EVALUATION OF AIS DATA FOR AGRONOMIC AND RANGELAND VEGETATION: PRELIMINARY RESULTS FOR AUGUST 1984 FLIGHT OVER NEBRASKA SANDHILLS AGRICULTURAL LABORATORY

BLAINE L. BLAD, PATRICK J. STARKS, CYNTHIA HAYS, University of Nebraska, Lincoln, Nebraska, USA; BRONSON R. GARDNER, Standard Oil of Ohio, Cleveland, Ohio, USA

ABSTRACT

Since 1978 scientists from the Center for Agricultural Meteorology and Climatology at the University of Nebraska have been conducting research at the Sandhills Agricultural Laboratory on the effects of water stress on crop growth, development and yield using remote sensing techniques. We have been working to develop techniques, both remote and ground-based, to monitor water stress, phenological development, leaf area, phytomass production and grain yields of corn, soybeans and sorghum. Because of the sandy soils and relatively low rainfall at the site it is an excellent location to study water stress without the necessity of installing expensive rainout shelters.

The primary objectives of our research with the AIS data collected during an August 1984 flight over the Sandhills Agricultural Laboratory are to evaluate the potential of using AIS to: (a) discriminate crop type; (b) to detect subtle architectural differences that exist among different cultivars or hybrids of agronomic crops; (c) to detect and quantify, if possible, the level of water stress imposed on the crops; and (d) to evaluate leaf area and biomass differences for different crops.

MATERIALS AND METHODS

AIS data were collected at approximately 1500 h solar time on August 7, 1984. In 1984 we conducted experiments on several different agronomic crops including six different corn hybrids, some of which were architecturally quite different. Other vegetative surfaces included soybeans, alfalfa, corn grass (corn planted into grass rather than bare soil), rangeland and a recently harvested oat field.

Different water stress levels were achieved by means of sprinkler irrigation. At various times during the growing season moderate to severe levels of water stress were established on some plots. Unfortunately, about 1.2 cm of rain were received the night preceding the AIS flight so only minor differences in water stress levels between the different plots were present at the time of the overflight.

After narrowing the AIS data to include only that portion of the AIS data set in the general vicinity of the research plots, frequency distribution curves were obtained for each AIS channel. Two types of frequency distribution curves were observed--one was single peaked and the other showed a bimodal distribution. Gray maps were produced using a channel representing each curve type. The gray map produced with the bimodal type curve was much more useful than the single peaked curve in pinpointing the locations of the various plots. Some difficulty, due in large measure to an adjustment in the flight path over the plots, was encountered in locating the plots on the gray map.

Once the research plots and surrounding features were identified from the gray map, 10 pixels from each of six different vegetation types on the imagery were selected for the discriminant analysis procedures. Also one pixel from each vegetation type was selected to produce spectral curves. The data reported on here were not calibrated except for making the radiometric corrections.

In our study we attempted to discriminate between the six vegetative types using data from the 128 AIS channels as the discriminating variables. We first used all 128 channels of data via the direct method, i.e., all variables were tested to meet a default tolerance test. Those variables which met the requirements were then used in the construction of discriminant functions to classify each of the six groups. Next we used the direct discriminant analysis procedure on each group of 32 channels (i.e., 1-32, 33-64, 65-97 and 98-128). Lastly, we employed a stepwise discriminant analysis procedure which selects independent variables for entry into the analysis based on their discriminating power (Kleeka, 1975). Of the five selection criteria available we selected the Wilk's method. This method employs the overall multivariate F ratio for the test of differences among group centroids. The variable which maximizes the smallest F ratio between pairs of groups also minimizes the Wilk's lambda, a measure of the group discrimination (Kleeka, 1975).

RESULTS AND DISCUSSION

An examination of the spectral curves for the different vegetative surfaces suggests the following: (1) The curves for the corn - corn grass are almost identical in shape and magnitude except that the corn grass shows slightly higher reflectance in the 1160-1307 nm range and some variability in the shape of the two curves in the region from about 1600-1710 nm. (2) The reflectance from corn was slightly less than for soybeans or alfalfa for almost all channels. Some features in the curves of the three crops between 1185 and 1310 nm and from 1605 to 1775 nm suggest that fine spectral resolution data in these regions may be useful in discriminating between these three crops. (3) The magnitude of the reflectance from the oat stubble is consistently higher than from any other surface throughout the entire range of the AIS. This may result from a greater contribution of soil reflectance due to reduced vegetative cover. High reflectance from this soil in TM5 and TM7 has been previously observed. (4) Compared to the corn the magnitude of the reflectance from the rangeland in the wavebands from 1150 to 1310 nm is less but from 1450-1760 nm and from 2000-2340 nm it is higher. Features of the curves in the 1185-1310 and 1605-1710 nm regions of the spectrum should be examined in greater detail for their use in discriminating rangeland and oat stubble from corn.

To this point, we have only been able to analyze the AIS data to meet objective (a). Future analysis is planned to meet the remaining objectives. For the discriminant analysis procedure using all 128 AIS channels we found that channels 1-50, 53 and 116 passed the tolerance test. Using the data from these channels we achieved a 100% classification accuracy with good separation of the different vegetative types.

When we used only the first 32 channels we achieved a classification accuracy of about 98% with good separation of all types except for the corn from the corn-grass. With channels 33-64 we had a classification accuracy of 100% and very good type separation. For channels 65-97 we had a classification accuracy of only 72% and all except channels 65, 66, 68, 71, 74 and 83 failed the tolerance test. We achieved a 100% classification accuracy using channels 98-128 but the separation was not particularly good.

Using the stepwise discriminant procedure twenty-six channels were selected to construct the five discriminant functions. The twenty-six channels selected were 2, 8, 9, 16, 23, 25, 30, 32, 34, 36, 42, 44, 49, 51, 61, 62, 63, 64, 65, 91, 99, 102, 113, 116, 117 and 127. The classification accuracy was 100% and the separation between vegetative types was very good--the best of all the procedures.

In conclusion, it should be emphasized that the results of this study are very preliminary and further analysis is required before definitive statements about the true value of AIS data for monitoring agronomic and rangeland vegetation can be made. Nevertheless, the results thus far suggest that AIS data does an excellent job of discriminating between the various types of vegetation examined at this site and that there are some features in certain AIS wavebands that may be useful in discriminating vegetation type.

REFERENCE

Kleeka, Wm. R. 1975. Discriminant analysis. In Statistical Package for the Social Science, 2nd Edition. Nie et al. (ed.), McGraw Hill, NY. Chapter 23, pp. 434-467.