TECHNICAL NEWSLETTER
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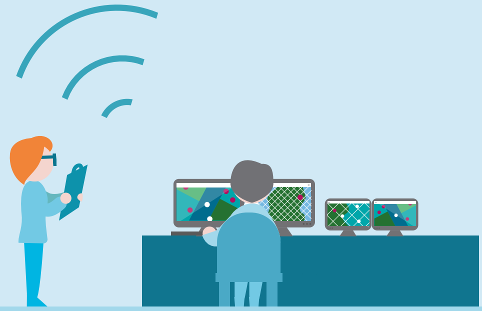


GUIDE TO AGRICULTURE INSURANCE PART II

Satellite imagery technology

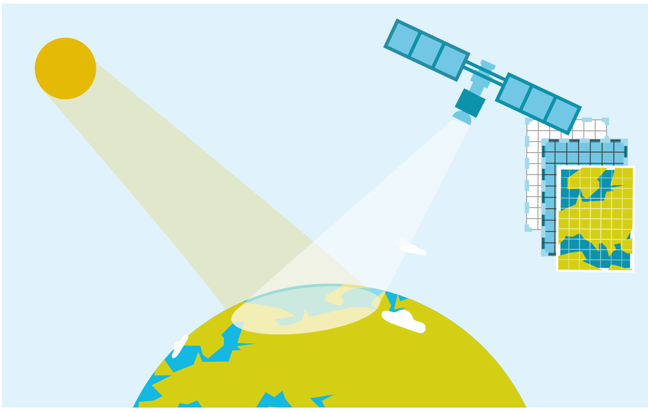
Following SCOR's previous newsletter dedicated to understanding the different types of satellite that can be used for agriculture insurance and how, this second volume will focus more on satellite imagery technology, assessing the key factors to be taken in account in the decision making process when selecting technology for agriculture insurance purposes.

SATELLITES: A BIG FAMILY

As stated in the previous volume, when they refer to satellites, people are very often referring to a very wide range of tools and technologies. This is not necessarily clear for everybody, and can lead to confusion when deciding to launch a project. Below is a brief classification overview that may therefore be useful.

Groups of satellites can be defined as follows:

- Telecoms satellites used for information transmission (TV, telephone, etc.)
- Weather satellites used for measuring weather parameters (temperature, moisture, wind speed, etc.)
- GPS satellites used for geo location
- Scientific Satellites dedicated to very specific missions
- Earth observation satellites. These are usually referred to under the general term "satellite imagery". They actually cover a whole range of sensors with different resolutions, revisit times and characteristics.



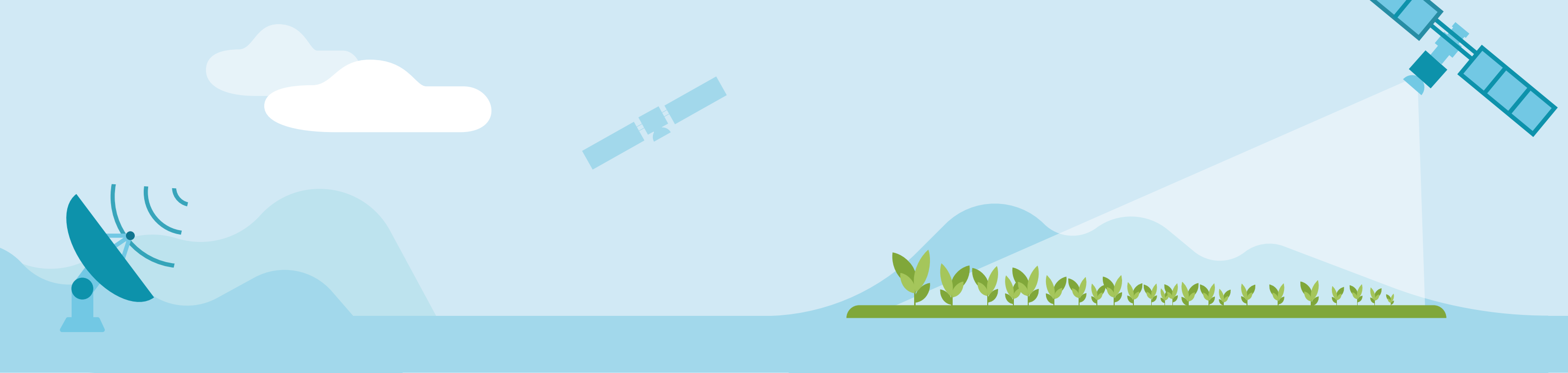
Earth observation satellites can be split into two main groups:

- Radar satellites, mainly SAR (Synthetic Aperture Radar)
- Optical satellites

Part I of this Newsletter described the use of optical satellite imagery. Part II will now dig a bit deeper into the technical dimensions and the main criteria for choosing an image and using it in the (re)insurance industry.

HOW TO CHOOSE A SATELLITE IMAGE

When implementing a satellite technology tool, regardless of the final objective, the first decision involved is which image to use. In order to make the best choice, there are four main criteria to consider.

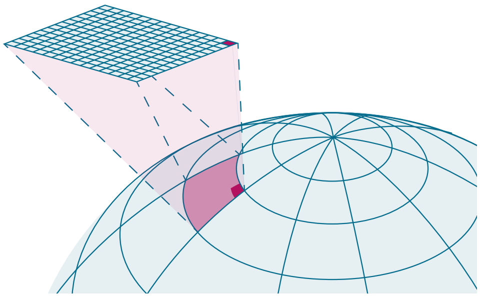


SPATIAL RESOLUTION

This is the best known image specification. Representing the size of one pixel on the ground, it gives the size of the smallest object that can be observed. Today, the resolution for optical satellite ranges from 0.30/0.5 m to 1 km. The satellites are usually divided in the following groups:

- Low resolution (around 1000m)
- Medium resolution (around 250 m)
- High resolution (around 10-20 m)
- Very high resolution (<1 m).

The spatial resolution must be chosen with care, as it will have an impact on the details visible on the image, and will also impact the cost involved. The higher the resolution, the higher the visible detail, but higher resolution also means a higher price (the correlation between price and resolution is more exponential than linear). A bad choice on this criteria can lead to a resolution too crude to solve the problem at hand, or too costly to make the service economically sustainable. In some cases, too high resolution can lead to an "overflow" of information hiding the "Big picture" and disturbs the decision making process.

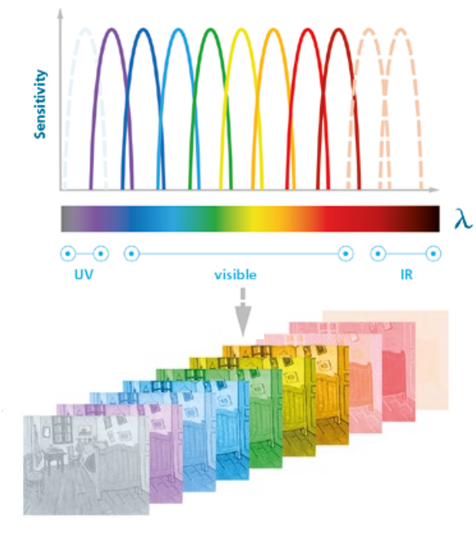


Typical use would involve medium resolution for index products on large areas, high resolution for infield analysis of commodity crops, and very high resolution for specialty high value crops.

SPECTRAL RESOLUTION

This parameter is also very important, but usually far less known to users. The sensor on board the satellite takes what could be called a "color" picture, but instead of taking one picture containing all the colors it splits the pictures taken into different "Bands", one for each color. These different bands are then used during processing to extract the information needed. The number and the width of the different spectral bands (colors) will define the relevance of the measurement. These bands can capture visible colors but can also work in the invisible spectrum, capturing Shortwave Infra-Red (SWIR) images that can provide information on water content for example, or near Infra-Red (NIR) images that are capital for chlorophyll content monitoring.

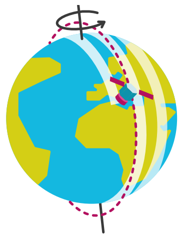
Large optical satellites can have between 3 and 15 spectral bands, depending on their spatial resolution. The choice of the correct spectral resolution depends on the object under observation, on the type of information to be derived from the images and on the expected quality of the final data. This choice should be left to the processing technique experts.

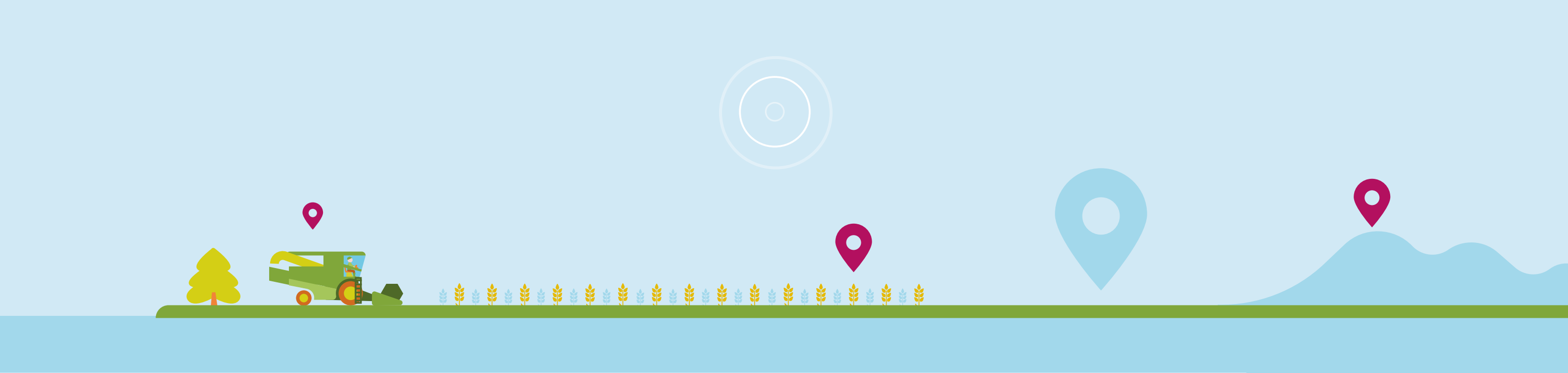


(multi-/hyper-) spectral image

REVISIT

This is a key point, especially in agriculture. Crop status is very sensitive to one thing: **Time!** Whatever the type of analysis involved, index or field, it is crucial take a picture at the right time. Due to its orbit altitude, the satellite itself will fly over a specific point on earth every 15 to 20 days. With a non-programmable satellite, that means you have one chance every 15 days to take a picture. If the objective is covered by cloud on the flyover day, you will have to wait another 15 days before you can try again.





To overcome this issue, new commercial satellites are now "agile", which means that the satellite itself can tilt on its axis to change its viewing angle and take a picture in any direction. This significantly increases the real revisit capacity, which can easily reach 3 days or even 24 hours in certain cases.

This means that, if on the flyover day your field is hidden by clouds, you can try again the day after by pointing the satellite left or right (forwards or backwards), regardless of its orbit.

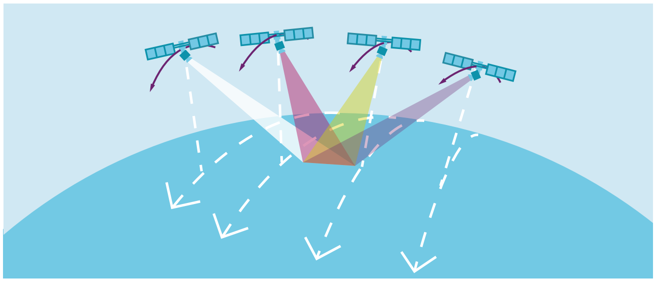


IMAGE SIZE

The image size or swath is another important parameter for agriculture, as the territories being monitored are often large. The swath can range from a few kilometers to more than a thousand kilometers. Of course it is linked in different ways to two other parameters, spatial resolution and revisit. The design of the sensor will define the level of tradeoff between swath and resolution: higher the resolution, lower the swath. The swath is also linked to the revisit time, because a satellite capturing more than 1,000 km in one flyover will have a shorter revisit period, and therefore more frequent opportunities to take a picture.

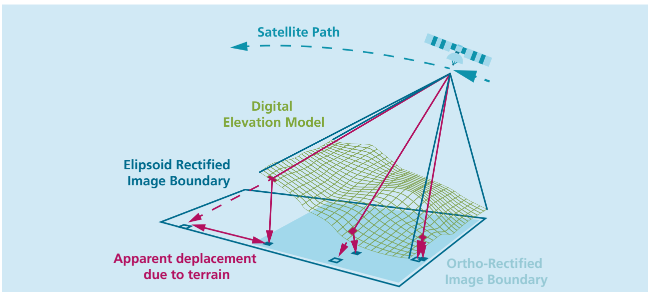
Even if the image size is generally seen as a secondary parameter, it is important to keep it in mind when choosing an image source, depending on the crop to be monitored.

FROM IMAGE TO INFORMATION

If the imagery is the primary source of data, the target for the (re)insurer is to develop and implement or optimize an insurance product. For this, the data contained in the image should be extracted and transformed into meaningful information that can be used in either the production of an index or the production of maps for loss adjustment optimization.

This part of the whole process is probably the most critical. Even with the best image, if the processing is inadequate, the quality of the final information will be poor and the reflection of the crop status inaccurate.

IN ORDER TO EXTRACT THE INFORMATION, VARIOUS STEPS ARE NECESSARY



The topography of the region can also impact the picture. In order to account for local variations due to slope and landscape, a Digital Elevation Model (DEM) is used. The picture is overlaid on this DEM and distorted accordingly.

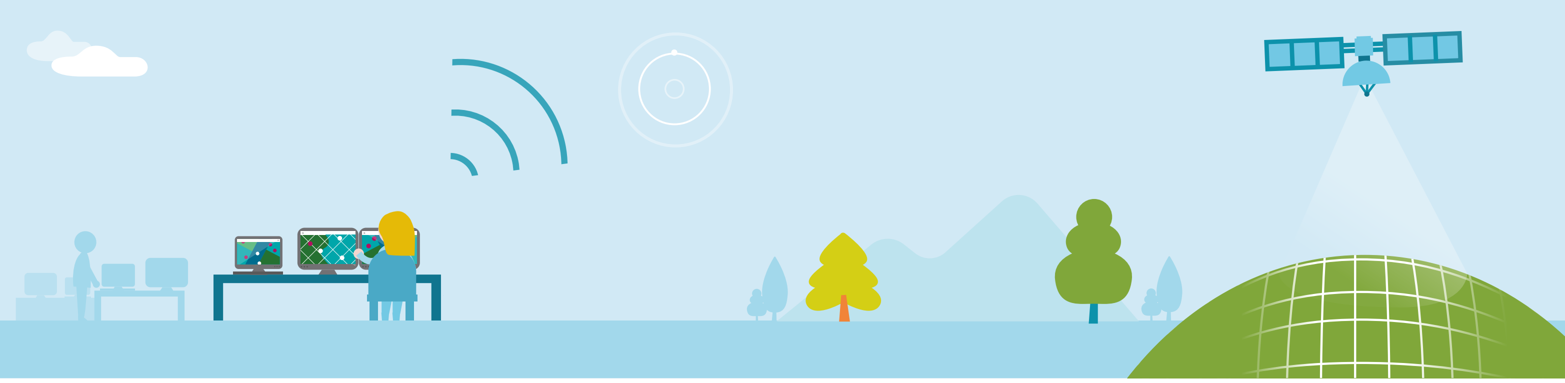
The resolution and precision of this DEM, and the precision of the process used, will determine the quality of the final data. Today, most satellite imagery providers offer "raw" or orthorectified pictures that are ready for use.

GEOMETRIC CORRECTION

The raw image downloaded from the satellite will be a picture of a sphere. In order to be used, it needs to be "flattened". This involves distorting the picture according to the angle of the satellite during shooting.

CLOUD CLEANING

Clouds are often mentioned as the main issue when using satellite imagery. In most regions of the world, using the correct method can take care of this issue with very good results.



When working on a production index with medium resolution images (for high resolution infield mapping other strategy are necessary) the most efficient way to solve this problem is to work with 10 to 15 days of composite images. The principle is to take a picture every 1 to 2 days and use a processing chain able to select from each picture the pixels clear of clouds or haze. Every ten days, the selected "clean" pixels are merged into a composite picture, which is then used as basis for further analysis.

In the case of high resolution pictures for infield monitoring, different images are taken and the best image for each field is chosen. This process is key but quite difficult, as different issues should be checked, such as clouds and cloud shadows, that will impact the quality of the measurement. Today this process is mainly automated, but it often requires human monitoring and quality control.

VEGETATION MONITORING

Once the images have been acquired and cleaned, the thematic processing can begin. There are currently two main strategies for this.

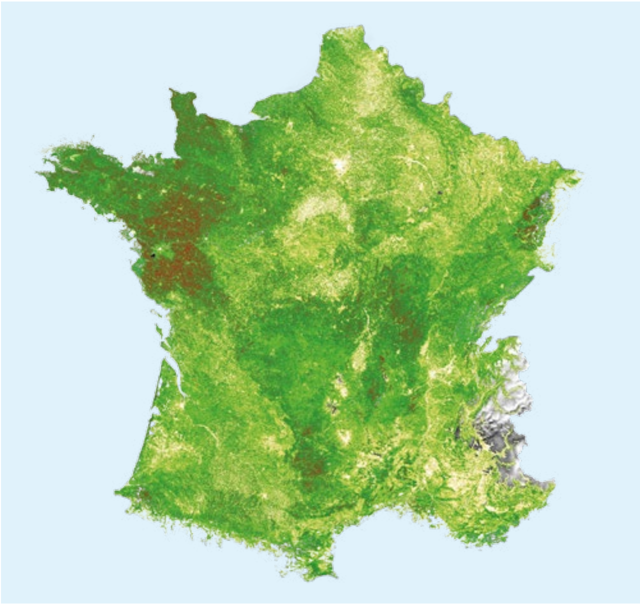
The first approach, which was developed in the early days of earth observation satellites in the late 70's and is still used today, is based on color ratios. As seen earlier, the data captured by the sensor (reflectance) is stored color by color or spectral band by spectral band. Scientists discovered long ago that the ratios between each of these different colors in the light reflected by the vegetation provided information on the status of this vegetation. The Near infra-red band being very sensitive to the chlorophyll found in vegetation, a specific ratio defined as:

$$\frac{(NIR - R)}{(NIR + R)}$$

(where NIR stands for the Near Infra-Red and R for the Red band) was identified as providing information on the vegetation status. This ratio, known today as the Normalized Difference Vegetation Index or NDVI, is still widely used in vegetation analysis.

Nevertheless, it also became rapidly apparent that this index, while being useful in many cases, also had significant limitations. The first of these was that, although vegetation can be characterized through the ratio NIR/R, other factors can also influence this ratio and therefore undermine the quality of the information on vegetation.

Parameters like soil and atmospheric conditions also impact the NDVI. For insurance, this can be problematic because if the data is used as a basis for index insurance for example, it is important to be sure that the cause of the variation measured is the vegetation failure and not another factor.



Source: Satellite Image UK-DMC2 – Airbus Defence & Space

Scientists decided to add some corrections to the original formula to correct the effect of these other parameters. This slowly gave birth to the large family of vegetation indices:

- Enhanced Vegetation Index :

$$EVI = G\,x\,\frac{(NIR - RED)}{(NIR + C1\,x\,RED - C2\,x\,Blue + L)}$$

- Soil Adjusted Vegetation Index:

$$SAVI = \frac{(1 + L)(NIR - Red)}{(NIR + Red + L)}$$

(Where: NIR is Near Infra Red light, RED is Red light, Blue is Blue Light, L,G,C1,C2. are specific constants)

Today, more than 40 of these indices have been developed for specific uses

Despite these adjustments, vegetation indices, which can be very useful in some cases, have specific limitations. Saturation of the index for high vegetation development (LAI > 4), or high dependency on the sensor itself (an NDVI value of one sensor is not comparable to a value on another sensor), can in some cases halt the development of insurance products.

In the mid-90s, certain scientists decided that a completely different approach to imagery processing for vegetation monitoring was possible. This method is based on the fact that the light emitted by the sun has to go through 3 main layers, atmosphere, vegetation (the canopy and the leaf itself) and the soil before being captured again by the satellite.

Through this approach, the scientists developed different models reproducing the impact on the original signal (light) of each "layer". These models (e.g. LOWTRAN, SAIL and PROSPECT) can be integrated into one system to simulate what could be the theoretical observed reflectance, depending on a set of plant parameters (the inputs of the models).

Very powerful processing chains embedding such models can be developed to retrieve plant parameters that "explain" the measured reflectance by satellite (model inversion process).

In this way we can access the real vegetation information, "filtering" the impact of other factors. The vegetation parameters measured in this case are no longer "ratios" but real physical values like Cover (percentage of ground covered by green vegetation) or Leaf Area Index (m^2 of leaves per m^2 of ground). These values are usually known as Biophysical Parameters. This methods, which have been used in agriculture services since the early 2000's, can be of great interest for agriculture. These values are strongly correlated to vegetation development, are very robust and are less subject to external effects.

WORKS AND POINT OF VIEW FROM OUR PARTNERS

AIRBUS

Earth observation satellites are increasingly numerous, and also increasingly specific, with acquisition capacities in terms of both coverage and revisit far greater than their predecessors.

It is now possible to obtain a daily, high resolution image of anywhere on the planet. This has naturally opened the door to a multitude of operating applications and services, particularly as the intrinsic qualities of these satellites (the spectral bands they can measure, or their ability to rotate on their axis and therefore look at both sides of their route) make them powerful sources of information.

Regular monitoring services have thus emerged, whether for monitoring the development of pipeline construction in hard-to-access areas or situations in conflict zones, or for applications linked to agriculture and the environment.

We can cite one of the pioneers in the field of precision agriculture here, FARMSTAR (co-developed by Airbus, Arvalis-Institut du Végétal and CETIOM, 690,000ha in 2017). In its 15 years of existence, FARMSTAR has allowed farmers to spare the soil and the water table from more than 100,000 tons of inputs. The farmers have used satellite imagery and agro-meteorological models to obtain advice on their plots of land, taking into account the different features involved in that land. This advice has enabled them to use the right amount of products, at the right time and in the right place.

FARMSTAR has long had many followers, with today almost 16,000 farmers using it in France, and is starting to be exported in 9 countries.

More recently, agriculture insurance has started to use space technology, for example the forage insurance developed by PACIFICA and Airbus to protect livestock farmers against climate risks, which is now being developed: the fodder production index is now being used by most agricultural insurers in France, with 1,400 contracts subscribed after a first year of commercial activity.

No doubt this is just the beginning…

—

Patrick HOUDRY
Head of Sales Agriculture & Forest Solutions,
Airbus

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CONCLUSION

After this quick analysis of the main factors and parameters to understand and take into account when implementing optical satellite technology for insurance purposes, what are the main lessons learned?

First of all, satellite imagery is a powerful tool if used properly, and there are several key factors to analyze before implementing it. Secondly, the type of image must be selected carefully. If there is no one-size-fits-all solution, one picture for each specific case is optimal (although not perfect).

Lastly, and maybe most important point, the processing, the way the pictures are transformed into information, is absolutely key. The quality of the imagery, and therefore the accuracy in terms of field reality, is heavily dependent on the method used.

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