L'observation de la Terre à très haut facteur de compression

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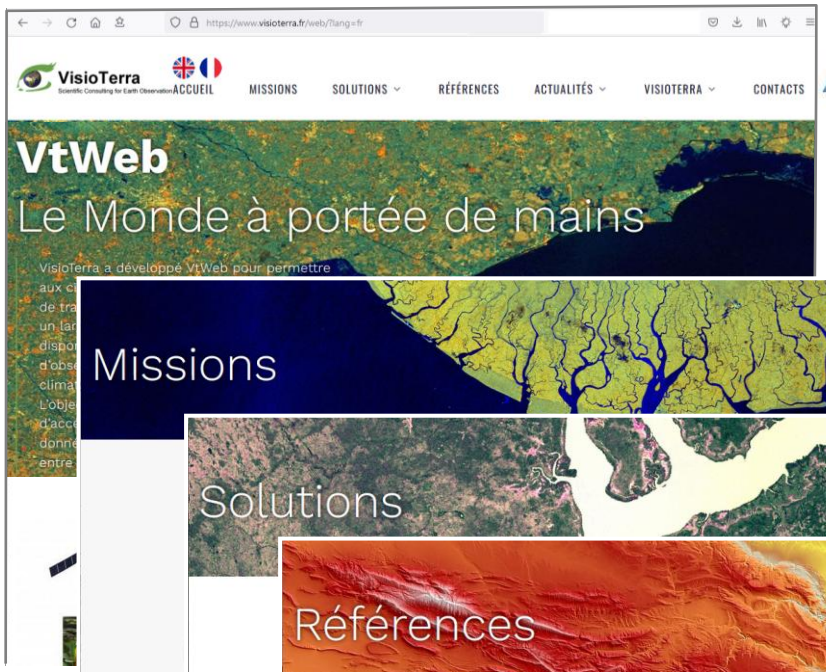
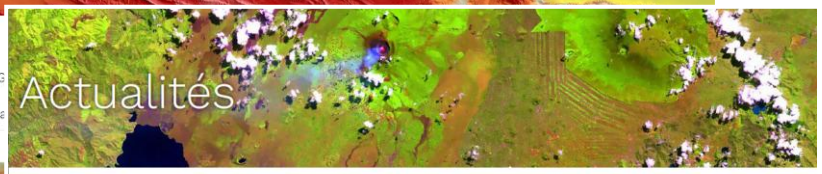
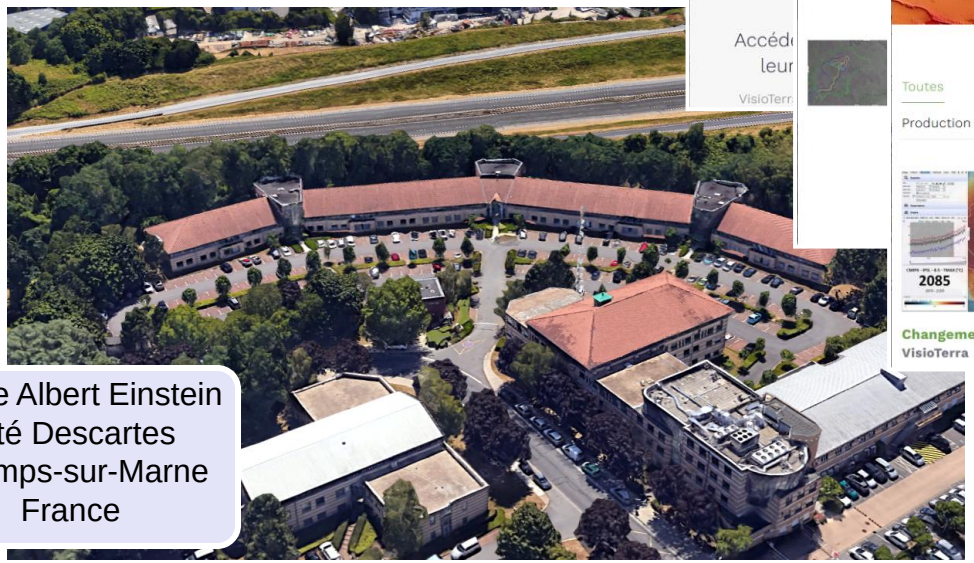
Compression of **Observations** & **Models** for **Earth Observation**

VisioTerra en quelques chiffres

- Créée en mai 2004
- 11 ingénieur(e)s
- C.A. 2023 : 820 K€
  - ESA ..... 50 %
  - TELESPAZIO ..... 22 %
  - AfEOS ..... 12 %
  - SERCO ..... 7 %
  - AGRECO ..... 6 %
  - CNES ..... 1 %
  - Cité des Sciences ..... 1 %
- http://visioterra.fr







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Cité Descartes
Champs-sur-Marne
France

Ingénierie en Observation de la Terre (O.T.) et éducation

janvier 1990 — mars 2004

GAEL Consultant

1. **Développement logiciel**
2. **Contrôle qualité**
3. **Production cartographique**

mai 2004

VisioTerra

Conseil Scientifique en Observation de la Terre

1. Développement logiciel	VtWeb, VtFlegtWatch, VtPace…
2. Production cartographique	géométrie, radiométrie, stat.
3. Etudes	expertise, études d'impact…
4. Education	Afrique, Moyen-Orient…
5. Communication	Sentinel Vision (ESA)

mars 1993

Université Paris-Est Marne-la-Vallée – Site du Pr. Serge RIAZANOFF

Professeur associé

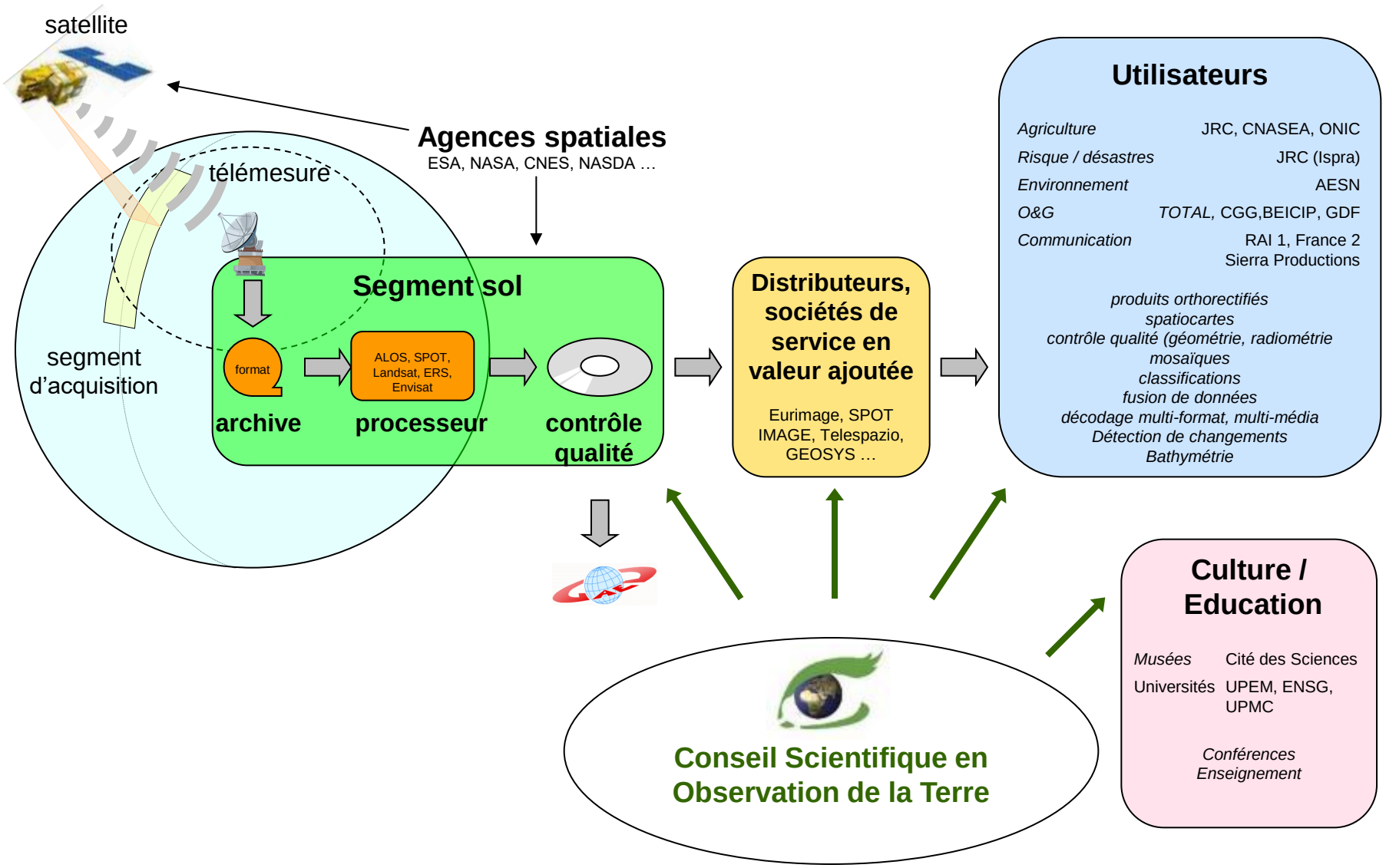
1. **Traitement d'images**
2. **Télédétection**
3. **Suivi des stagiaires**

ENSG (Ecole de l'IGN)

Université Paris 7

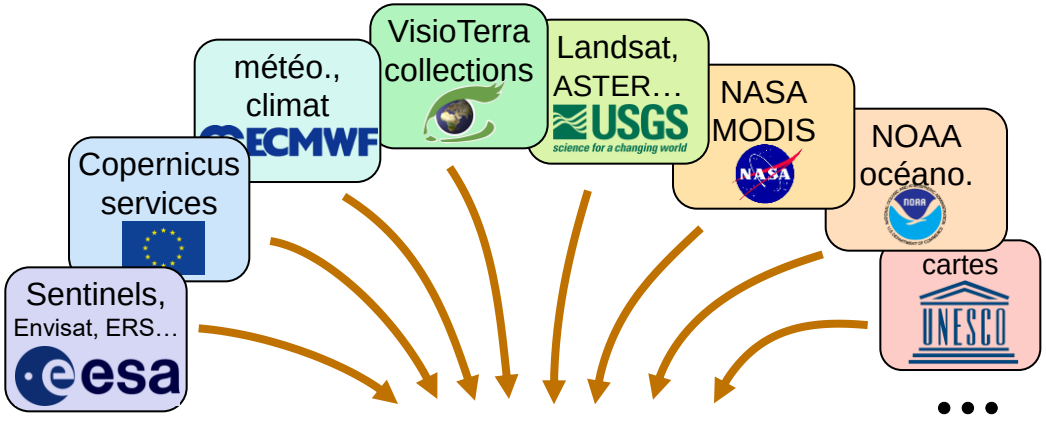
Monde (Algérie, Maroc, Palestine, Douala, Kinshasa...)

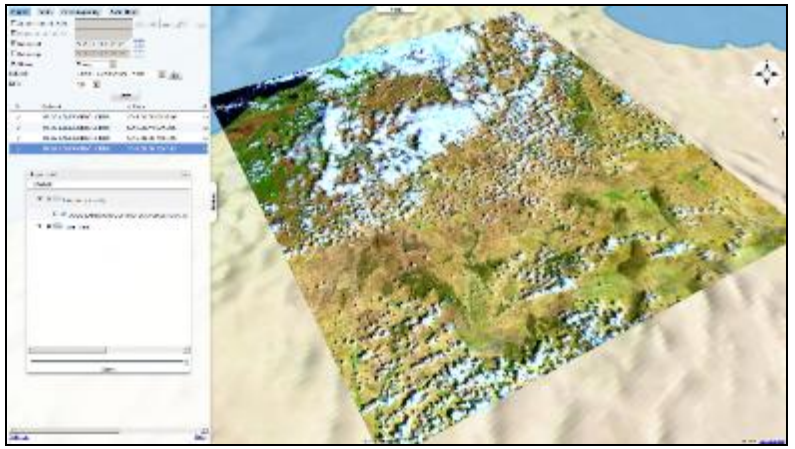
Compétences de VisioTerra – Des satellites aux utilisateurs

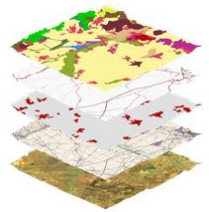


VtWeb – Concepts

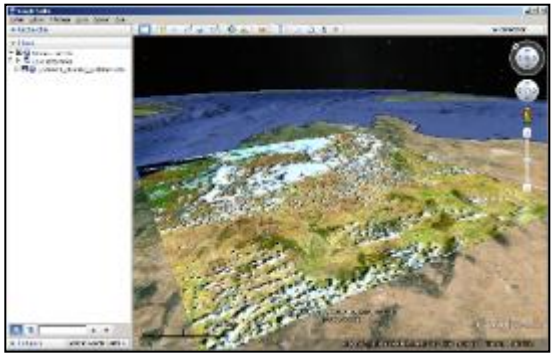
- www.visioterra.fr/?VtWeb
- données globales et gratuites
- fouille de données
- satellites / météo / ECV / Géol. / hydro./ alti./ LULC / populations…
- accès temps quasi-réel
- traitement automatique
  - ❑ pour le citoyen
    - style par défaut
    - styles prédéfinis
  - ❑ pour les scientifiques
    - ajustement des paramètres
    - vers une *P.O.F. toolbox*
- infrastructure(s) collaboratives(s)
- 2D webmapping / 3D globe virtuel
- dans l'aire d'intérêt
- archives pour analyser les changements
- services à valeur ajoutée, surveillance systématique, alarmes…







GeoTIFF, WMTS → G.I.S.

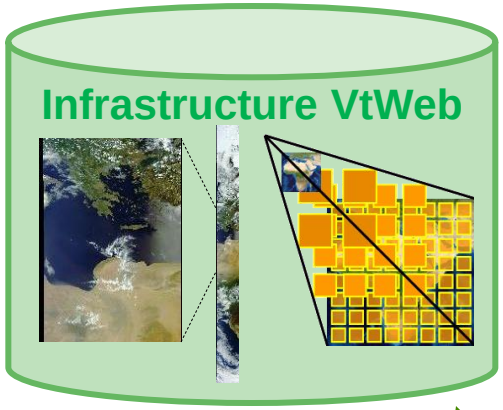


KML KMZ

VtWeb – *Data Processing Relay*
Relais de traitement des données

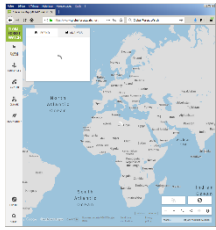
météo., climat ECMWF
VisioTerra collections
Landsat, ASTER… USGS science for a changing world
NASA MODIS
NOAA océano.
Copernicus services
cartes UNESCO
Sentinels, Envisat, ERS… esa
…

- L'infrastructure VtWeb à VisioTerra :
  - 1 Po (1000 To) de disques
    - 50 To ASAR and ERS
    - 150 To MERIS
  - 1 Gb/s fibre optique symétriqu
  - 6 serveurs

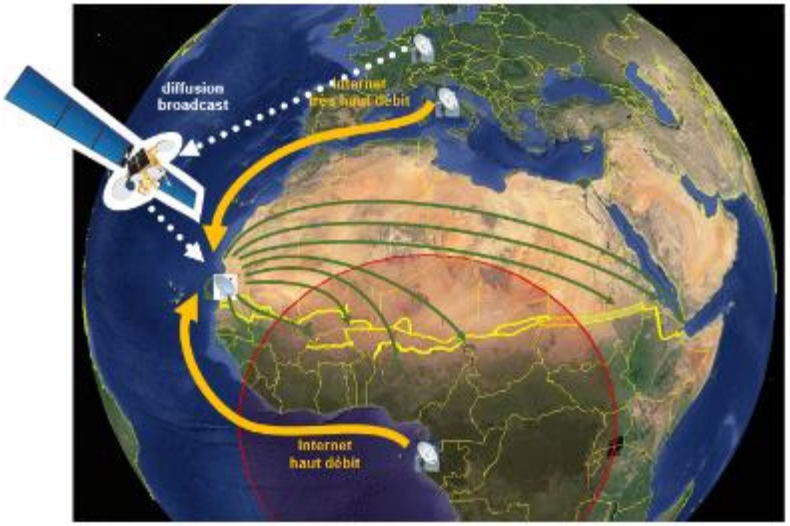


D'autres mobiles

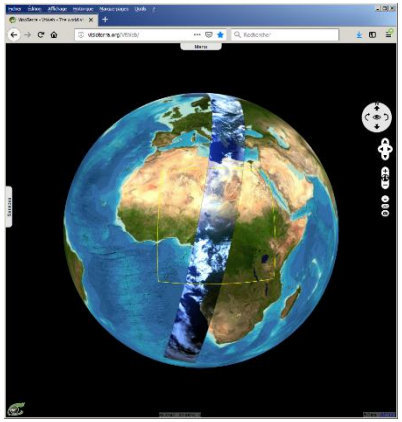
D'autres infrastructures



- solution DPR pour l'Afrique



VtWeb client



Google Earth

S.I.G.

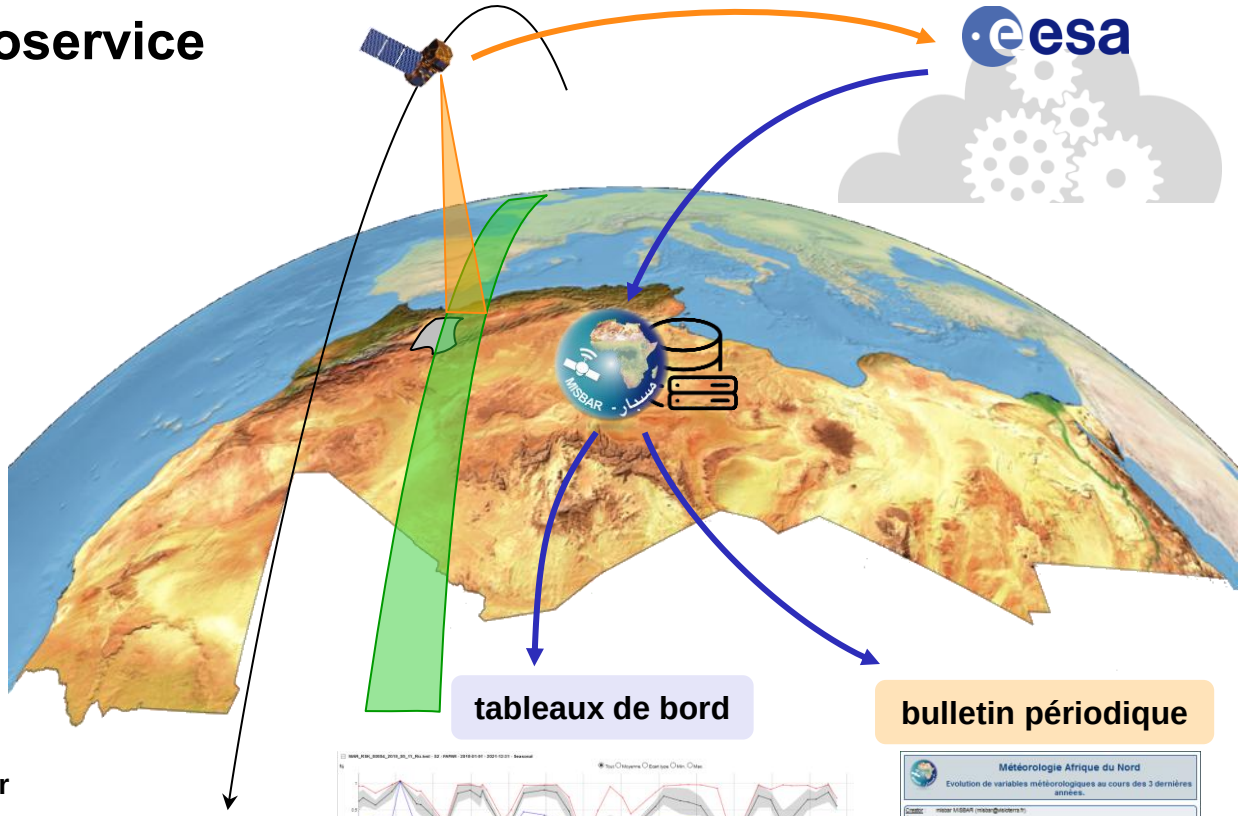
Principe d'un géoservice

Attributs d'un géoservice :

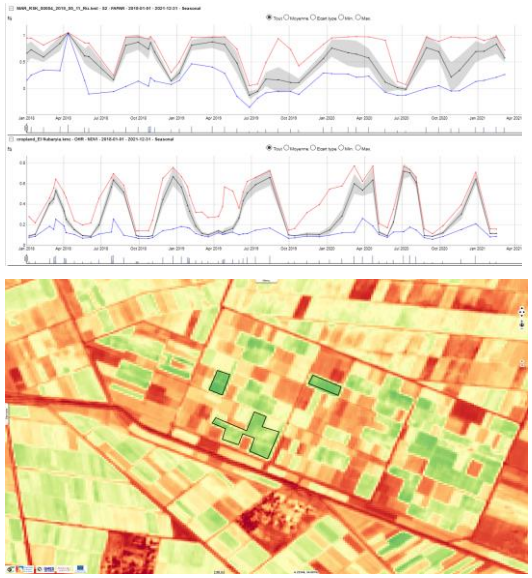
- Site
  - **élémentaire**
  - **groupe**
- Indicateur(s)
  - **prédéfini**
  - **programmé par l'utilisateur en POF-ML**
- Période
  - **mensuel**
  - **trimestriel**
  - **annuel…**
- Alertes (option)
  - **hors valeurs nominales**
  - **modérateur**
  - **liste de personnes à prévenir**
- Tableaux de bord
  - **agrégation spatiale (graphe)**
  - **agrégation temporelle (carte)**
- Bulletins périodiques
  - **modèle**
  - **visa**
  - **liste de distribution**

Un géoservice est :

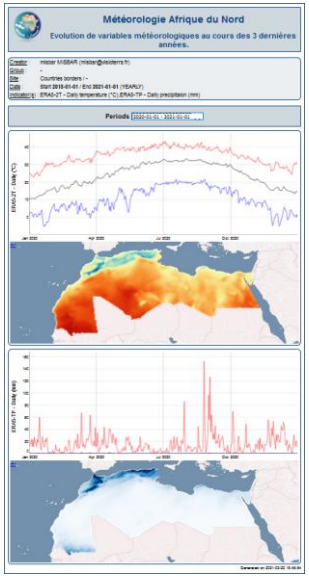
- automatisé
- contrôlé par son propriétaire
- une ressource qu'on peut partager



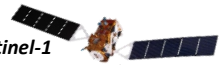
tableaux de bord



bulletin périodique



Une solution pour l'Afrique



Sentinel-1
(radar since 2014)

Sentinel-2
(optical HR since 2015)

ESA

CDSE (Copernicus Data Space Ecosystem

Sentinel-1/2/3/5P processors

Very high ratio compression (x50 to x150)

ESA

DestinE (Destination Earth)

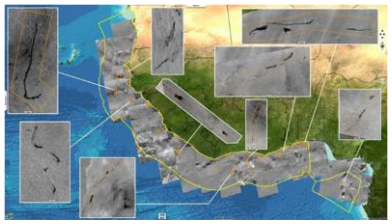
Sentinel-1/2 compressed archive and NRT

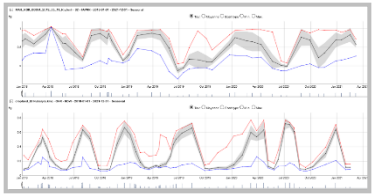
Massive provision 2014-2024

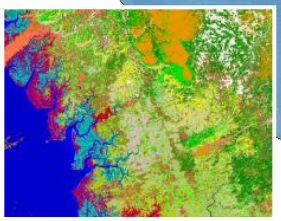
NRT synchronisation

Data & geoservices for:

- *Monitoring*
- *Business*
- *Education*
- *Research*

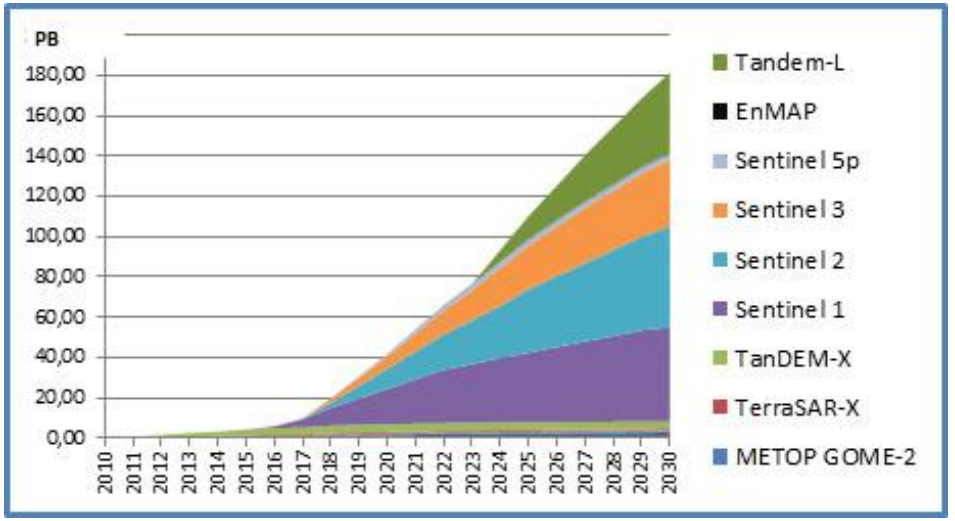






Summary

- **Problem**
  - Earth observation data, such as Sentinel (S1, S2, etc.) products, are extremely large, making storage costly and downloads slow, especially in regions with limited bandwidth or for scientists requiring large datasets.
- **Solution**
  - A compression service that reduces product sizes by 100x, 250x while maintaining acceptable quality.
  - This solution improves data accessibility, speeds up downloads, and optimizes resource management for constrained environments.
- **Qualification**
  - To evaluate the performance of the proposed compression solution, both generic metrics (RMSE, PSNR, SSIM, LPIPS) and thematic metrics (classification degradation, k-means++…) are used.



Discrete Cosine Transform (DCT)

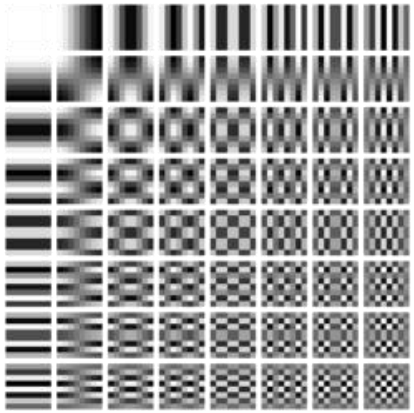
A Technique derived from the Fourier transform

- The Discrete Cosine Transform (DCT) is a transformation similar to
- the Discrete Fourier Transform (DFT).
  The Fourier transform represents a function by the spectral density from which it originates, as an average of trigonometric functions of all frequencies.

Visualization of the relationship between the time domain and the frequency domain of a function, based on its Fourier transform.

DCT for compression

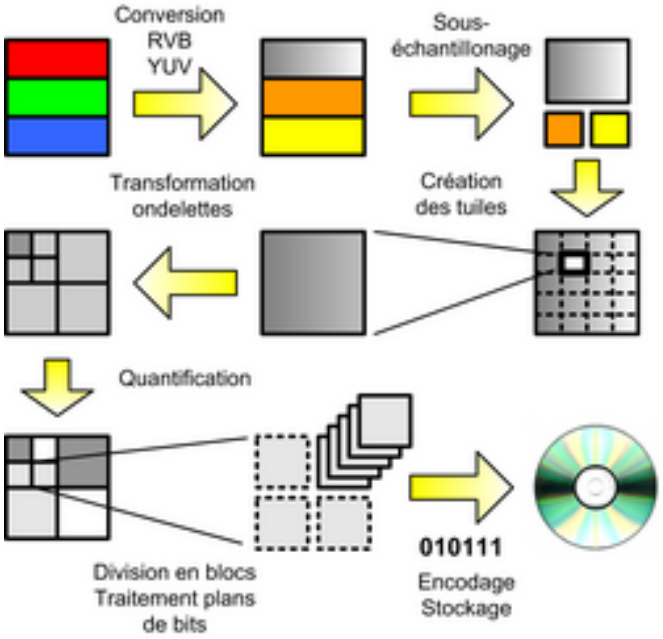
- The DCT itself does not achieve compression, but rather prepares the image for compression.
- Once in the frequency domain, the image's high-frequency coefficients can be coarsely quantised so that many of them (>50%) can be truncated to zero.
- The coefficients can then be arranged so that the zeroes are clustered (zig-zag collection) and Run-Length Encoded.
- The remaining data is then compressed with Huffman coding.



DCT basis functions, showing different frequency components used to decompose the image into spatial frequencies.

JPEG 2000

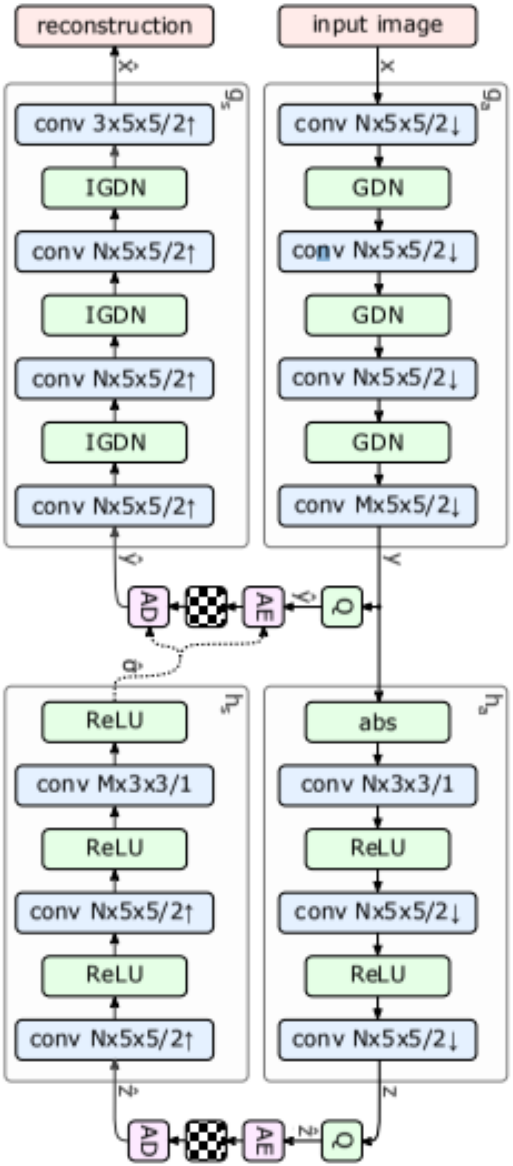
- **Discrete Wavelet Transform (DWT): The basis of JPEG 2000**
  - Analyzes the image at multiple scales with a hierarchical decomposition.
  - Divides the image into sub-bands: LL (low frequency), HL, LH, HH (high frequencies).
  - Compression using Embedded Block Coding with Optimized Truncation (EBCOT).



Main steps of JPEG2000 compression

AI for compression

- **Traditional approach vs. Learned Image Compression (LIC)**
  - Classical methods: JPEG, JPEG2000, BPG → based on fixed transformations (DCT, wavelets).
  - LIC: Automatically learns the best representation using neural networks.
- **Typical LIC model architecture**
  - Encoder: Converts the image into a compressible latent representation.
  - Quantization: Discretizes latent values for compression.
  - Entropic model: Predicts the distribution of latents for efficient coding.
  - Decoder: Reconstructs the image from compressed data.
- **Optimization**
  - Loss function combining:
    - Compression rate (minimizing latent entropy).
    - Reconstruction quality (e.g., MSE, SSIM, LPIPS).



LIC model architecture

Merci de votre attention

Thank you for your attention

Questions ?

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www.visioterra.fr