THE MODEL OF THE STOCHASTIC OPTIMIZATION OF THE AUTOMATED FORECAST OF DANGEROUS SQUALLS AND TORNADOES OVER THE TERRITORY OF THE REPUBLIC OF BYELORUSSIA

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1 The model of objective statistical forecast of dangerous squalls

Development of successful method of automated statistical well-in-advance forecast (from 12 hours to two days) of dangerous phenomena – severe squalls and tornadoes – could allow mitigate the economic losses. The prediction of these phenomena is a very hard problem for the synoptic till recently. The synoptic forecast of these phenomena is usual the subjective decision of an operator. Nowadays there is no successful hydrodynamic model for the forecast of such phenomena with the wind velocity more 20 m/s and more 24 m/s, hence the main tools for the objective forecast development are the methods using the statistical model of these phenomena recognition.

The meteorological situation involved the dangerous phenomena – the squalls and tornadoes with the wind velocity $V \geq 20$ m/s is submitted as the vector $\mathbf{X}(A) = (x_1(A), x_2(A), \ldots, x_n(A))$, where n – the quantity of the empiric potential atmospheric parameters (predictors). The values of these predictors for the dates and towns, where are these phenomena, were accumulated in the set $\{\mathbf{X}(A)\}$ – the learned sample of the phenomena A presence. The learned sample of the phenomena A absence or the phenomena B presence $\{\mathbf{X}(B)\}$ was obtained for such towns, where the atmosphere was instability, but the wind velocity was not so high ($V < 8$ m/s). The recognition model of the sets $\{\mathbf{X}(A)\}$ and $\{\mathbf{X}(B)\}$ was constructed with the help of Byes approach [1],[3]. This approach allow minimize the middle economic losses from forecast errors (of the I and II kinds).

It was necessary to decide the problem of the compressing the predictors space without the information losses in order to choose the informative vector-predictor and then to calculate the decisive rule of the recognition of the sets $\{\mathbf{X}(A)\}$ and $\{\mathbf{X}(B)\}$. It was made with the help of diagonalization of a sample matrix $\mathbf{R}$ algorithm [3]. The most informative predictorsrepresentatives from each of diagonal blocks and two independent predictors are composed vector-predictor of dimension $k = 6$ (from $n = 26$ potential predictors). The most informative predictors were estimated using the criterion by Mahalanobis distance Δ^2 and the criterion of the entropy minimum H_{min} by Vapnik-Chervonenkis [2],[3].

As a result, the informative vector-predictor of the most informative and slightly dependent predictors has been composed from six atmospheric parameters after this selection $(V_{700}, T_{ea}, Td_{ea}, H_0, (T'-T)_{500}, dT/dn_{ea})$ [3]. Here V_{700} – the value of the mean velocity of the wind on the level 700 hPa, T_{ea} – the maximal value of the temperature near the earth level, Td_{ea} – the maximal value of the dew point near the earth level, H_0 – the level of the isotherm of 0^0C, $(T' - T)_{500}$ – the difference between the values of the stratication curve of T and the moist adiabatic curve on the level 500 hPa, dT/dn_{ea} – the maximal difference between temperatures over the front on the earth level near the forecast point (R = 150 km). Then the linear discriminant function $U(\mathbf{X})$ was calculated by Byes approach. If the atmosphere is instability and the value of $U(\mathbf{X}) > 0$ at the station, we have the forecast of the squall ($V \geq 20$ m/s) near this station during the current day. The tornado objective forecast over the territories of Central Russia, Ukraine and Byelorussia were calculated by the using this statistical model with the condition that the value of the discriminant function $U(\mathbf{X})$ is more than the value equal 3. The tornado forecast examples submitted at [5]. These events are very seldom but the storm wind velocity $V > 25$ m/s are always by this forecast method.

2 Hydrodynamic-statistical models of the forecast of strong squalls and tornadoes for the two classes

The new statistical model and new discriminant functions $F_1(\mathbf{X})$ (for the wind velocity $V > 20$ m/s) and $F_2(\mathbf{X})$ (for the wind velocity $V > 24$ m/s) were developed on the base of the output data of the first hydrodynamic hemispheric model of the short-term forecast. The probability of dangerous winds for each of two classes $P_1(\mathbf{X})$ and $P_2(\mathbf{X})$ are $P_1(\mathbf{X}) = 100/(1+\exp(F_1(\mathbf{X}))$; $P_2(\mathbf{X}) = 100/(1+\exp(-F_2(\mathbf{X})))$. They were calculated operative in the nodes of the greed 150×150 km two times per day. The probability more than the empiric threshold $\mathbf{P}$ give us the forecast area of such squalls and dangerous wind. We obtained by same way [3] the new informative vector-predictors for each classes (k = 8 from n = 38 new parameters). This forecast of dangerous squalls and tornadoes over European part of Russia and Ukraine was recommended for the using in synoptic practice in 1994-2006 y.[4],[5]. This method was also adapted for the territory of Byelorussia. We used this method till 2006 year to 12-36 hours with successes. The second last hydrodynamic-statistical forecast model of squalls and tornadoes have based on the same statistical model using the output data of the new regional hydrodynamic model with the mesh 75×75 km [5],[8]. We submit here the new examples of the forecast of severe squalls on the summer of the year of 2011.

This day the squalls with the wind velocity $V = 18 - 22$ m/s were observed at the many stations of the Mogilev and Gomel areas, where the grate destructions were observed at 9 towns: the 22 roofs were destroyed (demolished). The electricity was turned off in Mogilev area. Its demonstrate, that very dangerous wind was between meteorological stations. This month the wind velocity $V = 20 - 22$ m/s was fixed at the towns Orsha, Bobruisk and Brest. The grate economic losses were observed there. The forecasts by the help of alls models were very successful.

In the august of the 2011 as in the august of 2010 [9] the day of 8.08.2011 was not so good! This day very severe squalls with the $V = 18 - 23$ m/s were observed at

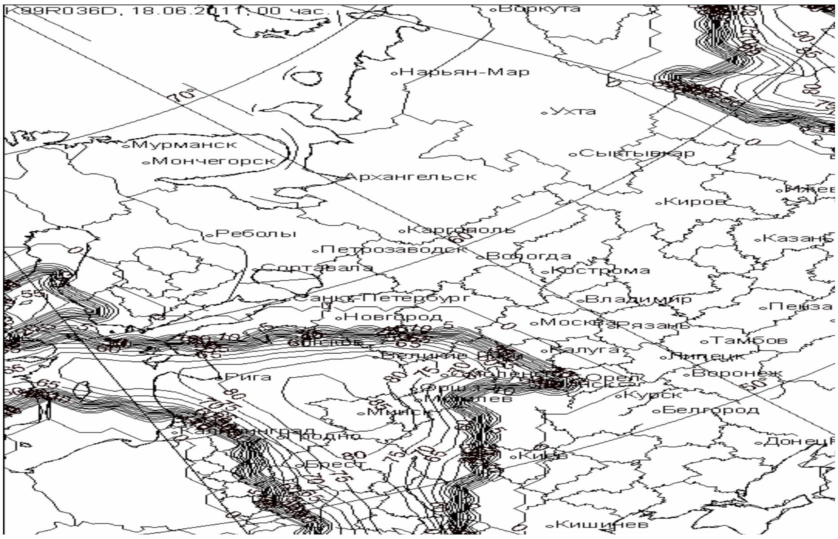

Figure 1: The area of the forecast to 36h ahead of the wind velocity $V > 20$ m/s, calculated with the help function $F_1(X)$ to the day 19.06.11. This area is restricted by the isoline probability $P = 65\%$

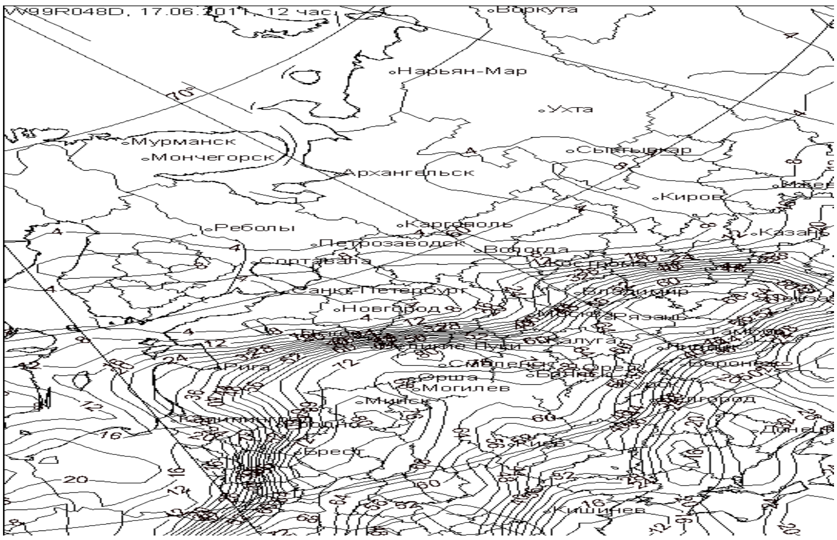

Figure 2: The area of the forecast to 48h ahead of the wind velocity $V > 24$ m/s, calculated with the help function $F_2(X)$ to the day 19.06.11. This area is restricted by the isoline of probability $P = 60\%$

Orsha, Mogilev, Slavgorod, Vitebsk. The very strong thunderstorms and precipitation are at these towns too. The forecasts areas of the wind of two classes are submitted on the next figures.

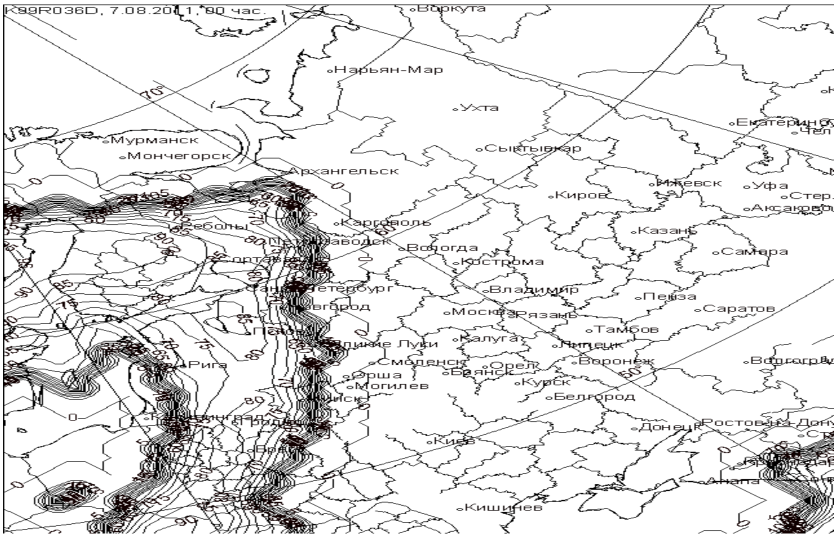

Figure 3: The area of the forecast to 36h ahead of the wind velocity $V > 20$ m/s, calculated with the help function $F_1(X)$ to the day 08.08.2011. This area is restricted by the isoline probability $P = 65\%$

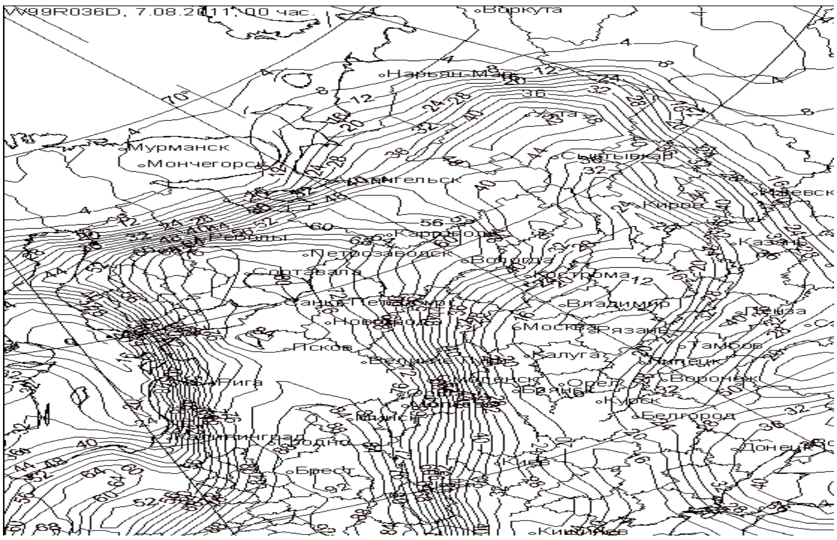

Figure 4: The area of the forecast to 36h ahead of the wind velocity $V > 24$ m/s, calculated with the help function $F_2(X)$ to the day 08.08.2011. This area is restricted by the isoline of probability $P = 60\%$

3 Conclusion

Three submitted stochastic models of automated forecast of dangerous squalls and tornadoes over the territory of the Republic of Byelorussia are used the stochastic optimization of forecasts with the minimum economical losses of the forecast errors.

The price of the error of the I kind is more higher than the price of the II kind. The optimal stochastic decisive rule was composed by the empiric approach using three hydrodynamic-statistical models of the automated forecasts of squall and tornadoes to current and to next days.

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