Procedures for DataQC within the EnMAP and DESIS Ground Segments


DLR–EOC, German Aerospace Center, Earth Observation Center
# Spaceborne EO imaging spectrometer missions

<table>
<thead>
<tr>
<th>Mission Instrument</th>
<th>ISS/MUSES DESIS</th>
<th>EnMAP HSI (2 instruments)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target lifetime</strong></td>
<td>2018-2023</td>
<td>2020-2025</td>
</tr>
<tr>
<td><strong>Satellite</strong> (mass, dimension, usage)</td>
<td>455 t, 109.0×97.9×27.5 m³ (multi-purpose)</td>
<td>1 t, 3.1×2.0×1.7 m³ (single-purpose)</td>
</tr>
<tr>
<td><strong>Orbit</strong> (type, local time at equator, inclination, height, repeat cycle)</td>
<td>not Sun-synchronous, various, 51.6°, 320 km to 430 km, no repeat cycle</td>
<td>Sun-synchronous, 11:00, 98.0°, 653 km, 398 revolutions in 27 days</td>
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<tr>
<td><strong>Coverage</strong></td>
<td>55° N to 52° S</td>
<td>74° N to 74° S</td>
</tr>
<tr>
<td><strong>Revisit frequency</strong></td>
<td>3 to 5 days (average)</td>
<td>≤ 4 days, ≤ 27 days (±5° tilting)</td>
</tr>
</tbody>
</table>

**Mission Instrument**

- **Off-nadir tilting** (across-track, along-track)
  - -45° (backboard) to +5° (starboard), -40° to +40° (by MUSES and DESIS)  
  - -30° to +30°, 0° (by EnMAP)
- **Spectral range**
  - 420 nm to 1000 nm  
  - 420 nm to 2450 nm
- **Spectral (res., acc.)**
  - 2.55 nm, na  
  - 6.5 nm, 0.5 nm (VNIR), 10.0 nm, 1.0 nm (SWIR)
- **Radiometry (res., acc.)**
  - 13 bits, na  
  - 14 bits, 5%
- **Spatial (res., swath)**
  - 30 m, 30 km (@ 400 km)  
  - 30 m, 30 km
- **SNR (signal-to-noise)**
  - 205 (no bin.) / 406 (4 bin.) @ 550 nm  
  - 500 @ 495 nm, 150 @ 2200 nm
- **Instrument mass**
  - 93 kg  
  - 350 kg
- **Capacity (km, storage)**
  - 2360 km per day, 225 GBit  
  - 5000 km per day, 512 GBit

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<td><strong>Space agency</strong></td>
<td>Teledyne, USA &amp; DLR, Germany</td>
<td>DLR, Germany</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Science Segment: GFZ et al.)</td>
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<tr>
<td><strong>Space segment</strong></td>
<td>Teledyne</td>
<td>OHB System AG</td>
</tr>
<tr>
<td></td>
<td>• VNIR Instrument by DLR</td>
<td>• VNIR Camera by DLR</td>
</tr>
<tr>
<td></td>
<td>• Support Calibrations by DLR</td>
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<tr>
<td><strong>Ground segment</strong></td>
<td>Teledyne</td>
<td>DLR (EOC, GSOC)</td>
</tr>
<tr>
<td></td>
<td>• Processing, Archiving, Processors, and Calibration by DLR</td>
<td>• Project Management</td>
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<td>• Command and Control</td>
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<td></td>
<td>• User Interf., Data Reception, Processing, and Archiving</td>
</tr>
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<td>• Processors and Calibration</td>
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Spaceborne EO imaging spectrometer missions

... many dedicated presentations in this session
Part 1:
Data Quality Control within Pre-Processing Chains
Overview - Processing Chain (EnMAP)
EnMAP & DESIS – Data Quality Indicators

- **Radiometric properties (L0 / L1B)**
  - Artifacts related to radiometric calibration (striping, banding)
  - Artifacts related to dual gain
- **Spectral properties (L0 / L1B / L2A)**
  - Spectral smile
- **Datatake / image properties (L0 / L1B)**
  - Saturation (cross-talk, blooming)
  - Other artifacts / suspicious pixel / repetitive pattern
  - Error messages in virtual channel, sensor & processor log files
- **Environmental conditions** during acquisition (L1C / L2A)
  - Sun elevation
  - Percentage of cloud, haze, cirrus and cloud shadow
  - Average scene visibility / AOT / WaterVapour
  - Problems in atm. correction (e.g., # DDV pixels, meaningful aerosol type, …)
  - Artifacts related to terrain correction / DEM
EnMAP Level L0/L1B Processing – detailed steps

- **Bad (dead & suspicious) pixel flagging**
- **Saturated pixel flagging (incl. blooming)**
- **Non-linearity correction**
- **Dark signal correction**
- **RNU correction**
- **Gain matching (VNIR)**
- **Spectral referencing**
- **Spectral / spatial straylight correction**
- **Radiometric referencing**
- **QL generation**
- **Cloud-haze and land-water masks generation**
  
  **L1C / L2A**

- **Geometric correction (incl. keystone correction)**
- **Atmospheric correction (incl. smile correction)**
Operational QC within pre-processing chains

- Radiometry
  - Artifacts related to radiometric calibration (striping, banding)

Examples using the airborne HySpex scanner (SWIR camera depicted)

BACHMANN et al., 2013: 
*Extending DLR’s operational data quality control (DataQC) to a new sensor - Results from the HySpex 2012 campaign*
Detecting Striping Artefacts
Detecting Striping Artefacts

Normalized detector map of HySpex scene
Detecting Striping Artefacts

Anomalous pix. at band 31, pixel 237

Normalized detector map of HySpex scene
DESIS – first results using 5 Earth datatakes

- Manufacturing defects as expected
- So far: low number of defective pixels on chip
- So far: consistency in defective pixels (no unstable / “flickering” pixels)
DESIS on-board calibration sources

(LED #1, LED #2, LED #3, LED #4, LED #5, LED #6, LED #7, LED #8, LED #9)  

Blue

Infra-red

(Lab. measurements)
In-orbit vicarious spectral characterization

- Approach:
  analysis of how atm. absorption features are resolved.
  Example: 762 nm Oxygen absorption

Cross-track change is “spectral smile”

Nominal center wavelengths
Nominal bandwidths

(Lab. measurements)
In-orbit vicarious spectral characterization

- Comparison of
  - nominal spectral smile (top)
  - observed spectral smile (below)

- Derivations for some cross-track elements indicate small change between pre- and post-launch spectral calibration

- Next steps: compare to calibration datatakes (LEDs)

First (preliminary) results!
Part 2:
“Offline” Data Quality Control – Vicarious Approaches
Radiometric Cal / Val (I)

- Approach based on
  - permanently instrumented CEOS RadCalNet sites
  - pseudo-invariant desert sites (PICS) thus using agreed community standards

- Allows for modeling at TOA & BOA level
- For vicarious calibration / “flat fielding”
- Also for sensor cross-calibration to other missions (e.g., S-2)

- DESIS tilting capabilities can also contribute to site BRDF characterization!

Source: http://calvalportal.ceos.org
Radiometric Cal / Val (II)

- Dedicated CalVal campaigns using airborne and in-situ measurements

- Preparatory campaigns in 2018: DLR HySpex and NASA AVIRIS NG overflights over Oberpfaffenhofen, incl. on-site measurements
Summary – Cal/Val/Mon/DataQC for EnMAP & DESIS

- **Calibration & monitoring**
  - On-board calibration sources (& sun calibration)
  - Inclusion of vicarious CalVal approaches

- **DataQC within pre-processing chain**
  - Integrated within L0 / L1B / L1C / L2A processors
  - Generation of QC-related metadata, QC flags + reports
  - Interactive procedures for additional parameters

- **Independent validation**
  - Incl. ground-based CalVal activities
Thank you very much for your attention!

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