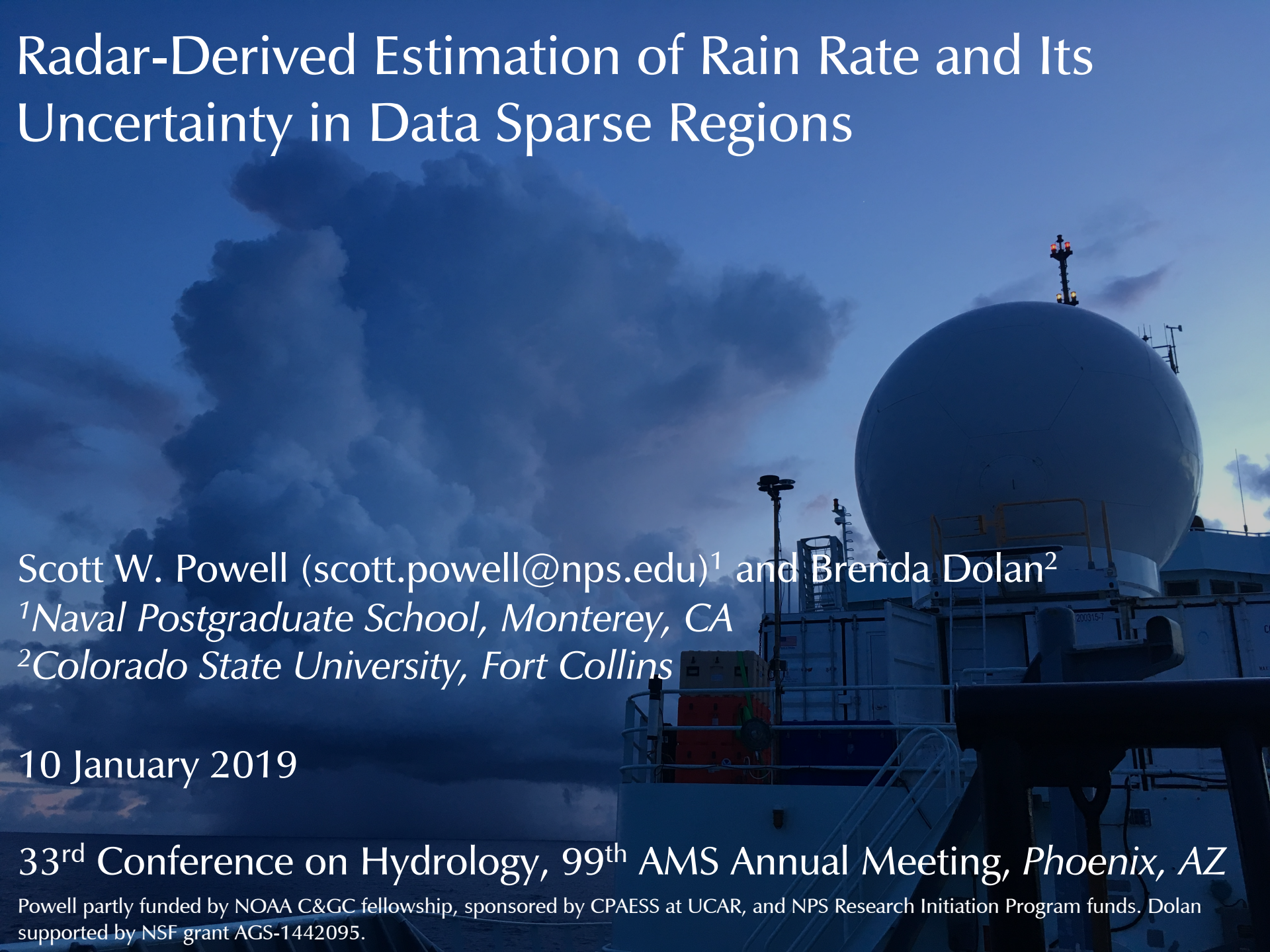
Radar-Derived Estimation of Rain Rate and Its Uncertainty in Data Sparse Regions



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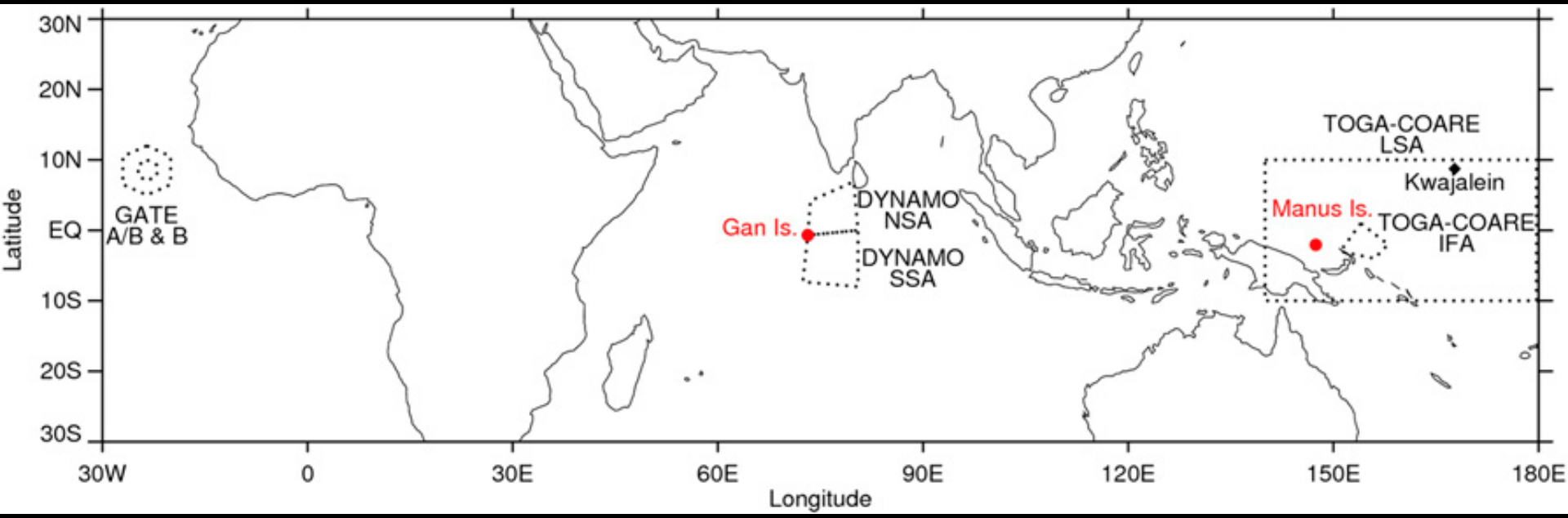
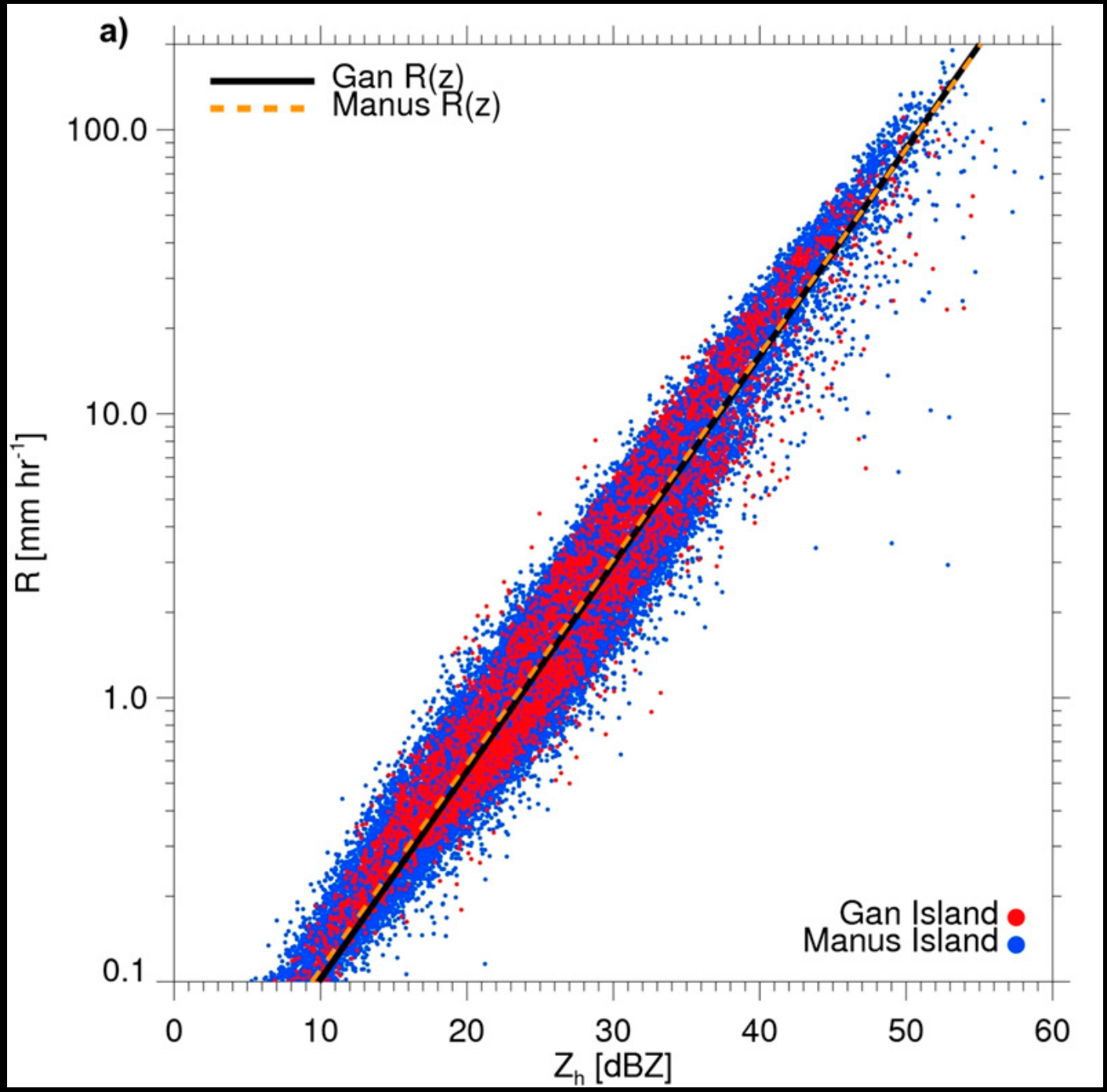
GOAL: Describe radar-estimated rain rates as a *range* based on ground-based observations from a disdrometer.

Why?

1. Many tropical oceanic radar datasets exist in data sparse regions without rain gauge data (e.g. radar on remote islands or ship for field campaigns).
2. Uncertainty bounds provide target for validation of other instruments.

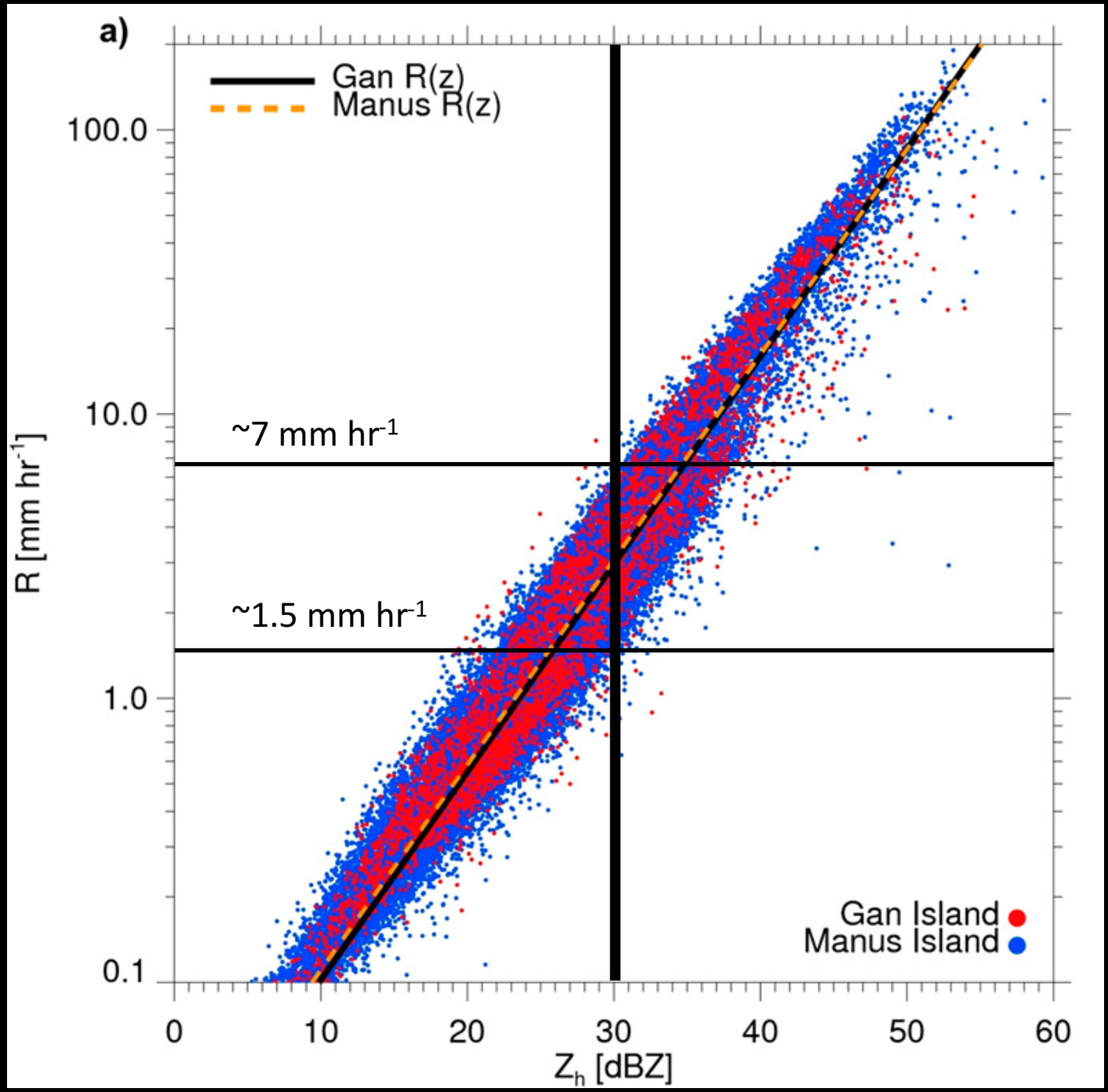
Thompson et al. (2015)





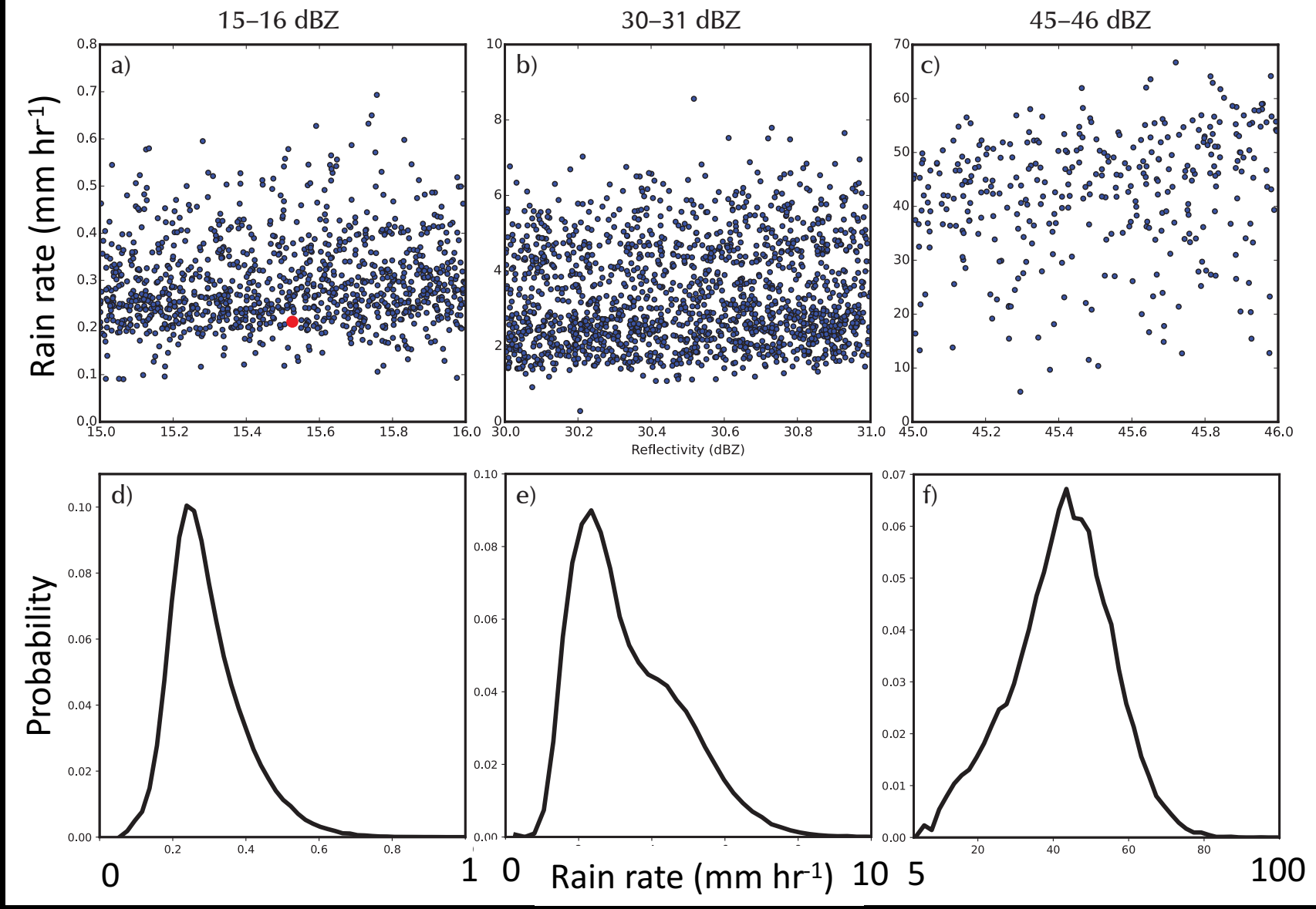
Thompson et al. (2015)

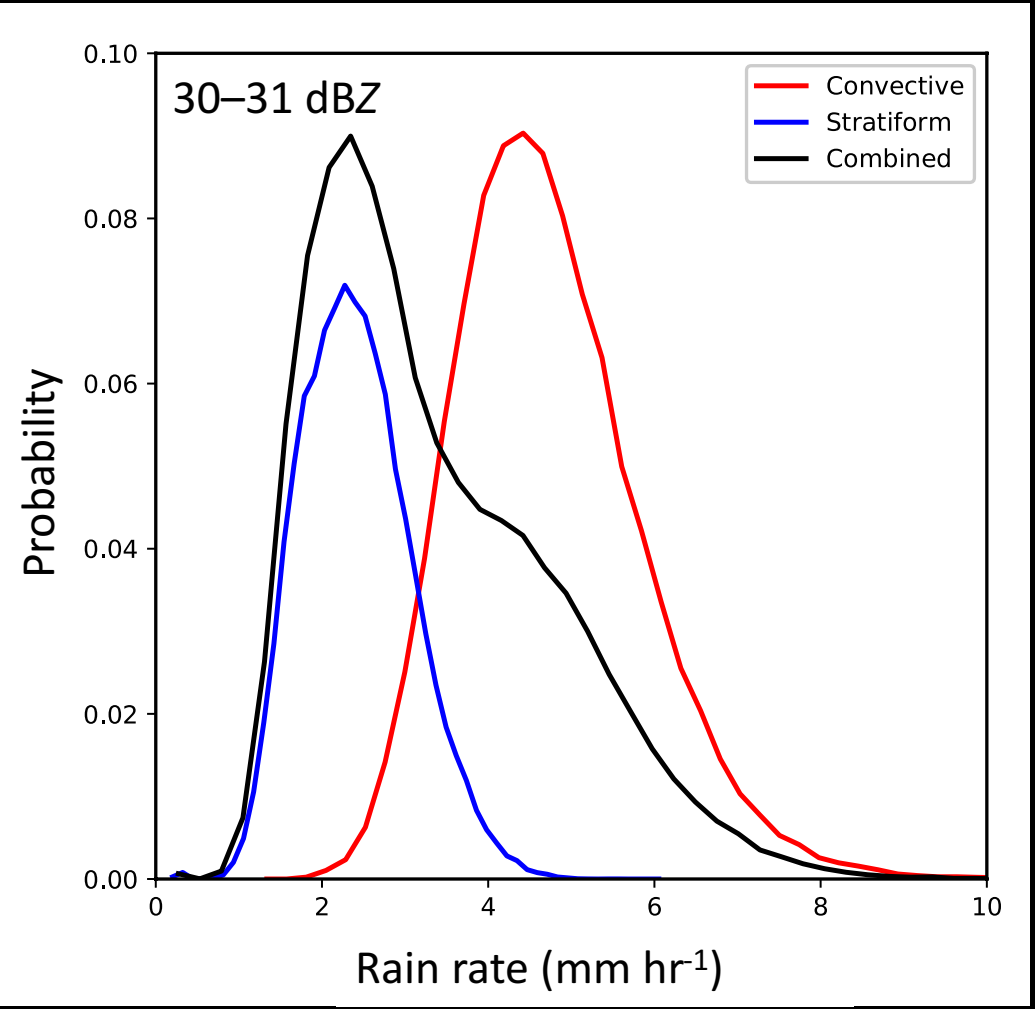
Z-R relationships derived from 2DVD data



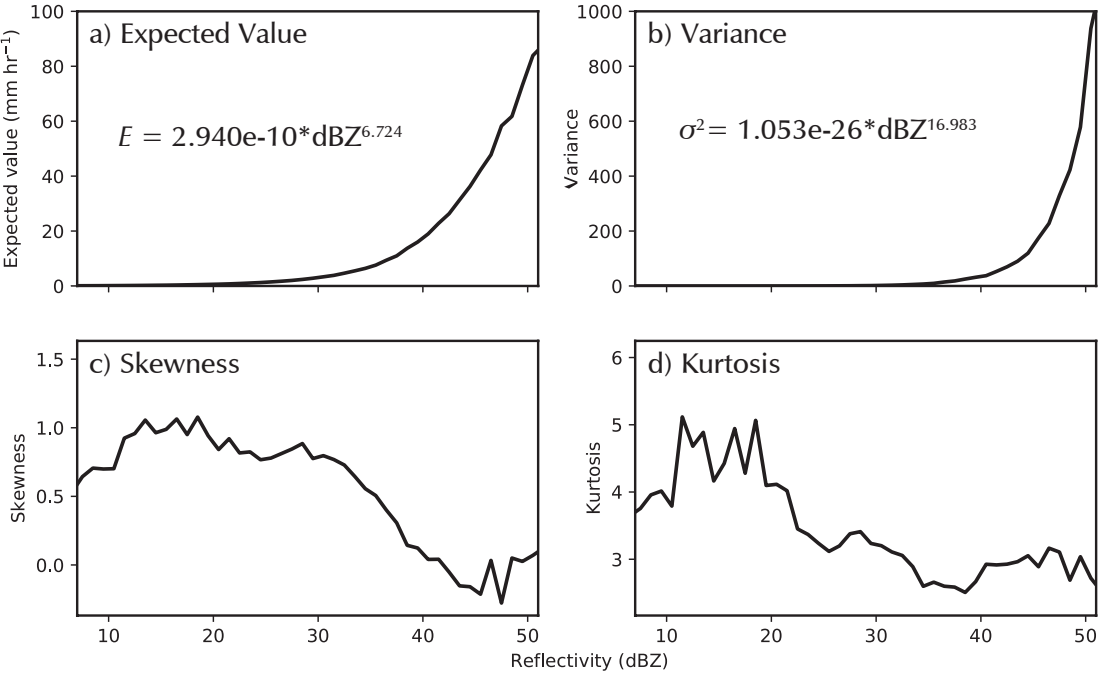
Thompson et al. (2015)

Z-R relationships derived from 2DVD data

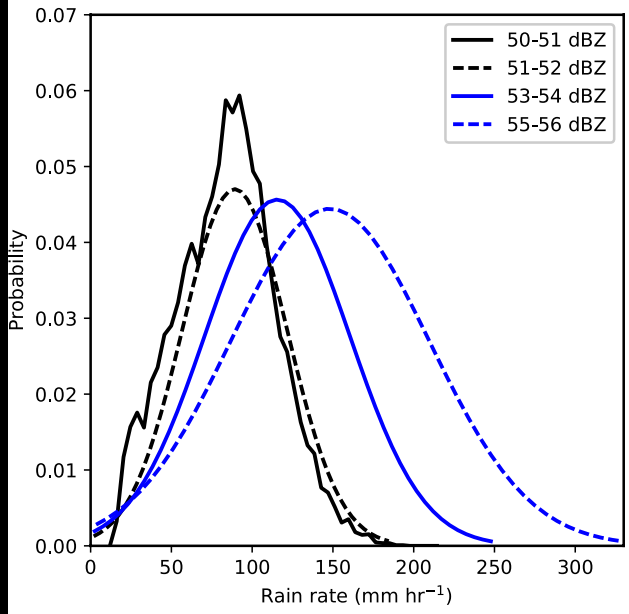

15–16 dBZ
30–31 dBZ
45–46 dBZ
a)
b)
c)
d)
e)
f)
Rain rate (mm hr-1)
Reflectivity (dBZ)
Probability
0
1 0
Rain rate (mm hr-1) 10 5
100



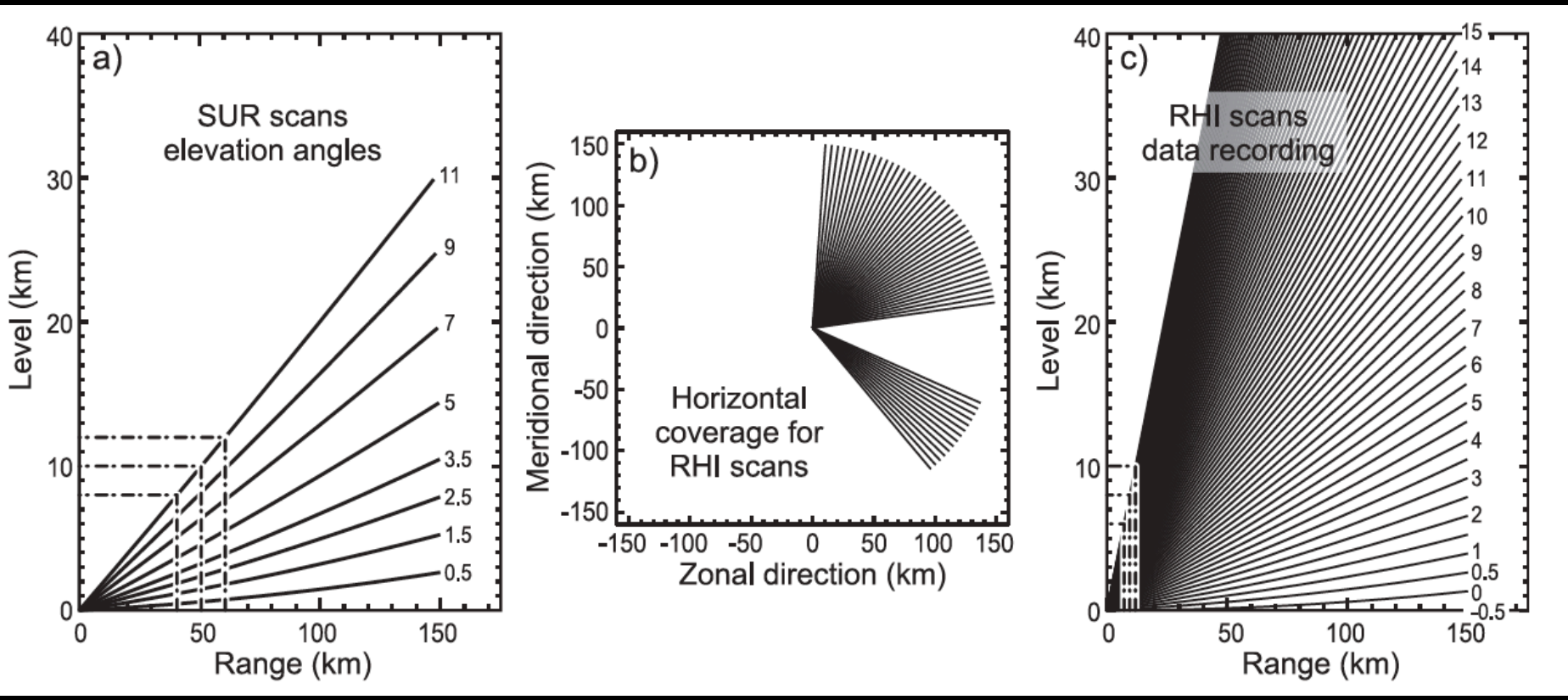
Separate PDFs can be generated for convective and stratiform precipitation.



Generating PDFs for high reflectivity (which is observed too infrequently to do with previously shown method)

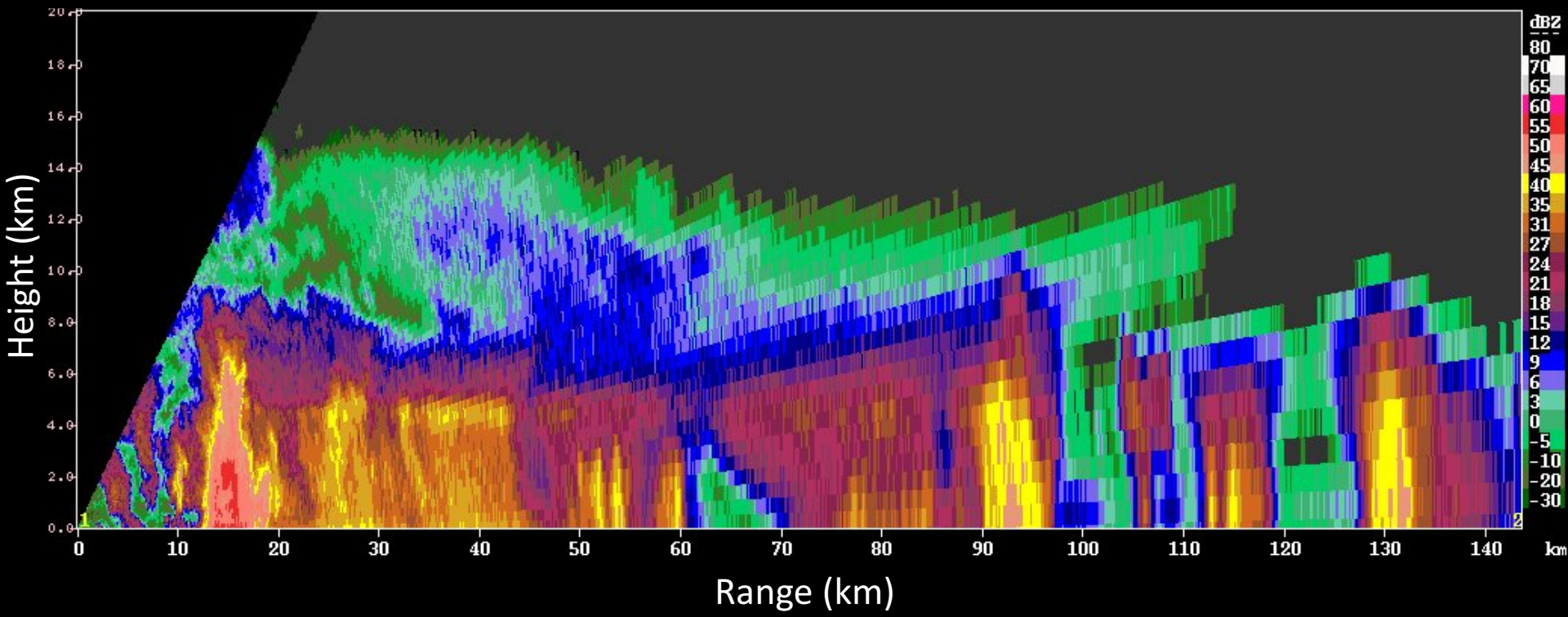


Zuluaga and Houze (2013)



We use data before it is re-gridded to rectilinear coordinates. But most data is above the surface.

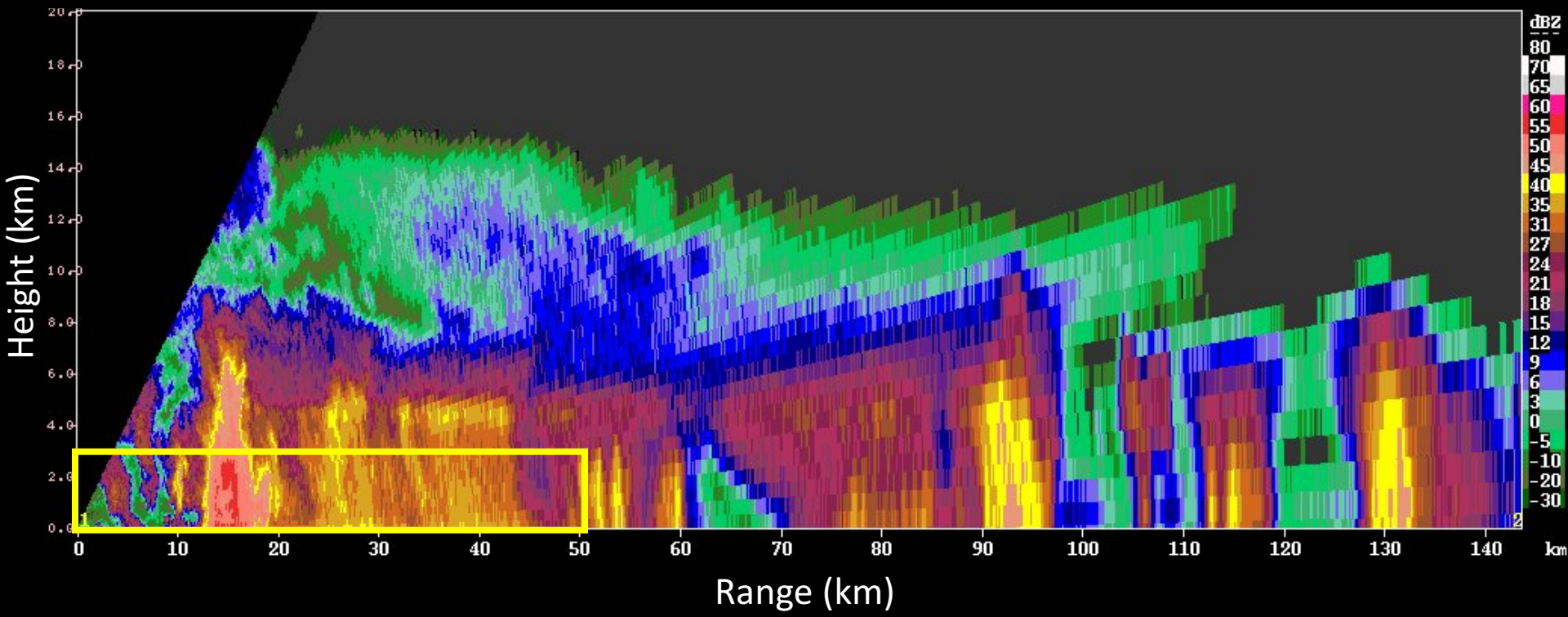
Example of RHI data from S-PolKa during DYNAMO.



Grid this data to 100 meter vertical and horizontal resolution within 50 km of radar.

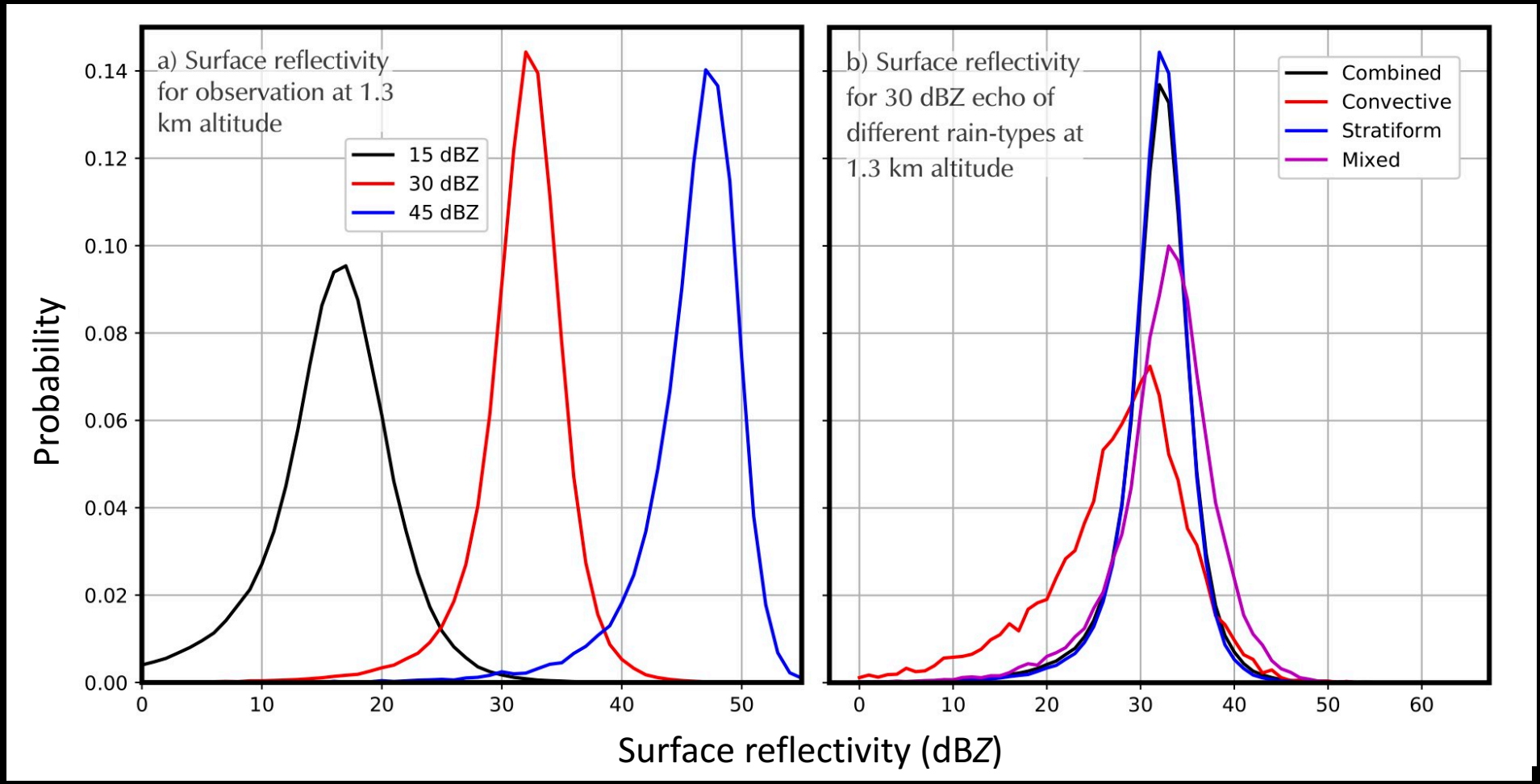
This generates PDFs for downward extrapolation of reflectivity to surface.

Example of RHI data from S-PolKa during DYNAMO.



Grid this data to 100 meter vertical and horizontal resolution within 50 km of radar.

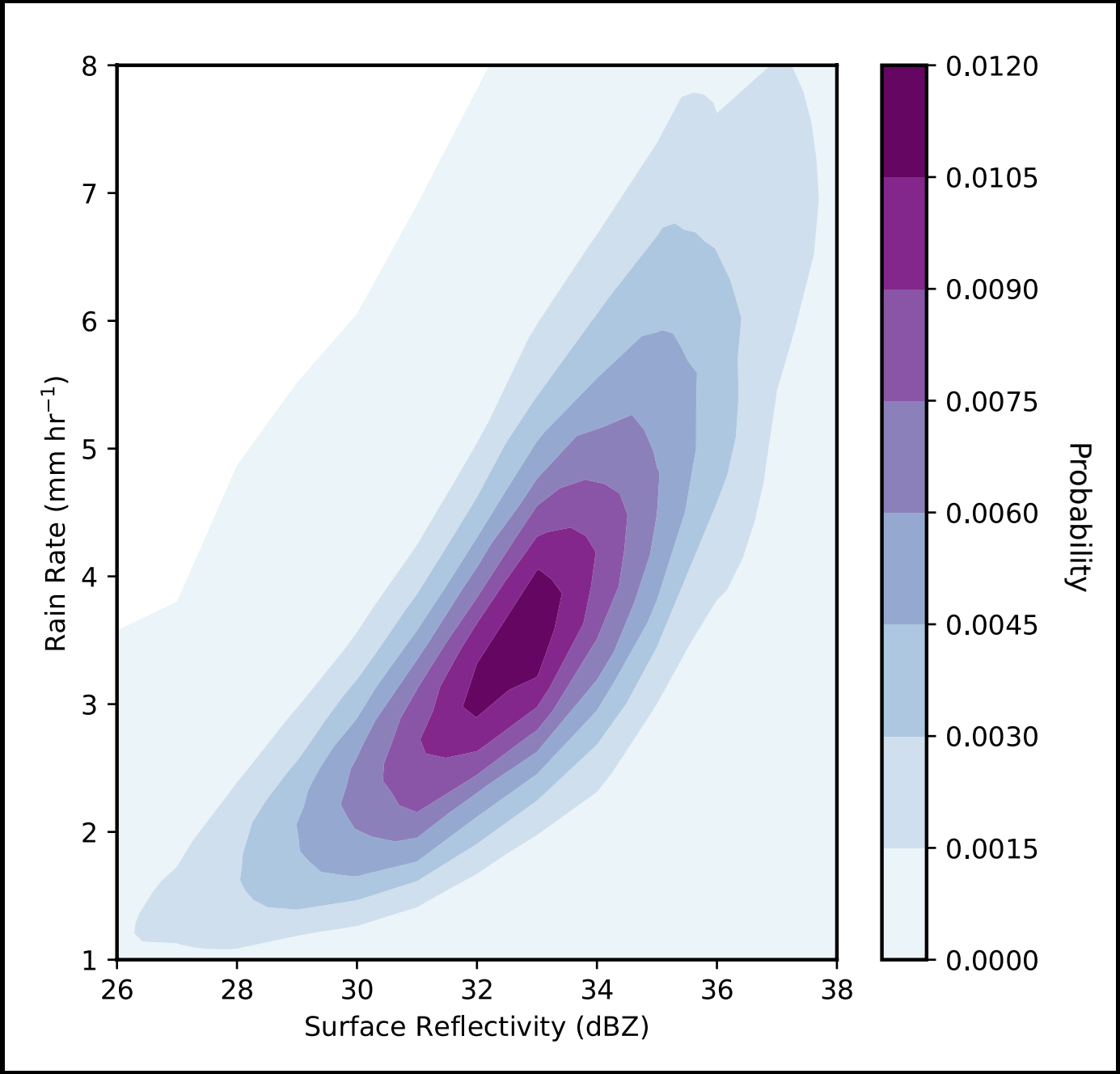
This generates PDFs for downward extrapolation of reflectivity to surface.

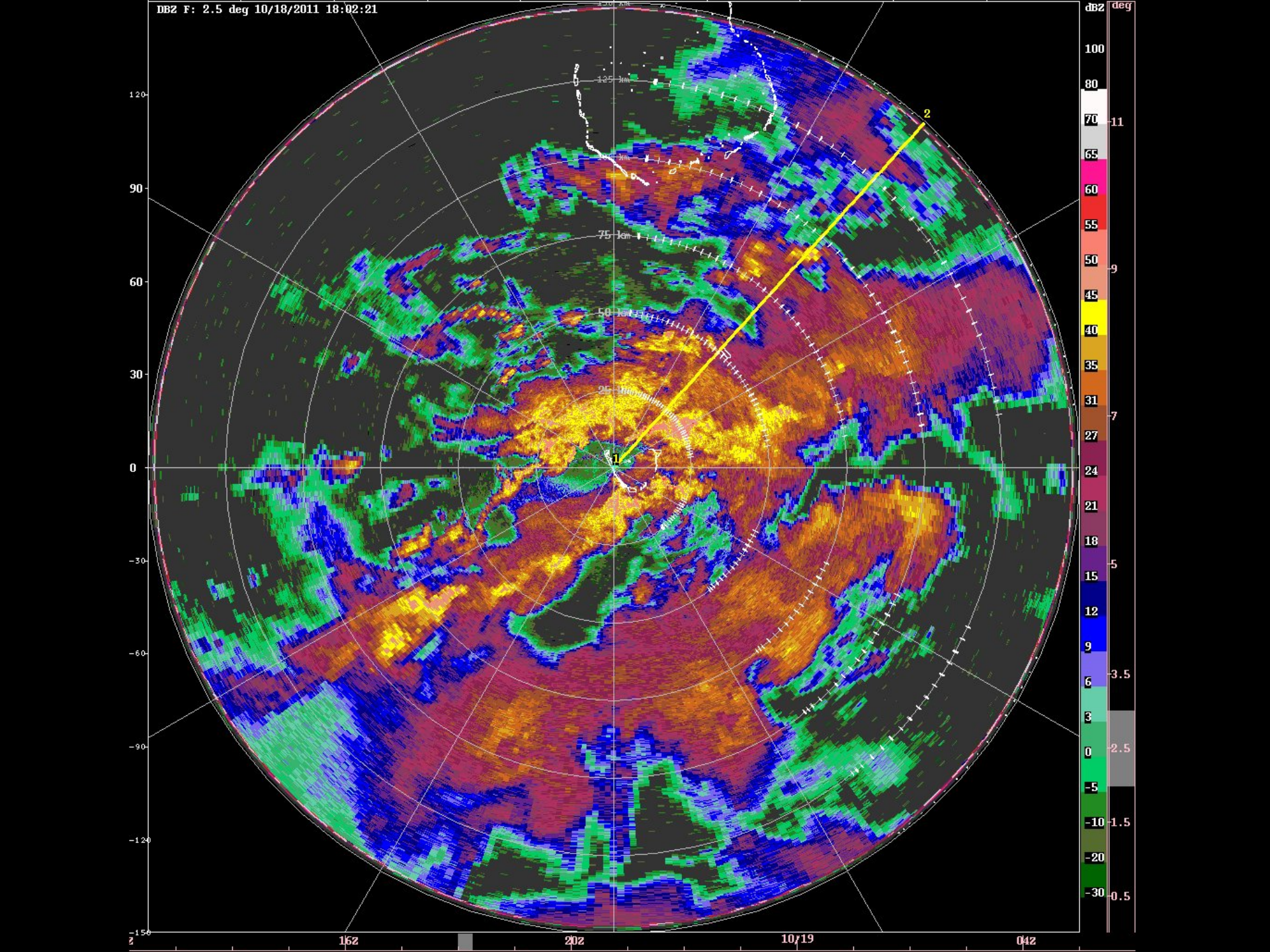

a) Surface reflectivity for observation at 1.3 km altitude
15 dBZ
30 dBZ
45 dBZ
b) Surface reflectivity for 30 dBZ echo of different rain-types at 1.3 km altitude
Combined
Convective
Stratiform
Mixed
Probability
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0
10
20
30
40
50
60
Surface reflectivity (dBZ)

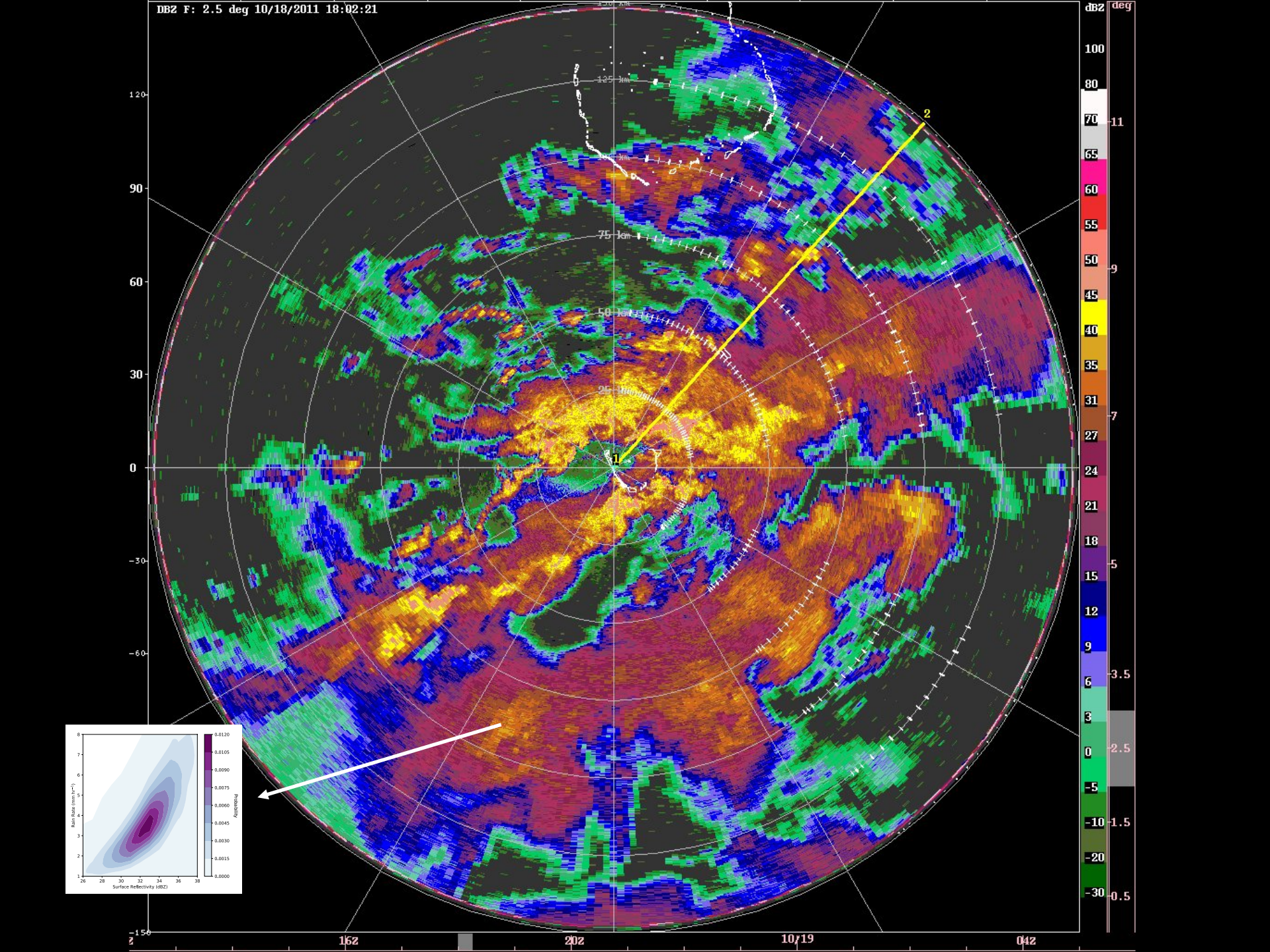
2D PDF containing spread in empirical rain rate relation and correction for extrapolation to surface

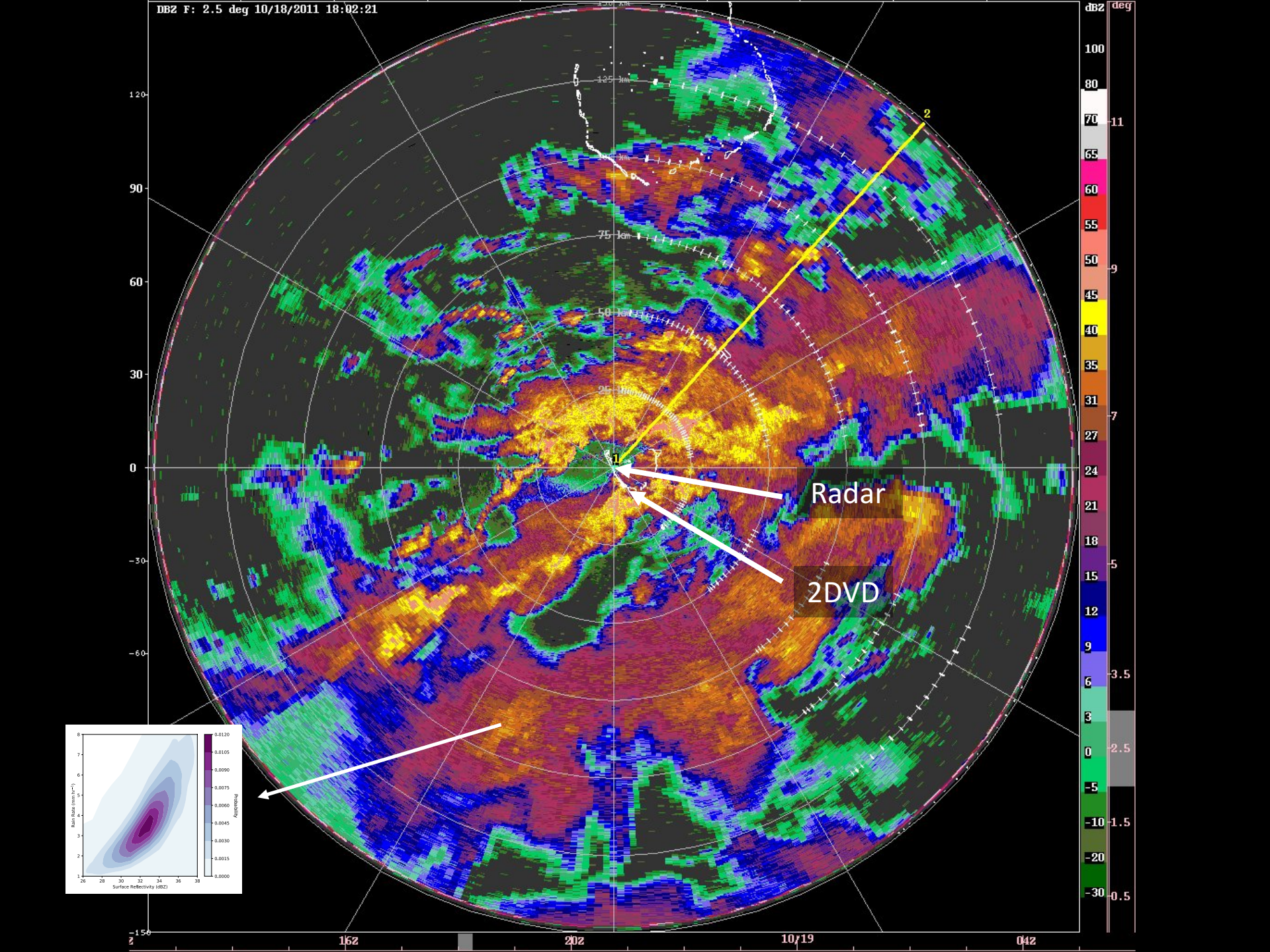
(This is for a 30 dBZ stratiform echo at 1.3 km.)

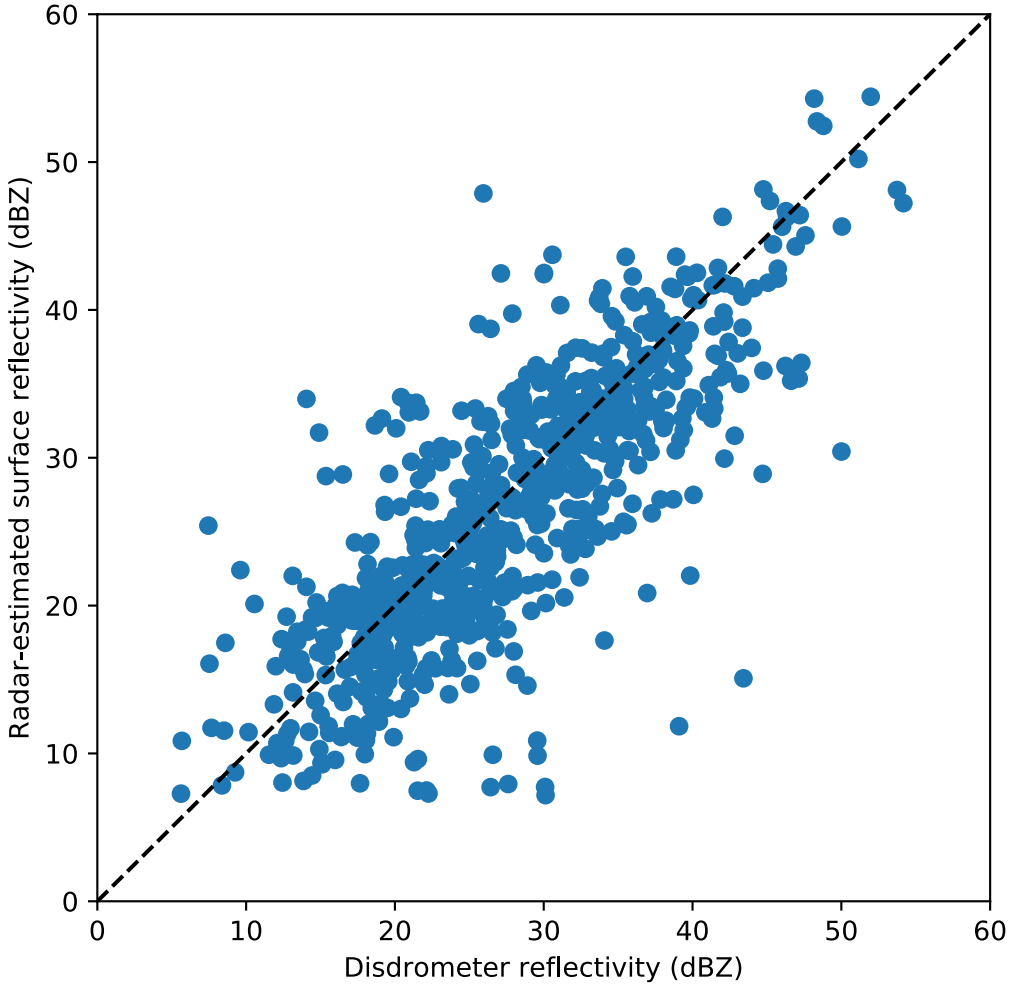
$$P(Z,R) = \frac{P_1(Z) * P_2(Z,R)}{\sum P_1(Z) * P_2(Z,R)}$$




DBZ F: 2.5 deg 10/18/2011 18:02:21
dBZ
deg
100
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
11
9
7
5
3.5
2.5
1.5
0.5
120
90
60
30
0
-30
-60
-90
-120
-150
75 km
50 km
25 km
1
2
16Z
20Z
10/19
04Z


DBZ F: 2.5 deg 10/18/2011 18:02:21
dBZ
deg
100
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
11
9
7
5
3.5
2.5
1.5
0.5
120
90
60
30
0
-30
-60
-150
75 km
50 km
25 km
1
2
162
202
10/19
042

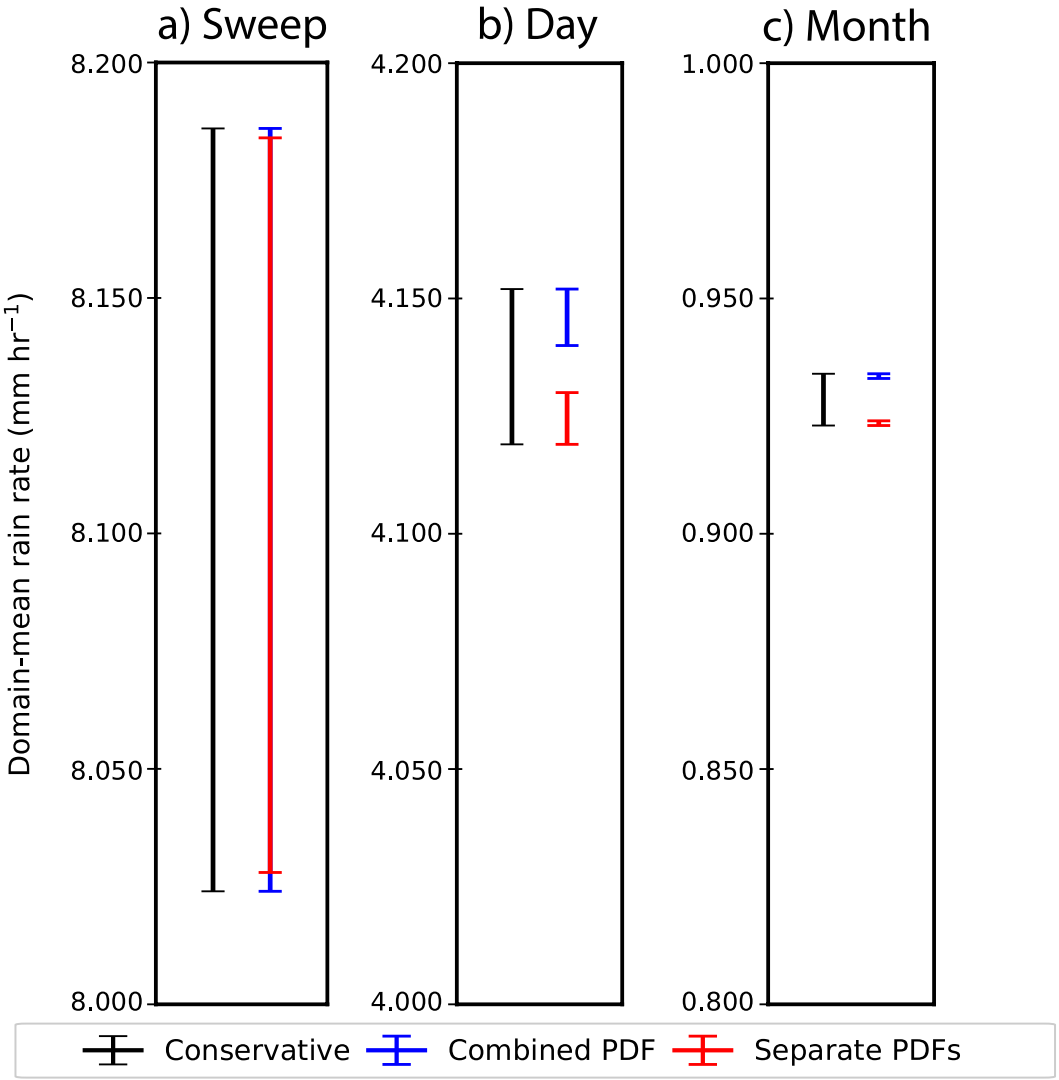

DBZ F: 2.5 deg 10/18/2011 18:02:21
dBZ
deg
100
80
70
65
60
55
50
45
40
35
31
27
24
21
18
15
12
9
6
3
0
-5
-10
-20
-30
11
9
7
5
3.5
2.5
1.5
0.5
120
90
60
30
0
-30
-60
-150
75 km
50 km
25 km
1
2
Radar
2DVD
16Z
20Z
10/19
04Z

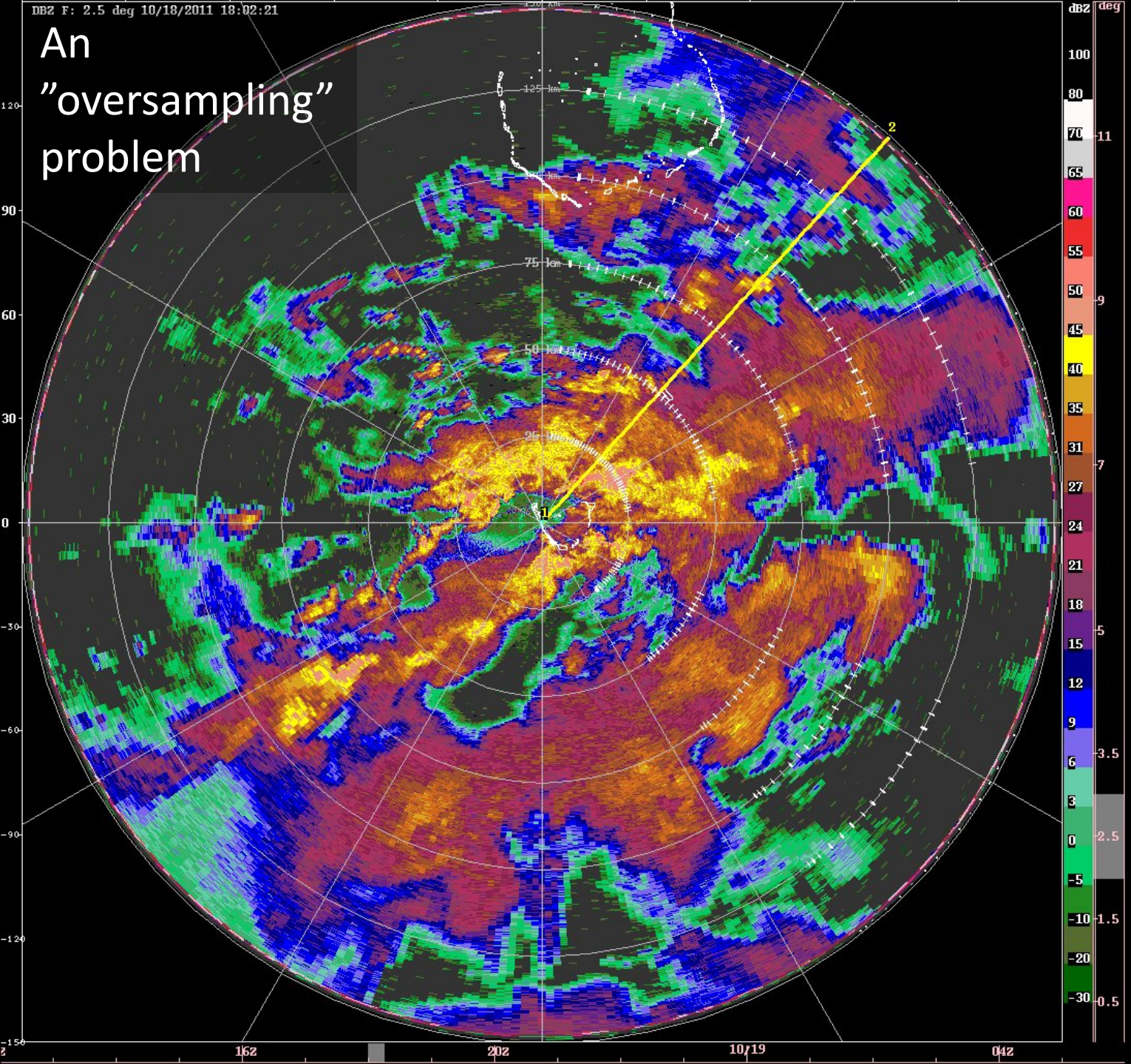


~95% of 2DVD observed rain rates fall within the error bounds determined from the radar-derived rain rate. However, for individual points, the uncertainty is very large!

A first attempt at applying this to real radar data.

But…there's a problem.





About 50,000 data points but only O(10) to O(100) degrees of freedom?

Conclusions

- Use 2D video disdrometer data as a climatological dataset of rain rate vs reflectivity (and other dual-polarization variables).
- To express uncertainty in rain rate, describe the spread in empirical (e.g. *Z*-*R*) relationships and surface reflectivity as a function of observed reflectivity above the surface. This generates a 2D PDF for surface rain rate per radar observation.
- Comparing radar-derived results to disdrometer observations, the method validates well, but…
- We have an oversampling problem and haven't accounted for spatio-temporal autocorrelation in radar volumes. Rain rate for two adjacent, similar echoes should not be independently estimated! If this is done, the calculated uncertainty goes to zero very quickly.