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DEPENDENCE OF CLIMATE UPON GEOGRAPHICAL FACTORS IN POLAND AND IN VIETNAM

The purpose of the present paper is to define the most important features of climates of Poland and Vietnam, resulting from their location, respectively, in moderate and tropical latitudes.

Analysis performed concerned dependence of such climatological elements as air temperature and humidity, prcipitation and wind velocity upon longitude and latitude as well as elevation above the sea level.

The analysis was carried out on the basis of measurements made over the period 1971-1980 in meteorological stations of the Institute of Meteorology and Water Economy (Poland) and the Vietnamese Hydrological-Meteorological Service.

General features of climate of Poland and Vietnam are described by annual changes of the climatological elements considered: air temperature (daily average t), water vapour pressure (e), precipitation (sum O_p) and wind velocity (v), see Tab. 1.

Table 1

The range of annual changes in climatological elements in Poland (52° N, 19° λE, 221H) and in Vietnam (16°N, 106° λE, 1000) in the years 1971-1980

Climatological elements	Poland		Vietnam	
	Min	Max	Min	Max
Average air temperature (°C)	-3.4	17.3	18.4	26.5
Water vapour pressure (hPa)	4.5	15.6	17.5	28.5
Precipitation (mm)	32.4	103.9	23.0	313.0
Wind velocity (m/s.)	2.7	4.1	1.6	2.4

Average values of climatological elements in the years 1971-1980 result from complex influences of geographical factors upon the intensity of heat and water vapour flows and atmospheric circulation in the moderate (Central Europe) and tropical (South-Eastern Asia) latitudes.

An effort was made to distinguish the changes of climatological elements determined by geographical location (sun angle and day length, distance of

Poland from Atlantic Ocean and of Vietnam from South-Chinese Sea) from the changes caused by land relief of countries analysed.

To that end, the fields of climatotological variables were described with equations of regression hyperplanes determined with regard to latitude (φ)and longitude (λ) and altitude above the sea level (H):

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Cooler half-year, Poland:					
$t =$	-0.396φ	-0.262λ	$-0.455H$	$+28.240$	0.97
$e =$	-0.086φ	-0.052λ	$-0.160H$	$+11.84$	0.95
$O_p =$	2.157φ	-0.829λ	$+4.430H$	-65.80	0.90
$v =$	0.505φ	$+0.021\lambda$	$+0.407H$	-23.85	0.72
Cooler half-year, Vietnam:					
$t =$	-0.678φ	-0.200λ	$-0.487H$	$+54.90$	0.98
$e =$	-0.592φ	-0.227λ	$-0.522H$	$+55.80$	0.92
$O_p =$	-3.824φ	$+3.693\lambda$	$-3.604H$	-299.50	0.35
$v =$	0.031φ	$+0.341\lambda$	$+0.017H$	-34.94	0.53
Warmer half-year, Poland:					
$t =$	-0.463φ	$+0.031\lambda$	$-0.622H$	$+38.19$	0.98
$e =$	-0.280φ	$+0.037\lambda$	$-0.330H$	$+26.73$	0.97
$O_p =$	-1.440φ	$+0.700\lambda$	$+5.525H$	$+119.32$	0.93
$v =$	0.376φ	-0.005λ	$+0.270H$	-17.00	0.70
Warmer half-year, Vietnam:					
$t =$	-0.025φ	$+0.045\lambda$	$-0.594H$	$+23.30$	0.98
$e =$	-0.015φ	-0.239λ	$-0.776H$	$+56.00$	0.95
$O_p =$	1.736φ	-24.047λ	$+7.184H$	$+274.50$	0.66
$v =$	0.080φ	$+0.286\lambda$	$-0.001H$	-30.13	0.46

The measures of influence of these most important geographical factors upon climate are constituted by the components: meridional, latitudinal and hypsometric of the gradient of the field mentioned, $\left(\frac{\partial y}{\partial \varphi}, \frac{\partial y}{\partial \lambda}, \frac{\partial y}{\partial H}\right)$, i.e. the coefficients of partial regression.

The gradient of the field of air temperature indicates that in the cooler half-year temperature falls towards the North of Poland by 0.4°C/1° jf and towards the North of Vietnam by 0.7°C/1° φ, it falls also in the Eastern direction in Poland by 0.3°C/1° λ and in Vietnam by 0.2°C/1° λ, and decreases along with increasing altitude by 0.5°C/100 meters both in Poland and in Vietnam.

The ranges of annual changes of geographical gradients of the climatological elements analysed in Poland and Vietnam are presented in Table 2.

Table 2

The range of annual changes of meridional, latitudinal and hypsometric gradients of temperature (*t*), water vapour pressure (*e*), precipitation (*Op*) and wind velocity (*v*).

Elements y	Meridional gradient $\frac{\partial y}{\partial \varphi}$	Latitudinal gradient $\frac{\partial y}{\partial \lambda}$	Hypsometric gradient $\frac{\partial y}{\partial H}$
Poland			
t	-0.67 to -0.27	-0.29 to 0.16	-0.69 to -0.38
e	-0.41 to -0.00	-0.09 to 0.12	-0.42 to -0.12
Op	-0.42 to - 4.25	-3.09 to 0.78	3.20 to 7.83
v	0.31 to - 0.53	-0.02 to 0.03	0.23 to 0.46
Vietnam			
t	-0.90 to 0.12	-0.31 to 0.13	-0.66 to -0.41
e	-0.94 to 0.34	-0.59 to 0.20	-0.78 to -0.54
Op	-15.69 to 17.48	-48.41 to 35.56	-10.31 to 13.51
v	-0.03 to 0.11	0.25 to 0.40	-0.66 to 0.04

Thus determined horizontal gradients $\left(\frac{\partial y}{\partial \varphi}, \frac{\partial y}{\partial \lambda}\right)$ having meridional and latitudinal components indicate changes in the values of a given element per 1oj and 1° l at the sea level. Elimination of the effect of latitude upon climate made it possible to find out the zonal nature of fields of climatological elements as well as the reach of Western circulation in Poland and monsoon circulation in Vietnam.

The fields of climatological elements are most deformed by land relief — expressed through altitude above the sea level — both in Poland and in Vietnam. The deformation is measured by hypsometric gradients. Along with the increase of altitude above the sea level one can observe the decrease of temperature and of water vapour pressure irrespective of the season. Hypsometric gradients of precipitation sums and wind velocities are in Poland positive over the whole year, while in Vietnam they change their sign in case of precipitation sums from negative in winter months to positive in summer months, while in case of wind velocities — *vice versa*.

The greatest decrease per 100 meters of altitude is observed for air temperature in July (0.5°C in Poland and 0.7°C in Vietnam), and for water vapour in Poland in July-August (0.4 hPa), while in Vietnam in May-June (0.8 hPa). Particularly high hypsometric gradients of precipitation are observed in Vietnam in June (11 millimeters/100 meters of altitude) and in August (13 mm(100 m). The highest gradients of the same kind are observed in Poland in June (9 mm/100 m) and in July (7 mm(100 m).

It should be noted that hypsometric gradients of air temperature (averages for the areas of Poland and Vietnam) are in some months close in their value to adiabatic humidity gradients (-0.5°C/100 m). Besides, hypsometric gradients have important annual amplitudes that are significant at the level of 5%.

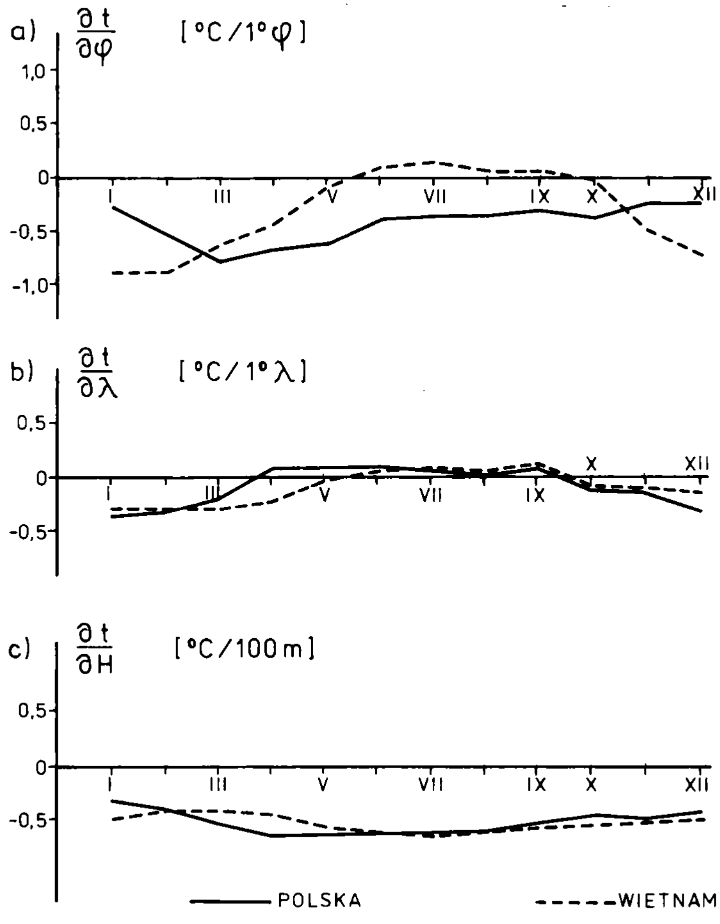

Fig. 1. Annual profile of gradients of average air temperature with regard to latitude (a), longitude (b) and altitude above the sea level (c): accordsing to equations of regression hyperplanes in Poland ——— and Vietnam ——

On the other hand, the meridional, latitudinal and hypsometric gradients defined by equations of linear regression have a somewhat different sense. They describe the observed increments of meteorological variables per one degree of latitude (φ) and longitude (λ) and per 100 meters of altitude. They do not reflect the interrelation between the altitude above the sea level and geographical location.

Finally, the horizontal gradient of the field — the vector along the regression hyperplane — indicates the direction of increase of a climatological variable after the influence of altitude above the sea level has been eliminated. In the case of air temperature field this is a horizontal gradient reduced to the sea level altitude.

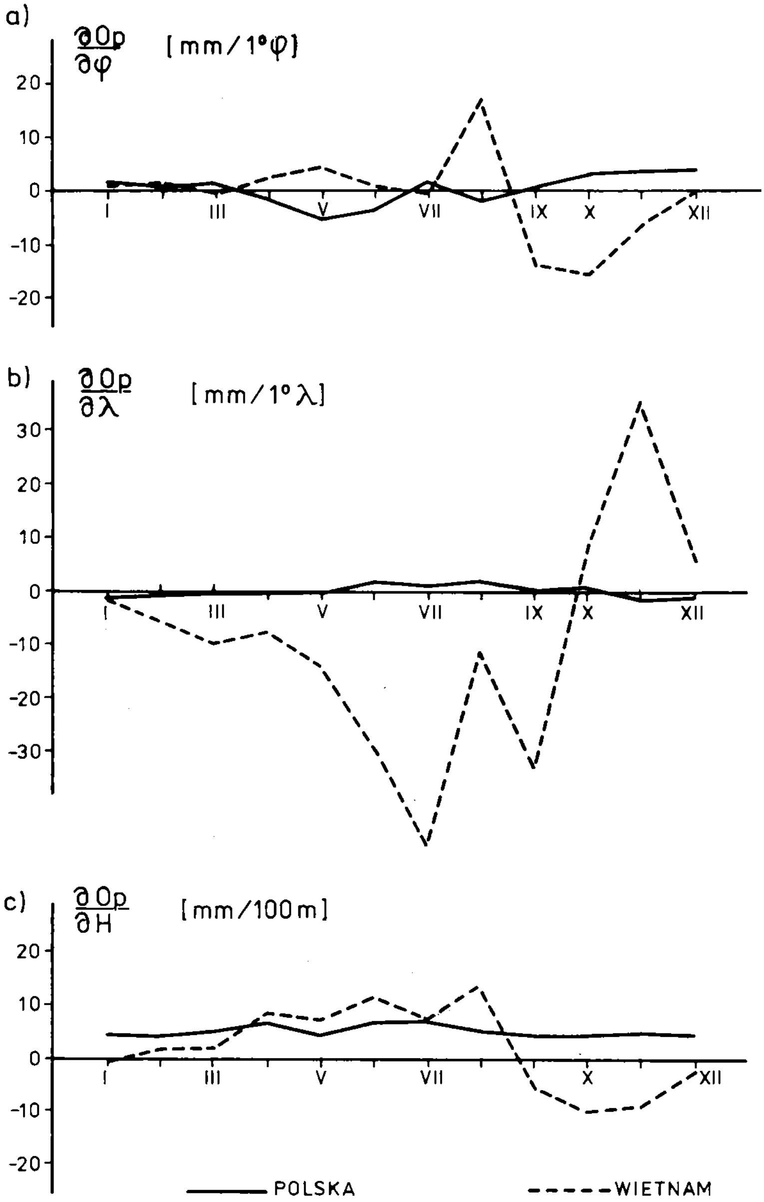

Fig. 2. Annual profile of gradients of precipitation totals with respect to latitude (a), longitude (b) and altitude above the sea level (c): according to equations of regression hyperplanes in Poland ——— and in Vietnam - - - -

Differences between the gradients determined according to regression lines and hyperplanes can be adopted as the measure of deformation of fields of climatological elements by the surface relief (Stopa-Boryczka, Boryczka et al., 1989).

The differences between the measured values and those calculated from equations of regression hyperplanes can be treated as indicators of the strength of influence exerted by local geographical factors, such as relief forms or water bodies. Negative differences in mountain valleys are caused by frequent inversions of air temperature.

The accuracy of approximation of fields of climatological elements with equations of regression hyperplanes is quite high — according to Fisher-Snedecor test all the coefficients of multiple correlation are significant at the level of confidence of 95%. On the basis of t-Student test it can be stated that hypsometric gradients (partial correlation coefficients with regard to H) are significant for most months at the confidence level of 95% or 90%. Therefrom conclusion can be drawn that in the general population of observations there exists a dependence of climatological element fields upon the altitude above the sea level. When compared to altitude above the sea level and to latitude the third factor, i.e. longitude, affects much less the fields of climatological elements both in Poland and in Vietnam.

In order to complement the previous considerations one should notice that gradients are relatively low in some months — insignificant at the confidence levels of 95% or 90%. The hypothetical regression hyperplanes (in the population) are contained in the confidence intervals of $y(\varphi, \lambda, H) \pm 3\sigma$ (where σ is standard error) with probability 99.7%.

Determination of the scope of influence of the most important geographical factors upon the fields of climatological elements has essential importance for spatio-temporal modelling of climate changes in moderate and tropical latitudes.

It is of foremost importance for practical purposes to have equations of regression hyperplanes, which can be used for forecasting of particular climatological elements — estimation of average values, say — monthly, seasonal or annual — where measurements have never been conducted.

By reading from a map the values of φ, λ, H for any locality and by introducing them into equations of regression hyperplanes for Poland and Vietnam we can calculate with high accuracy such quantities es e.g. temperature, humidity, precipitation and wind velocity.

Such a kind of notation for the fields of air temperature, precipitation or other climatological elements made it possible to construct appropriate objective maps for Vietnam (see Nguyen Van Than 1990). This problem has been methodologically solved already on the example of Poland (Stopa-Boryczka, Boryczka et al. 1989, 1990).

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