CEOS-WGCV

Terrain Mapping Subgroup (TMSG) update report

Peter Strobl, EC-JRC

Agenda Item 3.7

WGCV-54

16-17 October 2024

Sioux Falls, South Dakota, USA

Committee on Earth Observation Satellites

Overview

- Status
- DEMIX past and present
- GCPIX -> tomorrow!
- Outlook

TMSG status

Proceedings of the Terrain Mapping SubGroup (TMSG)

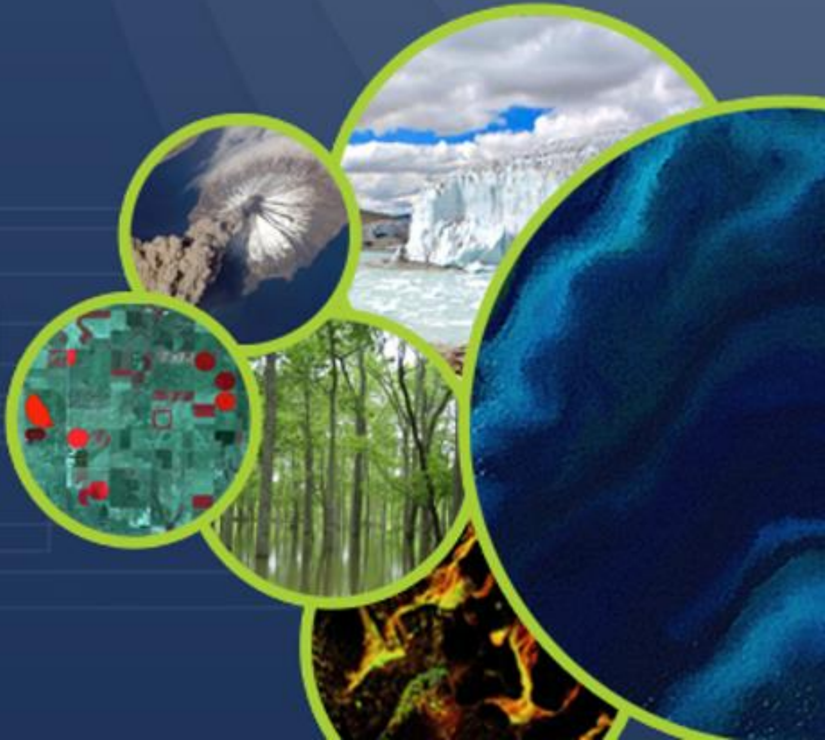
- Re-activated early 2020
- as of Oct 10th 2024:
  - 60 subscriptions (-5)
  - 15 countries
  - ~50% with CEOS background (12 agencies)
  - ~30% Geomorphometry.org (although they are overall more active!)
- ongoing activities: DEMIX 'follow on', GCPix 'preparations'
- virtual TMSG plenary 10 Oct 2024 – 20 participants

Minor update!

Subscription page: https://ec.europa.eu/eusurvey/runner/WGCV-TMSG_membership

Committee on Earth Observation Satellites

DEMIX Past & Present



DEMIX outcome

after

- 4 years,
- 3 plenaries,
- Teams groups
- 3 subgroups, each with 5-15 active members,
- 130+ subgroup meetings, each with at least 4 participants
- a conference paper and video,
- 4 peer-reviewed publications,
- a new 'DEMIX tiling' system,
- a processing platform
- and a comprehensive final report (almost...)!

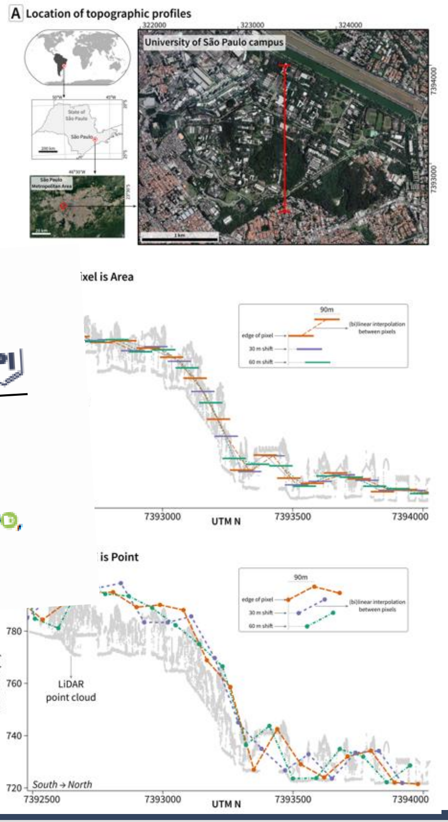
Terminology

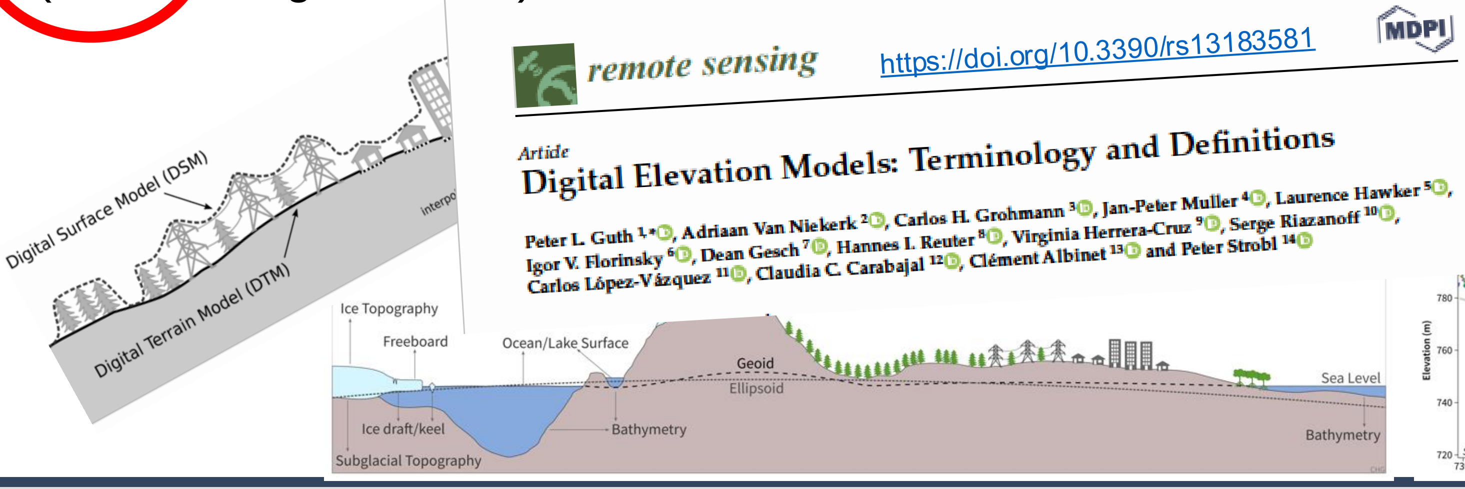
Revised terminology and developed comprehensive definitions (glossary)

Peer reviewed paper published,

83 citations as of 10/2024: [Guth et. al. 2021]

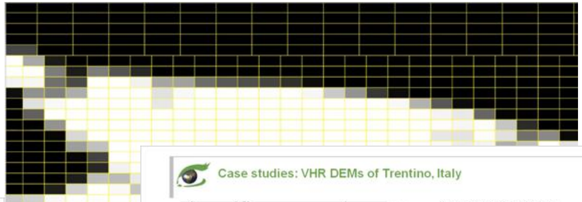
(129 in Google scholar)

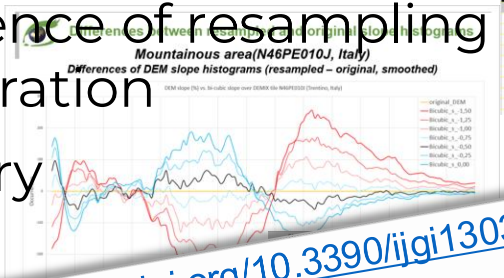




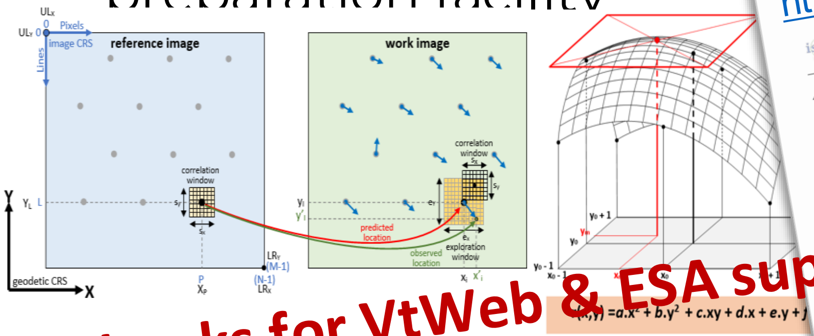
Preparatory and support activities

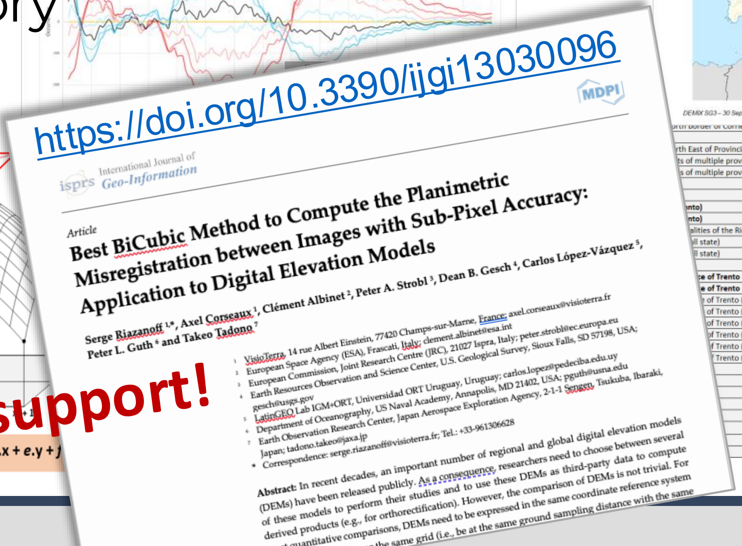
- ❖ Global master grid ('DEMIX-tiles') implemented
- ❖ Extensive study on influence of resampling on planimetric misregistration
- ❖ Reference DEM repository and DEMIX test tile preparation facility





...orth border of Corrientes)	5 m	DTM	Not found
	30 m	DSM	v2.1 (date not found)
...rth East of Provincia de Buenos Aires)	depend on tile	DTM	Not found
...ts of multiple provinces)	0.5 m	DTM	Not found
...s of multiple provinces)	0.5 m	DSM	Not found
	1.5 m	DTM	2021
	1.5 m	DSM	2021
...nto)	**2 m**	**DSM**	**(26.04.2021)**
...nto)	**2 m**	**DTM**	**(26.04.2021)**
...alities of the Rio Doce Basin Committee)	0.5 m (in GeoTIFF)	DSM	(26.05.2021)
...ll state)	1 m	DSM	Not found
...ll state)	1 m	DTM	Not found
	-	-	(2002)
...ce of Trento	**1 m (type 1), 2 m (type 2, 3)**	**DSM**	**Not found**
...e of Trento	**1 m (type 1), 2 m (type 2, 3)**	**DTM**	**Not found**
...e of Trento (Campolongo only)	1 m	DSM	Not found
... of Trento (Campolongo only)	1 m	DTM	Not found
... of Trento (without Campolongo)	0.5 m	DBM (DTM + Buildings)	Not found
...of Trento (without Campolongo)	0.5 m	DSM	Not found
...f Trento (without Campolongo)	0.5 m	DSM	Not found
...f Trento (without Campolongo)	0.5 m	DTM	Not found
	1 m	DTM	(17.02.2015)
	1 m	DSM	(17.02.2015)
	1 m	DTM	(2020)
	1 m	DSM	(2020)
	1 m	DSM	(2020)
	10 m	DSM ?	(2007)
	1 m	DTM	25.09.2022
	1 m	DSM	24.09.2022




https://doi.org/10.3390/ijgi13030096

MDPI

International Journal of Geo-Information

Article

Best BiCubic Method to Compute the Planimetric Misregistration between Images with Sub-Pixel Accuracy: Application to Digital Elevation Models

Serge Riazanoff [1,*], Axel Corseaux [1], Clément Albinet [2], Peter A. Strobl [3], Dean B. Gesch [4], Carlos López-Vázquez [5], Peter L. Guth [6] and Takeo Tadono [7]

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Abstract: In recent decades, an important number of regional and global digital elevation models (DEMs) have been released publicly. As a consequence, researchers need to choose between several of these models to perform their studies and to use these DEMs as third-party data to compute derived products (e.g., for orthorectification). However, the comparison of DEMs is not trivial. For ... quantitative comparisons, DEMs need to be expressed in the same coordinate reference system ... the same grid (i.e., be at the same ground sampling distance with the same

Thanks for VtWeb & ESA support!

DEMIX ‘wine contest’

WORKFLOW

Step 1		Obtain high quality source elevation data	**Obtain and mosaic DEMs covering test area** 6 candidate global DEMs, 1", geographic Source reference DTM: 1-5m UTM projection Source reference DSM: if available	
Step 2	MICRODEM	Prepare reference DEMs from the source data	**Aggregate reference DEMs to 1" spacing** Pixel-is-point Pixel-is-area For high lat COPDEM, separate Pixel-is-point For high lat ALOS, separate Pixel-is-area	**Convert to WGS84/EGM2008 if needed** Convert to ellipsoid, then to geoid Use grids from NGA via PROJ and national/regional mapping agency Use GDAL for areas in the USA
Step 3	MICRODEM	Evaluate the reference and test DEMs	**Process test areas and create GIS database** Compute test area statistics Create difference outputs Compute metrics Produce Evaluations table with initial tolerances	
Step 4	Jupyter Notebook	Rank the global DEMs	**Produce Wine Contest** Produce Opinions table Compute confidence levels Produce final rankings Adjust tolerances if required Filter database Produce graphics	

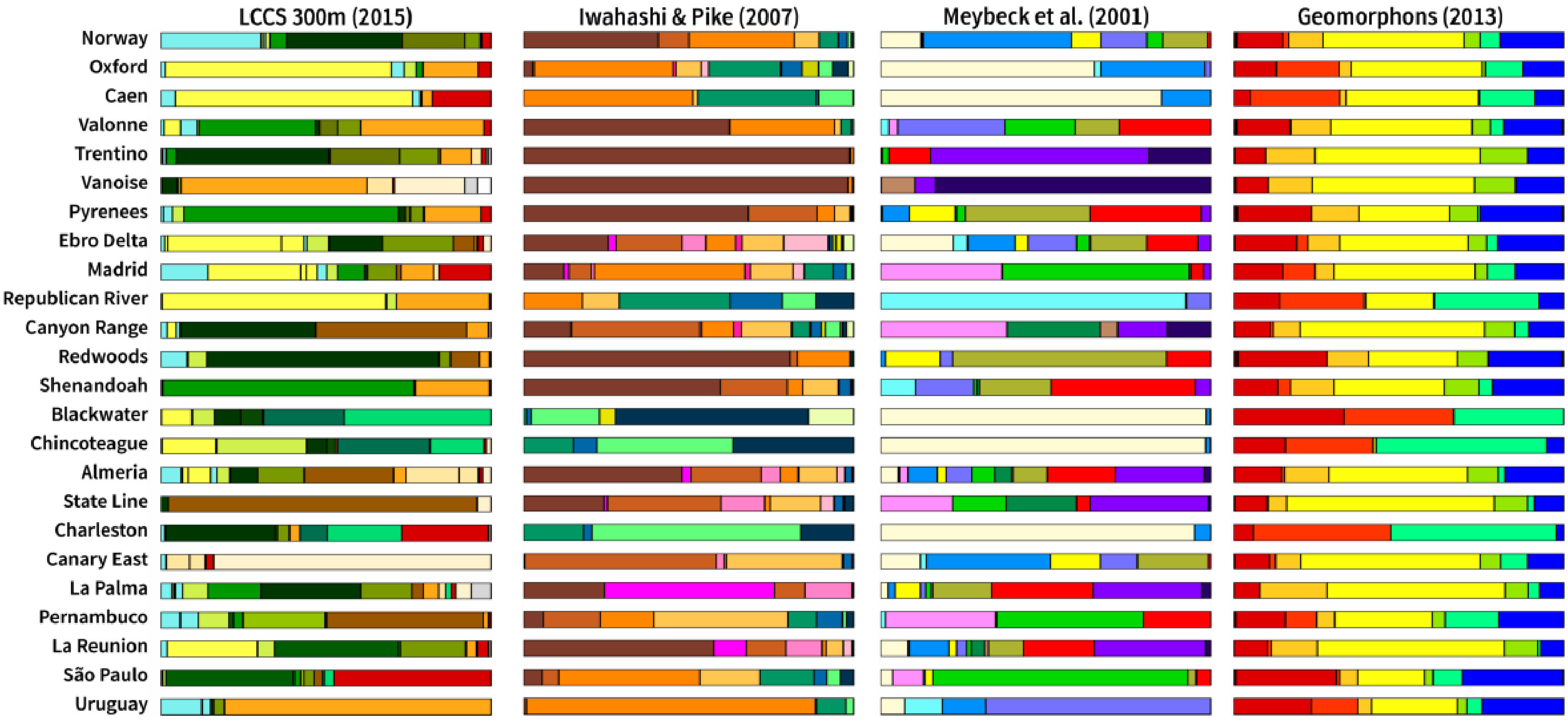
Courtesy: C. Grohman

DEMIX test area distribution

- 24 test areas, 236 DEMIX tiles (10x10km^2) on four different continents with reference data
- Reference data preparation tool
- All major geomorphological landforms and landcover types represented incl. coastal areas (partial water)
- 15 different criteria in 3 classes (Elevation, slope, roughness)
- Pixel by pixel comparison against reference data
- >55.000 individual test scenarios (rows in opinions database)

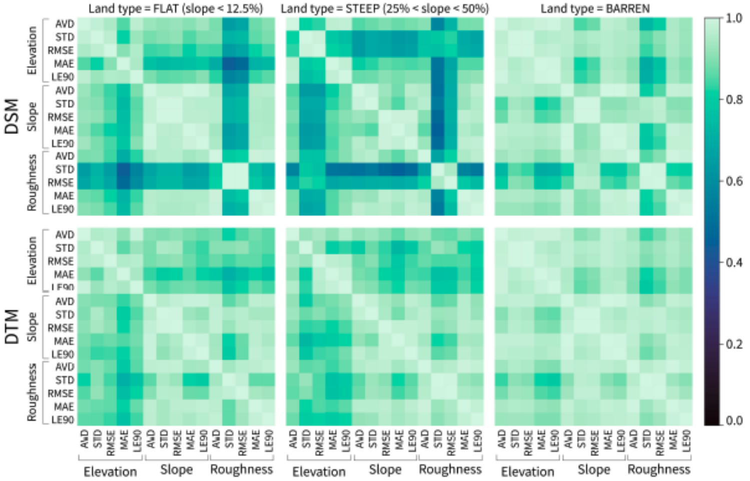
Courtesy: C. Grohman

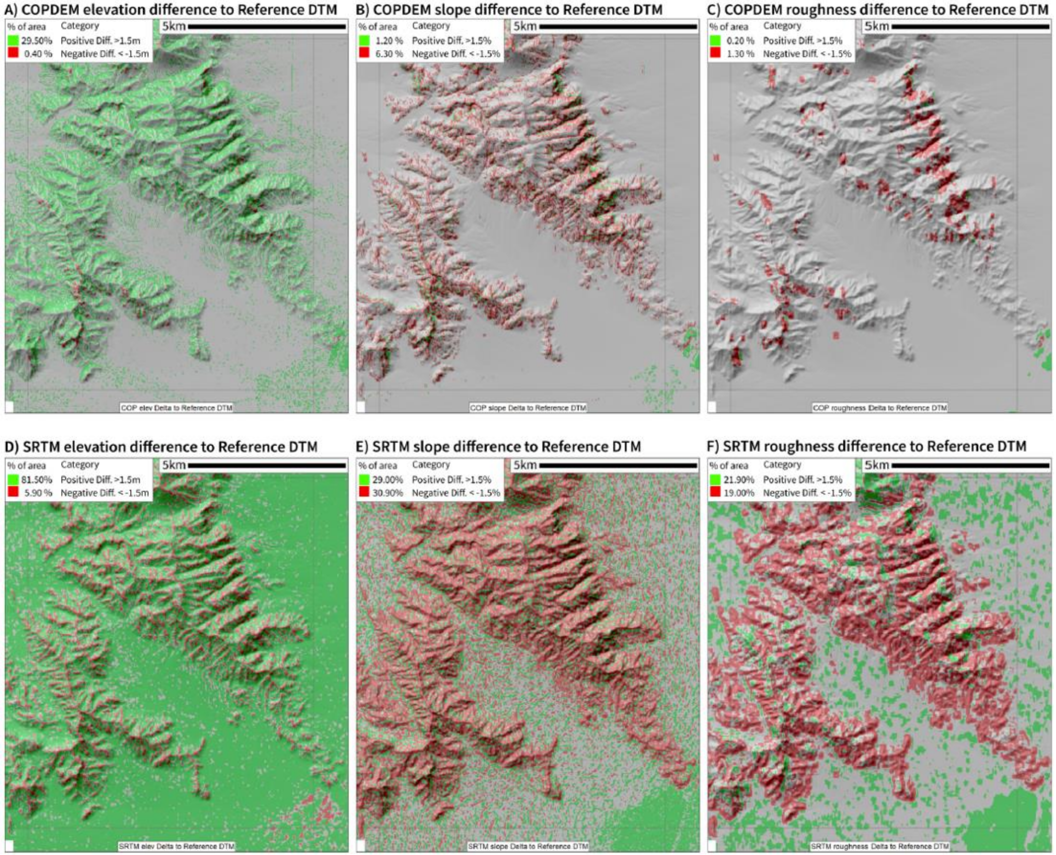
DEMIX test area variability



DEMIX test criteria

- 3 main classes of criteria: elevation, slope, and roughness difference





… and the winner is:

AWARDS

COPDEM | Overall best DSM

FABDEM | Best DTM
(except for steep terrain)

ALOS AW3D30 | Sometimes 2nd place
might be better in steep terrain than FABDEM

Courtesy: C. Grohman

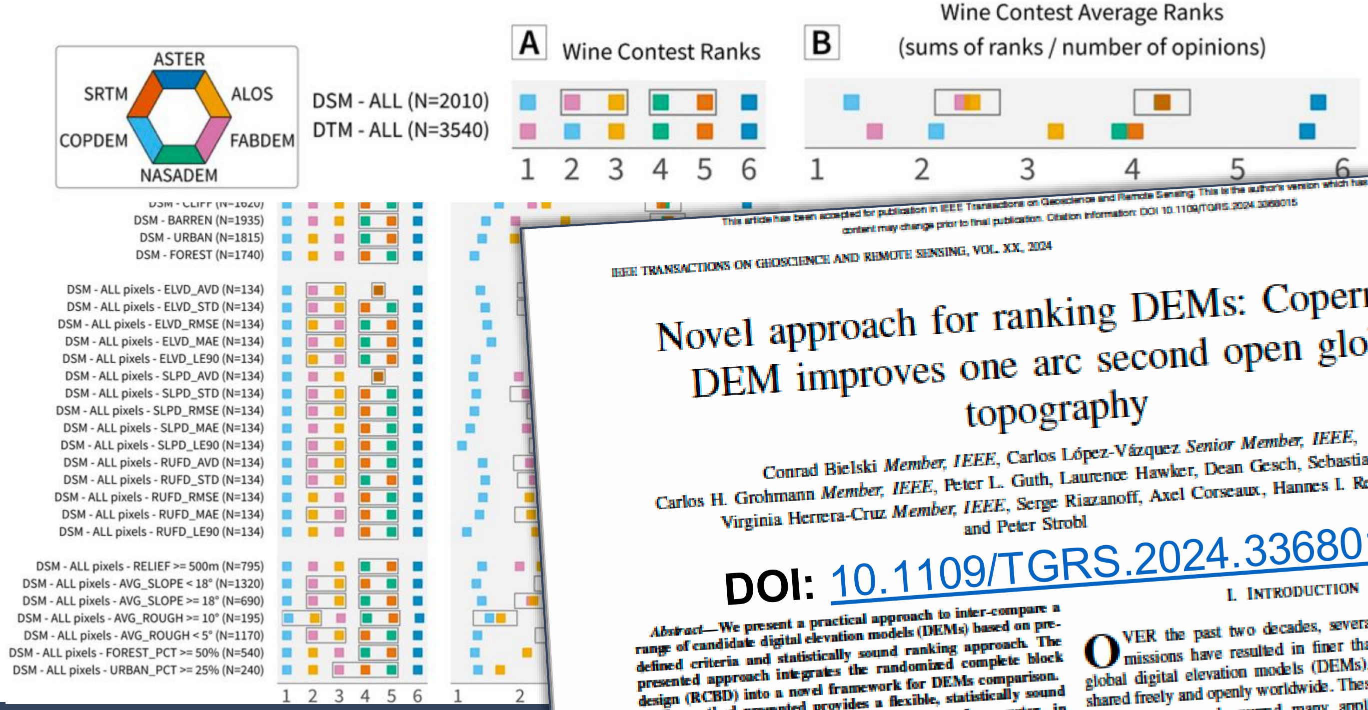
Overall appraisal

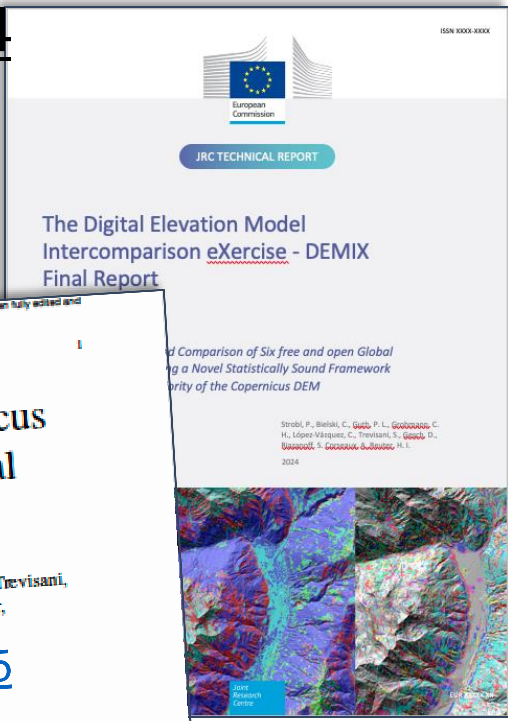
- CopDEM and FABDEM are clearly the frontrunners
- ALOS was generally the third best and sometimes second place
- FABDEM improves on CopDEM in most cases where a DTM is required
- SRTM and NASADEM are distinctly in the lower half of rankings, NASADEM only produced modest improvements and not throughout
- Encourage users to move away from using them, unless historic data are required
- ASTER should be used only exceptionally where truly justified

Job done!

Peer reviewed paper accepted: Bielski et al 2024

Final report close to release (JRC technical report)





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IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. XX, 2024

Novel approach for ranking DEMs: Copernicus DEM improves one arc second open global topography

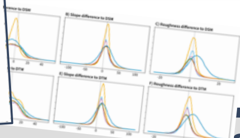
Conrad Bielski *Member, IEEE*, Carlos López-Vázquez *Senior Member, IEEE*, Carlos H. Grohmann *Member, IEEE*, Peter L. Guth, Laurence Hawker, Dean Gesch, Sebastiano Trevisani, Virginia Herrera-Cruz *Member, IEEE*, Serge Riazanoff, Axel Corseaux, Hannes I. Reuter, and Peter Strobl

DOI: 10.1109/TGRS.2024.3368015

Abstract—We present a practical approach to inter-compare a range of candidate digital elevation models (DEMs) based on pre-defined criteria and statistically sound ranking approach. The presented approach integrates the randomized complete block design (RCBD) into a novel framework for DEMs comparison. The method presented provides a flexible, statistically sound and customizable tool for evaluating the quality of any raster - in this case a DEM - by means of a ranking approach, which takes

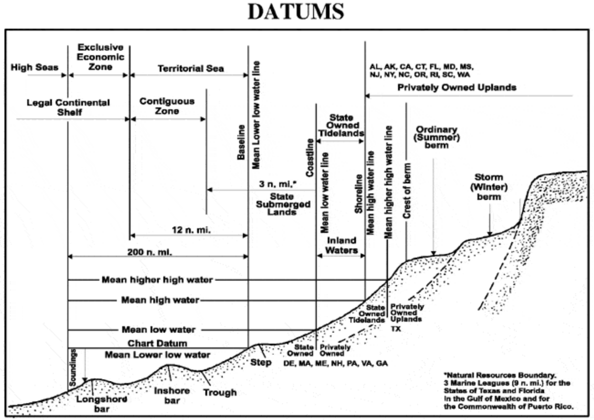
I. INTRODUCTION

OVER the past two decades, several Earth observation missions have resulted in finer than 100 m resolution global digital elevation models (DEMs), most of which are shared freely and openly worldwide. These data revolutionized earth sciences and spurred many applications that require accurate information about the shape of Earth's surface. Con-



Up to new shores!

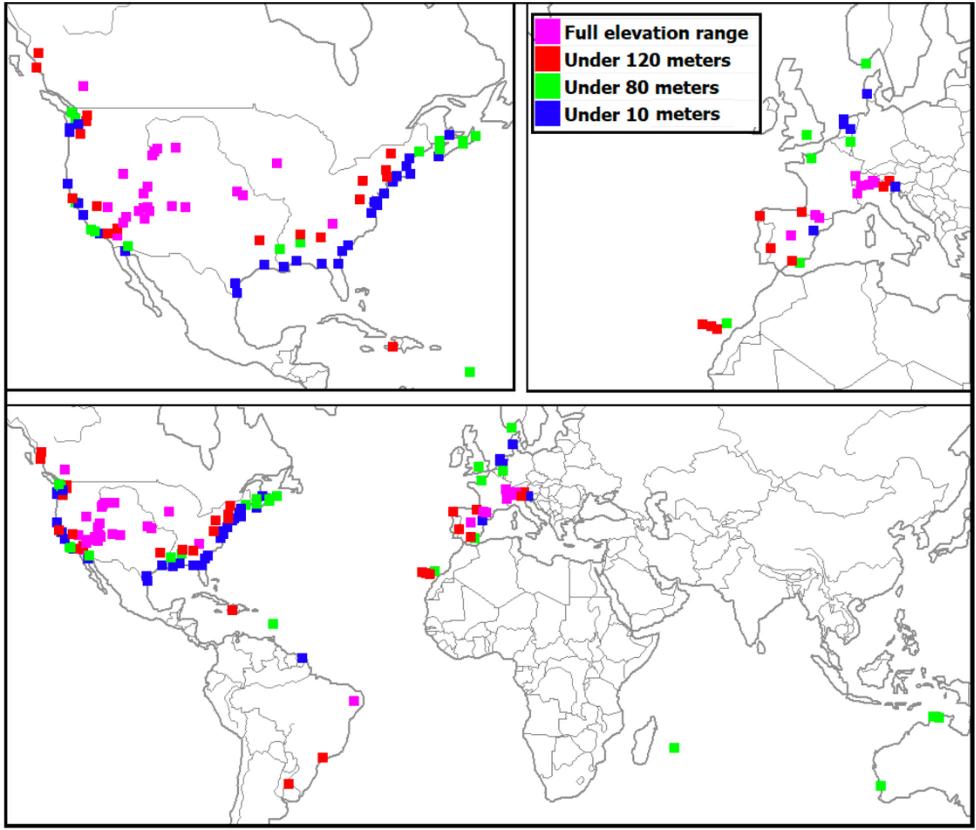
- Coastal areas globally are witness to growing disaster risks.
- The elevation/area around “Coastlines” are the interface between land and water (+/- 10m depth/height)
- Detailed elevation models are required to estimate tide areas (sea level rise), emergency (tsunami), environment (e.g. loss of biodiversity), inhabitants impact (e.g. urban development)
- **Objective: to test global coastal elevation datasets**



Source: Tidal Datums https://www.oc.nps.edu/nom/day1/tidal_datums_fig17.gif – Picture: ©AdobeStock- licenced obtained Further Reference: https://www.nature.com/articles/s41558-024-01950-2

More sites

- More test areas (124) and DEMIX tiles (3462).
- 4 additional global DEMs for a total of 6 DSMs and 4 edited DTMs. (SRTM, NASADEM, ASTER not evaluated)
- 16 derived land surface parameters (LSPs) in addition to elevation.



More criteria

17 geomorphometric parameters, 2 landform classifications, 2 hydr. vectors

Criterion	Meaning	Computing Category	Geomorpho-metric Category	Computation Area	Additional Grids Required	Algorithm	Computation Software
ELEV	Elevation	Grid FUV	Grid value	Single grid cell		N/A	N/A
SLOPE	Slope	Grid FUV	First derivative	3 × 3 neigh-borhood		[34]	MICRODEM
TPI	Topographic position index	Grid FUV	First derivative	7 × 7 neigh-borhood		[35]	MICRODEM
HILL	Hillshade	Grid FUV	Perceptive index or First derivative	3 × 3 neigh-borhood		Originally based on [36]	MICRODEM
OPEND	Downward openness	Grid FUV	Perceptive index	8 radials out to 250 m		[37]	MICRODEM
OPENU	Upward openness	Grid FUV	Perceptive index	8 radials out to 250 m		[37]	MICRODEM
RUFF	Roughness (standard deviation of slope)	Grid FUV	Second derivative	5 × 5 slopes (7 × 7 elevations)		[38]	MICRODEM
RRI	Radial roughness index	Grid FUV	Second derivative	5 × 5 neigh-borhood		[39]	MICRODEM
PROFC	Profile curvature	Grid FUV	Second derivative	3 × 3 neigh-borhood		[20]	WhiteboxTools
TANGC	Tangent curvature	Grid FUV	Second derivative	3 × 3 neigh-borhood		[40]	WhiteboxTools
ROTOR	Rotor	Grid FUV	Second derivative	3 × 3 neigh-borhood		[41]	Whitebox Workflows
PLANC	Plan curvature	Grid FUV	Second derivative	3 × 3 neigh-borhood		[42]	WhiteboxTools

Criterion	Meaning	Computing Category	Geomorpho-metric Category	Computation Area	Additional Grids Required	Algorithm	Computation Software
HAND	Height above nearest drainage (elevation above stream)	Grid FUV	Hydrology related	Entire test area	Flow accu-mulation, streams	[43]	Whitebox Workflows
WETIN	Wetness index	Grid FUV	Hydrology related	Entire test area	Flow accu-mulation, slope	[44]	WhiteboxTools
LS	Sediment transport (slope length factor)	Grid FUV	Hydrology related	Point and downslope neighbors	Flow accu-mulation, slope	[45,46]	Whitebox Workflows
CONIN	Convergence index	Grid FUV	Hydrology related	3 × 3 neigh-borhood		[47]	Whitebox Workflows
ACCUM	Flow accu-mulation, log transform	Grid FUV	Hydrology related	Entire test area		[48]	Whitebox Workflows
GEOM	Gemorphons	Per-pixel raster classification	Point classification	Local neigh-borhood		[49]	WhiteboxTools + MICRODEM
IP12	Iwahashi and Pike 12 category classification	Per-pixel raster classification	Point classification	10 cell neigh-borhood		[50]	SAGA
CHAN_MISS1	Channel network mismatch, 1 pixel wide channels	Vector comparison	Hydrology related	Entire test area		[17]	Whitebox Workflows + MICRODEM
CHAN_MISS3	Channel network mismatch, 3 pixel wide channels	Vector comparison	Hydrology related	Entire test area		[17]	Whitebox Workflows + MICRODEM

Fraction of unexplained Variance

FUV= 1-r²

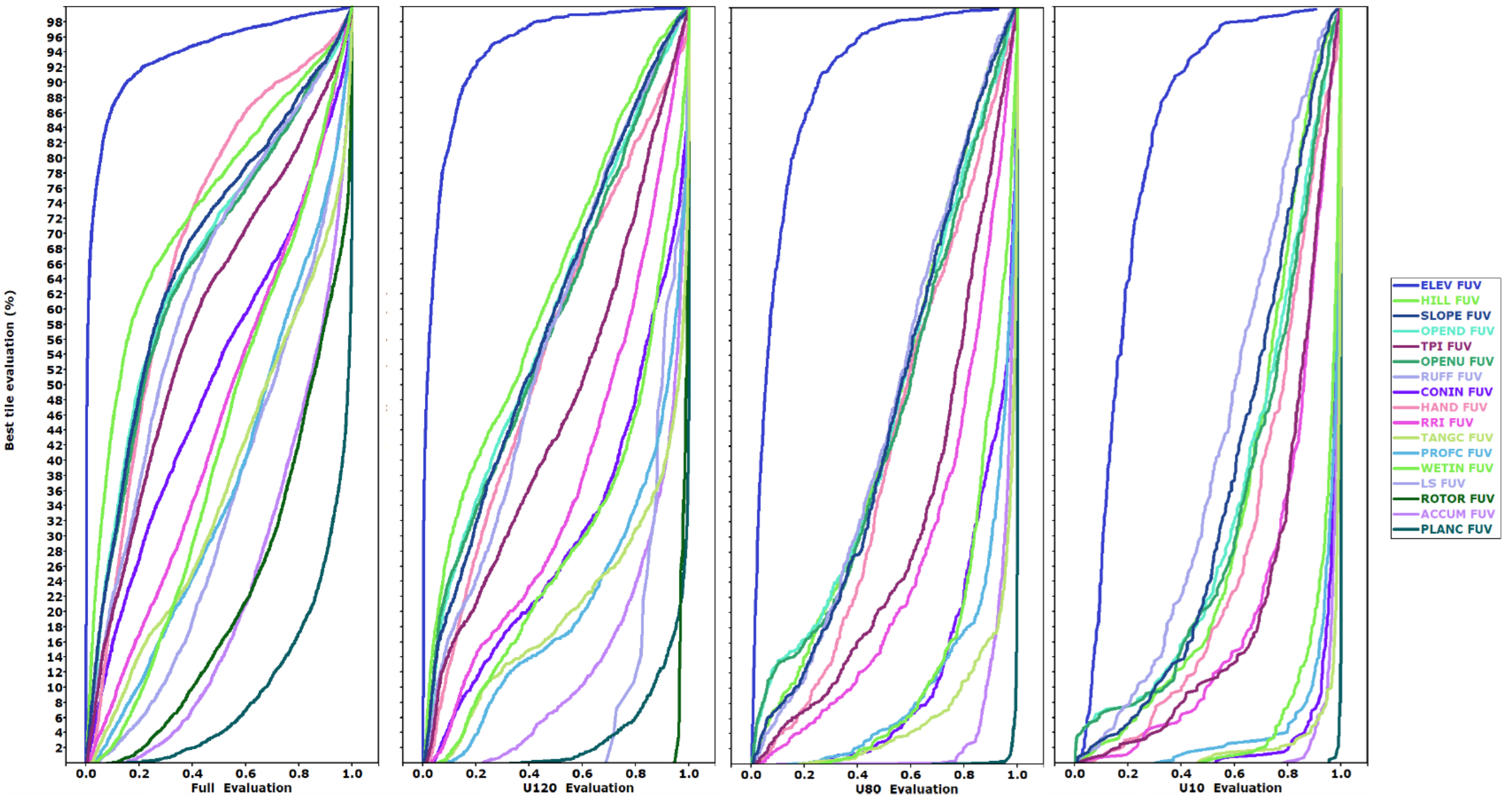
(Pearson coef)

0 = best fit

1 = no fit

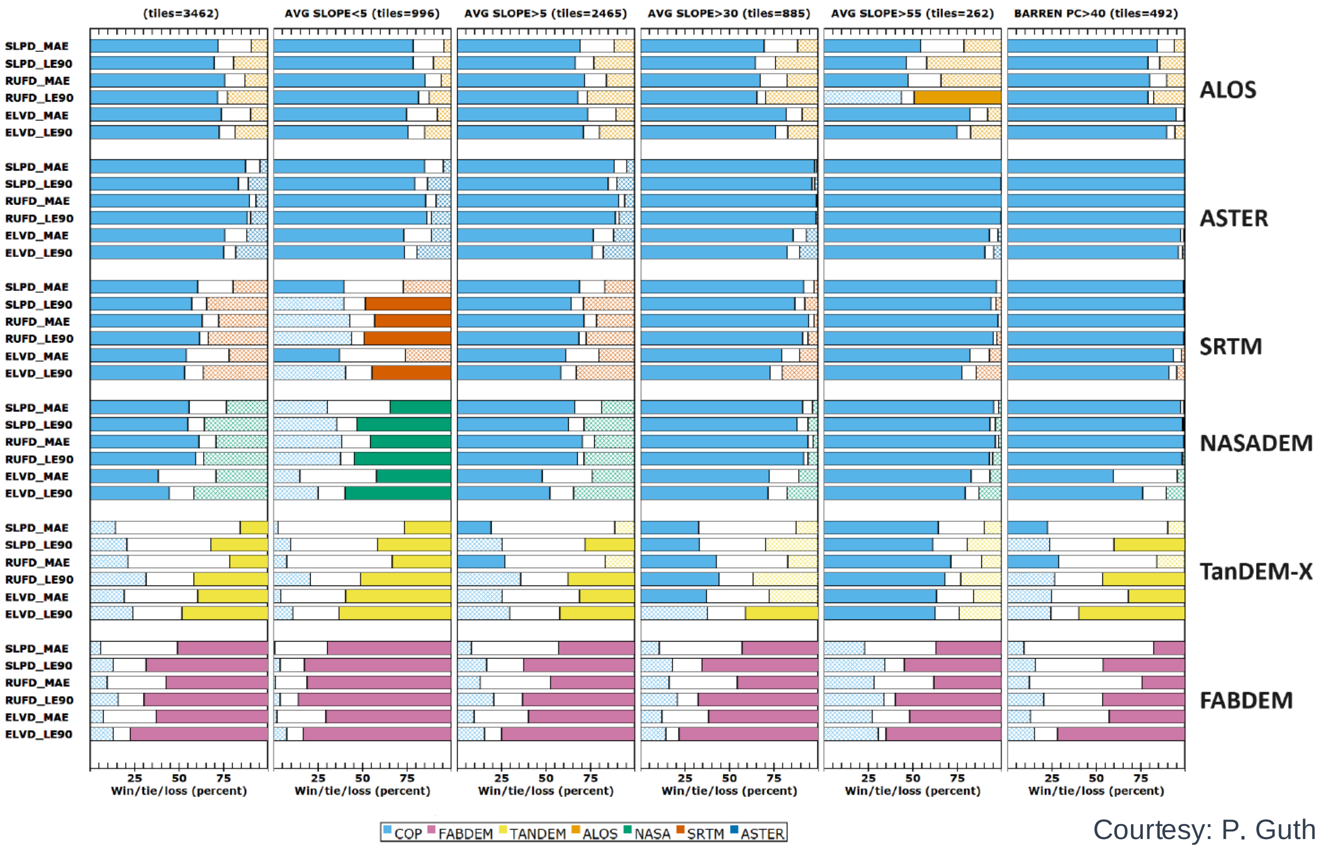
ELEVD ☺

ROTOR ☹



New comparison methods

- Direct comparison of DEM pairs performance against DTM reference
- Confirmation of. ‘wine contest’ findings
- Visually compelling



Courtesy: P. Guth

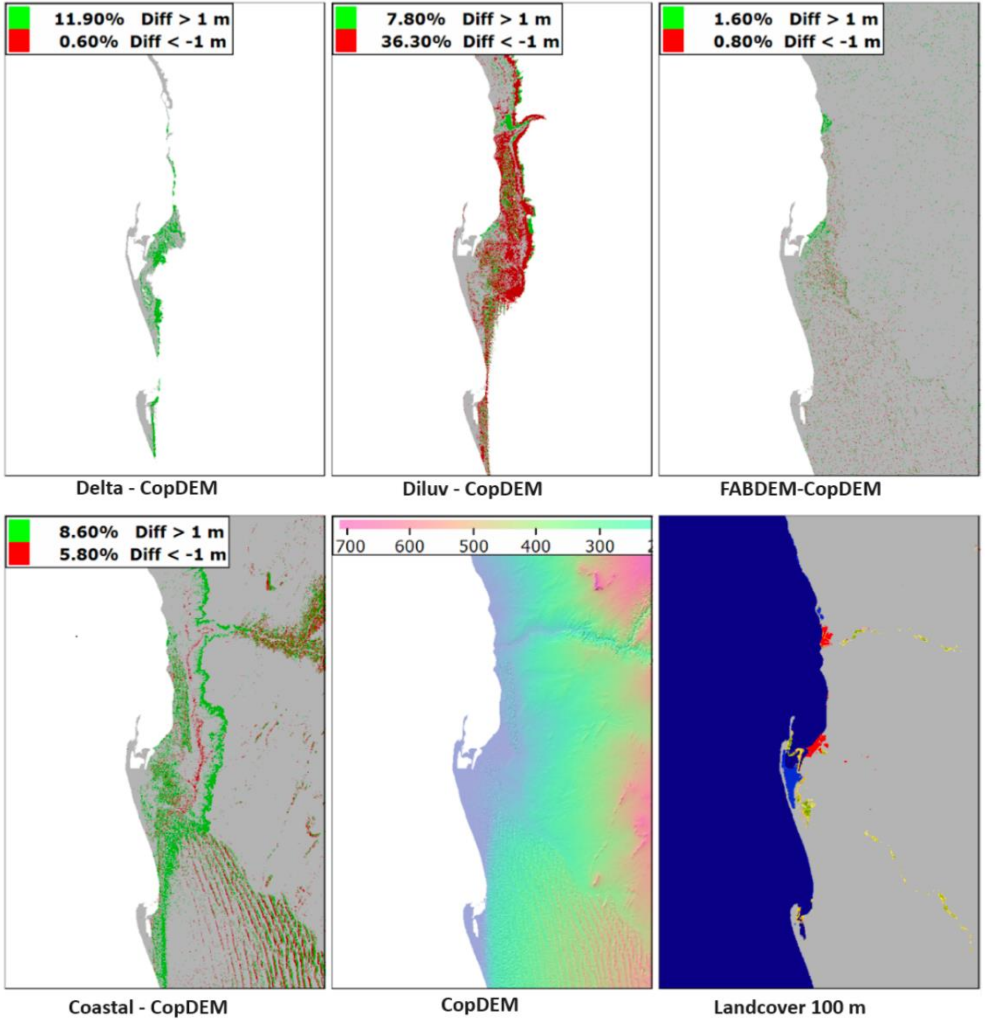
Focus on coastal areas

- Comparison to DTM
- CopDEM showing some weaknesses at lower elevation values
- But many products particular designed for coastal zones do not deliver better on more complex criteria

Courtesy: P. Guth

Hallucinating DTMs

- Comparison over mostly barren areas shows that AI-assisted removing of surface features not always enhances the DEM
- Least affected seems to be FABDEM



Courtesy: P. Guth

DEMIX reloaded—more DEMs, areas, criteria

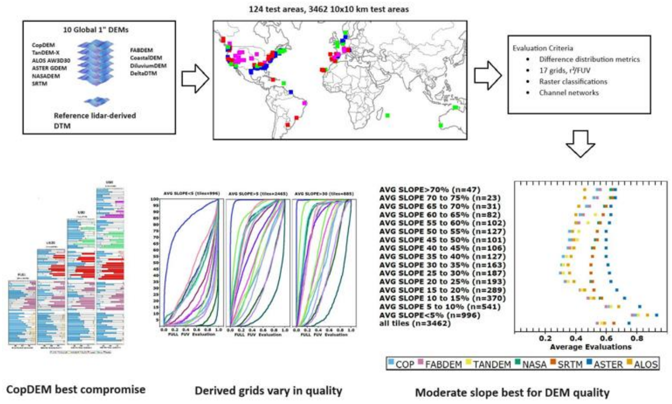
remote sensing MDPI

Article

Ranking of 10 Global One-Arc-Second DEMs Reveals Limitations in Terrain Morphology Representation

Peter L. Guth [1,*], Sebastiano Trevisani [2], Carlos H. Grohmann [3], John Lindsay [4], Dean Gesch [5], Laurence Hawker [6] and Conrad Bielski [7]

https://doi.org/10.3390/rs16173273



- Focussed assessment on coastal zones and low elevations
- Massively expanded number of test sites
- Many more complex criteria (e.g. for geomorphometry and hydrology)
- Subjective criteria for hundreds or thousands of test tiles not feasible.
- CopDEM remains best DEM, even compared to reference or edited DTMs.
- Edited DTMs improve on elevation metrics but worse for derived LSPs (hallucinate).

CEOS

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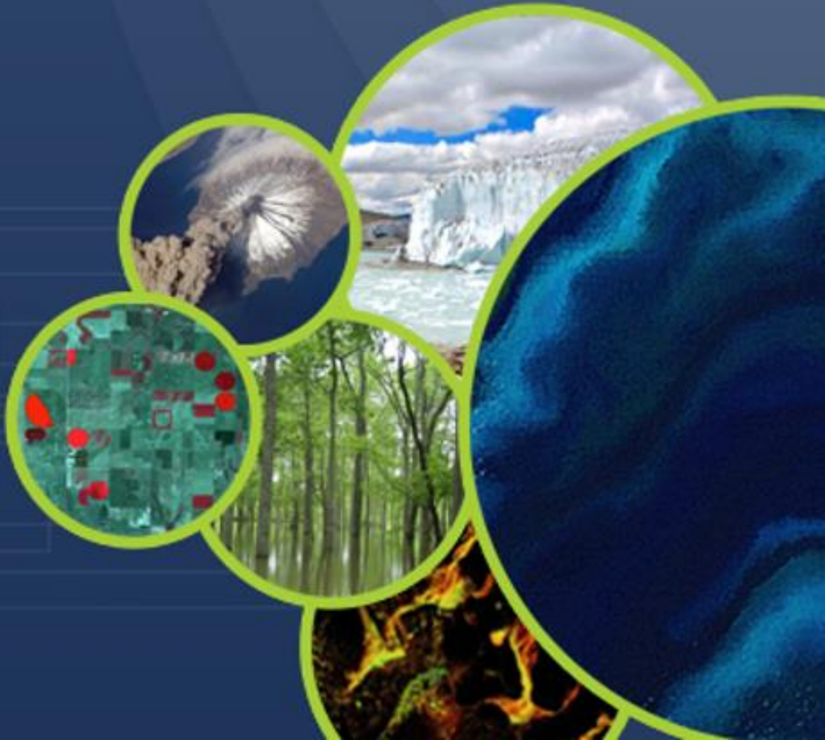
GCPIX (tomorrow)



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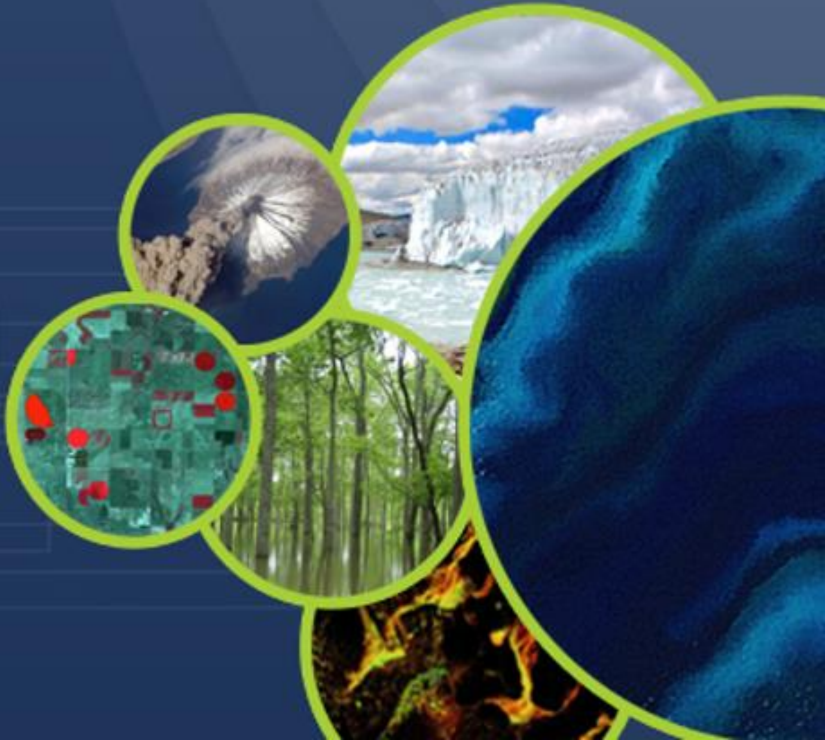
TMSG Quo Vadis?



TMSG & DEMIX future

- DEMIX report to be finished!
- Stop here or continue – change DEMIX ‘brand name’?
- Probably abandon or re-shape focus groups?
- Proceed with Teams group and channels?
- processing platform (VtWeb), relation to CAL …

- How to get GCPIX started (needs a moderator)!
- Linking DEM and GCP studies (3D GCPs)

- Should we look into global grids - who else?
- Finally a new (vice) chair?

TMSG is re-shaping! A perfect time to join and chime in.

Subscription page:
https://ec.europa.eu/eusurvey/runner/WGCV-TMSG_membership

Upcoming Meetings

- VH-RODA WS
  2-6 December 2024, Frascati, Italy
  https://earth.esa.int/eogateway/events/vh-roda

- Geomorphometry 2025
  09-13 June 2025, Perugia(!), IT
  https://www.geomorphometry.org/2025/
  - Piggy-backed by 2025 TMSG plenary

- Living Planet Symposium
  23-27 June 2025, Vienna, AT
  https://lps25.esa.int/

Thank you!

Big thanks to all active volunteers!
In particular the **sub-group leaders**:
Peter Guth, Carlos Grohman,
Conrad Bielski, Serge Riazanoff,
and **Carlos López-Vázquez**!

as well as ESA (Clement Albinet)
and USGS (Dean Gesch)
for their support!

any questions?

Peter.Strobl@ec.europa.eu

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