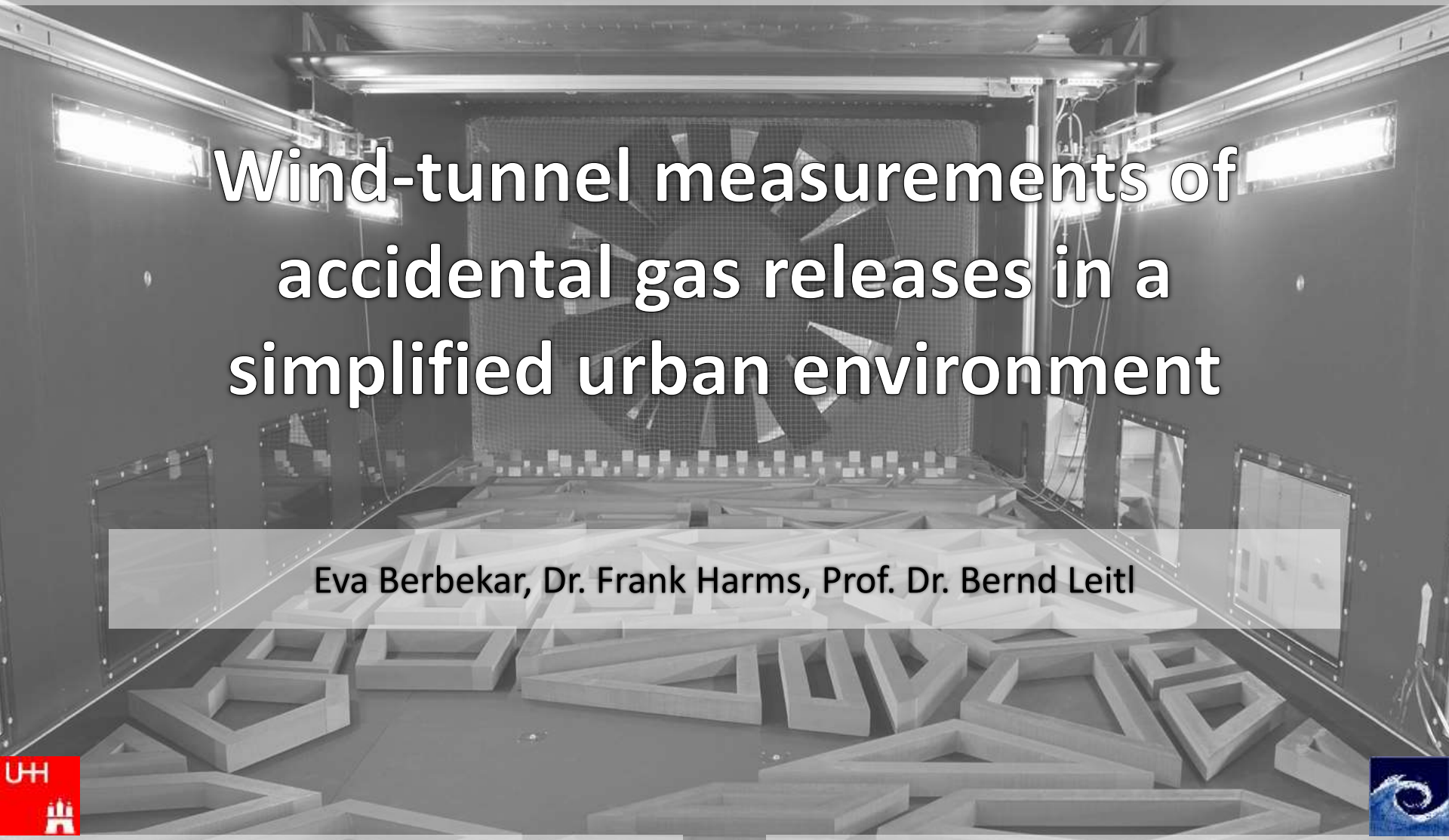
16th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 8-11 September 2014, Varna, Bulgaria



Wind-tunnel measurements of accidental gas releases in a simplified urban environment

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Motivation

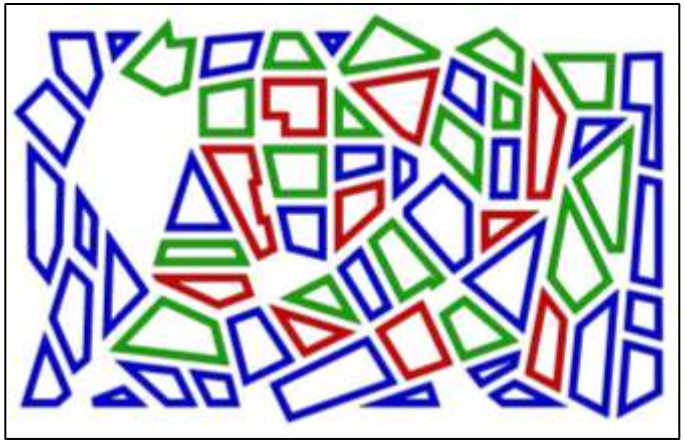
COST Action ES 1006: Evaluation, improvement and guidance for the use of local-scale emergency prediction and response tools for airborne hazards in built environments

Qualified reference dataset for local-scale hazmat dispersion models

- various emergency response tools
- variables of interest are different from general air quality modeling
- statistically representative dataset

Michelstadt

- idealized urban structure (Bastigkeit, 2011)
- aspect ratios typical for Central-European cities (Di Sabatino et al., 2010)
- flat roofs
- building height: **15 m**, **18 m**, **24 m**
- building width: 15 m
- street width: 18 m, 24 m
- scale: 1:225



Cologne

Hannover

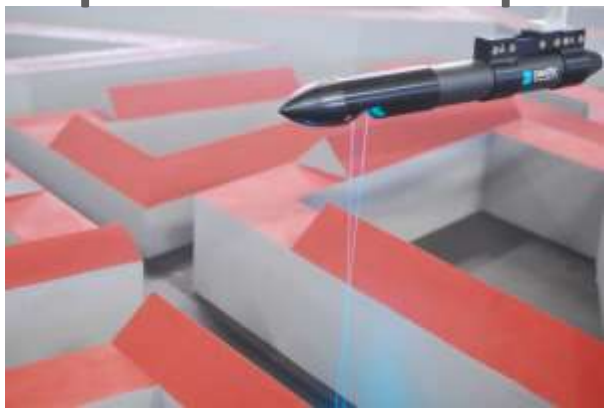
Prague

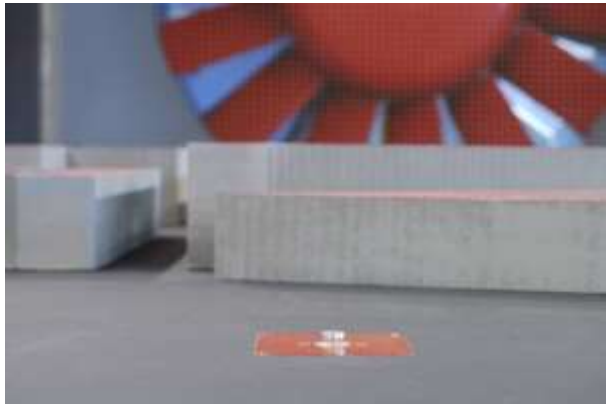
Vienna

Technical Meteorology

wind tunnel measurements

Experimental setup

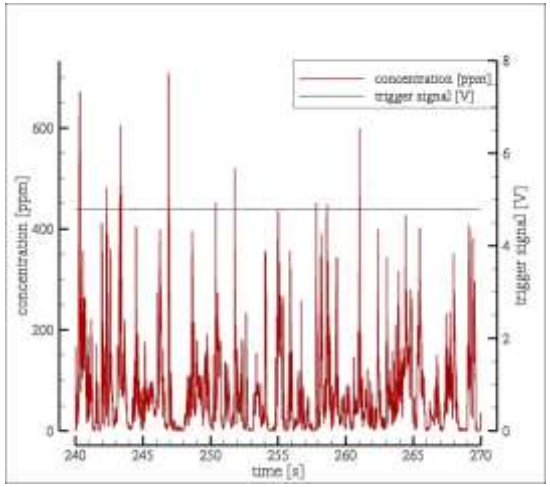


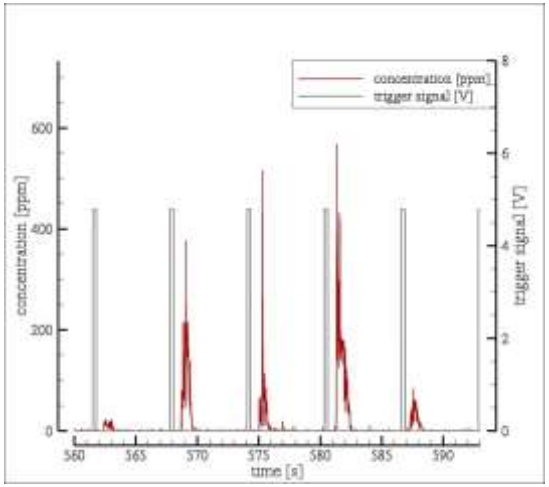


flow measurements

concentration measurements:

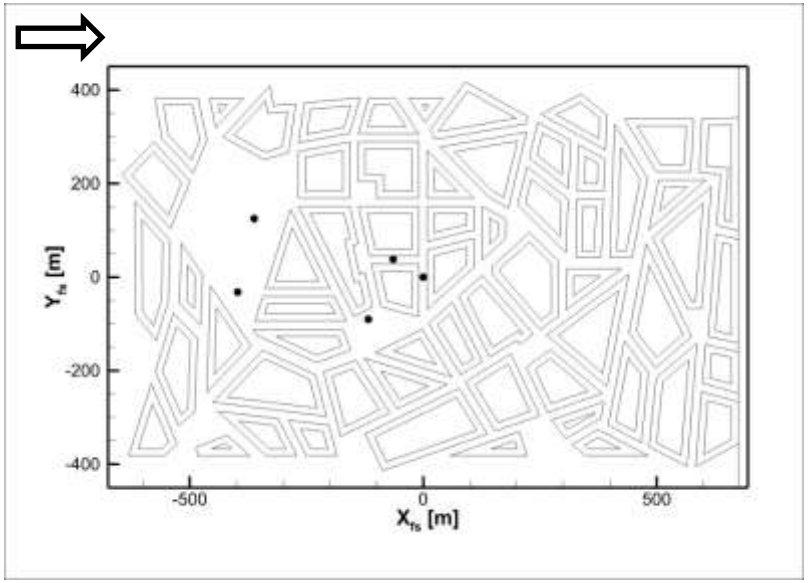
- continuous releases (about 15 – 20 hours full scale)
- puff releases (> 200 releases for each scenario)



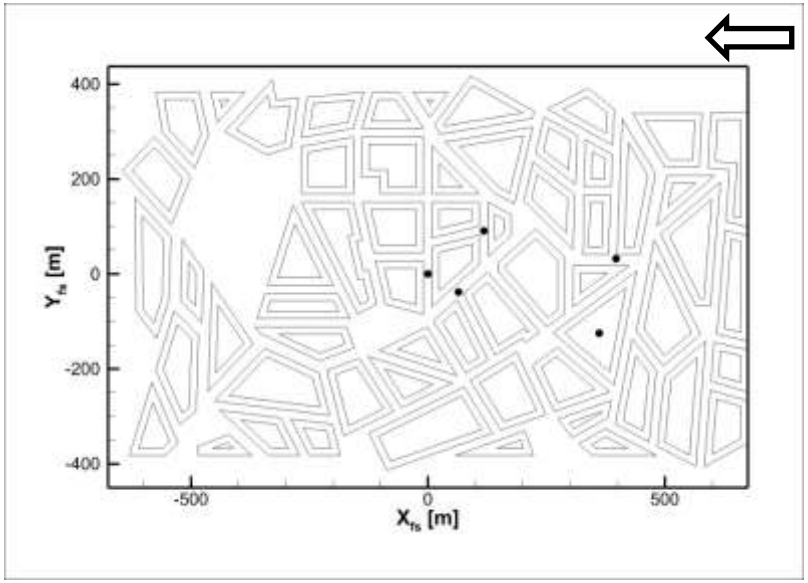


Dataset

Test name		Wind direction	Number of sources used	Number of continuous release measurements	Number of short-term release measurements
A	non-blind	0°	3	104	10
B	blind	180°	4	248	31



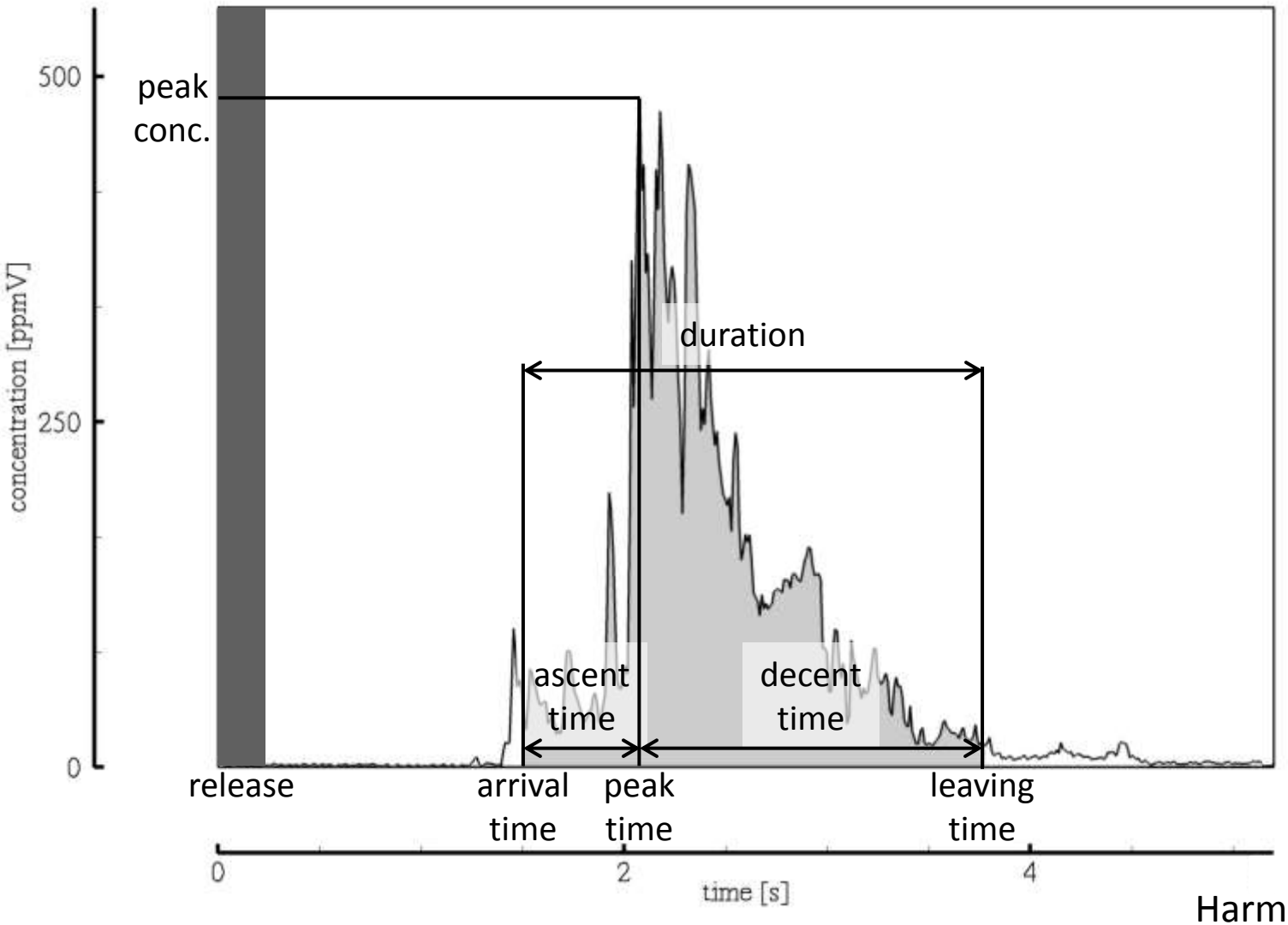
Non-blind test: directly available for modellers



Blind test: released only after the results of numerical simulations had been delivered

Technical Meteorology

Dosage-based parameters



Harms, 2010

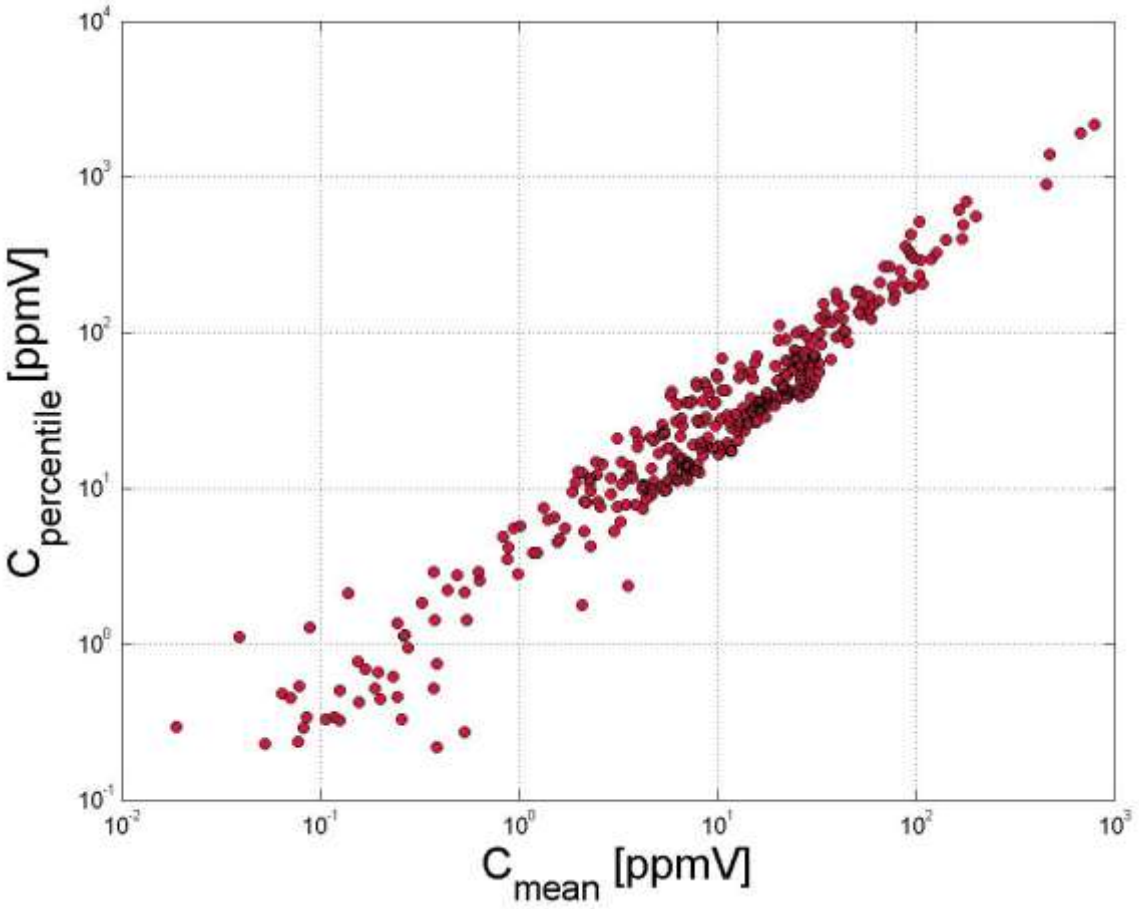
Dataset

- Flow field
  - mean u, v components with uncertainties and RMS (root mean square) values
- Continuous release dispersion
  - mean values and their uncertainty
  - percentiles, peak concentrations for different time averaging
- Puff dispersion
  - distribution of puff parameters, statistics (percentiles, mean, median, mode)
  - peak time and peak concentration for 15 s averaging
- Time series

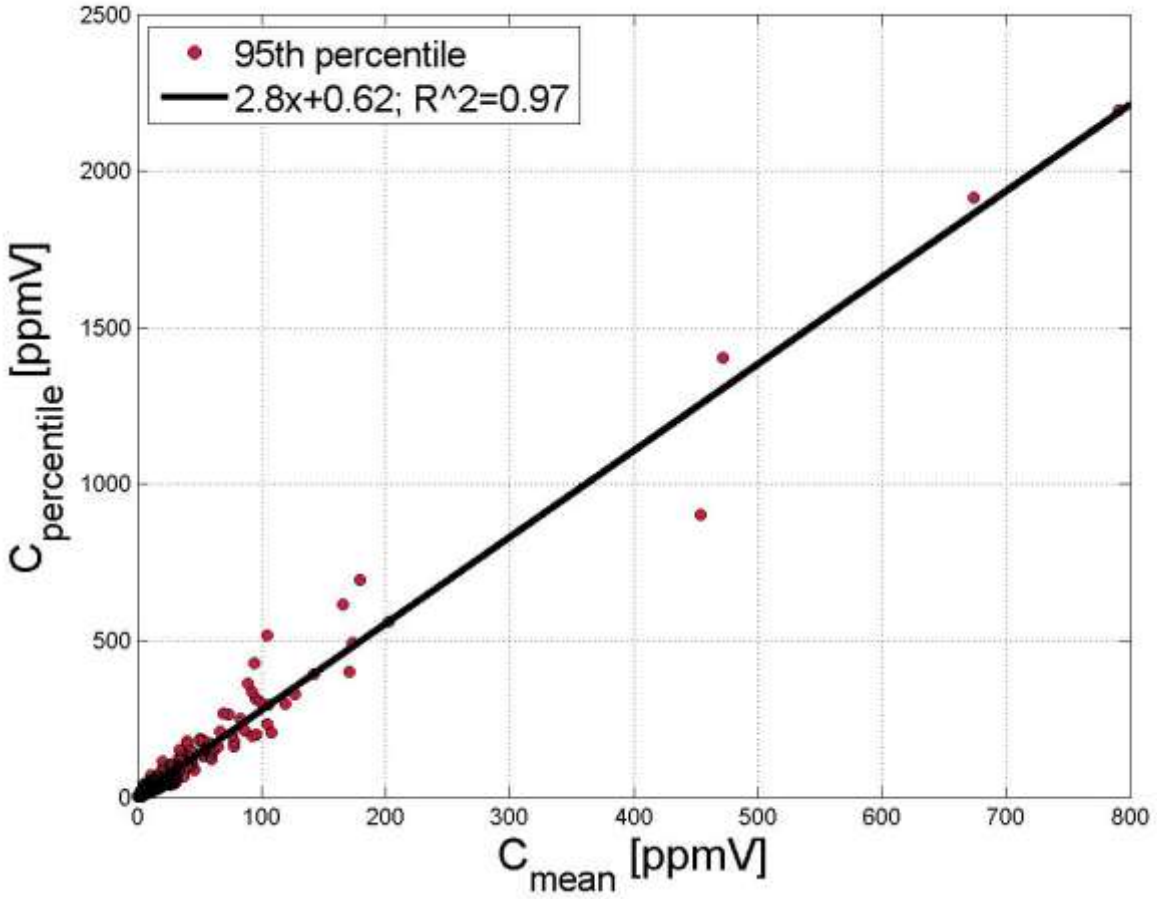
How to predict high concentrations for continuous releases?

- Numerical models predict only mean concentration
  - Gaussian
  - Lagrangian
  - RANS
  - only LES produces a distribution
- Efthimiou et al., 2014
  - mean and standard deviation from CFD results
  - gamma distribution

How to predict high concentrations?



How to predict high concentrations?



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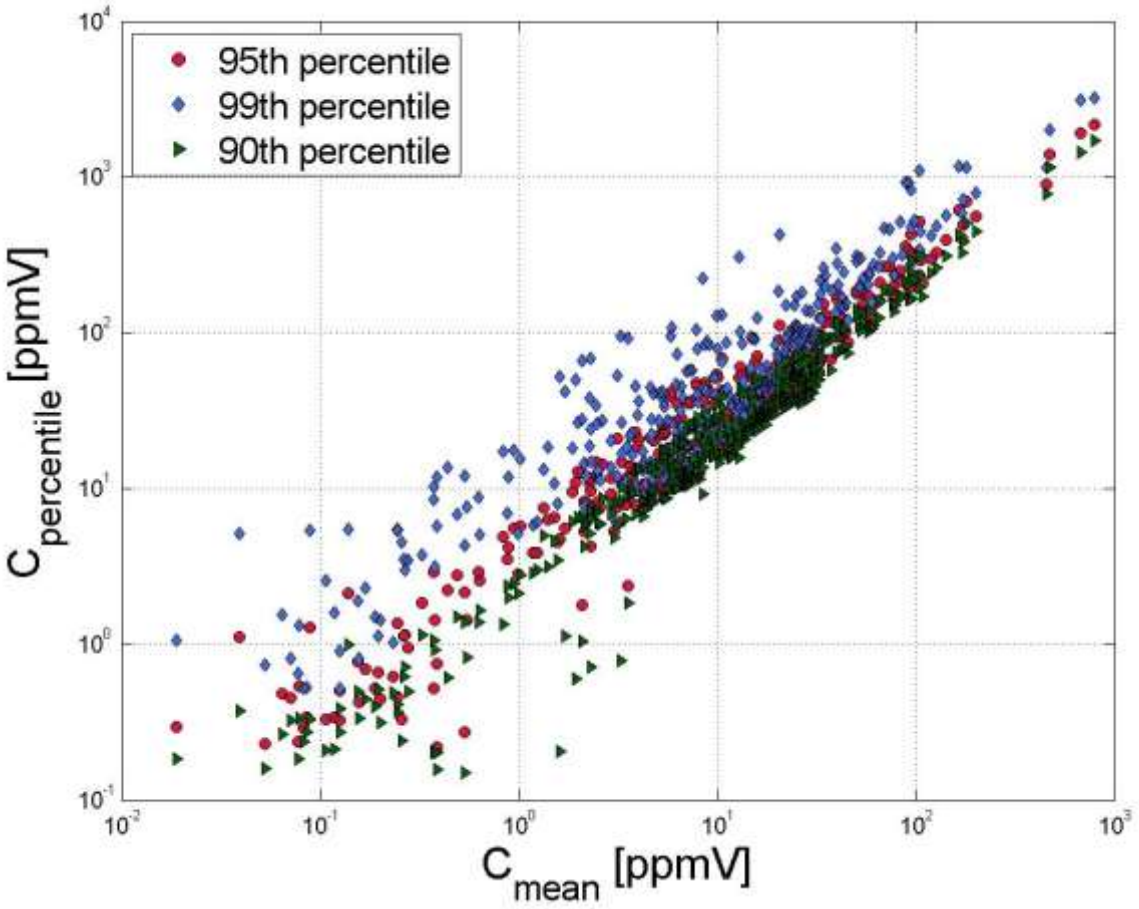

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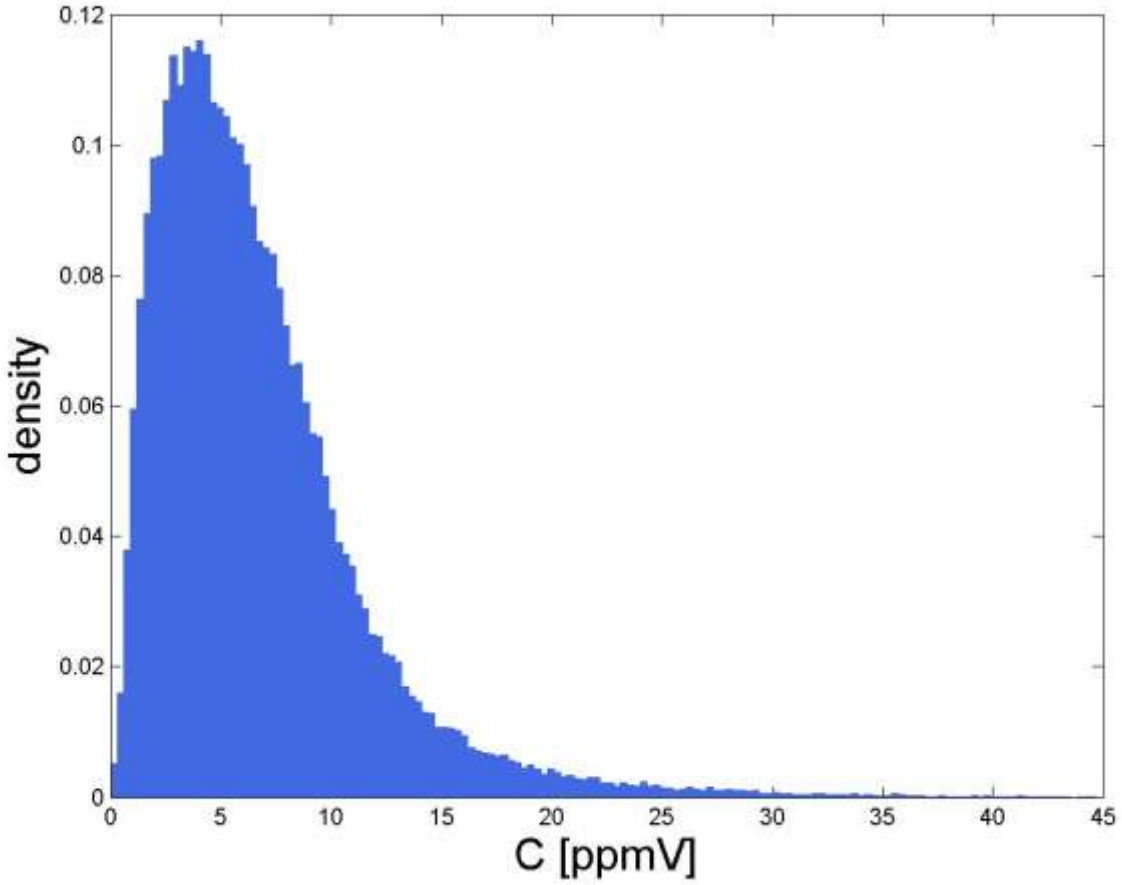

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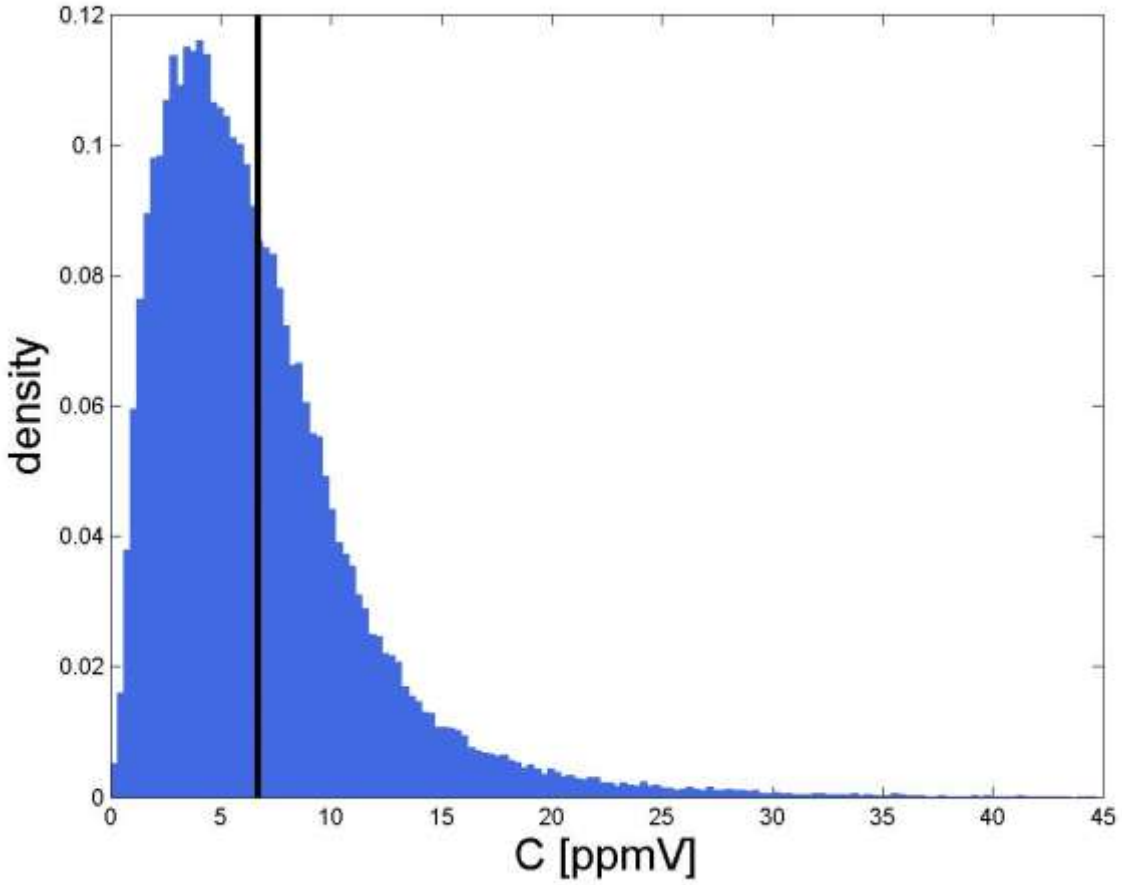

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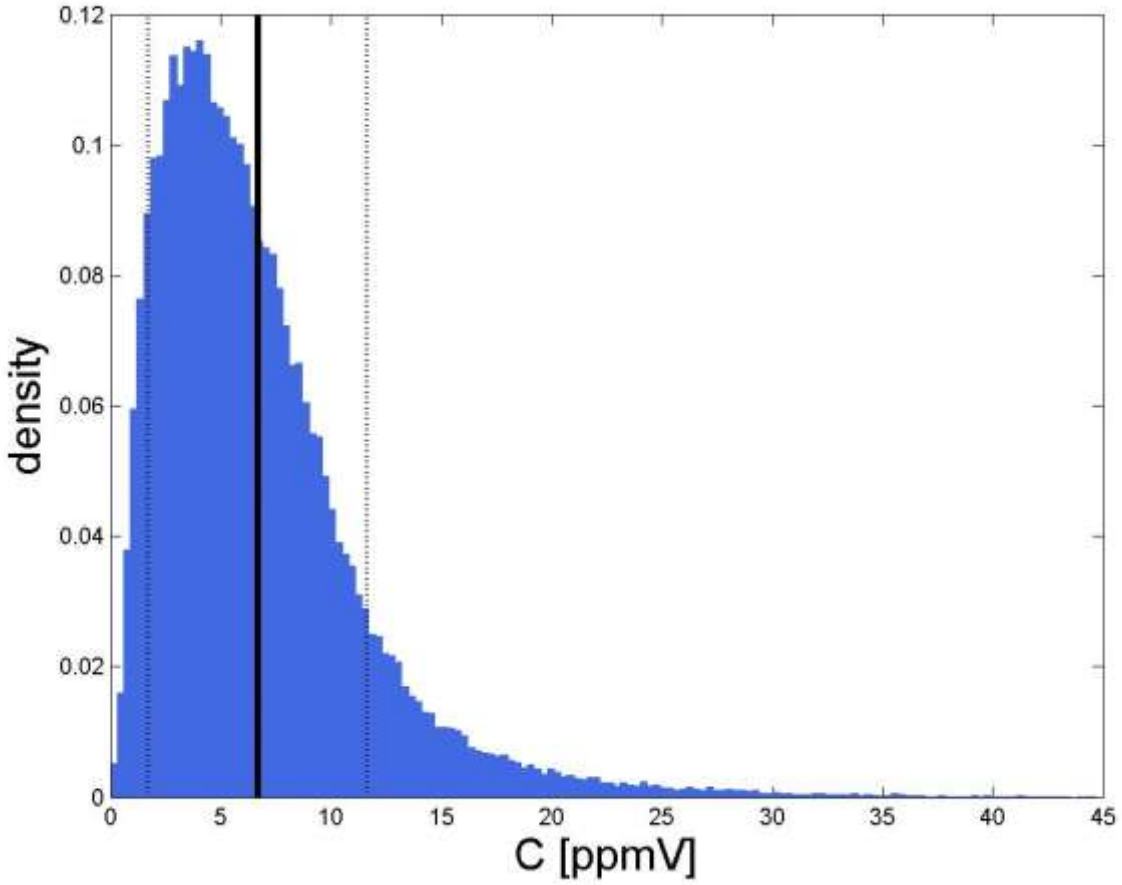

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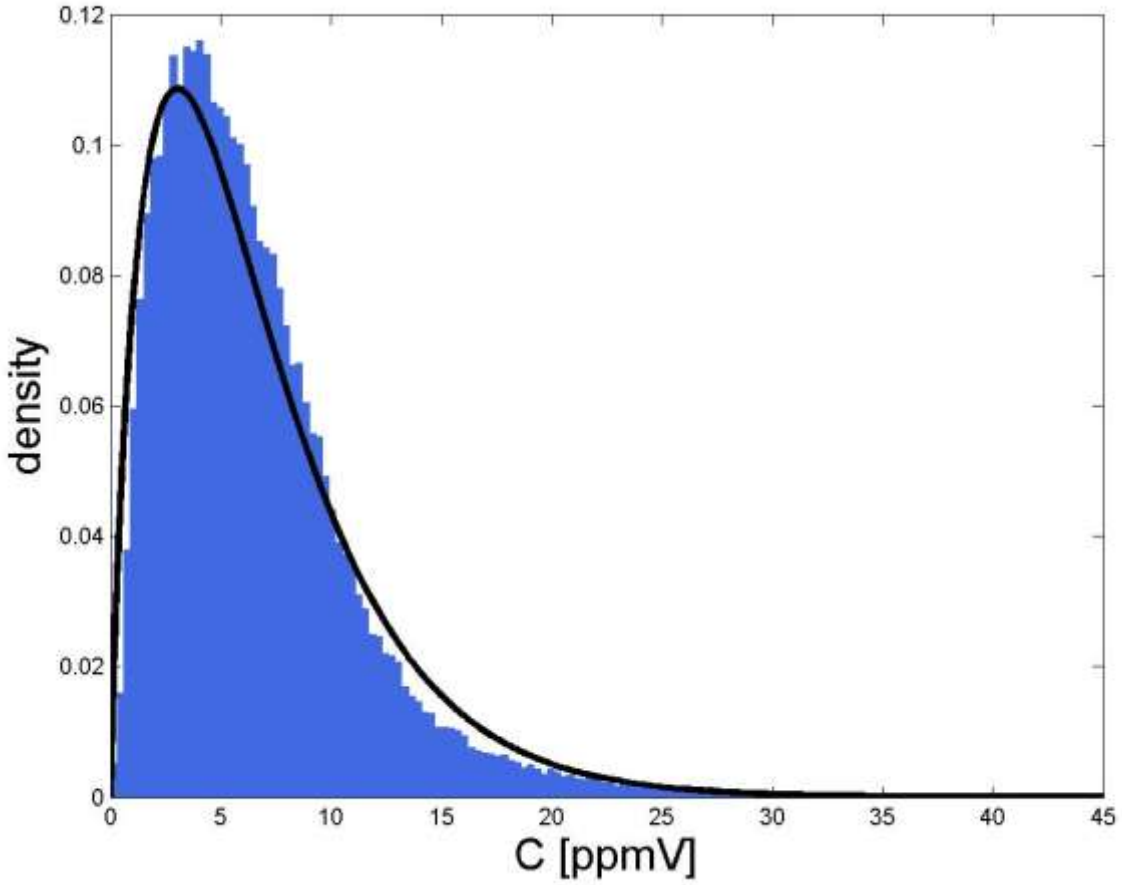

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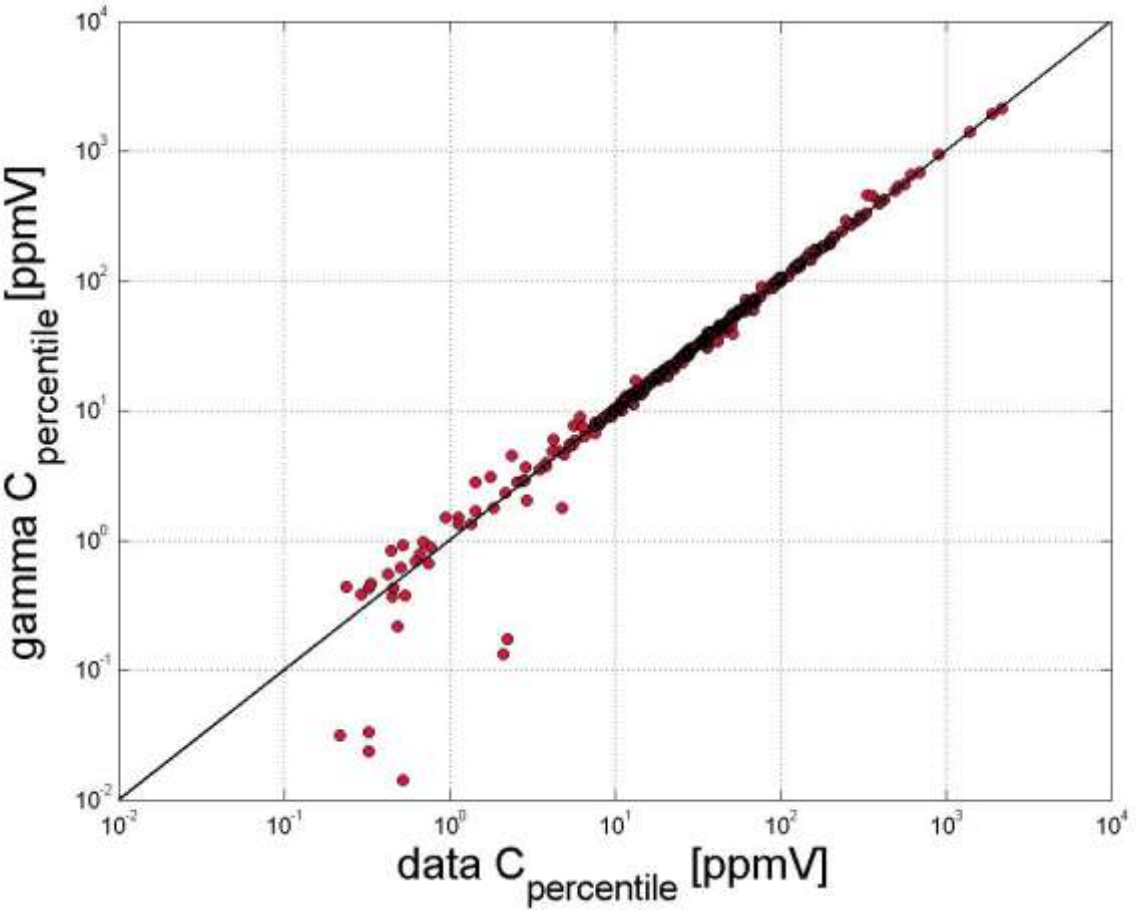

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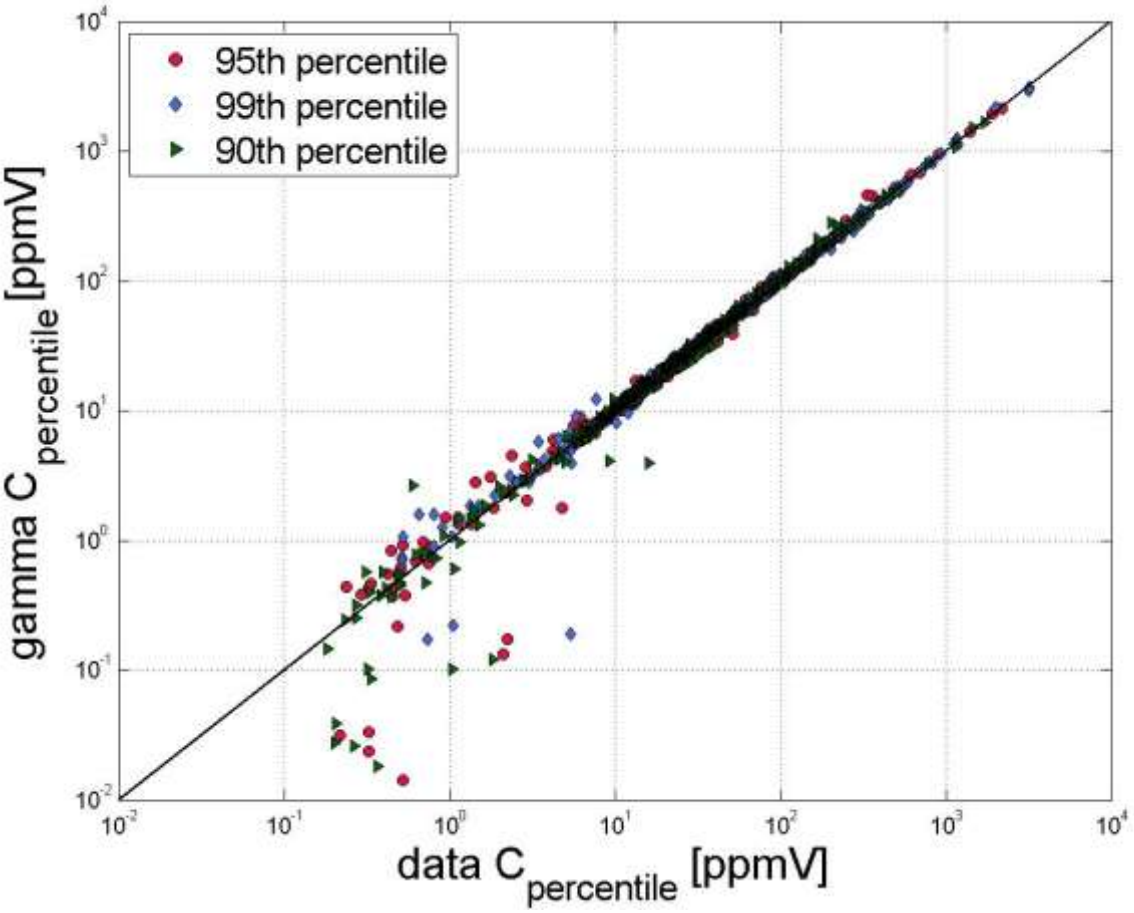

Conclusion, outlook

- Validation dataset
  - statistically representative dataset
  - flow measurements
  - continuous and puff releases
  - characteristics of transient phenomena: high concentrations, characteristic times

- Prediction of high concentrations
  - gamma distribution fitted on the mean and variance
  - test for other datasets
  - test other probability density functions

References

- Bastigkeit, I., 2011. Erzeugung von Validierungsdaten für wirbelauflöosende mikroskalige Strömungs- und Ausbreitungsmodelle. Ph.D. Thesis (in German). University of Hamburg, Germany
- Di Sabatino, S., Leo, L.S., Cataldo, R.,Ratti, C.,Britter,R.E. , 2010. Construction of Digital elevation models for a southern European city and a comparative Morphological analysis with respect to northern European and North American cities. Journal of Applied Meteorology and Climatology 49, 1377–1396
- Harms, F., 2010. Systematische Windkanaluntersuchungen zur Charakterisierung instationärer Ausbreitungsprozesse einzelner Gaswolken in urbanen Rauigkeitsstrukturen, Ph.D. Thesis (in German). University of Hamburg, Germany, 2010.
- Efthimiou, G., Berbekar, E., Harms, F., Bartzis, J. G., Leitl, B., 2014, Prediction of high concentrations and concentration distribution of a continuous point source release in a semi-idealized urban canopy using CFD-RANS modeling (under revision)

Thank you for your attention!