Modeling Meter Head Echo Observations Using the Arecibo Radar

Lars P. Dyrud*[(1)], Diego Janches [(2)]
(1) The Center for Remote Sensing Inc., Fairfax, VA, USA
(2) NWRA/ CoRA, Boulder, CO, USA

We have constructed a model of head echo SNR from HPLA radars, using an ablation model, meteor head echo RCS model, the radar equation, and Antenna gain pattern model. We find that we can obtain good agreement via modeled SNR and that observed for a broad range of head echo observations. We chose to model at the SNR level because it does not require dividing by small numbers to obtain an observed RCS, which makes automated procedures more robust, and since no upper atmospheric radars are actually calibrated. We also find good agreement between observed Doppler velocity and deceleration and the ablation model results. We find that the best fit comes from assuming the effective radius of the head echo scatter has a much weaker dependence with altitude then is predicted by air density change, or standard models for meteor trail radius. We will discuss the physical implications this has regarding the head echo plasma. We also find that using these techniques, we can estimate the angle of intersection with the radar beam to within 1-2 degrees. While we initially constructed this model to estimate the effectiveness of the Dyrud [Earth, Moon and Planets, 2007] RCS model for head echoes, we found that this was impossible with out properly fitting and estimating the angle and chord intersection made by the meteor trajectory and the Arecibo beam.

The automated modeling process attempts to match the observed SNR by optimizing the following parameters, meteor trajectory angle, altitude of closest approach to beam center, horizontal distance of closest approach to beam center, noise floor level, meteoroid initial mass, and meteoroid initial velocity. The model has been automated to fit these parameters by a combination of least squares fitting and brute force Monte Carlo modeling and comparison. We find these parameters can be consistently fit simultaneously, and we also find that the Dyrud RCS model performs better at predicting the observed SNR than other more simplified models. We will present results showing SNR modeling of individual head echoes as well as statistics compiled from over one hundred observations, including observations where the meteor passed through beam side-lobes providing a very detailed test for the RCS model. The results of this automated procedure should prove useful in refining and improving estimates of meteoroid properties using the Arecibo radar and any other radar where interferometric information is not available.