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AN APPROACH TO DEVELOP INTERPRETATION KEYS FOR THE ANALYSIS OF SINGLE BAND BHASKARA SATELLITE TV-DATA

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I INTRODUCTION

Bhaskara, the first Indian Earth Observations Satellite was launched on June 7, 1979. The two primary payloads onboard the Bhaskara satellite were two Television cameras (TV Camera) and two frequency Satellite Microwave Radiometers (SAMIR). The salient features of the TV camera and SAMIR payloads[1] are summarised and given in Table 1.

Since the Bhaskara TV data is having a low resolution and as the data was acquired in only one band, namely, 0.54-0.66 μm, the utility of the data from the point of view of information extraction on earth resources is limited. Moreover, because of its orbital characteristics the data is acquired at different times of the day and thus under various illumination conditions.

This note discusses an approach that is designed to increase the scope of utilisation of this data. This approach is developed using both digital and photographic techniques with a view to arrive at a standard set of keys for analysing and interpreting the TV data. The basis of the digital technique is the frequency distribution of gray tones (reflectance values) for identifying major cover types, classifying them and generation of three new data sets by assigning pseudo grey codes to the classified data. The pseudo gray coded data is then used to generate photographically colour codes for each of the cover type. Each pseudo data set is turned into a photographic film transparency and is assigned the colours red, green and blue respectively. The colour composite made using these transparencies is the new colour coded thematic ground cover picture from Bhaskara.

II METHODOLOGY

Let $Z = \{z_i \mid i = 1, \cdots, N\}$ be the data set corresponding to an image frame, where N is the total number of pixels and if f_i, $i = 1, \cdots, n_g$ be the frequency for the frame corresponding to the gray value i, then

$$N = \sum_{i=0}^{n_g} f_i \qquad \ldots(1)$$

where $n_g + 1$ is the number of gray levels recorded by the slow scan TV vidicon camera. Also, let

$I = \{m_i \mid 0 \le m_i \le n_g\}$ be the sequence of relative minima and $J = \{M_j \mid 0 \le M_j \le n_g\}$ be the sequence of relative maxima for the frequency distribution given in equation (1). From these two sequences I and J form the two sequence I' and J' of stable minima and maxima respectively such that

$$I' = \{i \mid i \in I;\ f_{i-1} > f_i < f_{i+1}\} \qquad \ldots(2)$$

and

$$J' = \{j \mid j \in J;\ f_{j-1} < f_j > f_{j+1}\} \qquad \ldots(3)$$

where, f_{k-1}, f_k and f_{k+1} are the frequencies at the three consecutive relative minima and maxima.

The sequences I' and J' are used to identify the clusters existing in the data set Z on the basis of the hypothesis that there exists atleast one stable maximum between two stable minima. The limits of the clusters are obtained in the following way

Let $I' = \{x_1, \cdots x_m\}$

and $J' = \{y_1, \cdots y_{m'}\}$

are the sequences of stable minima and maxima respectively then

$$C_i = \bigcup_{j=k}^{l} [x_j, x_{j+1}]$$

where, $y_i \in [x_l, x_{l+1}]$ and x_k-1 is the upper limit of C_{i-1}, C_i is the i-th cluster whose grey values lie between the range x_k and $x_{l+1}-1$.

Then a lookup table is generated with the clusters and their limits. This table is used to classify the data set Z.

The classified data set is assigned pseudo codes, one code for each cluster, where values are assigned by taking into consideration the light reflectance properties of the objects represented in the clusters. Three such data sets with three different grey coding for each cover type are generated and photographic transparencies are generated on a film recording system. Finally a colour coded imagery is generated photographically by exposing under controlled conditions with the three primary colours, namely, blue, green and red. The colour tones generated out of this product can be used as keys for classifying and interpreting the data for extracting resources information from Bhaskara TV Camera data.

III. ANALYSIS OF DATA, INTERPRETATION AND THEMATIC MAP KEY GENERATION

A typical Bhaskara TV imagery over Himalayan region in India was chosen for testing this approach.

The reseau marks in the imagery were blocked by counting the positions of the scan lines and pixels as there was no consistency in the location of reseau marks in the frame.

The methodology mentioned in the previous section was then applied to the imagery in order to check the consistency of the result and thereby to standardise the colour coding scheme for a single band TV data.

A. TEST SITE

The data for the test site whose coordinates are (29°50'N, 77°16'E), 31°45'N, 75°E), (31°30'N, 80°E) and (33°45'N, 77°45'E) covers an area of 329x329 sq kms on the ground and is shown in figure 1. The data was analysed by using the method discussed earlier in section II. The analysis gives eight distinct clusters. The distribution of population in each of the clusters and the range of gray values of each cluster is given in Table 2. From the clustered data set three separate photo-thematic transparencies/maps were generated by giving three sets of pseudo gray codes. One such photo-thematic-map is shown in figure 2. Using these three photo-thematic-maps, a colour coded picture is generated as discussed in section II.

For the above test site, the broad landcover information is available from the Forest Atlas of India[2] and is shown in figure 3. By comparing figure 3 and the colour coded picture it is possible to establish a correspondence between colour tones generated in the picture and the existing landcovers. Table 3 gives the range of gray values for the different clusters, their tones (keys) in the colour coded picture and the names of the landcovers.

It is observed from figure 3 and Table 3 that arable land shown in the existing map shows two colour tones in the colour coded Bhaskara imagery, namely, greenish, blue and orange, which may correspond to fallow/barren land and vegetated lands respectively. Again dull green tone is observed for both tropical moist deciduous forest as well as for Himalayan dry temperate forest. Also, for dry alpine scrub two tones, namely, brown and pinkish violet are seen in the colour coded Bhaskara imagery which may be because of the different dryness conditions. The light pink tone appearing in the picture could not be related with any ground cover and this may be appearing due to some mixed signatures from forest and snow. It is also noticed that water in Bhakra Nangal dam gives similar signature as snow. This may be due to specular reflectance of sun illumination from the dam water. This is difficult to distinguish from snow, probably because such high reflectance value is close to the levels corresponding to snow cover and both may be falling in the saturation region of the TV sensor response curve.

The above mentioned procedure was extended to the imagery obtained over two more test sites with a view to verify the consistency of the approach[3].

B. GENERATION OF KEYS

The test results from all the three sites mentioned above were combined to define keys that could be used consistently for the interpretation of all Bhaskara TV data. These keys in the form of colour tones, as explained before, were generated on the basis of clusters obtained from the spectral reflectance properties of various ground covers and by making use of available ground truth information. Table 4 gives broad ground covers and their interpretation keys.

IV. CONCLUSION

This approach of identifying clusters on the basis of a definition of relative maxima and minima in a data set and identification of a stable maximum between two minima seems to offer reasonably consistent interpretation keys for broad categories of land covers. The variations observed in the colour tones for similar ground covers may be attributed to, among other things, the omission of radiometric corrections required in the data due to the nonavailability of radiometric calibration information on TV data as well as acquisition of this data under different illumination conditions. These broad categories of land covers could be further sharpened, if one looks at the data alongwith the latest landcover maps and reference data. One major advantage of this approach is the exact delineation of a broad cover and its quantification as illustrated in Table 2.

It seems that the TV data when analysed using the above approach fulfils, to some extent, mission objectives of SEO, namely, the utilisation of Bhaskara TV data in the fields of forestry, hydrology (snow cover) and broad landuse.

V. REFERENCES

1. Final Configuration of Satellite for Earth Observations. Doc. No. SEO-ISAC-CT-79-05-5-015, ISRO Satellite Centre, Bangalore, May 1979.

2. Dasgupta, S.P. (Ed)., Atlas of Forest Resources of India, National Atlas Organisation, 1976.

3. Senchaudhuri, P. et. al.: An Approach to develop Interpretation Keys for the Analysis of Single band Bhaskara TV-Data, Tech. Rep. RSA-IP/TN-01/81, Space Applications Centre, Ahmedabad, January 1981.

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Table 1

Bhaskara Orbit and TV Sensor specifications

Bhaskara Orbit Specifications:

Altitude	:	525 kms (nominal)
Inclination	:	51^o
Type	:	Near circular (non sunsynchronous)

TV Payload specifications:

Type of camera	:	Slow Scan Vidicon, Two bands (0.54-0.66 um and 0.75-0.85 um)
Ground Resolution	:	1 km (approx.)
Ground Coverage per frame	:	340x340 km^2
Quantisation level	:	7 bits

SAMIR Payload specifications:

Frequency (GHz)	19.1	22.235
RF Bandwidth (MHz)	250	250
Brightness Temperature Resolution (o_K)	1	1
Spatial Resolution (kms)	150	230

Table 2. Statistics of clusters

Cluster No.	Cluster interval Lower limit	Upper limit	Population	% of total area
1.	9	52	9,645	6.18
2.	52	60	8,896	5.70
3.	60	64	7,534	4.83
4.	64	72	16,864	12.08
5.	72	87	27,638	17.72
6.	87	111	17,864	11.45
7.	111	123	4,784	3.05
8.	123	127	58,478	37.49
9.	0	9	2,315	1.50

Table 3. Correspondence between clusters, colour tones and land cover. Class/Cover type/ in the test site.

Sr. No.	Original Grey Values Range	Colour-Code	Possible Class/ Covertype
1.	9 - 52	Red	Himalayan moist Temperate Forest
2.	52 - 60	Brown	Dry Alpine Scrub
3.	60 - 64	Pinkish Violet	Dry Alpine Scrub
4.	64 - 72	Dark Green	Tropical moist deciduous forest and Himalayan dry Temperate forest
5.	72 - 87	Orange	Arable Land (with vegetation)
6.	87 - 111	Greenish Blue	Arable land (Barren/Fallow)
7.	111 - 123	Light Pink	Unclassified (mixed signature)
8.	123 - 127	Light Blue	Snow

Table 4. Keys for interpretation of Bhaskara-TV data

Cover Type		Colour Tone
Forest	i) Moist temperate forest	Red
	ii) Dry Alpine Scrub	Brown, Pinkish violet
	iii) Tropical moist deciduous forest, Himalayan dry temperate forest	Dull Green
Water Body	i) Deep sea water	Blue
	ii) Coastal sedimented water	White
	iii) Sedimented water	Greenish Blue
Barren/Fallow land		Greenish Blue
Vegetative Arable Land		Orange
Snow or cloud		Light Blue

Fig. 1: Original Bhaskara TV-data for the Test Site

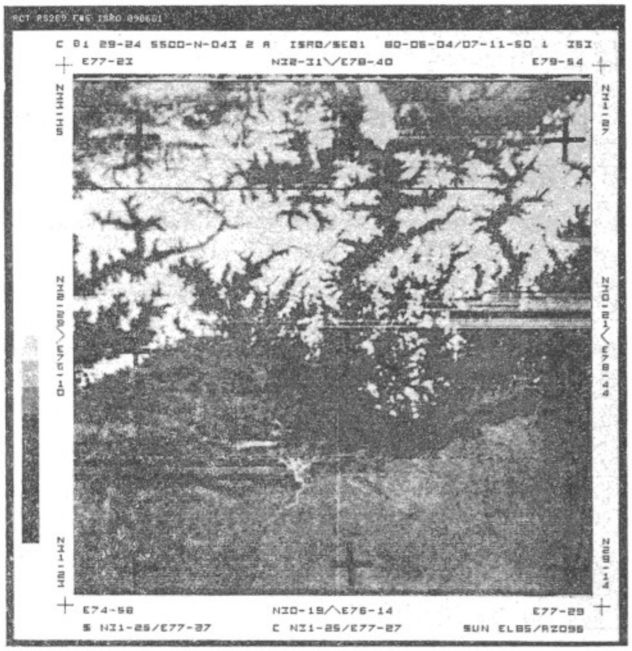


Fig. 2: Pseudo coded photo-thematic-map from figure 1

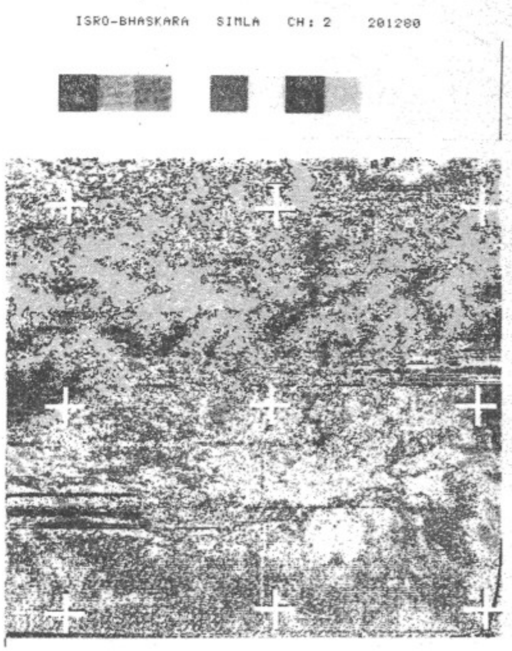
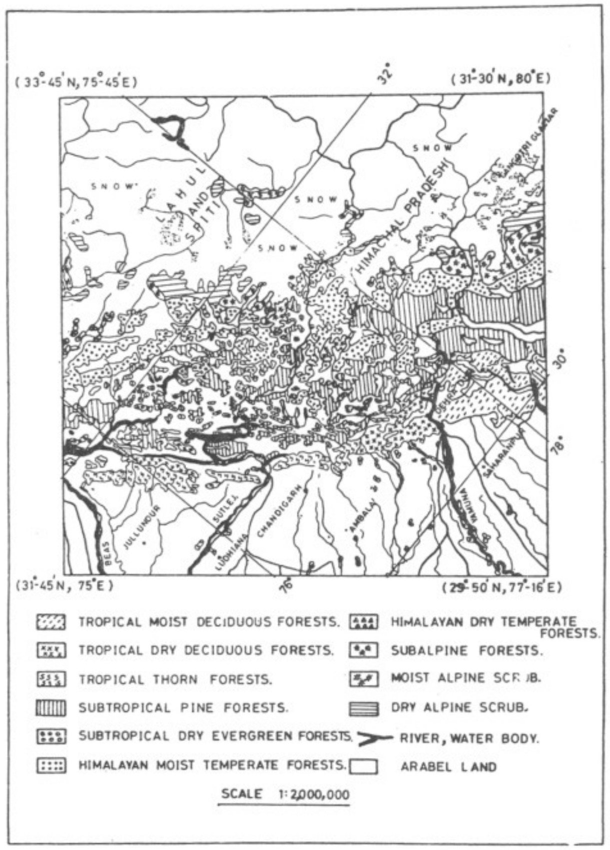


Fig. 3: Broad Landcover map for the Test Site



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