Surface snowfall microphysics and mode-dependent correlations with properties aloft

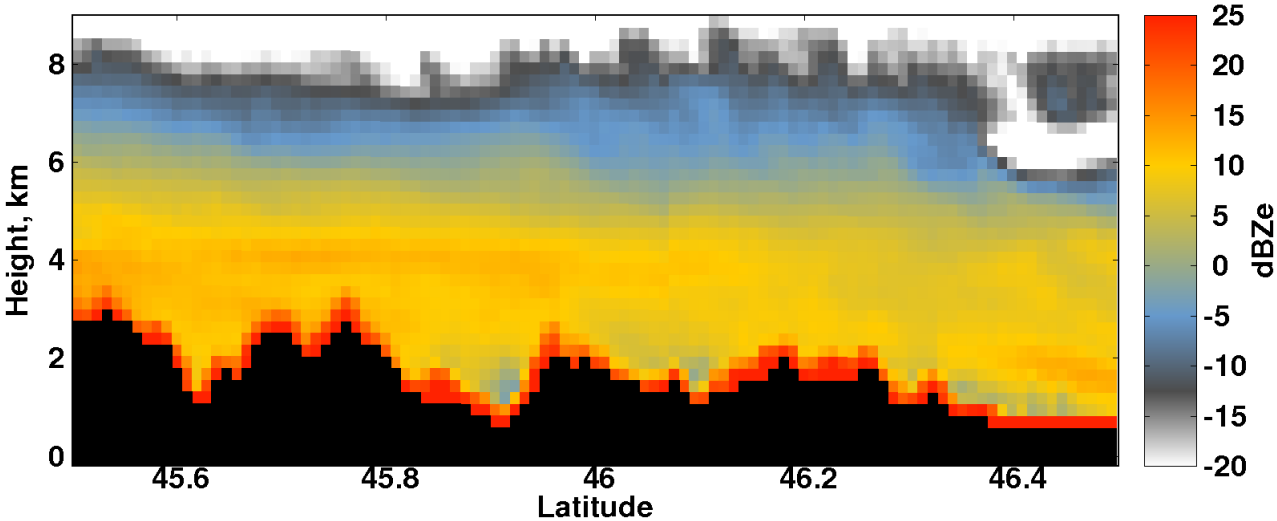
(T. Kuhn)

Norman Wood, Claire Pettersen
University of Wisconsin - Madison
Space Science and Engineering Center

Acknowledgements: GV experiments team, Larry Bliven, Gwo-Jong Huang, GHRC

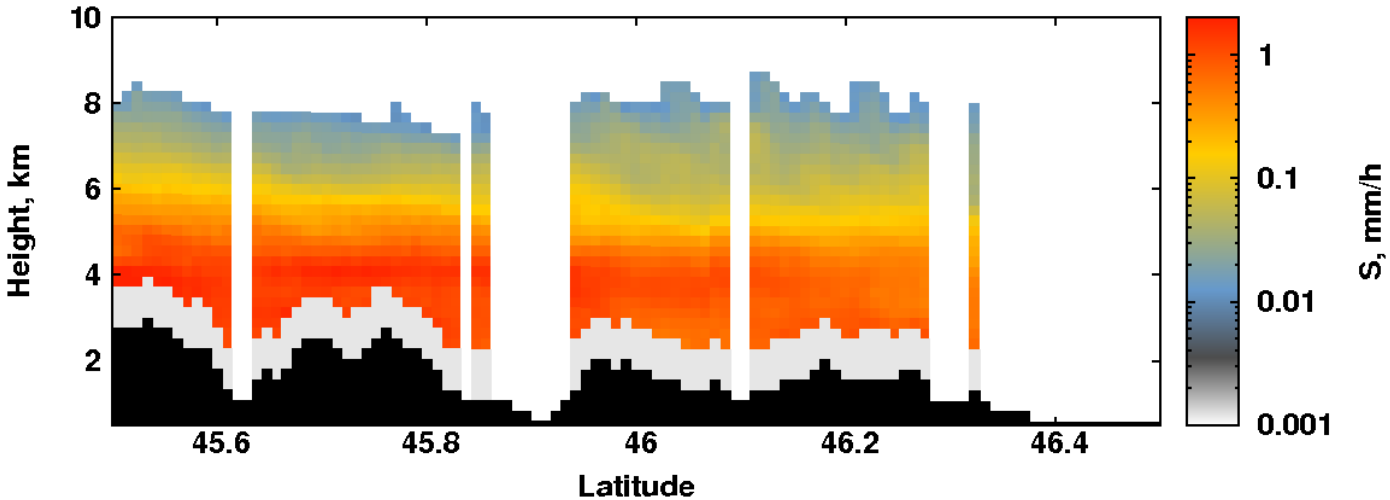
PMM Science Team Meeting 2018

Ground clutter



"Blind zone" transformations

- Microphysical processing
  - N(D), m(D), V(D), phase
- Advection

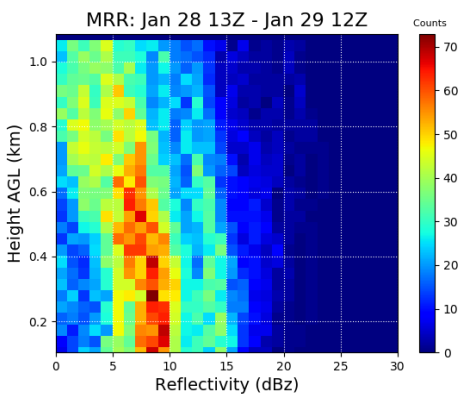


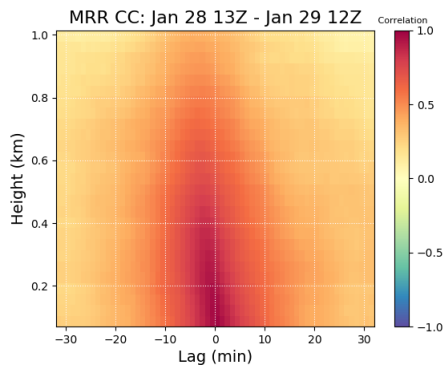
Vertical structure information for snow:

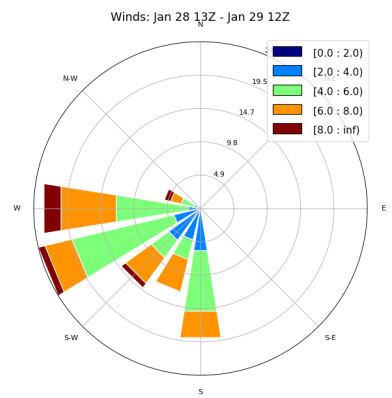
- Handling transformations across "blind zone" to improve surface snowfall estimates

Questions:

- How do snow PSD and other microphysical properties like m(D) above the blind zone relate to those at the surface?
- Are there commonalities related to snowfall mechanism or mode?
- Can satellite observables and ancillary information help identify snowfall mode and constrain these relationships?



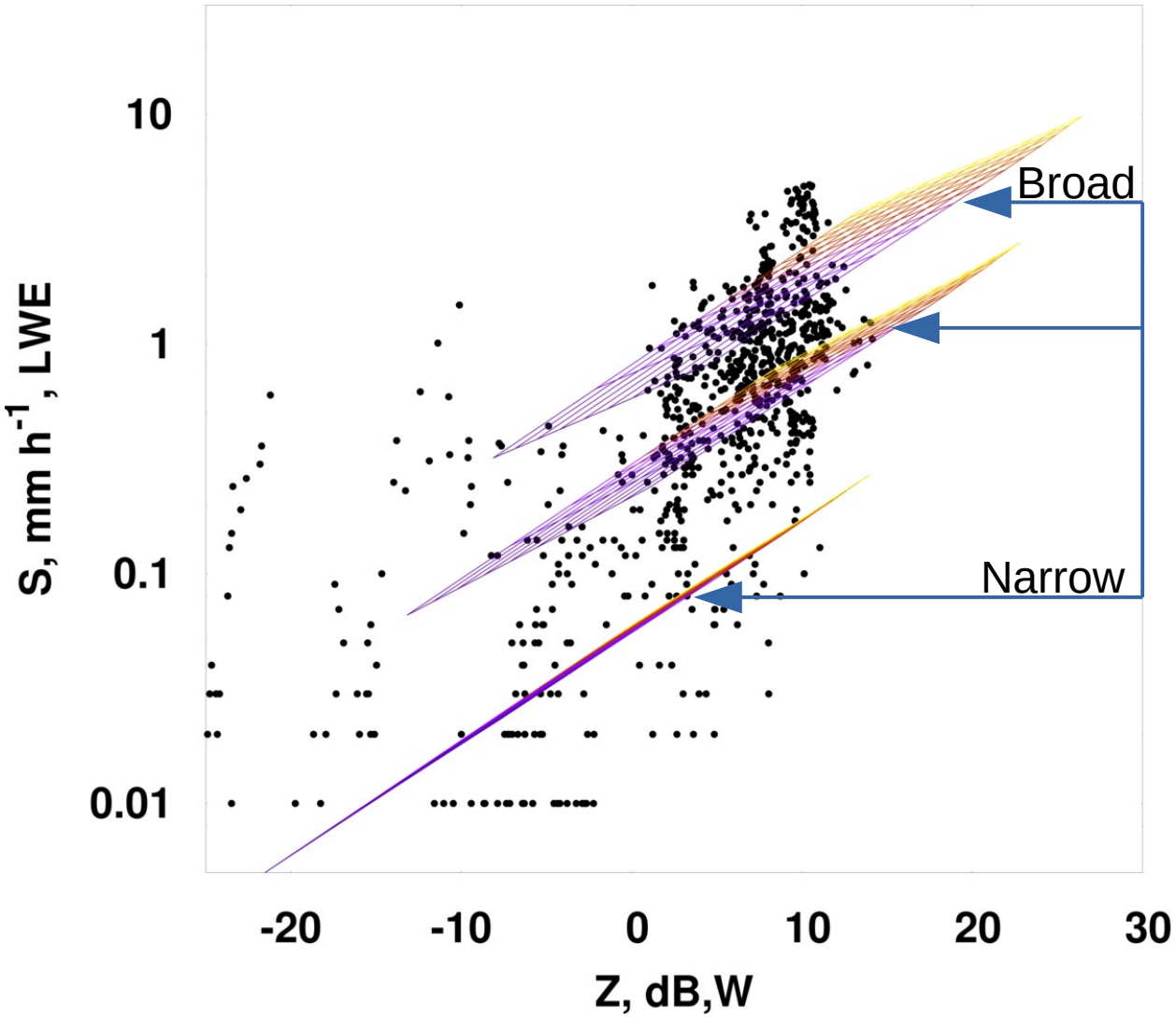




(Snowfall modes: Pettersen and Wood, Poster #201, Wednesday)

Objective: Constrain surface snowfall properties and quantify uncertainties, given near-surface-bin retrieval results, satellite-based observables, and ancillary data

PSD and mass effects on Z-S



Variations in PSD (broad to narrow) with fixed fallspeed (~ 1 m/s) and shape

GCPEx

January – February 2012

Five ground sites

Micro Rain Radars

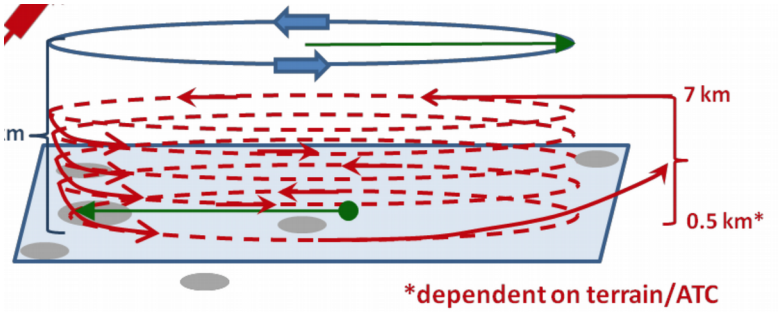
Diverse precipitation gauging varying by site:

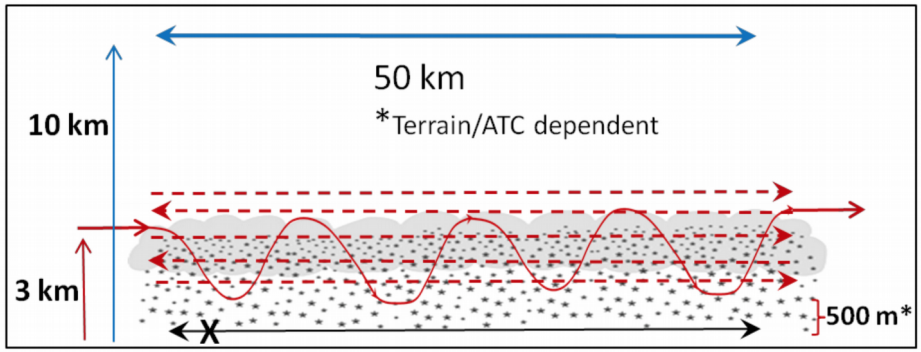
- Pluvios
- DFIR (CARE)
- FD12P (Huronia)
- Geonor (CARE)

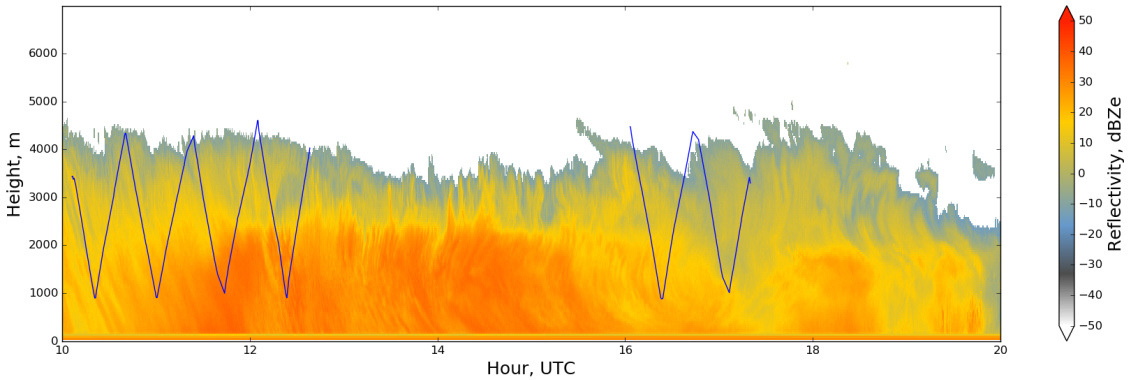
UND Citation microphysics flights

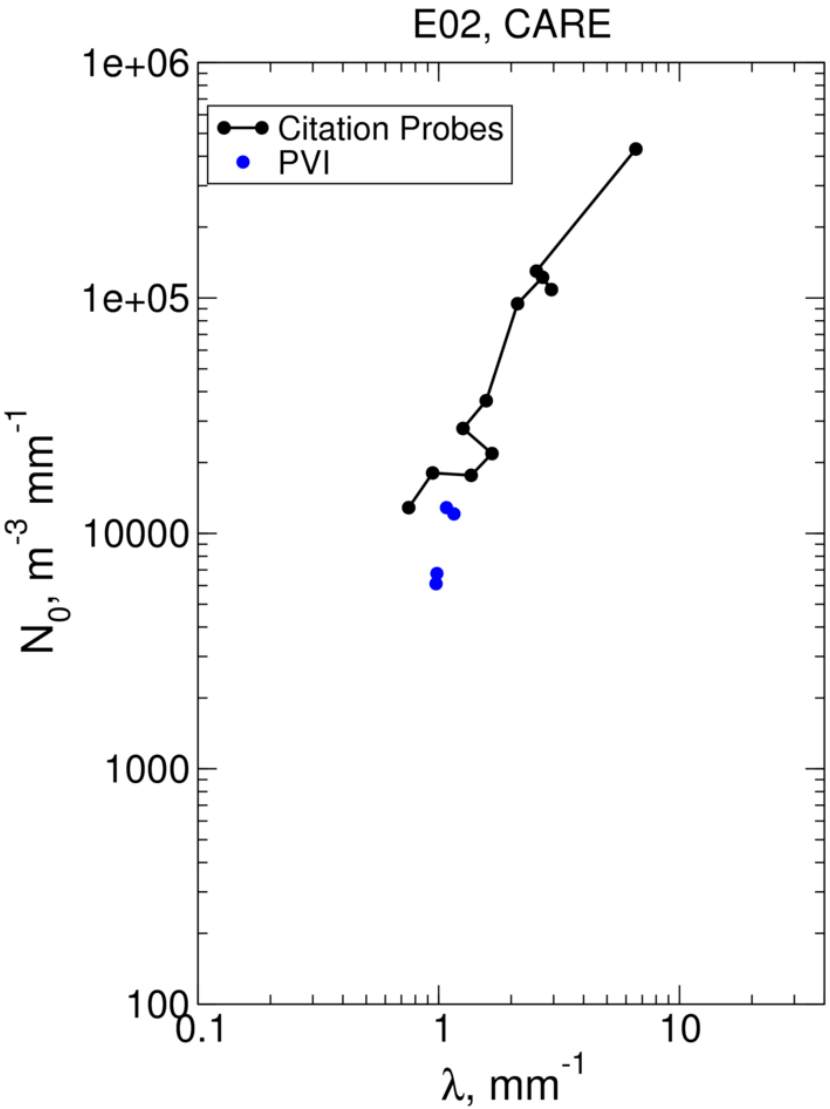
Precipitation Video Imager (PVI)

UND Citation flight patterns for microphysical sampling

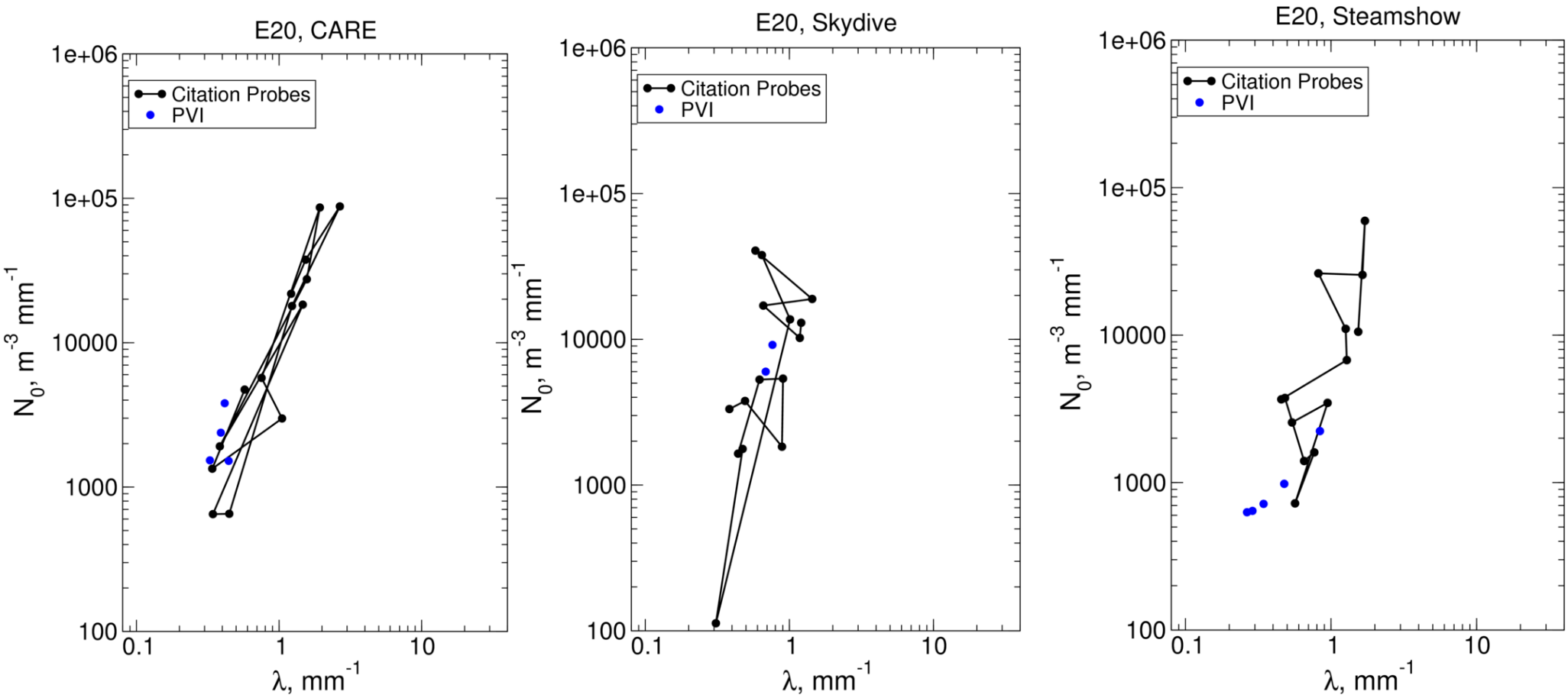




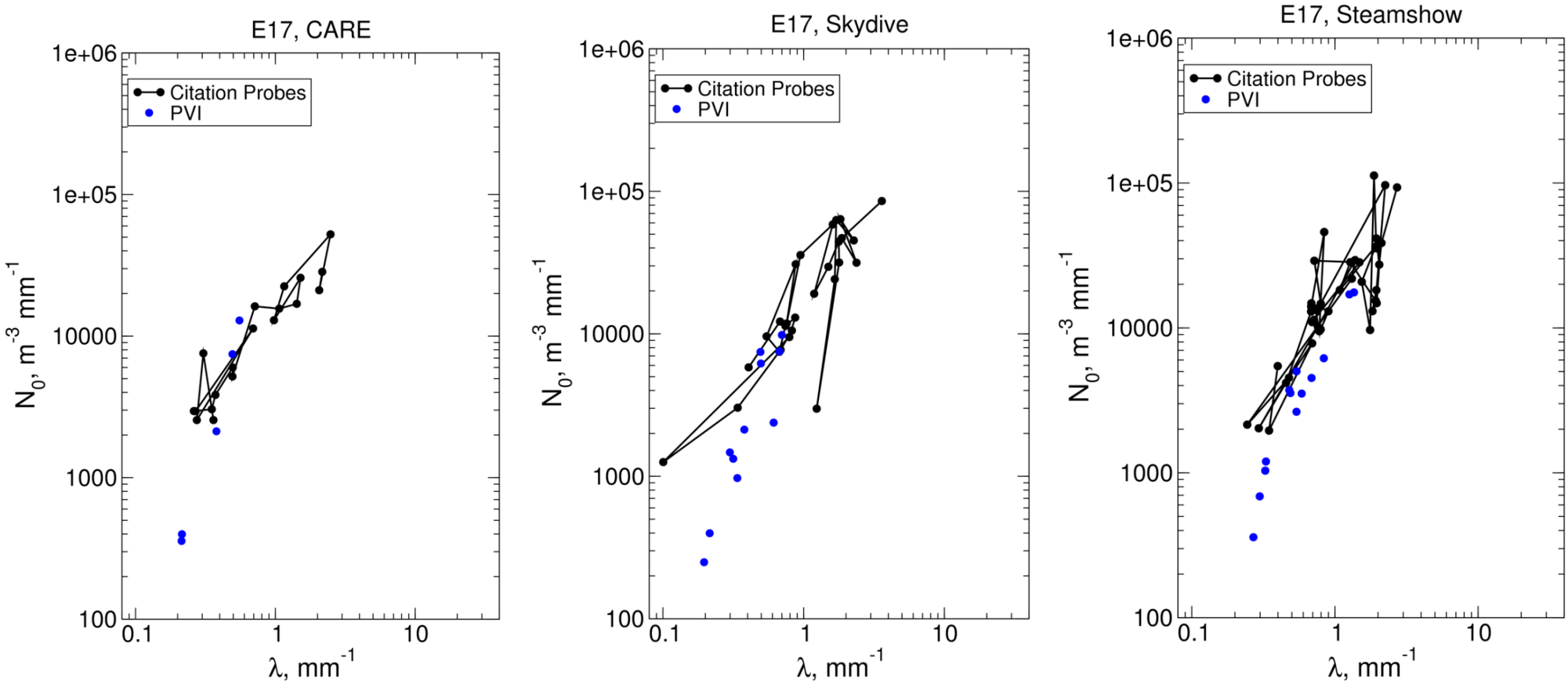




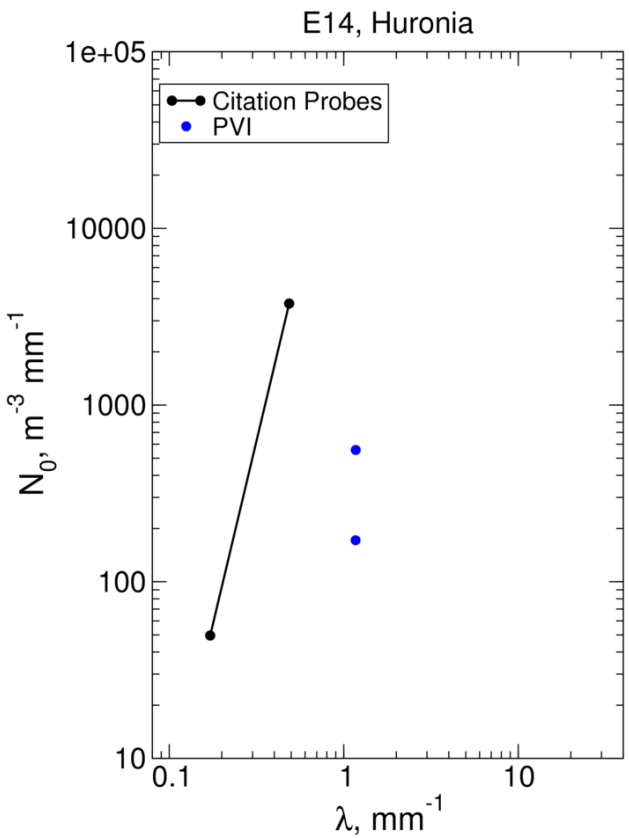
GCPEx E20 (Cyclone): "Persistent"

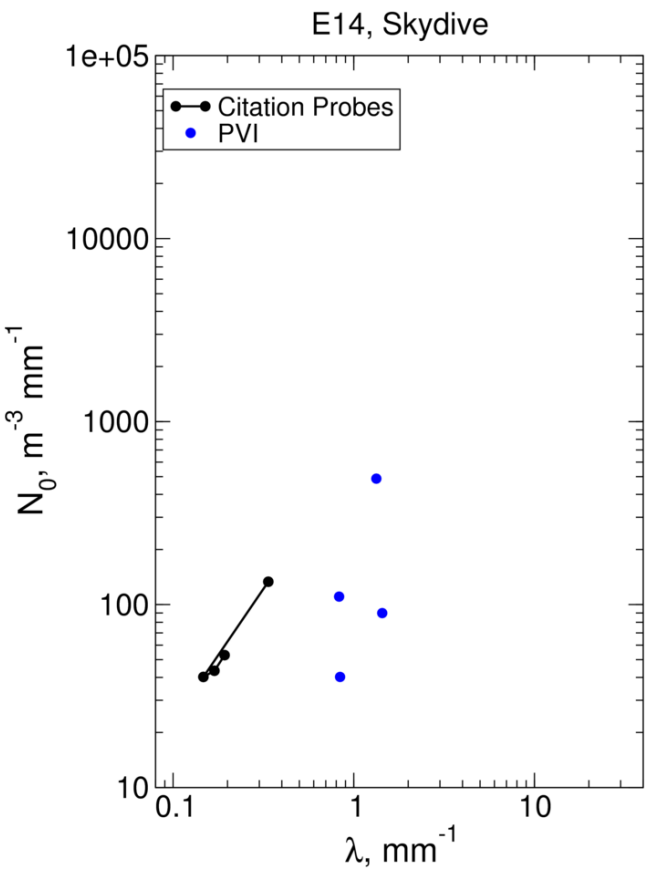


GCPEx E17 (Cyclone): "Predictive"



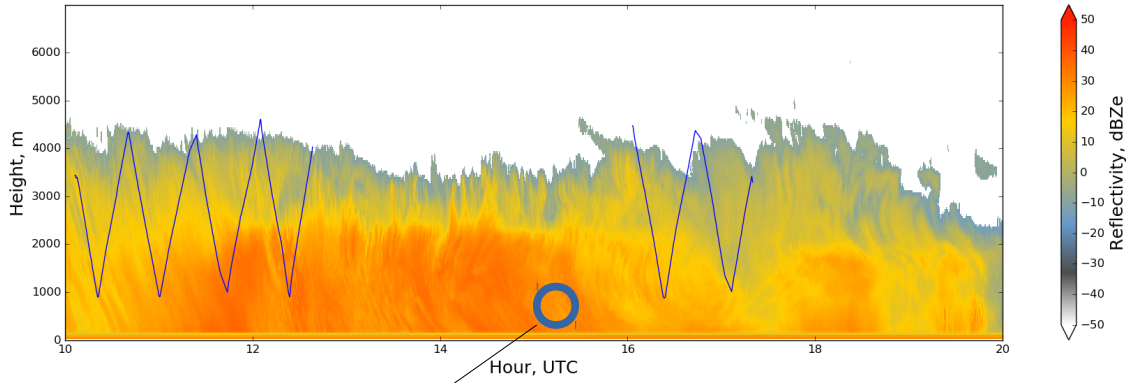
GCPEx E14 (Lake effect): "Variant"



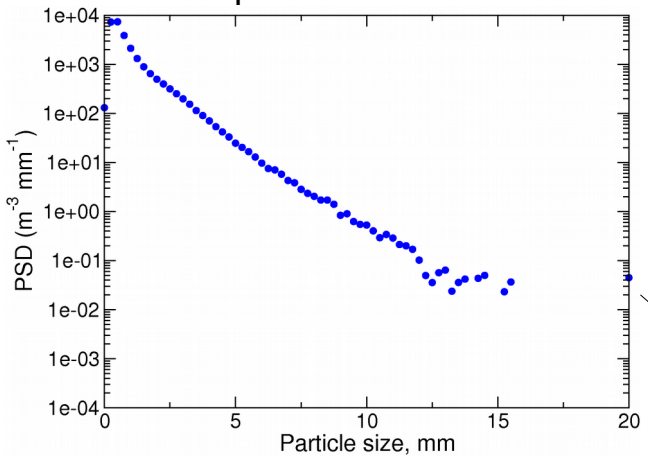


Assessing particle mass and area

Ze(t)



N(D_i, t)



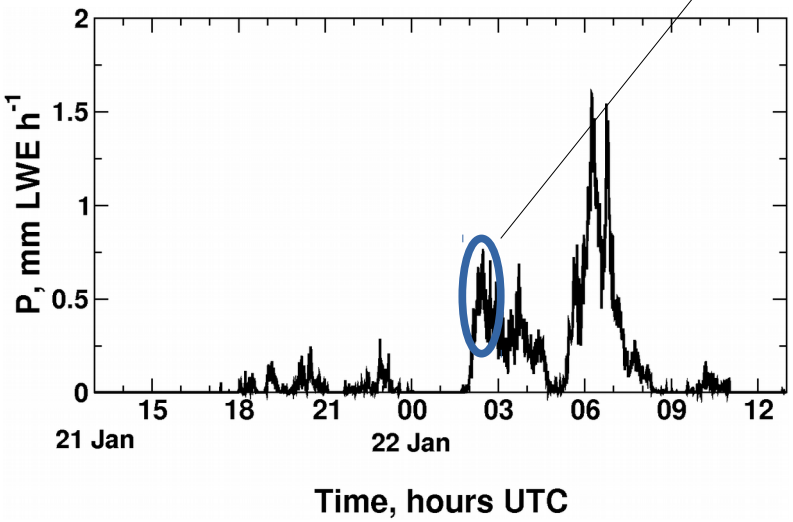
$$m \approx \alpha D_M^{\beta}$$

$$A_p \approx \gamma D_M^{\sigma}$$

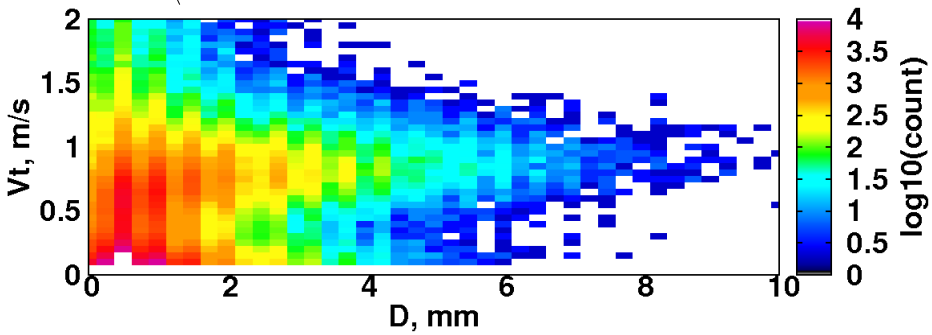
$$D_{obs} \approx \phi D_M$$

a priori P(α,β,γ,σ,φ)

S(t)

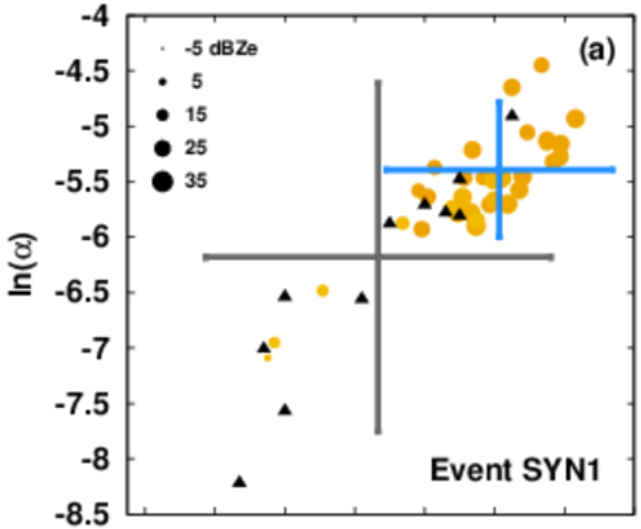


V(D_i,t)

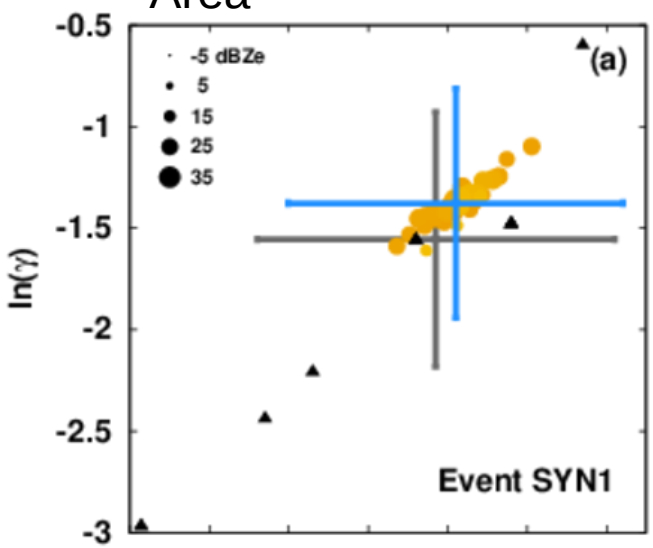


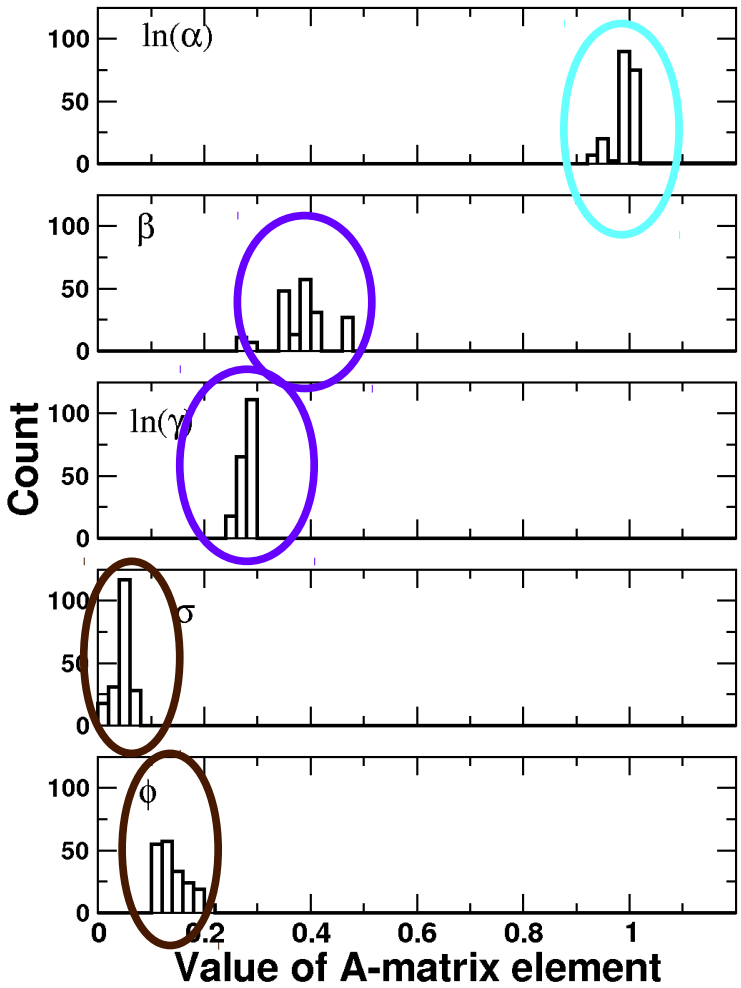
Performance

Mass



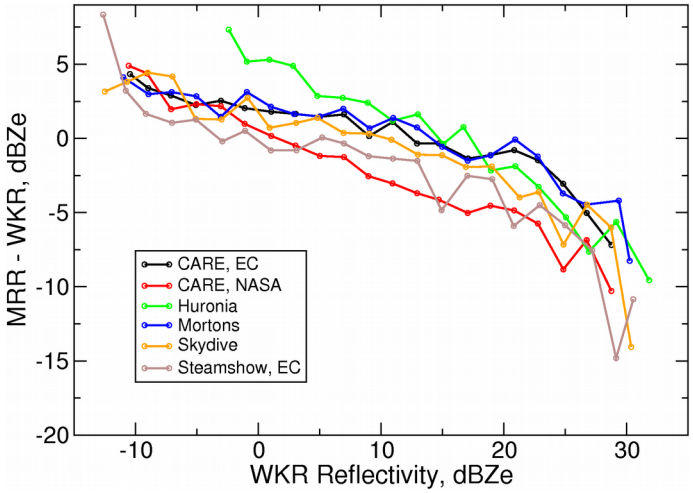
Area



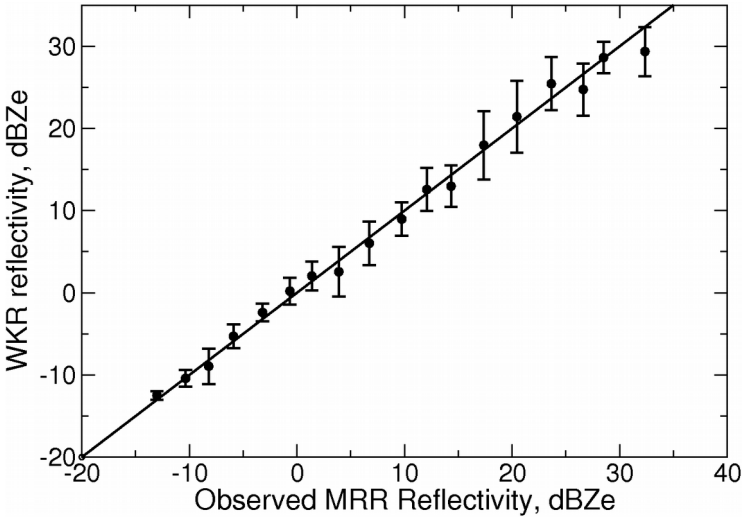


GCPEx adaptations

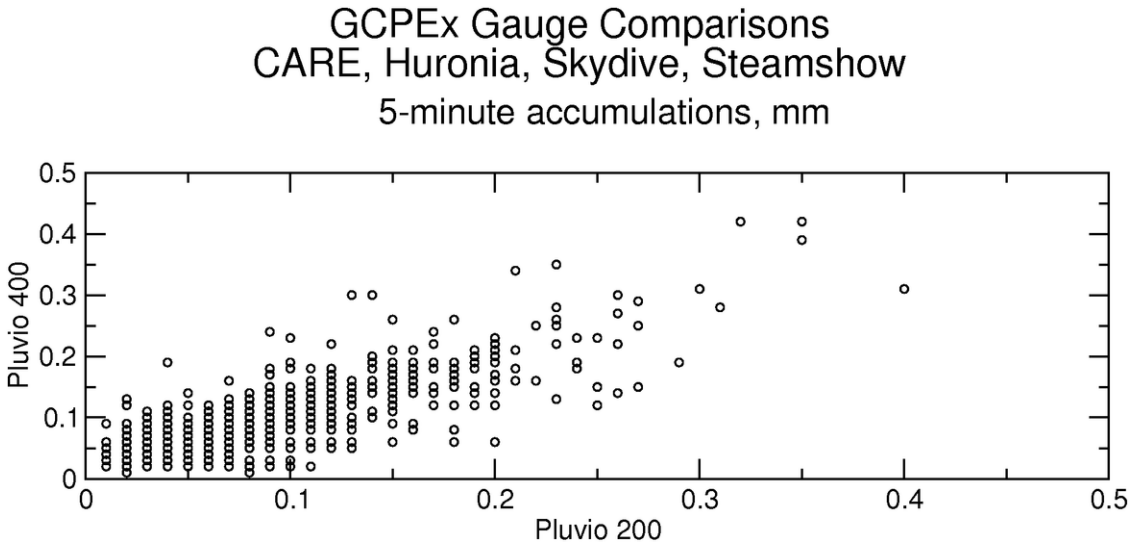
Micro Rain Radars (24 GHz)



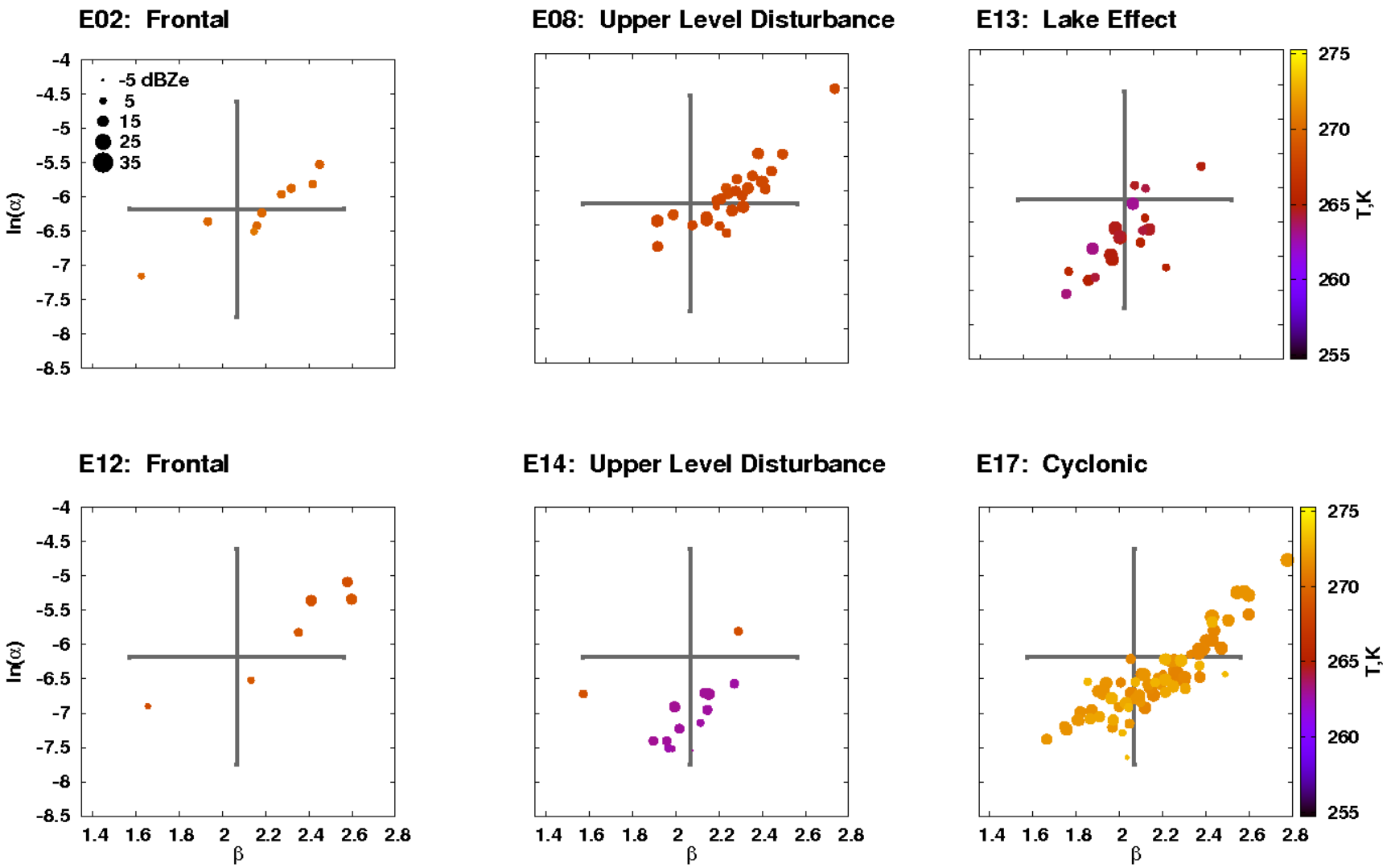
after compensation:



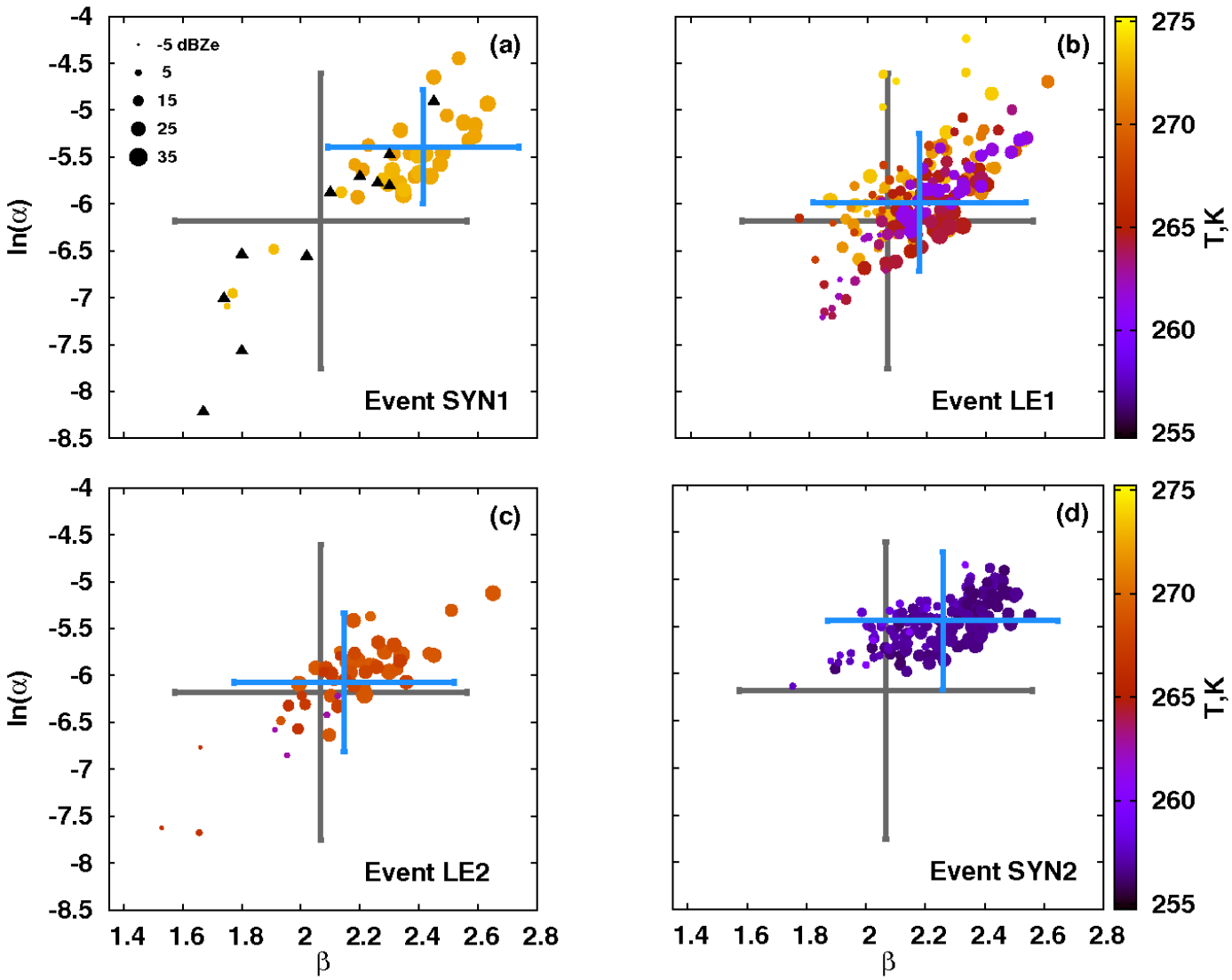
Precipitation gauges



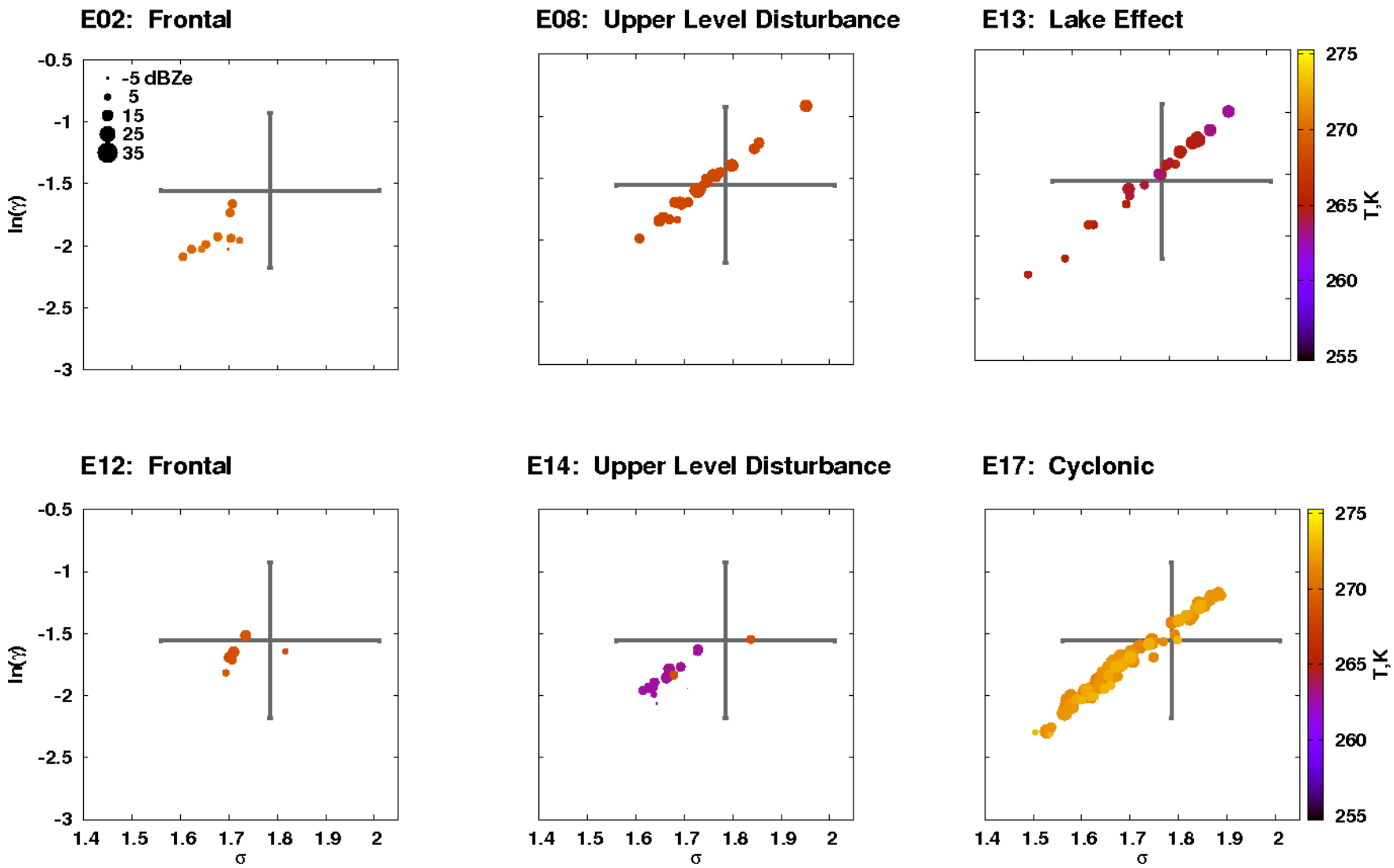
Mass from **GCPEx** CARE



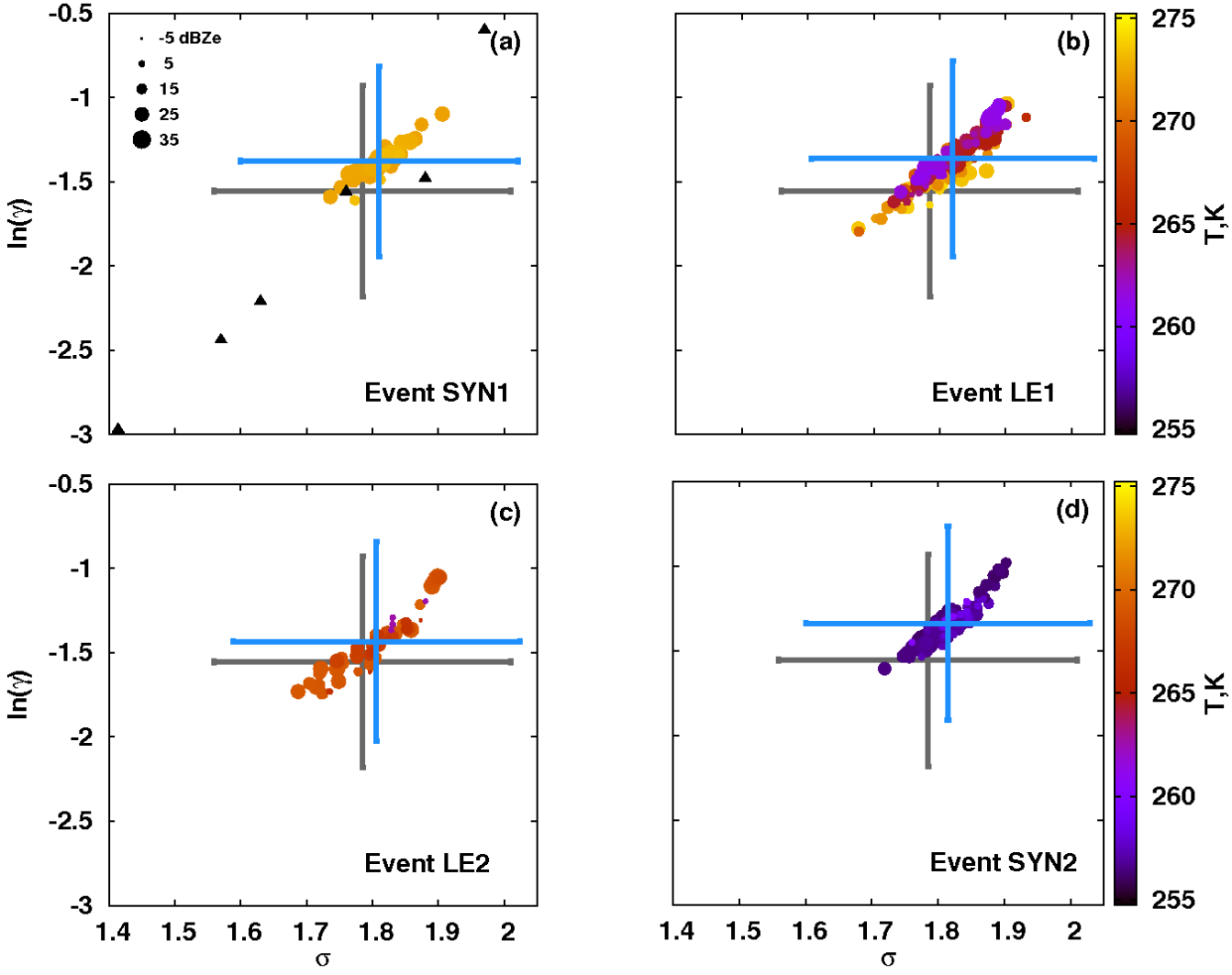
Mass from **C3VP** CARE



Area from GCPEx CARE



Area from **C3VP** CARE



Summary and Plans

Summary:

- PSD changes across the blind zone may be a significant source of uncertainty for surface snowfall estimates.
- We haven't yet quantified m(D) and A(D) changes across the blind zone.
- At the surface, m(D) and to a less pronounced degree A(D) show event-to-event variations.
- It's not yet clear how the across-blind zone differences in PSD, m(D) and A(D) could be diagnosed, e. g., from remote sensing observations and ancillary data.

Plans:

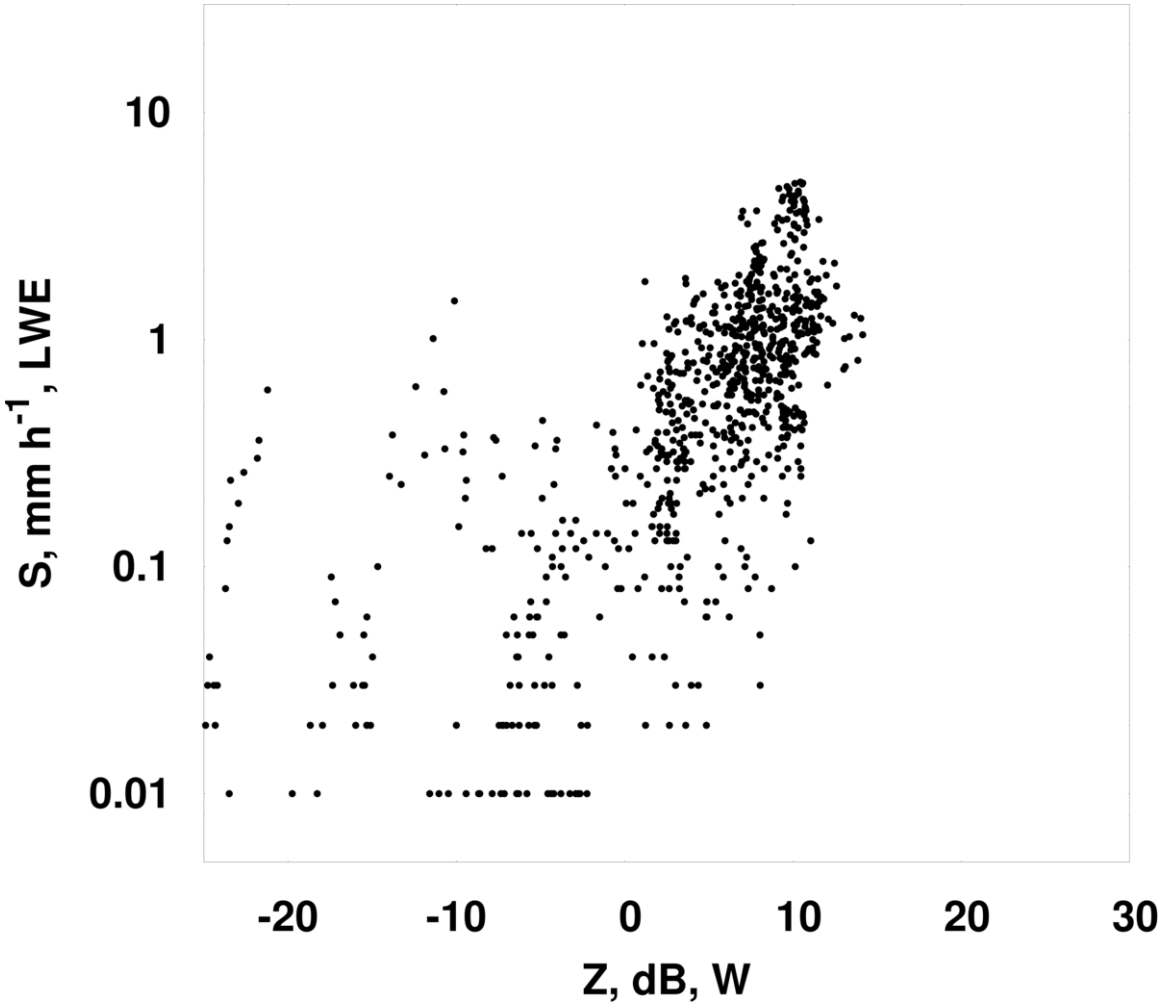
- Extend m(D), A(D) retrieval to other sites (within GCPEx, LPVEx and possibly other similarly instrumented experiments). Assess coincident m(D) and A(D) aloft where available to evaluate m(D) and A(D) changes across the blind zone.
- Attempt to relate PSD behavior across the blind zone to other diagnostics (e.g.,radar observables, ancillary meteorological or reanalysis data). More samples needed (LPVEx, OLYMPEx...)

What drives Z-S variability?

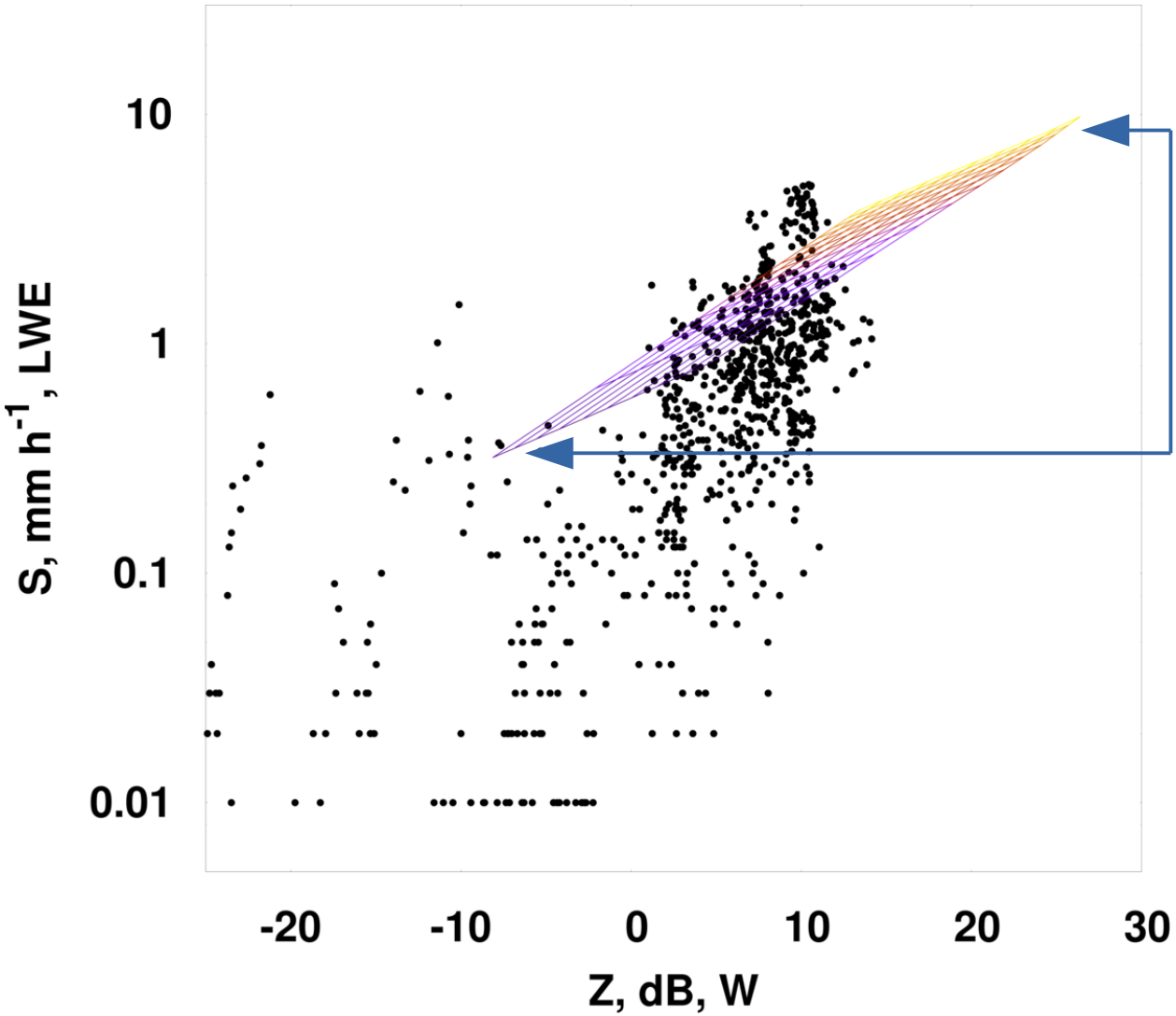
- PSD
- Particle properties:
  - mass
  - shape
  - mass and shape together control:
    - backscatter x-section
    - fallspeed

Which are most significant?

Observations of Z and S from C3VP



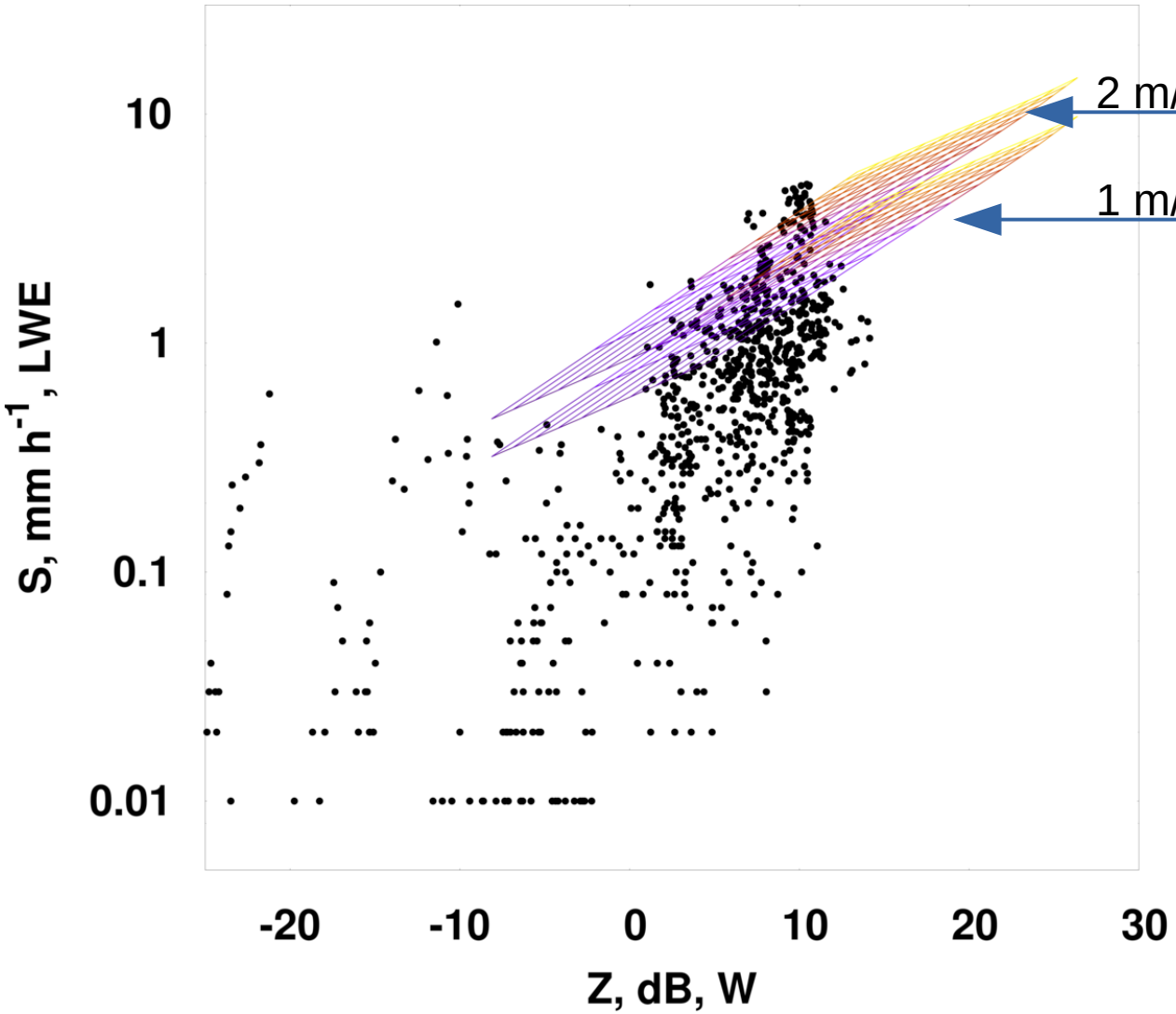
Mass, PSD and fallspeed effects on Z-S



Variations in m(D) for fixed PSD (broad), fallspeed (~ 1 m/s), and shape (spheroidal)

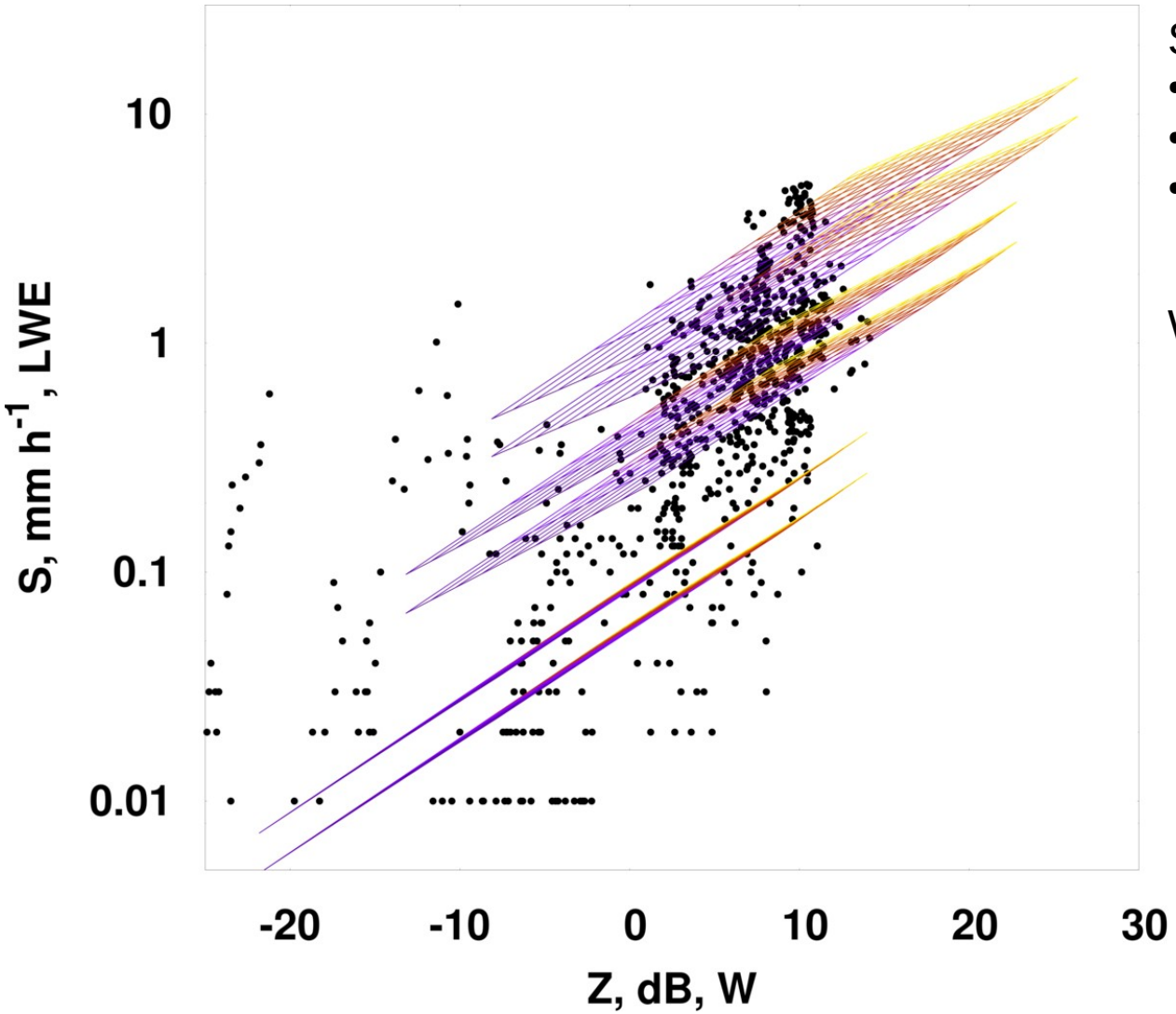
- $m(D) = aD^b$
- The colored grid shows variations in *a* and *b*

Mass, PSD and fallspeed effects on Z-S



Variations in fallspeed with fixed PSD and shape

Mass, PSD and fallspeed effects on Z-S

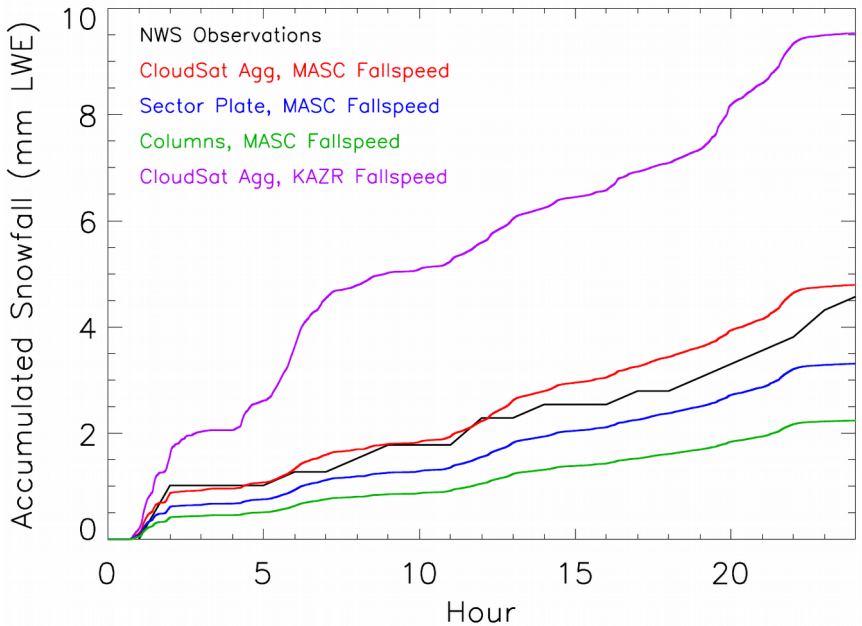


Sources of Z-S variation:

- PSD is primary
- Mass, i.e. m(D), is secondary
- Fallspeed is tertiary

What about shape?

Shape effects



(S. Cooper)

Different shapes, same m(D) and V(D): Pure shape variations (<u>independent of mass</u>) affect retrieval results non-negligibly, but have less effect on Z-S than PSD and mass.