B.20 HELIOPHYSICS TOOLS AND METHODS

NOTICE: Amended March 9, 2022. This amendment releases the final text for this program element, which had been listed as "TBD". Neither Notices of Intent nor Step-1 proposals are requested for this program element. Proposals may be submitted at any time. See Section 3.2 for details.

This is a new program that is replacing the Value-Added Enhancement program, previously offered through B.12 HDEE.

All proposers are to use the standard Heliophysics template for Current and Pending Support for the PI and all Co-Is, regardless of time commitment. See

https://science.nasa.gov/researchers/templates-heliophysic-division-appendix-b-roses-proposals.

Data Management Plans are not required, as those contents are covered by the requirements in Section 2.3.

1. Scope of Program

The Heliophysics Tools and Methods (HTM) program encompasses the Python software tools and method needs throughout Heliophysics, including Solar, Heliospheric, Magnetosphere, and Ionosphere/Thermosphere/Mesosphere (ITM).

As part of a mission-oriented agency, the Tools and Methods program preferentially seeks to fund those efforts that directly impact NASA Heliophysics missions or interpretation of mission data. Projects involving data from other U.S. agencies or institutions that are judged to be highly beneficial to NASA Heliophysics (HP) research are included in the scope for this program, if not available in a suitable form from their host's institution.

The specific context of this call is provided by information on the *Heliophysics Data page* at https://science.nasa.gov/heliophysics/heliophysics-data.

HTM is a component of the Heliophysics Research Program and proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in B.1 the Heliophysics Research Program Overview for Heliophysics-specific requirements. Common default requirements for all ROSES proposals are found in the *ROSES Summary of Solicitation* and the *Proposer's Guidebook* but those may be superseded by instructions in a program element like this one. The order of precedence is the following: ROSES Element B.20 (this document) takes precedence followed by B.1, followed by the *ROSES Summary of Solicitation*, and finally the *Proposer's Guidebook*. Proposers should be familiar with all these resources.

2. Heliophysics Tools and Methods

This call solicits proposals to advance the goal of a robust, vital, and cohesive Python environment for Heliophysics. Types of projects to be proposed under this call may include but are not limited to:

- Data readers/writers for standard formats (FITS, CDF, NetCDF)

- Analysis code, e.g., pySPEDAS or SolarSoft components; common research methods.
- Visualization: improvements on common packages, focused on our needs including graphics from line graphs to 2D and 3D representations of data and simulations.
- Large data and large simulation use; parallel implementations; data mining.
- Generic Python machine learning and artificial intelligence routines.
- Specific science tasks that require either wrappers of, e.g., SciPy and NumPy routines or novel code.
- Exposing software libraries written in other languages to Python integration by providing the required set of wrapper routines.

2.1 Background on Python in Heliophysics Community

A significant goal of this program element is to maintain and contribute to the current Python in Heliophysics Community (PyHC) effort. Useful information about the current status of work in this area can be found in the overview paper by Burrell, et al. [Snakes on a Spaceship, 2018], and more recent information can be found on the PyHC web site. The vision statement for PyHC states:

> "Facilitate scientific discovery by promoting the use and development of sustainable open-source Python software across the solar and space physics community; improving communication and collaboration between disciplines, developers, and users; establishing and maintaining development standards; and fostering interoperability and reproducibility."

And the strategic goals for this group are:

- Coordinate development across projects to minimize duplication of effort and share lessons learned
- Promote best practices for software development, documentation, testing, and dissemination
- Increase community awareness of and participation in projects
- Promote scientific reproducibility and software sustainability
- Educate and support the Python user community in solar and space physics
- Foster an open-source Python software ecosystem for Heliophysics research and education
- Identify community needs for future development
- Identify and pursue opportunities for financial support
- Enable efficient interdisciplinary research

The philosophy of this call is that the best way to make progress is to work on real projects of scientific community interest, with the aim to make functional code and to incorporate it into the existing PyHC framework.

The HP community has been developing a wide variety of tools for data access, production, and analysis based on the high-level, general-purpose Python programming language. Early career researchers, especially, tend to come from backgrounds where Python is the norm and languages (platforms/IDEs) such as IDL and MatLab are seldom used. Many senior researchers are also finding that Python provides a very

natural way to conduct analysis and data-processing tasks. Python has the advantage over some other currently popular languages in that it is open source, and thus provides no economic barriers for use. It is widely used, with a model for namespaces that encourages the development of packages of code centered on a particular task; this has led to the rapid development in recent years of many of the tools needed in HP research.

2.2 Programmatic Considerations

Proposals must discuss the relationship of the proposed effort to the present, as well as anticipated, state of knowledge in the field, and its applicability to the relevant datasets in Heliophyscis, and to any related NASA community research efforts.

Proposers should not duplicate work already being undertaken. The PyHC website includes pointers to many of these efforts. Listed below are the past selections that supported the PyHC effort:

- 2021 HDEE Selections
- 2020 HDEE Selections
- 2019 HDEE Selections

If an award is made, code that is produced must be released as open source through mechanisms to be agreed upon by the Python in Heliophysics Community (see PyHC and Section 2.1) and NASA.

This call will accept submissions throughout the year (no deadline). The rules for open proposal submissions are outlined in B.1 and in Section 3.2.

2.3 Heliophysics Data Policy Implementation

Consistent with the Heliophysics Data Policy, all projects under this program must involve scientific input, and all software and processes should support scientific utility, as evidenced by the support and participation of scientists. As a complement to this, all efforts must show evidence of good software engineering practices, for example, the use of clear, documented, tested, efficient code that fully accounts for IT security issues. Proposers to this call agree to the PyHC Standards that include requirements to provide documentation, version control, testing, standard packaging, and other elements intended to optimize the utility of the results. In line with the recommendations of the National Academy of Science (NAS) Space Studies Board report, *Open Source Software Policy Options for NASA Earth and Space Sciences*, the results of projects under this call will be made publicly available as open source software as detailed by the PyHC Standards. Each group awarded a grant effort under this call must work in collaboration with the whole PyHC group for the benefit of all. Awardees are expected to attend at least one of the PyHC group meetings (typically three days, to be budgeted in the proposal) and abide by group decisions. Proposals to this call must indicate explicitly the understanding of, and agreement with, the above points. After selection, any areas where there are questions or concerns in terms of governance, protocols, and procedures will be adjudicated by the cognizant NASA program officer.
Proposers should show an awareness of the wide variety of datasets now available, see Table B.20-1, below, for examples.

Table B.20-1: A sample of existing data repositories

Space Physics Data Facility (SPDF)	https://spdf.gsfc.nasa.gov
Virtual Solar Observatory (VSO)	https://www.nso.edu/data/vso
Virtual European Solar and Planetary Access site (VESPA)	http://www.europlanet-vespa.eu/EPN2020.shtml
European Space Astronomy Centre site (ESAC)	https://www.cosmos.esa.int/web/esdc
Coupling, Energetics, and Dynamics of Atmospheric Regions site (CEDAR)	http://cedar.openmadrigal.org
LASP Interactive Solar Irradiance Data Center	http://lasp.colorado.edu/lisird
Planetary Data Systems Planetary Plasma Interactions node	https://pds-ppi.igpp.ucla.edu
SuperMAG ground-based magnetometer site	http://supermag.jhuapl.edu

Most of these repositories are available through “restful” Web Services or other machine-to-machine protocols, increasingly including the general Heliophysics Application Programmer Interface. Proposers are also encouraged to utilize the Heliophysics Data Portal that provides metadata, documentation, and access points for an increasingly complete set of HP data and other products.

2.4 Proposal Content

Proposals must include explicit subheadings as given in each of the bulleted points below, in the order below, with a discussion of each topic indicated (explicitly note if not applicable):

- *Software or enhancement to be produced*: A clear description of the code(s) to be produced or community assistance to be implemented, including the scientific or other problems solved and the basic methods used, and the relationship to NASA strategic plans and the HP Data Policy.
- *Scientific utility*: An argument for why the codes or assistance are scientifically relevant and useful, and the uniqueness or scientific advantages of the proposed approach compared to alternatives. Specific research projects should be mentioned, along with an assessment of whether these will bring qualitatively new insights. This should be supported by, e.g., refereed publications or other citations and uses by people outside the PI team. A poor justification would be: "This work supports projects involving long-term changes in the heliosphere" without specific examples. An excellent justification would be: "The following three groups are awaiting this code to be able to do these cutting-edge scientific studies …". In the case of very generic capabilities (e.g., a CDF reader), the breadth of the utility may be more important than the support of specific projects.
- *Method of Production*: How the Enhancement will be produced, details of the technical approach, its requirements and feasibility, including a presentation of relevant algorithms.
- *Current Status*: The status of the code and its current means of support.
- *Documentation Plan*: A plan for providing required metadata and information needed for independent scientific usability consistent with PyHC standards.
- *Archive and Dissemination Plan*: A discussion of the use of GitHub or other code repositories and the methods of code distribution consistent with PyHC standards.

- *Need for Resources*: A discussion that demonstrates that the requested resources are necessary and sufficient for success in achieving the proposed effort. The resource discussion should include: how many hours of what specific level of support person are required, why and what level of science support is needed in terms of FTEs, and how HDEE resources complement other support.
- *The relationship of the proposed effort to other areas*, including the present and anticipated state of knowledge in the field, to the relevant datasets and code that should be available from any related existing or planned missions, and to any related NASA community research efforts.

The discussion of each of these points may be brief, but each point must be clearly addressed, and these points are the key elements of a proposal.

3. Proposal Preparation and Submission

3.1 General Considerations

Within the proposing team, the PI (or Science PI), and Co-Investigators (Co-Is) must each have specific and defined tasks in the project, and the tasks must be essential to the completion of the project. Proposals may be declared noncompliant if they are outside the scope of the HTM program (see Section 1 above) or if they fail to meet submission guidelines specified below (Section 3.2).

3.2 Submission Process

Proposals to this program element may be submitted at any time without any preliminary statement such as a Notice of Intent or Step-1 proposal. Certain restrictions related to duplicate proposals and resubmissions are described below. The NSPIRES page for this program element displays a "Proposals Due" date, but that is simply the end date for the current HTM, after which proposals may be submitted to HTM in the next ROSES.

While proposals can be submitted at any time, proposals will be evaluated approximately quarterly (see Section 4). Once ROSES-2023 is released in mid February of 2023, new proposals should be created in response to the HTM program element in ROSES-2023. However, proposals already started in response to this program element may be completed and submitted through March 2023.

Specifically, for the rolling submissions in this program element:

- A PI may at most submit two distinct (different) proposals in any given calendar year.
- A PI may resubmit the same or slightly modified proposal at most once in any given calendar year.
- A proposal with more than 50% new content is counted as a new proposal and not a resubmitted proposal.

A (maximum) of 6 pages is allowed for the Science/Technical/Management Section of proposals to this program element. The proposal must be submitted via NSPIRES or Grants.gov by the organization’s Authorized Organizational Representative (AOR). A budget and other specified information is required.

The process for preparation and submission of the 6-page proposals is the same as that for any other ROSES proposal. Guidelines for content and formatting proposals are specified in the *ROSES Summary of Solicitation* (SoS) and, if not present in the SoS, the *NASA Guidebook for Proposers*. Proposals must adhere to formatting requirements, e.g., margins, font sizes, line spacing, in Section IV(b)ii of the ROSES SoS.

Proposals must include the following within the Scientific/Technical/Management section: clear descriptions of (1) specific Heliophysics scientific problems that could be addressed with the Tools & Methods projects in conjunction with other HP resources, (2) the importance of the problems, and (3) the details of the technical approach to providing the promised software. The answers to the above points should arise naturally in following the required contents in Section 2.4.

4. Evaluation

Compliant proposals will be evaluated according to the three criteria as defined in Appendix D of the *NASA Guidebook for Proposers*: merit, relevance (to this program element), and cost, as clarified below.

The evaluation of scientific and technical merit will include:

- Compelling nature and scientific priority of science goals enabled by the Tools and Methods project, including the importance of the problem within the broad field of Heliophysics; the unique value of the investigation to enable scientific progress in the context of current understanding in the field, and the importance of carrying out the project now.
- Appropriateness and feasibility of the methodology, including the appropriateness of the selected algorithms for completing the development and the feasibility of the methodology for ensuring success.

Based primarily on these two factors within merit, the evaluation will consider the overall potential science impact and probable success of the investigation.

Relevance will be judged by whether the proposal addresses the strategic goals of a Python Tools and Methods project (See Section 2).

Cost reasonableness will include assessing the amount of work to be accomplished versus the amount of time proposed.

Approximate dates for the evaluations will be May 2022, August 2022, November 2022, February 2023, and May 2023.

5. Available Funds

It is anticipated that approximately $500K will be made available to support ~7 new selections of 1-year duration each year, with a median award value of $75K. Smaller efforts should request lower funds, while larger efforts need to specifically justify their larger requests. Investigations in the range of $50K – $100K are anticipated. Proposals are expected to be for one year, with a second year possible with strong justification.

6. Summary of Key Information

Expected program budget for one-year awards	$500K, see Section 5

Number of new awards pending adequate proposals of merit	~5-8, see Section 5
Maximum duration of awards	1, second year possible if well justified, see Section 5
Due date for proposals	Proposals may be submitted at any time until 11:59 pm Eastern time on March 29, 2023
Planning date for start of investigation	~ 4 months after proposal submission. Evaluation quarterly, see Section 4.
Page limit for the central Science-Technical-Management section of proposal	6 pages
Relevance	This program is relevant to the Heliophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 2.4 of this program element, Table 1 of *ROSES* and, finally, Section 3 of the *NASA Guidebook for Proposers*.
Detailed instructions for the submission of proposals	See NSPIRES Online Help, Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH22ZDA001N-HTM
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