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MODELLING MEASURED AEROSOL PARTICLE SIZE DISTRIBUTIONS FROM ANIMAL HUSBANDRY USING WIDE RANGE AEROSOL SPECTROMETER (5NM TO 20µM) - A NEW APPROACH TO SPECIFY PARTICULATE EMISSION FROM AGRICULTURAL SOURCES

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Introduction

Particulate emissions from agricultural sources and in particular from animal stables are in the focus of many reasons e.g. occupational, animal health, licensing procedures, environmental aspects, atmospheric research and mitigation strategies. Size dependence data are rare, especially in the submicron and nano size range (Onyeneke-Edwards 2006, Mahmoud-Yasin, 2006). The particle size distribution therefore is fundamental to characterize and compare different aerosol particle sources and to assume formation of secondary aerosol particles due to gaseous precursors from agriculture. The object of this work was to apply a standardized method for measuring and modelling particle size distributions down to small nano meter scale for the first time ever to agricultural sources and to test the method at different stables and animal species.

Material and Methods

The particle size distribution and the particle number concentration were measured with a wide range aerosol spectrometer (WRAS) in a particle range from 5 nm to 20 µm within 59 size channels. The WRAS consists of a light scattering aerosol spectrometer (LSAS), Grimm Inc. model 1.108 and a scanning mobility particle sizer (SMPS+C), Grimm Inc. model 5.403 with 5.500. The LSAS measures particles within the range between 0.3 µm to 20 µm diameter (optical latex equivalent diameter) and classifies the particles in 15 size channels. The SMPS+C consists of a condensation particle counter combined with a medium differential mobility analyzer for particle sizing in a range from 5.5 nm to 350 nm within 44 size channels. All systems are battery powered which also enables them for mobile use. The measurements have been done at different stables for cattle, swine, and poultry, located at two farm-building locations in south Germany. Additional measurements have been done at other locations e.g. upwind and downwind of the farm buildings or at manure pits. Ammonia concentration, temperature, relative humidity and wind speed have been determined simultaneously.

Comparing to methods in aerosol physics (e.g. Wittmaack, 2002) lognormal distributions have been calculated assuming a four particle size-modes and were combined using formula 1 for each data set.

$$n(D)=\sum_{i=1}^{4}\frac{N_i}{\sqrt{2\cdot\pi}\cdot\log(\sigma_{g,i})}\cdot\exp\left(-\frac{\left(\log\left(\frac{D}{D_i}\right)\right)^2}{2\cdot(\log(\sigma_{g,i}))^2}\right)$$ Formula 1

Each size-mode is fully described by the three parameters particle number concentration N_i, mean median particle diameter D_i and the standard deviation $_{g,i}$. Due to the wide range set-up the calculations have been carried out for nucleation-mode, accumulation-mode and coarse particle-mode.

Results

For all sampling sites particle number distribution have been calculated based on the measured particle size distributions and the adjusted lognormal distributions. Figure 1 shows a measured particle size distribution and the adjusted lognormal distribution for two different locations.

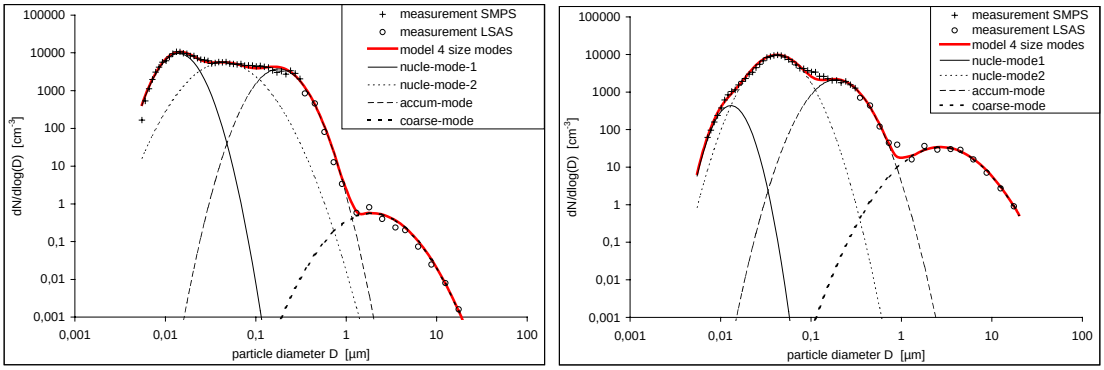

Figure 1: Measured particle size distribution ("+" indicate SMPS+C and "o" indicates LSAS) and modelled data (solid line). The dashed and dotted lines indicate the single modelled lognormal distributions. Left figure background aerosol, right figure pig stable.

There is a very good correlation between the measured particle size distributions and the results from the parameterisation. Using the parameters concentration N_i, mean median particle diameter D_i and standard deviation $_{g,i}$ derived from the modelling the complex data from nano meter to micrometer size scale can be easily fully described.
Particle formation due to gas-to-particle conversion from typical agricultural gaseous precursors was documented in this campaign for particles smaller than 10nm diameter as well as coagulation of aerosol particles affecting the particle size distribution up to particles with 2µm diameter. This results are comparable to principles of aerosol chemistry published within the last few years, but have never been investigated for agricultural sources within a size range between 5nm < D < 20µm yet.

Conclusion

The described method and results are useful to answer the contribution of particle formation due to agricultural sources in general, their chemical composition, occupational aspects and the interaction between aerosol particles and radiation (e.g. Jayaraman, 2006). The results are adjustable to further applications e.g. particle surface area distribution or

particle mass distribution. Therefore additional information about the emitted particulate matter like particle shape or particle density (e.g. Kannosto et.al., 2007) are required.

References

1. Jayaraman, A., H. Gadhavi, D. Ganguly, A. Misra, S. Ramachandran, T.A. Rajesh, Spatial variations in aerosol characteristics and regional radiative forcing over India: Measurements and modeling of 2004 road campaign experiment, Atmospheric Environment 40 (2006) 6504–6515.
2. Kannosto, J., A. Virtanen, T. Rönkkö, P.P. Aalto, and M. Kulmala, Density of boreal forest aerosol particles as a function of mode diameter, technical paper T13A147, proceedings of European aerosol conference 2007, September 9-14 2007, Salzburg, Austria.
3. Onyeneke-Edwards, H.C., 2006, Measuring Aerosol Particle Emission from cattle using Wide Range SMPS and OPC. Master's Thesis, School of Forest Science and Resource Management, Technical University of Munich, Germany, 43p.
4. Mahmoud-Yasin N., 2006, Measuring Aerosol Particle Emission from Swine and Poultry using Wide Range SMPS and OPC. Master's Thesis, School of Forest Science and Resource Management, Technical University of Munich, Germany.
5. Wittmaack, K., Advanced evaluation of size-differential distributions of aerosol particles, Aerosol Science 33 (2002) 1009–1025