



# Remote Sensing with Instant Home Delivery

The GeoGeek's Guide to Satellite Imagery

**Dale Lutz & Dmitri Bagh**

# Industries where Earth Observation Satellites are Changing Everything

1. Government
2. Intelligence Agencies
3. Environmental
4. Data analytics
5. Agriculture
6. Disaster management
7. Humanitarian
8. Monitoring assets and resources



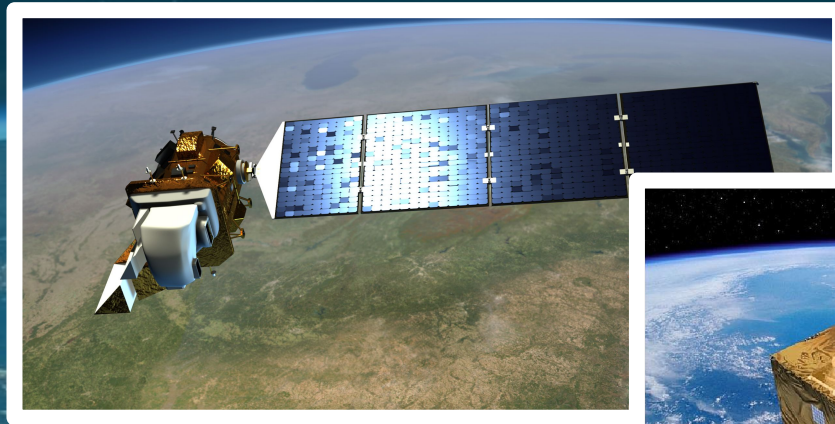
# Modern Providers

Landsat 8

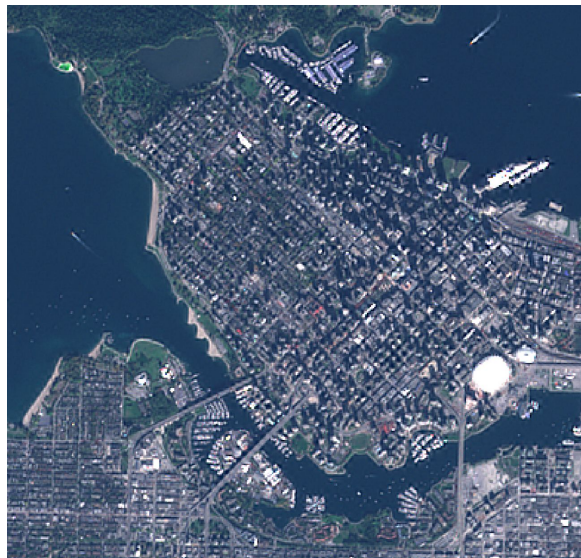
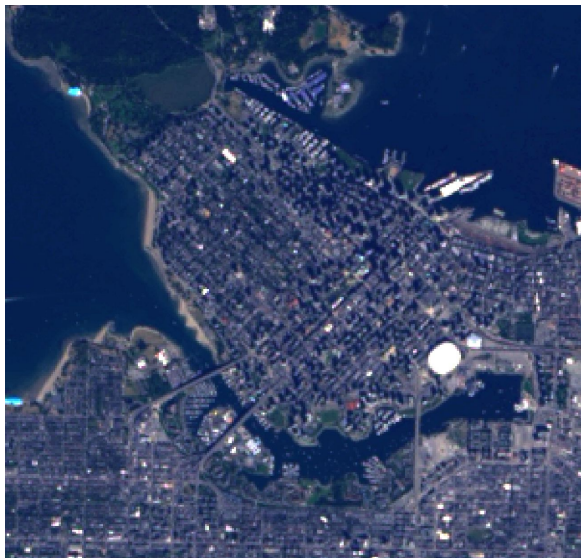
Sentinel

Planet

Urthecast



# Imagery comparison



	Landsat (NASA/USGS)	Sentinel 2 (ESA)	Planet	Urthecast (Future)
Resolution	15/30/100m	10/20/60m	3-5m	0.5-1m
Status	Free	Free	Paid	Paid
Frequency	~Bi-weekly	Weekly (or better)	Daily (Spring 2017)	A few times a day

**Mind-boggling volumes of data**  
**Amazon AWS**

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# S3: Secure, durable, highly-scalable object storage

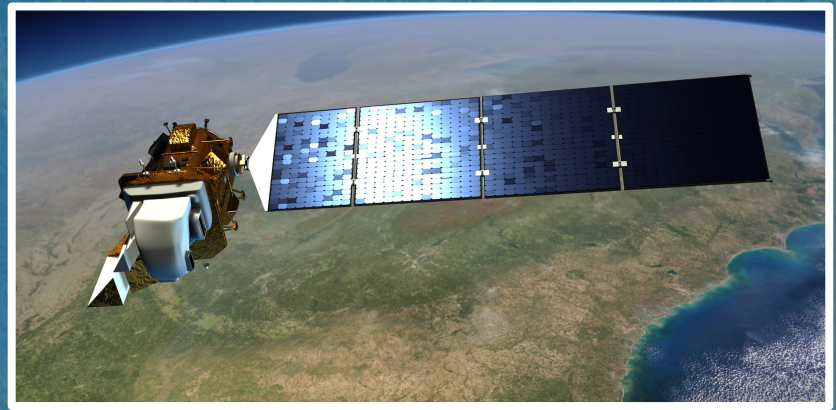
- 99.999999999% reliability
- 3+ million requests per second
- S3 is highly performant and applications can get 100's of requests a second
- \$0.03 per GB of storage (5TB of data \$150 a month)
- Can store single objects up to 5TB



# Landsat 8 (NASA/USGS)

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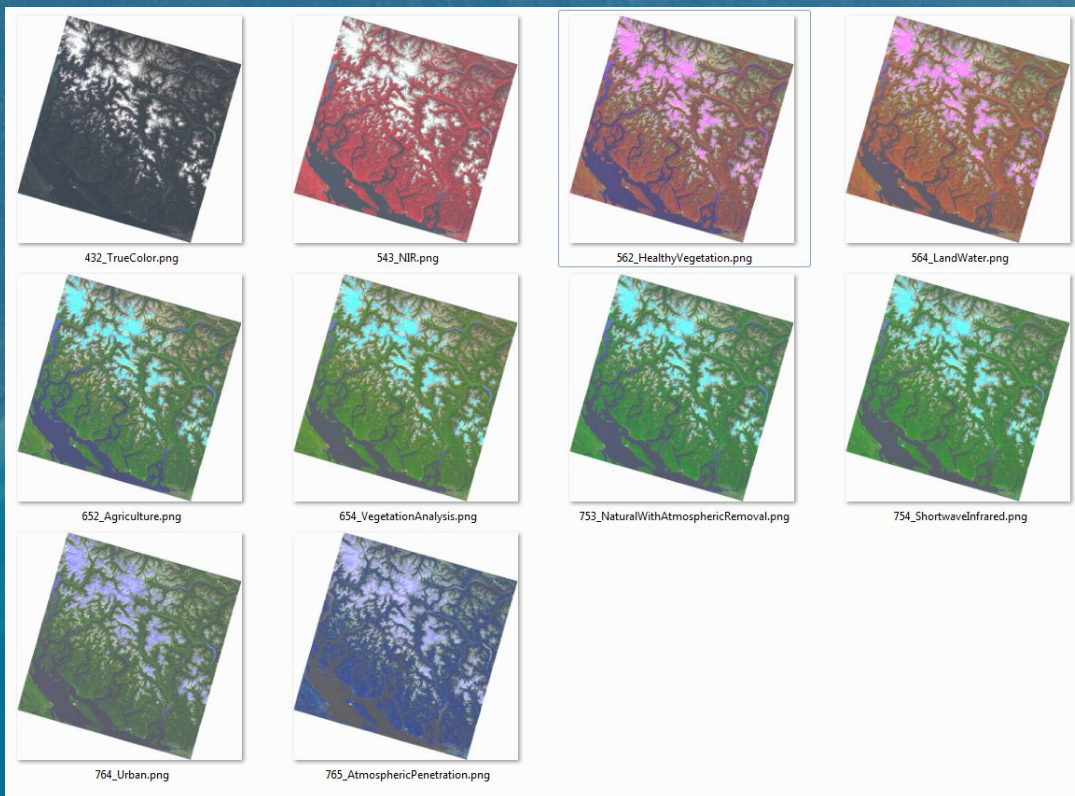
# Landsat 8 Bands



Spectral Band	Wavelength	Resolution	Solar Irradiance
Band 1 - Coastal / Aerosol	0.433 – 0.453 $\mu\text{m}$	30 m	2031 $\text{W}/(\text{m}^2\mu\text{m})$
Band 2 - Blue	0.450 – 0.515 $\mu\text{m}$	30 m	1925 $\text{W}/(\text{m}^2\mu\text{m})$
Band 3 - Green	0.525 – 0.600 $\mu\text{m}$	30 m	1826 $\text{W}/(\text{m}^2\mu\text{m})$
Band 4 - Red	0.630 – 0.680 $\mu\text{m}$	30 m	1574 $\text{W}/(\text{m}^2\mu\text{m})$
Band 5 - Near Infrared	0.845 – 0.885 $\mu\text{m}$	30 m	955 $\text{W}/(\text{m}^2\mu\text{m})$
Band 6 - Short Wavelength Infrared	1.560 – 1.660 $\mu\text{m}$	30 m	242 $\text{W}/(\text{m}^2\mu\text{m})$
Band 7 - Short Wavelength Infrared	2.100 – 2.300 $\mu\text{m}$	30 m	82.5 $\text{W}/(\text{m}^2\mu\text{m})$
Band 8 - Panchromatic	0.500 – 0.680 $\mu\text{m}$	15 m	1739 $\text{W}/(\text{m}^2\mu\text{m})$
Band 9 - Cirrus	1.360 – 1.390 $\mu\text{m}$	30 m	361 $\text{W}/(\text{m}^2\mu\text{m})$



# Landsat 8 Useful Band Combinations



# Official USGS viewer/downloader

<https://landsatlook.usgs.gov/viewer.html>

The screenshot displays the USGS LandsatLook Viewer web application. The browser address bar shows the URL <https://landsatlook.usgs.gov/viewer.html>. The page features a search bar at the top with the placeholder text "search for a location". Below the search bar, there are navigation and control icons. The main content area shows a satellite image of a city and river system. On the left side, there is a sidebar with the following sections:

- Welcome!** | [About](#) | [Quick Guide](#) | [Contact Us](#) | [Help](#)
- Search the Landsat Archive**
- Image Display - Displaying 3 of 79 images**
- Active Image**  
Fri, 16 Dec 2016 (GMT)
- Timeline slider: 19 Apr 2013 to 16 Dec 2016. Text: "Use the time slider to move through your search results."
- Radio buttons:  Active Image Only,  Image Mosaic
- Image Enhancements**  
 None,  Percent Clip,  Stretch 3 Std Dev
- Image Transparency**  
off  visible
- 
- Metadata and Data Access**
  - Displayed Images Only (Table View)
  - Displayed Images Only (Browse/Metadata)
  - All Query Results (Table View)
  - All Query Results (Browse/Metadata)

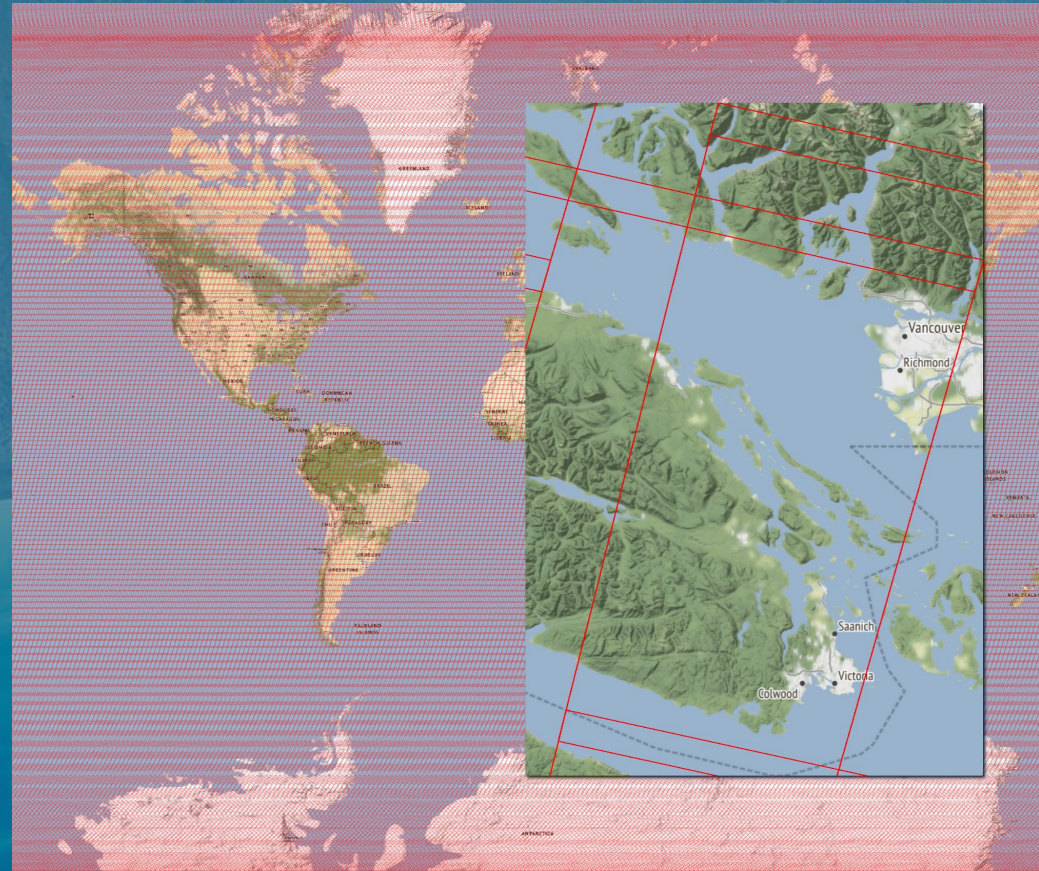
At the bottom of the page, there is a footer with the text "Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, ..." and the Esri logo. Below the footer, there are links for [Accessibility](#), [FOIA](#), [Privacy](#), and [Policies and Notices](#).

# Landsat 8 Tiles

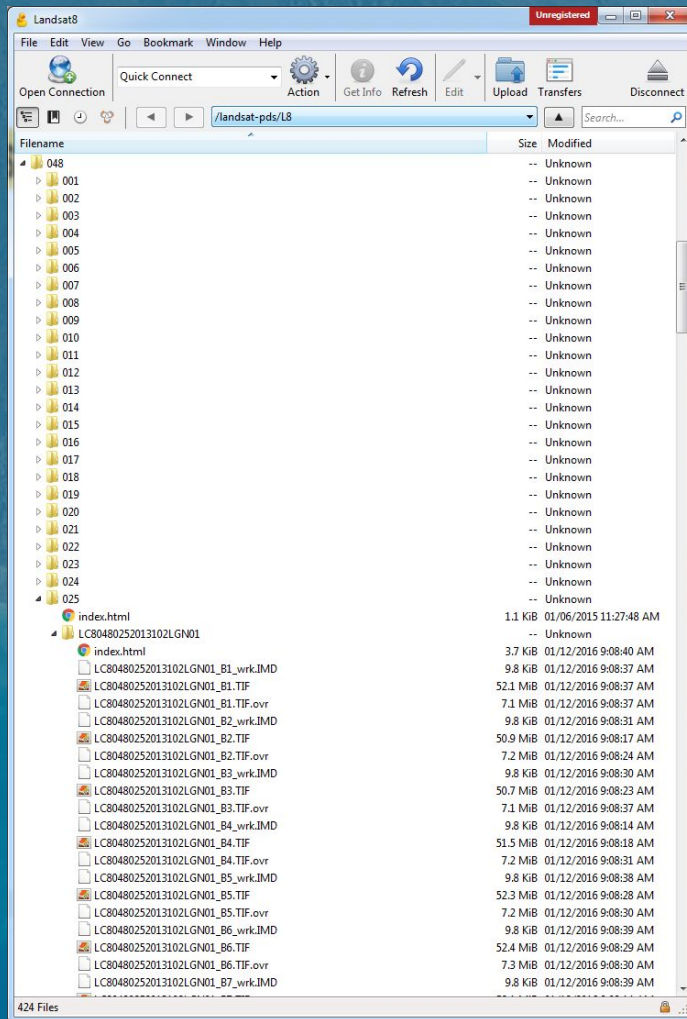
Almost 29,000 tiles

Tile Name Example:

LC80480262015225LGN01\_Bx



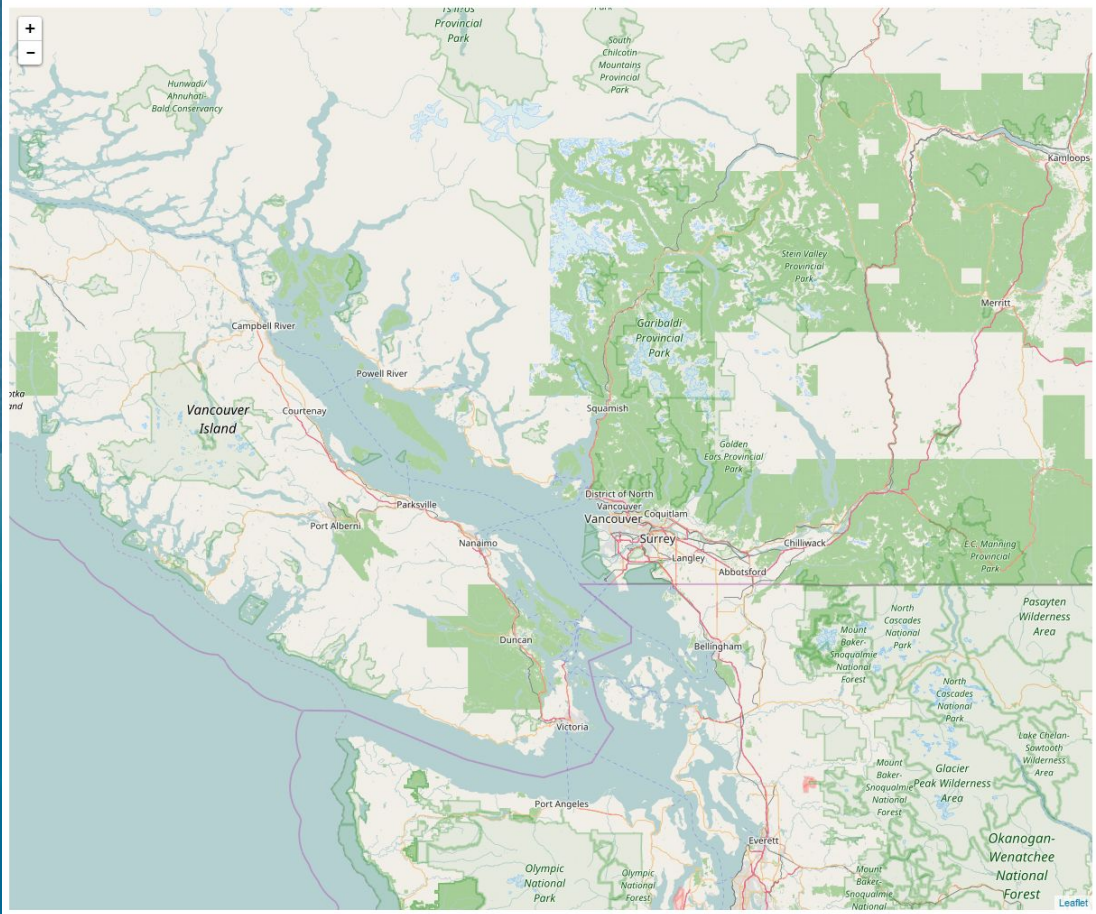
# Landsat 8 on AWS



## Landsat 8 File Selector

Specify the maximum % of cloud coverage, pan and zoom to your area of interest and click on the map. A new page will open where you can select the best image for your purposes.

Cloud Coverage  %

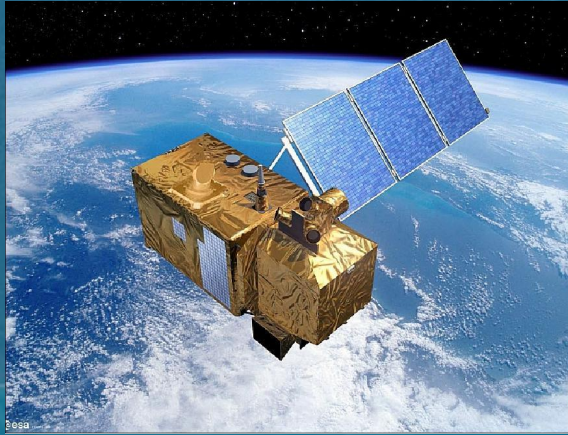


# Simple Landsat Download Assistant

# Sentinel 2 (ESA)

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# Sentinel 2 bands



Sentinel-2 Bands	Central Wavelength ( $\mu\text{m}$ )	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

# Sentinel Reading

- MGRS grid
- Metadata available (the data is in EU, Frankfurt (eu-central-1))
- Name example

`tiles/10/U/EV/2017/1/3/0/metadata.xml`

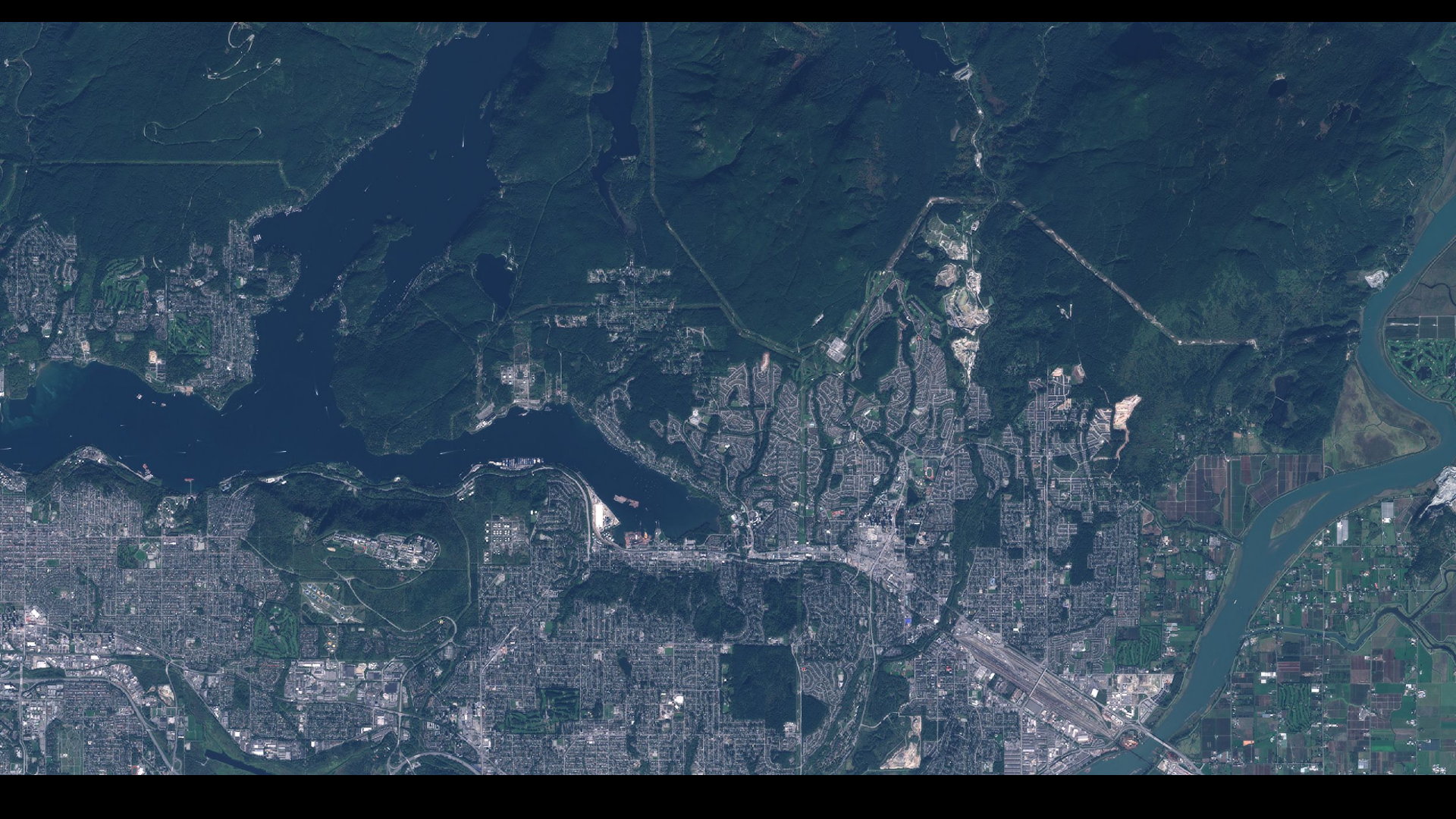
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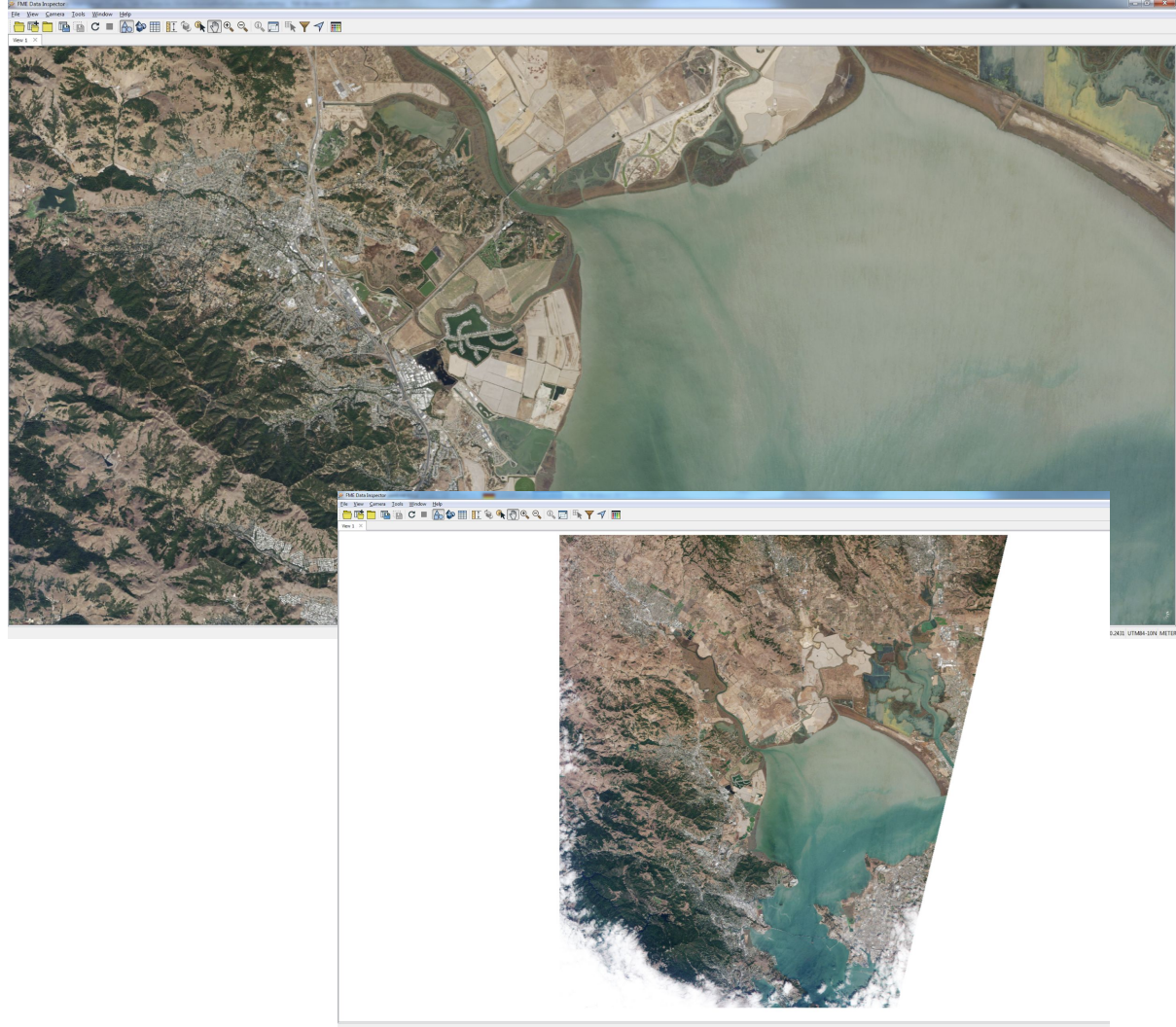


**Planet**

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# How To Access and Use Planet Data

Planet's satellites, called Doves, provide high-frequency, medium-resolution (3-5 metre) imagery archiving back to 2009.



An aerial photograph of a coastal city, likely Dubai, showing a large body of water, a beach, and a city built on a peninsula. The image is overlaid with a blue gradient and a yellow text box.

## Planet by the numbers

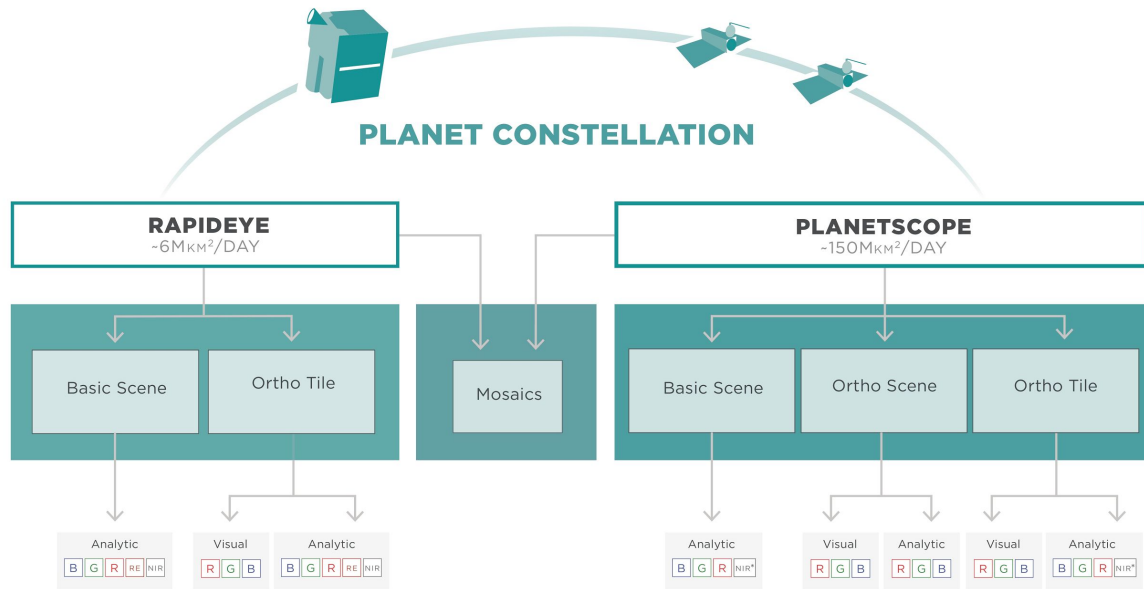
- More satellites than all other providers/agencies combined
- Can build up to 20 satellites per week (capacity)
- Collects 1,000,000 images or 7 tb of data per day
- “*We forgot 2 petabytes of data on S3*” (nervous laughter please)

# Planet Data

- API Key required
- Two satellite groups
  - RapidEye (RE)
  - PlaneScope (PS)

- Assets

- Visual (RGB24)
- Analytic (RGBNir64)+Red Edge with RE
- UDM (unusable data mask)  
(bit mask shown as UINT8)



\*NIR available on some PS2 imagery  
RapidEye Basic Scene product available soon

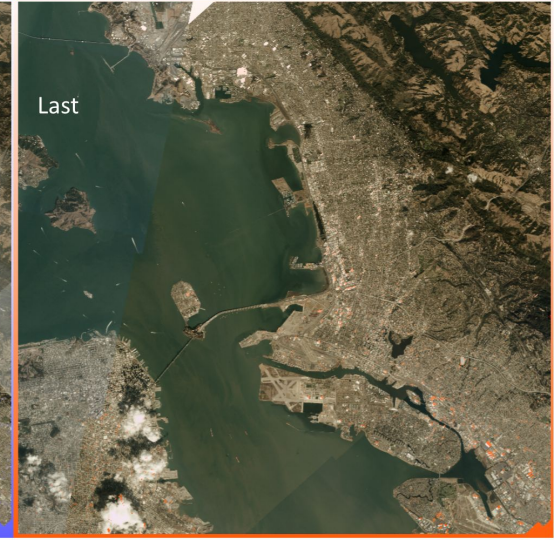
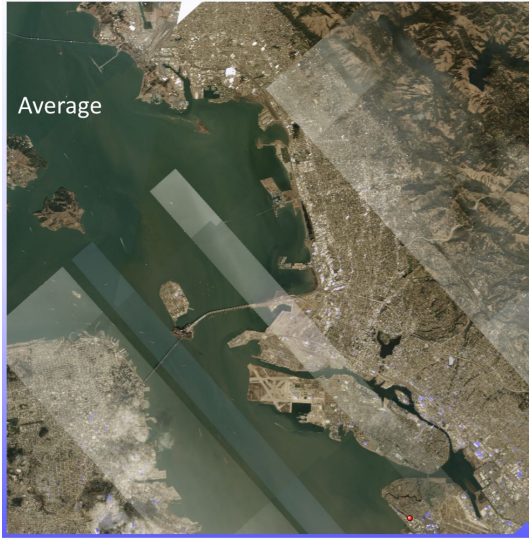
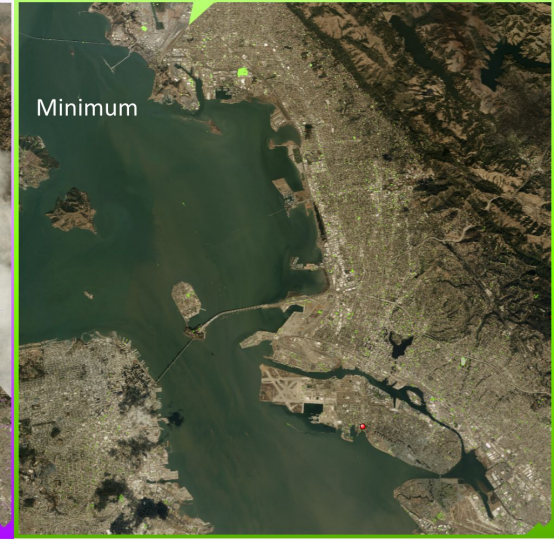
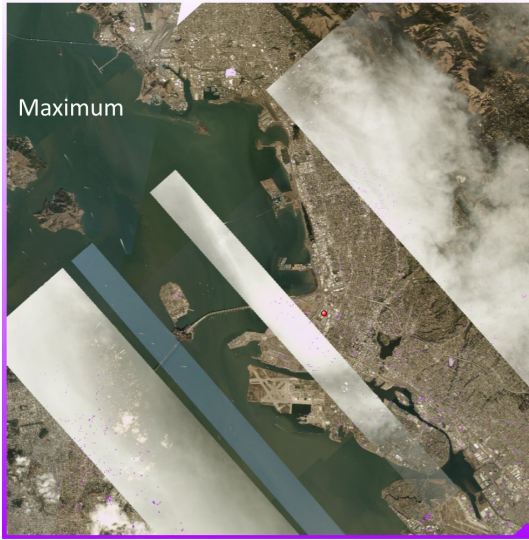


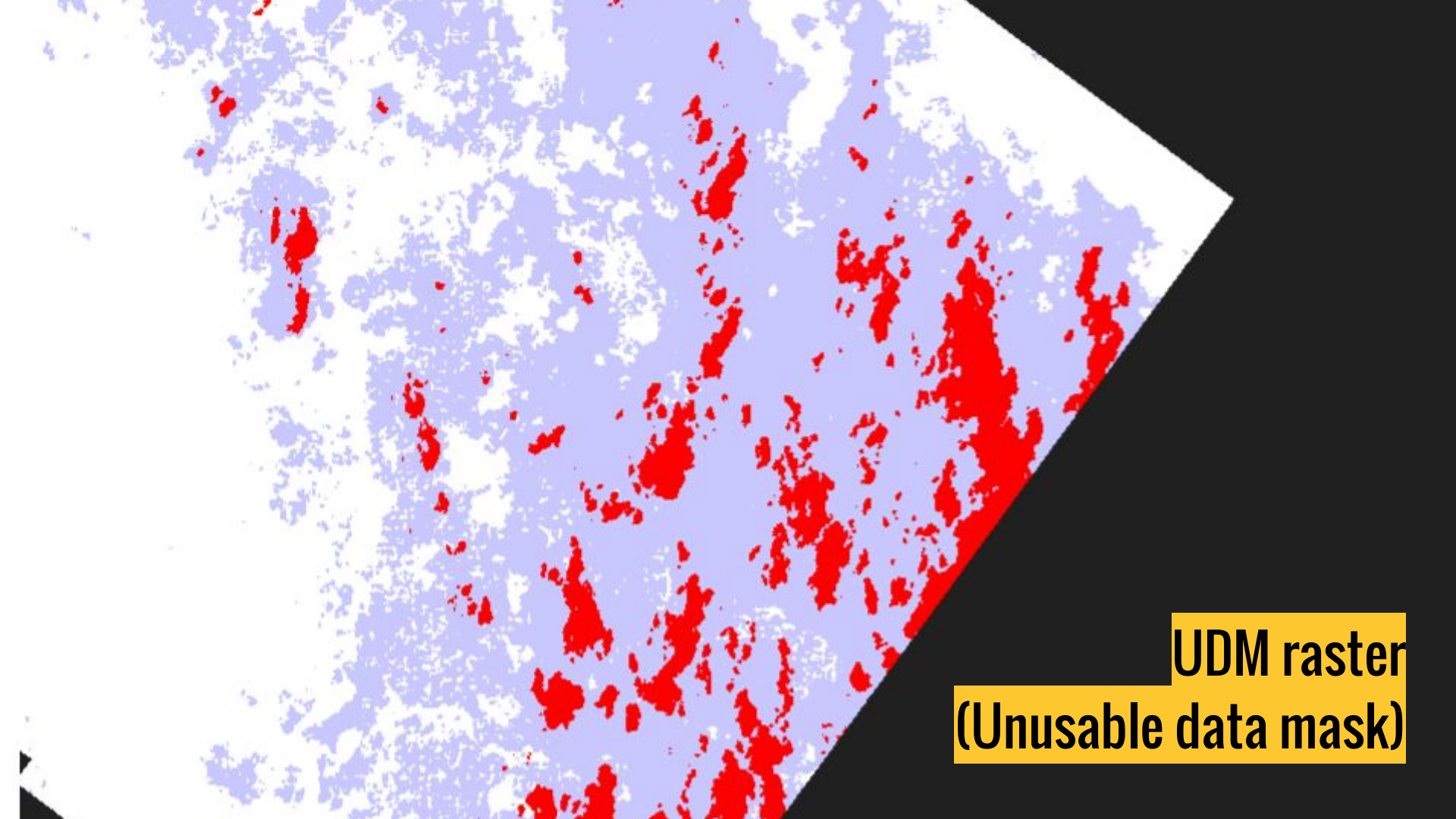
# Planet Data

- Initialization (first reading) takes time
- Data is delivered as GeoTIFF
- JSON metadata is helpful - lots of clouds over the planet

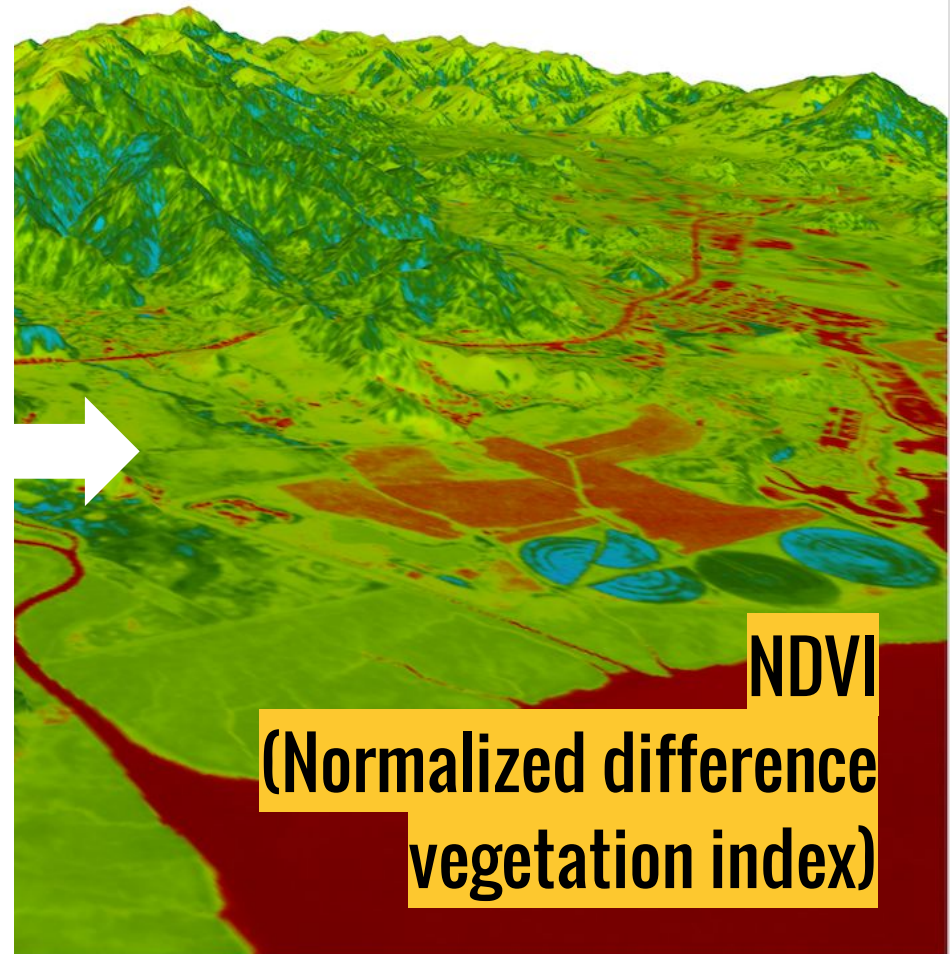
```
{ "type" : "AndFilter",  
  "config" : [  
    { "type" : "RangeFilter", "field_name" : "cloud_cover", "config" : { "lte" : @Evaluate($(CLOUDCOVER)/100) } },  
    { "type" : "RangeFilter", "field_name" : "black_fill", "config" : { "lte" : @Evaluate($(BLACKFILL)/100) } }  
  ]  
}
```

**Reading and mosaicking  
images that were taken  
over a period of time**





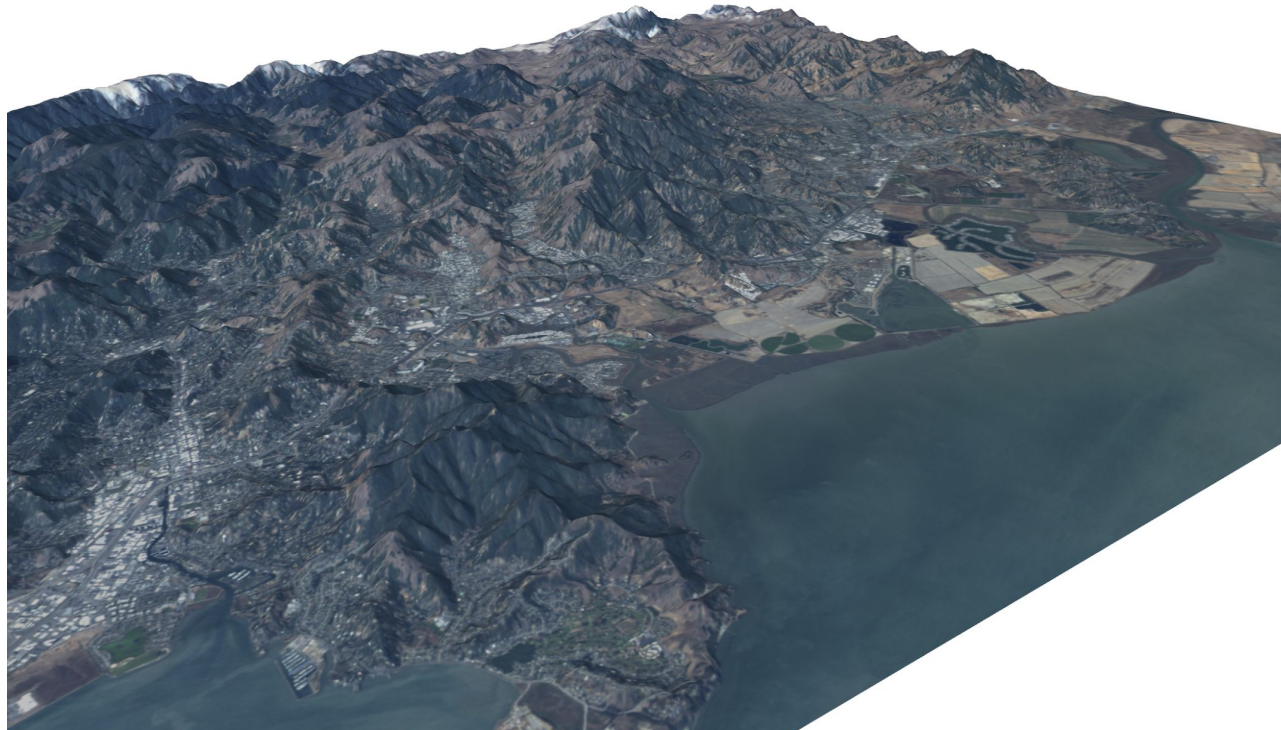
**UDM raster  
(Unusable data mask)**

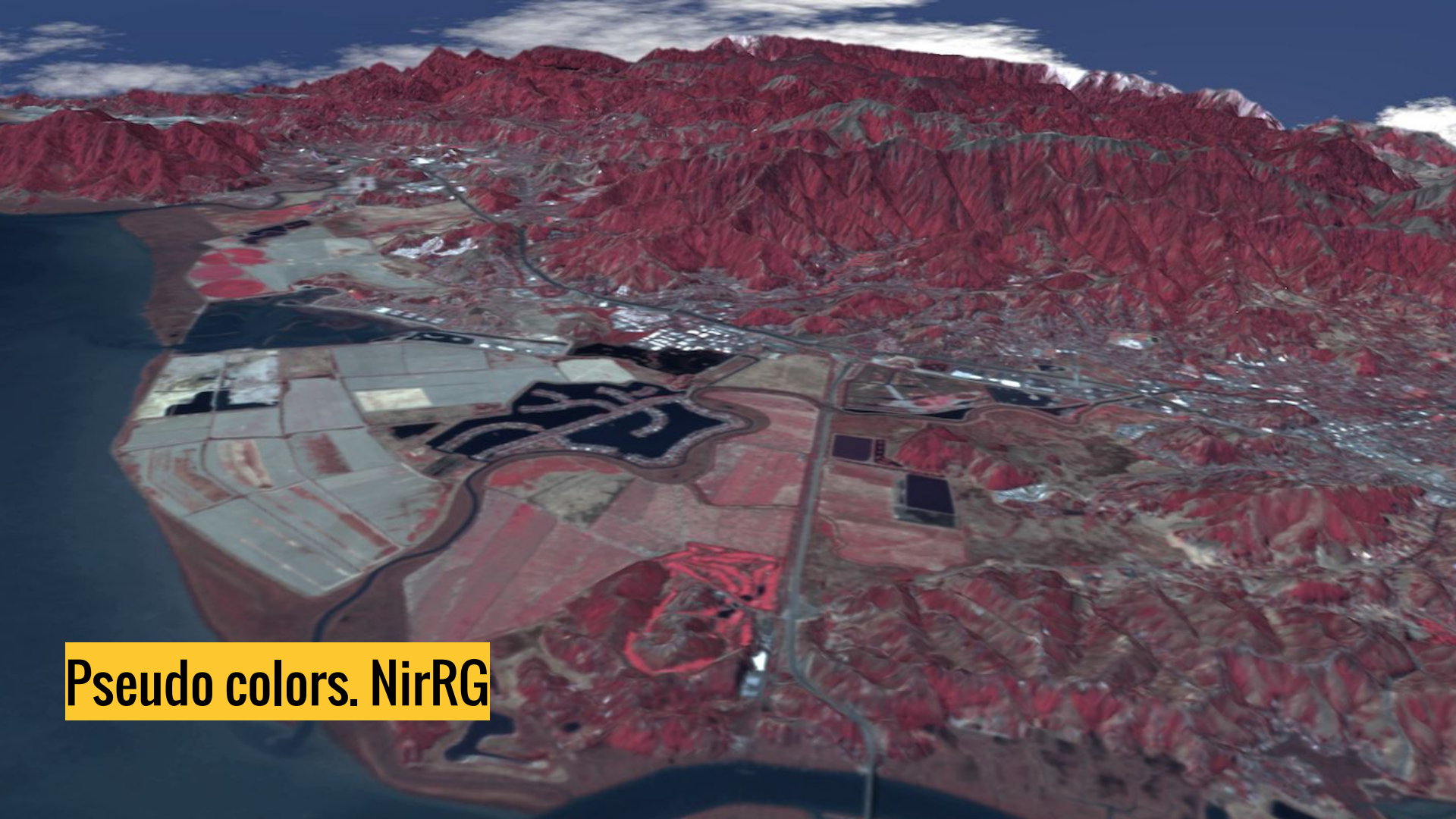


**NDVI**  
**(Normalized difference**  
**vegetation index)**

# 3D Visualization

Satellite imagery draped over a digital elevation model (DEM) or LiDAR scan allows you to visualize the landscape in 3D.





**Pseudo colors. NirRG**

# UrtheCast

# Today's visit



## UrtheDaily™ Sample Imagery (simulated)

The whole Earth, everyday, at 10:30 AM, at 5m / pixel, with multi-band spectral diversity.

Example image at 5m / pixel



# The OptiSAR™ Constellation

Revolutionizing the world's ability to monitor our planet. Every day. Rain or shine. Night and day.



# Uses for Satellite Imagery

1. Use the frequently and automatically updated imagery as a 'live' basemap for your GIS data.
2. Combine several images to get rid of cloud coverage.
3. Load specific areas into a database so you can compare it over time
4. Vectorize the image.
5. Add new imagery to your database only when it meets certain requirements, e.g. it's not covered by clouds.

**Supplemental data**  
**Mapzen Terrain tiles on AWS**

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# Global DEM coverage



Announcing Terrain Tiles on AWS: A Q&A with Mapzen

on 21 SEP 2016 | in Education, Government, Nonprofit | Permalink

We are excited to announce Terrain Tiles on AWS, a new AWS Public Dataset that makes global digital elevation models (DEMs) available for anyone to access from Amazon Simple Storage Service (Amazon S3). DEMs provide a way to examine the elevation of the Earth's surface and are available as terrain raster tiles. We connected with Mapzen, an open, sustainable, and accessible mapping platform which lets you display, search, and navigate our world. Mapzen gathered the elevation data from various public sources and is making it easy for startups, enterprises, and research institutions to access and use via Amazon S3. Elevation data has been one of the top public dataset requests, so we are excited about the recent launch. Making Earth observation data available in the cloud is accelerating scientific discovery and enabling the creation of new products.

Read our interview below with Mapzen about the newly released dataset and how they run entirely on open-source tools and are powered by open data.

**AWS Public Sector Resources**

- AWS in the Public Sector: Government, Education and Nonprofits
- Government and Education Case Studies
- Government and Education Resources
- AWS Public Sector Events
- AWS for US Federal Government
- AWS for State and Local Government

# **Simple visualization in a browser**

## **ThreeJS**

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## Three.js

JavaScript library/API for creating and displaying 3D computer graphics in a web browser.

- JSON
- HTML
- Javascript

# JavaScript Example

- Create a scene
- Load data
- Add background
- Add camera
- Add light(s)
- Add controls
- Render

```
//Add scene
scene = new THREE.Scene();
renderer = new THREE.WebGLRenderer();
renderer.setSize( window.innerWidth, window.innerHeight );
document.body.appendChild( renderer.domElement );

//load surface
var loader = new THREE.JSONLoader();
loader.load( 'surface.json', function ( geometry, materials ) {
    var surface_mesh = new THREE.Mesh ( geometry, new THREE.MeshFaceMaterial( materials ) );
    //smooth the surface
    surface_mesh.geometry.computeVertexNormals();
    //materials.side = THREE.doublesided;
    surface_mesh.geometry.doubleSided = true;
    scene.add (surface_mesh);
}, "/" )

//Add photo sphere
var loader = new THREE.TextureLoader();
loader.load( './background.jpg', function ( texture ) {
    var sphere = new THREE.SphereGeometry( 2048*2, 32, 32 );
    var material = new THREE.MeshBasicMaterial( { map: texture, overdraw: 0.5 } );
    var photoMesh = new THREE.Mesh( sphere, material );

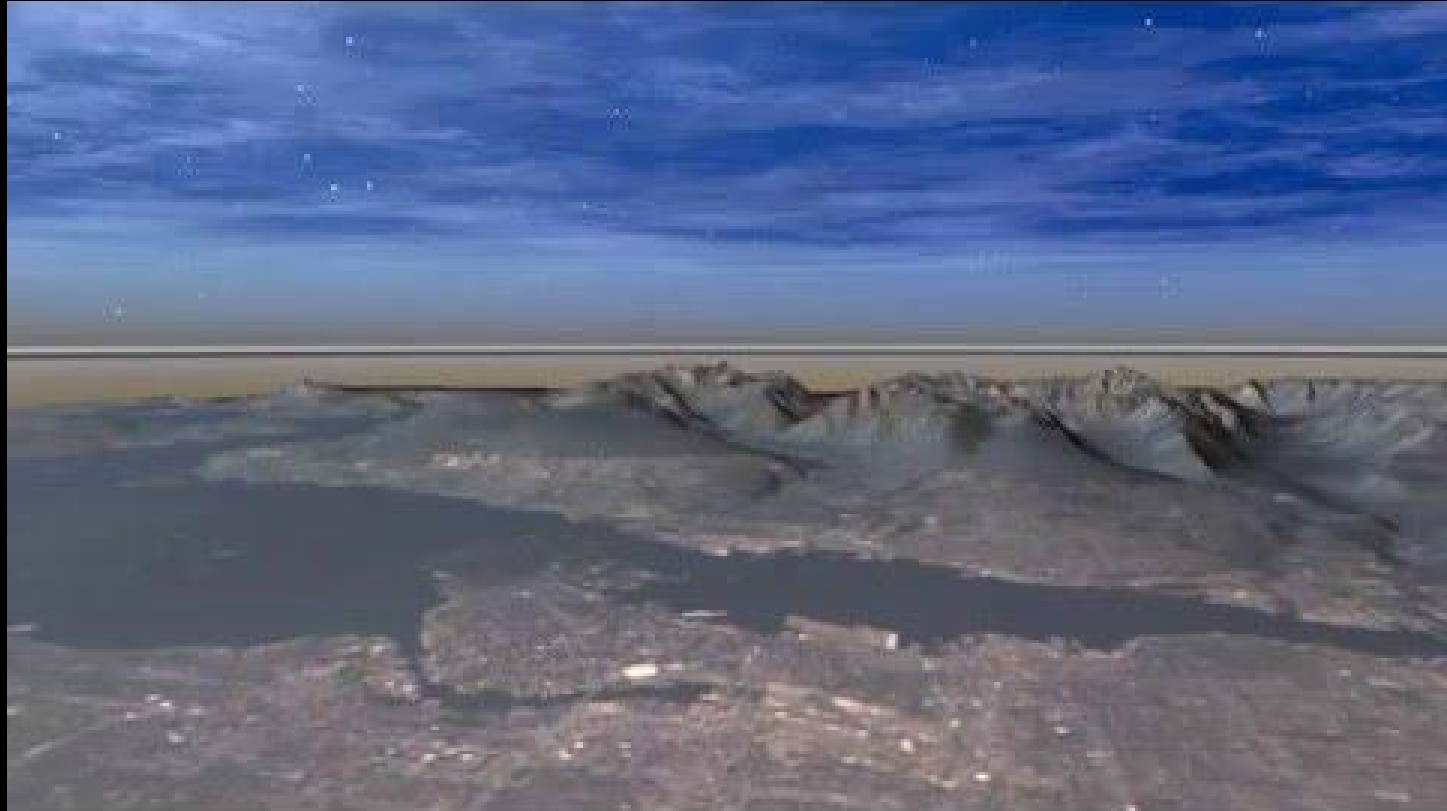
    //place texture on the inside surface of the sphere
    photoMesh.scale.x = - 1;
    photoMesh.geometry.computeVertexNormals();
    scene.add( photoMesh );
} );

//Add camera
camera = new THREE.PerspectiveCamera( 80, window.innerWidth / window.innerHeight, 0.1, 20000 );
camera.position.set( 497.19856513029453, -3.335177435777795, 499.9999999999962 );
camera.updateProjectionMatrix ();

//Attach light to camera
var light = new THREE.PointLight(0xFFFFFF, 1.2);
camera.add( light );
scene.add( camera );

//Add controls
controls = new THREE.FirstPersonControls( camera );
controls.movementSpeed = 25;
controls.lookSpeed = 0.1;
controls.lookVertical = true;
```





# Even More Additional Uses for Satellite Imagery



An aerial photograph of a mountain range, likely the Alps, with a prominent peak on the left. The image is split vertically: the left side is in its original teal color, and the right side is overlaid with a semi-transparent orange color. A large white rectangle is centered over the image, containing the text 'Thank you!'.

# Thank you!

**Live chat us at [safe.com](https://www.safe.com)**