



Activities of the DEMIX Subgroup 3 “Platforms and Processing”

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GEO MORPHOMETRY
PERUGIA **ITALY**

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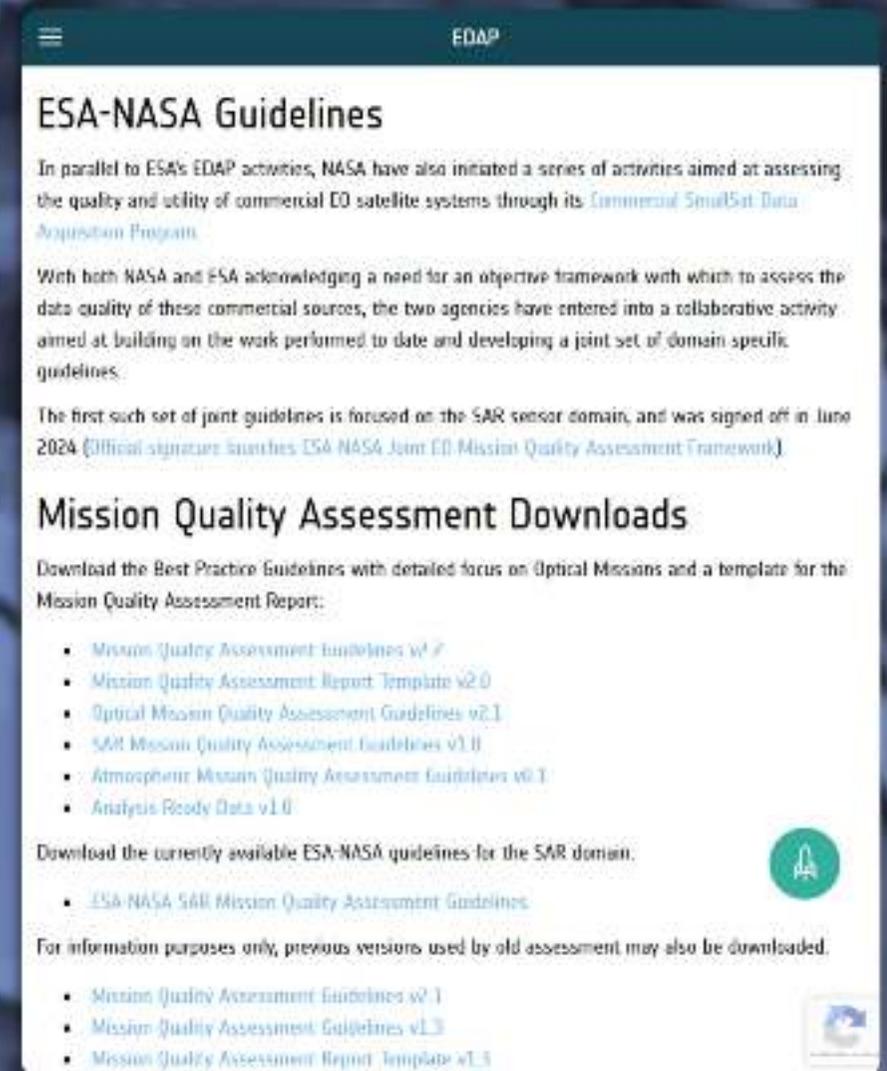


1. EDAP / EDAP+

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.**



The screenshot shows the EDAP website interface. At the top, there is a navigation bar with the EDAP logo. The main content area is titled "ESA-NASA Guidelines" and contains text about the project's goals and a list of downloadable documents. Below this, there is a section for "Mission Quality Assessment Downloads" with a list of specific documents and a download button.

ESA-NASA Guidelines

In parallel to ESA's EDAP activities, NASA have also initiated a series of activities aimed at assessing the quality and utility of commercial EO satellite systems through its [Commercial SmallSat Data Acquisition Program](#).

With both NASA and ESA acknowledging a need for an objective framework with which to assess the data quality of these commercial sources, the two agencies have entered into a collaborative activity aimed at building on the work performed to date and developing a joint set of domain specific guidelines.

The first such set of joint guidelines is focused on the SAR sensor domain, and was signed off in June 2024 (Official signature launches [ESA-NASA Joint EO Mission Quality Assessment Framework](#)).

Mission Quality Assessment Downloads

Download the Best Practice Guidelines with detailed focus on Optical Missions and a template for the Mission Quality Assessment Report:

- [Mission Quality Assessment Guidelines v1.7](#)
- [Mission Quality Assessment Report Template v2.0](#)
- [Optical Mission Quality Assessment Guidelines v2.1](#)
- [SAR Mission Quality Assessment Guidelines v1.0](#)
- [Atmospheric Mission Quality Assessment Guidelines v0.1](#)
- [Analysis Ready Data v1.0](#)

Download the currently available ESA-NASA guidelines for the SAR domain.

- [ESA-NASA SAR Mission Quality Assessment Guidelines](#)

For information purposes only, previous versions used by old assessment may also be downloaded.

- [Mission Quality Assessment Guidelines v1.1](#)
- [Mission Quality Assessment Guidelines v1.3](#)
- [Mission Quality Assessment Report Template v1.3](#)

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

| Product Information | Product Description | Auxiliary Information | Uncertainty Characterisation | Validation |
|---|---|-----------------------|-------------------------------------|-----------------------------------|
| Product Details | Sensor Calibration & Characterisation Pre-Flight | Product Flags | Uncertainty Characterisation Method | Reference Data Representativeness |
| Availability & Accessibility | Sensor Calibration & Characterisation Post-launch | Auxiliary Data | Uncertainty Sources Included | Reference Data Quality |
| Product Format | Retrieval Algorithm Method | | Uncertainty Values Provided | Validation Method |
| User Documentation | Retrieval Algorithm Tuning | | Geolocation Uncertainty | Validation Results |
| Metrological Traceability Documentation | Additional Processing | | | |



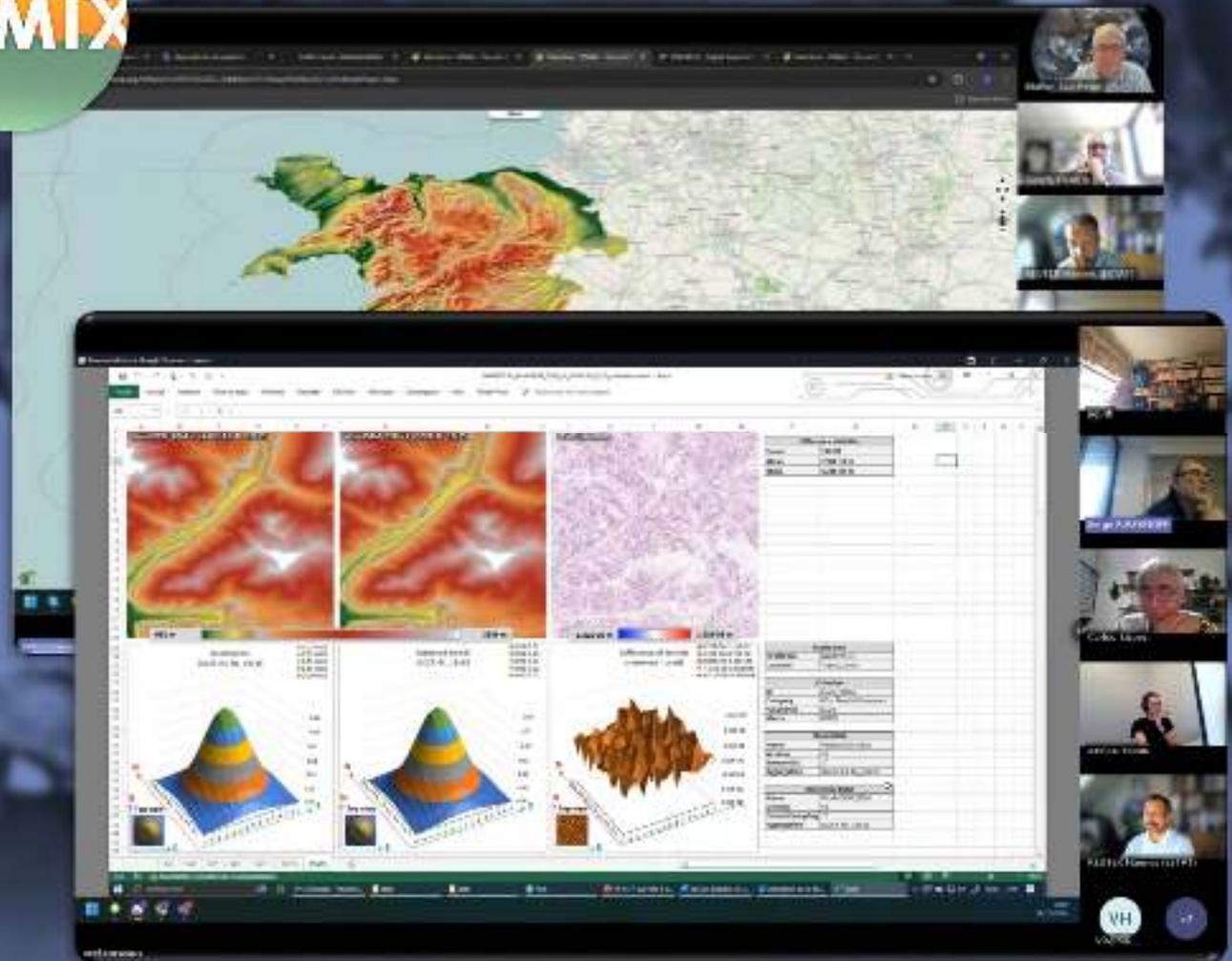
2. DEMIX

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**

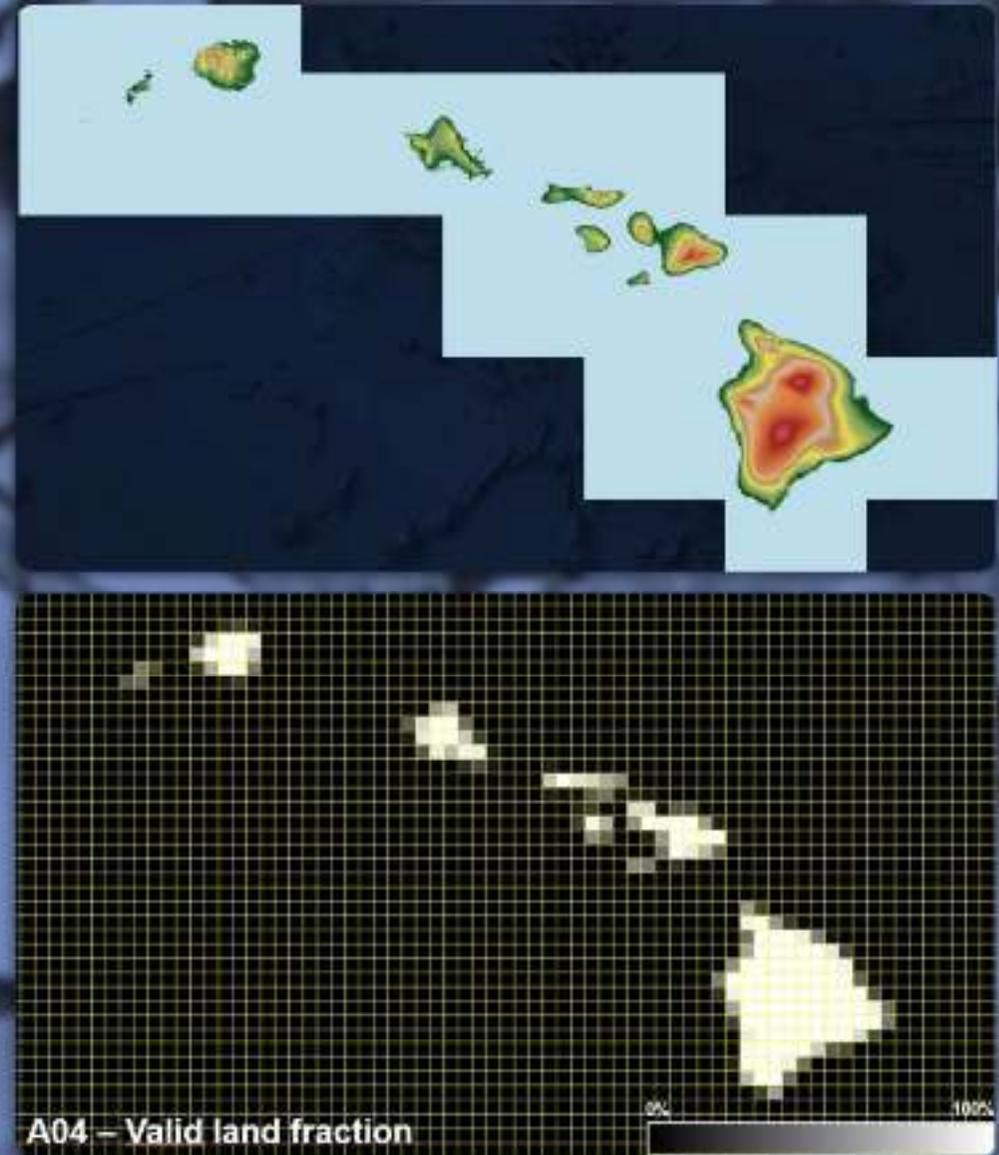


2. DEMIX

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 insignificant 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

| Criterion | Evaluations | | | | | |
|---------------|-------------|--------|------|---------|------|-------|
| | 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 |

| tolerance | Opinions | | | | | |
|-----------|----------|--------|-------|---------|-------|------------|
| | 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 |
| R_i | 11.0 | 11.0 | 14.0 | 27.0 | 27.0 | 36.0 |
| R_j^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**

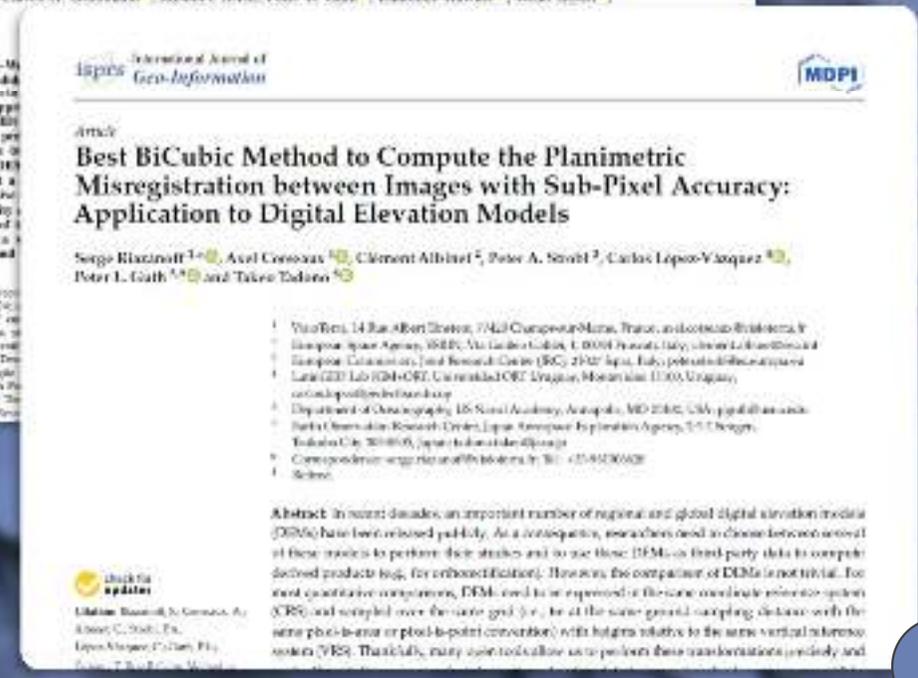
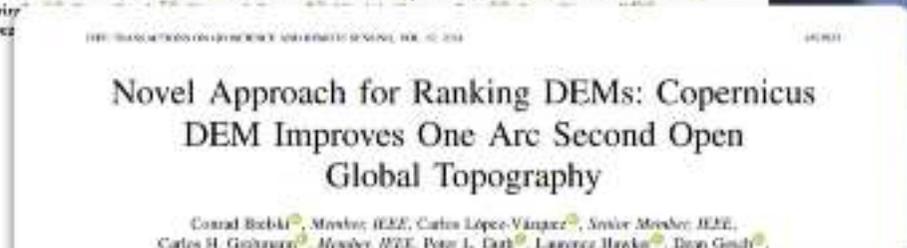
Guth, P. L., Van Niekerk, A., Grohmann, C. H., Muller, J.-P., Hawker, L., Florinsky, I. V., Gesch, D., Reuter, H. I., Herrera-Cruz, V., Riazanoff, S., López-Vázquez, C., Carabajal, C. C., Albinet, C., & Strobl, P. (2021). **Digital Elevation Models: Terminology and Definitions**. *Remote Sensing*, 13(18),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

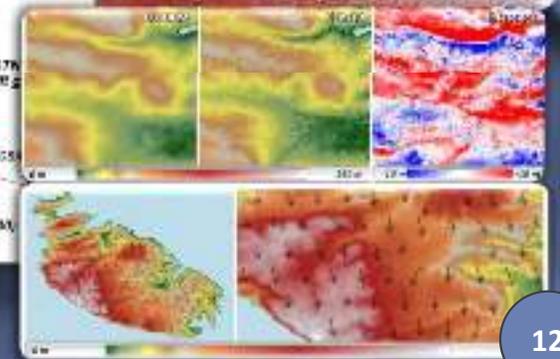
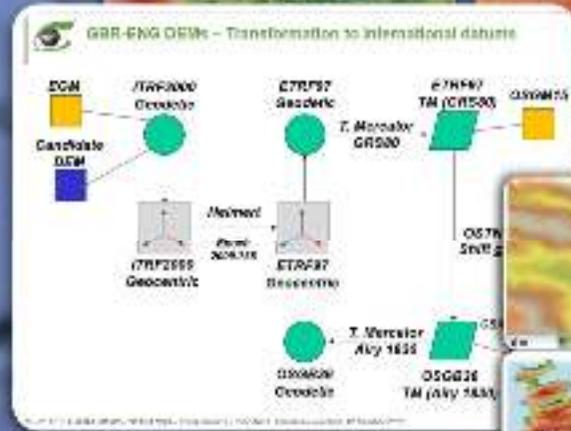
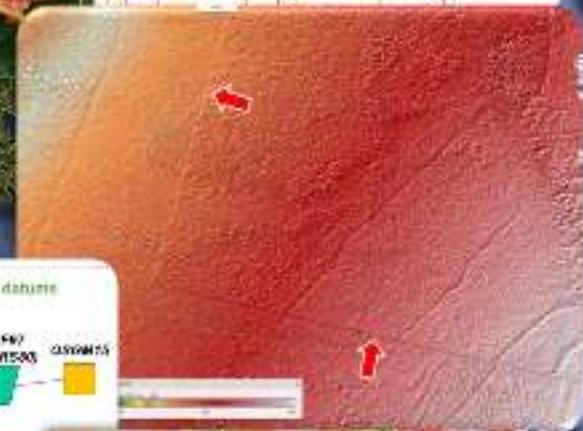
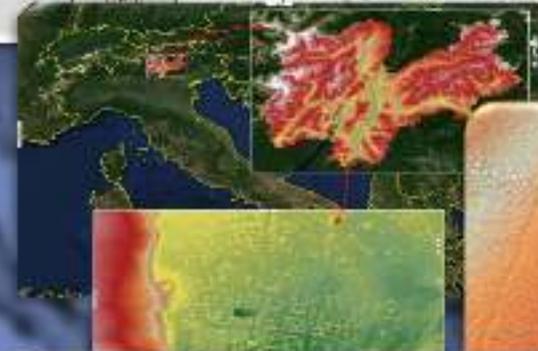
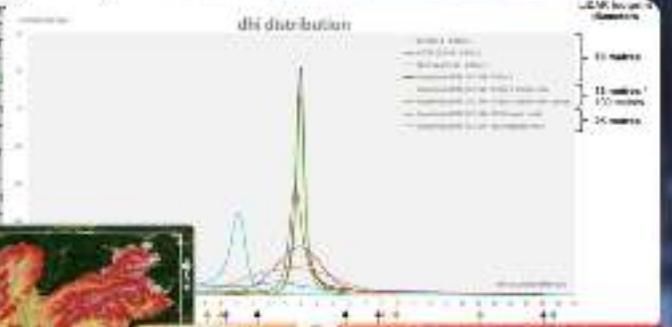
A. DEM studies

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

| LESS statistics | Reference data | Number of heights compared | Arithmetic mean (meters) | Standard deviation (meters) | RMSE (meters) | Median (meters) |
|-----------------------|--|----------------------------|--------------------------|-----------------------------|---------------|-----------------|
| SRTMGL1 | ICESat-1 | 57 152 763 | -0.551 m | 2.491 m | 2.554 m | -0.50 m |
| ASTER GDEM | ICESat-1 | 85 257 823 | -2.729 m | | | |
| ALOS World 3D | ICESat-1 | 57 955 255 | -0.154 m | | | |
| Copernicus DEM GLO-30 | ICESat-1 | 55 910 275 | 0.133 m | | | |
| | ICESat-2 terrain only | 13 815 724 | 0.125 m | | | |
| | ICESat-2 terrain with canopy GEDI lowest mode (v1.1) | 15 810 724 | -1.124 m | | | |
| | | 205 139 948 | 1.001 m | | | |

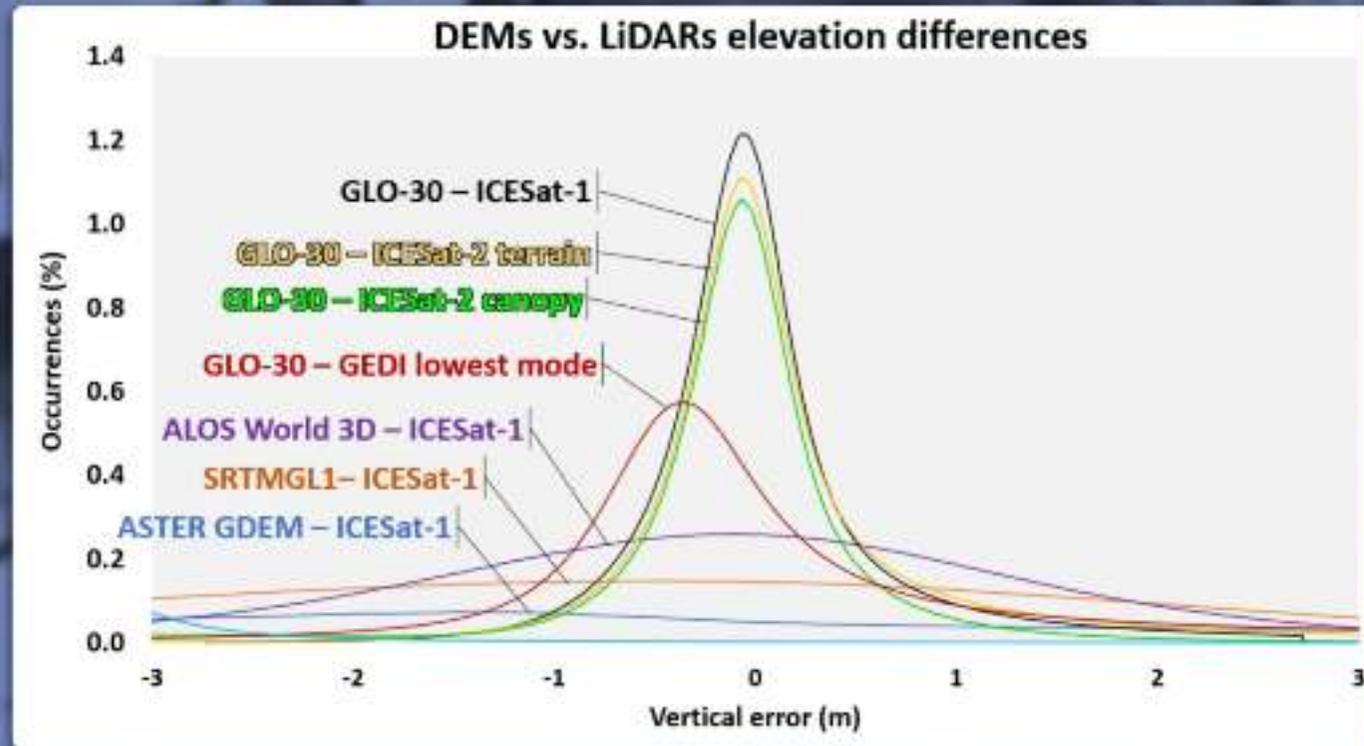


3. DEMIX SG3

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)



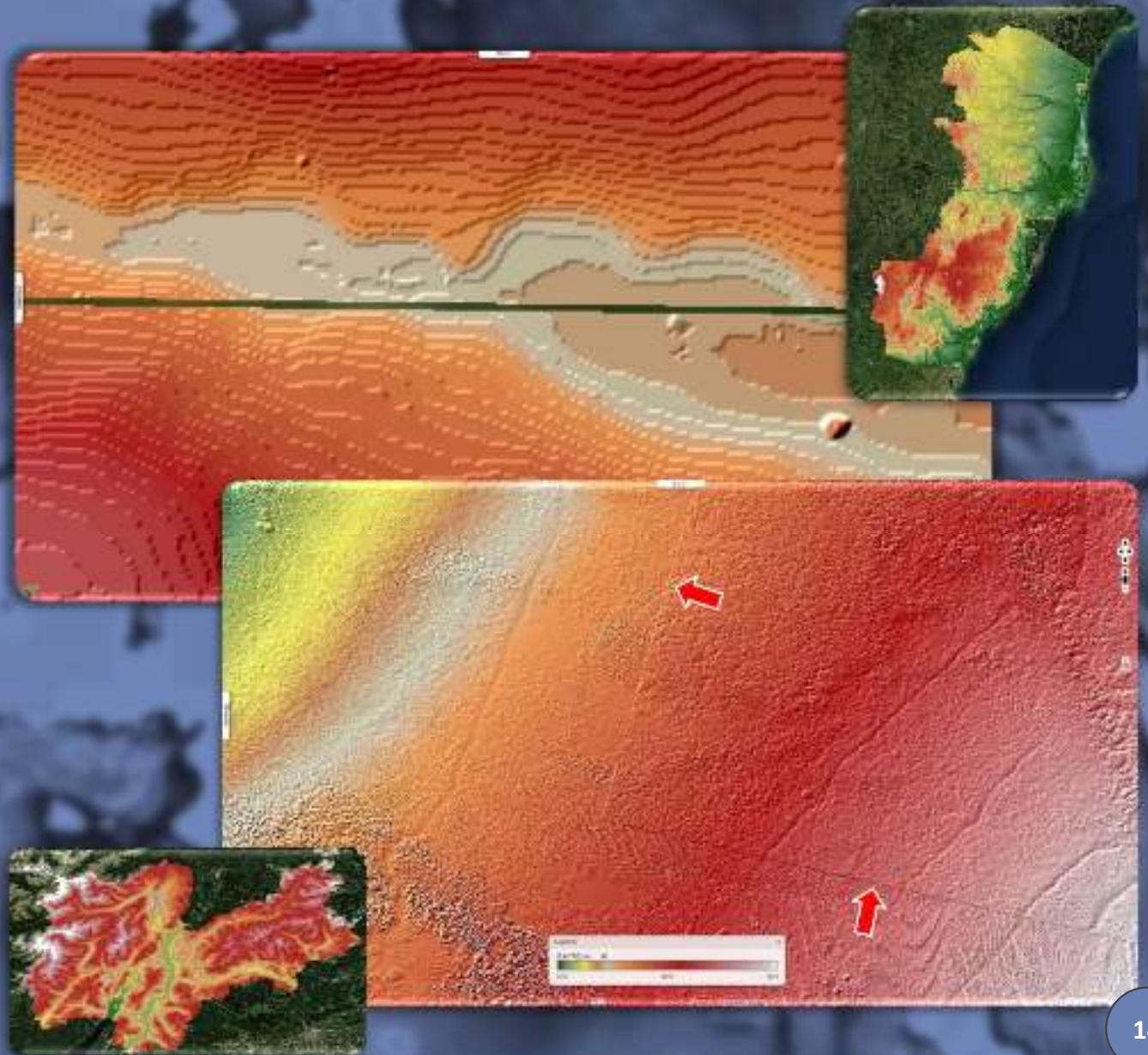
| LE95 statistics | Reference data | Number of heights compared | Arithmetic mean (metres) | Standard deviation (metres) | RMSE (metres) | Median (metres) |
|-----------------------|------------------------------|----------------------------|--------------------------|-----------------------------|---------------|-----------------|
| SRTMGL1 | ICESat-1 | 57 152 783 | -0.581 m | 2.491 m | 2.554 m | -0.60 m |
| ASTER GDEM | ICESat-1 | 88 267 823 | -2.708 m | 7.432 m | 7.911 m | -2.62 m |
| ALOS World 3D | ICESat-1 | 57 968 298 | -0.151 m | 1.653 m | 1.860 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 | 13 816 724 | 0.195 m | 0.979 m | 0.998 m | -0.01 m |
| | ICESat-2 terrain with canopy | 13 816 724 | -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 | 205 139 948 | -5.786 m | 3.180 m | 6.802 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)

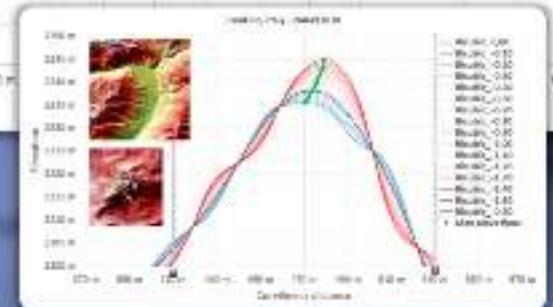
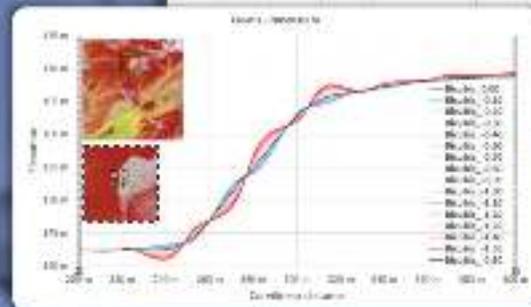
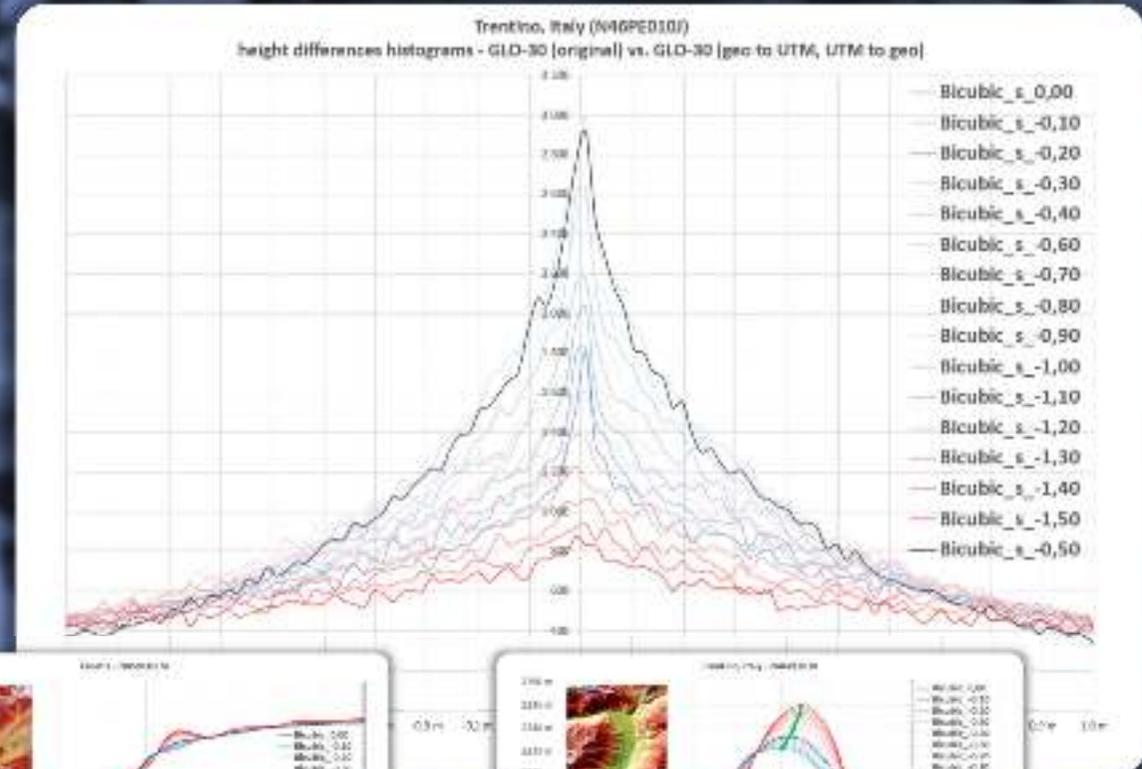
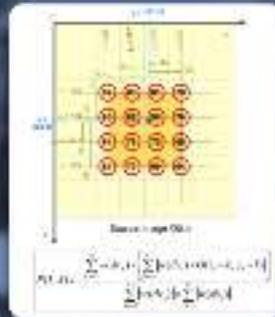


3. DEMIX SG3

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)**

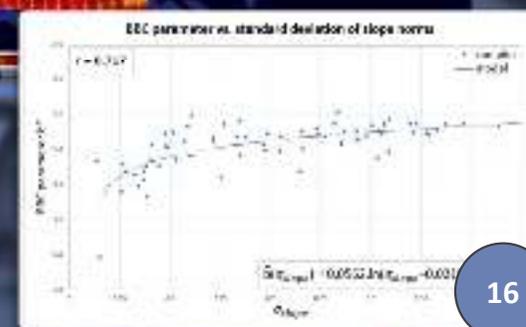
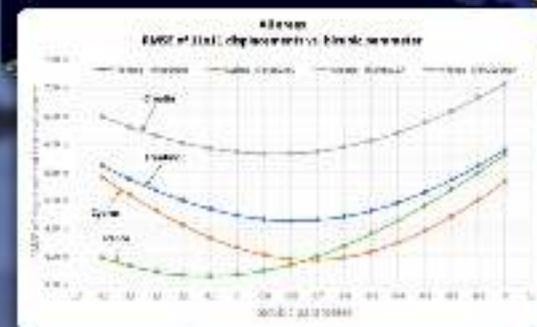
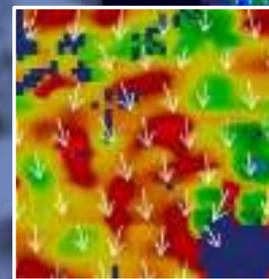
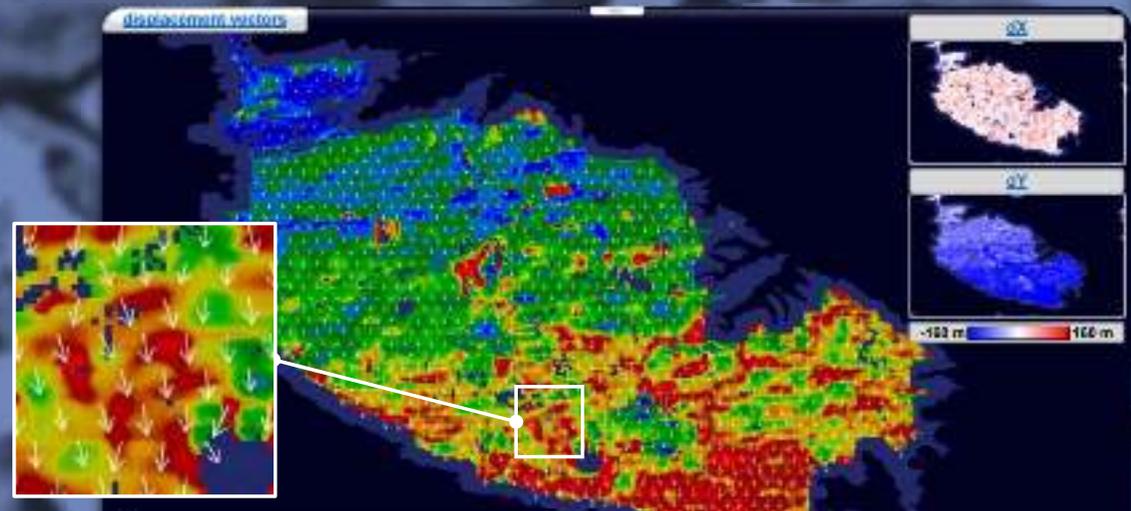
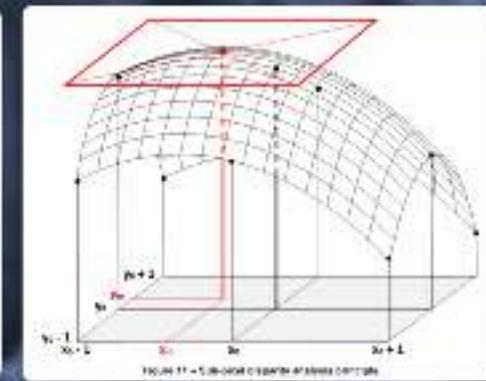
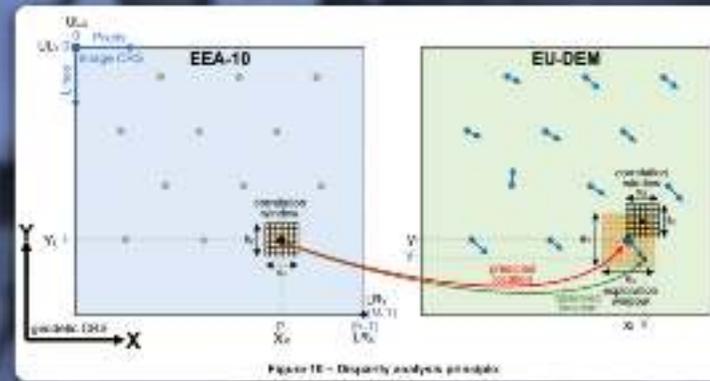
Riazanoff, S., Corseaux, A., Albinet, C., Strobl, P. A., López-Vázquez, C., Guth, P. L., & Tadono, T. (2024). **Best BiCubic Method to Compute the Planimetric Misregistration between Images with Sub-Pixel Accuracy: Application to Digital Elevation Models**. ISPRS International Journal of Geo-Information,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





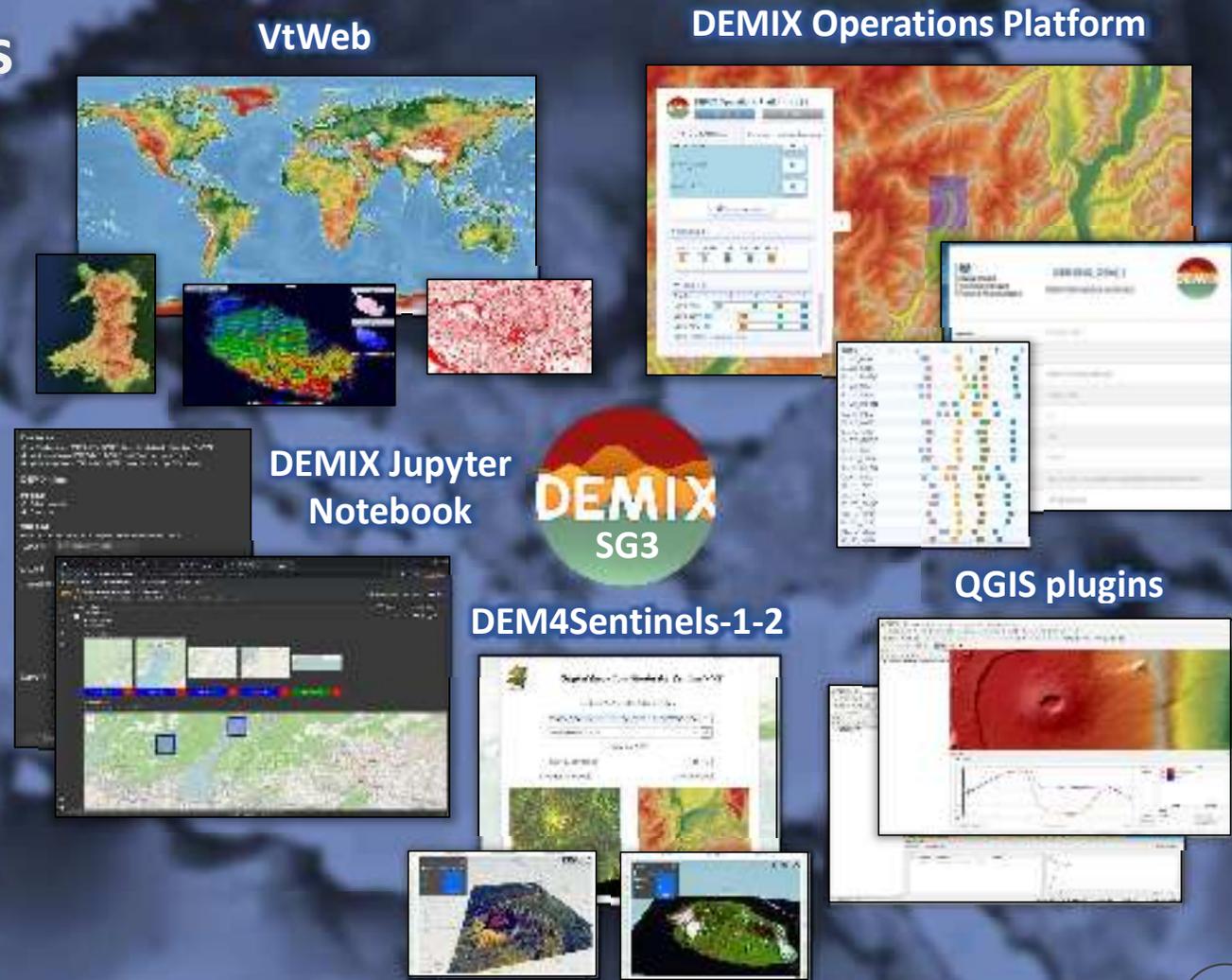
3. DEMIX SG3

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



3. DEMIX SG3

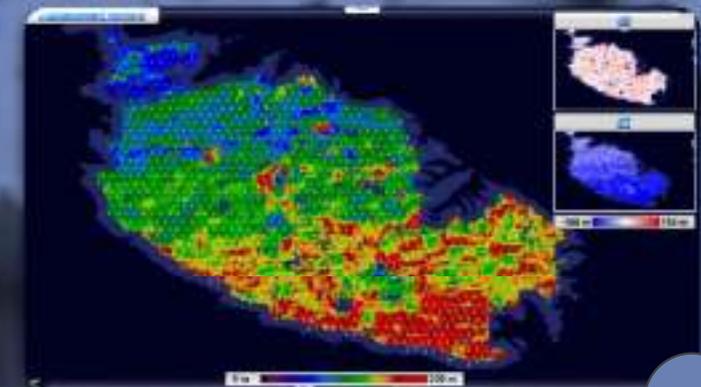
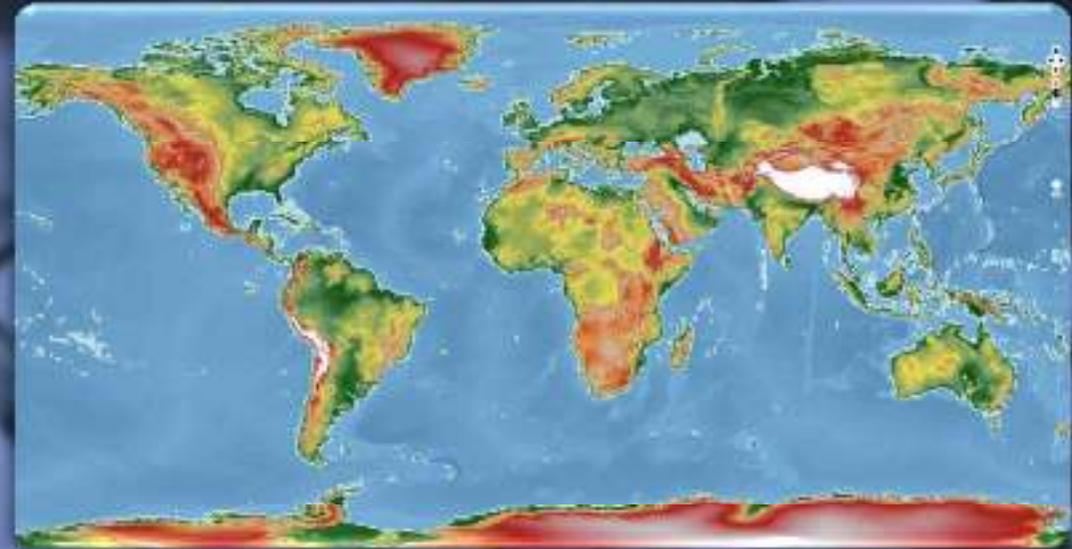
B. DEM tools and platforms (2)

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

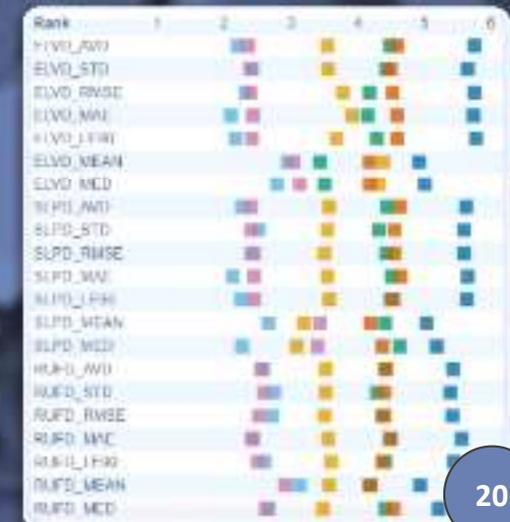
B. DEM tools and platforms (3)

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

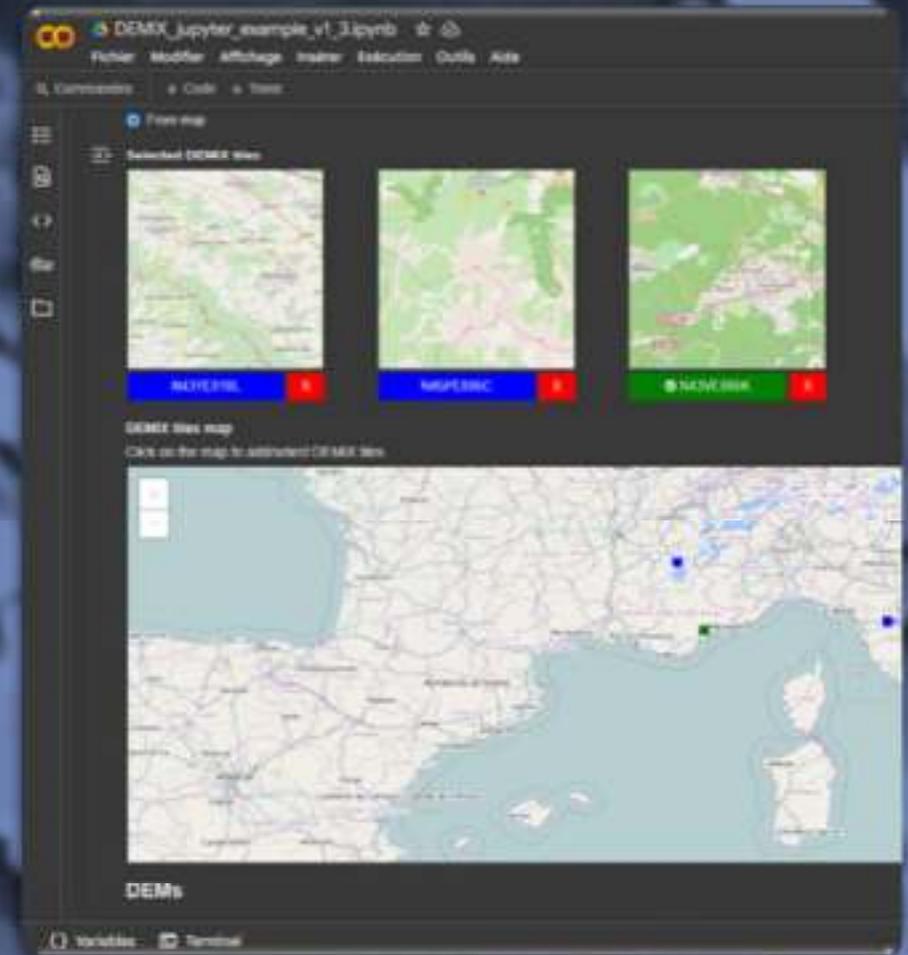
B. DEM tools and platforms (4)

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

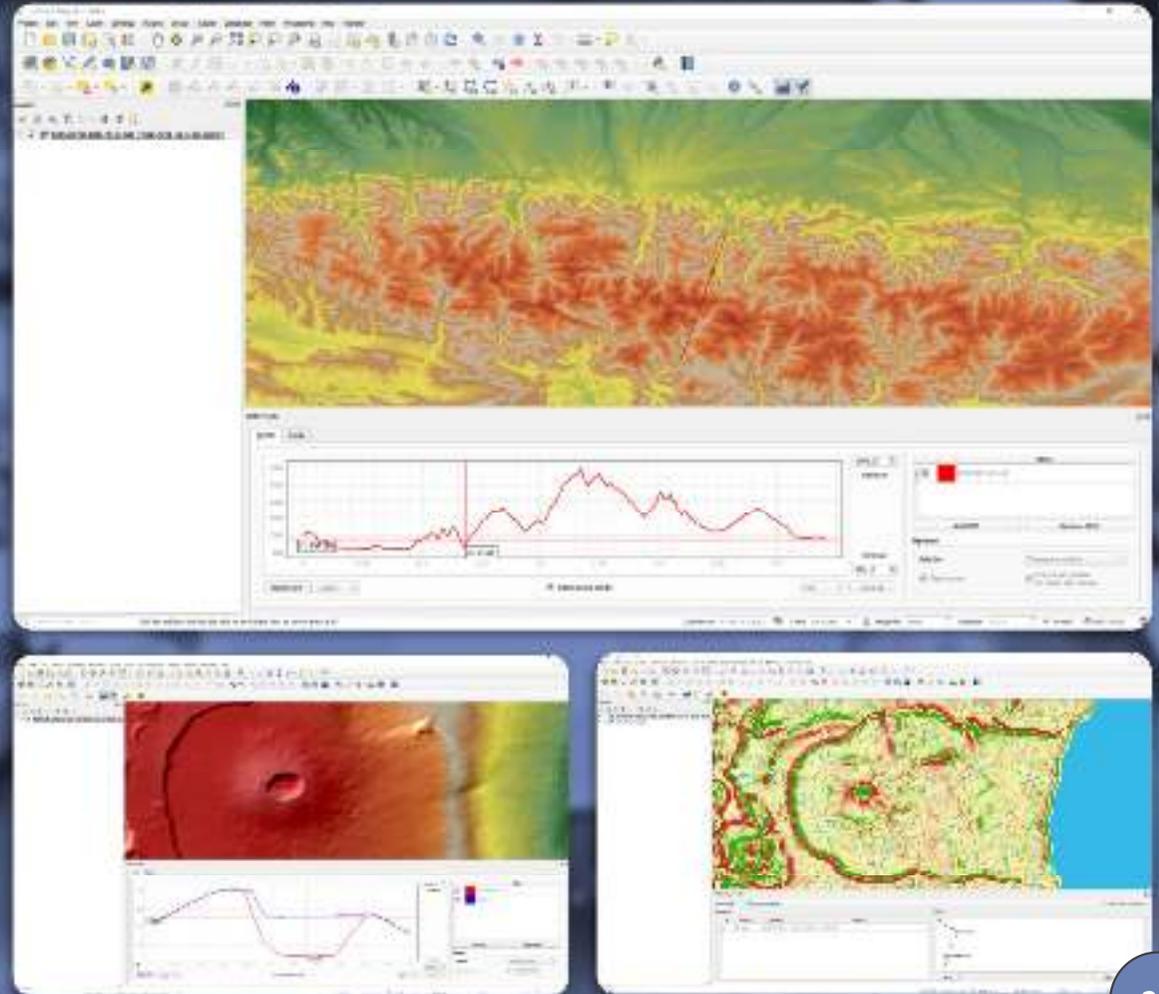
B. DEM tools and platforms (5)

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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