

IEA Wind TCP Task 52 Lunch Seminar Series  
2024-02-28

# Comparative data availability of LiDAR measurements at Alpine sites

## Motivation & Setup

- Energiewerkstatt's experience has shown, that LiDAR measurements at Alpine sites can be severely affected by low availability, in particular during Winter.
- Study in the framework of Task 52 (then Task 32) participation to put a number to this anecdotal experience.
- Results clearly illustrate the issue:  
Availability on Alpine sites in winter was on average less than 50%.  
At lowlands sites the availability remains in the order of 90% throughout the year.



## Study design

- Based on a selection of 10 LiDAR Windcube V2 measurements in Austria from the past years.
- Comparison from sites at Alpine locations with sites from low-lying, flat areas.
- Selection of measurements aimed at full coverage of the yearly cycle, as far as possible.
- Separation according to Austrian climate in
  - “Winter” = December to February
  - “Summer” = March to November
- Evaluation at different height ranges (not exactly the same do to different LiDAR setups)
  - “Height 1” between 40 m and 60 m.
  - “Height 2” between 75 m and 85 m
  - “Height 3” between 135 m and 145 m
  - “Height 4” between 180 m and 200 m
- Completed by meteorological measurements on site (temperature, pressure, humidity) and close-by meteorological stations (global irradiation, precipitation, depth of snow cover)

## Selected sites, elevations and characteristics

### Lowland sites

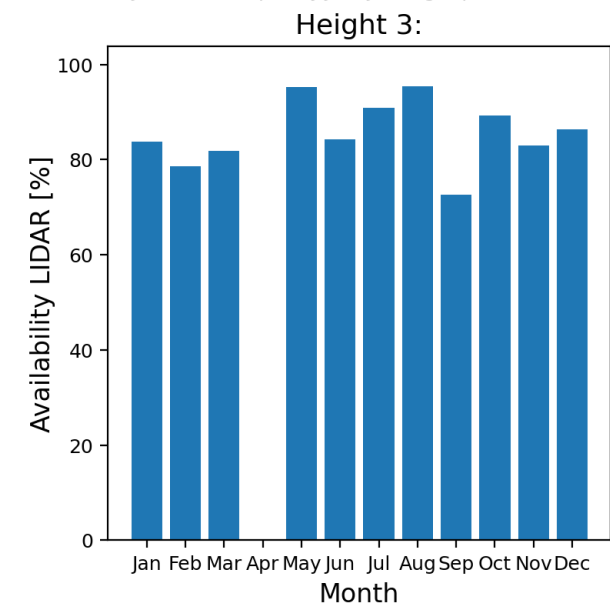
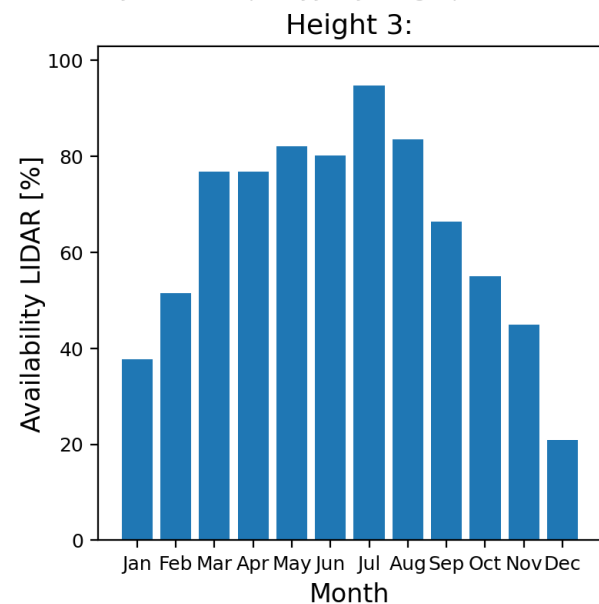
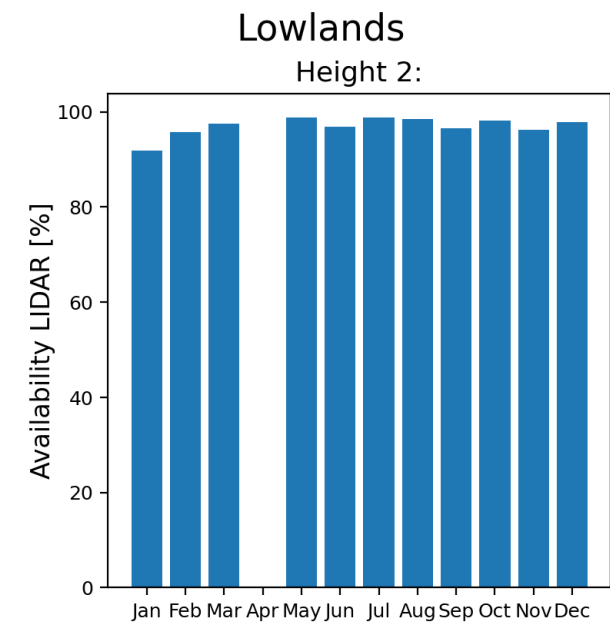
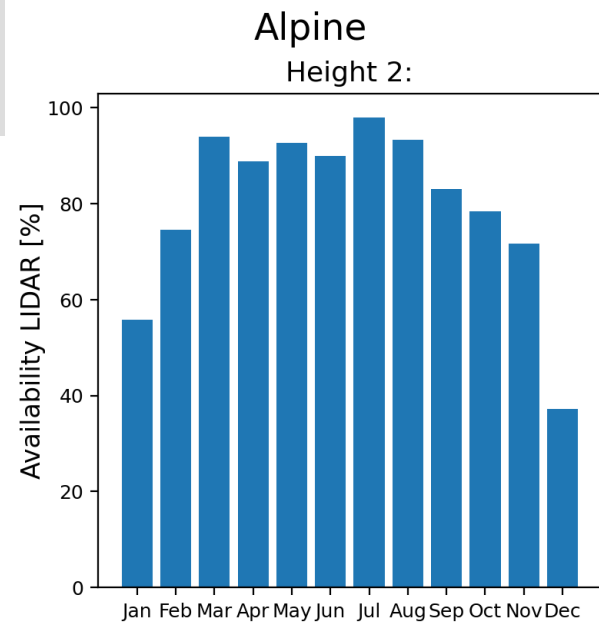
	Measurement period	Elevation	Vegetation / Orography
Site 1	Summer, Winter	200 m	Agricultural landscape (unforested), lowlands
Site 2	Fall – Spring	300 m	Agricultural landscape (unforested), lowlands
Site 3	Spring – Summer	200 m	Agricultural landscape (unforested), lowlands
Site 4	Fall – Winter	200 m	Agricultural landscape (sparse forest cover), lowlands
Site 5	Fall – Winter	300 m	Agricultural landscape (sparse forest cover), lowlands

### Alpine sites

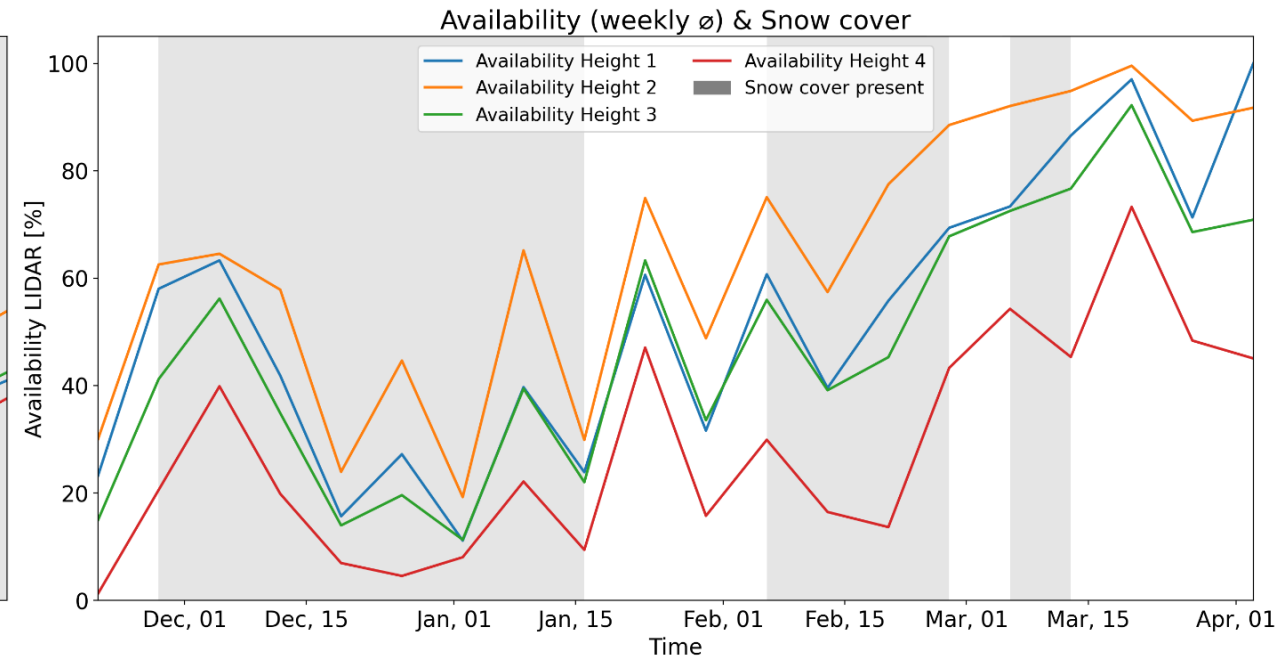
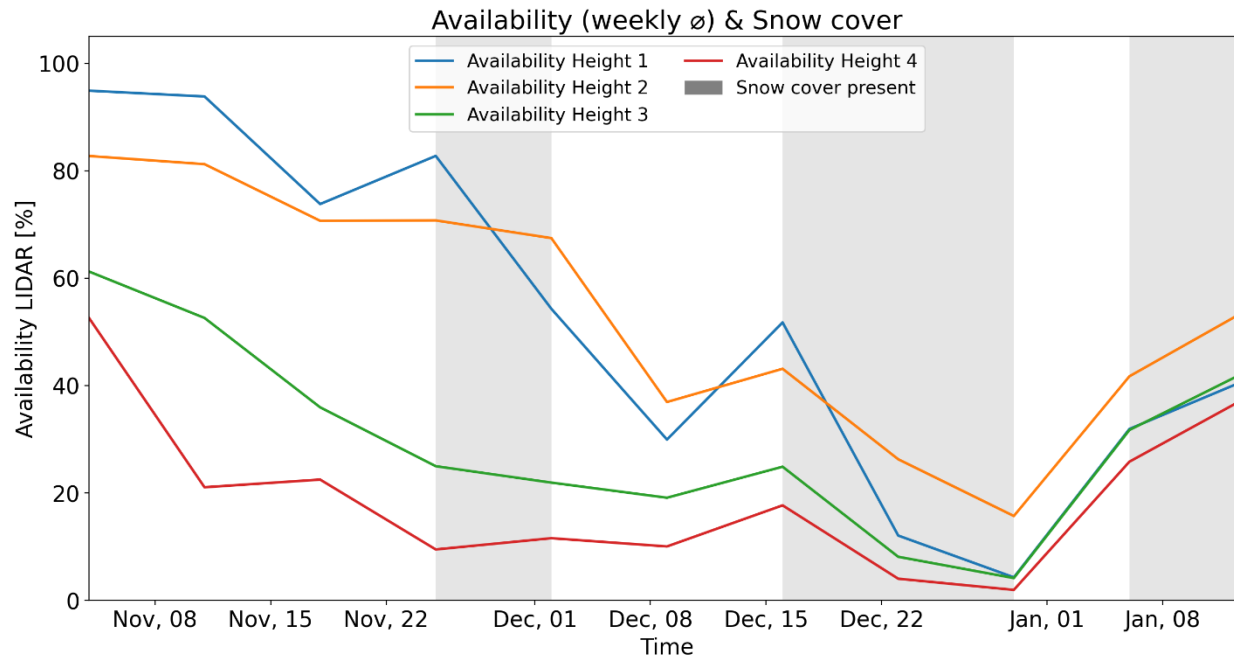
	Measurement period	Elevation	Vegetation / Orography
Site 6	Winter – Spring	1700 m	At the tree line, lowest point of a mountain ridge
Site 7	Summer – Winter	1500 m	Forest cover (not continuous), rolling hills
Site 8	Fall – Winter	1500 m	Thick forest cover, slight ridge
Site 9	Spring – Fall	1800 m	Above the tree line, summit plateau
Site 10	Summer	1500 m	Forest cover (not continuous), moderate ridge

## Results for availability

	Height 1	Height 2	Height 3	Height 4
Lowland – whole year	94%	96%	85%	54%
Alpine – whole year	65%	73%	55%	39%
Lowlands – Summer	96%	97%	86%	52%
Lowlands – Winter	92%	94%	82%	56%
Alpine – Summer	80%	83%	66%	49%
Alpine – Winter	32%	48%	30%	17%



## Correlation with snow cover?

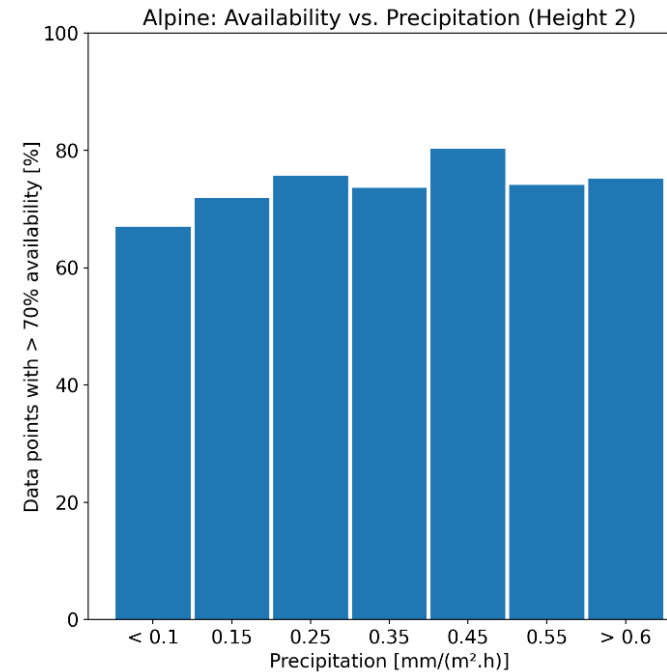
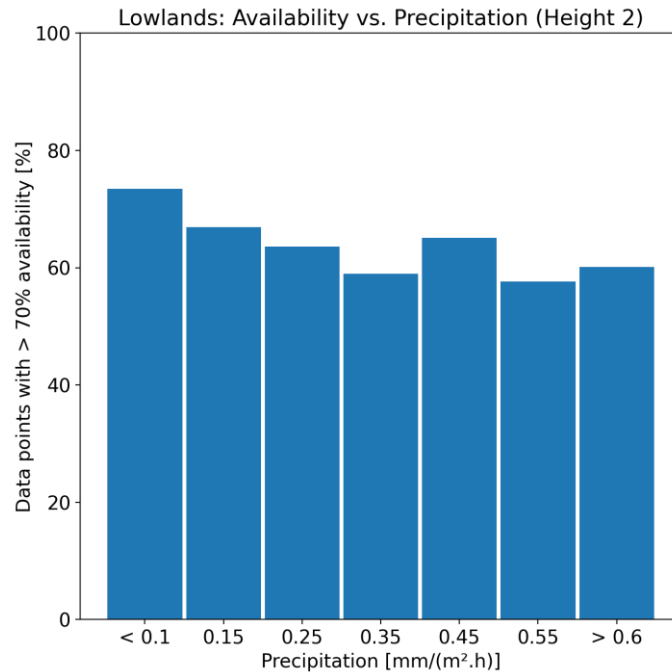


- Two example time series from Alpine sites.
- No correlation (?)
- Obvious yearly cycle.

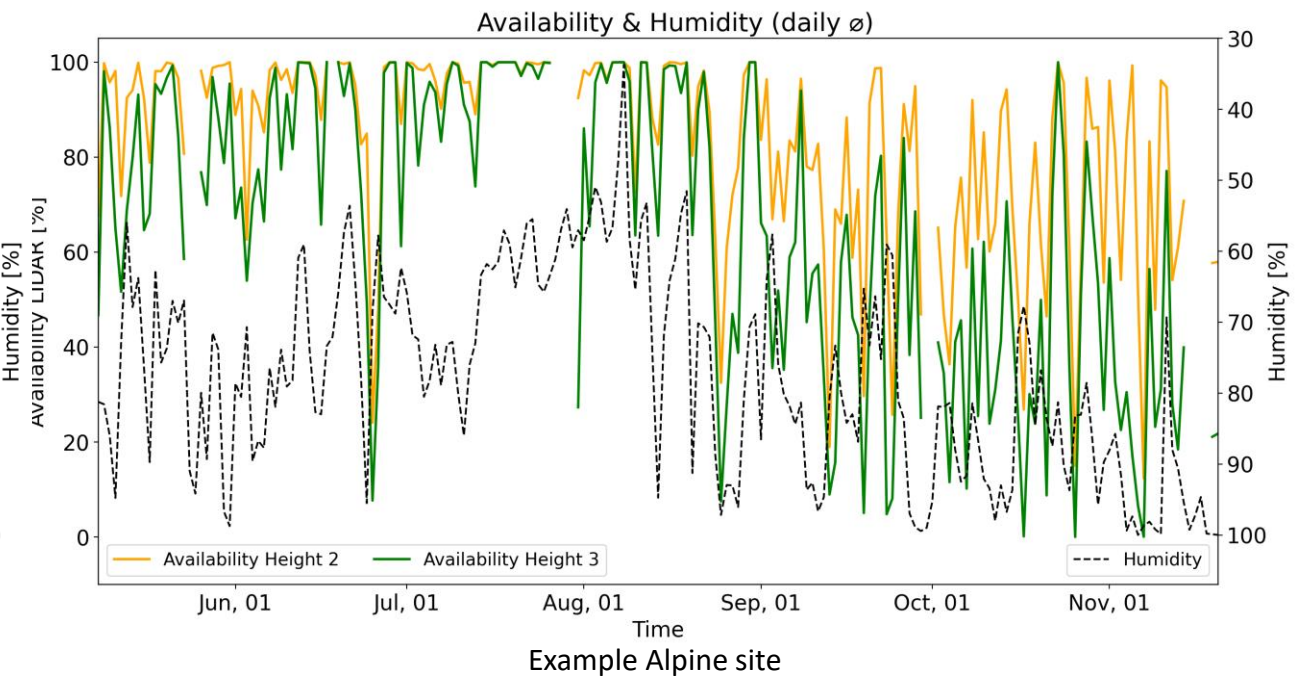
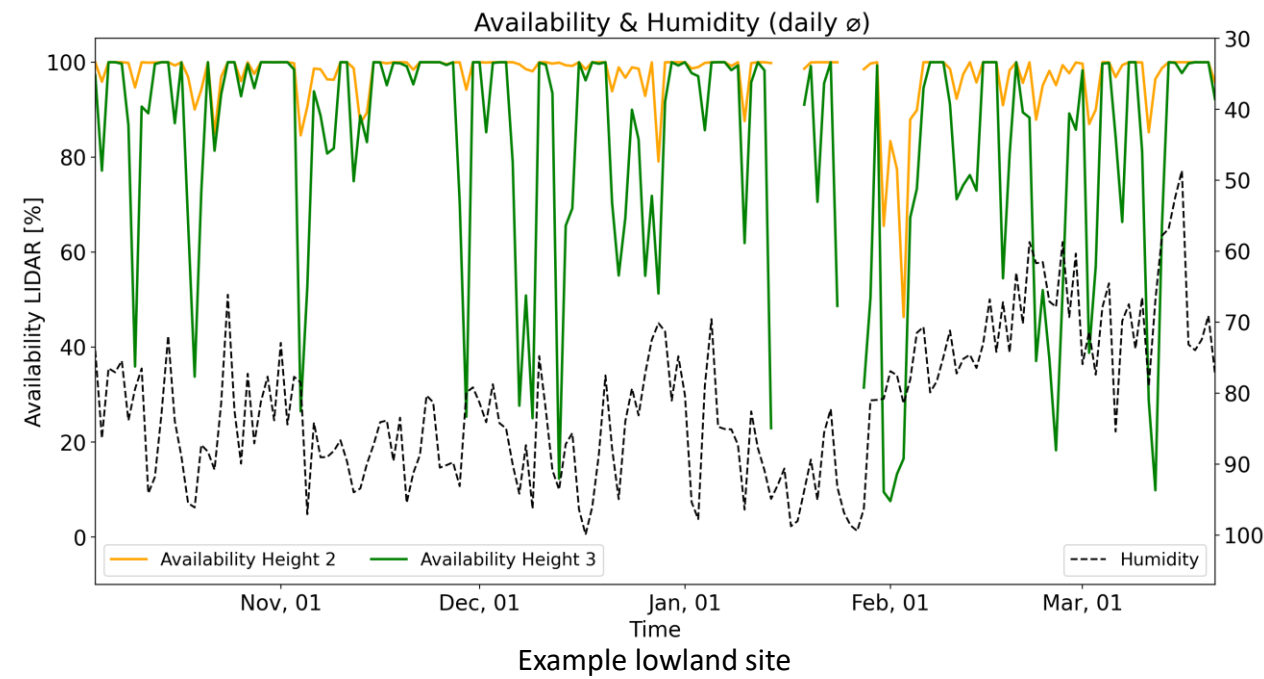
## Correlation with precipitation?

- No correlation (?)
- But only 533 time frames out of 160000 with more than 0.6 mm/h

light rain < 2.5 mm/h, moderate rain 2.5 to 10 mm/h, heavy rain 10 to 50 mm/h, violent rain > 50 mm/h

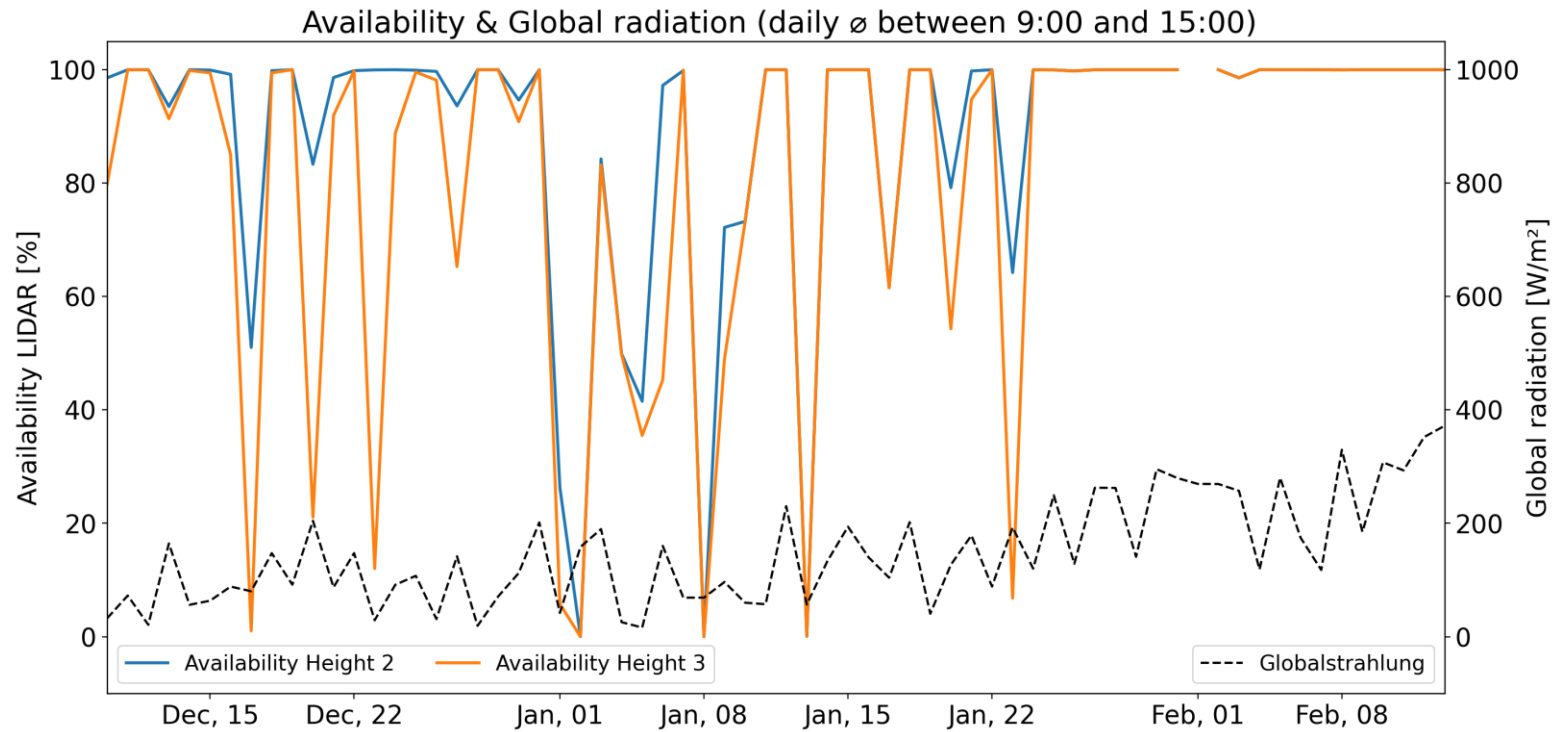


## Correlation with humidity (fog)?





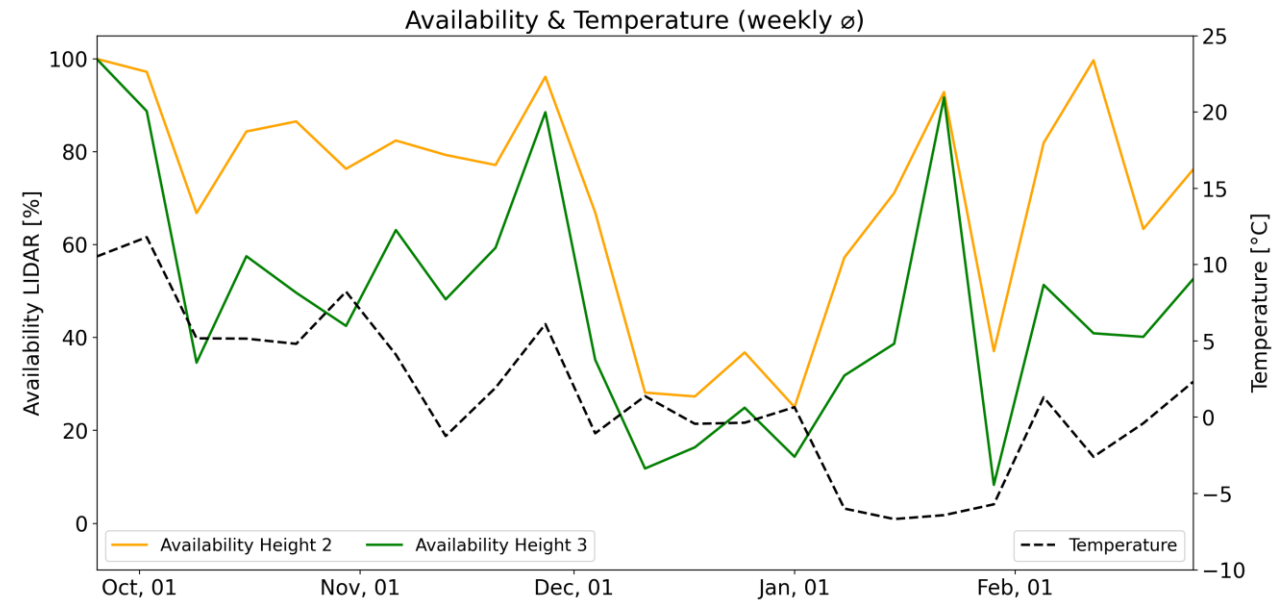
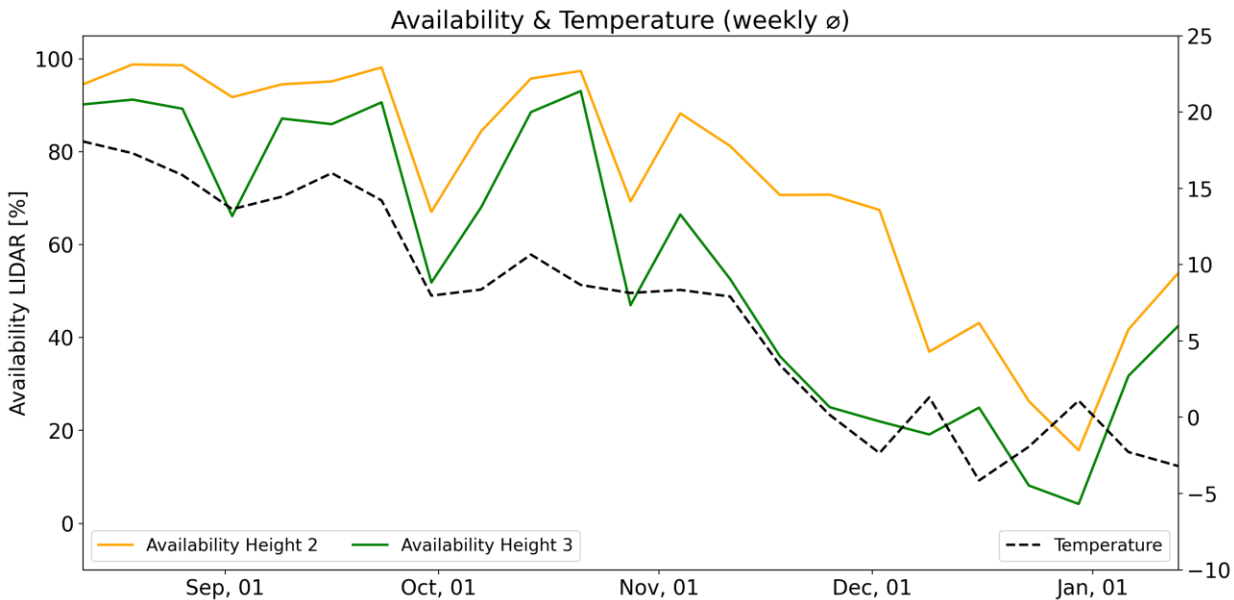
## Correlation with global irradiation?



Lowland site in winter

- Largely overcast throughout
- Yet different levels of availability

## Correlation with air temperature?



- Two example time series from Alpine sites.
- Some correlation (also in statistical test), but low temperature is no direct indicator.
- Temperature probably just a proxy for the yearly cycle.

## Conclusions

- On Alpine sites, LiDAR availability in winter at no height exceeded 50%. Neither fog or precipitation are a plausible cause for such a large fraction of time.
- Except some correlation with air temperature, no significant correlation could be found among the investigated quantities.
- The most likely cause for the observed low availabilities at Alpine sites in winter seems to be the stable atmospheric temperature gradient. With no mixing from convection, there are little aerosols at greater heights. When such air masses move against protruding mountains, sites at high elevations are immersed in clean air.
- Lowland sites, on the other hand, are within the shear-driven turbulent boundary layer with efficient mixing throughout the year, and thus see only very little variation of LiDAR availability.

# Thanks for your attention!

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