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Development of classification of maximum wind speeds in Poland with a description of their effects

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SUMMARY:
Wind storms such as synoptic, thunderstorms, downslope winds in Tatra and Karkonosze mountain regions, tornadoes, downbursts, and derechos are leading causes of economic loss in Poland. The recent classification of maximum wind speed in Poland was developed by Lorenc [1] in 2012. For the gust wind speeds in the range from 11 to 32 m/s at 10 m above ground, five names were proposed as follows: wind violent, storm, strong wind, strong and hurricane wind. It is not used in everyday life, and the author of this paper is in opposition to this proposal (for example, we do not have tropical storms in Poland, i.e. no hurricanes). The author's study of maximum wind speeds in Poland is based on: a set of annual maximum gust wind speeds measured at 39 meteorological stations from 1971 to 2005 (35 years), collected tornadoes reports for the years 1899- 2019 (120 years), and estimation of wind speeds of the extreme winds as a derechos, and recent tornadoes in Poland [2,3,4,5]. The author's proposals are given in Tables 3 and 4.
Poland in the near future is going to construct some important structures, such as a Central Air Terminal, and some nuclear power plants, so knowledge about strong and extreme winds in our country is very important for engineers who will design these types of structures.

Keywords: strong and extreme winds, wind speed, classification, EF tornado scale, P scale

1. EXISTING CLASSIFICATIONS OF WIND SPEEDS IN POLAND

Two classifications of weak and strong winds exist in Poland. The first is done by the Institute of Meteorology and Water Management (only for weak and strong winds, but not for extreme winds like tornadoes or derechos) [2]. This classification is given in Table 1. The second was proposed by Lorenc [1] who was a co-worker at the Institute of Meteorology and Water Management (IMWM). Lorenc's classification is given in Table 2.

Table 1. Classification of the levels of threats caused by strong wind [IMWM]

Degree threats	Wind speed criteria [m/s]	Description of the effects of wind action
1	Vav > 15 or V> 20	Damage to buildings, roofs, damage to trees, breaking branches and trees, traffic difficulties.
2	Vav > 20 or V> 25	Damage to buildings, roofs, breaking and uprooting trees, difficulties in communication, damage to overhead lines.
3	Vav > 25 or V> 35	Destroying buildings, tearing off roofs, destroying overhead lines, large damage to trees, significant difficulties in communication, life threatening..

Vav – mean wind speed, V- gust wind speed

The description of the effects of wind action in Table 1 is very poor and the author has improved it on the basis of real observation from five years. It is given in Table 3.

Table 2. Lorenc's classification of the wind speed in Poland

Class no	Wind speed at 10 m above sea level		Name of wind	Damage description
	(m/s)	(km/h)		
I	≥ 11-16	40-59	Gusty wind	The wind is chaotic in flow, it moves large tree branches and whole trees in gusts, it is difficult to use an umbrella and walk against the wind, during snowfall it causes blizzards. The risk of organizing outdoor sports events and skiing competitions in winter (e.g. ski jumping).
II	≥ 17-20	60-73	Violent wind	The wind breaks tree branches, damages awnings and breaks tents, knocks over wooden fences, billboards and road signs, raises clouds of dust, walking against the wind is very difficult, breaks off single roof tiles, hinders the work of cranes and poses a threat their operators, wind speed is felt by passing car.
III	≥ 21-24	74-86	Storm	The wind causes serious damage to buildings - breaks roof tiles, lifts lighter objects in the air, violates unsecured building structures, breaks large tree branches.
IV	≥ 25-28	87-103	Strong wind	The wind causes significant damage to buildings, towers and chimneys, breaks and uproots shallow-rooted trees, impedes the movement of passenger cars, swings transmission lines with a large deflection, and when planting or black ice is deposited, it tears them off due to overload.
V	≥ 29-32	104-117	Hurricane wind	The wind causes damage to entire buildings and halls with flat roofs, breaks sections of transmission lines and breaks their supporting structures, makes it difficult for trucks to drive, uproots trees and destroys larger tracts of forests - windbreaks in the mountains.
VI-1	≥ 33-49	≥ 118-178	Hurricane/to -rnado 1 st degree	The wind tears off the entire roof sheathing, overturns or moves mobile houses (trailers), uproots large trees or breaks them in larger areas, breaks transmission lines and railway traction, destroys strong building structures, "blows" cars from the road, knocks over lighter construction cranes, levitates destroyed objects (roofs, doors, windows, household appliances turn into flying projectiles).
VI-2	≥50-69	≥179-250	Very strong hurricane/tor -nado 2 nd degree	The wind causes general destruction and havoc. Uproots large and healthy trees, rips off the roofs of houses and transports them at a distance, collapses buildings with reinforced structures, damage bridge structures. Destroys entire tracts of forests and orchards, levitates cars and other objects that change into flying debris.
VI-3	≥ 70	≥ 251	Destructive hurricane/tor -nado 3 rd degree	Wind causes unimaginable damage. Rips off roofs and collapses buildings with a reinforced structure, bends steel structures. Overturns train and trucks, carries passengers cars. Uproots and breaks trees on entire tracts of forests. Levitating heavy objects. Requires the evacuation of the population.

2. WIND SPEED MEASURED AND ESTIMATED IN POLAND

2.1. Yearly maximum wind speeds measured at the meteorological stations

Wind speed records in gusts (measured in the years 1971-2005, were in the range of 25 – 40 m/s,

extreme values were also recorded: 6.11.1986 Bielsko Biała 48 m/s, 1.12.1975 Zakopane 47 m/s, 21.10 1986 Kalisz 46 m/s, 8.02.1990, Łeba 44 m/s, 4.12. 1999 Hel 41 m/s. All these data are given in the monograph [1].

2.2. Estimated wind speeds of tornadoes and derechoes

The estimated extreme wind speeds of tornadoes and derechoes were based on recent papers on these phenomena which happened in Poland in the past and recently [3,4,5].

3. DEVELOPMENT OF CLASSIFICATION OF MAXIMUM WIND SPEEDS IN POLAND

Recognizing the limitations of existing classifications of maximum wind speeds, the author based on the past and recent papers [3,4,5] and EF- Scale for tornado Intensity [6], the author proposes a new classification for strong and extreme winds which may happen in the future in Poland. It is divided into two categories of winds, i.e. strong and extreme winds. The concept of the author's classification is based on a separation of strong wind speeds from extreme wind speeds presented in Tables 3 and 4. The description of the effects of strong wind action given in Table 3 is based on the author's observation during the last five years.

Table 3. Classification of the levels of threats caused by strong wind [IMWM + Author]

Degree threats	Wind speed criteria [m/s]	Description of the effects of wind action
1	Vav > 15 or V> 20	It moves tree branches, billboards and road signs. Some of them can be knocked over. Breaks weaker tree branches that can block communication routes. It tears off individual roof tiles, scatters garden furniture, damages local power lines, tents and awnings. Wind speed is felt by vehicle drivers. Light objects float in the air. During snowfall the wind causes blizzards.
2	Vav > 20 or V> 25	It breaks tree limbs, breaks or tears up shallow-rooted trees, broken branches and trees block roads, tram and railway lines. It is possible that tree branches fall on vehicles. Broken power cables (tens of thousands of people are deprived of electricity), Wind significantly damages roofing, damages old farm and residential buildings. During gusts of wind, cars are pushed to the side of the road. It overturns billboards, road signs and fences, individual items are floating in the air, after an intense storm, cellars and apartments are flooded.
3	Vav > 25 or V≤ 30	Such synoptic wind velocities rarely occur in Poland - once every few years, their effects are similar to those described in the case of hazard level 2, but in larger dimensions, e.g., there are significantly damaged or completely broken roofs, damaged farm buildings and residential buildings, broken power poles and cables, roofs with reinforced concrete and steel structures are damaged. The described nature of the damage is typical of weaker tornadoes and squalls.

V_{av} – mean wind speed, V- gust wind speed

The second issue in Poland is the scale of extreme winds, i.e. tornados, derechoes, etc. Because tornadoes in our country occur on average several times a year, and we do not have statistics on derechoes, and the observations of damage and destruction have not been systematically and reliably described, so we do not have statistical material for the development of the intensity scale of tornadoes, derechoes and all extreme winds in Poland. In such a case, it makes sense to adopt one tornado intensity scale that is used internationally. Here you can consider the Improved Fujita Scale, denoted as EF, or the TORRO scale. As the EF scale is relatively new (2007), improved in several respects in relation to the F scale, e.g. the variety of structures, workmanship quality, type

of materials used, and the introduction of 28 Damage Indicators the author proposes to use the EF Scale with some modifications of wind speed for individual grades, marked with the symbol P (from the name of our country). The proposed extreme wind speed depending on the P scale degree is presented in Table 4. The description of the effects of the winds of the P1 to P5 scale is equal to the EF1 to EF5 scale.

Table 4. Classification of extreme wind speeds

EF0	EF1	EF2	EF3	EF4	EF5	Wind speed
105-137	138-178	179-218	219-266	267-322	>322	km/h
29.2-38.1	38.6-49.4	49.7-60.6	60.8-73.9	74.2-89.4	>89.4	m/s
P0	**P1**	**P2**	**P3**	**P4**	**P5**	
108 - 120	**121-170**	**171-220**	**221-270**	**271-324**	**>324**	**km/h**
30,0 - 33.3	**33.6-47.2**	**47.5-61.1**	**61.4-75**	**75-90**	**>90**	**m/s**

4. CONCLUSIONS

a) The proposed wind speed classification is developed using data that are available in Poland. It provides wind speeds for strong winds and extreme winds such as tornadoes, derechoes, etc.
b) The author proposes: for synoptic, downslope winds in Tatra and Karkonosze mountain regions, the classification of strong winds proposed by IMWM with an improved description of the effects of wind action – Table 3, and adaptation of the EF tornado intensity scale with some modifications to extreme winds presented in Table 4 - described as the scale P.

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