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INFLUENCE OF ATMOSPHERIC CONDITIONS ON TRAFFIC ACCIDENTS. THE CASE OF RADOM

When considering the influence exerted by the atmospheric conditions on transport we most often think of either the obvious direct impact of the atmosphere on the state of roads (slipperiness) or of the one entailing a worsening of driving conditions (fog or snow storm), while devoting much less thought to the influence of weather on the psychological and physical state of the persons participating in road traffic. Still, the processes taking place in the atmosphere influence certainly the psychophysical state of both the drivers and the pedestrians using roads.

Accident rate is a quite well measurable characteristic of the psychophysical state of the drivers, which changes under the influence of, in particular, pressure settings, nature and activity of atmospheric fronts, and thermal environment. The influence of these factors is felt both by the persons who are ill or particularly sensitive to weather changes, and by the healthy, but tired persons. Lowered efficiency of the organism entails increased probability of an accident, and the fact that the weather factors negatively influencing the organism occur most often along with the atmospheric phenomena making driving difficult, yet adds to the degree of hazard in road traffic.

In order to demonstrate the influence of atmospheric processes on humans, reflected through the increase or decrease of the number of road accidents and collisions, documentation was analysed concerning traffic accidents and collisions which occurred in 1993 in Radom, a town of approximately 250 thousand inhabitants in central Poland. In the search for dependence upon the meteorological data use was made of the classification of pressure settings and fronts, elaborated by Baranowska (1985), which served for determination of correlations with the daily numbers of road accidents and collisions. On the basis of the classification mentioned eleven types of settings were distinguished, which can be shortly characterized as follows: W — high pressure, OW — increased pressure area with weak gradients, ON — lowered pressure area with weak gradients, N — low pressure, Np — low pressure area with center over Poland, Ns — edge of a low pressure area, Z — low pressure embayment, Zw — low embayment in

high pressure area, Kf — high pressure wedge appearing behind a cool front, N-W — transitory situation between low and high pressure, W-N — transitory situation between high and low pressure. Atmospheric fronts were classified depending upon their kind (cool, warm, occluded, stationary) and intensity (strong, weak), determined on the basis of velocity of translocation and the magnitude of changes in the meteorological elements, caused by the front. It also became necessary to classify days into the ones with appearance of the phenomena which may make driving difficult (precipitation, fog, glaze) and the ones without such phenomena. Additionally, on the basis of distribution of the daily number of accidents (Nca) distinction was adopted of the safe days (Nca = 0 or 1), neutral days (Nca = 2 or 3), and dangerous days (Nca of at least 4), as perceived from the point of view of traffic participants. Then, the essence was analysed of the differentiation of daily accident numbers in the days characterized by the characteristics mentioned.

Table 1 suggests that the greatest increase of the accident rates is observed for the cyclonal situations, such as Low, Low with center over Poland, and Low embayment in a High, though this increase is not so big as the decrease associated with the anticyclonal situations. Yet, the result quoted can be influenced also by the phenomena making driving difficult, which appear together with the cyclonal situations, and by the lack of such phenomena in case of anticyclones.

Table 1

Average number of road accidents and collisions (Nca) during particular pressure situations (Radom, 1993)

Pressure situations	Numbe of days	Nca	Average Nca	Difference with respect to the overall average
N	65	266	4.09	+0.66
Np	26	103	3.96	+0.53
Ns	8	29	3.63	+0.20
Z	48	171	3.56	+0.13
ON	37	124	3.35	–0.08
OW	31	103	3.29	–0.14
W	84	213	2.54	–0.89
Zw	11	45	4.09	+0.66
WK	29	103	3.55	+0.12
N-W	9	31	3.44	+0.01
W-N	17	64	3.76	+0.33
Totals	365	125	3.43	0.00

The number of days classified as those without impediments to driving was 153, of which 36.6% featured high pressure situations, which are very rarely accompanied by the phenomena that make driving difficult. During the days of a good state of roads the degree of safety decreases with appear-

ance of a Low (only 8% of days with a Low are safe), of a Low with center over Poland, or a weak-gradient High (5%), and increases in a High (39%) and High wedge (38%) following a cool front. More than a half of cases of a Low (58%) are accompanied by neutral days, similarly as in the case of the weak gradient Low (59%). The dangerous days are most often encountered in the situation of an embayment (40%) or a High "null" (58%). A distinct decrease of the number of dangerous days is seen in the situation of a High (only 20% of all the occurrences), a wedge of a High (15%), and a Low "null" (18%), which can in this situation be considered as advantageous for the road traffic. There were so few other atmospheric situations in this group that no further conclusions were drawn on their basis.

Table 2

The shares of the days with a front in a year and the accident rate during these days (Radom, 1993)

Fronts	Nca [%]	Number of days [%]
Warm and strong (Fw!)	6.87	4.66
Cold and strong (Fc!)	10.07	6.58
Other strong (Fo!)	3.12	2.19
Warm and weak (Fw)	3.68	4.93
Cold and weak (Fc)	6.24	7.94
Other weak (Fo)	2.88	3.84
A multiple front day	6.39	6.30
Whole year	39.2	36.4

There were as many as 212 days with driving impediments in 1993 in Radom, out of which 52.4% were the cases of a Low (25%), an embayment of a Low, and Low over Poland — i.e. the group of situations of a cyclonal character, oftentimes accompanied by the weather making driving difficult. A significant decrease of the number of safe days is characteristic for an embayment (only 3% of all the occurrences) and the High wedge following a front (6%), while an important share of such days, in spite of existence of impeding phenomena, coincides with the High (21%) and Low over Poland (28%). The Low embayment mentioned is most often accompanied by the neutral days (52%), whose number is lower, on the other hand, in the situation of a High wedge behind a cool front. The increase of the number of dangerous days with conditions of difficult driving appears together with the wedge behind a cold front, an edge of the Low, or an embayment in a High, which — although occurring rather rarely — when appearing together with difficult driving conditions, entail a significant increase of the accident rate.

Due to low frequency of appearance of some pressure situations all of them were grouped into three kinds: cyclonal, anticyclonal, and remaining ones. Although the values quoted here do not have statistical meaning in

view of low cardinalities of respective data sets, there is a distinct trend of change in the Nca showing dependence upon the nature of atmospheric pressure situation. Thus, in the group without impediments (see Table 3) the number of days with high accident rates increases by 10% for the cyclonal situations. Simultaneously, the share of dangerous days decreases by the same proportion in the case of anticyclonal situation. In addition, there is a statistically significant (at the level of $\alpha = 0.10$) increase of the safe days during Highs and High wedges following cold fronts. In the group of days with impediments (Table 4) these trends are not so clear, the distribution is close to the average. On this basis it is feasible to forward the proposition that the cyclonal situations are more conducive to accidents than the anticyclonal ones.

Table 3

Accident rates in groups of pressure situations during the days without impediments to traffic (Radom, 1993)

Pressure situations	% of safe days	% of neutral days	% of dangerous days
N, Np, Z	18	43	39
W, Kf	39	42	19
other	27	46	27

Table 4

Accident rates in groups of pressure situations during the days with impediments to traffic (Radom, 1993)

Pressure situations	% of safe days	% of neutral days	% of dangerous days
N, Np, Z	14	36	50
H, Kf	16	34	50
other	21	34	45

The cyclonal situations, entailing the increase of accident rates, are unavoidably connected with appearance of atmospheric fronts, and so one might expect more frequent accidents during the days when fronts passed. In fact, even the most general characteristics provided by the percentage shares of days with atmospheric fronts and the corresponding shares of the numbers of traffic accidents and collisions (Table 2) illustrate well the increase of accident rate during the days with strong fronts, irrespective of the nature of the front, as well as lack of influence of the weak fronts. In altogether 72.1% of days with a weak front Nca was below the average, while in 69.4% of days during which a strong front or two fronts passed over Radom Nca exceeded the average. The highest increase of accident rates accompanied strong cold fronts, so that in 87.5% of such situations Nca was above the average, while for the strong warm fronts the respective share was at 82.4%. The increase of the daily number of accidents (from 0 to the absolute maximum of 14) was accompanied by the increasing frequency of the strong fronts, and the decreasing frequency of the weak fronts. Thus, only 33.3% of the strong front and multiple front days were associated with the Nca between 0 and 3, while 73.8% of the weak front days coincided with these Nca values. Altogether 42% of the days in the year with Nca exceeding 8 were associated uniquely with appearance of the strong fronts.

This general characterization demonstrates only the increase of accident rate brought by the active fronts. It does not, though, provide the explanation whether this dependence results from the phenomena which accompany the fronts, and make driving more difficult (precipitation, abrupt drops of temperature leading to glazing of the road surface, etc.), or from the weather-induced impact on humans due to the rapid changes in meteorological elements (pressure and temperature fluctuations, high degree of cloudiness).

Table 5

Accidents according to groups of fronts, during the days with impediments to traffic (Radom, 1993)

Atmospheric fronts	% of safe days	% of neutral days	% of dangerous days
Strong	10	30	60
Weak	50	31	19
No fronts	27	45	28
Average	28	42	29

Table 6

Accidents according to groups of fronts, during the days without impediments to traffic (Radom, 1993)

Atmospheric fronts	% of safe days	% of neutral days	% of dangerous days
Strong	8	23	69
Weak	13	60	27
No fronts	19	30	51
Average	15	34	51

There are only 26 days without impediments to driving in the group of days with an atmospheric front, which is quite obvious, since fronts are only very rarely not accompanied by strong atmospheric phenomena. Yet, even within such a limited set of observations the influence of the strong cold front in terms of increased accident rate, notwithstanding lack of impediments to driving, is well seen. On the other hand, appearance of a weak cold front, not accompanied by dangerous phenomena, entails a significant increase of the number of safe days, implying lack of meteorotropic action of the inactive fronts. In the group of days without fronts the distribution is almost perfectly following the averages. In the version of analysis accounting for the impediments to driving the set of days with fronts increases to 107. An active warm front causes an enormous increase of accident rates; all of its appearances are concentrated in the group of dangerous days. The strong fronts are generally well represented only in the class of dangerous days (differences with respect to the average frequency ranging between 20% and 50%), since in cases of strong fronts the small daily numbers of accidents do practically not occur. The weak fronts, and especially the warm one, are most often accompanied by neutral days (difference with respect to average frequency between 30% and 40%). They also bring a decrease of the share of dangerous days.

In order to deal with bigger sets of observations all fronts were classified into only two groups, namely of strong and weak fronts. It is this characteristic that shows most clearly the meteorotropic nature of influence exerted by the fronts (Tables 5 and 6). Passing of a strong front entails a doubling of

the frequency of days with high Nca with respect to the average, even if no phenomena making driving objectively more difficult accompany it. The influence of the weak fronts is quite to the contrary, since when they appear in the group without impediments they usually qualify to the class of the safe days (Table 5). The phenomena accompanying the passage of these fronts do not exert any important influence upon the levels of accident rates. One observes, though, an essential decrease — by 24% — of the number of days with high Nca in the presence of weak fronts, as well as an increase of the share of neutral days in case of such fronts (Table 6).

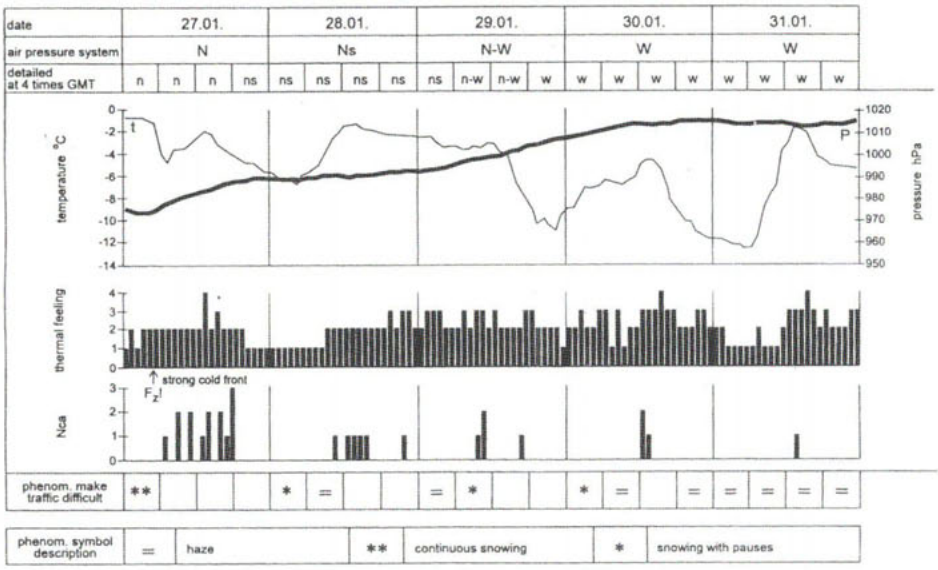

Fig. 1. Biometeogram showing ther weather conditions and thermal feeling during air pressure system transition from low to high in connection with number of road colisions and accidents in those days (Radom, 1993).

Summing up the results reported here one can state that the negative meteorotropic influence is exerted by the cyclonal settings either developing over Poland or with the center moving over our country, and by the low pressure wedge. These active situations, through the related high temporal variability of weather elements, have a negative impact on men, causing indirectly an increased frequency of accidents. A positive influence is exerted, on the other hand, by high pressure situations, featuring stability and lack of rapid changes of meteorological elements, and usually sunny weather, and so improves the psychophysical condition of humans, reflected through the decrease of the number of accidents. Certain situations, such as low pressure area featuring weak gradients and a change from a Low to a

High, have not been associated in the analysis with any definite bias in the data, and so may be regarded as neutral for the human organism.

It turned out that atmopsheric fronts constitute the strongest meteorotropic determinant of the accident rates. Thus, passage of a strong cold front, linked with weather changes which put a stress on the adaptive mechanisms of human beings, and in extremal conditions disturb the psychophysical efficiency of man, finds the most distinct reflection in terms of the increased number of accidents. The passage of weak fronts is not reflected in the dynamics of the number of accidents, remaining then at the average level. Meteorotropic impact of the strong fronts and multifront days can generally be concluded.

The biometeorogram enclosed constitutes the best illustration for the dependences uncovered. It presents the change of the pressure situation from cyclonal to anticyclonal, and the accompanying atmospheric phenomena, pressure and air temperature changes, as well as thermal feeling (according to the scale of 1 — very cold, 2 — cold, 3 — cool, 4 — comfortable) — see Baranowska et al., 1986, against the background of the number of accidents.

REFERENCES

Baranowska M., Wojtach B., 1985, Charakterystyka biometeorologiczna układów barycznych dla potrzeb osłony ruchu drogowego (Biometeorological characteristics of pressure settings for purposes of road traffic protection; in Polish), Typescript of IMGW.

Baranowska M., Boniecka-Żółcik H., Gurba A., 1986, Weryfikacja skali klimatu odczuwalnego dla Polski (Verification of the scale of perceived climate for Poland; in Polish), *Przegląd Geofizyczny*, 1.