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Title: Inversion of meteor radar cross section to plasma density using an FDTD numerical scattering model

Abstract:

Somewhere between 4 and 400 tons of material enters the Earth's atmosphere daily in the form of meteoroids, the vast majority of which are less than one gram in mass. These particles are responsible for the metal layers in the upper atmosphere, and have been implicated in the production of sporadic-E. Furthermore, even microgram meteoroids can cause considerable and even catastrophic damage to spacecraft due to their high velocities. The uncertainty in the mass flux derives from the difficulty in estimating the mass of meteoroids from ground-based measurements; both optical and radar methods have considerable errors. For radar measurements, which are generally more sensitive to small meteoroids, uncertainties lie in the ionization efficiency, the meteoroid composition, and measurement of the density of the meteor plasma.

This paper addresses the relationship between the measured radar cross section (RCS) from meteor observations and the meteor plasma density and distribution, which in turn relates to the parent meteoroid mass. A Finite-Difference Time-Domain (FDTD) forward model is used to relate plasma densities and different distributions to RCS; this model is then inverted using neural network techniques to provide a means of estimating the plasma distribution from measured RCS. We then apply this method to three data sets: i) a dataset of three-frequency HF/VHF meteor radar measurements from the Canadian Meteor Orbit Radar (CMOR); a set of dual-frequency VHF/UHF high-power large-aperture (HPLA) measurements from the ALTAIR radar; and iii) single-frequency measurements from the MAARSY meteor radar. The latter data, since it is single frequency, requires an assumption on the meteor plasma size, which is derived from the previous two datasets. We present the modeling and inversion process and the results of these data inversions as sets of plasma densities, which can then be used to infer parent meteoroid mass.