# Meteoroid mass estimation based on single-frequency radar cross section measurements

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Meteor mass estimates vary greatly depending on the method of measurement. Even estimates made by two radar systems operating at different frequencies might not agree. Each measurement technique has biases and constraints that limit observations to a portion of the total mass distribution and requires assumptions about the underlying physical processes that are difficult to characterize. This leads to a discrepancy of up to two orders of magnitude in determinations of the total mass flux entering Earth's atmosphere. In particular, radar estimates require assumptions about the ionization efficiency of the meteoroid and are subject to velocity and mass biases. The relationship between the radar frequency and the size of a meteor is determined by the scattering characteristics of the radar pulse, and has a significant effect on the resulting observation. Further, the mass of a meteor cannot be directly observed by a radar but must be inferred by relating observable quantities like the radar cross section (RCS) to physical parameters including the electron line density, from which mass can be calculated. This work presents a method for estimating meteor masses using single-frequency radar measurements by relating physical meteor characteristics to simulated RCS values. Marshall and Close (JGR, 2015) introduced a finite difference time domain (FDTD) model that simulates a radar echo reflecting from meteor head plasma in order to determine the RCS of a meteor for a given radar frequency. We improve this model by incorporating the result derived in Dimant and Oppenheim (JGR, 2017), which uniquely defines the meteor plasma distribution by its altitude, velocity, and the size of the meteoroid. The FDTD model then maps any combination of these parameters to an expected RCS. Since a single-frequency radar measurement returns information on the RCS, velocity, and altitude of the meteor, the remaining size parameter can be estimated and used to calculate the line density and the total mass of the observed meteoroid. By performing hundreds of simulations we use this model to construct tables that relate RCS values to the observed range of parameters for a set of coincident meteor observations from the MAARSY and EISCAT radars in Norway. We apply the described mass determination technique to several hundred such observations, estimating the mass independently for each of the two radar observations and comparing the results. Future work will use the results of this study to validate and calibrate this method of mass determination, and later apply it to other radar observations.