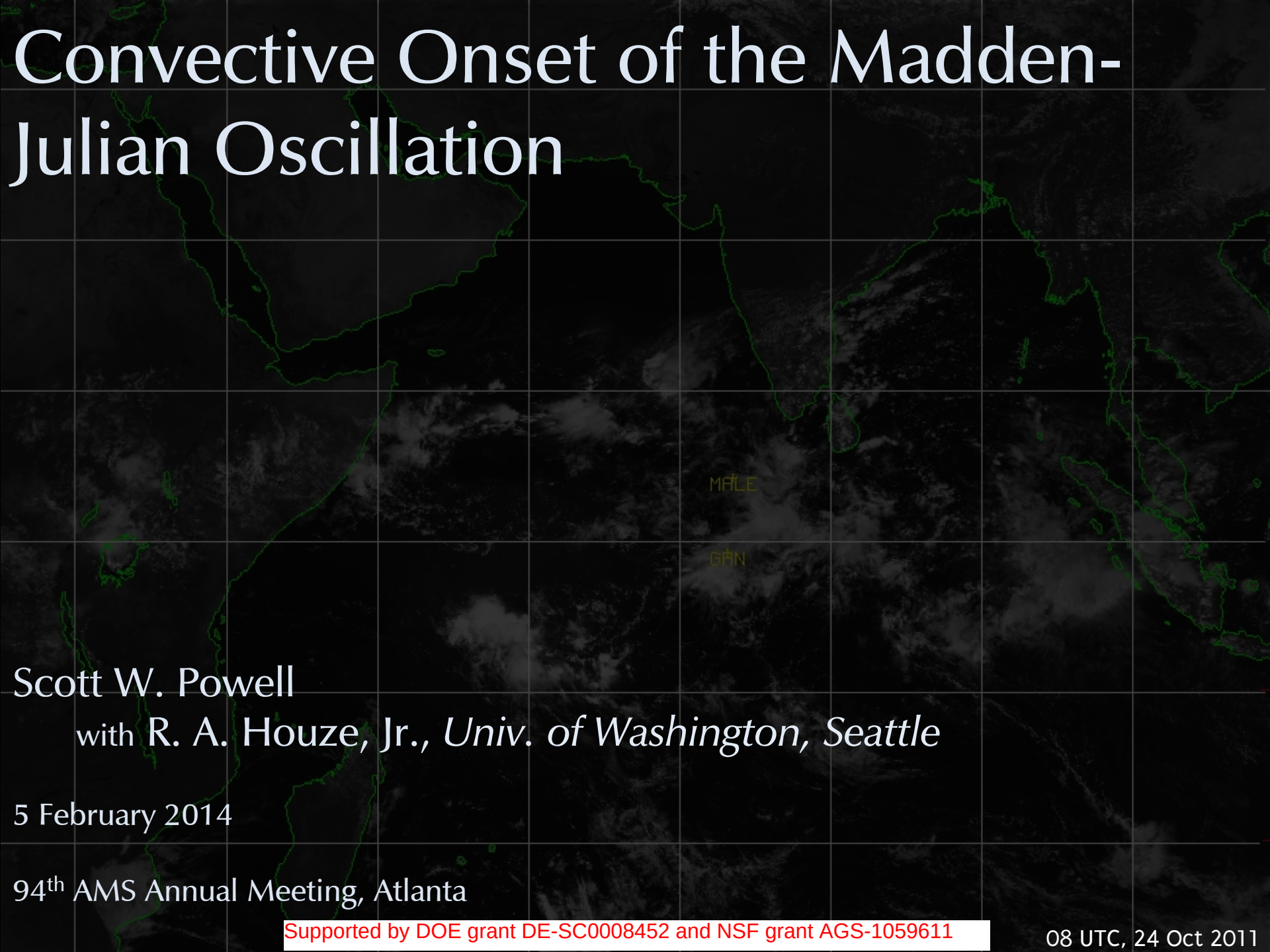
Convective Onset of the Madden-Julian Oscillation



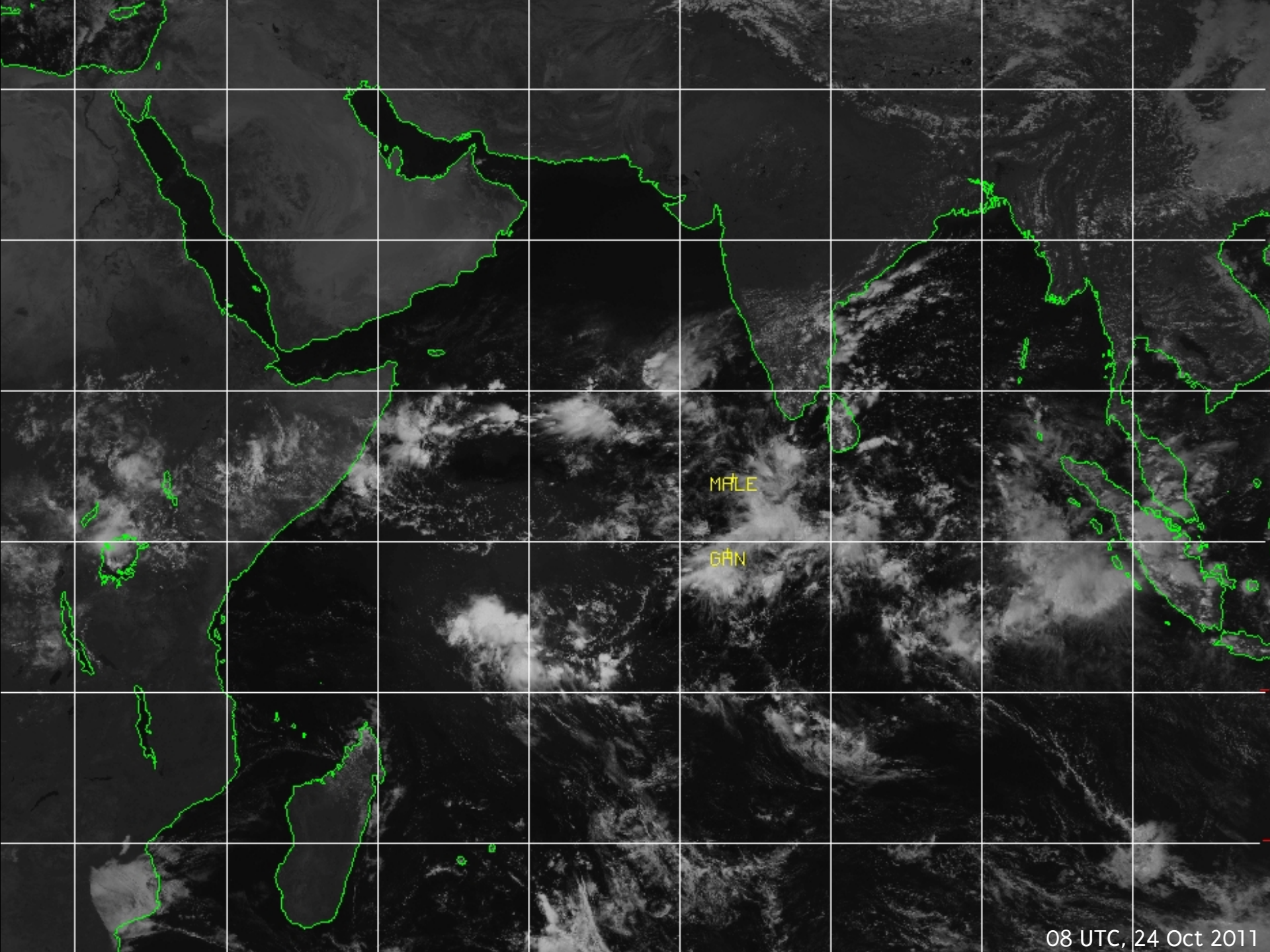
Scott W. Powell
with R. A. Houze, Jr., *Univ. of Washington, Seattle*

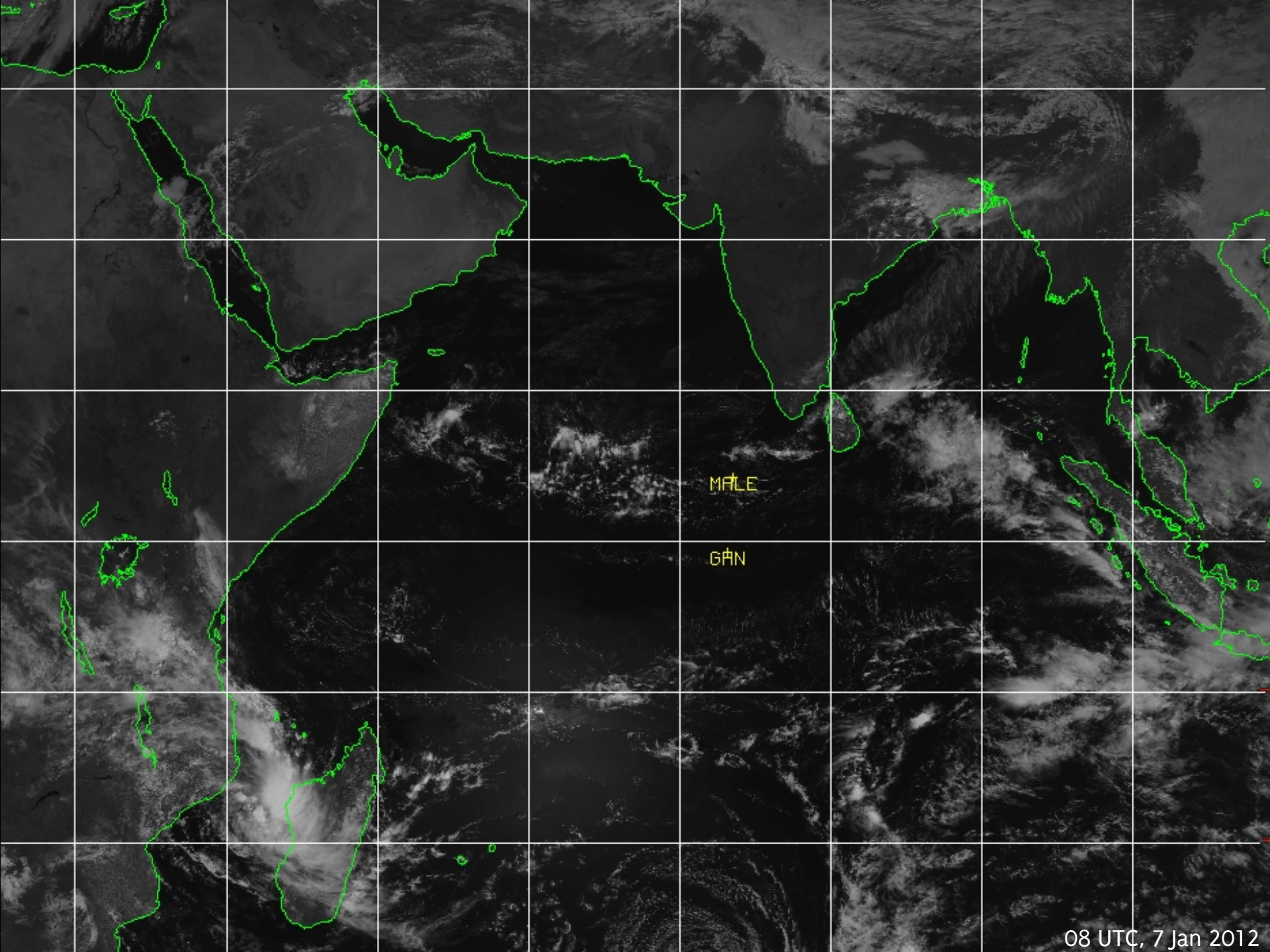
5 February 2014

94th AMS Annual Meeting, Atlanta

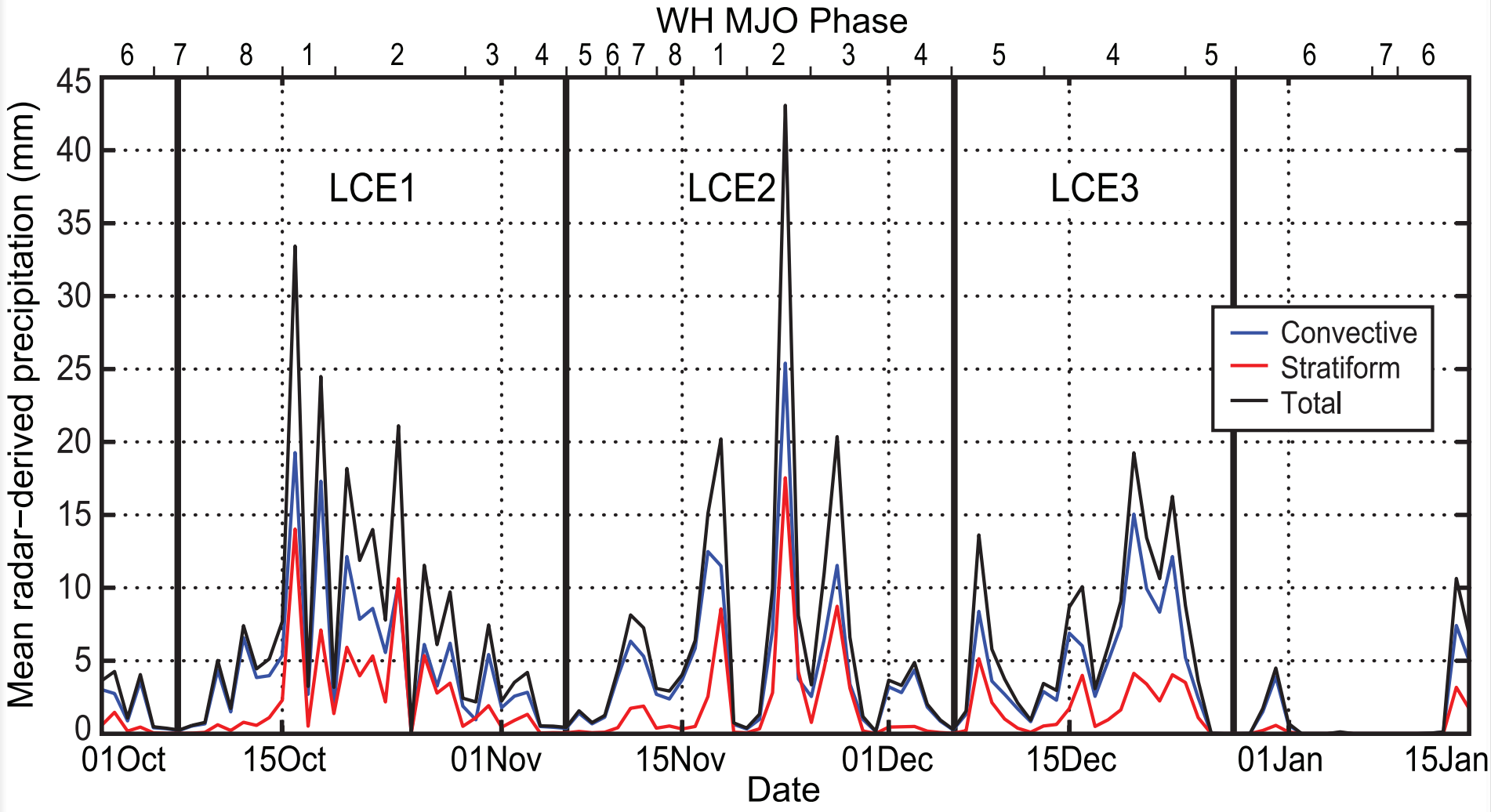
Supported by DOE grant DE-SC0008452 and NSF grant AGS-1059611

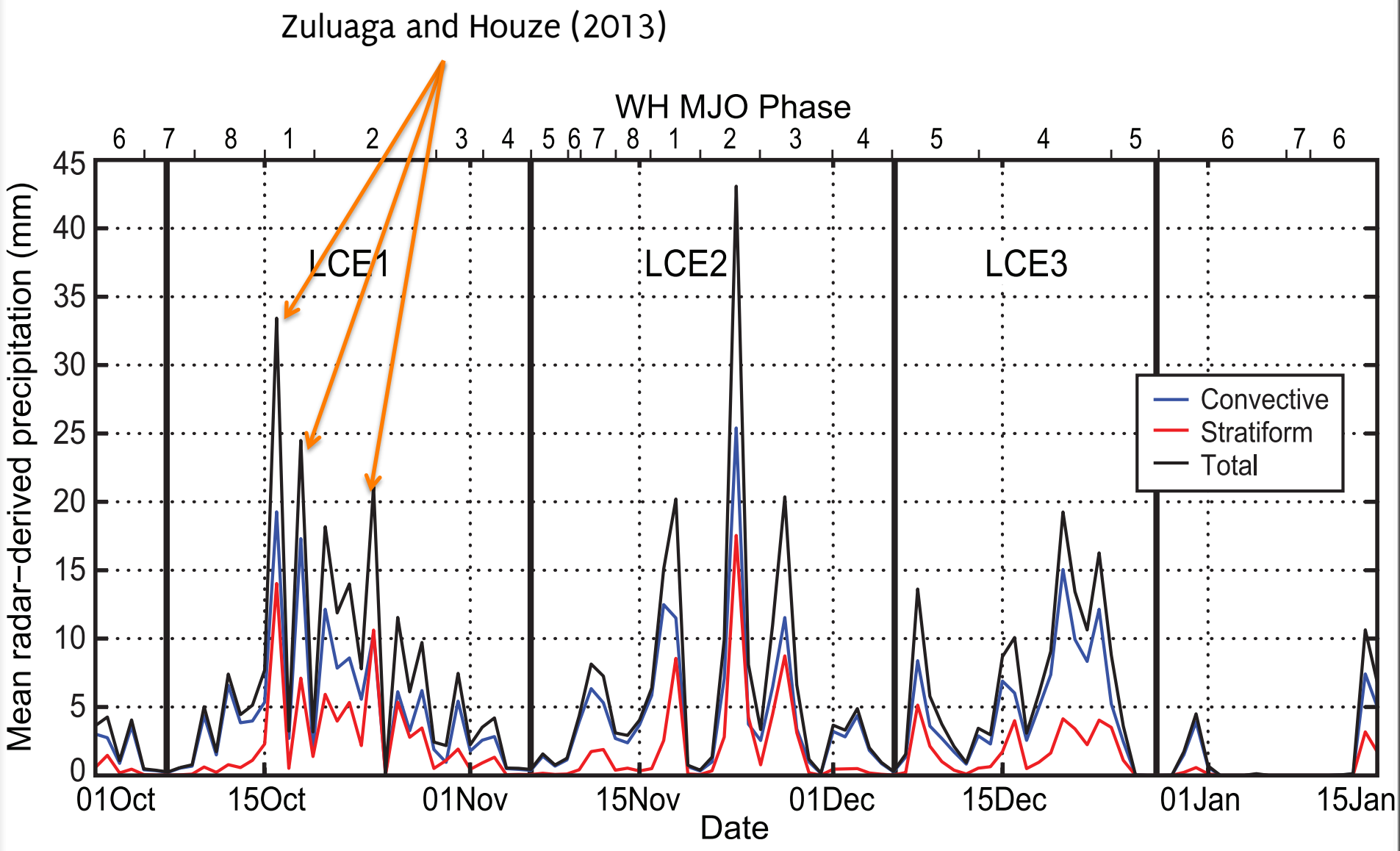
08 UTC, 24 Oct 2011

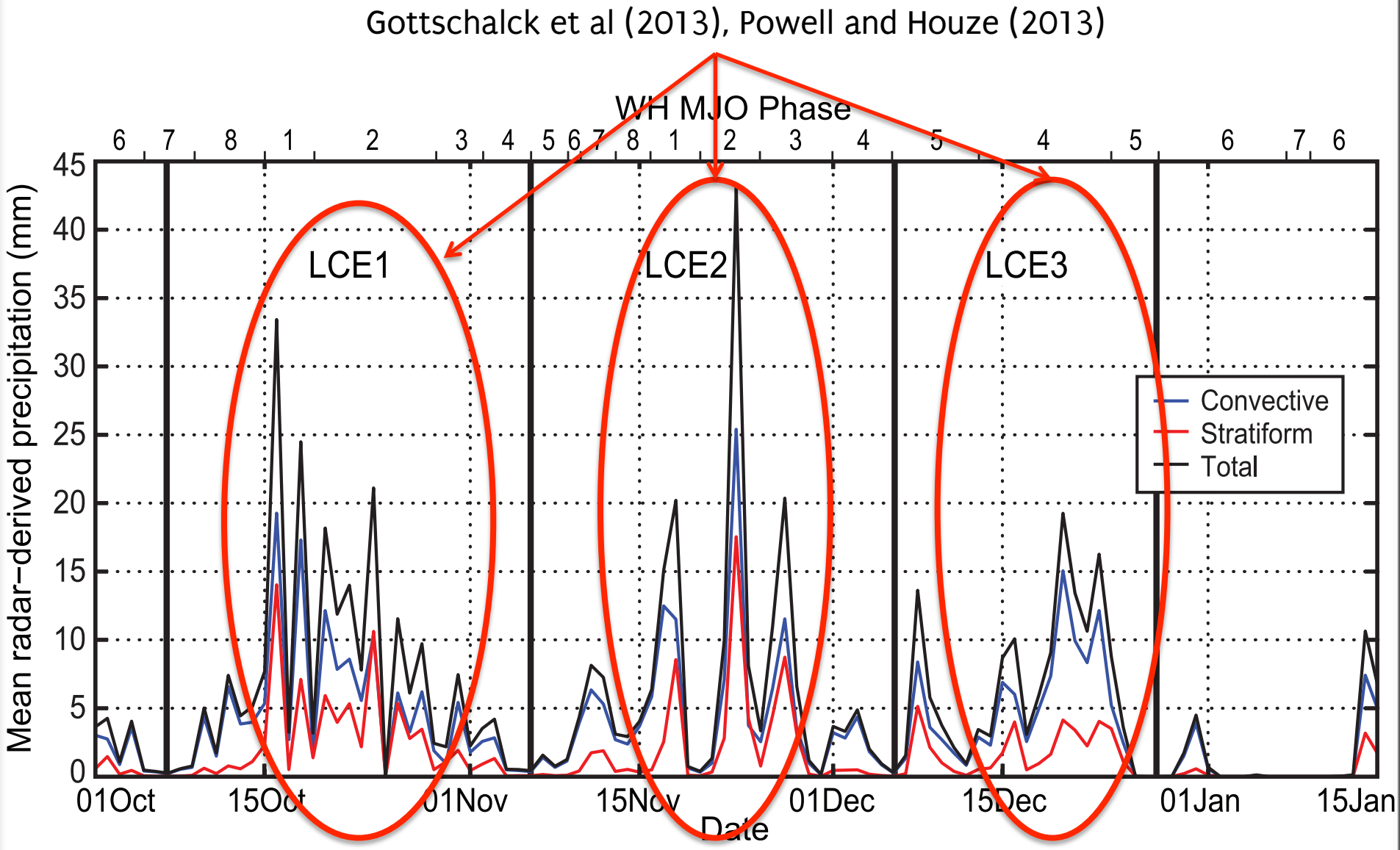

MALE
GAN
08 UTC, 24 Oct 2011

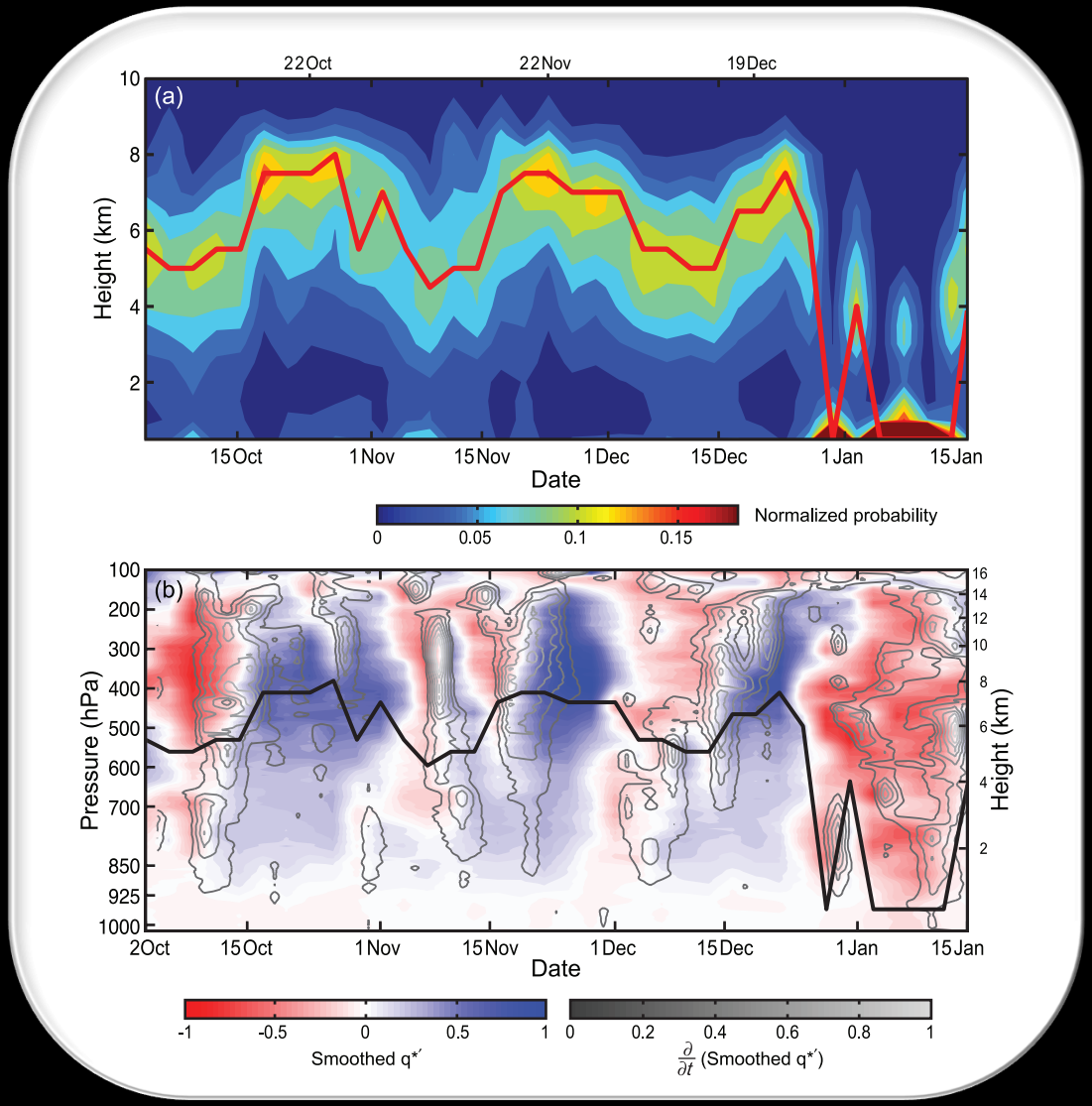

MALE
GAN
08 UTC, 7 Jan 2012

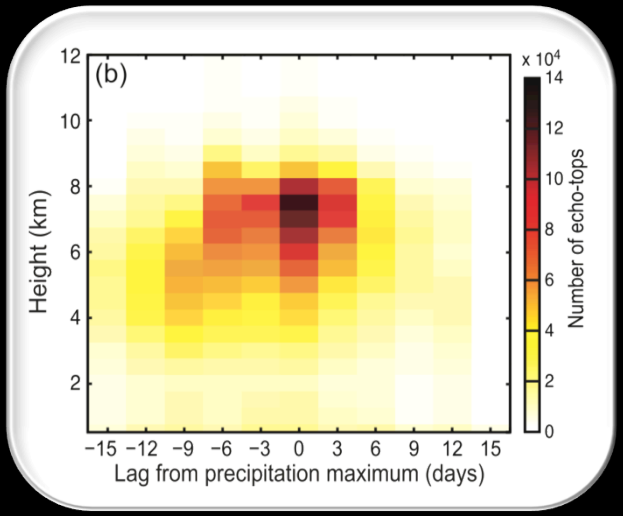
Variability in Convection

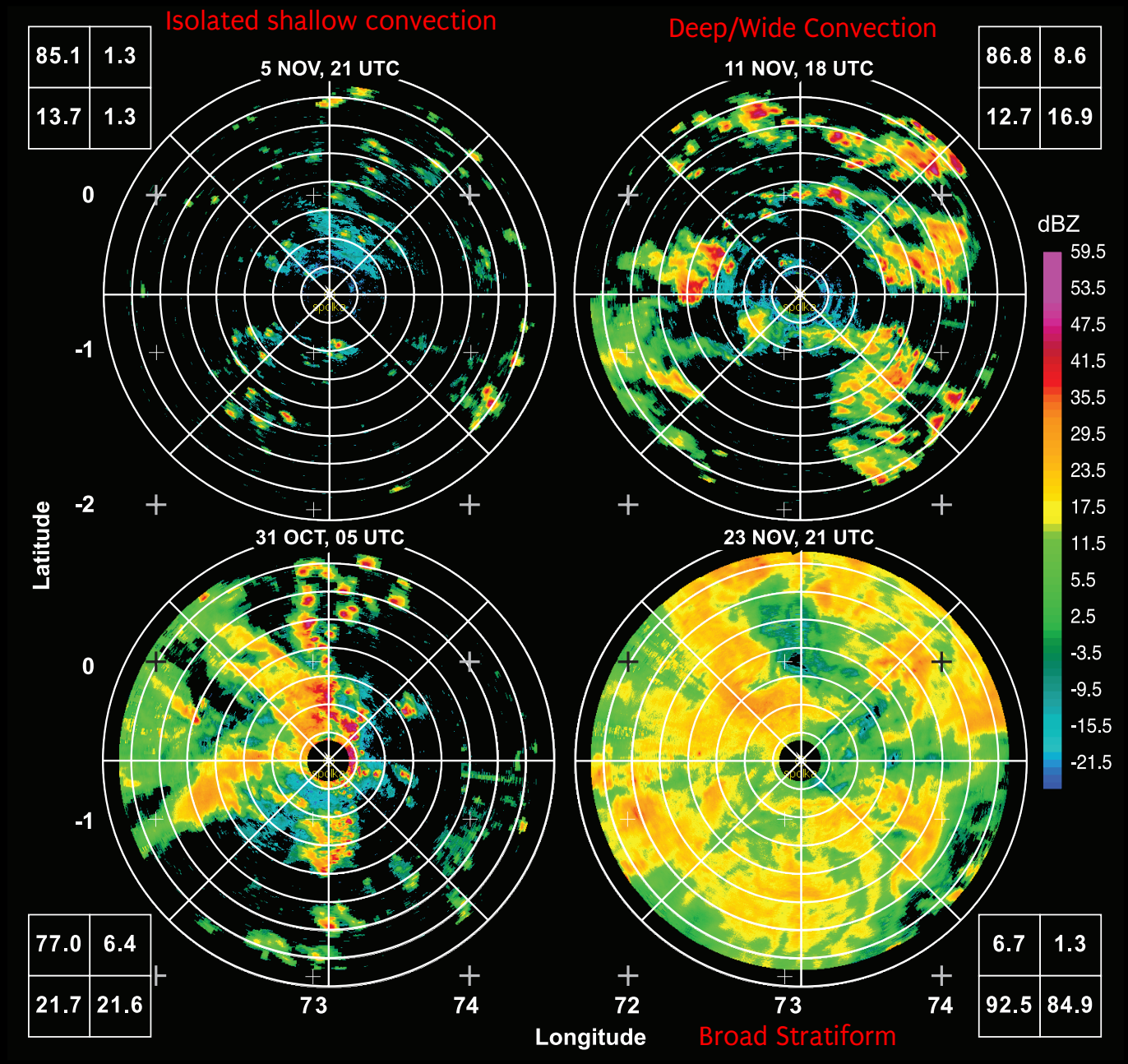

WH MJO Phase
6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 4 5 6 7 6
LCE1
LCE2
LCE3
Convective
Stratiform
Total
Mean radar−derived precipitation (mm)
0 5 10 15 20 25 30 35 40 45
01Oct 15Oct 01Nov 15Nov 01Dec 15Dec 01Jan 15Jan
Date

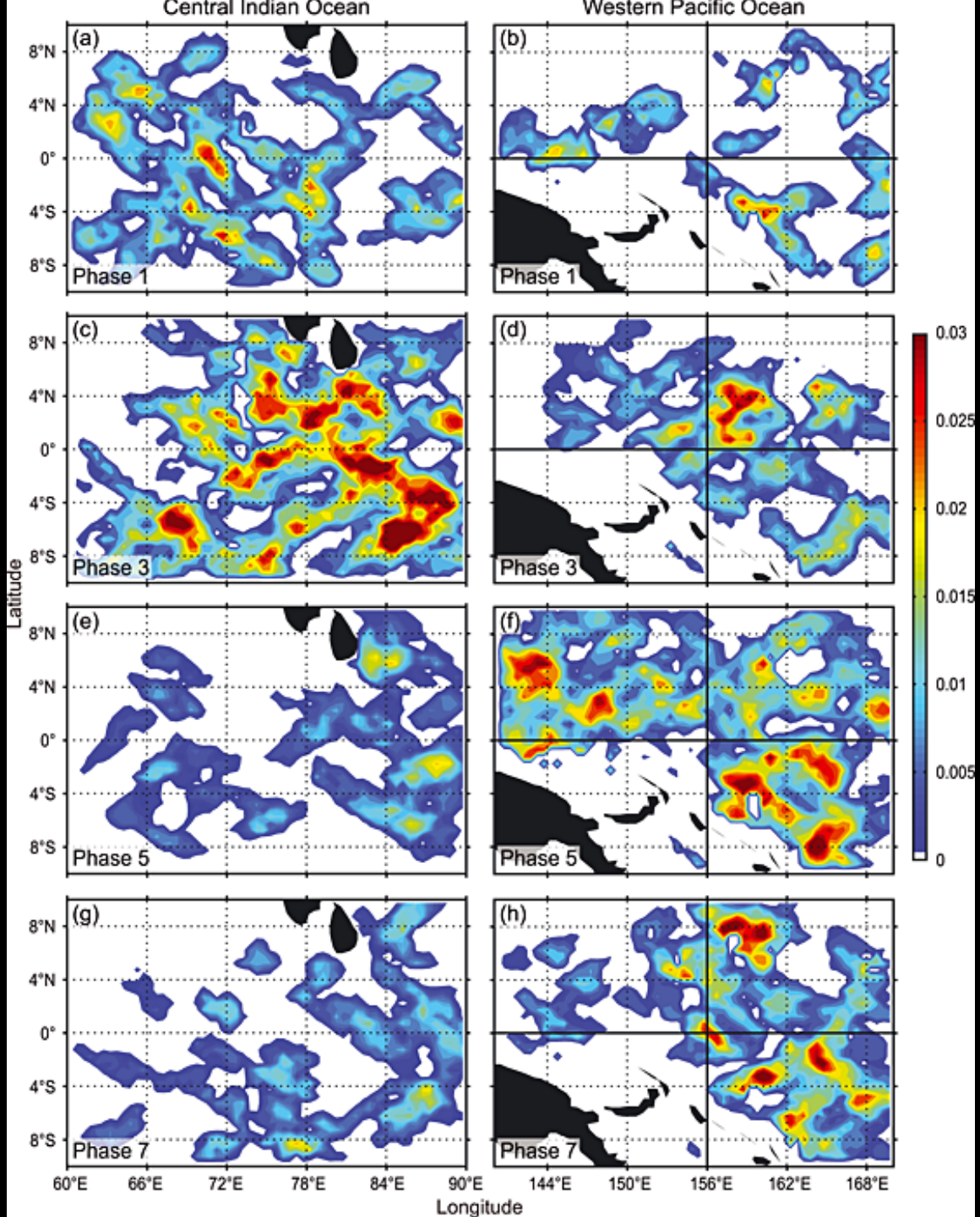

Zuluaga and Houze (2013)
WH MJO Phase
6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 4 5 6 7 6
LCE1
LCE2
LCE3
Convective
Stratiform
Total
Mean radar−derived precipitation (mm)
0 5 10 15 20 25 30 35 40 45
01Oct 15Oct 01Nov 15Nov 01Dec 15Dec 01Jan 15Jan
Date


Gottschalck et al (2013), Powell and Houze (2013)
WH MJO Phase
6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 4 5 6 7 6
LCE1
LCE2
LCE3
Convective
Stratiform
Total
Mean radar−derived precipitation (mm)
45 40 35 30 25 20 15 10 5 0
01Oct 15Oct 01Nov 15Nov 01Dec 15Dec 01Jan 15Jan
Date


22 Oct
22 Nov
19 Dec
(a)
Height (km)
10
8
6
4
2
15 Oct
1 Nov
15 Nov
1 Dec
15 Dec
1 Jan
15 Jan
Date
Normalized probability
0
0.05
0.1
0.15
(b)
Pressure (hPa)
100
200
300
400
500
600
700
850
925
1000
Height (km)
16
14
12
10
8
6
4
2
2 Oct
15 Oct
1 Nov
15 Nov
1 Dec
15 Dec
1 Jan
15 Jan
Date
-1
-0.5
0
0.5
1
Smoothed q*′
0
0.2
0.4
0.6
0.8
1
∂/∂t (Smoothed q*′)

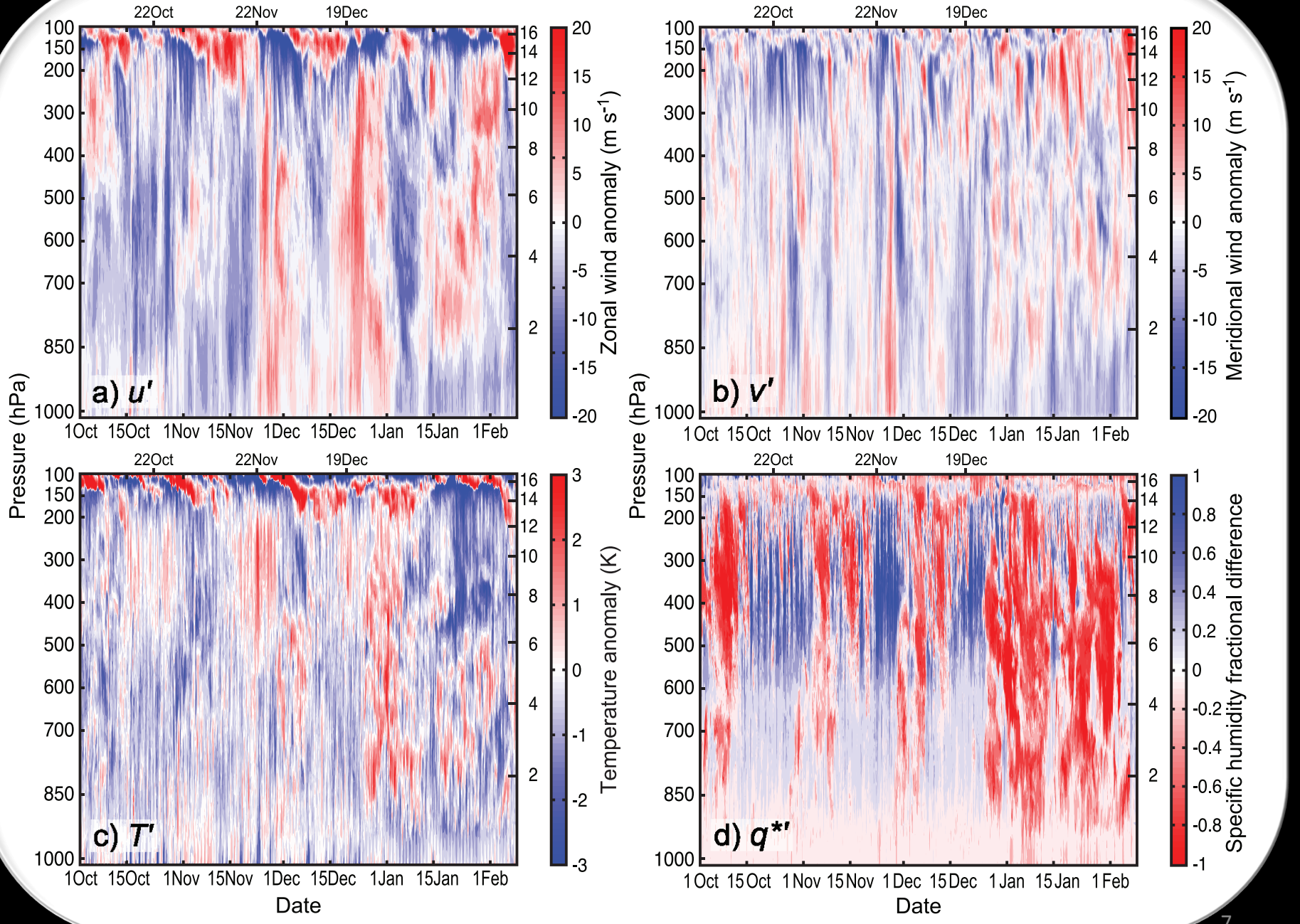

(b)
Height (km)
12
10
8
6
4
2
x 10^4
14
12
10
8
6
4
2
0
Number of echo-tops
−15 −12 −9 −6 −3 0 3 6 9 12 15
Lag from precipitation maximum (days)

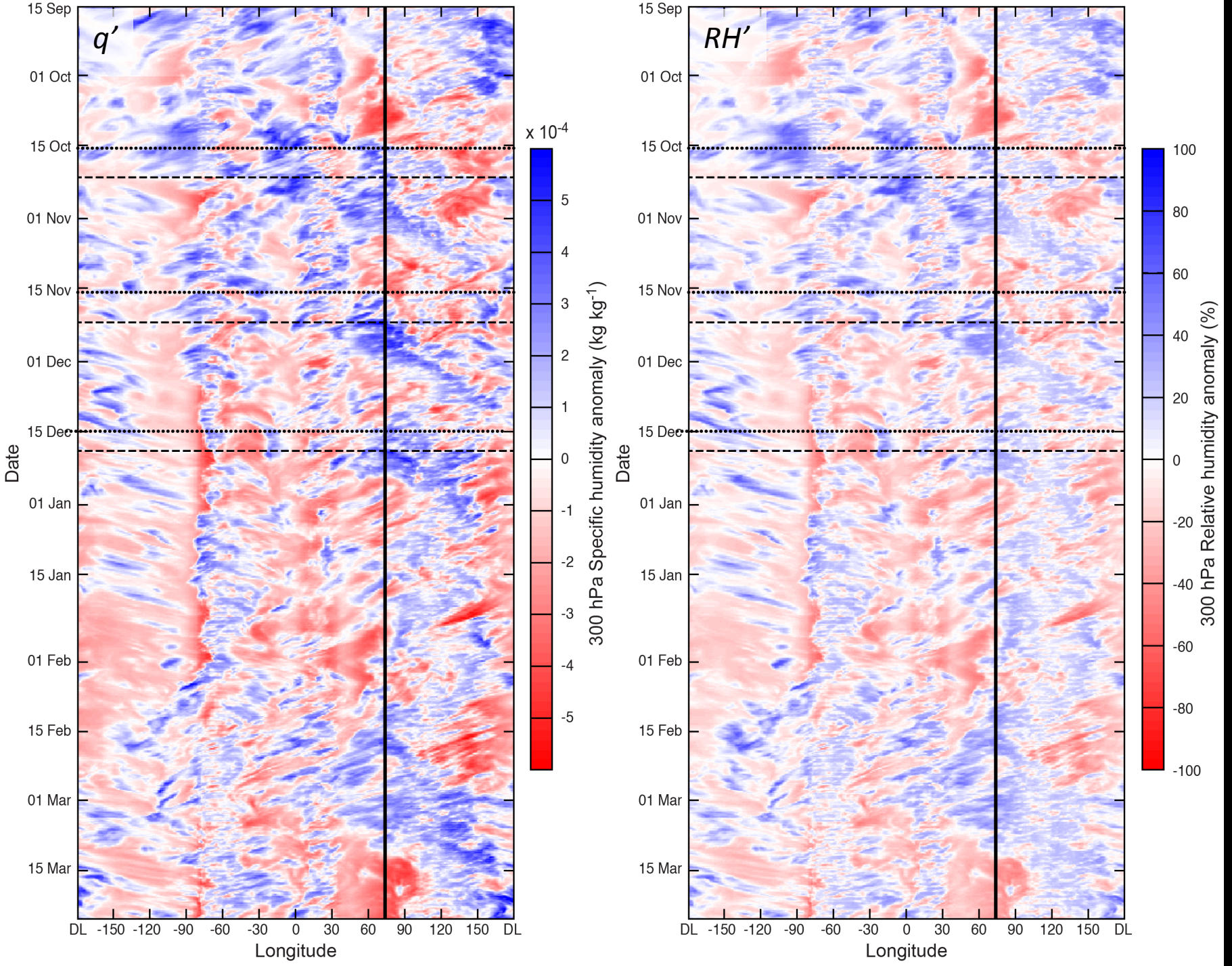

Isolated shallow convection
Deep/Wide Convection
Broad Stratiform
5 NOV, 21 UTC
11 NOV, 18 UTC
31 OCT, 05 UTC
23 NOV, 21 UTC
85.1
1.3
13.7
1.3
86.8
8.6
12.7
16.9
77.0
6.4
21.7
21.6
6.7
1.3
92.5
84.9
dBZ
59.5
53.5
47.5
41.5
35.5
29.5
23.5
17.5
11.5
5.5
2.5
-3.5
-9.5
-15.5
-21.5
Latitude
0
-1
-2
0
-1
72
73
74
73
74
Longitude

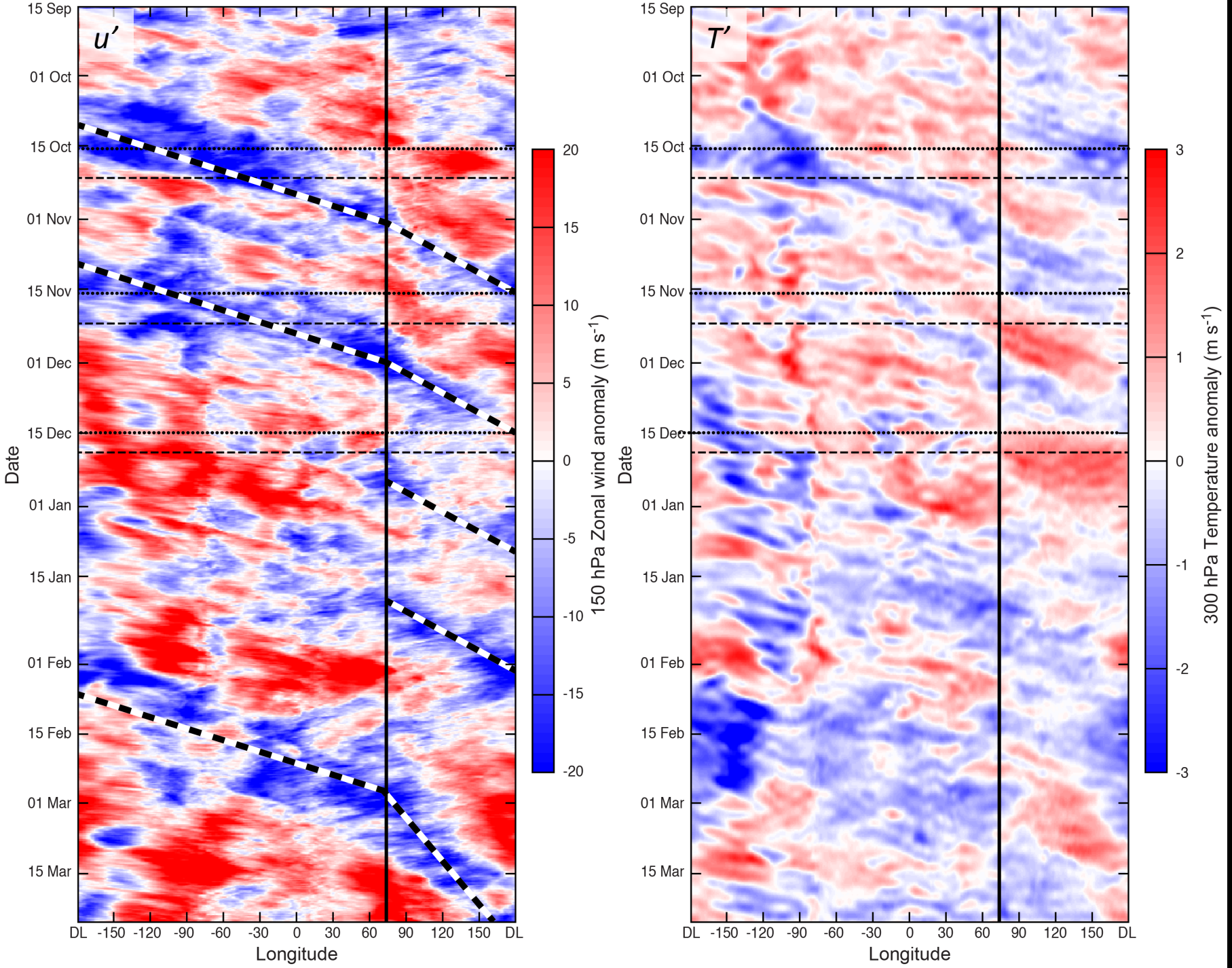


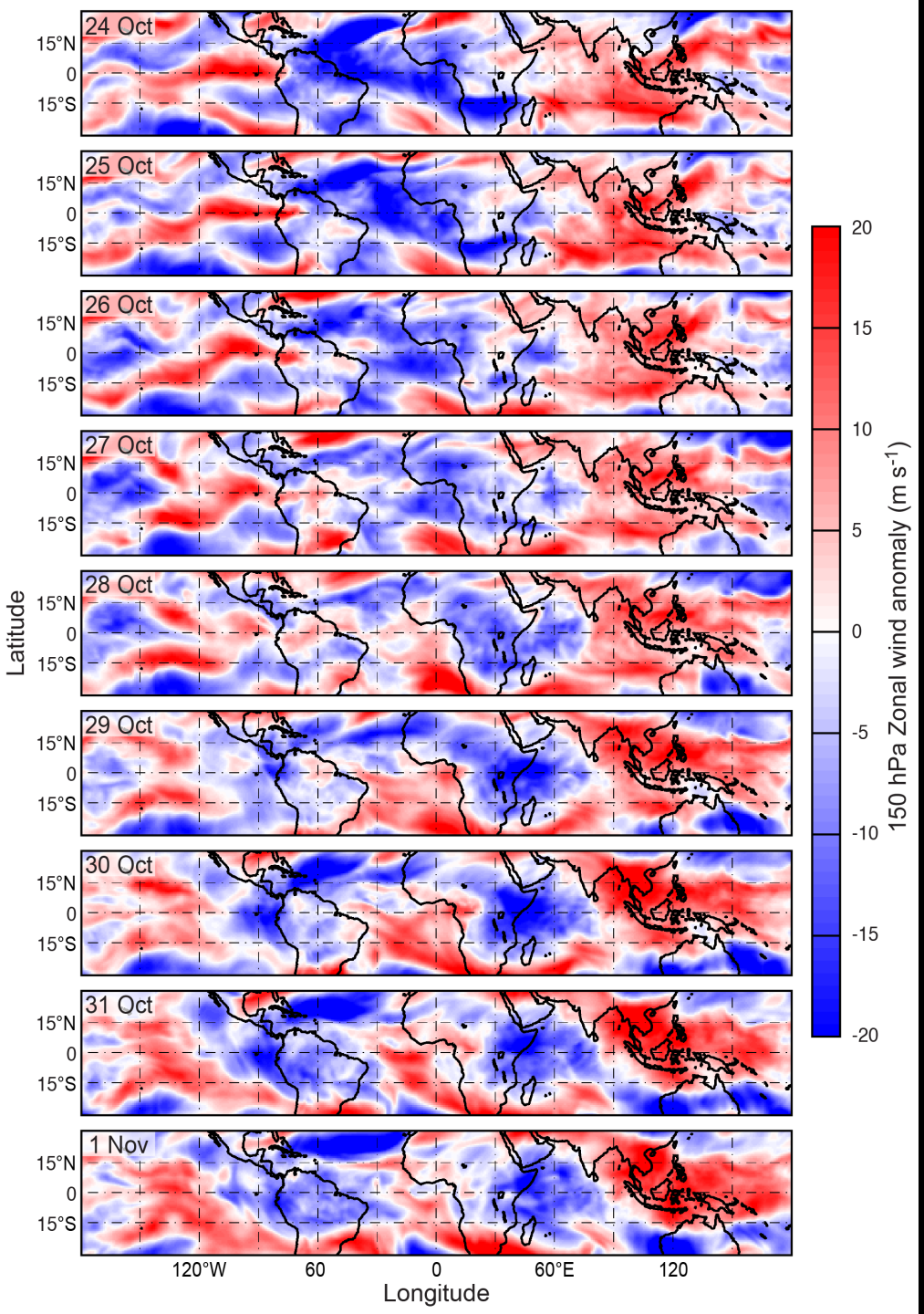
Barnes & Houze (2013)

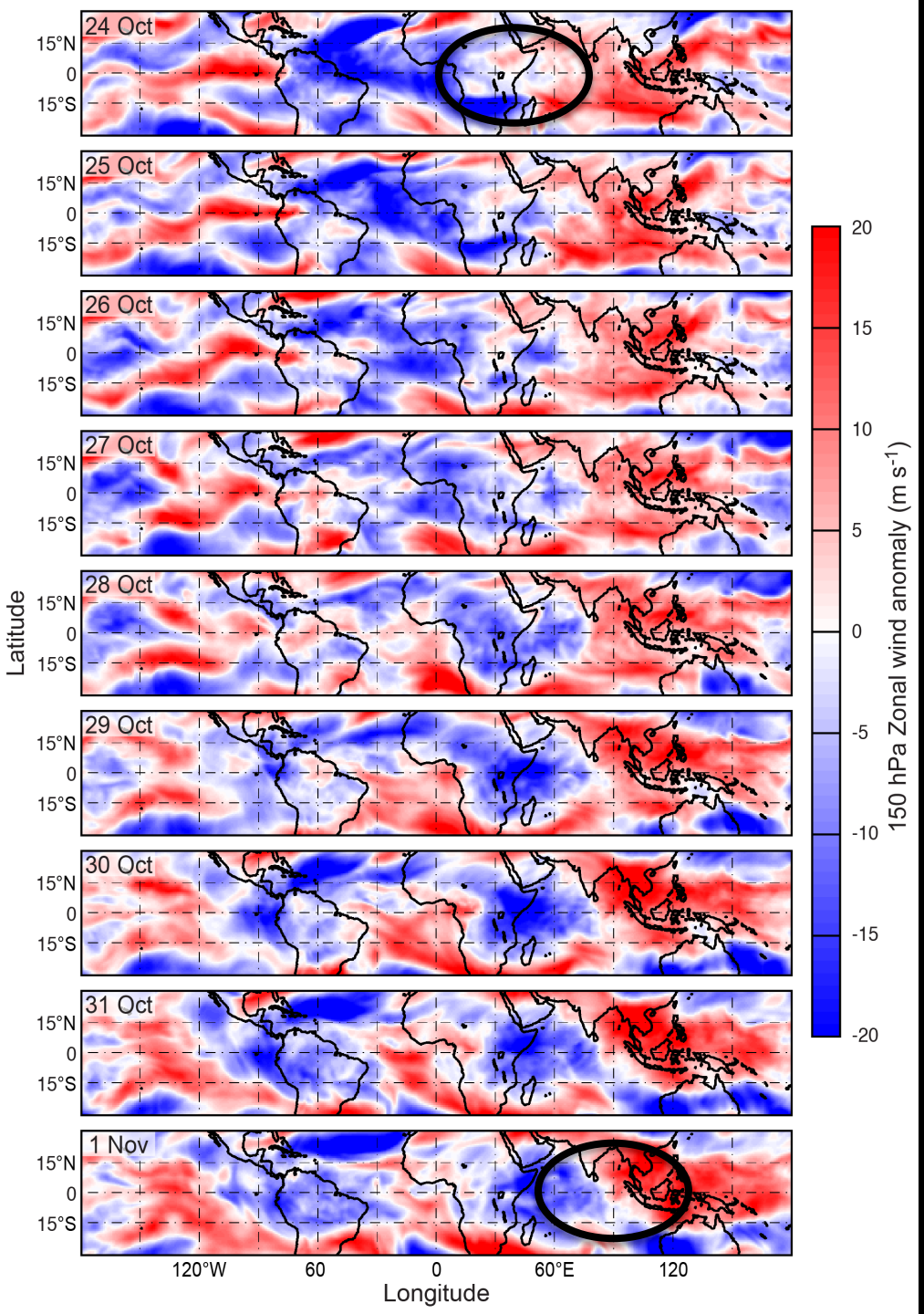
Large-Scale Environment

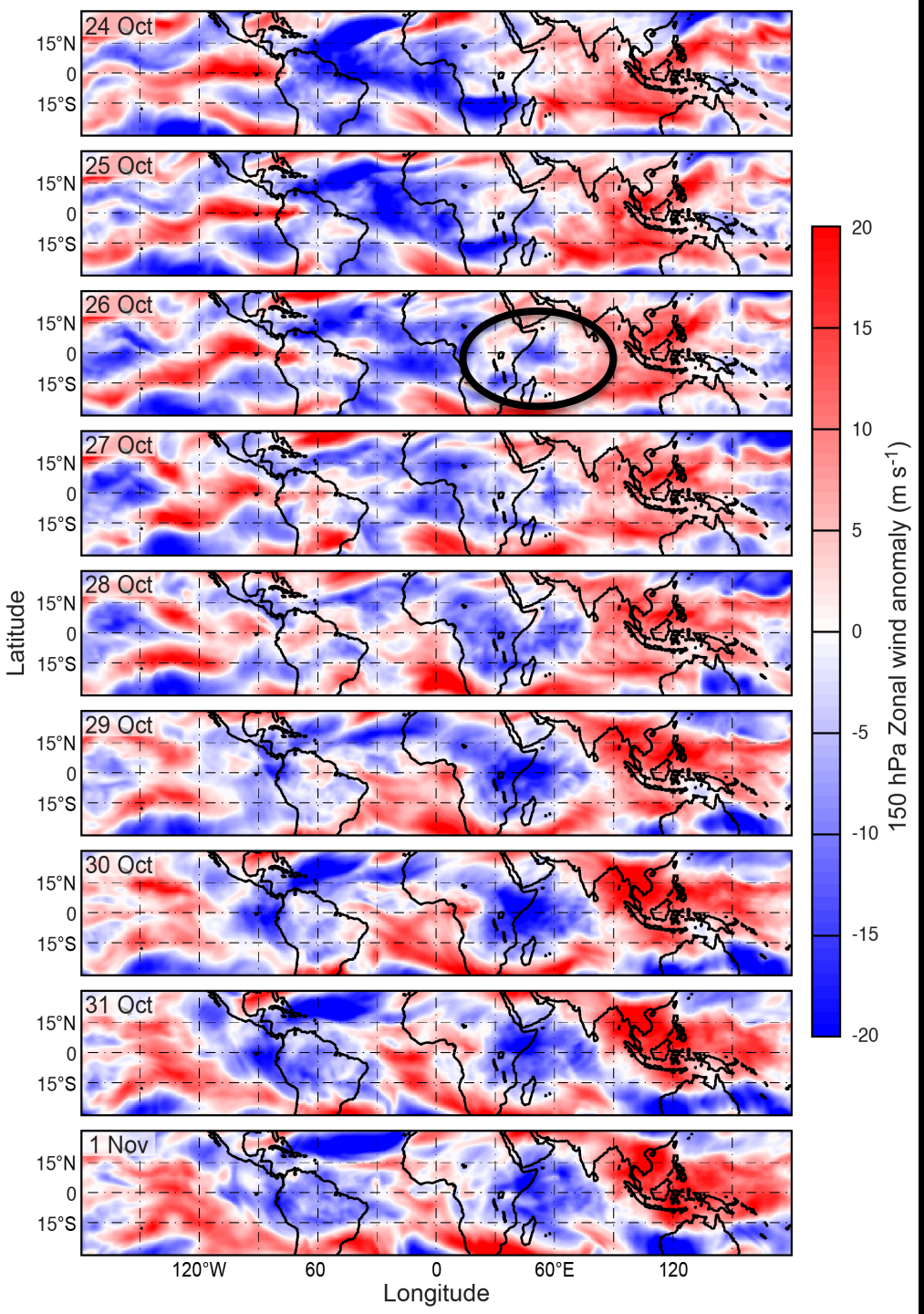

22Oct
22Nov
19Dec
Pressure (hPa)
100
150
200
300
400
500
600
700
850
1000
16
14
12
10
8
6
4
2
1Oct
15Oct
1Nov
15Nov
1Dec
15Dec
1Jan
15Jan
1Feb
Date
a) u′
b) v′
c) T′
d) q*′
Zonal wind anomaly (m s-1)
Meridional wind anomaly (m s-1)
Temperature anomaly (K)
Specific humidity fractional difference
20
15
10
5
0
-5
-10
-15
-20
3
2
1
0
-1
-2
-3
0.8
0.6
0.4
0.2
-0.2
-0.4
-0.6
-0.8
-1


q'
RH'
15 Sep
01 Oct
15 Oct
01 Nov
15 Nov
01 Dec
15 Dec
01 Jan
15 Jan
01 Feb
15 Feb
01 Mar
15 Mar
Date
DL -150 -120 -90 -60 -30 0 30 60 90 120 150 DL
Longitude
x 10-4
5 4 3 2 1 0 -1 -2 -3 -4 -5
300 hPa Specific humidity anomaly (kg kg-1)
100 80 60 40 20 0 -20 -40 -60 -80 -100
300 hPa Relative humidity anomaly (%)


u′
T′
15 Sep
01 Oct
15 Oct
01 Nov
15 Nov
01 Dec
15 Dec
01 Jan
15 Jan
01 Feb
15 Feb
01 Mar
15 Mar
Date
DL -150 -120 -90 -60 -30 0 30 60 90 120 150 DL
Longitude
20
15
10
5
0
-5
-10
-15
-20
150 hPa Zonal wind anomaly (m s-1)
3
2
1
0
-1
-2
-3
300 hPa Temperature anomaly (m s-1)

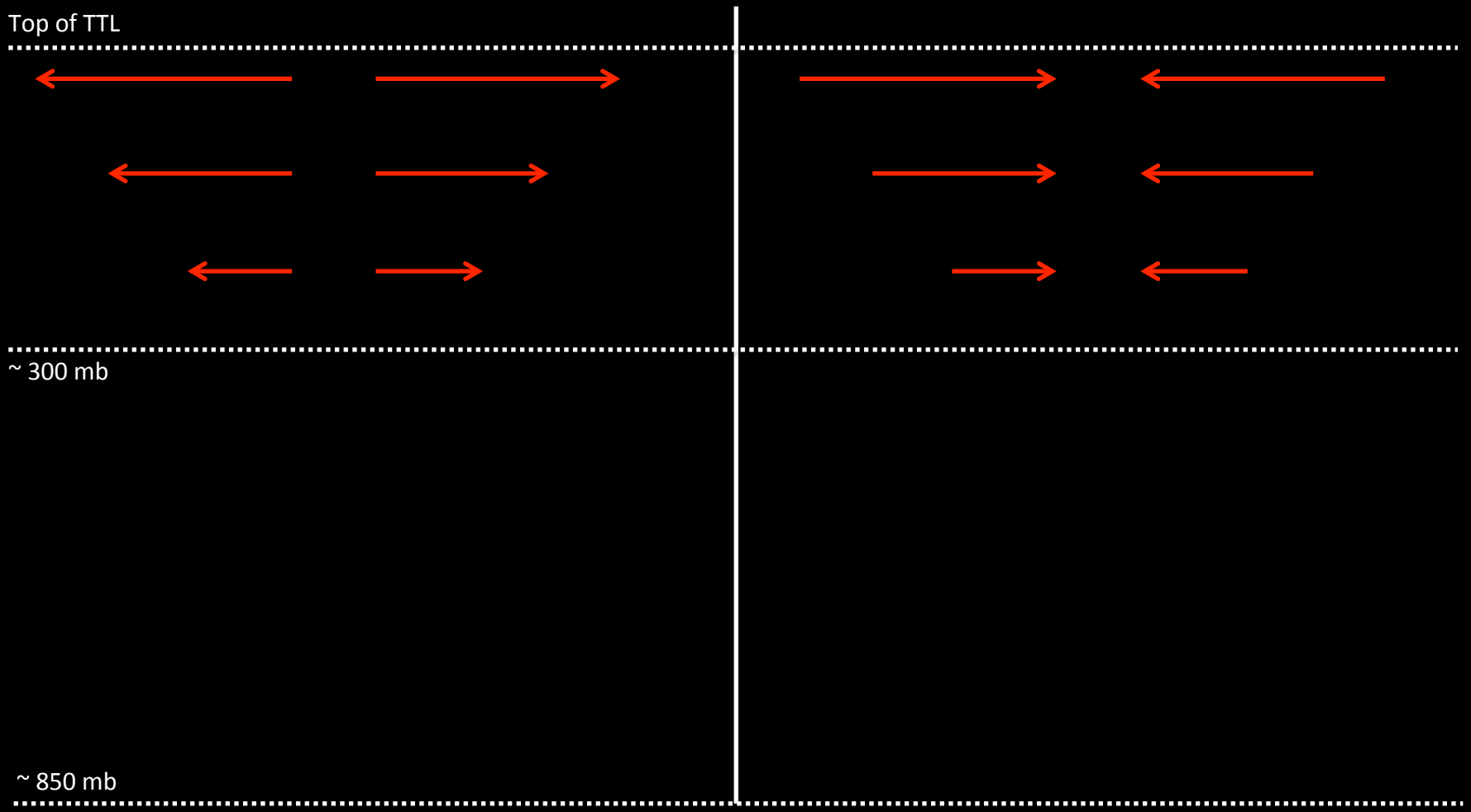

24 Oct
25 Oct
26 Oct
27 Oct
28 Oct
29 Oct
30 Oct
31 Oct
1 Nov
15°N
0
15°S
Latitude
120°W
60
0
60°E
120
Longitude
20
15
10
5
0
-5
-10
-15
-20
150 hPa Zonal wind anomaly (m s-1)


24 Oct
25 Oct
26 Oct
27 Oct
28 Oct
29 Oct
30 Oct
31 Oct
1 Nov
15°N
0
15°S
Latitude
120°W
60
0
60°E
120
Longitude
20
15
10
5
0
-5
-10
-15
-20
150 hPa Zonal wind anomaly (m s-1)


24 Oct
25 Oct
26 Oct
27 Oct
28 Oct
29 Oct
30 Oct
31 Oct
1 Nov
15°N
0
15°S
Latitude
120°W
60
0
60°E
120
Longitude
20
15
10
5
0
-5
-10
-15
-20
150 hPa Zonal wind anomaly (m s-1)

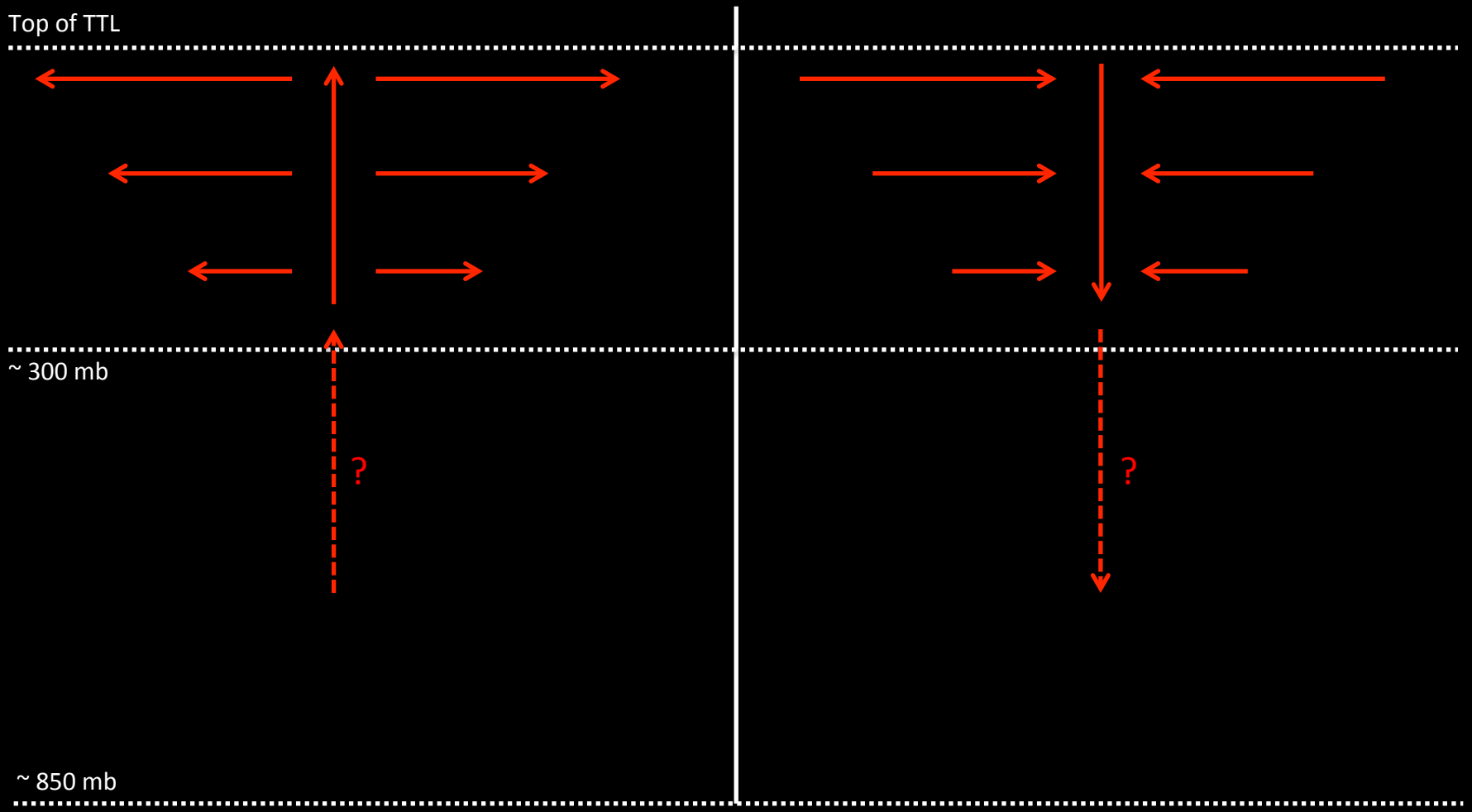
Conclusions

- Depth of convection increases rapidly at LCE onset.
- Humidity increase is rapid too.
- Humidity anomalies form in place where widespread, organized convection develops.



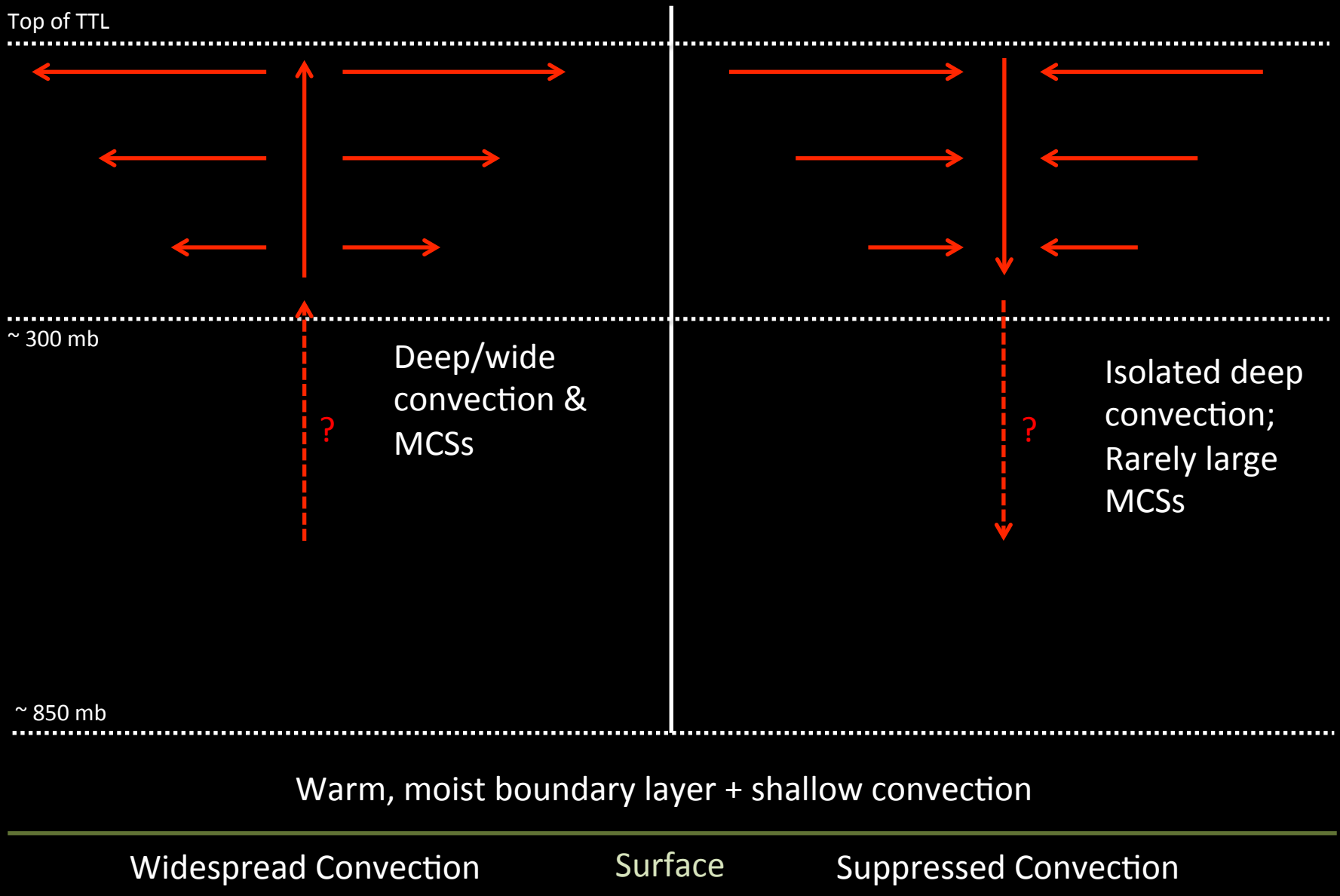
Warm, moist boundary layer + shallow convection

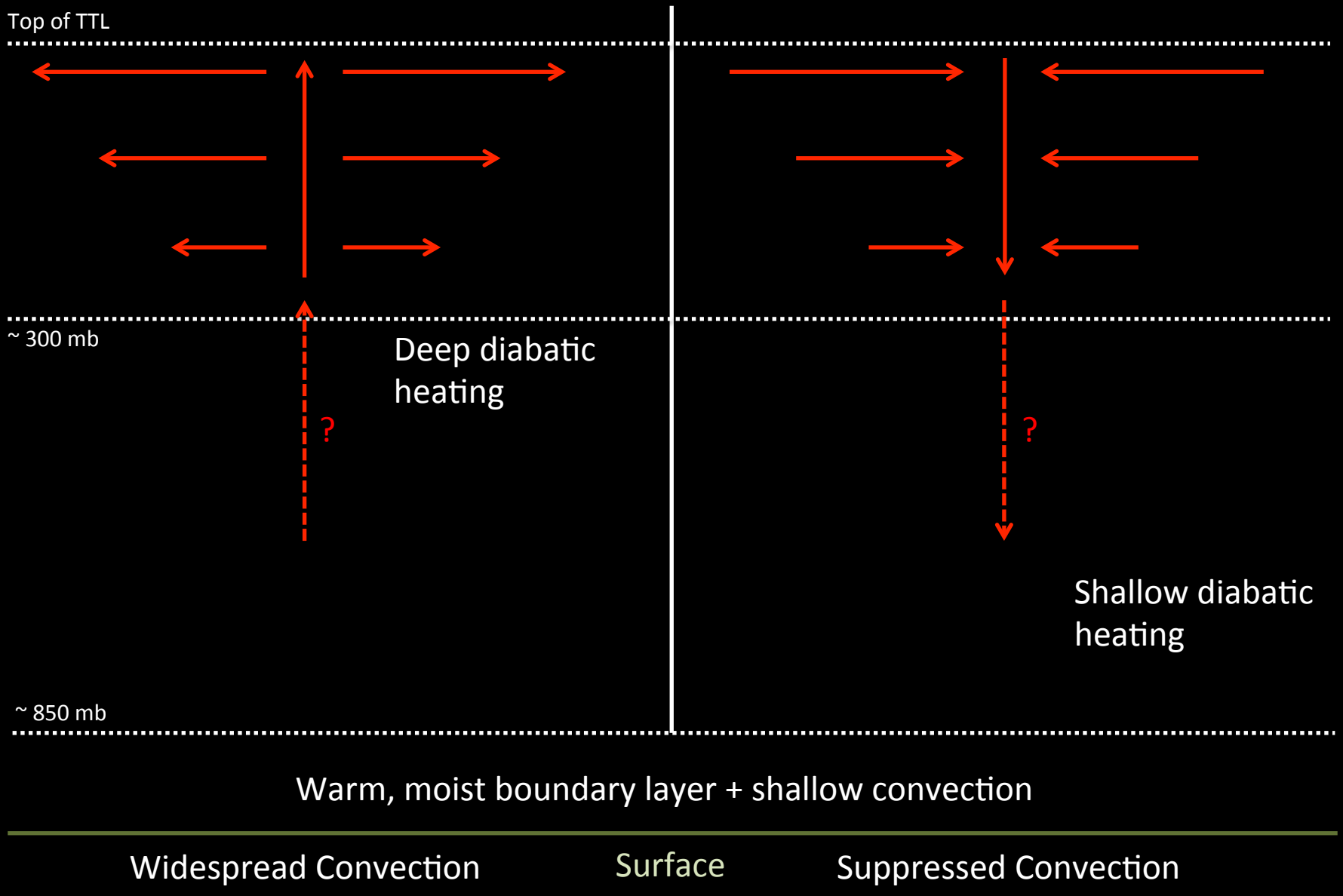
Widespread Convection | Surface | Suppressed Convection

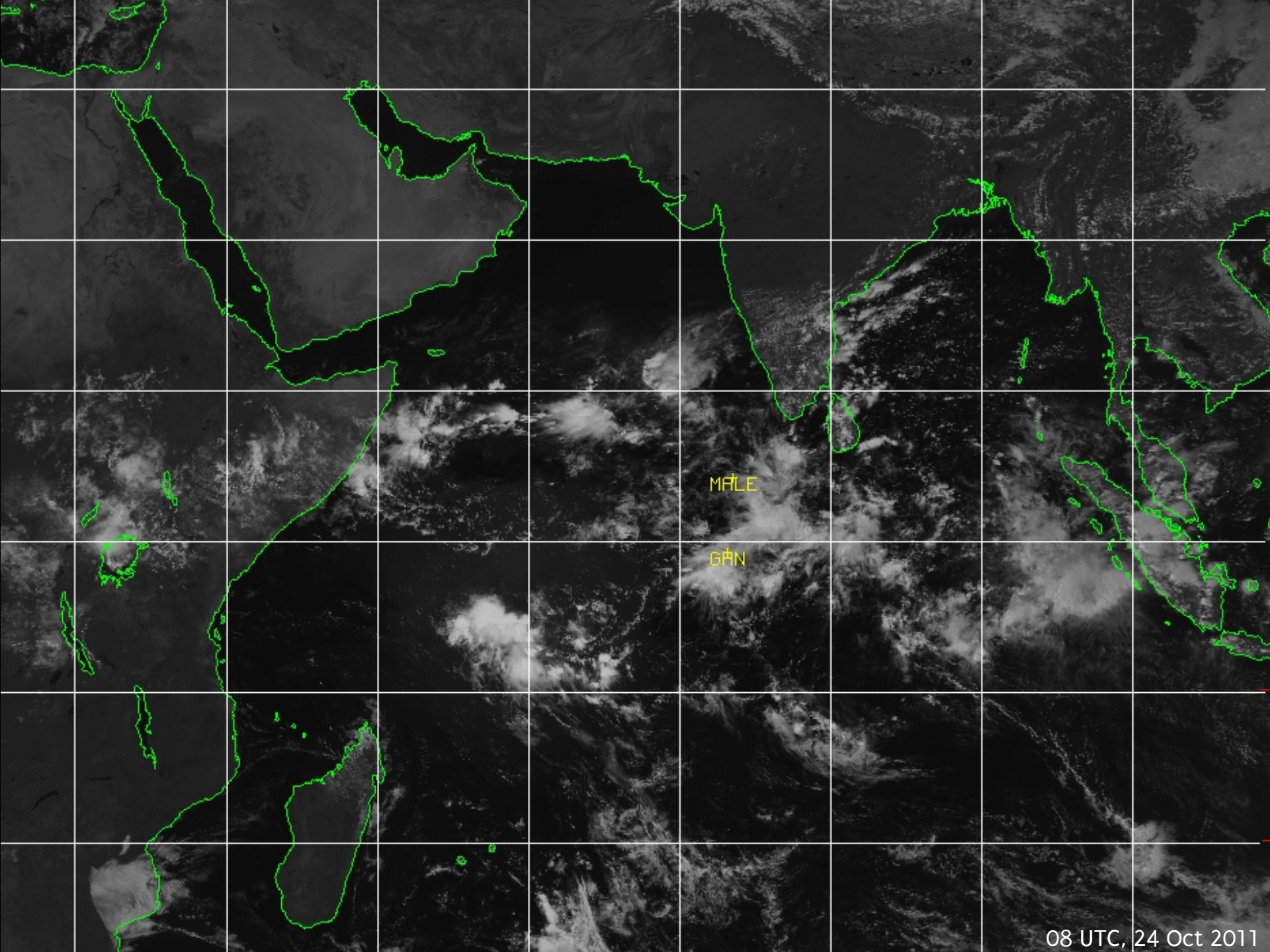


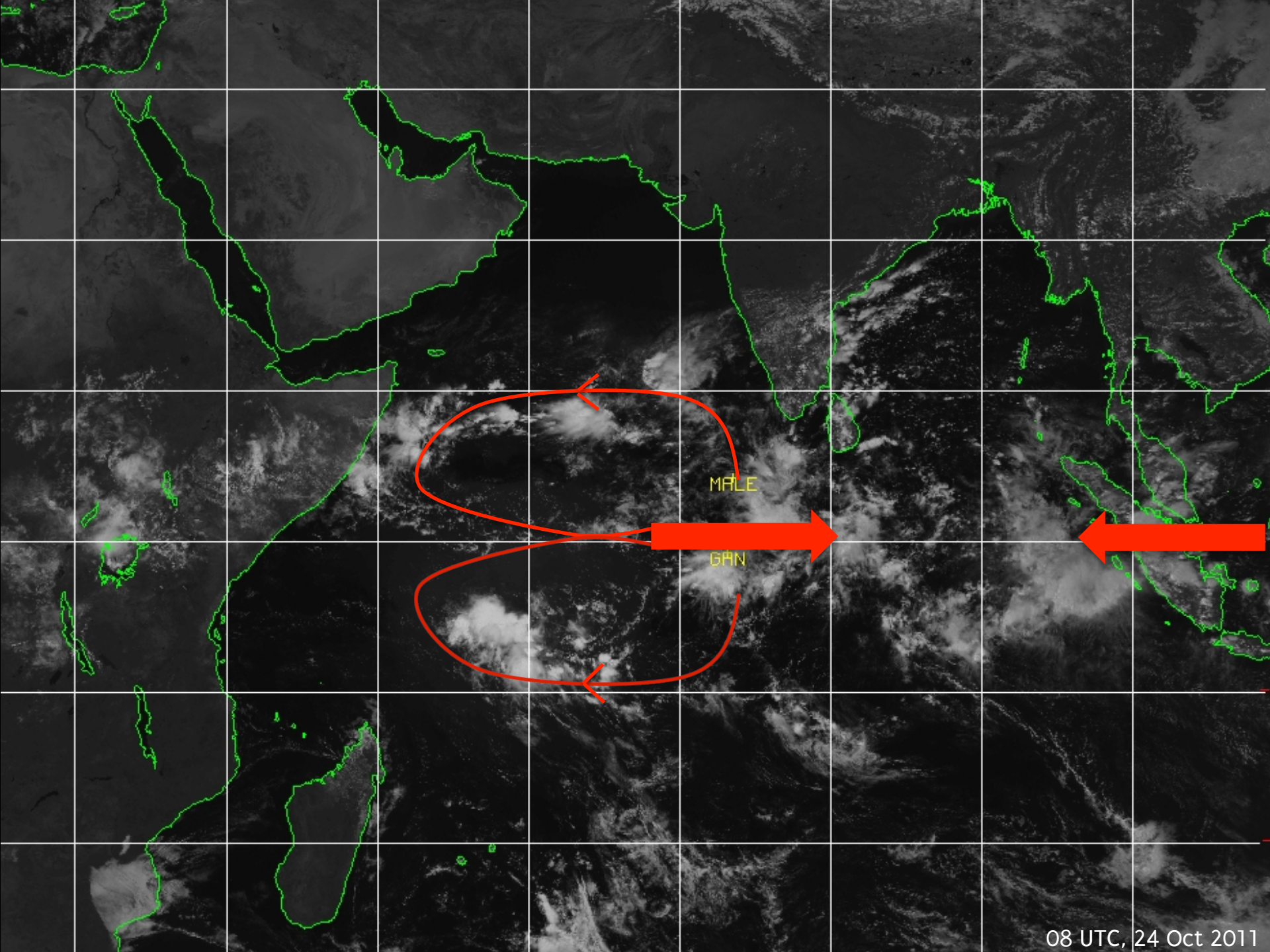
Warm, moist boundary layer + shallow convection

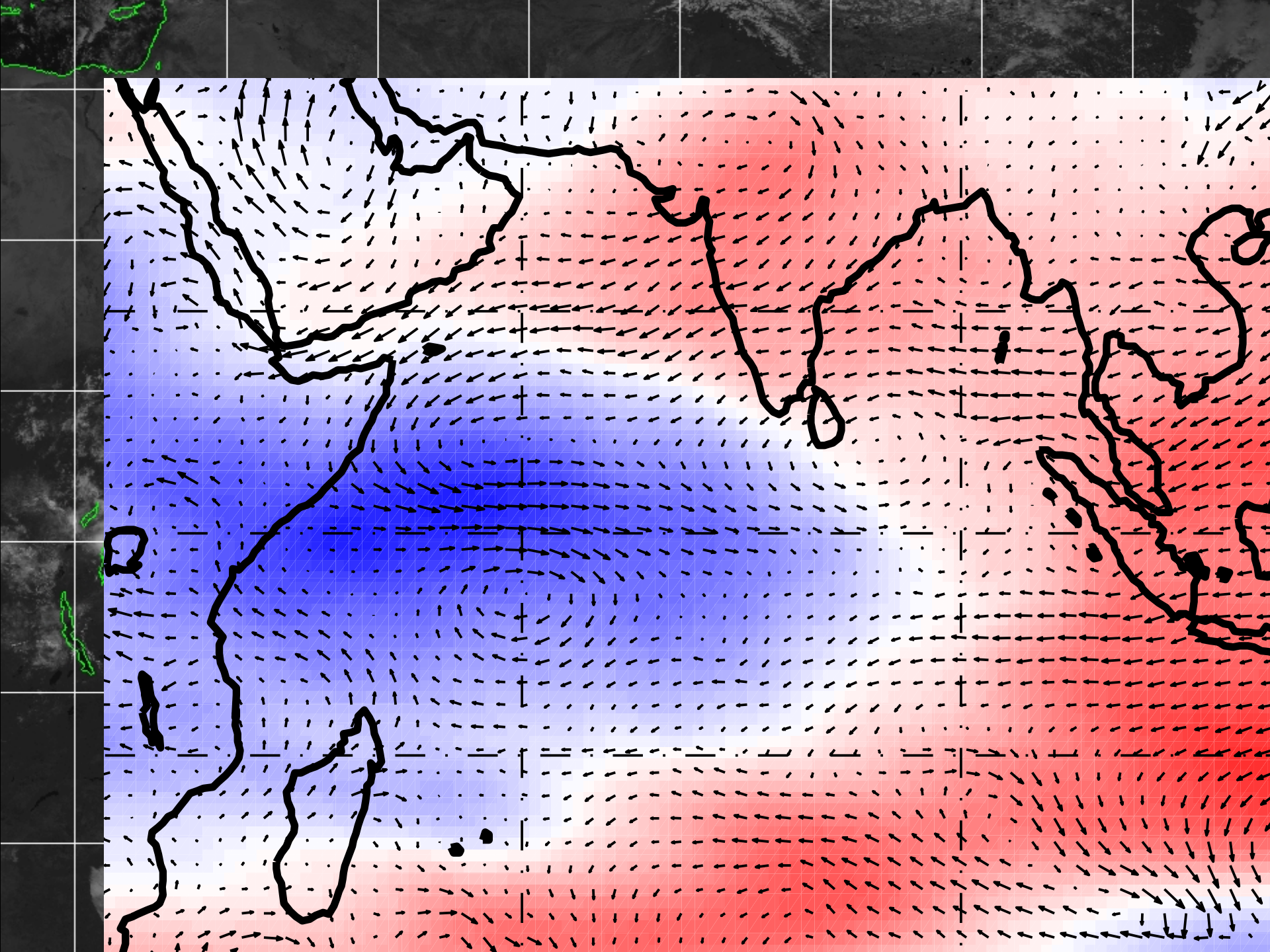
Widespread Convection | Surface | Suppressed Convection


Top of TTL
~ 300 mb
~ 850 mb
?
Deep/wide convection & MCSs
?
Isolated deep convection; Rarely large MCSs
Warm, moist boundary layer + shallow convection
Widespread Convection
Surface
Suppressed Convection


Top of TTL
~ 300 mb
Deep diabatic heating
?
?
Shallow diabatic heating
~ 850 mb
Warm, moist boundary layer + shallow convection
Widespread Convection
Surface
Suppressed Convection


MALE
GAN
08 UTC, 24 Oct 2011


MALE
GAN
08 UTC, 24 Oct 2011



Conclusions

- Depth of convection increases rapidly at LCE onset.
- Humidity increase is rapid too.
- Humidity anomalies form in place where widespread, organized convection develops.
- Westerly propagating UT divergence anomalies likely critical for stratiform, and thus MJO, maintenance.