

Climatological study

**The study of climate conditions at the Tokáň site
(period 2009/11 – 2010/10, complete overview)**

Part I (Text)

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1. Introduction

This report was worked out based on measurements during November 2009 - October 2010. At the end there is presented the complete overview of period 2008 - 2010. Same as in the last report (2008, 2009), nearby located stations, e.g. automatic station Varnsdorf and manual station Česká Lípa, have been used for comparing of measurements. Location in the map and coordinations of the stations were not changed.

2. Interval of measurements, preparation and evaluation of datasets

Meteorological measurements were running continuously in the period November 2009-October 2010. Positions of sensors and their height above the ground same as the kind of measurements and loading to the database have not been changed. Change of sending datasets was set in May 3th 2010. Since this date, the interval of sending and loading datasets has changed from 15 minutes to 10 minutes at all CHMI stations. Based on this change small interruptions in operating were detected. Those failures (breaks) did not affect next calculates such as daily and monthly values. More problems appeared in measurements of grass minimal temperature, because the sensor was covered by snow and did not measure air temperatures but snow temperatures. Daily data rows of meteorological elements were created by 15 min or 10 min. datasets according to the below written structure:

- Average daily temperature
- Maximal daily temperature
- Minimal daily temperature
- Grass minimal temperature 5 cm above the ground
- Average daily relative humidity
- Daily sums of precipitation
- Daily sums of sunshine duration
- Mean wind velocity and wind direction at times 07,14,21 hours
- Average daily wind velocity
- Maximal wind gust per day
- Average daily air pressure
- Average daily soil temperature in depths 5, 10, 20, 30, 50, 100 cm

All calculations were based on standard methods used by the CHMI. Monthly datasets were computed from daily datasets and consist of these values:

- Average month temperature
- Maximal and minimal month temperature
- Minimal month grass temperature
- Average month relative air humidity
- Maximal and minimal month relative air humidity
- Monthly sums of precipitation
- Monthly sums of sunshine duration
- Average month wind velocity
- Maximal monthly wind gusts
- Average month air pressure
- Maximal and minimal monthly air pressure
- Average monthly soil temperature in depths 5, 10, 20, 30, 50, 100 cm
- Maximal and minimal month soil temperature in depths 5, 10, 20, 30, 50, 100 cm
- Wind roses (relative frequencies according to the wind direction in every wind sector) for 12 months together and an average velocity for the wind direction

3. Data processing and presentation

The evaluation of climate at the Tokáň site was worked out based on the background of nearby stations Varnsdorf and Česká Lípa. It was used the whole 12 months period from November 2009 to October 2010. The assessment of climatological conditions was based on calculations of daily average, maximal and minimal values and continuously monthly average, maximal and minimal values. Daily datas were presented as charts and tables, monthly datas as a table overview. The complete evaluation at the end of this report uses that monthly table overview.

Air Temperature

Way of the temperature measurement was preserved during the whole period. Sensor of the temperature was located in the height 2 m above the ground, the sensor of the grass temperature 5 cm above the ground and sensors of the soil temperature in depths 5, 10, 20, 30, 50, 100 cm. The calculation algorithms of daily maximal and minimal values were already written and mentioned in the first report and have not been changed. The same standards are used for all climatological stations in the CHMI network.

Average daily temperatures in Tokáň same as the yearly average value were 1,6°C lower compared to the station Česká Lípa and 0,1°C lower to the Varnsdorf station. The largest differences of daily temperatures have exceeded 4°C between stations Tokáň and Č.Lípa and 5°C between stations Varnsdorf and Č.Lípa. Average daily Tokáň temperatures were always lower than the same ones at stations Č.Lípa and Varnsdorf. Daily temperature running shows a good relationship among all stations. The greatest gap was detected in the summer months (June 2010 Tokáň- Č.Lípa 2,8 °C), the least in the winter season (January 2010 Tokáň - Varnsdorf 0,4 °C). Running of average, maximal and minimal temperatures show Attachments 1-12.

Maximal and minimal temperatures have more variability than daily average temperatures. Maximal temperatures in Tokáň are mostly lower than maximal temperatures at nearby stations. The absolute highest temperature 33,3 °C was measured in Tokáň on 12th of July 2010. The same temperature was detected in Varnsdorf, but in Č.Lípa temperature reached 36,0°C. The absolutely lowest temperature during the whole period was measured in Tokáň (-20,9 °C), other stations had higher temperatures of more than 1 °C (Č. Lípa -19,9°C, Varnsdorf -19,7°C).

Grass minimal temperature and soil temperatures show attachments 13 – 24. The grass temperature measured at station Tokáň was lower during the summer season about 2-3 °C and during Winter season about 1-2°C than on nearby stations. Opposite trend, higher grass temperature, was detected from December to the beginning of March, when the sensor of temperature was probably covered by snow. Minimal grass temperatures were about 5-10 °C higher than temperatures at nearby stations and that is why this period was not included in the evaluation.

Soil temperatures were analysed in depths 5,20,50 cm below the surface only at Tokáň and Varnsdorf stations. Measurements at station Č.Lípa were not functional this time, so only Tokáň and Varnsdorf could be compared. Generally, it seems that the dependence between soil temperatures in all chosen profiles is very significant. While during November, temperatures were 1-2°C lower at Tokáň, from the half of December temperatures were around the same level. Against the second part of December, temperatures were slightly higher, first of all in the depth 50 cm below the ground. Temperatures in all profiles had the same character till the end of February. Because of the snow melting in last decade of March temperatures grew up very quickly and the winter trend was broken. Next months the soil temperatures at the Tokáň station were lower about 2-3°C compared to Varnsdorf. The

greatest gaps 3-4°C were measured in July. The decrease of sun radiation in autumn caused a reduction of gaps and differences between Tokáň and Varnsdorf. And so then the soil temperatures were very balanced on both stations.

Air Humidity

Daily relative humidity values were in the winter season about 1-4% lower in Tokáň than in Česká Lípa and against 1-3% higher than at the Varnsdorf station. During the summer period, air humidity at all stations was practically the same, only in July and August slightly lower at the Tokáň site. Better dependence was established between Tokáň and Varnsdorf than between Tokáň and Česká Lípa. Average air humidity values were mostly higher in the winter season and were oscillating in interval 80-100%. In the summer season the air humidity had much lower values, only in 60-80% interval. The absolute minimal value of air humidity was around 40%, measured at the end of April. Trends of increase and decrease during the whole period were very similar and the values were mostly consistent. Charts and tables of daily humidity are shown in attachments 25-30.

Wind conditions

Comparison of the average wind velocity and direction was done among stations Tokáň, Č.Lípa and Varnsdorf. So as in the previous period, wind conditions were measured on the top of the pillar at 10m height above the ground, at all stations. Automatic measurements (Tokáň, Varnsdorf) have been realised by Vaisala sensors, at Č.Lípa by a mechanic instrument (anemoindicator). Only two stations using an automatic sensor could create the wind gust evaluation.

Average daily wind velocity during a windy day was running at the Tokáň station mostly between 1 and 3 m/s against other stations, where average velocities were higher (2-5 m/s). Lower wind velocities at the Tokáň site were caused by the influence of terrain and the widespread woody character surrounding the nearby Tokáň station. Enclosures 31-36 show daily and monthly values. According to the average values the slightly windy months were July and August. Opposite of this, more windy months, were March and October. Velocity calculations were created separately for sectors and used for wind roses charts. The highest mean velocity, 1,1 m/s, has occurred in west-east axis in Tokáň, while Č.Lípa has prevailed the highest mean velocity of 2,4 m/s from the nord direction and in Varnsdorf the highest mean velocity, 2,6 m/s, came from the south and southwest direction. Very similar dividing for wind roses and higher wind velocity separated by each axis was presented in the previous report.

Maximal wind speed assigns the daily maximal gust (fluctuation) in 2 seconds period to the horizontal direction measured in 24 hours interval of the actual day. Gusts are the most variable meteorological measured element and its values depend on meteorological conditions, roughness of the surface and obstacles (buildings, tries, etc.) surrounding the area of measurement. Wind gusts change quickly at short distances. The maximal gust of 14,7 m/s was measured in Tokáň on the 22nd of August 2010, while at Varnsdorf station it was only 12,7 m/s. But higher wind gusts are more often measured in Varnsdorf than at the Tokáň station. Wind gusts are presented in attachments 37-42.

Wind direction was described by wind rose made for 8 sectors. Relative frequencies (%) of the wind from sectors are defined by the length on the axis. Wind roses from all stations were calculated by the same way based on basic climatological terms – 07,14,21 hours measures completed in period November 2009 – October 2010. One chart includes wind roses in Tokáň, Č.Lípa and Varnsdorf together (attachments 43).

The prevailing wind circulation in Tokáň was modified in the axis west – east, similar as in the previous report. In Varnsdorf southwest direction prevailed, in Česká Lípa northwest wind direction. Variability in circulation depends on the terrain of nearby stations. Shape of those charts shows a change in a small area circulation and simultaneously confirms trend from previous evaluations.

Sunshine duration

The way of calculating and an algorithm of daily sunshine duration sums was not changed. The daily sunshine sum depends on the year's season, location of the station in terrain and obstacles in surrounding. Woody surrounding of the Tokáň station caused, mainly in winter months with low circle of the sun, strong reduction of sunshine duration. The sunshine sensor was probably shaded by surrounded trees. The maximal daily sunshine duration did not exceed 2 hours per day during winter months, while at other stations it was significantly longer – maximal 6 hours. From the end of March differences between Tokáň and other stations were decreasing and during the summer season sunshine durations on all stations were balanced on level 10 – 14 hours per sunny days. Most days without sunshine were in January, in Tokáň 23 days (Č.Lípa 21, Varnsdorf 19). Attachments 44-49 show an overview of the daily sunshine running.

Precipitation

Daily sums of precipitation were calculated by the same way as in the last report. Daily sum is the precipitation per 24 hours interval from 07 hour of a previous day to an 07 hours present day. In the winter season daily sums at all stations were more balanced, against summer months, and reached maximal 10 – 15 mm. During summer months sums of precipitation have stronger variability among all stations. This is a result of a convective precipitation bounded on a storm and shower. The driest month was October with 23 days without rain and monthly sum of 14 mm. The wettest month was May with 28 day with precipitation. Maximal daily sum of precipitation, 95,4 mm, was measured in Tokáň August 7th. During this day highest daily sums were observed in Varnsdorf (89,4 mm) and Česká Lípa (83,6). The intensity of this heavy rainfall we can evaluate as a strong extreme, which occurs statistically once per 100 years. This rainfall caused floods and participated in the great monthly precipitation sum above 300 mm. Almost the same sum is usually measured after half a year. The precipitation is contained in attachments 50-55.

Air pressure

The air pressure is measured only in Tokáň, the other stations do not measure this element. Mean daily pressure values were computed based on the 07,14,21 hours and are described in attachments 56-57. The values are in order with the station's height above the sea level and are not re-calculated to 0 meters of the sea level. Higher variability was observed in winter months than in summer months and the interval of daily running was 940 – 990 hPa. The lowest average pressure of 940,1 hPa was measured on January 29nd 2010, the absolute highest average pressure, 986,4 hPa occurred on January 26nd 2010. Also absolute maximal and minimal values were detected in one month (January) and the consequently strongest decrease was registered during 4 days too.

Evaluation of period November 2009-October 2010

This evaluation contains measured and calculated values based on the period from November 2009 to October 2010. Attachment 58 shows the overview of monthly calculations. Monthly sums, mean, maximal and minimal values were prepared for final explanations and conclusions introduced below.

Monthly mean, maximal and minimal temperatures were in early running about 1 – 2°C lower per month at the station Tokáň than at other stations. Differences in monthly maximal temperatures were similar, but often higher for about 2°C. Regarding the minimal temperature Tokáň occurred about 4-5°C colder than nearby stations. Minimal and maximal temperatures have a tight dependence on the terrain and the woody area in surrounding.

Grass and soil temperatures

Grass temperatures were mostly lower at Tokáň about 1-3 °C, which shows a relationship with mean monthly temperatures. The sensor of the grass temperature was probably covered by snow in winter months and measured values were incorrect. Great failure of the sensor occurred from January to March when grass temperature gaps exceed 10 - 15°C in comparing to stations Česká Lípa a Varnsdorf. Soil temperatures running during the year was very good and was measured in 5 cm depth. It could be compared only with the station Varnsdorf, because in Česká Lípa the measurement was not in operation. Continuously lower soil temperatures about 1 – 2°C were detected in spring and summer.

Monthly mean of relative humidity was very balanced at all stations without great gaps. Even though the values were slightly lower than in the previous evaluation, mainly in summer months. In this time, monthly mean humidity was really lower at Tokáň than at nearby stations. Maximal air humidity has never been 100% at the Tokáň station.

Monthly sums of sunshine duration occurred from November 2009 to February 2010 were strongly lower than at other stations, also several times. Declining of sunshine duration was probably caused by the lower trajectory of the sun circle above surface and shadows of woods in the near surrounding. Probably, it was not caused by clouds or fog. In case of the higher sun circle above surface (March-October) declining is not observed.. During the summer half of the year, when the sun was going on a higher trajectory, that effect was not observed. The same trend was found in the previous evaluation too. Maximum of the monthly sum at the Tokáň station - 233 hours was measured in July 2010, minimum of the monthly sum was detected in December 2009. We have to take these "tiny" values as a result of the shadow of trees not as a real climatological extreme.

Monthly wind velocities at the Tokáň site were again significantly lower than at other stations. It appeared in the average as well as in the maximal values. Monthly average wind velocities were running from 0,5 m/s to 1 m/s while wind speeds at other stations were from 0,8 to 2,1 m/s. The same characteristic trend was found in the average of gusts. Against The maximal gust of 14,7 m/s, measured at the Tokáň station in August 2010, exceeded the measured maximum in Varnsdorf. Česká Lípa has not this wind sensor in operation. Wind roses show a relative frequency of a wind direction from every sector separately. The prevailing circulation at the Tokáň site was in west – east axis (almost 45 % of all winds). Measured calm reached 26%. Circulations at Č. Lípa and Varnsdorf stations are very different. In Česká Lípa the prevailing wind was from northwest (19%) and in Varnsdorf from southwest sector (16 %)

Monthly precipitation is generally very different during the whole year. In the winter season monthly sums were in Tokáň significantly higher, about 10 – 20 %, than at other stations. Except from May, when the precipitation was lower than in Varnsdorf. The monthly sum in the summer season is strongly depended on a heavy daily sum, occurred from the local precipitation, which is often only at one station. The significant daily and continuously monthly precipitation were recorded in July and then in August. July rainfall reached 157

mm. August rainfall was up to 310 mm at the Tokáň site. Those values of precipitation were in both cases strongly higher than at nearby stations. In opposite, the lowest amount of monthly precipitation, 14 mm, was observed in October 2010. The extreme precipitation in the 2 months had a main part of the whole year's sum of precipitation and this fact was seen at all stations.

Air pressure was measured only in Tokáň and measured values assigned right values to the level of height of the station, without a need to re - calculate to see the level. Monthly mean values were running between 957-971 hPa, the highest monthly value of 986,4 hPa was recorded in January 2010, so as the lowest value, 940,1 hPa.

Overview of the whole measured period (2008 – 2010)

Climatological conditions, presented in this part of report, were evaluated by using calculations during the whole period of measurements. Although it was a relatively short period of measurement, very significant differences of microclimate at the Tokáň station were discovered. The evaluation was done by comparing the Tokáň site with other stations in nearby surrounding. Station Tokáň was working in an automatic regime, the overall quality of measured and transferred data to database was very good. Failures and breaks in data rows were minimal. The basic 15 minutes interval of measurement has been changed to a 10 minutes interval since May 3rd 2010. It was done in accordance with other stations of CHMI network stations. The same methods and calculations were used for assigning regular 15/10 min. data to climatological terms (07,14,21 hours) and their next computes were also used for daily and monthly average and maximal and minimal values. Consistent measurements of the grass minimal temperature and the sunshine duration were not reliable in winter months. The sensor of the grass temperature was, during days with higher snow, probably covered by snow and temperatures were strongly overheated. Another problem was caused by sunshine duration. In winter months, probably by trees shadows, sunshine duration was strongly reduced and daily and monthly sums were basically the same.

It seems, according to the results of overview in attachment 59, that the Tokáň station was built at a good site and the station so far, surrounded by an area of NPČŠ, has presented excellent microclimatic conditions for observing. Woods and specific terrain conditions with the grass cover caused significant differences towards measurements on nearby stations. It is possible to say a conclusion, that Tokáň has showed continuously lower average, maximal and minimal daily and monthly values. A similar trend was in case of the grass temperature, but I'm afraid that again the snow cover made the measurements untrustworthy. The air humidity was during the first year slightly higher, in year 2010 practically equal compared to other stations. The average velocity was in Tokáň significantly lower, which is in accordance with our knowledge about circulations in woody and partly woody areas. The wind gust measurement at the Tokáň station was in year 2010 surprisingly the highest of all stations. It depends on a specific meteorological situation. Prevailing winds were detected in west – east axis and this type of circulation, different from the others, is hardly caused by terrain or by woody conditions of the site. Daily and monthly sums of precipitation were mostly higher in winter than in summer months in Tokáň. A significant part of the sum, compared to nearby stations, was probably added by horizontal precipitation from fog and dew. Regarding the convective rainfall (July, August 2010) higher values were measured as well. The running of air pressure shows only Tokáň, at other stations the element was not measured. A significant difference of this element would not be probably found. The position of the station was chosen very responsible and measurements at the station proved warranty of benefits the station can give us by monitoring its microclimate. It would be very suitable to continue those measurements through next years and operate with monitoring of the microclimate in the specific woody area.