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A Physics Based Model of the Ionization of Samarium by the MOSC Chemical Releases in the Upper Atmosphere

Abstract:
The release of Samarium vapor into the upper atmosphere was studied using during the Air Force Research Laboratory sponsored Metal Oxide Space Cloud (MOSC) rocket launches in May 2009. The Naval Research Laboratory supported these experiments with 3-D photochemical modeling of the artificial plasma cloud including (1) reactions with atomic oxygen, (2) photo excitation, (3) photoionization, (4) dissociativere combination, and (5) ion and neutral diffusion. NRL provided an experimental diagnostic instrument on the rocket with a dual frequency radio beacon on the rocket to measure changes in total electron content. The AFRL provided ground based diagnostics of incoherent scatter radar and optical spectroscopy and imagery. The NRL Chemical Release Model (CRM) has over 600 excited states of atomic Samarium neutrals, atomic ions, along with Samarium Oxide Ions and electrons. Diffusive transport of neutrals in cylindrical geometry and ions along magnetic field lines is computed along with the reactive flow to predict the concentrations of Sm, Sm-Ion, Sm0, and SmO Ion. Comparison of the CRM with observations demonstrates that Sm release into the upper atmosphere initially produces enhanced electron densities and SmO-Ions. The diatomic ions recombine with electrons to yield neutral Sm and O. Only the photo ionization of Sm yields a stable atomic ion that does not substantially recombine. The MOSC releases in sunlight yielded long duration ion clouds that can be replicated with the CRM. The CRM predicts that Sm releases in darkness would produce a lower density plasma cloud because of the lack of photo excitation and photoionization.