Inference of dominating snow growth processes from radar observations; Aggregation

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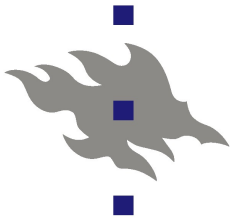
Our goal is to identify signatures characteristic to growth processes and NOT to attempt to classify hydrometeors



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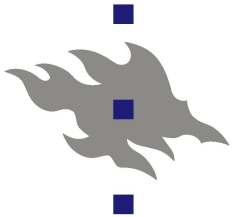
Radar signatures in snowfall

- ✓ Hogan et al. (2003) have shown that high Zdr values are often associated with presence of SLW
- ✓ Kennedy et al. (2009, 2011) and Bechini et al. (2011) – reported increased Kdp bands in snowfall and linking those to potentially enhanced snowfall below
- ✓ Andric et al. (2009) and Moisseev et al. (2009) – Zdr bands coinciding maximum reflectivity gradients and their link to snow growth mechanisms
- ✓ Surcel and Zawadzki (2010) – observed negative velocity gradient coinciding with maximum reflectivity gradient



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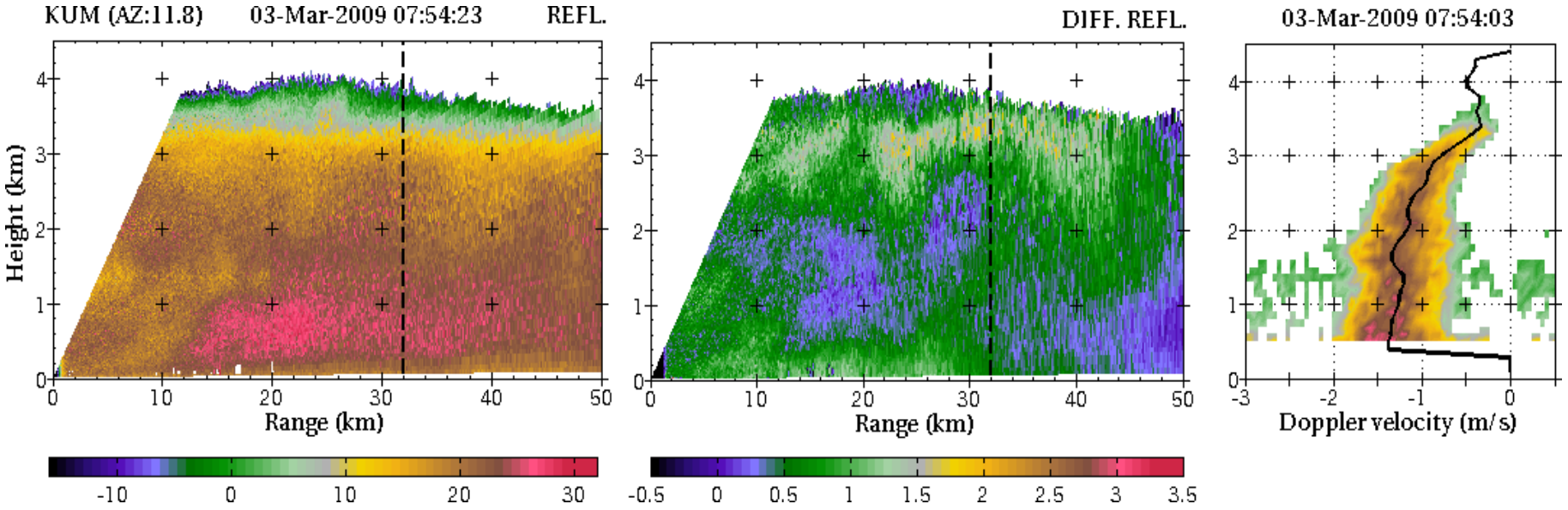
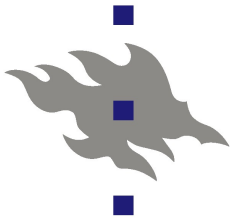
Link between dual-polarization and Doppler radar observations



It appears that dual-pol and Doppler observations are representing the same growth process (es)



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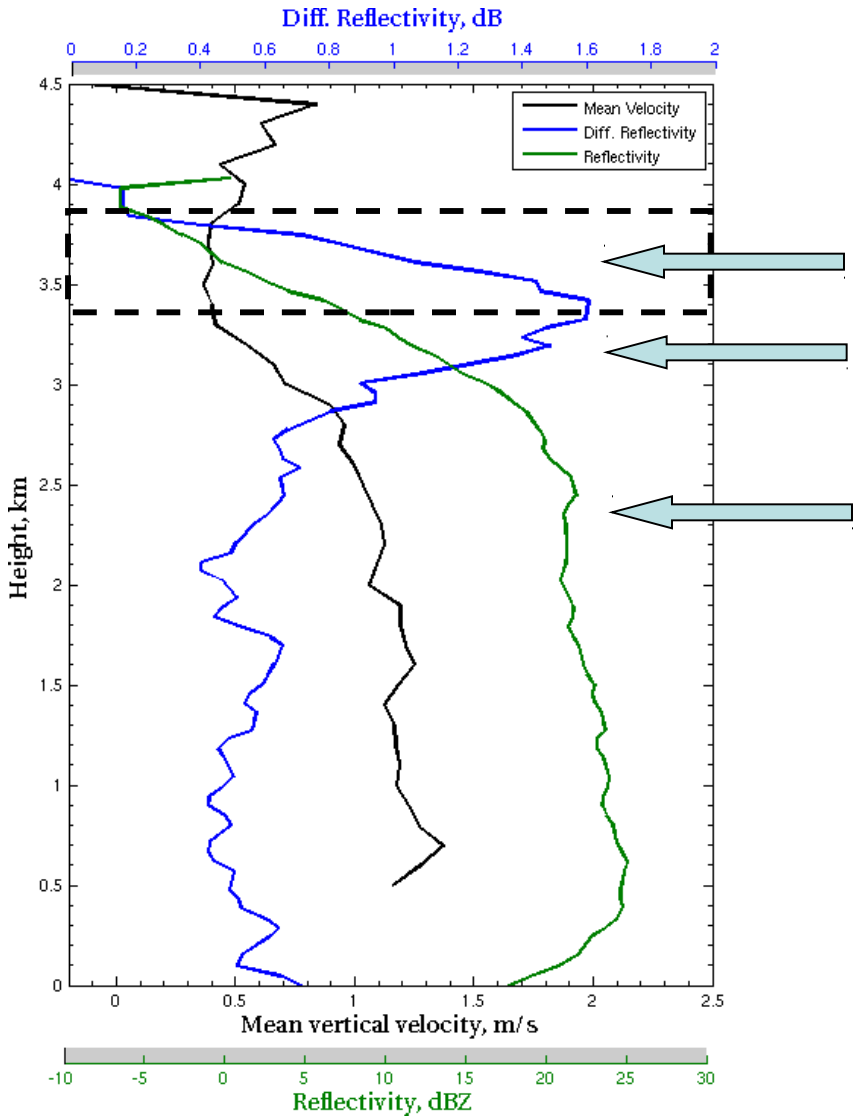

Vapor deposition growth

Onset of aggregation

Aggregates

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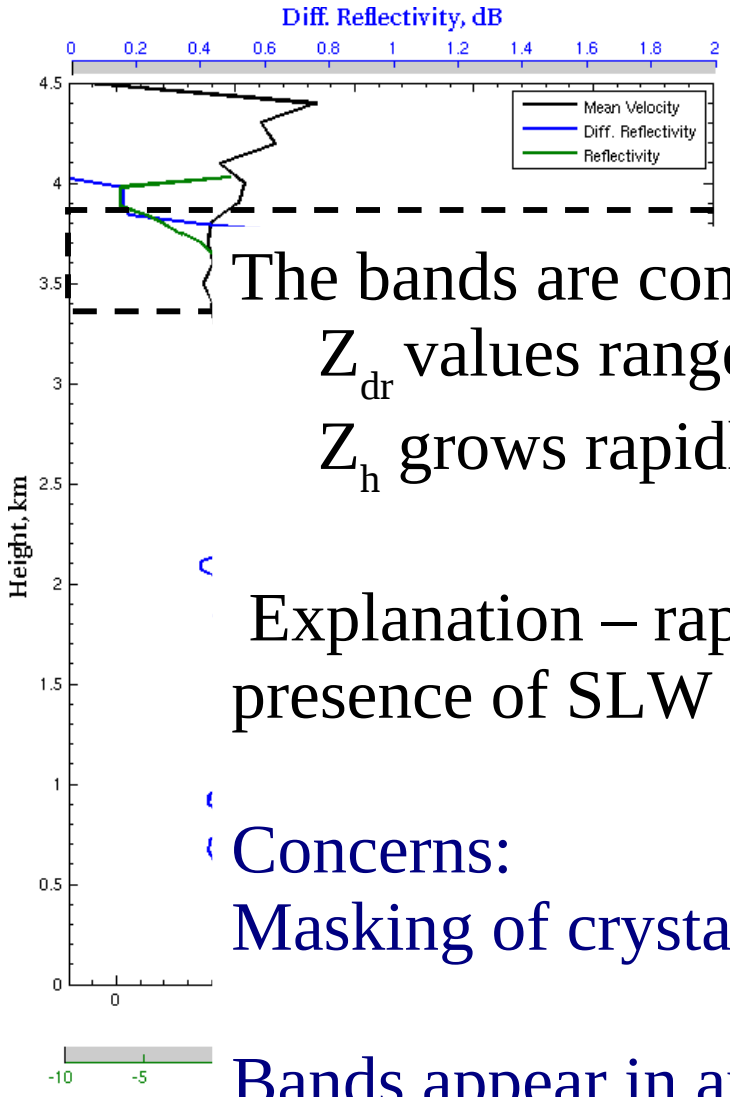


The bands are commonly observed:

Z_{dr} values range from 1 to 8 dB

Z_h grows rapidly just below bands

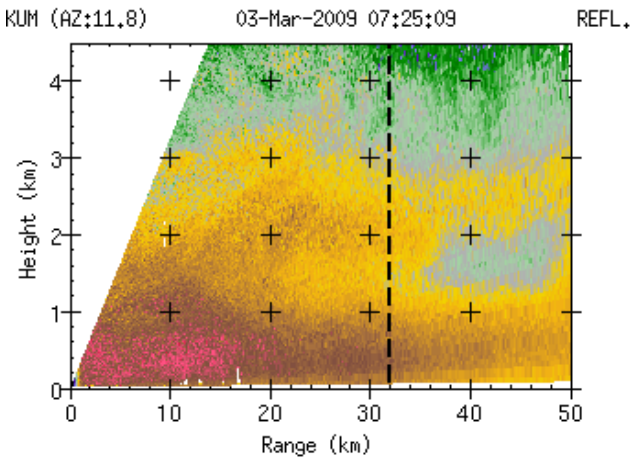
Explanation – rapid vapor deposition growth in presence of SLW succeeded by aggregation

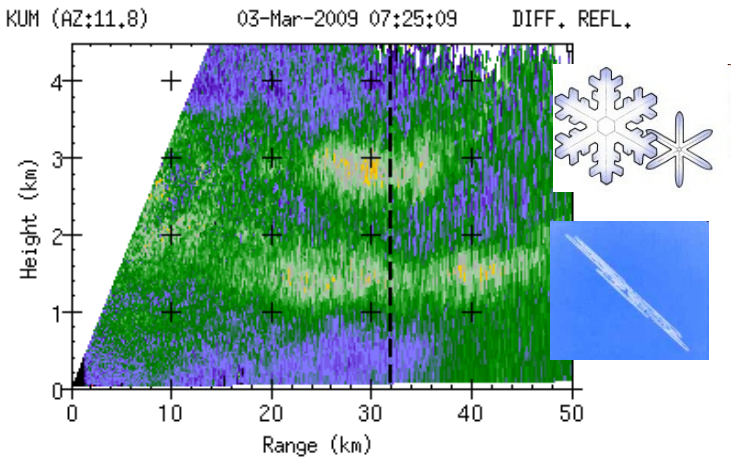
Concerns:

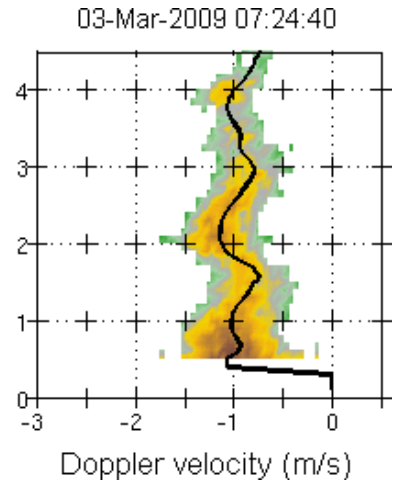
Masking of crystals by few aggregates

Bands appear in areas with a relatively low reflectivity (measurement error?)

Dual-pol and Doppler patterns are resilient







High Zdr bands show areas where dendritic and needle type ice crystals are growing.
Increase in reflectivity just below those bands indicate aggregation of those crystals.

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Light Precipitation Validation Experiment

IOP: Sept 15 -Oct 20, 2010
EOP: Oct 20 – Jan 12, 2011

Dmitri Moisseev
Univ. of Helsinki

Tristan L'Ecuyer
CSU

Walt Petersen
NASA-MSFC

"Kumpula OPS"

V. Bringi, C. Kidd
L. Carey, D. Hudak
B. Dolan, A. Tokay,
L. Baldini, S. Lim,
Chandra, S. Rutledge,
A. Battaglia

"Uniform Whiskey"

M. Lebsock, N. Wood,
A. Heymsfield, J. French,
L Oolman, B. Wadsworth,
T. Drew

Field

M. Kurri, M. Wingo,
P. Gatlin, P. Rodriguez,
J. Leinonen, T. Lauri,
L. Leponiemi, A. Aarva,
T. Posio, L. Latva,
J. Poutiainen, P. Bishor,
P. Rossi, A. Makela,
P. Saavedra

Measurement setup – LPVEx EOP

- C-band VPR
- 2x MRR
- Ott Pluvio
- 2D-video
- 2x Parsivel
- PVI
- AWS
- Snow depth

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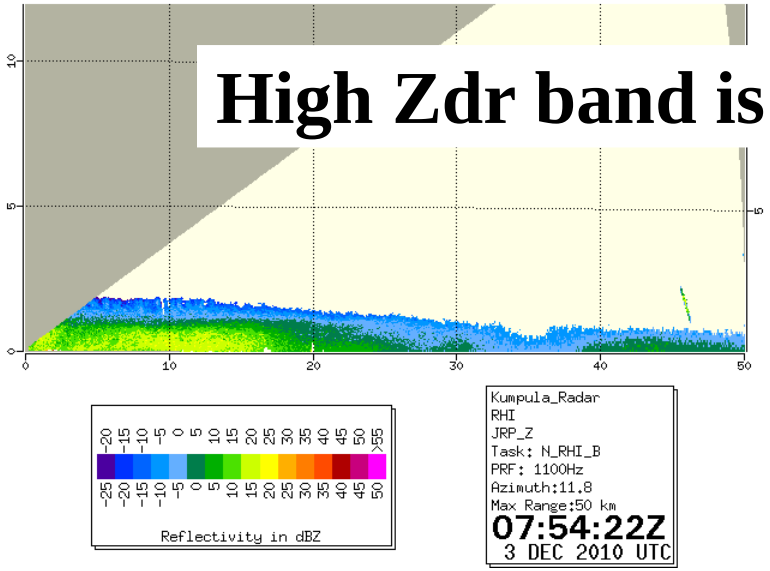
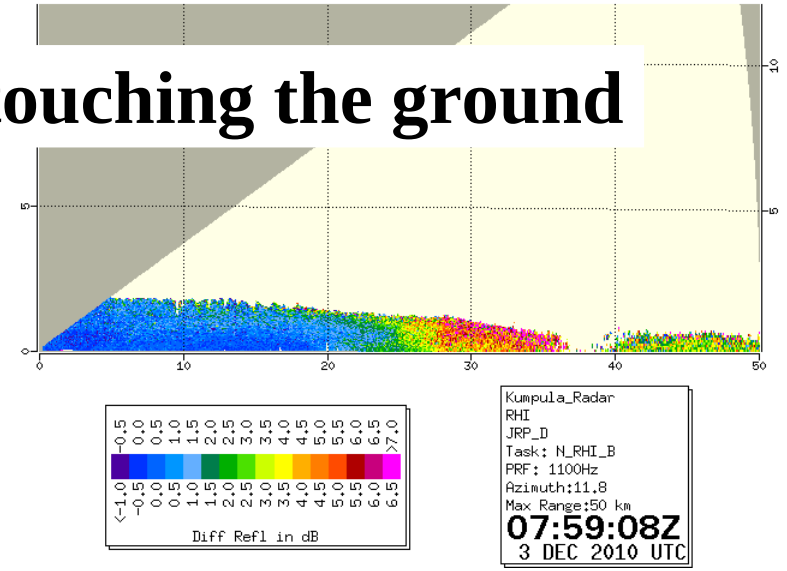
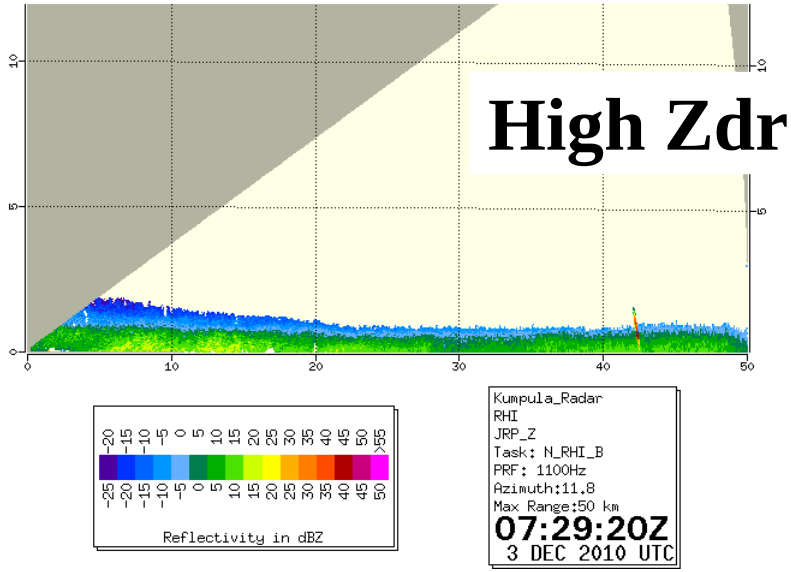
Dec 3, 2011 - Järvenpää

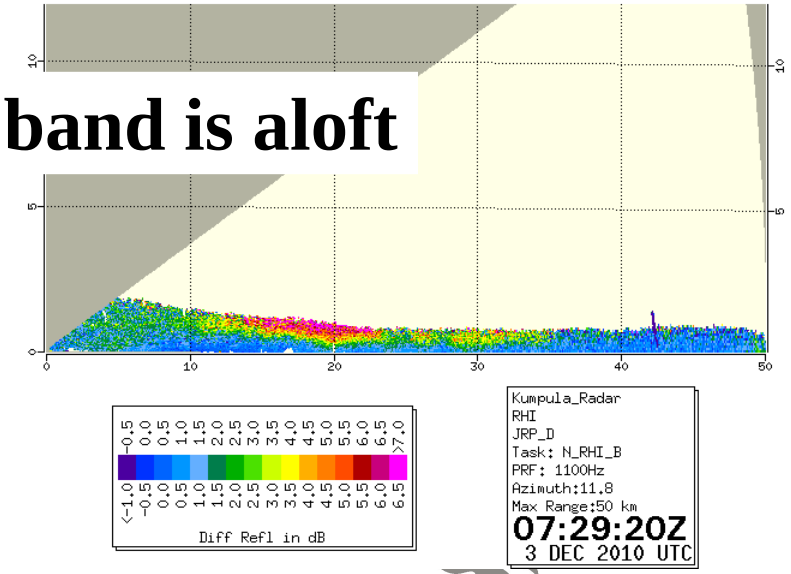


High Zdr band is touching the ground





High Zdr band is aloft



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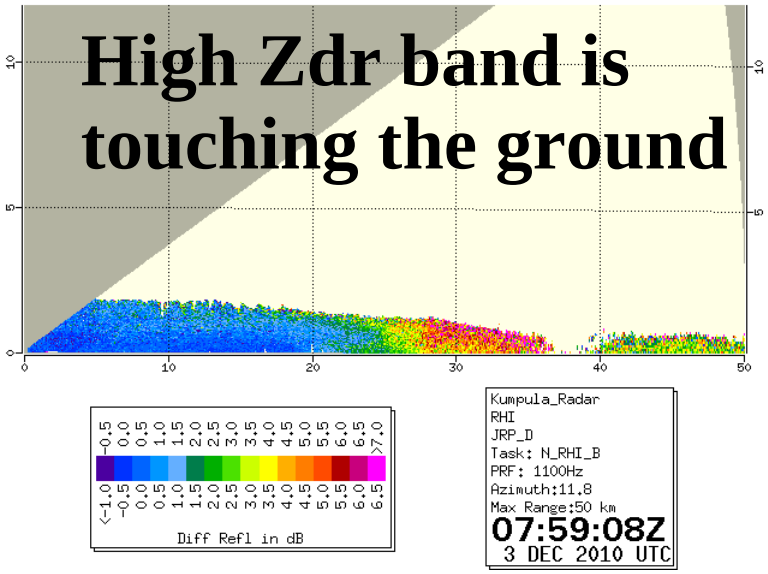

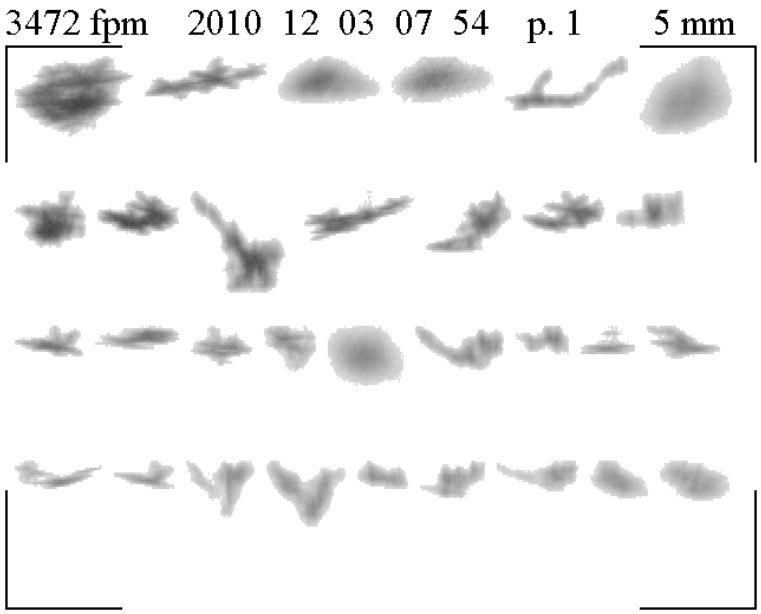

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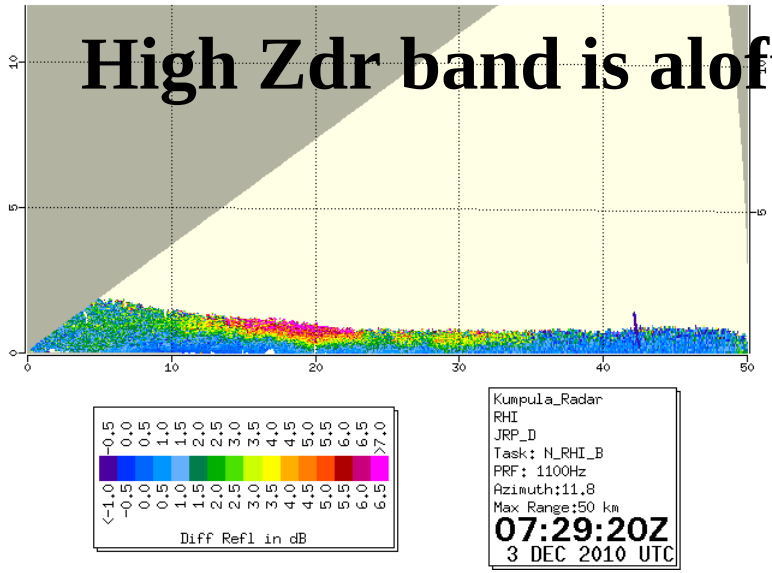

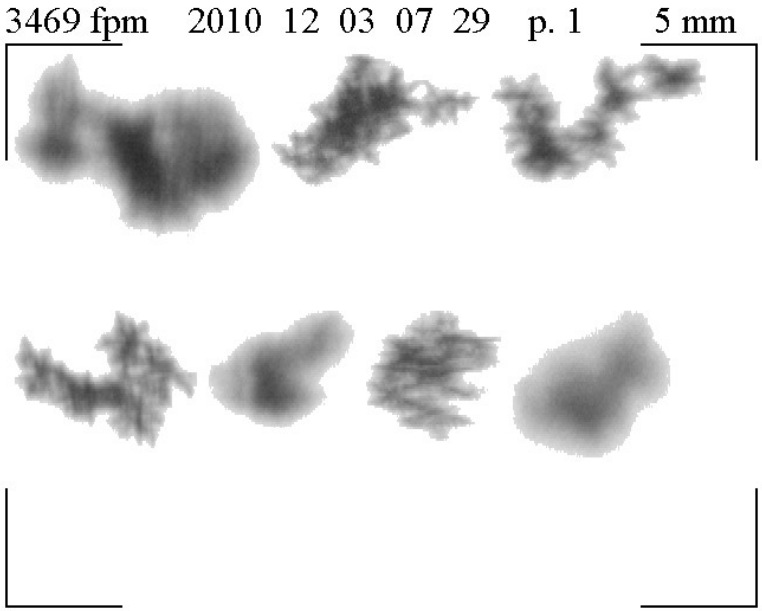

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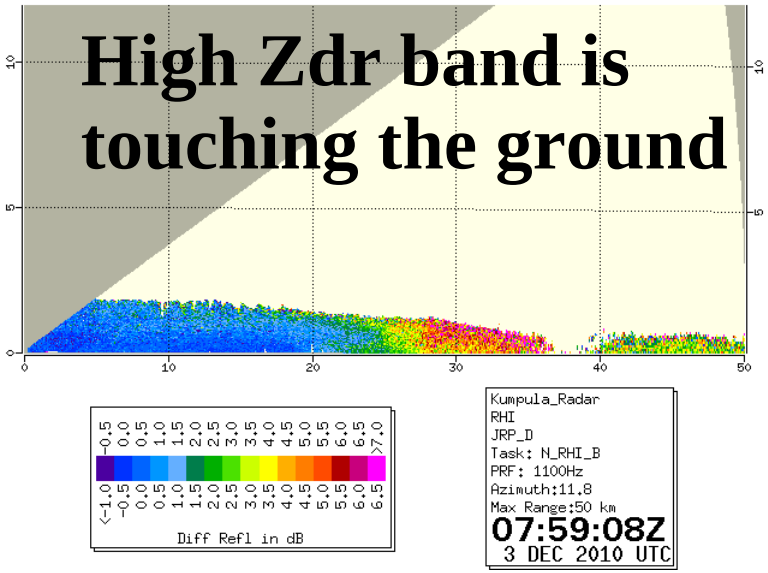

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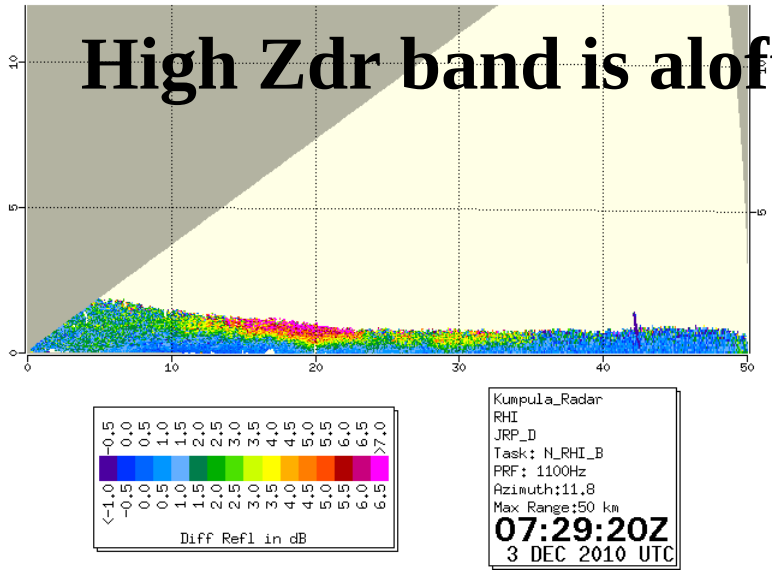
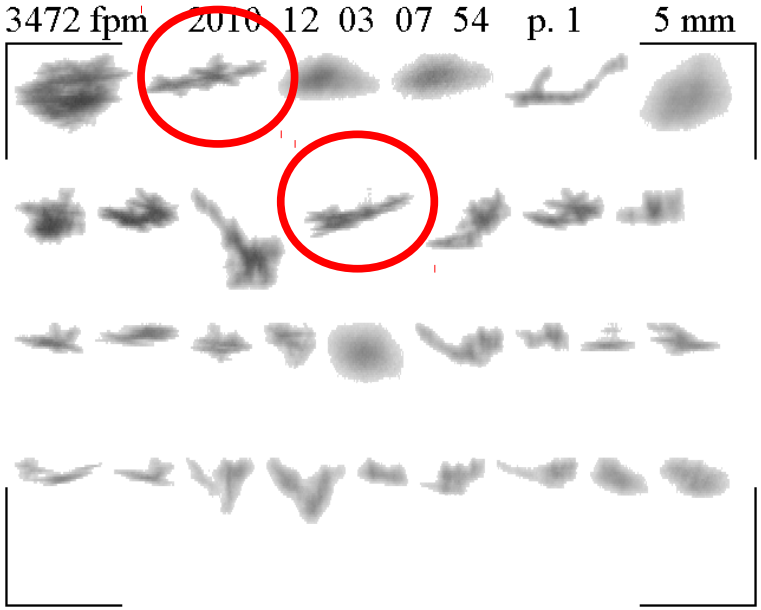
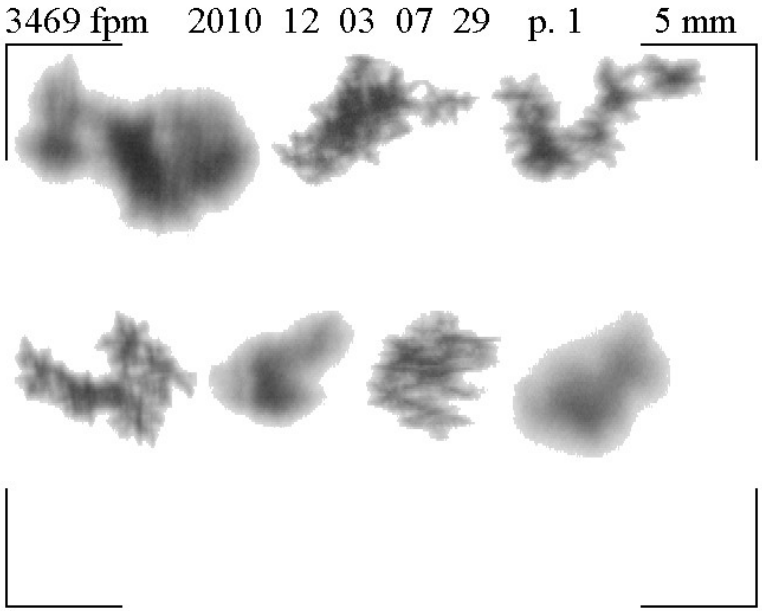
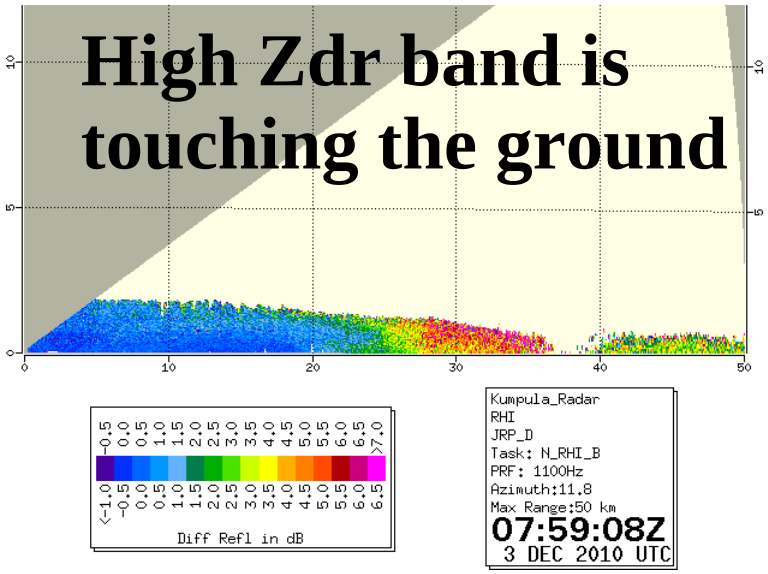
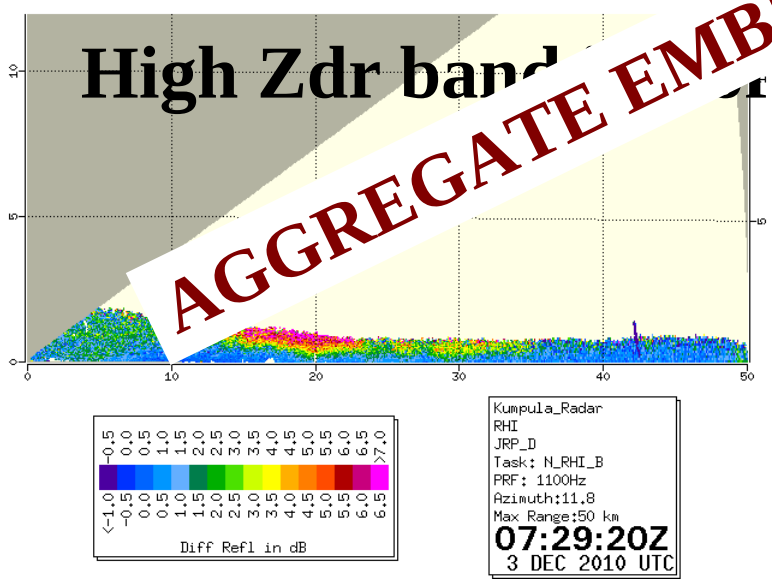
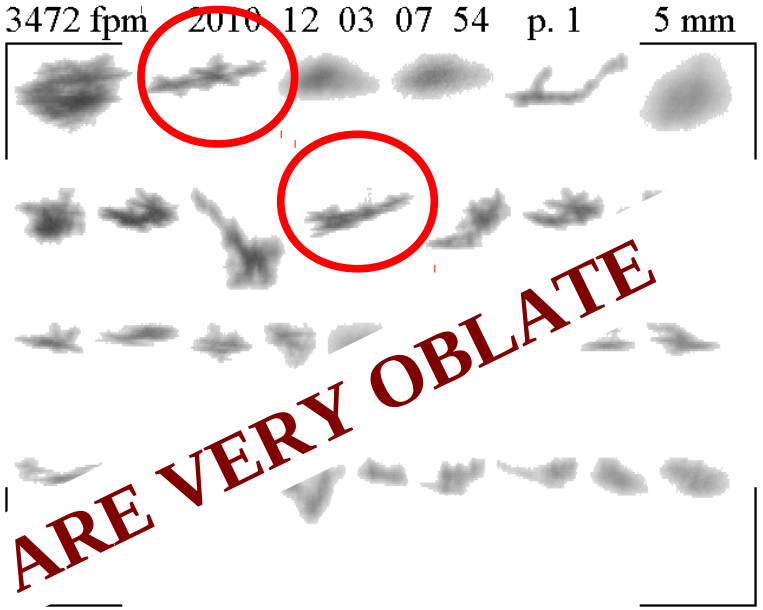


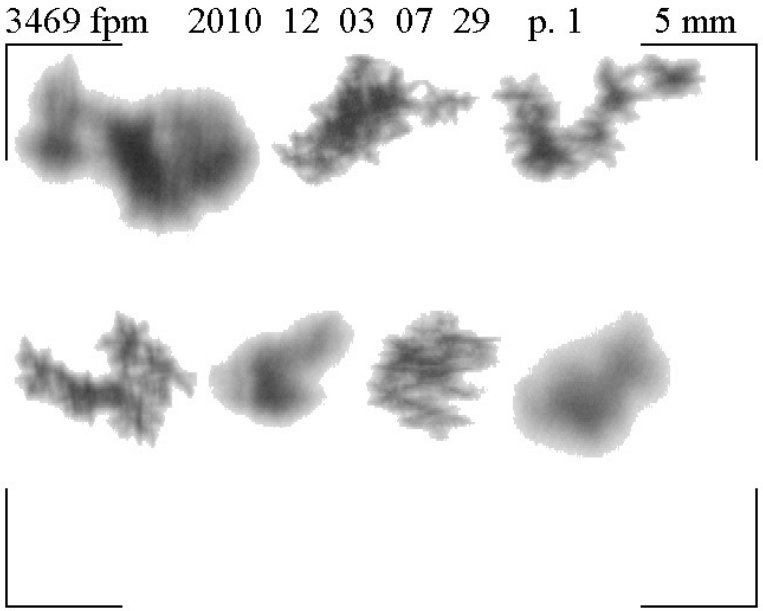






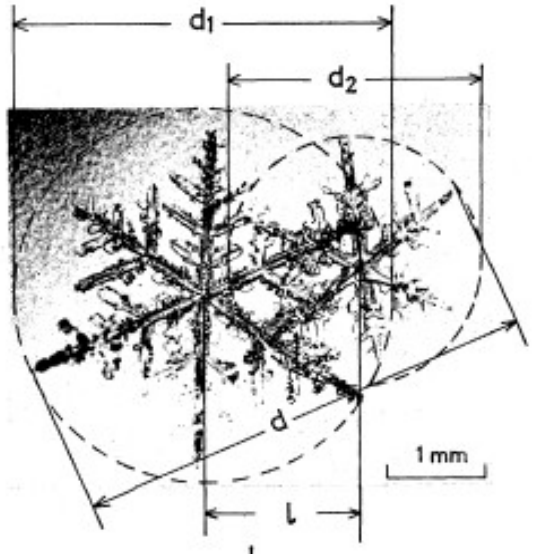




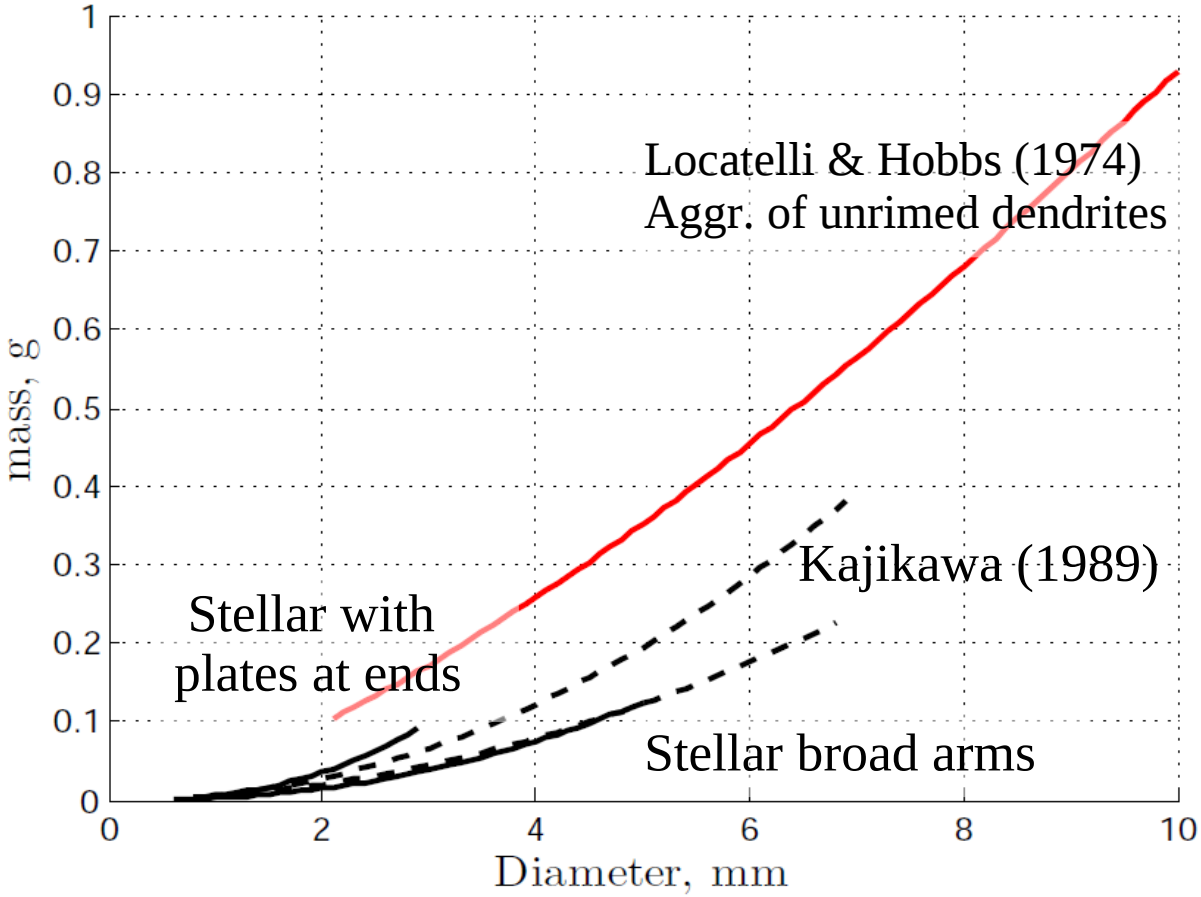


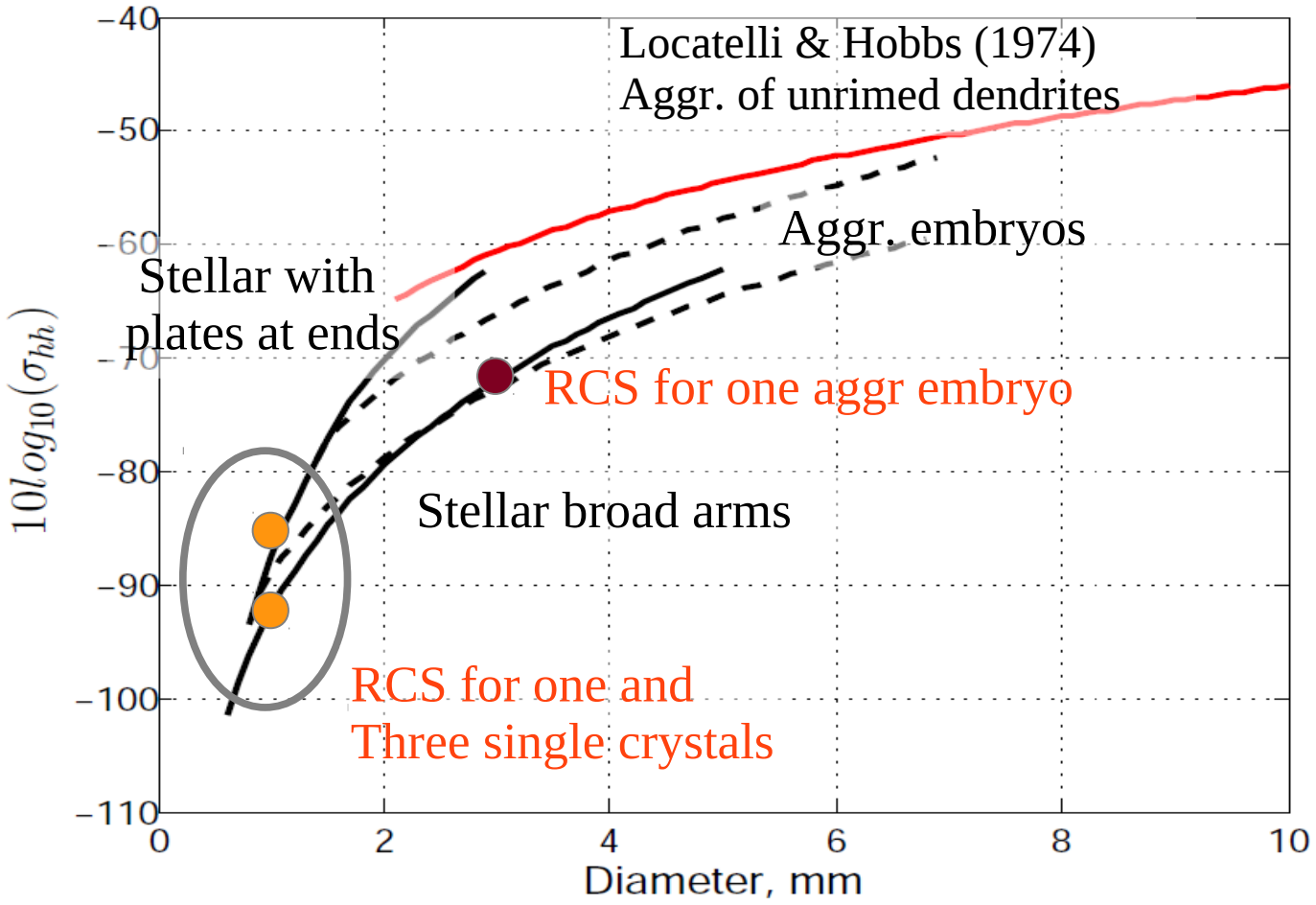
AGGREGATE EMBRIOS ARE VERY OBLATE

Early aggregates - Kajikawa (1982, 1989)



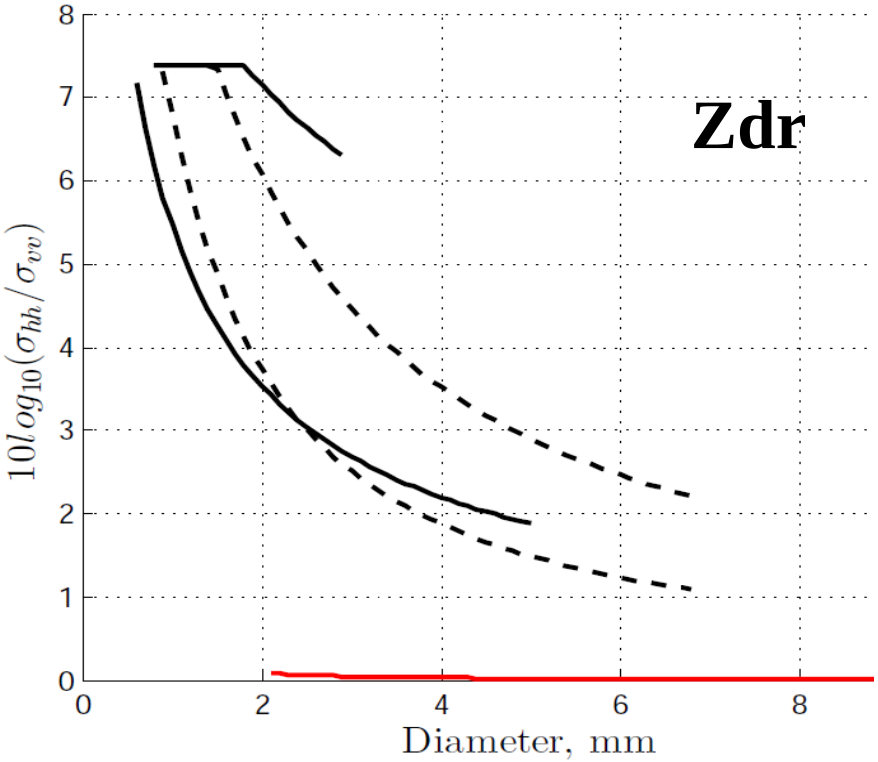
Early aggregate composed of two dendritic crystals

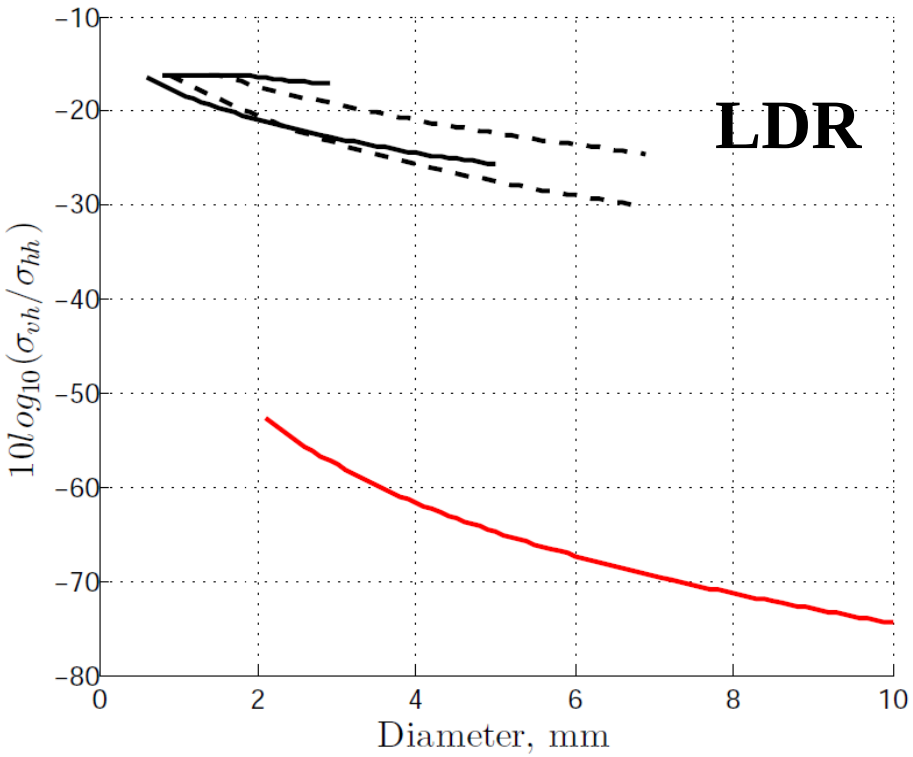




Density is calculated from m(d) assuming b/a = 0.1
RCS is calculated using Rayleigh disc approximation

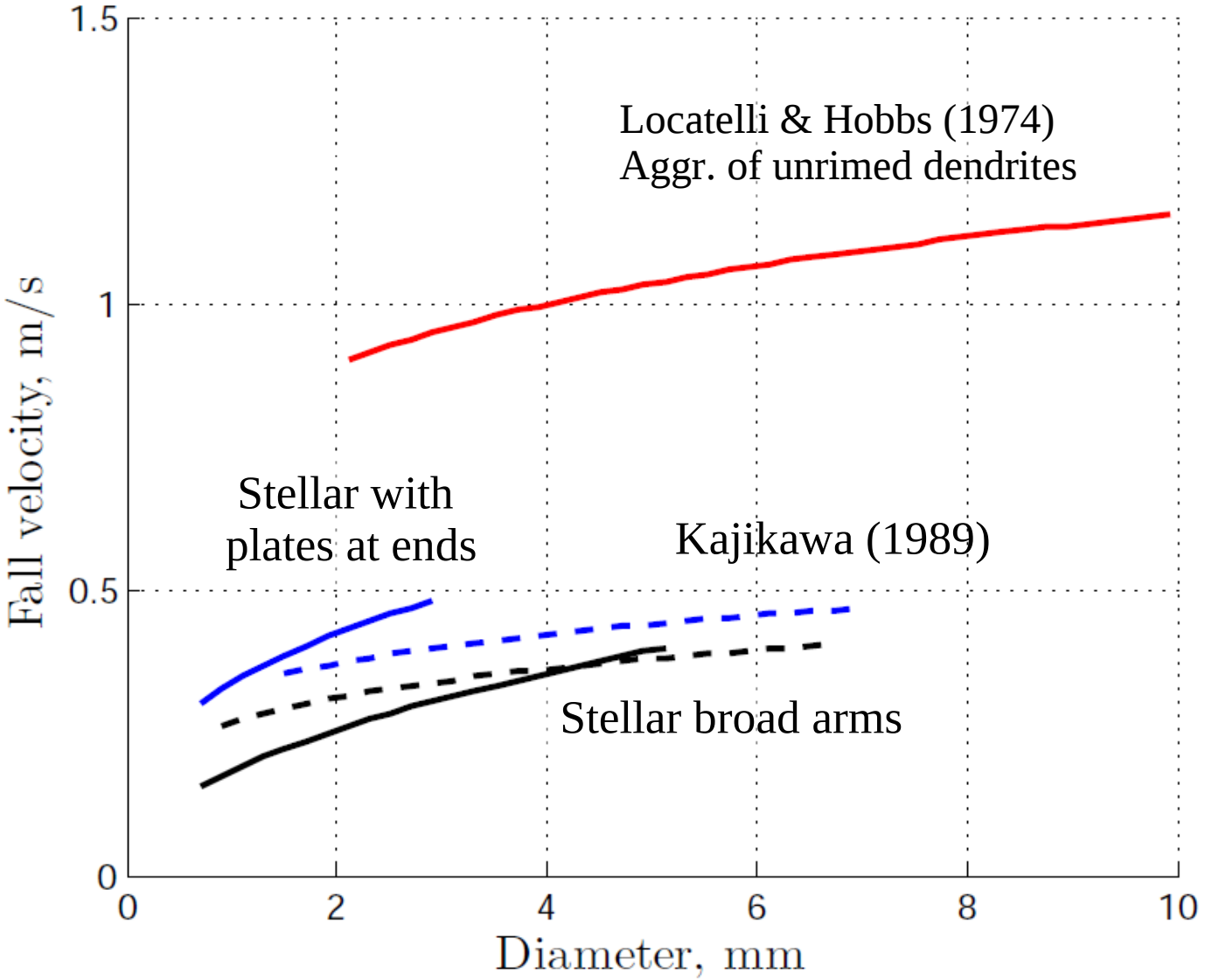
Dual-pol signatures





Almost the same signatures as for crystals

What about Doppler observations?



Conclusions

- ✓ Aggregates are not necessary spheroids with axis ratio 0.6 – 0.8
- ✓ Dual – pol radar signatures can be linked to those particles
- ✓ Doppler signatures can also be explained by presence of those particles
- ✓ Resilience of those signatures is caused by larger RCS of those aggregates

Conclusions

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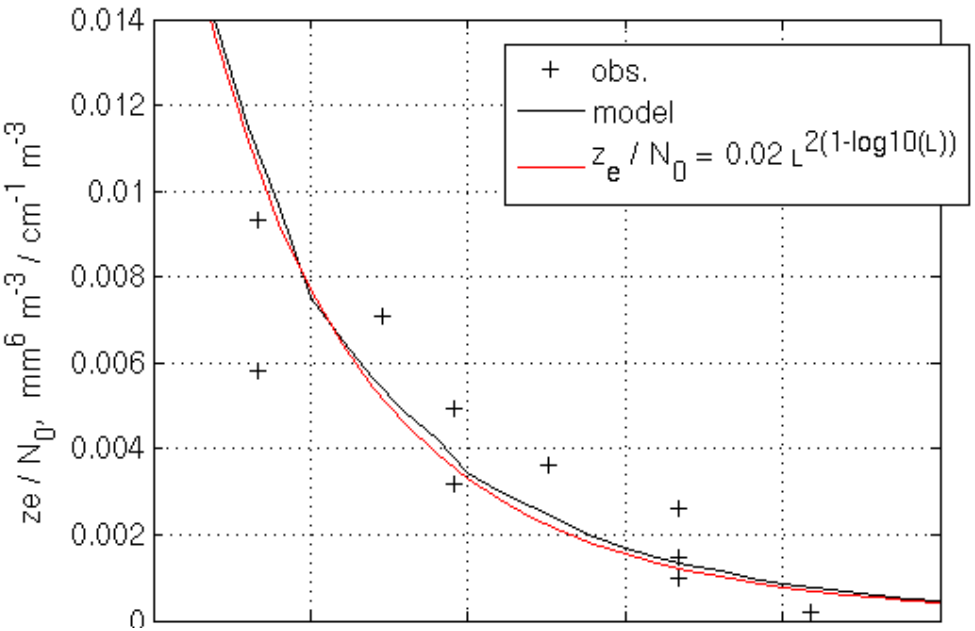
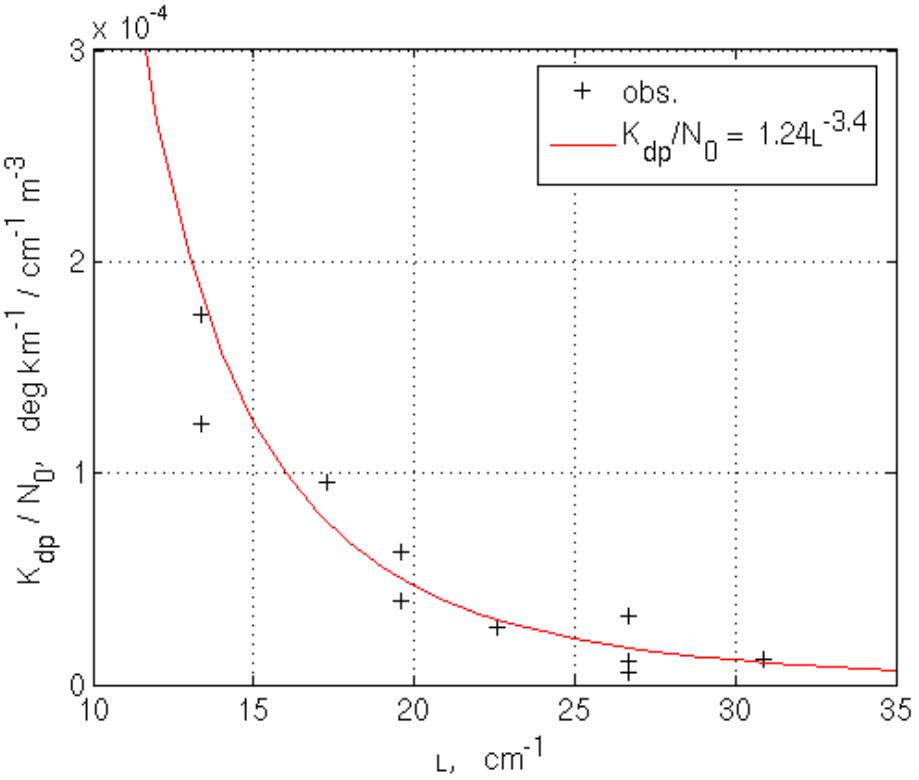
- ✓ Dual – pol radar signatures can be linked to those particles
- ✓ Doppler signatures can also be explained by presence of those particles
- ✓ Resilience of those signatures is caused by larger RCS of those aggregates
- ✓ **Zdr, Kdp are linked to an aggregation stage => Zdr and Kdp can be expressed as f(D0)**

See poster MIC 77 for more details





Kdp appears to be an intrinsic signature of the aggregation process

Therefore Kdp an Ze based estimation of snow PSD could actually make a lot of sense !!!

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