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METHODS OF EDITING CLOUD AND ATMOSPHERIC LAYER AFFECTED PIXELS FROM SATELLITE DATA

Principal Investigator: Paul R. Nixon
Co-Investigators: Craig L. Wiegand
Arthur J. Richardson
Michael P. Johnson
Benjamin G. Goodier

Agricultural Research Service
U.S. Department of Agriculture
P. O. Box 267
Weslaco, TX 78596

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16. Abstract

The location and migration of cloud, land and water features were examined in spectral space (reflective VIS vs. emissive IR). The 3 Jul 78 daytime HCMM data showed two distinct types of cloud affected pixels in our south Texas test area. High altitude cirrus and/or cirrostratus and "subvisible cirrus" (SCi) reflected the same or only slightly more than land features. In the emissive band, the digital counts ranged from 1 to over 75 and overlapped land features. Pixels consisting of cumulus clouds, or of mixed cumulus and landscape, clustered in a different area of spectral space than the high altitude cloud pixels. Cumulus affected pixels were more reflective than land and water pixels. On 15 Aug 78 the high altitude clouds and SCi were more emissive than similar clouds were at the earlier date. They merged indistinguishably with the land cluster, although cloud affected pixels were less emissive than most land features.

Cursory examination was made of four-channel TIROS-N data with the objective of developing a multispectral screening technique for removing SCi contaminated data. The task is complicated by the noise in the mid-infrared channel 3 (3.55 to 3.93 um) of TIROS-N.

17. Key Words (Selected by Author(s))

Heat Capacity Mapping Mission, HCMM, Clouds, Cloud Screening, Terrestrial Reflectance, Terrestrial Radiation, Atmospheric Sounding

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TYPE II QUARTERLY PROGRESS REPORT

Report Number 3
June 5, 1981 to September 5, 1981

A. Problems:

None

B. Accomplishments:

1. Location and Migration of Cloud and Landscape Features in Spectral Space.

The information presented here regarding the positions of cloud, land and water features in spectral space (reflective vs. emissive) improves the understanding of HCMM data. Similar methods should apply to other satellite data.

The relationships on 3 Jul 78 of VIS (reflective) to IR (emissive) for the 100,000 pixels of our south Texas test area are shown in the upper portion of Fig. 1. It is apparent from the densities of symbols that land and water features formed clusters. The large cluster represents mainly land features. The small cluster at the bottom center of the figure with low reflectivity is water of the Gulf of Mexico.

The lightest plotting symbol represents VIS vs. IR combinations that experienced one or two pixels having a common combination. The boldness of the symbols increases with increasing number of pixels sharing the same position in spectral space. The cores of the land and water clusters are plotted with the darkest symbol which represents over 90 pixels sharing the same VIS vs. IR combination.

The scattered pixel locations in Fig. 1 (upper) represent clouds or cloud contaminated pixels. They constitute 18.8% of the pixels on this day, 3 Jul 78.[1]

There were apparently two major cloud types. Pixels of one cloud type had low reflectivity--in the same range or a little greater than that of land features. Their emissivities ranged from very low digital counts (cold) to nearly those of the warm terrain. The tail to the left of the land cluster in Fig. 1 (upper) came from high altitude visible and "subvisible" clouds.

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[1] Wiegand, C. L., et al. Plant Cover, Soil Temperature, Freeze, Water Stress, and Evapotranspiration Conditions. Type III Final Report prepared for Goddard Space Flight Center. February 1981.

The HCMM VIS image of 3 Jul 78 showed a continuous cloud layer covering approximately 4% of the test area. Its shadow indicated that it was high altitude. The matching IR image revealed a cloud area of considerably greater extent than the VIS showed. The visible cloud area was surrounded by a transparent fringe which fits a classification we refer to as "subvisible cirrus" (SCi). Besides thin cirrus, our SCi classification includes thin cirrostratus, and even remnants of cirrocumulus which are not readily apparent in the VIS scene.

The positions in spectral space of selected cloud, land and water features are shown in the lower portion of Fig. 1. In Table 1, the symbols identifying the features are defined, the number of sample replications, and the number of pixels per sample are given. Where the modified cluster analysis[1] indicated that a candidate land or water feature was cloud covered, it was omitted from consideration, reducing the replications of that feature. In some cases similar spectral values for features caused overprinting.

High altitude inland clouds that were apparent in the VIS scene are identified by five V's (two pair are overprinted near the left axis). The V's and U's were from the thin cloud areas that were barely discernible surrounding the more apparent high altitude clouds. These fit our SCi classification. It is obvious from Fig. 1 (lower) that reflectance of these targets was approximately the same as land areas. However the VIS image and low IR values indicate that while land features could be seen through the thin clouds the thermal information about the land surface was lost by absorption and reradiation in the SCi layer.

The second cloud type consisted of scattered cumulus clouds with strong VIS band response. These are prevalent in our test area, especially near the coast, during the summer months. Figure 1 (upper) shows that pixels with this type contamination had reflectivities ranging from those of the upper limit of land features to very reflective. The associated emittances ranged mainly from 40 to 120 digital counts.

Selected pixels consisting entirely of cumulus clouds are identified as C's in spectral space in Fig. 1 (lower). Three of the five had VIS values of 150 digital counts and the other two were also highly reflective. The many pixels scattered in spectral space between these high values and land features (Fig. 1, upper) were part cumulus cloud and part land or water. Pixels of scene component mixtures are likely given the resolution of HCMM and the relatively small area of individual cumulus clouds. The trend in Fig. 1 (upper) of the scattered points that increase in emissive DC and decrease in reflective DC is explained by the increasing contribution of land area to the pixels as the cloud contribution decreases.

Cumulus cloud shadows represented by S's plotted below the land cluster (Fig. 1, lower), provided the lowest reflectances of the scene except for water bodies. Inland cloud shadows, from high clouds identified by H's, fell on the low edge of the land cluster but above the cumulus shadows. The H farthest to the left in the figure appears to have been under the influence of SCi.

Land. The most reflective land feature on 3 Jul was Padre Island dune sand, P's of Fig. 1 (lower). The next most reflective land feature was the dryland sorghum, D's, which was mature or had been harvested by this date. The warmest feature was nonirrigated buffelgrass, G's, on an inland ranch.

Water. The tight cluster of W's in the lower portion of the figure and identification in Table 1 confirms that the concentrated small cluster in the upper part of the figure was water of the Gulf of Mexico. Inland water bodies "A" were more reflective due to suspended solids, and slightly warmer on 3 Jul than the Gulf of Mexico.

Migration in Spectral Space. Figure 2 shows that on 15 Aug 78 clouds were at a different location in spectral space than on 3 Jul. The tail to the left of the land cluster is missing. The SCi clouds represented by U's and V's were much warmer than the SCi on 3 Jul, being difficult to separate from the land cluster. Their VIS values were very similar to land features.

An essentially cloud free winter day, 7 Feb 79, is shown in spectral space by Fig. 3. Cluster screening identified 0.2 percent clouds in the test area on this date. Obviously the land and water features were colder than they had been during the summer. Comparisons among figures show that the land cluster was more compact in winter than summer. This is reasonable considering the lower irradiation levels at this time of year to emphasize feature differences.

2. Multispectral Examples of Subvisible Cirrus.

Subvisible cirrus (SCi) cloud contamination has been found in TIROS-N data of 6 May 79 for our south Texas test area. Selected targets representing cloud, land and water features have been examined and multispectral transects have been made across SCi affected areas.

Channel 3 of TIROS-N (mid-infrared, 3.55 to 3.93 um) data are noisy, with some scan lines noticably more noisy than others. It remains to be seen whether the noise will prevent us from removing SCi contaminated pixels in TIROS-N data by multispectral analysis.

C. **Significant Results:**

None

D. **Publications:**

None

E. **Recommendations:**

Recommendations will be made when this study has progressed farther.

G. Data Utility:

We are using the same HCMM data sets for this study as were used for the initial HCMM contract. The data are of good quality. Examples of subvisible cirrus clouds (SCi) have been found in TIROS-N data. Noise in channel 3 (3.55 to 3.93 um) may prevent using TIROS-N data to develop a multispectral screening method for removing SCi contamination.

Table 1. Identification of selected cloud, land and water features that are shown by letters in Figures 1, 2 and 3.

SYMBOL	NUMBER OF SAMPLE SITES	NUMBER OF PIXELS PER SAMPLE	SITE IDENT. IF APPLICABLE	IDENTIFICATION
A	4	1	111,621,821,931	INLAND WATER BODIES
C	5	1		COASTAL CLOUDS
K	5	1		INLAND CLOUDS
D	2	5X5	421,422	DRYLAND SORGHUM
G	2	3X3	121,213	BUFFELGRASS(NONIRRIGATED)
I	3	9X9	533,631,633	MIXED IRRIGATED CROPS
M	2	3X3	531,731	CITIES,HARLINGEN,MCALLEN
O	1	3X3	701	OAK TREES,EXTENSIVE GROVE
P	3	1	801	PADRE ISLAND DUNE SAND
R	3	9X9	214,312,501	RANGELAND
S	5	1		COASTAL CLOUD SHADOWS
H	5	1		INLAND CLOUD SHADOWS
T	2	3X3	424,632	IRRIGATED CITRUS
U	5	3X3		INLAND SUBVISIBLE CIRRUS
V	5	3X3		COASTAL SUBVISIBLE CIRRUS
W	1	3X3	901	GULF OF MEXICO WATER

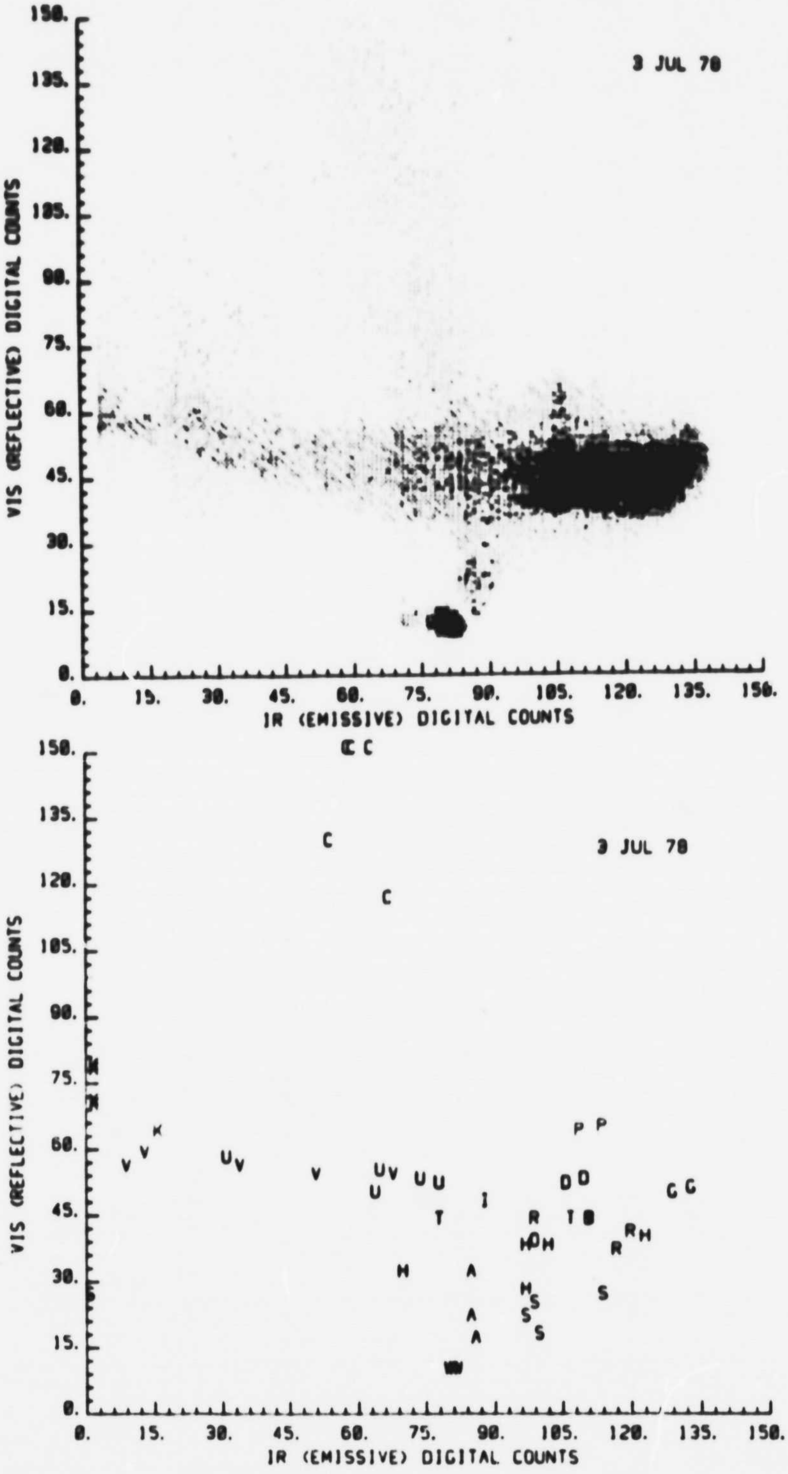

Figure 1. Location of 100,000-pixel south Texas test area in spectral space on 3 Jul 78 (upper illustration). Location of selected cloud, land and water features in spectral space on 3 Jul 78 (lower illustration). Consult Table 1 for identification of letters.

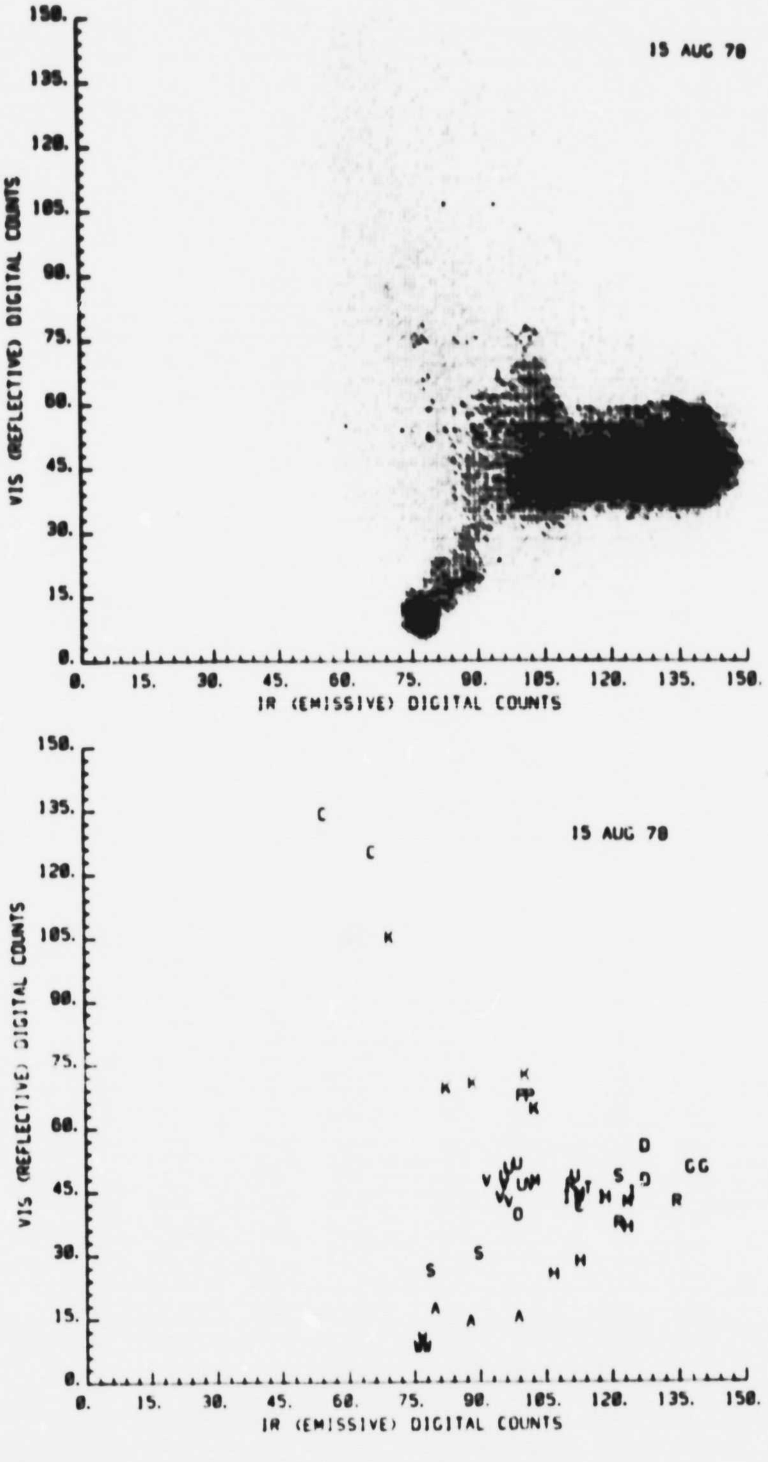

Figure 2. Location of 100,000-pixel south Texas test area in spectral space on 15 Aug 78 (upper illustration). Location of selected cloud, land and water features in spectral space on 15 Aug 78 (lower illustration). Consult Table 1 for identification of letters.

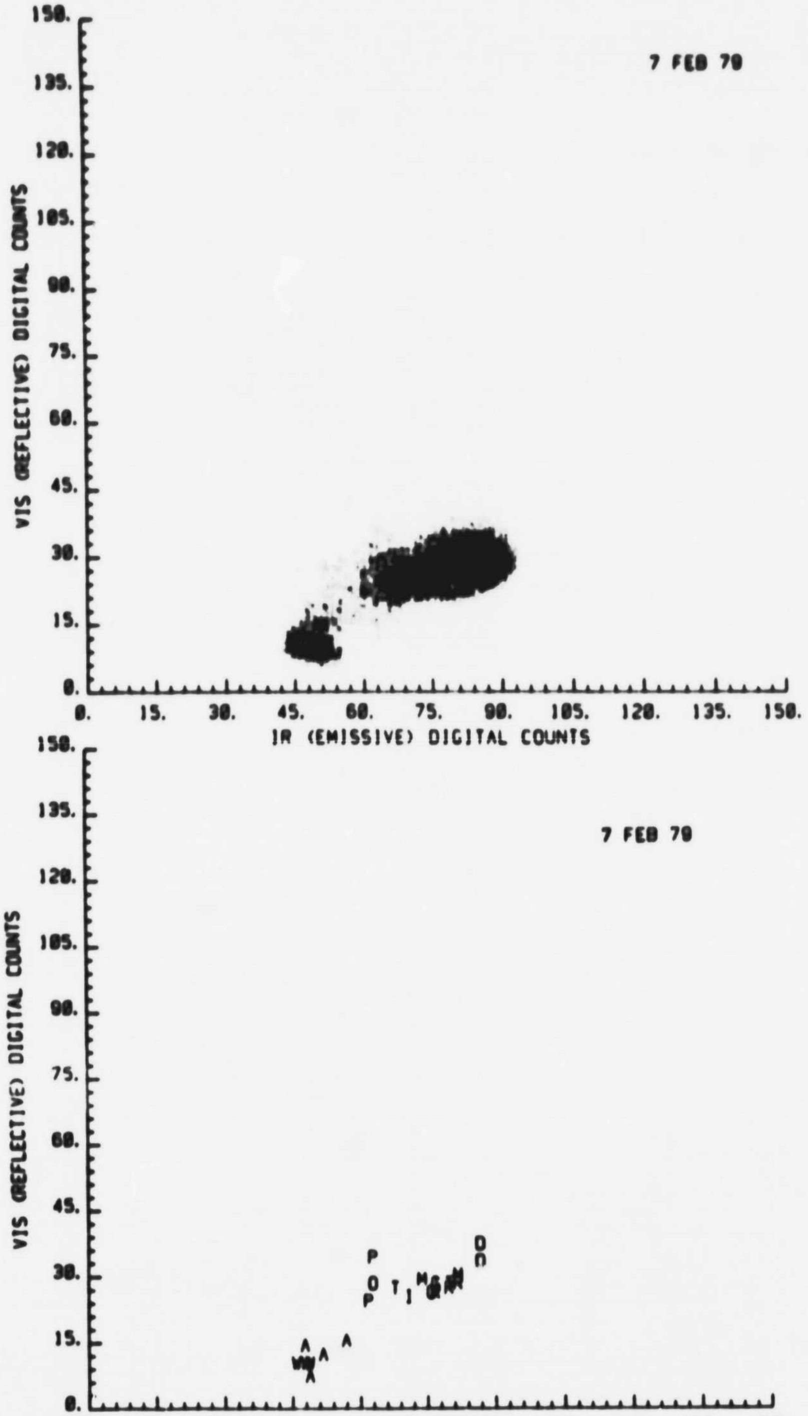

Figure 3. Location of 100,000-pixel south Texas test area in spectral space on 7 Feb 79 (upper illustration). Location of selected cloud, land and water features in spectral space on 7 Feb 79 (lower illustration). Consult Table 1 for identification of letters.