The spectral and radiometric quality of the DESIS data products and the influences on higher-level processing

M. Bachmann, K. Alonso, E. Carmona, U. Heiden, D. Marshall,
R. Müller, R. de los Reyes

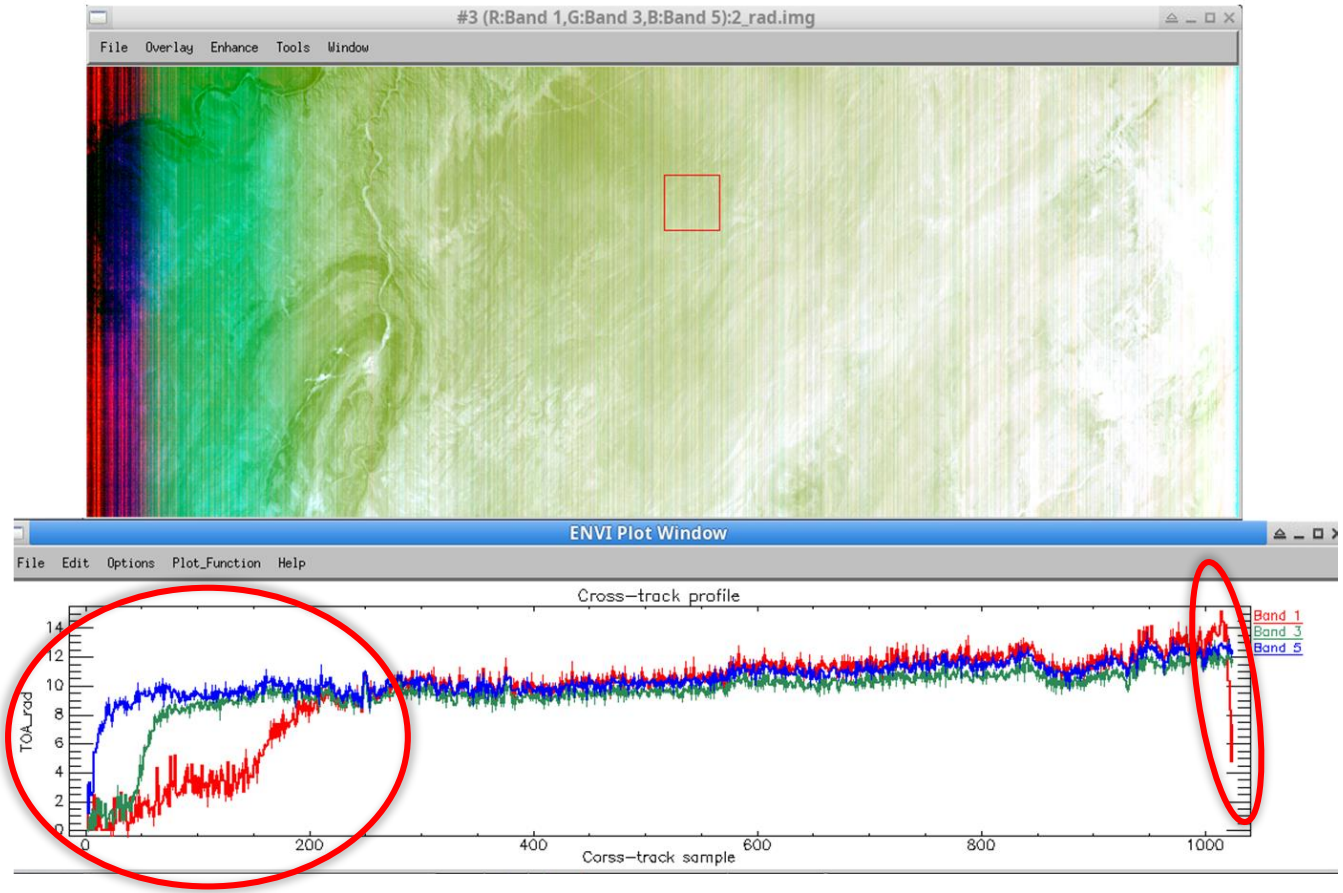
DLR–EOC

Objectives of this talk:

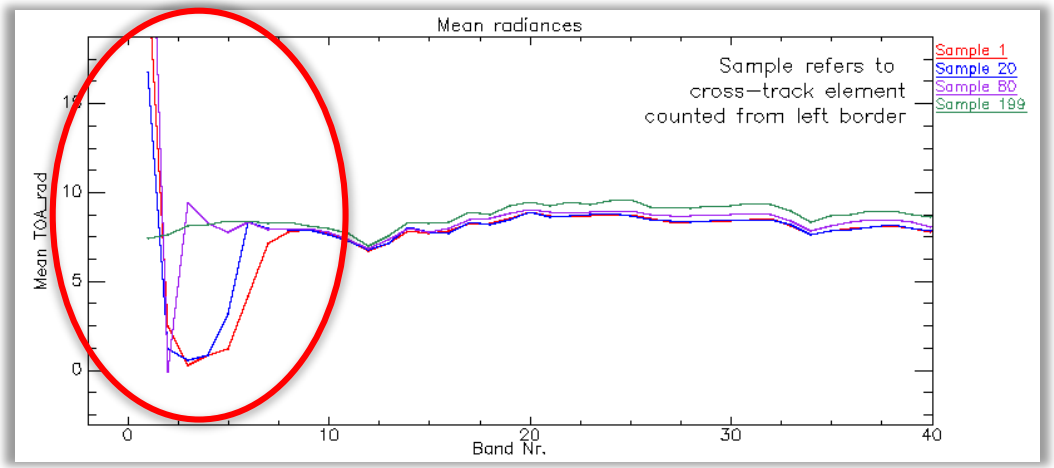
- Make (new) users aware of the specific properties of DESIS data

- Show examples of how the results on spectral and radiometric calibration (previous talk by K. Alonso)
  as well as the L2A processing (previous talk by R. de los Reyes)
  can affect the DESIS data products and the higher-level processing

Issues with first bands at cross-track borders…



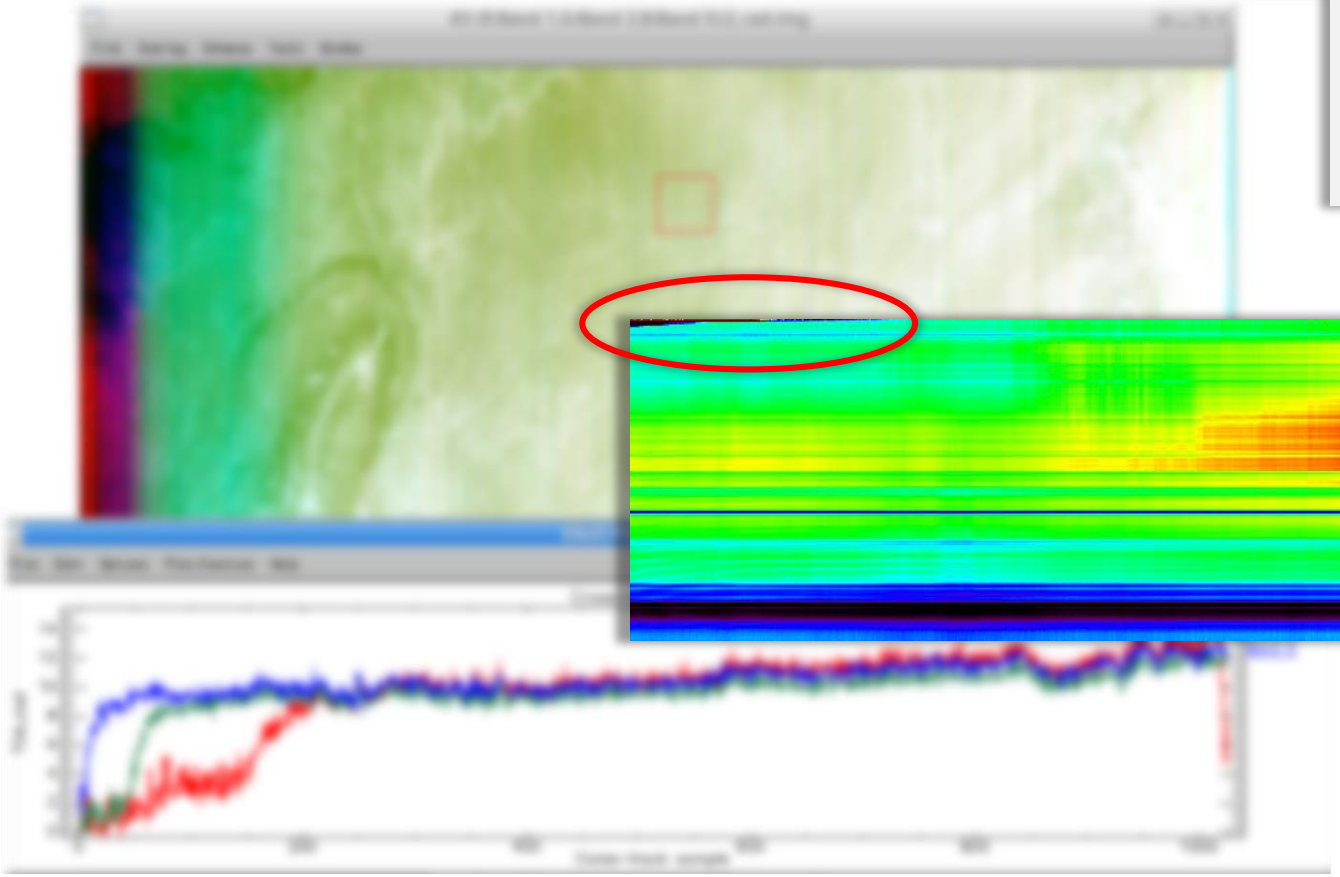
spatial (cross-track)…

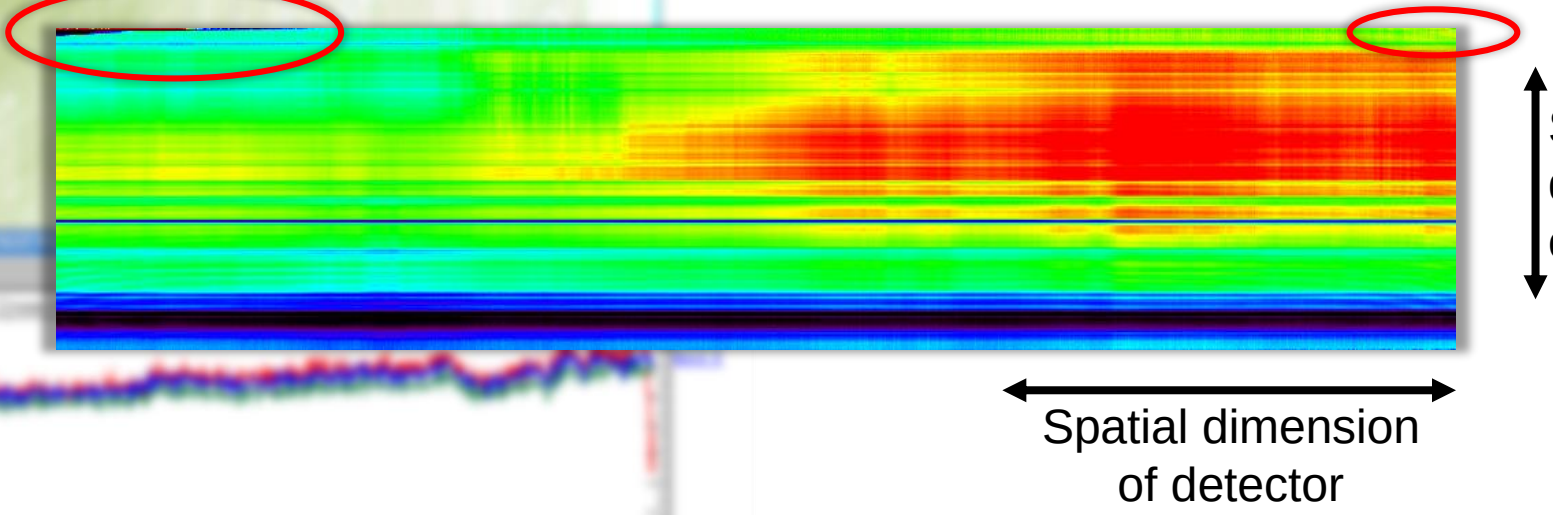


… and spectral

Issues with first bands at cross-track borders…

Edges of detector chip were damaged during manufacturing.
Be aware of this when using first ~10 bands (<430 nm).



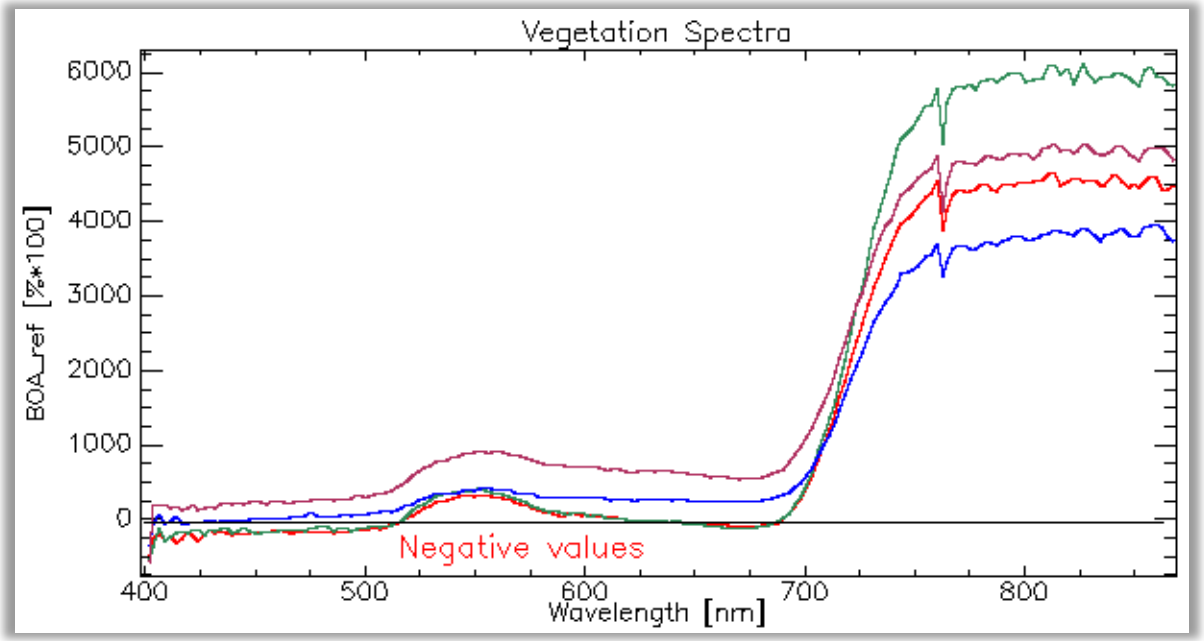


Negative reflectances in L2A – no bug, but a feature !

Negative reflectances in the VIS…

- occur only for very dark targets at short wavelengths (e.g., deep water, irrigated vegetation)
- caused by uncertainty in aerosol retrieval / correction
  in combination with challenging vicarious radiometric calibration in the „blue“
- were requested by water application community, will be implemented in the upcoming S2 processing

650 nm
Negative reflectances in yellow

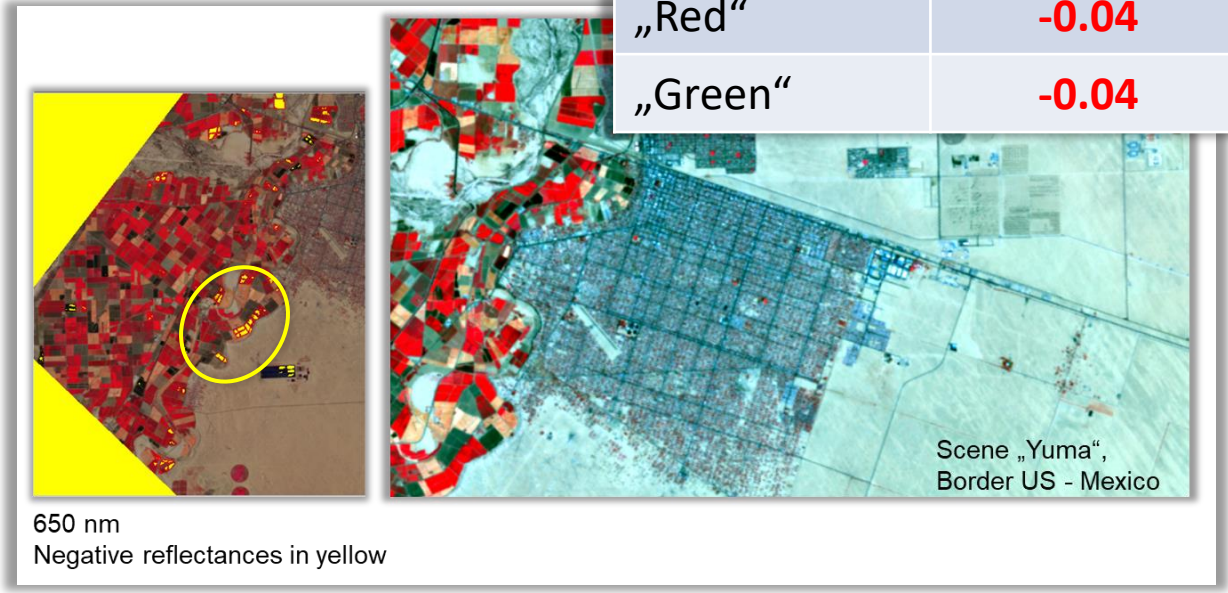


Negative reflectances in L2A – no bug, but a feature !

Negative reflectances in th
- occur only for very dark … getation)
- caused by uncertainty i… in combination with cha…
- were requested by wate… ng S2 processing

Might have implications on data anlysis !

	Red (650 nm)	NIR (780 nm)	NDVI
„Brown“	0.62	0.48	0.77
„Blue“	0.26	0.37	0.87
„Red“	**-0.04**	0.44	**1.02**
„Green“	**-0.04**	0.58	**1.01**



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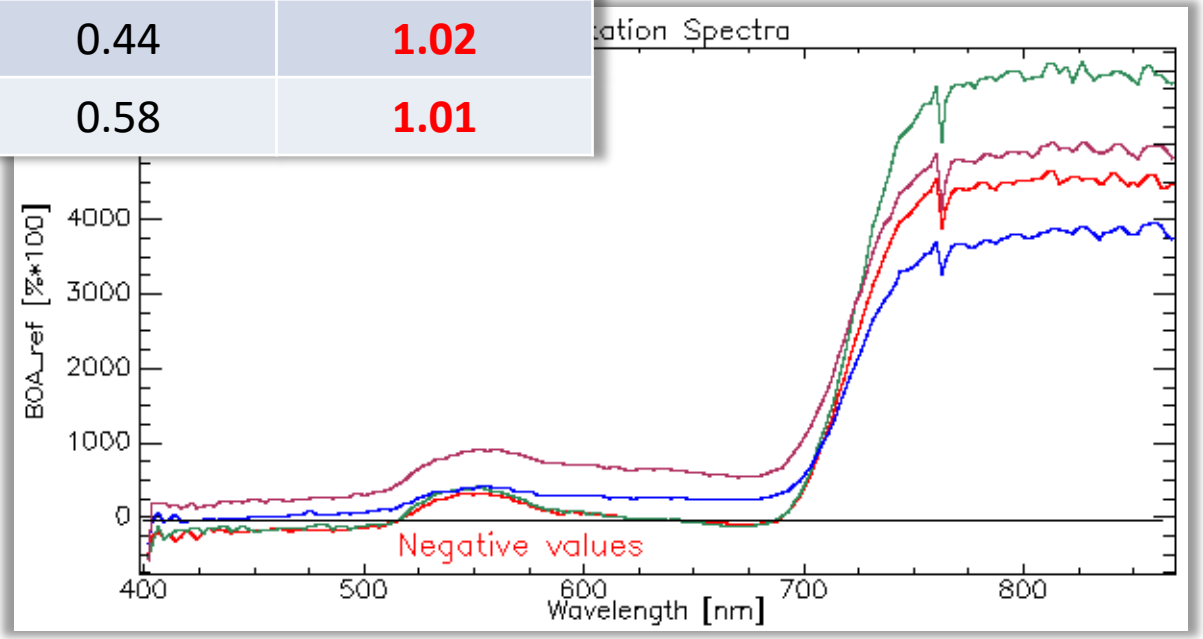
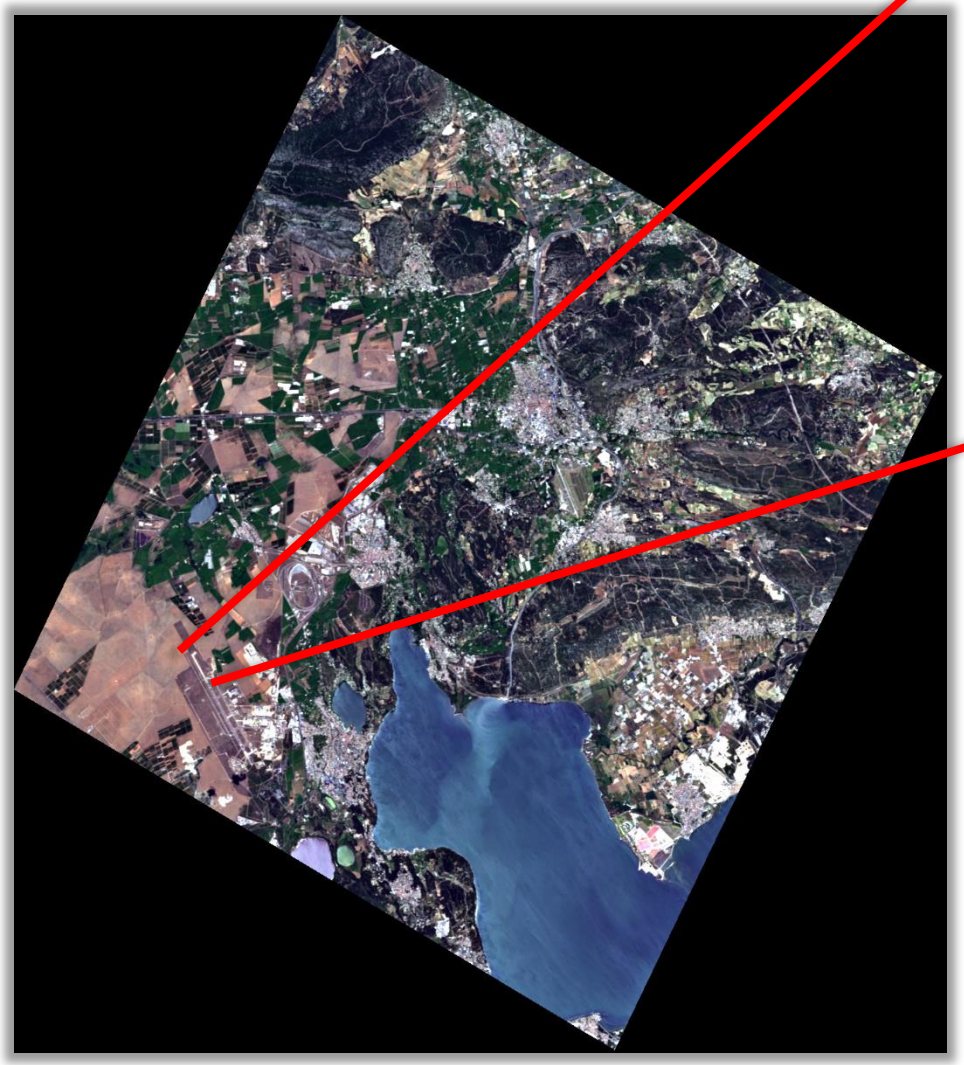


The DESIS L2A product…

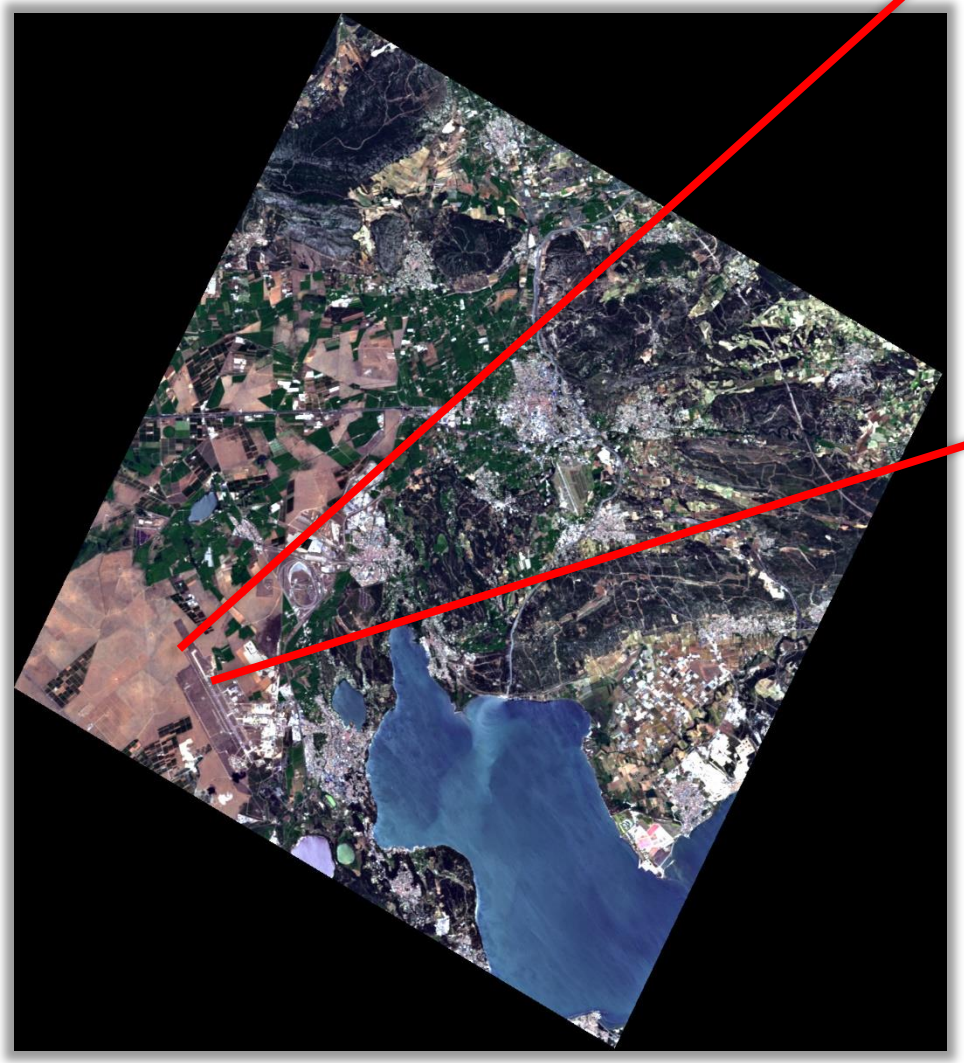
DESIS Scene „La Crau“ (RadCalNet site LCFR)

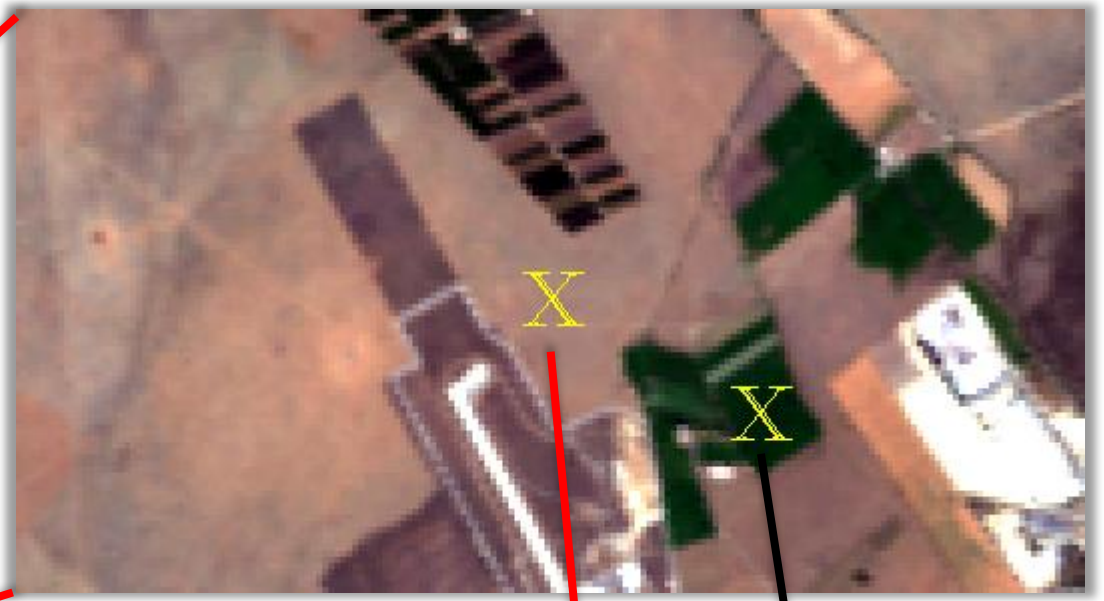
The DESIS L2A product…

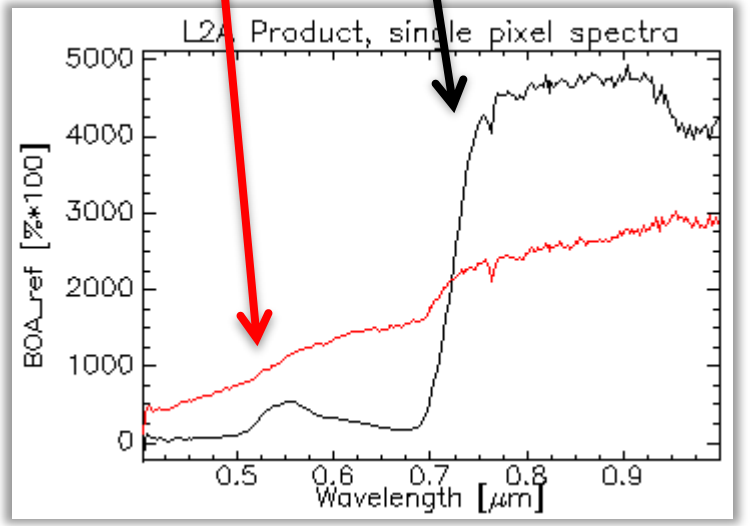


DLR

The DESIS L2A product…

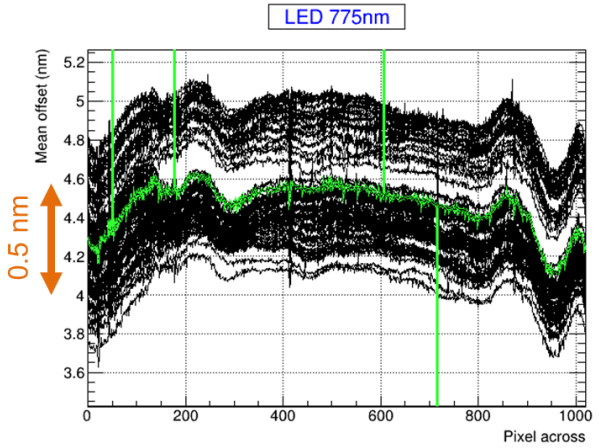


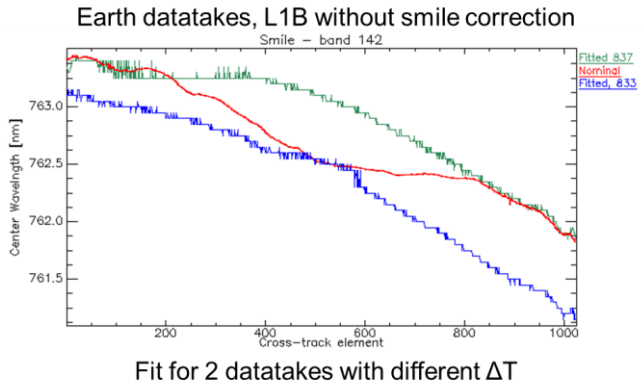




The L2A product… now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient





Fit for 2 datatakes with different ΔT

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

The L2A product… now adding spectral uncertainties @ L1B

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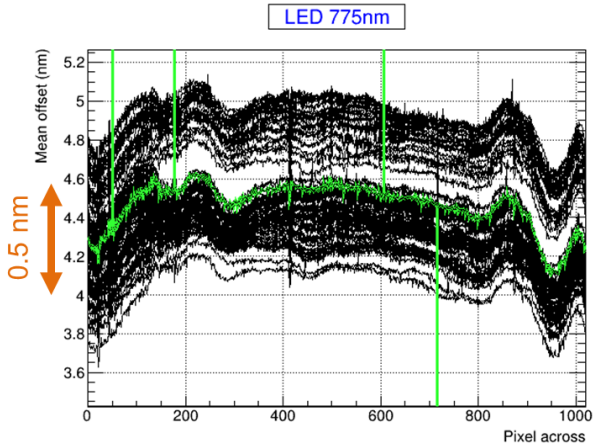

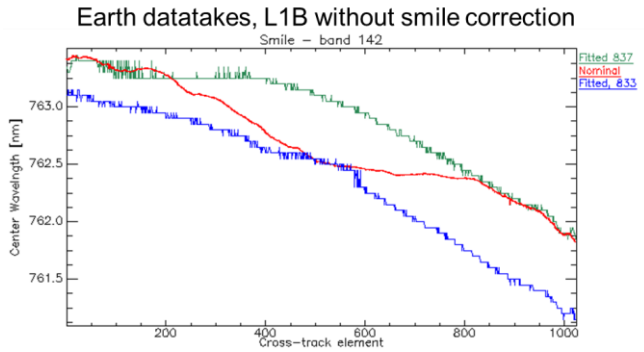

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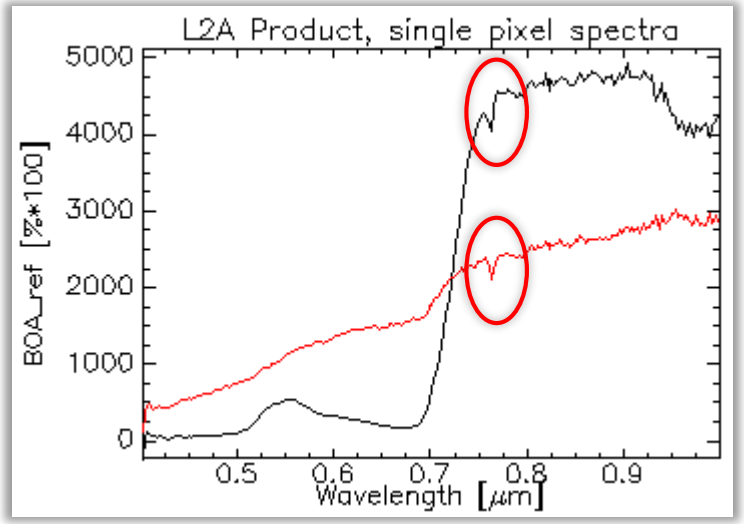
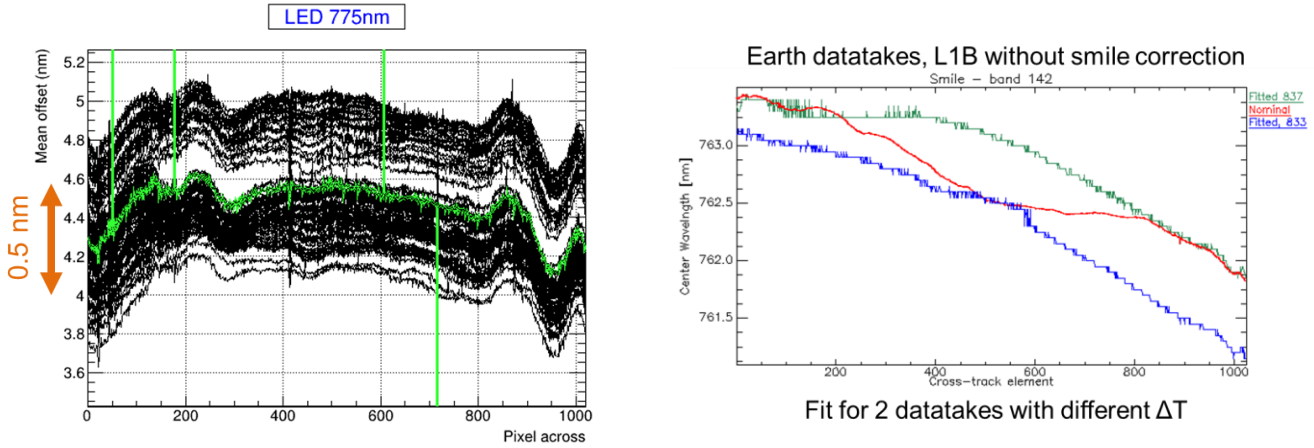
DESIS L2A Product



Oxygen absorption at 760 nm

The L2A product… now adding spectral uncertainties @ L1B

Slight spectral shifting due to temperature gradient

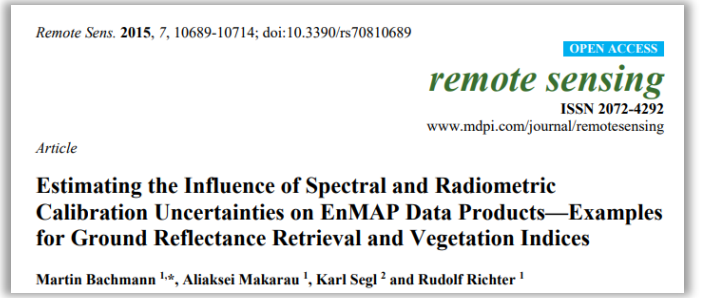


Corrected in L1B processor, remaining RMS ~0.1 nm (@ ~ 2.55 nm SSI)

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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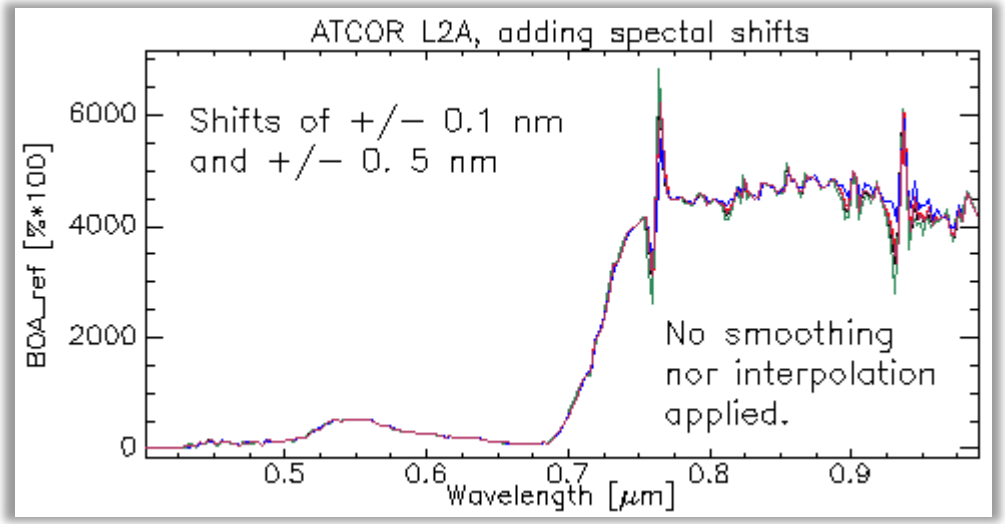
ISSN 2072-4292
www.mdpi.com/journal/remotesensing
Article

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

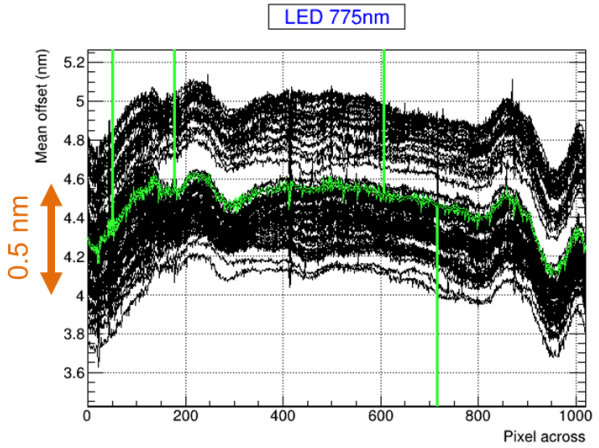
Martin Bachmann [1,*], Aliaksei Makarau [1], Karl Segl [2] and Rudolf Richter [1]

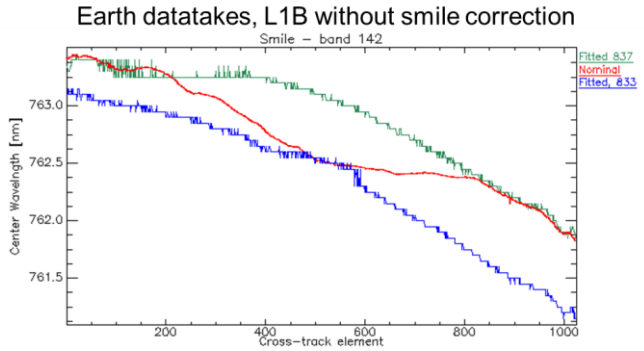
DLR

The L2A product… now adding spectral uncertainties @ L1B



Slight spectral shifting due to temperature gradient





Fit for 2 datatakes with different ΔT

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The L2A product… now adding spectral uncertainties @ L1B

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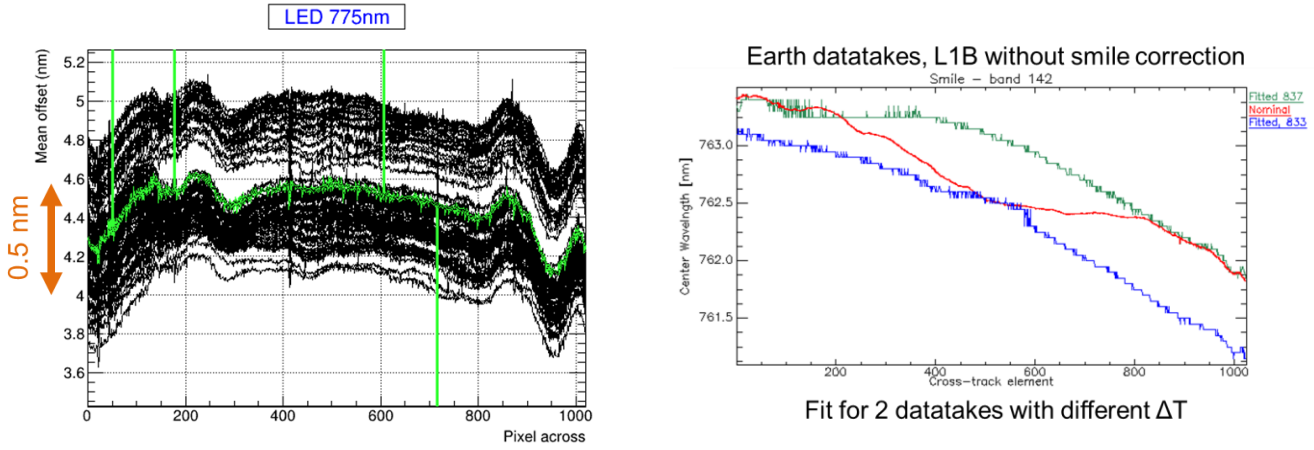

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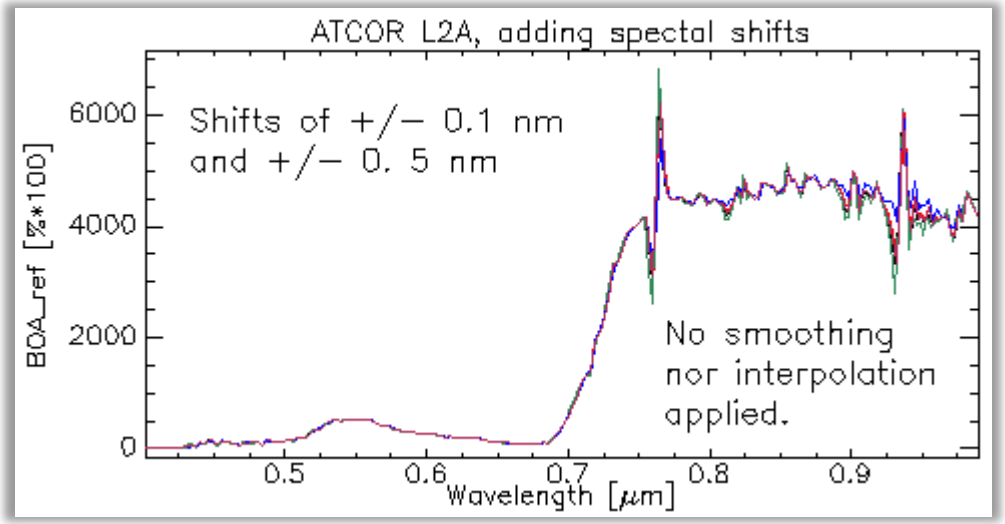

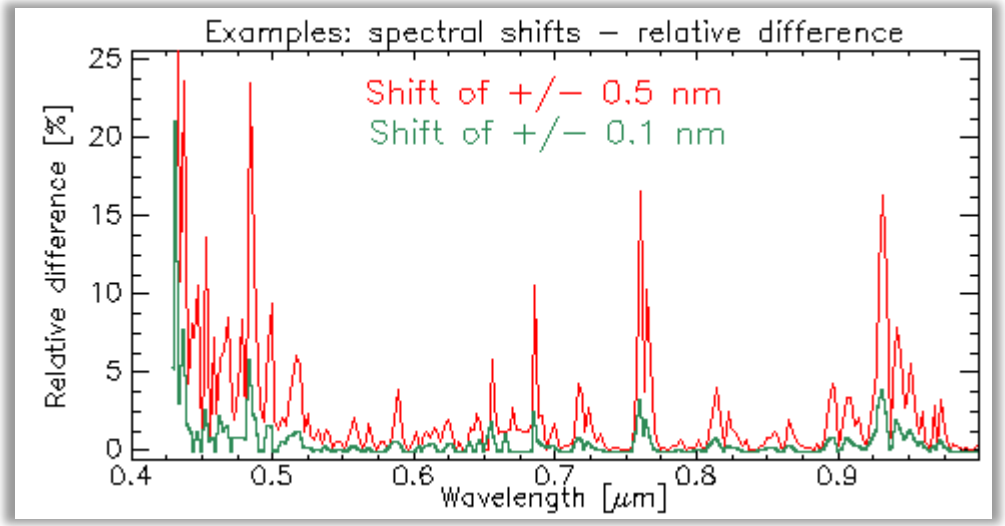

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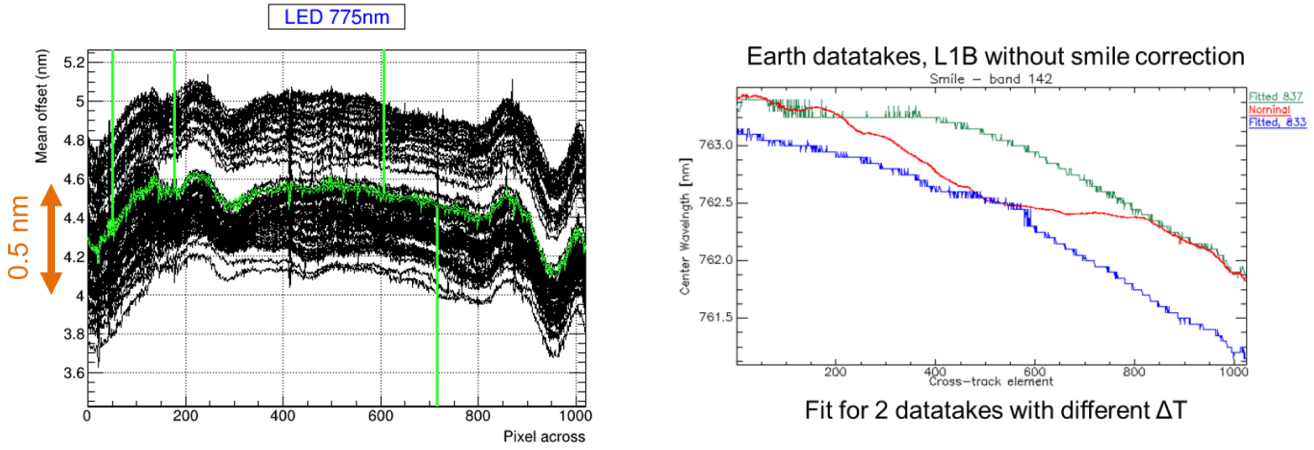

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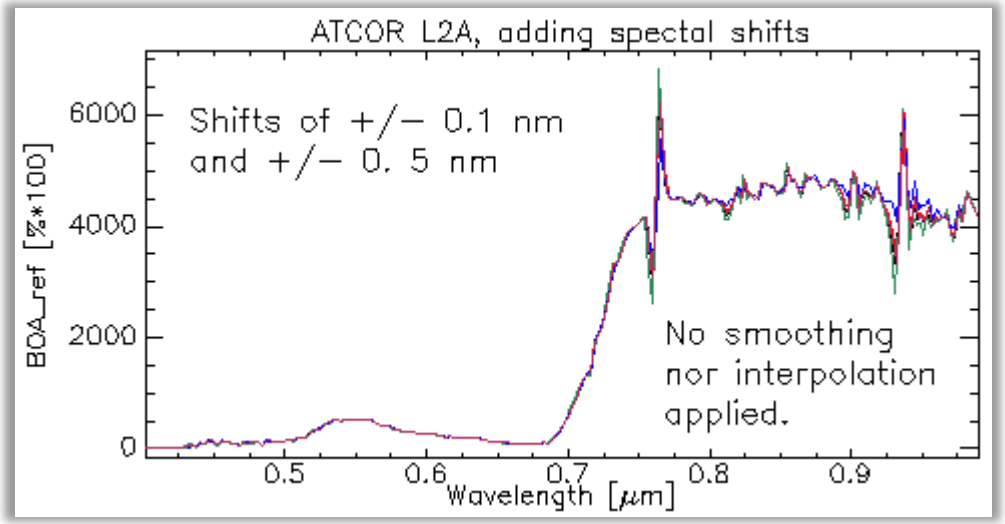

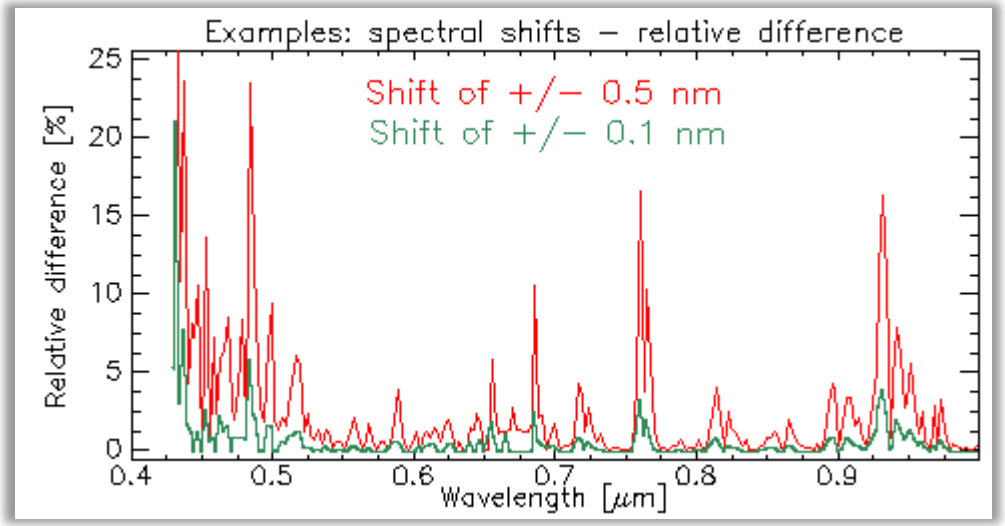

Sidenote:
WV retrieval influenced by 2% (±0.1nm) resp. 7% (±0.5nm)
AOT retrieval not significantly influenced in this example.

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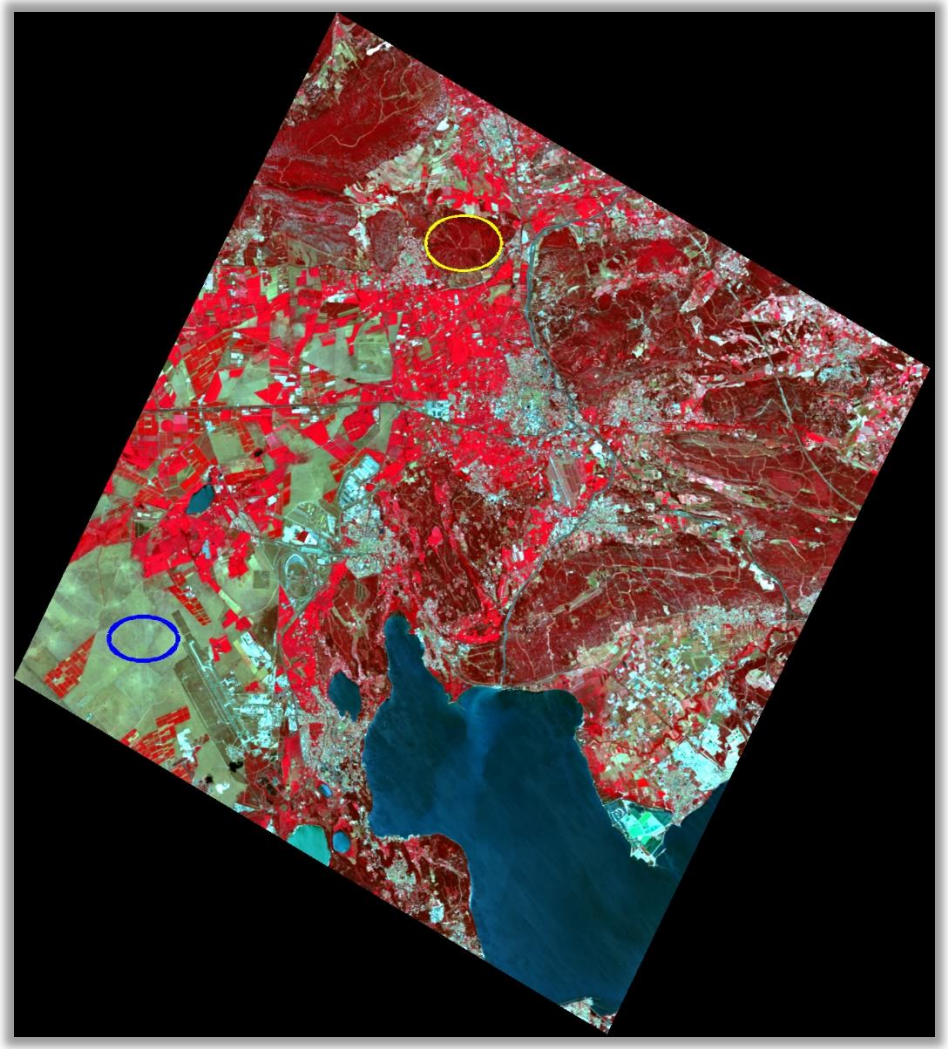
Influence on vegetation products



Examples using

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

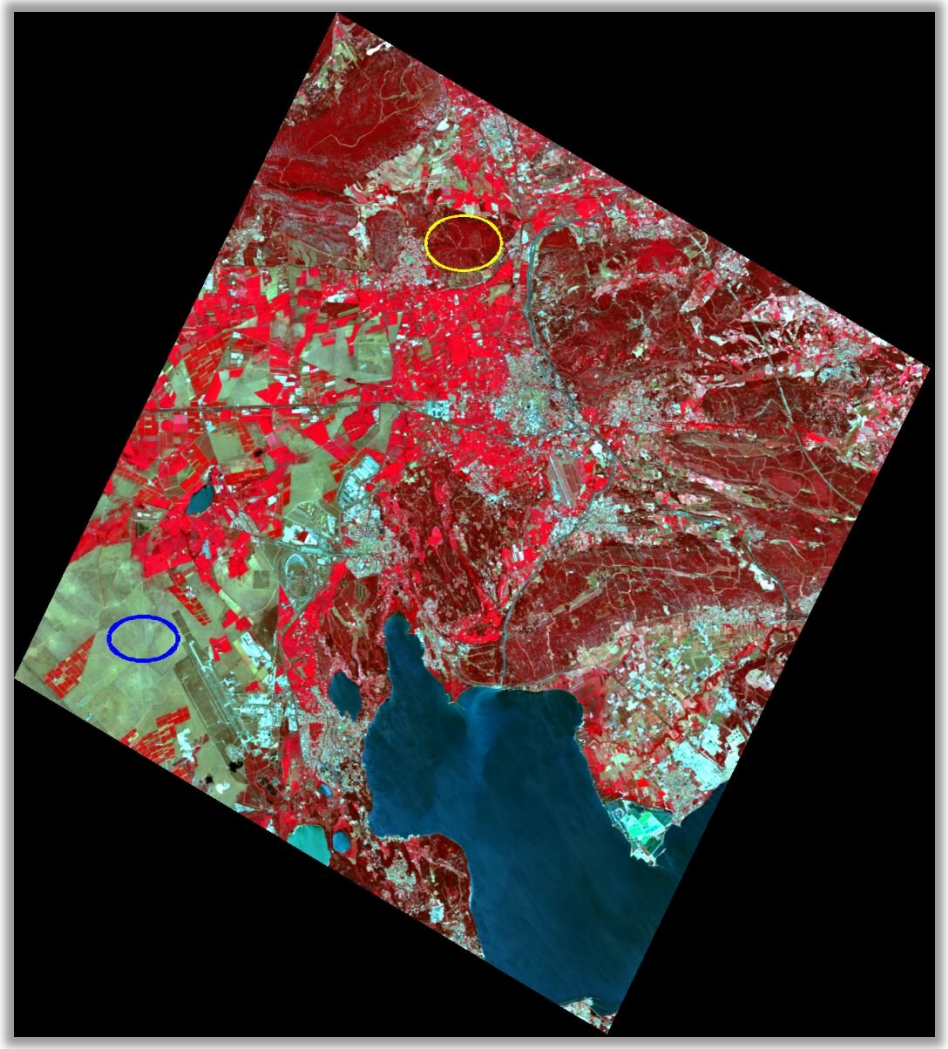
- Homogene dry grassland area (blue circle)

Notes:
Vegetation indices were calculated using ENVI „Vegetation Analysis“ tools *without* any band optimization (out-of-the-box)

Next, the **typical *relative* differences** are given to show the possible magnitude of the uncertainty.

Per-pixel values might differ, as do the values for different vegetation types, different scenes etc.

Influence on vegetation products



Examples using

- Heterogene 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%

- Homogene 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%

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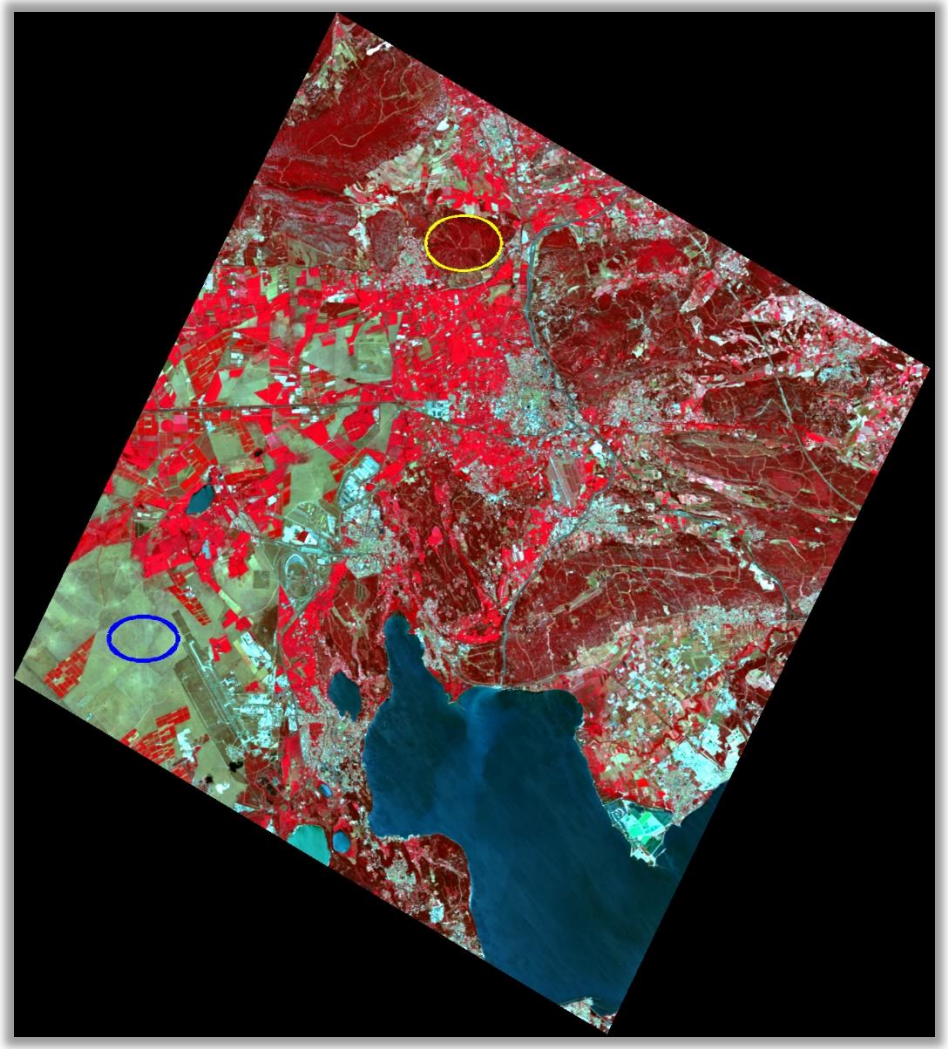
Influence on vegetation products



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Anthocyanin index	~1%	~3%

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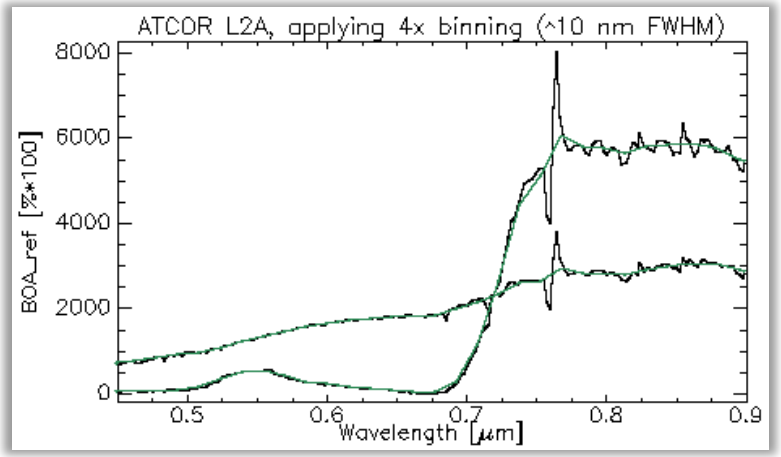
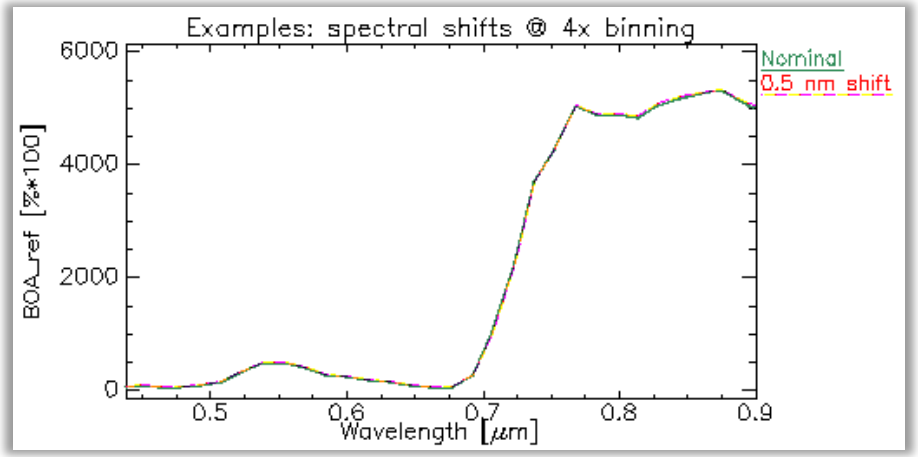
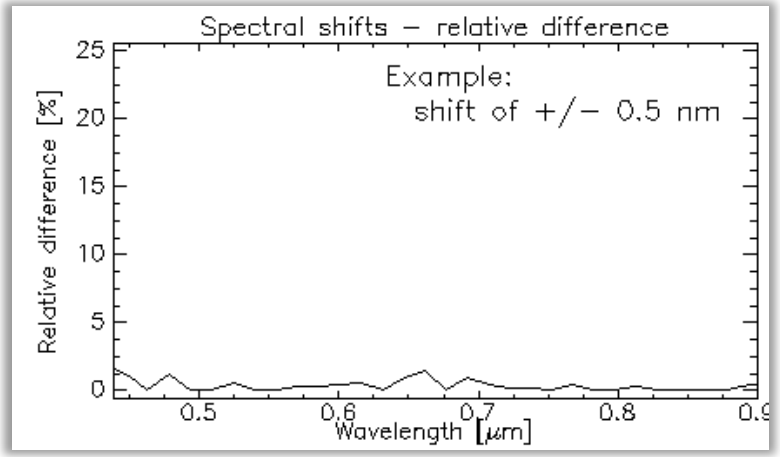
… and now for 4x binning (~10 nm FWHM):



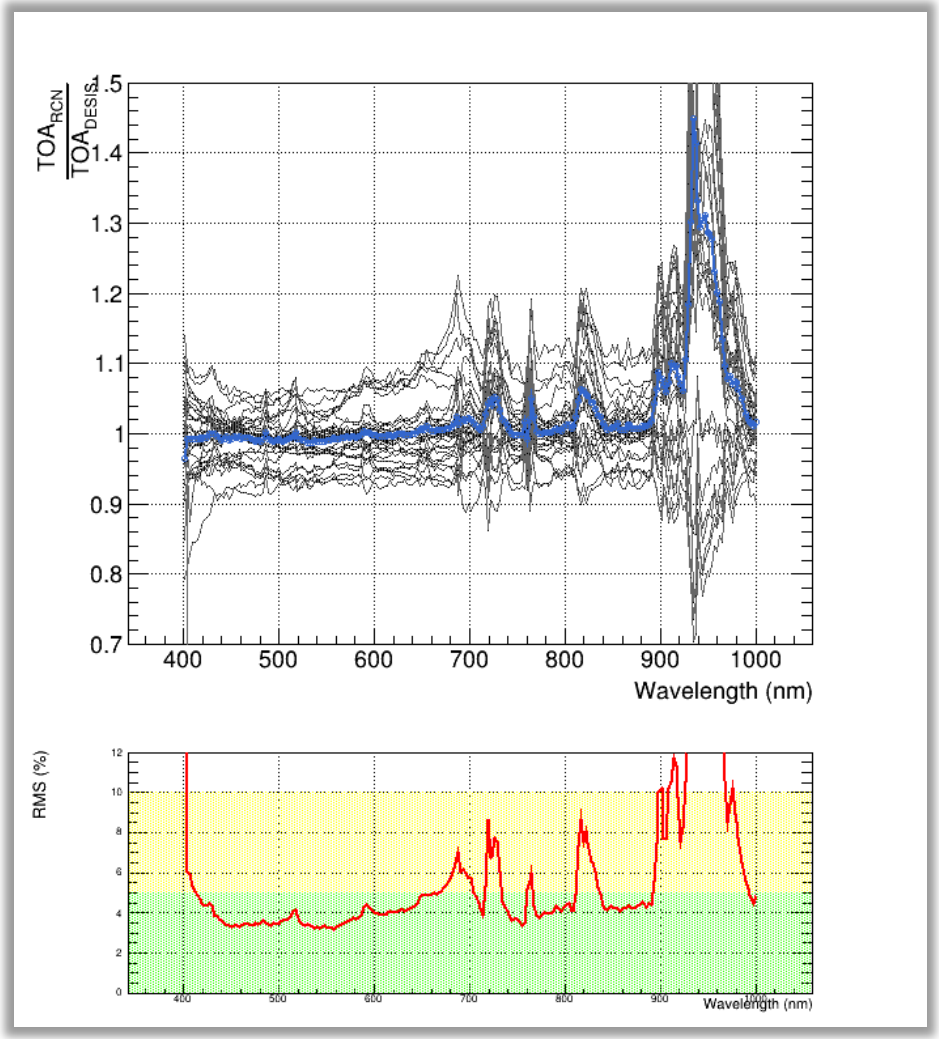




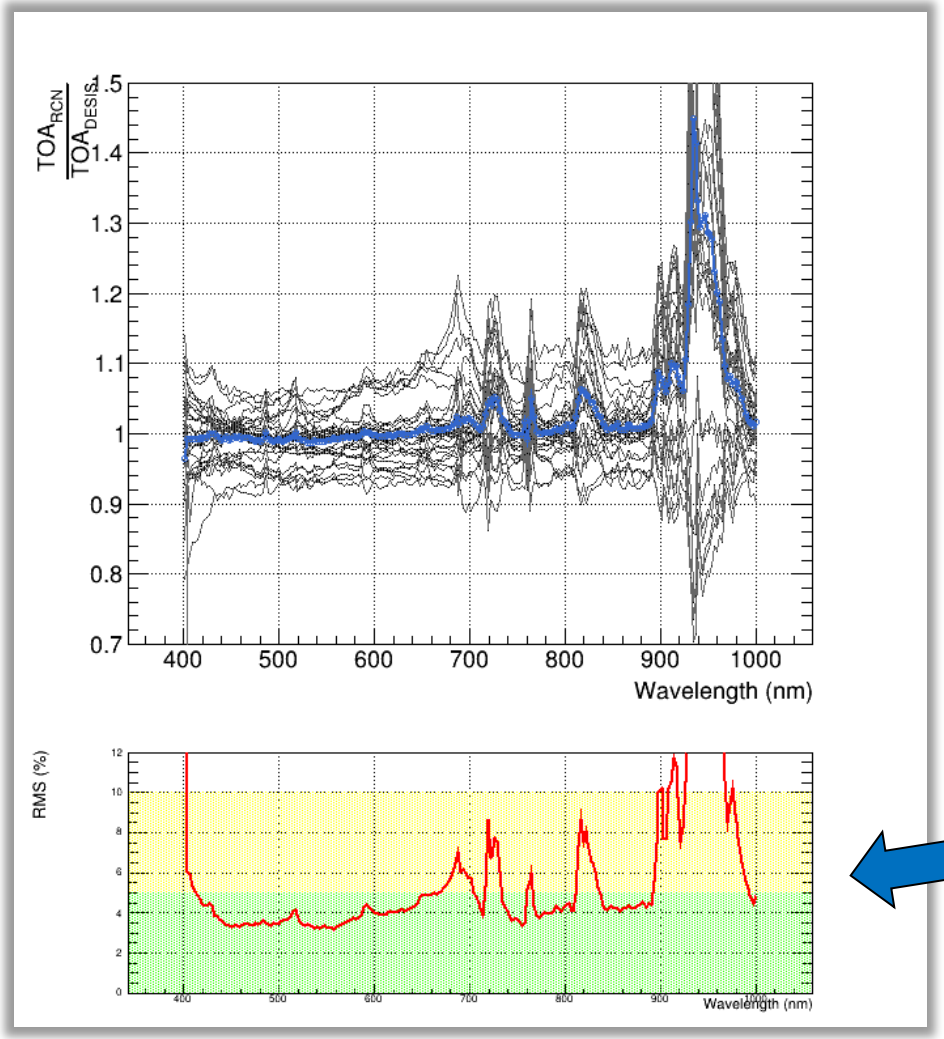
… and the typical relative difference (at max. 0.5 nm shifts):

	Shift of +/- 0.5 nm
Broadband (NDVI, SAVI, EVI)	<< 1%
RedEdge (Vogelmann)	<< 1%
Photochem. index (PRI)	~4%
Carotenoid index	<< 1%
Anthocyanin index	~ 1%

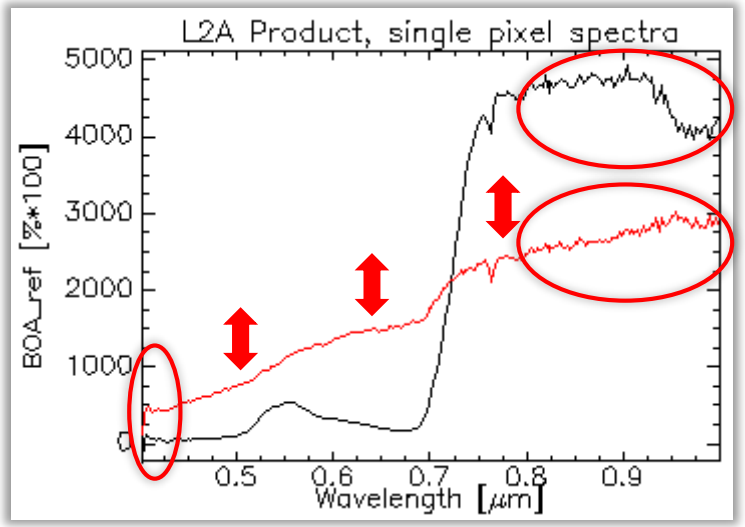
The L2A product… now adding radiometric uncertainties @ L1B



The L2A product… now adding radiometric uncertainties @ L1B



DESIS L2A Product



- Global bias („shift“) of spectrum
- Band-to-band radiometric „noise“
- Fringing (etaloning) above ~850 nm
- Degradation below ~450 nm

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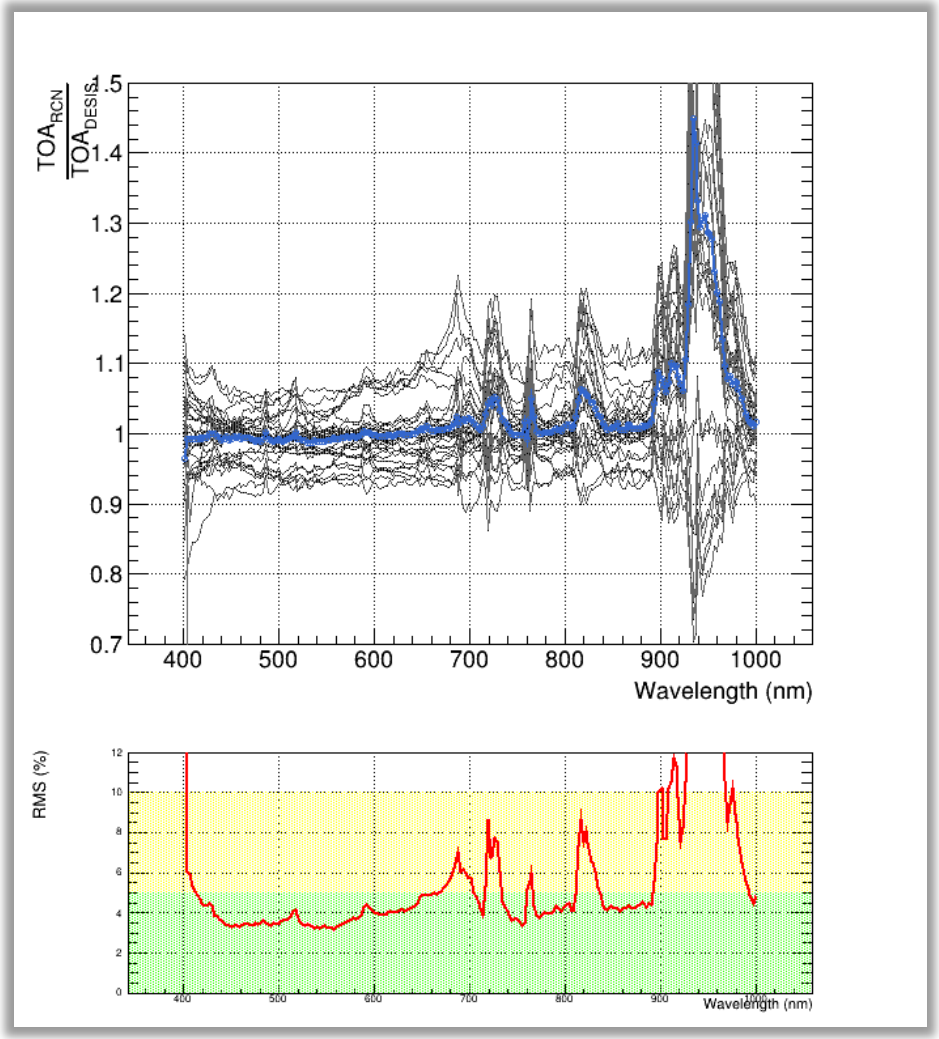
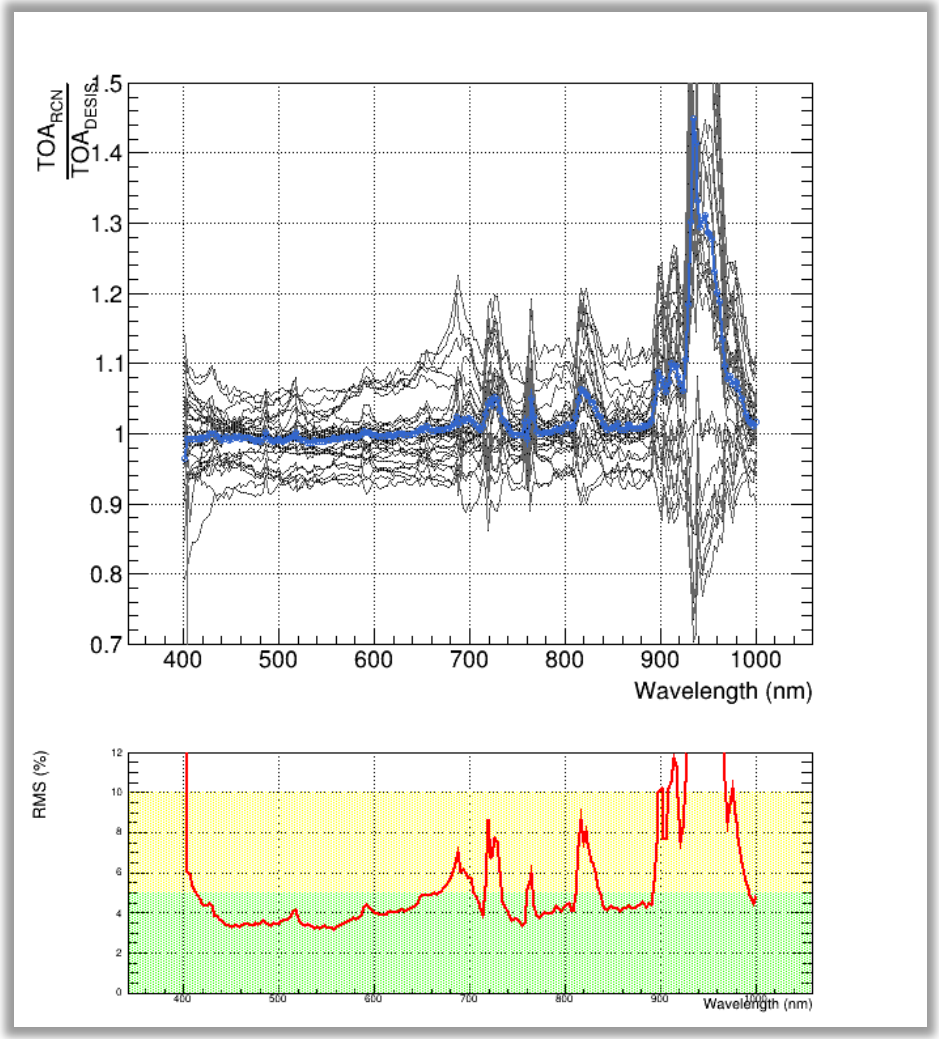
The L2A product… now adding radiometric uncertainties @ L1B



… long story cut short:

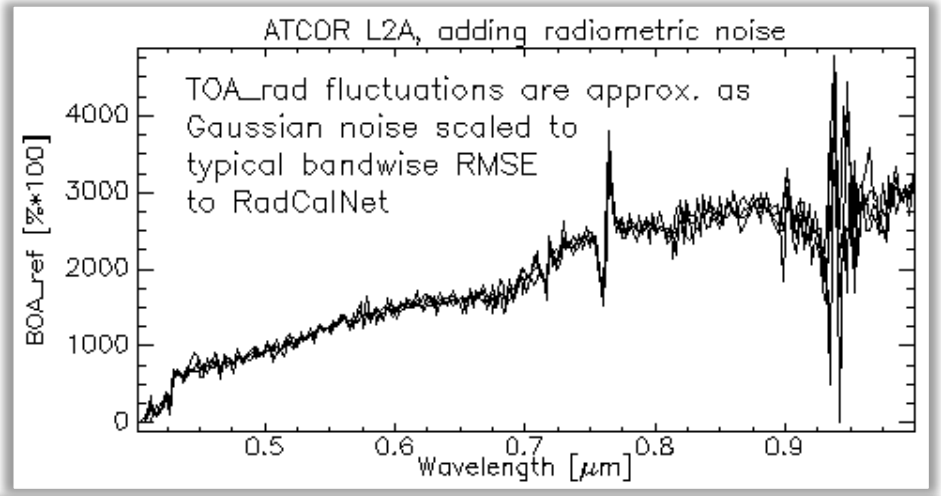
- Bias reduced within calibration approach (using many RadCalNet sites and scenes)
- Systematic radiometric „noise“ (de-calibrated detector elements) accounted for during de-striping step
- Fringing residuals might affects analysis & WV retrieval
  - included in the L2A uncertainty budget, see previous presentation
- Degradation < 450nm affects AOT retrieval
  - also incl. in L2A uncertainty budget

The L2A product… now adding radiometric uncertainties @ L1B

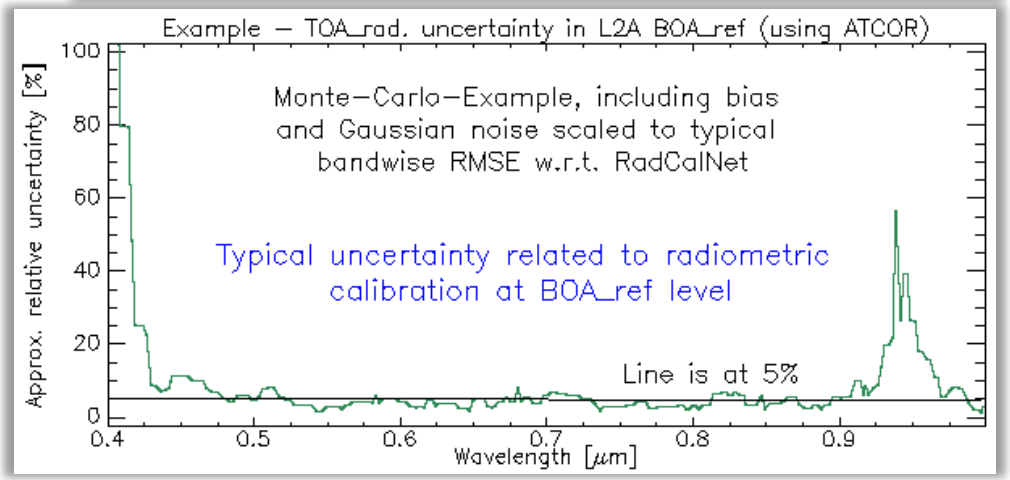


… long story cut short:

Simulated „worst-case“ BOA_ref spectra:



Resulting uncertainty @ BOA_ref:

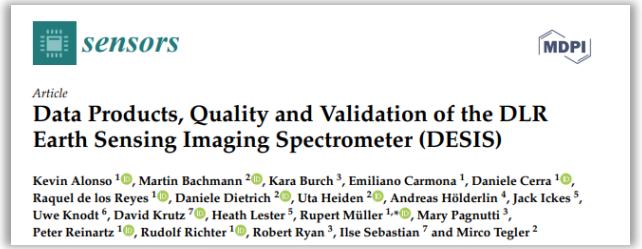


Conclusions

- DESIS is well-calibrated to RadCalNet (for most bands < 5% @ TOA) and cross-checked to S2 / L8
  - **Aging** is tracked within calibration updates, less accurate for shorter wavelengths (< 450 nm)
  - **Fringing** remains a problem to some degree (> 850 nm)
  - **Spectral shifts** are handled within processor
  - Be cautious when analyzing the first 10 bands, as these contain **defects**

- Data products (L1B, L1C, L2A) are validated (internally and externally)
  - **Striping**, spectral **smile** and rolling shutter corrections in place
  - **Geolocation** is typically in subpixel range (RMSE with respect to Landsat 8 OLI: x and y << 25m; N=177 scenes)
    - But: if no GCPs found, could be off by 15-30 pixels => check metadata entry!
  - Remaining **uncertainty of radiometric and spectral calibration** is relatively small
    - Further **improves when binning / spectral resampling** is applied

- Expect the possibility of **negative reflectances** in L2A
  - If calculating indices, better set all negative values to small positive number or zero

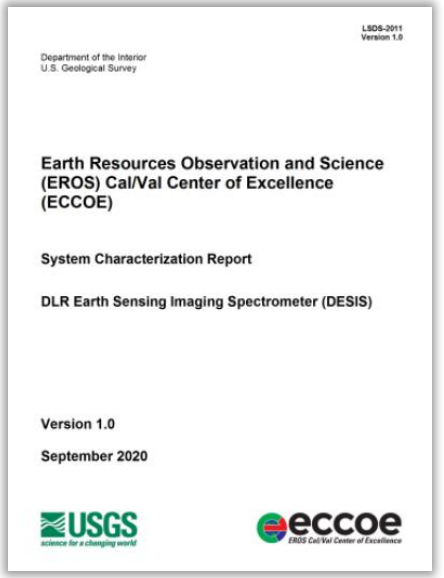

sensors

MDPI

Article

Data Products, Quality and Validation of the DLR Earth Sensing Imaging Spectrometer (DESIS)

Kevin Alonso [1], Martin Bachmann [2], Kara Burch [3], Emiliano Carmona [1], Daniele Cerra [1], Raquel de los Reyes [1], Daniele Dietrich [2], Uta Heiden [2], Andreas Hölderlin [4], Jack Ickes [5], Uwe Knodt [6], David Krutz [7], Heath Lester [5], Rupert Müller [1,*], Mary Pagnutti [3], Peter Reinartz [1], Rudolf Richter [1], Robert Ryan [3], Ilse Sebastian [7] and Mirco Tegler [2]


LSDS-2011
Version 1.0

Department of the Interior
U.S. Geological Survey

Earth Resources Observation and Science (EROS) Cal/Val Center of Excellence (ECCOE)

System Characterization Report

DLR Earth Sensing Imaging Spectrometer (DESIS)

Version 1.0

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