JULY 2019

Soil Wealth
NURTURING CROPS

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REMOTE SENSING

GLOBAL SCAN AND REVIEW

**How do you know if information is reliable?
Tired of searching the internet to find the answer to that problem?
Our global scan and review series provides leading, research-based information from around the world to Australian vegetable growers and advisors.**

KEY MESSAGES

- ✔ **Some remote sensing data can be accessed for free, as well as for a subscription cost, depending on the desired resolution, from a range of online resources**
- ✔ **Combining layers of remotely sensed data with other spatial data such as yield maps can provide valuable insights into variability for both short and long rerm results**
- ✔ **Cloud cover, resolution and crop attributes all need to be taken into account when collecting, analysing and interpreting data.**

WHAT IS REMOTE SENSING?

Over the past decade, the agricultural industry has seen a significant increase in publicly available remote sensing imagery and data. This technology is more accessible than ever, where users can access a wide range of information that can be implemented into their farming businesses, with the help of service providers and various commercially available platforms.

In this global scan, we address the types of remote sensing available, and its applications to vegetable production systems. Remote sensing is a type of geospatial technology that sits alongside Geographic Information Systems (GIS) and Global Positioning System (GPS) technologies. In context, remote sensing is the gathering of information about the earth, without making physical contact with its surface. Instruments used to collect this information (data) include satellites, airplanes, Unmanned Aerial Vehicles (UAVs) and tractor implements fitted with sensors. These sensors detect the strength of reflection and radiation of electromagnetic (EM) waves off the earth's surface including infrared light, ultraviolet light and microwaves

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(refer to Figure 1). In the case of satellites fitted with spectrometer sensors (e.g. Landsat series) information is collected, recorded and transmitted back to a receiving station to be processed into an image (Figure 2).

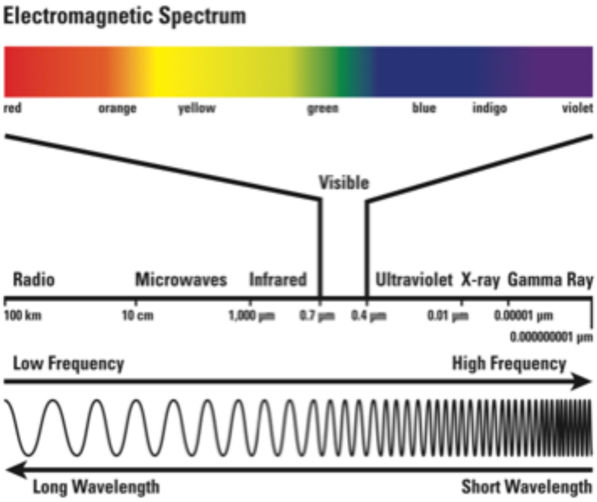

Figure 1: Electromagnetic spectrum (Source: USGS)

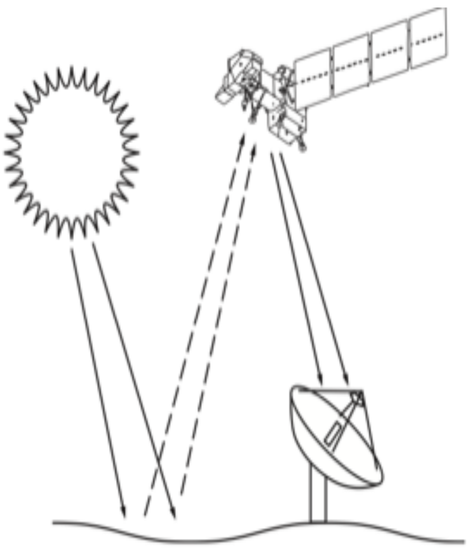

Figure 2: How remote sensing works via a satellite (Source: USGS)

TYPES OF REMOTE SENSING DATA AVAILABLE

There is a wide range of remote sensing data currently available. For the purpose of this global scan, we have focussed on the data that is relevant to precision agriculture, which are described below and summarised in Table 1.

Satellite Imagery

Satellite imagery, also known as earth observation imagery is collected by a number of satellites including Worldview 2 and 3, Landsat, MODIS and Sentinel. This information can be used for the whole farm, or for a single field variability assessment on a spatial and temporal (seasonal) basis.

Aerial Imagery

Aerial imagery can be collected primarily by helicopters, UAVs and airplanes. This imagery type includes film and digital images. As with satellite imagery, it can be used in mapping, and to assess spatial variability.

Elevation

Digital elevation data can be collected from Light Detection and Ranging (LiDAR) sensors on airplanes, satellites and UAVs. Elevation data is available from a number of sources at a common resolution of ~2.5m. Further analysis can also be undertaken in GIS applications, including slope, aspect, hill shade and catchment. For precision agriculture applications, elevation data can be collected from tractors fitted with auto-steer systems and provides greater accuracy (<10cm). Read more about utilising this data here.

Normalized Difference Vegetation Index

Normalized Difference Vegetation Index (NDVI) is the most commonly produced index from data collected by sensors on satellites and UAVs. NDVI is a ratio of the difference between red and infrared reflectance from the canopy, indicating healthy or underperforming biomass.

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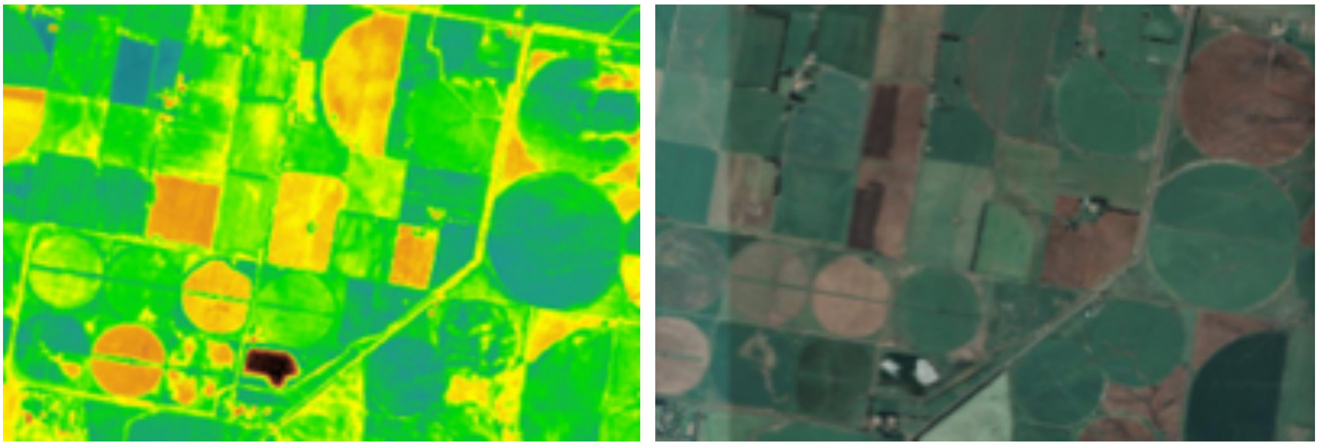
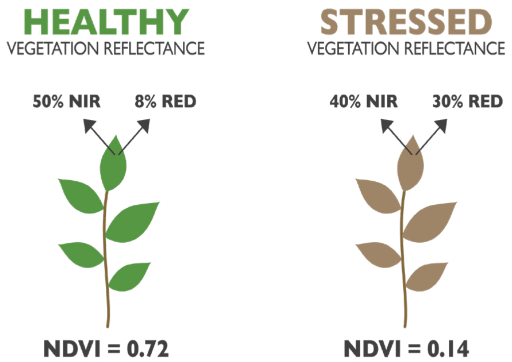


Figure 3: L: NDVI (L) and Satellite Image (R) of Tasmanian Northern Midlands Farmland (Source: LISTmap)



$$\text{NDVI} = \frac{\text{NIR} - \text{RED}}{\text{NIR} + \text{RED}}$$

Figure 4: Differences between healthy and stressed vegetation NDVI values (Source: Agricolus)

In general, NDVI indexes are higher for healthy green vegetation, and lower for stressed vegetation that may be less green or a lower biomass volume vegetation (Figure 4). In agriculture, NDVI is commonly used to assess canopy density, biomass and plant vigour (an example is shown in Figure 3). Note that recent irrigation can confound the imagery and distort any reflection on the canopy. To account for soil reflectance in a more sparse crop, growers can use the OSAVI index (optimised soil adjusted vegetation indices).

Thermal

Thermal imaging is not really all that common, but it is an interesting platform. Thermal data is collected by sensors on Landsat satellites, light aircraft and can also be collected using thermal cameras on UAVs. Thermal data can provide an indication of crop stress, with stressed crops having a higher core temperature than their non-stressed counterparts. Care must be taken to account for soil and ambient conditions at the time the image is captured (Figure 5).

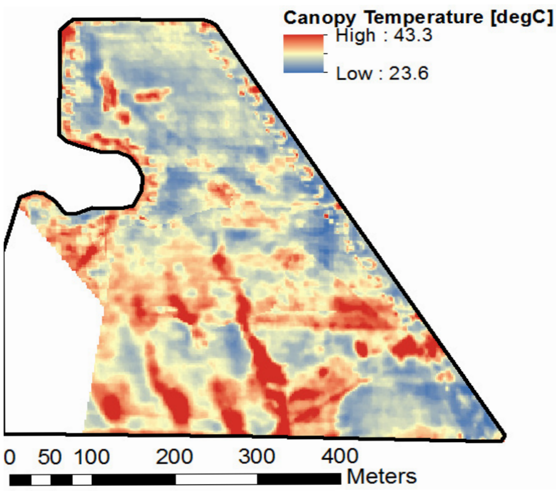


Figure 5: An example of thermal imagery (Source: WordPress)

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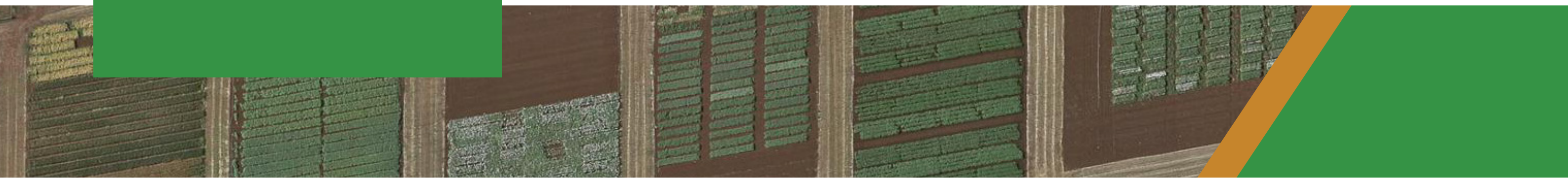

Table 1: Types of remote sensing and their advantages and disadvantages

REMOTE SENSING DATA	ADVANTAGES	DISADVANTAGES
Satellite Imagery	• Greater repeatability of data • Easily integrated with software • Greater spatial accuracy • Greater capture area	• Higher capture costs • Issues with cloud cover • Generally lower resolution • Image delivery time can be limiting
Aerial Imagery	• More affordable capture costs than satellite imagery • Generally higher resolution and clarity than satellite imagery • Cloud cover not as much of a constraint	• Spatial accuracy is variable but is improving with new technologies • Not suitable for multi-temporal analysis using commercially available software • Depending on the needs (i.e. management of the crop), such high resolution can be detrimental, resulting in too much ‘noise’
NDVI	• Provides a snapshot of variability to guide ground-truthing • Can provide an assessment of canopy density, biomass and plant vigour	• Cloud cover an issue in NDVI data collected from satellites • Care must be taken when comparing NDVI values across crops. Row spacing, crop type, development stage and variety will influence NDVI values • Proper calibration has to be performed if time-series analysis is required
Elevation	• A useful layer when analysing drainage and general crop variability • Good resolution available from LiDAR datasets	• Digital elevation data from airplanes and satellites have lower resolution than data from autosteer systems
Thermal	• Provides an indication of crop stress	• Currently has limited commercial use • Ambient weather conditions must be accounted for

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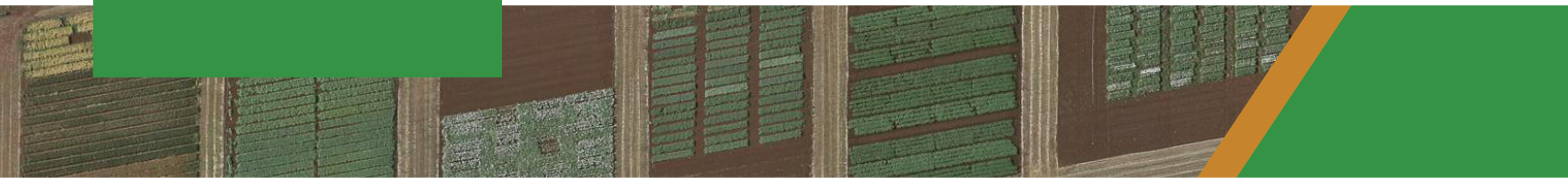

WHERE TO ACCESS DATA

Remotely sensed data can be accessed, viewed and downloaded directly from its source (e.g. NASA and USGS in the case of satellites), or through a number of platforms run by government and commercial operators. Table 2 outlines the most commonly used free and publicly available remote sensing data sources.

Table 2: Where to access remote sensing data

SOURCE	SUMMARY	DATA
USGS LandsatLook https://landsatlook.usgs.gov/viewer.html	LandsatLook Viewer allows users to view and download over 3 million Landsat images from around the world. There is over 40 years of satellite imagery available for free download as images.	• Satellite Imagery
USGS GloVis https://glovis.usgs.gov/app?fullscreen=1	USGS GloVis allows users to view and download remote sensing datasets from a range of satellite sensors. It has an easy to use timeline sidebar and allows users to download datasets.	• Satellite Imagery
USGS EarthExplorer https://earthexplorer.usgs.gov	USGS EarthExplorer allows users to search for, view and download remote sensing datasets from a range of sensors based on their location. Datasets include satellite imagery, NDVI, aerial imagery and elevation.	• Satellite Imagery • Aerial Imagery • NDVI • Elevation (STRM) • Thermal
NASA EarthData and WorldView https://earthdata.nasa.gov	NASA EarthData and WorldView allows users to freely view and download a range of remote sensing data.	• Satellite Imagery • Elevation • Thermal
Sentinel Hub Playground https://apps.sentinel-hub.com/	Sentinel Hub Playground allows users to freely view and download images of remote sensing data from Sentinel-2, Landsat 8 and MODIS satellites. The paid version allows users to download datasets for GIS applications.	• Satellite Imagery • Elevation • NDVI • Thermal
Geoscience Australia ELVIS http://elevation.fsdf.org.au	ELVIS allows users to view and download Australian Digital Elevation Model data.	• Elevation
Australian Government NationalMap https://nationalmap.gov.au	NationalMap is a platform that allows users to search for, view and download data from a comprehensive database.	• Elevation • NDVI • Aerial imagery • Satellite imagery

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In addition to these public sources, there are a number of commercial providers offering platforms to view remote sensing data specific to agriculture. Satellite imagery and NDVI data are the main offerings from these providers. Table 3 provides a summary.

Table 3: Data available on commercial platforms

NAME	SUMMARY	DATA
Data Farming https://www.datafarming.com.au	DataFarming provides free to view NDVI and NDVI-R (regional) data. At a cost, GeoTIFF, and VRT Zone prescription files can be created and exported.	• NDVI
Decipher https://www.decipher.com.au	Decipher provides free to view NDVI data. At a cost, GeoTIFF and VRT prescription maps can be created and exported.	• NDVI
IrriSat https://irrisat-cloud.appspot.com	IrriSat is a free platform that uses NDVI and weather observations to provide guidance on the amount of water that a paddock requires. Although imagery cannot be downloaded, CSV files containing irrigation schedules can be generated.	• NDVI
FluroSat https://flurosat.com	FluroSat provides at a cost, NDVI as well as Canopy Chlorophyll Content Index (CCCI), Modified Soil Adjusted Vegetation Index (MSAVI) and Normalized Difference Red Edge (NDRE). It can be used to develop agronomic and variable rate maps.	• CCCI • NDVI • MSAVI • NDRE

HOW TO USE THE DATA

Depending on the file type, you can overlay these datasets with other spatial data to further assess variability (e.g. see Figure 6). For those interested in Variable Rate Technology (VRT), this data can be used to assess variability, create management zones and subsequent Variable Rate prescription files.

Common datasets used with remotely sensed data in analysis are:

- Yield maps
- EM38 maps
- Gridded soil sample maps
- Engine load maps
- Soil type maps

This can be done using platforms such as DataFarming and Decipher, or one of the many other software packages available. There are also a number of service providers including agronomists that are able to assist with precision agriculture data.

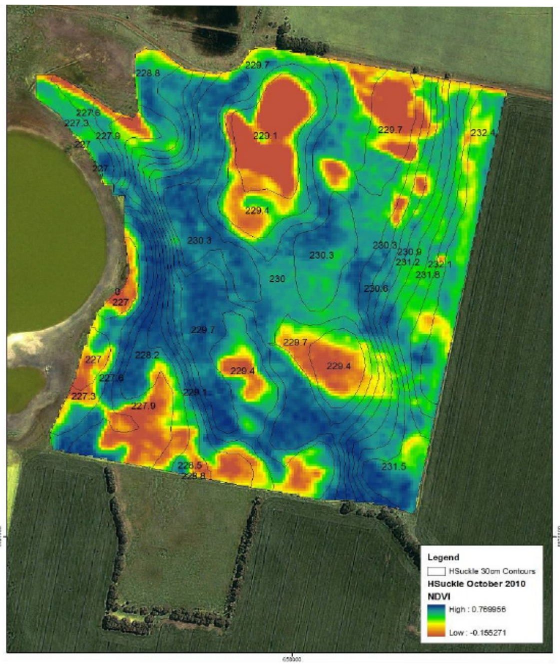

Figure 6: Assessing the correlation between elevation and water-logging effects using a contour map and NDVI imagery. (Source: Precision Agriculture)

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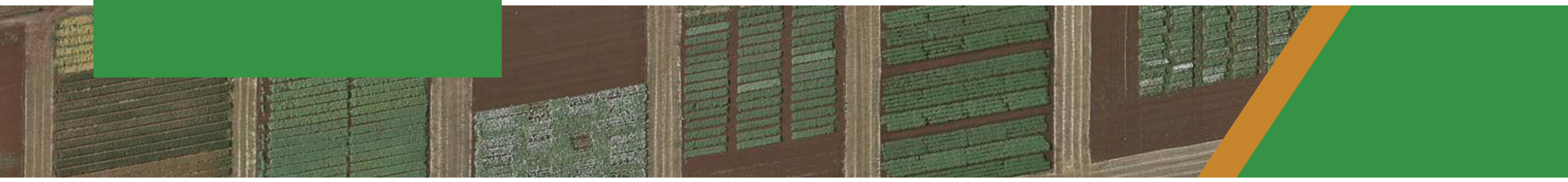
Integrated Crop Protection PROTECTING CROPS



CONSIDERATIONS

When using remotely sensed data, it is important that the following factors are taken into consideration:

Ground-Truthing

It is highly recommenced to ground truth spatial data to validate what the data is telling you e.g. it could relate to salinity, soil texture or soil moisture. Google Earth is a free platform but the location services are not sufficient in accuracy to use in the field. A grower can import a KMZ to an app like Decipher to assist with determining the potential cause of the variability, and subsequent management options (e.g. variable rate applications, drainage, etc.).

Resolution

When analysing data, remember to take into account the pixel size and what it is representing. For example, does the pixel size cover one row of the crop, consisting of predominantly green matter, or does it cover the soil and stubble as well? It's also important to note that for this reason row spacing has a significant impact on NDVI values too. Pixel sizes of >10m are unlikely to be useful in more precise analysis but may be useful in providing a general picture of variability across a paddock (e.g. see Figure 7).

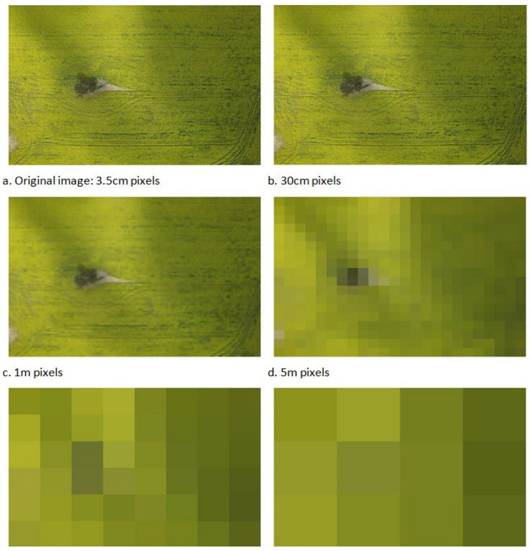


Figure 7: Flowering canola at a range of pixel sizes (Source: GRDC)

Cloud Cover and Shadows

Both the shadows cast from clouds and other objects (e.g. trees along the edge or in paddocks) can be an issue when analysing imagery. NDVI can be significantly impacted by these factors which can limit the comparability of NDVI values across different images.

Crop Type, Development and Variety Differences

It is important to take into account the growth habit of a crop, along with its development stage and nutrition status when drawing comparisons. Crops that have an erect growth habit will have a lower NDVI than their more prostrate counterparts, as more soil is captured by the sensor. Crops should not be compared when at different growth stages as growth habit, ground cover and plant colour can impact on NDVI values. Nutrition of the crop should also be accounted for, as this will impact leaf colour and growth too.

FURTHER READING

GRDC Utilising Spatial Data for Within-Paddock Soil and Crop Management. View here.

GRDC Data Sources to Help Manage Variability That Wont' Break The Bank – What's Out There?. View here.

GRDC Imagery and Other Spatial Data What Does It Mean?. View here.

GrindGIS Remote Sensing Applications in Agriculture. View here.

University of Missouri Precision Agriculture: Remote Sensing and Ground Truthing. View here.

USGS Tracking Change Over Time – Understanding Remote Sensing. View here.

VegNET Precision Agriculture in Vegetable Production Webinars. View here.

Society for Precision Agriculture Australia. View here.

Reviewed by the Queensland Department of Agriculture and Fisheries and University of New England from the project VG16009 (Adoption of precision systems technology in vegetable production).