Activities of the DEMIX Subgroup 3 "Platforms and Processing"

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VisioTerra

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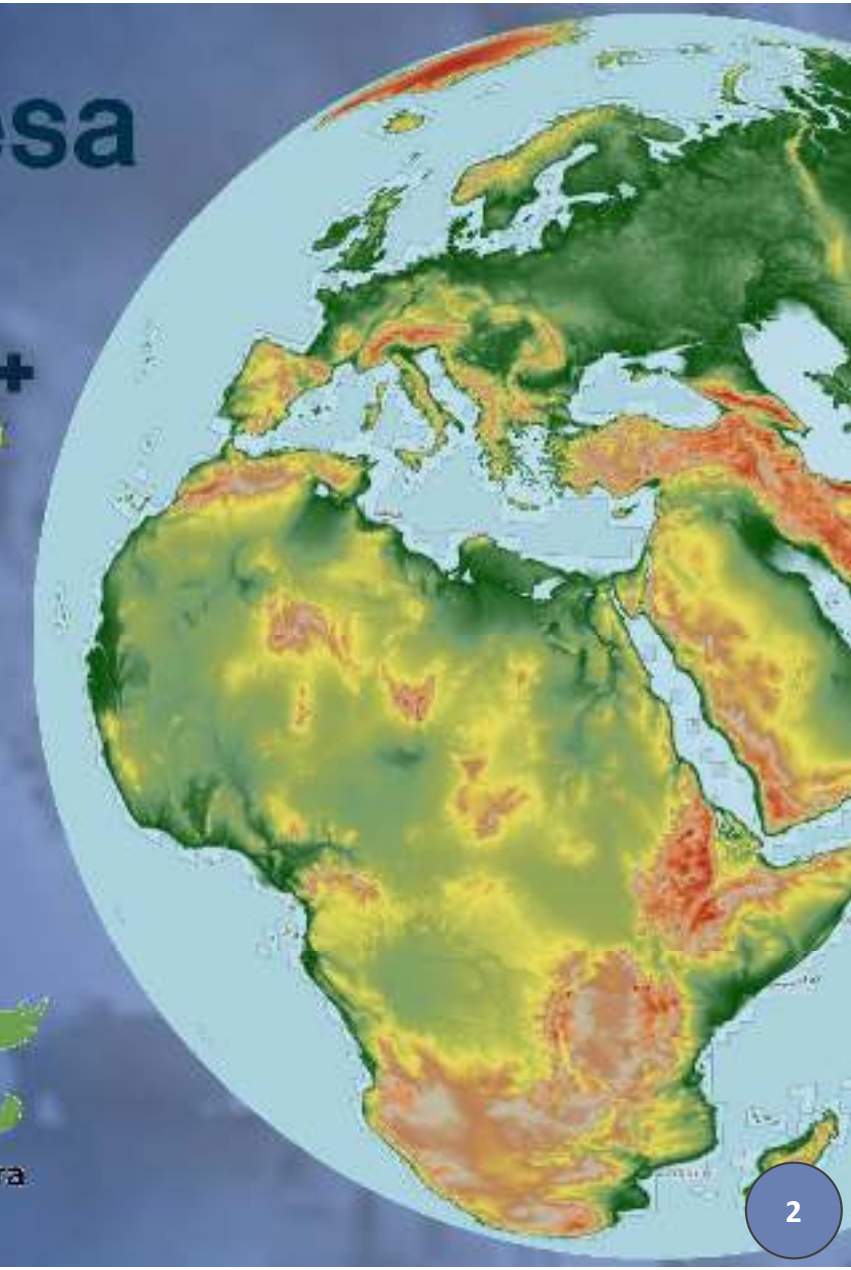
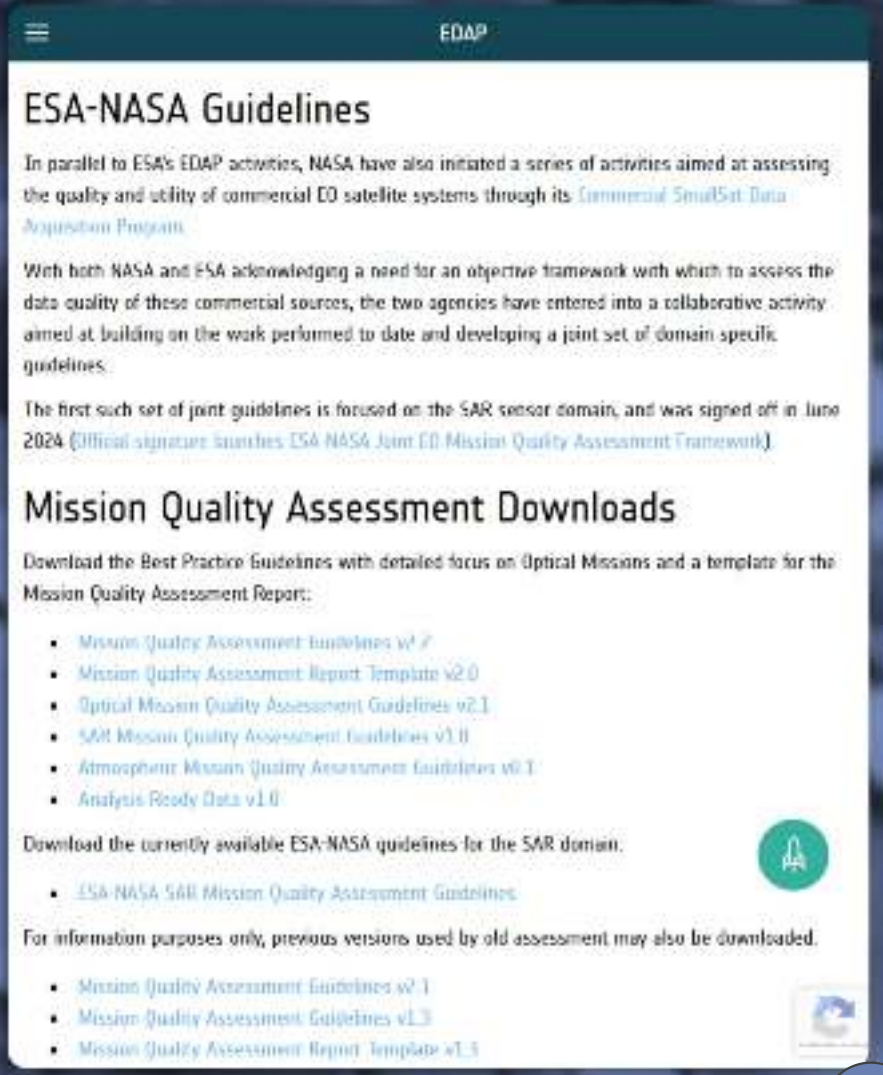


1. EDAP / EDAP+

1. EDAP / EDAP+

A. Introduction

- The Earthnet Data Assessment Project (EDAP) was funded in 2018 by the European Space Agency (ESA)
- It aims to assess the quality and suitability of candidate missions being considered for ESA's Earthnet Programme as Third-Party Missions (TPM).
- Domains:
  - Low Resolution (LR) to Very-High Resolution (VHR) optical missions
  - Synthetic Aperture Radar (SAR) missions
  - Atmospheric missions
  - Automatic Identification System (AIS) and Radio Frequency (RF) missions
  - Multi-mission studies and Digital Elevation Models (DEMs) assessments.



1. EDAP / EDAP+

B. Quality assessment guidelines

- Assessment of EO missions and products maturity based on their documentation
- Guidelines tailored to each mission or product type (optical, SAR, …)
- DEM guidelines under publication process
- DEM summarized in "maturity matrices"

Link to the assessment guidelines

Assessment criteria

Grade	Criteria
Not Assessed	Assessment outside of the scope of study
Not Assessable	Relevant information not made available
Basic	Many pieces of important information missing
Good	Some pieces of important information missing
Excellent	Almost all required information available
Ideal	All required information available

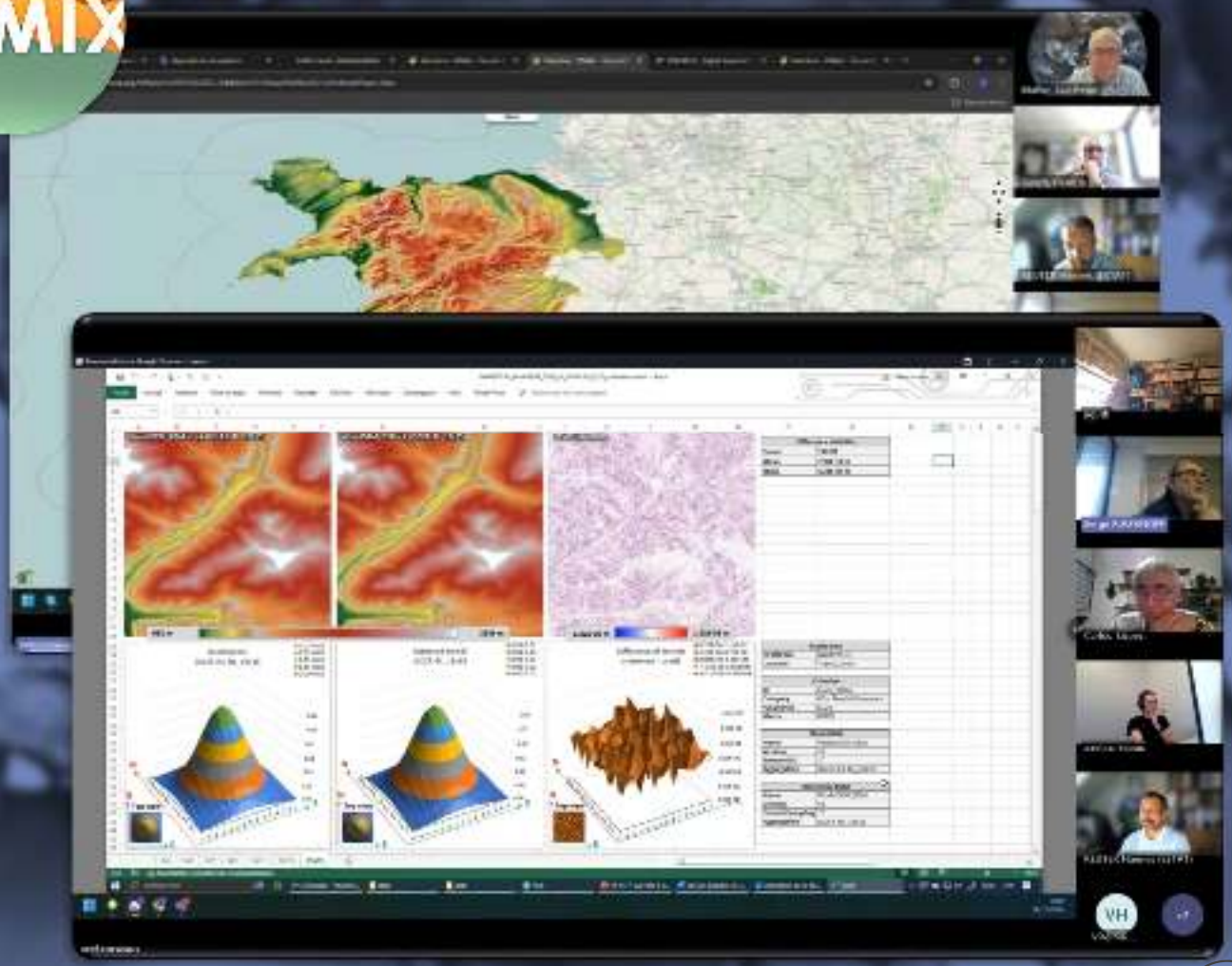
Copernicus DEMs assessment


2. DEMIX

2. DEMIX

A. Introduction

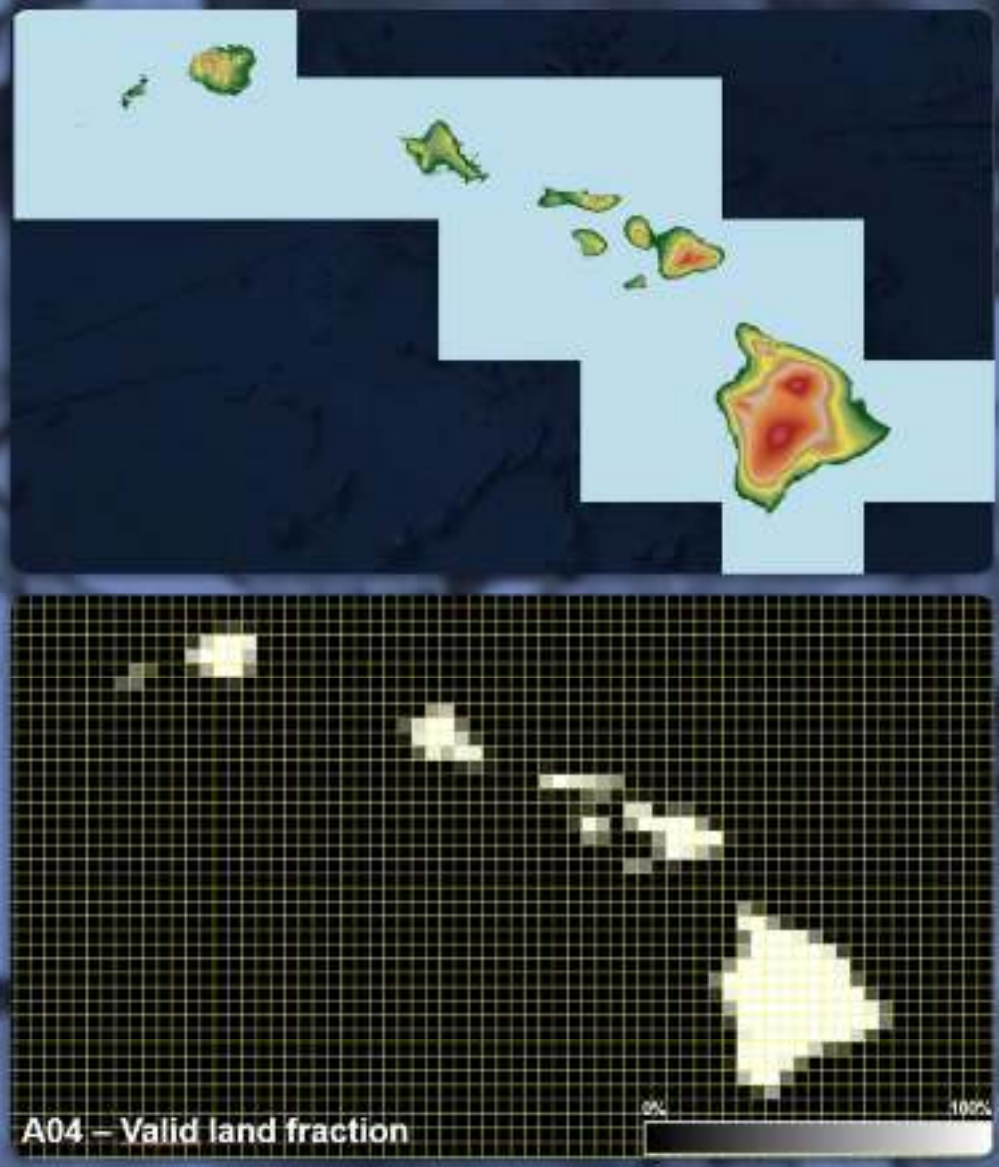
- The Digital Elevation Model Intercomparison eXercise (DEMIX) is an initiative of the Committee on Earth Observation Satellites (CEOS)
- Aims at providing harmonised terminology and methods, as well as practical guidelines and results allowing the intercomparison of continental or global Digital Elevation Models (DEM)
- Active since 2020, divided into subgroups:
  - SG1 – Terms and definitions
  - SG2 - Algorithms and Software
  - SG3 – Platforms and Processing



2. DEMIX

B. DEMIX grid and tiles

- The DEMIX Grid is a geographic grid based on the Defense Gridded Elevation Data (DGED) standard
- The DEMIX grid divides the world in DEMIX tiles (approx. 10x10 km)
- DEMIX tiles have a unique identifier allowing to easily retrieve their location
- These tiles are the unit of computation for DEMIX quality assessments



Peter L Guth, Peter Strobl, Kevin Gross, & Serge Riazanoff. (2023). DEMIX 10k Tile Data Set (1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7504791

2. DEMIX

C. Methodology

- DEM ranking based on the Randomized Complete Block Design (RCBD)
- Compatible with both qualitative and quantitative assessments
- Use of tolerances to avoid unsignificant differences in the ranking results

See detailed methodology:
C. Bielski et al. (2024). Novel Approach for Ranking DEMs: Copernicus DEM Improves One Arc Second Open Global Topography. IEEE Transactions on Geoscience and Remote Sensing, vol. 62, pp. 1-22, 2024, Art no. 4503922. 10.1109/TGRS.2024.3368015

	Evaluations					
Criterion	FABDEM	CopDEM	ALOS	NASADEM	SRTM	ASTER
ELVD_RMSE (m)	2.46	2.44	4.42	5.36	5.78	9.00
ELVD_LE90 (m)	2.38	2.29	6.04	8.36	8.67	14.20
SLPD_RMSE (%)	3.52	3.47	3.79	9.22	9.04	12.48
SLPD_MAE (%)	1.28	1.19	2.20	5.83	5.70	8.26
RUFD_AVD (%)	0.51	0.52	0.63	2.28	2.22	2.61
RUFD_RMSE (%)	1.24	1.25	1.03	3.15	3.09	3.70

	Opinions						
tolerance	FABDEM	CopDEM	ALOS	NASADEM	SRTM	ASTER	
0.5	1.5	1.5	3	4.5	4.5	6	
0.5	1.5	1.5	3	4.5	4.5	6	
0.5	2	2	2	4.5	4.5	6	
0.5	1.5	1.5	3	4.5	4.5	6	
0.2	2	2	2	4.5	4.5	6	
0.2	2.5	2.5	1	4.5	4.5	6	
Ri	11.0	11.0	14.0	27.0	27.0	36.0	
Rj^2	121.0	121.0	196.0	729.0	729.0	1296.0	sum=3192.0

2. DEMIX

D. Subgroups 1, 2 and 3

- **Subgroup 1 – Terms and definitions**

  Guth, P. L., Van Niekerk, A., Grohmann, C. H., Muller, J.-P., Hawker, L., Florinsky, I. V., Gesch, D., Reuter, H. I., Herrera-Cruz, V., Riazanoff, S., López-Vázquez, C., Carabajal, C. C., Albinet, C., & Strobl, P. (2021). Digital Elevation Models: Terminology and Definitions. Remote Sensing, 13(18), 3581. https://doi.org/10.3390/rs13183581

- **Subgroup 2 – Algorithms and Software**

  Bielski, C. et al. (2024). Novel Approach for Ranking DEMs: Copernicus DEM Improves One Arc Second Open Global Topography. IEEE Transactions on Geoscience and Remote Sensing, vol. 62, pp. 1-22, 2024, Art no. 4503922. https://doi.org/10.1109/TGRS.2024.3368015

- **Subgroup 3 – Platforms and Processing**

  Riazanoff, S., Corseaux, A., Albinet, C., Strobl, P. A., López-Vázquez, C., Guth, P. L., & Tadono, T. (2024). Best BiCubic Method to Compute the Planimetric Misregistration between Images with Sub-Pixel Accuracy: Application to Digital Elevation Models. ISPRS International Journal of Geo-Information, 13(3), 96. https://doi.org/10.3390/ijgi13030096

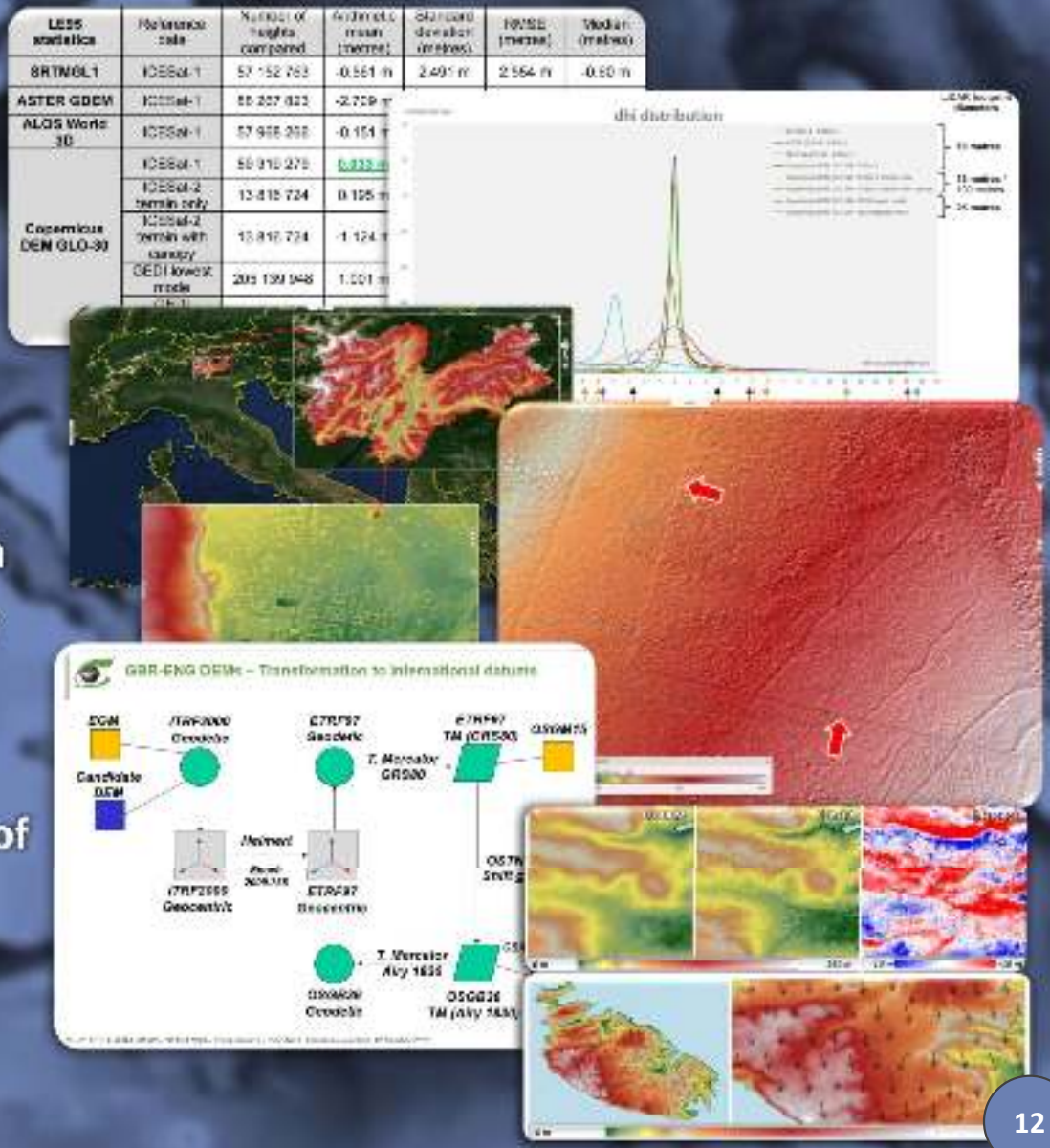
3. DEMIX SG3

A. DEM studies

3. DEMIX SG3

A. DEM studies

- **Global DEMs vs. LiDAR datasets**
  Assessment of ALOS World 3D, ASTER GDEM, Copernicus DEMs and SRTM using ICESat-1, ICESat-2 and GEDI LiDAR datasets
- **Very High-Resolution (VHR) DEMs**
  Analysis and integration of Very High-Resolution DEMs of Brazil (Espirito Santo), England, France, Italy (Trento), Uruguay, Wales
- **DEM transformation studies**
  Studying the impact of resampling methods, reprojection and datum changes on the quality of DEMs
- **Planimetric Misregistration Assessment**
  Retrieving a 2D vector field of displacements between two DEMs depicting the same area

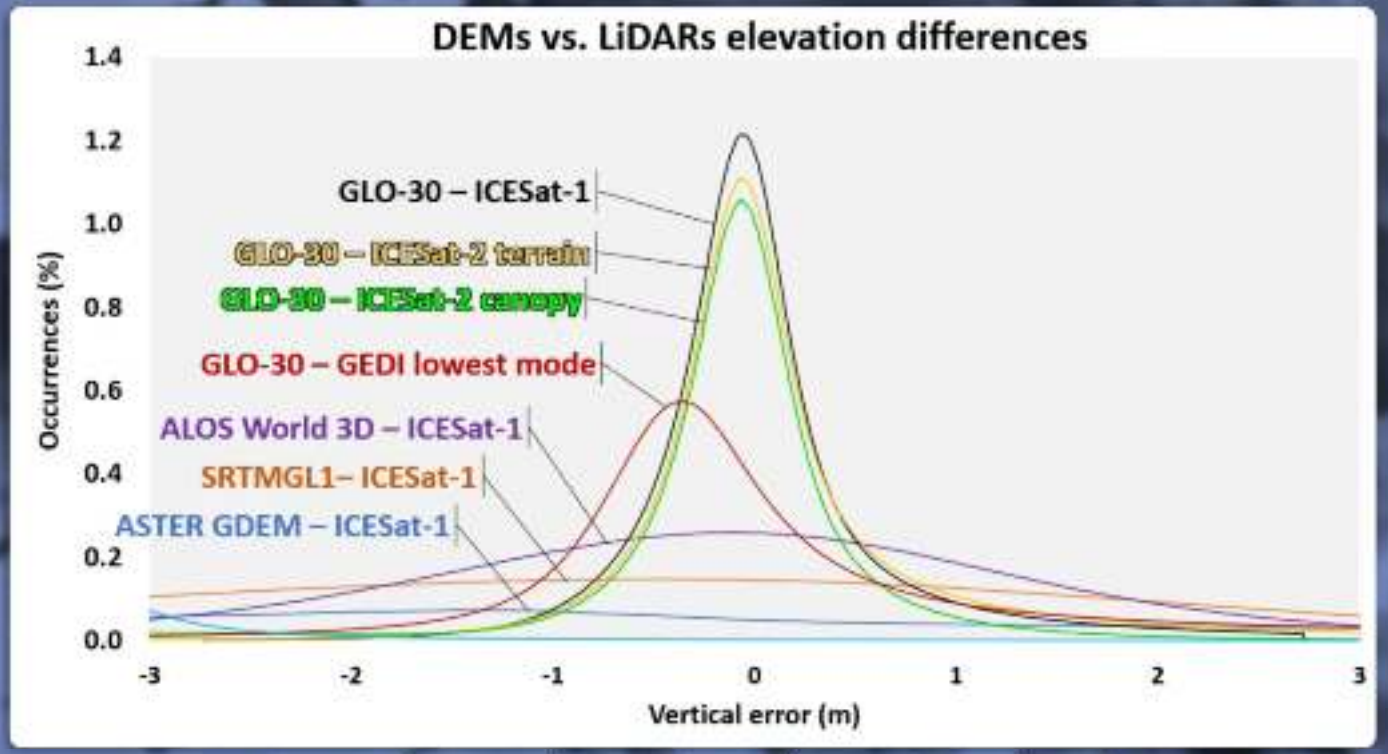


3. DEMIX SG3

A. DEM studies (2)

Global DEMs vs. LiDAR datasets

- Reference(s)
  - Global DEM Quality Assessment Summary
  - Copernicus DEMs Quality Assessment Summary
- Conclusion(s)
  - Copernicus DEM outperforms other global DEMs when compared with LiDAR data
- Limitation(s)
  - Copernicus DEM was validated using ICESat-1 data. This motivated the search for other reference data (VHR DEMs)



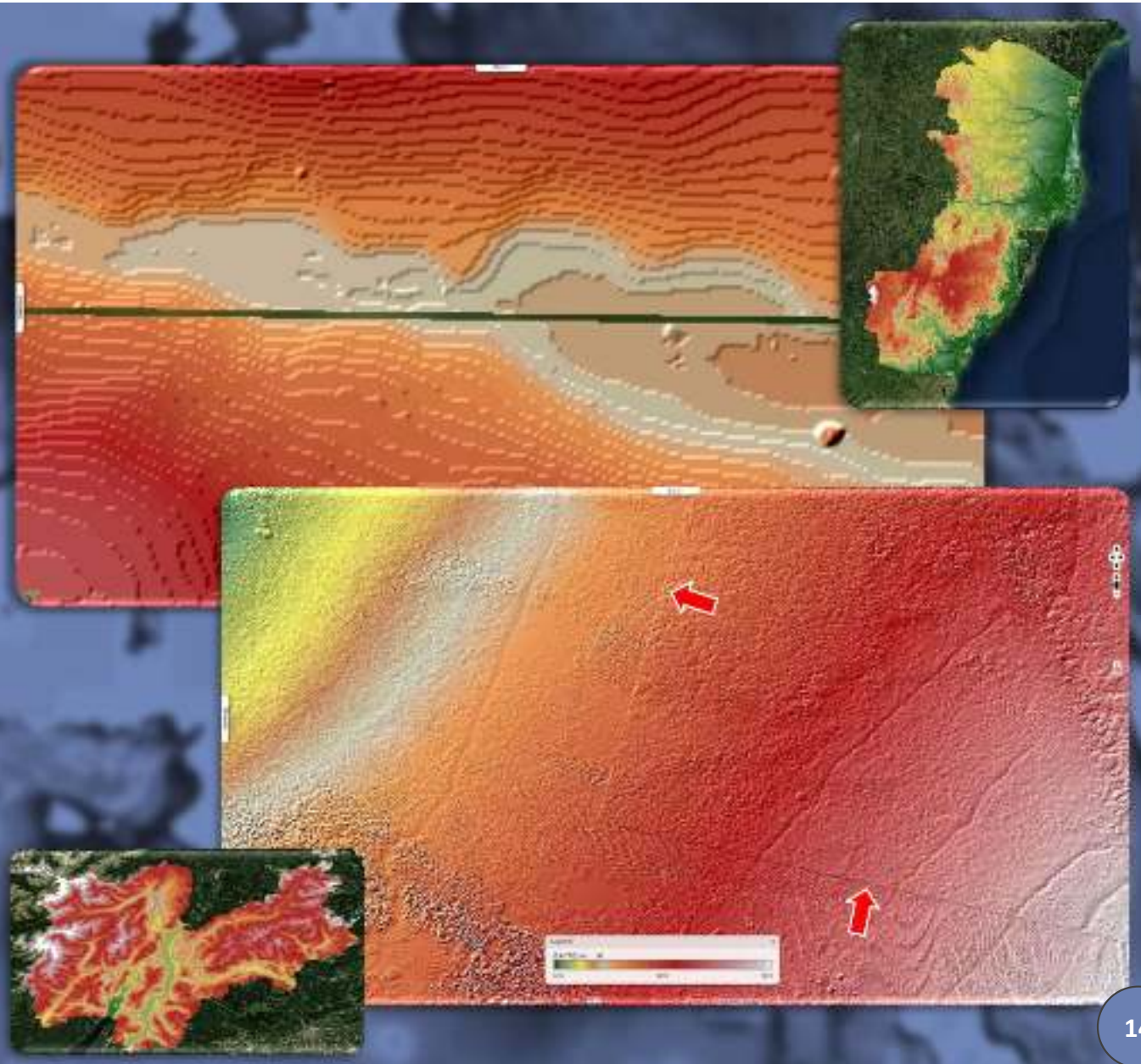
LE95 statistics	Reference data	Number of heights compared	Arithmetic mean (metres)	Standard deviation (metres)	RMSE (metres)	Median (metres)
SRTMGL1	ICESat-1	57 152 783	-0.581 m	2.491 m	2.554 m	-0.60 m
ASTER GDEM	ICESat-1	66 267 823	-2.709 m	7.432 m	7.911 m	-2.62 m
ALOS World 3D	ICESat-1	57 968 288	-0.151 m	1.653 m	1.660 m	-0.15 m
Copernicus DEM GLO-30	ICESat-1	59 319 279	0.033 m	0.827 m	0.828 m	0.04 m
	ICESat-2 terrain only	13 616 724	0.195 m	0.979 m	0.998 m	-0.01 m
	ICESat-2 terrain with canopy	13 616 724	-1.124 m	2.680 m	2.907 m	0.14 m
	GEDI lowest mode	205 139 948	1.001 m	3.281 m	3.431 m	-0.10 m
	GEDI highest return	205 139 949	-5.796 m	3.180 m	6.603 m	-4.61 m

3. DEMIX SG3

A. DEM studies (3)

Very High-Resolution (VHR) DEMs

- Reference(s)
  - VHR DEM Technical Note
- Conclusion(s)
  - VHR DEM products and providers are difficult to work with (server instabilities, lack of geometry metadata, inconsistent tiling, transformations to WGS84…)
  - These constraints motivated the development of platforms and tools to ease the access to these DEMs (see next section)

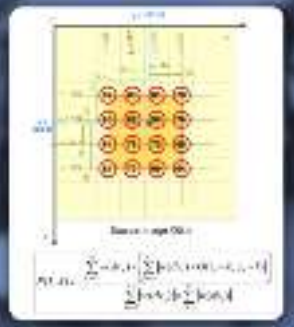


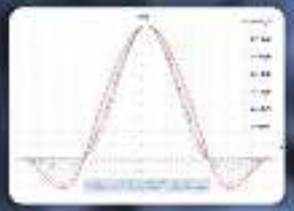
3. DEMIX SG3

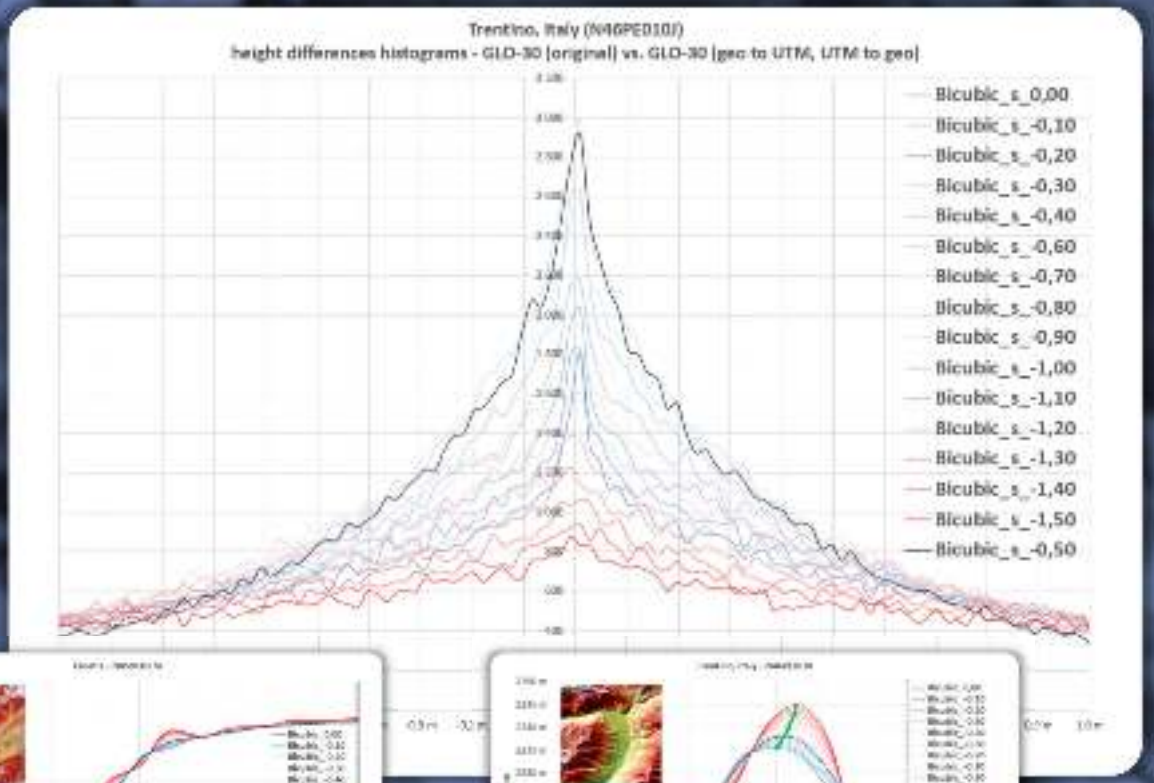
A. DEM studies (4)

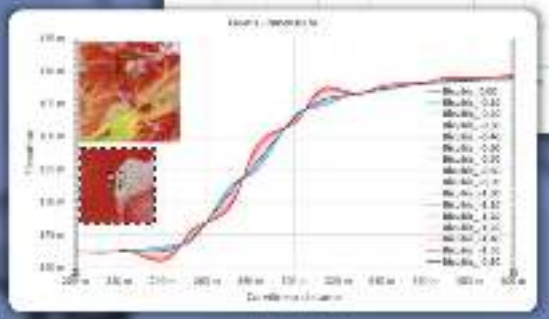
DEM transformation studies

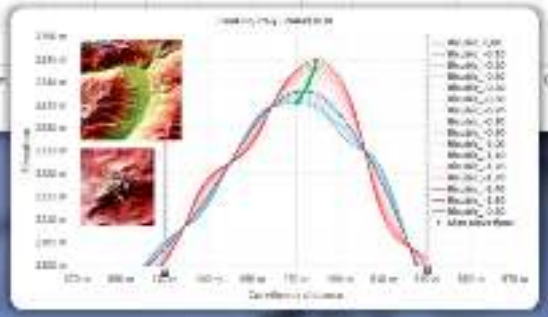
- Reference(s)
  - SG3 meetings agendas and presentations
- Conclusion(s)
  - No overall “Best” resampling method, depends on the study area and feature of interest (see statistics of the “best” bicubic parameter per area and feature below)











Best bicubic parameter per area and feature

Study area	heights	slope norms	slope azimuths	h. curvatures	v. curvatures	t.curvatures	slope norm stdev
Trentino, Italy	-0,6	-0,7	-0,7	-0,2	-0,7	-0,7	-0,7
La Réunion, France	-0,7	-0,7	-0,8	-0,9	-0,9	-0,9	-0,7
Les Landes, France	-0,8	-0,8	-0,8	-0,1	-0,9	-0,8	-1

3. DEMIX SG3

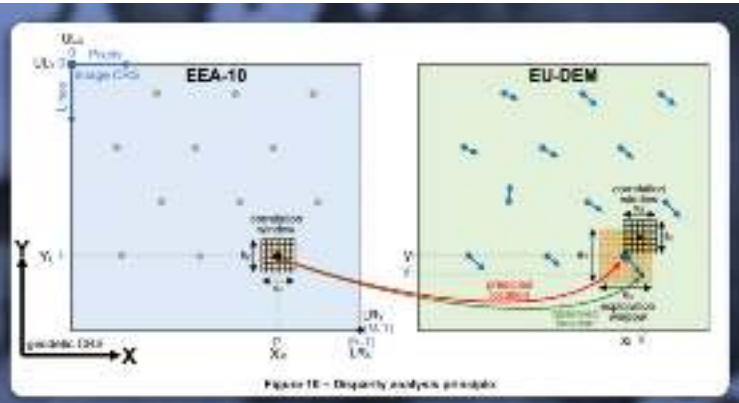
A. DEM studies (5)

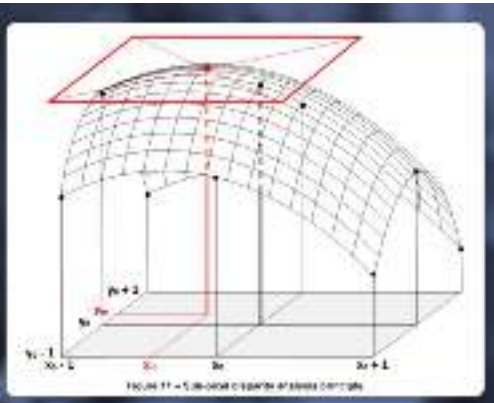
Planimetric Misregistration Assessment

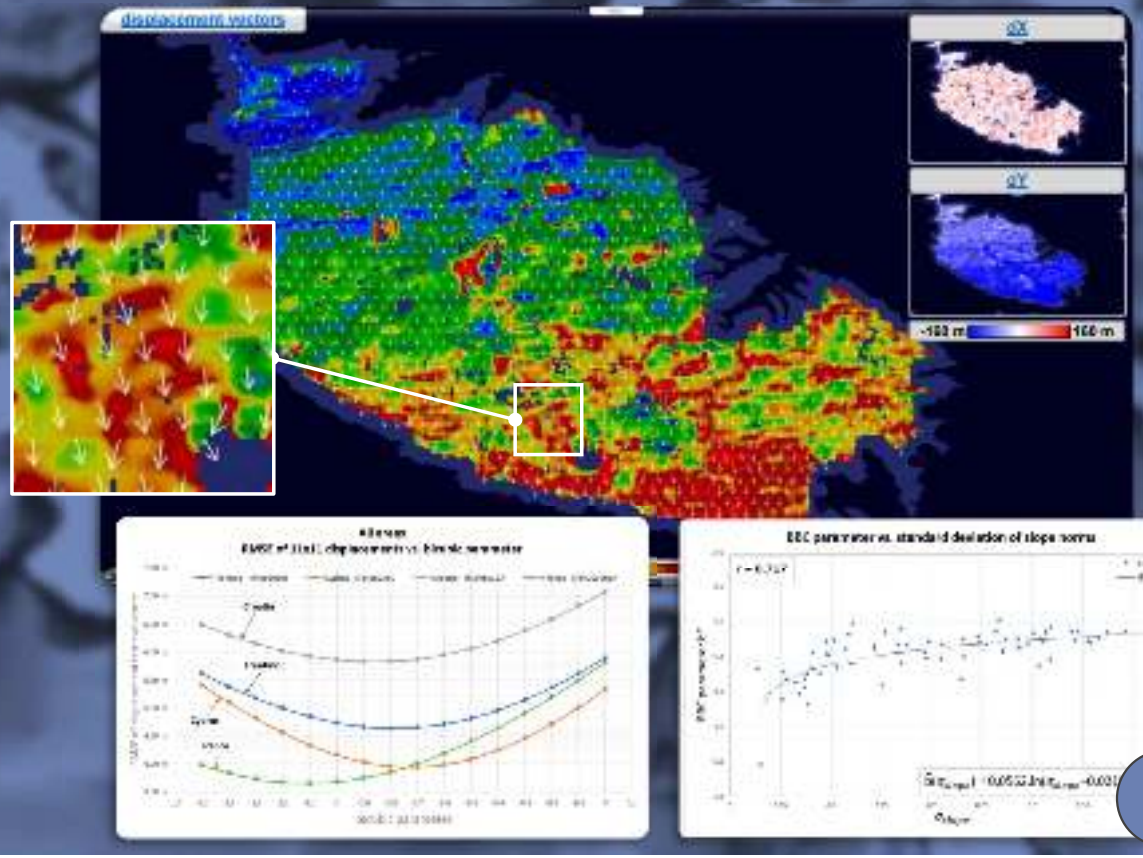
- **Reference(s)**

  Riazanoff, S., Corseaux, A., Albinet, C., Strobl, P. A., López-Vázquez, C., Guth, P. L., & Tadono, T. (2024). Best BiCubic Method to Compute the Planimetric Misregistration between Images with Sub-Pixel Accuracy: Application to Digital Elevation Models. ISPRS International Journal of Geo-Information, 13(3), 96. https://doi.org/10.3390/ijgi13030096

- **Conclusion(s)**
  - Best bicubic interpolation to coregister DEMs for this assessment depends on the roughness (5x5 stdev of slopes) of the area (r=0.717)
- **Limitation(s)**
  - Accuracy is the best with large correlation windows (c_x,c_y) = (21,21), which increases computation time







3. DEMIX SG3

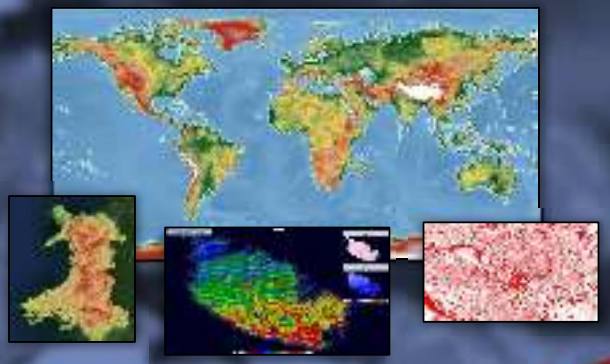
B. DEM tools and platforms

3. DEMIX SG3

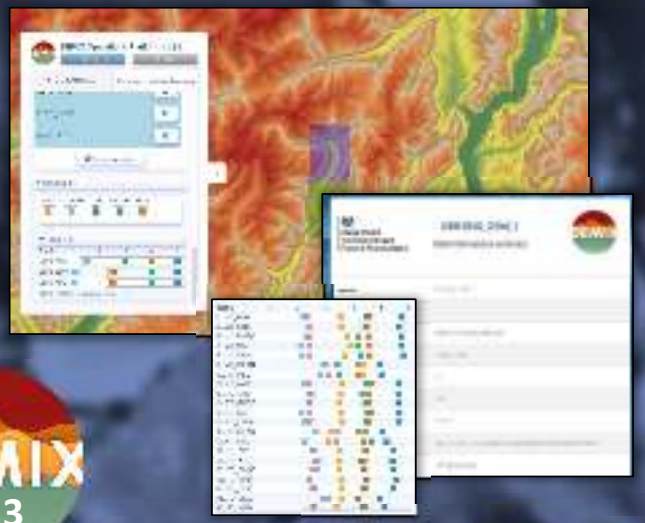
B. DEM tools and platforms

- **VtWeb**
  Process and visualize EO products easily
- **DEMIX Operations Platform**
  Export DEM elevations and rank DEMs according to criteria of interest
- **DEMIX Jupyter Notebook**
  Retrieve DEM elevations using Python code (Jupyter Notebook)
- **QGIS plugins**
  Retrieve and customize VtWeb layer styles easily into QGIS + process DEM elevation cross-sections
- **DEM4Sentinels-1-2**
  Retrieve the DEM used to process a Sentinel-2 L2A product

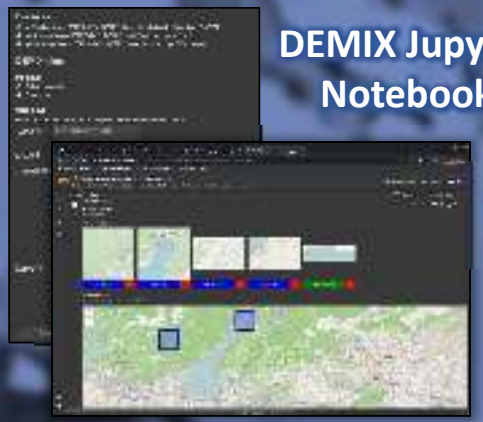
VtWeb



DEMIX Operations Platform



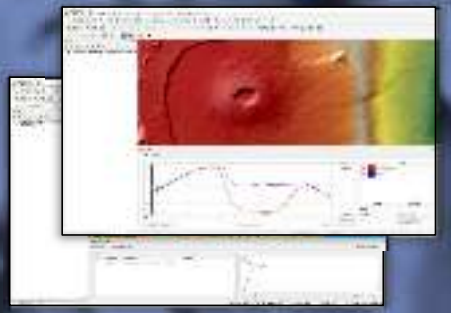
DEMIX Jupyter Notebook



DEMIX SG3

DEM4Sentinels-1-2

QGIS plugins



3. DEMIX SG3

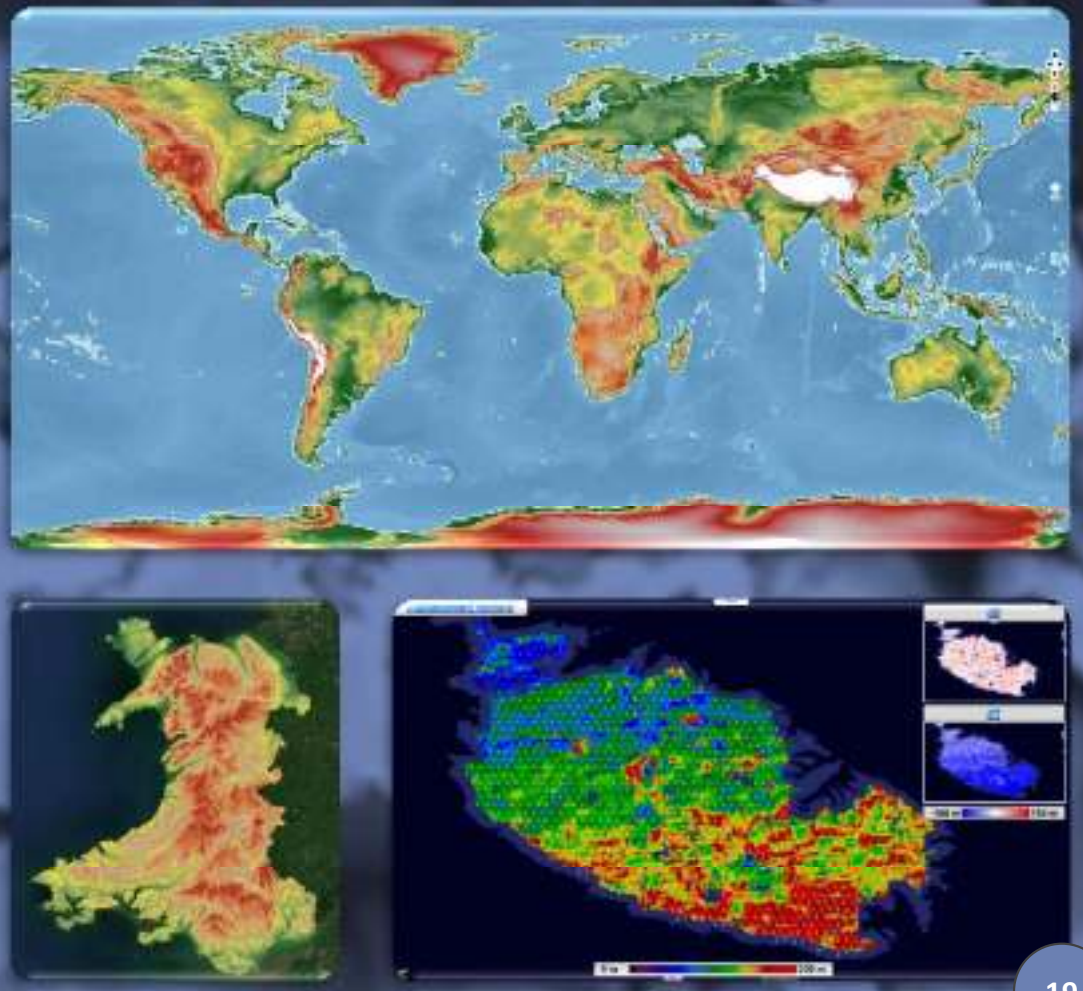
B. DEM tools and platforms (2)

VtWeb

Features:

- Visualise and process **numerous EO datasets** and their products (optical and SAR missions, Digital Elevation Models, …) at **any scale**,
- Use the **Processing On-the-Fly Macro Language** (POF-ML) to process **custom layers** (DEM slopes, elevation differences, etc…),
- Create "**hyperlooks**" to share products and a specific view with a simple URL. These links are showcased in **hyperlook documents**, which feature studies performed on the VtWeb platform.

Link: https://visioterra.org/VtWeb/



3. DEMIX SG3

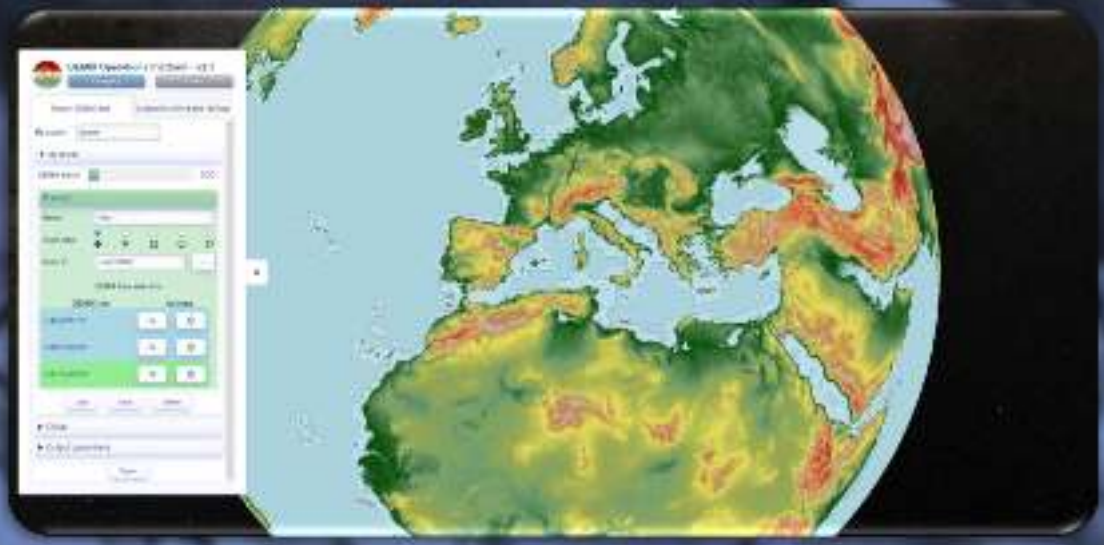
B. DEM tools and platforms (3)

DEMIX Operations Platform

Features:

- Access to local and global DEMs, with up to 1m of resolution
- Custom area selection (10x10km DEMIX tiles)
- Export DEMIX tiles with custom parameters, including Ground Sampling Distance (GSD), Coordinate Reference System (CRS), Vertical Reference System (VRS), resampling methods (aggregations and interpolations)
- GeoTIFF or ZIP export (organized per area)
- Precise metadata of each DEM
- DEM ranking, according to a set of criteria chosen by the user

Link: https://visioterra.org/DemixOperationsPlatform/



3. DEMIX SG3

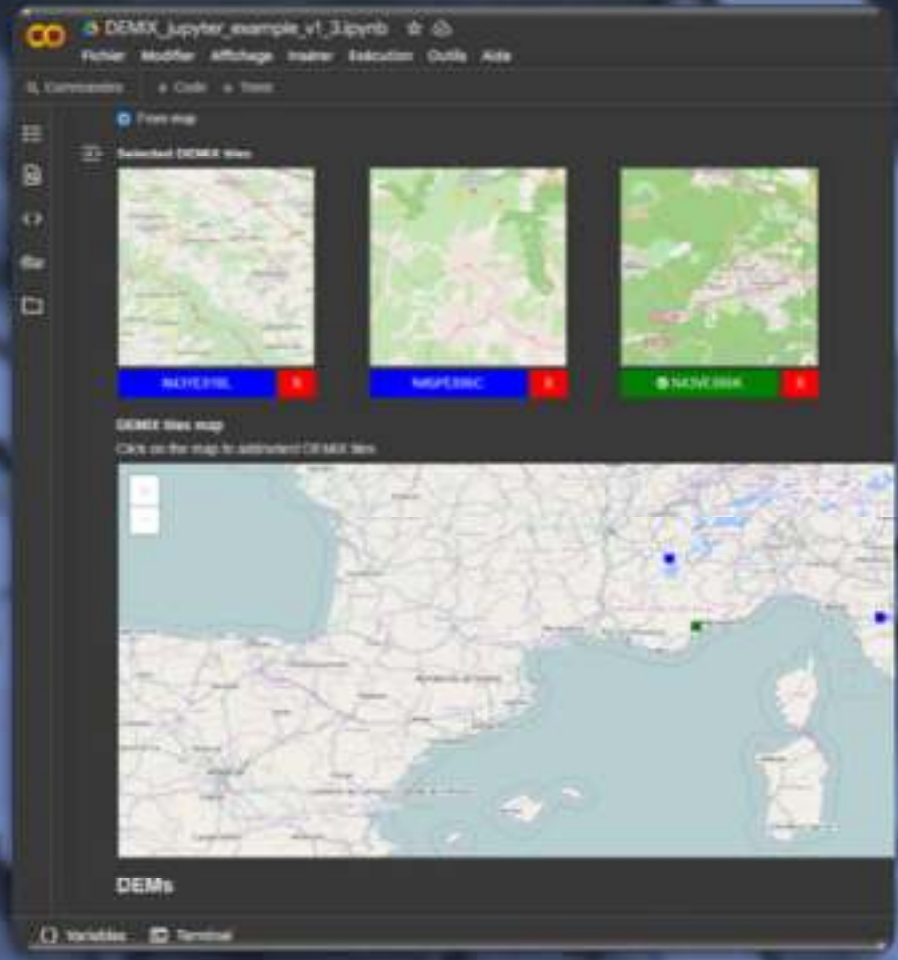
B. DEM tools and platforms (4)

DEMIX Jupyter Notebook

Features:

- Request **global DEMs elevations, ancillary layers values and scores** (criteria applied to DEMIX tiles and DEMs) in a **Jupyter Notebook** environment (**Python** programming language),
- Code **custom DEM criteria** using Python,
- Use the predefined Python widgets to **export DEMIX tiles** of elevation / ancillary data as **GeoTIFFs**.

Link: https://visioterra.fr/telechargement/P317_DEMIX/notebook/



3. DEMIX SG3

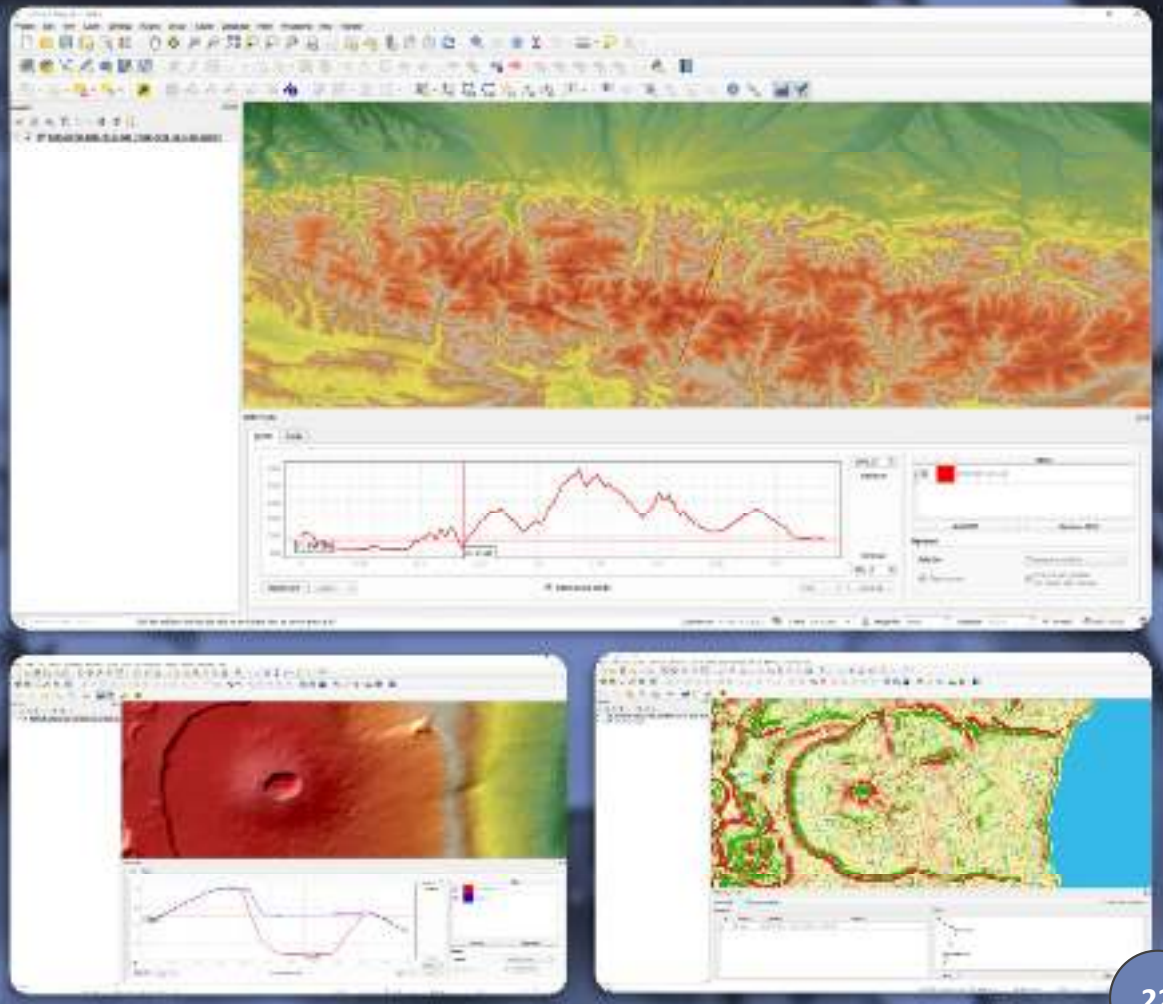
B. DEM tools and platforms (5)

QGIS plugins

Features:

- **VtDEMProfile** - Draw on map and retrieve cross-sections of global candidate DEMs (ALOS World 3D, ASTER GDEM, Copernicus DEM GLO-30, Copernicus DEM GLO-90)
- **VtWeb WMTS Editor** – Manipulate VtWeb layers on QGIS using the Processing On the Fly Macro Language (POF-ML)

Link: https://visioterra.fr/telechargement/P317_DEMIX/QGIS_plugins/



Thank you for your attention!

Interested? Subscribe to the DEMIX SG3 meetings!

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