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ON THERMAL CHARACTERISTICS ANALYSIS OF CITY CLIMATES

From the several-part *Atlas współzależności parametrów meteorologicznych i geograficznych w Polsce* (Atlas of correlations of the meteorological and geographical parameters in Poland), published by our faculty, we present some aspects of using forms of statistical and geographical periodic changes in the city heat island in various spatial and time scales, made for Warsaw and other European cities (Stopa-Boryczka, Boryczka et al., 1994, 1995).

The first step was establishing and nominating tens of models there (months, seasons, half-year and year periods) — fourth degree regression polynomials, describing latitude, longitude and hypsometric variety of air temperature in Europe (and separately for Poland).

And so a new item entered empirical formulae — altitude above sea level (besides latitude and longitude). The value of average temperature is in 98% described by a fourth degree polynomial. Only 2% covers local factors, including anthropogenic ones. In special cases the following profiles are used as models: longitudinal, latitudinal, hypsometric air temperature and profiles of components of temperature field gradients (longitudinal, latitudinal, hypsometric) — Figs 1a, 1b.

Differences between the measured values and those calculated from the model are a way of showing the influence of local factors, including anthropogenic ones, on the climate (city heat island) — Tables 1a, 1b, Fig. 2.

The sinusoids graphs of annual regressions in air temperature changes (average daily, maximum, minimum, daily amplitude), set for several tens of stations located near larger cities, describe the warmest and coldest places (time of day and time of year) in Europe (and Poland).

The sinusoids graphs of annual regressions (periods of 365.25 days) in air temperature changes between the centre (as a solid) and surrounding, determine the most important thermal characteristics of a city — i.e. Warsaw. The sinusoid extremes indicate places, where the city heat island is most intensive, or disappears. The amplitudes of regression sinusoids of air temperature between development — condensed, relaxed, park greens and city surroundings show the share of type of area in shaping the city heat island — Fig. 3.

Table 1a

Differences of air temperature $T_i - T_{obl}$ between T_i values and calculated by means of 4th degree multinominal T_{obl} in Europe — winter

Location	T_i	T_0	$T_i - T_0$		λ	H
Murmansk	-10.1	-9.595	-0.50	68°58'N	33°03'E	46 m
Reykjavik	0.1	0.469	-0.37	64°08'N	21°56'W	16
Aberdeen	3.0	2.890	0.11	57°12'N	01°12'W	59
London	4.6	5.012	-0.41	51°47'N	0°32'W	5
Dublin	4.9	5.059	-0.16	53°26'N	06°15'W	81
Oslo	-3.6	-2.084	-1.52	60°12'N	11°05'E	203
Stockholm	-2.0	-3.366	1.37	59°21'N	17°57'E	11
Paris	3.9	4.585	-0.68	48°58'N	02°27'E	53
Brussels	2.7	2.908	-0.21	50°48'N	04°21'E	104
Zurich	-0.2	-0.454	0.25	47°23'N	08°34'E	569
Helsinki	-5.1	-6.471	1.37	60°19'N	24°58'E	58
Prague	-1.7	-1.485	0.22	50°06'N	14°17'E	374
Budapest	0.5	0.824	-0.32	47°31'N	19°02'E	130
Bucharest	-1.0	1.987	-2.99	44°25'N	26°08'E	82
Sofia	-0.2	-0.122	-0.08	42°49'N	23°23'E	588
Belgrade	1.3	2.634	-1.33	44°48'N	20°28'E	132
Athens	10.1	8.006	2.09	37°97'N	23°72'E	107
Lisbon	11.3	11.19	0.11	38°46'N	09°08'W	110
Madrid	5.7	5.653	0.05	40°24'N	03°41'W	657
Naples	9.1	7.940	1.16	38°25'N	21°73'W	3
Moscow	-8.7	-9.671	0.97	55°45'N	37°34'E	156
Odessa	-1.2	-1.047	-0.15	46°29'N	30°38'E	64
Warsaw	-2.3	-2.553	-0.25	52°09'N	20°58'E	108

Table 1b

Differences of air temperature $T_i - T_{obl}$ between T_i values and calculated by means of 4th degree multinominal T_{obl} in Europe — summer

Location	T_i	T_0	$T_i - T_0$	Location	T_i	T_0	$T_i - T_0$
Murmansk	11.5	12.536	-1.04	Budapest	21.3	20.047	1.25
Reykjavik	10.7	10.747	-0.05	Bucharest	22.3	22.420	-0.12
Aberdeen	13.2	13.794	-0.59	Sofia	20.3	19.629	0.67
London	16.9	16.417	0.48	Belgrade	21.7	21.343	0.36
Dublin	14.7	14.401	0.30	Athens	26.5	24.987	1.51
Oslo	16.0	14.269	1.73	Lisbon	21.6	21.018	0.58
Stockholm	16.4	15.288	1.11	Madrid	22.8	21.196	1.60
Paris	18.4	18.066	0.33	Naples	22.9	23.300	-0.40
Brussels	17.2	17.314	-0.11	Moscow	17.6	17.442	0.16
Zurich	16.8	16.792	0.01	Odessa	21.2	21.988	-0.79
Helsinki	15.6	15.556	0.04	Warsaw	17.8	18.389	-0.59
Prague	17.2	17.670	-0.47				

Fig. 1a. Profiles of air temperature in Europe: longitudinal $T(\phi)$, latitudinal $T(\lambda)$ and hypsometric $T(H)$ — winter

$$T = 146.9 - 0.0087\phi - 0.2935\phi^2 + 0.0072\phi^3 - 0.00005\phi^4$$

$$T = 4.724 - 0.3461\lambda - 0.0057\lambda^2 + 0.0006\lambda^3 - 0.00001\lambda^4$$

$$T = 4.157 - 1.759H - 0.2003H^2 - 0.0091H^3 + 0.00013H^4$$

Fig. 1b. Profiles of air temperature in Europe: longitudinal $T(\phi)$, latitudinal $T(\lambda)$ and hypsometric $T(H)$ — summer

$$T = 71.9\phi - 0.0027\phi^2 - 0.0908\phi^2 + 0.0020\phi^3 - 0.00001\phi^4$$

$$T = 17.20 - 0.0127\lambda - 0.0014\lambda^2 + 0.0003\lambda^3 - 0.00001\lambda^4$$

$$T = 17.60 + 0.5702H - 0.1288H^2 + 0.0051H^3 - 0.00007H^4$$

Fig. 2. Annual changes of differences of air temperature $\epsilon_i = T_i - F(\phi_i, \lambda_i, H_i)$ between measured (T_i) values and calculated by means of 4th degree polynomial in Warsaw:
 1 — Bielany (relaxed development),
 2 — Obserwatorium (greens),
 3 — Okęcie (suburbia)

The discussed works also mention relations between various methods of dependence and intensity (simple regression, regression parable, hyper-surface regression equations) of the city heat island to the state of the atmosphere — air temperature, wind speed and nebulosity. The influence of condensed and relaxed development and park greens is also discussed.

Fig. 3. The course of daily changes of air temperature differences (ΔT) between the centre and surroundings of Warsaw in winter (XII, I, II) and summer (VI, VII, VIII) 1992.

A significant methodological and practical influence is in the described two types of model tendencies of climate changes, based on long chronological air temperature sequences, atmospheric rainfall and atmospheric circulation in several European cities.

Prognostic models of the first type describe natural (periodic) climate changes with the distinction of the anthropogenic (line) factor. The natural factor is the resultant of overlapping real cycles — included in dense oscillation spectra. Second type prognostic models were achieved by developing meteorological variables into the Tyler sequence (according to the smallest squares) in relation to four most important parameters of the Solar System. These statistic models were used to create two types of similar convergent prognosis: so-called climatologic and astronomic tendencies for changes in climate in the 21st century — Fig. 4.

REFERENCES

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