# ON THE HYDRODYNAMIC-STATISTICAL FORECAST MODEL OF THE TORNADOES AND OF THE SEVERE SQUALLS AT THE ATMOSPHERE WITH THE INSTABLE STRATIFICATION

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**Abstract.** The results of the development of the hydrodynamic-statistical models of the automated forecast of the severe squalls and of the tornadoes are submitted at this paper. The submitted forecast methods based on the different recognition statistical models and used the prognostic production of hydrodynamic models were tested successful in the operative synoptic practice and were recommended to use at this practice. The independent automated verification of these phenomena forecast was provided together with different hydrodynamic forecasts in Hydrometcenter of Russia. The result of the comparative analysis and the examples of the hydrodynamic-statistical forecast of squalls and tornadoes over the territory of Russia will be submitted at this report. The improvement methods of these forecast models in the instable atmosphere are discussed in the conclusion.

## Introduction

Development of successful method for automated statistical well-in-advance forecast (from 12 hours to two days) of dangerous summer winds, including severe squalls and tornadoes could allow to take proper measures against destruction of buildings and to protect people and to mitigate the losses. The prediction of these phenomena is a very difficult problem for the synoptic till recently. The synoptic forecast of these phenomena using existing graphic and calculation methods still depend on the subjective decision of an operator. The synoptic gives the storm warning of this dangerous phenomenon (the velocity of V>24m/s) only 3 hours ahead. Nowadays there is no successful hydrodynamic model for the forecast of such wind velocity at Russia, hence the main tools for the objective forecast development are the methods using the statistic model of these phenomena recognition.

## The statistical model of dangerous summer wind alternative forecast

The meteorological situation involved the dangerous phenomena – the squalls and tornadoes and wind with the velocity V=>20m/s is submitted as the vector **X**(A)=($x_1$(A), $x_2$(A), …$x_n$(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 {**X**(A)} – the learned sample of the phenomena A presence. The learned sample of the phenomena A absence or the phenomena B presence ({**X**(B)}) was obtained for such towns, where the atmosphere was instable and the thunderstorms and the rainfalls were observed, but the velocity values were not so high (V<8m/s). The recognition model of the sets {**X**(A)} and {**X**(B)} was constructed with the help of Byes approach [1,3].

It's necessary before to decide the problem of the compressing the predictors space without the information losses in order to choose the informative vector-predictor and to calculate the decisive rules of the recognition of the sets {**X**(A)} and {**X**(B)}. It was made with the help of a transmutation of a sample mean matrix **R** columns and lines algorithm. In a result we get the matrix **R** with diagonal blocks. The method of diagonalization of matrix **R** is described in [3]. The informative predictors - representatives from each of blocks and two independent predictors are composed vector-predictor of the dimension k=6 (from n=26 potential predictors) [3]. For this purpose we have estimated the most informative predictors using the criterion by Mahalanobis distance $\Delta^2$ [1, 3]: $\Delta^2$ =($m_i$(A)-$m_i$(B))↑2/$\sigma^2$ .
Here $m_i$(A) and $m_i$(B) are the components of **M**(A) and **M**(B) - of the vectors of the empiric expectation of the presence and the absence of A respectively, $\sigma^2_i$ – the mean variance of predictor i. Also the criterion of the entropy minimum by Vapnik-Chervonenkis $H_{min}$ was used for the assessment of the informativition of predictors [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 [3, 4]:
($V_{700}$, $H_0$, $(T\text{-}T')_{500}$ ,$dT/dn_{ea}$ , $T_{ea}$ , $Td_{ea}$ ), where -$V_{700}$ – the value of the mean velocity of the wind on the level 700 hPa, м/s; $H_0$ – the level of the isotherm of 0°C, hPa; $(T'\text{-}T)_{500}$ – the difference between the values of the stratification curve and the moist adiabatic on the level 500 hPa, °C; $dT/dn_{ea}$ – the maximal difference between the temperatures over the front on the earth level near the forecast point, °C; $T_{ea}$ – the maximal temperature on the earth level, °C; $Td_{ea}$ – the maximal temperature of the dew point on the earth level, °C.

The tornadoes objective forecast examples, calculated by this statistical model and using the discriminant function U(**X**), are submitted in the table 1 of [4,8]. If the value of U(**X**) is U(**X**)>3 then the forecast of the wind velocity V>24m/c has very high probability [8], if .the parameter of the instability $(T'-T)_{500}>0,5$.. The tornadoes in Ivananovo and Moscow on 9.06.1984. were successful predicted. The last tornado at Moscow area on 04.06.2009 was predicted too. This method was recommended for the territory of ETR and for Ukraine.

**The automated hydrodynamic-statistical forecast of squalls and tornadoes on the base of the hemispheric model**

The successful development of hydrodynamic models for short-term forecast and improvement of two-three-day forecasts of pressure, temperature and others parameters allow us to use the prognostic fields of hydrodynamic models for the calculation of the discriminant functions $F_1(\mathbf{X})$ ( vor the wind velocity V>19m/s) and $F_2(\mathbf{X})$ (for the vind velocity V>24m/s) values in the nodes of the greed and the values of the probability of dangerous winds of two classes $P_1(\mathbf{X})$ and $P_2(\mathbf{X})$, included squalls and tornadoes:.

$$P_1(\mathbf{X})=100/(1+\exp(-F_1(\mathbf{X}));$$
$$P_2(\mathbf{X})=100/(1+\exp(-F_2(\mathbf{X})).$$

As a result we have gotten the fully automated forecast of these phenomena. The statistical decisive rules $F_1(\mathbf{X})$ and $F_2(\mathbf{X})$ for the automated alternative and probability forecasts were obtained in accordance with the concept of “the perfect prognosis” using the data of objective analysis. For this purpose the new teaching samples were automatically arranged that include the values of n=38 physically substantiated potential predictors [8]. We obtained the informative vector-predictors of each class (k=8) by the same empiric-statistical selection method [3]. The discriminant functions $F_1(\mathbf{X})$ and $F_2(\mathbf{X})$ and the probabilities of the phenomena $P_1(\mathbf{X})$ and $P_2(\mathbf{X})$ [5] were calculated using the values of the prognostic fields of the first short-term hydrodynamic hemispherical model of Hydrometcenter (the author-Berkovich L.V.) in the nodes of the rectangular mesh 150x150 km:.

The author proposes the empirical threshold values $\mathbf{P}_{thr}$ specified for each phenomena and advance period 12-24-36h in order to get the these phenomena alternative forecast. The tornadoes in Moscow in the year 1998 and in the year 2001 were predicted to 24 h ahead. The forecast of dangerous squalls and tornadoes over European part of Russia was tested successful and was recommended for synoptic practice for the advance forecast period 12-36h [5, 8]). This method was adapted for the territory of Siberia in the years of 2004-2005. The forecast assessment of severe summer wind with the velocity V>24m/s over the territory of Siberia was W=86% for the earliness 36h, the value of Pirsy-Obukhov criterion was also high T=0,78 [6]. The forecast examples are submitted at this report such the forecast of severe wind (V=37m/s) at Novosibirsk and Altai region on 24.06.05, severe wind (V=27m/s) at Turukhansk on 04.07.05 and other examples [9].

## The model of the hydrodynamic-statistical forecast of the severe squalls and tornadoes on the regional model output data. The forecast examples

The values of the prognostic fields of the region hydrodynamic model of short-term forecast (the author –Losev V.M.) are calculated in the nodes of the degree 75x75km into operative system of Hydrometcenter two times per day. Nowadays we use the values of these prognostic fields in the same discriminant functions $F_1(\mathbf{X})$ and $F_2(\mathbf{X})$ for the forecast of squalls and tornadoes and severe wind of two classes. Also the new values of the probabilities $P_1(\mathbf{X})$ and $P_2(\mathbf{X})$ are calculating in the nodes of degree 75x75km in percent by the same formulas:The new threshold probability **P** gives the forecast areal of severe wind on the map.

The examples of the automated hydrodynamic-statistical forecast of severe squalls and tornadoes on the regional model base over the territory of ETR are submitted in the papers [8]. Here we submit some examples of the same forecast adapted for the territories of Siberia and Far East. The forecast (to 36h ahead) areal to 22.08.10 is submitted on the fig.1. This day severe squalls with V=28m/s was observed at the Tomsk region [9]. On fig.2 the areal of the forecast to 36h ahead on 3.07.10 is submitted. Very small areal is occurred by isoline P=70%. This day the tornado was observed at the Blagoveschensk region.

Also the new tornado was observed at the Blagoveschensk areal on 31.07.11. This forecast was also successful to 36h and to 12h ahead. The forecast maps will be submitted at this report together with other forecast examples.

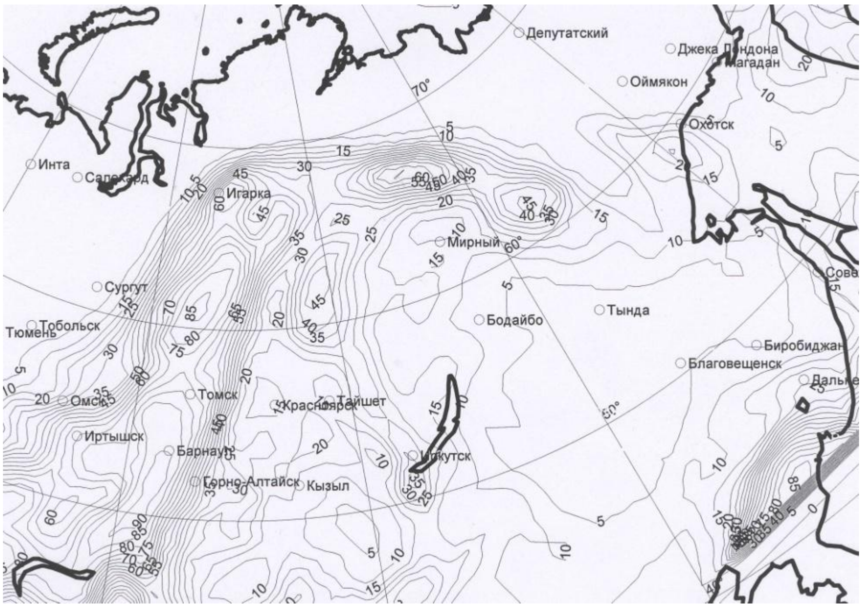


Fig.1 The forecast areal of the wind V>24m/s on the date 22.08.10 to36h ahead is occurred by isoline of the probability **P**=65%, the forecast areal of storm wind is occurred by isoline **P**=70%.

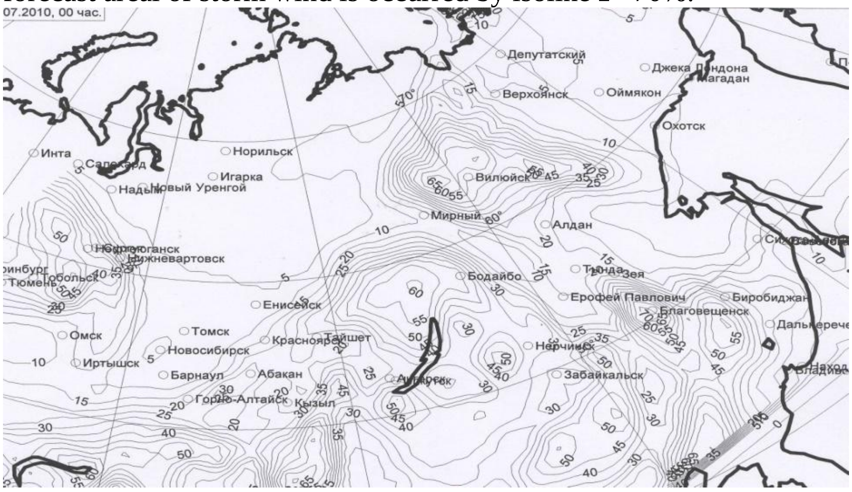


Fig.2 The areal of the forecast to 36h ahead of the wind V>24m/s on 03.07.10 is occurred by isoline P=60%, of the storm wind – is occurred by isoline P=70%.

## Conclusion

The assessments of new hydrodynamic-statistical forecast method of squalls and tornadoes over the territory of Russia were successful. They have shown also the stability of statistical forecast model of squalls, tornadoes and dangerous wind over the territory of Russia with the using of output production successful hydrodynamic models (hemispheric and regional models). Now we are going to develop the model of these storm wind forecast to 72h ahead with the using of the output production of a global model of Hydrometcenter of Russia (the author – Tolstykh M.A.).

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