

Parrot

SEQUOIA

Capture
the invisible

Understanding multispectral imagery using drones in agriculture

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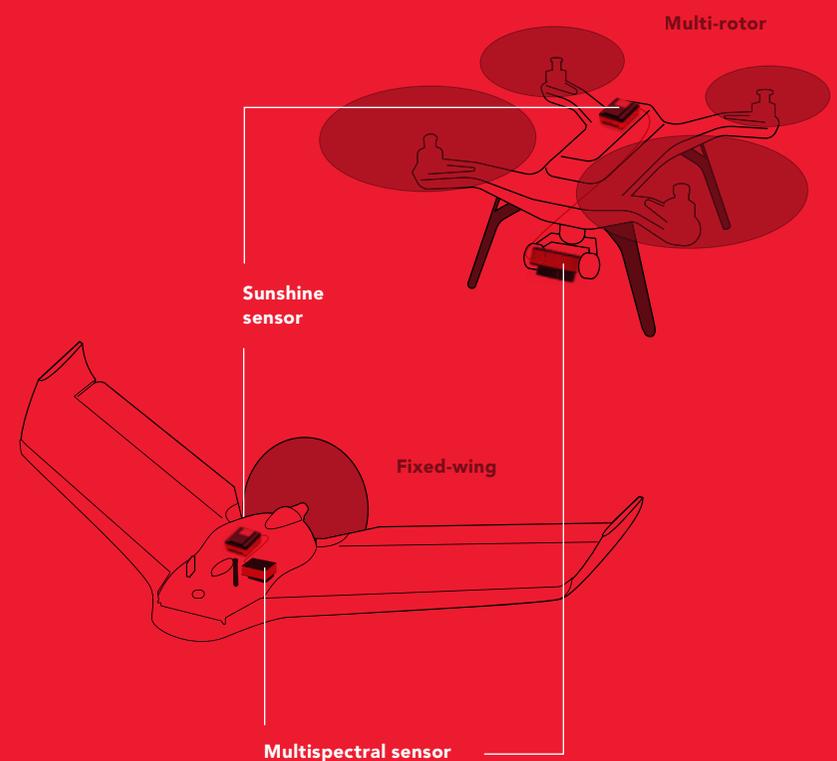
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The different models of multispectral sensors vary in terms of size, number of on-board sensors and integrated technologies. The most recent development in this cutting-edge technology, the Sequoia multispectral sensor, is revolutionizing remote sensing by providing innovative technology, compatibility with all kinds of drones and a complete and adaptable solution, while simultaneously positioning itself half the price of the market for this level of technology.

Sequoia comprises two sensors: The **multispectral sensor**, which is similar to a camera comprising five sensors mounted underneath the drone, facing the crops; and the **sunshine sensor**, which is positioned on the back of the drone, facing the sky.



The multispectral sensor



length
59 mm

width
41 mm

height
28 mm

Designed for everyone.

Easy to install

The integration of multispectral sensors in drones represents a true technological advancement. The great flexibility of drones in terms of use enables the farmer to adapt easily. Thanks to its convenient size and extreme lightness, Sequoia fits all drones, whether multi-rotor or flying-wing models. Its WIFI and USB ports make data readily accessible via any computer or smartphone/tablet.

Fast

To collect a maximum amount of data on a minimum number of flights, a multispectral sensor must be able to capture multiple spectral bands. Sequoia is equipped with four sensors that collect data in discrete spectral bands: Green, Red, Red Edge, and Near Infrared. Plus, Sequoia is equipped with an RGB camera for capturing images in the visible spectrum and for providing a clear picture of the fields. This multitude of sensors and a built-in GPS module enable Sequoia to take geotagged photos in all spectral bands on a single flight.

Minimal financial and safety risk

Developed jointly by several companies specializing in precision agriculture, Sequoia offers a complete solution that includes the acquisition of the agricultural drone, the indexed mapping software, the cloud-hosted digital platform for managing the data from the different fields and, lastly, an agronomic recommendation service. This combination of goods and services, which cover all of the activities necessary for implementing an aerial multispectral imagery solution, makes it possible to offer Sequoia at a price far below that of its competitors.

What happens when images are captured at two different times on the same day? Or when clouds appear and cover the sky during a flight?

If the intensity of the sunlight varies, the amount of reflected light from the crops will be altered and the results of the processed data will be distorted. To cope with light variability, Sequoia incorporates a second sensor, known as a sunshine sensor. The latter is mounted on the back of the drone. During the flight it will continuously sense and record the light conditions in the same spectral bands as the multispectral sensor. The light data thus collected allows the values of the identified spectral signatures to be confirmed.

Precision agriculture technologies must be adapted to the working conditions of farmers. The inclusion of an sunshine sensor in the Sequoia solution allows it to be used in clear as well as overcast conditions, thereby improving flexibility of use.

The sunshine sensor

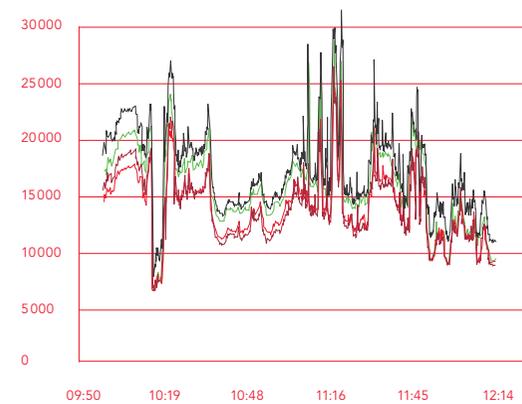


length
47 mm

width
39.6 mm

height
18.5 mm

Irradiance
($\mu\text{W}/\text{cm}^2$)



Changes in Sunlight

Green
Red
Red Edge
NIR

Time

The integrated technologies

GPS module

The Sequoia sunshine sensor has a built-in GPS module. While the GPS modules integrated into drones make it possible to keep an eye on their position during a flight, the Sequoia GPS module allows the position of each captured image to be identified. The GPS module makes it possible to significantly increase the precision of the data collected by the sensor without using data collected by the transport platform: plane, drone, tractor, etc. The integration of a GPS module into the sensor fulfills the objective of rendering Sequoia fully autonomous, thus dispensing with image monitoring by the autopilot of the drone. As a result, it can be used in any drone.

The Inertial Measurement Unit (IMU)

The Inertial Measurement Unit (IMU) is a unique feature of the Sequoia sensor. This technology (patent pending), installed in a multispectral sensor for the first time ever, makes it possible to refine the precision of the image calculations by providing data on the orientation of the sensor. The inertial measurement unit thus makes it possible to compensate for variations in the orientation of the sensor due to the movements of the drone. The sensor therefore no longer needs a stabilized basket and can be directly hooked up to any drone. The sunshine sensor also has an on-board Inertial Measurement Unit.

The magnetometer

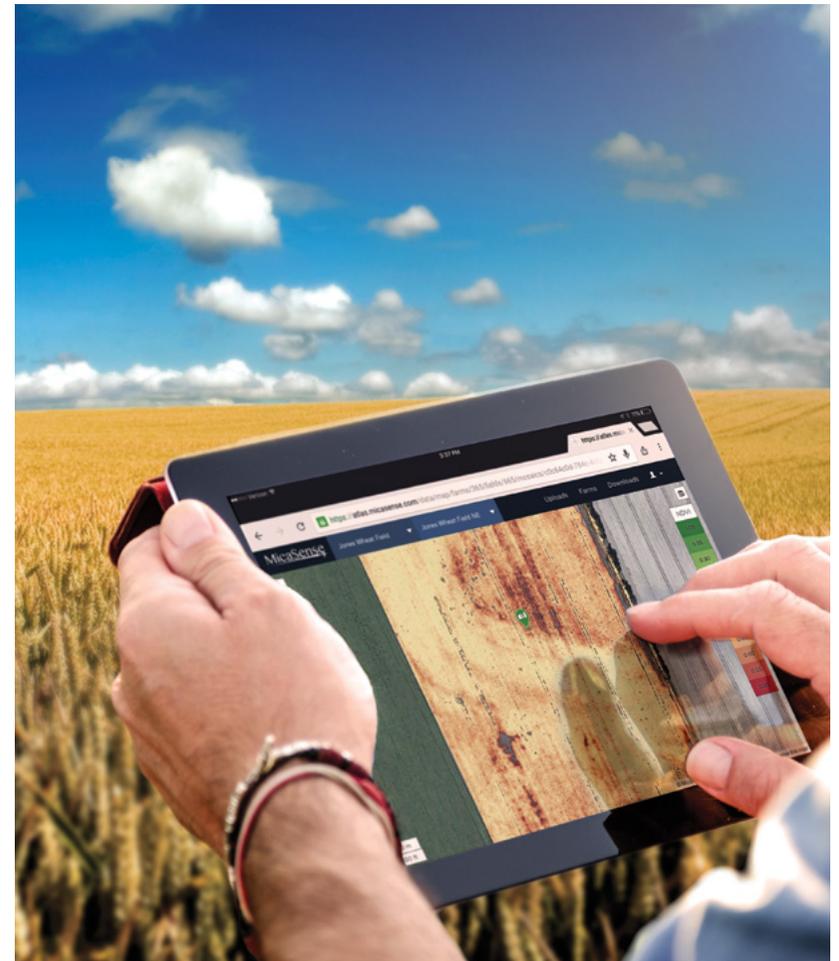
The magnetometer enables the sensor to maintain a heading. Acting like a compass, the magnetometer indicates north to the sensor and thus provides a direction to the captured images. This element fulfills the objective of making Sequoia adaptable to all drones, particularly those that do not have a communication interface with their on-board sensors.

By facilitating the daily planning of activities and by providing key information for decision-making and for creating an overall strategy for agricultural operations, the Sequoia solution increases agricultural efficiency.

Integrating the Sequoia solution into precision-agriculture techniques helps the farmer at each step of his production process and enables him to respond to the needs of his crops in the best possible manner, season after season, year after year.

A complete solution

NDVI Indexmap of a field powered by MicaSense ATLAS™



The drone by



The SenseFly's fixed-wing eBee Ag is the precision agriculture drone used by farmers and consultants the world over; the highly durable and fully automatic eBee Ag is the next logical step in your operation's evolution.

- Fully compatible with Sequoia: carry and communicate with the sensor
- Cover more acres, more easily.
- Drone-to-tractor workflow.
- Ultra-light for maximum safety.
- Backed by global support.

A Proven Performer:

200,000+ senseFly flights to date
58,000+ flight hours...

Learn more

www.sensefly.com

The mapping by



Capture information not visible to the naked eye, with the unique integration of Sequoia and Pix4Dmapper.

Images are converted into accurate index maps, like NDVI, and orthomosaics of your fields, giving you vital information for quick response, better yield and operational efficiency.

Local Processing.

Stay independent, process where and when you want.

Index Calculator.

Unlock the multispectral potential of your drone-collected imagery with this tailor-made combination of Sequoia and Pix4Dmapper: create your own indices to understand your field better.

Digital Scouting.

Index maps are the building blocks of crop scouting's future: time efficiency and an enhanced perspective of your field play a major role in more comprehensive scouting.

Integration.

Export maps into standard industry formats, such as shapefiles, for further use.

Learn more

www.pix4d.com

The cloud management by



MicaSense ATLAS™ : a complete solution for processing, storage, presentation, and analysis of your multispectral data.

Intuitive interface

simplifies data management for all your farms and fields.

Automatic cloud service

lets you to focus on your fields, not on processing raw data.

Identify changes over time

with specialized visualization tools.

Scout your way to problem areas

using any connected device.

Secure servers and support team

based in North America (Seattle, WA - USA).

Learn more

www.micasense.com

The fertilization prescriptions by



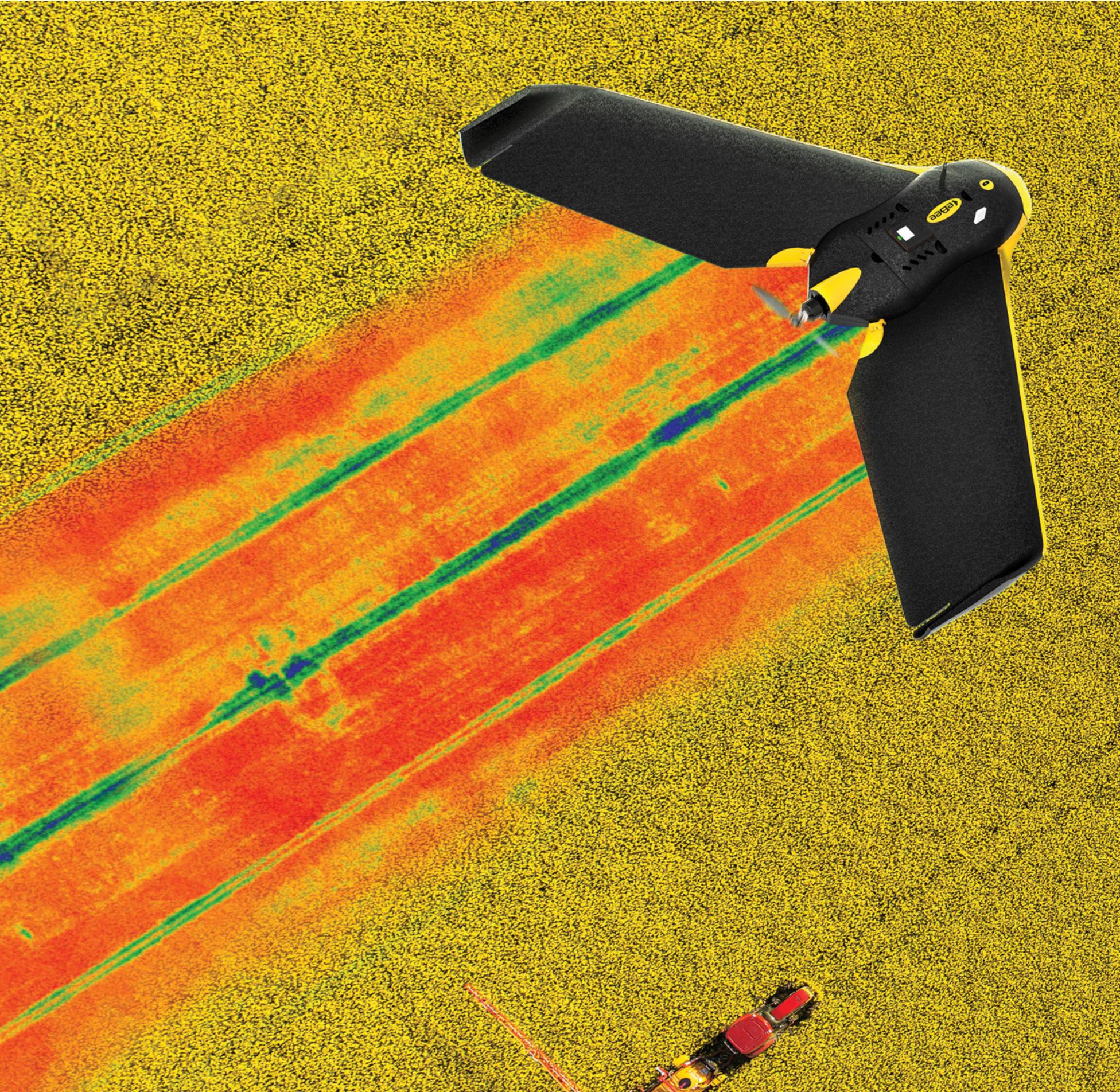
Airinov can help you turn your Sequoia and drone into a real farm management tool, truly useful. No need to be a GIS expert nor a software developer, everything happens on the Internet on our farmer-friendly platform synchronized with a smartphone app'.

Airinov support you from the first steps of flight logistics, through to agronomy interpretation and up to the final integration of the map into your tractor guiding system.

Have a try with your free trial coupon included with any Sequoia you buy.

Learn more

www.airinov.fr



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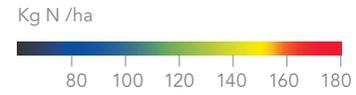
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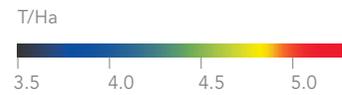
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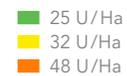
Estimate of the nitrogen absorbed in a field



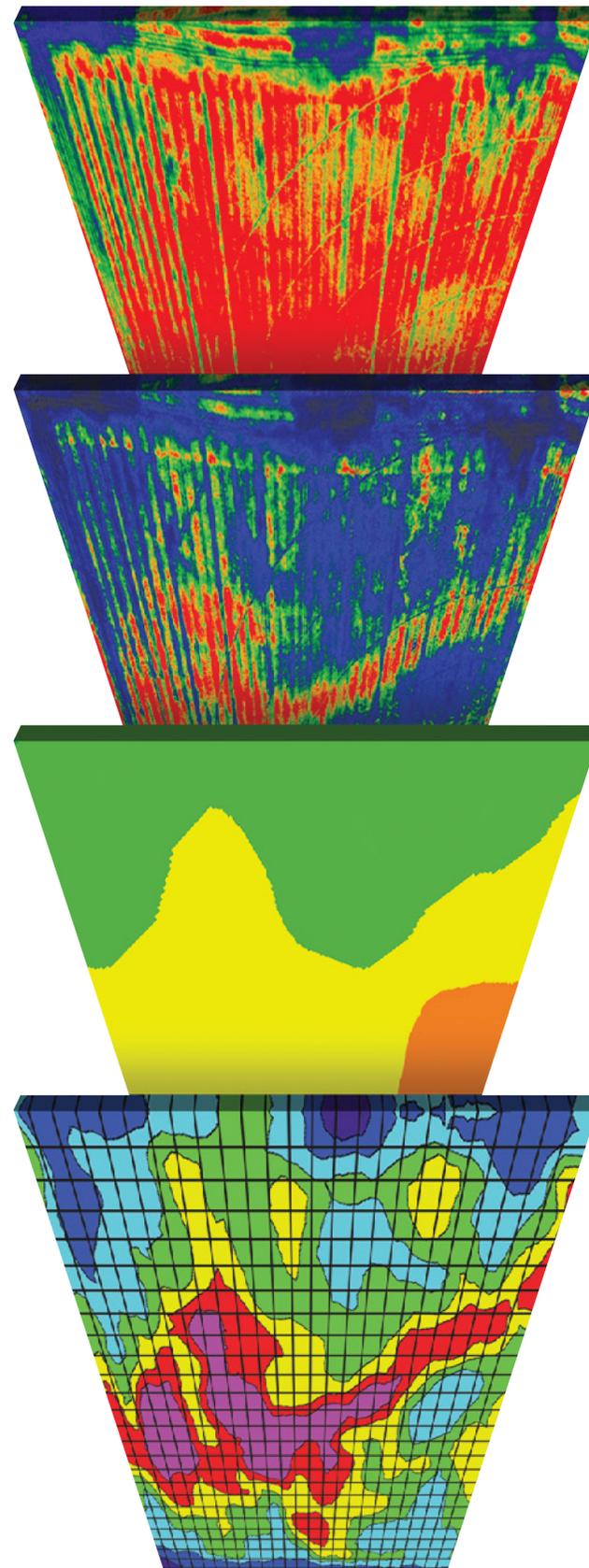
Estimate of dry biomass in a field



Recommended nitrogen fertilizer using manual modulation



Recommended nitrogen fertilizer using automatic modulation

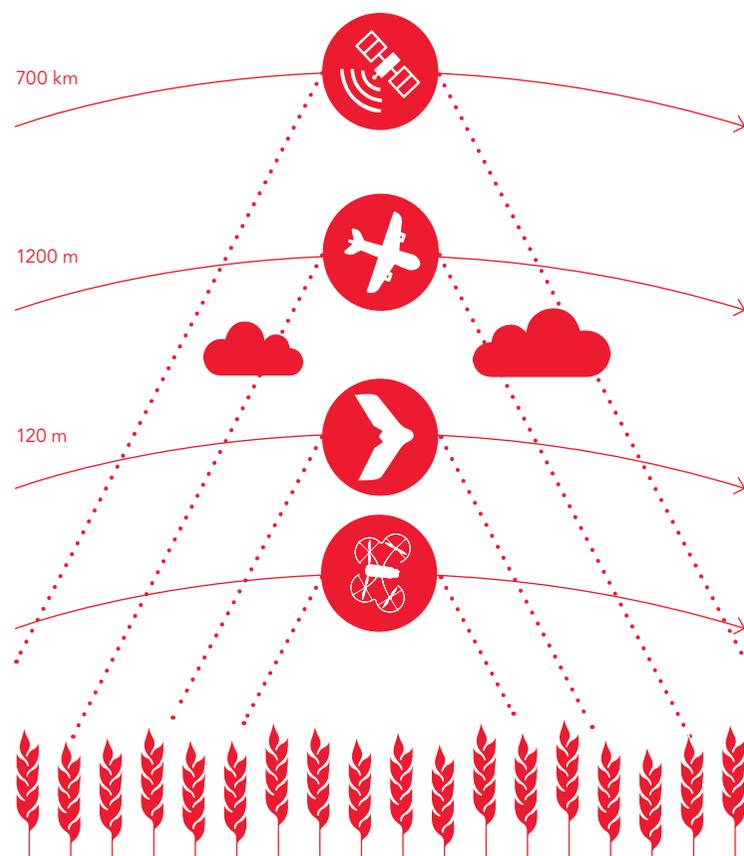


Precision agriculture and its intelligent techniques for detecting organic matter arrived on the scene at the end of the 20th century, with the aim of optimizing investments and returns in crop production. It thus offers a sustainable solution to irregularities in crop growth, volatile agricultural prices and damage to the environment. Agricultural fields exhibit a multitude of variables: soil fertility, plant health index, biomass, chlorophyll level, etc. These variables are directly correlated with the productivity and profitability of crops. Precision agriculture aims to identify these variables, to understand their origins and to act by adapting cropping practices accordingly.

Multispectral imagery, the newest of these agricultural techniques, provides the user with unrivaled information on the condition and development of his crops. The farmer can use it to optimize his input and estimate his return. The recent arrival of agricultural drones triggered a revolution in the use of this technique. Using drones for the aerial transport of sensors improves data precision to a level never attained before, not even with satellites. Furthermore, their versatility facilitates quick and easy crop monitoring, making it possible to obtain an increasingly greater amount of information on the fields over the course of the year. Their use has spread rapidly in the world of agriculture; agriculture now ranks second in the use of drones worldwide.

Aerial imagery

Among the various precision agriculture techniques, aerial imagery provides a global, yet precise, overview of crops and permits continuous monitoring of their development. By integrating different technologies, aerial imagery adapts to the various data needs of farmers and addresses them in a quicker and more intuitive manner. Drones are newcomers to this field and are also known as UAVs (unmanned aerial vehicles). They can cover hundreds of acres in a single flight, thus enabling farmers to compile a history of their crops without the costs and onerous procedures associated with manned flight services.



Today there are various platforms for acquiring these images: **satellites**, **airplanes** and now, also **drones**. The latter are becoming the preferred aerial-support platform for farmers. In reality, with their limited spatial resolution and slow image acquisition, satellites are more suitable for mapping large land areas (a minimum of 6000 acres) than for monitoring crop development. High operating costs and a lack of flexibility are both drawbacks to the use of airplane surveillance. By contrast, drones' high level of flexibility and ability to respond rapidly, their operating features and their image acquisition system make it possible to remedy the shortcomings of the other platforms, especially in cases of cloud cover or isolated fields. And all of this is accomplished with a resolution superior to that of standard satellite imagery.

Different drones for different needs

	 Fixed Wing	 Multi-rotor
Coverage	Large	Small
Flying height	From 230 to 500 feet	From 30 to 500 feet
Picture resolution	cm/inch per pixel	mm per pixel
Agricultural use	- Whole field coverage - Large field coverage	- Particular parcel coverage - Small field coverage
Flight time	Long	Short
Wind resistance	Strong	Low

Platforms



Satellite

- + Wide spectral capabilities including lidar
- + Extensive coverage
- Relatively low resolution (down to 30 cm/pixel)
- Image timing controlled by provider
- Limited coverage in some regions
- Imagery susceptible to cloud cover



Plane

- + Large single-flight coverage
- + High-resolution (down to 7 cm/pixel)
- + Wide spectral capabilities including lidar
- Typically expensive (not suited to smaller projects)
- Image timing controlled by provider (if external)
- Specific flight approval can be required
- Operations susceptible to weather
- Aircraft availability may be limited in remote regions



Drone

- + Cost-effective (suits smaller projects)
- + Imagery can be acquired on demand
- + Very high-resolution (fixed-wing: 2.5 cm/pixel, multi-rotor: sub-millimeter)
- + Typically unaffected by cloud cover (due to lower flight altitudes)
- + Excellent positional accuracy with GCPs or RTK
- + Single-flight coverage adapted to agricultural field size
- Drone regulations or bans can restrict usage
- Operations susceptible to bad weather
- No canopy penetration (unless heavy lidar payload)
- Difficult to reconstruct imagery with few tie points (for example, imagery of homogenous terrain or water)

Onboard sensors

1

See the chapter entitled
Agronomic indices: NDVI,
GNDVI and NDRE

2

See the chapter entitled
Optimizing fertilizer and
pesticide applications



The most popular fixed-wing drone for precision agriculture

The SenseFly eBee Ag is the most widely used drone in agriculture and is fully compatible with Sequoia. With its full drone-to-tractor workflow, you can scout your crops, analyze plant health, create prescriptions and begin treatments all on the same day.

Learn more
www.sensefly.com

In addition to standard RGB cameras, which take pictures in the visible spectrum (i.e., visible to the naked eye), there are now multispectral sensors that can capture images in near infrared, which is invisible to the naked eye.

RGB images have been used for a long time to observe crops in order to compile a history of the fields and to create management zones.

Multispectral sensors provide new information that is useful in decision-making. Indeed, infrared images, which cannot be seen with the naked eye, can be used to make a highly precise diagnosis of the condition of different fields. The images obtained constitute a highly effective tool for evaluating soil productivity and analyzing plant health. Specific wavelengths can be used to collect key data on vegetation cover. By obtaining the reflectance of the vegetation, multispectral imagery can be used for calculating vegetation indices (e.g., NDVI, GNDVI¹, LAI)². Unlike alternative imaging technologies, multispectral imagery can be used effectively throughout the crop cycle. In combination with the flight flexibility offered by the drone, multispectral imagery makes it possible to obtain data on multiple dates to monitor crop development without the light constraints of RGB. Whether used during sowing, irrigation, fertilization or harvesting, multispectral imagery can be used at each key step to help the farmer make the best choice at the right time.



Opposite page
Sequoia sensor
on the SenseFly's
eBee Ag

Multispectral imagery

Fundamental principle

Every surface reflects a portion of the light that it receives. The ratio of reflected light to incident light is known as reflectance and is expressed as a percentage. The perceived color of an object corresponds to the wavelength of the visible spectrum with the greatest reflectance. Because the human eye is sensitive to wavelengths between 400 and 700 nm - also known as the visible spectrum - we can perceive a variety of colors ranging from violet to red. However, wavelengths can also be shorter (ultraviolet) or longer (infrared) than those of the visible spectrum. Even though we cannot see them, they are just as indicative of the agronomic characteristics of a plant; Red Edge is sensitive to chlorophyll level and Near Infrared is sensitive to the leaf cellular structure. Well calibrated data in the Red Edge and Near Infrared can help monitor changes in crop health.

In plants, stress can be caused by many factors.

It can result from the damaging activities of other living organisms: fungi, insects, bacteria or weeds. This is referred to as biotic stress. Multispectral imagery can reveal the various development states of crops and thus predict which fields are likely to be invaded by other organisms.

Stress may also result from environmental conditions: freezing, heat, temperature shock, salinity, solar radiation, wind and lack of nutrients or water. This is referred to as abiotic stress. The Sequoia solution offers farmers specific and concrete recommendations to learn about and combat nutritional deficiencies and water stress in crops.³

Plants reflect solar radiation in a very specific way. This overall reflection of electromagnetic radiation is known as the spectral signature. The spectral signature of a plant is characterized by differences in reflectances among the spectral bands of the visible and infrared spectrums. Stress alters plant metabolism and growth. Although certain stress states lead to the appearance of visible symptoms such as leaves turning brown, others cannot be detected by the naked eye. However, all stress leads to changes in the spectral signature of plants. By analyzing the reflectance curves of his crops, the farmer can detect fields under stress in a timely fashion.

Plant stress and spectral signature

³ See the first chapter about Sequoia



**Vegetation Senescence/
Stress Map**
San Luis Valley, CO
Avisis Sept. 3, 1993 Data
U.S. Geological Survey

■ Green vegetation
■ Stressed vegetation
■ Dry vegetation and bare ground

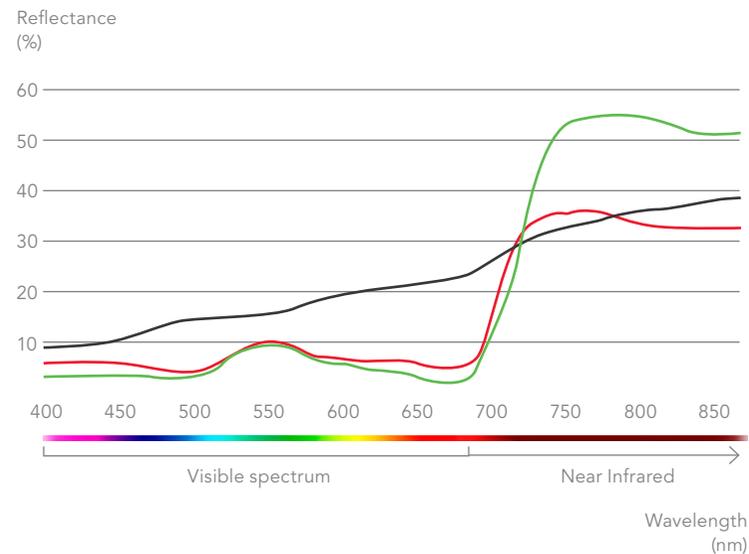
Reflectance curves

In the visible portion of the spectrum, the reflectance curve of a healthy plant exhibits the greatest reflectance in a green waveband (in the range of 550 nm). This is why plants appear green to us. However, the reflectance curve also shows that wavelengths longer than 700 nm, those in the near infrared range and therefore invisible to the human eye, reflect a considerably greater proportion of light. This combination of a low reflectance in the visible spectrum and a high reflectance in the near infrared is specific to vegetation. By comparison, the majority of the light in the visible spectrum reflected by dry plants is in the wavelengths corresponding to yellow and red, which accounts for their brown color. The deterioration of the health of the plant is thus visible.

However, most of the light in the visible spectrum reflected by a plant under stress is in the green range. Hence, to the naked eye, a plant under stress is indistinguishable from a healthy one. On the other hand, the difference can be seen in the reflectance of light in the infrared range, which is far less.

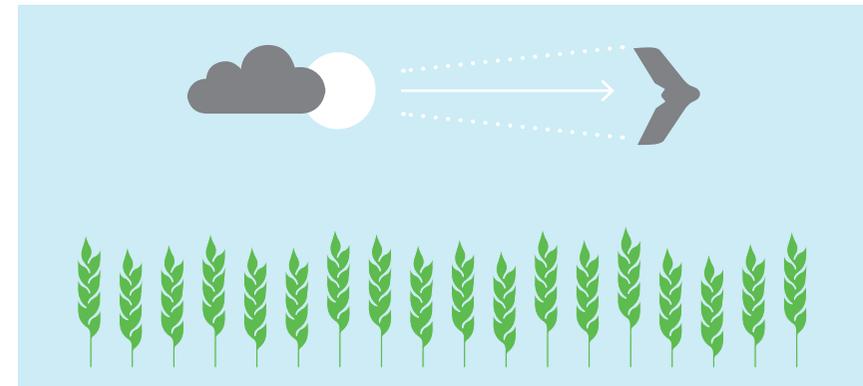
Vegetation Spectral Signature

- Green vegetation
- Stressed vegetation
- Dry vegetation

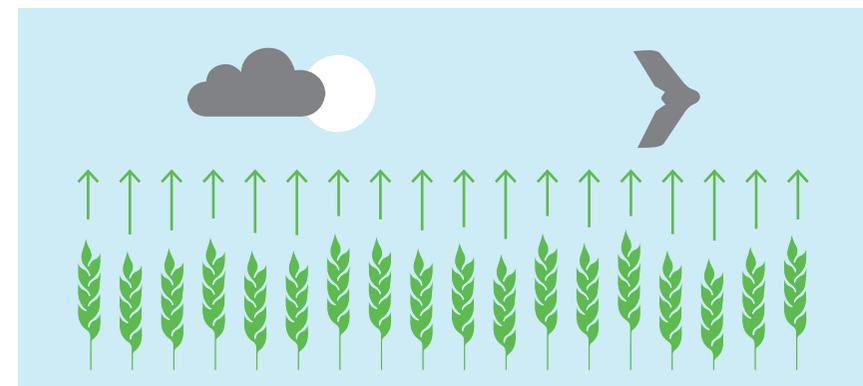


Application in agriculture

The sun radiates plants, which absorb the light during photosynthesis.



In the same manner as the plants, the sunshine sensor, mounted on the back of the drone, senses and records sunlight.



Plants reflect sunlight in different proportions, depending on the wavelengths.



The multispectral sensor located on the underside of the drone captures the light reflected by the plants over four spectral bands corresponding to Green, Red, the Red Edge, and Near Infrared.

- Green
- Red
- Red Edge
- NIR

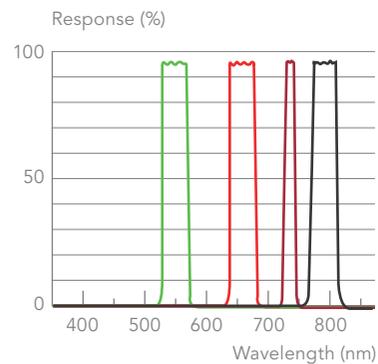
Spectral bands

Parrot
SEQUOIA

The best way to capture spectral bands

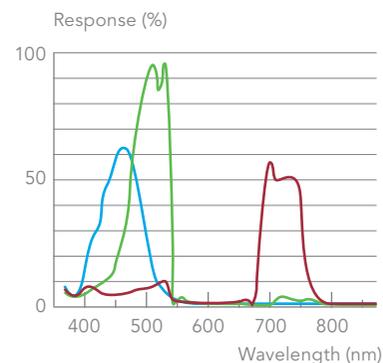
Designed according to INRA (Institut national de la recherche agronomique [French National Institute for Agricultural Research]) recommendations, Sequoia captures the discrete wavelengths, enabling it to obtain more precise agronomic indices (NDVI) for precision monitoring of the crops over time.

A multispectral sensor captures the light reflected over several wavelength bands. These spectral bands are various wavelength ranges, more or less prominent, which most often correspond to a color. Depending on the model, a sensor can detect anywhere from one to about twenty spectral bands. In order to use them more effectively, certain sensors filter the spectral bands in a so-called "discrete" fashion. A discrete band is characterized by steep and narrow slopes, thus limiting the data in the peripheral wavelengths, which are of little significance for this application. A discrete band makes it possible to avoid redundant data in the case of adjacent spectral bands. A multispectral image has many diverse uses, depending on the nature of the bands detected. Certain information can only be obtained using specific colors. Choosing which bands to capture is thus a very important step in the implementation of an aerial sensing system.



Discrete spectral bands

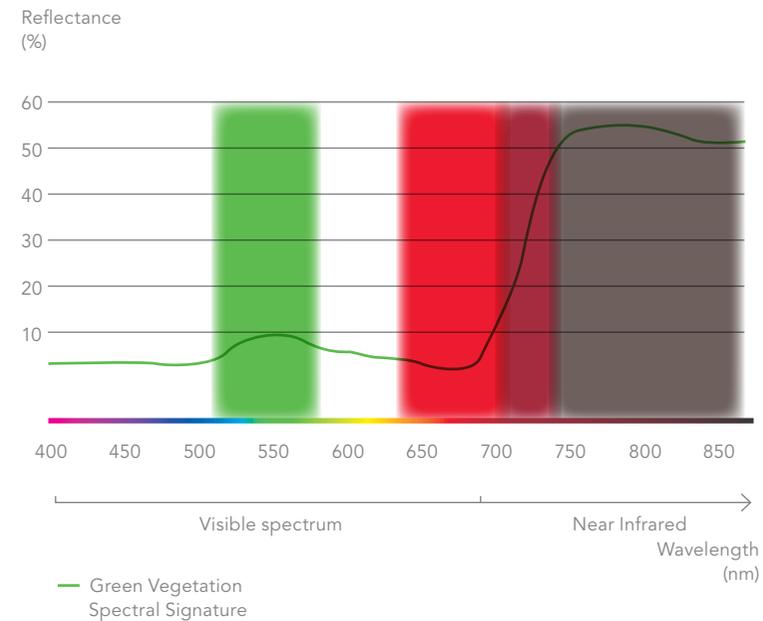
- Green (550BP40)
- Red (660BP40)
- Red Edge (735BP10)
- Near Infrared (790BP40)



Non discrete spectral bands

- Blue (450 nm)
- Green (500 nm)
- Red Edge (715 nm)

Green, Red, and Infrared are the main ones used in agriculture. The Red Edge (short band corresponding to the Near Infrared entry point) is also sometimes used for obtaining additional indices.



Band selection

Green corresponds to the reflected energy in the 500–600 nm spectral band. It is interesting to note that, out of the entire visible spectrum, the greatest reflectance of a plant is in this band. The reflectance peak is at around 550 nm. It has been proven that this spectral band is strongly correlated with the amount of chlorophyll contained in the plant.

Red corresponds to the reflected energy in the 600–700 nm spectral band. The strong chlorophyll absorption in this band results in a low reflectance. Reflectance varies significantly in relation to factors such as biomass, LAI, soil history, crop type, humidity and plant stress. For most crops this band gives an excellent contrast between the plants and the soil and it is extensively used for compiling most of the vegetation indices in agriculture.

The Red Edge is a very narrow band (700–730 nm) that corresponds to the entry point of Near Infrared. It is the point of sudden change in reflectance, from strong absorption of Red to substantial reflection of Near Infrared. This band is very sensitive to plant stress and provides information on the chlorophyll and nitrogen status of plants.

Near Infrared, which corresponds to the wavelengths in the 700 nm to 1.3 μm range, has the strongest reflectance of the bands studied. There is a very strong correlation between this reflectance and the level of chlorophyll in the plant. Moreover, a highly significant variation of the reflectance in this band is produced when a plant is under stress. Along with the Red spectral band, Infrared is extensively used for compiling most of the vegetation indices in agriculture.



Sensefly's eBee Ag flying over an oilseed field

Calculating agronomic indices

4
M. Ustuner, F.B. Sanli,
S. Abdikan, M.T. Esetlili,
Y. Kurucu; Crop type
classification using vegetation
indices of rapideye imagery;
ISPRS Technical Commission
VII Symposium, September 29–
October 2, 2014, Turkey

The Normalized Difference Vegetation Index (NDVI) is, without a doubt, the most commonly used vegetation index.

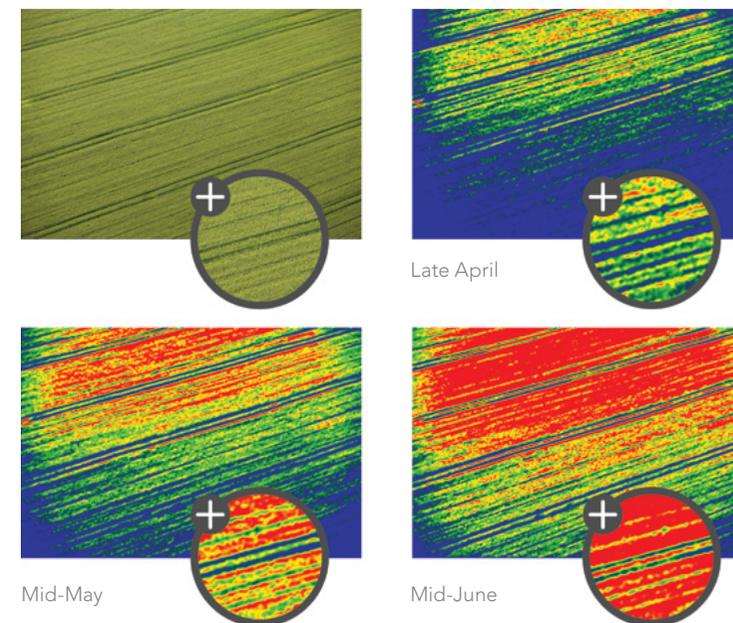
It is calculated from the reflectances of the Red (R) and Near Infrared (NIR) spectral bands. Its formula is: $\frac{PIR-R}{PIR+R}$; its value can range between -1 and +1. The values between -1 and 0 correspond to non-plant surfaces that have a reflectance in the Red that is greater than the reflectance in the Near Infrared: water, snow, or even clouds. Soil has an NDVI value close to 0. With their substantial reflectance in the Near Infrared, plants have an NDVI value from 0.1 to nearly 1.0; the higher the value, the greater the plant density.

NDVI is used for many different agronomic applications. It is most often calculated to identify plants' health status, to forecast their metabolic processes and to estimate biomass and crop yields.

The Green Normalized Difference Vegetation Index (GNDVI) and the Normalized Difference Red Edge (NDRE) index can also be calculated in the same fashion. The GNDVI is calculated from the reflectances in the Green and Near Infrared spectral bands, whereas the NDRE is obtained from those of the Red Edge and Near Infrared spectral bands. Studies have proven that these indices are much more reliable than the NDVI for certain crop types.⁴

In contrast to satellites and planes, the problems caused by the extreme sensitivity of the NDVI to atmospheric conditions and cloud cover are no longer an issue when drones are used. Nevertheless there are still some shortcomings, notably in terms of biomass estimation, which generally requires taking soil samples in order to ensure high accuracy.

Developed with the aid of the french company Airinov and the French National Institute for Agricultural Research (INRA), Sequoia imagery can be translated to very accurate values of biomass. Mapping spatial variability in biomass is useful for estimating fertilizer requirements, making expensive and time consuming soil sampling unnecessary.



Evolution of agronomic indicators over time

PIX4Dmapper

**The best way
to process
your imagery
into accurate
index maps**

The Sequoia solution offers PIX4Dmapper, a local software for calculating agronomic indices, including NDVI. PIX4Dmapper is offered by the Swiss company Pix4D, a data processing leader in the professional drone industry.

Learn more
www.pix4d.com

Opposite page
Sequoia sensor on
the 3DR's drone SOLO
flying over a young
corn field

The right information to make the right choice at the right time.

By capturing images that cannot be seen with the naked eye, the multispectral sensor provides the user with unrivaled information on the status of his or her crops. This information reveals the agronomic variations among different fields, thus enabling the farmer to identify areas in the field that need to:

-  **Refine fertilization**
by detecting nutrient deficiencies symptoms
-  **Optimize pesticide input**
through early detection of biotic stress
-  **Control crop irrigation**
by identifying areas where water stress is suspected
-  **Estimate crop yield**
by processing and exploiting agronomic indices



* Leaf Area Index (LAI)

Besides highlighting variations in growth within a field, when processed appropriately, multispectral images can measure biological variables and provide practical recommendations for cropping practices. The LAI corresponds to the exposed surface area of the vegetation cover per unit of ground surface area. It is a very good indicator of the condition of the crops and it enables a very precise estimate of the nitrogen needs of the plants. LAI also provides a good estimate of the amount of intercepted photosynthetically active radiation and so it is useful for crop growth/yield models.

Refine fertilization

A plant requires nutrients for photosynthesis and normal growth. Various studies have proven that a high chlorophyll index indicates a substantial nutrient content and that is indicative of good productivity⁵.

A lack of certain nutrients, especially those linked to chlorophyll production, such as nitrogen or magnesium, will manifest itself as a gradual change in the color of the plant, or a portion thereof, from green to brown. Once the change in color starts to become significant, it is often already too late.

Multispectral sensors allow the calculation of spectral indices that indicate chlorophyll content. A multispectral sensor thus provides its user with precise information on the health of crops. These findings then enable to analyze the underlying causes of the variations in growth and, if possible, to remedy them as quickly as possible. By detecting the progression of the chlorophyll level and other biological aspects of plants*, multispectral remote sensing makes it possible to identify fields affected by a nutrient deficiency at an early stage and to take preventive action.

Optimize the application of pesticides

The images obtained by remote sensing reveal which fields have favorable conditions for vigorous growth. These fields are the most likely to be the target of attacks by insects, fungi or diseases. Combined with agricultural know-how, multispectral images can alert the farmer to the vulnerability of certain fields. These early-stage alerts will not only enable the farmer to reduce the harmful impact of other organisms on his crops, but also to optimize his pesticide applications according to the risk level of the various fields, thereby reducing treatment costs and the emission of chemical products into the environment.

By revealing the fields in which plant growth is slow, multispectral remote sensing alerts the farmer to a possible state of biotic stress in his crops. On the basis of his experience and agricultural know-how, he can then determine whether the underlying cause of the stress is linked to the harmful activity of other organisms.

5

Matthieu De Pinel De La Taule, Samuel Morissette, Patrick Ménard, Karine Jean. Multispectral imagery as a soil productivity analytic and diagnostic tool in precision agriculture. 2012. <hal-00671100>

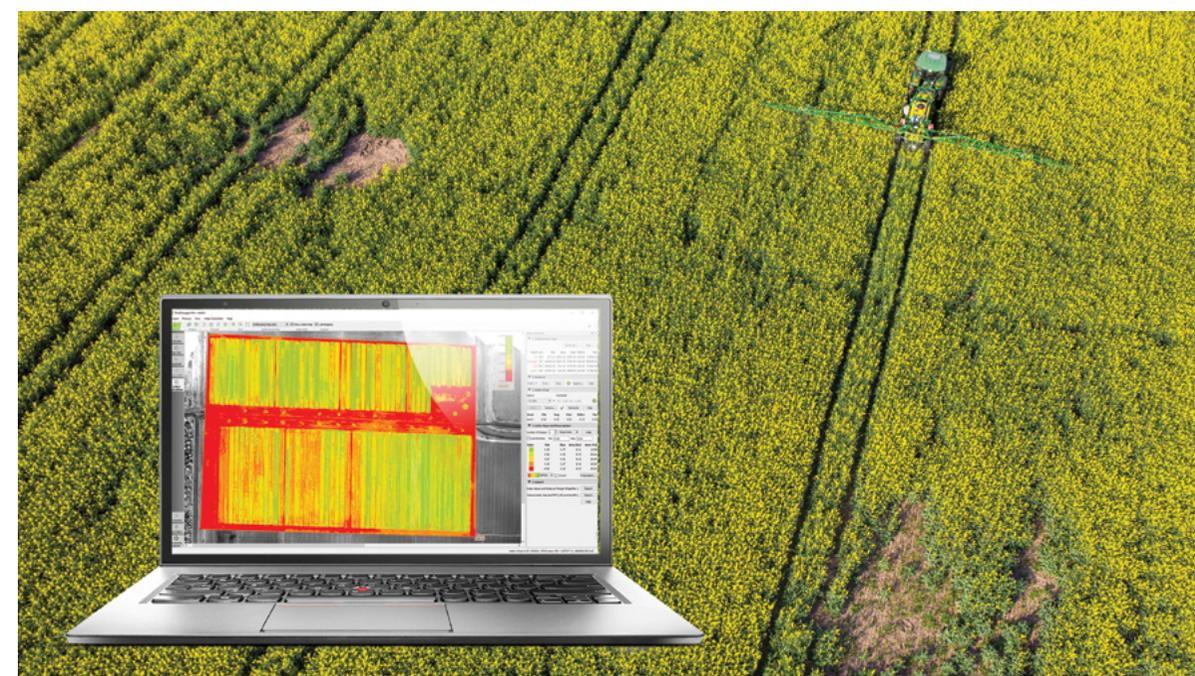


Get recommendations from Sequoia imagery

The Sequoia Solution includes the services of the French company Airinov, a pioneer and leader in the field of agricultural drones. By using the multispectral images captured by Sequoia, Airinov has successfully developed a very precise method for calculating LAI in collaboration with the French National Institute for Agricultural Research (INRA). By analyzing LAI with the data captured by Sequoia, Airinov makes recommendations for nitrogen fertilization of wheat and rapeseed. These recommendations are then adapted to be compatible with the parcel management or automatic modulation system.

Learn more
www.airinov.fr

NDVI mapping of a rapeseed field, powered by Pix4Dmapper





ATLAS

Manage and analyze your data over time

The Sequoia solution offers the ATLAS™ platform, produced by the US company MicaSense. ATLAS is a cloud-based data solution for processing, management, presentation, and analysis of multispectral data captured with the Sequoia sensor. This information is then organized to enable quantitative analysis over time, leading to better insights into changes in your crops. ATLAS automatically generates crop health and vegetation index maps, allowing for GPS guided field scouting using any connected device.

Learn more
www.micasense.com

Control crop irrigation

Adequate moisture levels are vital for crops. During transpiration plants extract nutrients from water as it moves from the roots to the leaves. Water absorbs heat released by the metabolic processes of the plant and eventually reaches tiny pores in a leaf where it evaporates, thereby removing heat from the plant. A shortage of water, therefore, leads to an increase in the internal temperature of the plant (water stress). Water stress may cause serious damage and can even kill the plant.

The water content of the plants within a field may vary considerably. The underlying cause of this difference often lies in the characteristics of the soil, in particular its capacity, or lack thereof, to absorb water and distribute it to the plants. Multispectral imagery can identify disparities of water in crops. By processing the captured images, disparities in moisture level among fields can be identified before visible symptoms appear. In light of this information, the farmer can then act accordingly. Thanks to the flexibility and user friendly nature of drones, water stress can be mitigated by a better understanding of the irrigation timing and requirements.

Estimate agricultural yields

Collecting multispectral images, especially in near infrared, provides a first indication of a plant's vigor. These images can then be used by data processing software to generate vegetation indices useful for decision-making. These indices are indicative of the status of biological variables such as biomass, leaf area index, soil history, chlorophyll level, etc. Several studies have proven that there is a correlation between the estimates of these variables obtained by calculating vegetation indices and the results obtained by soil sampling ⁶. Research has also been conducted to analyze the reliability of using vegetation indices on different dates to estimate crop yields ⁷. These investigations have demonstrated a strong correspondence between the estimates made by multispectral remote sensing and the actual yield of the field. However, the precision of the estimate may vary among different crops.

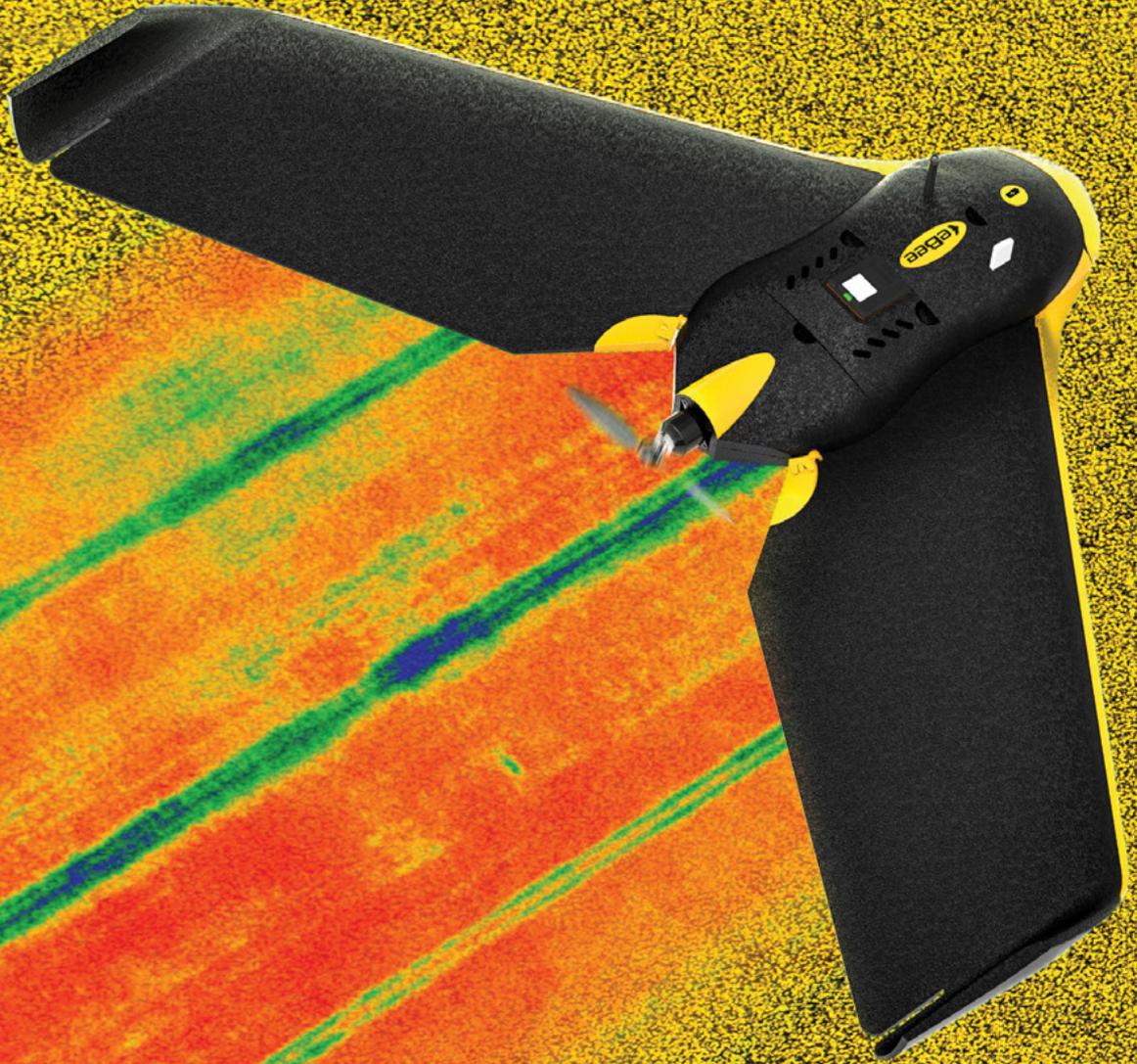
It is important to note that the final yield of a crop depends on numerous factors that cannot be ascertained by multispectral remote sensing: climate and weather conditions, significance of stress factors, inputs used, etc. These specific relationships may vary between crops, in a specific region and at a specific development stage. By correlating the data obtained from previous seasons with the current data and by comparing the results from the same developmental stage from one season to another, the farmer will obtain a database enabling him to refine his yield estimate even further.

⁶ Verger, A. et al., Green area index from an unmanned aerial system over wheat and rapeseed crops, Remote Sensing of Environment (2014), <http://dx.doi.org/10.1016/j.rse.2014.06.006>
Matthieu De Pinel De La Taule, Samuel Morissette, Patrick Ménard, Karine Jean. Multispectral imagery as a soil productivity analytic and diagnostic tool in precision agriculture. 2012. <hal-00671100>

⁷ Idso et al., 1977; Maas, 1988; Serrano et al., 2000; Shanahan et al., 2001

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