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Helicity in the atmospheric boundary layer

Michael Kurgansky, Boris Koprov, Victor Koprov, and Otto Chkhetiani

A.M. Obukhov Institute of Atmospheric Physics, Russian Academy of Sciences, Atmospheric Dynamics, Moscow, Russian Federation (kurgansk@ifaran.ru)

An overview is presented of recent direct field measurements at the Tsimlyansk Scientific Station of A.M. Obukhov Institute of Atmospheric Physics in Moscow of turbulent helicity (and potential vorticity) using four acoustic anemometers positioned, within the atmospheric surface-adjacent boundary layer, in the vertices of a rectangular tetrahedron, with an approximate 5 m distance between the anemometers and a 5.5 m elevation of the tetrahedron base above the ground surface (Koprov, Koprov, Kurgansky and Chkhetiani. Izvestiya, Atmospheric and Oceanic Physics, 2015, Vol.51, 565–575). The same ideology was applied in a later field experiment in Tsimlyansk with the tetrahedron's size of 0.7 m and variable elevation over the ground from 3.5 to 25 m. It is illustrated with examples of the statistical distribution of instantaneous (both positive and negative) turbulent helicity values. A theory is proposed that explains the measured mean turbulent helicity sign, including the sign of contribution to helicity from the horizontal and vertical velocity & vorticity components, respectively, and the sign of helicity buoyant production term. By considering a superposition of the classic Ekman spiral solution and a jet-like wind profile that mimics a shallow breeze circulation over a non-uniformly heated Earth surface, a possible explanation is provided, why the measured mean turbulent helicity sign is negative. The pronounced breeze circulation over the Tsimlyansk polygon which is located nearby the Tsimlyansk Reservoir was, indeed, observed during the measurements period. Whereas, essentially positive helicity is injected into the boundary layer from the free atmosphere in the Northern Hemisphere.