OpenScience

October 28, 2019

1 Open Science: Theory and Practice

1.1 Overview and Objectives

"Open Science" is something of an umbrella term encompassing everything related to reproducible, transparent science.

There have been some complaints that Open Science is amorphous and ambiguous, that its prescription for reproducibility is not, in itself, reproducible.

However, Open Science is broadly defined and meant to appeal to every area of science, from life sciences to computational sciences to theoretical sciences. What Open Science looks like is field-specific, but there are general principles that cut across all fields of science.

By the end of this lecture, you should be able to

- Define "open science" and its importance to scientific inquiry
- Recall the core strategies for reproducing and replicating results
- Connect open science practices to case studies in research misconduct

1.1.1 Case Study 1 (Andie Anderson)

Dr. Bob's major clinical research project is a prospective, longitudinal study of changes over time in plasma levels of protein X and their association with cardiovascular disease. If it is successful it would be publishable in a high-impact journal and give a substantial boost to his achieving tenure.

Dr. Miriam is offered an opportunity to analyze data from the first 3 time points of his protein X study. She performs a statistical analysis on a spreadsheet provided by Dr. Bob, but her results are not consistent with the hypothesis Dr. Bob wrote in his grant applications as she found no association of Protein X with cardiovascular risk. When Dr. Miriam presents her analysis to Dr. Bob, he is noncommittal and suggests that she has incorrectly analyzed the data. He says he will check her work and the next week, Dr. Bob returns the spreadsheet to Dr. Miriam, explaining that he has corrected a few mistaken data entries. He asks her to redo the analysis.

Office of Intramural Research. (2014). Differentiating between Honest Discourse and Research Misconduct. Retrieved from https://oir.nih.gov/sites/default/files/uploads/sourcebook/documents/ethical_conduct/case_studies-2014.pdf

1.2 Part 1: What is "Open Science"?

Simply put, Open Science is the **movement to make all scientific data, methods, and materials accessible to all levels of society**.

Why is this a good thing?

- The vast majority of research is publicly funded; it would seem logical that the public have access to it!
- Open and transparent research makes peer review and replication much easier.
- There is some convincing evidence that Open Science gives projects more downstream impact in the scientific community

Nonetheless, there are some downsides to making everything openly available.

- The deluge of science will overwhelm already heavily-burdened researchers.
- The tools could be used for more nefarious purposes (influenza strain, GPT-2 language model).

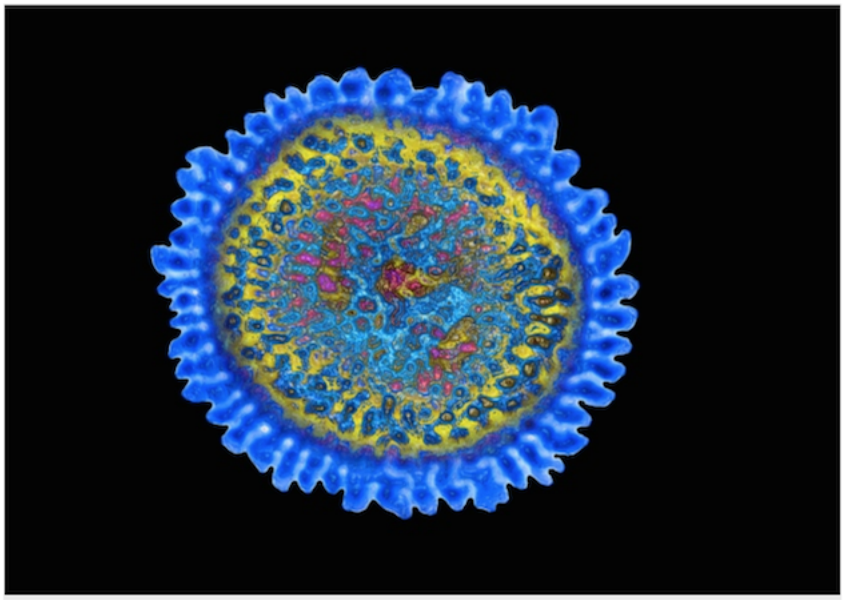
Work resumes on lethal flu strains

Study of lab-made viruses a 'public-health responsibility'.

Declan Butler

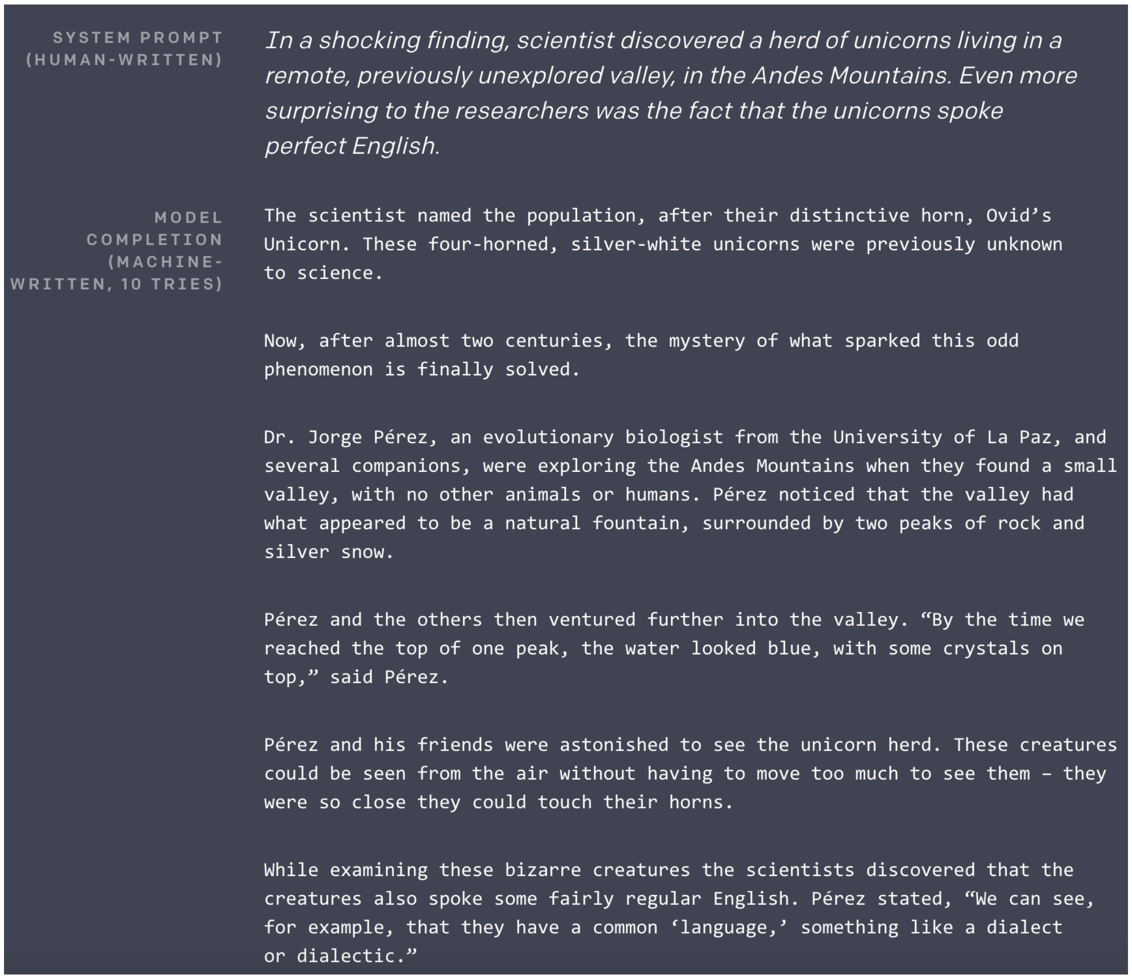
23 January 2013

PDF Rights & Permissions


JAMES CAVALLINI/SPL

A moratorium on research that modifies the potential virulence of avian influenza virus has now been lifted.

An international group of scientists this week ended a year-long moratorium on controversial work to engineer potentially deadly strains of the H5N1 avian flu virus in the lab.


SYSTEM PROMPT (HUMAN-WRITTEN)

In a shocking finding, scientist discovered a herd of unicorns living in a remote, previously unexplored valley, in the Andes Mountains. Even more surprising to the researchers was the fact that the unicorns spoke perfect English.

MODEL COMPLETION (MACHINE-WRITTEN, 10 TRIES)

```
The scientist named the population, after their distinctive horn, Ovid's
Unicorn. These four-horned, silver-white unicorns were previously unknown
to science.

Now, after almost two centuries, the mystery of what sparked this odd
phenomenon is finally solved.

Dr. Jorge Pérez, an evolutionary biologist from the University of La Paz, and
several companions, were exploring the Andes Mountains when they found a small
valley, with no other animals or humans. Pérez noticed that the valley had
what appeared to be a natural fountain, surrounded by two peaks of rock and
silver snow.

Pérez and the others then ventured further into the valley. "By the time we
reached the top of one peak, the water looked blue, with some crystals on
top," said Pérez.

Pérez and his friends were astonished to see the unicorn herd. These creatures
could be seen from the air without having to move too much to see them – they
were so close they could touch their horns.

While examining these bizarre creatures the scientists discovered that the
creatures also spoke some fairly regular English. Pérez stated, "We can see,
for example, that they have a common 'language,' something like a dialect
or dialectic."
```

My opinion–as you've probably guessed by the title of the lecture–is that the benefits of good Open Science practices outweigh the drawbacks, for the following reason:

I learn best when I can dig in and get my hands dirty.

Reading a paper or even a blog post that vaguely describes a method is one thing. Actually seeing the code, changing it, and re-running it to observe the results is something else entirely and, so I believe, is vastly superior in educational terms.

The scientific deluge is legitimate, though this was already happening even without the addition of open data, open access, and open source. And it would seem that, while we do absolutely need to exercise caution in our research and not pursue the ends by any means necessary, science is the pursuit of knowledge for its own sake and that should also be respected to the highest degree.

To that end, there are **six** main themes that comprise the Open Science guidelines.

1. Open data: all data used in the project should be made available.
2. Open source: all code written in the project should be publicly available.
3. Open methods: the exact procedure of the project is publicly documented.
4. Open review: correspondence between reviewers and authors is public.
5. Open access: resulting publications are publicly available.
6. Open education: all education materials are publicly available.

1.2.1 1: Open Data

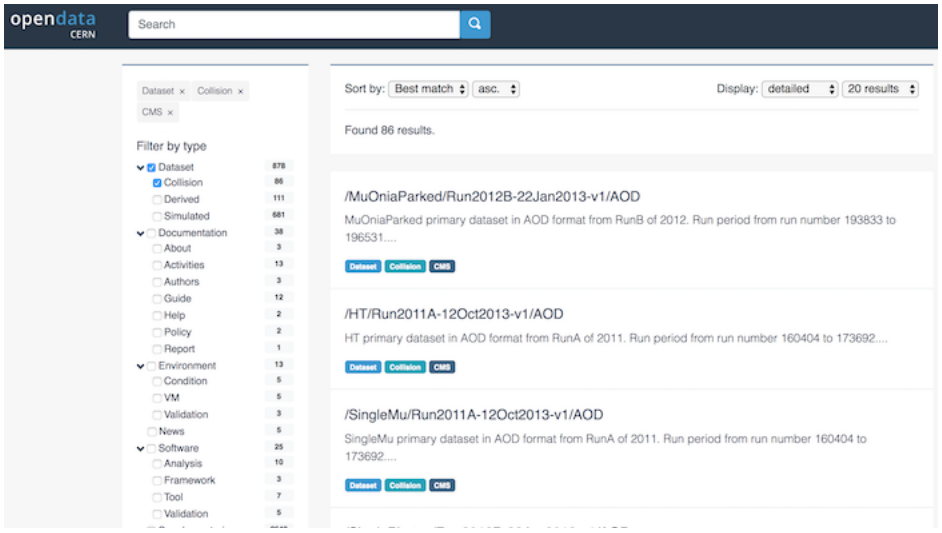
If you had to pick the “core” of Open Science, this would probably be it. All of the data used in your study and experiments are published online.

This is definitely a shift from prior precedent; most raw data from scientific experiments remain cloistered.

The situation is further complicated by Terms of Service agreements that prohibit the sharing of data collected. - For example: if you hooked up a Python client to listen to and capture public Twitter posts, you are forbidden from sharing the Twitter data publicly. - Which seems odd, given that the data are public anyway, but there you go.

Repositories and online data banks have sprung up around this idea. Many research institutions host their own open data repositories, as do some large tech companies.

- CERN, the organization behind the Large Hadron Collider, has posted its data online: http://opendata.cern.ch/about/CMS



Dataset × Collision × CMS ×

Filter by type

Dataset	878
Collision	86
Derived	111
Simulated	681
Documentation	38
About	3
Activities	13
Authors	3
Guide	12
Help	2
Policy	2
Report	1
Environment	13
Condition	5
VM	5
Validation	3
News	5
Software	25
Analysis	10
Framework	3
Tool	7
Validation	5

Sort by: Best match asc. Display: detailed 20 results

Found 86 results.

/MuOniaParked/Run2012B-22Jan2013-v1/AOD

MuOniaParked primary dataset in AOD format from RunB of 2012. Run period from run number 193833 to 196531....

Dataset Collision CMS

/HT/Run2011A-12Oct2013-v1/AOD

HT primary dataset in AOD format from RunA of 2011. Run period from run number 160404 to 173692....

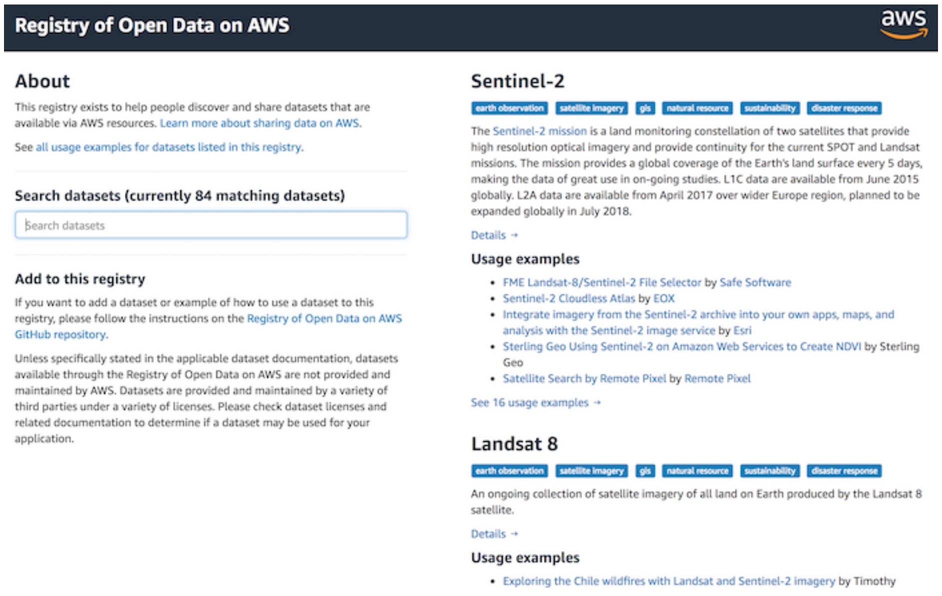
Dataset Collision CMS

/SingleMu/Run2011A-12Oct2013-v1/AOD

SingleMu primary dataset in AOD format from RunA of 2011. Run period from run number 160404 to 173692....

Dataset Collision CMS

- Amazon has released its own set of large public datasets: https://aws.amazon.com/public-data-sets/



Registry of Open Data on AWS

About

This registry exists to help people discover and share datasets that are available via AWS resources. Learn more about sharing data on AWS.

See all usage examples for datasets listed in this registry.

Search datasets (currently 84 matching datasets)

Search datasets

Add to this registry

If you want to add a dataset or example of how to use a dataset to this registry, please follow the instructions on the Registry of Open Data on AWS GitHub repository.

Unless specifically stated in the applicable dataset documentation, datasets available through the Registry of Open Data on AWS are not provided and maintained by AWS. Datasets are provided and maintained by a variety of third parties under a variety of licenses. Please check dataset licenses and related documentation to determine if a dataset may be used for your application.

Sentinel-2

earth observation satellite imagery gis natural resource sustainability disaster response

The Sentinel-2 mission is a land monitoring constellation of two satellites that provide high resolution optical imagery and provide continuity for the current SPOT and Landsat missions. The mission provides a global coverage of the Earth's land surface every 5 days, making the data of great use in on-going studies. L1C data are available from June 2015 globally. L2A data are available from April 2017 over wider Europe region, planned to be expanded globally in July 2018.

Details →

Usage examples

- FME Landsat-8/Sentinel-2 File Selector by Safe Software
- Sentinel-2 Cloudless Atlas by EOX
- Integrate imagery from the Sentinel-2 archive into your own apps, maps, and analysis with the Sentinel-2 image service by Esri
- Sterling Geo Using Sentinel-2 on Amazon Web Services to Create NDVI by Sterling Geo
- Satellite Search by Remote Pixel by Remote Pixel

See 16 usage examples →

Landsat 8

earth observation satellite imagery gis natural resource sustainability disaster response

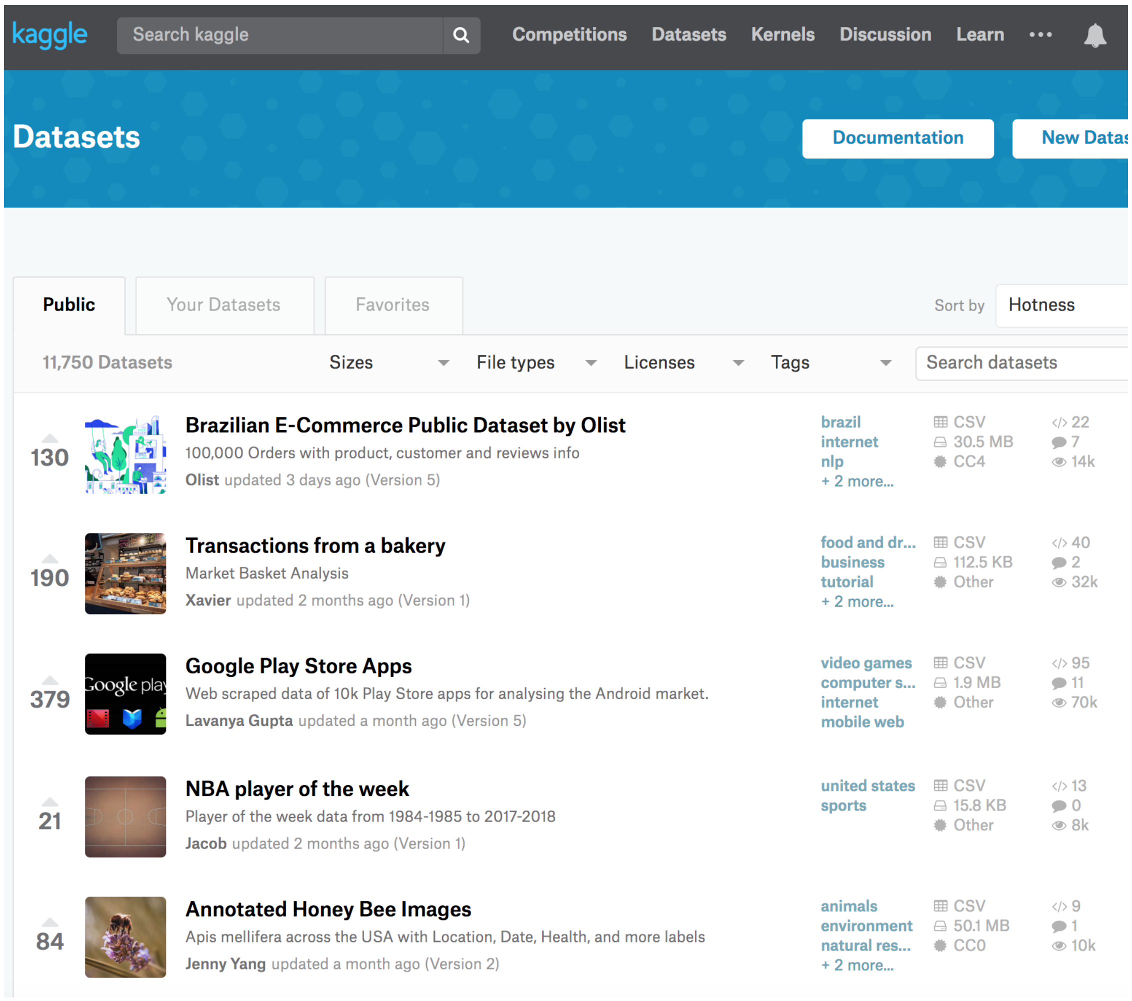
An ongoing collection of satellite imagery of all land on Earth produced by the Landsat 8 satellite.

Details →

Usage examples

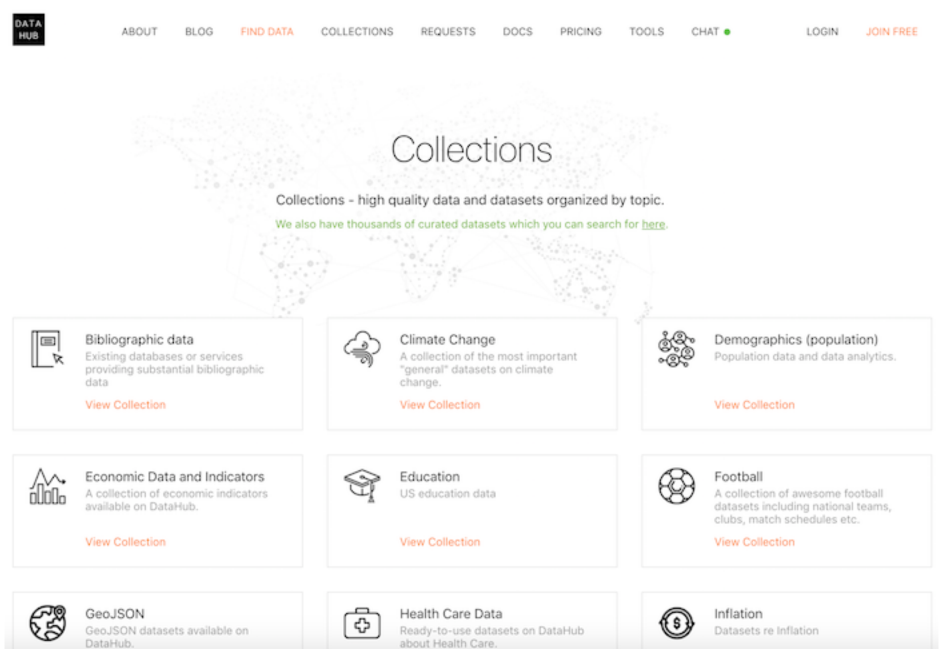
- Exploring the Chile wildfires with Landsat and Sentinel-2 imagery by Timothy

- Kaggle also has some pretty fantastic open datasets from its competitions: https://www.kaggle.com/datasets



Votes	Dataset	Tags	Files	Stats
130	**Brazilian E-Commerce Public Dataset by Olist** 100,000 Orders with product, customer and reviews info **Olist** updated 3 days ago (Version 5)	brazil internet nlp + 2 more...	CSV 30.5 MB CC4	22 7 14k
190	**Transactions from a bakery** Market Basket Analysis **Xavier** updated 2 months ago (Version 1)	food and dr... business tutorial + 2 more...	CSV 112.5 KB Other	40 2 32k
379	**Google Play Store Apps** Web scraped data of 10k Play Store apps for analysing the Android market. **Lavanya Gupta** updated a month ago (Version 5)	video games computer s... internet mobile web	CSV 1.9 MB Other	95 11 70k
21	**NBA player of the week** Player of the week data from 1984-1985 to 2017-2018 **Jacob** updated 2 months ago (Version 1)	united states sports	CSV 15.8 KB Other	13 0 8k
84	**Annotated Honey Bee Images** Apis mellifera across the USA with Location, Date, Health, and more labels **Jenny Yang** updated a month ago (Version 2)	animals environment natural res... + 2 more...	CSV 50.1 MB CC0	9 1 10k

- DataHub is a general-purpose repository for anyone to submit their own datasets. https://datahub.io/en/dataset



Collections

Collections - high quality data and datasets organized by topic.

We also have thousands of curated datasets which you can search for here.

Bibliographic data
Existing databases or services providing substantial bibliographic data

Climate Change
A collection of the most important "general" datasets on climate change.

Demographics (population)
Population data and data analytics.

Economic Data and Indicators
A collection of economic indicators available on DataHub.

Education
US education data

Football
A collection of awesome football datasets including national teams, clubs, match schedules etc.

GeoJSON
GeoJSON datasets available on DataHub.

Health Care Data
Ready-to-use datasets on DataHub about Health Care.

Inflation
Datasets re Inflation

I encourage you to google "open datasets" in your area of interest! Go check them out!

1.2.2 2: Open Source

This is probably the part you're most familiar with. Any (and *all*) code that's used in your project is published somewhere publicly for download.

There are certainly conditions where code can't be fully open sourced–proprietary corporate secrets, pending patents, etc–but to fully adhere to Open Science, the code has to be made completely available for anyone.

Like with open data, there are numerous **repositories** across the web that specialize in providing publicly-available versioning systems for both maintaining and publishing your code.

- GitHub is easily the most popular, and is where the materials for this lecture are published! https://github.com/

GitHub

- BitBucket is another option that also uses git to manage team codebases https://bitbucket.org/

ATLASSIAN
Bitbucket

- SourceForge is one of the oldest and most well-known online repositories https://sourceforge.net/

source
forge

If you’re looking for the actual source code, it’s pretty likely to be on one of these sites.

1.2.3 3: Open Methods

This is probably the trickiest item. How does one make *methods* reproducible?

Open source code is part of it, but even more important is the effort put into making the methods in the code understandable. This takes several forms:

- Documentation, both as accompanying doc files (e.g. JavaDoc) as well as in-code comments
- Proofs of the methods devised if they’re novel, or references to their original sources
- Pre-packaged examples that will run with little or no prior configuration on the user’s part
- Pre-registered methods *before* any work is conducted
- Self-contained virtual container scripts that satisfy all the prerequisites

1.2.4 Case Study 2 (Ummay Mowshome Jahan)

Hwang Woo-Suk, a South-Korean researcher, started his career as a scientist after getting his PhD at Seoul National University (SNU), and specialized in the reproduction of cattle. Working with in vitro fertilization and cloning of animals for years at SNU, he became a famous scientist in South-Korea, claiming to have cloned cows and pigs and genetically engineering a pig to produce human organs (among other accomplishments). He then began research on stem cells, and acquired powerful friends in the government, most notably the president himself, apparently demonstrating how he cured a sick dog using stem cell treatment. He also gained popularity in the public by appearing in media with sensational demonstrations. This led to his research being heavily financed, through government funds and donations from the public. In 2004 and 2005, articles were published by Hwang and colleagues, and these were the first times anyone could seemingly prove having created stem cells from cloning. These articles, being published in the highly respected journal Science, and the fact that he had collaborated with Dr. Gerald Schatten (a famous American scientist) on the two papers, was evidence for his earlier unpublished experiments.

Then, after a year, Hwang published an article in Nature describing the cloning of an Afghan dog, named Snuppy. Hwang was already a national hero in South Korea. South Korea was now regarded as the leading country of stem cell research, and the Korean people placed high expectations for him and his work. A survey showed that 30% of women said they would donate egg cells for Hwangs research.

However, already in 2004, an article in Nature reported that two junior scientists working with Hwang had donated eggs for the for the 2004 Science paper. Then, a South Korean investigative TV-show started doing research about his methods, reported that he had forced these junior scientists into donating their eggs. And that DNA-test showed that of one of the cell lines in the 2005 paper did not match the DNA of the somatic tissue donor. Science reported that a review board for Seoul National University in an investigation found out that donors had received payment for the eggs. Then, things started to fall apart. Following accusations of fabrication, Hwang informed Science that some of the pictures in the 2005 article were taken from another article (the pictures were later admitted being faked). One of Hwangs collaborators then told a news network that "there are no cloned embryonic stem cells". Hwang and Dr. Schatten later retracted their article from Science, stating that analyzing the data had led to the conclusion that "the results could not be trusted". An investigation of Hwangs work by Seoul National University concluded that large amounts of the 2005 Science paper had been fabricated.

Hwang undoubtedly made important contributions to science and stem cell research. The cloning of Snuppy appears to be genuine, and his nuclear extrusion technique was also used by Dr. Schatten and colleagues successfully cloning a monkey. The Hwang affair is therefore a remarkable story about a talented researcher that ended up wasting his career and talent.

1. What types of research misconducts are present in this case?
2. What type of consequence researchers can face after this type of research misconduct is occurred?

- https://stemcellswebzine.wordpress.com/2011/04/26/the-hwang-scandal/
- https://www.nature.com/news/2005/051219/full/news051219-3.html?utm_source=commission_junction&utm_medium=affiliate

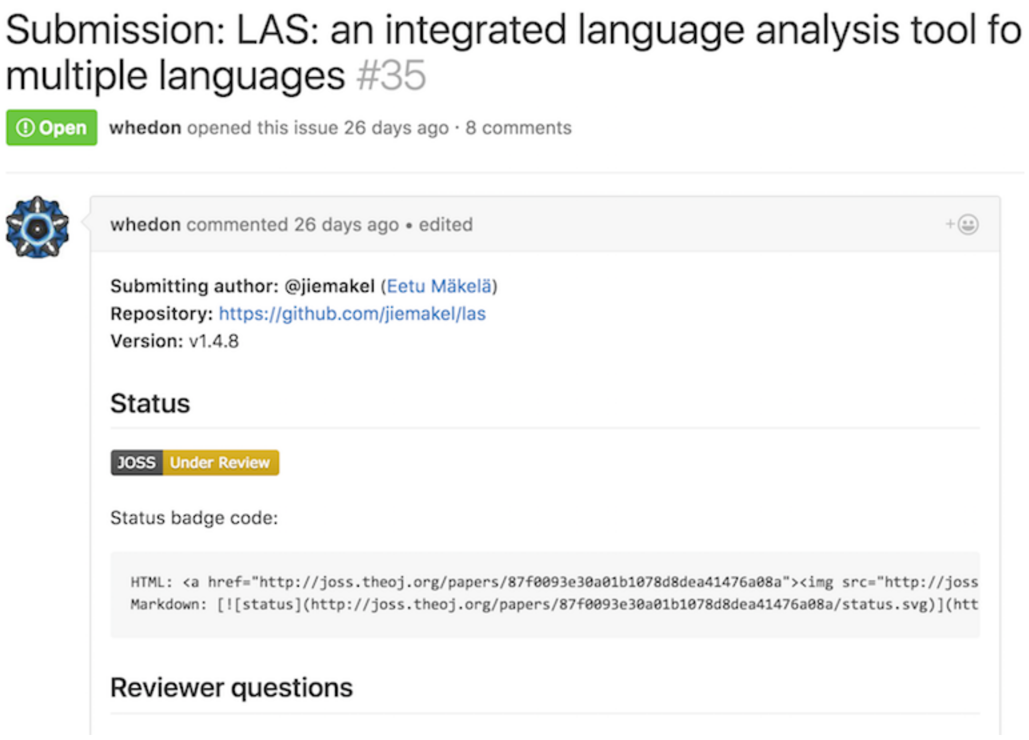
1.2.5 4: Open Review

The cornerstone of the scientific process is that of *peer review*: your peers, your colleagues, your fellow researchers should vet your work before it's officially included as part of the scientific literature.

However, this process is fraught with ambiguity and opacity. Conflicts of interest can potentially lead to biased reviews (if you're reviewing the paper of a competitor, it isn't exactly in your best interest to go easy on them), and it can be difficult to assess a published paper in the public sphere without a trail of edits from which to begin.

Online open review journals such as **The Journal of Open Source Software (JOSS)** have begun proliferating to address this shortcoming.

Reviews essentially take the form of GitHub tickets, and researchers in the field can discuss and debate the merits of the work in an open forum.



Submission: LAS: an integrated language analysis tool fo
multiple languages #35

Open whedon opened this issue 26 days ago · 8 comments

whedon commented 26 days ago • edited

Submitting author: @jiemakel (Eetu Mäkelä)
Repository: https://github.com/jiemakel/las
Version: v1.4.8

Status

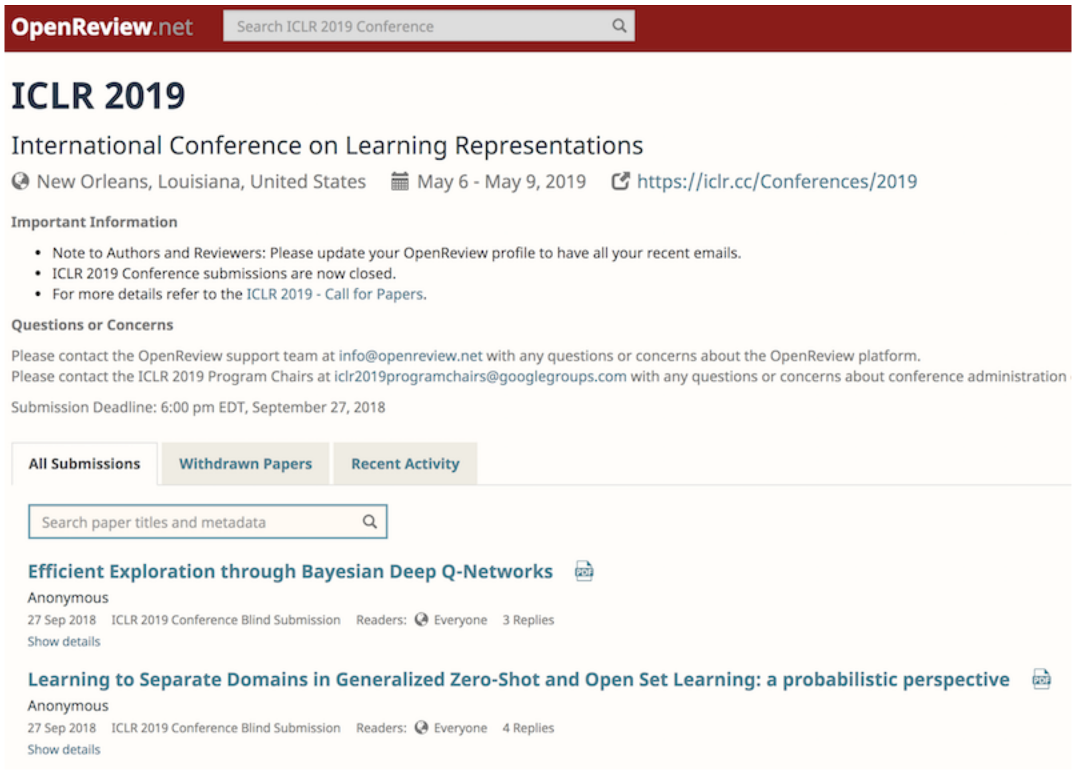
JOSS Under Review

Status badge code:

```
HTML: <a href="http://joss.theoj.org/papers/87f0093e30a01b1078d8dea41476a08a"><img src="http://joss
Markdown: [![status](http://joss.theoj.org/papers/87f0093e30a01b1078d8dea41476a08a/status.svg)](htt
```

Reviewer questions

There's also a site, called "Open Review", where conferences can elect to have their papers openly and publicly reviewed, threaded-comment style.



OpenReview.net Search ICLR 2019 Conference

ICLR 2019

International Conference on Learning Representations

New Orleans, Louisiana, United States May 6 - May 9, 2019 https://iclr.cc/Conferences/2019

Important Information

- Note to Authors and Reviewers: Please update your OpenReview profile to have all your recent emails.
- ICLR 2019 Conference submissions are now closed.
- For more details refer to the ICLR 2019 - Call for Papers.

Questions or Concerns

Please contact the OpenReview support team at info@openreview.net with any questions or concerns about the OpenReview platform.
Please contact the ICLR 2019 Program Chairs at iclr2019programchairs@googlegroups.com with any questions or concerns about conference administration

Submission Deadline: 6:00 pm EDT, September 27, 2018

All Submissions | Withdrawn Papers | Recent Activity

Search paper titles and metadata

Efficient Exploration through Bayesian Deep Q-Networks
Anonymous
27 Sep 2018 ICLR 2019 Conference Blind Submission Readers: Everyone 3 Replies
Show details

Learning to Separate Domains in Generalized Zero-Shot and Open Set Learning: a probabilistic perspective
Anonymous
27 Sep 2018 ICLR 2019 Conference Blind Submission Readers: Everyone 4 Replies
Show details

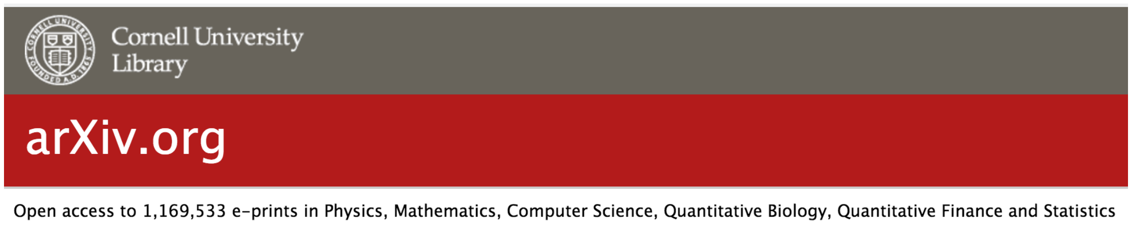
Would you be amenable to having your publication reviewed publicly, where both your reviewers' feedback and your responses are publicly viewable?

1.2.6 5: Open Access

Once a project is published, the paper should be made publicly available for anyone, anywhere to download and read for themselves.

Easily the most popular open access paper repository is **arXiv** (pronounced "archive"... geddit?). Other repositories modeled directly after its success, such as bioRxiv, have already started springing up.

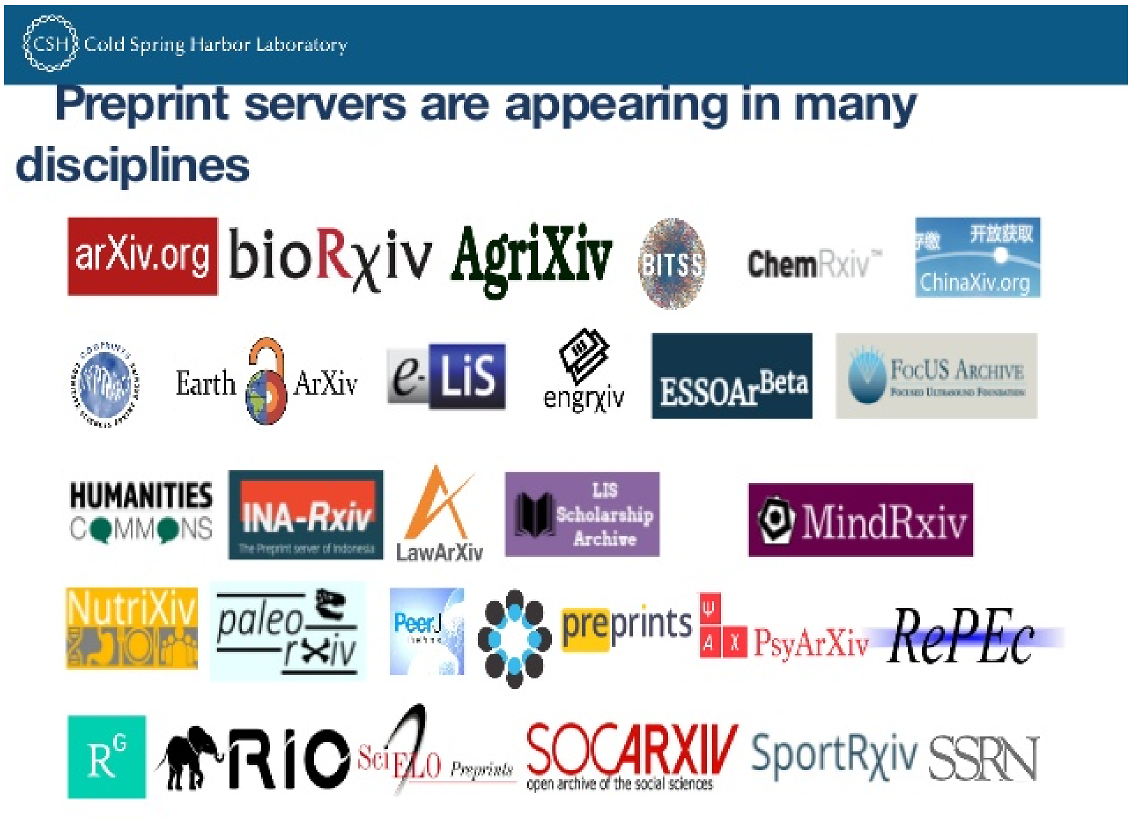
arXiv is already *hugely* popular.



Open access to 1,169,533 e-prints in Physics, Mathematics, Computer Science, Quantitative Biology, Quantitative Finance and Statistics

In fact, so many papers are archived here on a regular basis, that someone created their own open source "aggregator" service: http://www.arxiv-sanity.com , which collates the papers you want to read and helps filter out all the others.

Preprints have become *so* popular, that versions of arXiv have popped up for almost every area!


Cold Spring Harbor Laboratory

Preprint servers are appearing in many disciplines

arXiv.org
bioRχiv
AgriXiv
BITSS
ChemRxiv
ChinaXiv.org
EarthArXiv
e-LiS
engrχiv
ESSOAr Beta
FocUS Archive
HUMANITIES COMMONS
INA-Rxiv
LawArXiv
LIS Scholarship Archive
MindRxiv
NutriXiv
paleorxiv
PeerJ
preprints
PsyArXiv
RePEc
RG
RIO
SciELO Preprints
SOCARXIV
SportRχiv
SSRN

If you're already posting your papers on your own personal website, give arXiv a try! Some of them even have automated journal submission buttons baked into the site!

1.2.7 6: Open Education

This and Open Methods are closely related. In this sense, any course materials that come from research that is done are made available for others.

MIT OpenCourseWare is probably the best example of open education at work, but these types of sites are proliferating.

- Many courses are making their materials freely available on GitHub (this lecture is also freely available!).
- Tech companies such as GitHub (aptly named: GitHub Classroom) are developing educational tools specifically aimed at student classrooms. Amazon Web Services provides a similar platform for course materials, often bundled with its cloud compute services.

Note: This does not by default include MOOCs. If MOOCs make their materials freely available online, then and only then would it fall under this section.

So that's all great! But...

What can *I* do? Where do I start?

1.2.8 Case Study 3 (CT Peterson)

Professor Powers ran a laboratory where post-doctoral student Harrison Green works. Recently, he had been attempting to develop a new anti-sense technique that would more easily enable one to shut down the expression of a particular gene. At first, Green was having difficulty getting his technique to work. Suddenly, during a laboratory meeting, Green announced that he had gotten his technique to work and produced data showing statistically significant results.

About a week later when Powers was looking for some scrap paper, she found a random piece of paper with data recorded on it. The data appeared to be almost identical to those presented by Green and indeed, she recognized the writing as belonging to Green. She immediately noticed that the scratch paper had an extra data point that Green had apparently deleted from the treatment group. With that extra data point included, Green's results appeared no longer to be statistically significant. Indeed, this very fact was noted on the scratch paper: "p > .05. No Good."

The next day, Powers asked Green why he had deleted the data point. Green responded that it was an outlier and had been deleted because he had botched the experiment that day and felt justified in tossing the point out. Powers asked to see the raw data for that experiment, but when Green gave her his lab notebook, pages describing the experiment were clearly missing.

That evening, while pondering what to do, Powers reanalyzed Green's data and found that Green had miscalculated the t value, and that even with the discarded treatment value, Green's original results were actually statistically significant.

Do you think falsification of results occurred? Why or why not? What should Powers do, if anything?

References: https://www.medschool.umaryland.edu/media/SOM/Offices-of-the-Dean/Office-of-Research/documents/charrow_lecture_handout.pdf

1.3 Part 2: Open Science Best Practices

In the previous section we went over the absolute essentials for an Open Science project or research endeavor. It included some examples of real-world services and tools to help expedite the process.

Here, we'll go into a bit more detail as to exactly how you should tweak your projects to be truly Open Science. It's not really something you can just "tack on" at the end; rather, you'll need to design your projects from the onset to be part of the Open Science initiative.

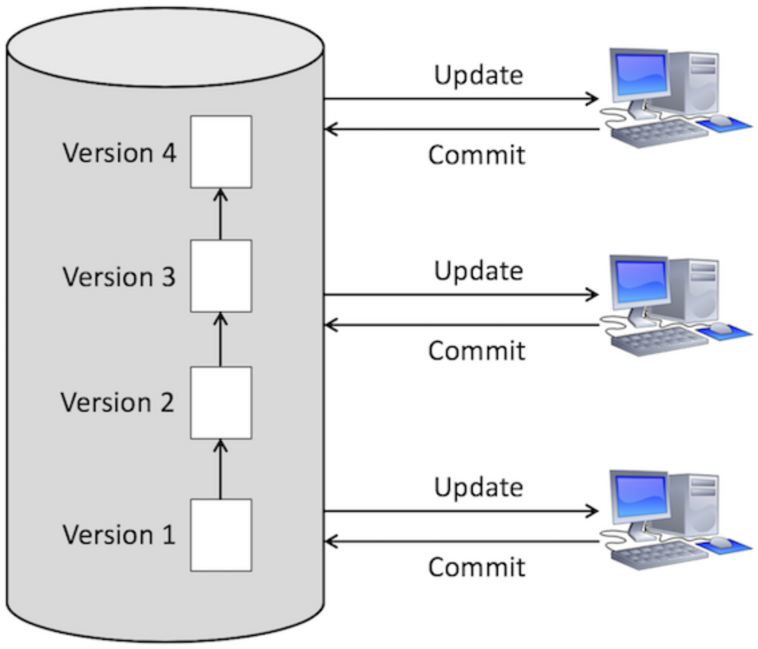
1.3.1 Version control

This is a good starting point for any project.

Version control keeps track of changes within your working documents.

It's a lot like Google docs, but for any kind of file–documents, spreadsheets, text files, program code.

You all know Dropbox? Has it ever saved your life? If so, the next time you start a coding project, use some form of *version control*.



There are several different version control systems out there for code, depending on what you like.

I personally prefer `git`, but I've used all of these before.

CVS

SUBVERSION

git

mercurial

A lot of these have graphical interfaces you can use if you really want to avoid the command line!

1.3.2 Anatomy of an open source project

There are some common files and folder hierarchies to implement at the very start of a new project. The shablona GitHub repository has all this documented very well, but here are the highlights:

- A `README` file of some kind. This is your introduction that summarizes your project, gives a basic overview of how to use it, what the prerequisites are, links to further (more detailed) documentation, and any problems that are known.
- Your `src` folder, containing all your source code.
- A directory of `tests` for your code. Always always always *always* ***always*** write tests!
- A `doc` folder containing *detailed* documentation about every aspect of your project, including any examples.
- A build script of some sort: a script you can run which automates the majority of the install process.
- Continuous integration (CI). This is bit more advanced, but the idea of continuous integration is to have your code exported out to an auto-compiler every time you update the code, so that you know *immediately* whether or not it builds successfully.
- A `LICENSE` file. This is often overlooked (like clicking through a EULA), but in the age of open source and Open Science it is *absolutely essential* to have a license of some sort.

```
shablona/
  |- README.md
  |- shablona/
     |- __init__.py
     |- shablona.py
     |- due.py
     |- data/
        |- ...
     |- tests/
        |- ...
  |- doc/
     |- Makefile
     |- conf.py
     |- sphinxext/
        |- ...
     |- _static/
        |- ...
  |- setup.py
  |- .travis.yml
  |- .mailmap
  |- appveyor.yml
  |- LICENSE
  |- Makefile
  |- ipynb/
     |- ...
```

1.3.3 Document, document, document

This is drilled into computer science students from day 1, and yet one constant across every software project is that the *documentation is terrible*. To meet basic adequacy standards, documentation should include

- **The code itself**. This is the radical notion that code should be easy to understand, especially if read by someone who did NOT write it.
- **Comments in the code**. Invariably there will be some logic in the code that doesn't make sense at first glance. This should be explained with clear comments, preferably with some examples.
- **README**. This is usually the user's first introduction to a new software package (GitHub makes this file the default landing page of a repository!). It should clearly state the purpose of the software, how to install and run it, and some basic usage examples before pointing the user to where they can go to learn more.

1.3.4 Examples and tests

Right after the `README`, this is the next place the user will go: examples for how to run the code. Is it command line? What options are there? What kind of data can I run through it? What should I expect for output? These sorts of questions can be addressed with

- **Quickstart**. This is file that is dedicated to getting the user up and running with the software as quickly as possible with an example. The goal is to put the user in the driver's seat as quickly as possible, and let them ask questions later.
- **Examples**. This usually takes the form of a bash script, written to invoke the code and have it run on a sample dataset that's provided. Alternatively, you can give a step-by-step guide of what commands to run, what inputs to give, and what the expected output should be.
- **Unit tests**. You'll learn more about this as you take higher-level software engineering courses, but the main idea is you want to write code that *tests* your main code. The user can also go here to get a feel for how the code should be used.
- **Containers**. This is a very advanced topic that we won't cover in this course, but the "wave of the future" is to build your software inside *containers* (e.g. Docker). Think of containers as super-lightweight virtual machines that anyone can build from a simple script. Using containers, you can package your software in such a way that you don't have to worry about operating systems or clashing software dependencies.

Containers, such as **Docker**, allow you to create *recipes* that build the precise environment you want, from the operating system all the way up to the exact version of OpenOffice you want.

This has *huge* implications in reproducibility: you can provide others with an exact set of instructions–even a pre-built "snapshot"–of the environment in which you conducted your work.

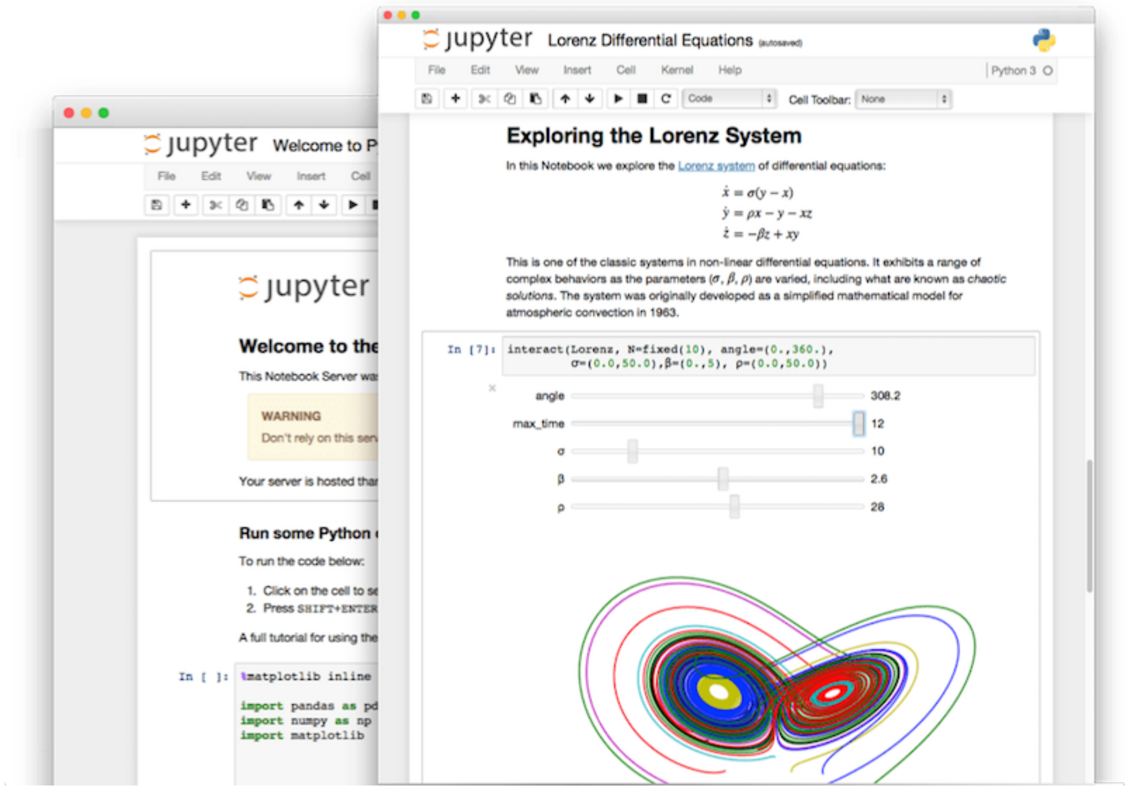
1.3.5 Scientific Notebooks

If you're an R or Python user, you've probably heard of "scientific notebooks".

They're interactive, usually web-based applications that blur the lines between - written documents - code modules - figures and tables

by interleaving all three within the same medium.

**These very slides were built entirely in Jupyter, a multi-language scientific notebook platform!



Welcome to the

This Notebook Server wa

WARNING
Don't rely on this ser

Your server is hosted tha

Run some Python

To run the code below:

1. Click on the cell to se
2. Press SHIFT+ENTER

A full tutorial for using the

```
In [ ]: %matplotlib inline

        import pandas as pd
        import numpy as np
        import matplotlib
```

Exploring the Lorenz System

In this Notebook we explore the Lorenz system of differential equations:

$$\dot{x} = \sigma(y - x)$$
$$\dot{y} = \rho x - y - xz$$
$$\dot{z} = -\beta z + xy$$

This is one of the classic systems in non-linear differential equations. It exhibits a range of complex behaviors as the parameters (σ, β, ρ) are varied, including what are known as *chaotic solutions*. The system was originally developed as a simplified mathematical model for atmospheric convection in 1963.

```
In [7]: interact(Lorenz, N=fixed(10), angle=(0.,360.),
                 σ=(0.0,50.0),β=(0.,5), ρ=(0.0,50.0))
```

```
angle     308.2
max_time  12
σ         10
β         2.6
ρ         28
```

While these slides were built in Jupyter, they were exported into HTML and PDF, so the code isn't technically live anymore.

However, through platforms like mybinder, you can turn any GitHub repository into a collection of active notebooks! You can do this yourself with these slides–all you need is a web browser!

binder
(beta)

Turn a Git repo into a collection of interactive notebooks

1.3.6 Study pre-registration

Pre-registration means *publishing your methods publicly BEFORE any work has been done.*

Why is this important?

Sites like Protocols.io https://www.protocols.io/ and OSF https://osf.io/prereg/ have pre-registration modules, sometimes linked with certain journals who agree to publish the results of the methods, regardless of whether they're positive or negative.

1.3.7 Licensing

Yes, this is super boring, I agree. Fortunately, the wonderful folks at GitHub have created an awesome resource for you to use.

Choose a License: It provides a handy choose-your-adventure flowchart for picking the perfect open software license for your project. I highly recommend it.

However, if you're just looking for a **tl;dr** version and want the basic lay of the land, GitHub's default licenses for new projects include

- MIT License (pretty much the "no warranty whatsoever, use at your own risk" license)
- Apache 2.0 License (almost exactly like the MIT, but allows for patents and trademarks)
- GPLv3 License (requires anyone who modifies your code to publish those modifications under GPLv3 too)

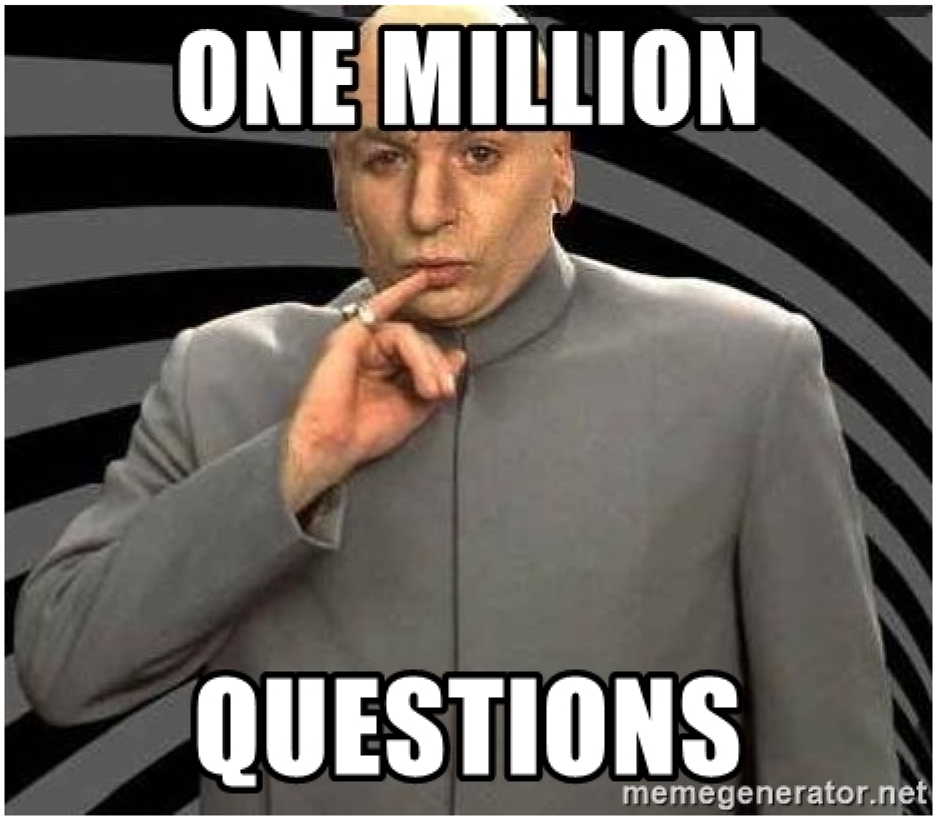
1.4 Final Thoughts

In my view, Open Science and its practices will only become more important. - Replicating previous results - Providing hands-on tools to the upcoming generation of scientists - Making cutting-edge resources accessible to broad audiences

Six major areas of Open Science - These have to be addressed from the beginning, not tacked on after the fact

Already lots of great open source tools and repositories to encourage Open Science practices - data repositories - tools for method replication and testing - standards for code structure, results presentation, and method preregistration

2 Questions?



2.1 Additional Resources

These slides! https://github.com/quinngroup/openscience-intro-oct2019

1. GitHub template for open source Python projects https://github.com/uwescience/shablona
2. Mozilla Open Science Lab https://science.mozilla.org/
3. Open Science Framework (OSF) for all phases of the scientific pipeline https://osf.io/
4. The Center for Open Science (COS), which supports OSF https://cos.io/
5. Docker https://www.docker.com/