

“Heliophysics in Europe” Workshop, 30 October – 3 November 2023, ESTEC, Noordwijk, NL

- “Heliophysics” (including space weather) encompasses space plasma physics throughout the solar system, from Sun to the solar wind, planets (including the Earth) and small bodies. As such, it includes topics covered by the entire ST division and part of PS division in European Geoscience Union.
- Heliophysics has a large and active international community, with significant expertise and heritage in the European Space Agency and Europe.
- Several ESA directorates have activities directly connected with Heliophysics, including ongoing and/or planned missions and instrumentation (Directorate of Science, Directorate of Earth Observation, Directorate of Human and Robotic Exploration, Directorate of Technology, Engineering and Quality, Directorate of Operations, and Directorate of Navigation).
- The ESA Heliophysics Working Group was established in 2021 by the ESA Director General to act as a focus for discussion, inside ESA, of the scientific interests of the Heliophysics community, including the European ground-based community and data archiving activities.

“Heliophysics in Europe” Workshop, 30 October – 3 November 2023, ESTEC, Noordwijk, NL

- After several internal discussions, the ESA Heliophysics Working Group organised ‘Heliophysics in Europe’ along with the community.
- The goal of the meeting was to improve communication between the European Heliophysics community and the various ESA directorates involved. It aimed to highlight opportunities existing in those directorates, but also to identify synergies spanning directorates and possible future coordination efforts.
- To maximize outreach to the community, the workshop was promoted across multiple mailing lists. Additionally, the Science Organising Committee (SOC) comprised of a broad range of the community
- The workshop also provided an opportunity for that community to discuss amongst themselves.
- Workshop link : [Heliophysics in Europe 2023 - ESA Heliophysics - Cosmos](#)

Meeting was broken into 4 sessions:

- **Session 1: ESA Heliophysics activities**
- **Session 2: Building Bridges in Heliophysics: open questions, missing observations, measurements, models, and investigative techniques**
 - Topic 1: Interdisciplinary science targets
 - Topic 2: Mission concepts
 - Topic 3: Multi-Instrument and general science
 - Topic 4: Data, analysis methods, instruments
- **Session 3: Building a European Heliophysics network and community hub**
- **Session 4: Workshop Reporting, Summary, SWOT discussion and next steps**

Session 1 summary

- ESA Helio WG formed to improve communication internally.
- Have already identified ways in which ESA could streamline activities, "low hanging fruit" in terms of ongoing activities:
 1. Archiving (cross discipline, interoperability, data standards , discoverability, etc.)
 2. Ground-based community connections – improving coordination/communication, data (see (1))
 3. In the near future kicking of a focus on European-centred modeling and connectivity
 4. ESA Heliophysics web portal for cross discipline information, mailing list, potential information/database on "Euro Helio scientists?" (taking note of data protection)
- Opportunities related to cubesats raised during discussion
- European Heliophysics Seminar series (expanding current internal version)
- The definition of Heliophysics in this context was also discussed, with the ESA definition being connected to the overall coverage by its programmes, with the aim to be as inclusive of all space plasma physics related topics, even up to and incorporating interdisciplinary aspect between Heliophysics and astrophysics.

Session 2 - Topic 1 – Inter-disciplinary Science

Heliophysics encompasses a diverse range of topics and objects, that share a common foundation in physics. This allows for interdisciplinary research and scientific collaboration across a wide range of areas, for example:

- A comprehensive understanding of the underlying principles of plasma physics is of crucial significance
- We need to look further into machine learning opportunities across fields
- Enabling cruise-phase science operations, (where cruise phase is period the mission is travelling to its main mission destination, for planetary missions for example before arrival at the target body) and re-imaging observations outside normal target/core science.
- Better bridges between space and ground based observations, modelling and theory are needed (ESA could help with that)
- More general discussion encourages cross-disciplinary interactions, build a wider community
- high frequencies in one regime/discipline may not be considered high frequency in another, so care is needed with nomenclature
- Interdisciplinary science requires data from multiple sources, and using many different tools and may require better measurements in some regions.
- We need a data repository/catalogue from different communities to facilitate interdisciplinary research => For example - including ground-based data and space -based data in the same location/repository.

Session 2 - Topic 2 - Missions

“Solar system and beyond” missions, including Cube Sats and mission concepts addressing interdisciplinary science

- In-situ and remote sensing combination is a new challenge
- Interesting orbits serve different communities and different science goals
- Ground based community to be included in the planning phase! Funding for such relevant observations is then an open question to be discussed!
- Heritage and continuation is needed – otherwise we lose expertise*
- Demonstration of technology, science, operational – separate or combine?***

Data & Science

- Better data+model visibility/accessibility for more diverse community interactions and new science questions
- Embrace big data using ML/AI techniques

**Training and (long-term) funding of next generation is needed (EOP mission concepts support early career researchers to develop mission concepts (NEOMI))*

ESA cross-directorates communication needed for interdisciplinary missions -**ESA Heliophysics WG

Session 2 - Topic 3 - Multi-instrument and general science

Studies of various energization/transport processes throughout Heliosphere to make full use of current/future missions

Coordinated space-ground based, multi-point measurements

Inner/middle/outer corona structure, solar wind, magnetosphere, and ionosphere

1) Science questions that were presented during the meeting

- Particles energization/acceleration/transport processes throughout heliosphere;
- Energy deposition in Earth's atmosphere;
- Source of high energy particles at the Sun & heliosphere;
- Role of cold plasma in planetary magnetospheres' dynamics;

2) Instruments and measurements that were presented during the meeting

- Gamma/X/EUV & magnetic field low-mid-high E particle distribution, ENA;
- Network measurements: all-sky cameras, Fabry-Perot Interferometers, SuperDARN radars, magnetometers, and ISRs

3) In what other science area can the measurements be used ?

- Application to astrophysical plasma, different planets, stellar-systems, black-hole;
- Monitoring sea ice, oil spills, HF absorption, radio blackouts, atmospheric tidal motion, meteor scatter
- Implication to lunar or Mars landers

Session 2 – Data, analysis methods, instrumentation

Common themes in presentations:

- *Novel instrument designs and analysis methods*
- *The importance of cruise-phase data*
- *Interdisciplinary, multi-method approaches*
- *Multitude of tools for data access, visualisation, archiving, real-time*
- *quick-look tools, etc.*

Common themes in discussion:

- *Standardisation of data formats (including metadata) is useful.*
- *This would allow use of generic visualisation tools.*
- *All data should follow the FAIR principles: findable, accessible, interoperable, reusable.*
- *Reproducibility of data processing chains is necessary.*
- *Use of machine learning to increase scientific impact.*
- *Discussion highlighted interests in multi-point missions/methods.*

Session 3 - Building a European Heliophysics network and community hub

- A European Heliophysics Community network was considered a good idea, and needed to be grown further (variety of reasons including networking, interdisciplinary science etc.)
- “Heliophysics” term considered to be a broad definition - space plasma physics everywhere+!
- Such a community activity would be facilitate better coordination and communication to respond to a variety of ESA calls and opportunities.
- Keen to have a dedicated community meeting every 1-2 years
- Follow this up with a dedicated EGU session (ST+PS divisions) and potentially a splinter each year.
- Advertise and build a mailing list (EHC newsletter was agreed to be a good thing to build on), need location for old mails on web page. EHC sign up here: <https://www.cosmos.esa.int/web/esa-heliophysics/european-community>
- Add ORCID keyword “EHC”
- Would like Early Career Researcher community as part of community
- Dedicated location on ESA pages also for centralised ESA information, include community calendar?
- Improve data accessibility

Session 4 - SWOT analysis

- The first part of Session 4 was dedicated to conducting a SWOT analysis, that is, identifying Strengths, Weaknesses, Opportunities and Threats for the EHC, in particular regarding space missions
- 5 groups conducted the analysis, and all the identified Strengths, Weaknesses, Opportunities and Threats are listed in the next page
- One of the key points that appeared repeatedly in the different groups is the fact that the EHC is multi-disciplinary, which can be viewed as a strength, but also a weakness because our community can appear as fragmented. Suggestions were made to overcome this weakness in organising ourselves better (e.g. as the EHC), to define big science questions relevant to the community at large and to leverage this multi-disciplinarity to apply it to space weather and climate change characterization.
- The lack of job security for early-career researchers was also noted as a threat to the community.
- The following page includes a summary of the SWOT analysis

Strengths

Interdisciplinarity
Cross-discipline representative person would support several communities
Fundamental strength (vs eg astronomy) that our science has day to day relevance to life on Earth
The community is very diverse (ground-based, in-situ, remote sensing, physical modelling, empirical modelling, machine learning, etc.)
we develop a lot of experiment - pushing technical boundaries
heliophysics is more multidisciplinary than individual fields belonging to heliophysics
usage of a multitude of methods to measure
People are highly motivated
diverse in topics
wide range of expertise - theory / experimental
we are forming a common community
We address a lot of fundamental topics and we can relate to other science easily
Strong ground segment and long time history of measurements
direct impact on society
We have many ideas and have provided many mission ideas from which a balanced portfolio could be created (if the ESA selection system would allow)
numerical experiments can be used to validate measurements and put them into context
our missions are small scale so they present more opportunities for scientists to explore new ideas and get involve on different levels
long history of missions - we know how to do missions
public awareness - people know space weather is important, and there is an economical & practical value
strong physical knowhow in the fields belonging to heliophysics
scientific software and visualisation development is most organised compared to any other field
We already have a lot of initiative going on in our community and need to expand!

Opportunities

heliophysics can relate to multiple directorates at ESA
Many collaborations possible (ground + space)
ISSI and similar initiatives offer great opportunities for collaboration
smallsats and swarms
We can have more workshops like this
cubesats are an opportunity - Earth orbit is close
New science as we have different perspectives on same stuff
Connect and exchange knowledge - get the bigger picture!
a number of universal processes which unify the community - coordinated efforts
plenty of missions / opportunities in that sense
group of people at ESA who talk within the agency - opportunity to leverage this effort
exploration of the solar system - sensing different environments in heliophysics
cubesat - modularity of experiments - big mission of small satellites
we are already miniturising experiments on cubesats
international/worldwide - mood to move towards great things - a new era
coordination as a community to share ideas / think outside the box
Because we relate to other science easily we can use other missions to achieve our science
from the youngster perspective: there's more community spirit with us than in other fields of physics
economic value and practical use could be used more as justifications
coupled system: opportunities to justify missions in Earth Observation
coupled system to the Sun: there are always measurements available

Weaknesses

we are divided into small subgroups
lack of communication or common meeting
CWe are too specialized - we need to provide wider opportunities to students - there is no way for ECS to get more knowledge to other fields of heliophysics (need schools covering the whole of heliophysics, and maybe more standard in data products)ompetitors pay us better...
Need better top-level strategic thinking and stronger representation from our leaders in position of influence
We have many communities - each of us is already in a community
we don't know the definition and size of our community
Our data is scattered among many repositories, knowledge among many individuals
There are barriers between operational and scientific data / users
We are terrible at PR and managing the message - allow competitors to reduce our potential impacts without proper rebuttal
space physics falls into a gap between Earth Observations and Science Programme
Interdisciplinary - we can meet people from different communities
lack of connection between different communities - fragmentation
not making good use of images in outreach
too many competing for the same funding
breadth of topics so hard to get behind one particular mission
not enough young scientists and engineers in agencies/institutes
We are too specialized - we need to provide wider opportunities to students - there is no way for ECS to get more knowledge to other fields of heliophysics (need schools covering the whole of heliophysics, and maybe more standard in data products)
underrepresented at management/decision making level
Data standardization is not easy because each instrument is specific: but if it is too difficult to use the data then the data is not used
ESA Sci programme: sole criterion is science, now economic or practical value
plasma physics is hard to explain; what are the main science questions (cmp. to planets, black holes)
hard to justify why we need the funding - why we need a 1B€ to another mission
everyone sees things from their own perspective - a real community spirit is lacking
multidisciplinary field needs much more communication between fields

Threats

competition for missions within the community
Danger of fragmenting into too many communities
Homogenous groups have clear advantage over scattered groups/communities
Lack of adequate positions for ECSs
Our data and tools might remain underutilised because they are scattered and there are learning curves, and/or they remain in a "beta version" stage
loss of talent because of bad working conditions especially in early career phases
loss of talent because mission funding is intermittent
concentrating too much on smallsats
we have been pushed towards operational rather than science
Lack of initiative in our ECRs (focussing on minutiae that they can easily be fixed rather than big picture) - rephrase: lack of focus?
space physics is complicated, we need too many instruments and too many satellites in a constellation to answer science questions. Costs of good mission ideas quickly become very high. time!
competing with other topics e.g. climate change / health
when budgets are reduced, as a small community we suffer more - impact can be irreversible
danger of being an imbalance community - lose a generation of engineers/scientists
We have big missions but we do not have many of them and research institutions are busy with small missions, which are seen as opportunities, but with no big impact scientifically, and that are limiting what we do else - resources are thin
we are too limited in international cooperation due to politics
Lack of confidence within the community
Poor understanding within our community of the way things work in reality
lack of funding to serve all the aspirations of a diverse community (e.g. by having a balanced program of mission sizes with regular/frequent launch opportunities)
We are served by a wasteful organisation (ESA) so that doing anything costs way more than could be done under the NASA system
Industry can be a threat: tempting to ask industry to do part of the work because of lack of money to do it ourselves and we loose the ability to do work to answer fundamental questions
lack money everywhere
space debris, overcrowding of space
security - our missions may not be resilient to cyber attacks
world situation - geopolitics, weaponisation of space

Session 4 - Workshop reporting and summary

- The last session was dedicated to short summaries from conveners of Sessions 1-3, followed by discussions with the audience members
- It was proposed to draft two lists of recommendations, one for the EHC and one for ESA, based on the discussions that took place during the week. The goals of these recommendations are to propose ways to keep building the EHC and maintaining the momentum initiated with this workshop, and to highlight some of the issues that were identified during the discussions (e.g. data discoverability and archiving)
- Discussion also continued on some of the points raised already earlier in the week, such as how to get early-career researchers involved in missions and instrument development

Recommendations

- The following pages contain a consolidated list of observations and recommendations, based on the workshop. They are split up as follows:
 - A set of observations and recommendations to the general community by the attendees
 - A set of observations and recommendations to ESA by the attendees

Suggestion is to have an update on the status of these recommendations at an EGU splinter session to be proposed by summary leads

- These slides were iterated by summary leads – Jonny Rae, Lucile Turc , Rumi Nakamura, Daniel Verscharen, Manuela Temmer, Charlotte Goetz and Matt Taylor.
- The entire registered email list of the meeting was invited to comment before 30th November.
- Summary was then then issued to ESA and general community via email lists in December 2023.
- The workshop and community zulip chat is available here: <https://euro-helio.zulipchat.com/>

Recommendations to Community from Attendees

1. The attendees observed that deciding on a single term to describe the community is challenging, but that the “European Heliophysics Community” was a good umbrella term, if well defined. **The attendees recommend that they should construct an agreed list of keywords describing fields to define this umbrella term e.g. Solar remote sensing, ionosphere, magnetosphere etc. which can be expanded.**
2. The meeting attendees observed and acknowledged that this somewhat experimental workshop was very successful in bringing together a remarkably diverse range of the community and providing valuable insights into the broad heliophysics-related activities across ESA. **The attendees recommend that such an activity is repeated, to build up the community, identify more synergies and improve communication across the community - potentially this next meeting could be named the “The 1st European Heliophysics Community workshop” to highlight and celebrate the ‘birth’ of the broad community. Session 4 material would form specific topics for discussion at that meeting.**
3. The attendees observed that a splinter meeting at EGU should be organised to take stock of the progress of these actions. **The attendees recommend that a yearly dedicated EGU splinter session be organised to discuss ongoing EHC related activities.**
4. The attendees noted that a number of email lists exist to communicate to the community. The European Heliophysics Community newsletter was identified as a good location to act as an information conduit. **The attendees recommend that the community sign up to the EHC newsletter*. The meeting attendees also recommend that there should also be a list of existing email lists drawn up from both community and ESA email lists via which the EHC should be advertised.**
5. The attendees observed that not all disciplines or career stages were represented. **The attendees recommend that the word is spread on connecting more people to this activity and community, using the lists in point 4.**
6. The attendees observed the need for a training programme or mentoring for Early Career Researchers (ECR), for future missions, as well as access/information to new activities in ESA programs. ECR is considered here to be 7 years from PhD or beginning of research in a certain topic. **The attendees recommend that interested ECRs join the ECR corner in Zulip to discuss further steps on organisation of the ECR community.**
7. The meeting attendees observed that unique keywords could be a rapid way to create community identity **The attendees recommend that ORCID keyword “EHC” is proposed for the community to start using.**
8. The meeting attendees observed the utility of Zulip for communicating in a more rapid, ad-hoc, informal manner. **The attendees recommend the continued use of Zulip** as a community communication and chat device.**
9. The attendees raised the idea of a community roadmap. **The attendees recommend that such a topic should be the focus of a dedicated session at a future meeting, such as the 1st EHC Community workshop , mentioned in point 2 above.**

*<https://www.cosmos.esa.int/web/esa-heliophysics/european-community>

**<https://euro-helio.zulipchat.com/>

Recommendations to ESA from Attendees

1. The attendees observed that the newly-formed ESA Heliophysics Working Group (HWG) is an excellent start to bringing cross-directorate collaboration on Heliophysics. **The attendees commend this activity and recommend that it should continue.**
2. The attendees observed that the ESA HWG has successfully established connections between various directorates within ESA. **The attendees recommend and urge the ESA HWG to ensure that it includes all entities in the ESA whose activities are relevant to Heliophysics.**
3. The meeting attendees observed and acknowledged that this somewhat experimental workshop was very successful in bringing together a remarkably diverse range of the community and providing valuable insights into the broad heliophysics-related activities across ESA. **The attendees recommend that the workshop should be repeated to foster more synergies and facilitate communication across the community and to the different ESA directorates. A workshop should be held next year, and at a TBD cadence after that. Potentially this 2024 meeting could be a combined ESA HWG meeting and “The 1st European Heliophysics Community workshop” to highlight and celebrate the ‘birth’ of the broad community.**
4. The meeting attendees observed that some aspects of the hybrid meeting worked, with good poster availability and Zulip chat, but that the engagement online could be improved by having more dedicated people online. This is not a criticism of those who did a sterling effort online, but that this could be enhanced with more support. **The meeting attendees recommend that future meetings should have several dedicated online conveners.**
5. The meeting attendees observed the strength of combining ground and space-based facilities as well as modelling. **The meeting attendees recommend that ESA HWG investigate more formal collaboration and coordination between its activities and ground-based facilities and modelling.**
6. The meeting attendees observed the good progress in a variety of data processing, archiving and visualisation and analysis activities. However, sometimes these are challenging to find or even know about. **The meeting attendees recommend that ESA HWG work towards improving data accessibility and discoverability (e.g. lists of useful data and archive links) of all missions and facilities relevant to Heliophysics.**
7. The meeting attendees observed that the presented programs were quite complex and used similar terminologies for activities that were completely different.. **The meeting attendees recommend that the ESA HWG provide a comprehensive guide that covers all relevant ESA activities related to Heliophysics (overall structure, types of missions, etc).**