

# Good COG / Bad COG

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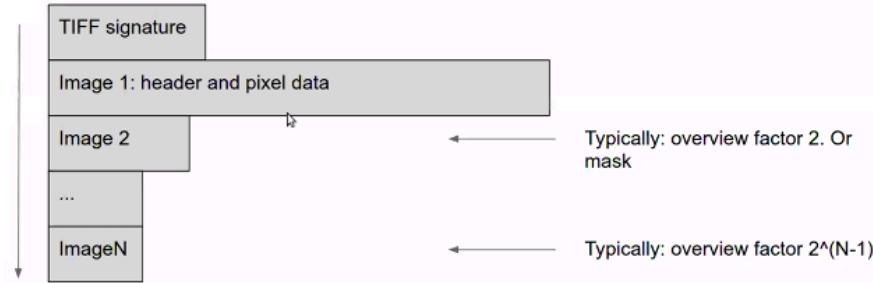
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COGs are not magical,  
they are GeoTIFF

## Specification

### TIFF format structure: high level



<https://github.com/cogeotiff/cog-spec/blob/master/spec.md>

## Specification

### Efficient tile retrieval

GeoTIFF driver improvements for more efficient HTTP requests

Tile (0,0)	Tile (0,1)	Tile (0,2)
Tile (1,0)	Tile (1,1)	Tile (1,2)
Tile (2,0)	Tile (3,1)	Tile (3,2)

Tile (0,N)
Tile (1,N)
Tile (3,N)

<https://github.com/cogeotiff/cog-spec/blob/master/spec.md>

# COGs are easy to create

GDAL (python, java, R, ...)

[cogeotiff/rio-cogeo](#)

[airbusgeo/cogger](#)

## Tools

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```
# GDAL
$ gdal_translate -of COG non-cog.tif cog.tif

# rio-cogeo
$ rio cogeo create non-cog.tif cog.tif

# cogger
$ gdal_translate -of GTIFF -co BIGTIFF=YES -co TILED=YES -co
COMPRESS=ZSTD -co NUM_THREADS=4 input.file geotif.tif
$ gdaladdo --config GDAL_NUM_THREADS 4 --config COMPRESS_OVERVIEW
ZSTD geotif.tif 2 4 8 16 32
$ cogger -output mycog.tif geotif.tif
```

## Profiles

- Compression (deflate, JPEG, WebP, ....)
- Overviews
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

<https://gdal.org/drivers/raster/cog.html#raster-cog>

# Everyone can use COGs

## Tools

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- GDAL
- Rasterio
- geotiff.js
- blacha/cogeotiff
- geospatialjeff/aiocogeo
- mapbox/cogdumper
- fabric-io-rodrigues/GeoTiffCOG
- QGIS
- ....

<https://www.cogeo.org>

# Is Cloud Optimized GeoTIFF the best Format?

# Sure

- ✓ Compatibility
- ✓ Multiple compression options (storage optimization)
- ✓ Fast read
- ✓ **It is just a GeoTIFF**

# Maybe not

- ✗ You can't update a COG in place (you need to rewrite the whole file)
- ✗ You need more than 3 dimensions
- ✗ You need **Ultra** fast tile service

# Good and Bad COGs?

## Tools

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<https://gdal.org/>

gdalinfo  
gdal\_translate

...

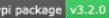
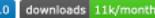
## Tools

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### rio-cogeo



*Cloud Optimized GeoTIFF (COG) creation and validation plugin for Rasterio.*

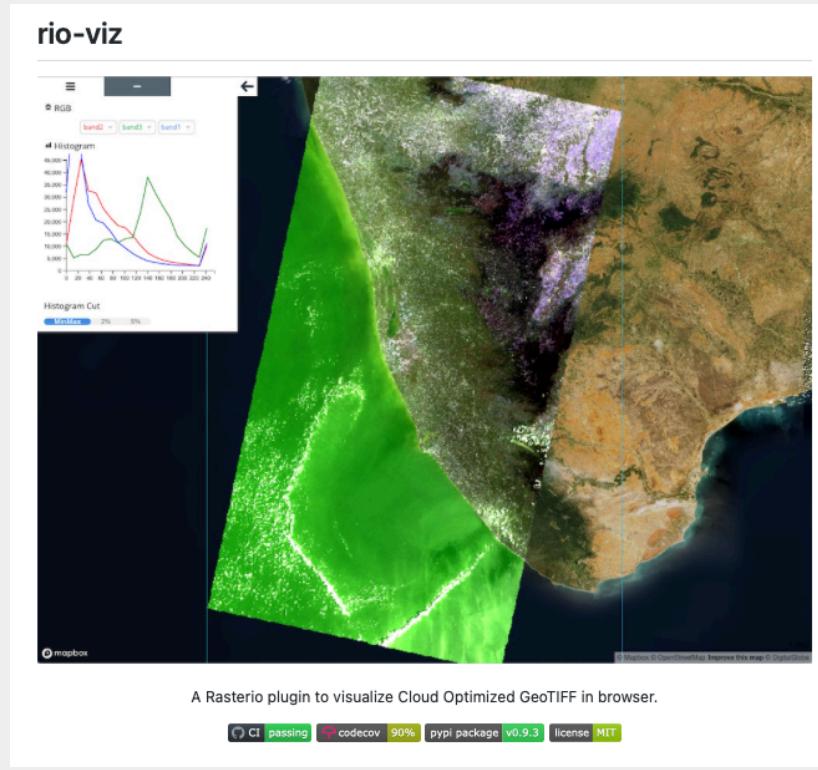
 CI passing  codecov 98%  pypi package v3.2.0  conda|conda-forge v3.2.0  downloads 11k/month  license BSD-3-Clause

<https://github.com/cogeotiff/rio-cogeo>

rio cogeo create  
rio cogeo info  
rio cogeo validate

## Tools

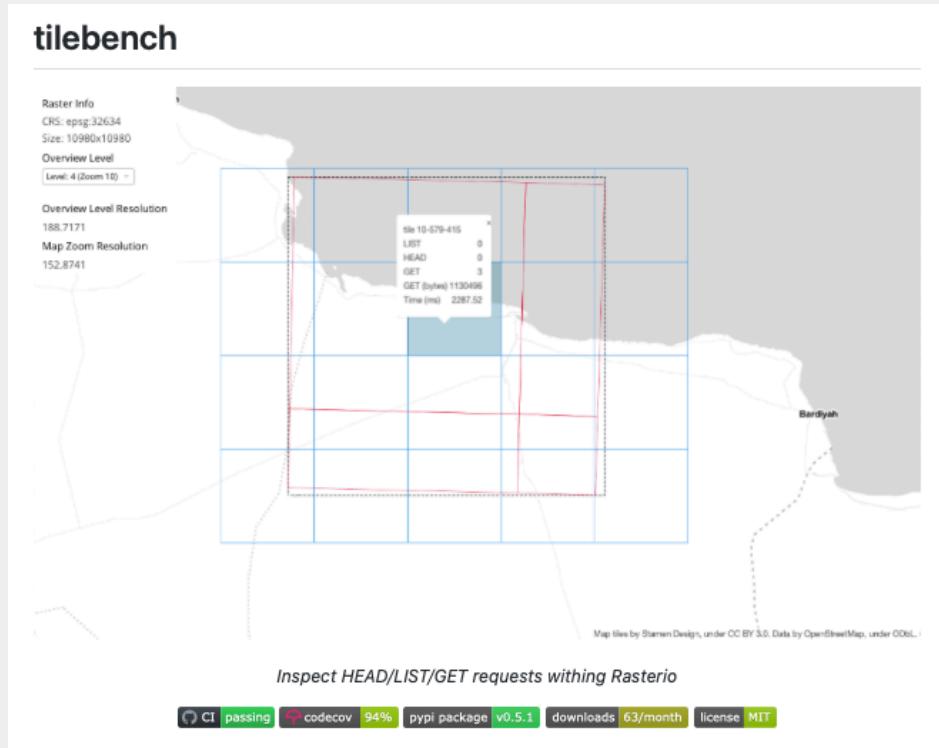
---



<https://github.com/developmentseed/rio-viz>

## Tools

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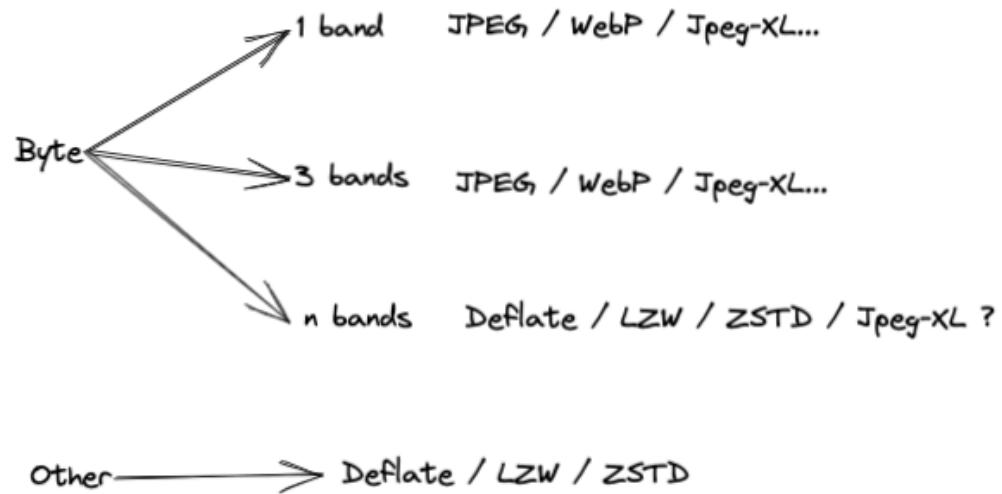


<https://github.com/developmentseed/tilebench>

## Profiles

- Compression (deflate, JPEG, WebP, ....)
- Overviews
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

## Compression



## Compression

```
# Non-COG - 232Mb
$ gdalinfo world_init.tif
Driver: GTiff/GeoTIFF
Files: world_init.tif
Size is 21580, 10780
...
Image Structure Metadata:
| INTERLEAVE=BAND
...
Band 1 Block=21580x1 Type=Byte, ColorInterp=Red

# COG Deflate - 97.3Mb
$ gdal_translate -of COG world_init.tif world_deflate.tif -co COMPRESS=deflate

# COG JPEG (1 band) - 17.2 Mb
$ gdal_translate -of COG world_init.tif world_jpeg.tif -co COMPRESS=JPEG

# COG JPEG (3 bands) - 18.1 Mb
$ gdal_translate -of COG world_init.tif world_jpeg_3b.tif -co COMPRESS=JPEG -b 1 -b 1 -b 1
```

## Compression

```
# Non-COG - 988.2Mb
$ gdalinfo iw-vh.tif
Driver: GTiff/GeoTIFF
Files: iw-vh.tif
Size is 25481, 19388
...
Image Structure Metadata:
| INTERLEAVE=BAND
|
| Band 1 Block=25481x1 Type=UInt16, ColorInterp=Gray
|   NoData Value=0

# COG Deflate - 473Mb
$ gdal_translate -of COG iw-vh_init.tif iw-vh_deflate.tif -co COMPRESS=DEFLATE
```



## Profiles

- Compression (deflate, JPEG, WebP, ....)
- **Overviews**
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

<https://gdal.org/drivers/raster/cog.html#raster-cog>

## Overviews

---

```
# 46Mb
$ gdalinfo im.tif
Driver: GTiff/GeoTIFF
Files: im.tif
Size is 6072, 7634
...
Band 1 Block=6072x1 Type=Byte, ColorInterp=Palette
    NoData Value=0

# 546kb
$ rio coge create im.tif im_cog.tif
$ gdalinfo im_cog.tif
Driver: GTiff/GeoTIFF
Files: im_cog.tif
Size is 6072, 7634
Band 1 Block=512x512 Type=Byte, ColorInterp=Palette
    NoData Value=0
    Overviews: 3036x3817, 1518x1909, 759x955, 380x478

# With useless overviews
$ rio coge create im.tif im_cog.tif --overview-level 9
$ gdalinfo im_cog.tif
Driver: GTiff/GeoTIFF
Files: im_cog.tif
Size is 6072, 7634
Band 1 Block=512x512 Type=Byte, ColorInterp=Palette
    NoData Value=0
    Overviews: 3036x3817, 1518x1909, 759x955, 380x478, 190x239, 95x120, 48x60, 24x30, 12x15
```



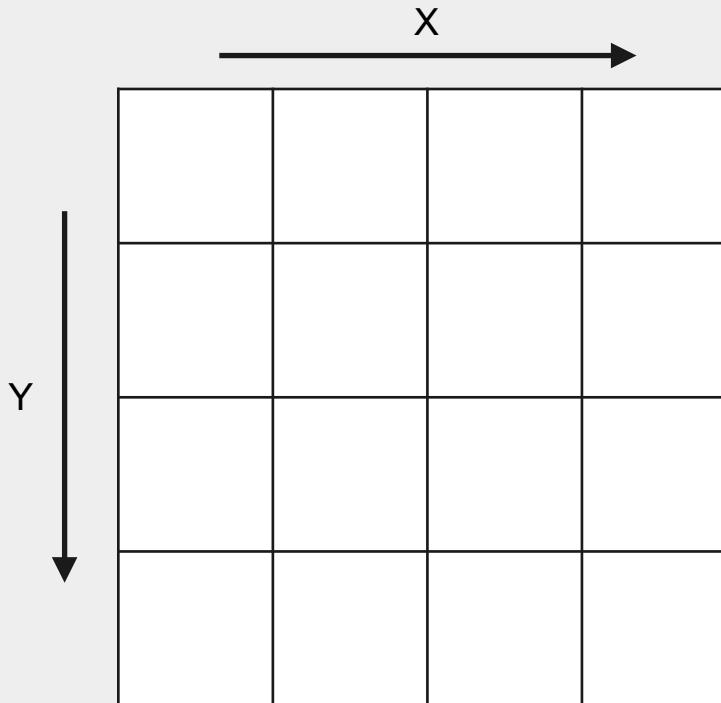
## Profiles

- Compression (deflate, JPEG, WebP, ....)
- Overviews
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

<https://gdal.org/drivers/raster/cog.html#raster-cog>

128, 256, 512, 1024 ...

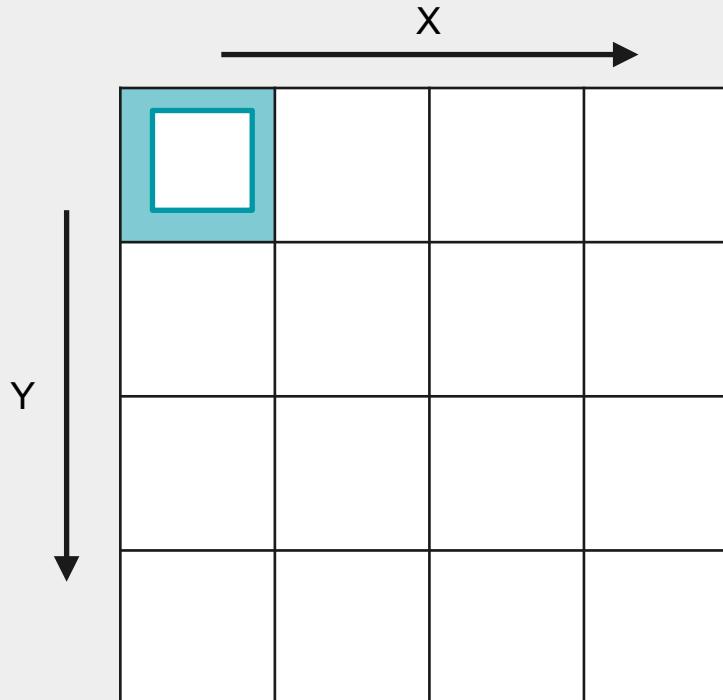
## Block Size



128, 256, 512, 1024 ...

## Block Size

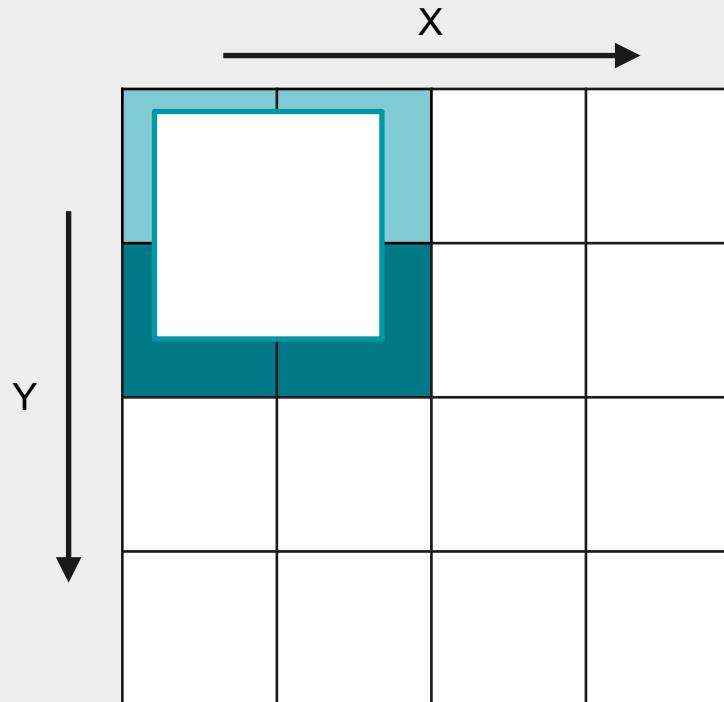
If the size is bigger than the read part then we can do 1 GET



128, 256, 512, 1024 ...

## Block Size

We can merge adjacent (in X dimension), but if the read part cross the Y dimension then we will need additional GET requests



```
$ rio cogeo info https://sentinel-cogs.s3.us-west-2.amazonaws.com/sentinel-s2-l2a-cogs/2020/S2A_34SGA_20200318_0_L2A/B05.tif
Driver: GTiff
File: https://sentinel-cogs.s3.us-west-2.amazonaws.com/sentinel-s2-l2a-cogs/2020/S2A_34SGA_20200318_0_L2A/B05.tif
COG: True
Compression: DEFLATE
ColorSpace: None
```

```
Profile
  Width:      5490
  Height:     5490
  Bands:      1
  Tiled:      True
  Dtype:      uint16
  NoData:     0.0
  Alpha Band: False
  Internal Mask: False
  Interleave: BAND
  ColorMap:   False
  ColorInterp: ('gray',)
  Scales:     (1.0,)
  Offsets:    (0.0,)
```

```
Geo
  Crs:        EPSG:32634
  Origin:     (699960.0, 3600000.0)
  Resolution: (20.0, -20.0)
  BoundingBox: (699960.0, 3490200.0, 809760.0, 3600000.0)
  MinZoom:    8
  MaxZoom:   13
```

```
Image Metadata
  AREA_OR_POINT: Area
  OVR_RESAMPLING_ALG: AVERAGE
```

```
Image Structure
  COMPRESSION: DEFLATE
  INTERLEAVE: BAND
```

```
Band 1
  ColorInterp: gray
```

```
IFD
  Id      Size       BlockSize  Decimation
  0      5490x5490  512x512   0
  1      2745x2745  256x256   2
  2      1373x1373  256x256   4
  3      687x687    256x256   8
  4      344x344    256x256  16
```

COG - 256 blocks - 42.4 Mb

```
$ rio cogeo create B05.tif B05_256.tif -p deflate --blocksize 256 --overview-blocksize 256
```

COG - 512 blocks - 42.9 Mb

```
$ rio cogeo create B05.tif B05_512.tif -p deflate --blocksize 512 --overview-blocksize 512
```

COG - 1024 blocks - 43.6 Mb

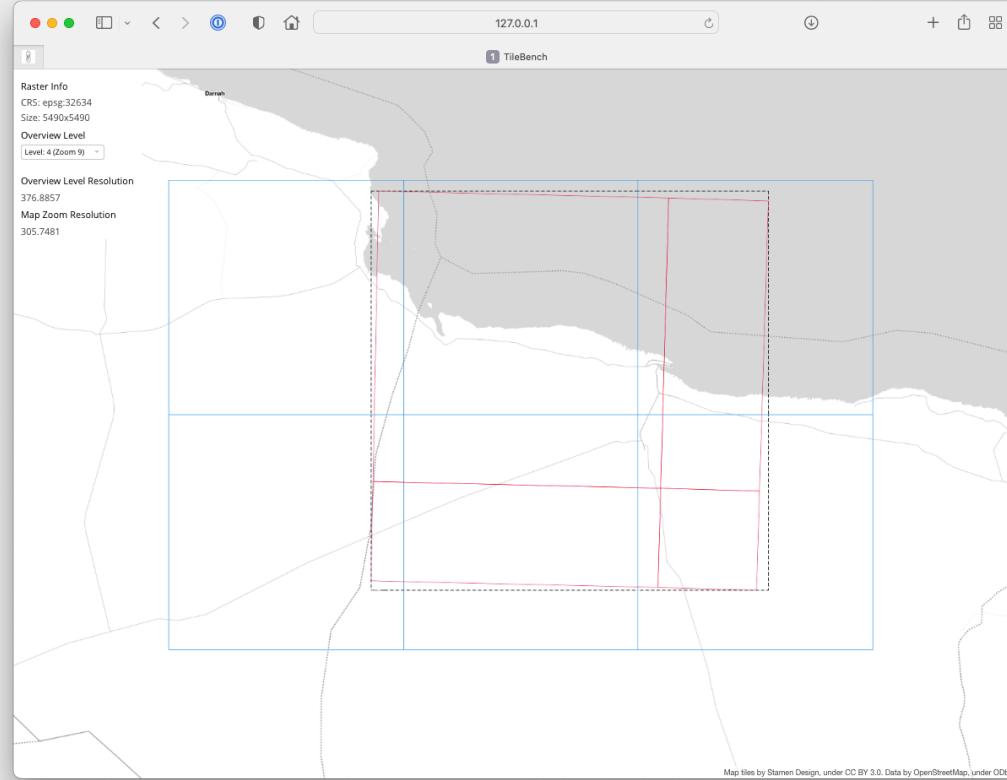
```
$ rio cogeo create B05.tif B05_1024.tif -p deflate --blocksize 1024 --overview-blocksize 1024
```

COG - 2048 blocks - 44 Mb

```
$ rio cogeo create B05.tif B05_2048.tif -p deflate --blocksize 2048 --overview-blocksize 2048
```

## Block Size

## Tilebench demo



## Block Size

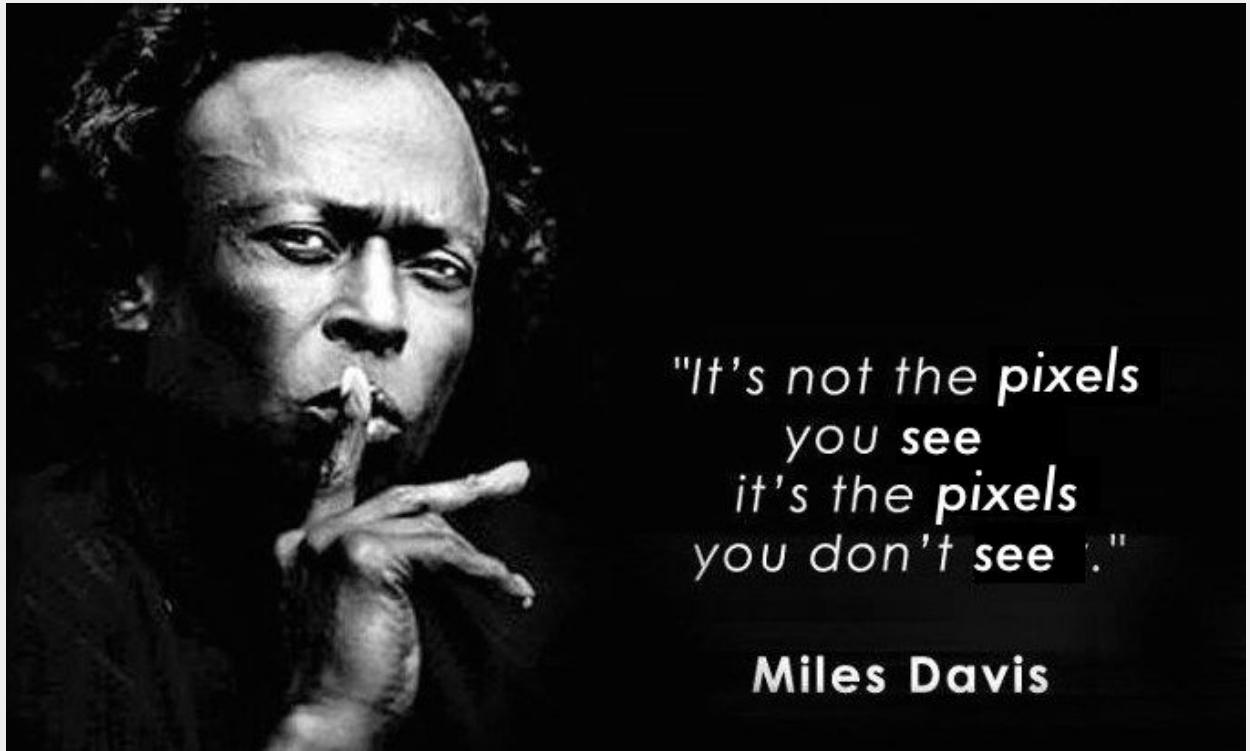
---

## Profiles

- Compression (deflate, JPEG, WebP, ....)
- Overviews
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

<https://gdal.org/drivers/raster/cog.html#raster-cog>

## Nodata



*"It's not the pixels  
you see  
it's the pixels  
you don't see ."*

**Miles Davis**

<https://github.com/mapbox/nodata>



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# Nodata

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[https://globalnightlight.s3.amazonaws.com/201206/SVDNB\\_npp\\_d20120601\\_t0113490\\_e0119294\\_b03074\\_c20120601071930512114\\_noaa\\_ops.rade9.co.tif](https://globalnightlight.s3.amazonaws.com/201206/SVDNB_npp_d20120601_t0113490_e0119294_b03074_c20120601071930512114_noaa_ops.rade9.co.tif)

Driver: GTiff  
File: [https://globalnightlight.s3.amazonaws.com/201206/SVDNB\\_npp\\_d20120601\\_t0113490\\_e0119294\\_b03074\\_c20120601071930512114\\_noaa\\_ops.rade9.co.tif](https://globalnightlight.s3.amazonaws.com/201206/SVDNB_npp_d20120601_t0113490_e0119294_b03074_c20120601071930512114_noaa_ops.rade9.co.tif)  
CGO: True  
Compression: LZW  
ColorSpace: None

Profile

Width:	13200
Height:	6240
Bands:	1
Tiled:	True
Dtype:	float32
NoData:	None
Alpha Band:	False
Internal Mask:	False
Interleave:	BAND
ColorMap:	False
ColorInterp:	('gray',)
Scales:	(1.0,)
Offsets:	(0.0,)

Geo

Crs:	EPSG:4326
Origin:	(-12.002083335, 64.002883335)
Resolution:	(0.00416667, -0.00416667)
BoundingBox:	(-12.002083335, 38.00286253499999, 42.99796066499999, 64.002883335)
MinZoom:	2
MaxZoom:	8

Image Metadata

AREA_OR_POINT:	Area
TIFFTAG_DATETIME:	2017-09-26 14:26:21
TIFFTAG_DOCUMENTNAME:	npp_d20120601_t0113490_e0119294_b03074/SVDNB_npp_d20120601_t0113490_e0119294_b03074
TIFFTAG_IMAGEDESCRIPTION:	IDL TIFF file
TIFFTAG_RESOLUTIONUNIT:	2 (pixels/inch)
TIFFTAG_SOFTWARE:	IDL 8.5-1, Exelis Visual Information Solutions, Inc., a subsidiary of Harris Corp
TIFFTAG_XRESOLUTION:	100
TIFFTAG_YRESOLUTION:	100

Image Structure

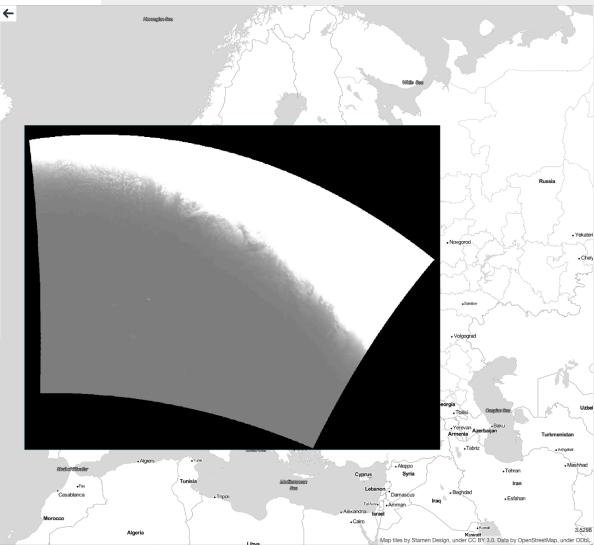
COMPRESSION:	LZW
INTERLEAVE:	BAND

Band 1

Metadata:	ColorInterp: gray
STATISTICS_MAXIMUM:	11181207.875
STATISTICS_MEAN:	7073.6160909262
STATISTICS_MINIMUM:	-999.29998779297
STATISTICS_STDEV:	33173.248131921
STATISTICS_VALID_PERCENT:	100

IFD

Id	Size	BlockSize	Decimation
0	13200x6240	256x256	0
1	6600x3120	128x128	2
2	3300x1560	128x128	4
3	1650x780	128x128	8
4	825x390	128x128	16
5	413x195	128x128	32

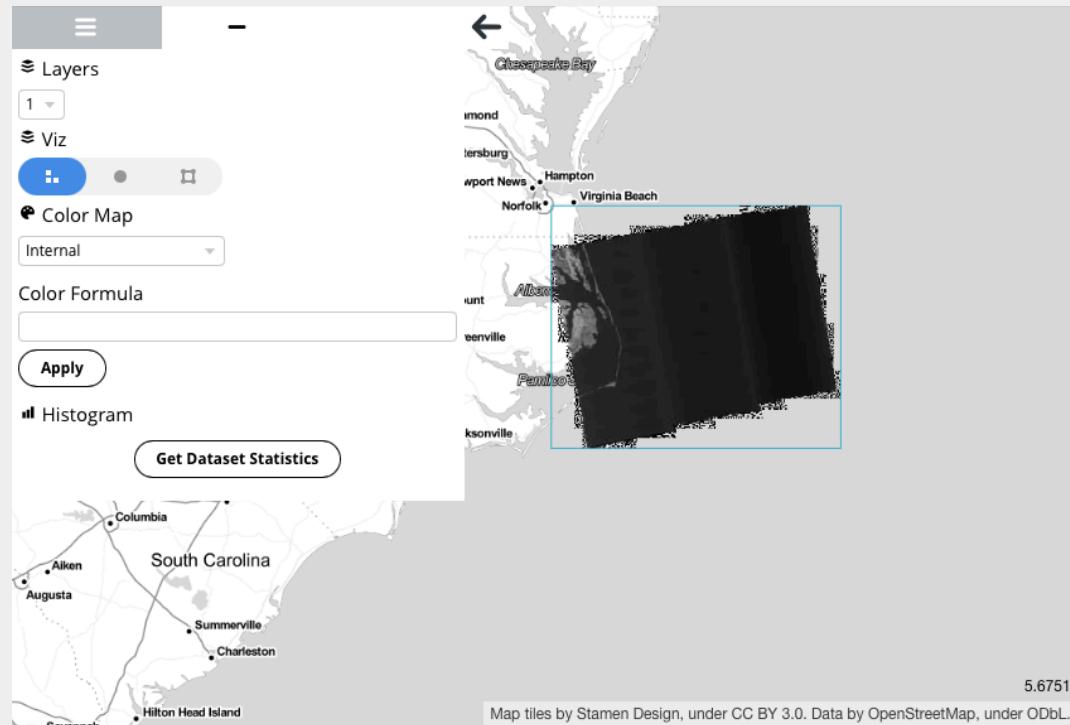


## Nodata



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 Don't use Nodata and lossy compression (JPEG)



## Profiles

- Compression (deflate, JPEG, WebP, ....)
- Overviews
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

<https://gdal.org/drivers/raster/cog.html#raster-cog>

# Metadata

---

\$ AWS\_REQUEST\_PAYER=requester rio cogeo info s3://naip-analytic/wa/2017/100cm/rgbir\_cog/48117/m\_4811762\_se\_11\_1\_20170723.tif

Driver: GTiff  
File: s3://naip-analytic/wa/2017/100cm/rgbir\_cog/48117/m\_4811762\_se\_11\_1\_20170723.tif  
COG: True  
Compression: DEFLATE  
ColorSpace: None

**Profile**

Width:	5306
Height:	7586
Bands:	4
Tiled:	True
Dtype:	uint8
NoData:	None
Alpha Band:	True
Internal Mask:	False
Interleave:	PIXEL
ColorMap:	False
ColorInterp:	('red', 'green', 'blue', 'alpha')
Scales:	(1.0, 1.0, 1.0, 1.0)
Offsets:	(0.0, 0.0, 0.0, 0.0)

**Geo**

Crs:	EPSG:26911
Origin:	(476378.0, 5323606.0)
Resolution:	(1.0, -1.0)
BoundingBox:	(476378.0, 5316028.0, 481684.0, 5323606.0)
MinZoom:	12
MaxZoom:	17

**Image Metadata**

AREA_OR_POINT:	Area
TIFFTAG_IMAGEDESCRIPTION:	OrthoVista
TIFFTAG_RESOLUTIONUNIT:	1 (unitless)
TIFFTAG_SOFTWARE:	Trimble Germany GmbH
TIFFTAG_XRESOLUTION:	1
TIFFTAG_YRESOLUTION:	1

**Image Structure**

COMPRESSION:	DEFLATE
INTERLEAVE:	PIXEL

**Band 1**

ColorInterp:	red
--------------	-----

**Band 2**

ColorInterp:	green
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**Band 3**

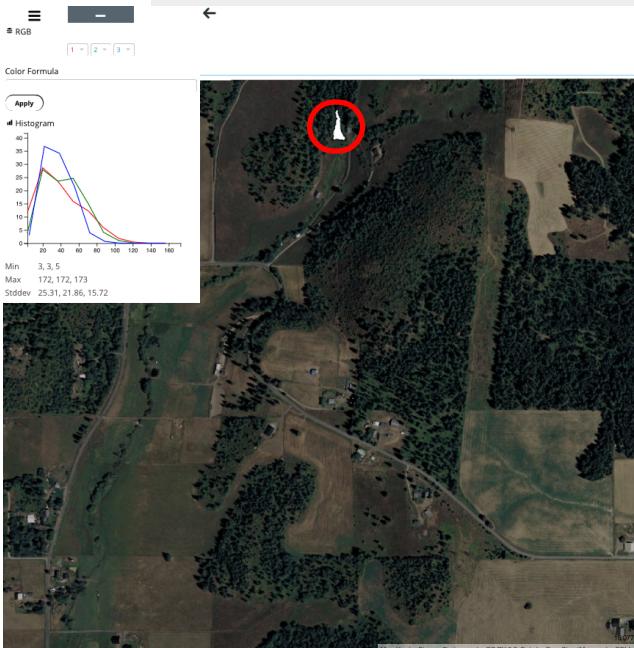
ColorInterp:	blue
--------------	------

**Band 4**

ColorInterp:	alpha
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**Blocks**

ID	Size	BlockSize	Decimation
0	5306x7586	512x512	0
1	2653x3793	128x128	2
2	1327x1897	128x128	4
3	664x949	128x128	8
4	332x475	128x128	16



Map tiles by Stamen Design, under CC BY 3.0. Data by OpenStreetMap, under ODbL.

<https://github.com/awslabs/open-data-registry/pull/576#issuecomment-653062451>

## Profiles

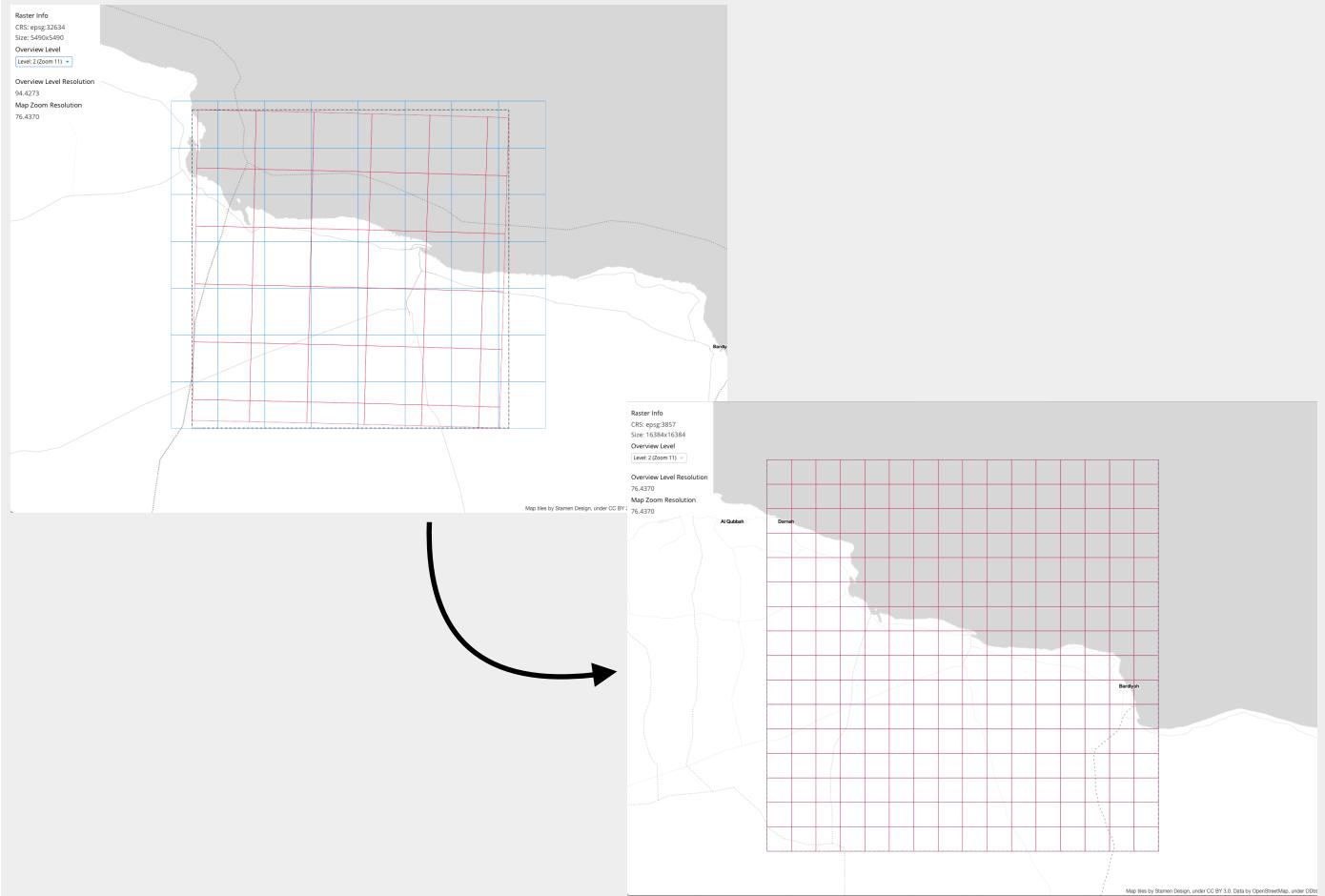
- Compression (deflate, JPEG, WebP, ....)
- Overviews
- Internal block size
- Nodata / Alpha / Mask
- Metadata
- Aligned to TMS grid

<https://gdal.org/drivers/raster/cog.html#raster-cog>

## Web Optimized

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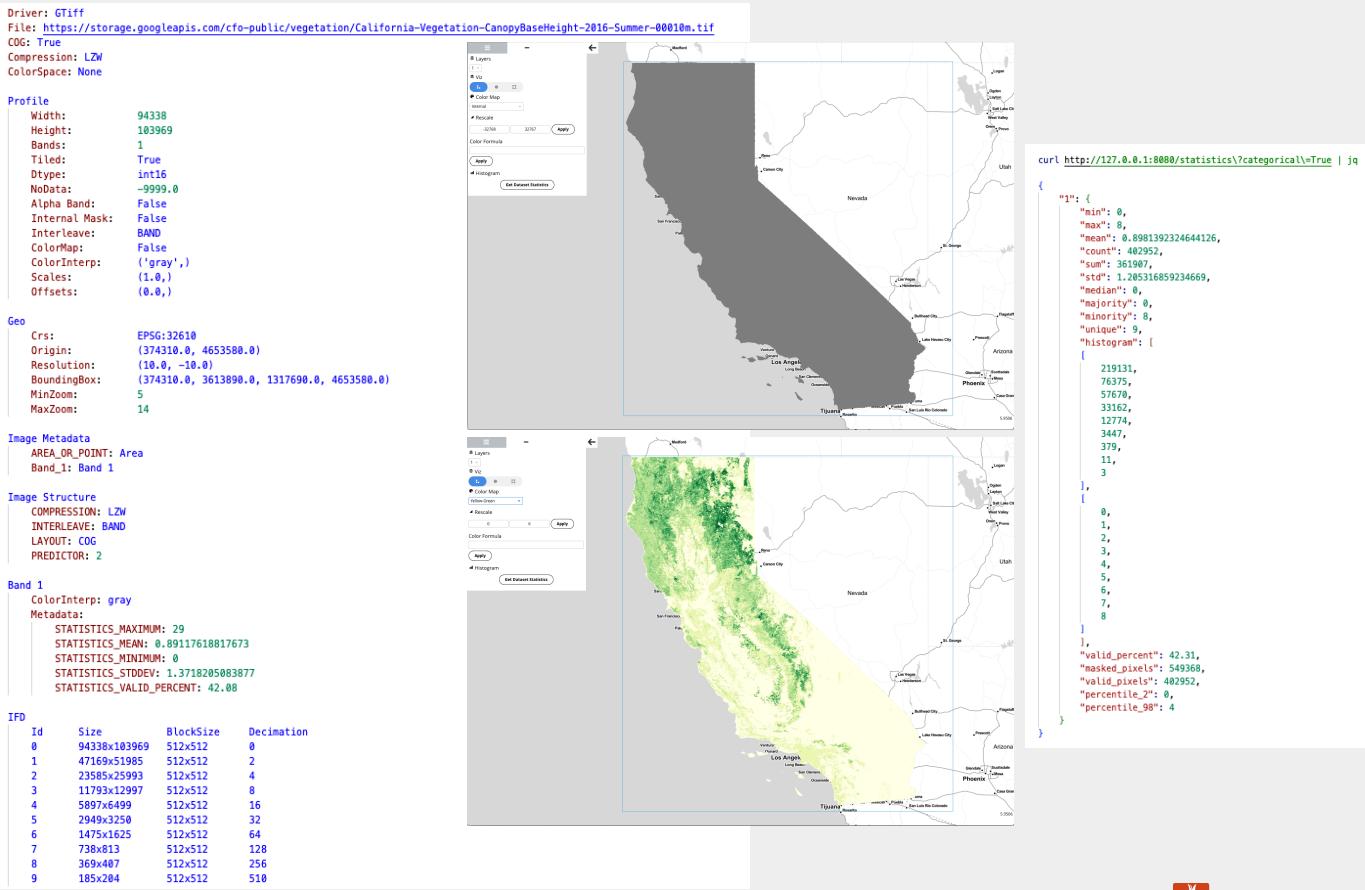
### Align internal blocks with TileMatrixSet



<https://gdal.org/drivers/raster/cog.html#raster-cog>

<https://cogeotiff.github.io/rio-cogeo/Advanced/#web-optimized-cog>

## Examples



## Examples

```
Driver: GTiff
File: s3://naip-analytic/wa/2017/100cm/rgbir_cog/48117/m_4811762_se_11_1_20170723.tif
COG: True
Compression: DEFLATE
ColorSpace: None

Profile
  Width:      5306
  Height:     7586
  Bands:      4
  Tiled:      True
  Dtype:      uint8
  NoData:     None
  Alpha Band: True
  Internal Mask: False
  Interleave: PIXEL
  ColorMap:   False
  ColorInterp: ('red', 'green', 'blue', 'alpha')
  Scales:     (1.0, 1.0, 1.0, 1.0)
  Offsets:    (0.0, 0.0, 0.0, 0.0)

Geo
  Crs:        EPSG:26911
  Origin:     (476378.0, 5323606.0)
  Resolution: (1.0, -1.0)
  BoundingBox: (476378.0, 5316020.0, 481684.0, 5323606.0)
  MinZoom:    12
  MaxZoom:    17

Image Metadata
  AREA_OR_POINT: Area
  TIFFTAG_IMAGENAMEDESCRIPTION: OrthoVista
  TIFFTAG_RESOLUTIONUNIT: 1 (unitless)
  TIFFTAG_SOFTWARE: Trimble Germany GmbH
  TIFFTAG_XRESOLUTION: 1
  TIFFTAG_YRESOLUTION: 1

Image Structure
  COMPRESSION: DEFLATE
  INTERLEAVE: PIXEL

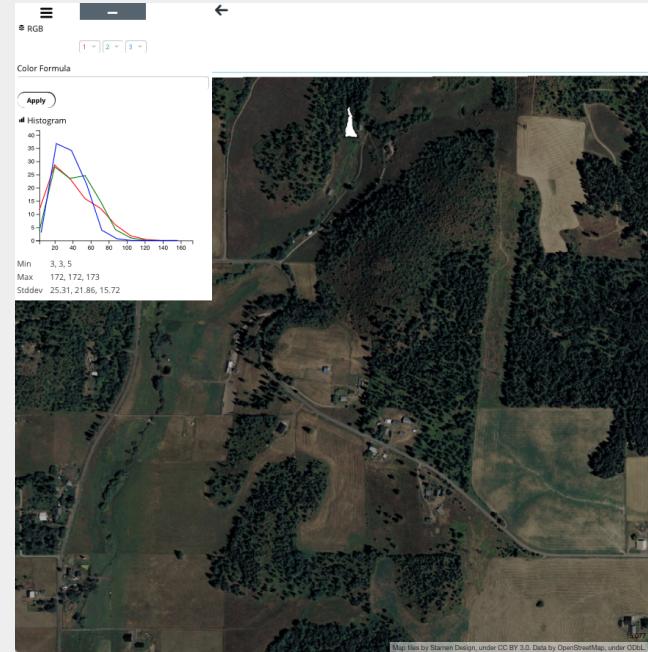
Band 1
  ColorInterp: red

Band 2
  ColorInterp: green

Band 3
  ColorInterp: blue

Band 4
  ColorInterp: alpha

IFD
  Id      Size      BlockSize  Decimation
  0      5306x7586 512x512    0
  1      2653x3793 128x128    2
  2      1327x1897 128x128    4
  3      664x949   128x128    8
  4      332x475   128x128   16
```



# Thanks

Vincent Sarago - @\_VincentS\_ / @cogeotiff

