2014 Workshop: Meteors

Long title
Meteoroids and Space Debris
Conveners
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Description

This year we will focus on identifying the major outstanding questions worthy of mission level investment on traditional/emergent platforms including sub-orbital, rocket, CubeSats, and satellites. This workshop is intended to expand the reach of meteor science using a systems science approach and talks will be accepted that further this goal with a majority of the time allocated to discussion, debate and planning.

A meteoroid is defined as a small, solid extraterrestrial object. Upon entry into a planet’s atmosphere, it heats and ablates off particles that then collide with the background neutrals, forming a dense plasma that extends around the meteoroid as well as behind it. These plasmas, referred to as meteors, have been studied for well over a century, yet many outstanding questions remain. In addition, space debris, also known as orbital debris, space junk, and space waste, is the collection of objects in orbit around Earth that were created by humans but no longer serve any useful purpose. These artificial meteors/Debris and meteoroids of astronomic origin are a long-standing threat to satellites, and both contribute to the flux of macroscopic particles into Earth's atmosphere. To address the outstanding questions currently under investigation in the field of meteor, meteoroid and debris science and engineering, we invite presentations on the physics of meteoroid and debris particles and their impacts effects on the atmosphere, ionosphere, and satellites. We also encourage presentations that address the engineering techniques for observing and characterizing the meteoroid and debris population, including any observational (i.e. lidar, radar, satellite and optical) or modeling method.

Justification

The proposed workshop is relevant to several major thrusts called out in CEDAR the New Dimension, Strategic Vision. Namely, The exploration of exchange processes at boundaries and transitions in Geospace such as the turbopause, plasma/neutral environment in the D region and near-Earth Space. These study of these regions are needed in accordance with the 2013-2022 Decadal Survey for Solar and Space Physics. In addition, a wide range of CEDAR ground and space-based measurements can be utilized to enhance our understanding of meteors including ground based radar and optical techniques as well as space-based spectroscopy and in-situ measurements.

Billions of particles from the Sporadic Meteoroid Complex (SMC) end their journey through the solar system when they fatally impact the Earth’s upper atmosphere. This results in the deposition of mass, momentum and energy in the transition region of the ionosphere between the D and E region where the neutral atmosphere begins to play an important role in the evolution of the plasma environment due to ion-neutral collisions. This ablated material (whose mass loading of the upper atmosphere is still uncertain to within 2 orders of magnitude) results in the neutral metal layers traditionally observed between 85-105 km using lidar and plays an important role in the atomic chemistry of mesospheric metals. In addition, ablated constituents from the micrometeoroid particles sediment and condense to form meteoric smoke particles. This dusty plasma in the D region is a source of the condensation nuclei (CN) for ice layer-related phenomena such as: Polar Mesospheric Clouds and Polar Mesospheric Summer Echoes (PMSEs). The CN as well as the related phenomena are influenced by the forcing of the neutral winds and tides as well as chemistry. Through the action of advection, down-welling and meridional circulation these CN are transported into the lower atmosphere and contribute to phenomena such as Polar Stratospheric Clouds and stratospheric aerosols. Furthermore, these small particles act as a transport mechanism of mesospheric metals to the Earth's surface and ocean. It is also worth noting that larger meteoric particles that survive the ablation process in the upper atmosphere provide a space weather hazard in the form of impacts as well as iron rich materials that are deposited in the ocean. Viewing Earth-Atmosphere-Geospace coupling and interactions as a complete and interactive system, meteors contribute across a wide range of spatial and temporal scales as both a driver and catalyst of significance to microphysics and phenomena. Meteors are routinely observed using a wide array of observational techniques in both the neutral and plasma environment and can be used as a tracer to study background parameters such as neutral winds,

temperatures and tides. Many open questions exist in the meteor field. These range from gaps in fundamental understanding such as: what is the scatter process that results in radar observed meteor head echoes? and what is the mass loading of the upper atmosphere by meteor ablation and why do estimates very so drastically? to more nuanced questions about the relationship between meteor properties defined by the meteor input function and atmospheric phenomena tied to meteors. As with any study that uses the tools of system dynamics and system science one must first define the system (i.e. defining the boundaries, inputs and outputs in a thermodynamic system) and then make the simplifying assumptions that yield the relevant physics to the problem at hand. For meteor related studies, this system definition has often been implicit and related to boundaries defined by meteor ablation heights. But, as our measurement capability and knowledge increases regarding the SMC, we continue to push these traditional boundaries to uncover new insight into the processes, drivers, and feedbacks related to meteors within the Earth-Atmosphere-Geospace system allowing us to learn more about the coupling and interactions that can be uncovered using meteor science.

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