



Scaling climate data analysis in the cloud with Google Earth Engine

Tyler Erickson, PhD

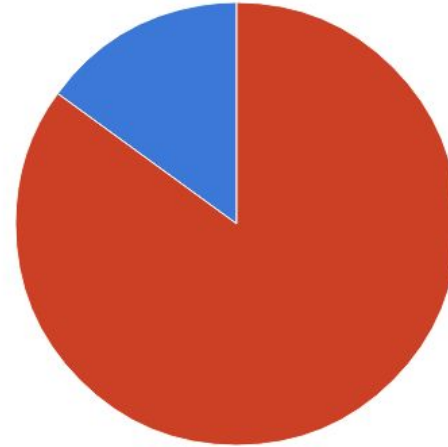
Developer Advocate, Google Earth Engine

15 March 2022



Geospatial Analysis

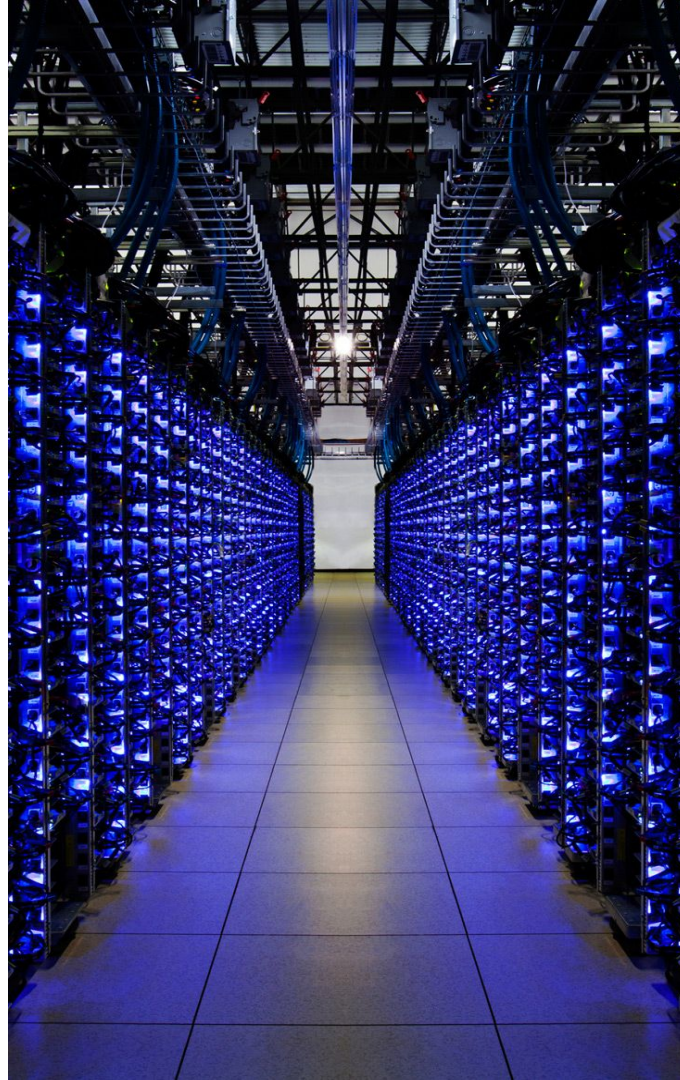
Many geospatial researchers spend a majority of their time doing "**IT work.**"



■ Data Management and Processing ■ Research and Analysis

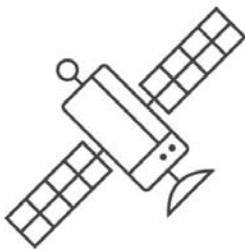
Benefits of Cloud-based Analysis

- Avoids the need to download duplicate copies of data
- Minimal setup time
- Increases the scale of possible analyses
- Improved reproducibility & replicability
- Can facilitate collaboration & sharing



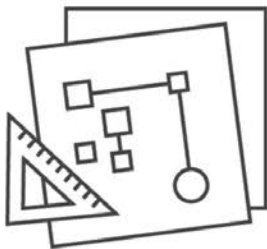


Google's **cloud platform** for easy **petabyte-scale analysis** of **satellite imagery** and other **geospatial data**.



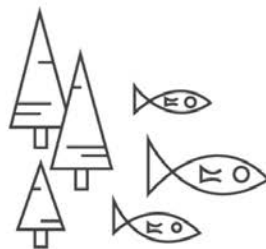
SATELLITE IMAGERY

+



YOUR ALGORITHMS

+

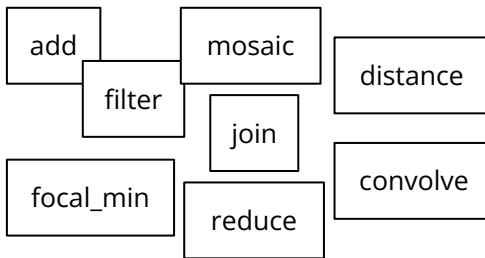


REAL WORLD APPLICATIONS

Requests

Results

Geospatial
Datasets



Algorithmic
Primitives



Storage and Compute



Data

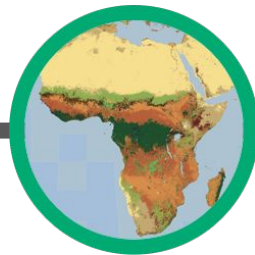
Public Data Catalog



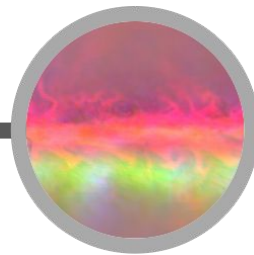
**Optical
Imagery**



**Boundary
Data**



**Terrain &
Land Cover**



**Weather &
Climate**

600+ public datasets

100+ datasets added yearly

30+ petabytes of data

1+ PB of new data every month

... and upload your own vectors and rasters



Data

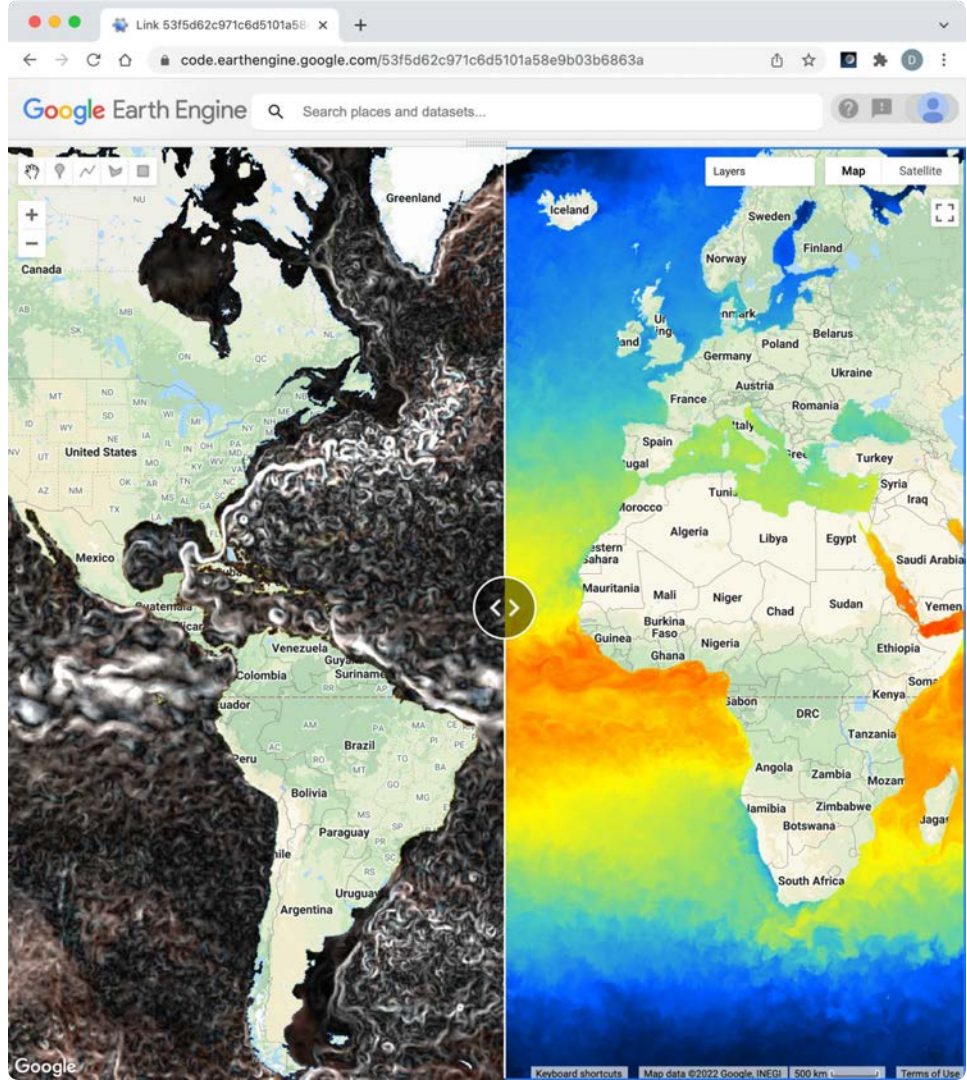
Geospatial Data

- Optical
 - Landsat, MODIS, AVHRR
 - Sentinel-2, Sentinel-3
 - GOES-16, GOES-17
- Boundaries
 - USGS HUCs
 - WWF HydroSHEDS Basins
 - Rivers Network
- Elevation
 - SRTM30M, NASADEM
 - NED
 - ALOS DSM
 - MERIT
- Precipitation
 - GPM, TRMM, GSMaP
 - PERSIANN, CHIRPS
- Weather Reanalysis
 - CFSR
 - NCEP/NCAR Reanalysis
 - ECMWF ERA5, ERA5-Land
- Weather Forecast
 - GFS, CFSV2, RTMA
 - ECMWF CAMS
- Climate Projections
 - CMIP5 NEX-DCP30, NEX-GDDP



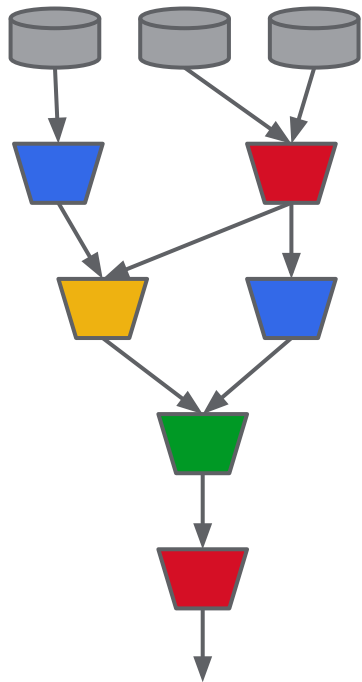
Data

HYCOM data





Computation

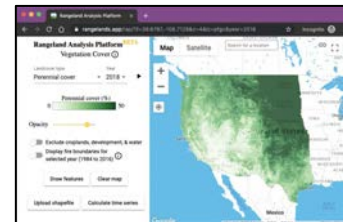
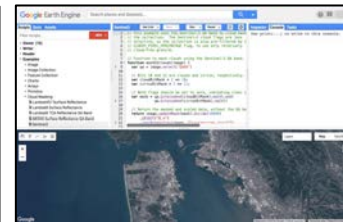
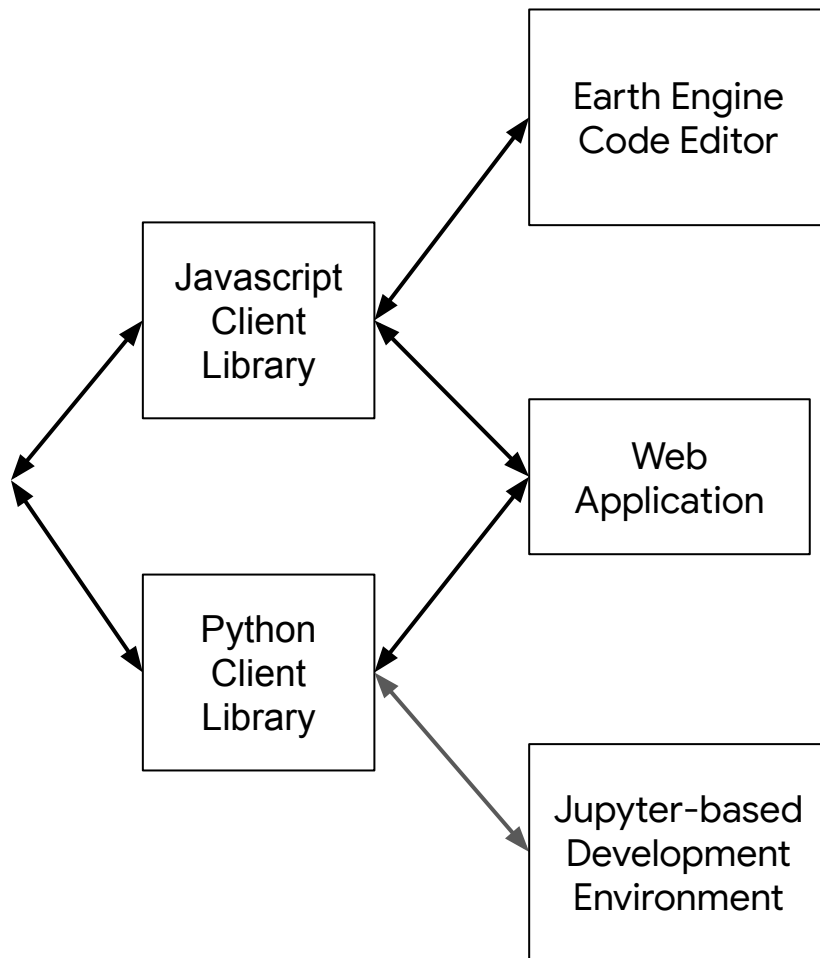


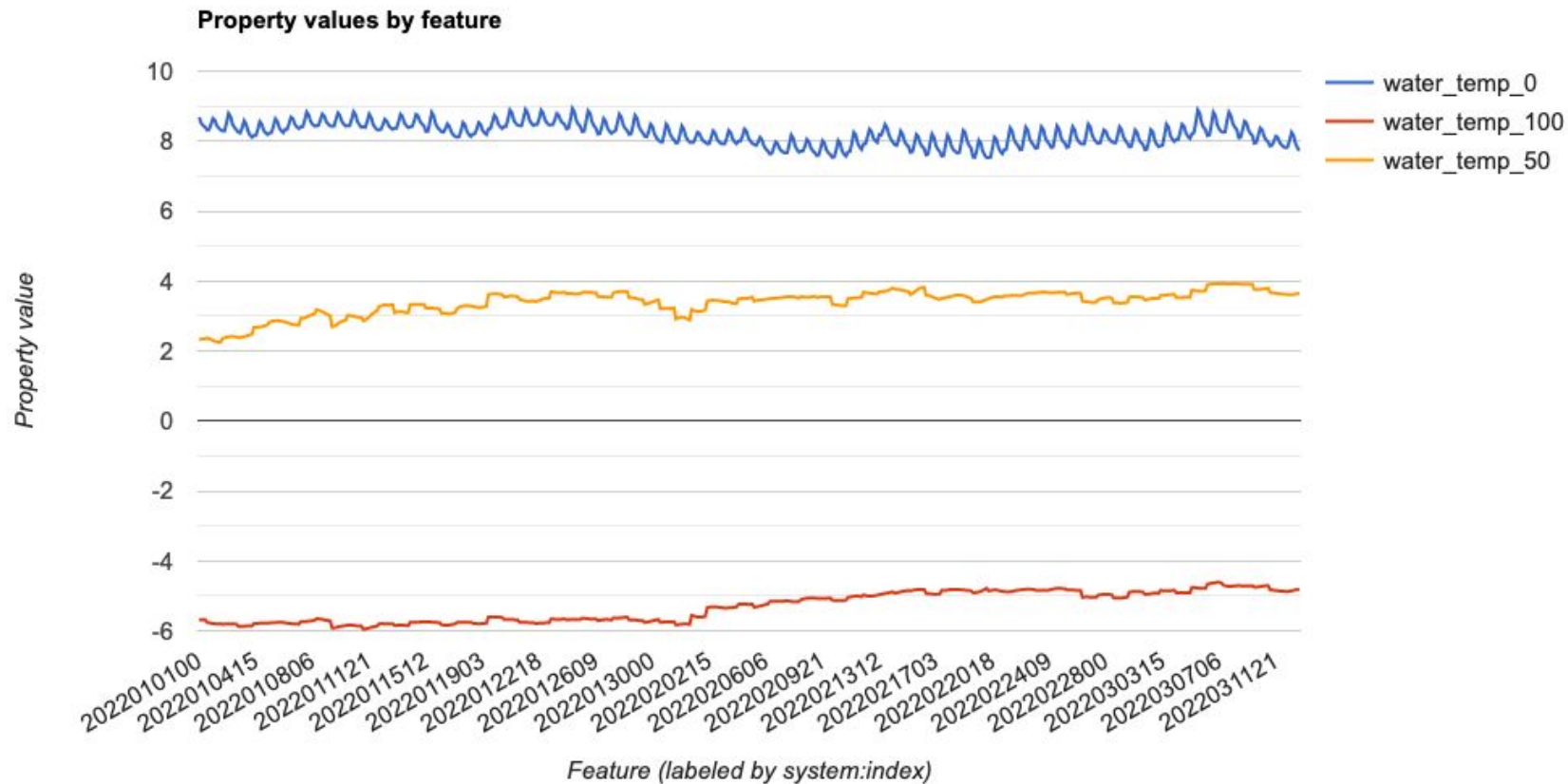


APIs



Earth Engine
Backend
Servers





Promoting Collaboration/Sharing



Time Series Visualization with Altair

File Edit View Insert Runtime Tools Help Cannot save changes

Share Settings

RAM Disk

Editing

Code Text Copy to Drive

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DOY line chart

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Prepare DataFrame

Line chart

Past and future climate

Future climate

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Prepare DataFrame

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Precipitation

Calendar heatmap

Chart PDSI data as a calendar heatmap. Set observation year as the x-axis variable, month as y-axis, and PDSI value as color.

Note that Altair features a convenient [method for aggregating values within groups](#) while encoding the chart (i.e., no need to create a new DataFrame). The mean aggregate transform is applied here because each month has three PDSI observations (year and month are the grouping factors).

Also note that a tooltip has been added to the chart; hovering over cells reveals the values of the selected variables.

```
[18] alt.Chart(pdsi_df).mark_rect().encode(
    x='Year:Q',
    y='Month:Q',
    color=alt.Color(
        'mean(PDSI):Q', scale=alt.Scale(scheme='redblue', domain=(-5, 5))),
    tooltip=[
        alt.Tooltip('Year:Q', title='Year'),
        alt.Tooltip('Month:Q', title='Month'),
        alt.Tooltip('mean(PDSI):Q', title='PDSI')
    ]).properties(width=600, height=300)
```

Mean of PDSI

4

2

0

-2

-4

Month

Year

The calendar heat map is good for interpretation of relative intra- and inter-annual differences in PDSI. However, since the PDSI variable is represented by color, estimating absolute values and magnitude of difference is difficult.

0s completed at 1:04 PM

code.earthengine.google.com/86c23c333938dae8d3f7b2cdbc06f65

Google Earth Engine

Search places and datasets...

Link b676c3a6039fe...

Get Link

Save

Run

Reset

Apps



Inspector

Console

Tasks

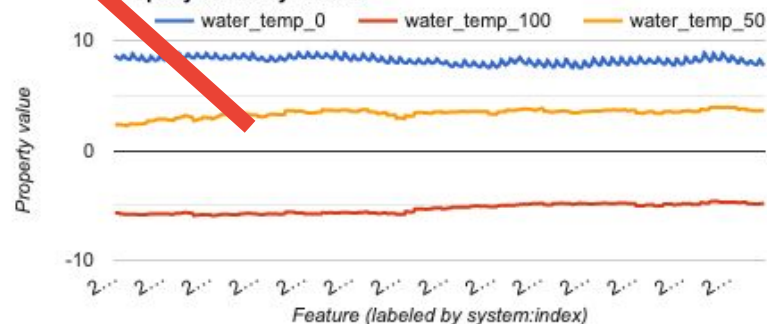
Imports (1 entry)

var geometry: Polygon vertices

```
1 var stats = ee.ImageCollection('HYCOM/sea_temp_salinity')
2   .filterDate('2022-01-01', '2023')
3   .filter(ee.Filter.eq('experiment', '930'))
4   .select(['water_temp_0', 'water_temp_50', 'water_temp_100'])
5   .map(function (img) {
6     return ee.Feature(null,
7       img.multiply(0.001)
8       .reduceRegion({
9         reducer: ee.Reducer.mean(),
10        geometry: geometry,
11        bestEffort: true
12      })
13   });
14 });
15 print(ui.Chart.feature.byFeature(stats));
16
```

Use print(...) to write to this console.

Property values by feature



Geometry Imports

Map

Satellite

Mexico

Guadalajara
Mexico City

Cuba

Santo Domingo

Puerto Rico

Guatemala

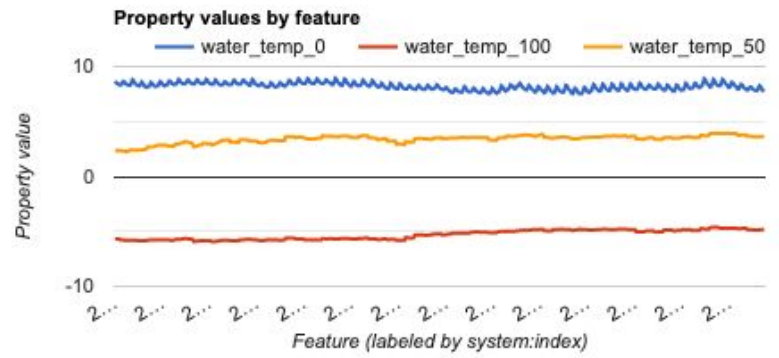
Nicaragua

Caribbean Sea

Caracas


```
Imports (1 entry)
var geometry: Polygon, 4 vert
1 var stats = ee.ImageCollection('HYDROSEA/temp_salinity')
2   .filterDate('2022-01-01', '2023')
3   .filter(ee.Filter.eq('experiment', 'S0'))
4   .select(['water_temp_0', 'water_temp_50', 'water_temp_100'])
5   .map(function (img) {
6     return ee.Feature(null,
7       img.multiply(0.001)
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16
```

Use print(...) to write to this console.



An aerial photograph of a river delta, likely the Amazon, showing a complex network of blue water channels branching out into a vast area of green and brown vegetation. The perspective is from a high angle, looking down at the landscape.

Earth Engine Apps

Dynamic, publicly accessible user interfaces for Earth Engine analyses.

[Get started.](#)

<https://www.earthengine.app>



Earth Engine Apps

🔍 Search places

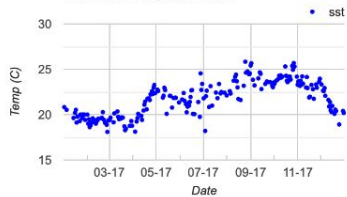
⋮

MODIS Ocean Temperature - Time Series Inspector

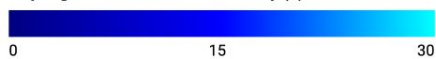
Click a location to see its time series of ocean temperatures.

lon: -19.16 lat: 22.31

Sea surface temp: time series



Map Legend: median 2017 ocean temp (C)





Aaron Zuspan

@aazuspan

...

Ever wonder where [#EarthEngine](#) analysis is taking place? 🛰️🗺️

I scraped all 57 million lines of public [#GEE](#) code to find the coordinates of every 📍 Point ever created.

Plus, some other interesting insights on the data and modules that people use 🧵 ...



LETTER

doi:10.1038/nature20084

High-resolution mapping of global surface water and its long-term changes

Jean-François Pekeff¹, Andrew Cottam¹, Noel Gorelick² & Alan S. Belward¹

The location and persistence of surface water (inland and coastal) is both affected by climate and human activity¹ and affects climate^{2,3}, biological diversity⁴ and human wellbeing^{5,6}. Global data sets documenting surface water location and seasonality are needed to understand the role of surface water in the Earth system. Statistical extrapolations of regional data⁷ and satellite imagery^{8,9,10,11} but measuring long-term changes at high resolution remains a challenge. Here, using three months Landsat satellite imagery¹², we present a global map of surface water location and seasonality at 30-metre resolution. We record the months and years when water was present, where occurrence changed and what form changes took in terms of seasonality and persistence. Between 1984 and 2000, 90,000 square kilometres, roughly equivalent to that of Lake Superior, though new permanent bodies of surface water covering 184,000 square kilometres have formed worldwide. All continental regions show an increase in permanent surface water, except the tropics, where there is one area of decline. Many lakes have

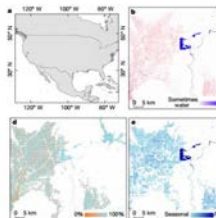
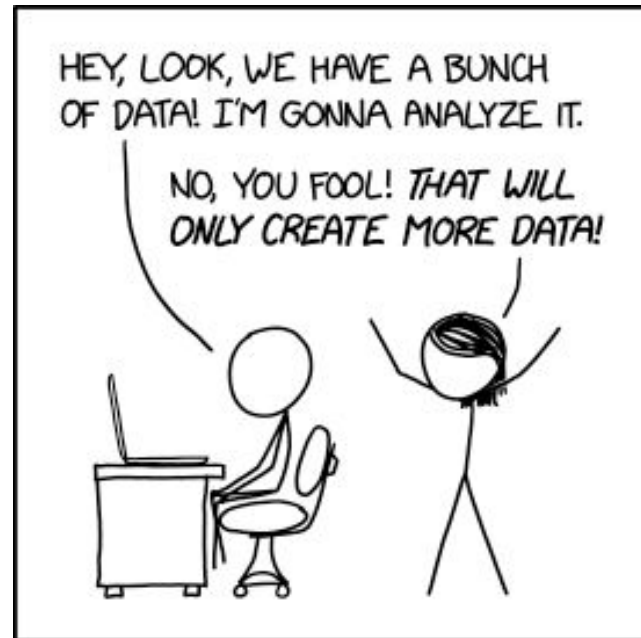
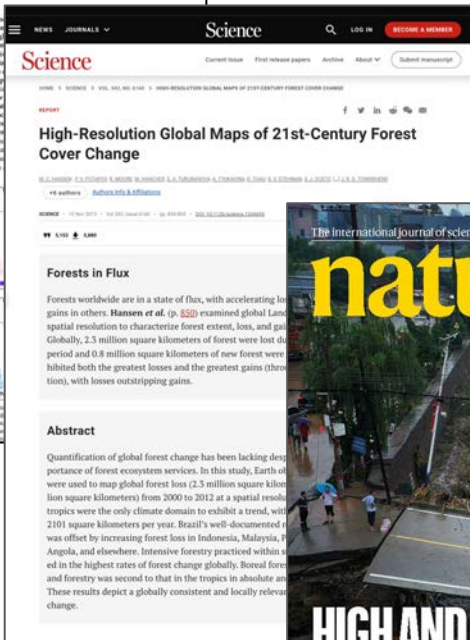


Figure 1 | Different facets of surface water dynamics. **a**, Map of the USA showing Sacramento Valley location (red square). **b**, Surface water occurrence 1984–2015. **c**, Surface water occurrence change intensity 1984–2015. **d**, Surface water occurrence 1984–2015. **e**, Surface water occurrence 2014–2015. **f**, Transitions in surface water class regions 1 areas in irrigation footprint a



source: xkcd.com/2582

Thank you!

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