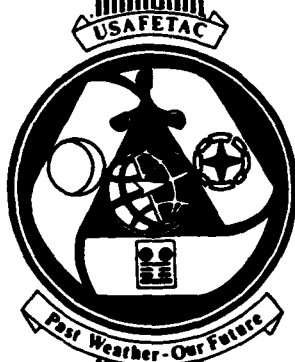


AD-A259 753

DTIC

ELECTE
JAN 4 1993

USAFETAC/PR-92/005



ASPAM

ATMOSPHERIC SLANT PATH ANALYSIS MODEL Statistical Paired Differences Pilot Study for Sample Size Determination

by

Capt Thomas H. Elio
Mr Charles R. Coffin
Major Lauraleen O'Connor

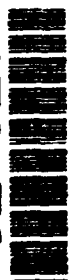
NOVEMBER 1992

*Approved for public release;
Distribution is unlimited.*

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL
INFORMATION SERVICE
SPRINGFIELD, VA 22161

ENVIRONMENTAL TECHNICAL
APPLICATIONS CENTER (USAFETAC)
Scott Air Force Base, Illinois, 62225-5116

92-32982



4208

92 12 28 162

REVIEW AND APPROVAL STATEMENT

USAFETAC/PR--92/005, *ASPAM (Atmospheric Slant Path Analysis Model) Statistical Paired Differences Pilot Study for Sample Size Determination*, November 1992, has been reviewed and is approved for public release. There is no objection to unlimited distribution of this document to the public at large, or by the Defense Technical Information Center (DTIC) to the National Technical Information Service (NTIS).

Walter F. Miller

WALTER F. MILLER

Chief, Simulations and Techniques Branch

FOR THE COMMANDER

Walter S. Burgmann

WALTER S. BURGMANN

Scientific and Technical Information

Program Manager

24 November 1992

REPORT DOCUMENTATION PAGE

2. Report Date: November 1992
3. Report Type: Project Report
4. Title: *ASPAM (Atmospheric Slant Path Analysis Model) Statistical Paired Differences Pilot Study for Sample Size Determination*
6. Authors: Capt Thomas H. Elio, Mr Charles R. Coffin, and Maj Lauraleen O'Connor
7. Performing Organization Names and Address: United States Air Force Environmental Technical Applications Center (SYT), Scott AFB, IL 62225-5116
8. Performing Organization Report Number: USAFETAC/PR--92/005
12. Distribution/Availability Statement: Approved for public release; distribution is unlimited.
13. Abstract: Describes methodology and results of a pilot study intended to determine the required sample size for a statistically significant seasonal study of the differences between ground truth (represented by upper-air soundings) and (1) Atmospheric Slant Path Analysis Model (ASPAM) optimum interpolation vertical profiles (OIVPs) and (2) alternate vertical profiles. This study builds on earlier ASPAM studies, incorporating lessons learned and user feedback. It found that a sample size of 50 observations was enough to determine if the differences between ground truth (upper-air soundings) and ASPAM vertical profiles were significant at the customer's confidence level.
14. Subject Terms: CLIMATOLOGY, ATMOSPHERE, PROFILES, UPPER-AIR, TEMPERATURE, MOISTURE, VERTICAL SOUNDINGS, SAMPLING, STATISTICS, STATISTICAL SAMPLING, SAMPLE SIZE, COMPUTERS, COMPUTING, COMPUTER MODELING,
15. Number of Pages: 42
17. Security Classification of Report: Unclassified
18. Security Classification of this Page: Unclassified
19. Security Classification of Abstract: Unclassified
20. Limitation of Abstract: UL

Standard Form 298

iii

REPRODUCED 1

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

PREFACE

This report documents a USAFETAC pilot study done for the Air Weather Service Special Projects Division (AWS/DOS). The study was initiated to determine the required sample size for a statistically significant seasonal study of the differences between ground truth (represented by upper-air soundings) and (1) Atmospheric Slant Path Analysis Model (ASPAM) optimum interpolation vertical profiles (OIVPs) and (2) alternate vertical profiles.

Specifically, AWS/DOS tasked USAFETAC to conduct a baseline ASPAM study that would determine the spatial, seasonal, and temporal statistical variability of the temperature and moisture optimum interpolation vertical profiles. The study only addresses the statistical accuracies of USAFETAC's version of the model.

In August 1990, USAFETAC's Special Projects Section (DOS) evaluated 112 cases from various climatic regimes, seasons, and time of day. This study led to the discovery of several minor ASPAM software problems. Other studies by the AWS Technology Division (AWS/XTX) postulated that HIRAS smoothing and/or limitations in the space-time resolution of observations might degrade OIVP performance.

This study builds on earlier ASPAM studies, incorporating lessons learned and user feedback. It found that a sample size of 50 observations was enough to determine if the differences between ground truth (upper-air soundings) and ASPAM vertical profiles were significant at the customer-stated confidence level.

The authors wish to thank those who worked closely with us on this project. They include Major Harold Massie (AWS/DOS) for providing test guidance; Capt Jeff McCoy for McIDAS support; the USAFETAC Point Analysis Team (Mr Mark Surmeier, Capts Greg Reding and David Martens, MSgt Richard Boyle, TSgts Heidi Tryon, Joan Bergmann and Catherine Bird), the USAFETAC Database Administration Section (TSgt Dennis Murphy and Mrs Nancy Toon); AFGWC's special projects people (Capt Farrar and Capt Lunn); the AFGWC database administrator (Capt Hanser); and the AFGWC HIRAS maintenance programmer (Capt Carlson). Finally, thanks to Mr Tom Kotz, USAFETAC/OL-A, for providing the data necessary for a thorough statistical evaluation.

TABLE OF CONTENTS

	Page
1. INTRODUCTION	1
1.1 ASPAM Background	1
1.2 Why the Study Was Conducted	1
1.3 How the Study Was Conducted	2
2. PILOT STUDY STATISTICS	3
2.1 Analysis Flow	3
2.2 Statistical Sampling	3
2.3 Population and Sample Size	5
2.4 Statistical Approach	6
2.5 Requirements and Development	9
3. DETERMINING SAMPLE SIZE	11
3.1 Objective	11
3.2 Paired Differences	11
3.3 Simple Random Samples	11
4. SUMMARY OF RESULTS AND CONCLUSIONS	12
4.1 Selecting the Sample Size	12
4.2 Desired Sampling Error	12
4.3 Resultant Confidence	13
4.4 Conclusions	13
BIBLIOGRAPHY	14
ACRINABS	15
APPENDIX A--Mean, Standard Deviation, Skewness, and Kurtosis	A-1
APPENDIX B--Mean Differences and Confidence Limits Sampling Error	B-1
APPENDIX C--Pilot Study Minimum and Maximum Sample Sizes	C-1

1. INTRODUCTION

1.1 ASPAM Background. AFGWC and USAFETAC provide detailed vertical atmospheric profiles to specified military agencies and Department of Defense (DoD) contractors. These profiles, called "point analyses," provide customers with the meteorological data they need to make decisions with respect to atmospheric conditions at a specific place and time. The computer model used to produce these point analyses (or PAs) is called the "Atmospheric Slant Path Analysis Model," or "ASPAM." The model was recently enhanced to accommodate new or improved meteorological databases and improved techniques, such as:

- The New Upper Air Validator (NUAV).
- The Real-time Nephanalysis (RTNEPH) cloud database.
- Finer resolution data fields in the High-Resolution Analysis System (HIRAS).
- More sophisticated mathematical techniques, such as statistical optimum interpolation, which weights various observations not only by their distance from the point of interest, but by the statistical accuracy of the different types of data used.
- Alternate vertical profiles, which provide temperature profiles one standard deviation warmer and moisture profiles one standard deviation drier than the "best" temperature and moisture profiles.

In August 1990, USAFETAC's Special Projects Section (DOS) evaluated 112 ASPAM vertical profiles from various climatic regimes, seasons, and time of day. The evaluation led to the discovery of several minor software problems. Although there were too few samples used to achieve statistical significance, the study provided a better understanding of the model's strengths and weaknesses, which included:

- The optimum interpolation vertical profile (OIVP) scheme did not use (or may have misused) RAOB data.
- OIVP moisture errors can (at times) significantly exceed RAOB instrument errors.
- The use of an eighth-mesh terrain database contributed to large density errors in areas of complex terrain.

Other studies by the AWS Technology Division (XTX) postulated that HIRAS smoothing, and/or limitations in the space-time resolution of observations, might also degrade OIVP performance.

1.2 Why the Study Was Conducted. As requested by the Air Weather Service Directorate of Operations, Special Projects Division (AWS/DOS), USAFETAC evaluated the Atmospheric Slant Path Analysis Model (ASPAM) to determine the seasonal statistical variance of the temperature/moisture optimum interpolation vertical profiles (OIVPs). This study builds upon several earlier ASPAM studies, incorporating lessons learned and user feedback. The study had two main purposes:

- Satisfy point analysis customer requirements for a statistically significant baseline analysis of the ASPAM temperature and moisture OIVP and alternate profiles by climatic regions, season and atmospheric level.

- Provide data for use in determining if modifications for the ASPAM code were required.

1.3 How the Study was Conducted. USAFETAC measured differences from the surface to 100,000 feet for the polar/arctic, mid-latitude, and moist tropical climatic

regions. The study describes sample size calculation for ASPAM differences from ground-truth.

Radiosonde observations (RAOBs), used as ground truth, were denied from the Air Force Global Weather Central's (AFGWC's) parallel High Resolution Analysis System (HIRAS) database. ASPAM profiles were subsequently analyzed at the denied RAOB locations, then compared with those RAOBs.

Finally, analysts determined the number of observations needed for a statistically valid variance study of ASPAM temperature and moisture accuracy.

2. PILOT STUDY STATISTICS

2.1 Analysis Flow. The pilot study consisted of separate sample size calculations for each region (arctic, mid-latitude, and moist tropics) of the mean error, standard deviation, examined differences between ASPAM's RAOBVP analysis (ground truth) and OIVP temperature and moisture profiles.

The mean and standard deviation of the differences for temperature and moisture were calculated from the surface to 100,000 feet above ground level in 1,000-foot increments to 10,000 feet and every 5,000 feet thereafter. The sample sizes were calculated using these results.

2.2 Statistical Sampling. A statistical sampling plan constitutes three distinct parts, all accomplished using strict statistical techniques:

- Calculation of sample size using sample errors.
- Selection of the sample.
- Evaluation of the results.

Sampling error (or "precision") is how closely the result from a sample duplicates the result that can be obtained from the complete population (Hansen et al., 1953). Another way of looking at precision is how close the mean of randomly selected samples are to each other. Usually, the precision is stated as a value added to and subtracted from the sample result. The population's characteristics are expected to lie somewhere between these limits. It's possible to estimate the sampling error that will result from the use of a particular sample size. If the number of items from which to choose is limited, choosing more items will result in less risk than in using

an estimate made from a smaller sample drawn at random. As the sample size becomes larger, the sample estimate differs less and less from the expected value. It is necessary to determine a degree of assurance that the sample selection is within the range stated.

This assurance is called the "confidence level." If a large number of samples are chosen from a given field (population), they will tend to cluster around a more realistic value of the field. Some of the samples, however, will tend to be extreme and lie outside the limits of this cluster. By statistical methods, it is possible to measure the percentage of time a sample of a given size would result in a condition that is within the stated range. The confidence level is usually expressed as a percentage; values of 95%, 99% and 99.9% reflect very high levels of assurance and meet most requirements.

It can be shown that, for a particular sample size, the wider the margin of precision, the more assurance (or confidence) the sample will fall within it. Conversely, the narrower the margin, the smaller the degree of assurance. Therefore, the precision or confidence level, or both, can be increased by increasing the sample size. Our goal in this study was to determine the sample size that would result in the desired level of assurance.

Confidence intervals can also provide a test of significance. If zero is within the confidence interval, then we say that the population mean difference is statistically equal to zero. If zero is *outside* the confidence intervals, then we can say that the population mean difference is statistically *not* equal to zero (Law and Kelton, 1991). That is, if a sample mean

difference is statistically equal to zero, then the same is implied for the entire population. For this study, a zero mean difference implies the RAOBVP and OIVP parameter values are not statistically different; thus, the OIVP approximates the ground truth RAOBVP reasonably well.

Confidence intervals are based on random sample means and standard errors. The random sample mean is used to measure a central value in the population of temperature or humidity differences. The sample standard deviation measures the scatter or spread in a series of differences around the sample mean. The standard error is the standard deviation of a distribution of random sample means; it measures the spread of a series of random sample means. Standard errors are used to make inferences about the likelihood that the population mean difference lies within the specified interval or range of differences.

The greatest advantage of using a statistical technique to decide on a sampling plan is its ability to measure the reliability and degree of assurance that can be placed on the results. The second most important advantage of statistical sampling is the assurance that the test will objectively bring to light a reasonable cross-section of the field being examined. If the sample is selected according to proper statistical standards, results are justified by using the statistical tables appropriate for the distribution (Hill, Roth, and Arkin, 1979).

In many practical sampling problems, we can assume the values in a dataset are a sample from a normal distribution since large classes of distributions approximate the normal distribution. This fact has great practical importance since it is relatively easy mathematically to work with the normal distribution. Some results may hold

well enough for practical applications when samples come from non-normal populations.

Even when the distribution of a population is far from normal, the sampling distribution of the mean approaches the normal distribution as the sample size increases (i.e., as it approaches infinity).

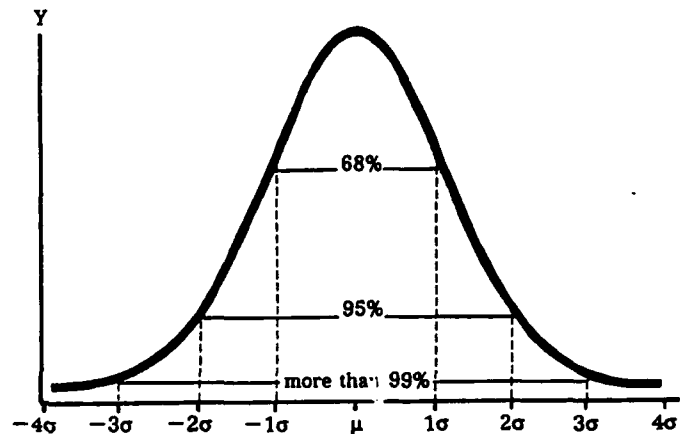


Figure 1. The Normal Distribution and the Empirical Rule from Schlotzhauer and Littel, 1987.

Although we cannot know the ~~exact~~ value of the error of the estimate of the mean, from the empirical rule for the normal distribution shown in Figure 1 we can say:

- 68% of the values are within one standard deviation of the mean.
- 95% of the values are within two standard deviations of the mean.
- More than 99% of the values are within three standard deviations of the mean (Schlotzhauer and Littel, 1987).

Skewness and kurtosis values are known as "shape" statistic and can be used as measures of departure from normality. "Skewness" means lack of data symmetry

about the mean. "Kurtosis" describes the heaviness of the tails of a distribution.

Positive skewness values indicate that the principal part of the distribution is concentrated on the *left* side of the distribution mean, with a longer tail to the right. Negative skewness occurs when the principal part of a distribution is concentrated on the *right* side of the distribution mean, with a longer tail to the left. When the absolute value of skewness is greater than 1.0, the distribution is highly skewed; when it is between 0.5 and 1.0, the distribution is moderately skewed, and when it is between 0.0 and 0.5, the distribution is nearly symmetric. Skewness values can be useful in determining the type of distribution. A normal distribution has a skewness value of about zero.

Extremely non-normal distributions may have large positive or negative kurtosis values, while nearly normal distributions have kurtosis values close to zero. Kurtosis is positive if the tails are *heavier* than for a normal distribution and negative if the tails are *lighter* than for a normal distribution.

2.3 Population and Sample Size. To determine the sample size, the behavior of the data must be summarized by determining the values of the variables that lie near the middle of a frequency distribution. Three measures of central tendency (means, medians, and modes) are commonly used to summarize statistical information. The mean is obtained by the addition of all the observations in a sample and division by the number of cases in the sample. The mean is defined as

$$\bar{X} = \frac{\sum_{i=1}^n x_i}{n} \quad (1)$$

where $\bar{X}$ is the mean, x_i the number of individual observations, and n is the total sample size. The mean doesn't always constitute the "typical" value for some meteorological elements. For example, a mean temperature is more representative than mean daily rainfall since rainfall has a greater tendency for extreme occurrences over short periods of time.

The mode, defined as the most probable value of a variable, is not influenced by extremes at all.

The median, the halfway point in a frequency distribution, is influenced by the number of observations, but not by the value of extreme members.

Once the mean is determined, the degree of variability is calculated using the standard deviation. The standard deviation

$$s = \sqrt{\frac{\sum x^2}{n} - (\bar{x})^2} \quad (2)$$

places emphasis on large deviations from the mean (Panofsky and Brier, 1968).

A *t*-test can be used to determine the departure of a sample mean ($\bar{X}$) from the true mean, μ . The student-*t* value can be computed by the following (Snedecor and Cochran, 1989):

$$t = \frac{(\bar{X} - \mu)}{s} \quad (3)$$

where $\bar{X}$ is the sample mean n is the sample size, and s is the standard deviation of the sample.

The confidence intervals can be used to assess the accuracy of the computed sample mean as an estimate of the population mean. The confidence interval for the true

mean difference of paired observations (between RAOBVP and OIVP values, for this study) is given by Snedecor and Cochran, 1989:

$$\bar{d} \pm ts_d \quad (4)$$

where $\bar{d}$ is the sample mean difference, n is the sample size, t is the t -test table value, and s_d is the standard deviation of the differences divided by the square root of the sample size.

The 90%, 95%, and 99% confidence intervals for paired observations in this study were estimated using the normal distribution and Chebyshev's inequality. The normal approximation is usually used when the sample size is greater than 30; however, even if the population is not normally distributed, the central limit theorem states that the sampling distribution of the mean approaches a normal distribution when the random sample size is increased; that is, as the sample size (n) approaches infinity. Chebyshev's inequality can also be used to determine confidence limits of the population mean; it is very conservative and can be applied to any type of distribution.

The skewness and kurtosis values given can be used to determine an adjusted t value in defining the confidence interval. Although skewness and kurtosis computations should only be applied to larger samples, they can also be informative in small samples.

A 95% confidence interval for an extremely large population based on the normal distribution (or Chebyshev's inequality for a non-normal distribution) means that we are 95% confident that the random interval will be chosen so that it happens to contain the true population mean difference. The range

of the confidence interval reflects sample size. Although large samples decrease the size of the confidence interval, a small sample might also provide adequate information. According to Arkin (1974) and Hansen, Hurwitz, and Madow (1953), the standard deviation can be determined from a random sample of 50 observations. Hansen, et al. (1953) states that if a simple random sample is drawn from a population that is approximated by the normal distribution, then 50 observations are enough to yield a reasonably reliable estimate of the standard error of a mean.

2.4 Statistical Approach. Two approaches for calculating the sample size were considered for the ASPAM pilot study:

The first, the simple random sample design, considered the mean standard deviation and customer accuracy requirements. The ratio between customer accuracy requirements, also referred to as sampling error (e.g., temperature accurate to 2°, 4°, and 6° C), and the standard deviation was found. The ratio was used with the 99, 95, and 90 percent confidence limits to obtain the estimated sample size for the population mean differences based on winter 1992 data. For example:

$$SE = t \left(\frac{s}{\sqrt{n}} \right) \sqrt{1 - \frac{n}{N}} \quad (5)$$

where SE is the sampling error (or customer defined accuracy), t is the Student's t -test statistic value at a given confidence level, s is an approximation of the standard deviation for the population of the paired differences, n is the required sample size, and N is the population size for each stratum (region). As given by Arkin (1974), we can calculate the desired sample size by solving for sample size n :

$$n = \frac{t^2}{R^2 + \frac{t^2}{N}} = \frac{1}{\frac{R^2}{t^2} + \frac{1}{N}} \quad (6)$$

where

$$R = \frac{SE}{\sigma} \quad (7)$$

The table shows how the sample size varies with the ratio (R) and the confidence levels.

Sample n	R	N	t	Confidence Level
9090	0.02	20,000	± 2.58	99%
6489	0.02	20,000	± 1.96	95%
228	0.17	20,000	± 2.58	99%
133	0.17	20,000	± 1.96	95%

The second approach was a simple random sample design that considered the standard deviation and sample mean at different confidence levels. The value is calculated

$$\epsilon\mu = t \left(\frac{s}{\sqrt{n}} \right) \sqrt{1 - \frac{n}{N}} \quad (8)$$

whereas N , n , t , s are as previously defined, ϵ is the value set by the investigator; that is, the sample mean estimate ($\bar{X}$) should not differ from the unknown population mean (μ) by more than $\epsilon\mu$. The product ($\epsilon\mu$) is essentially the sampling error stated in our first approach, but expressed in terms of $X - \mu$, called "sampling error" or "precision," which is the difference between a "sample" result and the result from a 100% check (the whole population). Solving for n gives

$$n = \frac{\left(\frac{ts}{\epsilon\mu} \right)^2}{\left[1 + \frac{1}{N} \left(\frac{ts}{\epsilon\mu} \right)^2 \right]} \quad (9)$$

As a first approximation we can estimate the sample size using

$$n_o = \left(\frac{ts}{\epsilon\mu} \right)^2 \quad (10)$$

where n_o is the sample size estimate. If n_o/n is appreciable (not negligible) we compute

$$n = \frac{n_o}{1 + \left(\frac{n_o}{N} \right)} \quad (11)$$

For example, for the following conditions, and keeping within a 10% sampling error:

Pilot sample mean ($\bar{X}$) . . . 3.50
 Population size, (N) 2,500
 Pilot sample size 20
 Standard Deviation (s) 0.7
 Epsilon (ϵ) 0.10
 99.73% Confidence level (t) ± 3.00

The sample size estimate is:

$$n_o = \frac{(3)^2(.7)^2}{(.1)^2(3.5)^2} = \frac{(9)(.49)}{(.01)(12.25)} = \frac{4.41}{0.1225} = 36 \quad (12)$$

Then, solving for n

$$n = \frac{36}{1 + \frac{36}{2500}} = \frac{36}{1 + 0.0144} = 35.48 \quad (13)$$

In other words, given our example conditions, a sample size of 36 is needed to have a statistically significant test.

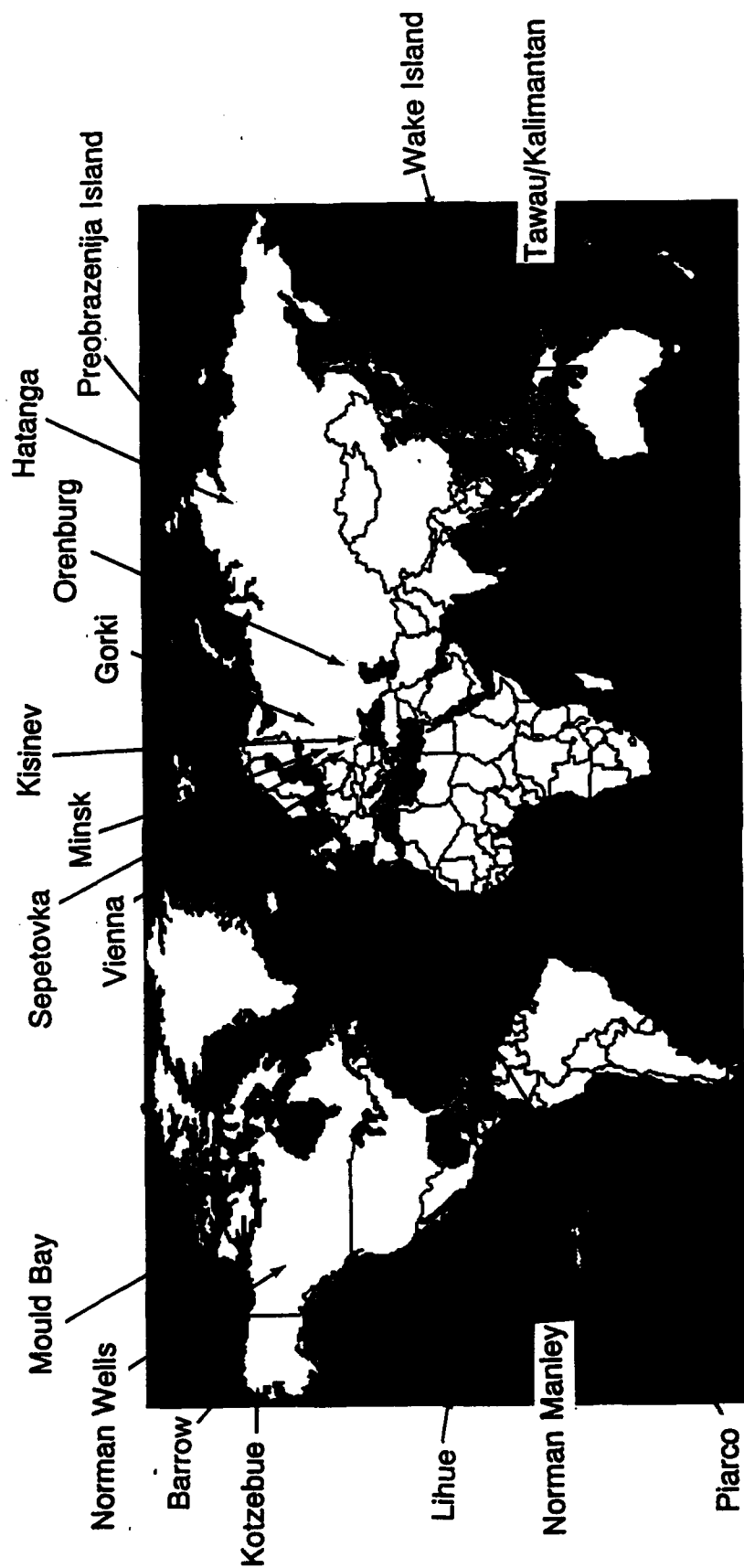


Figure 2. Upper-Air Stations Selected to Represent "Ground Truth."

2.5 Requirements and Development. This study resulted in the determination of the minimum sample size needed at three confidence intervals (99, 95, and 90%). This was accomplished in the following steps:

STEP 1. AWS/DOS and USAFETAC/DOS selected the ground-truth upper-air stations shown in Figure 2. None of these were on the "blacklists" of the High Resolution Analysis System (HIRAS) or the European Center for Medium-range Weather Forecasting (ECMWF)--that is, none of them had a known recent history of poor data. They were selected from the Arctic (WMO Blocks 70, 25, and 24), the mid-latitudes (WMO Blocks 9, 10, 11, and 12), and the tropics (WMO Blocks 98 and 48). Selections were made on the basis of high data density. Stations chosen also showed good reporting frequency at 00Z and 12Z from 1 to 15 November 1991, as shown by the number of observations in the USAFETAC upper-air database; there were at least a dozen 00Z and 12Z upper-air soundings for each station.

STEP 2. AFGWC denied the selected ground truth observations from the non-production HIRAS cycles from 18 January to 10 February 1992. AFGWC imposes a limit of 100 observations denied in one cycle. This limit (documented in the HIRAS maintenance code) insures no degradation in the analysis. Of the 100 observations, 83 are currently used as being from "blacklisted" stations. This left 17 observations per cycle that could be used for test stations. The following steps were used to run the off-line HIRAS between 18 January and 10 February 1992:

- A parallel, non-production version of HIRAS ran for 72 hours to eliminate any contamination by the stations whose observations were denied. AFGWC started this process

on 13 January 1992.

- Enough data was denied (17 observations times 2 cycles a day = 34 observations a day) to ensure that 50 observations from each region could be selected randomly. Denial began 18 January and was terminated on 10 February 1992.

STEP 3. AFGWC shipped the 00Z, 06Z, 12Z, and 18Z HIRAS data, HIRAS error fields, and denied observations for 18 January-10 February 1992 on the Global ETAC Operational Network (GEON) to USAFETAC/OL-A for QC and reformatting into the USAFETAC database format.

STEP 4. OL-A shipped the HIRAS data (on GEON) to USAFETAC. USAFETAC began receiving data-denied HIRAS and RAOB data from OL-A via GEON on 19 January and stored it out to Direct Access Storage Devices (DASD) to prepare for ASPAM analysis.

STEP 5. USAFETAC/SYT analysts randomly selected 50 vertical profiles per region by date and time, for a total of 150 events.

STEP 6. USAFETAC/DOS analysts produced a point analysis (PA) for each event using the OIVP option of ASPAM and the data-denied HIRAS fields. Ground-truth profiles were produced by specifying the RAOBVP option of ASPAM, using only the denied RAOB as input. This put the ground truth in the same format as the point analyses.

STEP 7. USAFETAC/DOS analysts performed manual quality control on each ASPAM RAOBVP and OIVP they had produced. They then used the Man-Computer Interactive Data Access System (McIDAS) to locate inconsistencies in the data.

STEP 8. ASPAM OIVP and RAOBVP ground truth analyses were used to conduct a paired difference statistical analysis to find the required sample size for each region. The analysis also determined the difference means, mean sampling error, and confidence limits in the two ways stated earlier in this chapter; that is:

- Using sampling errors of 1° for temperature and 0.05 g/m^3 of the highest RAOBVP and OIVP values (based on customer accuracy requirements stated in the USAFETAC/ECS (now DOS) Point Analysis Accuracy Study, August 1990).
- Inspecting a sample size of 50 used to determine sample size for full test.

3. DETERMINING SAMPLE SIZE.

3.1 Objective. The appropriate sample size for each of the three regions was determined using the desired confidence interval, standard deviation, and allowable sampling error. We examined the 95% and 99% confidence intervals for the paired differences, allowing sampling errors of 1° C for temperature and 5% for humidity. These sampling errors were based on customer requirements stated in the ASPAM accuracy study conducted by USAFETAC/ECS (now DOS) in 1990. The standard deviation of the differences between the RAOBVP ground truth and the OIVP is based on 59, 52, and 53 sample size differences from arctic/polar, mid-latitude, and moist tropics, respectively.

3.2 Paired Differences. The *t*-test can be used to test the null hypothesis that the population mean of OIVP-RAOBVP paired differences is equal to zero (Panofsky and Brier, 1968). Temperature differences and humidity differences were calculated by subtracting OIVP data values from RAOBVP ground truth data values. The mean values of the paired differences were based on random sample sizes given in 3.1. The mean differences at heights from the surface to 100,000 feet (HT_1K_FT) above ground level for temperature (° C), and absolute humidity (g/m³), are given in Appendix A. The standard error of the differences are also given.

The tabulated values in Appendix A show moderate skewness for a number of temperature differences except near the surface and at levels near the tropopause (100,000 feet). Kurtosis values for humidity differences are low in a number of cases; but

from 35,000 to 50,000 feet, the observation mean differences are very near zero and kurtosis values are extremely high, indicating deviation from a normal distribution. As the kurtosis value increases, the size of the sample necessary to place confidence in our estimated sample standard deviation increases. See the minimum and maximum columns in Appendix A-3 for humidity at the surface and between the 30,000 to 50,000 foot levels.

According to Law and Kelton (1991), the *t*-test can hold its own against troublesome skewness, especially when we deal with paired differences, assuming that the ground-truth RAOBVP and OIVP distributions are skewed in the same direction (as they are in this test--at least most of the time). If ground truth and OIVP distribution skewness values are frequently in opposite directions, we should use a more conservative technique; see 3.3.

3.3 Simple Random Samples. The tabular values in Appendices, C-2, C-3, and C-4 represent the desired sampling size based on an optimum (idealistic) sampling error of 1° C for temperature and a desired sampling error of 5% of the highest RAOBVP humidity value and 5% of the highest OIVP humidity value. The sample sizes in C-5 and C-6 were calculated for two cases: (1) sample mean differences were assumed to be normally distributed, and (2) sample mean differences were assumed to be *not* normally distributed. Because Case 2 uses the conservative Chebyshev's inequality to determine sample size, the resultant large sample sizes can be applied to any type of population other than normal.

4. SUMMARY OF RESULTS AND CONCLUSIONS.

4.1 Selecting the Sample Size. In computing confidence limits, it is common to select a reasonably normal sample size large enough to be able to make assumptions about a sampling distribution. The problem with gathering a large random sample is that it is not always practical, especially when we consider the amount of time it takes to collect HIRAS data and run ASPAM products. One way to overcome these limitations is to recognize the data distortion in the random sample; that is, inspect the skewness and kurtosis values.

4.2 Desired Sampling Error. The skewness and kurtosis values shown in Appendices A-2 through A-7 indicate that temperature and humidity differences do not yield a normal distribution in our test; however, even though the two datasets (such as RAOBVP and OIVP values) might be far from being normally distributed, the distribution of the differences (RAOBVP-OIVP) will be approximately normal (Sachs, 1984). Even so, our inclination is to lean toward relying on the more conservative 95% confidence level for the Chebyshev inequality.

Appendices C-2 and C-4 are useful if we wish to maintain the desired sampling error at 1° C for temperature and 5% of absolute humidity at minimum and maximum standard deviation. In C-2, for example, assuming the minimum standard deviation of 1.5309° C, we need at least 9 to 10 observations to be certain that the 95% normal confidence interval contains the true mean difference. However, we need a sample size of least 45 to 47 observations to be certain that the 95% Chebyshev's confidence interval (non-normal) contains the true mean difference. The minimum required sample size at the 99% confidence levels for 1° C for temperature and 5%

humidity (0.168 g/m³) are too large to be practical for the time constraints imposed on this study.

Note: Humidity amounts decrease exponentially in the vertical; therefore, the sampling errors for humidity shown in C-1 through C-4 are significant only from the surface to 300 mb (moist levels). The amount of humidity in the upper troposphere (above 300 mb) is negligible; this study does not attempt to measure sampling errors at these heights.

We looked at errors we would have to tolerate if we use a sample size of 50 for the full baseline study. Appendices C-5 (based on population size for a season) and C-6 (based on a very large population size approaching infinity) show the sampling errors for the sample size of 50 for each region. Note that in C-6 the sampling error for a very large population is very similar to our test using the seasonal population size. This indicates that using a seasonally sized population is sufficient, where "seasonal population" is defined as:

- 6 denied stations/region x 3 months
- 3 months/season x 30 days/month
- 2 observations/day = 1,080

Sampling errors of 2.9, 4.2, and 1.9° C for the arctic, mid-latitude, and moist tropic regions, respectively (shown in C-5 for a sample size of 50), coincide with maximum standard deviation of the mean differences for each region. Note that the sampling errors are within 2° C of the instrument error estimates (MGRCC, Document 353-87), which vary linearly with altitude from 0.4° C at the surface to 1.8° C at 30 kilometers.

4.3 Resultant Confidence. No matter what the sample size used, one can correct for data distortion. In order to use a small sample of data drawn from a non-normal distribution (such as the sample size of 50 per region per season used for this study), we must adjust the t values in the confidence intervals by using either the skewness and kurtosis values or Chebyshev's inequality. Appendices B-2 through B-7 show that the confidence interval contains zero, indicating that the population mean difference is statistically equal to zero. This is most evident in the 99% confidence limits.

By adjusting the t values at the 95% level, the skewness and kurtosis values fall within the range of the t values based on Chebyshev's inequality at the 95% confidence level. We therefore determined that using the 95% confidence interval based

on Chebyshev's inequality would make reasonable inferences about the population mean differences for the three regions.

4.4 Conclusions. A sample of 50 observations is enough for a statistically valid variance study of ASPAM temperature and moisture accuracy, provided the customer can accept the sampling errors given in Appendices C-5 and C-6 (95% confidence assuming Chebyshev's inequality). Sampling errors are based on the minimum and maximum standard deviation for temperature and humidity given in Appendices C-2, C-3, and C-4 for each region. If the length of the confidence interval for the mean differences is not small enough to meet customer requirements, a larger sample size will be necessary. Customer requirements will determine if a sample size of 50 is acceptable for future tests.

BIBLIOGRAPHY

- Arkin, H., *Handbook of Sampling for Auditing and Accounting*, McGraw Hill, 1974.
- Arkin, H., *Sampling Methods for the Auditor, An Advanced Treatment*, McGraw Hill, New York, 1982.
- Downing, D. and Clark, J., *Statistics, the Easy Way*, Barron's Educational Series, Inc., 1983.
- Hansen, M., Hurwitz, W., and Madow, W., *Sample Survey Methods and Theory*, John Wiley, 1953.
- Hill, H. P., Roth, J. L., and Arkin, A., *Sampling in Auditing, A Simplified Guide and Statistical Tables*, Robert E. Krieger, Huntington, New York, 1979.
- Law, A. M. and Kelton, W. D., *Simulation Modeling and Analysis*, Second Edition, McGraw Hill, 1991.
- Meteorological Data Error Estimates*, Meteorological Group Range Commanders Council (MGRCC), Secretariate Range Commanders' Council, White Sands Missile Range, New Mexico, Document 353-87.
- Panofsky, H. A. and G.W. Brier, *Some Applications of Statistics to Meteorology*, The Pennsylvania State University, University Park, Pa, 1968.
- Sachs, Lothar, *Applied Statistics, A Handbook of Techniques*, Second Edition, Springer-Verlag, 1984.
- Schlotzhauer, S.D. and R.C. Littel, *SAS System for Elementary Statistical Analysis*, SAS Institute Inc., Cary, NC, 1987.
- Snedecor, G. W. and Cochran W. G., *Statistical Methods*, Iowa State University Press/AMES, 1989.
- Surmeier, M. T., *IPAM Baseline Plan and Concept of Operations*, United States Air Force Technical Applications Center, Scott Air Force Base, IL, 28 Oct 1991.
- Surmeier, M. T., et al., *Point Analysis Accuracy, A Detailed Study of PAs Created using the Old PA Model and IPAM*, USAF Environment Technical Applications Center, Scott Air Force Base, IL, Aug 1990.

ACRINABS

ASPAM	Atmospheric Slant Path Analysis Model
AFGWC	Air Force Global Weather Central
ECMWF	European Center for Medium-range Weather Forecasting
HIRAS	High Resolution Analysis System
IPAM	Improved Point Analysis Model
MAX	Maximum
mb	Millibar
McIDAS	Man Computer Interactive Data Access System
MIN	Minimum
NUAV	New Upper Air Validator
OIVP	Optimum Interpolation Vertical Profile
PA	Point Analysis
RAOB	Radiosonde Observation
RAOBVP	RAOB-based Vertical Profile
RTNEPH	Real-time Nephanalysis
STD	Standard Deviation
SE	Sampling Error
USAFETAC	United States Air Force Environmental Technical Applications Center
WMO	World Meteorology Organization

Appendix A

MEAN, STANDARD DEVIATION, SKEWNESS, AND KURTOSIS

ARCTIC/POLAR OIVP-RAOBVP TEMPERATURE DIFFERENCES STATISTICS

HT_LK_FT	N Obs	MEAN OF DIFFERENCES	STANDARD DEVIATION OF DIFFERENCES	MAXIMUM DIFFERENCE BELOW MEAN	MAXIMUM DIFFERENCE ABOVE MEAN	STANDARD ERROR	Skewness	Kurtosis
1	59	-0.8983051	4.6375340	-21.0000000	7.0000000	0.6037555	-1.6140773	5.6328858
2	59	-0.3389831	4.2935805	-12.0000000	6.0000000	0.5589766	-1.0020733	1.7316117
3	59	0.8135593	3.2455517	-7.0000000	13.0000000	0.4225348	0.7460125	2.6581147
4	59	1.1716949	3.0439024	-6.0000000	10.0000000	0.3962923	0.3252448	0.6300992
5	59	1.1355932	2.3668517	-5.0000000	6.0000000	0.3081379	-0.0946434	0.3797406
6	59	0.8305085	2.2905544	-5.0000000	5.0000000	0.2982048	-0.1232275	-0.1238945
7	59	0.3559322	2.2496184	-6.0000000	5.0000000	0.2729754	-0.5472111	0.6981250
8	59	0.3550847	2.0865269	-5.0000000	5.0000000	0.2716427	-0.4726954	0.5089764
10	59	0	2.0844250	-6.0000000	3.0000000	0.2713690	-0.8394599	0.4361726
12	59	-0.0169492	1.8050841	-5.0000000	4.0000000	0.2350019	-0.3197849	0.5584405
14	59	-0.0338983	1.5309013	-4.0000000	4.0000000	0.1993064	-0.0307100	0.9399345
16	59	-0.0338983	1.5753062	-4.0000000	3.0000000	0.2050874	-0.2162075	-0.278492
18	59	-0.1864407	1.7367695	-5.0000000	4.0000000	0.2261080	-0.2755742	0.3516213
20	59	-0.0677966	1.4723241	-3.0000000	4.0000000	0.1716803	-0.0134739	-0.1265997
25	59	-0.1166441	1.7328942	-4.0000000	5.0000000	0.2256036	0.1899358	0.3896451
30	59	0.4745763	2.3514921	-6.0000000	5.0000000	0.3061382	-0.3086975	-0.0094229
35	59	0.6440678	1.7196903	-4.0000000	6.0000000	0.2238846	0.3046434	1.9614620
40	59	-0.2203390	1.2327121	-3.0000000	3.0000000	0.1604854	0.0942263	0.2326296
45	59	-0.4067797	1.2473233	-4.0000000	3.0000000	0.1623877	0.1111954	0.5705896
50	59	-0.7288136	1.6170493	-4.0000000	3.0000000	0.2105218	-0.0023716	-0.4955215
60	59	-0.0509475	1.6127053	-4.0000000	4.0000000	0.2099563	-0.0679994	0.1666251
70	59	-0.3729814	2.5723886	-9.0000000	7.0000000	0.3348965	-0.4252530	2.2434762
80	59	-1.1355932	3.5304470	-13.0000000	7.0000000	0.4596251	-0.7818417	2.5713273
90	59	-1.2711864	3.9515624	-18.0000000	9.0000000	0.5144496	-1.5213515	5.7897500
100	59	-0.6271186	4.1890593	-11.0000000	14.0000000	0.5453691	0.5191422	1.9409926
SFL	59	-3.4406780	5.1537438	-19.0000000	6.0000000	0.6709603	-0.4025754	0.7713737

ARCTIC/POLAR OIVP-RAOBVP ABSOLUTE HUMIDITY DIFFERENCES STATISTICS

HT_LK_FT	N Obs	MEAN OF DIFFERENCES	STANDARD DEVIATION OF DIFFERENCES	MAXIMUM DIFFERENCE BELOW MEAN	MAXIMUM DIFFERENCE ABOVE MEAN	STANDARD ERROR	Skewness	Kurtosis
1	59	0.0224441	0.3313587	-1.1741000	1.1390000	0.0431392	0.1932830	4.4188435
2	59	0.0110000	0.3373403	-0.9341000	1.1730000	0.0439180	0.1614716	2.4796210
3	59	0.0566797	0.3191245	-0.6483000	1.2130000	0.0415465	0.8236910	2.4080997
4	59	0.0763525	0.3466425	-0.7129000	1.1956000	0.0451290	0.8739584	1.9831016
5	59	0.0061119	0.3146265	-1.1300000	0.7498000	0.0409609	-0.8726460	2.1165719
6	59	0.0167658	0.3258250	-0.9950000	0.9905000	0.0424188	0.1045911	1.7759232
7	59	-0.0101739	0.3219873	-1.1650000	0.9596000	0.0419192	-0.4370169	2.8954790
8	59	-0.0337985	0.2953434	-1.1143000	0.7685000	0.0371485	-0.7364262	3.1396601
10	59	-0.0538217	0.2254849	-0.8776000	0.2937000	0.0293556	-1.2603449	2.9852650
12	59	-0.0542954	0.1714451	-0.5421700	0.3724000	0.0223202	-0.6083362	2.1277226
14	59	-0.0149475	0.1089915	-0.3724000	0.3782000	0.0141895	0.5114369	3.7314604
16	59	-0.0144205	0.0654667	-0.1834000	0.1938000	0.0089136	0.6966613	1.5953017
18	59	-0.0177167	0.0387574	-0.0991000	0.0733000	0.0050458	0.1177095	-0.2046043
20	59	-0.0171373	0.0226853	-0.0735000	0.0304100	0.0029534	-0.1278628	-0.1384587
25	59	-0.0084790	0.0093518	-0.0337500	0.0180800	0.0012175	0.0228624	0.6139419
30	59	0.0022483	0.0056117	-0.000075000	0.0403310	0.000730576	5.7273750	37.7915921
35	59	0.000384517	0.0016443	-0.000031000	0.0109580	0.000214067	5.3837581	31.4757657
40	59	0.000013951	0.000097570	-0.000060100	0.000742200	0.000012703	7.4129806	56.1895771
45	59	1.7220339E-6	7.8972293E-6	-9.5E-6	0.000051200	1.0281317E-6	4.2572581	26.6616827
50	59	1.7305085E-6	6.728719E-6	-8.4E-6	0.000042900	8.7600407E-7	3.9596259	24.0055631
60	59	-5.542373E-7	2.283775E-6	-6.5E-6	5.4E-6	2.9732218E-7	-0.0660484	0.3637408
70	59	-4.661017E-7	1.8537576E-6	-4.8E-6	5.2E-6	2.4133869E-7	0.0492466	0.5185946
80	59	-2.033893E-7	1.4311758E-6	-4.3E-6	2.6E-6	1.8632322E-7	-0.5396218	0.1184368
90	59	-3.29322E-7	1.8234666E-6	-4.95E-6	4.05E-6	2.3739514E-7	0.0531573	0.6138934
100	59	-8.769492E-7	1.8748937E-6	-5.93E-6	2.97E-6	2.4461115E-7	-0.5677713	0.5718254
SFC	59	-0.0078041	0.3110145	-1.1288000	0.9700000	0.0405948	0.3219137	5.0007525

MID-LATITUDES OIVP-ROABVP TEMPERATURE DIFFERENCES STATISTICS

HT_1K_FT	N Obs	MEAN OF DIFFERENCES	STANDARD DEVIATION OF DIFFERENCES	MAXIMUM DIFFERENCE BELOW MEAN	MAXIMUM DIFFERENCE ABOVE MEAN	STANDARD ERROR	Skewness	Kurtosis
1	52	0.3376923	1.5785133	-3.0000000	4.0000000	0.2199004	-0.0042336	-0.2846974
2	52	0.1538462	1.7420364	-4.0000000	4.0000000	0.2415770	-0.2695552	0.1414289
3	52	0.0761533	1.5997502	-3.0000000	6.0000000	0.2218454	0.7038192	2.3425816
4	52	0.2500000	1.4669563	-4.0000000	3.0000000	0.2034302	-0.1429206	0.3480802
5	52	0.0761533	1.4452032	-3.0000000	3.0000000	0.2004136	0.0285572	-0.6707318
6	52	0.0384615	1.5713306	-4.0000000	3.0000000	0.2179044	-0.4127719	0.4800009
7	52	-0.0761538	1.6119604	-4.0000000	3.0000000	0.2235387	-0.5093694	-0.1226944
8	52	-0.0761538	1.5374460	-4.0000000	3.0000000	0.2201392	-0.0197834	-0.3493567
10	52	-0.0769231	1.5319621	-3.0000000	4.0000000	0.2124449	0.1341090	-0.1974225
12	52	-0.3653846	1.7038462	-5.0000000	5.0000000	0.2362810	0.1312252	1.8346997
14	52	-0.3846154	1.6348394	-4.0000000	5.0000000	0.2267114	0.1784506	1.6959277
16	52	-0.1346154	2.0677623	-5.0000000	7.0000000	0.2867470	0.6854779	3.5563820
18	52	0.0576923	1.4829833	-6.0000000	6.0000000	0.2511228	-0.4529965	3.1236593
20	52	0.0384615	1.7145461	-4.0000000	6.0000000	0.2377648	0.2293956	2.9629382
25	52	0.0153846	2.1250499	-5.0000000	7.0000000	0.2946914	0.1714925	1.0080280
30	52	0.4615385	2.1370819	-6.0000000	5.0000000	0.2963599	-0.2633528	0.6477378
35	52	0.4007692	1.7655792	-3.0000000	4.0000000	0.2448418	-0.1336718	-0.111148
40	52	-0.0538462	1.4935760	-4.0000000	5.0000000	0.2071217	0.6591583	2.6811296
45	52	-0.1153846	1.2625434	-3.0000000	4.0000000	0.1750971	0.6506150	1.1629819
50	52	0.3846154	2.1434245	-7.0000000	9.0000000	0.2972395	0.5936708	5.7934499
60	52	1.4230769	3.4433577	-3.0000000	15.0000000	0.4775078	2.6015675	8.2347527
70	52	1.8076923	4.4238146	-3.0000000	21.0000000	0.6134727	2.4575294	7.1907027
80	52	1.9423077	6.1752620	-7.0000000	24.0000000	0.8563548	1.5174720	2.3662902
90	52	-0.4230769	6.9320120	-15.0000000	22.0000000	0.9612971	0.5151219	1.2572636
100	52	1.2307692	5.9051115	-10.0000000	18.0000000	0.8190858	0.4575609	0.3412212
SFC	52	0.4615385	2.0907034	-4.0000000	6.0000000	0.2899284	0.3307554	0.2750604

MID-LATITUDES OIVP-ROABVP ABSOLUTE HUMIDITY DIFFERENCES STATISTICS

HT_LF_FT	N Obs	MEAN OF DIFFERENCES	STANDARD DEVIATION OF DIFFERENCES	MAXIMUM DIFFERENCE BELOW MEAN	MAXIMUM DIFFERENCE ABOVE MEAN	STANDARD ERROR	Skewness	Kurtosis
1	52	0.0065192	0.3777233	-0.9670000	0.8160000	0.0523815	0.0409276	-0.0022757
2	52	-0.0061731	0.5281851	-1.9740000	1.5340000	0.0732461	-0.6555359	3.6402563
3	52	-0.0179231	0.6534892	-2.4710000	1.6800000	0.0906226	-1.1388191	4.5390179
4	52	-0.0319558	0.5704158	-1.9088000	1.3250000	0.0791024	-0.7349361	1.6834963
5	52	-0.0206462	0.5445603	-1.7282000	0.9160000	0.0755169	-0.6535733	0.7154458
6	52	-0.0540135	0.5345816	-1.4521000	1.7970000	0.0810669	0.1449082	1.4914013
7	52	-0.0170231	0.5571556	-1.4664000	1.7310000	0.0772640	0.2965545	1.4017195
8	52	-0.0540058	0.4698211	-1.0970000	1.6950000	0.0651608	0.8317092	3.2138607
10	52	-0.0717500	0.3278113	-0.8422000	1.1050000	0.0457366	0.8580335	2.4763287
12	52	-0.0751698	0.2561050	-0.5548000	0.6570000	0.0355154	0.6487265	0.3045789
14	52	-0.0324206	0.2187779	-0.5747000	0.7614000	0.0303390	0.8335946	2.9224395
16	52	-0.0176378	0.1717969	-0.4744000	0.6721000	0.0238239	1.2627532	4.6581137
18	52	-0.0160938	0.1289070	-0.3917000	0.3295000	0.0178762	0.5251767	2.1329660
20	52	-0.0150019	0.0717878	-0.1645700	0.2233000	0.0099552	0.9586378	1.7740823
25	52	-0.0079400	0.0201219	-0.0452400	0.0618700	0.0027904	1.2203688	1.9173383
30	52	0.0063378	0.0051620	-0.000100000	0.0181910	0.000715836	0.8630694	-0.1216529
35	52	0.0016304	0.0018997	-0.000029000	0.0193070	0.000263440	2.2417314	7.6446842
40	52	0.000254750	0.000745626	-0.000047100	0.0046317	0.000103400	4.4805664	23.7290441
45	52	0.000099579	0.000370435	-0.000016700	0.0022807	0.000051370	4.7923615	25.2666178
50	52	0.000022235	0.000143485	-0.000089000	0.000957600	0.000019898	5.9326774	37.4503788
60	52	-3.976154E-6	0.000012658	-0.000086500	8.1E-6	1.7553381E-6	-5.6261903	36.7131954
70	52	-1.394231E-6	3.4790924E-6	-0.000011400	6.4E-6	4.824633E-7	-0.0536239	0.5771265
80	52	-1.011538E-6	2.6249671E-6	-6.8E-6	4.9E-6	3.6401745E-7	-0.0091025	-0.6293338
90	52	-7.569231E-7	2.2298785E-6	-5E-6	5.1E-6	3.0567342E-7	0.4902786	0.1637609
100	52	-1.666346E-6	2.1603858E-6	-5.23E-6	8.31E-6	2.9959161E-7	2.0405321	8.3192943
SFC	52	0.1442500	0.4655715	-0.5660000	1.5160000	0.0845632	0.9702477	1.1446351

MOIST TROPICS **OVP-RAOBVP TEMPERATURE DIFFERENCES STATISTICS**

HT_LK_FT	N Obs	MEAN OF DIFFERENCES	STANDARD DEVIATION OF DIFFERENCES	MAXIMUM DIFFERENCE BELOW MEAN	MAXIMUM DIFFERENCE ABOVE MEAN	STANDARD ERROR	Skewness	Kurtosis
1	53	-0.2641539	1.9821409	-4.0000000	4.0000000	0.2722680	0.1972942	-0.0778243
2	53	-0.7358491	2.1586226	-5.0000000	5.0000000	0.2765096	0.8941832	1.0039408
3	53	-1.4150943	3.1527397	-6.0000000	17.0000000	0.4330621	3.9234805	22.3465789
4	53	-1.7924526	2.6483557	-9.0000000	10.0000000	0.3637796	1.0645402	7.6196424
5	53	-1.5349057	2.1522257	-7.0000000	5.0000000	0.2756309	0.1639131	1.3008260
6	53	-0.3584906	3.2171078	-6.0000000	11.0000000	0.4419037	1.2233836	2.8064211
7	53	-1.2452830	2.6231635	-10.0000000	5.0000000	0.3603192	-0.4527594	1.8179048
8	53	-0.6792453	2.1453169	-5.0000000	4.0000000	0.2948193	0.0015024	0.1849641
10	53	-0.0566036	1.6573275	-3.0000000	5.0000000	0.2276514	0.8335742	1.0590739
12	53	-0.2264151	1.6743316	-5.0000000	4.0000000	0.2327371	-0.2464534	1.0037325
14	53	-0.5849057	1.5245928	-6.0000000	3.0000000	0.2094139	-0.7799739	2.4960783
16	53	-0.4339623	1.7041740	-5.0000000	3.0000000	0.2340863	-0.1294529	0.0553200
18	53	-0.3207547	1.9163106	-4.0000000	3.0000000	0.2494894	-0.1606846	-0.5222453
20	53	-0.6415094	1.6183365	-4.0000000	3.0000000	0.2222956	-0.1598855	-0.1926762
25	53	-0.9433962	1.8125109	-5.0000000	2.0000000	0.2489675	-0.4699438	-0.2625187
30	53	0.0943396	2.1949606	-8.0000000	4.0000000	0.3315010	-0.6462241	2.2479756
35	53	0.4377358	2.2097882	-7.0000000	5.0000000	0.3335378	-0.5823279	1.8255494
40	53	0.5981132	2.6134630	-10.0000000	7.0000000	0.3589867	-1.1541462	4.7023167
45	53	0.7735849	2.4229190	-7.0000000	6.0000000	0.3328218	-0.6940654	1.8351929
50	53	0.2937189	2.4836183	-9.0000000	4.0000000	0.3411512	-1.6756973	4.1051855
60	53	-1.6792453	1.9587399	-8.0000000	2.0000000	0.2690911	-0.4220820	0.6310177
70	53	1.3962264	2.5820357	-5.0000000	9.0000000	0.3546699	0.8029316	1.8646703
80	53	0.3719866	1.9273827	-4.0000000	7.0000000	0.2547464	0.4931309	2.5243568
90	53	-0.2375472	2.6772438	-6.0000000	6.0000000	0.3677477	0.4806740	0.0813738
100	53	-0.5283019	3.1780726	-9.0000000	6.0000000	0.4365418	-0.6336729	1.0210979
SFL	53	-0.2375472	2.5218925	-5.0000000	5.0000000	0.3454086	0.2808413	-0.6121122

MOIST TROPICS **OIVP-RAOBVP ABSOLUTE HUMIDITY DIFFERENCES STATISTICS**

HT_1K_FT	N Obs	MEAN OF DIFFERENCES	STANDARD DEVIATION OF DIFFERENCES	MAXIMUM DIFFERENCE BELOW MEAN	MAXIMUM DIFFERENCE ABOVE MEAN	STANDARD ERROR	Skewness	Kurtosis
1	53	0.8317736	2.9711318	-9.2200000	6.5130000	0.40111e3	-0.8589117	1.4213746
2	53	0.7797170	2.8033951	-9.4100000	5.9700000	0.3950759	-0.9153171	2.1349614
3	53	0.5504717	2.5552402	-8.1530000	8.1200000	0.3509892	-0.3930423	2.5099229
4	53	0.2349243	2.5526795	-8.8950000	5.8960000	0.3506375	-0.7053081	0.9375045
5	53	-0.8343585	3.3944596	-8.9870000	4.7480000	0.4237106	-0.5487999	-0.2356833
6	53	-1.1353962	2.7600713	-7.7260000	5.0730000	0.3791249	-0.0735410	-0.6868573
7	53	-1.2939811	2.3002090	-6.8410000	2.9150000	0.3159580	-0.0715777	-0.7176784
8	53	-1.1902434	2.1640781	-6.0410000	3.2310000	0.2772590	-0.0511054	-0.5334467
10	53	-0.8475698	1.3639918	-4.7480000	3.3610000	0.2360370	0.3394767	-0.0612436
12	53	-0.6421079	1.5220766	-3.7910000	2.7640000	0.2390733	0.0408065	-0.2537123
14	53	-0.4292660	1.1343917	-3.2350000	2.4620000	0.1558207	-0.0215774	0.2444299
16	53	-0.3396547	0.8561089	-2.3970000	2.3140000	0.1217164	0.0607373	0.8449448
18	53	-0.3449491	0.6342740	-1.9220000	0.7235000	0.0371242	-0.6548711	0.0193340
20	53	-0.1713236	0.4914061	-1.2628000	1.0010000	0.0561262	-0.1034489	-0.2277105
25	53	-0.0615356	0.2344373	-0.5950400	0.4495740	0.0322024	-0.1124772	-0.2901795
30	53	-0.0289287	0.0795764	-0.2510900	0.1128000	0.0109307	-0.6325531	0.7912748
35	53	0.0279088	0.0249734	0.000893000	0.0937550	0.0034304	0.8383849	0.0844231
40	53	0.0085329	0.0085573	-0.000011600	0.0441438	0.0011754	1.5935121	4.2544067
45	53	0.0039354	0.0064451	-7.9E-6	0.0464302	0.000395308	5.9481308	39.9938227
50	53	0.0015648	0.0066864	-0.000117000	0.0490851	0.000918444	7.1580239	51.8857746
60	53	-0.000716660	0.000042994	-0.000187700	0.000046700	5.9056554E-6	-1.8573172	3.9597699
70	53	-9.622642E-7	2.8809872E-6	-7.9E-6	4.7E-6	3.9573402E-7	-0.2372950	0.0200764
80	53	4.0754717E-7	1.6096981E-6	-2.6E-6	4.4E-6	2.2110767E-7	0.3674809	0.1991425
90	53	3.6226415E-7	1.2509391E-6	-3.36E-6	3.06E-6	1.718297E-7	-0.4024273	0.3996088
100	53	3.8792453E-7	1.203594E-6	-4.02E-6	2.94E-6	1.6532543E-7	-0.7394928	2.8139778
SFC	53	0.2106276	3.1763088	-7.1400000	7.7150000	0.4362996	-0.1227556	-0.0844464

Appendix B
MEAN DIFFERENCES AND CONFIDENCE LIMITS
SAMPLING ERROR

ARCTIC/POLAR CONFIDENCE LIMITS FOR OIVP-RAOBVP TEMPERATURE DIFFERENCES

055	HT_LK_FT	XBAR	UL_92_NT	LL_92_NT	UL_95_NT	LL_95_NT	UL_90_NT	LL_90_NT	UL_99_CT	LL_99_CT	UL_95_CT	LL_95_CT	UL_90_CT	LL_90_CT
1	1	-0.49431	0.70708	-2.50429	0.30921	-2.10582	0.10997	-1.90458	5.13925	-5.9359	1.31859	-3.61520	1.03371	1.03371
2	2	-0.33898	1.14739	-1.82583	0.77897	-1.45694	0.59451	-1.27247	5.25079	-5.9297	2.17641	-2.45438	1.44974	1.44974
3	3	-0.81356	1.93750	-0.31038	1.65883	-0.03151	1.51719	0.10793	5.03891	-3.4118	2.71497	-1.08785	2.16567	2.16567
4	4	1.10149	2.15481	0.04758	1.89425	0.30913	1.76349	0.43990	5.06452	-2.4611	2.39497	-0.63158	2.36980	2.36980
5	5	1.13559	1.95524	0.31595	1.75187	0.51932	1.65018	0.52100	4.21697	-1.9458	2.52221	-0.25103	2.12163	2.12163
6	6	0.43641	1.62373	0.03728	1.42692	0.23410	1.32851	0.33251	3.81256	-2.1515	2.17243	-0.51141	1.79476	1.79476
7	7	0.35593	1.13498	-0.42312	0.94165	-0.22932	0.84503	-0.13317	3.28459	-2.5729	1.67387	-0.96201	1.29313	1.29313
8	8	0.37508	1.02765	-0.41748	0.84837	-0.23820	0.75873	-0.14856	3.02151	-2.4112	1.52748	-0.91731	1.17434	1.17434
9	10	0.00000	0.72164	-0.72154	0.54274	-0.54274	0.45319	-0.45319	2.71369	-2.7137	1.22116	-1.22116	0.86838	0.86838
10	12	-0.01695	0.50816	-0.64205	0.45305	-0.48695	0.37950	-0.40940	2.33307	-2.3670	1.04056	-1.07444	0.73506	0.73506
11	14	-0.03390	0.29626	-0.56405	0.36471	-0.43251	0.29894	-0.36674	1.95917	-2.0270	0.85298	-0.93079	0.60388	0.60388
12	16	-0.05390	0.51163	-0.37943	0.37629	-0.44407	0.30860	-0.37639	2.01699	-2.0848	0.85920	-0.95670	0.62238	0.62238
13	18	-0.13644	0.41501	-0.78789	0.26578	-0.63866	0.17116	-0.56404	2.07454	-2.4475	0.83105	-1.20393	0.53710	0.53710
14	20	-0.05790	0.44207	-0.57757	0.21556	-0.45116	0.25231	-0.38790	1.84901	-1.9846	0.79476	-0.93036	0.54558	0.54558
15	22	-0.11346	0.44814	-0.71875	0.33256	-0.56985	0.25811	-0.49540	2.13739	-2.3747	0.89657	-1.13346	0.50329	0.50329
16	24	0.47458	1.28890	-0.33975	1.08685	-0.13770	0.98543	-0.03667	3.53596	-2.5865	1.65220	-0.90305	1.45422	1.45422
17	26	0.64407	1.23900	0.04851	1.09184	0.19630	1.01796	0.27018	2.88291	-1.5949	1.65155	-0.76341	1.36050	1.36050
18	28	-0.22034	0.20555	-0.64721	0.10063	-0.44131	0.04767	-0.48935	1.38452	-1.8252	0.50145	-0.94252	0.29321	0.29321
19	30	-0.40678	0.32517	-0.83073	-0.08209	-0.73155	-0.13559	-0.57797	1.21710	-2.0307	0.32396	-1.13752	0.11286	0.11286
20	32	-0.72881	-0.15583	-1.28890	-0.30777	-1.14986	-0.37724	-1.08038	1.37640	-2.8340	0.21353	-1.47616	-0.05514	-0.05514
21	34	-0.05085	0.53764	-0.60533	0.36707	-0.47076	0.29978	-0.40147	2.04872	-2.1504	0.89376	-0.99565	0.62101	0.62101
22	36	-0.37288	0.51794	-1.26371	0.29691	-1.04267	0.18440	-0.93216	2.97608	-3.7219	1.13415	-1.87992	0.69879	0.69879
23	38	-1.13559	0.98701	-2.35820	-0.21634	-2.05494	-0.36202	-1.90317	3.46055	-5.7315	0.93272	-3.70391	0.33521	0.33521
24	40	-1.27119	0.09725	-2.63962	-0.24229	-2.30309	-0.41206	-2.13032	3.87331	-6.4157	1.04384	-3.58621	0.37505	0.37505
25	100	-0.62712	0.42356	-2.07780	0.46362	-1.71786	0.28345	-1.53788	4.82657	-6.0805	1.82704	-3.08128	1.11806	1.11806
26	SFC	-3.44068	-1.55592	-5.22543	-2.09876	-4.78260	-2.32017	-4.56115	3.26392	-10.1533	-0.42136	-6.46000	-1.29361	-1.29361

ARCTIC/POLAR CONFIDENCE LIMITS FOR OIVP-RAOBVP ABSOLUTE HUMIDITY DIFFERENCES

JPS	HT_1K_FT	XBARH	UL_99_NH	LL_99_NH	UL_95_NH	LL_95_NH	UL_90_NH	LL_90_NH
1	1	2.244497E-02	1.371944E-01	-9.230629E-02	1.087225E-01	-4.383440E-02	9.449658E-02	-4.959445E-02
2	2	1.100030E-02	1.278218E-01	-1.058210E-01	9.883594E-02	-7.683394E-02	8.434301E-02	-6.234301E-02
3	3	6.857766E-02	1.791933E-01	-4.133397E-02	1.517726E-01	-1.441329E-02	1.340623E-01	-7.029566E-04
4	4	7.635254E-02	1.763957E-01	-4.369063E-02	1.666106E-01	-1.370549E-02	1.517180E-01	9.870891E-04
5	5	6.111764E-01	1.150579E-01	-1.028441E-01	8.303344E-02	-7.540991E-02	7.451654E-02	-6.229281E-02
6	6	1.046816E-02	1.297028E-01	-9.596520E-02	1.017064E-01	-6.796879E-02	8.770871E-02	-5.797059E-02
7	7	-1.017390E-02	1.013311E-01	-1.216789E-01	7.364446E-02	-9.401225E-02	5.983113E-02	-8.017893E-02
8	8	-3.379747E-02	6.501665E-02	-1.326136E-01	4.049861E-02	-1.080956E-01	2.823959E-02	-9.583654E-02
9	10	-6.382168E-02	1.426429E-02	-1.419076E-01	-5.110422E-03	-1.225329E-01	-1.477778E-02	-1.129456E-01
10	12	-5.429541E-02	5.376448E-03	-1.136673E-01	-9.654915E-03	-0.893590E-02	-1.702060E-02	-9.157022E-02
11	14	-1.484751E-02	2.289652E-02	-5.259154E-02	1.353146E-02	-4.322643E-02	5.848931E-03	-3.854395E-02
12	16	-1.442044E-02	9.289720E-03	-3.813044E-02	3.406744E-03	-3.224766E-02	4.452556E-04	-2.930617E-02
13	18	-1.771571E-02	-4.274942E-03	-3.113948E-02	-7.625155E-03	-2.730827E-02	-9.290262E-03	-2.614316E-02
14	20	-1.713747E-02	-9.281515E-03	-2.499343E-02	-1.123074E-02	-2.304421E-02	-1.220535E-02	-2.206940E-02
15	25	-8.478946E-03	-5.240414E-03	-1.171732E-02	-6.043964E-03	-1.091397E-02	-6.445740E-03	-1.051219E-02
16	30	2.248339E-03	4.191672E-03	3.050063E-04	3.709491E-03	7.871866E-04	3.468471E-03	1.024277E-03
17	35	3.465169E-04	9.519357E-04	-1.849018E-04	8.126514E-04	-4.361747E-05	7.420072E-04	7.702471E-05
18	40	1.395065E-05	4.773970E-05	-1.983801E-05	3.355600E-05	-1.145431E-05	3.518415E-05	-7.262453E-06
19	45	1.730548E-06	4.480679E-06	-1.012796E-06	3.776297E-06	-3.342295E-07	3.439014E-06	5.053994E-09
20	50	1.730548E-06	4.480679E-06	-5.996824E-07	3.482517E-06	-2.149967E-06	3.193415E-06	2.675817E-07
21	60	-5.542373E-07	2.366397E-07	-1.345114E-06	4.040707E-06	-1.148842E-06	-5.770925E-08	-1.050765E-06
22	70	-4.651017E-07	1.758592E-07	-1.108063E-06	1.657568E-06	-4.487791E-07	-6.306609E-08	-1.691373E-07
23	80	-2.033394E-07	2.922299E-07	-6.990096E-07	1.692566E-07	-4.760363E-07	1.077699E-07	-5.145496E-07
24	90	-3.293229E-07	3.321490E-07	-9.677931E-07	1.454692E-07	-4.041123E-07	6.712784E-08	-7.257719E-07
25	100	-8.753497E-07	-2.252835E-07	-1.527615E-06	-3.877289E-07	-1.366171E-06	-4.684485E-07	-1.285450E-06
26	SFC	-6.780437E-02	2.317709E-02	-1.957362E-01	-6.614478E-03	-1.689937E-01	-2.701076E-02	-1.559974E-01
JPS	UL_99_CH	LL_99_CH	UL_95_CH	LL_95_CH	UL_90_CH	LL_90_CH		
1	4.538364E-01	-4.094872E-01	2.165706E-01	-1.716825E-01	1.604396E-01	-1.156015E-01		
2	4.831797E-01	-4.281797E-01	2.036309E-01	-1.855309E-01	1.515775E-01	-1.295375E-01		
3	4.841444E-01	-3.467551E-01	2.556338E-01	-1.182795E-01	2.016284E-01	-6.426907E-02		
4	5.276427E-01	-3.74376E-01	2.794331E-01	-1.267290E-01	2.207654E-01	-6.804030E-02		
5	4.157207E-01	-4.034970E-01	1.904358E-01	-1.782121E-01	1.371867E-01	-1.249630E-01		
6	4.410556E-01	-4.073192E-01	2.077534E-01	-1.740158E-01	1.526090E-01	-1.184714E-01		
7	4.090179E-01	-4.293657E-01	1.784624E-01	-1.936102E-01	1.239675E-01	-1.443153E-01		
8	3.376870E-01	-4.052839E-01	1.333700E-01	-2.009469E-01	8.507686E-02	-1.526738E-01		
9	2.297346E-01	-3.573780E-01	6.827465E-02	-1.959220E-01	3.011533E-02	-1.577597E-01		
10	1.549071E-01	-2.774977E-01	4.614570E-02	-1.547165E-01	1.712938E-02	-1.257202E-01		
11	1.270473E-01	-1.567424E-01	4.900517E-02	-7.870019E-02	3.055984E-02	-6.025386E-02		
12	7.471555E-02	-1.035365E-01	2.569075E-02	-5.453166E-02	1.410304E-02	-4.794393E-02		
13	3.274177E-02	-6.617449E-02	4.989291E-03	-4.042271E-02	-1.570221E-03	-3.386320E-02		
14	1.239621E-02	-4.667116E-02	-3.547317E-03	-3.042763E-02	-7.686876E-03	-2.558825E-02		
15	3.696043E-03	-2.065398E-02	-3.000212E-03	-1.395772E-02	-4.582967E-03	-1.237497E-02		
16	9.554171E-03	-5.057423E-03	5.535932E-03	-1.039254E-03	4.586193E-03	-9.95047E-05		
17	2.525185E-03	-1.756155E-03	1.347819E-03	-5.787855E-04	1.069532E-03	-3.004991E-04		
18	1.409756E-04	-1.130749E-04	7.111244E-05	-4.321075E-05	5.449909E-05	-2.669740E-05		
19	1.204335E-05	-8.559283E-06	6.348626E-06	-2.904599E-06	5.312555E-06	-1.567987E-06		
20	1.049055E-05	-7.029532E-06	5.672527E-06	-2.211510E-06	4.533722E-06	-1.072705E-06		
21	2.419825E-06	-3.527459E-06	7.937125E-07	-1.892187E-06	3.971037E-07	-1.505682E-06		
22	1.947235E-06	-2.879489E-06	5.199224E-07	-1.552126E-06	3.061821E-07	-1.238385E-06		
23	1.559842E-06	-2.066522E-06	6.350647E-07	-1.041844E-06	3.928445E-07	-7.996241E-07		
24	2.044679E-06	-2.703273E-06	7.389461E-07	-1.377600E-06	4.303424E-07	-1.088946E-06		
25	1.469142E-06	-3.323061E-06	2.238010E-07	-1.977699E-06	-9.419147E-08	-1.659705E-06		
26	1.814349E-07	-4.927520E-07	9.487251E-08	-2.704305E-07	4.209924E-08	-2.177074E-07		

MID-LATITUDES CONFIDENCE LIMITS FOR OIVP-RAOBVP TEMPERATURE DIFFERENCES

OBS	HT_1K_FT	XBAAT	UL_99_NT	LL_99_NT	UL_95_NT	LL_95_NT	UL_90_NT	LL_90_NT	UL_99_CT	LL_99_CT	UL_95_CT	LL_95_CT	UL_90_CT	LL_90_CT
1	1	0.30769	0.39341	-0.27852	0.74724	-0.13186	0.67457	-0.05918	2.4967	-1.8813	1.29274	-0.67734	1.09817	1.00817
2	2	0.13563	0.40179	-0.49310	0.63893	-0.33124	0.59873	-0.25104	2.5676	-2.2619	1.24094	-0.93323	0.92649	0.72649
3	3	0.07815	0.59825	-0.49775	0.54162	-0.34731	0.46777	-0.27566	2.3146	-2.1223	1.09446	-0.90215	0.80606	0.80606
4	4	0.25070	0.79479	-0.27679	0.65849	-0.15849	0.59095	-0.09095	2.2843	-1.7843	1.16544	-0.46544	0.90099	0.90099
5	5	0.09115	0.55285	-0.44055	0.49255	-0.30625	0.43205	-0.23974	2.1033	-1.9029	0.99802	-0.80671	0.73748	0.73748
6	6	0.03846	0.42201	-0.54539	0.47401	-0.39909	0.40357	-0.32675	2.2175	-2.1426	1.01903	-0.94211	0.71576	0.71576
7	7	0.09115	0.55248	-0.59479	0.35271	-0.54502	0.27510	-0.47080	2.1392	-2.3215	0.90977	-1.13208	0.61917	0.61917
8	8	0.09115	0.55248	-0.59479	0.35271	-0.54502	0.27510	-0.47080	2.1392	-2.3215	0.90977	-1.13208	0.61917	0.61917
9	9	0.09115	0.55248	-0.59479	0.35271	-0.54502	0.27510	-0.47080	2.1392	-2.3215	0.90977	-1.13208	0.61917	0.61917
10	10	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
11	11	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
12	12	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
13	13	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
14	14	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
15	15	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
16	16	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
17	17	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
18	18	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
19	19	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
20	20	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
21	21	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
22	22	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
23	23	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
24	24	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
25	25	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290
26	26	0.07692	0.49200	-0.64535	0.34967	-0.50351	0.27313	-0.43298	2.0475	-2.2614	0.87908	-1.03293	0.61290	0.60290

MID-LATITUDES CONFIDENCE LIMITS FOR OIVP-RAOBVP ABSOLUTE HUMIDITY DIFFERENCES

Q35	HT_LK_FT	YEAR	UL_99_NH	LL_99_NH	UL_95_NH	LL_95_NH	UL_90_NH	LL_90_NH
1	1	6.51231E-03	1.467969E-01	-1.337584E-01	1.117913E-01	-9.866281E-02	9.431061E-02	-9.127215E-02
2	2	-6.173977E-03	1.899002E-01	-2.023261E-01	1.409051E-01	-1.532512E-01	1.155874E-01	-1.289335E-01
3	3	-1.792353E-02	2.247644E-01	-2.606105E-01	1.640472E-01	-1.998933E-01	1.339695E-01	-1.699046E-01
4	4	-3.193577E-02	1.798936E-01	-2.437921E-01	1.268919E-01	-1.407935E-01	1.006199E-01	-1.465315E-01
5	5	-2.024514E-02	1.515382E-01	-2.228805E-01	1.099918E-01	-1.722341E-01	1.059232E-01	-1.472125E-01
6	6	-5.491145E-02	1.630337E-01	-2.711136E-01	1.087648E-01	-2.157959E-01	9.189464E-02	-1.898616E-01
7	7	-1.732133E-01	1.898999E-01	-2.297360E-01	1.381230E-01	-1.721692E-01	1.124714E-01	-1.465175E-01
8	8	-5.400577E-02	1.204948E-01	-2.295063E-01	7.683708E-02	-1.848484E-01	9.520370E-02	-1.432152E-01
9	9	-9.175000E-02	3.073260E-02	-2.142326E-01	8.908105E-05	-1.835391E-01	-1.509547E-02	-1.664045E-01
10	10	-7.516991E-02	1.974035E-02	-1.702300E-01	-3.854946E-03	-1.464847E-01	-1.564635E-02	-1.746936E-01
11	11	-3.242594E-02	4.872737E-02	-1.136685E-01	2.850021E-02	-3.334137E-02	1.842755E-02	-4.724811E-02
12	12	-1.730777E-02	4.616975E-02	-8.143129E-02	3.020771E-02	-4.546925E-02	2.229315E-02	-6.755970E-02
13	13	-1.609384E-02	3.177859E-02	-6.396628E-02	1.990154E-02	-5.198923E-02	1.386664E-02	-4.404444E-02
14	14	-1.500192E-02	1.165804E-02	-4.156189E-02	4.988073E-03	-3.499192E-02	1.682994E-03	-3.164690E-02
15	15	-7.940719E-03	-4.673049E-04	-1.541273E-02	-2.336379E-03	-1.354315E-02	-3.263294E-03	-1.261074E-02
16	16	6.337422E-03	2.244833E-03	4.422819E-03	7.775225E-03	4.900429E-03	7.435675E-03	5.134086E-03
17	17	1.530445E-03	2.335938E-03	9.249545E-04	2.159437E-03	1.101459E-03	2.071971E-03	1.184921E-03
18	18	2.347533E-04	5.316546E-04	-2.215457E-05	4.623767E-04	4.712327E-05	4.286490E-04	9.149199E-05
19	19	9.857489E-05	2.351477E-04	-3.899021E-05	2.017200E-04	-4.572258E-06	1.846751E-04	1.248241E-05
20	20	2.223462E-05	7.552096E-05	-3.105173E-05	6.218943E-05	-1.772019E-05	4.558335E-05	-1.111412E-05
21	21	-3.976154E-05	7.347755E-07	-8.697083E-06	-4.713346E-07	-7.520973E-06	-1.056123E-06	-4.793184E-06
22	22	-1.394251E-05	-1.721940E-07	-2.686267E-06	-4.254445E-07	-2.363017E-05	-2.502879E-06	-2.028799E-06
23	23	-1.011533E-05	-3.669974E-09	-1.986377E-06	-2.895914E-07	-1.742485E-06	-4.014452E-07	-1.521672E-06
24	24	-7.569221E-07	6.970542E-08	-1.583552E-06	-1.371060E-07	-1.376740E-06	-2.399358E-07	-1.774260E-06
25	25	-1.656345E-05	-8.640393E-07	-2.468652E-06	-1.064756E-06	-2.267926E-06	-1.164231E-06	-2.164462E-06
26	26	1.642500E-01	3.371501E-01	-2.938928E-03	2.938928E-03	3.460717E-02	2.724578E-01	5.604216E-02
Q35	UL_99_CH	LL_99_CH	UL_95_CH	LL_95_CH	UL_90_CH	LL_90_CH	UL_90_CH	LL_90_CH
1	5.303342E-01	-5.172957E-01	2.422360E-01	-2.271975E-01	1.741409E-01	-1.611015E-01	1.741409E-01	-1.611015E-01
2	7.262876E-01	-7.386347E-01	3.234343E-01	-3.357805E-01	2.282144E-01	-2.405606E-01	2.282144E-01	-2.405606E-01
3	9.840304E-01	-9.241495E-01	3.699788E-01	-4.257250E-01	2.720674E-01	-3.079155E-01	2.720674E-01	-3.079155E-01
4	7.470966E-01	-8.229802E-01	3.249052E-01	-3.879168E-01	2.211720E-01	-2.850936E-01	2.211720E-01	-2.850936E-01
5	7.345231E-01	-7.758154E-01	3.191800E-01	-3.694723E-01	2.210900E-01	-2.623003E-01	2.210900E-01	-2.623003E-01
6	7.564554E-01	-6.646823E-01	3.107875E-01	-4.185144E-01	2.054906E-01	-3.134275E-01	2.054906E-01	-3.134275E-01
7	7.555156E-01	-7.896530E-01	3.306649E-01	-3.647110E-01	2.302217E-01	-2.642679E-01	2.302217E-01	-2.642679E-01
8	5.976621E-01	-7.056134E-01	2.392178E-01	-3.472293E-01	1.545087E-01	-2.625203E-01	1.545087E-01	-2.625203E-01
9	3.656159E-01	-5.491159E-01	1.140647E-01	-2.975447E-01	5.460710E-02	-2.381071E-01	5.460710E-02	-2.381071E-01
10	2.799839E-01	-4.333235E-01	8.464936E-02	-2.349890E-01	3.847937E-02	-1.888100E-01	3.847937E-02	-1.888100E-01
11	2.709678E-01	-3.358110E-01	1.041051E-01	-1.677403E-01	6.466435E-02	-1.295055E-01	6.466435E-02	-1.295055E-01
12	2.206097E-01	-2.598702E-01	8.957497E-02	-1.243385E-01	5.860595E-02	-9.386739E-02	5.860595E-02	-9.386739E-02
13	1.526670E-01	-1.948557E-01	6.434700E-02	-9.653469E-02	4.110996E-02	-7.329745E-02	4.110996E-02	-7.329745E-02
14	9.454935E-02	-1.145537E-01	2.979438E-02	-5.980022E-02	1.685464E-02	-4.685849E-02	1.685464E-02	-4.685849E-02
15	1.796477E-02	-3.544411E-02	4.615870E-03	-2.044686E-02	9.892884E-04	-1.686933E-02	9.892884E-04	-1.686933E-02
16	1.347618E-02	-8.205295E-04	9.559097E-03	3.116566E-03	8.628501E-03	4.047153E-03	8.628501E-03	4.047153E-03
17	4.264644E-03	-1.007951E-03	2.815925E-03	4.447673E-04	2.473453E-03	7.874390E-04	2.473453E-03	7.874390E-04
18	1.249474E-03	-7.792477E-04	7.200449E-04	-2.105499E-04	5.856292E-04	-7.612225E-05	5.856292E-04	-7.612225E-05
19	5.122796E-04	-4.151217E-04	3.297442E-04	-1.325465E-04	2.429431E-04	-4.980534E-05	2.429431E-04	-4.980534E-05
20	2.212126E-04	-1.747435E-04	1.117748E-04	-6.730595E-05	8.590762E-05	-4.143839E-05	8.590762E-05	-4.143839E-05
21	1.355773E-05	-2.153031E-05	3.903093E-06	-1.185540E-05	1.621387E-06	-9.613396E-06	1.621387E-06	-9.613396E-06
22	3.430472E-06	-4.213464E-06	7.768541E-07	-3.565316E-06	1.496514E-07	-2.938113E-06	1.496514E-07	-2.938113E-06
23	2.523636E-06	-4.051717E-06	6.265400E-07	-2.644617E-06	1.533174E-07	-2.174394E-06	1.533174E-07	-2.174394E-06
24	2.329815E-06	-3.843561E-06	6.321071E-07	-2.145955E-06	2.304332E-07	-1.744679E-06	2.304332E-07	-1.744679E-06
25	1.329570E-06	-4.662262E-06	-3.181639E-07	-3.014508E-06	-7.076430E-07	-2.625039E-06	-7.076430E-07	-2.625039E-06
26	9.098815E-07	-4.813915E-07	4.547842E-07	-1.262842E-06	3.708521E-07	-4.235204E-07	3.708521E-07	-4.235204E-07

MOIST TROPICS **CONFIDENCE LIMITS FOR** **OIVP-RAOBVP TEMPERATURE DIFFERENCES**

QTS	HT_LK_FT	XBART	UL_99_RT	LL_99_RT	UL_95_RT	LL_95_RT	UL_90_RT	LL_90_RT	UL_99_CT	LL_99_CT	UL_95_CT	LL_95_CT	UL_90_CT	LL_90_CT
1	1	-0.25415	0.46280	-0.99111	0.28039	-0.80869	0.19254	-0.71884	2.45853	-2.98683	0.95106	-1.44936	0.60711	0.50711
2	2	-0.71585	0.05582	-1.52753	-0.14283	-1.32957	-0.24068	-1.23102	2.22925	-3.70295	0.59844	-2.07014	0.21298	0.21298
3	3	-1.41509	-0.25882	-2.57137	-0.54897	-2.28122	-0.69138	-2.13831	2.91553	-5.74572	0.59369	-3.36387	-0.02930	-0.02930
4	4	-1.77245	-0.72116	-2.76374	-1.06489	-2.52001	-1.18499	-2.39996	1.84534	-5.43025	-0.15544	-3.42946	-0.62836	-0.62836
5	5	-1.58491	-0.79557	-2.37424	-0.99364	-2.17617	-1.09120	-2.07861	1.37140	-4.54122	-0.24457	-2.91524	-0.63889	-0.63889
6	6	-0.35449	0.34139	-1.53837	0.52532	-1.24230	0.37949	-1.09467	4.06055	-4.77753	1.63058	-2.94706	1.05560	1.05560
7	7	-1.24528	-0.24323	-2.20734	-0.52464	-1.96592	-0.64355	-1.84702	2.35791	-4.84848	0.37615	-2.86672	-0.09226	-0.09226
8	8	-0.67925	0.10792	-1.46641	-0.08961	-1.26888	-0.18670	-1.17159	2.26895	-3.62744	0.64744	-2.00593	0.26418	0.26418
9	9	-0.09640	0.55123	-0.65443	0.39870	-0.51191	0.32357	-0.43678	2.21991	-2.33312	0.96783	-1.08104	0.67898	0.67898
10	10	-0.22642	0.39499	-0.84782	0.23906	-0.69189	0.16226	-0.61509	2.10096	-2.55379	0.82090	-1.27373	0.51834	0.51834
11	11	-0.58491	-0.02576	-1.14405	-0.16607	-1.00374	-0.23518	-0.93464	1.50928	-2.67909	0.35748	-1.52729	0.08523	0.08523
12	12	-0.43396	0.19105	-1.05397	0.03421	-0.90213	-0.04304	-0.82489	1.90690	-2.77483	0.61943	-1.48735	0.31511	0.31511
13	13	-0.32075	0.34534	-0.98889	0.17822	-0.81973	0.09559	-0.73740	2.17414	-2.41565	0.60195	-1.44346	0.47761	0.47761
14	14	-0.64151	-0.04798	-1.23504	-0.19692	-1.08610	-0.27028	-1.01274	1.58145	-2.86447	0.35882	-1.64184	0.06994	0.06994
15	15	-0.94340	-0.27865	-1.60814	-0.44546	-1.44133	-0.52762	-1.35917	1.54628	-3.43307	0.17696	-2.06375	-0.14670	-0.14670
16	16	-0.39434	0.49935	-0.77107	0.69734	-0.50866	0.59755	-0.40917	3.10935	-2.92067	1.45109	-1.26241	1.05914	1.05914
17	17	-0.03775	0.84818	-0.77271	0.44481	-0.56934	0.54464	-0.46917	3.07311	-2.99764	1.40366	-1.32818	1.00906	1.00906
18	18	-0.69811	1.65661	-0.25038	1.41609	-0.01986	1.29762	0.00961	4.28798	-2.89175	2.31355	-0.91733	1.84687	1.84687
19	19	-0.77358	1.64222	-0.11505	1.43923	0.10794	1.32940	0.21777	4.10140	-2.55463	2.27128	-0.72411	1.83861	1.83861
20	20	-0.24372	1.14389	-0.42785	0.96532	-0.39928	0.85274	-0.28670	3.69453	-3.12849	1.81820	-1.35218	1.37470	1.37470
21	21	-1.07925	-0.94080	-2.39769	-1.14108	-2.21741	-1.22948	-2.12861	1.01157	-4.37006	-0.46831	-2.07014	-0.41819	-0.41819
22	22	-1.39823	2.11320	0.44926	2.10557	0.68889	1.98853	0.80393	4.94293	-2.15047	2.99224	-0.99979	2.57117	2.57117
23	23	-0.39189	1.00476	-0.40499	0.83134	-0.22761	0.74401	-0.14024	2.94935	-2.34556	1.49325	-0.58947	1.14908	1.14908
24	24	-0.40755	0.77434	-1.18943	0.52795	-0.94304	0.40659	-0.82169	3.44993	-3.53532	1.44732	-1.86241	0.98925	0.98925
25	25	-0.52830	0.69726	-1.69347	0.34478	-1.40139	0.20072	-1.25733	3.83712	-4.89372	1.43614	-2.49274	0.66863	0.66863
26	26	-0.23755	0.71736	-1.13246	0.48527	-0.90036	0.37096	-0.78605	3.25654	-3.67163	1.35129	-1.76639	0.90096	0.90096

MOIST TROPICS **CONFIDENCE LIMITS FOR** **OIVP-RAOBVP TEMPERATURE DIFFERENCES**

JTS	HT_1K_FT	XBARM	UL_99_NH	LL_99_NH	UL_95_NH	LL_95_NH	UL_90_NH	LL_90_NH
1	1	8.317734E-01	1.921444E+00	-2.578970E-01	1.448005E+00	1.554090E-02	1.913328E+00	1.502193E-01
2	2	7.797170E-01	1.807870E+00	-2.484357E-01	1.549849E+00	9.565123E-03	1.422794E+00	1.364020E-01
3	3	5.504717E-01	1.447613E+00	-3.866696E-01	1.252493E+00	-1.515368E-01	1.136674E+00	-3.569032E-02
4	4	2.349244E-01	1.171127E+00	-7.012776E-01	9.361995E-01	-4.663504E-01	8.204891E-01	-3.506471E-01
5	5	-8.343548E-01	2.969488E-01	-1.965664E+00	1.306264E-02	-1.681780E+00	-1.267614E-01	-1.541955E+00
6	6	-1.135296E+00	-1.231324E-01	-2.147640E+00	-3.771453E-01	-1.893646E+00	-5.722576E-01	-1.768515E+00
7	7	-1.293941E+00	-4.503733E-01	-2.137589E+00	-6.620651E-01	-1.925897E+00	-7.663313E-01	-1.821631E+00
8	8	-1.180243E+00	-3.865617E-01	-1.973925E+00	-5.857254E-01	-1.774761E+00	-1.476466E+00	-1.275155E+00
9	9	-4.475593E-01	-1.539458E-01	-1.531194E+00	-3.354919E-01	-1.359648E+00	-4.189647E-01	-2.929555E-01
10	10	-6.421079E-01	-8.338222E-02	-1.200334E+00	-2.239613E-01	-1.060255E+00	-1.490455E-01	-6.894866E-01
11	11	-4.292560E-01	-1.322483E-02	-8.453073E-01	-1.176247E-01	-7.409074E-01	-1.463893E-01	-5.429211E-01
12	12	-3.395474E-01	-1.467190E-02	-6.646375E-01	-9.622189E-02	-4.830573E-01	-1.993516E-01	-4.903465E-01
13	13	-3.448491E-01	-1.122274E-01	-5.774707E-01	-1.706006E-01	-1.190975E-01	-1.993516E-01	-4.903465E-01
14	14	-1.713208E-01	5.236252E-03	-3.478778E-01	-3.906832E-02	-3.039732E-01	-6.088997E-02	-2.817515E-01
15	15	-6.153559E-02	2.444493E-02	-1.475161E-01	-2.869296E-03	-1.259405E-01	-7.757509E-02	-1.153117E-01
16	16	-2.892166E-02	2.562092E-04	-5.811535E-02	-7.067335E-03	-4.078999E-02	-1.067445E-02	-4.718297E-02
17	17	-2.790381E-02	3.706789E-02	-1.474974E-02	3.476954E-02	2.104308E-02	3.463752E-02	2.218010E-02
18	18	-6.532579E-03	1.167129E-02	5.394674E-03	1.088375E-02	6.182009E-03	1.049586E-02	6.569902E-03
19	19	-3.335791E-03	5.697162E-03	9.716194E-04	5.106006E-03	1.964775E-03	4.811854E-03	1.854677E-03
20	20	-1.364036E-03	4.017779E-03	-8.874107E-04	3.401721E-03	-2.720534E-04	3.094615E-03	3.103228E-03
21	21	-1.656018E-03	-8.922774E-07	-3.242548E-05	-4.849067E-06	-2.447169E-05	-6.767933E-06	-2.652282E-05
22	22	-9.622542E-07	9.434569E-04	-2.018974E-06	-1.707961E-07	-1.753732E-06	-3.013383E-07	3.829737E-08
23	23	-4.075672E-07	9.979046E-07	-1.6828103E-07	8.497625E-07	-3.466316E-03	7.767970E-07	-1.423140E-06
24	24	3.522542E-07	6.210494E-07	-9.652115E-08	7.059236E-07	1.860475E-03	6.492197E-07	1.118294E-07
25	25	3.879244E-07	8.293461E-07	-5.349703E-08	7.185774E-07	5.727168E-03	4.640197E-07	7.530455E-08
26	26	2.306224E-01	1.395543E+00	-9.342972E-01	1.103222E+00	-8.419765E-01	9.592429E-01	-4.979976E-01
JTS	JL_99_CH	LL_99_CH	UL_95_CH	LL_95_CH	UL_90_CH	LL_90_CH		
1	4.412937E+00	-3.249390E+00	2.668297E+00	-1.004750E+00	2.137746E+00	-4.741987E-01		
2	4.630476E+00	-3.071042E+00	2.512559E+00	-9.531247E-01	2.011960E+00	-4.425260E-01		
3	4.060364E+00	-2.959421E+00	2.129923E+00	-1.029980E+00	1.575637E+00	-5.726939E-01		
4	3.741294E+00	-3.271450E+00	1.812793E+00	-1.342944E+00	1.356464E+00	-8.871154E-01		
5	3.402747E+00	-5.071464E+00	1.072339E+00	-2.741056E+00	5.215134E-01	-2.190212E+00		
6	2.655873E+00	-4.926545E+00	5.706660E-01	-2.891458E+00	7.780159E-02	-2.348596E+00		
7	1.865599E+00	-4.455616E+00	1.278299E-01	-2.715792E+00	-2.829134E-01	-2.305047E+00		
8	1.792346E+00	-4.152833E+00	1.574220E-01	-2.517909E+00	-2.290146E-01	-2.131472E+00		
9	1.712802E+00	-3.407959E+00	3.046055E-01	-1.999745E+00	-2.824513E-02	-1.665894E+00		
10	1.449625E+00	-2.732341E+00	2.987219E-01	-1.582938E+00	2.692663E-02	-1.311142E+00		
11	1.124941E+00	-1.997473E+00	2.719270E-01	-1.130459E+00	6.936713E-02	-9.274922E-01		
12	9.775074E-01	-1.556817E+00	2.080691E-01	-8.873786E-01	4.983790E-02	-7.291472E-01		
13	5.261912E-01	-1.216091E+00	4.720997E-02	-7.369081E-01	-6.605153E-02	-6.236466E-01		
14	8.894145E-01	-8.325833E-01	1.262472E-01	-4.688887E-01	4.028315E-02	-3.829247E-01		
15	2.504880E-01	-1.333600E-01	8.337540E-02	-2.064466E-01	4.151222E-02	-1.645834E-01		
16	9.037777E-02	-1.382351E-01	2.025932E-02	-7.811664E-02	6.049460E-03	-6.390678E-02		
17	6.221246E-02	-6.394839E-03	4.334545E-02	1.247217E-02	3.848570E-02	1.693164E-02		
18	2.925723E-02	-3.221474E-03	1.382234E-02	3.243420E-03	1.229427E-02	4.771446E-03		
19	1.218847E-02	-5.517685E-03	7.319275E-03	-6.484935E-04	6.163375E-03	5.024063E-04		
20	1.074927E-02	-7.619503E-03	5.697851E-03	-2.568163E-03	4.503854E-03	-1.374186E-03		
21	4.239618E-03	-7.571693E-05	9.915072E-05	-4.323583E-05	2.237720E-04	-3.555847E-05		
22	2.995070E-06	-4.719604E-06	8.145390E-07	-2.743067E-06	3.040847E-07	-2.228613E-06		
23	7.618624E-06	-1.803929E-06	1.402372E-06	-5.874373E-07	1.115092E-06	-2.999974E-07		
24	2.080561E-06	-1.350731E-06	1.135478E-06	-4.109695E-07	9.121192E-07	-1.875909E-07		
25	2.041189E-06	-1.265240E-06	1.131493E-06	-3.560444E-07	9.169471E-07	-1.411200E-07		
26	4.591616E-00	-4.132373E+00	2.193971E+00	-1.732725E+00	1.626741E+00	-1.169536E+00		

Appendix C
PILOT STUDY
MINIMUM AND MAXIMUM SAMPLE SIZES

PILOT STUDY RESULTS - SAMPLE SIZES
***Based on Temperature Sampling Error of 1° C**

ARCTIC/POLAR

LEVEL OF CONFIDENCE

Minimum Standard Dev (1.531)	<u>95%</u> POPULATION		<u>99%</u> POPULATION	
	<u>SEASON</u>	<u>LARGE</u>	<u>SEASON</u>	<u>LARGE</u>
NORMAL	9	10	16	17
CHEBYSHEV	45	47	193	235
Maximum Standard Dev (5.153)				
NORMAL	97	106	160	188
CHEBYSHEV	357	533	768	2660

***Based on Humidity Sampling Error of 0.168 g/m³**

ARCTIC/POLAR

LEVEL OF CONFIDENCE

Minimum Standard Dev (1.823E-6)	<u>95%</u> POPULATION		<u>99%</u> POPULATION	
	<u>SEASON</u>	<u>LARGE</u>	<u>SEASON</u>	<u>LARGE</u>
NORMAL	1	1	1	1
CHEBYSHEV	1	1	1	1
Maximum Standard Dev (0.346)				
NORMAL	17	17	29	30
CHEBYSHEV	79	85	303	422

PILOT STUDY RESULTS - SAMPLE SIZES
***Based on Temperature Sampling Error of 1° C**

MID-LATITUDE

LEVEL OF CONFIDENCE

Minimum Standard Dev (1.263)	<u>95%</u>		<u>99%</u>	
	<u>POPULATION SEASON</u>	<u>LARGE</u>	<u>POPULATION SEASON</u>	<u>LARGE</u>
NORMAL	6	7	11	11
CHEBYSHEV	31	32	139	159
Maximum Standard Dev (6.932)				
NORMAL	165	195	262	346
CHEBYSHEV	513	978	883	4831

***Based on Humidity Sampling Error of 0.2879 g/m³**

MID-LATITUDE

LEVEL OF CONFIDENCE

Minimum Standard Dev (2.160E-6)	<u>95%</u>		<u>99%</u>	
	<u>POPULATION SEASON</u>	<u>LARGE</u>	<u>POPULATION SEASON</u>	<u>LARGE</u>
NORMAL	1	1	1	1
HEBYSHEV	1	1	1	1
Maximum Standard Dev (0.584)				
NORMAL	16	17	29	30
CHEBYSHEV	77	83	299	412

PILOT STUDY RESULTS - SAMPLE SIZES
***Based on Temperature Sampling Error of 1° C**

MOIST TROPICS

LEVEL OF CONFIDENCE

Minimum Standard Dev (1.524)	<u>95%</u> POPULATION		<u>99%</u> POPULATION	
	<u>SEASON</u>	<u>LARGE</u>	<u>SEASON</u>	<u>LARGE</u>
NORMAL	9	9	16	17
CHEBYSHEV	45	47	191	233
Maximum Standard Dev (3.178)				
NORMAL	39	41	68	72
CHEBYSHEV	172	204	520	1010

***Based on Humidity Sampling Error of 1.2015 g/m³**

MOIST TROPICS

LEVEL OF CONFIDENCE

Minimum Standard Dev (1.60E-6)	<u>95%</u> POPULATION		<u>99%</u> POPULATION	
	<u>SEASON</u>	<u>LARGE</u>	<u>SEASON</u>	<u>LARGE</u>
NORMAL	1	1	1	1
CHEBYSHEV	1	1	1	1
Maximum Standard Dev (3.176)				
NORMAL	27	28	48	50
CHEBYSHEV	125	142	425	700

SAMPLING ERRORS AT MAX STANDARD DEVIATION

*based on population=season (1,080 observations) and sample size of 50

TEMPERATURE (deg C)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	1.730	1.306	6.529	2.940
Mid-latitudes (52)	2.510	1.882	9.370	4.220
Moist Tropics (53)	1.136	0.851	4.256	1.910

HUMIDITY (g/m³)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	.117	0.088	0.439	.198
Mid-latitudes (52)	.211	0.159	0.79	.350
Moist Tropics (53)	1.136	0.851	4.256	1.910

SAMPLING ERRORS AT MIN STANDARD DEVIATION

*based on population=season (1,080 observations) and sample size of 50

TEMPERATURE (deg C)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	0.516	0.388	1.940	0.872
Mid-latitudes (52)	0.457	0.340	1.708	0.768
Moist Tropics (53)	0.545	0.408	2.042	0.919

HUMIDITY (g/m³)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	5.0E-7	3.0E-7	2.2E-6	9.0E-7
Mid-latitudes (52)	7.0E-7	5.0E-7	2.8E-6	1.2E-7
Moist Tropics (53)	4.0E-7	3.0E-7	2.0E-6	8.0E-7

SAMPLING ERRORS AT MAX STANDARD DEVIATION
 *based on large population (> 500,000) with sample size of 50

TEMPERATURE (deg C)+

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	1.780	1.342	6.710	3.020
Mid-latitudes (52)	2.570	1.930	9.614	4.330
Moist Tropics (53)	1.165	0.873	4.365	1.960

HUMIDITY (g/m³)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	.120	0.090	0.451	.203
Mid-latitudes (52)	.216	0.163	0.810	.364
Moist Tropics (53)	1.165	0.873	4.365	1.960

SAMPLING ERRORS AT MIN STANDARD DEVIATION
 *based on large population(> 500,000) with sample size of 50

TEMPERATURE (deg C)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	0.530	0.398	1.993	0.897
Mid-latitudes (52)	0.469	0.352	1.752	0.788
Moist Tropics (53)	.559	0.419	2.094	0.942

HUMIDITY (g/m³)

CONFIDENCE LEVEL				
REGION size	99% normal	95% normal	99% chebyshev	95%chebyshev
Arctic (59)	1.0E-7	4.0E-7	2.3E-6	1.0E-7
Mid-latitudes (52)	8.0E-7	1.3E-6	2.9E-6	7.0E-7
Moist Tropics (53)	5.0E-7	4.0E-7	2.1E-6	9.0E-7

DISTRIBUTION

HQ AF/XOW, Pentagon, Washington, DC 20301	1
HQ USAF/XOOOW, Rm BD927, Washington, DC 20330-5054	1
OSAF/SS, Rm 4C1052, Pentagon, Attn: Weather, Washington, DC 20330-6560	1
USTC J3/J4-OW, Scott Dr., Bldg 1900, Scott AFB, IL 62225-7001	1
AWS/XTX/DOS/SCA, Losey St., Bldg 1521, Scott AFB, IL 62225-5008	1
Det 3, DOXW, PO Box 95004, Henderson, NV 89009-5004	1
Det 4, AWS, Bldg 91027, Hurlburt Fld, FL 32544-5000	1
OL-B, HQ AWS, Hanscom AFB, MA 01731-5000	1
OL-N, HQ AWS, ASL(SLCAS-BW-W), Bldg 1646, Rm 24, Missile Range, White Sands, NM 88002-5501	1
HQ AFGWC/DOM/SY, MBB39, 106 Peacekeeper Dr., Ste 2N3, Offutt AFB, NE 86113-4039	1
AFSFC/DON, Stop 82, Bldg 715, Patrick Ave., Falcon AFB, CO 80912-5000	1
USAFETAC, Scott AFB, IL 62225-5000	6
OL-A, USAFETAC, Federal Building, Rm 305, Asheville, NC 28801-2723	1
AFSPACECOM/DOWA, Bldg 1, Stop 7, Peterson Rd., Peterson AFB, CO 80914-5001	1
721SPTS Weather, STE 2-210, 1 Norad Rd, Cheyenne Mtn, CO 80914-6113	1
50 OSS/WE, Stop 82, Falcon AFB, CO 80912-5000	1
45WS, Bldg 423, C. St., Patrick AFB, FL 32925-6537	1
AFTAC/DOW, Patrick AFB, FL 32925-5000	1
30WS, Coral Rd., Bldg 21150, Vandenberg AFB, CA 93437-5000	1
21OSS/OGSW, Hamilton Rd., Stop 22, Peterson AFB, CO 80914-5000	1
SSD/MWA, PO Box 92966, Los Angeles, CA 90009-2960	1
SSD/IMO, PO Box 92960, Los Angeles, CA 90009-2960	1
SM-ALC/LH-AWS, McClellan AFB, CA 95652-5609	1
CSTC/WE, 1080 Lockheed Way, Box 007, Bldg 1001, Sunnyvale, CA 94089-1230	1
OD 4/DX, Onizuka AFB, CA 94088-3430	1
SSD OD 4, Onizuka AFB, CA 94088-3430	1
Det 3, Space Systems, Bldg 430, Stop 77, Buckley ANGB, CO 80011-9599	1
USAF/DFF, Attn: Capt Paul Bellaire, Colorado Springs, CO 80840-5701	1
AFMC(I)/DOW, Bldg 266, Post 108P Chidlaw Rd., Wright-Patterson AFB, OH 45433-5000	1
FASTC/TAW, 4115 Hebble Creek Rd., Ste 33, Wright-Patterson AFB, OH 45433-5637	1
ASD/WE, Bldg 91, 3rd St, Wright-Patterson AFB, OH 45433-6503	1
AFTI/CIR, Wright-Patterson AFB, OH 45433-6583	1
WL/DOWA, Wright-Patterson AFB, OH 45433-6543	1
WL/DOW, Wright Patterson AFB, OH 45433-6543	1
2750ABW/WE, Bldg 206, Area C, Skeel Av., Wright Patterson AFB, OH 45433-6543	1
FASTC/TAW, Wright-Patterson AFB, OH 45433-6543	1
PL/WE, Kirtland AFB, NM 87117-5000	1
HQ AFOTEC/WE, Kirtland AFB, NM 87117-7001	1
RL/WE, Griffiss AFB, NY 13441-5700	1
RL/DOVL, 26 Electronic Pkwy, Bldg 106, Griffiss AFB, NY 13441-4514	1
325OSS/OSW, Florida Ave., Stop 22, Bldg 149, Tyndall AFB, FL 32403-5048	1
AFESC/RDXT, Bldg 1120, Stop 21, Tyndall AFB, FL 32403-5000	1
ESD/WE, Vandenberg Dr., Bldg 1624, Hanscom AFB, MA 01731-5000	1
PL/TSMIL, Research Library, Hanscom AFB, MA 01731-5000	1
3246TW/DOW, Bldg 60, Rm 60, Eglin AFB, FL 32542-5000	1
AFFTC/WE, Edwards AFB, CA 93523-5000	1
510 OSS/WE, Bldg 1200, Rm 6, Wolfe Ave, Edwards AFB, CA 93523-5000	1
6585 TG/WE, Range Rd, Bldg 1183, Holloman AFB, NM 88330-5000	1
SSD/SDW, PO Box 92960, Bldg 117, El Segundo, Los Angeles AFB, CA 90009-2960	1
UTTR/WE, Hill AFB, UT 84056-5000	1
USAF/CWOSW, Air Field Dr., Bldg 9206, USAF Academy, CO 80840-5000	1
AFTAC/WS, Patrick AFB, FL 32925-5000	1
ESMC/WE, Patrick AFB, FL 32925-5000	1
OL-A, AFCOS, Site R, Fort Ritchie, MD 21719-5010	1
USAFALCENT RA, Pope AFB, NC 28308-5000	1
CCSO/FL, Tinker AFB, OK 73145-6340	1
304 ARRS/DOOR, Portland IAP, OR 97218-2797	1
AFOSR/NL, Bolling AFB, DC 20332-5000	1
TFWC/WE, Nellis AFB, NV 89191-5000	1
AMC/XOWR, Bldg P40 N, Martin Ave, Scott AFB, IL 62225-5000	1

1SOW/OGSW, Attn: Lt Kelly, 150 Bennett, Bldg 90730, Hurlburt FLD, FL 32544-5000	1
HQ AFSOC/DOW, Bldg 1, Hurlburt FLD, FL 32544-5000	1
ATC/DOTW, Bldg 399, Rm B27, D St., East, Randolph AFB, TX 78150-5000	1
PACAF/DOW, Bldg 1102, Hickam AFB, HI 96853-5000	1
USSTRATCOM, J315, 901 SAC BLVD, STE BA3, Offutt AFB, NE 68113-5000	1
ACC/DOW, Bldg 21, 30 Elm St, Ste 215, Langley AFB, VA 23655-2093	1
1WG, Bldg 168, Hardee St., Ft McPherson, GA 30300-5000	1
USAFE/DOW, Unit 3050, Box 15, APO AE 09094-5000	1
17AF/DOW, Unit 4065, APO AE 09136-5000	1
COMNAVOCEANCOM, Code N312, Stennis Space Ctr, MS 39529-5000	2
NAVOCEANO (Rusty Russum), Bldg 8100, Rm 203D, Stennis Space Ctr, MS 39522-5001	2
NAVOCEANO, Code 9220 (Tony Ortolano), Stennis Space Ctr, MS 39529-5001	1
Maury Oceanographic Library, Naval Oceanography Office, Stennis Space Ctr, MS 39522-5001	1
Naval Research Laboratory, Monterey, CA 93943-5006	1
Naval Research Laboratory, Code 4323, Washington, DC 20375	1
Naval Postgraduate School, Chmn, Dept of Meteorology, Code 63, Monterey, CA 93943-5000	1
Naval Air Warfare Center-Weapons Division, Geophysical Sciences Branch, Code 3254, Attn: Mr. Roger Helvey, Point Mugu, CA 93042-5001	1
Armed Forces Medical Intelligence Center, Information Services Division Bldg 1607, Ft Detrick, Frederick, MD 21702-5004	1
Chief, APG Met Team, Bldg 1134, Attn: AMSTE-TC-AM CAB, Aberdeen Proving Ground, MD 21005-5001	1
Atmospheric Sciences Laboratory (SLCAS-AS-1 & 10-2c), White Sands Missile Range, NM 88002-5501	1
TECOM Atmos Sci Div, AMSTE-TC-AA (MacBlain), White Sands Missile Range, NM 88002-5504	1
White Sands Met Team, AMSTE-TC-AM (WS), White Sands Missile Range, NM 88002-5501	1
USA TECOM, ATTN: AMSTE-TC-AM (RE) TECOM Met Team, Redstone Arsenal, AL 35898-8052	1
Director, U.S.A.-CETEC, Attn: GL-AE (Whitmarsh), Fort Belvoir, VA 22060-5546	1
Technical Library, Dugway Proving Ground, Dugway, UT 84022-5000	1
OFCM, Attn: Col Dumont, Suite 900, 6010 Executive Blvd, Rockville, MD 20852	1
HQ NATO Staff Meteorological Officer IMS/OPS APO AE 09724	1
NOAA/MASC Library MC5, 325 Broadway, Boulder, CO 80303-3328	2
NOAA Library-EOC4W5C4, Attn: ACQ, 6009 Executive Blvd, Rockville, MD 20852	1
NOAA/NESDIS (Attn: Nancy Everson, E/RA22), World Weather Bldg, Rm 703, Washington, DC 20238	1
NGDC, NOAA, Mail Code E/GC4, 325 Broadway, Boulder, CO 80333-3328	1
NWS W/OSD, Bldg SSM C-2 East-West Hwy, Silver Spring, MD 20910	1
NIST Pubs Production, Rm A635, Admin Bldg, Gaithersburg, MD 20899	1
WSO, H & HS Marine Station Wea, MCAS Tustin CA 92710-5000	1
DTIC-FDAC, Cameron Station, Alexandria, VA 22304-6145	2
AUL/LSE, Maxwell AFB, AL 36112-5564	1
AWSTL, Scott AFB, IL 62225-5438	35