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NATIONAL METEOROLOGICAL CENTER

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A COMPARISON OF SOUNDINGS RETRIEVED FROM POLAR ORBITER RADIANCES BY TWO VERY DIFFERENT RETRIEVAL ALGORITHMS

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THIS IS AN UNREVIEWED MANUSCRIPT, PRIMARILY INTENDED
FOR INFORMAL EXCHANGE OF INFORMATION AMONG NMC STAFF MEMBERS.

This paper compares two sets of atmospheric vertical temperature profiles produced from NOAA-7 radiance measurements using two different methods. The first retrieval technique (here after referred to as R1) uses eigenvectors of covariance matrices of radiance, temperature, and water vapor mixing ratio to estimate cloud-free infrared sounding radiances and vertical temperature profiles from infrared and microwave spectrometer observations (Smith and Woolf, 1976). This technique is currently used by NESDIS to produce a global set of atmospheric temperature profiles twice daily on an operational basis. The other retrieval technique (henceforth called R2) employs an iterative inverse solution of the radiative transfer equation. This technique requires an initial estimate of the temperature and moisture profiles, usually obtained from an NMC forecast (Smith, 1970; Smith and Woolf, 1981). One potential advantage of this latter method, is that the individual soundings chosen for processing may be selected by a human being through the use of a McIDAS terminal. An operator of such a terminal can carefully edit the infrared and microwave data to be processed by viewing the data on a television console. The operator can also cause geographically proximate soundings of his choice to be spatially averaged before they are processed into temperature profiles. It should be noted that, while a considerable amount of man-machine interaction was used in order to produce the edited sounding sets reported on here, CIMSS has, in the past year, substantially automated the entire editing process. Such a spatially averaged sounding, called a sounding field of view, or SFOV, should be free of unrepresentative radiance information caused by soundings through low clouds, or over snow cover, or unusual terrain, etc. since the operator can exclude these from the average (Smith, et al., 1978). Of course, such spatial averaging reduces the horizontal resolution of the data. The set of soundings

described in this paper, on the other hand, was edited not by averaging, but by allowing many more soundings to be included over the same geographical area than are permitted in the operationally processed data with method R1 (Figure 1). Might this greater density of polar orbiter data be an improvement over the current data density, especially over the oceans? This study was undertaken to at least begin to address this question.

PROCEDURE

In order to simulate oceanic conditions, central Canada in the autumn was chosen as the study area. This region not only contains some radiosonde stations to provide "truth" data against which to compare both types of soundings, but also, the analyses and therefore the 12-hour forecasts used for the initial estimate in processing the test soundings, are less likely to be affected by NOAA-7 data from previous data assimilation cycles. Thus, comparisons between operationally processed NOAA-7 soundings and NOAA-7 test soundings stand a better chance of being unbiased than they might be if this study were conducted over, say, the U.S. Soundings for three cases were evaluated. The Cooperative Institute for Meteorological Satellite Studies (CIMSS) prepared the experimental sounding sets. For each case, NOAA-7 radiances over Canada were available for two consecutive orbits over Canada occurring roughly between 0800 GMT and 1100 GMT. NESDIS' operational processing not only used method R1 to retrieve temperature profiles, but also, operational constraints require that the data be thinned to a resolution of about 300 km (Figures 1-3). The same complete set of original radiance data was also available to CIMSS at the University of Wisconsin. While they used retrieval method R2, they also applied human editing of the entire set of unthinned soundings over Canada. Shelter temperatures were used in the retrieval process to simulate sea surface temperatures. The resulting set

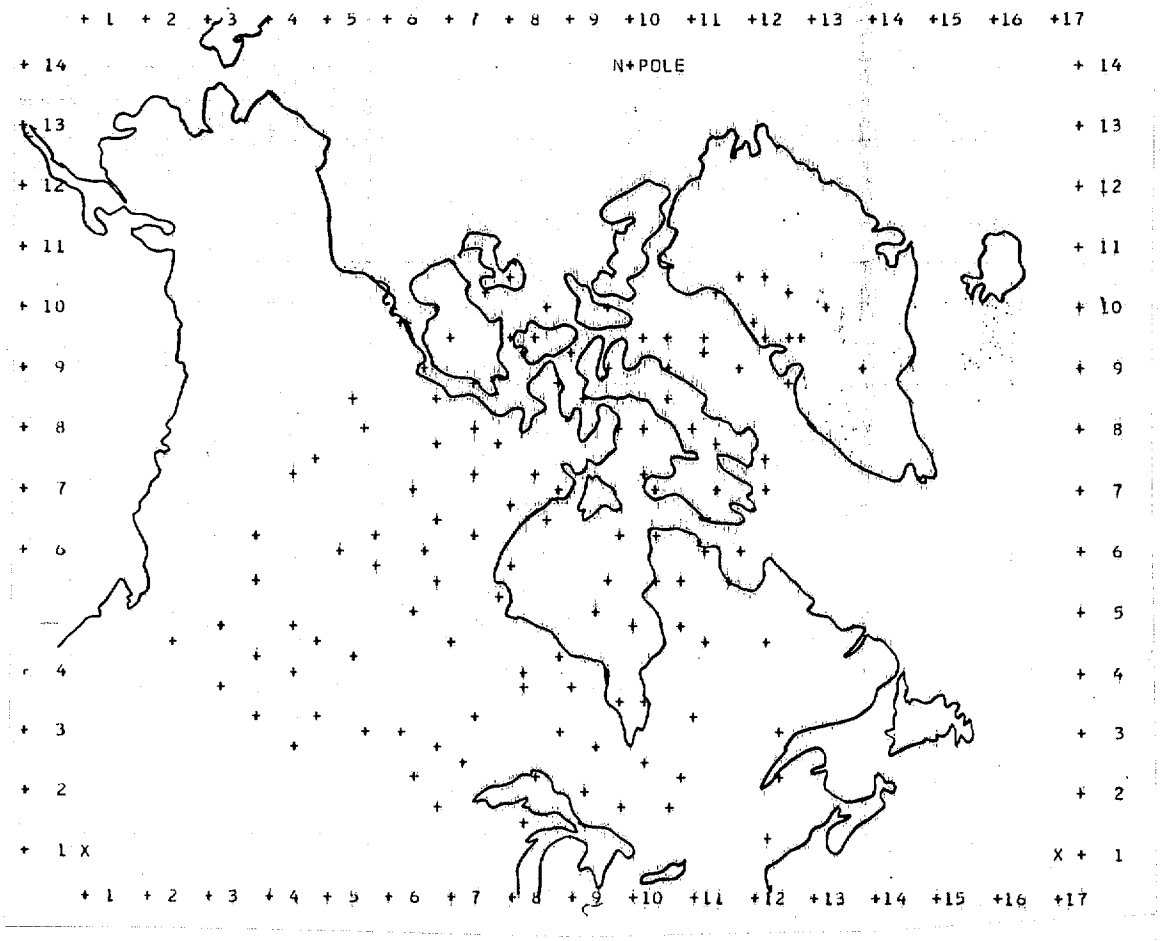


Figure 1. Locations of operational TIROS N soundings 12 z 05 September 1981.

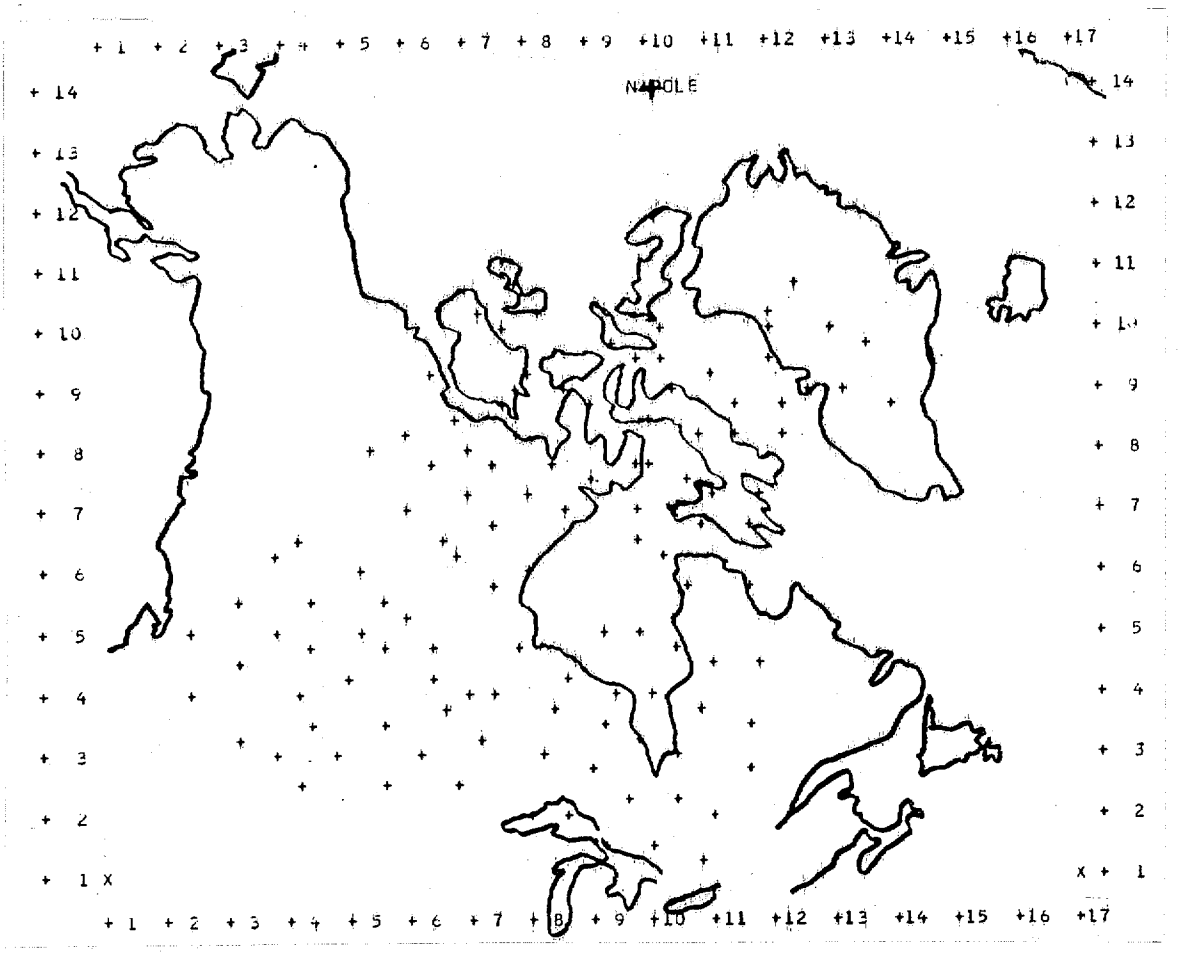


Figure 2. Same as Figure 1 but for 12Z 13 September 1986.

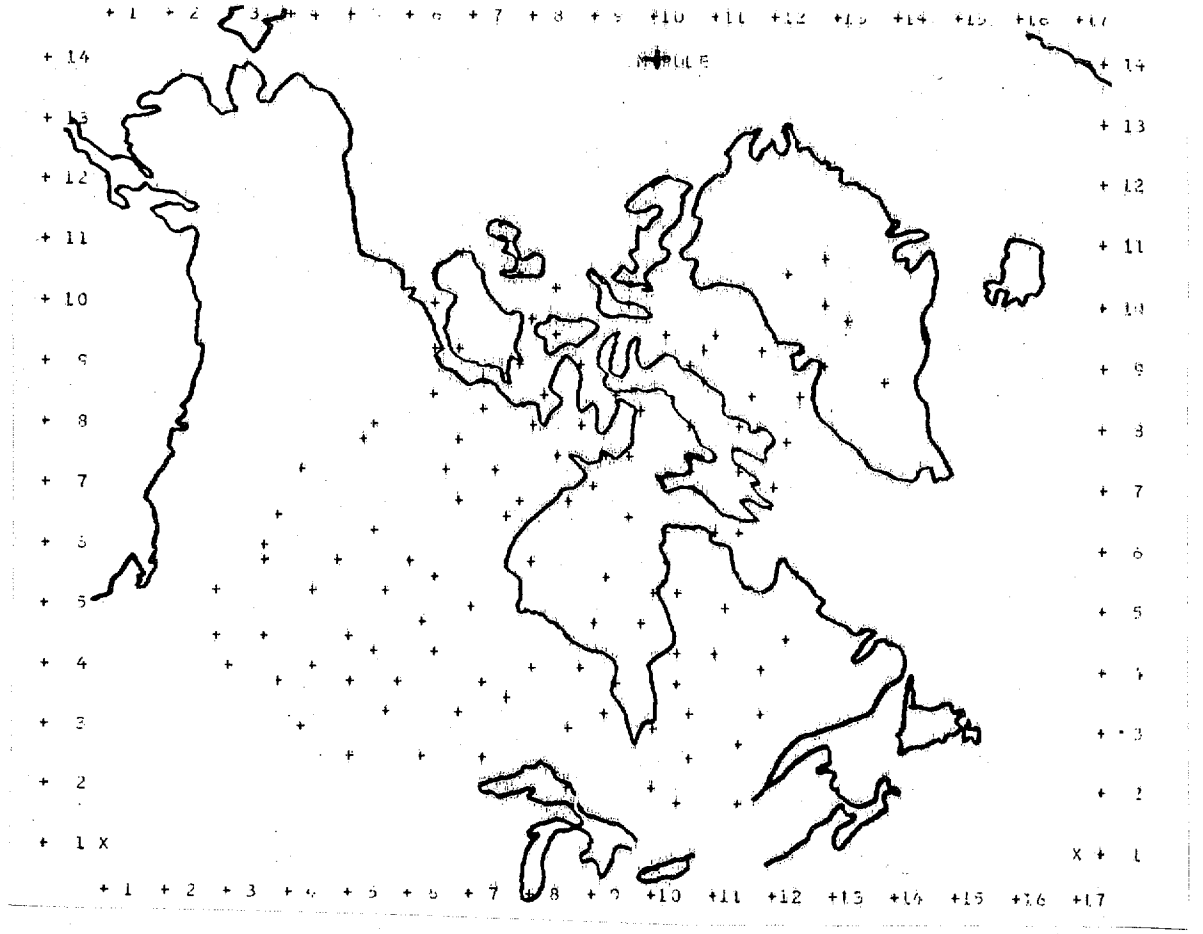


Figure 3. Same as Figure 1 but for 12Z 01 October 1981

of soundings has two-to-three times the density of the operationally processed sounding set (Figures 4-6). Approximately 100 soundings of each type (test and operational) were available for each case. These soundings were compared with each other by collocating both sets of satellite soundings with radiosondes having low ground heights and intercomparing satellite-minus-raob differences for both sets of soundings. The collocation method involved interpolating nearby satellite soundings to the locations of radiosonde stations using an inverse distance weighting scheme. The interpolation procedure requires that satellite observations be distributed reasonably uniformly in four quadrants around the raob site rather than to one side or the other. The maximum distance from a RAOB that data were sought for collocation (scan radius) was 300 km.

RESULTS

The collocation method described earlier produced from 10 to 16 distance-weighted mean soundings or collocated soundings, at radiosonde sites on the 3 dates. The results of this procedure are contained in Appendix 1, which contains tables of both the collocation-sounding thicknesses and the satellite-raob differences. These latter differences were also plotted on polar stereographic maps along with thickness contours from the appropriate LFM analysis (Appendix 2). In order to summarize the overall results for the three cases, all the satellite-raob differences were averaged, and plotted, along with the rms and standard deviation for the sample, as shown in Figure 7.

In Figures 7a, the September 5 case, thickness, relative to 1000 mb, from the operational soundings compare well with radiosonde thicknesses, though the standard deviation reaches 60 meters at 300 mb, equivalent to a difference of -1.5K over the 1000-300 mb layer. The test soundings produce thicknesses which are colder than those from the radiosondes by 10 meters at

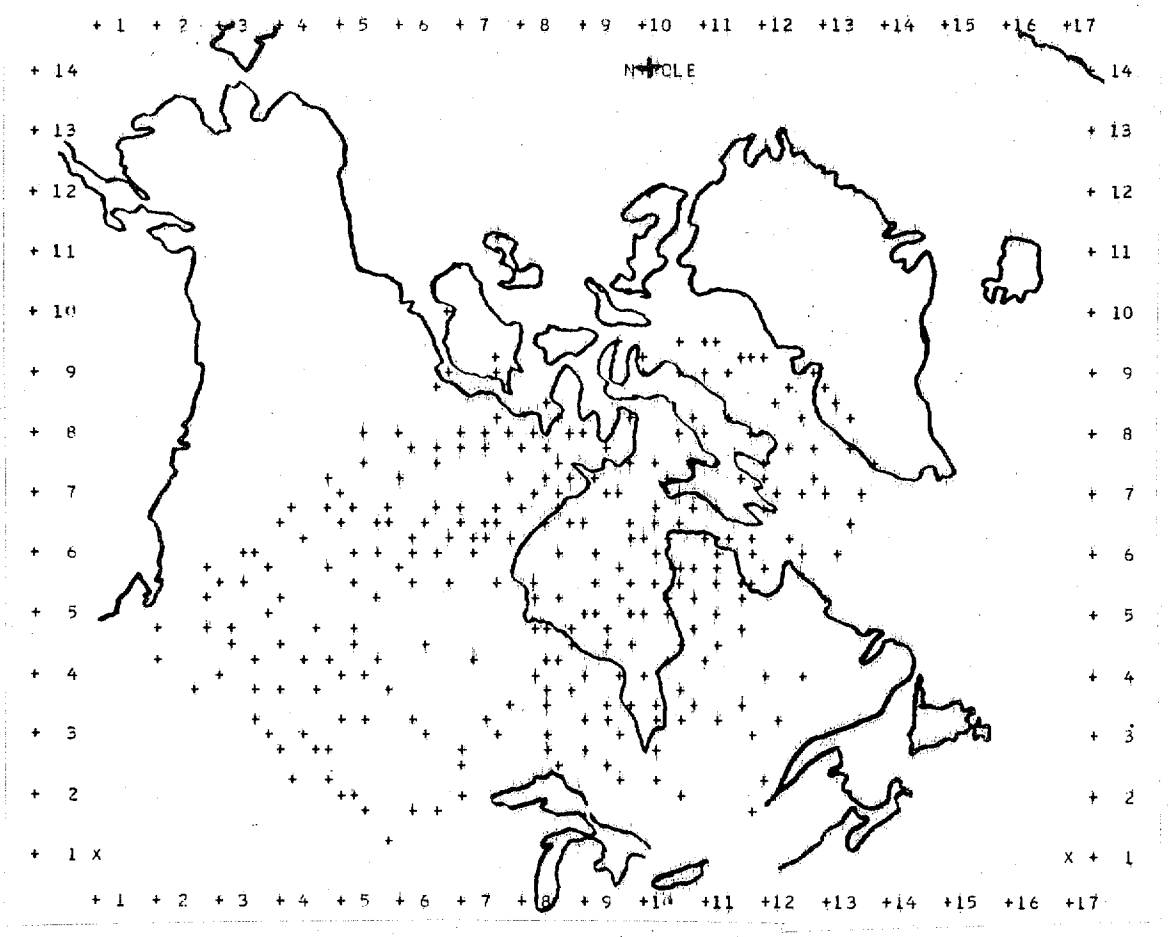


Figure 4. Locations of U. Wisconsin-processed TIROSN soundings, 122 05 September 1981.

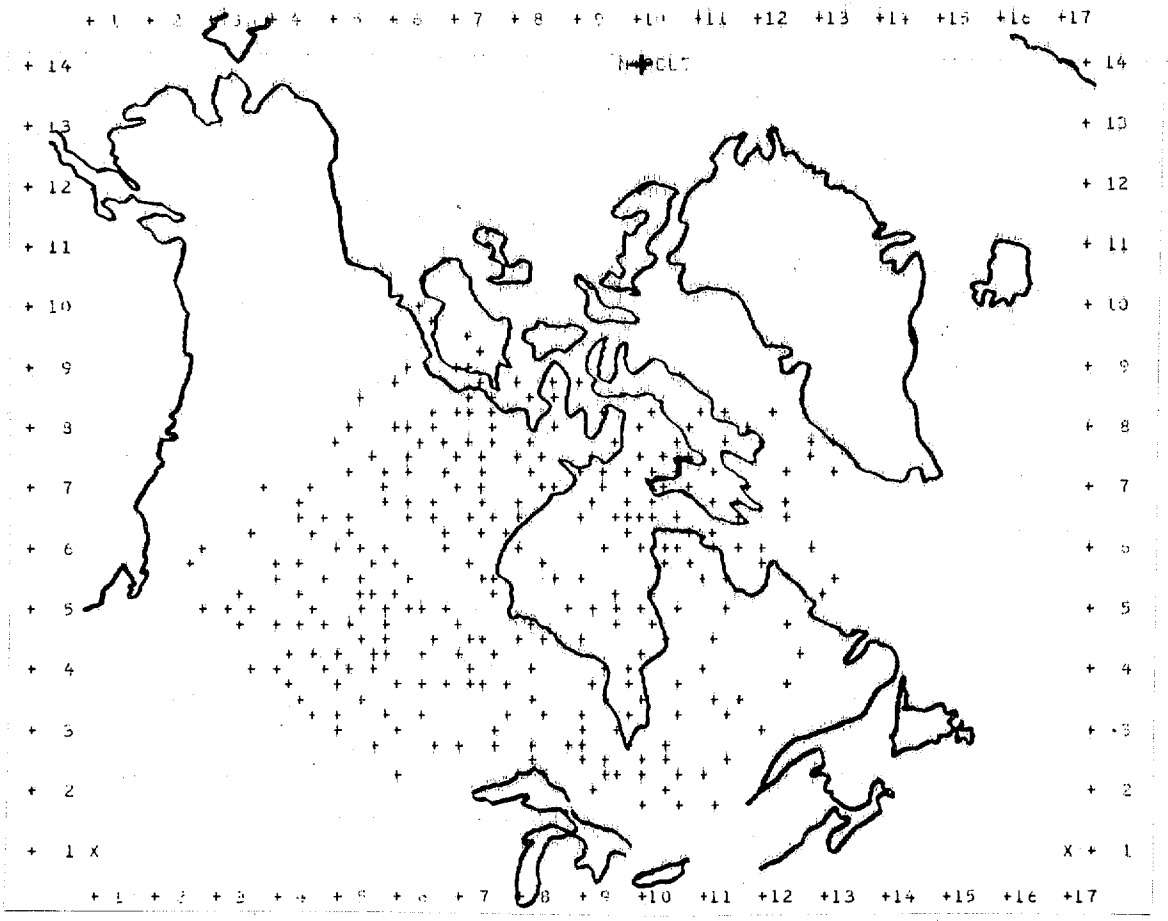


Figure 5. Same as Figure 4 but for 12z 13 September 1981.

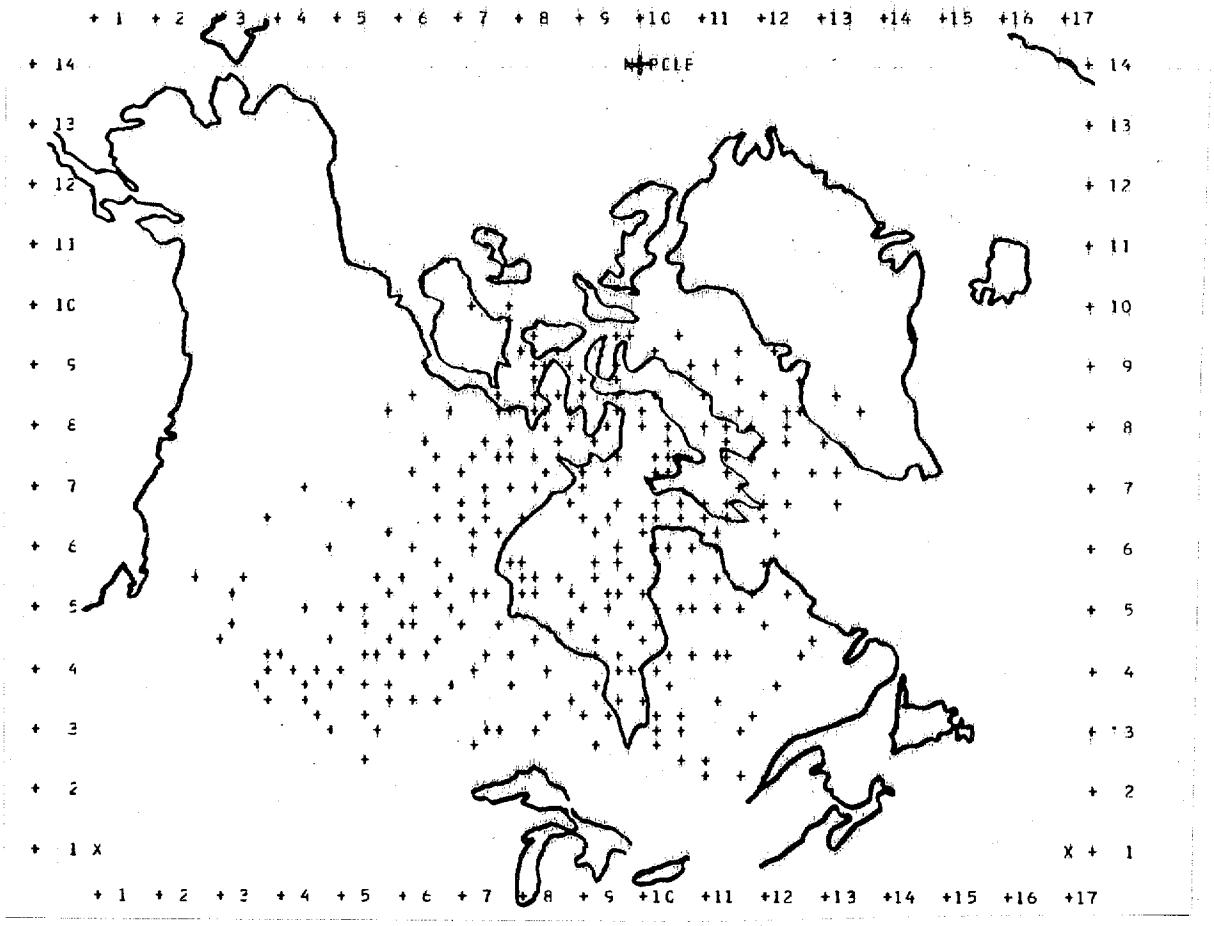
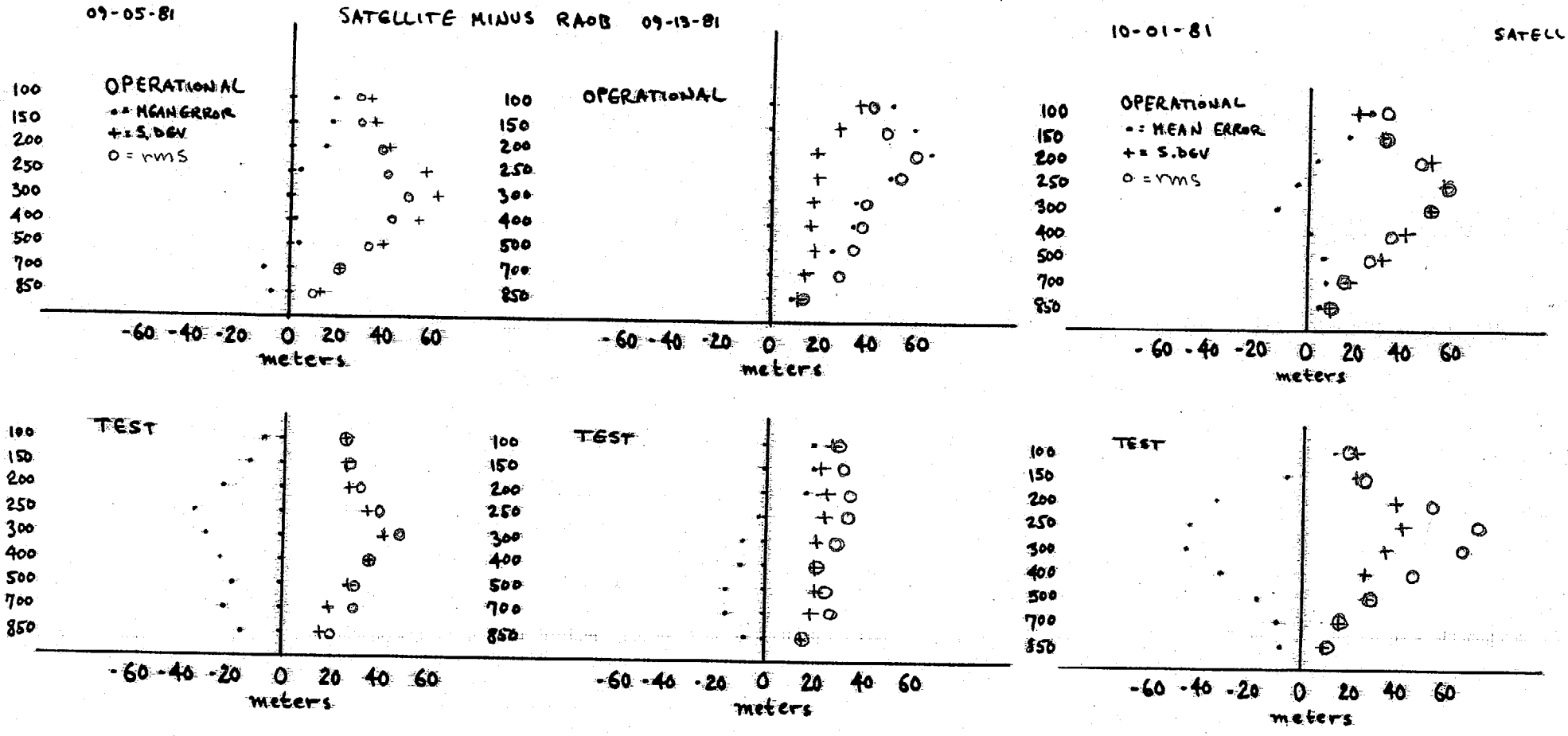


Figure 6. Same as Figure 4 but for 12Z 01 October 1981.



a. 12 GMT 5 Sep 1981 b. 12 GMT 13 Sep 1981 c. 12 GMT 01 Oct 1981

Figure 7. Mean error, rms error, and standard deviation of sample of satellite-minus-radiosonde thickness differences for three cases.

low levels and up to 40-50 meters at 300 mb (equivalent to about -1.0K bias over the 1000-300 mb layer). This pattern is also seen in the next two cases, Figures 7b and 7c. In Figure 7b, however, the University of Wisconsin test sounding thicknesses improve upon those from the operational retrievals, but only above 500 mb, while in Figure 7c, the test thicknesses are much too cold at middle levels, and produce degraded results in comparison with the competition.

While the three cases examined encompass a wide variety of flow patterns, the small number of cases limits the value of relating these flow pattern differences to the results of Figure 7 and Appendix 1. Some similarities and differences among all three cases are worth noting though. The test soundings all bear a cold bias, especially between 500 and 200 mb. The operational cases on the other hand, show no preference for warm or cold bias in low to middle levels, but are biased above about 250 mb by about +0.5K. The profiles of standard deviation of the samples are similar in both the test and operational soundings but the test soundings show a generally lower standard deviation, implying that they possess slightly greater consistency than the operational sounding sets.

SUMMARY AND CONCLUSIONS

A technique for acquiring vertical temperature profiles from polar-orbiter radiances based on the iterative inversion of the radiative transfer equation (Smith, 1970; Smith and Woolf, 1981) has been examined as a possible tool for producing high density soundings sets over the oceans. Three sets of such soundings over Canada along with soundings produced operationally were each transformed into sets of composite soundings at radiosonde sites, making direct comparison of both sounding methods with radiosonde observations possible. The test soundings bear an overall bias of -1.0K to -1.5K over the

1000-250 mb layer. The operational soundings show only a small bias of about +0.5K above 200 mb. The accuracy of the test soundings, as measured by comparisons with raobs, exceeded that of the operational soundings in one case (September 13, 1981) above 500 mb. The remaining two sets of test soundings were less accurate than the operational soundings.

It is not possible, based upon such a small sample of cases, to judge whether the sounding technique tested would improve upon the method now used in those regions. This experiment implies that the new technique would consistently produce cold-biased soundings, which would not be desirable.

ACKNOWLEDGEMENTS

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Appendix 1

Soundings at locations of RAOBS formed by collation and weighted averaging of surrounding operational or test soundings

05 SEP 1981

ERATIONAL CASE DATE(LABEL)= TIROS-N F8F1F0F9 F0F5F1F2 F0F0F0F0 WASHINGTON-D NUMBER REPORTS= 16

SNDG# 1 68.8 N/ 81.3

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1294.7	1.7
700.	2806.1	3.1
500.	5334.4	17.4
400.	6931.8	24.6
300.	8898.1	41.1
250.	10133.0	46.0
200.	11634.9	27.9
150.	13561.4	14.4
100.	16255.6	18.6

SNDG# 2 53.5 N/114.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1344.7	-7.3
700.	2910.2	-11.8
500.	5500.7	-4.3
400.	7126.1	-8.9
300.	9105.5	-9.5
250.	10314.3	9.3
200.	11766.3	31.3
150.	13633.0	28.0
100.	16280.2	25.3

SNDG# 3 53.2 N/ 70.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1344.4	-12.6
700.	2917.3	-25.7
500.	5547.3	-20.7
400.	7205.2	-22.8
300.	9233.8	-34.2
250.	10460.9	-31.1
200.	11935.8	-2.2
150.	13790.7	32.7
100.	16363.9	35.9

SNDG# 4 51.3 N/ 80.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1352.2	9.2
700.	2933.1	15.1
500.	5572.3	19.3
400.	7234.6	11.6
300.	9265.1	13.1
250.	10499.8	16.8
200.	11967.6	44.6
150.	13820.0	57.0
100.	16386.6	63.6

SNDG# 5 58.1 N/ 68.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1316.6	6.6
700.	2852.2	17.2
500.	5420.3	1.3
400.	7039.8	0.8
300.	9026.5	-2.5
250.	10250.2	21.2
200.	11723.3	34.3
150.	13606.5	17.5
100.	16238.6	19.6

SNDG# 6 58.4 N/ 78.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1314.8	2.8
700.	2842.9	-2.1
500.	5394.5	1.5
400.	7002.9	-0.1
300.	8974.1	1.1
250.	10190.1	27.1
200.	11657.6	54.6
150.	13541.5	48.5
100.	16188.7	53.7

SNDG# 7 63.8 N/ 68.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1294.6	2.6
700.	2801.5	18.5
500.	5322.6	79.6
400.	6915.9	112.9
300.	8881.0	118.0
250.	10114.9	111.9
200.	11615.0	92.0
150.	13536.7	53.7
100.	16220.3	37.3

SNDG# 8 58.8 N/ 94.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1320.8	-22.2
700.	2855.1	-37.9
500.	5402.8	-68.2
400.	7003.6	-97.4
300.	8958.7	-122.3
250.	10164.6	-106.4
200.	11623.6	-67.4
150.	13510.6	-60.4
100.	16176.5	-44.5

SNDG# 9 64.2 N/ 83.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1292.5	-10.5
700.	2790.8	-12.2
500.	5291.0	10.0
400.	6869.7	28.7
300.	8817.1	30.1
250.	10044.3	33.3
200.	11541.1	10.1
150.	13466.6	-14.4
100.	16164.9	-20.1

SNDG# 10 69.1 N/105.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1294.9	7.9
700.	2800.4	22.4
500.	5307.9	41.9
400.	6887.7	51.7
300.	8841.1	45.1
250.	10059.9	33.9
200.	11561.9	15.9
150.	13494.9	8.9
100.	16205.5	9.5

SNDG# 11 64.3 N/ 96.0

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1295.5	-7.5
700.	2798.7	-14.3
500.	5297.4	-5.6
400.	6870.5	7.5
300.	8801.8	28.8
250.	10017.0	34.0
200.	11501.3	8.3
150.	13420.7	-2.3
100.	16125.4	2.4

SNDG# 12 60.0 N/111.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1323.6	3.6
700.	2859.4	-7.6
500.	5404.7	-1.3
400.	7002.6	-3.4
300.	8952.2	-3.8
250.	10156.8	20.8
200.	11614.8	48.8
150.	13501.1	55.1
100.	16166.6	60.6

SNDG# 13 48.6 N/ 93.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1367.7	14.7
700.	2963.3	4.3
500.	5617.4	14.4
400.	7286.3	13.3
300.	9322.8	19.8
250.	10552.3	39.3
200.	12011.5	58.9
150.	13854.0	61.0
100.	16408.6	55.6

SNDG# 14 46.8 N/100.8

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1384.5	-8.5
700.	2999.1	-39.9
500.	5665.6	-61.4
400.	7339.0	-58.0
300.	9377.9	-59.1
250.	10604.7	-52.3
200.	12028.7	-28.3
150.	13897.5	10.5
100.	16453.3	26.3

SNDG# 15 48.2 N/106.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1387.1	-17.9
700.	3002.9	-24.1
500.	5663.4	-23.6
400.	7332.1	-24.9
300.	9363.7	-43.3
250.	10586.7	-40.3
200.	12038.4	-18.6
150.	13882.4	15.4
100.	16453.4	6.4

SNDG# 16 47.5 N/111.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1375.5	-32.5
700.	2974.6	-37.4
500.	5613.6	-34.4
400.	7269.6	-38.4
300.	9287.4	-40.6
250.	10508.7	-39.3
200.	11964.0	-4.0
150.	13817.9	9.9
100.	16405.8	27.8

05 SEP 1981

WISC

CASE DATE(LABEL)= TIROS-N F8F1F0F9 F0F5F0F6 00000000 WASHINGTONUW NUMBER REPORTS= 14

SNDG# 1 50.2 N/119.3

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1338.5	-17.5
700.	2891.2	-29.8
500.	5470.0	-48.0
400.	7091.7	-66.3
300.	9077.5	-70.5
250.	10285.4	-62.6
200.	11738.9	-39.1
150.	13604.6	-23.4
100.	16223.7	-4.3

SNDG# 2 53.5 N/114.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1338.7	-13.3
700.	2890.4	-31.6
500.	5464.7	-40.3
400.	7080.3	-54.7
300.	9052.9	-62.1
250.	10249.0	-56.0
200.	11691.4	-43.6
150.	13557.3	-47.7
100.	16198.5	-36.5

SNDG# 3 53.2 N/ 70.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1356.5	-0.5
700.	2940.0	-3.0
500.	5569.6	1.6
400.	7222.7	-5.3
300.	9245.0	-23.0
250.	10471.4	-26.6
200.	11933.0	-5.0
150.	13782.7	24.7
100.	16349.9	21.9

SNDG# 4 51.3 N/ 80.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1351.1	8.1
700.	2921.8	3.8
500.	5534.8	-18.2
400.	7180.6	-42.4
300.	9196.6	-56.4
250.	10422.3	-60.7
200.	11889.2	-33.8
150.	13749.7	-13.3
100.	16332.7	9.7

SNDG# 5 58.4 N/ 78.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1310.0	-2.0
700.	2837.1	-7.9
500.	5382.3	-10.7
400.	6985.9	-17.1
300.	8952.7	-20.3
250.	10157.7	-5.3
200.	11624.9	21.9
150.	13517.7	24.7
100.	16170.9	37.9

SNDG# 6 63.8 N/ 68.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1277.4	-14.6
700.	2773.2	-9.8
500.	5273.8	30.8
400.	6855.4	52.4
300.	8813.0	50.0
250.	10040.1	37.1
200.	11561.3	38.3
150.	13512.4	29.4
100.	16205.8	22.8

SNDG# 7 58.8 N/ 94.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1321.4	-21.6
700.	2863.1	-29.9
500.	5426.4	-44.6
400.	7035.8	-65.2
300.	9000.1	-80.9
250.	10194.3	-76.7
200.	11643.0	-48.0
150.	13524.1	-46.9
100.	16183.7	-37.3

SNDG# 8 64.2 N/ 83.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1275.1	-27.9
700.	2764.9	-38.1
500.	5252.2	-28.8
400.	6825.8	-15.2
300.	8772.8	-8.2
250.	9991.7	-19.3
200.	11505.1	-25.9
150.	13455.4	-25.6
100.	16157.5	-33.5

SNDG# 9 69.1 N/105.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1275.1	-11.9
700.	2769.0	-9.0
500.	5262.6	-3.4
400.	6838.5	2.5
300.	8784.6	-1.4
250.	10000.6	-25.4
200.	11512.8	-33.2
150.	13468.4	-17.6
100.	16185.5	-10.5

SNDG# 10 64.3 N/ 96.0

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1278.0	-25.0
700.	2776.3	-36.7
500.	5272.6	-30.4
400.	6843.8	-19.2
300.	8773.0	0.0
250.	9968.5	-14.5
200.	11459.1	-33.9
150.	13401.9	-21.1
100.	16114.6	-8.4

SNDG# 11 60.0 N/111.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1308.1	-11.9
700.	2840.0	-27.0
500.	5384.7	-21.3
400.	6981.7	-24.3
300.	8930.7	-25.3
250.	10117.4	-18.6
200.	11565.4	-0.6
150.	13453.8	7.8
100.	16126.2	20.2

SNDG# 12 48.2 N/106.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1376.9	-28.1
700.	2984.2	-42.8
500.	5638.9	-48.1
400.	7301.2	-55.8
300.	9328.6	-78.4
250.	10551.2	-75.8
200.	12002.8	-54.2
150.	13841.1	-25.9
100.	16409.6	-37.4

SNDG# 13 47.5 N/111.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1361.8	-46.2
700.	2956.0	-56.0
500.	5592.2	-55.8
400.	7241.7	-66.3
300.	9254.5	-73.5
250.	10472.4	-75.6
200.	11926.5	-41.5
150.	13777.9	-30.1
100.	16366.6	-11.4

SNDG# 14 47.6 N/117.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1352.4	-30.6
700.	2917.6	-52.4
500.	5515.3	-46.7
400.	7147.3	-44.7
300.	9143.8	-38.2
250.	10357.9	-24.1
200.	11816.2	-15.8
150.	13681.4	-20.6
100.	16292.9	0.9

13 SEP 1981

OPERATIONAL CASE DATE(LABEL)= TIROS-N F8F1F0F9 F1F3F1F2 F0F0F0F0 WASHINGTON-D NUMBER REPORTS= 12

SNDG# 1 68.8 N/ 81.3

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1326.5	22.5
700.	2877.8	26.8
500.	5458.9	15.9
400.	7079.8	16.8
300.	9056.4	13.4
250.	10262.6	39.6
200.	11710.7	87.7
150.	13571.9	68.9
100.	16192.1	59.1

SNDG# 2 53.5 N/114.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1344.8	-4.2
700.	2910.9	8.9
500.	5513.1	36.1
400.	7147.9	30.9
300.	9145.4	18.4
250.	10359.2	22.2
200.	11809.3	62.3
150.	13658.8	91.8
100.	16242.9	115.9

SNDG# 3 51.3 N/ 80.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1347.1	17.1
700.	2909.2	24.2
500.	5497.8	42.8
400.	7124.4	39.4
300.	9115.6	20.6
250.	10340.1	25.1
200.	11812.2	37.2
150.	13690.9	25.9
100.	16308.6	23.6

SNDG# 4 53.8 N/ 89.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1333.1	-14.1
700.	2882.1	19.1
500.	5453.3	36.3
400.	7072.3	55.3
300.	9054.7	47.7
250.	10278.3	61.3
200.	11752.9	65.9
150.	13637.8	60.8
100.	16268.0	51.0

SNDG# 5 63.8 N/ 68.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1333.0	6.0
700.	2890.0	22.0
500.	5473.6	38.6
400.	7096.2	51.2
300.	9073.7	58.7
250.	10281.8	66.8
200.	11732.0	87.0
150.	13594.1	89.1
100.	16213.1	58.1

SNDG# 6 69.1 N/105.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1301.9	10.9
700.	2823.4	6.4
500.	5350.7	8.7
400.	6938.6	26.6
300.	8877.3	35.3
250.	10076.1	64.1
200.	11528.3	66.3
150.	13408.6	36.6
100.	16066.8	24.8

SNDG# 7 64.3 N/ 96.0

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1309.3	17.3
700.	2842.6	27.6
500.	5396.3	26.3
400.	7003.0	23.0
300.	8965.2	15.2
250.	10170.9	40.9
200.	11624.4	54.4
150.	13500.3	20.3
100.	16143.6	3.6

SNDG# 8 60.0 N/111.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1319.3	-8.7
700.	2855.0	-12.0
500.	5401.8	-3.2
400.	7000.3	15.3
300.	8952.0	47.0
250.	10153.7	58.7
200.	11605.6	50.6
150.	13480.0	35.0
100.	16123.9	8.9

SNDG# 9 48.6 N/ 93.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1374.8	-14.2
[illegible]	2976.4	-28.6
[illegible]	5629.3	-26.7
[illegible]	7294.2	-41.8
300.	9227.8	-38.2
250.	10557.4	-48.6
200.	12015.9	-30.1
150.	13853.7	-12.3
100.	16394.0	8.0

SNDG# 10 48.2 N/106.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1385.0	-16.0
700.	2995.7	-28.3
500.	5660.6	-35.4
400.	7331.2	-34.8
300.	9369.5	-46.5
250.	10599.6	-46.4
200.	12055.0	-31.0
150.	13882.4	-3.6
100.	16401.5	15.5

SNDG# 11 47.5 N/111.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1387.5	-23.1
700.	2998.9	-46.1
500.	5664.6	-63.4
400.	7336.2	-51.8
300.	9376.8	-51.2
250.	10607.6	-50.4
200.	12063.8	-44.2
150.	13890.5	-17.5
100.	16406.7	8.7

SNDG# 12 47.6 N/117.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1379.5	-21.5
700.	2983.5	-39.5
500.	5640.0	-57.0
400.	7307.1	-59.9
300.	9342.9	-64.1
250.	10571.8	-75.2
200.	12028.1	-58.9
150.	13858.0	-39.0
100.	16383.6	-3.4

U. WISC CASE DATE(LABEL)= TIROS-N F8F1F0F9 F1F3F0F6 00000000 WASHINGTONUW NUMBER REPORTS= 10

SNDG# 1 68.8 N/ 81.3

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1317.6	13.6
700.	2860.1	9.1
500.	5433.1	-9.9
400.	7049.8	-13.2
300.	9024.7	-18.3
250.	10223.5	0.5
200.	11670.9	47.9
150.	13536.9	33.9
100.	16164.3	31.3

SNDG# 2 53.5 N/114.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1325.9	-23.1
700.	2878.7	-23.3
500.	5467.9	-9.1
400.	7097.0	-20.0
300.	9087.6	-39.4
250.	10293.9	-43.1
200.	11738.9	-8.1
150.	13588.2	21.2
100.	16185.2	58.2

SNDG# 3 53.2 N/ 70.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1322.0	-14.9
700.	2863.3	-22.7
500.	5438.8	-15.2
400.	7063.8	-10.2
300.	9064.2	10.2
250.	10302.1	48.1
200.	11807.3	53.3
150.	13719.6	55.6
100.	16350.5	46.5

SNDG# 4 51.3 N/ 80.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1328.0	-2.0
700.	2877.2	-7.8
500.	5459.7	4.7
400.	7085.7	0.7
300.	9082.2	-12.8
250.	10307.2	-7.8
200.	11788.5	13.5
150.	13677.8	12.8
100.	16301.4	16.4

SNDG# 5 53.8 N/ 89.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1317.4	-1.6
700.	2854.9	-8.1
500.	5422.4	5.4
400.	7041.3	24.3
300.	9030.2	23.2
250.	10251.4	34.4
200.	11730.0	43.0
150.	13618.6	41.6
100.	16247.0	30.0

SNDG# 6 54.0 N/101.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1319.6	-34.4
700.	2861.0	-46.0
500.	5431.7	-27.3
400.	7053.1	-35.9
300.	9041.9	-37.1
250.	10256.4	-22.6
200.	11720.5	-8.5
150.	13591.6	-7.4
100.	16202.2	-6.8

SNDG# 7 58.1 N/ 68.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1316.4	2.4
700.	2856.8	12.8
500.	5425.5	10.5
400.	7043.0	18.0
300.	9027.7	42.7
250.	10246.3	51.3
200.	11724.8	49.8
150.	13618.1	33.1
100.	16255.1	0.1

SNDG# 8 63.8 N/ 68.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1315.3	-11.7
700.	2857.1	-10.9
500.	5427.7	-7.3
400.	7044.0	-1.0
300.	9020.0	5.0
250.	10221.9	6.9
200.	11674.1	29.1
150.	13545.3	40.3
100.	16176.2	21.2

SNDG# 9 69.1 N/105.1

P(MB)	THICKNESS(M)	SAT-RAOB
[illegible]	0.0	0.0
[illegible]	1278.3	-12.7
700.	2784.3	-32.7
500.	5298.3	-43.7
400.	6881.1	-30.9
300.	8817.8	-24.2
250.	10001.6	-10.4
200.	11460.6	-1.4
150.	13364.7	-7.3
100.	16039.7	-2.3

SNDG# 10 60.0 N/111.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1300.0	-28.0
700.	2820.7	-46.3
500.	5356.5	-48.5
400.	6950.8	-34.2
300.	8900.5	-4.5
250.	10089.5	-5.5
200.	11543.7	-11.3
150.	13433.7	-11.3
100.	16092.5	-22.5

01 OCT 1981

OPERATIONAL CASE DATE(LABEL)= TIRGS-N F8F1F1F0 F0F1F1F2 F0F0F0F0 WASHINGTON-0 NUMBER REPORTS= 11

SNDG# 1 68.8 N/ 81.3

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1292.5	-1.5
700.	2805.7	-4.3
500.	5313.0	-3.0
400.	6884.0	-2.0
300.	8803.6	-32.4
250.	9993.2	-22.8
200.	11436.4	-19.6
150.	13305.2	-20.8
100.	15941.0	5.0

SNDG# 2 53.5 N/114.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1355.4	7.4
700.	2935.7	-15.3
500.	5559.7	-31.3
400.	7204.8	-56.2
300.	9204.5	-96.5
250.	10408.1	-102.9
200.	11839.6	-81.4
150.	13665.0	14.0
100.	16222.0	51.0

SNDG# 3 54.0 N/101.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1320.3	12.3
700.	2864.2	16.2
500.	5428.0	21.0
400.	7033.8	6.8
300.	8988.7	-28.3
250.	10181.4	-35.6
200.	11613.5	-23.1
150.	13459.4	22.4
100.	16060.3	43.3

SNDG# 4 58.4 N/ 78.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1301.5	14.5
700.	2824.2	23.2
500.	5355.9	22.9
400.	6946.2	13.2
300.	8889.7	6.7
250.	10080.5	37.5
200.	11516.6	63.6
150.	13374.7	61.7
100.	15999.5	46.5

SNDG# 5 63.8 N/ 68.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1309.7	6.7
700.	2848.1	23.1
500.	5410.3	38.3
400.	7018.1	26.1
300.	8973.8	11.8
250.	10163.9	31.9
200.	11591.9	59.9
150.	13433.4	61.4
100.	16029.9	47.9

SNDG# 6 58.8 N/ 94.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1301.8	5.8
700.	2817.2	6.2
500.	5326.6	6.6
400.	6898.4	18.4
300.	8817.1	37.1
250.	10000.6	50.6
200.	11434.6	44.6
150.	13295.1	35.1
100.	15927.7	47.7

SNDG# 7 64.2 N/ 83.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1289.8	18.8
700.	2792.0	37.0
500.	5283.1	60.1
400.	6846.7	73.7
300.	8766.1	63.1
250.	9962.1	59.1
200.	11414.9	31.8
150.	13294.5	21.5
100.	15942.8	29.8

SNDG# 8 69.1 N/105.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1285.9	-2.1
700.	2791.3	-5.7
500.	5284.5	-0.5
400.	6846.7	11.7
300.	8755.2	30.2
250.	9933.6	38.6
200.	11363.0	18.0
150.	13221.5	6.5
100.	15856.1	11.1

SNDG# 9 64.3 N/ 96.0

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1291.8	-0.2
700.	2802.1	-4.9
500.	5302.7	-12.3
400.	6870.0	-15.0
300.	8785.5	0.5
250.	9968.8	13.8
200.	11403.9	-1.1
150.	13267.9	-7.1
100.	15905.9	-9.1

SNDG# 10 60.0 N/111.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1326.5	-5.5
700.	2882.2	-9.8
500.	5464.8	-25.2
400.	7081.6	-48.4
300.	9046.0	-74.0
250.	10237.4	-72.6
200.	11665.8	-34.2
150.	13507.4	-2.6
100.	16107.2	17.2

SNDG# 11 48.2 N/106.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1346.2	-9.8
700.	2921.7	-14.3
500.	5538.4	-40.6
400.	7177.2	-61.8
300.	9169.0	-100.0
250.	10374.3	-104.7
200.	11809.9	-89.1
150.	13638.5	-20.5
100.	16195.1	6.1

U. WISC CASE DATE(LABEL)= TIRCS-N F8F1F1F0 F0F1F0F6 00000000 WASHINGTONUW NUMBER REPORTS= 12

SNDG= 1 68.8 N/ 81.3

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1288.3	-5.7
700.	2799.7	-10.3
500.	5303.4	-12.6
400.	6873.1	-12.9
300.	8795.4	-36.6
250.	9978.5	-37.5
200.	11420.2	-35.8
150.	13295.6	-26.4
100.	15940.6	4.6

SNDG= 2 51.3 N/ 80.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1302.2	15.2
700.	2834.2	21.2
500.	5374.8	-11.2
400.	6966.4	-49.6
300.	8913.7	-92.3
250.	10100.7	-95.3
200.	11542.4	-73.6
150.	13412.4	-23.6
100.	16040.6	-15.4

SNDG= 3 53.8 N/ 89.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1285.0	-1.0
700.	2795.6	-7.4
500.	5299.5	-20.5
400.	6869.8	-40.2
300.	8795.3	-54.7
250.	9972.8	-57.2
200.	11409.4	-30.6
150.	13281.4	-8.6
100.	15921.0	1.0

SNDG= 4 54.0 N/101.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1305.3	-2.7
700.	2840.8	-7.2
500.	5386.3	-20.7
400.	6979.0	-48.0
300.	8924.3	-92.7
250.	10107.3	-109.7
200.	11541.1	-95.9
150.	13402.8	-34.2
100.	16023.2	5.2

SNDG= 5 58.1 N/ 66.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1313.7	-12.3
700.	2856.5	-10.5
500.	5409.4	-26.6
400.	7003.7	-52.3
300.	8951.6	-64.2
250.	10138.2	-47.8
200.	11577.1	-8.9
150.	13445.5	-0.5
100.	16072.6	6.6

SNDG= 6 58.4 N/ 78.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1288.7	1.7
700.	2805.8	4.8
500.	5325.4	-7.6
400.	6905.5	-27.5
300.	8841.8	-41.2
250.	10025.0	-18.0
200.	11466.4	13.4
150.	13343.0	30.0
100.	15986.3	33.3

SNDG= 7 63.8 N/ 68.5

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1300.7	-2.3
700.	2837.9	12.9
500.	5388.1	16.1
400.	6984.8	-7.2
300.	8932.9	-29.1
250.	10111.0	-21.0
200.	11537.2	5.2
150.	13396.2	24.2
100.	16022.0	40.0

SNDG= 8 58.8 N/ 94.1

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1277.0	-19.0
700.	2779.5	-31.5
500.	5271.4	-48.6
400.	6835.4	-44.5
300.	8756.7	-23.3
250.	9935.4	-14.6
200.	11377.4	-12.6
150.	13256.9	-3.1
100.	15902.3	22.3

SNDG= 9 64.2 N/ 83.4

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1267.6	-3.4
700.	2756.0	1.0
500.	5227.4	4.4
400.	6783.4	10.4
300.	8706.3	3.3
250.	9896.9	-6.1
200.	11360.6	-22.2
150.	13265.0	-8.0
100.	15925.0	12.0

SNDG= 10 64.3 N/ 96.0

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1272.9	-19.1
700.	2773.2	-33.8
500.	5260.3	-54.7
400.	6821.2	-63.8
300.	8737.2	-47.8
250.	9913.4	-41.6
200.	11353.8	-51.2
150.	13233.6	-41.4
100.	15881.6	-33.4

SNDG= 11 60.0 N/111.9

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1322.2	-9.8
700.	2881.9	-10.1
500.	5457.4	-32.6
400.	7063.6	-66.4
300.	9018.8	-101.2
250.	10198.8	-111.2
200.	11622.1	-77.9
150.	13472.1	-37.9
100.	16082.7	-7.3

SNDG= 12 48.2 N/106.6

P(MB)	THICKNESS(M)	SAT-RAOB
1000.	0.0	0.0
850.	1330.6	-25.4
700.	2913.0	-23.0
500.	5531.0	-48.0
400.	7165.4	-73.6
300.	9155.7	-113.3
250.	10359.9	-119.1
200.	11803.9	-95.1
150.	13651.2	-7.8
100.	16217.2	28.2