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Cloudnet deficiencies caused by presence of targets below first range gate

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TROPOS

(AC)³

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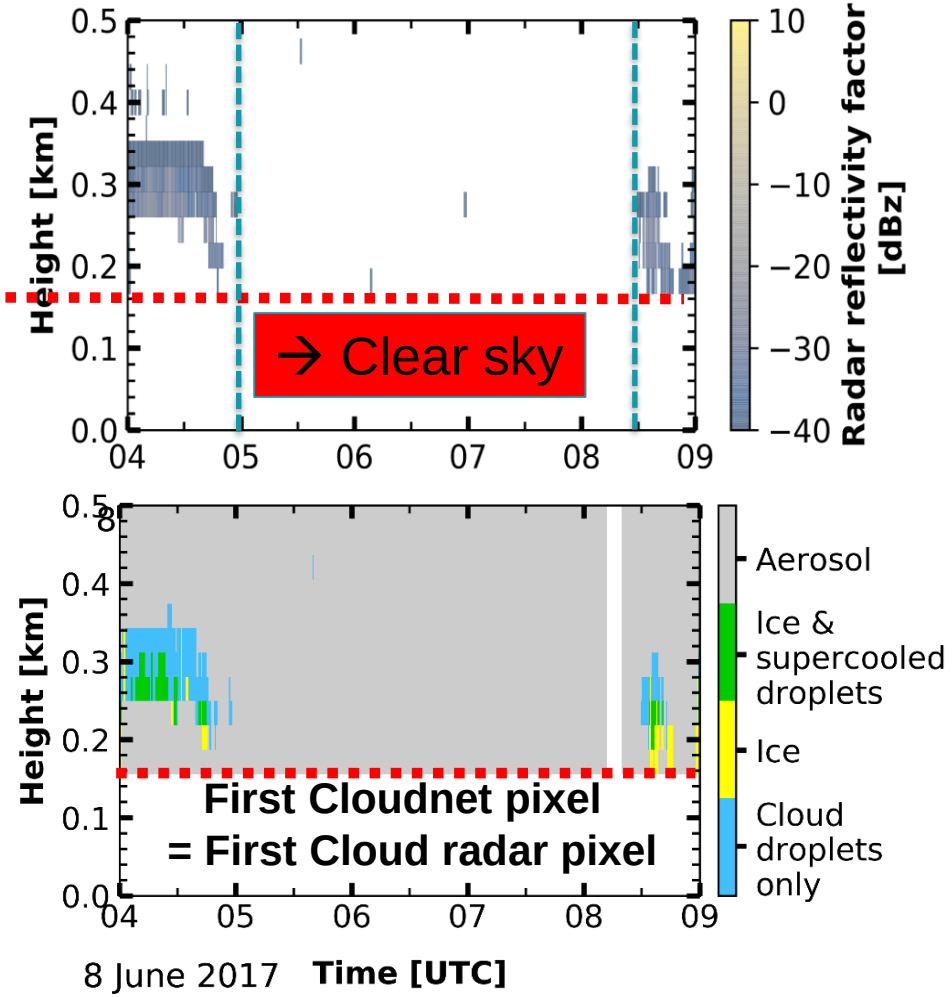
Lowest-level clouds can stay under the radar

Cloud radar: lowest detection range 165 m asl

Low-level clouds / fog: < 165 m asl



Griesche et al., ACP, 2020

Lowest-level clouds can stay under the radar

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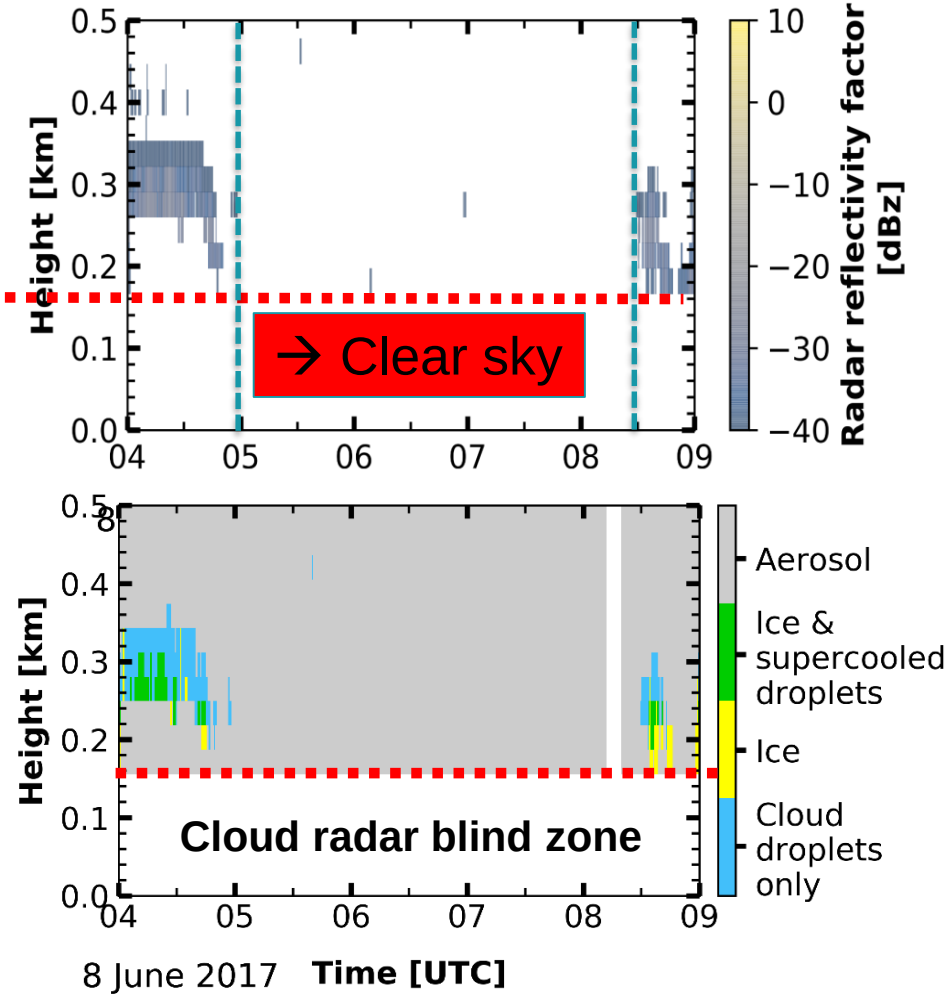
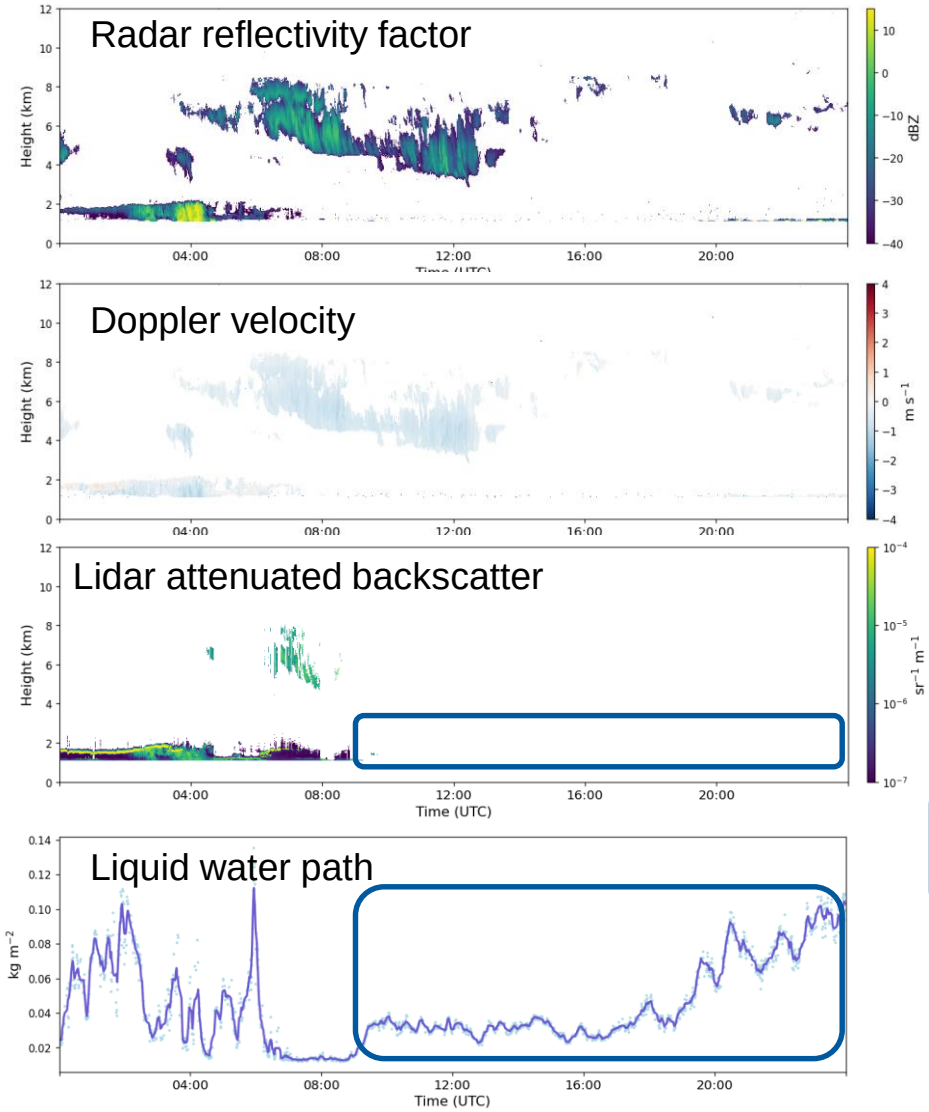


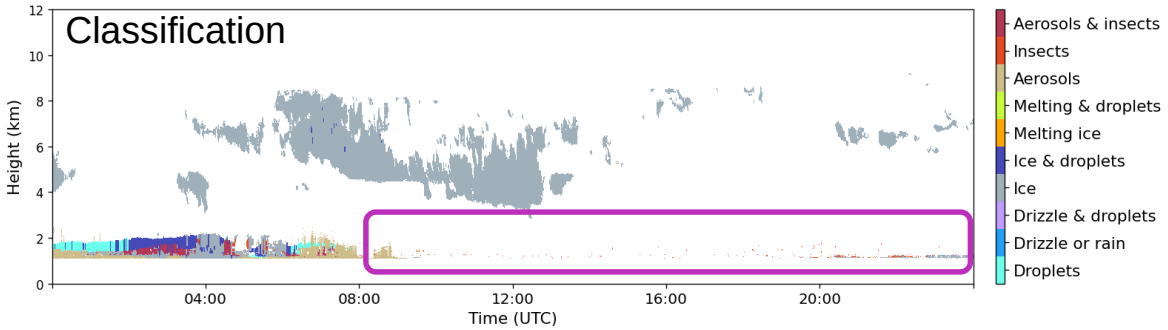
Griesche et al., ACP, 2020

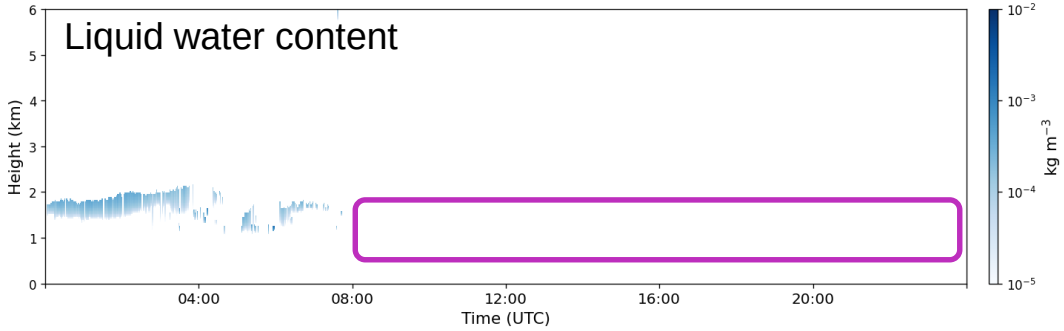
- **Ground-based**
- **Aircraft-based**
- **Satellite-based**

...also in mid-lats: Eriswil (Switzerland) 2024

Eriswil 10 January 2024





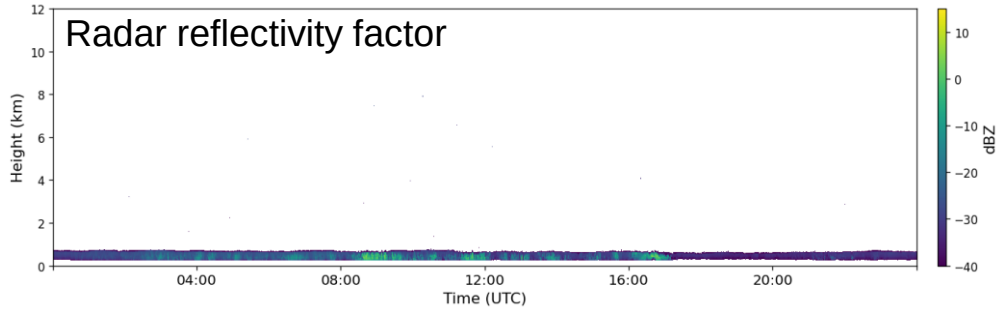


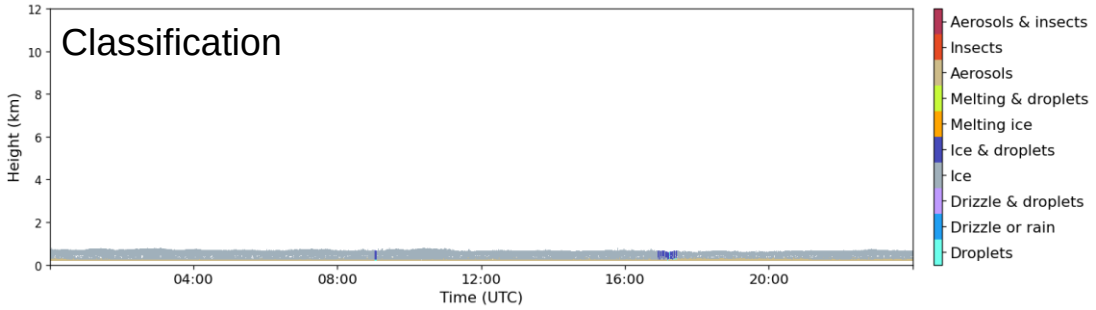
- Lidar beam attenuated below lowest Cloudnet range gate

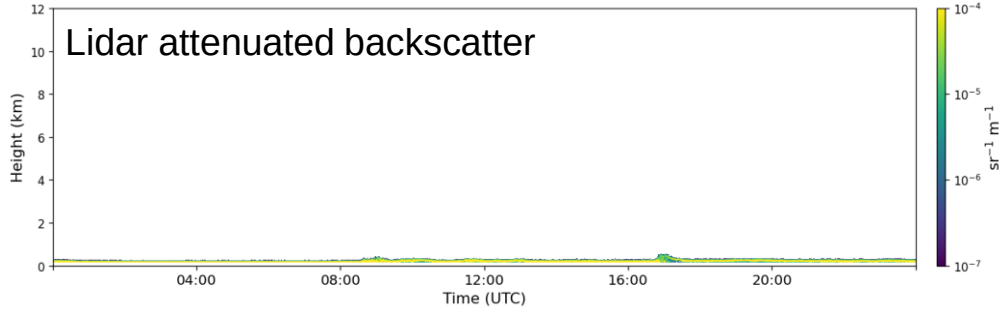
→No cloud identified
→No cloud properties derived

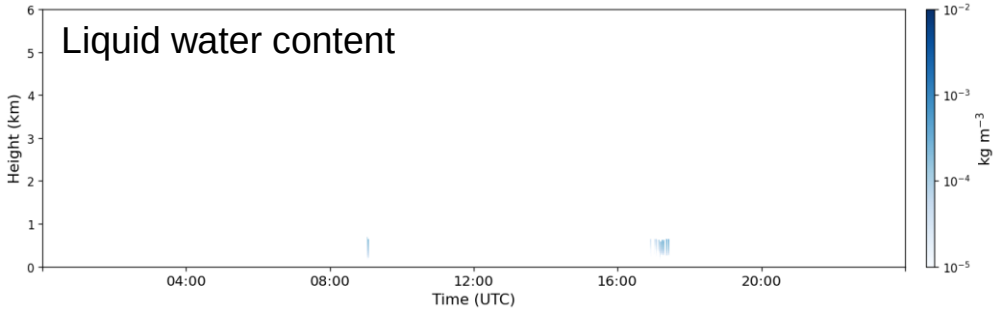
Complete lidar signal attenuation by lowest-level clouds in Palaiseau (France)

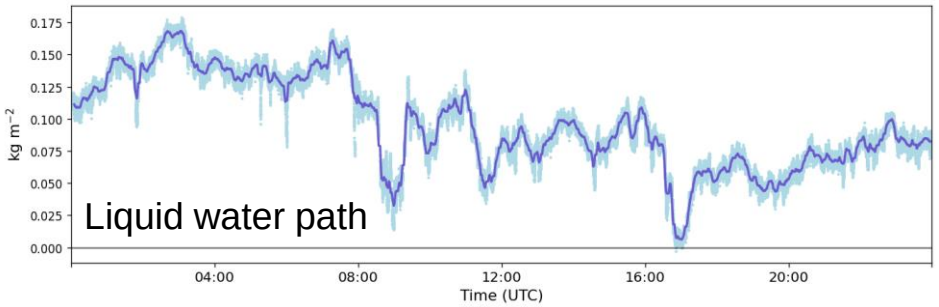
Palaiseau 13 January 2024











- Lidar beam attenuated below lowest Cloudnet range gate
- Radar signal detected

→ Pure ice cloud, no liquid-phase classified
→ No liquid cloud properties derived

- Same issue at Eriswil during approx. 30% of winter time

Complete lidar signal attenuation by lowest-level clouds

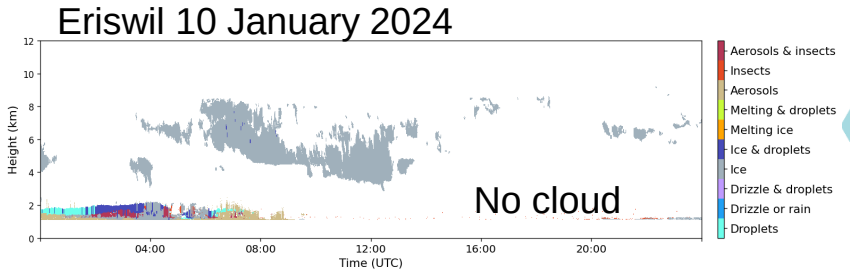
- Lidar beam attenuated below lowest Cloudnet range gate
- Clouds may be detected by cloud radar

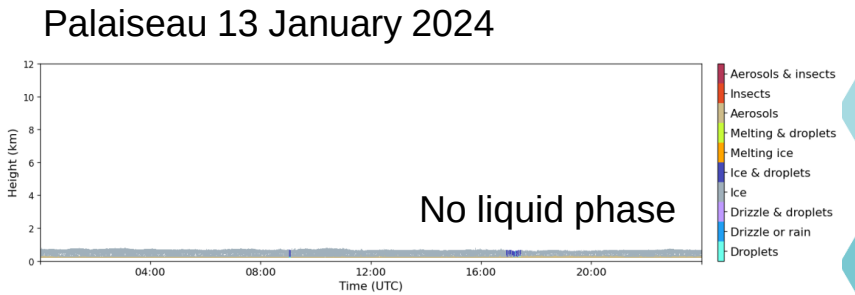
→ No cloud identified

→ No cloud properties derived

→ Cloud detected by cloud radar: pure ice cloud

→ No liquid cloud properties derived





Detection of low-level stratus clouds: lidar near field

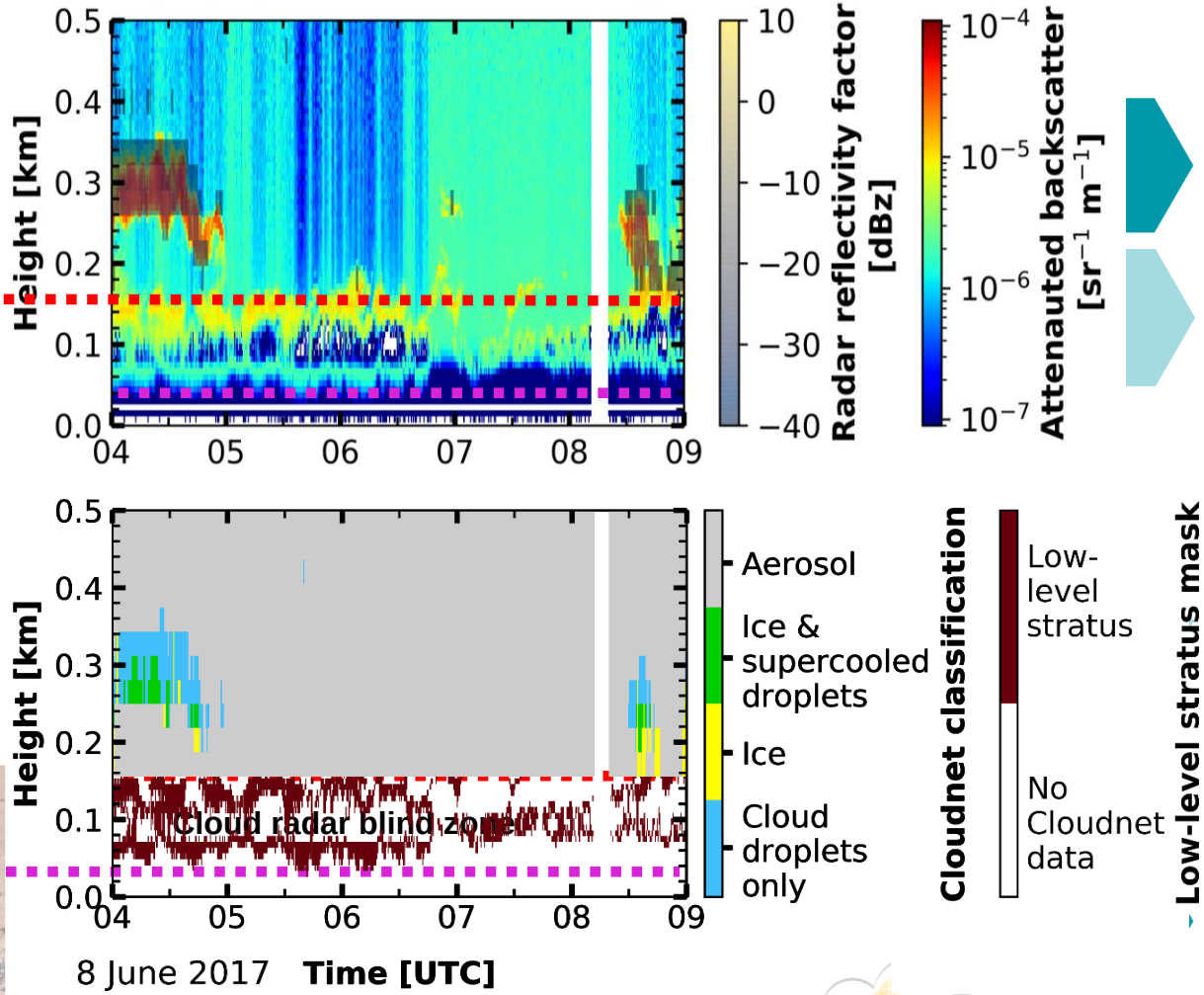
Cloud radar: lowest detection range 165 m

→ Clear sky

Low-level clouds / fog: < 165 m

Lidar: lowest detection range < 165 m

Picture: N. Fuchs



→ Low-level stratus detection by lidar

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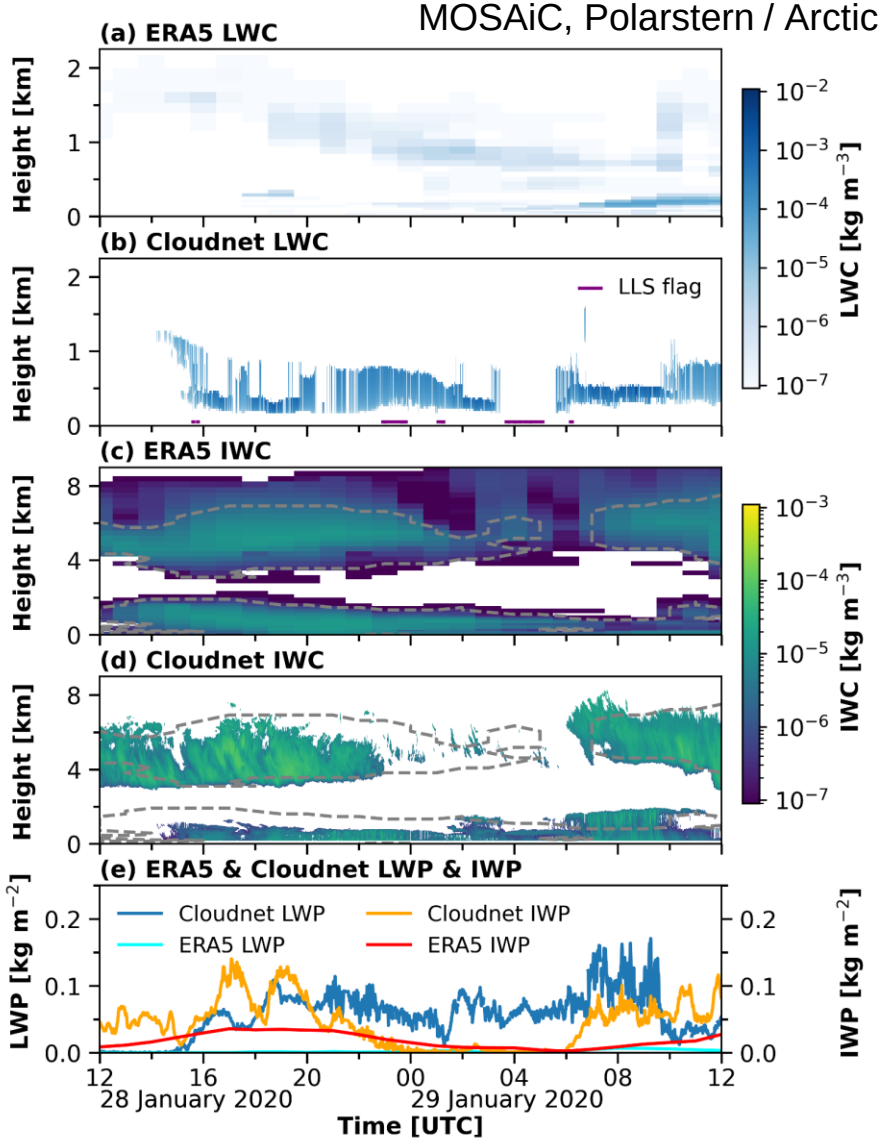
Cloudnet

Griesche et al., ACP, 2020

Model comparison: missing low clouds

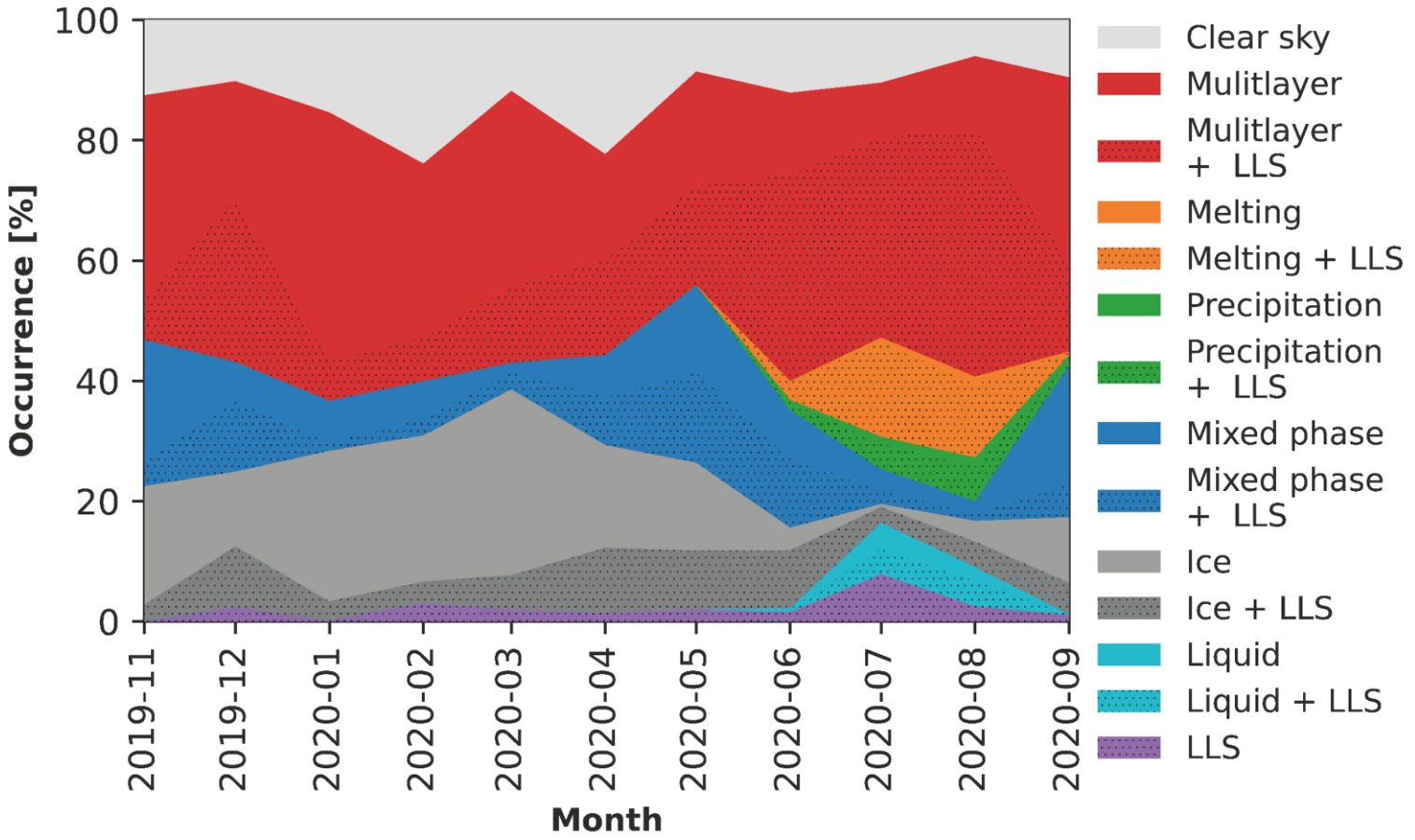
- Clouds sometimes missed due to lidar beam attenuation
- Low-level mixed-phase clouds likely underrepresented in Cloudnet data sets
- Missing in cloud statistics

MOSAiC, Polarstern / Arctic ocean



Griesche et al., Sci. Data, 2024

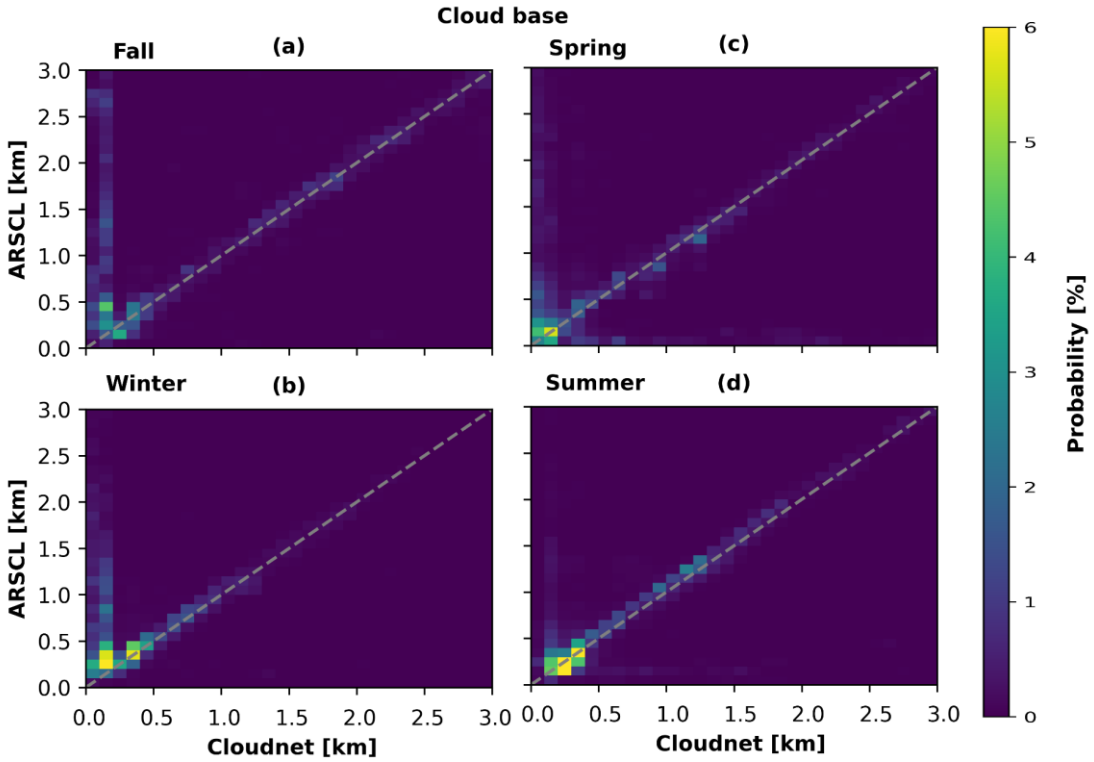
Low-level stratus clouds during MOSAiC (Arctic ocean)



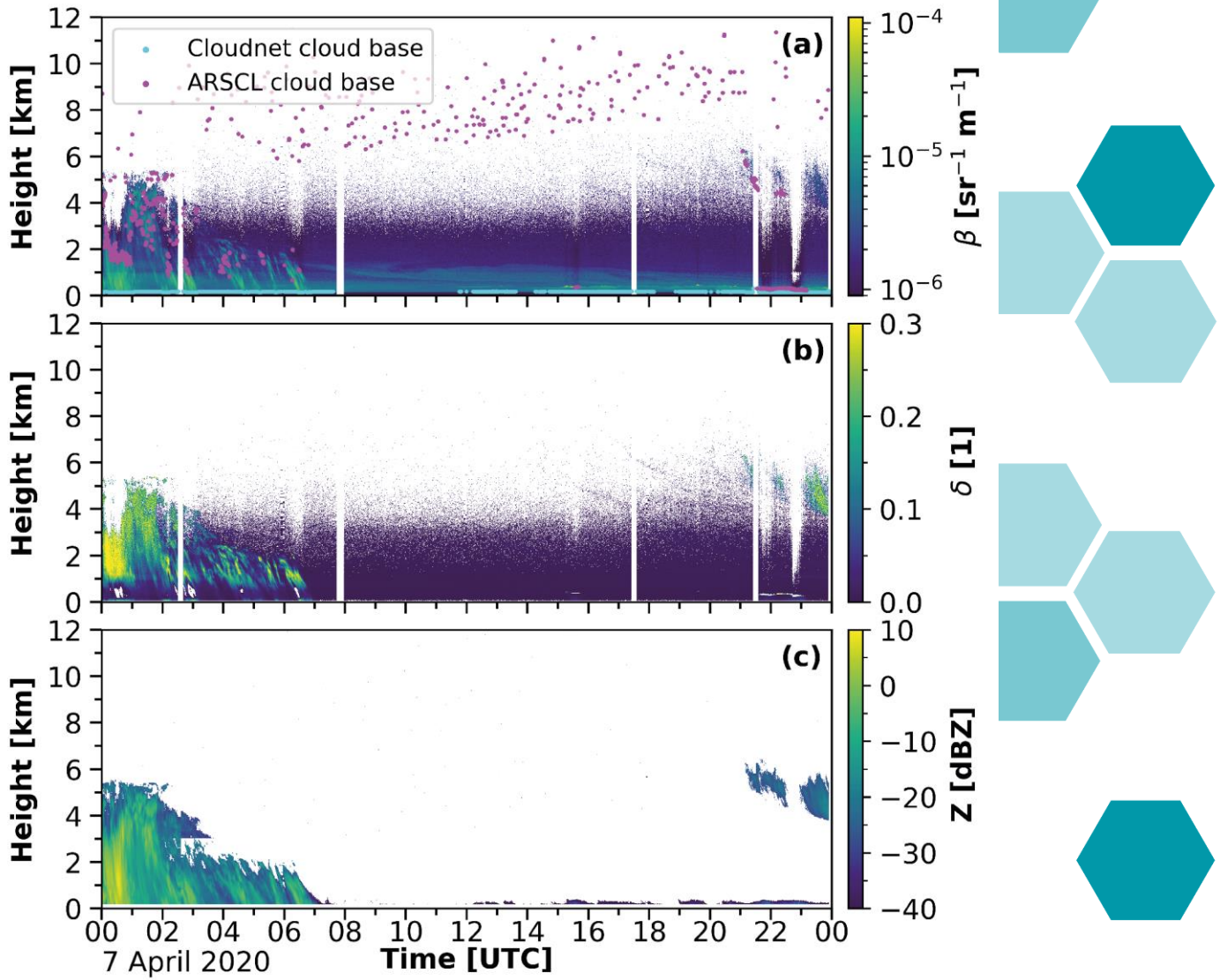
- Monthly occurrence of LLS up to 10% of the time.
- In combination with other clouds more than 50% of the time.

Low-level stratus: LLS

ARSCL comparison during MOSAiC (Arctic ocean)



- Low-level stratus clouds overestimated
- High level clouds overestimated by ARSCL



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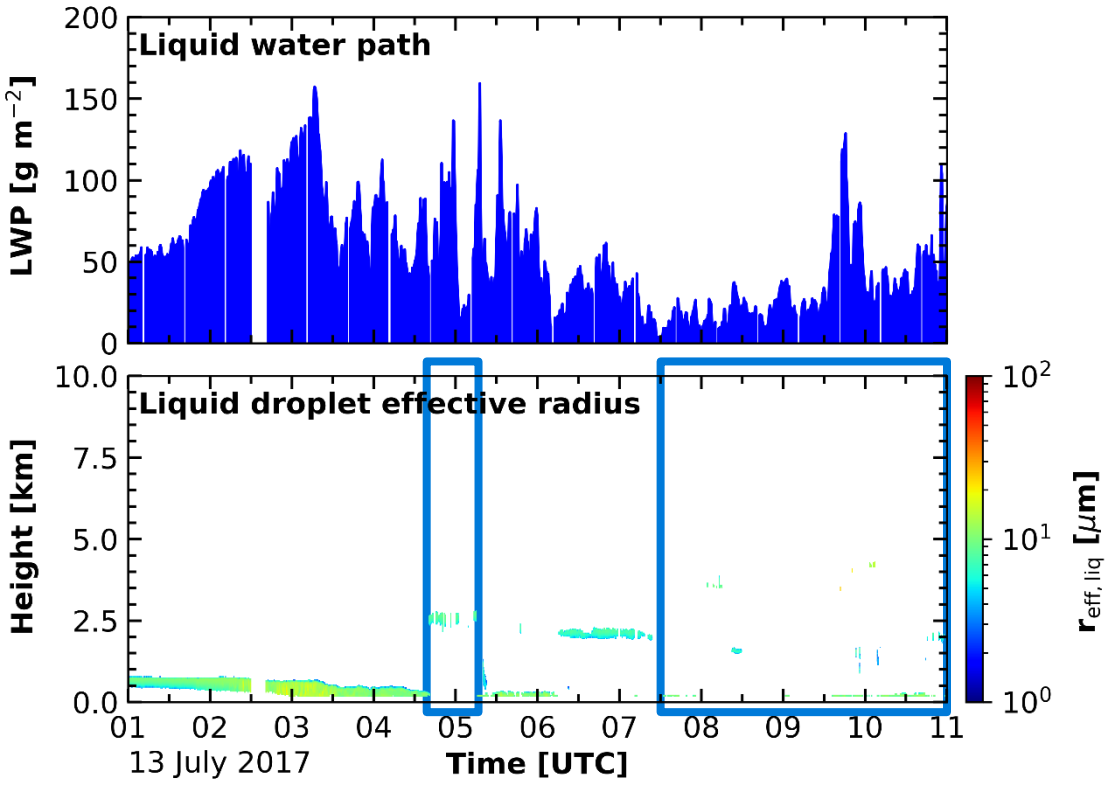
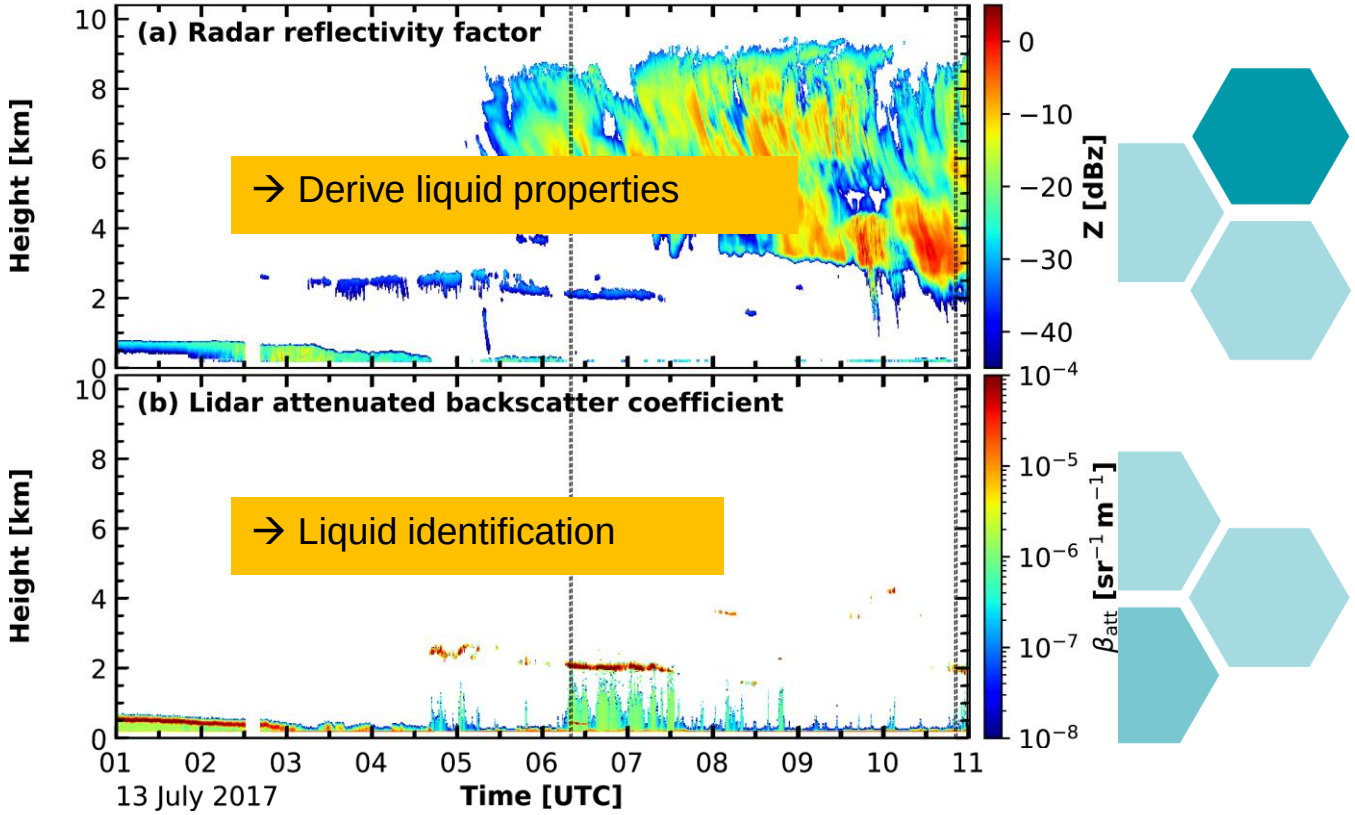
Cloud properties for radiative transfer simulations





→ Derive liquid properties

→ Liquid identification

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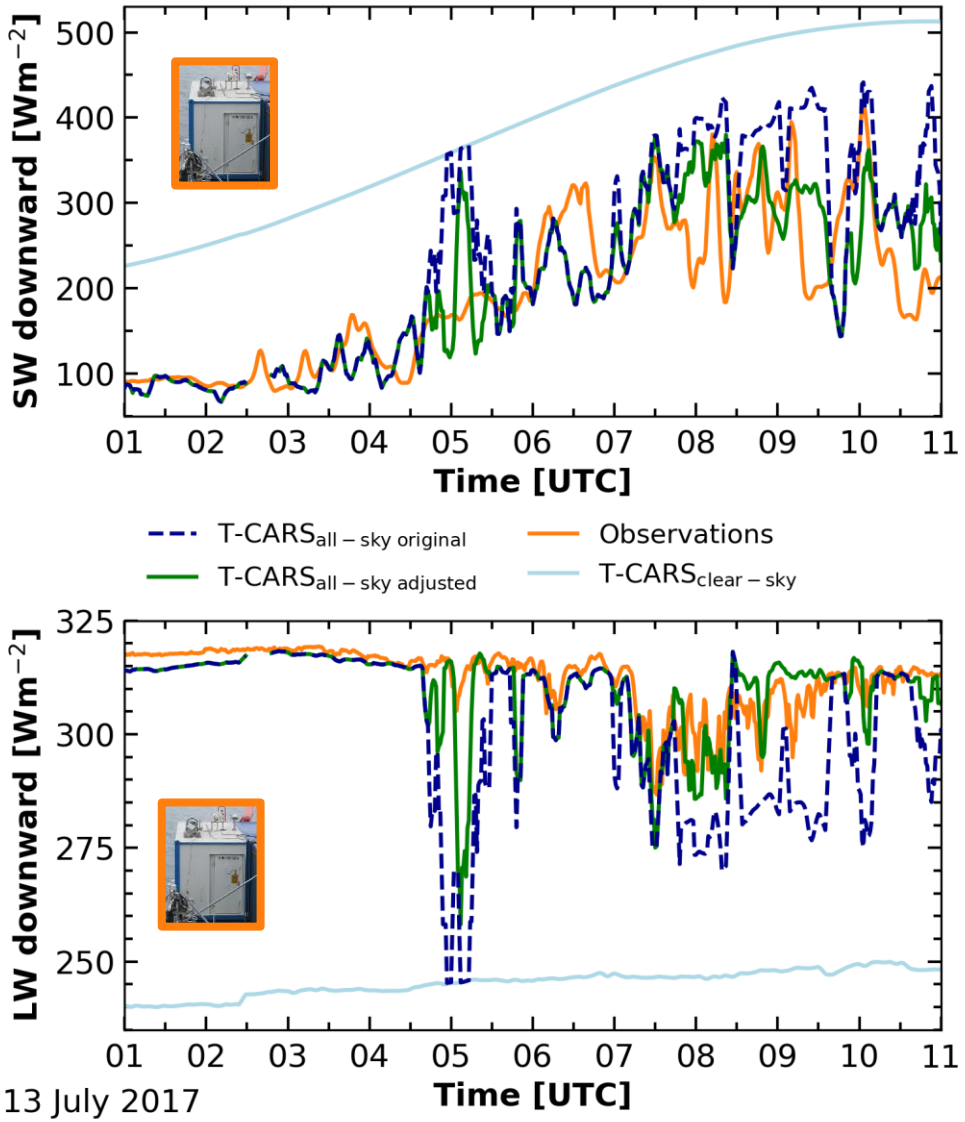
Surface shortwave and longwave cloud radiative effect



SW: shortwave radiation
LW: longwave radiation

T-CARS$_{all-sky\ original}$:

$\overline{\Delta SW_{\downarrow}}$ = 45 W m^{-2}

$\overline{\Delta LW_{\downarrow}}$ = -12 W m^{-2}

T-CARS$_{all-sky\ adjusted}$:

$\overline{\Delta SW_{\downarrow}}$ = 10 W m^{-2}

$\overline{\Delta LW_{\downarrow}}$ = -2.5 W m^{-2}

$$\Delta X_{\downarrow} = \text{Simulation}(X_{\downarrow}) - \text{Observation}(X_{\downarrow})$$

T-CARS$_{all-sky\ adjusted}$:

- Values calculated suggest **radiative closure**
- Mean flux differences below instrumental uncertainties
  - 20 W m^{-2} pyranometer ($SW_{\downarrow}$)
  - 10 W m^{-2} for pyrgeometer ($LW_{\downarrow}$)

(Lanconelli, 2011, Earth Syst. Sci. Data)

Griesche et al., ACP, 2024

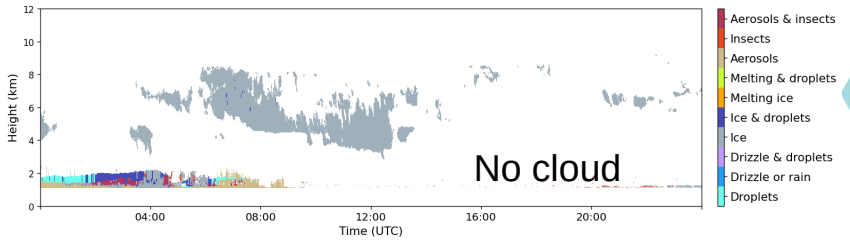
Summary

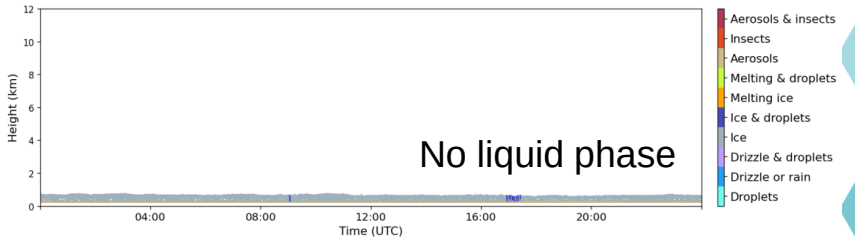
- Lidar beam attenuated below lowest Cloudnet range gate
- Clouds may be detected by cloud radar

  → No cloud identified
    → No cloud properties derived
  → Cloud detected by cloud radar: pure ice cloud
    → No liquid cloud properties derived

- Liquid clouds likely underrepresented in Cloudnet data sets
  → Missing in cloud statistics

- Missing liquid cloud cause large errors in radiative transfer simulations





Discussion - suggestions to adress the deficiencies

- Start Cloudnet mask at ground level
- Use lidar to detect low-level clouds
- Compare LWP to LWC for liquid cloud identification
- Use VOODOO to identify also higher reaching liquid clouds

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Thank you