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The PEAKO-peakTree toolkit:

ANALYZING & INTERPRETING CLOUD RADAR DOPPLER SPECTRUM PEAKS

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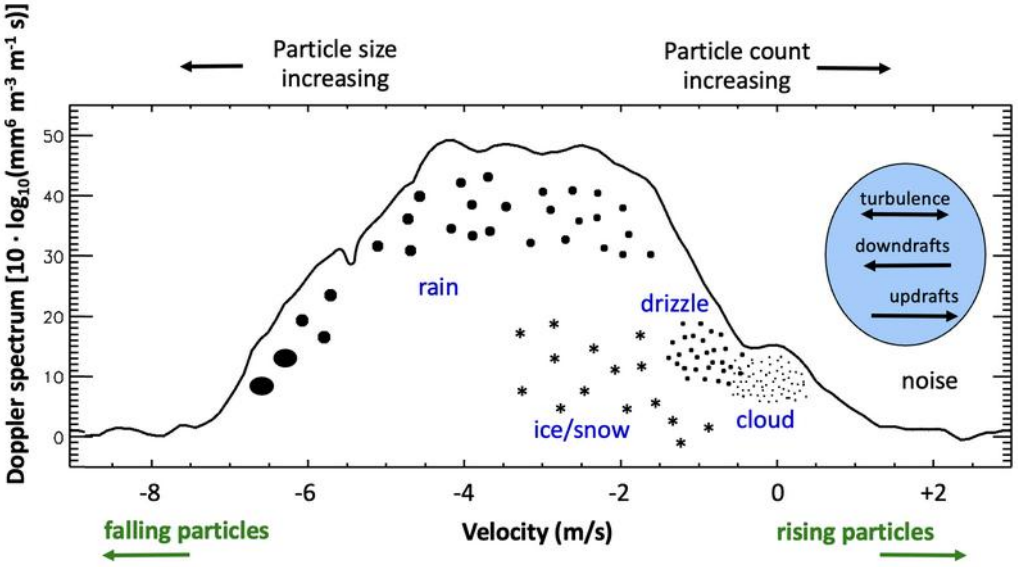
Heike Kalesse-Los

CLOUD RADAR DOPPLER SPECTRA

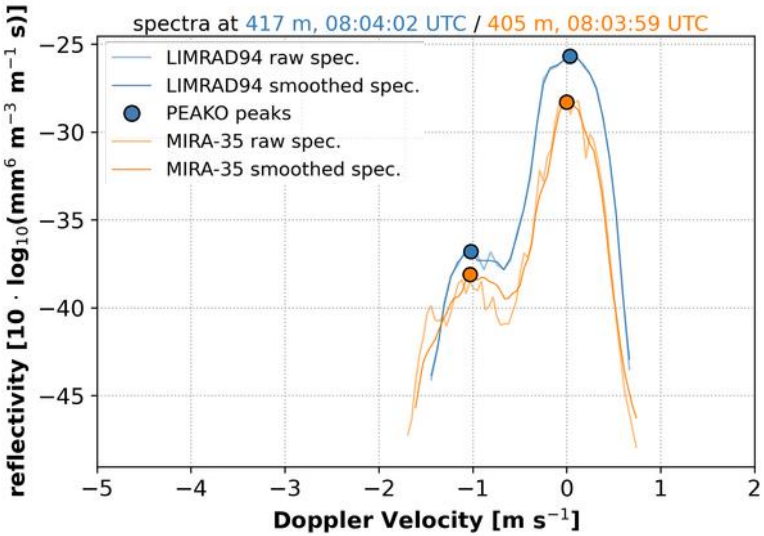


METEK 35.5 GHz cloud radar (MIRA-35)

RPG 94 GHz Cloud Radar (LIMRAD94)

PEAKO overview

PEAKO is a supervised radar Doppler spectrum peak finding algorithm. It finds the optimal parameters for detecting peaks in cloud radar Doppler spectra based on user-generated training data.



PEAKO is used to:

- create labeled data (peaks marked by a user in cloud radar Doppler spectra), which are used for training and testing the learned function
- train the algorithm using the labeled data to obtain the **optimal parameter combination for peak detection**
- detect peaks in cloud radar Doppler spectra using the learned function for new data sets

input to peakTree

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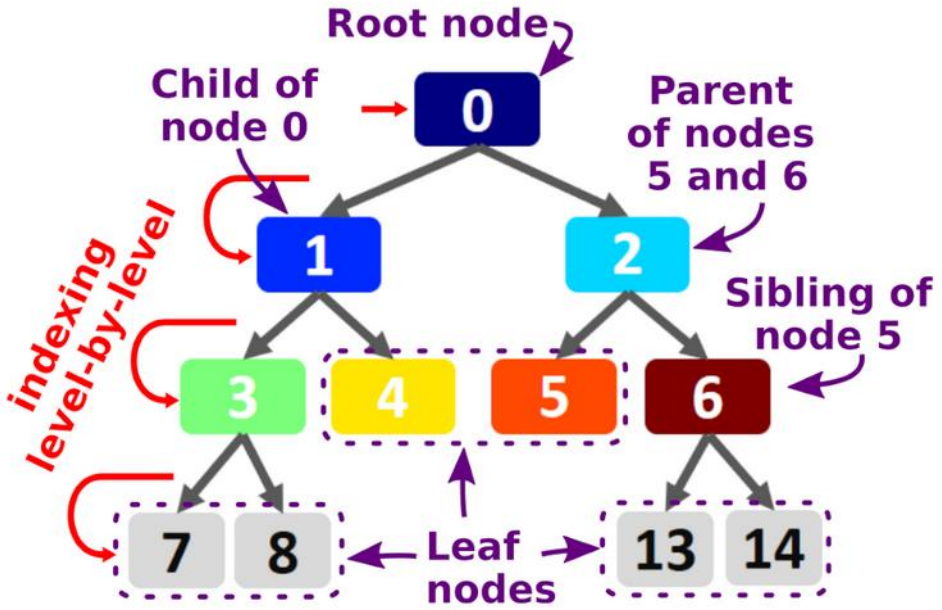
peakTree: Peak structuring with binary trees



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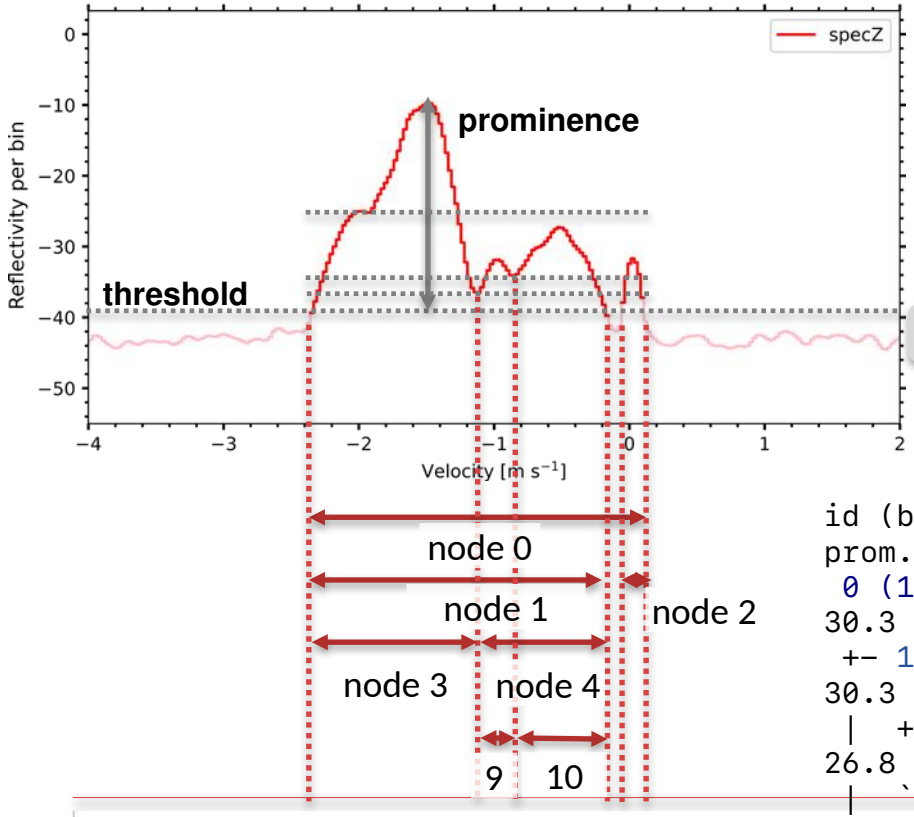
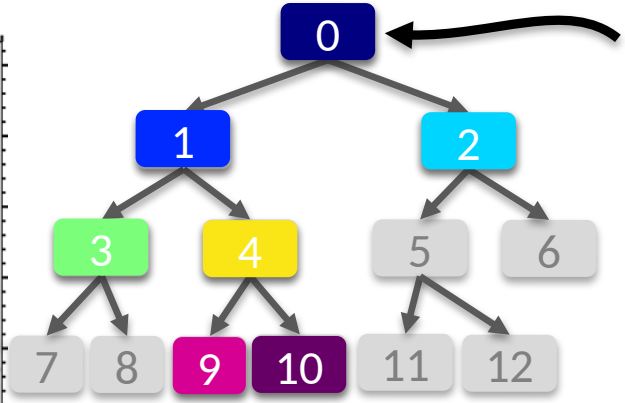
Represent (sub-)peaks as nodes in a binary tree





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,
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```


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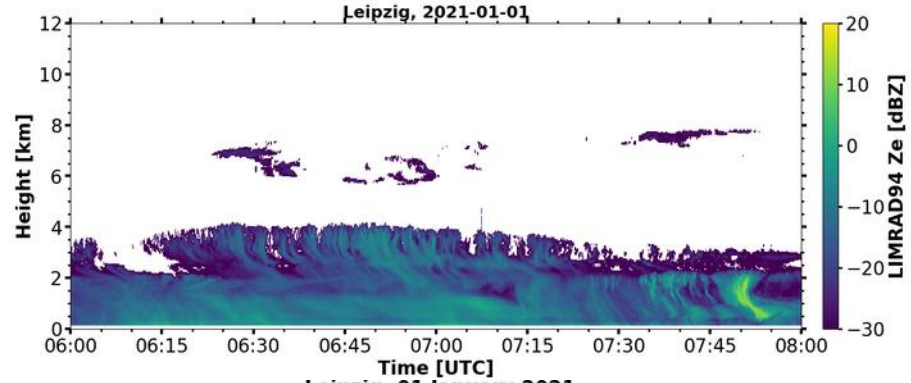
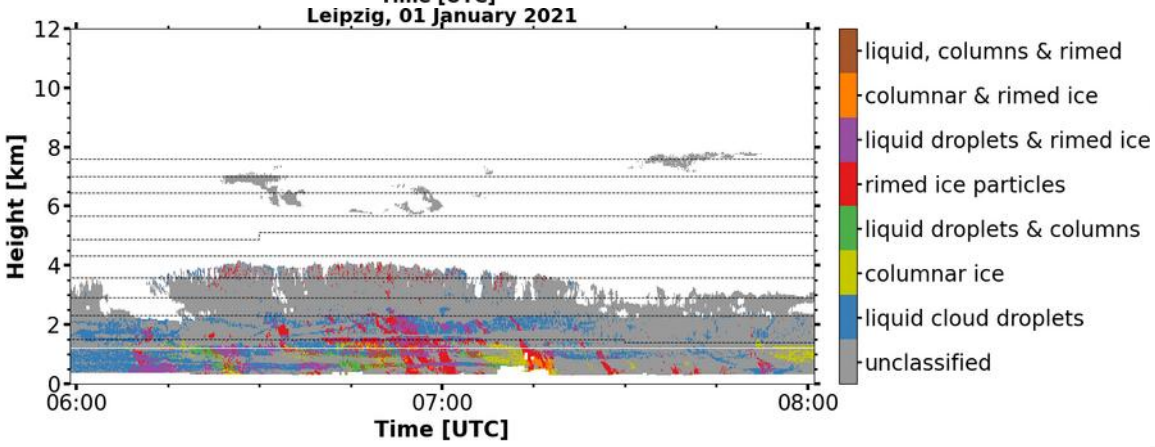
application examples

1. **hydrometeor classification**
   → statistics for long data sets

2. **deriving insect concentrations**

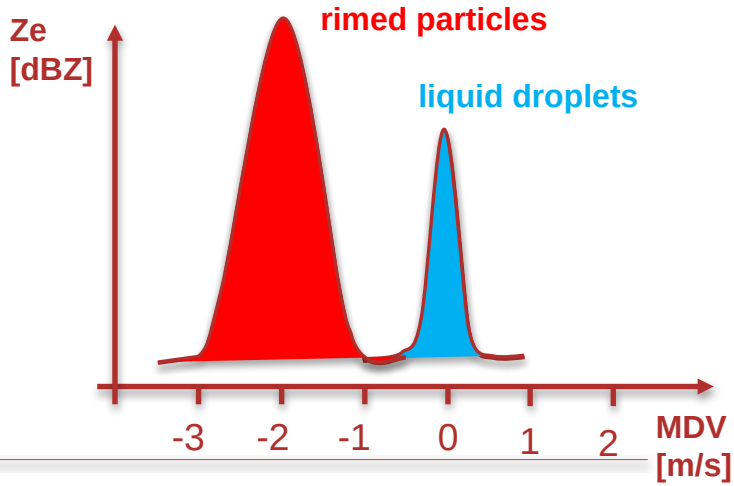
peak-based hydrometeor classification





assigning hydrometeor types based on peak properties

- liquid: low MDV, low Ze, low LDR
- columnar ice: low Ze, high LDR
- rimed particles: falling more than 1.5 m/s faster than another slower-falling peak



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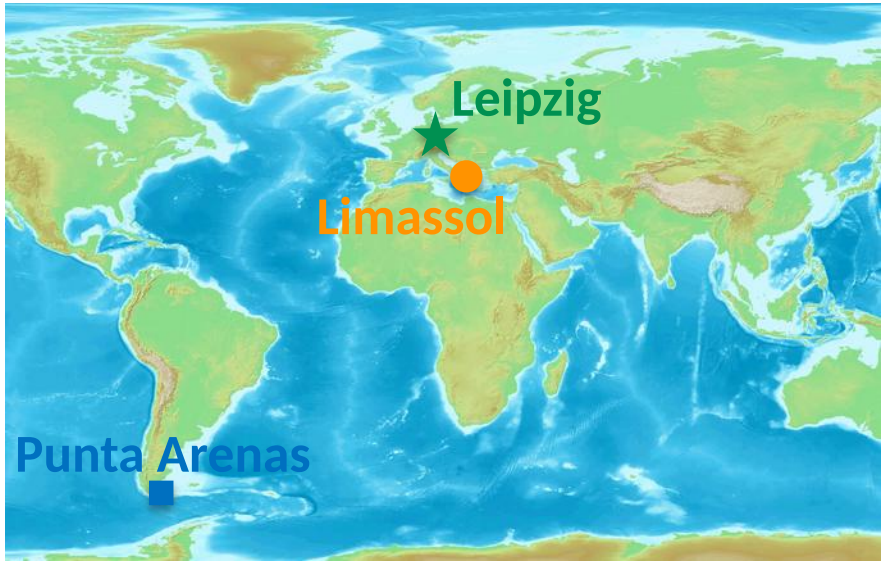
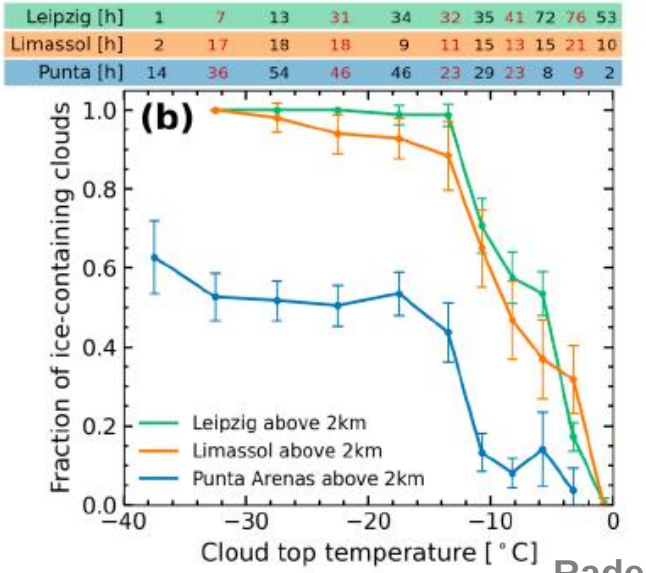
OBSERVED CONTRAST IN CLOUD PHASE

→ Central Europe vs. Southern Chile: stark contrast in ice formation efficiency in thin stratiform clouds likely due to INP availability (Radenz et al., 2021)

→ **contrasts in riming occurrence in thick cloud systems?**

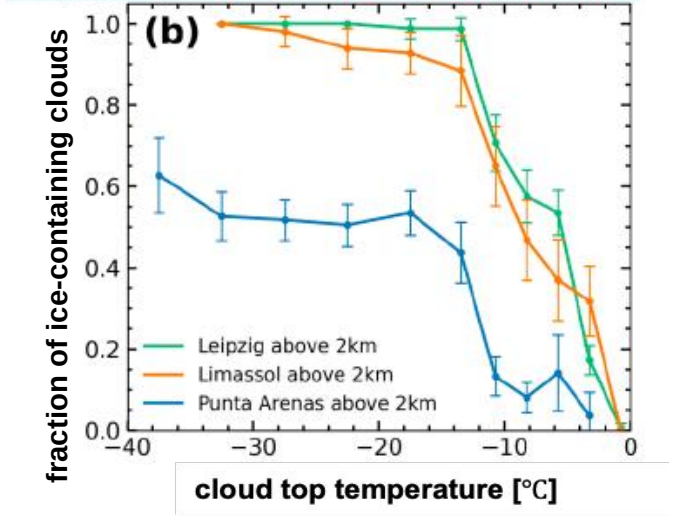


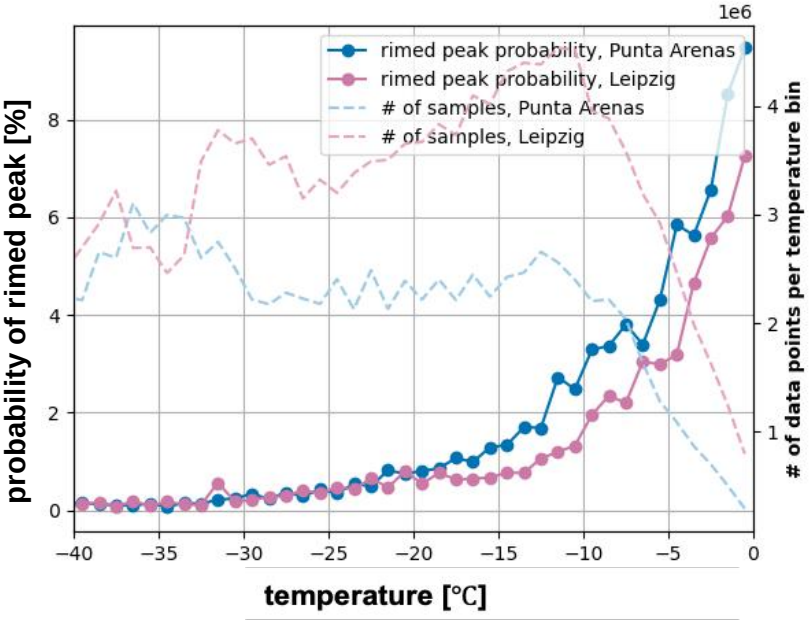


Radenz, 2021

OBSERVED CONTRAST IN RIMING

Leipzig [h]	1	7	13	31	34	32	35	41	72	76	53
Limassol [h]	2	17	18	18	9	11	15	13	15	21	10
Punta [h]	14	36	54	46	46	23	29	23	8	9	2





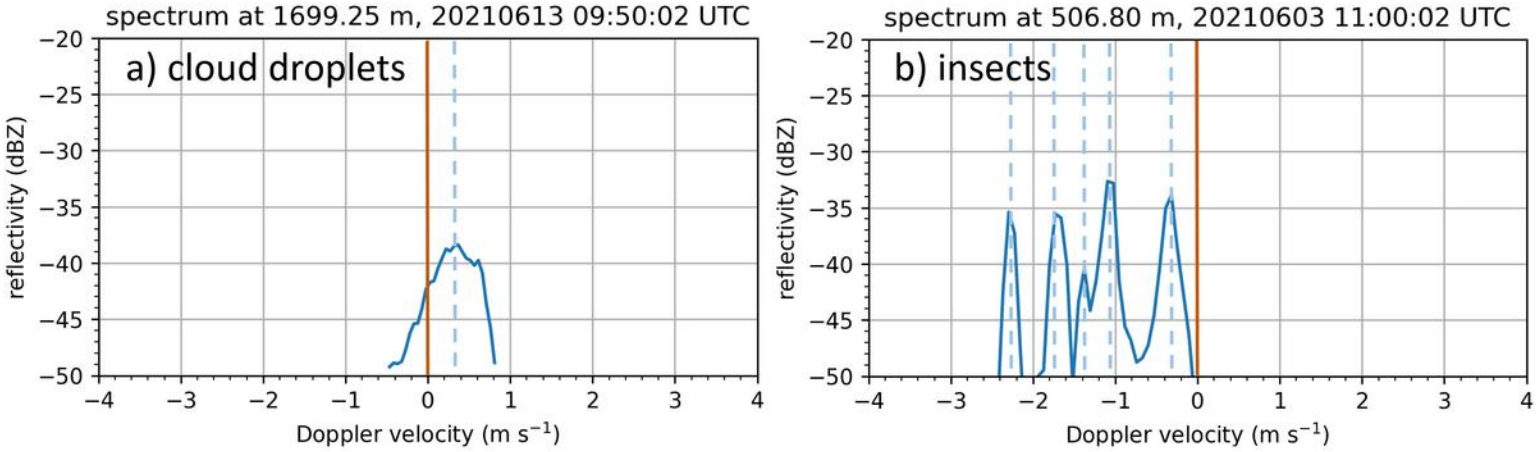
! preliminary !

DETECTING INSECTS WITH PEAKO/PEAKTREE

- insects have a characteristic signature in Doppler spectra (sharp, narrow peaks)
- for sufficiently narrow peaks, it can be assumed that one peak = one insect (Wood et al., 2009)

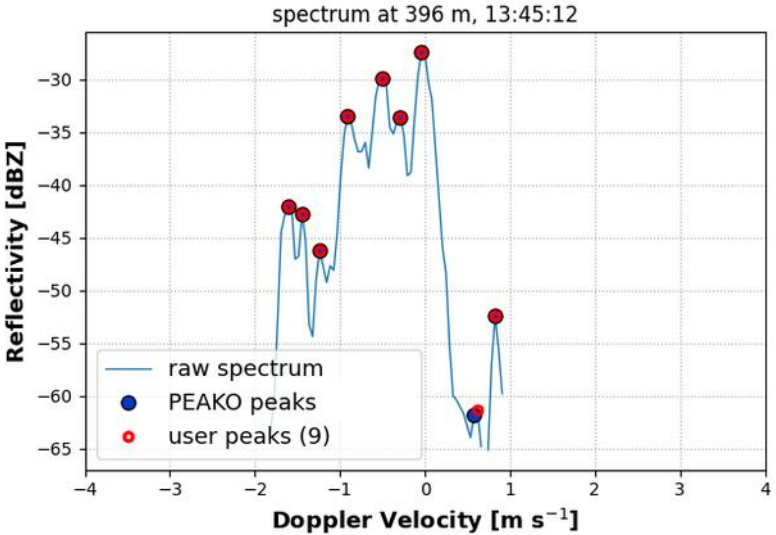
→number of peaks = number of insects

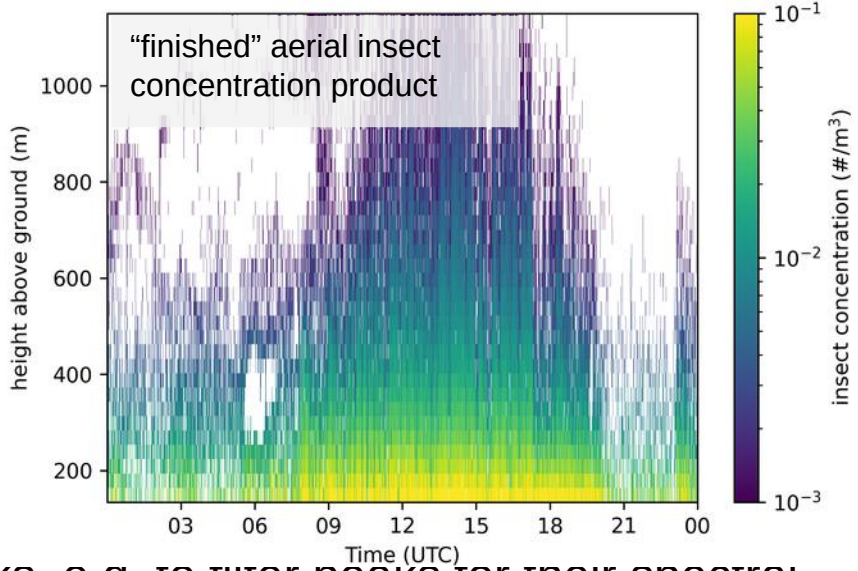
preprint



DETECTING INSECTS WITH PEAKO/PEAKTREE

- **PEAKO** for finding peak-finding parameters:





- **peakTree** to analyze individual peaks, e.g. to filter peaks for their spectral width, signal to noise ratio or reflectivity

THANKS FOR YOUR ATTENTION!

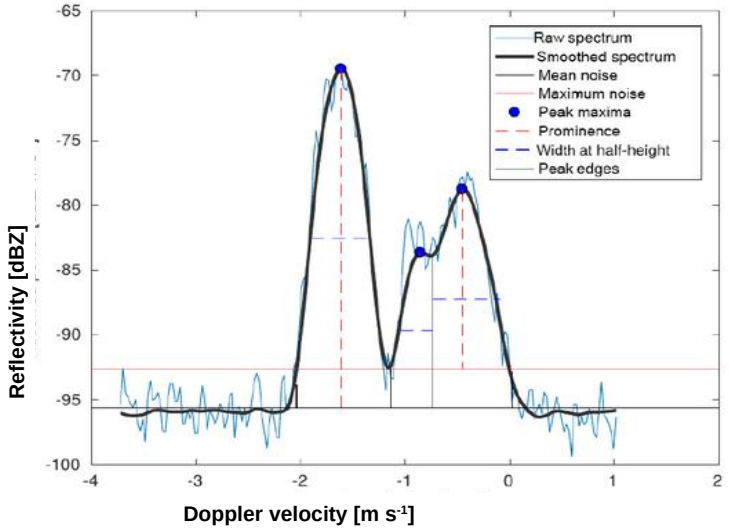
PEAKO: peak finding function

1) **average** neighboring spectra in **time and range**

2) smooth the averaged spectrum using a **smoothing span** [m s^{-1}] and a **polynomial** of a certain **degree** (Savitzky-Golay smoothing method)

3) find peaks (maxima in the resulting spectrum), using scipy.signal.find_peaks

4) keep only those peaks having a **minimum peak width** at half-height [m s^{-1}] and above a **minimum prominence** threshold [dB]



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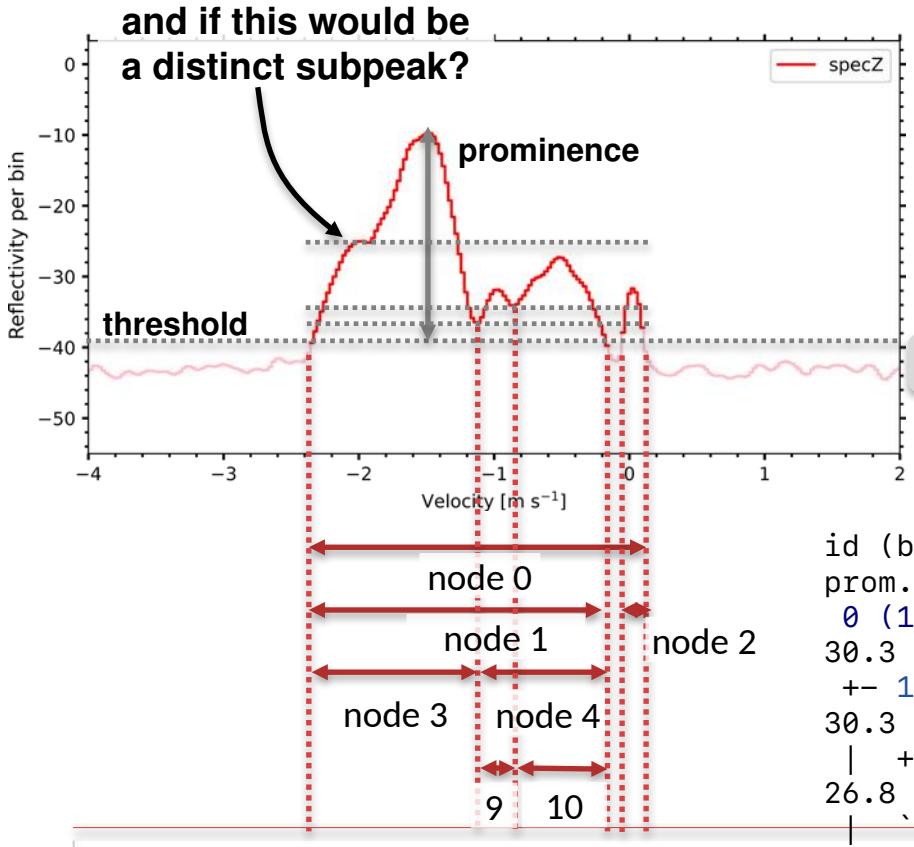

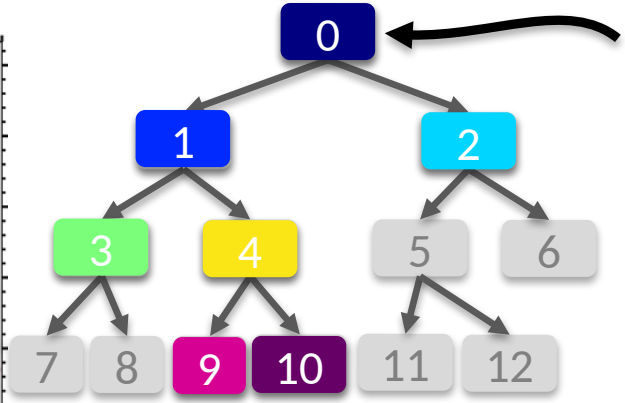

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