The stochastic optimization of the automated forecast of the severe squalls and tornadoes on the base of hydrodynamic-statistical forecast models

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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 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 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 $\mathbf{X}(A) = (x_1(), x_2(), \ldots, x_n())$, 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 and the thunderstorms and the rainfalls were observed, but the wind velocity is not so high ($V <$ 8-10 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 to minimize the middle economic losses of 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 to calculate the decisive rules 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 **R**algorithm [3]. The most informative predictors – representatives from each of diagonal blocks and two independent predictors are composed vector-predictor of dimension $k = 6$ (from $n = 26$ potential predictors) [3]. The most informative were estimated using the criterion by Mahalanobis distance Δ^2 ($\Delta^2 = (m_i(A) - m_i(B)) \uparrow 2/\sigma^2$) and 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 from six atmospheric parameters after this selection ($\mathbf{V_{700}}$, $\mathbf{T_{ea}}$, $\mathbf{Td_{ea}}$, $\mathbf{H_0}$, $(\mathbf{T} - \mathbf{T}')_{\mathbf{500}}$, $\mathbf{dT/dn_{ea}}$) [3]. Here $\mathbf{V_{700}}$ – the value of the mean velocity of the wind on the level 700 hPa, $\mathbf{T_{ea}}$ – the maximal value of the temperature near the earth level, $\mathbf{Td_{ea}}$ – the maximal value of the dew point near the earth

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level, $\mathbf{H_0}$ – the level of the isotherm of 0^oC, $(\mathbf{T'} - \mathbf{T})_{\mathbf{500}}$ – the difference between the values of the stratification curve and the moist adiabatic on the level 500 hPa, $\mathbf{dT/dn_{ea}}$ – the maximal difference between temperatures over the front on the earth level near the forecast point. Then the linear discriminant function $U(\mathbf{X})$, depended from these parameters, was calculated by Byes approach. If the value of $U(\mathbf{X}) > 0$ at the fix station, we have the forecast squall ($V > 20$ m/s) near this station during the current day. The tornadoes objective forecast examples (in Ivanovo, in Penza, in Dubna) were calculated by this statistical model with the using the discriminant function $U(\mathbf{X})$ (the value $U(\mathbf{X})$ was more than 3) [5]. 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 develop on the base of the output data of the first hydrodynamic hemispheric model. The probability of dangerous winds for each of two classes $P_1(\mathbf{X})$ and $P_2(\mathbf{X})$ ($P_1(\mathbf{X}) = 100/(1 + \exp(F_1(\mathbf{X}))$; $P_2(\mathbf{X}) = 100/(1+\exp(-F_2(\mathbf{X})))$ were calculated operative in the nodes of the greed 150x150km two times per day. The probability more than the empiric threshold $\mathbf{P}$ give us the forecast area of such squalls. 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 was recommended in 1993 years for the using in synoptic practice [4, 5]. This method was also adapted for the territory of Siberia. The examples of last hydrodynamic-statistical forecast model of squalls and tornadoes using the new regional hydrodynamic model output data in the nodes of mesh 75x75 km are submitted at [5]. Three submitted stochastic models of automated forecast of dangerous squalls and tornadoes over the territory of Russia are used for the development of the stochastic optimization of forecasts with the minimum economical losses of forecast errors. 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 next days.

References

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