VALIDATION OF CZECH REFERNCE MODEL SYMOS'97, ADAPTED FOR ODOUR DISPERSION MODELLING

Josef Keder, Jiri Bubnik and Jan Macour
Czech Hydrometeorological Institute

Overview

- Motivation
- Adaptations of SYMOS´97 for odour modelling
- Data set used for adapted model validation
- Results of comparison of model and experimental data
- Conclusions, ideas for further work

Motivation

- Odorous air pollutants considered important for their nuisance value and the number of complaints they cause
- After elimination of the most serious problems caused by the polluting substances, deteriorating air quality in Czech Republic, odorants also came into focus of public and legislators.
- Similarly as in case of “classical” pollutants, besides the olfactometric measurements, odour dispersion models application is also demanded
- Especially for the estimates of newly planned facilities impacts
- The gaussian dispersion model SYMOS’97, used as a reference modeling method in Czech, has been adapted for odour dispersion modelling
- Uncertainties connected with odour dispersion modelling are even substantial compared with models for “classical” pollutants
- **Odour model performance is of great interest.**

Model adapted

- The gaussian dispersion model SYMOS’97, used as a reference modelling method in Czech, adapted for odour dispersion modelling *http://air-climate.eionet.eu.int/databases/mds.html*)
- Model designated for calculations of dispersion of passive buoyant, continuous release from single or multiple sources (point, area or line) sources.
- Five stability classes by Czech national stability scheme applied within the model.
- The system enables , among others, the calculation of maximal possible hourly concentration
- Complex terrain corrections based on digital terrain model included as a routine part of model calculations.

Adaptation of SYMOS´97 (1)

- Odour subjective perception by humans proportional to the instantaneous peak concentration of the odorant rather then to mean values (well known and documented in the literature anywhere)
- SYMOS model, similarly as other dispersion models of this class, is set for calculation of hourly mean concentrations
- The basic procedure how to modify the SYMOS for odour concentration: recalculation of hourly means reached in particular hours into corresponding peak values which might occur during these hours
- Widely used peak-to-mean ratio (P/M ratio) approach (e.g. *Katestone Scientific,1998*) selected as suitable solution of this task, (*Keder, 2003*)

Adaptation of SYMOS´97 (2)

- The main advantage of the proposed approach: most input data management and calculation procedures included in the SYMOS modeling system could be maintained.
- **Substantial difference** of the model adapted for odours by such way: *modelling of odorant concentration field originated from only one source recommended* (it is not possible to simply sum the concentration contributions from different sources)
- The procedure
  - → fields of maximum possible hourly concentrations calculated from the input data on source parameters and meteorology
  - → corresponding stability category recorded for each grid value
  - → output concentration field is subsequently recalculated into peak values using the set of peak-to-mean ratio coefficients
  - → coefficients value depends on the source type, stability class and on the distance of the reference point to the source
- Set of P/M ratios, derived by Katestone Scientific (*Freeman and Cudmore, 2002*), has been selected and incorporated into model

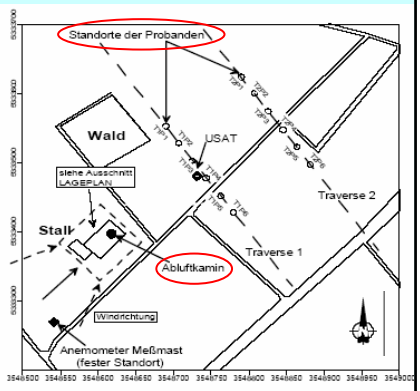
Data set for model validation (1)

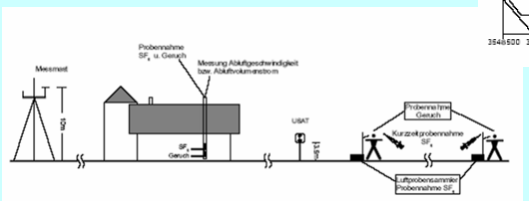
- Field experiment in the surrounding of the **pig farm** near Stadt Biberach a. d. Riss, Germany (*Bächlin, Rühling and Lohmeyer, 2002*)
- Flat terrain, all experiments performed during time with neutral stratification

Source: Bächlin and all

Data set for model validation (2)

- Total 14 data subsets corresponding to measurements series marked from **B** till **O** collected
- For each 10 minutes-long series, complete data sets available on:
  - → source parameters
  - → meteorology
  - → concentration data of odour and passive SF_6 tracer (mean at 12 and instantaneous at 2 points)
  - → subjective odour intensity in 6 point scale assessed by 12 trained panellists
- The concentration data were collected at the traverses in the lee of the source





Source: Bächlin and all

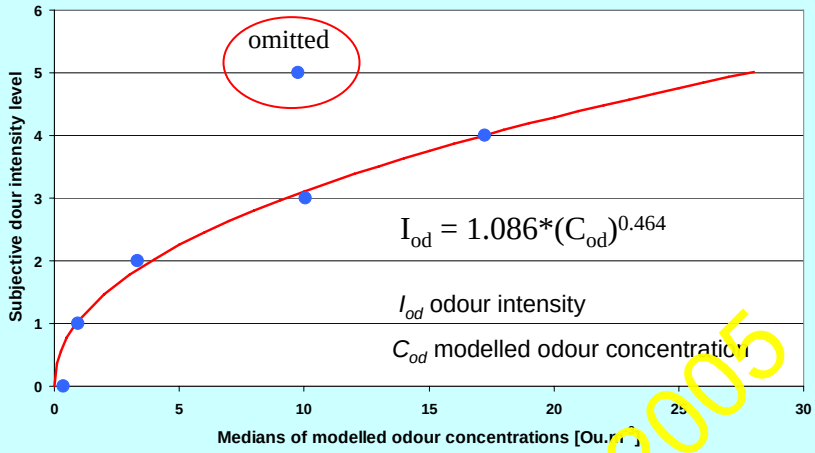
Data set for model validation (3)

- During the 10 minutes-long series the panellist recorded their estimate of odour intensity each 10 second
- Total 60 values of the odour intensity estimates available for each testing point and each series
- Maximum estimated odour intensity value found for each testing point in each series and used in subsequent analysis
- The hourly mean odour and SF_6 concentrations calculated by the SYMOS model at each testing point, using source and meteorology input data reported for each series
- Mean SF_6 values transformed into corresponding peak values using the set of P/M factors
- The paired measured and model data for series **B**, **C** and **E** till **O** were analysed and compared, series **D** excluded due to reasons reported by (*Bächlin and all*)

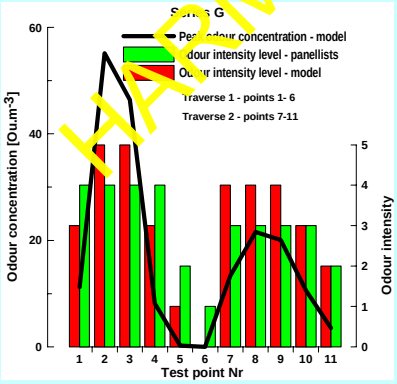
Analysis

- To enable comparison of modelled and estimated odour intensities, function relationship among **modelled peak** concentrations and **maximum odour** intensity values reported at testing points has been found
- Corresponding data pairs for all above mentioned series grouped into 6 classes according to odour intensity value (estimated by panellists)
- Medians of modelled odour concentrations estimated for each class marked 0 till 5 (class medians)
- Medians plotted against modelled odour concentration
- Data fit curve follows widely used **Stevens law** equation
- Outlying data for intensity level 5 were omitted

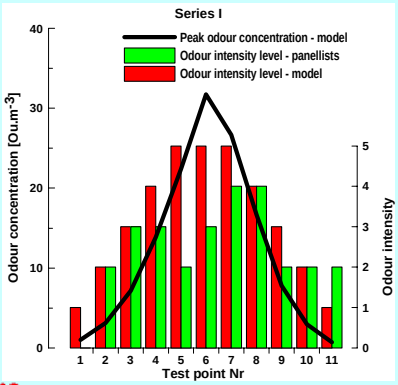
Analysis - data fit



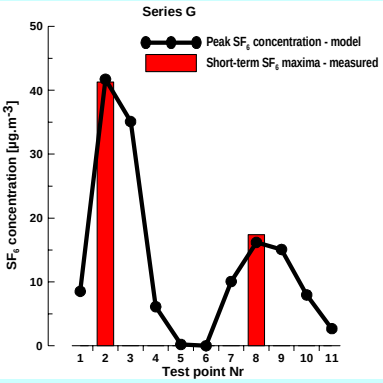
Results examples (1)



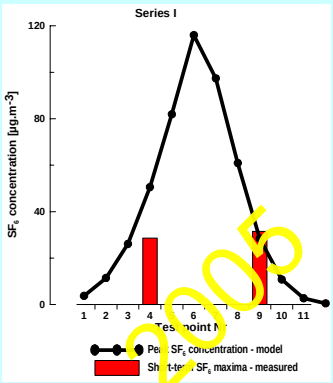
Modelled odour peak concentrations and odour intensities compared with estimated odour intensities



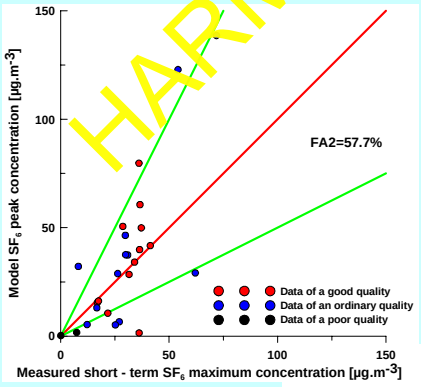
Results examples (2)



Modelled SF_6 peak concentrations compared with short-term SF_6 concentrations measured at 2 points



Results examples - statistics (3)



Modelled SF_6 peak concentrations compared with short-term SF_6 concentrations measured at 2 points
All series

		Perfect Model	Limits Kumar (2002), US EPA (1992)
Bias	6.08	0.0	Near 0
Fractional Bias	**0.18**	0.0	-0.5≤ FB≤ +0.5
NMSE	0.60	0.0	≤ 0.5
Corr	**0.74**	1.0	Near 1
Geometric mean bias Mg	**0.88**	1.0	0.75≤ Mg≤ 1.25
Geometric mean variance Vg	**1.02**	1.0	0.75≤ Vg≤ 1.25
FA2	57.69%	100%	Over 80%

Conclusions and scope of future work

- A satisfactory agreement of model and experimental data apparent from grafic representation
- Performance statistics satisfactory
- *At least for neutral stability and in flat terrain*
- The model slightly overestimates intensity classes near the plume centreline
- Despite of relative simplicity of adaptation procedure, the model provides **reasonable results applicable in the practice**
- Jump of P/M factors at transition from near to far field should be removed
- Tests in real conditions in CZ in progress

Thank you for your time!