Better crop estimates with satellites and remote sensing

By Wiltrud Durand and Fanie Ferreira

Remote sensing is the art and science of recording, measuring and analysing information about a phenomenon from a distance. In order to study large areas of the Earth's surface, geographers use devices known as remote sensors. These sensors are mounted on platforms, such as helicopters, aeroplanes and satellites, that make it possible for the sensors to observe the Earth's surface from above.

The sensors record the reflected or emitted energy digitally, and in the case of satellites this data is transmitted to a ground receiving station. Data from satellites is then converted from digital numbers into satellite imagery, using advanced image processing algorithms so that it can be used by scientists to extract information.

A brief overview

Satellite images recorded by Earth observation satellites have several bands (electromagnetic wavelengths) that are sensitive to and collects information on vegetation stage and condition, which can be associated with chlorophyll content or plant health.

The light reflected by the leaves of a crop depends on the amount and various types of leaf pigments. Measuring the difference in reflected light at various wavelengths of the electromagnetic (EM) spectrum makes it possible to distinguish vegetation from soil, green and senescent vegetation, and different crop types.

In South Africa, three sources of satellite imagery are utilised as part of the process to generate information for the Crop Estimates Committee (CEC) in the Department of Agriculture, Forestry and Fisheries (DAFF). These satellites have different levels of detail (pixel resolution) as well as frequency of recording imagery, and are selected according to their capabilities for a specific purpose.

SPOT 6 and SPOT 7 have a resolution of 1,5m and is used to map agricultural field boundaries. Landsat 8, with a resolution of 30m, and Sentinel 2A, with a 20m resolution, are used in combination within the cropping season to perform a grain crop type classification.

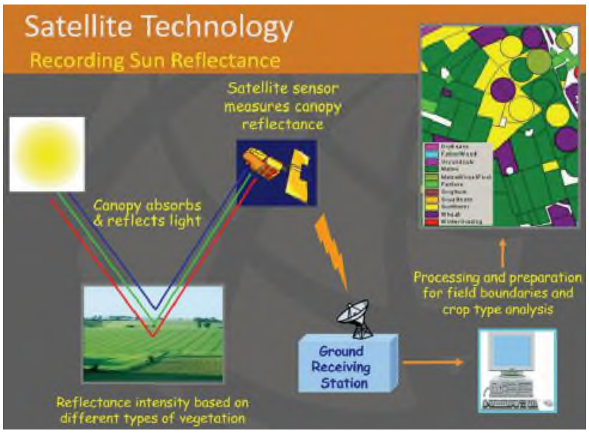

Figure 1: The processes involved in determining field boundaries and crop type analyses.

Field crop boundaries

The DAFF national field crop boundary layer contains a polygon for each individual commercial agricultural field in South Africa, with an attribute of the area in hectare for each field. Fields that are irrigated by means of a centre pivot are also labelled accordingly while small-scale farming fields are grouped together as clusters of cultivation.

The field boundary layer was initially mapped from SPOT 5 satellite imagery at a 2,5m resolution for the entire South Africa at a scale of 1:10 000. The process included strict control measures to ensure a consistent and accurate layer, with fields labelled as centre pivot, rainfed, horticulture (fruit orchards), old fields and small-scale farming.

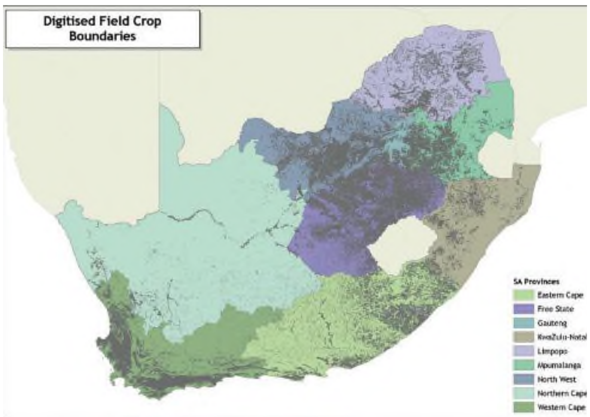

Figure 2: Digitised field crop boundaries for all nine provinces.

Fields in all nine provinces of South Africa were mapped, delineating approximately 800 000 cultivated fields, and represents a total of approximately 14 000 000 hectares. These fields have an average size of almost 40ha, with significant variation according to regional landscapes – some fields are even larger than 100ha (*Figure 2*).

The field boundaries are updated annually from the recently launched SPOT 6 and SPOT 7 satellites, featuring a resolution of 1,5m, with the

focus on irrigated fields such as centre pivots. The field boundary layer is used as a statistical sampling framework for the PICES (Producer Independent Crop Estimate System) survey, which identifies crop types on selected fields in South Africa to calculate provincial statistics.

The approach to map and use field boundaries as the frame for the surveys has reduced the area to be surveyed for area estimates by almost a third when compared to the original farm level area frame.

Crop type classification

The aim of the crop type classification is to identify the specific grain crop that is cultivated on each individual field in the summer grain provinces of Mpumalanga, Free State and North West. Summer grain crops are cultivated from September to April, and therefore regular cloud free satellite imagery is required during the growth season to track the crop growth phenology.

The most appropriate satellites to provide regular imagery are Sentinel 2 (two satellites in a constellation) at 20m resolution with a 5-day recording interval, and Landsat 8 at 30m resolution with a 16-day recording interval.

Information from the PICES survey is used to calibrate satellite imagery to perform the crop type classification. This step involves linking each individual crop type to a specific spectral reflectance value, which is used by the classification algorithm to assign a crop type to each field.

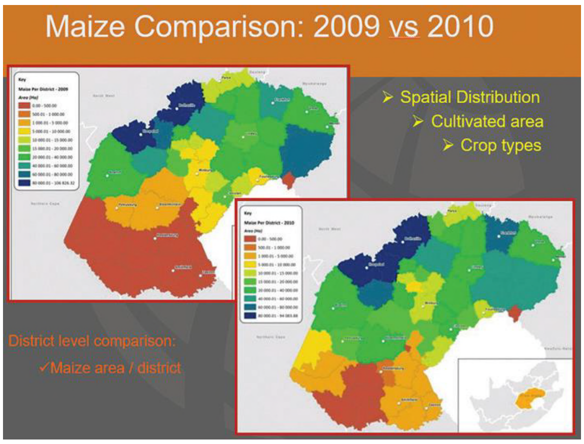

Figure 3: District level maize crop comparison.

Grain crops that are classified during this process include maize, sunflower, soya bean, groundnuts, dry beans and pastures. This information can then be summarised for a defined region or known administrative boundaries, such as districts, and displayed graphically (*Figure 3*).

Crop type information enables decision-makers and agronomists to understand where a crop of interest is cultivated, and this can also be summarised to district level and compared to previous seasons to identify changes in the cultivated area of a specific crop.

Crop type classifications can also assist in understanding different farm management systems, such as irrigation, double cropping and crop rotation practices. The continuous monthly processing of imagery enables the tracking of progress during the harvesting period and allows the calculation of the area harvested each month.

The use of satellites and remote sensing for agricultural purposes is an exciting and new field of research, where the focus is placed on developing operational automated systems with high accuracy and timely outputs. Due to its well-developed crop estimates system that captures high quality data, South Africa is in collaboration with international research organisations and at the forefront in the development of these monitoring systems.

For more information, contact Fanie Ferreira at Fanie.Ferreira@geoterraimage.com.