THE USE OF REMOTE SENSING FROM SATELLITE IMAGERY IN THE SUGAR INDUSTRY

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Abstract

The Work Group on Landsat Data in Natal was formed to initiate projects in Natal and to co-ordinate local efforts. The first project is in progress and one field exercise to confirm interpretation of Landsat imagery has been conducted. It has been shown that computer printouts of spectral signatures reflected by the land surface of the test area, as sensed by the multispectral scanner (MSS) on Landsat 2, gave an extremely accurate picture of the vegetation, water bodies and land management practices at the time of observation. This has served to strengthen the belief that its use could be a valuable aid in monitoring land use trends in the sugar industry.

Introduction

Tremendous strides are being made in the use of satellite imagery for resources surveys in such countries as the United States of America and the United Kingdom. South Africa is unfortunately lagging behind, particularly in the fields of land use and agriculture, and a more positive approach is needed. To this end the Work Group on Landsat Data in Natal was constituted at a meeting held in the offices of the Town and Regional Planning Commission in Pietermaritzburg on 1st March, 1977. The main objectives were to initiate projects in Natal and to co-ordinate local efforts. Organisations represented in the group were the Department of Agricultural Technical Services, the Department of Forestry, the Town and Regional Planning Commission, the Natal Parks Board, the University of Natal and the South African Sugar Association Experiment Station. The Council for Scientific and Industrial Research (CSIR) is the main cooperator responsible for obtaining, processing and supplying data, while the National Committee for Remote Sensing co-ordinates research and advises on its use.

The work group has prepared a specific project proposal in consultation with senior CSIR officials and this has been accepted and approved by the National Committee for Remote Sensing. The project title is "The use of Landsat imagery for land use data collection in Natal: Lake St. Lucia and environs", and its aims are:

(i) to enable project participants to gain experience with the technology of using Landsat imagery in land use management in the environs of St. Lucia and

(ii) to investigate the implications of incorporating Landsat data into rural and regional planning in Natal.

The Experiment Station's objective on behalf of the South African Sugar Association is primarily to use the project to assess agricultural trends in the industry. As a first step, determining whether burning before harvest is really on the increase was submitted as being of particular interest to the Experiment Station. Should the application of remote sensing techniques give reliable results this could relieve the extension service of time-consuming, industry-wide surveys.

Landsat

ERTS-1 was launched in July 1972 and was in operation until about October 1973. It was later renamed Landsat 1.

Landsat 2 was launched in February 1975. It performs 14 orbits per day in a near-polar, sun-synchronous orbit at a height of 910 kilometres, retracing its path every 18 days to provide precisely controlled repetitive imagery. This satellite carries the same sensors as its predecessor, in the form of two imaging systems. The Return Beam Vidicon (RBV) consists of a camera with a lens that projects an image on to a vidicon tube. This tube retains the image while it is scanned and converted into electrical impulses. Three of these cameras are mounted side by side and each is fitted with a different filter to give three images of the same part of the earth's surface in different parts of the visible spectrum. The Multispectral Scanner (MSS) consists of an oscillating mirror which scans the earth below. The light reflected from this mirror is split by prisms into four beams, each of which passes through a different filter and is then converted into electrical impulses. Thus, four simultaneous images in different parts of the spectrum are obtained. Table 1 shows the wave length ranges in micrometres of the spectral bands investigated by Landsat 1 and Landsat 2.

TABLE 1
Spectral bands investigated by Landsat 1 and Landsat 2

Sensor	Spectral band No.	Wave lengths μm
RBV	1	0,475-0,575
	2	0,580-0,680
	3	0,690-0,830
MSS	4	0,5-0,6
	5	0,6-0,7
	6	0,7-0,8
	7	0,8-1,1

The electrical impulses can either be transmitted to earth immediately if the satellite is within range of one of the receiving stations, or stored on magnetic tape for later transmission.

The MSS senses the reflected radiation in four spectral regions, conventionally called bands 4 to 7. The nominal instantaneous field of view is 79 metres, although the system is capable of detecting objects smaller than this in size. Each scane line is 185 kilometres long and is moved forward 79 m at a time across the image. The resulting continuous stream of data is divided into 185 km long sections, called scenes. The data are obtainable as photographic images or may be digitised as computer compatible tapes (CCTs).

Each scene in CCT form contains 2 340 scan lines, each with 3 210 picture elements (pixels). The four spectral bands are interleaved, so that the multispectral information for any one point is available at one point in the tape. Scan lines are split into four equal portions and placed on four magnetic tapes, thus dividing each scene into four north-south strips. Each strip is 185 km long × 48 km wide, whereas the actual size of a picture element (pixel) is 56 m × 80 m. A scene consisting of four strips is diagrammatically represented in Figure 1 and depicts the format of computer compatible tapes.

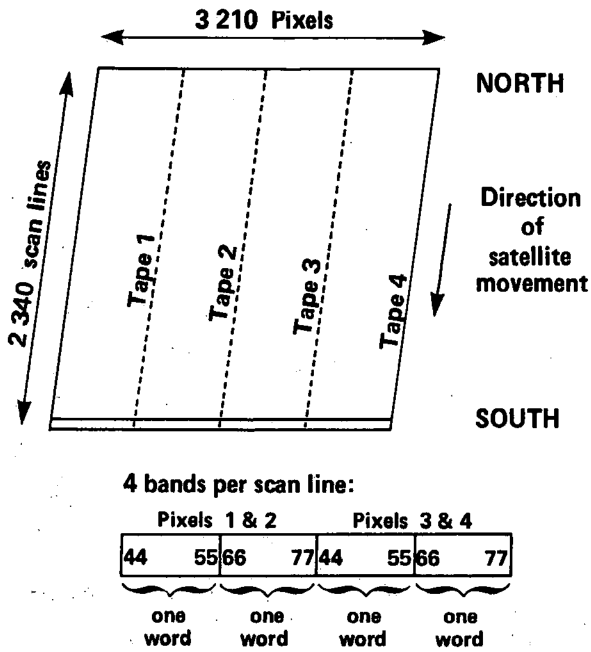

FIGURE 1 Format of Landsat CCT'S.

The St. Lucia exercise

Interpretation of remotely sensed data can best be done by comparison with close observations made on the site. These observations are called "ground truth". The Town and Regional Planning Commission in association with the Department of Forestry, the Natal Parks Board, the Natal Roads Department and the Trigonometrical Survey Office have recently completed a joint survey of natural resources. This covers a coastal strip along the eastern shores of Zululand and stretches from the St. Lucia Estuary to Sodwana Bay. The survey could provide a datum of ground truth. It was decided to select an area which extended about 30 kilometres inland and covered almost the whole of St. Lucia Lake and environs. The area falls within an overlap of the January 1973 and June 1975 Landsat images, so that changes in land use might be observed.

A trial area covering the southern section of the lake and its environs was chosen to correlate spectral signatures on the image and known ground truth. Sensed data were classified according to various land uses. MSS tapes were used for the analysis to which there are two approaches, the supervised and the unsupervised procedures. The former technique takes a segment of the data for which ground truth is available, and from this sample calculates statistics describing the spectral responses of the classes required. This procedure involves the input of a large amount of ground truth, and an *a priori* definition of the classes to be produced. This means that it cannot be used to do exploration.

The second technique involves asking the computer to identify different signals that it can distinguish, and the characteristics of each, and then relating these to ground truth. This approach was used because it suited the complex, exploratory St. Lucia situation far better because fewer *a priori* decisions and less rigorous knowledge of ground truth were required. It should be noted that the satellite records what the earth's surface reflects, and that it is this reflectance which is classified.

In this project the computer distinguished 16 spectral classes at the 95% confidence level. Participants in the project were provided with printouts of the unsupervised computer classification on a scale of 1 : 20 000, so that they could identify and indicate the classes of interest to them. Figure 2 shows a portion of the actual computer printout on a scale of 1 : 20 000.

FIGURE 2 Example of printout of computer spectral classification.

The different classes are shown as Figures 1 to 9 and letters A to G, there being sixteen in all. To identify classes that apply to sugarcane an overlay was made from the latest aerial photographs, showing all cane quota land in the area. This was checked against the latest quota maps and confirmed. To facilitate identifying the classes at a glance they were each given a different colour. This resulted in a patchwork design containing nine spectral classes within the boundaries of cane quota land.

As the Landsat scene was sensed during January 1973, some of the ground truth was naturally out of date and required revision by observations in the field. To do this a four-day field visit to the trial area was undertaken by the participants during the first week of October, 1978.

It was encouraging to find that only minor adjustments to class identification were necessary where land use had not altered spectral signatures entirely. Areas with excess soil moisture such as marshy ground and poorly drained or irrigated fields, and shadow due to topography have the same spectral signatures. These and a few other areas of uncertainty were inspected and clarified.

By visiting a sample of cane growers it was possible to verify the spectral classes for sugarcane and sugarcane land for a variety of conditions. Classes not connected with sugarcane at all but covered by the overlay, were then identified as land which had not been cleared and planted to cane when the satellite passed overhead in January 1973. Fields that had been harvested shortly before the time of sensing showed a reflectance different to that of actively growing cane. These were also identified to confirm the analysis.

The trial area originally chosen to correlate sensed data and ground truth did not cover all phases of cane cultivation occurring on the whole Landsat image, or scene. There were, therefore, some areas on which sugarcane was grown at the time of sensing that were identified as different vegetal cover because of similar reflectance. These were corrected during the field exercise.

Discussion

The use of Landsat imagery has been proved as a remote sensing technique. Its capabilities have so far been only superficially exploited. At present there are certain limitations which could almost certainly be overcome by improved application techniques and with experience. Some important aspects of its use that emerged from the exercise are :

(i) Further refinement in the application technique for sugarcane identification is required, higher resolution being desirable for accurate monitoring of management trends in the industry. Prospects are that by 1981 the resolution will be down to a 30 metre × 30 metre pixel.

(ii) Landsat was more accurate than aerial photography in sensing certain habitat types.

(iii) Soils cannot readily be classified as the satellite is designed to sense surface vegetal cover.

(iv) Erosion is not easy to distinguish directly, but may be inferred from changes in grass cover after a rain storm, for instance.

(v) Classification of water quality is difficult since "ground truth" needs to be ascertained at virtually the same moment that sensing takes place in order to obtain good correlation.

(vi) Images should be related directly to a co-ordinate system, preferably one that is commonly used.

(vii) A more refined classification would be necessary to exploit the full potential of the technique. This would be possible if specific classes of land use were studied in detail in selected training areas. Computer techniques for printing out individual classes and enhancing certain spectral bands are available. Malan and Schumann[2] and Keech[3] found enhancement greatly improved discernibility of feature distribution on images.

Conclusion

The vast store of data available in Landsat imagery is certainly of immense value to any investigation into land usage within the period of sensing. Adaptation and refinement of known techniques and the development of new ones places this wealth of data at the disposal of the researcher.

The project has so far merely revealed the possibilities and has served to strengthen the belief that remote sensing from Landsat imagery could be a valuable aid in monitoring land use trends.

Ready accessibility of Landsat CCT's is a prerequisite to efficient and timely investigation and warrants urgent negotiation with the National Aeronautical and Space Agency (NASA) on an agreement to make this possible.

REFERENCES

1. Work Group on Landsat Data in Natal (1977-78). Notes on various meetings. Unpubl.
2. Malan, O. G. and E. H. Schumann (1979). Natal shelf circulation revealed by Landsat imagery — SA Jnl Sc, **75(3)**: 136-137.
3. Keech, M. A. (1977). An assessment of ERTS-1 imagery as a base for natural-resources surveys in developing countries. Environmental remote sensing, Vol 2, Barrett, E. C. and L. F. Curtis, Edward Arnold: 256-257.