Understanding the Origin of Variable Compositions of Gradual Solar Energetic Particle Events by Combining Observations and Numerical Simulations

Nariaki Nitta¹, Meng Jin², and Christina Cohen³

¹Lockheed Martin, Advanced Technology Center, Palo Alto, California, United States of America (nitta@lmsal.com)
²SETI Institute, Mountain View, California, United States of America
³California Institute of Technology, Pasadena, California, United States of America

One of the mysteries of solar energetic particle (SEP) events is the compositional variability in those events that are clearly shock-related and may be called gradual events. In particular, the reason for the enhancement of Fe with respect to O or C at high energies has been debated over the past two decades, and yet it is still unsettled. One hypothesis relates the compositional variability with whether the CME-driven shock is quasi-parallel or quad-perpendicular near the Sun, but this may not be easily tested using remote-sensing data alone. In recent years, however, CME-driven shock waves have been modelled by fitting shock-like features in EUV and white-light images with relatively simple shapes, and in combination with magnetic field models, it is possible to compute shock parameters at the shock surface. In this presentation, we simulate a few CMEs whose associated SEP events show widely different Fe/O, using the Alfven wave Solar Model (AWSoM) that is part of the Space Weather Modeling Framework (SWMF). We constrain the input parameters of the simulations so that the observed pre-eruption corona, eruption and CME are well-reproduced. The shock surface, across which the shock parameters are highly non-uniform, is carefully traced, and the time-dependent connectivity of the shock surface with the observer at multiple spacecraft is compared with the SEP properties including composition. We discuss how much about the compositional variability of SEP events can be learned with this technique.