ESTIMATION OF DAILY MEAN AIR TEMPERATURE FROM SATELLITE DERIVED RADIOMETRIC DATA

Job Order 92-105

Prepared By
Lockheed Electronics Company, Inc.
Aerospace Systems Division
Houston, Texas
Contract NAS 9-12200

For
HEALTH APPLICATIONS OFFICE
LIFE SCIENCES DIRECTORATE

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas
January 1976
The Screwworm Eradication Data System (SEDS) at JSC utilizes satellite derived estimates of daily mean air temperature (DMAT) to monitor the effect of temperature on screwworm populations. The performance of the SEDS screwworm growth potential predictions depends in large part upon the accuracy of the DMAT estimates.
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FROM SATELLITE DERIVED RADIOMETRIC DATA

Job Order 92-105

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LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

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<th>Page</th>
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<td>4-9</td>
</tr>
<tr>
<td>6</td>
<td>Standard error for all U.S. stations when DMAT was calculated using day radiometric data only</td>
<td>4-10</td>
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</table>
ABBREVIATIONS, ACRONYMS AND SYMBOLS

ALT  Elevation in meters
ANOVA  Analysis of Variance
DMAT  Daily mean air temperature
DMATK  Daily mean air temperature in degrees Kelvin
K  Filter constant set to .125
TMET  Ground truth control station's observed mean air temperature
NOAA  National Oceanic and Atmospheric Administration
SEDS  Screwworm Eradication Data System
TSDK  Day radiometric temperature in degrees Kelvin
TSNK  Night radiometric temperature in degrees Kelvin
A_1, B_1, C_1  Multiple regression coefficients
ΔT  Temperature difference
°K  Degree Kelvin
1. INTRODUCTION

The Screwworm Eradication Data System (SEDS) at the Johnson Space Center, Houston, Texas utilizes satellite derived estimates of daily mean air temperature (DMAT) to monitor the effect of temperature on screwworm populations. A set of coefficients derived from multiple linear regression studies is used to convert radiometric data obtained by the National Oceanic and Atmospheric Administration (NOAA) satellite into estimates of daily mean air temperature. The performance of the SEDS screwworm growth potential predictions depends in large part upon the accuracy of the DMAT estimates.

1.1 PURPOSE

This technical memorandum evaluates the temperature accuracies obtained by SEDS production processor using spring data (March 29 through June 27, 1975).

1.2 BACKGROUND

Depending upon the amount of cloud-free data obtained from the twice daily satellite coverage, four basic methods are used to calculate DMAT. An accurate evaluation of SEDS performance requires an understanding of these methods.

The first three methods of calculating DMAT use current radiometric data. The cases are as follows:

- Case 1 - Both night and day radiometric data usable
  \[ \text{DMAT}_k = A_0 + A_1 \cdot TSNK + A_2 \cdot TSDK + A_3 \cdot ALT \]
- Case 2 - Only day radiometric data usable
  \[ \text{DMAT}_k = B_0 + B_1 \cdot TSDK + B_2 \cdot ALT \]
- Case 3 - Only night radiometric data usable
  \[ \text{DMAT}_k = C_0 + C_1 \cdot TSNK + C_2 \cdot ALT \]
Where the symbols are defined as follows:

- DMATK - Daily mean air temperature in degrees Kelvin
- TSDK - Day radiometric temperature in degrees Kelvin
- TSNK - Night radiometric temperature in degrees Kelvin
- ALT - Elevation in meters
- \( A_i, B_i, C_i \) - Multiple regression coefficients

Usable data is radiometric data which has survived all cloud detection tests. When no radiometric data is available, DMAT is estimated using ground data and a temperature difference field.

The ground truth fill-in utilizes a network of surface meteorological stations. Each point in the SEDS image is assigned to the "zone of influence" of a surface station. These zones are shown in figure 1. The size and shape of each zone is determined primarily by the density of the surface network.

A temperature difference (\( \Delta T \)) field for each zone is derived from days on which good quality radiometric data was available. The \( \Delta T \) field represents the difference between the ground truth control station's observed surface temperature and the radiometrically derived DMAT estimate for each point. When radiometric data is unavailable at a point, the DMAT estimate is made by adding the point's control station's observed surface temperature to the point's \( \Delta T \) value. This may be written for point \((x,y)\) as

\[
\text{DMAT}(x,y) = \text{TMET} + \Delta T(x,y)
\]
Figure 1. - Ground truth fill-in zone map.
where

- TMET - The ground truth control station's surface observed mean air temperature

- \(\Delta T(x,y)\) - The temperature difference field value at the point \((x,y)\).

When a DMAT estimate is made from radiometric data, the \(\Delta T\) field is updated. To prevent rapid fluctuation in the \(\Delta T\) field, a low pass filter is used. The update may be written:

\[
\Delta T(x,y) = K(DMAT(x,y) - TMET) + (1-K)\Delta T(-1)(x,y)
\]

where

- \(K\) - The filter constant which has been set to \(0.125\)

- \(\Delta T(-1)(x,y)\) - The temperature difference field from the previous day for the point \((x,y)\).

The DMAT estimate based on the \(\Delta T\) field is made for each point, but is used only when the radiometric data is cloudy or unavailable.
2. ANALYSIS OF MODEL

The basic model used to convert radiometric data to estimates of DMAT uses elevation as an independent variable. To test the need for elevation in the model, several regression studies were performed using SEDS data from the 28 September to 9 October time period. Each of the three methods of calculation described earlier were examined both with and without elevation as a variable. Additionally, the case where both radiometric passes produce usable data was examined to determine if the inclusion of latitude as variable was desirable. Summaries of these regression studies including the correlation matrix, coefficient of determination, standard error of estimates, analysis of variance, and tests of significance for the coefficients may be found in appendix A. These regressions were performed using data from the ground truth zone control stations shown in table I.

Using the results of these regressions, Analysis of Variance (ANOVA) was used to determine the significance of elevation and latitude as regression variables. Elevation was a highly significant variable for each method of calculation. The highest significance occurred for the day radiometric only usable and the lowest for both radiometric usable. Latitude was not a significant variable for this sample. The complete ANOVA's may be found in appendix B.
TABLE I. — GROUND TRUTH ZONE CONTROL STATIONS

<table>
<thead>
<tr>
<th>STATION NAME</th>
<th>SEDS ID</th>
<th>LATITUDE</th>
<th>LONGITUDE</th>
<th>ELEVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hermosillo</td>
<td>01</td>
<td>29:04</td>
<td>110:57</td>
<td>211 m</td>
</tr>
<tr>
<td>Chihuahua</td>
<td>02</td>
<td>28:38</td>
<td>106:04</td>
<td>1354 m</td>
</tr>
<tr>
<td>Guaymas</td>
<td>03</td>
<td>27:55</td>
<td>110:53</td>
<td>16 m</td>
</tr>
<tr>
<td>La Paz</td>
<td>07</td>
<td>29:04</td>
<td>110:20</td>
<td>10 m</td>
</tr>
<tr>
<td>Durango</td>
<td>09</td>
<td>24:01</td>
<td>104:40</td>
<td>1889 m</td>
</tr>
<tr>
<td>Mazatlan</td>
<td>10</td>
<td>23:12</td>
<td>106:25</td>
<td>3 m</td>
</tr>
<tr>
<td>Ciudad Victoria</td>
<td>11</td>
<td>23:44</td>
<td>99:08</td>
<td>321 m</td>
</tr>
<tr>
<td>Soto la Marina</td>
<td>12</td>
<td>23:46</td>
<td>98:12</td>
<td>25 m</td>
</tr>
<tr>
<td>Tampico</td>
<td>14</td>
<td>22:13</td>
<td>97:51</td>
<td>12 m</td>
</tr>
<tr>
<td>Tepic</td>
<td>15</td>
<td>21:30</td>
<td>104:53</td>
<td>915 m</td>
</tr>
<tr>
<td>Rio Verde</td>
<td>17</td>
<td>21:56</td>
<td>100:00</td>
<td>991 m</td>
</tr>
<tr>
<td>Guadalajara</td>
<td>18</td>
<td>20:36</td>
<td>103:23</td>
<td>1567 m</td>
</tr>
<tr>
<td>Pachuca</td>
<td>19</td>
<td>20:08</td>
<td>98:44</td>
<td>2426 m</td>
</tr>
<tr>
<td>Tuxpan</td>
<td>20</td>
<td>20:57</td>
<td>97:23</td>
<td>14 m</td>
</tr>
<tr>
<td>Mexico City</td>
<td>23</td>
<td>19:24</td>
<td>99:11</td>
<td>2298 m</td>
</tr>
<tr>
<td>Puebla</td>
<td>25</td>
<td>19:03</td>
<td>98:12</td>
<td>2162 m</td>
</tr>
<tr>
<td>Veracruz</td>
<td>26</td>
<td>19:09</td>
<td>96:07</td>
<td>13 m</td>
</tr>
<tr>
<td>Oaxaca</td>
<td>30</td>
<td>17:03</td>
<td>96:43</td>
<td>1500 m</td>
</tr>
<tr>
<td>Acapulco</td>
<td>31</td>
<td>16:50</td>
<td>99:55</td>
<td>82 m</td>
</tr>
<tr>
<td>Salina Cruz</td>
<td>32</td>
<td>16:10</td>
<td>95:12</td>
<td>70 m</td>
</tr>
<tr>
<td>Las Casas</td>
<td>33</td>
<td>16:44</td>
<td>92:28</td>
<td>2128 m</td>
</tr>
<tr>
<td>Tucson</td>
<td>70</td>
<td>32:07</td>
<td>110:56</td>
<td>2555 ft.</td>
</tr>
<tr>
<td>Fort Huachuca</td>
<td>71</td>
<td>31:35</td>
<td>110:20</td>
<td>4685 ft.</td>
</tr>
<tr>
<td>Deming</td>
<td>73</td>
<td>32:15</td>
<td>107:42</td>
<td>4324 ft.</td>
</tr>
<tr>
<td>El Paso</td>
<td>74</td>
<td>31:48</td>
<td>106:24</td>
<td>3916 ft.</td>
</tr>
<tr>
<td>Marfa</td>
<td>75</td>
<td>30:22</td>
<td>104:01</td>
<td>4858 ft.</td>
</tr>
<tr>
<td>Del Rio</td>
<td>76</td>
<td>29:22</td>
<td>100:55</td>
<td>1027 ft.</td>
</tr>
<tr>
<td>Cotulla</td>
<td>77</td>
<td>28:27</td>
<td>99:13</td>
<td>479 ft.</td>
</tr>
<tr>
<td>McAllen</td>
<td>78</td>
<td>26:11</td>
<td>98:14</td>
<td>112 ft.</td>
</tr>
<tr>
<td>Brownsville</td>
<td>79</td>
<td>25:54</td>
<td>97:26</td>
<td>20 ft.</td>
</tr>
<tr>
<td>Midland-Odessa</td>
<td>83</td>
<td>31:57</td>
<td>102:11</td>
<td>2851 ft.</td>
</tr>
<tr>
<td>San Angelo</td>
<td>84</td>
<td>31:22</td>
<td>100:30</td>
<td>1903 ft.</td>
</tr>
<tr>
<td>Abilene</td>
<td>85</td>
<td>32:25</td>
<td>99:41</td>
<td>1784 ft.</td>
</tr>
<tr>
<td>Austin</td>
<td>94</td>
<td>30:18</td>
<td>97:42</td>
<td>597 ft.</td>
</tr>
<tr>
<td>Waco</td>
<td>95</td>
<td>31:37</td>
<td>97:13</td>
<td>501 ft.</td>
</tr>
<tr>
<td>Corpus Christi</td>
<td>96</td>
<td>27:46</td>
<td>97:30</td>
<td>41 ft.</td>
</tr>
<tr>
<td>Victoria</td>
<td>97</td>
<td>28:51</td>
<td>96:55</td>
<td>104 ft.</td>
</tr>
<tr>
<td>Houston</td>
<td>98</td>
<td>29:58</td>
<td>95:12</td>
<td>96 ft.</td>
</tr>
<tr>
<td>Port Arthur</td>
<td>99</td>
<td>29:57</td>
<td>94:01</td>
<td>16 ft.</td>
</tr>
</tbody>
</table>
3. INTERPRETATION

The evaluation of the DMAT estimates requires an understanding of the multitude of factors which influence their quality. The mean air temperatures observed by the surface meteorological stations are used to verify the DMAT estimates. The underlying assumption is that these temperatures are correct. However, the quality of the stations used in SEDS varies. In general, the U.S. stations are of higher quality than many of the Mexican stations.

The U.S. stations are of two types. The so-called first order stations are mostly sited at airports. The stations are manned, calibrated, and observed by professional meteorologists. These stations are used as ground truth zone control stations and may be regarded as the best stations. A second group of U.S. stations are the cooperative stations. The observers at these stations are interested non-professionals, but the stations are sited and maintained by the U.S. National Weather Service. These stations also provide high quality data.

The Mexican stations are in some cases less useful than the U.S. stations. Many of these stations are run by a professional staff. However, the calibration and siting of the instruments are not always of the highest quality. The location of these stations is often in a town on the top of a building. Temperatures taken from these stations may not be as representative of the surrounding areas as might be desired.

The use of elevation as a variable in the DMAT estimates also produces lower quality data in Mexico. It has been shown that the relative quality of the elevation base map used in SEDS is poor in Mexico. Since this calculation depends mostly on the elevation variable, the effect is most pronounced in the DMAT estimates produced using day radiometric data only.
The initial guidelines for the spring evaluation indicated that the evaluation would be conducted in the U.S. only. Accordingly, the DMAT coefficients were derived using only U.S. and Mexican border stations. The resulting DMAT estimates for regions well away from the U.S.-Mexican border area should be handled with care. The higher elevations experienced in some parts of Mexico are outside the range of data over which the DMAT coefficients were calculated. This factor alone restricts the usefulness of many Mexican stations.

The spring evaluation data was calculated using only two sets of DMAT coefficients. The initial set was calculated using 15-29 March 1975 data. This set of coefficients was used until 5 June 1975 when a new set was introduced derived from 10-23 May 1975 data. This situation resulted because of the accelerated processing of this data and of the limited staff available for recalculation. Although extremely valuable, the resulting DMAT represents a system performing at less than its capabilities.

The emissivity base map used to correct the radiometric data was based on 15-29 March 1975 data. This map was not updated during the spring evaluation due to the limitations of time. By the end of the evaluation period, the applicability of this map was marginal, contributing to the slightly lower quality data.

The DMAT estimates derived from the ground truth fill-in utilizing the AT field must also be evaluated with care. The expectation would be that the error rate associated with DMAT estimates would increase with distance from the control stations. Thus, the best estimate of the performance of this technique would probably come from a network of stations that do not include the control stations.
4. EVALUATION AND RESULTS

The evaluation of the DMAT estimates depends upon the statistical comparison of surface observations of mean air temperature and of the satellite estimates. For review and clarification, a short discussion of common statistical measures of error may be found in appendix C.

Data was available for the 95 locations shown in table II. The geographical distribution of these stations is shown in figure 2; the ground truth zone control stations are indicated with a square.

Considering the information in the previous section, the data was stratified in a number of ways to enhance the understanding of SEDS performance. The following is a summary of this stratification:

- **Overall SEDS Performance** - The error of all stations without regard to method of calculation.
- **Ground Truth Fill-in** - The error associated with those DMAT estimates calculated using the AT field. These cases had no usable radiometric data.
- **Both Radiometric Usable** - The error associated with DMAT estimates calculated from both morning and night satellite passes.
- **Night Radiometric Only** - The error associated with DMAT estimates calculated from the night satellite pass; the corresponding morning pass was either missing or cloudy.
- **Day Radiometric Only** - The error associated with DMAT estimates calculated from the day satellite pass; the corresponding night data was either missing or cloudy.
### TABLE II. - SEDS LOCATION LIST OF WEATHER STATIONS
(Begin approx. 14 Nov 75 - Spg Eval Phase II)

<table>
<thead>
<tr>
<th>ID NO./LTR</th>
<th>LATITU</th>
<th>LONGITU</th>
<th>ID NO./LTR</th>
<th>LATITU</th>
<th>LONGITU</th>
<th>ID NO./LTR</th>
<th>LATITU</th>
<th>LONGITU</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMMSX</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>382/TMC</td>
<td>25:32</td>
<td>103:27</td>
<td>17382/RVS</td>
<td>21:56</td>
<td>100:00</td>
<td>28741</td>
<td>18:25</td>
</tr>
<tr>
<td>05</td>
<td>393/MST</td>
<td>25:52</td>
<td>100:14</td>
<td>18613/GDL</td>
<td>20:36</td>
<td>103:23</td>
<td>29762</td>
<td>18:01</td>
</tr>
<tr>
<td>06</td>
<td>405/LAP</td>
<td>24:09</td>
<td>110:20</td>
<td>19632/PCA</td>
<td>20:08</td>
<td>98:44</td>
<td>30775</td>
<td>17:03</td>
</tr>
<tr>
<td>08</td>
<td>423/0DG</td>
<td>24:01</td>
<td>104:40</td>
<td>21654/MZL</td>
<td>19:03</td>
<td>103:52</td>
<td>32833</td>
<td>16:10</td>
</tr>
<tr>
<td>11</td>
<td>499/SOT</td>
<td>23:46</td>
<td>98:12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>CEN/258</td>
<td>27:29</td>
<td>109:56</td>
<td>50MTT/781</td>
<td>17:59</td>
<td>94:32</td>
<td>60TCC/634</td>
<td>20:05</td>
</tr>
<tr>
<td>41</td>
<td>DMA/658</td>
<td>19:14</td>
<td>103:44</td>
<td>52NLD/286</td>
<td>27:30</td>
<td>99:30</td>
<td>62TMF/541</td>
<td>22:00</td>
</tr>
<tr>
<td>42</td>
<td>IZT/830</td>
<td>16:32</td>
<td>95:10</td>
<td>53NOG/080</td>
<td>31:14</td>
<td>110:59</td>
<td>63UPN/1924</td>
<td>102:02</td>
</tr>
<tr>
<td>47</td>
<td>MAM/399</td>
<td>25:52</td>
<td>97:31</td>
<td>58SLP/539</td>
<td>22:09</td>
<td>100:58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMMS &amp; SAHS</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>00</td>
<td>290/MYF</td>
<td>32:49N</td>
<td>117:08W</td>
<td>75MRF/3022</td>
<td>104:01W</td>
<td>92253/SAT</td>
<td>29:32N</td>
<td>98:28W</td>
</tr>
<tr>
<td>04</td>
<td>IFL/350</td>
<td>115:34</td>
<td>76261/DRT</td>
<td>29:22</td>
<td>100:55</td>
<td>94254/AUS</td>
<td>30:18</td>
<td>97:42</td>
</tr>
<tr>
<td>09</td>
<td>280/YUM</td>
<td>32:40</td>
<td>114:36</td>
<td>77COT/2827</td>
<td>99:13</td>
<td>95256/ACT</td>
<td>31:37</td>
<td>97:13</td>
</tr>
<tr>
<td>13</td>
<td>DNM/3215</td>
<td>107:42</td>
<td>84263/SJT</td>
<td>31:22</td>
<td>100:30</td>
<td>99221/BFT</td>
<td>29:57</td>
<td>94:01</td>
</tr>
</tbody>
</table>

**ADDITIONAL TEXAS STATIONS (CO-OP)**

<table>
<thead>
<tr>
<th>ID LATITU</th>
<th>LONGITU</th>
<th>NAME</th>
<th>ID LATITU</th>
<th>LONGITU</th>
<th>NAME</th>
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<td>31:11N</td>
<td>105:21W</td>
<td>04</td>
<td>31:54</td>
<td>103:55</td>
</tr>
<tr>
<td>04</td>
<td>31:54</td>
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This sheet dated: Tue 7 Oct 75.
Figure 2. - SEDS meteorological stations.
Each of these major data groupings was further divided as follows:

- **U.S. Stations** - The error associated with DMAT estimates calculated for U.S. stations only.
- **Mexican Stations** - The error associated with DMAT estimates calculated for Mexican stations only.
- **Ground Truth Control Stations Only** - The error associated with DMAT estimates calculated for the ground truth zone control stations.
- **Non-Control Stations** - The error associated with DMAT estimates calculated for stations other than the ground truth control stations.

Those cases calculated from the ΔT field were further stratified as follows:

- **U.S. Non-Control Stations** - The error associated with DMAT estimates calculated for U.S. stations other than the ground truth zone control stations.
- **Mexican Non-Control Stations** - The error associated with DMAT estimates calculated for Mexican stations other than the ground truth zone control stations.

The standard error associated with each of these stratifications for the 29 March to 13 June SEDS data may be seen in table III. This table clearly demonstrates the variation in calculated error rate depending upon the stratification. The complete week by week analysis may be found in appendix D.

Based on these data and the limitations discussed in the previous section, four stratifications were selected which seem to
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() indicates sample size less than 25.
most fairly reflect the capabilities of the SEDS DMAT estimates. The following groupings reflect this analysis:

- Ground Truth Fill-in - The U.S. non-control stations
- Both Radiometric Usable - All U.S. stations
- Day Radiometric Only - All U.S. stations
- Night Radiometric Only - All U.S. stations.

The DMAT performance as measured by the standard error of estimate for these four cases may be seen in figures 3 through 6. The best results were obtained when both radiometric passes were usable. Average performance in this case was near 2.5°C as measured by the standard error of estimate. The average performance for the night and day radiometric data only was near 3.9°C and 4.5°C, respectively. The performance of the ground truth fill-in was excellent with an average standard error near 2.75°C.

Overall, the results of the spring evaluation were encouraging. The study has demonstrated that the design goal of 3.0°C error is obtainable. Under closely monitored conditions, a DMAT standard error of 2.5°C should be expected.
Figure 3. - Standard error for U.S. stations not used as control stations when DMAT was calculated using the ΔT field.
Figure 4. Standard error for all U.S. stations when DMAT was calculated using both radiometric passes.
Figure 5. Standard error for all U.S. stations when DMAT was calculated using night radiometric data only.
Figure 6. Standard error for all U.S. stations when DMAT was calculated using day radiometric data only.
APPENDIX A.
SUMMARIES OF REGRESSION ANALYSES
Sept 28 - Oct 9, 1975

Model: Pay Radiometric Only Usable With Altitude

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R = .77961 Adjusted for degree of freedom.
SEE = 2.51465
(1.36 degree improvement over without altitude.)

ANOVA

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REG. - COEFFICIENTS

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Intercept 0  238.406  17.707
Sept 28 - Oct 9, 1975

Model: Day Radiometric Only Usable Without Altitude

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R = .26146 Adjust for degrees of freedom
SEE = 3.87548

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A-3
Sept 28 - Oct. 9, 1975

**Model:** Night Radiometric. Only Usable Without Altitude

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\[ R = .54887 \text{ Adjusted for degrees of freedom} \]

\[ \text{SEE} = 3.30179 \]

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Sept 28 - Oct 9, 1975

Model: Night Radiometric Only Usable With Altitude

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(1.447 degree improvement over without altitude)

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Sept 28 - Oct 9, 1975

Model: Both Radiometric Usable With Altitude

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<tr>
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\[ R = .87211 \text{ Ajusted for sample size} \]

\[ \text{SEE} = 1.761 \]

\((.578 \text{ degree improvement over without altitude})\)

ANOVA

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REG. COEFFICIENTS

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- \( R = 0.87165 \)
- Adjusted for degree of freedom
- SEE = 1.76395

### ANOVA

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Intercept 0 171.33666 25.59383
Sept 28 - Oct 9, 1975

Model: Both Radiometric Usable Without Altitude

Correlation Matrix

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R = .75915 Adjusted for sample size
SEE = 2.33891

ANOVA

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REG. COEFFICIENTS

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APPENDIX B
SUMMARIES OF ANALYSES OF VARIANCE
ANOVA.- Day Radiometric Only Usable 28 September to 9 October 1975 -

Significance of Elevation

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<th>Source</th>
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*Significant at the .99 level
ANOVA.-Night Radiometric Only Usable 28 September to 9 October 1975 -
Significance of Elevation

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*Significant at the .99 level
ANOVA.-Both Radiometric Data Usable 28 September to 9 October 1975 -

Significance of Elevation

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*Significant at the .99 level
ANOVA.-Both Radiometric Usable 28 September to 9 October -
Significance of Latitude.

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<td>971.469</td>
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</tbody>
</table>

*not significant
APPENDIX C
STATISTICAL MEASURES OF ERROR
STATISTICAL MEASURES OF ERROR

The nomenclature used when discussing error statistics is often confusing. The following definitions of commonly used terms may prove useful in clarifying the situation.

The error of estimate is the difference between the actual and the predicted value. SEDS uses multiple regression equations to predict values of daily mean air temperature from satellite observed radiometric data. The actual daily mean air temperature is observed on the surface at standard meteorological stations. The error of estimate for daily mean air temperature may be written:

\[ \varepsilon = TTK - DMATK \]

where

- \( \varepsilon \) - The error of estimate
- \( TTK \) - The surface observed daily mean air temperature in degrees Kelvin
- \( DMATK \) - The SEDS estimate of daily mean air temperature in degrees Kelvin

The mean error represents a systematic variation of the sample from the true value. When SEDS is operating perfectly, the mean or bias error will be equal to zero. The mean error of estimate may be written:

\[ \bar{\varepsilon} = \left( \sum_{i=1}^{n} \varepsilon_i \right) / n \]
where \( \bar{e} \) - The mean error of estimate
\( n \) - The sample size

The standard error of estimate is the standard deviation of the errors of estimate. The standard error, \( S \), may be written:

\[
S = \sqrt{\frac{\sum_{i=1}^{n} (\epsilon_i - \bar{e})^2}{(n - 1)}}
\]

In the past, root mean square (rms) error and standard error have been used as if they were the same. However, this is not true. The rms error may be written

\[
\text{RMS} = \sqrt{\frac{\sum_{i=1}^{n} (\epsilon_i)^2}{(n - 1)}}
\]

Thus, the rms and standard error are equal only when the mean error is zero. All errors reported during SEDS development and evaluation have been standard errors.
Assuming that the errors are normally distributed approximately 67 percent of the errors will lie within ± one standard error of the mean error and 95 percent within ± two standard errors.
APPENDIX D

DETAILED WEEKLY ANALYSIS OF MODEL PERFORMANCE
29 MARCH - 4 APRIL 1975

OVERALL SEDS PERFORMANCE FROM 3-29-75 TO 4-4-75
MISSING DATA = 90
BIAS ERROR = 0.471
RMS ERROR = 4.740
SAMPLE SIZE = 575

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = 0.283
RMS ERROR = 3.975
SAMPLE SIZE = 291

U.S. STATIONS ONLY
BIAS ERROR = 0.816
RMS ERROR = 3.952
SAMPLE SIZE = 164

MEXICAN STATIONS ONLY
BIAS ERROR = 1.961
RMS ERROR = 3.412
SAMPLE SIZE = 127

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = -0.051
RMS ERROR = 1.821
SAMPLE SIZE = 140

NON-CONTROL STATIONS ONLY
BIAS ERROR = 0.593
RMS ERROR = 5.223
SAMPLE SIZE = 151

U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = -1.290
RMS ERROR = 5.542
SAMPLE SIZE = 75

MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 7.451
RMS ERROR = 4.095
SAMPLE SIZE = 76

BOTH RADIOMETRIC USABLE

ALL STATIONS
BIAS ERROR = 3.663
RMS ERROR = 4.641
SAMPLE SIZE = 53

U.S. STATIONS ONLY
BIAS ERROR = -3.665
RMS ERROR = 3.426
SAMPLE SIZE = 20

ORIGINAL PAGE IS OF POOR QUALITY.
MEXICAN STATIONS ONLY
BIAS ERROR = 3.286
RMS ERROR = 3.091
SAMPLE SIZE = 33

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.425
RMS ERROR = 3.731
SAMPLE SIZE = 20

NON-CONTROL STATIONS ONLY
BIAS ERROR = 0.202
RMS ERROR = 5.143
SAMPLE SIZE = 33

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 1.343
RMS ERROR = 4.788
SAMPLE SIZE = 94

U.S. STATIONS ONLY
BIAS ERROR = -1.526
RMS ERROR = 5.270
SAMPLE SIZE = 34

MEXICAN STATIONS ONLY
BIAS ERROR = 3.025
RMS ERROR = 3.590
SAMPLE SIZE = 60

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.646
RMS ERROR = 3.735
SAMPLE SIZE = 50

NON-CONTROL STATIONS ONLY
BIAS ERROR = 0.999
RMS ERROR = 5.784
SAMPLE SIZE = 44

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = -0.198
RMS ERROR = 6.038
SAMPLE SIZE = 137

U.S. STATIONS ONLY
BIAS ERROR = 4.360
RMS ERROR = 4.883
SAMPLE SIZE = 48
MEXICAN STATIONS ONLY
BIAS ERROR = 2.456
RMS ERROR = 5.116
SAMPLE SIZE = 89

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 0.137
RMS ERROR = 5.459
SAMPLE SIZE = 63

NON-CONTROL STATIONS ONLY
BIAS ERROR = 0.275
RMS ERROR = 6.527
SAMPLE SIZE = 74
OVERALL SEDS PERFORMANCE FROM 4-12-75 TO 4-18-75

MISSING DATA = 111
BIAS ERROR = .734
RMS ERROR = 3.528
SAMPLE SIZE = 554

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = .459
RMS ERROR = 3.133
SAMPLE SIZE = 376

U.S. STATIONS ONLY
BIAS ERROR = -1.136
RMS ERROR = 2.500
SAMPLE SIZE = 192

MEXICAN STATIONS ONLY
BIAS ERROR = 2.124
RMS ERROR = 2.853
SAMPLE SIZE = 184

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = .549
RMS ERROR = 2.375
SAMPLE SIZE = 192

NON-CONTROL STATIONS ONLY
BIAS ERROR = .367
RMS ERROR = 3.756
SAMPLE SIZE = 184

U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = -1.590
RMS ERROR = 3.257
SAMPLE SIZE = 89

MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.162
RMS ERROR = 3.276
SAMPLE SIZE = 97

BOTH RADIOLURIC USABLE

ALL STATIONS
BIAS ERROR = .734
RMS ERROR = 3.528
SAMPLE SIZE = 554

U.S. STATIONS ONLY
BIAS ERROR = .459
RMS ERROR = 3.133
SAMPLE SIZE = 376

ORIGINAL PAGE IS OF POOR QUALITY
**18 April 1975**

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**Night Radiometric Only**

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12-13 April 1975

MEXICAN STATIONS ONLY
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RMS ERROR = 4.407
SAMPLE SIZE = 64

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.562
RMS ERROR = 4.435
SAMPLE SIZE = 58

NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.643
RMS ERROR = 5.259
SAMPLE SIZE = 56
**OVERALL SEDS PERFORMANCE FROM 4-5-75 TO 4-9-75**

- **Missing Data:** 117
- **Bias Error:** 1.253
- **RMS Error:** 3.931
- **Sample Size:** 548

**Ground Truth Data Only**

- **All Stations**
  - **Bias Error:** -0.060
  - **RMS Error:** 3.000
  - **Sample Size:** 323

- **U.S. Stations Only**
  - **Bias Error:** -1.306
  - **RMS Error:** 2.363
  - **Sample Size:** 213

- **Mexican Stations Only**
  - **Bias Error:** 2.254
  - **RMS Error:** 2.675
  - **Sample Size:** 113

**Ground Truth Control Stations Only**

- **Bias Error:** -0.193
- **RMS Error:** 1.918
- **Sample Size:** 160

**Non-Control Stations Only**

- **Bias Error:** -0.019
- **RMS Error:** 3.779
- **Sample Size:** 163

- **U.S., Non-Control Stations Only**
  - **Bias Error:** -1.718
  - **RMS Error:** 3.076
  - **Sample Size:** 102

- **Mexican Non-Control Stations Only**
  - **Bias Error:** 2.821
  - **RMS Error:** 3.086
  - **Sample Size:** 61

**Both Radiometric Usable**

- **All Stations**
  - **Bias Error:** 2.478
  - **RMS Error:** 3.483
  - **Sample Size:** 58

- **U.S. Stations Only**
  - **Bias Error:** -0.495
  - **RMS Error:** 3.710
  - **Sample Size:** 4
MEXICAN STATIONS ONLY
BIAS ERROR = 2.625
RMS ERROR = 3.457
SAMPLE SIZE = 54

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.670
RMS ERROR = 4.213
SAMPLE SIZE = 28

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.299
RMS ERROR = 2.694
SAMPLE SIZE = 30

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 3.035
RMS ERROR = 4.596
SAMPLE SIZE = 77

U.S. STATIONS ONLY
BIAS ERROR = 1.886
RMS ERROR = 4.203
SAMPLE SIZE = 34

MEXICAN STATIONS ONLY
BIAS ERROR = 3.890
RMS ERROR = 4.746
SAMPLE SIZE = 43

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.449
RMS ERROR = 4.834
SAMPLE SIZE = 42

NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.033
RMS ERROR = 4.128
SAMPLE SIZE = 35

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 3.680
RMS ERROR = 4.557
SAMPLE SIZE = 90

U.S. STATIONS ONLY
BIAS ERROR = 3.358
RMS ERROR = 4.526
SAMPLE SIZE = 25

ORIGINAL PAGE IS OF POOR QUALITY
5-11 April 1975

MEXICAN STATIONS ONLY
BIAS ERROR = 4.958
RMS ERROR = 3.902
SAMPLE SIZE = 65

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.505
RMS ERROR = 4.170
SAMPLE SIZE = 42

NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.834
RMS ERROR = 4.918
SAMPLE SIZE = 48
OVERALL SEDS PERFORMANCE FROM 4-19-75 TO 4-25-75
MISSING DATA = 118
BIAS ERROR = 1.784
RMS ERROR = 3.938
SAMPLE SIZE = 547

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = 1.717
RMS ERROR = 3.030
SAMPLE SIZE = 248

U.S. STATIONS ONLY
BIAS ERROR = -0.346
RMS ERROR = 2.578
SAMPLE SIZE = 151

MEXICAN STATIONS ONLY
BIAS ERROR = 2.370
RMS ERROR = 2.950
SAMPLE SIZE = 97

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.953
RMS ERROR = 2.944
SAMPLE SIZE = 120

NON-CONTROL STATIONS ONLY
BIAS ERROR = -0.358
RMS ERROR = 3.926
SAMPLE SIZE = 120

U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = -0.802
RMS ERROR = 2.984
SAMPLE SIZE = 74

MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.225
RMS ERROR = 3.587
SAMPLE SIZE = 46

BOTH RADIOMETRIC USABLE

ALL STATIONS
BIAS ERROR = 3.307
RMS ERROR = 3.956
SAMPLE SIZE = 87

U.S. STATIONS ONLY
BIAS ERROR = 2.873
RMS ERROR = 4.671
SAMPLE SIZE = 26

ORIGINAL PAGE IS
OF POOR QUALITY
MEXICAN STATIONS ONLY
BIAS ERROR = 3.491
RMS ERROR = 3.155
SAMPLE SIZE = 61

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.851
RMS ERROR = 3.034
SAMPLE SIZE = 42

NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.732
RMS ERROR = 4.144
SAMPLE SIZE = 45

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 3.353
RMS ERROR = 3.570
SAMPLE SIZE = 98

U.S., STATIONS ONLY
BIAS ERROR = 2.721
RMS ERROR = 3.877
SAMPLE SIZE = 39

MEXICAN STATIONS ONLY
BIAS ERROR = 3.771
RMS ERROR = 3.321
SAMPLE SIZE = 59

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.338
RMS ERROR = 3.563
SAMPLE SIZE = 53

NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.370
RMS ERROR = 3.619
SAMPLE SIZE = 45

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 1.595
RMS ERROR = 5.223
SAMPLE SIZE = 114

U.S., STATIONS ONLY
BIAS ERROR = 0.478
RMS ERROR = 5.523
SAMPLE SIZE = 50

ORIGINAL PAGE IS OF POOR QUALITY
MEXICAN STATIONS ONLY
BIAS ERROR = 3.306
RMS ERROR = 4.309
SAMPLE SIZE = 58

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.991
RMS ERROR = 5.109
SAMPLE SIZE = 56

NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.212
RMS ERROR = 5.347
SAMPLE SIZE = 58
OVERALL SEDS PERFORMANCE FROM 4-26-75 TO 5-2-75
MISSING DATA = 112
BIAS ERROR = 2.211
RMS ERROR = 3.919
SAMPLE SIZE = 563

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = 1.812
RMS ERROR = 3.057
SAMPLE SIZE = 278

U.S. STATIONS ONLY
BIAS ERROR = 2.455
RMS ERROR = 2.445
SAMPLE SIZE = 193

MEXICAN STATIONS ONLY
BIAS ERROR = 3.766
RMS ERROR = 3.757
SAMPLE SIZE = 75

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.538
RMS ERROR = 2.281
SAMPLE SIZE = 112

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.790
RMS ERROR = 3.643
SAMPLE SIZE = 116

U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.912
RMS ERROR = 3.014
SAMPLE SIZE = 74

MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.137
RMS ERROR = 3.776
SAMPLE SIZE = 42

BOTH RADIOMETRIC USABLE

ALL STATIONS
BIAS ERROR = 1.342
RMS ERROR = 3.748
SAMPLE SIZE = 127

U.S. STATIONS ONLY
BIAS ERROR = 2.211
RMS ERROR = 2.853
SAMPLE SIZE = 43
MEXICAN STATIONS ONLY
BIAS ERROR = 2.229
RMS ERROR = 3.214
SAMPLE SIZE = 64

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 0.951
RMS ERROR = 3.499
SAMPLE SIZE = 48

NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.659
RMS ERROR = 3.758
SAMPLE SIZE = 59

NIGHT RADIOMETRIC ONLY
ALL STATIONS
BIAS ERROR = 2.611
RMS ERROR = 4.046
SAMPLE SIZE = 124

U.S. STATIONS ONLY
BIAS ERROR = 1.495
RMS ERROR = 4.735
SAMPLE SIZE = 44

MEXICAN STATIONS ONLY
BIAS ERROR = 3.677
RMS ERROR = 3.556
SAMPLE SIZE = 48

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.215
RMS ERROR = 4.543
SAMPLE SIZE = 67

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.835
RMS ERROR = 3.432
SAMPLE SIZE = 57

DAY RADIOMETRIC ONLY
ALL STATIONS
BIAS ERROR = 3.774
RMS ERROR = 5.536
SAMPLE SIZE = 94

U.S. STATIONS ONLY
BIAS ERROR = 2.779
RMS ERROR = 6.191
SAMPLE SIZE = 31

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26 April - 7 May 1975

MEXICAN STATIONS ONLY
BIAS ERROR = 5.093
RMS ERROR = 4.287
SAMPLE SIZE = 63

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.395
RMS ERROR = 5.967
SAMPLE SIZE = 53

NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.380
RMS ERROR = 4.929
SAMPLE SIZE = 91
OVERALL SEDS PERFORMANCE FROM 5-3-75 TO 5-9-75
MISSING DATA = 89
BIAS ERROR = 2.621
RMS ERROR = 4.389
SAMPLE SIZE = 576

GROUND TRUTH DATA ONLY
ALL STATIONS
BIAS ERROR = 1.567
RMS ERROR = 2.933
SAMPLE SIZE = 224
U.S. STATIONS ONLY
BIAS ERROR = 0.851
RMS ERROR = 2.391
SAMPLE SIZE = 137
MEXICAN STATIONS ONLY
BIAS ERROR = 2.695
RMS ERROR = 3.342
SAMPLE SIZE = 87
GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.002
RMS ERROR = 2.467
SAMPLE SIZE = 111
NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.123
RMS ERROR = 3.245
SAMPLE SIZE = 113
U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = 0.692
RMS ERROR = 2.231
SAMPLE SIZE = 63
MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.925
RMS ERROR = 3.438
SAMPLE SIZE = 50

BOTH RADIOMETRIC USABLE
ALL STATIONS
BIAS ERROR = 1.486
RMS ERROR = 3.925
SAMPLE SIZE = 88
U.S. STATIONS ONLY
BIAS ERROR = -0.620
RMS ERROR = 2.774
SAMPLE SIZE = 26

D-17
MEXICAN STATIONS ONLY
BIAS ERROR = 2.369
RMS ERROR = 4.017
SAMPLE SIZE = 62

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.846
RMS ERROR = 4.602
SAMPLE SIZE = 49

NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.126
RMS ERROR = 3.119
SAMPLE SIZE = 44

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 2.516
RMS ERROR = 4.876
SAMPLE SIZE = 74

U.S. STATIONS ONLY
BIAS ERROR = 1.526
RMS ERROR = 4.373
SAMPLE SIZE = 49

MEXICAN STATIONS ONLY
BIAS ERROR = 4.456
RMS ERROR = 5.307
SAMPLE SIZE = 25

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.520
RMS ERROR = 4.752
SAMPLE SIZE = 37

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.512
RMS ERROR = 5.063
SAMPLE SIZE = 37

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 4.429
RMS ERROR = 5.192
SAMPLE SIZE = 190

U.S. STATIONS ONLY
BIAS ERROR = 1.945
RMS ERROR = 5.241
SAMPLE SIZE = 54
MEXICAN STATIONS ONLY
BIAS ERROR = 5.415
RMS ERROR = 4.849
SAMPLE SIZE = 136

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.810
RMS ERROR = 5.425
SAMPLE SIZE = 89

NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.974
RMS ERROR = 4.942
SAMPLE SIZE = 101
OVERALL SEDS PERFORMANCE FROM 5-10-75 TO 5-16-75
MISSING DATA = 103
BIAS ERROR = 2.175
RMS ERROR = 3.692
SAMPLE SIZE = 567

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = 3.017
RMS ERROR = 3.589
SAMPLE SIZE = 218

U.S. Stations Only
BIAS ERROR = 1.417
RMS ERROR = 3.052
SAMPLE SIZE = 98

Mexican Stations Only
BIAS ERROR = 4.323
RMS ERROR = 3.473
SAMPLE SIZE = 125

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.622
RMS ERROR = 2.953
SAMPLE SIZE = 107

Non-Control Stations Only
BIAS ERROR = 3.397
RMS ERROR = 4.087
SAMPLE SIZE = 111

U.S. Non-Control Stations Only
BIAS ERROR = 1.343
RMS ERROR = 1.378
SAMPLE SIZE = 144

Mexican Non-Control Stations Only
BIAS ERROR = 4.746
RMS ERROR = 3.972
SAMPLE SIZE = 67

Both Radiometric Usable

All Stations
BIAS ERROR = 2.834
RMS ERROR = 2.742
SAMPLE SIZE = 109

U.S. Stations Only
BIAS ERROR = 2.388
RMS ERROR = 2.578
SAMPLE SIZE = 60
MEXICAN STATIONS ONLY
BIAS ERROR = 3.490
RMS ERROR = 3.563
SAMPLE SIZE = 49

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.011
RMS ERROR = 3.346
SAMPLE SIZE = 49

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.74
RMS ERROR = 2.993
SAMPLE SIZE = 45

NIGHT RADIOMETRIC ONLY
ALL STATIONS
BIAS ERROR = 2.442
RMS ERROR = 3.949
SAMPLE SIZE = 84

U.S. STATIONS ONLY
BIAS ERROR = 3.975
RMS ERROR = 4.044
SAMPLE SIZE = 35

MEXICAN STATIONS ONLY
BIAS ERROR = 3.490
RMS ERROR = 3.563
SAMPLE SIZE = 49

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.011
RMS ERROR = 3.346
SAMPLE SIZE = 49

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.74
RMS ERROR = 2.993
SAMPLE SIZE = 45

DAY RADIOMETRIC ONLY
ALL STATIONS
BIAS ERROR = 1.779
RMS ERROR = 3.971
SAMPLE SIZE = 151

U.S. STATIONS ONLY
BIAS ERROR = 3.860
RMS ERROR = 3.183
SAMPLE SIZE = 71
MEXICAN STATIONS ONLY
BIAS ERROR = 2.595
RMS ERROR = 4.419
SAMPLE SIZE = 80

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.569
RMS ERROR = 4.175
SAMPLE SIZE = 83

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.635
RMS ERROR = 3.721
SAMPLE SIZE = 68
17-23 May 1975

OVERALL SEDS PERFORMANCE FROM 9-17-75 TO 5-23-75
MISSING DATA = 79
BIAS ERROR = 13.433
RMS ERROR = 4.295
SAMPLE SIZE = 506

GROUND TRUTH DATA ONLY

| ALL STATIONS | BIAS ERROR = 3.438 | RMS ERROR = 3.309 | SAMPLE SIZE = 281 |
| U.S. STATIONS ONLY | BIAS ERROR = 4.161 | RMS ERROR = 2.340 | SAMPLE SIZE = 111 |
| MEXICAN STATIONS ONLY | BIAS ERROR = 4.383 | RMS ERROR = 3.579 | SAMPLE SIZE = 150 |

GROUND TRUTH CONTROL STATIONS ONLY

| BIAS ERROR = 3.204 | RMS ERROR = 2.684 | SAMPLE SIZE = 128 |

NON-CONTROL STATIONS ONLY

| BIAS ERROR = 3.663 | RMS ERROR = 3.613 | SAMPLE SIZE = 133 |

U.S. NON-CONTROL STATIONS ONLY

| BIAS ERROR = 2.528 | RMS ERROR = 2.449 | SAMPLE SIZE = 48 |
|MEXICAN NON-CONTROL STATIONS ONLY | BIAS ERROR = 4.304 | RMS ERROR = 4.202 | SAMPLE SIZE = 95 |

BOTH RADIOMETRIC USABLE

| ALL STATIONS | BIAS ERROR = 1.830 | RMS ERROR = 3.767 | SAMPLE SIZE = 49 |
| U.S. STATIONS ONLY | BIAS ERROR = 1.086 | RMS ERROR = 3.318 | SAMPLE SIZE = 18 |
17-23 MAY 1975

MEXICAN STATIONS ONLY
BIAS ERROR = 2.263
RMS ERROR = 3.894
SAMPLE SIZE = 31

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.494
RMS ERROR = 3.948
SAMPLE SIZE = 27

NUN=CONTROL STATIONS ONLY
BIAS ERROR = 2.304
RMS ERROR = 3.537
SAMPLE SIZE = 22

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 2.713
RMS ERROR = 5.076
SAMPLE SIZE = 49

U.S. STATIONS ONLY
BIAS ERROR = 1.163
RMS ERROR = 5.162
SAMPLE SIZE = 14

MEXICAN STATIONS ONLY
BIAS ERROR = 3.325
RMS ERROR = 4.984
SAMPLE SIZE = 35

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.962
RMS ERROR = 3.996
SAMPLE SIZE = 20

NUN=CONTROL STATIONS ONLY
BIAS ERROR = 3.920
RMS ERROR = 5.472
SAMPLE SIZE = 29

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 3.930
RMS ERROR = 5.074
SAMPLE SIZE = 227

U.S. STATIONS ONLY
BIAS ERROR = 2.593
RMS ERROR = 4.749
SAMPLE SIZE = 167
MEXICAN STATIONS ONLY
BIAS ERROR = 5.628
RMS ERROR = 4.986
SAMPLE SIZE = 100

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.469
RMS ERROR = 5.231
SAMPLE SIZE = 105

NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.326
RMS ERROR = 14.922
SAMPLE SIZE = 122
OVERALL SEDS PERFORMANCE FROM 5-24-75 TO 5-30-75
MISSING DATA = 100
BIAS ERROR = 3.415
RMS ERROR = 4.077
SAMPLE SIZE = 565

GROUND TRUTH DATA ONLY
ALL STATIONS
BIAS ERROR = 3.737
RMS ERROR = 3.816
SAMPLE SIZE = 309
U.S. STATIONS ONLY
BIAS ERROR = 2.207
RMS ERROR = 2.695
SAMPLE SIZE = 132
MEXICAN STATIONS ONLY
BIAS ERROR = 4.878
RMS ERROR = 3.628
SAMPLE SIZE = 177
GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 3.525
RMS ERROR = 3.399
SAMPLE SIZE = 155
NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.950
RMS ERROR = 3.629
SAMPLE SIZE = 154
U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.550
RMS ERROR = 2.771
SAMPLE SIZE = 60
MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.844
RMS ERROR = 3.836
SAMPLE SIZE = 94

BOTH RADIOMETRIC USABLE
ALL STATIONS
BIAS ERROR = .720
RMS ERROR = 3.182
SAMPLE SIZE = 75
U.S. STATIONS ONLY
BIAS ERROR = -.028
RMS ERROR = 2.482
SAMPLE SIZE = 45
MEXICAN STATIONS ONLY
BIAS ERROR = 1.841
RMS ERROR = 3.785
SAMPLE SIZE = 30

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 0.007
RMS ERROR = 2.865
SAMPLE SIZE = 36

NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.370
RMS ERROR = 3.352
SAMPLE SIZE = 39

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 2.391
RMS ERROR = 4.464
SAMPLE SIZE = 65

U.S. STATIONS ONLY
BIAS ERROR = 1.746
RMS ERROR = 4.164
SAMPLE SIZE = 38

MEXICAN STATIONS ONLY
BIAS ERROR = 3.299
RMS ERROR = 4.787
SAMPLE SIZE = 27

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.723
RMS ERROR = 4.959
SAMPLE SIZE = 31

NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.000
RMS ERROR = 3.936
SAMPLE SIZE = 34

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 4.874
RMS ERROR = 4.801
SAMPLE SIZE = 116

U.S. STATIONS ONLY
BIAS ERROR = 3.192
RMS ERROR = 4.353
SAMPLE SIZE = 55
MEXICAN STATIONS ONLY
BIAS ERROR = 6.392
RMS ERROR = 4.710
SAMPLE SIZE = 61

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 4.539
RMS ERROR = 5.123
SAMPLE SIZE = 58

NON-CONTROL STATIONS ONLY
BIAS ERROR = 5.210
RMS ERROR = 4.479
SAMPLE SIZE = 58
OVERALL SEDS PERFORMANCE FROM 5-31-75 TO 6-6-75
MISSING DATA = 75
BIAS ERROR = 1.496
RMS ERROR = 4.038
SAMPLE SIZE = 590

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = 3.862
RMS ERROR = 3.640
SAMPLE SIZE = 289

U.S. STATIONS ONLY
BIAS ERROR = 1.070
RMS ERROR = 2.742
SAMPLE SIZE = 95

MEXICAN STATIONS ONLY
BIAS ERROR = 5.229
RMS ERROR = 3.467
SAMPLE SIZE = 194

GROUND TRUTH CONTROL STATIONS ONLY

BIAS ERROR = 3.572
RMS ERROR = 3.497
SAMPLE SIZE = 145

NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.154
RMS ERROR = 3.851
SAMPLE SIZE = 144

U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.772
RMS ERROR = 1.974
SAMPLE SIZE = 141

MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 5.301
RMS ERROR = 3.820
SAMPLE SIZE = 103

BOTH RADIOMETRIC USABLE

ALL STATIONS
BIAS ERROR = 1.189
RMS ERROR = 3.667
SAMPLE SIZE = 117

U.S. STATIONS ONLY
BIAS ERROR = 1.473
RMS ERROR = 3.081
SAMPLE SIZE = 83
31 May - 6 June 1975

MEXICAN STATIONS ONLY
BIAS ERROR = 1.805
RMS ERROR = 4.459
SAMPLE SIZE = 34

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = .555
RMS ERROR = 3.674
SAMPLE SIZE = 55

NON-CONTROL STATIONS ONLY
BIAS ERROR = -.135
RMS ERROR = 3.660
SAMPLE SIZE = 62

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 1.912
RMS ERROR = 4.443
SAMPLE SIZE = 109

U.S. STATIONS ONLY
BIAS ERROR = -3.556
RMS ERROR = 3.129
SAMPLE SIZE = 48

MEXICAN STATIONS ONLY
BIAS ERROR = .854
RMS ERROR = 4.376
SAMPLE SIZE = 61

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 1.394
RMS ERROR = 3.527
SAMPLE SIZE = 47

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.304
RMS ERROR = 5.070
SAMPLE SIZE = 62

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 1.678
RMS ERROR = 3.384
SAMPLE SIZE = 75

U.S. STATIONS ONLY
BIAS ERROR = 4.730
RMS ERROR = 2.454
SAMPLE SIZE = 53
MEXICAN STATIONS ONLY
BIAS ERROR = 3.962
RMS ERROR = 4.206
SAMPLE SIZE = 22

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.083
RMS ERROR = 4.185
SAMPLE SIZE = 33

NON-CONTROL STATIONS ONLY
BIAS ERROR = 1.260
RMS ERROR = 2.601
SAMPLE SIZE = 42
OVERALL SEDS PERFORMANCE FROM 6-7-75 TO 6-13-75
MISSING DATA = 59
BIAS ERROR = 3.806
RMS ERROR = 3.018
SAMPLE SIZE = 606

GROUND TRUTH DATA ONLY

ALL STATIONS
BIAS ERROR = 4.553
RMS ERROR = 3.116
SAMPLE SIZE = 309

U.S. STATIONS ONLY
BIAS ERROR = 2.503
RMS ERROR = 2.432
SAMPLE SIZE = 115

MEXICAN STATIONS ONLY
BIAS ERROR = 5.769
RMS ERROR = 2.835
SAMPLE SIZE = 194

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 4.344
RMS ERROR = 2.591
SAMPLE SIZE = 139

NON-CONTROL STATIONS ONLY
BIAS ERROR = 4.725
RMS ERROR = 3.485
SAMPLE SIZE = 173

U.S. NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.948
RMS ERROR = 3.047
SAMPLE SIZE = 55

MEXICAN NON-CONTROL STATIONS ONLY
BIAS ERROR = 5.579
RMS ERROR = 3.379
SAMPLE SIZE = 115

BOTH RADIOMETRIC USABLE

ALL STATIONS
BIAS ERROR = 2.527
RMS ERROR = 2.511
SAMPLE SIZE = 66

U.S. STATIONS ONLY
BIAS ERROR = 2.750
RMS ERROR = 2.457
SAMPLE SIZE = 30
MEXICAN STATIONS ONLY
BIAS ERROR = 2.758
RMS ERROR = 2.566
SAMPLE SIZE = 36

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.369
RMS ERROR = 2.274
SAMPLE SIZE = 34

NON-CONTROL STATIONS ONLY
BIAS ERROR = 2.795
RMS ERROR = 2.766
SAMPLE SIZE = 37

NIGHT RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 3.087
RMS ERROR = 2.375
SAMPLE SIZE = 97

U.S. STATIONS ONLY
BIAS ERROR = 2.608
RMS ERROR = 2.623
SAMPLE SIZE = 42

MEXICAN STATIONS ONLY
BIAS ERROR = 3.453
RMS ERROR = 2.118
SAMPLE SIZE = 55

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR = 2.599
RMS ERROR = 2.371
SAMPLE SIZE = 49

NON-CONTROL STATIONS ONLY
BIAS ERROR = 3.595
RMS ERROR = 2.296
SAMPLE SIZE = 48

DAY RADIOMETRIC ONLY

ALL STATIONS
BIAS ERROR = 3.231
RMS ERROR = 2.996
SAMPLE SIZE = 134

U.S. STATIONS ONLY
BIAS ERROR = 2.647
RMS ERROR = 2.923
SAMPLE SIZE = 91

ORIGINAL PAGE IS OF POOR QUALITY
MEXICAN STATIONS ONLY
BIAS ERROR  =  4.467
RMS ERROR   =  2.796
SAMPLE SIZE =  43

GROUND TRUTH CONTROL STATIONS ONLY
BIAS ERROR  =  3.297
RMS ERROR   =  2.507
SAMPLE SIZE =  58

NON-CONTROL STATIONS ONLY
BIAS ERROR  =  3.180
RMS ERROR   =  3.338
SAMPLE SIZE =  76

ORIGINAL PAGE IS
OF POOR QUALITY