Atmospheric boundary layer modelling in the numerical prediction operations.

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The basic conception of Hydrometeorological Research Center of Russia system for operational short-range forecasting is the reconstruction of the synoptic-scale and mesoscale weather patterns from the output product of a large-scale prediction scheme including Atmospheric Boundary Layer model and parameterization procedures./Berkovich, Tarnopolskii, Shnaydman, 1997/The results of the reconstruction of atmospheric boundary layer (ABL) internal structure from objective analysis and forecast data demonstrated the possibility of using the ABL model in operational prediction of meteorological fields and weather phenomena. Simultaneously these results showed the necessity of the improvement of the quantitative description of ABL turbulence structure. The improved model /Shnaydman,2004/ is applied for the reconstruction of the internal ABL structure for the Ukraine and European part of Russia in numerical operations. Here the turbulence parameters under different meteorological conditions obtained are given. The turbulent fluxes of the sensible heat changed from –30 to +45 Wt/m2, when the stratification varied from stable to unstable conditions. The friction velocity had mean values of 0.2-0.5m/s but get more than 1.0m/s near the areas of large roughness and the surface geostrophic wind reached 15m/s and more. The ABL heights have a substantial space and temporal variability from 100 to 1000m on average. But when the thermal stratification is unstable and the geostrophic wind on the level of 850hPa is larger than 20m/s the ABL top became 2000m and more. The vertical distribution of TKE depended on the stratification. TKE maximum was located near the surface when the stable or neutral stratification was observed. In this case TKE values were 0.4-0.6 m2/s2 when the surface geostrophic wind was less than 10m/s and the roughness was 10-20cm. The greater values of these parameters created TKE of 0.5-1.2 m2/s2. The unstable stratification led to shift TKE maximum to the levels 100-300m and the values got 0.8-2,3 m2/s. The vertical coefficient of the turbulence increased from the near-surface level reached the maximum on the heights of 50-300m and then decreased to the ABL top. The maximum of Kz changed in the wide limits from 1-56m2/s. depended on the combination of geostrophic wind, stratification, baroclinity and roughness.

As the example of the application of the developed model to the another areas of the North hemisphere the results of calculations are given for USA and Canada (20-55N,70-125W).At first it’s necessary to underline that the area considered distinguishes itself by the complex topography, the high mountains on the west, flat surface in the center and the elevations on the east. Another peculiarity of the calculation domain is the oceans at the west and east bounds. The internal ABL structure was reconstructed from operational objective analysis for 00:00 UTC April 12,2005 and forecast data for 36-hour prediction period. The ABL internal structure was represented by horizontal distribution and temporal dynamics of meteorological variables and turbulence parameters on 21 levels from 10m to

2000m. We focused on analysis of horizontal distribution and temporal dynamics of the ABL turbulence parameters and organized vertical motions. Analysis of the spatial distribution of vertical turbulence coefficient (Kz) showed that Kz were less than 1.0 m2/s near surface and increased to 1-15 m2/s at the top of surface layer (about 50m). Kz were largest between the levels from 50m to 250m with the maxims near the level 100m.At this level Kz changed from 3 m2/s to 25 m2/s with pronounced areas of Kz>15 m2/s in the center and northwest corner of the domain. In the rest of territory Kz was 1-6 m2/s. Above 250m the values Kz decreased sharply and the small areas of Kz reached 17 m2/s were located in the west and east bounds at the level 500m and 5 m2/s at the level 1000m. The similar features of the temporal dynamics was traced at all levels inside ABL. The analysis of Kz temporal changes at the level 100m. showed that Kz from 7 m2/s to 28 m2/s maintained during the whole prediction period in the east part of the domain. But regions with Kz>=20 m2/s were attracted to the east and west oceanic coasts, essentially larger in the daily hours and moved towards south. In these regions the intensive vertical turbulent exchange spread to the levels 500-1000m.The horizontal distribution of TKE is characterized by zonal elongated area of largest TKE between 30N and 55N. Three vertical sublayers distinguished in this area: near- surface (below 50m), middle (50-250m) and upper (above 250m). In surface sublayer TKE range is formed from 0.5m2/s2 to 2.5m2/s2. In middle one TKE range increased to 3.0 m2/s2and in the upper sublayer TKE maximum was less than 0.5m2/s2. Beyond the area of TKE maximums made amount to 0.5m2/s2 below 200m and 0.1 m2/s2 above this level. As whole TKE temporal dynamics manifested itself the trend of TKE reduction during the given period. But larger TKE are obtained in daily hours in comparison of the night ones. The largest dissipation rates are concentrated in the surface layer. Here the dissipation rates were 0.3-5.5 m2/s3. Above the surface layer the dissipation rates were less 1 m2/s3.

The space distribution and the temporal dynamics of organized vertical motions are the integral evaluation of the influence of main forcing and interaction physical mechanisms on the ABL structure formation. The interaction between the space-temporal dynamics of the pressure and turbulent exchange led to the creation of actual wind deviation from the geostrophyc speed vector. As it came next from the continuity equation the non geostrophyc deviation promoted to organize the upward and downward currents in low and high pressure areas correspondingly. In accordance with the distribution of the pressure, intensity of the turbulence and the topography the areas the vertical flows at the ABL top are traced from east to west in following order: downward-upward-downward-upward. The first two areas of organized vertical motion made conditional upon the distribution of the pressure and intensity of turbulence. In these areas the module of the vertical speed got 0.8-1.2 cm/s. Te effect of topography played a large contribution of the next two areas of the vertical motions which reached the module values of 0.5-0.8 cm/s. The temporal dynamics of organized vertical motions at the ABL top reflected the tendency of the forcing mechanism evolution. The intensity of downward and upward currents decreased during the prediction period.

Using the model output information of the spatial distribution of the meteorological variables and turbulence characteristics can improve the existing methods of prediction of the clouds and precipitation, air pollution quantitative description.

Berkovich, L.V., Tarnopolskii, A.G., Shnaydman, V.A.: 1997, " Hydrodynamic Model of the Atmospheric and Oceanic Boundary Layers" Russian Meteorology and Hydrology 7, 30-40

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