Statistical prognosis modeling of thunderstorm at the Heydar Aliyev Airport

Dr. N.Sh. Huseynov, B.M. Malikov

National Academy of Aviation (Azerbaijan Republic)

I. INTRODUCTION

There are considerable prognosis methods for prediction of probability thunderstorm that applicable in operational practice of meteorological provision of aviation. However, majority of numerical models, diagnostic parameters and indices sometimes are less sufficient for verification of probability of thunderstorm. Development of thunderstorms depend of variety factors that why the most of prognosis methods are not universal and such factors as local geographic peculiarities, synoptic situation etc. must be taken into account [6]. Hence the prognosis model developed for specific geographic area inapplicable or less effective for another region [6, 7]. Numerical models are successful in cases where the large scale synoptic forcing is well marked.

II. INVESTIGATION OF KEY METEOROLOGICAL ELEMENTS OF CONVECTION

Forecasting a thunderstorm is one of the most difficult tasks in weather prediction, due to their rather small spatial and temporal extension and the inherent nonlinearity of their dynamics and physics [2, 4, 10]. The prognosis models commonly have been developed on the basis of physical low of thermodynamic process in atmosphere [2, 5]. Hereby the rate of validity of some diagnostic parameters has been assessed for Azerbaijan Republic Airport Heydar Aliyev (tab. 1.).

№	Diagnostic parameter	Mean value (%)
1.	CAPE	60
2.	LI – lifted index	35
3.	SI – Showlter index	78
4.	TT – Total-totals	60

TABLE I: Assessment of diagnostic parameters effectiveness for operational forecast of thunderstorm at the Airport Heydar Aliyev.

III. STATISTICAL ANALYSES OF DATA

During the recent years, a variety of statistical techniques have been used to develop forecast models for thunderstorm and lightening. Some of statistical models that have been used include multiple linear regression, Binary logistic regression and classification and regression trees (CART) [1, 3, 10].

In the present study the statistical prognosis model was developed on the basis of application of the statistical analyses methods applied in meteorology. According to the task of the study there were considered interrelation of key meteorological elements temporal-spatial interrelation during development of convection in atmosphere. Obviously implication of more informative parameters quantifies the rate of model.

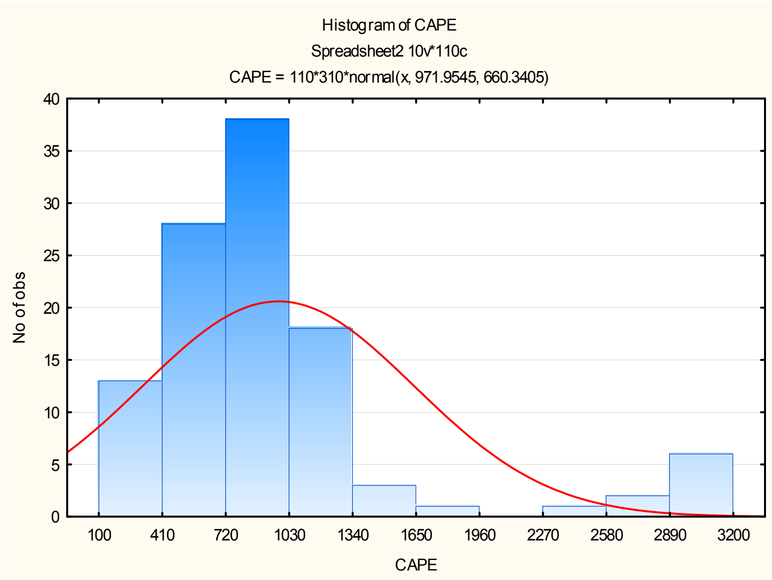
The method of the investigation was held on the following scheme:

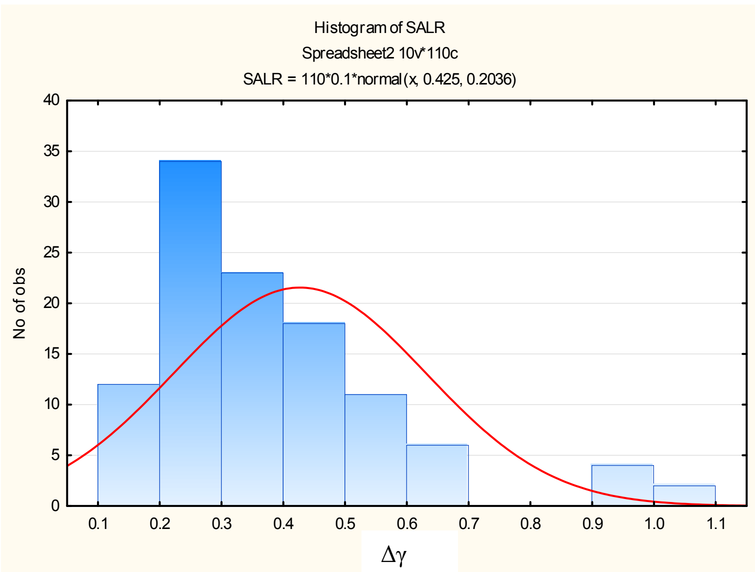
- Classification of raw data. As the raw data radiosonde derived data of the aerological station Mashtaga (WMO code 37860) was used;
- Definition of mean values and normal distributions;

- Correlation analyses for defining informative parameters (predictors) of the model. After the relationship was quantified between a set of parameters 3 predictors *CAPE*, mean values of vertical temperature lapse rate (ELR-SALR) difference $(\Delta\gamma)$, depth of instability layer (Δh) from a 10 potential predictors considered for analyses. For developing the statistical prognosis model, 150 cases of thunderstorm that occurred at the Azerbaijan Republics Heydar Aliyev Airport for the period 2008-2012 were considered.
- Discriminate analyses of Multivariate Exploratory Techniques applied for development of the model. This method was applied as the predictant (thunderstorm) is assessed on the basis of "YES" or "NO".
- Modeling was realized in software of the system "STATSOFT/STATISTICA".

In the investigation some studies of climatological features of thunderstorm activity over Heydar Aliyev Airport was taken into account [7]. According to climatic features the most of thunderstorms over Heydar Aliyev Airport occur on April-May (32%) and September-October (38%) [9].

Initially the variance analyses and normal distribution plotting was made (fig. 1) with the purposes to define ***t*** – Student criterion, for systematic relations between mean values included in the model.





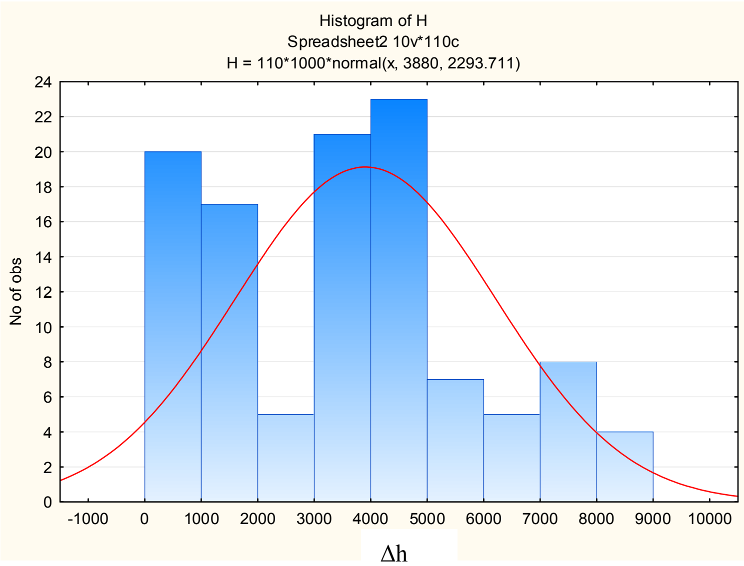


FIG. 1: Diagram of distribution of CAPE, $\Delta\gamma$, Δh .

The next hypothesis was formulated:

H_0: Normal distibution;

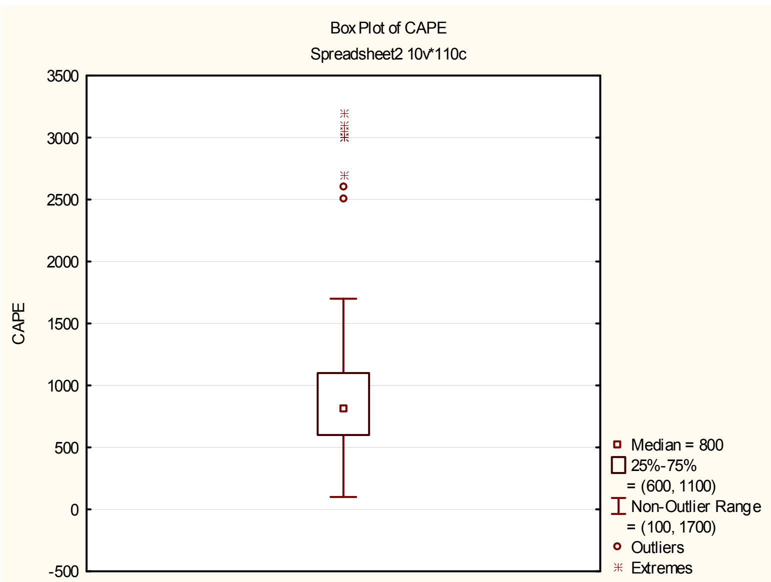
H_1: Non-normal distribution.

For test of significance of normal distribution the ***P*** – confidence interval was used (tab. 2):

	Criterion	***P*** – confidence interval	
1.	Kolmogorov-Smirnov	$P_1 \geq 0{,}01 \longrightarrow H_1$;	H_0 - rejected
2.	Shapiro-Wilks	$P_2 > 0{,}3 \longrightarrow H_0$;	H_1 - rejected
3.	Lillefors	$P_3 \geq 0{,}07 \longrightarrow H_0$;	H_1 - rejected

TABLE II: ***P*** – confidence interval definition methods.

On the fig. 2. the dispersion diagrams of *CAPE,* $\Delta\gamma$, Δh are showed.



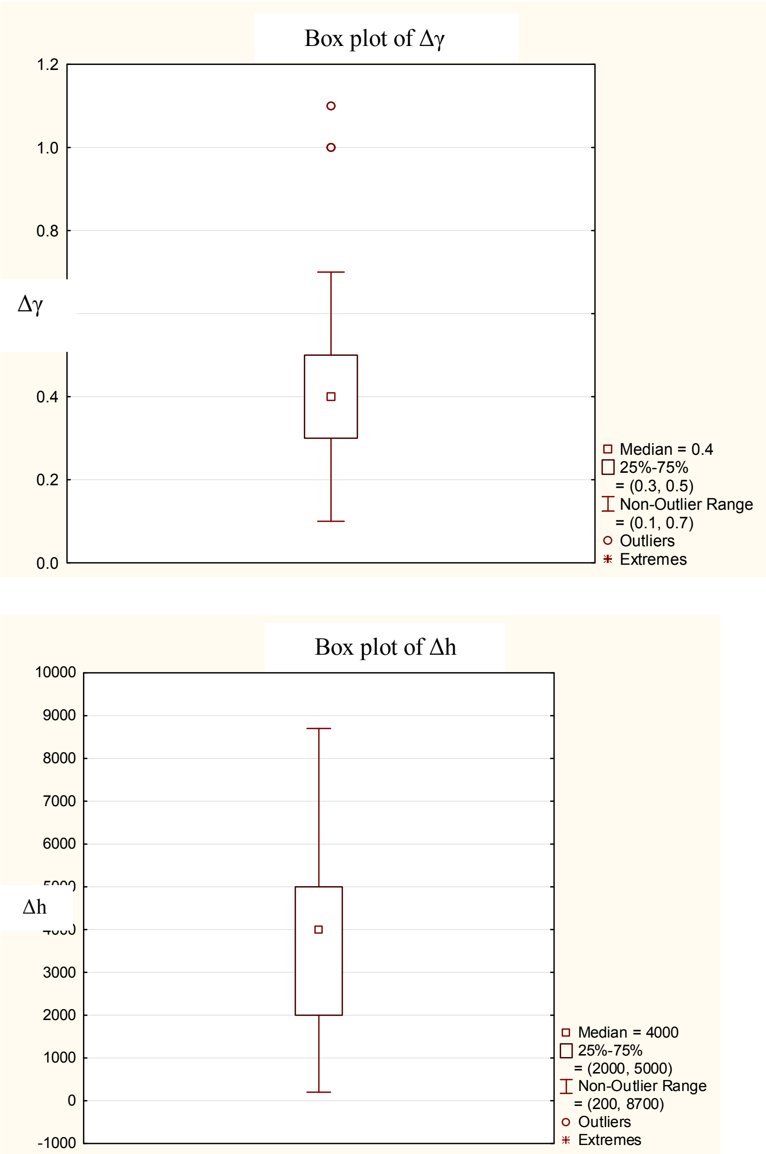


FIG. 2: Dispersion diagrams of *CAPE,* $\Delta\gamma$, Δh.

Following dispersion of predictors ***t*** – Students criterion was applied according to following algorithm (fig. 3).

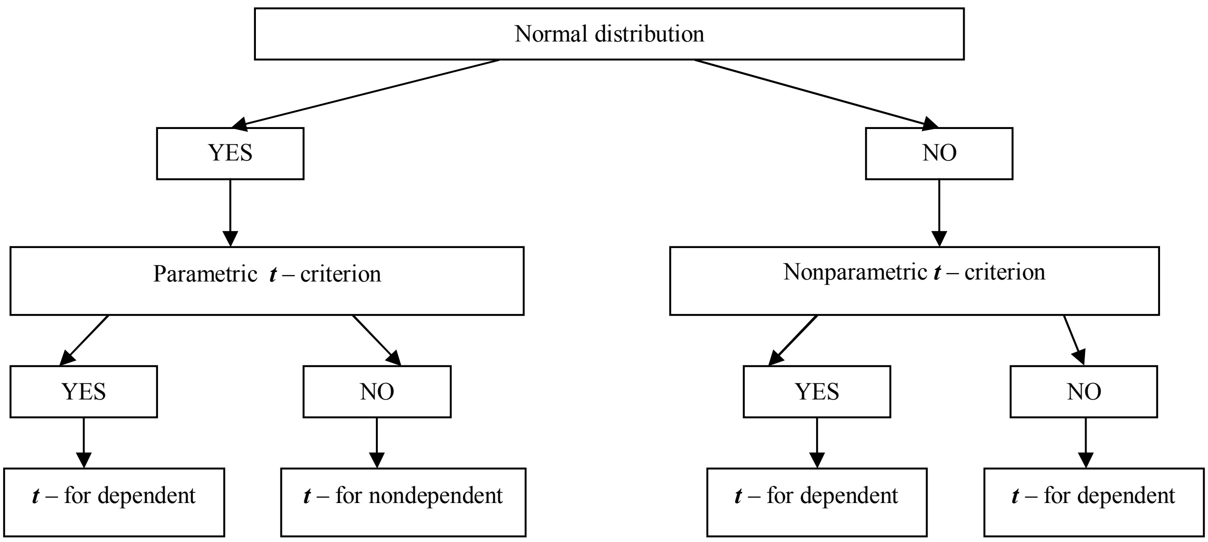


FIG. 3: Algorithm of t- Students criterion application.

IV. MODELING

The following hypothesis was considered for the model:

$H_0: \; R^2 = 0$ - basic hypothesis

$H_1: \; R^2 \neq 0$ - alternative hypothesis

The predictors were used in the model on the step by step scheme:

$X_1 \rightarrow Y \quad R_1^2$

$X_2 \rightarrow Y \quad R_2^2$

$X_n \rightarrow Y \quad R_n^2$

According to software Discriminate Analyses of Multivariate Exploratory Techniques in the system "STATSOFT/STATISTICA" the following statistical model of prognosis of thunderstorm at the Azerbaijan Republic Airport Heydar Aliyev was obtained [1]

$$F = 0.8827CAPE + 0.7760\Delta h + 0.7889\Delta\gamma \, . \tag{1}$$

In the system "STATSOFT/STATISTICA" the coefficient of determination of the model adequacy ($\boldsymbol{R^2}$) was defined as [1]:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(Y_1 - \hat{Y}_i)^2}{\sum_{i=1}^{n}(Y_1 - \overline{Y})^2} \leq 1 \, . \tag{2}$$

For parameterization of spatial distribution of predictors $P = \min\{CAPE, \Delta\gamma, \Delta h\}$ parametr could be used in which the predictors minimal values more than or equal to a threshold value.

V. AKNOWELDGMENTS

This work was supported by the Science Development Foundation under the President of the Republic of Azerbaijan – Grant EIF-2011-1(3)-82/39/2.

VI. REFERENCES

1. Брукс К., Краузерс Н. Применение статистических методов в метеорологии. – Л: Гидрометеоиздат, 1963, 416 с.
2. Гусейнов Н.Ш. Вертикальное распределение метеорологических элементов в пограничном слое атмосферы // Труды РГГМУ, 2006, №2, с. 79-85.
3. Гусейнов Н.Ш. Применение вероятностной логики и теории статистических решений для альтернативного прогноза гроз // Научные труды Национальной Академии Авиации, Том 5, № 3, 2003, том 5, № 3, с. 20-23.
4. Шметер С.М. Термодинамика и физика конвективных облаков. - Л.: Гидрометеоиздат, 1987, 288 с.
5. Шметер С.М. Физика конвективных облаков. - Л.: Гидрометеоиздат, 1972, 232 с.
6. Doswell C., Schutz D., 2006: On the use of indices and parameters in forecasting severe storms. Electronic J. Severe Storms Meteor., 1(3), 1-22.
7. Huseynov N.Sh., Malikov B.M. Synoptic situations generating the convective processes over the airdromes of Azerbaijan Republic / 10th Plinius Conference on Mediterranean Storms European Geosciences Union Tropical Conference Series, Nicosia, Cyprus, 22-24 September 2008, pp.53-54.
8. Huseynov N.Sh., Malikov B.M. Statistical analysis of the storms event at the airdrome Baku. Modeling of the accuracy isolines of the storms registration systems. // Atmospheric Research vol. 93, pp. 93-99.
9. Huseynov N.Sh., Malikov B.M. Regularity of distribution of precipitations on the airports of Azerbaijan Republic // Scientific Journal Advances in Geosciences (An Open Access Journal for Refereed Proceedings and Special Publications), Vol. 20, 2009, p. 9-12.
10. Rajeevan M., Madhulatha A. and others, 2012: Development of a perfect prognosis probabilistic model for prediction of lightning over south-east India. // Journal of Earth System Science, vol 121, issue 2, pp 355-371.