NEXT UPDATES OF ATMOSPHERIC CORRECTION PROCESSOR SEN2COR

SPIE REMOTE SENSING DIGITAL FORUM

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Bringfried Pflug (DLR), Jerome Louis (Telespazio), Vincent Debaecker (Telespazio), Uwe Müller-Wilm (Telespazio Vega), Carine Quang (CS), Ferran Gascon (ESA), Valentina Boccia (ESA)
1. Sen2Cor – processor overview
2. Sen2Cor history
3. Scene classification
4. AOT and WV retrieval
5. Surface reflectance estimation
6. Conclusions and Recommendations
**SEN2COR PROCESSOR OVERVIEW**

- Atmospheric correction processor for **Sentinel-2 data**

- Atmospheric Correction over **land surface**

- Processing **mono-temporal** orthorectified L1C **granules**

- **ESA-L2A CORE PRODUCT:** L2A-generation performed in the S2-PDGS, (Planet DEM; 10m/30m/90m Copernicus DEM; more frequent updates; product format and generation differs); can be downloaded from OpenHub: [https://scihub.copernicus.eu/dhus/#/home](https://scihub.copernicus.eu/dhus/#/home).

- **‘USER’ PRODUCT:** L2A-generation by the user by command line processing or via SNAP Toolbox plugin (SRTM resp. user DEM; 90m Copernicus DEM); Available from: [http://step.esa.int/main/third-party-plugins-2/sen2cor](http://step.esa.int/main/third-party-plugins-2/sen2cor)
SEN2COR PROCESSING CHAIN

Level-1C

optional

Cirrus Correction

Scene Classification
(11 classes) (20m)

series of threshold
tests on L1C
spectral bands,
band ratios and
indices

AOT Retrieval
(20m)

DDV-algorithm
Fall-back: VIS fixed

Water Vapour
Retrieval (20m)

Atmospheric
Pre-corrected
Differential
Absorption
Algorithm (APDA)

CCI-data

DEM

Radiative Transfer LUT
(libRadtran)

Level-2A

• terrain correction
  • adjacency corr.
  • BRDF correction

TOA to BOA
conversion

10m:
• 4 bands
• AOT, WV maps

20m (60m):
• 9 (11) bands
• SCL, AOT, WV
• cloud probability
• snow probability

SENITEL-2 MISSION PERFORMANCE CENTRE; Next updates of atmospheric correction processor Sen2Cor; SPIE Remote Sensing Digital Forum, 21-25 September 2020
### SEN2COR HISTORY

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4.0</td>
<td>Nov. 2017</td>
<td>- Improved AOT estimation</td>
</tr>
<tr>
<td>2.5.0</td>
<td>Feb. 2018</td>
<td>- Designed for PDGS processing</td>
</tr>
<tr>
<td>2.5.0</td>
<td>Feb. 2018</td>
<td>- Updated LUT for S2A spectral response v3.0</td>
</tr>
<tr>
<td>2.6.6</td>
<td>8. Oct. 2018</td>
<td>- Blue path radiance rescaling -&gt; OFF</td>
</tr>
<tr>
<td>2.7.x</td>
<td>6. May 2019</td>
<td>- Topographic correction under clouds disabled</td>
</tr>
<tr>
<td>2.8.0</td>
<td>6. May 2019</td>
<td>- PDGS optimizations</td>
</tr>
</tbody>
</table>

**ESA core production for Europe**

- Merge with evolutions of core production
- Option to disable terrain correction using a DEM

**‘user’ production (public versions)**

- Scene classification using ESA CCI Data package
- Improved AOT estimation
- Updated LUT for S2A spectral response v3.0

**Sen2Cor 2.8 Scene Classification Performance and Outlook**

- Reference mask for 20 granules:
  (by visual inspection and labelling of pixels or polygons)

<table>
<thead>
<tr>
<th></th>
<th>clear</th>
<th>shadows</th>
<th>clouds</th>
<th>UA</th>
<th>CE</th>
</tr>
</thead>
<tbody>
<tr>
<td>clear</td>
<td>287 480</td>
<td>5 080</td>
<td>10 247</td>
<td>94.9%</td>
<td>5.1%</td>
</tr>
<tr>
<td>shadows</td>
<td>2 611</td>
<td>13 433</td>
<td>150</td>
<td>83.0%</td>
<td>17.0%</td>
</tr>
<tr>
<td>clouds</td>
<td>4 908</td>
<td>165</td>
<td>47 859</td>
<td>90.4%</td>
<td>9.6%</td>
</tr>
</tbody>
</table>

- **PA** 97.5%  71.9%  82.2%  **OA**
- **OE** 2.5%  28.1%  17.8%  94%

+ High OA (94%), low omission (2.5%) and commission (5.1%) of clear pixels
- 10 000 cloud pixels classified as clear
- 17% commission of shadows
  (‘dark features’ mapped to shadows)
- 28% omission of shadows
  (cloud shadow; generic cloud top height distribution)

- cloud/cloud shadow/snow dilation; bright isolated pixels identification
- Reduction of class ‘dark features’ to topographic shadows
- Update of cloud shadow algorithm with cloud top height estimation
**Sen2Cor 2.8 AOT and WV Retrieval Performance**

- Reference: sunphotometer measurements of AERONET sites
  (AERONET: interpolated to 550 nm; time averaged over ±15 min to overpass time)
  (Sen2Cor: spatially averaged over 9x9 km² area; only clear land surface pixels)

  - Green triangles: Results for DDV-algorithm
  - Orange triangles: fall-back processing
  - Solid lines: Specification \( |\Delta \text{AOT550}| \leq 0.1 \times \text{AOT550}_{\text{ref}} + 0.03 \)
  - Dashed line: Sen2Cor_output = Reference
  - Linear trend lines for DDV and fall-back

<table>
<thead>
<tr>
<th>Uncertainty</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOT complete set ±0.24</td>
<td>WV ±0.24 g/cm²</td>
</tr>
<tr>
<td>AOT DDV subset ±0.11</td>
<td></td>
</tr>
<tr>
<td>AOT fall-back subset ±0.29</td>
<td>➢ New fall-back solution</td>
</tr>
</tbody>
</table>

+ Difference between ESA L2A core product and ‘user’ product not significant
SEN2COR: NEW FALL-BACK SOLUTION FOR AOT RETRIEVAL

- Reference: sunphotometer measurements of AERONET sites
  (AERONET: interpolated to 550 nm; time averaged over ±15 min to overpass time)
  (Sen2Cor: spatially averaged over 9x9 km² area; only clear land surface pixels)

Current fall-back: fixed, pre-defined AOT (0.2 at sea level)

New fall-back: AOT from CAMS product

Uncertainty ±0.35

Uncertainty ±0.19
SEN2COR 2.8 SURFACE REFLECTANCE ESTIMATION

- Reference: SR measurements at RADCALNET sites LaCrau and Gobabeb
  own measurements for vegetated sites

+ almost within ±2% of measured reference data
  - except bands 5 and 11

+ Shape of spectra (Pearson correlation >0.99)
  - Little undercorrection of SR (0.015 < RMSD < 0.025)
  - Bands 5 and 11 not worse

+ ESA L2A core product and ‘user’ product give equivalent SR spectra
L2A PRODUCTS EVOLUTION OUTLINE

TOOLBOX

2.8

2.8.1 - 2.8.4

PDGS

MPC 2A

ACIX

Fixes

New Scene Class
New QI
New PSD
Additional Band 1 on 20m Resolution
CAMS Support
Copernicus DEM

Landsat + Python 3.7 for Sen2Like

TOOLBOX + PDGS

PDGS

Sen2Like

2.9

2.10

3.0

Python 2.7

PSD 14.5

Python 3.7

PSD 14.X
CONCLUSIONS AND RECOMMENDATIONS

- good performance of Sen2Cor for all of scene classification, WV retrieval and SR estimation
- Several updates of the processor on the way

- ESA L2A core product gives equivalent results to ‘user’ products
  - core product:
    - easiest way to get L2A-products
    - based on a default configuration
  - ‘user’ product
    - opportunity to process with non-default configuration.
    - Can be used to generate a homogenous time series for an area of interest.

- Monthly L2A data quality report:
  [https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/document-library/](https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/document-library/)
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THANK YOU!
BYE BYE!

Carine Quang

Bringfried.Pflug@dlr.de

Jérôme Louis
Vincent Debaecker
Uwe Müller-Wilm

Ferran Gascon
Valentina Boccia