COLLEGE OF ENGINEERING
CLIMATE AND SPACE SCIENCES AND ENGINEERING
UNIVERSITY OF MICHIGAN

Michael W. Liemohn • Professor

October 3, 2019

Dr. Nicola Fox, Heliophysics Division Director
National Aeronautics and Space Administration
Heliophysics Division
300 E Street, SW
Washington, DC 20546-0001

Dear Dr. Fox:

The Heliophysics Advisory Committee (HPAC), an advisory committee to the Heliophysics Division (HPD) of the National Aeronautics and Space Administration (NASA), convened on 1 October through 3 October 2019 at NASA Headquarters (HQ). The undersigned served as Chair for the meeting with the support of Dr. Janet Kozyra, HPAC Designated Federal Officer (DFO), of NASA-HPD.

The meeting was convened specifically to conduct the Government Performance and Results Act/Modernization Act (GPRAMA) annual performance evaluation of HPD. During this part of the meeting, most HPAC members participated. Those in attendance at NASA HQ were Vassilis Angelopoulos (University of California, Los Angeles), Darko Filipi (Adcole Maryland Aerospace), George Ho (Johns Hopkins University Applied Physics Laboratory), Lynn Kistler (University of New Hampshire), Tomoko Matsuo (University of Colorado at Boulder), Rebecca Bishop (Aerospace Corporation), and me. A few committee members attended via telecon: Paul Cassak (West Virginia University) and Cora Randall (University of Colorado, Boulder).

Jennifer Kearns briefed the HPAC about GPRAMA and the Heliophysics Science Performance Assessment of the Strategic Objectives. The HPAC was tasked to review the HPD Fiscal Year 2018 progress with focused attention on these three Annual Performance Indicators [APIs]:

API HE-19-1: Demonstrate progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system;

API HE-19-2: Demonstrate progress in advancing understanding of the connections that link the Sun, Earth, and planetary space environments, and the outer reaches of the solar system; and,

API HE-19-3: Demonstrate progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Climate and Space Research Building
2455 Hayward St., Ann Arbor, Michigan 48109-2143
T: 734 763-6229
liemohn@umich.edu | clasp.engin.umich.edu

Michael W. Liemohn • Professor

Resulting from substantial deliberation, the HPAC voted unanimously for a "green" rating in all three APIs, finding "expectations for the research program fully met in context of resources invested." The specific summary text generated by HPAC for each of the APIs can be found below.

We thank the HPD staff for providing source material with highlights from the NASA-supported missions and research projects. This was most helpful in our assessment of the APIs for the GPRAMA review. We welcome any requests from NASA Heliophysics Division for clarification or elaboration on our findings.

Sincerely yours,

Michael W. Liemohn

Space Research Building, 2455 Hayward St.
Ann Arbor, Michigan 48109-2143
T: 734 763-6229
liemohn@umich.edu | clasp.engin.umich.edu

HE-19-1: As determined by the Heliophysics Advisory Committee (HPAC), demonstrate planned progress in exploring the physical processes in the space environment from the Sun to Earth and throughout the solar system.

The Heliophysics Advisory Committee determined in October 2019 that NASA remained on track in its annual performance towards achieving this performance goal. Below are examples of the scientific progress reported in FY 2019.

NASA missions led to significant advances in understanding of how solar flares, large explosions on the surface of the Sun, develop in the solar atmosphere. NASA's Interface Region Imaging Spectrograph (IRIS) owing to its unprecedented resolution, revealed how plasma turbulence plays a vital role in converting magnetic energy to heat, challenging the current model stating that particles are simply transported along the Sun's magnetic field.

Furthering our understanding of Sun-Earth interactions, the Time History of Events and Macroscale Interactions during Substorms (THEMIS) spacecraft provides the first direct evidence indicating that the Earth's dayside magnetosphere vibrates like a drum in response to single plasma jets striking the magnetopause. Such strikes during otherwise quiet intervals create oscillations associated with the natural frequency of the magnetopause surface.

Closer to Earth, the Solar Occultation for Ice Experiment (SOFIE) on the Aeronomy of Ice in the Mesosphere (AIM) Explorer observed nitric oxide (NO) oscillations in the upper atmosphere and identified overestimates of the molecule's absolute abundance. Refining current models of the lower thermosphere based on such observations is important because, at these altitudes collisions between neutral and charged atoms and molecules impact the ionosphere over the entire globe.

The committee of nine people voted **unanimously** for a **green** rating.

Space Research Building, 2455 Hayward St.
Ann Arbor, Michigan 48109-2143
T: 734 763-6229
liemohn@umich.edu | clasp.engin.umich.edu

The Heliophysics Advisory Committee determined in October 2019 that NASA remained on track in its annual performance towards achieving this performance goal. Below are examples of the scientific progress reported in FY 2019.

NASA missions made significant progress in advancing understanding of the connections that link the Sun, Earth and planetary space environments and the outer regions of the solar system in multiple arenas. Measurements from NASA's two Van Allen Probes and the Japanese Arase (ERG) mission illustrated that spatially localized waves on Earth's magnetic field can significantly reduce the number of charged particles in the electron radiation belts on time scales as short as ten minutes. Utilizing simultaneous data from the three spacecraft along with ground observations, multi-point observational analysis established that the spatial extent of the wave activity was as small as a few Earth radii. Another key result was to identify the likely source of the phenomenon known as STEVE, a narrow feature of auroral lights that was recently discovered by citizen scientists. Ground and space-based observations from NASA's THEMIS mission showed that this feature is due to enhanced motion of charged particles in the ionosphere, not from charged particles entering the region from above. Another example of progress is from NASA's IBEX mission, which observed the response of the outer boundary of the solar system (the heliosphere) to a large increase in the strength of the solar wind that began in 2014. IBEX observes high energy neutral atoms (ENAs) formed when a high energy charged particle from interstellar space captures an electron from a cold neutral particle at the solar system boundary. The signatures IBEX measured are consistent with the heliosphere being shaped by a balance between the outflowing solar wind and the flow and magnetic fields of the interstellar medium.

The committee of nine people voted **unanimously** for a **green** rating.

Space Research Building, 2455 Hayward St.
Ann Arbor, Michigan 48109-2143
T: 734 763-6229
liemohn@umich.edu | clasp.engin.umich.edu

He-19-3: Demonstrate planned progress in developing the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

The Heliophysics Advisory Committee determined in October 2019 that NASA remained on track in its annual performance towards achieving this performance goal. Below are examples of the scientific progress reported in FY 2019.

NASA missions from all Heliophysics disciplines were used to advance our understanding of extreme space weather phenomena as well as conditions capable of adversely impacting technology systems and human and robotic explorers. Observations from the GOLD mission showed that severe ionospheric plasma depletions which may affect radio signal propagation can occur 10 times more often than previously measured during solar minimum. Their study will help improve our forecast capability. A study of a coronal mass ejection (CME) that occurred on September 2017, using observations from Earth (NOAA/GOES), Mars (MAVEN), and solar (STEREO-A) environments demonstrated a new capability to detect space weather events across the entire Heliosphere, enabling study, modelling and improved understanding of their large scale evolution. Finally, NASA researchers created a new geospace index, the Thermosphere Climate Index (TCI), which quantifies succinctly the impact of solar variability on the thermosphere. This index will be invaluable in solar-cycle time-scale correlations with solar variability to improve our forecasts of space weather, with direct impacts on satellite re-entry and collision probability predictions.

FOR API HE-19-3: COMMITTEE VOTE IS **unanimous in favor of a green rating**.