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THEMATIC MAPPER STUDIES BAND CORRELATION ANALYSIS

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April 1976



GODDARD SPACE FLIGHT CENTER

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**THEMATIC MAPPER STUDIES
BAND CORRELATION ANALYSIS**

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GISS THEMATIC MAPPER BAND CORRELATION STUDY

Spectral data representative of Thematic Mapper candidate bands 1 and 3-7 were obtained by selecting appropriate combinations of bands from the JSC 24-Channel Multispectral Scanner, as indicated in Table 1. These data represent a rather limited, but nevertheless diversified set of crop conditions as indicated in Table 2. Of all the bands assigned, only candidate bands 4 (.74 μ - .80 μ) and 5 (.80 μ - .91 μ) showed consistently high inter-correlation from region to region and time to time. This extremely high correlation persisted when looking at the composite data set in a multi-temporal, multi-location domain. The GISS investigations lend positive confirmation to the hypothesis advanced by DeGasparis, Tucker and others that TM Bands 4 and 5 are redundant.

JSC 24-Channel MSS data were used to construct simulated TM bands, as indicated in Table 1, for a series of interband correlation studies. Note that TM band 2 was not simulated since the 24-Channel MSS detector most closely corresponding to this wavelength range was malfunctioning. The data used in these studies were acquired along a flight line selected from each of the four dates (two Intensive Test Sites). These data were considered in joint investigations into spatial degradation conducted by LARS, Earth Resources Laboratory (ERL) and GISS. A breakdown of the dates and sites, indicating the number of pixels, amount of area and crop mix is given in Table 2.

Shadowing and look angle effects tend to introduce correlations into the data which are not inherent in the ground scenes. In order

SIMULATION OF THEMATIC MAPPER BANDS WITH JSC 24-CHANNEL MSS

PROPOSED THEMATIC MAPPER		24 CHANNEL MSS
BAND	RANGE (μ)	RANGE USED
1.	.45 - .52	.46 - .50
3.	.63 - .69	.64 - .68
4.	.74 - .80	.76 - .80
5.	.80 - .91	.82 - .87
6.	1.55 - 1.75	1.52 - 1.73
7.	10.4 - 12.5	{ 10.1 - 11.0 11.0 - 12.0

TABLE 1.

CHARACTERISTICS OF SITES STUDIED WITH 24-CHANNEL MSS DATA

<u>DATE/SITES</u>	<u>NO. OF PIXELS</u>	<u>AREA</u>	<u>ESTIMATED CROP MIX OF TEST SITE COVERED</u>
Finney Co., KS 6-9-75 Flight Line # 1	1,544,200	19.39 sq. mi.	Wheat (24%) Alfalfa (18%) Recently Planted (40%) Summer Fallow (12%) Other (6%)
Williams Co., ND 6-22-75 Flight Line # 2	1,384,600	17.38 sq. mil	Wheat (35%) Grass/Pasture (21%) Summer Fallow (32%) Other (11%)
Finney Co., KS 7-6-75 Flight Line # 1	1,764,000	22.15 sq. mi.	Wheat (24%) Alfalfa (18%) Corn (19%) Grain Sorghum (21%) Fallow (12%) Other (6%)
Williams Co., ND 8-15-75 Flight Line # 2	1,314,600*	16.5 sq. mi.	Wheat (35%) Grass/Pasture (21%) Summer Fallow (32%) Other (11%)

*The three segments composing this flight line are populated as follows:

Part	I	438,200 pixels
	II	438,200 pixels
	III	438,200 pixels

TABLE 2

to compensate for this, unit color-vectors were constructed for each pixel by the following formula:

$$N'_i = N_i / \sqrt{\sum_{j=1}^n N_j^2}$$

where N'_i is the *normalized* count in the i th band. Correlation studies were conducted using both the raw and normalized (albedo compensated) data. Figures 1 through 4 represent results on a site by site and date by date basis. Note that except for cases of extremely high correlation the unit-vector representation tends to lower interband correlation (and strengthen anti-correlation) by removing some of the systematic variation in apparent albedo due to causes other than changes in ground reflectance (e.g., look angle effects, variation in instrument voltages). The albedo compensated correlations are more indicative of band redundancy than the uncompensated correlations.

The correlation coefficient in these figures was derived in the customary manner assuming linear interband relations:

$$r_{ij} = \frac{n \sum_{k=1}^n N_i^k N_j^k - \sum_{k=1}^n N_i^k \sum_{k=1}^n N_j^k}{\sqrt{n \sum_{k=1}^n \{(N_i^k)^2\} - \left\{ \sum_{k=1}^n N_i^k \right\}^2} \sqrt{n \sum_{k=1}^n \{(N_j^k)^2\} - \left\{ \sum_{k=1}^n N_j^k \right\}^2}}$$

In order to examine the statistical validity of the derived correlation coefficients, each line was divided into several segments of approximately equal length. Individual segment results are presented for the August 15, Williams County flight line in Figure 5. The relative interband correlations remain completely consistent from segment to segment. This spatial consistency of

FINNEY COUNTY, KANSAS - FLIGHT LINE #1 - 6/9/75

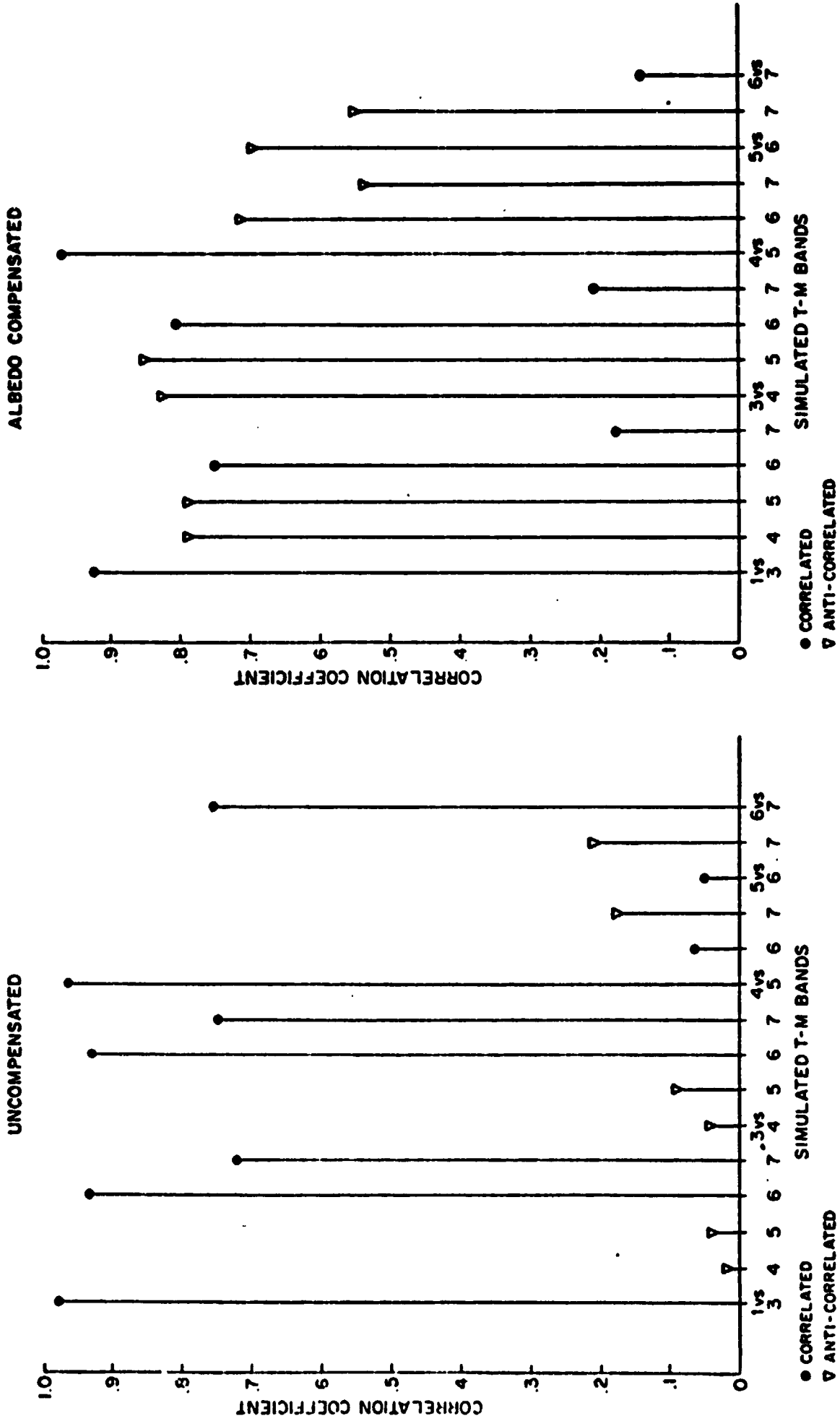


Figure 1

WILLIAMS COUNTY, NORTH DAKOTA - FLIGHT LINE #2-6/22/75

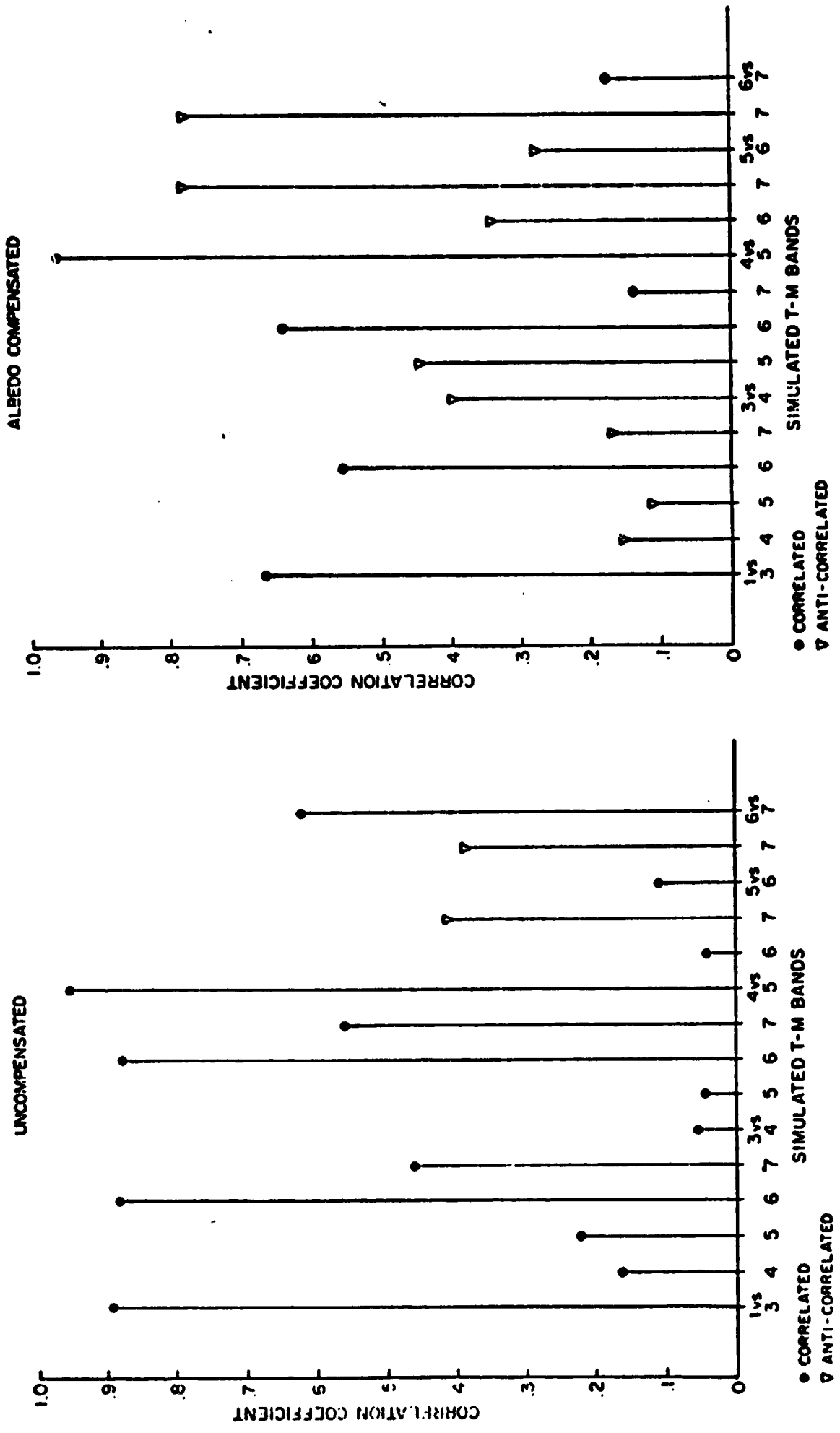


Figure 2

FINNEY COUNTY, KANSAS - FLIGHT LINE #1 - 7/6/75

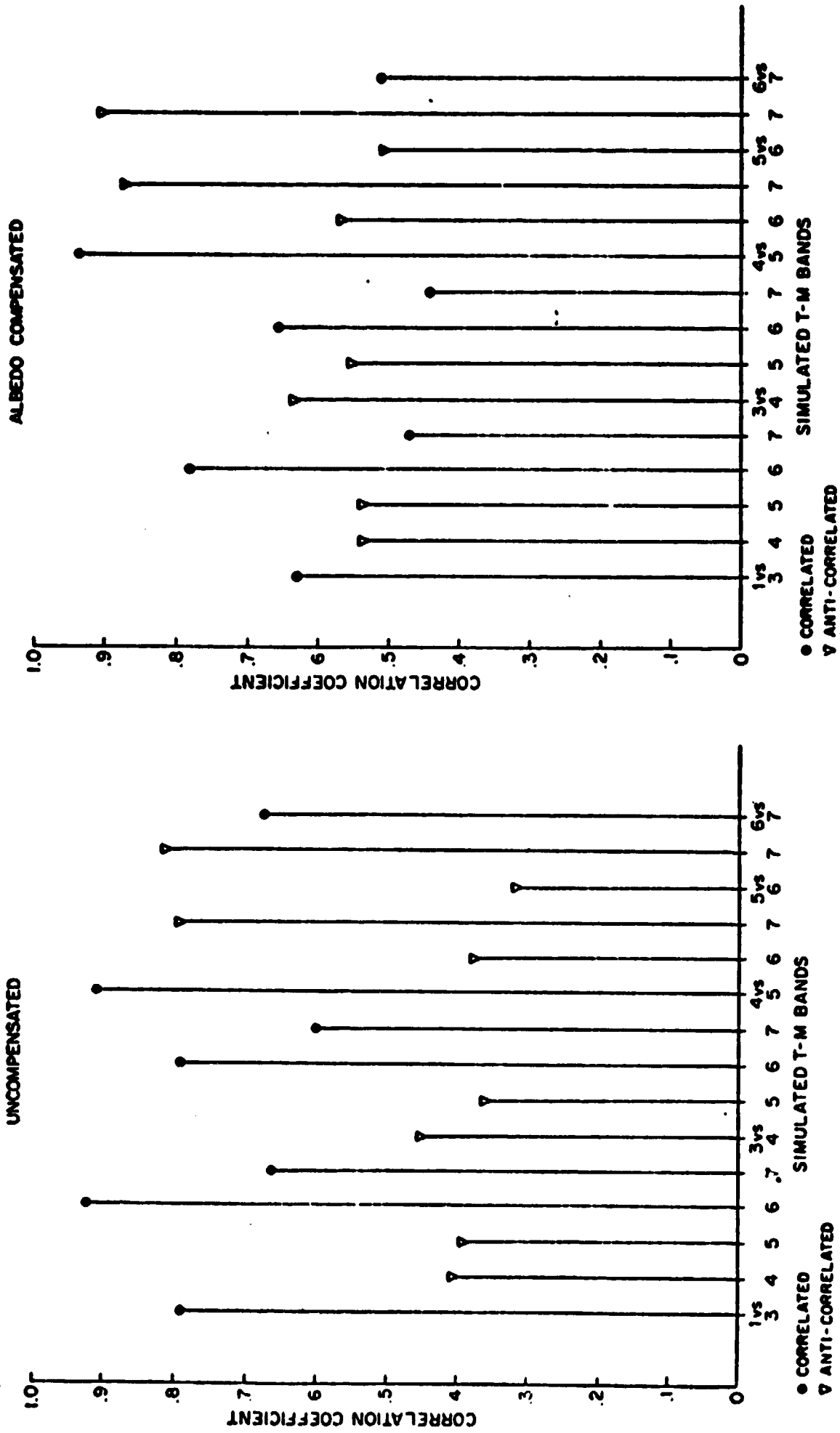
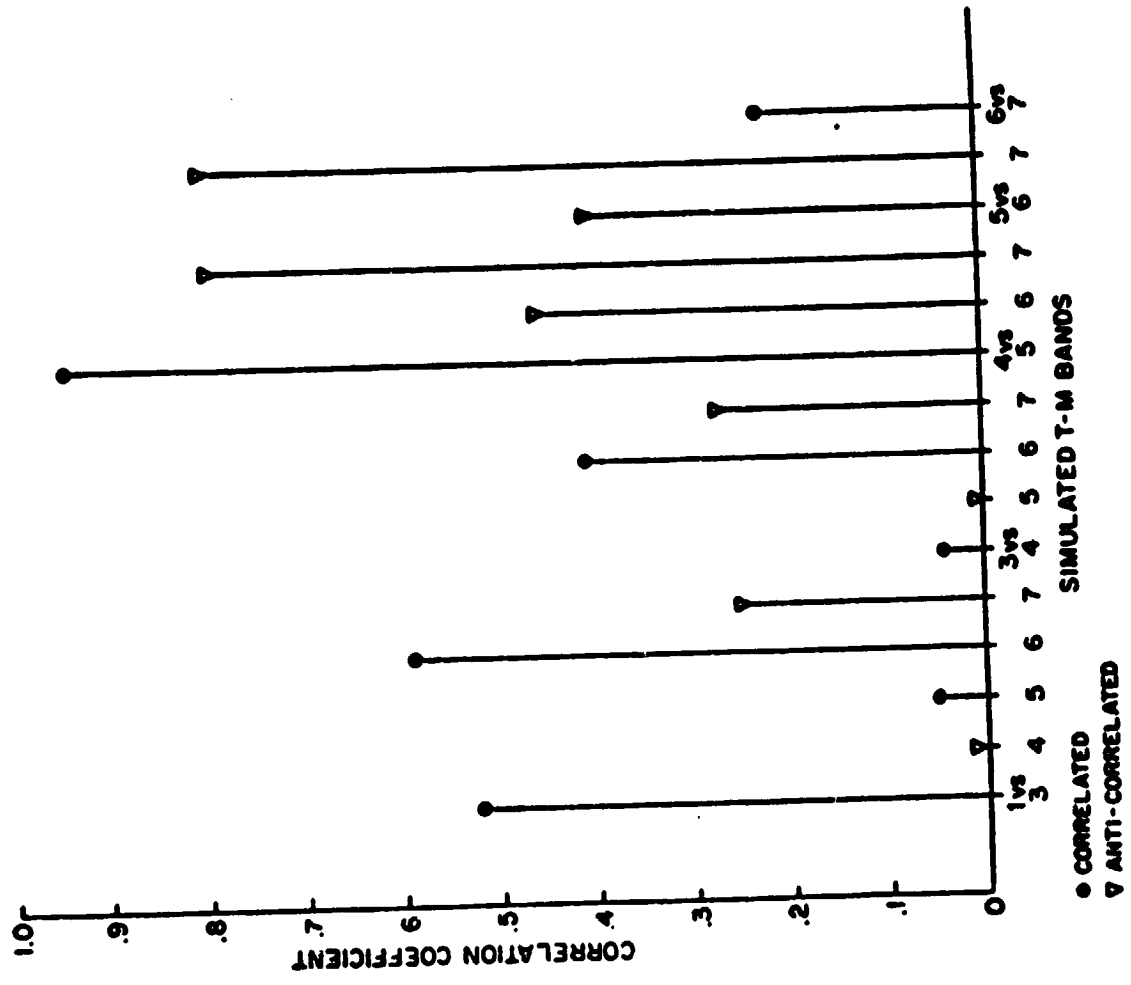


Figure 3

WILLIAMS COUNTY, NORTH DAKOTA - FLIGHT LINE #2-8/15/75

ALBEDO COMPENSATED



UNCOMPENSATED

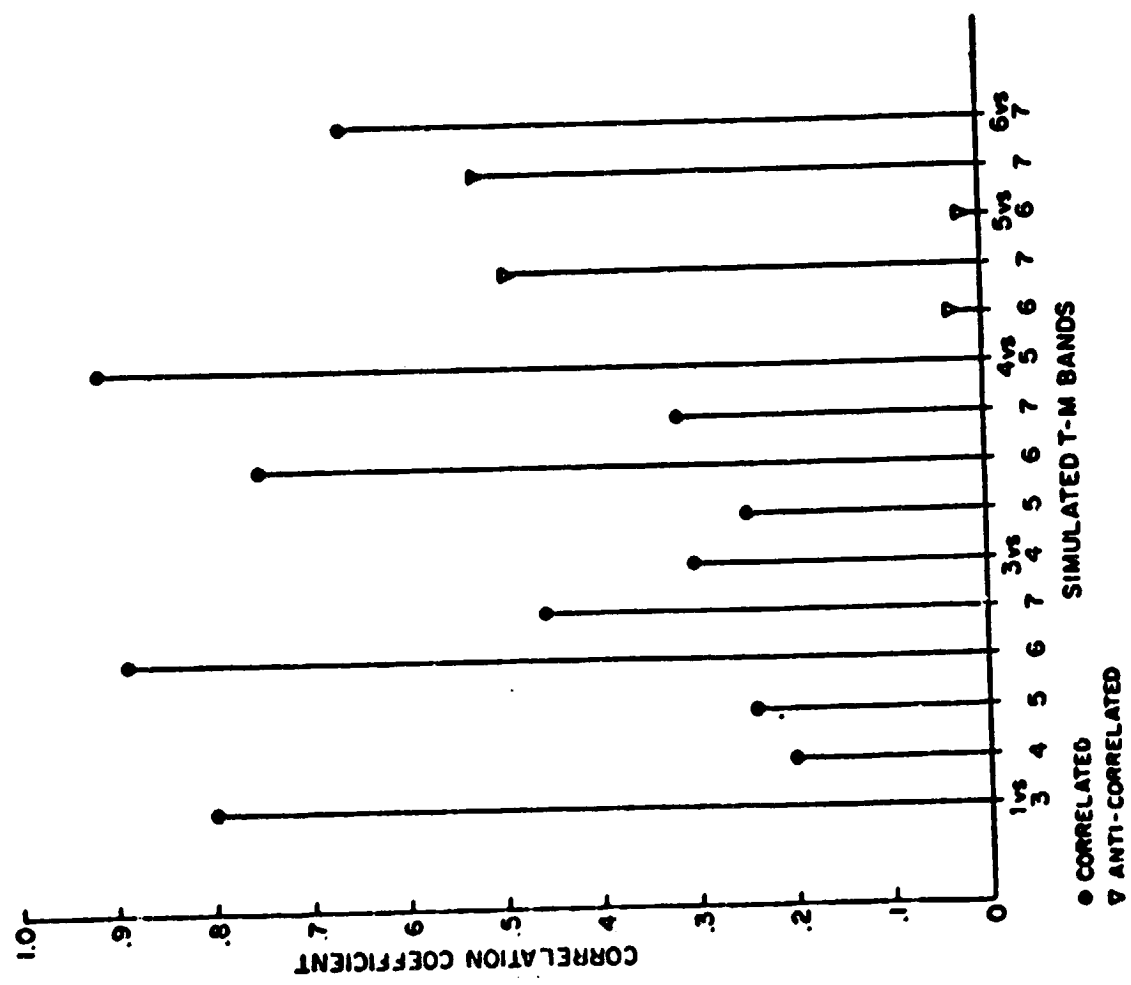


Figure 4

WILLIAMS COUNTY, N.D. - FLIGHT LINE #2 - 8/13/75

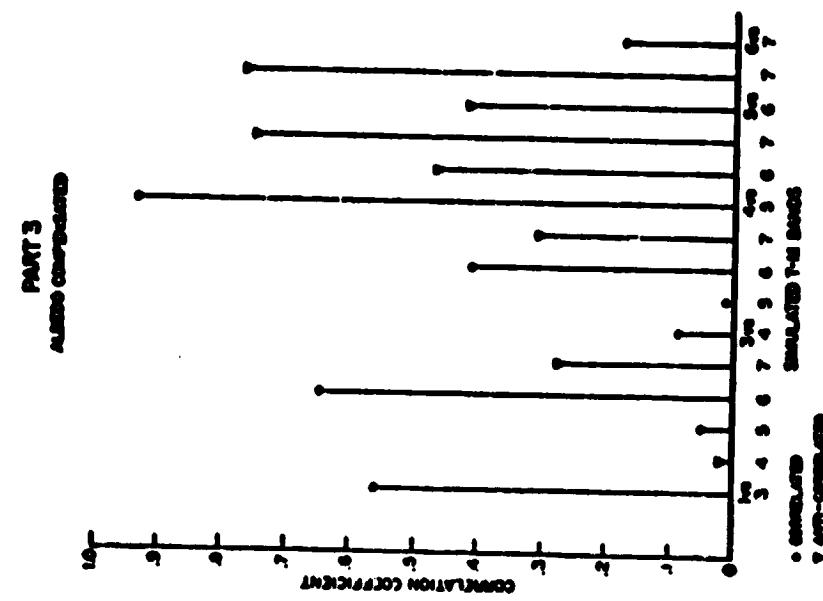
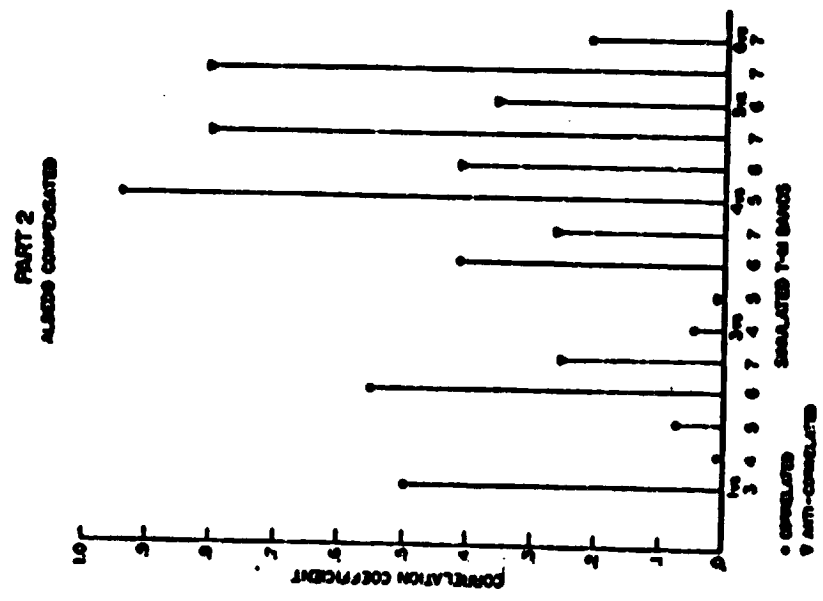
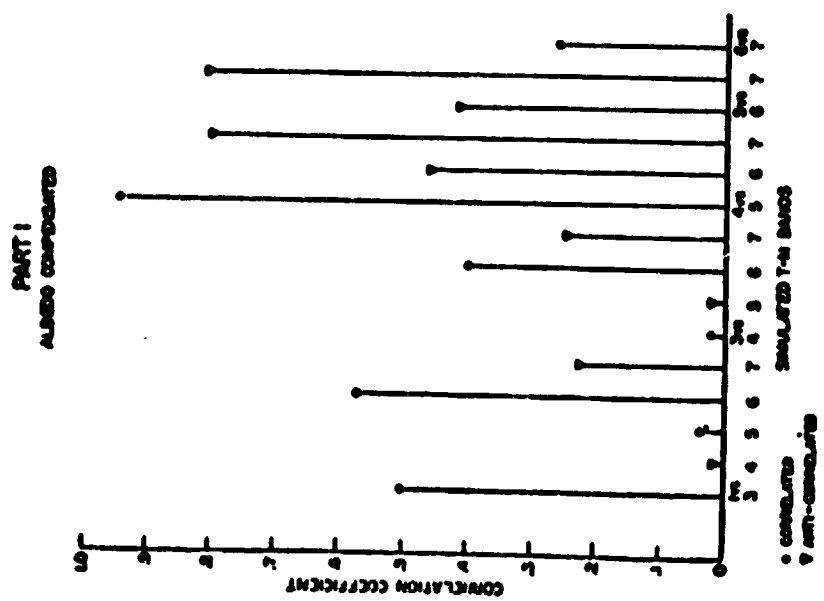


Figure 5

results was also present among the four segments of the July, Finney County flight line. However, the June 9, Finney County flight line and the June 22, Williams County flight line each displayed one anomalous segment. In both instances the segments contained appreciable cloud cover as compared to the uniformly cloud free condition for all other areas considered in this study.

The effect of cloud cover and shadow on interband correlation will be the subject of a future report.

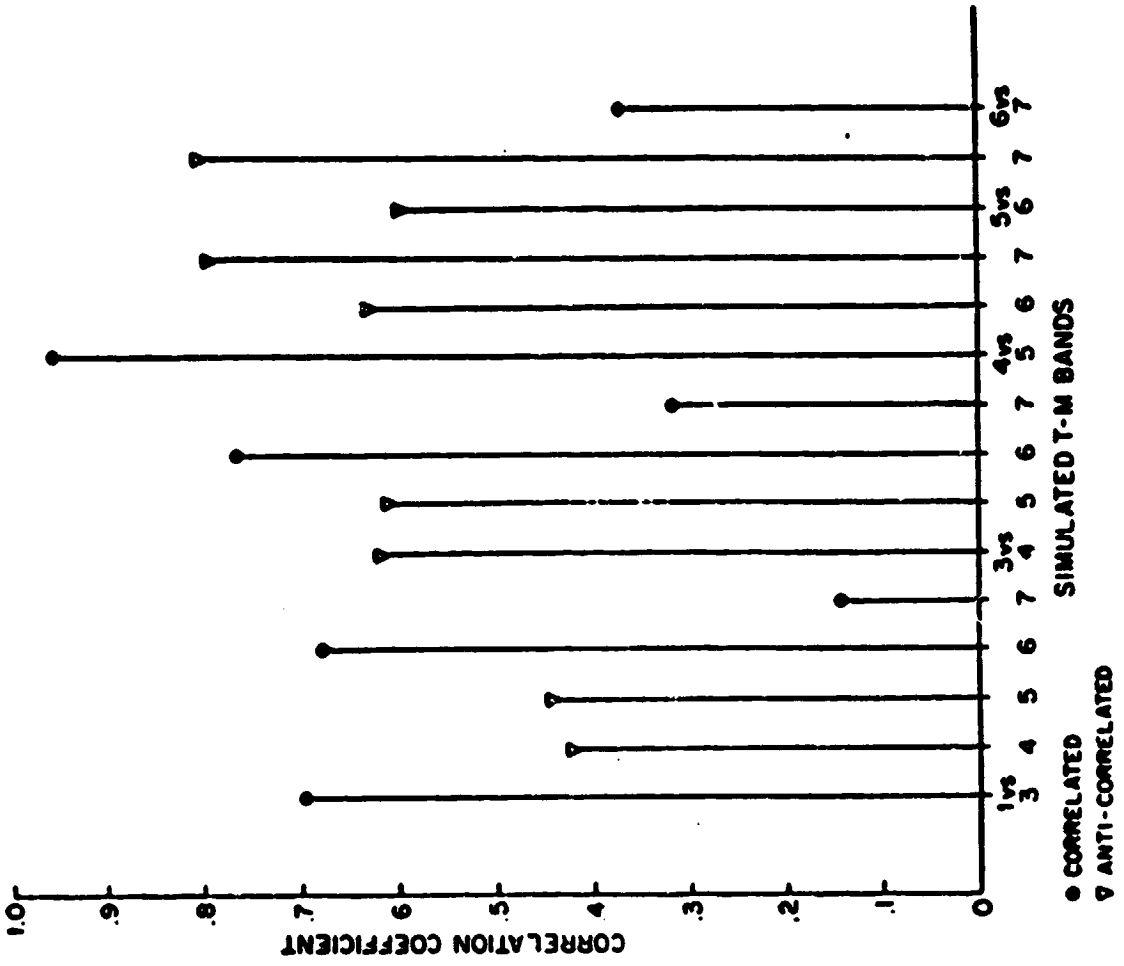
Figure 6 represents the multi-geographic, multi-temporal data set formed by the union of all 4 data sets in the study. This data set is composed of some six million pixels representing crops such as spring and winter wheat, corn, grain sorghum, alfalfa and pasture at up to five stages of maturity.

Conclusions:

Arguments appearing in a GSFC report dated December, 1975 issued by J. Harnage through ERPO conclude that Thematic Mapper Bands 4 and 5 are highly redundant. These findings are based on laboratory and field spectra obtained under a highly restrictive set of conditions. Although these arguments are convincing when taken in context, they constitute a hypothesis when extrapolated to a multi-spectral scanner such as Thematic Mapper. Investigations by GISS using real MSS data under a variety of conditions may be considered an independent test of this hypothesis. Although the MSS data used represent a rather limited mix of cropping practices, the agricultural situations represented are precisely the

ALL DATA SETS COMBINED

ALBEDO COMPENSATED



UNCOMPENSATED

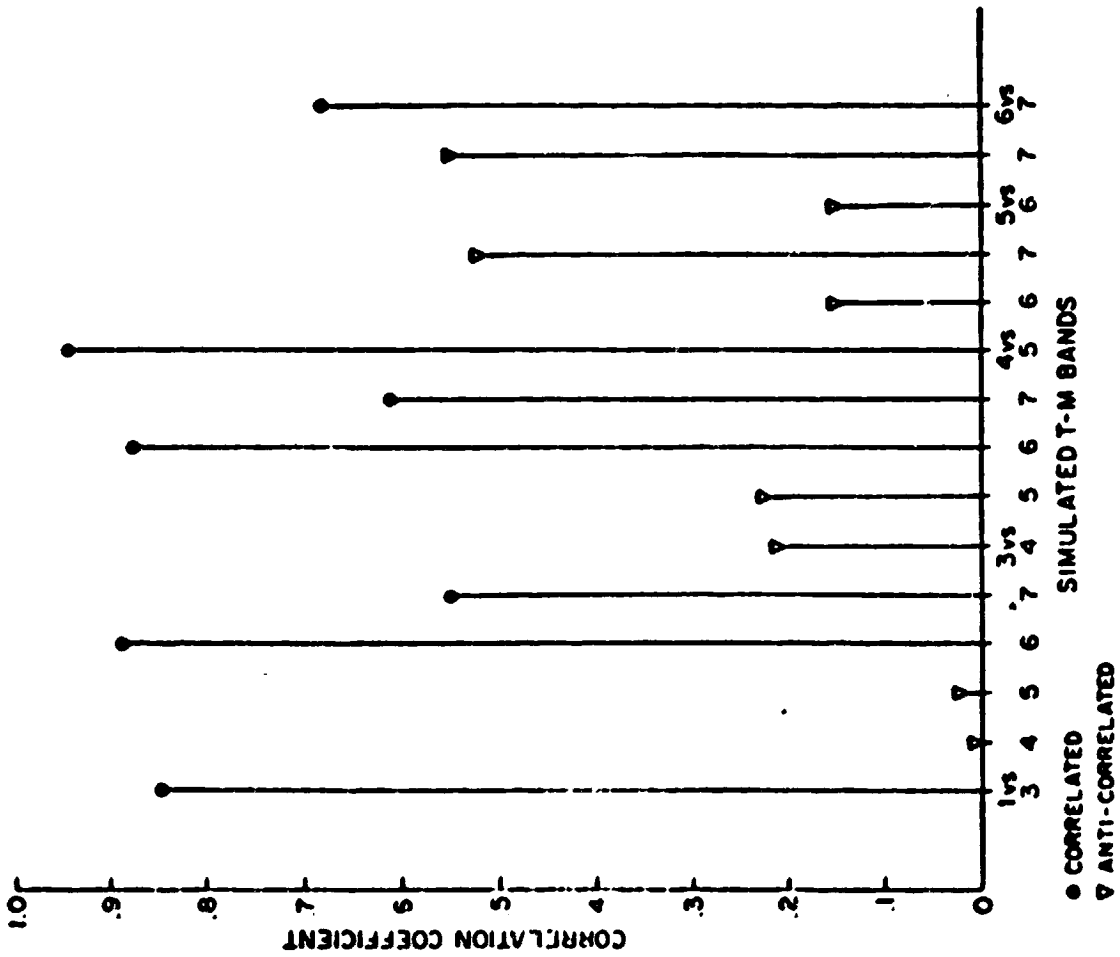


Figure 6

ones which have been heavily emphasized for consideration of Thematic Mapper design. The GISS findings are significant, and supportive of the contention that TM Bands 4 and 5 are highly redundant.

Appendix

Linear Correlation Coefficients 24 Channel MSS Data

LINE #	TM CHAN	MSS CHAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE A2: WILLIAMS COUNTY, NORTH DAKOTA. JUNE 22, 1975. FLIGHT

LINE #2. LINEAR CORRELATION COEFFICIENTS, UNCOMPENSATED DATA.

COMPARE WITH FIGURE 2 IN TEXT.

TM CHAN	MSS CHAN	20	21
1	3	0.32127	0.32127
2	3	0.45275	0.45275
3	3	0.56125	0.56125
4	6	0.41174	0.41174
5	6	0.25463	0.25463
6	8	0.61547	0.61547
7	8	0.65042	0.65042
8	9	0.84738	0.84738
9	9	0.00127	0.00127
10	12	0.95929	0.95929
11	12	0.91174	0.91174
12	12	0.93354	0.93354
13	20	0.86165	0.86165
14	21	0.07541	0.07541
15	21	0.23251	0.23251

TM CHAN	MSS CHAN	1	2	3	4	5	6	7	8	9	10	11	12
1	0	0.00000	0.51782	0.03799	0.00379	0.60399	0.13824	0.13808	0.02183	0.03270	0.11062	0.01509	0.10761
2	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
11	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24	0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

TABLE A3 (CONTINUED): FINNEY COUNTY, KANSAS. JULY 6, 1975. FLIGHT
 LINE #1. LINEAR CORRELATION COEFFICIENTS,
 ALBEDO COMPENSATED DATA.
 COMPARE WITH FIGURE 3 IN TEXT.

TM CHAN	MSS CHAN	20 & 21
1	3	0.00587
2	3	0.23222
3	6	0.69904
4	6	0.00208
5	6	0.45975
6	8	0.40574
7	8	0.80591
8	8	0.87280
9	8	0.89745
10	9	0.86879
11	9	0.73544
12	9	0.71336
13	9	0.92282
14	12	0.16389
15	12	0.00020
16	12	0.85795
17	12	0.87856
18	12	0.98504
19	20 & 21	0.94276
20	20 & 21	0.89279
21	20 & 21	0.72616
22	20 & 21	0.72616
23	20 & 21	0.75103
24	20 & 21	0.75103

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TM CHAN	MSS CHAN	1	2	3	4	5	6	7	8	9	10	11	12
1	1	0.00000	0.594268	0.481660	0.000000	0.58310	0.442080	0.288298	0.188713	0.135419	0.175893	0.389655	0.606350
2	1	0.00000	0.892301	0.822301	0.000000	0.817898	0.766445	0.421045	0.244022	0.157921	0.294670	0.653055	0.792600
3	1	0.00000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	1	0.00000	0.817898	0.799064	0.000000	0.817898	0.799064	0.541440	0.365443	0.239900	0.430787	0.637035	0.749124
5	1	0.00000	0.421045	0.382581	0.000000	0.421045	0.382581	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6	1	0.00000	0.244022	0.244022	0.000000	0.244022	0.244022	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7	1	0.00000	0.157921	0.157921	0.000000	0.157921	0.157921	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8	1	0.00000	0.294670	0.294670	0.000000	0.294670	0.294670	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9	1	0.00000	0.653055	0.653055	0.000000	0.653055	0.653055	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10	1	0.00000	0.749124	0.749124	0.000000	0.749124	0.749124	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
11	1	0.00000	0.792600	0.792600	0.000000	0.792600	0.792600	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
12	1	0.00000	0.817898	0.817898	0.000000	0.817898	0.817898	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
13	1	0.00000	0.822301	0.822301	0.000000	0.822301	0.822301	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
14	1	0.00000	0.830787	0.830787	0.000000	0.830787	0.830787	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
15	1	0.00000	0.837035	0.837035	0.000000	0.837035	0.837035	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
16	1	0.00000	0.843335	0.843335	0.000000	0.843335	0.843335	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
17	1	0.00000	0.849635	0.849635	0.000000	0.849635	0.849635	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
18	1	0.00000	0.855935	0.855935	0.000000	0.855935	0.855935	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
19	1	0.00000	0.862235	0.862235	0.000000	0.862235	0.862235	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	1	0.00000	0.868535	0.868535	0.000000	0.868535	0.868535	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21	1	0.00000	0.874835	0.874835	0.000000	0.874835	0.874835	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22	1	0.00000	0.881135	0.881135	0.000000	0.881135	0.881135	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23	1	0.00000	0.887435	0.887435	0.000000	0.887435	0.887435	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
24	1	0.00000	0.893735	0.893735	0.000000	0.893735	0.893735	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	2	0.00000	0.322793	0.322793	0.000000	0.322793	0.322793	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	2	0.00000	0.632717	0.632717	0.000000	0.632717	0.632717	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	2	0.00000	0.640353	0.640353	0.000000	0.640353	0.640353	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	2	0.00000	0.647989	0.647989	0.000000	0.647989	0.647989	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	2	0.00000	0.655625	0.655625	0.000000	0.655625	0.655625	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6	2	0.00000	0.663261	0.663261	0.000000	0.663261	0.663261	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7	2	0.00000	0.670897	0.670897	0.000000	0.670897	0.670897	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8	2	0.00000	0.678533	0.678533	0.000000	0.678533	0.678533	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9	2	0.00000	0.686169	0.686169	0.000000	0.686169	0.686169	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10	2	0.00000	0.693805	0.693805	0.000000	0.693805	0.693805	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
11	2	0.00000	0.701441	0.701441	0.000000	0.701441	0.701441	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
12	2	0.00000	0.709077	0.709077	0.000000	0.709077	0.709077	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
13	2	0.00000	0.716713	0.716713	0.000000	0.716713	0.716713	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
14	2	0.00000	0.724349	0.724349	0.000000	0.724349	0.724349	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
15	2	0.00000	0.731985	0.731985	0.000000	0.731985	0.731985	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
16	2	0.00000	0.739621	0.739621	0.000000	0.739621	0.739621	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
17	2	0.00000	0.747257	0.747257	0.000000	0.747257	0.747257	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
18	2	0.00000	0.754893	0.754893	0.000000	0.754893	0.754893	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
19	2	0.00000	0.762529	0.762529	0.000000	0.762529	0.762529	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	2	0.00000	0.770165	0.770165	0.000000	0.770165	0.770165	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21	2	0.00000	0.777801	0.777801	0.000000	0.777801	0.777801	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22	2	0.00000	0.785437	0.785437	0.000000	0.785437	0.785437	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23	2	0.00000	0.793073	0.793073	0.000000	0.793073	0.793073	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
24	2	0.00000	0.800709	0.800709	0.000000	0.800709	0.800709	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1	3	0.00000	0.378758	0.378758	0.000000	0.378758	0.378758	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	3	0.00000	0.726317	0.726317	0.000000	0.726317	0.726317	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	3	0.00000	0.768372	0.768372	0.000000	0.768372	0.768372	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	3	0.00000	0.800339	0.800339	0.000000	0.800339	0.800339	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
5	3	0.00000	0.832304	0.832304	0.000000	0.832304	0.832304	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
6	3	0.00000	0.864269	0.864269	0.000000	0.864269	0.864269	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
7	3	0.00000	0.896234	0.896234	0.000000	0.896234	0.896234	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
8	3	0.00000	0.928199	0.928199	0.000000	0.928199	0.928199	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
9	3	0.00000	0.960164	0.960164	0.000000	0.960164	0.960164	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
10	3	0.00000	0.992129	0.992129	0.000000	0.992129	0.992129	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
11	3	0.00000	1.024094	1.024094	0.000000	1.024094	1.024094	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
12	3	0.00000	1.056059	1.056059	0.000000	1.056059	1.056059	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
13	3	0.00000	1.088024	1.088024	0.000000	1.088024	1.088024	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
14	3	0.00000	1.120000	1.120000	0.000000	1.120000	1.120000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
15	3	0.00000	1.151975	1.151975	0.000000	1.151975	1.151975	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
16	3	0.00000	1.183950	1.183950	0.000000	1.183950	1.183950	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
17	3	0.00000	1.215925	1.215925	0.000000	1.215925	1.215925	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
18	3	0.00000	1.247900	1.247900	0.000000	1.247900	1.247900	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
19	3	0.00000	1.279875	1.279875	0.000000	1.279875	1.279875	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
20	3	0.00000	1.311850	1.311850	0.000000	1.311850	1.311850	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
21	3	0.00000	1.343825	1.343825	0.000000	1.343825	1.343825	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
22	3	0.00000	1.375800	1.375800	0.000000	1.375800	1.375800	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
23	3	0.00000	1.407775	1.407775	0.000000	1.407775	1.407775	0.000000	0.000000	0.000000	0.000000		

TABLE A4 (CONTINUED): WILLIAMS COUNTY, NORTH DAKOTA, AUGUST 15, 1975. FLIGHT LINE #2. LINEAR CORRELATION COEFFICIENTS, ALBEDO COMPENSATED DATA.

COMPARE WITH FIGURE 4 IN TEXT.

TM CHAN	MSS CHAN	1	2	3	4	5	6	7	8	9	10	11	12
1	1	0.00000	0.40000	0.15017	-0.00000	0.12760	0.11365	0.19208	0.17104	0.13129	0.11224	0.17126	0.06953
2	1	0.00000	0.65326	0.00000	-0.00000	0.48919	0.39642	0.27715	0.20575	0.15663	0.11521	0.25676	0.24023
3	1	0.00000	0.00000	0.00000	-0.00000	0.70382	0.51974	0.27715	0.12465	0.05166	0.08678	0.06672	0.00000
4	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.90346	0.29712	0.16349	0.13358	0.13062	0.00000	0.00000
5	1	0.00000	0.00000	0.00000	-0.00000	0.90346	0.90346	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
6	1	0.00000	0.00000	0.00000	-0.00000	0.29712	0.23136	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
7	1	0.00000	0.00000	0.00000	-0.00000	0.16349	0.04742	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
8	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
9	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
10	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
11	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
12	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
13	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
14	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
15	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
16	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
17	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
18	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
19	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
20	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
21	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
22	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
23	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
24	1	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.94722	0.00948	0.13062	0.00000	0.00000
13	13	0.53454	-0.12527	-0.14036	-0.00000	-0.16701	-0.17856	-0.19046	-0.20039	-0.18728	-0.14001	-0.17759	0.05212
14	13	0.18908	0.33481	0.33892	-0.00000	-0.37236	-0.37042	-0.36329	-0.31956	-0.26913	-0.21156	0.19728	0.06764
15	13	0.39076	0.12380	0.20892	-0.00000	0.38308	0.39346	0.36306	0.28356	0.20497	0.13074	0.09027	0.13999
16	13	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	13	0.34387	0.02529	0.24805	-0.00000	-0.51739	-0.52843	-0.50288	-0.41899	-0.35037	-0.25529	0.11192	0.12290
18	13	0.51972	0.11366	0.14083	-0.00000	0.41018	0.42583	0.35298	0.27859	0.20694	0.13074	0.09027	0.13999
19	13	0.59053	0.15136	0.14083	-0.00000	0.54621	0.60670	0.67838	0.77458	0.87921	0.95506	0.99999	0.99999
20	13	0.60541	0.10262	0.10262	-0.00000	0.61806	0.57734	0.60044	0.76734	0.87921	0.95506	0.99999	0.99999
21	13	0.67435	0.02459	0.02459	-0.00000	0.52252	0.58019	0.60044	0.60044	0.76734	0.87921	0.95506	0.99999
22	13	0.52403	0.07506	0.12838	-0.00000	0.61567	0.57620	0.60044	0.76734	0.87921	0.95506	0.99999	0.99999
23	13	0.71875	0.61732	0.42625	-0.00000	0.49527	0.47150	0.53671	0.65913	0.79818	0.90886	0.99999	0.99999
24	13	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24	14	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24	20 & 21	0.00000	0.00000	0.00000	-0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

20 & 21
 1 -0.19706
 2 -0.29974
 3 -0.24854
 4 -0.38214
 5 -0.25973
 6 -0.78983
 7 -0.79805
 8 -0.79302
 9 -0.69470
 10 -0.22613
 11 0.32816
 12 0.66176
 13 -0.20807
 14 0.90239
 15 0.87568
 16 0.93043
 17 0.93403
 18 0.91648
 19 0.66239
 20 -0.71827

