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Floods in the Carpathians: synoptic analysis and numerical modeling

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1. INTRODUCTION

The World Health Organization (WHO 2002) has published a diagram showing an almost continuous and dramatic increase in the number of flood disasters in Europe between the years 1975 and 2001. Obviously, they were connected with global atmospheric processes. The most significant floods in the past decade were registered in the western part of Germany in 1994; along the Dnestr river in Poland, the Czech Republic, Slovakia and the east part of Germany in 1997; in the Transcarpathian lowland and Hungary in 1998 and 2001; in Austria, Germany and the Czech Republic in 2002. Both catastrophic floods in the Carpathians in November 1998 lasted for 7 days and March 2001 lasted for 5 days are under consideration in the presented study.

In view of hydrometeorological conditions and regional orography are among the main natural causes for flooding formation, authors have been carried out a study of synoptic conditions favorable for heavy precipitation formation. For this purpose surface weather and absolute topography charts and also observational data for amounts and periods of precipitation were analyzed. In addition 3-D nowacasting numerical models developed in UHRI were constructed both for more detailed studying spatial distribution and intensity of precipitation in the frontal cloud systems passing over the West of Ukraine and for theoretical interpretations of the standard meteorological data.

2. SYNOPTIC CONDITIONS AND PRECIPITATION MODELING

The synoptic analysis of the flood cases has showed that heavy and long-term precipitation in the Ukrainian Carpathians were observed under following synoptic conditions: a) intense inflow of warm and moist air from southwest at heights of 3-5 km caused by low baric formations on active waves of cold front; b) the presence of the blocking process.

The type of blocking process was as follows: the cyclone was blocked by two anticyclones to the west-northwest and to the east from the place of interest. Mesoscale formations as micro-lows were constantly generated on the waves of cold front and high-altitude frontal zone was strongly active. Horizontal gradients of temperature and geopotential in high-altitude frontal zone exceeded 1.6-2.0 ^{o}C/100 km and 2.4 dam/100 km accordingly. Average horizontal wind speeds of 30-40 m/s recorded above the high-altitude frontal zone and the maximum of the speed exceeded 51 m/s. Wind shear to the west – northwest recorded in both cases caused dynamic instability and heavy precipitation. Dew-point deficits as low as 0–3 ^{o}C located near the ground surface and 0–6.2 ^{o}C found at the AT-700 heights clear defined on presence of a moisture reserve in the air mass.

Note in addition, that macroscale atmospheric conditions in the northern hemisphere observed in the studied cases resulted in the maintenance of the dynamic system in which fields of cloud and precipitation were constantly formed.

3-D diagnostic numerical model developed in UHRI was used for simulation of the state of the cloudy troposphere and precipitation caused the above floods in the Carpathians. Reader is referred to Krakovskaia et al. (2003), Palamarchuk et al. (1992), Pirnach et al. (1994), Pirnach (1998), etc., for detailed presentation of the system of equations, border conditions and numerics for the model construction. Note, clouds are defined by positive values of thermodynamical rate of condensation in diagnostic numerical models and, in turn, precipitation is defined as the integral thermodynamic condensation rate (E):

$$E = -\int_{0}^{H} \rho w \frac{\partial q_s}{\partial Z} dz \quad ,$$

were z is the height; $H$is the z-maximum; ρ is the density of air; $w$is the vertical component of wind velocity; q_s is the specific humidity of air.

Calculations were carried out for two terms (12 and 24 GMT) for almost every day of the floodings in the above two periods on the basis of standard radiosounding network data processed for use of the model.

In the analysis of numerical modeling outputs high attention was devoted to mountain and flat areas separately.

The detailed analysis of the results received in modeling has shown that strong precipitation was in most cases observed only in mountain areas of the Carpathians. At the same time over flat territories precipitation was less intensive, but had long-term character. Windward and the central hills of the Ukrainian Carpathians were covered by showers of different intensities near and after the afternoon. The fields of strong rainfalls were broken up at night, but an extended field of light precipitation was observed over the almost all Western Ukraine.

3. CONCLUSIONS

Analysis of the synoptic situations has showed that the primary reasons of formation strong and long-term precipitation were: a) the blocked cyclones; b) contraction between the polar and the arctic atmospheric fronts resulted in a sharpening of frontal zones; c) low dew-point deficits in the low troposphere; d) the big horizontal gradients of temperatures and geopotentials in high-altitude frontal zone. One more feature causing heavy precipitation was wind shear.

Three-dimensional nowacasting numerical models of frontal cloud systems passing over the west of Ukraine have been constructed and theoretical interpretations of the standard meteorological data in frontal clouds zone were conducted. Obtained in the model precipitation intensities and spatial distributions corresponded to observed patterns and amounts of precipitation in general.

4. REFERENCES

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