A first national demonstration in near-real time in South Africa over the 2016-2017 growing season

Agriculture in South Africa is already well monitored using remote sensing data. More particularly, the country has its own Operational Crop Monitoring system named PICES. It consists in flying with very light aircraft or helicopter over a sample of fields selected from a sample frame. In-situ data are collected once in the season based on point sample frame. This system has been in place for 10 years and is continuously improved from year to year.

The demonstration was done over the 2016-2017 growing season, over two agricultural regions of the country corresponding to the summer and winter grain growing seasons. It was conducted in close collaboration with the **Agricultural Research Council** (ARC) and the **GeoTerra Image** private company. Active interactions between this team and the consortium has allowed rapidly identifying the added-value of the Sen2-Agri products and system, in particular for crops forecasting.

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Sen2-Agri team during the South African Stakeholder meeting, organized on May 12, 2016 during the "Crop Estimates Liaison Committee", Pretoria, South Africa

This interest was confirmed during the National Stakeholder meeting which was organized during the "Crop Estimates Liaison Committee". CELC represents all stakeholders interested in crop development and statistics includes traders, millers, futures traders and industry. The CEC (crop estimates committee) is a closed committee of DAFF, ARC, provinces and Stats SA. All these stakeholders raised the importance of getting **accurate**, **reliable** and **early** indication of expected production for the **grain industry** (for trading, transport, storage and marketing), for **buyers and sellers** and for **managing surplus or deficit**. They also emphasized the importance of an "**official branding**" to give credibility to the figures.
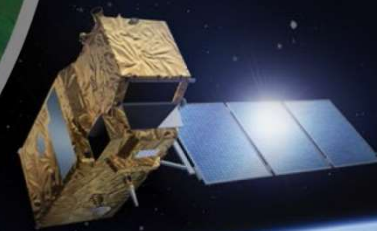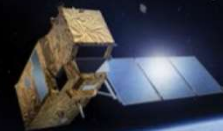
sentinel-2

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A demonstration site highly dynamic in terms of crop rotation

Fields in South Africa have an average size around 40 ha, but there exists significant variability, with some fields being much larger than 100 ha. The climate is sub-humid to semi-arid.

The main crops (**wheat**, **sunflower**, **maize**, **barley**, **soybean**, **oil seed** and **grasses and fodder crops**) are grown from September to June for winter crops and from April to November for the summer ones. During the demonstration, summer crops will be monitored over the Free State, Mpumelangs, Kwazulu Natal and North West provinces while winter crops will be observed in the Western Cape province, the total area representing around 620.000 km².

A key characteristic of this site is its high dynamics in terms of crop rotations. The succession of crops from one year to another, and even during the same year, are driven much more by yield concerns than by other agro-ecosystem or cultural aspect. High inter-annual yield variability is also typical of this country.

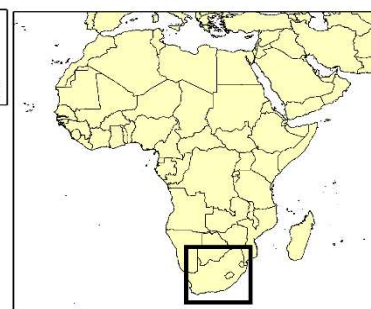**Agricultural practices in South Africa, Free State and Western Cape provinces**
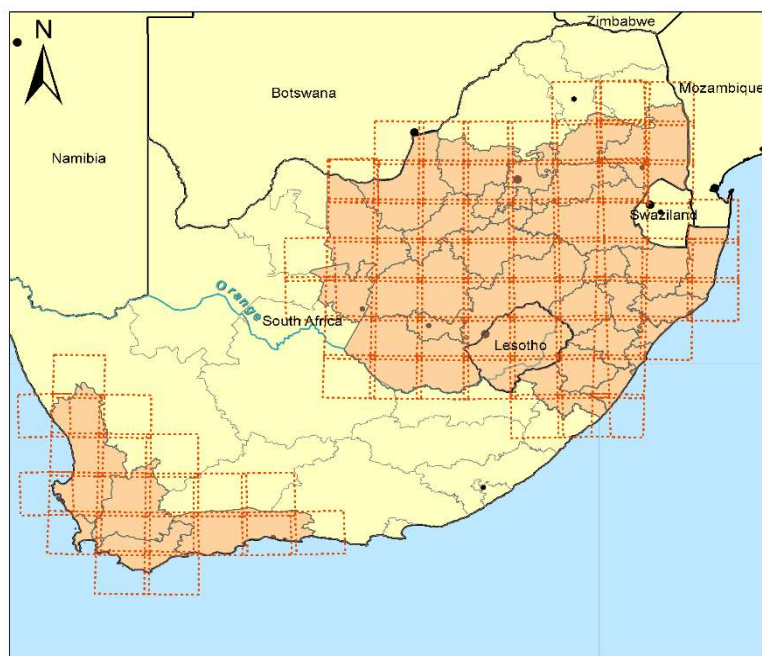
An end-user team with high remote sensing expertise and with key connections with the grain industry

The organisation at the heart of the Sen2-Agri South African national demonstration is the **Agricultural Research Council** (ARC). ARC is a science institution that conducts research with the aim of supporting and developing the agricultural sector.

The demonstration also involved the private company GeoTerra Image. This company has formed the National Crop Statistics Consortium (NCSC) in collaboration with the ARC (Institute for Soil Climate & Water) and SiQ and over the past 8 years, it has supported the Department of Agriculture in terms of annual crop estimates.
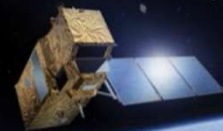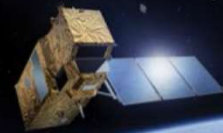
Coverage of the South African national demonstration site by the Sentinel-2 and Landsat-8 Earth observation missions

Monitoring the vegetation growing in near-real time

The **Sen2-Agri Composite product** provides, on a monthly basis, a cloud-free temporal synthesis of the surface reflectance values in all 10 and 20 meters Sentinel-2 bands. Using a **50-day compositing period** allowed generating a high quality product with high spatial and temporal consistency throughout the two Summer and Winter grains areas

The **Sen2-Agri Vegetation Indicator** product provides Leaf Area Index (LAI) maps from each Sentinel-2 and Landsat 8 acquisitions, at 10 meters spatial resolution. The very high number of cloud-free acquisitions allowed monitoring vegetation dynamics during the growing season, also being crop specific.

Cloud-free Composite product corresponding to May 2016 over the Free State province and to August 2016 over the Western Cape province, obtained from Sentinel-2 and Landsat 8 data collected during a 50-day period
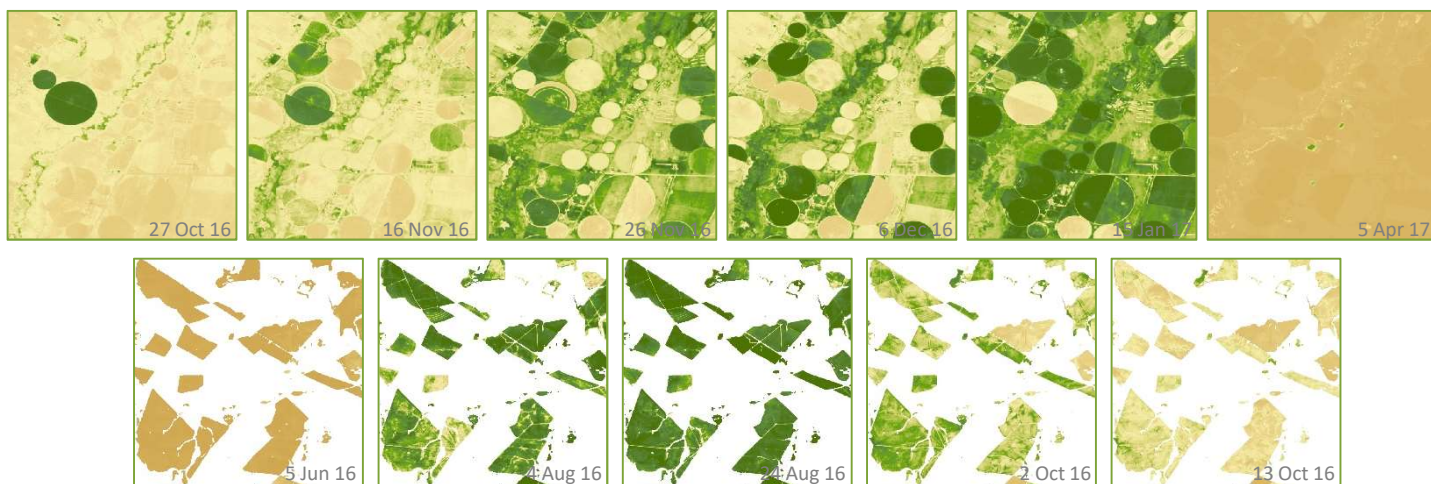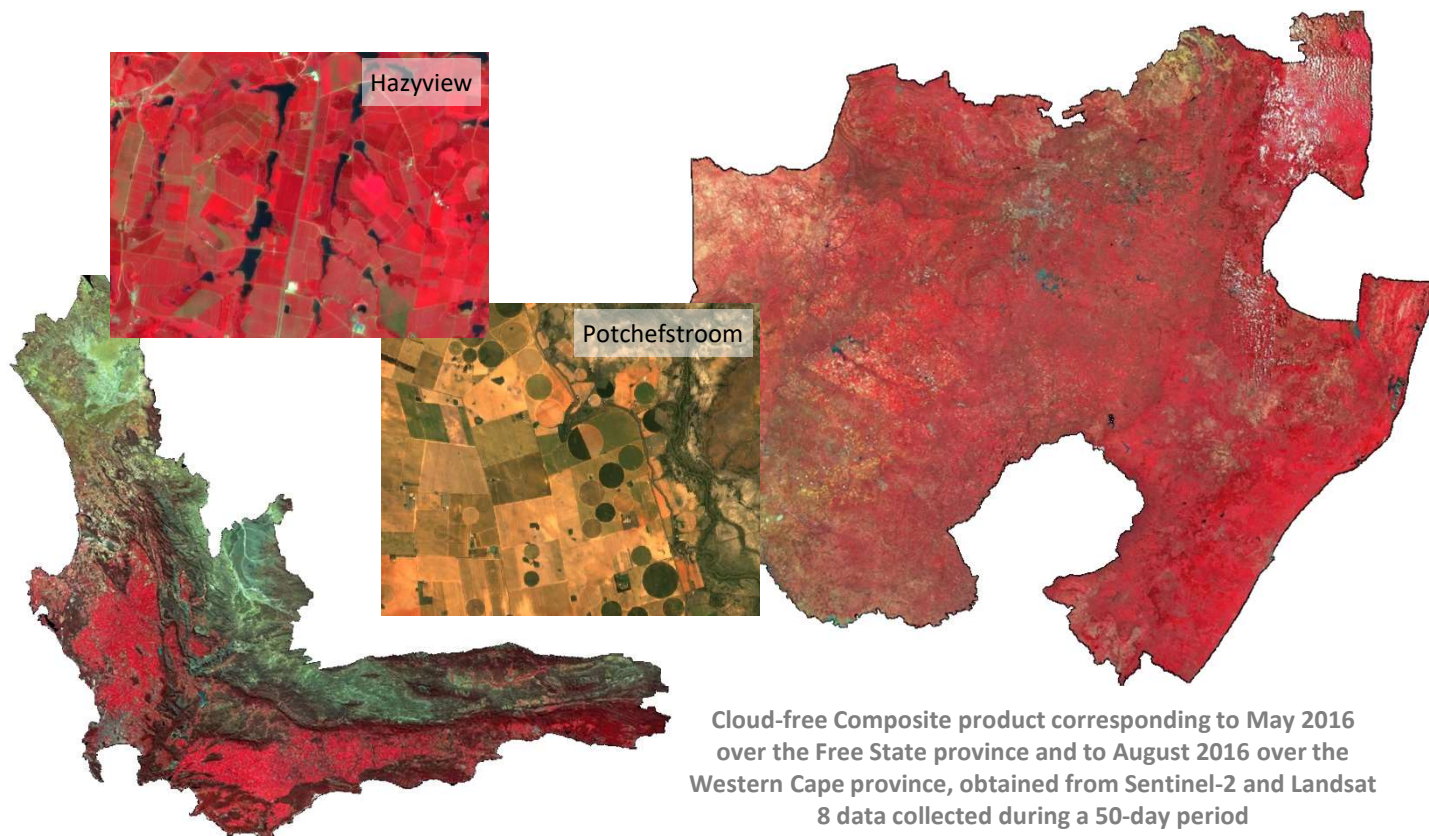
Time series of Leaf Area Index at 10 meter spatial resolution, derived from Sentinel-2 and Landsat 8 over the 2016-2017 growing season, for all land cover types (top) and for wheat only (bottom)
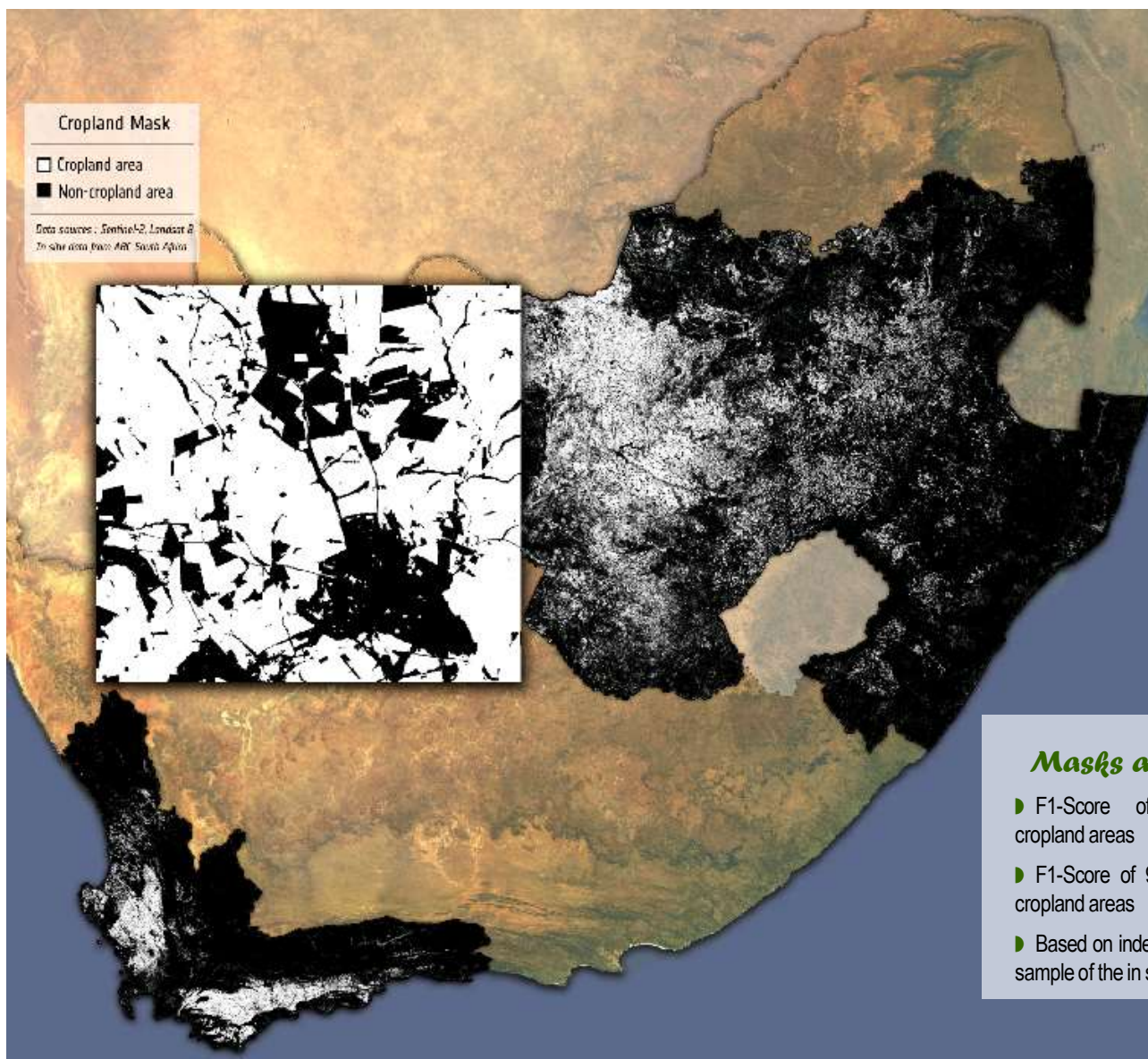
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Mapping cropland and crop types based on in-situ data derived from intensive aerial survey

The **Sen2-Agri Dynamic Cropland Mask** is a binary map at 10 meters spatial resolution, separating annual cropland areas from other ones, thus corresponding to a mask over annually cultivated areas. The first version of the map is delivered at the middle of the season, and is then updated on a monthly basis until the end of the season.

The Cropland Mask was based on in-situ data obtained from the South African Operational Crop Monitoring PICES. In total, around **12.000** samples (~451000 ha) and **11.000** samples (262.000 ha) were gathered over the Summer and Winter grains areas, respectively.
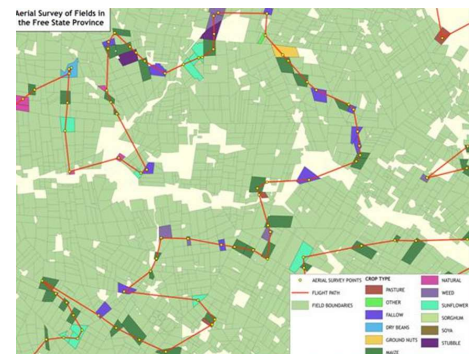
Example of aerial survey over the Free State Province
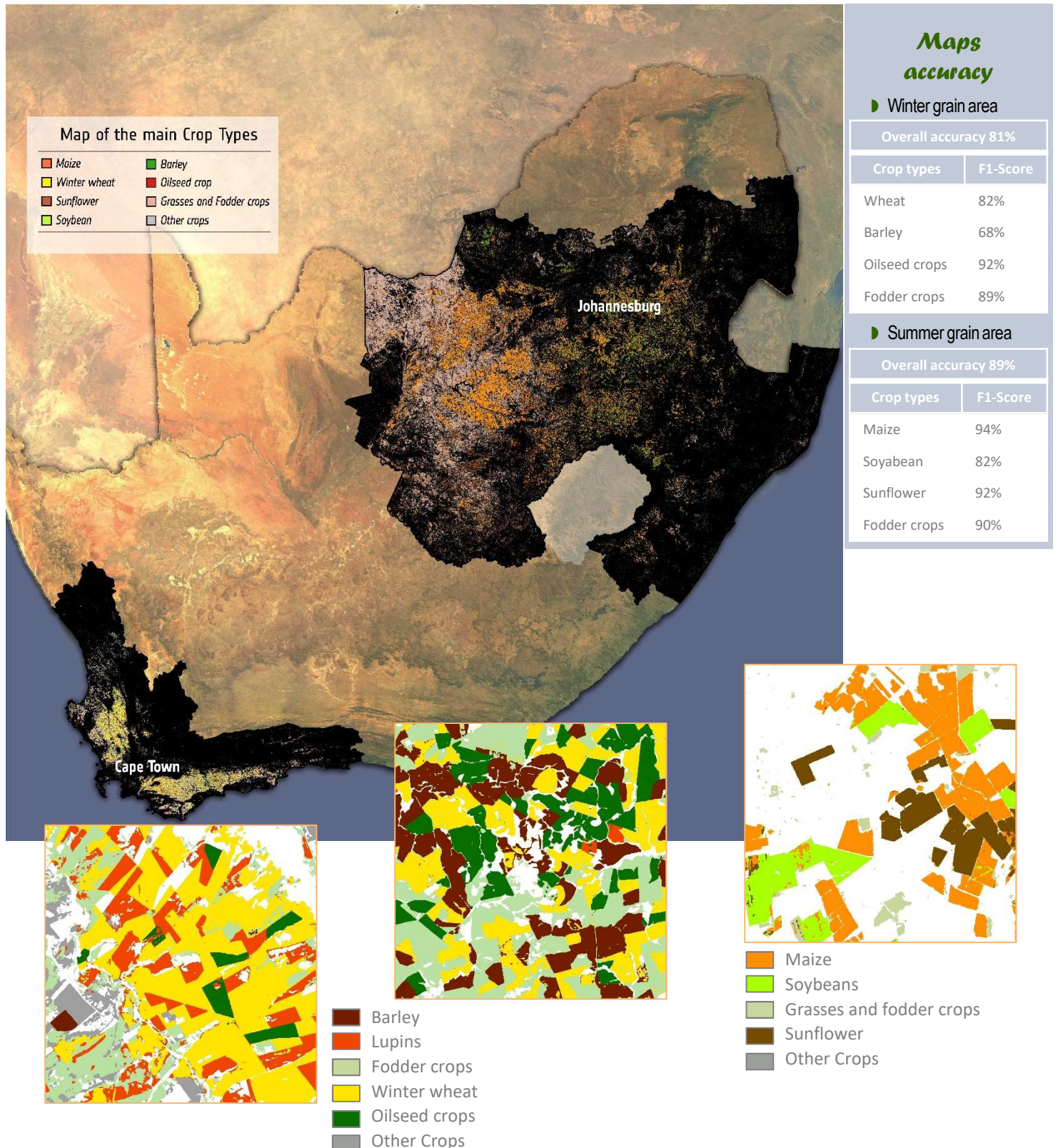

Masks accuracy

▶ F1-Score of 82% for cropland areas

▶ F1-Score of 91% for non-cropland areas

▶ Based on independent 25% sample of the in situ dataset.

Dynamic Cropland Mask from November 2016 (Western Cape) and March 2017 (Free State), corresponding to the end of the season, obtained using Sentinel-2 and Landsat 8 acquisitions and 75% of the in-situ dataset

The **Sen2-Agri Crop Type Map** identifies the main crop types (**wheat**, **sunflower**, **maize**, **barley**, **soybean**, **oil seed** and **grasses and fodder crops**) at 10 meters spatial resolution; it is delivered twice along the season, at the middle and at the end. The map is also based on the in-situ dataset collected from the South African **PICES**.

Map of the main Crop Types

- ■ Maize
- ■ Winter wheat
- ■ Sunflower
- ■ Soybean
- ■ Barley
- ■ Oilseed crop
- ■ Grasses and Fodder crops
- ■ Other crops

Johannesburg

Cape Town

Maps accuracy

▶ Winter grain area

Overall accuracy 81%	
Crop types	F1-Score
Wheat	82%
Barley	68%
Oilseed crops	92%
Fodder crops	89%

▶ Summer grain area

Overall accuracy 89%	
Crop types	F1-Score
Maize	94%
Soyabean	82%
Sunflower	92%
Fodder crops	90%

- ■ Barley
- ■ Lupins
- ■ Fodder crops
- ■ Winter wheat
- ■ Oilseed crops
- ■ Other Crops

- ■ Maize
- ■ Soybeans
- ■ Grasses and fodder crops
- ■ Sunflower
- ■ Other Crops

Sentinel-2 for Agriculture at a glance

Achieving sustainable food security for all people is a priority highlighted during the Millennium Summit of the United Nations in 2000, which defined the eradication of extreme poverty and hunger as one of the eight Millennium Development Goals. In response to such growing pressure, the development of agriculture applications is becoming a strategic target for the remote sensing community.

In this context, **ESA** has launched the **Sentinel-2 for Agriculture** project, as a major contribution to the R&D component of the GEOGLAM initiative and to the JECAM network activities. This 3-year project aims at demonstrating the benefit of the Sentinel-2 mission for agriculture across a range of crops and agricultural practices. The intention is to provide the international user community with validated open source algorithms and software to process Sentinel-2 data in an operational manner and derive Earth Observation products relevant for crop monitoring in the major worldwide representative agriculture systems.

The project is carried out in close collaboration with 20 organizations, centers, universities or companies belonging to the agriculture monitoring communities. They are our Champion Users, involved in the project since its very beginning.

The activities are split into several steps for coming to national and local demonstration:

◗ During **Phase 1**, user requirements have been collected and consolidated to set up relevant products and system specifications. Simulated test datasets representative of Sentinel-2 imagery were acquired over 12 test sites to benchmark algorithms and design the system.

◗ **Phase 2**, now closed, was devoted to the development of an open source processing system and the generation of prototype products based on the Phase 1 outcomes.

◗ Started after the Sentinel-2 commissioning phase, **Phase 3** aimed at demonstrating and validating the developed system with actual Sentinel-2 time series, with the additional objective to transfer the system to the Champion Users at operational level.

The Sentinel-2 for Agriculture project is carried out by a consortium led by the **Université Catholique de Louvain** (BE) and involving the **Centre d'Études Spatiales de la Biosphère** (FR) and the companies **CS - Systèmes d'Information** (FR), **CS Romania** (ROU) and **GISAT** (CZ).

The National Demonstration in South Africa was conducted in close collaboration with the **Agricultural Research Council**.