Wind lidar measurements of the atmospheric boundary layer in the Weddell Sea

***Günther Heinemann, Rolf Zentek**
University of Trier, Environmental Meteorology, Trier, Germany
*corresponding author: heinemann@uni-trier.de

DFG-SCHWERPUNKTPROGRAMM 1158 ANTARKTISFORSCHUNG mit vergleichenden Untersuchungen in arktischen Eisgebieten

DFG Deutsche Forschungsgemeinschaft

Universität Trier

1. Overview

The representation of the atmospheric boundary layer (ABL) in the Antarctic is a major challenge for numerical weather forecast models and regional climate models. Reference data sets are rare, particularly over the ocean areas. During the cruise PS96 of the research vessel Polarstern from December 2015 to February 2016, wind lidar measurements of the atmospheric boundary layer were performed in the eastern and southern Weddell Sea. The fully programmable scanning "Halo-Photonics Streamline" wind lidar was used to obtain a data set of high-resolution vertical profiles of wind, aerosols and turbulence at a high temporal resolution.

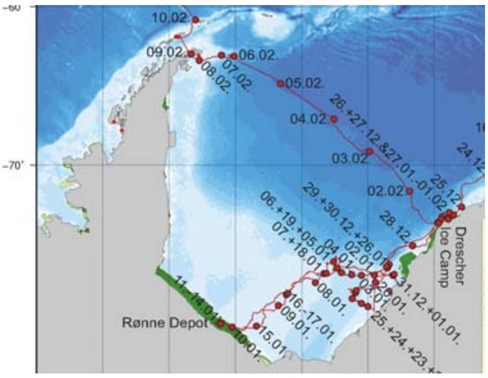

Fig.1: Left. Map of the Weddell Sea with cruise plot December 2015 – Feb. 2016 (© Arndt (AWI), modified).

Fig.2: RV Polarstern at the Ronne Depot. The position of the´lidar is indicated (photo: G. Heinemann.

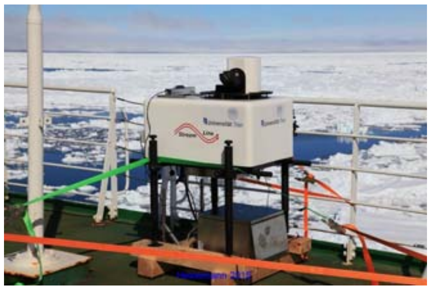

Fig.3: Wind lidar on RV Polarstern (photo: G. Heinemann).

2. Data and methods

The wind lidar can operate with a maximum range of 10km, but was used only for a range up to 3600 m due to the low aerosol concentration in the Antarctic. The operation principle is the Doppler effect by backscattering at aerosol particles. The main scan patterns were the vertical azimuth display (VAD, eight directions), the range-height indicator (RHI) and horizontal scans with fixed azimuth (Stare, two or three directions). For some periods the Doppler Beam Swinging (DBS, three directions) mode was used in addition. The VAD and DBS modes are designed for measurements of the wind profile. The VAD is more robust particularly in the Antarctic environment with low backscatter. The Stare mode allows for the determination of the horizontal wind vector and turbulence. The RHI mode is used for measurements of e.g. the internal boundary layer at the sea ice edge or ice shelf front. Since the lidar was on a moving ship, the ship's heading, roll and pitch angles had to be corrected. This was achieved by using an high-frequency Attitude Heading Reference System (XSENS MTi-G-700-GPS/INS) in combination with low frequency (1 Hz) data from the ship's navigation system. In addition to the wind lidar measurements, the routine meteorological measurements of the ship and radiosonde data (Vaisala RS92, ascents 2-3 times daily) were used.

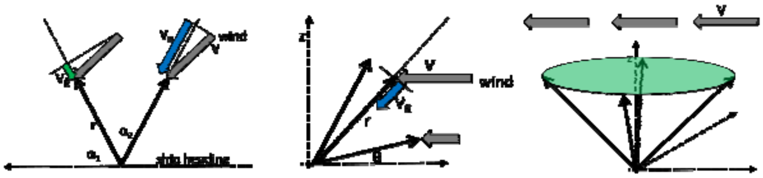

Fig.4: Types of main scan patterns (left Stare, middle RHI, right VAD). V_R = radial (line of sight LOS) wind), V = horizontal wind.

3. Measurements of the turbulent boundary layer

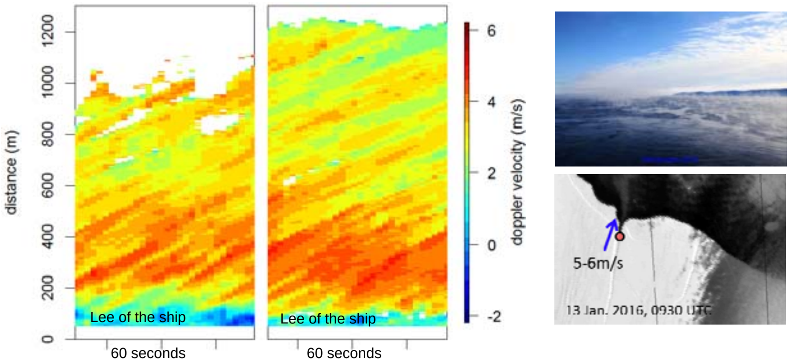

Fig.5: Left: Dual STARE wind measurements at 0800 UTC, 13 Jan. 2016 (2s-averages, directions of 0° (left) and 35° (right) for off-ice flow at the Ronne polynya showing propagating turbulence elements. Distance is measured from the fast ice edge. Right: Photo of sea smoke at 1000 UTC and satellite image (VIS) at 0930 UTC on 13 Jan. 2016.

4. Low-level jets

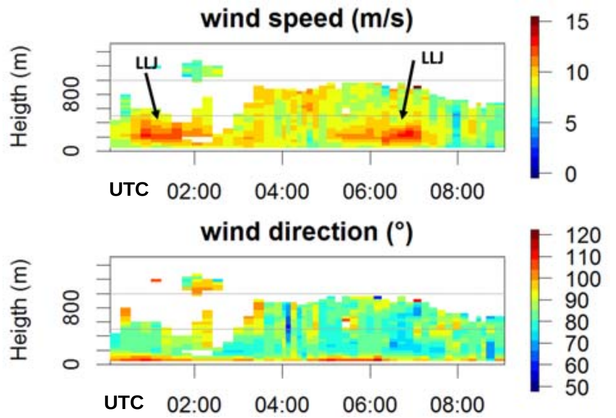

Fig.6: Low-level jets (LLJ) exceeding 10 m/s were measured on 17 Jan. 2016 in the lee of iceberg A23A.

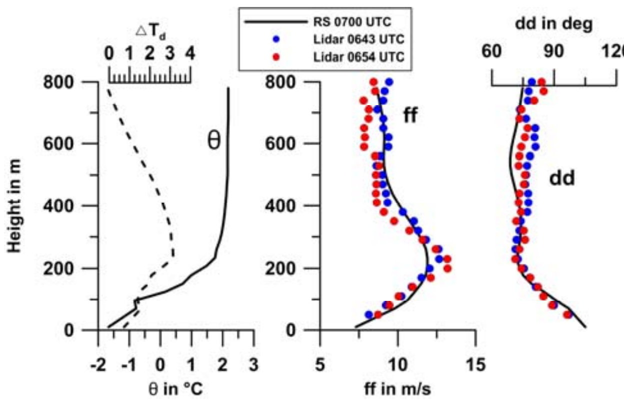

Fig.7: Right: comparison of lidar wind profiles with the radiosonde ascent on 17 Jan. 2016, 0700 UTC. Left: radiosonde profiles for potential temperature and dewpoint difference.

Conclusions

The wind lidar measurements during Polarstern cruise PS96 yielded a valuable data set for process studies and the verification of atmospheric models. Between 23 December 2015 and 30 January 2016, vertical wind profiles were measured every 10-15min. The horizontal wind structure was measured by the Stare mode for most of the time. Turbulence measurements and RHI focused on special measurement periods. To our knowledge, it is the first time that wind lidar measurements have been performed on a ship in the Antarctic.

Acknowledgements
This work was supported by the Deutsche Forschungsgemeinschaft (DFG) under grant DFG HE 2740/19 and by the Alfred-Wegener-Institute (AWI) Polarstern grant AWI_PS96_03.