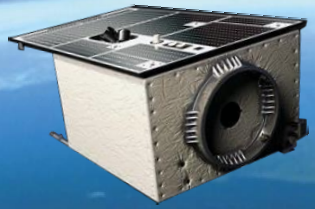
An alternative pre-processing chain for hyperspectral EnMAP data



Daniel Scheffler[1], Maximilian Brell[1], Niklas Bohn[1], Leonardo Alvarado[2], Mariana A. Soppa[2], Karl Segl[1], Astrid Bracher[2,3], Sabine Chabrillat[1,4]

[1]GFZ Potsdam, [2]AWI Bremerhaven, [3]University Bremen, [4]Leibniz University Hannover

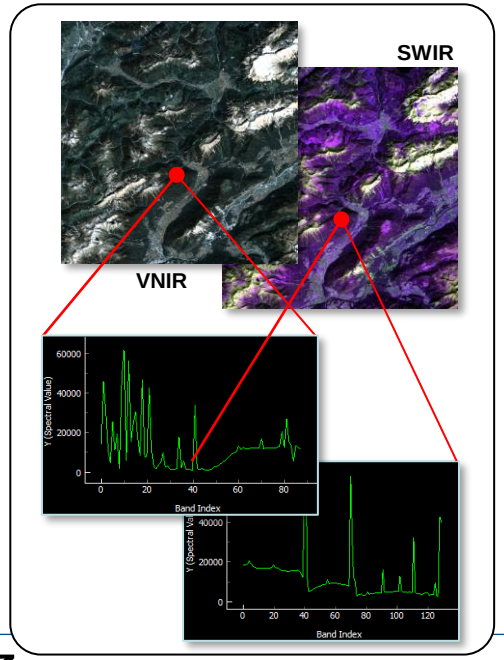
1st EnMAP user workshop, 10.10.2023

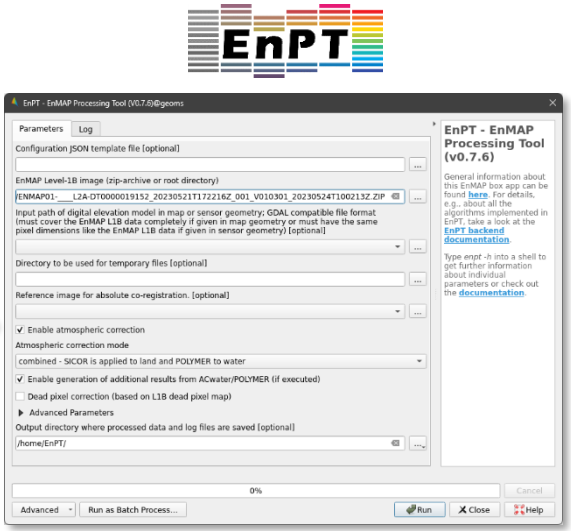
EnMAP Processing Tool - EnPT

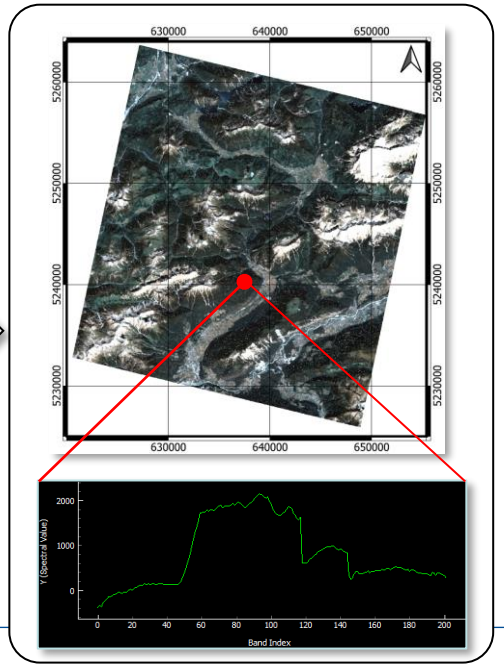
A pre-processing software for EnMAP hyperspectral data:

- **Input**: EnMAP Level 1B image (only radiometrically corrected, not ready-to-use)
- **Output**: EnMAP Level 2A image (accurately georeferenced, atmospherically corrected, ready-to-use)

Level 1B







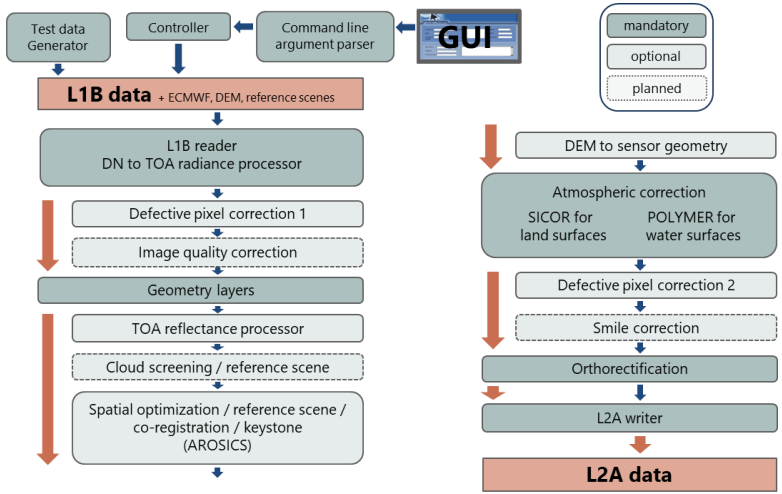
Level 2A

EnPT – The EnMAP Processing Tool - **Overview**

EnPT repository

A pre-processing chain to process EnMAP Level-1B data to Level-2A

- GFZ open-source alternative to the processing chain of the EnMAP Ground Segment
- Available as a **standalone Python package** or accessible via a graphical user interface as a **plugin of the EnMAP-Box**
- Relies on open-source algorithms such as **AROSICS, SICOR and Polymer (HYGEOS)**

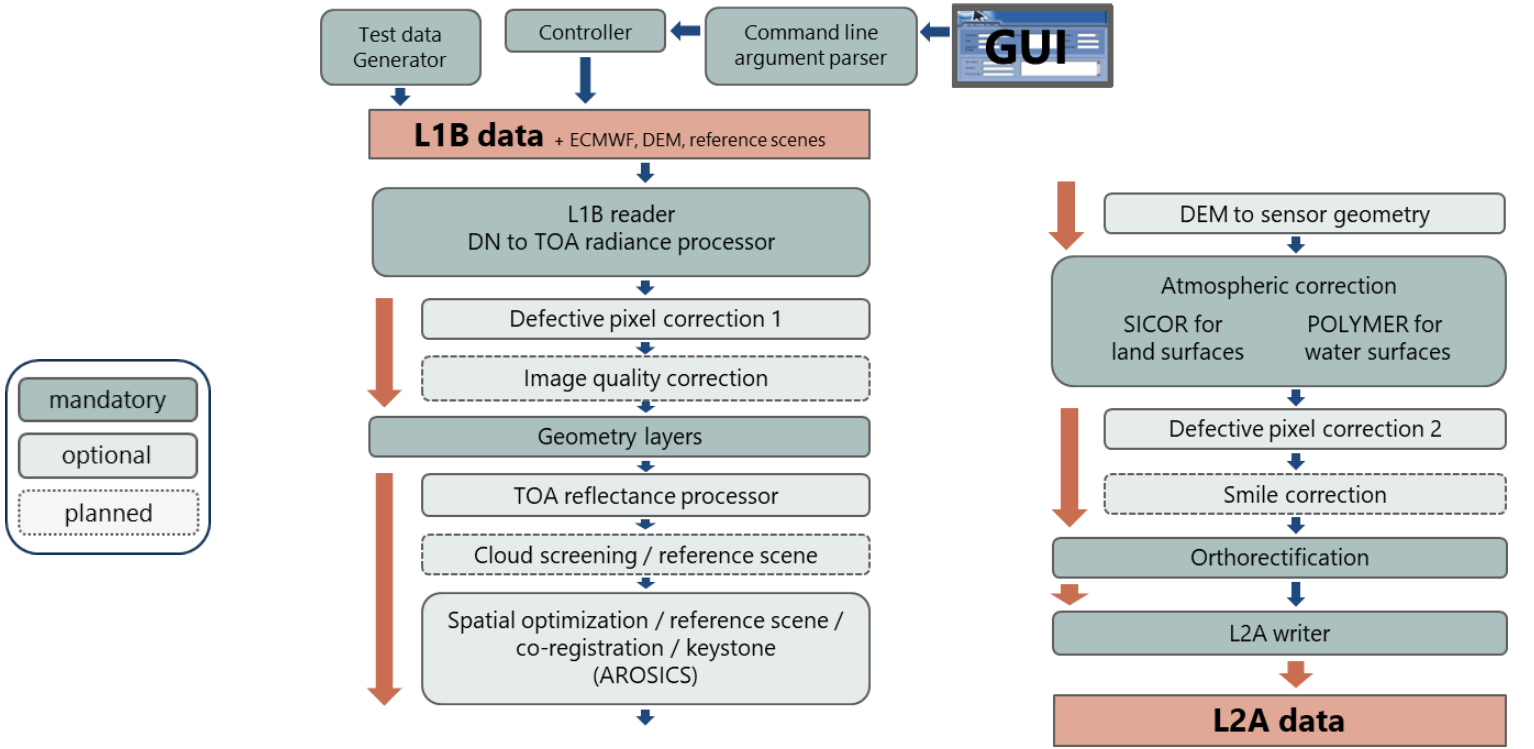


AROSICS ICOR HYGEOS

Scheffler, Daniel, Bohn, Niklas, Guillaso, Stéphane, & Segl, Karl. (2023, August 9). EnPT - EnMAP Processing Tool (Version v0.19.4). Zenodo. https://doi.org/10.5281/zenodo.3742344

EnPT – The EnMAP Processing Tool - **Workflow**

EnPT repository



EnPT – The EnMAP Processing Tool – **Co-Registration**

Automatic detection and correction of spatial mis-registrations

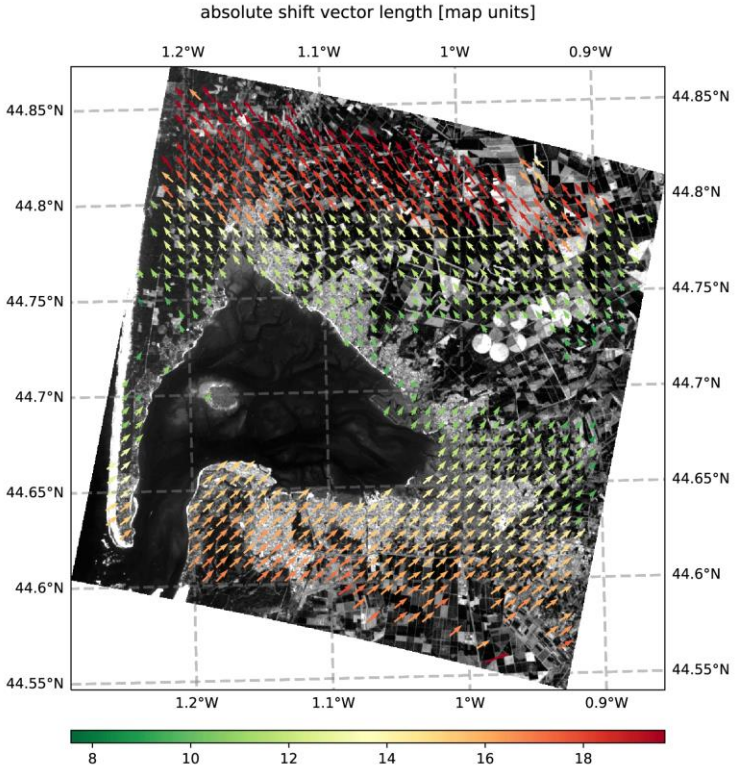
- Based on AROSICS (Scheffler et al. 2017)
- Automatic tie-point creation with regard to a user provided reference image
- Open-source Python package available at: https://git.gfz-potsdam.de/danschef/arosics

AROSICS repository

GitLab

python Package Index

CONDA-FORGE

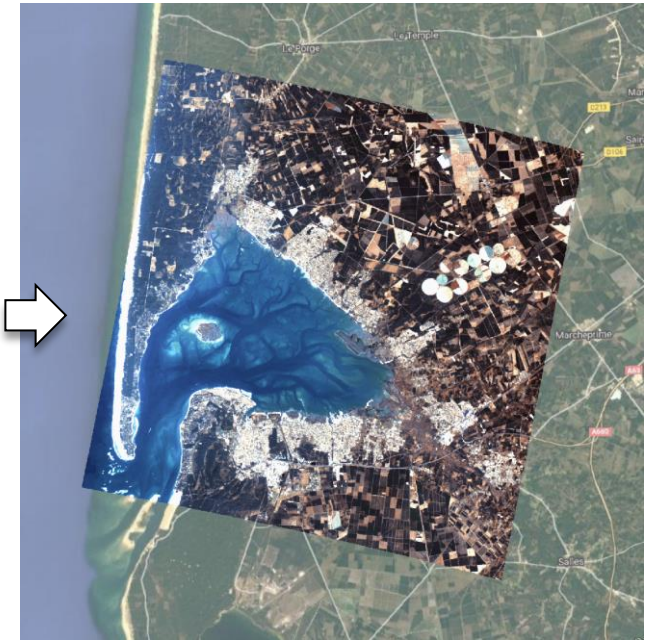


EnPT – The EnMAP Processing Tool – **Orthorectification**

Transformation from sensor to map geometry

- Based on rational polynomial coefficients (RPC)
- Requires a digital elevation model
- Result refined by the tie points created by AROSICS

Arcachon, tile 2, Level 1B

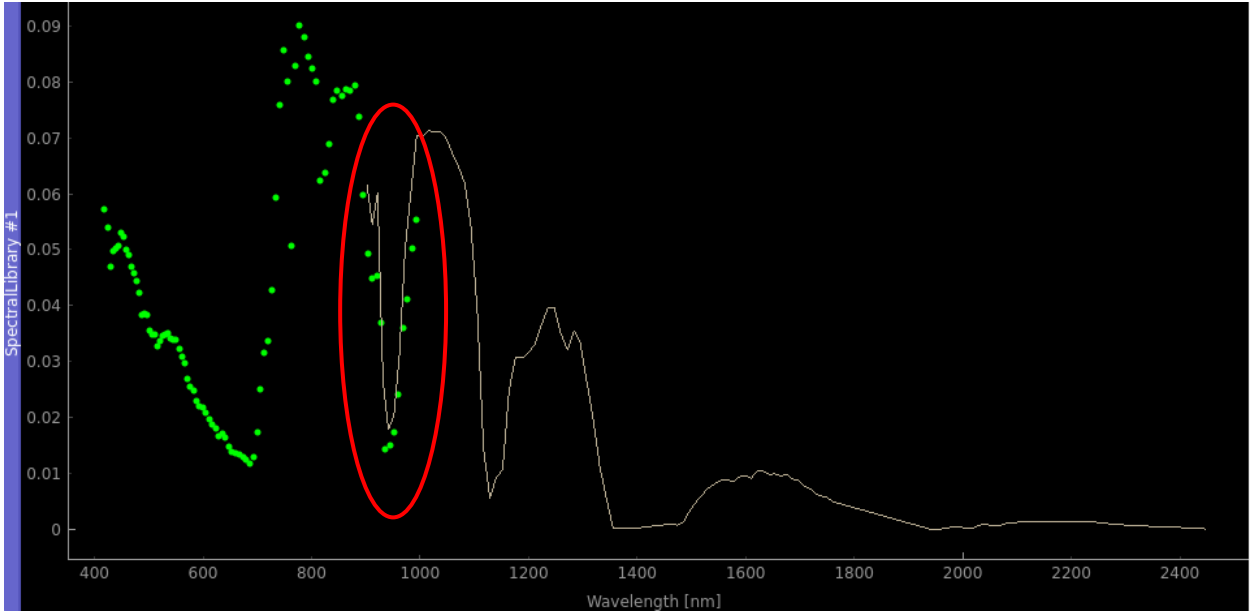


Arcachon, tile 2, Level 2A

Scheffler, Daniel, Bohn, Niklas, Guillaso, Stéphane, & Segl, Karl. (2023, August 9). EnPT - EnMAP Processing Tool (Version v0.19.4). Zenodo. https://doi.org/10.5281/zenodo.3742344

EnPT – The EnMAP Processing Tool – **VNIR/SWIR Stacking**

Spectral overlap between VNIR and SWIR needs to be handled:



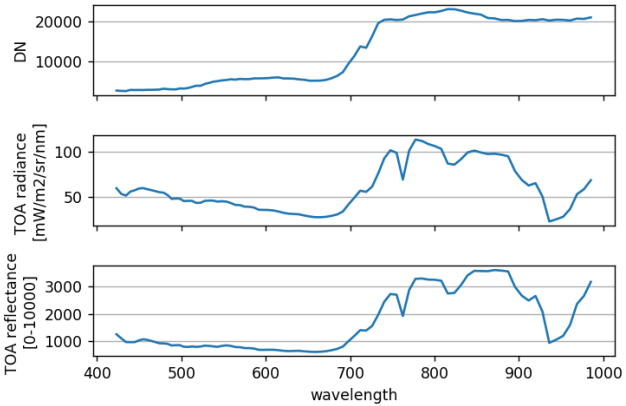
EnMAP Level 1B radiance data

EnPT – The EnMAP Processing Tool – **Atmospheric Correction**

Two algorithms implemented:

SICOR repository

- **SICOR (GFZ)**: mainly for land surfaces
- **ACwater/Polymer (AWI)**: water surfaces



Three modes of atmospheric correction:

- **land**: SICOR applied to all surfaces
- **water**: ACwater/Polymer applied to water only
- **combined:** SICOR applied to land and ACwater/Polymer to water surfaces

Bohn, Niklas, Scheffler, Daniel, Brell, Maximilian, & Segl, Karl. (2022). SICOR - Sensor Independent Atmospheric Correction (0.18.0). Zenodo. https://doi.org/10.5281/zenodo.5973187

EnPT – The EnMAP Processing Tool - **SICOR**

SICOR repository

Sensor **I**ndependent atmospheric **COR**rection of optical Earth Observation data

(Bohn, Scheffler, Brell, Preusker, Diedrich, Hollstein 2016)

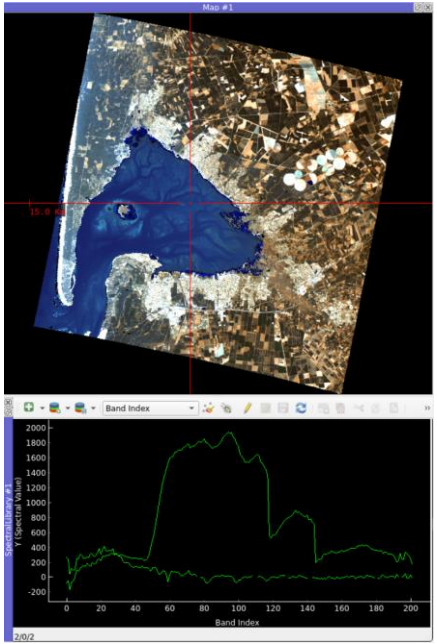
- **Optimal Estimation (OE)**
- **MODTRAN® Radiative Transfer Code**

- **Available as Git Repository and as Python package on PyPI and conda-forge:**

https://git.gfz-potsdam.de/EnMAP/sicor

https://pypi.org/project/sicor

https://anaconda.org/conda-forge/sicor



EnPT – The EnMAP Processing Tool - **SICOR**

SICOR repository

- **Features:**

  - **Simultaneous retrieval of atmospheric water vapor, surface liquid water, and ice** path lengths by fitting absorption features at 940 and 1140 nm (Green et al. 2006, Fig. 1)

  - **SLIC Segmentation + Empirical Line Solution** (Thompson et al. 2019)

  - Optional output of several **retrieval uncertainty measures** from OE:

    * Jacobian of solution state
    * Convergence message
    * Number of iterations
    * Gain matrix
    * Averaging kernel matrix
    * Value of cost function
    * Degrees of freedom
    * Information content
    * Retrieval noise
    * Smoothing error

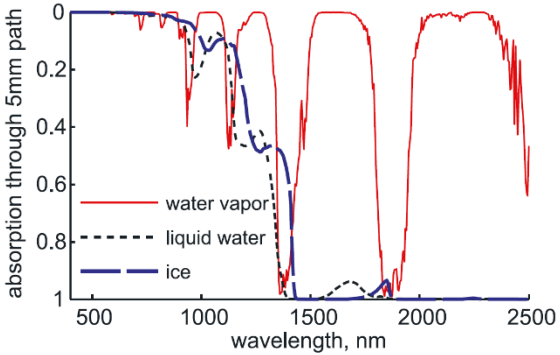
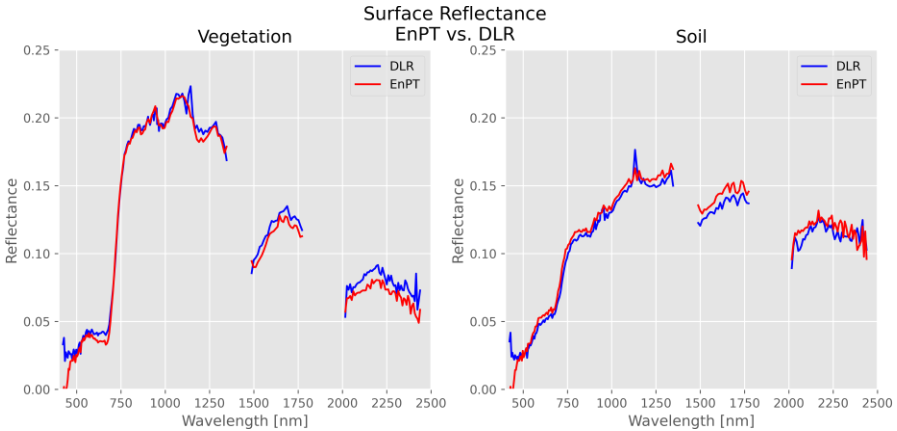


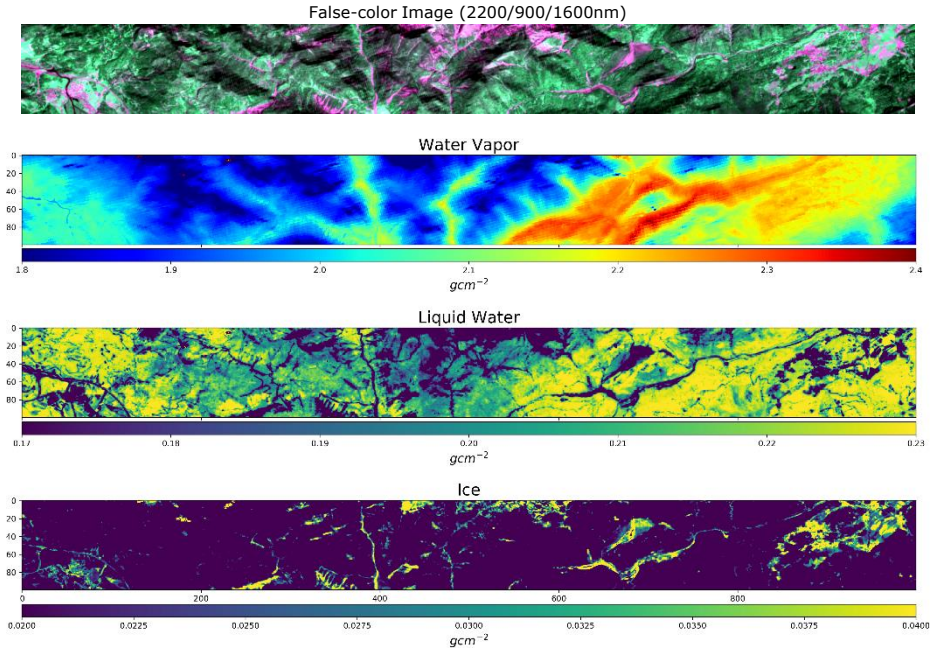
Fig. 1: Absorption spectra of water vapor, liquid water, and ice at 10 nm spectral resolution, calculated for 5 mm path lengths (Green et al. 2006).

EnPT – The EnMAP Processing Tool - **SICOR**

SICOR repository

Products: surface reflectance (HDRF), water vapor, liquid water and ice maps





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EnPT – The EnMAP Processing Tool - **Outlook**

EnPT repository

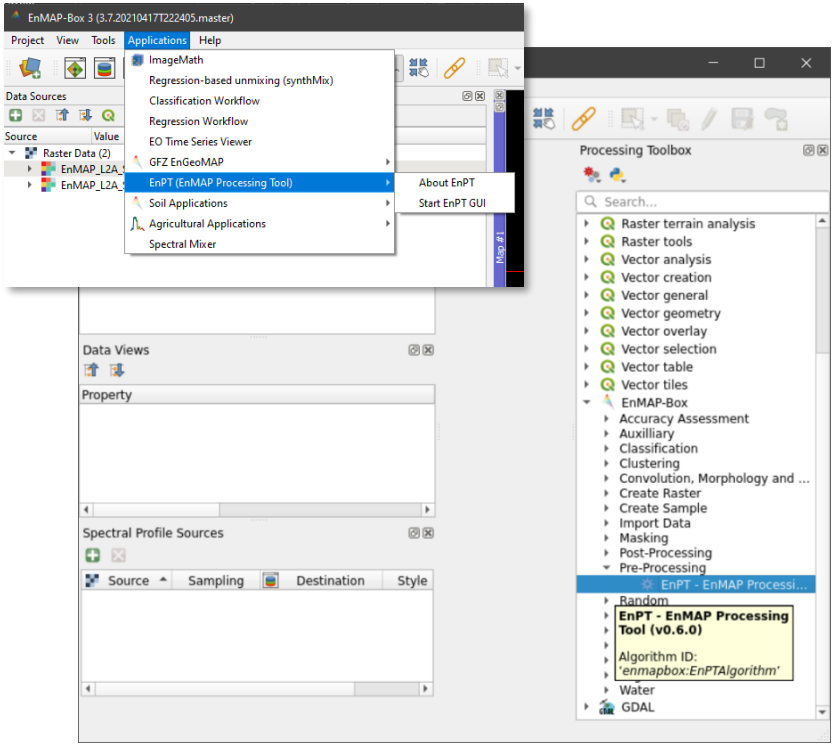
Planned features and improvements:

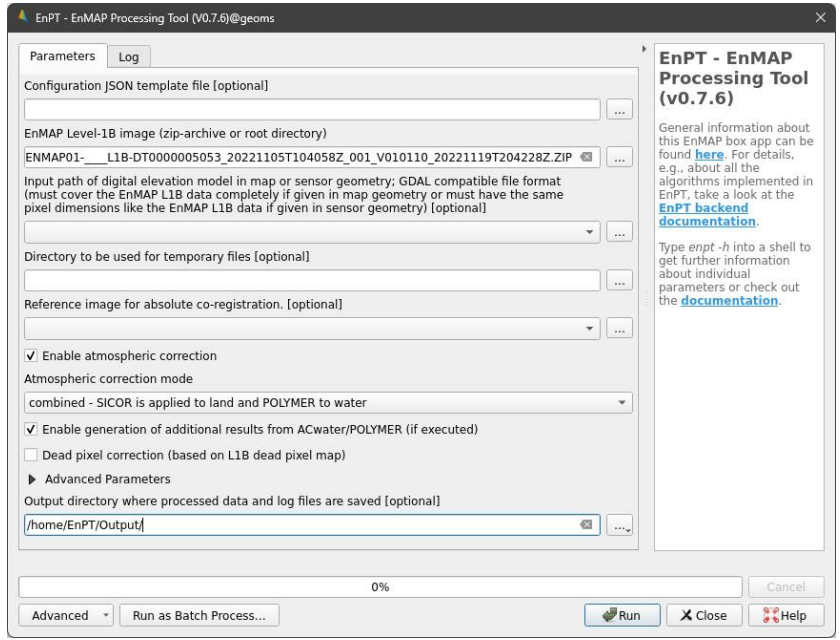
- Add SICOR retrieval maps to EnPT L2A output
- Revise and speed-up the orthorectification module
- Implement ISOFIT as alternative atmospheric correction approach
  - Improved overall correction performance
  - BOA reflectance uncertainties
- Improve water mask, include own cloud masks?
- Evaluate EnPT on real EnMAP data and publish results

Scheffler, Daniel, Bohn, Niklas, Guillaso, Stéphane, & Segl, Karl. (2023, August 9). EnPT - EnMAP Processing Tool (Version v0.19.4). Zenodo. https://doi.org/10.5281/zenodo.3742344

EnPT – The EnMAP Processing Tool - **GUI**

EnPT repository



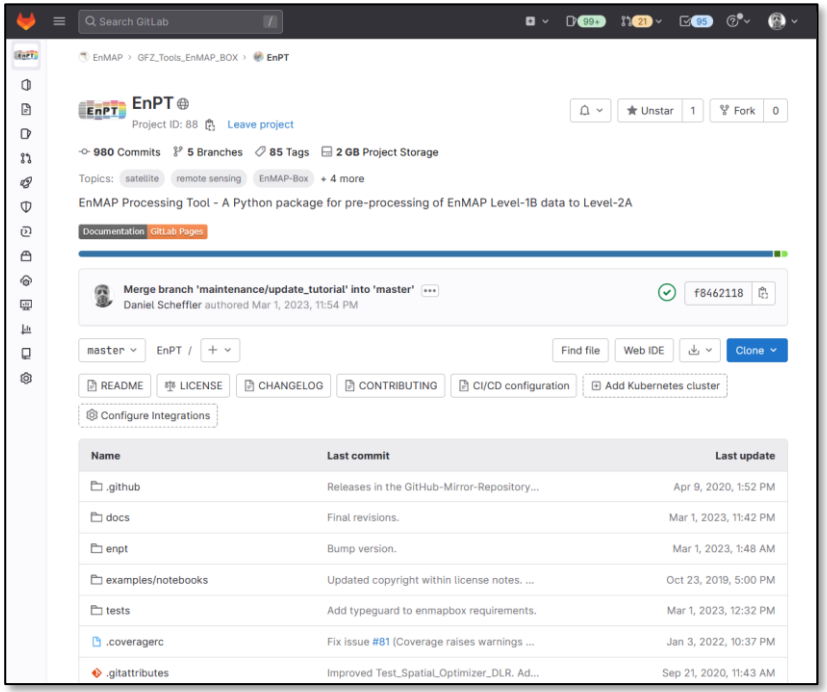


Scheffler, Daniel, Bohn, Niklas, Guillaso, Stéphane, & Segl, Karl. (2023, August 9). EnPT - EnMAP Processing Tool (Version v0.19.4). Zenodo. https://doi.org/10.5281/zenodo.3742344

EnPT – The EnMAP Processing Tool – **Code Repository**

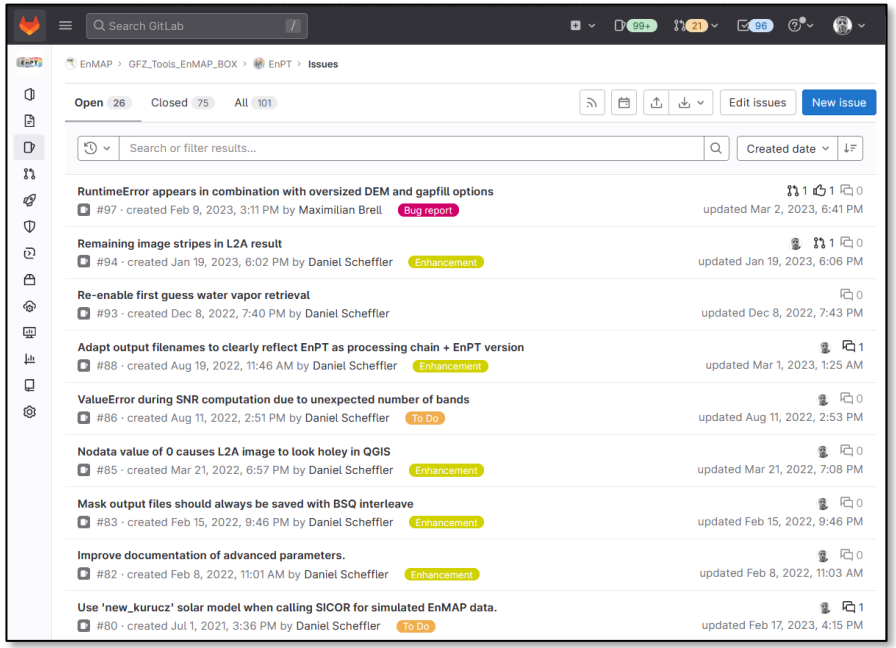
EnPT repository

GitLab



https://git.gfz-potsdam.de/EnMAP/GFZ_Tools_EnMAP_BOX/EnPT

Issue tracker:

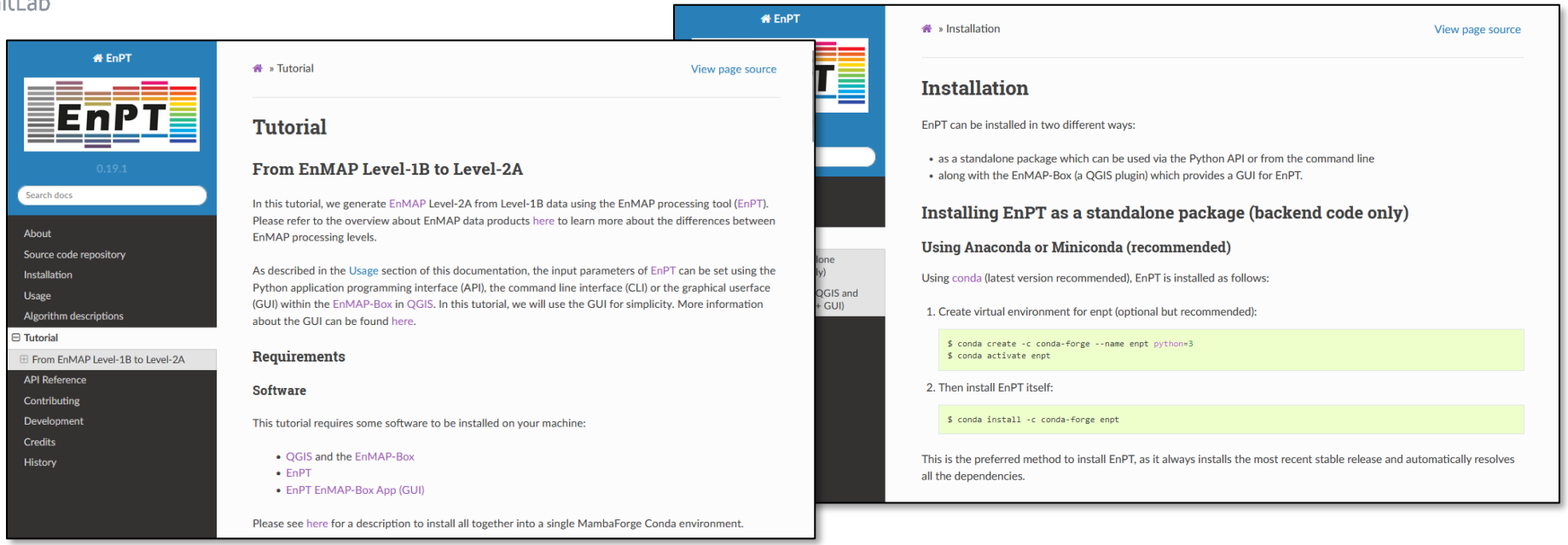


EnPT – The EnMAP Processing Tool - **Documentation**

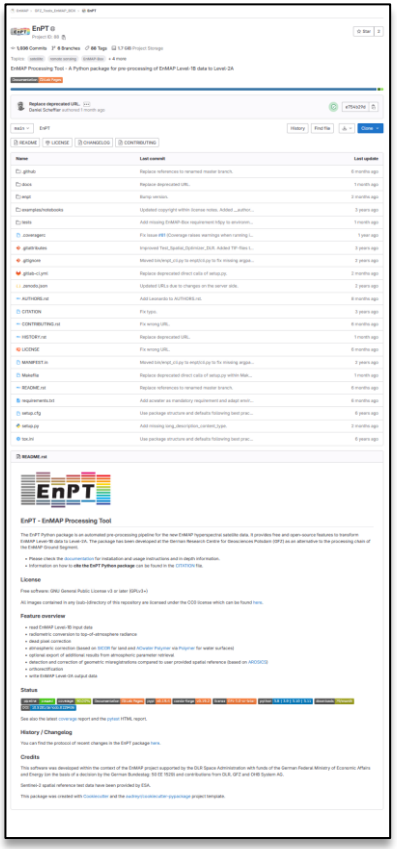
EnPT repository

GitLab

GitLab documentation page:



https://enmap.git-pages.gfz-potsdam.de/GFZ_Tools_EnMAP_BOX/EnPT/doc/



EnPT @ GitLab

AROSICS @ GitLab

SICOR @ GitLab

Thank you for your attention!

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