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LONG -TERM OBSERVATIONS OF CLOUDNESS IN HURBANOVO

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Abstract. In our work, we are analyzed climatological performance characteristics of cloudiness at climatological station in Hurbanovo. The climatological data of cloud cover in the period 1901 – 2010 were evaluated. They present 110-year long-term series and therefore include also the long changes in annual course of cloudiness. Using standard statistical methods mean values of cloudiness, the number of cloudless, and fair, partially and fully clouded days in individual months, as well as daily and annual means have been computed. The trend has been examined using the determination coefficient. For the qualitative analysis of cloudiness meteorological synoptic data about type of cloudiness in Hurbanovo in the period from February 1995 to January 2011 were used. Furthermore, a qualitative analysis of the cloud cover was conducted. The ten clouds genera adopted in the international classification were considered. The cloud genera frequency was expressed as the number of cases per month, taking into account particular synoptical terms (morning, noon, evening).

Introduction

Cloudiness is one of the major factors which exert influence on the radiation balance of the Earth and the atmosphere and in consequence they impact on the ground and air temperature as well as on the occurrence of precipitation. Amount and type of clouds are comprehensive indicators of the state of the atmosphere and they are one of the most important components to bring into being of weather and climate. In Slovakia there is the amount of cloudiness observed in three standard climatological terms as well as cloud cover of sky expressed in tenth cover of visible horizon. The high and the cloud types are not determinate in climatological observations. These characteristics of clouds and the amount of cloudiness also are observed in eights in synoptical terms. The results of these meteorological observations are coded in international message - SYNOP. The climatological monitoring of cloudiness systematically is realized at climatological station Hurbanovo ($\varphi = 47^o\ 52'$, $\lambda = 18^o\ 12'$, H = 115 a.s.l.) from the year 1872, the synoptic data are available from the year 1995.
The observations of cloudiness characteristics are the qualitative valuations and so they can be very subjective. The observer makes often some mistakes when clouds are near the horizon.

Data and methods

In this contribution there are analyzed the long-term series amount of cloudiness gained from results of term climatological observation in Hurbanovo during the period 1901 – 2010. Mean daily cloudiness is calculated as the arithmetic mean from its 3 climatological observations at 7, 14 and 21 o'clock of mean local solar time. The effective climatological characteristics of cloudiness are the evaluation of occurrence and periods with days with characteristic cloudiness. The mean number of clear days (the mean daily cloudiness is less than 2 tenths), number of days with cloudiness (the mean daily cloudiness is equal or less than 8 tenths and equal or greater than 2 tenths) and overcast days (the mean daily cloudiness is greater than 8 tenths) in the annual course are given. The present standard climatological evaluation of cloudiness is enriched analyze of the results of the cloud type at meteorological station Hurbanovo. The cloud type is processed from observed synoptic data in 3 chosen terms: 6 a.m., 1 p.m. and 8 p.m. UTC. These terms are responsible to 3 climatological terms approximately. The long-term synoptic data about occurrences low (St, Sc, Cu, Cb), middle (Ac, As, Ns) and high (Ci, Cs, Cc) clouds are analyzed in the period from February 1995 to January 2011.
The acquired cloud characteristics are executed according to standard statistical methods. The presented long-term series in Hurbanovo are analyzed by means of linear regression method, whose relevance is examined using the determination coefficient.

Results and discussion

The analysis results for the annual course of mean daily cloudiness was done for the long-term series in Hurbanovo during the period 1901 – 2010 are presented in Fig. 1. This figure shows that the smallest average daily cloudiness occurs in summer season – from July to August, when it doesn't achieve even 50 % cover of sky and in one case evenly decreases under 4 tenths of

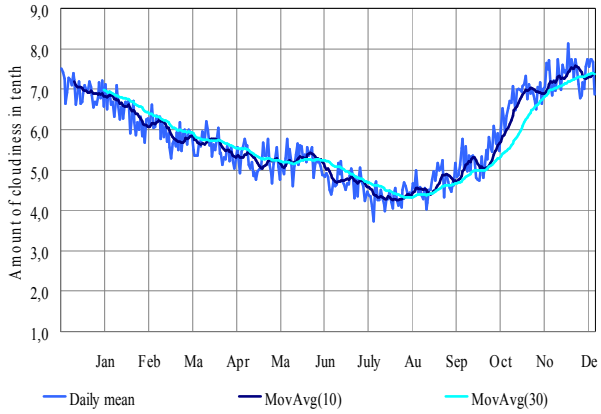


Figure 1. Annual course of the mean daily cloudiness in tenths at Hurbanovo station observed during the period 1901-2010

covering. In accordance with the assumption, the biggest cloudiness is in winter season, especially in December, when the cloud cover of sky decrease under 7 tenths only exceptionally. It is not out of the question, that covering of clouds exceeds 80 % in December. The occurrence of maximum of cloudiness in annual course in December and the minimum in August agreed with course of cloudiness in Danube lowland region. The cloudiness increases from August to December when achieves the maximum and then until March decrease in consequence. From April to June there is amount of cloudiness comparatively aquable, then it anything else decreases and the mainly minimum achieves in August.

Large differences between maximum and minimum values of cloud cover in monthly periods attest that it is large-scale changeable of cloudiness in Hurbanovo Tab. 1.

Table 1. The mean, average of daily maximum and minimum in month and in yearl amount of cloudiness at climatological station Hurbanovo in long term period 1901 - 2010

Period	Mean of cloudiness	Maximum of cloudiness	Minimum of cloudiness
I	7,0	9,5	4,7
II	6,4	9,1	3,6
III	5,9	8,2	2,5
IV	5,5	7,6	1,9
V	5,2	7,9	2,7
VI	5,2	7,3	2,2
VII	4,7	6,9	2,6
VIII	4,4	6,5	1,7
IX	4,7	8,6	2,1
X	5,4	8,5	3,1
XI	7,0	8,7	4,7
XII	7,4	9,1	4,9
Year	5,7	6,9	4,5

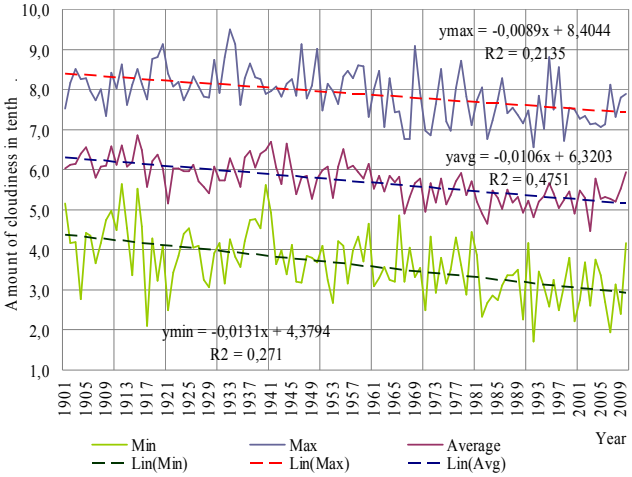


Figure 2. Long-term series of mean, maximum and minimum annual cloudiness in tenths with linear trends at Hurbanovo station observed during the period 1901-2010

The 110-years series with linear trends of annual mean, maximum and minimum of cloudiness amount in tenths at Hurbanovo station are presented at Fig. 2 and 3. The results presented in Fig. 2 show in the long term decreasing trends for maximum, minimum and mean annual values of cloudiness amount in the past century. The trend of difference between maximum and minimum annual cloudiness shows increasing values in long term series (Fig.3).

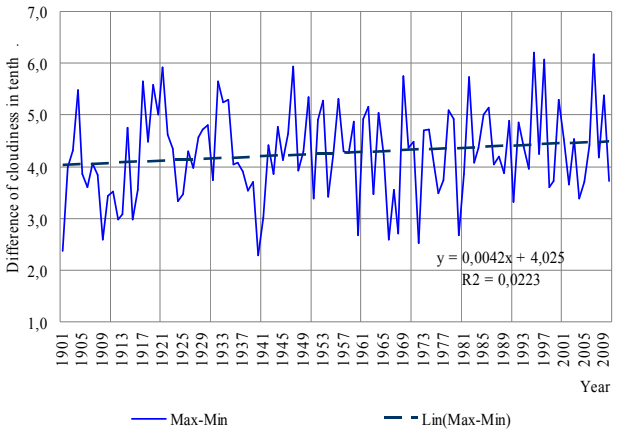


Figure 3. Long-term series of differences between maximum and minimum annual cloudiness in tenths with linear trend at Hurbanovo station observed during the period 1901-2010

The results of the evaluation of characteristic days at climatological station Hurbanovo within the period 1990 – 2010 are presented in Table 2 and Fig. 4 and 5.

Table 2. The annual course of the mean clear and overcast days at Hurbanovo within the period 1901-2010

Month	Clear days	Days with cloudiness	Total cloudiness
I	3,5	12,1	15,4
II	4,1	12,3	11,8
III	5,2	15,2	10,6
IV	5,6	15,9	8,5
V	5,9	18,2	6,9
VI	5,2	18,4	6,5
VII	7,7	17,9	5,4
VIII	9,2	16,9	4,8
IX	8,5	15,2	6,2
X	7,0	14,6	9,4
XI	3,0	12,5	14,5
XII	2,8	10,9	17,3

The clear days are observed on the average most frequently in Hurbanovo in August – 9,2 days. The maximum of the clear days in the annual course was recorded at station in August – 21 days in the year 1992. The clear days do not occur for the all month 11 times, maximum in July – 5 times. The overcast days are observed in the long-term average most frequently in December – 17,3 days. The maximum of overcast days during the month occurred at station Hurbanovo in January 1933 – 28 days and December 1920 and 1934 – 27 days.

The long-term occurrence course of characteristic days and their linear trends at Hurbanovo station are presented at the Fig. 4. These characteristics of 110-years series of cloudiness in Hurbanovo show, that the annual number clear days as far as increase in consequence, the overcast days significantly decrease. The relationships among evaluated characteristic cloudiness days (clear and overcast days and the other days with cloudiness) are shown in Fig. 5. The long-term means of occurrence the characteristic cloudiness days at climatological station Hurbanovo show, that the overcast days are as much again how the clear days approximately.

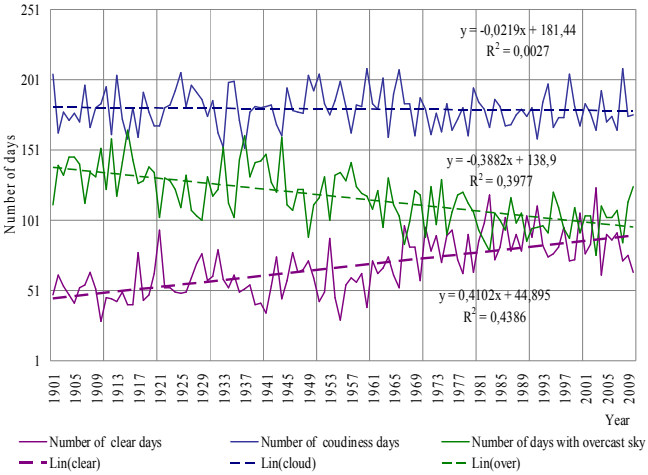


Figure 4. Long-term series of occurrences of characteristic days with cloudiness with linear trends at Hurbanovo station observed during the period 1901-2010

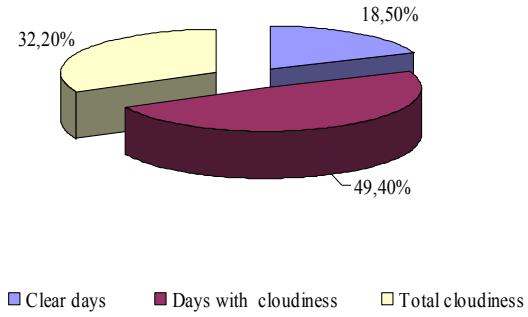


Figure 5. Annual relative occurrences of characteristic days with cloudiness at climatological station Hurbanovo within the period 1901 - 2010

The standard climatological characteristics of the amount and occurrence of cloud coverage give in long-term observations a good knowledge for climate chararakteristics of region. However, the knowledges about occurrence of cloud types or cloud layers are important for determinate the influence of cloudiness on radiation, precipitation or temperature regime of atmosphere too.

The evaluation results for the annual mean relative occurrence of low, middle and high clouds in Hurbanovo within February 1995 – January 2011 period are graphically presented in the Fig. 6a – 6c.

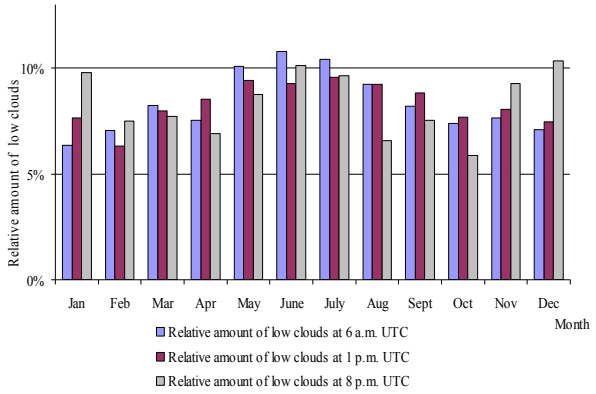


Figure 6a. Low clouds (Sc, St, Cu, Cb) – annual relative occurrences of mean monthly low clouds at climatological station Hurbanovo within February 1995 - January 2011 period at 6 a.m., at 1 p.m. and at 8 p.m. UTC

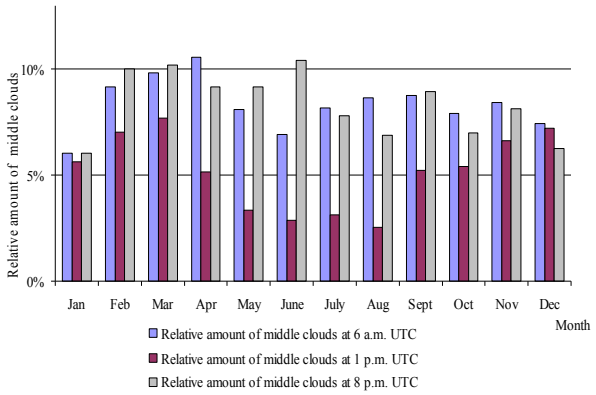


Figure 6b. Middle clouds (Ac, At, Ns) – annual relative occurrences of mean monthly middle clouds at climatological station Hurbanovo within February 1995 - January period 2011 at 6 a.m., 1 p.m. and 8 p.m. UTC

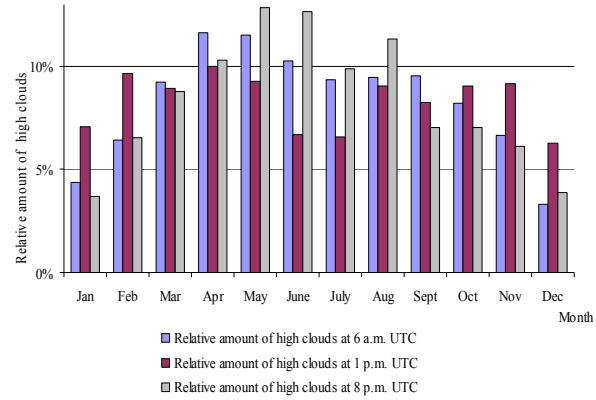


Figure 6c. High clouds (Ci, Cc, Cs) – annual relative occurrences of mean monthly high clouds at climatological station Hurbanovo within February 1995 - January 2011 period at 6 a.m., 1 p.m. and 8 p.m. UTC

Maximum of low clouds is occurred in winter seasons in the evening, in summer seasons in the morning observation and in spring and autumn at noon. The middle clouds have most changeable frequency during the day in the summer time, maximum relative occurrence of middle clouds is in the evening without February – April, when the maximum is in the morning. Middle clouds have the shining minimum at noon. Maximum of high clouds occur is in summer, i.e. in the morning and evening. The adverse course of high clouds is at noon observation.

The visualization of annual mean relative occurrence of low, middle and high clouds during in Hurbanovo in 3 tested observation terms is at the Fig. 7.

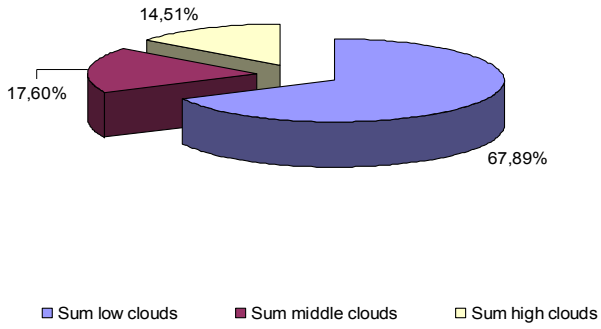


Figure 7. Mean relative annual occurrences of cloud layers over the climatological station Hurbanovo within February 1995 - January 2011.

The results of the occurrence of cloud types Ci, Cc, Cs, Ac, As, Sc, St, Ns, Cu and Cb over Hurbanovo within February 1995 – January 2011 period are presented in the Fig. 8a – 8c. The most frequently type of clouds is Stratocumulus and then is following Cumulus. The cloud type Stratocumulus has the maximum frequency of annual occurrence in the morning (41,95 %) and in the evening (44,44 %) too. Cumulus has the highest occurrences at noon (42,68 %). It is good agreed with the evolution of convective activities during the day. The third most frequently cloud genera are Stratus and than are following Altocumulus. The other cloud genera are occurred less, frequently only less than 2 % (Cb, Ns, Cc).

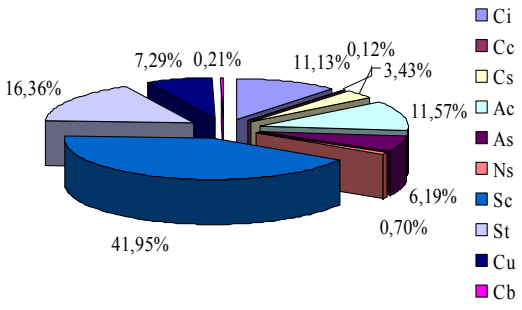


Figure 8a. Mean relative occurrences of cloud types over the climatological station Hurbanovo within February 1995 - January 2011period at 6 a.m.

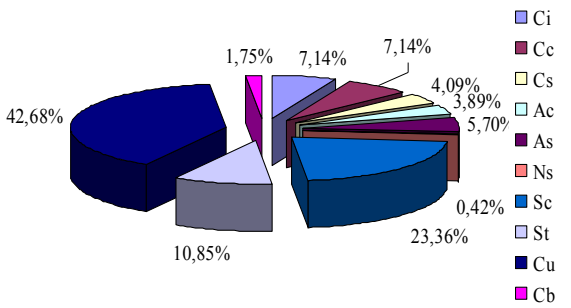
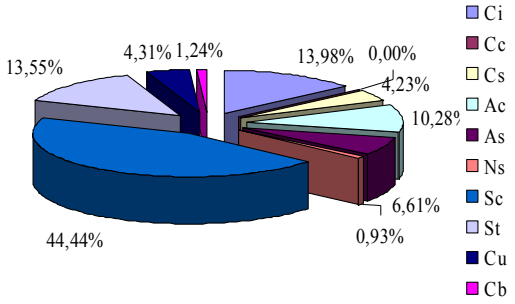


Figure 8b. Mean relative occurrences of cloud types over the climatological station Hurbanovo within February 1995 - January 2011period at 1 p.m.



- Dominated clouds are Stratocumulus in the morning and at the evening - its occurrence is approximately 42 % per year.
- Cumulus has the highest frequency at noon observation time - its occurrence is approximately 43 % per year.
- The most cloudiness in annual course of cloud layers is creating in the low layer – approximately 68 %.

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Figure 8c. Mean relative occurrences of cloud types overt the climatological station Hurbanovo within February 1995 - January 2011 period at 8 p.m.

Conclusion

The analysis of cloudiness leads to the conclusion that cloud cover over the station Hurbanovo during the last 110 years can be characterized by the following feature:
- Mean annual clod cover in long term period is 5,7, however it is varied from year to year throughout the all analyzed series.
- Minimum cloudiness in annual average occurrence is being in August and maximum in December.
- Annual number of total cover days is approximately as much again how the clear days
- Linear trends of annual occurrence mean, maximum and minimum values of cloudiness have long term decrease tendency.

The analyze of synoptic data of occurrence cloud types and cloud layers over the climatological station Hurbanovo in the period from February 1995 to January 2011 provides the following results:
- Daily course of occurrence of cloud types is very changeable.

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