Application of Gaussian Process based inversion algorithm to SMPS data

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This document contains a short description of the application of the inversion algorithm by Mølgaard et al. (2016) to data from a TSI SMPS. In that article the algorithm was successfully applied to DMPS data collected in an environment where the changes in the aerosol happens at time scales shorter than a scan. The application to SMPS data is more tricky, because the transfer functions are more difficult to calculate, and the SMPS produces raw data much faster than a DMPS.

I provide the following MATLAB scripts:
read_raw_data_v2.m: Reads in raw data written in TSI format.
transferDD2011_v2_2.m: Calculates the transfer function for some point in time based on (Dubey and Dhaniyala, 2011, 2008; Mamakos et al., 2008). It follows the steps in Dubey and Dhaniyala (2011), but skips the diffusion broadening. Unlike the algorithm by Dubey and Dhaniyala (2011), it can also handle downscan (scans with decreasing voltage). A few of the sub-functions are copies of functions written by others.
kernelOneScan.m: Calculates the kernel needed for the inversion.
SMPSinversion.m: Calls the previous functions, sets up the model and calls the inversion, plots some output. I created this script by modifying a script written by Jarno Vanhatalo and myself. Note that you need to have GPstuff v4.5 installed to run this model. Download from http://research.cs.aalto.fi/pml/software/gpstuff/.

Data was collected at the SMEAR III station in Helsinki using an SMPS, which contained parts borrowed from Finnish Meteorological Institute (FMI). Pasi Aalto set up the SMPS. Some raw data are found in the file somedataTSI.txt. Something went wrong when exporting this file, so data from every eighth scan are missing, but the data can still be used for testing the algorithm.

Running the model for the first 14 scan in the data file gives the concentrations in the figure. Clearly, the model can extract some of the variation at time scales shorter than the scan duration.

References

Dubey P, Dhaniyala S (2008). Analysis of Scanning DMA Transfer Functions. Aerosol Science and Technology, 42, 544-555.

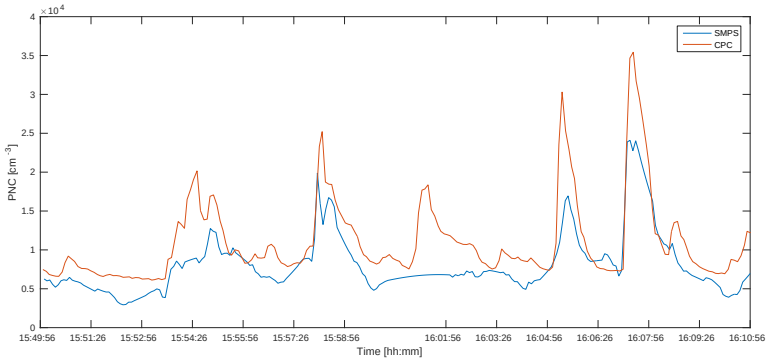

Figure 1: Particle concentrations obtained from the SMPS and a separate CPC for a period on 2 December 2015. Ticks at beginning of scans. Data from the scan starting at 16:00:26 are missing, so the our algorithm provides an interpolation for this time interval.

Dubey P, Dhaniyala S (2011). A New Approach to Calculate Diffusional Transfer Functions of Scanning DMAs. Aerosol Science and Technology, 45, 1031–1040.

Mamakos A, Ntziachristos L, Samara Z (2008). Differential mobility analyser transfer functions in scanning mode. Journal of Aerosol Science, 39, 227–243.

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