# Complementarity wind measurements from co-located X-band weather radar and Doppler lidar

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# Introduction


- **Ranges**: 10-20km
- **Wavelength**: shorter (1.54 µm)
- **Signal**: based on aerosol presence
- **Limitations**: attenuation of the beam by precip, fog, etc.

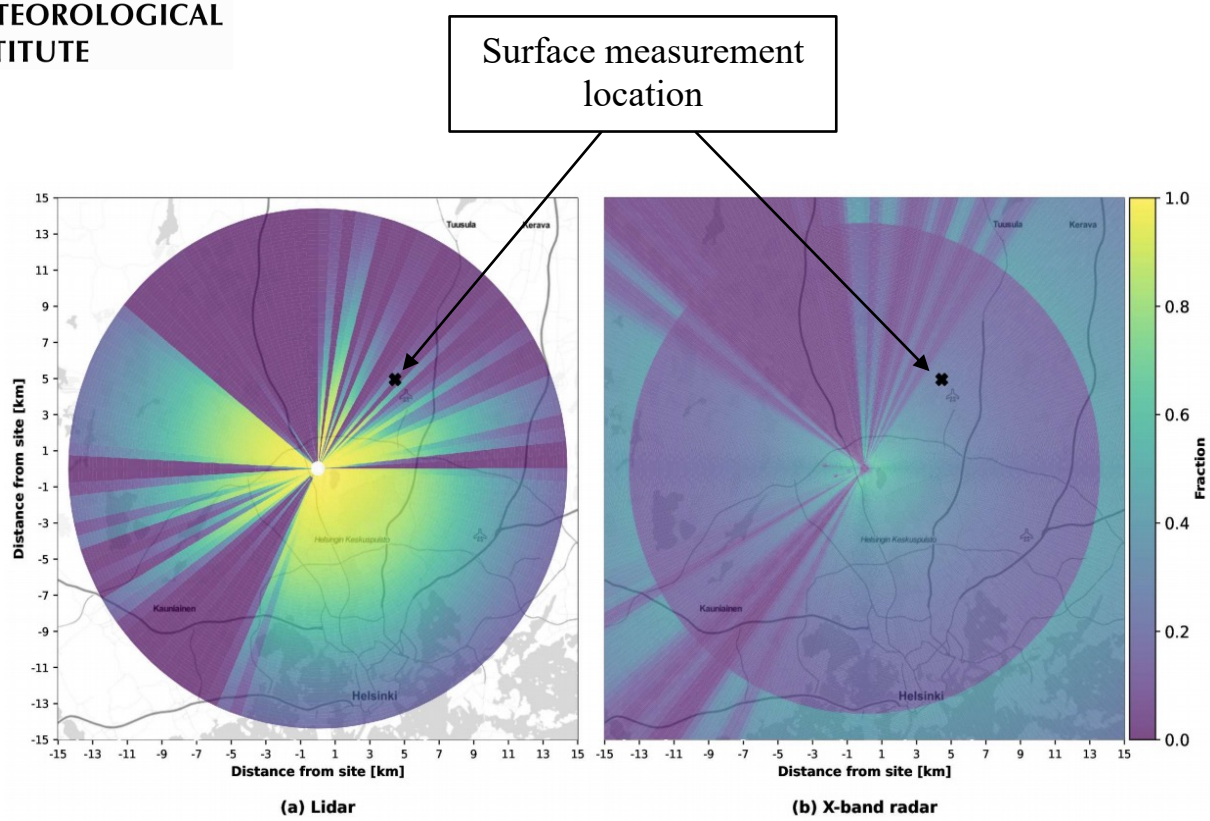
- **Ranges**: 10-50km
- **Wavelength**: longer (X-band, ~3cm)
- **Signal**: based on hydrometeors
- **Limitations**: clean air conditions

- Lidar/Radar→ similar remote sensing technologies that measure wind fields
- WMO: *"Wind profiles…outside the main populated areas are a top priority among variables that are not [currently] adequately measured"*
- **Goal**: Combine data availabilities to "close the data availability gaps"

# Methodology

FINNISH METEOROLOGICAL INSTITUTE

- Measurement campaign in Vantaa, Finland from May 2021 to November 2021
- **Instruments**
  - Vaisala WindCube400S Doppler lidar
  - Vaisala WRS400 X-band weather radar
- Aim to quantify differences in measurement performance in different conditions
  → Horizontal visibility
  → Cloud base height
  → Precipitation intensity

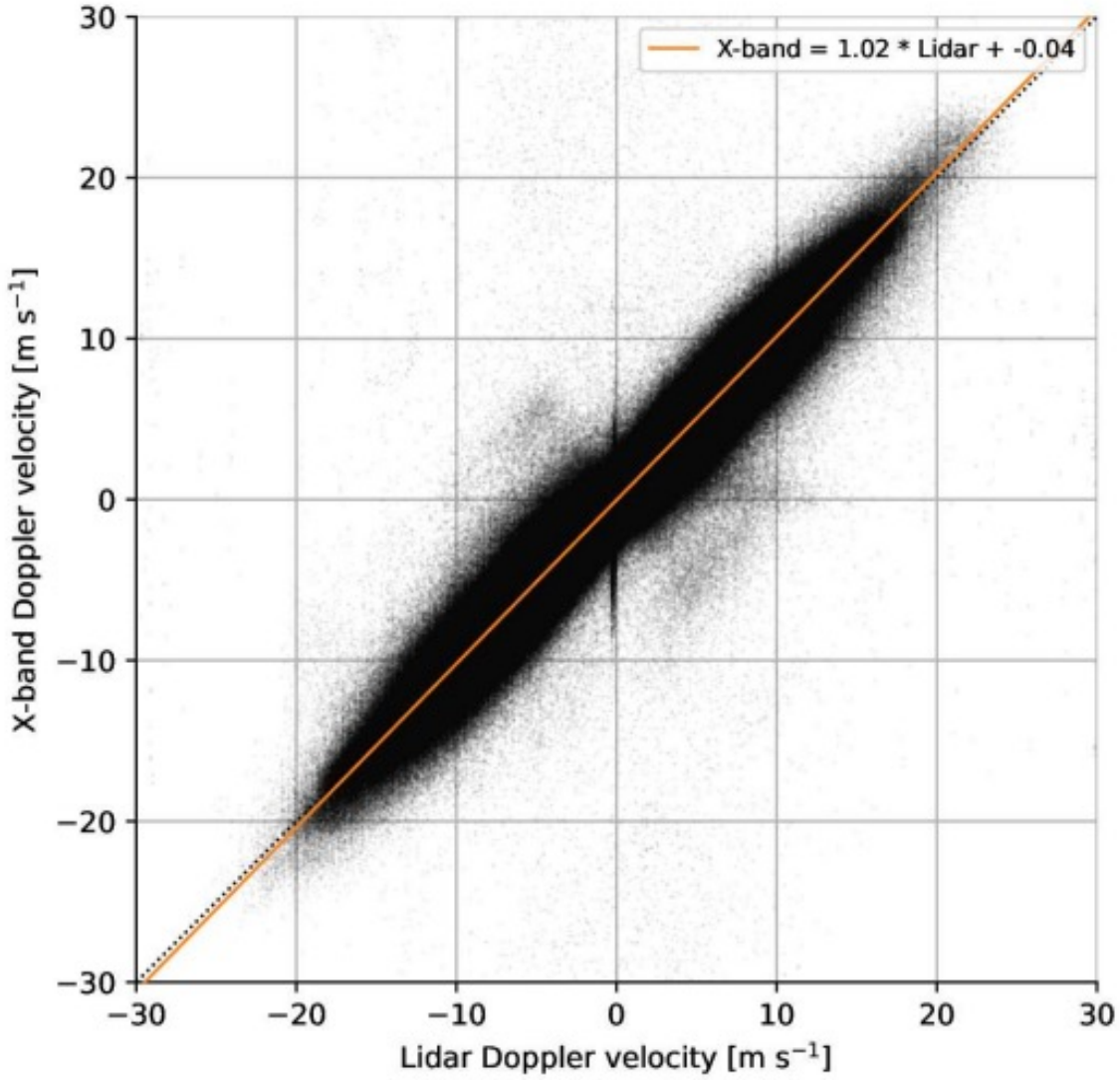



Data availability during the entire campaign

EGU Atmospheric Measurement Techniques
https://doi.org/10.5194/amt-15-6507-2022

# Agreement of Doppler velocity measurements

- Radial velocity measurements interpolated to a common Cartesian grid for comparison.
- Measurements have good agreement:
  - R2 = 0.96
  - RMSD = 1.31 m/s
  - ME = -0.047 m/s
- Some artefacts visible that suggest using clutter filtering for Doppler lidar might be necessary.



Horizontal visibility: Vaisala FS11P sensor as 1 min average

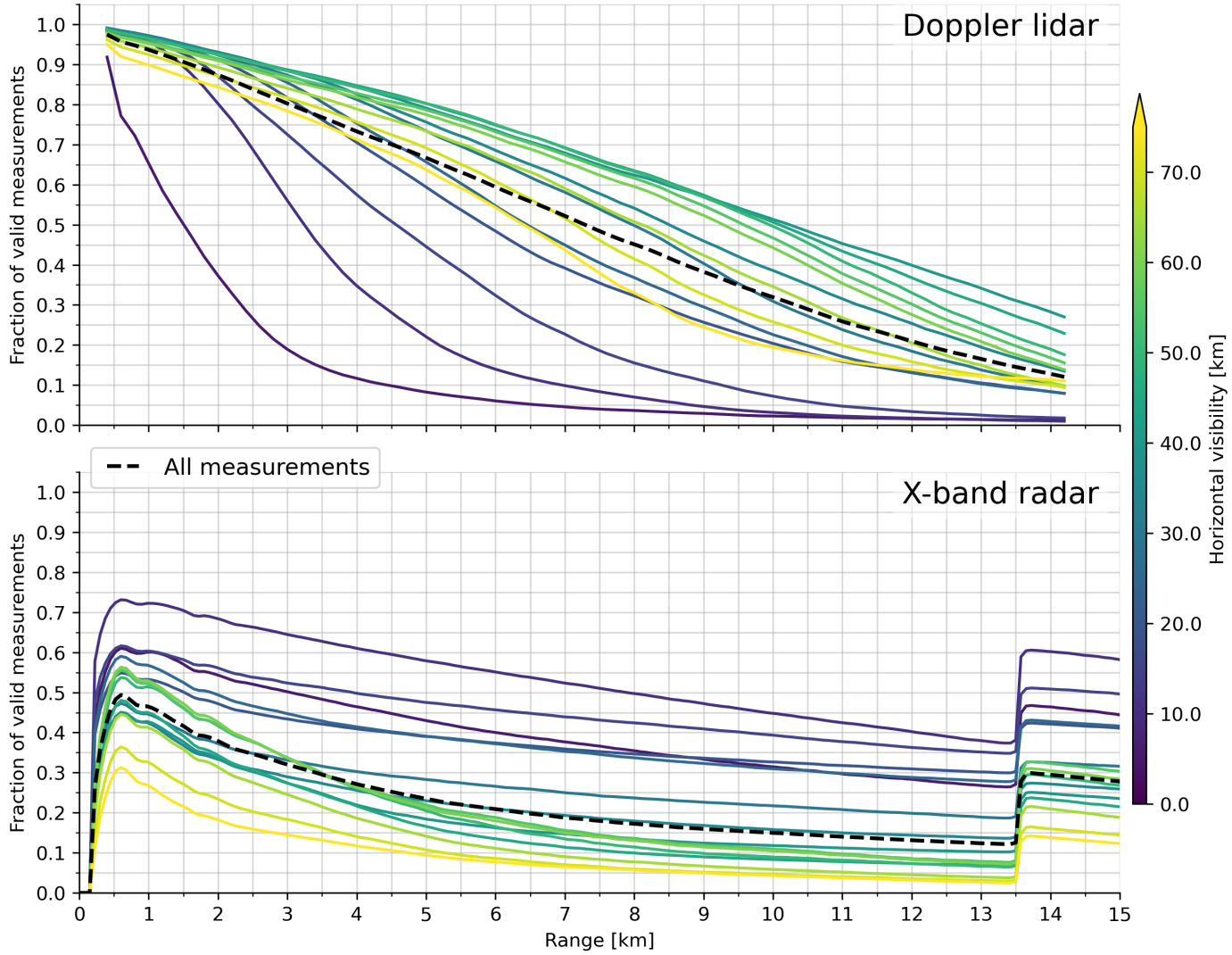
# Data availability as function of horizontal visibility

## Doppler lidar has

- low data availability in low visibility conditions.
- highest data availability when horizontal visibility is 40-50km.

## X-band radar has

- high data availability in conditions with low horizontal visibility.



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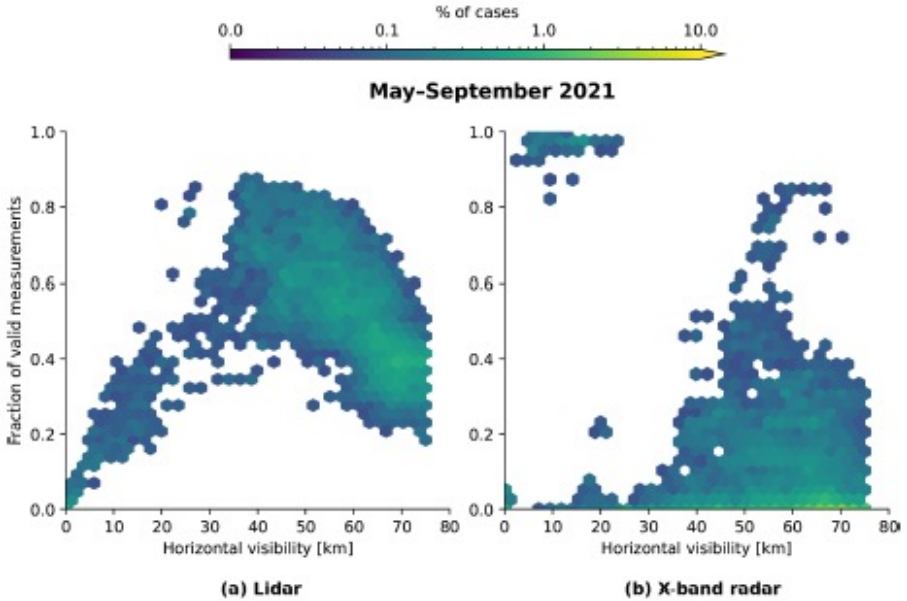
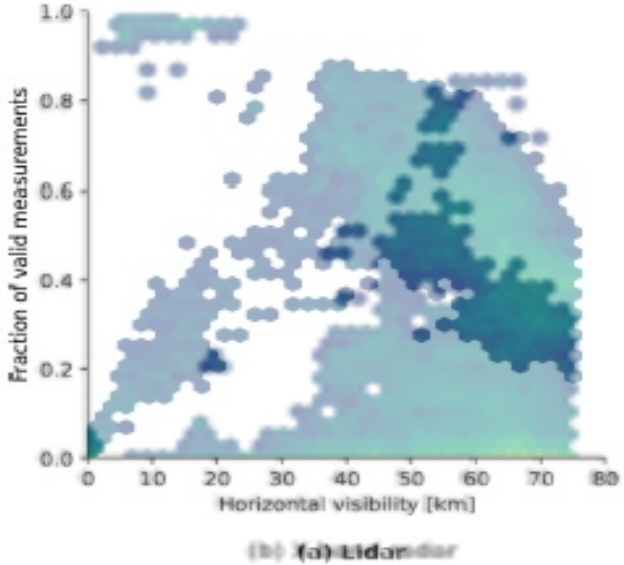
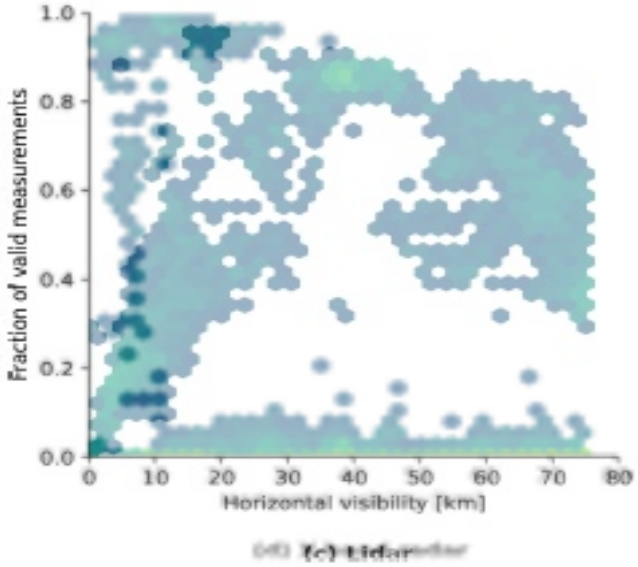


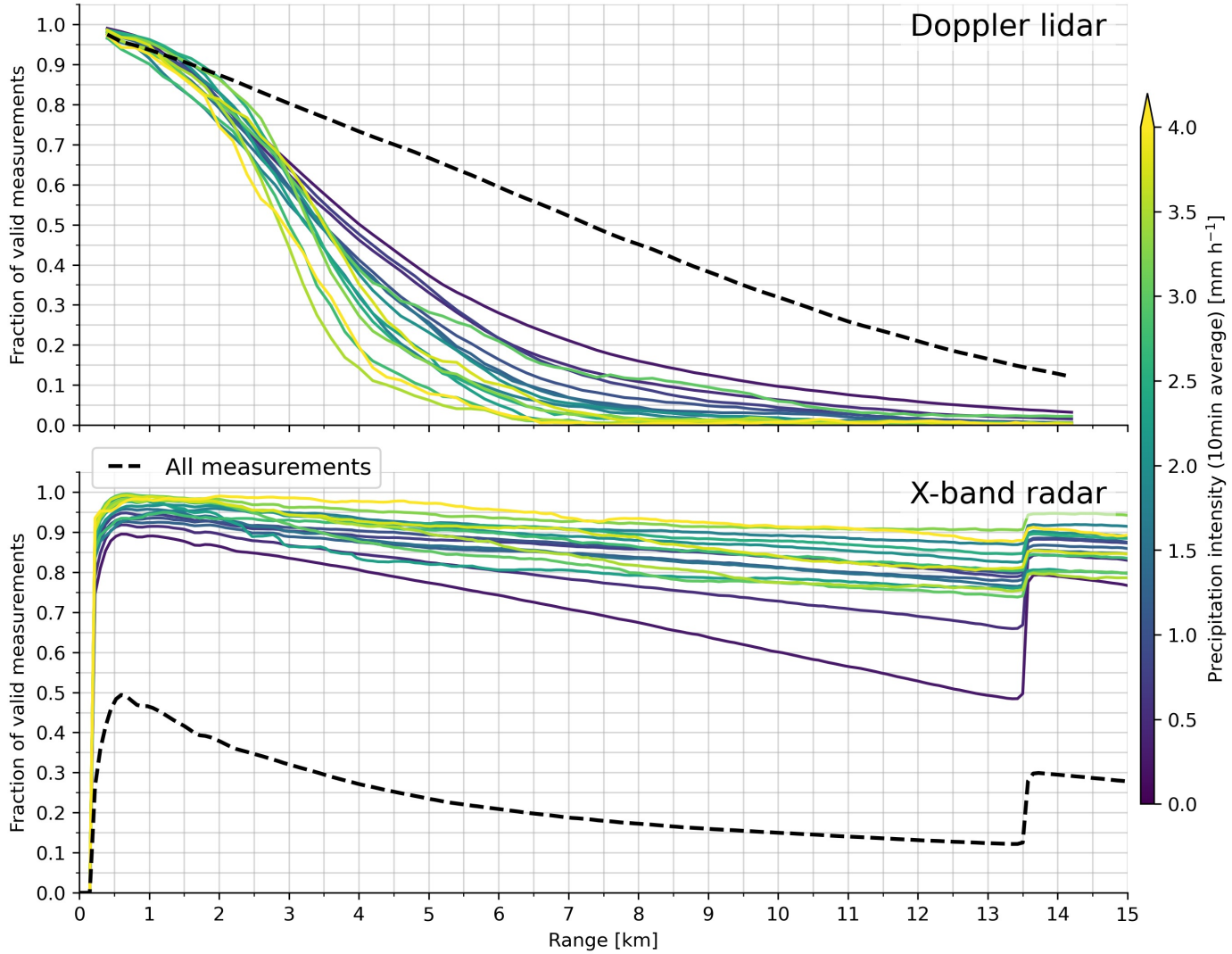



# Data availability as function of precip intensity

**Doppler lidar:** any precipitation indicates low data availability beyond first kilometers in range.

**X-band radar:** any precipitation indicates high data availability.



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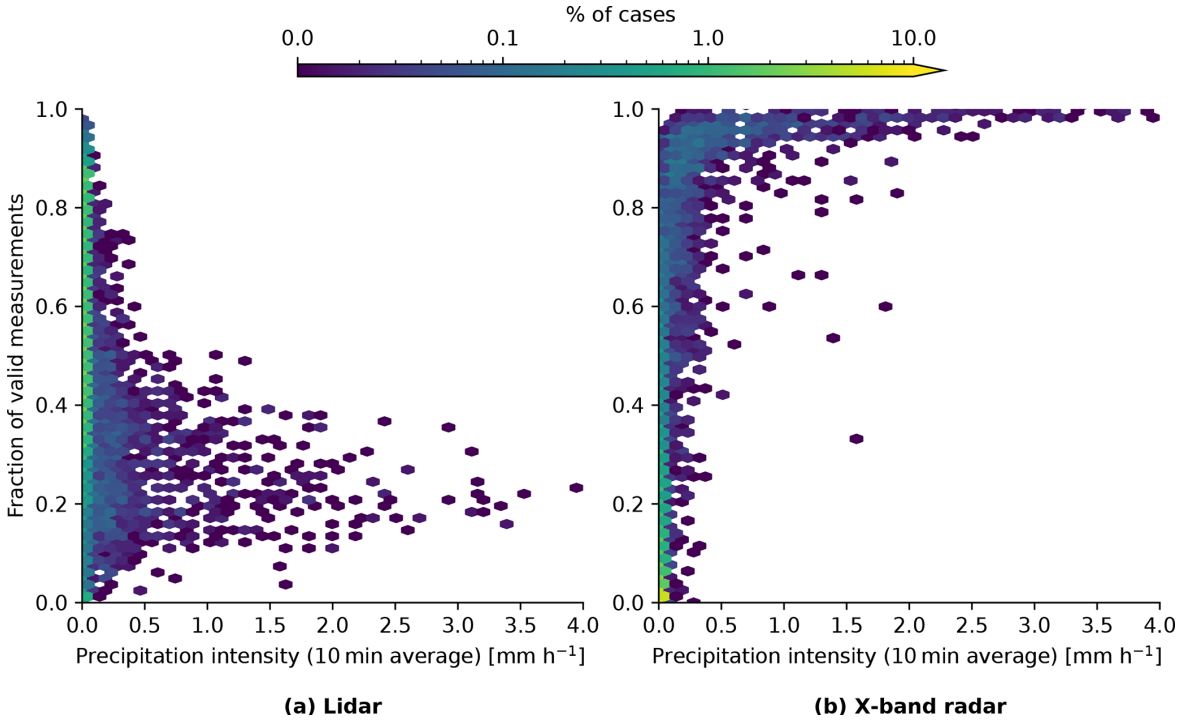
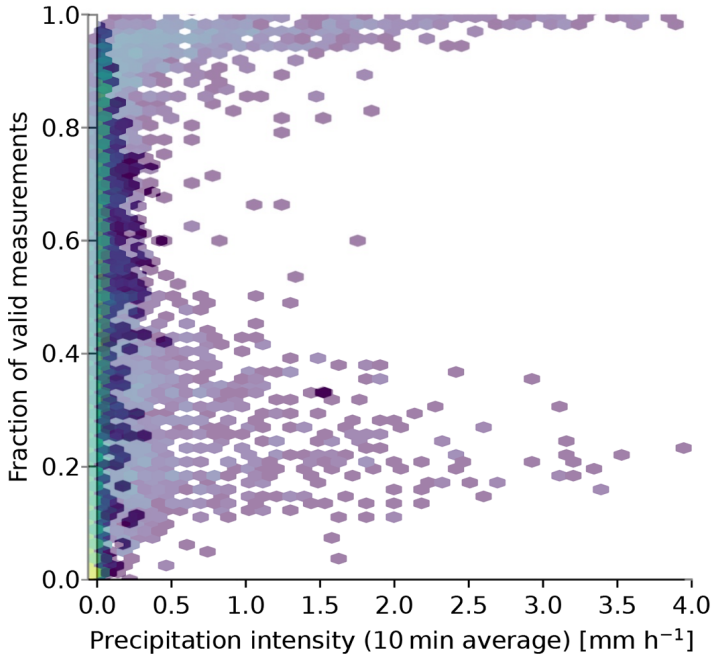


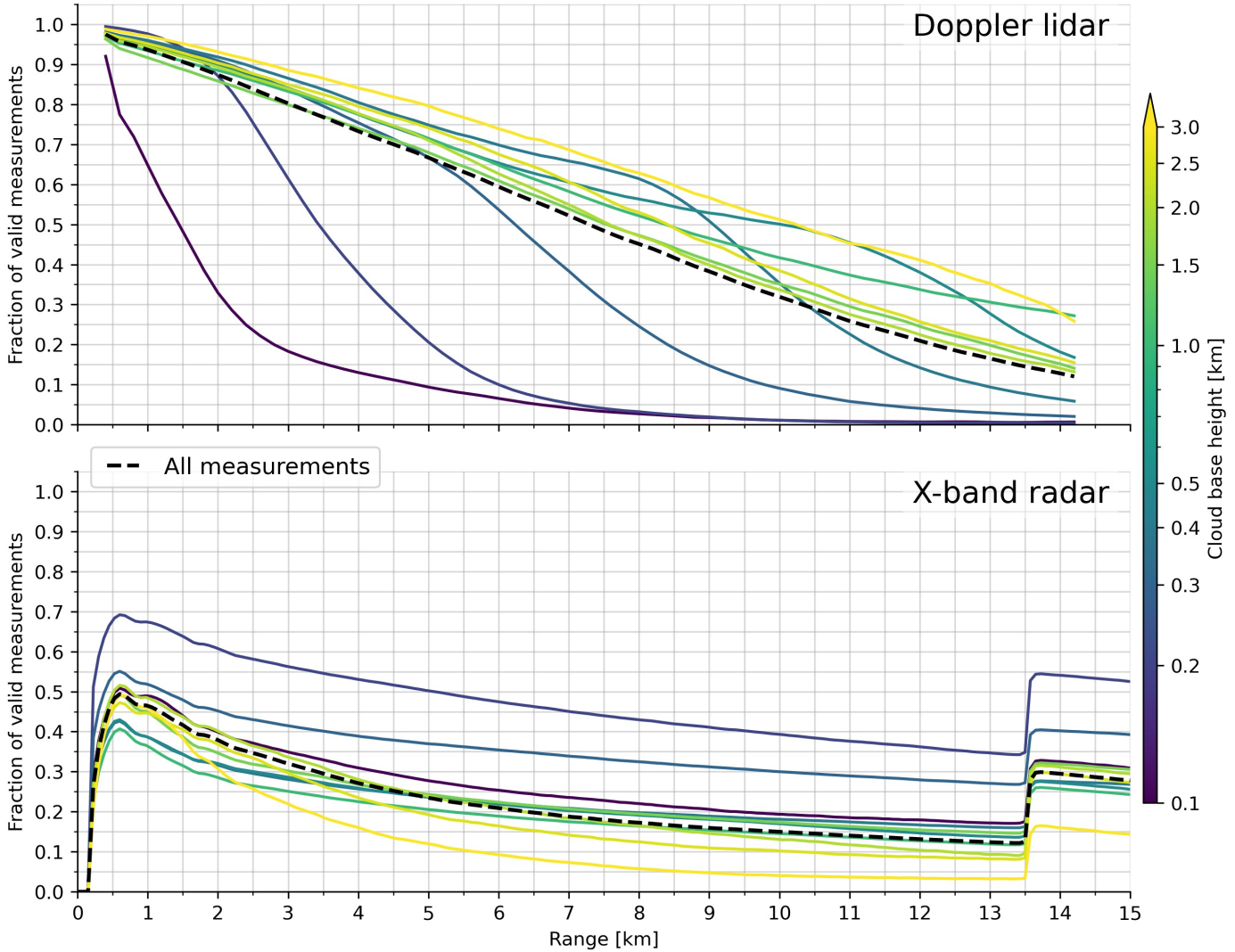



Cloud base height: Vaisala CL31 ceilometer as 1 min measurement

# Data availability as function of cloud base height

**Doppler lidar**: cannot measure past cloud base.

**X-band radar**: has best data availability in low cloud base height conditions.



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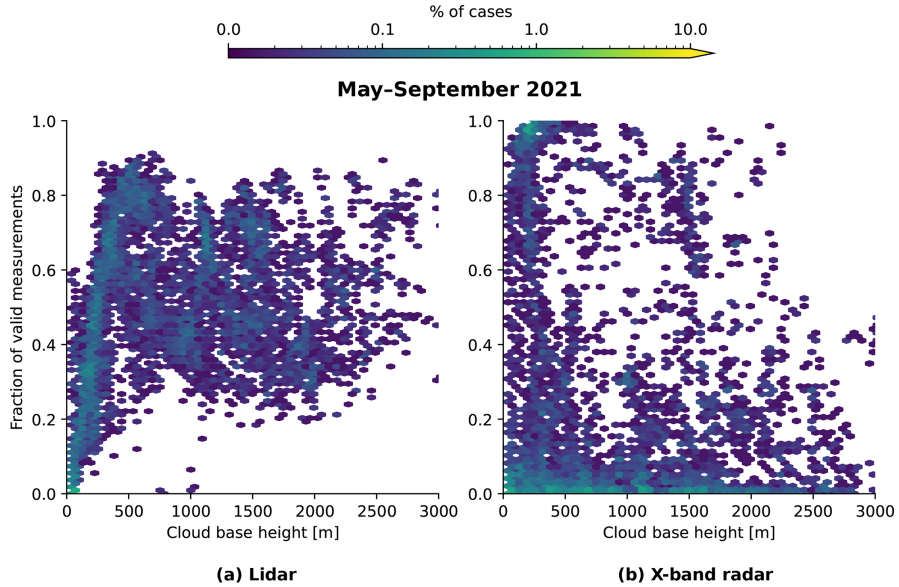
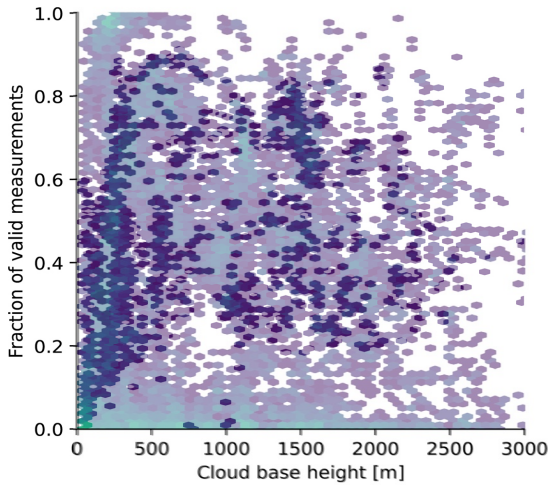
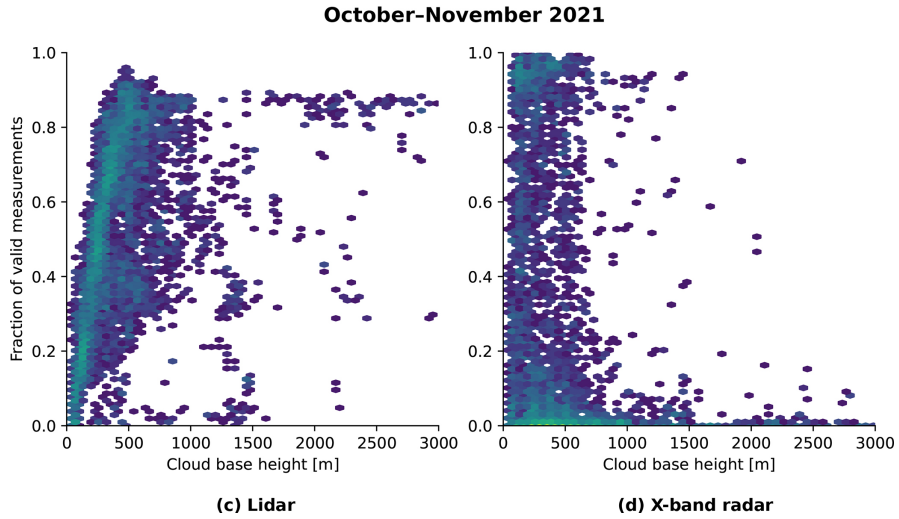
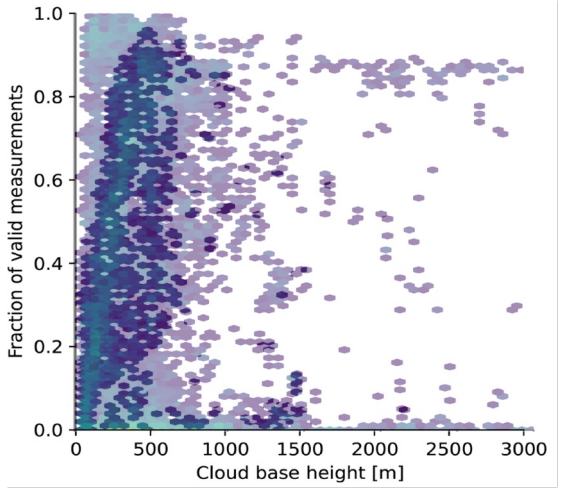


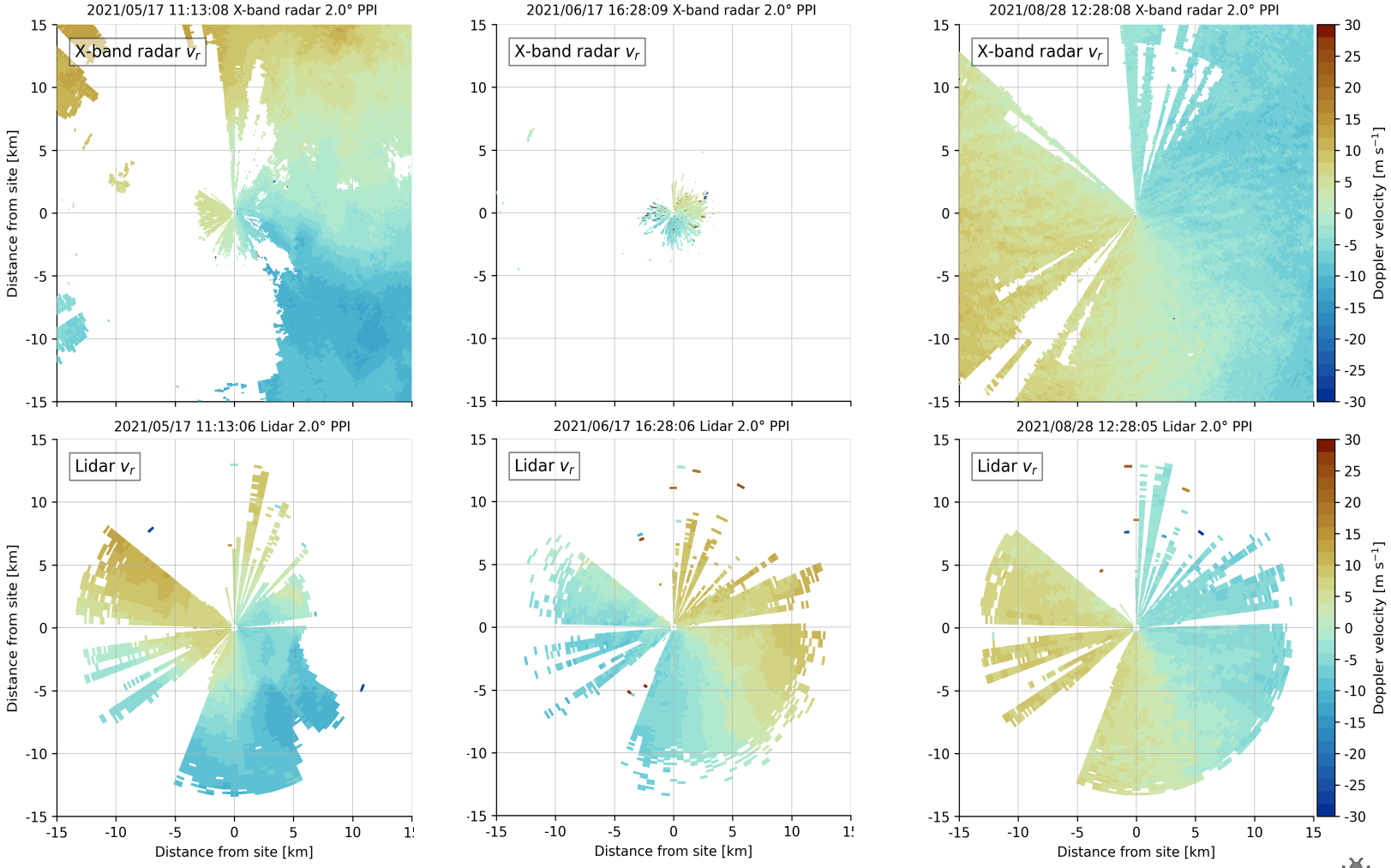



# Measurement campaign: Radar vs. Lidar

- Doppler lidar has best data availability in clear air conditions with horizontal visibility of 40-50 km
- X-band weather radar has best data availability in precipitation
- For both instruments, clear air conditions with insects give good availability




**Thunderstorm/ precipitation**

**Clear air, no insects, horizontal visibility > 60km**

**Clear air, insects, horizontal visibility ~45km**

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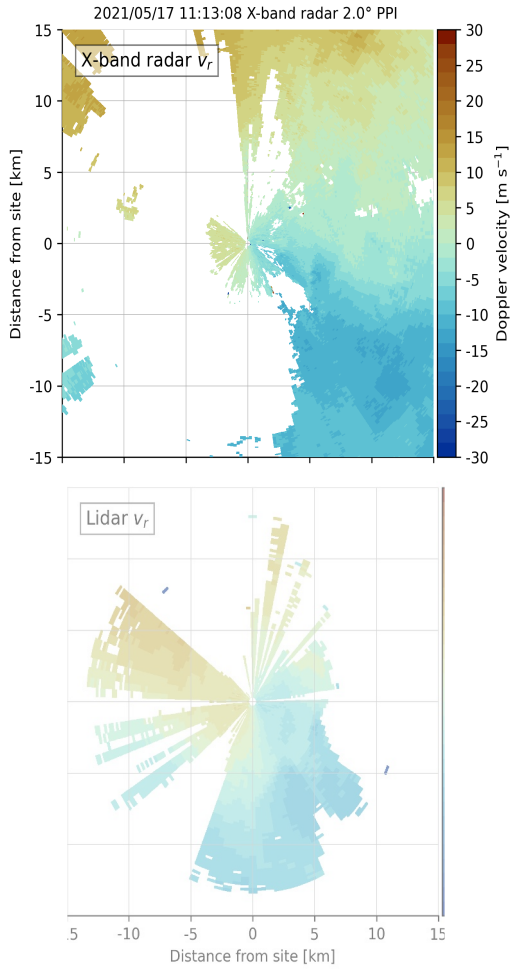


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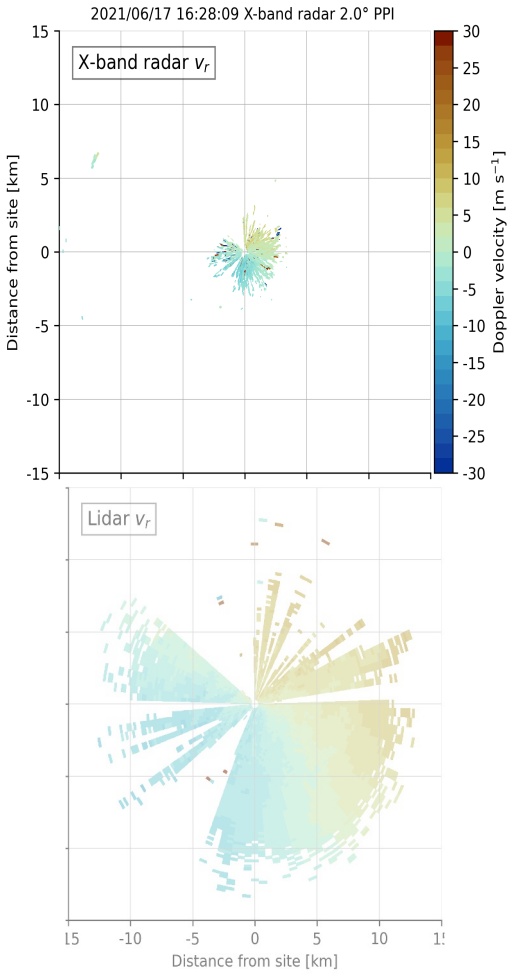
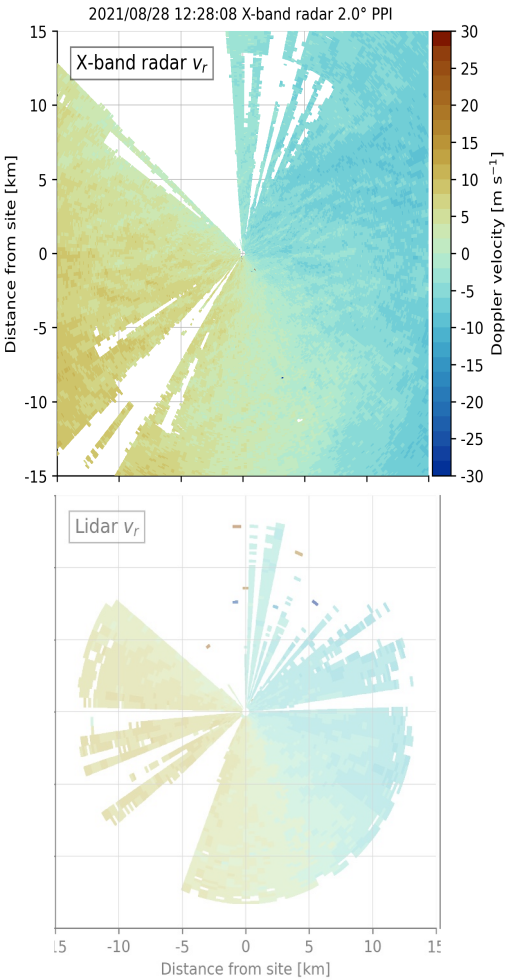



**Clear air, no insects, horizontal visibility > 60km**




**Clear air, insects, horizontal visibility ~45km**

# Takeaways

| Conditions | *Works best for:* | |
|---|---|---|
| | *Lidar (long range)* | *Radar* |
| **Horizontal Visibility** | 10-50km | >20km |
| **Precip** | Light precip | Any |
| **Cloud Base conditions** | Cannot measure above cloud base | Low base |
| **Clean Air** | Yes | No* |

- **Conclusion**: lidar and radar work as complements in a variety of different meteorological conditions
- **Further studies**: explore conditions where both devices have low/high availability at the same time
  - What conditions would there be no data for both devices?

# Questions? Thanks! 

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