Explorer U.S. Participating Investigators
Abstracts of selected proposals
(NNH10ZDA001N-EXUSPI)

Below are the abstracts of proposals selected for funding for the Explorer U.S. Participating Investigators program. Principal Investigator (PI) name, institution, and proposal title are also included. 8 proposals were received in response to this opportunity, and 3 were selected for funding.

Jeffrey Forbes/University of Colorado
USPI-GOCE: Middle Thermosphere Variability due to Sources From Above and Below

This proposal seeks funding for 4 U.S. Participating Scientists (USPIs) to participate in the ESA GOCE mission within the context of a single 4-year science investigation focused on elucidating and understanding the competition between magnetospheric and lower-atmospheric driven variability of the middle thermosphere (ca. 250 km). The proposed investigation encompasses how the middle thermosphere response differs from that at higher altitudes (ca. 450 km) and across a range of spatial scales (i.e., gravity waves, tides, traveling atmospheric disturbances, and global storm response). The effort focuses on analysis and interpretation of total mass densities and east-west (cross-track) winds to be obtained from sensitive accelerometer measurements from the GOCE satellite in circular orbit near 250 km, and total mass densities from accelerometers on the GRACE satellites near 450 km. The NCAR Thermosphere-Ionosphere-Mesosphere Electrodynamics General Circulation Model (TIME-GCM) will be driven at high latitudes by magnetospheric inputs based on observations, and by observation-based inputs at its stratospheric lower boundary, to aid in interpretation of the measurements. The proposed investigation is inherently compelling and significant for ionosphere-thermosphere science because (a) the middle thermosphere is a relatively unexplored region; (b) satellite-based wind measurements are rare, but critical to behavior of the system; and (c) GOCE will provide the opportunity to study the response of winds and densities continuously (one orbit every 90 minutes) from solar minimum (2009) to solar maximum (2014) over all latitudes (near-circular orbit).

The proposed work is relevant to a number of high-priority science themes articulated in the 2003 Decadal Survey on Solar and Space Physics, the 20009 Heliophysics Roadmap and NASA's 2010 Science Plan for its Science Mission Directorate. In particular, the 'Heliophysics Observatory' will be greatly enhanced for the purposes of understanding solar effects on the ionosphere-thermosphere system -- the so-called 'final link' in the solar-terrestrial chain. This investigation is also relevant to the need to accurately track all objects orbiting our planet, which is increasingly becoming a prerequisite for the safe utilization of space for research, exploration, commercial and military purposes. Our capacity to perform this task with precision is challenged by the unpredictable variability of the system, and by lack of observations. This GOCE investigation will contribute to resolution of this societal problem by (a) providing measurements in a sparsely-observed

and critical atmospheric region; (b) providing quantitative information and new insights on the relative importance of different drivers of the system; and (c) constraining physics-based models of the system. Data products will be produced and made available to the scientific community through this investigation, further extending its impact.

John Moses/Naval Research Laboratory
US Participation in the Solar Orbiter Multi Element Telescope for Imaging and Spectroscopy (METIS)

Solar Orbiter will provide the next major step forward in the exploration of the Sun and the heliosphere after the successful ESA missions Ulysses and SOHO, as well as the NASA missions TRACE, RHESSI, STEREO and ISAS mission Hinode. Solar Orbiter is a key element of the International Living with a Star program, focused on the space research that has the objective of understanding the processes governing the connected Sun-heliosphere system.

The Multi Element Telescope for Imaging and Spectroscopy, METIS, investigation is conceived to perform off-limb and near-Sun coronagraphy. This investigation is motivated by the aim of addressing the three key scientific questions identified as the focus of the HELEX program. These questions concern: the origin and heating/acceleration of the solar wind streams; the origin, acceleration and transport of the solar energetic particles; and the transient ejection of coronal mass and its evolution in the inner heliosphere (coronal mass ejections, CMEs).

The investigation aims to provide crucial tests apt to verify the hypotheses and models on the following main issues of solar coronal physics, that have been developed primarily during the SOHO era:
-Is the slow solar wind originating according to more than one physical process and which is the level of contribution of the possible different sources of slow wind to the heliospheric wind observed *in situ*?
-How does the magnetic field topology control the outflow velocity and composition of the slow and fast solar wind?
-Is the magnetic field controlling the emergence of the fast wind at the base of coronal holes?
-Do polar plumes and inter-plume regions have a role in channeling the fast wind?
-Is ion cyclotron dissipation of fast Alfvén waves the primary energy deposition process in the fast wind?
-Is the reconnection at the base of coronal holes responsible for the generation of waves and turbulence that energize the fast wind?
-Which is the nature of coronal heating in open and closed field regions?
-Which is the source of the seed particles of the Solar Energetic Particles (SEPs)?
-Which is the role of coronal shocks driven by coronal mass ejections in energizing SEPs?
-Which are the mass and magnetic fluxes carried out from the Sun during transient events?

-How does the evolution of the coronal magnetic field, inferred from the large-scale evolution of the outer corona, trigger coronal mass ejections?
-How does the corona re-adjust after coronal mass ejections on medium-term time scales, ranging between 3 and 10 days (not yet established in the outer corona)?
-How do the quiescent streamers evolve on time scales ranging between 3 and 10 days?

The METIS instrument concept was successfully prototyped in the U.S. led sub-orbital program entitled; "Helium Resonance Scattering in the Corona and Heliosphere (HERSCHEL)". The aim of the proposed program is to maximize the return on this initial investment as well as the investment in U.S. funded instruments on Solar Orbiter requiring supporting METIS observations. This will be achieved through enhancements of the METIS program by the provision of key support in areas of unique US expertise.

William Peterson/University of Colorado
Investigations of the Mid-Latitude Thermospheric Response to Variations in Solar Irradiance and Geomagnetic Activity Using Photoelectron and Other Observations from the Canadian ePOP Mission

The thermosphere/ionosphere system is so complex that full understanding will come only when investigators can verify that models adequately reproduce observational data obtained under all solar and geomagnetic conditions. The empirical MSIS and IRI models that work well during normal geomagnetic conditions are based on very limited data and do not adequately reflect changes in neutral mass density and other parameters during periods of extreme solar and geomagnetic conditions. Also recent reports have shown that the solar irradiance models, including those used in generating TIMED/SEE data products below ~20 nm systematically underestimate solar energy input on daily and solar rotation time scales. Extensive model runs of large-scale, community-based, thermospheric general circulation models are now the best way to interpret how changes in energy inputs from solar irradiance, Joule heating, and particle precipitation are distributed to the thermosphere during periods of extreme solar and geomagnetic activity. However, the quantitative limitations and therefore usefulness of these models under extreme conditions remains to be determined using reliable time-variable solar irradiance data and comprehensive in-situ mass composition data.

Data from the Canadian e-POP/CASSIOPE (Enhanced Polar Outflow Probe / CAScade Demonstrator Small-sat and Ionospheric Polar Explorer Satellite) will provide the first comprehensive set of simultaneous thermospheric photoelectron and ion and neutral mass spectrometer observations since the AE and DE-2 satellites. We propose to acquire, process, and analyze ePOP data, in conjunction with data from NASA's, SDO/EVE, and the Field Line Interhemispheric Plasma (FLIP) model to identify areas where ionosphere/thermospheric models need improvement.
The e-POP/CASSIOPE mission is tentatively scheduled for launch on a Space Exploration Technologies (SpaceX) Falcon-9 rocket in late 2011. The focus of e-POP science is to understand the plasma processes driving the escape of ionospheric plasma to the magnetosphere. To meet this objective, the e-POP payload contains a suite of high

time-resolution state-of-the-art instruments to monitor the energy inputs to and the response of the topside (i.e. above 300 km) ionosphere. Included in the payload are a high time resolution electron energy-angle imaging spectrometer (Suprathermal Electron Imager, SEI) and ion and neutral mass/velocity spectrometers. The Canadian e-POP Science Team recognizes the value of the e-POP observations to improving our understanding of energy balance in the sub-auroral thermosphere and ionosphere. To augment their science expertise, they invited Dr. Peterson to become a member of the team and actively participate in the analysis of the full ePOP data set.

Our investigation will have two thrusts. First, we will develop, produce, document, and analyze photoelectron energy spectra from ePOP Suprathermal Electron Imager (SEI) data. We will analyze SEI data, irradiance data from the NASA SDO/EVE instrument, and photoelectron production models to confirm or refute our previous work showing that the all EUV and XUV irradiance models are systematically low below ~20 nm during periods of solar activity. Second we will follow up on some recent studies showing very good FLIP model agreement with Atmosphere Explorer-C (AE-C) molecular ion densities below 300 km but increasing divergence above 300 km. We will use ePOP ion and neutral mass spectrometer data and models to determine if the divergence is due to the sensitivity of the AE-C instruments or deficiencies in the model. The ePOP data assembled and analyzed as proposed here can be used to validate thermospheric models which will further our understanding of the fundamental physical processes of the space environment from the Sun to the Earth. All data we process and/or analyze will be archived on NASA's Heliophysical Data Environment.