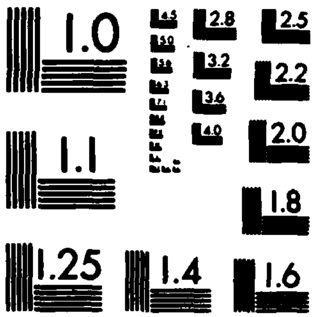
AD-A137 192 A METHOD TO ESTIMATE THE VERTICAL DISPERSION PARAMETER 1/1
IN A 10 KM RANGE(U) FOREIGN TECHNOLOGY DIV
WRIGHT-PATTERSON AFB OH L XIAOEN ET AL. 23 DEC 83

UNCLASSIFIED FTD-ID(RS)T 1647-83 F/G 4/1 NL

END
DATE
FILMED
3 84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(2)

FTD-ID(RS)T-1647-83

FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

A METHOD TO ESTIMATE THE VERTICAL DISPERSION PARAMETER
IN A 10 Km RANGE

by

L. Xiaoen, J. Xinyuan, and Y. Jinte

FOREIGN TECHNOLOGY DIVISION

EDITED TRANSLATION

FTD-ID(RS)T-1647-83 23 December 1983

MICROFICHE NR: FTD-83-C-001553

A METHOD TO ESTIMATE THE VERTICAL DISPERSION PARAMETER IN A 10 Km RANGE

By: L. Xiaoen, J. Xinyuan, and Y. Jinte

English pages: 14

Source: Daqi Kexue, Vol. 5, Nr. 4, December 1981,
pp. 368-375

Country of origin: China
Translated by: SCITRAN
F33657-81-D-0263
Requester: DET 22
Approved for public release; distribution unlimited.

GRAPHICS DISCLAIMER

All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

A METHOD TO ESTIMATE THE VERTICAL DISPERSION PARAMETER IN A 10 Km RANGE /368

Lei Xiaoen, Jia Xinyuan, and Yang Jinte

(Institute of Atmospheric Physics, Academia Sinica)

ABSTRACT

Based on the Monin-Batchelor Similarity Theory and the concept of effective roughness length, this paper presented an empirical vertical dispersion model in a 10 kilometer range. It could be used under a flat and homogeneous, as well as complex, topographical condition.

I. FOREWORD

The application of the similarity theory(1) to a flat and uniform terrain in a close distance (within 2 kilometers) has already had precise conclusions(2,3). But, what happens when it is applied to the situation of a complex terrain and a further distance (for example, as far as 10 kilometers)? This is a problem of great concern to us.

In this paper, the concept of similarity theory was applied to derive the vertical dispersion model (i.e. the correlation between the vertical dispersion, parameter $\bar{Z}$, and the downwind distance, $\bar{X}$) for a flat and uniform terrain. Next, the results were compared to the turbulent dispersion model(4) which is widely used in the plain area. Its applicability in a 10 kilometer range was discussed. Thirdly, the concept of effective roughness length(5) was used to extend the dispersion model from a plain terrain to a more complex topography. Furthermore, through a comparison with the observed data, the effectiveness and applicability of this dispersion model were discussed under a complex tower surface condition.

II. DERIVATION OF THE CORRELATION BETWEEN $\bar{Z}$ AND $\bar{X}$

According to the method of Ito(6), and usual expression between $\bar{X}$ and $\bar{z}$ is

$$\bar{X} = \frac{1}{k u_*}\int \bar{u}(s) f'(\zeta)\zeta\, ds + A, \qquad (1)$$

The revised manuscript was received on July 18, 1980.

where $\overline{u}(\overline{z})$ is the average wind speed, u_* is the speed unit on the ground level, $\zeta = \frac{\overline{z}}{L}$, L is the length unit on the ground level, $f'(\zeta) = \frac{\partial}{\partial \zeta} f(\zeta)$, $f(\zeta)$ is a generalized function, A is a constant to be determined and k is the Kalman constant. Both were chosen to be 0.36.

In the neutral situation, the logrithmic wind profile expression was substituted into (1). After integration and calculation, one gets

$$\overline{X} = \frac{z}{k^2}\left[\ln\frac{z}{z_0} + \frac{z_0}{z} - 1\right], \qquad (2)$$

when z_o is the roughness length of the ground.

In non-adabatic situations, we substituted the logrithmically linear, BWIB[7] type, and exponential[8] wind profiles into (1), respectively. Through integration and rearrangement, we finally obtained the following, respectively

/369

$$\overline{X} = \frac{1}{k^2}\Big[\frac{\beta^2}{3L^2}(z^3 - z_0^3) + (z^2 - z_0^2)\Big(\frac{\beta}{4L} - \frac{\beta^2}{2L^2}z_0\Big) - (z - z_0)\Big(1 + \frac{\beta z_0}{L}\Big) + \frac{k\beta z_0^2}{L} + \Big(\frac{\beta z^2}{2L} + z\Big)\ln\frac{z}{z_0}\Big] \qquad (3)$$

$$\overline{X} = -\frac{4L}{3k^2 r}\Big\{ y^3 \ln\frac{(1 + y_0)^2(1 + y_0^2)z}{(1 + y)^2(1 + y^2)z_0} + 2y^3(\mathrm{tg}^{-1}y - \mathrm{tg}^{-1}y_0) - 2(y^2 - y_0^2) - \ln\frac{(1 + y_0^2)^2 z}{(1 + y^2)^2 z_0}\Big\} \qquad (4)$$

$$\overline{X} = \frac{z_0}{k^2 m}\Big\{\frac{H^{2m+1}}{2m + 1} - \frac{H^{m+1}}{m + 1} + \frac{m}{(2m + 1)(m + 1)}\Big\} \qquad (5)$$

where β is the generalized constant in the logrithmically linear wind profile. In later calculation, it was chosen to be 6[9]. $y = (1 - r\frac{\overline{z}}{L})^{1/4}$, $y_o = (1 - r\frac{z_o}{L})^{1/4}$, and r was chosen to be 15 in computations[7]. m is a parameter related to the stability and topographical roughness, and $H = \overline{z}/z_o$.

III. VERTICAL DISPERSION MODEL OF FLAT AND UNIFORM TOPOGRAPHIES

In order to derive the vertical dispersion model, the key is to properly choose the stability parameters L and m. The so-called flat and uniform terrain is an idealized condition, which for z_o is .01 meter. In the following calculation, the Pasquill[4] stability classification method was adopted. The stability parameters L and m were chosen based on existing measured results[4,10,11,12]. The values are given in Table 1.

Table 1. Stability Constants

1. Stability Classification
2. L(meter)

1. 稳定度类	A	B	C	D	E	F
m	−0.19	−0.15	−0.1	−0.02	—	—
2. L(米)	—	—	—	—	150	35

After the parameters were selected, calculations were carried out with respect to (2) - (5). A comparison of the results showed that the exponential pattern described by equation (5) was most suited for types D-A. For types E and F, it was better to use the linear logarithmic relation (3). Hence, we finally obtained the following vertical dispersion model for a flat and uniform topography.

$$
\left.
\begin{aligned}
&1.\ \text{A类}: \bar{X} = 0.15 + 2.08 \times 10^{[illegible]} z^{[illegible]} - 1.13 \times 10^{[illegible]} z^{[illegible]} \\
&2.\ \text{B类}: \bar{X} = 0.13 + 3.02 \times 10^{[illegible]} z^{[illegible]} - 1.84 \times 10^{[illegible]} z^{[illegible]} \\
&3.\ \text{C类}: \bar{X} = 0.11 + 5.39 \times 10^{[illegible]} z^{[illegible]} - 3.83 \times 10^{[illegible]} z^{[illegible]} \\
&4.\ \text{D类}: \bar{X} = 0.08 + 3.58 \times 10^{2} z^{[illegible]} - 3.33 \times 10^{2} z^{[illegible]} \\
&5.\ \text{E类}: \bar{X} = 7.69 z \ln z + 2.77 \times 10^{1} z + 7.85 \times 10^{-1} z^{2} + \\
&\qquad 1.54 \times 10^{-1} z^{2} \ln z + 4.1 \times 10^{-3} z^{3} \\
&6.\ \text{F类}: \bar{X} = 7.69 z \ln z + 2.77 \times 10^{1} z + 3.37 z^{2} + \\
&\qquad 6.59 \times 10^{-1} z^{2} \ln z + 7.54 \times 10^{-3} z^{3}
\end{aligned}
\right\} \quad (6)
$$

1. Type A; 2. Type B; 3. Type C; 4. Type D; 5. Type E; 6. Type F.

Can the dispersion model (6) be applied to a 10 kilometer range? We carried out a comparative analysis between the calculated results obtained from equation (6) and the widely recognized Briggs[4] intrapolation formula (applicable within 10 kilometers) /370 in a 0.1 - 10 kilometer range. Within this range, a total of 20 points had been chosen for statistical analysis. The σ_z values in each selected distance (σ_z is the standard deviation of the smoke mass particle distribution in the vertical direction. Under a normal distribution situation, the relation between $\bar{z}$ and σ_z is $\sigma_z \approx 1.25\ \bar{z}$. This relation was used in the conversion in this paper[13].) was compared with the Briggs values. The ratios are given in Table 2.

Table 2. Comparison of the Dispersion Models in Eq. (6) and the Briggs Model in the 0.1 - 10 Kilometer Range.
1. Stability Type; 2. σ_z (this work)/σ_z (Briggs)

1 稳定度类	A	B	C	D	E	F
2 σ_z(本文)/ σ_z(Briggs)	1.09±0.261	1.05±0.149	1.06±0.235	0.98±0.313	0.91±0.095	1.11±0.254

From the table, it can be clearly seen that, within the 0.1 - 10 kilometer range, the dispersion model (6) and the Briggs intrapolation formula are very consistent.

When the vertical dispersion is estimated empirically by using the similarity theory concept to a range as far as 10 kilometers, the problem is whether a puff of smoke is still located in a constant flux layer. With regard to the thickness of a constant flax layer, Monin[8] pointed out that the average is 50 meters. Thuillier[14] also pointed out that within a 50 meter thick ground layer, the similarity theory determing the mean wind speed profile is a useful tool. Hence, we can consider that a constant flux layer is at least 50 meters thick. But, the thickness of this layer has an apparent relation with stability. Under a neutral condition, it is usually chosen to be 100 meters, which has already been proven by a lot of observation data[15]. Furthermore, with increasing roughness, its thickness will further increase. As Soma pointed out, for a city area, the thickness was at least 200 meters. Lappe also pointed out that its thickness can reach 140 meters. Panofsky[16] pointed out that under a gust condition, the variation of u_* was still considerably small up to an altitude of 150 meters.

For an unstable atmosphere, the vertical variation of u_* is even slower. Based on the meteorogical observations at several positions along the Japanese coast, Sensku[17] discovered that the logarithmically linear region between wind and temperature frequently exceeded 100 meters. Sometimes, it is as high as 200 meters. We[18] had also discovered that the logarithmically linear law was well satisfied up to an altitude of 100 meters. Therefore, for a neutral condition, the constant flux layer is chosen to be over 100 meters. Even up to 200 meters in altitude, the error would not be too large.

In order to explain the average altitude of the smog when the horizontal range is 10 kilometers, we presented the values of $\bar{z}$ and $\frac{\bar{z}}{L}$ at a 10 kilometer distance in Table 3.

Table 3. Average Vertical Displacement of Smog Particles and $\bar{z}/L$.
1. Stability Type, 2. $\bar{z}$(m) at a distance 10 kilometer

1 稳定度类	A	B	C	D	E	F
2. 10 公里处 $\bar{z}$(米)	2390	1230	565	190	61	31
$\bar{z}/L$	—	—	—	—	0.41	0.88

From the table, one can see that the smog can still be considered to disperse in a constant flux layer (50 meters in thickness) within a 10 kilometer range in approximation for types E and F. Moreover, the values of $\bar{z}/L$ are all less than 1. This shows that the logarithmically linear law can be satisfied very well up to a 10 kilometer range. For type D, the mean altitude of the smog 10 kilometers away is 190 meters. We can still consider that it is dispersing in a constant flux layer in approximation. However, for types C-A, the constant flux layer is exceeded.

Therefore, for types C-A, due to the limitation of the constant flux layer hypothesis, the similarity theory on the ground level is no longer satisfied when the dispersion model (6) is applied to a 10 kilometer range. Despite the fact that there was a lack of theoretical basis in deriving the vertical dispersion model (6), however, as an empirical treatment, it does not seem to cause any large error. For example, the results of types A-C are in considerable agreement with the results obtained by Briggs. Therefore, as a whole we can recommend the vertical dispersion model (6). However, one must remember that there is no theoretical basis for types A-C.

IV. EFFECTIVE ROUGHNESS LENGTH AND ITS COMPUTATIONAL METHOD /371

Horizontal homogeneity is an important premise in the similarity theory. However, the actual terrain is very complex. It is very difficult to satisfy this hypothesis. For an inhomogeneous topography, the meaning of z_0 will change[19]. Usually the parameter z_0 is determined on a mast or a tower. It is a local parameter. Strictly speaking, it can only represent the value at the measuring point.

With regard to an inhomogeneous terrain, Fiedler and Panofsky[5] presented the concept of "effective roughness length." It could be derived from the neutral wind profile theory under a homogeneous condition by using the measured mean stress near the ground in the region under consideration.

The smog dispersion test data to be used later in this paper had been obtained under various topographical conditions[18,20]. Therefore, the terrains were very rough and inhomogeneous. We adopted the following method to derive the effective roughness length $\bar{z}_0$ for each experimental point within a range under consideration.

From (2) we can obtain

$$\frac{\bar{X}_m}{\bar{X}_j} = \frac{\bar{z}_m\left[\ln\frac{\bar{z}_m}{\bar{z}_0} - 1 + \frac{\bar{z}_0}{\bar{z}_m}\right]}{\bar{z}_j\left[\ln\frac{\bar{z}_j}{\bar{z}_0} - 1 + \frac{\bar{z}_0}{\bar{z}_j}\right]} \qquad (7)$$

where $\bar{z}_m$ and $\bar{z}_j$ represent the mean vertical positions at distances of $\bar{X}_m$ and $\bar{X}_j$ downwind from the same smog path, respectively. $\bar{z}_0$ represents the average roughness length of the inhomogeneous terrain between $\bar{X}_m$ and $\bar{X}_j$. With respect to each smog path, several values of $\bar{z}_0$ could be calculated. Then, the average was obtained. Finally, the values of $\bar{z}_0$ for many smog paths were used in order to find the total average, which is the effective roughness length taken into consideration by us in each region.

Based on the aforementioned method, the values of $\bar{z}_0$ were calculated for seven different terrains, and the results are shown in Table 4.

Table 4. Calculated Results of Effective Roughness Length $\bar{Z}_0$(m)
1. Terrain; 2. Number; 3. Number of Smog Paths;
4. Calculated Using Equation (7); 5. Calculated
Using Equation (8); 6. Local Roughness

1. 地 形	2. 次 数	3. 烟 道 数	4. (7)式计算	5. (8)式计算	6. 局地粗糙度
A	28	10	0.4	0.35	0.57
B	48	10	0.8	0.99	0.35
C	40	4	0.2	0.22	0.63
D	17	5	0.2	—	—
E	27	10	0.1	—	—
F	13	3	0.2	—	—
G	11	2	0.7	—	—

From these results one can see that the effective roughness length is not in agreement with the locally measured roughness length (derived from the average wind speed profiles measured on towers).

In order to further demonstrate the representation and reliability of the $\bar{z}_0$ calculated based on equation (7), we changed the turbulent form used by Fiedler and Panofsky[5] into the following, which we could observe and measure:

$$\underline{z}_0 = z\exp -\left\{1.3k \times [1 - 144Fz/\bar{u}(z)]/\left[\frac{\sigma_z}{X} + \frac{7.8Fz}{u(z)}\right]\right\} \qquad (8)$$

where F is a parameter. Equation (8) was used to calculate the smog dispersion test data in three terrains identical to those calculated using equation (7). The results are also shown in Table 4. From the table one can see that these two computational methods are in good agreement with each other.

V. VERTICAL DISPERSION MODEL IN HOMOGENEOUS ROUGH TOPOGRAPHY /372

A 10 kilometer range vertical dispersion model has already been derived for a flat and homogeneous topography. In this section, we will attempt to extend the aforementioned dispersion model to complex terrains using the effective roughness length concept mentioned in Section (IV). The method is to primarily replace z_o in (2)-(5) by the effective roughness length $\bar{z}_o$. This also means that an inhomogeneous rough terrain is considered to be a homogeneous terrain with an effective roughness length $\bar{z}_o$ in the treatment.

In addition, as we pointed out before, m is related to the roughness. The rougher the ground is, the larger m becomes. In order to derive the relation between m and $\bar{z}_o$, we used a fact which has been proven in a macroscopic observation, i.e. the effect of an abrupt change in roughness. It decreases as the distance increases. At a very far distance, the effect of the terrain can be neglected. Hence, it is possible to use equation (5) to derive the values of m corresponding to each stability type for various values of $\bar{z}_o$. The values of m when $\bar{z}_o$ = 1 meter are shown in Table 5.

Table 5. Values of m when $\bar{z}_o$ = 1 meter.
1. Stability Type

1. [illegible]	A	B	C	D
m	−0.255	−0.195	−0.114	0.0446

A comparison of the values of m in Table 1 to those in Table 5 shows that as the terrain gets rougher, the absolute value of m becomes significantly larger.

In order to provide the vertical dispersion model for rough terrains, we used the $\bar{z}_o$ = 1 meter terrain to represent a rough terrain. Using Table 5 and the values of L in Table 1, the following vertical dispersion models, similar to those homogeneous rough terrains in (6), could be obtained

$$
\left.
\begin{array}{ll}
1.\ \text{A 类:} & \bar{X} = 2.11 \times 10^{1} + 4.05 \times 10^{1}\bar{z}^{0.765} - 6.16 \times 10^{1}\bar{z}^{0.[illegible]} \\
2.\ \text{B 类:} & \bar{X} = 1.57 \times 10^{1} + 4.9 \times 10^{1}\bar{z}^{0.685} - 6.47 \times 10^{1}\bar{z}^{0.44} \\
3.\ \text{C 类:} & \bar{X} = 1.12 \times 10^{1} + 7.65 \times 10^{1}\bar{z}^{0.687} - 8.77 \times 10^{1}\bar{z}^{0.773} \\
4.\ \text{D 类:} & \bar{X} = 6.76 + 1.58 \times 10^{2}\bar{z}^{1.09} - 1.65 \times 10^{2}\bar{z}^{1.065} \\
5.\ \text{E 类:} & \bar{X} = 7.69\bar{z}\ln\bar{z} - 8\bar{z} + 8.04 + 7.08 \times 10^{-2}\bar{z}^{2} + \\
 & \quad 1.54 \times 10^{-1}\bar{z}^{2}\ln\bar{z} + 4.1 \times 10^{-3}\bar{z}^{3} \\
6.\ \text{F 类:} & \bar{X} = 7.69\bar{z}\ln\bar{z} - 9\bar{z} + 9.19 + 2.17 \times 10^{-1}\bar{z}^{2} + \\
 & \quad 6.59 \times 10^{-1}\bar{z}^{2}\ln\bar{z} + 7.54 \times 10^{-2}\bar{z}^{3}
\end{array}
\right\} \quad (9)
$$

1. Type A; 2. Type B; 3. Type C; 4. Type D; 5. Type E; 6. Type F.

In order to quantitatively determine the magnitude of the effect of ground roughness on σ_z, we carried out a comparative analysis on the values of σ_z calculated using (9) and (6). Within the 0.1 - 10 kilometer range, the ratios of σ_z for the same distance and same stability type are given in Table 6. From the table one can see that: (1) the effect of terrain roughening caused σ_z to increase, and this effect decreases with increasing $\bar{X}$ (rising $\bar{z}$); (2) as it varies from instability toward stability, the effect of roughness also increases. Under a stable situation, the effect of terrain is the largest, the range affected is the farthest and thickest, and the magnitude of increase for σ_z is also the largest; (3) in a neutral condition, the effect of a rough terrain could cause σ_z to increase to 2-3 times of that in a flat terrain within 1 kilometer. This conclusion is in good agreement with an actually measured dispersion parameter (at 800 meters) in a certain complex terrain[18] which showed that on the average it was 1.9-2.5 times that in a plain.

In order to verify the applicability of the aforementioned results under a complex topography condition, we calculated the vertical dispersion parameters for seven complex terrains, respectively[18,20]. Moreover, a comparison was made with respect to the actual smog data. The result showed that: for data collected on 208 occasions under neutral conditions,

σ_z measured/ σ_z calculated = 0.97 ± 0.21. Among 108 pieces of information in non-neutral conditions, σ_z measured/ σ_z calculated = 0.96 ± 0.21. Such results are considered to be satisfactory.

Table 6. Ratios of $\sigma_{z\ 1}$ for $\bar{Z}_o$ = 1 meter to $\sigma_{z\ 0.01}$ for $\bar{Z}_o$ = 0.01 Meter /373

1. Stability Type; 2. $\bar{X}$ (meter).

$\sigma_{z1}/\sigma_{z0.01}$ 稳定度类 1 / $\bar{X}$(米) 2	A	B	C	D	E	F
100	1.41	1.74	2.14	2.81	2.98	3.18
150	1.26	1.55	1.96	2.43	2.75	2.88
200	1.16	1.46	1.82	2.31	2.61	2.58
500	1.02	1.23	1.48	1.95	2.08	1.96
700	0.98	1.16	1.41	1.78	1.97	1.79
1000	0.95	1.13	1.36	1.66	1.85	1.76
2000	0.91	1.05	1.24	1.45	1.66	1.59
5000	0.92	1.00	1.10	1.26	1.44	1.39
7000	0.92	1.00	1.08	1.20	1.44	1.33
10^4	0.92	1.00	1.06	1.15	1.39	1.35

The experimental data used in the earlier verification were obtained with a sampling distance ranging from 40-520 meters. Due to the limitation of the photographic method, the sampling distance is too short. In order to analyze the applicability of the results obtained in this work at a farther distance, we carried out a comparative analysis using the dispersion test data obtained in the city of St. Louis in the United States of America[21] (test data on 12 occasions in the evening under neutral conditions at a sampling distance ranging from 0.78-7.8 kilomcters). Pasquill[21] used the following formula to match some of the test data:

$$\bar{X} = \frac{\bar{z}}{k^2}\left[\ln\left(\frac{c\bar{z}}{z_0}\right) + \frac{z_0}{\bar{z}}(1 - \ln c) - 1\right] \quad (10)$$

where c = 0.6, z_o = 3 meters. We used equations (2) and (3) separately to conduct the corresponding calculation. The ratios of the calculated values to the actual values are shown in Table 7. For the purpose of comparison, the calculated results obtained by Pasquill are also given in the table.

Table 7. Comparison of Calculated and Actually Measured St. Louis Data under Neutral Conditions.

1. Calculation Formula; 2. (2) $\bar{z}_o$ = 3 meters;
3. (3) $\bar{z}_o$ = 3 meters - L = 10^4 meters;
4. (3) $\bar{z}_o$ = 3 meters - L = -10^4 meters;
5. $\bar{z}_{calculated}/\bar{z}_{measured}$

1 计算公式	(10)	2 (2)$\bar{z}_0$ = 3 米	3 (3)$\bar{z}_0$ = 3 米, L = 10^4米	4 (3)$\bar{z}_0$ = 3 米, L = -10^4米
5 $\bar{z}_{计}/\bar{z}_{测}$	1.20±0.38	0.92±0.28	0.98±0.32	0.86±0.27

From these results one can see that the three models adopted by us are more consistent with the reality than (10) within the 8 kilometer range.

In order to further analyze the reliability of (9), we carried out a comparative analysis on our results and the corresponding results obtained by Smith[22] (derived from the two-dimensional dispersion equation numerically). The ratios of σ_z within the range from 0.1-10 kilometers are given in Table 8.

Table 8. Comparison of Results Ohtained by (9) and by Smith in 0.1 - 10 Kilometer Range.

1. Stability Type; 2. σ_z (this work)/σ_z (Smith)

1 稳定度类	A	B	C	D	E	F
2 σ_z(本文)/σ_z(Smith)	1.33±0.566	1.53±0.633	1.42±0.329	1.05±0.094	1.11±0.277	1.35±0.456

From the table one can see that the two are in good agreement with each other. With the exception of Type B, the ratio between the two is always within a factor of 2. The consistency is the best under neutral conditions. Moreover, the

scatter is also very small. But for types C-A, the results obtained in this work are larger than those obtained by Smith. For types E and F, the results obtained by this work are slightly larger. In summary, although there are some differences between /374
the two vertical dispersion models for homogeneous rough terrain derived by two different methods, the consistency of the two is still very good from the practical point of view.

VI. SUMMARY AND CONCLUSIONS

Through the analysis above, it is possible to obtain the following viewpoints:

1. For a flat and homogeneous terrain, the effectiveness of using an empirical method based on the similarity theory concept to estimate the vertical dispersion within a 10 kilometer range is equivalent to that of the Briggs intrapolation formula which is widely used and commonly recognized at the present moment. This dispersion model could be conveniently extended from a homogeneous flat terrain to a homogeneous rough terrain. However, in an unstable situation, due to the limitation of the constant flux layer, there is still a lack of theoretical basis despite the fact that it is possible to extend it to a 10 kilometer range based on experience. This would require the further development of a planetary boundary layer similarity theory.

2. For a complex terrain, the similarity theory could not be used, in principle. However, in reality, it is not possible to really find a completely homogeneous terrain. Essentially, it is necessary to consider the extent of the effect of this inhomogeneity on the application of the theory. In this paper, the relation between $\overline{X}$ and $\overline{z}$ in a neutral condition was used to determine the effective roughness length. The results were compared with those obtained using the method of Fiedler and Panofsky, which showed that the method used in this work was feasible.

Using the effective roughness length obtained through calculation in this work, the dispersion model of a homogeneous flat terrain was extended to rough terrains. A comparison with the actually observed data and the relevant results obtained by Smith showed a very good agreement.

3. A comparison of the vertical dispersion characteristics of various rough terrains showed that the rougher the terrain is, the larger the dispersion parameter becomes. For the same roughness, the effect of terrain on dispersion gradually increases from instability to stability. It is most apparent in stable situations. The actual measured data also supported this fact(23,24,25).

In summary, for homogeneous flat terrains, from a neutral to a stable layer, it is possible to use the similarity theory concept to empirically estimate the vertical dispersion in 10 kilometers. For complex terrains, after replacing local roughness lengths with effective roughness lengths, the similarity theory can also be applied in approximation. From this, an empirical vertical dispersion model could be obtained. With regard to its applications in the areas of atmospheric pollution, environmental quality evaluation, and engineering design, the accuracy is sufficient.

Acknowledgement: Comrades Zhou Mingli and Ren Zhenhai provided valuable opinions concerning the manuscript, which deserves our special thanks.

REFERENCES

[1] Pasquill, F., Lectures on air pollution and environmental impact analyses, 1975.
[2] Pasquill, F., *Quart. J. Roy. Meteor. Soc.*, 97(414), 369—385, 1971.
[3] Seinfeld, J. H., Air pollution-physical and chemical fundamentals, McGraw-Hill Book Company, 1975.
[4] Gifford, F. A., *Nuclear Safety*, 17(1), 1976.

5. Fiedler, F. and Panofsky, H.A., same as (2), 98, 213-220, 1972.

[6] Ito, S., *Paper in Meteorology and Geophysics*, 21(2), 143—241, 1970.
[7] Businger, J. A., *J. Atmos. Sci.*, 28, 181—189, 1971.
[8] Monin, A. S. and Obukhov, A. M., *Trudy Geofiz Inst, Akad Nauk S. S. S. R.*, No. 24,(151), 1954.
[9] Yaglom, A. M., *Boundary-Layer, Met.*, 11, 89—102, 1977.
[10] Touma, T. S., *J. Air. Poll. Control. Asso.*, 27, 9, 1977.
[11] Courtney, F. E., Joint conference on applications of air pollution meteorology, November 29-December 2, 1977, pp. 64—67.

12. Brennan, P.T., same as (11), pp. 154-159, 1977
13. Pasquill, F., same as (2), No. 392, 1966.

[14] Thuillier, R. H., *J. Appl. Meteor.*, 8, pp. 399—806.
[15] Counihan, J., *Atmospheric Environment*, 9(10), 871—886, 1975.

[16] Panofsky, H. A., 同 [9], 4, 251—264, 1973.

[17] Sosaku, T., Symposium on Atmospheric Diffusion and Air Pollution, 180—183, 1974.

[18] 大气试验技术小组，大气科学，1977，第一期，26—35.

[19] Mcbean, G. A., WMO, Commission for Atmospheric Science Working Group on Atmospheric Boundary-Layer Problems, First Session, Final Report, Appendix C, 1976.

[20] 中国科学院大气物理研究所，山区污染与气象学，1978，科学出版社.

[21] Pasquill, F., Atmospheric Diffusion, 1974, Wiley and Sons, London.

[22] Hosker, R. P., Physical Behavior of Radioactive Contaminants in the Atmosphere, Proceedings of a Symposium, Vienna, 291—308, 1973.

[23] Egan, B. A., 同 [1], 112—135, 1975.

[24] Hovind, E., 同 [17], 214—217, 1974.

[25] Start, G. E., 同 [17], 226—232, 1974.

manuscript was received on July 18, 1980.

is to p

END

DATE
FILMED

8-84

DTIC