13B.4 HIGH RESOLUTION RESPONSE OF HETEROGENEOUS VEGETATION COVER TO MOISTURE CONDITIONS USING SPOT-XS DATA

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1. INTRODUCTION

Normalized Difference Vegetation Index (NDVI) information is often used for monitoring vegetation response to varying moisture conditions. Many researchers have been able to obtain useful and reliable results in determining various vegetation state variables from NDVI values (e.g., Justice et al. 1991). The relationship between large-sale vegetation state and rainfall distribution has also been found to be strong (e.g., Peters et al. 1991). However, these types of activities are often based on 1 km resolution data that encompass significantly varying vegetation types within each pixel. The degree of response of a remotely sensed low resolution pixel will vary depending upon the heterogeneous nature of land cover at the sub-pixel scales (Marsh et al. 1992). This research project utilizes multi-temporal SPOT-XS (multispectral) imagery with a 20 m resolution to detect vegetation response in the late summer to dry, normal, and wet climate conditions southeast of the Black Hills of South Dakota, United States. Three nearly cloud-free images were extracted and statistical pattern recognition applied to classify each image into 5 land cover categories: forest, mixed forest/grassland, grassland, alfalfa, and bare soil. This research is done so as to improve the interpretation of low resolution imagery commonly used in real-time large-scale vegetation monitoring.

2. DATA AND ANALYSIS

The Modified Palmer Drought Severity Index (PDSI) for South Dakota Climate Division 4, the Black Hills, was used as an indicator of moisture state as derived from climatological observations. Figure 1 displays the monthly PDSI for 1985-1995. A set of three cloud-free SPOT-XS images were identified that were as close as possible to anniversary dates but represented disparate moisture states. The image from 3 September 1989 was gathered at the end of a very intense drought, and the 31 August 1993 image was taken at the end of the summer of great flooding in the Upper Midwest. The closest adjacent near-normal moisture condition image was from 19 August 1991. The three dots on the NDVI times series in Figure 1 denote these dates.

The 1993 SPOT image was geometrically corrected and geo-referenced to the Universal Transverse Mercator (UTM) projection using nearest neighbor resampling. 1991 and 1989 images were registered to the 1993 image. Statistical pattern recognition techniques generated 50 or more clusters that were then assigned to the five land classes present in the study area. A number of random points proportional to the coverage of each class were than extracted, and NDVI calculated from band 2 (red) and band 3 (near-infrared) reflectance. A detailed accuracy assessment of the land cover classification was performed based on both ground surveys and aerial photos of the region.

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3. RESULTS

Table 1 displays the NDVI mean and variance for each year and land cover type, and also includes comparative differences and standard deviations of differences between the normal year, 1991, and the two moisture extreme years, dry 1989 and wet 1993. As may be expected, the alfalfa and grassland land covers respond most strongly to moisture variations, and have the largest NDVI differences between the dry and wet years and the normal year. Forests consist mostly of evergreen conifers in this region, leading to smaller changes in NDVI with moisture extremes. Even on this 20 m scale, the heterogeneous mixed forest/grassland pixels display variations of NDVI with moisture intermediate between the forest and grassland types. Therefore, the degree of heterogeneity of land cover in a coarse resolution pixel will affect the magnitude of the response to moisture regime variations, and complicate the interpretation of climate-vegetation signals.

4. ACKNOWLEDGMENTS

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5. REFERENCES

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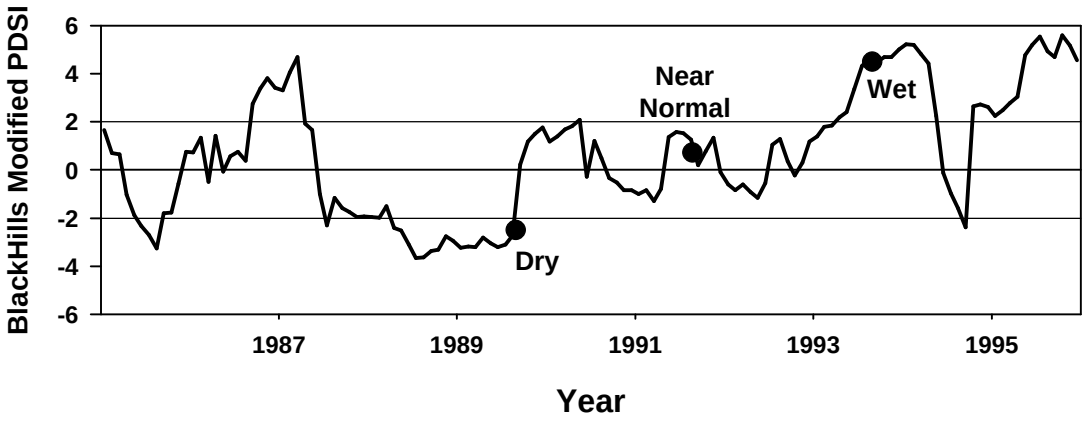

Figure 1. Modified Palmer Drought Severity Index (PDSI) for the Black Hills, South Dakota Climate Division 4. The symbols represent the timing of the satellite images selected on the basis of growing season drought status. 3 September 1989 is the drought image, 31 August 1993 is the abundantly moist image, and 19 August 1991 is the near-normal image.

Table 1. Statistical evaluation of NDVI for 5 land cover types under variable moisture conditions.

Land Cover Types	Years	Forest	Mixed (Grassland/ Forest)	Grassland	Alfalfa	Bare Soil
Mean	Normal 1991	132.26	129.08	123.20	134.39	106.04
	Dry 1989	121.14	113.99	101.00	107.39	93.49
	Wet 1993	138.61	138.37	133.57	155.41	114.51
Mean Differences	Dry - Normal 1991 – 1989	-11.23	-15.09	-22.20	-27.00	-12.54
	Wet - Normal 1993 - 1991	6.34	9.28	10.37	21.00	8.47
Standard Deviation	Normal - Dry 1986 - 1991	4.39	5.76	4.74	11.20	5.79
	Wet - Normal 1993 - 1991	2.17	4.52	5.34	10.05	5.47
Variance	1989	21.69	17.70	18.88	31.11	17.03
	1991	13.56	21.07	25.88	104.95	19.80
	1993	10.59	15.30	34.79	57.50	35.37