

# **DRAFT: The Openscapes Flywheel: A framework for managers to facilitate and scale inclusive Open science practices**

Erin M. Robinson

Julia S. Stewart Lowndes

## **Table of contents**

Abstract . . . . .	1
Introduction: Transitioning Towards Open . . . . .	2
Openscapes Approach . . . . .	3
The NASA Openscapes Framework . . . . .	5
Engage bright spots . . . . .	5
Empower a learning culture . . . . .	6
Amplify open leaders . . . . .	7
The Openscapes Flywheel: reinforcing practices for trail building managers . . . . .	8
Conclusion: Onward Openly together . . . . .	10
Data Accessibility Statement . . . . .	10
Acknowledgements . . . . .	10
Author Information . . . . .	11
Authors' Contributions . . . . .	11
Funding Information . . . . .	11
Competing Interests . . . . .	11
References . . . . .	12

## **Abstract**

Solutions to large-scale environmental and social challenges require radical collaboration that blends technology and people — and the Open science movement is answering that call by transforming how we work together. While often the focus is on data, publications, code, software developers, and researchers, the transition to Open involves investment across agencies and organizations of all kinds. One critical and often-overlooked part of transitioning to Open is that it requires support from managers and leadership, who do not need to be Open science

experts but who can imagine the return on investment and support their teams through time and resources to learn new skills and technologies, take risks, and even fail through the process. In this paper we describe our work developing the Openscapes Flywheel with NASA Earth science data centers, using the concept where transformations occur from relentlessly pushing a giant, heavy flywheel that builds momentum over time. We offer three practical ways managers can support their teams and grow morale and technical capacity across their organizations: (1) Engage bright spots, through welcoming them and creating space and place; (2) Empower a learning culture through, investing in learning and trust and working openly (3) Amplify Open science leaders, through leveraging the common and inspiring the bigger movement. Together these lessons create kinder and more inclusive organizations that are more resilient as data volumes increase and software evolve, and dispel the hero myth of science. Engaging, empowering and amplifying efforts to support people while modernizing our workforce is the way that we will meet the world's greatest challenges, from climate change to social justice to democracy. We can already see how working this way increases inclusion, reproducibility, and resilience within and across government, academic, and non-profit organizations, and are hopeful for what we can do together in growing this movement.

**Keywords:** Open science, management, data science kinder science, NASA Earthdata

## Introduction: Transitioning Towards Open

Solutions to large-scale environmental and social challenges require radical collaboration, but have been limited by the hero model, where science is competitive, siloed, and rewards an individual hero, often a white man. While we know that science has never been done by individuals, Science perpetuated the hero myth for hundreds of years<sup>1</sup>. Open science is a global movement that offers transparency, efficiency, reproducibility, reuse, and community with intentional focus on inclusion - the vision of a new paradigm for science<sup>2</sup>. The Open science movement was codified by the Budapest Open Access Initiative<sup>3</sup>, and after decades of grassroots community building work and technology development, we are seeing the turn toward Open science with the recent publication of the UNESCO Recommendations on Open Science<sup>2</sup>, increasing numbers of funders coordinated by the Open Research Funder Group<sup>4</sup>, and now large government institutions supporting Open access publishing<sup>5</sup> and research policy, including NASA's Transform to Open Science<sup>6</sup>. While Open science is not new, the transition to Open practices in a digital, data intensive world, requires investment in a new way of working<sup>7 8</sup>.

Meanwhile, at many scientific organizations, managers and leadership are facing a need to modernize - upskill the workforce, update technology, foster a more inclusive culture, support a distributed workforce, steward and analyze more data, and create and share reports more efficiently, transparently, and reproducibly, to name a few - often without a roadmap and with flat budgets. Open science offers consistency and resilience for managers, yet we are still seeing many research teams continuing to do science as usual, because they don't have the bandwidth to transition<sup>9</sup>. Researchers feel squeezed from all sides, responsible to do more with less, while

gaps widen within teams and organizations about who “is technical”, or interacts with data, code, and software. Largely, if researchers transition to Open science it is often self-taught, done on the side, as a volunteer effort and often not rewarded in traditional academic or government systems.

Transitioning towards Open science isn’t just something to feel good about and it isn’t all or nothing. It doesn’t happen by going to a single workshop and it isn’t a box to check. It is a practice that requires investment in people as well as technology - enabling people to collaborate and interoperate with technology to achieve their science goals and share in modern ways via the open web. Increasingly, managers are participating in our Openscapes mentorship programs with their research teams and researchers are becoming managers, and in both cases are wanting to sustain Open science on their own. Here, we describe our work developing a framework with NASA Earth science data centers, that we have repeated, reinforced, and generalized with the flywheel concept<sup>10</sup>. Our work has helped network Open science leaders, break down silos, and make lasting, meaningful, and transformative changes within and across their organizations that is amplified far beyond. Core to this work is that it involves slowing down to speed up - and we hope the Openscapes Flywheel can be as useful for others as it has been for the teams we work with.

## **Openscapes Approach**

Openscapes works with professional research teams in government, academia, and nonprofits, and we help these teams modernize their workflows and shift culture within their teams and organizations by incorporating Open science into their existing work<sup>11</sup>. We consider the transition to Open science as a journey through a landscape full of data, software, and communities, with many existing pathways forward (Figure 1). We help people transition from feeling like sad animals who can feel stuck and lonely with this expansive landscape of possibility just out of view, to navigating this landscape safely together, with reduced bushwacking and trampling. Openscapes welcomes research groups at the trailhead, helping individuals work as teams and identify where they are all starting from. The trails and environments that teams work in differ, and while there are many common pieces and skills to reuse and remix, each adventure will be different.

Through Openscapes Champions, our flagship program, we mentor cohorts of research teams in their transition to Open and kinder science<sup>12</sup>. By the end of 2022 we have led 16 cohorts with over 112 teams (> 520 individuals) over 2-4 months as they identify their trailhead and define their pathway together<sup>13</sup>. Meeting regularly remotely, we provide dedicated learning time for folks of different roles and skills to explore collaborative approaches for project management, data analysis, and stewardship, and practice incorporating them into their existing work while also reflecting with colleagues. Grounded in meeting researchers where they are<sup>14</sup>, Openscapes Champions helps teams tackle big challenges as smaller steps<sup>15</sup>



## The NASA Openscapes Framework

NASA Earth Science Data Systems missions collect Earth data, including sea ice, physical oceanography, vegetation and many other parameters<sup>25</sup> that are used by researchers around the world for many purposes, including pressing questions in ecology and environmental science that are part of addressing the climate crisis. Currently, NASA is migrating this data to the cloud, and NASA's science data centers (Distributed Active Archive Centers, or DAACs) are supporting researchers using Earthdata to migrate their analytical workflows to the Cloud. These are paths that have not been created before but build from existing ones.

Through a NASA grant to Openscapes, we are supporting and strengthening the community of NASA DAAC staff that are creating cloud learning resources - a project that blends technology and people for radical collaboration<sup>26</sup>. We help this community of cross-DAAC staff - the NASA Openscapes Mentors - learn existing paths and develop new paths together by identifying common priorities, needs, and gaps to fill, while testing cloud learning resources, giving feedback, and investing in teaching. Our project increases visibility of Mentors and research teams with cloud and strengthens the community of practice around Open science at NASA.

The NASA Openscapes Framework scales the Openscapes Approach beyond the Champions program into a movement by engaging, empowering, and amplifying Open science leaders within organizations. We are iteratively co-developing the Framework with the Mentors - our goal is for Openscapes to leave NASA when the project concludes, with the mentor community sustaining itself. The Framework has three components: (1) Engage bright spots, through welcoming them and creating space and place; (2) Empower a learning culture through, investing in learning and trust and working openly (3) Amplify Open science leaders, through leveraging the common and inspiring the bigger movement.

### Engage bright spots

**Welcome bright spots.** As we designed our project, we intentionally avoided coming in from the outside to change the culture. Instead, we focused on identifying and connecting the bright spots<sup>27</sup> - people across the organization already role-modeling the desired change you want to see. We reached out to DAAC managers with a welcoming description of our project and asked them to share the opportunity with people in their group who were working with research teams moving to the Cloud and interested in teaching and collaborating. We then provided a short self-nomination form so that folks had agency to opt-in, and asked them to sign up as pairs and trios so they would have a team member from their DAAC to reinforce and practice what they learned with the larger cohort. Opting-in was a critical first investment from both managers and staff; this helped build agency and enthusiasm in alignment with their jobs. These nominees became the Mentor Cohort, representing five DAACs in year one, and seven in year two.

**Create space and place.** As we all had different backgrounds, different experiences and expertise, technical skills and technologies, with DAACs in different stages of migrating data to the cloud, our early conversations tended towards what was unique and distinct. Part of welcoming bright spots is listening across different experiences and vocabularies to identify a shared agenda. It took time (and gentle but consistent facilitation) for those conversations to shift from what was unique to what we had in common - we found shared goals and challenges as we identified our trailhead on the path of working together.

We provided scaffolding and facilitation through regular meetings, and managed software where Mentors could collaborate. Each DAAC had a different way of working, but Mentors were all agreeable to trying to use common places. Our shared software began with Google Drive and Slack. From there we took time to learn how to use new software, and practiced how we wanted to use it together. We also prioritized sharing stories via talks, blogs, and Twitter<sup>26</sup>, so that this articulation work of community building was visible and valued, and also didn't land on the Mentors.

Part of creating space and place is to remove or reduce barriers to participation. This took two forms with the Mentors - managerial and technical. On the managerial side, we were clear from the beginning that NASA Openscapes would require ~8 hours/month, and that that investment would align with their jobs. We advocated to their managers that this is not extra, unpaid labor, but it is part of their jobs and they are evaluated on these contributions (see Amplifying section). We also confirmed from NASA leadership that everyone could use GitHub as part of NASA's commitment to Open science, and (blending managerial and technical) we created a GitHub organization we manage for the group.

Further on the technical side, many in our group had not ever accessed NASA Earthdata in the Cloud. The primary block seemed to be who would pay for access, how much will it cost to use the Cloud, and how will researchers pay for cloud computing resources? Those questions are important, but they are not the first questions for staff supporting research teams, so we took them off the table. We partnered with 2i2c<sup>28</sup> to host a JupyterHub that is supported by AWS credits. The 2i2c JupyterHub greatly reduced "time to cloud" for Mentors and helped them experience it for the first time and build confidence as daily users. With management support to participate in this cross-DAAC activity, job alignment, a shared interest in collaborating and learning together, along with an established space, place, and barriers removed, the group could focus on how we wanted to co-develop and teach tutorials together.

## **Empower a learning culture**

**Invest in learning and trust.** To strengthen skills and confidence with teaching pedagogy for open data science, we invested in building trust through psychological safety<sup>20</sup> and growth mindset<sup>29</sup>, and gave this way of working a name: kinder science<sup>30</sup>. We did this through art and storytelling<sup>31</sup>, and role-modeled facilitation including live-google docing, screensharing,

and making mistakes<sup>16</sup>, and voiced the code of conduct along with efficiency tips and inclusion tips at early meetings. We also partnered with The Carpentries<sup>32</sup> for an introductory Python and GitHub workshop, as well as Instructor Training. We were the earliest adopters of Quarto<sup>33</sup>, which we learned together to make collections of Jupyter notebooks - these collections provided the dual benefit of helping identify gaps during tutorial development, as well as being a welcoming entryway for Earth science researchers in our first teaching event - the cross-DAAC Cloud Hackathon in November 2021<sup>34</sup>.

**Work openly - iterating, sharing the imperfect.** The Mentors combined their common skills and shared goals as they co-developed tutorials for the 2021 Cloud Hackathon. The practice of sharing imperfect work came from the foundation of learning and trust, and enabled us to iterate faster, help each other, share a common teaching style with live-coding, and see emerging ways to advocate for supporting researchers. The Mentors put into practice what they learned immediately, amplifying and continually reinforcing each other as they supported 65 participants to have their first welcoming experience in the Cloud. One example that stands out was one Mentor stepping in to teach on the first morning when another Mentor had an emergency - having built trust, camaraderie, and confidence with the content through regular meetings, tutorial review, feedback, and teaching dry runs.

Teaching, learning, and development came from everyone, synchronously and asynchronously, through screensharing demos with Jupyter notebooks, shared links on Slack, and co-development in Google Drive, 2i2c, GitHub and Quarto. As the materials refined and the Mentors practiced more, they have grown confident in facilitating with empathy, teaching and learning from every experience, and seeing new ways of contributing. Once we started to find the common, the possibilities grew and as did what we felt we could take on together.

## **Amplify open leaders**

**Leverage the common.** This is where the investments we had made slowing down allowed the Mentors to speed up. With this foundation of space, place, learning culture, and working openly, Mentors were all able to reuse and remix the Hackathon tutorials in nearly ten teaching events to date - including leading internal workshops for their DAAC peers, user working groups, science mission teams, early adopter research teams, university teams, and our first NASA Openscapes Champions Cohort. Creating visualizations, cheatsheets, and python packages has also been a recent focus for supporting researchers, and have already been reused in websites, tutorials, and presentations.

Much time has been saved since materials were not reinvented but continually iterated, tested, and improved, all while role-modeling Open science. All of this takes time and practice - from coordinating and communicating with each other and participants, remembering which commands to type live, fixing merge conflicts, as well as developing collaborative rapport in giving and receiving feedback and not having to ask to reuse openly shared work.

**Celebrate these people and share this work - inspire the bigger movement.** Through conversations with NASA leadership, blog posts, tweets, presentations, and anywhere that we were given or could make a platform, we intentionally lifted up the Mentors and their contributions early and consistently, showcasing their work and co-presenting with them. In co-presenting shared work, the Mentors have also highlighted how each of their organizations has benefited, which resonates with others in their organizations and attracts others across the NASA Earthdata community interested in similar work. Uplifting the Mentors' work does not dim our own contributions. It helps amplify each other, continually brightening and connecting bright spots as we all are part of and inspire the bigger movement.

## The Openscapes Flywheel: reinforcing practices for trail building managers

We have learned many lessons through our work with the Openscapes Mentors and Champions and generalized and tested them as part of our Openscapes Flywheel (Figure 2, Box 1) that gains momentum as it is repeated and reinforced with dedicated effort, feedback, and learning. The Flywheel guides our own work as we iterate with teams, and our goal is that others can continue to utilize it as they help their organizations transition to Open science safely and efficiently. This Flywheel is a concrete approach to help people find their pathways as they move into the Open science landscape, focusing on inclusion and community building at every step of the way. As one Mentor, Ileana Fenwick says, it's about being "the community member who you would want to meet at the beginning of your journey"<sup>35</sup>.

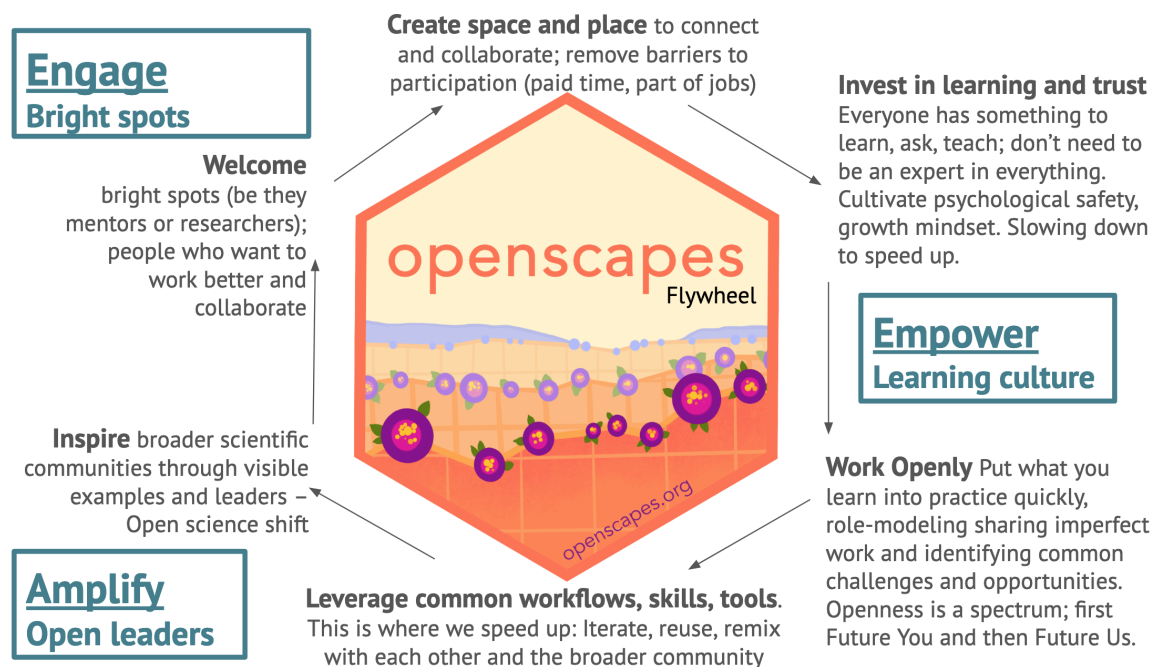


Figure 2: Openscapes Flywheel for expanding the Open science landscape.



### **i** Box 1: The Openscapes Flywheel

1. **Welcome bright spots** - Bright spots are folks that want to do better, even if they don't know what that means yet. There is no purity test or technical yardstick; welcome their enthusiasm and support them to grow. Initially, you don't need to find the most resistant toughest collaborators; work with the willing to build momentum and help others feel the change you envision together.
2. **Create space and place** - Bright spots are often siloed in large organizations, so one powerful step is to connect bright spots. This includes prioritizing time and having places where folks can collaborate and skill-build. It also means reducing barriers to participation be they technical or managerial.
3. **Invest in learning and trust** - Everyone has something to learn, ask, teach; no one is an expert in everything and it is important that people build confidence asking questions and learning from each other. Importantly, this involves cultivating psychological safety, growth mindset, and reinforcing the power of yet. This means slowing down to speed up - taking stock at the trailhead to confirm that everyone is there and ready.
4. **Work Openly** - Put what you learn into practice quickly, role-modeling sharing imperfect work and identifying common challenges and opportunities. Openness is a spectrum; first think about collaborating with Future You and then Future Us - the ideas of our teams, and communities, and who will be joining and continuing our work, whether that is next week or next century.
5. **Leverage common workflows, skills, tools** - This is where we speed up: iterating, reusing, and remixing our resources and those of the broader community. This means leveraging from, with, and for each other - from others' code and documentation, with others synchronously and asynchronously, and for others by contributing back our own resources and learning processes.
6. **Inspire others and grow the movement** - Communicating your work-in-progress helps build community, and make visible and credit this important work. This doesn't have to be a grand act; share something you've learned, your story, or a tool tip that inspires other bright spots and the flywheel turns again.

The Openscapes Flywheel is a starting point for managers and will continue to evolve as they engage, empower, and amplify bright spots across career stages and institutions to be leaders<sup>36</sup>. In our experience, having names for the practices involved is powerful for communicating externally and internally about where there is momentum and where they are stuck ("this is a heavy part of the flywheel"). Importantly, both top-down (managers) and bottom-up/grassroots (mentors) efforts should be involved, with direct communication chan-

nels between them, to strengthen and build trails together<sup>37</sup>.

## **Conclusion: Onward Openly together**

The Open science trail systems, as in real life, don't just happen overnight. They become worn in through use or they are built with intentional investment, and both these grassroots and top-down approaches are true for the long-standing and ongoing efforts of the Open movement. Increasing the number of teams who can travel these paths safely requires investment in not only the paths themselves but in the people who travel and maintain these paths. This is about all of us acting together as a "we". In the book, 'All We Can Save', Dr. Ayana Elizabeth Johnson and Dr. Katherine Wilkinson write about the meaning of each word in the title for tackling the climate crisis together<sup>38</sup>:

"We" speaks to the collective, to collaboration, to community, to the relational work at hand.... "We" speaks to justice, to how we do the work that needs doing and whose contributions are valued. We cannot, we must not, go it alone."

With the Openscapes Approach and Flywheel, together we can create kinder and more inclusive organizations and they dispel the hero myth of science. In addition to bright spot researchers and mentors, there are bright spot managers out there that we are grateful to work with and learn from. These managers see the vision and potential for Open science and have empowered the bright spot mentors and research teams, invested in changing the path and are cultivating a teaching culture to build more resilient organizations. Engaging, empowering and amplifying efforts to support people while modernizing our workforce is the way that we will meet the world's greatest challenges, from climate change to social justice to democracy. We can already see how working this way increases the diversity within our organization and beyond and are hopeful for what we can do together in growing this movement.

## **Data Accessibility Statement**

All Openscapes Champions curriculum materials are found [here](#). NASA Openscapes work is documented on the project website and materials are shared openly in the Github organization here (<https://github.com/NASA-Openscapes>).

## **Acknowledgements**

We are grateful to all teams that have participated in Openscapes Champions Cohorts. We are grateful to all NASA DAAC Mentors, their managers, and Openscapes Mentors who have co-developed the Openscapes Framework with us. Eli Holmes has been instrumental in bringing ideas from Geof Moore and early adopters. We are grateful to Dr. Allison Horst for all

Openscapes artwork and specifically for collaborating with us on the Openscapes Landscape in Figure 1.

## **Author Information**

Erin Robinson works at the intersection of community informatics, Earth science and management. Robinson is the CEO of Metadata Game Changers LLC and is pursuing a Ph.D. in Information Science at University of Colorado, Boulder focused on how research teams collaborate and share data. She articulated the Openscapes Framework based on her observations of the Openscapes Champions program. Robinson co-designed and co-leads the NASA Openscapes Framework project where she and Lowndes continue to refine the Framework.

Julia Stewart Lowndes, PhD is a marine ecologist working at the intersection of actionable environmental science, data science, and open science. She is a Mozilla Fellow and Senior Fellow at the National Center for Ecological Analysis and Synthesis (NCEAS) at the University of California Santa Barbara, having earned her PhD from Stanford University in 2012 studying drivers and impacts of Humboldt squid in a changing climate. Lowndes directs Openscapes after launching the Openscapes Champions Program in 2018.

## **Authors' Contributions**

Both authors made substantial contributions to the conception and design of the Openscapes work described in this paper. E. R. started the initial draft of this paper oriented toward managers. J.S. provided specific examples from Openscapes Champions teams that support the generalized findings. Both J.S. and E.R contributed to additional drafting and revising this paper critically.

## **Funding Information**

This work was supported by NASA grant #20-TWSC20-2-0003, entitled, "Openscapes: Enabling a new era of science on the cloud in response to the 2020 NASA ROSES Element E2."

## **Competing Interests**

The authors have no competing interests to declare.

## References

1. Elkins-Tanton, L. [Time to say goodbye to our heroes?](#) (2021).
2. UNESCO. [UNESCO recommendation on open science](#). (2021).
3. Budapest Open Access Initiative. [Budapest open access initiative](#). (2001).
4. [Open research funders group](#).
5. The White House. [OSTP issues guidance to make federally funded research freely available without delay](#). (2022).
6. NASA. [TOPS](#). (2022).
7. Nelson, T. A., Goodchild, M. F. & Wright, D. J. [Accelerating ethics, empathy, and equity in geographic information science](#). *Proceedings of the National Academy of Sciences* **119**, e2119967119 (2022).
8. The Royal Society. *Final report - science as an open enterprise | royal society*. <https://royalsociety.org/topics-policy/projects/science-public-enterprise/report/>.
9. Plomp, E. [Open science should not be a hobby](#). (2022).
10. Collins, J. *Good to great: Why some companies make the leap...and others don't*. (Harper Business, 2011).
11. Openscapes team. [Openscapes](#).
12. Openscapes team. [Openscapes Champions Series - Openscapes Champions Lesson Series](#). (2022).
13. Lowndes, J. S. S. *et al.* Supercharge your research: a ten-week plan for open data science. *Nature* (2019) doi:[10.1038/d41586-019-03335-4](https://doi.org/10.1038/d41586-019-03335-4).
14. Lowndes, J. S. S. *et al.* [Our path to better science in less time using open data science tools](#). *Nature Ecology & Evolution* **1**, 1–7 (2017).
15. Lowndes, J. S. [Open Software Means Kinder Science](#). *Scientific American Blog Network* (2019).
16. Mayes, A. C. *et al.* *Acabunoc/open-leadership-training-series 0.9*. (Zenodo, 2019). doi:[10.5281/zenodo.3466013](https://doi.org/10.5281/zenodo.3466013).
17. Lowndes, J. S. S., Cabunoc Mayes, A. & Sansing, C. [3 lessons from remote meetings we're taking back to the office | Opensource.com](#). *OpenSource.com* (2020).
18. Lakey, G. *Facilitating group learning: Strategies for success with diverse learners, second edition*. (PM Press, 2020).
19. Slater, D. [A training of trainers module on adult learning and ADIDS](#). (2016).

20. Edmondson, A. [Psychological Safety and Learning Behavior in Work Teams](#). *Administrative Science Quarterly* **44**, 350–383 (1999).
21. Beck, M. W. *et al.* [The importance of open science for biological assessment of aquatic environments](#). *PeerJ* **8**, e9539 (2020).
22. Bastille, K. *et al.* [Improving the IEA approach using principles of open data science](#). *Coastal Management* **49**, 72–89 (2021).
23. Horst, A. [Artwork by @allison\\_horst - #rstats, data science & stats illustrations](#). (2022).
24. Fay, G. [Openscapes is awesome! Building lab resources to sustain future us with tools from open data science](#). (2022).
25. Earth Science Data Systems, N. [NASA Earth Science Data Systems](#).
26. NASA Openscapes Mentors. [NASA-openscapes](#).
27. Heath, C. & Heath, D. *Switch: How to change things when change is hard*. (Crown Business, 2010).
28. Holdgraf, C. [2i2c](#).
29. Dweck, C. S. *Mindset: The New Psychology of Success*. (Random House Publishing Group, 2006).
30. Robinson, E., Lowndes, J. S. S. & Robertson, T. [A chat with tara robertson](#). (2021).
31. Lowndes, J. S. S. & Horst, A. [Tidy data for efficiency, reproducibility, and collaboration](#). (2020).
32. Carpentries. [The Carpentries](#). (2022).
33. Quarto developer team. [Quarto](#). (2022).
34. PODAAC, NSIDC, LP DAAC & NASA Openscapes Mentors. [2021 cloud hackathon](#). (2021).
35. Fenwick, I. [A journey to data science: Tools for equity and diversity in STEM](#). (2022).
36. Moore, G. A. *Crossing the chasm, 3rd edition: Marketing and selling disruptive products to mainstream customers*. (Harper Business, 2014).
37. Friesz, A. *et al.* [3 takeaways for planning for the year of open science](#). (2022).
38. Johnson, A. E. & Wilkinson, K. K. *All we can save: Truth, courage, and solutions for the climate crisis*. (One World, 2020).