



National Aeronautics and
Space Administration



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

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A NASA OPEN-SOURCE SCIENCE INITIATIVE:
TOPS: TRANSFORM TO OPEN SCIENCE

New Funding Opportunity!

\$3 million/year: to advance adoption of Open Science

F.14 Transform to Open Science Training ([TOPST](#))

- 1) Develop ScienceCore
- 2) OpenCore summer schools
- 3) OpenCore virtual cohorts

Nov 3, 2022 – Office Hours

Nov 10, 2022 – (Optional) Notice of Intent Due

Dec 8, 2022 – Proposal Due



Some of the biggest recent breakthroughs were enabled by open science

First image of a black hole

“We’re deeply grateful to all the open source contributors who made our work possible.” –Dr. Katie Bouman

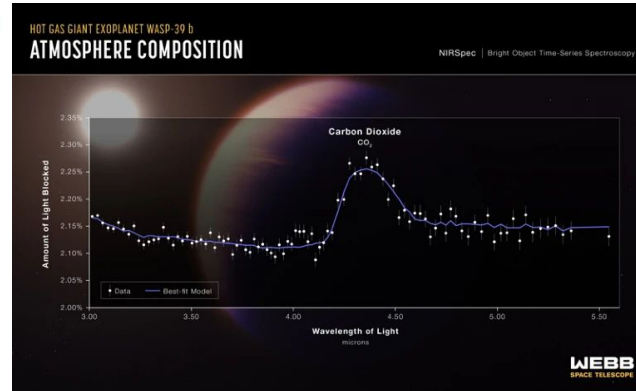


“with the open source projects in NumFOCUS, we were able to iterate our algorithms so fast that they enabled us to finish our work in two years”

we greatly improve[d] our own work by adopting well-tested community packages that contain the collected wisdom of many other projects.” –Dr. Lindy Blackburn

“The open source community is very important for scientists; imagine if we had to do everything from scratch every single time.” –Dr. Chi-Kwan Chan

Astronomers see CO₂ on exoplanet for first time



“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

- Open collaboration that was advertised in the years leading up to data collection with open Slack community (341 people and counting!!)
- JWST data was made public immediately upon collection
- All data reduction and scientific interpretation can be reproduced through open software and data archived via Zenodo Community Collection
- Open preprint server (Arxiv)
- Published Nature Open Access



Close Science: Advances are slower

Wiley Interdisciplinary Reviews: Climate Change, Volume 2, Issue 1,

Advanced Review

Tropospheric temperature trends: history of an ongoing controversy

Peter W. Thorne,^{1,2*} John R. Lanzante,³ Thomas C. Peterson,⁴ Dian J. Seidel⁵ and Keith P. Shine⁶

Changes in atmospheric temperature have a particular importance in climate research because climate models consistently predict a distinctive vertical profile of trends. With increasing greenhouse gas concentrations, the surface and troposphere are consistently projected to warm, with an enhancement of that warming in the tropical upper troposphere. Hence, attempts to detect this distinct 'fingerprint' have been a focus for observational studies. The topic acquired heightened importance following the 1990 publication of an analysis of satellite data which challenged the reality of the projected tropospheric warming. This review documents the evolution over the last four decades of understanding of tropospheric temperature trends and their likely causes. Particular focus is given to the difficulty of producing homogenized datasets, with which to derive trends, from both radiosonde and satellite observing systems, because of the many systematic changes over time. The value of multiple independent analyses is demonstrated. Paralleling developments in observational datasets, increased computer power and improved understanding of climate forcing mechanisms have led to refined estimates of temperature trends from a wide range of climate models and a better understanding of internal variability. It is concluded that there is no reasonable evidence of a fundamental disagreement between tropospheric temperature trends from models and observations when uncertainties in both are treated comprehensively. © 2010 Crown copyright WIREs Climate Change 2011 2 66–88 DOI: 10.1002/wcc.80

INTRODUCTION

Since the earliest attempts to mathematically model the climate system's response to human-induced increases in greenhouse gases,¹ a consistent picture of resulting atmospheric temperature trends has emerged. The surface and troposphere (the lowest 8–12 km) warm with a local maximum trend in the

upper levels in the tropics, while the stratosphere above cools (Figure 1).

In a 1990 paper, Spencer and Christy² claimed that since the start of routine satellite temperature observations in 1979 there had been no tropospheric warming, despite apparently rapid surface warming. The paper raised questions about both the veracity of the surface temperature record and our understanding of the climate system's response to greenhouse gas increases, and it has been heavily cited in both scientific and political arenas. Taken at face value, these questions would have fundamental and far-reaching implications for understanding of the climate

*Correspondence to: Peter.Thorne@noaa.gov

¹Met Office Hadley Centre, FitzRoy Road, Exeter, UK

²Cooperative Institute for Climate and Satellites, NOAA National Climatic Data Center, 151 Patton Avenue, Asheville, NC, USA



1990 - Highly cited paper: no upper atmosphere warming. Therefore - we don't understand climate enough to change any policy

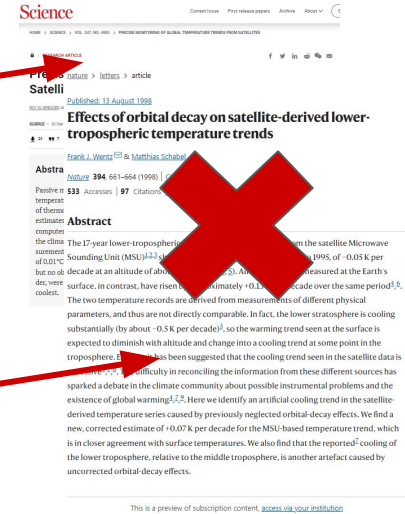
Data open but difficult to access

1998 - Authors didn't account for orbital decay + other effects and introduced artificial cooling trend

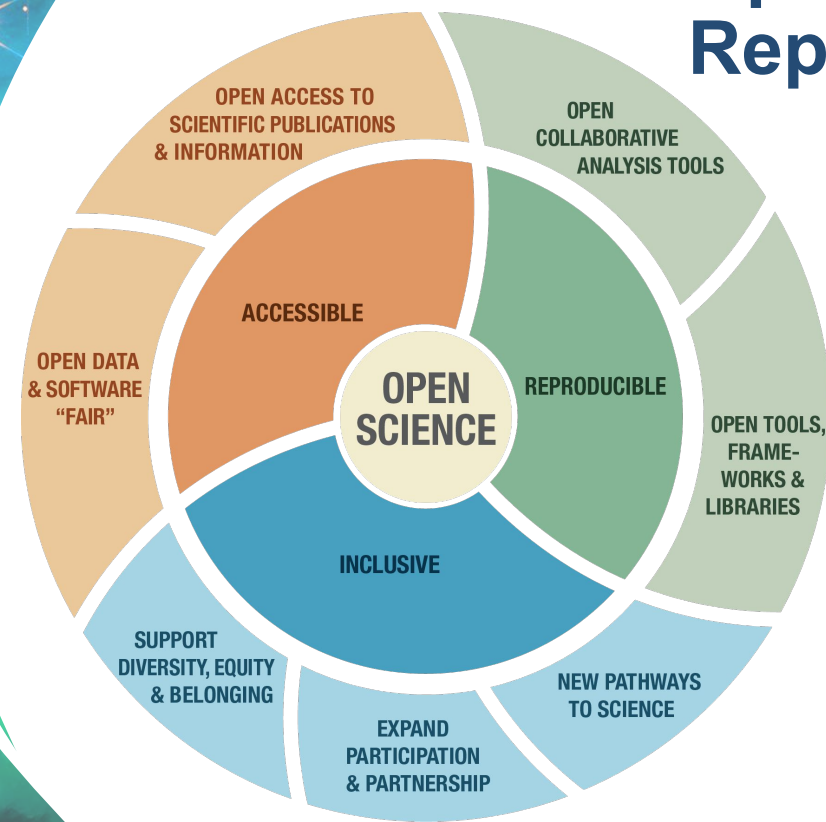
2003 - Close code so new analysis took 5 years & \$\$\$

Open science:

- More people looking at code improves quality
- Easier to revise/build, test hypotheses



Open Science: 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

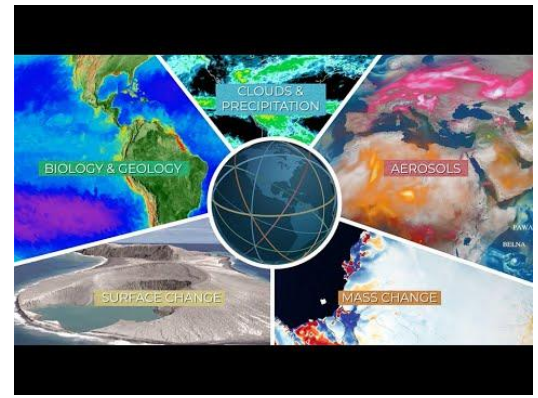
NASA is looking ahead at really big challenges

We need **more** WE science rather than ME science¹— sharing data, software, results openly

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

Open Science:

- Accelerates the pace of science
- Increases the impact of science
- Expands applications of data and science
- Shares hidden knowledge & expands participation in science



Video credit: NASA



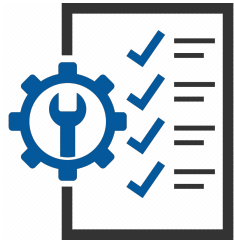
Image credit: Twentieth Century Fox

1: quote from Harlan Krumholz, Yale School of Medicine at 2022 CZI meeting

NASA's Open-Source Science Initiative

Unlocking the full potential of a more equitable, impactful, efficient, scientific future

\$20M/year



Policy development, education, compliance tools

Updating NASA Science policies on scientific information to better enable the activation of open science (eg. SPD-41a)



Core Services for Science Discovery

Developing core data and computing services to enable open science



ROSES Elements

Supporting open-source software, tools, frameworks, libraries, platforms, and training with over \$5 million dollars in grants per year



Community Building & Partnerships - Transform to Open Science (TOPS)

Accelerating adoption of open science and expanding participation of marginalized communities in science

NASA's Open-Source science is the *activation* of an open science community

A continuum of open-source science

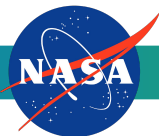
Data access (\$\$)
Accessible Publications (\$\$)
Siloed systems
Limited communication
Proprietary Software
"Closed-Tent" culture



Free unlimited data access
Fully documented open software and algorithms
Fully linked data and publications
Open Access Journal publications
Fully Transparent processes
Reproducible across platforms
"Teaching" culture
Open science meetings



FULLY CLOSED



FULLY OPEN



No public access data
No publications
No insight into processes
No reproducibility
"Black Box" culture



Free data access
Open software and algorithms
"Green" Journal publication
Documented processes
Reproducible in specific environments
"Open-Tent" culture

Why Now?

We **now** have the tools to make open science a reality. Advances in technology have created accessible, reproducible, inclusive science at a scale not possible a few years ago.

There is national and global **momentum** for the move to open science.

Equal and open access benefits the public



Plans and Policies around the world that supports moving toward open science

Country/Region	Date	Document	Type	Comments
Europe	2016	The EU's open science policy	Policy	
Sweden	2018	Open access to research data	Recommendation	The recommendation is part of promoting a transition to open access to research data. The goal is to complete the transition no later than 2026.
Europe	02/2018	Plan S.	Plan	Research papers must be immediately free to read and published under a licence that, allows anyone can download, reuse or republish the paper.
Canada	02/2020	Roadmap to Open Science	Plan	
Unesco	11/2021	Recommendation on Open Science	Plan	
France	07/2021	Second French Plan for Open Science	Plan	
Spain	July 2022	National Plan for Open Science	Bill	In Spanish- Regulatory act
USA	08/2022	USA Open Access Publications Nelson Memo.	Policy	All US agencies to have updated public access policies to make publications and research funded by taxpayers publicly accessible, without an embargo or cost.Policies to be fully implemented by the end of 2025.
Germany	2022	Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) measures	Plan	Package of Measures to Support a Shift in the Culture of Research Assessment
Switzerland	2022	CERN OPEN SCIENCE POLICY	Policy	Website



Leading the Path to Open-Source Science



NASA's Transform to Open Science (TOPS) is a \$40 million 5-year mission geared towards accelerating the adoption & understanding of open science

Key Goals:

- 20,000 earn open science certification
- 2x participation by historically underrepresented communities
- 5+ major discoveries

2023 is NASA's Year of Open Science

NASA Science has designated 2023 as the Year of Open Science. Throughout the year NASA will be energizing and uplifting open science across the scientific community through:



Visibility

Open Science everywhere: Articles, announcements, Twitter Spaces, conferences

2023 Big annual meetings
Open Science Themes, integrated into society comms



Capacity Sharing Resources

Online, free, Open Science curriculum on Open edX

Workshops, events, virtual cohorts, science team meetings, hackathons

Many paths to Open Science



Incentives

Open Science Badge/Certification

High profile prizes and challenges

High profile awards in support of open science research

Internship programs



Changing the Game

Require open data, open software, open access

Dual-Anonymous Peer Review

Funding decisions consider open science activities

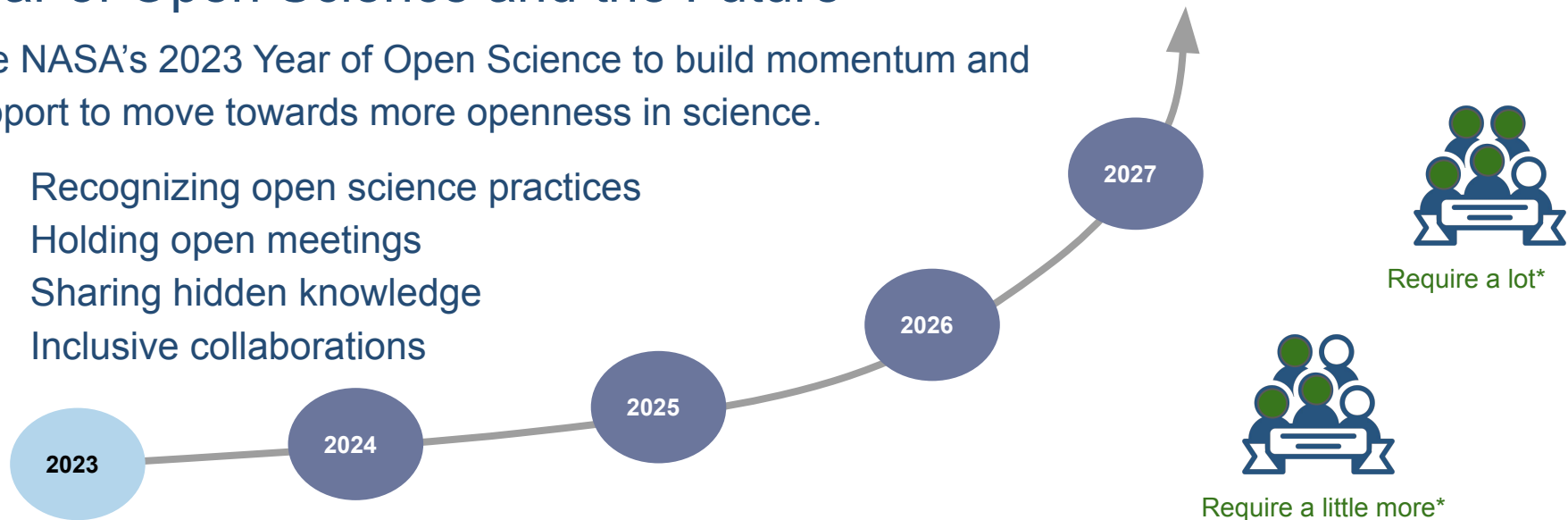
Awards, promotions, evaluations consider Open Science activities and teams as well as individuals

Area of Action: Moving towards Openness

Year of Open Science and the Future

Use NASA's 2023 Year of Open Science to build momentum and support to move towards more openness in science.

- Recognizing open science practices
- Holding open meetings
- Sharing hidden knowledge
- Inclusive collaborations



**Proposed: Update necessary systems to allow for documentation of past open science activities and proposed data, software, and publication plans*

Require a little*



Open Science Results Speak for Themselves....

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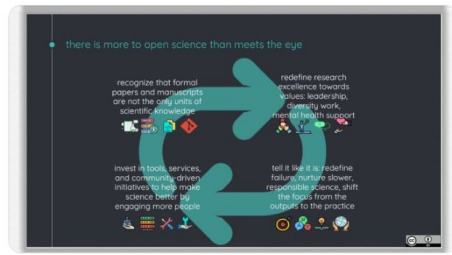
First image of black hole



Paola Masuzzo @pcmasuzzo

Replying to @ChelleGentemann and @theNASEM

An aspect we should talk more about, open research practices as a driver to a real reform in the research endeavour. I try to depict it in this image :)



Scott Collis (He/Him) @CycloGenesisAU

Being an open scientist has:
1) accelerated my career. It has allowed me to choose projects which benefit more people.
2) Has created long lasting collaborations and friendships. When you are open you are... open!
3) Made me a better scientist. "Show your working!"



6:36 AM · Mar 12, 2022 · Twitter Web App



Dr. Julia Stewart Lowndes @julesquid

Replying to @ChelleGentemann and @theNASEM

Congrats Chelle!
The welcoming, inclusive, collaborate-and-reuse culture of the #rstats community is something that changed my science-life and my life-life. Hard to distill but here are a few attempts:
openscapes.org/blog/2020/02/2...
openscapes.org/blog/2019/02/1...
openscapes.org/blog/2019/08/2...

3:15 PM · Mar 11, 2022 · Twitter Web App

Belize GEO @BzGEO · Mar 11

Replying to @ChelleGentemann and @theNASEM

Our friends @SERVIRGlobal have many examples of how algorithms + code from one region have been customized for use in another. An example is gold mining monitoring, where Amazonia + W. Africa have collaborated in an #OpenScience context, leveraging #GEE. 🇵🇳



Lucas Sterzinger @lucassterzinger

Replying to @ChelleGentemann and @theNASEM

Probably the most common answer, but using @xarray_dev, @dask_dev, @ProjectJupyter, and @matplotlib has been the backbone of my research since day 1. Working with these tools also motivates me to make the data and code for my plots open source, making my science more reproducible

7:41 AM · Mar 11, 2022 · Twitter Web App



Pierre de Buyt @pdebuyt

Replying to @ChelleGentemann and @theNASEM

In remote sensing: using @PyTrollOrg satpy as a comparison point for reading geostationary satellite data, @scitools_iris and panoply from @NASA for plotting said data.

12:15 PM · Mar 11, 2022 · Twitter Web App



Sam Ehrenstein @elasticsnake

Replying to @ChelleGentemann and @theNASEM

In computer science, research moves very fast. It would not be possible to keep up with the latest work if not for the arXiv and open-access conferences.

1:47 PM · Mar 14, 2022 · Twitter Web App



Ricardo Barros Lourenco @rblourenco

Replying to @ChelleGentemann and @theNASEM

I've briefly returned to the public-private sector (between 2019-21) and the nicest thing about working with OSS during all my career was the ability to show new methods to be applied in that company, which was of clear understanding, helping auditing efforts.



Max Grover @mgroverwx · Mar 11

Replying to @ChelleGentemann and @theNASEM

Here's a great use-case of @PyART, which is funded by @doescience @armnewsteam! Over 200 citations so far, with many including awesome code like this paper which enables #OpenScience!

Milind Sharma @Gewitter_Blitz · Mar 11

The power of open source software! The authors (@jehcssou and @deeplycloudy) also provide a clean code to encourage reproducible science. I could apply their technique to my dataset within a few hours. Neat! Yes to #OpenScience



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 YOOS activities

- Develop open science action plans
- Share your data, software, publications
- Nominate science teams for summer schools
- 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