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THE ENVIRONMENTAL VEGETATION INDEX
A TOOL POTENTIALLY USEFUL FOR ARID LAND MANAGEMENT

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16. Abstract

NOAA-6 AVHRR data sets acquired over South Texas and Mexico during the spring of 1980 and after Hurricane Allen passed inland are analyzed. These data were processed to produce the Gray-McCrary Index (GMI's) for each pixel location over the selected area, which area contained rangeland and cropland, both irrigated and non-irrigated. The variations in the GMI's appear to reflect well the availability of water for vegetation. GMI area maps are shown to delineate and to aid in defining the duration of drought; suggesting the possibility that time changes over a selected area could be useful for irrigation management.

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THE ENVIRONMENTAL VEGETATIVE INDEX

A TOOL POTENTIALLY USEFUL FOR ARID LAND MANAGEMENT

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1. BACKGROUND

Within the past decade, the development of techniques to interpret useful agricultural information from the remotely-sensed data acquired by satellite-borne instruments has shown promising results. Investigations based upon data sets acquired by the Multi-Spectral Scanner (MSS), an instrument aboard each Landsat Satellite system, have provided techniques to delineate crop acreage, crop type (with limitations), and course measures of vegetative growth stages (Ashburn, 1979; Thompson, 1979). The refinement of these techniques is dependent upon better temporal distributions of these data for each target area; however, this effort has been handicapped by the Landsat system design which permits data acquisition for a given target only once per 18 days per satellite (nine days if a two-satellite system is operating). Often, a given target's acquisition was precluded due to extensive cloudiness. Many temporal gaps existed during the Large Area Crop Inventory Experiment (LACIE) which limited the LACIE capability adequately to define crop calendars, normal time-dependent vegetative indices, and probable limits for stress detection.

J. Hickman, USDA, FAS, CCAD and D. McCrary recommended investigating the capabilities of the operational environmental satellite systems to monitor agriculture as a task in the Agriculture and Resources Inventories Survey Through Aerospace Remote Sensing program (AgRISTARS). An investigation was completed into the responses of the NOAA-6 Advanced Very High Resolution Radiometer (AVHRR) for the detection of greenness of vegetation and it was determined that the Local Area Coverage (LAC) data sets in these data were highly correlated to nearly synoptic MSS data within identical target areas (about 1600 sq. km) (Gray, 1980). This finding has led to the suggestion that operational processing of NOAA satellite systems data for monitoring global vegetation should be undertaken. It is expected the variations in the AVHRR responses will provide information about reactions of vegetation to moisture availability and/or thermal effects.

2. DATA ACQUISITION AND PROCESSING

The spring drought of 1980 in South Texas offered an opportunity to test this thesis with respect to water deficit. Upon advice of Dr. C. Weigand, USDA/SEA/AR of Weslaco, Texas this study was begun with AVHRR/LAC data tapes for the 1980 dates of 22 March, 14 April, 19 April, and 28 April acquired from the Satellite Data Services Division (SDSD, NCC, EDIS, NOAA). Later the data for 18 June, 9 July, 24 August and 19 October were added.

These sets which contain five data channels were edited and processed to provide calibrated albedo data for Channels 1 and 2 within the selected scene. The AVHRR Channel 1 filter accepts radiation from .55 to .74 μm with a wing between .88 and .96 μm., but its principal band width is .572 to .686 μm. The Channel 2 range is .71 to 1.09 μm with its principal band width from .715 to .987 μm. Calibration, in this context, converts the digital count as transmitted from the satellite AVHRR system to percent albedo using the following linear equation:

$$A_{ijk} = IC_{ijk} * S_k + Y_k \qquad (1)$$

where the subscripts imply the pixel number, scan line number and the channel number; A, the calibrated albedo as a percentage; IC, the raw digital count of the channel; S, the slope of the calibration line of that channel; and Y, its intercept on the albedo axis. These data sets also included data from the 3.33 - 3.93 μm and 10.5 to 11.5 μm bands, but analyses of these bands have been postponed.

AVHRR data sets are acquired over such an expanse that related angles to each pixel vary greatly. To permit comparisons between various times these data have been normalized to a synthetic overhead sun. Analyses, then, are based upon calibrated, solar-zenith corrected albedo values for Channels 1 and 2 from the NOAA-6 AVHRR instrument.

3. DATA INTERPRETATION AND ANALYSIS

3.1 Sensor Evaluation

The response capabilities of the NOAA operational AVHRR system were investigated. This evaluation was made using the pre-launch response curves of the AVHRR channel filters and four ground-based spectra of a soil, well-watered wheat, alfalfa, and wheat under a water-deficit stress (Jackson, 1980). The synthesized differences (Channel 2 minus Channel 1) for the NOAA-6 instrument show values to be 0.9, 22.5, 16.4 and 16.8 respectively. The ratios (Channel 2 divided by Channel 1) are 1.1, 12.4, 9.8, and 6.3.

Likewise, the spectra of clouds and water indicate the Channel 1 albedos exceed those of Channel 2. A complete range of spectra for various crops and for the variations with time were not available but the above samples indicate the AVHRR data responses can be used to evaluate the areal extent and state-of-health of vegetation. Of course, signal degradation for those targets which contain non-vegetative areas, such as water bodies, urban developments, geological outcroppings, bare soil, etc. can be anticipated. For this reason, areas of interest are selected which are nearly homogenous and large enough that errors in location are not critical.

3.2 Data Analysis

Two techniques have been used in this study to evaluate the AVHRR LAC data as a tool for arid land management: 1) false color displays through the Integrated Multivariant Data Analysis and Classification System (IMDACS) of the Foreign Agricultural Service, Crop Condition Analysis Division (FAS, CCAD) computer facility, and 2) scanline graphs across the areas of interest. The analyses of interest areas with IMDACS images were restricted to a qualitative level, only, by the operational characteristics of the system.

The more useful tool is the scanline graph of AVHRR data. Of particular utility, the Environmental Vegetative Index (EVI), defined to be near infrared albedo minus the red-yellow visible albedo (see synthesize differences above) is formulated.

$$EVI = A_{ir} - A_{vis} \quad (2)$$

which expressed in terms of equation 1 is

$$EVI_{ij} = A_{ij2} - A_{ij1} \quad (3)$$

In Figure 1 each negative EVI has been set to a -0.5 ramp if the channel 1 albedo was less than 10.01; -1.5 ramp, greater than 20.00; and -1.0 ramp, otherwise. These ramped classes are assumed to be water, cloud, and mixed content targets, respectively. These ramps can be keys to verify locations of scanline data. Note the ramps related to Lake Falcon and the Gulf of Mexico on both the upper and lower graphs of Figure 1.

Nearly congruent scanline segments were selected for specific transects within the area; one, which is presented in the Figure 1, extends from 26.75°N, 100.00°W to 26.31°N, 97.00°W. The data are graphed with the arguments of longitudinal location and EVI using each instantaneous field-of-view (IFOV) of each segment.

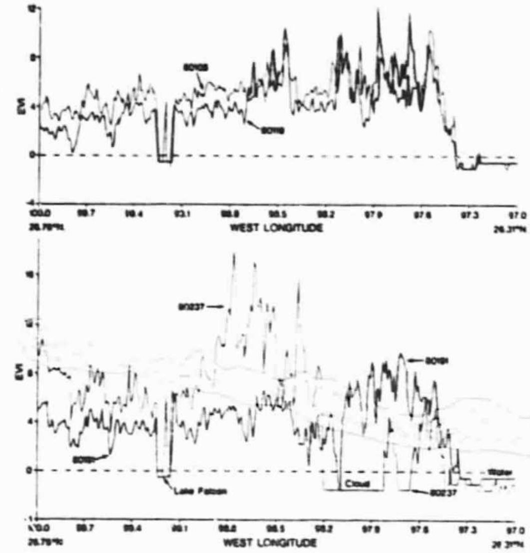

Figure 1. Co-located EVI scanlines. Upper pair illustrates decreasing EVI with drought. Line 80191 of lower pair depicts continued drought while 80237 occurred after Hurricane Allen. Shaded areas on upper and lower graphs are croplands, and clouds, respectively.

The mean EVI decreased over the range land and native vegetation (that portion of the graphs westward of 98.75°W) from a mean level of 4.53 on 14 April 1980 (80105) to 2.77 on 28 April 1980 (80119). During this same period, the Crop Moisture Index (CMI) (___, 1980) decreased from about -1 to less than -2. Note that east of this zone are several locations where the EVI's for 28 April 1980 are greater than those of 14 April. In each case, irrigated crops exist on either side of three major highways located at 98.6°, 98.1°, and 97.75°W on these scanlines. These EVI increases are expected with normal crop practices in these areas.

Table 1 presents the probable normal levels of the EVI with time. The average rainfall over the area and some data ranges from these satellite data sets were analyzed with LACIE technology for this estimation.

TABLE 1

Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
5	9	13	14	12	12	16	17

When the lower pair of curves is examined, the mean EVI for 9 July 1980 (80191) of 3.66 for the native vegetation zone is considerably below the estimated value for that date in the table - about 9 points lower. At this time, the CMI was less than 04.

The 80237 curve is for 24 August 1980, about 5 days after the widespread inundation of the area by Hurricane Allen. For this date the mean EVI for the native vegetation has increased to 7.19 and even more dramatically for the areas of cultivation (average greater than 10.0). Note the separation between the 80191 and 80237 curves. The area east of 98.2l contains considerable cloudiness, surface water and mixed content pixels for this later date. The CMI for 16 August 1980 was +3.

4. CONCLUSIONS AND RECOMMENDATION

The results depicted in the graphs indicate the EVI responded to plant growth stress due to water deficits. Although sufficient data to establish a firmly reliable "normal" time distribution of EVI's for all crops or regions are yet to be acquired, the EVI is responsive to changes in vegetation due to drought and subsequent recovery with adequate rainfall.

An additional AgRISTARS task is proposed to acquire more frequent data sets for the Mississippi Valley - Great Plains area to help define the crop year in terms of the EVI. Further, research may be extended into foreign areas.

The data for all channels of the AVHRR instruments are continuously broadcast by the satellite transmitters and may be acquired as long as the satellite is within the field of view of any receiving station. The engineering designs for such stations are available from NOAA or NASA for nominal costs (Schwalb, 1978). The custom cost of these stations is about one quarter million dollars; however, a spartan station might be built under $50K using off-the-shelf items of antennas, disk drives, mini computers and servo mechanisms.

It is suggested that operational use of locally acquired NOAA-7, etc. data can provide information useful for arid land management. This experiment demonstrated that the EVI (derived from NOAA-n AVHRR data) does provide an index of vegetative greenness.

5. REFERENCES

Ashburn, P., 1979, "Utilization of the Vegetative Index Number in the USSR", Technical Memorandum #11, USDA, FAS, Oct. 1979.

Gray, T. I. and McCrary, D. G., 1980, "Meteorological Satellite Data, A Tool to Describe the Health of the World's Agriculture", AgRISTARS Report in preparation, Houston.

Jackson, R. D., Pinter, P. J., J., Reginato, R. J., and Idso, S. B., 1980, "Handheld Radiometry", USDA, SEA, Agricultural Reviews and Manuals, ARM-W-19, Oct. 1980.

Schwalb, A., 1978, "The TIROS-N/NOAA A-G Satellite Series", NOAA Technical Memorandum NESS 95, Washington, D.C., March 1978.

Thompson, D. R. and Wehmanen, D. A., 1979, "Using Landsat Digital Data to Detect Moisture Stress", Photogrammetric Engineering and Remote Sensing, 45(2):201-207, Feb. 1979.

__________ 1980, "The Crop Moisture Index", Weekly Weather and Crop Bulletin, 67(16):27, 67(28):23, 67(34):19, Washington, D.C.