Way of Water

Gennadii Donchyts
Cloud Geographer

Kel Markert
Cloud Geographer

October 2023 | #GeoForGood23

Presentation Link:
goo.gle/g4g23-water-slides

In this module, you learn to ...

01	Examples	15 min
02	Water dynamics mapping (JRC)	10 min
03	Water detection with optical satellite imagery	30 min
04	Questions and Discussion	5 min

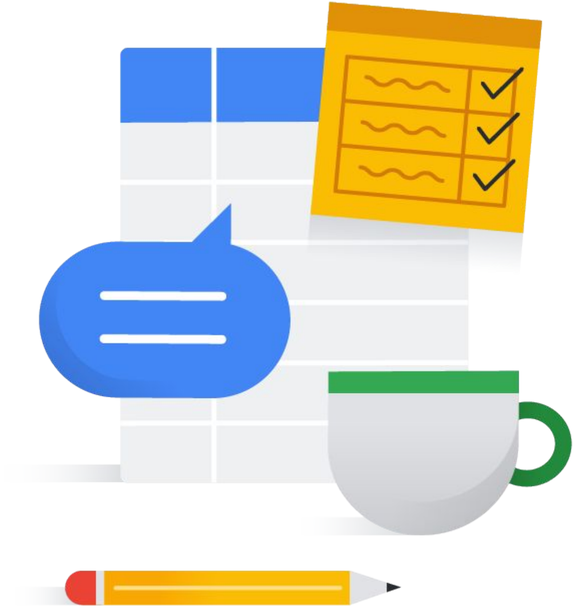
Instructor-led training slide

01 | Examples

15 min | Group

Water Examples

water cycle
precipitation
moisture
water mapping
water change mapping
floods
droughts
bathymetry
...

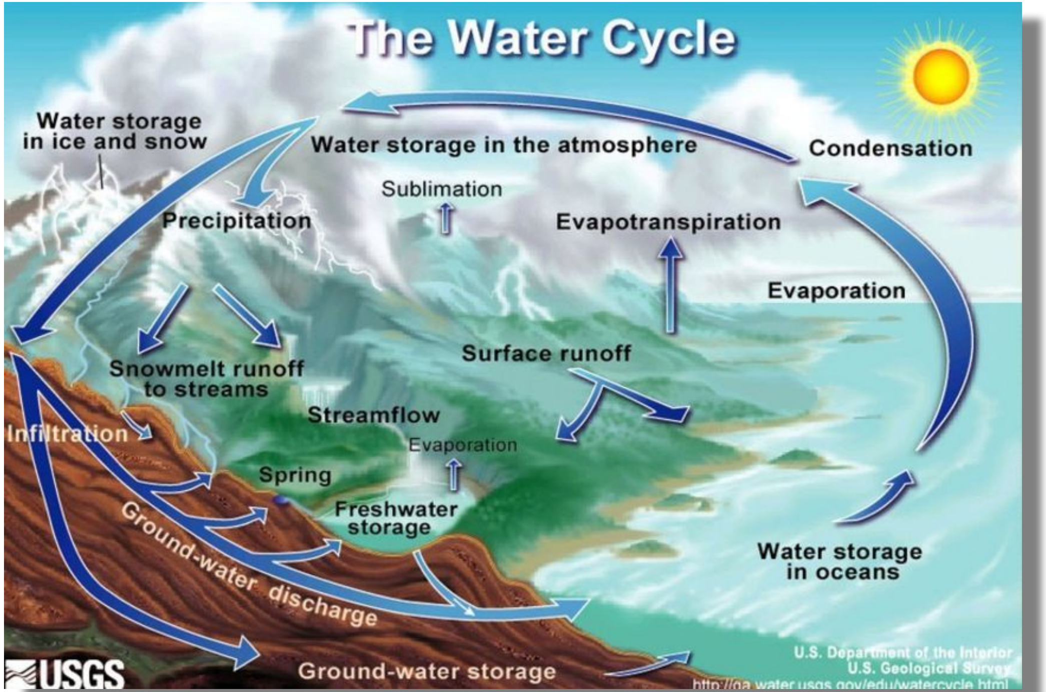


How to **map** waterbodies?

Where have **floods** happened?

Is my **coastline eroding**?

How much water do we have in **rootzone**?



How large are **intertidal changes**?

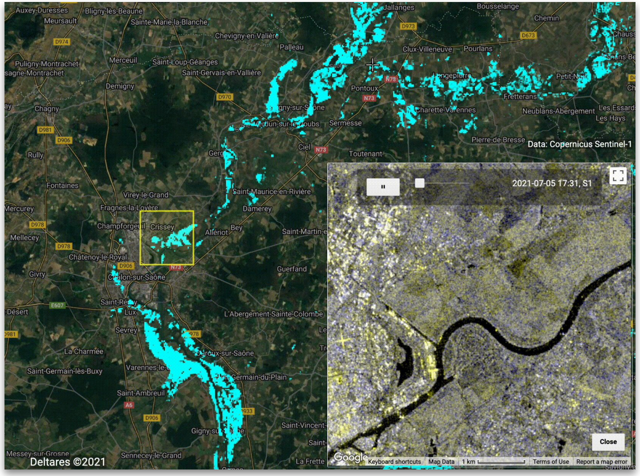
Can we detect **water pollution** (oil, algae, plastic)?

How quickly do **glaciers melt**?

Do we have **enough water** to drink and irrigate crops?

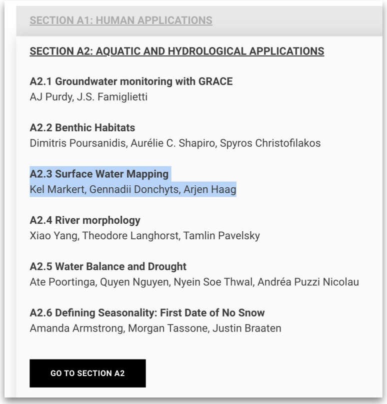
Is there a **droughts** occurring and where?

Flood Mapping



EU 2021 flood app
https://gena.users.earthengine.app/view/flood-eu

The New York Times
https://www.nytimes.com/interactive/2021/07/17/world/europe/europe-flood-map.html


SECTION A1: HUMAN APPLICATIONS

SECTION A2: AQUATIC AND HYDROLOGICAL APPLICATIONS

A2.1 Groundwater monitoring with GRACE
AJ Purdy, J.S. Famiglietti

A2.2 Benthic Habitats
Dimitris Poursanidis, Aurélie C. Shapiro, Spyros Christofilakos

A2.3 Surface Water Mapping
Kel Markert, Gennadii Donchyts, Arjen Haag

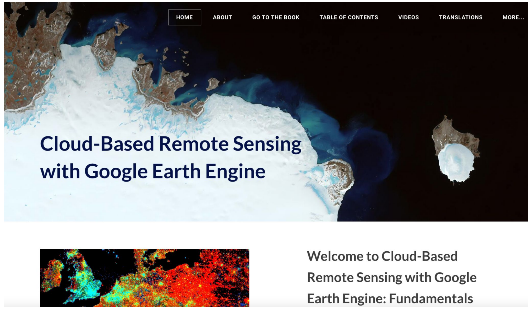
A2.4 River morphology
Xiao Yang, Theodore Langhorst, Tamlin Pavelsky

A2.5 Water Balance and Drought
Ate Poortinga, Quyen Nguyen, Nyein Soe Thwal, Andréa Puzzi Nicolau

A2.6 Defining Seasonality: First Date of No Snow
Amanda Armstrong, Morgan Tassone, Justin Braaten

GO TO SECTION A2

Go to section A2



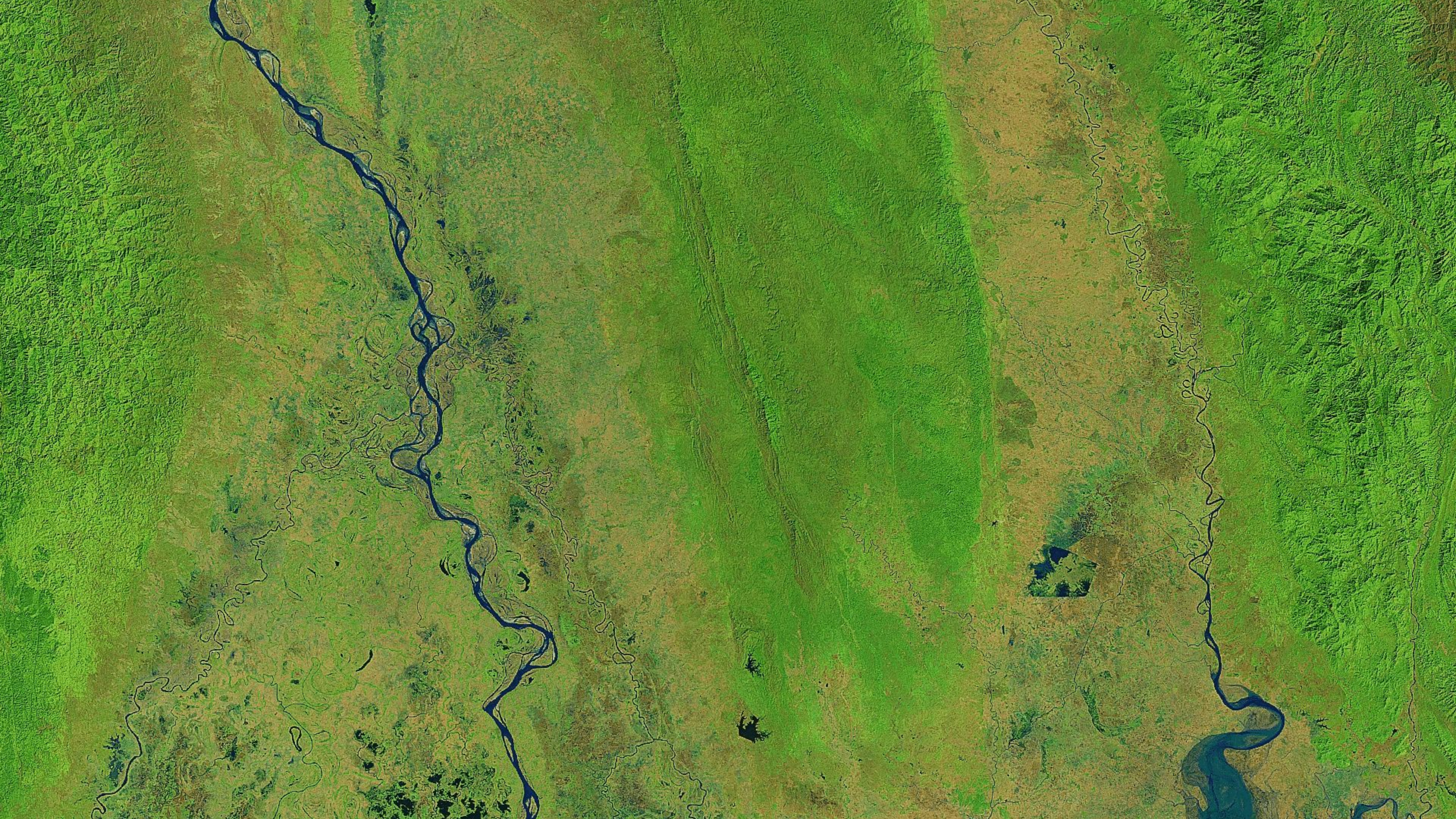
https://www.eefabook.org/

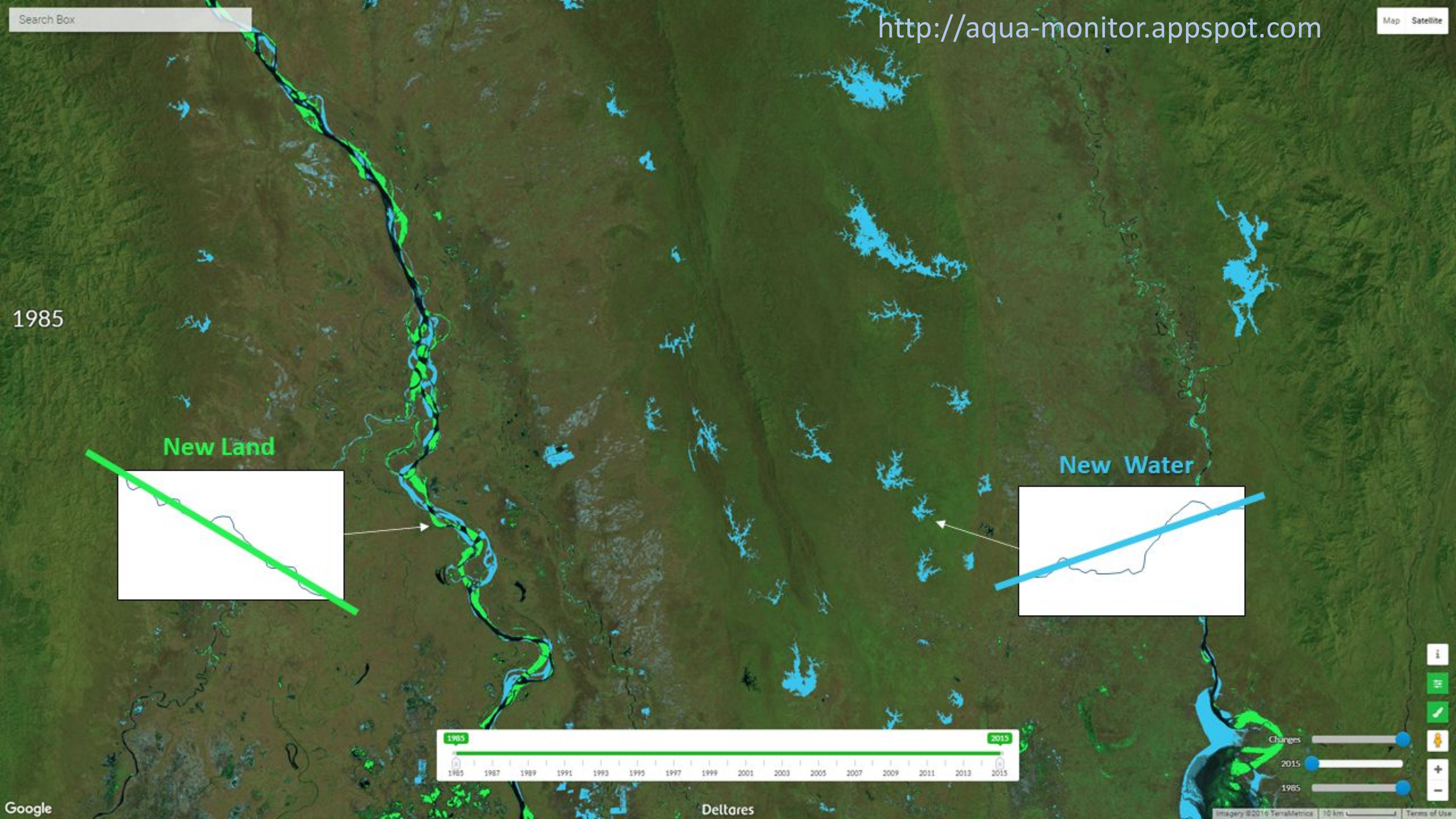
Launch The Hydrologic Remote Sensing Analysis for Floods (HYDRAFloods)

LAUNCH TOOL

https://servir.adpc.net/tools/hydrologic-remote-sensing-analysis-floods-hydrafloods

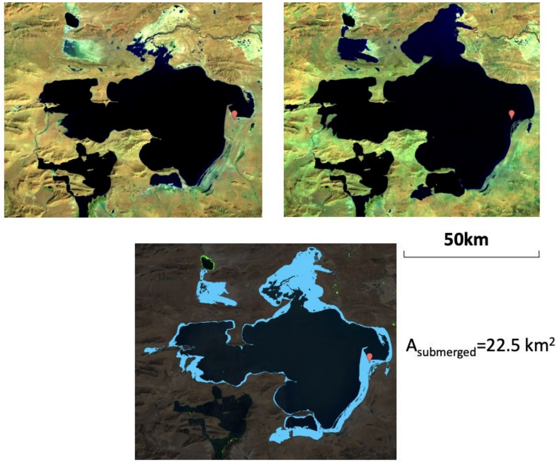

1984

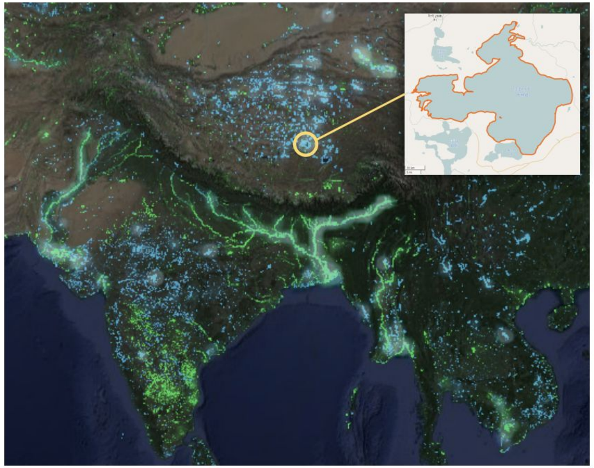


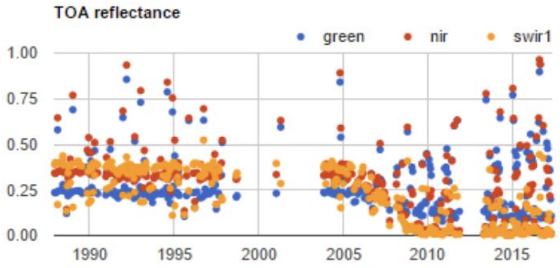


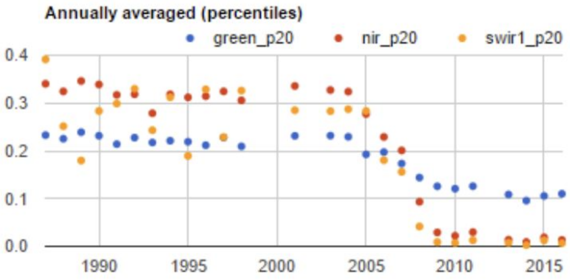
Search Box
http://aqua-monitor.appspot.com
Map
Satellite
1985
New Land
New Water
1985
2015
1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
Changes
2015
1985
Google
Deltares

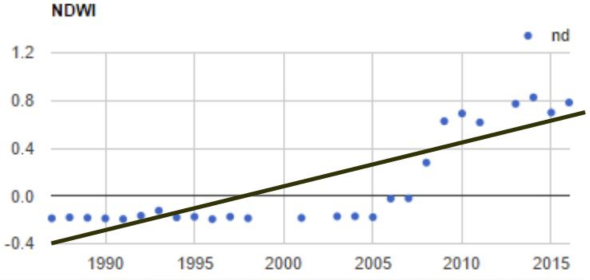
Surface water change detection using annual percentile composite images and linear regression of spectral water indices



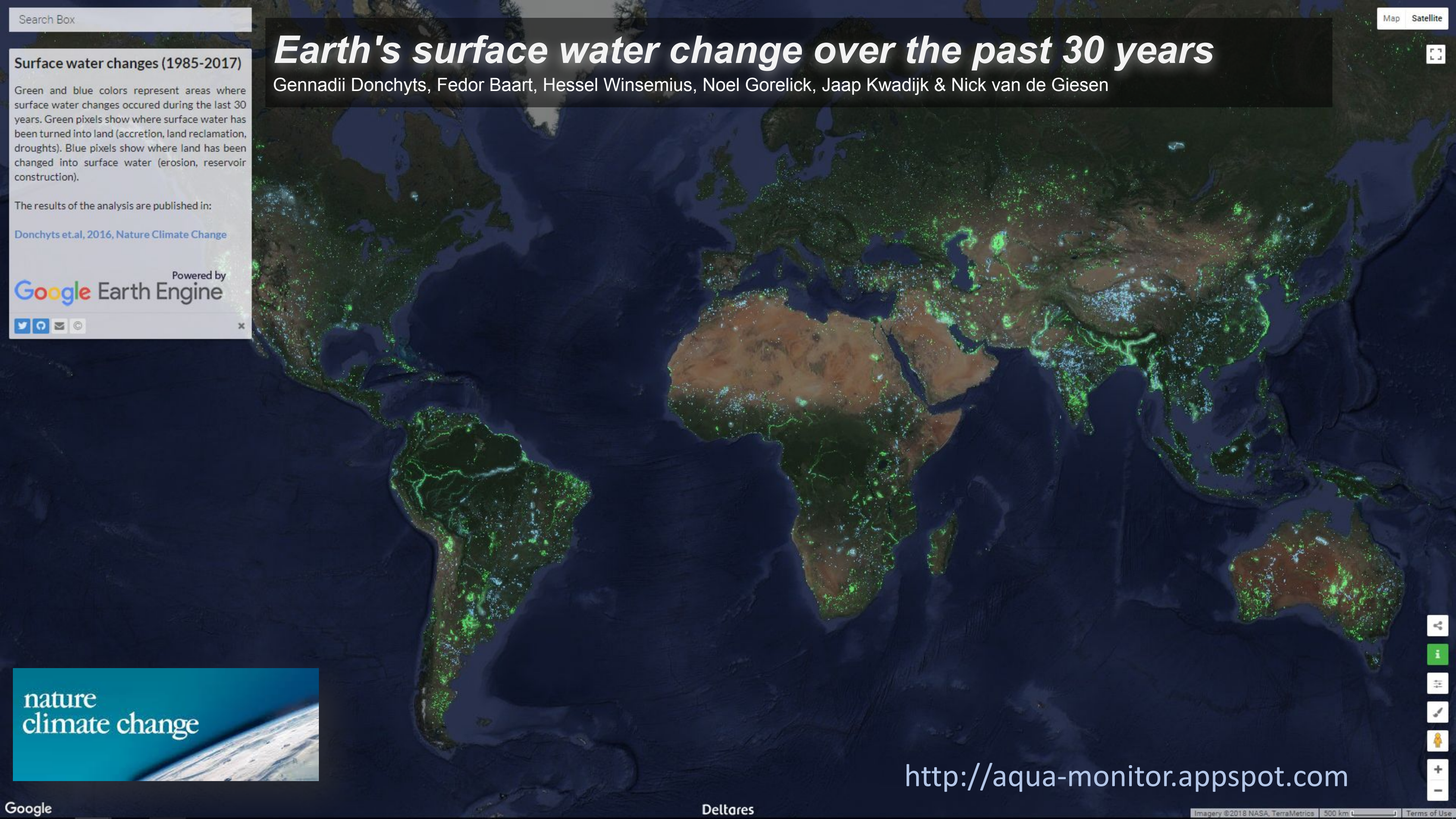


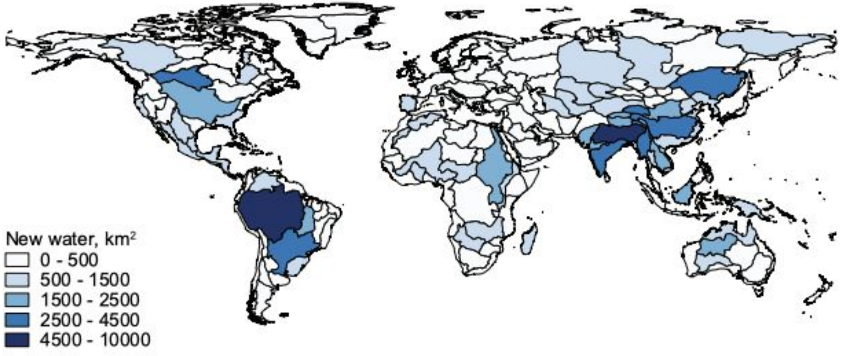


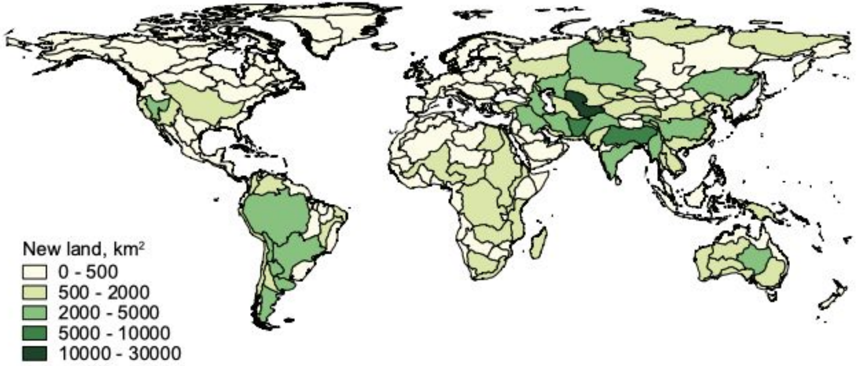




Check Chapter 5-6 in [Donchyts G, 2018]


Earth's surface water change over the past 30 years
Gennadii Donchyts, Fedor Baart, Hessel Winsemius, Noel Gorelick, Jaap Kwadijk & Nick van de Giesen
Search Box
Surface water changes (1985-2017)
Green and blue colors represent areas where surface water changes occured during the last 30 years. Green pixels show where surface water has been turned into land (accretion, land reclamation, droughts). Blue pixels show where land has been changed into surface water (erosion, reservoir construction).
The results of the analysis are published in:
Donchyts et.al, 2016, Nature Climate Change
Powered by Google Earth Engine
Map
Satellite
nature climate change
http://aqua-monitor.appspot.com
Google
Deltares

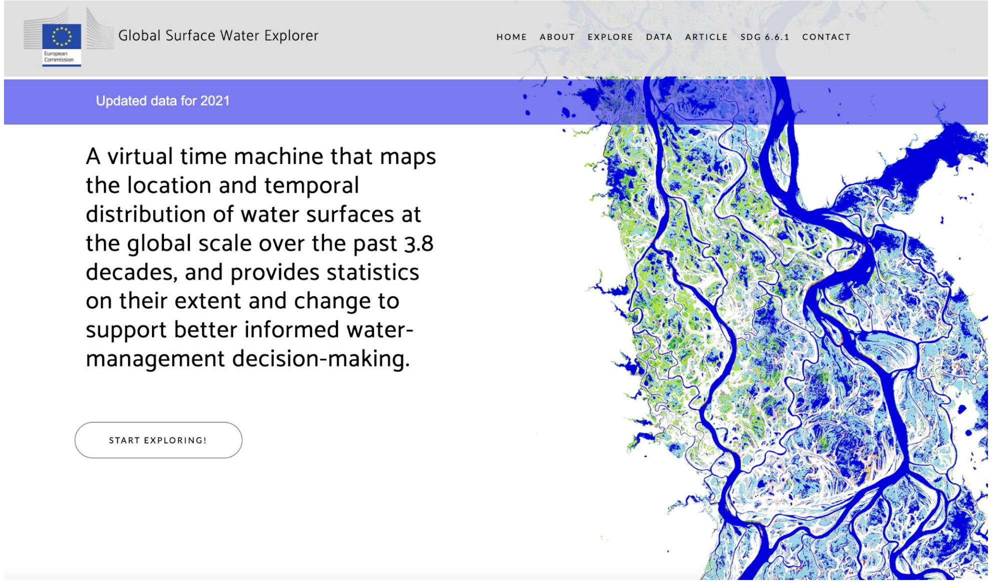


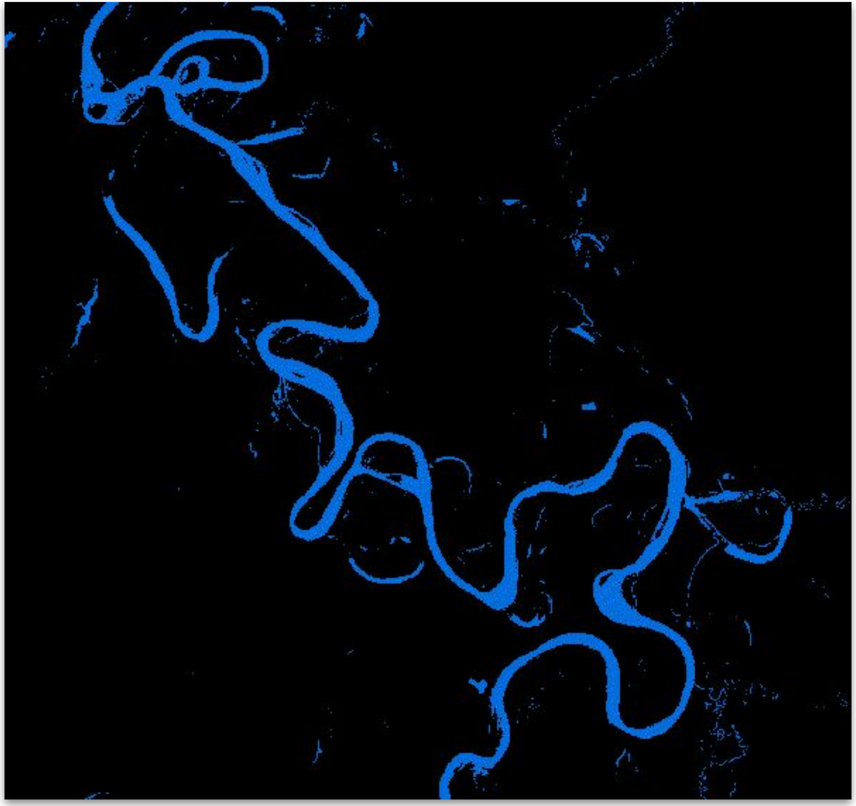


Name	Area, km2
Tibetan Plateau	7661
Amazon River	7058
Ganges-Brahmaputra Rivers	5495
Rio de la Plata	4410
River Nelson	4101
India	3677
River Amur	3494
Yangtze River	3238
Tigris & Euphrates Rivers	2636
Thanlyin;Sittang;Ayeyarwady	2592
Indus River	2312
Mississippi River	2231
Mekong River	2074

Name	Area, km2
Aral Sea	27841
Ganges-Brahmaputra Rivers	9580
Hamun Lake	6044
Tigris & Euphrates Rivers	4897
Amazon River	4888
Lake Eyre	4672
Rio de la Plata	4020
India	3851
Lake Urmia, Caspian Sea	3759
Great Salt Lake;Malheur Lake	3752
Ural River	3455
Amur River	3344
Ob River	3068

Figure 6.2: Largest surface water and land changes from 1985 until 2015 grouped by drainage basins. Left: changes from land to water in blue. Right: changes from water to land in green.



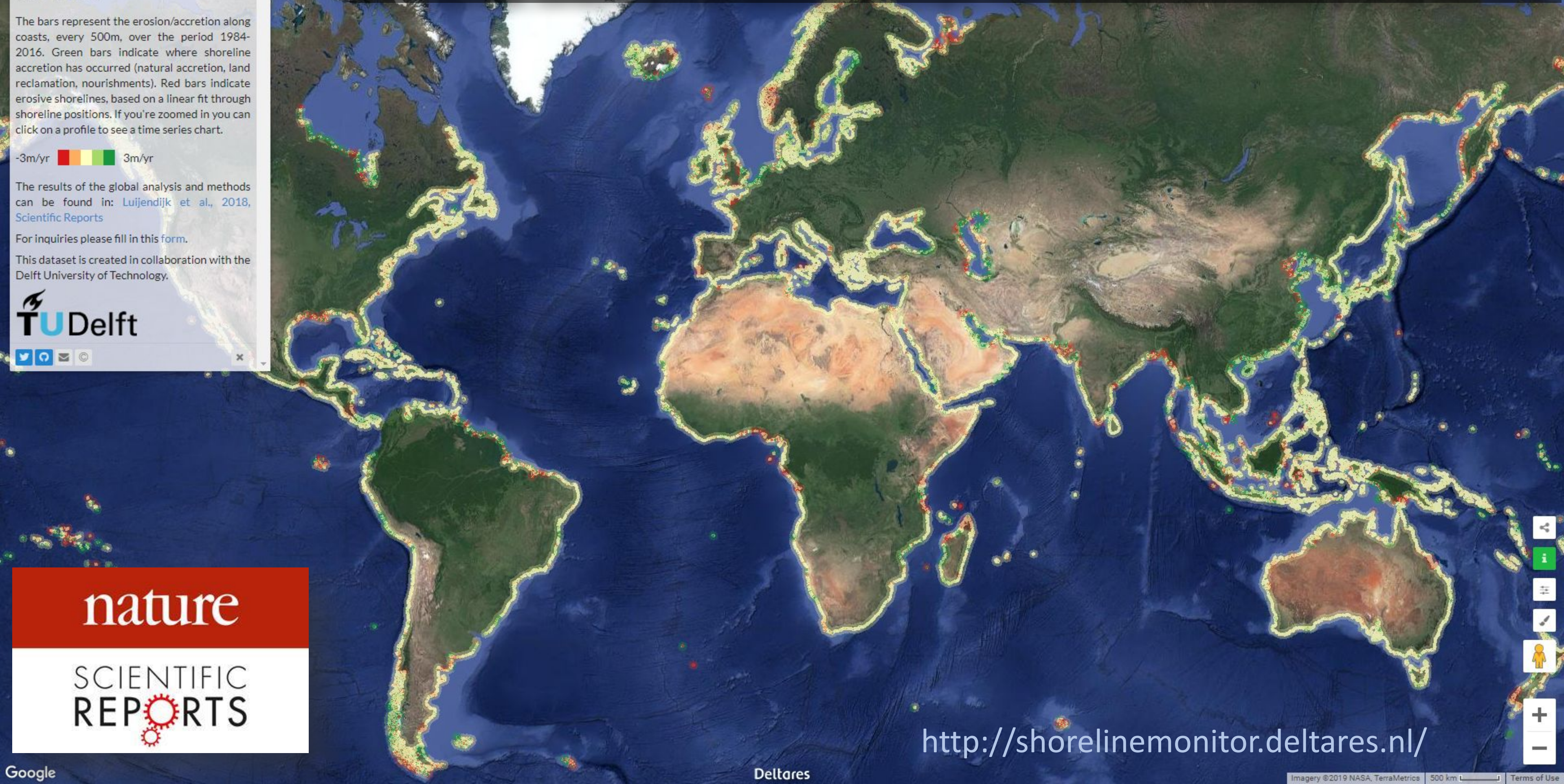


- Global Surface Water
  - Introduction
  - Water Occurrence (1984-2015)
  - Water Occurrence Change Intensity
  - Water Class Transition

https://developers.google.com/earth-engine/tutorials/tutorial_global_surface_water_01

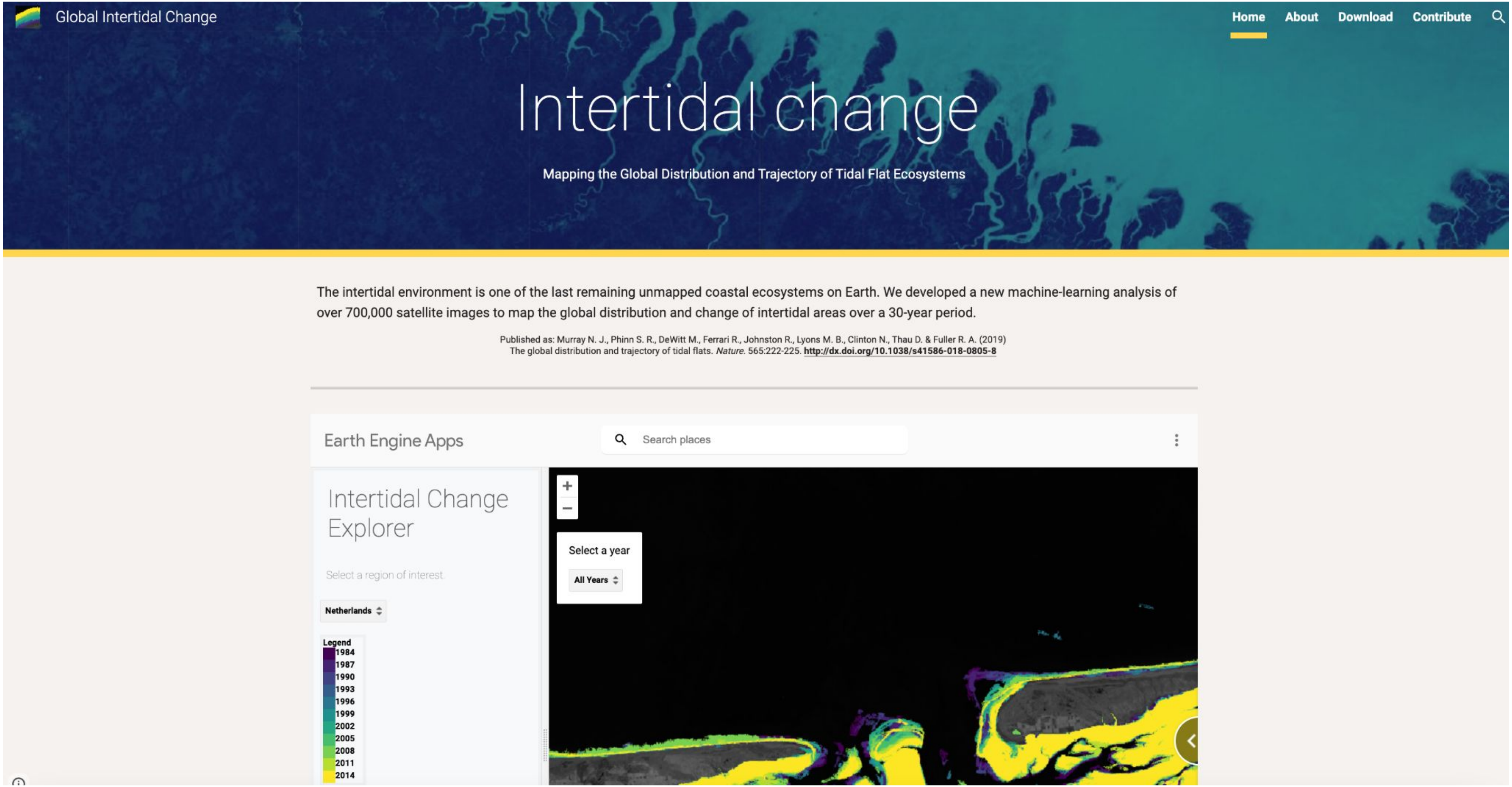
The State of the World's Beaches

Arjen Luijendijk, Gerben Hagenaars, Roshanka Ranasinghe, Fedor Baart, Gennadii Donchyts & Stefan Aarninkhof

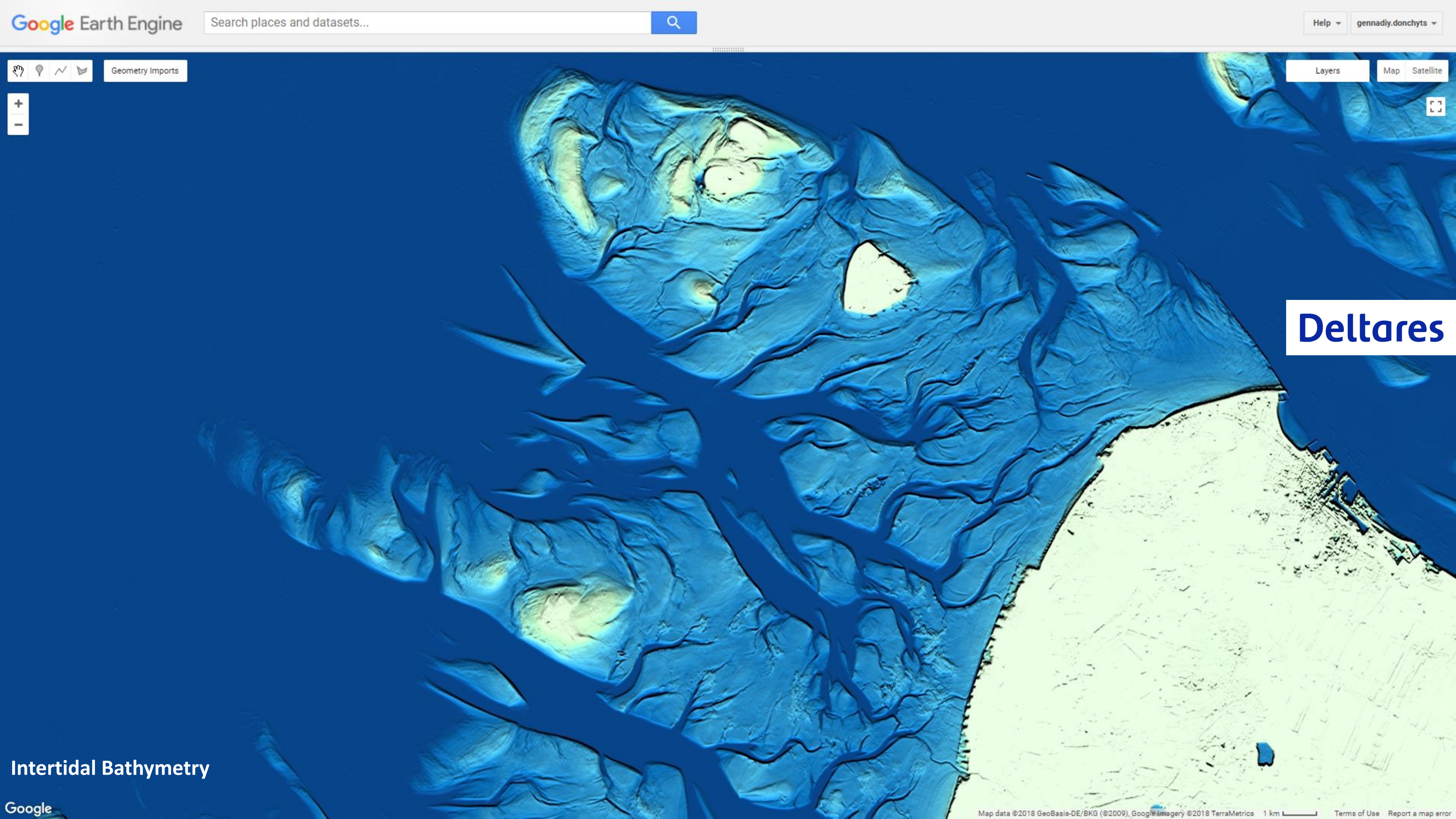


https://www.intertidal.app/

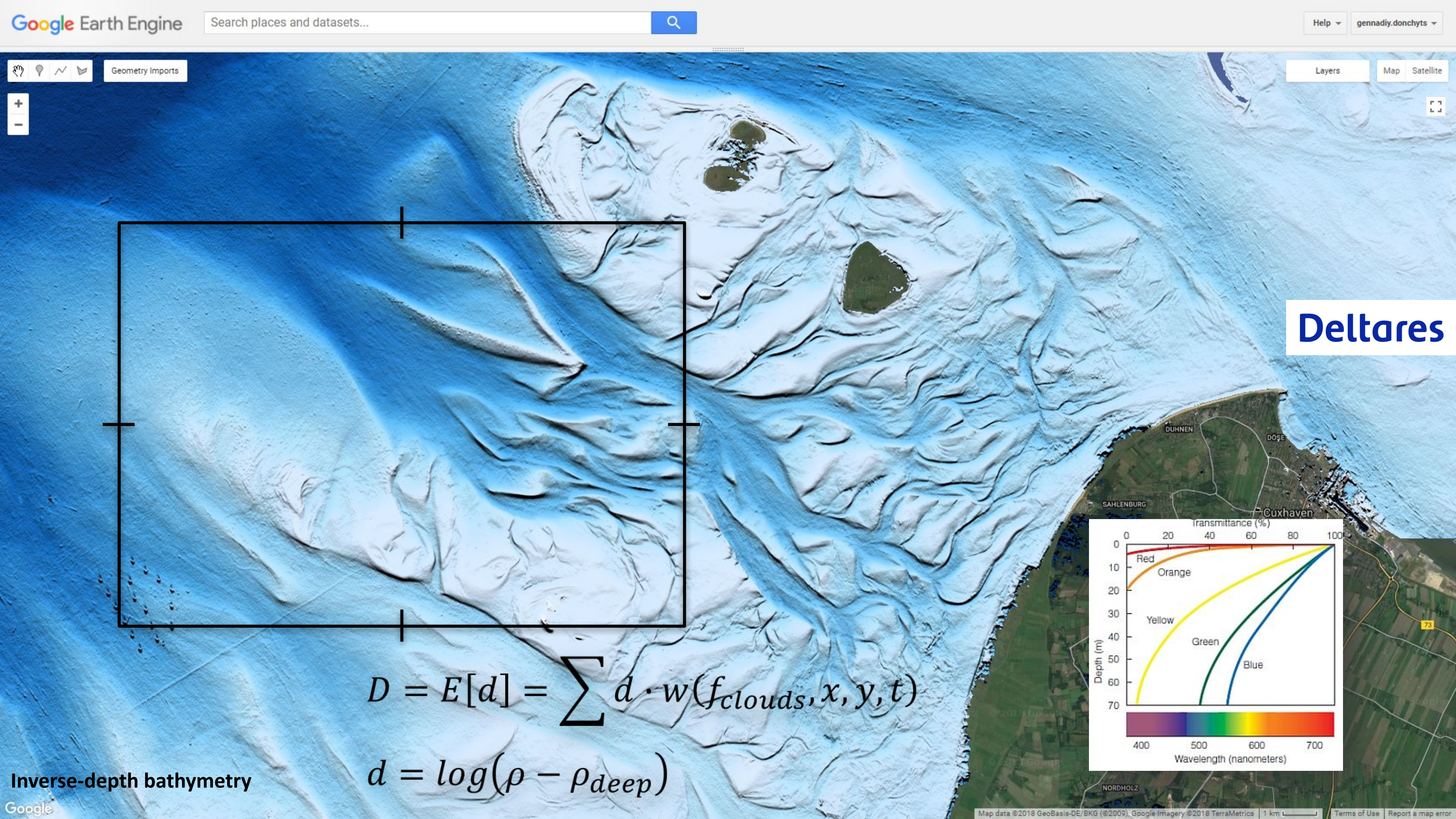
nature




2017-01-03



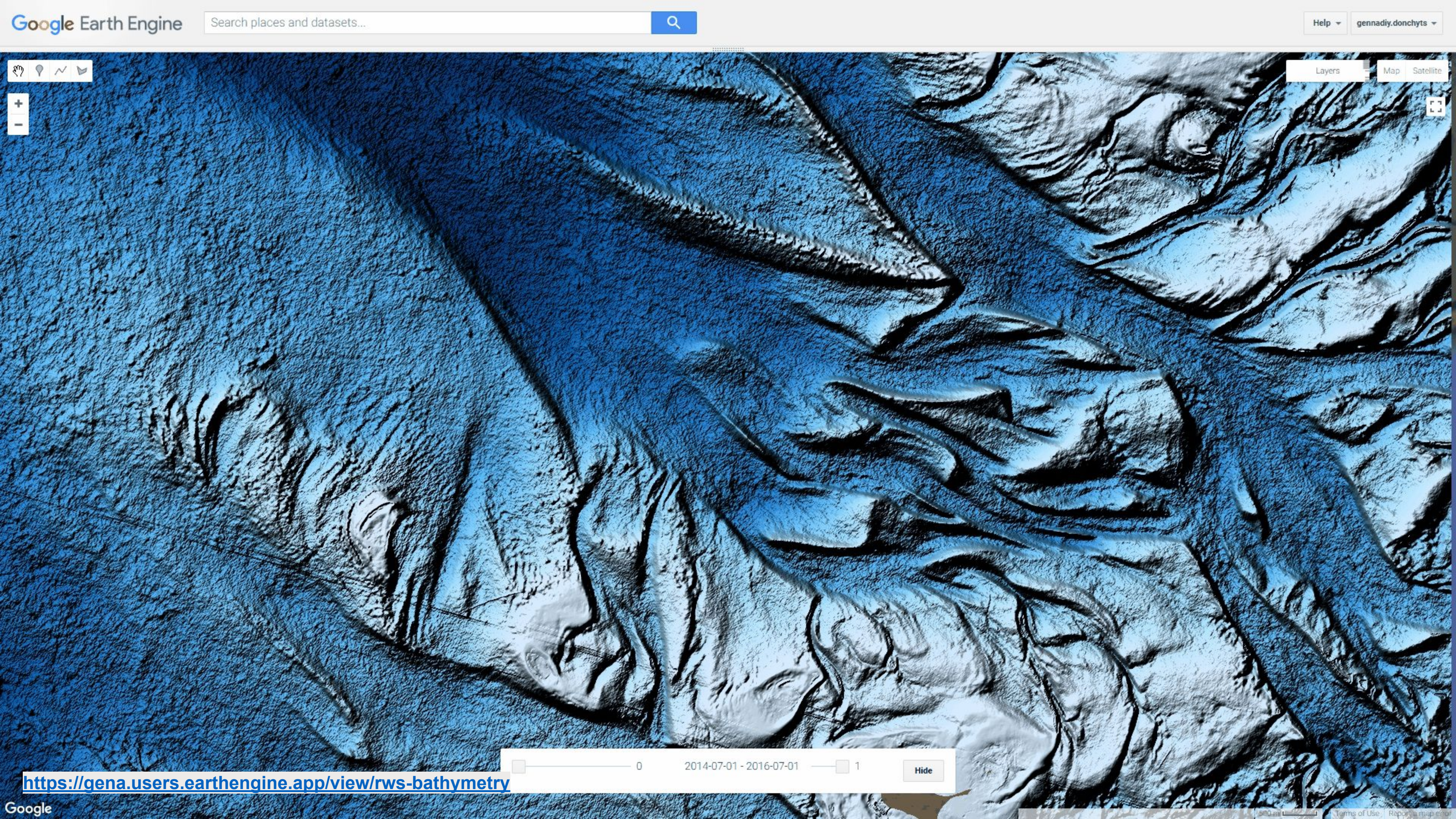
Intertidal Bathymetry



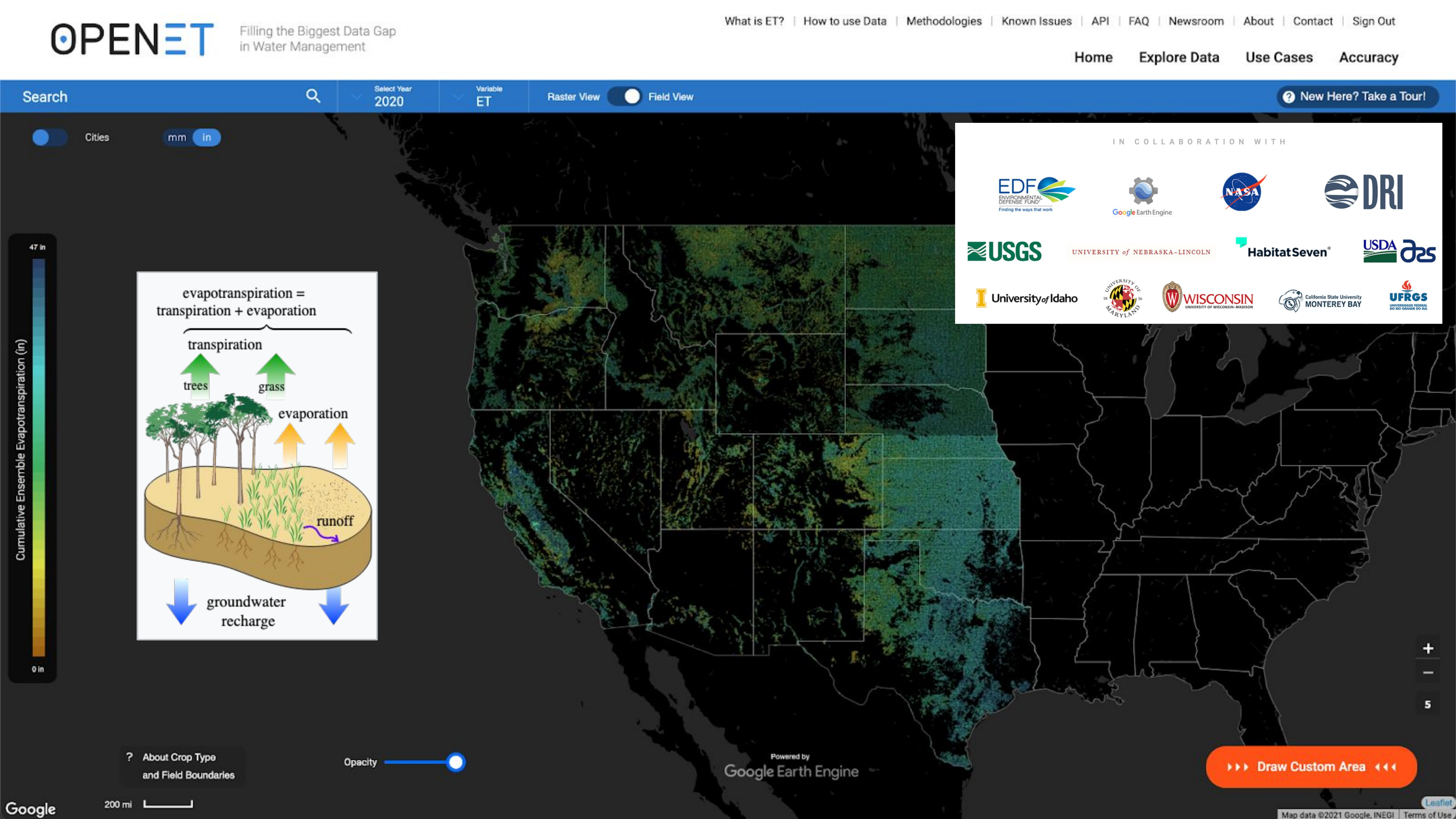
Inverse-depth bathymetry

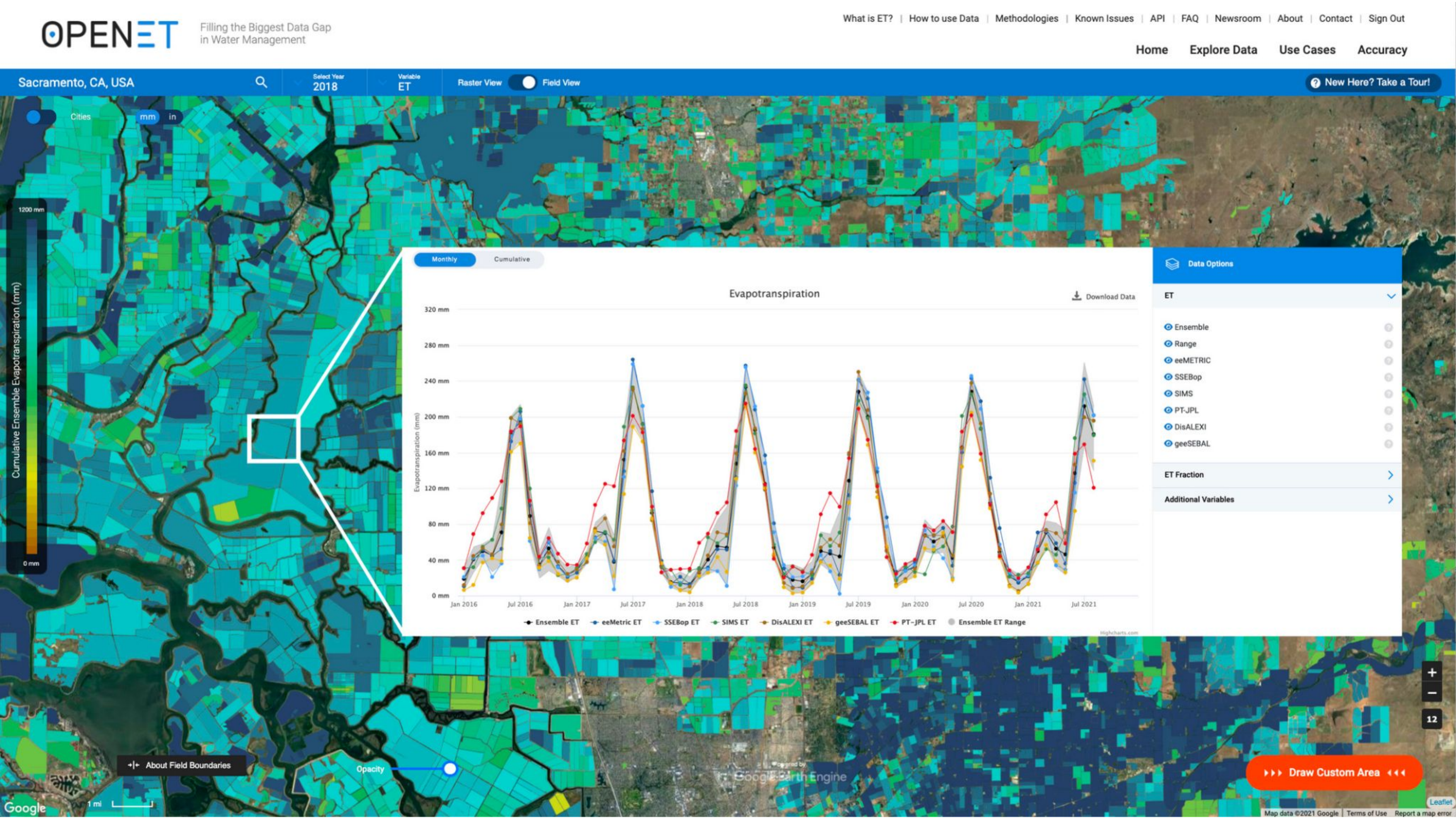
$$D = E[d] = \sum d \cdot w(f_{clouds}, x, y, t)$$

$$d = log(\rho - \rho_{deep})$$

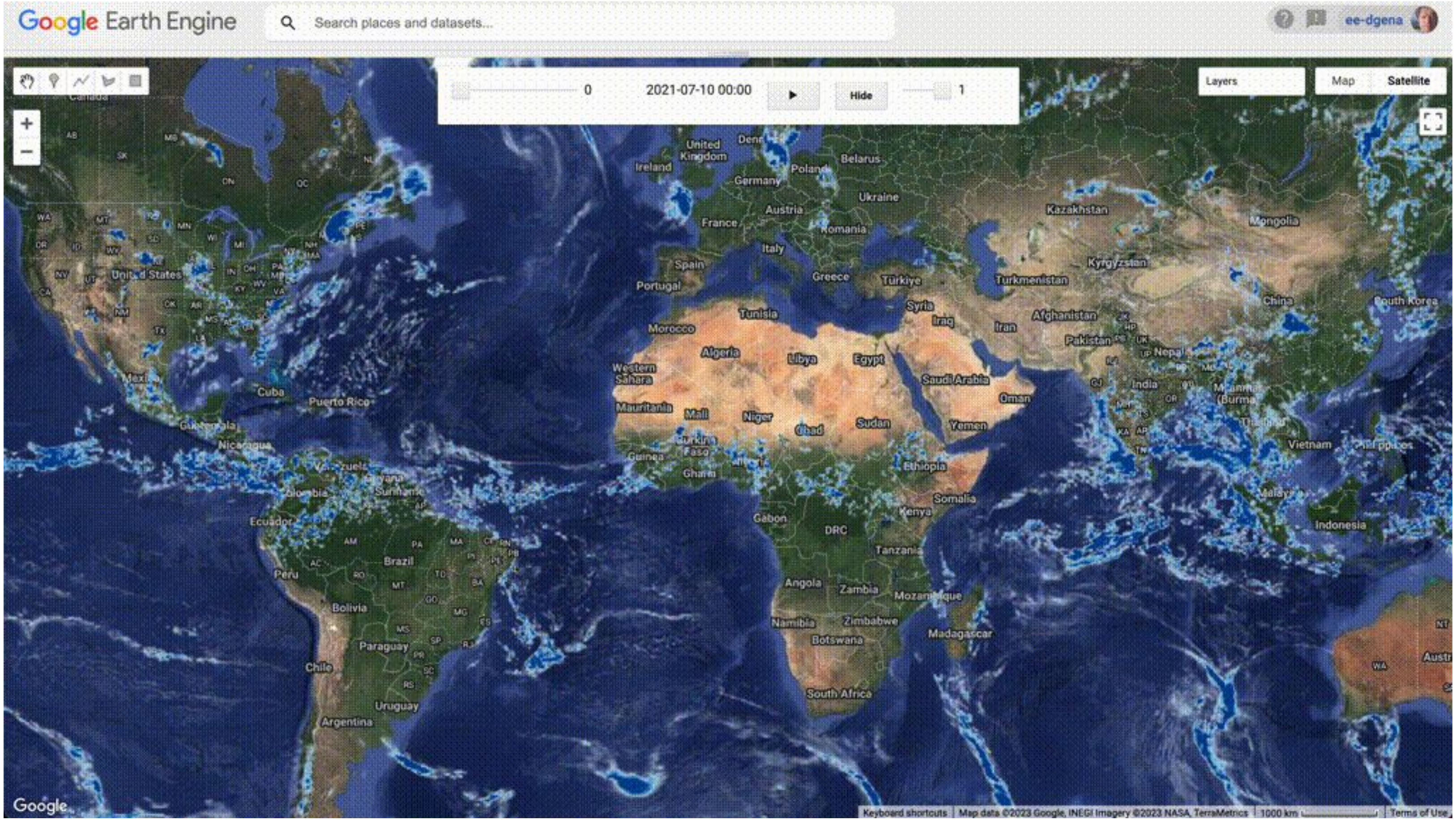


https://gena.users.earthengine.app/view/rws-bathymetry

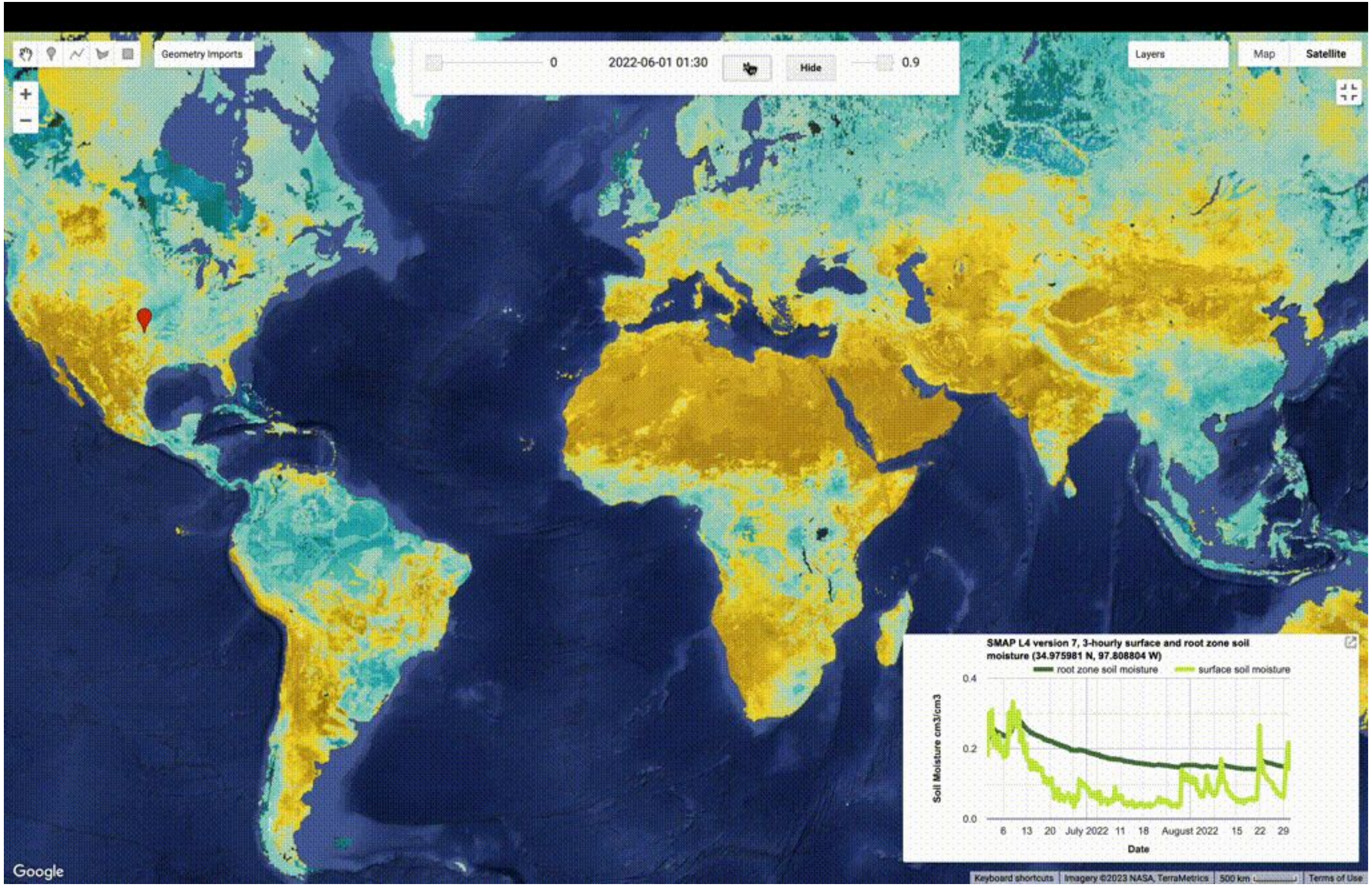

OPENET
Filling the Biggest Data Gap in Water Management
What is ET? | How to use Data | Methodologies | Known Issues | API | FAQ | Newsroom | About | Contact | Sign Out
Home
Explore Data
Use Cases
Accuracy
Search
Select Year
2020
Variable
ET
Raster View
Field View
New Here? Take a Tour!
Cities
mm
in
47 in
Cumulative Ensemble Evapotranspiration (in)
0 in
evapotranspiration =
transpiration + evaporation
transpiration
trees
grass
evaporation
runoff
groundwater
recharge
IN COLLABORATION WITH
EDF ENVIRONMENTAL DEFENSE FUND Finding the ways that work
Google Earth Engine
NASA
DRI
USGS
UNIVERSITY of NEBRASKA–LINCOLN
HabitatSeven
USDA ARS
University of Idaho
UNIVERSITY OF MARYLAND
WISCONSIN UNIVERSITY OF WISCONSIN–MADISON
California State University MONTEREY BAY
UFRGS
? About Crop Type and Field Boundaries
Opacity
Powered by Google Earth Engine
Draw Custom Area
+
–
5
Google
200 mi
Leaflet
Map data ©2021 Google, INEGI | Terms of Use


OPENET
Filling the Biggest Data Gap in Water Management
What is ET? | How to use Data | Methodologies | Known Issues | API | FAQ | Newsroom | About | Contact | Sign Out
Home
Explore Data
Use Cases
Accuracy
Sacramento, CA, USA
Select Year 2018
Variable ET
Raster View
Field View
New Here? Take a Tour!
Cities
mm
in
1200 mm
Cumulative Ensemble Evapotranspiration (mm)
0 mm
Monthly
Cumulative
Evapotranspiration
Download Data
320 mm
280 mm
240 mm
200 mm
160 mm
120 mm
80 mm
40 mm
0 mm
Evapotranspiration (mm)
Jan 2016
Jul 2016
Jan 2017
Jul 2017
Jan 2018
Jul 2018
Jan 2019
Jul 2019
Jan 2020
Jul 2020
Jan 2021
Jul 2021
Ensemble ET
eeMetric ET
SSEBop ET
SIMS ET
DisALEXI ET
geeSEBAL ET
PT-JPL ET
Ensemble ET Range
Data Options
ET
Ensemble
Range
eeMETRIC
SSEBop
SIMS
PT-JPL
DisALEXI
geeSEBAL
ET Fraction
Additional Variables
About Field Boundaries
Opacity
Draw Custom Area
12
Google
1 mi
Leaflet
Map data ©2021 Google
Terms of Use
Report a map error

Precipitation (GFS)



SMAP (https://developers.google.com/earth-engine/tutorials/community/smap-soil-moisture)



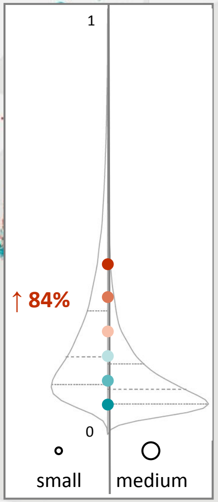
nature
SCIENTIFIC REPORTS

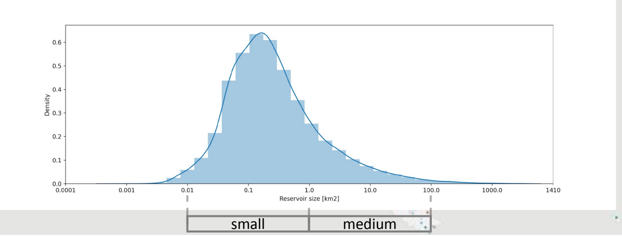
High-resolution surface water dynamics in Earth's small and medium-sized reservoirs

Gennadii Donchyts, Hessel Winsemius, Fedor Baart, Ruben Dahm, Jaap Schellekens, Noel Gorelick, Charles Iceland & Susanne Schmeier

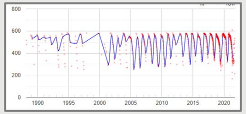
Seasonal Variability

intra-annual mean-normalized surface water area standard deviation

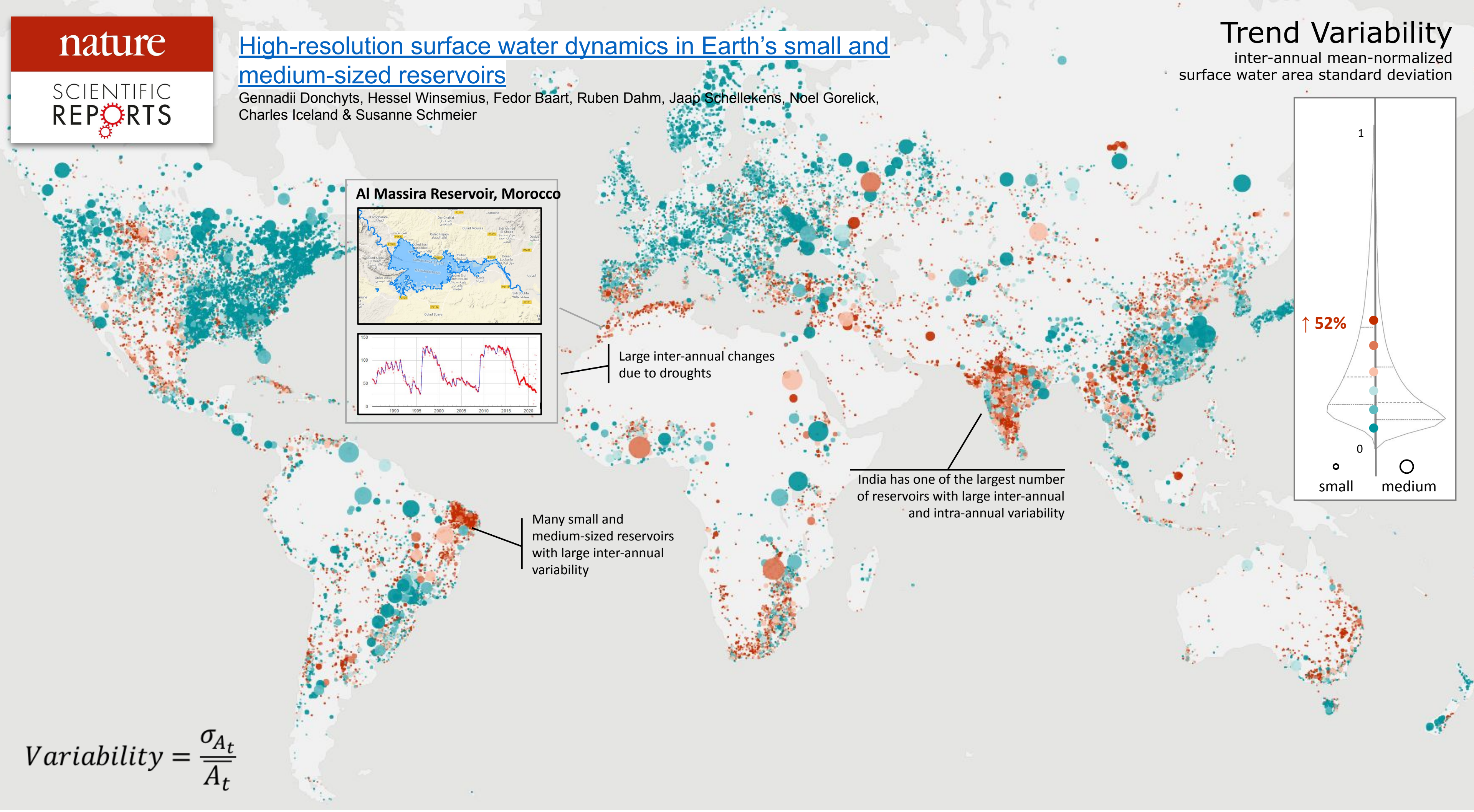




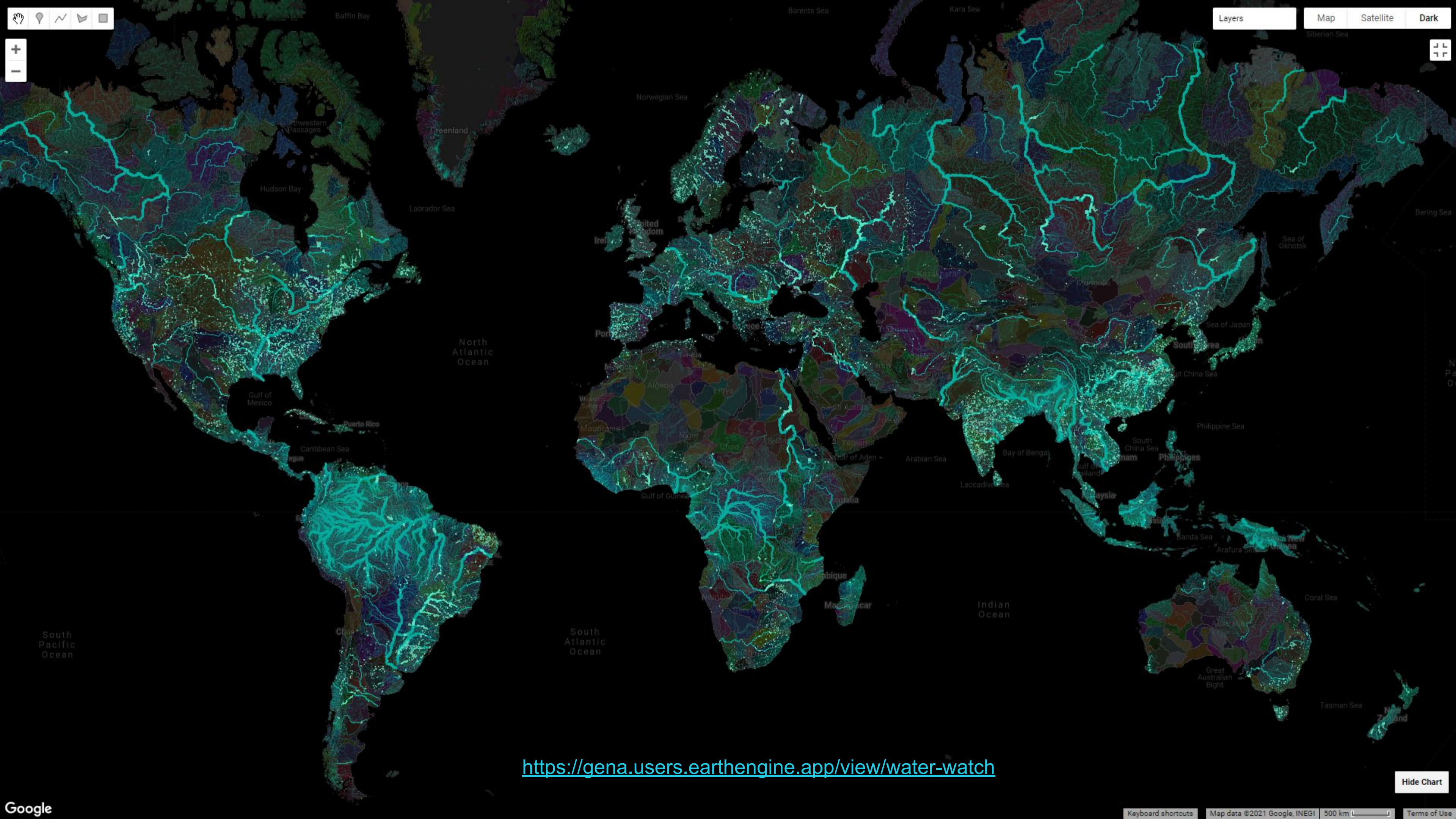
Hirakud Reservoir, India



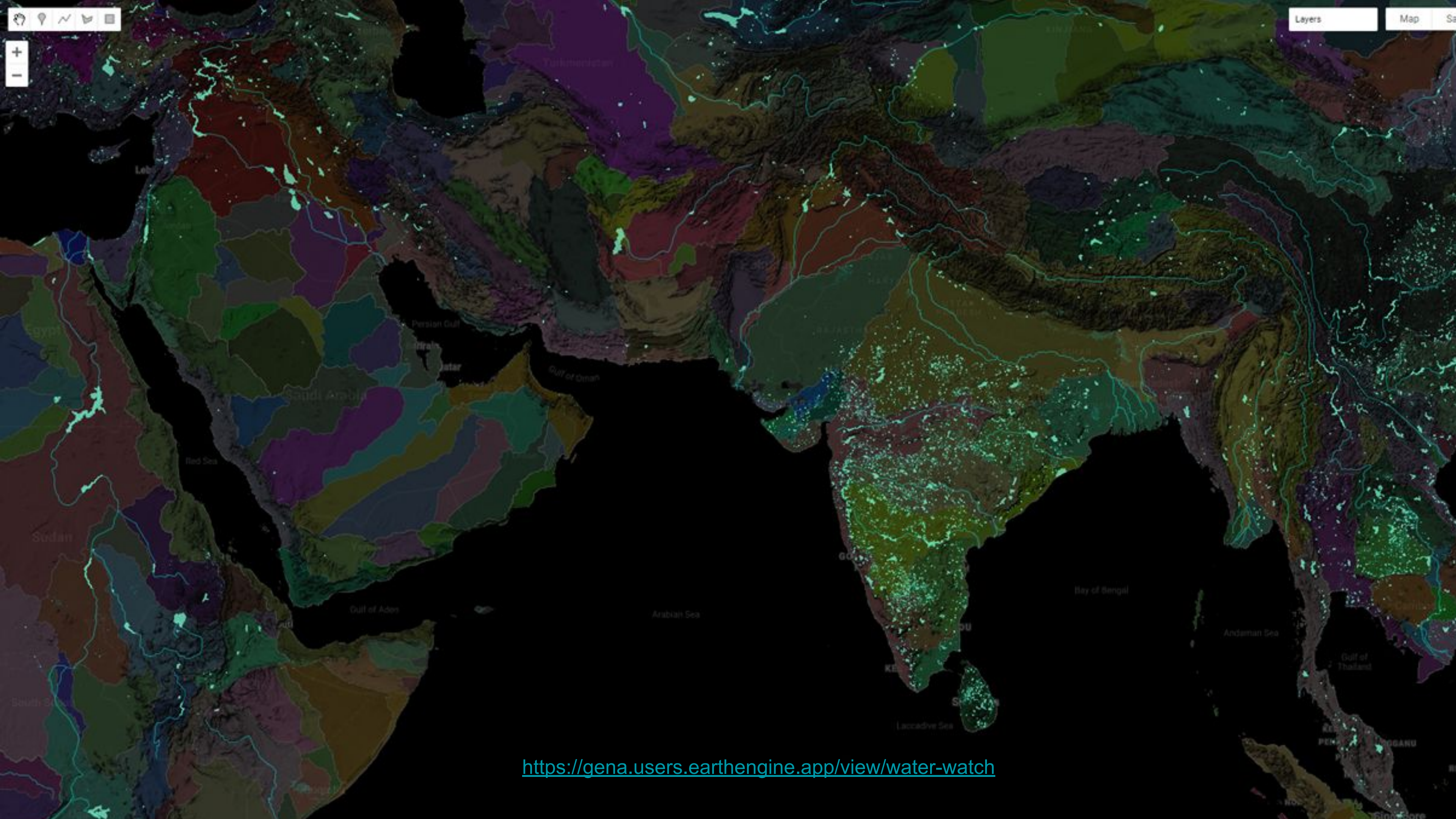
Large seasonal variability of reservoirs in dry areas



nature
SCIENTIFIC REPORTS
High-resolution surface water dynamics in Earth's small and medium-sized reservoirs
Gennadii Donchyts, Hessel Winsemius, Fedor Baart, Ruben Dahm, Jaap Schellekens, Noel Gorelick, Charles Iceland & Susanne Schmeier
Trend Variability
inter-annual mean-normalized surface water area standard deviation
1
↑ 52%
0
small
medium
Al Massira Reservoir, Morocco
Large inter-annual changes due to droughts
India has one of the largest number of reservoirs with large inter-annual and intra-annual variability
Many small and medium-sized reservoirs with large inter-annual variability
$$Variability = \frac{\sigma_{A_t}}{\bar{A}_t}$$

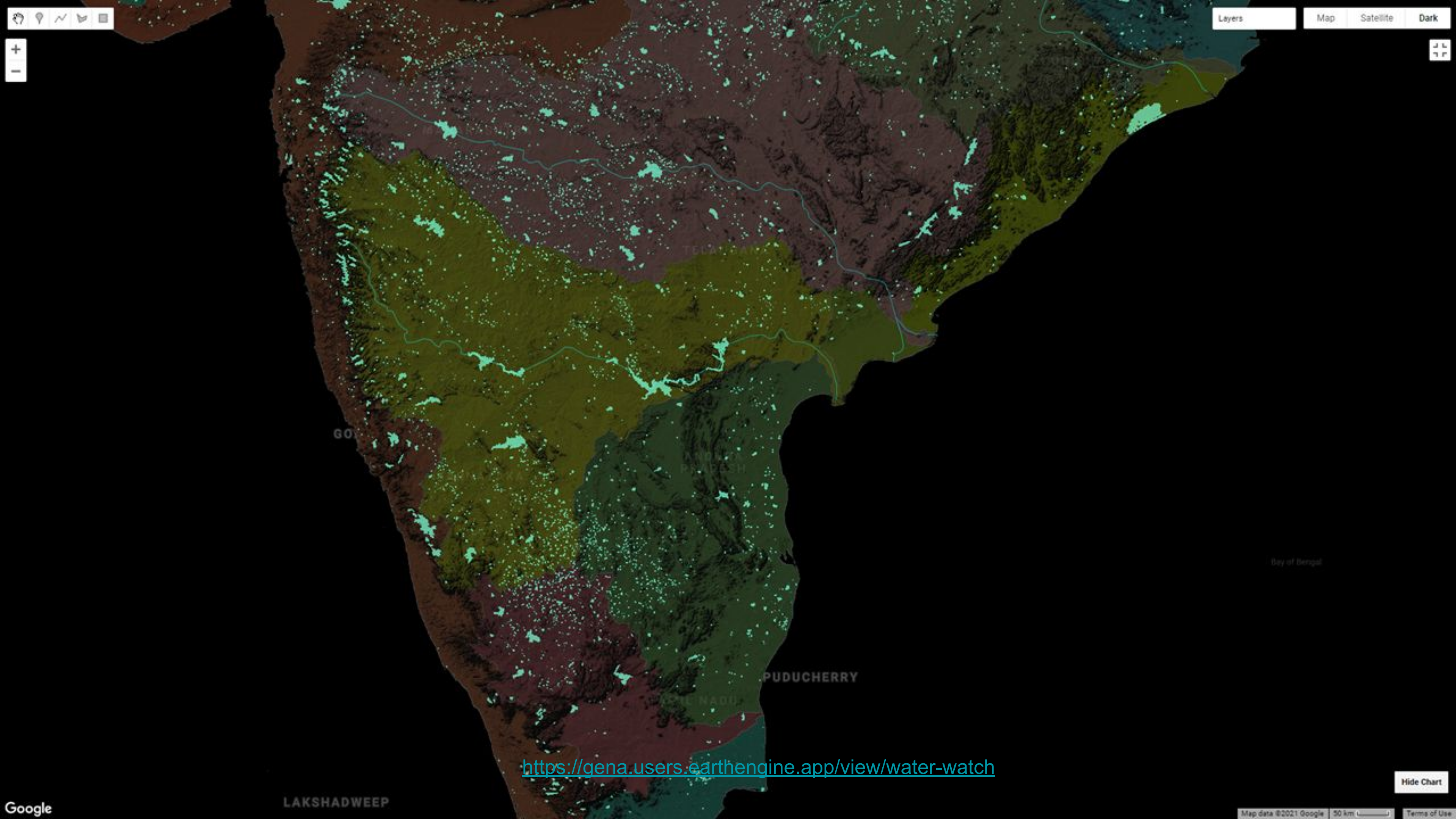


Layers
Map
Satellite
Dark
Baffin Bay
Barents Sea
Kara Sea
Norwegian Sea
Greenland
Hudson Bay
Labrador Sea
Bering Sea
North Atlantic Ocean
Gulf of Mexico
Puerto Rico
Caribbean Sea
Sea of Japan
Philippine Sea
South China Sea
Bay of Bengal
Arabian Sea
Gulf of Guinea
Indian Ocean
South Atlantic Ocean
South Pacific Ocean
Coral Sea
Tasman Sea
Great Australian Bight
https://gena.users.earthengine.app/view/water-watch
Hide Chart
Google
Keyboard shortcuts
Map data ©2021 Google, INEGI
500 km
Terms of Use

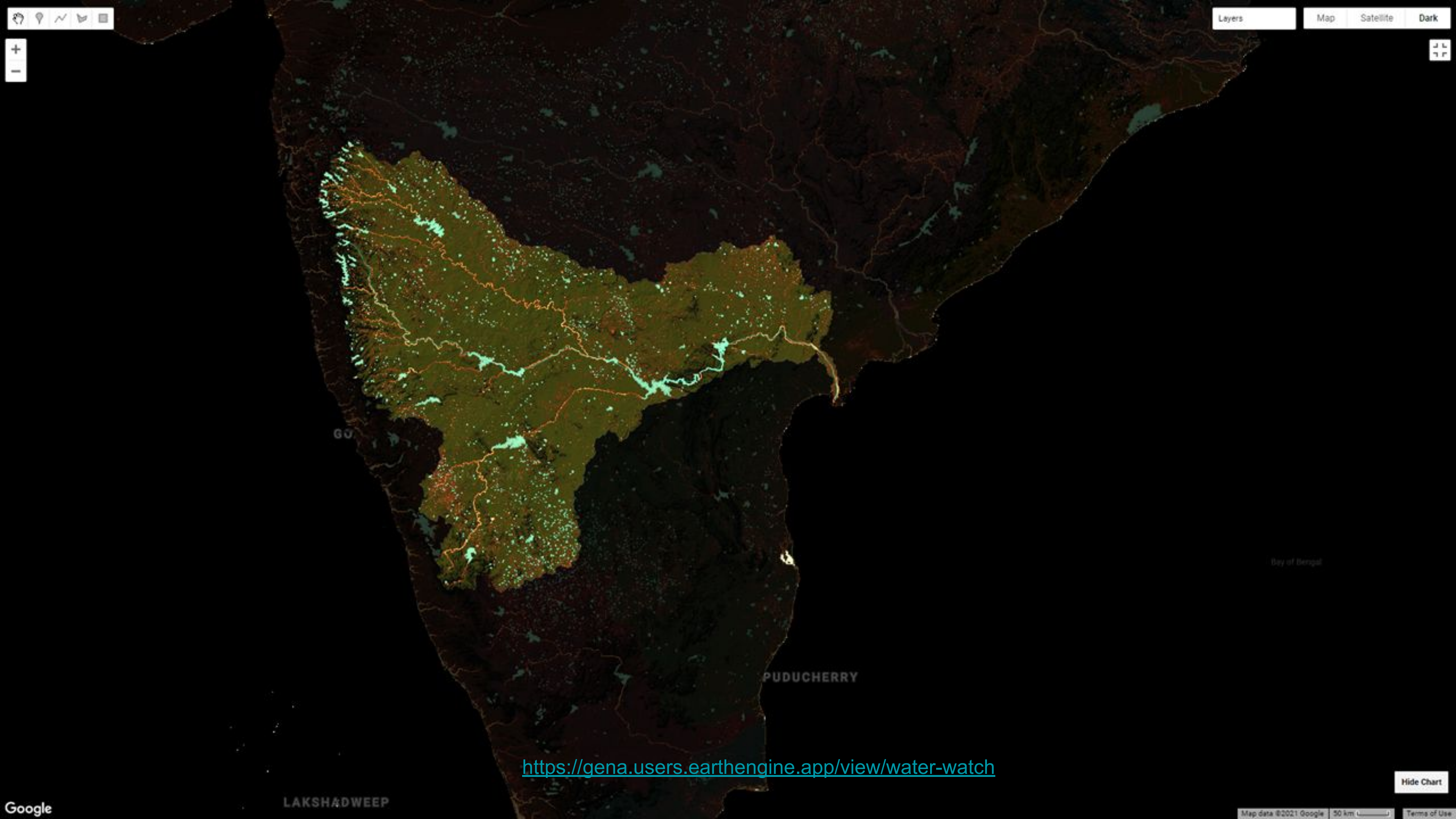


https://gena.users.earthengine.app/view/water-watch

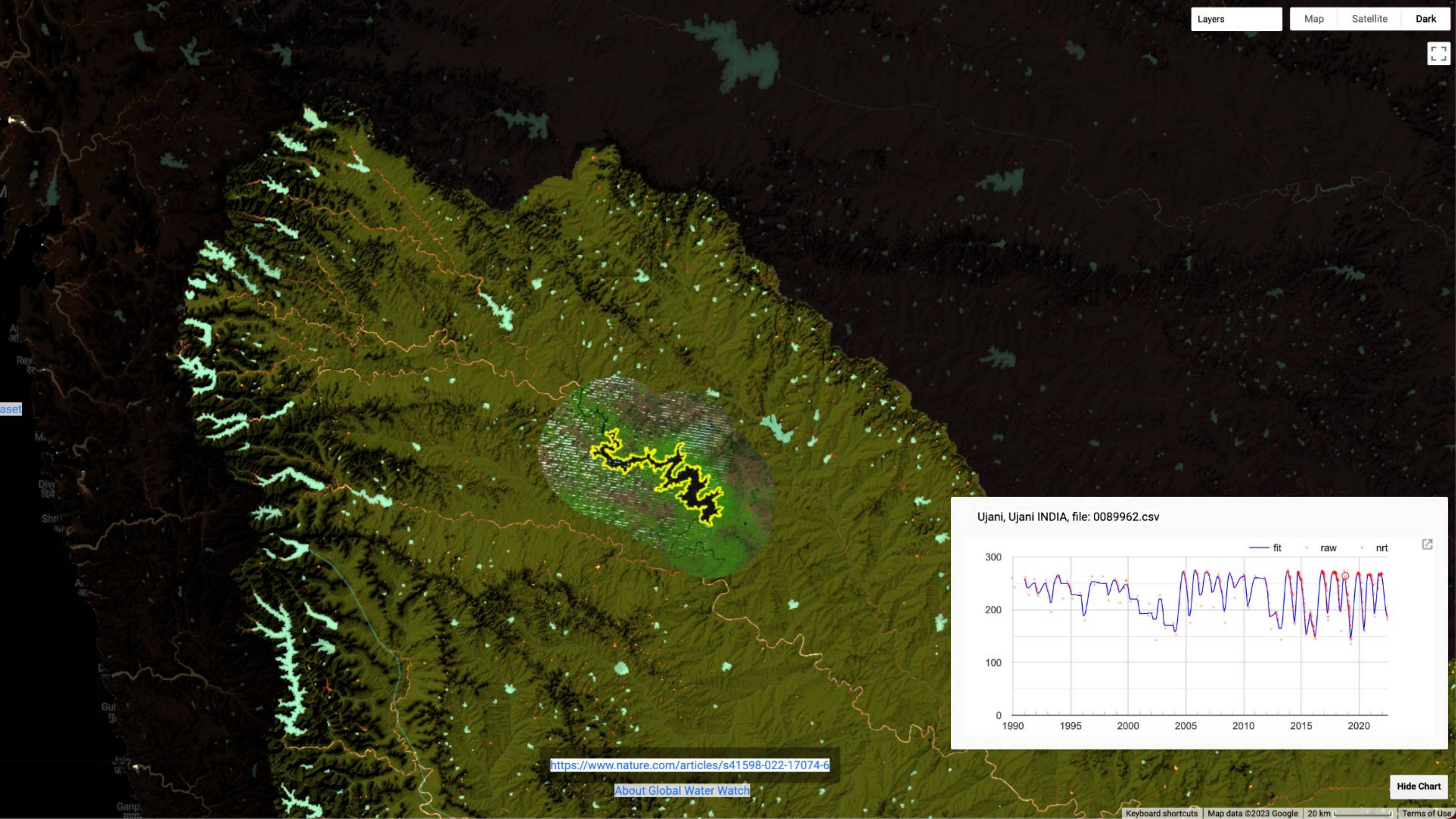
https://gena.users.earthengine.app/view/water-watch

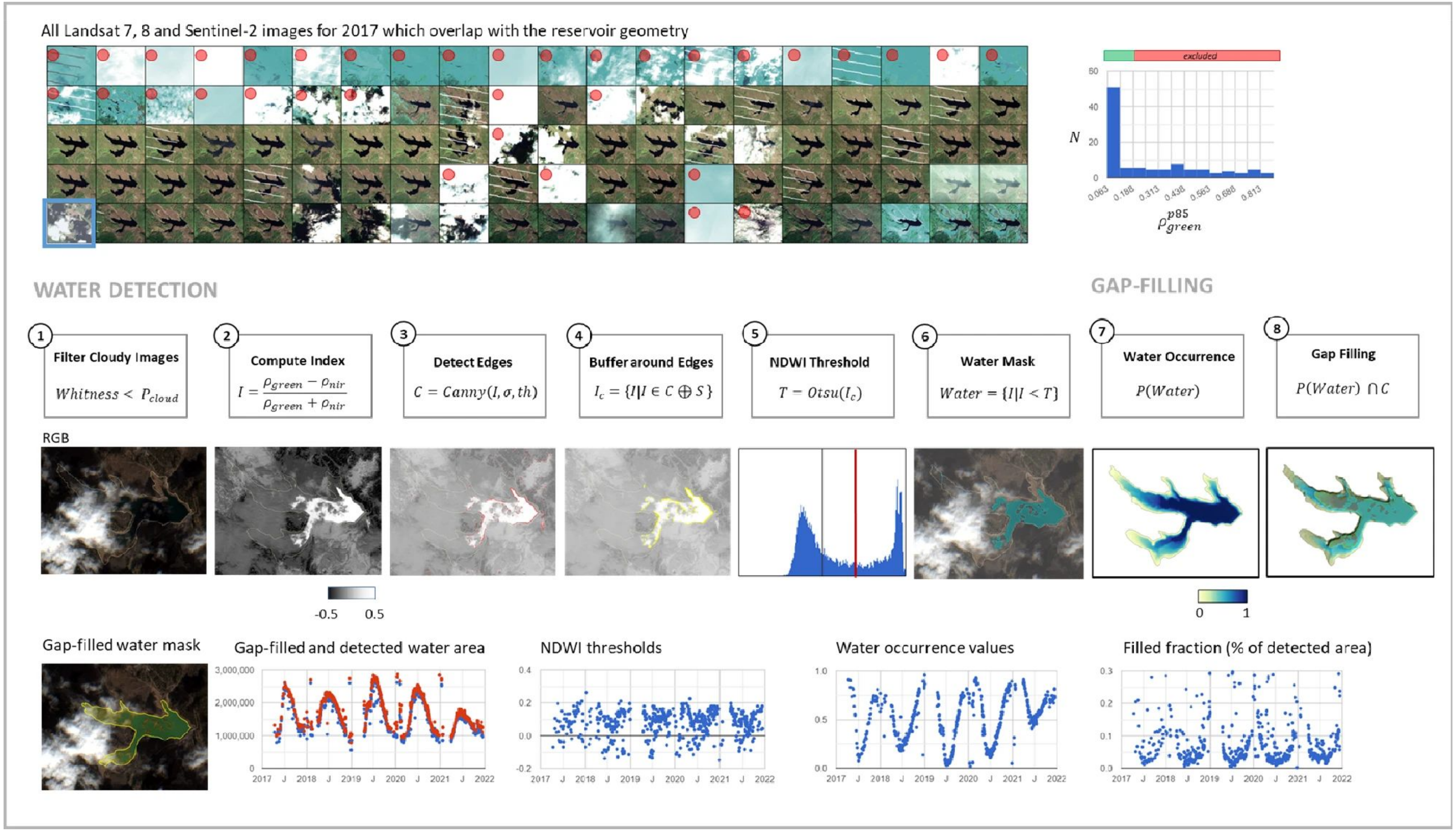


https://gena.users.earthengine.app/view/water-watch



https://gena.users.earthengine.app/view/water-watch

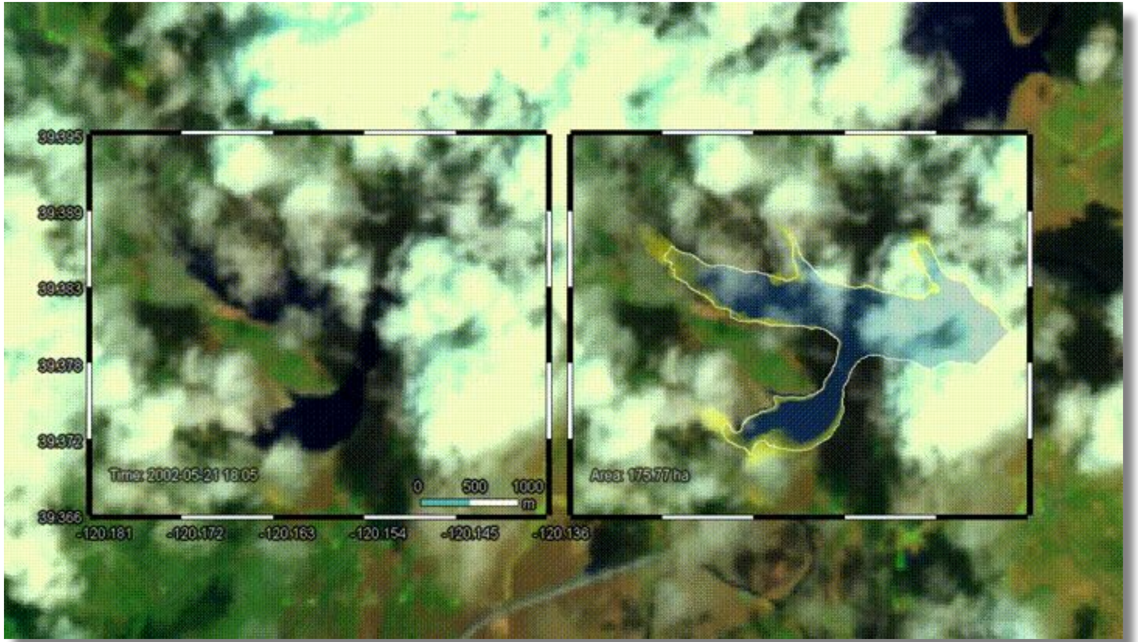

Layers
Map
Satellite
Dark
Ujani, Ujani INDIA, file: 0089962.csv
fit
raw
nrt
300
200
100
0
1990
1995
2000
2005
2010
2015
2020
https://www.nature.com/articles/s41598-022-17074-6
About Global Water Watch
Hide Chart
Keyboard shortcuts
Map data ©2023 Google
20 km
Terms of Use



All Landsat 7, 8 and Sentinel-2 images for 2017 which overlap with the reservoir geometry
excluded
N
WATER DETECTION
GAP-FILLING
1 Filter Cloudy Images
$Whitness < P_{cloud}$
2 Compute Index
$I = \frac{\rho_{green} - \rho_{nir}}{\rho_{green} + \rho_{nir}}$
3 Detect Edges
$C = Canny(I, \sigma, th)$
4 Buffer around Edges
$I_c = \{I | I \in C \oplus S\}$
5 NDWI Threshold
$T = Otsu(I_c)$
6 Water Mask
$Water = \{I | I < T\}$
7 Water Occurrence
$P(Water)$
8 Gap Filling
$P(Water) \cap C$
RGB
-0.5 0.5
0 1
Gap-filled water mask
Gap-filled and detected water area
NDWI thresholds
Water occurrence values
Filled fraction (% of detected area)

[Code]

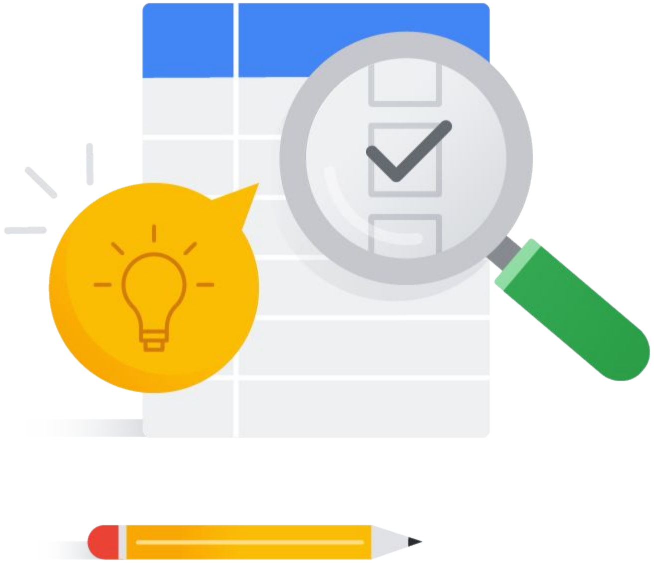
[Paper]



39.395
39.389
39.383
39.378
39.372
39.366
-120.181
-120.172
-120.163
-120.154
-120.145
-120.136
Time: 2002-05-21 18:05
0
500
1000
m
Area: 175.77 ha

02 Water dynamics mapping (JRC)

10 min | Individual

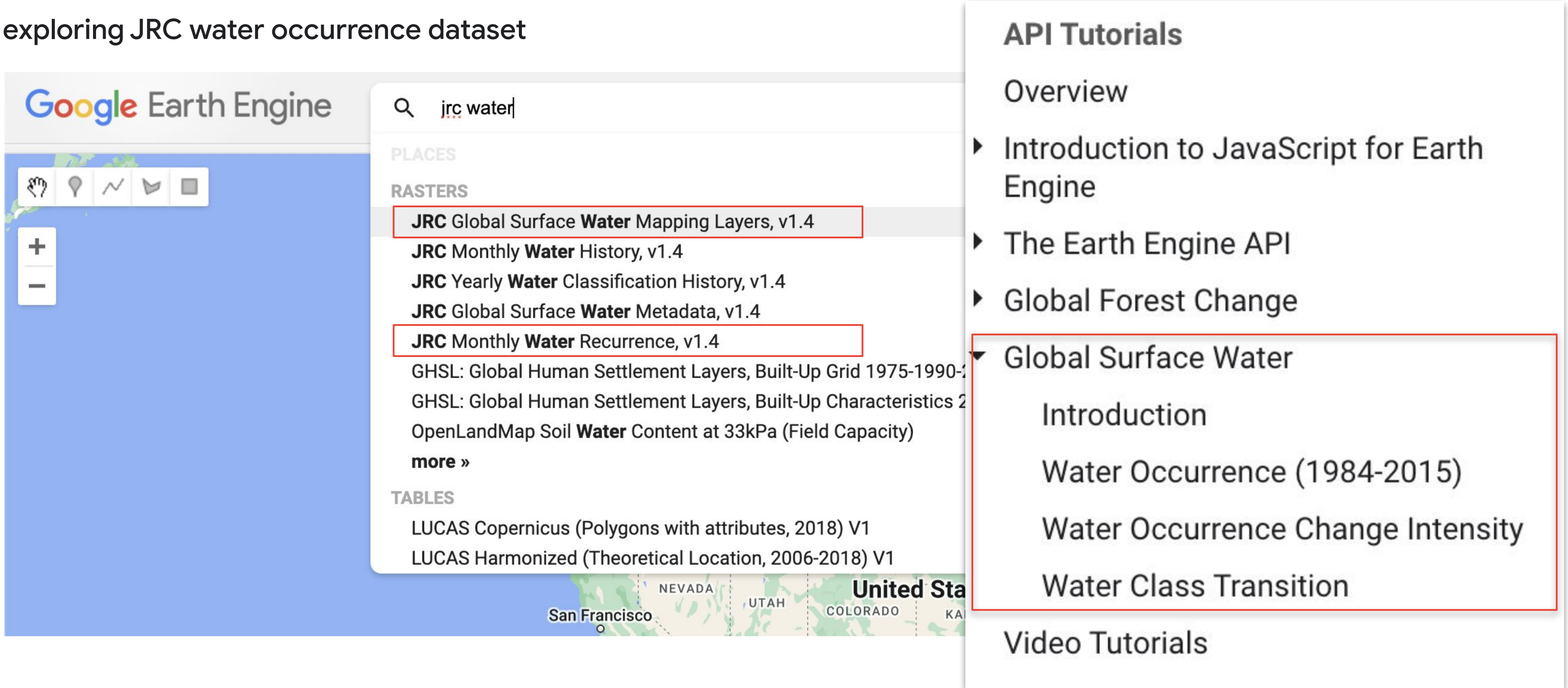


Steps

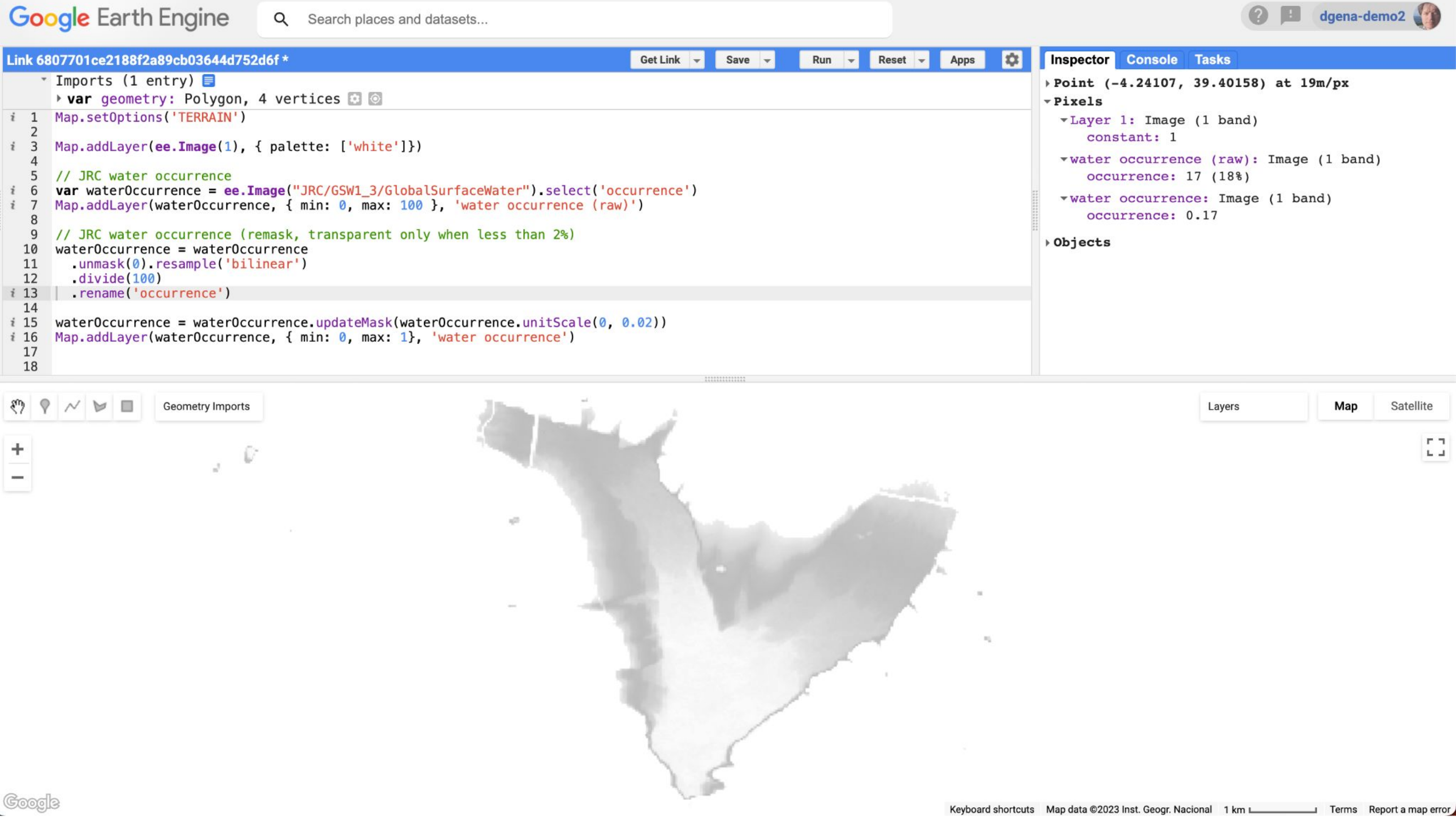
visualize water occurrence
explore monthly water occurrence
compute and plot monthly surface water area

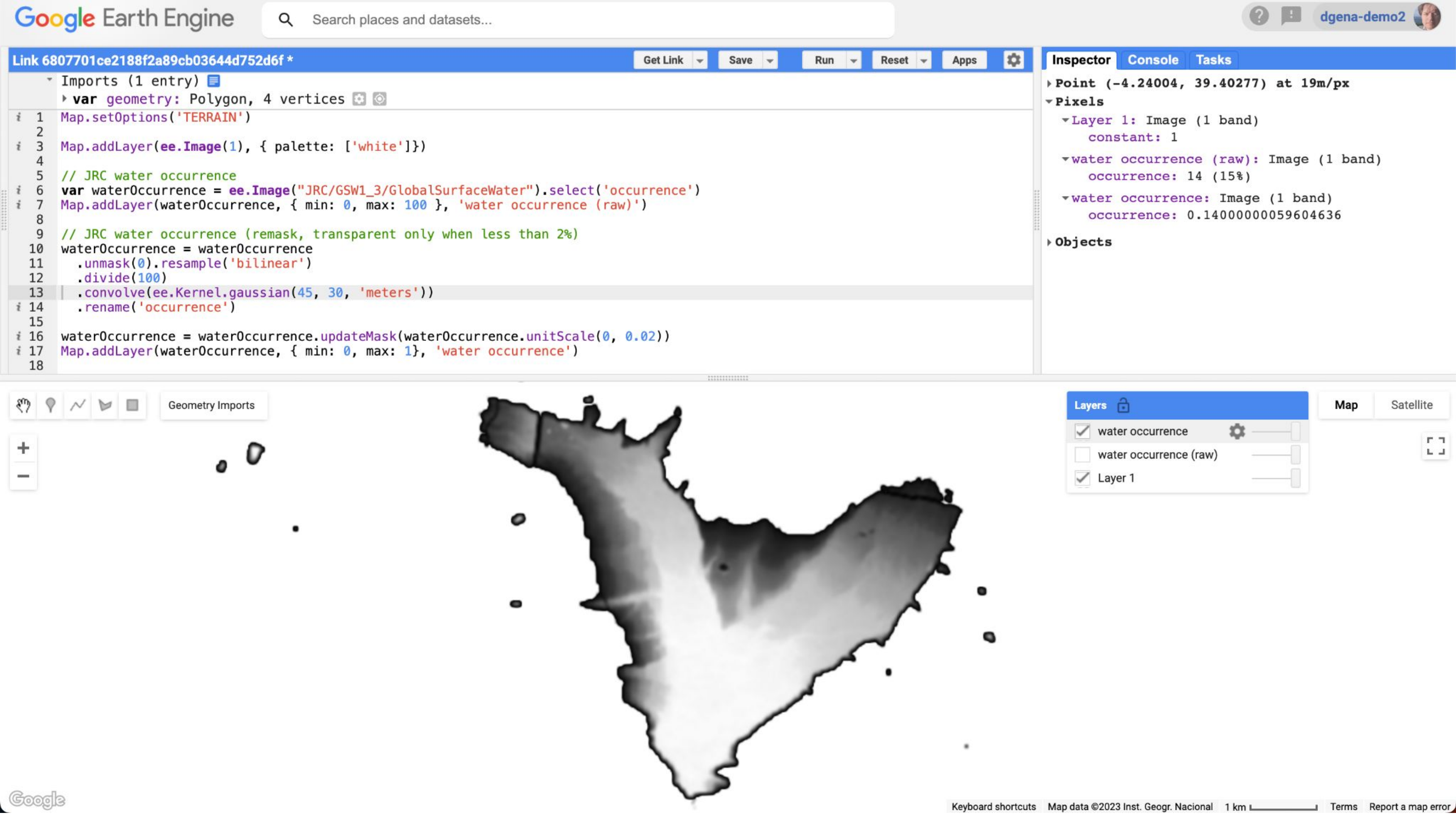
Water occurrence (1985-2022)

exploring JRC water occurrence dataset



[Code]


Google Earth Engine
Search places and datasets...
dgena-demo2
Link 6807701ce2188f2a89cb03644d752d6f *
Get Link
Save
Run
Reset
Apps
Inspector
Console
Tasks
Imports (1 entry)
var geometry: Polygon, 4 vertices
Map.setOptions('TERRAIN')
Map.addLayer(ee.Image(1), { palette: ['white']})
// JRC water occurrence
var waterOccurrence = ee.Image("JRC/GSW1_3/GlobalSurfaceWater").select('occurrence')
Map.addLayer(waterOccurrence, { min: 0, max: 100 }, 'water occurrence (raw)')
// JRC water occurrence (remask, transparent only when less than 2%)
waterOccurrence = waterOccurrence
.unmask(0).resample('bilinear')
.divide(100)
.rename('occurrence')
waterOccurrence = waterOccurrence.updateMask(waterOccurrence.unitScale(0, 0.02))
Map.addLayer(waterOccurrence, { min: 0, max: 1}, 'water occurrence')
Point (-4.24107, 39.40158) at 19m/px
Pixels
Layer 1: Image (1 band)
constant: 1
water occurrence (raw): Image (1 band)
occurrence: 17 (18%)
water occurrence: Image (1 band)
occurrence: 0.17
Objects
Geometry Imports
Layers
Map
Satellite
Keyboard shortcuts
Map data ©2023 Inst. Geogr. Nacional
1 km
Terms
Report a map error


Google Earth Engine
Search places and datasets...
dgena-demo2
Link 6807701ce2188f2a89cb03644d752d6f *
Get Link
Save
Run
Reset
Apps
Imports (1 entry)
var geometry: Polygon, 4 vertices
Map.setOptions('TERRAIN')

Map.addLayer(ee.Image(1), { palette: ['white']})

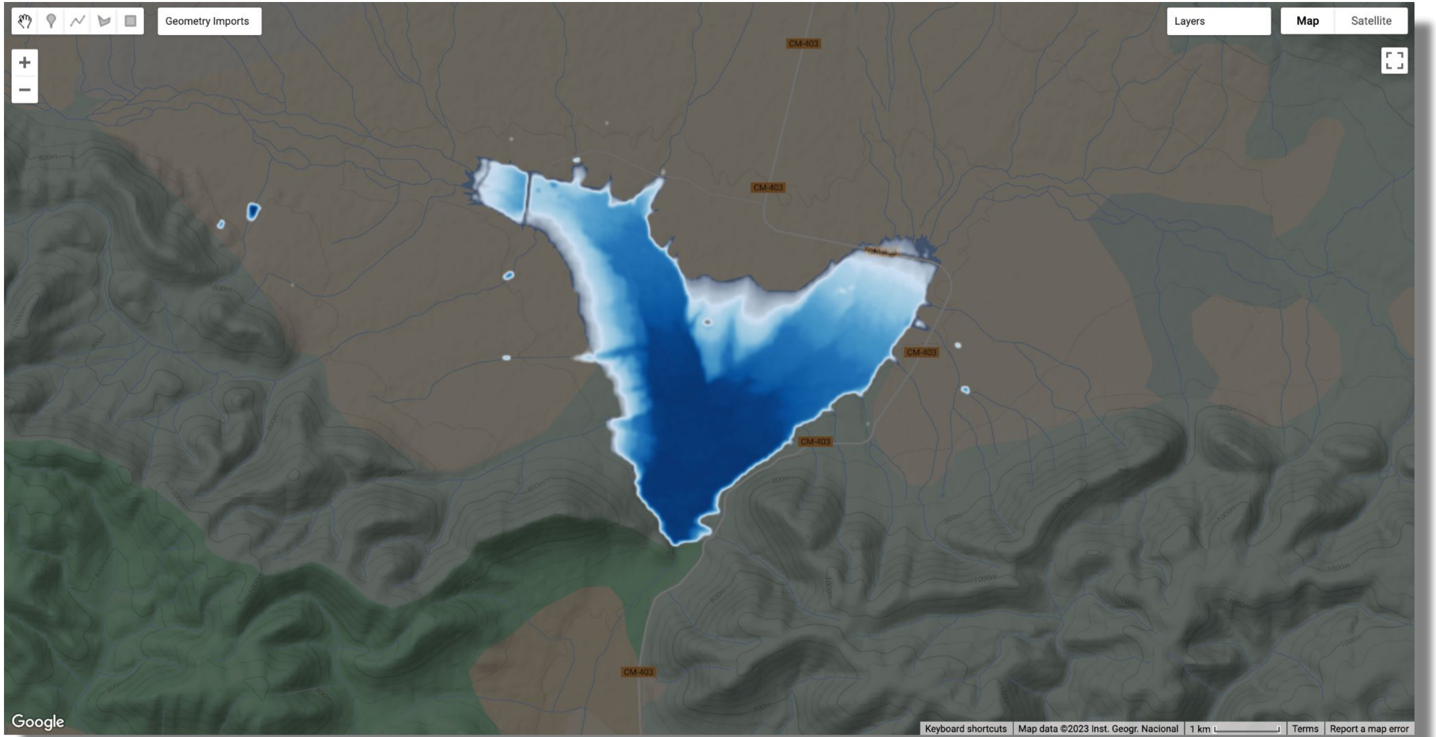
// JRC water occurrence
var waterOccurrence = ee.Image("JRC/GSW1_3/GlobalSurfaceWater").select('occurrence')
Map.addLayer(waterOccurrence, { min: 0, max: 100 }, 'water occurrence (raw)')

// JRC water occurrence (remask, transparent only when less than 2%)
waterOccurrence = waterOccurrence
  .unmask(0).resample('bilinear')
  .divide(100)
  .convolve(ee.Kernel.gaussian(45, 30, 'meters'))
  .rename('occurrence')

waterOccurrence = waterOccurrence.updateMask(waterOccurrence.unitScale(0, 0.02))
Map.addLayer(waterOccurrence, { min: 0, max: 1}, 'water occurrence')
Inspector
Console
Tasks
Point (-4.24004, 39.40277) at 19m/px
Pixels
Layer 1: Image (1 band)
constant: 1
water occurrence (raw): Image (1 band)
occurrence: 14 (15%)
water occurrence: Image (1 band)
occurrence: 0.14000000059604636
Objects
Geometry Imports
Layers
water occurrence
water occurrence (raw)
Layer 1
Map
Satellite
Google
Keyboard shortcuts
Map data ©2023 Inst. Geogr. Nacional
1 km
Terms
Report a map error

Water occurrence (1985-2022)

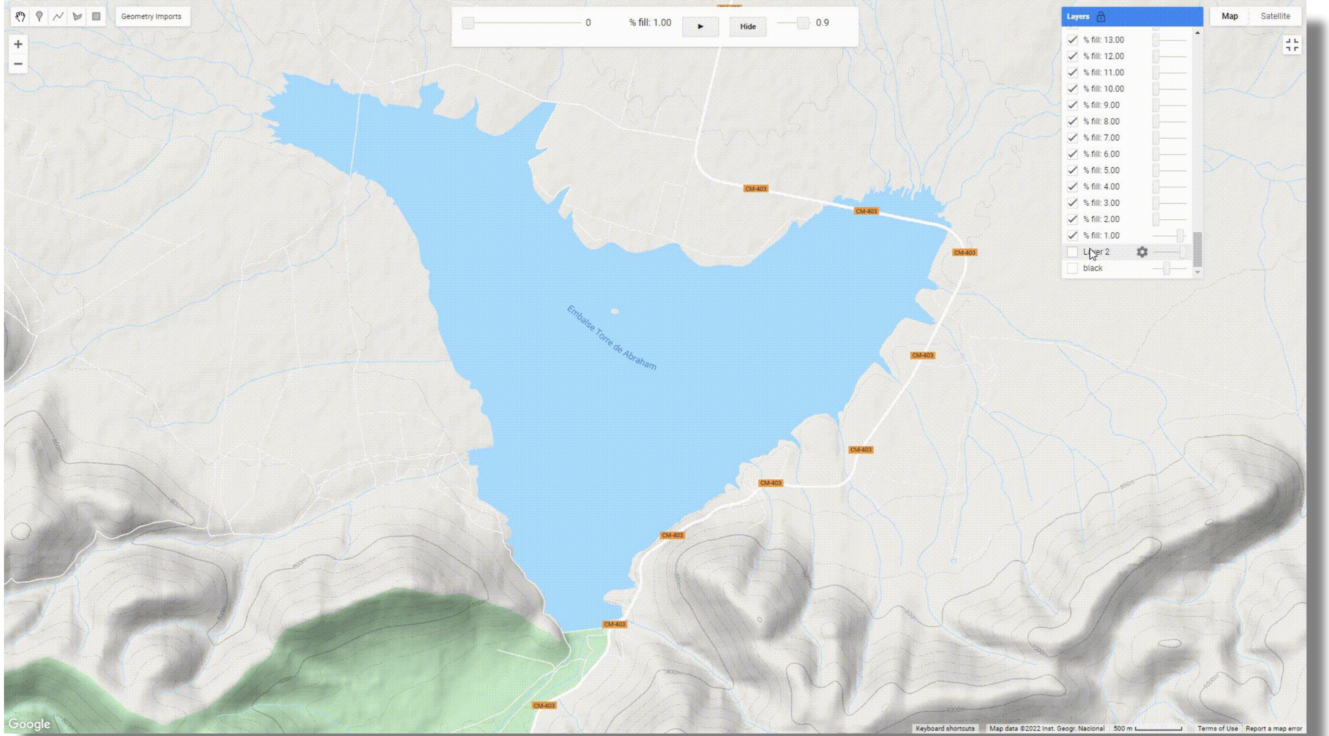
exploring JRC water occurrence dataset



[Code]

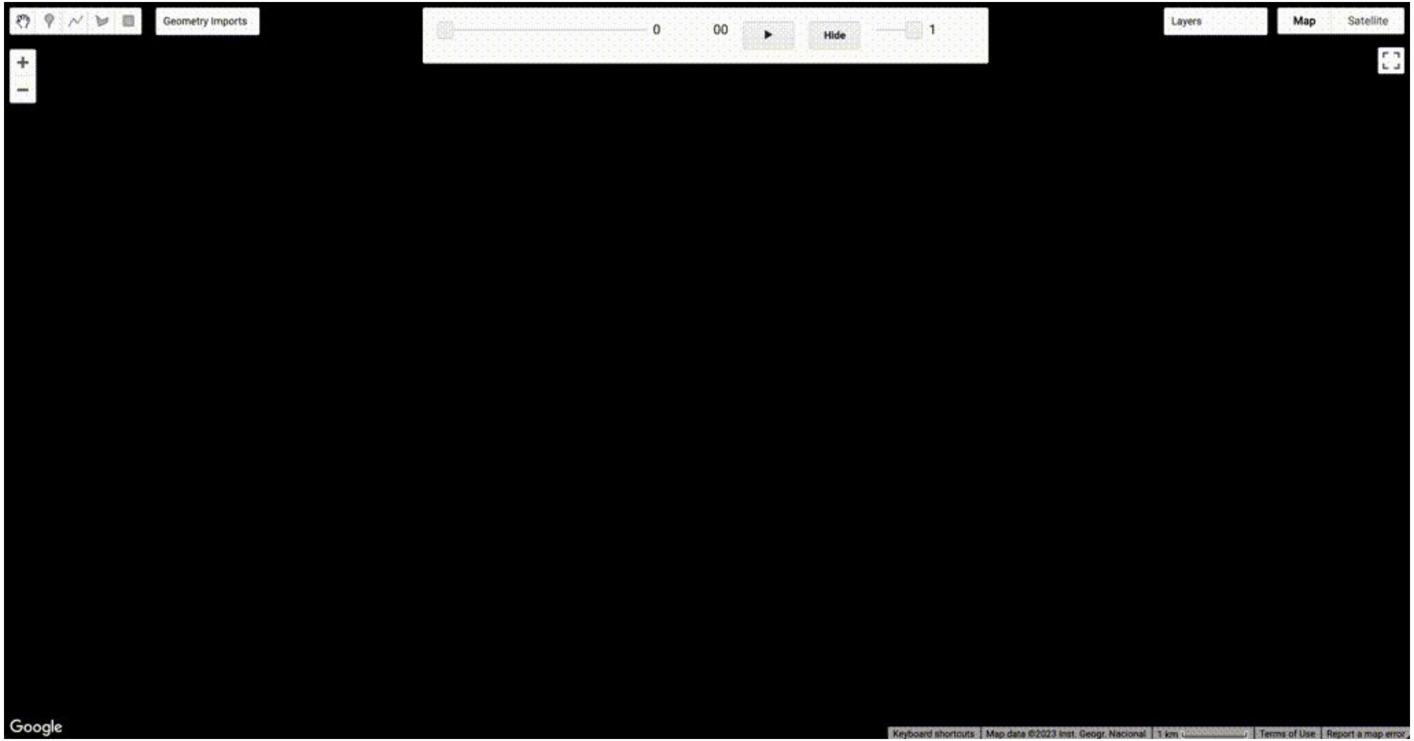
Water is dynamic

exploring JRC water occurrence dataset



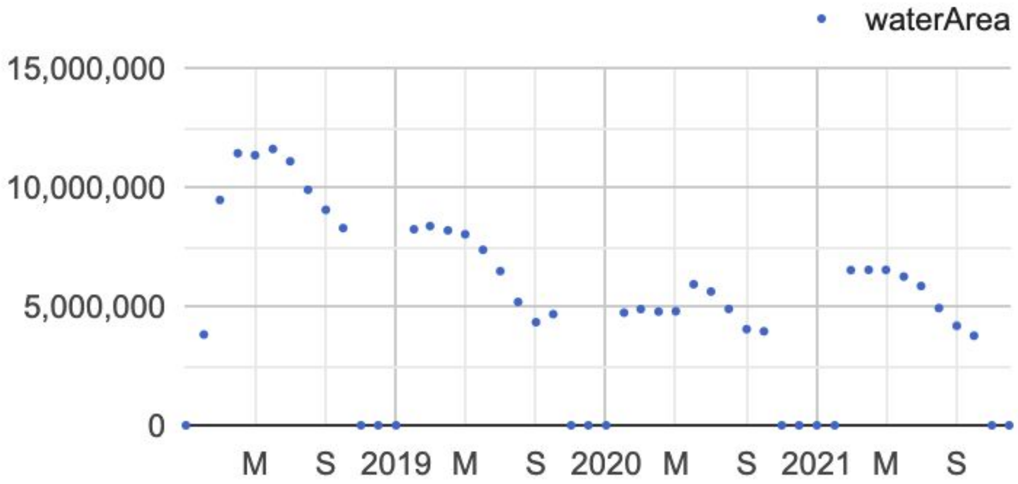
[Code]

Monthly JRC water occurrence



[Code](#) To quantify surface water area changes, we will use monthly JRC water occurrence

Monthly JRC water occurrence

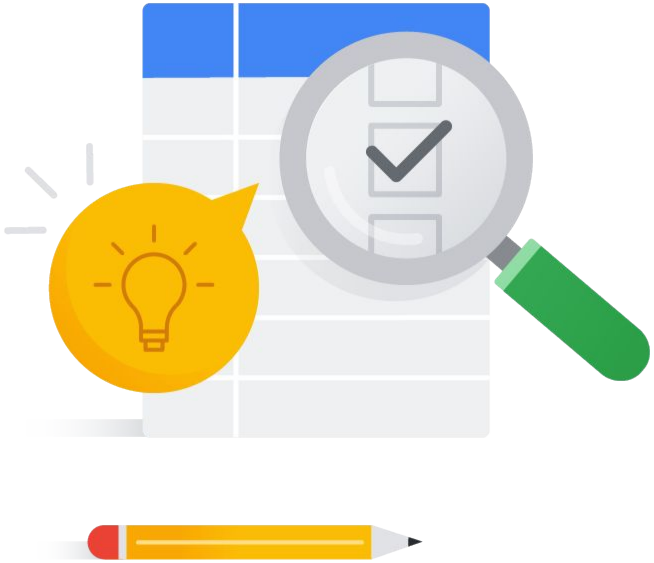



```
var waterMonthlyMask = waterMonthly
  .map(function(i) {
    return i.eq(2).updateMask(i.gt(0))
         .copyProperties(i, ['system:time_start'])
  })

waterMonthlyMask = waterMonthlyMask.map(function(i) {
  var waterArea = ee.Image.pixelArea().updateMask(i)
    .reduceRegion(ee.Reducer.sum(), geometry,
scale).get('area')

  return i.set({ waterArea: waterArea })
})

var chart = ui.Chart.feature.byFeature(waterMonthlyMask,
   'system:time_start', ['waterArea'])
  .setOptions({
    lineWidth: 0,
    pointSize: 1
  })
print(chart)
```

[Code]()

03 Water detection with optical satellite imagery

25 min · Individual



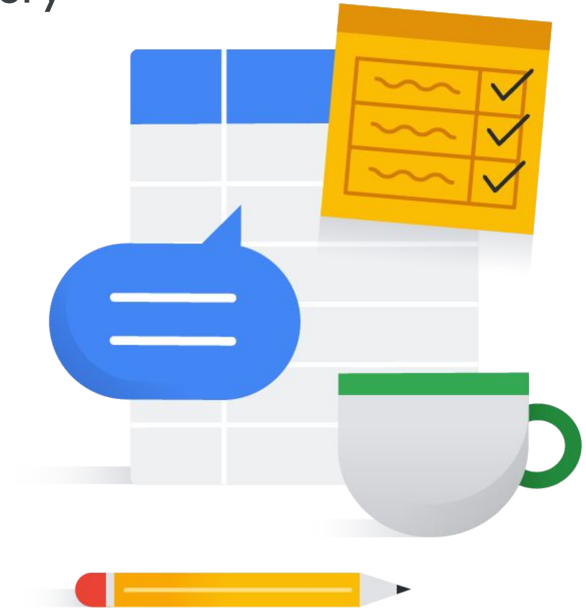
multispectral optical imagery (Sentinel-2)
compute NDWI, MNDWI, NDVI, ...
compute and plot surface water area
filter noisy (cloudy) images using cloud frequency
temporal smoothing

Code

Instructor-led training slide

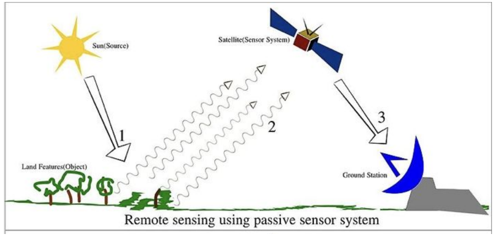
Quick overview of multi-spectral remote sensing theory

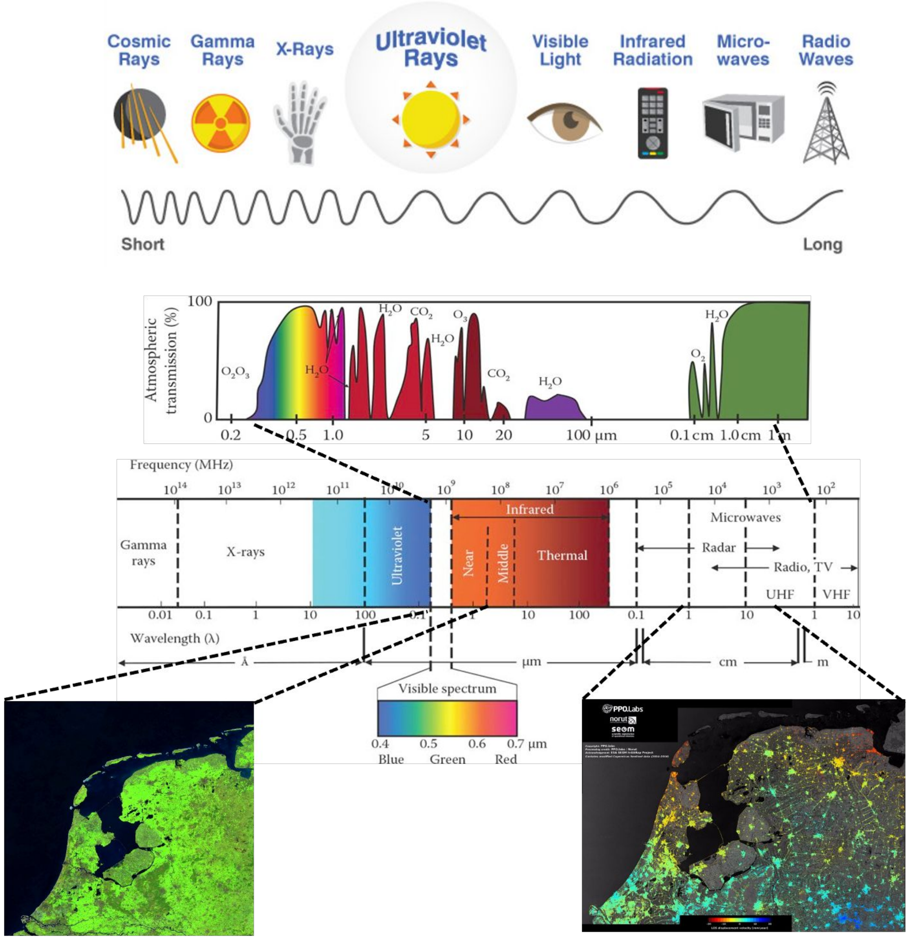
5 min | Group



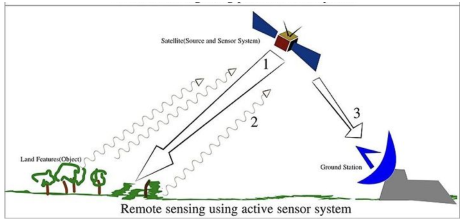
Earth Observations and Remote Sensing

optical / passive

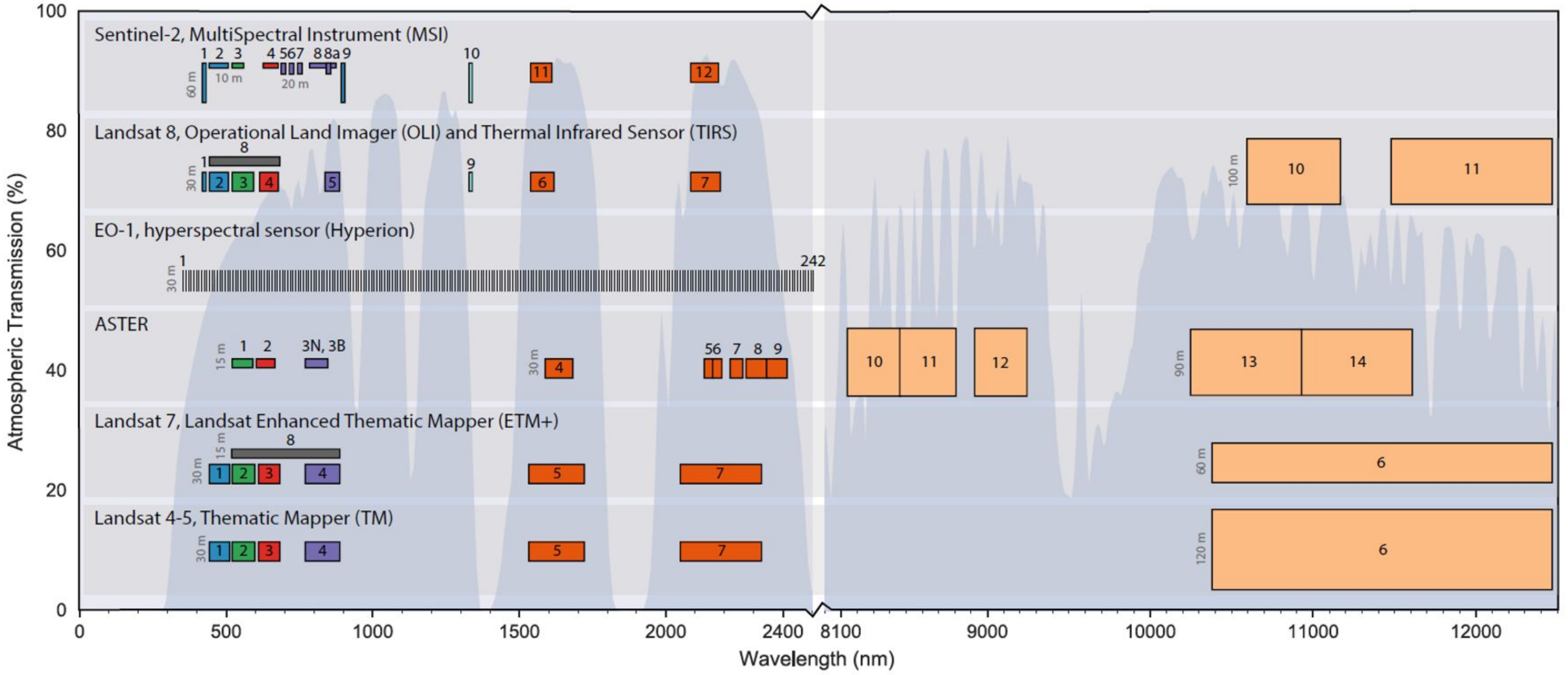




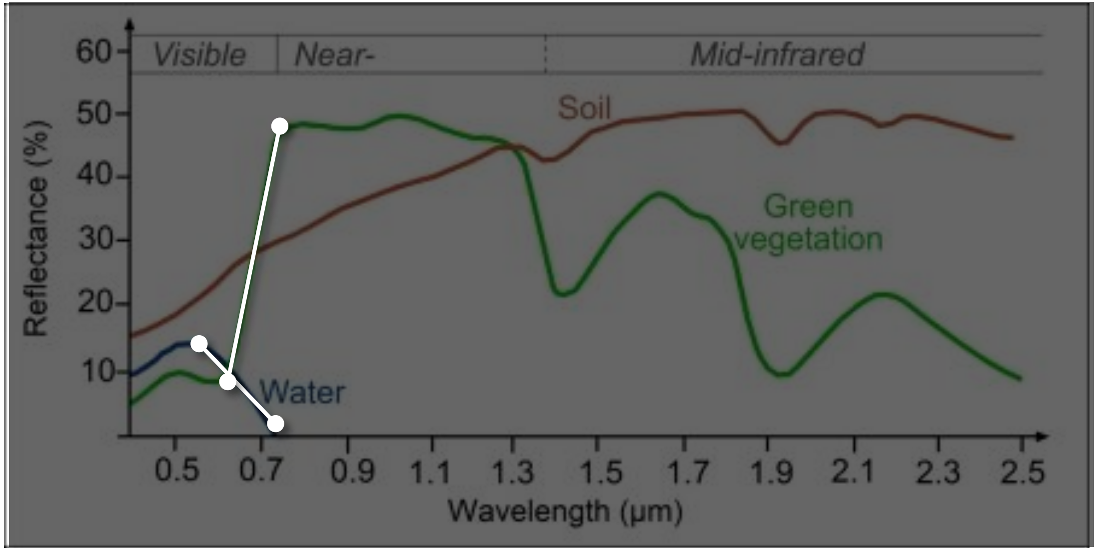
radar / active



Spectral Bands



Spectral Signatures, Spectral Water Indices



McFeeters, 1996

$$NDWI = \frac{\rho_{green} - \rho_{nir}}{\rho_{green} + \rho_{nir}}$$

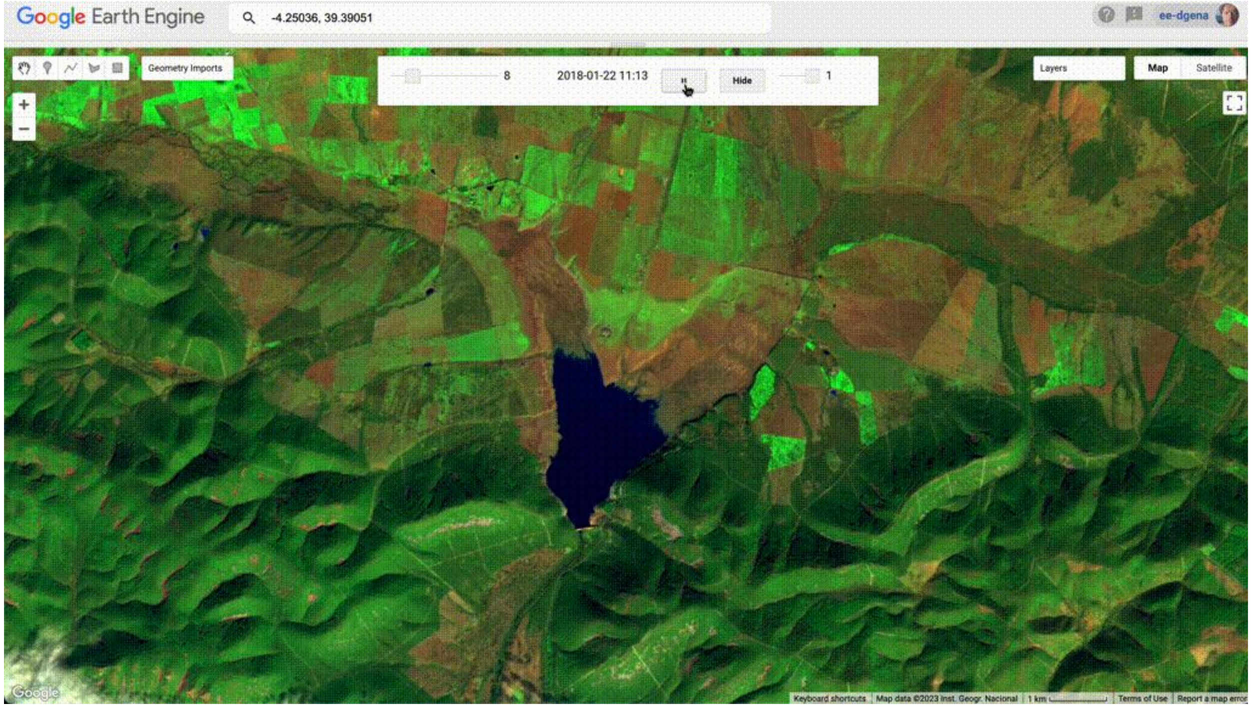
Code

Rouse, 1974

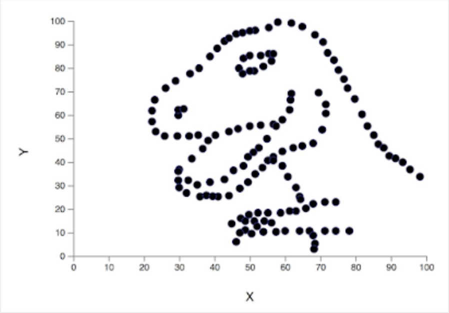
$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}}$$

Code

Let's have a look at our images (Sentinel-2)



Always visualize your data, never trust statistics-only!



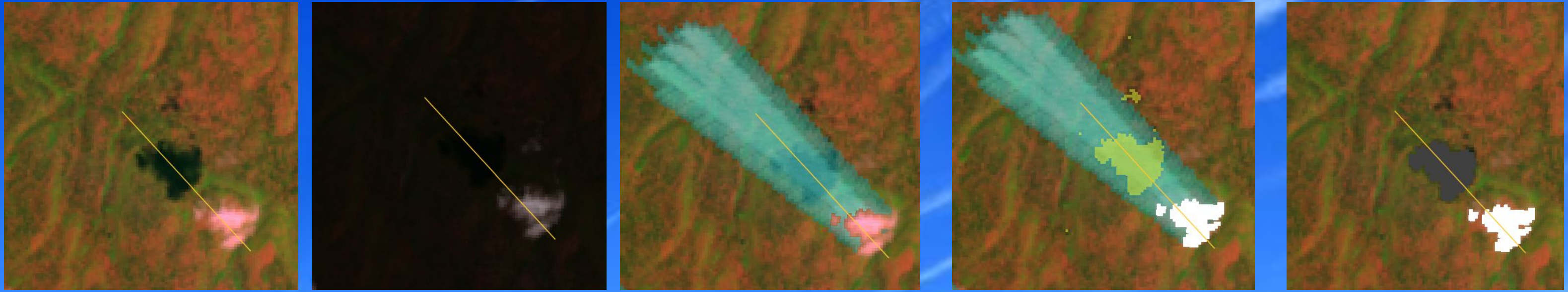
N = 142 ; X mean = 54.2633 ; X SD = 16.7651 ; Y mean = 47.8323 ; Y SD = 26.9354 ; Pearson correlation = -0.0645

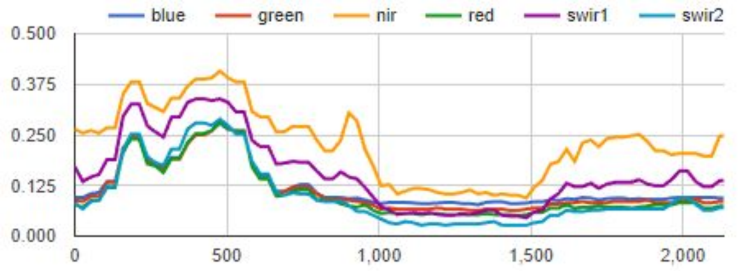
[Code]()

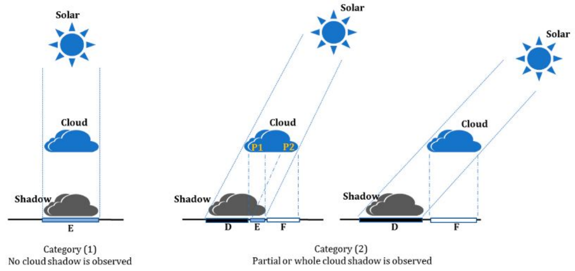
… a lot of noise from clouds and shadows

Cloud and cloud shadow masking, many algorithms exist today for cloud masking

Reflectance | Cloud Score | Project (Solar) | Dark IR Pixels | Mask



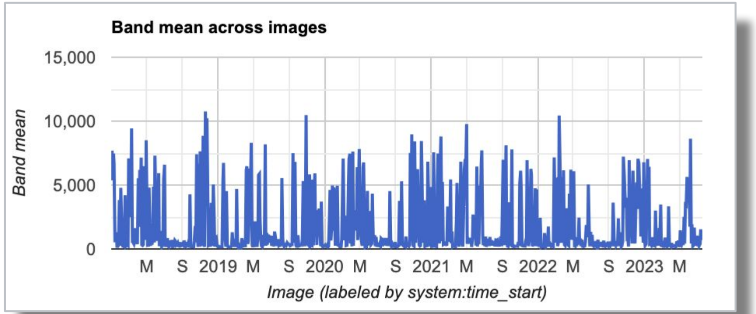


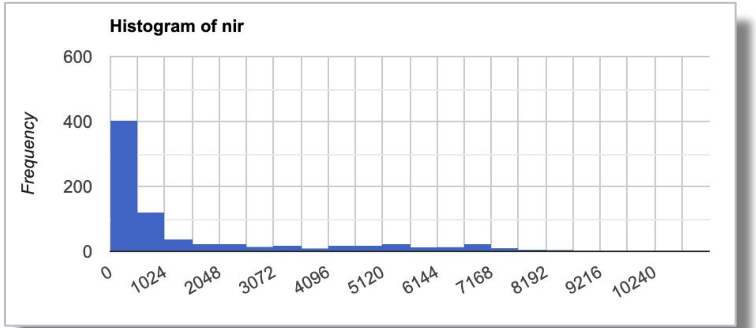


https://code.earthengine.google.com/f0d60d5c0070a54aa074f69fb77536f9

Simple masking: Code (Landsat), Code (Sentinel-2)

Let’s first inspect all values of a single (NIR) band, as well as compute a histogram

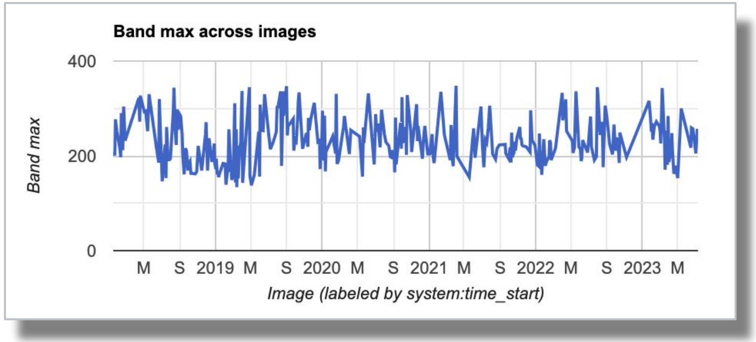


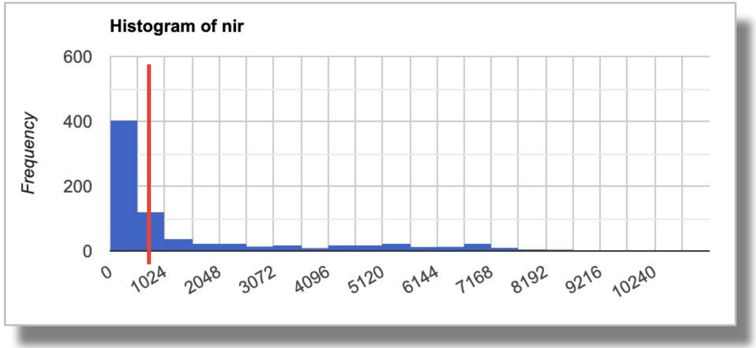



```
images = images.map(function(i) {
  return i.set({
    nir: i.select(['B8']).reduceRegion(ee.Reducer.mean(), pt,
scale).values().get(0),
  })
})

print(ui.Chart.feature.byFeature(images, 'system:time_start', ['nir']))

print(ui.Chart.feature.histogram(images, 'nir', 30))
```

[Code]

Let's skip the top brightest images



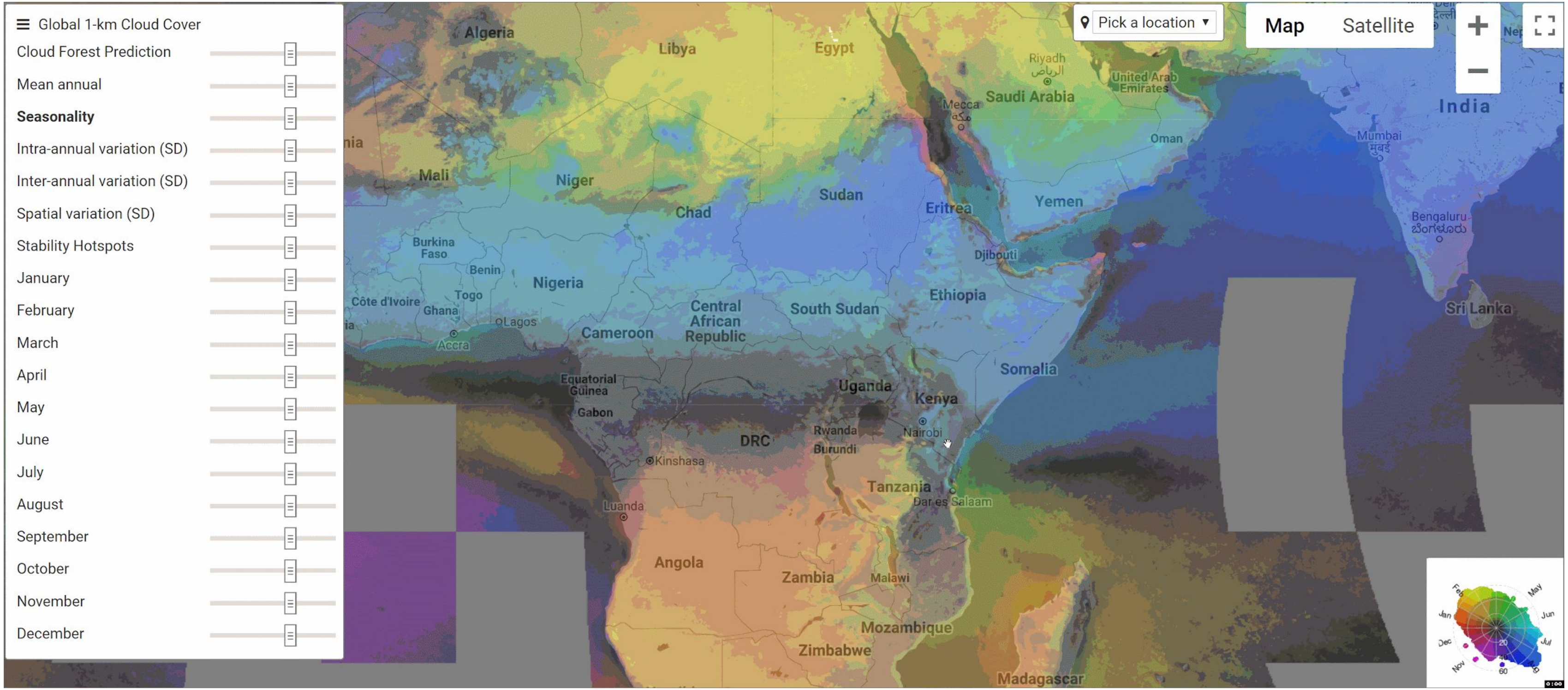



```
images = images.filter(ee.Filter.lt('nir', 350))
```

[Code]

Global 1-km Cloud Cover

Wilson AM, Jetz W (2016) Remotely Sensed High-Resolution Global Cloud Dynamics for Predicting Ecosystem and Biodiversity Distributions. PLoS Biol 14(3)

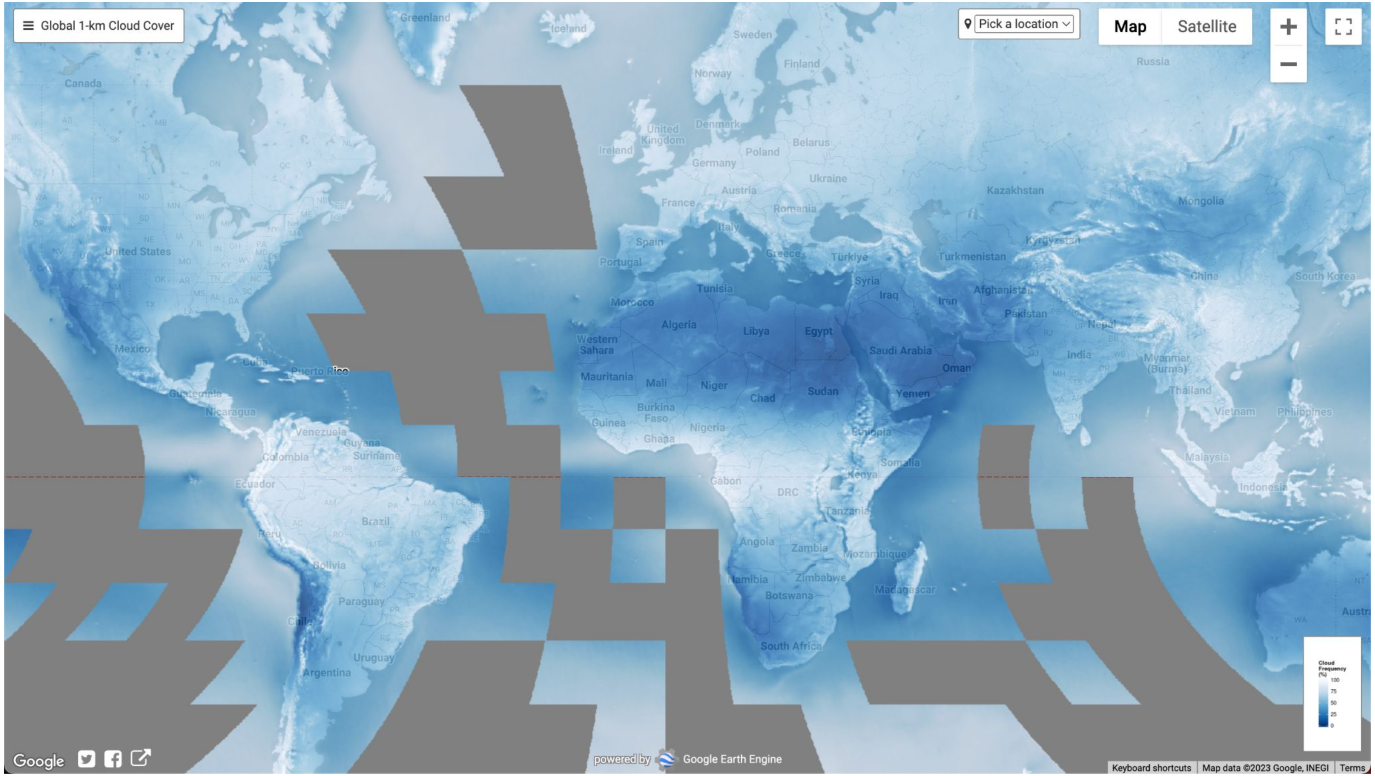


https://www.earthenv.org/cloud, or https://gee-community-catalog.org/projects/gcc

Instead of a fixed band brightness value, we can parametrize it using cloud frequency statistics

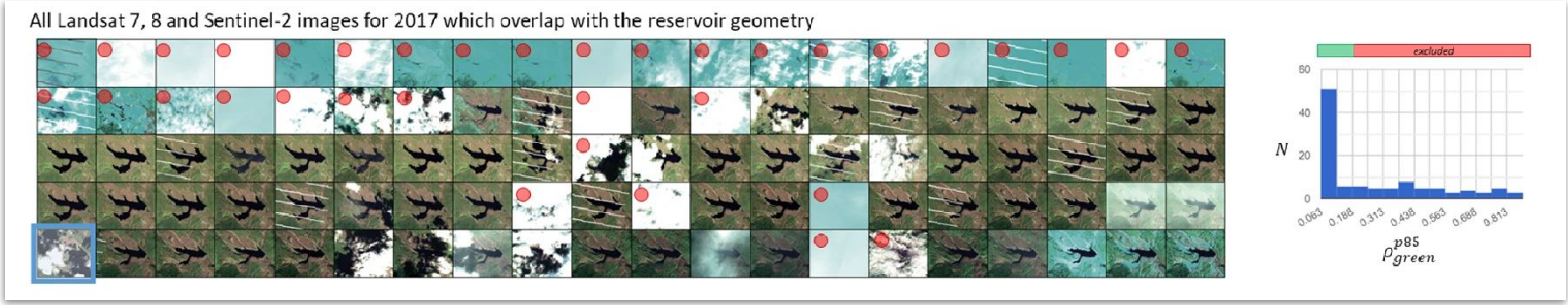
Global 1-km Cloud Cover

Wilson AM, Jetz W (2016) Remotely Sensed High-Resolution Global Cloud Dynamics for Predicting Ecosystem and Biodiversity Distributions. PLoS Biol 14(3)



https://www.earthenv.org/cloud, or https://gee-community-catalog.org/projects/gcc

Instead of a fixed band brightness value, we can parametrize it using cloud frequency statistics



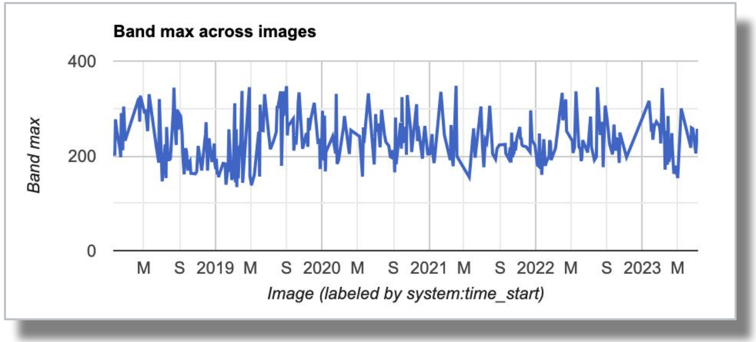
1. Compute statistic over the area of interest indicating image cloudiness
2. Skip top N of brightest images with N computed from the cloud frequency for this area

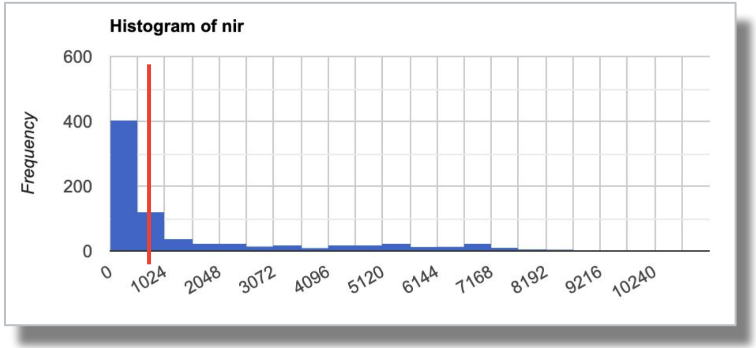
N = 100 * 0.35 = 35 in the above example

Use mean annual cloud frequency instead of hardcoding the threshold


```
// compute threshold from mean cloud frequency
var cloudFrequency =
ee.Image("projects/sat-io/open-datasets/gcc/MODCF_meanannual")
  .divide(100)
  .reduceRegion(ee.Reducer.first(), pt, scale).values().get(0)
print('Mean cloud frequency: ', cloudFrequency)

var percentile = ee.Number(cloudFrequency).int()
var threshold =
ee.List(images.aggregate_array('nir')).reduce(ee.Reducer.percentile([percentile]))
print('NIR threshold: ', threshold)
images = images.filter(ee.Filter.lt('nir', threshold))
```

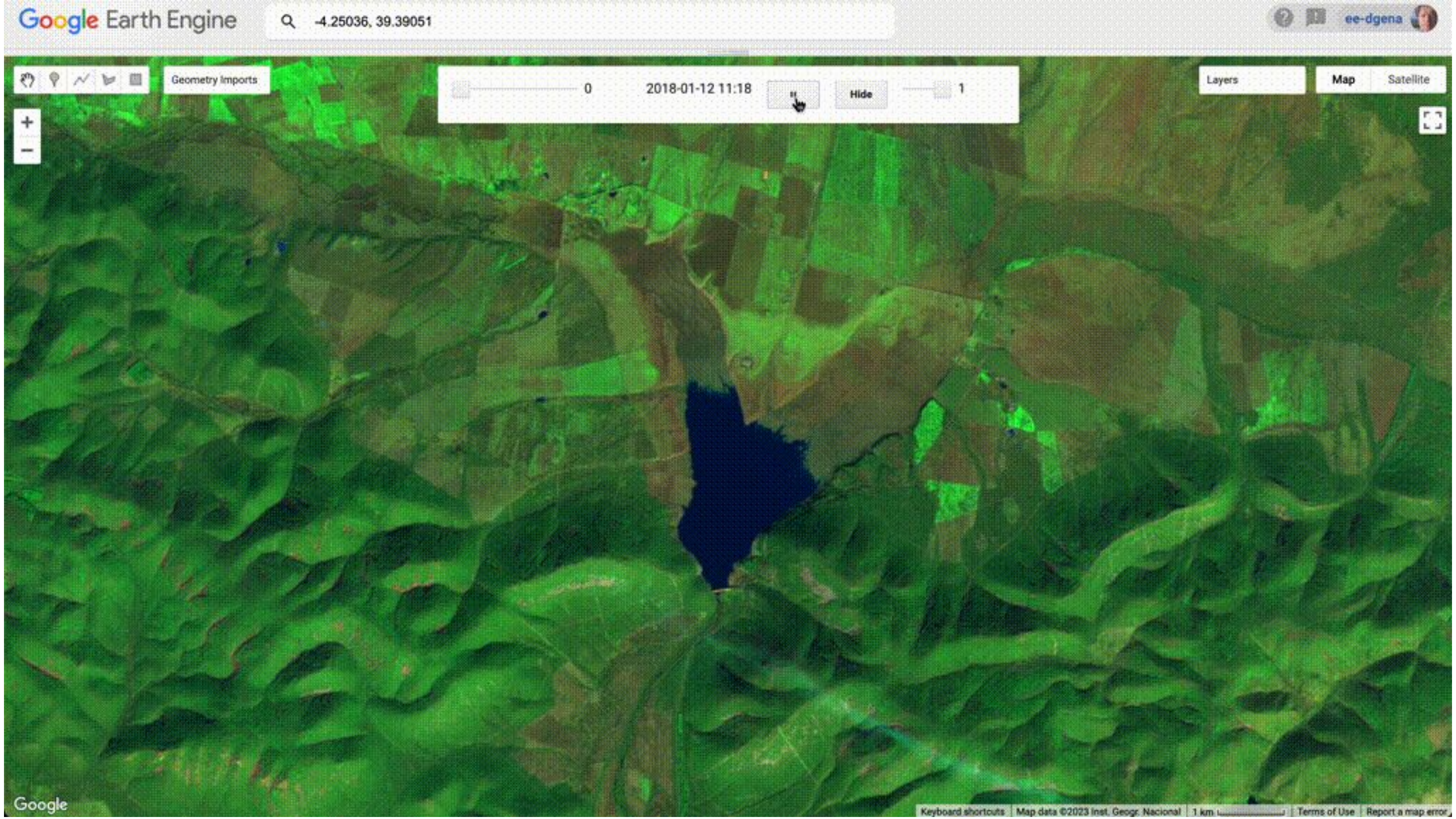
[Code]()






```
Mean cloud frequency:
47.74

NIR threshold:
410.3478260869565
```

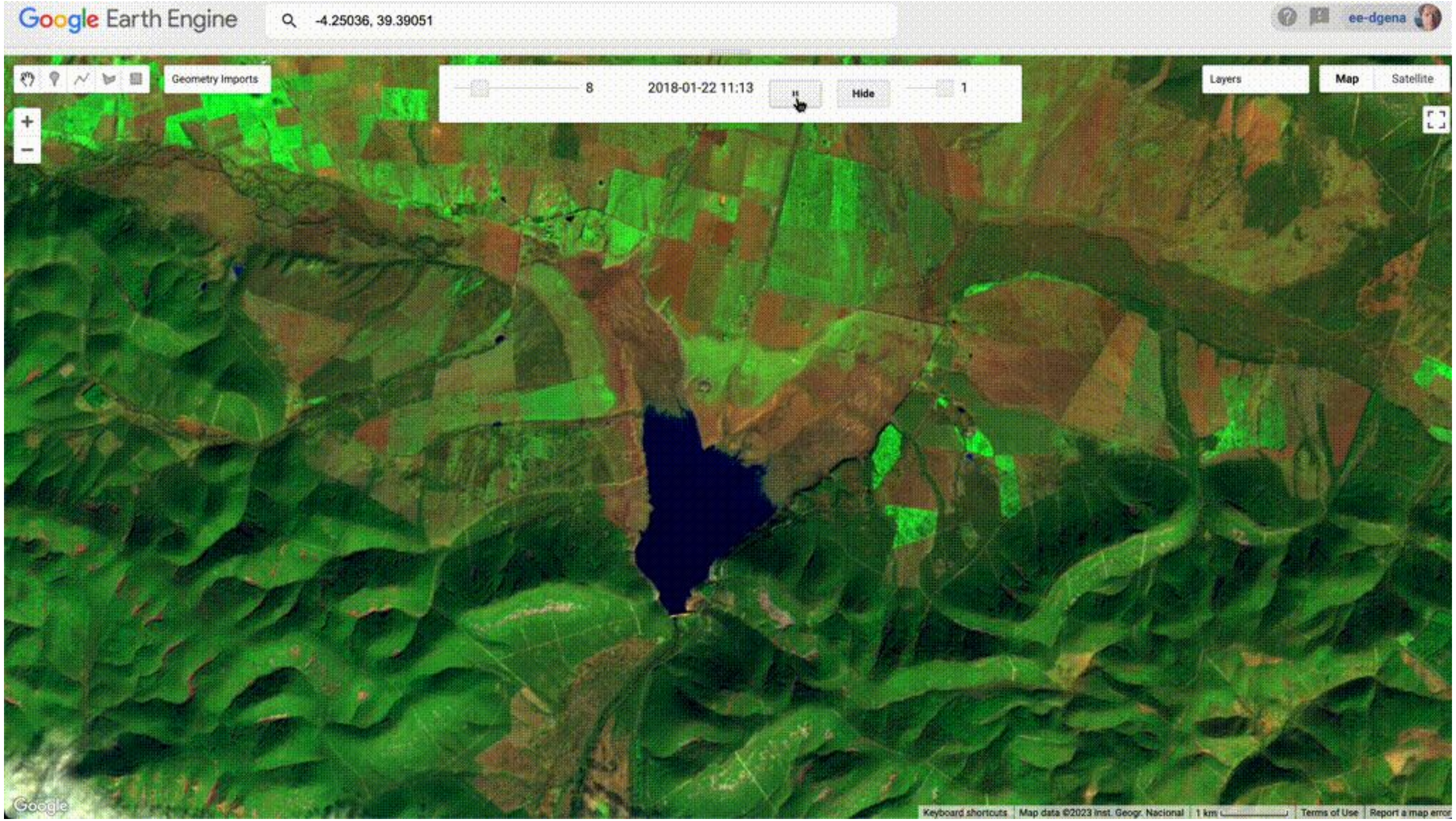
Let's see how our images look like after filtering



[Code]

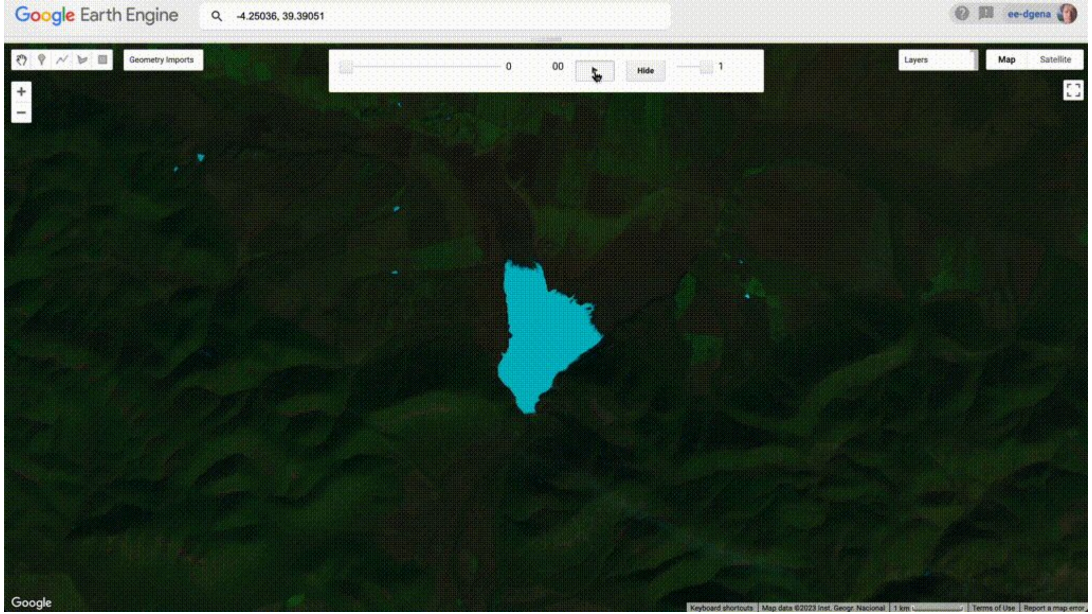
Fewer cloudy images!

Cloudy



Google Earth Engine
-4.25036, 39.39051
ee-dgena
Geometry Imports
8
2018-01-22 11:13
Hide
1
Layers
Map
Satellite
Google
Keyboard shortcuts
Map data ©2023 Inst. Geogr. Nacional
1 km
Terms of Use
Report a map error

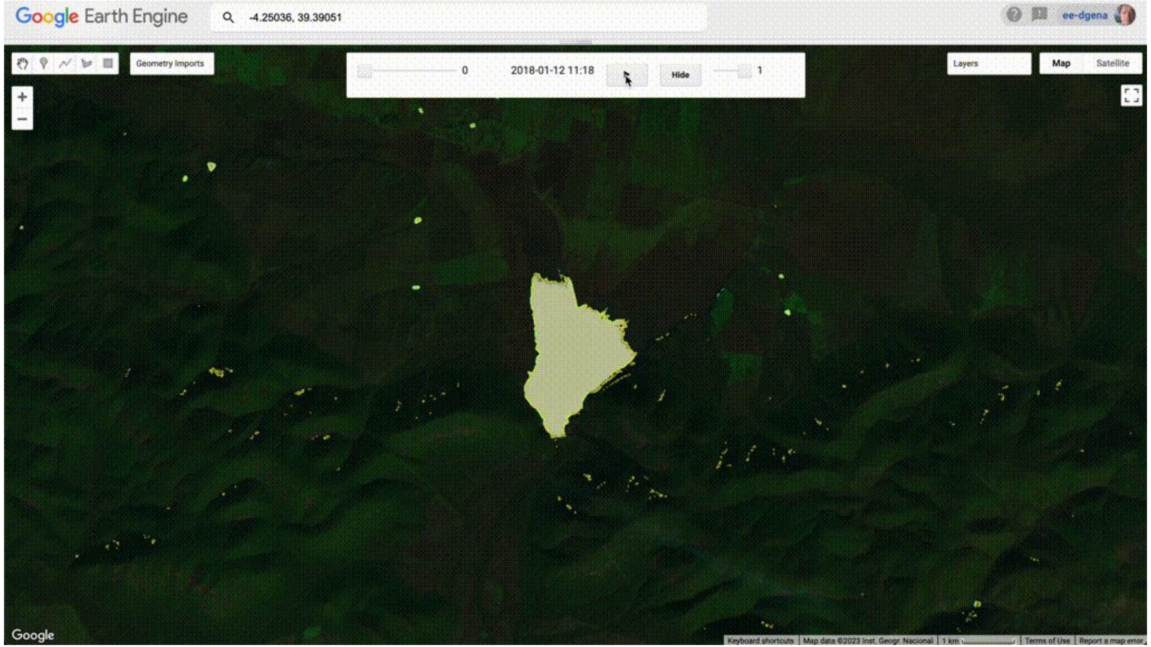
Let’s compute and visualize NDWI




```
var imagesRGB = images.map(function(i) {
  var ndwi = i.normalizedDifference(['B3', 'B8'])

  var ndwiRGB = ndwi.visualize({
    min: 0,
    max: 0.3,
    palette: ['black', 'cyan'],
    opacity: 0.7
  })

  return i.visualize(vis)
    .blend(ndwiRGB)
    .set({ label: i.get('label') })
})
```

Code

Let's add naive thresholding (NDWI > 0)



[Code]

```
var imagesRGB = images.map(function(i) {
  var ndwi = i
    .normalizedDifference(['B3', 'B8'])

  var ndwiRGB = ndwi.visualize({
    min: 0,
    max: 0.3,
    palette: ['black', 'white'],
    opacity: 0.7
  })

  var ndwiEdgeRGB = ee.Algorithms.CannyEdgeDetector(ndwi, 0.9)
    .selfMask()
    .visualize({
      palette: ['cyan']
    })

  var water = ndwi.gt(0).selfMask()

  var waterRGB = water.visualize({
    palette: ['yellow'],
    opacity: 0.2
  })

  var waterEdgeRGB = ee.Algorithms.CannyEdgeDetector(water, 0.9)
    .selfMask()
    .visualize({
      palette: ['yellow']
    })

  return i.visualize(vis)
    .blend(ndwiRGB)
    .blend(ndwiEdgeRGB)
    .blend(waterRGB)
    .blend(waterEdgeRGB)
})
```

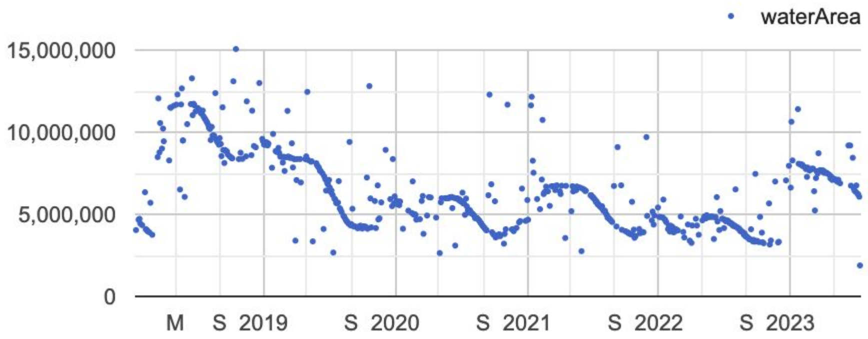
Experiment with different spectral indices (NDWI, MNDWI, ...) when one does not work


```
var imagesRGB = images.map(function(i) {
  var waterIndices = ee.Image([
    i.normalizedDifference(['B4', 'B8']).unitScale(0, 0.3),
    i.normalizedDifference(['B3', 'B12']).unitScale(0.3, 1),
    i.normalizedDifference(['B3', 'B8']).unitScale(0, 0.3)
  ])
  .visualize({ min: 0, max: 1, opacity: 1 })

  return i.visualize(vis)
  .blend(waterIndices)
})
```

E.g., Ma, Shengfang, et al. "Application of the water-related spectral reflectance indices: A review." *Ecological indicators* 98 (2019): 68-79.

Code

Let’s compute and plot surface water area time series using a simple thresholding method




```
images = images.map(function(i) {
  var ndwi = i.normalizedDifference(['B3', 'B8'])

  var waterArea = ee.Image.pixelArea().updateMask(ndwi.gt(0))
    .reduceRegion(ee.Reducer.sum(), geometry, scale).values().get(0)

  return i.set({ waterArea: waterArea })
})
```

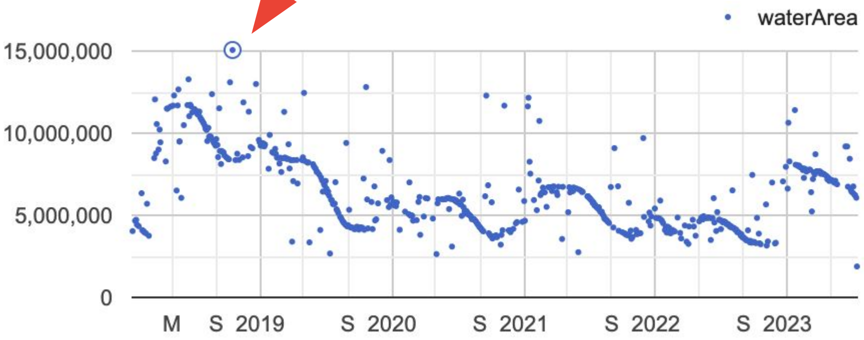
… we have some noise, but we can already clearly see reservoir dynamics

Code

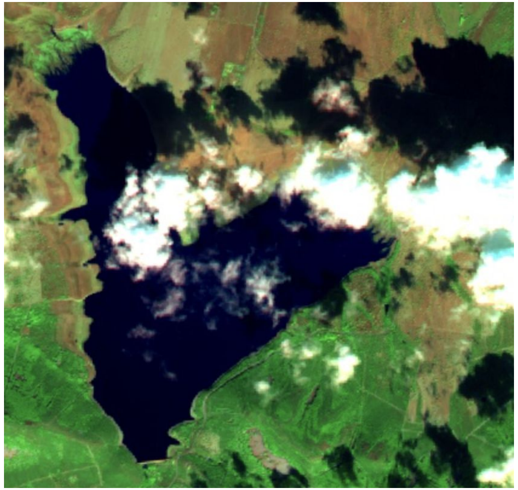
let’s add custom chart/image inspector for more visualization:

```
var inspectLayer = ui.Map.Layer(ee.Image(), {}, 'inspector')
Map.layers().add(inspectLayer)

function addChartInspector(v) {
  var image = images.filterDate(v).first()
  image = image.visualize(vis)
  inspectLayer.setEeObject(image)
}

chart01.onClick(addChartInspector)
```

Click!

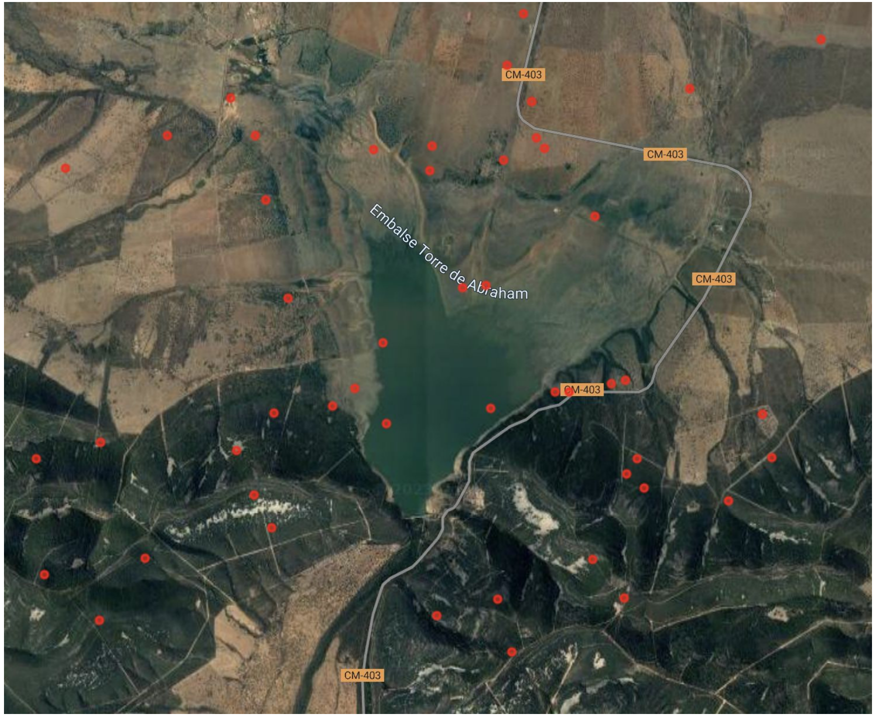


Inspect



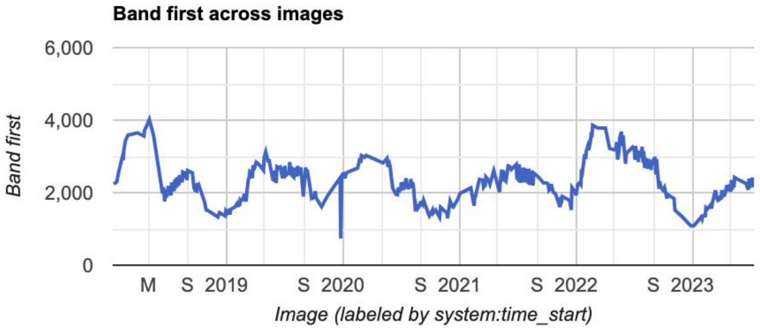
[Code]

Let’s sample random points in our AOI instead of a single one to skip noisy images



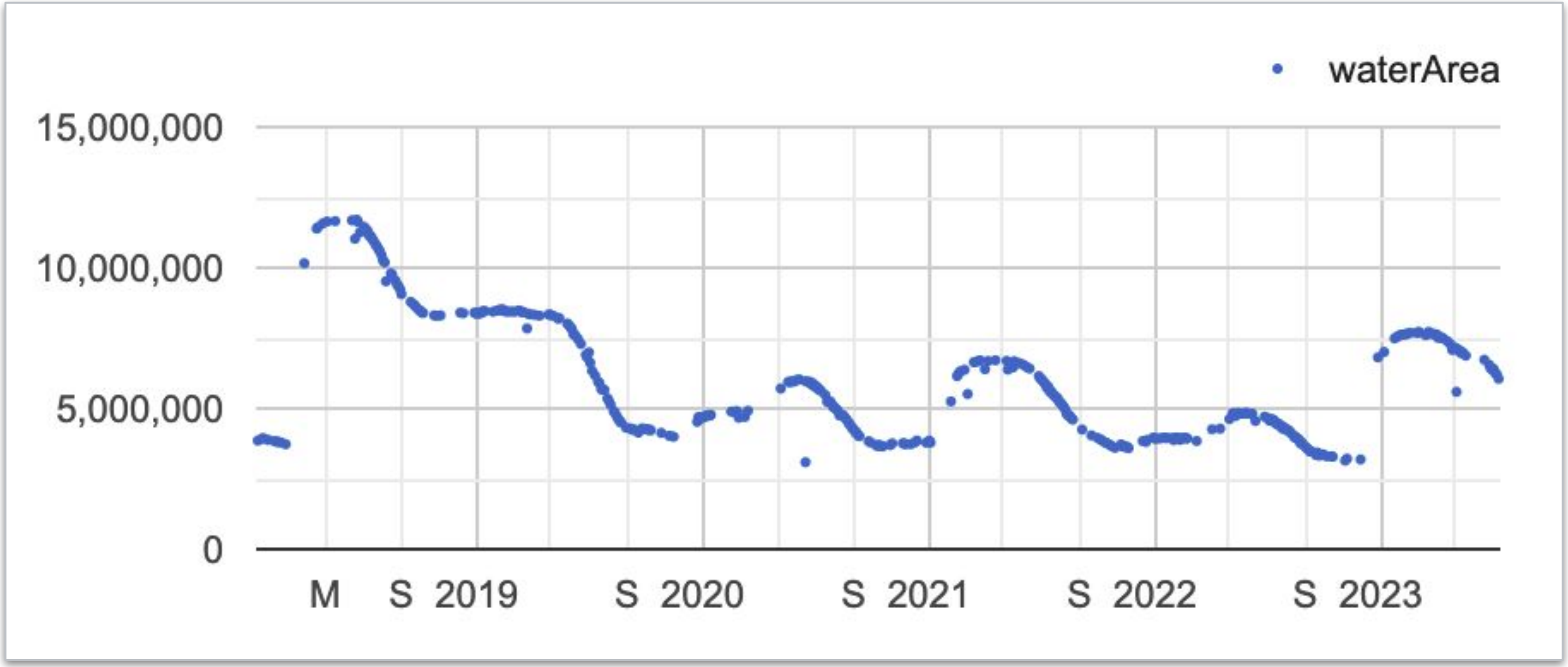

```
pt = ee.Image().sample({
  region: geometry,
  scale: 10,
  numPixels: 50,
  seed: 42,
  dropNulls: false,
  geometries: true
}).geometry()
```

… cleaner max nir time series:

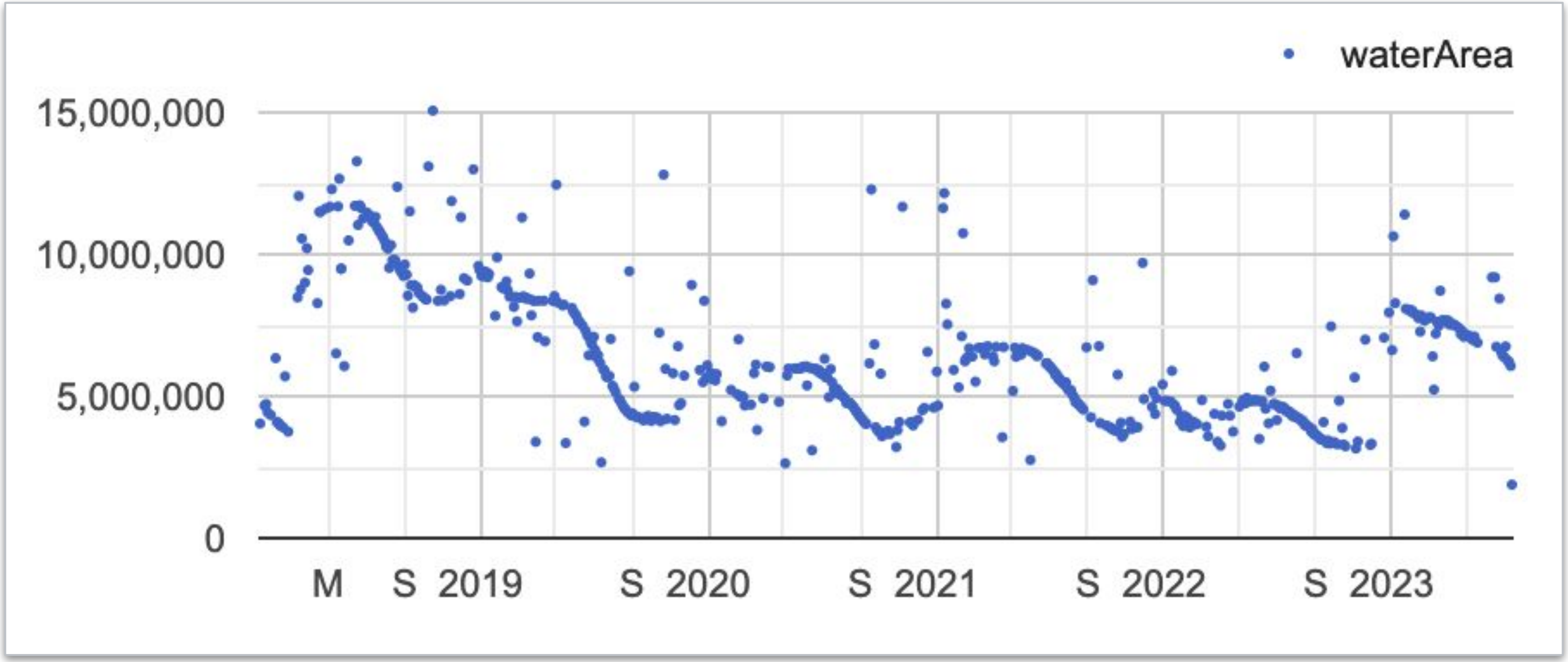


[Code]

Whoa! That's looks much better, the noise is almost gone!

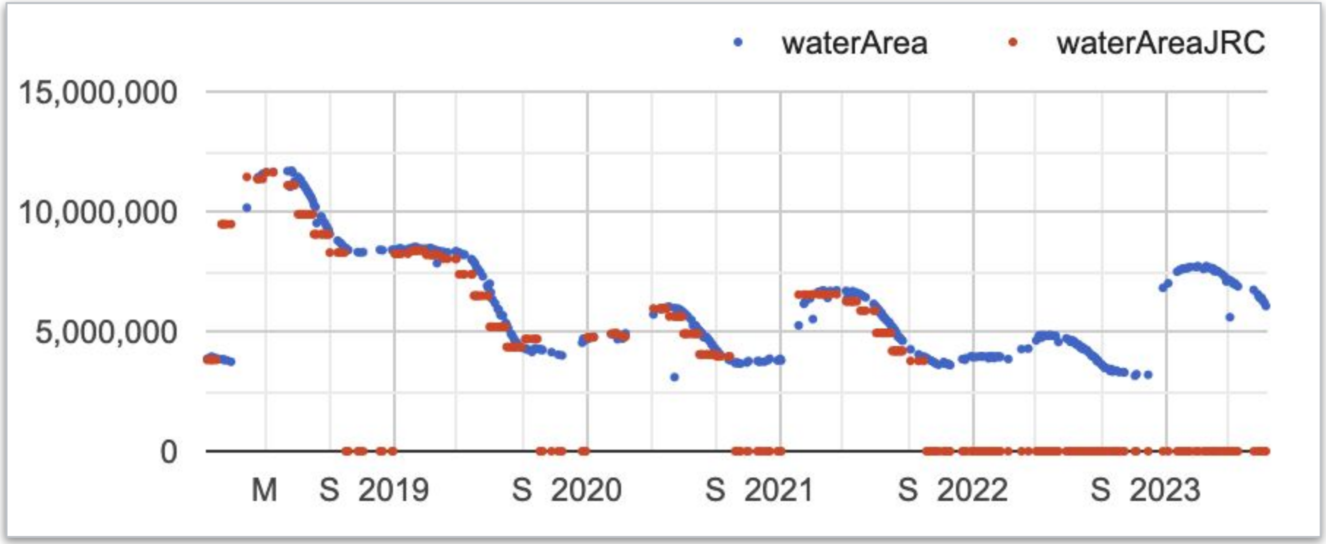


Old values



waterArea
15,000,000
10,000,000
5,000,000
0
M
S
2019
S
2020
S
2021
S
2022
S
2023

Adding JRC monthly water occurrence




```
var images03 = images.map(function(i) {
  …
  var empty = ee.ImageCollection([ee.Image.constant(0).float().rename('water')])
  var waterMonthly = empty.merge(ee.ImageCollection("JRC/GSW1_4/MonthlyHistory")
    .filterDate(i.date(), i.date().advance(1, 'month'))).mosaic().eq(2)

  var waterAreaJRC = ee.Image.pixelArea().mask(waterMonthly)
    .reduceRegion(ee.Reducer.sum(), geometry, scale).get('area')

  return i.set({ waterArea: waterArea, waterAreaJRC: waterAreaJRC })
})
…
```

Code

Discussion and Questions

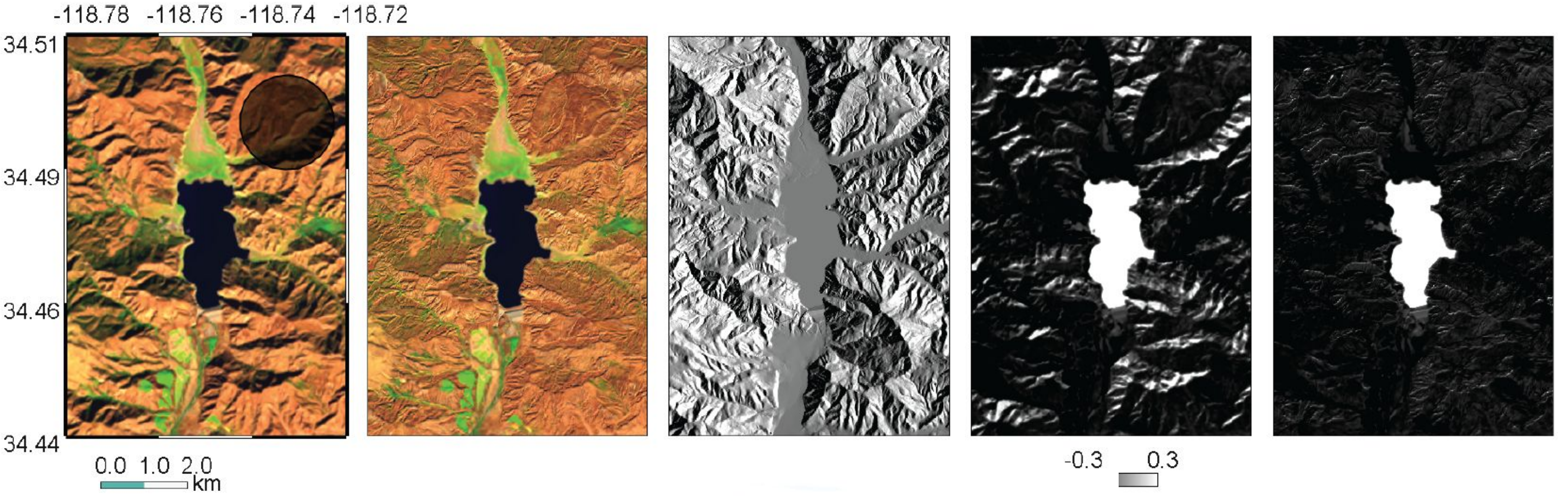
5 min   Group

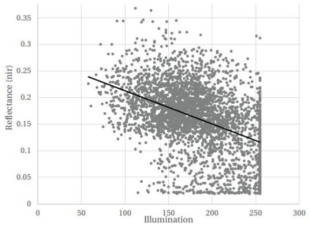
Thank you!

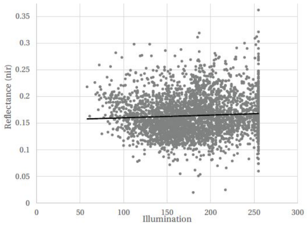
Basins, rivers, and water

[Code]

Topographic correction







$$L(\lambda) = a(\lambda) \cdot IC + b(\lambda)$$

$$L_n(\lambda) = L(\lambda)\frac{cos(\theta) + C(\lambda)}{IC + C(\lambda)}$$

$$C = b / a$$

Tan et. al., 2013, Source:
https://code.earthengine.google.com/9e96c0046aa0881552406ba6e4cb63b1

https://courses.spatialthoughts.com/gee-water-resources-management.html

Courses   Back to Main Site

Google Earth Engine for Water Resources Management (Full Course Material)

Application-focused Introduction to Google Earth Engine.

Ujaval Gandhi