Coordinated Arrays of Distributed Instruments: A New Window on Geospace Science and Space Weather Effects

John Foster

MIT Haystack Observatory, Westford, MA 01886, USA; 781-981-5621; jfoster@haystack.mit.edu

Earth's Geospace environment, defined by the extent of the terrestrial magnetic field into space, includes the closely-coupled regions of the outer atmosphere (Earth's magnetosphere, ionosphere, and thermosphere) and their interactions with the lower atmosphere, oceans, and life on our planet's surface. These regions are characterized by dynamic processes which link solar activity to the changes in the near-Earth space environment known as Space Weather. Man's utilization of space is expanding rapidly, and with it the need to monitor and understand geospace characteristics and dynamics on a global, real-time basis. Ground-based, in-situ, and space-based observing systems provide the raw materials to support our growing understanding of this important region. Compatibly-constructed, multi-purpose instruments fielded to produce continuous overlapping observations of geospace characteristics, combined with innovative signal-processing, data distribution and display techniques, are needed to support this requirement.

There are abundant areas for scientific exploration and advancement in observing and treating Geospace as a global, coupled, complex system. This paper will describe several geospace research areas and the instrumentation and coverage needed to study them. 1) Coupling and feedback in upper-atmosphere processes and their drivers lead to an interconnection of large-scale structure between the mid-latitude ionosphere and the overlying plasmasphere. Space and ground-based observations with IMAGE EUV and GPS TEC arrays reveal significant high/low-altitude field-aligned connectivity for both embedded plasmaspheric structures and the erosion/SED plumes involved in cold plasma redistribution in the magnetosphere-ionosphere system. 2) The mid-latitude ionospheric trough is associated with a complex cause-effect-feedback interaction between the ionosphere and magnetosphere, particularly during space weather events. Magnetospheric disturbances drive currents into the low-conductance sub-auroral night time ionosphere, setting up fast westward and noonward ionospheric flow channels, the sub-auroral polarization streams (SAPS). Enhanced ion recombination due to ion-neutral collisions further reduces the trough density and conductance resulting in increased SAPS flow speeds and numerous plasma instabilities. Such disturbances persist for hours, spanning several (2-10) degrees of latitude, and across local times from midnight to noon. 3) The global redistribution and outflow of ionospheric heavy ions impacts the evolution of geomagnetic storms. An overview system perspective and global observations are needed in order to address the extensive interconnection of phenomena which characterizes the complex, coupled geospace system during major storms.

Both the CEDAR 2010 Strategic Plan and the DASI initiative (Distributed Arays of Scientific Instruments) embrace the concept of addressing Geospace as a complex coupled system and call for arrays of research instrumentation to meet the need for the extensive observations needed to address geospace system phenomena. Coordinated instrument arrays are required to observe and understand such large and mid-scale phenomena and the smaller-scale embedded structure and processes which accompany them. Appropriate instrumentation includes GPS TEC, mid-latitude SuperDARN, incoherent scatter radars, magnetometers, ionosondes, beacon-satellite receivers and optical observing systems.

978-1-4244-6051-9/11/$26.00 ©2011 IEEE