The S3 SYN product for biophysical variables retrieval: an assessment

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Background

1. Vegetation retrieval algorithms developed for FLEX and OLCI and first validated in End-to-End
2. Inspection OLCI L2 SYN SDR product
3. OLCI SYN processed over Argentina and Europe
4. Comparison against S2-300m and L2 OTCI and FAPAR products
S3 & FLEX tandem mission

L2 SYN product:
Surface Directional Reflectance (SDR):

- SLSTR channels (S1 to S6 for both nadir and oblique views) and for
- All OLCI channels, except for the oxygen absorption bands Oa14, Oa15, and the water vapour band Oa20
Biophysical variables FLEX/S3

- **LAI** = **Leaf Area Index**
  Range ~ 1 - 10

- **Cab** = leaf Chlorophyll (a + b) content
  Range ~ 0 - 100 µg .cm⁻¹

- **fAPAR** = fraction of Absorbed Photosynthetically Active Radiation
  Range: 0 - 1

- **FCover** = Fractional vegetation Cover
  Range: 0 - 1
Hybrid retrieval method

Radiative Transfer Model (RTM) SCOPE (v 1.70)  
(FCover: PROSAIL < García-Haro et al., 2018)

Machine Learning Algorithm Gaussian Process Regression (GPR)
Hybrid retrieval scheme

OPTIMIZATION steps!

3 types of model:
- OLCI
- FLORIS
- OLCI + FLORIS (synergy)

- **DR**: Dimensionality Reduction
- **PCA**: Principal Component Analysis
- **A-SGM**: Automated Scene Generator Module
E2E validation results: Cab, LAI

### Reference:

![Image of Cab validation results](image1)

*SZA: 30°
DZA: 0°

\[
RRMSE \, (\%) = \frac{RMSE}{\sqrt{\text{mean}}_{\text{obs}}}
\]

<table>
<thead>
<tr>
<th>Metric</th>
<th>OLCI</th>
<th>LAI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cab</strong></td>
<td><img src="image2" alt="Estimated image" /></td>
<td><img src="image3" alt="Estimated image" /></td>
</tr>
<tr>
<td><strong>Validation (Estim. vs. Ref.)</strong></td>
<td>R²: 0.91; RMSE: 7.6 µg.cm⁻²; RRMSE: 16.9%</td>
<td>R²: 0.86; RMSE: 1.1; RRMSE: 28.0%</td>
</tr>
<tr>
<td><strong>Absolute error per pixel</strong></td>
<td><img src="image4" alt="Error distribution" /></td>
<td><img src="image5" alt="Error distribution" /></td>
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</tbody>
</table>
Validation results: fAPAR, FCover

<table>
<thead>
<tr>
<th></th>
<th>Estimated image</th>
<th>Validation (Estim. vs. Ref.)</th>
<th>Absolute error per pixel</th>
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</thead>
<tbody>
<tr>
<td><strong>fAPAR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OLCI</td>
<td><img src="image1" alt="fAPAR OLCI image" /></td>
<td><img src="image2" alt="fAPAR OLCI validation" /></td>
<td><img src="image3" alt="fAPAR OLCI error" /></td>
</tr>
<tr>
<td>Reference:</td>
<td><img src="image4" alt="fAPAR reference image" /></td>
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<td></td>
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<tr>
<td>[RRMSE (%) = \frac{RMSE}{V_{\text{mean}} / V_{\text{obs}}} \times 100]</td>
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**FCover**

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<tr>
<td>OLCI</td>
<td><img src="image5" alt="FCover OLCI image" /></td>
<td><img src="image6" alt="FCover OLCI validation" /></td>
<td><img src="image7" alt="FCover OLCI error" /></td>
</tr>
<tr>
<td>Reference:</td>
<td><img src="image8" alt="FCover reference image" /></td>
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</table>
OLCI SYN reflectance product (20/06/18)

GPR models trained on simulated data + 310 bare soil spectra
GPR absolute and relative uncertainties

**SD (absolute uncertainty)**
- Cab - Standard deviation around the mean
- LAI - Standard deviation around the mean
- fAPAR - Standard deviation around the mean
- FCover - Standard deviation around the mean

**CV (relative uncertainty)**
- Coefficient of Variation - Cab
- Coefficient of Variation - LAI
- Coefficient of Variation - fAPAR
- Coefficient of Variation - FCover
SciHub SYN collection

2018/10/10

(B8, B6, B4)
Assessment SYN product over Argentina from hub

SYN Data available from October 2018

Crop area in South Hemisphere (Argentina) for significant phenology changes

Collection of S3 SYNERGY images with cloud percentage <50%

October 2018- February 2019

- **Oa01** (400.0nm)
- **Oa02** (412.5nm)
- **Oa03** (442.5nm)
- **Oa04** (510.0nm)
- **Oa05** (555.0nm)
- **S1N** (555.0nm)
- **S1O** (560.0nm)
- **Oa06** (620.0nm)
- **Oa07** (659.0nm)
- **Oa08** (673.75nm)
- **Oa09** (681.25nm)
- **Oa10** (708.75nm)
- **Oa11** (753.75nm)
- **Oa12** (778.75nm)
- **Oa16** (865.0nm)
- **Oa17** (865.0nm)
- **S3N** (65.0nm)
- **S3O** (885.0nm)
- **Oa18** (1020.0nm)
- **Oa21** (1610.0nm)
- **S2N** (659.0nm)
- **S2O** (665.0nm)
- **S5N** (1610.0nm)
- **S5O** (2250.0nm)
- **S6N** (2250.0nm)
- **S6O** (2250.0nm)
Radiometric artefacts: N vs O SLSTR

Aerosol different estimation (between N and O views of SLSTR?)
Radiometric artefacts in visible

(B8, B5, B3)

Lower λ more affected by radiometric discontinuities...
S3A_SY_2_SYN_20181224T132515_fAPAR
Cloud-free 5-daily composite maps

LCC : 15-10-2018

LAI : 15-10-2018

FAPAR : 15-10-2018
Comparison vs S2 L2A over Argentina

8 Tiles: [T21]
HTA, HTT, HTU, HTV, HUA, HUT, HUU, HUV

Cloudy percentage < 50%
Comparison SYN vs S2-SNAP: LAI

- SYN product masks out some water bodies
- S3: overestimation of high LAI values

S2 RGB mosaic of 18/02/2019
S2 product derived from it
S3 product derived from S3A_SY_2_SYN from 20/02/2019
Comparison SYN vs S2-SNAP: Cab

- S2 product: some bare soil areas with high Cab values
- S3 product: probably overestimation of high Cab values

S2 RGB mosaic of 18/02/2019
S2 product derived from it
S3 product derived from S3A_SY_2_SYN from 20/02/2019
S2 Cab = Cab_LAI/LAI
Comparison SYN vs S2-SNAP: fAPAR

- Similar fAPAR products

S2 RGB mosaic of 18/02/2019
S2 product derived from it
S3 product derived from S3A_SY_2_SYN from 20/02/2019
S3A_SY_2_SYN_20181224T132515_fAPAR / Comparison with L2 FAPAR product
S3A_SY_2_SYN_20190104T134014_fAPAR / Comparison with L2 FAPAR product
Comparison with L2 FAPAR product
S3A_SY_2_SYN_20181224T132515_Cab / Comparison with L2 OTCI product
Comparison with L2 OTCI product
Comparison with L2 OTCI product
Conclusions

• FLORIS-OLCI vegetation retrieval algorithms developed in preparation of FLEX-S3 tandem mission

• OLCI SYN time series processed into: LAI, Cab, fAPAR, Fcover

• SYN product radiometric artifacts for lower wavelengths (Oa01-5) affect vegetation products

• Maps generally consistent with L2 S2/S3 products

• Improvements ongoing
Thanks