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

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16. Abstract

Subvisible cirrus clouds (SCi) were easily distinguished in mid-infrared (MIR) TIROS-N daytime data from south Texas and northeast Mexico. The MIR (3.55-3.93 μm) pixel digital count means of the SCi affected areas were more than 3.5 standard deviations on the cold side of the scene means. (These standard deviations were made free of the effects of unusual instrument error by factoring out the Ch 3 MIR noise on the basis of detailed examination of noisy and noise-free pixels). SCi affected areas in the IR Ch 4 (10.5-11.5 μm) appeared cooler than the general scene, but were not as prominent as in Ch 3, being less than 2 standard deviations from the scene mean. Ch 3 and 4 standard deviations and coefficients of variation are not reliable indicators, by themselves, of the presence of SCi because land features can have similar statistical properties.

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TYPE II QUARTERLY PROGRESS REPORT

Report Number 5
December 5, 1981 to March 5, 1982

A. Problems:

Slow progress in locating suitable data for analysis.

B. Accomplishments:

1. Satellite Mid IR Channel Clearly Detects Subvisible Cirrus Clouds

Absorbing-emitting atmospheric layers that are essentially transparent in the visible wavebands commonly occur in our south Texas and northeastern Mexico test area, especially in the summer months. We refer to these layers as subvisible cirrus (SCi).

Examination of the TIROS-N 06 May 79 daytime test area scene on a I^2S Image Processing System showed the presence of SCi as areas of colder than expected temperatures in Channel (Ch) 3 (3.55-3.93 µm) and Ch 4 (10.5-11.5 µm) data. These SCi areas were centered at 98.7°W longitude, 25.4°N latitude in Mexico, and 98.6°W, 27.3°N in Texas. Except for SCi, the test area had no clouds.

A problem with TIROS-N has been noise in Ch 3 data. Display of Ch 3 on the image processing system showed the expected features of a mid-infrared (MIR) scene. However, close inspection revealed noise characterized by one or more "noise-free" scan lines followed by noisy lines, followed by noise-free lines, etc. By noise-free, we mean free of unusual instrumentation errors. The noise-free and noisy lines did not generally prevail across the entire scene, but frequently changed from one class to the other, one or more times along the scan. To test if Ch 3 could be used in our study of SCi, we identified a noise-free 140 pixel area in the Gulf of Mexico for comparison with a nearby 450 pixel noisy area. The mean Channel 3 counts were 625.2 and 620.0, respectively; not greatly different, considering the possible effect of Gulf currents. A similar comparison of adjacent noise-free and noisy Ch 3 data in Texas (each less than 76 pixels) gave means of 456.8 and 459.0. These suggest that mean values for a given landscape feature are representative of the feature whether they come from noise-free, mixed or noisy data, provided the sample is large enough. However, the standard deviations did vary markedly between noise-free and noisy data. They were 10.6 and 62.6 counts, respectively, for the Gulf of Mexico, and 18.8 and 78.0 for the land area.

The relation of TIROS-N data from selected areas of south Texas and northeastern Mexico to the scene as a whole is shown in Fig. 1. The four axes represent the channels of satellite data, and are identified by channel number. Digital counts for the various channels increased from the center of figure outward (64 counts/in for Ch 1 and Ch 2, 160 counts/in for Ch 3 and Ch 4). The lines and shading between axes have no meaning except to guide the eye from comparable data in one channel to that in another.

The shaded area represents all data of the study area (over 170,000 pixels) that fall within ± 2 standard deviations of the mean. The standard deviations of "noise-free" Ch 3 for the scene and areas of interest were estimated by prorating on the basis of 65% of the available data being noisy, according to the characteristics discussed above for the land area.

Shown in the figure are mean digital counts from SCi affected areas in Mexico and Texas, and their corresponding nearby nonaffected areas. Each of these four areas exceeded 700 pixels. In Ch 1 (0.55-0.90 µm) and Ch 2 (0.725-1.10 µm) the SCi and clear areas all fell well within the ± 2 standard deviations of the entire area.

In Ch 3, the non-SCi-affected areas fell in the center of the shaded area indicating that they were close to the mean of that channel for the entire test area. However, in Ch 3, the SCi areas in Mexico and Texas were very different from the other features, being more than +3.5 standard deviations from the scene mean. Clearly, the MIR (Ch 3) distinguished the SCi condition from the non-SCi-affected land features.

In Ch 4, the non-SCi-affected area was close to the mean of the Texas-Mexico test area. However, it can be seen in Fig. 1 that the SCi areas were indicated as colder than the test area mean, but deviated from it by less than 2 standard deviations.

2. Coefficient of Variation is Unreliable Indicator of Subvisible Cirrus Clouds

Examination of thermal pixel values of a HCMM south Texas scene for the freeze night of 03 Jan 79 showed that in subvisible cirrus cloud (SCi) affected areas, the standard deviations and the ratios of standard deviations to the means were small in comparison with those in clear non-SCi areas (Wiegand, C. L., et al.)[1].

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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.

These differences were not as prominent in an investigation of TIROS-N daytime data of SCi and clear areas in Texas and Mexico (first four data columns of Table 1, same areas discussed in previous section). While the MIR (Ch 3) and IR (Ch 4) showed less variability in the SCi areas than their adjacent clear areas, the difference was slight in the Ch 4 Texas data. Furthermore, in Ch 4, the standard deviation and coefficient of variation were greater in the SCi area of Mexico than the clear area of Texas (both part of the same satellite scene). The Ch 3 standard deviations of Texas clear and Mexico SCi are quite similar. Thus, use of standard deviations or coefficients of variation must be discarded as a method, in itself, of screening for SCi.

C. Significant Results:

Subvisible cirrus (SCi) cloud conditions can be distinguished from non-SCi conditions in meteorological satellite mid-IR (3.55-3.93 μm) data.

D. Publications:

None

E. Recommendations:

None

F. Funds Expended: (through 28 Feb 1982)

Allotment for FY 82 ----------------------------

Location and indirect program costs----
Salaries ------------------------------
Travel and transportation -------------
Transportation of things --------------
Services, supplies and equipment -----

Total expenditures --------------------------

Balance

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 Ch 3 (3.55-3.93 μm) caused problems in the investigation of SCi screening methods. The mean pixel values of TIROS-N Ch 3 data appear to be approximately correct, as the errors seem to be distributed about the true mean.

Table 1. Spectral charrcteristics of selected features of a 06 May 79 TIROS-N scene.

	Texas		Mexico		Gulf of Mexico	Southeast Colorado		
	SCi	Clear	SCi	Clear		Cloud	C.Shadow	Clear
				Channel 1 (0.55-0.90 um)				
Mean	125.3	127.7	111.1	119.8	56.8	281.8	76.6	148.3
Mode	124.0	128.0	108.0	112.0	56.0	276.0	68.0	148.0
Median	124.7	127.6	109.6	116.9	56.5	286.0	73.2	147.9
Std. dev.	5.24	4.40	11.56	11.88	1.60	51.04	9.08	3.83
Coef. of var.[1]	.042	.034	.104	.099	.028	.181	.119	.026
No. of pixels	1157	1168	702	956	816	46	41	65
				Channel 2 (0.725-1.10 um)				
Mean	158.2	155.1	141.3	141.0	48.0	279.4	74.0	159.6
Mode	156.0	156.0	136.0	136.0	48.0	304.0	64.0	156.0
Median	157.4	155.2	140.3	139.5	48.0	282.0	70.0	158.5
Std. dev.	7.16	5.92	13.20	12.00	.56	45.12	10.52	4.76
Coef. of var.	.045	.038	.093	.085	.012	.162	.142	.030
No. of pixels	1157	1168	702	956	816	46	41	65
				Channel 3 (3.55-3.93 um)				
Mean	439.7	287.3	506.2	295.0	625.2	559.3	522.2	200.7
Mode	432.0	320.0	532.0	324.0	632.0	380.0	532.0	188.0
Median	442.8	289.1	512.4	304.8	625.6	565.6	530.8	197.0
Std. dev.[2]	17.36	22.48	21.64	33.88	9.36	22.36	12.36	12.52
Coef. of var.	.040	.078	.043	.115	.015	.040	.024	.062
No. of pixels	1157	1168	702	956	816	46	41	65
				Channel 4 (10.5-11.5 um)				
Mean	383.5	339.2	408.7	344.4	443.4	730.7	400.1	335.3
Mode	384.0	340.0	416.0	352.0	444.0	796.0	396.0	328.0
Median	382.6	337.1	406.4	342.1	443.6	758.0	397.4	332.0
Std. dev.	7.88	8.52	17.00	20.32	1.72	75.84	22.12	10.20
Coef. of var.	.021	.025	.042	.059	.004	.104	.055	.030
No. of pixels	1157	1168	702	956	816	46	41	65

[1] All coefficients of variation in this table are expressed as decimal fractions.

[2] Standard deviation adjusted by removal of estimated instrumentation noise.

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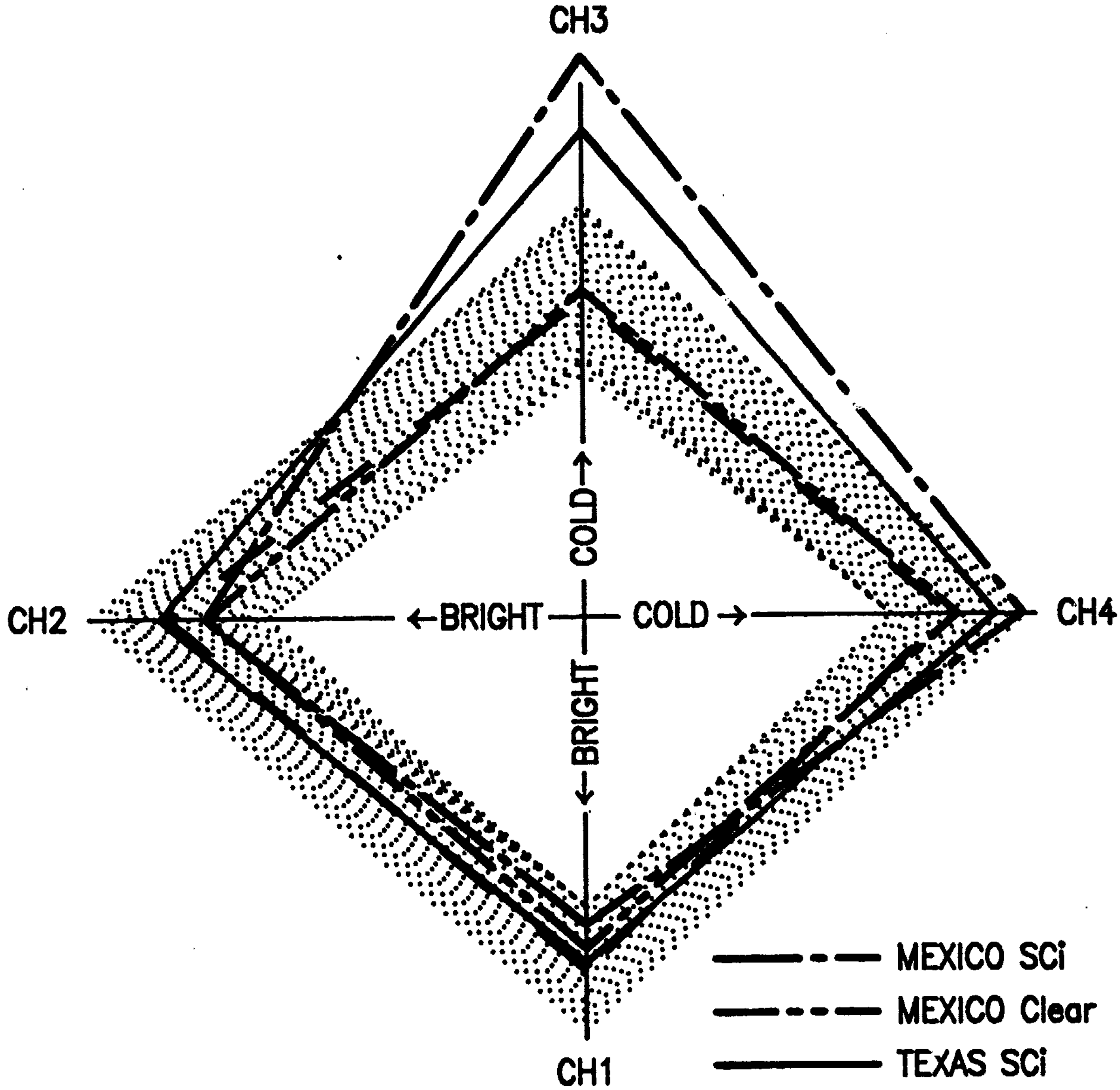

Fig. 1. Mean digital values in four spectral channels (Ch) of clear and subvisible cirrus (SCi) affected areas, and the range of values between ± 2 standard deviations (shaded) in the 170,000 pixel test area of south Texas and northeast Mexico. TIROS-N daytime 06 May 79.