The EnMAP processing chain

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What is the EnMAP processing chain?

- EnMAP data is not directly usable:
  - It has to be unpacked, uncompressed, tiled, screened and radiometrically corrected.
  - Optionally it should also be corrected geometrically and atmospherically.
- These processing steps are performed by the EnMAP processing chain before delivering the data to the users.
- For details (ATBD, product specification), see also: https://www.enmap.org/data_access
Processing overview

- The processing chain consists of 5 processors:
  - L0, L1B, L1C, L2A, OP
- The chain can produce 4 different outputs:
  - Only L0 is archived, higher levels (LX) are processed on demand.
    - Delivered data is always based on latest processor version and CAL tables
    - LX processing taking into account user-defined processing options

<table>
<thead>
<tr>
<th>Product type</th>
<th>Processing</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>L0</td>
<td>Transcription</td>
<td>For archiving</td>
</tr>
<tr>
<td>L1B</td>
<td>Radiometric</td>
<td></td>
</tr>
<tr>
<td>L1C</td>
<td>Geometric</td>
<td>For scientists</td>
</tr>
<tr>
<td>L2A</td>
<td>Atmospheric</td>
<td></td>
</tr>
</tbody>
</table>
L1B processing overview

- Inputs:
  L0 tiles, CAL tables

- Processing steps:
  L1B, L1C, L2A, OP

- Output:
  Radiometrically corrected image at-sensor-radiance
L1B processing

- For details, see L1B ATBD on [https://www.enmap.org/data_access](https://www.enmap.org/data_access)
- Processing options
  - Product Format: GeoTIFF, JPEG2000, BSQ, BIL, BIP
L1B product

- Spectral images
  - Units: $W/m^2/\text{sr}/\text{nm}$ (at sensor radiance)
  - Two data cubes for SWIR/VNIR in sensor geometry. SWIR/VNIR data is not aligned (~20 lines offset).
- Metadata
  - Also contains information of levels L1C and L2A.
  - RPC in metadata can be used to perform geometric correction. Attitude and orbit data is also available.
- Masks/Quicklooks in sensor geometry
L1C processing overview

- Inputs: L0 tiles, CAL tables
- Processing steps: L1B, L1C, L2A, OP
- Output: Radiometrically and geometrically corrected image at-sensor-radiance
- Processing options
  - Product Format: Geotiff, JPEG2000, BSQ, BIL, BIP
  - Map Projection: UTM(+/1 Zone), Geographic, European LAEA
  - Image Resampling: Bilinear, Bicubic, Nearest Neighbour
L1C processing

- Orthorectification
  - Direct georeferencing using detailed sensor model
  - Accuracy improved using GCPs (extracted from S2 reference in L0 before tiling the datatake)
  - Used DEM: Copernicus DEM with up to 30 m resolution (COP-DEM GLO-30)
- SWIR/VNIR data is aligned
  - SWIR/VNIR data cubes are merged to one image, with the bands ordered by increasing wavelength
  - Sensor to band mapping can be derived from metadata entry expectedChannelsList

<table>
<thead>
<tr>
<th>Band order before L1C:</th>
<th>V</th>
<th>N</th>
<th>I</th>
<th>R</th>
<th>S</th>
<th>W</th>
<th>I</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band order after L1C:</td>
<td>V</td>
<td>N</td>
<td>I</td>
<td>R</td>
<td></td>
<td></td>
<td></td>
<td>R</td>
</tr>
</tbody>
</table>
L1C product

- Spectral image
  - Units: $W/m^2/sr/nm$ (at sensor radiance)
  - One data cube in ortho geometry containing all SWIR/VNIR bands
  - Tiles contain 10 lines from the neighboring tiles, to avoid problems when mosaicking.

- Metadata
  Also contains information of levels L1B and L2A.

- Masks/Quicklooks in ortho geometry
L2A processing overview

- Inputs:
  L0 tiles, CAL tables
- Processing steps:
  L1B, L1C, L2A, OP
- Output:
  Radiometrically, geometrically and atmospherically corrected reflectances
- For more details, see this talk:
  *The EnMAP Ground-Segment L2A Processor - Products and Specifics*
Notable processor updates

- **V01.02.00 (07.03.2023)**
  - Destriping in across-track direction implemented in L1B
  - Improvements in co-registration accuracy
- **V01.03.00 (02.05.2023)**
  - Absolute geometric accuracy improved
  => All EnMAP data before v01.03.00 is being reprocessed
- **V01.03.02 (13.06.2023)**
  - Changes to support band swap:
    SWIR bands with wavelengths 1939, 1949 and 1958 nm replaced by 1450, 1767 and 1782 nm on 05.07.2023
- **V01.04.00 (15.09.2023)**
  - Re-activated adjacency correction in atmospheric correction over water

See [https://www.enmap.org](https://www.enmap.org) for news on important updates.
Processors Verification, Validation & Quality Control

- Products produced by the processing chain must fulfill strict mission requirements, for example concerning radiometric and geometric accuracy.
- These requirements were/are reviewed and validated (internally and externally) extensively during the development, commissioning and routine phases.
- Continuous Quality Control of processing chain and its products, see quarterly reports on website: [https://www.enmap.org/mission/](https://www.enmap.org/mission/)
  (also see talk *Operational data quality control and instrument monitoring for the spectral, radiometric and geometric data properties within the EnMAP Ground Segment*)