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SPECIAL USER SERVICE PROJECTS AT THE SATELLITE REMOTE SENSING CENTRE

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I. ABSTRACT

The Satellite Remote Sensing Centre of the National Institute for Telecommunications Research at Hartbeeshoek, South Africa, routinely provides a number of standard products and services to users. In addition, Special Users Service Projects are supported as part of the National Programme for Remote Sensing.

These special users may receive funding for their approved remote sensing projects; more importantly, they access expert assistance and the use of the image processing facilities at the Satellite Remote Sensing Centre.

Several Special User Service Projects are discussed briefly, and a major project is reported on in more detail. This is the National Forest Mapping Project. Its aim is to produce 1:250 000 scale map sheets with aid of LANDSAT data, showing four classes of forestry which are of importance to South Africa.

II. INTRODUCTION

Remote sensing technology transfer occurs at two levels in South Africa - academically at the universities via short courses and semester courses, and practically at the Satellite Remote Sensing Centre (SRSC) by means of Special User Service Projects (SUSPs).

The SUSPs serve a dual purpose. They provide opportunities for users to learn the techniques of machine processing of remotely sensed data in a 'hands on' environment. Secondly they are practical, experimental applications in selected areas considered to be of national importance. The success of a number of projects at SRSC has promted several agencies, in the government as well as the private sector, to invest in image processing facilities of their own. Thus SUSPs both transfer and promote the use of remote sensing technology.

III. NATIONAL PROGRAMME FOR REMOTE SENSING

In 1975 the Council for Scientific and Industrial Research (CSIR) established the National Committe for Remote Sensing (NCRS) to be the main advisory body for a South African National Programme for Remote Sensing (NPRS). The members of the NCRS are drawn from South African organisations with an interest in research in remote sensing. As shown in Figure 1 the NCRS operates through a number of specialist Working Groups. At present the three Working Groups are Land Use/Land Cover; Geosciences; and Data Acquisition, Processing and Display.

The purpose of the NPRS is to encourage and support research aimed at increasing the effectiveness with which satellite and aircraft remote sensing techniques can be used for the study of natural phenomena, resources and related problems which are of importance to South Africa.

An 'Opportunity to Submit Research Proposals' is distributed annually by the NCRS. The document lists the areas of research and development in which projects can be considered for funding and support. Projects from neighbouring countries are also considered for support. For instance, a feasibility study on mapping the natural forests in Zimbabwe using remotely sensed data has been completed (1979-1981), as has an investigation of the usefulness of Landsat data to assess flooding and soil moisture conditions in Botswana (1981-1983). Two other projects - A Landsat false colour mosaic map of Lesotho and a similar map of a portion of Antartica are currently under way.

Proposals are reviewed by the Working Groups and recommendations on support are submitted to the NCRS.

IV. SPECIAL USER SERVICE PROJECTS

Image processing facilities for satellite remote sensing studies are expensive and often not available within the user's organization. Moreover many users are not familiar with the techniques and procedures needed to apply remote sensing in their fields of speciality.

The SRSC is both a satellite data reception and processing centre. Two parabolic dish antennae (12,1 metre and 10 metre) assure continuous and regular data reception. Satellite data from LANDSAT 4 and METEOSAT II, (and soon NOAA) spacecraft are archived and catalogued at the Centre. These data are available to users in computer compatible tape (CCT) format from archival high density digital tapes (HDDT), and in the form of a range of hard copy products.

The SRSC has a dedicated image analysis system (IAS) consisting of a Perkin-Elmer 8/32 computer, 300 megabyte disc storage and Comtal 8000 colour display facilities. The usual magnetic tape drive and digitizer input, and line printer output are part of the overall station hardware system. A Polaroid colour graphic camera is linked to the Comtal display for instant hardcopy, while Optronics Colorwrite and Fire Laser colour film recorder are available for high quality output products. A 35mm camera, permanently mounted in front of a second colour monitor, provides colour slides. A scanning micro-densitometer (Optronics Photoscan) completes the hardware.

The software consists of an IAS package developed by Macdonald, Dettwiler and Associates (MDA) of Canada. The SRSC has made considerable adaptations and additions to this package. Years of experience in the use of the IAS have built up a high level of analyst expertise.

Special users therefore are users who not only have been granted funding, but have also been allowed access to the image processing facilities and specialized assistance at the SRSC. This special assistance is also available to neighbouring countries.

The SRSC undertakes to give expert advice to special users, provide them with a back-up service for the selection and preparation of remote sensing data which will be required in their projects, and to assist them with image processing. Table 1 shows a time and cost breakdown for special users 1983/84.

Upon completion of the study, the SRSC will provide the user with non-standard imagery products relevant to the needs of the study. (e.g. colour classification maps or overlays). The special user is subsequently provided with a description of the methods and techniques used, for incorporation in his final study report. The special user's organization is responsible for the overall report on the study.

V. SPECIAL USER PROJECTS 1983/1984

A total of seven SUSPs were supported during 1983/84. Five of these projects concerned renewable resources, one dealt with non-renewable resources and one covered an image processing problem area.

Six of these projects are briefly identified below. The seventh will be discussed in more detail. The final reports are not yet complete and conclusions and results are therefore not possible for most projects at this stage.

A. BETHAL-LANDSAT GEOCODING

This project combines LANDSAT digital data with other relevant, geocoded, economical, transportation and agricultural data for two purposes.

1. The location of future extensions to the existing grain silo network in the western region served by the Eastern Transvaal Cooperative.

2. The developement of a practical crop forecasting model for the area.

Supervised classification using graphic masking techniques was performed to classify the crops (mainly maize) in the different yield areas (Van Rensburg and Sandham, 1983, pp. 1-15).

B. FOREST INVADERS.

The objective of this project was to attempt to locate and quantify forestry and forest invader species in commercial forest plantations. Some success was obtained using the first two principal components from registered, summer and winter LANDSAT images of the plantation. Unsupervised classification was used on the four-band multitemporal data.

C. KAROO VEGETATION.

The Karoo is an extensive, semi-arid biome in South Africa.

Support in this project was confined to chosing likely training areas of different Karoo vegetation and soil types. Histogrammes were then produced for each training area. The user will run analysis of variance tests on the data and develop numerical signatures from the histogrammes.

The purpose is to determine the reliability of mapping important floristic and physiognomic vegetation units in the eastern Karoo by making use of manual and computer-assisted interpretation (Jarman and Jackson, 1981, pp. 25-27).The signatures will be run through PIPS image analysis system at the University of Natal.

D. BOTSWANA VEGETATION.

The aim of this cooperative project was to assess the ability of LANDSAT data to discriminate between differences in vegetation structure in a specific area in south Botswana. Unitemporal, multitemporal, and principal component, supervised classification methods were used.

E. IMAGE COMPARISONS.

Initially 'eyeballing' techniques evaluated geological usefulness of analogue standard film products of four areas over four different seasons. Image processing techniques were then used on the digital data to attempt to show which processes and/or what date or combinations of dates were best for geological interpretation. Edge enhancements, principal component transformations, differencing, normalization and rationing were done between bands and between seasons (Byrne et al,1980, pp 175-184; Eyton, 1983, 231-235; and Newton, 1981, pp. 42-53).

F. GROUND CONTROL POINTS (GCPs).

The project objectives were to indentify the optimum number, nature and distribution of GCPs for precision correction of LANDSAT data. Over one hundred GCPs were selected on the Johannesburg image and various combinations used in the precision correction. The data is still being analyzed, as is the 1:250 000 hardcopy print of the final precision correction using all one hundred GCPs.

VI. NATIONAL FOREST MAPPING PROJECT

A. NEED

Existing forest maps of South Africa are mostly at a scale smaller than 1:1000 000 and merely indicate the whereabouts of forests. An accurate forest map is required for planning and development by the Department of Forestry, as is a reliable data base of plantations. The locations of indigenous forests, commercial plantations and woodlots as well as data on their distribution and area are necessary for immediate Forestry Güide Planning and for long term forest policy decisions. A map is also required for national inventory purposes. No such forest map exists at a convenient scale (Malan et al, 1980, pp 1-2).

B. PURPOSE

The aim of the project is to produce a forest map of South Africa and neighbouring countries with significant forestry, at a scale of 1:250 000, in four forest classes, with the aid of LANDSAT imagery. The four forestry classes are Pine, Eucalyptus, Wattle and Indigenous. The minimum mapping unit (MMU) is twenty five hectares (sixty two acres). This represents 2mm x 2mm on a 1:250 000 map sheet. Within these constraints of scale and MMU, all the needs outlined above cannot be met. These limitations will be discussed at a later stage in this paper.

Forestry is evident on thirty one, 1:250 000 map sheets along the eastern and southern regions of Southern Africa as shown in Figure 2. Fifteen of these sheets contain significant tracts of forestry and will require computer classification of LANDSAT imagery. In the remaining sixteen map sheets, forests will be mapped manually with the aid of precision corrected, false colour composite, LANDSAT prints at 1:250 000 scale.

C. PROCEDURE

Bi-temporal LANDSAT data are chosen from the SRSC catalogue and inspected for quality and cloud cover. Black and white negatives at 1:1000 000 are used to select up to thirty five, well distributed GCPs for precision correction and registration of the two images.

At the same time, the forester/special user is supplied with a 1:250 000, false colour composite of the LANDSAT image for selection of training areas.

All available forest maps, plantation maps and inventories are collected and indicated roughly on the image. Where insufficient reference data exist, the areas are flown and normal colour, and colour infrared, aerial photography taken.

At the SRSC work goes ahead with the precision correction and registration of the LANDSAT data. Once this has been completed, the IAS work sessions are arranged and supervised training is done on the eight-band data. When a training area is correctly classified using a Bayes maximum-likelihood classifier, the same set of signatures is used on the next training area and the signature file edited by addition, deletion and merging of the appropriate signatures. When the best compromise has been reached, a full scene, eight-band classification is carried out using the final signature file. The output product is a 1:250 000, precision corrected, colour coded LANDSAT classified image.

Poor classification results are often evident in mountainous areas, where Pines in the sun are spectrally similar to Eucalyptus on the shady slopes. Shadow is also a problem in these areas. Wattle has a spectral range that covers both Pines and Eucalyptus. When classification accuracy is not acceptable, as indicated by the known reference data, the only solution is to try a better combination of data sets or to make the best classification possible and then do comprehensive field checks using a light aircraft.

The unsupervised classification programme at the SRSC is limited to four bands of data. When using this classifier, a principal components transformation is used to compress the eight band data into four bands of first and second components. Another data compression method used is to compute the eigenvectors and eigenvalues of both images and accept only the four LANDSAT bands whose loadings contribute most to the first two principal components of each data set (Schreier et al,1982, pp. 111-119).

D. MAP PRODUCTION

The LANDSAT classified areas are first transferred to the draft 1:250 000 map sheets. Corrections are then made by the special user, using surface reference and other auxiliary data. Copies of the sheet are distributed to referees nominated by the Forestry Council (an autonomous body representative of private and government forestry interests). These referees are usually forest managers familiar with the area covered by the map sheets. They undertake a qualitative evaluation of the map and feed back information to the special user.

The draft sheet is split into its component classes, and drawn one class per drafting transparency. These are then sent to the Directorate of Surveys and Mapping in Cape Town and printed as the green vegetation layer on the national, 1:250 000, topo-cadastral map sheet. The forestry classes are shown in four, distinct shades of green. At present two experimental sheets have been printed and five others are being prepared for printing.

Limitations of the end product relate largely to its scale (1:250 000) which, in turn, is dictated by the resolution and spectral range of the LANDSAT system. As can be expected from this choice of scale, reliable absolute surface hectarages per forest class cannot be derived from the map product. Many key features such as roads and fire breaks can unavoidably not be shown to true scale, if at all. This limitation is compounded by the MMU of twenty five hectares.

However the positive results outweigh these limitations. These map sheets will for the first time, clearly indicate the locations and extent of four classes of forestry. Also the relative percentage areas for these classes can be derived. In the current national series of topo-cadastral maps, no sub-classes are shown for afforested areas. A substantial improvement in information content will result in the incorporation of the four-class forestry data into this series.

Lastly, the practical 'know how' developed in the preparation of these map sheets, is essential for taking advantage of future, higher resolution, multispectral sensors which will allow larger scale, more detailed, forest mapping, and the extension to other remote sensing forestry applications.

VII CONCLUSION

Special User Service Projects at the SRSC both transfer and promote the use of remote sensing technology. Digital image processing techniques are transferred in a practical framework to special users and are also made known to other users via reports, papers and colloquia.

While, superficially, LANDSAT MSS appears to be a fairly coarse mapping tool, both in resolution and number of bands, these projects clearly demonstrate its successful use in important regional mapping applications.

The SRSC is encouraged by the tendency of some government departments and mining houses to invest in their own digital image processing hardware and software. This will eventually ensure the demand for satellite digital data and the funding for upgrades to receive data from more sophisticated satellites and sensors.

VIII. ACKNOWLEDGEMENTS

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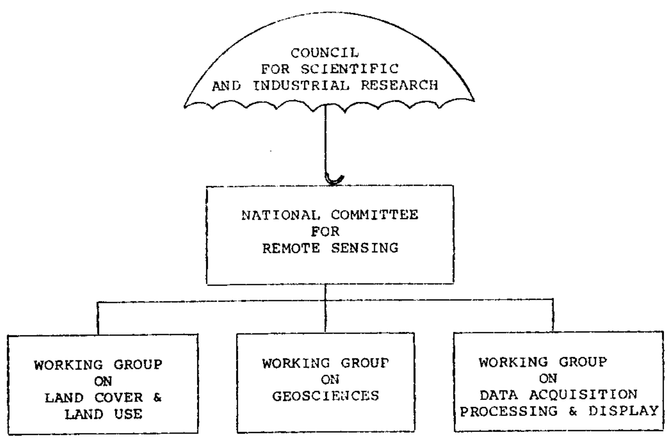

Figure 1. Composition of the Working Groups of the National Committee for Remote Sensing.

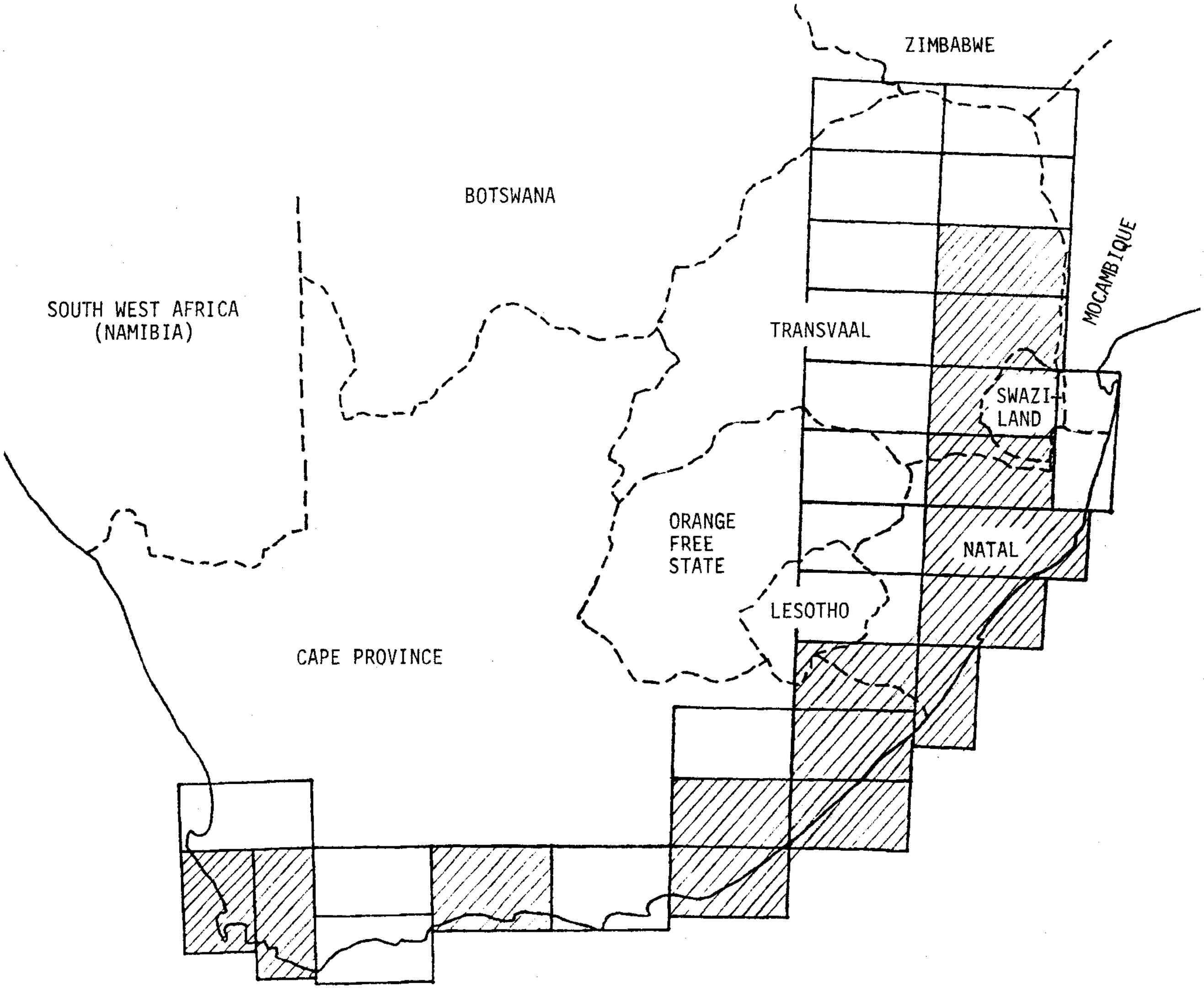

Figure 2. Map showing the coverage of the 1:250 000, forestry map sheets. The shaded rectangles indicate map sheets requiring computer classification.

Table 1. Time and cost of Special User Service Projects for 1983/1984
At the time of writing R 1,00 = $ 0.80
These costs are for image processing support only and exclude other direct support for manpower and running costs.

PROJECT NAME	PROJECT N°	TIME (Weeks)	AMOUNT (Rand)
Bethal-LANDSAT Geocoding	FAA8	8	7 644
National Forest Mapping	FAC3	14	14 069
Forest Invaders	FAC4	2	2 785
Karoo Vegetation	FAD10	1	1 287
Botswana Vegetation	FAD15	2	5 407
Image Comparisons	FB6	3	10 000
Ground Control Points	FD7	1	2 277
TOTAL		31	43 469

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