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


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
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Negatives might have implications on data analysis!

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<thead>
<tr>
<th></th>
<th>Red (650 nm)</th>
<th>NIR (780 nm)</th>
<th>NDVI</th>
</tr>
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<tbody>
<tr>
<td>&quot;Brown&quot;</td>
<td>0.62</td>
<td>0.48</td>
<td>0.77</td>
</tr>
<tr>
<td>&quot;Blue&quot;</td>
<td>0.26</td>
<td>0.37</td>
<td>0.87</td>
</tr>
<tr>
<td>&quot;Red&quot;</td>
<td>-0.04</td>
<td>0.44</td>
<td>1.02</td>
</tr>
<tr>
<td>&quot;Green&quot;</td>
<td>-0.04</td>
<td>0.58</td>
<td>1.01</td>
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650 nm
Negative reflectances in yellow

Scene „Yuma“, Border US - Mexico
The DESIS L2A product…

DESIS Scene „La Crau“ (RadCalNet site LCFR)
The DESIS L2A product…
The DESIS L2A product...
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

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DESIS L2A Product

Oxygen absorption at 760 nm
The L2A product... now adding spectral uncertainties @ L1B

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

Examples using
• **Heterogeneous** vital green forest / shrub area (yellow circle)
• **Homogeneous** 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
- **Heterogeneous** vital green forest / shrub area (yellow circle)

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<td>&lt;1%</td>
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- **Homogeneous** dry grassland area (blue circle)

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

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

Monte-Carlo Example, including bias and Gaussian noise scaled to typical bandwise RMSE w.r.t. RadCalNet

Typical uncertainty related to radiometric calibration at BOA_ref level

Line is at 5%
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