Surface ozone and artificial β^- activity in Dresden-Wahnsdorf

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ABSTRACT

In the German Democratic Republic ozone and radioactivity network at 5 stations simultaneous measurements of surface ozone are made by the chemical method of Cauer and of artificial activity by filter sampling. The daily maximum values of surface ozone and the daily mean of radioactivity show relations in their seasonal trend. The results of these investigations at Dresden-Wahnsdorf station (51.1° N, 13.7° E) are discussed.

In years without nuclear tests (1963 and 1964) there was a statistically significant positive correlation between ozone and radioactivity from March until September. In a year with fresh fission production (1962) there was such a correlation during the time of decreasing activity from June until August. From October until February the correlation in the years 1962 to 1964 was mostly negative, in part statistically insignificant.

The relation of ozone and radioactivity data for large-scale weather systems and during periods with and without precipitation was investigated for daily deviations of ozone and radioactivity from their seasonal trend, smoothed by overlapping ten-day averages. Deviations which were higher or lower than the single value of the standard deviation as well as averaged values of the deviations are discussed.

On days with southerly air flow in the 500 mb region there is an increase of ozone and radioactivity; there is a decrease on days with northerly air flow. The influence of wash out is indicated by an increase during dry weather periods and a decrease during periods with precipitation.

From March until September there are similar deviations from the seasonal trend for both ozone and radioactivity. From October until February there is an inverse trend due to the influence of large-scale weather systems with a stable stratification (central high pressure systems). Ozone decreases due to the accumulation of reducing trace constituents in surface air, while radioactivity decreases due to the increased rate of scavening by dust.

1. Introduction

Atmospheric ozone and artificial fission products have gained great importance for the enlightment of the problems of the general circulation of the atmosphere. While the nature of both these tracer elements is different physically and chemically, their modes of formation and destruction are similar. Their sources are in the stratosphere, their sinks at the ground. Furthermore, there are relations regarding their geographical distribution and their annual variation. JUNGE (1962) has drawn attention to a detailed analysis of the variations of ozone and radioactivity being of great significance to the treatment of problems associated with vertical transport, inter-hemispherical exchange and destruction and the rate of deposition within the atmosphere and at the earth's surface.

Expecting relations between ozone and artificial fission products as to their time and local variation to occur not only in higher layers of the atmosphere but even near the earth's surface appears to be justified though there are differences in the times of residence and the rate of deposition, which has already been mentioned by a number of authors. However, due to the absence of longer measuring series of simultaneous surface ozone and activity measurements it was so far impossible to give reasonable evidence. NEUWIRTH (1955) quotes LOSSNITZER as having remarked as early as in 1951/52 that clouds of radioactive air were assumed to be of some concern to meteorology in connection with ozone measurements. NEUWIRTH (1955) further says that he had investigated the relations between surface ozone and artificial activity using ozone measurement made on the Feldberg/Black Forest and at St. Blasien based upon a rather small volume of data; however, there were no conclusive results. Relations between both elements are to be expected, "because the transfer rate of radioactive debris is similar to that of ozone if sedimentation of debris is not taken into account".

In this connection attention should be drawn to a remark made by F. I. Badgley on a study by MACHTA (1959). The question "whether or not surface ozone could be used for a correlation with radioactivity" is answered by Miyake (cf. MACHTA (1959), p. 287) by saying "that he has conducted the correlation calculation without finding any relations". MIYAKE & KANAZAWA (1964), however, have recently investigated the relations between atmospheric ozone and radioactive fall-out for various stations of the Northern hemisphere between 30° and 51° N (U.K., Canada, Japan, U.S.A.) using also data of surface ozone "though there are only a few available data". Unfortunately, details of the investigation have not yet been published. In a more recent paper VASSY & TANAEVSKY (1964) report on the relations between artificial radioactivity and surface ozone. The authors find that a pronounced increase of ozone within 24 hours is associated with a significant increase of activity.

On a network basis in the German Democratic Republic (GDR) since 1952 surface ozone measurements have been made at 7 stations, radioactivity measurements since 1960 at 9 stations. With simultaneous measurements of surface ozone and artificial atmospheric activity being available of 5 stations (Arkona 54.7° N, 13.4° E; Brocken 51.8° N, 10.6° E; Dresden-Wahnsdorf 51.1° N, 13.7° E; Kaltennordheim 50.7° N, 10.2° E; Potsdam 52.4° N, 13.1° E) it was now possible to investigate the problem of existing relations based upon a larger volume of data. An extract of the results of these investigations conducted at Dresden-Wahnsdorf Observatory is presented hereinafter. An evaluation of the data from remaining stations is being prepared.

2. Investigations made hitherto

Meteorological processes are decisive contributors to the behaviour of space and time variations of atmospheric ozone and radioactive contaminants. According to MARQUARDT (1964) there is between surface ozone and artificial activity for a number of stations of the GDR network a positive correlation of the interdiurnal variability, and an inverse diurnal variation of surface ozone and natural activity on meteorological undisturbed days (MARQUARDT, 1961). From investigations made by the author (WARMBT, 1964*b*) we obtained a parallel diurnal variation between surface ozone and artifical activity in Dresden-Wahnsdorf. There was the further result of a quasi-parallel run of the five-day overlapping averages of maximum concentration of surface ozone and of the diurnal means, smoothed in the same manner, of artifical activity in Dresden-Wahnsdorf in July/August 1963 (WARMBT, 1964*b*). There was the further evidence that the absolute monthly maxima of surface ozone and of artificial activity in Dresden-Wahnsdorf in summer months do frequently occur on the same days.

3. Recent research results

As an extension of research work made hitherto we have for Dresden-Wahnsdorf investigated the statistical relations between surface ozone and artificial activity, utilizing a larger volume of data, and shown relations to a number of meteorological processes.

Geographical situation of the station: The Dresden-Wahnsdorf Meteorological Observatory is situated on the highest point (246 m above m.s.l.) of an elevation, wind-exposed and sloping down towards the Elbe river valley, about 15 km Northwest of the City of Dresden.

Measuring methods: Surface ozone is measured chemically (Cauer method) followed by a conductometric evaluation (after Teichert/Greifenhagen). WARMBT (1964*a*) has reported in detail on the methods and results of air-chemical investigations of surface ozone (1952/61). In 1962/63 measurements had been made at 6 hour intervals (00, 06, 12, and 18 hours), in 1964 every 3 hours (00, 03, 06, ... hours). The duration of the measurements is 1 hour, the volume of air is 100 litres. Atmospheric activity is controlled by deposition of radioactive aerosol onto a fibre filter, after 3 days the sample is evaluated by a Geiger-Müller counter. The filter is replaced after a 24 hour operation at 7 a.m.

Investigation period: The statistical evaluation was made for the interval 1962/64. While in 1962 there were still fresh fission products in the atmosphere, the remaining investigated period coincides with decreasing activity. The nuclear test explosion of October 16, 1964, in the Takla Maran desert (People's Republic of China) was, however, clearly noticeable (Fig. 3), though the bomb had merely a small strength of explosion of ~20 kt TNT.

3.1. *Correlation calculations*

To eliminate random variations in the measurements we have applied 5-day overlapping averaging to the daily values of maximum ozone concentration (x_i) and the diurnal means of artificial activity (y_i). The maximum ozone concentration is, as is well-known, after JUNGE (1962) particularly suitable for investigations of atmospheric exchange and transport processes as they are typical for the lower troposphere ozone content. The x_i and y_i values have additionally been combined into decades and decadic means. In order to illustrate more clearly the predominant annual variation the decadic means have been averaged by 3-fold overlapping (Fig. 1). It can be seen that the annual variations of both elements are rather different in detail. In the years 1963/64 the predominant trend is clearly seen.

For an investigation of how far there are any relations between diurnal variations of surface ozone and artificial activity we have computed the correlation factor for each month. To avoid any spurious correlation we eliminated the annual variation in both elements. Consequently, we have determined the diurnal deviations of x_i and y_i from the annual variation of the decades, i.e. by linear interpolation between the smoothed decadic means for each day (i) a normal value (0) of the annual curve for ozone and activity was determined. Hence, daily deviations for ozone are $d = x_i - x_{i0}$ and for activity $e = y_i - y_{i0}$. In ad tio we have computed for the daily deviations the monthly standard deviation of surface ozone (σ_m) and of activity (τ_m).

For a simplification of the following operations and to exclude the varying annual amplitude of diurnal deviations we have established standardized values

$$\xi_i = \frac{x_i - x_{i0}}{\sigma_m} \quad \text{for ozone}$$

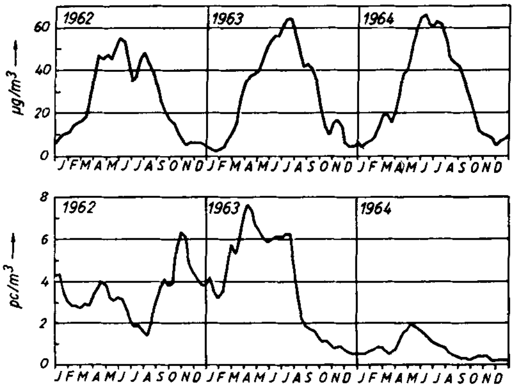

FIG. 1. Smoothed annual variation of diurnal maximum concentration of surface ozone and artificial β^- activity, Dresden-Wahnsdorf (1962–1964).

and $$\eta_i = \frac{y_i - y_{i0}}{\tau_m} \quad \text{for activity.}$$

The correlation coefficient is then derived, as is well known, from

$$r = \frac{1}{k}\sum \xi_i \eta_i$$

where k = number of pairs of values.

Table 1 presents the standard deviations of the daily deviations and the correlation coefficients. Fig. 2 shows the variation of the ξ_i and η_i values for 1964. On account of the standardization the deviations of both elements in the individual months are of equal magnitude. The same applies to the 1962/63 data which, for reasons of available space, are not published in this paper. All ξ_i and η_i values ≥ 1, ≤ -1 are specially marked by hatching as these significant deviations (peaks) will be discussed with a view to relations to meteorological processes.

Discussion: In the years when there were no nuclear tests (1963/64) surface ozone and activity are marked from March to September by positive correlation, proved by a confidence limit $P = 5\%$. During this period the daily variations of both elements are controlled by meteorological processes by which, due to vertical exchange, air enriched with ozone and fission products is transported down to the ground. It should be noticed that in summer months there are high positive correlation coefficients even in years with high activity

TABLE 1. *Standard deviations and correlation coefficients of deviations of maximum concentration of surface ozone and artificial activity.*

Bracketed values are statistically not significant ($P > 5\%$).

	Ra (pcm^{-3}) τ_m	O_3 (μgm^{-3}) σ_m	r
1962			
Jan.	0.75	4.0	(0.012)
Feb.	0.53	5.9	(0.214)
March	0.92	6.0	(0.086)
Apr.	1.25	8.6	(−0.127)
May	0.57	6.6	(0.281)
June	0.70	10.6	0.983
July	0.48	11.3	0.900
Aug.	0.31	6.0	0.445
Sept.	0.71	7.9	0.429
Oct.	1.71	5.1	(0.138)
Nov.	4.28	3.0	0.775
Dec.	1.51	2.9	(0.107)
1963			
Jan.	1.18	1.8	0.689
Feb.	0.73	2.4	−0.371
March	1.78	7.0	0.609
Apr.	1.79	7.8	0.796
May	2.39	7.6	0.507
June	1.28	9.0	0.509
July	1.22	8.2	0.847
Aug.	1.11	11.1	0.816
Sept.	0.38	8.3	0.669
Oct.	0.18	5.2	(−0.268)
Nov.	0.21	9.5	(−0.215)
Dec.	0.11	3.0	0.585
1964			
Jan.	0.06	3.5	−0.441
Feb.	0.13	7.0	−0.545
March	0.19	10.7	0.568
Apr.	0.31	9.9	0.485
May	0.29	8.5	0.566
June	0.29	8.4	0.538
July	0.27	14.2	0.751
Aug.	0.10	5.7	(0.220)
Sept.	0.07	7.3	0.479
Oct.	0.15	5.5	(−0.015)
Nov.	0.19	6.5	−0.547
Dec.	0.04	4.0	(−0.035)

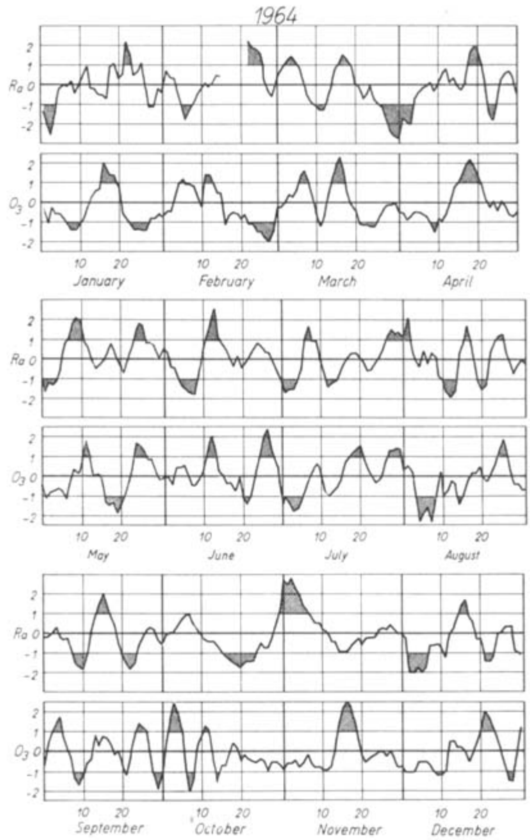

FIG. 2. Normalized deviations of maximum concentration of surface ozone and artificial β^- activity of annual variation of 1964 (ordinate: units of standard deviation).

values (1962/63). To illustrate this, we separately present the behaviour of the standardized values for the months of July from 1962 to 1964 (Fig. 3).

From October to February the correlation is generally negative and in most cases statistically not proved. During this period, when there is a predominantly stable stratification of the atmosphere, mass exchange due to vertical transport is of minor importance. It must further be mentioned that surface ozone during this period is chemically destroyed by reducing tracer elements, while atmospheric activity is generally decreased due to the small transfer rate and the increased rate of scavenging by dust (ZIER, 1964).

Deviations from this normal behaviour are observable with the occurrence of fresh "clouds" of fission products. They are supposed to be responsible for such investigations during the nuclear tests (cf. Miyake in MACHTA (1959)) not having supplied the expected results. Our data revealed such disturbing effects in 1962 and in October/November 1964 (Chinese nuclear test). It is, however, remarkable, that during periods of decreasing activity even in 1962

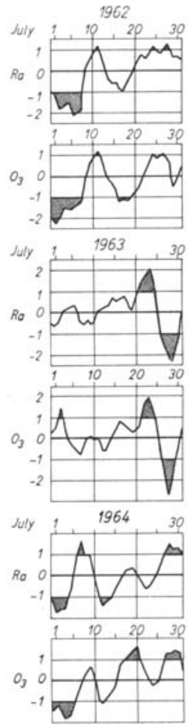

FIG. 3. Normalized deviations of maximum concentration of surface ozone and artificial β^- activity of annual variation of months of July 1962 to 1964 (ordinate: units of standard deviation).

(June to September) there is a positive correlation, similar to the one of the 1963/64 summer months.

3.2. *Relations to meteorological processes*

To investigate how meteorological processes produce significant deviations of ozone and activity from the annual variation, we have investigated the periods (hatched areas in Fig. 2 und 3) with $\xi_i, \eta_i \geq 1, \leq -1$ as to their possible relations to large-scale weather systems and precipitation activities.

Large-scale weather systems. To illustrate the large-scale synoptic development we have utilized the large-scale synoptic patterns published monthly by the Deutscher Wetterdienst, following HESS-BREZOWSKY (1952). The classification is for periods with a uniform flow at 500 mb over Central Europe. Such a procedure naturally involves some deficiencies, as the source regions of the air masses occurring over

TABLE 2. *Classification of large-scale weather systems.*

Large-scale synoptic patterns	Large-scale weather systems
HM, BM	H
TM, TrM	L
W	W
SW, TrW, TB, S, SE	S
HN, HB, N, NW	N
HF, HNF, NE, wW	E
U	U

Central Europe do not allow unambiguous identification. Further, the allocation of upper-air flow involves a certain variability. For a reasonable limitation of the number of categories we have combined the large-scale synoptic patterns into large-scale weather systems (LSW), Table 2. (For abbreviations cf. HESS-BREZOWSKY, 1952.)

In such a way we obtain 6 large-scale weather systems:

Central high pressure over Central Europe . . – H
Central low pressure over Central Europe . . – L
Large-scale synoptic system with predominantly westerly flow . . . . – W
Large-scale synoptic system with predominantly southerly flow . . . . – S
Large-scale synoptic system with predominantly northerly flow . . . . – N
Large-scale synoptic system with predominantly easterly flow . . . . – E
Transitional situations which are of smaller number and which have no uniform direction of flow . . . . – U

Precipitation. To illustrate precipitation conditions we have applied a largely simplified system and classified days with precipitation (R) and without precipitation (D). A day is called D if it is within a period of ≥ 2 days duration without any precipitation or, respectively, with an amount of precipitation of 0.0 mm. Single days without precipitation, however, embedded into a period of precipitation days are marked R. Such a rough procedure can be no more than a first approximation to the time development of precipitation activity as neither its type, its amount nor its duration have been taken into account. We, nevertheless, kept to such a simple classification, convinced that a more detailed subdivision would have complicated the statistical evaluation. For the

TABLE 3. *Large-scale weather systems and normalized deviations for surface ozone and artificial activity.*

Large-scale weather syst.	H	L	W	S	N	E	U	Σ
SURFACE OZONE								
(a) *October–February*								
All days	108	34	81	88	103	24	16	454
Days with $\xi_i \leqslant -1$	28	15	8	29	16	4	3	103
$\xi_i \geqslant 1$	17	1	21	12	18	6	2	77
(b) *March–September*								
All days	103	22	143	157	113	72	32	642
Days with $\xi_i \leqslant -1$	11	7	31	20	32	15	8	124
$\xi_i \geqslant 1$	36	2	19	33	9	11	4	114
(c) *Year*								
All days	211	56	224	245	216	96	48	1096
Days with $\xi_i \leqslant -1$	39	22	39	49	48	19	11	227
$\xi_i \geqslant 1$	53	3	40	45	27	17	6	191
ACTIVITY								
(a) *October–February*								
All days	106	34	81	88	103	20	16	448
Days with $\eta \leqslant -1$	17	5	14	11	22	1	2	72
$\eta \geqslant 1$	18	—	10	19	10	8	2	67
(b) *March–September*								
All days	103	22	139	156	113	72	32	637
Days with $\eta_i \leqslant -1$	9	9	23	19	42	19	4	125
$\eta_i \geqslant 1$	23	—	22	42	11	23	5	126
(c) *Year*								
All days	209	56	220	244	216	92	48	1085
Days with $\eta_i \leqslant -1$	26	14	37	30	64	20	6	197
$\eta_i \geqslant 1$	41	—	32	61	21	31	7	193

same reason we restrained from arrangement of the data by years with and without fresh fission products.

Discussion. In Tables 3 and 4 the number of normalized deviations ξ_i, $\eta_i \geqslant 1$, $\leqslant -1$ for large-scale weather systems and precipitation characteristics are presented. Fig. 4 shows the percentage distribution of selected ξ, η classes, Fig. 5 the ξ and η mean values for the same meteorological parameters.

TABLE 4. *Days with and without precipitation and normalized deviations for surface ozone and artificial activity.*

Surface ozone	D	R	Σ	Activity	D	R	Σ
(a) *October–February*							
All days	172	282	454	All days	170	278	448
Days with $\xi_i \leqslant -1$	54	49	103	Days with $\eta_i \leqslant -1$	20	52	72
$\xi_i \geqslant 1$	27	50	77	$\eta_i \geqslant 1$	40	27	67
(b) *March–September*							
All days	300	342	642	All days	298	339	637
Days with $\xi \leqslant -1$	38	86	124	Days with $\eta_i \leqslant -1$	37	88	125
$\xi \geqslant 1$	92	22	114	$\eta_i \geqslant 1$	92	34	126
(c) *Year*							
All days	472	624	1096	All days	468	617	1085
Days with $\xi \leqslant -1$	92	135	227	Days with $\eta_i \leqslant -1$	57	140	197
$\xi \geqslant 1$	119	72	191	$\eta_i \geqslant 1$	132	61	193

From *March to September* there are on the average positive deviations of ozone and activity with the large-scale weather systems H and S and during dry periods (D). Negative deviations of both elements do occur with the L- and N-systems and on days with precipitation (R). The ozone and activity deviations during this period are of equal sign and amount—making the aforementioned positive correlation of the ξ, η values for the period March to September appear rather sensible.

From *October to February* relations are not so clear as they are during the period discussed before. With regard to the activity the trend of deviation as compared with the period March to September remains unchanged, while with ozone there is an opposite tendency of the sign. H- and S-systems are, on the average, associated with negative ξ deviations, W-systems with positive ones. Further, for ozone there is no predominant trend of deviation observable during dry intervals and on days with precipitation. From the partially opposite behaviour of ozone and activity associated with meteorological parameters the negative correlation of the standardized deviations of both these quantities is explained.

The *annual survey* comprises the results of both the periods. On the average, activity is marked by a significant dependence on meteorological parameters, while ozone shows such a relation only with the large-scale weather

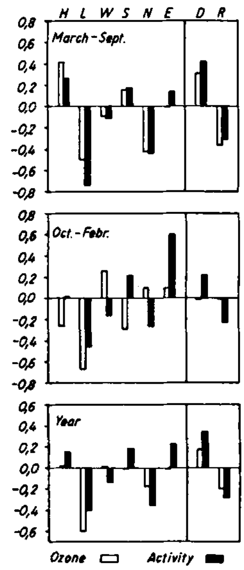

FIG. 5. Averaged values of ξ, η for Large-Scale Weather Systems and Precipitation Characteristics (ordinate: units of standard deviation).

systems L and N and with the precipitation characteristics.

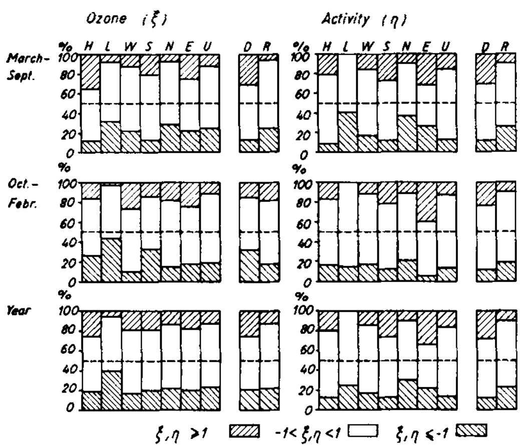

FIG. 4. Frequency distribution of different ξ, η classes of ozone and activity for Large-Scale Weather Systems and Precipitation Characteristics.

For an interpretation of the background of time variations of ozone and activity within the near-ground layer of air the following effects are to be taken into account: (1) Annual variation of ozone and activity. (2) Shifts of the general circulation. (3) Average vertical circulation of large-scale synoptic patterns. (4) Micro-scale turbulent motions. (5) Physical and chemical processes removing ozone and radioactive aerosol from the atmosphere.

In the annual variation the maxima of ozone concentration (May/June) and the concentrations of long-lived fission products (April) occur with only minor time shifts (JUNGE, 1962). During the period March to September, as compared with the period October to February, an increased ozone and activity supply may be expected, i.e., positive deviations are observed with subsidence processes of major high-pressure areas and with large-scale weather systems with southerly upper-air flow. Our investigations have revealed (WARMBT, 1964*b*) that during periods of enhanced convective exchange ozone and activity maxima coincide in the diurnal variation, too. Since these anticyclonic situations in most cases do not produce precipitation the positive deviation of both elements during dry periods (D) is easily comprehensible. Negative deviations, however, are associated with precipitation—producing meteorological processes, which are, chiefly, the central low-pressure situations (L), the large-scale weather systems with northerly and westerly upper-air flow and, finally, the precipitation days themselves. As to activity the decreasing effect is understandable when considering the precipitation, because wet fallout and dry fallout belong to those processes which remove long-lived fission products from the atmosphere. Ozone being, as is well-known, hardly water-soluble, the negative deviation on precipitation days is interpreted by the little developed vertical exchange during precipitation occurrences, whereby ozone supply from upper ozone layers is decreased, rather than by some wash-out effect.

During the period *October to February* ozone and radioactive contaminants have their maximum in the annual variation. During this period when synoptic situations with stable stratification prevail (H, S), ozone is destroyed chemically through trace gases concentrating near the surface, which implies deviations on the average to be negative. It is, however, noteworthy that the average deviation with westerly situations is positive. Since these large-scale weather systems in this season are generally associated with pronounced vertical mixing, ozone-enriched air is moved from higher layers down to the ground, and chemical destruction is reduced. Quite different to ozon the activity occurring with large-scale weather systems with stable stratification (H, S, E) is not uniform. Washout processes have equal effects on activity; they are, however, of no importance to ozone for the said reasons.

There is the remarkable observation that the average deviation of activity with large-scale weather systems with southerly and easterly upper-air flow is during both periods positive and that there is a rather high percentage of the η value $\geqslant 1$ (see Table 3, Fig. 4). This phenomenon is suggested to be due not only to the minor washout effect of these little precipitation and cloud producing large-scale weather systems, but rather due to circulation.

Following the various circulation models (e.g. Brewer-Dobson, 1949) it is generally assumed that injection of ozone and long-lived fission products in the troposphere mainly occurs at tropopause level of moderate latitudes (30°–45°). Tropical air masses, therefore, will be marked by a higher activity than those transferred from northern latitudes. There is, unfortunately, the impediment to the clarification of the circulation-originated background in that injection of fresh fission products from nuclear tests occurred at northern as well as equatorial latitudes. It might for this reason appear to be sensible that high activities are also associated with subsidence when there is polar air advection (large-scale weather system E). It is suggested that the high positive deviations associated with large-scale weather system E and the high percentage of η values $\geqslant 1$ originate from clouds of radioactive air produced by the Novaya Zemlya tests (autumn 1961 and 1962) especially observed in the year 1962 which finally had been transferred down to near-ground layers by subsidence within large-scale high-pressure situations (centred over Fennoscandia).

The occurrence of high activities at moderate latitudes during large-scale anticyclonic situations has already been mentioned by other authors. Neuwirth (1955) and M. Hinzpeter & Meyer (1961) have drawn attention to the occurrence of such "deposit spaces". Similar observations can be derived from measurements by Reiter (1964). Combining the data from Reiter (1964, Table 34, p. 450) for Farchant (850 m above m.s.l. near Garmisch-Partenkirchen), who used the large-scale weather patterns for the classification of artificial activity, into large-scale weather systems the result is that on the average the highest values of activity (pc/m³) occur with H situations (2.72) and S situations (2.32), the lowest with central low pressure situations (1.40).

4. Concluding remarks

Although between ozone and artificial activity there are differences regarding their physical and chemical nature, their origin, their time of residence within the atmosphere and their rate of deposition in the atmosphere and at the ground, there are still some common features. The time variations of ozone and artificial activity in the surface layer are controlled by the average vertical circulation of large-scale synoptic systems. From March to September the changes are parallel, from October to February they are in most cases opposite. For an interpretation of the effects the various deposition and destruction processes and the large-scale transport of ozone and long-lived fission products ought to be taken into consideration. It should further be observed that the investigation had been conducted during a period of decreasing artificial activity. When there are fresh fission products the relations are disturbed. The results are suggested to be typical for flat interior country regions.

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ОЗОН В ПРИЗЕМНОМ СЛОЕ И ИСКУССТВЕННАЯ β-РАДИОАКТИВНОСТЬ В ДРУДЕН-ВАИСДОРФЕ

В ГДР на 5 станциях по измерению озона и радиоактивности проводились одновременные измерения приземного озона в профильтрованных пробах воздуха с помощью химического метода Cauer и искусственной радиоактивности. Имеется связь между сезонными тенденциями суточного максимума приземного озона и суточного среднего значения радиоактивности. Обсуждаются ресультаты этих исследований в Друден-Ваисдорфе. В годы без ядерных испытаний (1963–1964) имелась статистически значительная положительная корреляция между азоном и радиоактивностью в период с марта по сентябрь. В годы с ядерными испытаниями (1962) такая корреляция была в течение периода уменьшения активности с июня до августа. С октября по февраль корреляция с 1962 по 1964 год была главным образом отрицательной, частично статистически несущественной. Связь между суточными отклонениями озона и радиоактивности от их сезонных изменений была исследована для крупномасштабных метереологических систем в периоды без осадков и с осадками. При этом данные сглаживались за период в 10 дней. Обсуждаются отклонения большее и меньшее чем единичное стандартное отклонение и осредненные величины отклонений.

В дни, когда течение воздуха в области 500 мл бар было с юга, происходило увеличение озона и радиоактивности, а когда с севера — уменьшение. Увеличение озона и радиоактивности в периоды с сухой погодой и уменьшение в периоды с осадками показывают влияние вымывания. В период с марта по сентябрь отклонения от сезонной тенденции у озона и радиоактивности подобны друг другу. В период с октября по февраль имеется инверсия тенденций, вызванная влиянием крупномасштабных метереологических систем с устойчивой стратификацией (центральные системы с высоким давлением). Уменьшение озона обязано накоплению востонавливающих примесей в приземном воздухе, в то время как уменьшение радиоактивности вызвано увеличением скорости удаления посредством пыли.