A STUDY ON THE OCCURRENCE OF FOG IN THE UPPER MURES BASIN

Zs. Magyari-Sáska[1]

ABSTRACT

The proesent study aims do describe the fog phenomena in the Upper Mures Bassin and an analysis of the persistence of fog in the region. The data source is NCDC, comprising data about fog occurence,average daily visibility, as well as daily minimum temperatures. The study includes both a descriptive statistics of the phenomena and a part of frequantial analysis. The descriptive statistics succeeds in identifying the valley fog in the area as being typical to the winter months. The frequential analysis targets both detecting the number of days with fog in the area with a visibility under 1000 m, as well as the number of consecutive days in which the mean daily visibility is under 1000 m. The result of this analysis is the statement that, in the long run, the proportion of consecutive days having a visibility under 1000m with respect to the numer of days with visibility under 1000m is around 40% at Joseni and approximately 80% for Toplița.

*

1. THE FOG PHENOMENA

Fog is an agglomeration of water particles being in pending above the ground. The phenomena appear when water vapors from the atmosphere become saturated, mostly due to the cooling of temperature bellow dew point. There are several types of fog, depending on water condensation conditions:

- Radiation fog is formed by the cooling of ground after sunset in calm conditions with clear sky, which produces condensation in the nearby air. This type of fog could have at most 1m height from ground in calm conditions.
- Advection fog occurs when moist air appears over a cool surface and is cooled. It is common as a warm front passes over an area with significant snow.
- Evaporation fog, is the most localized type and is created by cold air passing over much warmer water or moist land
- Valley fog forms in mountain valleys as the result of a temperature inversion, often during winter. It is caused by heavier cold air settling into in a valley, with warmer air passing over the mountains above. It is in fact a radiation fog blocked by local topography.
- Upslope fog forms when winds blow air up a slope, adiabatically cooling (without heat transfer) appear as it rises, and causing the moisture in it to condense.

2. DESCRIPTIVE STATISTICAL CHARACTERIZATION

The descriptive statistical characterization is necessary from multiple motifs. First of all it's based on this characterization makes possible the estimation of spatial and temporal apparition of fog. Regarding the fog phenomena an analysis which takes care of several meteorological factors can identify different types of fog. On the other hand a

[1] *„Babeş-Bolyai" University, Faculty of Geography, 400006 Cluj-Napoca, Romania*

spatial correlation between fog apparition, or a regression between topography and fog apparition could be also useful.

Figure 1 and 2 presents a global aspect of the fog apparition in the study area.

Comparing these figures the following notification can be made:

- The fog apparition and strongly related to it the reduced visibility is characteristic for Calimani station, situated at 2021m altitude;
- Bucin station also situated on a crag at 1279m, has different characteristics, the foggy days and a reduced visibility days with visibility below 1000m is comparable with the stations in the Giurgeu Depression
- Regarding the foggy day number Toplita station has more foggy days than Joseni, even if the mean visibility is much reduced is Joseni that in Toplita

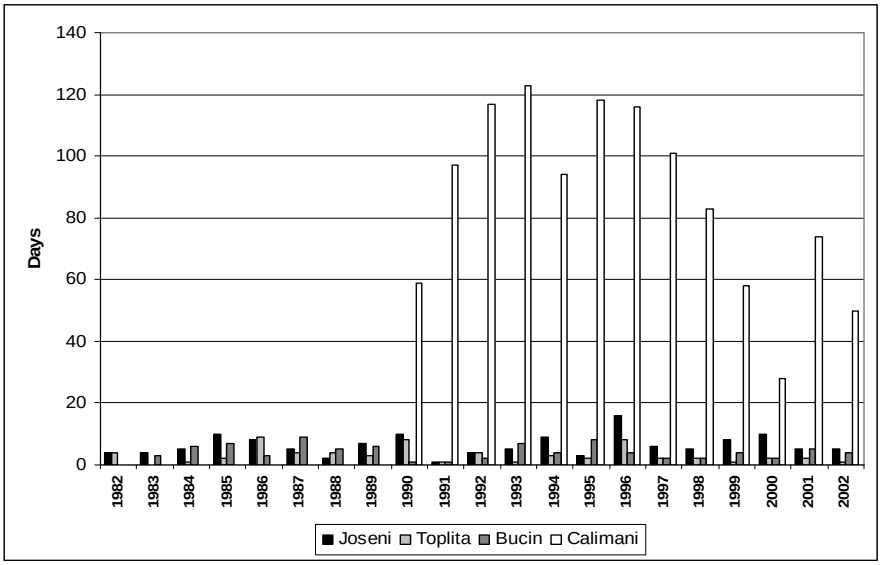

Fig. 1. – ***Annual average of foggy days***

A complete characterization of mean foggy days with different visibility limits is presented bellow.

Annual number of foggy days

Table 1.

	JOSENI	TOPLIȚA	BUCIN	CĂLIMANI
Annual mean foggy days	59.95	71.09	74.05	211.61
Annual mean days having mean daily visibility bellow 1000m	6.28	3.04	4.25	86.00
Annual mean days having mean daily visibility bellow 500m	4.28	1.28	2.10	82.92

The total number of days in which the mean daily visibility is below 5m has the following distribution in the studied period (1982-2002): Joseni 4 days, Toplita 0 days, Bucin 3 days, Calimani 354 days.

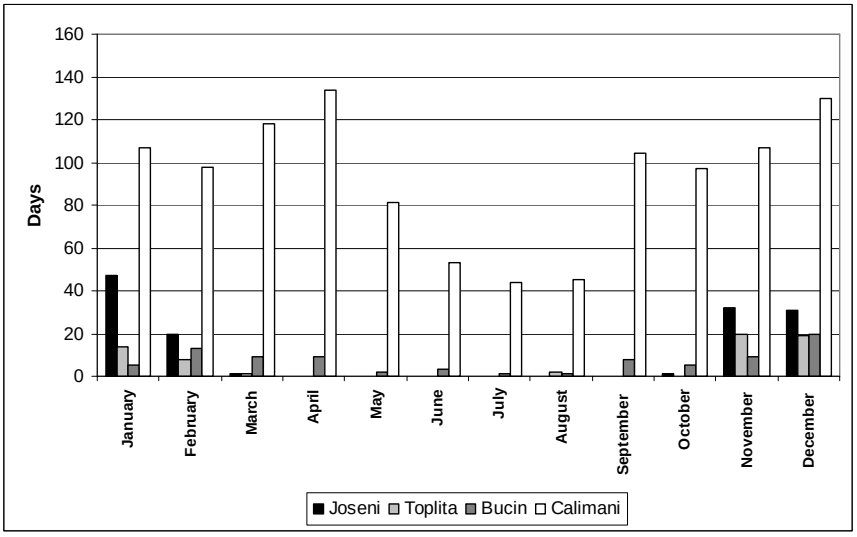

Fig. 2*: Monthly average number of foggy days having mean daily visibility bellow 1000m*

It's important to notice that the number of foggy days have a rising trend from May to October at Toplita comparing with Joseni. It's also evident that the fog represents risk in Giurgeu Depression mostly in winter period. Based on this observation we start to study the condition of fog apparition in winter month (November, December, January and February). The result was that temperature inversions are an essential factor in fog presence, having a daily mean visibility bellow 1000m.

Studying the station pairs (Joseni-Bucin, Toplita-Calimani) we can conclude that in case of Joseni-Bucin pair the temperature inversions are strongly correlated with daily mean visibility, while for Toplita-Joseni station this is not obvious. This result is not surprising because of Calimani station high altitude, encountering almost all times foggy conditions.

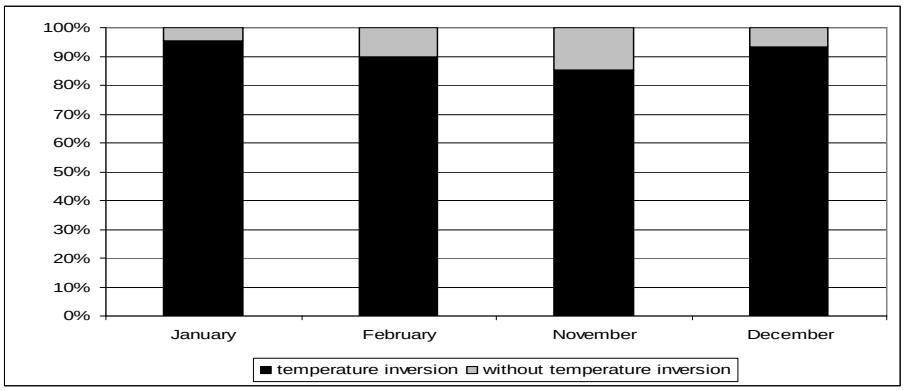

Fig. 3: Frequency of days with temperature inversion correlated to fog apparition (mean daily visibility bellow 1000m)

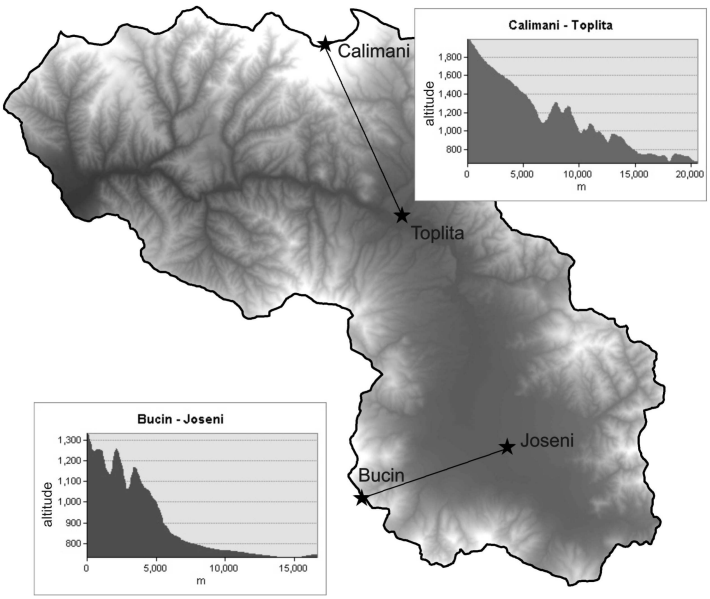

Fig. 4: Position of meteorological stations in the study area and the longitudinal profiles between them

An eventual correlation between Joseni and Toplita stations was also studied, both of them situated in the Depression.

Percentage of common fog apparition at Joseni and Toplița stations

Table 2.

MONTH	PERCENTAGE OF COMMON FOG APPARITION
January	74.65%
February	64.65%
November	74.67%
December	65.32%

Almost in 70% of the cases if the fog presence is observed at Joseni was also observed at Toplita. The Pearson correlation value has interpretable values for January, November and December.

Correlation values of mean daily visibility between Joseni and Toplița stations

Table 3.

MONTH	CORRELATION VALUE
January	0.31
February	–
November	0.86
December	0.46

The only month with significant correlation value is November, in case of the other month the correlation value does not show a true correlation between mean visibility values. As a conclusion a visibility interpolation based on this relation cannot be made.

The persistence of fog was also studied based on consecutive days with fog having visibility bellow 1000m. The study was also made just for the mentioned winter month for Joseni and Toplita stations.

The results show up an important correlation between successive foggy days at Joseni and Toplita. This correlation values was 0.70 for foggy days and a little bit higher (0.73) when the maximum daily mean1000m visibility was imposed.
The mean annual successive day number, when visibility was bellow 1000m is 2.05 for Joseni and 1.25 for Toplita.

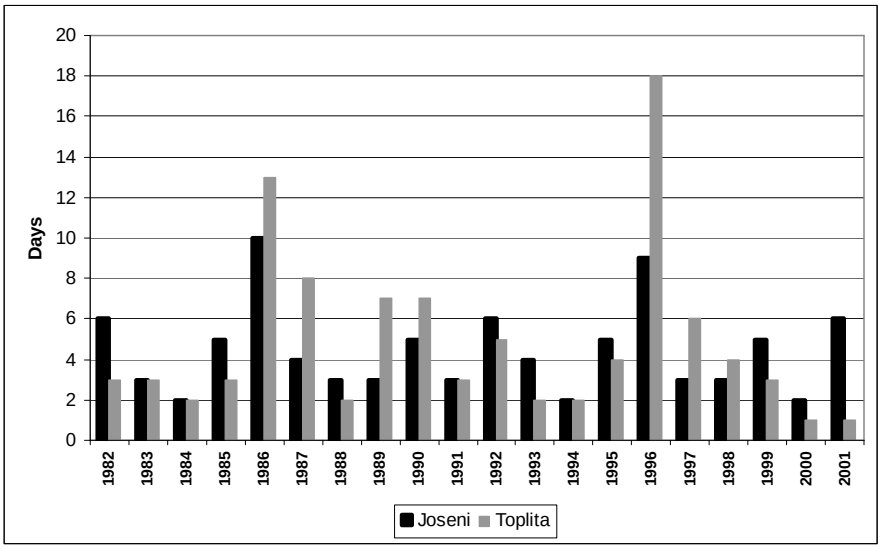

Fig. 5: Number of consecutive foggy days (without visibility limitations)

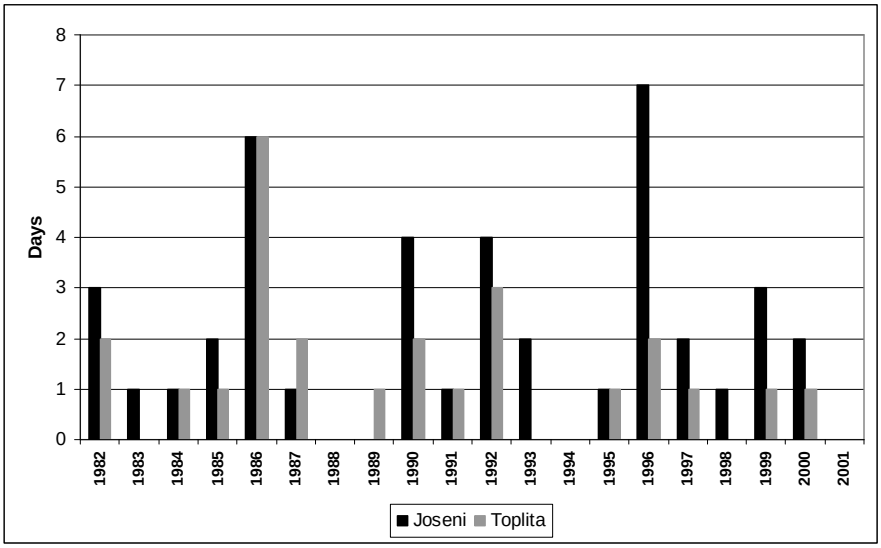

Fig. 5: Number of consecutive foggy days (mean daily visibility bellow 1000m)

3. FREQUENCY ANALYSIS

This part of the research wants to determine the most suitable distribution laws which can characterize the fog apparition, together with the return periods for different quantiles representing annual days number with visibility bellow 1000m and the longest number of successive days with mean daily visibility bellow 1000m.

Both characteristics are in discrete space, so discrete distribution laws should be studied. The used software were EasyFit and R. Our former research showed up that R offer high precision in distribution fitting and quantile determination for different return periods. It's only lack is that doesn't have a proper method for estimating distribution fitting, even if different statistical test are present (Anderson-Darling, Kolmogorov-Smirnov, Chi-Square). For this phase of the analysis EasyFit was used.

The studied discrete distribution laws were:

- binomial
- negative binomial
- Poisson
- discrete uniform
- geometrical
- hypergeometrical
- logarithmical

The following observation should be made before using these laws:

1. the logaritmical law can be used only if the data series does not contain zero. Because of a zero value present at Toplita, in this study thsi law was omitted
2. the parameter estimation was made by fitdistr function in R, using maximum likelihood method
3. binomial and hypergeometrical laws does not have a parameter estimation method in R, so their values was determined manually

The table bellow holds the estimated parameters for every used discrete distribution law:

Estimated parameters for different distribution laws for the study of foggy days number

Table 4.

DISTRIBUTION	JOSENI	TOPLIȚA	BUCIN	CĂLIMANI
Negativ binomială (n,μ)	9.0797; 6.2857	3.7766; 3.0476	18.3004; 4.2499	7.6998; 86
Discret uniformă (a,b)	1; 10	0; 9	1; 9	28; 123
Geometrică (p)	0.13725	0.24706	0.19048	0.01149
Poisson (λ)	6.2857	3.0476	4.25	86
Binomială (n,p)	7665; 0.00082	7665; 0.000397	7300; 0.000582	4745; 0.0112
Hipergeometrică (N,m,n)	7665; 132; 365	7665; 64; 365	7300; 85; 365	4745; 1118; 365

For determining the best distribution the Anderson-Darling test was used because this method is more sensible at distribution tails where the extreme values can appear. Based on this method the following result were obtained:

Joseni: negative binomial
Toplita: Poisson
Bucin: Poisson
Calimani: negative binomial

The number of foggy days having visibility bellow 1000m for different return periods is presented bellow:

Estimated number of foggy days with mean daily visibility bellow 1000m for different return periods

Table 5.

Return period (years)	JOSENI	TOPLIȚA	BUCIN	CĂLIMANI
10	11	5	7	129
20	12	6	8	145
50	14	7	9	164
100	16	8	10	178
150	16	8	10	186
200	17	8	10	191
500	18	9	11	207

A similar study was made for determining the maximum consecutive foggy days with visibility bellow 1000m. The analysis was made only for Joseni and Toplita and just for winter month. The resulted distribution laws are:

Joseni: Poisson
Toplita: hypergeometric

The quantiles for different return periods are bellow:

Estimated numbers of consecutive foggy days with mean daily visibility bellow 1000m for different return periods

Table 6.

Return period (years)	JOSENI	TOPLIȚA
10	4	4
20	5	5
50	5	5
100	6	6
150	6	6
200	7	6
500	7	7

4. CONCLUSIONS

Using NCDC database we could identify the valley fog, characteristic for the study region. For this identification we used three meteorological components: the presence of fog, daily mean visibility and daily minimum temperature.

The pronounced correlation between the periods in which mean daily visibility is bellow 1000m at Joseni and Toplita stations related to that fact that does not exists significant correlation between daily mean visibility between stations the interpolation of visibility can be made just for persistent fog.

Comparing the data series presenting foggy days with daily mean visibility below 1000m and the number of successive days with mean visibility bellow 1000m both of them resulted from frequency analysis, we can observe two opposite directions for long term period (over 200 years) at Joseni and Toplita stations. At Joseni we have a slightly ascending trend (from 36% to 38%) in percentage of successive day with mean daily visibility bellow 1000m from all foggy days with mean visibility bellow 1000m, while at Toplita we can observe a slightly descending trend (from 80% to 77%) for the same characteristic.

On the other hand for a short time period (0-20 years) we could observe a significant percentual rise of successive foggy days with mean daily visibility bellow 1000m. Noticing the high value of successive foggy days in 2006, related to the fact that the analyzed data series ends in 2002, we have a validity of our analysis.

R E F E R E N C E S

1. Haidu I. (2002), Analiza de frecvență şi evaluarea cantitativă a riscurilor, Riscuri şi catastrofe, Casa Cărții de Ştiință, Cluj-Napoca (pp. 180-207)
2. Magyari S. Zs, Haidu I. (2006), *Posibilități de modelare spațială în mediu programat*, Editura Universității „Al.I. Cuza”, Iaşi (pp.57-65)
3. Moldovan F. (2003), *Fenomenele climatice de risc*, Editura Echinox, Cluj-Napoca, (pp. 135-140)
4. Ricci V. (2005), *Fitting Distributions with R*, http://cran.r-project.org/doc/contrib/Ricci-distributions-en.pdf (12.12.2006)
5. *** (2006), *Discrete Distributions*, www.en.wikipedia.com (12.12.2006)
6. *** (2006), *Engineering Statistics Handbook*, http://www.itl.nist.gov/div898/ handbook/index.htm (12.12.2006)