NILU
TEKNISK RAPPORT NR: 6/82
REFERANSE: 20682
DATO: JUNI 1982

DISPERSION OF POLLUTION FROM AREA SOURCES

BY

K.E. GRØNSKEI

NORWEGIAN INSTITUTE FOR AIR RESEARCH
P.O.BOX 130, N-2001 LILLESTRØM
NORWAY

ISBN--82-7247-323-2

NILU
TEKNISK RAPPORT NR: 6/82
REFERANSE: 20682
DATO: JUNI 1982

DISPERSION OF POLLUTION FROM AREA SOURCES

BY

K.E. GRØNSKEI

NORWEGIAN INSTITUTE FOR AIR RESEARCH
P.O.BOX 130, N-2001 LILLESTRØM
NORWAY

LIST OF CONTENT

DISPERSION OF POLLUTION FROM AREA SOURCES

1 INTRODUCTION

Various computational procedures may be used to determine the pollution contribution from area sources.

Three main groups of procedures are identified:

1. Simulation by a large number of point sources (1,2).
2. Calculation by virtual point sources (3,4).
3. Integration of line sources along the wind direction (5,6).

The procedures may be approached in a receptor oriented way including a narrow plume assumption or a source oriented way.

Experience with the virtual point source approach show that a large number of sources give unacceptable computor time for a source oriented approach in a grid system. Further the virtual point source approach cause difficulties calculating concentration contribution from nearby low level sources (i.e., emission from car traffic) within the area source.

In this report the effect of different emission height and of different initial mixing is investigated by integration of the line source model.

The intention is to improve NILUs multiple source Gaussian model and to evaluate some assumption made in exposure calculations for Oslo (7).

2 FORMULAS

Vertical pollution distribution as a result of dispersion from a line source is often approximated by a Gaussian distribution.

Dispersion formulae:

$$C = \frac{Q_A \; dx}{\sqrt{2\pi}\; u\; \sigma_z} \left\{ \exp\left[-\tfrac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right] + \exp\left[-\tfrac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] \right\} \qquad (2.1)$$

x : horizontal coordinate perpendicular to the line source (m)

z : vertical coordinate (m)

C : pollution concentration (g/m^3)

$Q_A dx$: source intensity of a line source ($g/m \cdot s$)

u : wind velocity perpendicular to the line source (m/s)

σ_z : standard deviation in the vertical pollution distribution (m)

H : effective emission height (m)

Dispersion parameters

For the standard deviation (σ_z) the following function is used:

$$\sigma_z = b\left(\frac{x+x_o}{h}\right)^q; \qquad x_o = \left(\frac{\sigma_{zo}}{b}\right)^{1/q} \qquad (2.2)$$

$\sigma_z o$: initial mixing

b and q are given values (according to McElroy/Pooler) depending on stability class (see Table 2.1). McElroy/Poolers dispersion parameters are developed for low level sources over an urban area.

Table 2.1: Stability parameters (b and q ref. to equation 2.2) given for different stability classes.

h = 1 m Stability class	MacElroy/Pooler b m	 q	Pasquill b m	 q
A			0.28	0.90
B	0.05	1.18	0.23	0.85
C	0.09	1.10	0.21	0.80
D	0.72	0.74	0.20	0.76
E	0.76	0.65	0.15	0.73
F	0.73	0.59	0.12	0.67

For a rural area Pasquill's values are recommended.

Plume rise:

The plume rise ΔH is dependent on emission conditions and ambient wind velocity. Equation (2.3) describing the effect of momentum should first be considered. The effect of buoyancy may be reduced by wake effects, important for low level sources.

$$\Delta H = 2(\frac{V_s}{u} - 1.5)D$$

$$H = h_s + 2(\frac{V_s}{u}) - 1.5)D \qquad (2.3)$$

H :effective stack height (m)

h_s:stack height (m)

V_s:emission velocity (m/s)

u :horizontal wind velocity (m/s)

D :diameter of the stack (m)

For small sources in an urban area stack height (h_s) is equal to the building height (h_B).

When the momentum of the smoke emitted from the stack is large enough for the plume to escape wake effects of the buildings, the density difference between the gas and the ambient air may cause further plume rise. The discussion follows Briggs diffusion estimation for small sources (8).

The smoke will be caught by the wake of the buildings when

$$2\left(\frac{V_s}{u} - 1.5\right)D \leq 0.5\ h_s;\quad \frac{V_s}{u} \leq 1.5 + 0.25 \cdot \frac{h_s}{D}:$$

When $u \geq 2\text{-}3$ m/s this will happen for most small sources in an urban area. When $u \leq 1\text{-}2$ m/s most plumes emitted from the roofs in an urban area will remain elevated. Air pollution episodes are included in this group.

Tracer studies should be carried out to clarify these conditions. This becomses particularly important when the relative contributions from car traffic and home heating are considered.

The plume rise is reduced by wake effects but the pollutants are not mixed in the wake when

$$0.5\ h_B \leq 2\ \left(\frac{V_s}{u} - 1.5\right)\ D \leq\ 1.5\ h_B$$

Assumption made in NILUs multiple source models

For area sources it is assumed that part of or all of the effluents from small sources circulate within the aerodynamic cavity that forms in the lee of the buildings. In previous calculations (7) a partial entrainment was assumed in the following way:

$$H = 2\ h_B \qquad (2.4)$$

h_B : building height
H : effective emission height

In Oslo H is varied between 30 m in the centre of the city and 10 m in the surroundings. It is further assumed that the influence of the wake causes an initial mixing σ_{zo}:

$$\sigma_{zo} = H/2.15 \qquad (2.5)$$

For emission from ground sources the same initial mixing was assumed.

Equation (2.1) is integrated to consider an area source with constant emission intensity Q_A:

$$C_H = \frac{Q_A}{\sqrt{2\pi}\, u} \int_o^D \frac{1}{\sigma_z}\{\exp[-\tfrac{1}{2}(\frac{z+H}{\sigma_z})^2] + \exp[-\tfrac{1}{2}(\frac{z-H}{\sigma_z})^2]\}dx \qquad (2.6)$$

The pollution concentration close to the ground (C_o) is relevant for exposure calculation.

$$C_o = \sqrt{\frac{2}{\pi}}\,\frac{Q_A}{u} \cdot F \qquad (2.7)$$

$$F = \int_o^D \frac{1}{\sigma_z} \{\exp [-\tfrac{1}{2}(\frac{H}{\sigma_z})^2]\}dx \qquad (2.8)$$

The equation is integrated, using Simpson's method with the interval (o-D) divided in 20-40 parts. F is shown as a function of D in Figure 2.1a and 2.1b.

Since the contribution from different area sources is additive, the decay in the concentration at a distance L-D from an area source with diameter D is found:

$$C_D(L) = \sqrt{\frac{2}{\pi}}\,\frac{Q_A}{u} \int_{L-D}^{L} \frac{1}{\sigma_z} \cdot \exp[-0.5 \cdot (\frac{H}{\sigma_z})^2]dx \qquad (2.9)$$

The following assumptions used for the calculations in Oslo are considered:

a. Area source along the ground in the suburban areas $H = 0$ m $\sigma_{zo} = 4.6$ m
b. Area sources as a result of home heating in the suburban area $H = 10$ m $\sigma_{zo} = 4.6$ m
c. Area source along the ground in the center of the town $H = 0$ m; $\sigma_{zo} = 14$ m
d. Area source as a result of home heating in the center of the town $H = 30$ m; $\sigma_{zo} = 14$ m

The parameters describing emission height and initial dispersion correspond to the values used in the calculations for Oslo (7).

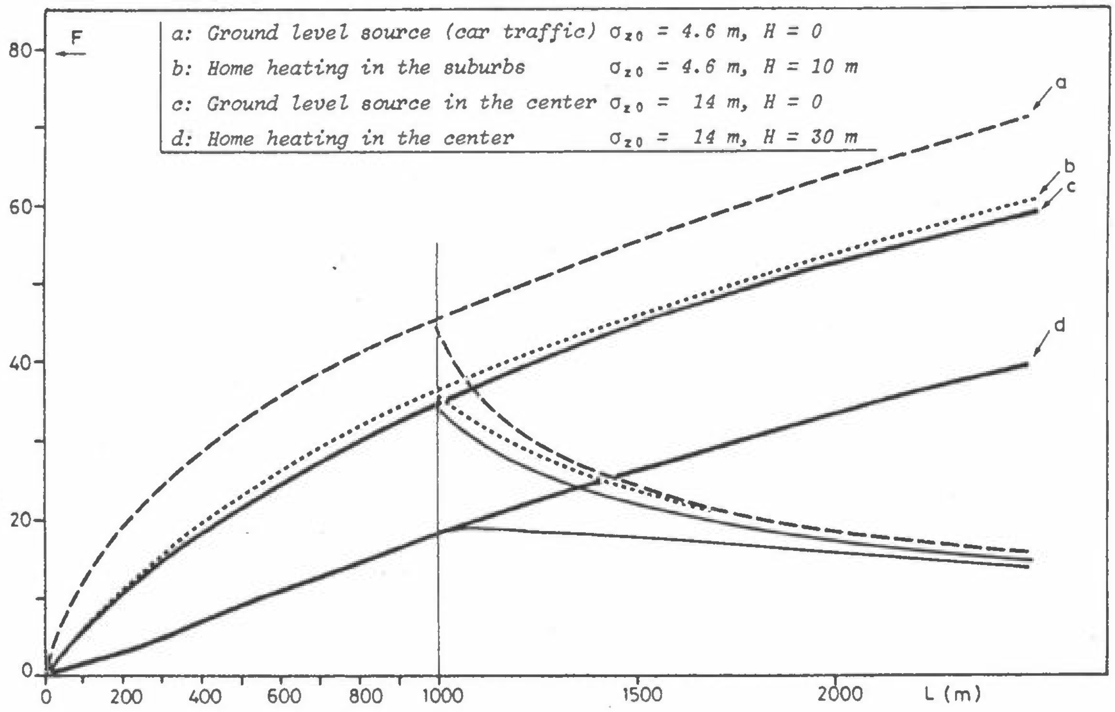
Area source along the ground (car traffic) and above the roof of the houses (home heating) is shown. Two curves are drawn for each source. One curve shows the F-values as the area source extend beyond 2000 m. The second curve shows the increase and decrease in concentration in an 1000 m wide area source.

In 2.1a the F-function is shown for air pollution episodes (F-stability). In 2.1b the F-function is shown for normal atmospheric conditions (C-stability).

The figure shows the importance of emission height and further the relative importance of car traffic emission and of emission from home heating for the concentration along the ground.

The figure further shows that 0.5-1 km from the edge of the area source the pollution contribution is about the same whether it is car traffic or home heating.

a)



b)

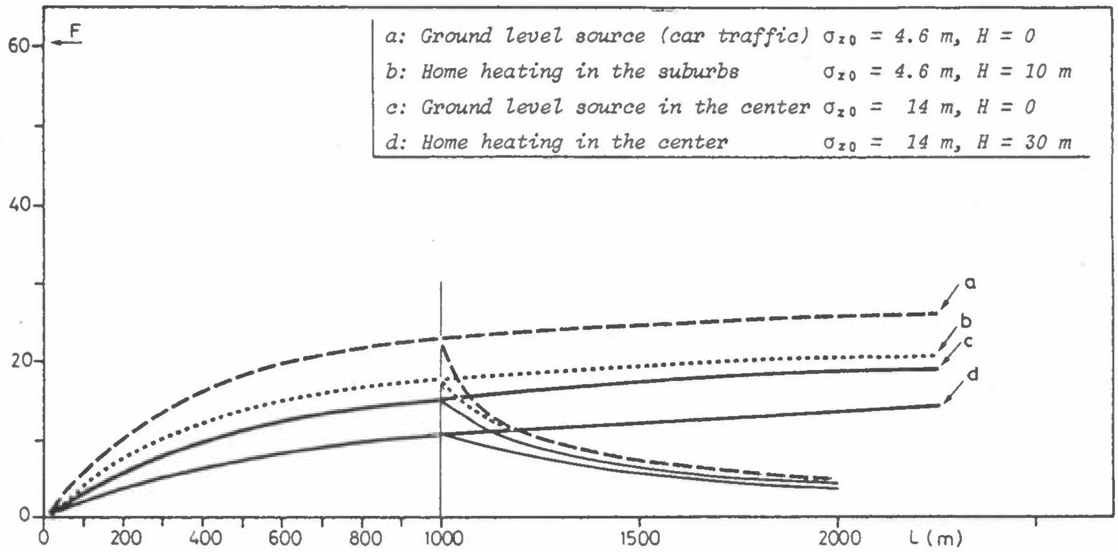


Figure 2.1: Normalized pollution concentration (F) as a function of the size of the area source (L). The decay in F downwind of a 1 km wide area source is shown in the same figure for each of the area sources.

a) Normalized concentration in pollution episodes (stab. F)
b) Normalized concentration for normal condition (stab. C).

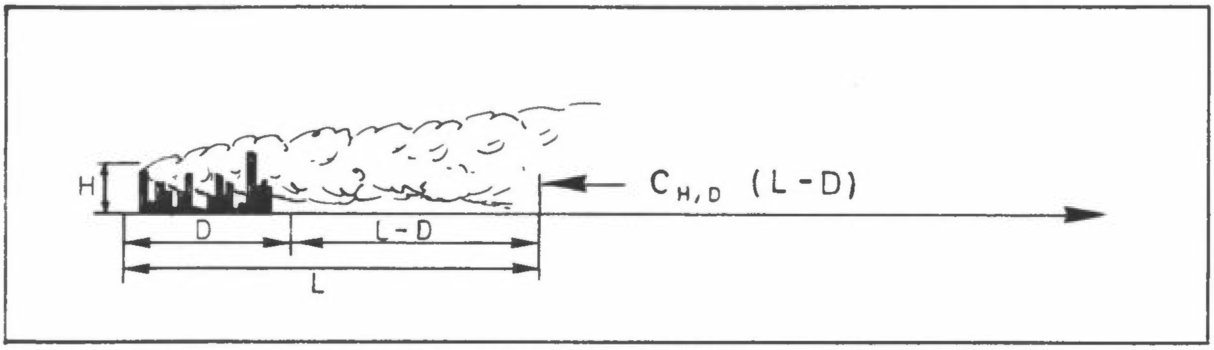


Figure 2.2: Concentration calculation downwind of an area source
$C_{H,D}$ (L-D): concentration downwind of an ara source with emission height H and with D. The concentrations are calculated at a distance (L-D) from the edge of the area source example: home heating in small furnaces.
$C_{o,D}$(L-D): concentration downwind of an area source close to the ground.

To study the influence of emission height the following formulae is used:

$$R = \frac{C_{O,D}(L-D)}{C_{H,D}(L-D)} = \frac{\int_{L-D}^{L} \frac{1}{\sigma_z}(x) \, dx}{\int_{L-D}^{L} \frac{1}{\sigma_z(x)} \exp\left(-0.5\left(\frac{H}{\sigma_z}\right)^2\right) dx}$$

The symbols ($C_{O,D}$(L-D) and $C_{H,D}$(L-D)) are explained in Figure 2.2

Using equation 2.2 and h = 1 m for $\sigma_z(x)$ a value x=x' exists where

$$R = \exp(+0.5\ (\frac{H}{b(x'+X_o)^q})^2);\ x' \in [L-D, L]$$

The formulae show:

$$R > 1$$

when

$$L \to \infty;\ R \to 1.$$

Using the smallest value of x':

$$R \leq \exp(+0.5\ (\frac{H}{b(L-D+X_o)^q})^2)$$

When:

$$b(L-D+X_o)^q > mH\ ;\ X_o = (\frac{H}{2.15b})^{1/q}$$

then:

$$R < R_{mH} = \exp\ (\frac{0.5}{m^2}) \qquad (2.10)$$

As a consequence the relative source contribution from equal area sources at the ground and with emission height H is smaller than R_{mH} when the distance L-D from the area source (diameter D) is larger than the value given by equation (2.11).

$$L-D = (\frac{mH}{b})^{1/q} - (\frac{H}{2.15b})^{1/q} \qquad (2.11)$$

m = 1 $\quad R_{mH} = 1.65$

m = 2 $\quad R_{mH} = 1.13$

m = 3 $\quad R_{mH} = 1.06$

m = 4 $\quad R_{mH} = 1.03$

In Figure 2.3 the relation given in equation (2.11) is shown for m = 2 for different stability classes . The figure show that for normal and good dispersion conditions in the atmosphere, the distance is a few hundred meters. In air pollution episodes (classes

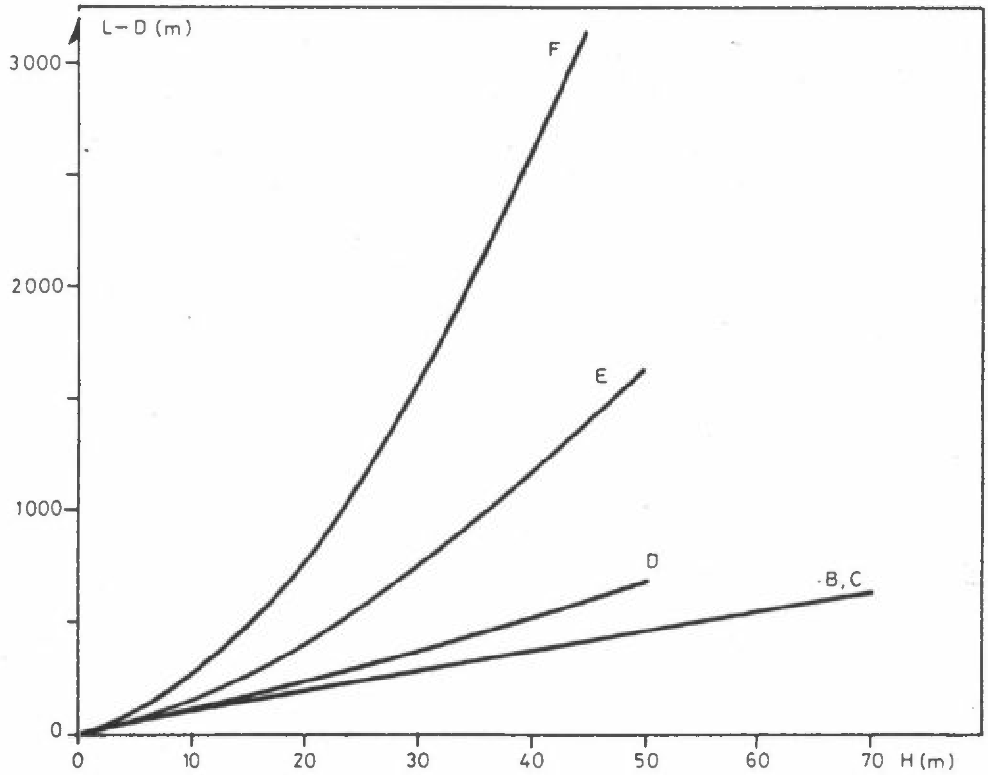


Figure 2.3: The relation between emission height H and the distance from an areasource (L-D) when m = 2 in equation (2.11). The relation is given for different stability classes. When the distance is larger for a certain emission height, the pollution contribution from an area source close to the ground will be less than 13% larger than the contribution from an identical area sources with emission height H.

E and F) the difference in emission height also have to be considered for larger distances (1-2 km).

3 THE NORMALIZED CONTRIBUTION FROM AREA SOURCES USING OTHER TYPES OF DISPERSION MODELS

3.1 Highways

Close to roads General Motors dispersion parameters are recommended for ground level emission

$$\sigma_z = (a+bx)^c \qquad (3.1)$$

Table 3.1: Dispersion parameters (ref. 10).

	a m	b	1-c
Stabil atmosphere	1.49	0.15	0.23
Neutral atmosphere	1.14	0.10	0.03
Unstable atmosphere	1.14	0.05	-0.33

Downwind of an area source with size D, the F function may be integrated:

$$F = \int_0^D \frac{dx}{(a+bx)^c}$$

New integration variable

$$y = a + bx$$

$$F = \int_a^{a+bD} \frac{dy}{b\,y^c}$$

$$F = \frac{1}{(1-c)b}\left[(a+bD)^{1-c} - a^{1-c}\right] \qquad (3.2)$$

The F-function is given for different dispersion conditions.

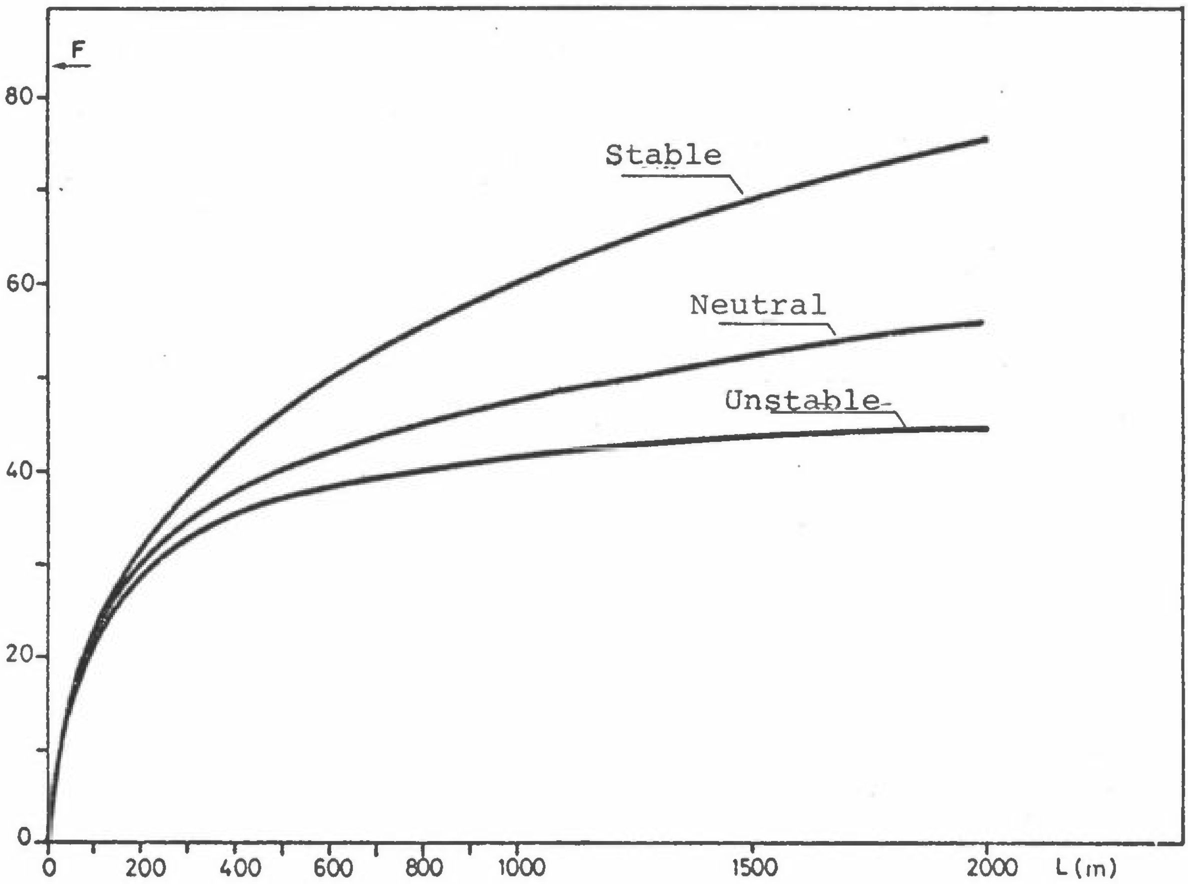


Figure 3.1: Dispersion function F downwind of an area source as a function of the width of the area source L

$$F = \frac{C(L)\ u}{\sqrt{\frac{2}{\pi}}\ Q}$$

$C(L)$: *the concentration downwind of an area source with width L.*

u : *wind speed*

Q : *area source intensity.*

3.2 Time dependent numerical models

When the x-axes is located along the transporting wind, a simple one level model may be written

$$\frac{\partial c}{\partial t} = -u \frac{\partial c}{\partial x} + \frac{\partial K \frac{\partial c}{\partial z}}{\partial z} + Q \qquad (3.3)$$

Integrating this equation from the ground level to the height H, the following equation is considered for the average concentrations:

$$\frac{\partial \bar{c}}{\partial t} = - \bar{u} \frac{\partial \bar{c}}{\partial x} - \kappa \bar{C} + \frac{Q}{H_m} \qquad (3.4)$$

H_m: Height of integration (mixing).

Considering a quasistationary situation the following equation may be considered:

$$\frac{d\bar{c}}{dx} = - \frac{\kappa}{u} \bar{C} + \frac{Q}{u \cdot H_m} \qquad (3.5)$$

The solution of 3.5 may be written

$$C(x) = \frac{Q_A \sqrt{\frac{2}{\pi}}\, u}{\sqrt{\frac{2}{\pi}}\, u\, H_m \kappa} \left(1-\exp\left(-\frac{\kappa}{u}x\right)\right) \qquad (3.6)$$

In this boxmodel

$$F = \frac{\sqrt{\frac{2}{\pi}}\, u}{H_m \kappa} \left(1-\exp\left(-\frac{\kappa}{u}x\right)\right) \qquad (3.7)$$

Corresponding to equation 2.8 the decay in concentration at a distance (L-D) from an area source with diameter D may be written

$$C_D(L) = \frac{\sqrt{\frac{2}{\pi}}\, u}{\sqrt{\frac{2}{\pi}}\, u} \frac{Q_A}{\kappa H_m} \left(1-e^{-\frac{\kappa}{u}D}\right) e^{-\frac{\kappa}{u}(L-D)}$$

Corresponding to equation 2.8 and 3.2:

$$F_D(L-D) = \frac{\sqrt{\frac{2}{\pi}}\, u}{\kappa H_m} \left(1-e^{-\frac{\kappa}{u}D}\right) e^{-\frac{\kappa}{u}(L-D)} . \qquad (3.8)$$

The turbulent flux (diffusivity K) is assumed to be proportional to the concentration and parameterized by a factor of proportionality (κ). This factor, depending on the vertical concentration profile and on the diffusivity, should vary horizontally. In order to compare the time dependent model with the previous methods of dispersion calculations the stationary concentration distribution is considered.

For $\kappa = 10^{-3}\ s^{-1}$ $u = 1$ m/s equation 3.7 and 3.8 are given in Figure 3.2.

If $x >> \frac{u}{\kappa}$ $\qquad C(x) \rightarrow \frac{Q_A}{\kappa H_m}$

κ should be functions of wind and temperature stratification.

In order to compare the models the relative horizontal veriation in concentration is considered.

Using equation 2.1 for a Gaussian formulae for a ground level source:

$$\frac{1}{c}\frac{dc}{dx} = -\frac{1}{\sigma_z}\frac{d\sigma_z}{dx} \qquad (3.9)$$

Using equation 3.5 for the stationary solution of the time dependent model

$$\frac{1}{c}\frac{dc}{dx} = -\frac{\kappa}{u} \qquad (3.10)$$

Assuming $\frac{K}{u}$ to be linear dependent on height (14)

$$\frac{d\sigma_z}{dx} \propto \frac{K}{u\sigma_z} \qquad (3.11)$$

According to equations 3.9, 3.10 and 3.11:

$$\kappa \propto \frac{K}{\sigma_z^2}$$

K: turbulent diffusion coefficient at the height $z = \sigma_z$.

Using Bussingers equations for the stable surface boundary layer (11):

$$\kappa \propto \frac{u_*}{(0.74+4.7\,\frac{\sigma_z}{L})\cdot\sigma_z}$$

L : Monin Obukhov's length
u_*: friction wind speed

According to Venkatram (12) the following equation applies in a stable boundary layer:

$$L = A\,u_*^2 \qquad A = 1.1\cdot 10^{-3}\ s^2\ m^{-1}$$

It is seen that κ and the F-function is dependent on vertical scale of the cloud that is not possible to include in a one level model.

According to these estimations $|\kappa| < 10^{-5}\ s^{-1}$ in the low wind situation with inversion.
($u_* < 0.1$ m/s and $H_m > 10$ m).

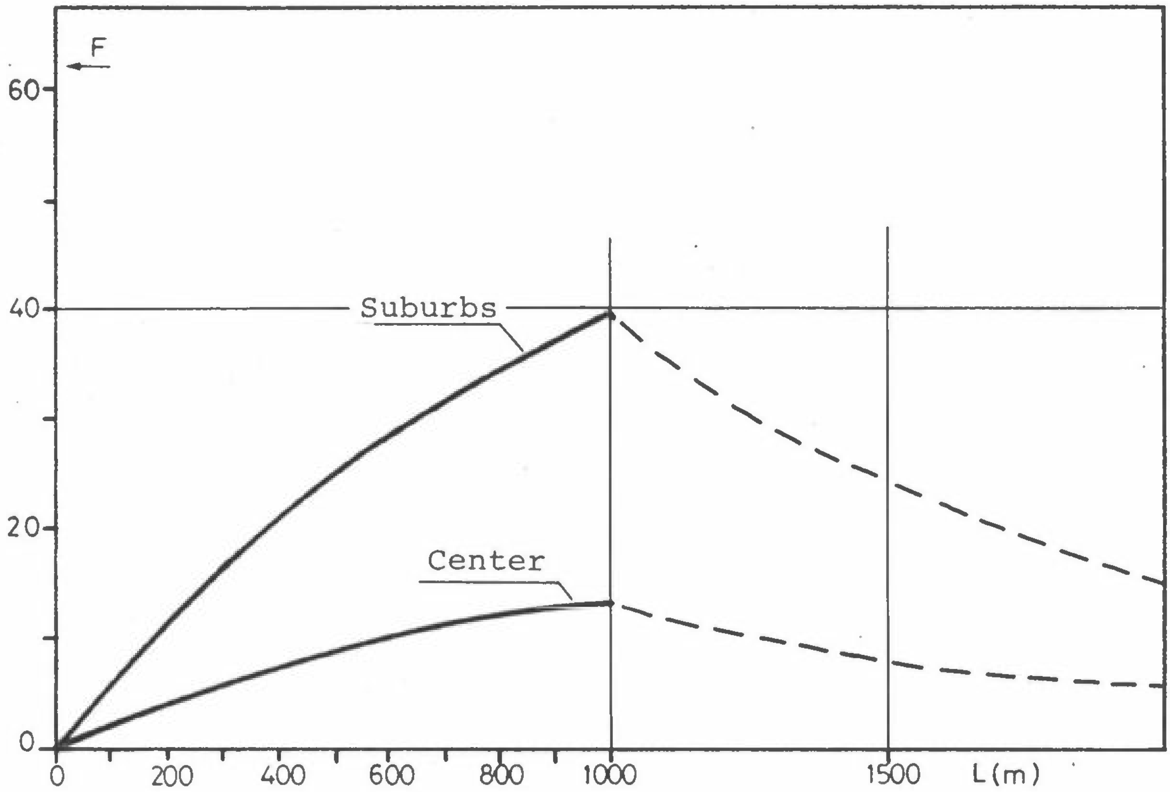


Figure 3.2: The normalized dispersion function for the stationary solution of the numerical one level model.

$$F(x) = \frac{\sqrt{\frac{\pi}{2}}\, u}{H_m \kappa} \left(1 - e^{-\frac{\kappa x}{u}}\right)$$

A similar approach is chosen for an urban street model.

$$\Delta C = \text{ko}\ \frac{Q \quad (1-H/B)}{(u+u_o)} \cdot f(x) \cdot g(z)$$

as $u \rightarrow 0$

$$\Delta C = Q \cdot \frac{k_o}{u_o} (1 + H/B)$$

Using this analogy

$$\frac{k_o}{u_o} (1 + H/B) = \frac{1}{\kappa H_m}$$

In the same way as different $\frac{k_o}{u_o}$ values are used for different street canyons, different $\frac{1}{\kappa H}$ values are selected for different areas.

In street canyons:

$$\frac{k_o}{u_o} \in [14,20 \text{ s/m}]$$

In Oslo:

$$\frac{1}{\kappa H_m} \in [16,\ 50 \text{ s/m}]$$

$\frac{1}{\kappa H_m} = 16$ s/m in the center of Oslo

$\frac{1}{\kappa H_m} = 50$ s/m in the suburbs of Oslo

A numerical one level model that describes the main characteristics of dispersion over an urban area will tend to underestimate dispersion close to the area source, overestimate dispersion far from the area source.

4 APPLICATION OF TIME DEPENDENT MODELS FOR CALCULATION OF EPISODE CONCENTRATIONS IN OSLO

Using the model for calculating daily SO_2 concentrations for the period 1.12.70-11.1.71, κ was given as a function of the temperature difference between Werrings villa close to Holmenkollen (T_w) and Fornebu (T_F)

$$\kappa = a \cdot \frac{dT}{dz} + b$$

$$a = +0.5 \cdot 10^{-3} \left(\frac{^{o}C}{100\ m}\right)^{-1} s^{-1} \qquad \frac{dT}{dz} \approx \frac{Tw - Tf}{\Delta Z_{w-f}}$$

$$b = -1.3 \cdot 10^{-3}\ s^{-1} \qquad \Delta Z_{w-f} = 4.1 \cdot 10^{2}\ m$$

The values were restricted in the following way:

$$\kappa \in [-1.8-0.3] \cdot 10^{-3} s^{-1}$$

For the first episod calculations in Oslo $\kappa = 0$. Unreasonable high concentrations were found specially in the western part of the area.

For the second set of calculations the following values were chosen:

$$a = 0.1 \cdot 10^{-3} \left(\frac{^{o}C}{100\ m}\right)^{-1} s^{-1}$$

$$b = -0.3 \circ 10^{-3} \qquad s^{-1}$$

The values were restricted in the following way:

$$\kappa \in [-0.4,-0.1] \cdot 10^{-3}\ s^{-1}$$

By selecting a and b in this way stronger inversion situations than actually occurred is considered in the calculation of episode concentrations. More careful calculations are needed for this purpose.

The values that were used for the initial height of area sources in Oslo (H), are shown in Figure 4.1. The height of integration (H_m) is estimated to be two times the height of area sources. It is seen that the empirical value of the effectivity of vertical dispersion is larger than the one estimated from the atmosphere turbulence in air pollution episodes (see chapter 3).

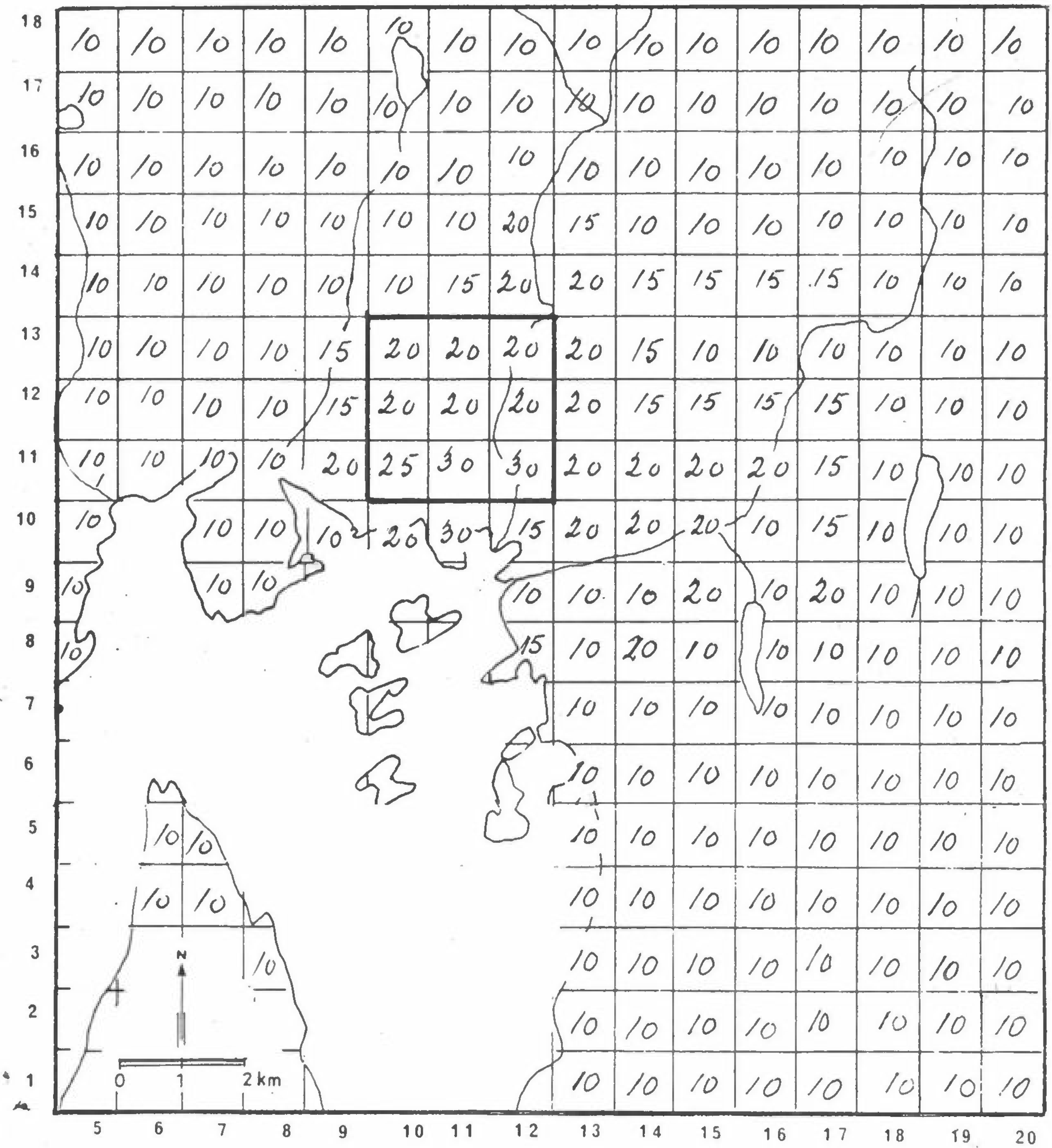


Figure 4.1: Initial height of area sources (H) in Oslo.

5 CONCLUSION

Downwind of an area source, the concentration is dependent on height of emission. The difference becomes smaller with increasing distance and increasing turbulence. The effect of emission height has to be considered when the distance is smaller than a few hundred meters for normal and good dispersion conditions (the emission height is less or equal to 30 m). In air pollution episodes the emission height is important for the concentration 1-2 km from the area source, and the effect should be included in the grid model (1 km grid distance).

The sensitivity of normalized concentration distribution on different dispersion parameters may be seen by comparing Figures 2.1, 3.1 and 3.2. The parameterization of vertical dispersion by a decay factor in a one level model tend to under-estimate dispersion close to the area source, over-estimate dispersion far from the area source according to boundary layer turbulence theory.

It is difficult to conclude on the applicability of the assumptions in the Oslo calculations (7) from the present data. McElroy- Poolers dispersion parameters are expected to work in an urban area. Plume rise for area sources in low wind conditions should be considered. Concerning the model applied in air pollution episodes more work is needed to describe vertical mixing of pollution from area sources. Measurements of SO_2 indicate that the results may be used as a first approximation.

When the relative pollution contribution from car traffic and from home heating are considered, the uncertainty should be underlined.

6 REFERENCES

(1) Fortak, H. Rechnerische Ermittlung der SO_2-Grundbelastung aus Emissionsdaten. Anwendung auf die verhältnisse des Stadtgebietes von Bremen. Institute for Theoretical Meteorology, Free University of Berlin 1966.

(2) Bringfelt, B. Hjort, Th. Ring, S. A numerical air pollution dispersion model for central Stockholm. *Atmos. Environ.* 8, 131-148 (1974).

(3) Schjoldager, J. Program Kilder. Beregning av spredning fra punktkilder og volumkilder. Programbeskrivelse og brukerveiledning. Kjeller 1974. (NILU TN 2/75.)

(4) Nieuwstadt, F.T.M. van Dop, H. Validation of a multiple source diffusion model based on the Gaussian plume model. In: *Proc. 6th NATO/CCMS International Technical Meeting on Air Pollution Modelling*, Frankfurt 24-26. Sept. 1975, NATO/CCMS.

(5) Busse, A. Zimmerman, J.R. Users guide for the climatological dispersion model. Research Triangle Park, N.C., 1973 (EPA-R4-73-024).

(6) Gifford, F.A. Hanna, S.R. Urban air pollution modelling. In: *Proceedings of Second Int. Clean Air Congress*, H.M. Englund and W.T. Beery, eds.), New York, Academic Press, 1970, pp. 1146-1151.

(7) Grønskei, K.E. Gram, F. Larssen, S. Beregning av sprednings- og eksponeringsforhold for visse luftforurensningskomponenter i Oslo. Lillestrøm 1982. (NILU OR 8/82.)

(8) Briggs, G.A. Diffusion estimations for small emissions. Oak Ridge, Tennessee, NOAA, 1973. (ATDL Contribution File No. 79.)

(9) Grønskei, K.E. Simplified treatment of vertical diffusion under inhomogeneous atmospheric conditions. Lillestrøm 1981. (NILU TN 14/80.)

(10) Chock, D.P. A simple line-source model for dispersion near roadways. *Atm. Environ.*, 12, 823-829 (1978).

(11) Businger, J.A. Turbulent transfer in the atmospheric surface layer. In: *Workshop on Micrometeorology*, D.A. Haugen, Ed., Boston, American Met. Soc. pp 67-98.

(12) Venkatram, A. Estimating the Monin-Obukhov length in the stable boundary layer for dispersion calculations. *Boundary Layer Meteorol.* 19, 481-485 (1980).

(13) Larssen, S. Grønskei, K.E. Beregningsmetoder for luftforurensninger ved trafikkårer. Lillestrøm 1981. (NILU OR 5/81.)

(14) Grønskei, K.E. Simplified treatment of vertical diffusion under inhomogeneous atmospheric conditions. Lillestrøm 1981. (NILU TN 14/80.)

NORSK INSTITUTT FOR LUFTFORSKNING

NILU

TLF. (02) 71 41 70

(NORGES TEKNISK-NATURVITENSKAPELIGE FORSKNINGSRÅD)
POSTBOKS 130, 2001 LILLESTRØM
ELVEGT. 52.

RAPPORTTYPE Teknisk rapport	RAPPORTNR. TR 6/82	ISBN--82-7247-323-2
DATO JUNI 1982	ANSV.SIGN. B. Ottar	ANT.SIDER 24
TITTEL Dispersion of pollution from area sources		PROSJEKTLEDER K.E. Grønskei NILU PROSJEKT NR 20682
FORFATTER(E) K.E. Grønskei		TILGJENGELIGHET ** A OPPDRAGSGIVERS REF.
OPPDRAGSGIVER Statens forurensningstilsyn		
3 STIKKORD (á maks.20 anslag) Dispersion	area sources	Oslo

REFERAT (maks. 300 anslag, 5-10 linjer)

Forurensningsbidrag fra arealkilder i ulik høyde er vurdert ved å integrere ligningen for en linjekilde. Virkningen av initialspredning på grunn av bygningsturbulens er belyst ved antagelser innarbeidet i tidligere beregninger i Oslo. Resultater fra Highway-modell, numerisk modell og gatemodell er også diskutert.

TITLE Dispersion of pollution from area sources

ABSTRACT (max. 300 characters, 5-10 lines)

Pollution contribution from area sources at different emission heights are considered by integrating the equation for a line source. The effects of the initial dispersion caused by building turbulence is considered. The results of a Highway model, a numerical model and an street canyon model are further discussed.

**Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C