An alternative pre-processing chain for hyperspectral EnMAP data

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

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)**

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

- **Test data Generator**
- **Controller**
- **Command line argument parser**

**L1B data** + ECMWF, DEM, reference scenes

- **L1B reader**
  - DN to TOA radiance processor

- **Defective pixel correction 1**
- **Image quality correction**
- **Geometry layers**
- **TOA reflectance processor**
- **Cloud screening / reference scene**
- **Spatial optimization / reference scene / co-registration / keystone (AROSICS)**

**DEM to sensor geometry**

- **Atmospheric correction**
  - SICOR for land surfaces
  - POLYMER for water surfaces

- **Defective pixel correction 2**
- **Smile correction**
- **Orthorectification**
- **L2A writer**

**L2A data**

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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

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

Spectral overlap between VNIR and SWIR needs to be handled:

EnPT – The EnMAP Processing Tool – Atmospheric Correction

Two algorithms implemented:

• **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

Sensor Independent atmospheric CORrection 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**

- **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**

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

![Diagram showing vegetation and surface reflectance](image)

![False-color Image (2200/900/1600nm)](image)

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
EnPT – The EnMAP Processing Tool – Code Repository

EnPT repository

Issue tracker:

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

EnPT – The EnMAP Processing Tool - Documentation

GitLab documentation page:

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

Thank you for your attention!

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