2024 Decadal Survey for Space and Solar Physics: Space Weather Inputs

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Key Points:

- Space weather will play a central role in the 2024 decadal survey
- A summary of the recommendations from 2003 and 2013 decadal surveys are provided
- Scientists, operators and end-users are encouraged to submit white papers

Abstract:
The next decadal survey process for space and solar physics will start soon with white papers due during the second half of 2022 and the committees and panels working over all of 2023. Space weather science and operations will play an essential role in this survey. Therefore, the community is invited to prepare white papers and get involved in advancing space weather research and capabilities in the upcoming decades. A summary of the recommendations related to space weather from the last two decadal surveys is also provided.

Main text:
The decadal survey for solar and space physics is organized under the National Academies of Sciences, Engineering, and Medicine (NASEM) approximately every ten years. The decadal surveys strongly guide the direction of NASA Heliophysics division and other agencies, particularly NSF and NOAA, and participation in this process through the submission of white papers is an important way of communicating the community's priorities. The goal of the decadal survey is to develop a strategy and to make recommendations for activities, missions and science for a 10-year period, with the decadal survey process that is currently starting, covering the period of 2024-2035. The two most recent decadal surveys for geospace science and heliophysics released their reports in 2003 and 2013. The 2003 decadal survey was chaired by Lou Lanzerotti, who became the founding editor-in-chief of *Space Weather*. That report[1] was organized into seven main chapters, one of which was entitled "Effects of the Solar and Space Environment on Technology and Society", which dealt primarily with space weather recommendations. The key space weather recommendations in 2003 focused primarily on organization between different agencies and departments, but also mentioned "the continuance of space-based measurements such as solar wind data from the L1 location as well as near Earth", the "transition [of] solar and geospace imaging instrumentation into operational programs for the public and private sectors", the "establish[ment of] an overall verification and validation program for all publicly funded models and system-impact products before they become operational ", the "establish[ment of] procedures to identify and prioritize operational needs, [… and] to determine which of the competing models, public or private, is best suited for a particular operational requirement," and the creation of "a new, centralized database of extreme space weather conditions." Some of these recommendations have only been implemented in the past few years, for example, through the PROSWIFT Act. Within the top-level mission recommendations – the top three recommendations were mission concepts that became the Parker Solar Probe (PSP), the Magnetospheric Multiscale mission (MMS) and the Van Allen Probes), a few have not been implemented yet, and the ones most relevant to space weather include a magnetospheric constellation of fifty to hundred nanosatellites (Medium-7) and a solar wind sentinel of three spacecraft at 0.98 AU (Medium-8) and a stereoscopic magnetospheric imager (Medium-9). In addition, another key recommendation (Small-5) related to space weather

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1029/2022SW003181.

was to fund a distributed network of ground-based instruments to provide global-scale ionospheric and upper atmospheric measurements. A workshop of the NASEM was organized in 2006 upon a request of NSF to further discuss this recommendation[2]. Distributed arrays of small instruments (DASI) were also discussed in the 2013 decadal survey and a solicitation was released in 2019 by NSF with awards made in 2019-2020.

The 2013 decadal survey[3] committee's overall recommendations included rechartering the national space weather program and working in a multiagency partnership to achieve continuity of solar and space observations (measurements from L1, space-based coronagraph and solar magnetic field measurements, new observational capabilities, NOAA R2O program, development of distinct lines for basic, applied and operational research). In addition to its organization into three panels by research areas, the 2013 decadal survey for space and solar physics included five working groups, one of which was "Research to Operations/Operations to Research", co-led by Michael Hesse and Ronald Turner. This was a new working group as compared to the 2003 decadal survey committee. The 2013 decadal report was organized into seven main chapters, including a chapter entitled "Space Weather and Space Climatology: A Vision for Future Capabilities". The key recommendations from this chapter were:

- Building, launching and operating satellites at L1 and L5
- Building, launching and operating satellites at high-altitude GEO for ionospheric imaging and low-altitude LEO for radiation belt monitoring and direct in-situ measurements of the ionosphere-thermosphere
- Developing, testing and transitioning models into operations, including with assimilative capabilities
- Integrating research with operational activities
- Leveraging the strength of NASA community through PI-led missions, hosted payloads and microsatellites
- Coordinating between multiple agencies, including NSF, NASA, USGS, DOE, DOD and NOAA

Overall, this summary is provided, first, to highlight the central role space weather has played in the two most recent decadal survey cycles, a role that we expect to be even more prominent in the upcoming decadal survey. Second, this summary highlights, that, while the majority of recommendations are implemented, it often occurs on a longer timeframe than that originally recommended or forecasted. For example, operational missions at L1 occurred with DSCOVR in 2015 and will occur with SWFO-L1 in 2025, while a L5 mission is currently under planning stage by ESA for a launch in the second half of the 2020s. The first operational coronagraph, CCOR, will launch onboard GOES-U in 2024. Third, this provides a brief outline of the recommendations, related to space weather, over the past two decades, in terms of instrumentation, missions, as well as programmatic, and can help guiding the drafting of white papers for the upcoming decadal survey.

As such, the editorial board of Space Weather encourages space weather researchers, forecasters, operators and end-users to work on white papers and get involved with the decadal survey process. Following a first workshop (Heliophysics 2050[4]) in May 2021, the community has held regular discussions over the past year to discuss priorities and prepare white papers. In addition, NASEM has organized, with sponsorship from NOAA, NASA and NSF a series of workshops in 2020-2022 to plan the space weather operations and research infrastructure[5]. People who haven't participated in these discussions can get involved by contacting one of the discussion organizers (https://www.hou.usra.edu/meetings/helio2050/discussion/) and by working on white papers. While space weather holds a central role within the solar and space physics community, we also encourage white papers to distinguish between required fundamental research, missions and instrumentation and applied research and operational missions and instrumentation, as highlighted in a recent editorial[6]. The editorial board anticipates providing pathways to peer-reviewed publications in the new future for space weather related articles not just associated with the US decadal survey, but also with space weather policy, recommendations and instrumentation/mission concepts from other countries to reflect the global effort given to the global problem. Interested potential authors should watch out for a forthcoming announcement.

Acknowledgments:
No data was used nor generated for this paper. The authors thank feedback from Lou Lanzerotti on a draft of this editorial.

References

1: National Research Council. 2003. The Sun to the Earth -- and Beyond: A Decadal Research Strategy in Solar and Space Physics. Washington, DC: The National Academies Press. https://doi.org/10.17226/10477

2: *Distributed Arrays of Small Instruments for Solar-Terrestrial Research: Report of a Workshop*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11594.

3: National Research Council. 2013. Solar and Space Physics: A Science for a Technological Society. Washington, DC: The National Academies Press. https://doi.org/10.17226/13060

4: https://www.hou.usra.edu/meetings/helio2050/program/Heliophysics-2050-Workshop-Preceding.pdf

5: National Academies of Sciences, Engineering, and Medicine. 2021. Planning the Future Space Weather Operations and Research Infrastructure: Proceedings of a Workshop. Washington, DC: The National Academies Press. https://doi.org/10.17226/26128.

6: Space Weather as the Nexus of Applied and Fundamental Space Science: The Need for Separate Funding Mechanisms and Definition, Space Weather Editors, Space Weather (2021), 19, e2020SW002695, https://doi.org/10.1029/2020SW002695