Dual frequency head echo measurements and optical observations of faint meteoroids at Northern polar latitudes

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To complement the meteor head echo measurements of the high power large aperture radar MAARSY in Northern polar latitudes, two measurement campaigns with additional observation techniques were conducted. An optical measurement campaign was carried out during the night times with good weather conditions between the years 2014 to 2016. For this purpose, two camera systems were installed at two different sites allowing a totally independent measurement of the meteor trajectory and other physical meteor quantities. We present an initial survey of 105 double-optical-radar detections, showing a good agreement on the observed trajectories, source radiants and velocities. A comparison of the count rates exhibits a meteoroid detection mass of the MAARSY radar in the range from 0.1 to 1 microgram at speeds ranging from 30 to 60 km/s. The good time resolution of 1 ms (1kHz PRF) of the radar in combination with the 30 to 50 frames per second time resolution of the cameras provides a sufficient data to evaluate the evolution of the ablation curves obtained from the radio-optical measurements at different altitudes. In some cases, the radar indicates a more complex morphology of the returned signal, while the light perceives a rather smooth behavior.

In 2016 and 2017 the observation were extended by the EISCAT UHF radar (929 MHz) to gain additional information on the plasma cloud surrounding the ablating meteoroid. Therefore, the EISCAT beam was pointed into the MAARSY observation volume at an altitude of 100 km. The interferometric solution of MAARSY was used to calculate the location of the meteor head echo within the EISCAT beam to render the radar cross sections at both frequencies. Under the assumptions of Rayleigh scattering and an overdense Gaussian plasma distribution, the plasma sizes and scattering masses are derived. In combination with the observed deceleration, meteoroid densities are estimated. Our data include also a subset of optical and dual-frequency observations for the same meteoroid. Further, we diagnose additional meteor parameters by inserting and comparing the observed meteor quantities into a meteor ablation model (MARS- Meteor Ablation Model for Radio and Optical Surveys). Our observations seem to fit best to the model data for masses between 1 to 100 microgram with densities around 1000 kg/m^3 for the majority of the events.