A study of the stable boundary layer in strong gap flows in northwest Greenland using a research aircraft

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1. Introduction

The Nares Strait between northwest Greenland and Ellesmere Island (Canada) is a preferred region of gap flows. Modelling studies show that a pronounced near-surface wind maximum due to channelling by the topography of the Nares Strait is also associated with a low-level jet (Samelson and Barbour 2008). This channelling effect is important for the formation of the Northwater polynya (NOW) at the north end of Baffin Bay. The NOW is mainly wind-driven, it is biologically very productive and the most ice-productive polynya of the Arctic. The mean area of the NOW during winter is about 30000 km² (Preußer et al. 2015). The present paper presents a study for the NOW during summer using an instrumented research aircraft. This is the first observational study documenting the complete stable boundary layer (SBL) and low-level jets (LLJs) in that area.

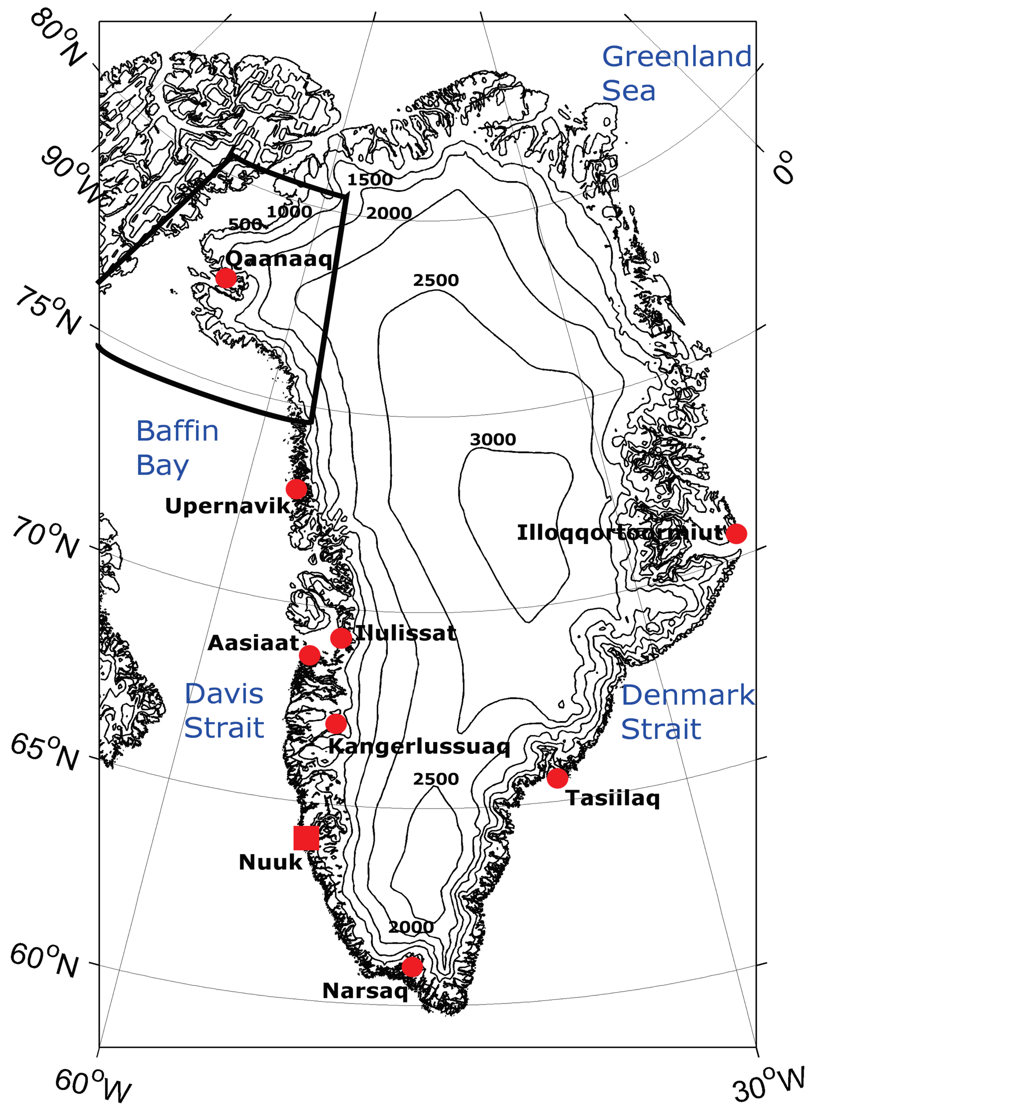

Fig.1: Map of Greenland with topography (ETOPO5 dataset; *NGDC*, 1993). The elevation contour interval is 500 m. The experimental area (see Fig.2) is indicated by a tetragon (from Heinemann et al. 2011).

2. Data and experiment setup

The aircraft-based experiment IKAPOS (‘**I**nvestigation of **Ka**tabatic winds and **Po**lynyas during **S**ummer) was performed in June 2010. A total of four NOW flights and two katabatic wind flights over the Humboldt and Steenstrup glacier have been performed.

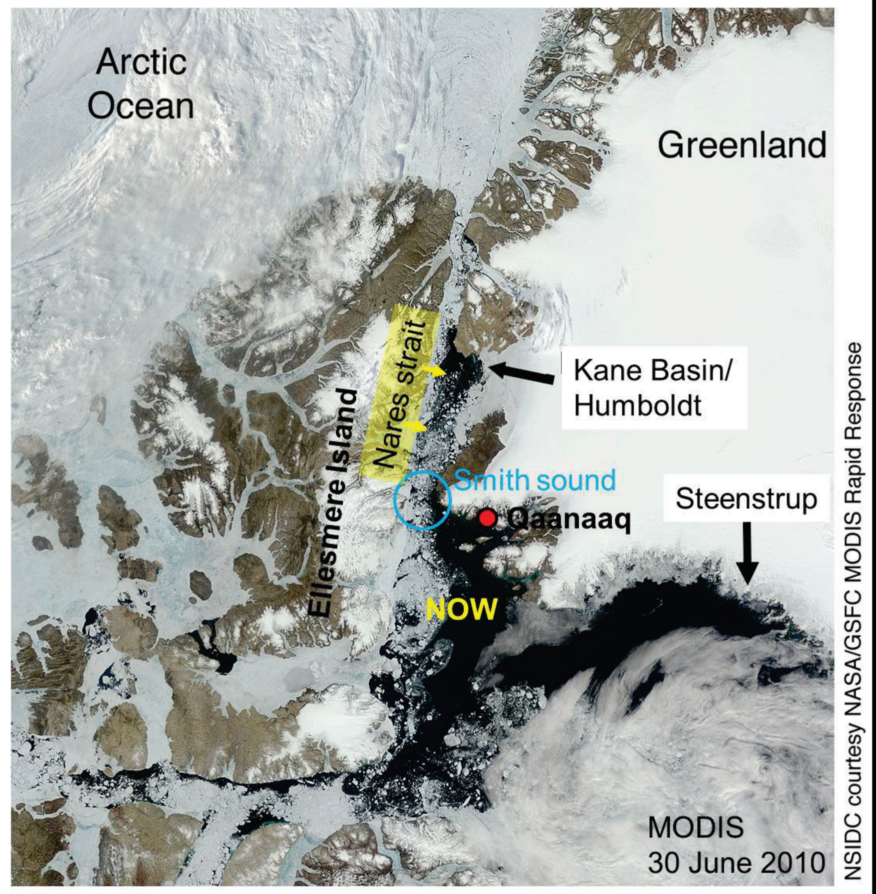

Fig.2: MODIS satellite image for 30 June 2010 (modified from NSIDC, 2010) indicating the measurement areas for the katabatic wind (Humboldt and Steenstrup glaciers) and the NOW programmes.

Fig.3: The research aircraft POLAR 5 (owned by the Alfred-Wegener Institute, AWI). POLAR 5 was instrumented with turbulence sensors, basic meteorological equipment, radiation and surface temperature sensors, two laser altimeters, video and digital cameras. The turbulence measurement system is installed on a nose boom (sampling rate of 100 Hz). A detailed description of the experimental setup and the flight missions are given by the field phase report (Heinemann et al., 2011). The calibration of aircraft sensors is documented in Drüe and Heinemann (2013).

3. Case study for 23 June 2010

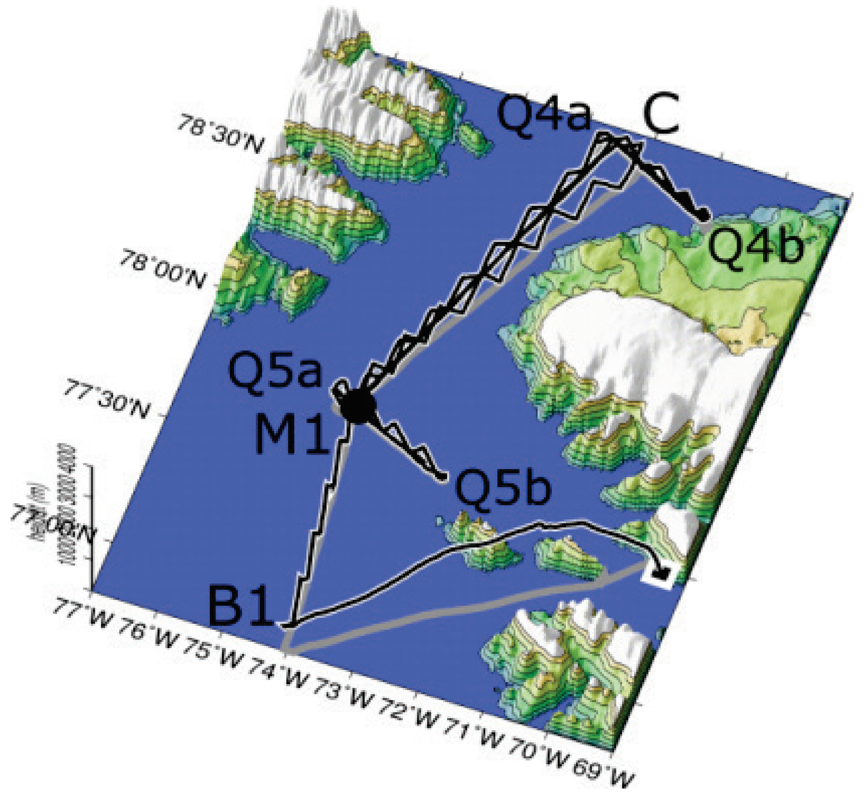

Fig.4: Flight path for NOW4 on 23 June 2010. Square: Qaanaaq airport. Contour lines of topography are indicated every 100 m (up to 600 m).

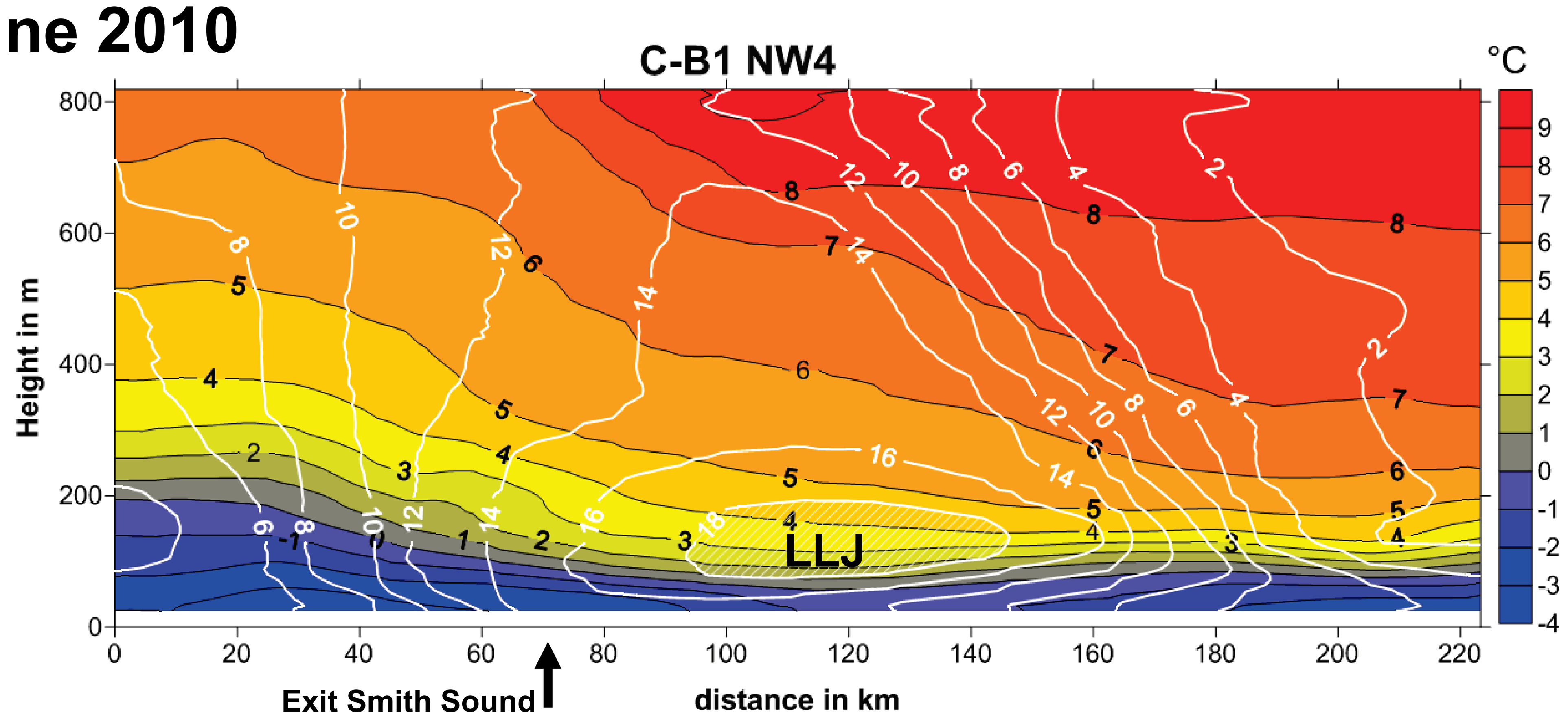

Fig.5: Cross-section of potential temperature and wind speed along the main profile C-M1-B1 for NOW4. Distances are given relative to point C southward. The view is from the west. The low-level jet (LLJ, jet core marked by hatching) occurs south of the Smith Sound exit, which is consistent with gap flow theory (Gabersek and Durran 2004). The flow through the gap and over the surrounding mountains leads to the lowering of isotropic surfaces and the acceleration of the flow.

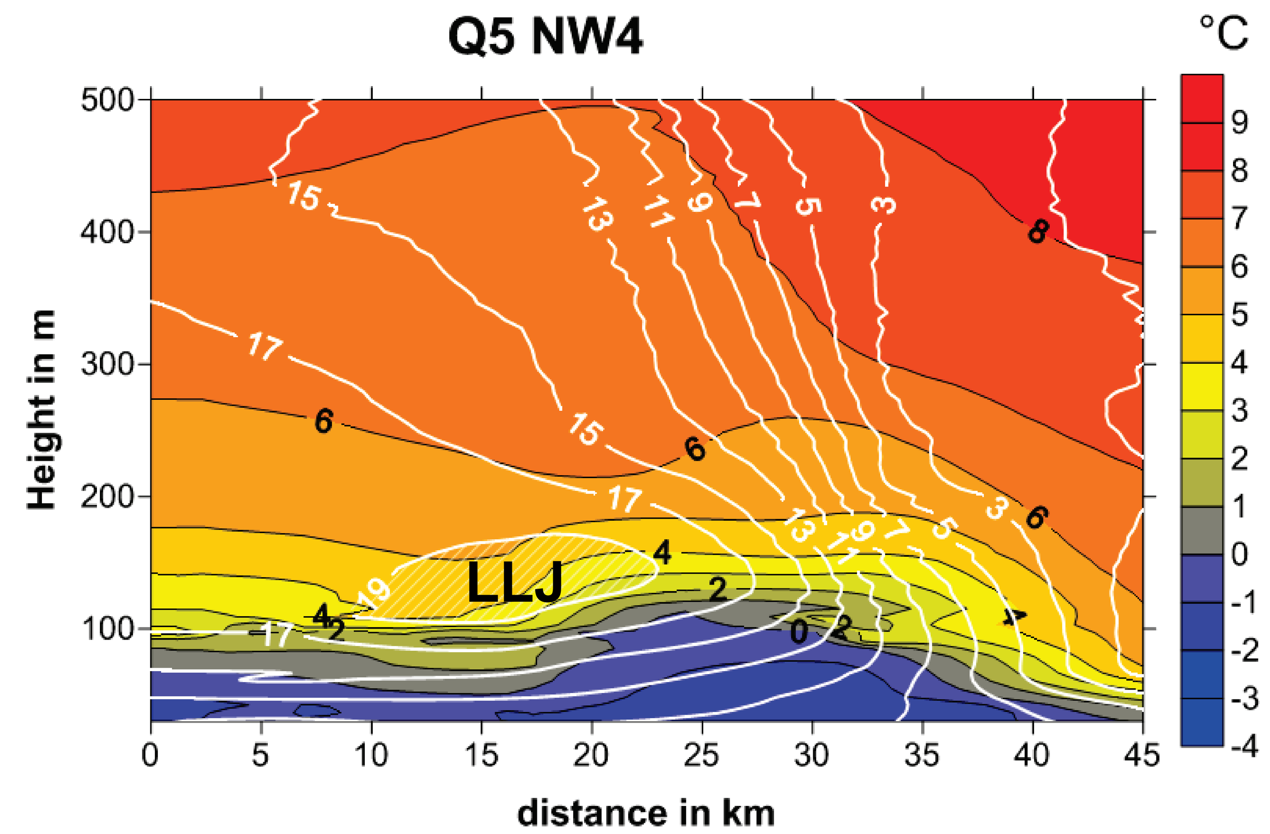

Fig.6: Cross-section of potential temperature and wind speed (jet core marked by hatching) along the cross profile Q5 for NOW4 (see Fig.4). The view is from the south. The shading effect of the Greenland mountains on the flow is visible. Wind speed decreases from 19 m/s in the jet core to less than 3 m/s in the lee of the mountains.

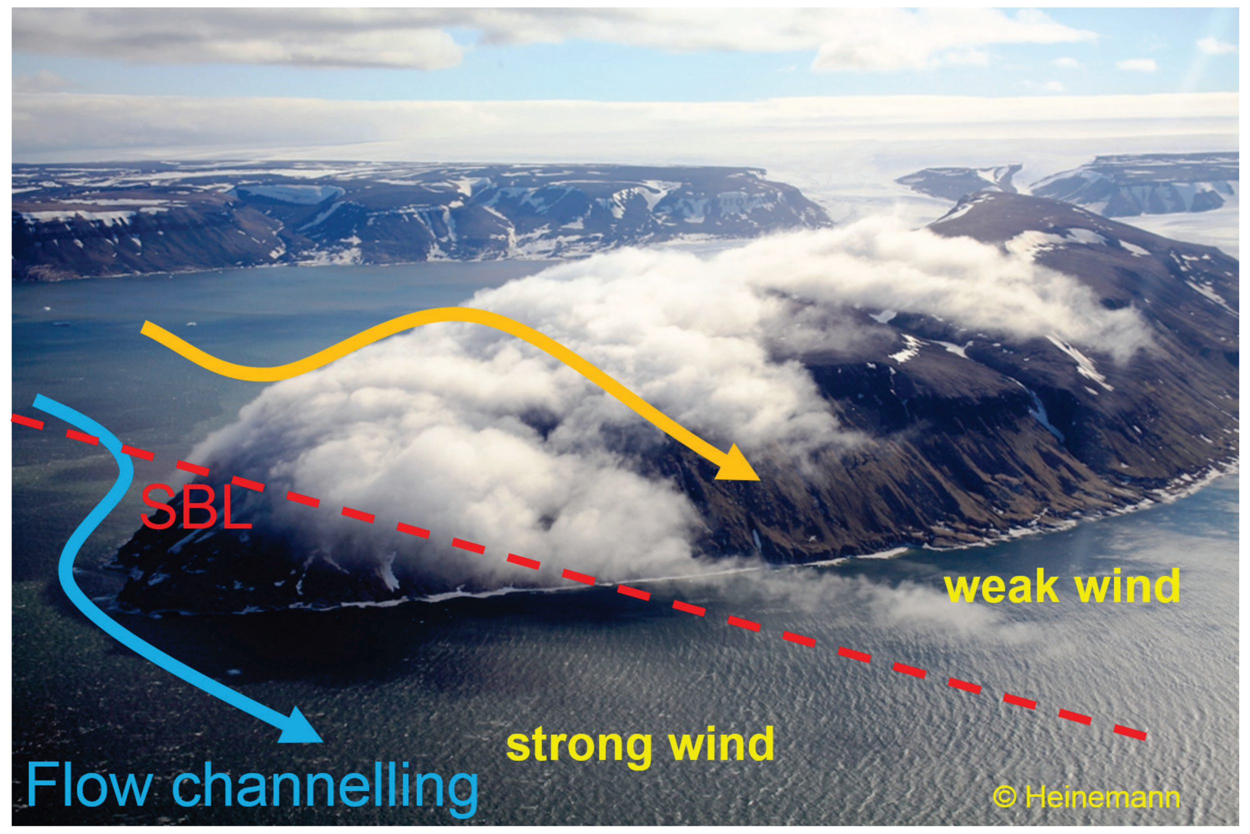

Fig.6: Visualization of flow channeling and flow over the mountains at Smith Sound (foto taken from Polar 5 by G. Heinemann).

4. Conclusions

- In the area of the Nares Strait a stable, but fully turbulent SBL was found during conditions of relatively warm synoptically induced northerly winds.
- Strong surface inversions were present in the lowest 100 m to 200 m.
- A well-pronounced low-level jet (LLJ) system with up to 22 m s^{-1} was documented by aircraft measurements.
- The channeling process is consistent with gap flow theory.

References

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