

Operational quality control for spaceborne hyperspectral sensors examples for the spectral performance assessment of DESIS and EnMAP

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Knowledge for Tomorrow



Objectives of this talk

Previous contributions on EnMAP and DESIS

- DESIS – overall calibration and mission, see talk by E. Carmona
- EnMAP – overall mission, see talk by T. Storch
- EnMAP – radiometric performance, processor Cal/Val, see talk by M. Pato
- EnMAP – in-orbit calibration, see talk by D. Marshall

Focus:

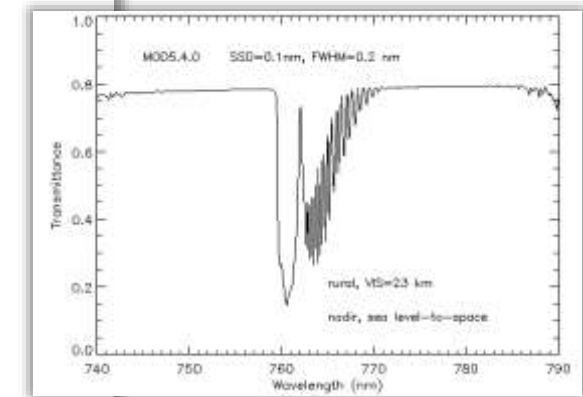
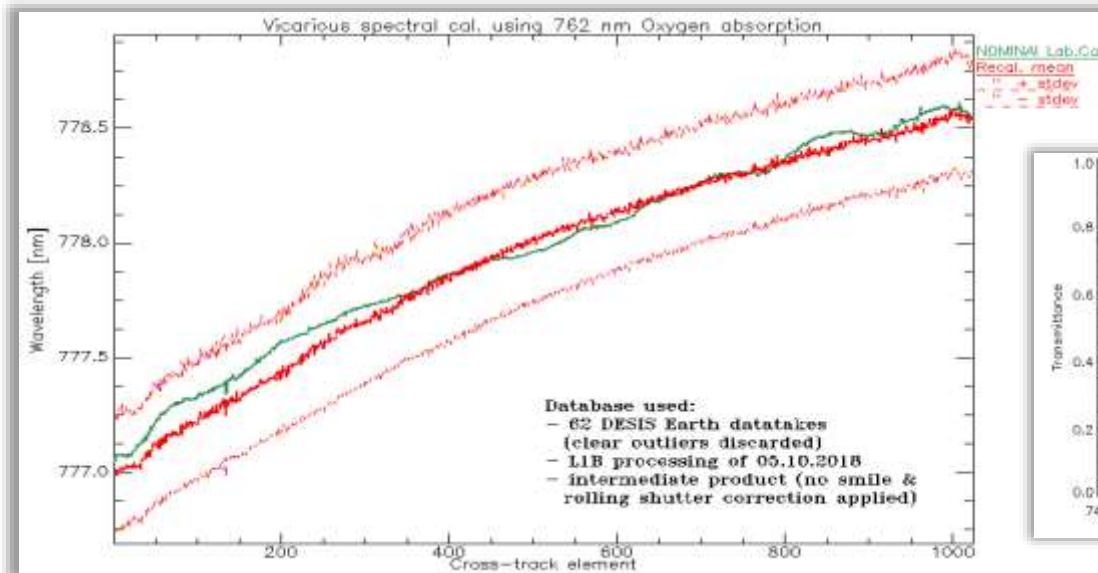
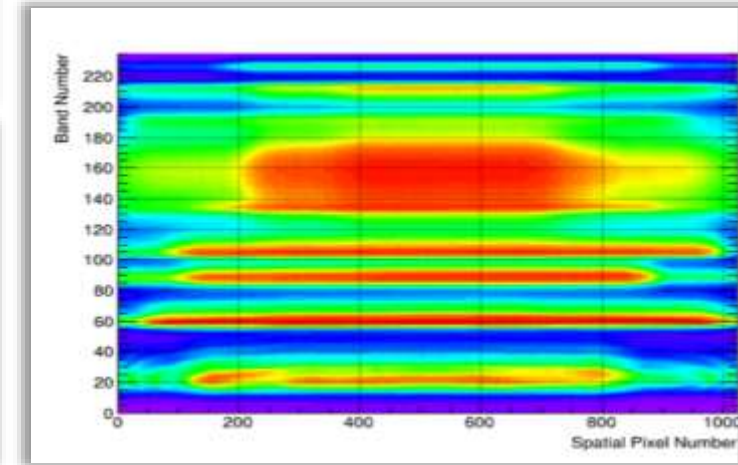
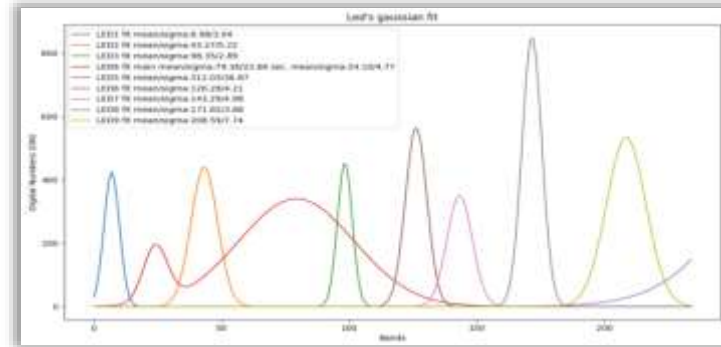
- **Spectral performance of DESIS and EnMAP based on Earth Datatakes**
- **Examples from resulting uncertainty for L3+ thematic products**



DESIS: In-Orbit Spectral Characterization

- Using on-board calibration sources (LEDs)
 - ✓ • Pre- and post-launch characteristics
 - Incl. temperature stability & other HK / telemetry data

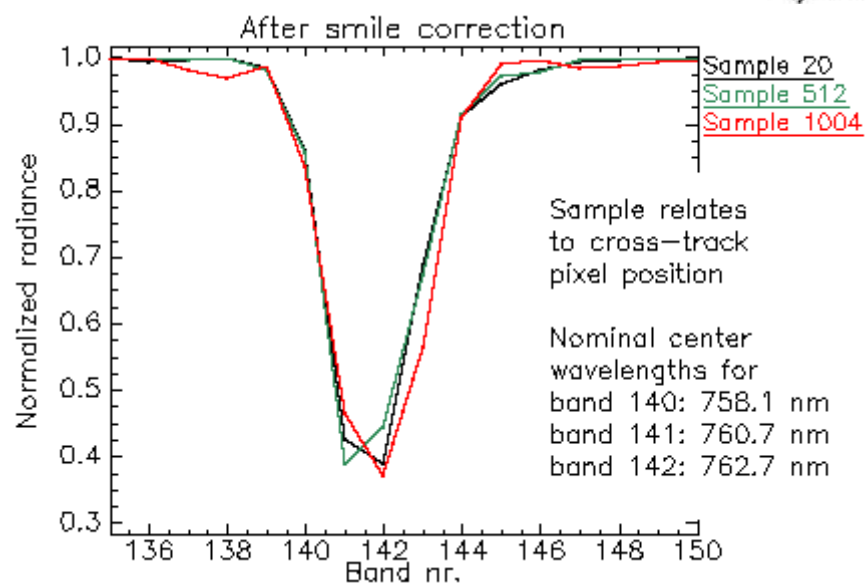
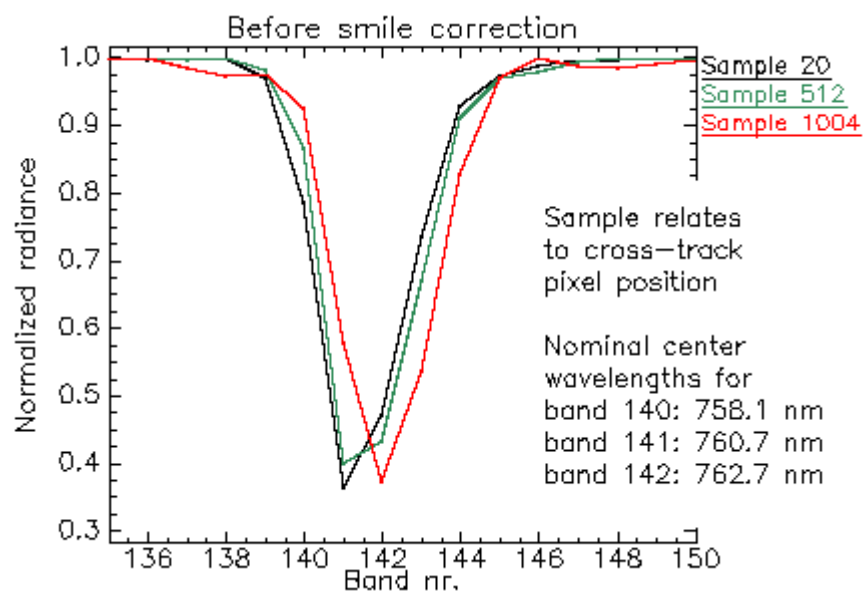
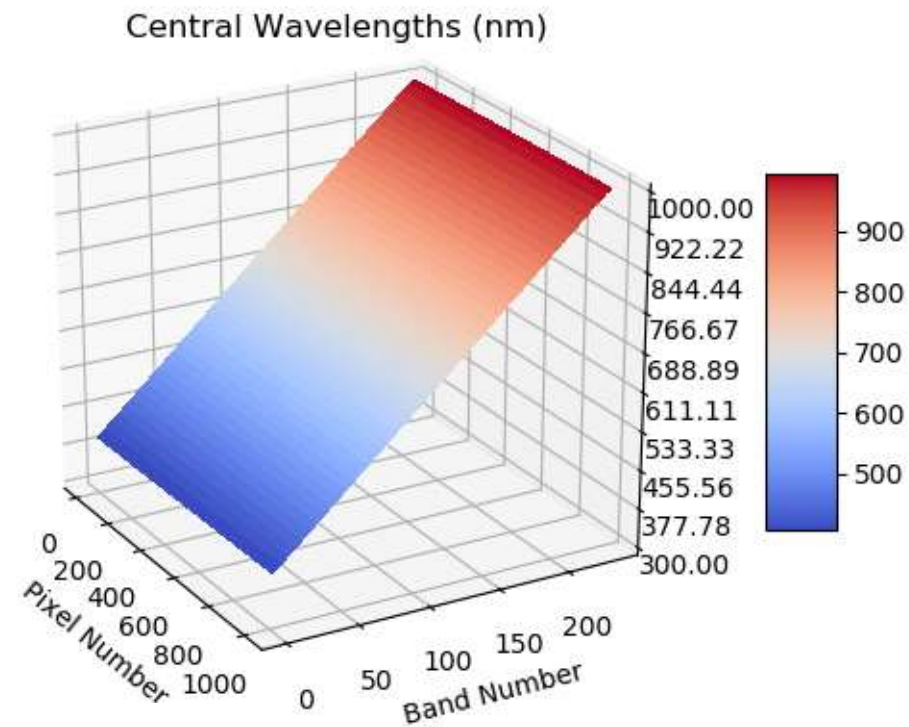
- Using atmospheric absorption features
 - ✓ • Smile pre- and post-launch



Note: cross-track index is flipped here

DESIS: Smile Correction / Spectral Monitoring

- Bicubic interpolation to the central pixel wavelength.
- Assessments, performed on DESIS data, around Oxygen absorption band.

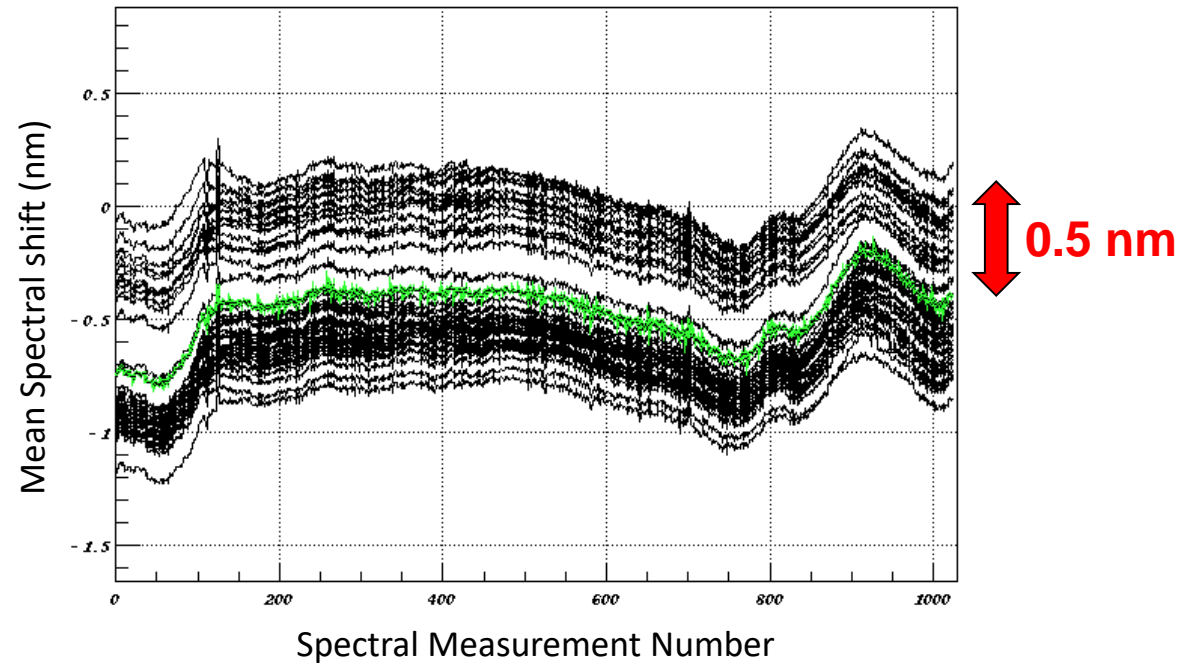


DESIS: Influences on Spectral Stability

DESIS
Temperature gradient in housing
(see talk by E.Carmona)

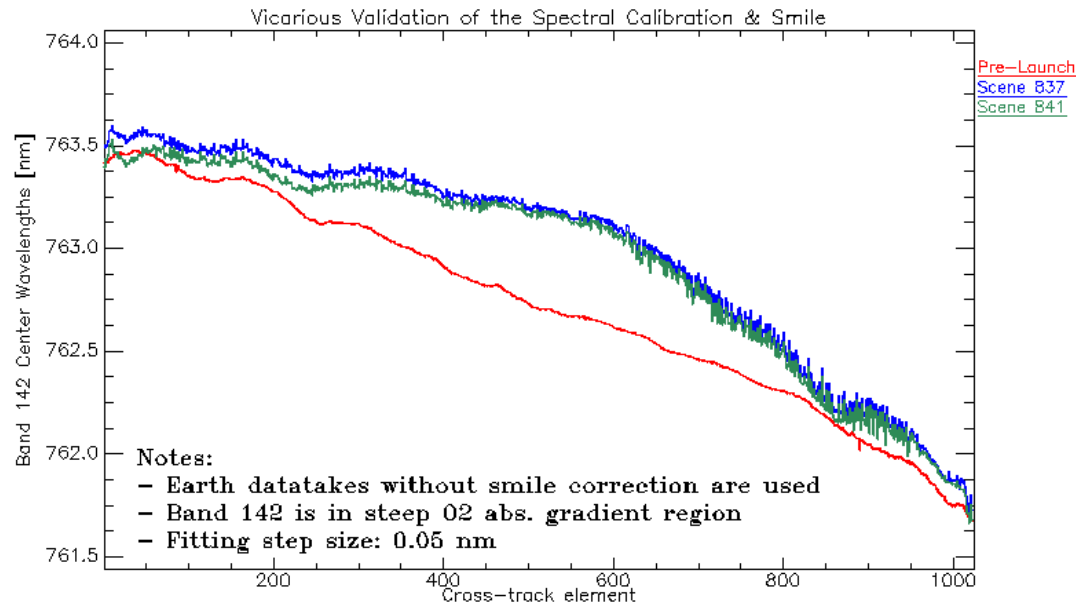
Note: FPA stabilized to 0.1k

LED @ 660 nm

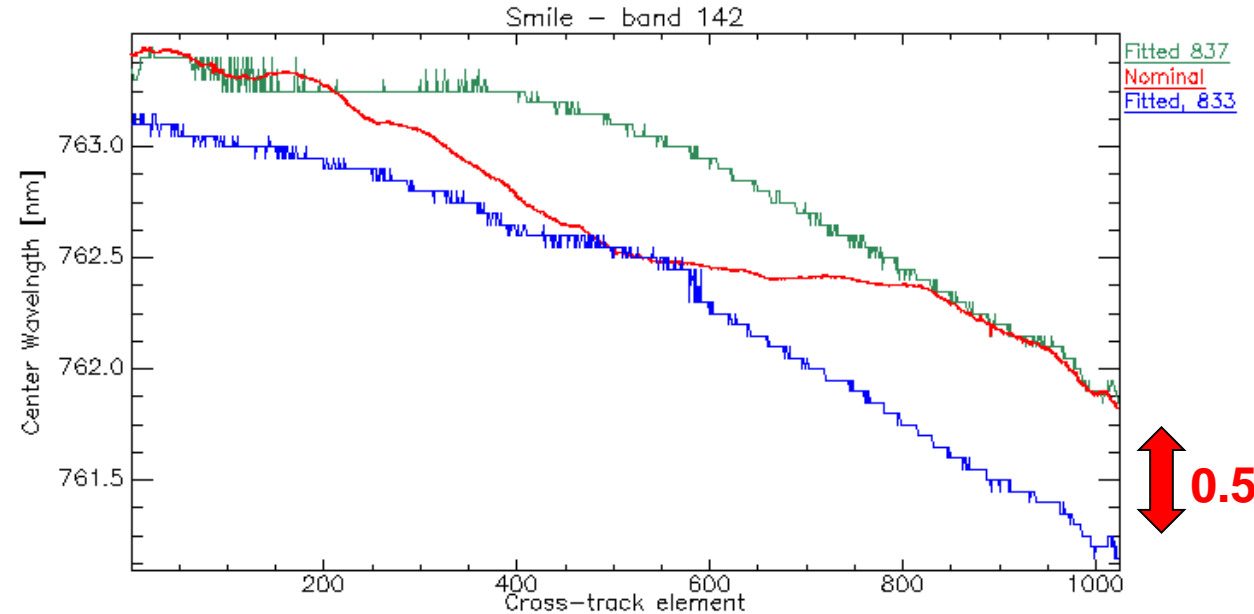


DESIS: Influences on Spectral Stability

- Vicariously performed on DESIS Earth datatakes, L1B processing, no smile correction applied
- Shift confirmed for Oxygen absorption region (762 nm) & other wavelengths (483, 524 & 819 nm)



Left: fit for 2 datatakes with same ΔT

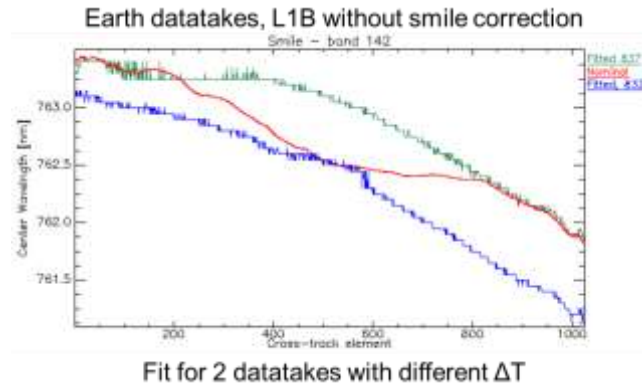
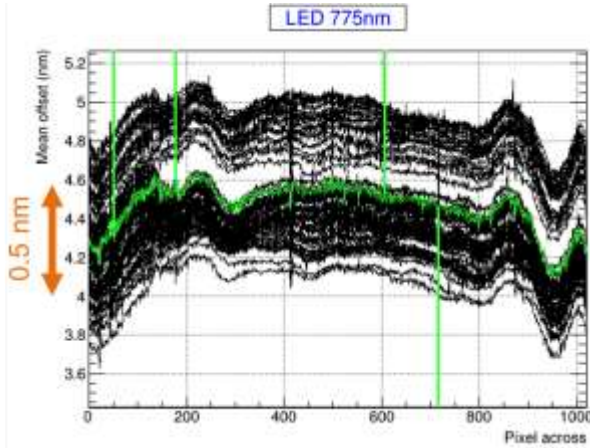


Right: fit for 2 datatakes with different ΔT



DESIS: Influences on Spectral Stability

Slight spectral shifting due to temperature gradient



Corrected in L1B processor, remaining RMS ~ 0.1 nm (@ ~ 2.55 nm SSI)

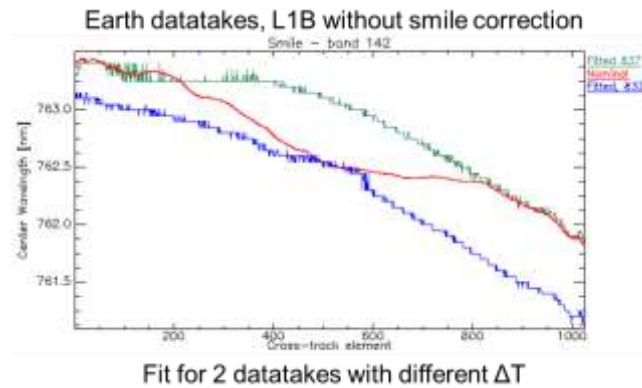
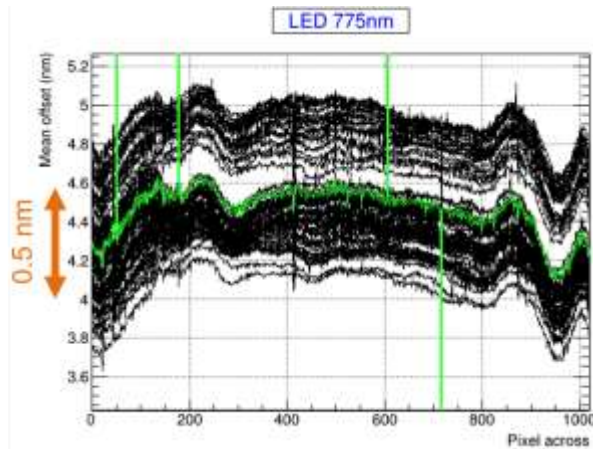


Correction possible based on housekeeping data, implemented in L1B processing



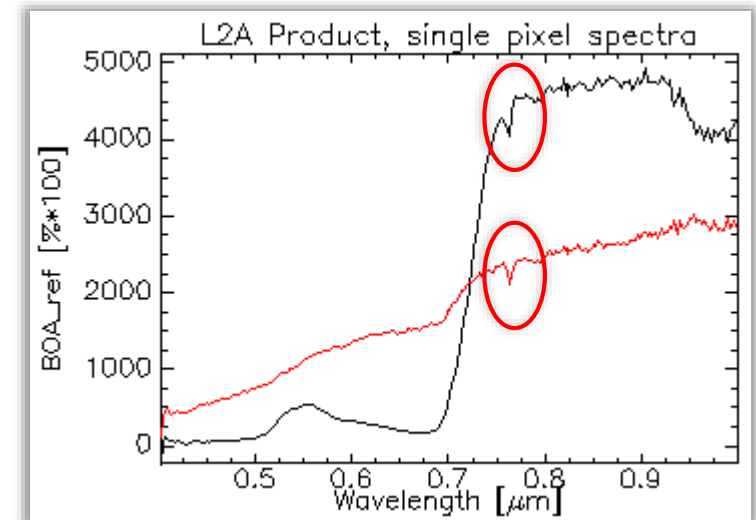
The L2A product... now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient



Corrected in L1B processor, remaining RMS ~0.1 nm (@ ~ 2.55 nm SSI)

DESIS L2A Product

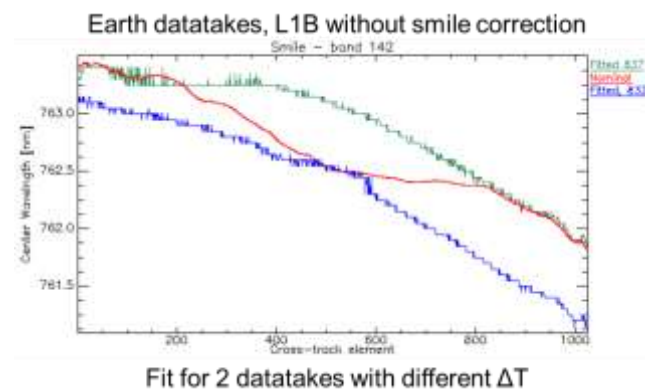
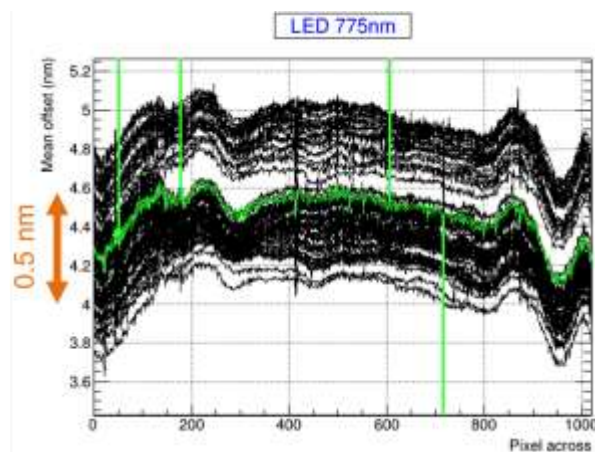


Oxygen absorption at 760 nm



The L2A product... now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient



Corrected in L1B processor, remaining RMS ~0.1 nm (@ ~ 2.55 nm SSI)

Approach:

- Shifting the center wavelengths at TOA_RAD
 - by +/- 0.1 nm (nominal corrected case)
 - by +/- 0.5 nm (uncorrected case)
- Process to BOA_ref using ATCOR
 - Interactive, but using same settings as DESIS L2A (PACO)
 - No smoothing nor interpolation

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Article

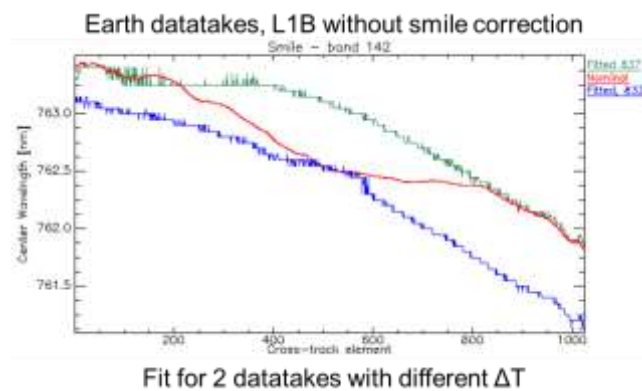
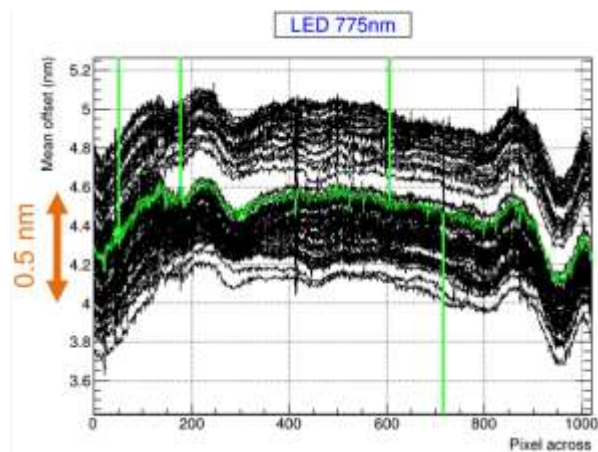
Estimating the Influence of Spectral and Radiometric Calibration Uncertainties on EnMAP Data Products—Examples for Ground Reflectance Retrieval and Vegetation Indices

Martin Bachmann ^{1,*}, Allaksei Makaran ¹, Karl Segl ² and Rudolf Richter ¹

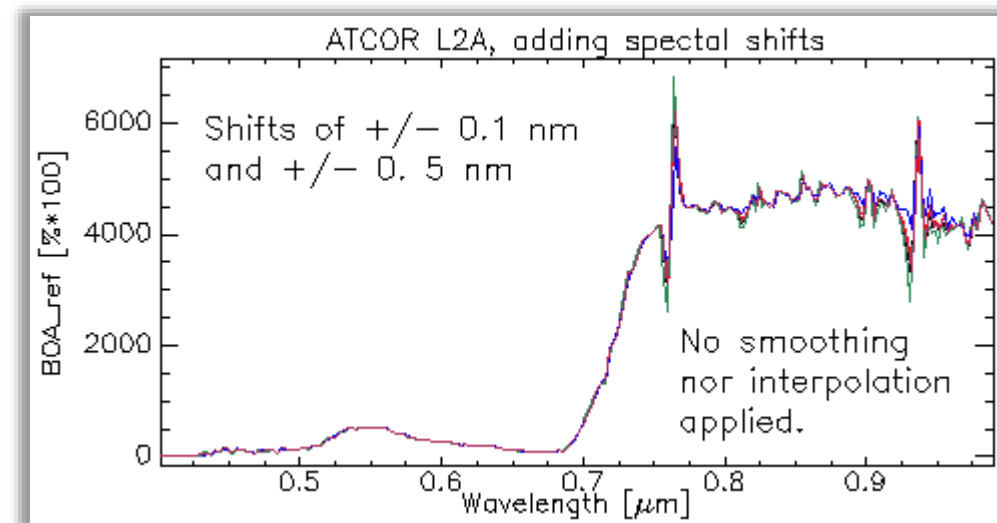


The L2A product... now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient

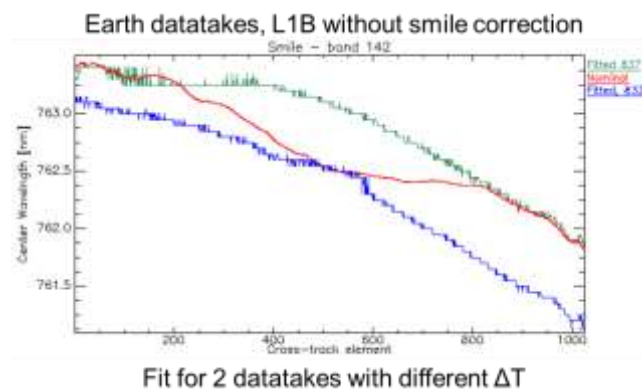
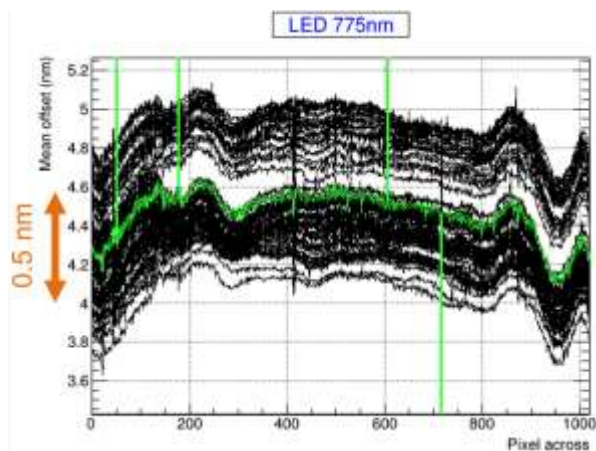


Corrected in L1B processor, remaining RMS ~ 0.1 nm (@ ~ 2.55 nm SSI)

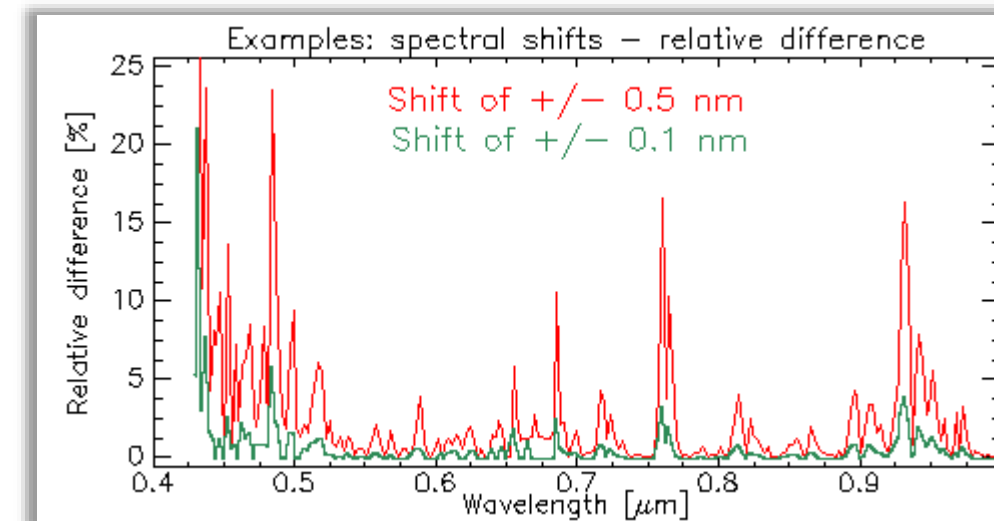
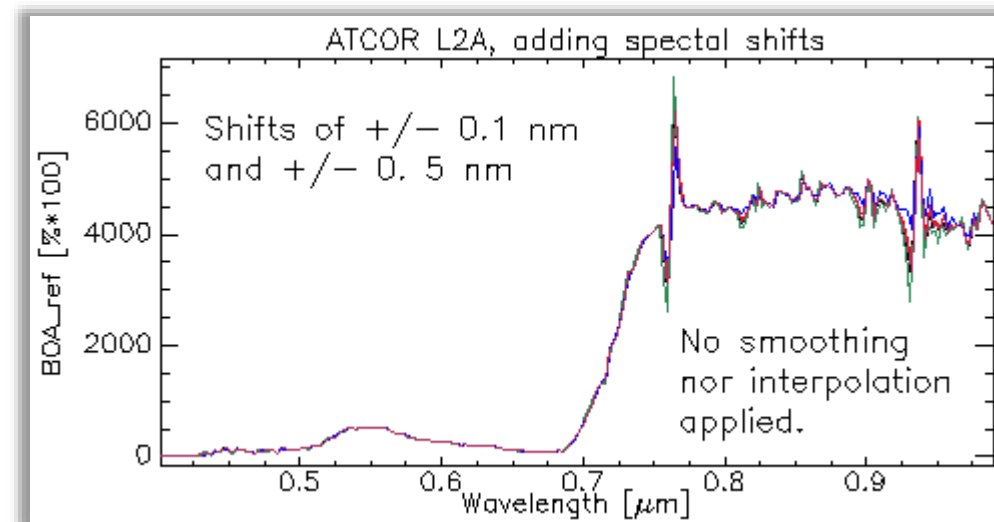


The L2A product... now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient

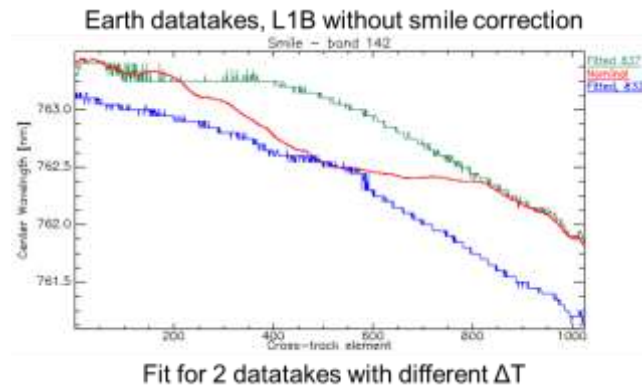
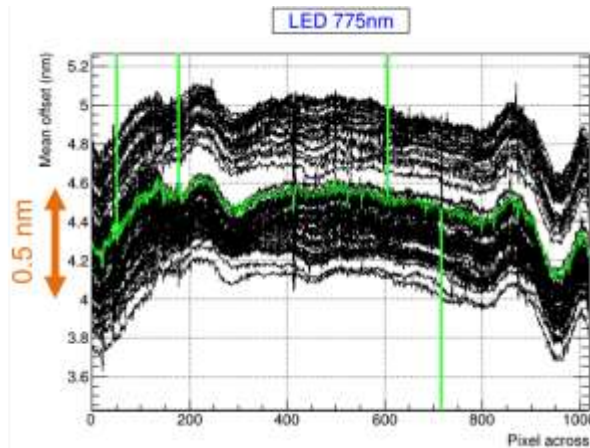


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The L2A product... now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient

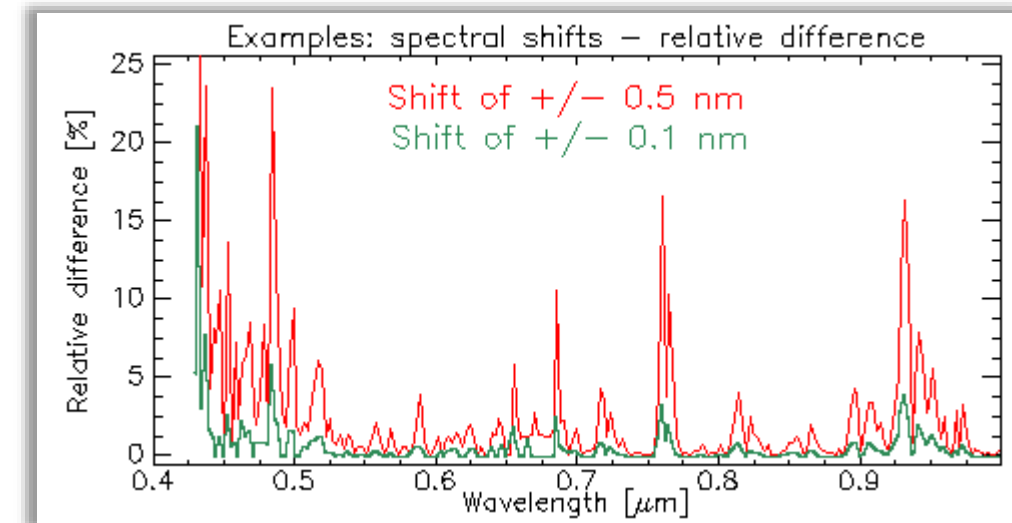
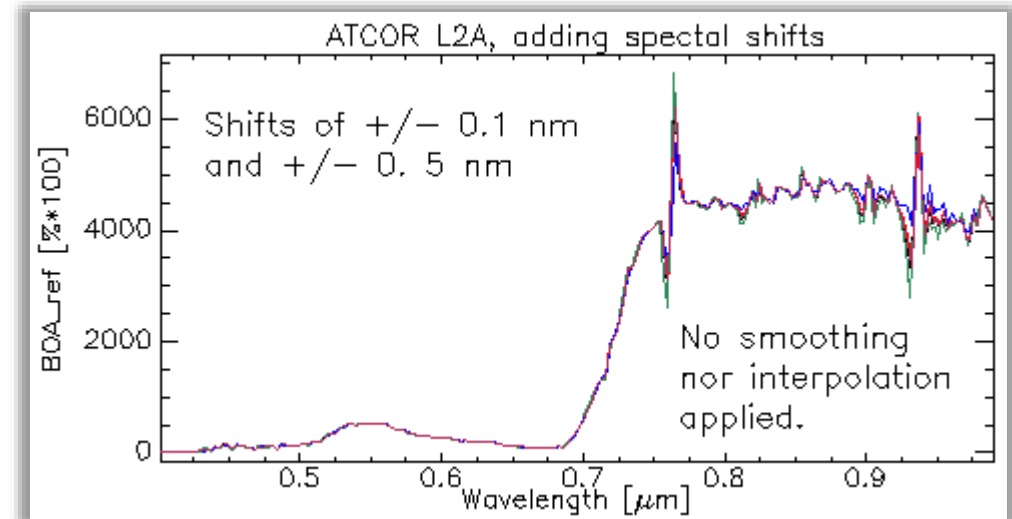


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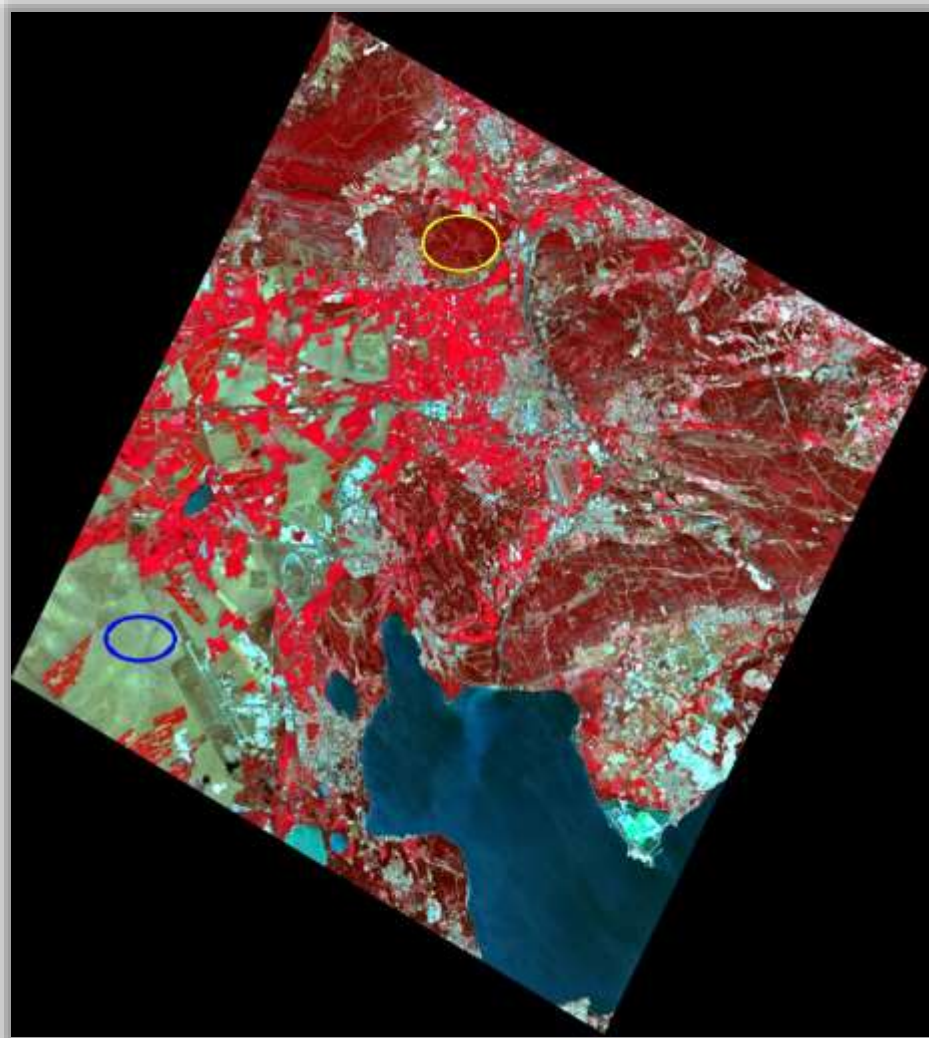
Sidenote:

WV retrieval influenced by 2% (± 0.1 nm) resp. 7% (± 0.5 nm)

AOT retrieval not significantly influenced in this example.



Influence on vegetation products



Examples using

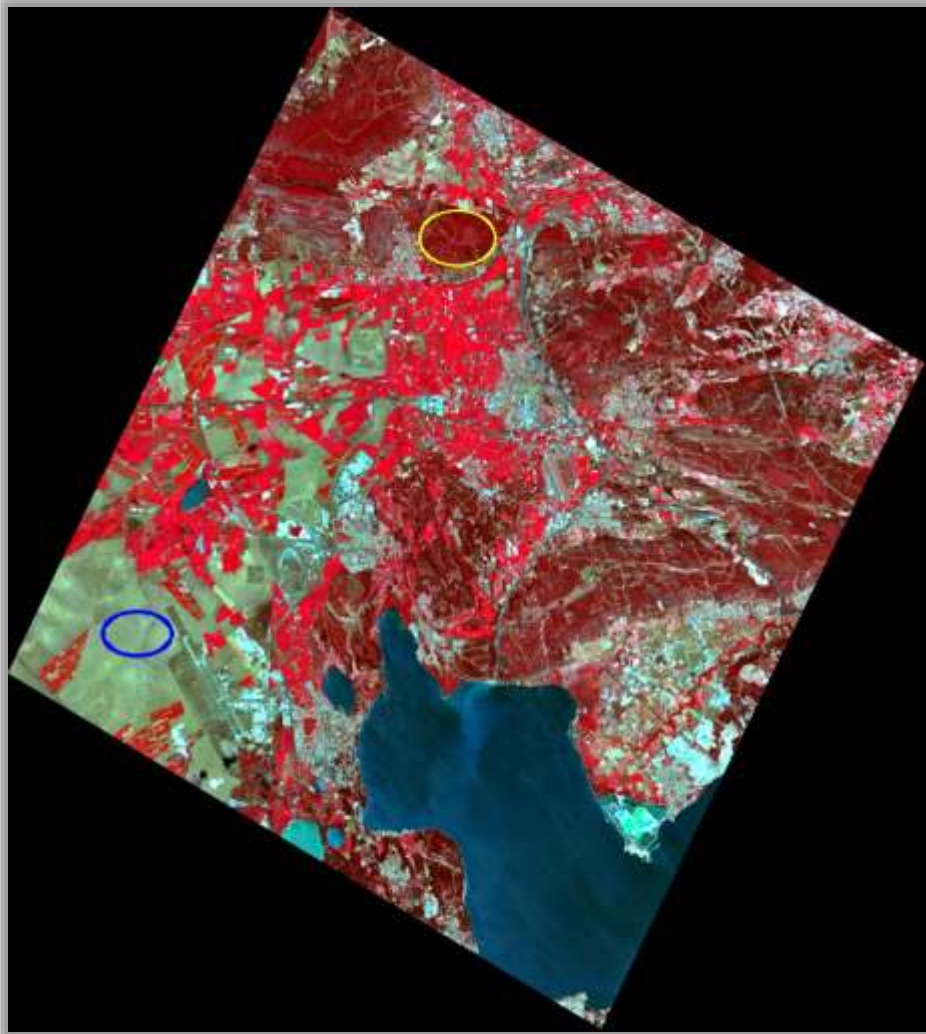
- Heterogeneous vital green forest / shrub area (yellow circle)

	Shift of +/- 0.1 nm	Shift of +/- 0.5 nm
Broadband (NDVI, SAVI, EVI)	<1%	~1%
RedEdge (Vogelmann)	<1%	~1.5%
Photochem. index (PRI)	~2%	up to 60%
Carotenoid index	<1%	~3%
Anthocyanin index	~1%	~5%

- Homogeneous dry grassland area (blue circle)

	Shift of +/- 0.1 nm	Shift of +/- 0.5 nm
Broadband (NDVI, SAVI, EVI)	<1%	~2%
RedEdge (Vogelmann)	<1%	~1.7%
Photochem. index (PRI)	~2%	~10%
Carotenoid index	<1%	~2%
Anthocyanin index	~1%	~3%

Influence on vegetation products



Examples using

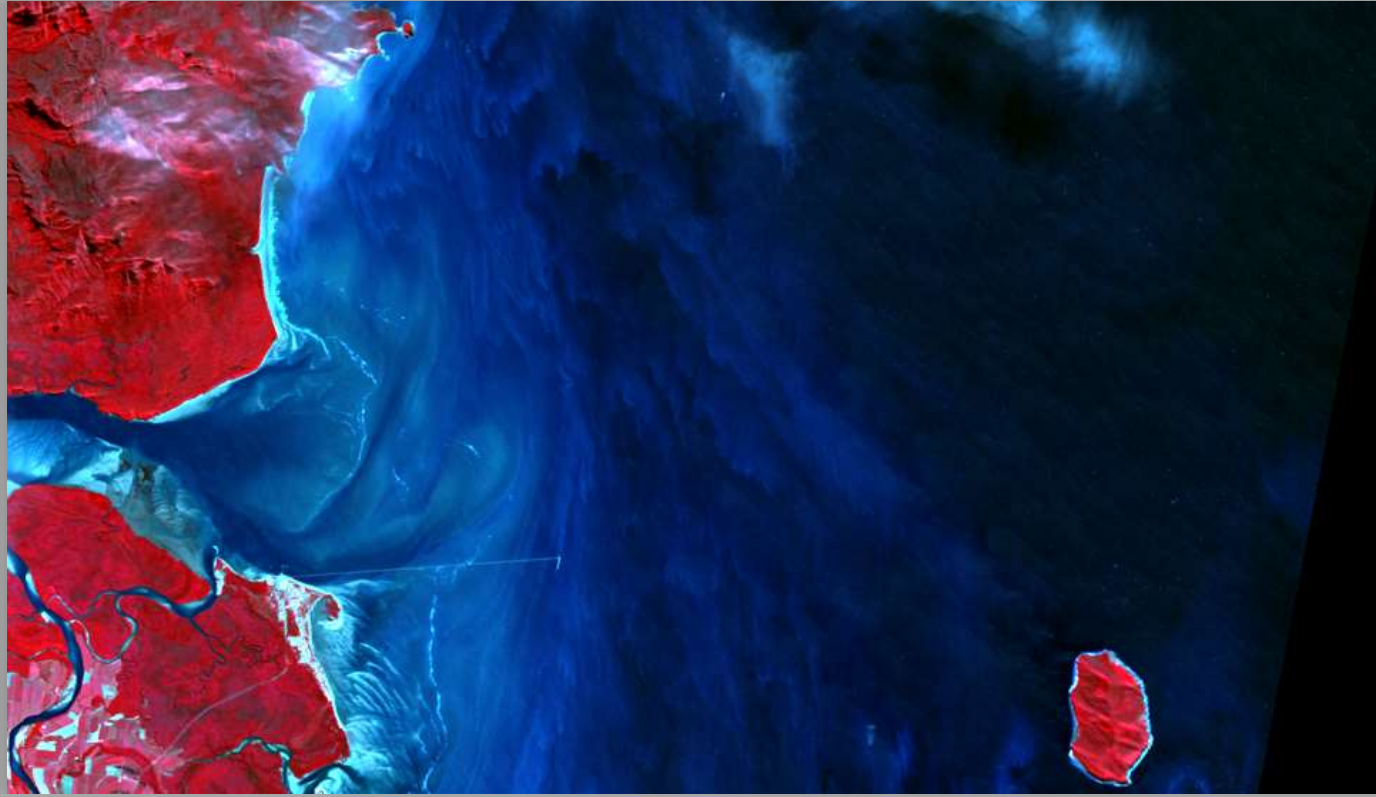
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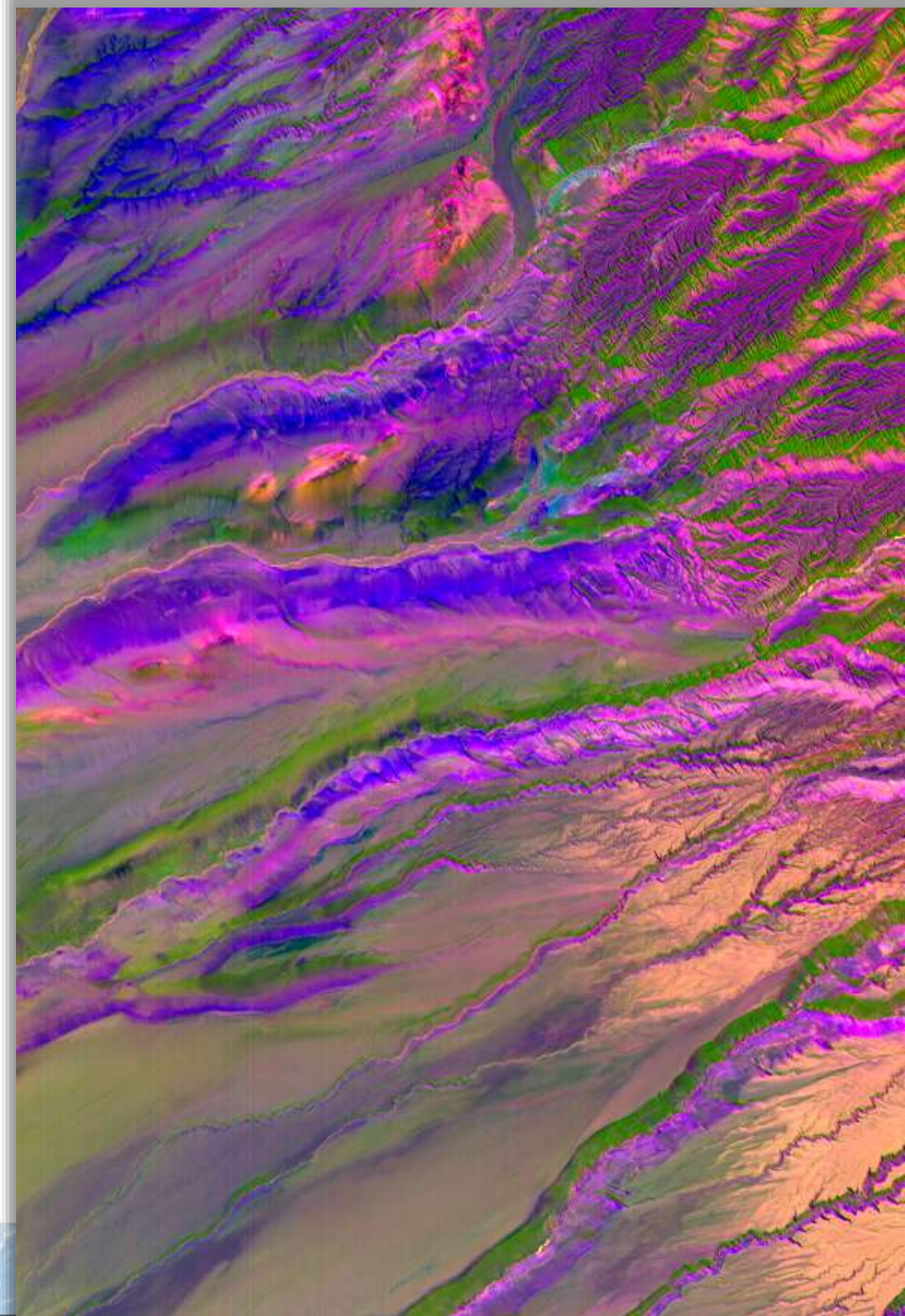
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EnMAP – Focus on Vicarious Validation using Earth Datatakes



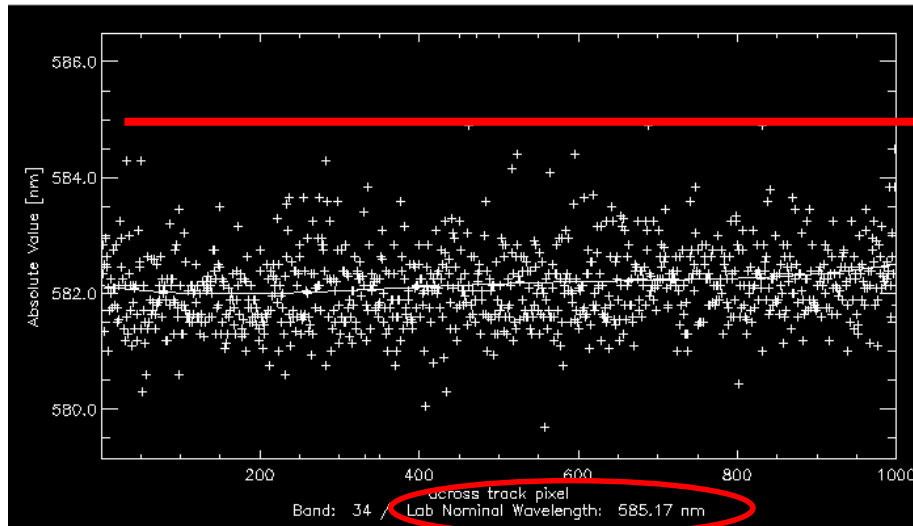
Lucinda Jetty, Australia (CIR)



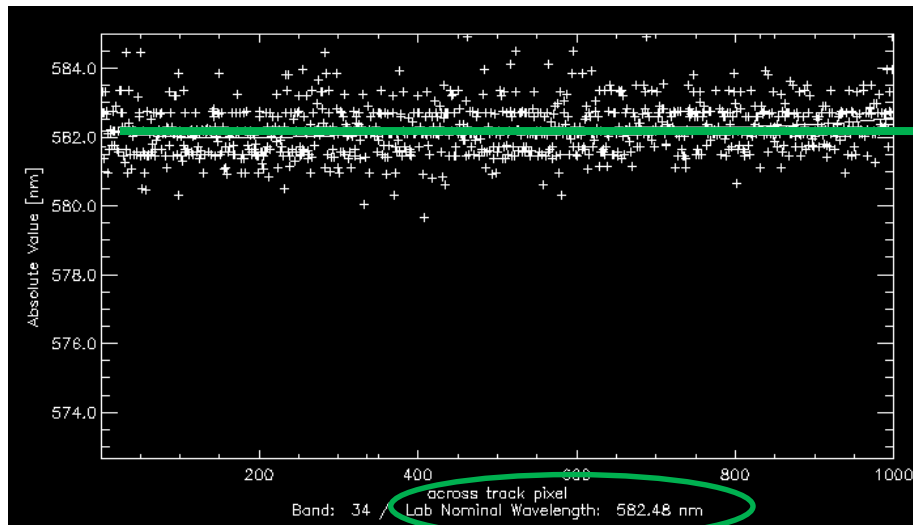
Desert Playa, Peru
(SWIR, PC-Transfo.)

EnMAP – Pre- to Post-Launch Changes

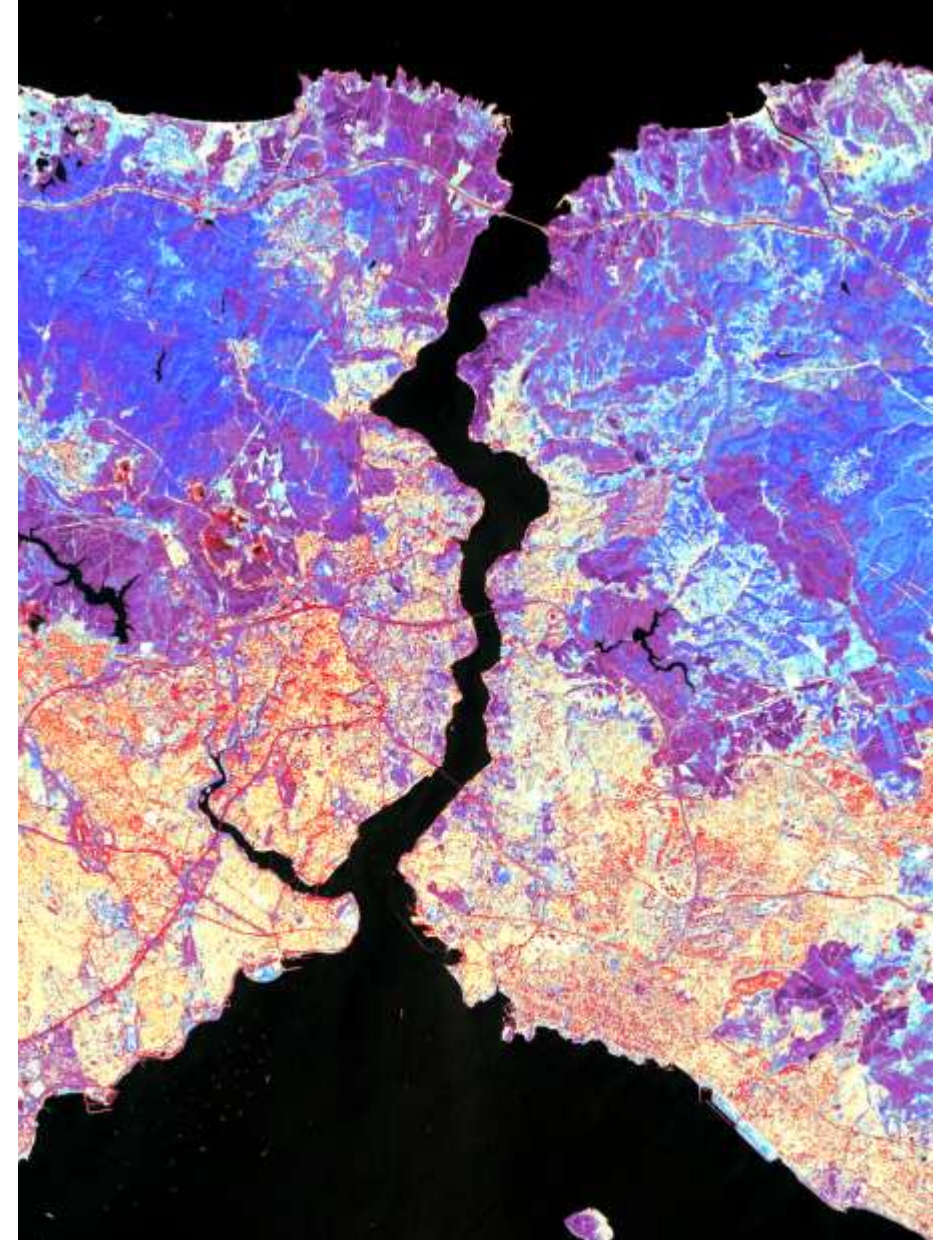
Results from spectral validation for pre- to 1st post-launch calibration tables



Nominal CW, pre-launch Cal. table



Nominal CW, updated Cal. table ✓



1st datatake "Istanbul"
Color composite for SWIR : red: 2176 nm, green: 1633 nm, blue: 1213 nm

ENMAP – Spectral Stability Estimation using all Earth Datatakes

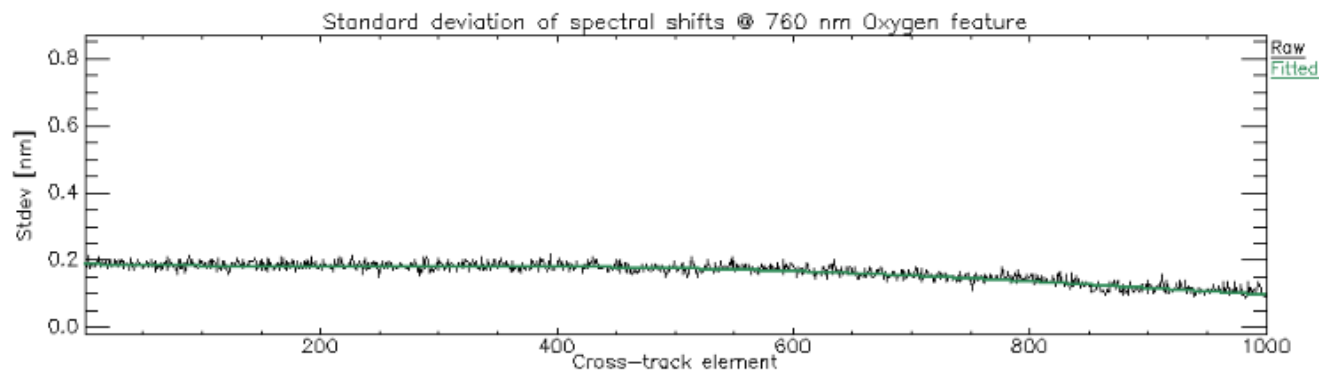
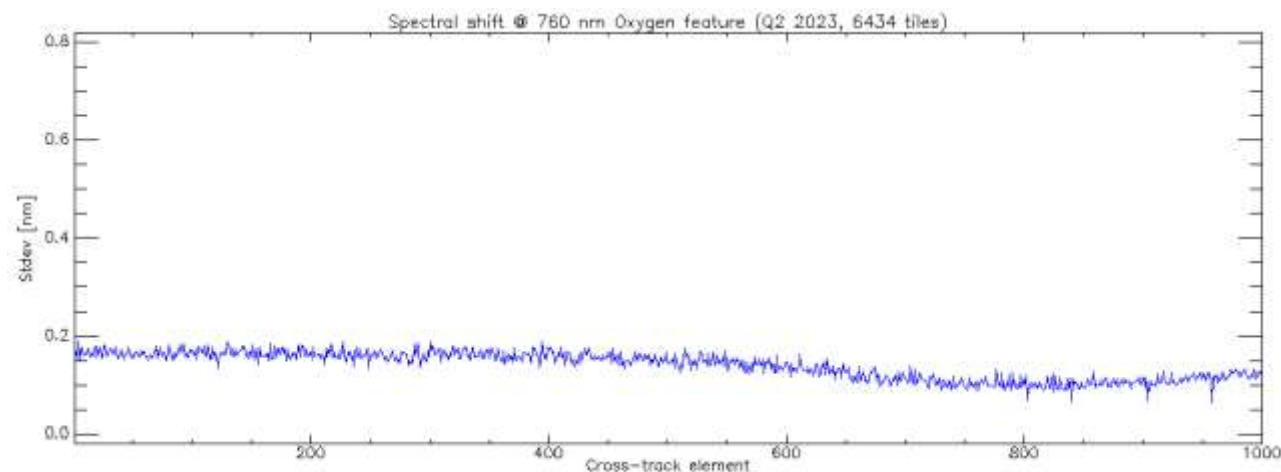


Figure 6-13 Spectral stability VNIR at 760 nm, expressed at 1 sigma; 2770 tiles



Approach:

fit of normalized TOA_rad to range of simulated spectrally shifted atm. absorption features of O₂ @760 nm, CO₂ @ 2060 nm

Result:

Overall good agreement with OBCA and interactive analysis

Figures:

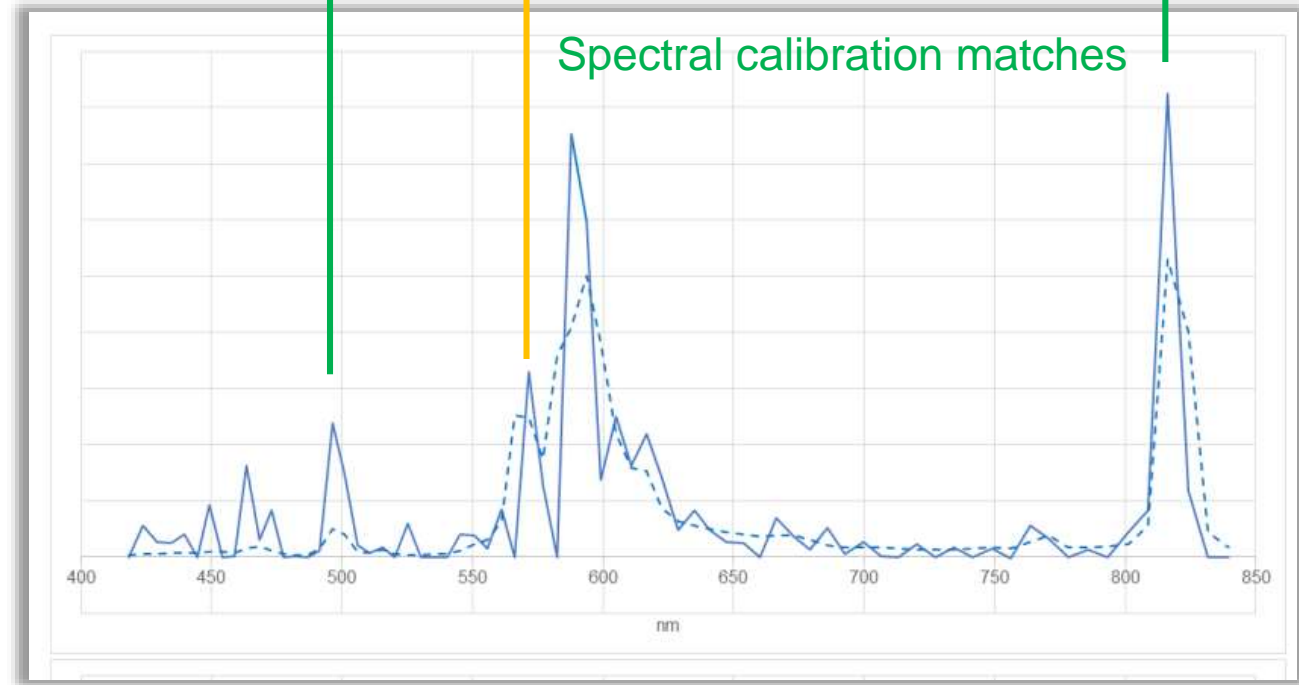
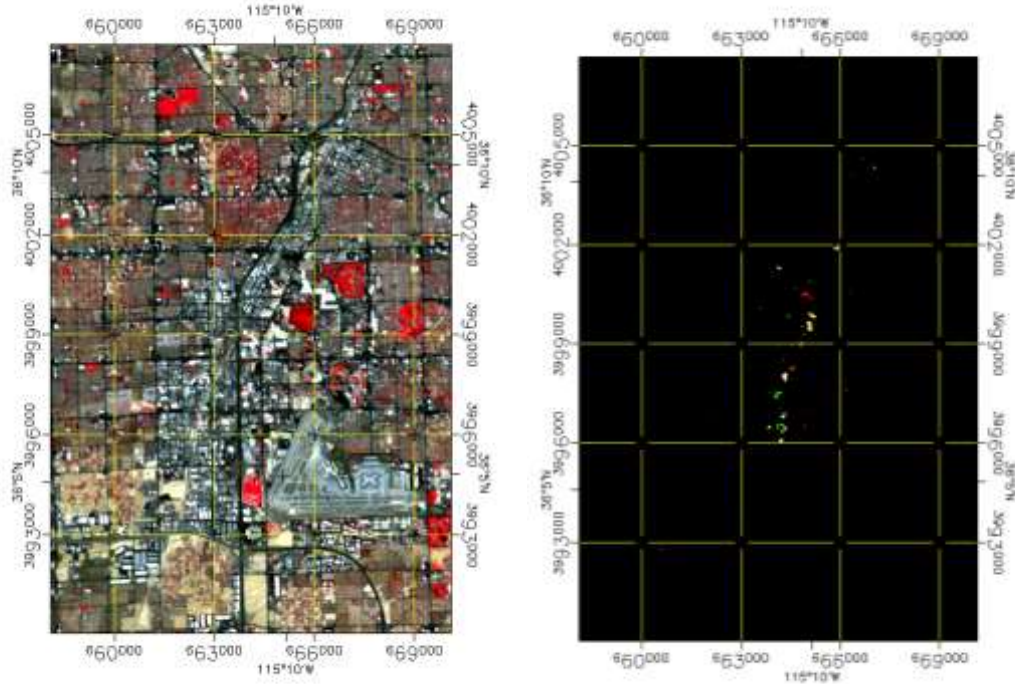
Examples for EnMAP VNIR @ 760 nm expressed as stdev @ 1 sigma

Top: Q4 2022, 2770 image tiles

Bottom: Q2 2023, 6434 image tiles

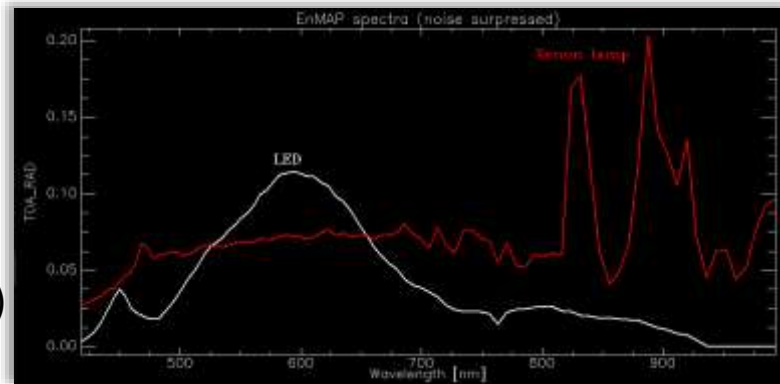


EnMAP – Las Vegas Lights at Night



Actual TOA_rad EnMAP (solid) Vs. SpecLib by C. Elvidge
Example: HPS – high pressure sodium lamp

EnMAP
 top-left: CIR day
 top-right: broad-band
 RGB night
 right: night-time image
 spectra (noise-surpressed)



preprints.org > environmental and earth sciences > remote sensing > doi: 10.20944/preprints202307.0967.v1

Preprint Article Version 1 Preserved in Portico This version is not peer-reviewed

First Nighttime Light Spectra by Satellite—by EnMAP

Martin Bachmann and Tobias Storch

Version 1 : Received: 13 July 2023 / Approved: 14 July 2023 / Online: 14 July 2023 (07:32:53 CEST)



Summary and Conclusion

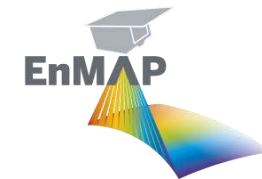
- Accurate spectral calibration matters
 - Mandatory when correcting for spectral smile
 - Influences thematic L3+ products, especially when characterizing narrow and sensitive parameters like plant pigmentation
- Procedures for spectral calibration monitoring established in DESIS and EnMAP ground segments
 - Calibration based on OBCA for both sensors
 - Validation based on atmospheric absorption features (if narrow spectral resolution is given)
 - Automated, possible for certain features (O₂ @ 760 nm, CO₂ @ 2060 nm)
 - In-depth manual analysis
 - Experimental using night time lights
 - Additional independent validation (I2R @ DESIS, GFZ @ EnMAP) plus support by user community



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Thank you for your attention !

EnMAP:
www.enmap.org

DESI:
www.dlr.de/eoc/desktopdefault.aspx/tabid-13614/

