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Thesis: Influence of lee waves on meteorological conditions in the northern foreland of the Tatra Mountains

Key words: aviation, transects sampling, foehn, lee wave, rotor, Tatra Mountains

ABSTRACT

The aim of the study was to investigate the influence of a mountain lee wave on the near-surface meteorological conditions in the northern foreland of the Tatra Mountains (Poland), especially on atmospheric pressure, wind speed and wind direction. The hypotheses were as follows:

1) mountain lee wave can cause local pressure anomalies in the near-surface tropospheric layer, which are formed in regular equal-width bands oriented parallel to the main ridge of the Tatra Mountains. Positive and negative anomalies of air pressure are arranged alternately below lee wave and their location correspond respectively to descending and ascending currents. The anomalies are assumed to be a response of the surface-pressure field under the influence of downward and upward component of the air movement in the atmosphere. The magnitude of the anomalies in the following bands decreases due to natural wave motion damping with increasing distance from the mountain range.

2) mountain lee wave can cause formation of rotors (air vortices with horizontal axis) in the near-surface layer of the troposphere. Below wave crests the occurrence of calm or variable wind direction is expected, including the episodes of northerly flow, i.e. opposite to the prevailing air mases advection.

Motivation of the study was both scientific and practical. The mountain lee waves in the northern foreland of the Tatra Mountains remain poorly recognized so far. The phenomenon significantly affects also the aviation, in particular the glider activity in local aero club in the city of Nowy Targ.

The field studies were performed in the years 2013-2014 with special automatic network set up to provide data on near-surface meteorological conditions. The instrumentation consists of 9 meteorological stations organized as a linear transect of 29,1 km in length, beginning in the middle of the Tatra Mountains and oriented perpendicular to the main mountain range. Cloud patterns over the study area were recorded by satellite images (MODIS) and by 2 sky cameras

that were placed 11 km east from the transect. Gliding flights over the study area also formed part of the field campaign. These flights were organized in cooperation with local aero club in Nowy Targ and its objective was to determine the location and speed of ascending and descending lee-wave currents over the study area. Synoptic maps, atmospheric soundings (station Poprad-Ganowce, Slovakia) and meteorological data from stations Kraków-Balice (Poland) and Eger (Hungary) were also used in the studies.

Nine cases with mountain lee waves occurring in the northern foreland of the Tatra Mountains, including the longest period of 60 hours, were chosen for detailed studies. The selection was based on the analysis of wind conditions at Kasprowy Wierch Peak and selected isobaric surfaces (700, 600, 500, 400, 300, 250 hPa), distribution of Scorer parameter in the troposphere, wave clouds, aviation data as well as the magnitude of normalized difference of atmospheric pressure between northern and southern foreland of the Tatra Mountains (Eger – Kraków).

In the light of achieved results the first hypothesis seems to be false. Only in a few cases the distribution of an pressure anomalies was in line with the hypothesis. In most cases the air pressure anomalies significantly differed from expected: there were no pressure anomalies in the study area or, contrary to the hypothesis, positive and negative anomalies were located respectively below ascending and descending wave currents. Conclusion should be cautious, since large part of the anomalies, especially in the northern part of the study area, were of low values and pressure-field variations could be explained by errors of air pressure measurements accuracy.

The second hypothesis seems to be true. It was documented that during lee-wave activity in the northern foreland of the Tatra Mountains local disturbances in the flow of air could occur and they are usually the episodes of north wind, often severe and prolonged. Such events may occur both at one place or simultaneously at several places separated by the same distance equal to the wavelength.

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