VLIV PROUDĚNÍ ATMOSFÉRY NA FYZIOLOGICKÉ PROCESY HORSKÉHO SMRKOVÉHO POROSTU NA LOKALITĚ BÍLÝ KŘÍŽ

THE IMPACT OF THE ATMOSPHERIC FLOW ON THE PHYSIOLOGICAL PROCESSES OF MOUNTAIN SPRUCE STAND IN THE LOCALITY BÍLÝ KŘÍŽ

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Abstract

Weather conditions of the vegetation stand are essential to study as a basis for physiological research, because they influence the physiological processes very much. The paper analyses the prevailing wind direction and its relation to the windspeed in the locality Bílý Kříž in Moravian-Silesian Beskyds. It was found that the prevailing and the most important wind (because only this wind direction can reach higher windspeed) comes from the south (38.9% in the 19999 vegetation season, 33.7% in May 2000). The impact of the development of windspeed and turbulence on the physiological processes (determined by evapotranspiraton) studied in May 13th-14th and 27th-28th ,2000, showed that they are more intensive when the windspeed is higher and the turbulence more developed. All the analysed data were obtained by means of an Edisol system, which is a system designed to measure surface fluxes of substances and energy over the whole forest stand.

Introduction

The physiological processes of the vegetation stands, especially transpiration and CO_2 assimilation and respiration, are very much influenced by the weather conditions. The most important are windspeed, wind direction and the development of turbulence, because they belong to the factors that determinate how the mentioned physiological processes are developed and what is their footprint. The understanding of these aspects provides a very important environmental characteristic of the stand.

Methods

The measurement over the whole forest stand, which is in this case considered as a “big leaf”, was provided by the system Edisol. It is a system to measure surface fluxes of energy and substances (latent heat flux, sensible heat flux, flux of the momentum, water vapour and carbon dioxide) by the eddy-covariance method, but it is also producing the values of different meteorological characteristics as windspeed, wind direction, friction velocity, Monin-Obuchov length, air concentration of CO_2 and water vapour. Its main component is ultrasonic anemometer (Gill Instrument, U.K.) which is situated on the mast 12 m above the earth surface. It measures three vectors of windspeed in high frequency, wind direction and sonic temperature. The next component is infrared gas analyser (LI-COR 6262, U.S.A) which measures the instantaneous air concentration of CO_2 a H_2O. These signals are joined together by the software Edisol (University of Edinburgh) which computes the fluxes by the eddy-covariance method.

The detailed description of the system is in Moncrieff et al. (1997).

All the data were taken from the Edisol measurement as a mean for 30 minutes of high frequency measurements.

Parameter of the turbulence (the integral turbulence characteristic) in the air is computed according to the equation:

$P_T = \delta w / u_*$, (2)

where δw is the standard deviation of the vertical compound of the windspeed,

u_* is friction velocity of the moving air (Foken 1997, Aubinet 2000).

Table 1: Characteristic of turbulence

Characteristics	Type of turbulence
$\delta w/u_*$ is equal or close to 1.4	dynamic, best for eddy-covariance measurement
$\delta w/u_* < 1.4$	mechanic (caused by the obstacles in the air)
$\delta w/u_* > 1.4$	little developed

The measurement is carried out in the Experimental Ecological Study Site (EESS) Bílý Kříž over the Norway spruce stand. The main characteristic of the locality for the beginning of the vegetation season 2000 is in the Table 2.

Table 2: Characteristic of the EESS Bílý Kříž in Moravian-Silesian Beskydy Mts. at the beginning of the vegetation season 2000

Position	N 49 ° 30´17 ´´, E 18° 32´28´´, 800 - 900 m a.s.l., slope 13° with SSW orientation
Annual mean air temperature	4.9 °C
Annual precipitation	1100 mm
Stand	evenaged monoculture of Norway spruce
Stand age	18 years (planted in 1981 by four years old seedlings)
Soil type	Ferric Podzols on sandstone (flysch type)
Stand density	2500 trees per ha (last thinning in 1996)
Stand area	6.15 ha
Leaf area index (projected)	7.2± 0.2
Mean tree height (end of the season)	7.5± 0.1 m

Results and discussion

The prevailing wind in EESS comes from the south direction (Figure 1), which means the wind coming up the slope. It is followed by the southwest and then north wind directions, the one which is coming over the edge of the hill. We are showing only the data from May 2000, but the analysis of all the vegetation season 1999 has given comparable results, the main differences occured in the southwest and northwest directions (Table 3). The windspeed is influenced by the wind direction (Figure 2), whenever the windspeed is higher than 4 $m.s^{-1}$ then the wind is coming exclusively from the south.

We chose 4 days in May 2000 (13^{rd}-14^{th}, 27^{th}-28^{th}) to show the differences in measured characteristics according to the wind and atmosphere attributes.

All the days were sunny. Maximum and minimum daily temperatures are in Table 4. There was north wind in the days May 13^{rd}-14^{th}, maximum windspeed reached 1.9 m/s (daily mean was 0.8 and 0.9 m/s respectively), whereas in the days May 27^{th}-28^{th} there was south wind with the maximum 9.4 m/s (daily mean 5.9 and 4.8 respectively) (Figure 3).

The good development of turbulence occurred in the days 27^{th}-28^{th}, while in the days 13^{rd}-14^{th} the turbulence was rather mechanic (Figure 4).

All these attributes influenced measured evapotranspiration (Figure 5). The value of evapotranspiration grew, the stomata were more open and in this consequence the concentration of CO_2 in the air decreased as the result of its bigger uptake by the trees (Table 4). The evapotranspiration distincly rosed in the days 27^{th} –28^{th}. The sum of the evapotranspiration (mm) for the days 27^{th}-28^{th} reached 178 % of the sum for the days 13^{rd}-14^{th}.

Table 3: Distribution of wind direction (%) in the locality Bílý Kříž in Moravian-Silesian Beskydy Mts. in May 2000 and 1999 vegetation season (May – October)

wind direction (%)	**N**	**NE**	**E**	**SE**	**S**	**SW**	**W**	**NW**
May 2000	17.7	6.1	3.1	4.9	33.7	20.6	8.3	5.6
vegetation season 1999	16.5	8.4	4.5	4.5	38.9	9.6	5.3	12.3

Conclusion

The prevailing wind in the locality Bílý Kříž comes from south direction (May 2000 data: 33.7%, vegetation season 1999: 38,9%) and there is a strong dependance of the windspeed on the wind direction.

The impact of windspeed and development of turbulence on the physiological processes were well seen. The sum of the evapotranspiration (mm) in the days May 27^{th} and 28^{th} reached 178 % of the sum of the days 13^{rd} and 14^{th}, because of the south wind direction with high windspeed (maximum 9.4 m/s) and more developed turbulence.

Souhrn

Podkladem pro studium fyziologických procesů porostů rostlin je popis meteorologických charakteristik lokality. Tento příspěvek přináší popis lokality Bílý Kříž v Moravskoslezských Beskydech z hlediska převažujícího směru větru, závislosti rychlosti větru na jeho směru a jejich vlivu na vývoj turbulence a evapotranspiraci smrkového porostu. Převažujícím směrem proudění ve vegetační sezóně 1999 (duben až říjen) bylo proudění jižní (38.9%). Dny 13.-14. a 27.-28.5.2000 byly vybrány pro demonstraci vlivu velikosti rychlosti větru a stupně vývinu turbulence na fyziologické procesy. Evapotranspirace byla vyšší ve dnech s vyšší rychlostí větru a s dynamickým typem turbulence. Použitá data byla naměřena eddy-kovariančním systémem Edisol.

Table 4: Meteorological characteristics measured over the mountain spruce stand in the locality Bílý Kříž in Moravian-Silesian Beskyds in the day 13rd-14th and 27th-28th May 2000

May 2000	**13rd**	**14th**	**27th**	**28th**
Maximum daily temperature (°C)	14.5	17.9	22.5	21.7
Minimum daily temperature (°C)	-0.6	3.3	11.0	9.4
CO_2 concentration (ppm) (mean for the hours with sunshine duration)	346.5	345.2	339.6	343.5

Figure 1: Wind rose for May 2000 in the locality Bílý Kříž

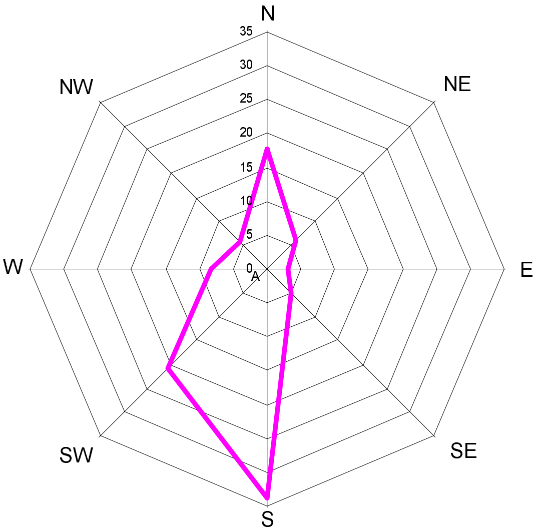


Figure 2: Windspeed (m/s) in relation to the wind direction (deg) for May 2000 in the locality Bílý Kříž

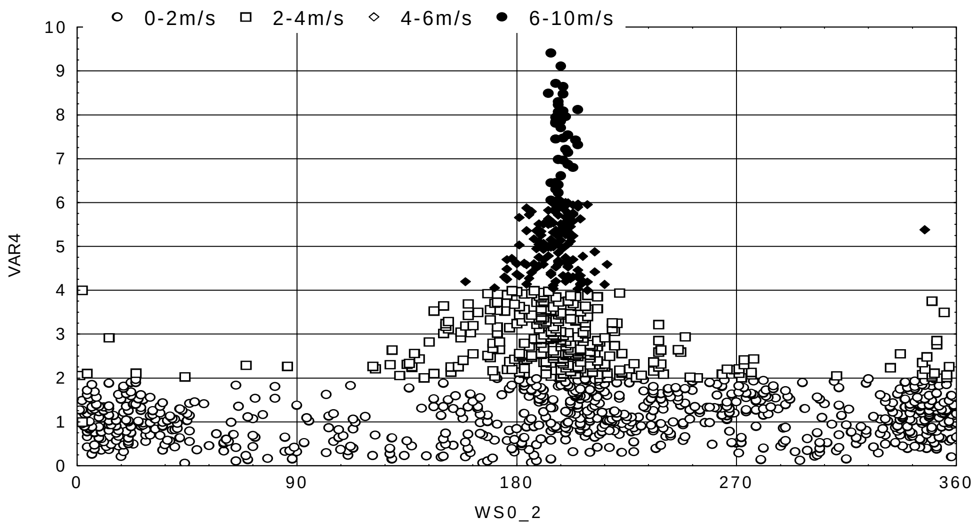


Figure 3: Windspeed (m/s) and wind direction (deg) over the spruce stand in the locality Bílý Kříž for the days 13rd–14th, 27th-28th May 2000

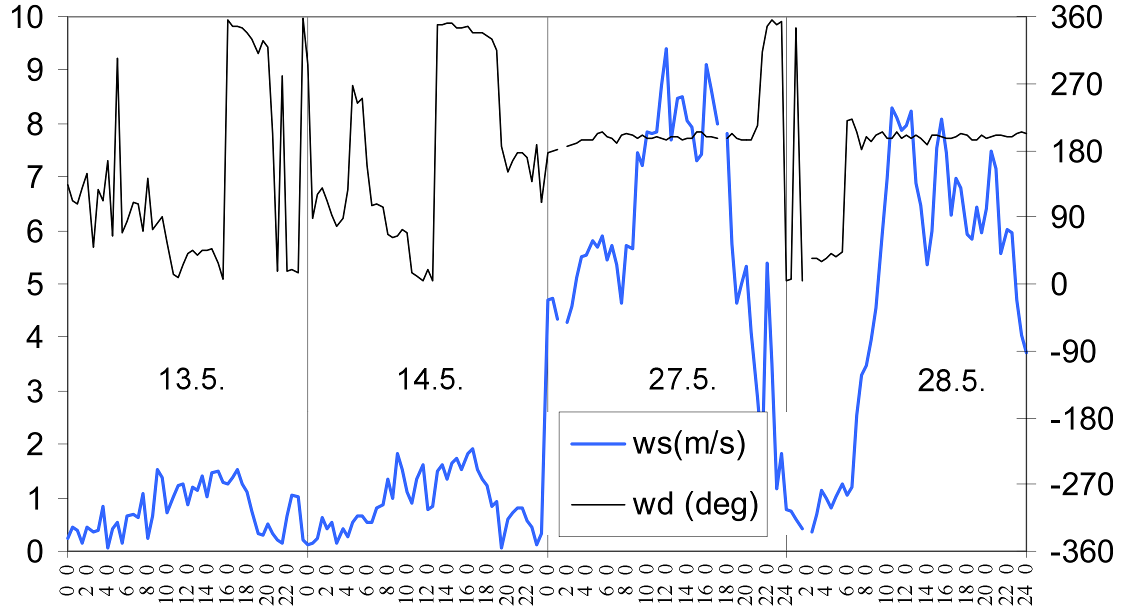


Figure 4: Course of parametr of turbulence in the locality Bílý Kříž for the days 13rd–14th, 27th-28th May 2000

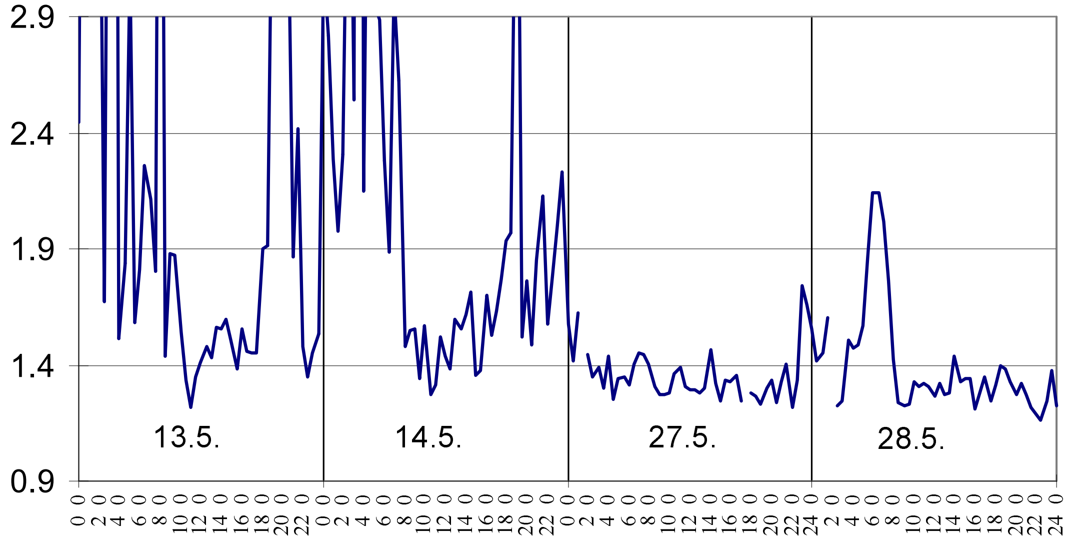
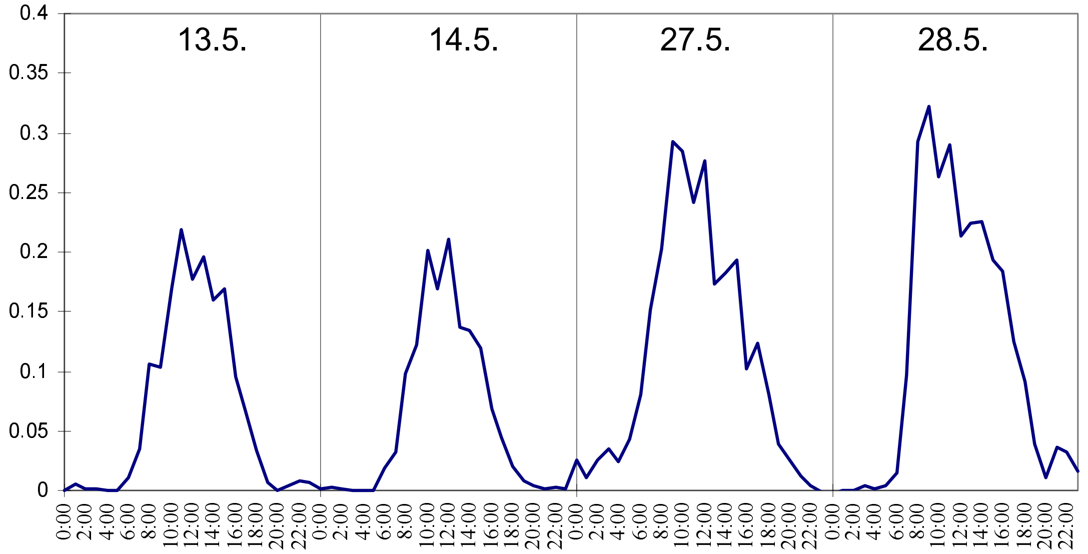


Figure 5: Evapotranspiration (mmol/m^2.s) over the spruce stand in the locality Bílý Kříž for the days 13rd–14th, 27th-28th May 2000



Klíčová slova: eddy-kovarianční měření, rychlost a směr větru, přízemní vrstva atmosféry, parametr turbulence

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