Geophysical Research Abstracts
Vol. 13, EGU2011-7791, 2011
EGU General Assembly 2011

A high-order size-resolved ultrafine particle model for a traffic tunnel

Peter Vos, Irina Nikolova, and Stijn Janssen
Flemish Institute for Technological Research (VITO), Boeretang 200, 2400 Mol, Belgium (peter.vos@vito.be)

Motivation

- **Ultrafine particles** Ultrafine particles (UFP) are the smallest constituents of airborne particulate matter and are typically low in mass but high in number. There is increasing scientific evidence that (traffic related) ultrafine particles may be more harmful to health than the coarser particles which account for most of the mass in the regulated PM_{10} and $PM_{2.5}$ fractions [1].
- **A tunnel model** No consensus has been reached whether UFP transformation processes (such as deposition, coagulation, condensation) should be taken into account for appropriately modelling the dispersion of UFP [2]. Due to their confined space and the controlled conditions, traffic tunnels form the ideal environment to investigate this hypothesis.

The model

The presented UFP tunnel model consists of a number of modules that implement the most important transport and transformation processes, *i.e. emissions, advection, deposition, coagulation, condensation*. The model calculates a continuous UFP number distribution at every location inside the tunnel (assuming a uniform concentration along every cross section). Despite its resemblance with existing Aerosol Box Models, the presented UFP tunnel model differs from existing models in the following sense:

- **A continuous description** Most UFP models employ a discrete representation of the solution (e.g. by using the size bin approach) based upon the discrete formulation of the General Dynamic Equation. We start from the continuous formulation and use corresponding numerical methods.
- **High-accurate state-of-the-art numerical methods** We have combined the Discontinuous Galerkin method with a high-order spectral element approach (typically up to 12^{th} order). Such high-order methods are known to yield high-accurate solutions.
- **A fully size-resolved approach** Next to a size-resolved description of the solution, we have also adopted a fully size-dependent description of the various transformation processes. As such, as well the deposition speed, the coagulation coefficient as the condensation rate do depend on the particle size.
- **A two-dimensional model** Aerosol dynamics box-models generally only depend on the particle size. The presented model calculates the UFP concentration in function of the particle size and the (axial) position inside the tunnel. As result, the model can be classified as a two-dimensional time-dependent model.

Results

Next to the presentation of the model, we also plan to elaborate on

- **The validation of the model** A typical bottleneck in UFP dispersion modelling is the lack of size-resolved measurement data for model validation. We have validated our model by means of the results of a very recent road-tunnel size-resolved UFP measurement campaign [3].

- **The estimation of emission factors** The presented model allows us to back-calculate emission factors from measurements, as well as comparing these results to existing emission models.
- **The identification of the relevant UFP transformation processes** The use of a continuous representation of the solution together with a high-order numerical method allows us to accurately identify the transformation processes that significantly affect the dispersion of UFP inside a traffic tunnel. We will present the results of the corresponding size-resolved time-scale analysis.

References

[1] Oberdörster, G., Oberdörster, E., Oberdörster, J., *Nanotoxicology: an emerging discipline evolving from studies of ultrafine particles*. Environ. Health Perspect., 113(7), 823–839, 2005

[2] Kumar, P., Robins, A., Vardoulakis, S. and Britter, R., *A review of the characteristics of nanoparticles in the urban atmosphere and the prospects for developing regulatory controls*, Atmos. Environ., 44(39), 5035-5052, 2010

[3] Cheng, Y. H., Liu, Z. S., Chen, C. C., *On-road measurements of ultrafine particle concentration profiles and their size distributions inside the longest highway tunnel in Southeast Asia*. Atmos. Environ., 44(6), 763-772, 2010