A QUANTITATIVE ANALYSIS OF TIMS DATA OBTAINED ON THE LEARJET 23 AT VARIOUS ALTITUDES

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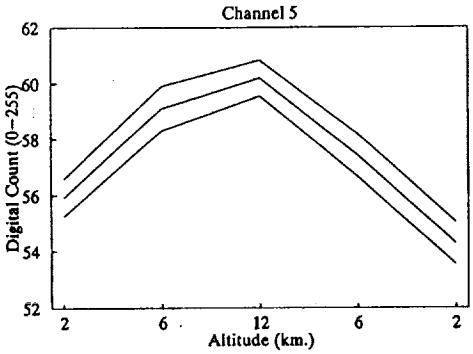
Summary

A series of TIMS data acquisition flights were conducted on the NASA Learjet 23 at different altitudes over a test site. The objective was to monitor the performance of the TIMS (its estimation of the brightness temperatures of the ground scene) with increasing altitude. The results do not show any significant correlation between the brightness temperatures and the altitude. The analysis indicates that the estimation of the temperatures is a function of the accuracy of the atmospheric correction used for each altitude.

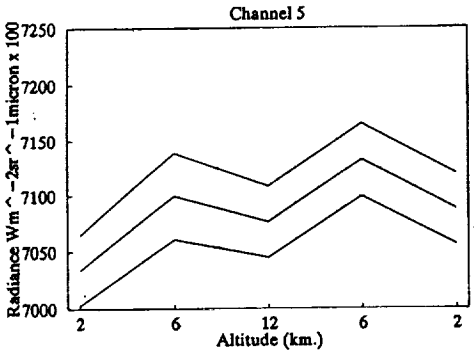
Five flights were flown in succession at altitudes of 2 km (low), 6 km (mid), 12 km (high), and then back again at 6 km and 2 km. The area selected was the Ross Barnett reservoir near Jackson, Mississippi. The mission was flown during the predawn hours of Feb. 1, 1992. Radiosonde data was collected for that duration to profile the characteristics of the atmosphere. Ground truth temperatures using thermometers and radiometers were also obtained over an area of the reservoir. The results of two independent runs of the radiometer data averaged 7.03 ± .70°C for the first run and 7.31 ± .88°C for the second run. Brightness temperatures were obtained for each channel for all flights. These were calculated by assuming the emissivity of the target to be 1.0 and computing the corresponding blackbody temperature given the upwelling ground radiance for each channel. Of particular interest were the temperatures corresponding to the region for which the ground truth data was available. Those regions were identified in each of the flights. The statistics of the raw video data, the corresponding radiance incident at the sensor, the upwelling ground radiance after it has been corrected for the atmosphere and finally the brightness temperatures were computed for those regions of each flight.

The results of the brightness temperature of the region from channel 5 of the TIMS - the band least affected by the column of water and ozone - do not reveal a significant variation with altitude. The temperature varied from a mean value of 7.26 ± .42 °C at 2 km, to 8.22 ± .45 °C at 6 km and to 8.35 ± .38 °C at 12 km. Considering the system accuracy of the TIMS sensor and the cumulative effect of the errors that can be introduced at various stages of the process of converting the raw data to brightness temperature, a variation of less than a degree between the temperatures obtained is not considered significant. The variation does not seem to be a function of the altitude as there is no continuous trend of change in temperature values from the low to the high altitudes. Rather, there seems to be a jump from the low altitude temperature to the mid and high altitude values, which are relatively close to each other,in spite of the high altitude being twice as high as the mid altitude.

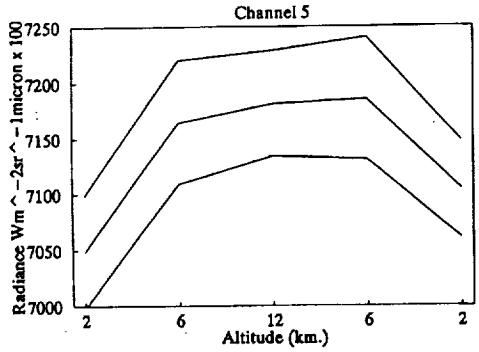
In this paper, the methodology used to obtain the brightness temperatures is described. The results of each stage of data conversion are illustrated. Also included are statistics for all the channels at each altitude and graphs for results of analysis on channel 5.



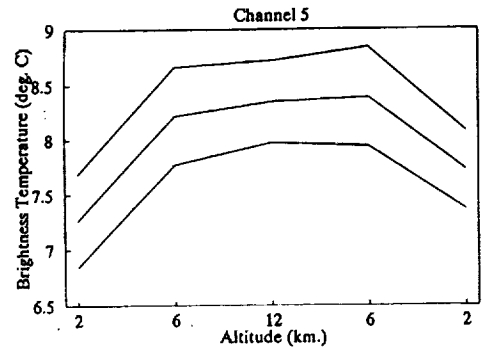
Variation of Ch#5 average video count with altitude.



Variation of Ch#5 radiance at sensor with altitude.



Variation of Ch#5 upwelling ground radiance with altitude.



Variation of Ch#5 Brightness Temperature with altitude.

Table 1 Digitized Raw Video

Ch#	Mean-sigma	Mean	Mean+sigma	sigma
1	53.57	54.45	55.33	0.88
2	53.00	53.77	54.54	0.77
3	54.34	55.06	55.78	0.72
4	54.89	55.48	56.07	0.59
5	55.25	55.91	56.57	0.66
6	54.81	56.09	57.37	1.28

Ch#	Mean-sigma	Mean	Mean+sigma	sigma
1	53.92	54.66	55.4	0.74
2	55.52	56.27	57.02	0.75
3	56.87	57.56	58.25	0.69
4	57.71	58.36	59.01	0.65
5	58.32	59.12	59.92	0.80
6	58.11	59.61	61.11	1.50

Ch#	Mean-sigma	Mean	Mean+sigma	sigma
1	55.79	56.50	57.21	0.71
2	57.54	58.20	58.86	0.66
3	57.44	58.09	58.74	0.65
4	57.15	57.74	58.33	0.59
5	59.56	60.20	60.84	0.64
6	59.60	60.84	62.08	1.24

Table 2 Radiance at Sensor

Ch#	Mean-sigma	Mean flux1	Mean+sigma	sigma
1	6107.271	6156.892	6206.513	49.62061
2	6476.706	6515.484	6554.263	38.77849
3	6704.340	6741.429	6778.518	37.08908
4	6968.603	6997.923	7027.243	29.31978
5	7002.743	7033.566	7064.390	30.82368
6	6777.586	6827.190	6876.794	49.60391

Ch#	Mean-sigma	Mean flux2	Mean+sigma	sigma
1	6013.600	6056.766	6099.933	43.16620
2	6499.201	6538.567	6577.933	39.36593
3	6741.725	6778.419	6815.114	36.69470
4	6986.802	7020.963	7055.125	34.16165
5	7060.608	7099.624	7138.639	39.01520
6	6819.643	6880.537	6941.430	60.89335

Ch#	Mean-sigma	Mean flux3	Mean+sigma	sigma
1	6059.631	6101.236	6142.842	41.60599
2	6510.972	6546.439	6581.909	35.46958
3	6706.780	6741.702	6776.624	34.92172
4	6813.435	6846.065	6878.696	32.63078
5	7044.588	7076.431	7108.273	31.84239
6	6810.463	6861.764	6913.068	51.30400

Table 3 Radiance from Ground

Ch#	Mean-sigma	Mean grd1	Mean+sigma	sigma
1	5926.766	6020.224	6113.682	93.458
2	6415.357	6492.179	6569.001	76.822
3	6656.563	6716.856	6777.148	60.292
4	6953.435	6998.664	7043.893	45.229
5	6998.044	7048.213	7098.381	50.168
6	6740.201	6817.743	6895.285	77.542

Ch#	Mean-sigma	Mean grd2	Mean+sigma	sigma
1	6016.547	6108.779	6201.011	92.232
2	6558.239	6618.023	6677.806	59.783
3	6787.691	6852.267	6916.842	64.575
4	7082.597	7150.960	7219.323	68.363
5	7109.192	7164.826	7220.461	55.635
6	6830.949	6922.543	7014.137	91.594

Ch#	Mean-sigma	Mean grd3	Mean+sigma	sigma
1	6250.651	6311.322	6371.993	60.671
2	6661.366	6704.410	6747.454	43.044
3	6896.086	6951.107	7006.128	55.021
4	7558.171	7604.735	7651.299	46.464
5	7134.094	7181.590	7229.085	47.495
6	6831.457	6902.734	6974.012	71.278

Table 4 Brightness Temperature

Ch#	Mean-sigma	Mean temp1	Mean+sigma	sigma
1	4.372	5.07	5.768	0.698
2	5.788	6.35	6.912	0.562
3	5.910	6.36	6.810	0.450
4	6.675	7.02	7.365	0.345
5	6.838	7.26	7.682	0.422
6	6.282	7.00	7.718	0.718

Ch#	Mean-sigma	Mean temp2	Mean+sigma	sigma
1	5.044	5.72	6.396	0.676
2	6.832	7.26	7.688	0.428
3	6.886	7.36	7.834	0.474
4	7.647	8.17	8.693	0.523
5	7.772	8.22	8.668	0.448
6	7.122	7.96	8.798	0.838

Ch#	Mean-sigma	Mean temp3	Mean+sigma	sigma
1	6.765	7.21	7.655	0.445
2	7.572	7.89	8.208	0.318
3	7.681	8.08	8.479	0.399
4	11.010	11.62	12.230	0.610
5	7.973	8.35	8.727	0.377
6	7.134	7.78	8.426	0.646