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Meteor radar masses derived from single- and dual-frequency head-echo observations and model inversion

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1 Extended Abstract

Estimation of meteoroid masses from ground-based radar observations is significantly complicated by our limited knowledge of the meteor plasma structure. Nonetheless, high-power, large-aperture (HPLA) radar provides insight into the smallest observable meteoroids, where the fluxes are highest. Mass estimates from radar require at least as many measurements as unknowns to be determined. In this work, we use a two-parameter distribution used to describe the meteor plasma, assuming that the head plasma is spherically symmetric. We derive a method to estimate these two parameters, the peak plasma density and the meteor plasma radius, from either single-frequency or dual-frequency measurements of the meteor radar cross section (RCS). When only single frequency measurements are available, the mass is derived by using the Jones model of the meteor size as a function of altitude and velocity, and then using the measured RCS to determine the peak plasma density. With dual-frequency measurements of the RCS, we can estimate the two meteor plasma parameters uniquely. Both inversion models are based on a finite-difference time-domain (FDTD), physics-based forward model of the meteor radar scattering process, used to generate a lookup table based on the input plasma parameters.

From September 2016 to March 2017, meteor observations were made using the VHF (53.5 MHz) MAARSY radar, on the Norwegian island of Andoya, simultaneously with the UHF (931 MHz) EISCAT radar near Tromso. Simultaneous ground-based optical observations were also conducted from two locations, one at the ALOMAR observatory about 2 km from MAARSY and the other 15 km south at Saura. We estimate the meteor plasma parameters from these observations using the single-frequency inversion technique described above, with RCS values from the MAARSY radar. Additionally, by changing the assumed plasma distribution within the meteor plasma, we are able to determine the distribution-dependent uncertainty in the derived meteoroid masses. In this paper we also demonstrate the method and performance of the dual-frequency inversion technique, and will apply this to the combined MAARSY / EISCAT dataset in the near future.