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In situ cloud ground-based measurements in the Finnish sub-Arctic: intercomparison of three cloud spectrometer setups

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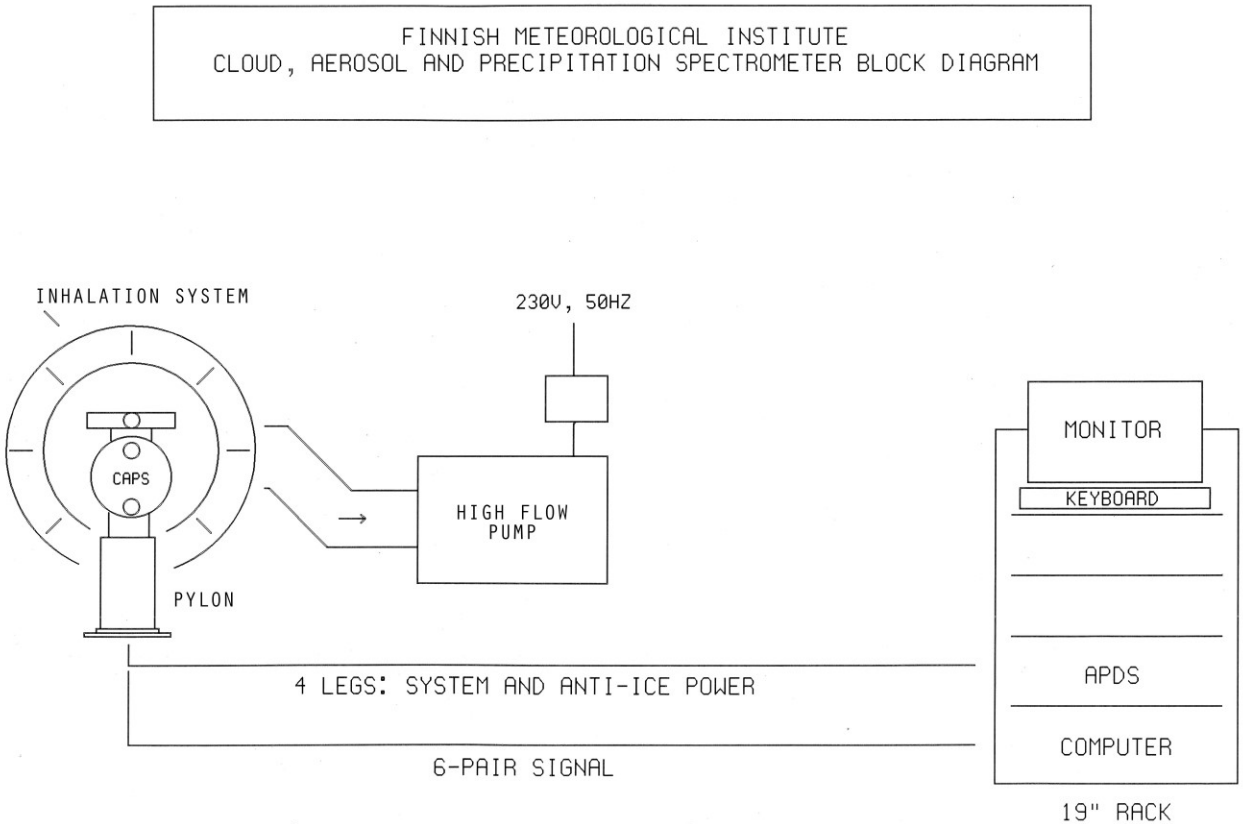
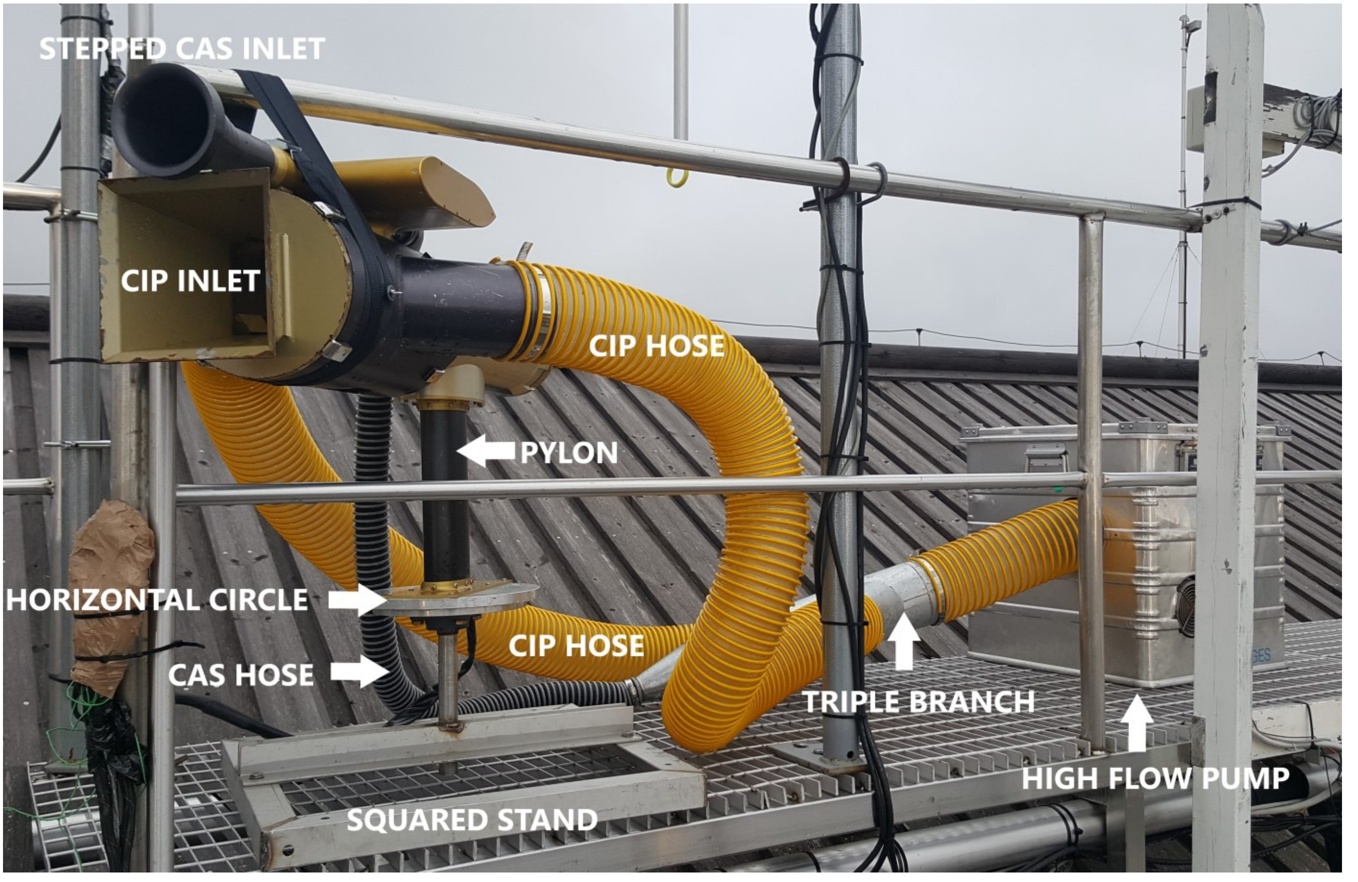
CAPS



FIGS1: CAPS ground setup schematic figure.

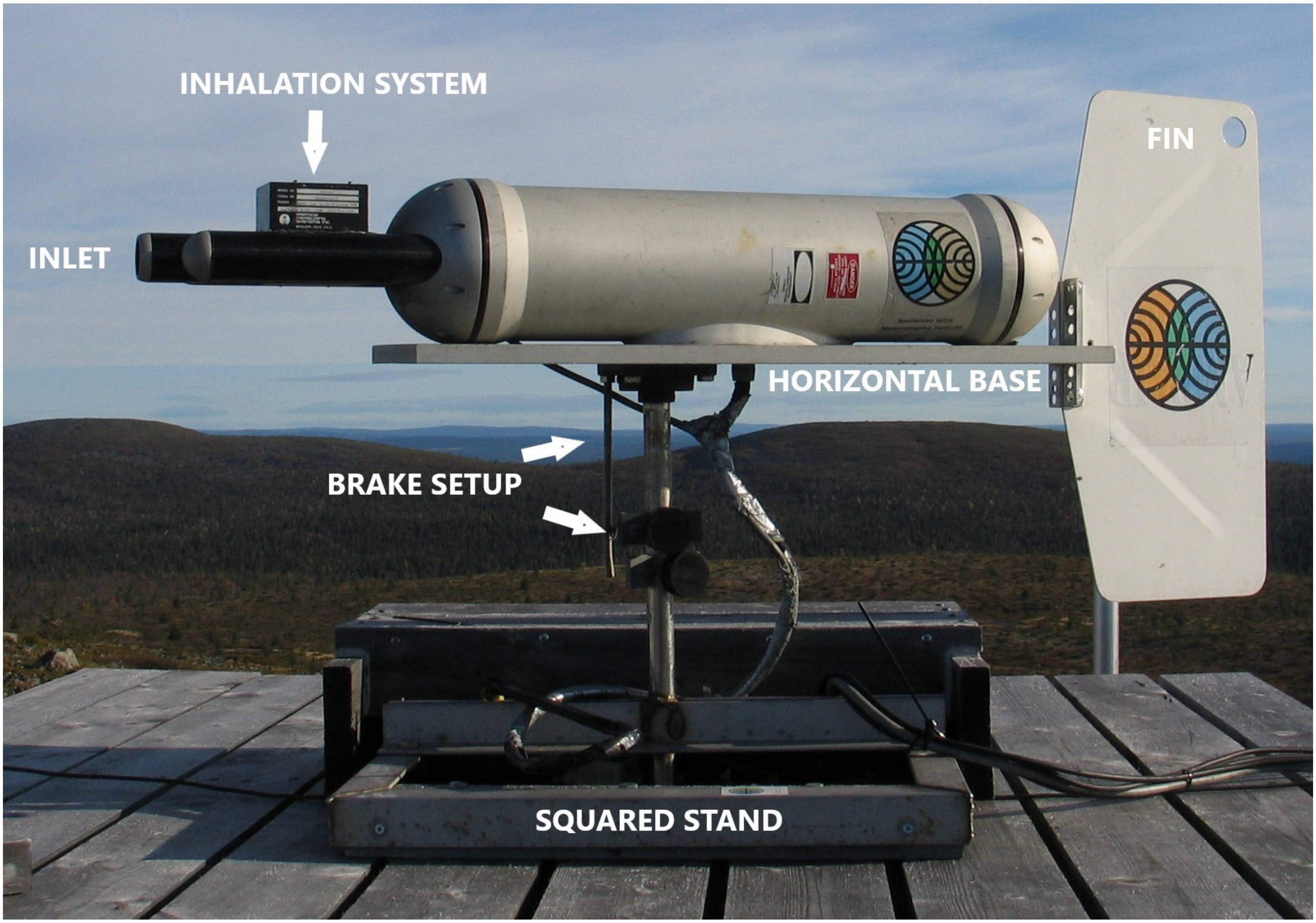


FIGS2: CAPS ground setup as installed on Sammaltunturi station.

FSSP

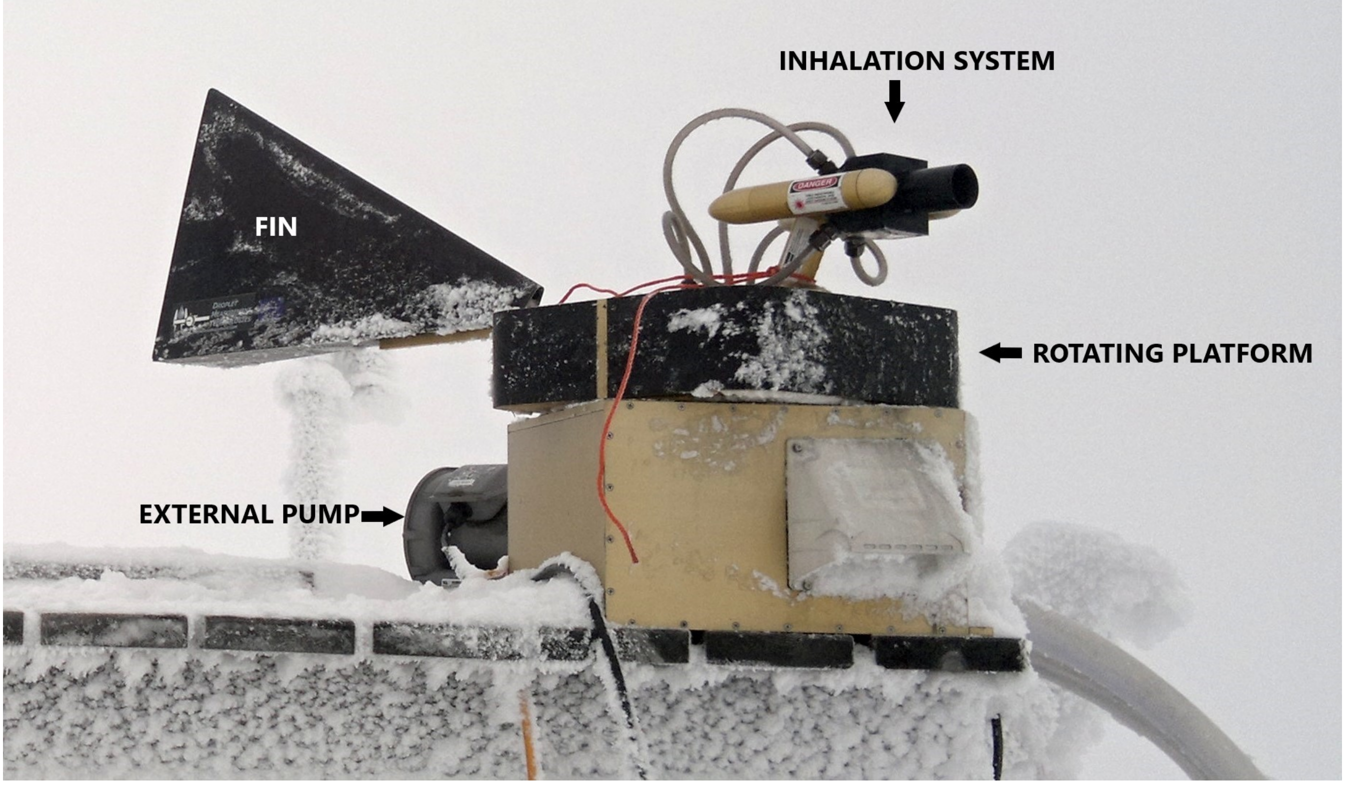
The FSSP inhalation system

The FSSP inhalation system was used to enable the operation of the FSSP-100 in a static ground environment. Its design allow it to operate under typical weather research environment conditions. It consisted of a sample tube accelerator, a 400 Hz fan motor and a 400 Hz inverter within an all-weather housing assembly. The sample tube accelerator was inserted in the sample tube from its forward end so that the end of the accelerator was flushed with the base of the sample tube. The all-weather housing assembly fitted between the FSSP optics tubes and against the center sample tube base.



FIGS3: FSSP ground setup as installed on Sammaltunturi station.

CDP



FIGS4: CDP ground setup as installed on Sammaltunturi station.

All the sectors of the wind rose out of the wind-isoaxial conditions were investigated in detail to reveal more biases. In Fig. S5 we summarized the most representative cases. Fig. S5a shows the whole wind iso-axial conditions sector as it was defined previously (200 – 235°) and ensures that there was good agreement (R^2 = 0.70 and slope 0.57). Fig. S5b shows that the CAS probe had more losses (factor from 3 to ~ 10) in N_c when the wind direction was perpendicular to the CAS fixed direction, covering the sector from 115 to 154° (R^2 = 0.32 and slope 0.72). We also used observations when the wind direction ranged from 0 to 74° (Fig. 9c). There, due to the installation of the brake in FSSP' setup, an abnormality was created which clearly affected FSSP' ability to operate properly. The agreement between the two instruments in this sector of the wind rose was found the worst of all cases (R^2= 0.08 and slope 0.33). Finally (Fig. 9d), we used observations when the wind direction ranged from 95 to 114° in order to demonstrate one case when the wind direction was out of both, the wind iso-axial and perpendicular area. As expected, the CAS probe was affected by the wind direction. CAS was undercounting again when deriving N_c (slightly less than in the case of perpendicular direction, R^2 = 0.54 and slope 0.64). Figure 10 presents the number size distributions for the same cases to investigate further the counting ability of the two instruments and find out the size bins where the probes had the biggest difference in counting. For size range from 1.2 to 7 µm, both cloud probes behaved the same in all wind directions. In Fig. 10a (200 – 235°) we noticed that the number size distribution in wind iso-axial case had only some minor differences in sizing (slight shift in FSSP sizing towards bigger sizes, about 1.5 µm) that were expected as we mentioned in the previous paragraph. In Fig. 10b (115 to 154°), where the wind was perpendicular to the CAS probe we lost a significant number (maximum losses in counts up to 75%) of droplets in the size range from 8 to 30 µm. In Fig. 10c (0 to 74°), where the FSSP faced operational malfunction due to its brake installation setup, it undercounted cloud droplets (maximum losses in counts up to 85%) for sizes larger than 11.8 µm. Finally, in Fig 10d (95 to 114°) we observed that the behaviour of CAS was affected by the wind direction in a similar way as it was found for the perpendicular case. However, in this case CAS lost fewer droplets (maximum losses in counts up to 45% for size range from 8 to 30 µm).

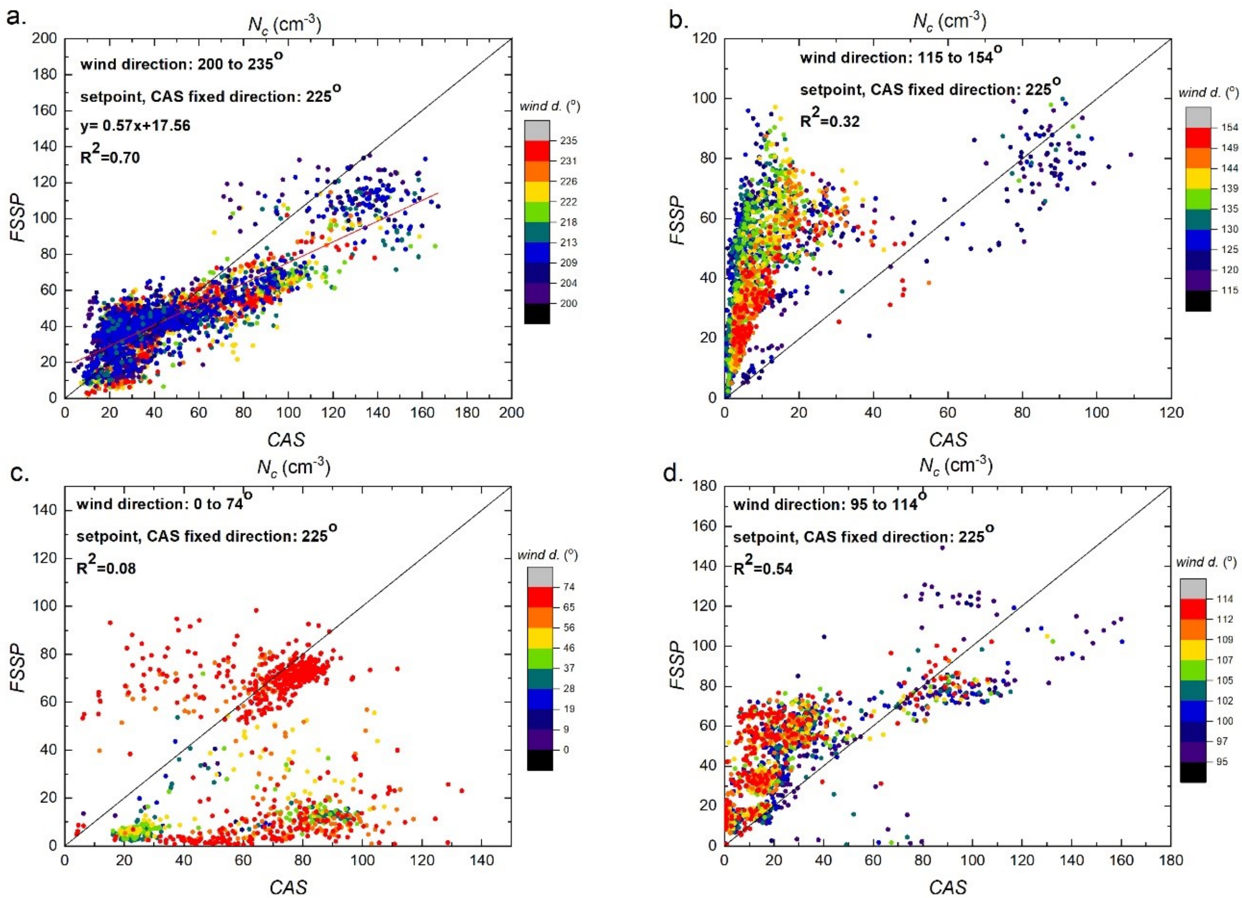


Figure S5. Comparison of number concentration (N_c) as it was derived from the CAS and the FSSP is presented for four different representative sectors of the wind rose during the station was inside a cloud. (a) 200 to 235° represented observations during the wind iso-axial conditions; (b) 115 to 154° represented observations during wind direction was perpendicular to the fixed CAS direction; (c) wind sector (0 to 74°) where the FSSP had operation problems due to its brake installation and (d) one wind sector when the wind direction was between iso-axial and perpendicular conditions (95 to 114°).

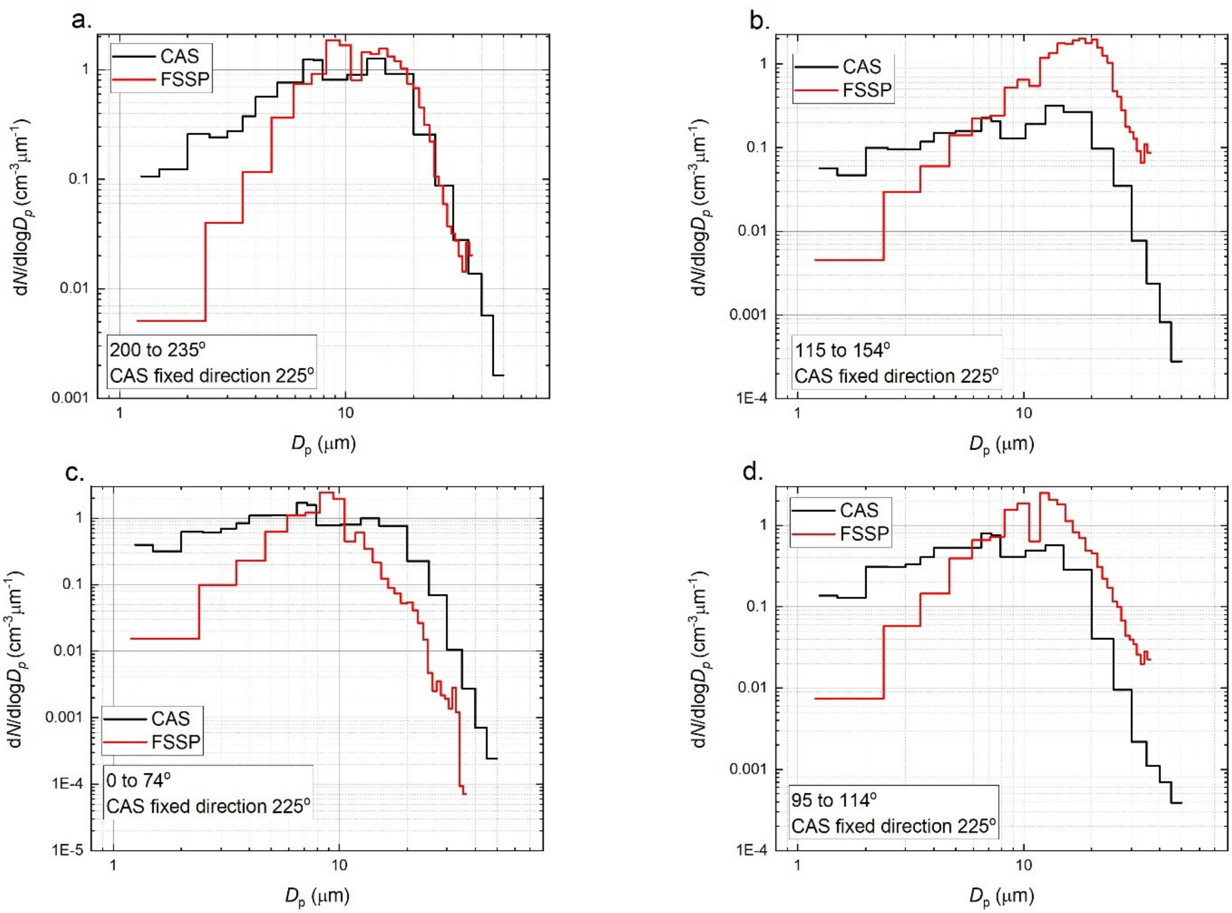


Figure S6. Size distributions of the CAS and the FSSP for four different representative sectors (same to Fig. 9) of the wind rose (a) 200 to 235° represented observations during the wind iso-axial conditions; (b) 115 to 154° represented observations during perpendicular wind direction to the fixed CAS direction; (c) wind sector (0 to 74°) where the FSSP had operation problems due to its brake installation and (d) one wind sector when the wind direction was between iso-axial and perpendicular conditions (95 to 114°).