Hydrodinamical-statistical model of forecast to 36 hours ahead of dangerous convective daytime and nighttime phenomena - squalls, tornadoes and rainfalls

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Forecast of dangerous convective weather phenomena that cannot be predicted using existing hydrodynamic models depends strongly on the intuition of a meteorologist. The statistical model was developed that takes into account a large number of atmospheric parameters and thus successfully realizes objective automated forecasts of the phenomena involved for and two days.

The problems of the alternative prognosis of dangerous phenomena (presence and absence) is solved a problem of the theory of classification when the image of an existing object (meteorological situation) is presented as a n-dimensional vector $X=(x_1, ..., x_n)$ in the n-dimensional space of parameters rn. The problem to build in rn the decisive rules of recognition follows the problem of selection of the most informative and independent parameters. This is done in order to get rid of dependent parameters which worsen the covariation matrix and to change to a space with smaller dimension. The independent parameters are chosen with the use of diagonalization of the selective average correlation matrix Rav by permutation of its rows and columns in such a way that the matrix elements located outside certain blocks are small, thus the set of parameters splits into the blocks including interconnected parameters that are only slightly dependent on parameters belonging to a different block.

The process of diagonalization of R_{av} and selection of the most informative factors within a group can be done under the condition that the number of groups is determined during calculations rather than is specified before. The biunique correspondence was established between matrix R_{av} and a connected graph Γ whose vertices correspond to x_i and the edges correspond to r_{ij}. On specifying a closeness threshold ro only those edges of Γ stay preserved whose $r_{ij}>=r_o$. Then the closed graph Γ splits into a certain number non-closed subgraphs and isolated vertices xk thus determining the block structure.

Specifying different values of ro we obtain different sets of subgraphs and isolated vertices. Our program allows us to obtain for each $r=r_o+(-)dr$ (dr=0.01, 0.02,...0.05) the corresponding set of subgraphs and vertices. Then we take from each block the most informative predictor using the Mahalonobis distance and the entropy criterion by Vapnik-Chervonenkis [1]. As a result we get the informative groups of the slightly dependent predictors. Then taking combinations of informative predictors from each block (at least two) with independent informative predictors (isolated vertices of the graph) we have combinations of all most informative groups of predictors without exhaustive search.

For the investigated phenomenon “squall” and for the optimum value of r_o=0.5 the selective correlation matrix Rav got splited into five blocks of strongly dependent predictors and a certain number of isolated diagonal elements, the most informative parameter being the presence of a front. The approximate dimension of the informative vector-predictor it proved to be six. The estimations of the success of separation in the examination sample for the chosen vector-predictor consisting of six elements were the highest. During routine utilization the linear discriminant function depending of six atmospheric parameters is calculated automatically and then is used to predict the squalls (V>=20 m/s) in any given location of the European part of Russia [2,3].

In development of forecast for strong rainfalls (Q>= 15mm/12 h) we have selected in a similar way from 40 atmospheric parameters a 7-dimensional vector-predictor and calculated corresponding linear discriminant functions for automated forecast in the 150x150 km net covering the European part of Russia. The forecast of daytime rainfall is being done for the current and the next days to 24 and 36 hours ahead in six regional bureaus of Hydrometeorological Service [4]. Such forecast method for rare daytime squalls and tornadoes (V=25m/s) done in 1996-1998 was also recommended for practical usage at the territory of High Volga, St-Petersburg and North area and at the territory of the Central region and at the North Caucasus. The result of forecast of these phenomena to 36 hours ahead is good enough too. The independent assessments of criterion of Pirsi-Obukhov are 0,34-0,58 for different convective phenomena, more better than the assessment of such synoptic and hydrodinamical forecast /5/.

References

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