LAND USE MAPPING AND TRACKING

WITH A

NEW NOAA-7 SATELLITE PRODUCT

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INTRODUCTION

The daily products, Globally Monitored vegetation Index, operationally produced by National Earth Satellite and Data Information Service, NOAA are analyzed for maxima within each seven day period from May through July 1982. The maxima are related to known land uses over North America to develop a use classification system. Weekly variations over active cropped areas are related to vigor of the crops and growth stages. The analysis techniques usually provide global maps of agricultural areas over which most of the transient meteorological effects have disappeared meaning that near absence of clouds and minimum atmospheric attenuation exist.

BACKGROUND

With the advent of the U.S. satellite age, weather surveilence became a primary task resulting in the organization of an operational activity (now NESDIS) to collect and use satellite instrumental data for preparation of timely products. These products did and do support the weather services in the United States and elsewhere about the earth. The earlier products were reconstructed scenes of videcon signals. Each product generation, while addressing its current tasks, needed improvements. Thus each family of instruments fostered development of newer families. One of the latest operational instruments is the Advanced Very High Resolution Radiometer (AVHRR) which has been designed to acquire radiometric information remotely and transmit such data back to earth. Its capabilities include three resolution rates and three transmission modes to diseminate data from five (or four) selected radiometric bandpass channels. It has been designed to provide total global areal coverage once daily by sunlight and once during the night period. Before its final integration with the satellite vehicle, the definition of the bandpass limits for each channel must be set. For the TIROS-N unit, channel 1 was defined to span 500 n.m. through 1100 n.m; channel 2, 680 to 1200 n.m.; channel 3, 3550 to 3930 n.m.;

and channel 4, 10500 to 11500 n.m. (all limits approximate). Then for the succeeding vehicles, NOAA-n's new definitions were established for channel 1, 550 to 700 n.m. and channel 2, 690 to 1050 n.m. Those for NOAA-7 are channel 1, 550 to 690 n.m. and for channel 2 710 to 1000 n.m., plus the addition of channel 5, 11500 to 12500 n.m.

These reflective wavelenghts of channel 1 and channel 2, onboard NOAA 6 & 7, were selected by hydrologists for the purpose of identifying melting snow; but too late to be included on the TIROS-N AVHRR. (Schneider, 1977) Fortunately, these chosen channels in the reflective solar spectrum are nearly optimized for detection of vegetation. Gray and McCrary (1981a) demonstrated this capability by comparing their vegetation index (later named the Gray McCrary Index - GMI) with the Landsat data-based Ashburn Index. Subsequent investigations by Perry and Lautenschlager (1982) have verified these findings. Then Gray and McCrary (1981b) showed the response of the GMI could track the health, or lack thereof, of vegetation, define water surfaces and detect cloudiness. Accordingly, they recommended in late 1980 that NESS develop a new product - the daily vegetation global map and a weekly "best value" vegetation index composite map.

PRODUCT DESIGN

NESS had had the experience of producing weekly snow maps based upon the "minimum Brightness" weekly composite mapping - basically, mapping daily brightness as observed by the satellite each day for a week, then saving only the lowest brightness at each of the grid locations. Beginning in April 1982, the vegetation index mapping procedure was begun; consisting of daily gridded data being produced and then a seven day series are surveyed to extract the "best" vegetation index for each grid point which are recompiled into a "best" composite map. This new product was developed through cooperation between the Applications Laboratory and Special Products Division of National Earth Satellite Services and the Satellite Data Services Division of the Environmental Data and Information Services. A report is to be published (Tarpley, 1982). Supporting evidence for this technique is illustrated by the spectral curves shown in Figure 1 and in the NOAA-7 Channel 2 & 1 computed responses listed in Table 1.

TABLE 1

Assumed Surface	% Reflectance		Indices (2-1)	(2-1)/2+1	2/1
Vegetation Types:	Ch 2	Ch 1	GMI	NVI	Ratio
Well-watered wheat	19.66	0.83	18.83	.919	23.7
water-stressed wheat	16.65	2.93	13.72	.701	5.7
Alfalfa	14.00	1.64	12.36	.790	8.5
Soybeans	28.27	2.12	26.15	.860	13.3
Diseased Soybeans (11.5%)	13.39	2.82	10.57	.652	4.8
Non-Vegetation:					
Concrete	19.44	15.60	3.84	.110	1.25
Asphalt	7.35	5.11	2.24	.180	1.44
Sand	13.40	8.69	4.89	.221	1.54
Reddish Soil	7.80	8.78	-0.98	-.055	.89
Water	0.01	0.37	-0.36	-.958	.02
Ice/clouds	54.75	79.16	-24.41	-.182	.69

Thus, the "best" response for each given location will be a clear surface, i.e. water, soil, and/or vegetation, provided that location did not present a cloud/ice signature for each of the seven days; and, vegetational signatures would dominate.

DATA ANALYSIS

Analyses consist of several actions: (1) subjective evaluation of photographic/hard copy displays; (2) examination of digital output for comparison with other index techniques; (3) and the production of index changes with time. During the presentation of this paper, color products from the Advanced Graphics Laboratory, University of Texas/Austin are shown for the North American area to illustrate the subjective technique (Fig. 2).

Data for selected periods have been extracted for three given areas over the United States: (1) an area near Chicago, Illinois, (2) the Texas High Plains, and (3) Florida, north of Lake Okeechobee. Three products for each period and each area were acquired from the digital tape products, one of the outputs of the vegetation mapping techniques. These are examined for the purpose of comparing navigation of the NESDIS operational products to that of the U.S. AgRISTARS EW/CCA data base (or how does the indexing of the 1024 by 1024 i,j grid match that of the 512,512 grid) and for the representativeness of the operational index versus those in the U.S. EW/CCA data base.

Several locations on the North American continent are specified on the operational vegetation index product to be compared to the other grid (Table 2).

TABLE 2

Feature	Geographic N	Locations Column 1024 Grid	Row 512 (x10)	Difference Col 3 minus (Col 4)/5
S. Baja CA	22.9 109.8W	348,802	1746 4009	-1.2+0.2
N. Gulf CA	31.5 114.6W	356,745	1785 3726	-1.0-0.2
S. James Bay	51.2 80.0W	513,690	2570 3449	-1.0+0.2
S. L. Mich.	41.6 87.4W	484,737	2426 3683	-1.2+0.4
W. Okeechobee	26.9 18.1W	407,821	2542 4103	-1.2+0.4
S. Florida	25.1 80.6W	409,832	2553 4157	-1.2+0.6

As illustrated in Table 2, the 512 by 512 gridded data base used by the Foreign Agriculture Service, Crop Condition Assessment Division (FAS,CCAD) and the AgRISTARS Early Warning/Crop Condition Assessment (EW/CCA) project, provides a higher i number than the operational Globally Monitored Index (GMI) but the j values are approximately correct. Considering the evaluation procedures used for operational computations of the EVI (environmental vegetation index) in Houston, the four GMI's to be used for a single data base location would consist of these grid locations:

$$I_p = 2I-1 \qquad J_p = 2J$$

$$I_{p-1} = I_p-1 \qquad J_{p+1} = J_p+1,$$

where the subscript p indicates the operational 1024, 1024 grid system and the non subscripted data refer to a location in the 512,512 array.

Analysis of the GMI area values with respect to the data base EVI values consists of paring the sums of the assumed four representative GMI's with EVI's archived in the data base. 147 pairs were correlated for the period of 6-12 July, 1982 (Actually only two data passes, 2 days, existed in the data base for this period; but, the composite did not necessarily select the same days as "best") for a correlation coefficient of .811 (Fig. 3). In scale of values for the GMI, note that 1) the GMI represents the sum of four grid locations, whereas the EVI is a single mean integer value (ranging from 4 through 13 in the sample used; 2) the GMI is computed from the AVHRR raw count data and changed from 10 bit data to 7 bit data while the EVI is computed from albedo values; 3) the GMI value at a given location is the "best" single value of seven days, but the EVI is the mean of about 2000 screened pixels (j and 4) the GMI is the equivalent of skip line and skip pixel sampling of global area coverage (GAC) data (4 km pixel size) and the EVI is computed from all available local area coverage (LAC) data which pass the screening tests.

CONCLUSIONS AND RECOMMENDATIONS

The Globally Monitored Index (GMI) weekly composite charts represent useful data to assess world agriculture to the extent that any other vegetation index is useful. However, variations in the dimensions of various geographical features indicate a need to improve the navigation techniques used to assign AVHRR data to earth locations.

The difference in scalar values of the GMI with respect to the ranges used by FAS/CCAD and EW/CCA in their data base currently represent a problem. Thus, rescaling the GMI - using albedo type values rather than raw count derivations - will improve the acceptability of the product.

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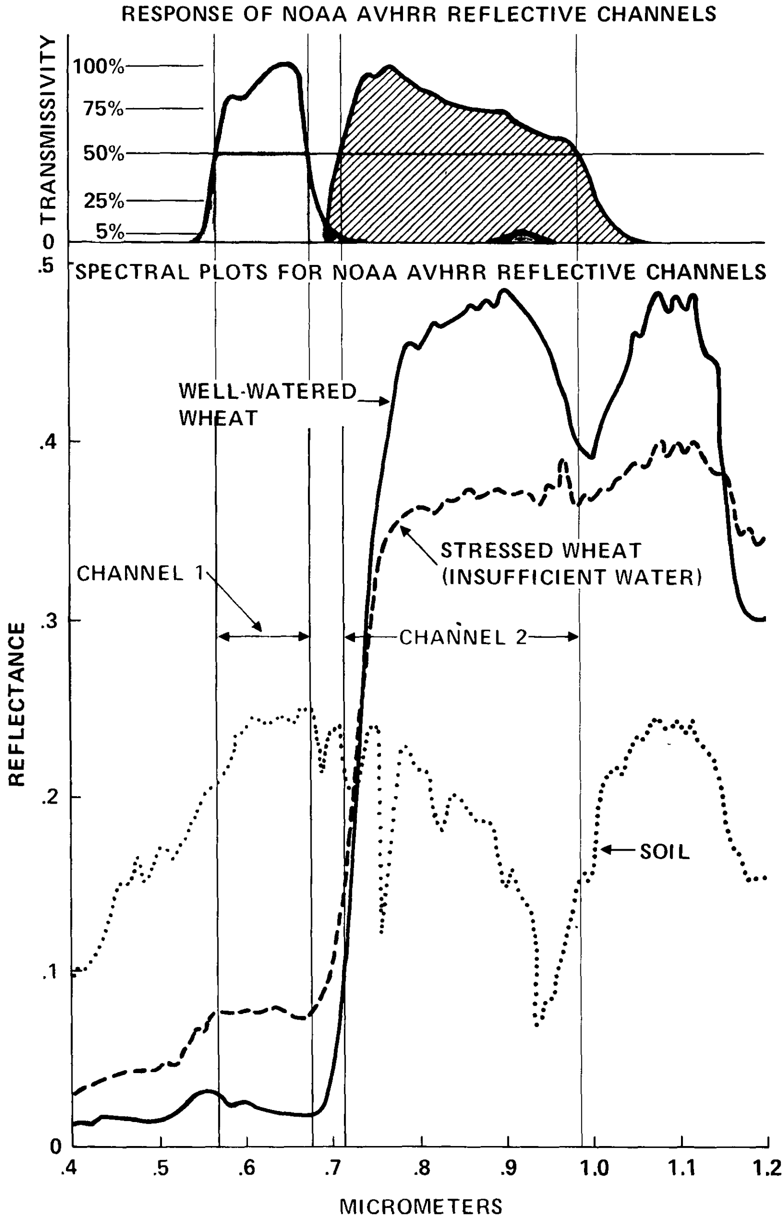

Fig. 1. Part A Spectral responses of various surfaces and agricultural plants. The curve marked soybeans on righthand graph is that of a diseased planting with 11.8% affected. The upper curves are the response curves of channels 1 and 2 for NOAA-6.

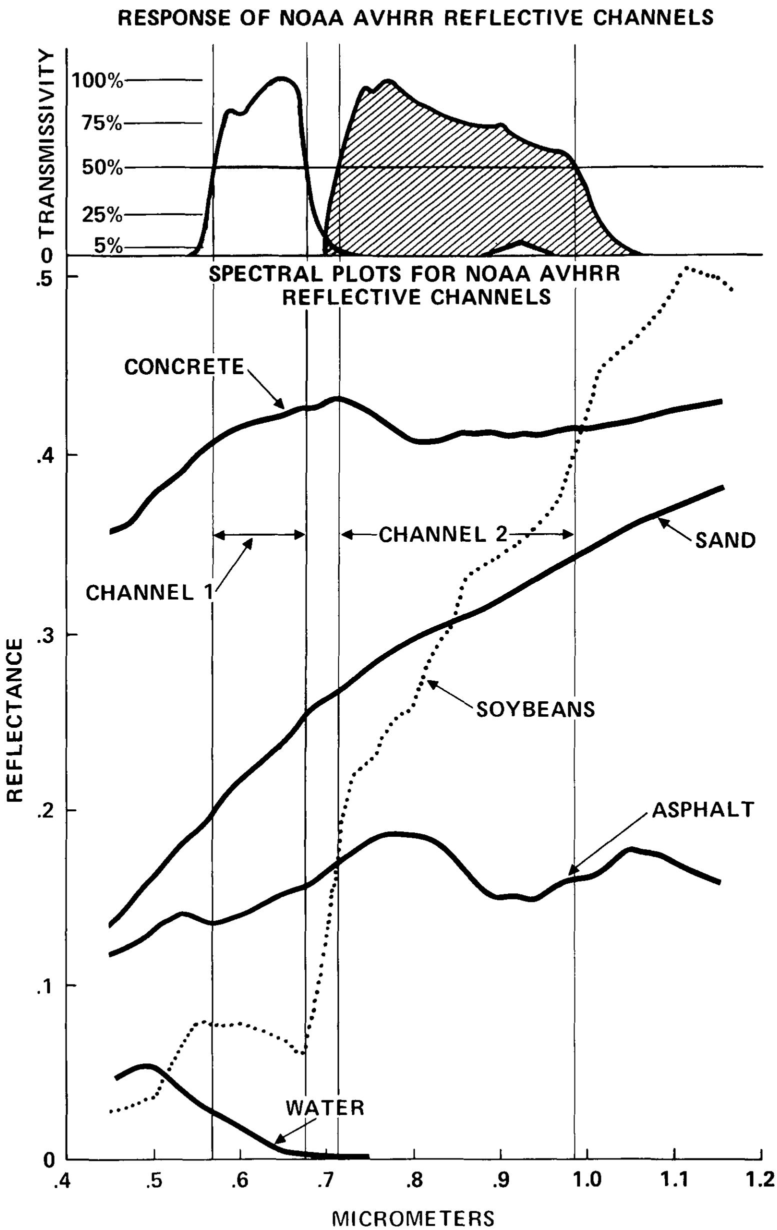
RESPONSE OF NOAA AVHRR REFLECTIVE CHANNELS
TRANSMISSIVITY
100%
75%
50%
25%
5%
0
SPECTRAL PLOTS FOR NOAA AVHRR REFLECTIVE CHANNELS
CONCRETE
CHANNEL 1
CHANNEL 2
SAND
SOYBEANS
ASPHALT
WATER
REFLECTANCE
.5
.4
.3
.2
.1
0
.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
MICROMETERS

Fig. 1
Part B

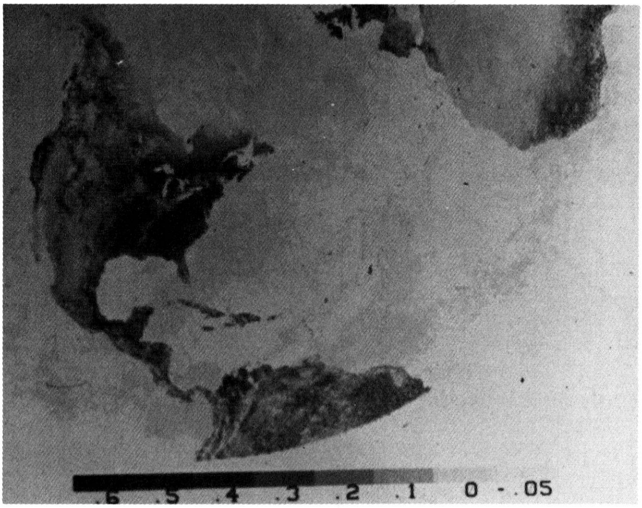

Fig. 2. A portion of the Globally Monitored Indices for North America. The darker the area, the better the "greenness" of the vegetation.

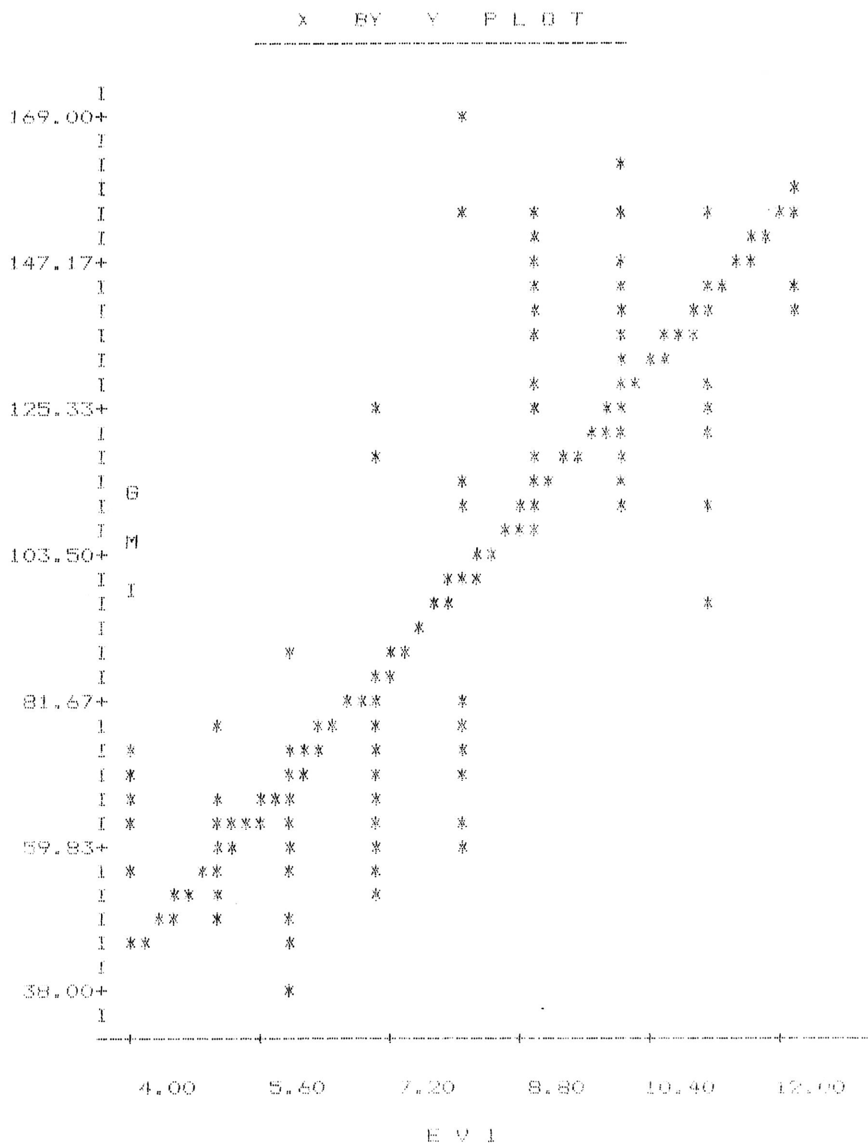

Fig. 3. A plot of the sums of the GMI values (y axis) vs the EVI values for 147 i,j locations during the period of 6 through 12 July 1982. The correlation coefficient is .811.