# DETERMINATION OF MAXIMUM GUST IN CONVECTION STORMS 

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#### Abstract

Determination of maximum gust in convection storms. Many times when storm damage occurs mainly in summer in buildings, trees or other objects, people automatically say it was a tornado! Although it is difficult for many to understand that currents descendants wind from can cause the large damage and occur frequently in the summer months. Storm winds from can exceed $110 \mathrm{~km} / \mathrm{h}$. Although most wind speeds out of the storms from 54 to $90 \mathrm{~km} / \mathrm{h}$, occasionally they may exceed $110 \mathrm{~km} / \mathrm{h}$. Storms which produce such wind gusts are, generally, identified later, so meteorology warnings are difficult issued. As a result of these causes were sought techniques by which we can quickly determine the degree of danger and to anticipate the evolution of cloudy formation which has the capacity to develop dangerous wind gusts. Convective wind speed was estimated using the relationship VIL - ET (vertically integrated liquid -echo Top) from data from weather radar WSR-98D from the Bobohalma, as exemplified in a few extreme situations.


Keywords: VIL, ET, convective wind, gusts, storm nucleus

## 1. INTRODUCTION

Convective winds intense are dangerous events that can cause property damage and human victims.

To determine whether a storm has the potential to produce dangerous gusts, meteorologists have used a technique developed by Dr. Stacy Stewart of the National Weather Service (NWS) (Stewart, 1991) and subsequently amended of meteorologists of the Air Force's Air Weather Service (AWS), (AWS, 1996). This technique uses the maximum height of the storm cloud (Echo top-ET) and Vertically Integrated Liquid -VIL, measured and calculated values of radar WSR98D, to determine the potential to produce wind gusts at the exit of storm.

It should be noted that this technique ET-VII is designed to estimate the potential the maximum speed and not occurrence its.

Mackey 1998 in his dissertation aims to develop a technique to predict downdurst using aerological data and the products offered to radar WSR-88D. Sullivan in 1999 evaluate the maximum wind speed using the formula out of dowbrust AWS.

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## 2. DATA AND METHODS

Convective winds are associated with increased convective cumulus clouds and thunderstorms developing. If a cumulus cloud develops in to a mature storm, upward currents carrying moist and warm air is defeated by the downward current created by rain drops and ice. If this current of cold air is brought to a level that is colder than the environment, may fall to the ground. Figure 1. At ground level this downward current is surface wind. This wind is known as the first gust. Figure 2. Speeds of 15 or $25 \mathrm{~m} / \mathrm{s}$ are frequent for these gusts. High speeds and surface roughness contact can cause very strong winds. They are all the stronger the more the air mass is warmer. Although convective winds occur suddenly and violently, are of short duration.

Winds descendants are characteristic for mature storms, but for their occurrence is not necessary achieving stage of maturity.


Figure 1. Conceptual model of convective wind formation (Wakimoto 2001)


Figure 2. Convective wind coming from descendent current affects buildings
Estimation of wind speed out of a storm during its evolution, was the basis for many research, especially for the airports. Following these studies have reached
more results and different formulas for calculating the horizontal wind velocity derived from descendent current. Among these was used, for this analysis, Stewart's formula and improved by researchers at l'Air Force's Air Weather Service in 1996.

$$
\mathrm{W}=\left[(\mathbf{1 5 , 7 8 0 6 0 8} \cdot \mathrm{VIL})-\left(\mathbf{2}, \mathbf{3 8 1 0 9 6 4 \cdot 1 0 ^ { - 6 } \cdot \text { ET } ^ { 2 } ) ] ^ { 1 / 2 } ( \text { AWS, 1996 } ) ~}\right.\right.
$$

where: VIL vertically integrated liquid $\left[\mathrm{kg} \cdot \mathrm{m}^{-2}\right]$, ET echo top [ km ].
When calculating the gusts velocity were used (the appropiate) values corresponding VII and ET, datas Doppler radar from WSR-98D from Târnăveni the near Bobohalma. It used the product 38 (CR- relectivitate composite) contain information parameters on storm: location, maximum relfectivity, height of clouds, the speed of the storm, content hail, VIL.

To highlight the utility of AWS formula were analyzed a few situations where were products damage due to gusts of wind.

## 3. CASE STUDIES

### 3.1. Case Nimigea 23 June 2007

„A powerful storm made havoc last night in the village of Nimigea (Bistriţa-Năsăud). Storm did not take more than a quarter of an hour, but in this time he ripped trees from the roots and destroyed over 100 houses roofs. Hundreds of people will spend the night in the dark, for the wind broke power lines and telephone cables. The worst was affected the village of Nimigea de Jos. An old oak over 300 years, declared a natural monument, was removed right from his roots and crashed over a house. (23 June 2007)"(http://www.ziare.ro)


Figure 3. Case Nimigea 23 June 2007 (RDBB)
According to classification Beaufort staircase damage to buildings occurs at $23-24 \mathrm{~m} / \mathrm{s}$. Of figure 3 . is noted that the estimated convective wind before proceeding over the village center was $24 \mathrm{~m} / \mathrm{s}$, over the village center decreases to
$23 \mathrm{~m} / \mathrm{s}$ and at the exit of town have speeds of $26 \mathrm{~m} / \mathrm{s}$. The value of reflection maximum is 71 dBZ at 15.13 UTC above the town.

### 3.2. Case Cluj-Napoca 3 August 2009

,, Roofs torn off and villages without current, after a storm in Cluj county. A strong storm snatched the roofs of two buildings in Cluj-Napoca, and interrupted the electricity supply in some areas of the county of Cluj. (3 August 2009)" (http://www.ziare.ro/) Figure 4.


Figure 4. Case Cluj-Napoca 3 August 2009 (RDBB)
In figure 4 is shown route storm that hit the city of Cluj-Napoca on August 3, 2009, route identified by Doppler radar from Bobohalma. The storm was identified 9.45 o'clock UTC. In Velocity field, estimated convective wind for area affected, has intensities of 18 to $20 \mathrm{~m} / \mathrm{s}$. Maximum estimated wind was $29 \mathrm{~m} / \mathrm{s}$ and the storm has had a lifetime, with intensities of over $18 \mathrm{~m} / \mathrm{s}$, of one hour and 25 minutes and has traveled over 70 km . On entering the city of Cluj-Napoca storm was already in reduction. The meteorological station of Cluj-Napoca the maximum gust was $21 \mathrm{~m} / \mathrm{s}$.

### 3.3. Case Cluj-Napoca 20 July 2011

The roofs of five buildings were damaged bythe storm that hit the county of Cluj at about 16.00 p.m. The houses were in the central area. The first of them was took the up in the area National Theatre, and the second on Maniu street. Other two roofs have fallen on Heroes Boulevard, being plucked by the wind, and two on Pitesti street and Dorobaţilor street. Terraces from Heroes street, dashed by storm at 16.00 p.m (20 July 2011)" (http://www.ziare.ro)

The event of 20 July 2011 was an extreme and rarely case. This is because the convective system that produced damage has formed south of the Feleac hill at 12.15 o'clock UTC (15.15 local time).

Although circulation was from the southern sector was assumed that massive hill of Felacului (approx. 700-800 m) will be form an orographic barrier for convective systems which will come in that direction and that they will avoid the hill. But Feleac Hill proved to be an aggravating factor because the area north of city Cluj-Napoca, because of diurnal warming was formed a bag of hot air. Of figure 5 is observed the jump which it makes cumulonimbus cloud over the Feleac and its rapid development.

Maximum reflexivitatii value of 71 dBZ was made exactly in the area with the greatest damage and estimated gust was $27 \mathrm{~m} / \mathrm{s}$ and occurred 12.52 o'clock UTC. Current descending and convective wind its associated was amplified by ,,the fall" cloud base after its passage over the hill Feleac. To meteorological station of Cluj-Napoca, found on Citadel Hill near the center of town at a height of about 120 m above maximum gust measured was only $17 \mathrm{~m} / \mathrm{s}$.

According to Beaufort scale damages produced in the center of ClujNapoca is within in the range 24 to $27 \mathrm{~m} / \mathrm{s}$, and the phenomenon has manifested itself over a period of about a half an hour and at one point there was even a gust by $29 \mathrm{~m} / \mathrm{s}$. The system had a lifetime of 2 hours and covered about 75 km


Figure 5. Case Cluj-Napoca 20 July 2011 (RDBB)

### 3.4. Case Cluj-Napoca 27 July 2011

This case was selected because supercelula passed near the meteorological station of Cluj-Napoca, the north of the city, an area by hill and orchards therefore a less populated area and recorded minor damage. Maximum gust measured at the weather station of Cluj-Napoca was $20 \mathrm{~m} / \mathrm{s}$ equal to that expected using the formula AWS. And in this situation one maximum gusts was done exact when the weather radar detected maximum reflectivity, for example 14.08 o'clock UTC of 63 dBZ value. Figure 6.


Figure 6. Case Cluj-Napoca 27 July 2011 (RDBB)

## 4. CONCLUSIONS

Is important to know the mechanism and potential which has a cumulonimbus cloud to develop dangerous winds and to be able send timely warnings. The cases analyzed have highlighted the usefulness of AWS formula.

Thus, AWS equation was used to construct Table 1, useful table in operative meteorology. It plays back the estimated value in $\mathrm{m} / \mathrm{s}$ the maximum wind gust what can produce in a storm

Table 1. AWS ET/VIL potential wind gust (m/s) table

|  | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 | 66 | 68 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 5. | 9 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 18 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 | 32 |
| 5.6 | 9 | 11 | 12 | 13 | 14 | 16 | 17 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 31 | 32 | 32 |
| 58 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 32 | 32 |
| 6 | 8 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| 6.2 | 8 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| 6.4 | 8 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 | 30 | 31 | 31 | 32 |
| 6.6 | 3 | 9 | 11 | 12 | 13 | 15 | 16 | 17 | 18 | 18 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 31 | 32 |
| 6 | 7 | 9 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 31 | 31 | 32 |
| 7 | 6 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 |
| 7 | 6 | 8 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 | 31 |
| 7.4 | 5 | 8 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 | 30 | 31 | 31 |
| 7.6 | 5 | 7 | 9 | 11 | 12 | 13 | 14 | 16 | 17 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 24 | 25 | 26 |  | 27 | 27 | 28 | 28 | 29 | 30 | 30 | 31 | 31 |
| 78 | 4 | 7 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 31 |
| 8 | 2 | 6 | 8 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | 30 | 30 | 1 |
| 8 | 0 | 5 | 8 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 | 30 | 31 |
| 8.4 | 0 | 5 | 7 | 9 | 11 | 12 | 13 | 15 | 16 | 17 | 17 | 18 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 |  | 26 | 27 | 27 | 28 | 28 | 29 | 30 | 30 | 31 |
| 8.6 | 0 | 4 | 7 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 | 30 |
| 8 | 0 | 2 | 6 | 8 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | 30 | 30 |
| 9 | 0 | 0 | 5 | 8 | 10 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 |  | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 | 30 |
| 9.2 | 0 | 0 | 4 | 7 | 9 | 11 | 12 | 13 | 14 | 16 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 28 | 29 | 30 |  |
| 9.4 | 0 | 0 | 3 | 6 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 | 30 |
|  | 0 | 0 | 1 | 6 | 8 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 19 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 | 30 |
| 9.8 | 0 | 0 | 0 | 5 | 7 | 9 | 11 | 12 | 13 | 15 | 16 | 17 | 18 | 18 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 |
| 10 | 0 | 0 | 0 | 4 | 7 | 9 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 | 29 |
| 10.2 | 0 | 0 | 0 | 2 | 6 | 8 | 10 | 11 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 | 29 |
| 10 A | 0 | 0 | 0 | 0 | 5 | 8 | 9 | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 18 | 19 | 20 | 21 | 22 | 22 | 23 | 24 | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 |
| 10.6 | 0 | 0 | 0 | 0 | 4 | 7 | 9 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 21 | 22 | 23 | 24 | 24 | 25 | 25 | 26 | 27 | 27 | 28 | 28 | 29 |
| 10.8 | 0 | 0 | 0 | 0 | 3 | 6 | 8 | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 20 | 21 | 22 | 23 | 23 | 24 | 25 | 25 | 26 | 26 | 27 | 28 | 28 | 29 |

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