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On the efficiency of rocket-borne particle detection in the mesosphere

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Abstract. Meteoric smoke particles have been proposed as a key player in the formation and evolution of mesospheric phenomena. Despite their apparent importance still very little is known about these particles. Important questions concern the smoke number density and size distribution as a function of altitude as well as the fraction of charged particles. Sounding rockets are used to measure smoke in situ, but aerodynamics has remained a major challenge. Basically, the small smoke particles tend to follow the gas flow around the payload rather than reaching the detector if aerodynamics is not considered carefully in the detector design. So far only indirect evidence for the existence of meteoric smoke has been available from measurements of heavy charge carriers. Quantitative ways are needed that relate these measured particle population to the atmospheric particle population. This requires in particular knowledge about the size-dependent, altitude-dependent and charge-dependent detection efficiency for a given instrument. In this paper, we investigate the aerodynamics for a typical electrostatic detector design. We first quantify the flow field of the background gas, then introduce particles in the flow field and determine their trajectories around the payload structure. We use two different models to trace particles in the flow field, a Continuous motion model and a Brownian motion model. Brownian motion is shown to be of basic importance for the smallest particles. Detection efficiencies are determined for three detector designs, including two with ventilation holes to allow airflow through the detector. Results from this investigation show that rocket-borne smoke detection with conventional detectors is largely limited to altitudes above 75 km. The flow through a ventilated detector has to be relatively large in order to significantly improve the detection efficiency.

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