Spectral Index Data – OptRX sensor –

emphasis on applications in vineyard and row crop contexts

Guidance on using agricultural datasets in archaeological and heritage management applications

Technical and conceptual notes to support data exchange via API platforms and Ecosystem Services Platforms (online GIS platforms)

AgLeader OptRx sensors are active multi-spectral sensors which provide values for two vegetation indices calculated based on Near Infrared(NIR), Red Edge and Mid Infrared (MIR) band values, the NDRE and NDVI indices, and the coordinates at which the spectral readings were taken, including the elevation. These sensors can be mounted on various platforms and are typically mounted in a multi-sensor array on a cart or tractor with a dGPS system. These measurements are typically acquired real time and stored for later analysis and can be mapped spatially. There are several similar sensors which report spectral indices related to vegetation vigour, which allow an assessment of the spatial variability in the vigour of the crop growing within a field. The OptRx sensor is notable for being configurable to provide multiple measurements along the z-axis above the ground through a sensor arraay, making it more suitable for assessing vine crops trained on vertical supports, and for the reporting of NDRE values. The NDRE and NDVI indices are related to chlorophyll production and overall greenness, which is in turn related to crop health, both of which are related to the appearance of archaeological cropmarks. OptRx data are frequently collected repeatedly across a single growing season and across multiple years to assess the impacts of management decisions and to support in-season management decisions. The OptRx sensor uses an active spectral imaging and is therefore less affected by variations in light than a passive spectral imaging sensor.

The indices used are:

NDVI = (NIR-Red) / (NIR+Red)

NDRE = (NIR-RedEdge) / (NIR+RedEdge)

Data Type

Vector point measurements

Text file – Derived NDRE and NDVI measurements are reported as an irregularly spaced collection of points with associated attributes, with X,Y coordinates in latitude and longitude decimal degrees and Z coordinates in meters.

Common Data Derivatives

Vector file – georeferenced point data.

Vigour zones – polygonal areas delimited as significantly different in NDRE and NDVI from neighboring areas in the field.

Identifiers

Data from OptRx sensors representing within-field variability in crop vigour and greenness is not widely available in public repositories. Individual farmers and land managers must be approached.

Vocabulary (thematic tags)

(Thematic tags, term lists, thesauri)

The following tags are recommended to provide compatibility across archaeological and agricultural vocabularies.

AGROVOC: plant response http://aims.fao.org/aos/agrovoc/c_25446; crop monitoring http://aims.fao.org/aos/agrovoc/c_37838

GEMET: multiple use management area https://www.eionet.europa.eu/gemet/en/concept/5424

Getty AAT: Crop marks http://vocab.getty.edu/page/aat/300248611; landscape archaeology http://vocab.getty.edu/page/aat/300252459; Landscapes (environments) http://vocab.getty.edu/page/aat/300008626 ; spectroscopy http://vocab.getty.edu/page/aat/300179535

For UK collections: Evidence (England) CROPMARK ; Event Type (England) EVALUATION

Data structure – single date vigour data

For any point datasets representing in-field variability in vigour

Core attributes of data types (see above)

Critical information for inclusion

- Raw point data – point values including gps locations and attributes: NDRE and NDVI
- Cleaned point data – a geolocated or georeferenced matrix of cell (pixel) rows and columns where each cell contains the numeric values with cleaning to remove erroneous measurements applied; extent is defined by a bounding box in a WGS84 degrees or UTM metres
- Processed raster data – vigour maps which represent a grid of values, based on the interpolation or gridding of cleaned point datasets; extent is defined by a bounding box in a WGS84 degrees or UTM metres
- Vector Interpretation – Polygonal areas are created to define management zones which delimit areas of the field which have similar requirements for e.g. irrigation and fertilisation.

Data Processing

Raw OptRx data recommended processing - cleaning:

- Correct for dGPS signal delay / timing errors
- Remove points which represent measurements that are statistical outliers relative to the index distribution at the field level.

Cleaned NDRE / NDVI data recommended processing:

- Interpolation to create a raster and facilitate visual interpretation of variations in spectral index values.

Processed raster data:

- Rescaling of measured spectral index values to visually emphasize local outliers.
- Separation of measured spectral index values into multiple vertical zones so that only one measurement is represented in each pixel.
- Creation of raster derivatives e.g. variation between years, Deviation from local mean vigour Deviation from local mean vigour at multiple crop development stages.

Management zones:

- No further processing needed.

Metadata standard

Point Metadata		
(All data types)		
Duration/Collection date	Mandatory	Date (ISO 8601)
Instrumentation details	Mandatory	Character String (Free text)
Field Name	Mandatory	Character String (Free text)
Bounding Box	Mandatory	Coordinates (WGS84, decimal degrees)
Nominal Spatial Resolution	Mandatory	Decimal / Numerical
Weather data reference	Mandatory	Character String (Free text)
Crop type	Mandatory	Character Strong (controlled vocabulary)
Crop phenological stage	Mandatory	Character Strong (controlled vocabulary)
Calibration	Optional	Character String (Free text)
Processing	Optional	Character String (Free text)

Raster Metadata		
(All data types)		
Duration/Collection date	Mandatory	Date (ISO 8601)
Instrumentation details	Mandatory	Character String (Free text)
Field Name	Mandatory	Character String (Free text)
Bounding Box	Mandatory	Coordinates (WGS84, decimal degrees)
Nominal Spatial Resolution	Mandatory	Decimal / Numerical
Weather data reference	Mandatory	Character String (Free text)
Interpolation type	Mandatory	Character String (Free text)
Crop type	Mandatory	Character Strong (controlled vocabulary)
Crop phenological stage	Mandatory	Character Strong (controlled vocabulary)
Index Value Represented	Mandatory	Character Strong (controlled vocabulary)
Related data reference	Mandatory	Character String (Free text)

Management Zones Metadata		
(All data types)		
Field Name	Mandatory	Character String (Free text)
Bounding Box	Mandatory	Coordinates (WGS84, decimal degrees)
Crop type	Mandatory	Character Strong (controlled vocabulary)
Crop phenological stage	Mandatory	Character Strong (controlled vocabulary)
Index Value Represented	Mandatory	Character Strong (controlled vocabulary)
Related data reference	Mandatory	Character String (Free text)

Comparable Sensors

Specifications	**OptRX®**	**CropCircle® ACS-470**	**GreenSeeker®**	**CropSpec®**	**WeedSeeker®**	**WEEDit®**
Manufacturer	Ag Leader Technology	Holland Scientific	Trimble Navigation Limited	Topcon Precision Agriculture	Trimble Navigation Limited	Rometron B.V.

Height of operation (m)	0.25–2.5	0.25–2.5	0.6	Tractor cab height	0.45–0.75	1
Spectral range (nm)	670–780	450–880	660–770	730–810	660–770	Red Led
Field of view (m)	Height × 0.6 (up to 8 sensors on CANbus)	Height × 0 .6 (up to 8 sensors on CANbus)	0.6–1.6	3 m wide strip on each side of the tractor	0.3–0.38	0.1
View angle	Nadir	Nadir	Nadir	Oblique	Nadir	Nadir
Data output	NDVI, NDRE and nitrogen recommendati ons	Band informatio n, NDVI, NDRE and user-defined index	NDVI or four alternatives and nitrogen recommendati on	Biomass index and nitrogen recommendati on	NDVI	Fluorescen ce from chlorophyll
Application s	Corn, wheat and user defined for other agrochemicals	Crop biomass and nitrogen uptake	Yield potential and nitrogen responsivenes s, spring and winter wheat, canola, corn, sorghum, corn	Winter wheat and barley, spring wheat and barley, potatoes.	Green plants on soil or stubble	Green plants on soil or stubble

Table 1: After Pallottino et al. 2019. Sensor characteristics of the OptRx and comparable spectral sensors.

Scope Note

Applications of OptRx (or similar instrument) NDVI and NDRE measurements in archaeology

The visibility of cropmarks in high spatial resolution multispectral data is well established, and broadly matches their visibility in conventional RGB imagery. The use of band ratios, including NDVI and NDRE, to enhance the appearance of cropmarks is also established. However, cropmark appearance in crops other than cereals and grasses is not well documented. Assessment of crops other than cereals and grasses is a core application of the OptRx sensor. When assessing OptRx data, expectations of the appearance of cropmarks should take into consideration crop type as well as weather data and crop development (phenological) stage. The general expectation is that in early crop phenological stages, NDVI will reflect differential crop development, indicative of variability in the density and greenness of the vegetation. In mid- to late- crop phenological stages, in particular for crops that form multi-layered leaf canopies (e.g. vine crops, corn), NDRE will reflect variations in the amount of chlorophyll available in plants' foliage, including in lower layers which are less visible in NDVI.

The spatial sampling configurations possible for the OptRx sensor are important to its applications. OptRx data are typically collected at a 0.3m sampling interval along the direction of sensor travel (y-axis). In row crops, the spatial resolution is dependent on row spacing, but sub-2m resolution (on the x-axis) should be possible in most non-tree crops. The vertical resolution (z-axis) of the data is

dependent on the number of sensors configured in a vertical array in a row crop, and sub meter resolution can be achieved. In non-row crops, the spacing of sensors in a multi-instrument array impacts the resolution on the x-axis and typically there is only one level on the z-axis in the sensor array.

The capacity of OptRx data to reveal individual small archaeological features is dependent on the spatial density of the sampling and the crop type. However, these data may reveal larger individual archaeological features or indicate areas with a concentration of smaller features which have an aggregate effect on crop development. In crops which do not produce visible cropmarks observable from aerial platforms, NDRE data and vertical sensor arrays may improve the visibility of cropmarks. OptRx data may be combined with locations of known archaeological features to assess the interaction between crop root systems and archaeological deposits. OptRx data should be interpreted with reference to information on agricultural interventions (e.g. irrigation and fertilisation), weather records, and available soil survey data.

Scope Note

Archaeological influences on measured OptRx (or similar instrument) NDVI and NDRE to consider in Precision Agriculture

Where crop root systems interact with archaeological deposits in the shallow subsoil or topsoil, the presence of buried archaeology may explain some in-field variations in NDVI and NDRE values. In these situations, models of predicted timing and consistency of crop development and assessments of yield could be improved by accounting for the likelihood of increased local variability in SMD, shallow subsoil structure, and micronutrients.

Relevant Literature

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