

JPEG 2000

Whitepaper

Overview and benefits for modern geospatial
imagery applications



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What is JPEG 2000?

JPEG 2000 is an ISO standard (ISO/CEI 15444¹) created by the Joint Photographic Experts Group for image compression. It provides both lossless and lossy compression, which enables scalability in resolution, quality and ease with data handling (download, upload, sharing, streaming and processing).

JPEG 2000 in GIS and Remote Sensing

JPEG 2000 is now an open standard solution to compress very large, multiple-band, and greater bit-depth images. Its popularity is growing in the remote sensing community due to its capabilities.

Furthermore, with the generalisation of the use of Geographic Information Systems (GIS), important requirements such as resolution scalability, quality and accessibility of highly detailed images over very large areas have become important key factors in enabling users to exploit information more easily, smoothly and quickly.

JPEG 2000 has been adopted² as a standard by several organisations to compress, store, transmit and display geospatial imagery. These major organisations include:

- National Geospatial-Intelligence Agency (NGA)
- North Atlantic Treaty Organization (NATO)
- Open Geospatial Consortium (OGC)

¹ Jpeg.org: <http://www.jpeg.org/jpeg2000/index.html>

² Adoption by the GIS & remote sensing community: Bernard V. Brower – Office of Chief Engineers, ITT Corp.

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Advantages of the JPEG 2000 Format

JPEG 2000 is ideally suited for handling remote sensing data. The three main advantages of this format are compression, scalability and streaming.

The compression reduces the storing size, providing the essential scalability needed for displaying and navigating very large images, and streaming is key for disseminating remote sensing images through a network.

JPEG 2000 Compression

JPEG 2000 format is a standard format with excellent compression capabilities. The advantages are:

- Data Storage takes up less disk space
- Downloading/uncompressing is much faster

An important advantage of the JPEG 2000 format is also that it supports both reversible (lossless) and irreversible (lossy) compression.

The choice of compression can be adapted to the need of the user. For example, users performing radiometric processing on their data may prefer lossless compression, while those performing visual interpretation may only need lossy, but “visually lossless,” compression.

As an example, the file size of a 400 square kilometre pan-sharpened four-band Pléiades scene is 12 GB in GeoTIFF and only 6 GB (lossless compression) or 2.6 GB (lossy compression) in JPEG 2000.

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JPEG 2000 Scalability

Associated to its compression capability, the main advantage of JPEG 2000 is the flexibility and scalability of the codestream. The codestream obtained after compression can be decoded in different ways depending on the user's needs.

For example, the scalability gives users:

- Fast access to various resolutions of the image without having to create and store pyramids
- The ability to display, pan and zoom into a specific area of interest without decompressing the entire image

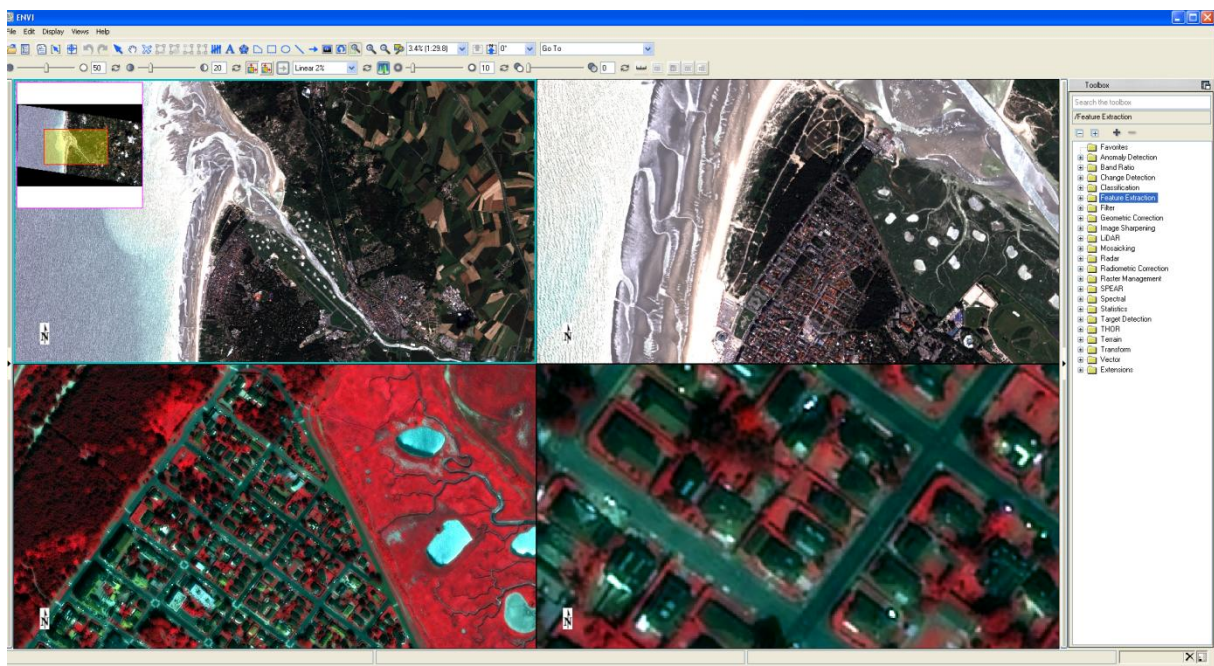


Figure 1: Different composite colour images of different zones with different resolutions of a pan-sharpened Pléiades image of La Baie de la Canche/Pas de Calais/France (1.6 GB compressed) in ENVI 5. No pyramid is created to display and navigate the image.

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JPEG 2000 Interactive Protocol (JPIP)

To take advantage of the JPEG 2000 functionality and scalability within a client/server environment, an ISO protocol has been developed: the JPEG 2000 Interactive Protocol (JPIP).

Using this protocol, a client can access a region of interest in an image with specific resolution and/or quality without having to decompress and/or download the entire image. Only the needed portions (by region, resolution level and/or quality) of the image are streamed through the network.

For example, a user may need to quickly review an area of interest from a 400 square kilometre pan-sharpened Pléiades scene (more than 10 GB uncompressed). Downloading and storing the entire image can be prohibitive, whereas streaming only a portion of the area of interest takes just a few seconds.

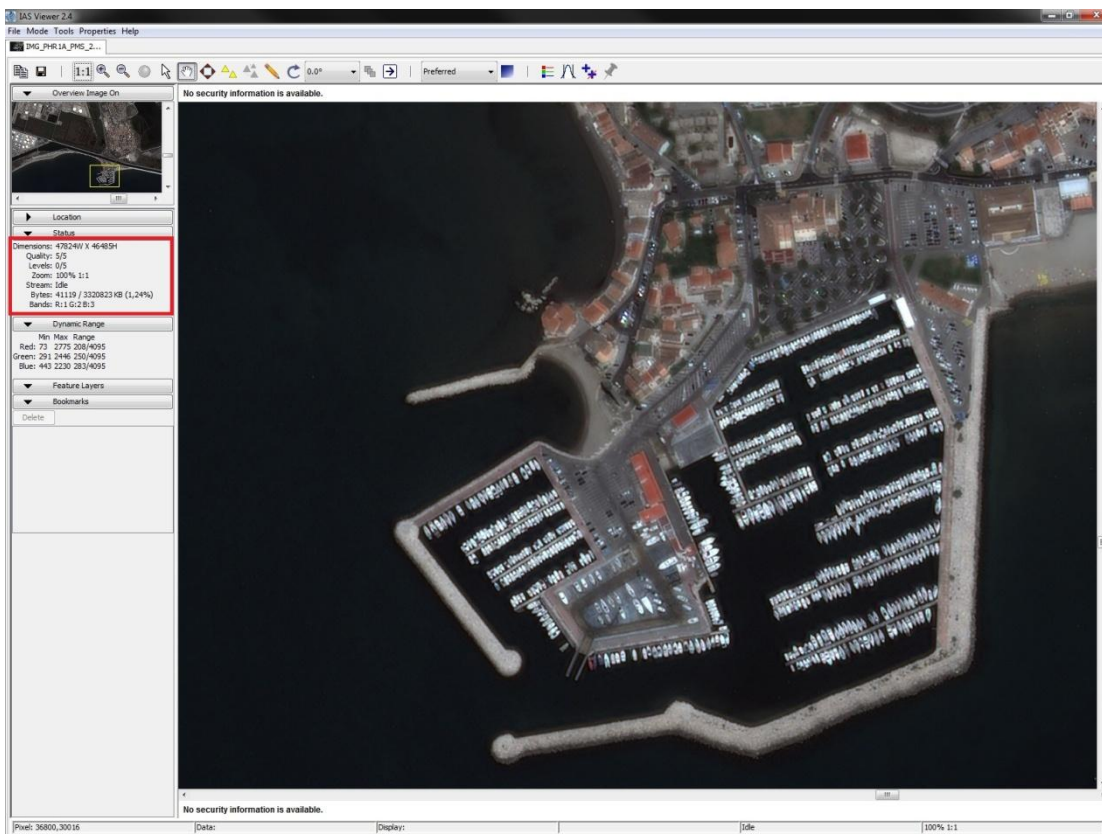


Figure 2: Stream and display of an area of interest in a pan-sharpened Pléiades scene of Marseille/France (more than 3 GB compressed) using IAS Viewer. Only 1.24% of the image is downloaded.

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Pléiades and JPEG 2000

With Pléiades 1A in orbit and Pléiades 1B scheduled for launch Saturday 1 December 2012, the Pléiades constellation provides very high-resolution optical products in record time, offering daily revisit capacity to any point on the globe and acquisition capabilities tailored to meet the full spectrum of civil and military requirements.

To utilize the reactivity that the Pléiades system offers thanks to its space component, CNES and Astrium have retained JPEG 2000 as a standard format for Pléiades products; however, imagery may be ordered in two different formats: GeoTIFF or JPEG 2000. JPEG 2000 files can be **up to 5 times smaller than GeoTIFF files**, making data warehouse management, handling, post-processing and streaming much easier for the user, while completely preserving the original image quality.

The table below illustrates an example for a 50cm, pan-sharpened 4-band, 400 square kilometre product.

JPEG 2000	GeoTIFF
Bit-Depth 12 bits <ul style="list-style-type: none">• Optimised³: 2.6 GB• Regular⁴: 6 GB (max)	Bit-Depth 12 bits <i>(storage 16 bits)</i> <ul style="list-style-type: none">• 12 GB
Bit-Depth 8 bits <ul style="list-style-type: none">• Optimised: 2.6 GB• Regular: 6 GB (max)	Bit-Depth 8 bits <ul style="list-style-type: none">• 6 GB

TABLE 1: EXAMPLES OF PLÉIADES PRODUCT FILE SIZE

For 12-bit products, a JPEG 2000 file is two times smaller with a Regular compression, and around five times smaller with an Optimized compression, than the same product delivered as a GeoTIFF.

► *JPEG 2000 12 bits vs. GeoTIFF 12 bits: the image features the same dynamic and the same quality, but the file size is much smaller.*

Theoretically, for JPEG 2000, file sizes are the same for 8 and 12 bits in Optimized and Regular compression. This is related to the fact that the JPEG 2000 compression process determines a targeted bit-rate (3.5 bits/pixel for Optimized compression, 8 bits/pixel for Regular), which can be directly linked to a target file size, whether the dynamic range is 8 or 12 bits.

► *JPEG 2000 12 bits vs. JPEG 2000 8 bits: the image features a larger dynamic, but the file size is the same.*

³ Astrium's denomination of the Lossy Compression

⁴ Astrium's denomination of the Lossless Compression

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Key points to note

The Pléiades data user may choose between two compression rates, depending on their production needs:

- **JPEG 2000 Optimized** is meant for people needing fast download and easy data sharing. It has a compression of 3.5 bits/pixel. It uses a “lossy” compression: the compression rate is optimized to avoid any spatial effect, but it is not reversible. A spectral effect of 1/1000 is tolerated.
- **JPEG 2000 Regular** is perfect for users seeking to do some high precision post-processing. It has a compression of around 8 bits/pixel. It uses a lossless compression: the JPEG 2000 compression is completely reversible and does not include any effects in terms of information content.
- Both JPEG 2000 compressions ensure no impact in terms of image quality. However, they have a direct impact on the file size: the Optimized compression file size is twice as large as the Regular compression file size.
- JPEG 2000 uses a new and very efficient compression technology, which generates much smaller files than GeoTIFF format. The difference is due to the compression of the data which is not the same and also because GeoTIFF is always coded on power of two: either 8 or 16 bits. Pléiades acquires 12-bit images, so GeoTIFF 16-bit products store four bits for no use.
- Upon request, when a GeoTIFF product has been ordered, Astrium GEO-Information Services will deliver an additional JPEG 2000 product, free of charge, for personal format assessment.
- **JPIP** (JPEG 2000 Interactive Protocol) is an ISO protocol. It is ideal for users who want to take advantage of the JPEG 2000 within a client/server environment as they can access a region of interest with specific resolution and/or quality without having to decompress and/or download the entire image

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About This White Paper

Astrium and Exelis Visual Information Solutions (Exelis VIS) have teamed-up to provide technical information about the widely used JPEG 2000 format. The complementary solutions of both companies and their long-lasting relationship allow them to offer up-to-date and useful intelligence to the geospatial community.

About Exelis Visual Information Solutions

Exelis Visual Information Solutions provides desktop, cloud and mobile software solutions to help professionals across industries transform geospatial imagery and complex data into actionable information. The company's 150,000 customers from more than 80 countries use our custom services and products – ENVI, E3De, IDL and IAS – to quickly and easily visualize, analyze and deliver all types of data and imagery for better, more informed decision making.

We proudly announces the release of ENVI 5, the next generation of ENVI, the company's industry-leading image analysis software which is used across industries by professionals who want to uncover hidden information in geospatial imagery. ENVI 5 introduces imagery consumers to an innovative and streamlined user process for their image analysis workflow, making complex analysis tasks easier.

More information on www.exelisvis.eu

About Astrium Services

Through its GEO-Information business, Astrium Services is recognised as one of the leaders in the geospatial information market, not least thanks to the now fully integrated skills and resources of the former *Spot Image* and *Infoterra*. The company provides decision-makers with complete solutions enabling them to increase security, boost agricultural performance, maximize oil & gas or mining operations, improve their management of natural resources, and protect the environment. It operates and has exclusive distribution rights the data delivered from the SPOT, TerraSAR-X, TanDEM-X and Pléiades satellites, coupled with a complete range of space-based data sources and airborne acquisition capability allowing it to offer an unrivalled scope of Earth observation products and services. This extensive portfolio covers the entire geo-information supply chain, from the generation of images to the provision of quality value-added information to end-users.

By leveraging the synergies and expertise available across the whole of Astrium Services, its GEO-Information teams develop innovative, yet competitive, custom-made solutions based on the combination and integration of Earth observation, navigation and high-end telecommunications.

More information on: www.astrium-geo.com

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Contacts

Exelis Visual Information Solutions

Tour de l'Horloge
4 Place Louis Armand
75603 Paris Cedex 12 France
+33 (0)1 73 02 46 20
www.exelisvis.eu
exelisvis.europe@exelisvis.com

Astrium GEO-Information Services

5, rue des satellites
31030 Toulouse cedex 4
France
+33 (0)5 62 19 40 40
www.astrium-geo.com
CustomerTechnicalSupport@spotimage.fr