THE MODEL OF STATISTICAL FORECAST OF STORM WIND AND HEAVY RAINFALLS AT THE TERRITORY OF BELARUS

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Abstract

The results of the development of automated forecast methods of storm wind at the territory of the Republic of Belarus based on the hydrodynamic-statistical model are submitted at this paper. The international collaboration between Hydrometcenter of Russia and Hydrometcenter of the Republic of Belarus began ten years ago. Now the forecasts of storm wind with the earliness 12-24-36-48h send by the help of operative technology to Hydrometcenter of Belarus two times a day from Hydrometcenter of Russia.

The examples of the forecasts of storm and dangerous winds (including squalls and tornadoes) also are submitted at this paper.

1 Introduction

Advance forecast (to 12-24-36-48 hours) of storm wind (including the squalls and tornadoes) that destroy buildings makes possible to take proper measures in order to reduce the losses. Prediction of these phenomena stays a very difficult problem for synoptic still nowadays. The existing synoptic graphic and calculation methods depend on subjective decisions of operators. These methods usually use the dependence of these phenomena only from two-three parameters, but appear of these phenomena is connected with great convective cloudiness entailed the hydrodynamic and thermodynamic instability. Nowadays there is no hydrodynamic model for forecast of the storm wind (including the squalls and tornadoes), hence the main tools of objective forecast are the statistic methods of classification [1]. At first the recognition statistical model of meteorological situations with the storm wind was developed for the prediction of these phenomena (storm wind). The new objective statistical forecast method (to 12h ahead) of summer storm wind (including the squalls and tornadoes) was successfully developed on this statistical model base. The next step for automated forecast creation was the development of the forecast method using the hydrodynamic forecasts of the weather elements out the hydrodynamic model of short-term forecast for operative synoptic practice. The new automated hydrodynamic-statistical storm wind forecast of two classes (for the wind with the velocity V more 19 m/s and for the wind with the velocity V more 24 m/s) were experienced at the different regional Department of the Meteorology, after them they were recommended for the using in the operative synoptic practice. The assessments of these experiences for the territory of the Republic of Belarus are very well. During ten years the hydrodynamic-statistical forecast of

storm wind with the velocity more than 19 m/s was automatically calculated in Hydrometcenter of Russia and was given operatively two times a day to Hydrometcenter of the Republic of Belarus by meteorological telegrams. Nowadays these storm wind and dangerous wind (V¿24 m/s) forecasts are operatively given by e-mail to Minsk from the data bank of Hydrometcenter of Russia as a official method in order to help in synoptic practice.

2 Statistical model of the recognition and the prediction of storm wind forecast over the territory of the Republic of Belarus

At our investigation at first we have had the sample of parameters for the cases of presence of storm wind with the velocity more than 19 m/s $\{\mathbf{X}(A)\}$ and the sample of parameters for the absence of that storm wind but with the presence of thunderstorms $\{\mathbf{X}(B)\}$. The number of parameters was 26. There were potential physically substantiated atmospheric parameters (predictors). The temperature on the earth level, on the levels 850, 700, 500 hPa, the mean velocity value on those levels, the temperature of dew point on same levels and other predictors have had a normal distribution according their histograms and the goodness-of-fit test of Kolmogorov A.N. [2]. Then we have obtained the possibility to use for the recognition of the set X(A) and set X(B) the following linear (according the Box criterion [2]) discriminant function F(X). In the expression F(X) M(A) and M(B) are empiric values of the vectors of expectation of the presence and absence of phenomenon A (the storm wind), V(A), V(B) are the empiric covariance matrixes of the presence and absence of A. **V** is mean covariance matrix, **R** is mean correlation matrix.

We have to select the most informative and week dependent parameters without loosing the information before the construction of the decision rule (discriminant function F(X)). Our empiric statistical method of the choosing of the informative vector-predictor is described at [3]. For this purpose the mean correlation matrix **R** was calculated. It is possible to put this matrix **R** in the one-one mapping to the connected graph **G**. The points of this graph **G** are 26 predictors, and binary coefficients of correlation between two different predictors are put in the corresponding to the edges of this graph **G**. Given the fix value of binary coefficient r_{ij}=**r** as the threshold of the connection we keep only those edges, that correspond to $r_{ij} > \mathbf{r}$. Then the connected graph **G** is break up into the set of connected subgraphs $\mathbf{G}_i$, $i = 1, 2, ..., k$. Changing the connection threshold **r** we receive different sets of connected graphs $\mathbf{G}_i$. and (respectively different values of the number k) corresponding to them sets of different diagonal blocks of the matrix **R**. At the next step the most informative predictors were selected without loosing information, those predictors being either representatives of diagonal blocks or independent informative predictors according certain criterion of informativition (we used as a criterion the Mahalanobis distance Δ^2 and the Vapnik-Chervonenkis criterion of the minimum entropy H_{min} [7]). After this selection in the accordance to the assessments of the recognition of the sets $\{\mathbf{X}(A)\}$ and $\{\mathbf{X}(B)\}$ on

the teaching and example samples we have obtained the vector-predictor including six atmospheric parameters: $(V_{700},\ H_0,\ (T'-T)_{500},\ \partial T/\partial n_{ea},\ T_{ea},\ Td)$.

These assessments of the recognition on the independent prognostic samples of presence and of absence are 0,95 and 0,82 according. The synoptics of four regional department of meteorology have made the validation of this method during two years [4]. The objective statistical method of squall forecast on the North-West territory of Russia have had the best assessments of the prediction (the criterion $T = 1 - a - b = 0,77$). The assessment of forecast using the mane synoptic method by Reshetov was not so high with the value of criterion $T = 0,53$. Here a and b are the errors of first and second kind according;

V_{700} the value of the mean velocity of the wind on the level 700 hPa, m/s;

H_0 the level of the isotherm of $0°C$, hPa;

$(T'-T)_{500}$ the difference between the values of the stratification curve and the moist adiabat on the level 500 hPa, $°C$;

$\partial T/\partial n_{ea}$ the maximal difference between temperatures over the front on the earth level within the diameter of 500 km;

T_{ea} the maximal temperature on the earth level, $°C$;

Td the maximal temperature of the dew point on the earth level, $°C$.

3 The model of automated hydrodynamic-statistical forecast of storm and dangerous wind and heavy rainfalls of two classes

The values of atmospheric parameters used at this new objective statistical method of squalls and storm wind were calculated by synoptic. The development of the hydrodynamic models of the short-term weather forecast allowed to us to develop the automated statistical forecast of the weather phenomenon squalls and dangerous wind.

We have made the new selection of new informative vector-predictor from new set of forty potential predictors. The selection was made by same method [3,4] of diagonalization of new mean correlation matrix **R**. The two new discriminant functions were calculated for two classes: $U_1(\mathbf{X})$ for the recognition of the wind with the velocity more than 19 m/s; $U_2(\mathbf{X})$ for the recognition of the wind with the velocity 25 m/s and more according.

These functions and the probabilities of forecast $P(\mathbf{X}) = 1/(1 + exp(-U(\mathbf{X}))$ were calculated in the nodes of the grid 150×150 km of hemispheric hydrodaynamic model for the European part of Russia. The areas 150×150 km with mean probability P=55% extracted the areas with the velocity wind 20 m/s and more. This forecast of summer day-time wind (with V=20 m/s and more) to 12h and 24h ahead was given to Minsk during ten years automatically by telegrams from Hydrometcenter.

The forecast (to 12-24-36h ahead) of dangerous wind with the velocity more than 24 m/s on the territory of Belarus was made at 2003-2005 years automatically in Hydrometcenter of Russia and was given to Hydrometcenter of Belarus. The areas

with dangerous wind were extracted by the threshold probability **P**=60%. With the successes of hydrodynamic forecast we have decided to use in the discriminant function $U_2(\mathbf{X})$ the output prognostic fields to 36h ahead of new variant of hemispheric model. For the extraction of the areas with dangerous wind we have used the threshold of forecast probability **P**=52%. Really we have had the storm wind and even tornadoes there. The independent experiences of these phenomena forecast were implemented during 2003-2005 years on the base of output production of semispheric model [5,6]. The using of output production of new region forecasting model of Hydrometcenter of Russia in our statistical model as input parameters have allowed us to develop the hydrodynamic-statistical forecast of storm and dangerous wind with the earliness 48h [7]. The forecasts of the wind with the velocity more 24 m/s to 10.06.09 and to 11.06.09 and other dates are submitted at this paper.

For the forecast of heavy summer rainfalls with the quantity $Q > 14$ mm/s and $Q > 44$ mm/s was developed same statistical model with the selection of informative and independent parameters. Same period the automated statistical forecast of heavy rainfalls of two classes over the territory of Belarus is given operatively to Hydrometcenter of Belarus from Hydrometcenter of Russia. The examples of the rainfallas also will be submitted at this report.

These submitted statistical models of forecast of these phenomena have allowed to develop the successful automated forecasts of storm wind and heavy rainfall as the effective help to synoptic of Belarus.

References

[1] Anderson T. (1963). The Introduction in the Polydimenshial Statistical Analysis. Moscow.

[2] Bolshev L. N., Smirnov N. V. (1965). The Tables of the Mathematical Statistics. Moscow.

[3] Perekhodtseva E. V. (1985). The Forecast of the Squalls by the Statistic Classification Methods at the Base of the Diagnostic and Prognostic Connections. *The Proceedings of the Hydrometcenter of USSR.* Vol. **271**, pp. 37-60.

[4] Perekhodtseva E. V. (1992). The Objective Physic-Statistical Method of the Forecast of the Squalls (with the velocity 20m/s and more) on Nowaing Day for the European Territory of Russia. The Methodic Recommendations.

[5] Perekhodtseva E. V. (2002). Hydrodynamic-Statistical Model of Forecast to 36 h Ahead of Dangerous Convective Phenomena Squalls, Tornadoes and Rainfalls. *Research activities in atmospheric and oceanic modeling.* Rep. **32(2)**, pp. 21-23.

[6] Perekhodtseva E. V., Zolin L. V. (2008). The hydrodynamic-statistical forecast and the expert system of the tornadoes forecast on the European part of Russia. *The Proceedings of the Hydrometcenter of Russia.* Vol. **342**, pp. 45-54.

[7] Perekhodtseva E. V. (2009). On the Hydrodynamic -Statistical Forecast of Heavy Precipitation and Storm Wind, Including the Squalls and Tornadoes. For the Territory of Republic Belorussia. *Meteospektr.* Vol. **4**, pp 119-120.

[8] Vapnik V. N., Chervonenkis L. Ya. (1974). The Theory of Recognition of Images. Moscow.

Figure 1: The area of the forecast of very dangerous wind (squalls) to 11.06.09 to 48h ahead(the area is restrict by the red isoline of the probability P=64%).

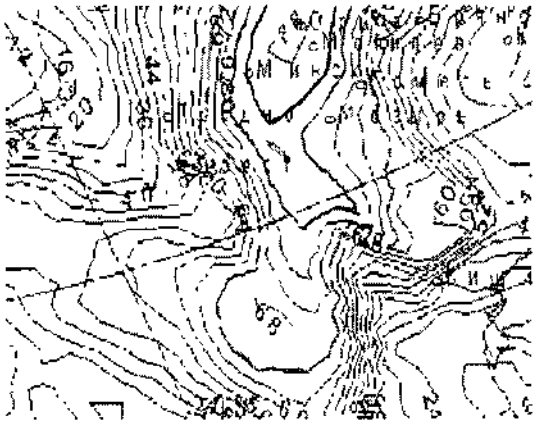

Figure 2: The area of the forecast of very dangerous wind to 11.06.09 to 12-18h (the area is restricted by red isoline of the probability P=80).