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Estimation of aerial insect concentration with cloud radars

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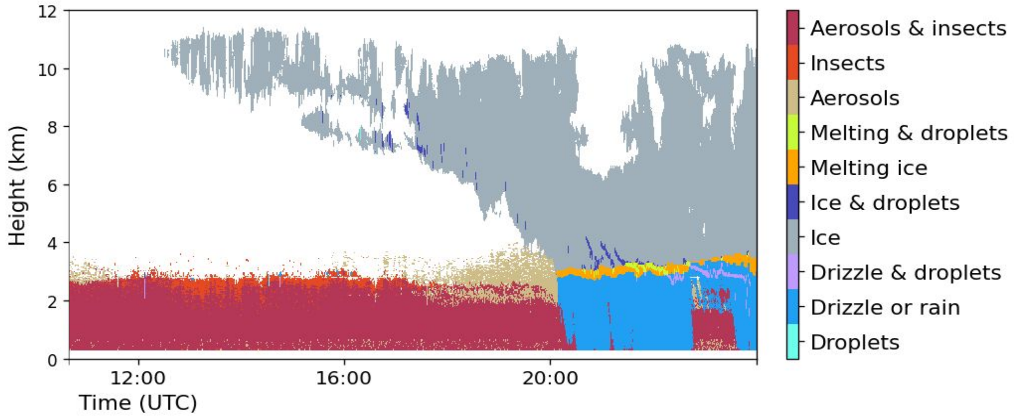
Motivation

- studies have reported strong declines in:
  - insect population sizes (e.g., Thomas et al., 2004)
  - insect abundances (e.g., van Klink et al, 2020)
  - insect biomass (e.g., Hallmann et al, 2017)
- insects are vital to food security and a functioning eco system
- flying insects traverse at “high” altitudes (>50 m) for mating, food and migration
  - active fliers: contribute to their velocity and directionality, but can still be caught in up-/downdrafts
  - non-active fliers: rely on wind and thermals for their movements
- information about where and when flying insects occur in the air space is sparse (Knop et al., 2023)
- cloud and weather radars continuously observe flying insects, albeit usually as unwanted clutter

Methodology – identifying insects

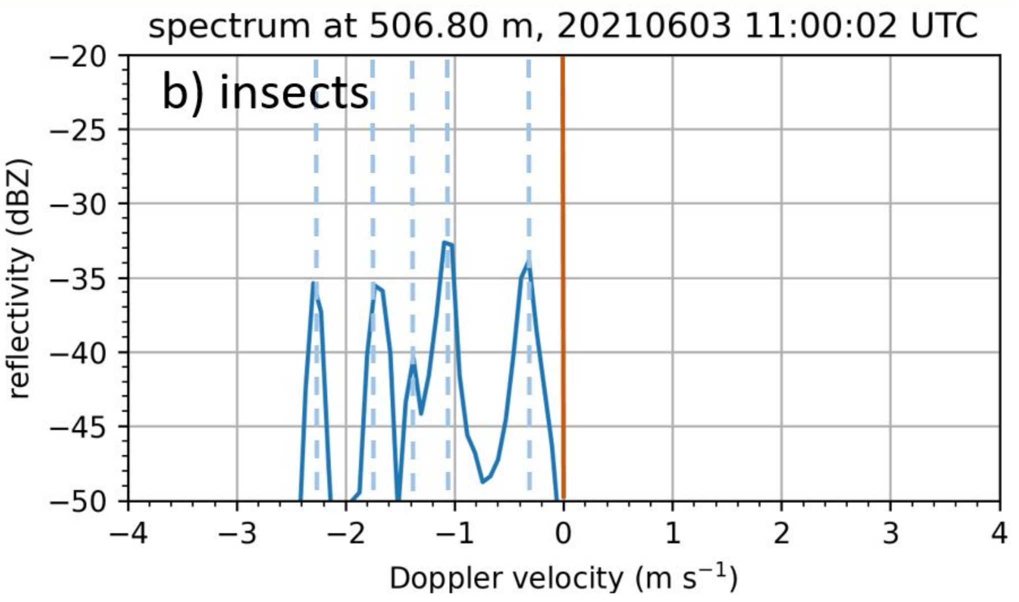
from Cloudnet products:

- filter insect pixels with Cloudnet target classification
  - some misclassification issues regarding insects, but if we generously remove clouds and precipitation profiles these issues are reduced
- insect mask from Cloudnet target classification (assumption: all insects)



from cloud radar raw data:

- insects appear as sharp, narrow peaks in the Doppler spectrum
- assumption: every narrow peak = 1 insect (Wood et al., 2009)



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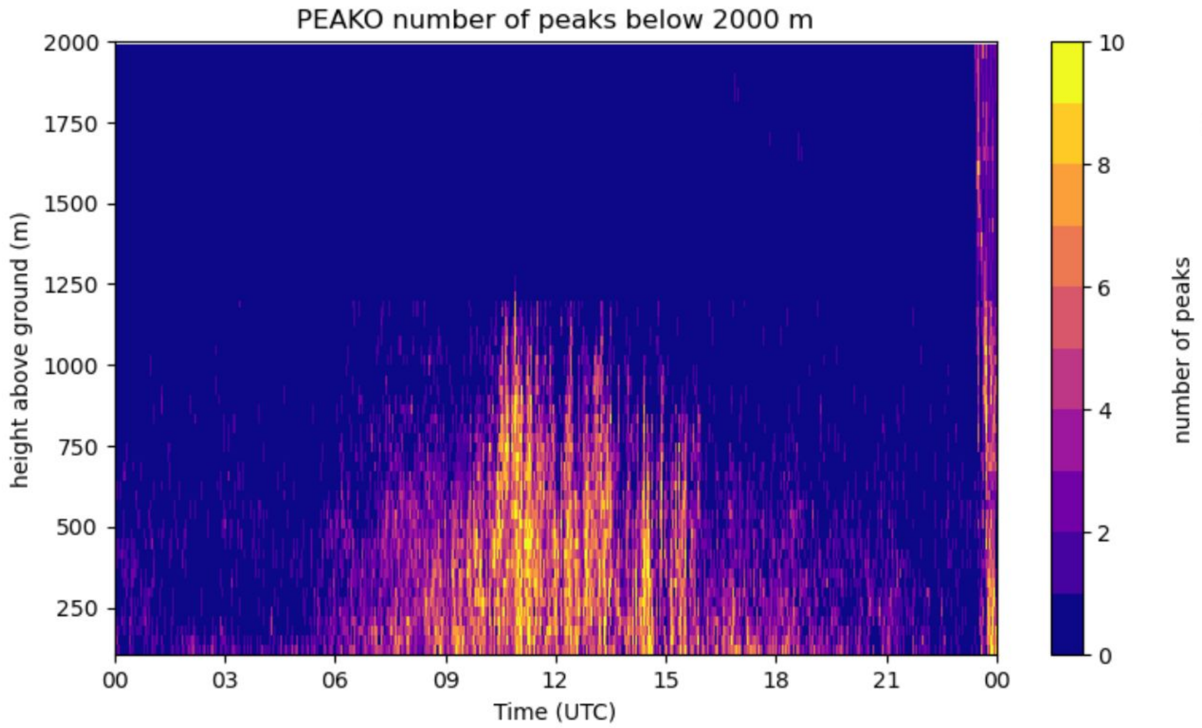
Methodology – peak finding algorithms

PEAKO (Kalesse et al., 2019; Vogl and Radenz et al., 2024):

- originally used to differentiate between different hydrometeor populations
- yields optimal parameters for peak detection based on user-marked training data set
- parameters depend on cloud radar configuration (e.g. chirp table)

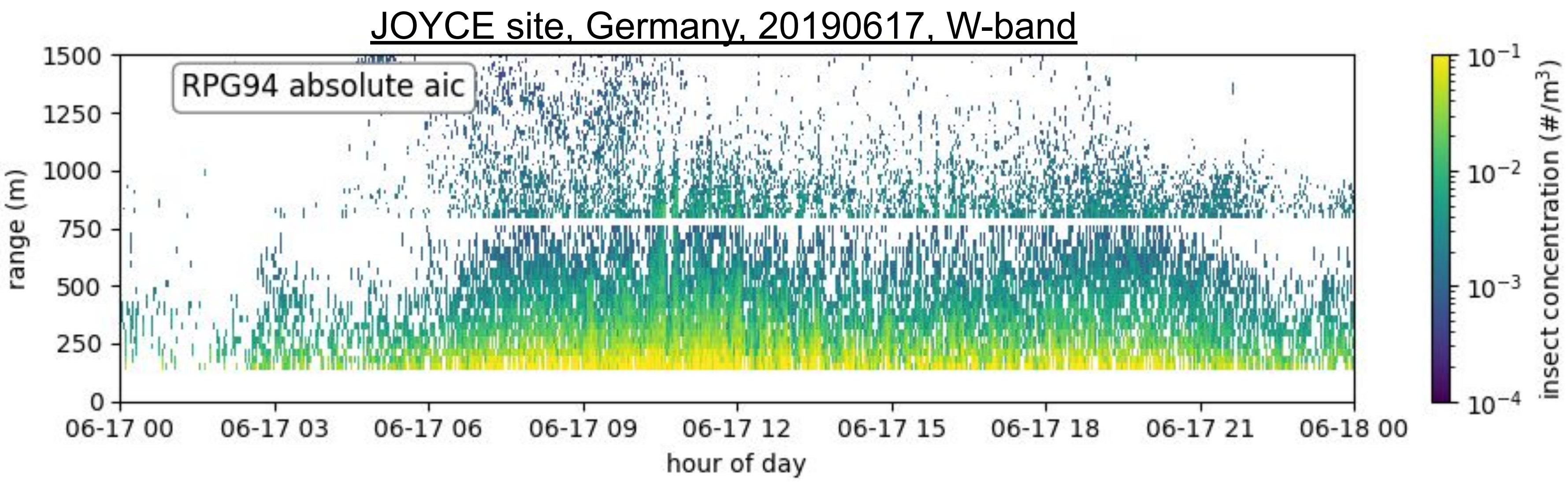
peakTree (Radenz et al., 2019; Vogl and Radenz et al., 2024)

- also originally used to study different hydrometeor types in an observation volume
- yields cloud radar variables for each individual peak



Methodology – information from cloud radar Doppler spectra

- application of PEAKO/peakTree algorithms to determine the number of peaks per range gate
- detected peaks are filtered with reflectivity, spectral width and signal-to-noise ratio
- divide number of peaks by radar observation volume to get aerial insect concentration ***aic***



Advantages of using Cloudnet cloud radar data

- observations at different frequencies
- high temporal resolution
  - technically few seconds, but resampling to a few minutes yields a smoother data set and is still sufficient for most entomological purposes
- high vertical resolution
  - depending on the specific data set, usually tens of meters
- sites all over Europe in (i) different climatic regions and with (ii) different site characteristics (urban, rural, continental, coastal)
- outlook: long standing time series for some sites to assess trends in insect activity between different years

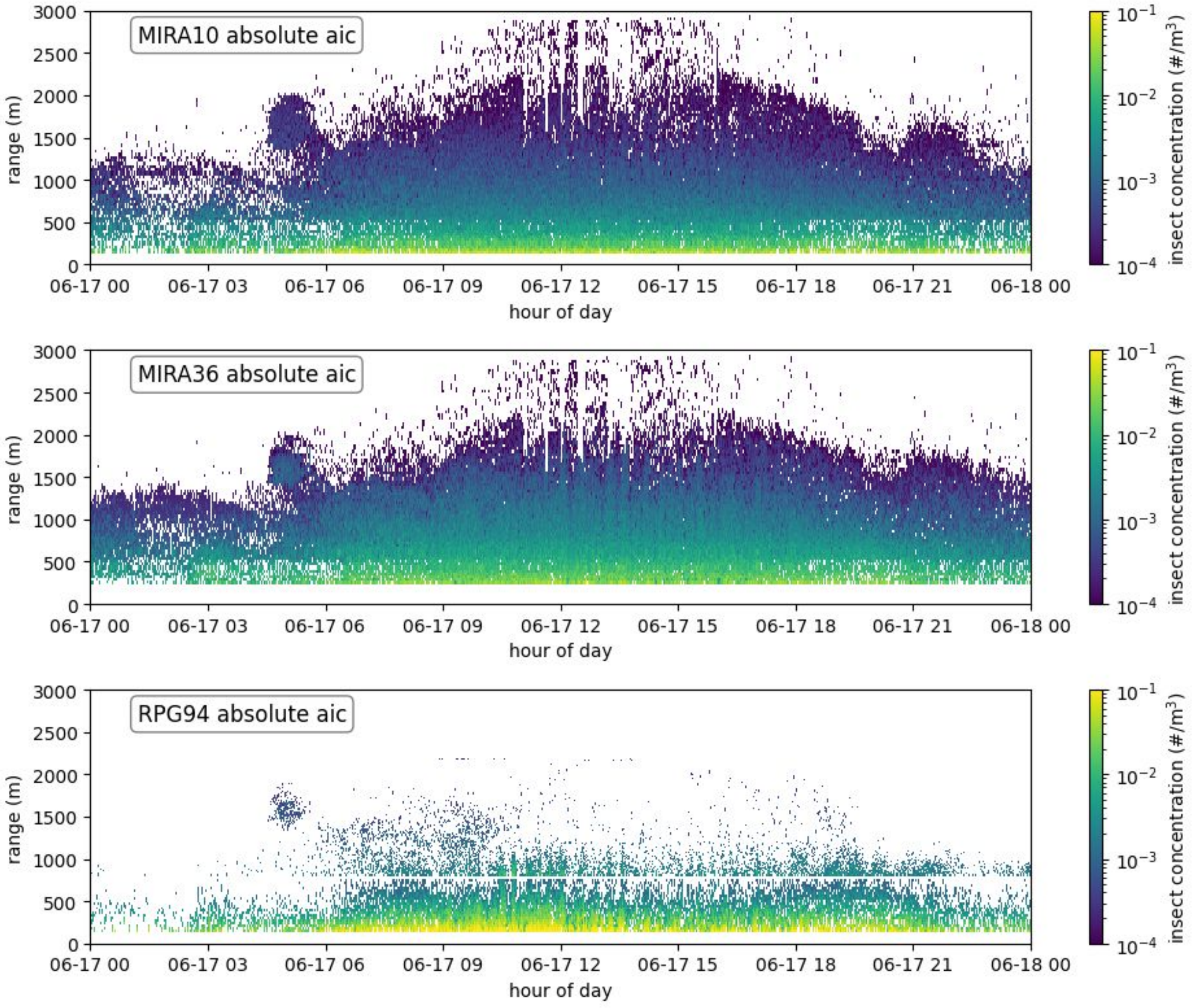
RESULTS

Derivation of aic at different frequencies

This is work in progress and all results are preliminary and may still be adjusted!

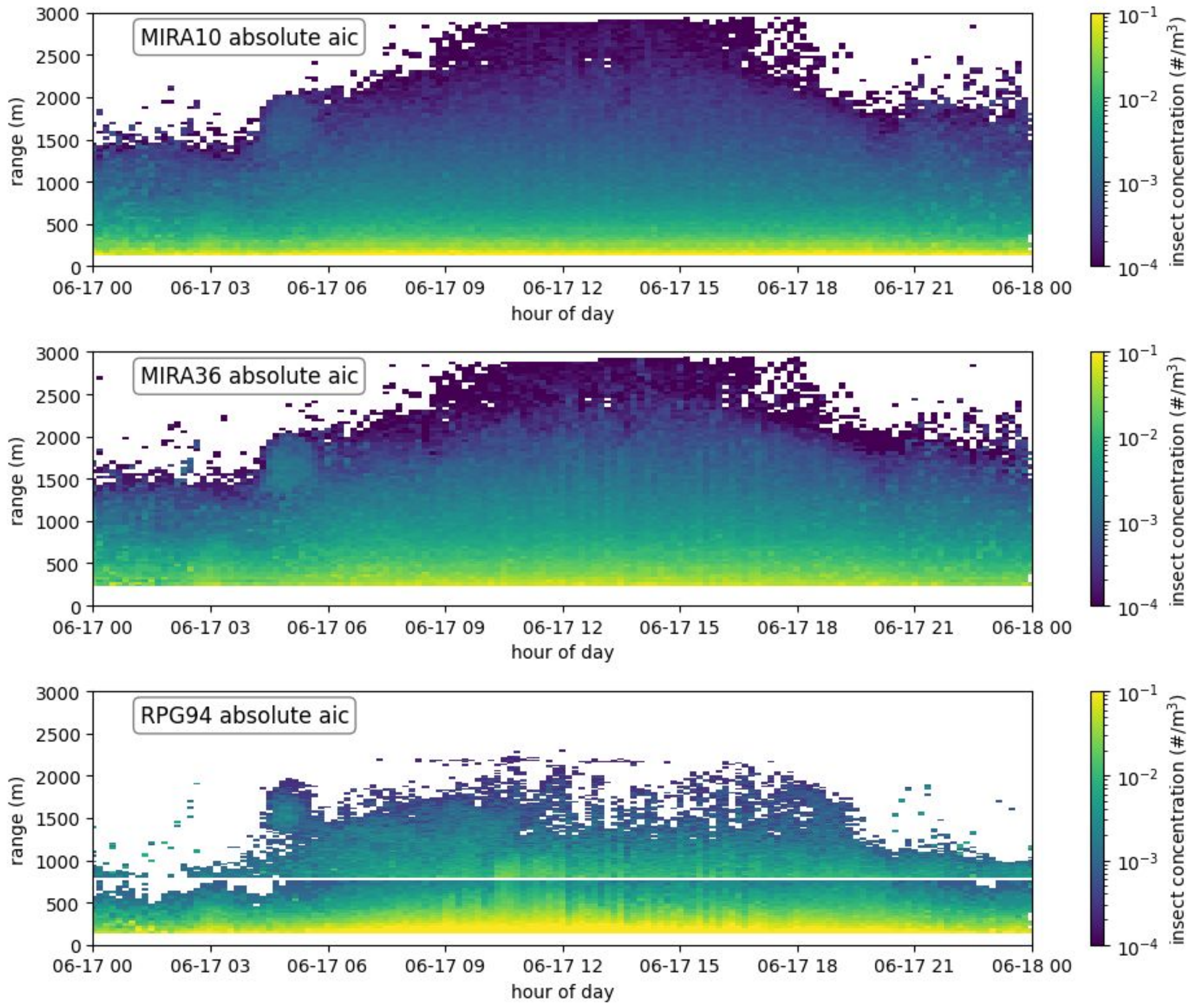
- analysis of 3-month data set from Jun-Aug 2019 in Jülich, Germany (JOYCE) for collocated measurements of X-, Ka and W-band radars

JOYCE site, Germany, 20190617



Derivation of aic at different frequencies

JOYCE site, Germany, 20190617



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- analysis of 3-month data set from Jun-Aug 2019 in Jülich, Germany (JOYCE) for collocated measurements of X-, Ka and W-band radars
- remove some noise by resampling to 10 min periods

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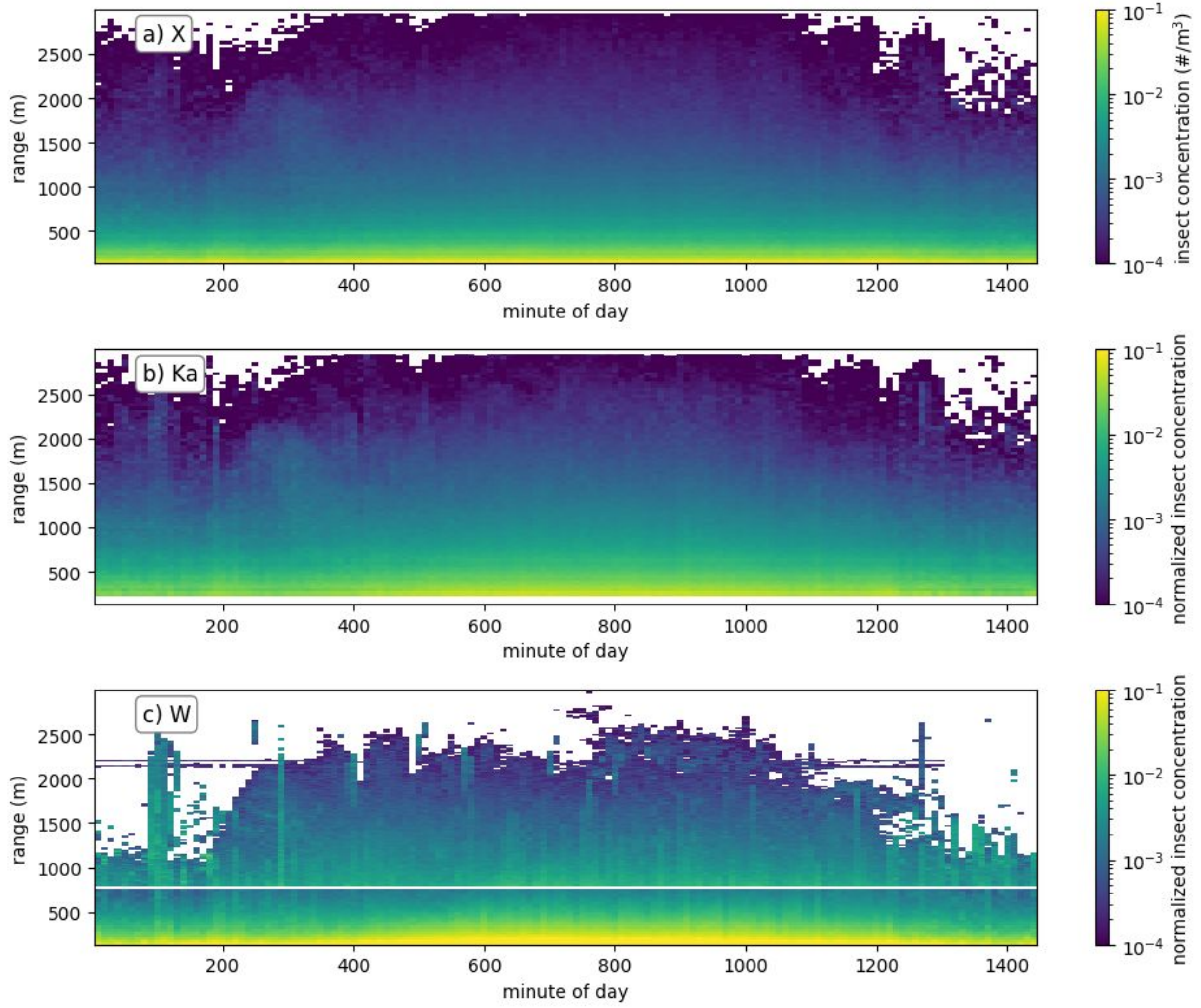
Derivation of aic at different frequencies

This is work in progress and all results are preliminary and may still be adjusted!

- analysis of 3-month data set from Jun-Aug 2019 in Jülich, Germany (JOYCE) for collocated measurements of X-, Ka and W-band radars
- statistical analysis of diel cycle, dependence on meteorological factors (e.g., temperature, wind), differences between ***aic*** at different radar frequencies
- here: mean ***aic*** for 10 min intervals over 14 days (06 June – 19 June 2019

JOYCE site, Germany, 14 days mean



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Conclusion & outlook

- cloud radars are a valuable tool for the detection of flying insects
- aerial insect concentration is derived from a combination of Cloudnet products and cloud radar Doppler spectra data (as of now: only for precipitation free situations)

outlook:

- application of this approach to 3 months JOYCE data set
- evaluation of other Cloudnet sites to find promising candidates for further application of this method and to assess interannual trends

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Thank you !

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