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Detection of Moisture and Moisture Related Phenomena from Skylab

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COMPENSATIONS OF RADIOMETRIC DATA FOR CLOUD COVER

An attempt is being made to compensate the radiometric antenna temperature as measured by S193 for the areas where cloud cover occurred. It was shown by Wu (1973) that the effect of cloud cover depends on the density and the type of the cloud. An analysis of the amount and type of clouds over the individual S193 footprints has been completed for the June 5 pass over Texas, Figure 1, as described in the May progress report. Cloud cover varied from none to almost 100% heavy cloud cover as extracted from the S190A photography. The influence of cloud cover on the S194 radiometric temperatures are probably negligable, but should slightly increase the correlation of the S193 data with soil moisture content. For the cases where cloud cover exists , corrections can be made by modification to developed methodology, Wu (1973) or by the techniques described by Benoit (1968).

EFFECT OF ANTENNA PATTERN

An attempt is being made to find the effect of antenna pattern of S194 L-band radiometer on the antenna temperature measurement. The S194 sensor has a 15° half-power beam width. This implies that 50% of the energy received by the antenna will be received in the 15° solid pyramid centered about the vertical axis. The antenna

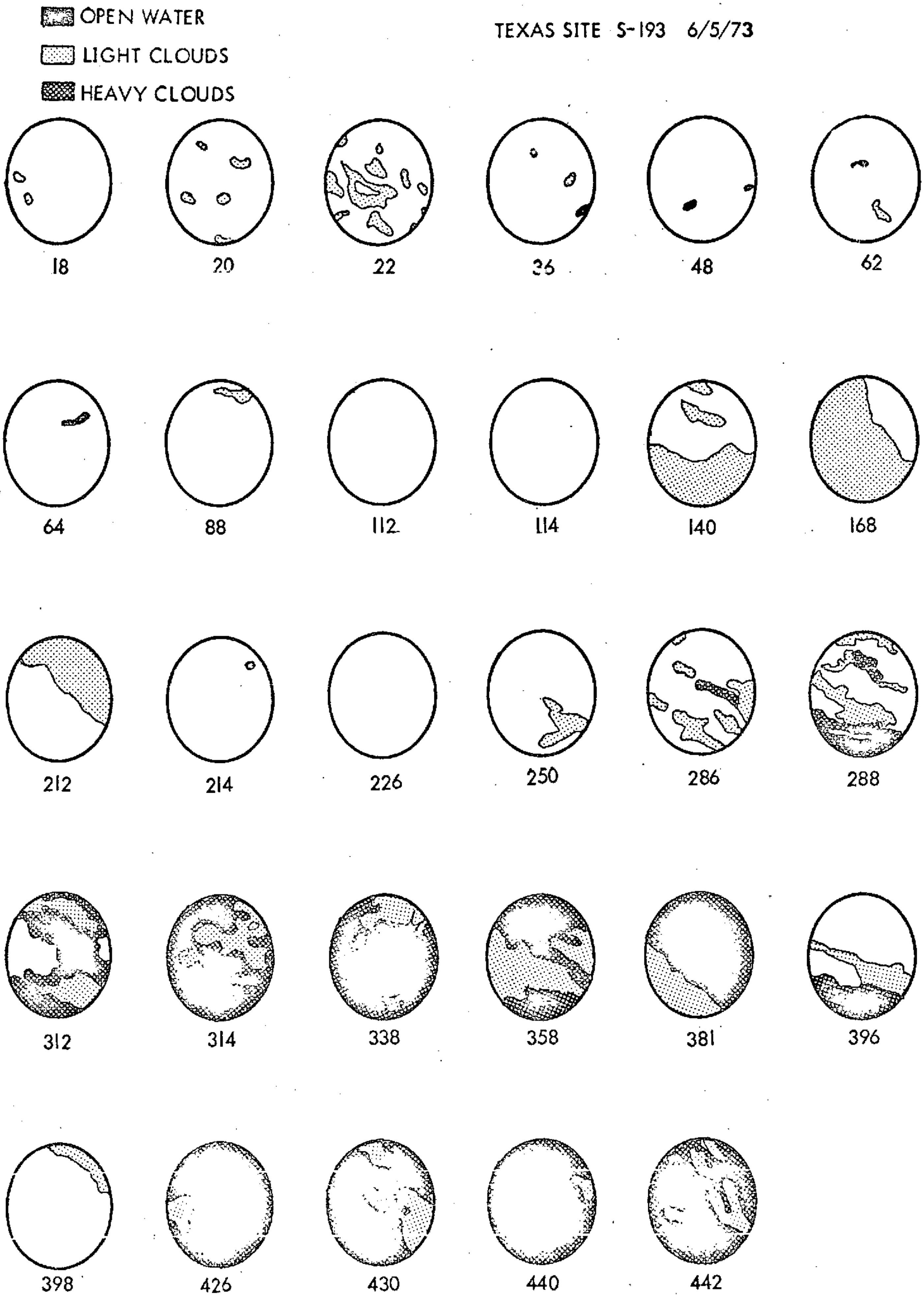
OPEN WATER
LIGHT CLOUDS
HEAVY CLOUDS
TEXAS SITE S-193 6/5/73
18
20
22
36
48
62
64
88
112
114
140
168
212
214
226
250
286
288
312
314
338
358
381
396
398
426
430
440
442

Figure 1

will receive over 90% of the energy available in the field of view in a 36° solid pyramid. Both of these angles are contained in the primary lobe of the antenna. The 36° angle will encompass a swath width of approximately 144 nmi at the 234 nmi orbital altitude. The radiometer antenna temperature recorded by the sensor will be influenced to a greater extent by the brightness of the material contained within the 15° beam width.

The sampling of the radiant energy received by the antenna was done at a rate to ensure a minimum of 97% ground coverage overlap. The distance on the ground between the centers of two consecutive resolution cells is about 2 nmi. Because of such a small distance, the difference in the radiometric antenna temperature between two consecutive cells may be due to random fluctuations due to noise rather than to any changes in ground emission. Thus, for a meaningful analysis, it is important to establish the effect of antenna pattern to show at what distance ground effects begin to predominate over those of the noise.

An attempt is being made to find out what type of ground variation, as a function of time, is required to produce the radiometric data. If g(t) is the ground temperature as a function of time (i.e. surface brightness temperature as a function of distance or time), a(t), the antenna pattern as a function of time, and w(t) as some type of window function or distorting factor, then the data d(t) (radiometric measurement as a function of time) is given by:

$$d(t) = a(t) * [g(t)w(t)]$$

where * implies convolution. Taking the Fourier transform of above we find:

$$D(f) = A(f)\ [G(f) * W(f)]$$

$$G(f) * W(f) = H(f) = D(f)/A(f)$$

where g(t) is the inverse Fourier transform of G(f). An attempt shall be made to see if it is possible to obtain a better g(t) for S194 radiometer by suitable choice of w(t). A similar attempt shall be made in finding the effect of S193 antenna pattern.

VEGETATION AND LAND USE

In order to understand the contribution of vegetation to Skylab measurements, recent research has also been directed toward the preparation of a vegetation, land-use type map of the western Texas site. This map is being prepared from the S190A and S190B vertical color photography and from ground truth photographs taken during the soil moisture sampling missions. To date, only the map representing the June 5, 1973 test area has been completed (Figure 2). Table I describes in some detail vegetation characteristics of each category on the map.

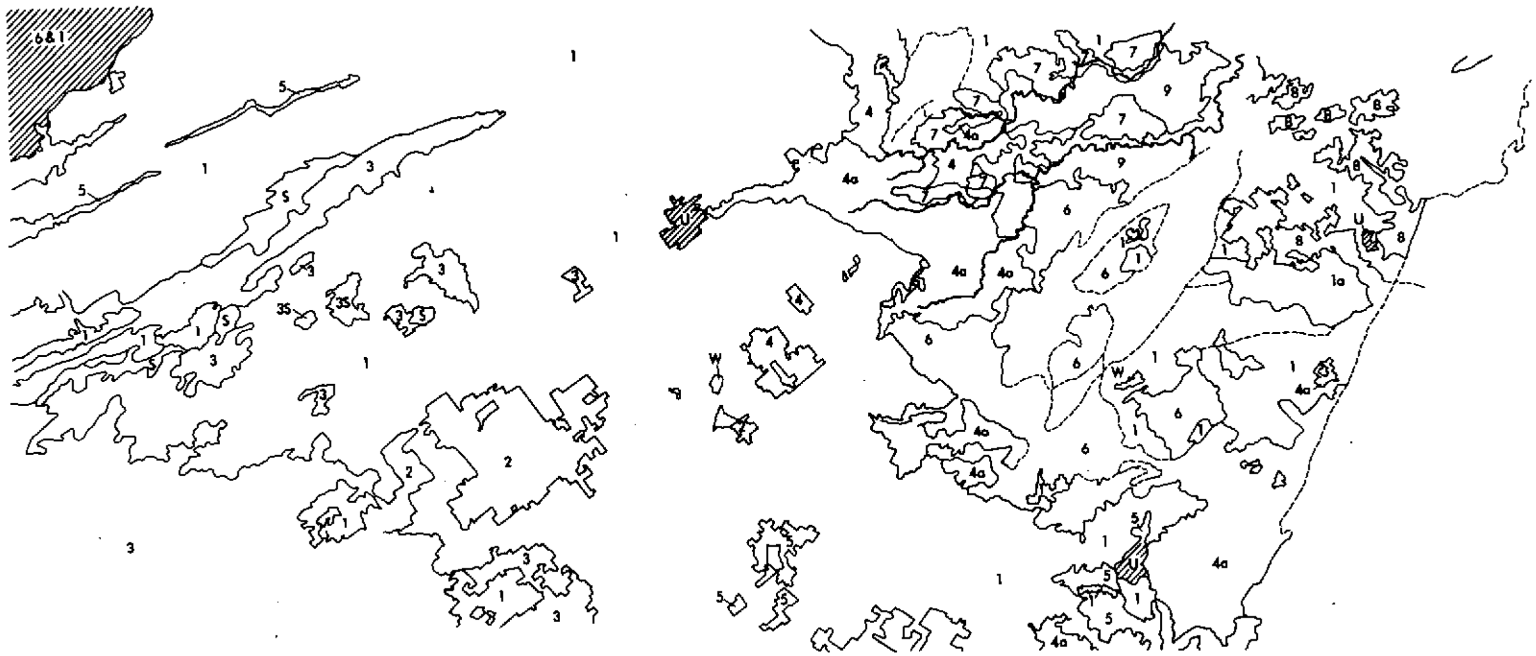

Figure 2 . Vegetation type map of the June 5, 1973 Texas test site. Numbers refer to map categories and are referenced to Table .

TABLE I

Texas Test Site
(June 1973)

Vegetation-Land Use

Map Category	UNESCO Formula	Description
1	V-D-2b	Dominantly bare ground, some emergent shoots of cotton and grain sorghum less than 5 cm in height.
1a	V-D-2b	Same as above; variations due to soil type differences.
2	V-C-3c	Short grassland; dominant graminoid growth forms are less than 50 cm tall. Woody synusia of shrubs covering less than 10% of the area.
3	V-C-6a	Short grass communities practically without woody synusia.
4	V-B-3c	Medium tall grassland; dominant graminoid growth forms are 50 cm to 2 m tall; woody synusia of broad leaf deciduous shrubs covering 10% or less.
4a	V-B-3c(1)	Same as above, but total plant coverage per unit area is significantly less.
5	V-D-2b(2)	Mainly anual low forb communities less than 1 m tall.
6	V-B-3c(2)	Medium tall grassland; dominant graminoid growth forms are 50 cm to 2 m tall; woody synusia of broad leaf deciduous shrubs covering 10-40%
7	III-C-2a	Xeromorphic (sub-desert) shrubland without succulents. Open stands of shrubs with various xerophytic adaptions. Mainly less than 2 meters tall.

Map Category	UNESCO Formula	Description
8	III-B-3a(1)	Temperate deciduous shrubland. Moderately dense scrub with more or less continuous grass under story. Shrubs 2 to 3 m tall. Grass less than 50 cm tall.
9	III-B-3a(2)	Temperate deciduous shrublend. Essentially the same as category 8, but the percentage of shrub coverage is lower and individual plants are more widely separated.
9a	III-B-3a(3)	Same as above, but much less total vegetative cover, i.e., more bare soil.
S		Bare saline soils, often found in dry channel or depressions.
W		Water.
U		Urban.

The vegetation of the test area is classified according to the methods established in the *International Classification and Mapping of Vegetation* (UNESCO, 1973). The categories used in the classification are units of vegetation, including both zonal formations and the more important and extensive azonal and modified formations. The system is based upon vegetation physiognomic rather than floristic considerations and considering the nature of the Skylab project to which it is applied, this is quite appropriate.

Supplementary terms referring to climate, soil and landforms are included in the names and occasionally in the definitions, where they help the identification of a given unit. Although most units are defined physiognomically, they broadly indicate environmental conditions.

Considering the specific details, the classification is divided into five major categories: (i) Closed Forest, (ii) Woodland, (iii) Scrub, (iv) Dwarf-Scrub and Related Communities, (v) Herbaceous Vegetation.

Figure 3 is the same map except that those S193 footprints for which soil moisture data are available have been superimposed on the land-use, vegetation categories. The relative amounts of each vegetation type within each footprint are given in Table II. The percentage of each type of vegetation within each footprint was determined by utilizing a Hewlett-Packard calculator-digitizer system. This simply involves entering a numerical integration

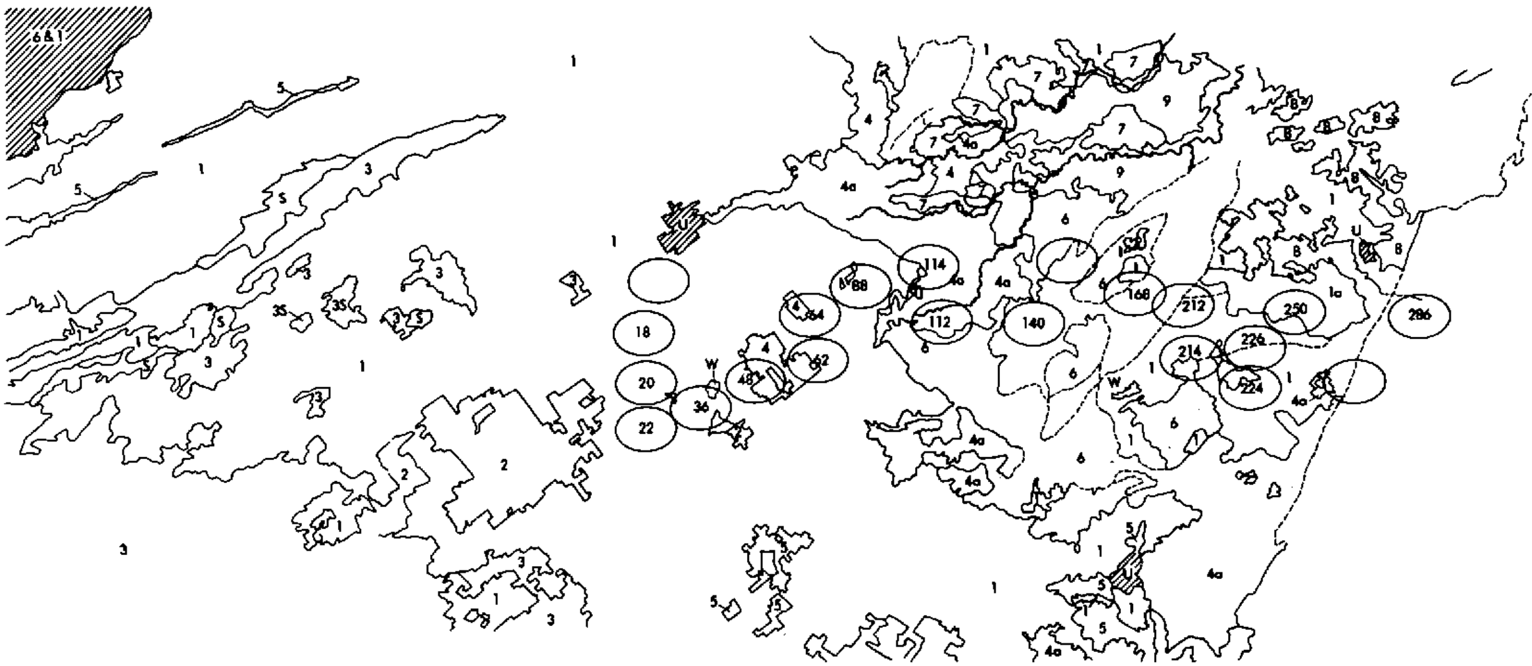

Figure 3 . Vegetation type map of the June 5, 1973 Texas test site showing the relative position of the S193 footprints for which soil moisture information is available. The footprint numbers correspond to those of Table I .

TABLE II

Footprint Number	Map Category	Percent Coverage
18	1	100
20	1	100
22	1	100
36	S	4
	W	8.2
	1	87.8
48	1	48.6
	4	51.4
62	1	29.1
	4	70.9
64	1	82.2
	4	17.8
88	1	96.4
	4	3.6
112	4a	60.2
	6	39.8
114	1	20.7
	4a	68.7
	6	10.6
140	6	11.9
	cloud	88.1
168	1	7.5
	6	19.6
	cloud	72.9
212	1	30.2
	cloud	69.8
214	1	11.2
	6	88.2
226	1	88.0
	1a	12.0
250	1	86.4
	1a	13.6
286	1	23.9
	8	76.1

program into the programable calculator which allows continuous sampling by the digitizer. Digitizing is done on a sensitive surface in order that continuous coordinates can be read off and fed into the calculator. When the digitizer is returned to the starting point, a display appears which represents the enclosed area. This is then readily convertible to square miles, kilometers or any appropriate aerial measurement or simply to percent coverage as has been done in this case.

Since the area was classified from satellite photography, areas under heavy clouds have not been classified; therefore, the map is incomplete with respect to the total test strip. Although they are not complete at this time, similar maps are being produced for the other data sets in Texas and Kansas.

In addition to plotting the S193 footprints on these maps, S194 footprints were plotted and categorized in preparation for further analysis of the contribution of vegetation to the S194 measurements, Figure 4. The footprint was taken to be a circle of 60 nautical miles in diameter.

Table III lists the footprint numbers, categories within each footprint and percentage of each footprint occupied by each category. The key to the categories is to be found in Table I .

As in the case of the S193, not all footprints for the pass have been considered. This is due to the fact that

TABLE III

Footprint Number	Categories Present	Percent Coverage
1	3	2.49
	3s	0.96
	1	82.7294
	2	12.93
	s	0.26
	U	0.63
2	1	83.2419
	2	11.65
	3	2.23
	3s	0.84
	s	0.998
	U'	1.05
3	1	83.30
	2	11.95
	3	2.21
	3s	0.11
	s	0.72
	4	0.49
	4a	0.16
	U	1.06
4	1	82.6800
	2	11.66
	3	2.21
	s	0.49
	W	0.1513
	U	1.06
	4	1.47
	4a	0.28
5	1	13.00
	2	10.68
	3	1.54
	4	2.57
	4a	0.512
	s	0.49
	U	1.06
	W	0.15
6	1	84.6419
	2	9.53
	3	1.06
	4	2.57
	4a	0.77
	s	0.21
	U	1.06
	W	0.15
7	1	87.2119
	2	7.00
	3	0.53
	4	2.57
	4a	1.27
7	s	0.21
	U	1.06
	W	0.15
8	1	88.1675
	2	5.13
	3	0.283
	4	2.57
	4a	2.39
	6	0.03
	U	1.06
	s	0.21
	W	0.15
9	1	86.4938
	2	3.56
	3	0.28
	4	2.57
	4a	4.42
	5	0.29
	6	0.96
	s	0.21
	U	1.06
	W	0.15
10	1	82.8588
	2	2.31
	3	0.283
	4	2.57
	4a	7.92
	5	0.50
	6	2.13
	s	0.21
	U	1.06
	W	0.15
11	1	77.8931
	2	1.50
	3	0.2831
	4	2.57
	4a	11.67
	5	0.76
	6	3.78
	7	0.38
	U	1.06
	s	0.21
	W	0.15
12	1	73.4000
	2	0.63
	3	0.04
	4	2.57
	4a	14.88
	5	0.88

TABLE III (cont.)

Footprint Number	Categories Present	Percent Coverage
12	6	5.80
	7	0.38
	U	1.06
	s	0.21
	W	0.15
13	1	65.52
	2	2.76
	4	2.57
	4a	17.79
	5	0.88
	6	7.61
	7	0.57
	S	0.21
	U	1.06
	W	0.15
	Cloud	0.88
14	1	60.4119
	2	2.76
	4	2.57
	4a	20.07
	5	0.61
	6	8.79
	7	0.91
	d	0.21
	U	0.96
	W	0.15
	C	2.57
15	1	59.6688
	2	2.76
	4	2.57
	4a	17.33
	5	0.40
	6	11.03
	7	1.22
	S	0.21
	U	0.25
	W	0.15
	C	4.41
16	1	64.7681
	2	2.76
	4	3.65
	4a	21.58
	5	0.10
	6	17.04
	7	1.22
	W	0.13
	S	0.21
	C	6.55
17	1	41.4269
	2	2.76
	4	3.65
	4a	21.80
	6	21.14
	7	1.50
	S	0.15
	W	0.13
	C	7.43
18	1	40.1644
	2	0.09
	4	3.65
	4a	19.92
	6	23.54
	7	1.50
	9	0.57
	W	0.16
	C	10.40
19	1	35.225
	4	3.54
	4a	18.83
	6	26.03
	7	1.50
	9	1.60
	W	0.16
	C	13.12
20	1	35.1013
	4	2.59
	4a	17.48
	6	27.00
	7	1.50
	9	1.30
	W	0.16
	C	14.87
21	1	32.3206
	4	1.42
	4a	16.10
	6	29.69
	7	1.50
	9	2.44
	W	0.16
	C	16.37
22	1	30.2006
	1a	0.36
	4	1.33
	4a	14.95
	6	32.9575

TABLE III(cont.)

Footprint Number	Categories Present	Percent Coverage
22	1	30.2006
	1a	0.36
	4	1.33
	4a	14.95
	6	32.5975
	7	1.25
	9	2.62
	W	0.16
	C	16.5406
23	1	28.0350
	1a	1.08
	4	0.27
	4a	14.2419
	6	33.7525
	7	0.96
	8	0.11
	W	0.16
	C	17.4475
	9	3.66
24	1	26.7919
	1a	1.96
	4a	12.7113
	6	34.6931
	7	0.66
	8	0.82
	9	4.14
	W	0.16
	C	18.0650
25	1	24.8231
	1a	3.0825
	4a	10.1244
	6	37.1956
	8	1.87
	9	4.1481
	W	0.16
	C	18.59

the S190B data base is partially cloud covered. Further information will be filled in from other sources such as ERTS photography, however, to complete the classification.

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