Modeling the mechanism of foehn wind in Tatra Mountains and its impact on atmospheric conditions on the leeward side

A foehn is a non-periodic wind, occurring in all mountains around the world. Foehns are thermodynamic – descending along leeward mountain slopes. They are very often warm, dry and gusty winds, reaching high speeds (up to 50 m/s). The descending air masses on the leeward slopes warm up according to the dryadiabatic gradient, so there is a spontaneous heating and drying of the air masses referred to as the foehn effect. In the Tatra Mountains and Podhale, this type of wind is called a *halny*. Due to its violent nature, the *halny* brings a lot of damage to the population of the Podtatrze. The negative effects include damage to forest ecosystems, windfalls, damage to buildings and power grids, increased avalanche activity in the mountains, violent surges in river systems, and winter hardening of plants. *Halny* winds cause rapid changes in atmospheric conditions, which can cause health problems for people, especially meteoropaths. They can cause fatigue, aggressive behaviour and aggravate states of depression. The most favourable circulation conditions for the occurrence of a *halny* are during the winter period, due to the increase in the activity of the baric systems in Europe. *Halny* winds can also have positive functions. In Zakopane, as well as in the entire Orawsko-Nowotarska basin, high concentrations of various air pollutants are recorded during the heating season. The *halny* may cause the "weathering" of the basin from these pollutants.

The primary objective of the project is to characterize the mechanism of the *halny* flow on the leeward side of the Polish Tatra Mountains and to evaluate the intensity and extent of the foehn effect on the northern side, depending on atmospheric stability and thermodynamic conditions in the study area in the years 1995–2022. The mechanism of the *halny* flow is a very complex issue and not fully understood yet. The flow of air masses after crossing a mountain ridge is one of the least understood mechanisms in flow dynamics. Undoubtedly, the novelty of the project lies in the recognition of the flow mechanism during thermal inversions in the Orawsko-Nowotarska basin. Air temperature inversion consists of an increase in temperature with increasing altitude (on Kasprowy Wierch warmer than in Zakopane) and the occurrence of cold air stagnation in the basins. So far, there are only conjectures about the behaviour of foehns above the inversion layer, so the project's study will be novel in atmospheric research. The research will contribute to a better understanding of the mechanism of *halny* winds and their effects. The project will provide information on the maximum extent of the *halny* effect in Poland, which has so far only been analysed for isolated cases. It is believed that the foehn effect with strong *halny* winds can be felt even in central Poland. The results will allow for better forecasting of the extent, and thus the identification of potential damage, and the possibility of taking preventive measures, which is important for the inhabitants of Podtatrze and tourism in the Tatras.

The implementation of the project takes into account the use of primarily WRF (Weather Research and Forecasting Model) simulations and measurement data from synoptic stations of the Institute of Meteorology and Water Management – National Research Institute (IMWM – NRI). The simulation results will be used to characterize the mechanism of the *halny* flow. It is assumed that the inversion of air temperature in the Orawsko-Nowotarska basin causes the blocking of air masses descending from the mountains, which move over the inversion layer. In such situations, despite the occurrence of *halny*, no foehn effect below the inversion layer will be recorded on the leeward side of the Polish Tatra Mountains. However, it can be assumed that a very strong *halny* will be able to overcome the barrier of the blocking thermal inversion.

A comprehensive analysis will enable a better understanding of the *halny* at multiple scales and contribute to a range of implantation applications as the *halny* affects various sectors of human and economic activity. The results on the mechanism of the *halny* flow will be relevant for, among other things, forecasts of the occurrence of foehn winds. Information on atmospheric conditions on the leeward side during the *halny* will provide important information on the dispersion of pollutants in the Orawsko-Nowotarska basin, and will also be crucial for determining the degree of avalanche danger in the Tatras.