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Experimental and numerical study of secondary flow dynamics in a cylindrical fluid layer.

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Secondary flows in the form of horizontal rolls are a common feature of a large variety of flows of different nature and scale. Roll vortices are often observed in the atmospheric boundary layer. Depending on their size and strength, rolls play a significant role in transporting momentum, heat and moisture through the atmospheric boundary layer. Horizontal rolls, generated in convective flow above a partially heated bottom in a rectangular box were studied in details in (Sukhanovsky et al. EPJ B, 2012). The main goal of this study is investigation of boundary layer dynamics in a more complicated case – in a cylindrical layer with discrete heat source. The structure of velocity fields is studied by PIV measurements. It is found that different types of horizontal rolls (transverse and radial) appear simultaneously. The formation of transverse rolls is periodic in time and dependence of characteristic frequencies on Grasshof number is obtained. Series of long time temperature measurements are analyzed by wavelet-analyses for several fixed locations over the heating area. Azimuthal dependence of characteristic frequencies of temperature fluctuations and is shown. Numerical simulations are carried out by the CFD package FLUENT. Numerical results are in a good agreement with results obtained in experiment. Analyses of heat transfer in the boundary layer showed that secondary flows lead to remarkable heat transfer enhancement. The study is supported by Program of UD RAS, project No 12-T-1-1008 and RFBR projects (11-01-96031, 11-01-96000).