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Article

The polar regions: a natural laboratory for boundary layer meteorology – a review

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Abstract

Polar regions offer the opportunity to study many processes under strongly simplif ed conditions ('natural laboratory'). For example, the plateau areas of the polar ice sheets represent areas with an almost ideal homogeneous surface over a scale of several 100 km, which are extraordinary suited for studies of the stable boundary layer (SBL). In coastal areas we f nd often a transition of the SBL to a convective boundary layer (CBL) over polynyas, which allows for near-ideal studies of internal boundary layers. The sea ice areas in polar regions are another example for natural laboratory conditions, since they represent large areas with well-def ned heterogeneities of two surface types. The present review shows examples of how the polar areas can be used as a natural laboratory for f eld experiments in the Arctic and Antarctic with a focus on the work performed by German research groups.

Zusammenfassung

In den Polargebieten können zahlreiche Prozesse unter stark vereinfachten Randbedingungen ("natürliches Labor") untersucht werden. So stellen z.B. die Plateaus der polaren Eisschilde Gebiete mit einer nahezu völlig homogenen Oberf äche über eine Skala von mehreren 100 km dar, die sich hervorragend für Studien der stabilen Grenzschicht (SBL) eignen. In den Küstenbereichen f ndet man oft den Übergang einer SBL zur konvektiven Grenzschicht (CBL) über Polynjas mit der Möglichkeit zur Untersuchung von internen Grenzschichten unter fast idealen Bedingungen. Ein weiteres Beispiel für ein natürliches Labor sind polare Meereisf ächen, die Gebiete mit extrem ausgeprägter Heterogenität von zwei Oberf ächentypen darstellen. Der Übersichtsartikel zeigt Beispiele zur Nutzung der Polargebiete als natürliches Labor anhand von Ergebnissen von Feldexperimenten in der Arktis und Antarktis, wobei der Schwerpunkt auf Arbeiten von deutschen Forschergruppen liegt.

1 Introduction

One of the basic problems of experimental meteorology is the fact that only few processes can be studied under laboratory conditions. Large wind tunnels (e.g. the wind tunnel of University Hamburg, SCHATZMANN et al., 2000) can be designed to study some phenomena particularly under hydrodynamical aspects, but they are limited with respect to the upscaling to real atmospheric scales, stable or convective conditions and realistic synoptic boundary conditions. Therefore, f eld experiments are necessary for the investigation of processes on their real spatial scales. Recent examples for large f eld experiments are the COPS experiment aiming at the study of convective precipitation (WULFMEYER et al., in print) and the Lindenberg experiment LITFASS 2003 aiming at the boundary layer over heterogeneous surfaces (MENGELKAMP et al., 2006). The main disadvantage of f eld experiments is that the boundary conditions are very complex in general and cannot be controlled. Thus the experimental meteorologist has to select the experimental area carefully and has to wait for the appropriate synoptic conditions. But even if these conditions are met, the interpretation of the data may be diff cult because of the complex boundary conditions. In order to study atmospheric boundary layer (ABL) processes and to develop parameterizations, it is generally tried to simplify the boundary and forcing conditions as much as possible. In the classical boundary layer studies, extended homogeneous areas have generally been selected (e.g. BUSINGER et al., 1971). However, only few areas in the world can be found with homogeneous surface conditions over large scales, particularly for the study of stable boundary layers (SBL). In the polar regions we f nd large areas with homogeneous surface conditions, well-def ned heterogeneities on large and small scales, and the interaction of the surface and the atmosphere under extreme conditions. A variety of phenomena, such as katabatic winds, drainage f ows, the stable boundary layer, topography-generated gravity waves, foehn events or snow physics processes can be studied under near-ideal conditions in the polar areas. Thus, the polar regions can be regarded as a natural laboratory, where 'laboratory' datasets can be generated to improve parameterizations that will be tested afterwards in mid-latitude conditions.

In the present review it will be illustrated how the polar areas can be used as a natural laboratory for f eld experiments in the Arctic and Antarctic. This overview

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