INVESTIGATING KDP SIGNATURES INSIDE AND BELOW THE DENDRITIC GROWTH LAYER WITH W-BAND DOPPLER RADAR AND IN SITU SNOWFALL CAMERA

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THE CORSIPP CAMPAIGN JOINED SAIL & SPLASH IN THE ROCKY MOUNTAINS (NOV 15, 2022 – JUNE 6, 2023)

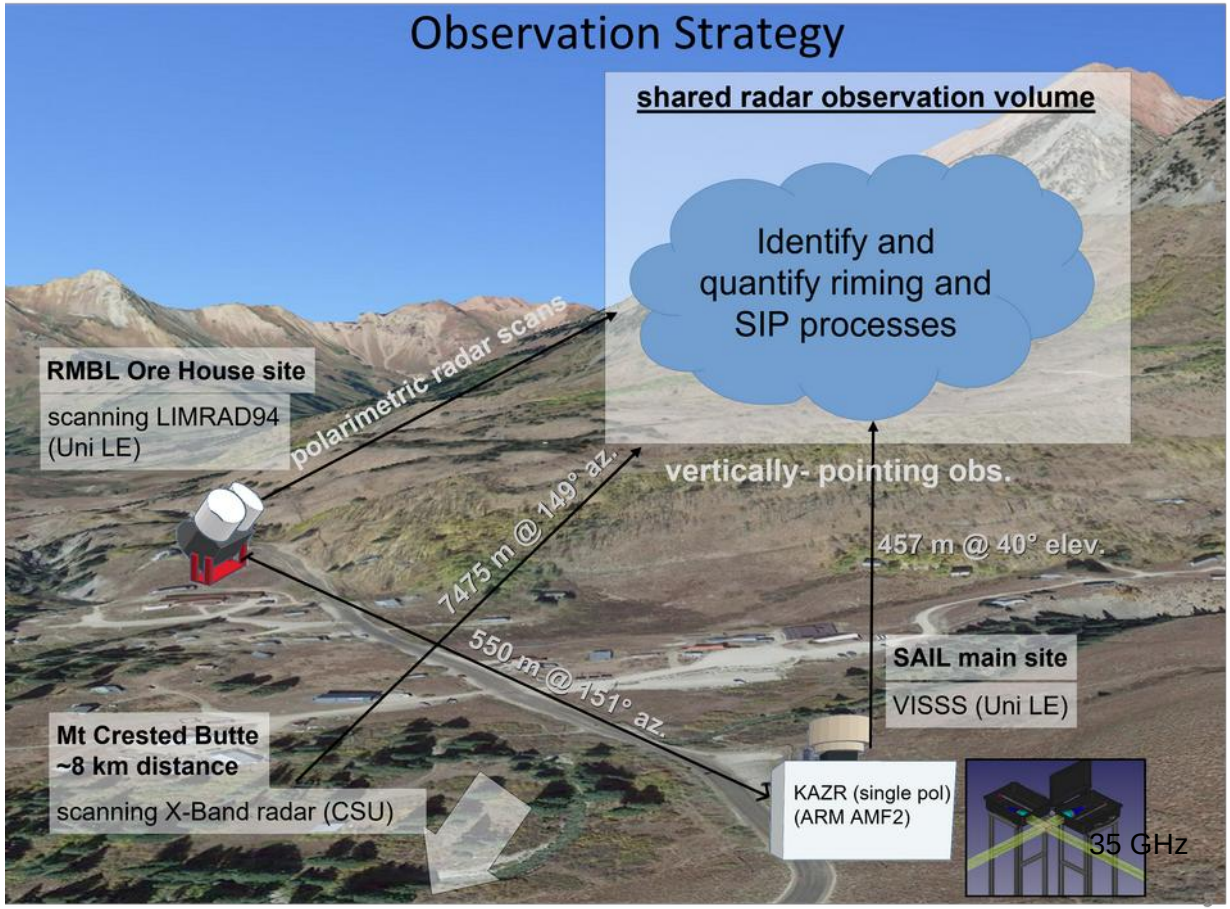
94 GHz W-Band Cloud Radar LIMRAD94

Source: Ben Schmatz

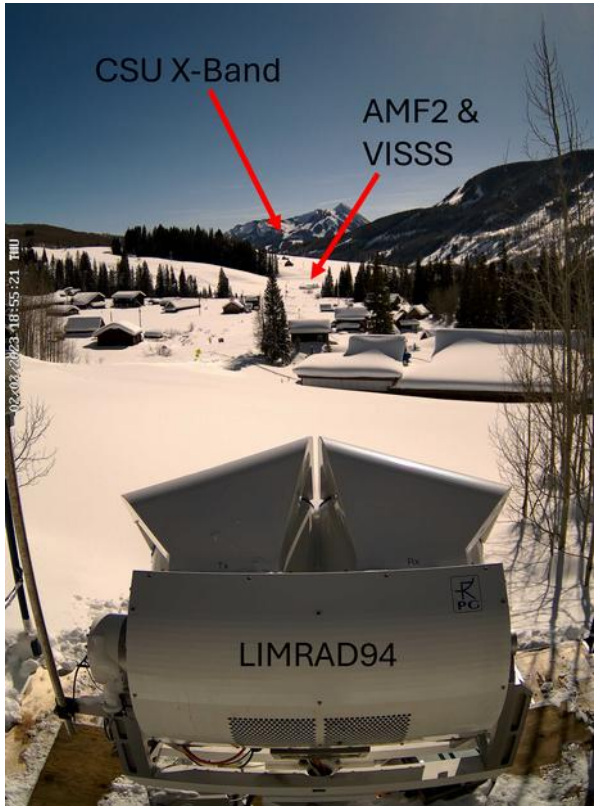
In-Situ Snowfall Camera VISSS

Source: Isabelle Steinke

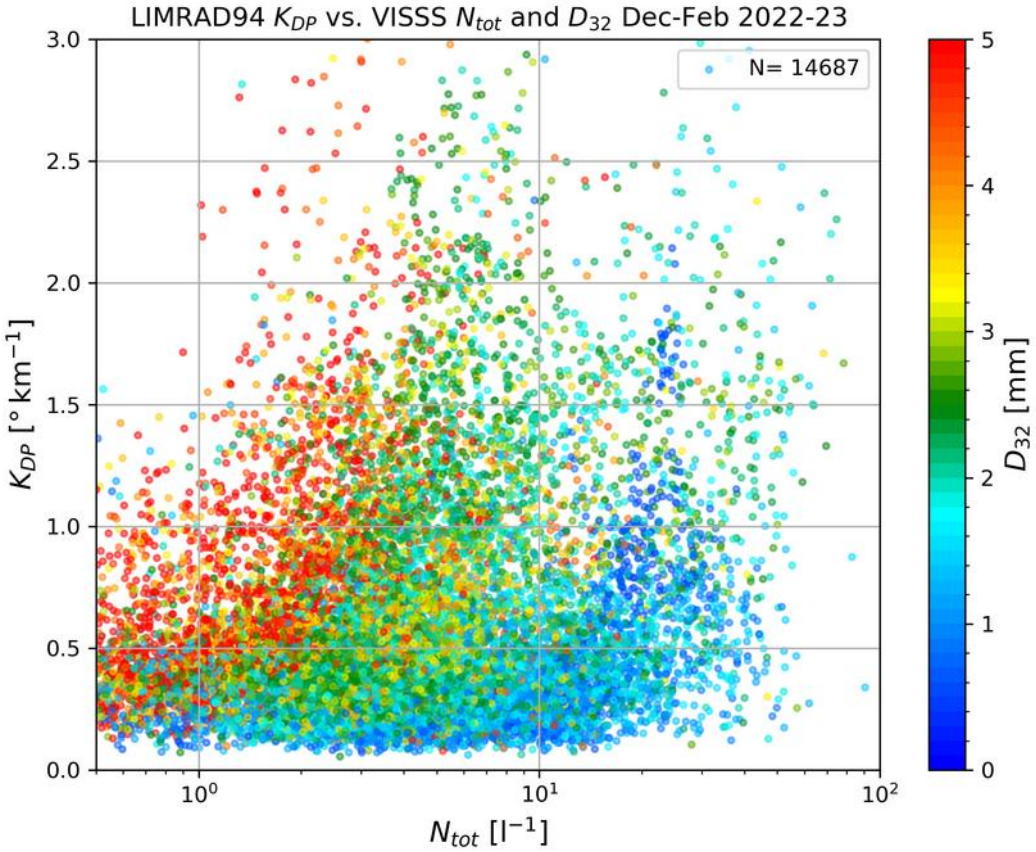
Leipzig University team: Heike Kalesse-Los (PI), Maximilian Maahn (PI), Veronika Ettrichrätz (Postdoc), Anton Kötsche (PhD Student)



AMF2 and CSU X-Band deployed during ARM SAIL / NOAA SPLASH campaign

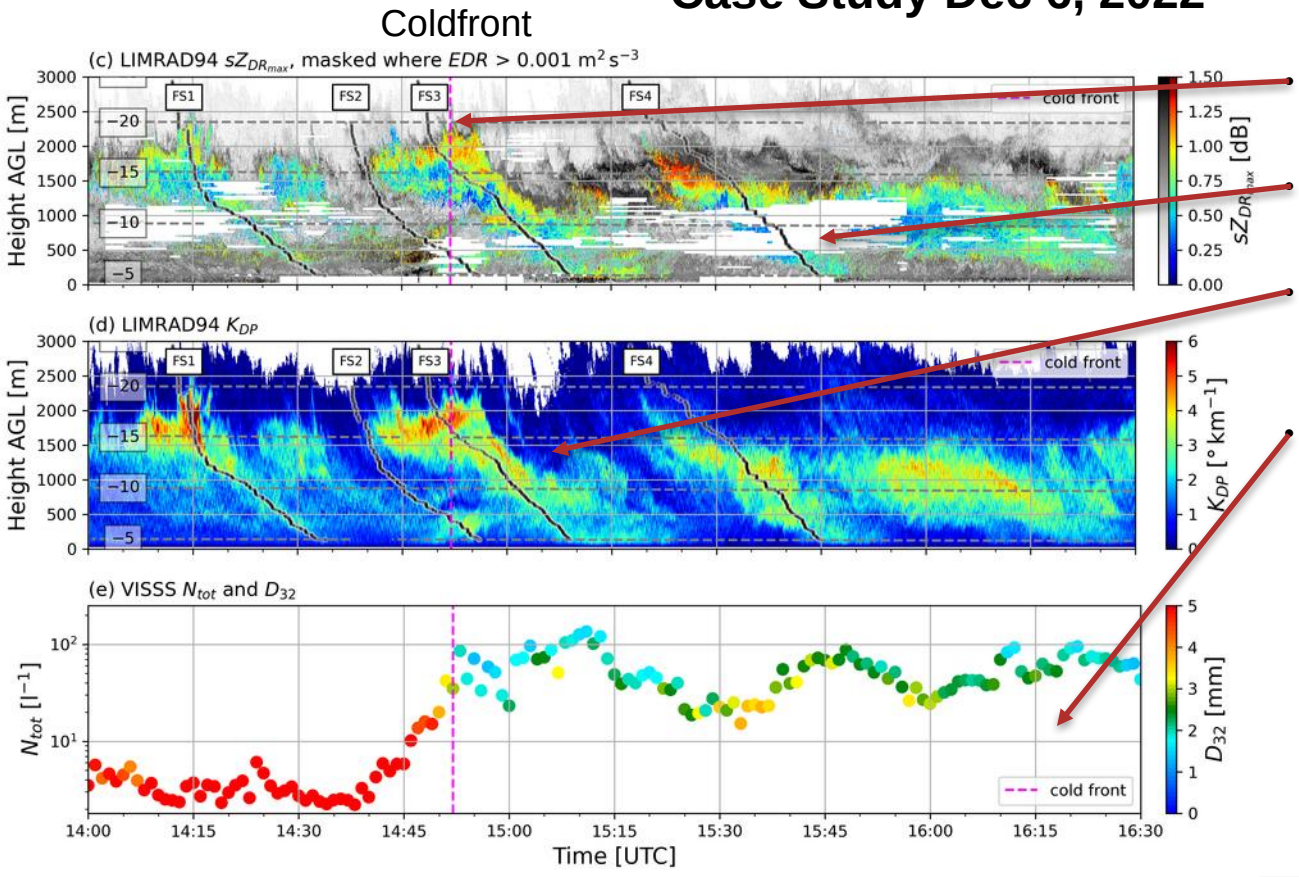


WHICH PARTICLE SIZES ARE RELATED TO KDP SIGNATURES?



- LIMRAD94 KDP spatially averaged (median) between 100 and 500 m AGL (52 range gates)
- LIMRAD94 KDP temporally averaged (median) to fit the VISSS time resolution of one minute.
- Colors are “effective” diameter (D32) = ratio between 3rd and 2nd moment of PSD
- **Different Ntot and D32 at ground related to similar KDP**

Case Study Dec 6, 2022



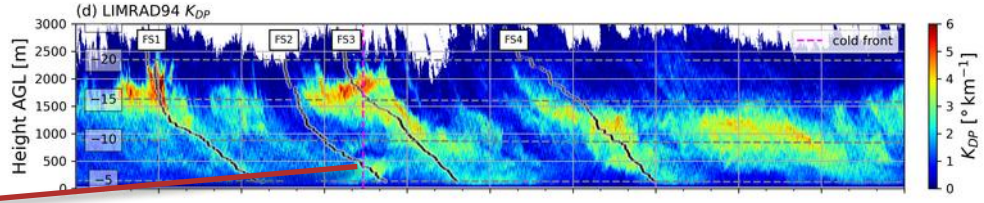
Complex synoptic situation with coldfront passage at 14:55 UTC

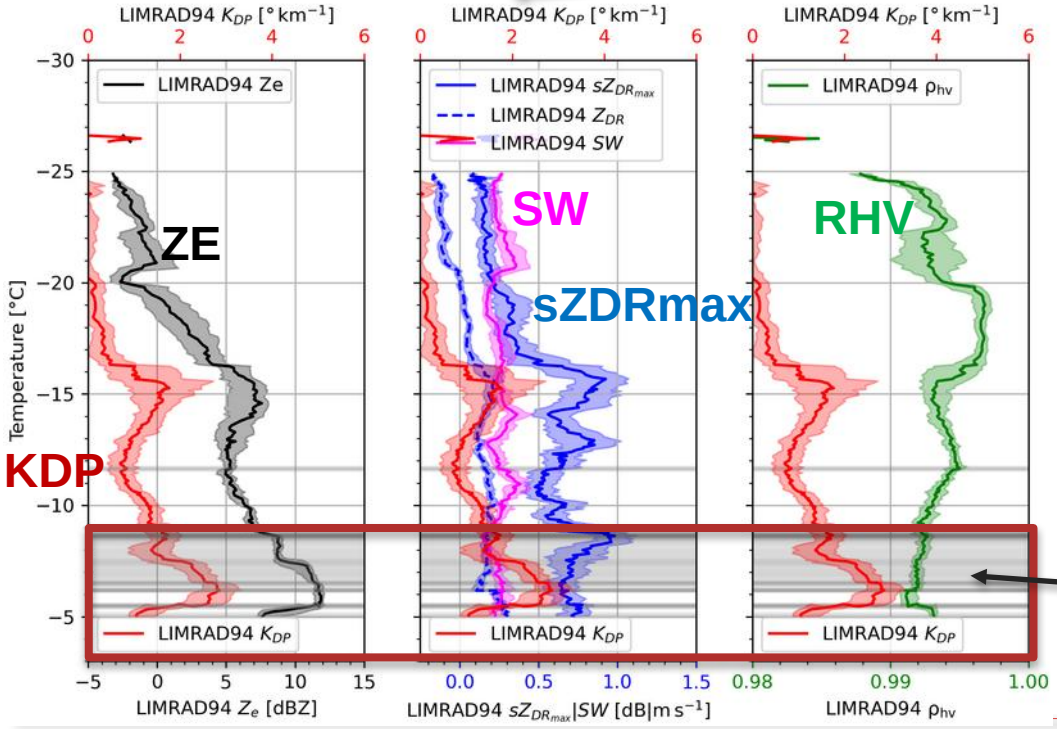
Turbulence along shear layer due to orographic blocking

Multiple fallstreaks with similar KDP values but very different microphysical processes

Strong changes in particle number concentrations and particle sizes before and after the coldfront

Fallstreak during coldfront





KDP - Specific diff. Phase (deg/km)

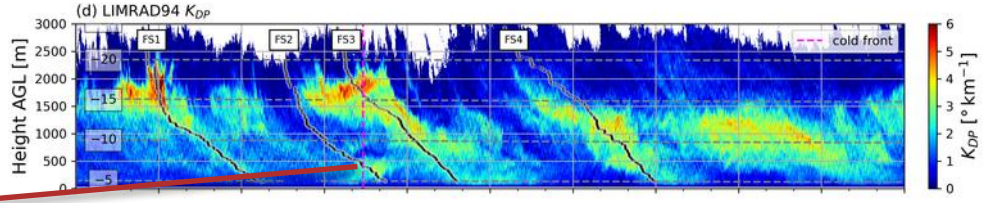
sZDRmax – max ZDR in spectra (dB)

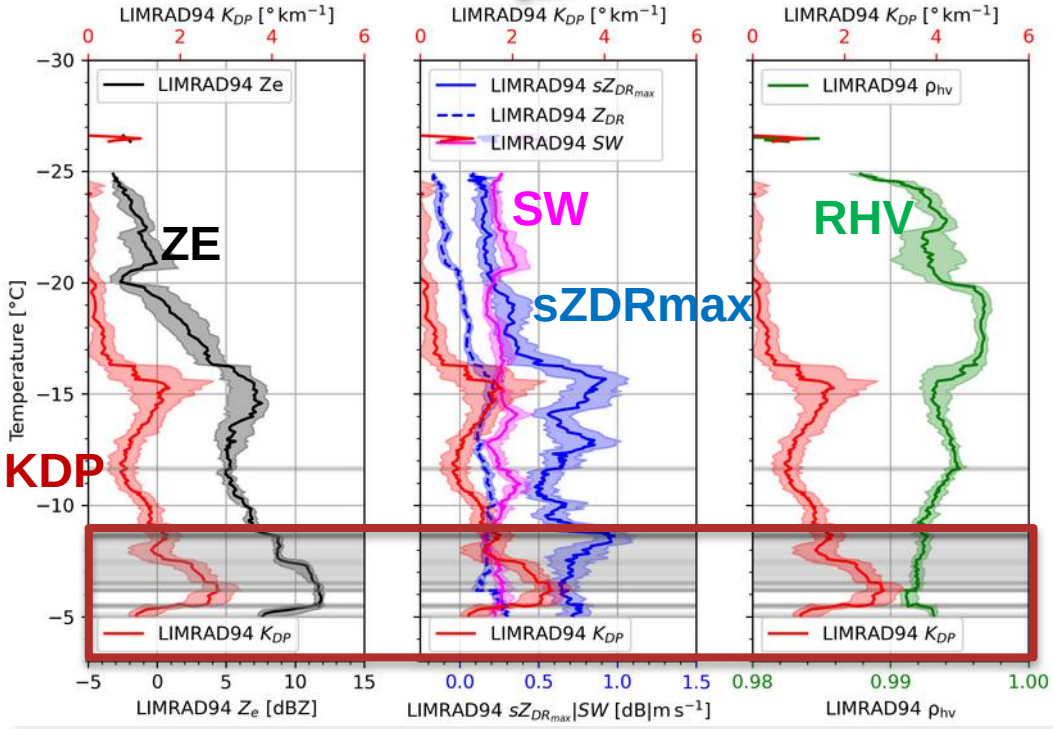
RHV – Correlation coefficient

SW – Spectral Width

Grey areas: <u>strong turbulence</u>

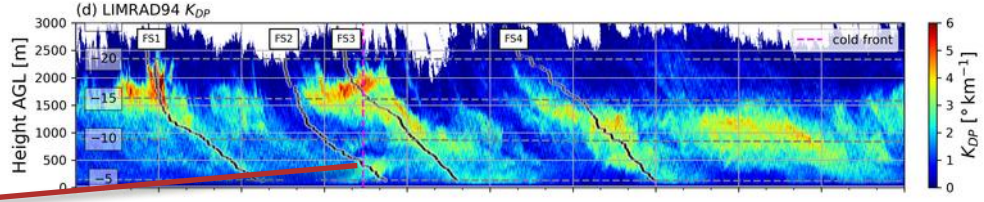
Fallstreak during coldfront



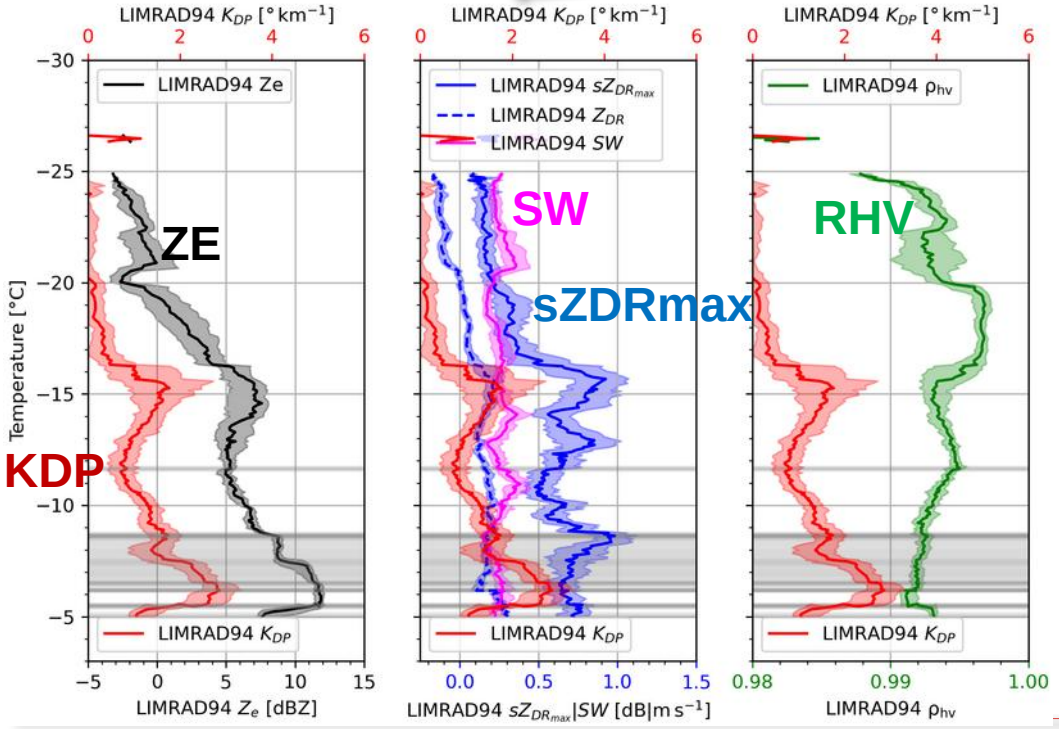


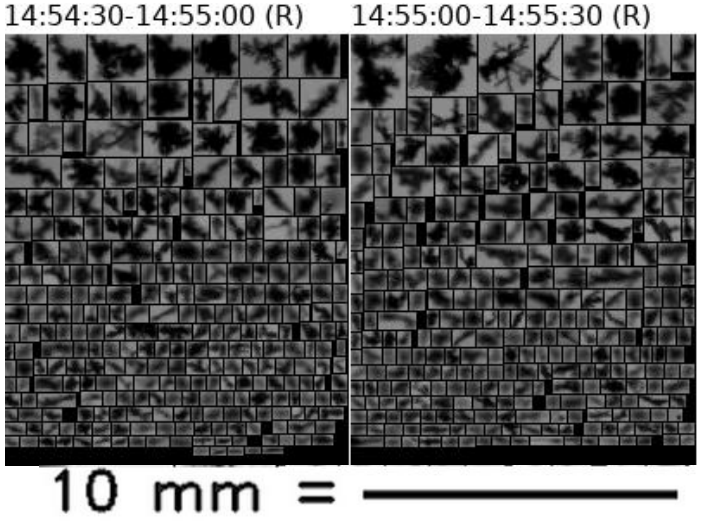
- Weak dendritic growth aloft, KDP around 1 deg/km
- Turbulent layer close to surface caused by incoming cold air → strong wind increase
- Increased KDP and ZE very close to surface → likely caused by blowing snow

Fallstreak during coldfront

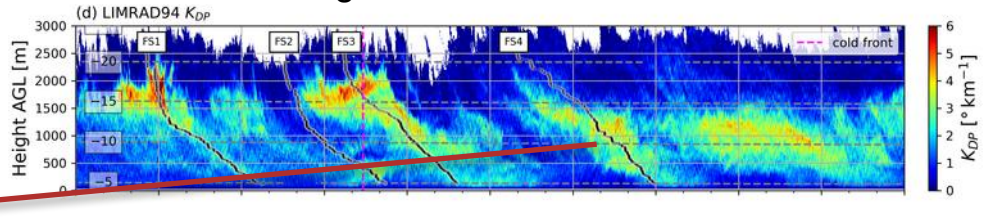


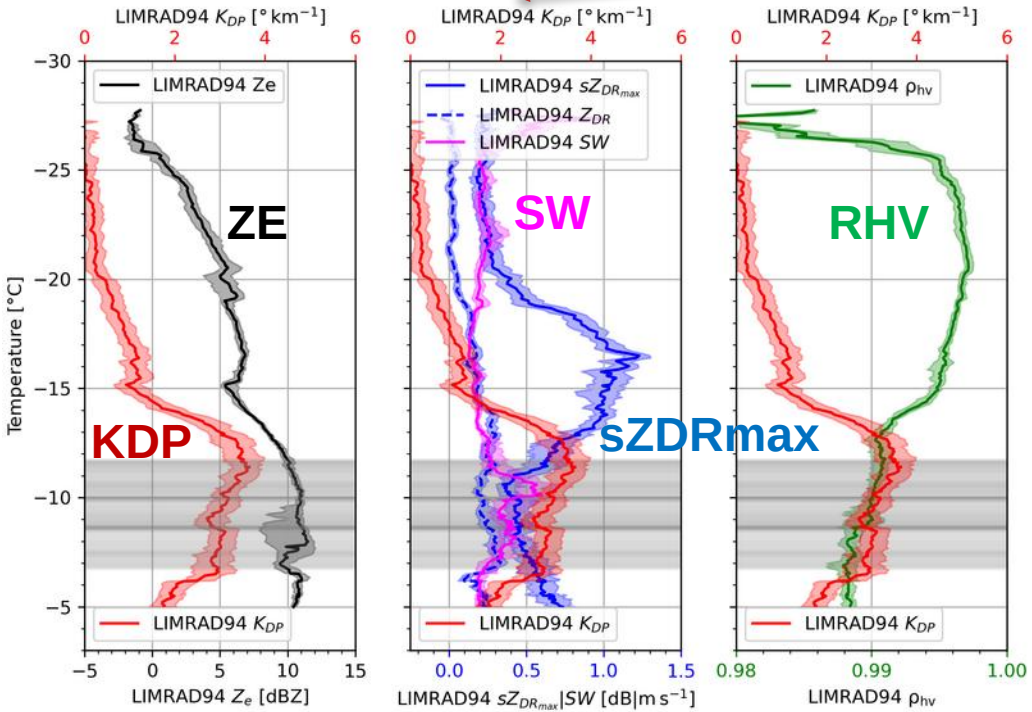
VISSS images





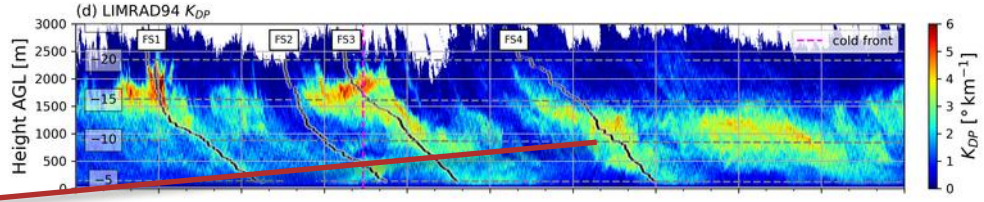
Fallstreak after coldfront

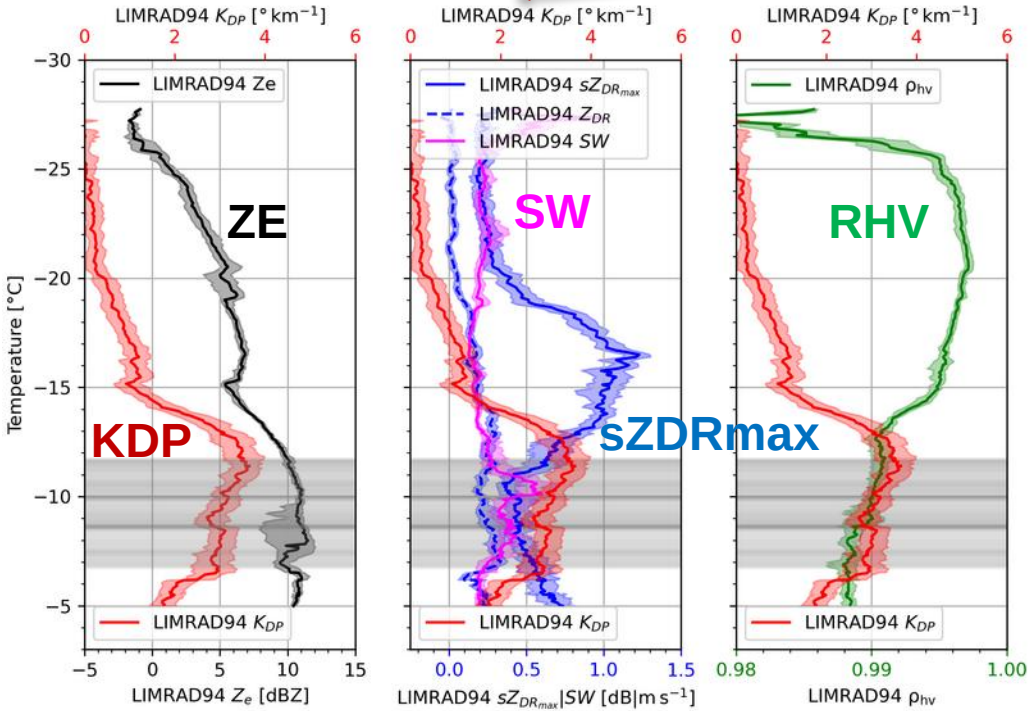


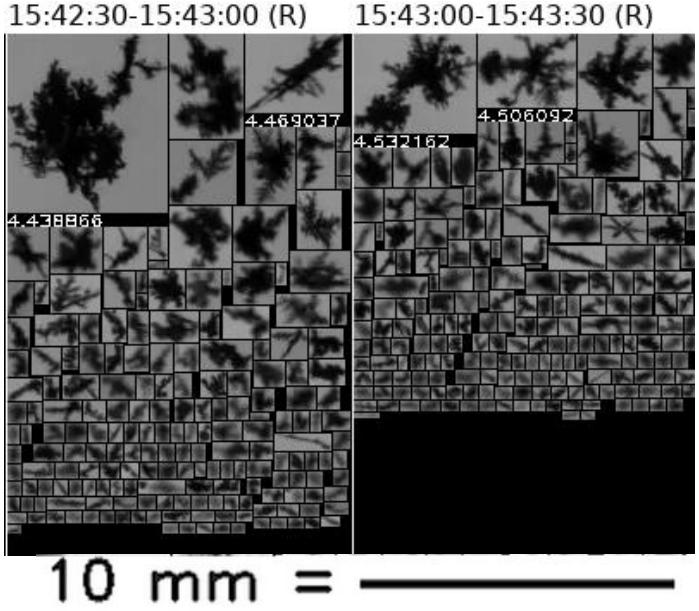


- Strong sZDR enhancement without KDP enhancement → larger anisotropic particles with low number concentration (plates/dendrites)?
- Peak in KDP below sZDRmax peak, sZDRmax already decreasing → Aggregates of large anisotropic particles producing KDP?
- sZDRmax decreases in turbulent layer → broadening of spectra and random orientation
- KDP constant in turbulent layer → breakup of aggregates? **SIP by ice-ice collision?**
- Dendrite branches observed by VISSS

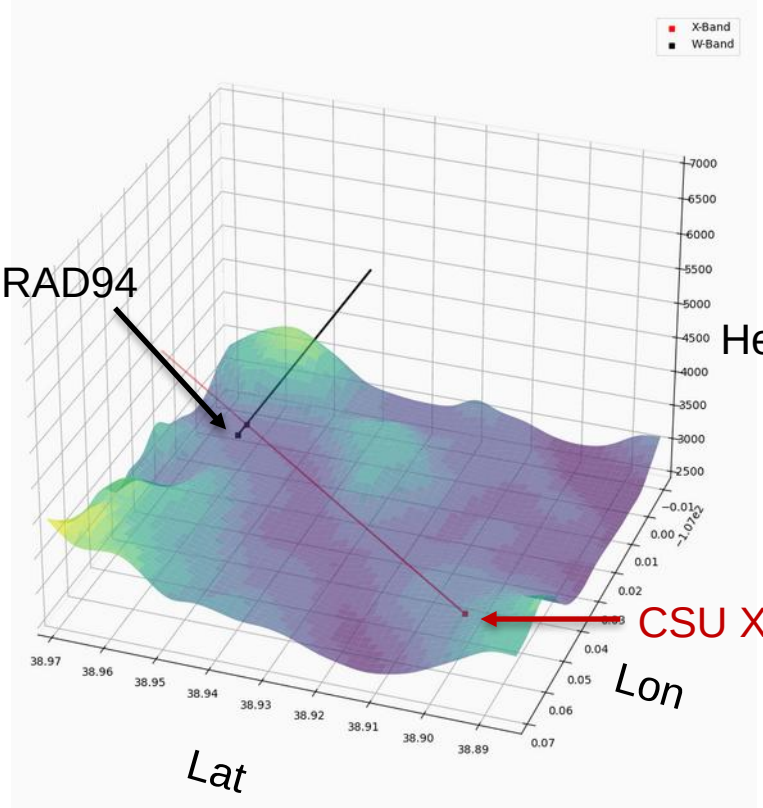
Fallstreak after coldfront

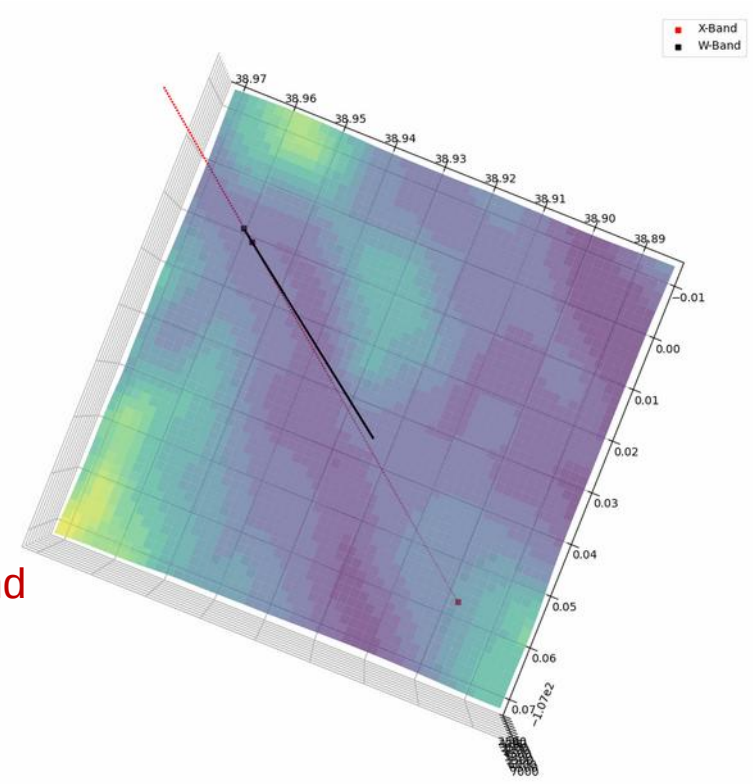






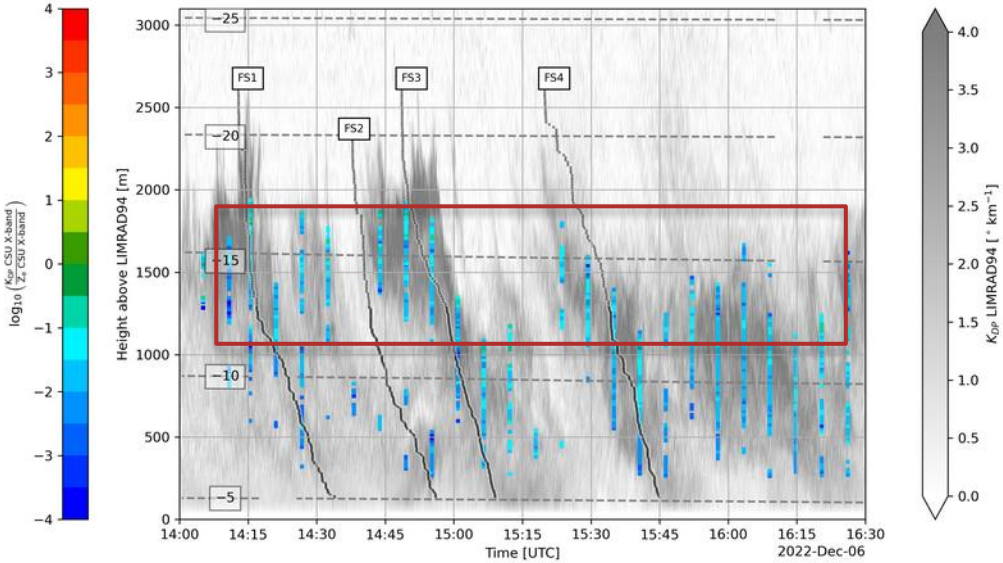
Using additional data from CSU X-band radar



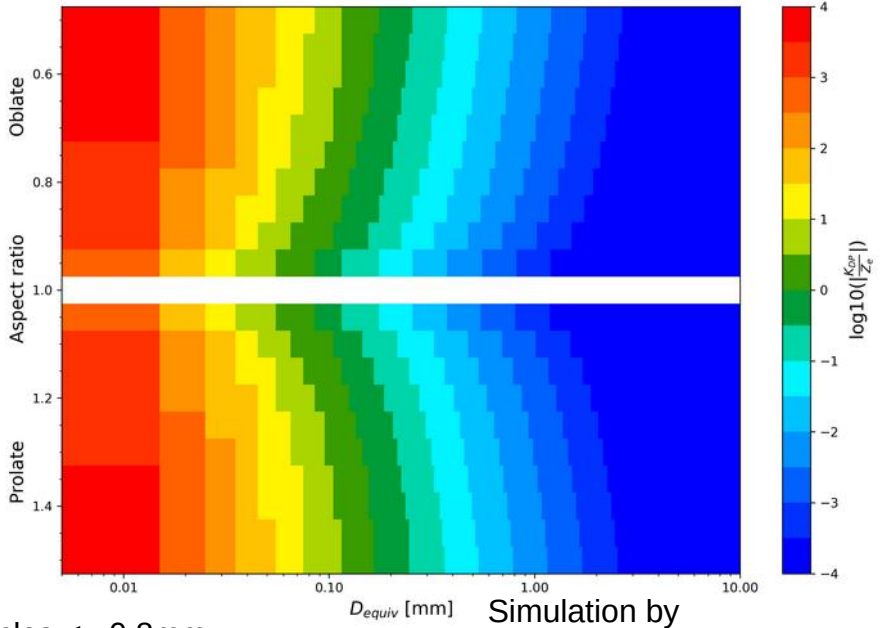


Ratio of X-Band Ze and KDP to estimate size of particles producing KDP

Measured KDP/Ze ratio X-band



Simulated KDP/Ze ratio X-band

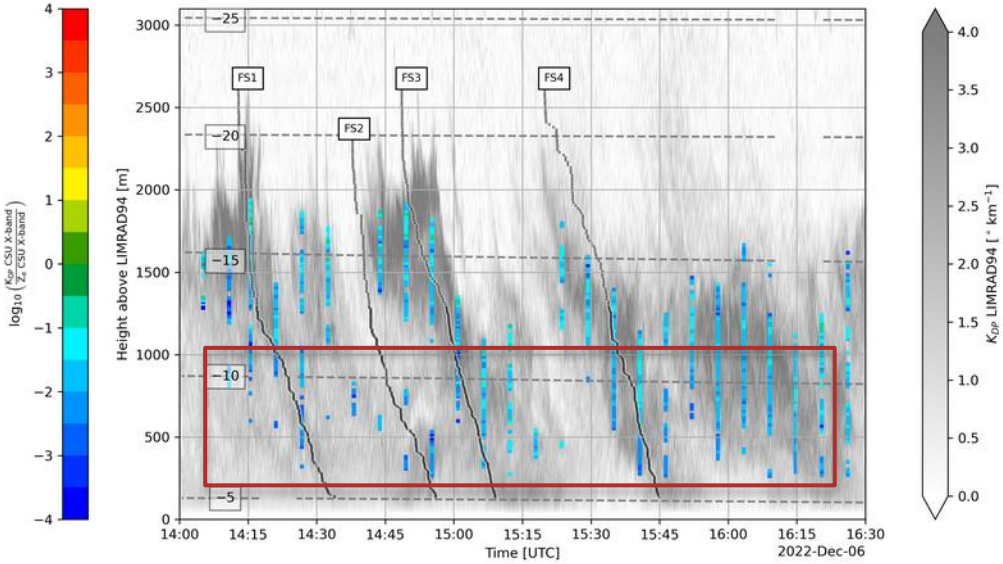


- **In DGL** KDP/Ze ratio between -1 and -2 → Diameter of particles < ~0.8mm

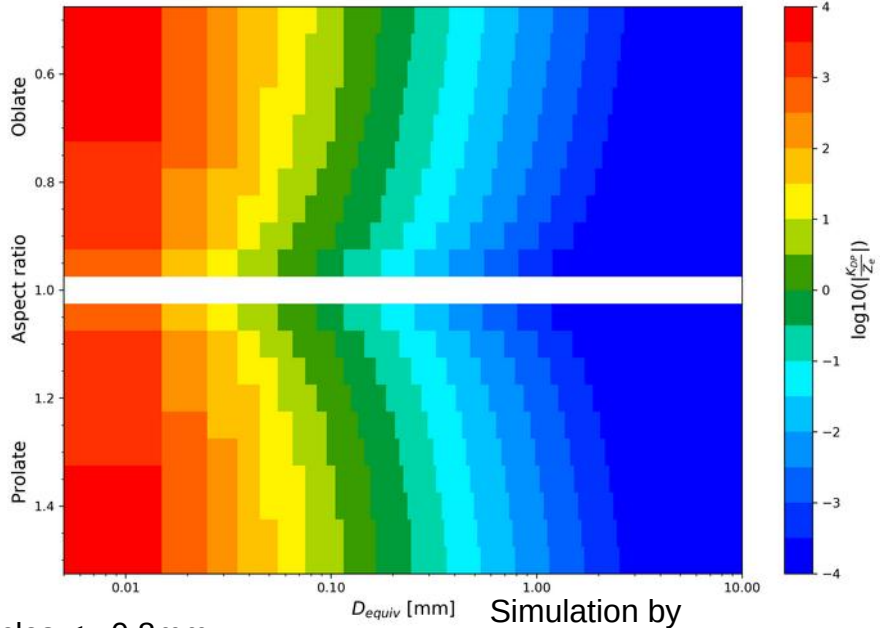
Simulation by Alexander Myagkov

Ratio of X-Band Ze and KDP to estimate size of particles producing KDP

Measured KDP/Ze ratio X-band



Simulated KDP/Ze ratio X-band

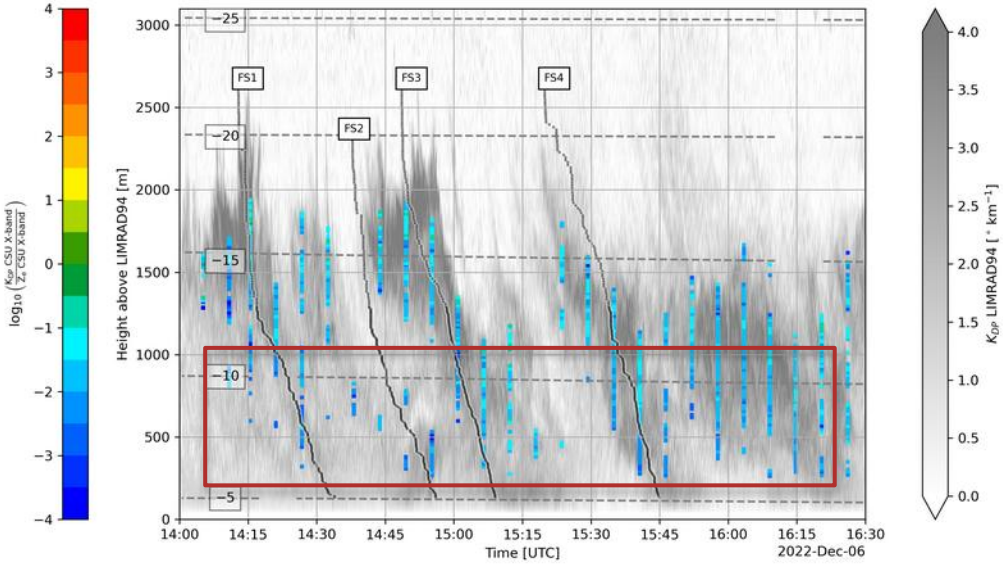


Simulation by Alexander Myagkov

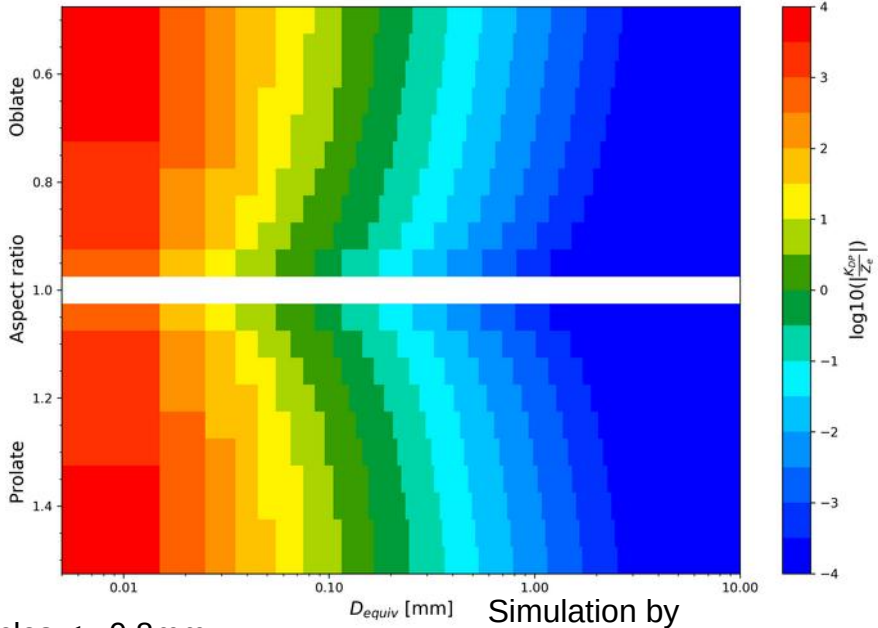
- **In DGL** KDP/Ze ratio between -1 and -2 → Diameter of particles < ~0.8mm
- **Below DGL** KDP/Ze ratio between -2 and -2.5 → Diameter of particles < ~1.2mm

Ratio of X-Band Ze and KDP to estimate size of particles producing KDP

Measured KDP/Ze ratio X-band



Simulated KDP/Ze ratio X-band

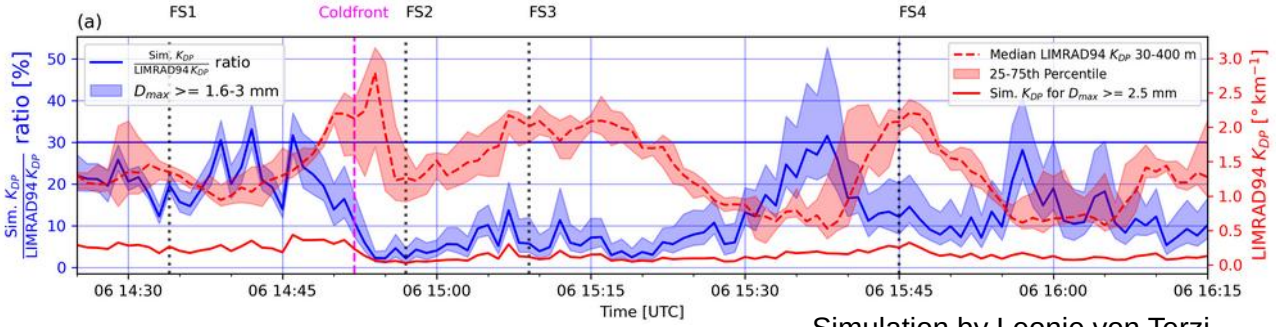


Simulation by Alexander Myagkov

- **In DGL** KDP/Ze ratio between -1 and -2 → Diameter of particles < ~0.8mm
- **Below DGL** KDP/Ze ratio between -2 and -2.5 → Diameter of particles < ~1.2mm

<u>But: spheroidal approximation, might not correctly estimate contribution of aggregates</u>

KDP from larger aggregates? LIMRAD94 and VISSS observations



Simulation by Leonie von Terzi

KDP observations near surface

Simulated KDP

Ratio Simulated / Observed KDP

- Modeling KDP based on VISSS PSD data using DDA
- **Only particles larger than 2.5mm included**
- Dendrite aggregates used as particles for simulation

- Contribution to KDP of 10-15 % can be attributed to aggregates with a maximum diameter>= 2.5 mm.

- When the PSD contains a large number of aggregates → contribution of up to 20 %

Conclusion:

- Similar W-band KDP values can be produced by strongly variable particle number concentrations.
- Small ice particles (<1.2mm) are the main contributors to the observed W-band KDP
- Up to 20% of the observed KDP can be attributed to large dendrite aggregates
- Blowing snow likely caused W-band KDP of up to 3 deg/km
- Despite the dampening effect of turbulence mentioned above, we observed an increase in KDP inside a strong turbulent layer → might be due to SIP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Investigating KDP signatures inside and below the dendritic growth layer with W-band Doppler Radar and in situ snowfall camera

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Thank you for your attention!

KDP Panel

Ze Panel

VISSS Panel