

I'm from the government  
and I'm here to help



National Aeronautics and  
Space Administration



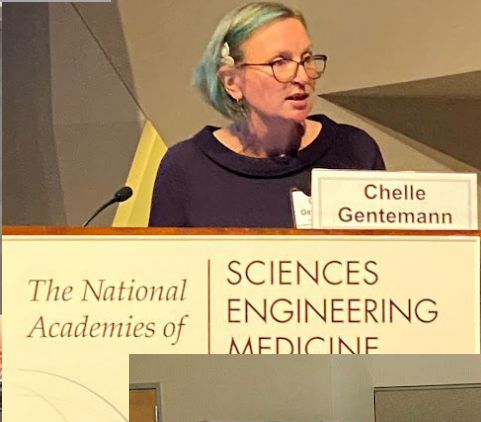
A NASA OPEN-SOURCE SCIENCE MISSION:  
**TOPS: TRANSFORM TO OPEN SCIENCE**

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Amy (Uyen) Truong, Chief Science Data Office Coordinator



Who am I? Dr. Chelle Gentemann  
More: [@ChelleGentemann](https://twitter.com/ChelleGentemann) 



# Discovery of gravitational waves

A simulated image of two black holes in the final stages of their merger. The black holes are depicted as dark, circular voids with glowing, distorted horizons, set against a background of a dense field of stars in various colors (blue, white, yellow, orange). The overall scene is a representation of the spacetime curvature around the merging black holes.

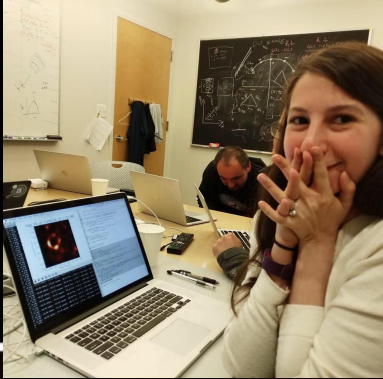
Result from collaboration and open science efforts across **over a thousand researchers**, many institutions and instruments

<https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.116.061102>

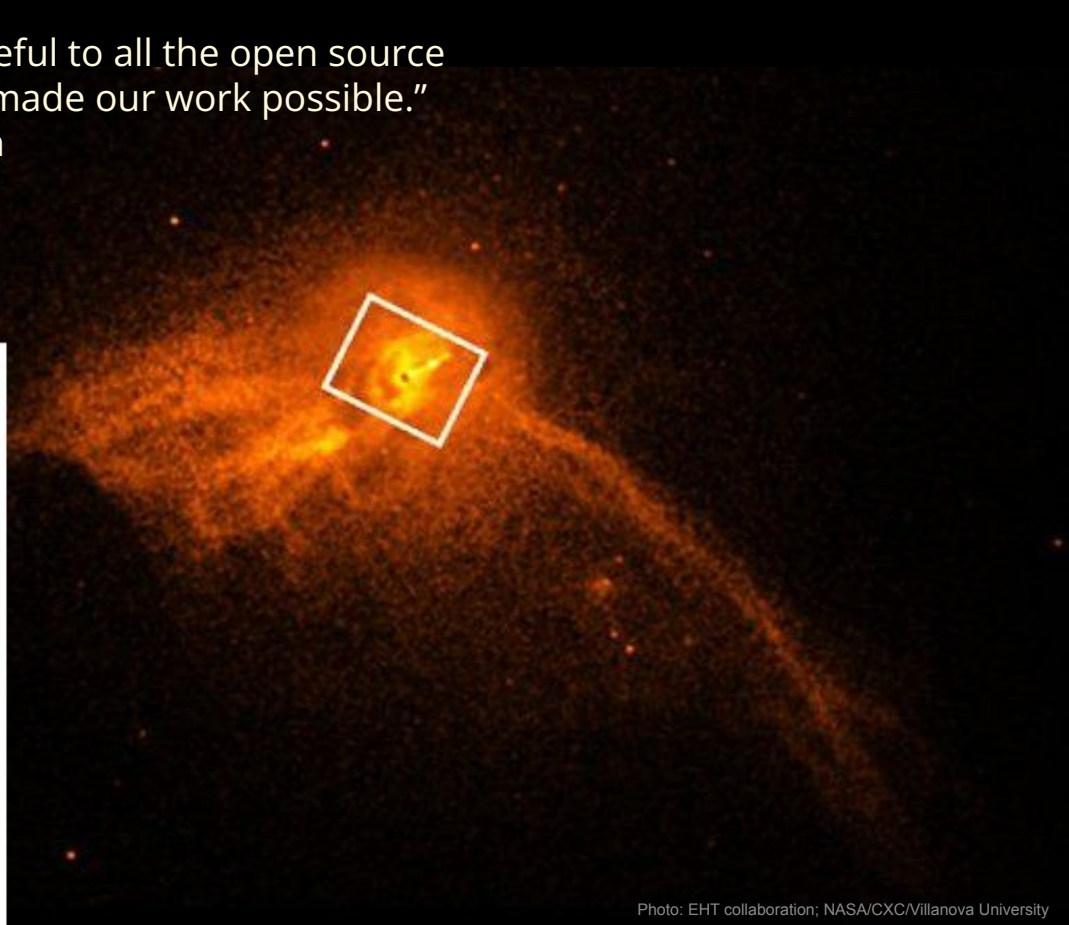
*Image credit: The SXS (Simulating eXtreme Spacetimes) Project*



# Breakthrough discoveries: First image of a black hole

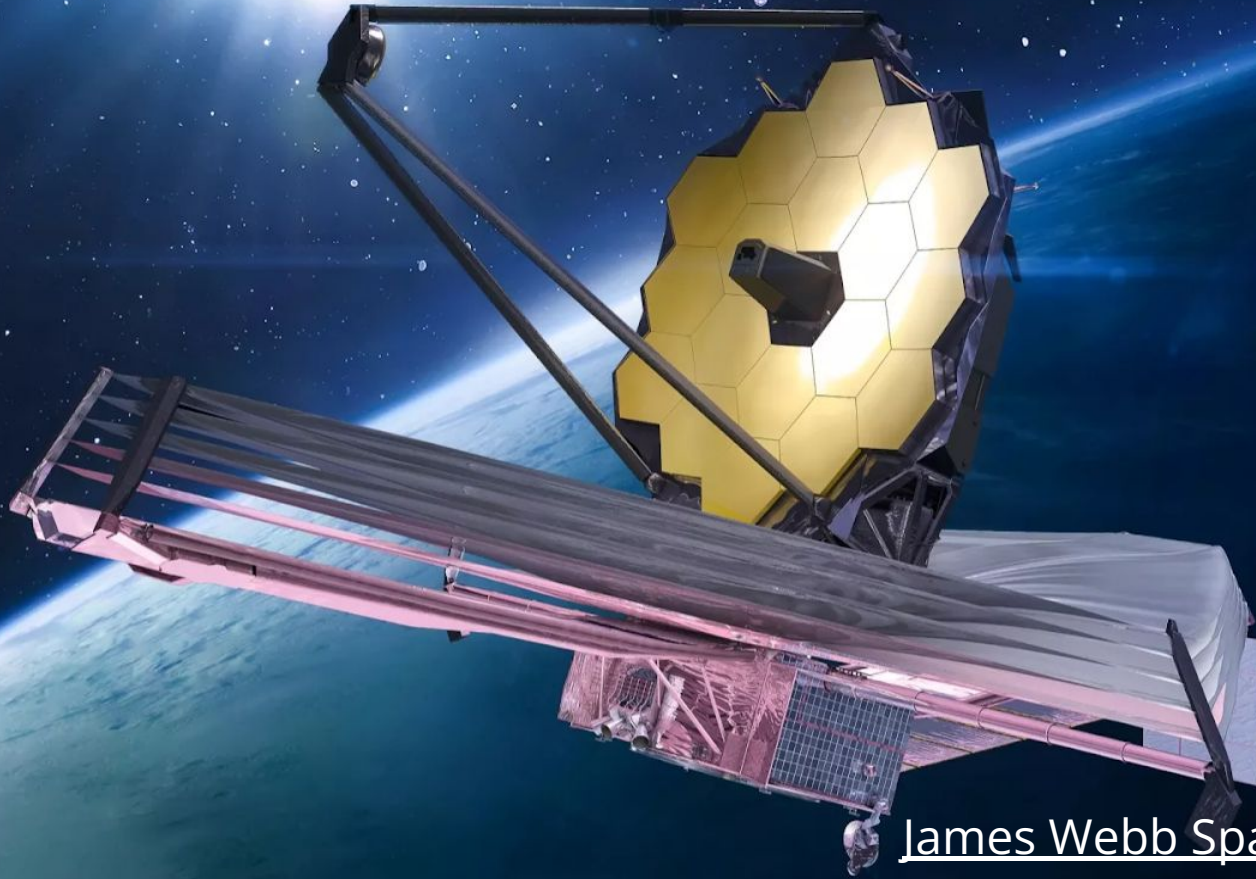


"We're deeply grateful to all the open source contributors who made our work possible."  
- Dr. Katie Bouman





# Accelerating Science:



James Webb Space Telescope  
Early Release Science Program

<https://www.nasa.gov/feature/goddard/2017/nasas-james-webb-space-telescope-early-science-observations-revealed>





“Whether it’s the [core data pipeline](#) that turns raw images into science-ready data, [simulation tools](#) to help astronomers understand how to best use the telescope, or [the tools that astronomers will use](#) to make new discoveries, open source is at the heart of all of [JWST’s] innovation.”

- [Afron Smith](#)

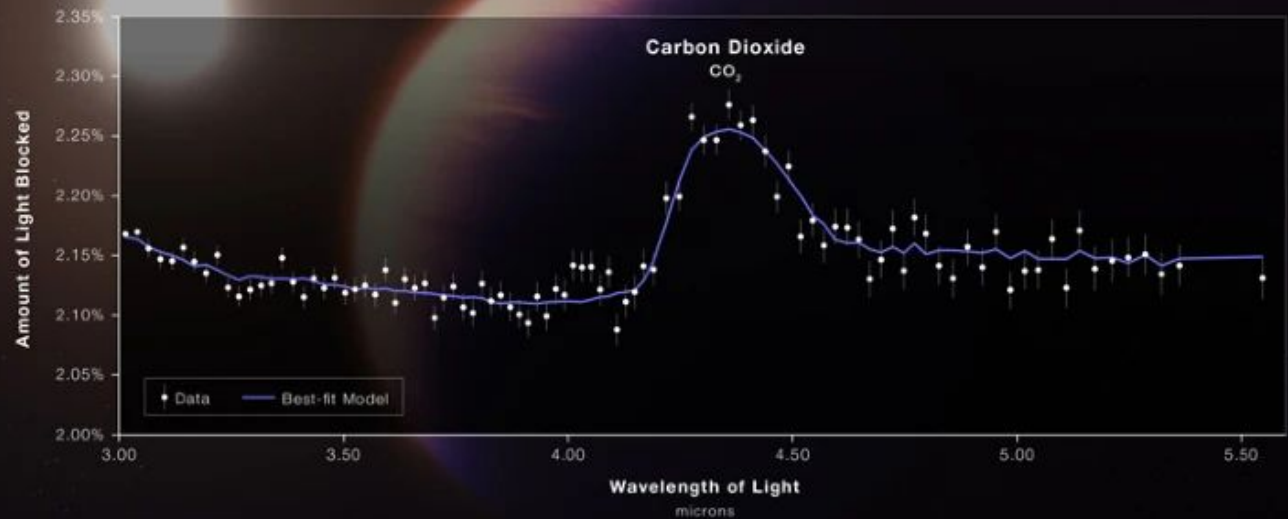
(“[How open source is supporting NASA’s new eyes in space](#)”, Numrich, 2022)



# Astronomers see CO<sub>2</sub> on exoplanet for first time

## HOT GAS GIANT EXOPLANET WASP-39 b ATMOSPHERE COMPOSITION

NIRSpec | Bright Object Time-Series Spectroscopy



"NASA's open science guiding principles are centered in our Early Release Science work, supporting an inclusive, transparent, and collaborative scientific process."  
- co-author Dr. Natasha Batalha





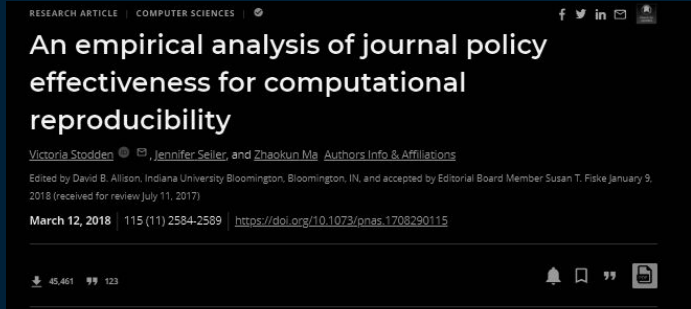
# Is all of science this awesome?







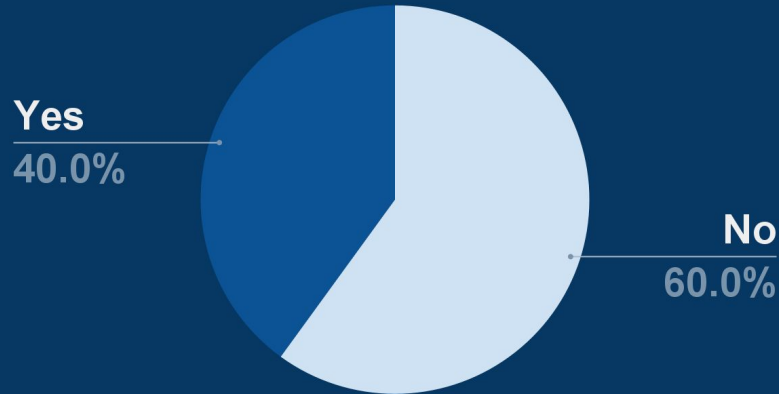
# Can we build-on and extend results?



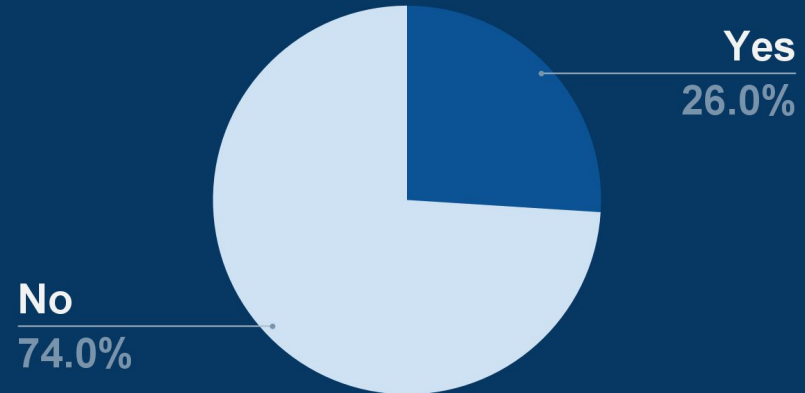
Tested 204 scientific papers published in AAAS Science (top journal):

- Data?
- Reproduce?

## Data Made Available?



## Reproduce results?



<https://www.pnas.org/doi/full/10.1073/pnas.1708290115>





# Can we rapidly iterate and resolve problems?

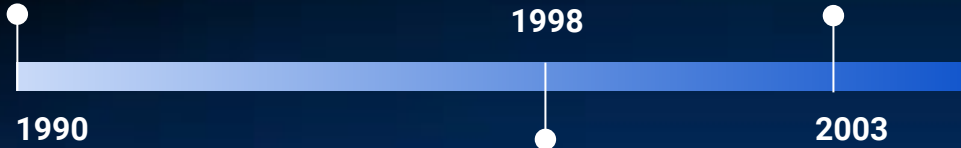


## Global cooling in upper atmosphere reported

Analysis of satellite data showed cooling, therefore global warming is a farce

## New version released

Closed code. Took 5 years & lots of funding a different group to re-do analysis



## Error in analysis discovered

Authors didn't account for orbital decay and other effects - introduced an artificial cooling trend





# Can anyone participate?

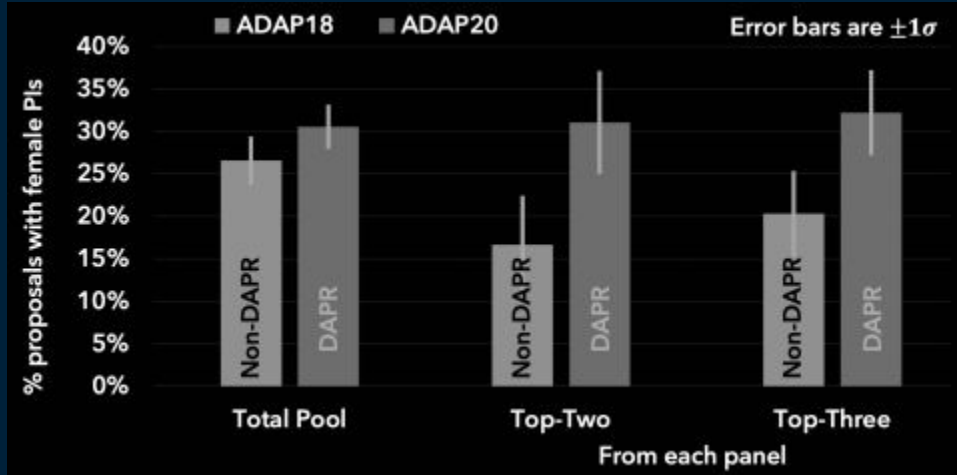


access to journals worldwide via Wiley licenses

WILEY



# Is it a level playing field?



Dual anonymous peer review (DAPR) analysis

<https://science.nasa.gov/researchers/dual-anonymous-peer-review>

## Systemic Racism Reflected in Grant Allocations, Researchers Argue

NEWS FEATURE

November 8, 2022 • *Physics* 15, 173

Researchers call for reform in how funding is allocated in response to a study that finds racial disparities in the National Science Foundation's awarding of research grants.



<https://physics.aps.org/articles/v15/173>



# Why?



# Local Data

Bring the data to you

Months to download

New version? Download again

Storage and maintenance costs

Discourages external collaborations

Reinforces institutional advantages



# Closed Software

Redundant efforts

Error prone

Impedes advancements

Difficult to share, version, etc.

Reinforces closed science





# Local Infrastructure

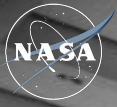
**Compiler-specific OS**

**Unique environment**

**Software restrictions**

**Reinforces institutional advantages**





# Pay-wall Publishing

Restricts access to knowledge

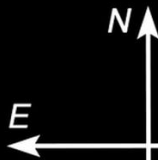
Perpetuates exclusionary practices

Reinforces institutional advantages



# NASA is looking ahead at really big challenges

We need ***more*** WE science  
rather than ME science<sup>1</sup> –  
openly sharing data,  
software, & results





We need *more* people -  
more hands, more eyes,  
more brains - with diverse  
experiences to participate  
so that we ask the best  
questions and find the best  
solutions

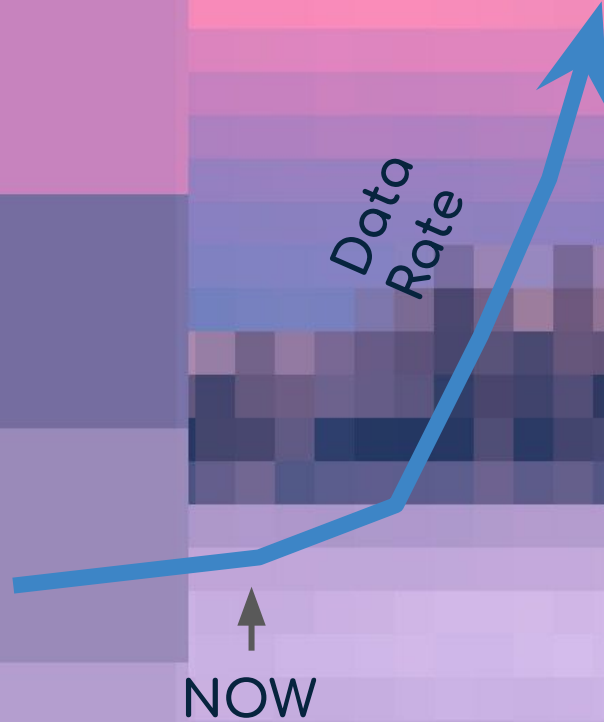


Image credit: JPL



What can we do  
about this?

# Cloud-based Data



Cloud-based data

Easier to collaborate

Easier to reproduce and build on

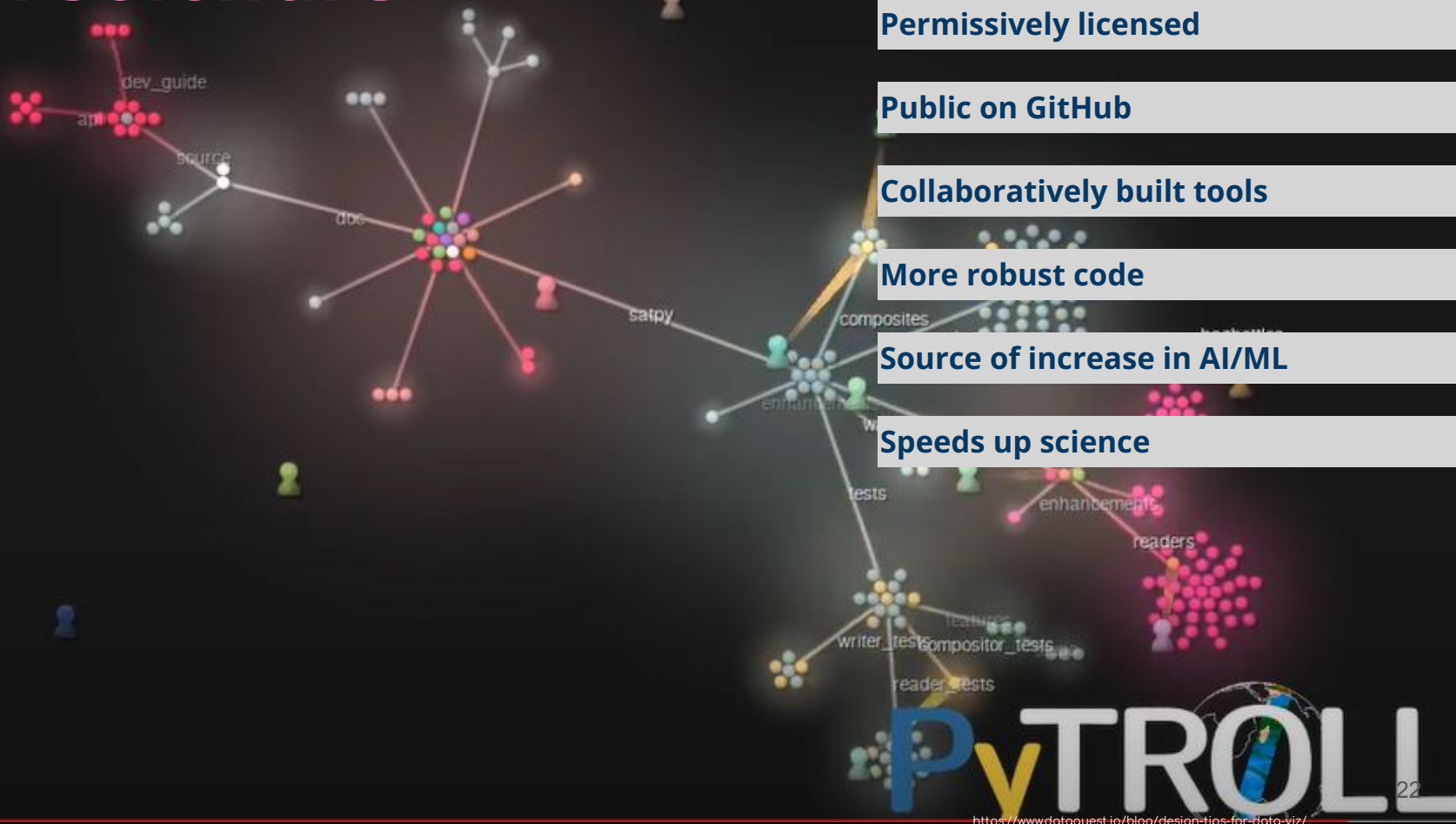
Access not bandwidth-limited

More Interdisciplinary research

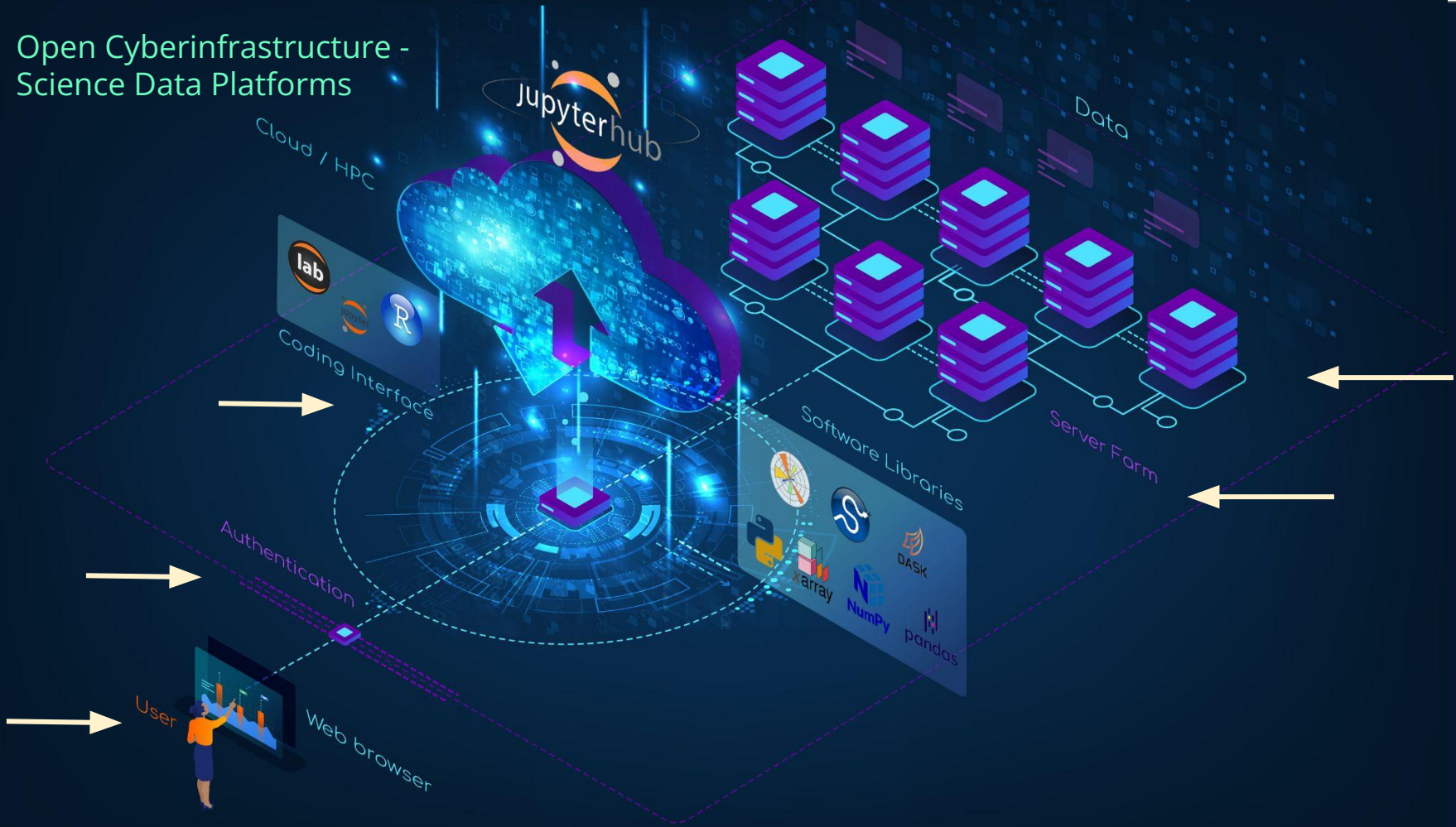
Broadens participation

# Open Software

2018-Apr-22



# Open Cyberinfrastructure - Science Data Platforms





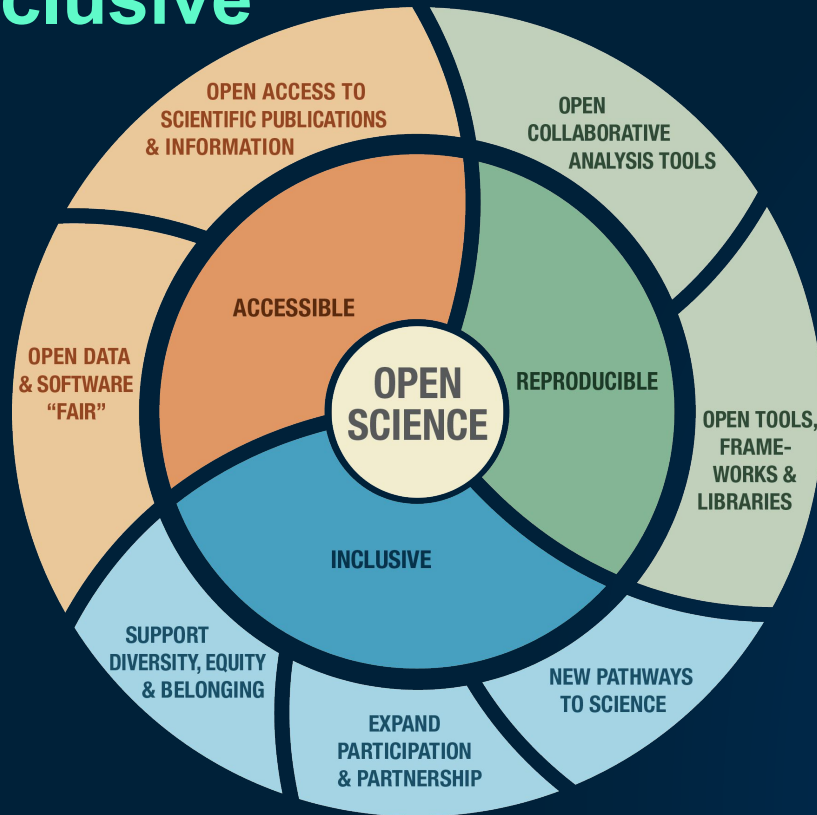
# Publishing in open executable notebooks

The screenshot displays the Jupyter Book website interface. On the left is a navigation sidebar with sections: TUTORIALS (Create your first book, Get started with references), TOPIC GUIDES (Structure and organize content, Write narrative content, Write executable content, Build and publish outputs, Web and internet features, Sphinx usage and customization, Advanced Jupyter Book Usage, Contribute to Jupyter Book), REFERENCE (Configuration reference, MyST syntax cheat sheet, Command-line interface reference, Glossary), and ABOUT JUPYTER BOOK (Gallery of Jupyter Books, The Jupyter Book toolchain and components). The main content area features a search bar, a heading "Build beautiful, publication-quality books and documents from computational content.", a "Get started" button, and a "JB" logo. Below are six content cards: "Text content" (Structure books with text files and Jupyter Notebooks with minimal configuration), "MyST Markdown" (Write MyST Markdown to create enriched documents with publication-quality features), "Executable content" (Execute notebook cells, store results, and insert outputs across pages), "Live environments" (Connect your book with Binder, JupyterHub, and other live environments), "Build and publish" (Share your built books via web services and hosted websites), and "UI components" (Create interactive and web-native components and services). A "Contents" sidebar on the right lists "Built with Jupyter Book", "Connect with us", and "Acknowledgements". At the bottom, it states "This documentation is organized into a few major sections." and lists "Tutorials" as step-by-step introductory guides to Jupyter Book.





# Open Science is Accessible, Reproducible & Inclusive



## Creates research that is:

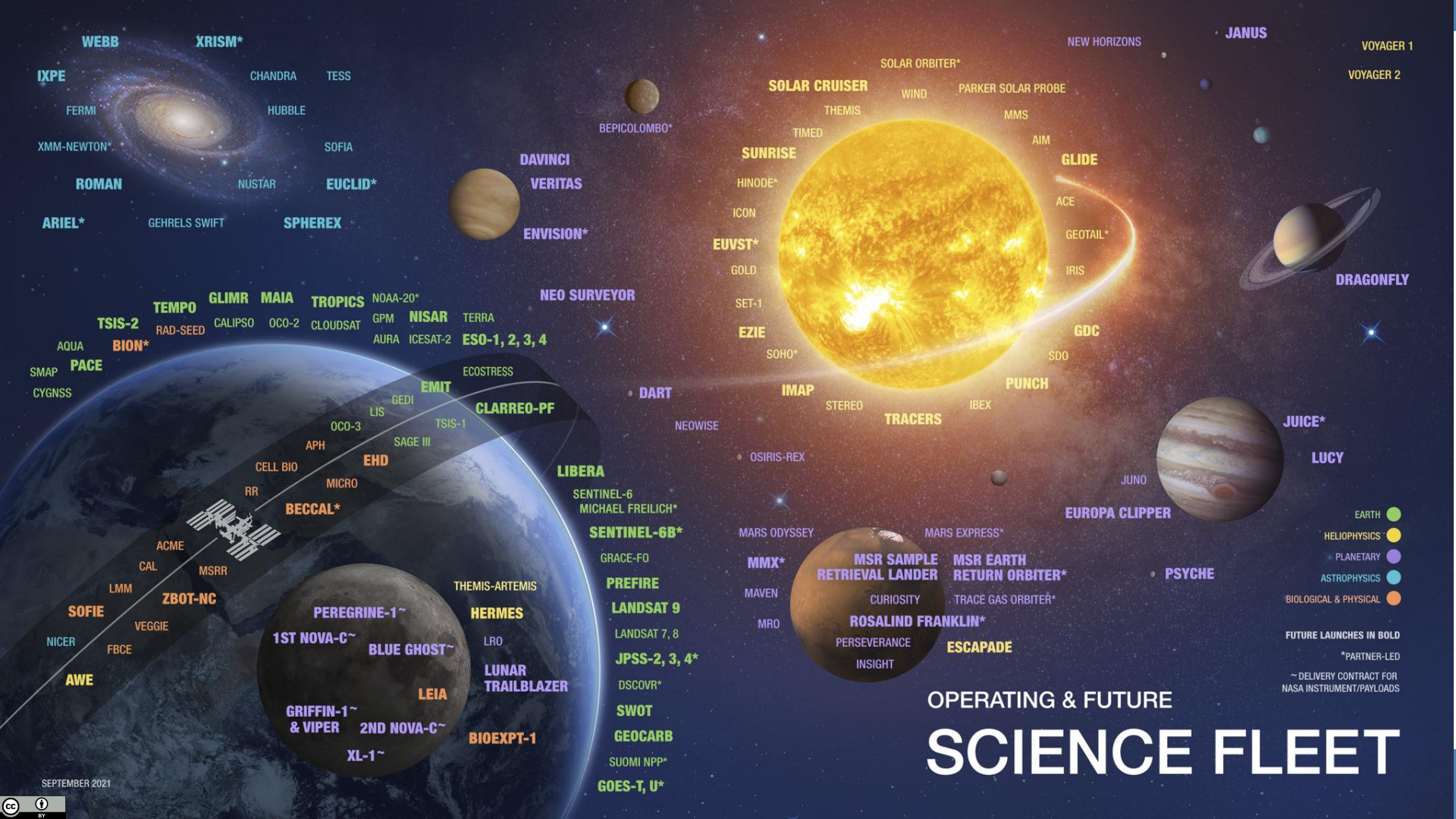
- Cited more
- Creates a bigger impact
- Increases transparency
- Generates more scholarly collaborations

## Inclusive science means more:

- Collaborative projects
- Access to 'hidden knowledge'
- Equitable Systems
- Participation



What does big  
government do  
well?



WEBB XRISM\*  
 IXPE CHANDRA TESS  
 FERMI HUBBLE  
 XMM-NEWTON\* SOFIA  
 ROMAN NUSTAR EUCLID\*  
 ARIEL\* GEHRELS SWIFT SPHEREX

NEW HORIZONS JANUS  
 VOYAGER 1  
 VOYAGER 2

DAVINCI  
 VERITAS  
 ENVISION\*

SOLAR ORBITER\*  
 SOLAR CRUISER  
 WIND PARKER SOLAR PROBE  
 THEMIS MMS  
 TIMED AIM  
 SUNRISE  
 HINODE\*  
 ICON  
 EUVST\*  
 GOLD  
 SET-1  
 EZIE  
 SOHO\*  
 IMAP  
 STEREO  
 TRACERS  
 IBEX  
 PUNCH  
 SDO  
 GDC  
 SDO  
 GLIDE  
 ACE  
 GEOTAIL\*  
 IRIS

DRAGONFLY

NEO SURVEYOR  
 DART  
 NEOWISE  
 OSIRIS-REX  
 LIBERA  
 SENTINEL-6  
 MICHAEL FREILICH\*  
 SENTINEL-6B\*  
 GRACE-FO  
 PREFIRE  
 LANDSAT 9  
 LANDSAT 7, 8  
 JPSS-2, 3, 4\*  
 DSCOVER\*  
 SWOT  
 GEOCARB  
 SUOMI NPP\*  
 GOES-T, U\*  
 TERRA  
 ES0-1, 2, 3, 4  
 ICESAT-2  
 ECOSTRESS  
 CLARREO-PF  
 TSIS-1  
 SAGE III  
 EHD  
 MICRO  
 BECCAL\*  
 RR  
 ACME  
 CAL  
 MSRR  
 ZBOT-NC  
 LMM  
 VEGGIE  
 FBCE  
 AWE  
 SOFIE  
 NICER  
 AWA  
 THEMIS-ARTEMIS  
 HERMES  
 LRO  
 LUNAR TRAILBLAZER  
 BIOEXPT-1  
 PEREGRINE-1~  
 BLUE GHOST~  
 LEIA  
 1ST NOVA-C~  
 GRIFFIN-1~ & VIPER  
 2ND NOVA-C~  
 XL-1~

JUICE\*  
 LUCY  
 JUNO  
 EUROPA CLIPPER  
 PSYCHE

MARS ODYSSEY  
 MARS EXPRESS\*  
 MMX\*  
 MAVEN  
 MRO  
 MSR SAMPLE RETRIEVAL LANDER  
 MSR EARTH RETURN ORBITER\*  
 CURIOUSITY  
 TRACE GAS ORBITER\*  
 ROSALIND FRANKLIN\*  
 PERSEVERANCE  
 INSIGHT  
 ESCAPEDE

EARTH ●  
 HELIOPHYSICS ●  
 PLANETARY ●  
 ASTROPHYSICS ●  
 BIOLOGICAL & PHYSICAL ●  
 FUTURE LAUNCHES IN BOLD  
 \*PARTNER-LED  
 ~ DELIVERY CONTRACT FOR NASA INSTRUMENT/PAYLOADS

OPERATING & FUTURE  
**SCIENCE FLEET**



The background for the 'Policy' section features a dark blue color with a large, semi-transparent padlock icon in the center. Surrounding the padlock are several hexagonal icons: a server rack, a fingerprint, a gear, and a Wi-Fi signal. A globe is visible at the bottom of this section, with a network of lines connecting various points on its surface.

**Policy**

The background for the 'Infrastructure' section is dark blue with a large, stylized cloud icon in the upper right. The cloud is composed of a grid of small blue squares. To the left of the cloud, there are several horizontal lines of varying lengths, suggesting data flow or network connections.

**Infrastructure**

NASA's  
Open-Source  
Science Initiative  
\$20M/yr

The background for the 'Funding' section is dark blue with a pattern of glowing white and light blue lines that resemble a circuit board or a network diagram. The lines are interconnected, forming a complex web of paths.

**Funding**

The background for the 'Outreach' section is a vibrant space scene with a starry sky in shades of purple and blue. On the right side, there is a network of glowing blue lines connecting various points, similar to the 'Funding' section but with a more organic, web-like structure.

**Outreach**





# Proposed new policy:



## Data

**Scientific data** should be **FAIR** and shall be made publicly available with a clear, open, and accessible data license no later than the publication of the research, and be citable.

**Mission data** shall be openly available with no period of exclusive access.

## Software

**Research software** shall be publicly available no later than the publication of the research, assigned a permissive software license, and be citable.

**Mission software** shall additionally be developed openly in a publicly accessible, version-controlled platform that allows for contributions and engagement from the community.

## Publications

**Manuscripts** versions of as-accepted manuscripts shall be deposited in a NASA repository and made publicly available **immediately**. **Publishing as open access is supported and posting preprints is encouraged.**

**Mission publications** shall additionally be made publicly available at the time of their publication.

**Science workshops and meetings** shall be open to broad participation and documented in public repositories.

**Open science activities will be considered in reviews of proposals.**



# NASA is Leading the Path to Open Science

NASA's Transform to Open Science (TOPS) is a \$40 million 5-year mission to accelerate adoption of open science

## TOPS' Strategic Goals:

- Support 20K researchers to earn NASA's open science badge
- Double the participation of historically excluded groups across NASA science
- Enable five major scientific discoveries through open science principles



Engagement



Capacity Sharing



Incentives



Coordination



*Join us as we embark on the 2023 Year of Open Science with NASA TOPS!*

<https://science.nasa.gov/open-science/transform-to-open-science>

# 2023 NASA's Year of Open Science

## High level visibility

- Publications, articles, working TOPS into HQ comms
- Announce new Open Science awards
- Announce recognition of Open Science activities

## Conferences

- Targeting domestic meetings
- These meetings will have TOPS representation at NASA booth, town halls, OpenCore workshop, high-visibility in society comms and at conference

## Virtual Cohorts

- Learners who complete part of OpenCore will be followed up with an enrolled in virtual cohorts to encourage completion of course

## Summer Schools

- 3-4 institutions funded to run 6-8 weeks of OpenCore / Science Team summer schools - train entire science teams all together in 1 week.

## Targeted Workshops

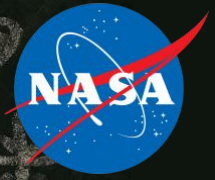
- In-person workshops with strong outreach to historically underrepresented communities to learn open science and build community at the same time

Conference	Date	Size	BPS	PDS	Helio	Earth	Astro	HUGS*
AGU Fall	Dec	25K	x	x	x	x	x	
AMS	Jan	6K			x	x		
AAAS	Mar	9K	x	x	x	x	x	
LPSC	Mar	2K		x				
EGU	Apr	18K	x	x	x	x	x	
AAS	Jun	3K		x	x		x	
IGARSS	Jul	3K				x		
SASE	Oct	3K						x
Amer. Indian Sci.&Eng	Oct	2K						x
SACNAS	Oct	6K						x
ASGSR	Nov	1K	x					
AGU Fall	Dec	25K	x	x	x	x	x	
Targeted workshops	May/ Sep	200						x
<b>Totals</b>		<b>~100K</b>	<b>5</b>	<b>6</b>	<b>6</b>	<b>6</b>	<b>5</b>	<b>4</b>

\*HUGS- historically underrepresented groups

# We need YOU!

National Aeronautics and  
Space Administration







TOPS



# How YOU can Get Involved:

**To implement a cultural shift, we need community engagement from the broad spectrum across the scientific community!**

We are looking for community partners to co-develop activities

- Share your data, software, publications
- Join NASA science meetings
- Organize events
- Join TOPS email list!

**Learn more and collaborate with us - we're working on GitHub!**



TOPS Email List



TOPS Website





# Q&A

Learn more and collaborate with us!



TOPS Email List



TOPS Website

