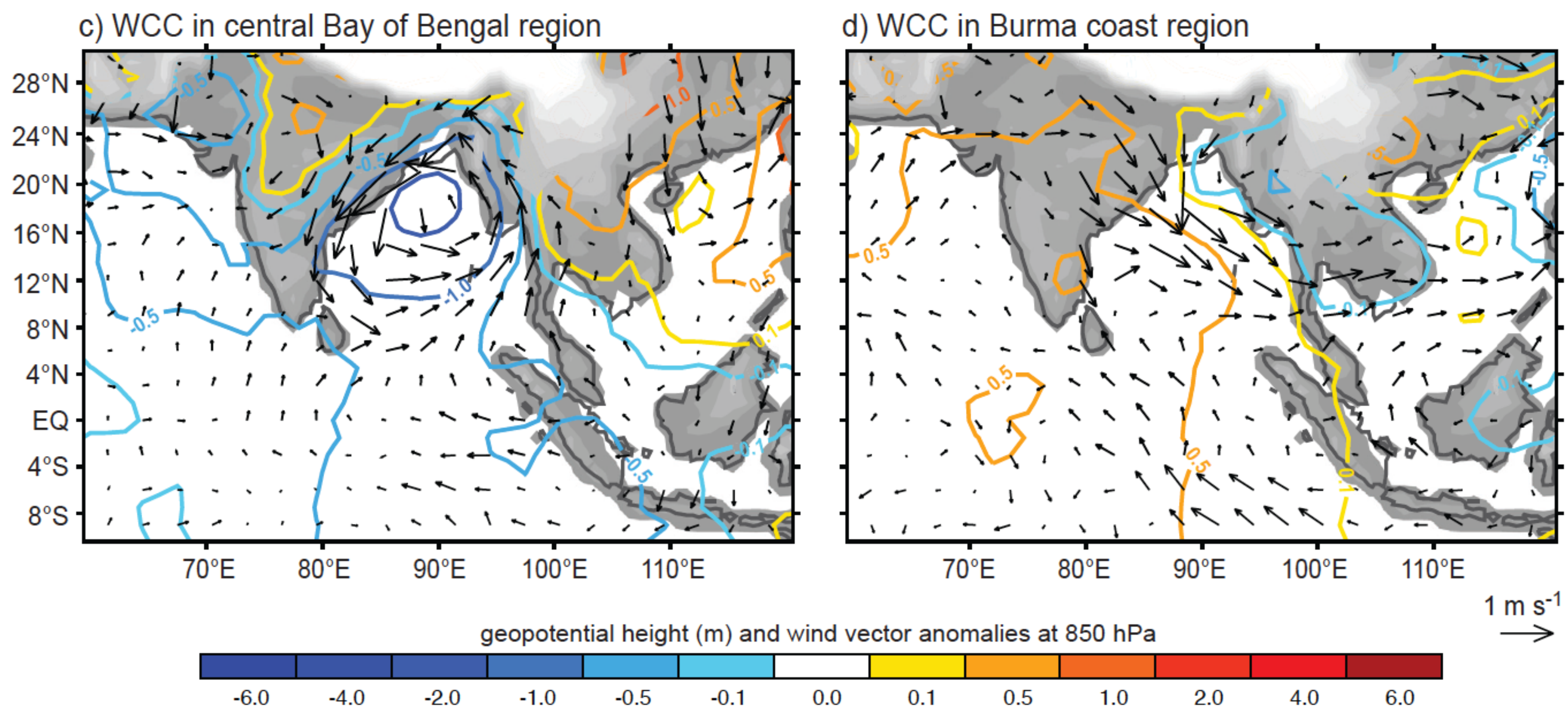


Asian Monsoon



Two types of WCCs

Composite 850 hPa Anomaly Fields



Extensive stratiform precipitation regions develop when well organized mesoscale convective systems reach a mature stage.

BSRs occur in regions where upscale development of mesoscale convection occurs

Is that all?

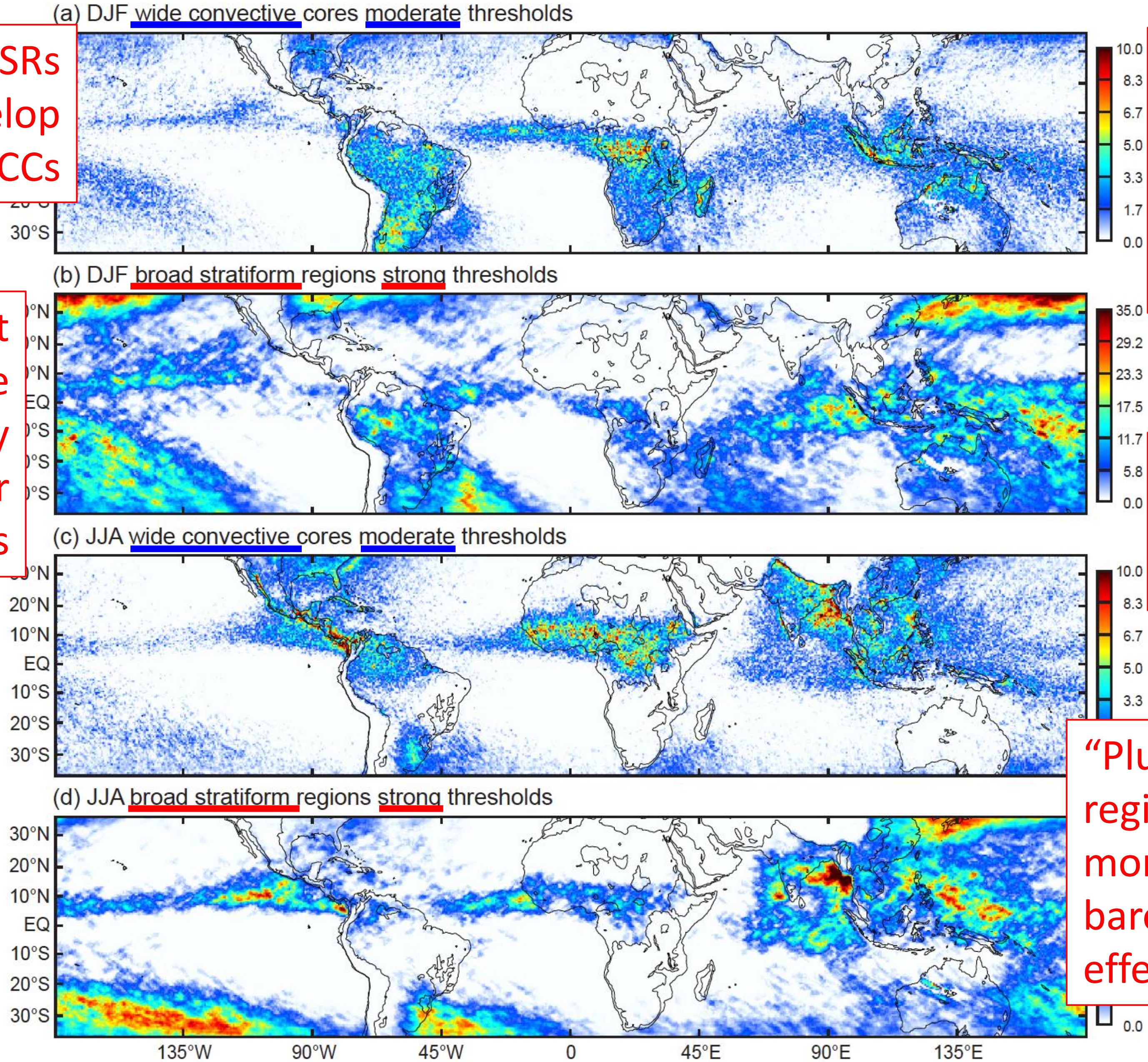
Strong BSRs develop from WCCs

Fronts produce BSRs in winter in subtropics

Manifest more strongly over oceans

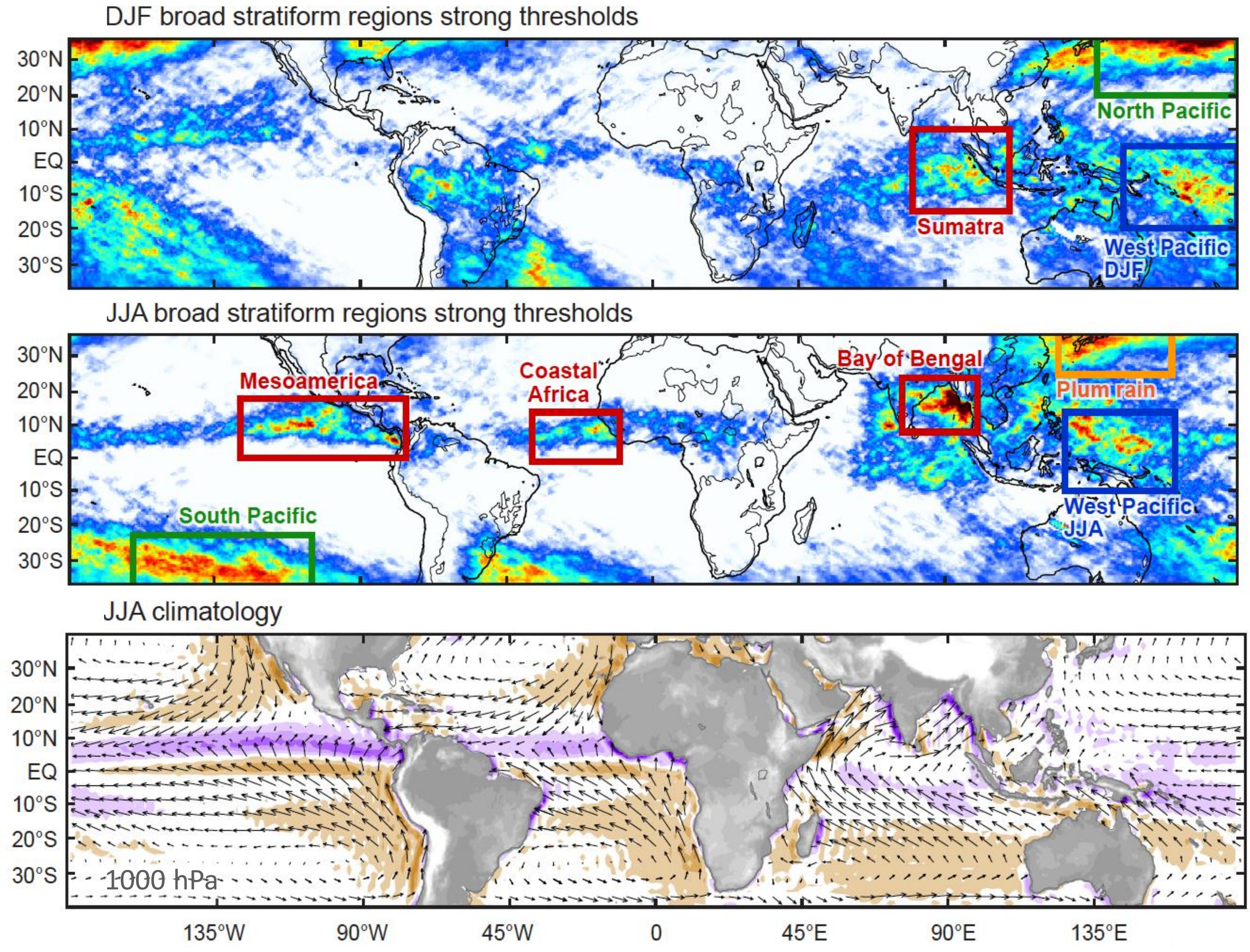
Monsoon regions different?

“Plum rain” region in JJA: monsoon + baroclinic effects



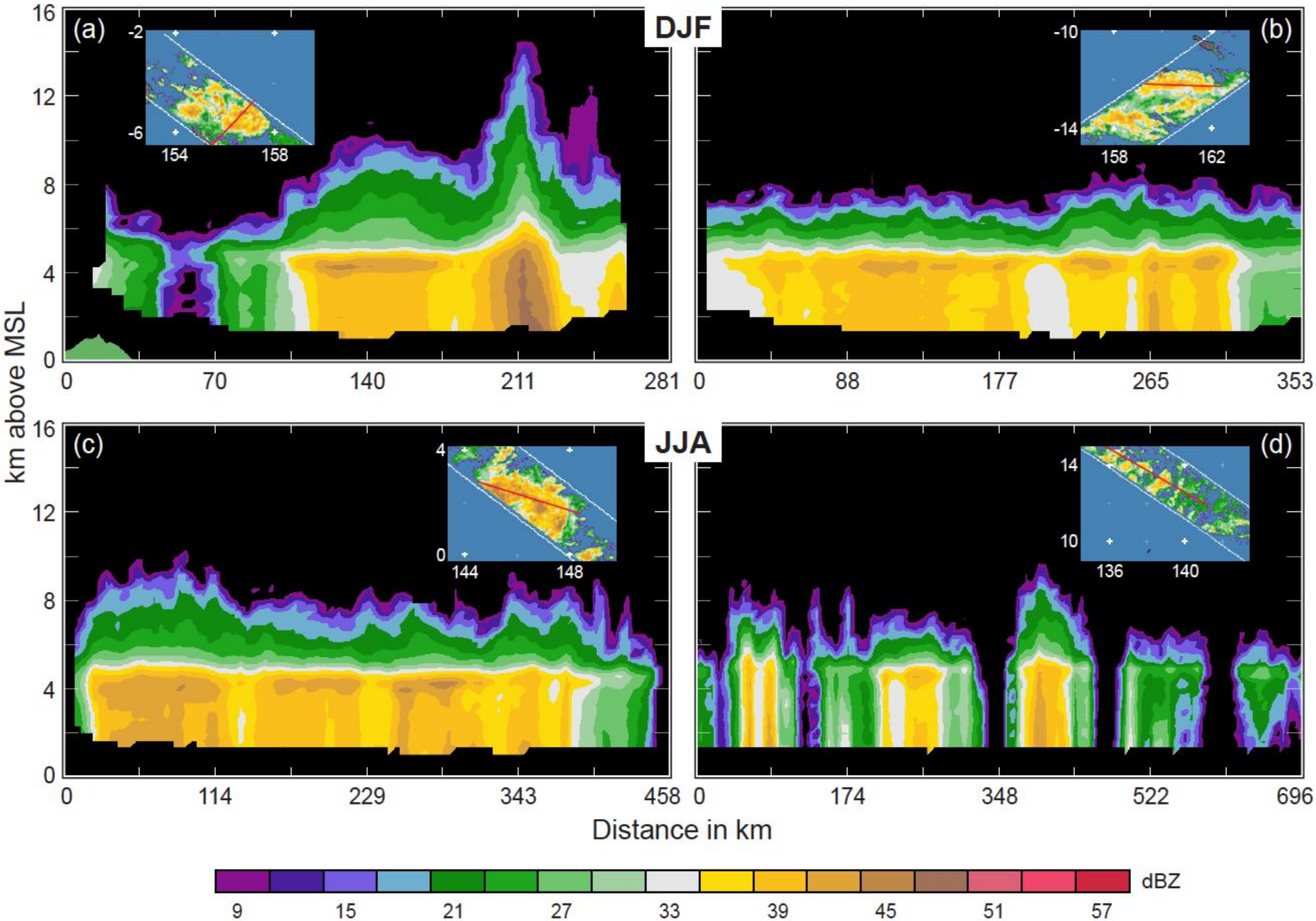
The stratiform radar echo structures vary regionally!

This has implications for assumptions about latent heating distributions in the tropics

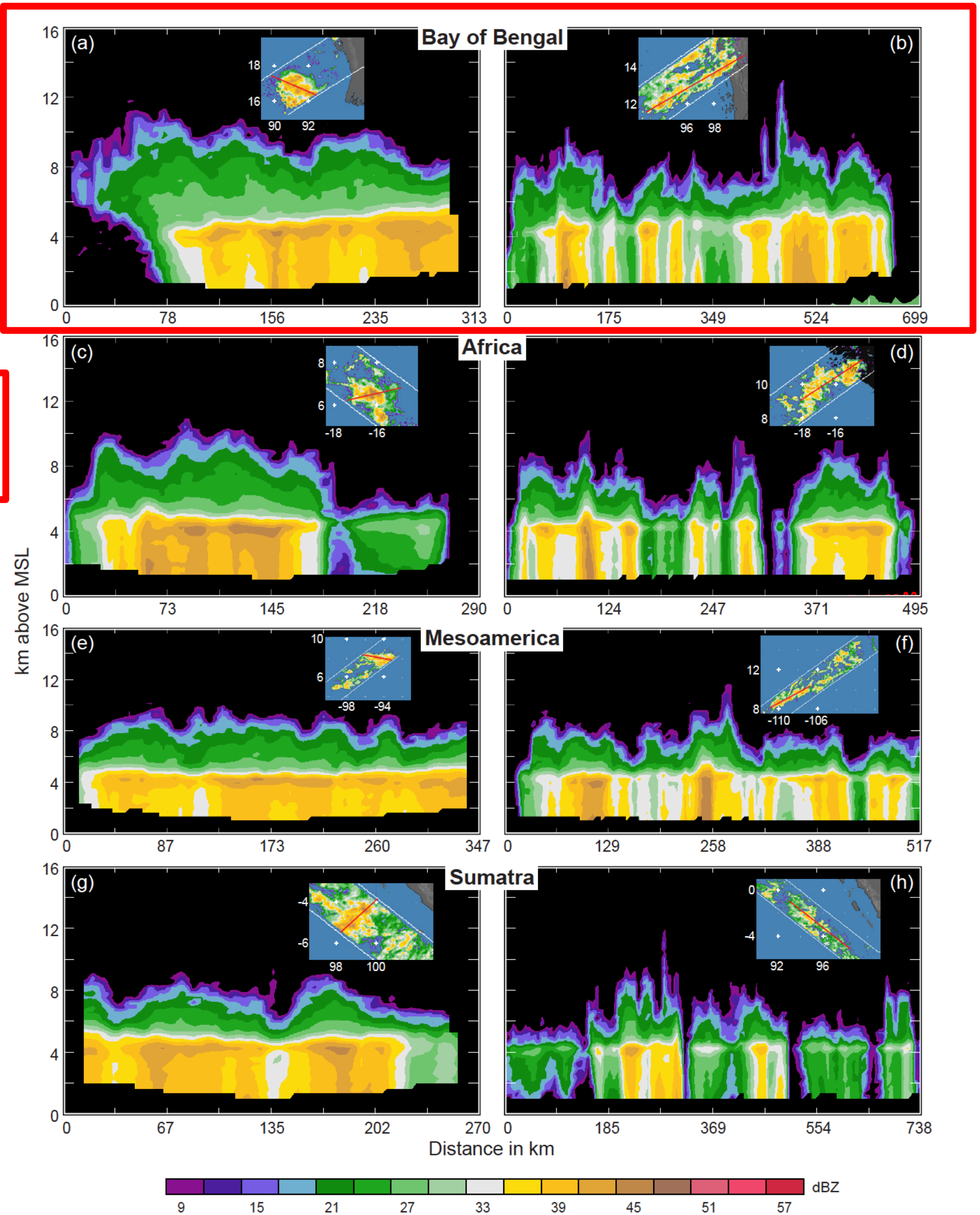

DJF broad stratiform regions strong thresholds
North Pacific
Sumatra
West Pacific DJF
JJA broad stratiform regions strong thresholds
Mesoamerica
Coastal Africa
Bay of Bengal
Plum rain
West Pacific JJA
South Pacific
JJA climatology
1000 hPa
30°N
20°N
10°N
EQ
10°S
20°S
30°S
135°W
90°W
45°W
0
45°E
90°E
135°E

Next we will look at some vertical cross sections obtained from the Zebra visualization software to see the different kinds of structures exhibited by the BSR echoes

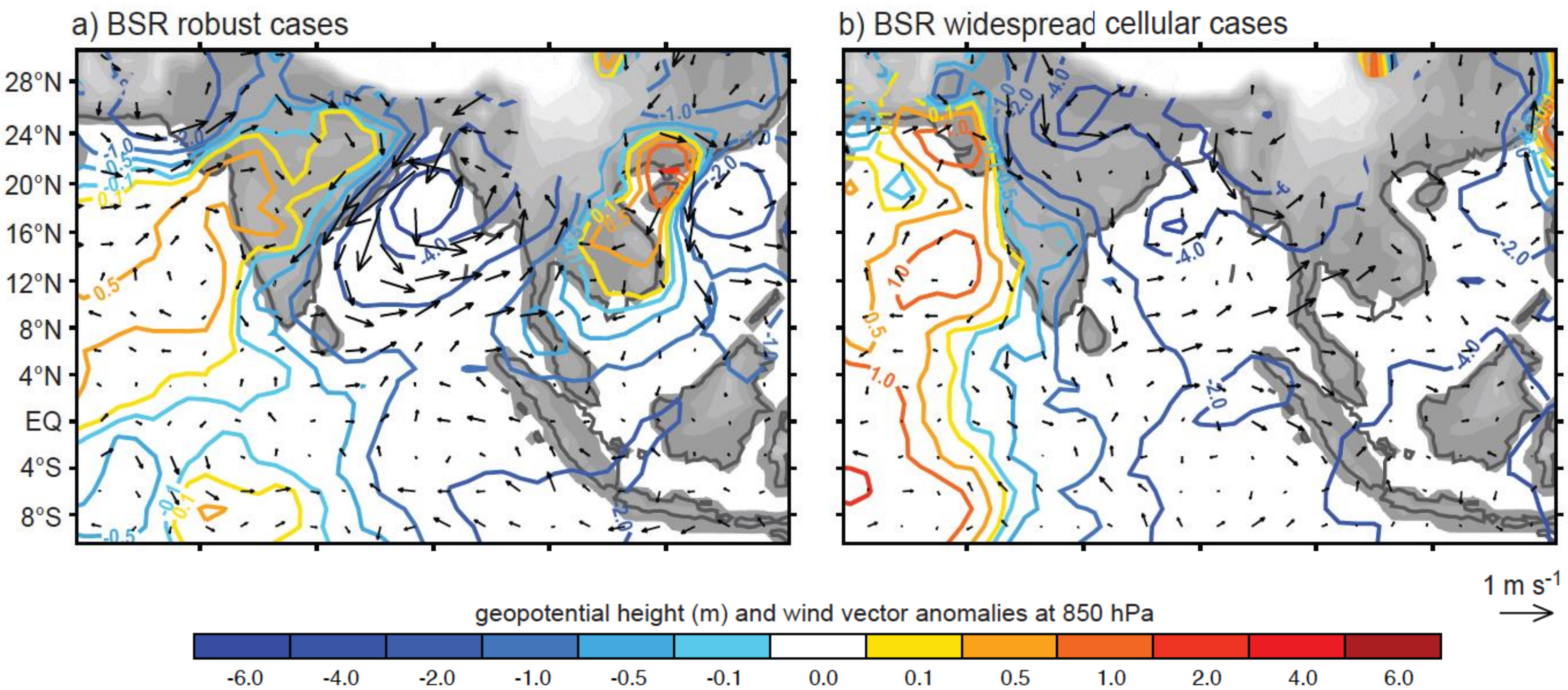
West Pacific Warm Pool



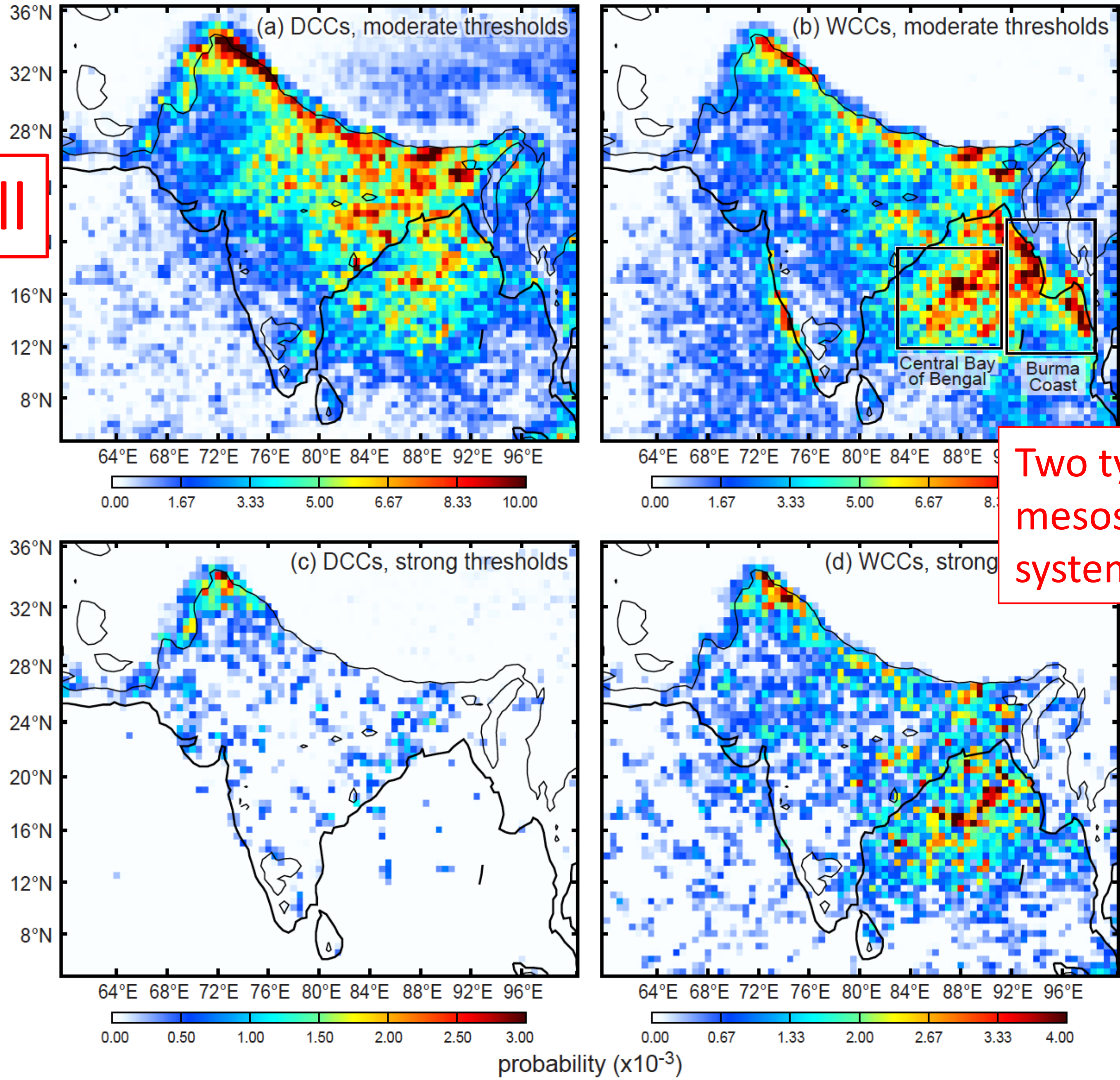
Monsoonal cases



Composite 850 hPa Anomaly Fields

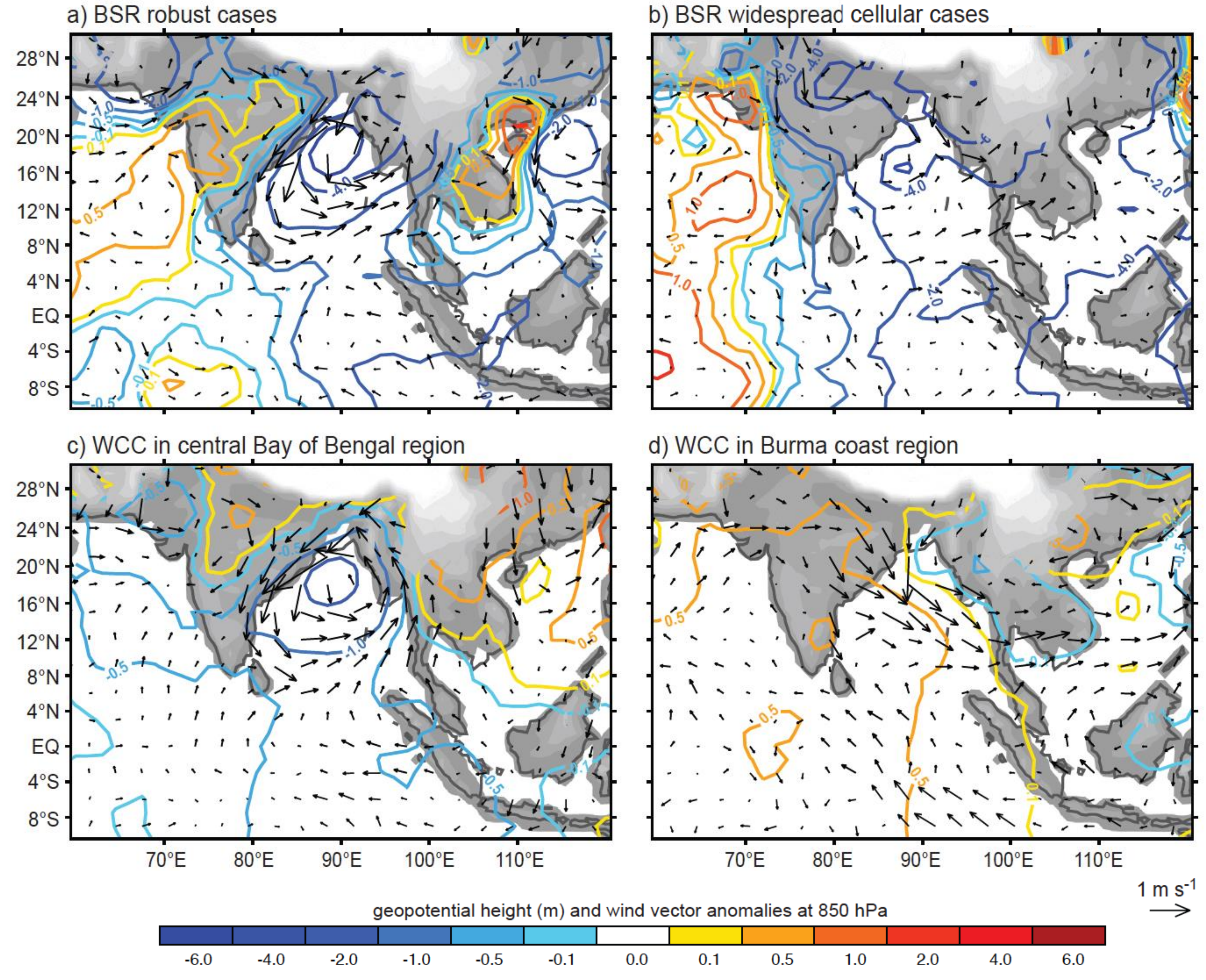


Recall

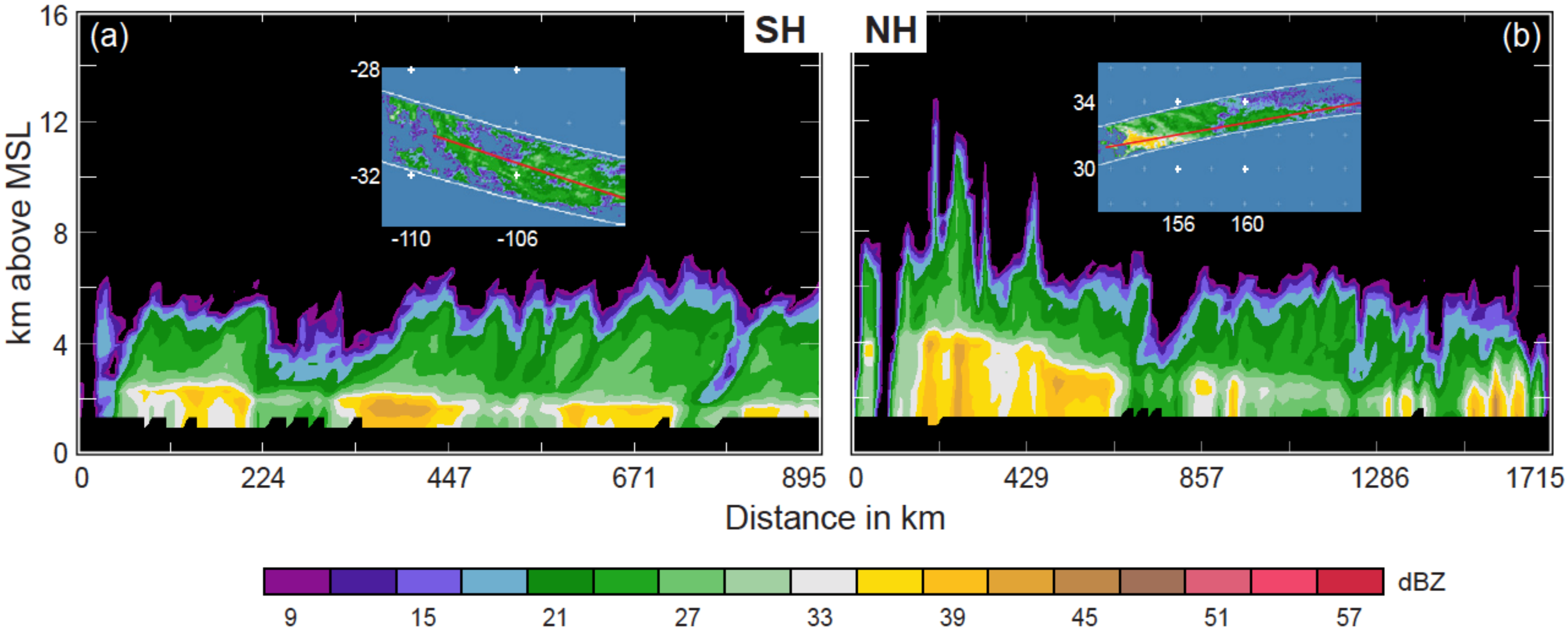


Two types of mesoscale systems

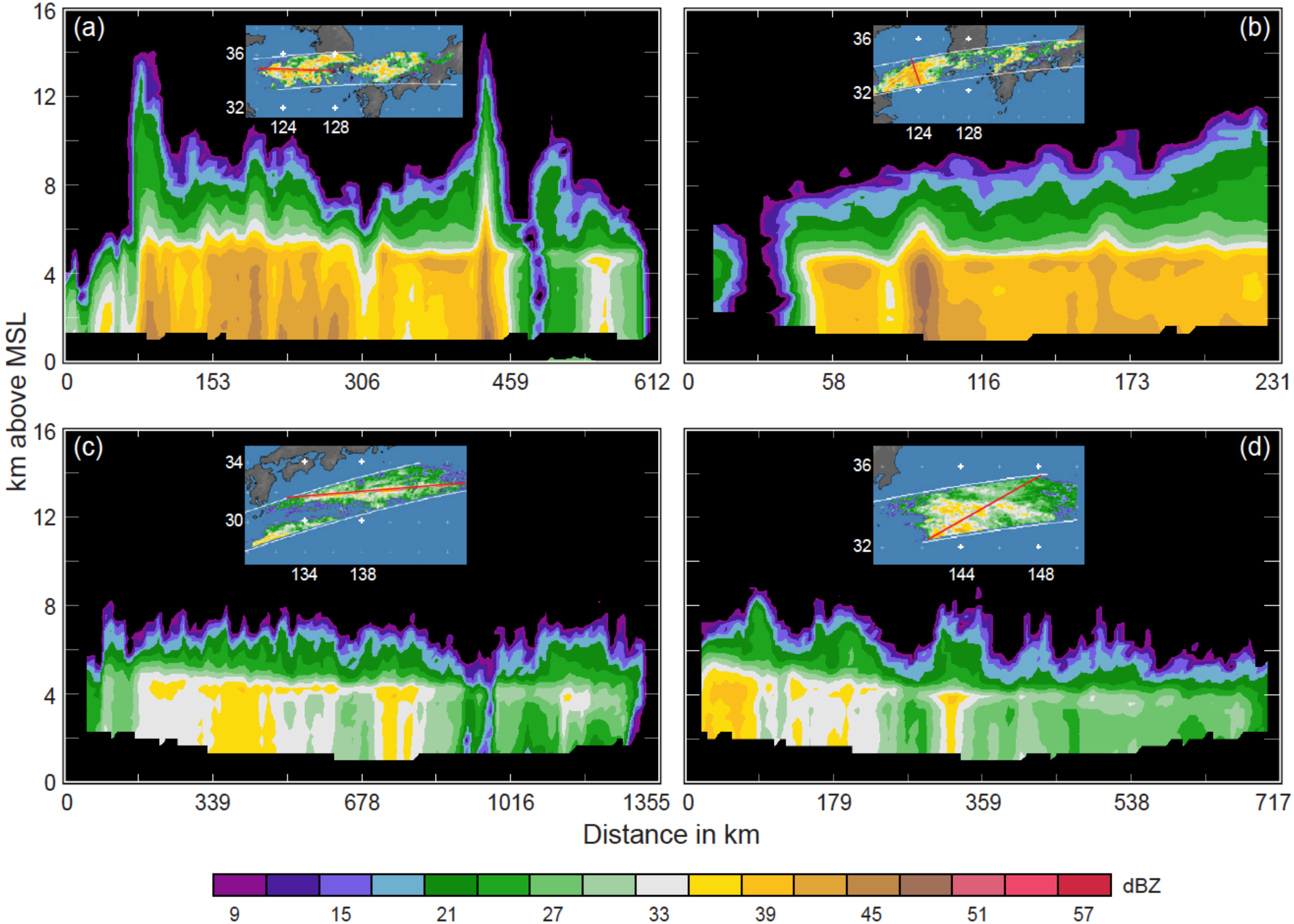
Composite 850 hPa Anomaly Fields



Frontal systems



“Plum Rain” region



Conclusions:

The nature of convection varies across low latitudes

Convective cores

- Shallow isolated echoes—oceanic
- Deep intense cores—continental, not in rainiest zones
- Concentrated on upstream side of coasts and/or mountains

Upscale growth of convection ("aggregation," "organization")

- Mesoscale organization coincides with rainiest areas
- Mesoscale organization associated with less deep & intense convection

Stratiform development

- Wherever mesoscale aggregation occurs
- Manifests most strongly over oceans

Stratiform structure varies!

- Mesoscale system type—over open tropical oceans
- Widespread cellular form—in ITCZ and monsoonal coastal regions
- Frontal—over subtropical oceans in winter

End

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