A giant particle collector (GPaC) for sampling of super micron particles on an aircraft platform

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Motivation

Sampling aerosol particles from an airborne platform moving at high speed is a challenging task. Several inlet systems have been designed for a representative particle collection with minimal alteration effects, e. g. the CARIBIC inlet (Hermann et al., 2001) or the Low Turbulence Inlet (Huebert et al., 2004).

During the SAMUM project, which was dedicated to the investigation of mineral dust (e. g., Heintzenberg, 2009), a significant amount of particles with diameters larger than 5 µm had to be investigated. The existing inlet systems were not capable of transmitting these particles into samplers mounted inside the aircraft cabin. Another existing sampling system for large particles, the Big Particle Sampler (Levin et al., 2005), could not be used for the available aircraft. For this reason, a new Giant Particle Collector (GPaC) was created for use inside a standard PMS wing pod.

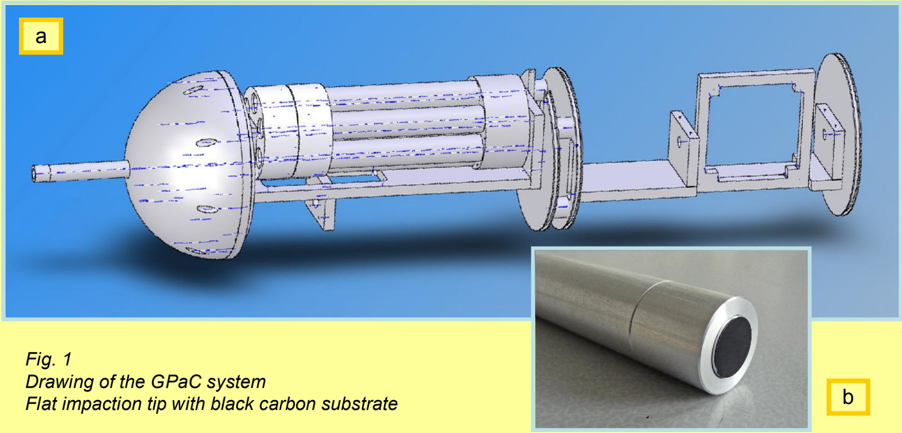
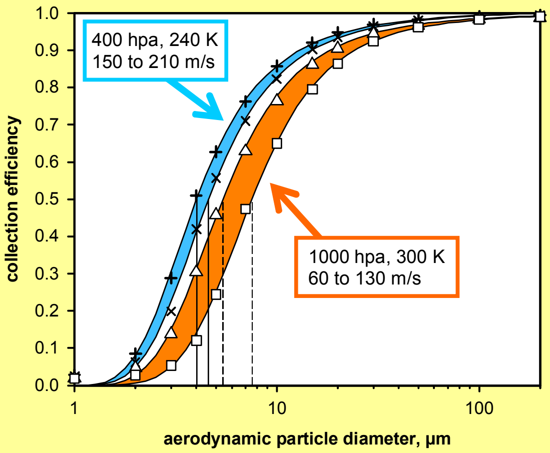


Fig. 1
Drawing of the GPaC system
Flat impaction tip with black carbon substrate

- under-wing free-stream impactor
- undisturbed sampling
- no inlet system
- impaction efficiency determined by aircraft flight conditions
- computer-controlled electro-mechanical system
- six samples per flight
- suitable for electron microscopy or other single particle analysis methods (e. g., offline laser mass spectroscopy)

Fig. 2: Impaction efficiency for the tip substrate for different flight conditions

- efficiencies calculated by extensive computational fluid dynamics
- compressible air flow and full Reynolds stress model
- variation of the nominal 50% cut-off diameter between 3 and 8 µm
- low dependency of the cut-off diameter on angle of attack: less than 10 % at 4° deviation from central axis, but 45 % at 7°
- dependency of efficiency on angle of attack: up to 7 % at 4° deviation from central axis, up to 50 % at 7°



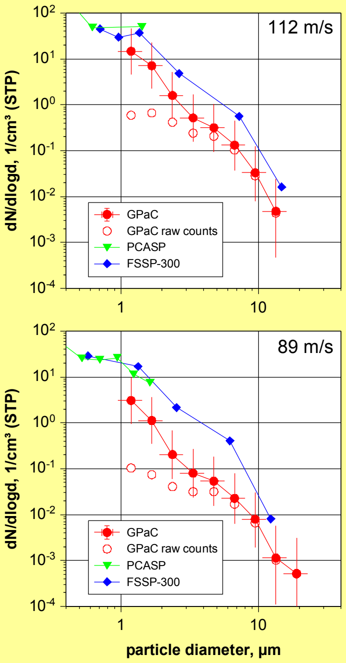


Fig. 3: Number size distributions derived from GPaC by scanning electron microscopy and optical particle spectrometers (FSSP-300, PCASP); the open circles show the GPaC data without efficiency correction

- general shape of the size distribution is represented, but deviation is significant for low impaction efficiencies
- there remains a difference of about a factor 2 to 12 in concentration or 1.5 to 2 in particle size
- agreement better for higher flight speeds or at higher altitudes
- some potential sources of uncertainty are not yet accounted for
    - (potential systematic) inhomogeneity of particle deposition
    - adhesion efficiency of < 1
    - discrepancy in particle size definition (optical measured diameter versus projected area equivalent diameter)
    - particle density estimation from electron microscopy to calculate aerodynamic diameter for efficiency correction

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Affiliations/Acknowledgement

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