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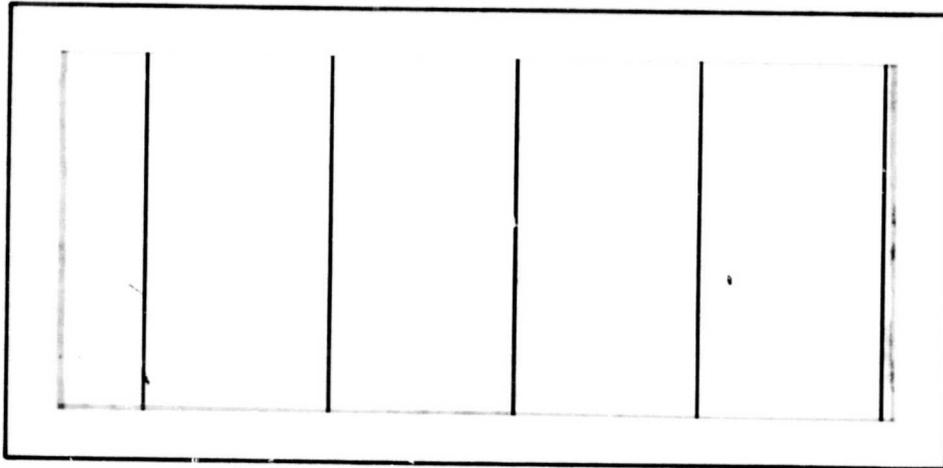
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SCIENCE APPLICATIONS, INC.

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IN THE ATMOSPHERE FROM LANDSAT DATA
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DETERMINATION OF AEROSOL CONTENT
IN THE ATMOSPHERE FROM
LANDSAT DATA

Progress Report Nos. 9 and 10

Contract No. NAS5-20899

I.D. Number 22260

Period Covered: February 1, 1977 to
July 24, 1977

Principal Investigator: Dr. M. Griggs

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Prepared for:
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ACCOMPLISHMENTS

In this period Volz measurements were made at San Diego and the Salton Sea; Volz data and Landsat data were analyzed for other sites, including the LACIE sites for which radiometer calibration data were finally received. A new series of measurements for Landsat 2 overpasses at selected sites was arranged with Mr. Flowers of NOAA and with Dr. Pitts of NASA.

Volz Measurements

In this period Volz data were obtained for five Landsat 2 overpasses at San Diego and for two overpasses at the Salton Sea. These data are given in Table 1 together with those for five earlier San Diego overpasses, not previously tabulated.

In this period it was learned from Mr. E. Flowers and Dr. L. Stowe of NOAA that there is some question of the reliability of the Volz instruments used in the NOAA-EPA turbidity network. Apparently the instruments being used have thermopile detectors and require frequent calibration. Unfortunately, due to man-power problems, calibrations have not been made as frequently as desired. Mr. Flowers is hopeful that the situation will improve soon. It should be noted that the Volz instrument used at San Diego and the Salton Sea has a silicon detector and has shown a remarkably constant calibration for several years.

Table 1. VOLZ DATA FOR LANDSAT OVERPASSES

<u>Date</u>	<u>Aerosol Optical Thickness</u>	<u>Aerosol Content</u>
<u>San Diego</u>		
10-08-76	.116	.54N
10-26-76	.316	1.48N
11-04-76	.093	.44N
12-01-76	.061	.29N
01-24-77	.121	.57N
02-11-77	.115	.54N
03-01-77	.145	.68N
03-19-77	.250	1.17N
04-24-77	.221	1.04N
07-05-77	.173	.81N
<u>Salton Sea</u>		
05-29-77	.210	.99N
06-16-77	.154	.72N

New Series of Measurements

Arrangements were made with Mr. E. Flowers of NOAA to continue special Volz measurements at selected sites of the NOAA-EPA turbidity network for Landsat 2 overpasses in the period March to September 1977. Dr. D. Pitts of NASA - Houston will continue to supply Volz data for the LACIE sites. The Barrow and Grand Prairie sites as described in PR 7 and 8 were found not to be useful, and are not included in the present series of measurements. Thus the current sites are as listed in Table 2.

TABLE 2. CURRENT TEST SITES

NOAA - EPA Sites

San Diego, California	32 ⁰ 45'N	117 ⁰ 10'W
Salton Sea, California	33 ⁰ 20'N	115 ⁰ 50'W
Miami, Florida	25 ⁰ 44'N	80 ⁰ 10'W
Atlantic City, New Jersey	39 ⁰ 27'N	74 34'W
Kadena AB, Okinawa	26 ⁰ 21'N	127 ⁰ 46'E
Anderson AB, Guam	13 ⁰ 34'N	144 ⁰ 55'E
Adrigole, Ireland	51 ⁰ 24'N	9 ⁰ 27'W

LACIE Sites

Burke Co. N. Dakota	58 ⁰ 53'N	102 ⁰ 19'W
Divide Co. N. Dakota	48 ⁰ 53'N	103 ⁰ 11'W
Toole Co. Montana	48 ⁰ 53'N	111 ⁰ 47'W
Hill Co. Montana	48 ⁰ 42'N	109 ⁰ 55'W

Landsat Data

In this period the Volz data for the LACIE sites were finally received. Useful data were found for nine Landsat 2 overpasses, and the digital data have been analyzed. One overpass at Atlantic City has been analyzed. Twelve CCT's are presently on order.

LACIE Sites. The results for the four LACIE sites are given in Table 3 and in Fig. 1. MSS 7 data are not plotted due to the uncertainties of the calibrated CCT. It is seen that the radiances for all sites are generally higher than expected from the ocean data at San Diego. This was anticipated to some degree since these are small bodies of water surrounded by higher albedo land, and in general inland bodies of water seem to be polluted, either naturally by silt or algae, or by man. Some comments on the individual sites are appropriate:

Burke - This Volz site is about 3 km away from a river about 400 m in width. It is seen that while MSS4 is in fair agreement with the San Diego data, MSS5 and 6 are significantly higher. Of particular interest at this site is the overpass of 5-28-76 when an isolated cumulus cloud cast a shadow adjacent to the river. In this shadow, the radiances, shown in Table 3, are much lower than the river radiances, clearly demonstrating the higher-than-usual albedo of the river water. Since both the cloud shadow and the river are surrounded by the same high albedo land, the higher river radiances must be attributed to water pollution.

Divide - This Volz site is about 500 m from a lake about 2 x 0.5 km. The radiances for both overpasses appear high, but there is evidence of water pollution in the black and white prints of the Landsat data. Also the Volz readings seem quite variable as a function of time, although the sky seems clear.

Hill - This Volz site is about 8 km from a dammed river about 1 km in width. The radiances for both overpasses appear high. Water pollution is clearly apparent in the Landsat prints upstream from the target area.

Toole - It was originally planned to use a large (3 x 1 km) lake about 6 km from the Volz site, but it apparently dried up in the summer of 1976, so a smaller (0.5 x 0.5 km) lake about 3 km from the Volz site has been used. These results show better agreement with the San Diego radiances.

In summary, the smallest target (Toole) shows the best agreement with the San Diego results, indicating that the surrounding high albedo land has less effect on the water radiance than does the water pollution. The effect of water pollution is clearly demonstrated in the Burke results where cloud shadow radiances are lower than the water radiances.

Atlantic City. The results for one overpass are given in Table 3, and as seen in Fig. 2, they appear generally higher in comparison with the previous Atlantic City data and the San Diego results.

TABLE 3. LANDSAT 2 DATA

Date	cos Sun Zenith	Volz	Normalized MSS Radiance			
			MSS4	MSS5	MSS6	MSS7
<u>BURKE</u>						
5-28-76 (River)	.82	.58N	2.69	1.64	1.12	.59*
(Cloud Shadow)			2.05	1.31	.94	.57*
7-21-76	.79	.95N	3.11	1.82	1.62	.99
<u>DIVIDE</u>						
8-09-76 (Lake)	.74	.30N	2.81	1.82	1.14	.49+
9-14-76	.62	.30N	2.64	1.67	.94	.56+
<u>HILL</u>						
5-16-76 (River)	.80	.62N	2.93	1.71	1.05	.63*
9-19-76	.59	.48N	3.77	1.89	.82	.57+
<u>TOOLE</u>						
7-10-76 (Lake)	.81	.44N	2.28	1.27	.78	.59*
7-28-76	.78	.44N	2.03	1.23	.82	.47+
9-20-76	.59	.30N	2.32	1.36	.86	.57+
<u>ATLANTIC CITY</u>						
9-28-76	.64	.77N	2.79	1.58	1.07	.68*

*Count < 1.0

+Count < 0

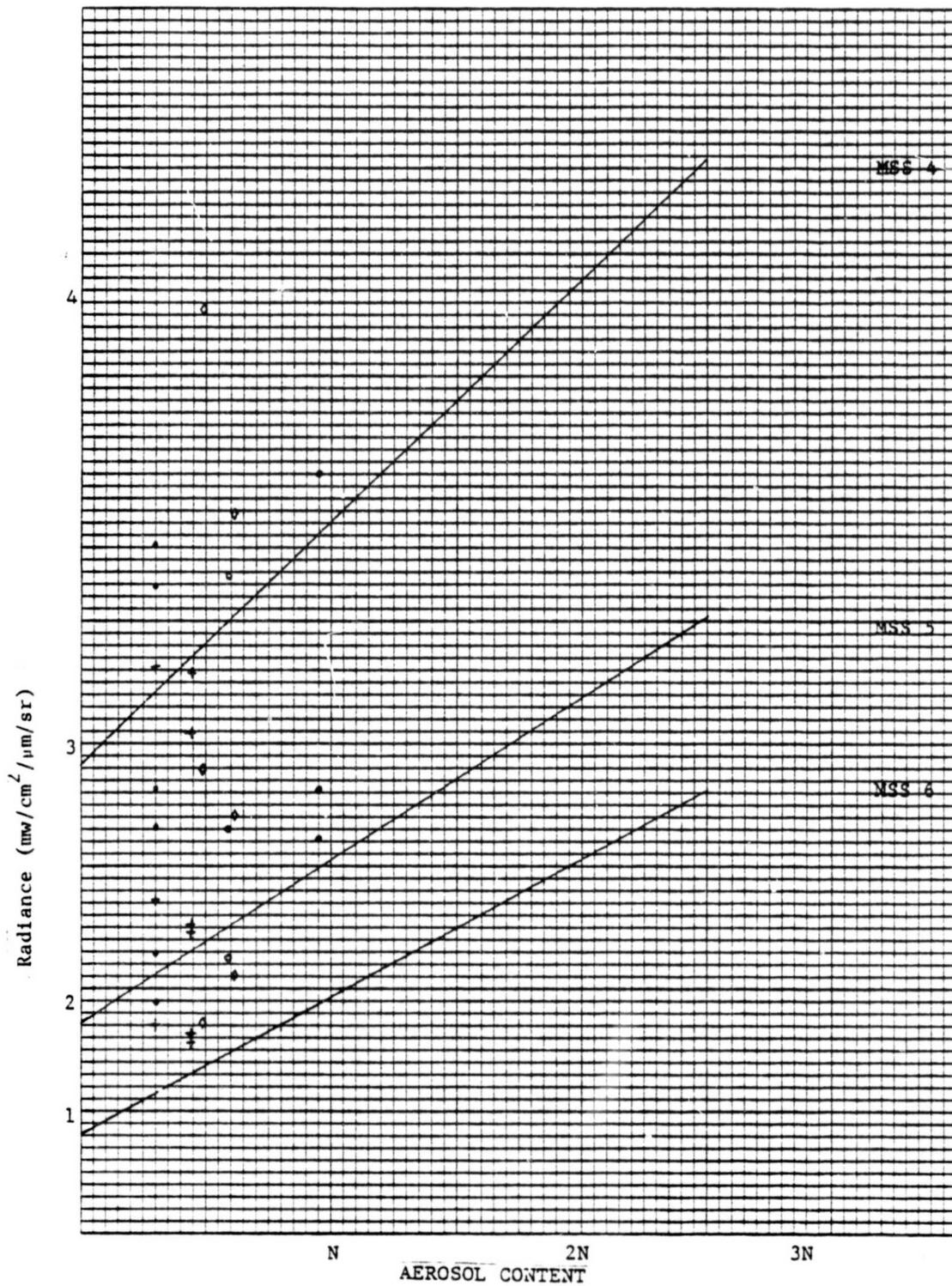


Figure 1. Radiance vs. Aerosol Content for Landsat 2, LACIE Sites (o Burke; ● Divide; ◊ Hill; + Toole; -- Linear Regression for San Diego)

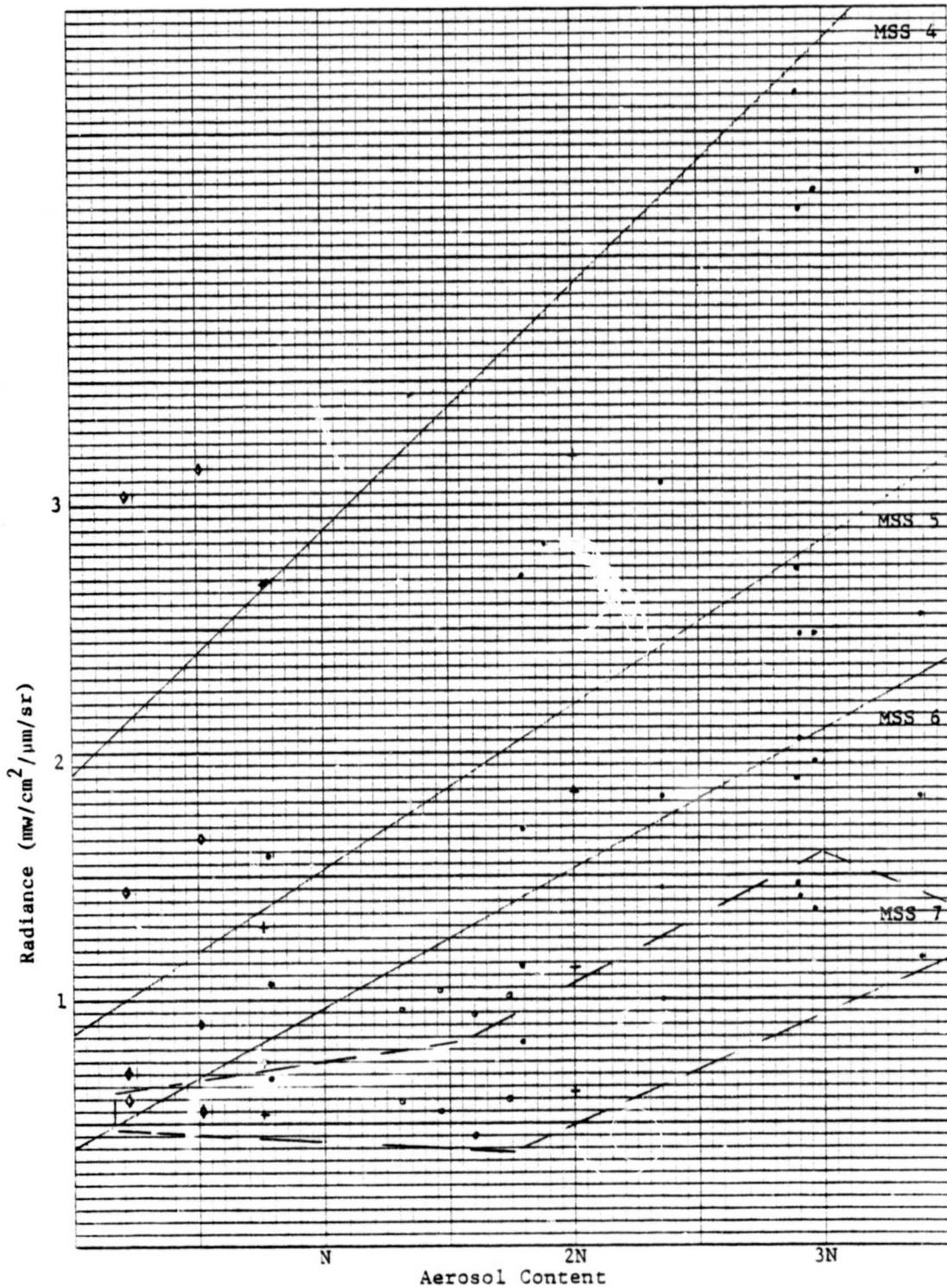


Figure 2. Radiance vs. Aerosol Content for Landsat 2, Other Sites (o Miami; ● Atlantic City; ◇ Barrow; + Adrigole; - Linear Regression for San Diego)

Discussion of Previous Salton Sea Data

It was noted in PR 7 and 8 that five Salton Sea points show higher radiance values which could not be readily explained. To investigate this problem further, the surface meteorological data at Imperial County Airport (60 km south of the Salton Sea) were obtained for the dates of the nine Salton Sea overpasses. No correlation was found between the radiances and surface humidity or temperature. It was found that higher radiances generally occurred when the wind was from the South or East. This suggests the possibility that two different types of particles, with different optical properties, might be causing the difference in radiances. However, a straight line fitted to the five high points intercepts the radiance axis at a higher radiance than the line through the other points. The intercept should be independent of the particle type since it represents the radiance due to pure Rayleigh scattering. Hence it is suspected that the five higher radiance values are due to undetected water pollution.

Plans

Volz data will be taken at San Diego and the Salton Sea, weather permitting. Volz data and Landsat data from the other sites will be analyzed as received.

SIGNIFICANT RESULTS

There are no significant results to report in this period.

PUBLICATIONS

A paper by Yu Mekler et al. on "Relative Atmospheric Aerosol Content from Earth Observations" J. Geophys. Res. 82, 967-970 (1977), suggested basically the same technique as developed in our NASA contracts over the past several years. We submitted a comment on the paper including recent results, which has been accepted for publication. Ten copies of this comment were sent to NASA.

RECOMMENDATIONS

No changes in the program appear necessary at the present time.