Procedures for DataQC within the EnMAP and DESIS Ground Segments

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Spaceborne EO imaging spectrometer missions

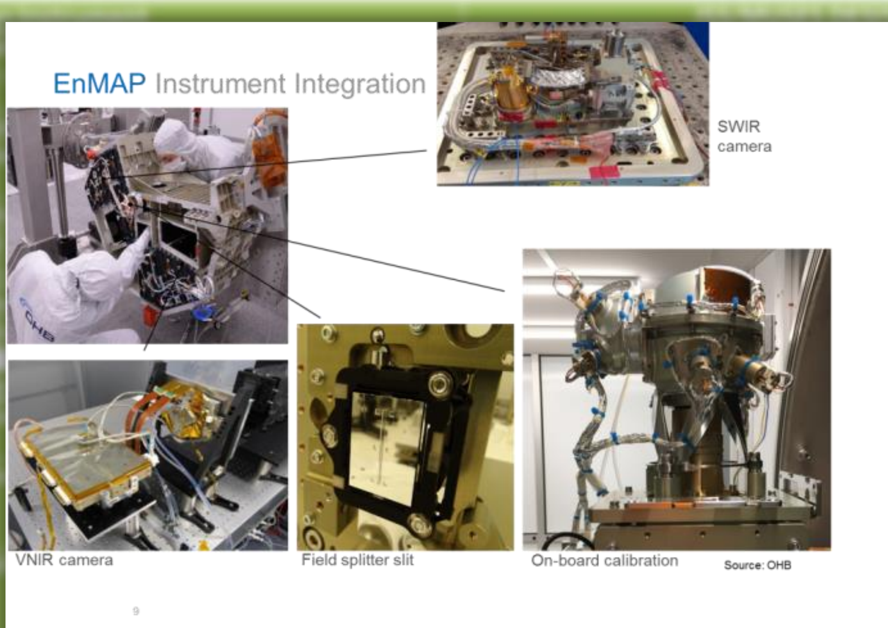
Mission Instrument	ISS/MUSES DESIS	EnMAP HSI (2 instruments)
Target lifetime	2018-2023	2020-2025
Satellite (mass, dimension, usage)	455 t, 109.0×97.9×27.5 m^3 (multi-purpose)	1 t, 3.1×2.0×1.7 m^3 (single-purpose)
Orbit (type, local time at equator, inclination, height, repeat cycle)	not Sun-synchronous,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

Mission Instrument	ISS/MUSES DESIS	EnMAP HSI (2 instruments)
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

Mission Instrument	ISS/MUSES DESIS	EnMAP HSI (2 instruments)
Space agency	Teledyne, USA & DLR, Germany	DLR, Germany (Science Segment: GFZ et al.)
Space segment	Teledyne • VNIR Instrument by DLR	OHB System AG • VNIR Camera by DLR • Support Calibrations by DLR
Ground segment	Teledyne • Processing, Archiving, Processors, and Calibration by DLR	DLR (EOC, GSOC) • Project Management • Command and Control • User Interf., Data Reception, Processing, and Archiving • Processors and Calibration

Spaceborne EO imaging spectrometer missions

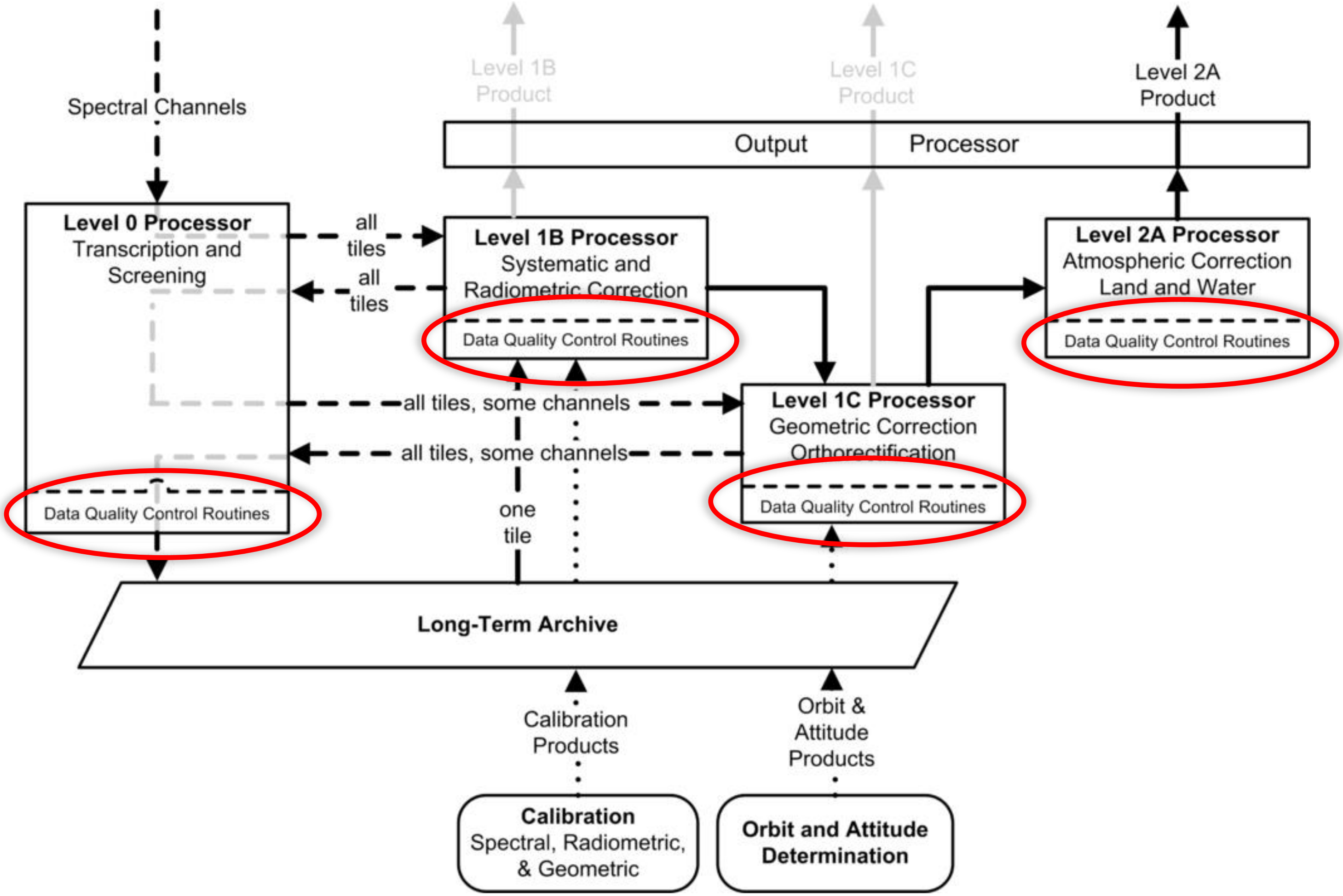
… many dedicated presentations in this session



EnMAP Hyperspectral Imager

Part 1:
Data Quality Control within Pre-Processing Chains

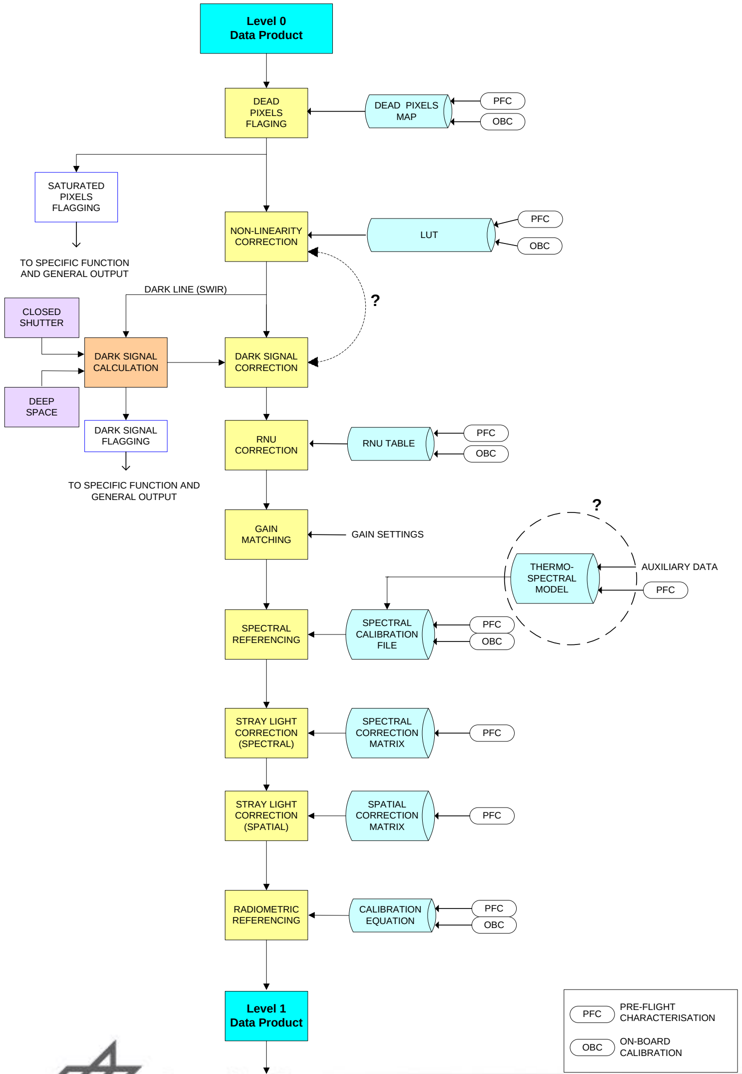
Overview - Processing Chain (EnMAP)



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 flaging**
- **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**

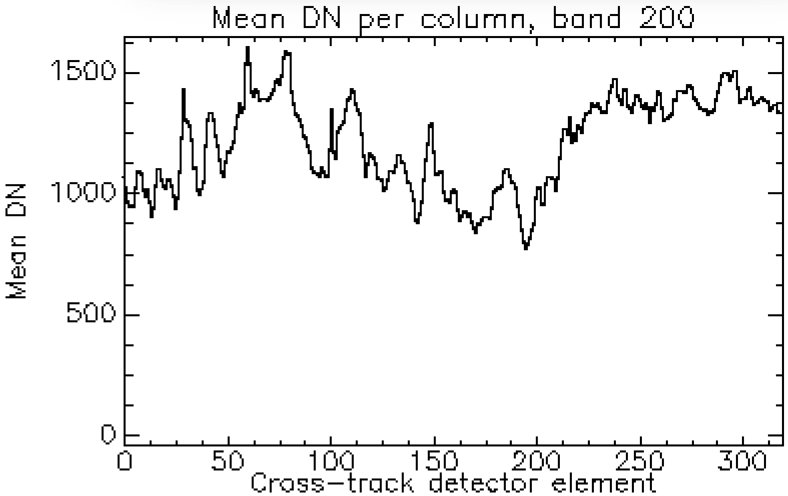
L1C / L2A

- Geometric correction (incl. keystone correction)
- Atmospheric correction (incl. smile correction)

Operational QC within pre-processing chains

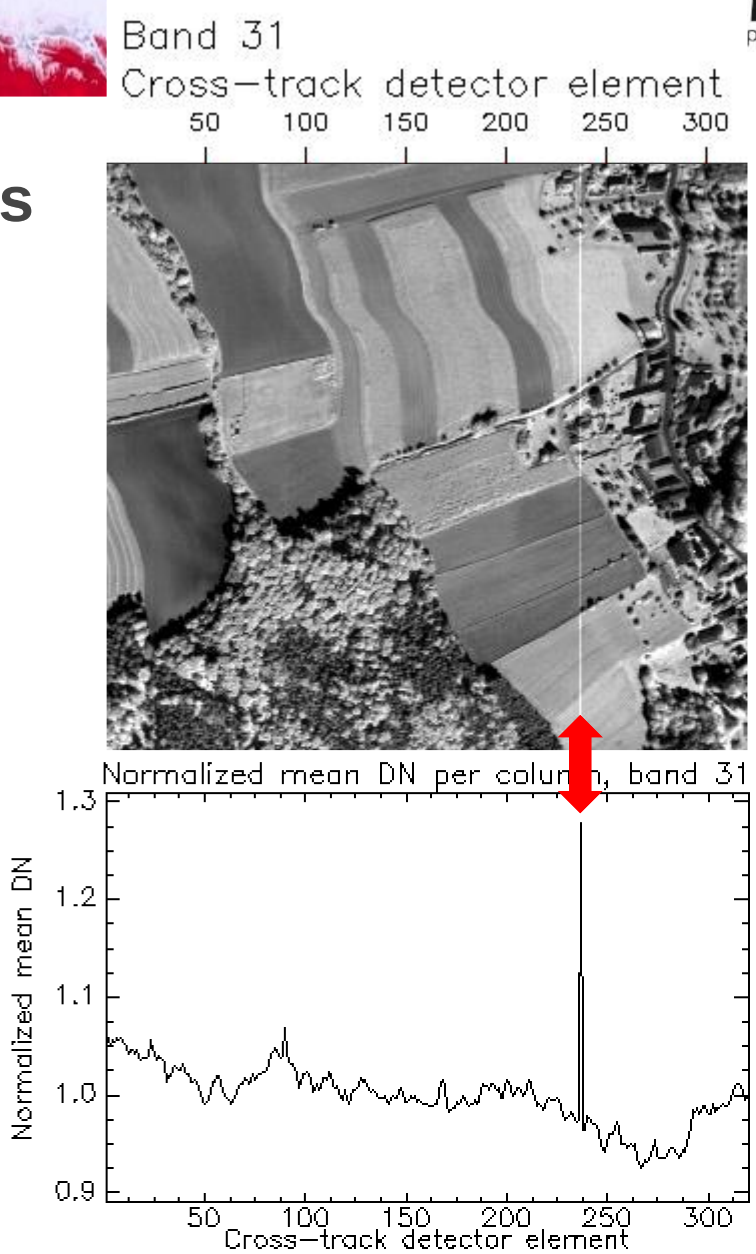
- **Radiometry**
  - Artifacts related to radiometric calibration (striping, banding)

Examples using the airborne HySpex scanner (SWIR camera depicted)

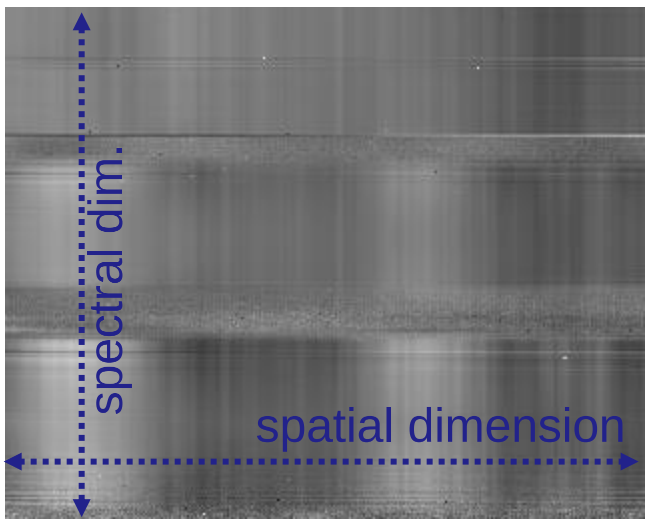


BACHMANN et al., 2013:
Extending DLR's operational data quality control (DataQC) to a new sensor - Results from the HySpex 2012 campaign
EARSeL SIG-IS, Nantes, 2013.

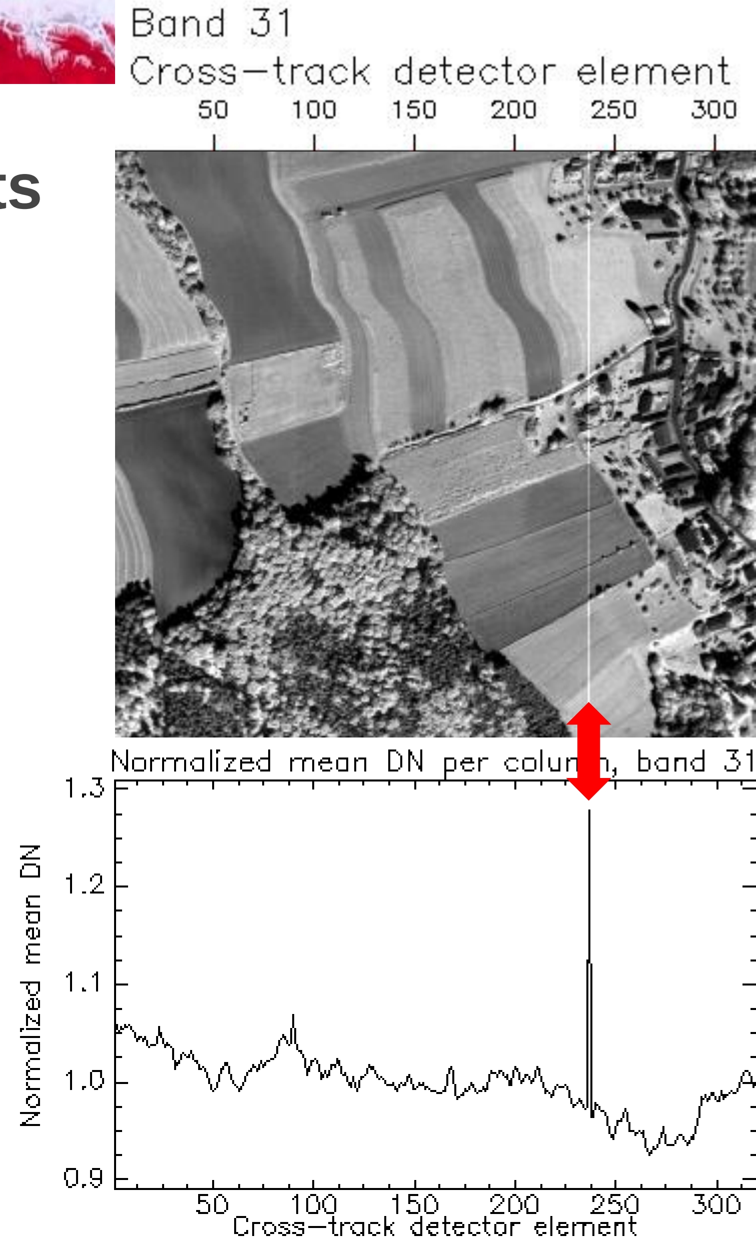
Detecting Striping Artefacts



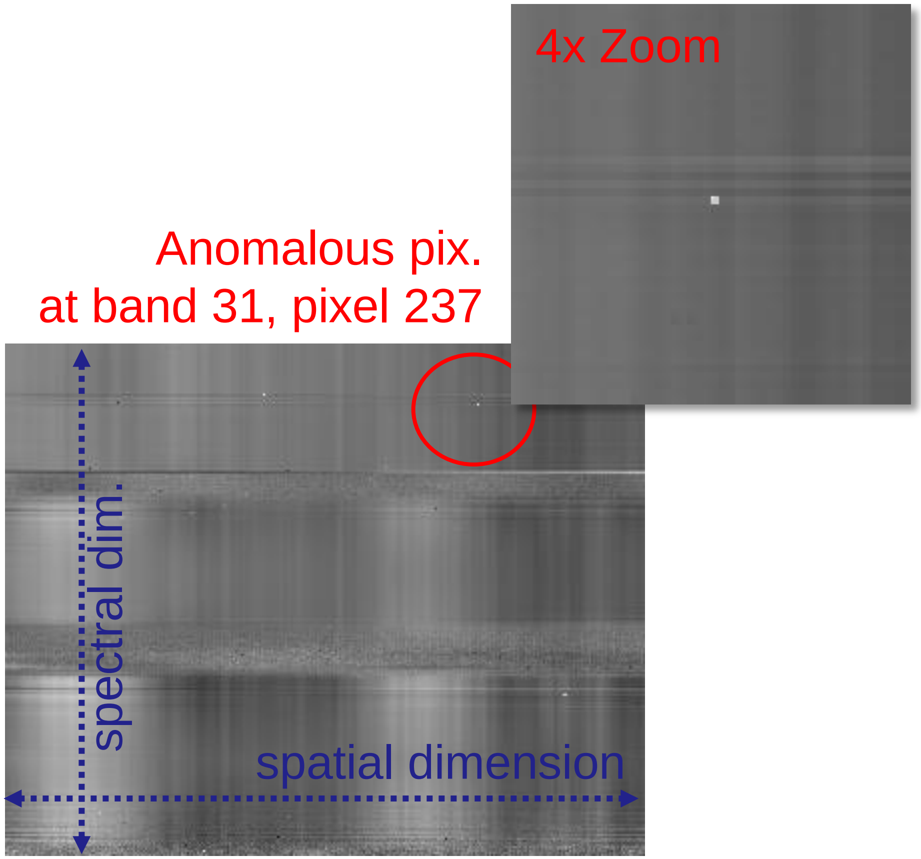
Detecting Striping Artefacts



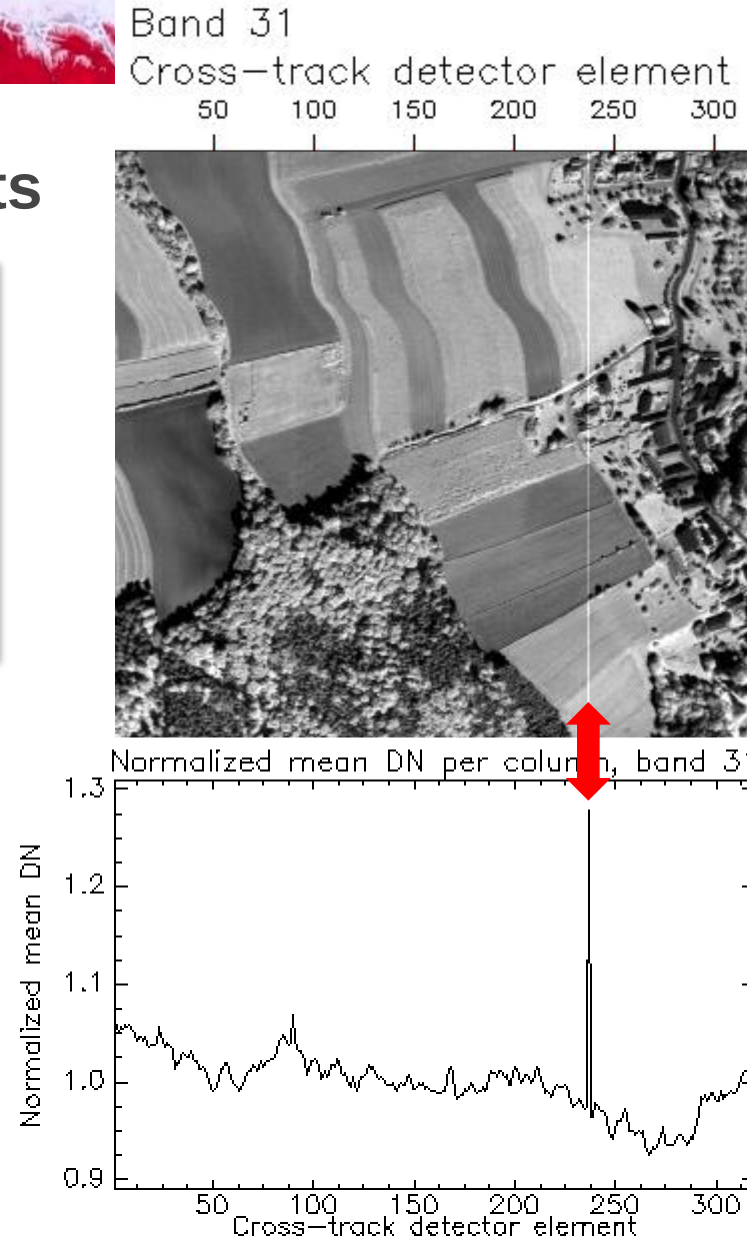
Normalized detector map of HySpex scene



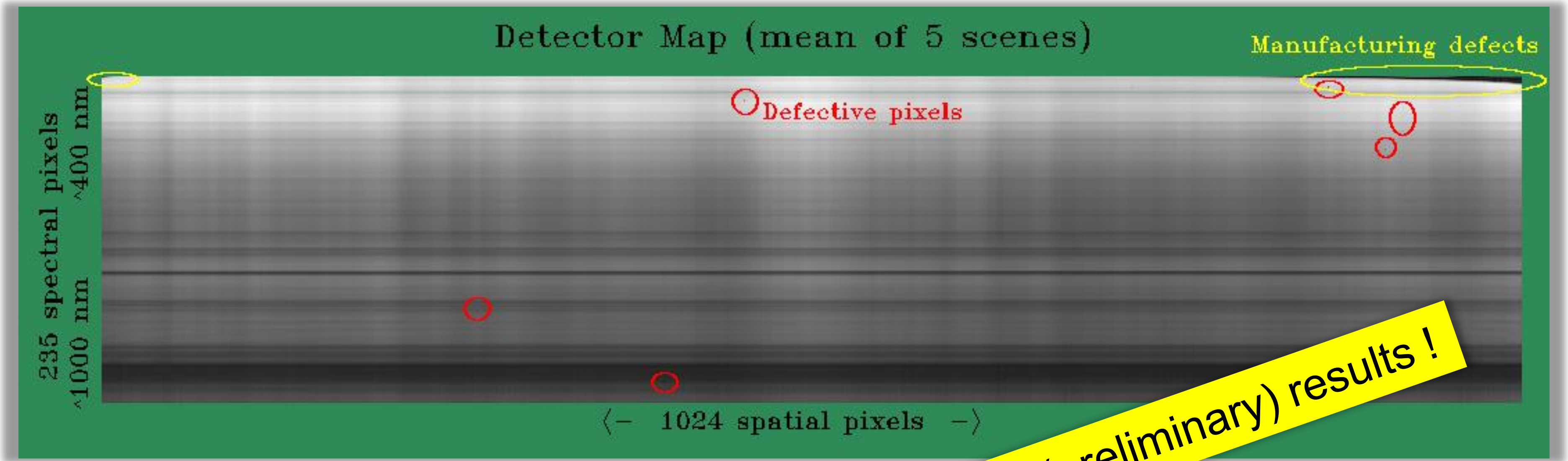
Detecting Striping Artefacts



Normalized detector map of HySpex scene



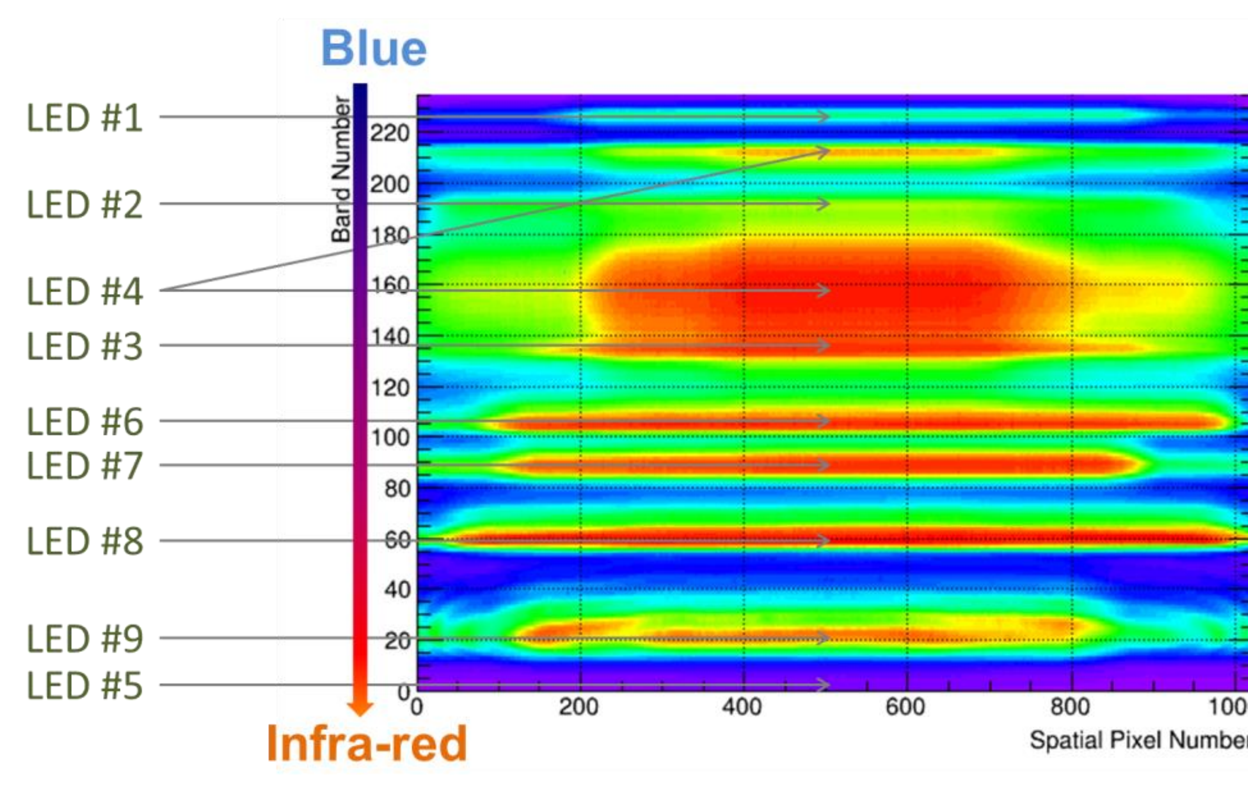
DESIS – first results using 5 Earth datatakes

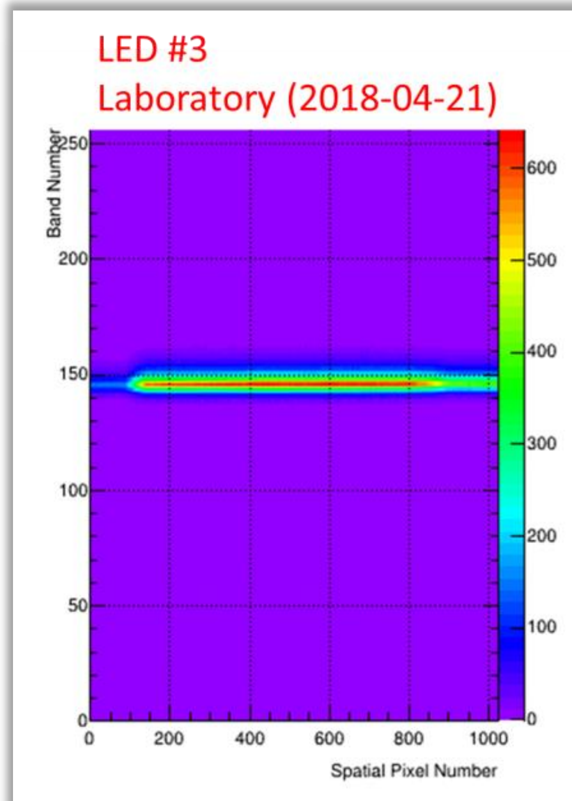


First (preliminary) results !

- 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



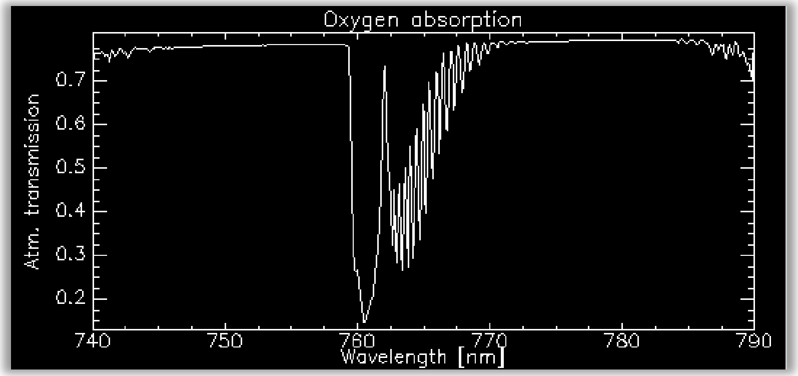


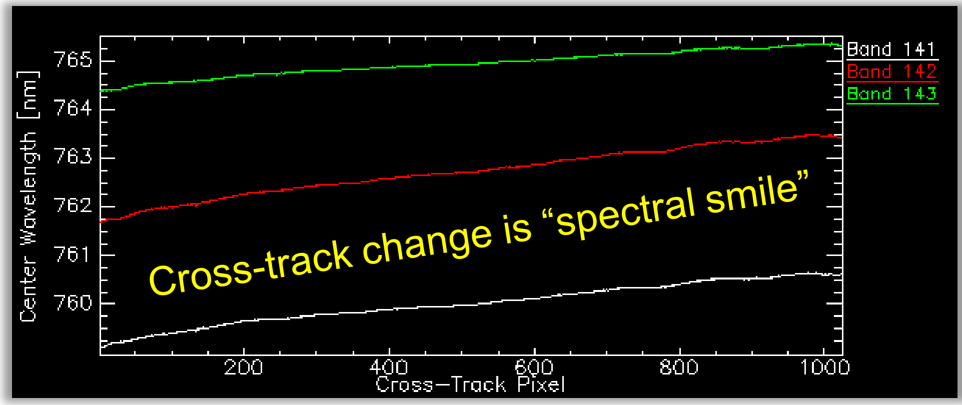
(Lab. measurements)

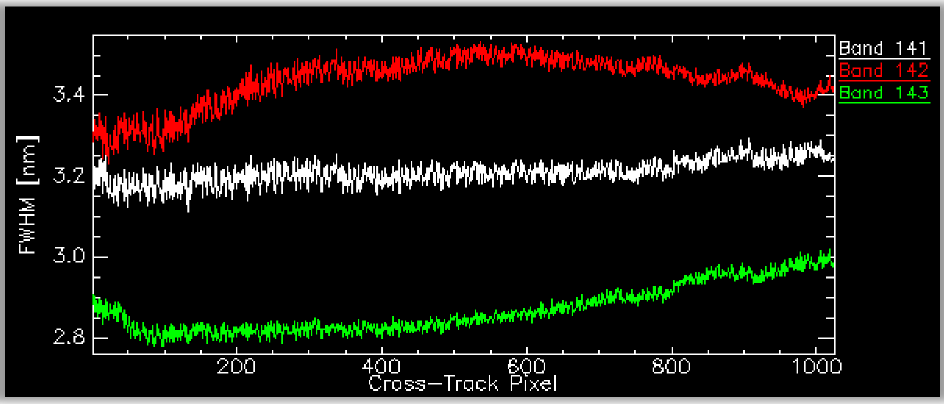
Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft

In-orbit vicarious spectral characterization

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







Nominal center wavelengths

Nominal bandwidths

(Lab. measurements)

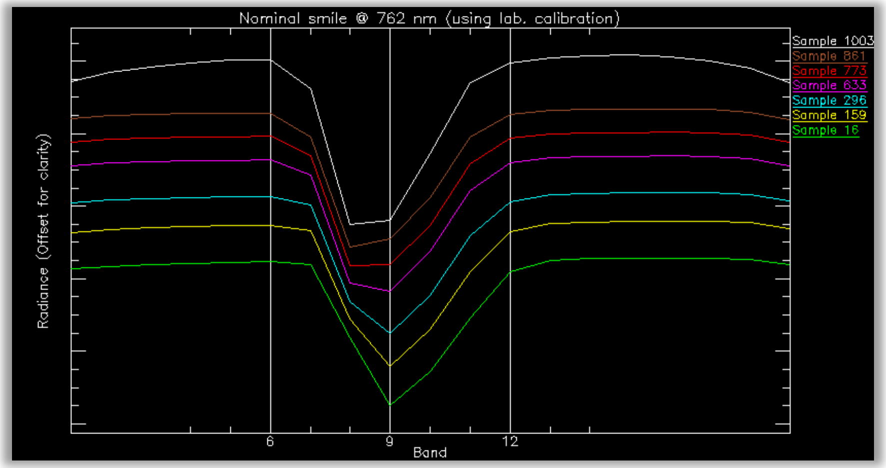
In-orbit vicarious spectral characterization

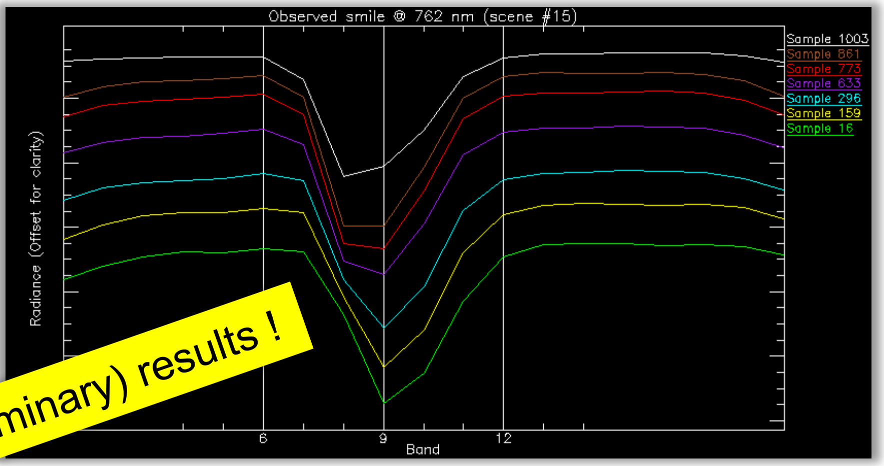
- Comparison of
  - nominal spectral smile (top)

  Vs.
  - 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

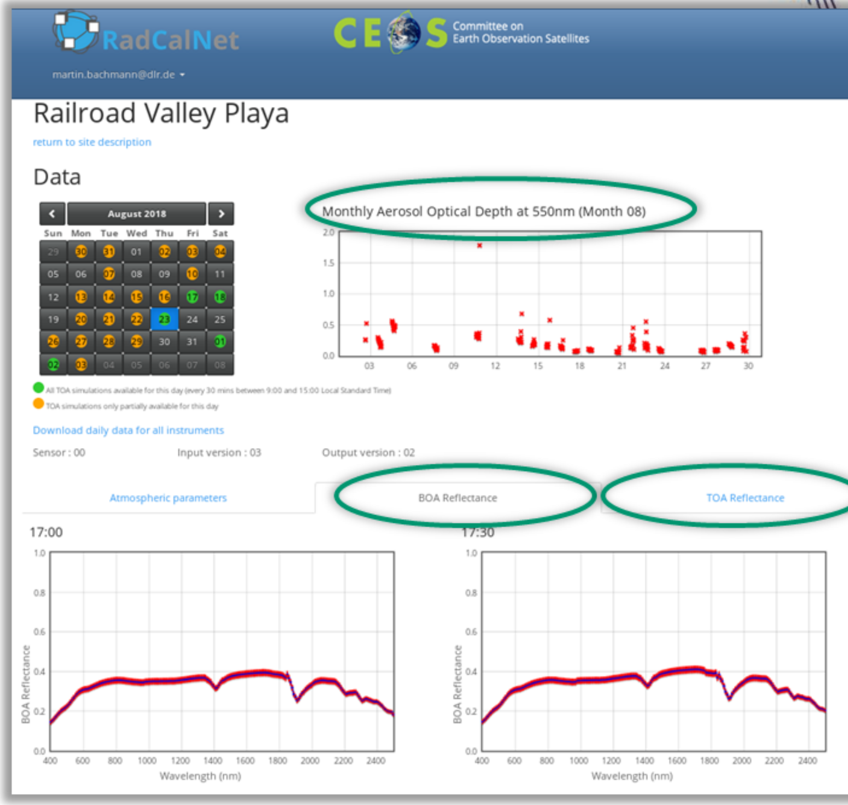
Radiometric Cal / Val (I)

- Approach based on
  - permanently instrumented CEOS RadCalNet sites
  - pseudo-invariant desert sites (PICS)

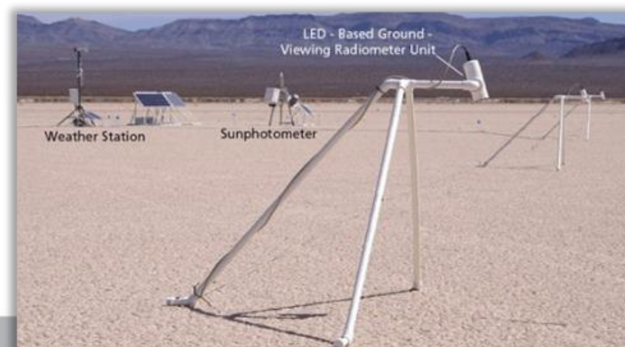
thus using agreed community standards

- 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 !



http://radcalnet.org



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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