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Portfolio in Cartography and Remote Sensing

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► **To cite this version:**

Polina Lemenkova. Portfolio in Cartography and Remote Sensing. Doctoral. Salzburg, Austria, Austria. 2023, pp.24. hal-04612624

HAL Id: hal-04612624

<https://hal.science/hal-04612624v1>

Submitted on 14 Jun 2024

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Portfolio in Cartography and Remote Sensing

RS: Satellite image processing
Cartography: DEM and terrain modelling
Mapping and modelling Earth Observation (EO) data

Polina Lemenkova

December 21, 2023

Summary

Image processing

- Image processing
- Image segmentation
- Parametric classification
- Image analysis
- Color composites
- Time series analysis
- Computing vegetation indices
- Image classification
- Sequential pattern recognition
- Multi-source RS data processing

Programming

- Scripting and applied programming
- Python for data analysis, spatial and statistical modelling
- R language for terrain mapping
- Workflow modelling

Remote sensing methods in geophysics

- Technical skills in geophysical data processing
- Topographic 3D modelling by GMT scripting toolset
- Modelling cross-sections by GMT for analysis of slope steepness

Data science

- Statistical data analysis

Publications

Bibliography

My technical skills:

Professional background

- ⇒ Background in RS, image processing, applied geophysics and physical geography, geology, climate-related issues, environmental analysis and monitoring.
- ⇒ Strong extensive experience in RS data processing: satellite image classification, clustering, segmentation, analysis and interpretation;
- ⇒ Satellite images I worked with: Landsat 7 TM/ETM+, 8-9 OLI/TIRS (NASA/USGS), Sentinel-2A (Copernicus satellite missions), VHR SPOT, World Imagery, Pléiades-1A and 1B products of ESA.
- ⇒ Strong cartographic skills (print-quality maps, graphical plots and illustrations).
- ⇒ Programming and scripting skills; console-based data processing: Python and R for image processing and statistical analysis, modelling and visualization.

Software skills

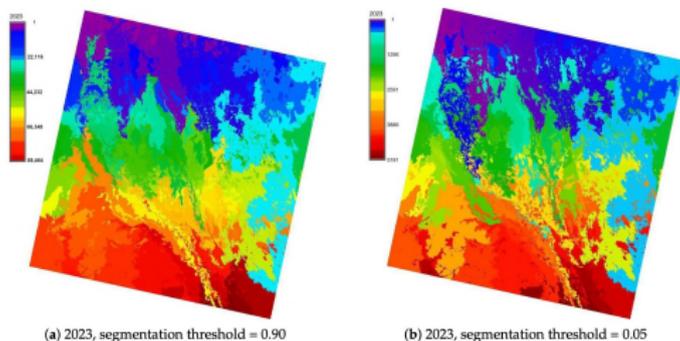
- ✓ Strong practical experience in GIS: GRASS GIS, GMT, QGIS, SAGA GIS, Erdas Imagine, ENVI GIS, ArcGIS, Idrisi, eCognition, GeoMedia.

Example

Examples of my works and links to papers with DOI are in the following slides.

Image segmentation: Landsat 8-9 OLI/TIRS

Segmentation of the image using techniques of thresholding (similarity analysis) using GRASS GIS module 'i.segment'. Edge detection, texture analysis, template matching and tracking for analysis of random segments using seeds at various levels.



Highlight

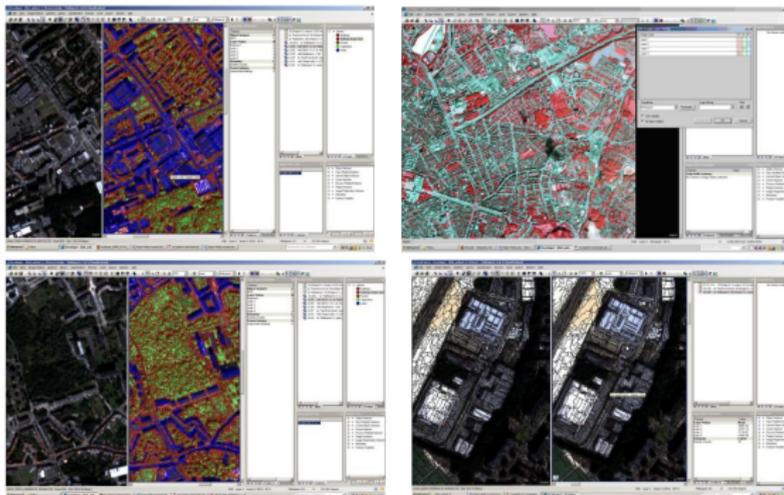
Segmentation the Landsat 8-9 OLI/TIRS image of Sudd area (South Sudan) with varied parameters: (a) minsize=5, threshold=0.90, (b) minsize=100, threshold=0.05.

Example

Source: *Image Segmentation of the Sudd Wetlands in South Sudan for Environmental Analytics by GRASS GIS Scripts*, Analytics, 2(3), 745–780): DOI: [10.3390/analytics2030040](https://doi.org/10.3390/analytics2030040).

Parametric classification in image segmentation using eCognition

Estimation of object parameters for object based image analysis (OBIA) using multi-scale segmentation of data derived from the satellite images with varied parameters and scale.

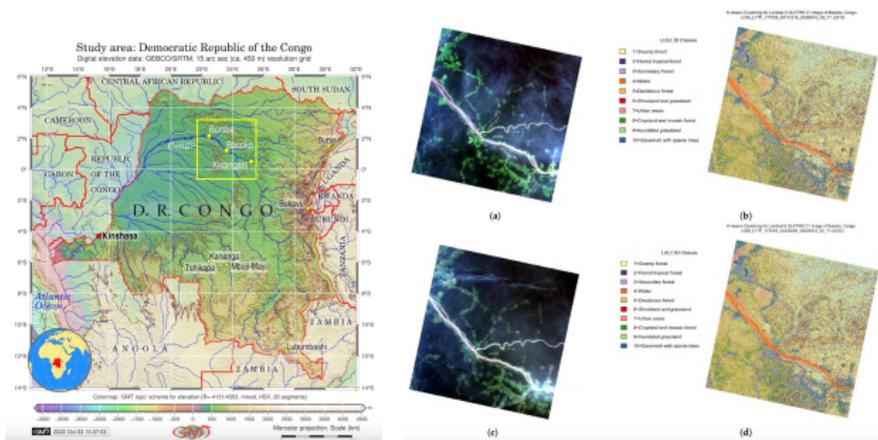


Examples of the VHR Pléiades ESA archive image processing using eCognition: a case of Brussels, Belgium.

Example

Source: *Topology, Homogeneity and Scale Factors for Object Detection: Application of eCognition Software for Urban Mapping using Multispectral Satellite Image*, INSO2015 Proceedings: DOI: [10.48550/arXiv.1901.00726](https://doi.org/10.48550/arXiv.1901.00726).

Image analysis: Landsat 8-9 OLI/TIRS



Highlight

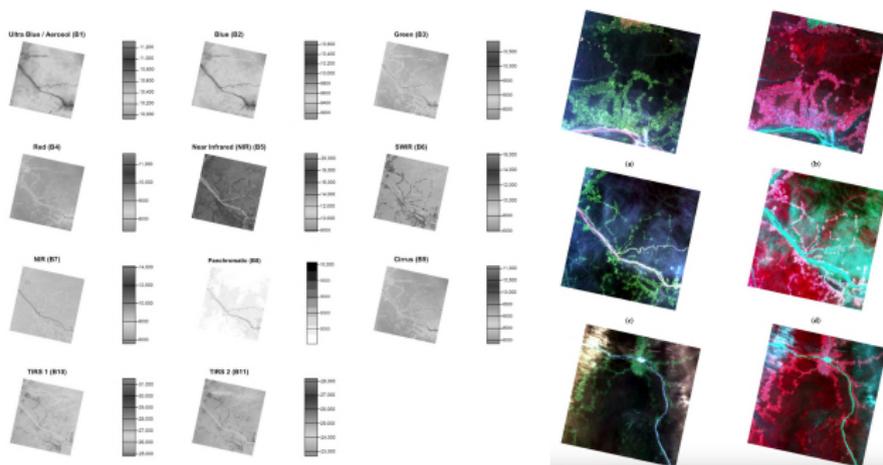
Libraries of the R language - RStoolbox, raster and terra - used to classify satellite images by k-means clustering and dynamics of vegetation in tropical rainforests.

Example

Source: *R Libraries for Remote Sensing Data Classification by K-Means Clustering and NDVI Computation in Congo River Basin, DRC*. Appli. Sci. 2022; 12(24):12554. DOI: 10.3390/app122412554.

Colour composite images: associating spectral monochrome bands to a primary colour triplets (RGB)

Creating natural or true/false color composites of an image using R to display a combination of visible Red, Green and Blue bands to the corresponding channels.



Highlight

The generated images reveal spatial details due to the intensity of pixels in false colour composites for water areas and sharpened view of urban areas in natural colour composites.

Time series analysis for mapping landscape dynamic

A set of satellite images taken from the same area at different times, time series analysis supports investigating the dynamic processes in ecosystem monitoring.



(a) 28 February 2017



(b) 1 April 2017



(c) 6 July 2017



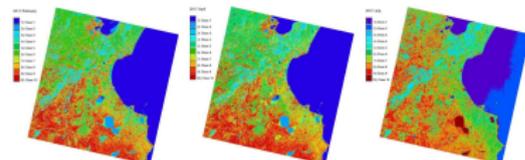
(d) 21 February 2023



(e) 10 April 2023



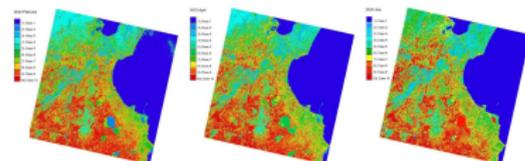
(f) 15 July 2023



(a) 28 February 2017

(b) 1 April 2017

(c) 6 July 2017



(d) 21 February 2023

(e) 10 April 2023

(f) 15 July 2023

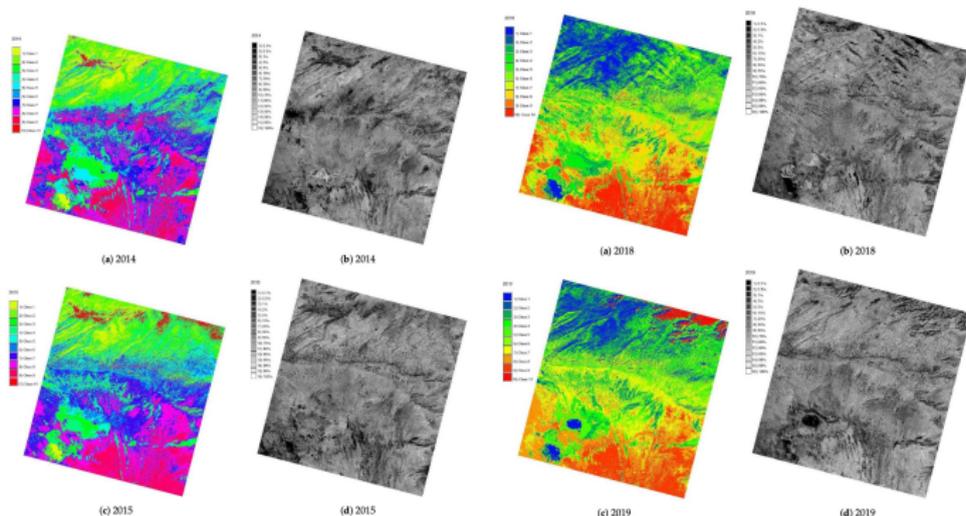
Highlight

Comparative analysis of images using GRASS GIS for mapping lacustrine environment in arid landscapes to evaluate the effects of seasonal fluctuations in land cover types.

Example

Monitoring Seasonal Fluctuations in Saline Lakes of Tunisia Using Earth Observation Data Processed by GRASS GIS. Land. 2023; 12(11):1995. DOI: [10.3390/land12111995](https://doi.org/10.3390/land12111995).

Image classification and quality assessment



Classification of pixels into 10 classes according to landscape types (coloured scenes), and computing rejection probability values with pixel classification confidence levels (monochrome images).

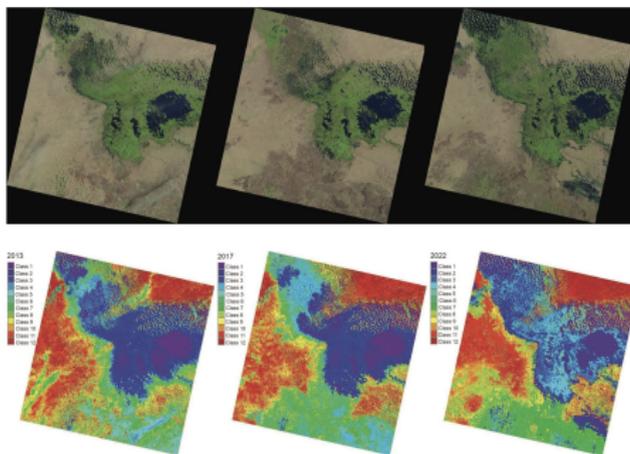
Highlight

RS data processing by GRASS GIS scripts for landscape analysis using k-means clustering technique.

Example

A GRASS GIS Scripting Framework for Monitoring Changes in the Ephemeral Salt Lakes of Chotts Melhrir and Merouane, Algeria, Appl. Syst. Innov. 2023, 6(4), 61; DOI: [10.3390/asi6040061](https://doi.org/10.3390/asi6040061)

Sequential pattern recognition



Highlight

Unsupervised automatic classification techniques for RS data processing using “i.maxlik” GRASS GIS module: analysis of lake shrinkage during recent decade.

Example

Using open-source software GRASS GIS for analysis of the environmental patterns in Lake Chad, Central Africa, 2023. Die Bodenkultur Journal of Land Management Food and Environment 74(1):49-64: DOI: [110.2478/boku-2023-0005](https://doi.org/10.2478/boku-2023-0005).

Multi-source geospatial data analysis: satellite and aerial images, maps

RS Data Analysis

Overlay of high-resolution satellite images, maps and historical aerial photographs enables to reveal land cover structures otherwise hidden from the eyes.



Highlight

Different parameters of RS data enables to adjust scale-depending mapping. Example: Landsat 8–9 OLI/TIRS has narrower spectral bands, higher calibration, finer radiometric resolution and geometry and better signal-to-noise parameters compared to Landsat-7 TM/ETM+. In turn, aerial photographs enable to enlarge target regions.

Example

Multispectral Satellite Image Analysis for Computing Vegetation Indices by R in the Khartoum Region of Sudan, Northeast Africa, Journal of Imaging. 2023; 9(5):98:

DOI: [10.3390/jimaging9050098](https://doi.org/10.3390/jimaging9050098).

My GitHub repository with programming codes and scripts: <https://github.com/paulinelemenkova>

My skills in applied programming and scripting languages:

- ✓ Python (Matplotlib, terra, Seaborn, NumPy, SciPy, Pandas and other libraries)
- ✓ R (a wide variety of packages)
- ✓ MATLAB and its open source analogue Octave language
- ✓ AWK and pother Unix utilities for console-based data processing
- ✓ Shell scripting in GMT and GRASS GIS syntax
- ✓ Data converting, reprojecting and formatting by GDAL and PROJ.

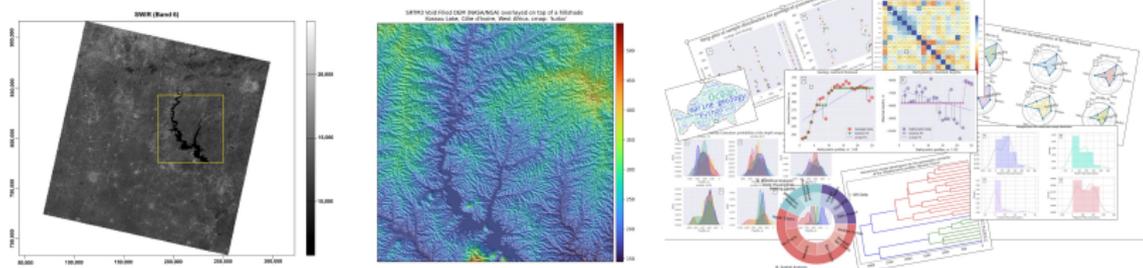
My skills in markup languages:

- ✓ \LaTeX , \TeX . Compilers: Lua \LaTeX , Xe \LaTeX . HTML/CSS, XML, gedit, LyX document processor, Notepad++.
- ✓ Bibliographies: Bib \LaTeX , Biber, MakeIndex.
- ✓ Strong experience in \LaTeX => submission of scientific papers

My skills in standard Office suite:

- ✓ Proficiency in Word, Excel, Access, PowerPoint for usual document processing.

I use Python for spatial and statistical data analysis and modelling



Examples of my mapping DEM and graphical plotting using libraries of Python for spatial data analysis.

Highlight

I use various libraries of Python for data analysis, modelling and visualization. I have experience in DEM modelling by library 'EarthPy' for terrain analysis (image left). I also worked with diverse libraries (Matplotlib, Seaborn, NumPy, Plotly) for statistical data visualization and various technique of plotting (image right). Python is a very useful tool in multi-disciplinary research applications, and I use it in my research.

Example

Example paper: *Satellite Image Processing by Python and R Using Landsat 9 OLI/TIRS and SRTM DEM Data on Côte d'Ivoire, West Africa*, in: Journal of Imaging, 8(12), 317: DOI: [10.3390/jimaging8120317](https://doi.org/10.3390/jimaging8120317).

R programming for terrain modelling (DEM, slope/aspect, relief hillshade)

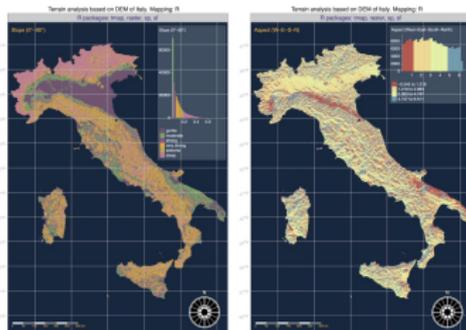
```

RStudio File Edit View Find Navigator Editor Product Debug Source Control Window
Data: RasterSource_1.pnm - Editor

Data: RasterSource_1.pnm - Editor
Data: RasterSource_1.pnm - Editor

# Example: DEM processing with R
library(terra)
DEM = rast("DEM.tif")
SLOPE = slope(DEM)
ASPECT = aspect(DEM)
RELIEF = relief(DEM)
HILLSHADE = hillshade(DEM)

# Plotting
plot(SLOPE)
plot(ASPECT)
plot(RELIEF)
plot(HILLSHADE)
    
```



Highlight

I have advanced skills in R: diverse packages for DEM modelling, satellite image processing, statistical data analysis and plotting. I apply R for geomorphological modelling and geospatial data analysis or topographically diverse surfaces.

Example

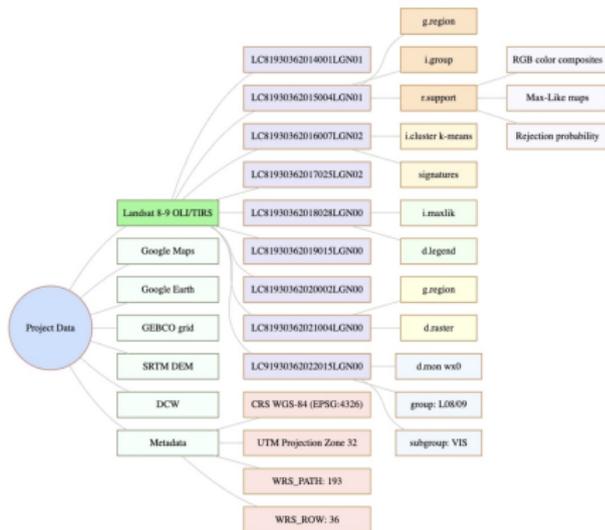
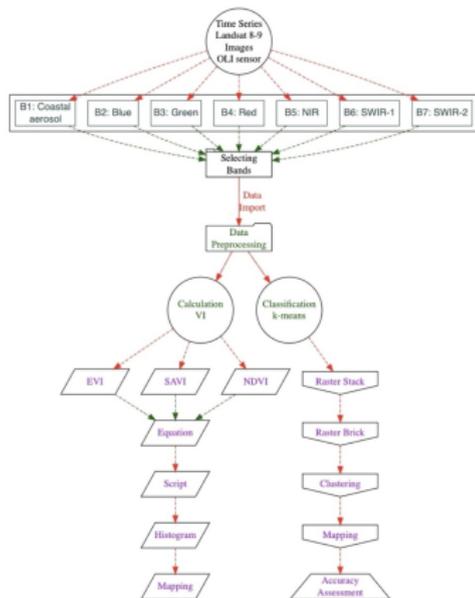
Example of my research based on R for data analysis and modelling: *Tanzania Craton, Serengeti Plain and Eastern Rift Valley: mapping of geospatial data by scripting techniques*, in: *Estonian Journal of Earth Sciences*, 71(2), 61–79: DOI: [10.3176/earth.2022.05](https://doi.org/10.3176/earth.2022.05).

Workflow modelling

Conceptual workflow modelling for organising multiple tasks

Workflow modelling and organizational flowcharts

I use R packages *DiagrammeR* and *mermaid* for plotting workflow graphs when processing RS data and organising projects on satellite image processing.



Acoustic remote sensing data and methods for geophysical signal processing

Geophysical Data Analysis

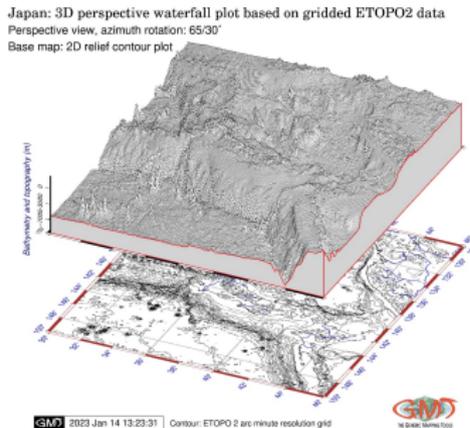
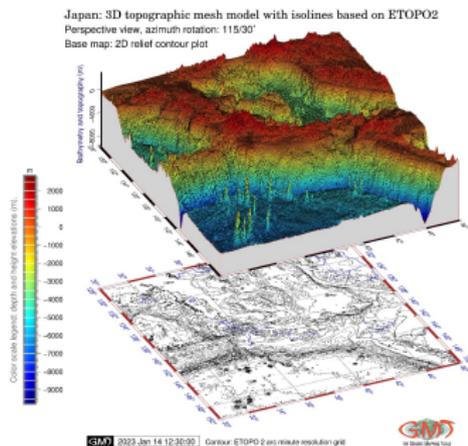
I worked in *Schmidt Institute of Physics of the Earth, RAS, Dept. of Natural Disasters, Anthropogenic Hazards and Seismicity of the Earth. Lab. of Regional Geophysics and Natural Disasters* =>

I have a strong hands-on experience in processing geophysical RS data (acoustic signals) and theoretical background in processes related to soil properties and inner structure of the Earth. I process acoustical signals by applied methods of RS data analysis to characterise land structures and properties of materials.

Examples

1. *Ultrasonic P- and S-Wave Reflection and CPT Soundings for Measuring Shear Strength in Soil Stabilized by Deep Lime/Cement Columns in Stockholm Norvik Port.* Archives of Acoustics, 48(3), 325-346. DOI: [10.24425/aoa.2023.145243](https://doi.org/10.24425/aoa.2023.145243).
2. *Computer Vision Algorithms of DigitSeis for Building a Vectorised Dataset of Historical Seismograms from the Archive of Royal Observatory of Belgium.* Sensors. 2023; 23(1):56. DOI: [10.3390/s23010056](https://doi.org/10.3390/s23010056)
3. *Simplex Lattice Design and X-ray Diffraction for Analysis of Soil Structure: A Case of Cement-Stabilised Compacted Tills Reinforced with Steel Slag and Slaked Lime,* Electronics, 11(22):3726, 2022: DOI: [10.3390/electronics11223726](https://doi.org/10.3390/electronics11223726).
4. *Dynamics of Strength Gain in Sandy Soil Stabilised with Mixed Binders Evaluated by Elastic P-Waves during Compressive Loading.* Materials 15(21):7798, 2022. DOI: [10.3390/ma15217798](https://doi.org/10.3390/ma15217798).
5. *Coherence of Bangui Magnetic Anomaly with Topographic and Gravity Contrasts across Central African Republic,* Minerals, 13(5), 604: DOI: [10.3390/min13050604](https://doi.org/10.3390/min13050604).
6. *Shear bond and compressive strength of clay stabilised with lime/cement jet grouting and deep mixing: A case of Norvik, Nynäshamn,* Nonlinear Engineering 11(1):693-710, 2022: DOI: [10.1515/nleng-2022-0269](https://doi.org/10.1515/nleng-2022-0269).
7. *Seismic monitoring of strength in stabilized foundations by P-wave reflection and downhole geophysical logging for drill borehole core.* Journal of the Mechanical Behavior of Materials, 32(1), 2023, 20220290. [10.1515/jmbm-2022-0290](https://doi.org/10.1515/jmbm-2022-0290)

Topographic 3D modelling by GMT scripting toolset



Examples of my 3D mapping of Japan Archipelago and terrain grid using ETOPO2 data and GMT.

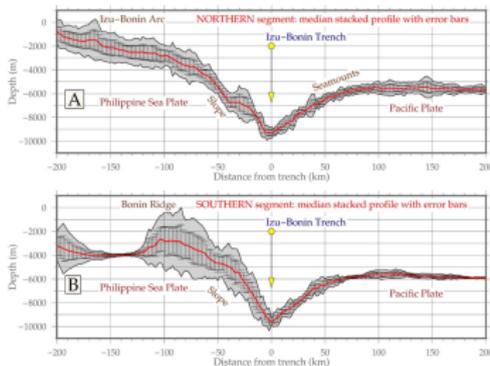
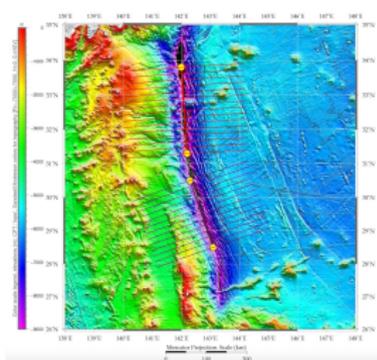
Highlight

I can map 3D and perspective plots by GMT scripting for visualization of the terrain. I use various data: GEBCO/SRTM and ETOPO1 grids for geomorphological mapping.

Example

Full paper: *Quantitative Morphometric 3D Terrain Analysis of Japan Using Scripts of GMT and R*, in: *Land*, 12(1), 261: DOI: [10.3390/land12010261](https://doi.org/10.3390/land12010261).

Modelling cross-sections by GMT for analysis of slope steepness



Examples of my modelling of the cross-section profiles using GMT.

Highlight

I can map cross-sections by GMT to visualise a complex sequence of terraces and deposits including ancient layers in structural terraces. It is useful for analysis of landscape dynamics from buried fill terraces to present. Cross-sections can be used for modelling the effects of erosion, floodplains or hydrological analysis of river valleys.

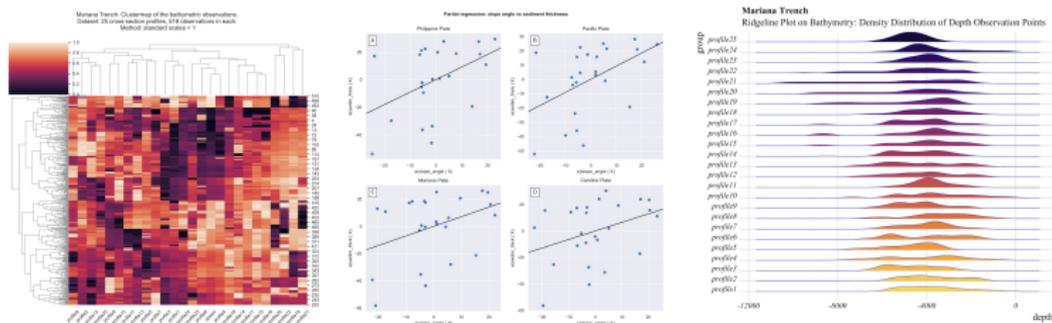
Example

Example paper: *Variations in the bathymetry and bottom morphology of the Izu-Bonin Trench modelled by GMT*, in: Bulletin of Geography. Physical Geography Series, 18(1), 41–60: DOI: [10.2478/bgeo-2020-0004](https://doi.org/10.2478/bgeo-2020-0004).

Statistical data modelling and analysis

Statistical Analysis

My skills in statistical analysis include a variety of data modelling techniques using tabular data format (processing tables): plotting histograms, box plots, QQ quantiles, regression analysis, cluster analysis (dendrograms, data grouping, k-means), ANOVA, correlation matrices, PCA, density curves KDE, 3D scatter plots, pie charts, etc.



Examples of my plotting using libraries of Python and R for data analysis (here: submarine geoarchaeology analysed by cross-section profiles).

Examples

Paper: *Statistical Analysis of the Mariana Trench geomorphology Using R Programming Language*, Geodesy and Cartography, 45(2), 57–84: DOI: [10.3846/gac.2019.3785](https://doi.org/10.3846/gac.2019.3785).

Publications: my experience on RS data processing reported in journals

I continuously publish my research on satellite image analysis

- I have a strong publication record and experience in publishing scientific papers.
- I have strong skills in academic writing on RS and Earth Observation topics. In my papers I report the whole process of performed research, logical structure and organising of workflow, performing related tasks (literature review on RS data processing, flowcharts, RS data analysis, visualization of the processed satellite images and mapping, description of results).
- The most of my articles are published in journals indexed in [Scopus/WoS](#).
- My papers are publicly available in open access mode on [ResearchGate](#), [Academia.edu](#), [Google Scholar](#) and other research-related websites of academic and professional community.
- To promote papers, I retweet them in Twitter and LinkedIn, and post on Facebook. Sharing helps to improve metrics, gain citations, attract social feedback, and have a greater impact.
- Selected examples of my recent publications are provided in this presentation.

Soft skills:

- * Motivation for cross-disciplinary research: cartographic visualization and mapping + remote sensing + GIS + Earth Observation data
- * Working in international and multi-disciplinary teams with different educational backgrounds.
- * Time management skills: attention to deadlines, multi-task regime, communication.

Bibliography

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- [9] P. Lemenkova. "Mapping Ghana by GMT and R scripting: advanced cartographic approaches to visualize correlations between the topography, climate and environmental setting". In: *Advances in Geodesy and Geoinformation* 71 (1 May 2022). Article no. e16, pp. 1–20. DOI: [10.24425/gac.2022.141169](https://doi.org/10.24425/gac.2022.141169).
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- [20] P. Lemenkova. "GEBCO Gridded Bathymetric Datasets for Mapping Japan Trench Geomorphology by Means of GMT Scripting Toolset". In: *Geodesy and Cartography* 46 (3 2020), pp. 98–112. DOI: 10.3846/gac.2020.11524.
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- [24] P. Lemenkova. "The geomorphology of the Makran Trench in the context of the geological and geophysical settings of the Arabian Sea". In: *Geology, Geophysics and Environment* 46 (3 Oct. 2020), pp. 205–222. DOI: 10.7494/geo1.2020.46.3.205.