“SENTINEL-2 FOR AGRICULTURE”: SUPPORTING GLOBAL AGRICULTURE MONITORING

Bontemps S., Arias M., Cara C., Dedieu G., Guzzonato E., Hagolle O., Inglada J., Morin D., Rabaute T., Savinaud M., Sepulcre G., Valero S., Defourny P., Koetz B.
• Major international attention about food supply (insecurity, price volatility)
• International land grabbing challenging national food security

Need for better agricultural monitoring capabilities
EO observation can help
• **EO response to operational agricultural applications:**
  – Emerging collaborative initiatives endorsed by G20 in the context of GEO (AMIS, GEOGLAM)
  – JECAM initiative opening the door to move from local experiments to global solutions
  – CEOS support to global agriculture users requirements
  – US and Chinese efforts on 30-m global croplands mapping
  – **Sentinel-2 mission to finally reach agriculture expectations**
    (jointly with Landsat-8 and Sentinel-1)
Marrakesh (Morocco) - Sentinel-2 - 12 July 2015

Water consumption for irrigation of summer vegetation (in red)
5-day revisit for NRT agriculture monitoring

Valencia (Spain) – April – June 2015
flooding dynamic of rice field and
monitoring the start of growing season

20 April 2015
30 April 2015
10 May 2015
15 May 2015
20 May 2015
25 May 2015
04 June 2015
09 June 2015
14 June 2015
19 June 2015

Simulation of Sentinel-2 (2 satellites) 5 days revisit frequency with SPOT5-Take5
5-day revisit for NRT agriculture monitoring

**Valencia** (Spain) – April – June 2015
flooding dynamic of rice field and
monitoring the start of growing season

- 20 April 2015
- 30 April 2015
- 10 May 2015
- 15 May 2015
- 20 May 2015
- 25 May 2015
- 04 June 2015
- 09 June 2015
- 14 June 2015
- 19 June 2015

*Simulation of Sentinel-2 (2 satellites) 5 days revisit frequency with SPOT5-Take5*

16 July 2015 by Sentinel-2a
Sentinel-2 for Agriculture project

- Launched by ESA in February 2014
- Objective:
  - Preparation for national to regional agricultural monitoring based on Sentinel-2
    Providing validated algorithms to derive EO products relevant for crop monitoring and best practices to process S2 data in an operational manner for major worldwide representative agriculture systems
  - Consolidate best practices for EO agricultural monitoring
    Benchmarking & validation of algorithms for 4 EO products over a wide range of conditions (JECAM community)
  - Strengthening national capacity for agricultural monitoring
    Transfer to users including local system installation & training
    Demonstration of validated agricultural EO products at national scale
**Sentinel-2 for Agriculture planning**

**Design:**
- User Requirements
- EO product specification
- Algorithm Development

**Processing System:**
- Testing & validating of EO prototypes (12 sites) in 2015 agriculture season

**Use cases:**
- 3 national cases
- 5 local cases
- Transfer to national users

**Algorithm Development 2014**

**Prototypes of EO products 2015**

**Demonstration & Validation 2016**
User-driven approach

**Consortium**

**Support & data provider**

**Champion Users**

1st User Consultation organized by ESA in 2012
2nd User Consultation during the first months of the project through surveys

Survey filed up by 42 institutions

- Public National: 58%
- NGO: 2%
- Public sub-national: 10%
- Private: 12%
- International: 21%
Toolbox for 4 S2-based products in line with the GEOGLAM core products

- **Cloud Free Surface Reflectance Composites**: Monthly cloud free surface reflectance composite at 10-20m.

- **Dynamically Cropland Mask**: Binary map identifying annually cultivated land at 10m, updated every month.

- **Vegetation Status**: Vegetation status map at 20m delivered every 10 days (NDVI, LAI, phenology index).

- **Cultivated Crop Type Map**: Crop type map at 10m for the main regional crops including irrigated/rainfed discrimination.

- **Open Source Toolbox**: Capacity building and training.
Benchmarking for selecting the best algorithm for each product

- Literature review
- Test Data Set (EO + in-situ data)
- Scientific analysis

Select 5 suitable algorithms
Run the algorithms over 12 sites globally distributed
Compare results between algorithms and sites
Identify the best algorithms

12 test sites, relying on JECAM network, spread over the world, which represent more than 17 major crop types

South Africa  France  Maricopa (USA)  Argentina  Morocco
A unique dataset made of Sentinel-2 like EO time series and in-situ data

<table>
<thead>
<tr>
<th>Site</th>
<th>S4-T5</th>
<th>L8</th>
<th>RE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>12</td>
<td>11</td>
<td>15</td>
<td>38</td>
</tr>
<tr>
<td>Belgium</td>
<td>8</td>
<td>3</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>-</td>
<td>9</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>China</td>
<td>18</td>
<td>10</td>
<td>-</td>
<td>28</td>
</tr>
<tr>
<td>France</td>
<td>32</td>
<td>8</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>Madagascar</td>
<td>12</td>
<td>15</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Morocco</td>
<td>24</td>
<td>16</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>Pakistan</td>
<td>-</td>
<td>13</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Russia</td>
<td>-</td>
<td>5</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>South Africa</td>
<td>23</td>
<td>15</td>
<td>26</td>
<td>64</td>
</tr>
<tr>
<td>Ukraine</td>
<td>17</td>
<td>11</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Maricopa (US)</td>
<td>54</td>
<td>15</td>
<td>-</td>
<td>69</td>
</tr>
<tr>
<td>Total of dates</td>
<td>200</td>
<td>131</td>
<td>53</td>
<td>384</td>
</tr>
</tbody>
</table>

**SPOT 4 Take 5 over JECAM Argentina**

Crop / no crop
Crop type
LAI

In-situ data split in calibration and validation data sets

along the 2013 growing season
• Testing 2 algorithms families:
  1) Supervised algorithm (SVM / RF classifiers) when in-situ data
  2) Unsupervised algorithm (K-mean, trimming-based) when no in-situ data
• Per-pixel vs per-object approach

Supervised approaches better than unsupervised ones
Unsupervised ones reaching the OA target (50% middle at the season & 80% end of the season)
Efficient annual cropland mapping along the season

**Objects Used for Post-Filtering Process**

Ukraine site subset

6 months of observations enough to reach the final cropland accuracy
Crop type benchmarking

- Supervised algorithms (RF / SVM / fusion of both)
- Different pre-processing of input data (smoothing, temporal regular resampling)
Crop type map with good accuracy for the 5 main crops

Successful development thanks to JECAM collaborative network
• Components that form the toolbox (independent executables)
• Orchestrator to manage the components and execute jobs
Ready for demonstration

Algorithm Development 2014

Benchmarking over System designed

Prototypes of EO products 2015

System in development

First prototypes products in generation

Demonstration & Validation 2016

France (Toulouse)

Mali
First S2-based prototype product
Toulouse area (France) - Sentinel-2 – 06 July 2015

New red-edge band to discriminate summer crops: maize vs sunflower

Infrared false color composite

New red-edge color composite
orange versus yellow

Contains Copernicus data (2015)
First S2-based prototype product
Toulouse area (France) - Sentinel-2 – 06 July 2015

New red-edge band to discriminate summer crops: maize vs sunflower

Summer Crops Map – 6 July 2015

- **Sunflower**
- **Maize**

Contains Copernicus data (2015)
• Demonstrate products and system using Sentinel-2 over:
  – 3 countries, possible candidates being Ukraine, South Africa, Mali
  – local cases (290*290 km)

• Full demonstration possible ONLY IF:
  – In-situ data are ensured (JECAM network, project effort)
  – S2 data as continuous acquisitions every 10 days along the full growing season
• Unique contribution to the global issue of food security:
  – **Crop dynamics:** Frequent and free coverage (5 days globally)
  – **Crop mapping:** at field scale in complex landscapes (10 m resolution)
  – **Crop status:** Improved spectral bands for crop health and growth
  – **Crop Forecasting:** Long term perspective to build multi-year archive
  – **Operational Crop Monitoring:** Systematic and global coverage
  – **Compatibility** with other existing missions to complement time series

⇒ **Major European contribution to GEOGLAM**, the global system of agricultural monitoring systems, including the Sen2Agri toolbox to exploit S2 data
Thank You!

www.esa-sen2agri.org

**SENTINEL-2 FOR AGRICULTURE**

**SENTINEL-2 FOR AGRICULTURE WITH SPOT 5 TAKE 5**

The end of life of the SPOT 5 satellite, planned in a few weeks, and the success met by the SPOT 4 Take 5 experiment two years ago encouraged renewing this last operation.

Thanks to an ESA-CNES cooperation, SPOT 5 has been placed in a 5-day orbits on April the 2nd, allowing to acquire a new Sentinel-2 like dataset. The experiment started on April the 8th with the first image acquisition and will last 5 months until September the 8th. The first L2A images should be released by CNES early June. From this date, there will be a continuous data stream characterized by a 2-week delay between the image acquisition by the sensor and the L2A image availability.

150 sites will be observed, including 8 sites for our project located in Belgium, Burkina Faso, China, France, Mali, Russia, South Africa and Ukraine. All these sites are part of the JECAM network, which ensures us dataset of in-situ measurements during this season.

Over these 8 sites, we will generate our 4 key products: monthly composites, dynamic cropland mask, crop type map and LAI products. Over the French and Mallan sites, this production will take place in near-real time from June while the products over the other 6 sites will be generated in autumn.

That will provide us with an extra possibility to run and test our algorithms. Most importantly, it gives us the unique opportunity to cover the growing season 2015 in the Northern Hemisphere and thus, to smooth the transition with the first Sentinel-2 data.

---

**UPCOMING EVENTS**

**Sentinel-2 for Science Workshop**

5/20/2014, Fiscarotti, Italy

**Sentinel-2 for Agriculture User Workshop**

5/19/2014, Fiscarotti, Italy

**Sentinel-2 for Agriculture 1st User Workshop** organized on May 19th, 2014 at FAO Headquarters in Rome.

---

**RELATED ACTIVITIES**