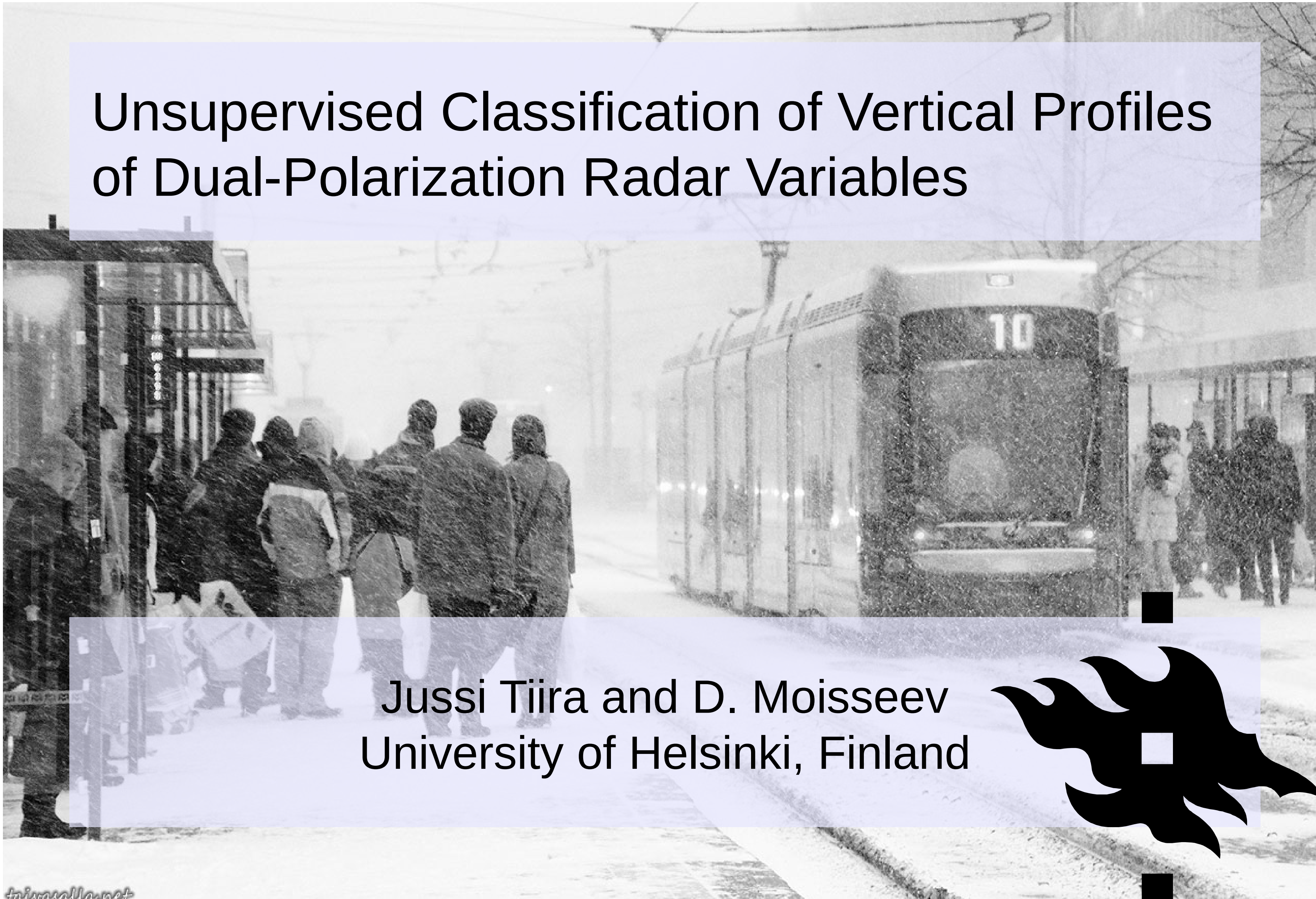
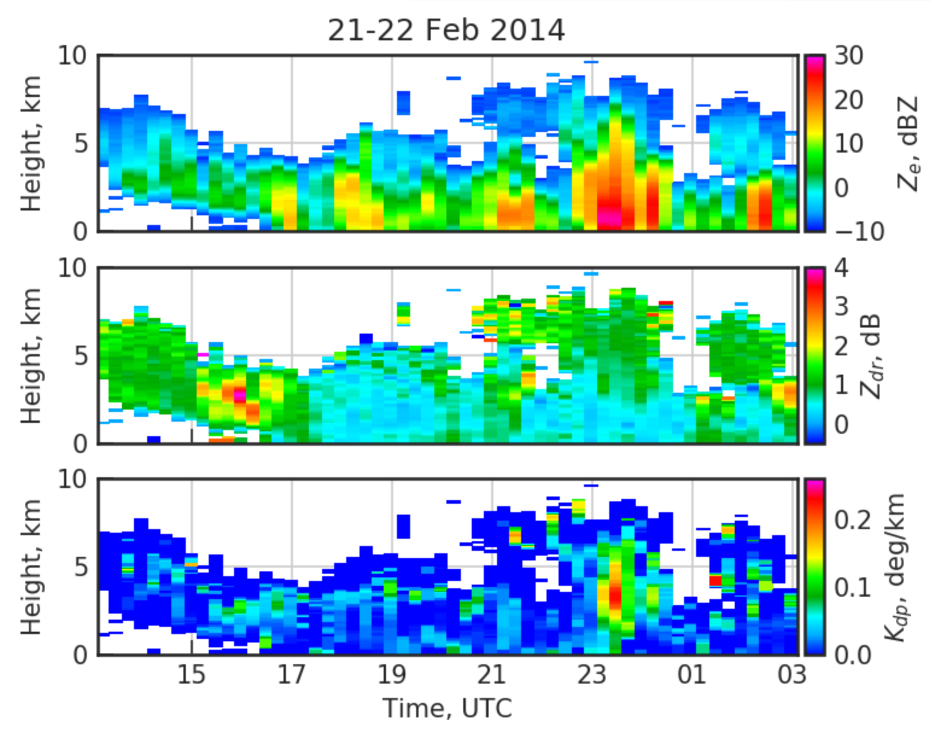
Unsupervised Classification of Vertical Profiles of Dual-Polarization Radar Variables



Jussi Tiira and D. Moisseev
University of Helsinki, Finland

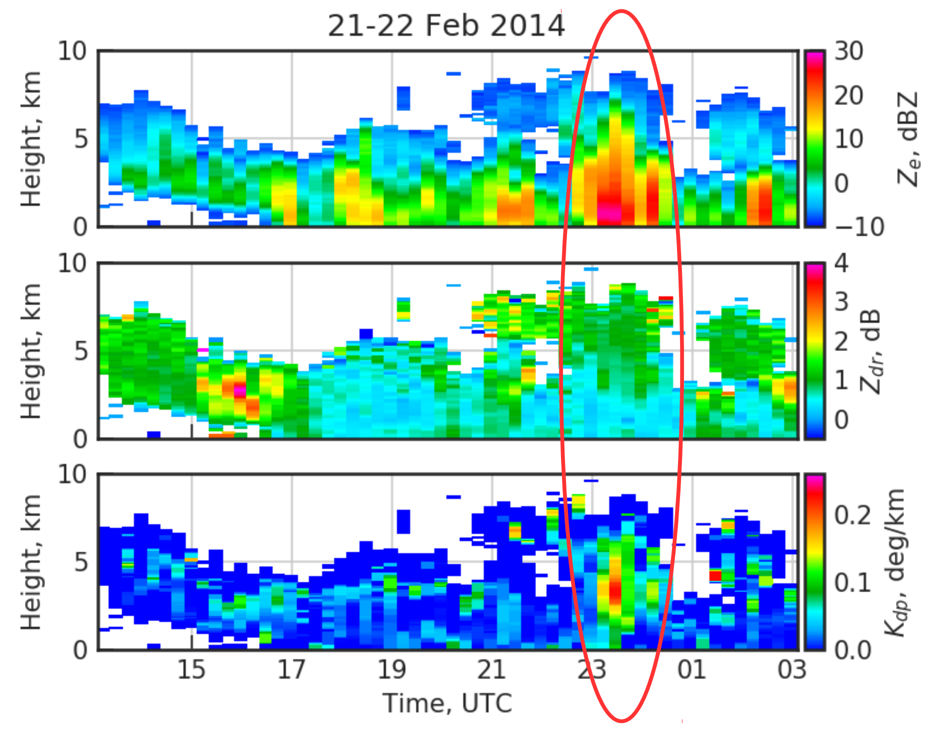
Motivation

- Can we use vertical profiles of polarimetric radar variables as fingerprints of snow growth processes?
- Could this lead to:
  - Adaptive Z-S
  - Intelligent VPR correction



Motivation

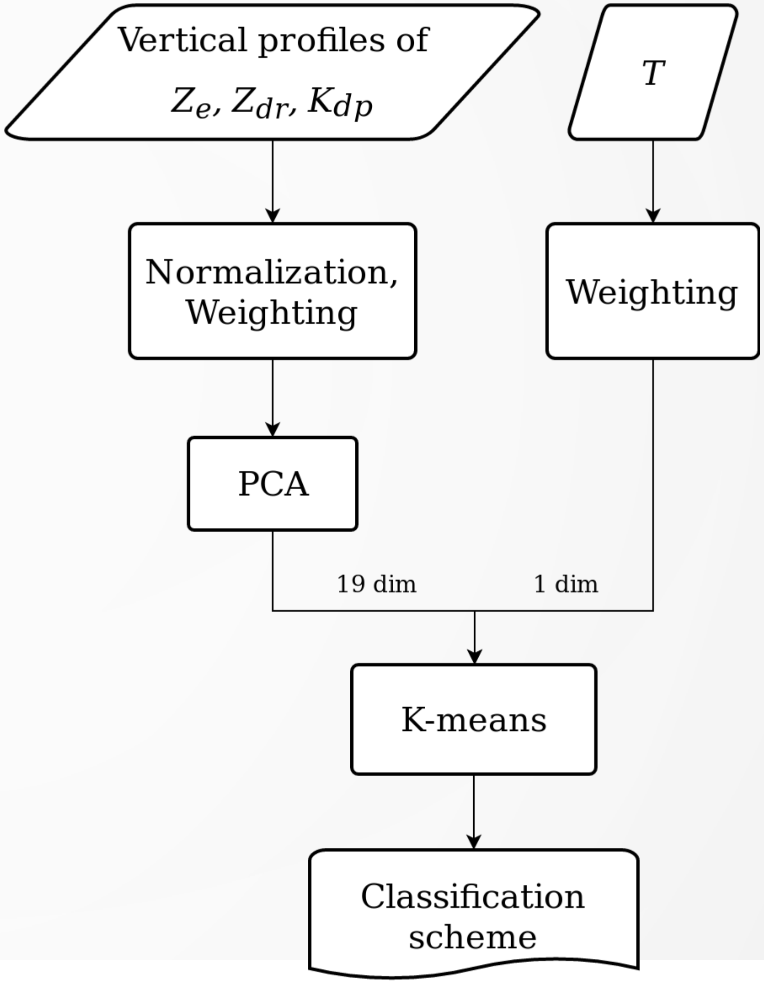
- Can we use vertical profiles of polarimetric radar variables as fingerprints of snow growth processes?
- Could this lead to:
  - Adaptive Z-S
  - Intelligent VPR correction



The first question to answer: can we classify vertical profiles to a finite number of classes and link them to the processes?

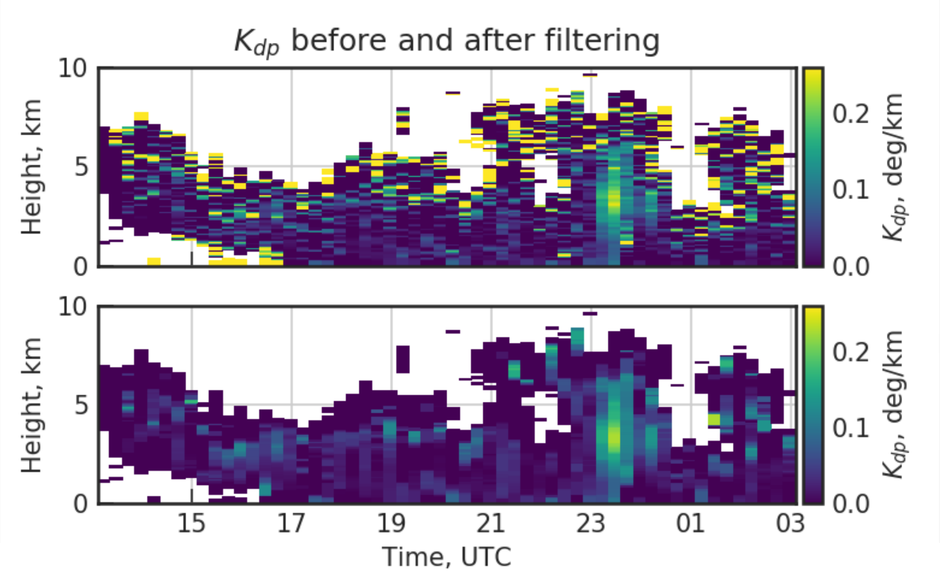
Classification method

1. **Input:** Preprocessed polarimetric vertical profiles from RHI scans and ground temperature
2. **Feature scaling** and weighting of radar variables prior to Principal component analysis (PCA)
3. **Dimension reduction** of vertical profiles using PCA
4. K-means **clustering** of the combination of PCA-reduced profiles and weighted *T*
5. **Output:** Profile classes defined by K-means centroids



Preprocessing

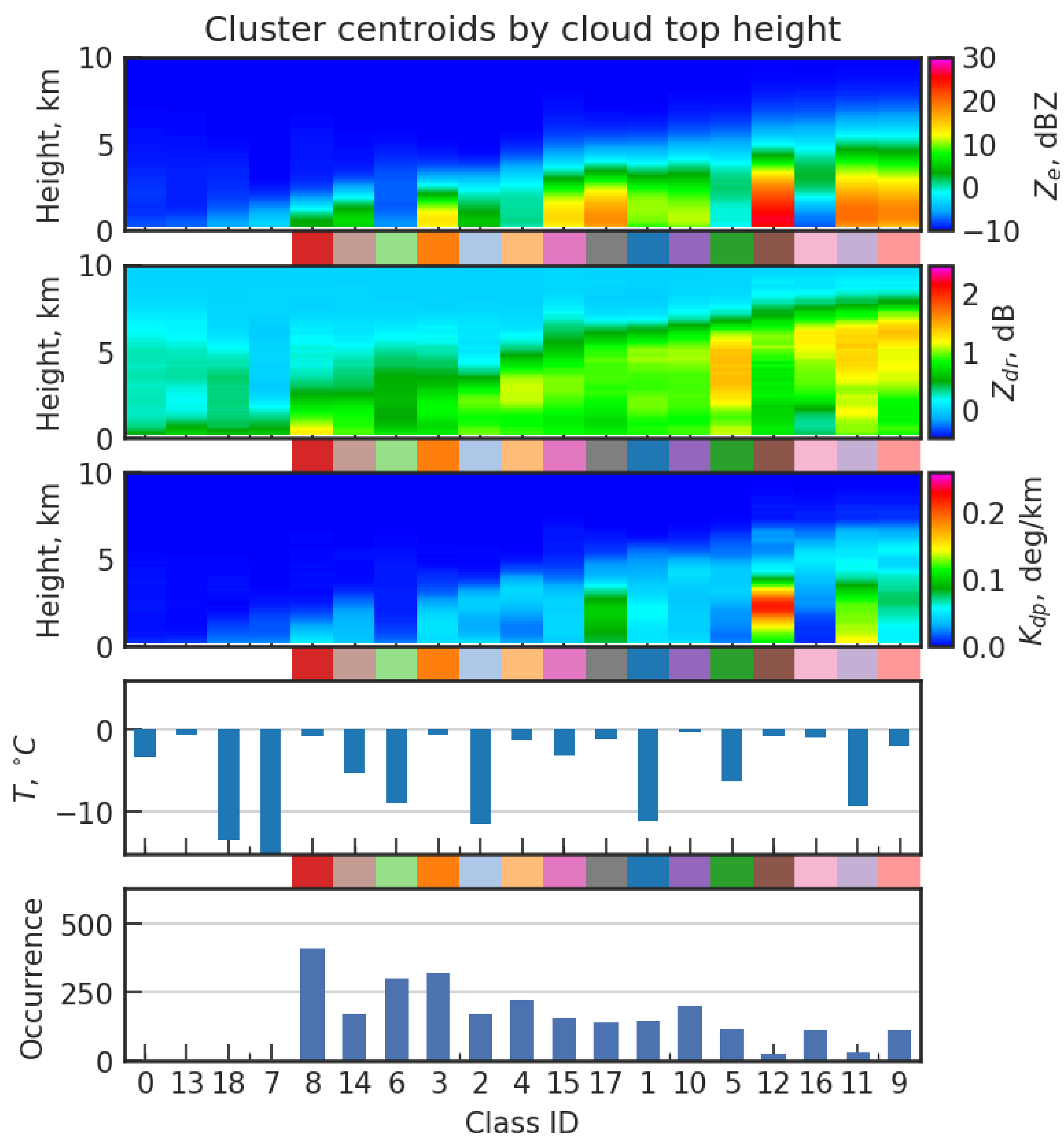
- Vertical profiles extracted from RHI scans carried out every 15 minutes
- Z_{dr} and very noisy K_{dp} recovered using median filter
- A combination of median and threshold based filters for GC



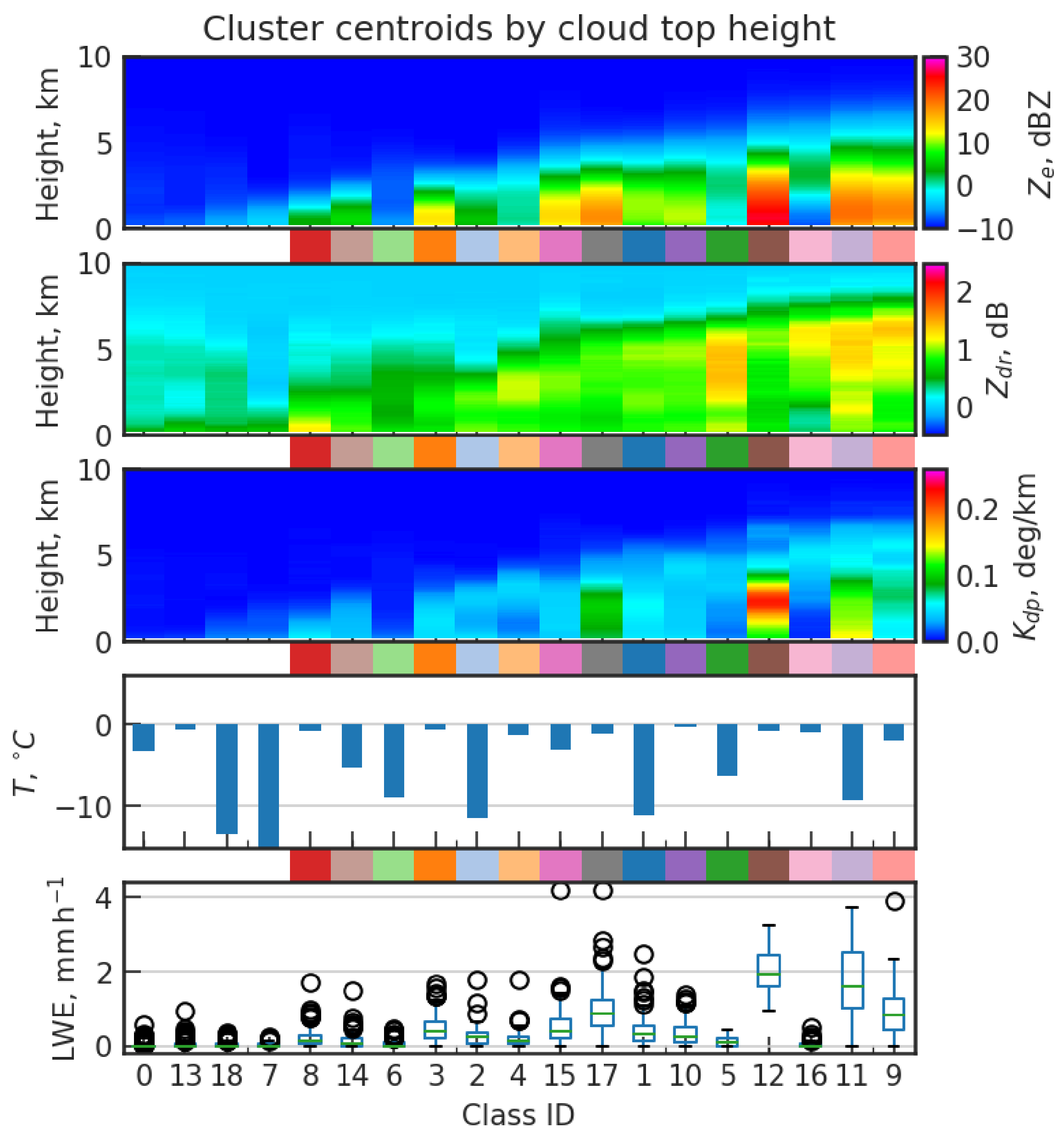
Data

- 75 snow cases from 3 winters 2013/14, 14/15, 15/16
- Data collected over Hyytiälä, U. Helsinki measurement station in Finland
- RHI observations from the FMI Ikaalinen C-band radar, 64 km from the station
- Surface temperature is measured at the station

- Output of the classification: 19 profile classes (K-means centroids)
- They explain over 90% of the profile variance

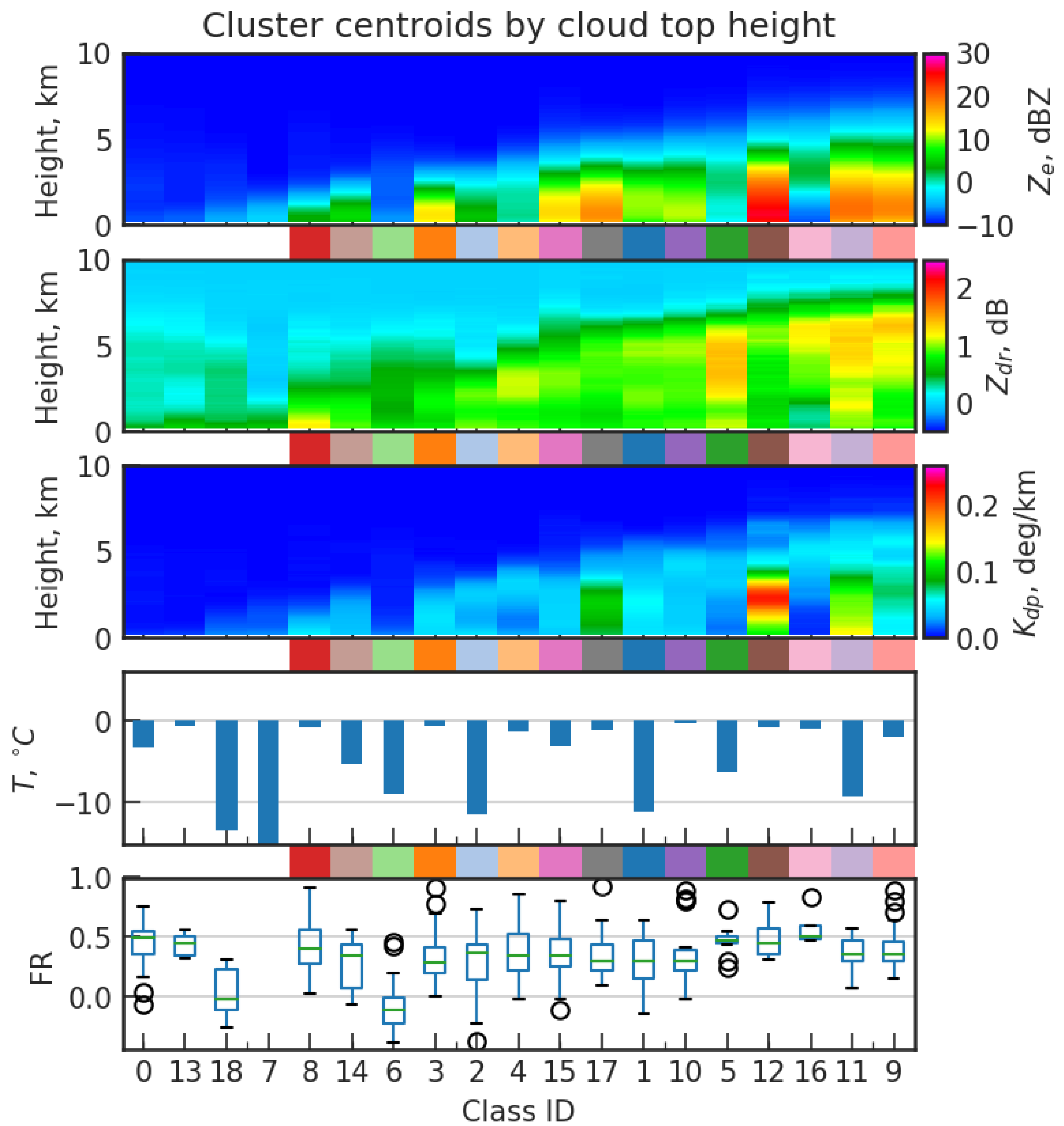


- Classification vs. mean LWE precipitation rate
- Sampled over next 15 minutes after each RHI



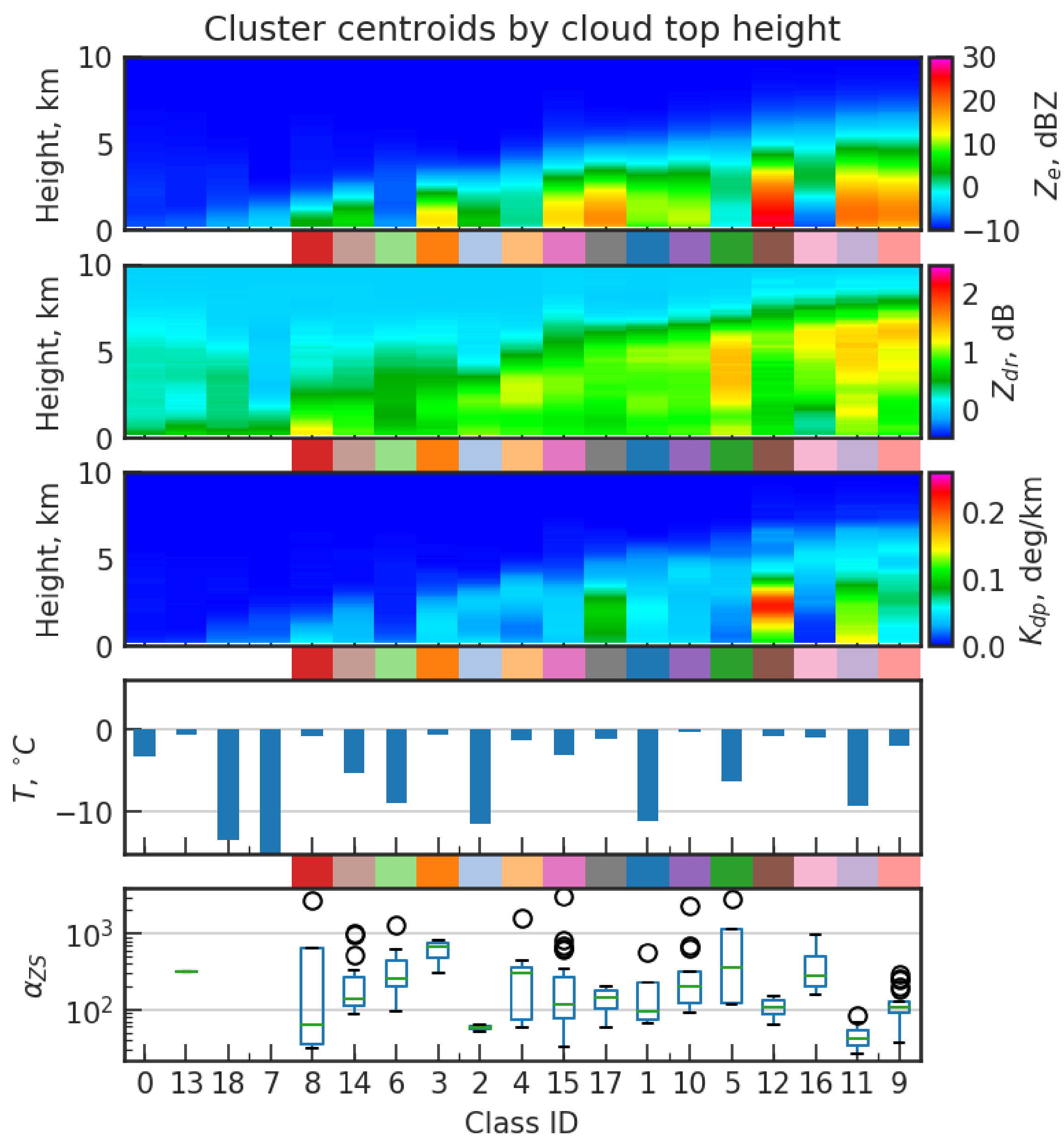
- Classification vs. Rime mass fraction
- Rime mass fraction is derived using Moisseev et al. (2017) method

$$m = \frac{\alpha}{1 - FR} D^{\beta}$$



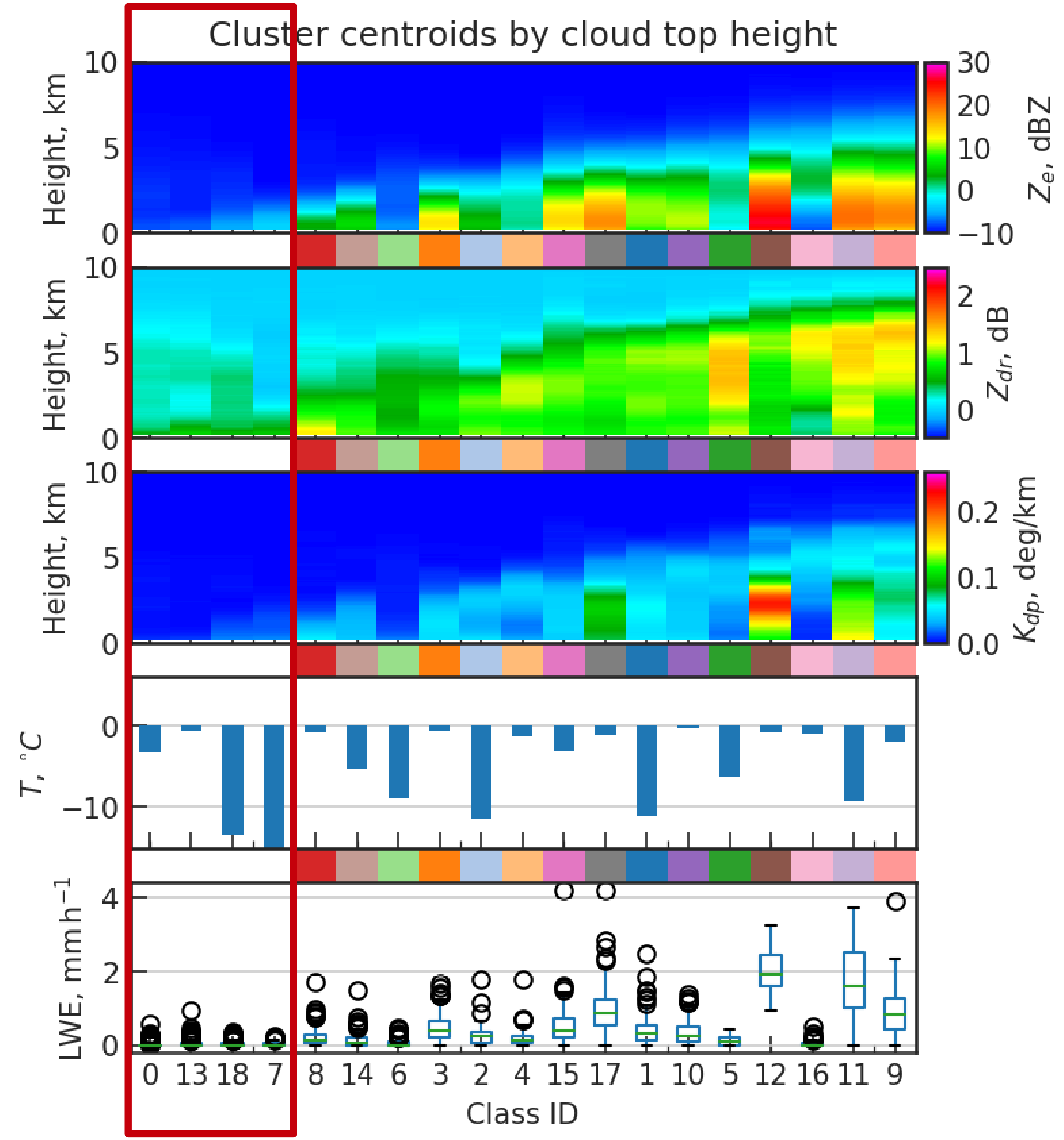
- Classification vs. prefactor of Z-S relation
- a_{zs} defined from 5 minute disdrometer observations assuming exponential PSD, using instantanious m(D) and v(D) relations (von Lerber et al. 2017)

$$Z_e = \alpha_{zs} S^{\beta_{zs}}$$

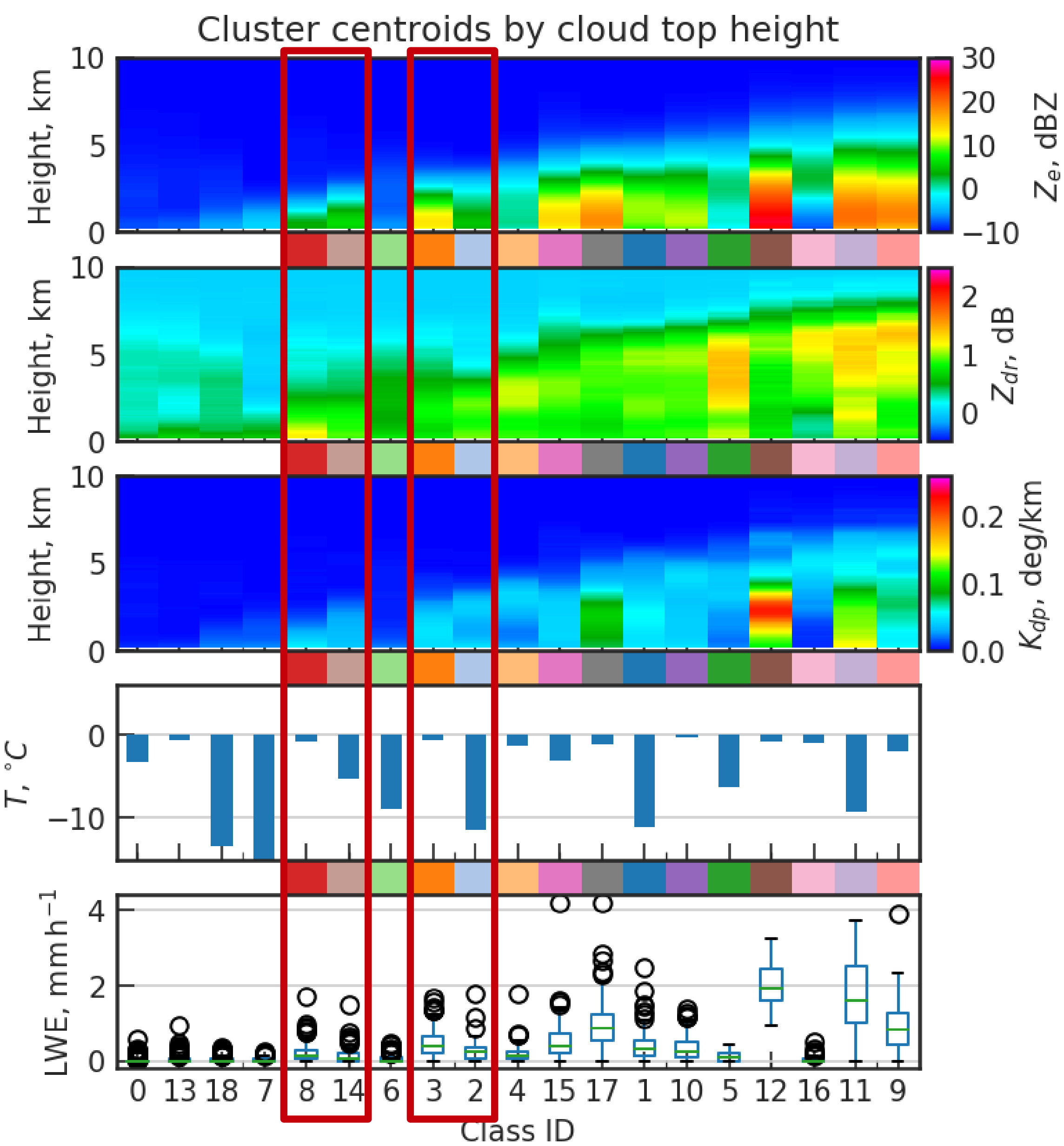


- Several classes may correspond to same growth processes

Non-precipitating classes

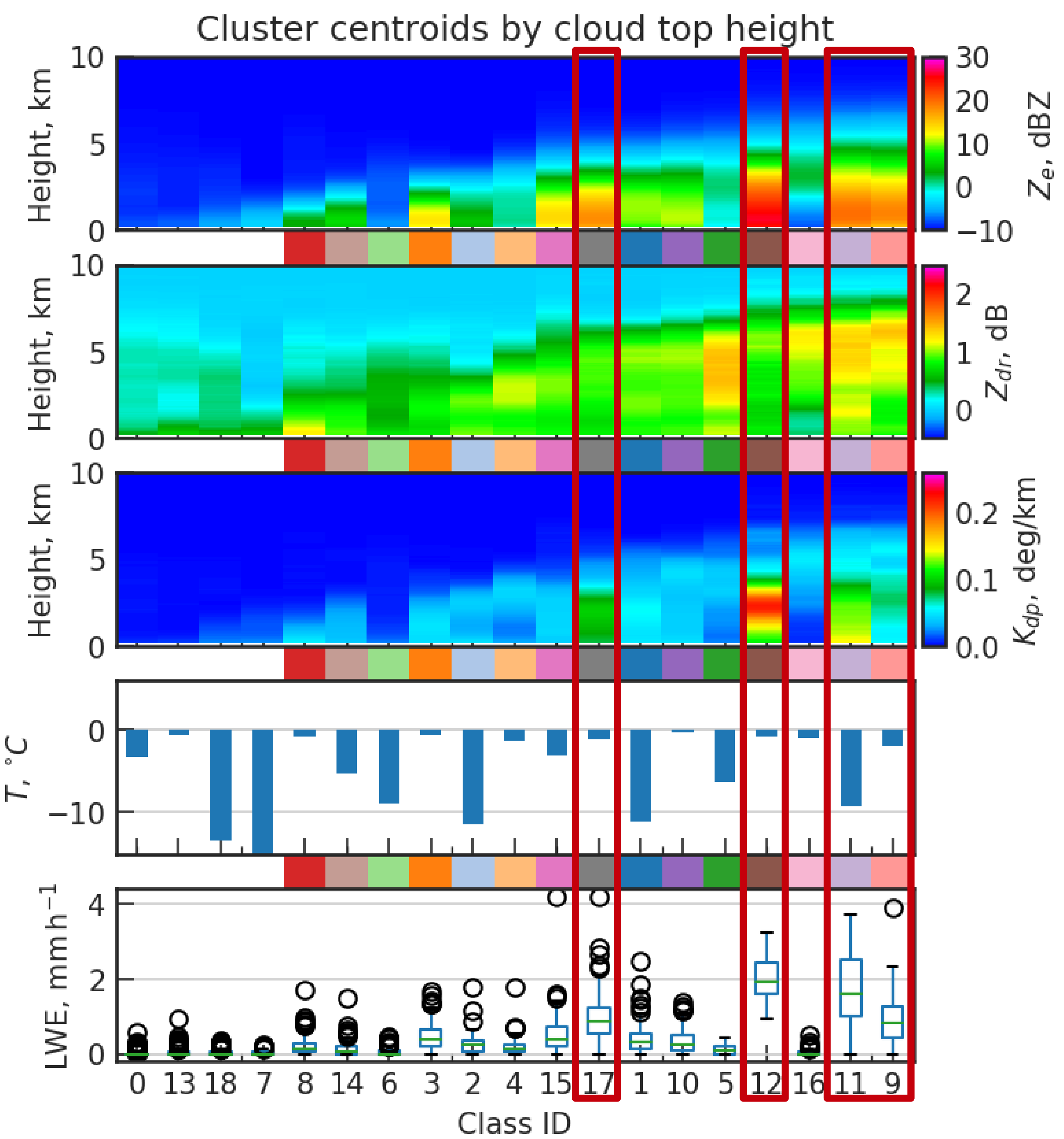


- Several classes may correspond to same growth processes



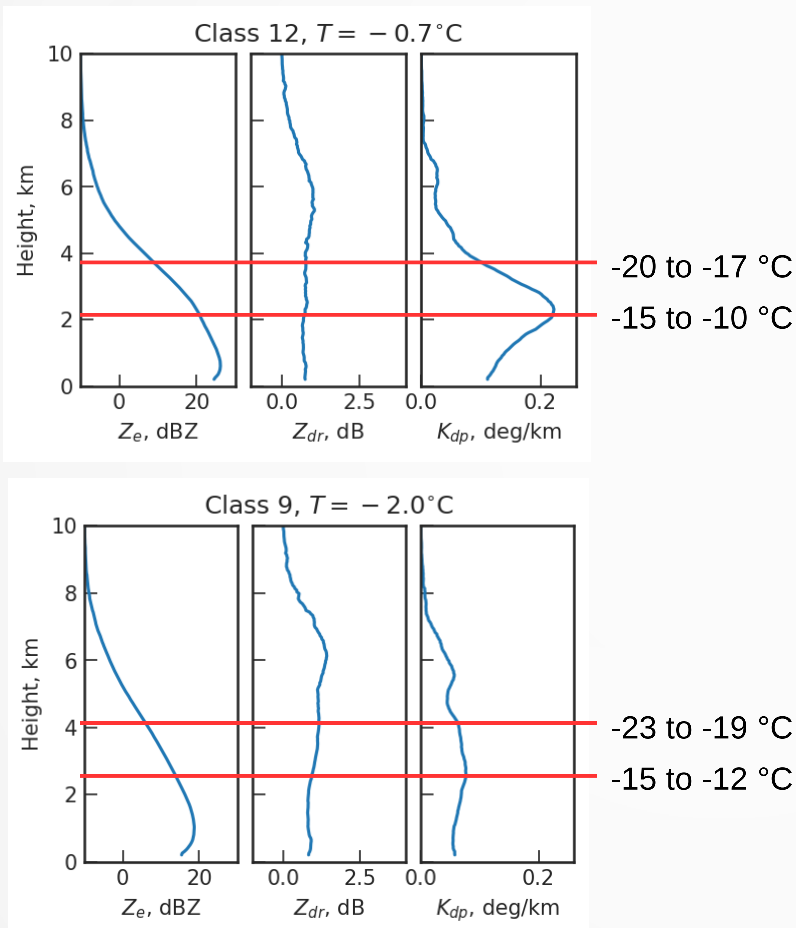
Shallow precipitating cloud - Ice crystals precipitating out of liquid cloud?

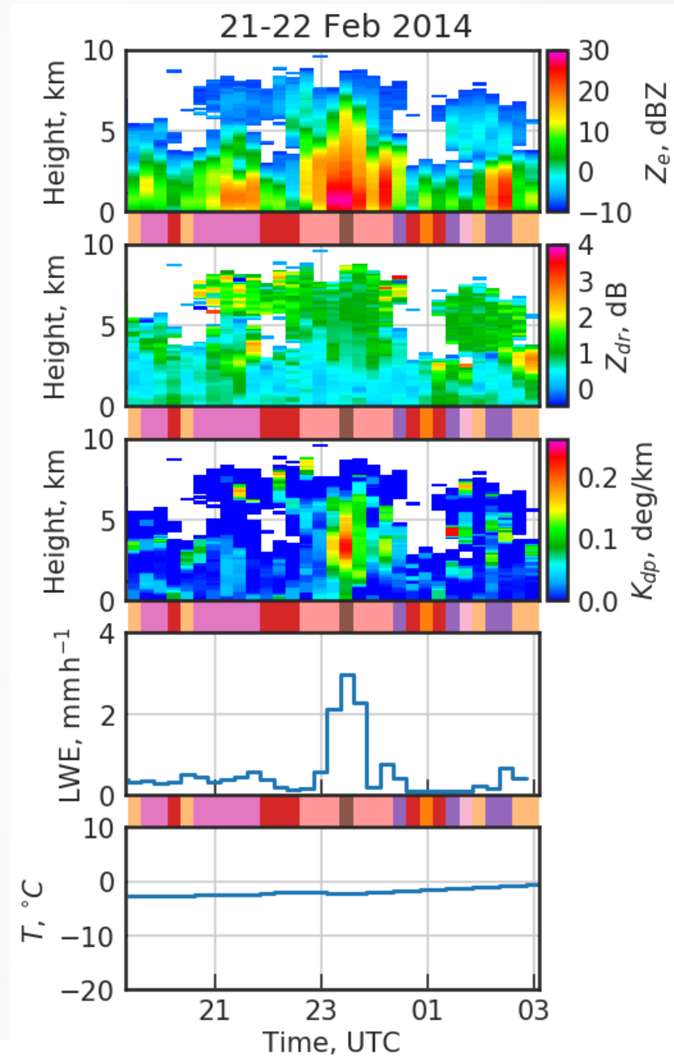
- Several classes may correspond to same growth processes



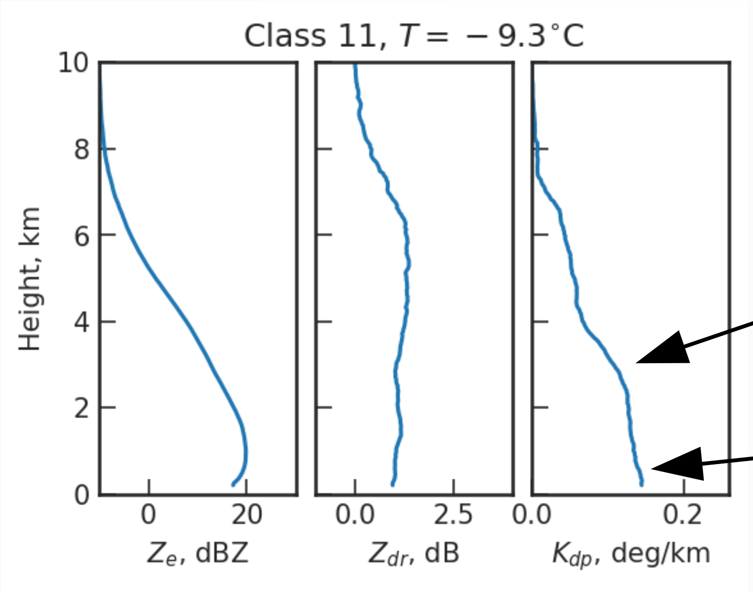
Classes with K_{dp} bands – Dendritic growth zone?

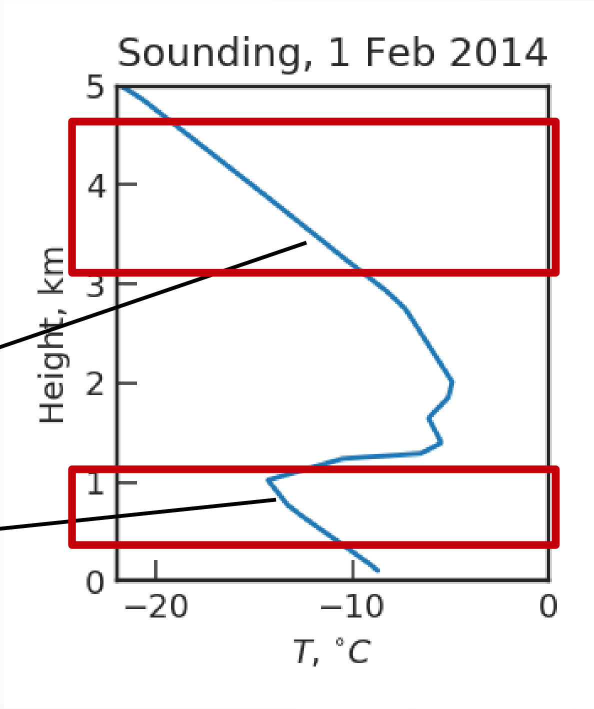
Dendritic growth: classes 12 & 9





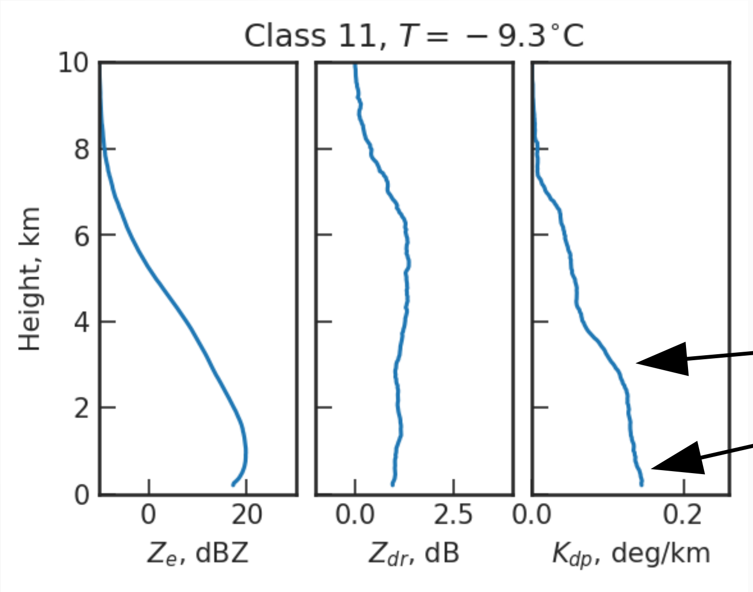
Dendritic growth in inversion: class 11

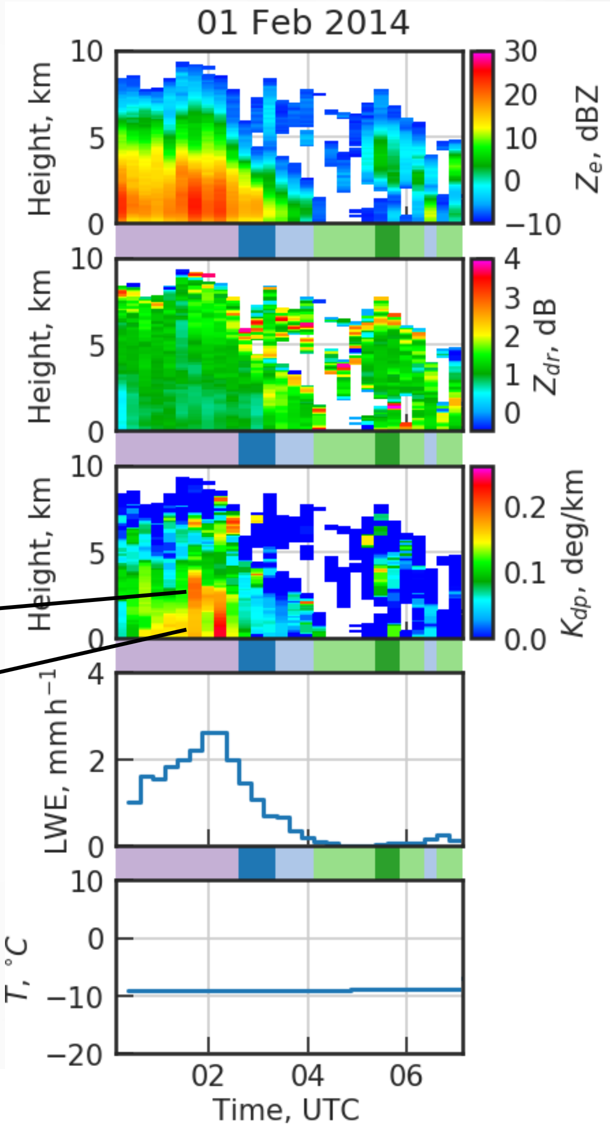




Blurred K_{dp} band caused by two growth layers

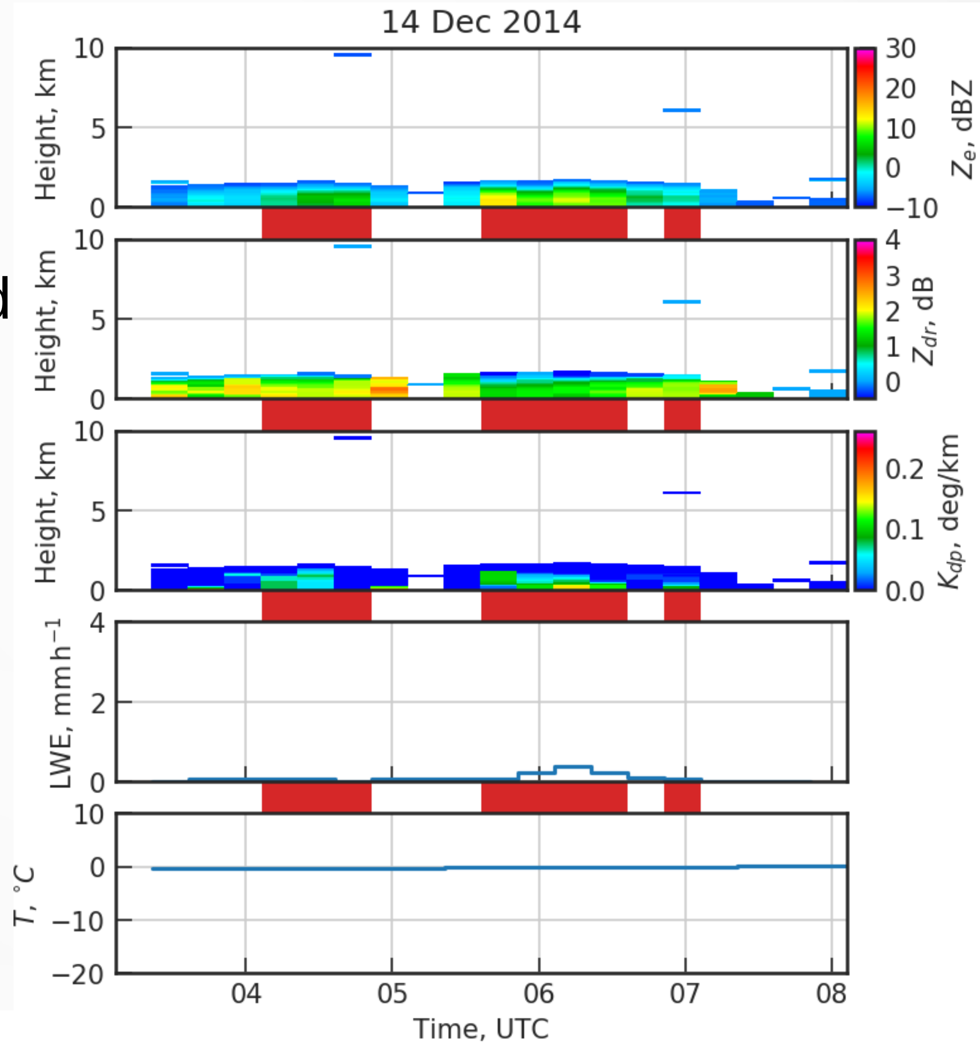
Dendritic growth in inversion: class 11





Nimbostratus, class 8

- Ice crystals precipitating out of supercooled liquid cloud layer
- Shallow cloud, elevated Z_{dr} values
- Sounding shows saturation in respect to liquid



Summary

- The presented method that uses PCA and K-means produces profile classes with distinct, physically meaningful features
- Using the test data 19 classes were identified
- High K_{dp} classes are associated with increased snowfall rate
- Several classes could represent same growth processes and need to be combined
- Further study linking growth processes and profile classes is ongoing