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CRITERIA FOR CLIMATE AND WEATHER RELATED RISKS IDENTIFICATION OVER THE REPUBLIC OF MOLDOVA TERRITORY

Maria Nedealcov [1]

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Abstract. The accelerating pace of climate change is associated to weather-climate related risks manifestations, which in recent years are becoming more intensive and more frequent. Unfortunately, we find that far at regional level there are no a basic scientific information which could highlight their specific spatio-temporal manifestation. In this context, criteria for several weather-related risks identification were quantified, the main ones being material damages, the number of casualties and victims and not the least - and the period they occur. The identified weather and climate related risks may be subject to a complex spatiotemporal analysis, having as a research tool - Geographic Information Systems.

Introduction

The accelerating pace of climate change is associated with the manifestation of extreme events, which in recent years have become more intensive and more frequent. Unfortunately, we find that basic scientific information that would allow optimal organization and functioning of territorial systems is lacking at regional level. The achievement of Moldova Association Agreement with the European Union provisions - through a series of directives on the management of natural hazards, determines necessity of the proposed research. Within the identification process of weather and climatic related risk have been taken into account definition of unified *risk* as *the probability of negative consequences and losses* resulting from the interaction provided by dangerous phenomena, of natural, anthropogenic and vulnerable conditions origins, proposed by the experts of the UN Development Programme (UNDP). In this context, we mention, that the *vulnerability* are

[1] Institute Ecology and Geography ASM

conditions determined by natural, social, economic and ecological or *processes,* which enhances the exposure of one or another community to the danger influence (Reducing Disaster Risk, global report, 2005).

1. Investigation materials and methods

Given the regional peculiarities of weather and climate related risks manifestation over the Republic of Moldova territory, but also their definition as a phenomenon, weather and climatic risks during cold and warm periods of the year were identified - risks which were accompanied by great material damages, victims and displaced people. In this purpose, the informational Database was developed (fig.1) regarding risk manifestation, collected from the international [1] and national [2] databases, according to abovementioned criteria.

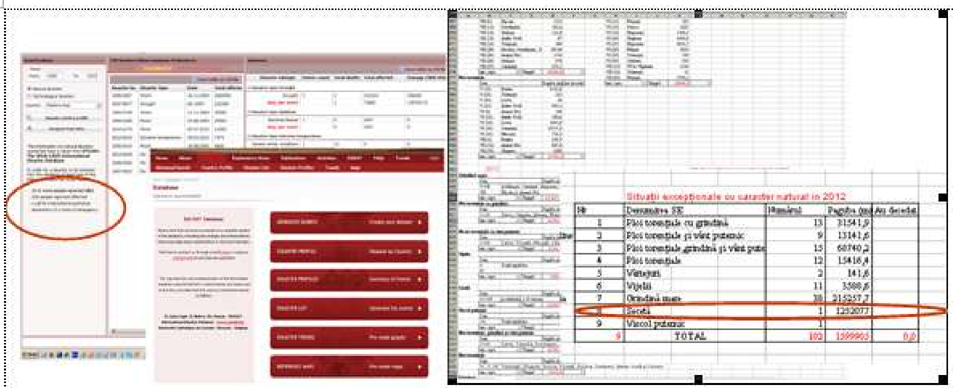

Fig.1. The Database development process based on various criteria of identification

Weighted estimation (fig.2) of weather and climate related risk factors as material losses and human victims, according to CRED and data and of Emergency Department for example, reveals that the drought of 2007 led to the most significant damages representing approximately 52% of total losses, while floods in August, 1994, triggered in the Republic of Moldova have caused about 54% of the total deaths recorded during the years 1960-2015.

Therefore, during the warm season, drought is a weather-related natural disaster, which itself can lead to great material loss, followed by torrential rains accompanied by strong winds or hail (Figure 1).

Drought monitoring as well wet periods can be performed using the Standardized Precipitation Index (SPI) and Standardized Precipitation and Evapotranspiration Index (SPEI). SPI was proposed by *McKee et al.* in 1993 and is recommended by the World Meteorological Organization. SPEI was developed by *Serrano, Moreno and Begueria* in 2010.

As mentioned above, the Standardized Precipitation Index (SPI) is a simple index based on the probability of precipitation. For its calculation only monthly rainfall are needed for a period of at least 30 years. The precipitation is normalized using a probability distribution so that SPI values are actually seen as standard deviations from the median. SPI can be calculated for different time scales. Positive SPI values characterize wet periods and negative ones - dry periods. SPI distribution for a whole period is normal; the average is zero, and standard deviation - the unit. The drawback of this index is that it uses only precipitation, without taking into account the thermal regime and evapotranspiration.

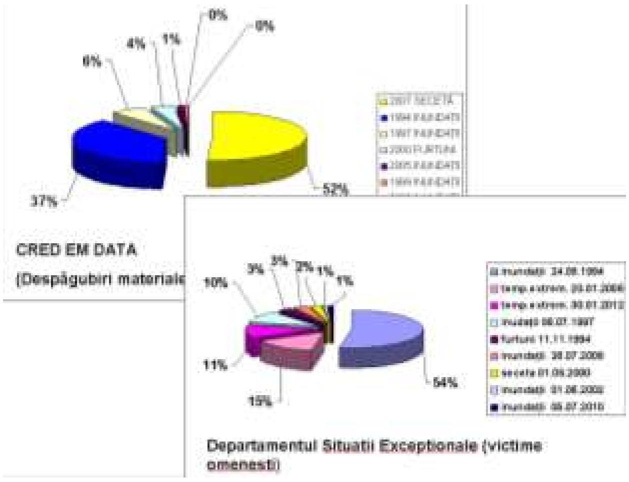

Fig. 2. The weighted estimation of different categories of climate related risks

SPEI Index calculation is based on data that characterizes the amount of atmospheric precipitation, thermal regime and latitude of the place, and allows taking into account the potential evapotranspiration. SPEI is based on the SPI Index original calculation procedure and uses the same time scales. SPEI calculation is based on the difference between the monthly precipitation and potential evapotranspiration, being a simple methodology of water balance and also can be calculated at different time scales. So for SPEI Index calculation a full set of data series characterizing atmospheric precipitation, heat and the potential evapotranspiration were used. In this context, it was created special software to automatically calculate SPEI for a wide range of time scales. The software is available for free on the web by the Spanish National Research Council [3].

For the cold season, number of days with white frost, glazed frost and blizzard spatiotemporal distribution was estimated, their manifestation being in most cases accompanied by material losses and essential traffic destabilization, etc.

The massive amounts of data processing, for a complex spatiotemporal analysis, are only possible based on Geographical Information Systems – a modern research tool.

3. Analysis of the results

The estimated response surface evaluation of three variables three-dimensional interpreted (fig.3) indicates the relationship between the two-dimensional predictors in the formation of values that characterize the manifestation of damage from torrential rains in June, the last 15 years (2000-2014) indicate that they are largely caused by increased number of monthly precipitation amounts, for their torrential manifestation.

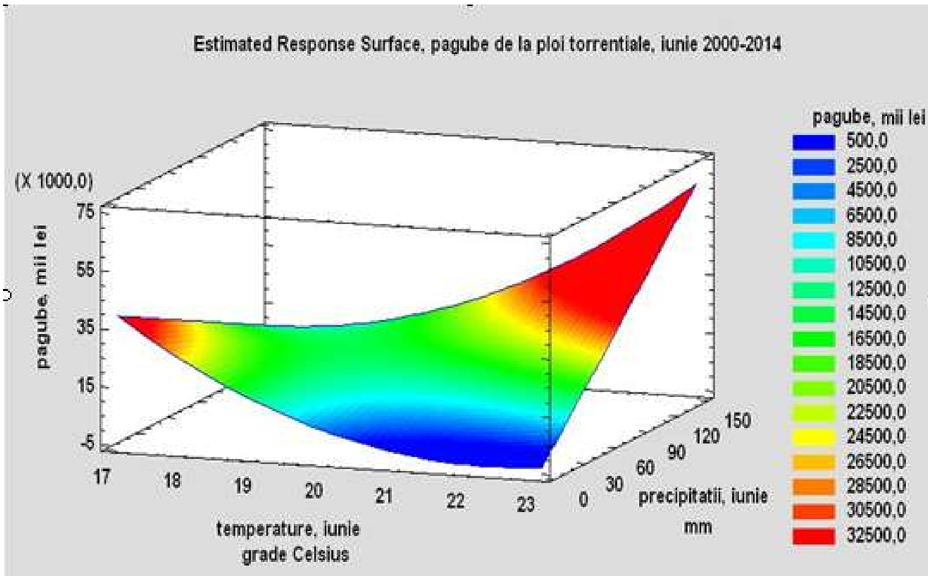

Fig. 3. The surface chart estimation on the damages as a result of torrential rains (June) for the Republic of Moldova territory

The quantile plot (fig.4) on Dry Periods Index (Izu) reveals, that also in recent years during May to August months are registered extremely dry periods identified in the north of the country (fig. 4a) in the following descending order - 2015, 2012, 2009, 2007 while in the south of Moldova (fig.4b) the years' ordering is reversed: 2007 2009, 2012, 2015.

According to the extreme values theory, we note that the return period of extremes can be quite short. At the same time, we find that if extreme years (identified by the highest values of Izu) coincide in time across the country, but the intensity - differ throughout the space. We note that in these years (except 2015), maize and winter wheat's yields were recorded to be as the lowest yields in the last 56 years (1960-2015) due to the installation of dry periods in May-August; a very sensitive period in terms of development stages. The drought of 2007 caused high material losses to the state, about 1,002,090.8 lei, according to the Department of Emergency Situations of the Republic of Moldova [2].

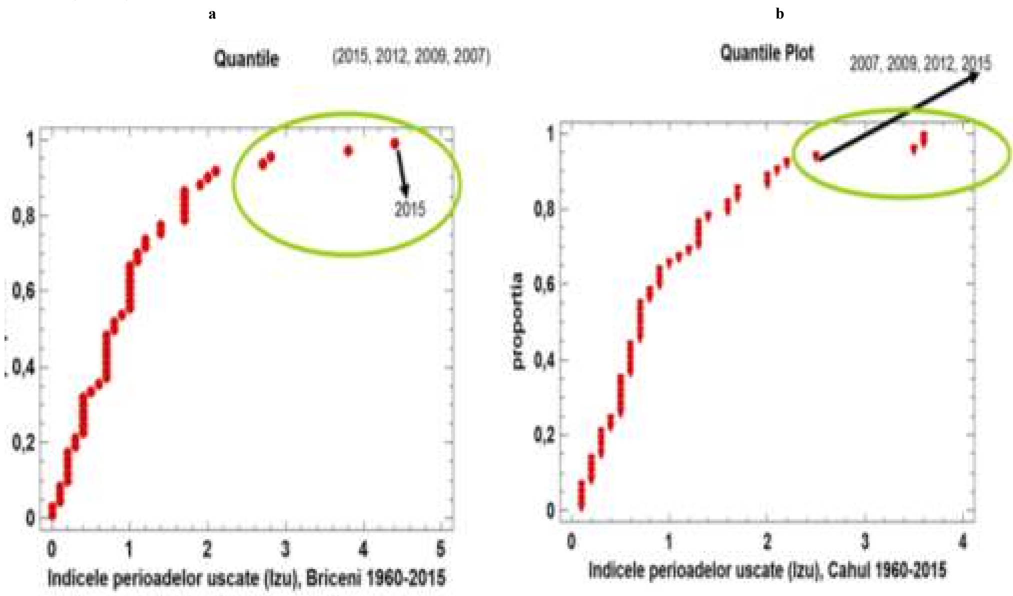

Fig. 4. The quantile graph of Dry Periods Index (Izu) with identified extreme years in the north (a) and south (b) of the Republic of Moldova

Among climate risks during the cold season, last time, is registered strong glazed frost, heavy snow, heavy sleet deposits, and strong frosts resulting in life losses and substantial material damage (fig.5)

So, in the context of climate change, in the central part and even more pronounced in the south there has been a downward trend in the number of days with glazed frost, as a result of climate warming tendency. A slight increase namely 0.0269 days/year is recorded in the north of the country. The data cartographic modeling reveals that the number of days with glazed frost at altitude equally increases (fig.6).

Polei puternic

Anii	Numărul	Paguba (mii	Au decedat	Luna
1998	1			III
2000	1	338134		II,IV,VII
2002	1	12,8		I
2008	1	1265,9		
2010	1	31		
2014	1	973,3		I
Total	6	338423		

Viscol puternic (intensiv)

Anii	Numărul	Paguba (mii	Au decedat	Luna
2000	1			I
2001	1	181		III
2002	1			I
2004	1		4	I
2005	1			II
2006	1			I
2012	1			III
2013	1			II
2014	1			I
Total	9	181	4	

Ninsori puternice

Anii	Numărul	Paguba (mii	Au decedat	Luna
1999	1			I
2009	1	1323,6		XII
Total	2	1329,6		

Depuneri puternice de lapoviță

Anii	Numărul	Paguba (mii	Au decedat	Luna
1999	2	23		II
2007	1	3856,9		I
Total	3	3879,9		

Geruri puternice

Anii	Numărul	Paguba (mii	Au decedat	Luna
2006	1		37	I
Total	1	0	37	

Fig. 5. The identification of climate risks during cold season

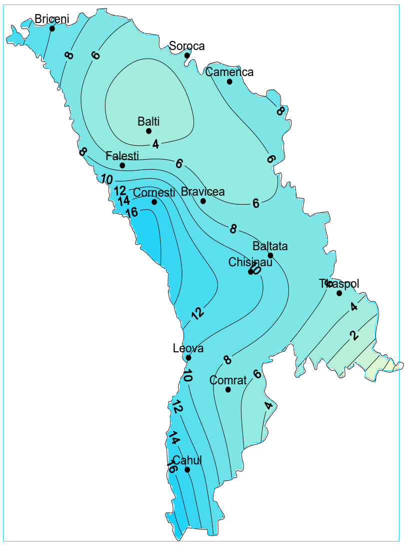

Fig.6. Spatial distribution of the number of days with glazed frost (1960-2015)

The evolution of the number of days with white frost indicates, that this phenomenon has a trend of growth within the central region of the country (0.0902 days/year) and in the south (0.0143 days/year).the analysis of material losses, indicates that the manifestation of strong glazed frost in the last 15 years led to damages of 338 423 000 lei notably in 2000, 2002, 2008, 2010 and 2014.

Cartographic Modeling reveals that most of white frost days are registered in southwest and at altitudes in central and northern regions. So, besides the synoptic conditions and the specific climate change, orographic conditions have tremendous significance in the spatial redistribution of white frost within the country (fig.7).

The number of days with blizzard over the Republic of Moldova territory has registered an increase in the north-east and south-west of the country (fig.8) which is explained largely by the specific of atmospheric circulation both during the cold season as well as the orographic factor.

Damages caused after the blizzard in 2001 being material losses amounting to 181 thousand lei and causing 4 deaths.

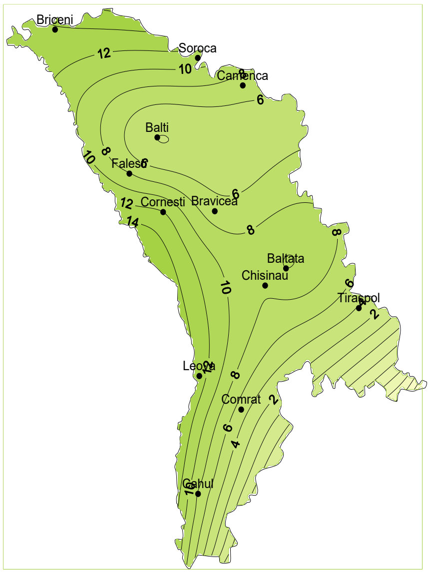

Fig. 7. The spatial distribution of the number of days with white frost (1960-2015)

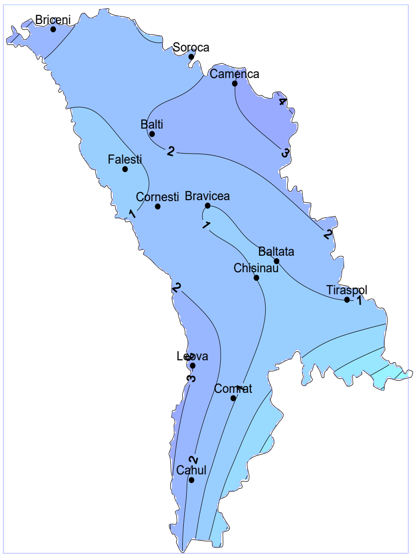

Fig. 8. Spatial distribution of the number of days with blizzard (1960-2015)

In conclusion we find that in recent decades, the accelerating pace of climate change determines the manifestation of weather and climate related risks with increasing severity during of severe events occurring during both cold and warm seasons the year, being accompanied in the most cases by large material losses. Knowledge of risk areas, and regional trends manifestation thereof - would allow local authorities to take proper measures to minimize their disruptive influence.

References

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