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Wind profiles from DCR and DL

CCRES Workshop Palaiseau 14-15 Nov 2022

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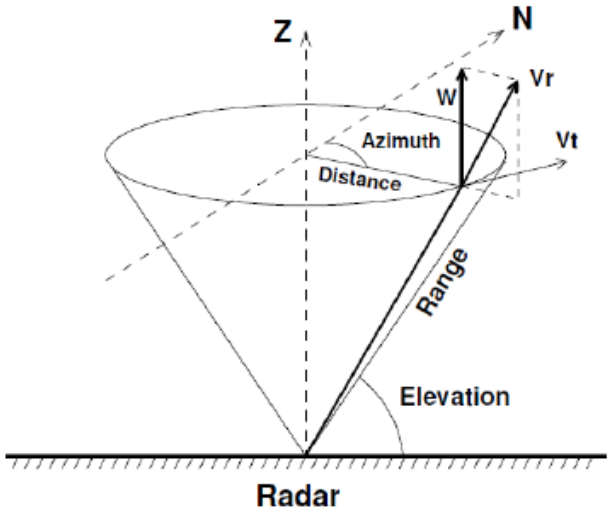
Motivation

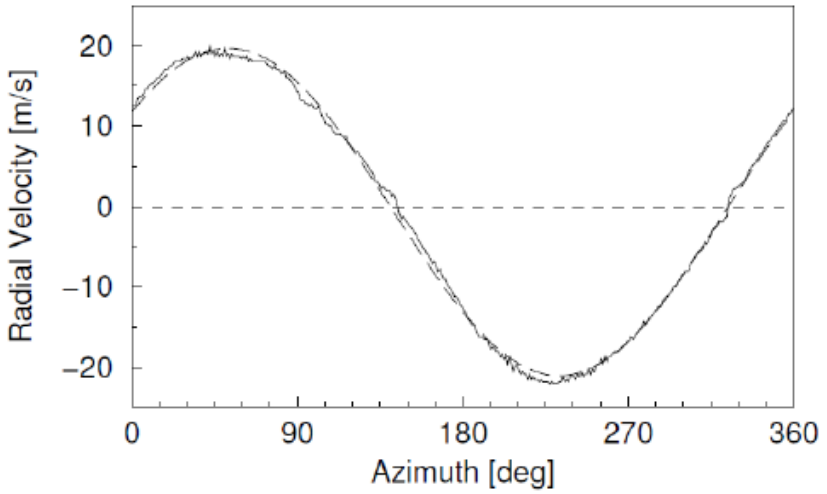
- Profiles of the horizontal wind can be obtained by ground-based remote sensing
  - Radar wind profiler (RWP)
  - Doppler wind lidar (DWL)
  - Doppler cloud radar (DCR)

➢ **ACTRIS cloud remote sensing network can provide wind profiles (DWL, DCR)**

Wind profiles - Methodology

- 3D wind vector can be derived from off-zenith azimuth scans by analyzing the Doppler shift along the line of sight („VAD scan“ Velocity Azimuth Display)





Holleman et al., 2005

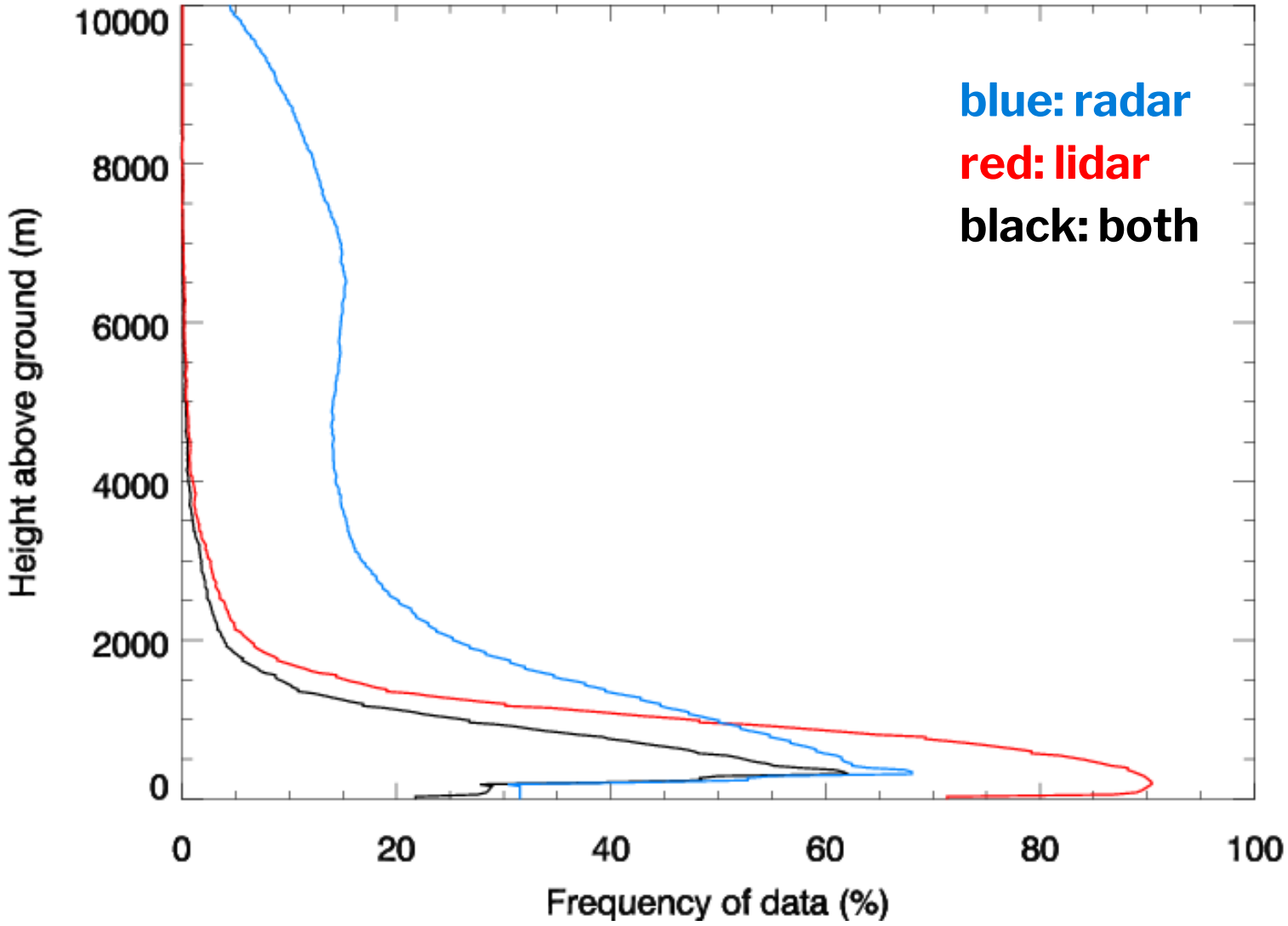
Wind profiles - Methodology

- Detection needs tracers that float with the air flow
  - RWP: Clear-air fluctuations of the refractive index (Bragg scattering)
  - DCR tracers: Cloud particles, Insects
  - DWL tracers: Aerosols
- Problems/Limitations:
  - Absence of tracers
  - Fall speed of particles (esp. rain)
  - Own movement of tracers (insects)
  - Attenuation of signal (esp. by clouds for DWL)
  - Assumption of homogeneous wind field (turbulence)
- Combination of methods (DCR+DWL) increases coverage

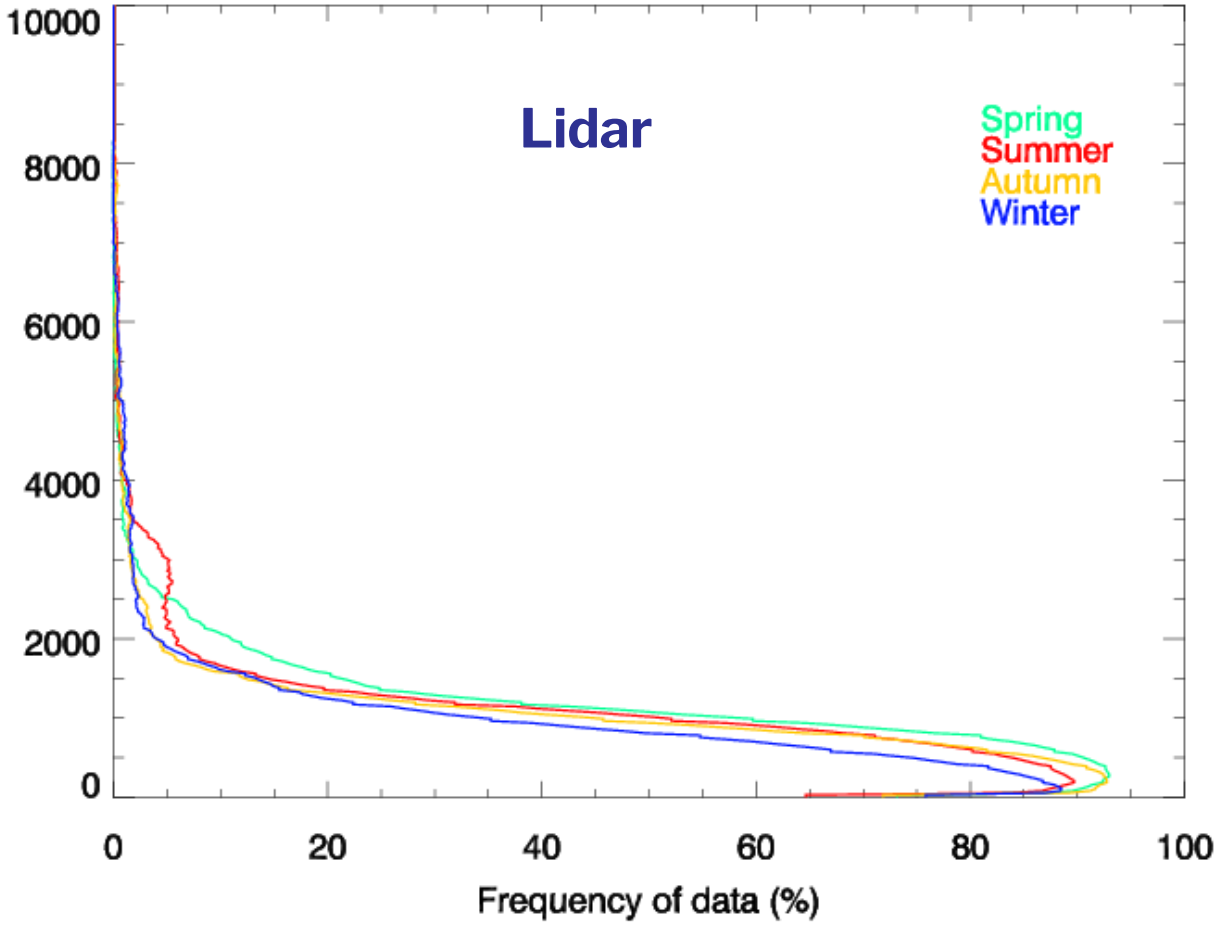
Combined product for wind profiles

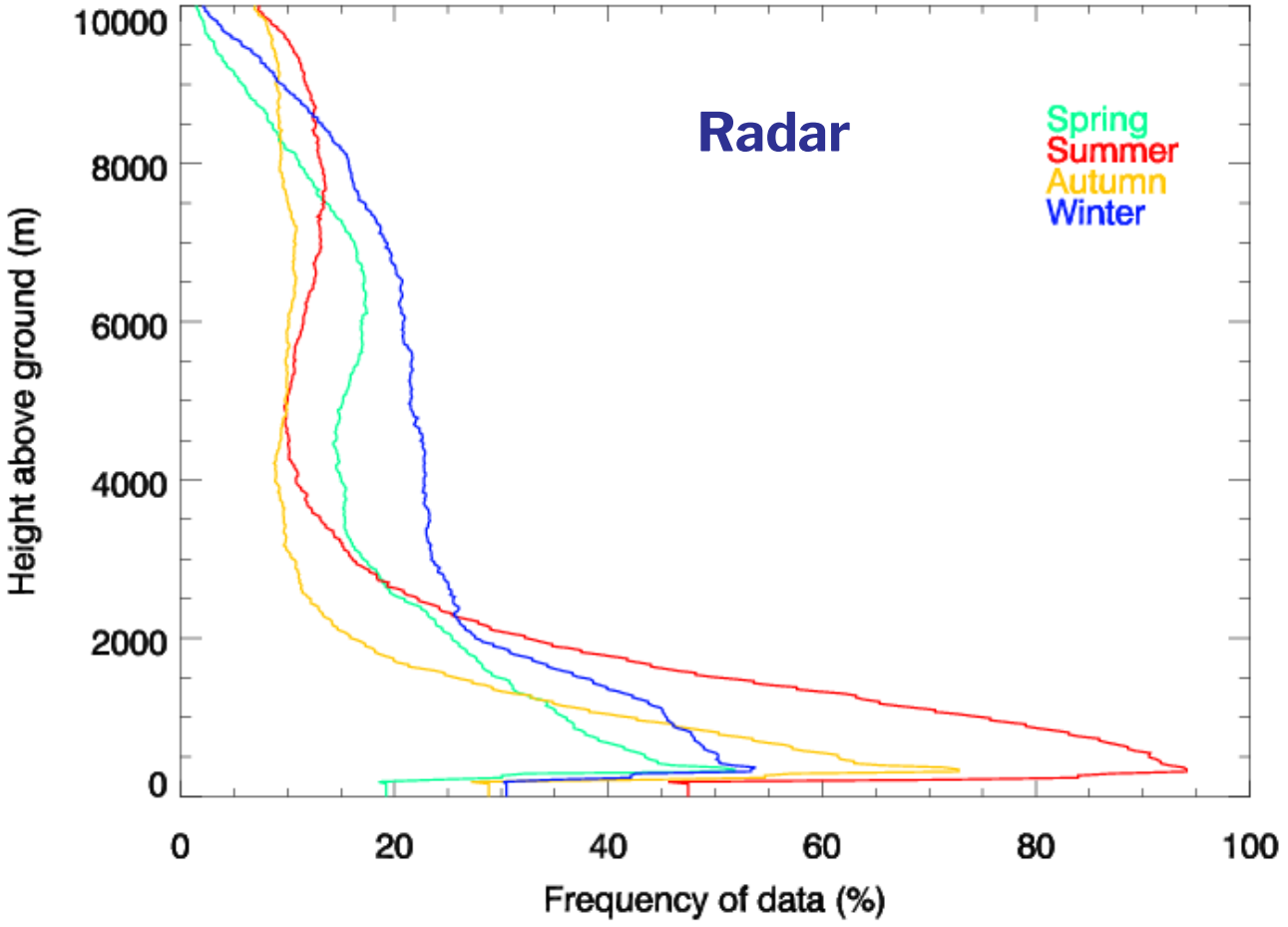
- **Doppler lidar VAD scan**
  - zenith angle 15°, every 15 minutes
  - 10 degrees angular resolution, spatial resolution 30 m
- **Cloud radar VAD scan**
  - zenith angle 8°, every 30 minutes
  - ~5 degrees angular resolution, spatial resolution 30 m
- **Combined product**
  - if both methods are available, a weighted mean of both speed and direction is used depending on the uncertainty of the fit, alternatively take always wind lidar if available
  - 26 m vertical resolution, 30 min temporal resolution

Data availability 2021

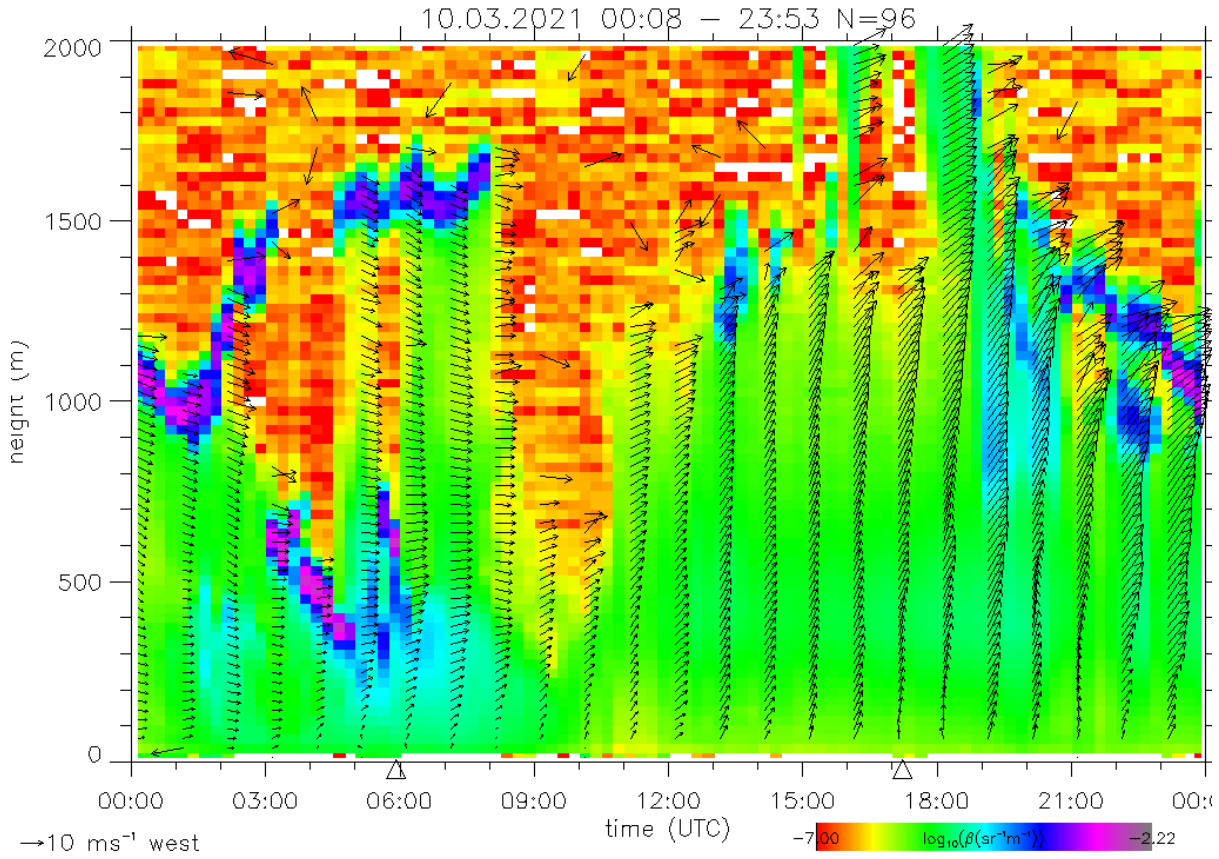


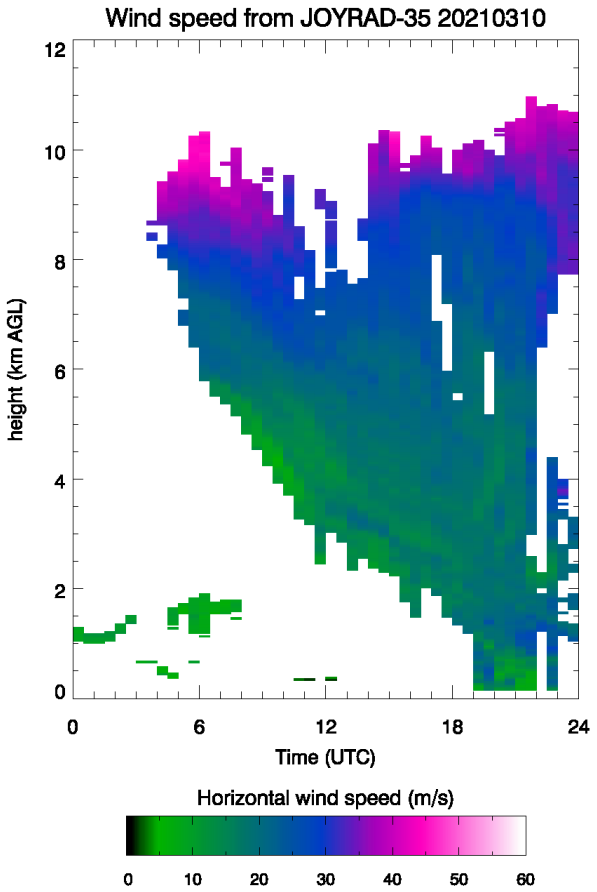
Data availability per season

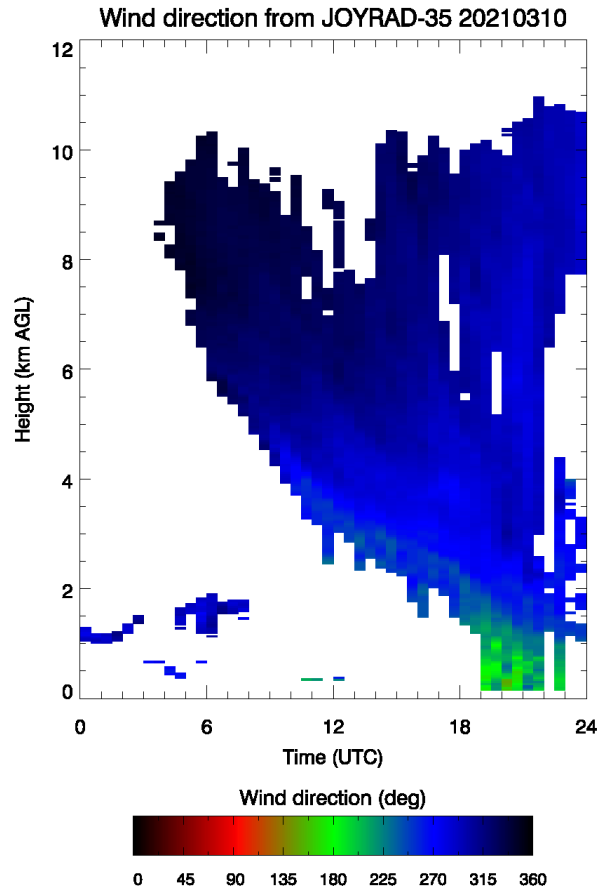




Example day - 10.03.2021







left: Wind lidar (0-2 km)
Wind direction + intensity

right: Cloud radar (0-12 km)
Wind speed/direction

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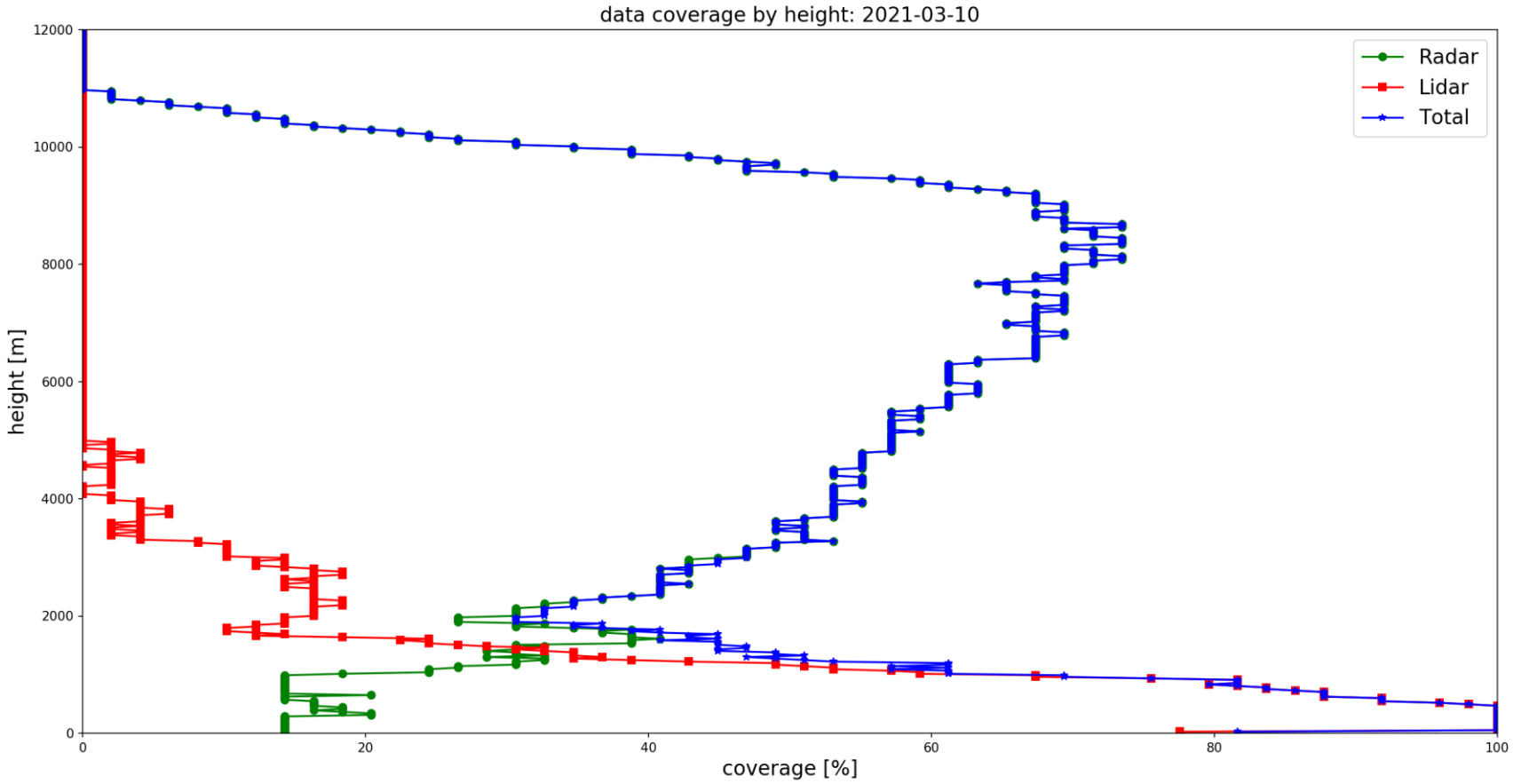
Example day – data coverage

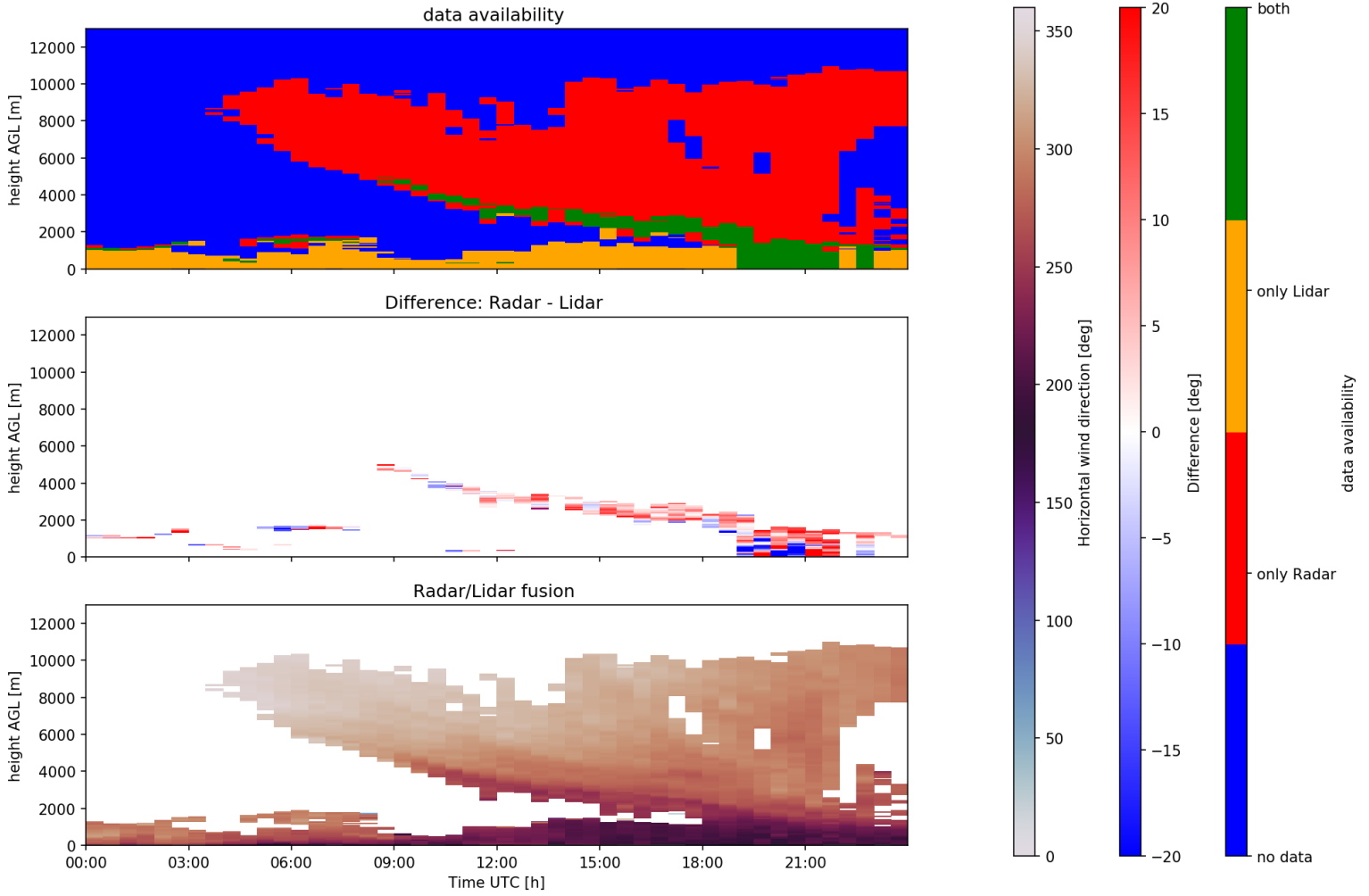


Example day – wind direction

availability

difference radar-lidar

fusion

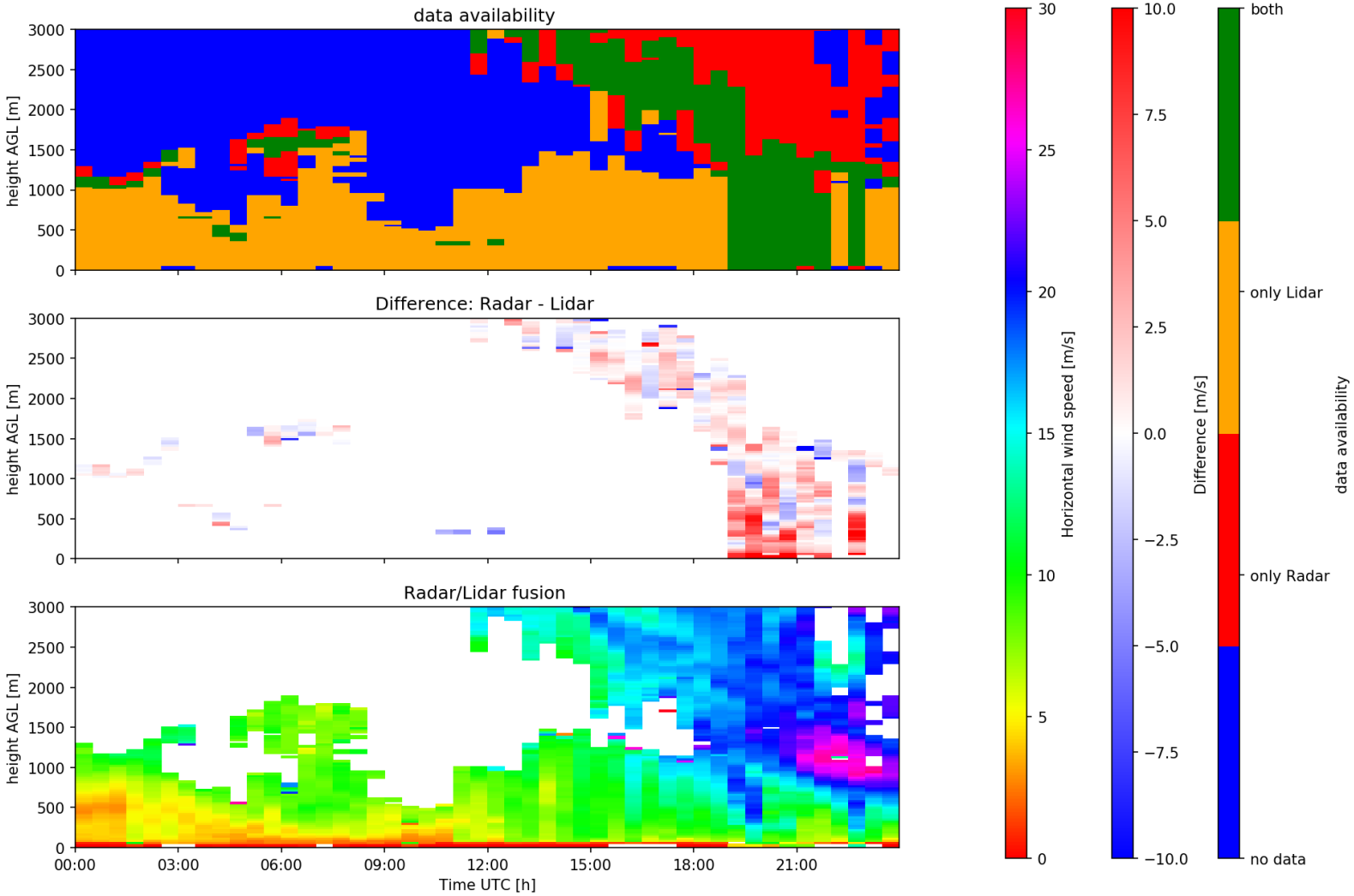


Example day – wind speed boundary layer

availability

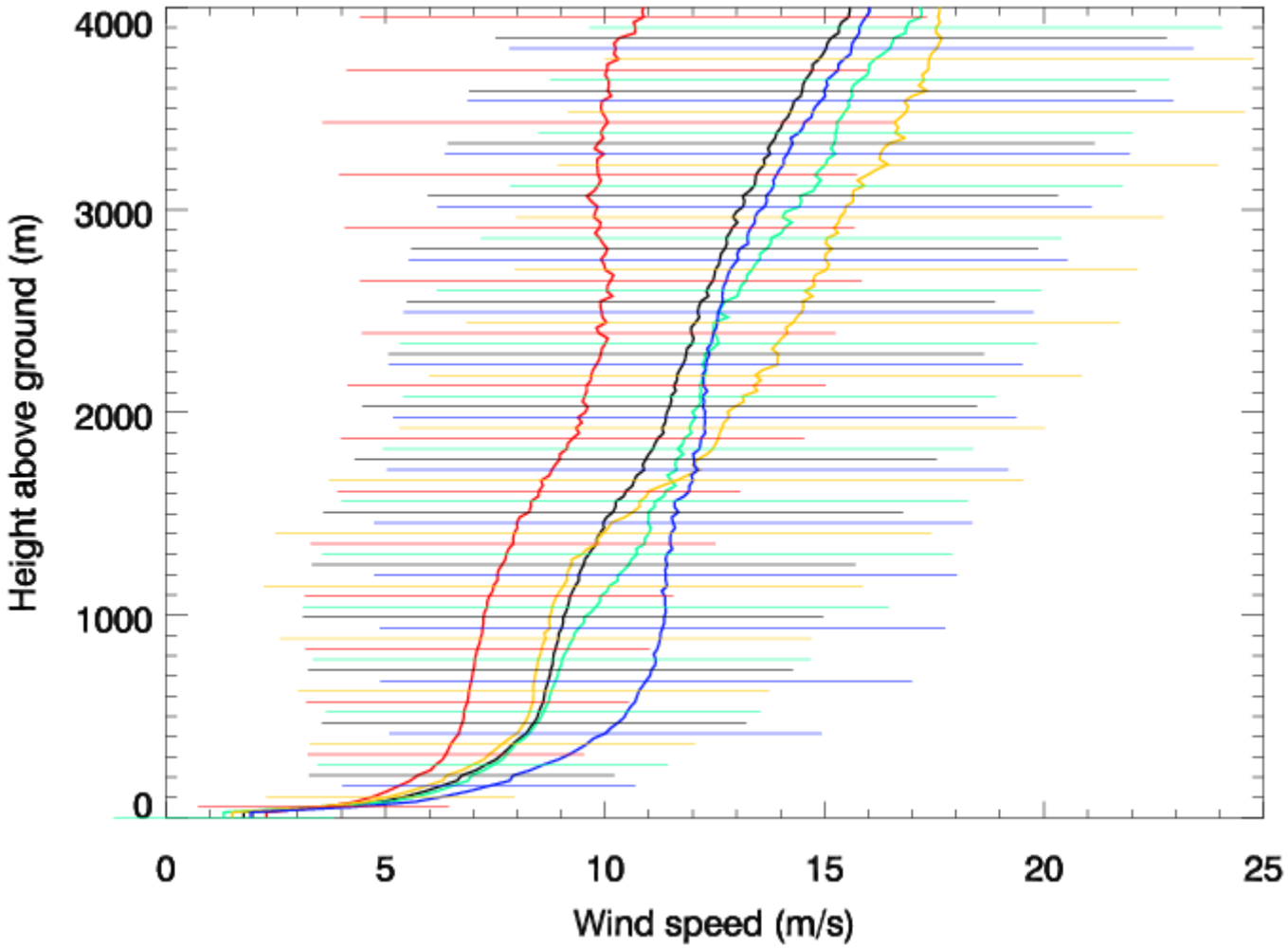
difference radar-lidar

fusion



Statistics

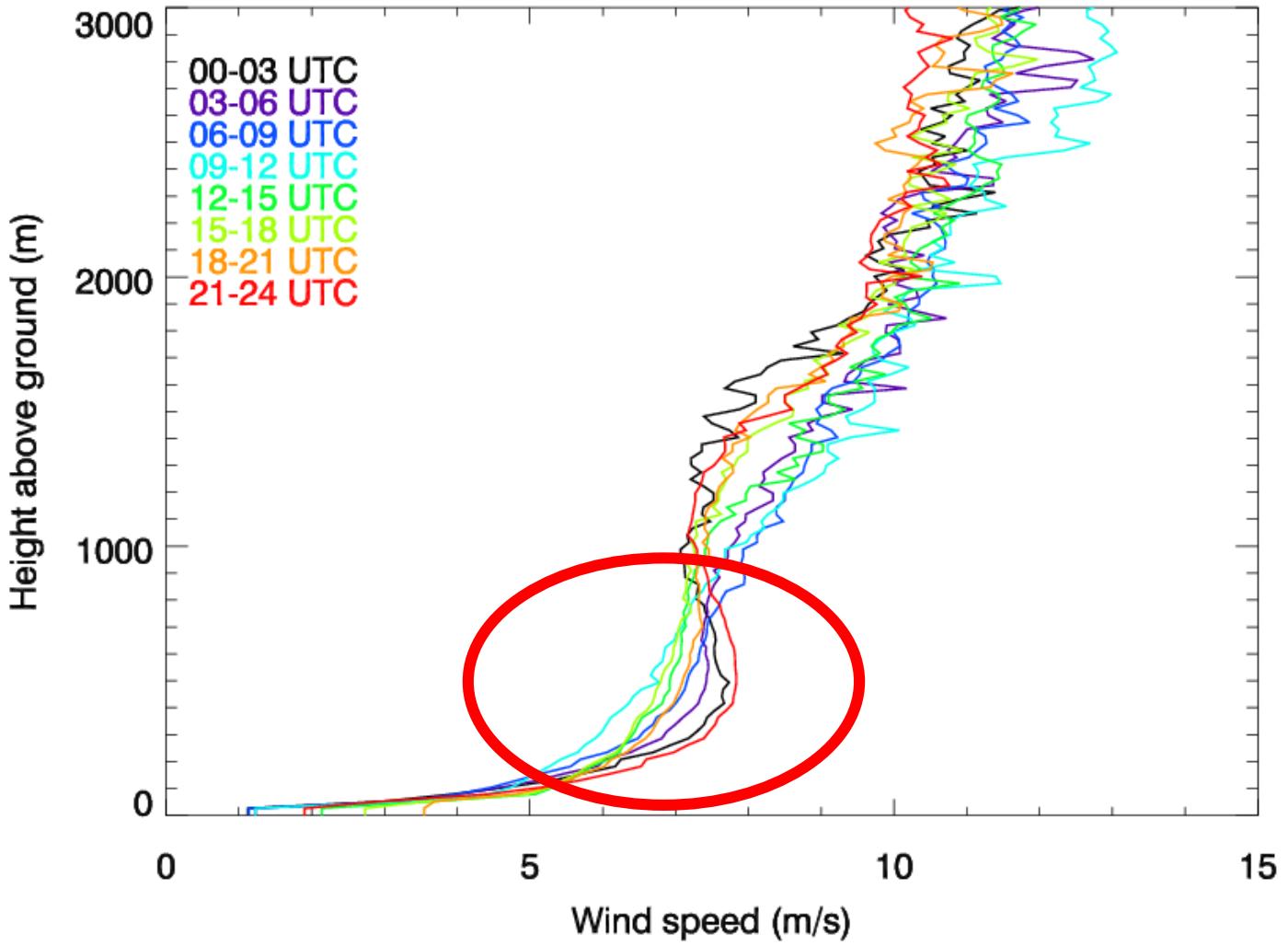
Mean horizontal wind speed per season in 2021



blue: winter,
green: spring,
red: summer,
yellow: fall,
black: all

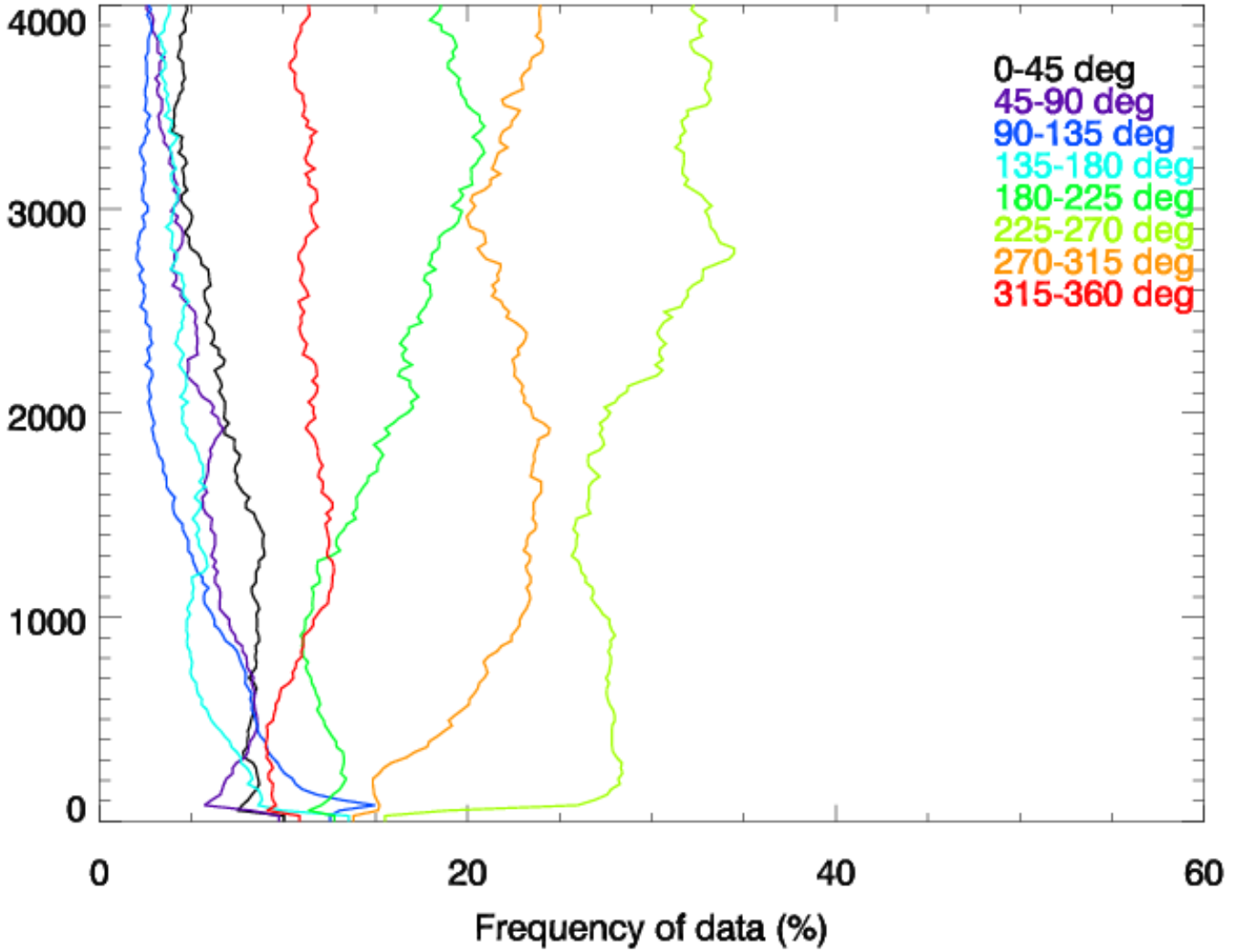
Statistics

Diurnal cycle of wind speed in 2021



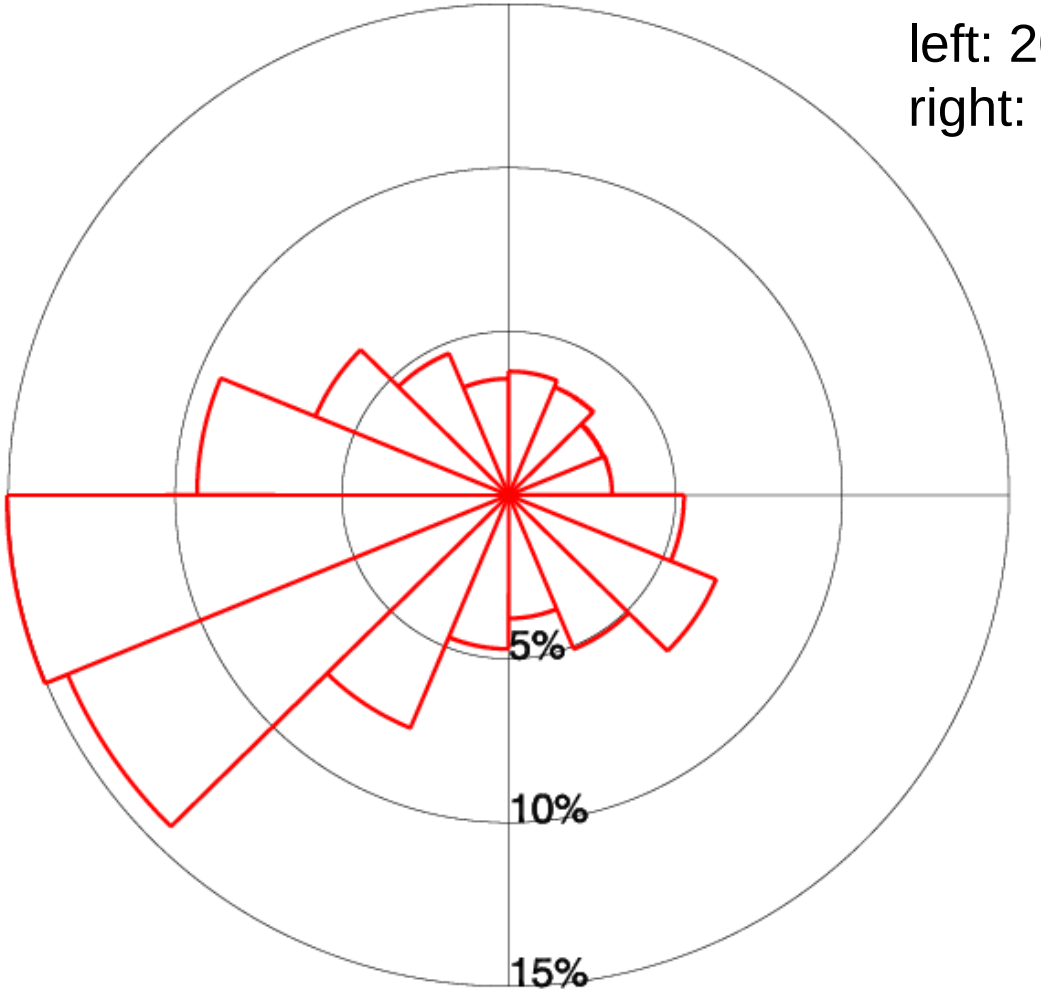
Statistics

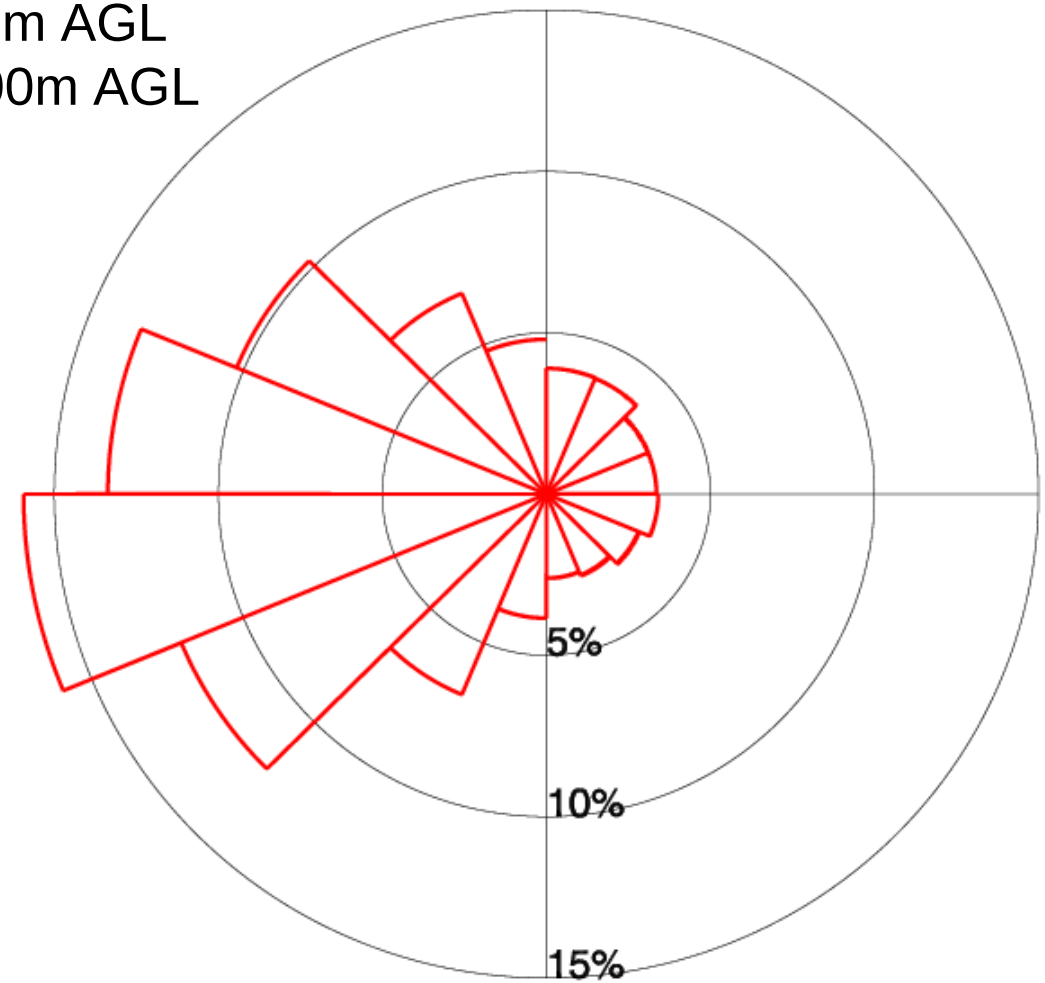
Wind direction in 2021



Wind roses

left: 200m AGL
right: 900m AGL

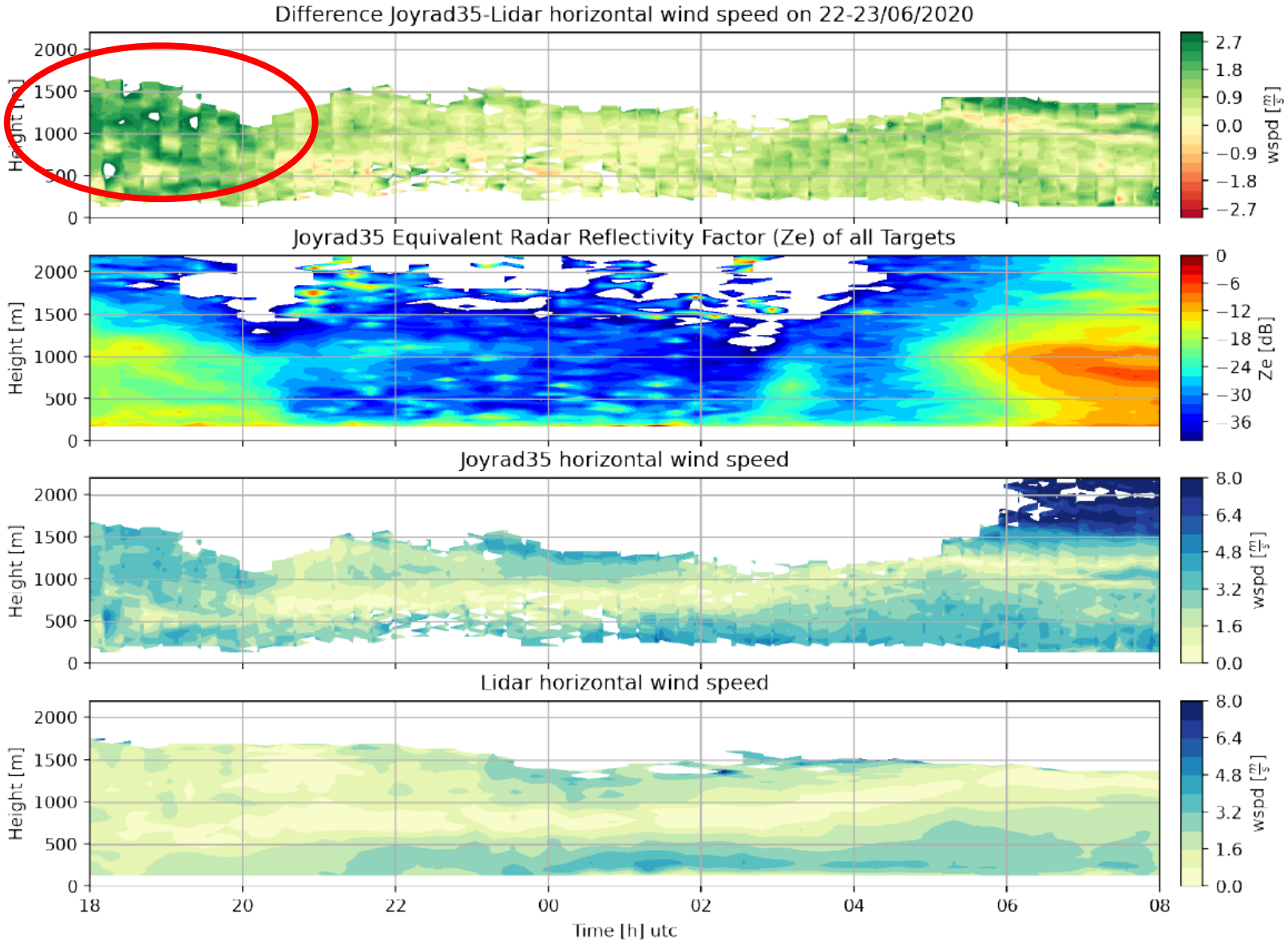




Application: Insect detection

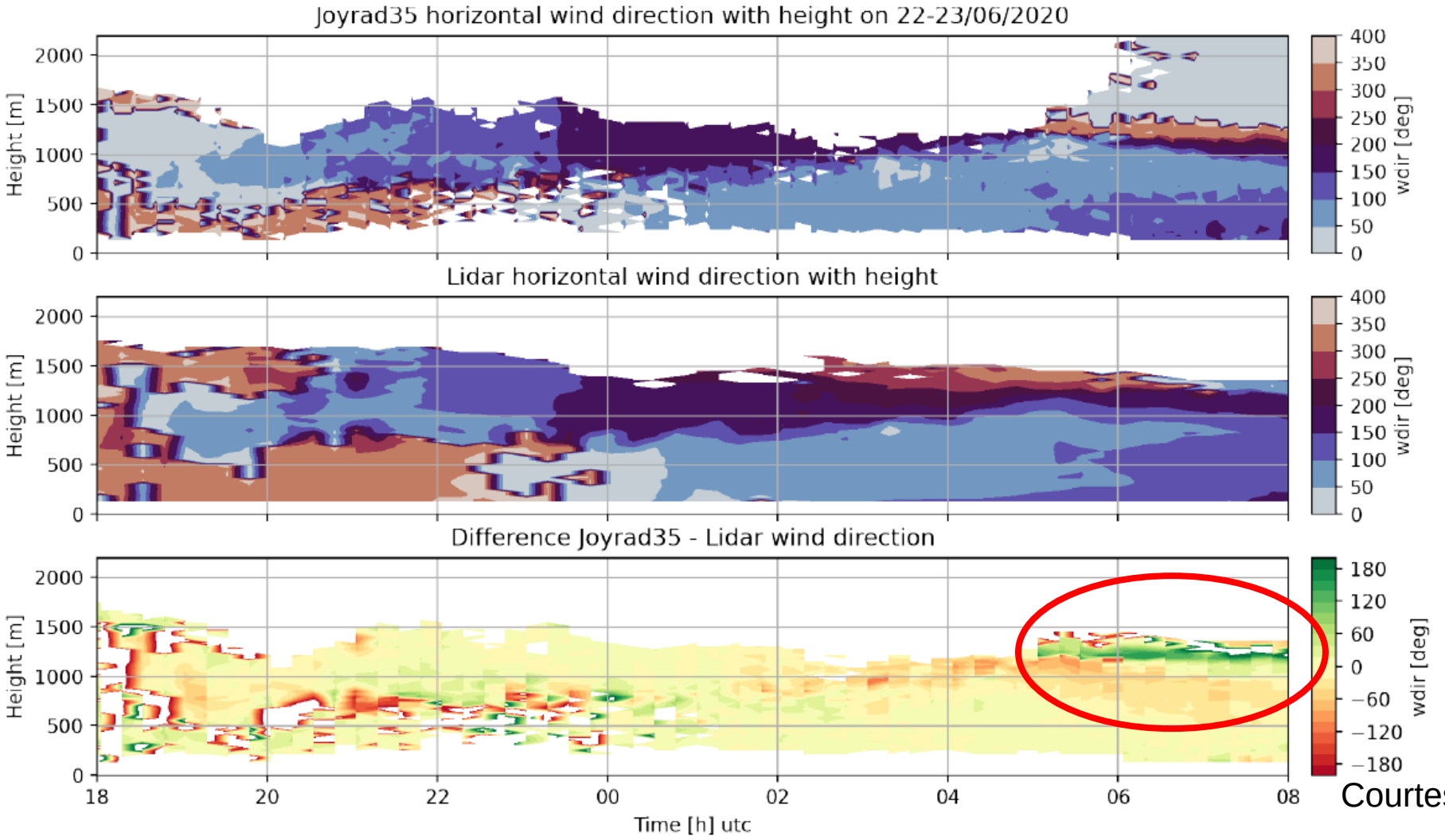
- Insects are efficient targets to produce radar backscatter due to their size (1mm-1cm)
- Lidar backscatter is not affected by insects
- During warm periods (roughly T > 10°C), the Doppler radar signal is dominated by insects
- Comparison between radar and lidar allows the detection of insects
- Problem: Insect speed is not necessary the wind speed!

Insect detection - wind speed



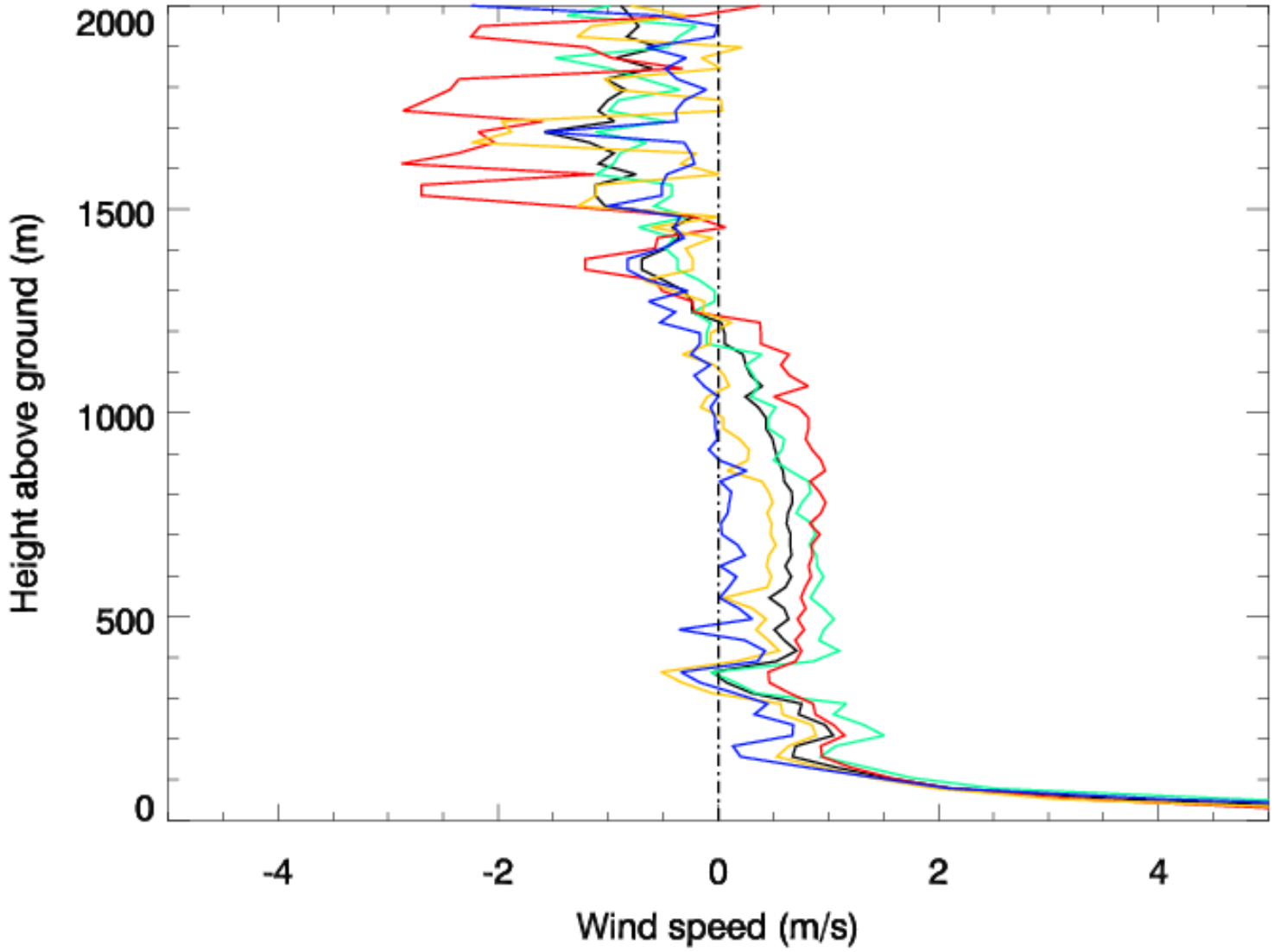
Courtesy Katharina Weiß

Insect detection – wind direction



Courtesy Katharina Weiß

Wind speed difference Radar-Lidar



blue: winter

green: spring

red: summer

yellow: fall

black: all year

Summary / Further steps

- Which stations are able to provide wind profiles?
  - need a scanning DCR
  - Add also Radar Wind Profiler?
- Implementation -> SOP for wind profiles necessary
  - Which settings?
  - How to ensure synchronous scanning?
  - Which frequency of scans?
- Software:
  - Code to provide 3D wind vector from Doppler velocities incl. error estimation available in IDL
  - Merging the DL and and DCR and generating common products in Python

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Thank you

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