VISSR ATMOSPHERIC SOUNDER

Monthly Progress Report No. 12
For the Period 1 August 1974 to 31 August 1974

Contract No. NAS5-21965

For National Aeronautics and Space Administration
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INTRODUCTION

During August work began on a calibration analysis of a high temperature internal blackbody reference for the VAS. Results should be available for inclusion in the September progress report. Further results of simulation analysis are summarized in the following sections.

1. The Effect of Location Errors on Sounding Channel Retrievals

The effect of location errors on sounding was studied using the VAS simulator by misaligning the window channel grid of radiance measurements. The misaligned grid was formed from the aligned window channel grid as follows:

$$I^{MA\pm}_{i_j} = (1-f)\, I_{i_j} + f\, I_{i_{j\pm1}}$$

where I_{i_j} is the "measured" radiance for a sample labelled by line number i and sample number j and $I^{MA\pm}_{i_j}$ is the radiance for a fraction misalignment f. Since samples are taken at 0.084 mr intervals, the misalignment is 0.084 x f mr.

Simulations were performed on the scene subgrids using channel 5 with several misalignments ranging between 0.002 and 0.025 mr. As was mentioned in a previous report the misalignment due to discontinuous sampling has a standard deviation of .024 mr for a single line scan and is reduced if multiple scans of the same line are averaged. The range of misalignments possible due to cloud motions depends both on cloud speeds and on the order with which the different spectral channels are sampled. For a cloud speed of 30 km/hr a misalignment of 0.014 mr occurs in 1 minute. The simulation results are shown in Tables 1 and 2 which indicate that the misalignment errors are sufficiently small that they can not be separated from the inaccuracies of the simulations (see Appendix).

2. The Effect of Diffraction on Window Channel Retrievals

Window channel clear column retrievals using the histogram technique are affected by diffraction and have an important influence on sounding channel retrievals. The histogram technique relies on the fact that, for scenes which are partially clear, a histogram of the observed radiances for each FOV displays a peak near the clear column radiance. The procedure discussed here uses analog radiances and will require modification to deal with digital data. We are beginning to study techniques for histogram analysis of digital data using SMS data on McIDAS.

Typical histograms are illustrated in Figure 1. The detector noise makes some observed radiances larger than the clear column radiance. The clear column retrieval technique depends on the detector noise being randomly distributed so that the large radiance tail of the histogram is approximately Gaussian. A Gaussian function with standard deviation equal to the detector noise standard deviation is used to fit the upper tail of the histogram and the location of its peak is taken as the clear column radiance. As illustrated in Figure 1 this technique results in a negative bias which depends on the height of the peak near the clear column radiance as well as on the spatial extent of the weighting function. Actually, these two sources of error are related because diffraction tends to decrease the height of the peak since fewer completely clear FOV are observed if the FOV

TABLE 1. **Effect of Misalignment on Channel 5 Retrievals (f = .02, .04 and .06)**

	f = .02 (.0017 mr)				f = .04 (.0034 mr)				f = .06 (.0050 mr)			
			WEIGHTED				WEIGHTED				WEIGHTED	
	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS
1	+.12	.19	+.02	.13	+.11	.16	+.05	.13	+.11	.18	+.02	.13
2	-.01	.11	-.02	.11	-.06	.10	-.07	.11	-.01	.11	-.02	.11
3	+.03	.10	-.05	.09	+.05	.11	+.01	.01	+.05	.10	-.03	.08
4	+.28	.31	-.15	.18	+.34	.36	+.20	.22	+.30	.32	+.16	.19
5	-.03	.14	-.11	.15	+.07	.14	-.01	.13	-.02	.13	-.09	.14
6	+.28	.29	+.17	.19	+.28	.30	+.16	.18	+.32	.33	+.18	.21
7	+.29	.34	+.11	.21	+.18	.21	-.03	.12	+.31	.36	+.13	.22
8	-.03	.15	-.06	.15	-.01	.20	-.09	.20	-.03	.15	-.07	.15
9	+.15	.22	+.04	.16	+.08	.15	-.05	.15	+.16	.23	+.05	.16
10	+.10	.16	+.05	.15	+.07	.12	-.01	.10	+.11	.17	+.06	.15
11	+.09	.17	+.041	.15	+.03	.10	-.04	.12	+.10	.17	+.05	.15
12	-.03	.12	-.07	.12	-.11	.17	-.14	.19	+.02	.12	-.06	.12
13	+.41	.48	-.41	.47	+.19	.28	+.17	.26	+.38	.45	_.39	.45
14	+.02	.10	-.02	.10	-.02	.09	-.05	.11	+.02	.10	-.02	.10
15	+.26	.31	+.09	.18	+.34	.37	+14	.22	_.32	.36	+.13	.20
16	+.08	.14	+.05	.13	+.19	.24	+.13	.21	+.08	.14	+.05	.13

TABLE 2: **Effect of Misalignment on Channel 5 Retrievals (f = ± .1, ± .3)**

	f = +.1 (.0084 mr)				f = +.3 (.025 mr)				f = −.1 (.0084 mr)				f = −.3 (.025 mr)			
			WEIGHTED				WEIGHTED				WEIGHTED				WEIGHTED	
	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS	MEAN	RMS
1	+.06	.20	−.01	.19	+.03	.14	−.03	.15	+.30	.32	+.17	.21	+.36	.39	+.20	.2[illegible]
2	−.07	.14	−.09	.16	+.00	.10	−.05	.10	+.06	.15	+.03	.13	−.05	.13	−.10	.1[illegible]
3	+.08	.19	+.02	.14	+.16	.20	+.09	.13	+.12	.22	+.05	.16	+.01	.14	−.03	.1[illegible]
4	+.29	.35	+.13	.24	+.34	.35	+.15	.17	+.36	.41	+.21	.29	+.37	.40	+.20	.2[illegible]
5	+.06	.13	−.02	.15	+.06	.15	+.02	.15	+.02	.13	−.07	.13	+.15	.19	+.02	.1[illegible]
6	+.18	.23	+.07	.19	+.31	.34	+.14	.20	+.19	.20	+.09	.12	+.03	.12	−.04	.1[illegible]
7	+.25	.29	+.06	.19	+.20	.25	+.03	.18	+.36	.38	+.10	.19	+.32	.33	−.08	.1[illegible]
8	−.06	.19	−.11	.20	−.09	.18	−.16	.23	+.15	.26	+.07	.24	+.27	.29	+.15	.2[illegible]
9	+.16	.17	+.05	.09	+.09	.15	+.01	.10	+.19	.21	+.05	.12	+.14	.21	−.03	.1[illegible]
10	+.15	.18	+.08	.13	+.22	.25	+.09	.15	+.12	.19	+.08	.14	+.13	.19	+.09	.1[illegible]
11	+.05	.14	+.00	.10	−.01	.13	−.06	.16	+.14	.18	+.09	.16	+.16	.18	+.10	.1[illegible]
12	+.05	.09	−.00	.09	−.01	.10	−.05	.11	+.01	.12	−.05	.12	−.03	.10	−.11	.1[illegible]
13	+.27	.36	+.31	.37	−.22	.35	−.11	.29	+.51	.62	+.50	.61	+.93	.96	+.75	.7[illegible]
14	−.01	.11	−.05	.12	+.05	.14	+.01	.14	−.01	.13	−.08	.16	+.13	.19	+.04	.1[illegible]
15	+.42	.43	+.17	.22	+.63	.67	+.38	.43	+.32	.36	+.12	.23	+.20	.41	+.04	.1[illegible]
16	+.11	.18	+.05	.17	+.03	.16	−.04	.14	+.16	.22	+.11	.20	—	—	—	—

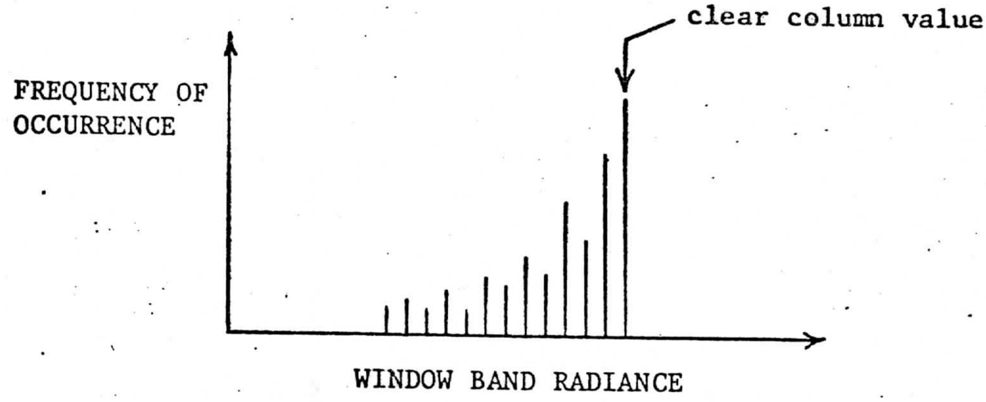

FIGURE 1a: Typical histogram of radiances close to the clear column value obtained with a noiseless detector with "ideal" spatial weighting.

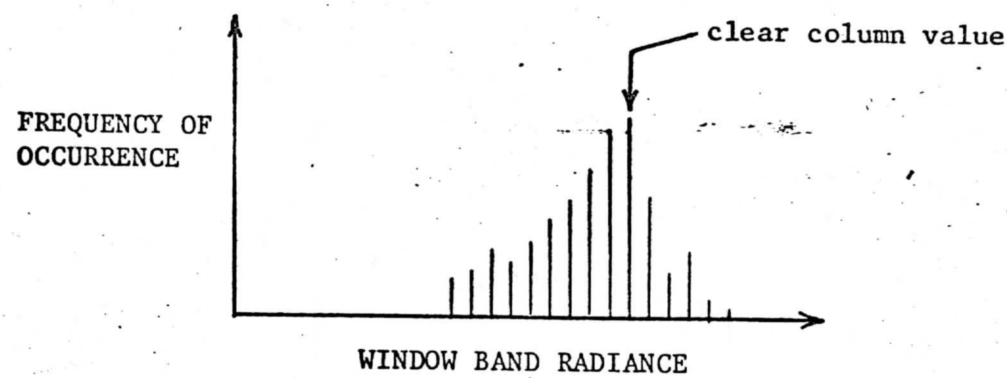

FIGURE 1b: A typical histogram obtained with a noisy detector with "ideal" spatial weighting.

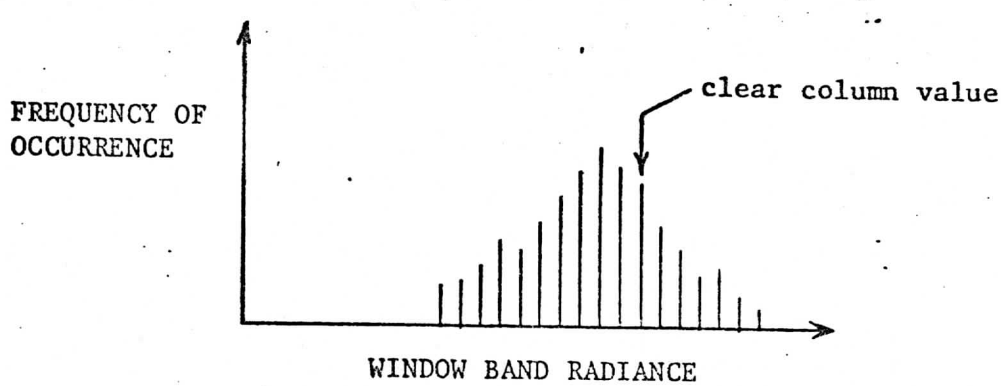

FIGURE 1c: A typical histogram obtained with a noisy detector with "real" spatial weighting.

becomes larger.

Use of the large .384 mr detector for window channel retrievals was found to be adequate for the whole simulator scene; the mean error of the histogram fit (for 16 different random noise additions) was - .184 ergs/etc with a standard deviation of .038. Essentially all of the bias error is due to diffraction. However, the .384 mr detector was found to be inadequate for 90 x 90 km subgrid retrievals and use of the .192 mr detector for all window channel retrievals would improve the results. Subgrid simulation results for the .192 mr detector are shown in Table 1. The zero noise case shows the amount of the bias errors caused by diffraction. The bias errors are quite substantial for some of the subgrids.

It appears that a correction algorithm will be necessary. A simple correction technique has been developed which depends on the shape of the histogram. It indicates that correction routines based on the histogram characteristics rather than on individual FOV characteristics may be successful. Individual FOV corrections would require a very large amount of data analysis because of the large spatial extent of the FOV. The correction algorithm used here relies on the qualitative relation that the bias error becomes larger as the histogram peak becomes smaller. The following empirical relation was obtained:

$$R \equiv \frac{\text{peak value of the histogram}}{\text{mean radiance prior to the peak}}$$

$$\text{Corrections} = \frac{+\,1.2}{2 + R}$$

The results of this correction are shown in Table 2 where a noise of .1 ergs/etc was assumed. The correction was also applied to a different

TABLE 1: Histogram Fit Results for Clear Column Window Channel Radiance Retrieval (.192 mr Detector)

	.42 ergs/etc Noise*		.21 ergs/etc*		0.0 ergs/etc
SUBGRID	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	ERROR
1	-.58	.07	-.28	.07	-.13
2	-.16	.08	-.06	.02	+.01
3	-.19	.03	-.25	.03	-.08
4	-.46	.05	-.30	.03	-.18
5	-.31	.05	-.23	.13	-.09
6	-.24	.07	-.24	.06	-.11
7	-.48	.09	-.48	.17	-.18
8	-.17	.15	-.20	.03	-.08
9	-.36	.18	-.18	.05	-.09
10	-.29	.12	-.21	.05	-.11
11	-.59	.08	-.29	.03	-.15
12	-.18	.04	-.13	.05	-.06
13	-2.31	.54	-1.89	.17	-.56
14	-.24	.21	-.24	.09	-.13
15	-.51	.23	-.38	.13	-.20
16	-.36	.19	-.37	.03	-.22

* The results of 4 additions of random correlated noise were averaged.

TABLE 2 Effect of the Correction Algorithm for Window Channel Histogram Retrieval of Clear Column Radiances (4 Additions of .1 erg/etc noise were made).

SUBGRID	MEAN	CORRECTED MEAN	STANDARD DEVIATION
1	-.31	-.04	.10
2	-.08	-.01	.02
3	-.19	+.04	.03
4	-.25	-.04	.06
5	-.15	+.13	.03
6	-.21	-.03	.02
7	-.34	-.14	.07
8	-.16	+.02	.03
9	-.25	-.08	.02
10	-.25	-.04	.04
11	-.21	-.03	.03
12	-.11	-.02	.04
13	-.90	———	.08
14	-.20	+.01	.03
15	-.45	-.23	.17
16	-.37	-.06	.16

scene with similar results. It is obvious that two test cases do not prove very much about the generality of the correction routing. However, they do give some hope for succes with this type of approach and more study is planned on correction routines.

APPENDIX: SIMULATOR ACCURACY

The simulator results consist of retrieved clear column radiance errors. Mean and RMS errors are obtained from the results of 10 different "measurements" (A measurement is simulated by the addition of random correlated noise to the detector radiance for each FOV). Since we are limited by computer time to a small number of "measurements", the mean and RMS radiance errors can vary substantially if any given set of retrievals is repeated.

From probability theory we can obtain confidence limits for variation of the mean and RMS errors. For normally distributed errors;

$$\bar{x} + t_{\frac{1-p}{2}} \frac{S_x}{\sqrt{n}} < \mu < \bar{x} + t_{\frac{1+p}{2}} \frac{S_x}{\sqrt{n}}$$

$$\frac{(n-1)\, S_x^2}{\chi^2_{\frac{1+p}{2}}} < \sigma^2 < \frac{(n-1)\, S_x^2}{\chi^2_{\frac{1+p}{2}}}$$

where

$\bar{x}$ = sample mean for n samples.

S_x^2 = sample variance

μ = mean

σ^2 = variance

p = fractional probability that the bounds given are not exceeded.

t_p = value of the abscissa of the t-distribution for n-1 degrees of freedom such that the integral from $-\infty$ to t_p is p.

χ^2_p = value of the abscissa of the chi-square distribution for n-1 degrees of freedom such that the integral from o to χ^2_p is p.

For p = 0.7, the 70% confidence level, and for 10 samples we get:

$$\mu = \bar{x} \pm 0.35\ S_x$$

$$0.8\ S_x < \sigma < 1.4\ S_x$$

The RMS errors tabulated are not the same as S_x because they represent deviations from the true clear column value instead of the sample mean. However, there is a simple relation between them given by:

$$S_x^2 - (\text{RMS error})^2 - (\text{mean error})^2$$

For most cases which we encounter the mean error is sufficiently small compared to the RMS error that the value of S_x does not vary too much from the RMS error. A useful approximation to use when evaluating the simulator data is that the mean and RMS errors are accurate to $\pm$ (RMS ERROR)/3.