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PROBLEMS WITH THE CLASSIFICATION AND PREDICTION OF EXTREME WEATHER PHENOMENA

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A b s t r a c t. Problems concerning classification and prediction of extreme weather phenomena were discussed. Classification of more important meteorological elements and extreme events are shown.

K e y w o r d s: extreme weather phenomena, classification, prediction

Extreme weather phenomena are an old sphere of human interest, but rather a disorderly one. It is not really surprising, because all extreme things tend to create a temporary sensation, only to be forgotten soon afterwards. Some of them occurring on a micro- or mesoscale (e.g., storms or whirlwinds), are not always registered because of insufficient density of stations. In the era of a rapid development of information media, the amount of data concerning such phenomena is quickly growing. These data, however, are dispersed, incomplete and published only occasionally, e.g., in various weather calendars. It seems, though, that they should be collected and published by suitable national, European, and global centres, rather like the internet-based North American Natural Disaster Information Centre or the Worldwide Earthquake Monitoring Centre.

Extreme phenomena cause researchers a lot of trouble. To begin with, the term *phenomenon* brings to mind such meteorological phenomena as, for example, storm, halo, rainbow, virga or glaze, which have nothing to do with any extreme. Perhaps a better term might be an *extreme event*, or, more precisely, an extreme weather (climatic, hydrological, etc.) event. Secondly, there is no satisfactory, precise definition of the term *extreme*. It implies the possible occurrence of two extreme values, or of several equivalent ones. It is also possible to talk about mean extreme values.

However, in the case of some elements and phenomena, only their maximum value can, in principle, be considered. This is when the beginning of their scale is zero (or when they do not occur in a continuous manner). Does it make sense, for example, to talk about the lowest annual rainfall when it is 0.0 mm, as is the case in Iquique in Chile? The question also arises whether the extreme values of a given parameter are tantamount to an extreme event? Perhaps only in some cases. The example of Chile just quoted is not something unusual, but if the annual rainfall of 0.0 mm persists there for 14 years (and is the average for that period!), it does perhaps deserve to be treated as an extreme event (or state), with particular long-term economic consequences.

Every extreme value can of course be dethroned by another, more extreme, which will extend the current range of the changeablity of a given meteorological element and will push the previous value to a group of - what kind of events? - perhaps anomalous ones?

Such nomenclature seems sensible, provided that an anomaly is not every departure from an average of many years, as many climatologists, and even the WMO definition, assumes, but a certain positive and negative extreme range of values [7]. But not every weather anomaly, nor even, as already mentioned, not every extreme value, constitutes an extreme event, which we rather tend to associate with severe consequences. In addition, there is a difficulty in estimating such events when they have no established scale of intensity and it is not clear how they should be measured, e.g., the force of a tropical cyclon: according to the wind speed, range of operation, the value of material losses, or the number of casualties? Which event should be considered worse: the cyclon of 7 October 1737, which caused a 12-metre wave in the Bay of Bengal and the Ganges Delta, drowned about 20.000 boats and killed about a quarter of a million people, or the *Vera* typhoon of 27 September 1959, which devastated the island of Honsiu, took the life of about 5.000 people, and left homeless about a million and a half [8] ?

The result is that an attempt to define and systematise extreme phenomena cannot be objective and requires making some subjective assumptions and classification criteria. It is first necessary to specify with regard to what features and what possible threats a given event can be treated as extreme.

In this connection, the present paper attempts to classify such events depending on: 1) environment of occurrence, 2) origin, 3) type of parameter, 4) time, 5) range of operation, 6) possible damages, including the accumulation of later results (Table 1). The table is certainly not exhaustive, but it provides a selection and ordering of extreme events, indicating by means of crosses their conditioning. A similar attempt has already been made by Limanówka (personal communication).

Points 5), 6) and 7) comprise economic and social problems occurring in several areas. First, the problem of damages: legal arrangements, sources of financing, level of compensation. Objective estimation of material damages alone is a difficult task. Besides, administrative parlance has the notions of a natural disaster and an ecological catastrophe. The occurrence of any of the events in question is typically connected with inestimable losses, entailed by the often numerous casualties. Including an extreme event in any of these categories is conditioned by various factors, since it entails decisions of serious financial and political consequences.

Second, the problem of expenditures for measures protecting from the consequences of extreme events. Such expenditures are generally greater e.g., in the case of hydrotechnical constructions than in the case of setting up systems of meteorological protection. However, one kind of such initiative will not replace another. On the one hand, one should bear in mind that hydrological catastrophes (occurring not through man's own fault) have their beginning in meteorological processes, not necessarily extreme ones, but growing gradually. It is undoubtedly an argument for developing a system of monitoring such processes, which should result in their sufficiently early prediction. On the other hand, prediction alone, however correct, will not prevent damages if proper ground infrastructure is lacking. This requires comprehensive scientific analysis and economic calculation. This is not easy, because only that which is repeatable often enough is predictable [3]. Meanwhile, it is well known that extreme events occur extremely irregularly - every few, several, several tens, several hundred years. It is this fact which permits one to claim that they occur at random, although they must be governed by particular physical causes and not by blind chaos or the magic of places or dates. If, for example, in Montreal, in two consecutive years of 1986 and 1987, on the same day of May 29, there occurred heavy hailstorms causing losses of the order of tens of millions of dollars [8], we are entitled to think that the events were brought about by particular physical states of the atmosphere and climatic conditions, and not a fatal *genius loci* or *genius temporis*.

At present it is only occasionally that the possibility of the occurrence of dangerous

Table 1. Classification of more important meteorological elements and extreme events

Meteorological elements and extreme events	Environment	Genesis	Dimension	Time					Area		Damage					
				Minutes Hours	Day and night	Month	Season	Year Many years	Local	Region	Estimated measurable	Unmeasurable	Potential deaths	Cumulation of results	Natural calamity	Ecological disasters
sunshine duration	Atmospherical	synoptic situation	number of hours number of days			x	x	x	x	x						
cloudiness		- „ -	number of days frequency			x	x	x	x	x	x	x				
atmospheric pressure		- „ -	hPa, number of days, frequency	x	x	x	x		x	x						
sultriness		- „ -	vapour pressure number of days		x	x	x	x	x	x		x		x		
high temperat. low temperat.		- „ -	number of days ^{0}C, frequency		x	x	x	x	x	x	x	x	x	x		
ground frost		- „ -	number of days ^{0}C, dates	x	x	x	x	x	x	x	x					
storm		- „ -	v of wind, rainfall number of days	x	x	x	x	x	x	x	x	x	x			
fog		- „ -	visibility, number of days	x	x	x	x	x	x	x	x	x	x			
wind : hurricane		- „ -	m/s, gust of wind, number of days,	x	x	x	x	x	x	x	x	x	x			
tornado			m/s, n. of chance	x	x	x	x	x	x	x	x	x	x			
whirlwind			- „ - - „ -				x	x	x		x	x	x			
tropic. cyclone			m/s, n. of chance	x	x	x	x	x	x	x	x	x	x	x	x	
monsoon			rainfall, term		x	x	x	x		x	x	x	x	x	x	
atmospheric drought		- „ -	course of days			x	x	x	x	x	x			x	x	x
precipitation: glaze		- „ -	mm, l/m^2, intensity ?	x	x	x	x	x	x	x	x	x	x			
Hail			weight, diameter	x	x	x	x	x	x		x	x	x			
Snow			thickness, aqueous	x	x	x	x	x	x	x				x		
Rainfall			mm, efficiency	x	x	x	x	x	x	x	x	x		x	x	
Acid rainfall			pH, mm	x	x	x	x	x	x	x	x	x		x		x
smog		anthropogenical	concentration of pollutions, visibility	x	x	x	x	x	x			x	x			
ozone (high)		- „ -	concentration (D)			x	x	x		x		x		x		
carbon dioxide		- „ -	concentrat. (ppm)					x		x				x	x	
atomic explos.		- „ -	concentration (Bq) doze	x	x	x	x		x	x	x	x	x	x		x
hydrological drought	Hydrological	synoptic situation	quantity of water, course of days			x	x	x		x	x			x	x	x
spring flood		- „ -	flow of water, height of wave	x	x	x	x	x	x	x	x	x	x	x	x	
summer flood		- „ -	- „ -	x	x	x	x	x	x	x	x	x	x	x	x	
winter flood		- „ -	- „ -	x	x	x	x	x	x	x	x	x	x	x	x	
crack of dike		anthropogenical	quantity of water, flow of water	x	x				x	x	x	x	x			
El Nino	Oceanograph.	synoptic situation	thickness of layer, warm water, term		x	x	x	x		x	x	x		x		
tsunami		eruption of a volcano,	height of wave	x	x				x		x	x	x			
		earthquake														
snow avalanche	Lithospherical	cumulation of snow	mass of snow, number of events	x	x	x	x	x	x	x	x	x	x			
landslip of mass soil		synoptic situation, rainfall	mass and genera of earth	x	x				x		x	x	x			
eruption of a volcano		?	quantity of dust and gas	x	x	x	x	x	x		x	x	x	x	x	
earthquake		?	according to a scale	x	x				x	x	x	x	x	x	x	
locust and other biolog. and ecolog. events	Biological	?	according to a harms	x	x	x	x	x	x	x						x

events, growing with time in a given place, can be predicted early enough. A correct prognosis depends on our current familiarity with and the possibility of following live the state of the physical processes generating those events. The general causes of the occurrence of atmospheric, hydrospheric and climatic extreme events usually lie in the macro- and meso-scale synoptic-climatic conditioning (see Table 1). Of the 34 events compiled in the table, as many as 22 cases (i.e., 65%) are connected with a synoptic situation. However, general synoptic conditions do not sufficiently differentiate the state of meteorological elements [9]. This fact, as well as the excessively discreet way of carrying out observations, are the reasons why we are usually unable to control the growth of dangerous events precisely enough. For many years it has been known that the influence of certain, so-called initial, states of the atmosphere on its later states persists only briefly, often no more than a few tens of hours. Therefore predicting the direction of their development quickly becomes impossible [4]. That is why a constant and detailed control of them would be necessary within the system of monitoring weather types in regional weather bureaux, at least in some sore regions and seasons. It might then be possible to capture the traits of the peculiar 'memory of the atmosphere', as well as specify the time of the development (accumulation) of the processes resulting in effect in an extreme event. The aim of such activities and the bearing of the necessary expenditures is so obvious, particularly after the 1997 flood, that it requires no special rationale.

Finally, it is worth mentioning another aspect of extreme events, or rather extreme values: the cognitive-climatological aspect. Some climatologists claim that the extreme values of meteorological elements are more sensitive to climatic changes than their average values [5,6]. If that is the case, then the possible increase in the occurrence of extreme events may be interpreted as a reaction to the advancing climatic changes. However, opinion with regard to this are divided and the issue is not so obvious for, as Górski [2] points out, the occurrence of extreme events '... does not testify ... to climatic change. The analysis of their occurrence points to the fact that they are the result of natural weather changeablity, predicted by the statistic distribution of a constant mean and variation.' Similarly, e.g., according to the research presented in 'Climate of Europe' [1], in Europe alone one finds great regional differences in the observed tendencies of climatic change. These differences are probably still contained within the range of natural fluctuations, observed during the period of instrumental research (and perhaps during the period of earlier historical data). In order to solve this issue, one should undertake proper research and determine which meteorological elements, and/or which extreme events are the likely indicators of climatic change, for if they are, it is probably not all of them. This postulate contains in itself another one: the need to keep evidence of extreme events and to examine their changeability with statistic methods, regardless of whether and when this might find application in their forecasting.

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