

The stable atmospheric boundary layers, formed during the nights as well as severe winter seasons, are less dramatic than day-time unstable boundary layers, which can lead to thunderstorms in late afternoons. Probably for this reason, but also due to various technical difficulties, the former are less intensively studied than the latter. However, the former is equally important as the latter: as the surface is cooled by longwave radiation during the night, the downward heat flux of the stable boundary layer compensates this cooling tendency. Thus, for predicting the temperature of the following morning, a precise prediction of the heat flux in the stable boundary layer becomes crucial, especially, in operational weather predictions.

The present project focuses on the strongly-stratified, very stable boundary layers (VSBLs), because a reliable transport description for these layers is still not available even today. The main reason for this is their complex, time-dependent and intermittent structure.

The goal of the present project is to develop a solid formulation for describing the intermittent, nonstationary VSBLs by combining analyses of governing equations and data. Here, we aim to be *solid* by maintaining a direct link of our analysis to the governing equation system of the atmospheric boundary layers. Our direct multi-scale analysis of this system is supplemented by the data analysis based on the wavelets.

By following those basic strategies, we will focus on the three important and inter-related aspects of the VSBL: nonstationarity, the Coriolis effect, and the intermittency. Specifically, we will address the following research questions:

- Nonstationarity: How the time-dependent evolution of the very stable anisotropic boundary layer flows can be presented fully by a time-dependent formulation?
- Coriolis: How the Coriolis effect contributes and modifies the turbulent evolution of the nocturnal very stable atmospheric boundary layers?
- Intermittency: What are the basic *quantitative* characteristics of the *intermittency* in very stable atmospheric boundary layers, that need to be further incorporated into their representations in numerical forecast models?

The VSBL is inherently nonstationary and consists of motions characterized by different time scales, with the coexisting small and large eddies, gravity waves and slow inertial oscillations. To tackle the problem of the nonstationary nature of VSBL, we will first identify basic parameters which describe this system, such as the properly non-dimensionalized kinetic energy and the non-dimensionalized time. Next, our goal will be to determine dependencies between these parameters, by analyzing trajectories in the phase space of this system. To study the effect of the Coriolis force we will employ the multi-scale asymptotic expansion of the governing equations. In this way, we will treat the Coriolis effect either as a perturbation or a dominant term, which is a source of the wave dynamics. Intermittency of VSBL is related to the presence of sporadic patches of turbulent eddies, alternating with areas of local re-laminarisations, where the flow becomes smooth and irrotational. We will describe the basic characteristics of the intermittency with the use of discrete wavelets. For this, the whole time series of wind velocity and temperature will be decomposed into a sum of isolated intermittency events with varying characteristic duration times.

For these data analyses we will adopt the data sets from the MOSAiC (Multidisciplinary Drifting Observatory for the Study of Arctic Climate) expedition conducted during October 2019 to October 2020 over the Arctic Sea. This experiment provided year-long observations of the VSBL and results of the measurements are available in the open database.