Inter-comparison of atmospheric correction methods applied to Sentinel-2 images

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INTRODUCTION

The correction of atmospheric effects in Sentinel-2 (S2) is of paramount importance for its widespread use in several applications. This communication resumes three case studies with the same objective: Assess the performance of different atmospheric correction methods applied to Level-1C S2 products.

In particular, the BOA reflectance values obtained by SEN2COR, MAJA, 6S and iCOR have been compared.
CASE STUDY 1. INTRODUCTION

Sola et al., 2018a. A rigorous evaluation of the accuracy of BOA reflectance products requires their comparison with ground measurements obtained with spectroradiometers. Thanks to the collaboration with researchers from the University of Zaragoza these measurements were collected and compared with simultaneous S2 images.

- Performance of 4 atmospheric correction methods evaluated on S2 images
- 4 dates, 6 plots and 9 spectral bands assessed
- Results suggest the suitability of the applied corrections
- Minor differences observed between the 4 methods (MAJA, SEN2COR, 6S, iCOR)

CASE STUDY 1. MATERIAL AND METHODS

Phase 1. Retrieval of input data

1. Retrieval of ground data
   - Selection of the study area
   - Delimitation of plots
   - Data acquisition with spectroradiometer
   - Generation of the spectral library

2. Retrieval of Sentinel-2 data
   - Image download
   - TOA reflectance
     - SEN2COR
     - Maja
     - 6S
     - ICOR
   - BRDF adjustment

Phase 2. Validation. Statistic analysis

Validation S-2 BOA-BOA
Validation S-2 TOA-BOA
Validation S-2 spectral indices

BRDF adjustment
CASE STUDY 1. RESULTS

Visual comparison of TOA and BOA scenes

Sentinel 2 image. Level-1C T30TXM . 23/07/2016

Sentinel 2 image. Level-2A MAJA T30TXM . 23/07/2016

4 dates were studied: 2016-07-23, 2016-08-22, 2016-09-01 and 2016-09-28
CASE STUDY 1. MATERIAL AND METHODS
CASE STUDY 1. RESULTS
Spectral signatures of the different land covers

Overestimation
Adequate correction with all methods in VIS region
CASE STUDY 1

Scatterplot of each spectral band

BOA reflectance measured by ASD (X axis) VS BOA reflectance measured by S2 (Y axis)
Inter-comparison of atmospheric correction methods applied to Sentinel-2 images

CASE STUDY 1

NDVI comparison

Also NDII and NBR indices were assessed

<table>
<thead>
<tr>
<th>RMSE</th>
<th>Level-1C</th>
<th>SEN2COR</th>
<th>6S</th>
<th>MAJA</th>
<th>iCOR</th>
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</thead>
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<tr>
<td>NDVI</td>
<td>0.0316</td>
<td>0.0307</td>
<td>0.0280</td>
<td>0.0307</td>
<td>0.0255</td>
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<tr>
<td>NDII</td>
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<td>0.0304</td>
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<td>0.0368</td>
<td>0.0370</td>
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<tr>
<td>NBR</td>
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<td>0.0298</td>
<td>0.0350</td>
<td>0.0494</td>
<td>0.0539</td>
</tr>
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</table>

RMSE of spectral indices from different AC methods for the six plots and four dates. Best method for each index highlighted in bold.
CASE STUDY 1

Statistical agreement of the different methods

The results obtained by the RMSE and R² suggest a varying performance of AC methods depending on the land cover and spectral bands.

Although minor differences were observed in most cases, MAJA and iCOR showed a better performance according to the RMSE in the analysis per land cover. Regarding the band wise analysis, MAJA ranked first in all spectral bands.
CASE STUDY 2. INTRODUCTION

Sola et al., 2018b. The performance of 6S, MAJA and SEN2COR applied to Sentinel-2 scenes are compared by:

- Evaluation of spectral signatures of six crop types on two specific dates

<table>
<thead>
<tr>
<th>Granule</th>
<th>Date</th>
<th>Time</th>
<th>Cloud coverage</th>
</tr>
</thead>
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<tr>
<td>T30TXM</td>
<td>04/05/16</td>
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<td>0 %</td>
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<tr>
<td>T30TXM</td>
<td>23/08/16</td>
<td>11:05</td>
<td>0%</td>
</tr>
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</table>

- NDVI time series along a complete year

CASE STUDY 2. RESULTS

Spectral signatures of crop types

Higher values in B6-B8 with SEN2COR

Clear reflectance decrease in VIS region
CASE STUDY 2. RESULTS
NDVI time series of each crop

NDVI >1 in one date

Higher values of NDVI with BOA reflectances

MAJA and SEN2COR show higher NDVI values in most cases
CASE STUDY 3. Work in progress

Surface reflectance values obtained using MAJA, 6S, iCOR and SEN2COR are compared with validated MODIS surface reflectance products acquired simultaneously.

Assessment 1: Comparison of BOA reflectance on three cloudless S2 scenes with MOD09GA daily collection, which includes images with 500 m spatial resolution and 7 spectral bands. A subset of 21x21 km in an agricultural area is selected as study area.
CASE STUDY 3. Work in progress

Assessment 2: 14 agricultural parcels corresponding to 5 main crop types (barley, corn, vetch, corn and sunflowers) are selected in the same study area, and the Level 2A S2-derived NDVI time series of a complete agricultural year are compared with MODIS-derived NDVI from MOD09GQ.006 collection, with daily scenes including NIR and red bands at 250m resolution.

Due to the coarse resolution of MODIS the study is limited to big agricultural parcels, i. e., 50-165 ha.
CONCLUSIONS

The results suggest minor differences between the four tested atmospheric correction processors.

Case study 1 showed a varying performance of the methods depending on the land cover, spectral band and atmospheric conditions. Although minor differences were observed in most cases, MAJA and iCOR showed a better performance according to the RMSE in the analysis per land cover.

Summing up, the results obtained on this inter-comparison of AC methods showed a clear enhancement of the accuracy of BOA reflectance estimation compared to the performance of uncorrected Level-1C product.

Further research is required to assess the performance of AC methods on different land covers with a larger campaign of ground measurements. Besides, the quality of cloud mask. Besides, the quality of geophysical and cloud masks must be assessed to decide which method is the best to correct the S2 imagery.
ACKNOWLEDGEMENTS

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