



## A BOW-ECHO AND SEVERE WEATHER OBSERVED OVER POLAND ON 11<sup>TH</sup> AND 12<sup>TH</sup> AUGUST, 2017

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### ABSTRACT

The paper presents results of research based on analysis of weather conditions during the storm front on 11<sup>th</sup> and 12<sup>th</sup> August, 2017, which has been relocated through a significant area of Poland. The front with an unprecedented force struck the infrastructure of the Academic Training Centre in the village of Czernica (ATC Czernica) on 11<sup>th</sup> August, 2017 about 23:05 CET. Due to wind impact of near-hurricane force, significant damage in the facility's infrastructure and the biggest losses are incurred in forest resources. The data from the front passage through Gdynia was observed on a mobile meteorological station located at the Naval Academy in Gdynia. Describing the phenomenon and displaying the losses caused is one of the historical goals set before the article, because such a rapid weather phenomenon has not been recorded in the more than 50-years history of the Center in Czernica.

Key words:

storm front, violent weather phenomenon, bow-echo front.

### Research article

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## INTRODUCTION

Violent hydrometeorological phenomena such as: hurricane winds, tornadoes, cyclones, cloudbursts, and on the other hand, melting glaciers, steadily associated with lack of water and catastrophic droughts — accompany the changing climate conditions associated with global warming. Observed number and intensity of these phenomena is evidence of climatic changes that we see in the last years of the last century and currently.



Phot. 1. Damage of the tree stand in the ATC Czernica [photo C. Dyrzcz]

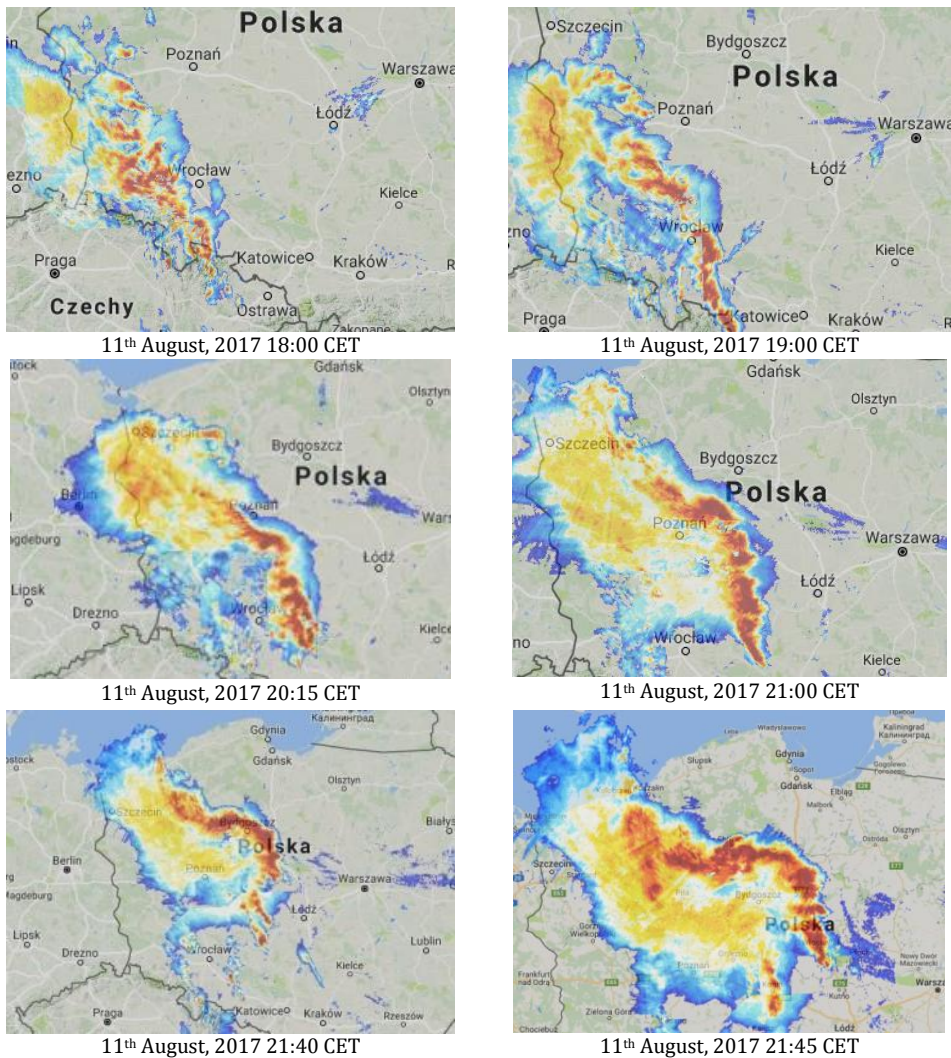
An example of the above may be the last storm front, which occurred on 11<sup>th</sup> and 12<sup>th</sup> August, 2017 in a large area of Poland. The front moved with unprecedented power through the area of the ATC Czernica on 11<sup>th</sup> August, 2017, around 23:05 CET. As a result of the impact of the wind with a force similar to a hurricane, considerable damage was caused to the infrastructure of the Center, and the largest losses were incurred in the forest stock. Dozens of trees have been fallen down and destroyed, which blocked the roads and passages in the Center (phot. 1).

## DATA AND METHODS

The aim of the article is to present the results of the analysis of available data of the storm front movements through the area of Poland on 11<sup>th</sup> and 12<sup>th</sup> August, 2017 with an indication of the actual damage at the Academic Training Center in Czernica.

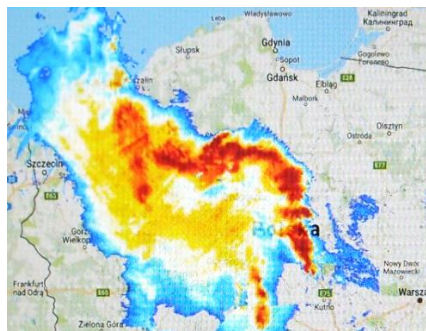
Following methods were used to achieve the above objectives such analysis and inference. Implementation of the research was based on the historical material gathered by research institutes, in publications and own observation in the ATC Czernica and the METOC laboratory. Photographs of the destruction at the ATC Czernica were made by the author, because he was in the center at that time. The primary sources of the data are from the Polish Institute of Meteorology and Water Management and from the mobile weather station situated on the main square in the Polish Naval Academy in Gdynia.

Location of the rain zone on 11<sup>th</sup> August, 2017 from 18:00 CET to 23:50 CET are presented in fig. 1. The storm front accompanied with heavy rain is shown in color red and its shape is changing during the time.

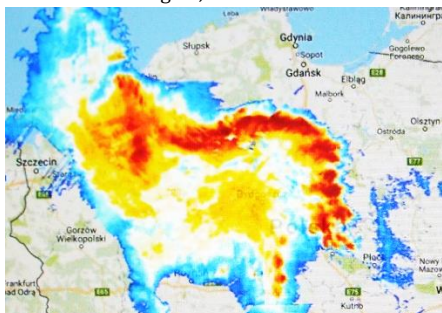




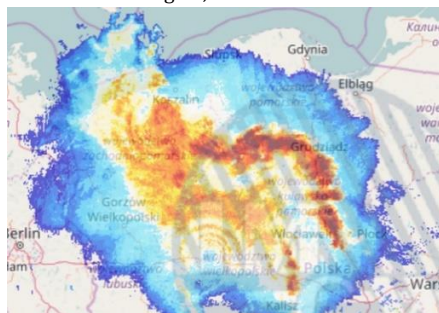
11<sup>th</sup> August, 2017 22:00 CET



11<sup>th</sup> August, 2017 22:30 CET



11<sup>th</sup> August, 2017 22:50 CET



11<sup>th</sup> August, 2017 23:00 CET



11<sup>th</sup> August, 2017 23:05 CET



11<sup>th</sup> August, 2017 23:10 CET



11<sup>th</sup> August, 2017 23:15 CET



11<sup>th</sup> August, 2017 23:20 CET

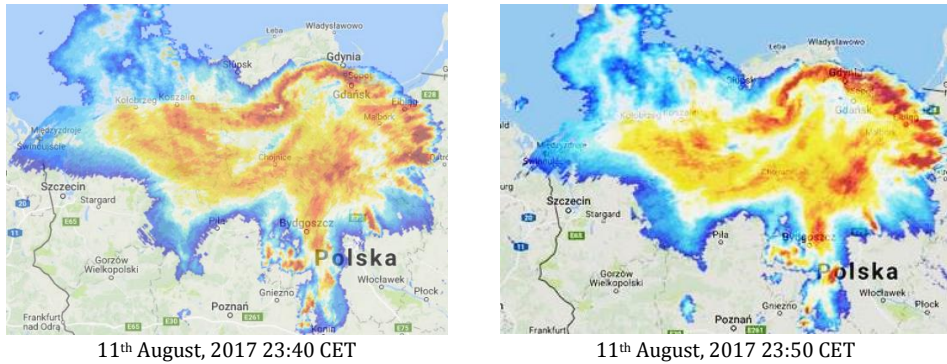


Fig. 1. Location of the rain zone on 11<sup>th</sup> August, 2017 [based on the data from the Polish Institute of Meteorology and Water Management]

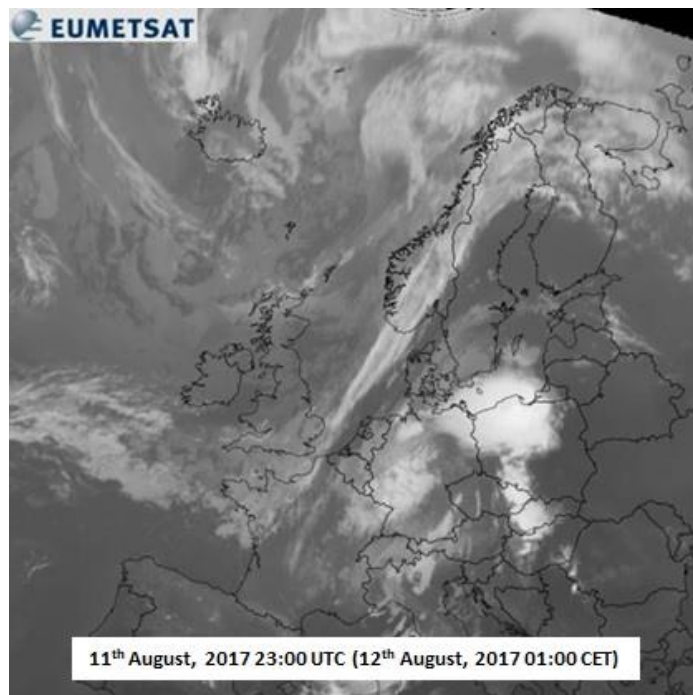


Fig. 2. Satellite image from 11<sup>th</sup> August, 2017 23:00 UTC [based on the data of the EUMETSAT]

Satellite image from 11<sup>th</sup> August, 2017 at 23:00 UTC (01:00 CET) is shown in fig. 2. The white color white is presented clouds, which over the north part of Poland are most dense.

The cause of such dangerous weather phenomena was the passage of the cold front on 11<sup>th</sup> August, 2017 at approx. 23:00 LT through the area of ATC Czernica.

The front had a large spread and moved from south-west to north-east. The location of the front was depicted on the following map (surface analysis) of the German Meteorological Service (Deutscher Wetterdienst) from 00:00 UTC on 12<sup>th</sup> August, 2017. A fragment of the map with a marked front is depicted in fig. 3.

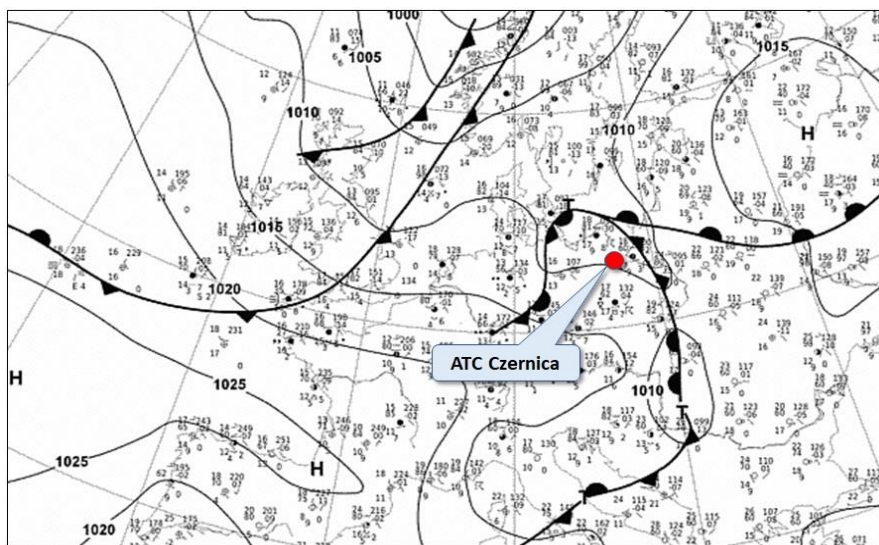


Fig. 3. Surface analysis from 00:00 UTC (02:00 LT) on 12<sup>th</sup> August, 2017 about 3 hours after passing the storm front by ATC Czernica [fragment of Deutscher Wetterdienst map from 00:00 UTC on 12<sup>th</sup> August, 2017]

## CONDITIONS

In the initial stage of development, the front occurred in a linear form, which took place in Lower Silesia in the afternoon hours, however, the intensity of storm phenomena was rapidly increasing. Moving to the north-east on Kujawy, the shape of the front has evidently changed and adopted the form of the bow-echo. After that form the storm front changed the shape to the *comma-echo* (from 23:15 LT on 11<sup>th</sup> August, 2017). Such a front arrangement can generate very strong winds of unprecedented destructive power. The front systems taking the form of bow-echo were observed in Poland in modern times and caused huge destructions and an example of this destructive phenomenon is the storm of 11<sup>th</sup> August, 2017. At 22:30 LT, just before the front reached of ATC Czernica in the image presented of meteorological radars the shaped form of the front in the form of a bow-echo (color blue), depicted in the fig. 4.

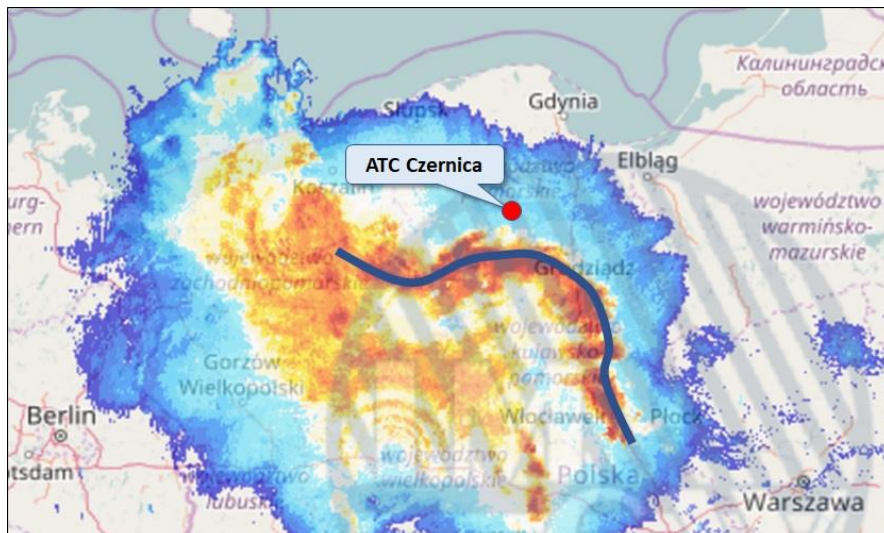


Fig. 4. Storm front shaped in the form bow-echo (color blue) on 11<sup>th</sup> August, 2017 at 22:30 LT in the position before reaching ATC Czernica

During the storm, squall winds exceed the speed of 100 km/h, which is accompanied by heavy rain and hail. A characteristic feature of the squall is its directional variability, the value of which sometimes reaches over 100°. Observed at several nearby ATC Czernica meteorological stations, the values of the maximum wind speed and wind direction are presented in tab. 1.

Tab. 1. The maximum wind speed and direction on the meteorological station in vicinity of the Academic Training Centre in Czernica [data from the Polish Institute of Meteorology and Water Management, the Monitor System]

Weather station	Time of observation CET	Maximum wind speed [m/s]	Wind direction
GRUDZIĄDZ	22:30	28.6	225°
CHOJNICE	22:50	31.2	217°
STAROGARD GDAŃSKI	23:10	21.7	213°
KOŚCIERZYNA	23:20	21.8	183°

At 22:50 the Weather Station in Chojnice reported most-wind a greater value of 31.2 m/s (112.3 km/h), which on the Beaufort scale of 11°B. At the remaining nearby ATC Czernica stations, the values were slightly smaller.

In ATC Czernica, judging by the damage done by the wind, its value can be estimated to exceed the data measured in Chojnice and amounting to over 120 km/h,

since the losses, especially the tree stand, are very large. It is fully probable that the storm that went through ATC Czernica was one of the strongest in the history of the center and brought the greatest material losses. All persons in the center did not suffer any injuries, however, it was not without material damage, which did not affect the safety of people staying in the center and its staff.



Phot. 2. Damage of tree stand and an infrastructure of ATC Czernica [photo C. Dyrzcz]

In fig. 5 are shown hydrometeorological data recorded at the meteorological station of the METOC Laboratory of the Polish Navy Academy in Gdynia (the station is located on a square in the area covered with academic buildings) illustrate rapid changes in meteorological elements during the passage of the front by the station position at 23:40 LT on 11<sup>th</sup> August, 2017. Colors in the graph mean: light green — humidity [%], blue — temperature [°C], red — pressure [hPa], yellow — wind speed [m/s] and dark green — intensity of rainfall [mm] / h]. All the observed meteorological elements were visible changed.



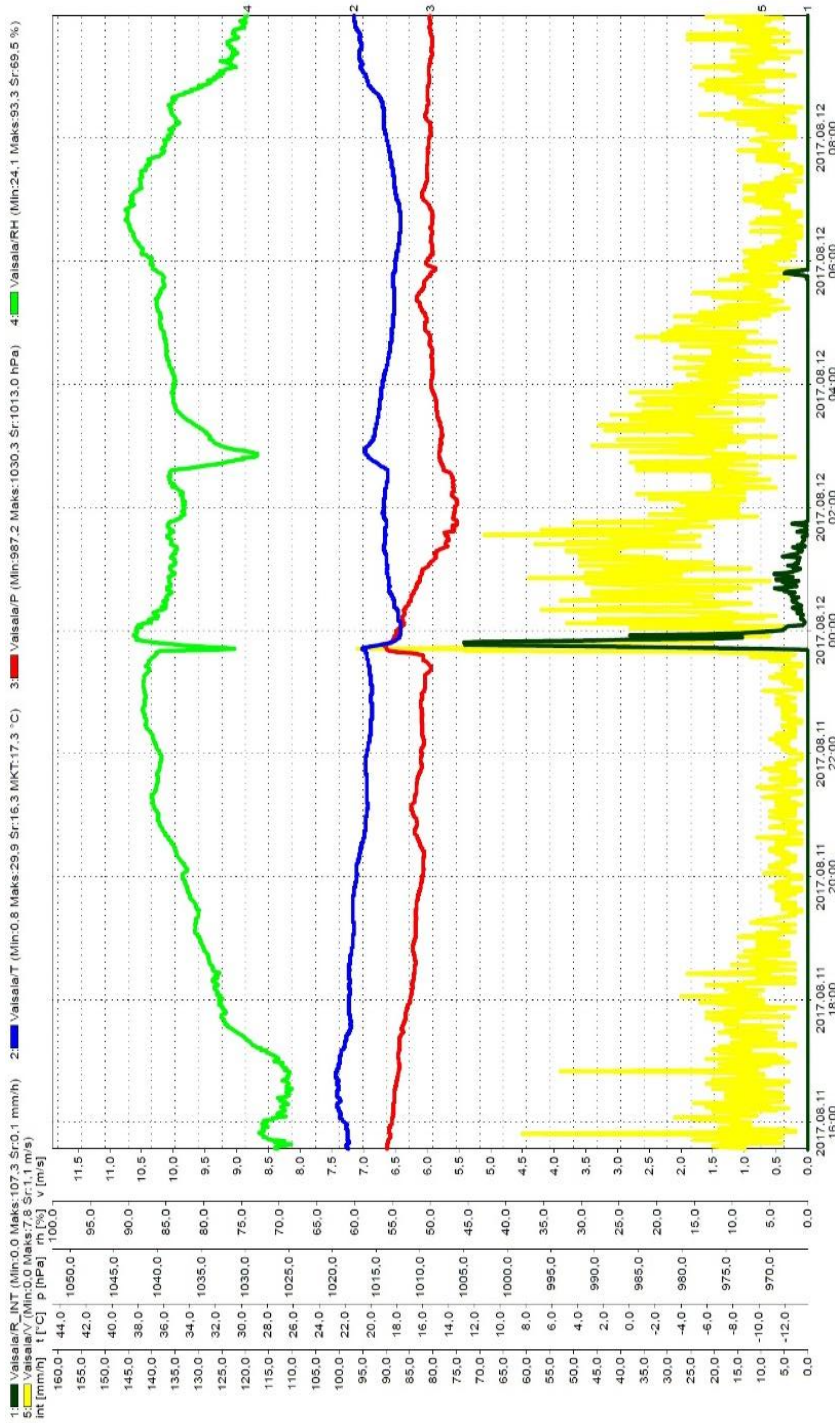


Fig. 5. Data from the meteorological station of the Naval Academy observed during the approaching, the passage and after the storm front

## DISCUSSION AND CONCLUSIONS

Fujita Theodore in *Manual of downburst identification for Project NIMROD* written, that life cycle of a bow echo can be described as a gradual transition from a large, strong, and tall echo to a bow which often turns into a comma-shaped echo [3]. A typical morphology of radar echoes associated with strong and extensive downbursts is presented in fig. 6.

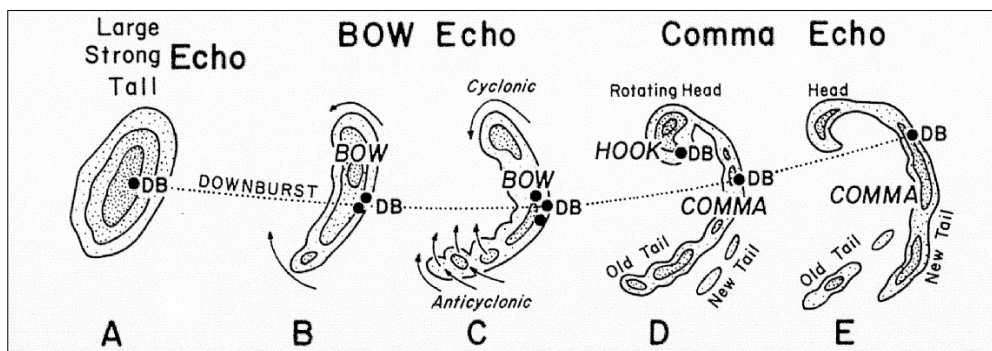


Fig. 6. A typical morphology of radar echoes associated with strong and extensive downbursts (DB) [1]

Although initial downbursts (DB) begin inside a large, strong, and tall echo (A), the downburst intensifies as a distinct bow-echo develops (B). When the maximum downburst intensity is reached (C), the bulge of the bow becomes so eminent that the echo appears somewhat like a broken bow or spearhead. A bow-echo with a rotating head displays the impressive shape of a comma (D). The head, by virtue of its rotation, often induces a hook accompanied by weak downbursts. Usually a comma echo appears during the weakening stage of downbursts (E). The tail of comma extends over a long distance while swinging cyclonically like a hurricane rainband. The end of the comma tail cannot always catch up with the first swing. Thus, a new tail forms on the advancing side of the old one. Eventually, the old tail is left behind, being overshadowed by the new tail [3]. The similarity of the forms presented above is very close to the situation that took place over Poland on 11<sup>th</sup> August, 2017 (fig. 7).

In fig. 7 is presented the movement of the storm front and its formation (echo, bow-echo and comma-echo stages) from 14:00 LT on 11<sup>th</sup> August, 2017 to 00:00 LT on 12<sup>th</sup> August, 2017 and the largest destruction of forest stand (the blue area). Analysis of the location of the storm front in particular periods is based on meteorological radar images depicted in fig. 1.

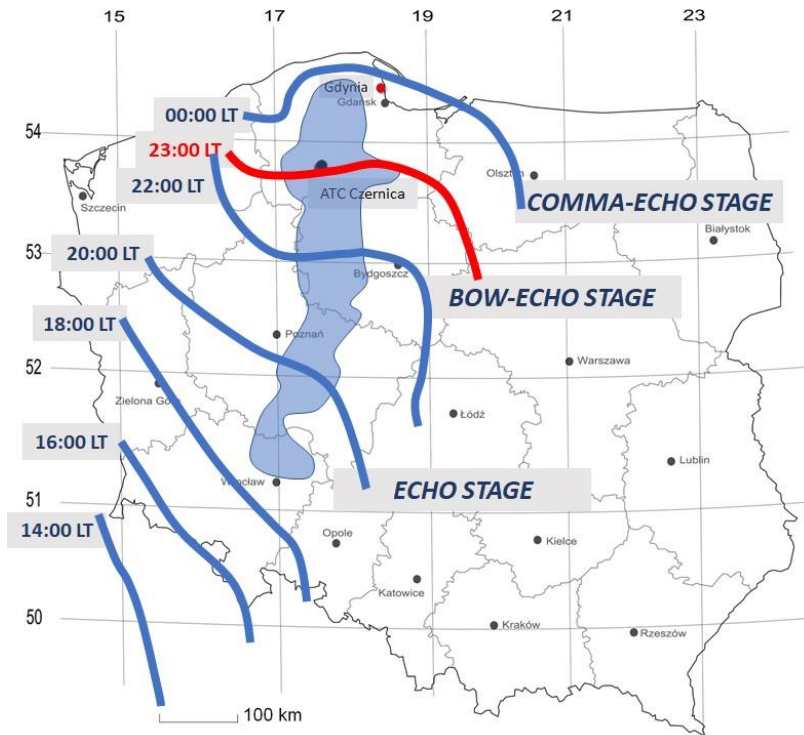


Fig. 7. Movement of the storm front in the time from 14:00 LT on 11<sup>th</sup> August, 2017 to 00:00 LT on 12<sup>th</sup> August, 2017 and the largest destruction of forest stand (the blue area)

In the conclusion of the analysis was made of the following generalizations:

1. The greatest damage occurred in the bow-echo stage of the storm front, which passed through Poland on 11<sup>th</sup> August, 2017 and apparently experienced the vicinity of ATC Czernica.
2. The occurrence of this type of violent meteorological phenomena, dangerous to people, carrying large losses and material damage resulting from climate change can be expected more often also on the territory of Poland.
3. The application for future activities is important in forecasting these phenomena and proper warnings and preparation to avoid the destructive effects of violent weather phenomena.

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## **ZJAWISKO BOW-ECHO I GWAŁTOWNA POGODA OBSERWOWANA NAD POLSKĄ 11 I 12 SIERPNIĄ 2017 ROKU**

### **STRESZCZENIE**

W artykule przedstawiono wyniki badań w oparciu o analizę warunków pogodowych podczas frontu burzowego w dniach 11 i 12 sierpnia 2017 roku, który przemieścił się przez znaczny obszar Polski. Front z niespotykaną siłą uderzył w infrastrukturę Akademickiego Ośrodka Szkoleniowego w miejscowości Czernica (AOS Czernica) 11 sierpnia 2017 roku o godzinie 23.05 czasu środkowoeuropejskiego (CET). W związku z uderzeniem wiatru o siłę zbliżonej do huraganu zostały wyrządzone znaczne szkody w infrastrukturze ośrodka, a największe straty poniesiono w zasobach drzewostanu. Dane meteorologiczne przejścia frontu burzowego przez Gdynię zarejestrowano na mobilnej stacji meteorologicznej znajdującej się w Akademii Marynarki Wojennej w Gdyni. Analiza zjawiska i zobrazowanie strat spowodowanych przez front jest jednym z historycznych celów stawianych przed artykułem, ponieważ tak gwałtowne zjawisko pogodowe nie zostało zarejestrowane w dotychczasowej ponad pięćdziesięcioletniej historii ośrodka w Czernicy.

#### Słowa kluczowe:

front burzowy, gwałtowne zjawisko pogodowe, front burzowy w kształcie łuku.

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