

Sebastian van der Linden¹

Andreas Janz²

Benjamin Jakimow²

Fabian Thiel¹

Patrick Hostert²

¹Universität Greifswald

²Humboldt-Universität zu Berlin

EnMAP-Box 3

Visualisierung und Analyse von EnMAP Daten

GFZ
Helmholtz-Zentrum
POTSDAM



Gefördert durch:



aufgrund eines Beschlusses
des Deutschen Bundestages

The slide collection is provided free of charge under a Creative Commons Attribution-ShareAlike 4.0 International License [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

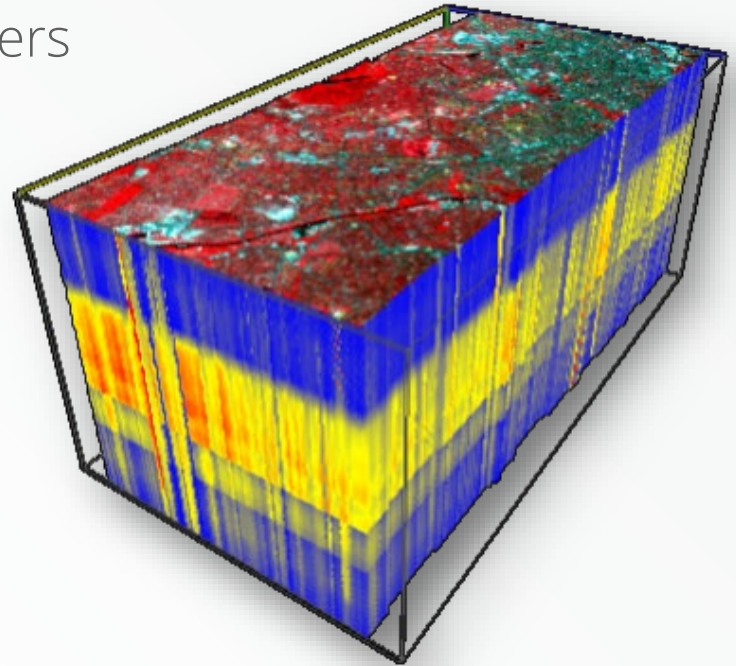


UNIVERSITÄT GREIFSWALD
Wissen lockt. Seit 1456



EnMAP-Box – Motivation and Aims

- ❖ Offer a free and open source environment for visualizing and analyzing EnMAP data
- ❖ Increase the number of EnMAP data users
- ❖ Integrate full GIS functionality with advanced image/spectral processing
- ❖ Suite of application-oriented advanced Workflows (Vegetation, Geology, ...)
- ❖ Foster the availability and exchange of state-of-the-art approaches for the analysis of imaging spectroscopy data and spectral libraries



EnMAP-Box – Imaging Spectroscopy in QGIS

EnMAP-Box GUI and Algorithm Provider



- ▶ EnMAP-Box
 - ▶ Accuracy Assessment
 - ▶ Auxilliary
 - ▶ Classification
 - ▶ Clustering
 - ▶ Convolution, Morphology and Filtering
 - ▶ Create Raster
 - ▶ Create Sample
 - ▶ Import Data
 - ▶ Masking
 - ▶ Post-Processing
 - ▶ Random
 - ▶ Regression
 - ▶ Resampling and Subsetting
 - ▶ Testdata
 - ▶ Transformation

❖ Comfortably import multiple sensors

The screenshot displays the EnMAP-Box 3 (3.8) software interface. The main window shows a 'Processing Toolbox' with a search bar containing 'math'. A 'Project' menu is open, listing various data sources and processing options, with 'Sentinel-2 L2A' selected. In the foreground, the 'Import Sentinel-2 L2A product' dialog box is open, showing a 'Band list' with 14 items, each with a checkbox and a 'Select All' button. The dialog also includes a 'Log' tab, a 'Metadata file' section, and an 'Output raster layer' section. The 'Run' button is highlighted in blue.

Import Sentinel-2 L2A product

Prepare a [spectral raster layer](#) from the given product. [Wavelength](#) information is set and data is scaled into the 0 to 10000 range.

Metadata file

The MTD_MSIL2A.xml metadata file associated with the product.

Band list

Bands to be stacked together. Defaults to all 10m and 20m bands ordered by [center wavelength](#). Note that the destination pixel size matches the smallest/finest pixel size over all selected bands.

Output raster layer

Raster file destination.

0% Cancel

Run Close Help

Create Sensor Synergies

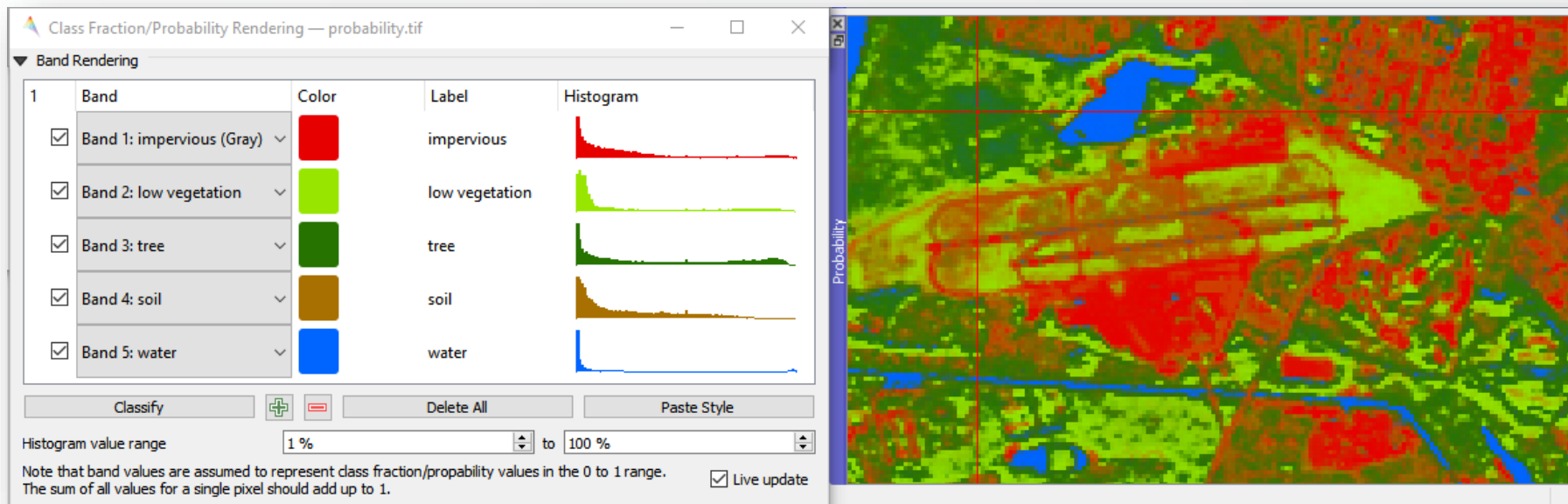
The screenshot displays the QGIS interface. The main map window shows a satellite image of a forested area with a red crosshair and a 30 km scale bar. A spectral plot window in the bottom left shows reflectance values (0.02 to 0.26) versus wavelength (1000 to 2000 nm). The 'Processing Toolbox' on the right lists the 'Import EMIT L2A product' algorithm. The 'Import EMIT L2A product' dialog box is open, showing parameters for NetCDF file, skip bad bands, output raster layer, and open output file after running algorithm. The dialog also includes a progress bar at 0% and buttons for Run, Close, and Help.

Various imaging spectrometers

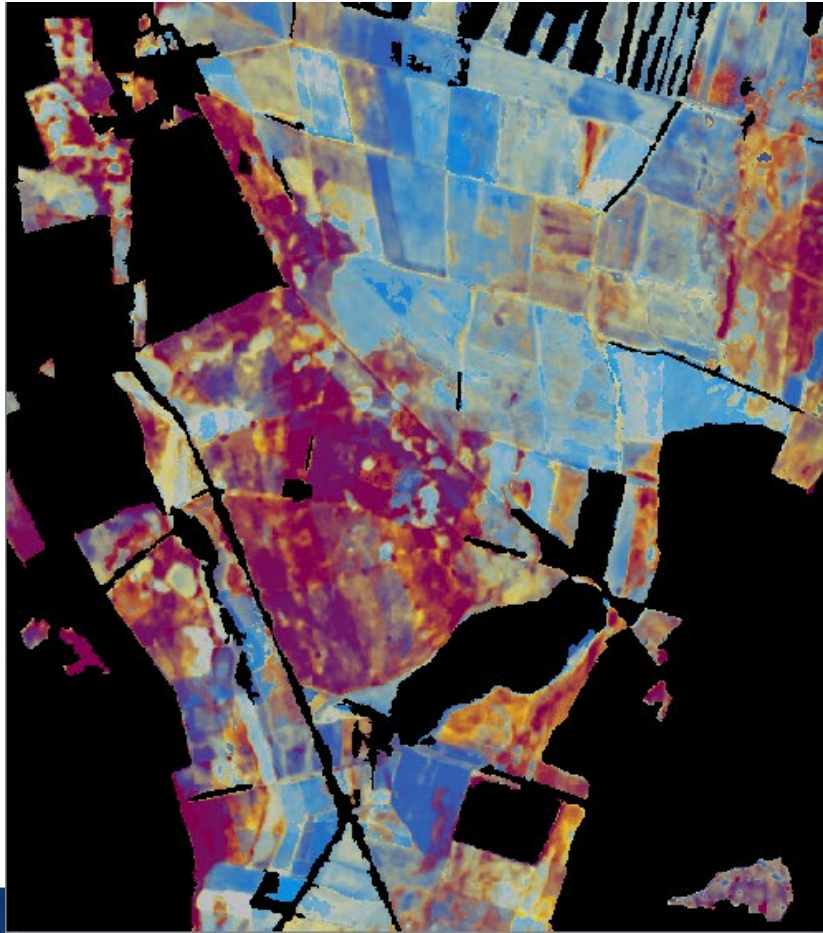
- ❖ PRISMA
- ❖ DESIS
- ❖ EMIT

Basic Tools – Class Fraction Statistics

- ❖ General tools optimized for quantitative results from EnMAP products



Basic Tools – Bivariate Color Renderer



Raster layer NDFI

Band 1 Band 1

Band 2 Band 2

Color plane ■ ■

5966.0

989.0

16.0 106.0

▼ Settings

Cumulative count cut 2,0 - 37,0 %

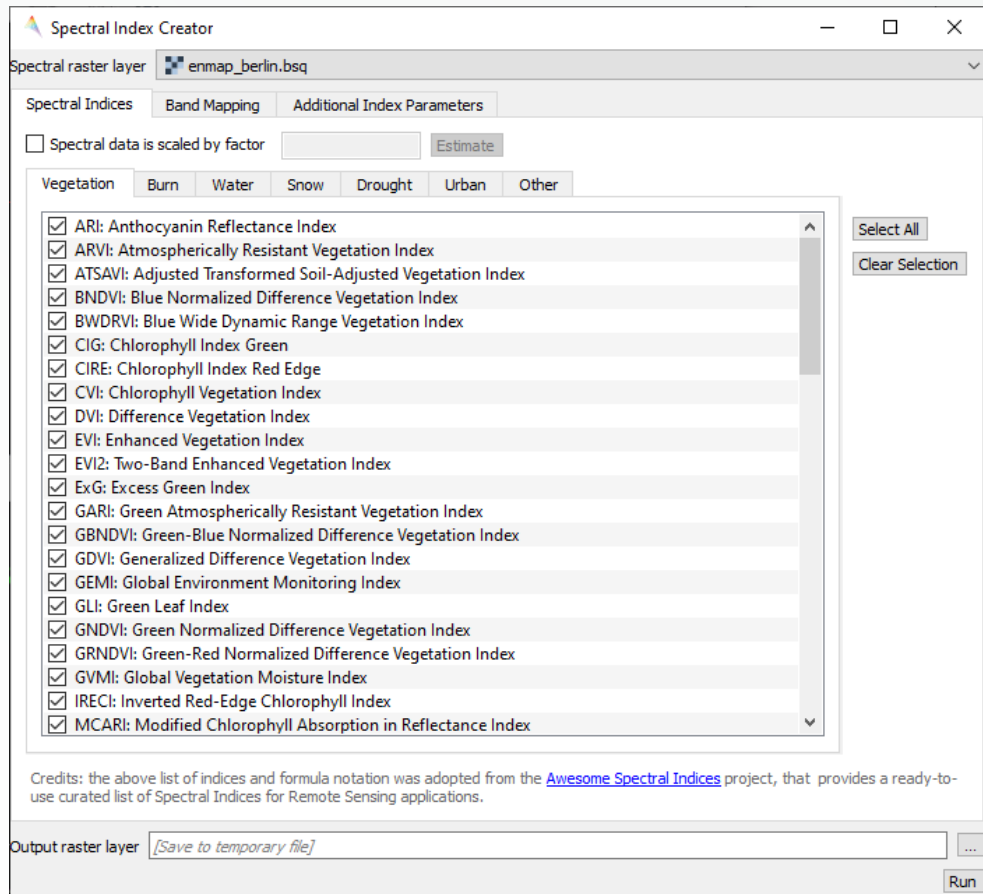
Extent Current canvas

Accuracy Estimate (faster)

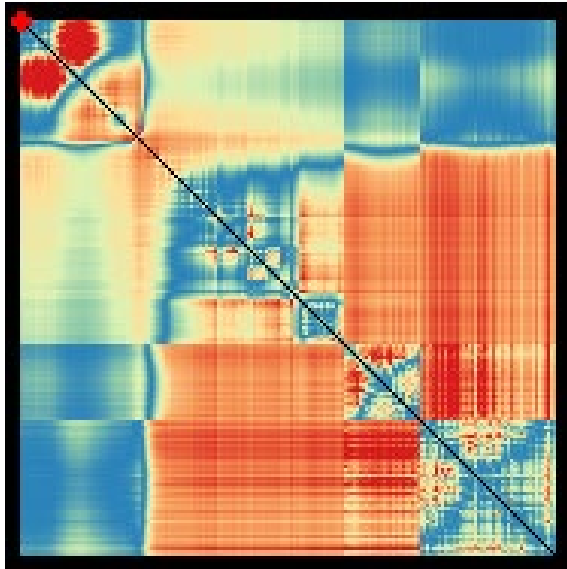
Live update

Spectral Tools – Spectral Index Creator

- ❖ Extensive index list taken from *Awesome Spectral Indices* project.




Spectral Tools – Spectral Index Optimizer



Raster Layer Styling

scores2.tif

RGB
 Gray
 Pseudo
 Default
 Style Linking

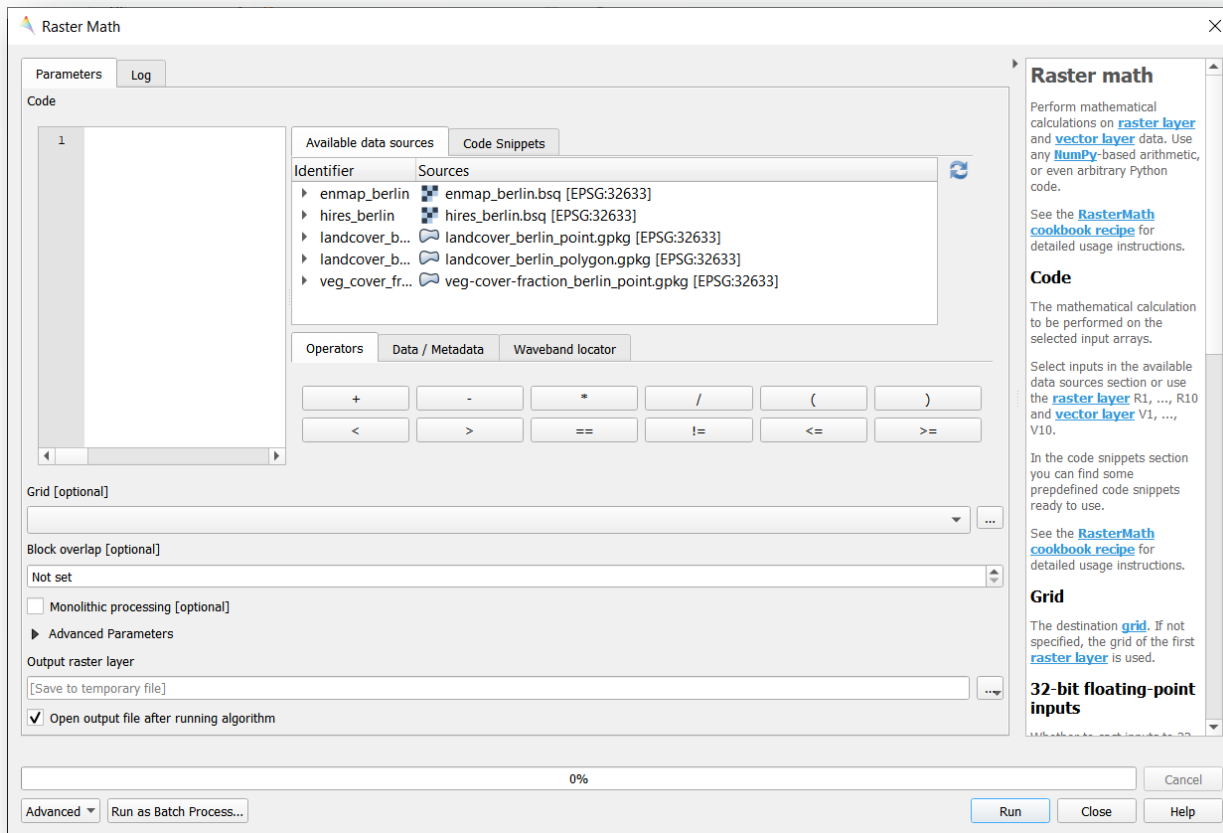
Color ramp 

Band

- Band 01: roof - RMSE (Gray)
- Band 01: roof - RMSE (Gray)
- Band 02: roof - MAE
- Band 03: roof - R^2
- Band 04: pavement - RMSE
- Band 05: pavement - MAE
- Band 06: pavement - R^2
- Band 07: low vegetation - RMSE
- Band 08: low vegetation - MAE
- Band 09: low vegetation - R^2
- Band 10: tree - RMSE

Raster Tools – Raster Math

❖ Easy numpy scripting with data IO fully handled



The screenshot shows the Raster Math application window. It features a 'Parameters' tab and a 'Log' tab. The main area is divided into several sections:

- Code:** A text area containing the number '1'.
- Available data sources:** A table listing various data sources with their identifiers and sources.

Identifier	Sources
▶ enmap_berlin	enmap_berlin.bsq [EPSG:32633]
▶ hires_berlin	hires_berlin.bsq [EPSG:32633]
▶ landcover_b...	landcover_berlin_point.gpkg [EPSG:32633]
▶ landcover_b...	landcover_berlin_polygon.gpkg [EPSG:32633]
▶ veg_cover_fr...	veg-cover-fraction_berlin_point.gpkg [EPSG:32633]
- Operators:** A set of buttons for mathematical operations: +, -, *, /, (,), <, >, ==, !=, <=, >=.
- Grid [optional]:** A dropdown menu.
- Block overlap [optional]:** A dropdown menu set to 'Not set'.
- Monolithic processing [optional]:** A checkbox that is currently unchecked.
- Advanced Parameters:** A section with a collapsed arrow.
- Output raster layer:** A dropdown menu set to 'Save to temporary file'.
- Open output file after running algorithm:** A checked checkbox.

At the bottom, there is a progress bar showing 0%, a 'Run as Batch Process...' button, and 'Run', 'Close', and 'Help' buttons.

Raster math

Perform mathematical calculations on [raster layer](#) and [vector layer](#) data. Use any [NumPy](#)-based arithmetic, or even arbitrary Python code.

See the [RasterMath cookbook recipe](#) for detailed usage instructions.

Code

The mathematical calculation to be performed on the selected input arrays.

Select inputs in the available data sources section or use the [raster layer](#) R1, ..., R10 and [vector layer](#) V1, ..., V10.

In the code snippets section you can find some predefined code snippets ready to use.

See the [RasterMath cookbook recipe](#) for detailed usage instructions.

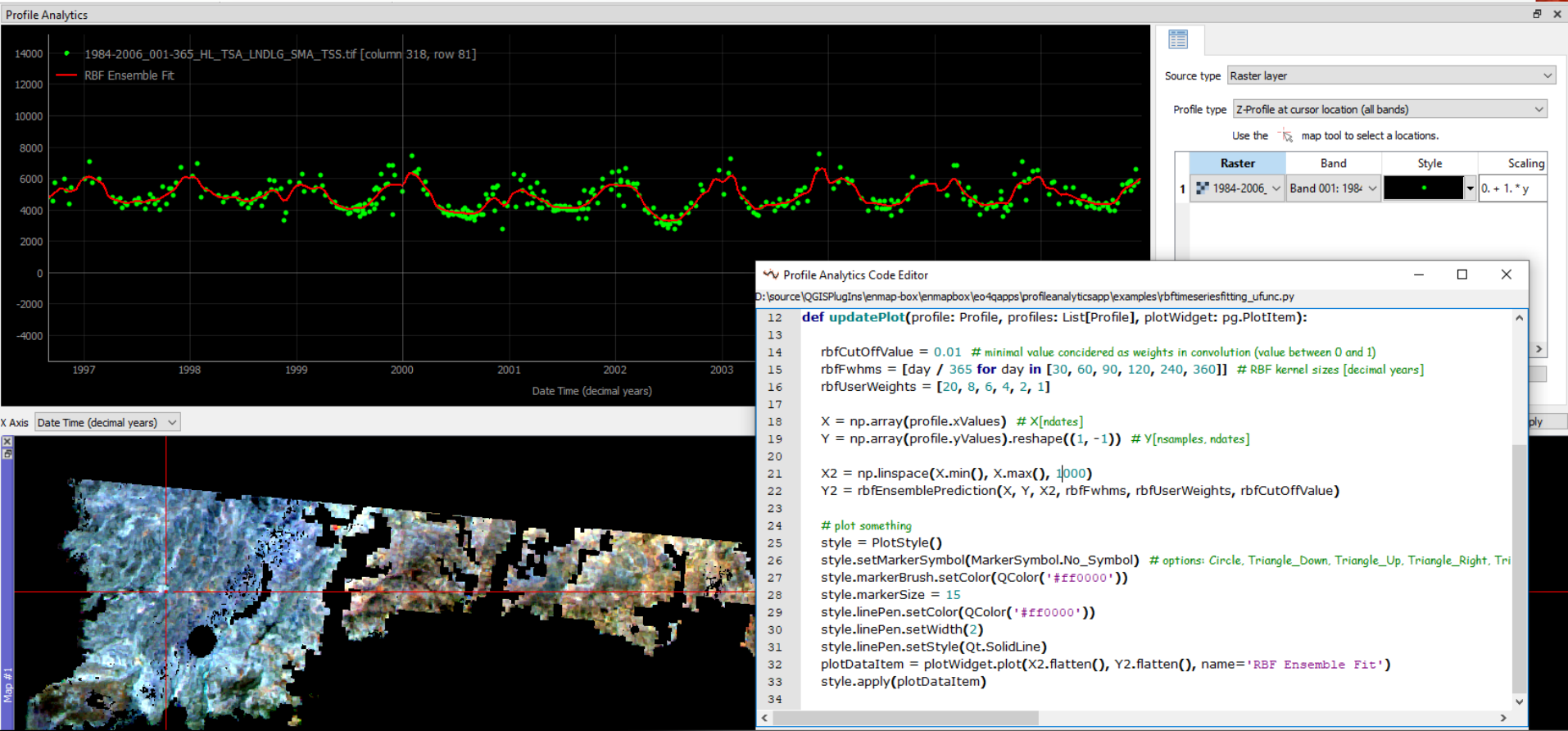
Grid

The destination [grid](#). If not specified, the grid of the first [raster layer](#) is used.

32-bit floating-point inputs


Raster Tools – Profile Analytics (PA) App


Profile Analytics



The application displays a time-series plot of data from 1984-2006. The x-axis is labeled 'Date Time (decimal years)' and ranges from 1997 to 2003. The y-axis ranges from -4000 to 14000. The plot shows green circular markers representing the original data and a red line representing the 'RBF Ensemble Fit'. The data exhibits a clear seasonal cycle with peaks around 6000 and troughs around 4000.

Below the plot, a raster map is shown with a red crosshair indicating the location of the profile. The map displays a complex, multi-colored pattern, likely representing a spatial variable.

Source type: Raster layer
 Profile type: Z-Profile at cursor location (all bands)
 Use the  map tool to select a locations.

Raster	Band	Style	Scaling
1 1984-2006	Band 001: 1984		0. + 1. * y

Profile Analytics Code Editor

```

D:\source\QGISPlugins\enmap-box\enmapbox\eo4apps\profileanalyticsapp\examples\ybfseriesfitting_ufunc.py
12 def updatePlot(profile: Profile, profiles: List[Profile], plotWidget: pg.PlotItem):
13
14     rbfCutOffValue = 0.01 # minimal value considered as weights in convolution (value between 0 and 1)
15     rbfFwhms = [day / 365 for day in [30, 60, 90, 120, 240, 360]] # RBF kernel sizes [decimal years]
16     rbfUserWeights = [20, 8, 6, 4, 2, 1]
17
18     X = np.array(profile.xValues) # X[ndates]
19     Y = np.array(profile.yValues).reshape((1, -1)) # Y[nsamples, ndates]
20
21     X2 = np.linspace(X.min(), X.max(), 1000)
22     Y2 = rbfEnsemblePrediction(X, Y, X2, rbfFwhms, rbfUserWeights, rbfCutOffValue)
23
24     # plot something
25     style = PlotStyle()
26     style.setMarkerSymbol(MarkerSymbol.No_Symbol) # options: Circle, Triangle_Down, Triangle_Up, Triangle_Right, Tri
27     style.markerBrush.setColor(QColor('#ff0000'))
28     style.markerSize = 15
29     style.linePen.setColor(QColor('#ff0000'))
30     style.linePen.setWidth(2)
31     style.linePen.setStyle(Qt.SolidLine)
32     plotDataItem = plotWidget.plot(X2.flatten(), Y2.flatten(), name='RBF Ensemble Fit')
33     style.apply(plotDataItem)
34
  
```

X Axis: Date Time (decimal years)

Map #1

Spectral Library Tools

Snap to pixel center
 search settings
 define values for each field
 scale profiles
 overlay color
 sampling

move pixel : CTRL + <Arrow>
 Save profile: CTRL + S

show / hide
 Plot Plot Settings Form View Table

multiple profile visualizations

Enhanced Profile Source Panel
 Enhanced Plot Settings

Individual / generated labels and colors

multiple profile fields

filter profile by attributes

Name Value
 > Point
 [x] sbr name 'cropland'
 [x] sbr class 'vegetation'
 EnMAP
 Color #f2b013
 Source enmap_berlin.bi
 Sampling Single Profile
 Scaling 0.0 + 1.0 * y
 Offset 0.0
 Scale 1.0
 [x] EnMAP3x3Mean enmap_berlin.bi
 Color #f75a07c
 Source enmap_berlin.bi
 Sampling Kernel
 Aggregation Mean

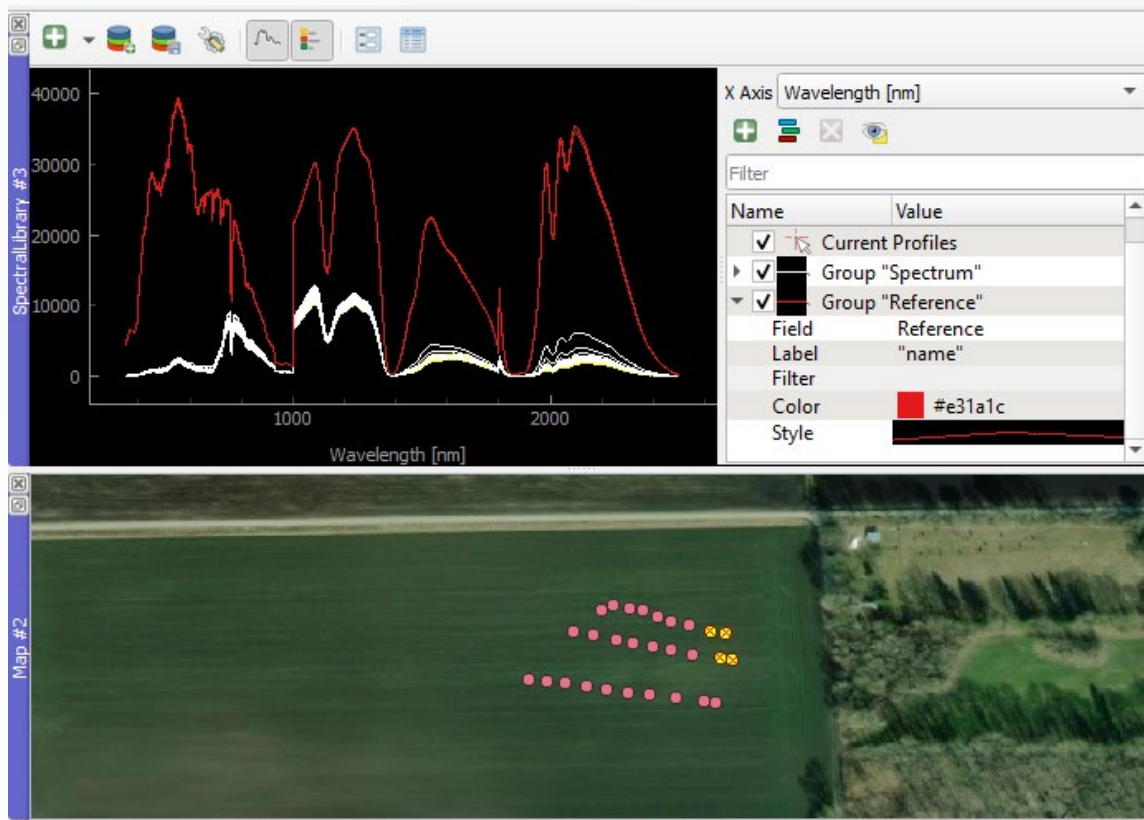
X Axis [Wavelength (nm)]
 Max. Profiles 100

name	class	EnMAP	EnMAP3x3Mea
1 forest	Profile	BLOB	Profile
2 forest	Profile	BLOB	Profile
3 forest	Profile	BLOB	Profile
4 cropland	Profile	BLOB	Profile
5 cropland	Profile	BLOB	Profile
6 cropland	Profile	BLOB	Profile

Name Value
 Model [x] Center Pixel
 Color #b9a99
 Field EnMAP3x3Mean
 Label "name" 3x3 mean
 Style [x]
 Filter "class"='vegetation'

Spectral Library Tools – Data Format and Import

- ❖ Spectral Profiles in Geopackage Format
- ❖ Flexible Attributes stored with Spectra: location, white reference...



EnSoMAP

also
EnGeoMAP for
mineral
mapping

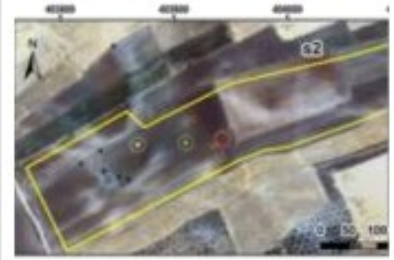
Input:
Hyperspectral Image
Soil data (for quantitative analyses)

A. Bare soil pixels selection
- Preprocessing
- Water Mask
- Green & Dry Vegetation Mask

B. Soil properties mapping
- Soil parameter selection
- Soil algorithm selection

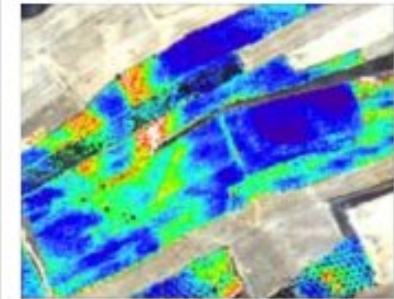
C. Quantitative analyses
- Calibrate with field data (EnSoCal)
- Quantitative Validation (EnSoVal)
- Extract SSL(EnSoLib)

Output:
Bare Soil Map
Soil properties Maps
Prediction accuracy Map
Quantitative Soil Maps

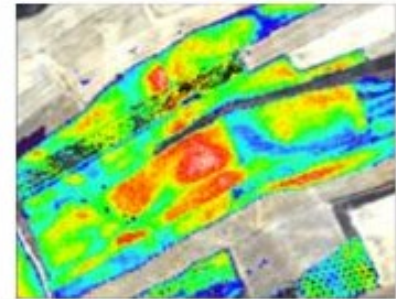


Hyperspectral image

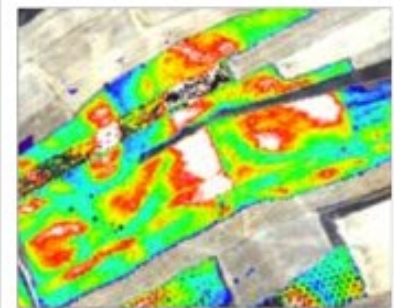
Soil properties maps (%)



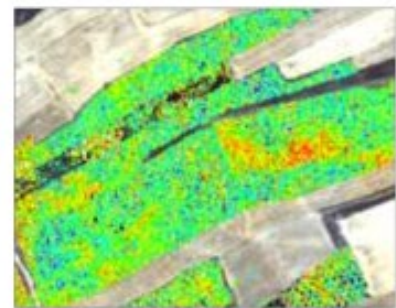
Organic carbon content



Clay content



Iron oxide content



Carbonate content

❖ OC-PFT: Retrieval of Phytoplankton Functional Types.

EnMAP-Box 3 (dev)@PC-14-3607

Project View Tools Applications Help

Data Sources

Filter

Name

- Rasters (0)
- Vectors (0)
- Models (0)
- Other Files (0)

Data Views

Filter

Property

OC-PFT@PC-14-3607

Parameters Log

OC-PFT

Input

Sensor

EnMAP (Environmental Mapping and Analysis Program, German)

Model

LAKE CONSTANCE

Atmospheric correction

ENPT-ACWATER Polymer

Processor output size

Standard output

Output Folder

[Save to temporary folder]

0%

Advanced Run as Batch Process... Run Close

OC-PFT

OC-PFT is an abundance based approach for the retrieval of Phytoplankton Functional Types (PFTs) from satellite or in situ chlorophyll-a (Chl-a) measurements using functions describing the relationship between PFT specific Chl-a to total Chl-as obtained from a large HPLC based phytoplankton pigment data set. Prior to this specific pigments serving as marker pigment for specific PFT have been converted to specific PFT-Chl-a applying the diagnostic pigment analysis [\[using Losa et al., 2017; updated as in Alvarado et al., 2022\]](#).

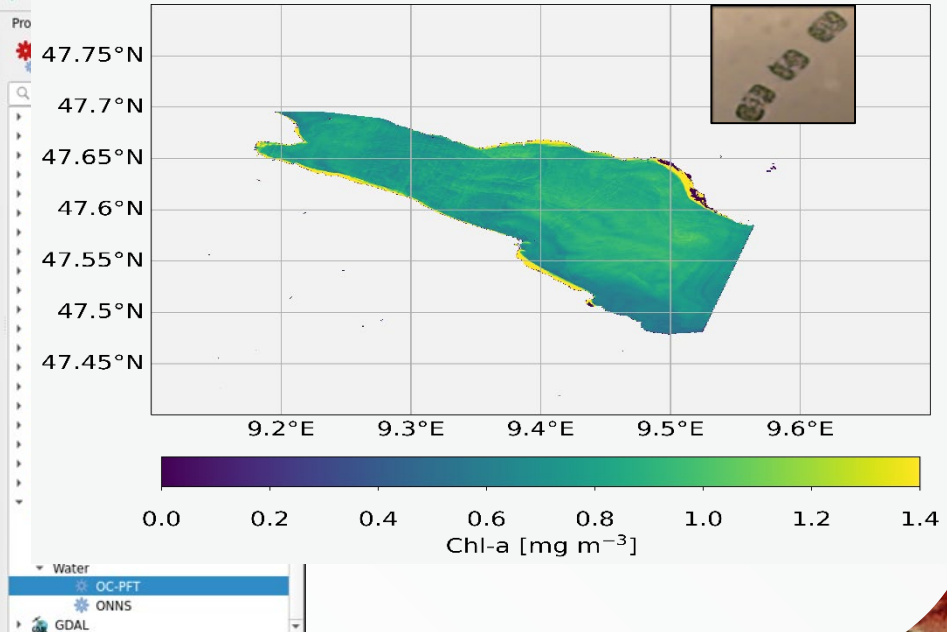
Input

The level-2 Chl-a data in NETCDF4 (Standard Polymer output) and GeoTiff formats (EnPT-ACWater output).

Sensor

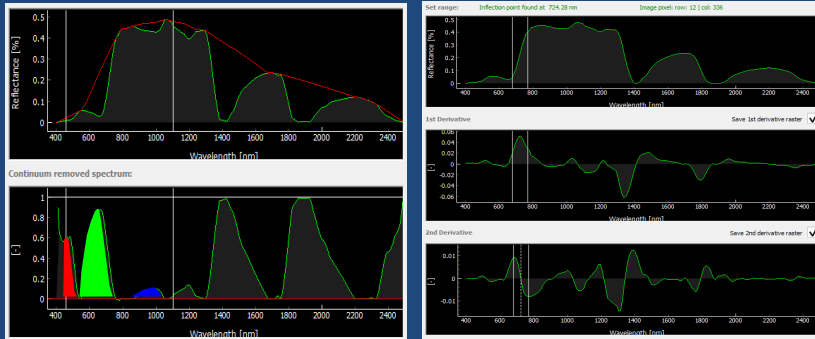
Level-2 Chl-a data from the

Diatoms: Lake Constan (July 9, 2022)

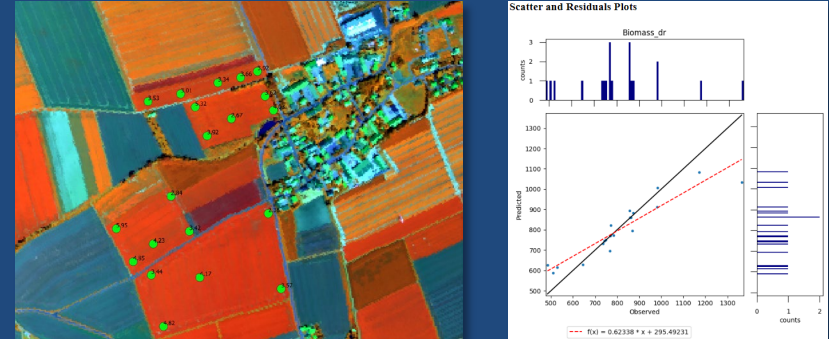


Agriculturally relevant information can be derived from hyperspectral data in the EnMAP-Box via diverse methods:

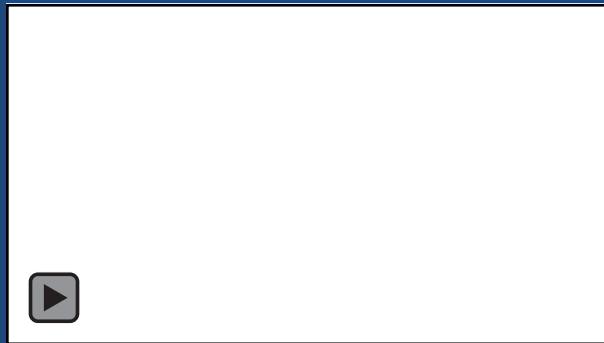
Parametric Methods (e.g. Indices, ASI, iREIP)



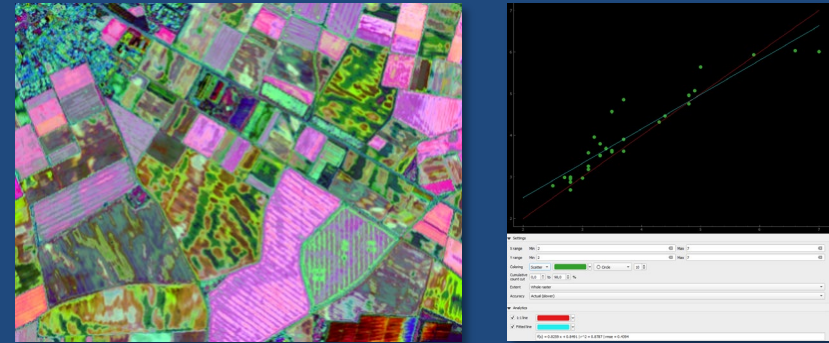
Non-Parametric Methods (e.g. Regression Workflow)



Physically-Based Methods (e.g. IVVRM, PWR, Invert LUT)



Hybrid Methods (e.g. ANN Vegetation Processor)



EnMAP Cookbook

▢ HUB Datacube Cookbook

▢ General

▢ Raster dataset

Open a raster dataset from file

Open a raster dataset from GDAL dataset

Close a raster dataset

Get raster metadata

Set raster metadata

Get and set no data value

Get raster band

Read raster data

Write raster data

Loop through all raster bands

Convert a vector to a raster

Clip a raster with a vector

Calculate zonal statistics

Create raster from array

Create memory raster

Replace no data value of raster with new value

▢ Raster band dataset

VectorData

▢ Grid

▢ Extent

▢ RasterDriver

▢ Projection

▢ MapViewer

HUB Workflow Cookbook

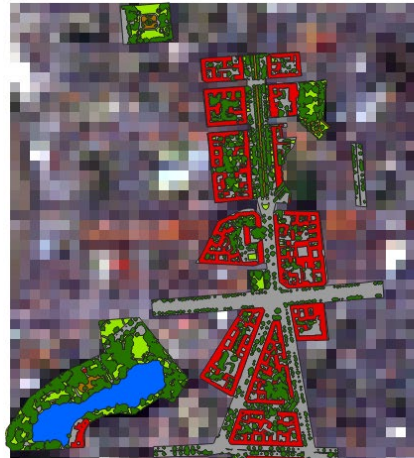
Clip a raster with a vector

Clip a raster with the extent from a vector.

```
import enmapboxtestdata
from hubdc.core import *

rasterDataset = openRasterDataset(filename=enmapboxtestdata.enmap)
vectorDataset = openVectorDataset(filename=enmapboxtestdata.landcover_polygons)
grid = rasterDataset.grid().clip(extent=vectorDataset.extent())
clipped = rasterDataset.translate(grid=grid, filename='raster.tif', driver=GTiffDriver())
```

Note that the result raster grid is snapped to the original raster grid to prevent subpixel shifts. Because of this, some vector geometries may slightly lap over the grid borders.



- ❖ Jakimow B, A Janz, F Thiel, A Okujeni, P Hostert, S van der Linden (2023). EnMAP-Box: Imaging Spectroscopy in QGIS. SoftwareX, *in review*.

Manuscript File [Click here to view linked References](#)

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

EnMAP-Box: Imaging Spectroscopy in QGIS

Benjamin Jakimow^{a,*}, Andreas Janz^a, Fabian Thiel^b, Akpona Okujeni^a,
Patrick Hostert^a, Sebastian van der Linden^b

^a*Geography Department, Humboldt-Universität zu Berlin, Unter den
Linden 6, 10099, Berlin, Germany*

^b*Institute of Geography and Geology, University of
Greifswald, Domstraße 11, 17489, Greifswald, Germany*

Abstract

Satellite missions like EnMAP and PRISMA generate raster images that describe the Earth's environment with hyperspectral resolution. Such imaging spectroscopy data is of high value for applications in, e.g., ecological



Contact

- ❖ For detailed information, installation, application tutorials have a look at <https://enmap-box.readthedocs.io/en/latest/>
- ❖ Or write us: enmapbox@enmap.org

