Is the Scientific Paper Obsolete?

Dr. Steven Lazarus
Florida Institute of Technology
Melbourne FL
Unidata Russell L. DeSouza Award
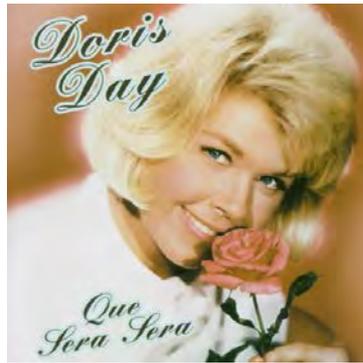September 10, 2018

Que Sera, Sera?

Attempts to predict the future have a long and inglorious history.

The future is ours to see...

SHALL WE PLAY A GAME?

- Driverless Cars
- Personalized Ads
- Voice-controlled/Voice Activated Technology
- Facial and Optical Recognition
- Gesture-Based Computing
- Predictive Policing

As technology evolves, so does our language…
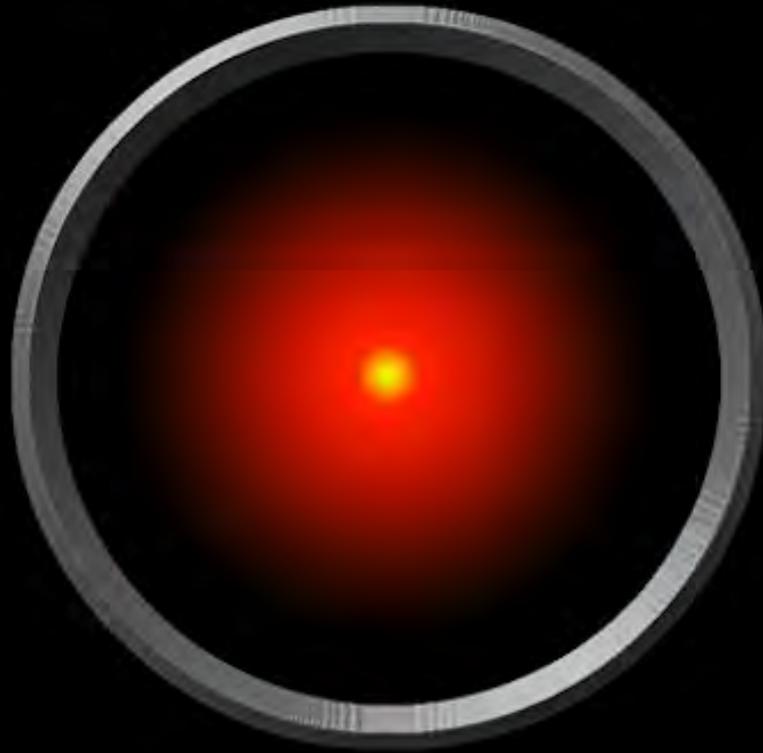
Nomophobia

The fear of losing your mobile device

Logizomechanophobia

The fear of computers. The origin of the word log is Greek (meaning talk or word), machano is Greek (meaning machine) and phobia is Greek (meaning fear).

...and so does our paranoia?

What happens in cyberspace...

Artificial General Intelligence (AGI)

Molecular Assembling

Nanotechnology

Hive Minds

Intelligence Augmentation (IA)

Radical life extension

Powerful spacecraft propulsion engines

Useful quantum computers

Mind uploads (complete human brain emulations)

The Cloud

Immutable/Invariant Laws

Scientific computing benefits from an "invariant" known as Moore's Law, i.e., the density of integrated circuits grows exponentially and thus computers of the next decade will be dramatically superior to those of today, even if the precise technology path is unclear.
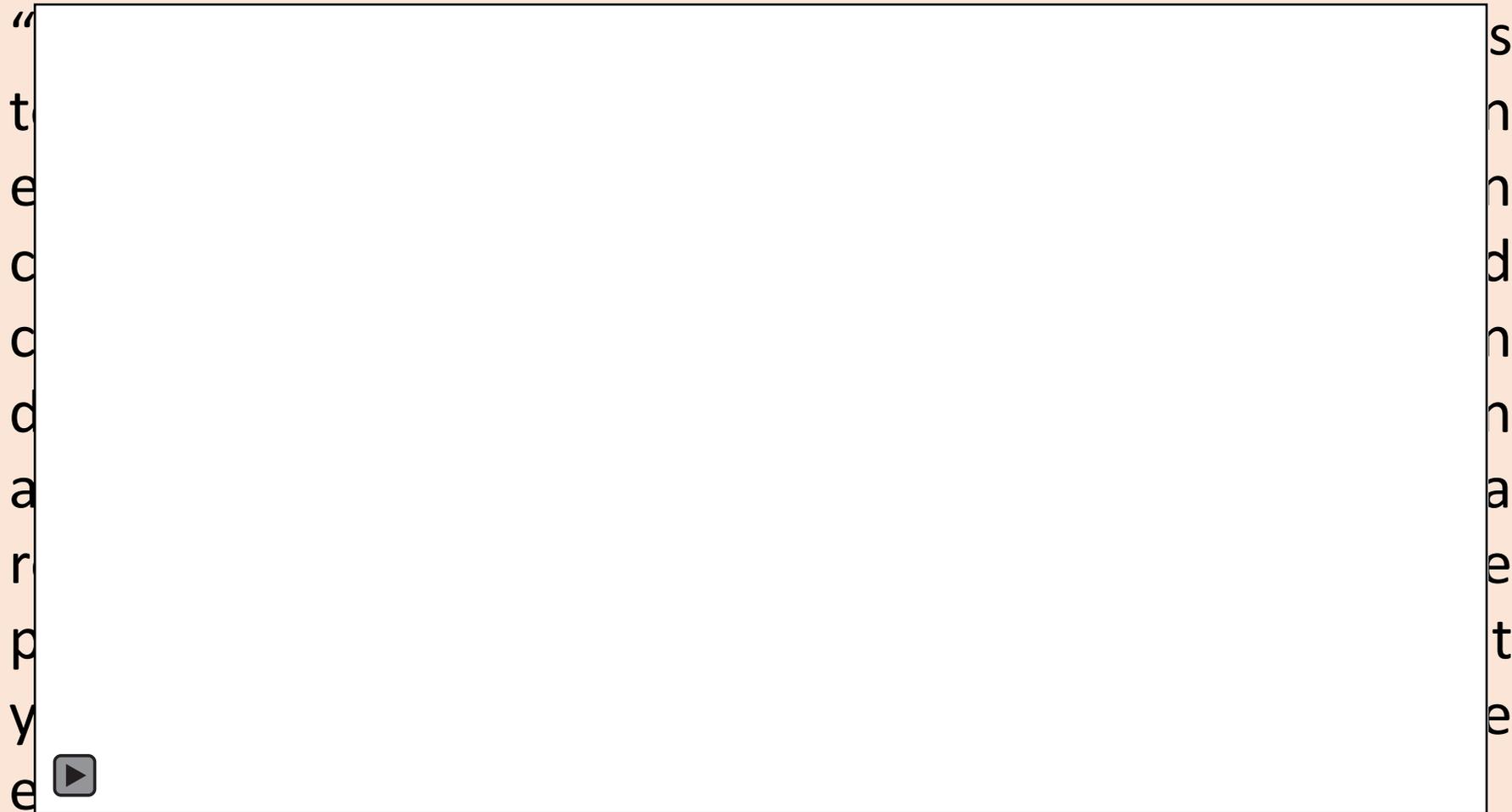
Murphy's Law

Cole's Law?
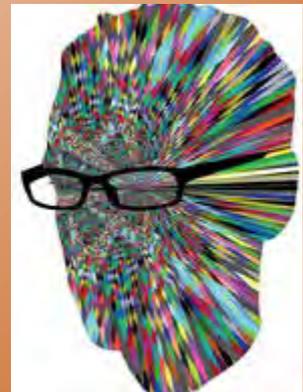
Champing at the bits?

"

James Somers APR 5, 2018

Is there a method to the (space) madness?

Scientific methods evolve at the speed of software

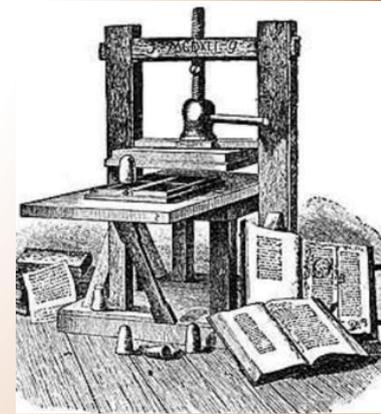The skill most in demand is facility with programming languages and "data science" packages.

Yet the basic means of communicating scientific results hasn't changed for 400 years.

Papers may be available online, but they're still text and pictures on a page!

Press on

It took nearly 100 years, following the invention of the printing press, to invent the modern book.

"There was this entire period where they had the new technology of printing, but they were just using it to emulate the old media."

Bret Victor, former Apple researcher

(iPad prototype)

As software development and computer technology continues it's inexorable march forward, one has to ask whether or not we've even made optimal use out of what we have already created.

What would you get if you designed the scientific paper from scratch today? Bret Victor

Scholarly articles for **Collective dynamics of 'small-world' networks."**
Collective dynamics of 'small-world' networks - Watts - Cited by 37115

"Software is a dynamic medium; paper isn't."

It seems odd that, up until now, research is typically shared on paper only.

For the Watts and Strogatz article, Victor brought the swirling dots alive by combining explanatory text with interactive illustrating each step.
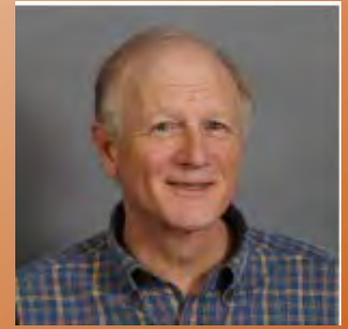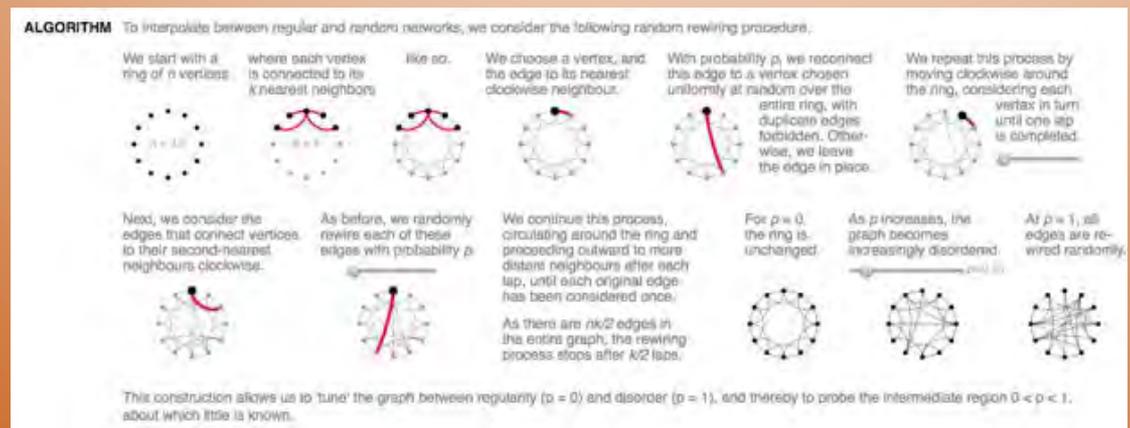
The Computational Notebook

Brainchild: Theodore Gray (inspired by an old Apple code editor!)

Back in the day, you would run code one line at a time, or all at once. The Apple editor let you highlight any part of the code and run just that piece.

Designed to transform scientific programming into an interactive exercise that helps the user come to a more intimate understanding of their data.

"To write a paper in a notebook is to reveal your results and methods at the same time"
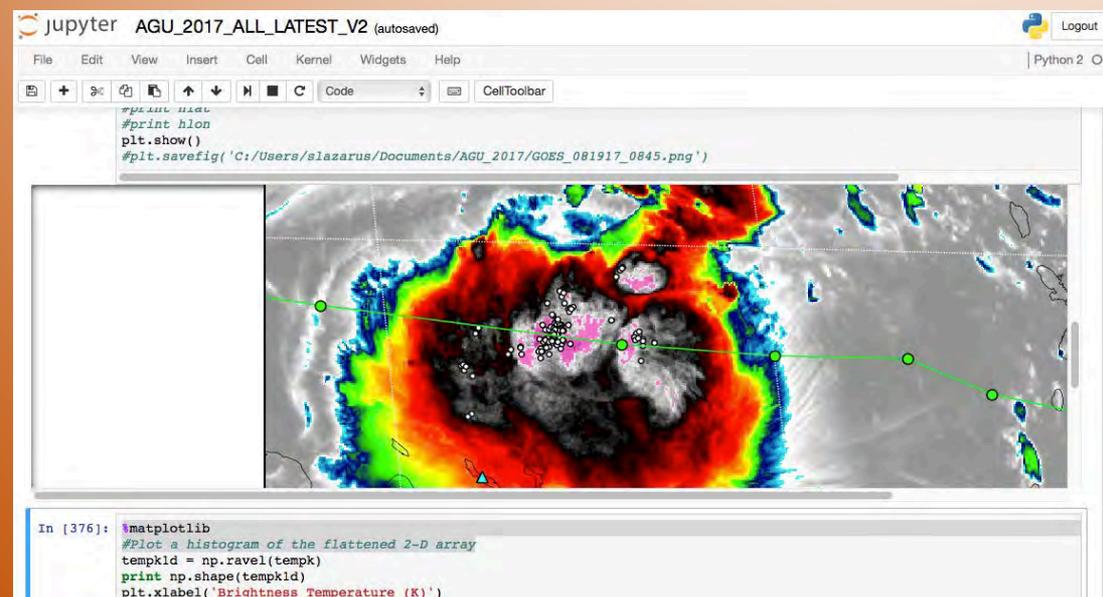
"Algebra of thought"

Leibniz (1646-1716) developed the sense that a similar notation (i.e., integration/derivatives) applied more broadly could create a universal language that would eliminate ambiguity and turn complex problem-solving of all kinds into a kind of calculus.
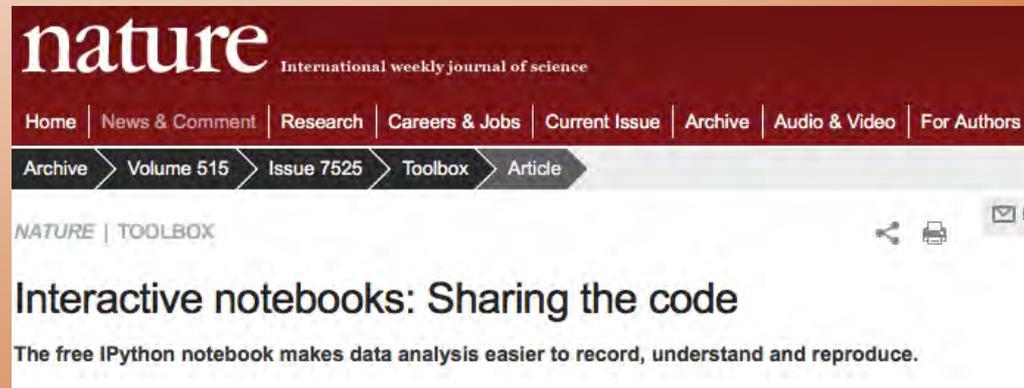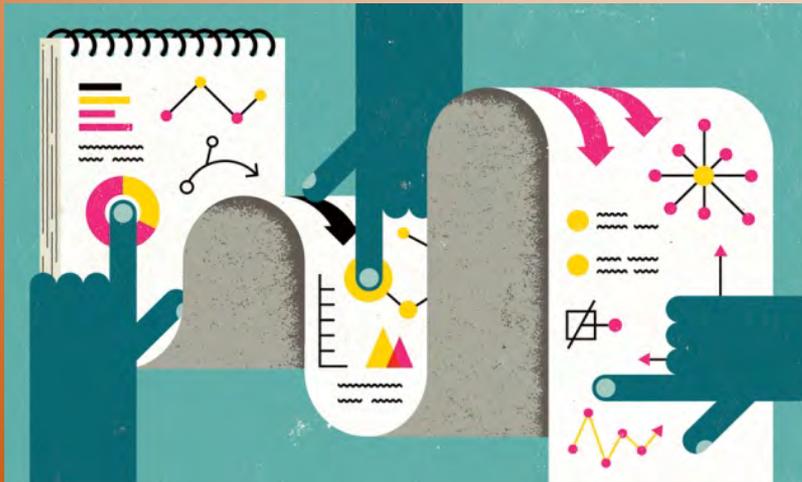
"As practitioners in many fields become more literate with computation, they'll vastly expand the range of what's discoverable." Wolfram (blog post)

$$\frac{d}{dx} \int_{g(x)}^{h(x)} f(t)dt = f(h(x))h'(x) - f(g(x))g'(x)$$

Open Source Science/Computational Essays

"...*obviously* all scientific communication, all technical papers that involve any sort of data or mathematics or modeling or graphs or plots or anything like that, *obviously* don't belong on paper. That was just *completely obvious* in, let's say, 1990," Theodore Gray (Apple)

With millions of scientists worldwide producing *incremental* contributions, the only way to have those contributions add up to something significant is if others can reliably build on them. "That's what having science presented as computational

nature — International weekly journal of science

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Archive > Volume 515 > Issue 7525 > Toolbox > Article

NATURE | TOOLBOX

Interactive notebooks: Sharing the code

The free IPython notebook makes data analysis easier to record, understand and reproduce.

Common Cause (aka Computational Socialism?)

Fernando Pérez (Ipython)

If science is to be an open enterprise, the tools that are used to do it should themselves be open

Commercial software whose source code (or data!) you were legally prohibited from reading is "antithetical to the idea of science"

Building tools to make it "work better" for scientists: tools that made it easier to manage data sets and draw plots, and that encouraged a more open style.

It's not just that the software is free, but that <u>anyone</u> can inspect its code and modify it, contributing their changes back to the community.

If you build it, they will come

Ipython (Jupyter Notebook)

It's no accident – it's the growing library of extra features (image processing, creating music, building AIs, analyzing language, graphing data sets, etc.). Useful tools!

Built by a community of open-source contributors working for free.

Programming-language communities, like any social network, thrive—or die—on the strength of these feedback loops.
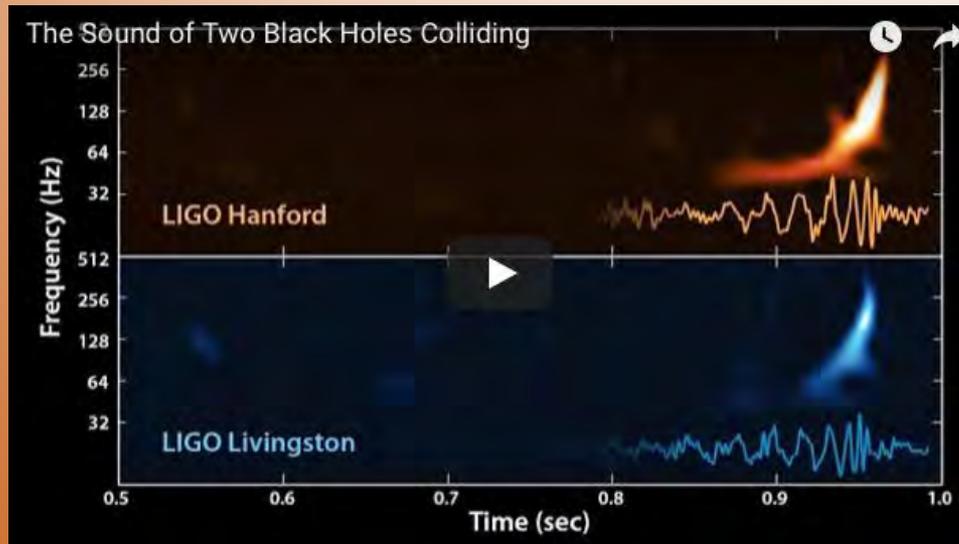
Clever is as clever gets

The IPython team built their notebooks as simple <u>web pages</u>.

Any time Google, Apple, or a random programmer open-sourced a new plotting tool, or published better code for rendering math, the improvement would get rolled into IPython.

Published in the traditional way, as a PDF, but with a supplemental Ipython notebook.

https://losc.ligo.org/s/events/GW150914/GW150914_tutorial.html
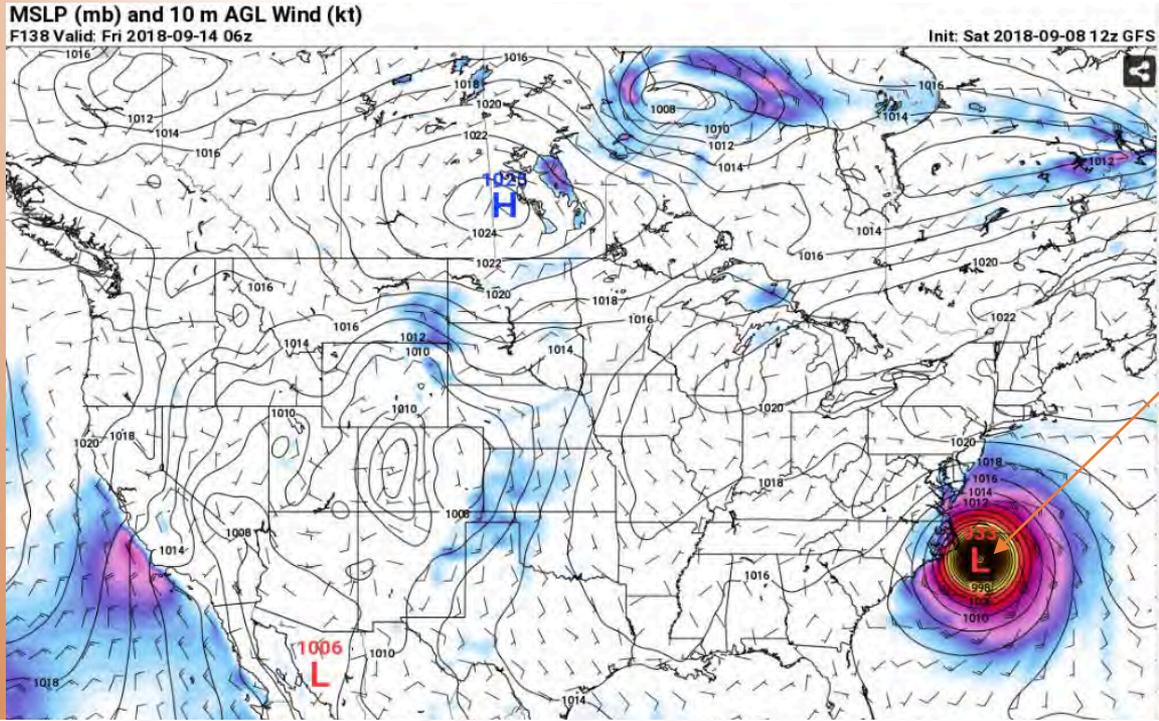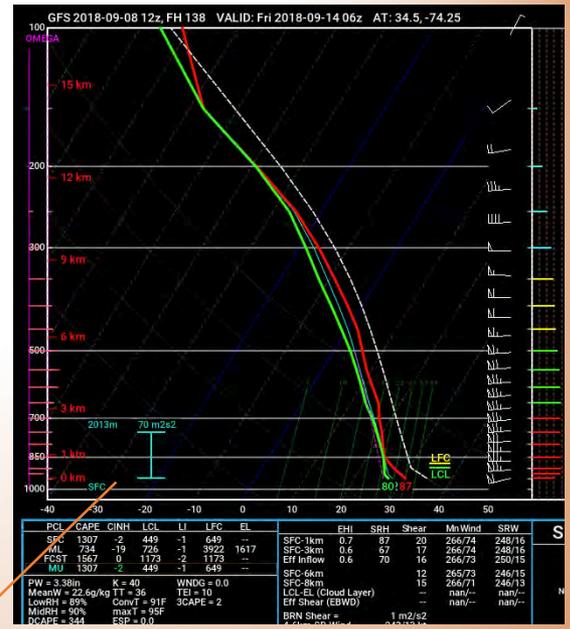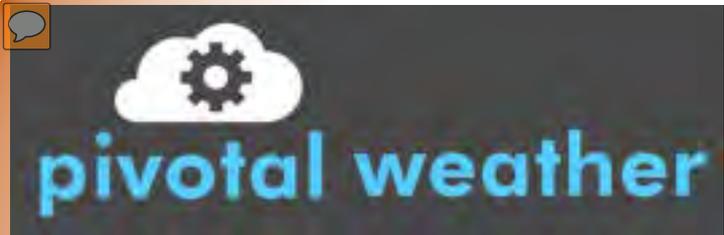
SHARPpy

8 IDV Jetstream Plugin

The IDV Jetstream plugin allows easy access to Jetstream installations of the TDS, RAMADDA and ADDE from the IDV. The plugin URL is `http://science-gateway.unidata.ucar.edu/jetstream.jar`. See here for how to install an IDV plugin from a URL.

http://www.pivotalweather.com/   https://tropicaltidbits.com/analysis/models/

Reimagining what "Journals On-Line" means?

Inertia

Sometimes things move too fast, others too slow!

Will computational notebooks only take root if they're backed by a single super-language, or by a company with deep pockets and a vested interest in making them work?

There are now over 1.3 million notebooks hosted publicly on Github.
It's hard to sell the scientific community on a piece of commercial software or data.

Sea Change?

It will be awhile before computational notebooks replace PDFs in scientific journals!

Why?   Because that would mean changing the incentive structure of science itself.

Until journals *require* scientists to submit notebooks, and until sharing your work and your data becomes the way to earn prestige, or funding, people will likely just keep doing what they're doing.
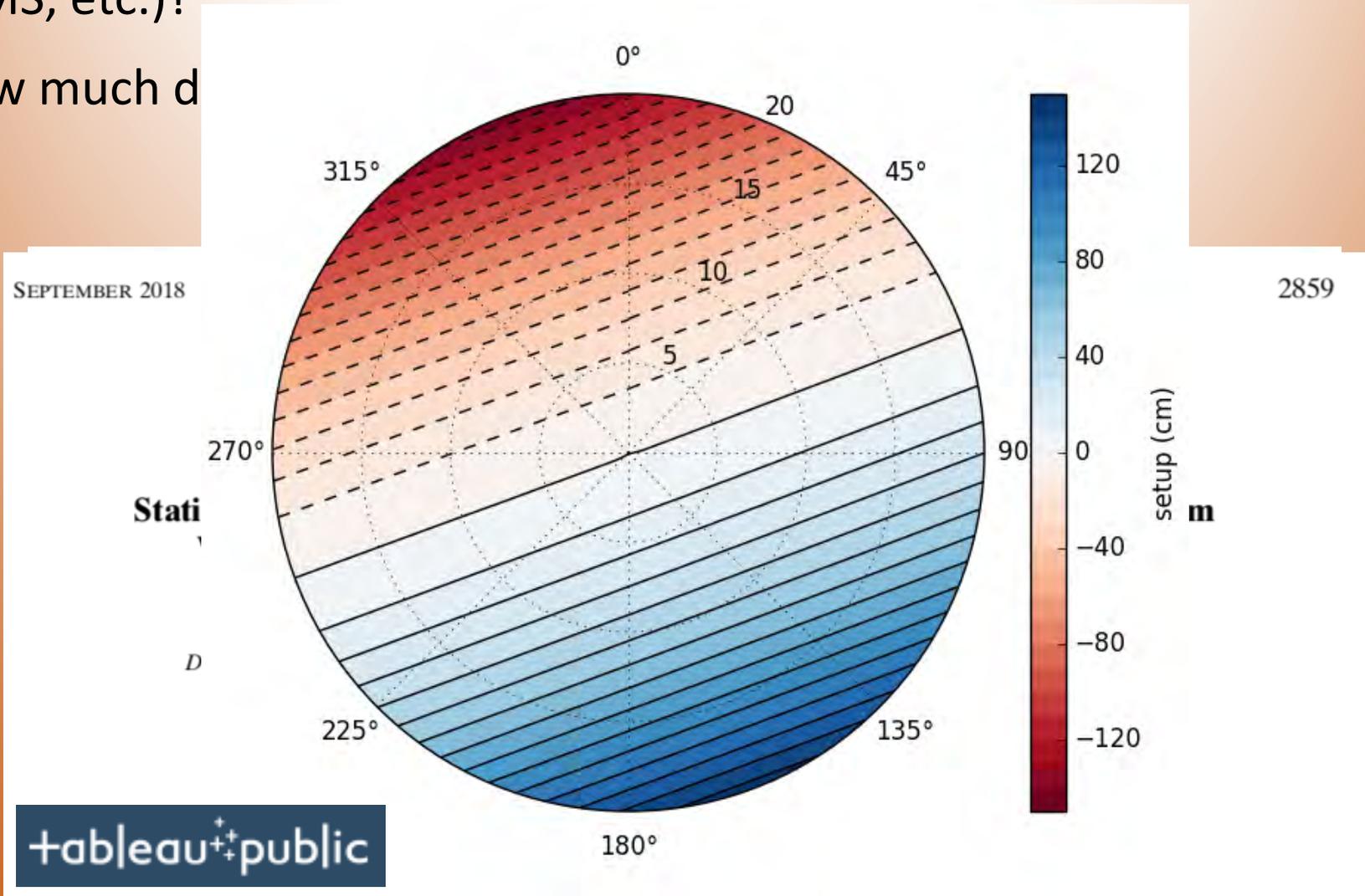
Some data is basically so costly, so expensive, and so good that nobody would ever share it.

PROTESTING AGAINST NEW TECHNOLOGY – THE EARLY DAYS

Dynamic Tools (linking up research, data)

How do we make visible and accessible, not just our results but our derived datasets as well (yeah, I know there's THREDDS, OPeNDAP, WMS, etc.)?
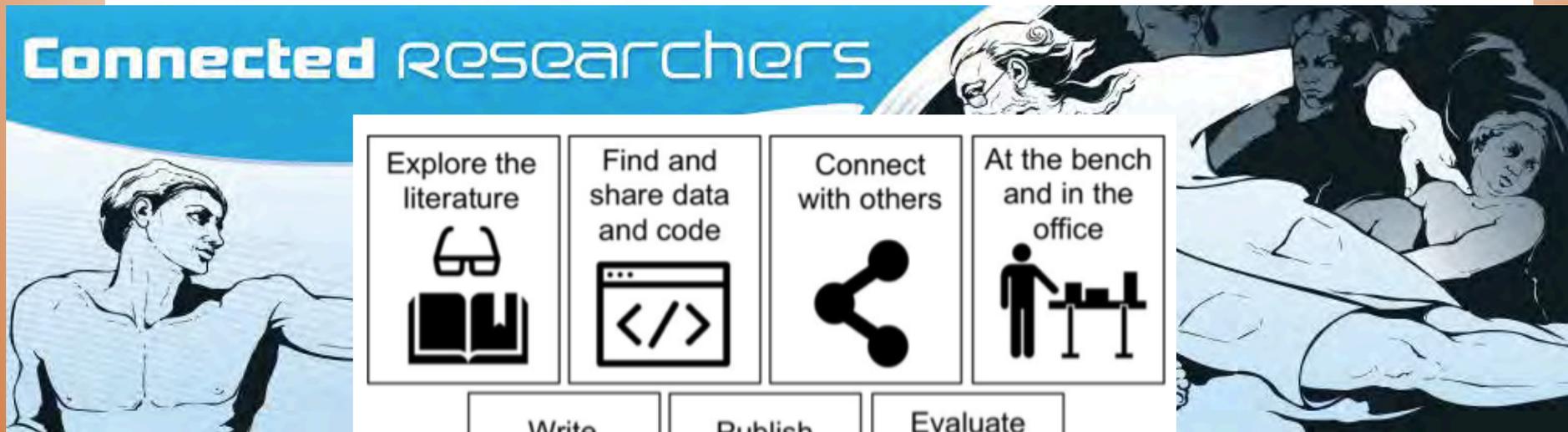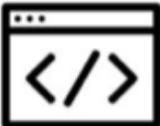
How much d

Which online tools do you use for open science?

Do you share your research ideas openly with others? Do you make your research process transparent? Do you make your research findings accessible?

If so, which online tools are useful?

Connected researchers

| Explore the literature	Find and share data and code	Connect with others	At the bench and in the office

Write	Publish	Evaluate research

Digital tools for researchers

The axis of praxis

"…nobody in their sane mind challenges the fact that the *praxis* of scientific research is under major upheaval," Pérez, the creator of Jupyter, wrote in a blog post in 2013.
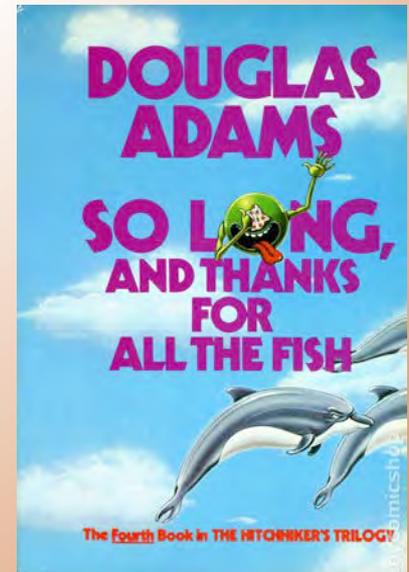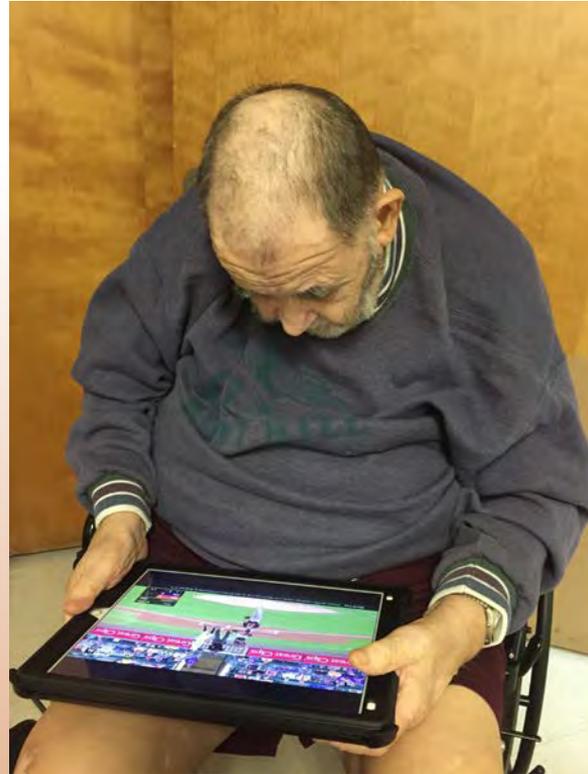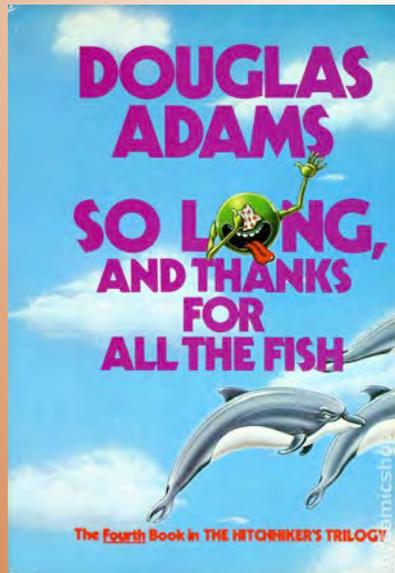

The Jupyter logo is an abstracted version of Galileo's original drawings of the moons of Jupiter. "Galileo couldn't go anywhere to buy a telescope," Pérez said. "He had to build his own."
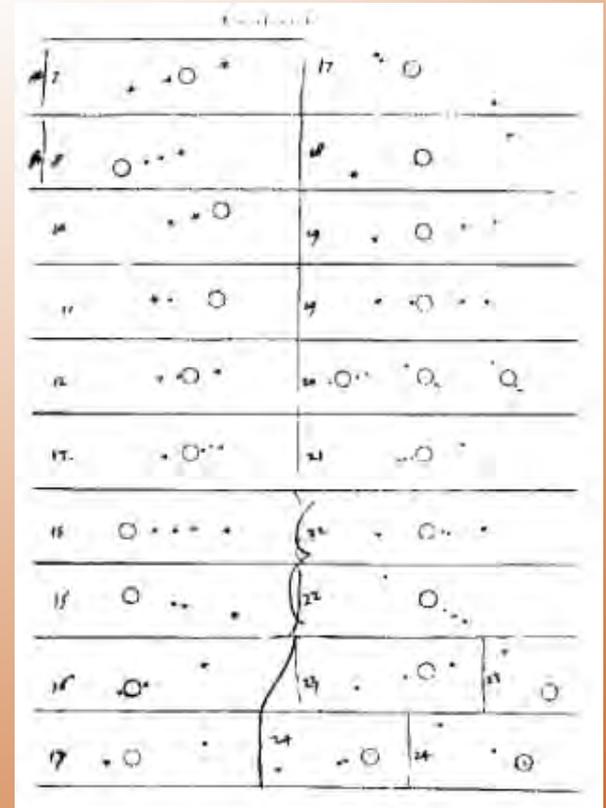
Questions/Comments?

So long, and thanks for all the fish!