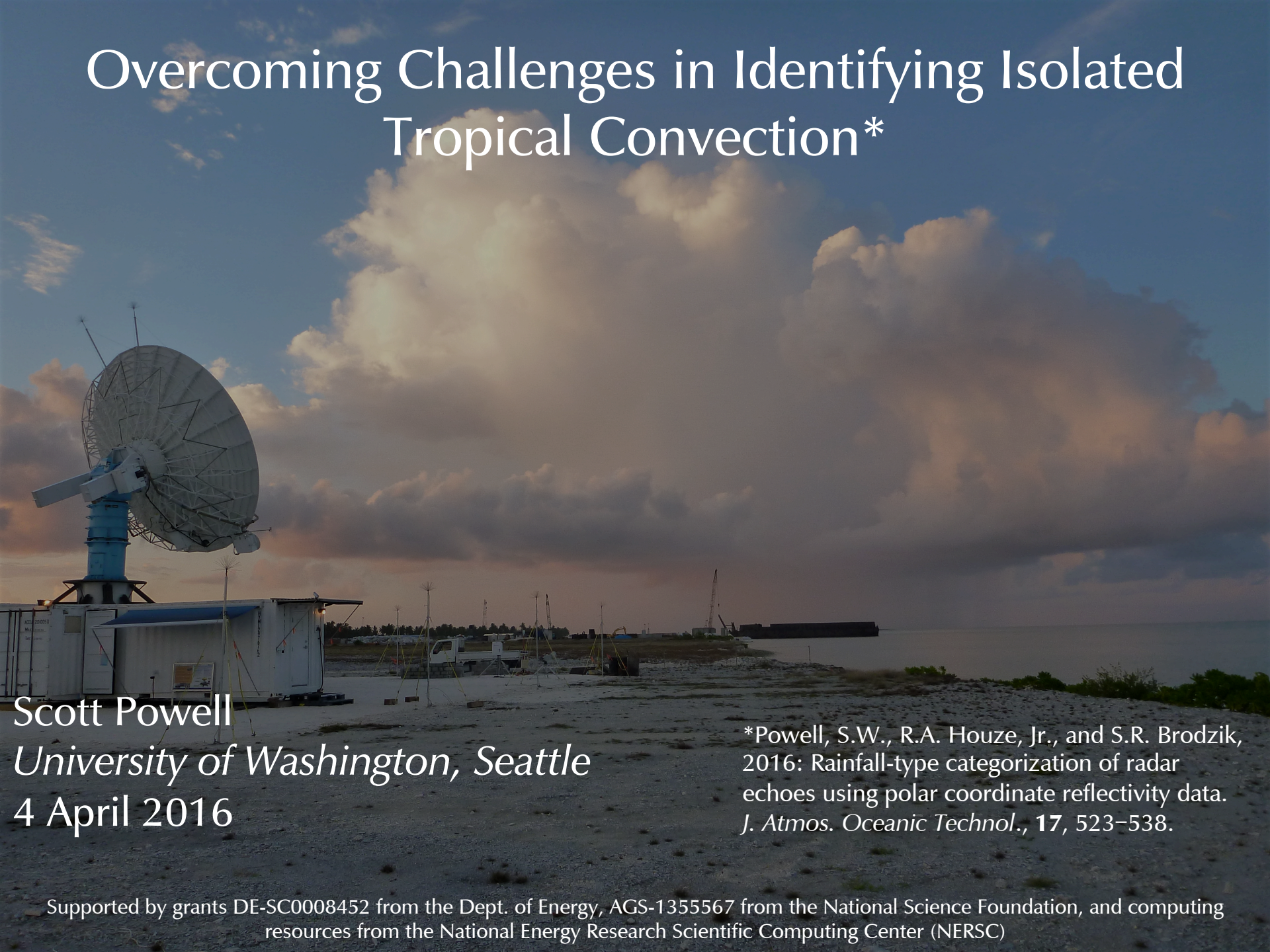
Overcoming Challenges in Identifying Isolated Tropical Convection*

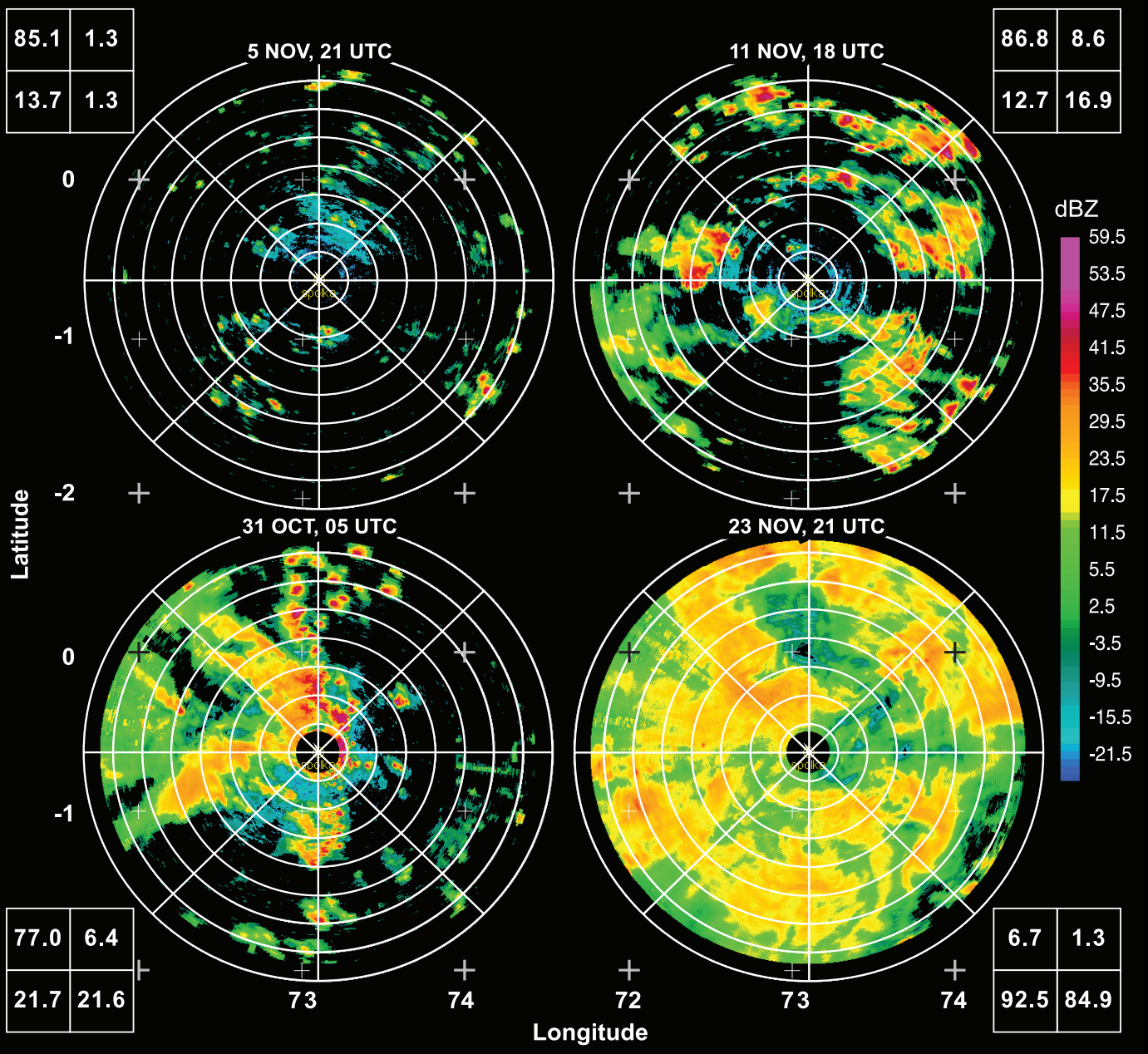


Scott Powell
University of Washington, Seattle
4 April 2016

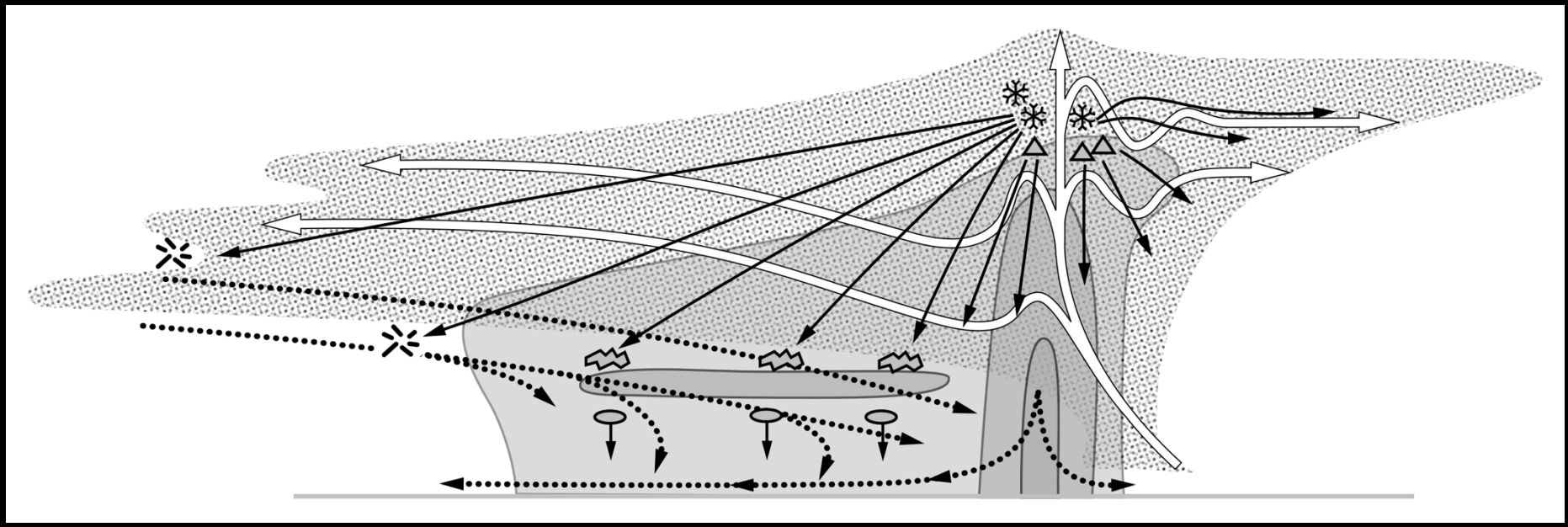
*Powell, S.W., R.A. Houze, Jr., and S.R. Brodzik, 2016: Rainfall-type categorization of radar echoes using polar coordinate reflectivity data. *J. Atmos. Oceanic Technol.*, **17**, 523–538.

Supported by grants DE-SC0008452 from the Dept. of Energy, AGS-1355567 from the National Science Foundation, and computing resources from the National Energy Research Scientific Computing Center (NERSC)

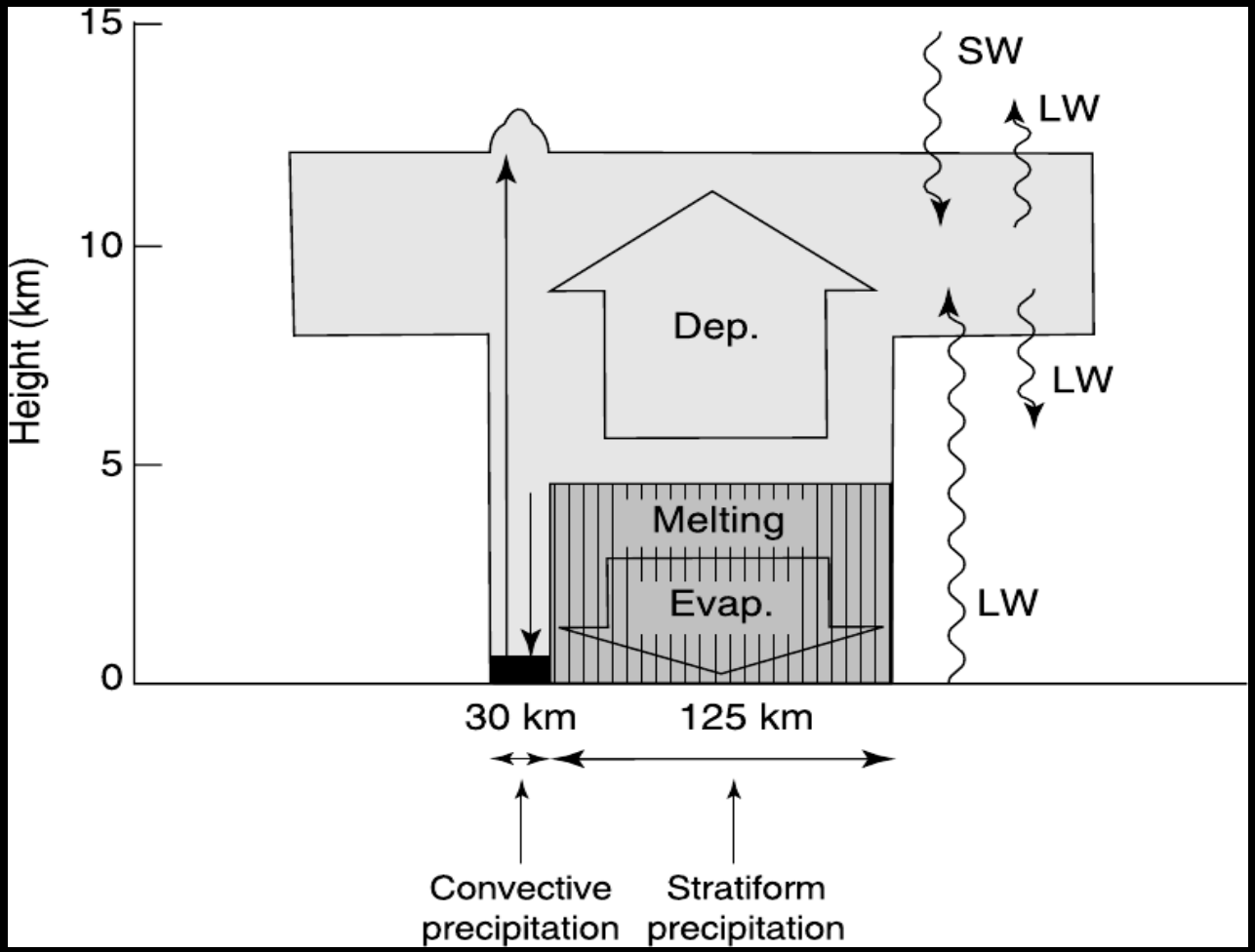
Powell and Houze (2013)



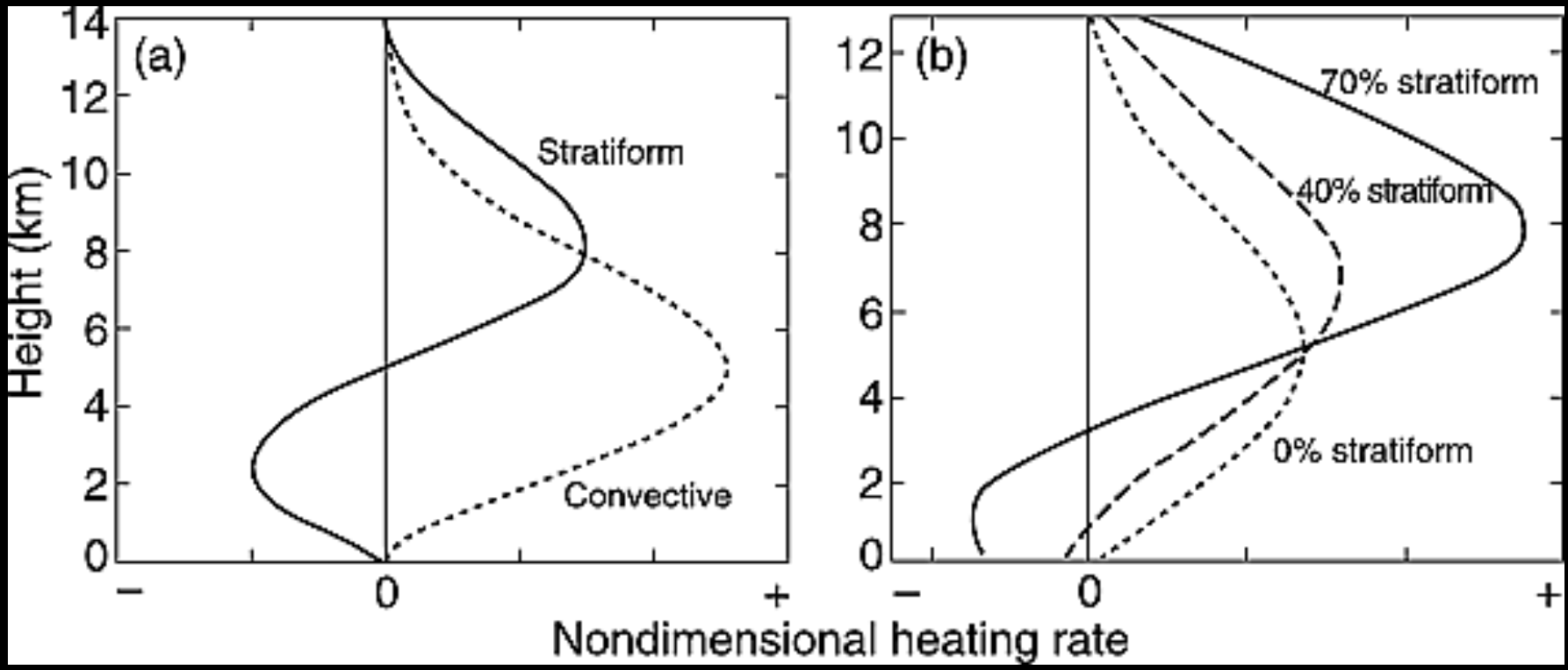
Cetrone and Houze (2011)

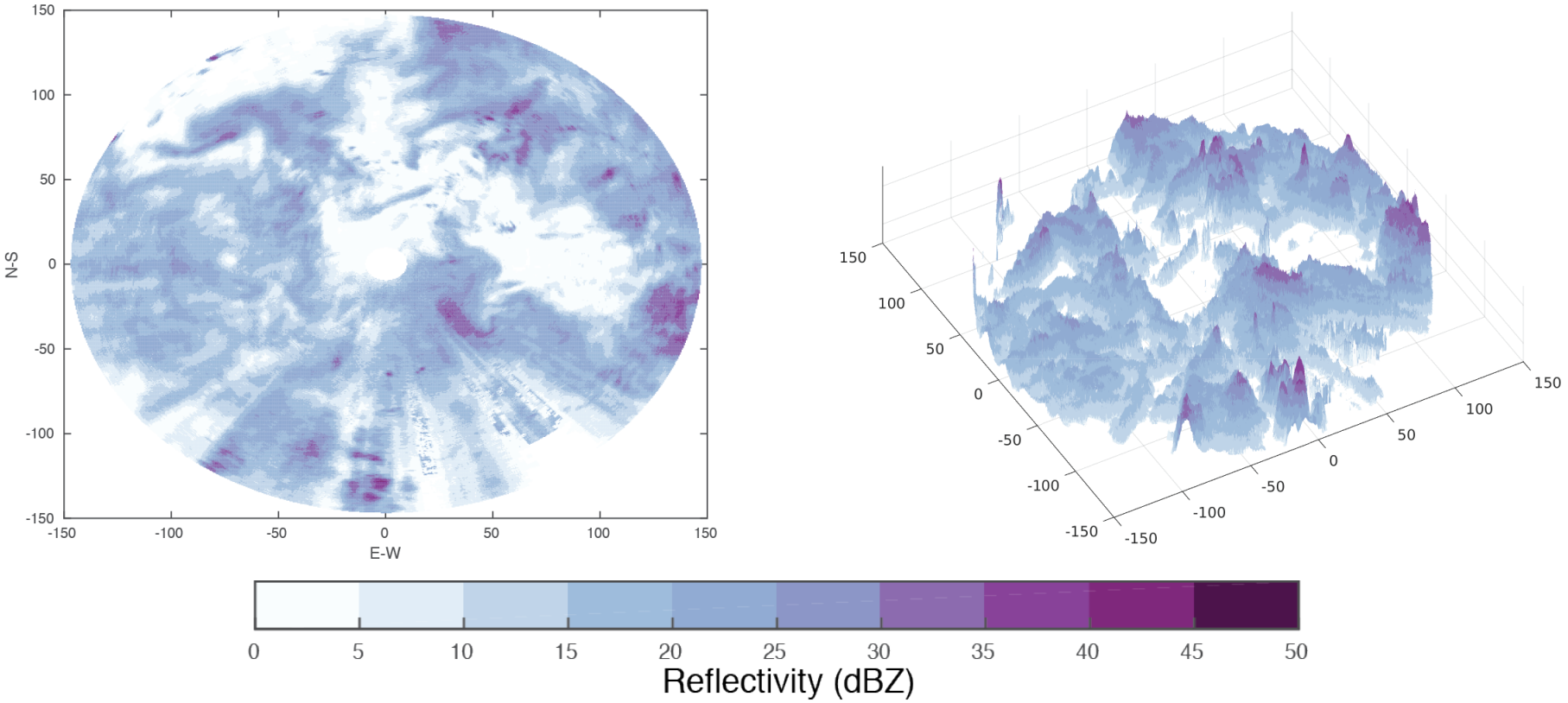


Houze (1982)


15
10
5
0
Height (km)
SW
LW
Dep.
LW
Melting
Evap.
LW
30 km
125 km
Convective precipitation
Stratiform precipitation

Schumacher et al. (2004)

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-150 -100 -50 0 50 100 150
E-W
150
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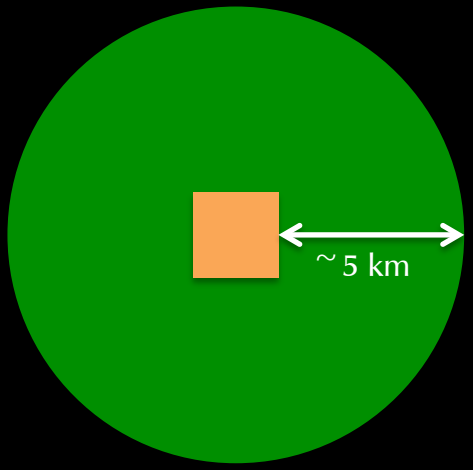
-50
-100
-150
-150 -100 -50 0 50 100 150
0 5 10 15 20 25 30 35 40 45 50
Reflectivity (dBZ)

Steiner et al (1995) says convective if…

1. Reflectivity exceeds some threshold (often 40–45 dBZ)

Steiner et al (1995) says convective if…

2. Reflectivity exceeds background reflectivity by some threshold

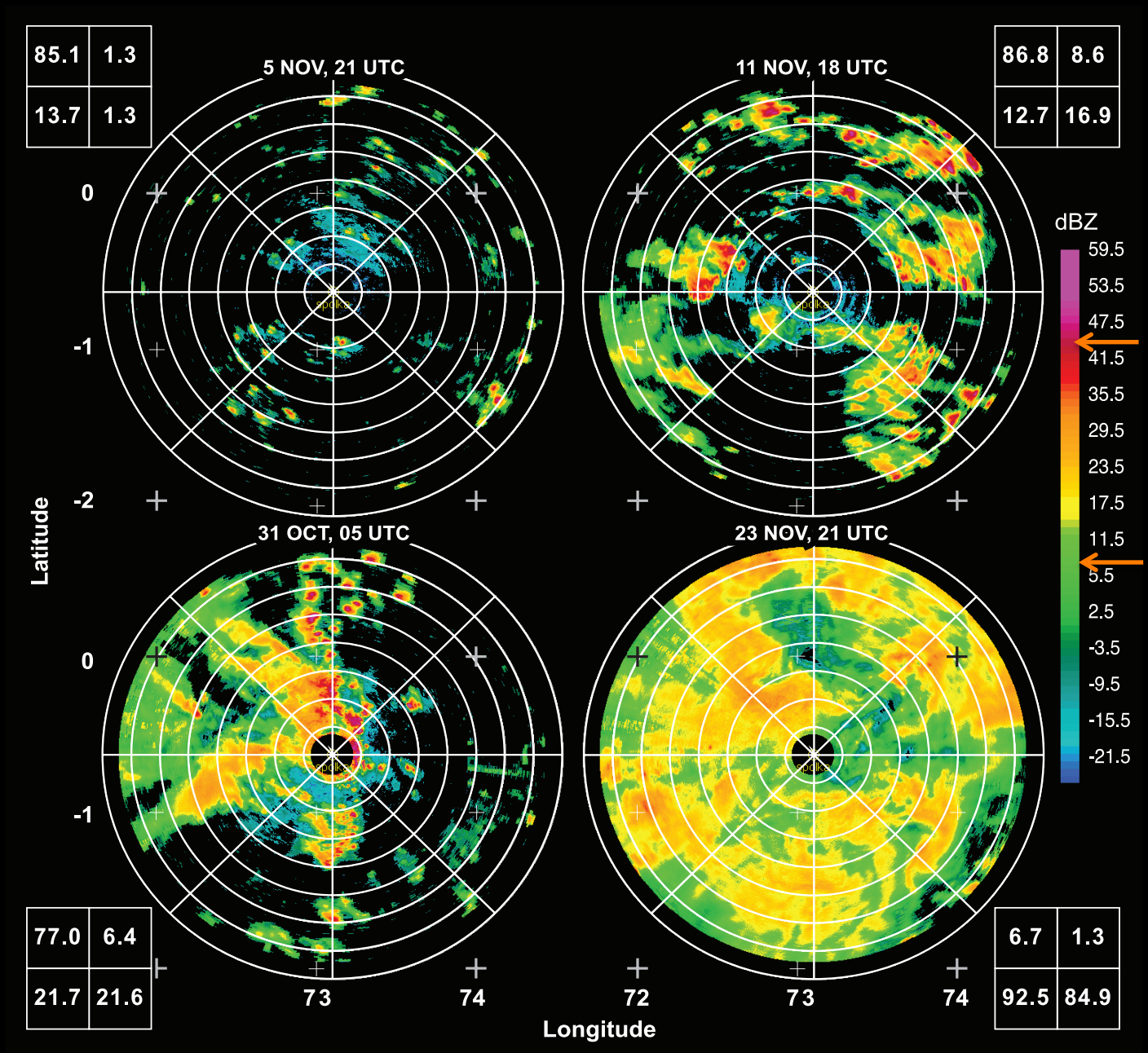


Steiner et al (1995) says convective if…

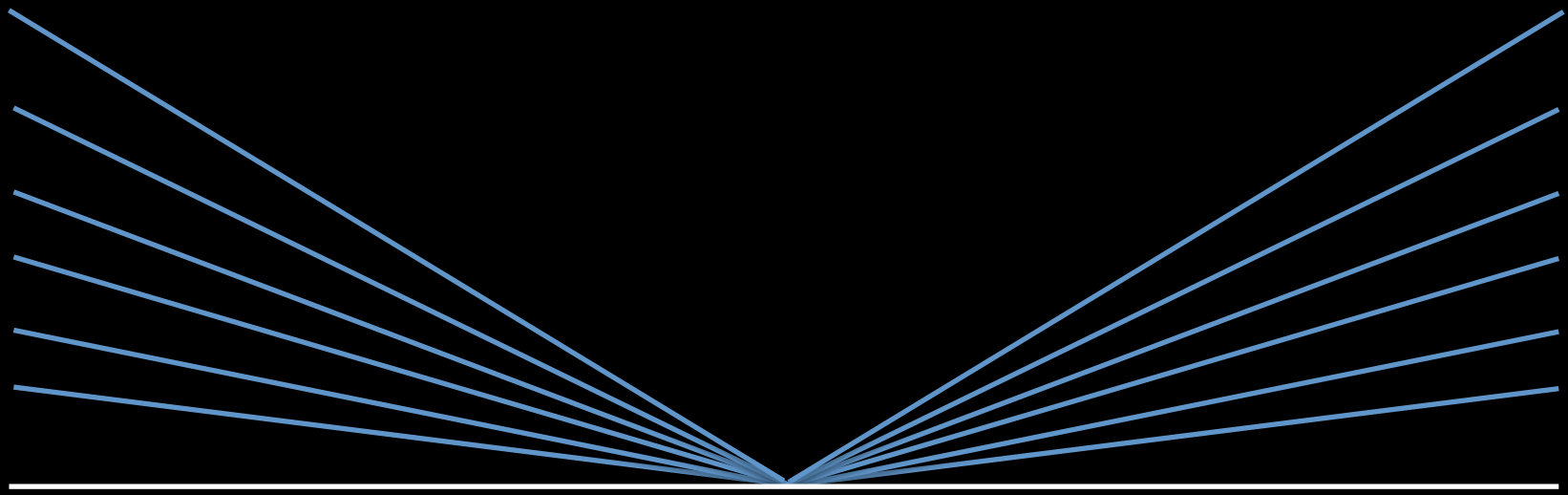
1. Reflectivity exceeds some threshold (often 40–45 dBZ)
2. Reflectivity exceeds background reflectivity by some threshold
3. If an echo is within as much as 5 km of a convective core

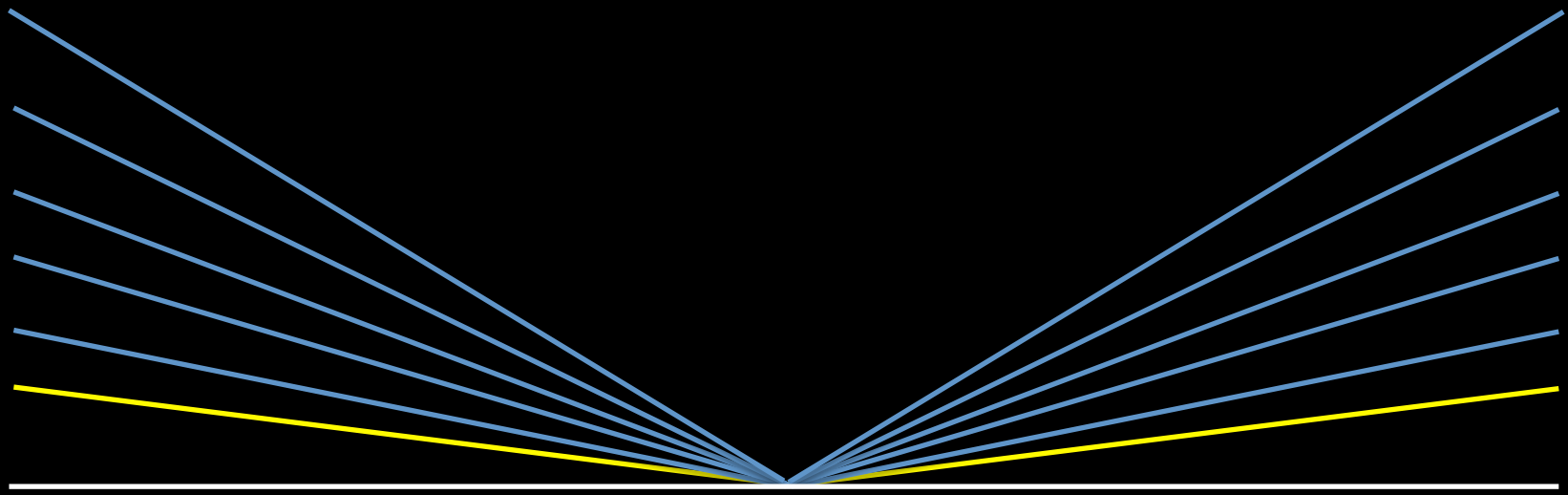
…otherwise stratiform.

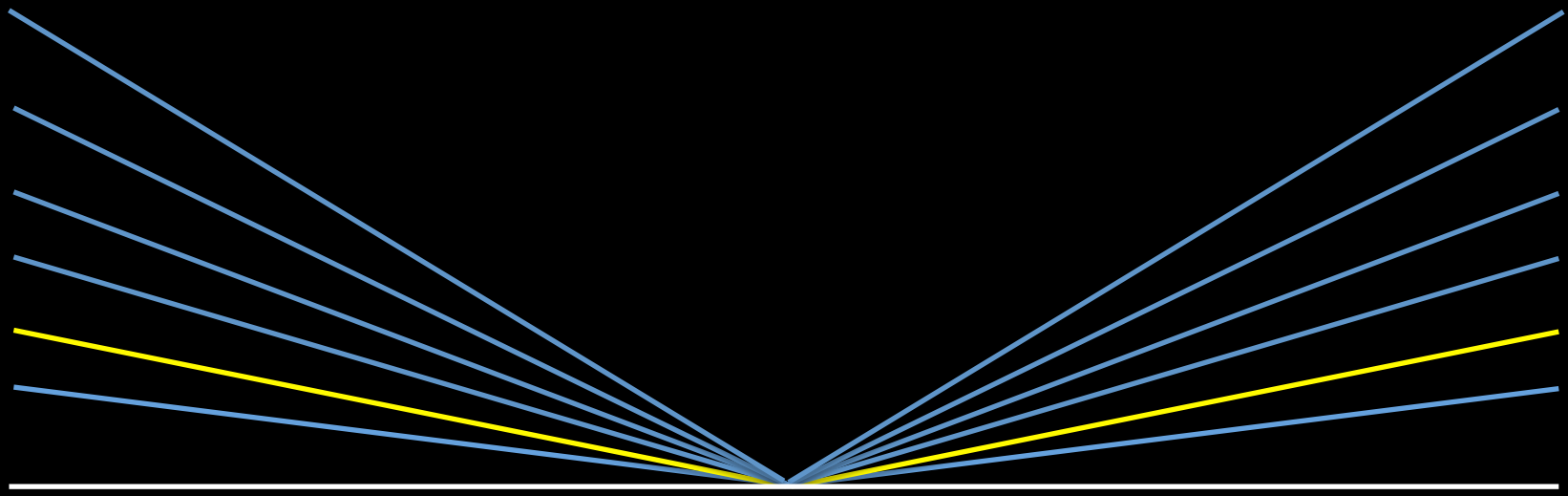
Powell and Houze (2013)

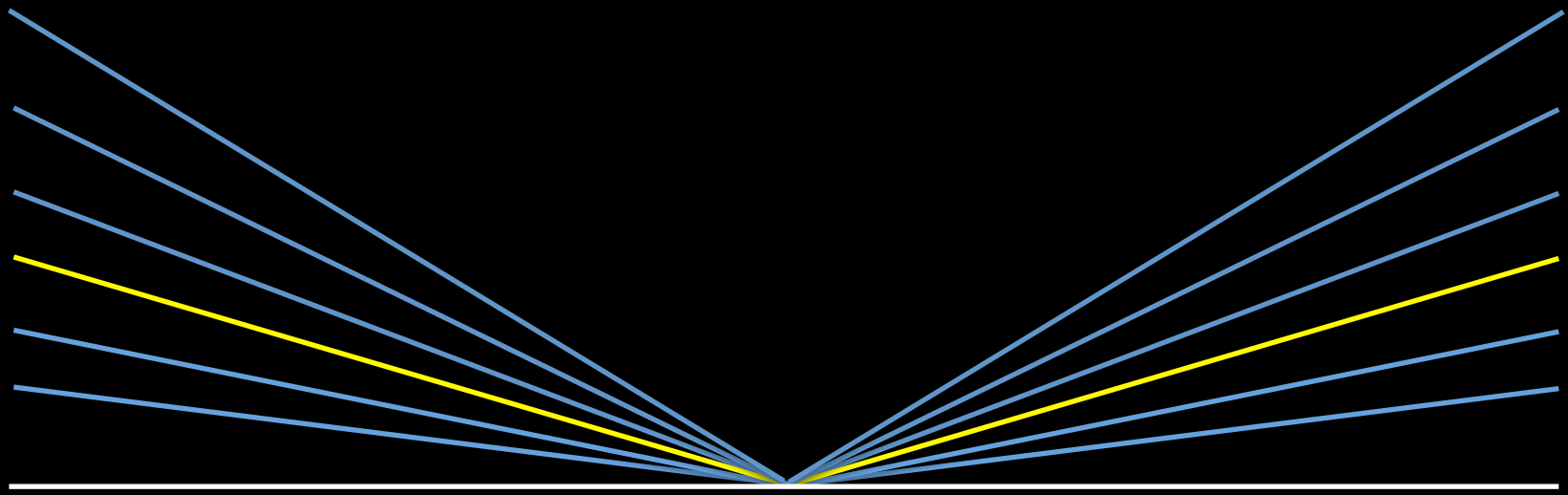


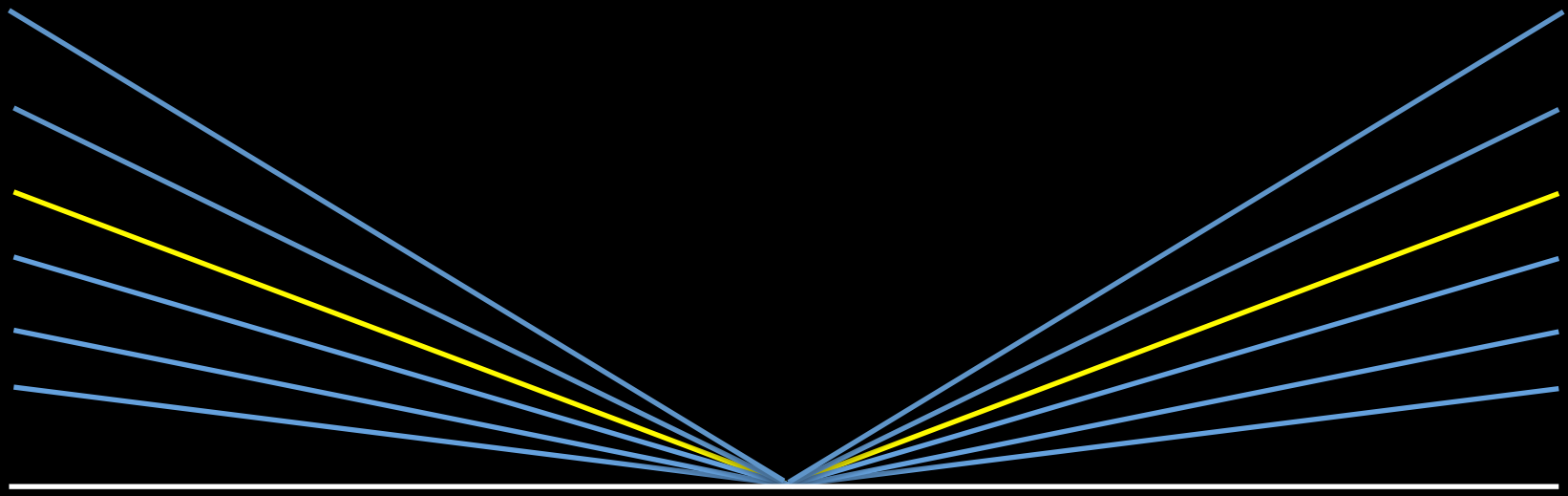
Problems with Interpolating Radar Data

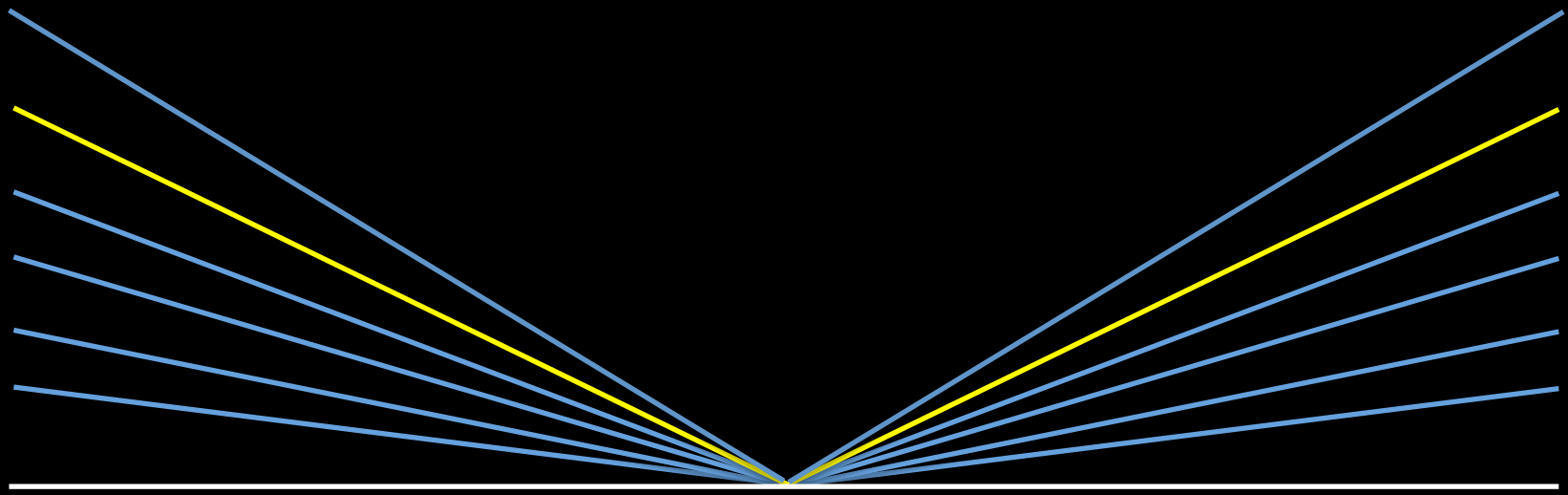


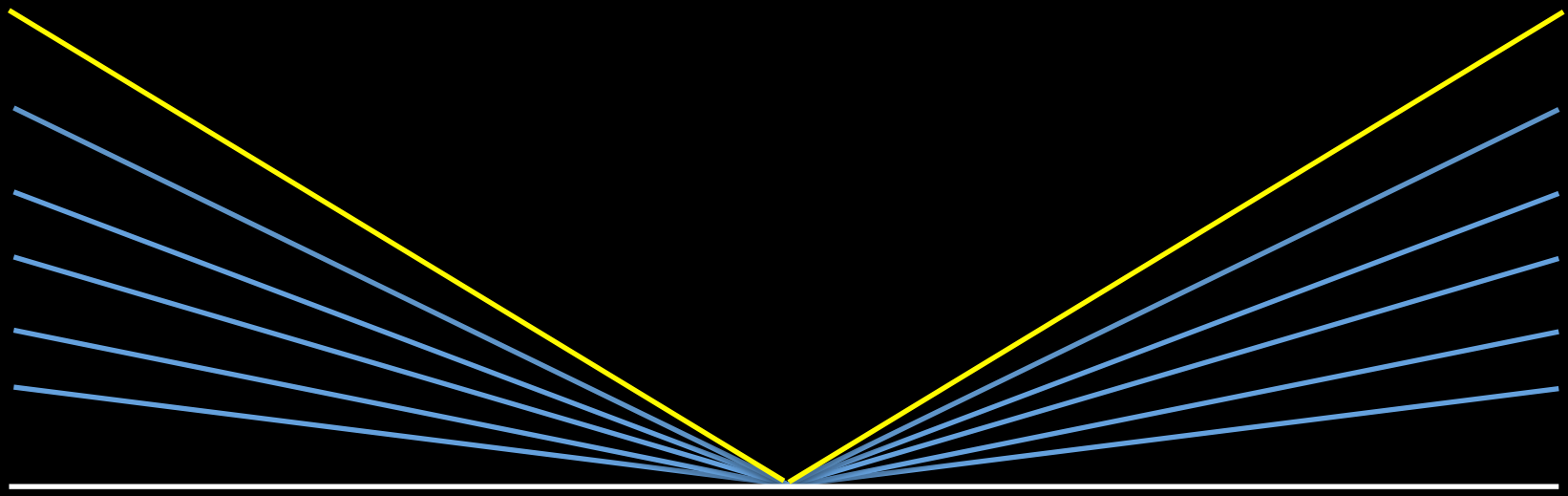




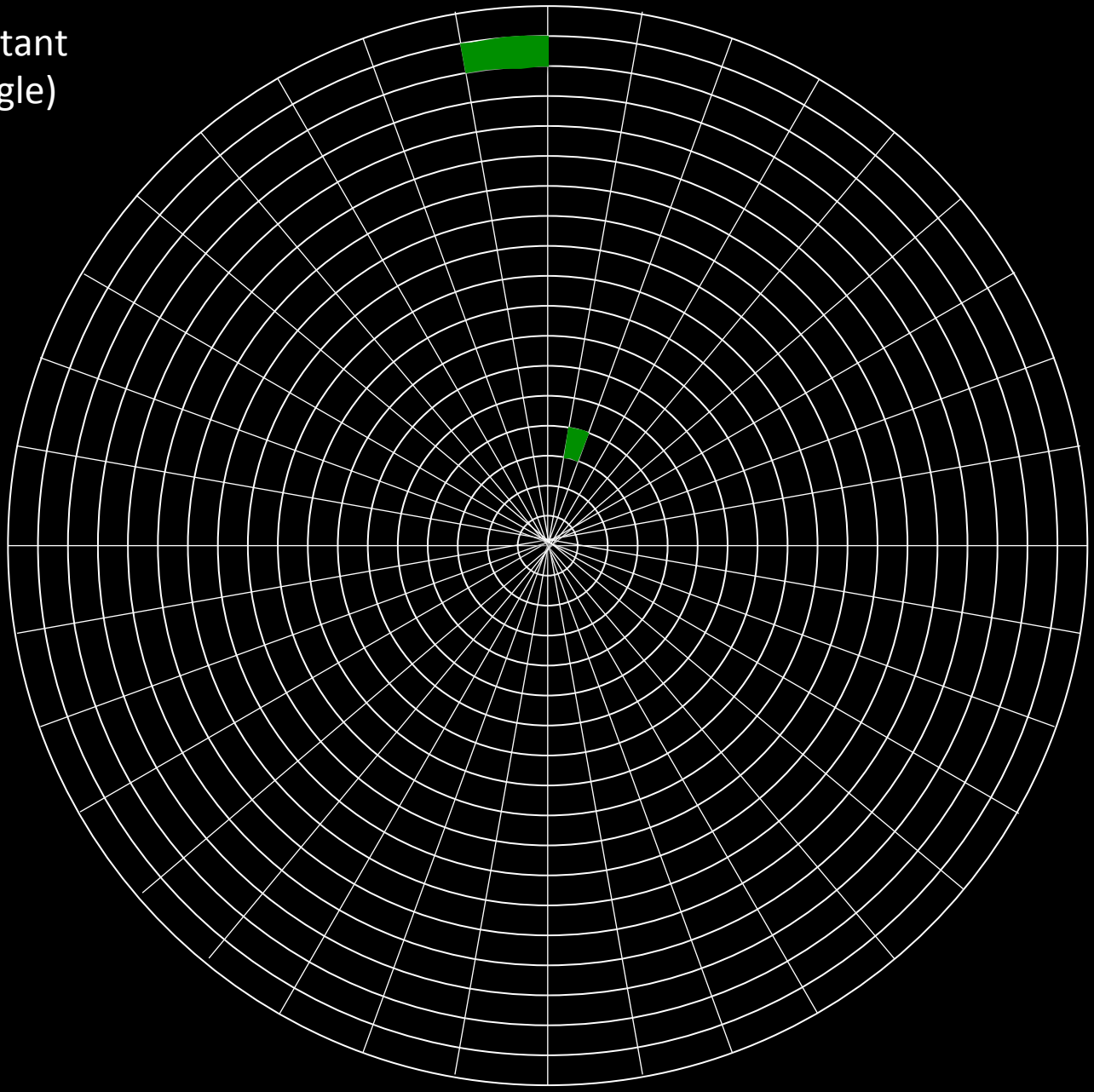


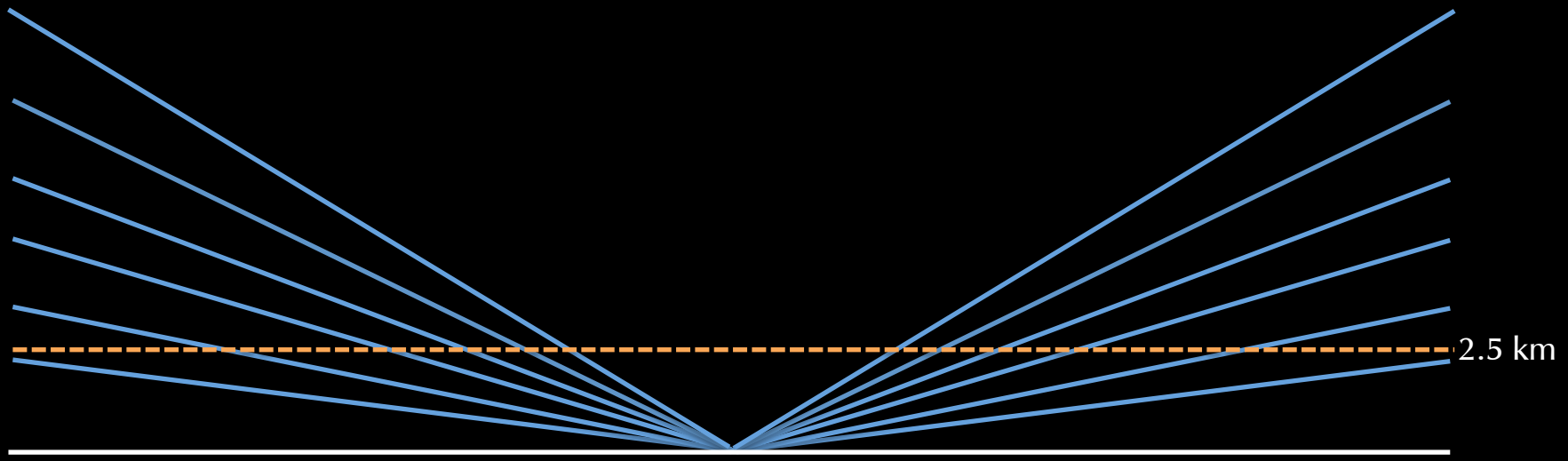






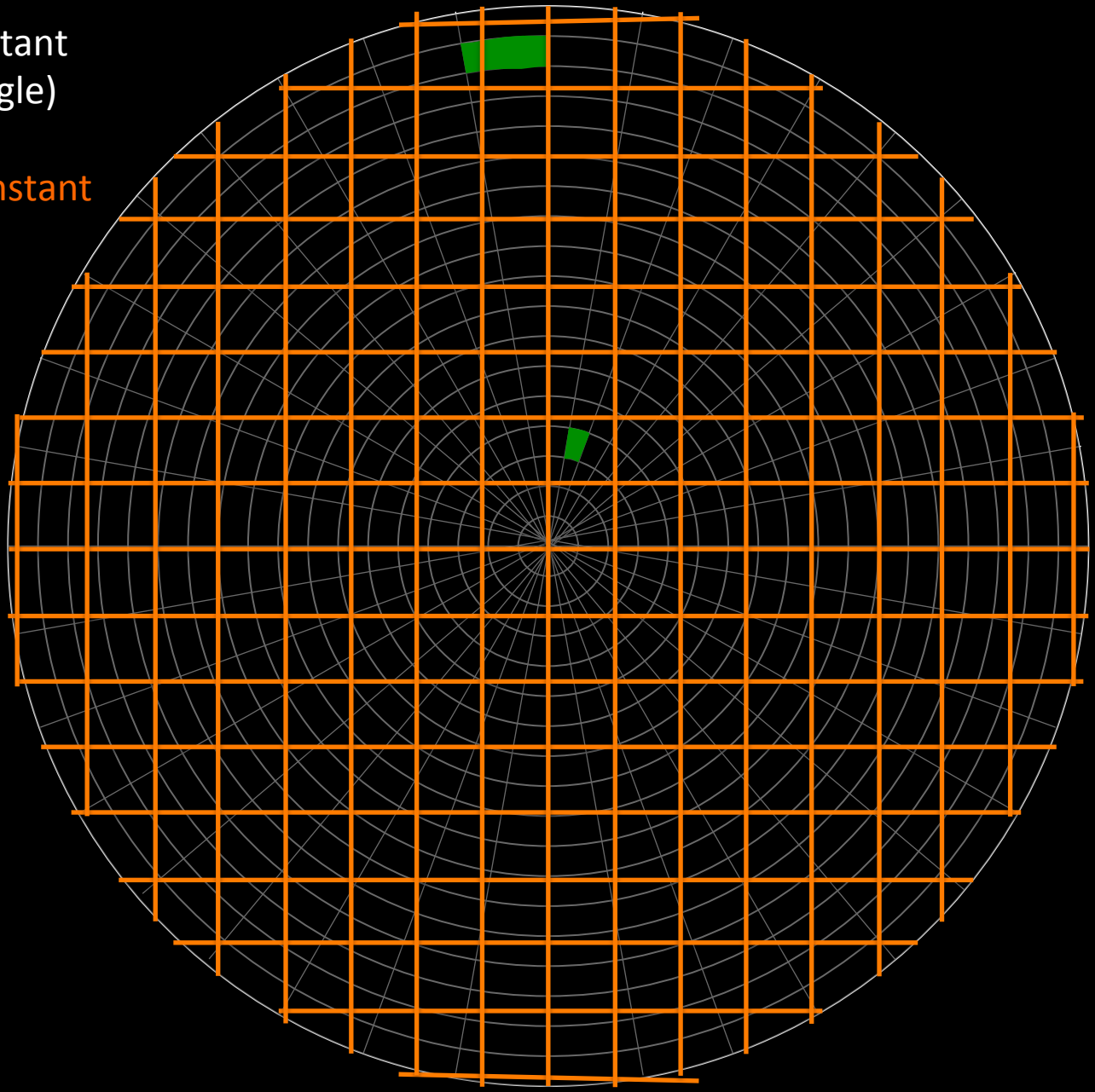
Sweep (constant elevation angle)

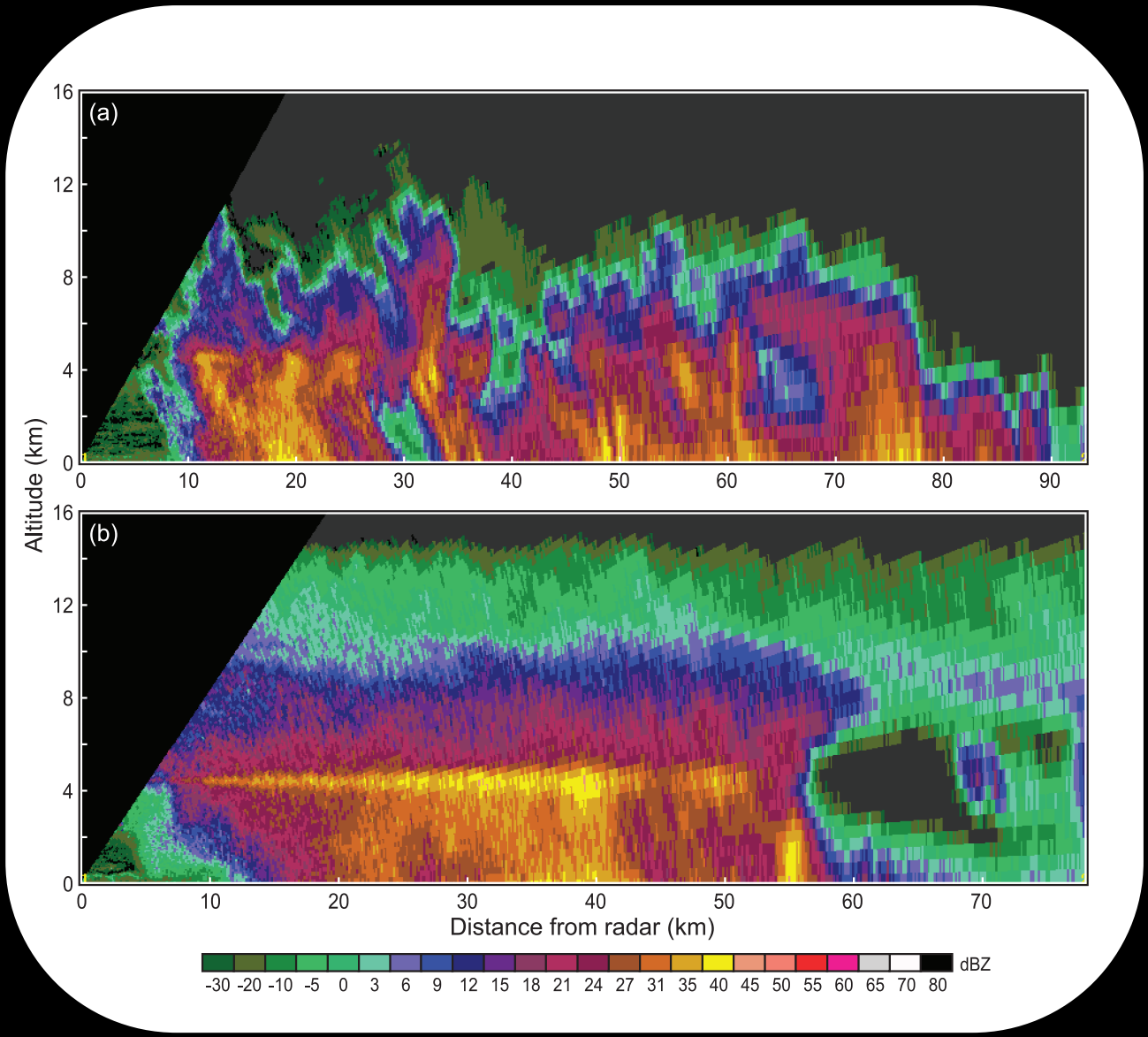



2.5 km

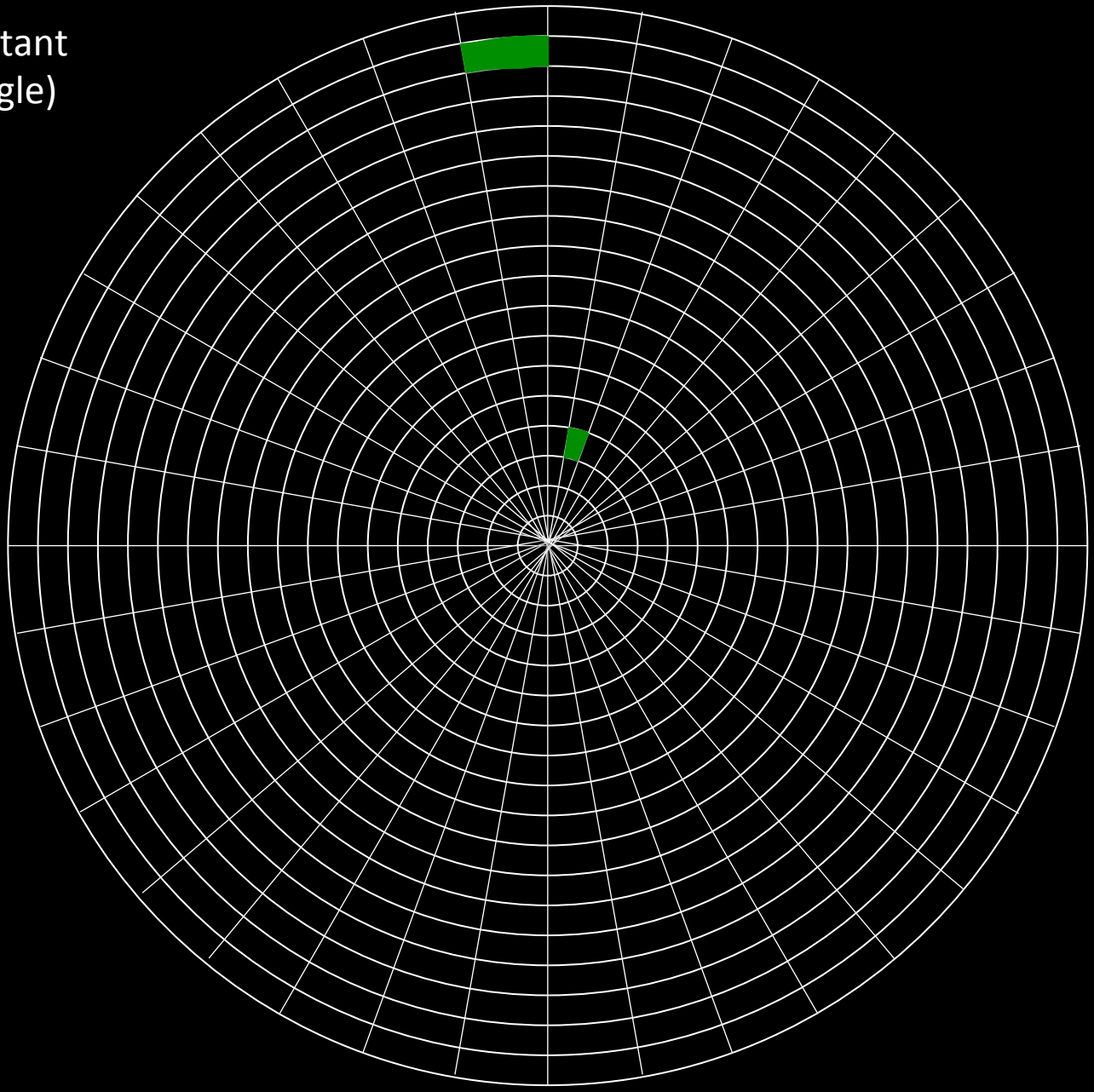
Sweep (constant elevation angle)

Gridded (constant height)

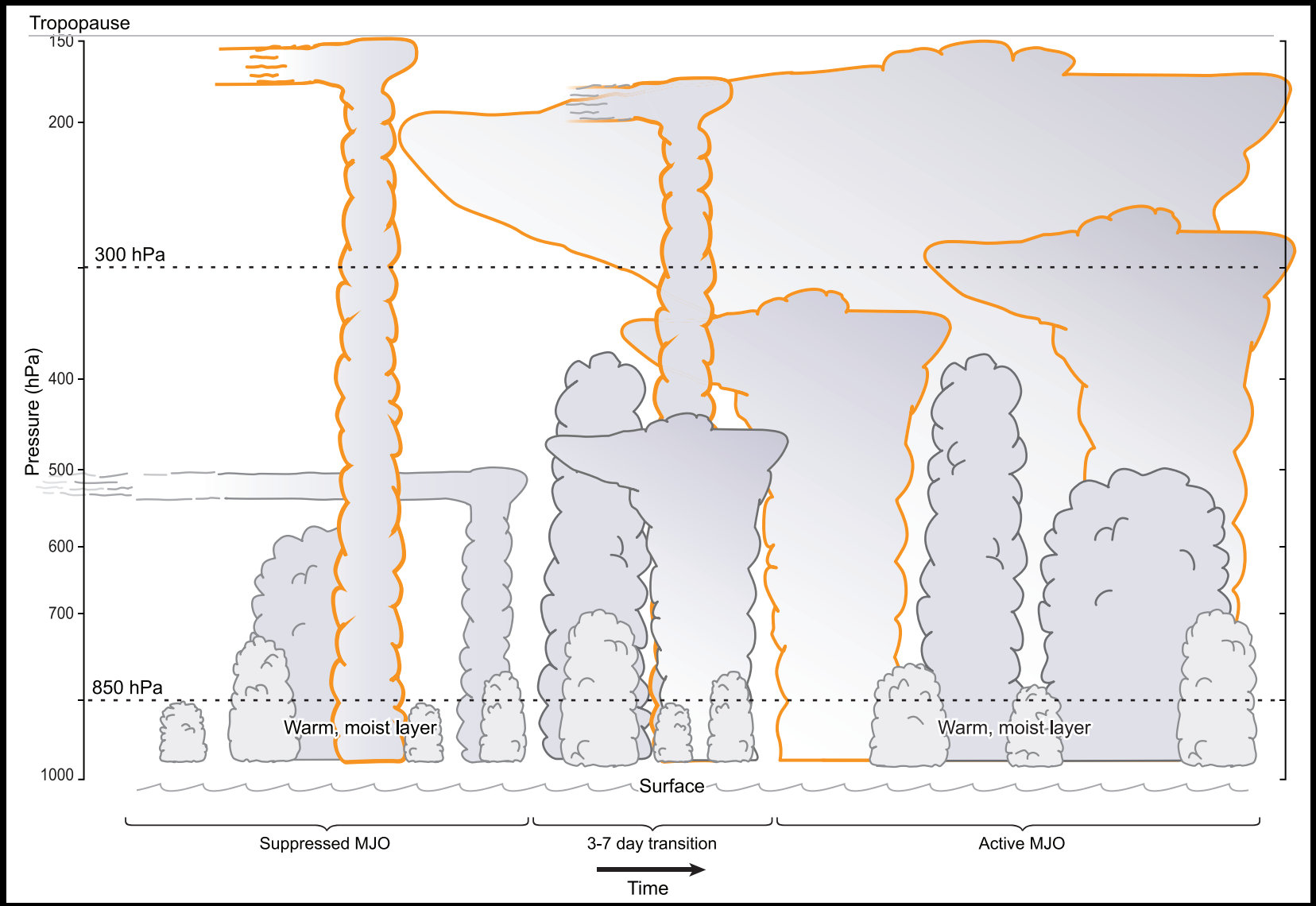


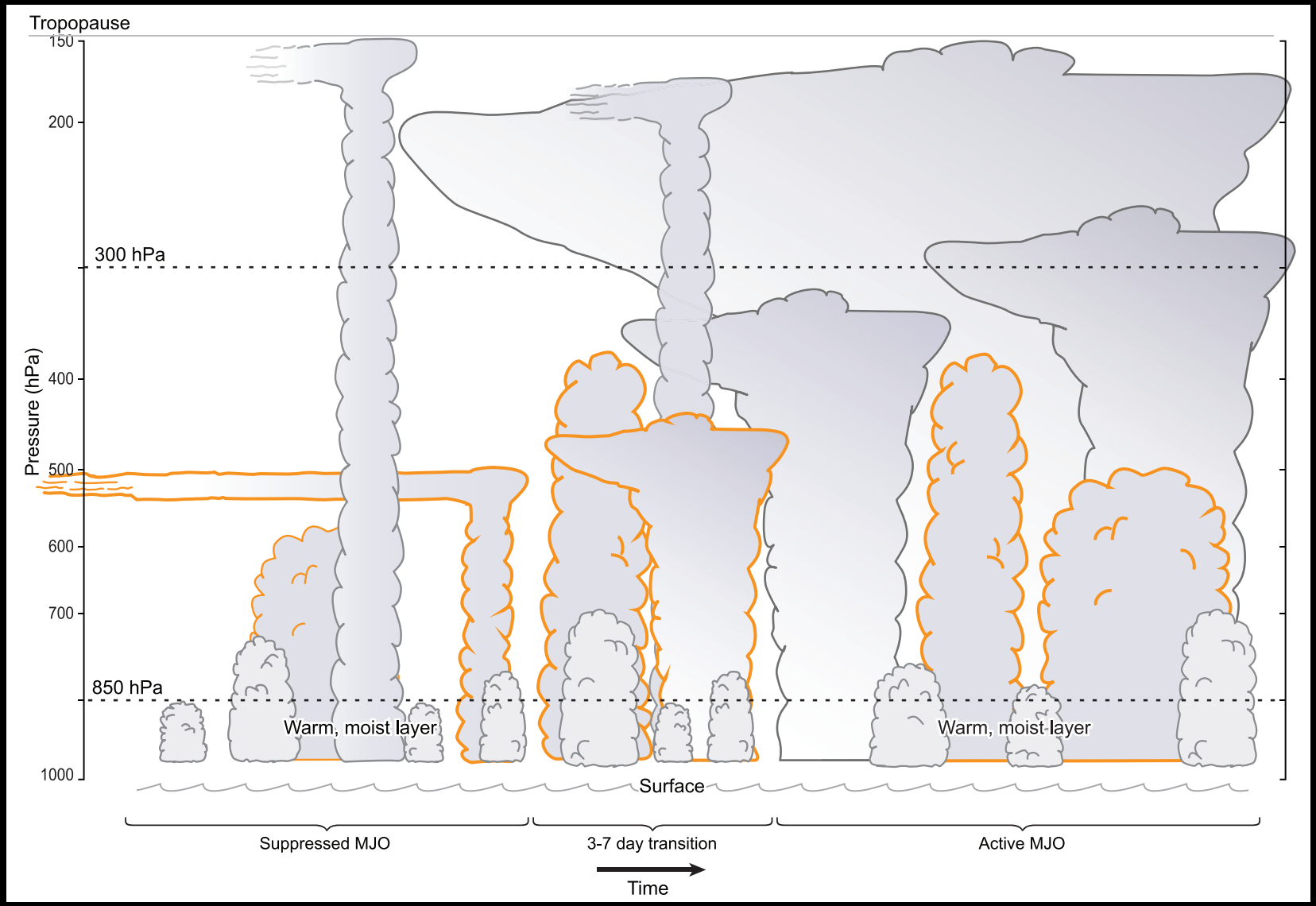

(a)
(b)
Altitude (km)
Distance from radar (km)
dBZ
-30 -20 -10 -5 0 3 6 9 12 15 18 21 24 27 31 35 40 45 50 55 60 65 70 80

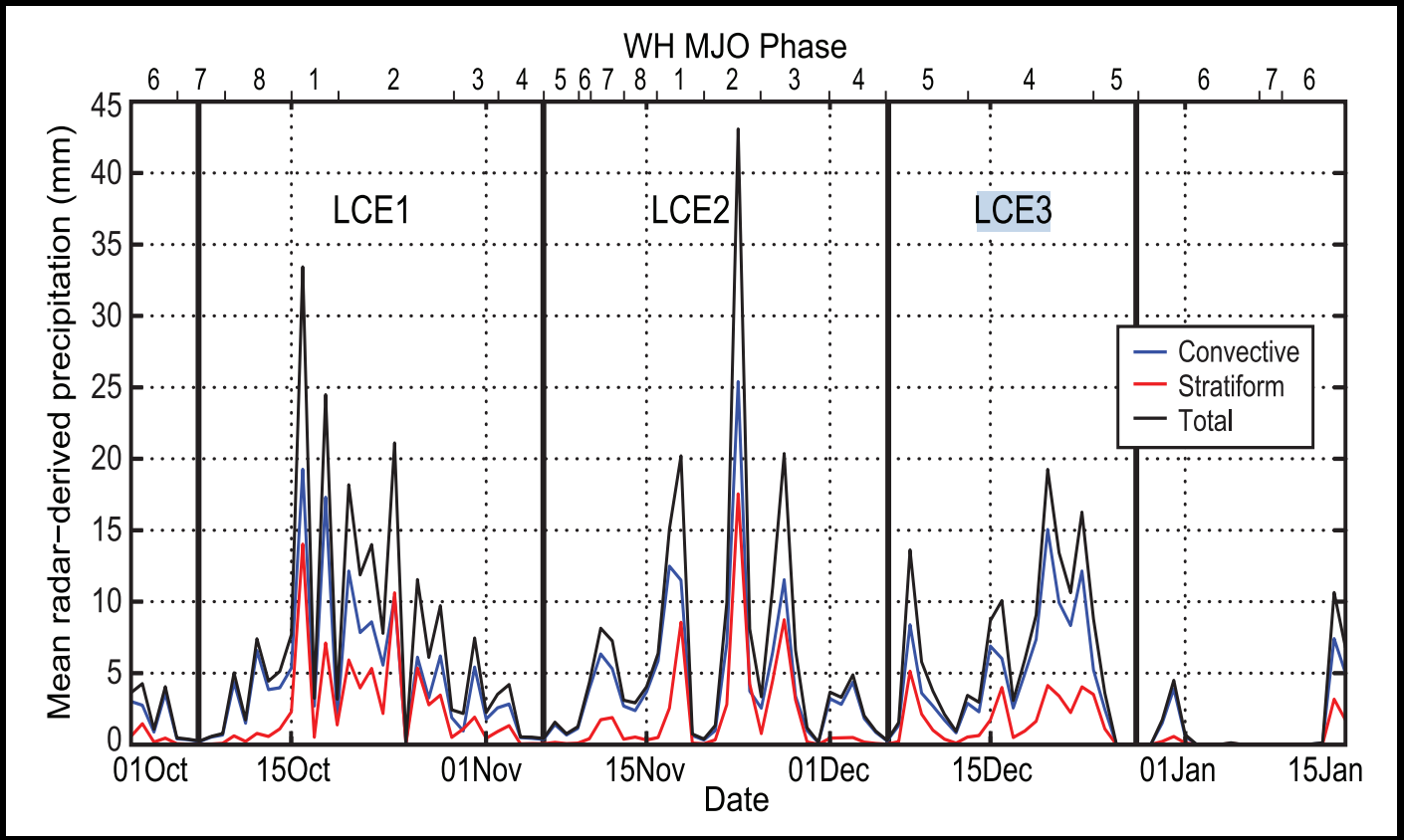
Sweep (constant elevation angle)

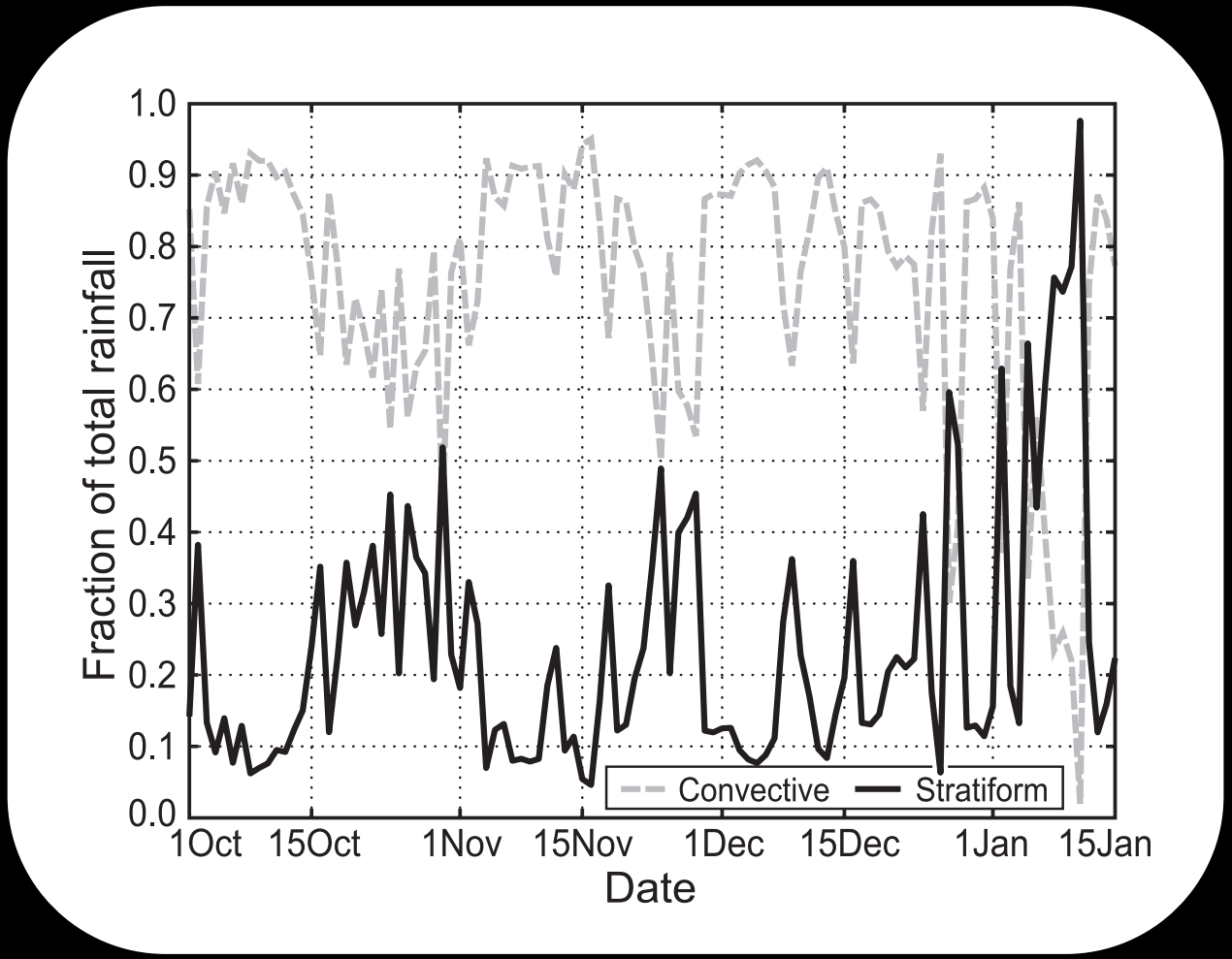


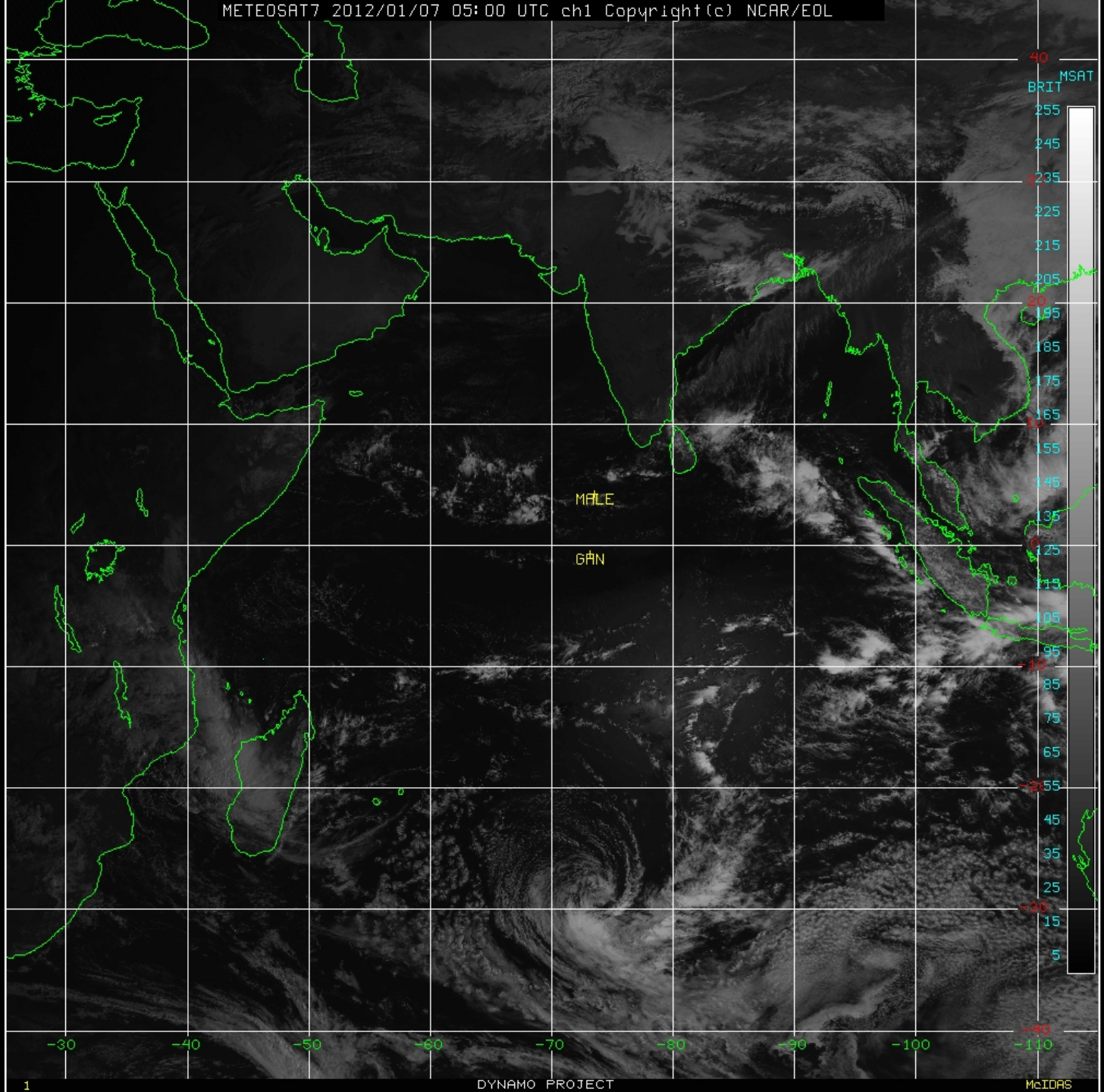
Difficulties Identifying Isolated Convection


Tropopause
150
200
300 hPa
400
500
600
700
850 hPa
1000
Pressure (hPa)
Warm, moist layer
Warm, moist layer
Surface
Suppressed MJO
3-7 day transition
Active MJO
Time


Tropopause
150
200
300 hPa
400
500
600
700
850 hPa
1000
Pressure (hPa)
Warm, moist layer
Warm, moist layer
Surface
Suppressed MJO
3-7 day transition
Active MJO
Time


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


Fraction of total rainfall
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1Oct
15Oct
1Nov
15Nov
1Dec
15Dec
1Jan
15Jan
Date
Convective
Stratiform


METEOSAT7 2012/01/07 05:00 UTC ch1 Copyright(c) NCAR/EOL
MALE
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MSAT
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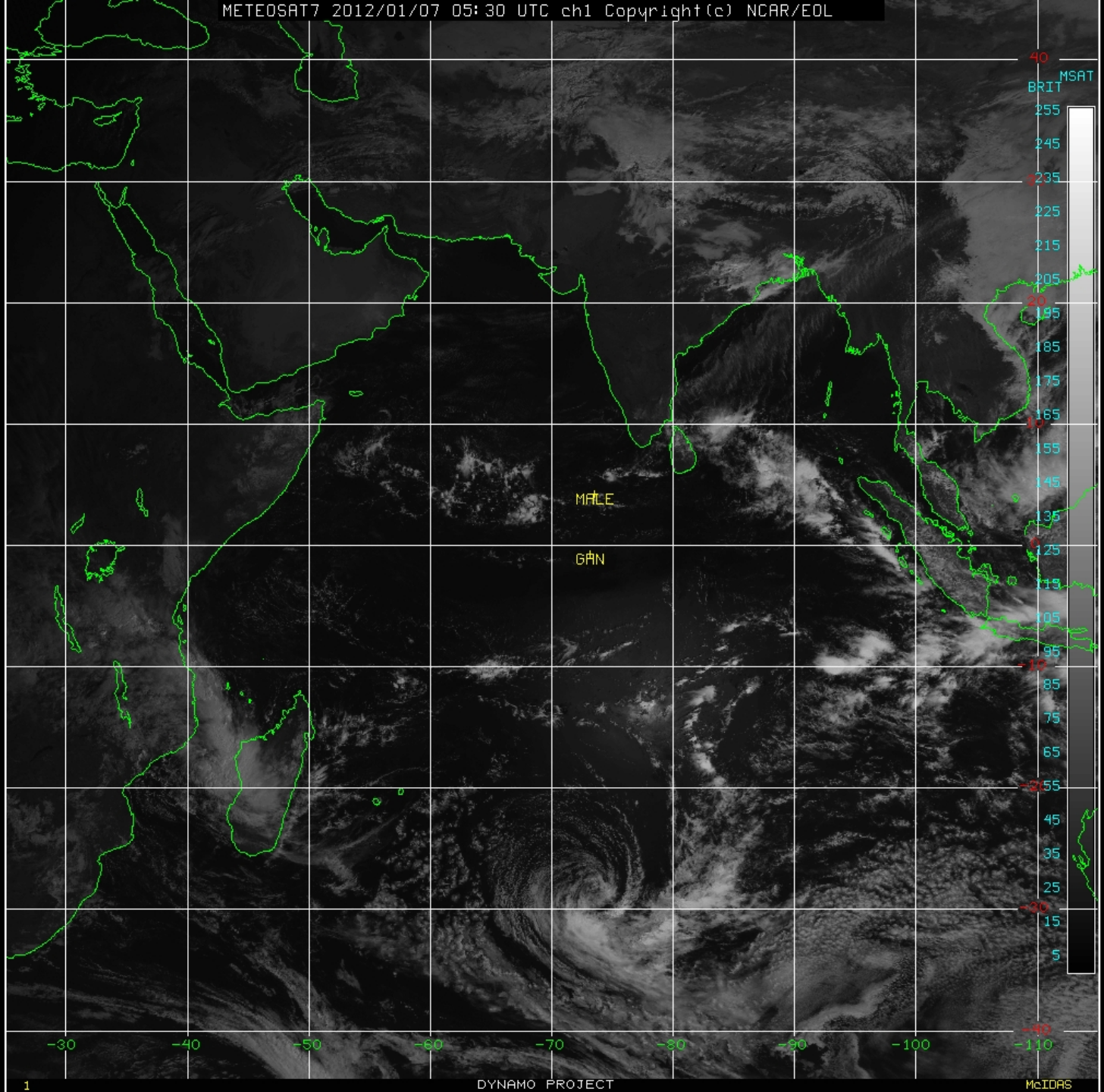
DYNAMO PROJECT
McIDAS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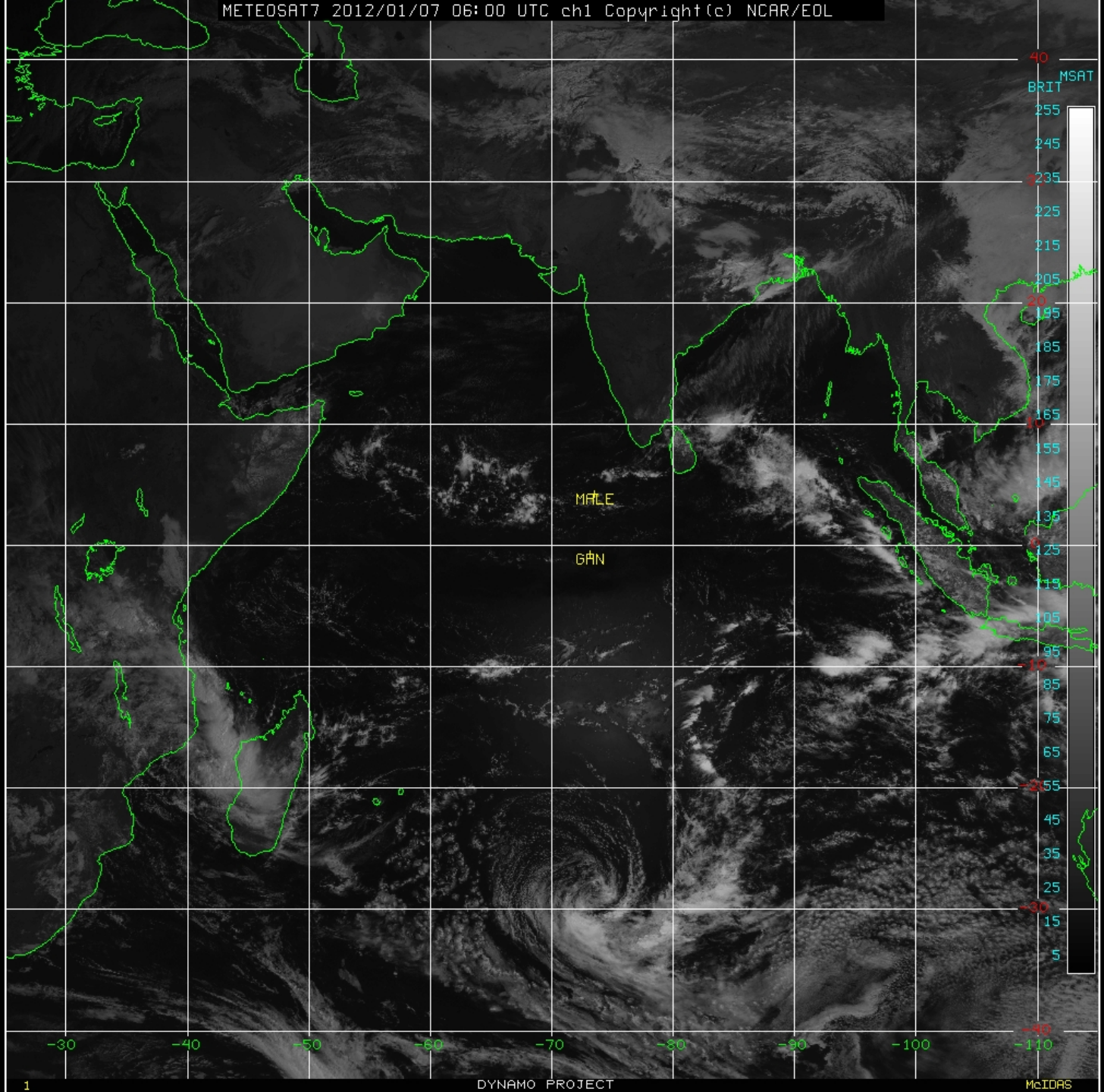
DYNAMO PROJECT
McIDAS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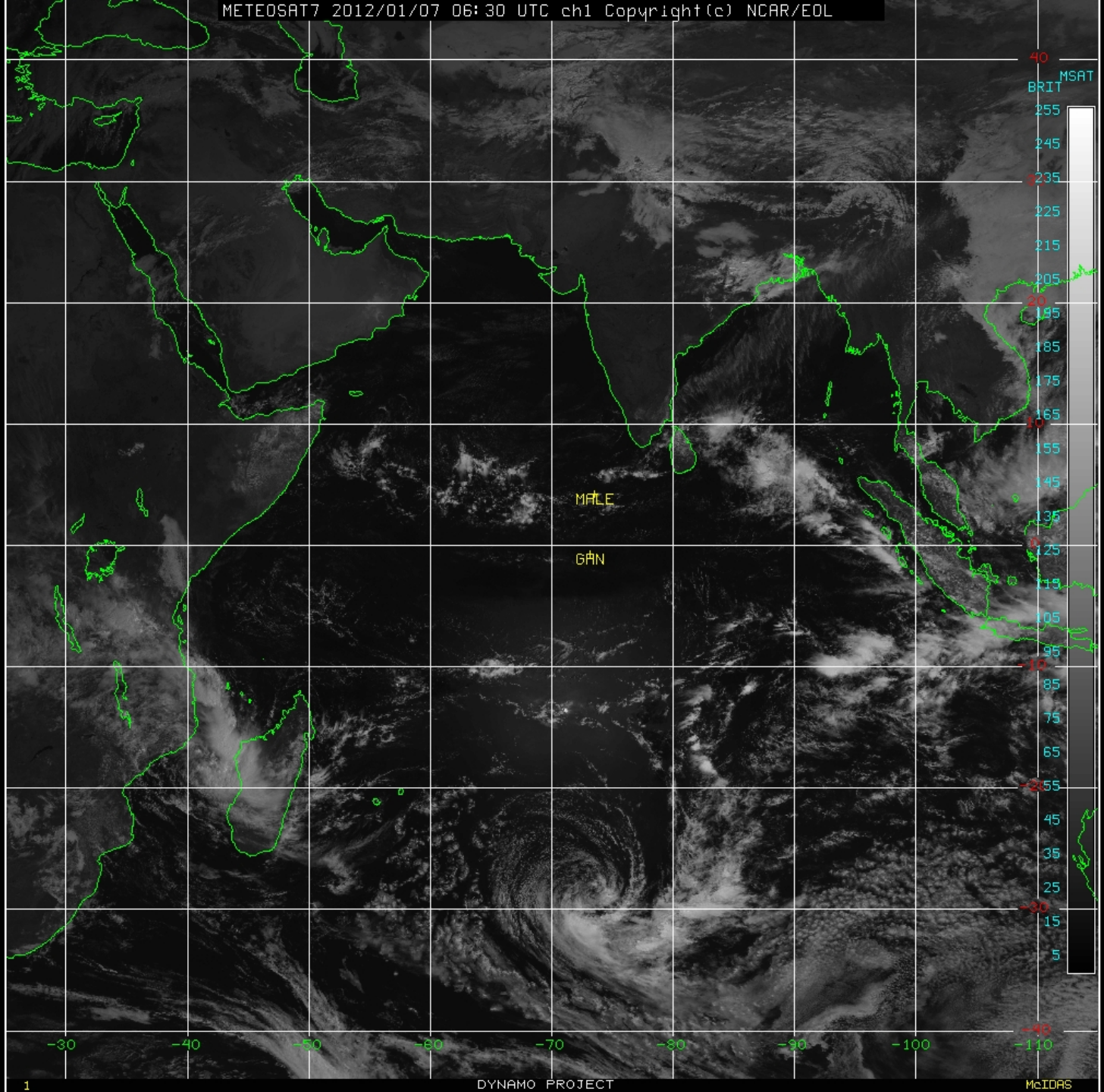
DYNAMO PROJECT
McIDAS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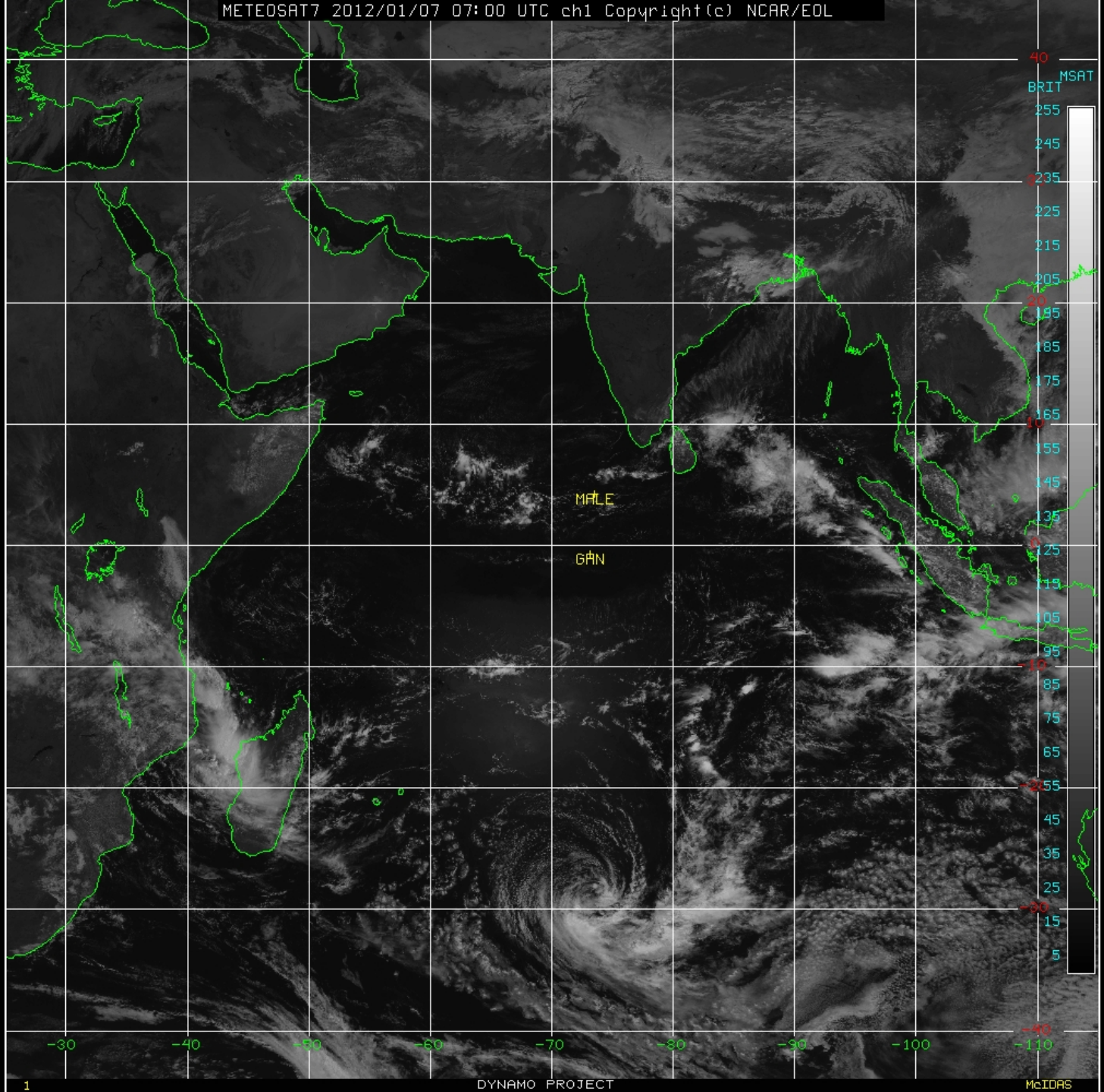
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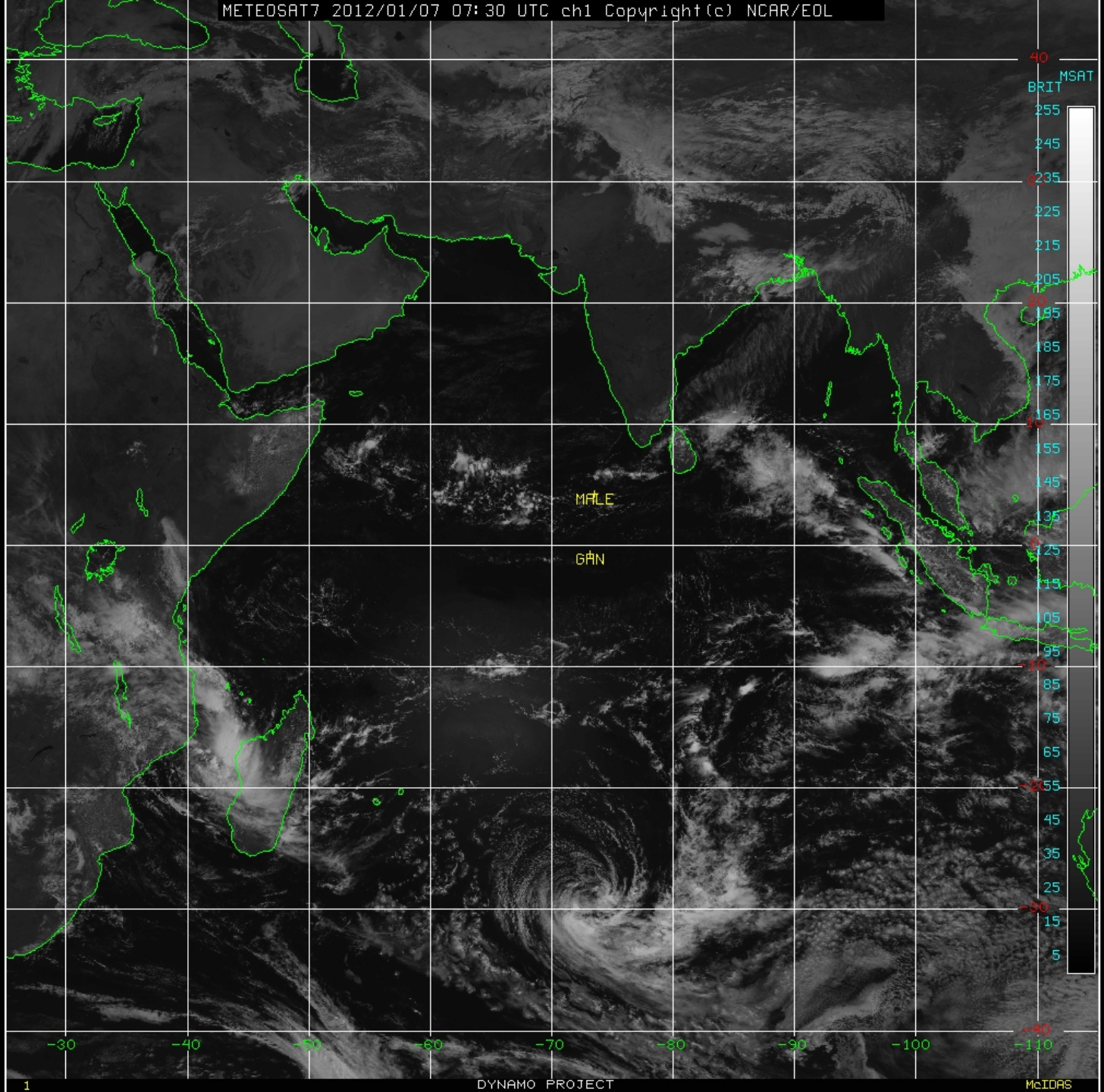
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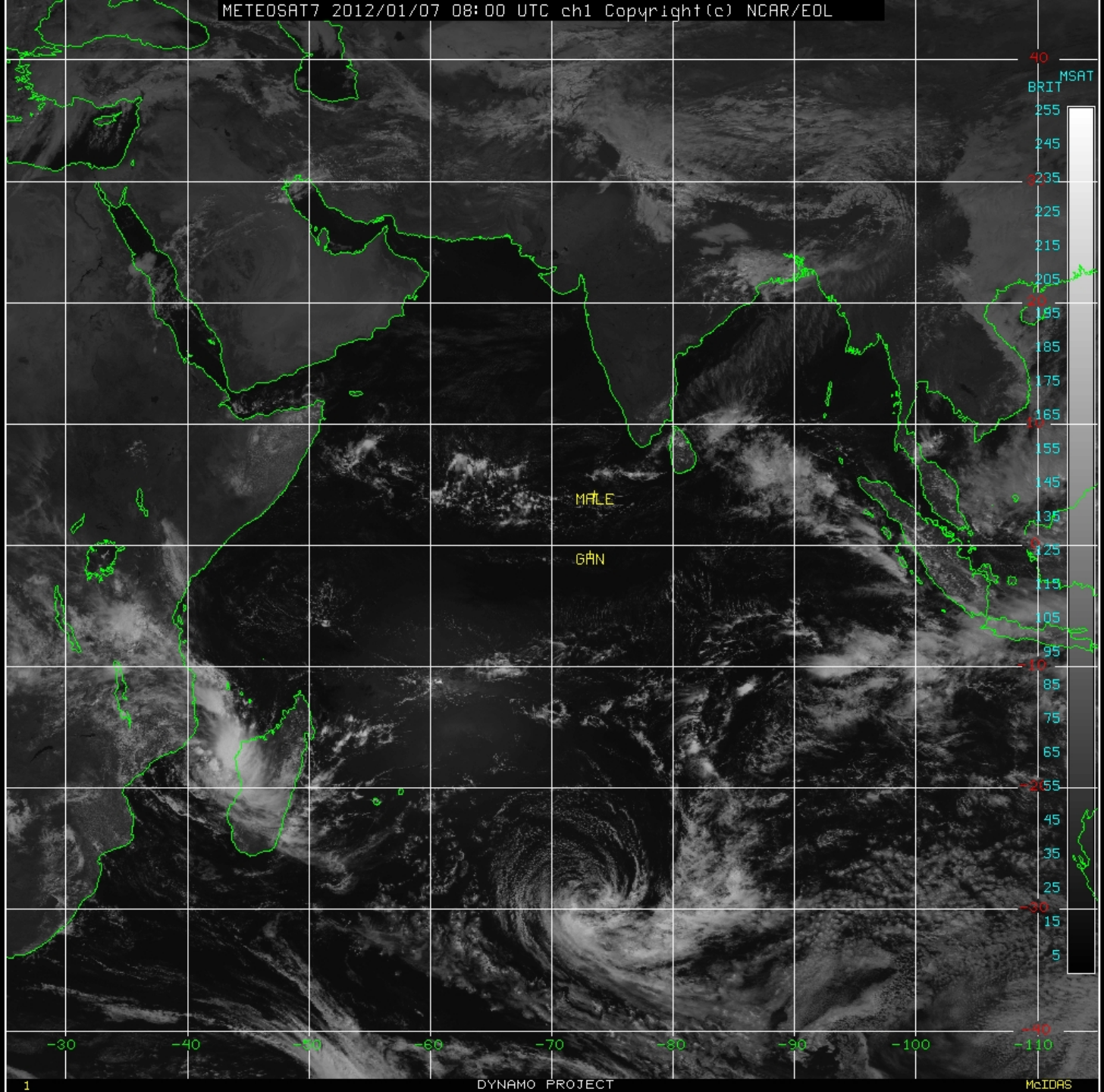
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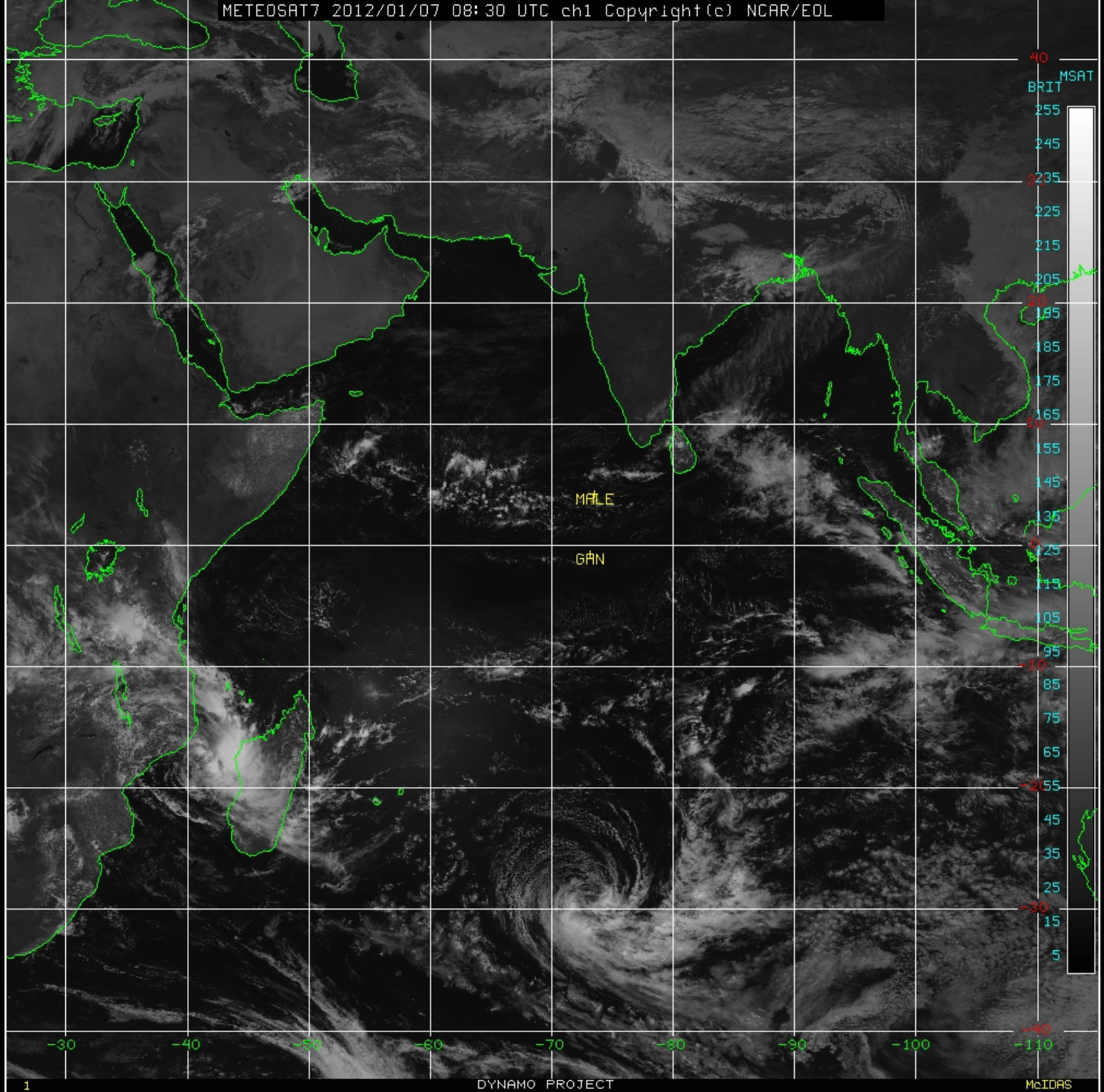
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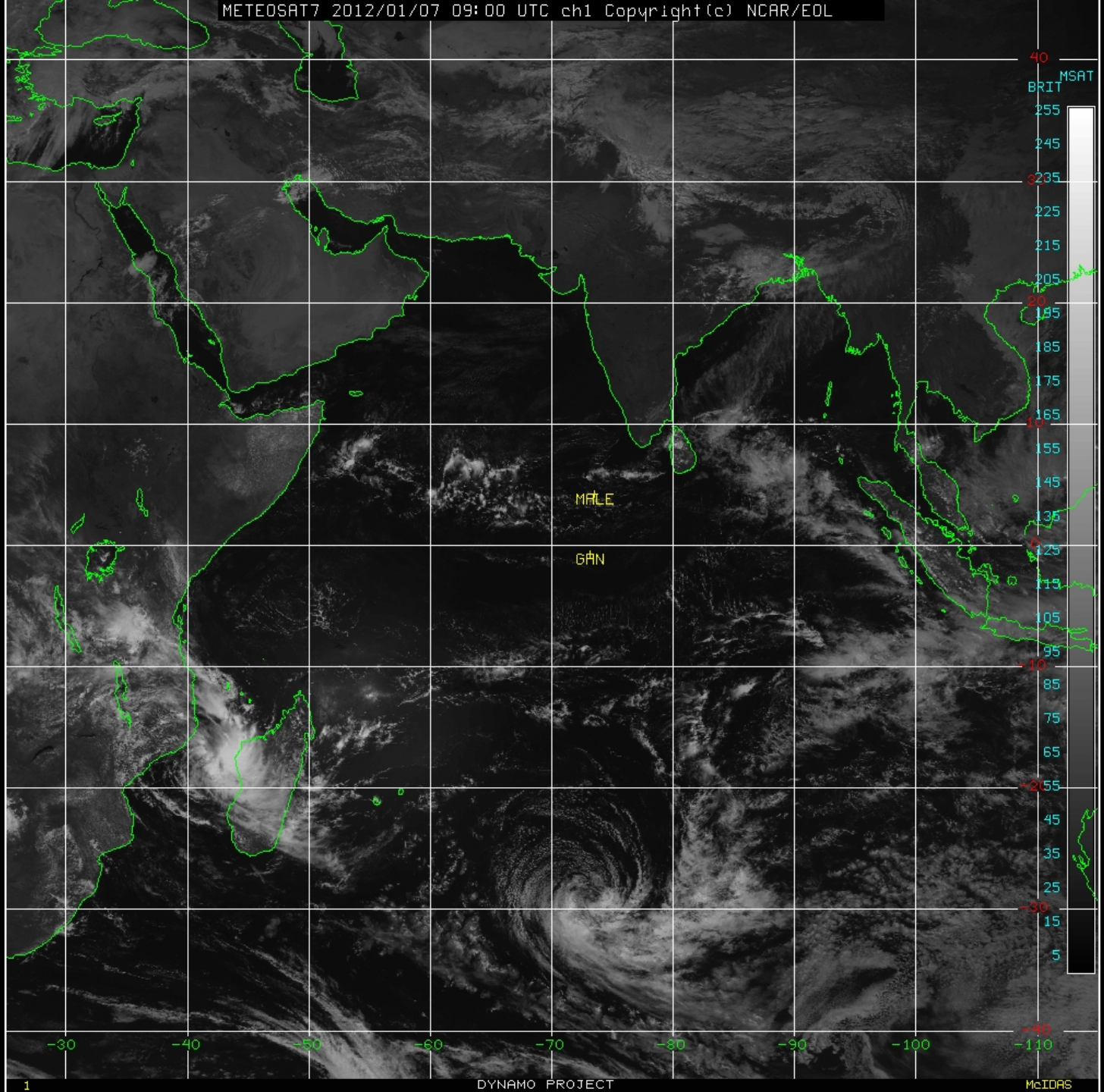
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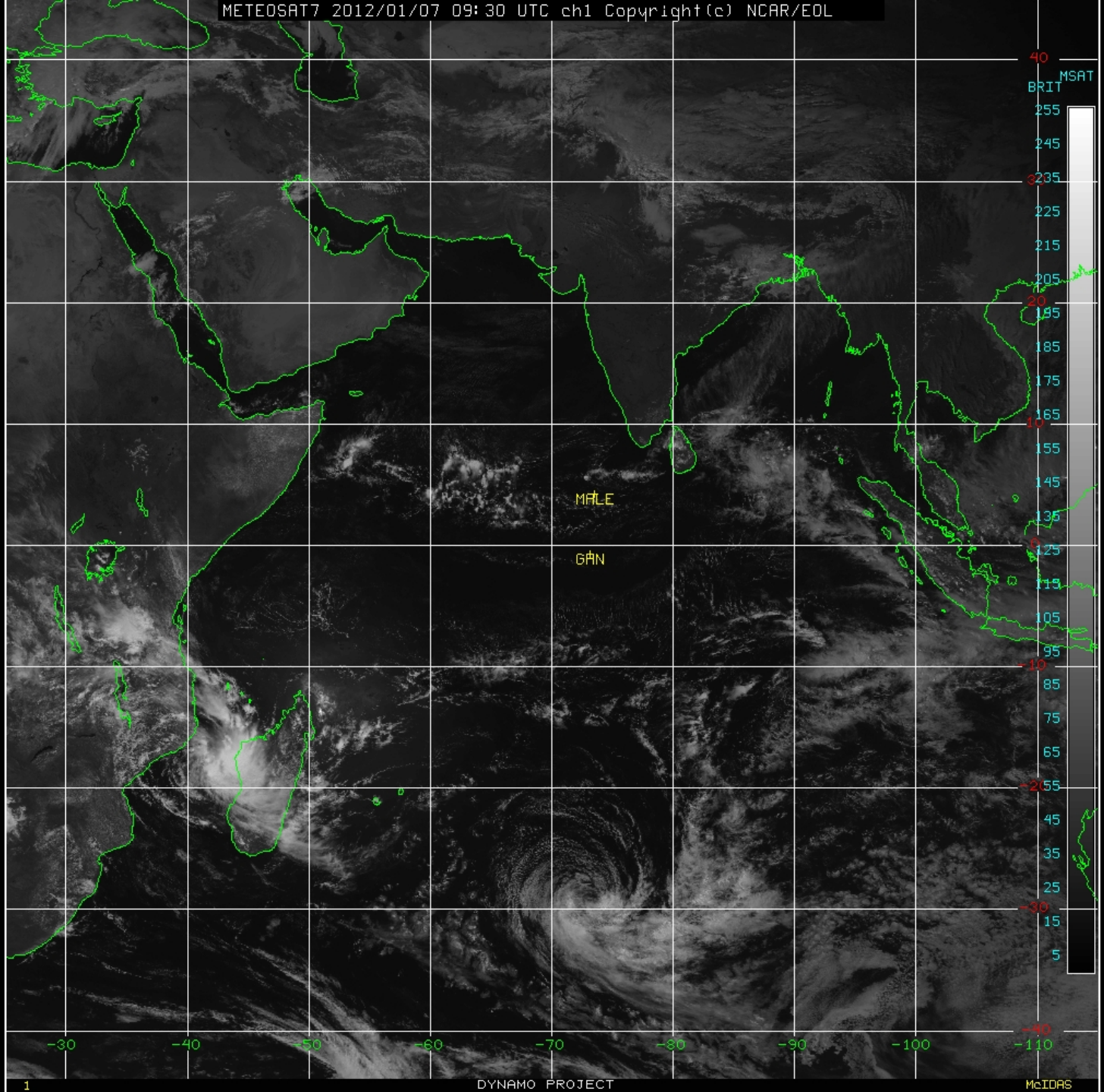
McIDAS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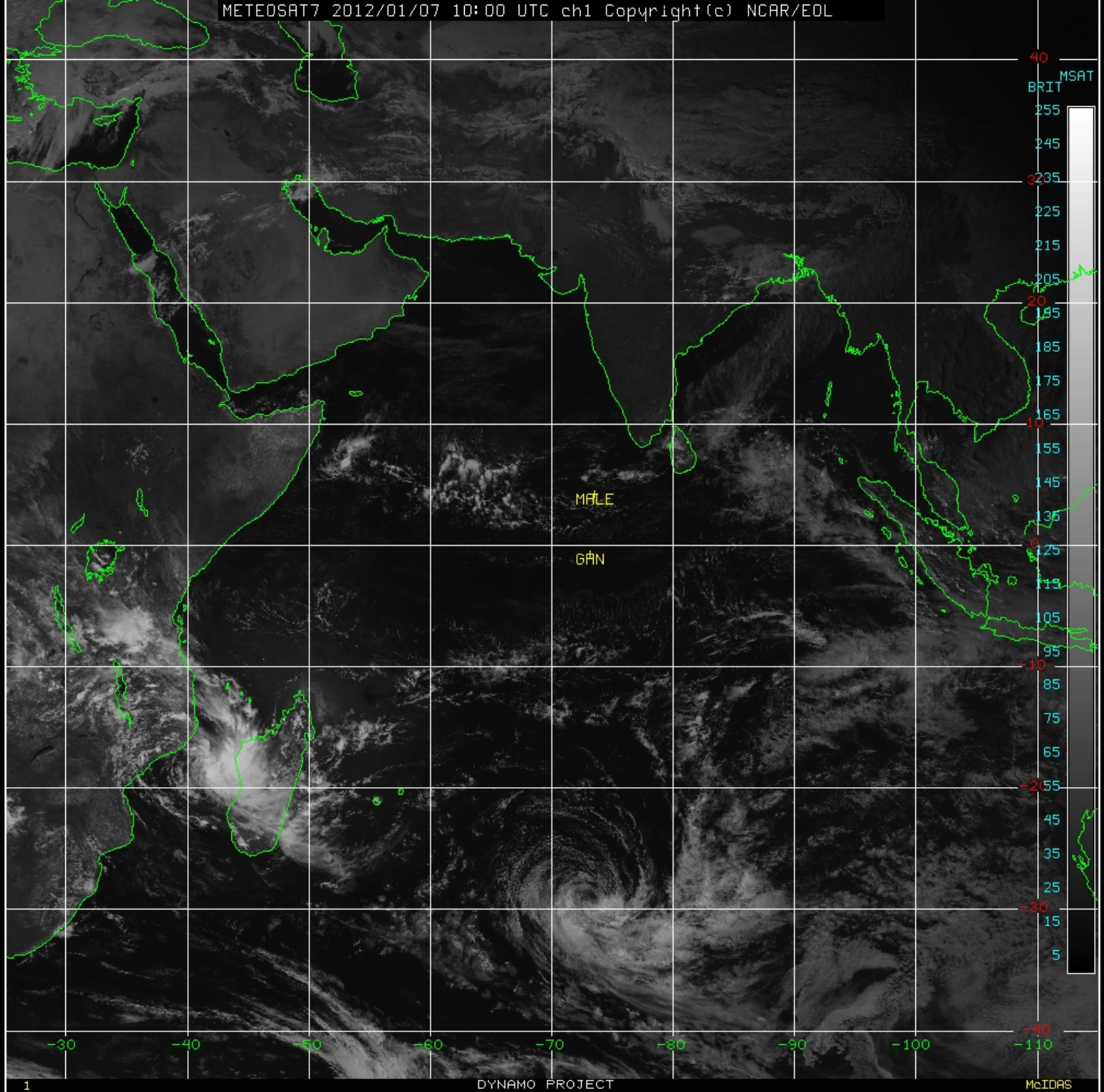
McIDAS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DYNAMO PROJECT
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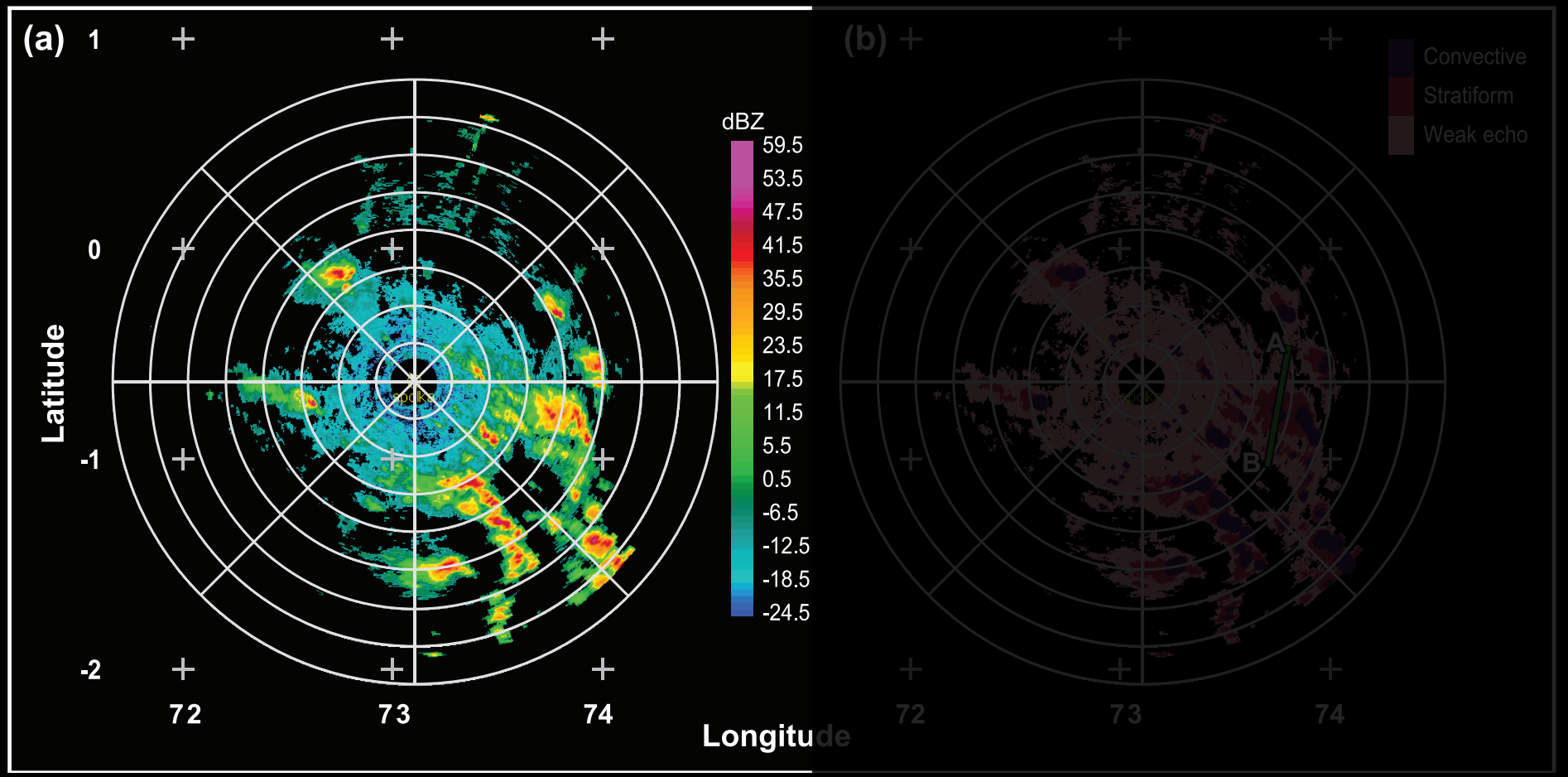
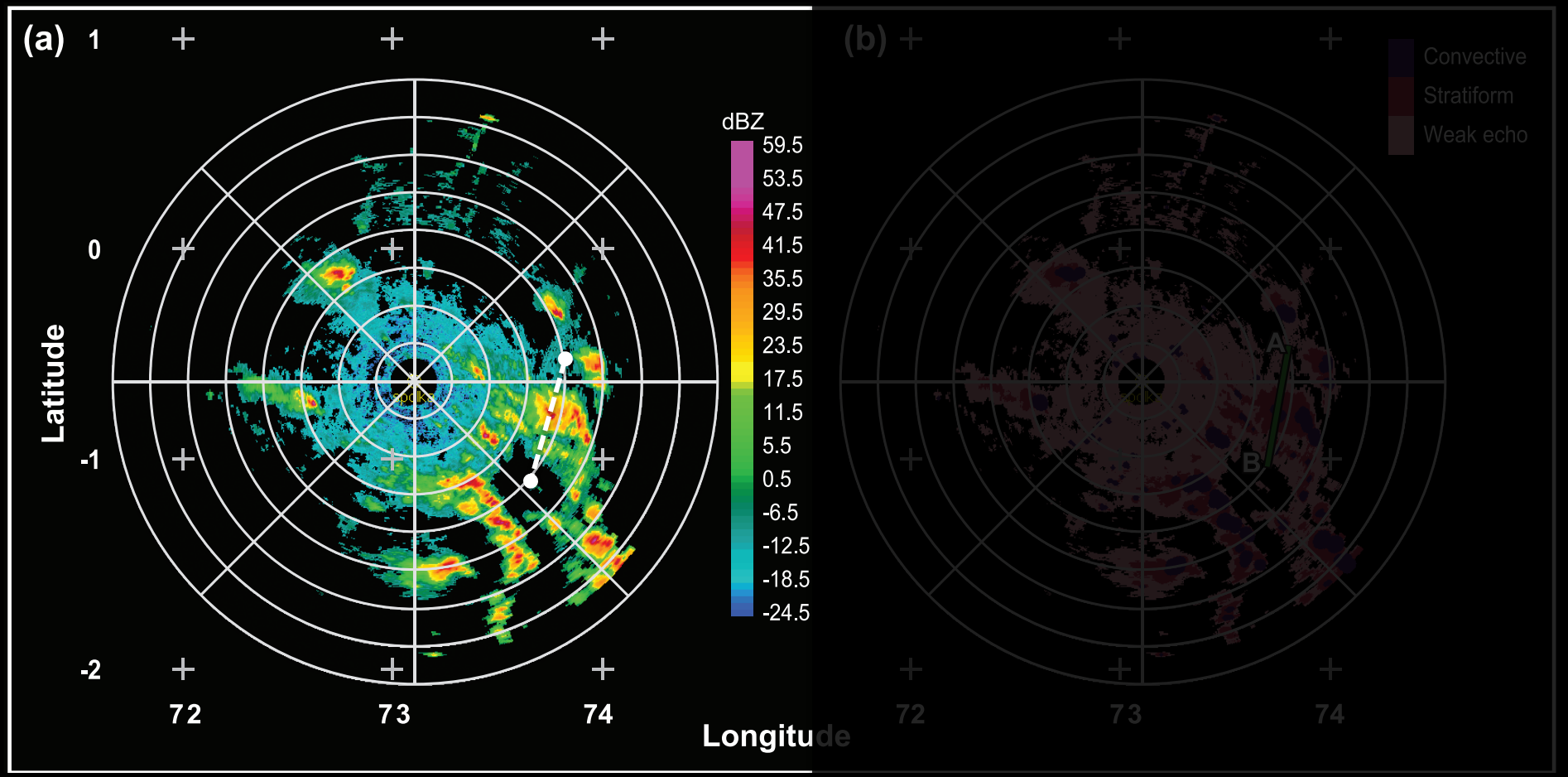
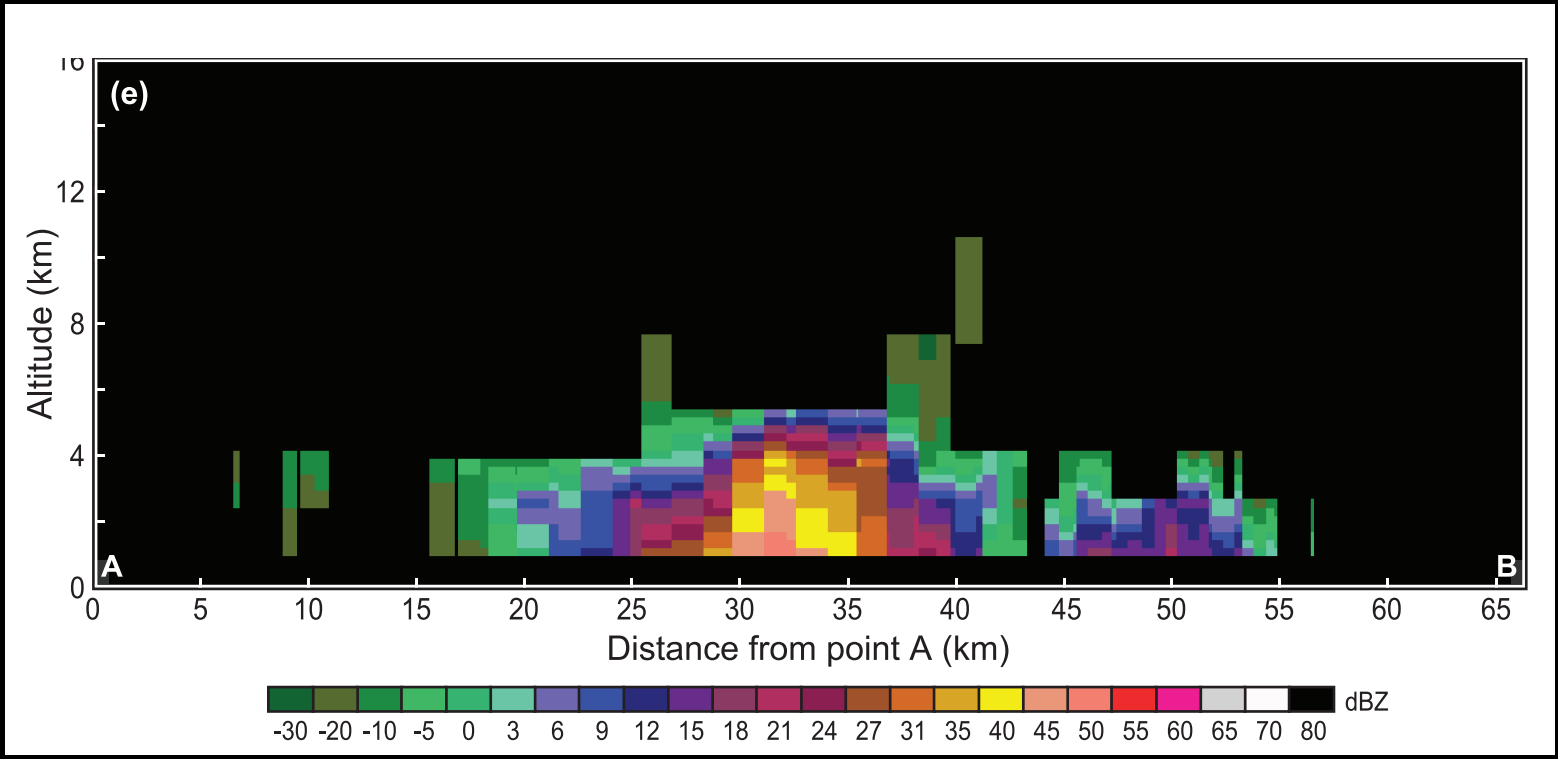
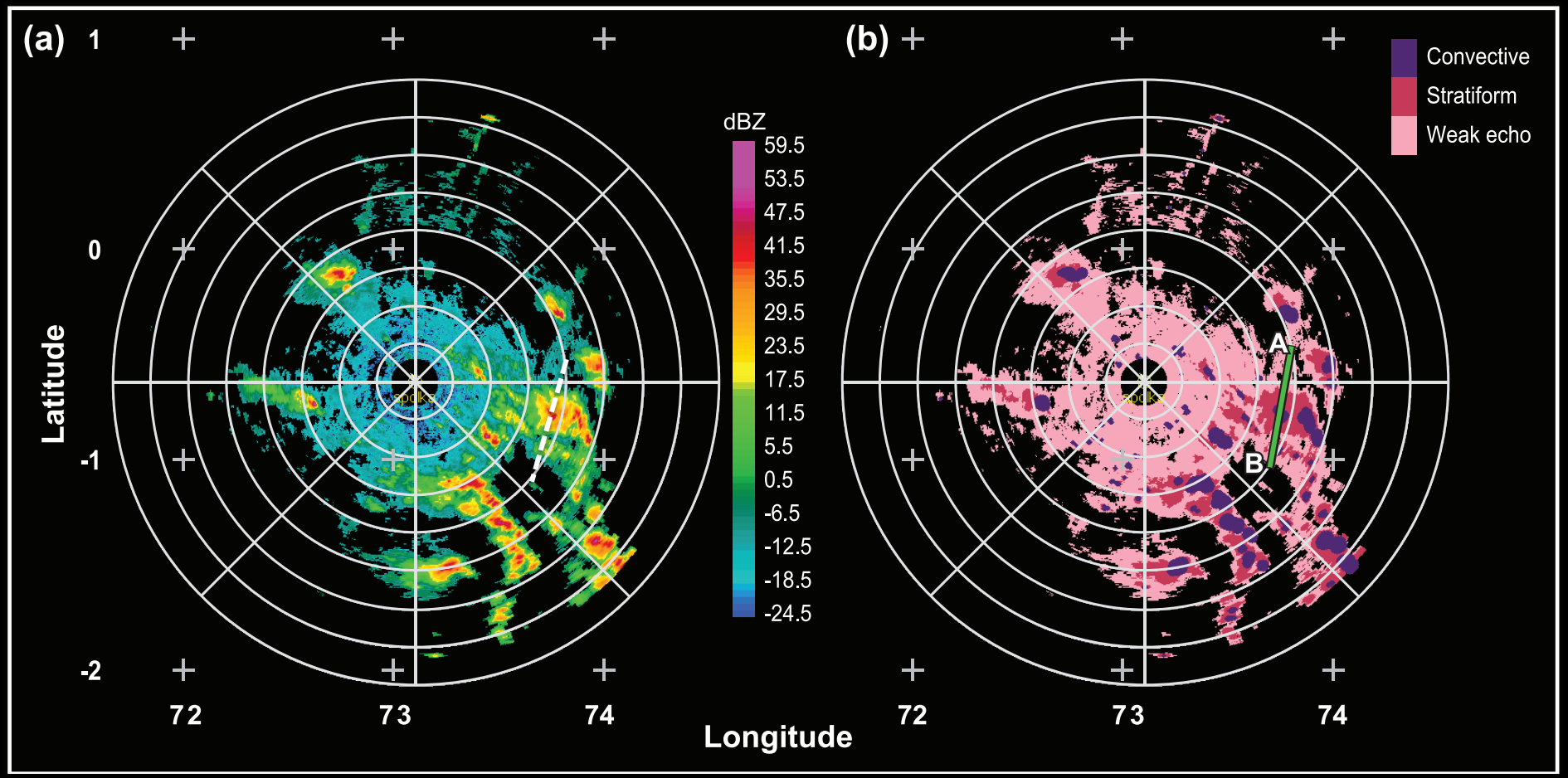
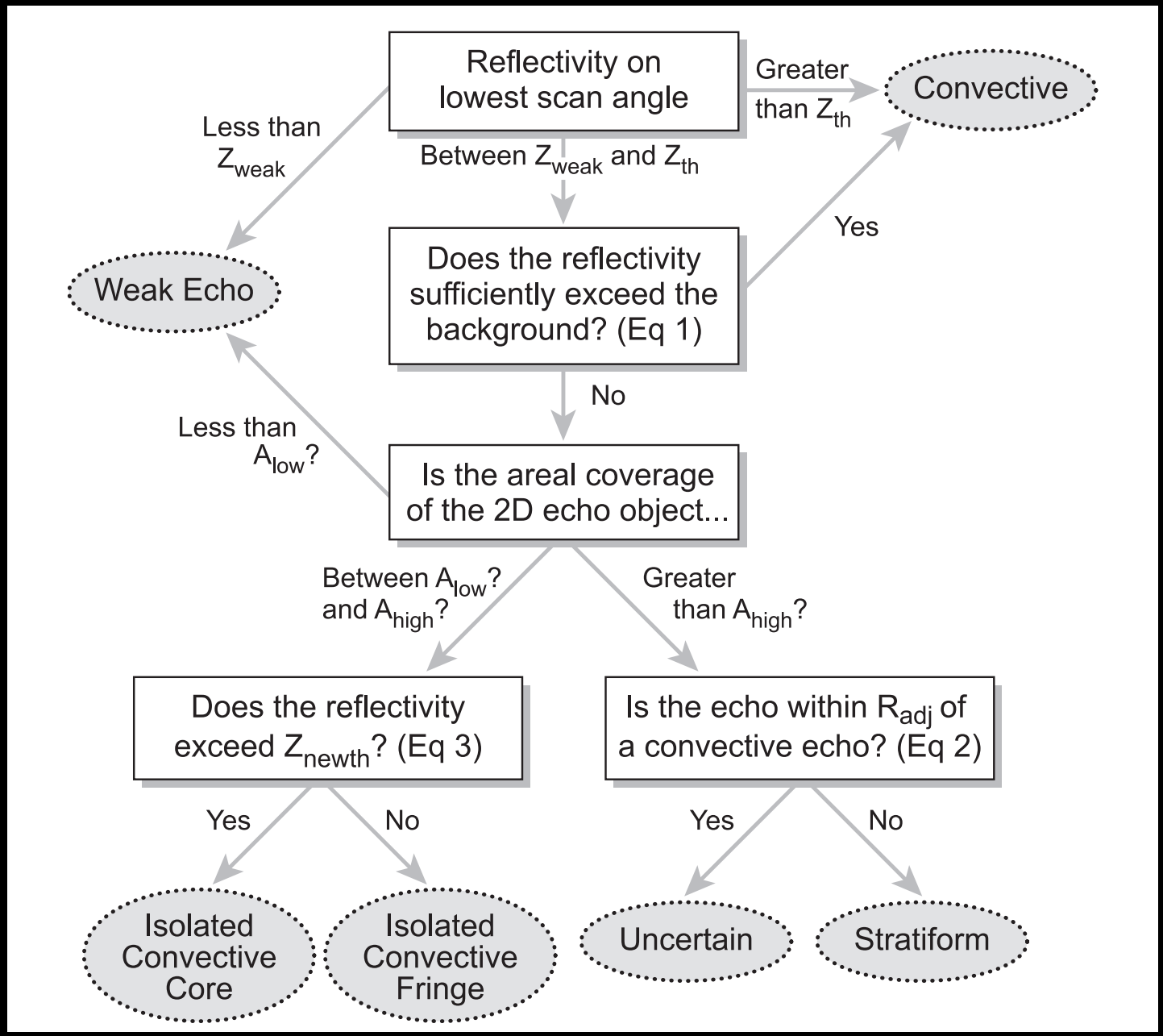

(a)
1
0
-1
-2
Latitude
72
73
74
Longitude
dBZ
59.5
53.5
47.5
41.5
35.5
29.5
23.5
17.5
11.5
5.5
0.5
-6.5
-12.5
-18.5
-24.5
(b)
Convective
Stratiform
Weak echo
A
B

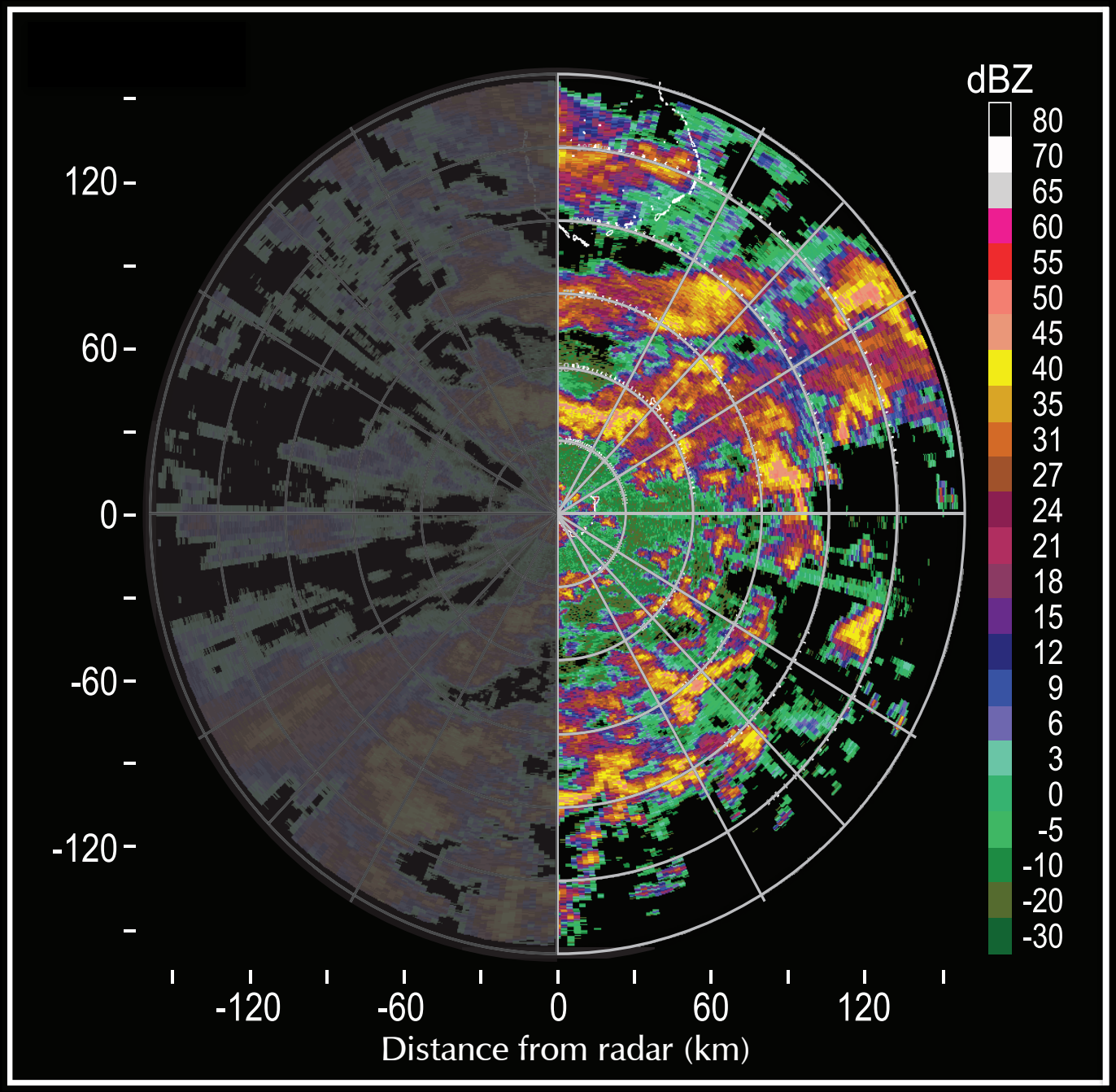

(a)
1
0
-1
-2
Latitude
72
73
74
Longitude
dBZ
59.5
53.5
47.5
41.5
35.5
29.5
23.5
17.5
11.5
5.5
0.5
-6.5
-12.5
-18.5
-24.5
(b)
Convective
Stratiform
Weak echo
A
B

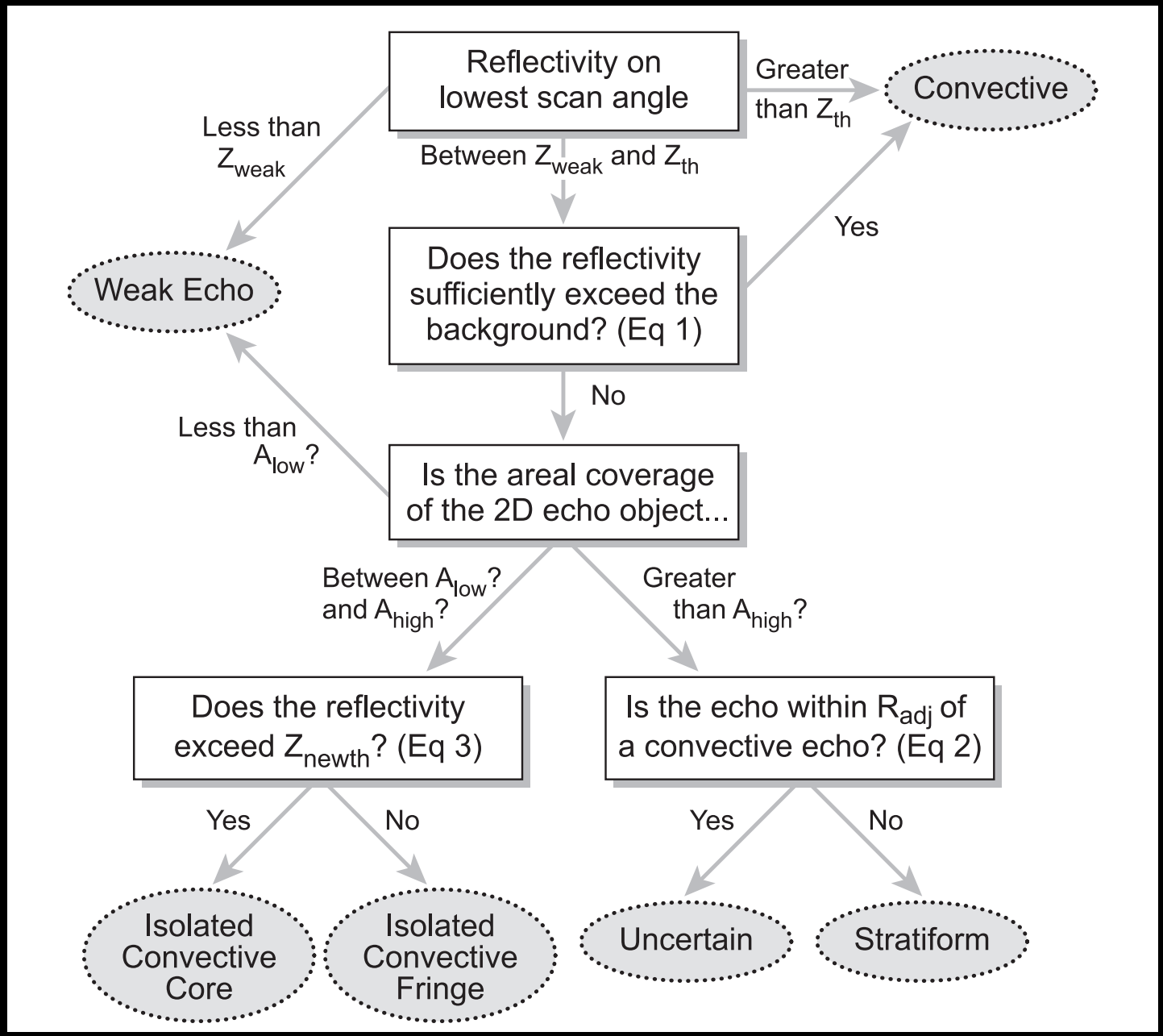

(e)
Altitude (km)
0
4
8
12
16
A
B
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Distance from point A (km)
dBZ
-30 -20 -10 -5 0 3 6 9 12 15 18 21 24 27 31 35 40 45 50 55 60 65 70 80


(a)
(b)
dBZ
59.5
53.5
47.5
41.5
35.5
29.5
23.5
17.5
11.5
5.5
0.5
-6.5
-12.5
-18.5
-24.5
Latitude
Longitude
1
0
-1
-2
72
73
74
Convective
Stratiform
Weak echo
A
B

Fixing the Problems


Reflectivity on lowest scan angle
Greater than Z_{th}
Convective
Less than Z_{weak}
Between Z_{weak} and Z_{th}
Weak Echo
Does the reflectivity sufficiently exceed the background? (Eq 1)
Yes
No
Less than A_{low}?
Is the areal coverage of the 2D echo object...
Between A_{low}? and A_{high}?
Greater than A_{high}?
Does the reflectivity exceed Z_{newth}? (Eq 3)
Is the echo within R_{adj} of a convective echo? (Eq 2)
Yes
No
Yes
No
Isolated Convective Core
Isolated Convective Fringe
Uncertain
Stratiform


dBZ
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
120
60
0
-60
-120
-120
-60
0
60
120
Distance from radar (km)


Reflectivity on lowest scan angle
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Convective
Less than Z_{weak}
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Weak Echo
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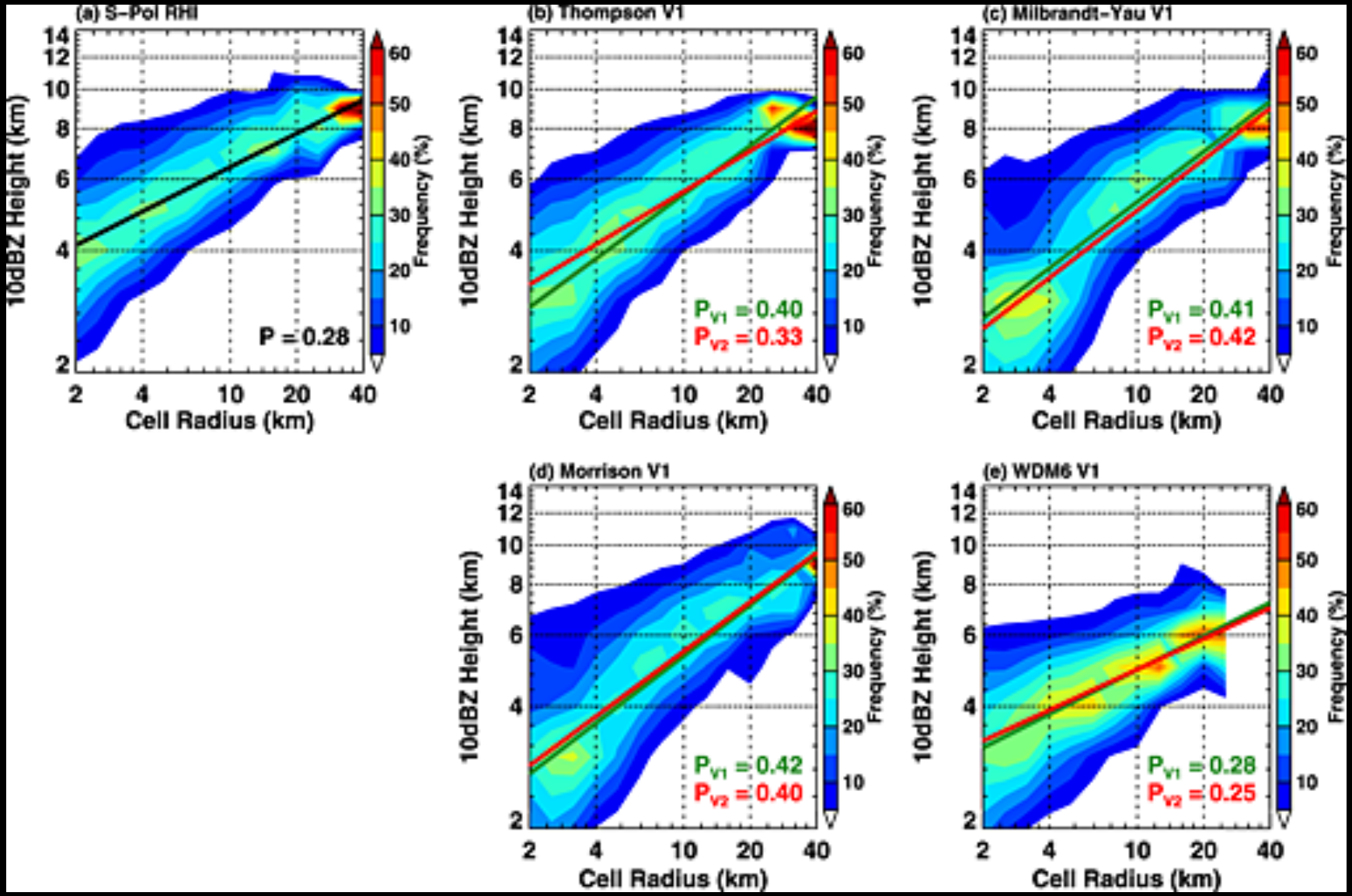
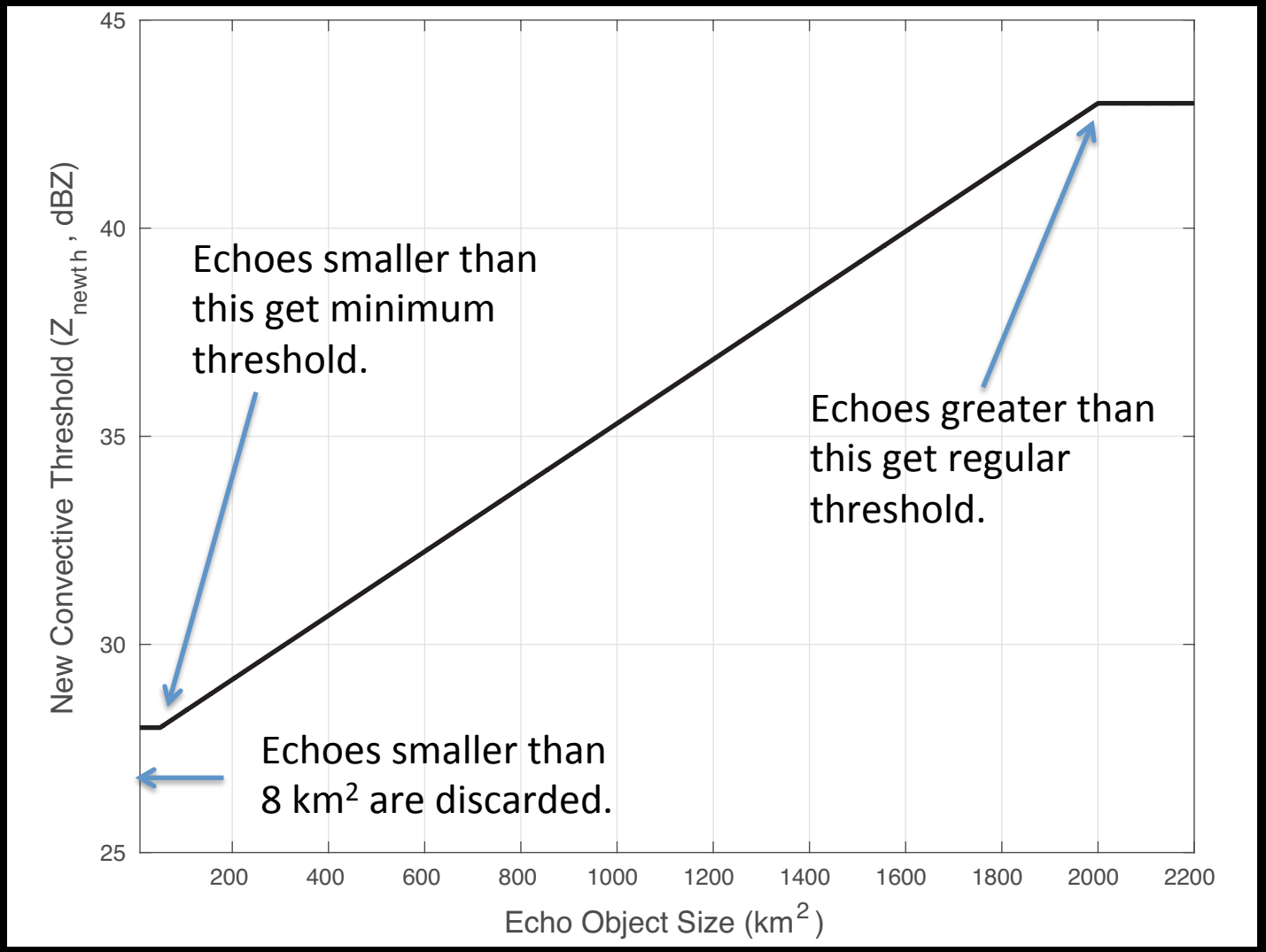
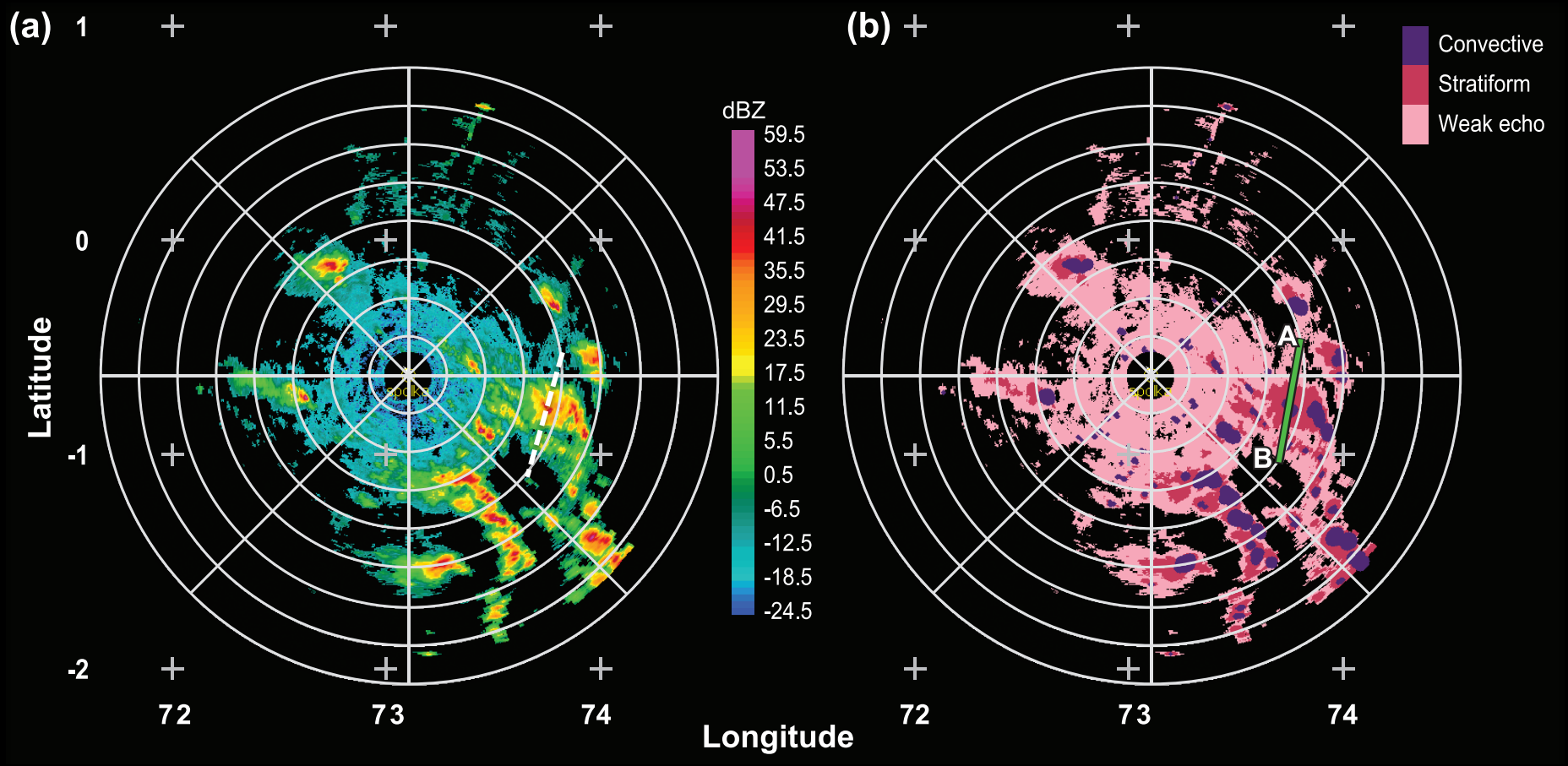
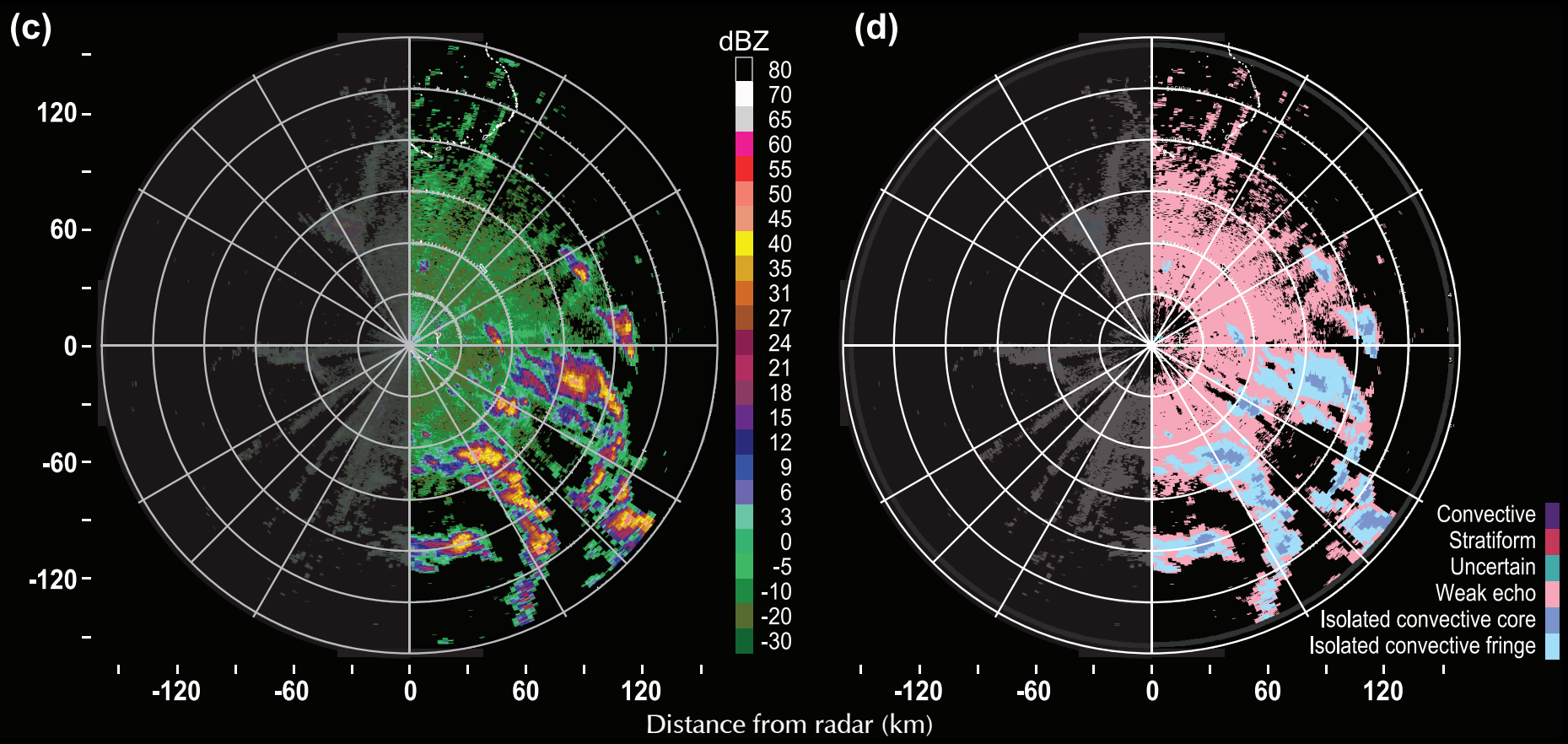
Yes
No
Yes
No
Isolated Convective Core
Isolated Convective Fringe
Uncertain
Stratiform

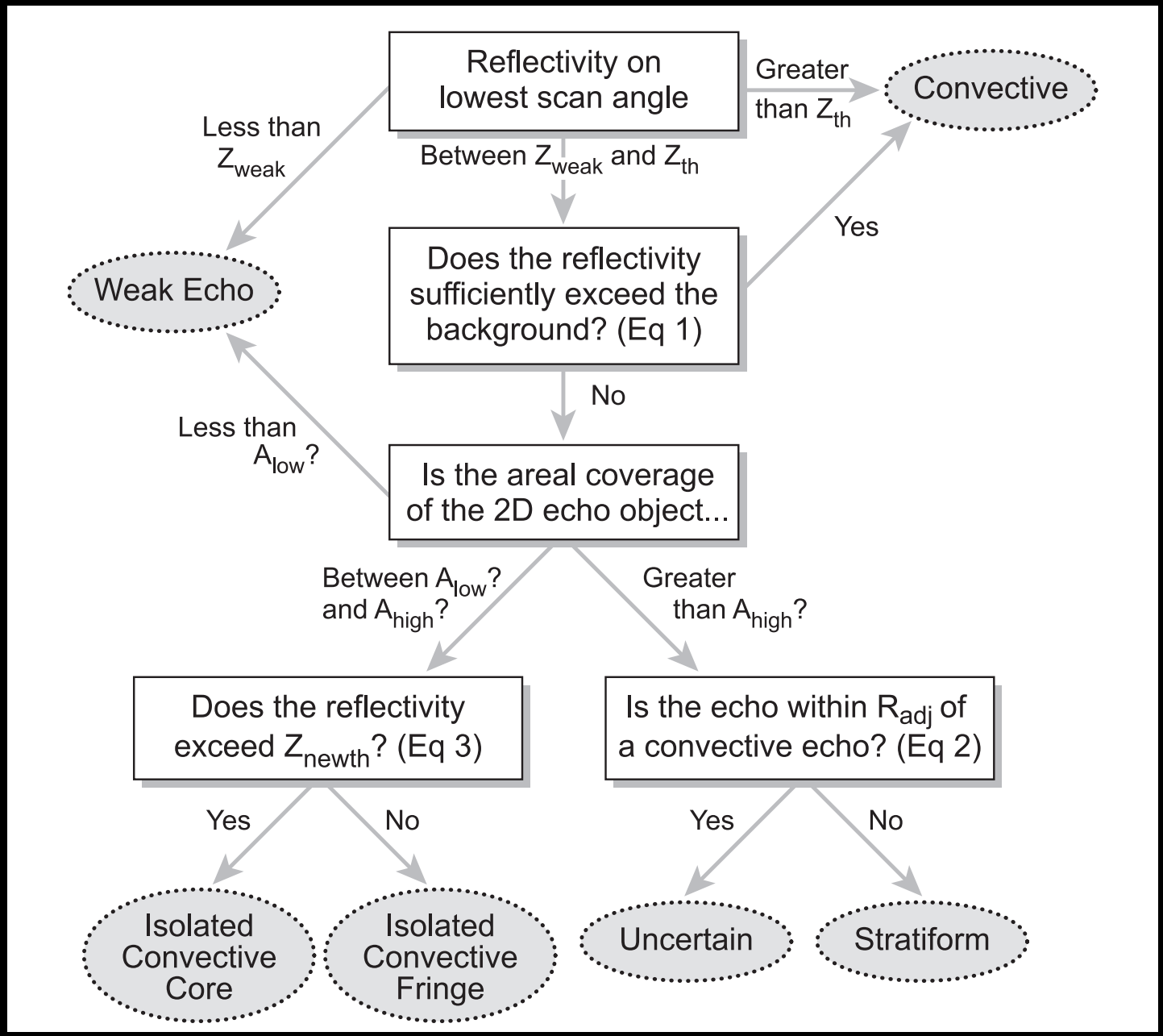
Hagos et al. (2014)




45
40
35
30
25
New Convective Threshold (Z_{newth}, dBZ)
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Echo Object Size (km^2)
Echoes smaller than this get minimum threshold.
Echoes greater than this get regular threshold.
Echoes smaller than 8 km^2 are discarded.


(a)
(b)
1
0
-1
-2
Latitude
72
73
74
Longitude
dBZ
59.5
53.5
47.5
41.5
35.5
29.5
23.5
17.5
11.5
5.5
0.5
-6.5
-12.5
-18.5
-24.5
Convective
Stratiform
Weak echo
A
B


(c)
(d)
dBZ
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
120
60
0
-60
-120
-120
-60
0
60
120
Distance from radar (km)
Convective
Stratiform
Uncertain
Weak echo
Isolated convective core
Isolated convective fringe


Reflectivity on lowest scan angle
Greater than Z_{th}
Convective
Less than Z_{weak}
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Weak Echo
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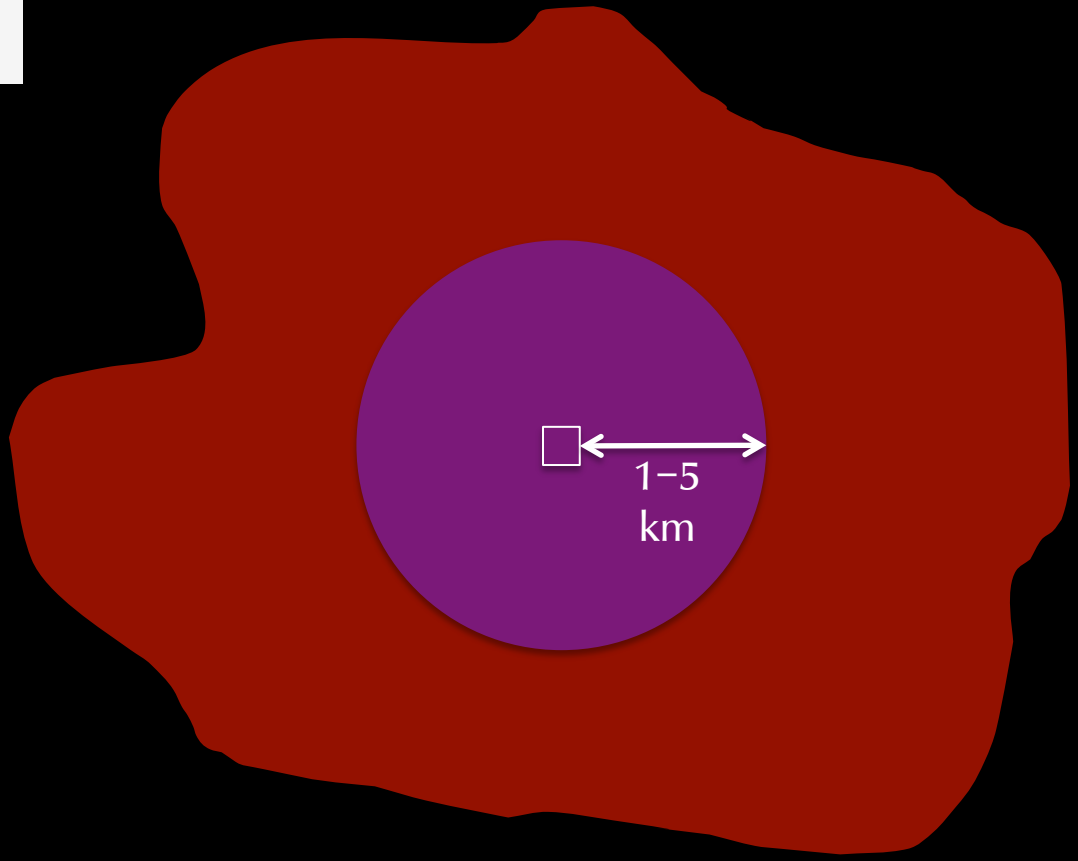
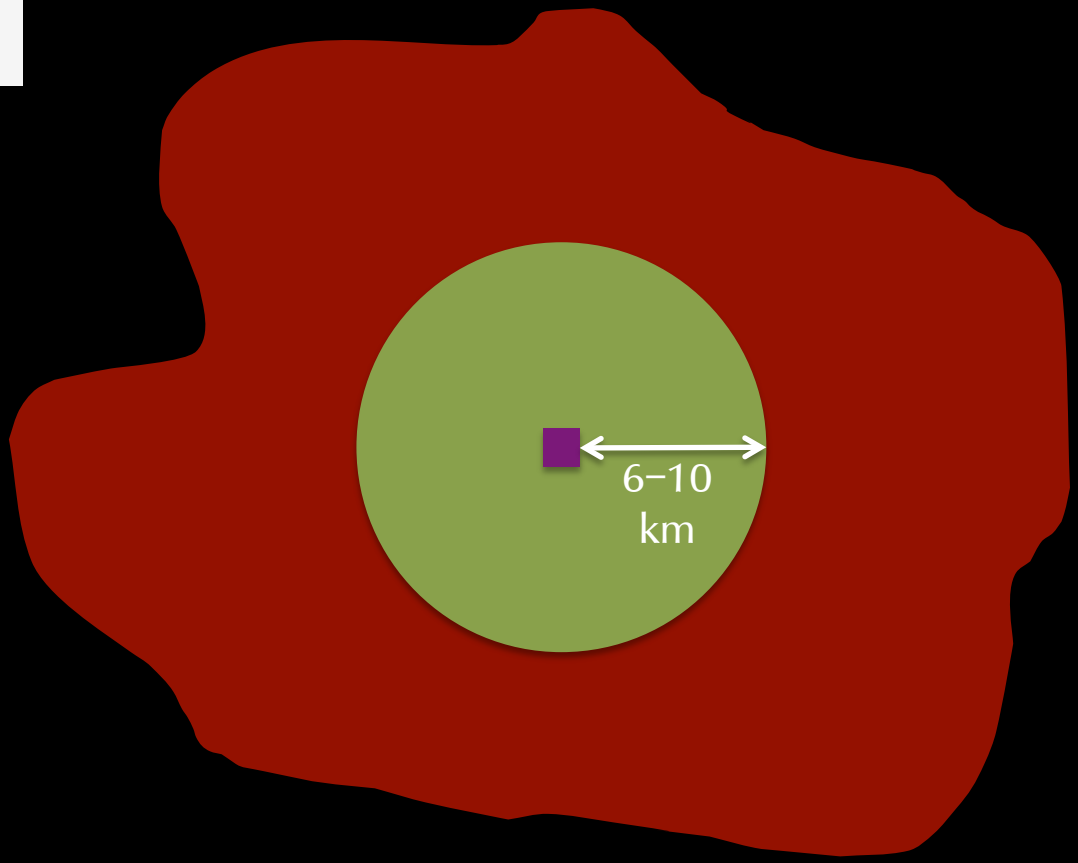
Yes
No
Yes
No
Isolated Convective Core
Isolated Convective Fringe
Uncertain
Stratiform

Stratiform
Convective

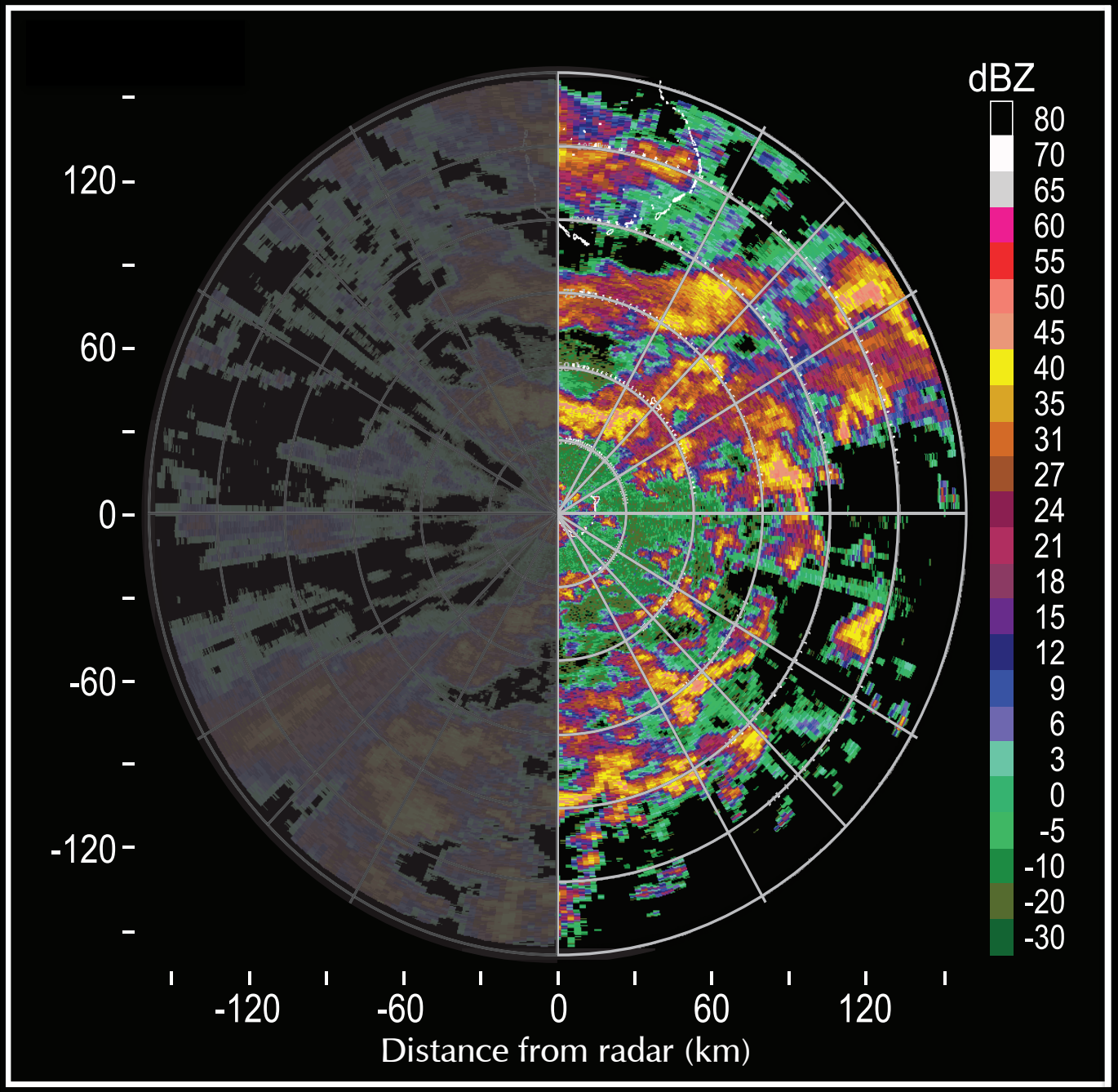


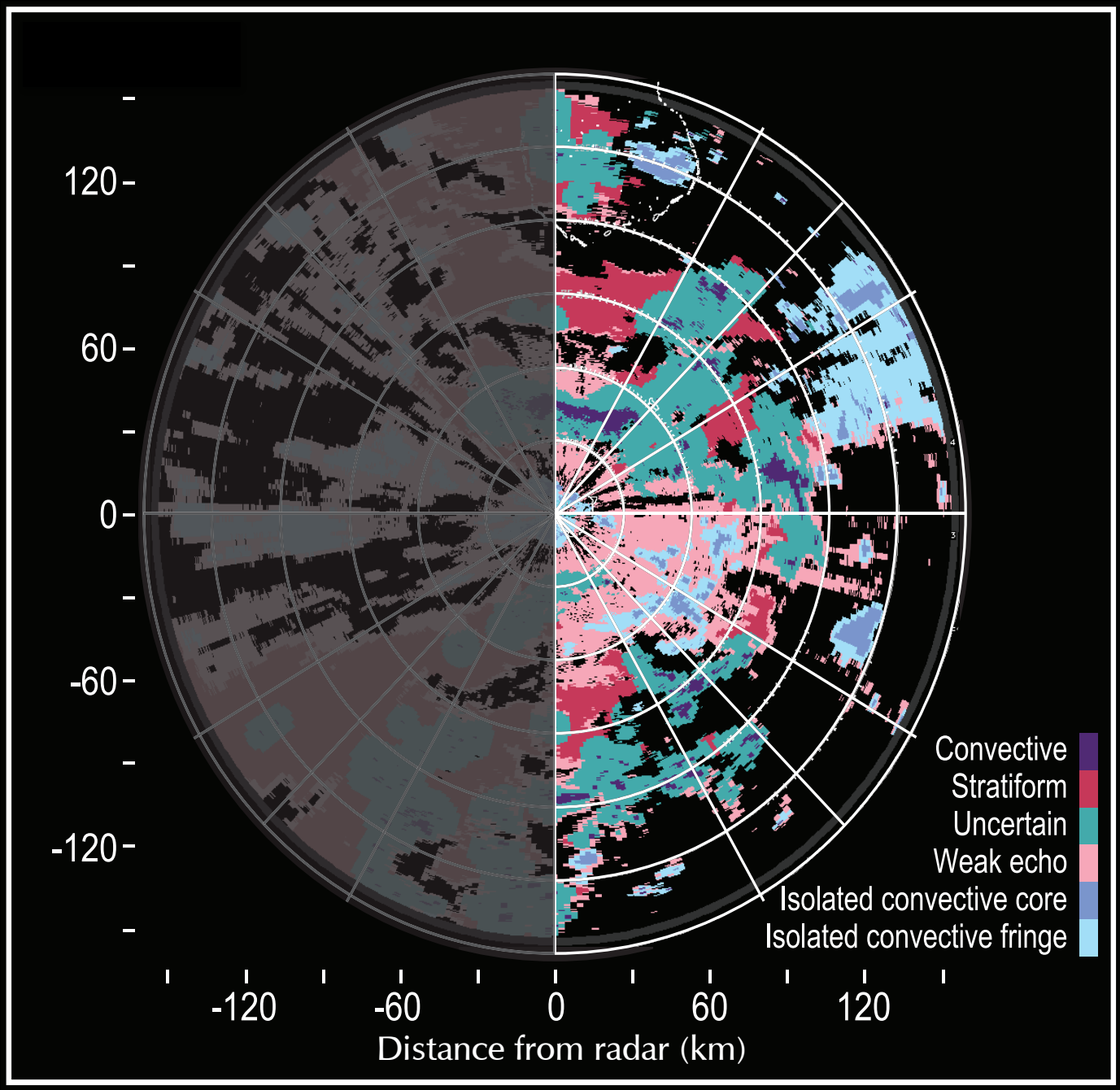
For large echo objects only

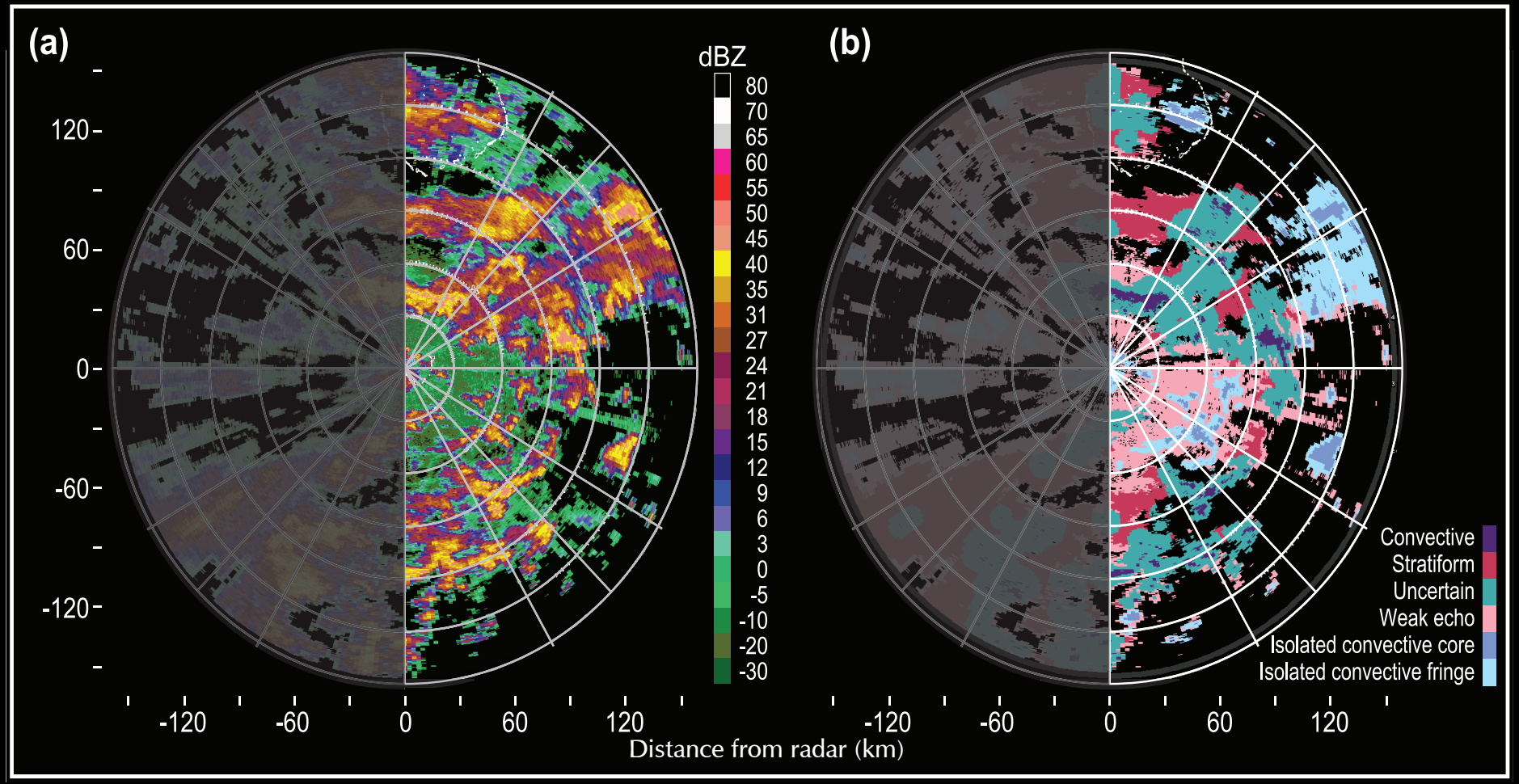
Stratiform
Convective
Uncertain



For large echo objects only

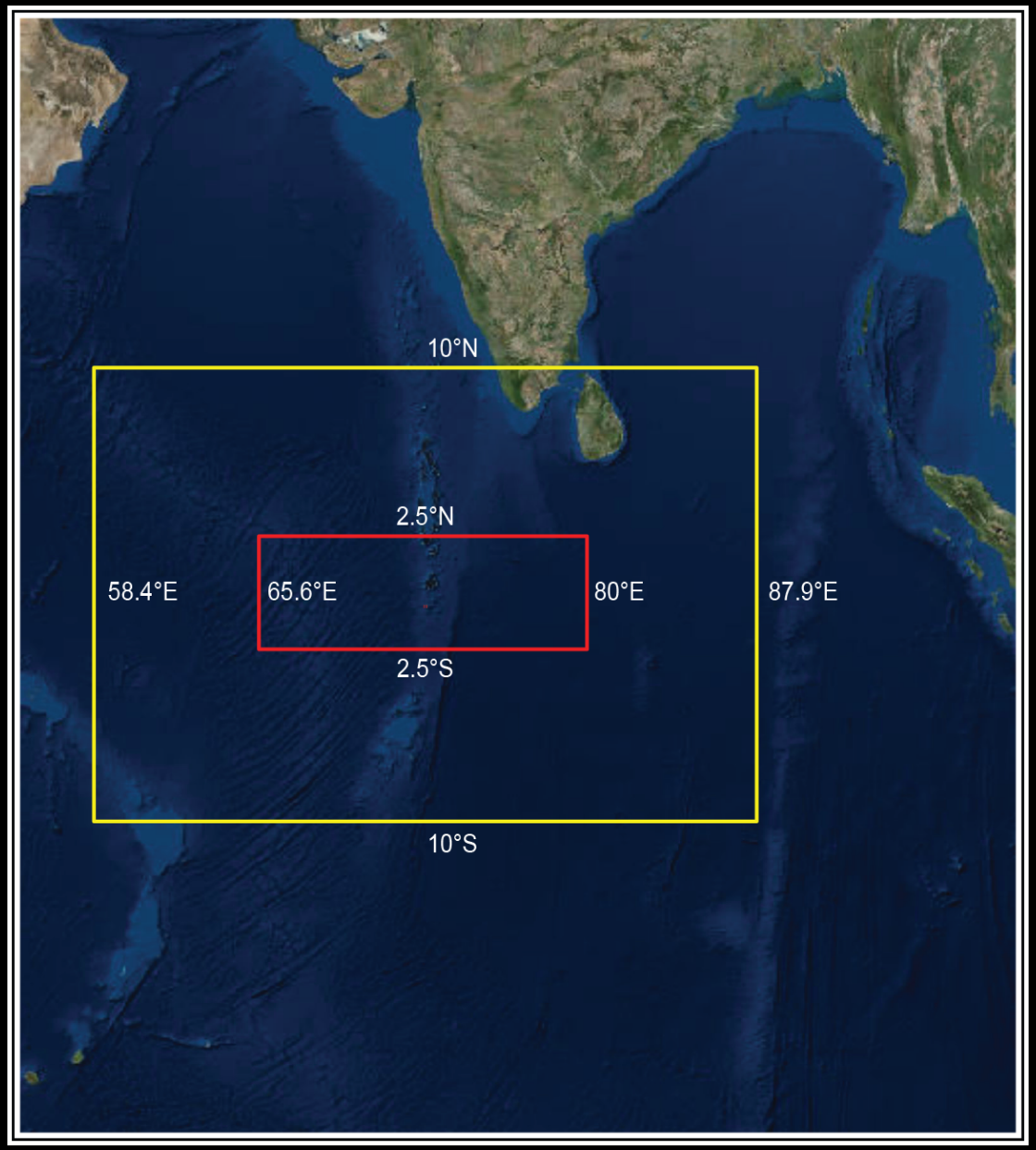

dBZ
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
120
60
0
-60
-120
-120
-60
0
60
120
Distance from radar (km)


120
60
0
-60
-120
-120
-60
0
60
120
Distance from radar (km)
Convective
Stratiform
Uncertain
Weak echo
Isolated convective core
Isolated convective fringe


(a)
(b)
dBZ
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
120
60
0
-60
-120
-120
-60
0
60
120
Distance from radar (km)
Convective
Stratiform
Uncertain
Weak echo
Isolated convective core
Isolated convective fringe

WRF V3.5.1

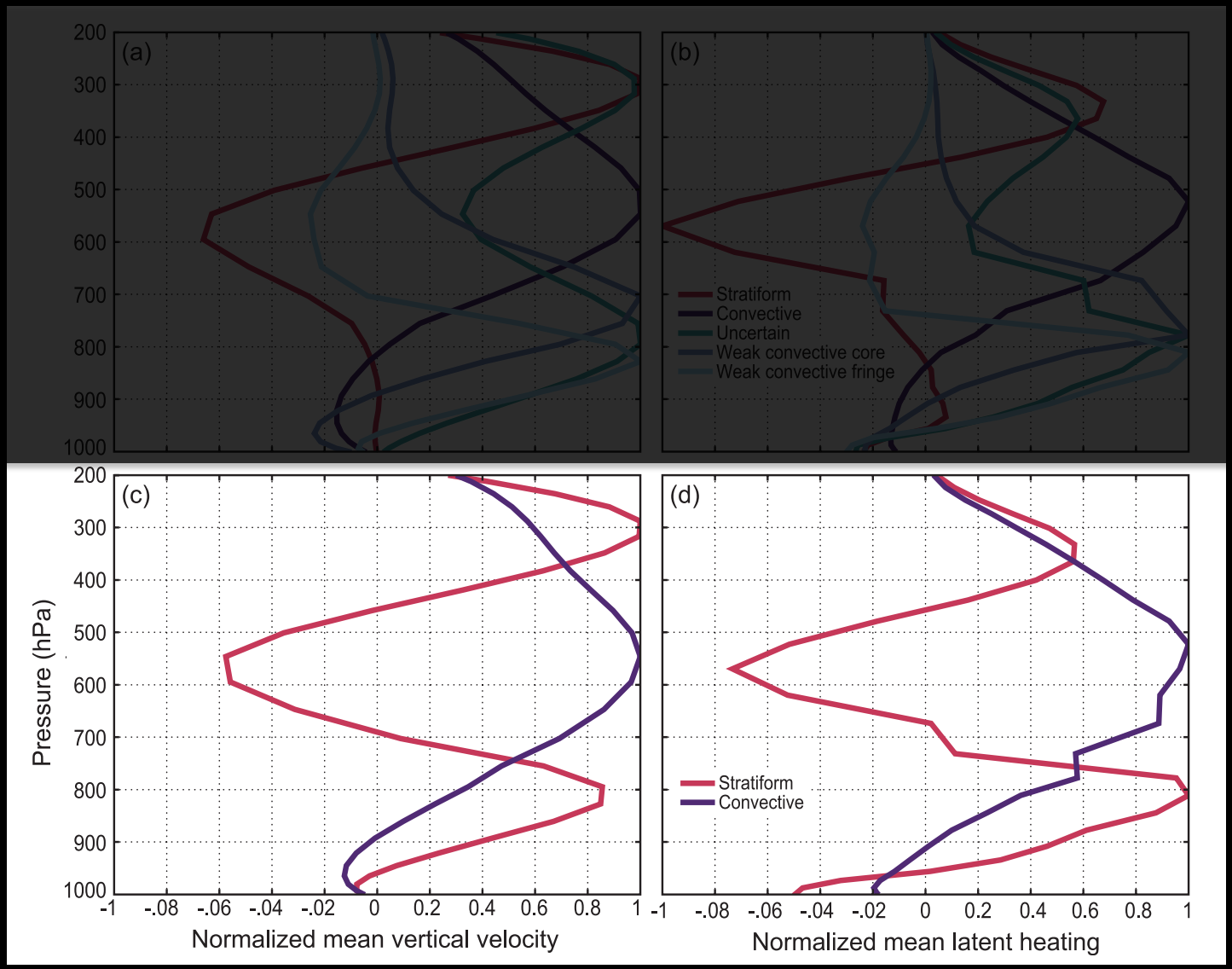
- 2 km grid spacing
- 1–20 October and 4–20 November 2011
- Simulated reflectivity on model level nearest 2 km altitude



Vertical velocity

Latent heating

Old Algorithm

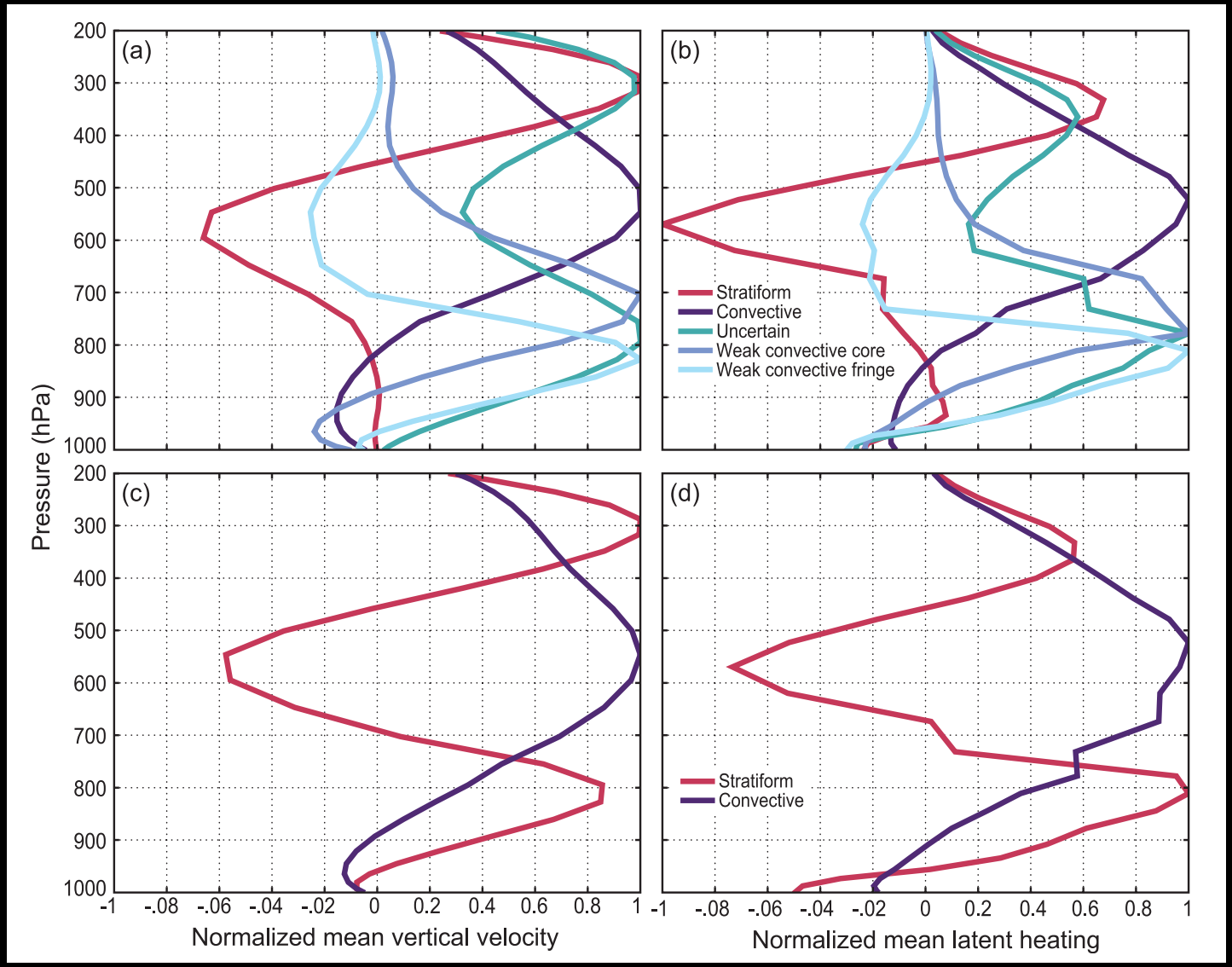


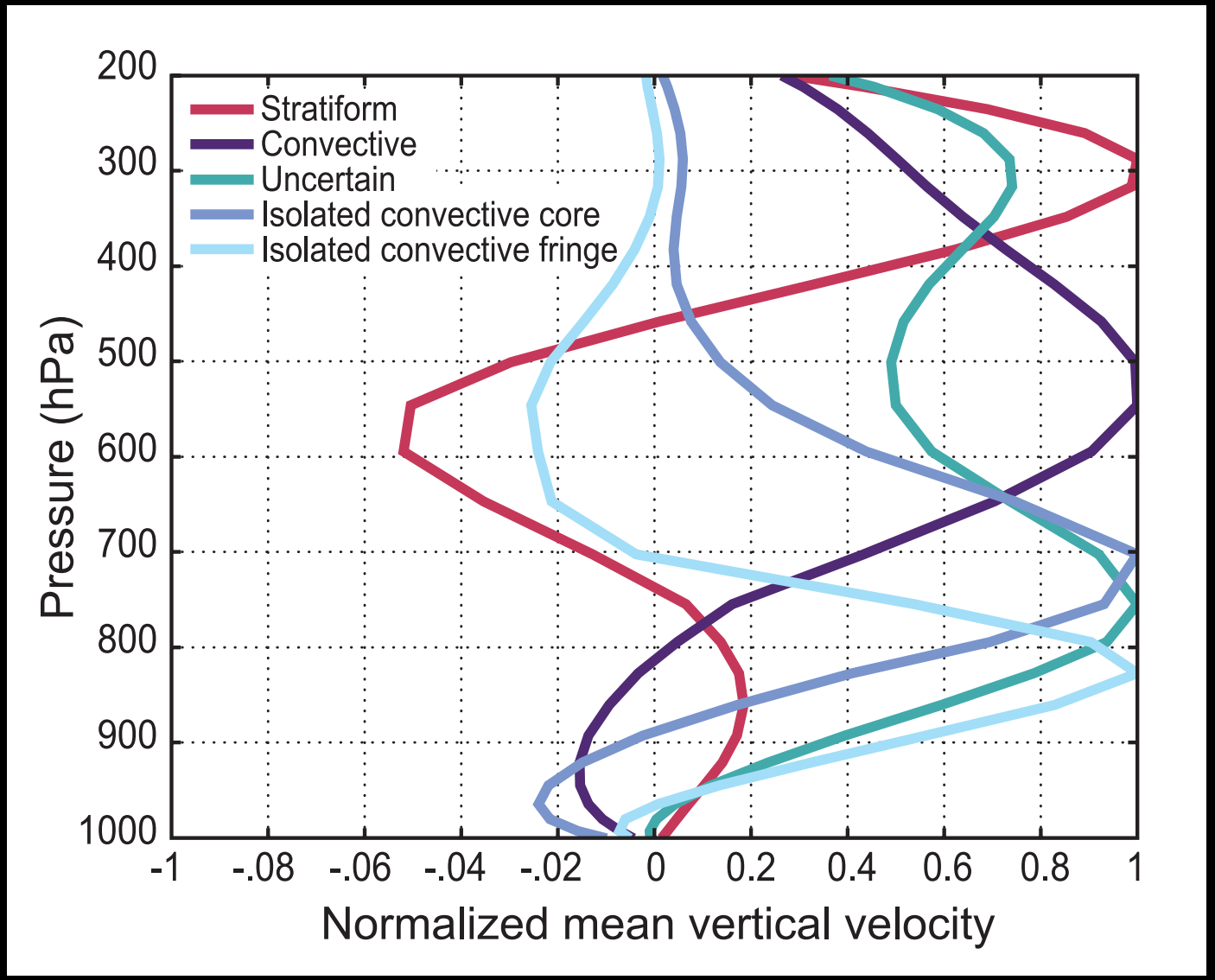
Vertical velocity

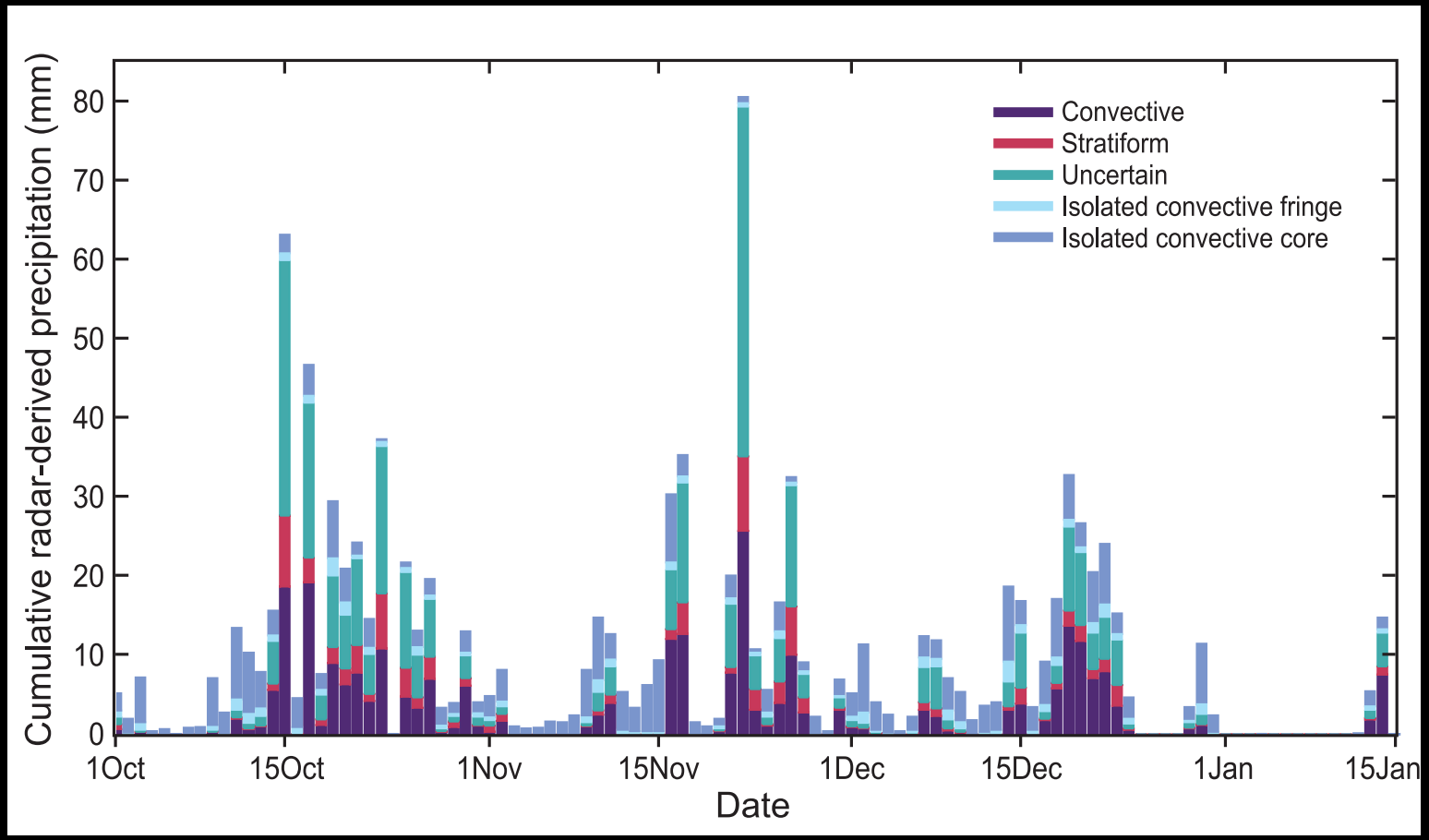
Latent heating

New Algorithm

Old Algorithm

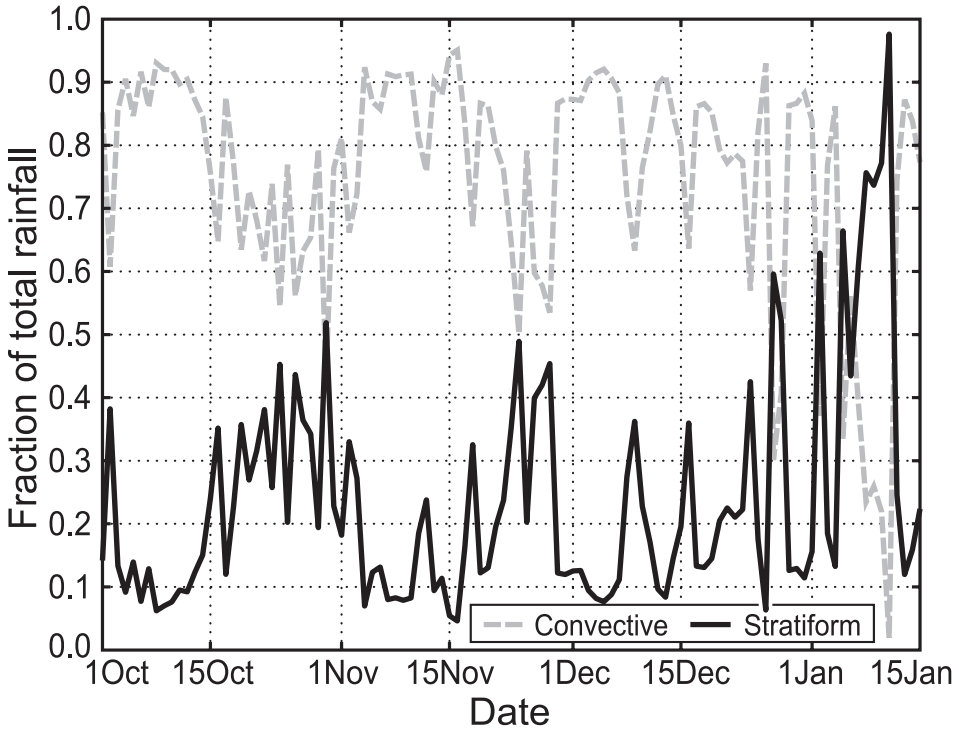


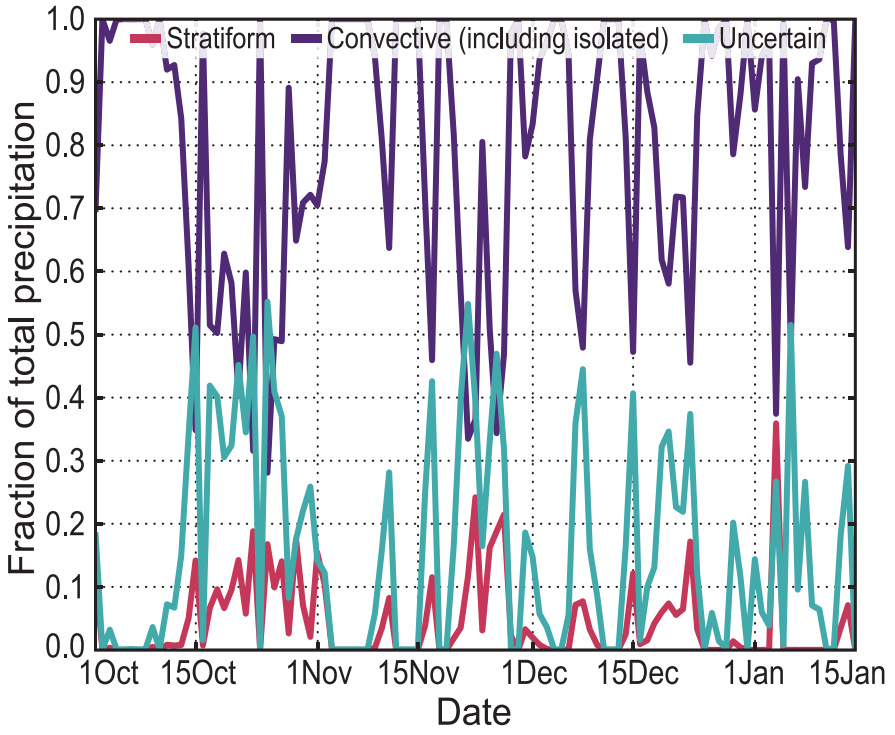

Stratiform
Convective
Uncertain
Isolated convective core
Isolated convective fringe
Pressure (hPa)
200
300
400
500
600
700
800
900
1000
-1
-.08
-.06
-.04
-.02
0
0.2
0.4
0.6
0.8
1
Normalized mean vertical velocity


Cumulative radar-derived precipitation (mm)
0
10
20
30
40
50
60
70
80
1Oct
15Oct
1Nov
15Nov
1Dec
15Dec
1Jan
15Jan
Date
Convective
Stratiform
Uncertain
Isolated convective fringe
Isolated convective core

Old Algorithm

New Algorithm



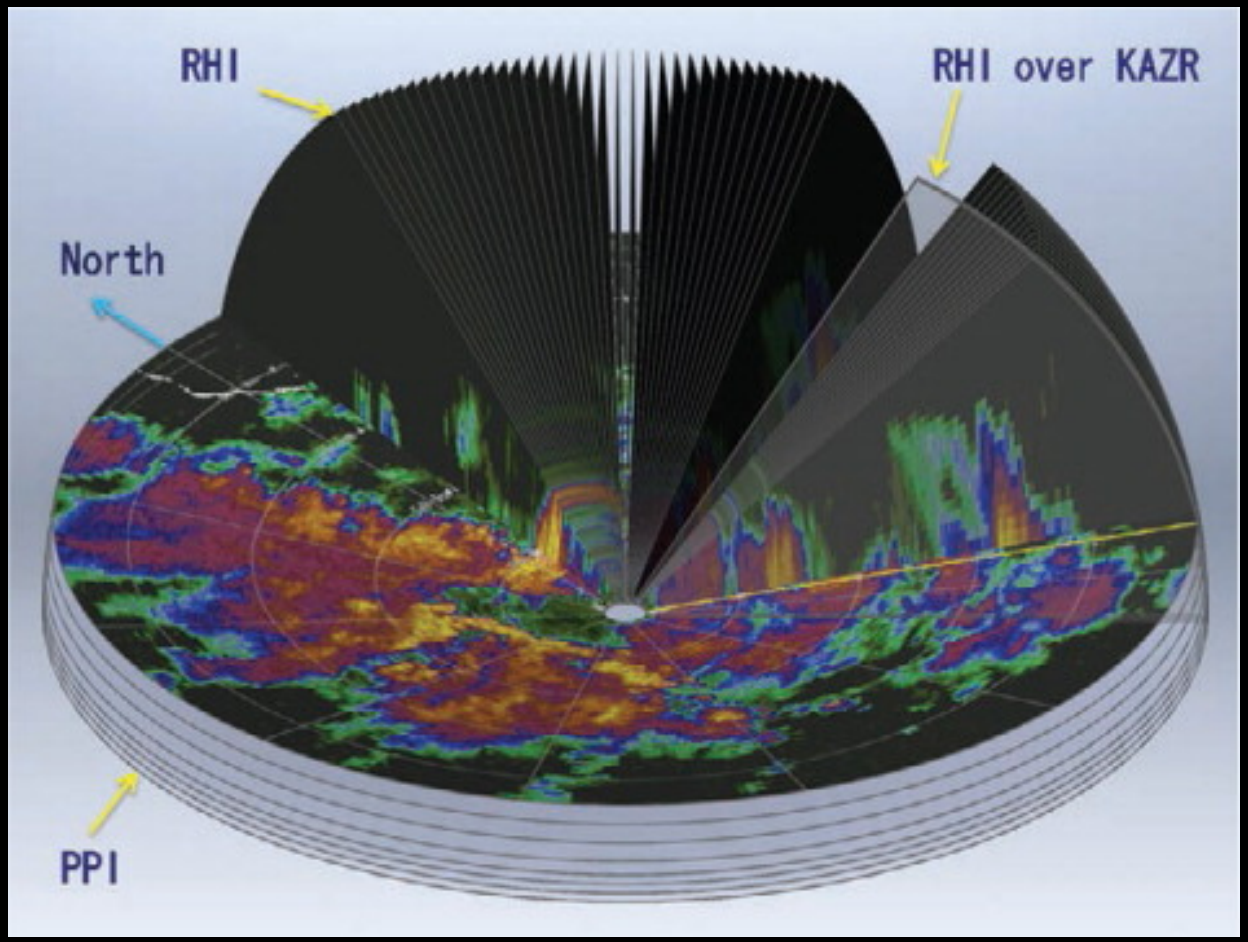


End

Extra Slides

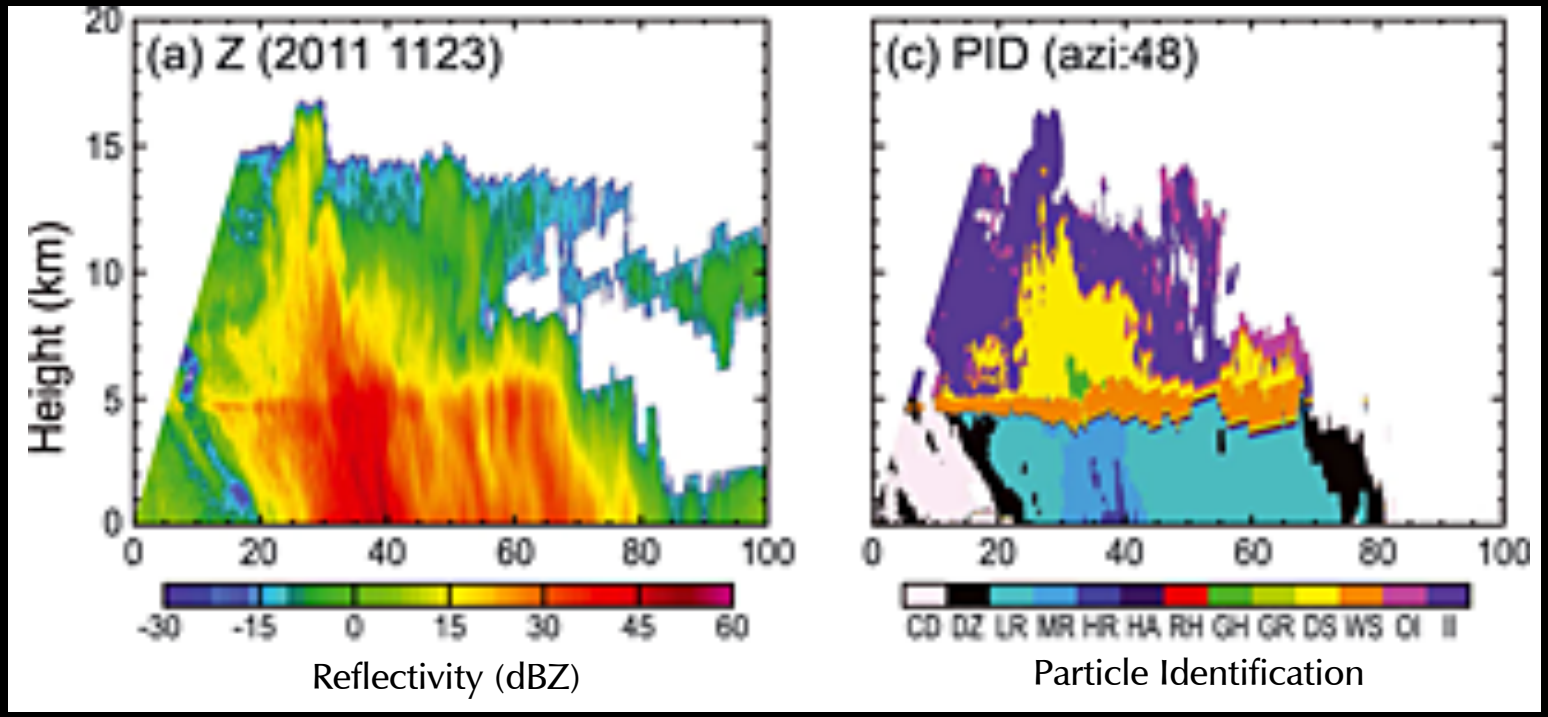
Conclusions

Yoneyama et al. (2013),
from S. Ellis



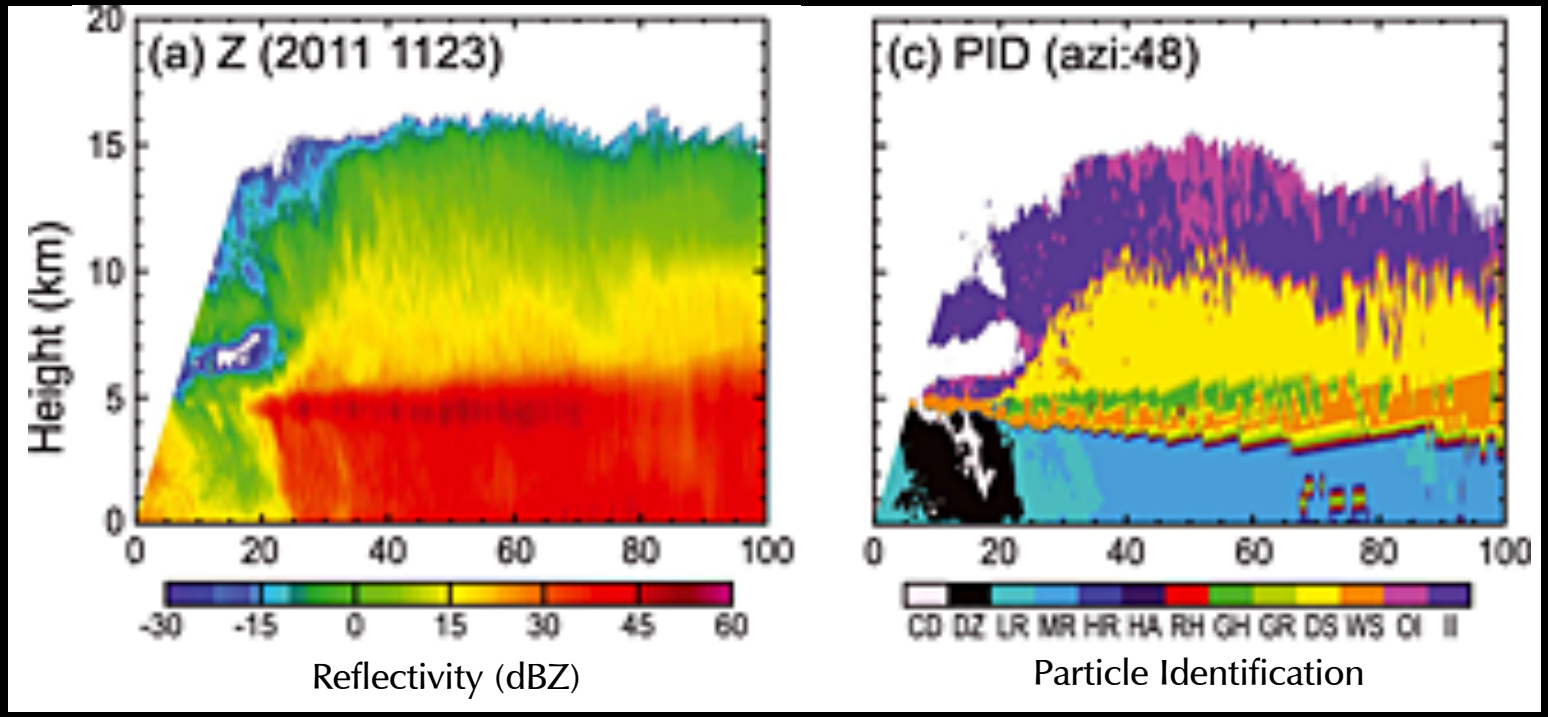
Rowe and Houze (2014)

Convective

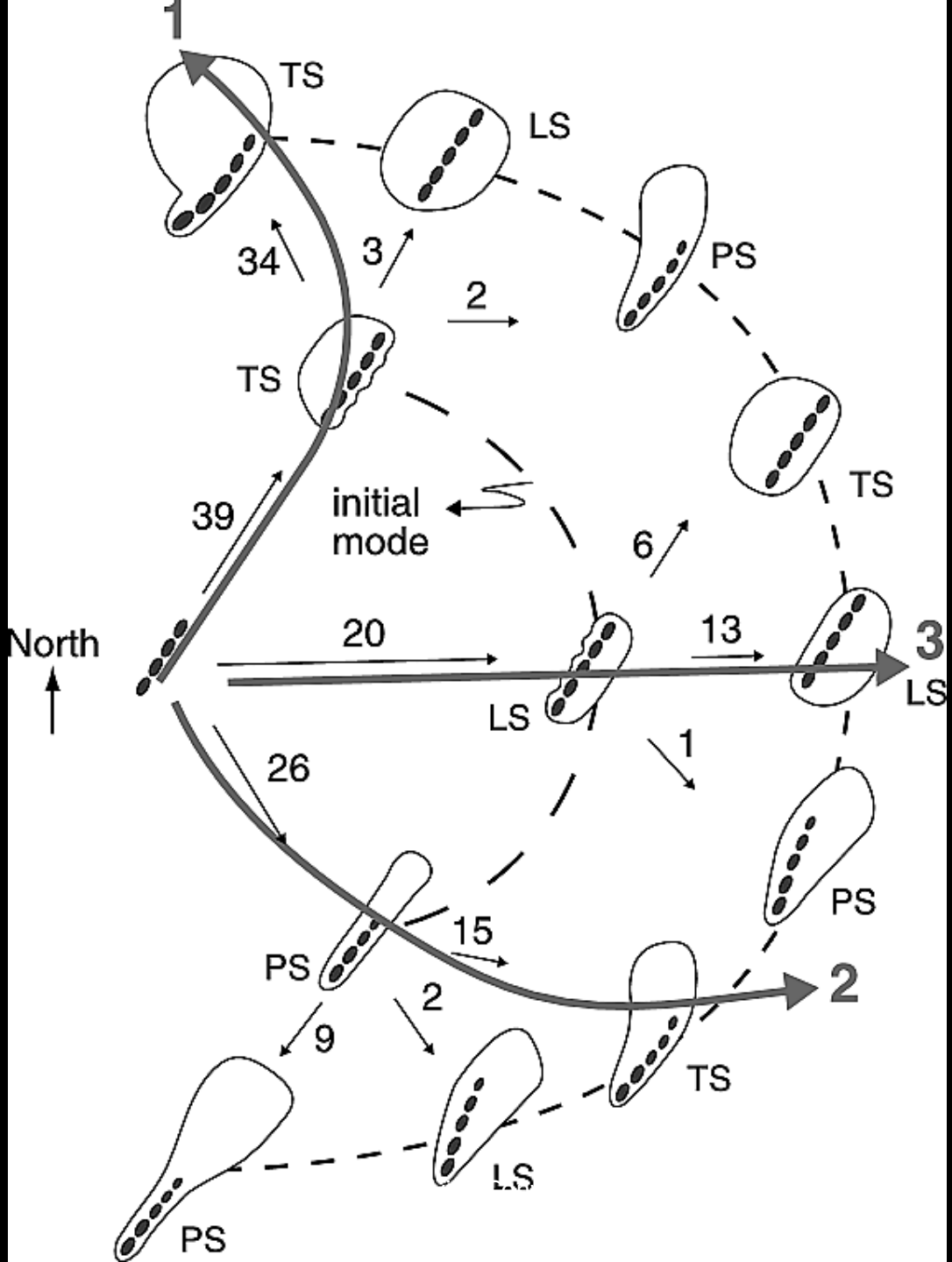


Rowe and Houze (2014)

Stratiform

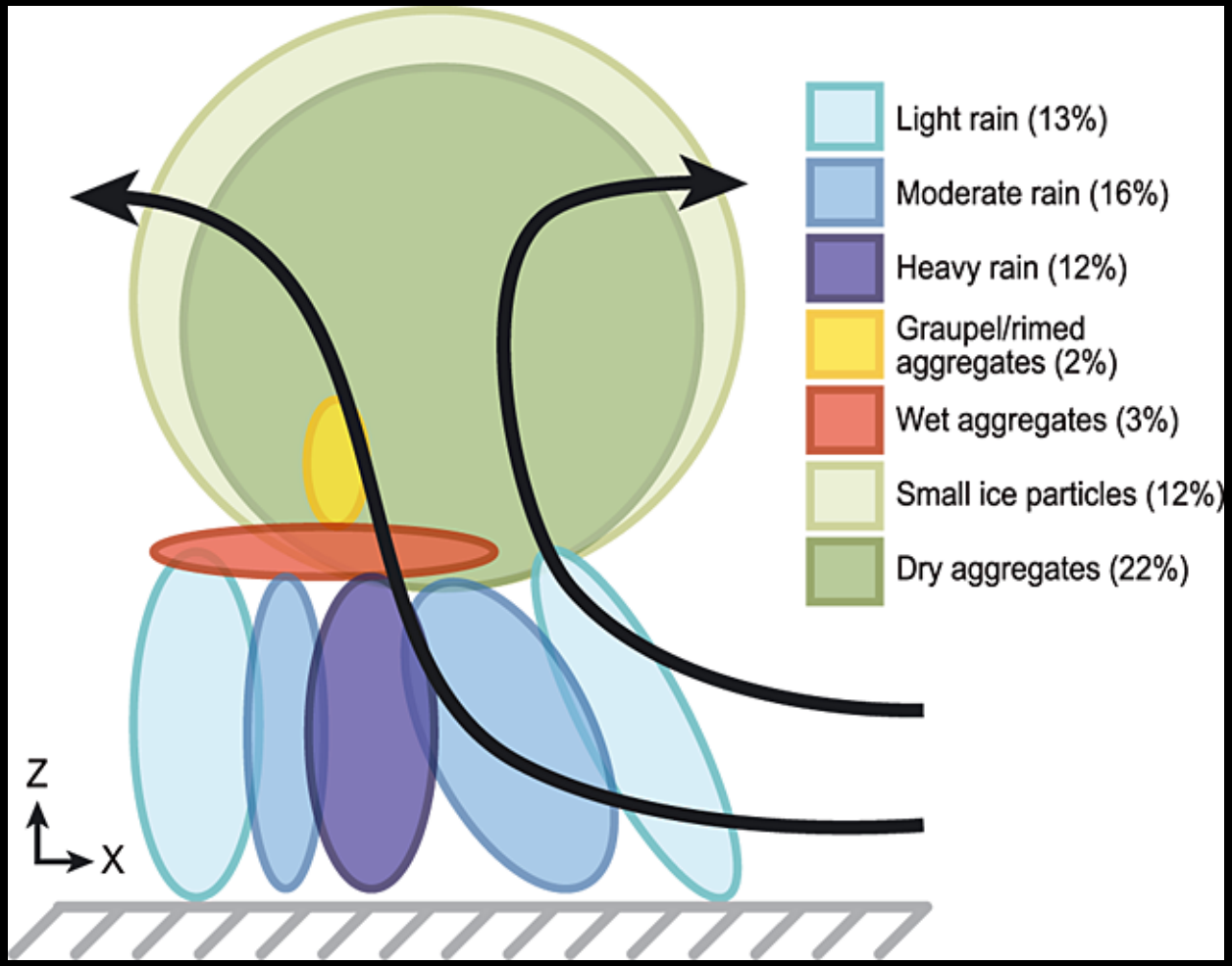


Parker and Johnson (2000)



Barnes and Houze (2014)

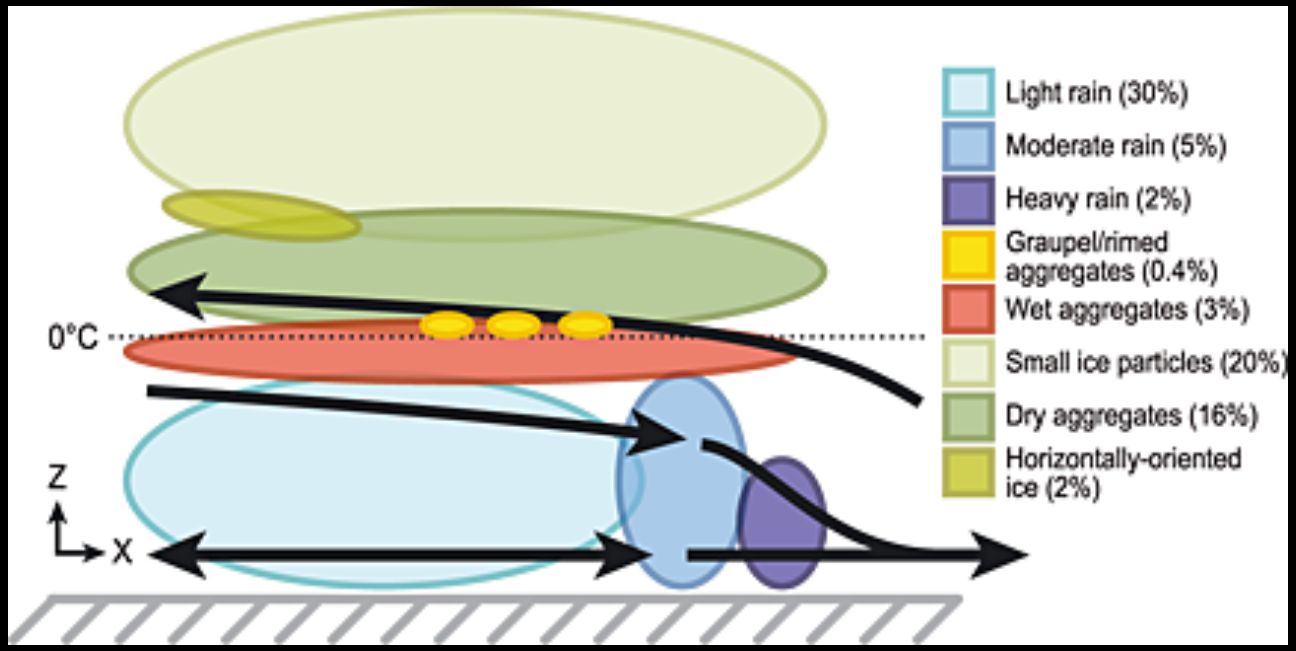
Convective



O(1–10 km)

Barnes and Houze (2014)

Stratiform



O(100 km)