

## **Cloud Optimized GeoTIFF (COG) File Format**

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This RFC provides information to the NASA Earth Science community. This RFC describes an Earth Science Data Systems (ESDS) standard. Distribution of this memo is unlimited.

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### **Abstract**

This document designates the Cloud Optimized GeoTIFF (COG) file format as a standard for NASA Earth Science Data Systems. COG is an extension of the mature, well-established, and heavily used GeoTIFF file format, accepted as a NASA standard in 2019. The Open Geospatial Consortium (OGC) approved version 1.0 of the OGC Cloud Optimized GeoTIFF Standard in July 2023. This was followed by Cloud Optimized GeoTIFF (COG) being published as an official OGC Standard in October 2023. Support for COG is growing in the geospatial software community and usage within NASA is starting as well.

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**1 Introduction**

This document designates the Cloud Optimized GeoTIFF (COG) file format as a standard for NASA Earth Science data systems. COG is an extension of the mature, well-established, and heavily used GeoTIFF file format, accepted as a NASA standard in 2019. The Open Geospatial Consortium (OGC) approved version 1.0 of the OGC Cloud Optimized GeoTIFF Standard in July 2023. This was followed by Cloud Optimized GeoTIFF (COG) being published as official OGC Standard in October 2023. Support for COG is growing in the geospatial software community and usage within NASA is starting as well.

GeoTIFF has already been approved as a [NASA/ESDS standard](#), COG introduces new capabilities and is backwards compatible with GeoTIFF and TIFF. The additional capabilities to allow only part of the file to be accessed enhances cloud usage without impacting legacy tools.

**2 Evidence of Implementation**

**2.1 COG Data**

COG data are available from NASA Earth science data providers.

LP DAAC:

HL30.002- [https://doi.org/10.5067/HLS/HL30.002\(C2021957657-LPCLOUD\)](https://doi.org/10.5067/HLS/HL30.002(C2021957657-LPCLOUD))  
HLSS30.002- [https://doi.org/10.5067/HLS/HLSS30.002\(C2021957295-LPCLOUD\)](https://doi.org/10.5067/HLS/HLSS30.002(C2021957295-LPCLOUD))  
ECO\_L2T\_LSTE.002- -  
[https://doi.org/10.5067/ECOSTRESS/ECO\\_L2T\\_LSTE.002\(C2076090826-LPCLOUD\)](https://doi.org/10.5067/ECOSTRESS/ECO_L2T_LSTE.002(C2076090826-LPCLOUD))  
ECO\_L1CT\_RAD -[https://doi.org/10.5067/ECOSTRESS/ECO\\_L1CT\\_RAD.002\(C2595678301-LPCLOUD\)](https://doi.org/10.5067/ECOSTRESS/ECO_L1CT_RAD.002(C2595678301-LPCLOUD))  
OPERA\_L3\_DIST-ALERT-HLS\_PROVISIONAL\_V0- -  
[https://doi.org/10.5067/SNWG/OPERA\\_L3\\_DIST-ALERT-HLS\\_PROVISIONAL\\_V0.000\(C2517904291-LPCLOUD\)](https://doi.org/10.5067/SNWG/OPERA_L3_DIST-ALERT-HLS_PROVISIONAL_V0.000(C2517904291-LPCLOUD))

**2.2 COG software**

COG support among major geospatial software and programming language specific libraries is well established and continues to grow. Below is a sample of some of the most well-known examples. An up-to-date list can be seen at: <https://www.cogeo.org/>

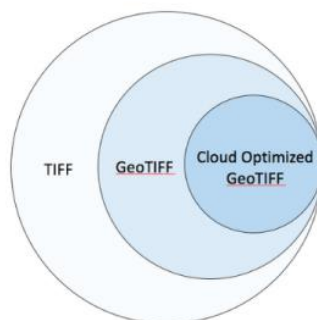
- QGIS 3.2 has stellar COG support, with an option to select online files in the data import, including authentication for private data (tutorial coming soon). Older versions can read

Cloud Optimized GeoTIFF's files using Virtual Raster Builder with a vsicurl file format to refer to the online URL. See the [tutorial](#) for details.

- [GDAL](#) supports the creation of COG files with [Cloud Optimized GeoTIFF Generator](#)
- [Earth Observing System Engine](#) and [Land Viewer](#) are both able to leverage Cloud Optimized GeoTIFF files for live web tile serving and on the fly band math.
- [Rasterio](#) (Python Library) Plugins:
  - [Rio-cogeo](#) create and validate COGs
  - [Rio-tiler](#) read tiles from COGs
  - [Rio-glui](#) explore COGs on a web-browser.
- [Google Earth Engine](#) now supports output of COG files from any Earth Engine operation, see: [Exporting - Configuration Parameters](#). Earth Engine supports reading COG data hosted on Google Cloud Storage, see: [COG-backed Earth Engine Assets](#).
- [GRASS GIS](#) can read Cloud Optimized GeoTIFFs by using Virtual Raster Builder with a vsicurl file format to refer to the online URL and registration within GRASS GIS using [r.external](#). Writing of COG files is also possible via [r.out.gdal](#)
- GeoServer can leverage S3-hosted COGs by using the [COG Support](#) community module.
- RasterFrames brings the power of Spark DataFrames to geospatial raster data and is able to read Cloud Optimized GeoTIFFs using [GeoTrellis](#).
- [GeoTiffCOG C#](#) is a C# Library for querying GeoTiff files, including Cloud Optimized GeoTIFFs.
- R (software environment for statistical computing and graphics) supports COG via the Terra package that utilizes GDAL.

### 3 COG File Structure

The [COG](#) file structure builds on the established [GeoTIFF format](#). Similar to how GeoTIFF built off the existing standard TIFF images by adding geo-referencing information, COG builds off of GeoTIFF to add features needed to optimize data use in a cloud-based environment.

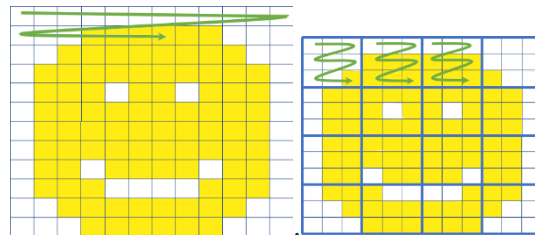


A COG file is a TIFF file as specified by the current TIFF specification, version 6.0 [2].

Thus, the files are compatible with existing software and libraries that can handle TIFF format, such as Photoshop and the libtiff library. TIFF provides the ability to define tags that can carry information not previously defined in the TIFF format. The information in these tags is ignored by standard TIFF software but can be used by other software. GeoTIFF uses a small set of TIFF tags to store georeferencing information. All GeoTIFF tags can be accessed by TIFF compatible software, nothing is stored in a way that would hide the information.

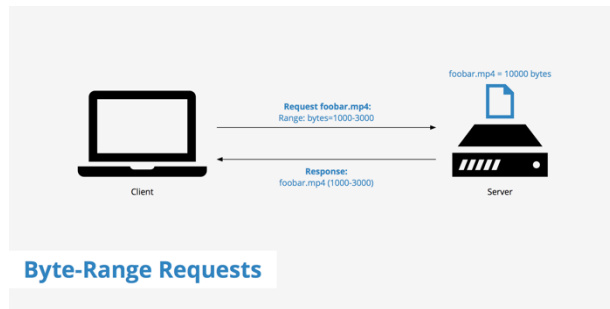
Cloud Optimized GeoTIFF relies on two complementary pieces of technology.

The first is the ability of a GeoTIFF to not only store the raw pixels of the grid coverage, but to also organize those pixels in ways that are more efficient for cloud storage and retrieval.



*Diagram showing traditional row by row organization vs. COG tile organization (Diagram adopted from [Element 84](#))*

The second is [HTTP GET range requests](#), that let clients ask for just the portions of a file that they need. Together these enable fully online processing of data by COG-aware clients, as clients are allowed to stream only the needed parts of the GeoTIFF.



*Diagram showing how clients can make requests for specific byte ranges, rather than the entire file.*

#### 4 Interoperability and Applicability Considerations

COG is not necessarily suitable for every data type. There are other scientific file formats which can embed a much richer set of metadata and are well-established within the NASA community, e.g., HDF5 and netCDF4, that are approved for use in NASA Earth science data systems.

Nevertheless, the COG file format maintains sustained interest and demand, primarily serving as a distribution format for satellite data through a cloud-based distribution system. COG's capabilities allow for reduced data volume transfers from cloud-based systems to legacy data storage. Large geospatial files with single data type covering large spatial areas or time periods, or containing multi-bands are candidates for COGs.

#### 5 Future versions of the specification

Users of this version (1.1) of the COG specification should be aware that the specification is under continued development within the OGC. Future versions may introduce changes that could be incompatible with current use. The specification itself contains notes identifying areas that are likely to be revised in future versions.

#### 6 References

##### Normative References

- OGC Cloud Optimized GeoTIFF Standard, OGC Document 21-026, July 14, 2023  
<https://docs.ogc.org/is/21-026/21-026.html>

##### Informative References

- Adobe Systems Incorporated. TIFF Revision 6.0 Final, June 3, 1992,  
<https://www.adobe.io/open/standards/TIFF.html>
- OGC GeoTIFF Standard: <https://www.ogc.org/standard/geotiff/>

- Cloud Optimized GeoTIFF: <http://www.cogeo.org/>

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## **Appendix A**

### Glossary of acronyms

LP DAAC	Land Processes DAAC
COG	Cloud Optimized GeoTIFF
DAAC	Distributed Active Archive Center
TIFF	Tagged Image File Format
GDAL	Geospatial Data Abstraction Library
GeoTIFF	Geographic Tagged Image File Format
ESDS	Earth Science Data Systems
HDF	Hierarchical Data Format
HTTP	Hypertext Transport Protocol
NASA	National Aeronautics and Space Administration
NetCDF	Network Common Data Form
OGC	Open Geospatial Consortium
RFC	Request for Comments
GRASS	Geographic Resources Analysis Support System
QGIS	Quantum Geographic Information System