Reply to Short Comment from W. Junkermann

Thank you for your comments.

Regarding to the comment on sampling errors, we have presented in Figure S3 the measurement setup used in the helicopter measurements. Based on those dimensions and sample flows we calculated the diffusion losses of the particles in the sampling lines (See figure 1). Figure 1 shows that the losses are max 70% for the 2.5 nm particles in diameter, thus the measured concentration actually underestimates the total particle number concentration. However, any corrections to the total particle number concentration cannot be made due to the fact that the particle size distribution is not known precisely. In stack measurements the effects of sampling errors due to the diffusional losses can be assumed to be significantly lower due to the larger particle size of measured primary particles. We will modify the manuscript so that this additional information is included.

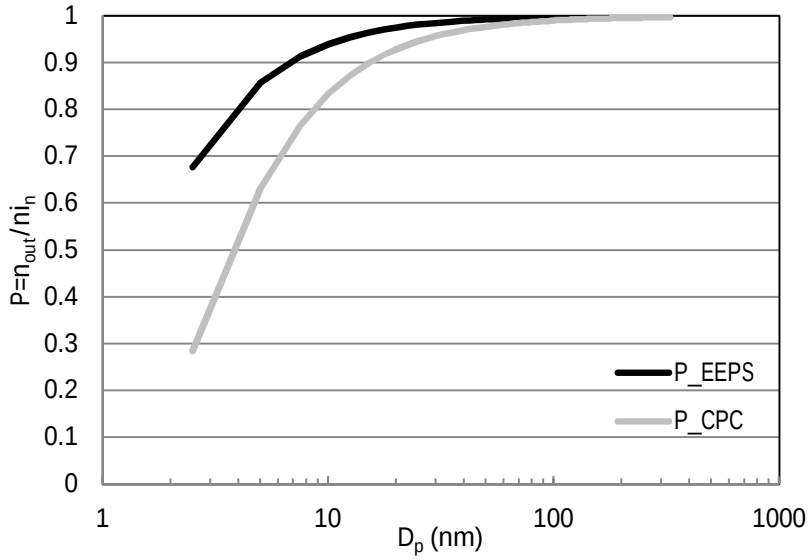

Figure 1 Diffusion losses in the helicopter sampling lines for EEPS and CPC.

Related to the comment on flight guidance: flight guidance was made based on predominant wind direction and observations during flights (visual perception by the pilot, following the measured concentrations (gases and particles) online and with the help of remote-sensing team (LIDAR data)). Based on our own experience the power plant plume is not difficult to follow, but it requires continuous online observations during measurements. In this study we were able to afterwards check correct flight directions also by utilizing LIDAR data.

The measurements were made during one day (24.3.2014) in two consecutive flight periods and the flight times are shown in Figure S2 with two black rectangles. The LIDAR data in S2 shows that the wind direction is different at different heights. This has been taken into account in data analyses and in measurements. Your comments on the presentation of flight

directions will be taken into account in revised manuscript. It is true that the wind direction changed during the measurement day enforcing us to change the flight direction accordingly.

Temperatures in the stack are presented in the manuscript (130 °C for "FGD+FF off"-case and 78 °C for the "FGD+FF on"-case). The dilution of the flue gas sample was performed with dry pressurized air which was heated up to 200 °C. We agree with the comment that stack measurement is challenging and we thank you for raising this issue. In general, in combustion particle emission studies the special difficulty is typically related to the measurements of particles consisting of semi-volatile compounds such as sulphuric acid and hydrocarbons. The sampling system and the parameters of the dilution system can affect the results, especially the measured particle number concentration and particle number size distribution, significantly. In this study, the aim of stack measurements was not to measure the concentrations and number size distributions of semi-volatile particles, but instead the number and size distribution of non-volatile particles. This was ensured by using heated dilution air and further by treating the flue gas sample with a thermodenuder. In our previous studies the thermodenuder has been observed to remove semi-volatile particles efficiently from the aerosol sample (see e.g. Rönkkö et al 2011; Lähde et al 2009).

We agree with you also regarding to challenges in determination of the fraction of primary and secondary particles in the flue gas plume. We would like to note that our observation on secondary particle formation in atmospheric flue gas plume is based on the increase of particle number in the flue gas with simultaneous flue gas dilution, not so much on the comparison of stack and flue gas plume measurements. In general, we hope more discussion from scientist for this problematic topic and, especially, more experimental and modelling research.

Regarding the suppression of particle production by co-emitted NO_x, we agree that this may have an effect. After the NOx concentration has diluted to background levels, however, this should not be a major factor any more. Our simple model does take the NO_x emission into account; we will clarify this in the prepared revision.

Sincerely,

Fanni Mylläri et al.

Lähde, T., Rönkkö, Virtanen, A., Schuck, T.J., Pirjola, L., Hämeri, K, Kulmala, M., Arnold, F., Rothe, D., Keskinen, J. (2009) Heavy duty diesel engine exhaust aerosol particle and ion measurements. Environ. Sci. Technol., 2009, 43 (1), 163-168.

T. Rönkkö, A. Arffman, P. Karjalainen, T. Lähde, J. Heikkilä, L. Pirjola, D.Rothe, J.Keskinen. Diesel exhaust nanoparticle volatility studies by a new thermodenuder with low solid nanoparticle losses, ETH Conference on Combustion Generated Nanoparticles, 2011.