The Need for Coordinated Ground-Space Observations of the Magnetosphere-Ionosphere-Thermosphere System

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In this white paper we want to highlight that coordinated ground-space measurements are critical in order to "characterize and understand how the ionosphere-thermosphere behaves as a system" and what they can reveal for magnetospheric dynamics, one of the standing unresolved problems in ionospheric system science. **The "significant challenges in studying global dynamics with a single satellite" that have led to the recommendation of a constellation of satellites also very strongly demonstrate that ground assets** that are already deployed by various groups, as well as future plans, **would be critical in overcoming these challenges for the highest possible scientific yield**. A properly interpreted ground-based view in the polar regions can provide information about huge areas in the magnetosphere, which can offer significant additions and context to the actual in situ measurements made within different regions of the magnetosphere.

It is imperative to stress that concerted small and large scale ground based observations are critical in providing not only with the time history and context of IT responses (which are not possible to ascertain with just in situ measurements), but also comprehensive measurements from altitudes not accessible to the in situ measurements (such as from Fabry-Perot Interferometers, radars, magnetometers, All-Sky Imagers). **We want to impress upon the community, NASA and all the developing missions that what we typically have thought of as "supplementary" measurements for large missions are actually necessary and enabling measurement for reaching closure on science objectives relevant to magnetosphere-ionosphere-thermosphere science. We wish to forge a new understanding of how we think of space missions in the Earth's space environment and how we expect them to accomplish their science closure.**

The real necessity for such measurements is the scientific return. There is an added piece to this discussion that has to do with the programatic challenges of ground based measurements at large and we want to stress that a larger collaboration is needed for that as we look ahead at how Heliophysics can and will evolve in the next 30 years.

Ground based measurements have traditionally been enabled by the National Science Foundation while space-based measurements by NASA. Collaboration and coordination for enhancing science return has so far mostly been done at the grass roots level with great success. These have been mostly done after the fact for larger missions but we have the opportunity to engage in this kind of coordination at the ground level. **We propose that Helio2050 considers requesting that NASA and NSF engage such a collaboration from the beginning in order to fully leverage available resources and plan necessary infrastructure and operations support to maximize the impact of ground based assets.**

Early coordination between NASA and NSF is essential so that:

1. the current ground based capabilities are evaluated in light of Helio2050 science questions & priorities that will come out of the workshop

2. future coverage needs are identified both in terms of the specifics of instrumentation and their implementation as well as the funding that can support the needed infrastructure.

It is imperative that NASA considers the full scope of activities needed to maintain state of the art in current ground based measurements and associated needed infrastructure as well as enable new or updated infrastructure. NASA funding for such efforts should also be a priority in the planning phase. We therefore recommend that the community develops a) a list of ground-based capabilities expected to be operational in the next few decades, b) a list of additional capabilities that, if developed, would produce optimal science return and c) a plan for funding any needed additional capability, which could include a combination of NASA-NSF partnership.

There are numerous examples that we can look to for guidance and input, such as from the THEMIS, Van Allen and sounding rocket communities to name a few. THEMIS for example, has a funded ground based arsenal (ASIs and magnetometers) to address its science questions and also provides leadership for the Heliophysics/Geospace System Observatory (HGSO). HGSO is a successful example of a framework for the current space-ground coordination effort but is the minimum that we could do–after the fact–for increasing collaboration. NASA has the opportunity to maximize the science impact of the any mission by taking actions now as we look at the most compelling physics problems that we want to solve in Heliophysics looking forward to the future.

It is important to note that NSF will have to also consider changing its mode of operating if they are to better respond to community's needs of executing missions with the collaboration of both agencies. Specifically, NSF will have to allow for its facilities portfolio in Heliophysics to encompass consideration for upcoming NASA strategic missions. We remain hopeful that the two agencies will forge the right path for such a collaboration.