MERIS land products
LAI, fAPAR, fCover
Principles & validation

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Objectives

- Routine estimation of canopy biophysical variables:
  
  \[ f\text{APAR}, \ f\text{Cover}, \ \text{LAI}, \ \text{LAI} \times \text{Cab} \]

  - from MERIS - Top Of Canopy / Atmosphere Reflectances (FR & RR)

- Estimation **algorithm** based on artificial neural networks/RT models

- **Validation by**
  
  - Spatial and temporal consistency
  - Comparison with other products
  - Comparison with ground measurements
Justification of the principles of the algorithm

Definition of the variables of interest:
- \( \text{LAI} \): currently effective (no aggregation except soil/canopy)
- \( f\text{APAR}_{10h} \): very close to the daily integrated value (clear sky)
- \( f\text{Cover} \) (green elements)
- \( \text{LAI}.\text{Cab} \)

Selection of the algorithm:
- Using coupled atmosphere/surface RT models
- Radiative transfer models used: SAIL/PROSPECT/SMAC
- Inversion technique: neural network
  - Efficient
  - Easy to upgrade
  - Fast to run
- Learning data base representative of the actual cases encountered
The diurnal integral is the closest to the instantaneous values for 10:00 solar time.

Study to be extended over experimental observations (hemispherical photographs, PAR balance) (partly done).

Dates = 80,172,355 ; Lat=65:65 ; LAI = 1-10 ; ALA = 15°-75°
Performances for 10:00 solar time (simulations)
Principles of the algorithms

Prior Distributions
Biophysical Variables $V$
Geometry

Training Database Generation

$V$ → RTM → $R$

Neural Network Training

$R$ → ANN

weights and bias

Operational Use

$R$ → ANN → $\hat{V}$

MERIS Data
$R_{TOC}$
Geometry

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6/22
Generation of the training data base

Distribution of the radiative transfer model variables

Leaves

Canopy

Atmosphere
Simulation of TOA reflectances

<table>
<thead>
<tr>
<th>#</th>
<th>Centre (nm)</th>
<th>Width (nm)</th>
<th>Potential Applications</th>
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<tbody>
<tr>
<td>1</td>
<td>412.5</td>
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<td>Yellow substance and detrital pigments</td>
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<tr>
<td>2</td>
<td>442.5</td>
<td>10</td>
<td>Chlorophyll absorption maximum</td>
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<tr>
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<td>490</td>
<td>10</td>
<td>Chlorophyll and other pigments</td>
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<td>4</td>
<td>510</td>
<td>10</td>
<td>Suspended sediment, red tides</td>
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<td>Chlorophyll absorption minimum</td>
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<td>Suspended sediment</td>
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<td>Water vapour, land</td>
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Stochastic Orthogonal experimental plan

Goal: get a good sampling of the main interactions and the range of variation of each input variable

<table>
<thead>
<tr>
<th>Input variable</th>
<th>Number of classes</th>
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<tr>
<td>Date</td>
<td>Date</td>
</tr>
<tr>
<td>Background</td>
<td>$B_{a}$</td>
</tr>
<tr>
<td>Canopies</td>
<td>LAI / site</td>
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<tr>
<td></td>
<td>ALA</td>
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<tr>
<td></td>
<td>HotS</td>
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<tr>
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<td>vCover</td>
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<tr>
<td>Leaves</td>
<td>$C_{ap}$</td>
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<td></td>
<td>$C_{m}$</td>
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<tr>
<td></td>
<td>$N$</td>
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<td></td>
<td>$C_{bp}$</td>
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<td>Atmosphere</td>
<td>$r_{550}$</td>
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<td></td>
<td>$C_{O3}$</td>
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<td>$C_{wv}$</td>
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<td>$P_{atm}$</td>
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<tr>
<td>Total number of cases simulated</td>
<td>73728</td>
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</table>

36864 18432 Training data base Hyperspecialization Test

Date
4

LAI / site
4

ALA
3

HotS
1

vCover
1

$C_{ap}$
4

$C_{m}$
2

$N$
2

$C_{bp}$
2

$r_{550}$
3

$C_{O3}$
2

$C_{wv}$
2

$P_{atm}$
2

Total number of cases simulated
73728
realistic training data base
Theoretical performances

**a**

RMSE = 0.063  
R = 0.954  

**b**

RMSE = 0.071  
R = 0.948  

**c**

RMSE = 0.679  
R = 0.846  

**d**

RMSE = 31.45  
R = 0.886  

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Theoretical uncertainties (over test data base)

$fAPAR$ and $fCover$ relatively independent on actual product values

$LAI$ and $LAI.Cab$ depend strongly on actual product values (saturation...)
VALIDATION

Direct validation

TOA:
- Barrax (FR)
- VALERI (RR)

Indirect evaluation

TOA: BELMANIP (CYTTARES) extracts
- Temporal consistency
- Comparison with
  - fAPAR: MGVI, CYCLOPES V2 & MODIS
  - LAI: ECOCLIMAP, CYCLOPES V2 & MODIS
Direct validation over Barrax

- MERIS L1b FR
- LAI TOA_VEG
- Ground measurements: LAI2000
- Upscaling: extraction of pure pixels
Direct validation over Barrax

Quite encouraging results
Some saturation for LAI > 4
Direct LAI validation over VALERI

- RMSE = 2.1
- RMSE = 0.91
- RMSE = 0.85
Direct $f\text{APAR}$ validation over VALERI sites
Validation based on 30 BELMANIP sites
Indirect Evaluation over BELMANIP sites

**Fundulea (#317)**
ECOCLIMAP Composition: 22% Deciduous Broadleaf, 78% Crops

- MERIS TOA_VEG
- MODIS 8days 1km
- CYCLOPES VGT 10days 1km
- ECOCLIMAP

**fAPAR**

**fCover**

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Intercomparison between products over 29 BELMANIP sites
Indirect Evaluation over BELMANIP sites
CONCLUSION

- First version fully documented of the algorithm
  - Good overall performances
  - Saturation for high LAI (around 4)
- Algorithm soon available in BEAM
  - Getting feedback from users
  - With improved cloud screening
- Improvements foreseen for future version
  - Improved LAI distribution
  - Improved soil data base
  - Streamlining the learning data base by comparison to actual MERIS data
  - Learning on actual MERIS data