peakTree: A framework for structure-preserving radar Doppler spectra analysis

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International Symposium on Tropospheric Profiling
Toulouse, 23.05.2019

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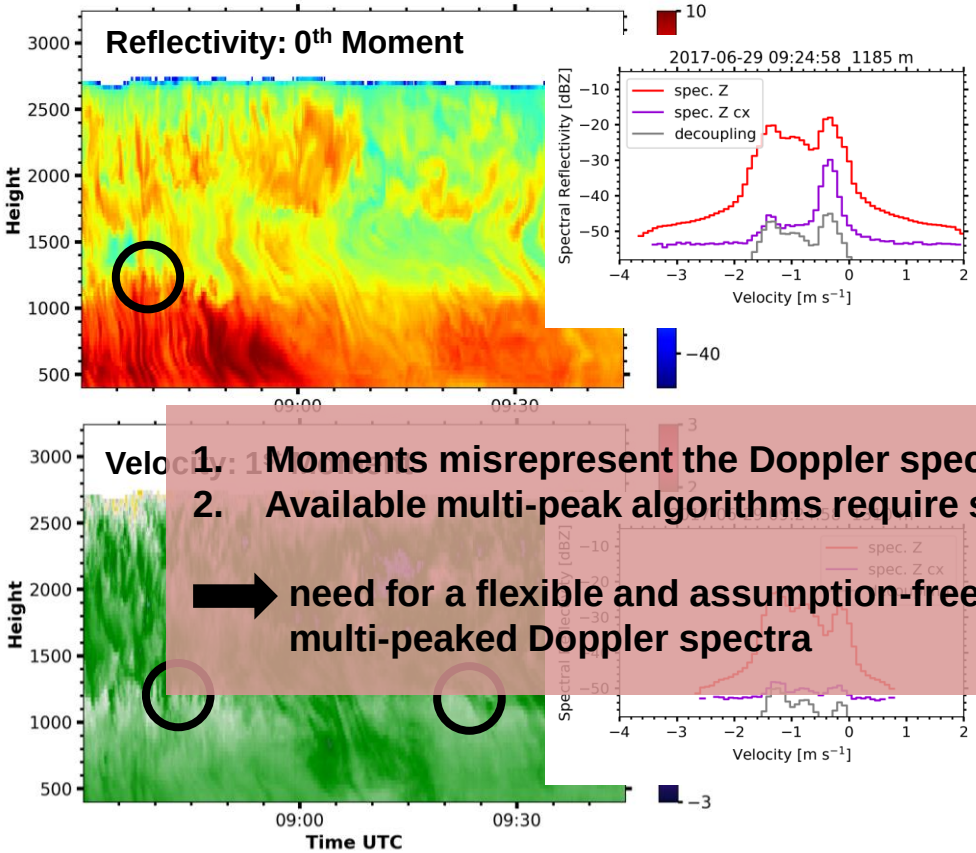
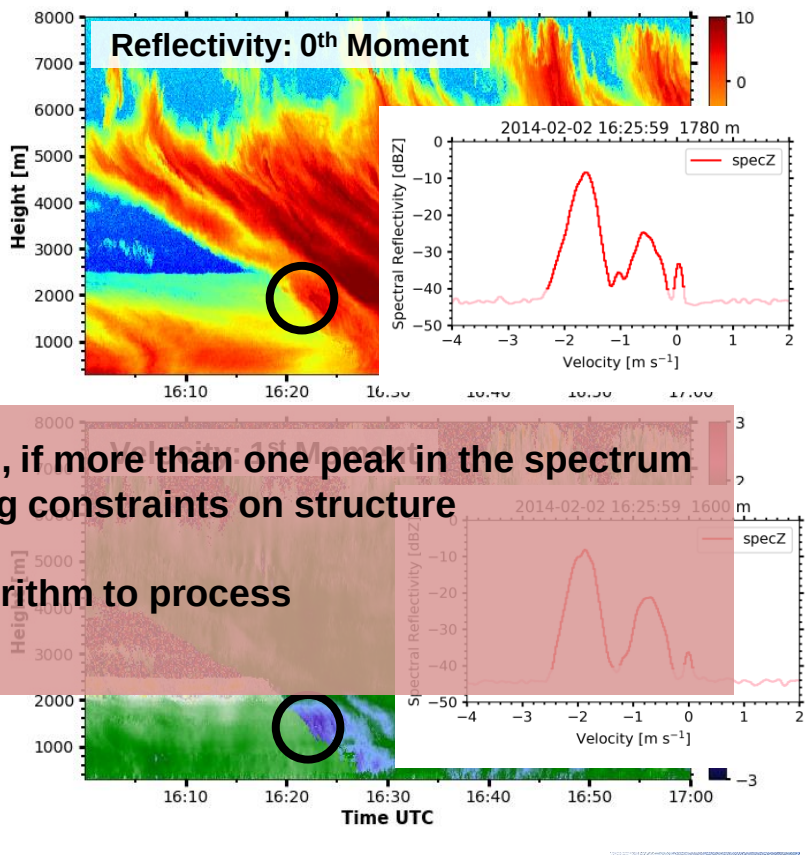
Contents

- The problem: multi-peaked spectra
- Represent peaks in Doppler spectrum as binary trees
- Example: Separating particle populations
- Conclusions and Outlook

The Problem: Assumption of mono-modality





1. Moments misrepresent the Doppler spectrum, if more than one peak in the spectrum
2. Available multi-peak algorithms require strong constraints on structure

➡ need for a flexible and assumption-free algorithm to process multi-peaked Doppler spectra

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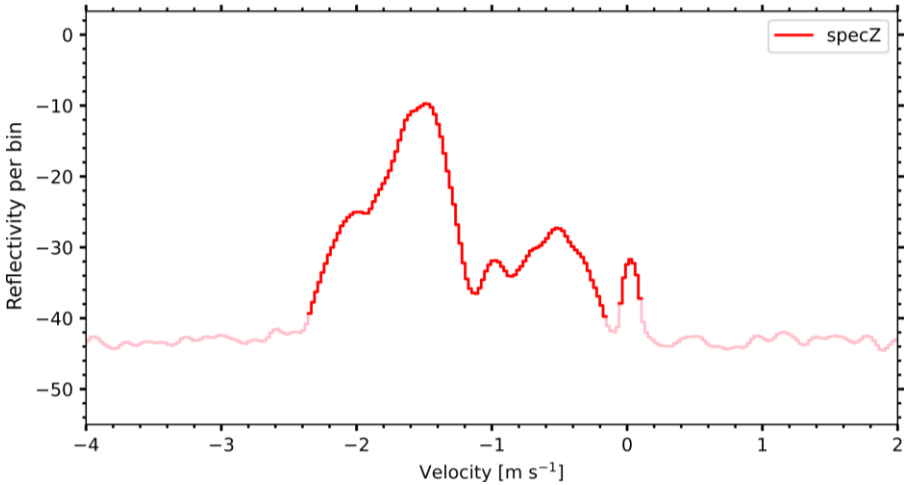
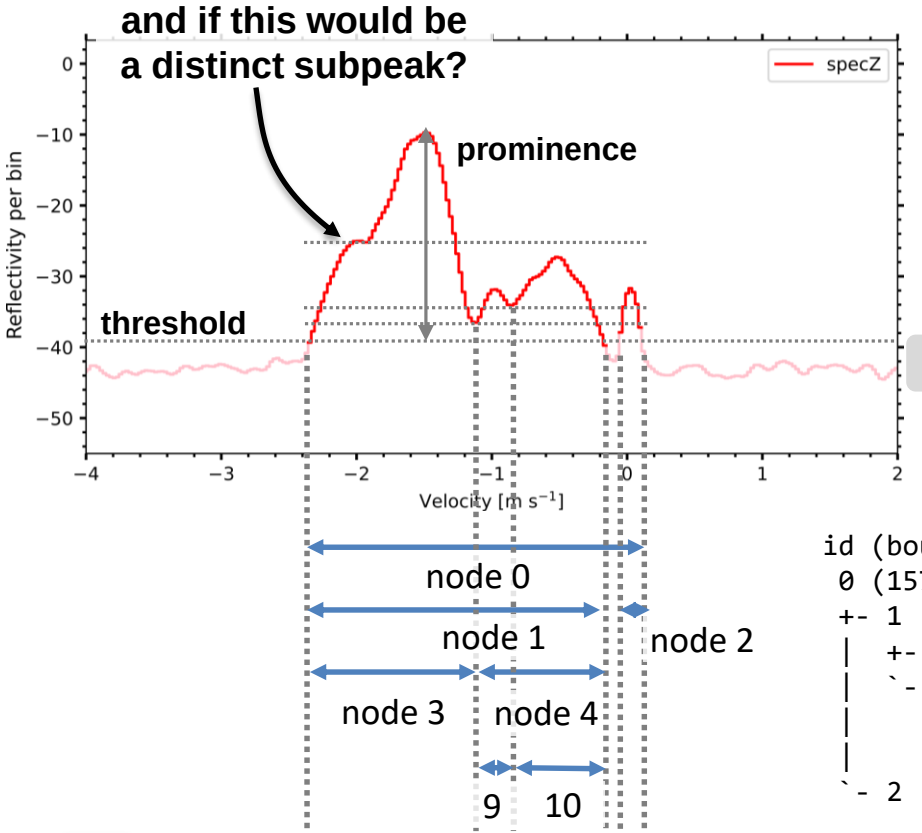
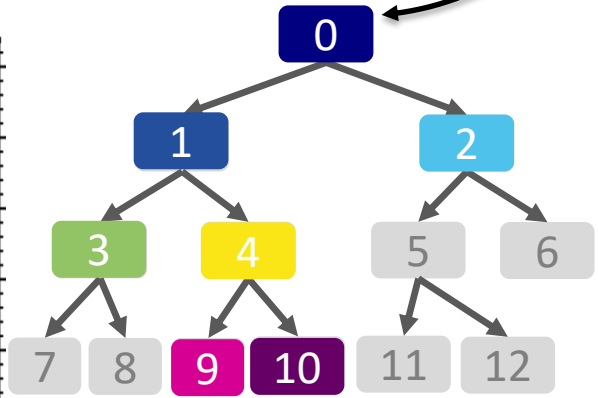
Represent (sub-)peaks as nodes in a binary tree



Represent (sub-)peaks as nodes in a binary tree





node 0 is equal to 'traditional' moments

$$i_{\text{left child}} = 2\,i_{\text{parent}} + 1$$

$$i_{\text{right child}} = 2\,i_{\text{parent}} + 2$$

$$i_{\text{parent}} = \left\lfloor \frac{i_{\text{child}} - 1}{2} \right\rfloor$$

id (bounds)	Z	v	σ	γ	thres.	prom.
0 (157, 260)	0.98,	-1.52,	0.22,	2.54,	-40.0,	30.3
+- 1 (157, 249)	0.96,	-1.52,	0.20,	2.09,	-40.0,	30.3
| +- 3 (157, 209)	0.85,	-1.55,	0.14,	-1.41,	-36.5,	26.8
| `- 4 (209, 249)	-14.97,	-0.61,	0.21,	-0.57,	-36.5,	9.2
| +- 9 (209, 220)	-22.54,	-0.95,	0.06,	0.18,	-34.1,	2.2
| `-10 (220, 249)	-15.74,	-0.55,	0.14,	-0.22,	-34.1,	6.8
`- 2 (254, 260)	-25.26,	0.03,	0.04,	-0.02,	-40.0,	8.3

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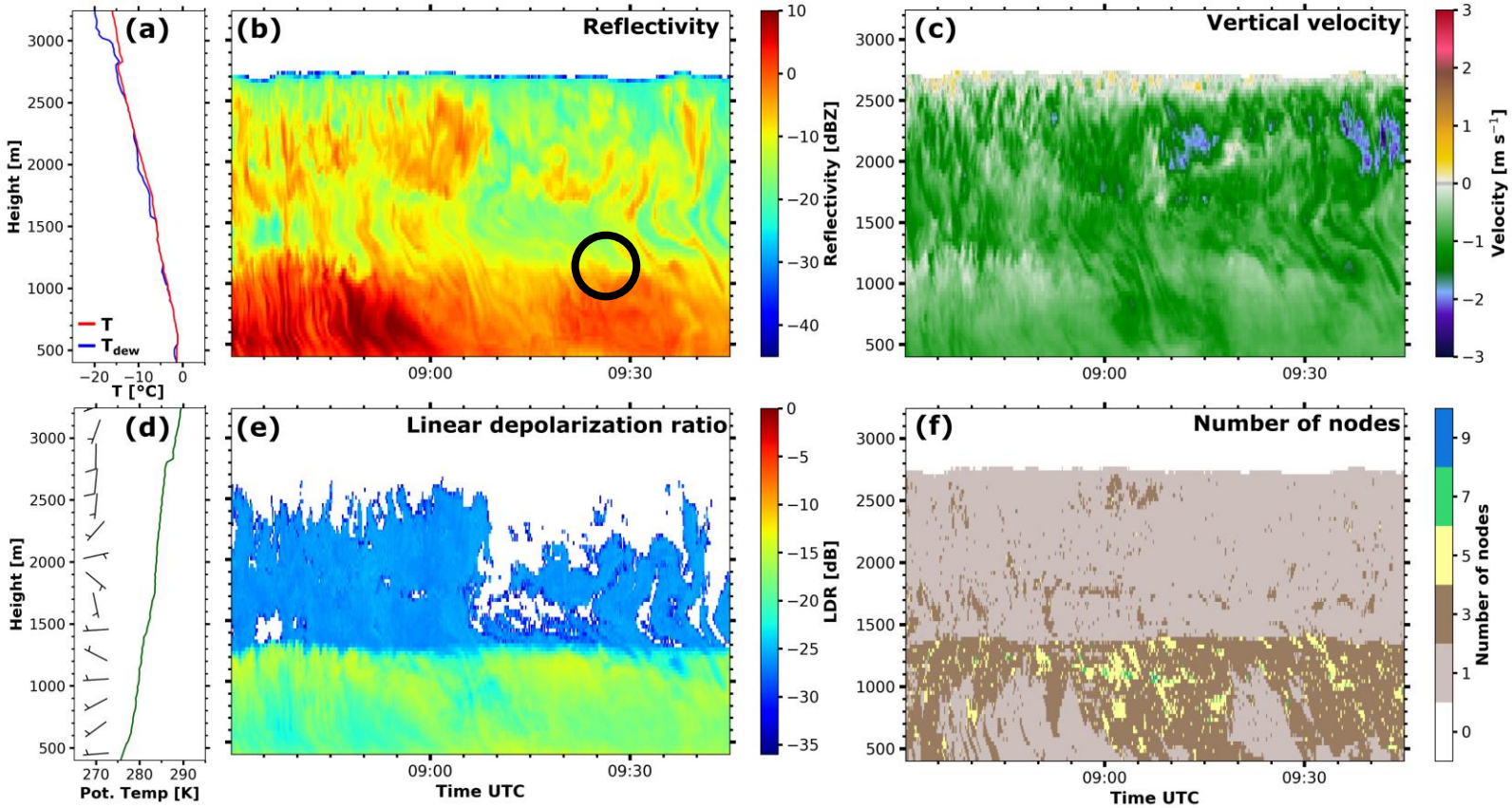
Example: 29 June 2017 MIRA @ Polarstern (→ Talk by H. Griesche on Tuesday)



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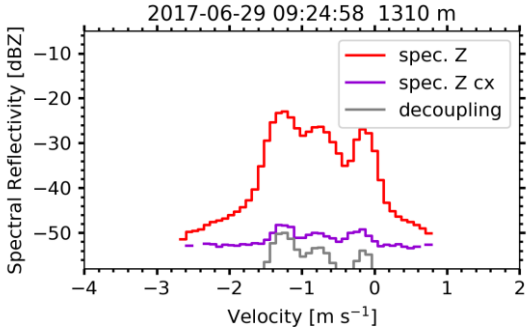
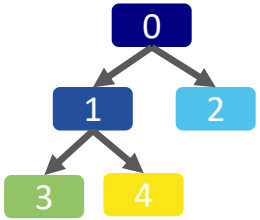
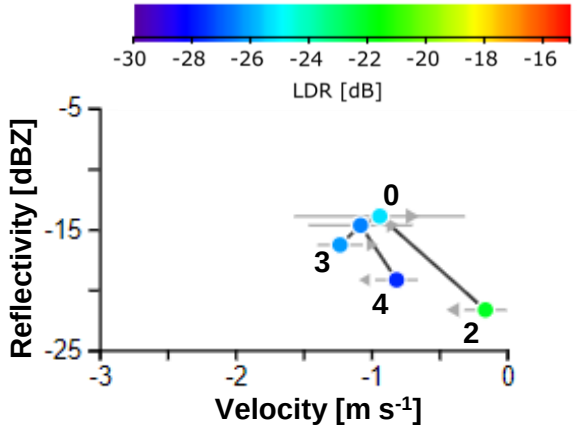
Visualizing the moments

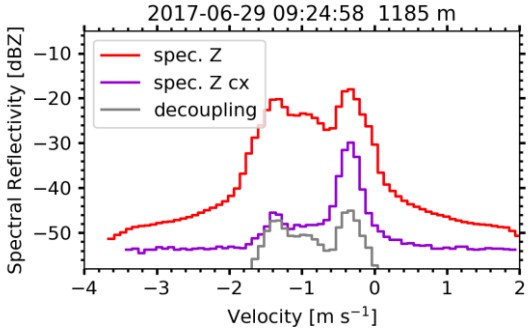


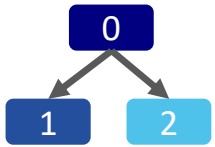


moments per node

id	Z	v	σ	γ	LDR
0	-13.98,	-0.93,	0.45,	0.71,	-25.3,
+- 1	-14.74,	-1.08,	0.27,	0.59,	-26.5,
| +- 3	-16.35,	-1.23,	0.12,	0.30,	-26.3,
| `- 4	-19.25,	-0.81,	0.11,	-0.21,	-27.7,
`- 2	-21.72,	-0.16,	0.11,	-0.58,	-22.0,

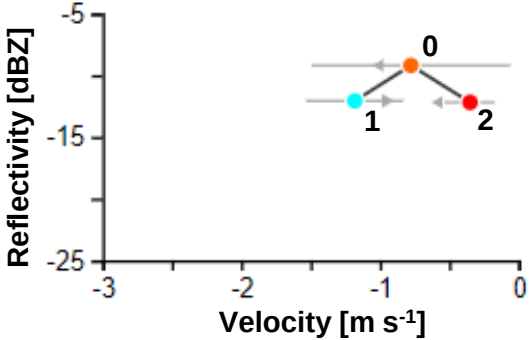




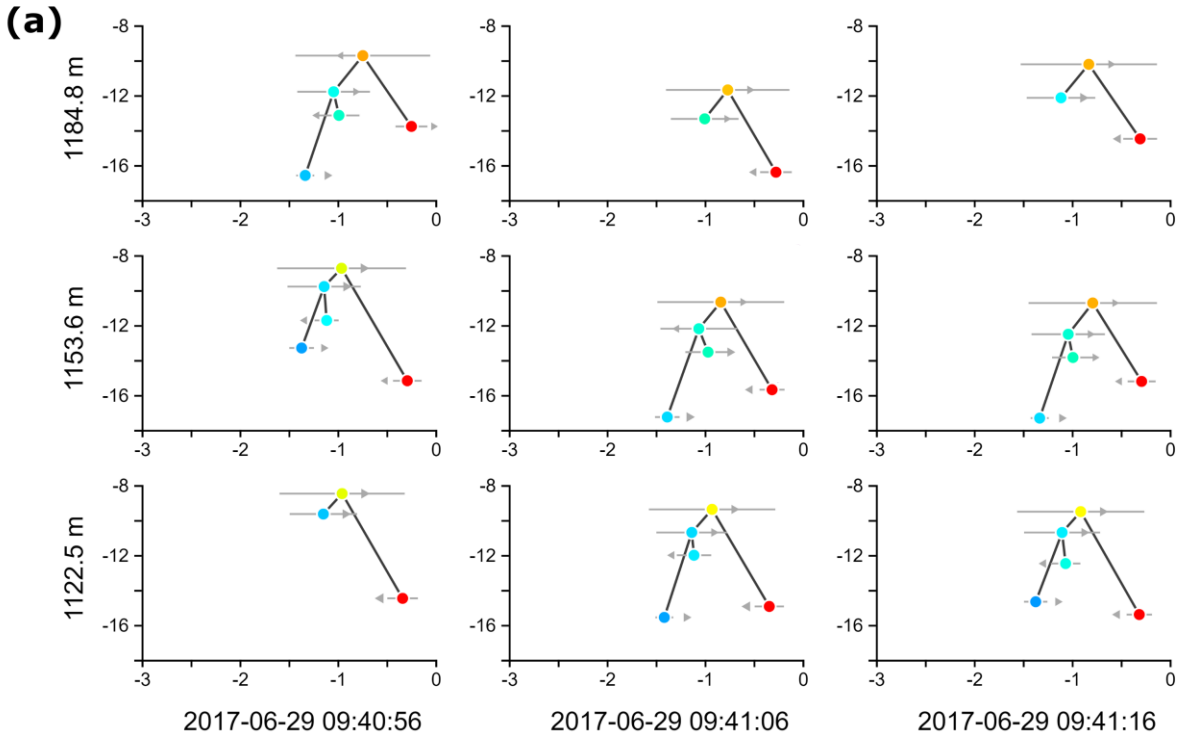


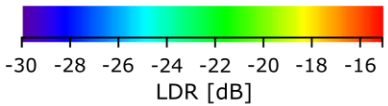
moments per node

id	Z	v	σ	γ	LDR
0	-9.23,	-0.78,	0.51,	-0.18,	-16.3,
+- 1	-12.11,	-1.18,	0.25,	0.43,	-24.9,
`- 2	-12.23,	-0.35,	0.13,	-0.21,	-13.6,

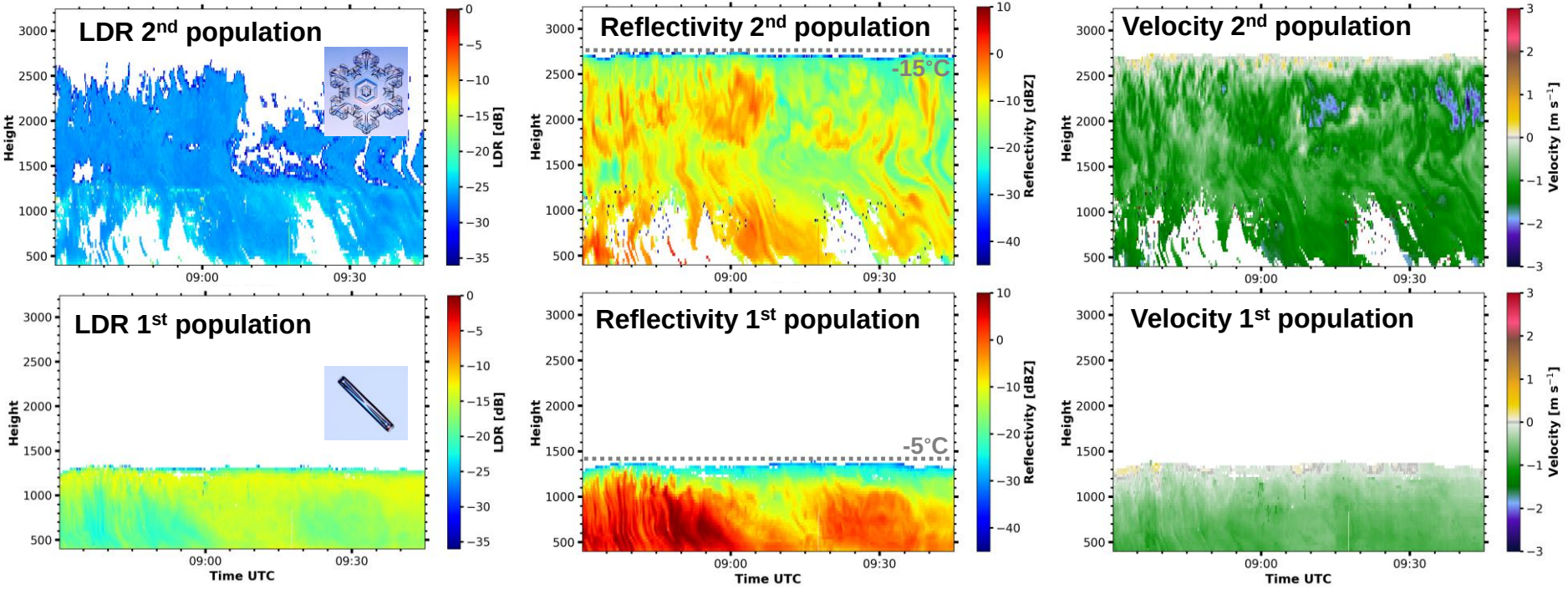


Grouping particle populations





Separating particle populations



Myagkov et al., AMT, 2016
Bühl et al., ACP, 2016

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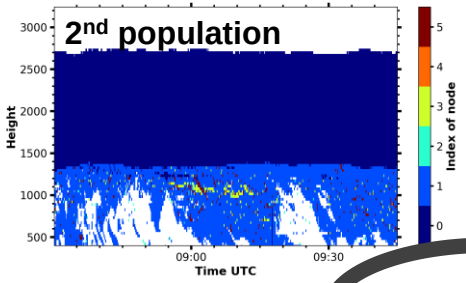
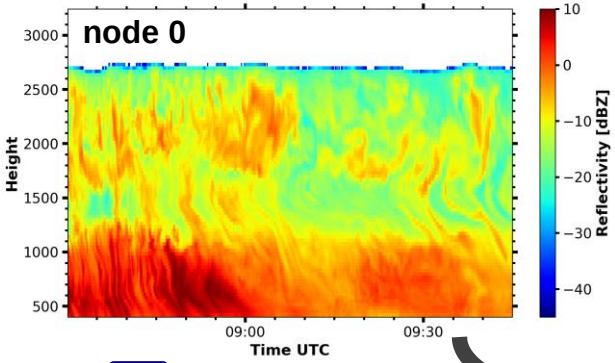
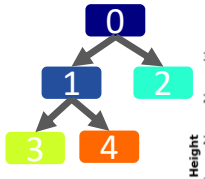
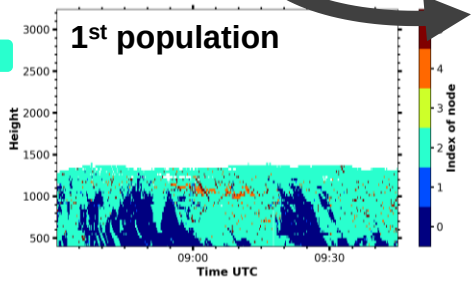
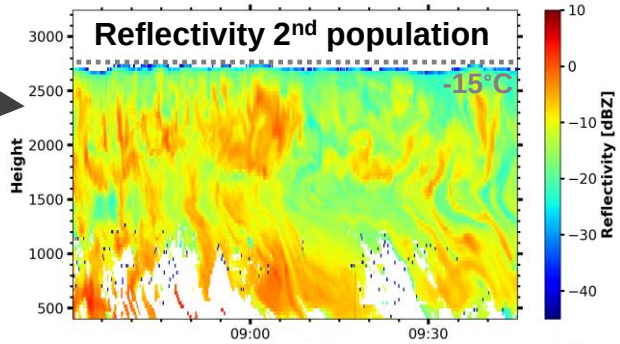
Separating particle populations

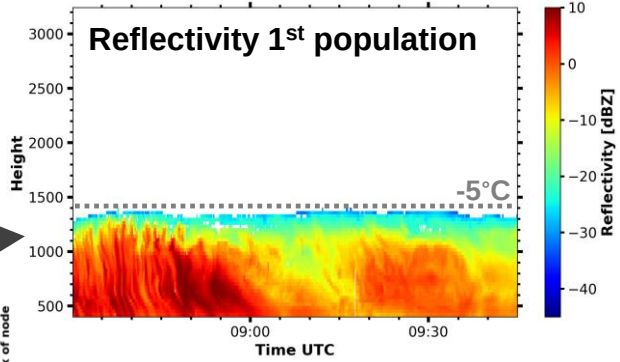


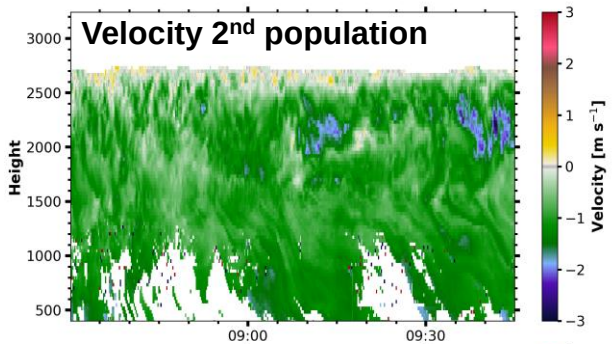


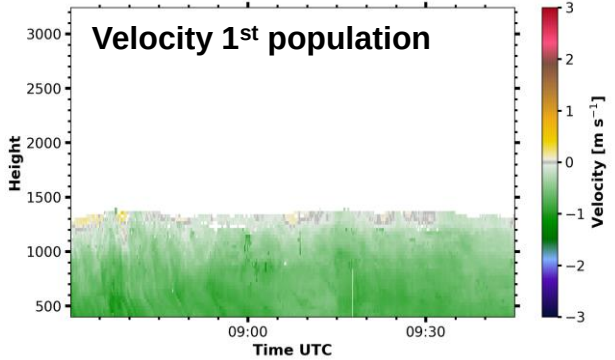






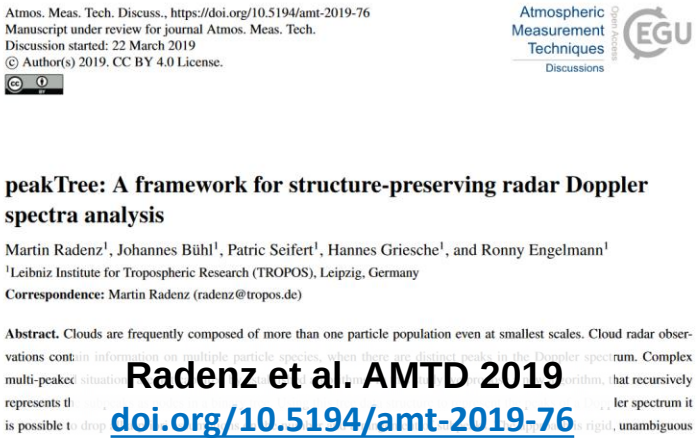






Conclusions and Outlook

- **Binary trees** are a flexible and (mathematically) rigid **data structure** for sub-peaks of **multi-peaked cloud radar spectra**.
- **No** prior **assumptions** on **number, arrangement** or **hierarchy** of peaks required.
- Backward compatible (node 0 = moments of full spectrum)
- tree representation can be used to separate particle populations
- future: combine with peako
  (Kalesse et al., AMTD 2019 + Poster upstairs)


Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2019-76
Manuscript under review for journal Atmos. Meas. Tech.
Discussion started: 22 March 2019

Atmospheric Measurement Techniques Discussions

peakTree: A framework for structure-preserving radar Doppler spectra analysis

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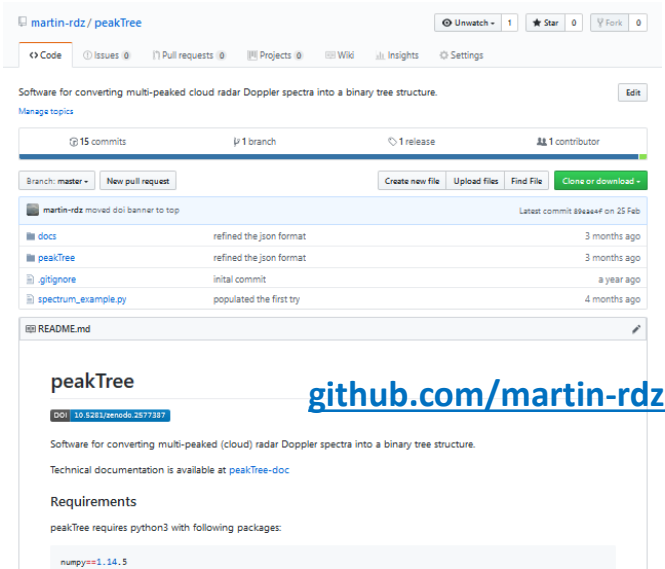
Abstract. Clouds are frequently composed of more than one particle population even at smallest scales. Cloud radar obser-
vations cont… information on multiple particle species, when the … Doppler spectrum. Complex
multi-peaked situati… algorithm, that recursively
represents th… ler spectrum it
is possible t… rigid, unambiguous

Radenz et al. AMTD 2019
doi.org/10.5194/amt-2019-76



github.com/martin-rdz/peakTree

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