Radar Meteor Science: Where are we and where next?

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Abstract

The modern era of HPLA (High-Power, Large Aperture) radar meteor observations is just a decade old. In this time there have been major advances in both technique and meteor science. These advances—especially with respect to radio science issues—are briefly reviewed and the new issues raised by these results discussed. Suggestions for the next generation of observations and observational techniques are given. Among these suggestions are multi-frequency common-volume radar meteor observations to learn more about the scattering mechanism and the plasma physics of the meteor head- and trail-echoes.

Summary

The modern era of HPLA (High-Power, Large Aperture) radar meteor observations is just a decade old [1]. In this time there have been major advances in both technique and meteor science that we briefly review. The micrometeoroid mass flux into the upper atmosphere has long been recognized as providing the atomic metal ions necessary to the formation of sporadic-E and lidar-visible metal layers [2, 3]. While this mass flux as a function of local time, season, and latitude remains very much an issue [4], recent VHF and UHF HPLA (High-Power, Large Aperture) radar meteor head-echo observations have provided estimates of this flux using direct radial or 3-D Doppler and deceleration measurements that yield good particle mass estimates under reasonable assumptions [5]. These observations have shown that the micrometeoroid speed distribution is much higher than previously assumed [6] and that the well know visible meteor showers contribute little mass to the upper atmosphere relative to the daily sporadic meteoroid flux [6, 7]. Other issues now being addressed with HPLA radars include details of the meteoroid interaction with atmosphere and the related radio science and plasma physics issues that must be resolved in order to understand what the radar actually “sees” [8]. In particular, we now recognize that the meteoroid interaction with the atmosphere is anything but simple with meteoroids undergoing fragmentation and terminal (explosive) events thus complicating observations and pointing to a significant mass flux component in nanometer particle form rather than atom-level ablation products [9]. Observations of long-lived range-spread (meteor) trail-echoes (RSTEs) have led to the understanding that these events are caused by the rapid alignment of the meteor trails along the geomagnetic field yielding FAI-scattering [10]. RSTE observations then enable the study of the plasma processes including diffusion and electrodynamic instabilities that drive the trail-plasma to B-field align [11, 12]. These studies also cast new light on the diffusion rates determined using “classical” meteor radar observations of decaying trail-echoes and on the formation of altitude-narrow ion layers. We find that multi-frequency, common-volume radar meteor observations will prove especially useful in resolving the issues raised. Finally we note that modern HPLA radar meteor observations have led to advances in the planetary astronomy aspects of micrometeoroids [13, 14].

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