Page 1.

I appreciate having the opportunity to give you a very brief report about our work in a working group of the VDI.

This working group has developed Recommendations for Turbulence Parameterisation for Atmospheric Dispersion Calculations which will come into operation within the next months.

VDI = Association of Engineers

KdRL = The Commission on Air Pollution Prevention of VDI and DIN - Standards Committee KRdL

Page 2.

Chairman of the WG is Klaus Maßmeyer. Unfortunately, he cannot attend the meeting and hence he has asked me to take his part.

The participants of the WG come from the universities, national weather services in Austria and Germany, research centres, and even from the EU itself

Page 3.

In the past atmospheric dispersion modelling was carried out in the frame of Regulatory Purposes mainly by Gaussian type models, which describe the atmospheric turbulence via dispersion parameters σ_y and σ_z .

These σ_y and σ_z were derived from dispersion experiments over fairly flat but rough terrain (Research centres Karlsruhe and Jülich).

I.e. for rather high roughness length

for 6 stability classes

for 3 emission heights

Page 4.

Necessary meteorological input data were derived from synoptic data . . .
From this data base stability classes were routinely estimated which are part

- **either of meteorological statistics**
- **or time series of met. Data**

which are available for more than 100 sites in Germany.
Recently, the DWD has transferred these data into scaling parameters according to similarity theory, which are necessary for modern approaches of the PBL.
For this job appropriate meteorological pre-processors, i.e. the Holtslag-pp, was applied and modified for conditions in Germany

<u>Page 5.</u>
In Germany an update of technical guidelines for environmental protection is in progress.
The objective is to apply modern atmospheric dispersion models ...
Within the guideline-framework of VDI already two dispersion models were put in operation =>
The application of such models implies the need for an updated turbulence parameterisation.
Within the WG of the VDI such a TP was developed.
The focus of the WG aimed at the following:
It should be practical and consistent.
And it should be applicable to all kinds of dispersion models

<u>Page 7.</u>
There was an agreement in the WG that certain application limits for the updated turbulence parameterisation must be taken into account from the point of view of PBL theory ...

t travel time of pollutant with respect to turbulent time scale T_L
In a first step empirically boundary layer parameterisations
- which have been derived from meteorological field experiments and not from tracer experiments -
were evaluated in a literature survey...

***Page 8*.**

The parameterisations for σ_u, σ_v, σ_w and T_{Lu}, T_{Lv}, T_{Lw} which were investigated are based on similarity scaling theory.
It was a matter of fact that the parameterisations behave not reasonable behaviour in some cases,
i.e. they were unsteady with changing stability ...
...
Criteria for the selection of an appropriate parameterisation:
...

Page 9.

Within the formulas for the TP the following scaling parameters were used ...
The literature survey revealed that the
- corresponding coefficients and
- height dependencies

show more or less variations
The WG has paid attention to get smooth transitions between different height ranges as well as between different stability regimes.
This allows a “careful” application also in middle and upper parts of the convective PBL.

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Example for the recommended parameterisation of std dev. of turbulent velocities ...
=> Broad agreement within scientific community

The parameterisation of turbulent time scales is quite less secure and large differences can be recognised between different parameterisation schemes.
With respect to similarity scaling theory there exist 2 different representations for the turbulent time scale:
- length scale/velocity scale*height dependance
- velocity scale/dissipation rate of TKE

The latter - applying ε -
- gives no discontinuities between stability regimes,
- is consistent with PBL-experiments.

Proper selection of Kolmogorov constant C_0 is necessary

Page 11.

Classical formulas to derive
diffusion coefficients for Eulerian models
dispersion parameters for Gaussian type models, exhibits the same behaviour like the Taylor-theorem

Page 12.

Mixing height z_i is a necessary input parameter for the recommended TP
Within the COST 710-Action its determination was discussed.
However, on the basis of the narrow meteorological input data (stab.class, wind speed) only very crude procedures are available to determine this scaling parameter.
The WG recommends a combination of
- simple classification acc. to stratifciation and
- an empirical approach for stable stratification (Holtslag, Westrhenen)

but is open for approaches which are more suitable

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The graphs represent
the standard deviations of turbulent velocities as a function of the height above ground

- from different approaches cited in the literature
- together with the recommendations of the WG

Vertical profiles $\sigma_{u,v,w}$ are rather similar and not controversal.

Page 14.

Turbulent time scales as proposed by different authors express large differences!

The continuous increase of turbulent time scales with the height above ground seems to be unreasonable.

Page 15.

Bulbous curvature of the diffusion coefficients
with a maximum in the lower third of the boundary layer
was treated to be most reasonable

The well-known behaviour of the vertical diffusion coefficient in the surface layer
which is proportional to '$\kappa u_* z$'
is met by most of the approximations

Page 16.

Stability dependence of the recommended vertical profiles is shown for
- neutral, near stable and unstable stratification

The bold lines represent the area where the parameterisation is treated to be most reliable,
i.e. in the lower 10% of the mixing layer.

Characteristic decrease of $\sigma_{u,v,w}$ with height

Bulbous shape of the profile for σ_w in unstable conditions

Page 19.

From the theoretical point of view the recommended TP meets the requests of the WG

In a second step we have examined how the TP works when applied to real atmospheric dispersion situations.

Select data from tracer experiments
- carried out at the Research Centre Karlsruhe,
- the Prairie-Grass Experiments
- as well as wind tunnel data

They cover a wide range of different
- thermal stabilities
- roughness lengths
- emission heights

Dispersion calculations were carried out with a particle model

<u>Page 20.</u>

Calculated concentrations tend to be slightly overestimated with respect to the measured data.
However, this seems to be acceptable for the application within the frame of regulatory purposes.
Prairie-Grass-Experiments, level terrain, small z_0=0.6m
small emission height H≅0.5m,
different stabilities expressed as 1/L,
source distances 50m, 200m, 800m
Compare plume widths
- from concentration measurements
- with calculated values ◆

However, differences between measurements and calculation become larger
- with increasing source distance
- and for unstable stratification

Reason: For strong convective situations the TP doesn't take into account the skewness of the turbulent velocity distribution . This leads to an overestimation of the calculated concentrations in the case of the Prairie-Grass-Experiments

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Calculated concentrations (line) applying particle model together with recommended TP vs concentration measurements ( ).

H=100m: fairly good agreement
H= 60m: calculation overestimates measurement
Location of calculated maximum concentration is shifted to larger distances.

Page 22.
Remaining problems
Modelling of time series with periods of decreasing mixing height, e.g. during the development of stable boundary layer after sunset
not applicable to non-level terrain;
however, application is possible in a sufficient distance from roughness elements, i.e. distances of about 10m. This holds for “urban canopy layers, too.
a more general problem reflects the dependence of the Kolmogorov constant C_0 upon stabilty and direction of co-ordinates
Comment of Schatzmann:
TP is derived for horizontal homogeneous conditions where some kind of equilibrium can be presupposed. This TP cannot be applied for situations where sharp changes of roughness lengths prevail, like e.g. in the urban canopy layer.
Comment of Baklanov:
Why the lower limit of MH is set to 250m?
Lower values may occur?