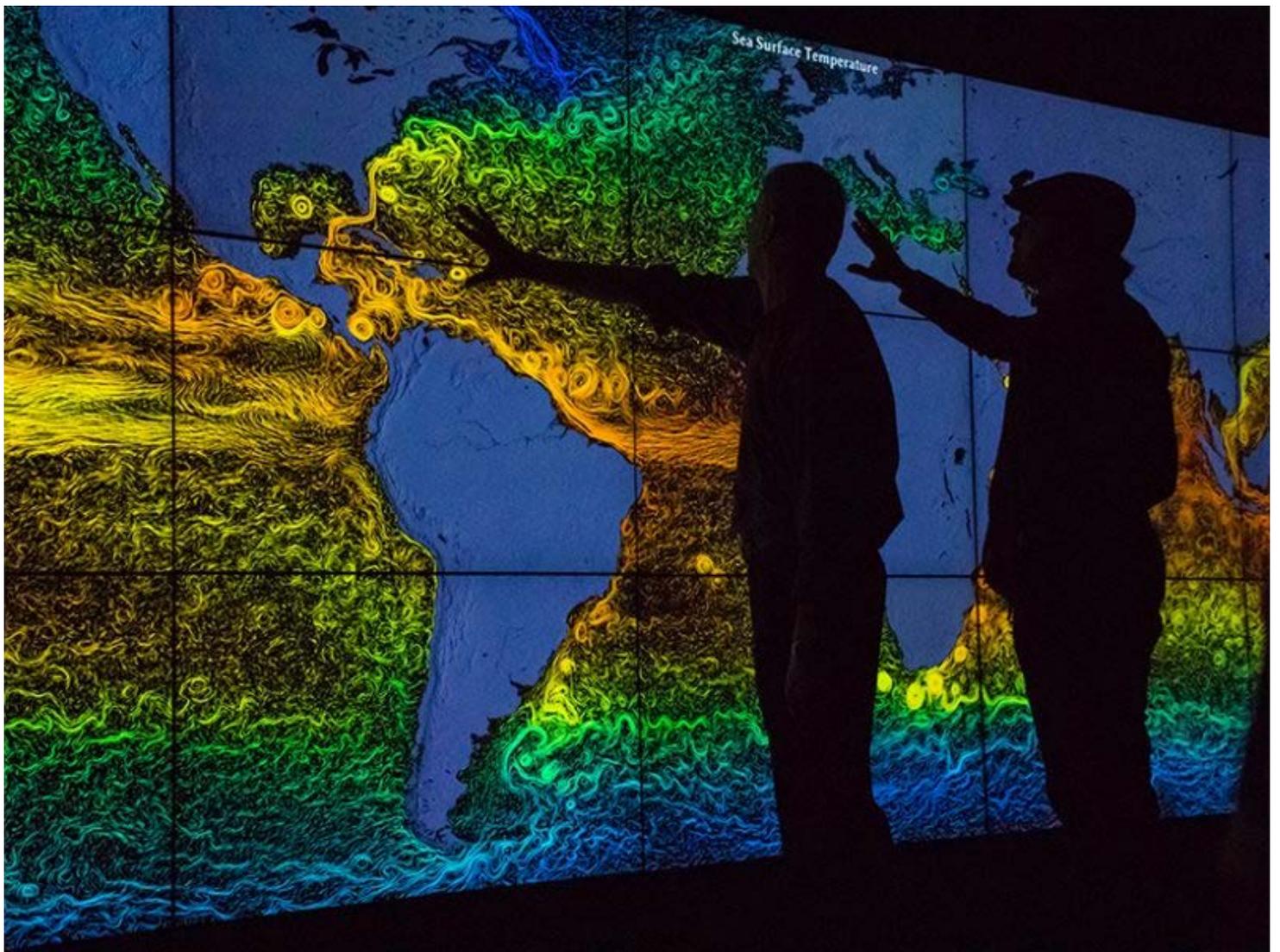




# Earth Science Is Ready for Preprints

The EarthArXiv preprint archive, in operation for almost a year and a half, makes the latest Earth science research available to a wider community.



Leonardo DiCaprio (right) and Earth scientist Piers Sellers discuss NASA's climate missions for a climate change documentary that DiCaprio is producing. Earth scientists can discuss their prepublication research with their colleagues without having to travel using the EarthArXiv preprint resource. Credit: [NASA/Goddard/Rebecca Roth, CC BY 2.0](#)

By Tom Narock, Evan B. Goldstein, Christopher A.-L. Jackson, Alodie A. Bubeck, Allison M. L. Enright, Jamie I. Farquharson, Alfonso Fernández, David Fernández-Blanco, Stéphanie Girardclos, Daniel E. Ibarra, Sabine K. Lengger, Anson W. Mackay, Victor Venema, Brandon Whitehead, and Jean-Paul Ampuero □ 23 April 2019

For years, publication in a peer-reviewed scientific journal has served as the official announcement that a piece of research has entered the accepted body of scientific knowledge. However, chances are good that the data, method innovations, and preliminary conclusions contained in a scientific paper have been circulating among the researchers' colleagues for a year or more before the paper is officially published. By the time a journal issue goes to the printing press, the research may have made significant progress beyond what the published papers document.

Preprints—published, non-peer-reviewed scholarly papers that often precede publication in a

peer-reviewed journal—have been a part of science since at least the 1960s [*Cobb*, 2017]. *ArXiv*, arguably the most prominent preprint system, has served the physics, mathematics, and computer science communities for more than 25 years.

Preprints and postprints enable rapid communication of results before and during peer review, as well as offering access for those without journal subscriptions.

Rapid citations and social media discussions provide evidence that preprints provide broad accessibility to academic work and lead to faster reuse within the scientific community [e.g., *Ginsparg*, 1997; *Gentil-Beccot et al.*, 2009; *Shuai et al.*, 2012; *Johansson et al.*, 2018]. Because preprints are freely accessible, they enable knowledge to spread beyond typical journal subscribers at university and research settings.

In recent years, as additional disciplines have started their own preprint servers, *EarthArXiv* has

emerged as a community-led initiative devoted to open scholarly communication in the Earth sciences. *EarthArXiv* began accepting preprints and postprints—the authors' nontypeset version of an accepted and peer-reviewed manuscript—from all subdomains of Earth science and related domains of planetary science during the *10th International Open Access Week* on 23 October 2017.

In addition to manuscripts, authors may also upload associated research materials, such as analysis software, data sets, and field notes. Preprints and postprints increase the openness of science, enabling rapid communication of results before and during peer review (preprints) as well as offering access for those without journal subscriptions (postprints).

*EarthArXiv* is both a preprint server and a volunteer community devoted to open scholarly communication. In our first year, *EarthArXiv* volunteer moderators accepted some 500 submissions, which had a total of about 60,000 downloads. We are taking these milestones as an opportunity to discuss the growth and next steps for *EarthArXiv*, as well as to encourage others to join us in this movement toward openness.

## EarthArXiv Hits the Ground Running

*EarthArXiv* opened its (digital) doors with a targeted social media campaign. After a rapid beginning, *EarthArXiv* has

received 10 new submissions per week on average (Figure 1). Scientific quality and perceived impact are not conditions for acceptance. Instead, a community-generated **moderation policy** is used to screen submissions for scope and required metadata (e.g., contact information and keywords).

Accepted submissions are assigned a Crossref Digital Object Identifier (DOI) to track provenance and enable citability.

The DOIs are integrated into a range of systems (e.g., Google Scholar), providing further dissemination and making it easier to track citations. EarthArXiv's 500 accepted submissions are associated with 1,419 unique authors and have attracted, on average, over 2,760 monthly downloads (Figure 1) [*Narock*, 2018b]. This monthly download rate excludes the first 2 months of operation, when interest was exceedingly high.



EarthArXiv opened its (digital) doors with a targeted social media campaign.

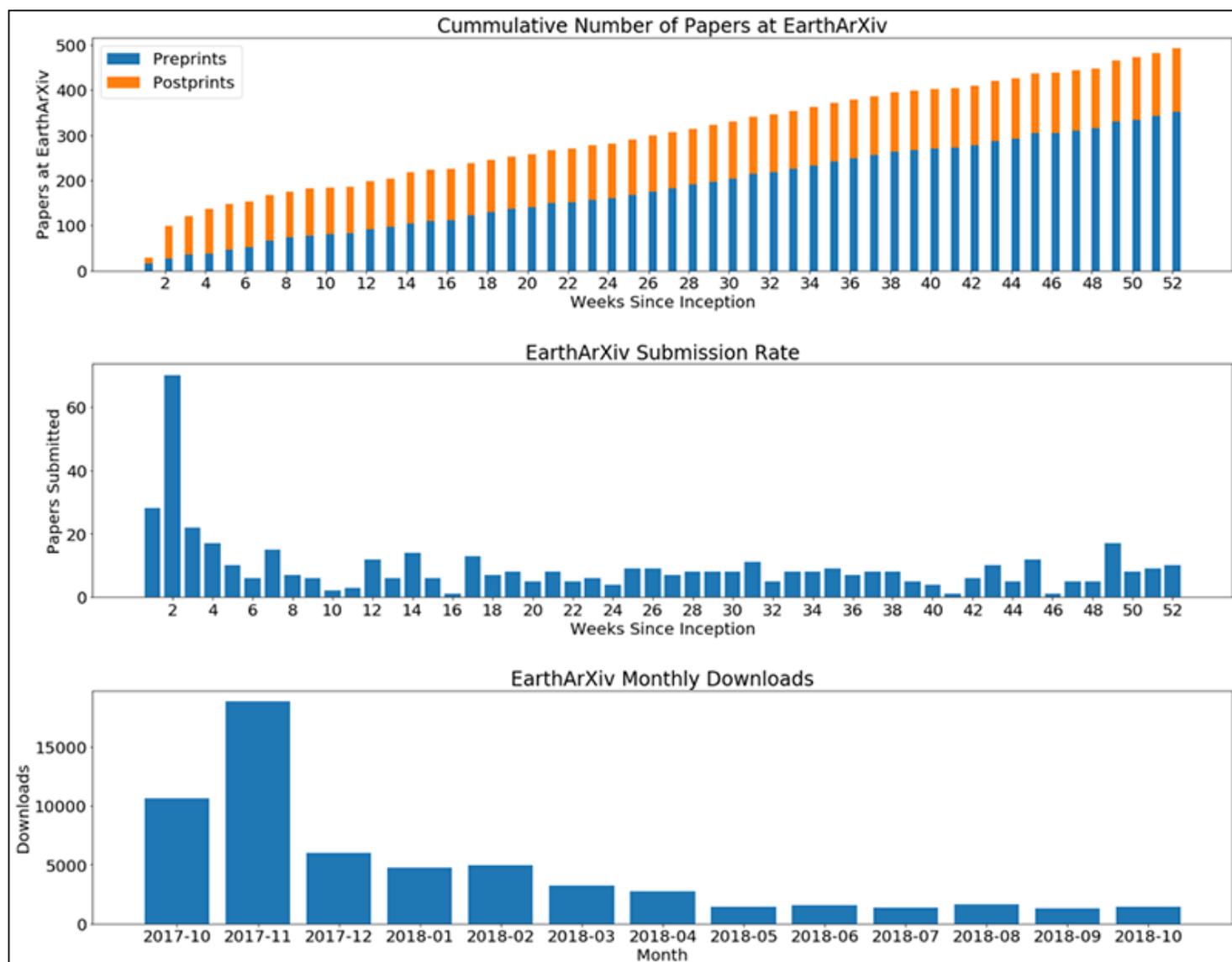


Fig. 1. EarthArXiv by the numbers: Since this archive of preprint and postprint Earth science articles was launched in late October 2017, there has been a steady stream of submissions and downloads. Unusually high numbers during the first 2 months of operation may indicate how highly this resource was anticipated prior to its launch.

Of the 500 accepted submissions, 235 (47%) are associated with a second DOI corresponding to a peer-reviewed journal. The remaining 265 submissions (53%) do not have a second peer-reviewed DOI and are thus considered preprints. We encourage authors to return to EarthArXiv and provide a second, journal-assigned DOI after their preprint is accepted in a peer-reviewed journal.

Because these two DOIs (the EarthArXiv-assigned DOI and the subsequent journal-supplied peer-reviewed DOI) correspond to different versions, they are not in conflict, and they can be “merged” to provide a single citation count. However, compliance with this policy is not mandatory, so some of the 265 preprints without peer-reviewed DOIs may also now be peer-reviewed publications. Thus, we may be underestimating the number of peer-reviewed

manuscripts in the repository.

For the 253 peer-reviewed articles in EarthArXiv, 89% are open-access publications.

Of the 235 EarthArXiv manuscripts currently associated with a second DOI from a peer-reviewed journal, 87 were initially deposited as preprints in EarthArXiv before publication in a peer-reviewed venue, and 140 were deposited in EarthArXiv after being published in a peer-reviewed journal. Because 352 manuscripts in EarthArXiv were deposited

before or during peer review, we can say with confidence that EarthArXiv is being used as a preprint server.

We cross-checked the DOIs of the 235 peer-reviewed articles in EarthArXiv with the [Unpaywall](#) API, which revealed 209 (89%) matches. Of these 209 matches, 15 of these DOIs (7%) appear in gold open-access journals—defined by publication in journals included in the Directory of Open Access Journals (DOAJ). This suggests that EarthArXiv itself is a source of open-access content.

## Spanning the Disciplines

We can gauge the range of subdisciplines that contribute to EarthArXiv by examining the disciplinary tags that submitting authors assigned to their manuscripts. The five most common tags (in order) are geology (136), geophysics and seismology (118), geomorphology (86), tectonics and structure (80), and sedimentology (79) [[Narock, 2018a](#), [2018b](#)].

In addition to self-assigned tags, the peer-reviewed journals in which EarthArXiv manuscripts appear also give a sense of the contributing subdisciplines. The 235 manuscripts on EarthArXiv that are associated with a peer-reviewed DOI come from [more than 100 unique journals](#) across a range of subject areas. Particularly of note for AGU members, 48 EarthArXiv manuscripts are linked to articles in AGU journals (20% of the 235 manuscripts having a peer-reviewed DOI), and eight AGU journals have more than one article in EarthArXiv:

- *Geophysical Research Letters* (12 articles)
- *Tectonics* (9 articles)
- *Journal of Geophysical Research: Solid Earth* (7 articles)
- *Water Resources Research* (5 articles)
- *Journal of Geophysical Research: Earth Surface* (5 articles)

- *Journal of Geophysical Research: Atmospheres* (3 articles)
- *Geochemistry, Geophysics, Geosystems* (3 articles)
- *Journal of Geophysical Research: Oceans* (2 articles)

The disciplinary tags and journal titles suggest that some subdisciplines have contributed to EarthArXiv more than others. For example, more papers have been submitted for seismology (116 submissions) than for hydrology (45 submissions) or geochemistry (also 45 submissions).

We take these statistics, and the increasing preprint-to-postprint ratio (Figure 1), as evidence that the Earth sciences are embracing preprints and **open access**. EarthArXiv enables manuscripts and data sets to be openly accessible. Other scientific fields have seen open accessibility lead to a range of benefits, including a **citation** advantage [e.g., *McKiernan et al.*, 2016; *Piwowar et al.*, 2018].

## Using EarthArXiv

We encourage all Earth, environmental, and planetary scientists, regardless of their subdiscipline, to contribute preprints (and postprints) to EarthArXiv and make their research open. Before interested authors submit an article, they should review EarthArXiv's **moderation policy**. Authors should also investigate information regarding target journal policies on preprints and postprints, which can be found on individual journal web pages, through **Sherpa/RoMEO**, by contacting relevant journal editors directly, and by contacting EarthArXiv (see our active Twitter account **@EarthArXiv**) and our community members.

Other scientific fields have seen open accessibility lead to a range of benefits, including a citation advantage.



Earth, environmental, and planetary scientists from all subdisciplines can contribute preprints and postprints to EarthArXiv. Credit: Tom Narock, modified from [Pexels](#)

Within the first year of EarthArXiv, we have successfully advocated for changing and clarifying preprint policies at a number of journals. With the opening of AGU's Earth and Space Science Open Archive ([ESSOAr](#)), we hope that the Earth, environmental, and planetary science community will continue to embrace preprints.

We are working to develop a preprint advocacy organization akin to Accelerating Science and Publication in biology ([ASAPBio](#)) through our network of EarthArXiv ambassadors. Raising awareness of preprints in all domains of Earth science is a key initiative, yet advocacy must also include increasing access to scientific literature for [geographically underrepresented groups](#) and for small institutions for which subscription costs are prohibitive.

Preprint comments are rare on other services, but EarthArXiv offers this capability as an option to readers.

Preprints can also be used for journal clubs (e.g., [PREReview](#)), which can give feedback to authors before the manuscript is published, enabling authors to incorporate comments into future revisions. Although preprints are not peer reviewed, the [Center for Open Science](#) (which supports EarthArXiv) has integration with [Hypothes.is](#), an open-source browser extension that allows public

commenting on EarthArXiv manuscripts.

Hypothes.is comments are visible to all other users, enabling efficient, open, and collaborative discussion that allows authors to receive feedback, even after publication. Preprint comments are rare on other services [*Kaiser*, 2017], but EarthArXiv offers this capability as an option to readers. Thus, EarthArXiv preprints are complementary to traditional peer review and journals, not a direct alternative.

Unrestricted access to scientific literature can accelerate the dissemination of research, and the potential societal impacts can be transformative [e.g., *Tennant et al.*, 2016]. Preprints are one means of facilitating this rapid dissemination. Preprints and postprints offer open access to scholarly literature that may otherwise be inaccessible throughout the review process or situated behind a paywall. We encourage you to [join the open science discussion](#) by [submitting a preprint](#) or [looking over our resources](#).

## Acknowledgments

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## References

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- Cobb, M. (2017), The prehistory of biology preprints: A forgotten experiment from the 1960s, *PLoS Biol.*, 15(11), e2003995, <https://doi.org/10.1371/journal.pbio.2003995>.
- Gentil-Beccot, A., S. Mele, and T. C. Brooks (2009), Citing and reading behaviours in high-energy physics: How a community stopped worrying about journals and learned to love repositories, *Scientometrics*, 84(2), 345–355, <https://doi.org/10.1007/s11192-009-0111-1>.
- Ginsparg, P. (1997), Winners and losers in the global research village, *Ser. Libr.*, 30(3–4), 83–95, [https://doi.org/10.1300/J123v30n03\\_13](https://doi.org/10.1300/J123v30n03_13).
- Johansson, M. A., et al. (2018), Preprints: An underutilized mechanism to accelerate outbreak science, *PLoS Med.*, 15(4), e1002549, <https://doi.org/10.1371/journal.pmed.1002549>.
- Kaiser, J. (2017), The preprint dilemma, *Science*, 357, 1,344–1,349, <https://doi.org/10.1126/science.357.6358.1344>.
- McKiernan, E. C., et al. (2016), How open science helps researchers succeed, *eLife*, 5, e16800,

<https://doi.org/10.7554/eLife.16800.001>.

Narock, T. (2018a), eartharxiv/API: First release of COS preprint querying code (version v1.0), Zenodo, Geneva, Switzerland, <http://doi.org/10.5281/zenodo.1467250>.

Narock, T. (2018b), narock/preprint\_analysis: First release of COS preprint analysis code (version v1.0), Zenodo, Geneva, Switzerland, <http://doi.org/10.5281/zenodo.1467248>.

Piwovar, H., et al. (2018), The state of OA: A large-scale analysis of the prevalence and impact of open access articles, *PeerJ*, 6, e4375, <https://doi.org/10.7717/peerj.4375>.

Shuai, X., A. Pepe, and J. Bollen (2012), How the scientific community reacts to newly submitted preprints: Article downloads, Twitter mentions, and citations, *PLoS One*, 7(11), e47523, <https://doi.org/10.1371/journal.pone.0047523>.

Tennant, J. P., et al. (2016), The academic, economic and societal impacts of Open Access: An evidence-based review, version 3, *F1000Research*, 5, 632, <https://doi.org/10.12688/f1000research.8460.3>.

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*30 April 2019: This article was corrected to reflect the number of DOIs cross-checked by the authors and the percentage appearing in open-access journals.*

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