Specification of atmospheric density profiles for the fireball observations in Finland

E. Lyytinen[1] and M. Gritsevich[1,2]

[1]Finnish Fireball Working Group
[2]Finnish Geodetic Institute, P.O.Box 15, FI-02431 Masala, Finland

This study is focused on the effects of the atmospheric density or constant pressure height changes on fireball entry modeling. When meteoroid entry into the atmosphere is registered instrumentally, many details may be revealed, including its velocity and deceleration values. The calculated meteoroid mass value is, however, proportional to the third power of the surrounding atmospheric density. Especially in high northern latitudes, like Finland, in winter a given pressure may be at least three kilometers below the standard atmosphere heights and differ even more from the simplified exponential scale-height atmosphere model. Thus the real mass value may significantly differ from calculations, if the atmospheric model correction is not taken into account. Furthermore, if the situation strongly changes with the change to stratospheric altitudes, this may also result in an erroneous ablation coefficient value revealed from the observations. This is especially crucial for low-velocity meteorite droppers with small ablation rate and consequently high terminal-to-initial mass ratio.

Besides the general description of importance of the atmospheric corrections, we demonstrate how to introduce them in the model published in [1]. The input data in this model are velocity values at different heights, supplemented with times of the records or entry slope angle. Since the method [1] is general and can be applied to a large number of different meteor observations at once, the air-density-height relation is also generalized as a known exponential density law. Here we suggest more rigorous approach allowing to handle each particulate case in a greater details based on the real corresponding atmospheric measurements provided by weather services. In the improved model the velocity at each height is introduced as a function of the air mass above meteoroid, calculated along the path (i.e. with account for the trajectory slope). The air mass at each height is accurately calculated based on the measured pressure at this height taken from current atmospheric data and involving an interpolation procedure (when there is a need to match the heights). The registered meteoroid heights are adjusted to the corrected values so that the air mass above meteoroid would be the same as calculated from the exponential density model at the corrected height for each considered data point. The output model parameters are similar to [1], including initial mass of meteoroid and its change along the trajectory.

Similar atmospheric corrections apply also for the models that use the approximate analytic formula to describe the trajectory, which is optionally in use in the fb_entry program [2]. The proposed atmospheric correction has been implemented in processing the fireball data collected recently in Finland by the Finnish Fireball Working Group.

Acknowledgements: We would like to thank Panu Lahtinen and other researchers from the Finnish Meteorological Institute for their help with obtaining actual atmospheric data for the studied fireball events.

References: [1] Gritsevich M.I. Determination of parameters of meteor bodies based on flight observational data. Advances in Space Research, 44(3):323–334, 2009. [2] Lyytinen E. and Gritsevich M. A flexible fireball entry track calculation program. In Proceedings of the International Meteor Conference 2012, La Palma, Canary Islands, Spain, ISBN 978-2-87355-024-4, volume 2, pages 155–167.