NASA Science Mission Directorate
Transform to Open Science (TOPS)

Community Panel Summary Report: May 2022

Executive Summary:

Open science—a collaborative approach to scientific research and practices that enable the open sharing of data, information, and knowledge—allows for new and critical voices to engage in science from idea inception to result dissemination. NASA has made a commitment to advancing open science, building a more inclusive and accessible scientific community at NASA and beyond, through the Open-Source Science Initiative (OSSI). To catalyze and inspire the change necessary for this initiative, OSSI has created the Transform to Open Science (TOPS) mission and declared 2023 as the Year Of Open Science.

TOPS is a $40 million, five-year program that looks to enable open science via increasing the reach and visibility of open science projects, creating additional opportunities for the community to engage in open science, and curating and sharing open science tools and resources.

In order to engage the scientific community from the onset, the TOPS Community Panel was created to provide feedback on TOPS' mission, plans, and recent activities. Panelists were chosen via an open call on the NASA website, and represent a broad and diverse group of academic backgrounds, research areas, and open science experience. This group was invited to speak on their open science journey, lessons learned in conducting open science, and provide input on future steps to be taken by TOPS, TOPS partners, and the greater NASA scientific community.

This Panel Summary Report contains a summary of presentations given by TOPS and TOPS partners to the panelists and an overview of panelists' feedback on strengths, weaknesses, opportunities, and threats regarding the presented information. This feedback will be used to improve TOPS plans for the open science curriculum (OpenCore), community engagement, and overall missions and goals.

Panelists:

James Colliander, Kelle Cruz, Monica Granados, Dominique Harrison, Kelsey Hightower, Pen-Yuan Hsing, Kari Jordan, Logan Kilpatrick, Brian Nosek, Fernando Perez, Malvika Sharan, Gloria Washington, Talitha Washington, Lou Woodley, Qiusheng Wu

Panel Information:

Agenda

Day 1: Introduction to TOPS and Areas of Action

Links to slides, video recording, transcription.

Day 2: TOPS Curriculum Plans

Links to slides, video recording, transcription.

Day 3: TOPS Community Engagement

Links to slides, video recording, transcription.

Summary: PDFs of all slides, all days.

1) Key Findings - Summary of project and results
    a) High-level objective and goals of participation
    b) Effectiveness of TOPS strategies for advancing project goals
    c) Describe the key attributes/qualities of the TOPS strategies that were primary driver(s) of your assessment

2) Day 1: TOPS Design and Strategy (Summary: Sarah Martin, Editor: Pen-Yuan Hsing, Review: Qiusheng wu, Malvika Sharan)

TOPS is a 5-year, $40 million, NASA-funded Open-Source Science Initiative (OSSI) to make science more accessible, reproducible, and inclusive. NASA recognizes that moving toward openness will require a culture shift within the scientific community toward transparency and collaboration. TOPS reflects NASA's effort to foster adoption of open science and capitalize on global momentum to make the shift to open science a reality.

Open science means different things to different communities. TOPS encourages a definition of open science that is Findable, Accessible, Interoperable, and Re-usable (FAIR). It enables transparent and collaborative scientific practices, opens up hidden knowledge, is more equitable, and actively works to broaden participation specifically for those traditionally under-represented in scientific institutions (while acknowledging that what constitutes under-representation can be context-dependent). We recognize that open science is a continuum of various practices and that we need more people with diverse experiences to participate so that we can ask better questions and find solutions. Importantly, we now have the technology and tools to realize the full potential of open science.

TOPS is designed to produce five major scientific discoveries through open science practices, double participation by historically underrepresented communities, and train 20,000 members of the science community in open science.

The open science movement also focuses on policy and compliance tools, core services for science discovery, funding elements, and community-building partnerships. To realize these goals, TOPS focuses on four key areas:

1) Engagement/Visibility: high-level support and visibility that is focused on building community

2) Capacity Sharing: free public OpenCore curriculum available through Open edX

3) Incentives: prizes, certifications, and awards for leadership

4) Moving Toward Openness: open meetings, the 2023 Year of Open Science

In 2022, TOPS will:

- Convene meetings with the external advisory panel
- Hold community meetings
- Begin development of the OpenCore curriculum on open science

In 2023, TOPS will focus on:

- Community building activities with the presence at major science meetings
- Launch the OpenCore curriculum
- Develop Research Opportunities in Space and Earth Sciences (ROSES) solicitations

There is already a Zenodo group for outputs related to TOPS: https://zenodo.org/communities/tops.

Panelist Feedback:

Strengths:

- Greater access to resources (data, software, publications, and other outputs) means increased capacity to do science. The scientific community is starting to recognize that openness is critical to scientific innovation and for solving the kinds of environmental problems we are facing, like climate change.
- Collaborative work has proved more effective than even the enterprise proprietary space in terms of tech innovation.
- By using open-source software, we can collaborate to quickly fix bugs that we couldn't if the software was closed-source.
- Science is an iterative process that builds on existing knowledge; making that knowledge available to more people advances the cause of science in general.
- Research components and outcomes developed using taxpayer money should be made public with full freedoms for reuse and sharing.

- Open science brings in diverse voices that ask different questions about access, benefits, and advantages of scientific outcomes. It both accelerates the pace of science (e.g., COVID-19 vaccines) and increases its impact.
- Technological advances (e.g., cloud computing and cyber infrastructure) have dramatically increased the accessibility to large-scale datasets in the past decade.

Weaknesses:

- Many people don't practice open science because they lack the tools and resources to do it. How do we overcome these barriers? In several cases where open science efforts were not explicitly collaborative, open science groups have come across siloed.
- More attention could be paid to improving the user experiences and user interfaces (UX/UI) of open science tools.
- Data and code are commonly accessible on GitHub, Zenodo, OSF, and many other domain-specific repositories, but the average user doesn't know what to make of them or what they can do with them. We need to help users better understand what's behind the data and how to read/use them. This step is needed to democratize open science practices for non-data-scientists.
- We need to encompass the global science practitioner community, especially outside of North America and Europe, in terms of TOPS engagement and applicability of outputs.
- We also need to recognize and ideally involve science practitioners, such as citizen scientists, outside of traditional academic institutions as described in the UNESCO Recommendation on Open Science.
- NASA has competitive funding opportunities, such as NASA's Research Opportunities in Space and Earth Sciences (ROSES), that could support open science, but much of this has been limited to U.S. institutions. Even if NASA can't directly provide funding to those outside the U.S., exploring ways to support these non-U.S. institutions in getting the funding they need would be very helpful.

Opportunities:

- We can draw on the vast experience of the open science community outside of NASA, represented by the diverse field of panelists. We can build on proven ideas and solutions instead of reinventing the wheel. It will take many people with different perspectives to process the vast amounts of data we are beginning to collect (71 PB within NASA alone) on Earth and in space. Openness has the potential to transform the way we discover new ideas and train new scientists.
- Make peer review more open, inclusive, and equitable.

- Let NASA demonstrate a system where open science practices are recognized and appreciated, in contrast with current academic institutions that commonly don't reward this kind of good citizenship.
- Use NASA's highly visible platform and resources to bring siloed open science communities together to collaborate so that open science becomes the default. If NASA does open science well, it can set a great example for the global scientific community. The world's knowledge belongs to everyone regardless of where they live or the level of education they have. TOPS can show that science can be used to solve problems for all of humanity, not just a few individuals.
- Open science has the potential to increase science productivity and therefore return on investment (source).
- By reproducing and making NASA datasets more interoperable, we can find new applications and solve new problems. TOPS could expand the coverage of open science practices beyond data, code, and peer-reviewed publications to include the diverse outputs of science such as, but not limited to, open-source hardware, educational/outreach materials, media (audio/video/images), websites, social media, etc.
- TOPS could also produce a set of policy recommendations based on the experience for other institutions, governments, and legislatures to follow.
- We need to take collective action to close the gap between open science values and the existing incentives and rewards structure that often don't value work directed towards open science.

Threats:

- The existing legal environment is closed-source with restricted access by default, so we need to address the legal challenges of making science open. Scientists need training on open-source licensing.
- Existing policies in many institutions and agencies do not support open-source approaches. The reward system in science does not support or reinforce openness. Sustainable change requires both building new norms for openness bottom-up and altering the policies and incentives top-down.

3) Day 2: Curriculum Development Strategy (Summary: Sarah Martin, Editor: Qiusheng Wu, Review: Pen-Yuan Hsing, Malvika Sharan, Logan Kilpatrick)

The American Geophysical Union (AGU) team presented their proposed curriculum and goals. Their aim is to engage diverse communities that can provide input on the initial curriculum plan. A successful curriculum is defined as solving contemporary problems and addressing relevant issues. It also leverages diversity and is mindful of the role and

material impact of language and culture. This curriculum is designed to uplift, celebrate, and enable diverse communities.

The proposed OpenCore curriculum will be hosted on GitHub. It will be broken down into five modules and is meant to guide learners of all levels to a better understanding of what open science is and how to do it. We want someone who completes this course to say, “I know how to share my results; I know how to share my research in a way that anyone can access it. And anyone can build on it.” The curriculum takes learners through the “why” of open science and the “how” of sharing scientific outputs; it describes best practices for sharing results and analysis and how to apply open science to peer-reviewed publications. The modules are mutable and will be updated over time. The OpenCore curriculum is discipline-agnostic. Completion of the modules will be marked by a badge or certificate.

1. The first module is the **Ethos of Science** module. This is the only required module (2.5 hrs, online or in-person). It will include best practices for building open science communities, increasing collaboration, and introducing open principles to project design as well as an overview of open science norms. This module also will explore the historical impact of “closed” science and how open science seeks to create a more diverse and equitable scientific community.

2. The second module is the **Open Tools and Resources** module. It is designed to give participants real-world experience working with collaborative tools such as Git, GitHub, and Jupyter Notebooks. This module may need to be updated frequently as tools are constantly changing.

3. The third module, **Open Software**, looks at code-centered practices and the impact of choosing open-source code. The module also will include a discussion about the relationship between sharing code and equity.

4. The fourth module, **Open Data**, focuses on the best possible data repositories on both ends. Participants will develop a data management plan that is useful to researchers, follows FAIR principles, uses metadata, and cites FAIR data in publications.

5. The last module, **Open Results**, covers the use of data repositories—as both a user and a contributor. Participants make a data management plan that uses license/copyright, metadata tagging, and the assignment of persistent identifiers (PIDs).

AGU went over its call for a Curriculum Development Team. This call for applications seeks participation from individuals actively engaging with Open Science communities, open software and data, and related practices. The Curriculum Development Team will consist of Curriculum Module Leads, Content Subject Matter Experts (SMEs), and voluntary maintainers. There will be one Module Lead and 5-7 Content SMEs involved in the open science curriculum design process assigned to each module. A total of 25-35 Content SMEs are needed for the five modules. The primary purpose of the Content SMEs is to provide resources, tools, and teaching materials to curate the module content. Additionally, the development of the curriculum will involve the role of a Maintainer to moderate and merge

content beyond automated and straightforward changes (e.g., spelling correction). The Maintainer, leveraging their experience and skills, will work within a framework provided by the Curriculum Module Coordinator and OpenCore Team. At least 1 to 2 members of the Curriculum Development Team from each module will be asked to volunteer in this role. Leads and SMEs will receive compensation and acknowledgement through the TOPS curriculum partnering association, the American Geophysical Union (AGU). Lead has a 1-year commitment. The session ended with a discussion about what happens before, during, and after someone takes the course.

Panelist Feedback:

Strengths:

- The OpenCore Curriculum (videos, scripts, workshops, materials) will be open access and can be modified for whatever purpose or audience desired (classroom, professional, etc.). It can be contextualized for different data and different people in different settings. It is designed to support additional curricula. Summer school, workshops, and hackathons will be conducted to increase engagement and train multiple people/teams at one time.

Weaknesses:

- We need to figure out licensing issues for educational resources and find and utilize those that are open-source (i.e. those that use the Creative Commons Attribution [CC BY] or Attribution-ShareAlike [CC BY-SA] licenses). We also need education on licensing and copyright.
- Getting everyone up to speed and comfortable with using GitHub can be challenging, but rewarding.
- Massive Online Open Courses (MOOCs) have been reported to have high attrition rates. We can consider doing an open-access discord, blended learning, and other opportunities to build community and increase completion rates.

Opportunities:

- If we can get this curriculum to undergraduates, they might look to NASA for other research opportunities in the future. Consider putting together a syllabus for undergraduate or high school that teachers can look at so they can make use of it or build on it. Examples include: Open Life Science, The Turing Way, The Carpentries, Openscapes, Open Hardware Makers, PREreview.
- We can make use of existing open-source education materials to boost their visibility/elevate their content.
- Being able to train researchers *at scale* is a real breakthrough in terms of reaching critical mass. Training trainers can lead to an exponential growth of skilled people. Consider getting a badge for *doing* open science. Or, once you do the training, you

get invited to the organization (NASA Open Science) on GitHub as a way of showcasing your training. People can see that you are participating in the NASA open science movement.

- It would be worthwhile to make the badges visible on LinkedIn or GitHub given the popularity of these platforms. Putting introductory videos on YouTube (linked to Open EdX) can greatly increase the exposure of the curriculum, help people find people looking for tutorials, and redirect viewers to Open EdX.
- It would be great to increase the visibility without proprietary vendor lock in. Therefore, all raw materials of the course (e.g. audio/video, text, images, code) should be published to long term archives such as the Wikimedia Commons, Internet Archive, OSF, or Zenodo.
- Don't limit to GitHub and Jupyter. Good toolsets can come from the broader community (even if they didn't do the training). Reproducibility can be used to combat disinformation, impacting a broader swath of society. The more open science is, the more we can help our communities (through a better understanding, for example, of the impacts of climate change).

Threats:

- Don't make the courses/certifications only available through closed-source systems like LinkedIn. Even though they have great visibility, they will restrict access.
- Courses need to be of a reasonable length to fit into teaching schedules. We will have to keep modules fresh and up-to-date to maintain credibility in the community.

4) Day 3: Community Engagement Strategy (Summary: Sarah Martin, Editors: Malvika Sharan, Monica Granados, Review: Logan Kilpatrick)

Day three began with Chelle acknowledging the importance of conducting TOPS work—including the panel meeting—openly. Steve Crawford, NASA SMD Data Officer, gave a deep dive into NASA's policies on scientific information, which is undergoing a review and will include provisions for FAIR data, open development of mission software, preprints, and opening workshops and meetings. Steve also reviewed the CHORUS agreement and the SMD Discovery Engine, making high priority datasets available through AWS and funding through NASA's ROSES program. The team is currently working to improve the NASA software release process policies and processes, particularly NASA Procedural Requirements (NPR 2210), and engaging with the Office of General Counsel and the Office of Chief Engineer to improve and update the software release policy.

Greg Tananbaum, Open Research Funders Group Coordinator, next reviewed Cross-Sector Developments in the Alignment of Open Scholarship Incentives, where he discussed the National Academies of Sciences, Engineering, and Medicine (NASEM) Roundtable, which bring together senior leaders from universities, funding agencies, professional societies, foundations, and industry to discuss incentives for adopting open

science practices as well as NASEM's Higher Education Leadership Initiative (HELIOS) project, which is a community of practice looking to implement outcomes from the Roundtable.

Yvonne Ivey from TOPS went over plans for community engagement. There is a need for more equity and inclusion in science, but ensuring communication and engagement are delivered equitably is challenging. As we ramp up TOPS and as the Year of Open Science in 2023 becomes closer, the need for strategic outreach that increases engagement and participation with excluded communities is key to our success. We need champions to train the trainers and evangelize the community.

Panelist Feedback:

Strengths:

- As NASA and other agencies move their data to the cloud, these data may be harder to find, but easier to download and use (includes metadata). There are so many open science resources already out there. Curation and evaluation of data are needed more than creation.
- Already having a policy that can guide practices is an important and necessary foundational element. Panelists and audience members shared some existing materials on best practices and recommendations from which to curate.

Weaknesses:

- There are some areas of NASA data that cannot be open-source for security reasons. Allowing a 12 month embargo period is also not in line with recent open access recommendations and could be a source of criticism (NASA currently doesn't have plans to change that). Some solutions include appropriate open source licensing, incentives and right to retention of manuscripts, and the posting of accepted manuscripts immediately for others to access.
- Policy compliance is often hard to assess, and a process should be put in place to track and/or automate compliance. Scientists often don't know about policies as these policies are developed without scientists' involvement.
- There is a well-recognized need to work on training and open communication to improve awareness. Some compliance is unnecessarily hard, so some priorities will include integrating open-agenda in the existing scientific process (such as compliance to publish all research for open access).
- We need to make structural changes for scientific systems to be more open-friendly first, with the assumption that cultural behavior changes will follow if the path is made easier. Otherwise, the constraints might negatively affect people's engagement. Both technical and cultural barriers to participation have reduced adoption of open science at NASA.

- To make these resources reproducible and transferable outside NASA, a more broader view for data policy should be integrated via international standards, framework, and practices.
- We must also explore ways to set up incentives for people to report on successful reproduction of prior work, move away from the single best solution in science, build on other's research, and build trust in the scientific community through collaboration.

Opportunities:

- In principle, many barriers to doing open science have been reduced in recent years, but it is still hard to assess where researchers feel more or less engaged with open science in practice.
- Research is being designed to draw what policies/practices help in the effective implementation of open science.
- One outcome of open collaboration will be that scientists working in one area (for instance, biological and physical sciences) can access datasets from Earth science (such as solar wind data) and evaluate their research cross-disciplinary.
- Having the community build on existing licenses can also help get around some internal legal barriers and allow widely accepted standards to be implemented at the institutional level.
- HELIOS (a cohort of colleges and universities who are committed to collective action to advance open scholarship) works to bring in groups whose voices have not been part of the conversation (humanities, arts, social sciences).
- Peer-to-peer interactions have facilitated sharing info about what is working and what is not in line with building an open information ecosystem in their departments/institutions. Action-oriented working groups are set up that help identify and implement solutions, joined so far by 70 universities.
- Professional societies are also an important part of the effort to establish best practices for scientists working in a specific field and establish incentives so that early career researchers/professionals are rewarded for following the open scholarship path.
- NASA will lead the charge on open science in the U.S. Federal government , but other federal agencies might also be interested in operationalizing this approach. How can we help them? How do we help individual researchers figure out how to operationalize open science?
- We need to expand beyond NASA by aligning the incentives within the existing research framework, which normally often is universities and academic institutions. For example, making it easy to upload data to Jupyter has increased participation. Building meaningful incentives for doing open science, such as effective

collaboration, transparency, publication, career advancement, tenure, or funding-related alignment can be helpful in moving scientists into this realm of thinking and effectively building a shared understanding for how they can apply open science effectively.

- TOPS is looking to pair with institutions to run six-week summer schools based on the 5-module OpenEx curriculum. Then move beyond, having people develop discipline-specific modules available on the OpenEx platform. TOPS hopes to host multiple general or discipline-specific hackathons to engage the public (especially traditionally underrepresented groups). Priorities will include connecting with minority serving institutions, looking for actionable measures for how to overcome barriers to entry (such as lack of funds or a complicated grant proposal process) and providing appropriate starting points such as professional consultation or training, templates, and identifiable channels where participants can get help. The panelists and audience shared resources such as open grants (https://www.ogrants.org/) that host previously funded proposals that can be used for guiding the development of new proposals.

Threats:

- We need to actively avoid threats such as unclear policy or undisclosed interests that hide information, prevent reproducibility, or lead to vendor lock-in of computing tools. Although NASA currently has partnerships with AWS, Google, and Microsoft, we should reconsider and avoid the use of proprietary infrastructure when promoting and implementing open science practices.
- Can NASA use its leverage to influence open science policy outside of NASA (nationally and internationally)?
- Licensing NASA software and data ownership are tricky (who produced it? Civil servant, contractor, grantee?); hence, legal counsel at NASA are helping with these issues.
- Currently, unrestricted data is released with a Creative Commons Zero (CC0) public domain dedication for public access and reuse. We need to give publishers time and opportunities to adapt to the open publication model to get everyone involved in meeting the TOPS goal.
- We should also include publishers in the conversation where they should have a say and educate scientists about copyright law surrounding their work so they don't sign it away.
- Free access to compute resources (e.g., mybinder) have been struggling with crypto miners using them for non-scientific uses. Greater resources to increase security would help secure this valuable resource for reproducibility and increasing participation in science.

- Another major point raised was to avoid relying solely on volunteer champions for open science work. One solution could be to create paid positions, especially to avoid burnout of volunteers, which in open science is a huge problem. Often open science work is seen as an added responsibility for already overworked and underpaid academics. As a result, only a handful of individuals tend to carry the major workload to ensure open practices beyond their 'day job.' We need to invest in the sustainability of individuals and organizations working in open science, especially when NASA TOPS will collaborate with them. While integrating their learning into NASA's strategy, NASA TOPS can provide appropriate support towards their sustainability so that they can continue to do their work. Recruitment of specialized community, data, or training experts should be prioritized in NASA to reduce the workload on volunteers and facilitate openness in NASA's research. People engaging with open science in NASA should be connected through community building to help them identify networked support and find people off of whom they can bounce ideas. It was acknowledged that we may not know the exact right way forward yet (for instance, we can't pay or employ everyone), but it was agreed that the aim is to move away from a free-work culture and embed sustainability into open science work.

5) Appendix A: Email

Hello Panel!

The TOPS Community Panel Summary report is due June 17, 2022. We hope that you will add your comments directly to the gdoc link below. The Panel Summary does not require consensus, and we hope you are able to work together to create constructive guidance. The slack channel can be used to work together and if meetings are needed, we are happy to help coordinate them. We will bookmark the Panel Summary Report to the slack channel.

Instructions:

1. Please provide your ORCid so that we may give credit for your participation in this gsheet.
2. We are asking for 3 volunteers - 1 for each Day. The Lead will synthesize responses and then work with the other leads to write the 'Key Findings' section. Please DM Chelle on slack to volunteer or just put your name in the document where it says '(Lead: Volunteer)'.
3. The link to the Panel Summary Report outline can be found here. We are looking for inputs on the BOCS (barriers, opportunities, change, sustain) or SWOT (strengths, weaknesses, opportunities, and threats) perceived in our current approach based on the three days outlined during the community panel.

We've provided resources to assist in your analysis—recordings, transcripts, and the slide decks. The Panel Summary outline includes suggestions for content and length.

What happens next:

Please email chelle.gentemann@nasa.gov or slack her once the Panel Summary is complete. It is important that you meet the 6/17 deadline. This will help inform decisions on future TOPS activities. We will upload the panel summary report to Zenodo, CC-BY license, and post to GitHub as part of the record of this meeting.

If you have any questions or are unable to participate please reach out to me at Yvonne_ivey@nasa.gov. If I don't have an answer, I'll direct the question(s) to the correct people.

Thanks for all the hard work and participation in the Transform to Open Science mission!

Best,

Yvonne

6) Appendix B : Daily Recap

Day 1: NASA's Open Science Vision

Time (ET)	Agenda Item	Speaker
12:00 pm	Introduction and Review of Code of Conduct	Karla Mastracchio
12:05 pm	Welcome and Meeting Objectives	Chelle Gentemann
12:15 pm	NASA's Open Science Vision	Kevin Murphy
12:20 pm	Introduction of Panelists	Yvonne Ivey
1:00 pm	Break	
1:10 pm	Transform to Open Science (TOPS): Introduction	Chelle Gentemann
1:20 pm	Transform to Open Science (TOPS): Areas of Action	Yvonne Ivey
1:40 pm	Q&A	Yvonne Ivey & Chelle Gentemann
2:00 pm	Break	

2:10 pm	Discussion: ● How can TOPS best support adoption of open science? ● How can TOPS best support open science communities? ● What are future directions TOPS should consider?	Chelle Gentemann & Yvonne Ivey & Steve Crawford
2:55 pm	End of Day Wrap Up	Yvonne Ivey

Part 1: Day one presented panelists and participants with the TOPS overview: The What, Why, and How of TOPS and Open Science. TOPS encourages a more nuanced, inclusive definition of Open Science. It starts with a recognition that Open Science means different things to different communities. TOPS encourages a definition of science that is Accessible, Inclusive, and Reproducible (AIR). It enables transparent and collaborative scientific practices, opens up hidden knowledge, is more equitable, and actively works to broaden participation. Open-Source Science is NASA's method to put Open Science into practice and the activation of a community of practice and a capitalization on global momentum that can make a shift to open science a reality. Open science is science and that includes data, software, and publications.

Moving toward openness will mean a fully transparent process and will require a culture shift. TOPS is the activation of the open science community that will result in fully transparent processes. As we move towards openness, we move toward an information environment that includes free unlimited data access, fully documented open software and algorithms, and fully linked data and publications in open access journals.

Part 2: Why now? What does the path to open science look like? What is the scope of the TOPS initiative? What are TOPS measurable objectives? The world is rapidly changing and we need to keep up with those changes at scale. We need more people with diverse experiences to participate so that we ask the best questions and find the best solutions. TOPS is a 5-year initiative designed to be directly responsible for 5 major scientific discoveries in open science, double the participation by historically underrepresented communities, and reach 20,000 members of the science community (including leaders, managers, and scientists) through a Massive Online Open Course (MOOC).

The Open-Source Science Initiative consists of 4 areas of action: policy and compliance tools, core services for science discovery, funding elements, and community building partnerships. NASA ROSES supports open-source software, tools, frameworks, libraries, platforms, and training with over $5 million in grants per year.

Part 3: To realize these goals there are four focus Areas: 1) Engagement/Visibility 2) Capacity Sharing 3) Incentives and 4) Moving Toward Openness. Area 1 includes high-level support and visibility, and is focused on building community. Area 2 is focused on capacity sharing and the OpenCore Curriculum. TOPS contributes to the gamification of open science courses through badges and certifications via prizes, challenges, and hackathons!

The TOPS open science curriculum, OpenCore, consists of 5 modules that will be taught at in-person workshops, summer schools, virtual cohorts, and via independent learning. All modules are free and open to the public and will be licensed CC-BY or CC0. Modules will be provided in the Open edX learning management system. As part of Area 3, Incentives, open science awards will be offered to recognize significant leadership and encourage progress toward open science and showcase the benefits of open science. Area 4, Moving Towards Openness, will use the Year of Open Science to build momentum and support to move towards more openness in science. To move towards openness, TOPS makes a commitment to recognize open science practices, hold open meetings, share hidden knowledge and encourage inclusive collaborations.

Day 2: Transform to Open Science Curriculum Plans

Time (ET)	Agenda Item	Speaker
12:00 pm	Introduction and Review of Code of Conduct	Karla Mastracchio
12:05 pm	Overview of OpenCore Curriculum: Engagement of Open Science Community	Shelley Stall & Chelle Gentemann
12:30 pm	Discussion: ● Approach to Engagement with Subject Matter Experts	Shelley Stall & Chelle Gentemann
1:00 pm	Break	
1:10 pm	Testing, Management, and Maintenance: Continued Engagement, Community Involvement	Chris Erdmann, Laura Lyon, Shelley Stall
1:25 pm	Discussion: ● Feedback on Curriculum Testing Approach ● Community Development Approach	Chris Erdmann, Laura Lyon, Shelley Stall
2:00 pm	Break	
2:10 pm	Transform to Open Science (TOPS): Underrepresented Community Engagement Plans	Yvonne Ivey

2:20 pm	Discussion: ● Open doesn't mean open for everyone. To some communities, openness has resulted in exploitation. How do we ensure that openness is equitable? ● How do we ensure that communities historically excluded from science are reached by TOPS?	Yvonne Ivey & Chelle Gentemann
2:55 pm	End of Day Wrap Up	Shelley Stall

Day two was about the proposed curriculum and was led mostly by the AGU team. The AGU team went over their proposed curriculum and their goals. The goal is to invite diverse communities that can provide input on the initial curriculum plan. A successful curriculum is defined as relevant and speaks to solving contemporary problems and addressing relevant issues. A curriculum also is successful if it leverages diversity, has an understanding, and is mindful of the role and material impact of language and culture.

The TOPS OpenCore curriculum is designed to be inclusive and is intended to uplift, celebrate, and enable diverse communities and communities of practice. The endstate is a "Grand Badge" that participants can add to their credentials. Module 1 is required for everyone. Participants who have more advanced knowledge of open science can test out of modules 2-5. The proposed curriculum is described in more detail below.

The proposed open-source curriculum is broken down into 5 modules and is meant to guide learners of all levels. It takes learners through the "why" of open science, through "the how" of sharing software, best practices for sharing results and analysis openly, and how open science can be applied to peer reviewed publications.

The learning map starts with the Ethos of Science module, which is the only module required for all participants. The module will include best practices for building open science communities, increasing collaboration, and introducing open principles to project design, as well as an overview of open science norms. This module will also explore the historical impact of "closed" science and how open science seeks to create a more diverse and equitable scientific community.

The second module is the Open Tools and Resources Module, which is designed to give the participant real-world experience working with collaborative tools.

The third module, Open Software, centers on code-centering practices and the impact of choosing a source code. There will also be a discussion about the relationship between sharing code and equity.

The fourth module, Open Data, focuses on data repositories. Participants develop a data management plan that follows FAIR principles, including assigning a license/copyright, metadata tagging, and assigning PIDs.

The last module, Open Results, covers the use of data repositories from the perspectives of users and contributors. Participants make a data management plan that uses license/copyright, metadata tagging, and the assignment of PIDs.

During the third and final section of this panel, the AGU team went over its call for a Curriculum Development Team. This call for applications seeks participation from individuals actively engaging with Open Science communities, open software and data, and related practices. The session ended with an open discussion of open tools and resources along with a discussion of what happens before, during, and after someone takes the course.

Day 3: Engagement with Communities

Time (ET)	Agenda Item	Speaker
12:00 pm	Introduction and Review of Code of Conduct	Karla Mastracchio
12:05 pm	NASA's Open Science Policies	Steve Crawford
12:30 pm	Discussion: Policy	Steve Crawford
1:00 pm	Break	
1:10 pm	Cross-Sector Developments in the Alignment of Open Scholarship Incentives	Greg Tananbaum
1:30 pm	Open Discussion	Greg Tananbaum
2:00 pm	Break	
2:10 pm	Transform to Open Science (TOPS): Underrepresented Community Engagement Plans	Yvonne Ivey
2:30 pm	Discussion: Open Topics Suggested by Panel	Chelle Gentemann, Yvonne Ivey
2:40 pm	Next Steps and Panel Wrap-up	Yvonne Ivey

Under the Open-Source Science Initiative, there are Policy (development, education, compliance tools), Core Services for Science Discovery, ROSES Elements, and Community Building and Partnerships. Day three began with Steve Crawford, Senior Program Executive for Scientific Data and Computing, providing a deep dive into the Open-Source Science Initiative using open-source science principles as a framework. These principles are the foundation of open science: transparent, accessible, inclusive, and reproducible.

The Open-Source Science Initiative (OSSI) is NASA's method to put open science into practice. OSSI will implement NASA SMD's Strategy for Data and Computing and is a cluster of activities to enable and support moving science towards openness. It includes policy adjustments, open-source software and enabling cyberinfrastructure. OSSI is designed to make open science possible by updating policies. SPD-41 is the NASA SMD Information Policy and brings together existing NASA and Federal guidance. It applies to all SMD-funded activities related to producing scientific information. Future NASA competitive awards such as SALMON and ROSES will be in compliance with SPD-41. Current missions and grants are encouraged to adopt SPD-41 to the extent possible. The current policy and the move toward proposed changes in data, research software, and publications were reviewed. Changes include that scientific data should be FAIR, mission software will be developed in the open and in a publicly accessible version controlled platform, open access publishing is encouraged, and workshops and meetings will be open and accessible. SMD is currently in the process of reviewing the responses to a Request for Information (RFI) and revising SPD-41a. Once adopted it will be incorporated into ROSES23.

SMD's goal is to minimize the burden in making NASA information as open as possible. CHORUS was discussed as a shift towards open science. NASA researchers who publish in a CHORUS member's journal will automatically satisfy the open access requirements for SMD publications. SMD will create a discovery capability to enable open-source science. The scope includes scientific data from the five NASA SMD divisions as well as software, documentation, and publications. Expanding access to SMD publications includes publishing as open access and encourages using preprint servers. SMD is funding the Astrophysics Data System (ADS) and will expand the ADS holdings in Heliophysics and Planetary Science.

Yvonne Ivey from TOPS went over capacity sharing resources. There is a need for more equity and inclusion in science, but ensuring that communication and engagement are delivered equitably is challenging. As we ramp up TOPS and as the Year of Open Science in 2023 becomes closer, the need for strategic outreach that increases engagement and participation with excluded communities is key to our success. Capacity sharing resources and a successful implementation plan will help us get there. Capacity sharing resources include 1) TOPS Champions: Scientists to help teach modules at events and act as open science champions; 2) Cohorts: Active open science practitioners who engage with learners through a virtual cohort model to increase Open Science Badge achievement efforts; 3) Summer Schools: Institutions selected to run ~6-week sessions to teach the 5 modules to

selected science teams and under-represented researchers; 4) Curriculum Expansion: Groups funded to migrate/create discipline-specific modules and data science skills modules to the Open edX TOPS platform; and 5) Hackathons: Events to advance data science skills and open science. In order to address our key objective of doubling participation in open science, we will also engage with institutions serving minority communities by partnering with bridge programs and NASA's Minority University Research and Education Project (MUREP).

7) Appendix C : Resources

Below is a list of resources that were provided by panelists during the meeting.

UNESCO Recommendation on Open Science

The aim of this Recommendation is to provide an international framework for open science policy and practice that recognizes disciplinary and regional differences in open science perspectives and the importance of involving communities outside of traditional scientific institutions or knowledge structures.

Project Implicit

The mission of Project Implicit is to educate the public about bias and to provide a "virtual laboratory" for collecting data on the internet. Project Implicit scientists produce high-impact research that forms the basis of our scientific knowledge about bias and disparities. Brian Nosek, Executive Director of the Center for Open Science at the University of Virginia, is one of the co-founders.

Affective Biometrics Lab

The mission of Affective Biometrics Lab (ABL) is to give voices to individuals or communities that feel marginalized through artificial intelligence (AI) Systems that leverage human physical, physiological, or behavioral characteristics for identity or emotion recognition.

Contextualizing Openness: Situating Open Science

Contextualizing Openness offers a look at open science and the democratization of knowledge in international development and social transformation. This book presents contributions from 12 projects that form the Open and Collaborative Science in Development Network (OCSDNet) that are organized around four central themes: Defining Open Science in Development, Governing Open Science, Negotiating Open Science, and Expanding Open Science for Social Transformation.

Producing open-source Software: *How to Run a Successful Free Software Project*

Free software projects - where "free" refers to freedom, not price - have evolved a distinct culture, an ethos in which the liberty to make the software do anything one wants is a central tenet. Yet the result of this liberty is not a scattering of individuals each going their own separate way with the code, but enthusiastic collaboration and frequent

compromise. Producing open-source Software attempts to describe the techniques by which this may be done.

Science The Endless Frontier: A Problem of Scientific Reconversion

Science The Endless Frontier is a report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, written in July 1945. While Chapter 5 of the book does not explicitly mention "open," the document led to start of U.S. federal investment in scientific research. Chapter 4 calls for a broadening of participation in science.

Strengthening Emerging Science Partnerships Will Advance Global Research

A new report focused on improving international scientific partnerships calls on the U.S. to take bold and meaningful steps that will strengthen connections in an increasingly global network of science and technology.

GitHub Tutorial - Beginner's Training Guide

A tutorial on how to use GitHub to create new repositories, clone repositories locally, commit changes, and manage project files.

Version Control with Git

Version Control with Git is a lesson on keeping track of what you've done and to collaborate with other people. Anything that changes over time or needs to be shared can and should be stored in a version control system.

Health Data Research UK Innovation Gateway

The Health Data Research UK (HDRUK) Innovation Gateway provides a common entry point to discover and request access to health datasets in the United Kingdom (UK). Users can search for health data tools, research projects, and publications, and can collaborate via a community forum. One of the obstacles to open science and making research outputs reusable is the lack of financial dedication such as to cover for Research Data Management (RDM) costs. HDRUK provides a good example.

Canadian Roadmap for Open Science

The objective of the Roadmap for Open Science is to provide overarching principles and recommendations to guide Canadian open science activities. The recommendations are intended for science and research funded by federal government departments and agencies.

ICESat-2 Hackweek

The ICESat-2 Hackweek is a five-day collaborative learning experience designed to coalesce people and resources around exploring, creating, and promoting effective computation and analysis workflows for the large and complex data returned by the ATLAS sensor aboard NASA's ICESat-2 satellite.

Code for Science and Society

Code for Science and Society (CS&S) seeks to advance the power of data to improve the social and economic lives of all people through public education, scientific research, and technology development and deployment. CS&S also aims to improve the public's ability to find, collect, and share the open data they use to make more informed decisions in the benefit of the public interest.

Google Developers Experts

The Google Developer Experts program is a global network of highly-experienced technology experts, influencers, and thought leaders who have expertise in Google technologies, are active leaders in the space, natural mentors, and who contribute to the wider developer and startup ecosystem.

Turing Way from the Alan Turing Institute

The Turing Way project is open-source, open collaboration, and community-driven. The project involves and supports a diverse community of contributors to make data science accessible, comprehensible, and effective. The Turing Institute's Data science and AI educators' programme aims to teach participants evidence-based practices on how to teach data skills and the pedagogy behind these.

Open Life Science

The Open Life Science (OLS) program helps individuals and stakeholders in research to become open science ambassadors. This is a 16-week long personal mentorship and cohort-based training.

PREreview

PREreview is a platform, resource center, and convener. PREreview provide ways for feedback to preprints to be done openly, rapidly, constructively, and by a global community of peers.

Openscapes

Openscapes champions open practices in environmental science to help uncover data-driven solutions faster. Regardless of research question, environmental scientists are united by the need to analyze data—and to do so in a way that is efficient, reproducible, and easily communicated. With tools specifically created to meet modern demands for collaborative data science, Openscapes helps create a positive open culture to enable better science in less time.

Open Hardware Makers

Open Hardware Makers is an online mentorship program. Inspired by Mozilla Open Leadership programs, it aims to support new hardware projects in their way of acquiring best practices, building welcoming and inclusive communities, and connecting to existing networks.

Open Post Academics

Open Post Academics is an international, cross-disciplinary, collaborative, peer-led community for PhDs to bring their expertise to the world, whether through a new career, thought leadership or projects to showcase their knowledge. They convene folks with PhDs and other communities through open, cross-disciplinary spaces.

Mozilla Open Leaders

Mozilla Open Leaders is a training series that teaches best practices in "working open." This is a way of working where: everyone is invited to collaborate on something amazing, and any new product or knowledge is shared widely and freely. Mozilla Open Leaders is for anyone starting up or leading open projects, such as project leads, collaborators, or small groups of co-leaders responsible for project success and growth.

NASA Cosmic Data Stories (CosmicDS)

The NASA Cosmic Data Stories (CosmicDS), a community-based program, contains interactive data stories designed by NASA astronomers to connect NASA science with learners of all ages.

Gathering for Open Science Hardware (GOSH)

GOSH supports open source hardware (as defined by the Open Source Hardware Association) for science by convening meetings such as the Gathering for Open Science Hardware (GOSH), publications, activities and providing a forum for the community. There is a Roadmap for making Open Science Hardware ubiquitous by 2025, and numerous policy documents.

Glue

Glue is an open-source Python library to explore relationships within and between related datasets.

Pangeo

Pangeo is a community of people working collaboratively to develop software and infrastructure to enable Big Data geoscience research. Some of the products produced by this community include interconnected software packages and deployments of this software in cloud and high-performance-computing environments.

Open Educational Resources (OER)

Open Educational Resources (OER) is rooted in the human right to access high-quality education. This shift in educational practice is not just about cost savings and easy access to openly licensed content; it's about participation and co-creation. OER offers opportunities for systemic change in teaching and learning content through engaging educators in new participatory processes and effective technologies for engaging with learning.

OpenScience Project

OpenScience Project provides a plethora of open-source scientific software.

Open Science by Design

Open Science by Design is a publication of the National Academies of Sciences, Engineering, and Medicine focused on openness and sharing of information, which are fundamental to the progress of science and to the effective functioning of the research enterprise.

Reproducibility and open science with the Jupyter ecosystem

Reproducibility and open science with the Jupyter ecosystem is a course taught by Fernando Pérez. This slide deck provides information about the course; all materials are on the Stat 159 GitHub

Citizen Science Association (CSA)

The Citizen Science Association (CSA) is a member-driven organization that connects people from a wide range of experiences around one shared purpose: advancing knowledge through research and monitoring done by, for, and with members of the public.

Ethical Alternatives & Resources

Ethical Alternatives & Resources provides a vast array of resources that are ethical, from browsers, to search engines, to messaging services, and more.

AGU Thriving Earth Exchange

The American Geophysical Union (AGU) Thriving Earth Exchange helps scientists, community leads, and sponsors work together to solve local challenges related to natural resources, climate change, and natural hazards. The Community Science Exchange is a new platform led by a coalition of societies and partners aimed at developing and promulgating leading practices, resources, and information around community science.

IndigiData: Indigenous Data Science Education

IndigiData is a one-week (4-6 day) Indigenous data science education workshop held each summer to introduce data science and informatics skills to tribal undergraduate and graduate students.

Federated Research Data Repository

Federated Research Data Repository (FRDR) through the Digital Research Alliance of Canada provides a scalable, federated platform for digital research data management (RDM) and discovery. Anyone can use FRDR to search for and download data across Canadian repositories. Faculty members from Canadian post-secondary institutions, or their designates, may use FRDR to publish their data.

Community Coordinated Modeling Center

NASA's Community Coordinated Modeling Center (CCMC) is a multi-agency partnership enabling, supporting, and performing research and development for next-generation space science and space weather models. The CCMC is located at NASA's Goddard Space Flight Center (GSFC) in Greenbelt, Maryland.

Higher Education Leadership Initiative for Open Scholarship (HELIOS)

The Higher Education Leadership Initiative for Open Scholarship (HELIOS) is a cohort of colleges and universities committed to collective action to advance open scholarship within and across their campuses. Leaders from U.S. colleges and universities have joined this community of practice, working together to promote a more transparent, inclusive, and trustworthy research ecosystem.

DataSeer

DataSeer fills the need for a low-cost, scalable solution to show researchers how to comply with stakeholder data sharing policies.

Creative Commons Zero v1.0 Universal

Creative Commons Zero v1.0 Universal (CC0) waives copyright interest in a created work and dedicates the work to the world-wide public domain.

My Binder

My Binder allows users to open interactive notebooks in an executable environment, making code immediately reproducible by anyone, anywhere.

Open Research Funders Group

Open Research Funders Group (ORFG) is a partnership of philanthropic organizations committed to the open sharing of research outputs. ORFG members collectively hold assets in excess of $255 billion, with total giving in the $12 billion range.

Python in Heliophysics Community

Python in Heliophysics Community (PyHC) facilitates 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.

Open Grants

Open Grants is an open repository of funding proposals designed to elevate their recognition as scholarly products, improve access for the public and other grant seekers, and bring transparency to this facet of the research process.

Articles

Gentemann, C., Erdman, C., and Kroeger, C. (2022). Opening Up to Open Science. Issues in Science and Technology, 38 (3): 57-59. https://issues.org/opening-up-open-science-gentemann-erdmann-kroeger/

Sharon, M. (2020). Ten Arguments against Open Science that you can win. The Turing Way and the Software Sustainability Institute. https://www.software.ac.uk/blog/2020-12-17-ten-arguments-against-open-science-you-can-win

2i2c Customer Right to Replicate document describes 2i2c's commitment to a customer's "right to replicate", and how this translates into specific infrastructure commitments from 2i2c.

Carroll, S.R., Herczog, E., Hudson, M. et al. (2021). Operationalizing the CARE and FAIR Principles for Indigenous data futures. Scientific Data, 8(108). doi:10.1038/s41597-021-00892-0

Goodman, A., Peek, J., Accomazzi, A. et al. (2021). The "Paper" of the Future. Authorea. doi: 10.22541/au.148769949.92783646/v2

National Academies of Sciences, Engineering, and Medicine. 2018. *Open Source Software Policy Options for NASA Earth and Space Sciences*. Washington, DC: The National Academies Press. doi: 10.17226/25217

National Academies of Sciences, Engineering, and Medicine. 2021. *Developing a Toolkit for Fostering Open Science Practices: Proceedings of a Workshop*. Washington, DC: The National Academies Press. doi: 10.17226/26308

Oliphant, T. (2006). Guide to NumPy. https://web.mit.edu/dvp/Public/numpybook.pdf

Gentemann, C. (2021). The secret to writing a great NASA proposal. Medium. https://medium.com/nasa-butterfly/how-to-write-a-great-nasa-proposal-2c6010faf7ab