# Synergy of ceilometer and Doppler wind lidar observations

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The greatest climate change is taking place in the Arctic, where the warming rate is there times higher than global average since 1980. This extraordinary rate of warming is named the Arctic amplification. In the Arctic the air near the surface is predominantly stably stratified, and the vertical profiles of temperature are mostly characterized by the presence of temperature inversions. The Arctic inversion effectively shields the Arctic surface from the free atmosphere. It is shallow, believed to be typically a few hundred meters or less, and dynamically isolated from the free atmosphere. In consequence, there is a large interest in the observations of vertical the vertical structure of the atmospheric boundary layer (ABL). The ABL information is needed to better understand the observations that are carried out near the ground.

Studies of profiles of the ABL in the Arctic are of great importance as the observations there are quite rare. Simultaneous use of several systems like wind lidar and ceilometer is even rare. In addition, a challenge for all laser remote sensing systems is the low aerosol concentration most of the time. At the Villum Research Station (VRS) at Station Nord, Greenland (81° 36' N 16° 40' W, Fig. 1.), the laser backscatter intensity signal of a ceilometer (CL51) is used to estimate the depth of the surface-based aerosol layer, but only above 100 m as below this height the CL51 measurements are noisy or irregular. A Doppler wind lidar (DWL) has been operating in parallel providing observations between 40 m and 200 m. A methodology that combines profiles of carrier-to-noise ratio (CNR) observations from DWL with backscatter of CL51 and thus estimation of the depth of the ABL for cases below 100 m is achieved.

The station hosts individual scientific projects focusing on atmospheric, marine and terrestrial research. In addition to this, the station is also used as a permanent base for an extensive long-term monitoring station within the Arctic Monitoring and Assessment Programme (AMAP; www.amap.no). The Aerosol, Cloud, Trace gases Research InfraStructure (ACTRIS; www.actris.eu) and the Integrated Carbon Observation System (ICOS; www.icos-cp.eu) all report scientific data, besides the mentioned programs to the European Monitoring and Evaluation Program (EMEP) and WMO-Global Atmosphere Watch (WMO-GAW).


**FIG. 1** Map of the area north of the Arctic Circle (66°30′ N) showing the position of the Villum Research Station at Station Nord. The Arctic Circle limits the area with polar night and midnight sun often considered as the Arctic region.

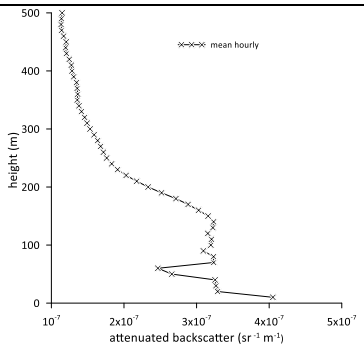


**FIG. 2** Example of a profile of attenuated backscatter measured by CL51. The outlier at 50 m is believed to be an instrument effect.

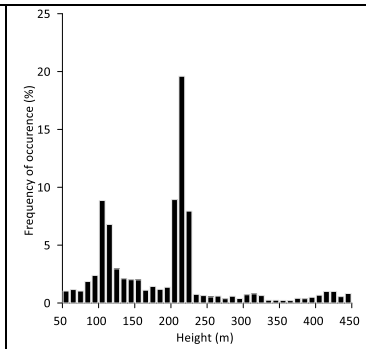


**FIG. 3** Histogram of the depth of the aerosol layer (AL) for 2018 from combined CL51 and DWL measurements. AL depths concentrate at ≈100 m and at ≈230 m