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Danuta Danielak, Witold Lenart

TEN YEARS OF EXPERIMENTAL HYDROCLIMATOLOGICAL STUDIES IN THE MASOVIAN GEOGRAPHICAL OBSERVATORY OF WARSAW UNIVERSITY AT MURZYNOWO NEAR PŁOCK

Since 1974 the Faculty of Geography and Regional Studies of Warsaw University has had a field station meant for research and didactic purposes, called presently Masovian Geographical Observatory in the village of Murzynowo on the Vistula, 15 kms down the river from Płock (Fig. 2). The scope of studies conducted in the station encompasses physical geography and problems of environment protection (Lenart 1978).

Hydrological and meteorogical measurements and studies conducted there concern the stationary analysis of selected elements of water balance, analysis of climatic changes taking place under the influence of industrial construction development, hydrological, hydrogeological, hydrobiological and aerosanitary monitoring, studies of water cycle in an experimental water basin as well as in water basins subject to the influence of anthropogenic pressure. Implementation of these quite broad and long-term studies takes place within the framework of a number of centrally financed research programmes, various orders, as well as Master and Doctoral dissertations.

Since 1978 the observatory has conducted meteorological stations, at Murzynowo, and in the area of the greatest Polish oil refinery in Płock. The measurement programme is gradually being broadened, in particular with respect to evaluation of the real precipitation, to measurement of the atmosphere chemistry, as well as observation of parameters and phenomena which influence the amount of area evaporation (actinometry, humidity and thermal parameters of the soil, gradient measurements of temperature, moisture, wind velocity and evaporation from the free water surface).

The meterological station at Murzynowo has relatively long measurement series of precipitation obtained with the rain-gauges of Hellmann type having receiving surface placed on the ground level (cavity pluviometers). Three such devices have been functioning since the beginning

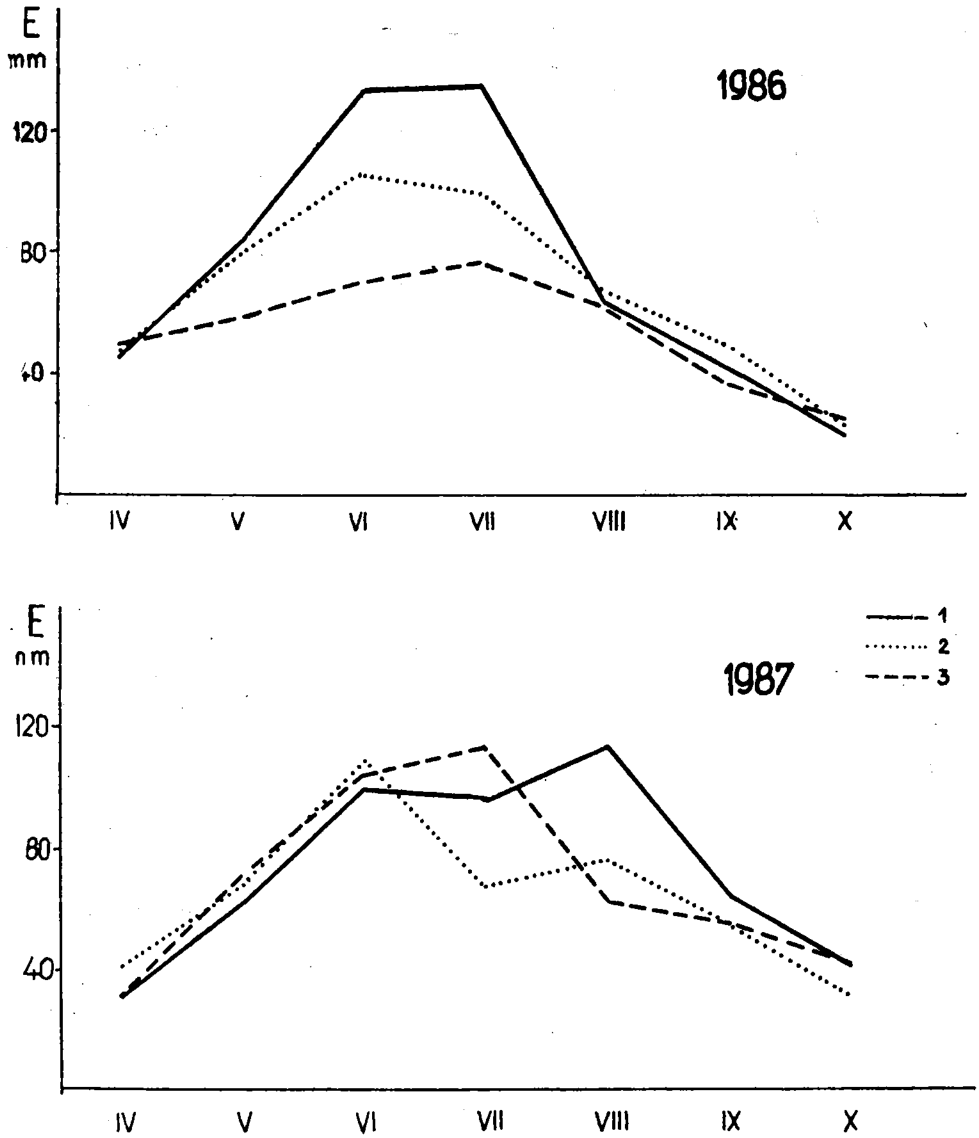

Fig. 1
Evapotranspiration totals at Murzynowo

of the station. Two of them are equipped with anti-splash grids according to the instructions of WMO. In one of the cavities there is, in place of a pluviometer, a mechanical pluviograph, and one of the rain-gauges is equipped with a string sensor. In 1986 a rain-gauge construction was mounted in Murzynowo with double open work shielding. With this respect advantage was taken of contacts with the Valdai Branch of the State Hydrological Institute in Leningrad. Aplication of the "Valdai" rain-gauge is justified first of all by the conditions of permanent precipitation and generally in the winter season.

Some results coming from the pluviometric field at Murzynowo were already published (Lenart 1981, 1985). In particular, use was made of the rich comparative material related to the adaptation to Polish conditions of the precipitation correction formula, proposed by the Danish Meteorological Institute

$$\frac{P_o - \Delta P_v}{P_o} = exp\,(a\,ln\,\bar{I}\bar{V} - b\,ln\,\bar{I} + c\bar{V} + d) \qquad (1)$$

where:

P_o —precipitation sum at the ground level, in millimeters;

$\bar{V}$ —wind velocity at the height of 10 mt. average taken over the precipitation period, in mt/sec.;

$\bar{I}$ —intensity of precipitation (millimeters per hour);

a, b, c —empirically determined coefficients.

It can be concluded that the aerodynamic error caused by the disturbances of the precipitation streams in the vicinity of the receiving vessel can be determined each time due to parallel measurements of wind velocities made at the level of the receiving device during precipitation and of precipitation intensity, the latter magnitude replacing fairly well the spectrum of precipitation droplets. Another serious problem is the extremely uneven distribution of precipitation cases within classes of wind velocity and rain intensity. The effect is the uncertainty of the correction proposed for cases with low precipitation intensity and high wind intensity, and vice versa. Observations from Murzynowo indicate that for wind velocities below 2.5 meters per second and rain intensities above 5 millimeters per hour the aerodynamic error equals the error of the corrective method, and therefore it can be neglected. In the opposite cases, i.e. for low rain intensities (below 0.25 mm per hour) and high wind velocities (above 8 m/sec.) the aerodynamic error expressed in percentage points is very important, reaching tens or even hundreds percent, and is very difficult to determine. That is why the series of pluviometric measurements in Murzynowo shall be prolonged in order to gather the maximum number of cases extreme in terms of precipitation intensities and wind velocities.

Experimental determination of the two other kinds of precipitation corrections was also carried out in Murzynowo; it was related to the moistening of the internal walls of the pluviometer and to evaporation of water from the reservoir. A single precipitation event causes wetting of the internal walls by the water layer of 0.13 millimeter, so that when measured precipitation sum of 0.0 mm is indicated by a meteorological station, this may mean that the true measurable precipitation amounted up to 0.4 mm (due to moistening, evaporation and aerodynamic error). Evaporation of water which is moistening the walls of the reservoir depends upon the season — during summer this may take 4—6 hours, while during winter even more than one day.

Interesting and rather surprising conclusions can be drawn from the comparison of precipitation sums measured by cavity rain-gauges and by those with the Valdai shield. They were compared within the precipitation classes of 0—5, 5—10 and more than 10 millimeters for the summer seasons of 1987 and 1988 (Table I).

More rain is caught by the cavity pluviometer and not by that with the Valdai-type shield. The difference is not very significant, but distinct, and even more distinct for less abundant precipitation events. To a certain extent this is explained by the decidedly lower losses due to moistening and evaporation in the cavity pluviimeter. That is why the differences at lower precipitation intensities are bigger. In view of

Table 1

Precipitation totals as measured with various types of pluviometers in Murzynowo

Classes of precipitation total magnitudes, in mm	Number of cases	Type of pluviometer		
		cavity	standard	"Valdai"
1987				
0—5	35	75.7	66.3	70.0
		114.2%	100.0%	105.6%
5—10	12	85.9	80.0	81.9
		107.4%	100.0%	102.4%
>10	4	66.3	64.2	65.2
		103.3%	100.0%	101.6%
1988				
0—5	27	65.1	53.1	54.9
		122.6%	100.0%	103.4%
5—10	9	65.4	58.8	59.6
		111.2%	100.0%	101.4%
>10	7	139.8	130.0	135.0
		107.5%	100.0%	103.8%

this, conclusion should be drawn from these results that the measurements provided by the Valdai rain-gauge are a few percent underestimations due to aerodynamic disturbances around the pluviometer itself and the Valdai shields. Therefore the applicability of these shields is limited to the winter season.

In 1980 two evaporimeters GGI-3000 were installed on land in the meteorological station at Murzynowo, with the method of water level read-out modified in Wrocław Agricultural Academy. This modification consists of application of mechanical recording of the water level of a microlimnigraph. In order to determine the differentiation of evaporation within the area of the experimental water basin the modified Wild's scales of the surface of 200 sq cms were used.

Evaporation meter GGI-3000, commonly used in Central and Eastern Europe, belongs to devices which function in conditions of an intensive heat exchange with the soil. It is a disadvantage, since evaporation values obtained cannot represent evaporation from larger water bodies (such as lakes and rivers), and on the other hand are not close enough to the real quantities of evaporating water from detention. Third, the sums indicated differ on the low side from the potential evapotranspiration. These features made the Soviet specialists propose a thermally isolated version of the evaporation pan. The GGI TM model eliminates the heat flows between water and soil, resulting from thermal differences related to daily temperature changes. Practically the whole heat exchange is limited to the one with the atmosphere. A prototype of this device was prepared on the basis of documentation obtained from the USSR and will be installed in Murzynowo. Serial production of this device is also in preparation.

Because of lack of lysimeters and soil evaporation measuring devices within the meteorological station, ground evaporation can only be determined via indirect methods. Thus, making use of meteorological data, ground evaporation was calculated with various methods adapted to Polish conditions (see Danielak and Lenart 1988). Annual evaporation totals obtained this way, approximating 500 millimeters, seem justified when compared to the corrected precipitation level of more than 600 millimeters and outflow of some 100 millimeters.

In 1986 and 1987, systematic ten-day soil humidity measurements have been conducted at Murzynowo and in the area of the oil refinery in Płock. Thus, it became possible to apply the method of field water use in the studies of evaporation from various anthropogenic surfaces (grass, fallow,...), referring to the formula

$$S = P_o + W_1 - W_2 \qquad (2)$$

where:

S — is field water use,

P_o — actual precipitation,

W_1, W_2 — are soil humidities corresponding to the beginning and the end of the calculation period.

Values of field water use are presented as a function of air humidity deficiency. It has been observed that the relation is more distinct for lower deficiency values, i.e. when values of ground evaporation are close to those of potential evaporation. On this basis the upper bound on the distribution function $E_o(d)$ could be determined:

$$E_o = ad^{0.67} \tag{3}$$

where:

E_o — is average ten-day potential evaporation in millimeters,

d — is the average ten-day air humidity deficiency (in hPa),

a — is seasonal empirical parameter.

Parameter "a" depends upon the surface cover and the development of vegetation. It can be treated as an index of transpiration. It displays a distinct seasonal variation for grass-covered areas, while is stable for the fallowed surface. The highest values of "a" for grass are attained in June and July (1.99), while the lowest ones — in October (0.85).

After the average values E_o had been calculated for particular ten--day periods, the evaporation β was determined as the ratio of the field water use to potential evaporation. Magnitudes of β were presented as a function of relative soil humidity, V_o. Dependence upon V_o was determined with the equation:

$$\beta = b\,(th\,V_o)^{0.75} \tag{4}$$

where "b" is a seasonal empirical parameter. This parameter determines the possibilities of the share of soil humidity in the evaporation process. The values of "b" range from 0.61 in April to 1.38 in July for the grass surface, while for the fallow surface they range from 0.84 in the spring, through 0.90 in summer to 0.77 in autumn.

Making use of dependences (3) and (4) and adopting the monthly values of parameters "a" and "b" the sums of monthly field evaporation were calculated according to the ultimate equation:

$$E = ad^{0.67}\,b(thV_o)^{0.75} \tag{5}$$

Results of calculations for the growing seasons 1986 and 1987, for fallow and grass surfaces in natural and anthropogenic conditions in Płock, are shown in Fig. 1. Appropriate comparison of the evaporation sums obtained with the values of field water use points out significant interdependence (correlation coefficient of 0.92).

Hydrologists from the University of Warsaw organized at the beginning of the 1980s an experimental water basin in Murzynowo, the basin encompassing 15 hectares and covering a portion of the slope of the Płock Upland towards Vistula. The purpose of the studies performed there is verification of physico-mathematical models of water cycle, these models involving differential equations with distributed parameters. The measurements carried out try to account for possibly many parameters influencing water cycle. Besides actual precipitation and evaporation such phenomena are taken into account in measurements as interception in a forest stand, radiation exchange within the forest, infiltration and humidity of soil, heat flux in the soil etc. Results have already been partially published, and theoretical foundations of the studies are also prepared for publication (Soczyńska 1984). The results of research conducted in the experimental basin in Murzynowo are being made use of in the international cooperation within the framework of IHP UNESCO.

The same programme includes, since its IV-th phase, the subject of "Floodplain water resources hazard management", presently carried out in collaboration with hydrologists and chemists from the Federal Republic of Germany. From the Polish side the object of research is the downstream part of the right-hand side confluent of the Vistula near Płock. This area is well equipped with adequate measurement installations from the Observatory. Hydrogeochemical changes taking place in the valleys of large rivers are presently an especially interesting subject of studies.

The observatory in Murzynowo is also conducting studies of urban climate. Within this domain the work has virtually been terminated devoted to estimation of deformation of heat and humidity under the influence of a large industrial plant, such as petrochemical plant in Płock (see Lenart and Danielak, 1988).

On the other hand, studies concerning implementation of local environmental monitoring system, involving quick diagnosis-forecast of aerosanitary conditions, are being continued. It is this purpose that shall be served by the measurement field with a 49-meter mast, making it possible to register the changes of thermal and humidity stratification o fthe ground-boundary layer of air. This equipment shall cooperate with "sodar" (acoustic registering of thermal stratification in the layer of 0—1000 mts) and the raman lidar for remote measurement of concentration of pollution.

It should be expected that at the turn of the 1990s the process of organization of the system of environment-related measurements in the region of Płock shall be terminated, and that the Masovian Geographical Observatory shall have at its disposal one of the most complete networks of hydrological, geochemical and meteorological measurement device in Poland fit for studying the functioning of various local natural systems.

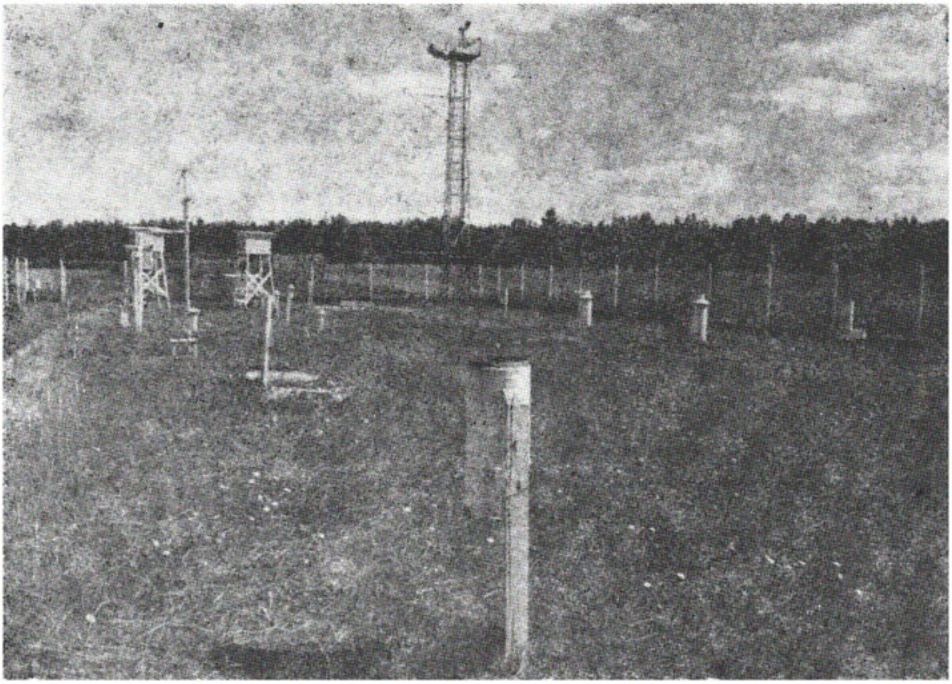

Fig. 2. The Geographical Observaeory at Murzynowo

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