Characterizing the Cloud-Aerosol Transition Zone using a CL31 ceilometer

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INTRODUCTION

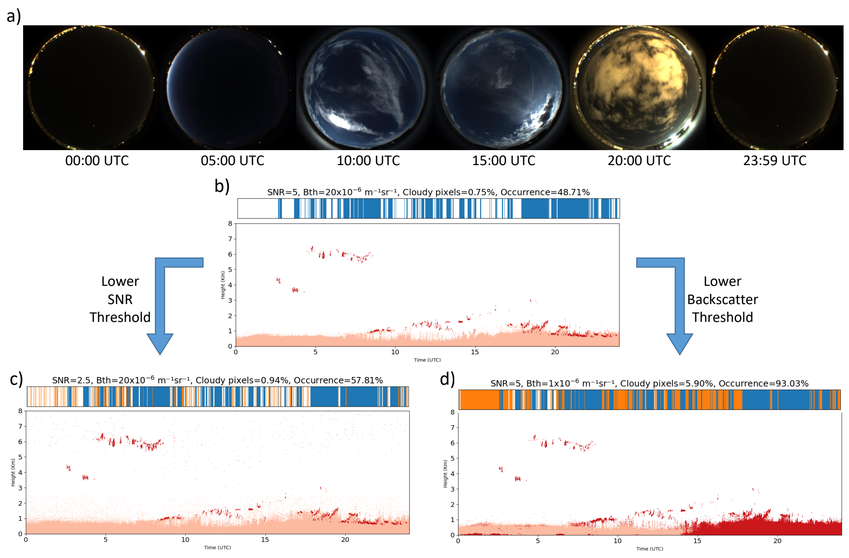
- **Cloud and aerosol** contribution to the Earth's radiative budget constitutes one of the most significant uncertainties in future climate projections.
- Recent research suggests the existence of a **transition zone** between cloudy and cloud-free air, which is mainly composed of humidified aerosols and subvisible cloud fragments (Koren et al. 2007).
- In the present study, backscatter profiles retrieved by a **Vaisala CL31 ceilometer** located at a Mediterranean site (Girona, NE of Spain) were processed to assess the frequency of transition zone situations.
- The study applies and compares two widely used **cloud detection algorithms**: the method provided by the ceilometer manufacturer, and the algorithm from Cloudnet (Illingworth et al. 2007; Tukiainen et al. 2020).

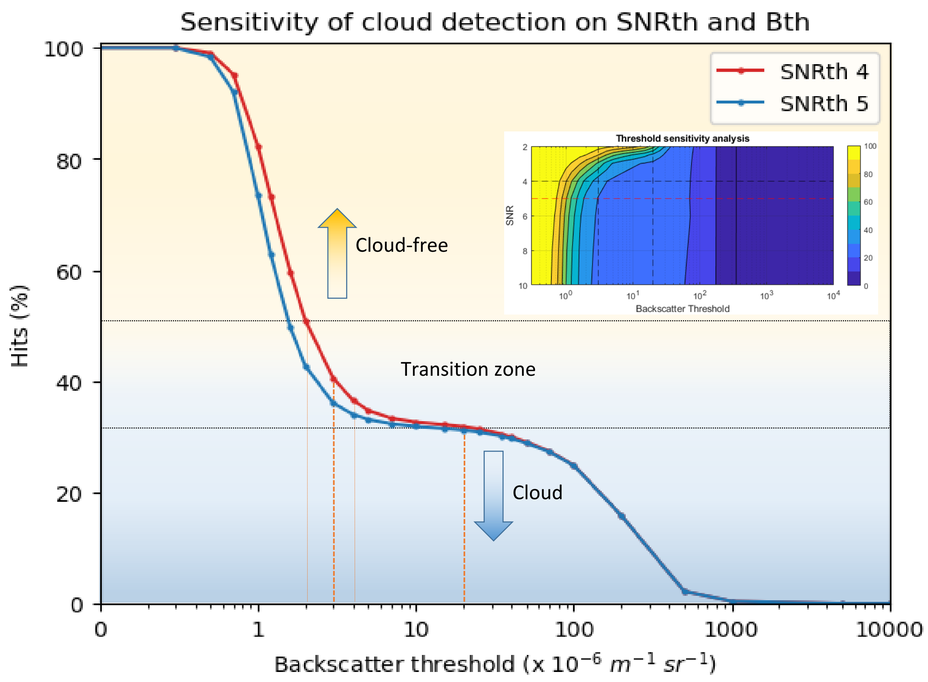
DATA

- One year (2022) of ceilometer backscatter profiles.
- Measurements taken at the station operated by the Environmental Physics Group of the University of Girona (41.96°N, 2.83°E, 115m a.s.l).
- Ceilometer model Vaisala CL31, with measurements at 16 seconds rate.

DETECTION SENSITIVITY ANALYSIS

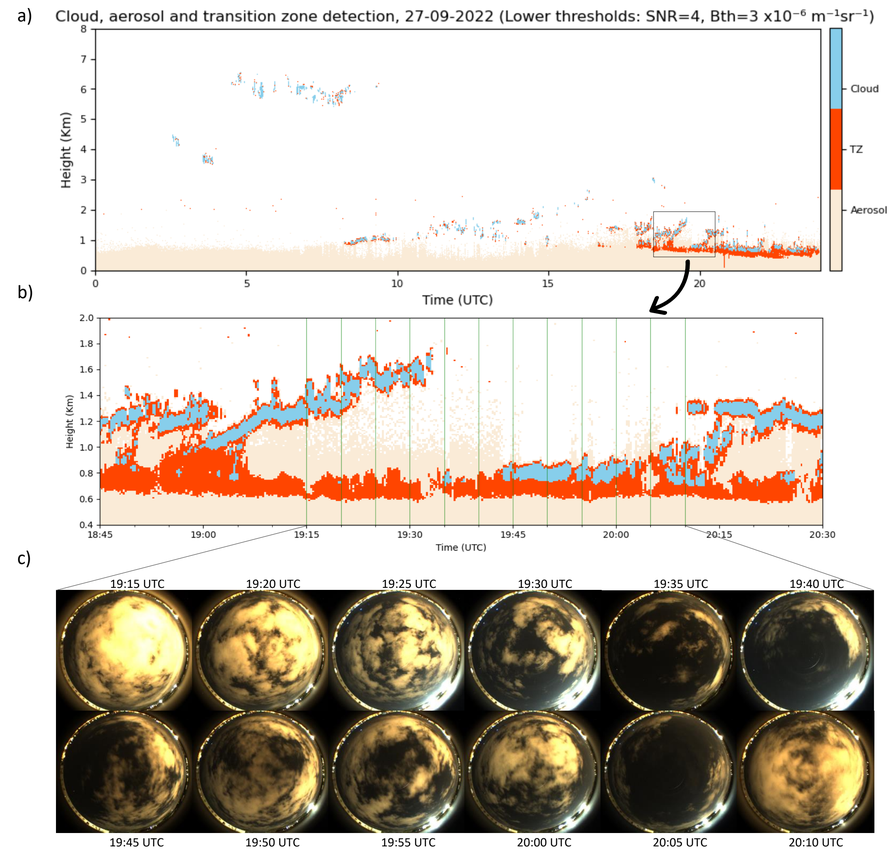
- Background noise is identified and removed based on the signal-to-noise ratio (SNR), using Cloudnet lidar processing algorithms.
- Several scenarios have been checked by varying the thresholds for backscatter signal (Bth) and Signal-to-Noise Ratio (SNRth).
- The predefined thresholds for cloud detection were SNR = 5 and Bth = 20×10^{-6} $m^{-1}sr^{-1}$. These produce an excellent agreement with detection and occurrence from Vaisala algorithm.



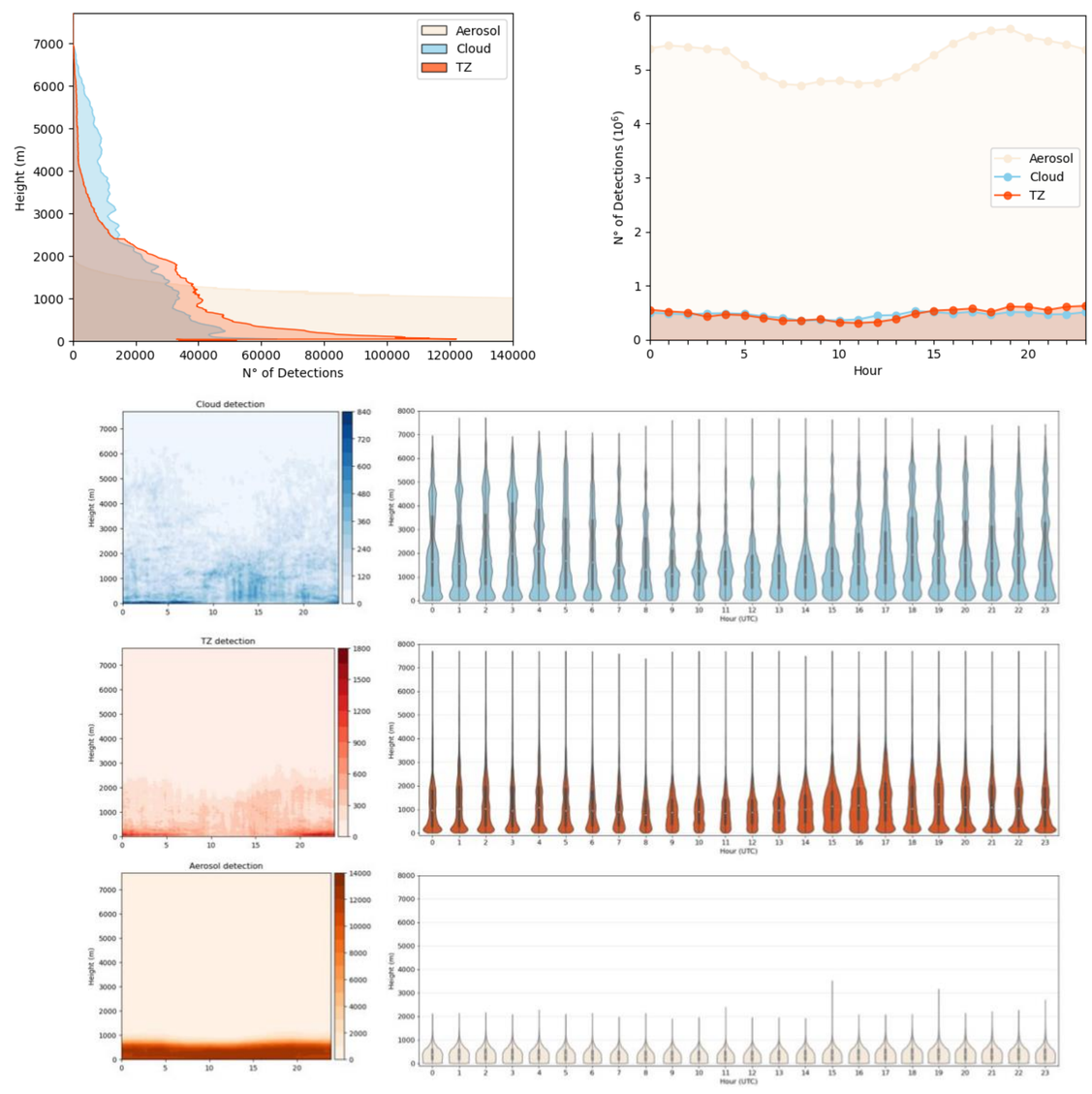


TRANSITION CONDITIONS

- In this study, we consider as Cloud-Aerosol Transition Zone situations, all those cases where there is a shift in the cloud detection when employing different sets of thresholds, from predefined to relaxed, by lowering either SNRth and/or Bth.



DETECTION DISTRIBUTION



CONCLUDING REMARKS

- Cloud occurrence estimations between Cloudnet and Vaisala algorithms are consistent (over 94% in accordance).
- Ceilometer backscatter retrievals show a gradual transition from cloud to cloud-free. Furthermore, cloud detection is influenced by the thresholds used.
- There is 9.3% (5.4-20%) variation in cloud occurrence between the chosen conditions. Similar TZ estimations have been found in Calbó et al. (2017) and González et al. (2023).
- Particles detected near clouds induce higher backscatter values than those found further away.
- When combining height and temporal information, the TZ was mainly found below 800 m during night periods.
- These findings highlight the importance of either including an additional phase between 'pure clouds' and 'pure aerosols' or treating them as a continuum of suspended particles in the atmosphere.

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