Publication Title: Estimating Meteoroid Pre-atmosphere Physical Conditions Using Radar Polarization Measurements and a State-of-the-art Chemical Ablation Model


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Introduction: Meteoroids with small enough diameters (between 100-1000 μm), and with sufficiently high entry velocities (11-72 km s⁻¹), burn up, or ablate, entirely in the Earth’s upper atmosphere (75-110 km) due to collisions with ambient air molecules [1]. The bulk of the incoming meteoroid input comprises of the sporadic interplanetary dust background and is not associated with any known meteor showers [2]. However, this sporadic background can be assigned as particles belonging to one of six astronomical source populations, each with differing incoming velocities and entry angles relative to Earth [e.g., 3, 4]. Much is still unclear about the formation, evolution and propagation of interplanetary dust throughout our Solar System, as well as the transport of, and chemical interaction of such particles within our own atmosphere. Studying these meteoroids offers an opportunity to better understand these processes, as well as allowing characterization of the different properties and compositions of particles originating from each of the six different astronomical source populations.

Our work: Ground-based meteor radars offer a powerful technique to probe Earth’s upper atmosphere, in particular for mesospheric dynamics [e.g., 5-9]. However, a limitation is that they can only detect and track particles ablating within their field-of-view. At the time of detection, the particles have already undergone mass loss and deceleration, which in many cases may be significant. Using meteor radars alone, it is not possible to determine the absolute mass of the detected particle, the initial particle mass and entry velocity, at what altitude the particle first interacts with the Earth’s atmosphere and begins to decelerate, nor its composition.

However, using a full-wave electromagnetic model along with measurements of the echo return polarization from the meteor trail (Stober et al., in prep.) we can derive the electron line density, q. This is possible thanks to a recent upgrade of the Southern Argentina Agile Meteor Radar (SAAMER) system located in Tierra del Fuego, Argentina. We developed a new methodology that combines the estimated q with the Chemical Ablation Model (CABMOD, [10]) which allows us to constrain the meteoroid flight back to the top of the atmosphere and estimate its initial conditions, including its mass. The derived initial meteoroid velocity and mass can then be used for a more accurate estimation of meteoroid orbits and their mass distribution.

![Figure 1: 3D profile of estimated velocity (v) and total electron line density, q, both as a function of altitude from CABMOD (blue line) which best corresponds to the estimates of q and v for a specific altitude as detected by the SAAMER meteor radar (red filled circle).](image.png)