

## Earth Science is Ready for Preprints: The First Year of EarthArXiv

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Preprints — scholarly papers that precede publication in a peer-reviewed journal — speed the delivery and accessibility of academic work and lead to faster reuse by the scientific community, as evidenced by rapid citations and social media discussions (e.g., Gentil-Beccot 2009; Shuai et al 2012; Johansson et al. 2018). Being freely accessible, preprints enable knowledge to spread beyond typical journal subscribers at university and research settings. The original preprint repository — [ArXiv](https://arxiv.org/) — has been in use for over 25 years and covers primarily physics, mathematics, and computer science. In recent years other disciplines have started their own preprint servers and EarthArXiv has emerged as a community-led initiative devoted to open scholarly communication. EarthArXiv became the first preprint server for the Earth Sciences on October 23<sup>rd</sup>, 2017, during the 10th International Open Access Week when it began accepting preprints and also postprints — the non-typeset version of a published article — from all subdomains of Earth science and related domains of planetary science. Both 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). In our first year, EarthArXiv accepted ~500 submissions which had a total of ~60,000 downloads — we are taking these milestones as an opportunity to discuss the growth and next steps for EarthArXiv, as well as encourage others to join us in this movement toward openness.

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). Instead of evaluating the scientific quality of a submission, a moderation policy<sup>1</sup> is used to screen submissions for scholarly Earth and Planetary Science content. Accepted submissions are assigned a Digital Object Identifier (DOI) to track provenance and enable citability. EarthArXiv's 500 accepted submissions are associated with 1,419 unique authors and have attracted, on average, 2763 monthly downloads (Figure 1). We note that this monthly download rate excludes the first two months of operation when interest was exceedingly high.

Of the 500 accepted submissions, 235 (47%) are associated with a second digital object identifier (DOI) corresponding to a peer-reviewed journal, and 265 (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. However, compliance with this policy is not mandatory, so the 53% of EarthArXiv manuscripts without a peer-reviewed DOI is likely an underestimate of the number of non-peer reviewed manuscripts in the repository — i.e., some of the 265 preprints without peer-reviewed DOIs may also be peer-reviewed publications. Out of the 235 EarthArXiv manuscripts currently associated with a second DOI from a peer-reviewed journal, 87 were initially deposited in EarthArXiv before publication in a peer-reviewed venue (as preprints), and 140 were deposited in EarthArXiv after the creation of a second peer-reviewed DOI (as postprints). With 352 manuscripts in EarthArXiv being deposited before peer-review, we can say with confidence that EarthArXiv is being used as a preprint server.

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<sup>1</sup> <https://eartharxiv.github.io/moderation.html>

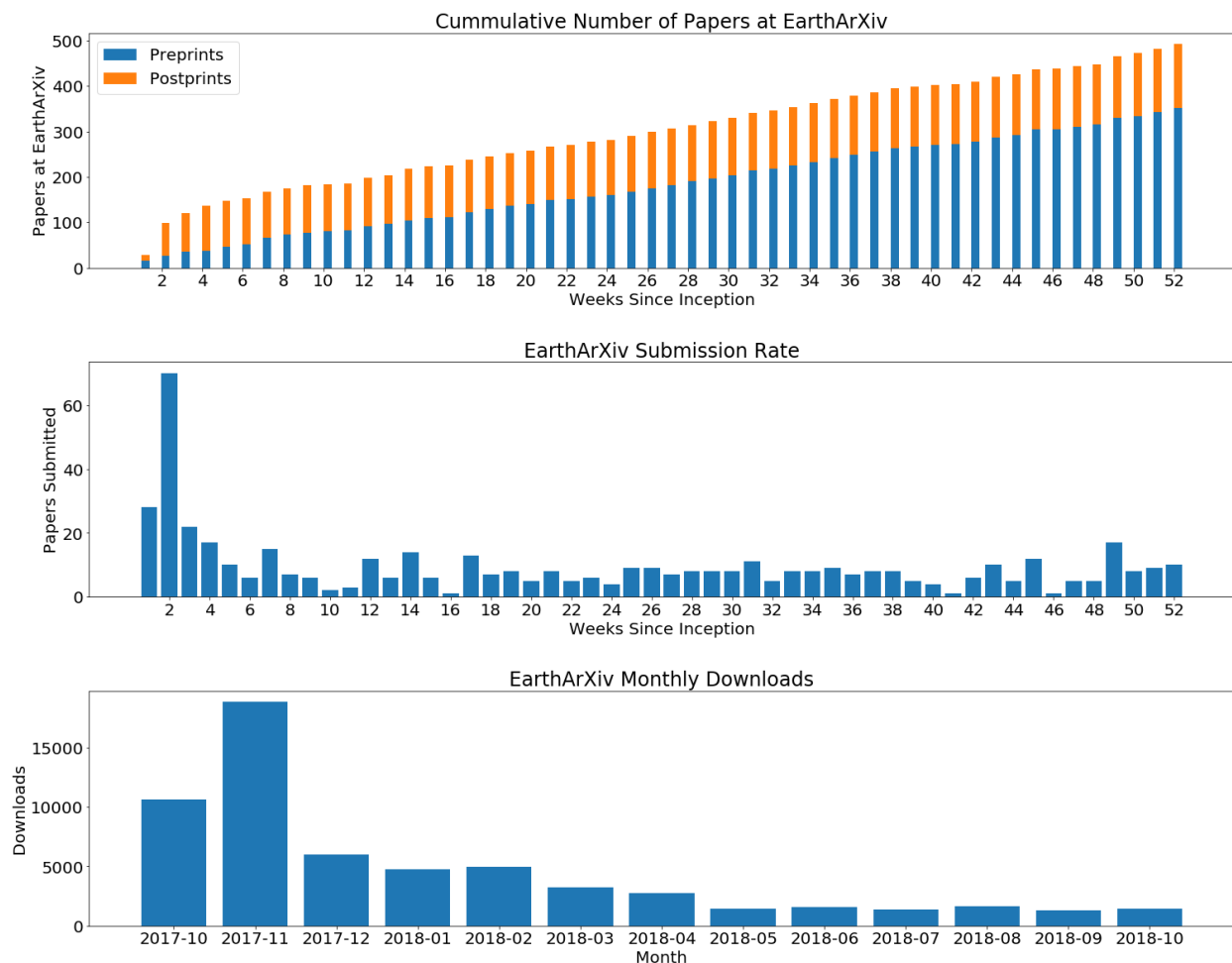


Figure 1. EarthArXiv cumulative submissions by week, weekly submissions, and monthly downloads. Software and data used in this analysis are freely available (Narock 2018a; 2018b).

We can gauge the range of sub-disciplines that contribute to EarthArXiv by examining the disciplinary tags assigned to manuscripts by the submitting author. The prevalence of each tag is provided in Narock (2018a; 2018b) and the five most common (in order) are: Geology (136), Geophysics and Seismology (118), Geomorphology (86), Tectonics and Structure (80), and Sedimentology (79). In addition to self-assigned tags, EarthArXiv manuscripts that appear in a peer-reviewed journal also give a sense of the contributing sub-disciplines. 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 (Supplementary Table<sup>2</sup>). Particularly of note for American Geophysical Union (AGU) members — 48 EarthArXiv manuscripts are linked to AGU articles (20% of the 235 manuscripts having a peer-reviewed DOI), and 8 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

<sup>2</sup> [https://github.com/ebgoldstein/BAtools/blob/master/EarthArXiv/Top\\_Journals.csv](https://github.com/ebgoldstein/BAtools/blob/master/EarthArXiv/Top_Journals.csv)

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). Both the disciplinary tags and journal titles suggest that some sub-disciplines have embraced EarthArXiv more than others. For example — geophysics, sedimentology and tectonic/structure submissions are more numerous than hydrology, geochemistry, climate/atmospheric science and planetary science.

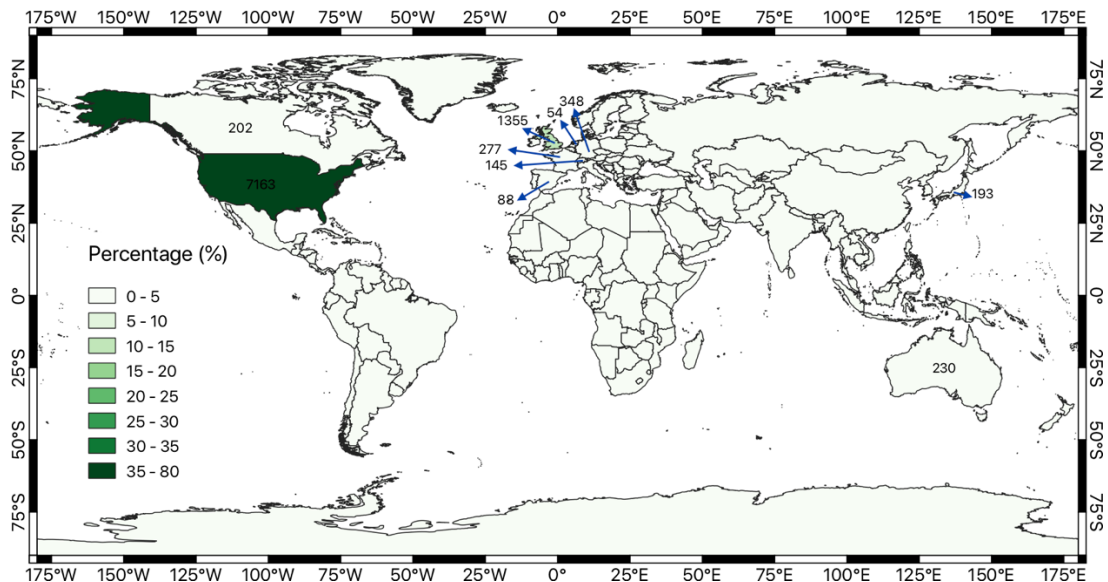


Figure 2. Visits to EarthArXiv.org in the first months of operation. Colors indicate percentage of total visits while numbers indicate total number of visits.

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. These statistics, and web site visit analytics (Figure 2), will guide our outreach efforts in year two and we encourage all Earth, Environmental and Planetary scientists, regardless of your subdiscipline, to contribute preprints (and postprints) to EarthArXiv and make your research open. EarthArXiv enables both manuscripts and datasets to be openly accessible, which has a range of benefits including a citation advantage (e.g., McKiernan et al., 2017; Piwowar et al., 2018). Interested authors should review EarthArXiv’s moderation policy prior to submission. 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<sup>3</sup>, by contacting relevant journal editors directly, and by contacting EarthArXiv (see our active twitter account @EarthArXiv) and our community members — within the first year we have had success advocating for changing and clarifying preprint policies at a number of journals. With the opening of a second preprint service — AGU’s 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 ASAPbio through our network of EarthArXiv ambassadors. Advocacy efforts will focus on increasing submission for subdisciplines that have less representation on EarthArXiv, and encouraging researchers to cite

<sup>3</sup> <http://www.sherpa.ac.uk/romeo/search.php>

preprints. Preprints can also be used for journal clubs, with the benefit being that feedback can be given to authors before the manuscript is published and enabling authors to incorporate comments into future revisions (e.g., PREreview). Though 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 post-publication).

Unrestricted access to scientific literature can accelerate the dissemination of research, potentially leading to transformative societal impacts (e.g., Tennant et al., 2016). Preprints are one means of facilitating this rapid dissemination, and both 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.

Acknowledgement: We thank the EarthArXiv community – all those who have submitted manuscripts and the Center for Open Science who hosts EarthArXiv. We are also grateful to the EarthArXiv Advisory Council and our international group of Community Ambassadors who advocate for open science and have provided valuable feedback on this article.

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