The goal of the present project is to provide improved description of vertical transport rates of heat, moisture and momentum in the stable atmospheric boundary layer.

Both for numerical weather prediction as well as climate projections it is crucial to represent well a thin layer of the atmosphere, of a depth of the order of one kilometer, right above the surface of the Earth, called the atmospheric boundary layer (ABL). The ABL flows take two distinctive forms: a typical day-time state under the sun, which is ‘’ convective’’ and a typical night type which is ‘’stable’’. The latter one dominates in particular in the ice-covered regions of the Arctic Ocean, especially during a long polar night. The associated heat budget of the Arctic stably-stratified ABL is a crucial input for an accurate climate projections. At the same time, the ABL is so thin that a typical atmospheric model does not resolve its structure well. Thus, its physical description must rely on a certain statistical approach such as similarity theory.

A crucial contribution to studies of ABL flows was made by Russian scientists, Alexander Obukhov and Andrei Monin more than a half of century ago. Their study remains a powerful guiding principle even today. The main claim of the theory is that a complex vertical structure of the stably-stratified ABL is characterized by a single vertical scale, called the Monin-Obukhov scale. As it turns out, the assumptions behind the Monin-Obukhov theory work well when ABL is only weakly stratified. However, as the degree of the stratification of the ABL incrases, the theory begins to work less well. In spite of various proposals put forward to improve parametrizations of the stable ABL, this subject remains an open area of research.

It is within the scope of the present study to investigate particular situations where the predictions of the Monin-Ohukov theory deviate from observations. For this we will seek answer to the following list of questions

- What are the characteristic scales of the stably-stratified ABL? How they change with the change of atmospheric conditions (especially the degree of stratification)?
- How the anisotropy of the stably-stratified ABL flow influences the scaling laws?
- How can the initial-condition dependency and the transience of the ABL be incorporated into the analysis?
- Under what circumstances does the horizontal transport play an important role?
- Can universal vertical profiles for mean ABL quantities be derived as solutions of the equation system?
- How the ABL intermittencies can be accounted for in the construction of scaling laws?

In order to answer these questions we base our study on a premise that any physical phenomena (ABL in the present project) can be understood by examining the structures of its governing equations even without solving them explicitly. In this project we will analyse the equation systems that govern the ABL flows by non-dimensionalization, especially in terms of the symmetries. Both, non-dimensionalization and symmetry analysis are already well established methodologies in applied mathematics with many physical applications (notably in fluid mechanics). However, their applications to ABLs are new. The results from these investigations will be thoroughly verified by observational data analyses.

The project constitutes of a new look of ABL problems by methodologies not hitherto applied to this domain. Assessing a degree of applicability of these methodologies in ABL studies would be the most obvious, but important outcome of the project. If successful, we expect that these methodologies will be widely adopted in the ABL research in future. That would be the strongest impact that can be envisioned from the project.

An ultimate long-term impact from the present project is that it is going to provide a more robust description of the ABL in both weather-forecast and global climate models, based on a subsequent operational development.