A STUDY OF GENERATION OF AVAILABLE POTENTIAL ENERGY IN SOUTH CYCLONES AND HAZARD EVENTS OVER THE URAL

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I. INTRODUCTION

The concept of available potential energy (APE) clarifies the role of baroclinicity in specifying the atmospheric state which is capable of generating kinetic energy. Lorenz (1955) formalized the concept of available potential energy, which has proved to be very useful in energetic analyses of the atmospheric general circulations as the appropriate companion to kinetic energy (Lorenz 1967; Huang 1998). APE has also been shown to be a useful quantity for smaller-scale stratified flows (Winters et al. 1995).

This study represents analyses of south extratropical cyclones that produced heavy precipitation and large-scale wind fields in the Ural region. In this paper, influence diabatic generation APE due latent heat release on hazard events is presented.

II. PRESENTATION OF RESEARCH

The Eta model is a hydrostatic mesoscale weather forecast model with an accurate treatment of complex topography using eta (η) vertical coordinate system and step-like mountains, which eliminates errors in computation of pressure gradient force over steeply sloped terrain present in sigma (σ) coordinate system. The model version used here follows that described by Black and Mesinger. The model employs a semi-staggered Arakawa E-grid in which wind points are adjacent to the mass points, configured in rotated spherical coordinates. The mesoscale Eta model is run operationally with a horizontal grid spacing of 48 km and 38 vertical levels, with layer depths that range from 20 m in the planetary boundary layer to 2 km at 50 mb. The model top is at 25 hPa. Split explicit time differencing is used with a time step of 120 s. Spatial differencing is done with a conserving Arakawa type scheme. The model's step mountains are derived using the official United States Geological Survey (USGS) topographical data.

Initial and lateral boundary conditions is following. Hydrometcentre global (T40L15) analysis and 6 hourly global model forecasts are used for initial and lateral boundary conditions. Wind, temperature, relative humidity and geopotential height interpolated to 26 pressure levels are used.

Results of numerical modelling were used for compute APE and generation of APE due latent heat release. Parameterization scheme are used to estimate diabatic heating due latent heat release. A research project, focused on case studies of severe convective events, has been running since 1961.

III. RESULTS AND CONCLUSIONS

Selected cases of severe convective events are discussed below. Diagnostic calculations reveal that generation available potential energy due to sensible heating influence on development heavy precipitation. Latent heat release is generally in good agreement with observed weather features and cyclone development. During the development of the extratropical cyclone, the generation APE within the region under investigation is increased. In addition, convective instability and low-tropospheric water vapour flux convergence are significant over the Ural, and therefore the environment is highly supportive for convection development. On the other hand, there is an overall tendency of the simulations to favour cyclone development leeward of the Ural mountain range. APE generation primarily results from the convective latent heat release ahead of the cold front in the warm sector. The diabatic heating fields in the cyclone vicinity and convection area contribute more effectively to increasing or maintaining the baroclinicity of the cyclone system than of the sub-regions themselves. The results exhibit a clear dependence heavy precipitation and of low-tropospheric warm air advection on the characteristics of the generation APE. Therefore, spatial details of the regional simulation are shown to be highly sensitive to the structure-scale wind fields of the generation of APE.

It is established, that in southern cyclones the APE are concentrated in the field of fronts. The minimal APE is observed in rear parts investigated baric formations.

It is established, that in southern cyclones generation of APE due to phase transformations of water (on the average 10 W/m^2 in a layer from a terrestrial surface up to 300 hPa) prevails. Areas of generation are dated for warm sector of a cyclone. In a rear part of a cyclone prevails dissipation of APE. It is necessary to note, that the areas borrowed by generation APE in southern cyclones, as a rule (in 60 % of cases), get range structure focused along a face-to-face surface. During research seasonal dependence of generation APE has been revealed. As one would expect, the greatest values of generation are observed in a cold season (from October till March).

The model of an atmosphere has allowed to reveal influence of geographical conditions on formation water generation APE. Influence of large lakes (Aral sea) on development of the southern cyclones displaced on territory of Central Asia, expressed in strengthening generation APE Is revealed. Besides it is possible to note influence of orography (mountain of Southern Urals Mountains) on development of cyclones. On the western slopes of Urals Mountains the strengthening of generation APE caused by additional development of ascending streams of air also is precisely shown.

The joint analysis temperatures, humidity and speed of a wind with power characteristics of an atmosphere have been lead water atmospheric pressure. It is established, that with pressure drop in a cyclone, the size of APE decreases.

On the other hand change of generation of the APE caused by phase transitions of water, has more complex dependence. From the moment of formation before achievement of a stage of a young cyclone generation APE decreases. It is connected by that occurrence of southern cyclones occurs, as a rule, above a warm water table of the Mediterranean, Black and Caspian seas. At an output of a cyclone inflow water the pair from a terrestrial surface is sharply reduced to a land, in a cyclone drier and cold air acts, and it leads to some reduction of generation APE. At a stage of the maximal development pressure in a cyclone continues to fall, and speeds of ascending movements reach the maximum, and it again leads to growth of generation APE. Further to a stage of filling there is a reduction of generation down to values close to zero. During the analysis of vertical structure of generation APE presence of a maximum (on the average 6 W/m^2) at all stages of evolution in average troposphere (700-400 hPa) is revealed. The important result of research is the revealed law, that in 90 % of cases in a place of occurrence of initial cyclonic circulation, there is an area with the raised values of generation of APE.

Differential characteristics of a field of speed of a wind (a vertical component of a whirlwind of speed and horizontal divergence velocity of a wind) have been in addition calculated. It is established, that these characteristics also test essential changes in time and can be level with power characteristics indicators of evolution of a cyclone. Research has shown, that presence of greater positive values vorticity in a free atmosphere defines development sever convection at sufficient instability of an atmosphere. Above a boundary layer it is possible to divide precisely enough a cyclone into areas with convergence (northeast part of a cyclone) and divergence (southeast part of a cyclone). Since height of an isobaric surface 500 hPa the situation in distribution of a sign, as a rule, varies.

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