# On the back of the clouds

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(Received 3 August 2013, accepted 26 February 2014)

**Abstract**

The duration of some natural phenomena is too long and their examination needs a special software with 'time laps' system and a camera with high resolution. The trail of the clouds, the apparent movement of the Moon, the Sun, the growth of the plants, the evaporation of the raindrops, the melting of the ice, etc. happen so slowly that instead of making a normal film from photos where 30 ones are taken in a second, it is more worth making films from photos taken in every minute or even hour because if they are played at a normal speed, the examined phenomena can be seen in an accelerated way. With such records analysis can be made more easily with different kinds of analyzing software.

**Keywords:** Classical Mechanics teaching.

**Resumen**

La duración de algunos fenómenos naturales es tan larga y su examinación necesita un software especial con un sistema de 'lapsos temporales' y una cámara de alta resolución. El sendero de nubes, el movimiento aparente de la Luna, el Sol, el crecimiento de las plantas, la evaporación de las gotas de lluvia, el derretimiento de hielo, etc. suceden tan lentamente que en lugar de hacer un filme normal de fotos en donde 30 de ellas son tomadas en un segundo, merece la pena hacer filmes de fotos tomadas en cada minute o incluso hora porque si son reproducidas a velocidad normal, el fenómeno examinado puede verse en una forma acelerada. Tal análisis de grabaciones se puede hacer más fácilmente con la ayuda de diferentes tipos de software de análisis.

**Palabras clave:** Enseñanza de la Mecánica Clásica.

**PACS:** 01.40.gb, 01.40.ek, 01.50.Pa **ISSN 1870-9095**

## I. INTRODUCTION

A cloud can be defined as a set of tiny waterdrops and icecrystals floating in the different heights of the atmosphere. Meteorology differentiates 10 main types of clouds. The following factors are taken into consideration: the height, the size, the form, the texture, the light intensity and the colour of the cloud. Its features are determined by the many physical processes, which are studied by the physics of environmental streams.

During the extracurricular lesson we decided to measure the speed of the clouds with the help of the webcam. As we did not know the width of the clouds we needed two data: the height of the cloud in the atmosphere and the α angle typical of the webcam.

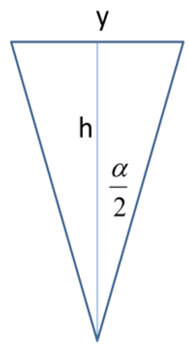
## II. CALCULATING THE ANGLE TYPICAL OF THE WEBCAM

The webcam similarly to the human eye is able to sense only part of the space around it. The width of the plane seen by the camera is determined by the so called viewing angle, which is a constant feature of the camera. In many cases it is indicated in the description of the camera. If this data information is not available for us, it can be easily determined with geometric methods as well. Draw concentric bows on an A4 sheet, then put the camera in the centre. Create the image formed on the computer. After that going on the bows find the points with the help of the pencil tip where the pencil tip can be seen on the edge of the screen. Connecting the points two lines crossing each other can be seen. The angle of the lines crossing each other is the viewing angle of the camera.

With the help of the viewing angle the real width of the plane in h height can be determined in the picture taken by the camera.

$$y = 2\mathrm{h}\ \mathrm{tg}\frac{\alpha}{2}, \tag{1}$$

where α is the angle value typical of the webcam, the viewing angle. H is the distance of the examined plane from the camera and y is the width of the examined plane.



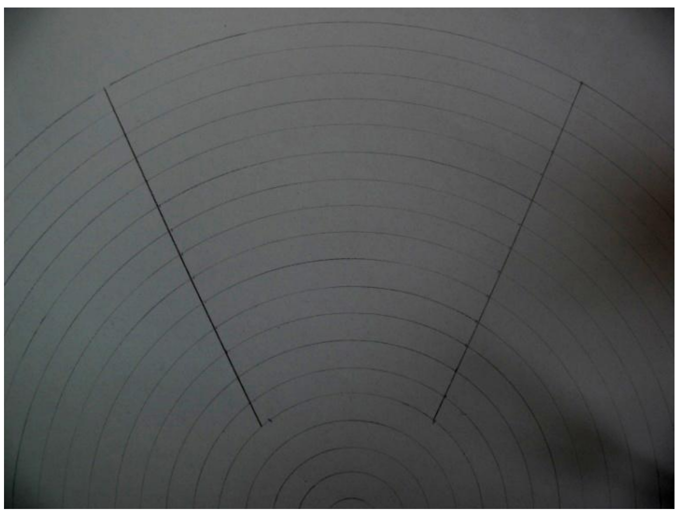



**FIGURE 1.** The horizon-points indicated on the concentric lines drawn on an A4 sheet.

## III. CHECKING THE VIEWING ANGLE OF THE CAMERA

The viewing angle was made on an A4 sheet with geometric methods. As the tiny angle divergences are not striking in such small-size construction, we checked the viewing angle of the camera with known values of object-distance and object-size. We put the camera in the back of the classroom opposite the blackboard. After that we measured the distance between the blackboard and the camera with a tape measure as well as the length and width of the blackboard. Then a photo was taken with the camera. With the help of the Tracker video analysis software the values of the blackboard were calibrated into real values and the width of the full screen was measured with the programme. The viewing angle was calculated again from the rate of the width of the screen and the camera-blackboard distance. The value was almost the same as the one we calculated on the sheet: $\alpha$=52,84°

## IV. DETERMINING THE HEIGHT OF THE CLOUDS FROM SEALEVEL

If the distance between the camera and the object is known, the real width of the image on the full screen can be calculated on the basis of (1). On 10 May 2012 we recorded the movements of the clouds from the window of the Physics equipment store of the Secondary Calvinist Grammar School. The Webcamlaboratory software was used and it was set to take a photo in every 15 seconds with the fixed webcam. The clouds seemed to be quite close to us and moved fairly fast on the overcast sky. On the basis of the pictures of the clouds we selected the ones that were the most similar to them from the cloud atlas and the parameters available were collected. The clouds examined resembled the Cumulus(Cu) set of clouds most.


**FIGURE 2.** The clouds were identified according to their photos . The photo on the left shows the record made from the window of the equipment store, whereas in the photo on the right the flat Cumulus humilis from the Wikipedia can be seen.

| | |
|---|---|
| Classification of clouds | low-level |
| main group | Cumulus |
| diameter | 1-20 km |
| colour | white, nacreous |
| contour | blurred |

The Cumulus humilis is a long-stretching type of cloud with blurred contour. Its edge is white or nacreous, its middle is of greyish shade. It is formed in middle-height (2-5km) as a result of the thermic convection. It can develop in any part of the world except for the Antartic (as the cold surface hinders the convection). The water steam precipitates in the air streaming upwards and contacting the cold air higher above, which can also be observed in the record: several smaller puffs in contrast with their larger mates did not swim into the picture area but mysteriously emerged from the blue background. This process also took place inversely: some parts of the clouds dissolved on the records due to the continuous warm stream.

In summer the cumuli collapse by late afternoon in most of the cases. The Cumulus humilis is not a cloud of rain but it can predict the arrival of rain coming in near future(12-24h), it is especially true if its developed form, the Cumulus congestus can be seen. It is a cauliflower-like cloud in several km height. On 10 May higher cumuli did not develop either by late afternoon and neither did it rain.

## IV. DETERMINING THE SIZE OF THE CLOUDS

The real length of the total camera screen width was calculated from the height of the clouds.

$$y_{\min} = 2 \cdot 2\text{km} \cdot \text{tg}26{,}42° = 1{,}987\text{km},$$

$$y_{\max} = 2 \cdot 5\text{km} \cdot \text{tg}26{,}42° = 4{,}968\text{km}.$$

The total width of the screen was set on the minimum and maximum calibrations and a small and a big cloud were selected. If we leave the calibration fixed, the programme makes it possible that we can determine the width and length values of the objects in planes of the calibrations. This way the size of the clouds were measured to be 1-3km wide.

## V. DETERMINING THE SPEED OF THE CLOUD

A peculiar point of the cloud was selected and with the help of the programme its movement was followed. The x axis of the coordinate system was taken in the line of the direction of the cloud movement During the measurement the analysis was run with the minimum and maximum values.

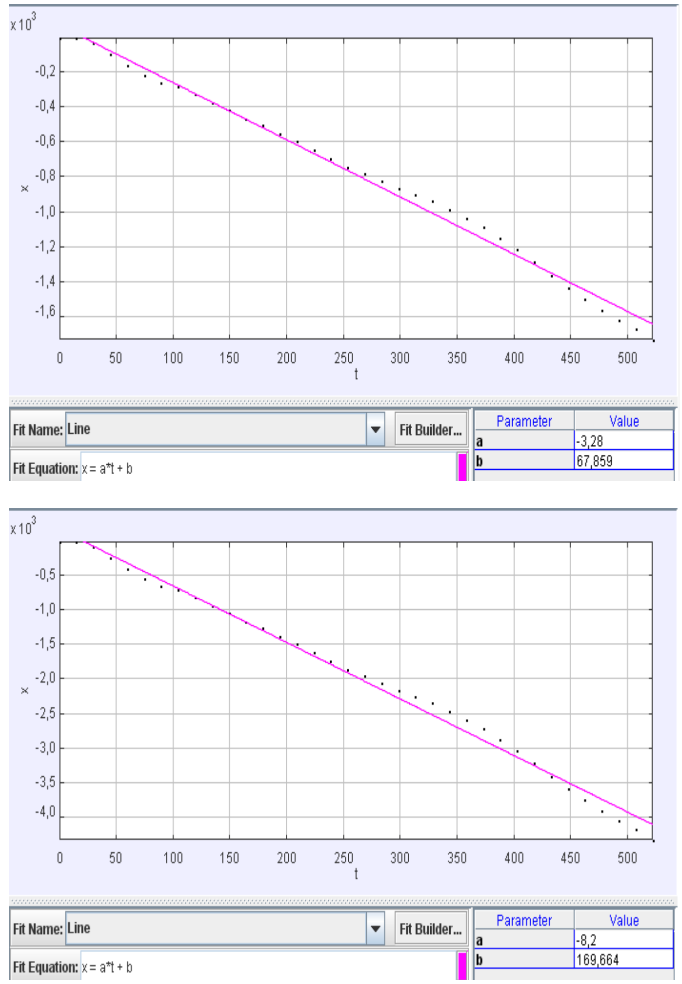



**FIGURE 3.** The pictures of the x(m)-t(s) graph from the video analysis . On the left the picture of the cloud supposingly in 2km distance can be seen whereas on the right the picture of the cloud supposingly in 5km height is shown.

We inserted linear lines on the x-t graphs; the steepness of the lines was in accordance with the possible speed-values of the cloud. The result was: 3,28-8,2 m/s≈12-30 km/h

## VI. DETERMINING THE SPEED -DIRECTION OF THE CLOUDS

First we orientated the window of the equipment store with the help of https://maps.google.hu/ We typed the address of the school and using the maximum enlargement we cut the satellite photo of the school. (These photos were taken in accordance with the orientation of the maps) After that we applied the photo taken by the camera parallel with the plane of the windowframe, where we indicated the streaming direction of the clouds. The direction of the speed of the clouds was north-west that is south-east wind was blowing in the height of the clouds.

## VII. CONCLUSIONS

The Cumulus cloud most frequently develops with the arrival of a coldwave. The measured speed figures also supported the approach of the coldwave . The speed of the coldwave stream is usually 25-40km/h, the wind appearing spasmodically turn into north-west and can become stormy. Its typical precipitation is shower, thunderstorm with hail.

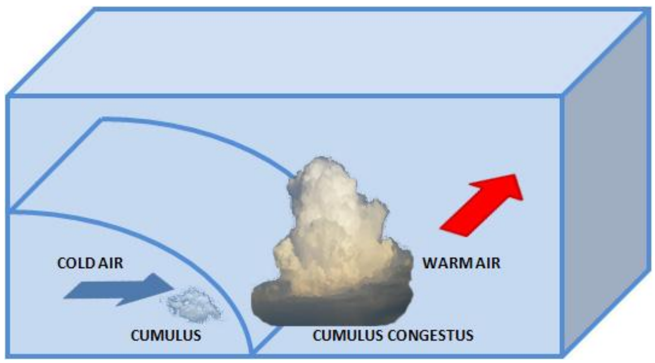



**FIGURE 4.** As a result of the coming coldwave there is an intense upstreaming on the border of the warm air which helps the cumulonimbus (Cumulus congestus) to develop

The streaming direction of the examined clouds was north-west. On the day after the records there was 3mm rainfall a few kilometers north-west from Nagyecsed, then in 2 days 24mm. (on that day it was raining all over the country). On 13 May 5mm rain fell on average in the region and on 14 May it stopped raining.

Originally we were thinking about a simple speed-measuring-idea during the lesson however we found several interesting things about the atmospheric phenomena. We tried to find connections between the type, the speed of the clouds and the atmospheric streams. We experienced cause and effect relations on our skin as on the days after the lesson there was a heavy rainfall.

On the meteorological websites we could check the streaming direction of the wind, its power, the possible occurrence of precipitation and its quantitative values. We learned the name and features of some typical clouds, we explored the streaming effects of the rotation of the Earth and we looked up on the sky more frequently.

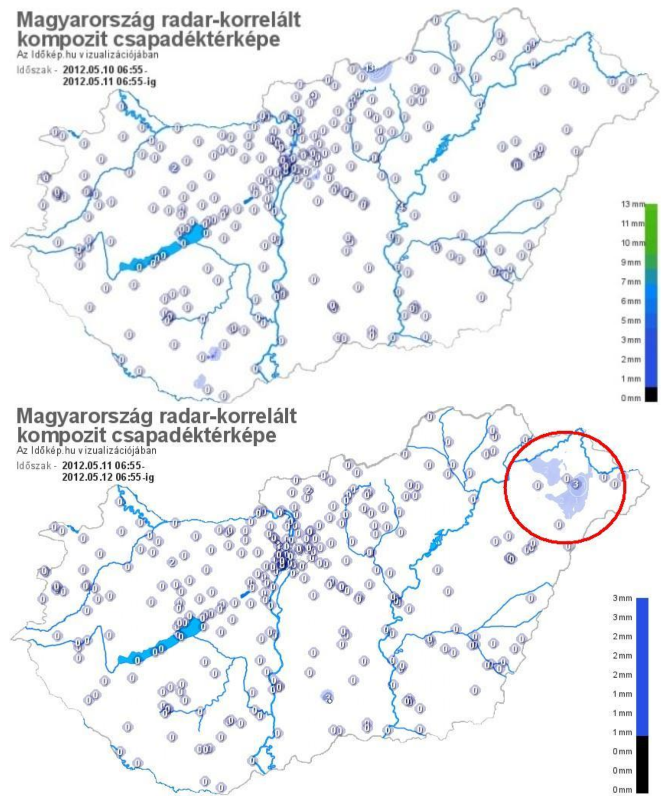



**FIGURE 5.** Radar-correlated composite precipitation map of Hungary. As a result of the arriving coldwave there was a heavy rainfall in the area around Nagyecsed

## ACKNOWLEDGEMENTS

I wish to express my thanks to my tutor Dr. Juhász András, my students, the "Webcamlaboratory" for the free software use, and also to Kürti Anetta.

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