



Supplement of

New particle formation in the fresh flue-gas plume from a coal-fired power plant: effect of flue-gas cleaning

Fanni Mylläri et al.

Correspondence to: Topi Rönkkö (topi.ronkko@tut.fi)

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Supplementary Information 1

Table S1. Coal properties

		Coal
Moisture	%	11.0 - 11.3
Ash	%	10.5 – 11.4
Volatiles	%	32.8 – 33.1
Sulphur	%	0.27 – 0.41
Heating Value	GJ/t	24.6 – 24.9
Carbon	%	62.3 – 63.1
Hydrogen	%	4.1 – 4.2
Nitrogen	%	1.8 – 2
Oxygen	%	-
Chlorides	mg/kg	76 – 236
Ca	mg/kg	4300
Mg	mg/kg	1800
Na and K	mg/kg	4500

Supplementary Information 2

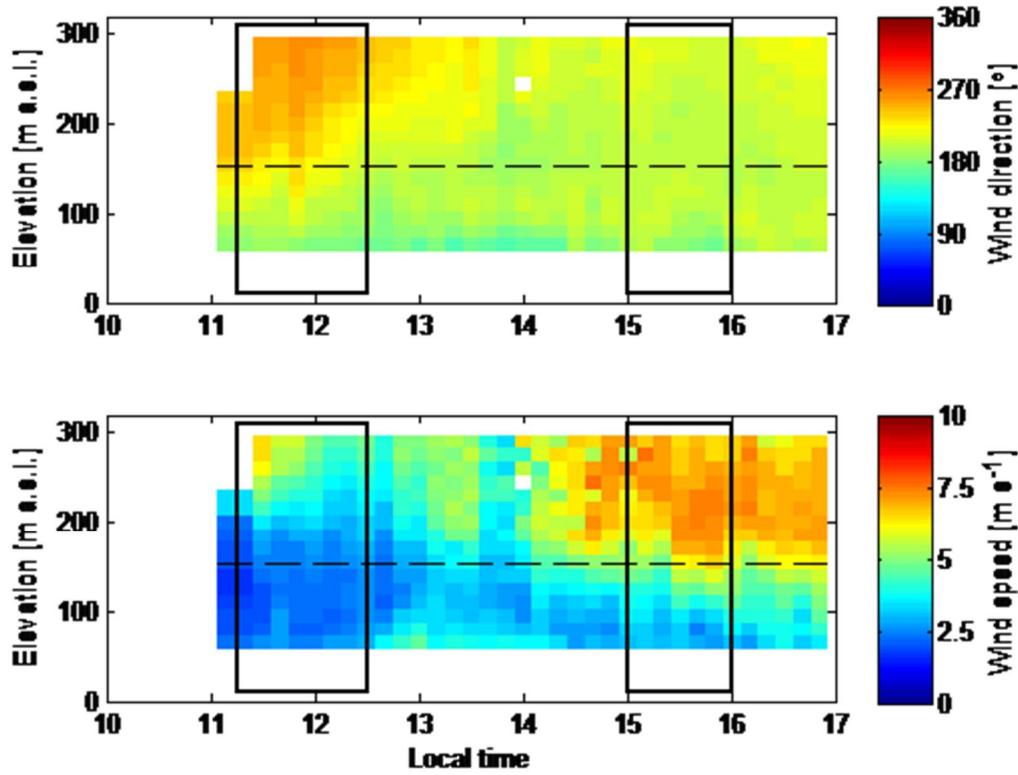


Figure S2. Lidar measurements from the studied time period, local time is UTC +2. The rectangles present the flight times and the dashed line shows the stack height.

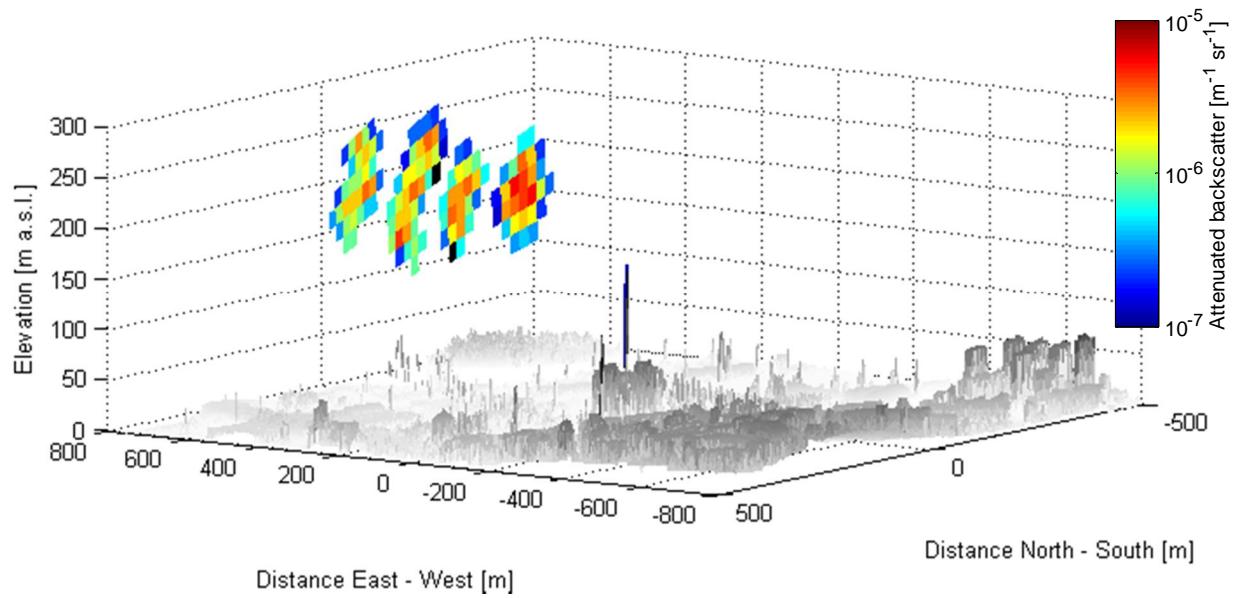


Figure S2. Lidar data from 14:43 from the measurement day, the stack is at the middle and wind is blowing 180 ° angle.

Table S2. Weather conditions during the flights calculated based on Kumpula data.

	FGD+FF off	FGD+FF on
Temperature (°C)	6.9±0.54	6.6±0.73
Global radiation (W/m ²)	347±57	466±82
Visibility (m)	36000±5210	29043±4186

Supplementary Information 3

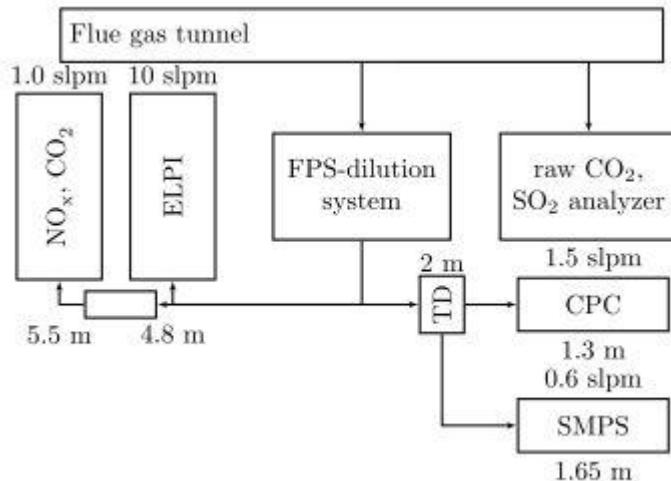


Fig S3. (a) Instrument installation at stack

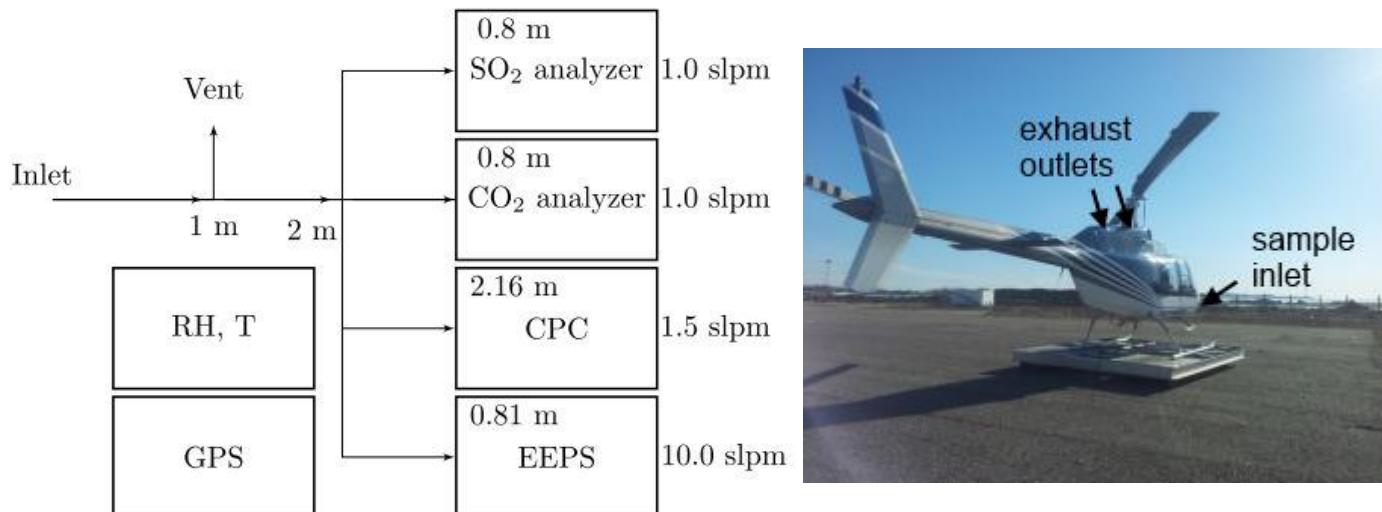


Fig S3. (b) Instrument installation in the helicopter and figure of the helicopter (sample inlet and exhaust outlets shown).

Supplementary Information 4

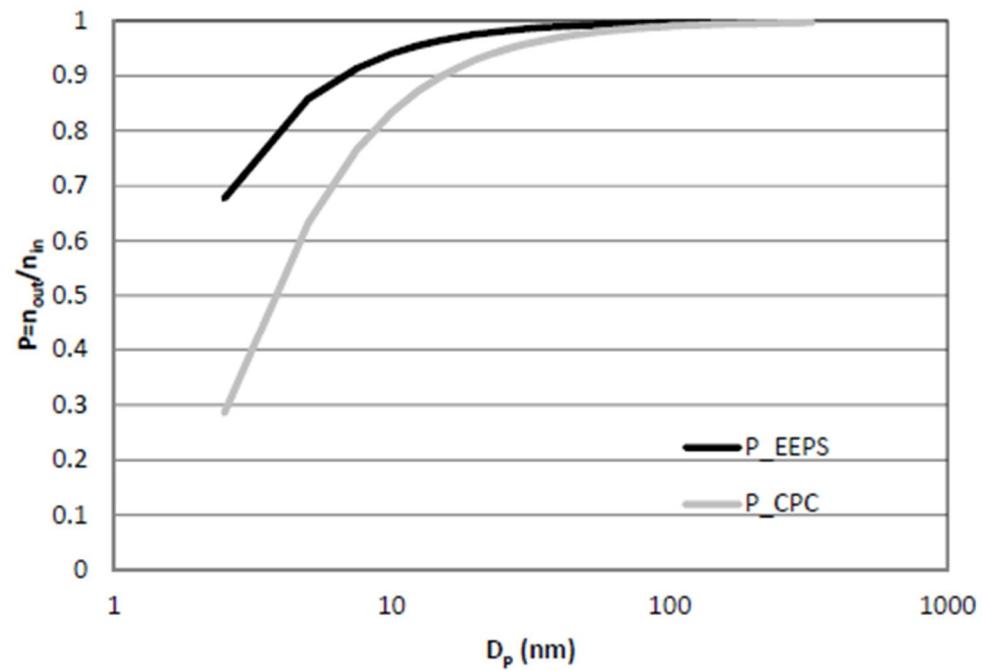


Figure S4. Diffusion losses of the particles in the helicopter sampling lines for CPC and EEPS. The diffusion losses were calculated based on the Fig. S3b.

Supplementary Information 5

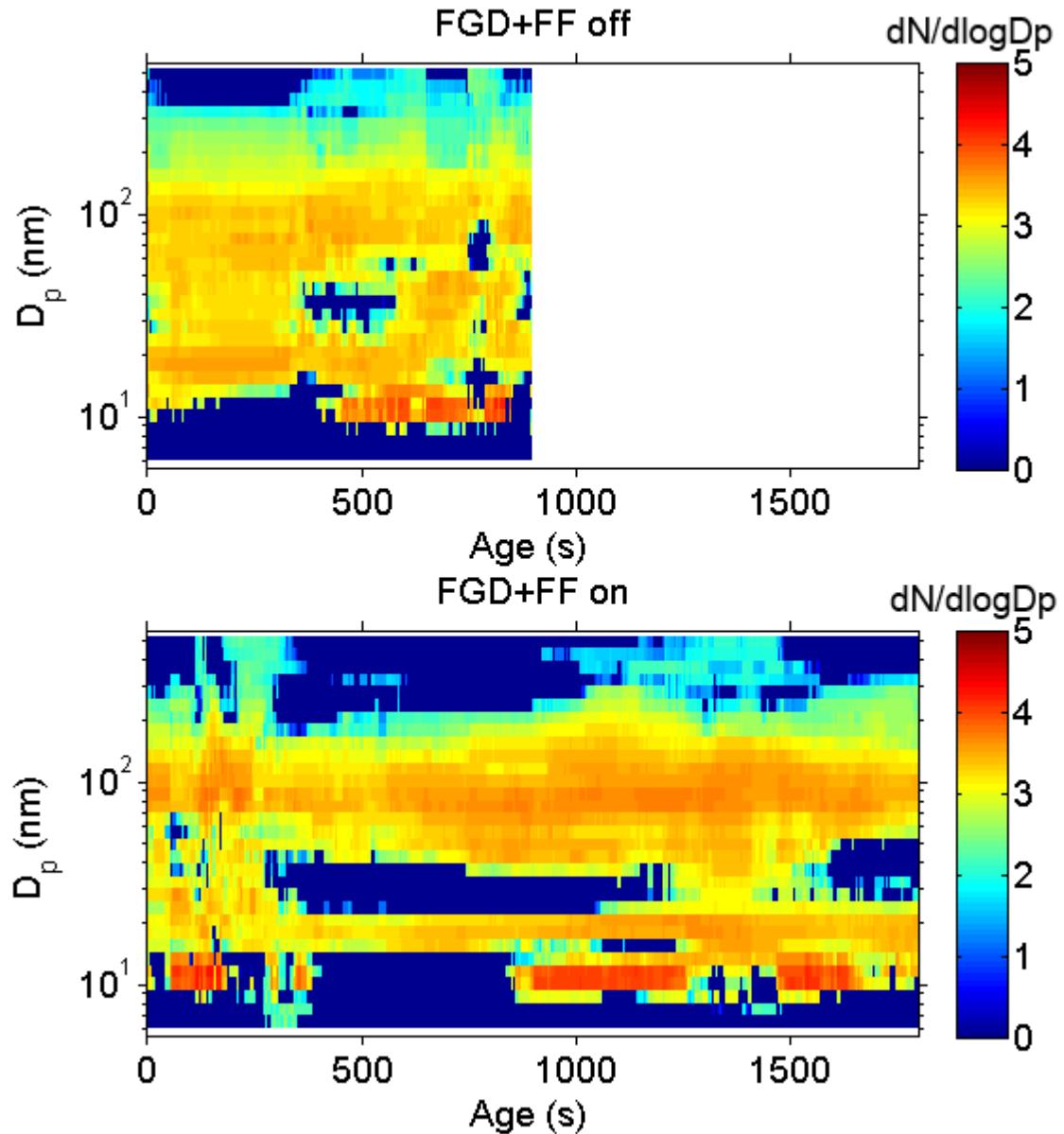


Figure S5. The particle number size distribution calculated from EEPS data as a function of plume age. Measurement was made with the EEPS installed to helicopter. The results are calculated 10 second moving median values.

Supplementary Information 6

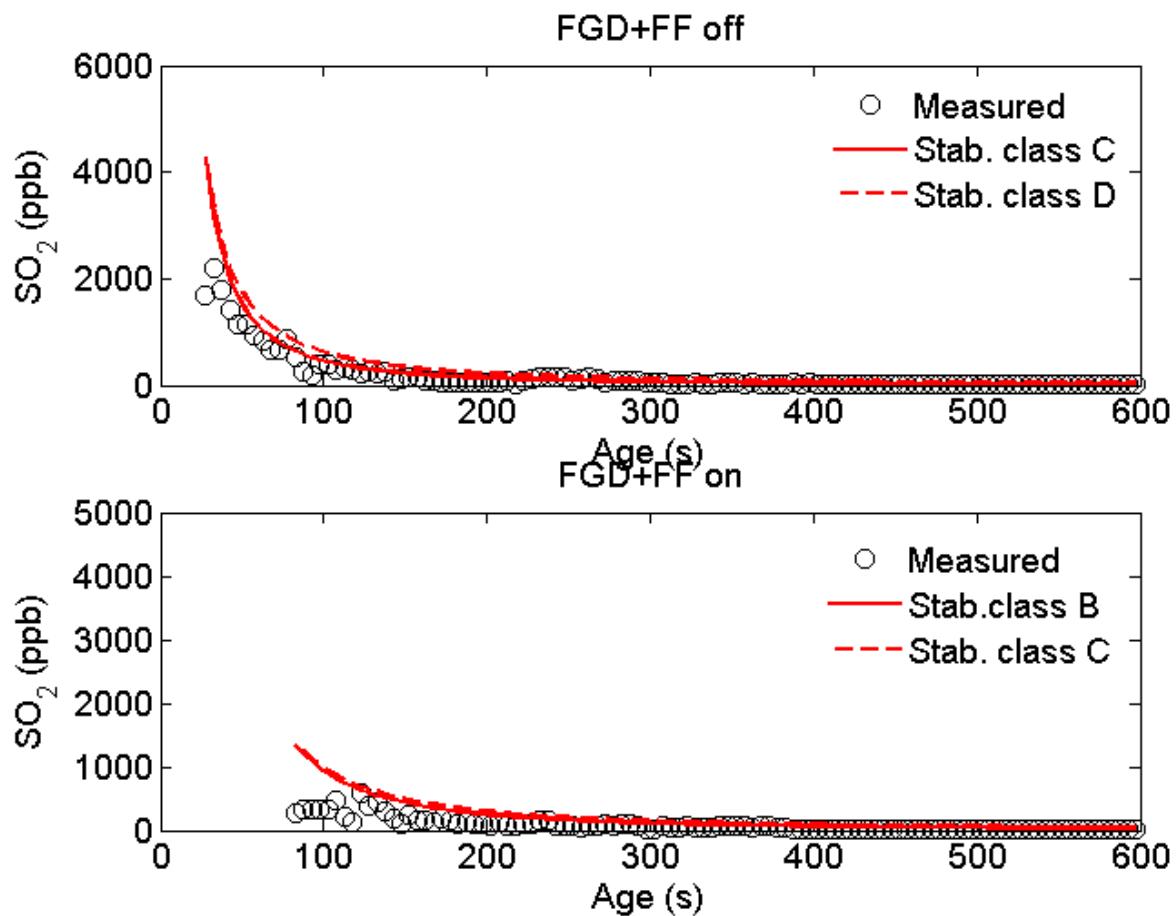


Figure S6. SO_2 concentration measured from the atmosphere with the helicopter and the modelled SO_2 concentration dilution in the atmosphere. The Gaussian dilution model was applied to the SO_2 concentration measured at the stack (divided by the initial dilution ratio calculated based in the CO_2 concentrations) and after that the SO_2 concentration has let to dilute.

Table S3. Details of the measurement equipment used in gaseous measurements. "in-situ" in flow rate column stands for a case that the concentration of the compound is measured directly from the source and there is no separate sample flow for the equipment. In response time column "not specified" means that there was no exact value given for the instrument.

Gas	Manufacturer	Operation Principle	Concentration range	Precision	Flow rate	Response time	sampling frequency
Stack measurements							
SO ₂	SICK sensor Intelligence GM32 type	Differential Optical Absorption Spectroscopy, UV light	0-15 ppm/0-7,000 ppm	±0.3 ppm	in-situ	5 seconds	0.016 Hz
raw CO ₂	SICK sensor Intelligence, GM35 type	IR technique	0-22.5%/0-100%	±2%	in-situ	not specified	0.016 Hz
H ₂ O	SICK sensor Intelligence, GM35 type	IR technique	0-25%/0-100%	±2%	in-situ	not specified	0.016 Hz
NO _x	SICK sensor Intelligence, GM32 type	Differential Optical Absorption Spectroscopy, UV light	NO: 0-40 ppm/0- 1,900 ppm NO ₂ : 0-50 ppm/0- 1,000 ppm	NO: ±0.8 ppm NO ₂ : ±2.5 ppm	in-situ	5 seconds	0.016 Hz
O ₂	Enotec Oxitec 5000	Zirconium oxide detector	ppp-100%	±0.2% from measurement value	in-situ	0.5 seconds	0.016 Hz
Flue gas plume measurements							
CO ₂	Picarro G1301-m	Cavity Ring-Down Spectroscopy (CPDS) technique to measure the gas specific absorption spectrum	300 ppm-700 ppm	< 200 ppb	0.35-0.45 L/min	0.05 seconds	> 0.5 Hz
SO ₂	Thermo Scientific Inc.	ultraviolet (UV) fluorescence method where SO ₂ molecule absorbs UV light reaching an excited state at specific wavelength	0-1000 ppb	50 ppt	0.5 l/min	Is modified from 80 seconds to 5 sec, but this was taken into account in calculations	1 Hz