Radar detectability studies of slow and small zodiacal dust cloud particles using Arecibo 430-MHz meteor head echo observations

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The total amount of meteoric input in the upper atmosphere is a hotly debated quantity, for which estimates vary by two orders of magnitude, depending on measuring techniques. The majority of the input is in the form of microgram size particles, which, in most cases, completely ablate injecting metals in the mesosphere. These metals are the primordial material for most of the layered phenomena (LP) occurring in the mesopause region (MR). Accurate knowledge of this quantity is crucial for the study of LPMR and, in many cases, it can contribute to the improvement of Whole Atmosphere Models (WAMs) by constraining parameters such as the vertical transport in the middle atmosphere. In an effort that ultimately aims to estimate this quantity, we utilize a new Zodiacal Dust Cloud (ZDC) model that follows the dynamical evolution of dust particles after ejection, utilizing the orbital properties of comets and asteroids. One of the main results of this model is that it predicts that 85–95 % of the dust in the inner solar system comes from Jupiter family comets (JFCs), with the remainder coming from the asteroid belt and Oort Cloud comets (OCCs)(Nesvorny et al., 2010). Furthermore, the modeled results show that most of the dust, which drifts down towards the inner solar system under the influence of the Poynting-Robertson drag, has a mass in the range 1–10 µg at a near-prograde orbit with a mean speed of about 14 km/s, producing a global meteoric mass input around 32 t/d (Nesvorny et al., 2011a). The low average speed and the absence of significant orbital eccentricities, also a result of the model, do not agree with various types of meteor radar observations, which record average speeds closer to 30 km/s. One of the key problems with this model is that it is currently quantitatively only constrained by the Infrared Astronomical Satellite (IRAS) observations of the ZDC and only qualitatively constrained with terrestrial observations using radars (Nesvorny et al, 2011b). Furthermore, the radars utilized do not have the sensitivity to observe the particle masses dominant in the ZDC model when they travel at low speed (i.e., low ionization production) and thus it remains unbound by ground-based observations. In this paper, we discuss a methodology to better constrain the ZDC physical model utilizing ground-based meteor radar observations of head echoes and modelling. For this, we integrate and employ existing comprehensive models of meteoroid ablation, ionization, and radar detection and thus enable accurate interpretation of radar observations. This will address potential biases that could, in principle, prevent them to detect the large population of small slow particles predicted by the ZDC model.

Acknowledgements: This work was supported by the NASA awards 12-PAST12-0007 and 12-PATM12-0006. The Arecibo Observatory is operated by SRI International under a cooperative agreement with the National Science Foundation.

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