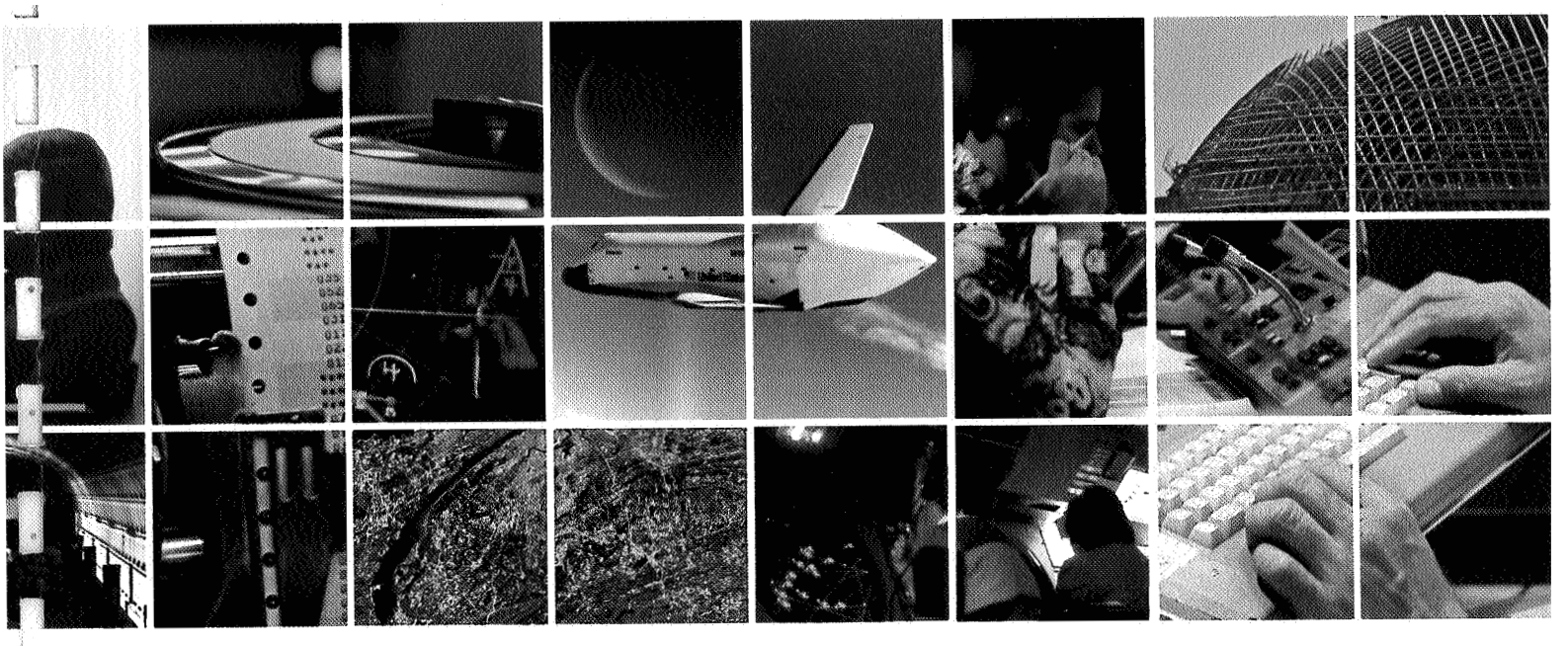
VECTOR WIND GUST MODEL

FINAL REPORT

(For the Period February 14, 1979 - April 13, 1984)

Contract NAS8-33433

April 13, 1984



CSC
COMPUTER SCIENCES CORPORATION
APPLIED TECHNOLOGY DIVISION

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Prepared By

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Table

I. INTRODUCTION

The purpose of this report is to summarize studies performed under contract **NAS8-33433** during the period April **14, 1979,** through April **13, 1984.** These studies have been described in monthly and annual reports, in national meeting proceedings, and in the open literature. If the previously published work has not been revised, it will be abstracted in Section II of this report. Revised or expanded work or work that has not yet been published will be included in Section III. Conclusions and recommendations are given in Section IV.

II. SUMMARY OF PUBLISHED WORK

Abstracts of annual reports, papers published in conference proceedings, and papers published in the open literature are presented in chronological order below.

Adelfang, S.I., and Evans, B.A. (1980), "Vector Wind Profile Gust Model," Annual Report for Period 4/79 through 4/80. NASA CR–161475, Marshall Space Flight Center, Alabama.

> A statistical model based on the gamma distribution is proposed for wind perturbations observed in detailed vertical wind profiles. Model parameters are estimated from Jimsphere wind profile data. Digital filtering is used for extraction of wind perturbation data in selected wavelength bands. The probability distribution of wind perturbations in four wavelength bands is derived. The analytical techniques established in this study are applicable to Space Shuttle launch analyses.

Adelfang, S.I., and Smith, O.E. (1981), "Vector Wind Profile Gust Model," Annual Report for Period 4/80 through 4/81. NASA TM–82441, Marshall Space Flight Center, Alabama.

> The further development of a vector wind gust model suitable for Space Shuttle launch analysis is described. Emphasis is given to verification of the hypothesis that gust component variables are gamma distributed, gust modulus is approximately Weibull distributed, and zonal and meridional gust components are bivariate gamma distributed. A method of testing for bivariate gamma distributed variables is described, two distributions for gust modulus are proposed, the results of extensive hypothesis testing of one of the distributions are presented, and the validity of the gamma distribution for representation of gust component variables is established.

Smith, O.E., and Adelfang, S.I. (1981), "Gust Model Based on the Bivariate Gamma Probability Distribution," Jour. Spacecraft and Rockets, Vol. 18, No. 6, Nov–Dec 1981, p. 545. Paper also presented at the AIAA 19th Aerospace Sciences Meeting, St. Louis, January 1981.

> The conventional approach to gust modeling for vertically rising vehicles involves the application of a digital filter to a sample of Jimsphere wind profiles, defining the resulting residual amplitudes as gusts,

and developing statistical summaries or power spectra of the gusts. In this paper a new approach models the largest gust amplitude and gust length using the properties of the bivariate gamma distribution. The gust amplitude and gust length are strongly dependent on the filter function. Gust amplitude increases with altitude and is larger in winter than in summer.

Smith, O.E., Adelfang, S.I., and Tubbs, J.D (1982), "A Bivariate Gamma Probability Distribution with Application to Gust Modeling," NASA TM-82483, Marshall Space Flight Center, Alabama. Elements of this report were included in a paper presented at the American Statistical Association National Annual Meeting, August 16-19, 1982, at Cincinnati, Ohio. This paper is being reviewed for publication in Communications in Statistics.

A five-parameter bivariate gamma distribution (BGD) having two shape parameters, two scale parameters, and a correlation parameter has been derived. This general BGD is expressed as a double series and as a single series of the modified Bessel function. This general BGD reduces to the known special case for equal shape parameters. The conditional distributions are of special interest. An approximating distribution for the modulus of two orthogonal independent gamma distributed variates has been derived. Practical functions for computer evaluations for the general BGD and for many special cases are presented. Problems in parameter estimation and hypotheses testing are discussed. Applications of the general BGD are to be found in reliability theory, signal noise, and meteorology. In this paper, applications to wind gust modeling for the ascent flight of the Space Shuttle are illustrated.

Adelfang, S.I., and Smith, O.E. (1983), "Information Retrieval from Wide Band Meteorological Data, An Example," Proceedings of the Ninth Conference on Aerospace and Aeronautical Meteorology, June 6-9, 1983, Omaha, Nebraska. American Meteorological Society, Boston, Massachusetts.

New concepts for analysis of wind perturbations in vertical wind profiles are applied to a sample of detailed wind profiles. Digital filters are used to extract sets of band-pass filtered profiles with essentially non-overlapping wavelengths. Probabilities are calculated over different geometric regions within the domain of bivariate gamma distributed variables; probabilities over the same regions are also calculated from

the observed distributions and a comparison is presented to illustrate the accuracy of the statistical model. These and other statistical results are calculated from samples of Jimsphere wind profiles at Cape Canaveral, Florida, for various wavelength bands, altitudes, and seasons.

III. NEW OR REVISED STUDIES

A. Wind Perturbation Statistics

Design and performance analyses of launch vehicles requires realistic assessment of wind profile perturbations. To satisfy this requirement, statistics of wind perturbations have been calculated for two Space Shuttle launch sites: Cape Kennedy, Florida (KSC), and Vandenberg Air Force Base, California (VAFB).

Data

Three data bases are available for analysis: two from VAFB and one from KSC. At KSC, during the 1960's, there was an intensive Jimsphere wind profile measurement program in connection with the Saturn/Apollo program and other NASA research and development efforts (Vaughan, 1968). A data set for design and simulation studies consisting of 150 profiles per month was selected from the large Jimsphere data base at KSC (Brown, 1978). The profiles were subjected to quality control procedures and data editing was used when obvious data errors were found: this data base is referred to as the KSC design sample.

At VAFB, the number and quality of Jimsphere profiles was not up to the KSC standard so that it was necessary at first to create detailed profiles by supplementing available rawinsonde data with perturbations generated by a turbulence model developed by Fichtl and Perlmutter (1976). This data base, also consisting of 150 profiles per month, is known as the VAFB design sample. Recently, as more VAFB Jimsphere profiles became available, another data base was assembled consisting of 150 edited profiles for each of three seasonal periods: winter, summer, and transition. This data base is referred to as the VAFB Jimsphere seasonal data.

All the wind profiles utilized were band-pass filtered to obtain perturbations in the 420-2470m wavelength band. This wavelength band, in combination with the wide range of launch vehicle velocities, translates into a temporal frequency range that includes vehicle control system response modes and coincident structural loading. A general description of the digital filtering technique is given by Demandel and Krivo (1971). To obtain band-pass filtered profiles in the 420-2470m wavelength range, it was necessary to execute two low-pass filters. A schematic of the filtering process is

illustrated in Figure 1. The filter weights are listed in Table 1.

Statistics

The purpose of the statistical analysis is to determine if significant differences exist in the magnitude of wind perturbations at KSC and VAFB. Since two data bases exist for VAFB, it is necessary to establish a basis for choosing one for future engineering application. Since the VAFB seasonal data is based on Jimsphere data, it is preferred at the outset with one reservation: At the present time there is insufficient Jimsphere data to assemble a monthly design sample. If the seasonal data is shown to represent the expected variability, monthly data will not be required for engineering applications.

The u and v component absolute perturbations in the 420 to 2470m wavelength band at 12 km for the various data bases are illustrated in Figures 2 through 6. There is a clear indication that the largest perturbations are observed in Jimsphere wind profiles during the winter and transition periods (KSC design, February and April; VAFB, winter and transition).

As illustrated in Figures 7 and 8, wind perturbation percentiles based on Jimsphere profiles at VAFB are larger in winter and smaller in summer than percentiles based on simulated detailed wind profiles (VAFB design). Thus the variation between winter and summer percentiles is much larger for distributions based on Jimsphere wind profiles. The choice of VAFB data (either simulated or Jimsphere) leads to different conclusions when comparison with KSC data is attempted. VAFB winter percentiles are much larger than KSC February design percentiles; the reverse is true if VAFB January or VAFB February design data are used. VAFB summer v component percentiles agree quite well with KSC July design percentiles; VAFB summer u component percentiles are consistently larger than KSC July design percentiles. If VAFB July design data are used, the percentiles are consistently larger for both components in comparison with KSC July design percentiles.

As illustrated in Figures 9 and 10, the choice of VAFB data for the transition period between winter and summer also affects the comparison with KSC. Distributions based on several transition months were calculated from VAFB design data. The u component distributions are in good agreement with KSC design distributions for April. In contrast, the u component distribution based on VAFB Jimsphere data during

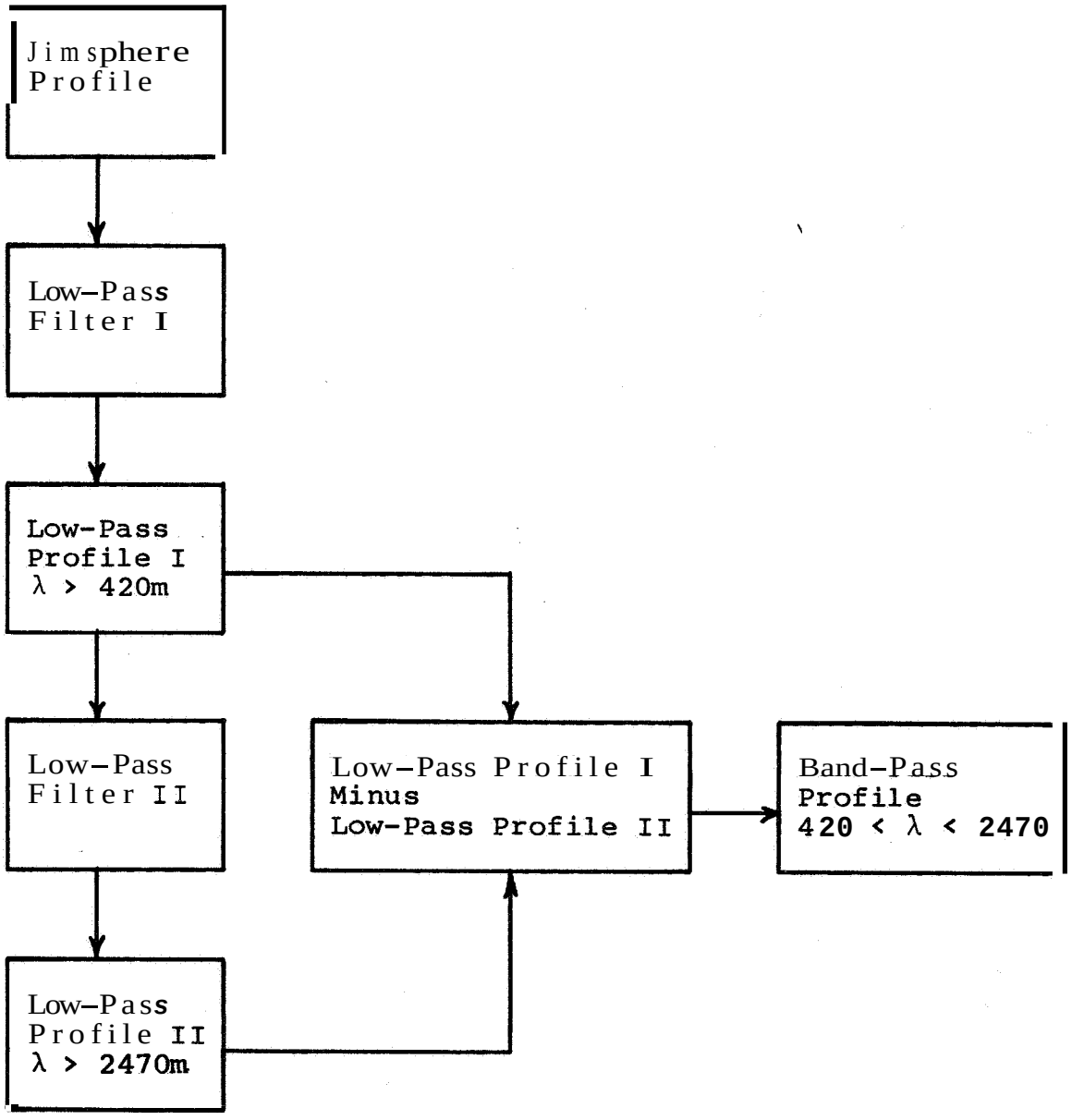

Figure 1. Schematic of Filtering Process

Table 1. Filter Weights, h_i, for Low-Pass Filters I and II

Filter I			Filter II		
Altitude	h_i	Filter Weight	Altitude	h_i	Filter Weight
Z_0(1)	h_0	.116360050	Z_0(2)	h_0	0203331671
$Z_0 \pm$ 25m	$h_{+1,-1}$	.112681533	$Z_0 \pm$ 250m	$h_{+1,-1}$	.182602840
$Z_0 \pm$ 50m	$h_{+2,-2}$	.102183235	$Z_0 \pm$ 500m	$h_{+2,-2}$	.130080937
$Z_0 \pm$.	.	.086369542	$Z_0 \pm$.	.	.068650095
$Z_0 \pm$		.067415386	$Z_0 \pm$.	.	0020649325
$Z_0 \pm$	.	.047750214	$Z_0 \pm$ 1250m	$h_{+5,-5}$	-.003649032
$Z_0 \pm$.	.	.029618173			
$Z_0 \pm$	.	.014711243			
$Z_0 \pm$	.	.003949048			
$Z_0 \pm$		-.002560992			
$Z_0 \pm$.	.	-.005394941			
$Z_0 \pm$	.	-.005565475			
$Z_0 \pm$		-.004229394			
$Z_0 \pm$		-.002423366			
$Z_0 \pm$.		-.000884042			
$Z_0 \pm$		.000021198			
$Z_0 \pm$.		.000259004			
$Z_0 \pm$		.000022211			
$Z_0 \pm$	.	-.000405784			
$Z_0 \pm$.	.	-.000771288			
$Z_0 \pm$ 500m	$h_{+20,-20}$	-.000925530			

(1) Z_0 = 500, 525 ... 19,500m

(2) Z_0 = 1750, 1775 ... 18,250m

transition indicates larger perturbations at the extreme percentiles. The v component distributions based on VAFB design data indicate smaller perturbations in comparison with KSC design data: there is better agreement between VAFB transition and KSC design.

In conclusion, the probability distribution of wind perturbations at VAFB is strongly dependent on the choice of data base; the choice also affects the results of comparison with KSC. The largest perturbations are found in the VAFB Jimsphere winter data. These perturbations are larger than those found in the KSC design Jimsphere data base. They are also significantly larger than perturbations in the VAFB design data base. It is recommended that for future engineering applications, the VAFB design data base be revised by substitution of VAFB seasonal data to include these large perturbations.

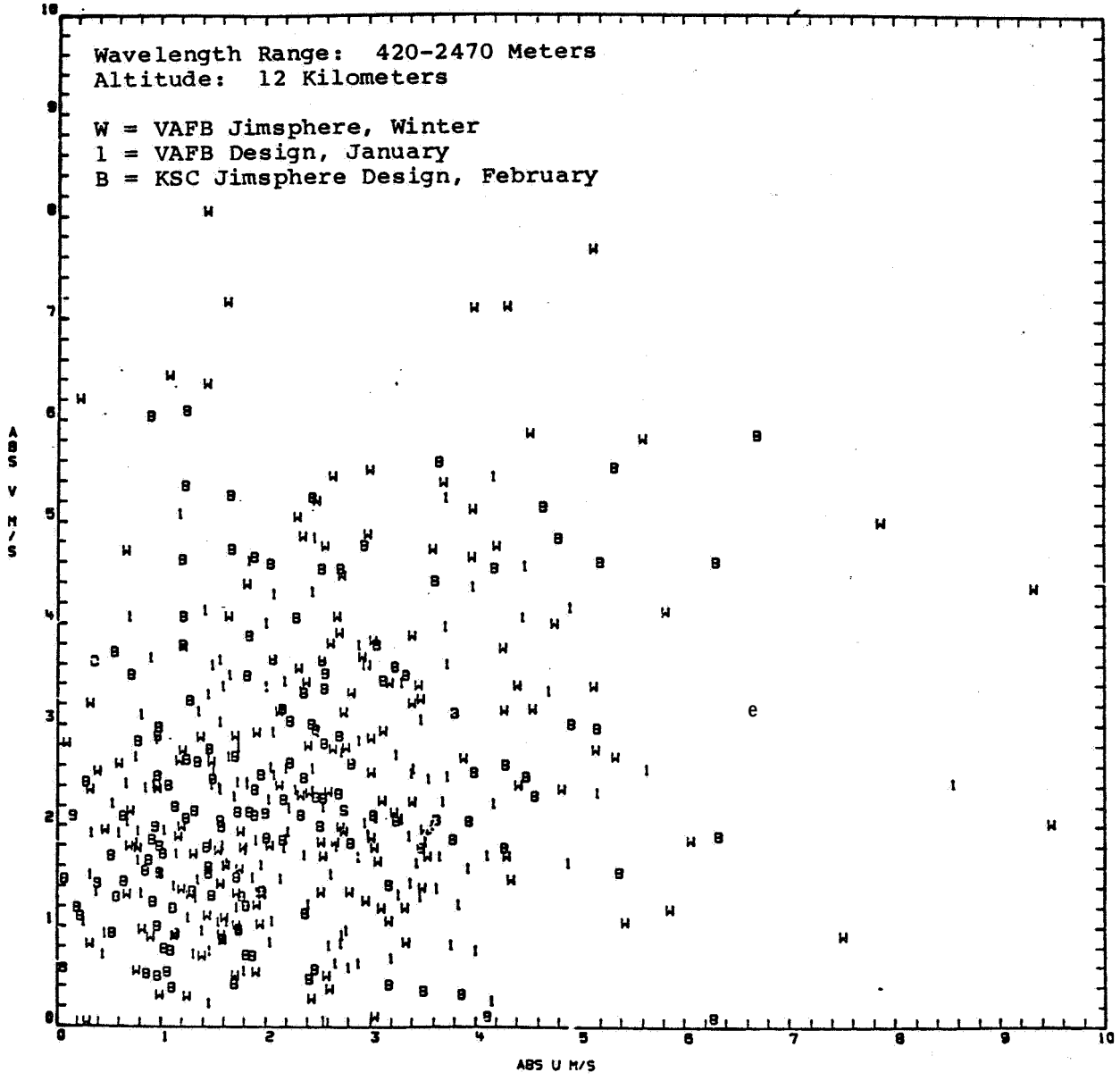

Figure 2. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Winter, VAFB Design January, KSC Design February)

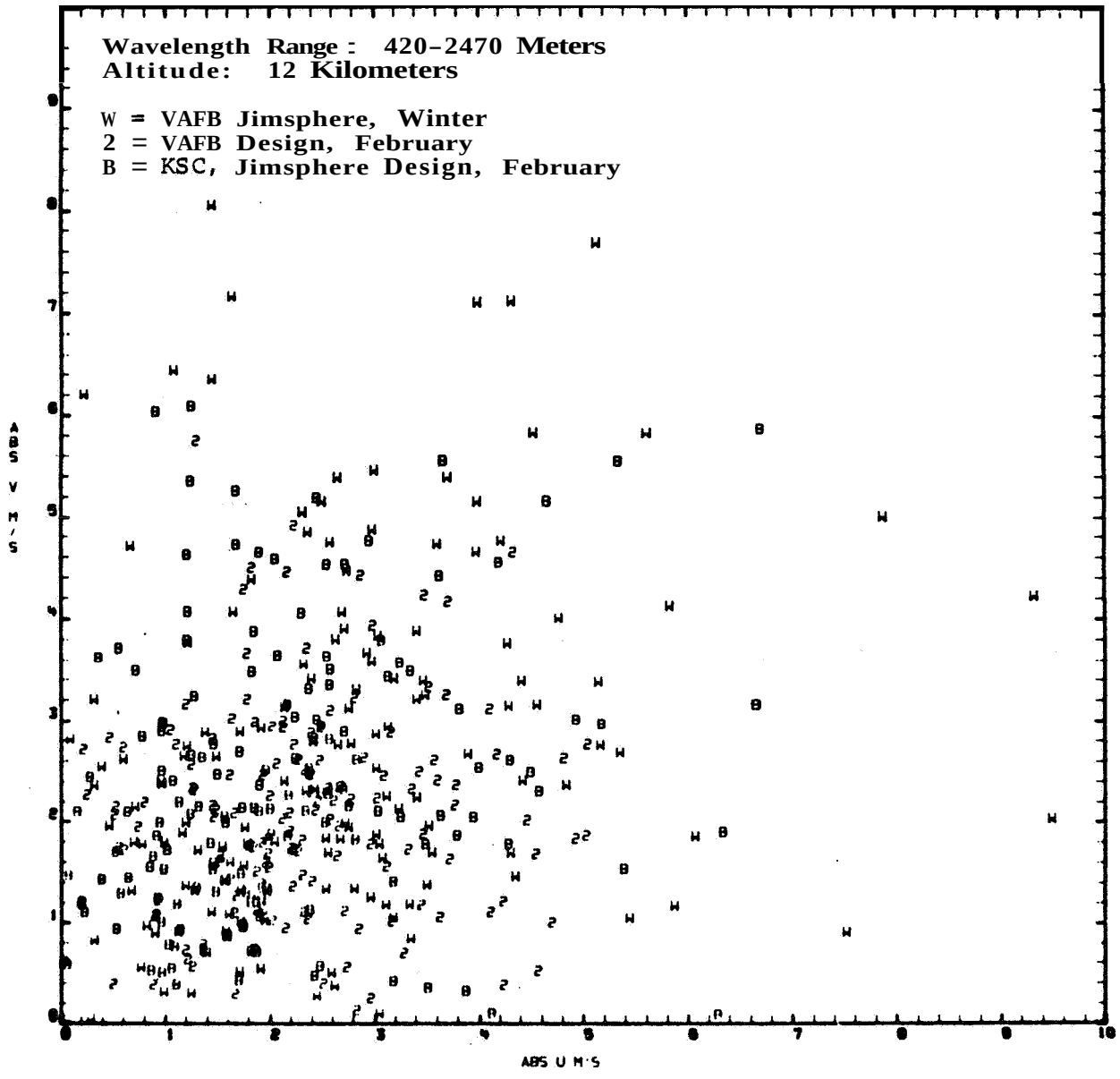

Figure 3. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Winter, VAFB Design February, KSC Design February)

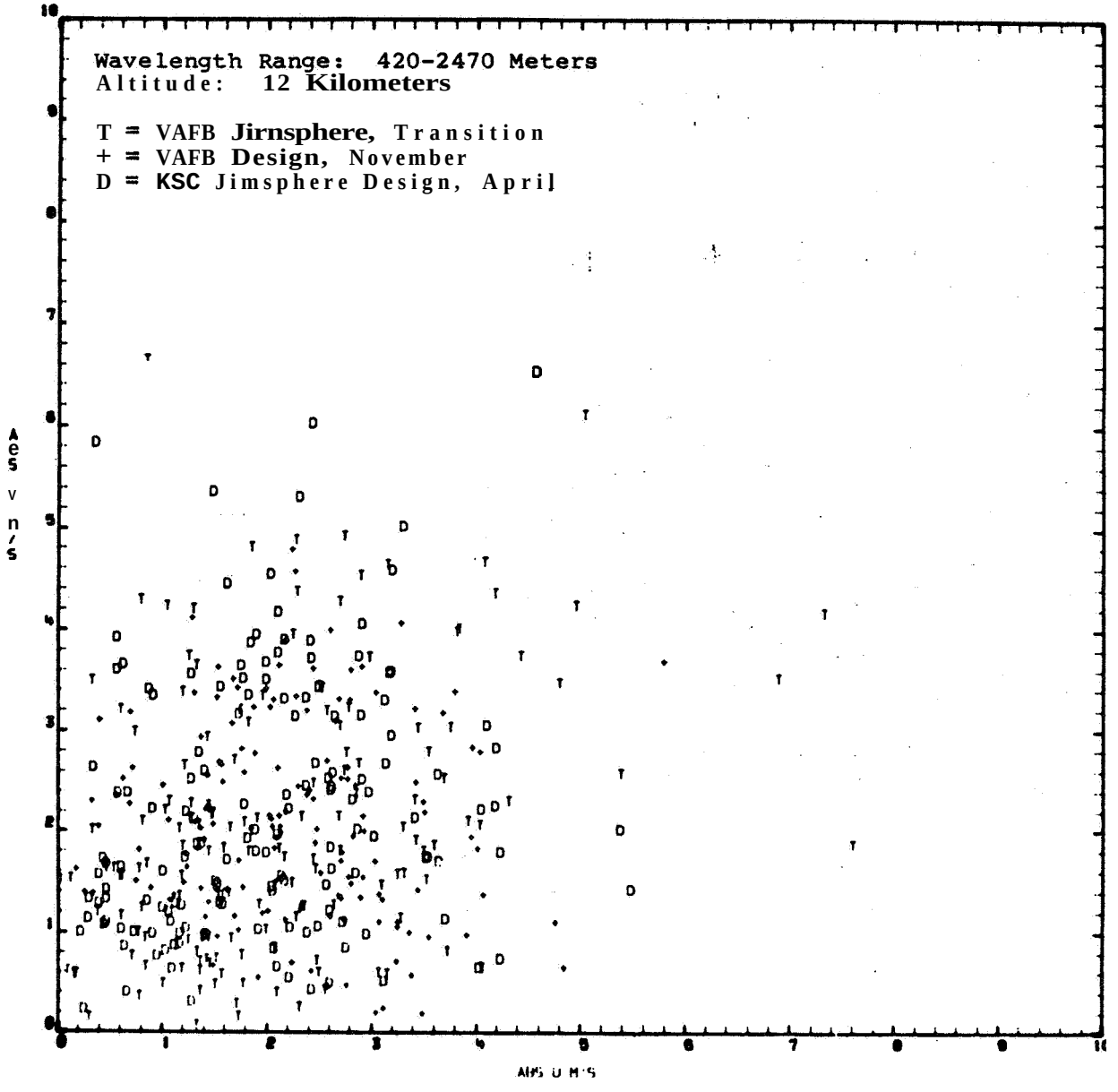

Figure 4. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Transition, VAFB Design November, KSC Design April)

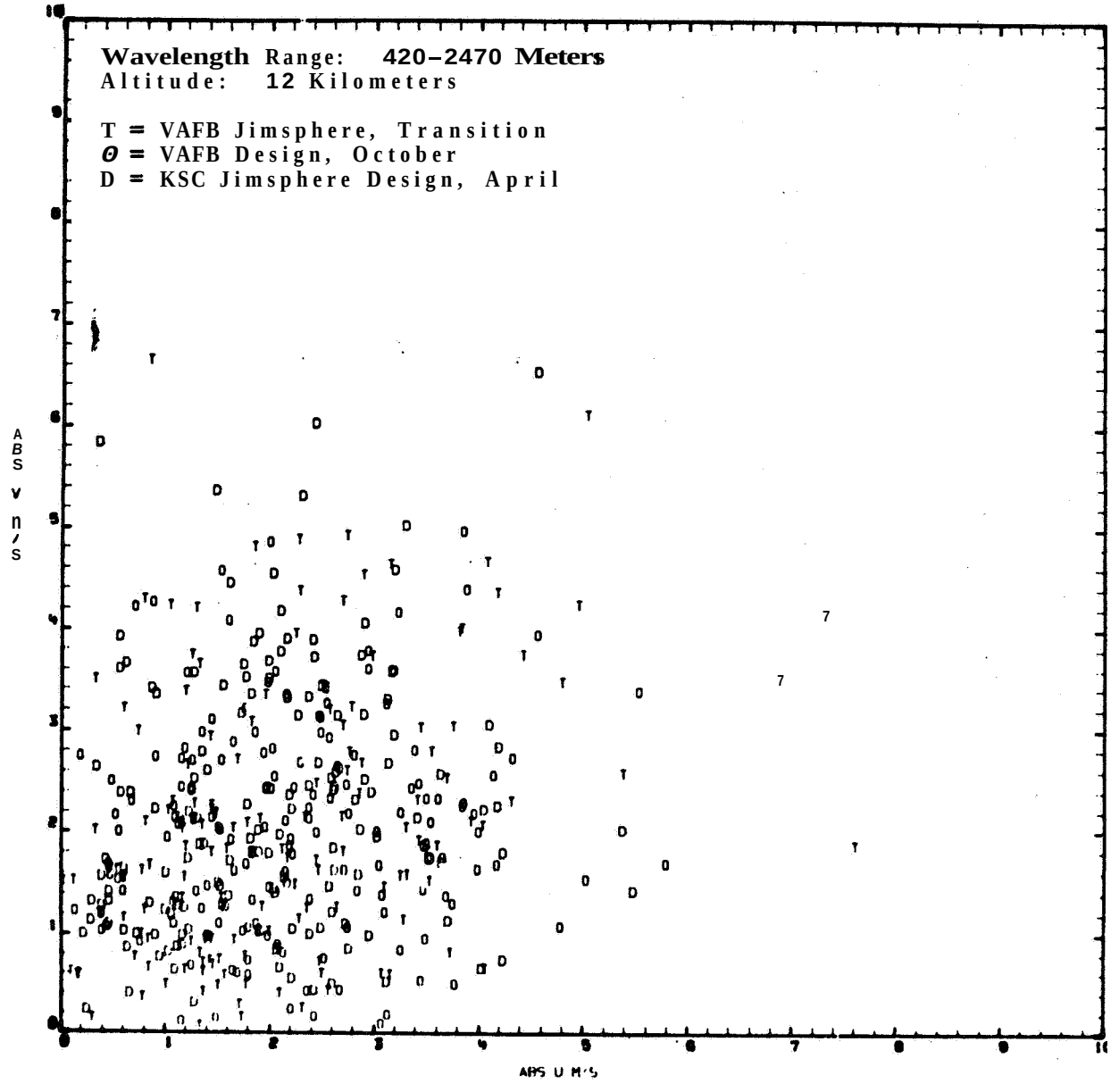

Figure 5. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Transition, VAFB Design October, KSC Design April)

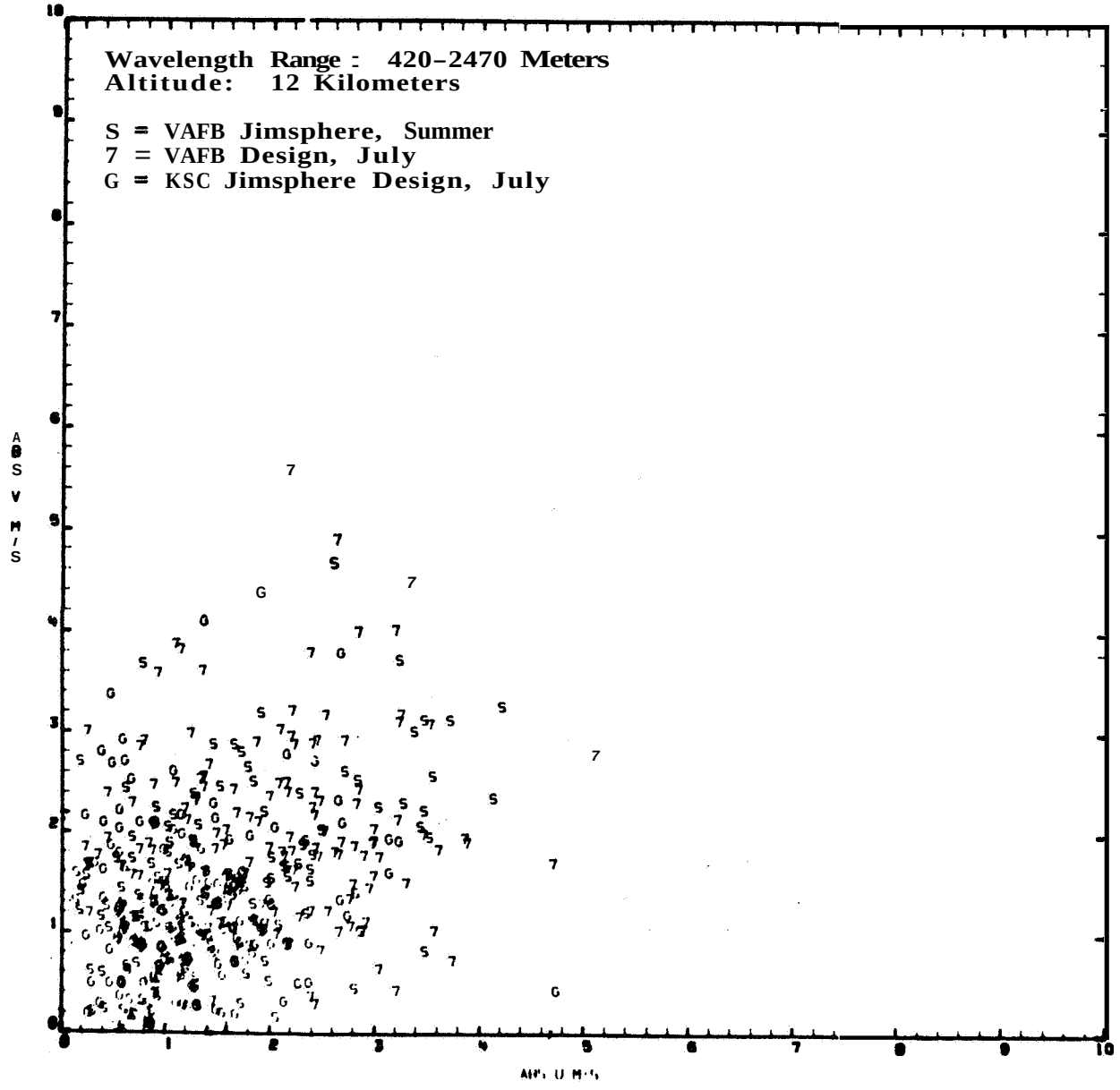

Figure 6. Absolute u and Absolute v Component Perturbation at 12 km (VAFB Summer, VAFB Design July, KSC Design July)

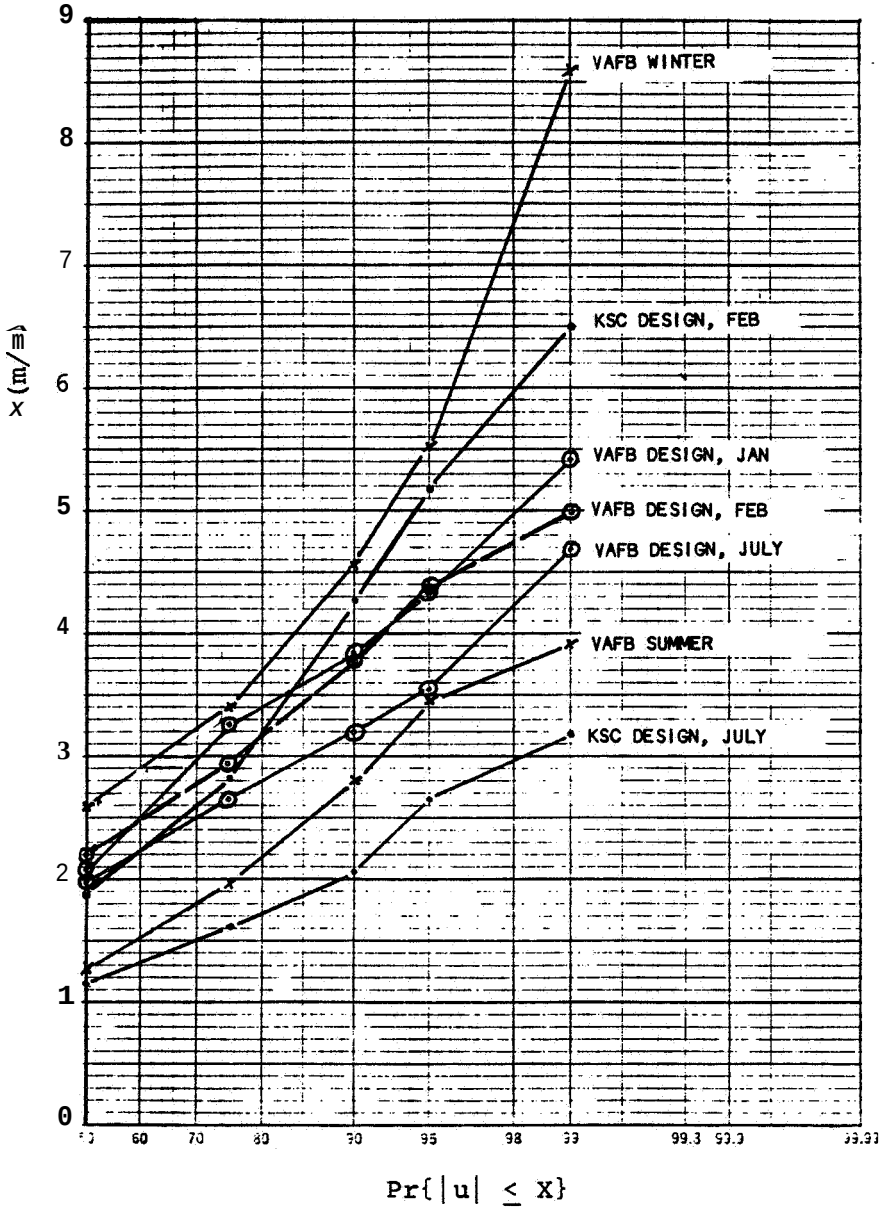

Figure 7. Probability Distribution of Absolute-u Component Perturbation in the 420-2470 Wavelength Band at 12 km During Summer and Winter

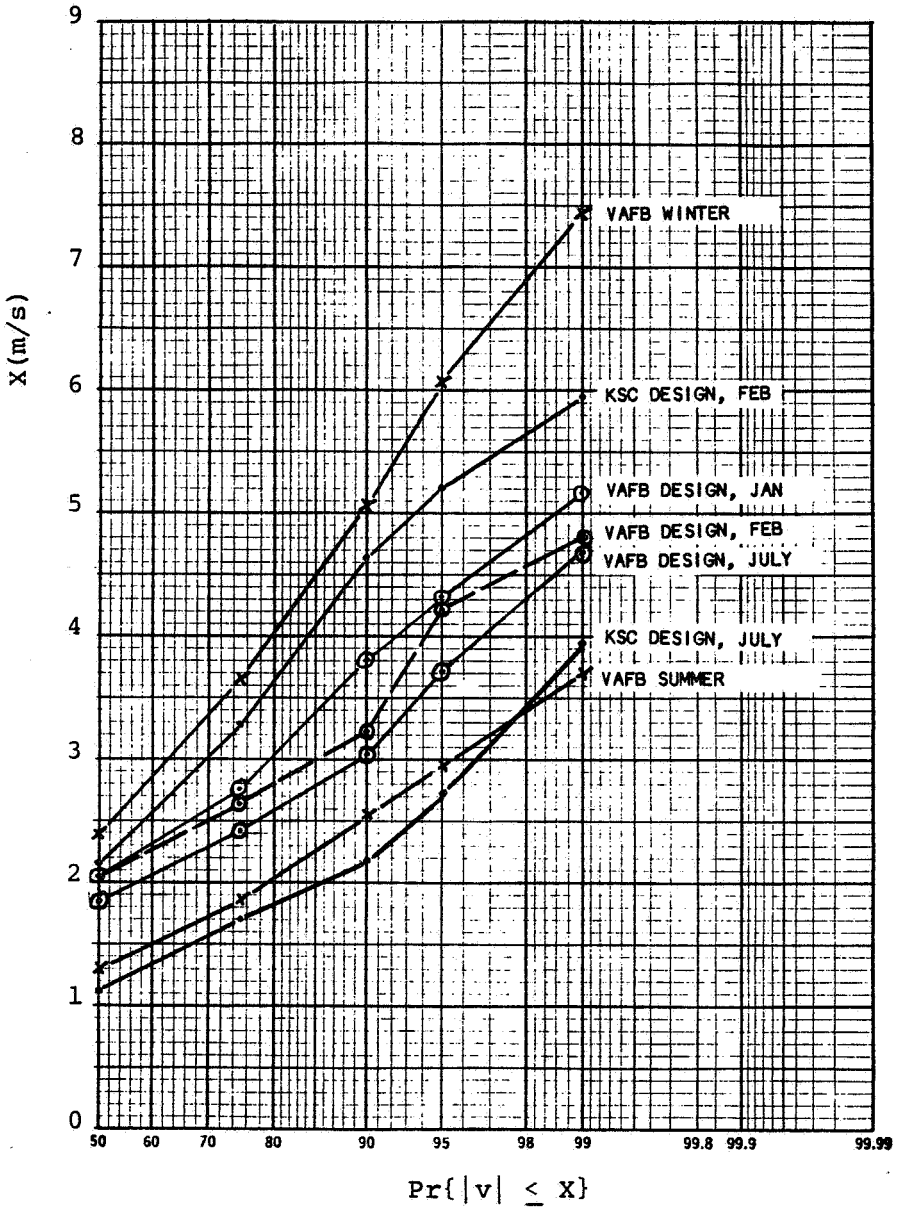

Figure 8. Probability Distribution of Absolute-v Component Perturbation in the 420-2470 Wavelength Band at 12 km During Summer and Winter

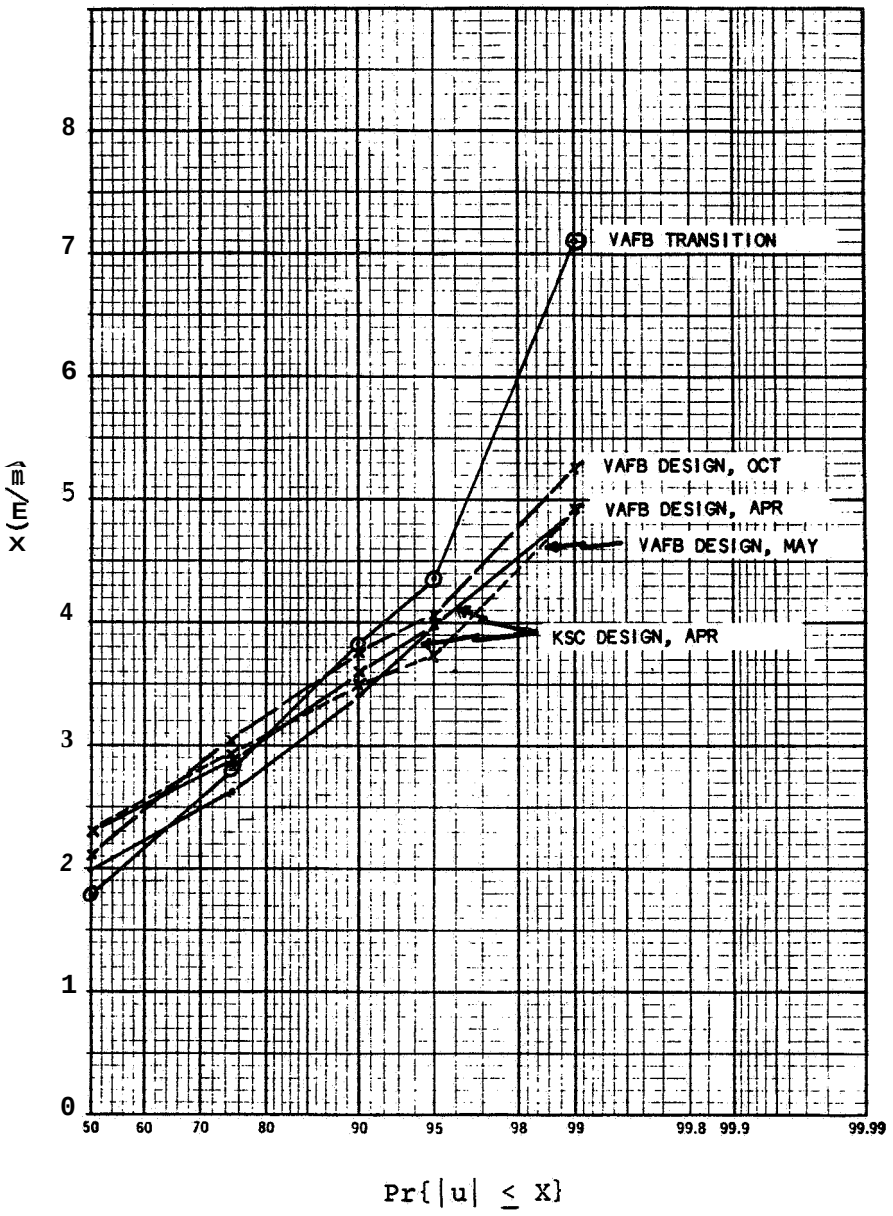

Figure 9. Probability Distribution of Absolute-u Component Perturbation in the 420-2470 Wavelength Band at 12 km During Transition Season

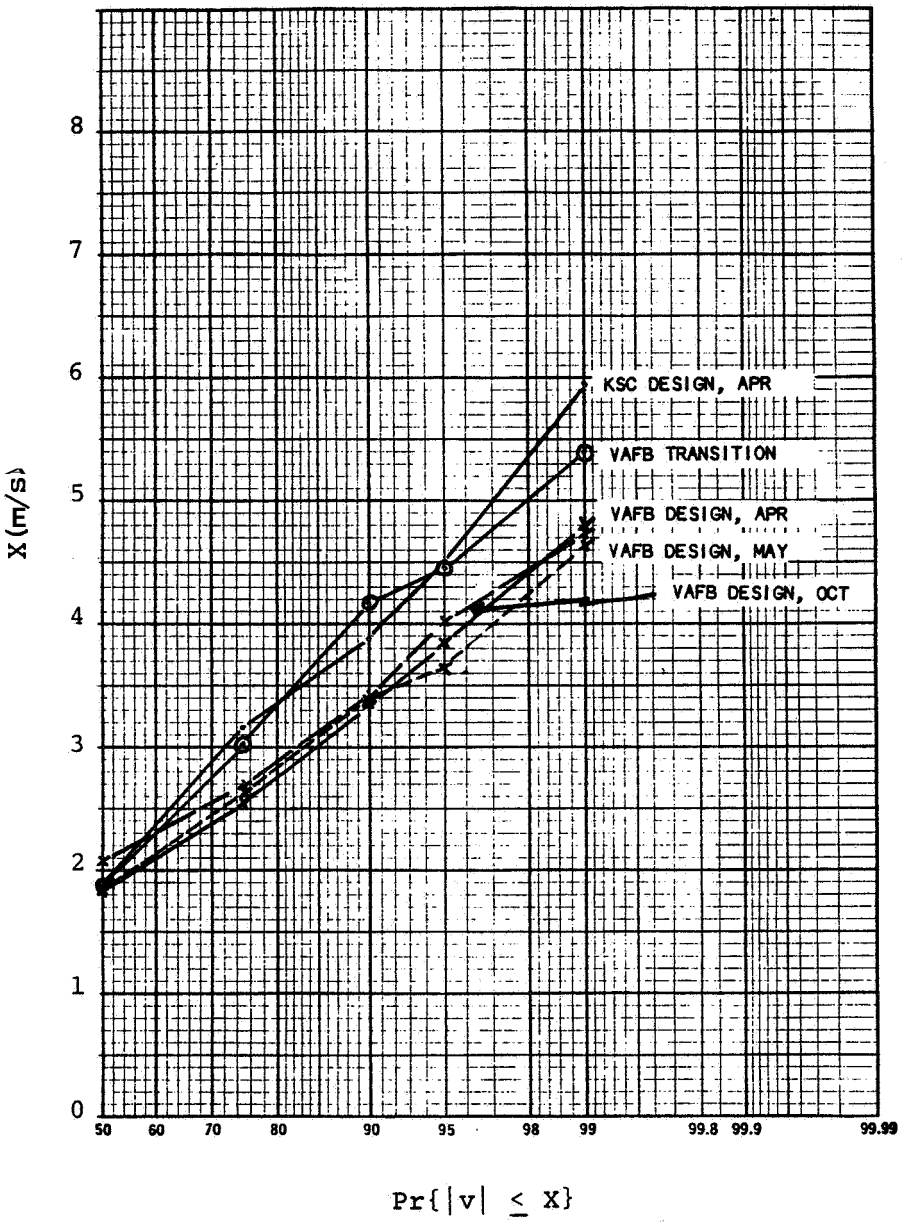

Figure 10. Probability Distribution of Absolute-v Component Perturbation in the 420-2470 Wavelength Band at 12 km During Transition Season

B. Discrete Gust Criteria

The new data described in Section III.A and in previous reports abstracted in Section II can be the basis for revision of existing discrete gust criteria guidelines for use in aerospace vehicle development (NASA TM 78118). To enhance utilization, the guidelines were established by treating gusts in two idealized forms: a quasi-square wave (QSW) non-repetitive form and an approximate sinusoidal form. The QSW form is associated with a length range of 60 to 300m; this is equivalent to a wavelength range of 120 to 600m for a periodic perturbation. It is appropriate to use the later wavelength range for comparison with other data. The QSW form has an amplitude that is independent of wavelength and varies from 6 to 9 m/s depending on altitude. At altitudes above 1 km, the amplitude is a constant, 9 m/s. Peak-to-peak amplitudes associated with the sinusoidal form are considered at best to be preliminary, but are included in this discussion for comparison with the QSW form and results of this study. The principal deficiency of the two forms is the lack of supporting statistical data that justify selection of the gust magnitudes. The results of this study will contribute to alleviation of this deficiency. In addition, there is an indication that future discrete gust criteria can include launch site and seasonal variability, if required.

Discrete gust amplitudes obtained from existing criteria and this study are summarized in Table 2. The 99 percentile values listed under IV were calculated from perturbation distributions at 12 km. Other distributions at 4, 6, 8, 10, and 14 km indicated smaller perturbation (Smith et al., 1982). The large perturbations in the vicinity of 12 km are associated with large wind shear and flow disturbances in the vicinity of the jet stream. Estimates of the 99 percentile discrete gust amplitude at KSC and VAFB (IV) vary by a factor of two for summer and winter and a factor of four for the two wavelength bands (90-420, 420-2470). The winter values for IV are in fair agreement with the sinusoidal gust model (II) and the conditional gamma distribution estimates (111). The 99 percentile of the observed distribution of the largest perturbation amplitude in the 2-15 km altitude range (V) is in most cases somewhat larger than the estimate of the 99 percentile amplitude at 12 km (IV). It should be pointed out that A_{99} is estimated in IV according to the assumptions that A_{99} occurs concurrently with $|u'|_{99}$ and $|v'|_{99}$ and that $|v'|_{99}$ is equivalent to $|u'|_{99}$; these assumptions lead to overestimation of Agg. The 9 m/s amplitude of the QSW gust (I) seems to be too large for wavelengths between 120 and 600 meters. If we assume that the QSW gust represents an extreme value beyond the 99 percentile, it is not supported by Jimsphere data at either KSC or VAFB.

Table 2 Discrete Gust Models A for Launch Vehicle Design Criteria

	A(m/s)											
			III									
			KSC	VAFB (Jimsphere)	KSC				VAFB (Jimsphere)			
					FEB		JULY		Winter		Summer	
λ(m)	I	II	FEB	WINTER	IV	V	IV	V	IV	V	IV	V
120	9.0	2.7	2.0	3.2								
420	9.0	4.4	3.0	4 8								
90-420					2 2	3.0	1.2	2.3	2.5	4.2	1.8	3 4
420-2470					9.2	8.2	4.5	6.2	12.1	9 6	5.5	7.4
600	3.0	8.1	9.7	11.3								
2470		13.1	13.6	15 6								

I. Quasi-square wave (QSW) embedded jet model, no percentile given, tabular values for altitude ≥ 1 km, NASA TM-78118

II. Sinusoidal gust model. ≥ 99 percentile. 2-15 km, NASA TM-78118

III. Conditional gamma (Smith et al., 1982), parameters calculated from band pass (90-420 m, 420-2470 m) filtered Jimsphere profiles, 99 percentile of "A" estimated at 12 km from $|u'|_{99}$ | L_u according to $A_{99} = 1.41\ |u'|_{99}\ |\ L_u$. Note that $L_u \simeq \lambda/2$.

IV. Observed distribution of u-component perturbation at 12 km; $A_{99} = 1.41\ |u'|_{99}$

V. Observed distribution of extreme vertorbation amplitude, 99 percentile, 2-15 km

C. Two Dimensional Wind Perturbation Statistics

The development of a computational model based on Gunst and Webster's (1973) expression for the bivariate gamma (BG) distribution (BGD) is of interest in applications to wind gust modeling for the ascent flight of the Space Shuttle. Smith et al. (1982) have derived expressions for probabilities over different geometrically shaped regions. These expressions have been used for calculation of expected probabilities and cell counts within squares and equal-area sectors of the domain of the bivariate gamma distributed variables. The parameters for the BGD are calculated from absolute gust component amplitudes, $|u'|$ and $|v'|$, and associated gust lengths, $L_{u'}$ and $L_{v'}$ at a specified reference altitude. The goodness of fit of the model is given preliminary evaluation by comparison of the observed number of occurrences within the cells and the expected number if the variables are BG. The chi-square statistic is calculated for observed and expected cell counts $\geq$ 5.

An example of the statistics calculated for VAFB-summer at 12 km for variables $|u'|$ and L_u is given in Table 3. An extensive set of tables for two wavelength bands (90-420 and 420-2470 m), in the same format, is given in Appendix A for February, April, and July at KSC and winter, transition, and summer at VAFB.

Five statistical summaries for each pair of non-dimensional variables are included in each table. The values given across the top and along the left margin are for the non-dimensional variables. These scales can be dimensionalized by dividing them by the appropriate-value of B obtained from Table A1 in Appendix A. For example, as indicated in the uppermost matrix in Table 3, 3 and 4 along the top margin divided by B_{Lu} (5.0005×10^{-3} 1/m) yields values of 600 m and 800 m, respectively, for L_u and, similarly, 1 and 2 along the side margin divided by $B|u'|$ (1.7866 s/m) yields .56 m/s and 1.12 m/s; thus the entry 9 in the table at the intersection of left margin value 2 and top margin 4 indicates that there are 9 occurrences of $|u'|$ between .56 and 1.12 m/s for L_u between 600 and 800 meters. The expected count, obtained from the bivariate gamma distribution, given in the second matrix yields 9.54 for the same 1x1 cell. The four numbers listed at the top of the expected cell count table are the BGD parameters ρ, γ_1, γ_2, and η. It is indicated that the calculated value of chi-square is based on only 8 of the possible 100 cells: this unacceptable application of chi-square can be overcome by increasing the sample

Table 3. Observed and Expected (Gamma) Cell Counts, VAFB Summer, Jhsphere, 12 km, Wavelength Range, 420–2470 m, Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * Lu$

$B\|u'\| * \|u'\|$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	8	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	11	11	9	10	6	1	1	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	9	9	7	3	0	1	2	0	0	0	0	0	0	0	0	0	0	0
4	0	1	2	9	5	3	2	2	0	0	0	1	0	0	0	0	0	0	0	0
5	0	0	1	2	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
7	0	0	1	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3578 γ_1 = 2.6448 γ_2 = 3.8826 η = .4335

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.93	4 39	5.34	3 95	2 29	1 15	53	23	.10	.04
2.00	1 37	7 66	11 08	9 54	6 30	3 54	1 79	84	37	.16
3.00	71	4 85	8.41	8 47	6 41	4 05	2.27	1 16	56	.25
4.00	27	2 21	4 54	5 28	4 53	3 20	1.97	1 10	57	28
5.00	.09	86	2.05	2.72	2 62	2 05	1 38	84	47	.24
6.00	.03	30	82	1 24	1 33	1 14	84	55	33	.18
7.00	.01	10	31	52	61	58	46	33	21	.12
8.00	00	03	11	20	26	27	23	18	12	08
9.00	00	01	04	07	11	12	11	09	07	04
10.00	.00	.00	01	03	04	05	05	04	03	02

CHI-SOUARE- 6.41015 CELLS USED' 8lI.E .CELL COUNTS GREATER THAN OR EOUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9 00	10.00
1.00	.00622	.03552	.07113	.09746	.11271	,12040	12393	12547	.12611	12637
2.00	.01532	.09567	.20512	.29503	.35228	.38358	39907	40621	.40934	41067
3.00	.02009	.13276	.29827	.44467	.54462	.60292	.63352	64841	.65526	65827
4.00	.02191	.14934	.34510	.52673	.65686	,73646	.78019	.80242	.81307	81795
5.00	.02250	.15565	.36506	.56484	.71243	.80569	.85866	88649	.90027	90677
6.00	.02268	.15782	.37273	.58077	.73724	.83813	.89672	,92824	.94423	95196
7.00	.02273	.15852	.37547	.58696	,74752	.85226	91394	,94764	.96502	97359
8.00	.02274	.15873	.37640	.58924	.75155	.85809	.92132	95620	.97440	98348
9.00	.02275	.15879	.37670	.59003	.75305	.86039	,92436	95983	.97847	98784
10.00	.02275	.15881	.37679	.59030	.75360	.86126	.92556	96132	.98018	.98970

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 **Degrees** **Sample Size:** 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	8	13	31	38	31	25	5
EXPECTED	.18233	2.27353	7.98986	16.80820	26.36406	33.12780	33.13936	23.46334	6.65151

CHI-SOUARE- 2.74946 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00122	.01637	.06964	.18169	.35745	.57831	.79923	.95566	1.00000
SECTOR PROBABILITY	.00122	.01516	.05327	.11205	.17576	.22085	.22093	.15642	.04434

size, This could easily be achieved at KSC by grouping monthly data to obtain a seasonal sample that would be at least three times the size for a single month. VAFB data have already been grouped to obtain seasonal samples of 150; therefore, use of chi-square for VAFB seasonal data awaits the results of the measurement program that has been developed to support future Shuttle launches.

The third matrix contains the expected cumulative probability distribution calculated by accumulation of expected cell counts in the second table divided by the total sample count of 150; note that the expected probability associated with the 10x10 square is 98.970 percent.

The fourth matrix lists the observed and expected (BG) counts from a sample of 150 that occur in 10 degree equal-area sectors in the $|u'|$, L_u domain illustrated schematically in Figure 11.

The last matrix lists the sector probability and cumulative probability for the expected (BG) distribution.

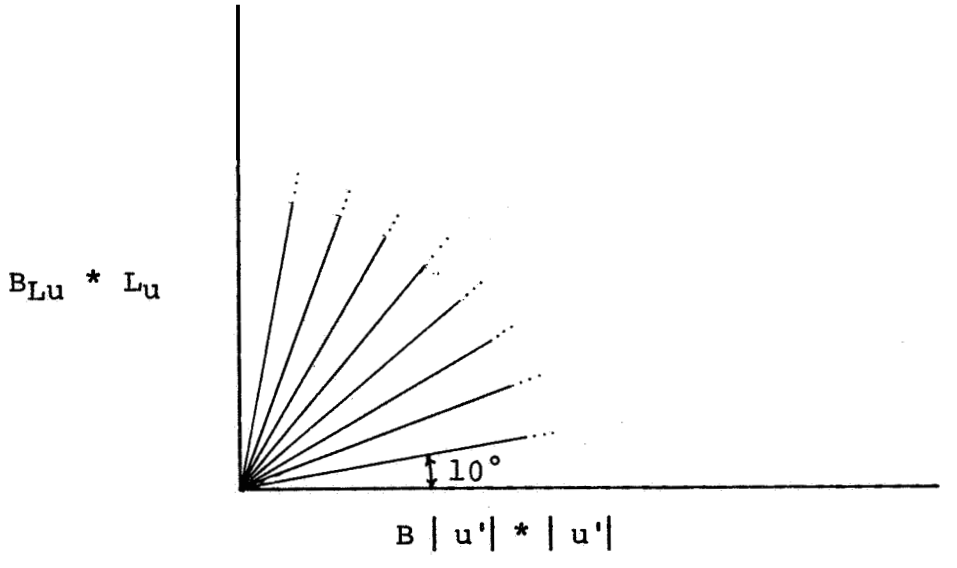

Figure 11. Schematic of Equal Area Sectors

D. Wind Component Correlation Statistics and Coordinate System Rotation

The existence of zero correlation, ρ, between wind components would greatly simplify the theoretical treatment of winds aloft statistics. When winds are defined in the standard meteorological coordinate system, the correlations are generally quite small: for example, during February at Cape Canaveral, ρ is less than .43 at all altitudes (z) below 70 km, is less than .29 for z < 19 km, and is less than .17 for z between 1 and 6 km.* It is generally known that, when the wind components are expressed in a coordinate system that is rotated by an angle θ with respect to the meteorological coordinate system, the correlation between the rotated wind components is periodic: i.e.,

$$\rho(\theta) = \rho(\theta + \pi) \tag{1}$$

Absolute extreme values are equivalent and the maximum and minimum values are separated by a rotation angle increment of $\pi/2$ (90 deg.). If the wind components are expressed in the meteorological coordinate system, then the rotation angle, θ_0, required to produce zero correlation is

$$\theta_0 = \frac{1}{2} \text{ ARC TAN } \left(\frac{2\rho\sigma_{\bar{x}}\sigma_{\bar{y}}}{\sigma_{\bar{y}}^2 - \sigma_{\bar{x}}^2} \right) \tag{2}$$

$$\theta_0 \leq \pi/4$$

The minimum rotation angle θ_M required to obtain the maximum correlation is dependent on the sign of ρ and θ_0:

If $\rho < 0$	and	$\theta_0 < 0$	$\theta_M = \theta_0 - \pi/4$
	and	$\theta_0 > 0$	$\theta_M = \theta_0 + \pi/4$
If $\rho > 0$	and	$\theta_0 < 0$	$\theta_M = \theta_0 + \pi/4$
	and	$\theta_0 > 0$	$\theta_M = \theta_0 - \pi/4$

*Range reference atmosphere, 0–70 km, Cape Canaveral, FL, Document 361-83, RCC, White Sands Missile Range.

The rotation angle θ_{MA} required to obtain the maximum absolute correlation is:

$$\begin{aligned} &\text{If } \theta_0 < 0 \qquad \theta_{MA} = \theta_0 + \pi/4 \\ &\qquad \theta_0 > 0 \qquad \theta_{MA} = \theta_0 - \pi/4 \end{aligned} \tag{3}$$

The rotated correlation coefficient is given by

$$\rho_\theta = \frac{\rho\sigma_{\bar{x}}\sigma_{\bar{y}}\,[\mathrm{SIN}^2\theta - \mathrm{COS}^2\theta] + \mathrm{COS}\theta\,\mathrm{SIN}\theta(\sigma_{\bar{y}}^2 - \sigma_{\bar{x}}^2)}{\sigma_{\bar{x}\theta}\;\sigma_{\bar{y}\theta}} \tag{4}$$

where $\sigma_{\bar{x}\theta}$ and $\sigma_{\bar{y}\theta}$ are the rotated variances

$$\sigma_{\bar{x}\theta}^2 = \sigma_{\bar{x}}^2\mathrm{SIN}^2\theta + \sigma_{\bar{y}}^2\mathrm{COS}^2\theta + 2\rho\sigma_{\bar{x}}\sigma_{\bar{y}}\mathrm{COS}\theta\,\mathrm{SIN}\theta \tag{5}$$

$$\sigma_{\bar{y}\theta}^2 = \sigma_{\bar{y}}^2\mathrm{SIN}^2\theta + \sigma_{\bar{x}}^2\mathrm{COS}^2\theta - 2\rho\sigma_{\bar{x}}\sigma_{\bar{y}}\mathrm{COS}\theta\,\mathrm{SIN}\theta \tag{6}$$

Substitution of θ_M or θ_{MA} into Equation 4 yields the maximum correlation, ρ_M. Figure 12 illustrates unrotated and maximum absolute correlation between 0-70 km at Cape Canaveral, Florida, for an annual data sample. The unrotated values are small (<.4) and unsteady. The maximum values increase rapidly in the first 20 km; the relatively constant and large value of ρ_M between 20 and 60 km is also observed at other locations (Figure 13). Plots of θ_{MA} as a function of altitude are illustrated in Figure 14. At altitudes above 20 km, θ_{MA} is nearly constant, 40 degrees; from Equation 3, θ_0 is also nearly constant, 5 degrees. At altitudes above 20 km, the choice of orientation of the coordinate system in meteorology which describes the wind vector in terms of zonal and meridional components is near the orientation required for zero correlation.

The results summarized herein support the conclusion that significant correlation between wind components exists when winds are analyzed in non-meteorological coordinate systems. This concept has application in the engineering analysis of the impact of wind perturbations on aerospace vehicles.

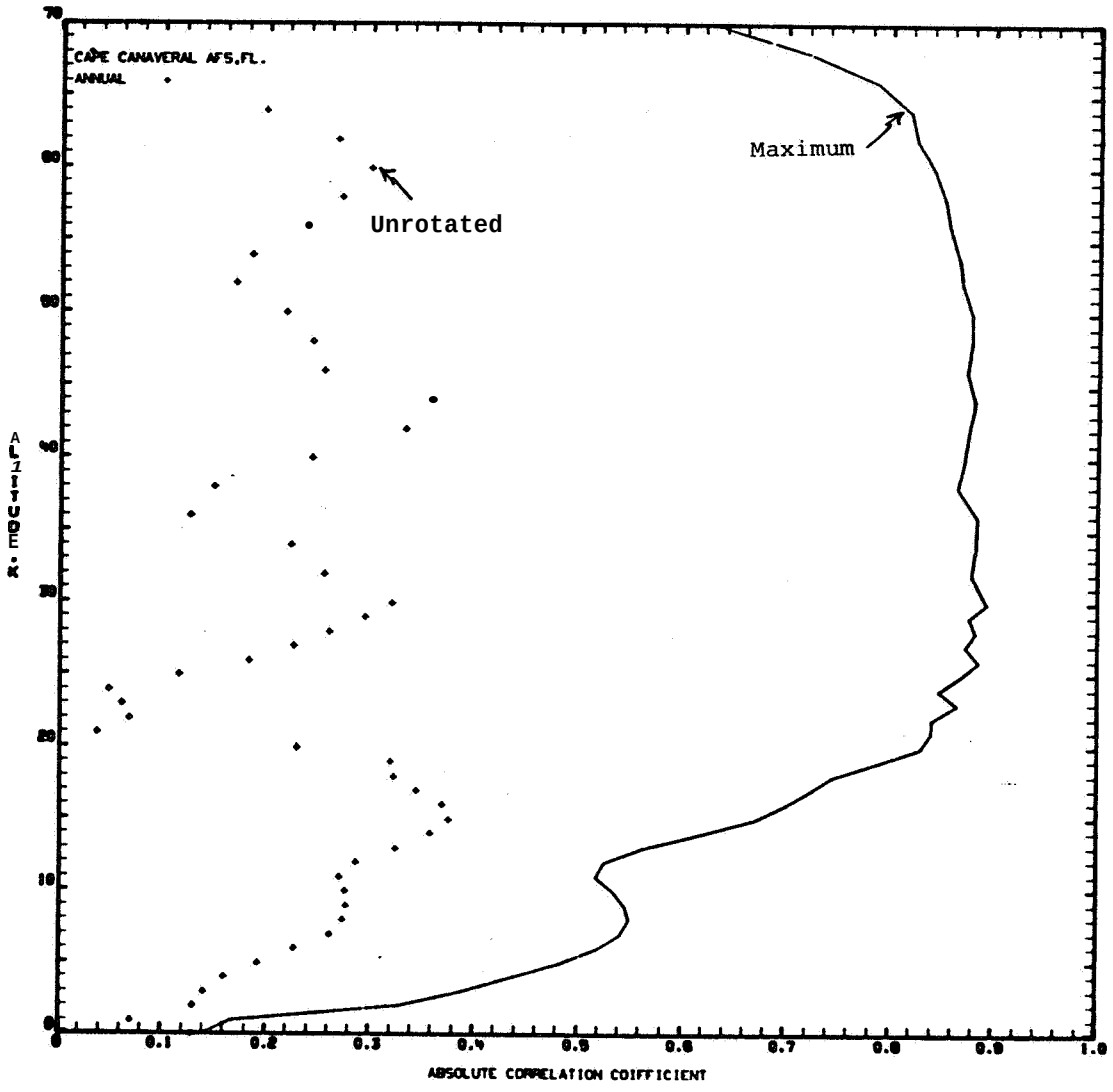

Figure 12. Unrotated and Maximum Correlation, Cape Canaveral, Florida, Annual

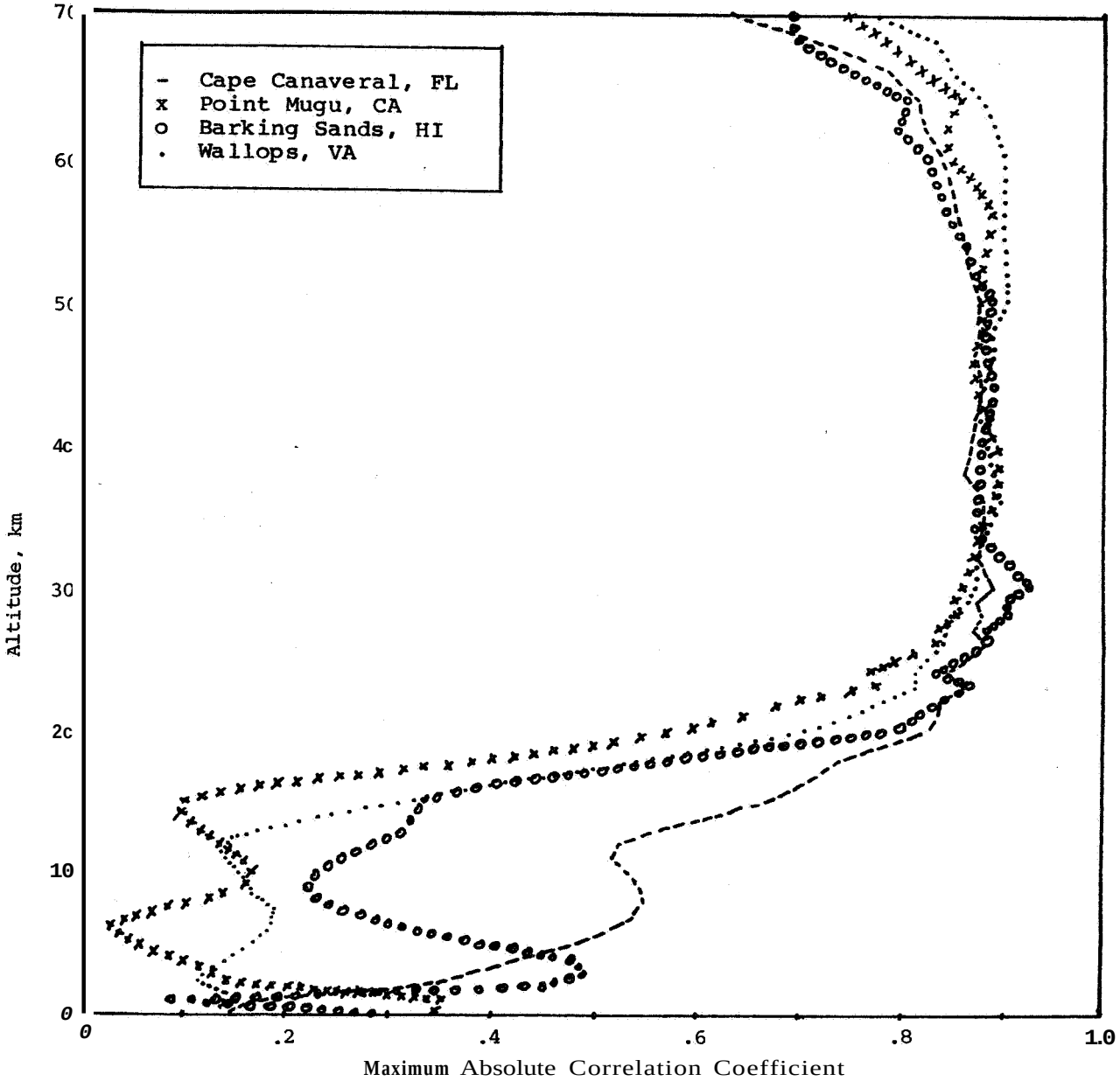

Figure 13. Maximum Wind Component Absolute Correlation Achieved by Rotation with Respect to the Meteorological Coordinate System

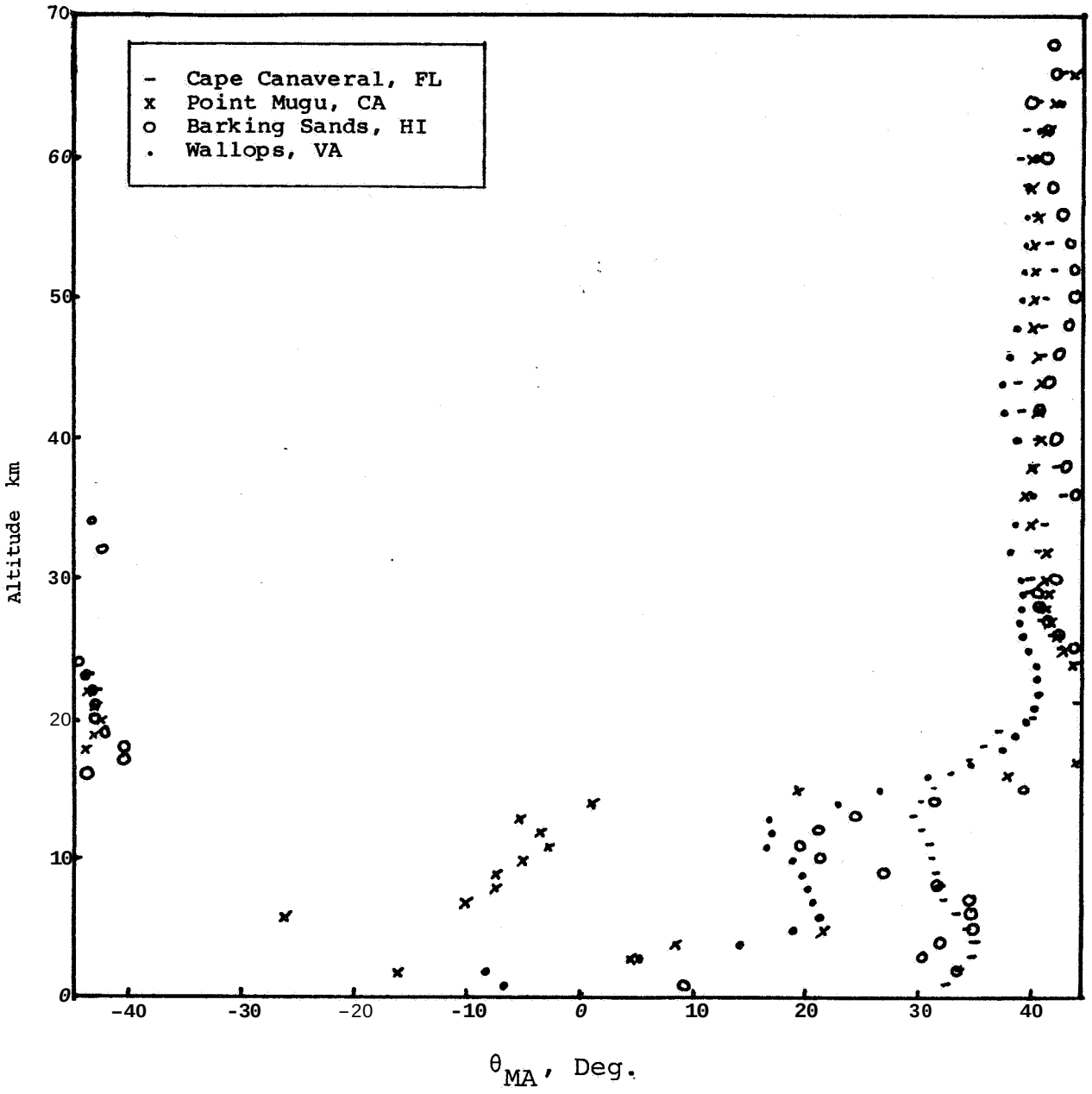

Figure **14.** Rotation (Deg.) with Respect to the Meteorological Coordinate System to Achieve Maximum Wind Component Absolute Correlation **for** an Annual Data Sample

IV. CONCLUSIONS AND RECOMMENDATIONS

This work has produced a unique analysis of detailed wind profiles. The results have indicated significant variability of wind perturbation statistics with location, altitude, season, and wavelength range. The results provide the basis for the establishment of improved discrete gust design criteria guidelines for ascending launch vehicles. New analytical techniques and methods for evaluation of bivariate gamma probability distributions were used in the development of a vector wind gust model. These techniques may have broader application in other engineering and scientific studies.

Some aspects of the vector wind gust model present computational difficulties that may not be advantageous to future users. In its present state of development, the model does not require any simplifying assumptions. It would be useful to investigate whether simplification of the model is possible without a significant loss of accuracy. This would be accomplished by examination of sample estimates of model parameters to establish the validity of assumptions such as zero correlation or equivalence of scale or shape parameters.

It may be desirable for practical applications to use alternative models for description of gust statistics. For example, the Wiebull distribution has been shown to provide a good fit to observed distributions of gust modulus. Use of a gust model based solely on gust modulus would represent an oversimplification of the nature of wind perturbations and their effect on ascending launch vehicles. Model simplification should not eliminate a description of the joint relationship between wind gust components. This joint relationship is an important consideration in selection of realistic inputs for simulation studies of vehicle control system response and resultant vehicle structural loading.

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APPENDIX

Table A1. Scale Parameter B at 12 km

B

KSC		(s/m) |u'|	(s/m) |v'|	(1/m) L_u	(1/m) L_v
FEB	I	4.3472	3.3213	2.592 E-2	2.567 E-2
	II	1.0520	1.2828	5.012 E-3	5.307 E-3
APRIL	I	6.0048	3.8315	2.988 E-2	2.213 E-2
	1.1	1.6187	1.3598	4.138 E-3	4.357 E-3
JULY	I	7.9454	10.0275	3.207 E-2	3.057 E-2
	II	2.3754	1.8363	3.977 E-3	4.933 E-3
VAFB Jimsphere					
Winter	I	3.2484	2.4363	3.520 E-2	3.050 E-2
	II	0.9712	0.9403	5.624 E-3	6.046 E-3
Transition	I	4.5208	4.0500	4.180 E-2	2.496 E-2
	II	1.1307	1.1761	5.756 E-3	4.459 E-3
Summer	I	6.2414	6.1112	3.837 E-2	2.486 E-2
	II	1.7866	2.0673	5.001 E-3	5.280 E-3

I $90 < \lambda < 420$

II $420 < \lambda < 2470$

Table A2. Observed and Expected (Gamma) Cell Counts, KSC February, Jimsphere. 12 km, Wavelength Range, 90-420 m
Non-dimensional $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_U$

B |u'| * |u'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	16	7	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4	11	10	9	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	8	13	6	3	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0
4	0	2	10	3	3	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0
5	1	3	1	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3528 γ_1 = 2.2586 γ_2 = 2.7000 η = .3914

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	5.37	10.64	7.47	3.78	1.64	.65	.24	.09	.03	.01
2.00	6.10	14.76	12.65	7.61	3.82	1.72	.72	.29	.11	.04
3.00	2.92	8.71	9.07	6.44	3.73	1.90	.89	.39	.16	.06
4.00	1.09	3.94	4.88	4.01	2.64	1.50	.77	.37	.17	.07
5.00	.36	1.56	2.25	2.11	1.54	.98	.55	.29	.14	.06
6.00	.11	.56	.94	.99	.81	.56	.34	.19	.10	.05
7.00	.03	.19	.36	.43	.39	.29	.19	.12	.07	.03
8.00	.01	.06	.13	.18	.17	.14	.10	.07	.04	.02
9.00	.00	.02	.05	.07	.07	.06	.05	.03	.02	.01
10.00	.00	.01	.02	.03	.03	.03	.02	.02	.01	.01

CHI-SQUARE= 25.80741 CELLS USED= 81(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.03583	.10676	.15656	.18178	.19270	.19704	.19867	.19926	.19947	.19954
2.00	.07647	.24581	.37997	.45593	.49236	.50817	.51460	.51710	.51804	.51838
3.00	.09596	.32338	.51800	.63689	.69819	.72668	.73902	.74410	.74612	,74689
4.00	.10326	.35696	.58410	,72972	.80859	.84710	.86460	.87215	.87527	.87653
5.00	.10568	.36975	.61189	.77156	.86079	.90582	.92701	.93647	.94053	.94221
6.00	.10643	.37426	.62264	.78892	.88356	.93234	.95582	.96658	.97131	.97332
7.00	.10665	.37576	.62657	.79572	.89294	.94367	.96845	.97999	.98515	.98740
8.00	.10671	.37624	.62795	.79826	.89664	.94831	.97377	.98574	.99117	.99356
9.00	.10672	.37638	.62841	.79918	.89804	.95015	.97594	.98814	.99371	.99618
10.00	.10673	.37643	.62856	.79950	.89856	.95086	.97680	.98911	,99476	.99728

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	5	14	27	28	32	26	18	1
EXPECTED	1.33667	8.97547	14.43951	21.43202	26.46312	28.38213	26.08565	18.59702	6.28841

CHI-SQUARE= 5.08574 CELLS USED= 7(I.E. .CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00891	.05541	.15168	.29456	.47098	.66019	.83410	.95808	1.00000
SECTOR PROBABILITY	.00891	.04650	.09626	.14288	.17642	.18921	.17390	.12398	.04192

Table A3. Observed and Expected (Gamma) Cell Counts. KSC February, Jimsphere, 12 km, Wavelength Range, 90–420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lv} • Lv

B | v | * | v' |

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	12	10	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	16	a	4	5	2	I	I	0	0	0	0	0	0	0	0	0	0	0	0
3	0	13	11	a	8	3	I	0	2	0	0	0	0	0	0	0	0	0	0	0
4	0	2	2	4	2	I	0	I	0	0	0	0	0	0	0	0	0	0	0	0
5	0	3	5	3	2	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	3	0	I	3	I	0	0	0	0	0	0	0	0	0	0	3	0	0	0
7	0	I	I	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

P = .2401 γ_1 = 2.4888 γ_2 = 2.8753 η = .2581

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	3.17	1.37	5.99	3.46	I.69	.75	.31	.IC	.05	.02
2.00	5.10	13.10	11.83	7.55	4.05	1.96	.88	.38	.16	.06
3.00	3.26	9.32	9.41	6.64	3.91	2.05	1.00	.46	.PO	.09
4.00	I.58	5.00	5.59	4.32	2.76	I.57	.82	.40	.19	.08
5.00	.67	2.33	2.86	2.41	I.66	1.01	.56	.29	.I4	.07
6.00	.26	I.00	1.34	I.22	.90	.58	.34	.19	.10	.05
7.00	.10	.40	.59	.57	.45	.31	.19	.11	.06	.03
8.00	.03	.16	.25	.26	.21	.15	.10	.06	.03	.02
9.00	.01	.06	.10	.11	.10	.07	.05	.03	.02	.01
10.00	.00	.02	.04	.05	.04	.03	.02	.02	.01	.01

CHI-SQUARE= 4.81902 CELLS USED= 6(I.E. .CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.0211	.07025	.11015	.13319	.14447	.14947	.15155	.15238	.15270	.15282
2.00	.05514	.19163	.31042	.38378	.42206	.44012	.44809	.45144	.45280	.45334
3.00	.07589	.27554	.45702	.57464	.63896	.67071	.68535	.69178	.69449	.69560
4.00	.08740	.31936	.53809	.68452	.76725	.80944	.82953	.83862	.84259	.84426
5.00	.09184	.33932	.57712	.73960	.83339	.88229	.90610	.91713	.92205	.92418
6.00	.09357	.34769	.59440	.76499	.86476	.91753	.94361	.95589	.96145	.96390
7.00	.09421	.35101	.60163	.77605	.87882	.93365	.96101	.97402	.97998	.98264
8.00	.09444	.35227	.60454	.78067	.88487	.94073	.96376	.98217	.98837	.99115
9.00	.09452	.35274	.60567	.78253	.88739	.94374	.97211	.98574	.99206	.99491
10.00	.09455	.35291	.60609	.78327	.8884I	.94499	.97352	.98726	.99364	.99653

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	I	2	3	4	5	6	7	8	9
OBSERVED	0	7	13	27	28	34	21	17	3
EXPECTED	1.98453	9.17625	16.68598	22.39586	25.86638	26.77957	24.35603	17.28690	5.46855

CHI-SQUARE= 4.86688 CELLS USED- 7(I.E. .CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.01323	.07441	.18564	.33495	.50739	.68592	.84830	.96354	1.00000
SECTOR PROBABILITY	.01323	.06117	.11124	.14931	.17244	.17853	.16237	.11525	.03646

Table A4. Observed and Expected (Gamma) Cell Counts, KSC February, Jimsphere, 12 km. Wavelength Range, 420-2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

sample Size = 150

$B_{Lu} * Lu$

B |u'| * |u'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	I		5	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0		10	13	13	4	7	0	1	0	0	0	1	0	0	0	0	0	0	0
3	0		4	12	e	2	a	2	3	1	0	1	0	0	0	0	0	0	0	0
4	0		3	3	2	4	1	I	0	0	I	0	0	0	0	0	0	0	0	0
3	0		I	3		0	2	I	0	0	0	0	0	0	0	0	0	0	0	0
6	0		0	2	3	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0		0	0	I	a	n	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0		0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2990 γ_1 = 2.3407 γ_2 = 4.1985 η = .4004

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.70	4.47	8.87	8.15	4.20	2.45	1.29	.63	.29	.13
2.00	.81	5.93	10.48	10.62	8.08	5.17	2.95	1.55	.76	.36
3.00	.38	3.24	6.63	7.65	6.52	4.60	2.86	1.62	.85	.43
4.00	.IY	1.35	3.19	4.15	3.93	3.04	2.05	1.25	.71	.37
5.00	.04	.50	1.33	1.93	2.02	1.71	1.25	.82	.49	.28
6.00	.01	.17	.51	.82	.94	.86	.68	.47	.30	.18
7.00	.00	.05	.18	.32	.40	.40	.34	.25	.17	.11
0.00	.00	.02	.06	.12	.16	.18	.16	.13	.09	.06
9.00	.00	.00	.02	.04	.06	.07	.07	.06	.05	.03
10.00	.00	.00	.01	.02	.02	.03	.OS	.03	.02	.02

CHI-SQUARE= 7.61953 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00467	.03445	.08025	.12123	.14922	.16554	.17412	.17831	.18027	.18114
2.00	.01005	.07938	.19506	.30684	.38872	.43950	.46771	.48221	.48925	.49252
3.00	.01250	.10350	.26341	.42620	.55153	.63299	.68026	.70555	.71828	.72449
4.00	.01349	.11345	.29459	.48504	.63654	.73829	.79925	.83288	.85032	.85893
5.00	.01378	.11705	.30705	.51038	.67536	.78850	.85777	.89685	.91755	.92800
6.00	.01387	.11825	.31162	.52041	.69165	.81054	.88433	.92656	.94929	.96094
7.00	.01389	.11863	.31321	.52416	.69809	.81965	.89570	.93963	.96350	.97587
8.00	.01390	.11875	.31374	.52549	.70052	.82326	.90037	.94514	.96962	.98239
9.00	.01390	.11878	.31391	.52595	.70141	.82464	.90222	.94738	.97216	.98515
10.00	.01390	.11879	.31396	.52610	.70172	.82515	.90293	.94827	.97320	.98629

Observed and Expected (Gamma) Counts within Equal Area Sectors

'Sector Size: 10 Degrees Sample Size: 150

	I	E	3	4	5	8	7	9
OBSERVED	0	0	I	14	18	32	36	42
EXPECTED	.08164	1.22708	4.87272	11.44843	20.30355	29.63358	35.90748	32.96873

CHI-SQUARE= 6.66718 CELLS USED= 6(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00054	.00872	.04121	.11753	.25289	.45045	.68983	.90961	1.00000
SECTOR PROBABILITY	.00054	.00818	.03248	.07632	.13536	.19756	.23938	.21978	.09039

Table AS. Observed and Expected (Gamma) Cell Counts, KSC February. Jhsphere, 12 km, Wavelength Range, 420–2470 m
Non-dimensionalized |v'| or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lv} * Lv

B |v'| * |v'|

	1	2	3	4	5	6	7	E	9	10	11	12	13	14	15	IS	17	18	19	20
1	3	6	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	2	8	4	4	1	2	3	1	0	0	0	0	0	0	0	0	0	0	0
3	0	2	6	3	6	11	3	5	2	1	1	0	0	0	0	0	0	0	0	0
4	0	0	6	4	6	2	3	4	0	2	0	0	0	0	0	0	0	0	0	0
5	0	0	2	5	3	3	3	1	2	0	0	0	0	0	0	0	0	0	3	0
6	0	0	2	2	3	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	2	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3064 γ_1 = 3.1086 γ_2 = 4.6700 η = .3707

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.14	1.21	2.21	2.20	1.60	.98	.53	.26	.12	.05
2.00	.35	3.33	6.82	7.54	6.06	4.02	2.35	1.25	.62	.29
3.00	.26	2.83	6.57	8.15	7.28	5.29	3.35	1.92	1.03	.52
4.00	.13	1.61	4.21	5.81	5.71	4.53	3.11	1.02	1.09	.58
5.00	.05	.75	2.19	3.35	3.60	3.10	2.29	1.51	.92	.52
6.00	.02	.31	1.00	1.68	1.97	1.83	1.45	1.02	.66	.39
7.00	.01	.12	.*a	.77	.98	.98	.83	.62	.42	.27
8.00	.00	.04	.17	.33	.45	.48	.44	.35	.25	.16
9.00	.00	.01	.06	.13	.20	.23	.22	.18	.14	.09
10.00	.00	.00	.02	.05	.08	.10	.10	.09	.07	.05

CHI-SQUARE= 6.66884 CELLS USED= 5(I.E.,CELL COUNTS GREATER THAN OR EQUAL 10 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00094	.00499	.02371	.03035	.04005	.05065	.05906	.06081	.06162	.06199
2.00	.00375	.03347	.09364	.15493	.20964	.24700	.26715	.27624	.27721	.27954
3.00	.00499	.05411	.15811	.27731	.37604	.44041	.48093	.50305	.52168	.53242
4.00	.00587	.06574	.19782	.35577	.49335	.59214	.65440	.69012	.70920	.71885
5.00	.00623	.07111	.21779	.39804	.55960	.67905	.75658	.80238	.82757	.84066
6.00	.00636	.07330	.22687	.41814	.59283	.72451	.81173	.86435	.89392	.90963
7.00	.00641	.07412	.23029	.42691	.60813	.74633	.83909	.89585	.92824	.94571
8.00	.00642	.07442	.23169	.43051	.61474	.75617	.85184	.91091	.94495	.96353
9.00	.00643	.07452	.23220	.43191	.61746	.76039	.85750	.91778	.95273	.97194
10.00	.00643	.07455	.23238	.43244	.61853	.76213	.85991	.92079	.95622	.97577

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	I	P	3	4	5	E	7	8	9
OBSERVED	0	0	5	22	26	30	39	26	2
EXPECTED	.09091	1.69468	7.18130	16.60457	27.38504	35.13728	34.63200	22.43088	4.84333

CHI-SQUARE= 4.35571 CELLS USED= 6(I.E.,CELL COUNTS GREATER THAN OR EWU TO 5)

EXPECTED DISTRIBUTION

M E	IO.	20.	30.	CO.	SO.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00061	.01190	.05978	.17048	.35304	.58729	.81817	.96771	1.00000
SECTOR PROBABILITY	.00061	.01130	.04788	.11070	.18257	.23425	.23088	.14954	.03229

Table A6. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphere, 12 km, Wavelength Range, **90-420 m** Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = **150**

$B_{Lu} * Lu$

$B\|u'\| * \|u'\|$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	11	8	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	13	9	9	6	7	1	2	1	0	0	0	0	0	0	0	0	0	0	0
3	0	3	8	9	7	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	1	4	4	4	4	3	0	1	0	0	0	0	0	0	0	0	0	0	0
5	0	0	2	5	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3985 γ_1 = 2.3865 γ_2 = 3.5184 η = .4839

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.14	7.45	7.35	4.66	2.40	1.09	.46	.19	.07	.03
2.00	2.32	10.29	12.74	9.76	5.85	3.02	1.42	.62	.26	.11
3.00	.98	5.58	8.69	8.06	5.66	3.34	1.75	.84	.38	.17
4.00	.31	2.25	4.30	4.75	3.87	2.59	1.52	.81	.40	.18
5.00	.09	.77	1.79	2.31	2.16	1.63	1.06	.62	.33	.17
6.00	.02	.24	.66	.99	1.05	.89	.64	.41	.24	.13
7.00	.01	.07	.23	.39	.47	.44	.35	.24	.15	.09
8.00	.00	.02	.07	.14	.19	.20	.17	.13	.09	.05
9.00	.00	.01	.02	.05	.07	.06	.06	.06	.05	.03
10.00	.00	.00	.01	.02	.03	.03	.03	.03	.02	.02

CHI-SQUARE= 2.40191 CELLS USED= 8(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01424	.06389	.11289	.14399	.15997	.16726	.17036	.17162	.17211	.17231
2.00	.02972	.14794	.28190	.37810	.43307	.46051	.47375	.47845	.48068	.48157
3.00	.03625	.19167	.38358	.53352	.62623	.67595	.70018	.71122	.71599	.71799
4.00	.03833	.20873	.42933	.61091	.72940	.79640	.83076	.84716	.85458	.85760
5.00	.03891	.21448	.44701	.64402	.77691	.85480	.89624	.91676	.92639	.93071
6.00	.03906	.21624	.45320	.65684	.79676	.88059	.92631	.94956	.96077	.96594
7.00	.03910	.21675	.45522	.66146	.80449	.89123	.93926	.96412	.97634	.98209
8.00	.03910	.21688	.45584	.66303	.80733	.89539	.94456	.97028	.98308	.98919
9.00	.03911	.21692	.45602	.66354	.80833	.89695	.94664	.97279	.98590	.99222
10.00	.03911	.21693	.45608	.66370	.80866	.89750	.94742	.97377	.98704	.99347

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	5	19	23	35	39	21	1
EXPECTED	.23200	2.45327	8.11915	16.71816	25.97458	32.45585	32.55269	23.81299	7.68131

CHI-SQUARE= 3.75328 CELLS USED= 6(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00155	.01790	.07203	.18348	.35655	.57302	.79004	.94679	1.00000
SECTOR PROBABILITY	.00155	.01636	.05413	.11145	.17316	.21647	.21702	.15675	.05121

Table A7. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphare, 12 km, Wavelength Range, 90–420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * Lv$

$B|v'| * |v'|$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	16	5	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4	13	15	7	6	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
3	3	3	13	8	8	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
4	2	5		4	4	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
5	0	1	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
9	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11		0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2287 γ_1 = 2.1858 γ_2 = 2.7620 η = .2571

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	4.87	10.53	9.26	4.72	2.31	1.03	.43	.17	.07	.03
2.00	5.96	14.26	12.50	7.08	4.72	2.05	.93	.40	.17	.07
3.00	3.26	8.73	8.55	5.11	3.50	1.84	.90	.42	.19	.08
4.00	1.83	4.24	4.60	3.52	2.24	1.27	.66	.33	.15	.07
5.00	.56	1.84	2.19	1.92	1.25	.75	.42	.22	.11	.05
6.00	.21	.74	.97	.97	.69	.41	.24	.13	.07	.03
7.00	.07	.29	.41	.39	.30	.21	.13	.07	.04	.02
8.00	.02	.11	.16	.17	.14	.10	.06	.04	.02	.01
9.00	.01	.04	.06	.07	.06	.05	.03	.02	.01	.01
10.00	.00	.01	.02	.03	.03	.02	.01	.01	.01	.00

CHI-SQUARE= 7.24926 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.03250	.10272	.15795	.18944	.20482	.21167	.21455	.21571	.21617	.21634
2.00	.07220	.23750	.37607	.45612	.50364	.52414	.53321	.53715	.53882	.53924
3.00	.09396	.31743	.51303	.63697	.70370	.73647	.75154	.75815	.76095	.76212
4.00	.10347	.35519	.58149	.72678	.81053	.86175	.88713	.89802	.90285	.90487
5.00	.10720	.37116	.61208	.77152	.86157	.90783	.93011	.94036	.94491	.94687
6.00	.10858	.37747	.62485	.79008	.88437	.93335	.95724	.96837	.97337	.97557
7.00	.10906	.37986	.62994	.79777	.89409	.94446	.96920	.98092	.98610	.98843
8.00	.10922	.38074	.63190	.80085	.89810	.94913	.97431	.98619	.99161	.99402
9.00	.10928	.38105	.63264	.80205	.89971	.95105	.97643	.98845	.99395	.99640
10.00	.10930	.38116	.63291	.80261	.90034	.95182	.97730	.98938	.99492	.99739

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	1	7	13	16	25	39	25	23	1
EXPECTED	1.87988	9.19029	14.71942	20.02629	23.89242	26.07274	25.73194	20.92166	8.56736

CHI-SQUARE= 7.67176 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.01253	.06713	.16525	.29876	.45904	.63146	.80341	.94288	1.00000
SECTOR PROBABILITY	.01253	.05460	.09812	.13351	.15928	.17242	.17195	.13948	.05712

Table A8. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphere, 12 km, Wavelength Range, 420–2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lu} * Lu

α $\|u'\|$ * $\|u'\|$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	7	3	.	0	0	0	0	0	0	e	0	0	7	0	0	0	0	0	0
2	0	8	9	5	1	2	0	0	1	0	0	0	7	7	0	7	0	0	0	0
3	0	3	5	8	4	2	1		0	1	0	0	■	0	0	0	0	0	0	0
4	0	1	8	9	4	3	2	3	2	1		3	0	0	0	0	0	0	0	0
5	0	1	9	8	5	0	1	0	0	1		0	0	0	0	0	3	0	0	0
6	0	0	4	3	4	1	0	0		0		0	0	0	0	0	0	3	0	0
	0	0	5	1	1	0	1	0	1	0		7	3	3	0	0	e	0	0	0
a	0	0	c	o	o	1	3	0	0	0		0	1	3	0	1	0	0	0	0
9	0	0	1	1	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	■	0	0	0	0	0	0
12	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	■	0	0	0	■	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	1	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	a	0

Expected Cell Count

ρ = .2625 γ_1 = 3.2219 γ_2 = 3.5734 η = .2764

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.58	2.27	2.50	1.75	.98	.48	.21	.09	.P*	.01
2.00	1.68	7.15	8.67	6.65	4.06	2.16	1.05	.17	.20	.08
3.00	1.50	7.05	9.47	8.01	5.35	3.09	1.62	.79	.36	.16
4.00	.90	4.64	6.88	6.37	4.62	2.88	1.62	.94	.41	.19
5.00	.44	2.50	4.06	4.09	3.20	2.14	1.28	.71	.37	.18
6.00	.19	1.19	2.11	2.30	1.93	1.38	.88	.51	.28	.15
7.00	.08	.52	1.01	1.18	1.06	.80	.54	.33	.19	.10
8.00	.03	.22	.45	.57	.54	.43	.31	.20	.12	.07
9.00	.01	.09	.19	.26	.26	.22	.16	.11	.07	.04
10.00	.00	.03	.08	.11	.12	.11	.08	.06	.04	.02

CHI-SQUARE= 3.89820 CELLS USED= 7(I.E.,CELL COURTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00387	.01901	.03567	.04734	.05386	.05705	.05848	.05908	.05933	.05941
2.00	.01506	.07787	.15231	.20833	.24192	.25950	.26790	.27167	.27328	.27391
3.00	.02506	.13485	.27242	.38194	.45108	.48926	.50846	.51748	.52152	.52321
4.00	.03105	.17177	.35519	.50706	.60710	.66449	.69448	.70912	.71592	.71891
5.00	.03399	.19137	.40186	.58099	.70236	.77402	.81255	.83193	.84118	.84541
6.00	.03527	.20060	.42517	.61963	.75388	.83471	.87909	.90188	.91299	.91829
7.00	.03579	.20461	.43590	.63823	.77954	.86571	.91368	.93868	.95106	.95696
8.00	.03599	.20626	.44056	.64666	.79157	.88063	.93064	.95696	.97019	.97766
9.00	.03606	.20690	.44249	.65031	.79696	.88749	.93859	.96565	.97929	.98594
10.00	.03609	.20715	.44326	.65183	.79929	.89053	.94219	.96964	.98353	.99031

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector *Size:* 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	2	15	33	30	28	25	15	2
EXPECTED	1.00157	7.37967	16.90481	25.23624	29.96561	29.80054	24.00736	13.21130	2.49285

CHI-SQUARE= 2.99514 CELLS USED: 6(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00668	.05587	.16857	.33682	.53659	.73526	.89531	.95338	1.00000
SECTOR PROBABILITY	.00668	.04920	.11270	.16824	.19977	.19867	.16005	.05808	.01662

Table A9. Observed and Expected (Gamma) Cell Counts, KSC April, Jimsphere, 12 km, Wavelength Range, 420–2470 m Non-dimensionalized $|v'|$ or L_V

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * Lv$

B |v'| * |v'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	3	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	14	4	6	7	3	3	3	0	1	0	0	0	0	0	0	0	0	0	0
3	0	4	11	8	3	1	1	2	0	1	1	0	0	0	0	0	0	0	0	0
4	0	0	3	7	8	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	1	1	14	3	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
6	0	0	3	6	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2242 $\quad \gamma_1$ = 3.0288 $\quad \gamma_2$ = 3.7219 $\quad \eta$ = .2485

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.55	2.51	3.13	2.43	1.49	.79	.39	.18	.08	.03
2.00	1.39	6.83	9.20	7.70	5.07	2.89	1.50	.73	.33	.15
3.00	1.17	6.19	9.08	8.23	5.85	3.58	1.98	1.02	.49	.23
4.00	.68	3.88	6.17	6.04	4.60	3.00	1.76	.96	.49	.24
5.00	.33	2.02	3.48	3.65	2.97	2.06	1.28	.73	.39	.20
6.00	.14	.95	1.75	1.97	1.70	1.24	.81	.49	.27	.15
7.00	.06	.41	.81	.98	.89	.69	.47	.30	.17	.10
8.00	.02	.17	.36	.46	.44	.36	.26	.17	.10	.06
9.00	.01	.07	.15	.20	.21	.18	.13	.09	.06	.03
10.00	.00	.03	.06	.09	.09	.08	.07	.05	.03	.02

CHI-SQUARE= 9.19109 CELLS USED= 61(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00366	.02040	.04125	.05743	.06736	.07266	.07524	.07642	.07693	.07714
2.00	.01296	.07525	.15745	.22497	.26871	.29330	.30588	.31190	.31463	.31583
3.00	.02075	.12433	.26705	.38946	.47217	.52060	.54636	.55916	.56519	.56792
4.00	.02525	.15469	.33854	.50120	.61456	.68298	.72049	.73967	.74897	.75331
5.00	.02743	.17036	.37739	.56440	.69756	.77970	.82572	.84977	.86170	.86738
6.00	.02838	.17760	.39630	.59642	.74089	.83133	.88277	.91008	.92384	.93049
7.00	.02876	.18072	.40885	.61147	.76190	.85692	.91151	.94080	.95572	.96352
8.00	.02891	.18200	.40852	.61818	.77154	.86895	.92525	.95565	.97126	.97896
9.00	.02896	.18250	.41003	.62105	.77579	.87437	.93155	.96256	.97855	.98647
10.00	.02898	.18269	.41063	.62224	.77760	.87674	.93435	.96567	.98186	.98991

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees **Sample Size: 150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	3	9	27	32	37	23	18	1
EXPECTED	.121193	5.79453	15.011572	22.16125	28.09589	30.33578	27.24984	17.47584	4.11063

CHI-SQUARE= 5.55125 CELLS USED: 6(I.E.,CELL COUNTS GREATER THIN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00483	.04346	.13710	.28488	.47219	.67843	.85609	.97260	1.00000
SECTOR PROBABILITY	.00483	.03863	.09364	.14778	.18731	.20224	.18167	.11650	.02740

Table A10. Observed and Expected *(Gamma)* Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 90–420 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_U$

$B|u'| * |u'|$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	10	9	3	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	7	10	10	7	5	2	1	1	1	0	0	0	0	0	0	0	0	0	0
3	0	3	7	6	8	7	1	2	1	0	0	0	0	0	0	0	0	0	0	0
4	0	1	2	9	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	1	3	1	2	4	2	2	1	0	0	0	0	0	0	0	0	0	0	0
6	0	2	0	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .4053 γ_1 = 2.3808 γ_2 = 3.6733 η = .5034

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	1.78	6.99	7.44	4.97	2.66	1.26	.55	.23	.09	.04
2.00	1.85	9.32	12.54	10.17	6.35	3.39	1.64	.74	.32	.13
3.00	.74	4.86	8.29	8.18	6.01	3.68	1.99	.98	.45	.20
4.00	.22	1.87	3.96	4.69	4.02	2.80	1.69	.92	.46	.22
5.00	.06	.62	1.59	2.32	2.19	1.73	1.17	.70	.38	.20
6.00	.01	.18	.57	.92	1.04	.93	.69	.46	.27	.15
7.00	.00	.05	.19	.35	.45	.44	.37	.26	.17	.10
8.00	.00	.01	.06	.12	.18	.20	.18	.14	.10	.06
9.00	.00	.00	.02	.04	.07	.08	.08	.07	.05	.03
10.00	.00	.00	.00	.01	.02	.03	.03	.03	.03	.02

CHI-SQUARE= 3.17325 CELLS USED= 8(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01189	.05848	.10807	.14173	.16098	.16736	.17103	.17256	.17318	.17343
2.00	.02422	.13294	.26612	.36705	.43714	.46816	.47275	.47919	.48192	.48303
3.00	.02916	.17025	.35967	.51412	.61431	.66986	.69771	.71071	.71646	.71891
4.00	.03065	.18424	.39909	.58578	.71275	.78696	.82612	.84576	.85411	.85803
5.00	.03104	.18875	.41421	.61573	.75727	.84304	.88996	.91376	.92517	.93038
6.00	.03114	.19008	.41933	.62698	.77551	.86744	.91897	.94591	.95902	.96523
7.00	.03116	.19044	.42094	.63093	.78245	.87734	.93131	.95991	.97426	.98114
8.00	.03116	.19054	.42142	.63224	.78494	.88113	.93679	.96591	.98081	.98810
9.00	.03116	.19056	.42156	.63265	.78579	.88252	.93870	.96819	.98352	.99105
10.00	.03117	.19057	.42160	.63277	.78607	.88300	.93892	.96910	.98461	.99226

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	3	6	10	26	33	43	20	9
EXPECTED	.14929	1.84107	6.79702	15.19964	25.10489	32.84240	34.06905	25.56792	8.43872

CHI-SQUARE= 5.49024 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00100	.01327	.05858	.15935	.32721	.54616	.77329	.94374	1.00000
SECTOR PROBABILITY	.00100	.01227	.04531	.10076	.16787	.21895	.22713	.17045	.05626

Table All. Observed and Expected (Gamma) Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 90–420 m Non–dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lv} • Lv

B |v'| * |v'|

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	3	5	1	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	7	7	7	5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	5	9	8	7	6	1	1	1	0	1	0	0	0	0	0	0	0	0
4	0	0	4	4	5	5	4	2	1	0	0	1	0	0	0	0	0	0	0	0
5	0	0	1	3	5	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	1	2	2	3	2	0	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	0	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

P = .3321 γ_1 = 2.9943 γ_2 = 4.3395 n = .3998

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.31	2.08	3.19	2.78	1.83	1.02	.51	.24	.11	.04
2.00	.64	4.86	8.54	8.45	6.22	3.83	2.09	1.05	.50	.22
3.00	.92	3.70	7.55	9.53	7.06	4.82	2.89	1.57	.80	.38
5.00	.19	1.93	4.52	5.80	5.36	4.03	2.64	1.56	.85	.43
5.00	.07	.84	2.23	3.21	3.28	2.71	1.92	1.22	.71	.39
6.00	.02	.32	.97	1.56	1.75	1.57	1.21	.82	.51	.30
7.00	.01	.11	.39	.69	.85	.82	.68	.53	.33	.7L
8.00	.00	.04	.15	.28	.38	.40	.35	.Za	.19	.13
9.00	.OD	.01	.05	.11	.16	.1a	.17	.14	.11	.07
10.00	.00	.00	.02	.04	.07	.0E	.08	.07	.05	.04

CHI-SQUARE= 1.80286 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO E)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00208	.01595	.03720	.05573	.06792	.07472	.07812	.07971	.08041	.08071
2.00	.00634	.05259	.13080	.20565	.25933	.29161	.30896	.31755	.32156	.32334
3.00	.00913	.07005	.20856	.34029	.44098	.50542	.54271	.56110	.57003	.57478
4.00	.01038	.09420	.25296	.42333	.55974	.65107	.70535	.73471	.74969	.75693
5.00	.01086	.10025	.27391	.46566	.62393	.73330	.80029	.83789	.85762	.86745
6.00	.01102	.10256	.28270	.48442	.65476	.77461	.84965	.89273	.91589	.92770
7.00	.01107	.10337	.28611	.49282	.66840	.79375	.87333	.91973	.94508	.95823
8.00	.01108	.10365	.28736	.49595	.67408	.80209	.88403	.93227	.95891	.97290
9.00	.01109	.10373	.28779	.49713	.67633	.80556	.88865	.93733	.96518	.97965
10.00	.01109	.10376	.28794	.49755	.67718	.80694	.89056	.94071	.96792	.98266

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	7	17	30	79	47	15	4
EXPECTED	.12289	1.95145	7.67822	17.04806	27.41285	34.56927	33.80873	22.22768	5.18484

CHI-SQUARE= 7.57823 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00082	.01383	.06499	.17864	.36140	.59186	.81725	.96543	1.00000
SECTOR PROBABILITY	.00082	.01301	.05116	.11365	.18275	.23046	.22539	.14818	.03457

Table A12. observed and Expected (Gamma) Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 420–2470 m
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * Lu$

$B|u'| * |u'|$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	8	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	10	9	5	3	1	1	2	0	0	1	0	0	0	0	0	0	0	0	0
3	0	9	7	7	8	5	3	5	0	0	0	0	0	0	0	0	0	0	0	0
4	0	1	8	7	5	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0
5	0	2	3	8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2955 γ_1 = 2.9129 γ_2 = 3.6080 η = .3289

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.87	3.44	3.80	2.65	1.48	.72	.32	.14	.05	.02
2.00	1.85	8.19	10.20	7.97	4.92	2.64	1.29	.59	.25	.11
3.00	1.32	6.64	9.41	8.26	5.67	3.35	1.78	.88	.41	.16
4.00	.66	3.76	6.01	5.88	4.45	2.86	1.65	.87	.44	.21
5.00	.28	1.78	3.19	3.44	2.85	1.99	1.23	.70	.37	.19
6.00	.11	.76	1.60	1.78	1.60	1.20	.90	.46	.27	.14
7.00	.04	.30	.65	.85	.82	.66	.47	.30	.18	.10
8.00	.01	.11	.27	.38	.39	.34	.25	.17	.11	.06
9.00	.00	.04	.11	.16	.18	.16	.12	.09	.06	.04
10.00	.00	.01	.04	.06	.08	.07	.06	.05	.03	.02

CHI-SQUARE= 5.11395 CELLS USED= 9(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00581	.02877	.05409	.07176	.08159	.08639	.08854	.08944	.08981	.08995
2.00	.01813	.09572	.18904	.25984	.30250	.32489	.33541	.34042	.34248	.34332
3.00	.02695	.14882	.30495	.43075	.51123	.55592	.57850	.58915	.59393	.59599
4.00	.03137	.17834	.37445	.53958	.64973	.71352	.74709	.76357	.77125	.77468
5.00	.03323	.19209	.40944	.59753	.72667	.80369	.84546	.86660	.87674	.88141
6.00	.03394	.19785	.42522	.62520	.76500	.85004	.89711	.92146	.93340	.93902
7.00	.03419	.20010	.43183	.63746	.78273	.87216	.92235	.94868	.96140	.96806
8.00	.03428	.20093	.43446	.64259	.79048	.88216	.93404	.96151	.97535	.98204
9.00	.03430	.20123	.43546	.64466	.79373	.88650	.93923	.96732	.98155	.98853
10.00	.03431	.20133	.43582	.64546	.79504	.88831	.94146	.96986	.98451	.99139

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees **Sample Size: 150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	11	26	34	31	25	12	3
EXPECTED	.61512	5.17160	13.35374	22.10425	28.76173	31.19594	27.59116	17.19797	4.00849

CHI-SQUAPE= 6.34115 CELLS USED= 5(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00410	.03858	.12760	.27496	.46671	.67468	.85862	.97328	1.00000
SECTOR PROBABILITY	.00410	.03448	.08902	.14736	.19174	.20797	.18394	.11465	.02672

Table A13. Observed and Expected (Gamma) Cell Counts, KSC July, Jimsphere, 12 km, Wavelength Range, 420–2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lv} • Lv

$B\|v'\| * \|v'\|$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	6	15	5	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	6	8	5	6	7	7	1	1	1	0	0	0	0	0	0	0	0	0	0
3	0	0	4	9	6	10	4	1	2	0	0	0	0	0	0	0	0	0	0	0
4	0	0	5	4	7	1	3	1	2	0	1	0	0	0	0	0	0	0	0	0
5	0	0	1	2	1	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3761 $\quad Y_1$ = 2.3066 $\quad Y_2$ = 4.1676 $\quad \eta$ = .5055

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.90	5.33	7.58	6.30	4.02	2.21	1.10	.51	.23	.10
2.00	.85	6.29	11.04	10.94	8.05	4.96	2.71	1.36	.65	.29
3.00	.32	2.99	6.54	7.77	6.66	4.65	2.83	1.56	.80	.38
4.00	.09	1.08	2.87	4.05	4.00	3.16	2.14	1.29	.71	.37
5.00	.02	.33	1.08	1.77	2.01	1.76	1.34	.88	.53	.29
6.00	.01	.10	.36	.69	.89	.88	.73	.53	.34	.20
7.00	.00	.03	.11	.25	.36	.40	.36	.28	.20	.13
8.00	.00	.01	.03	.08	.14	.17	.16	.14	.11	.07
9.00	.00	.00	.01	.03	.05	.06	.07	.06	.05	.04
10.00	.00	.00	.00	.01	.02	.02	.03	.03	.02	.02

CHI-SQUARE= 23.25596 CELLS USED= 8(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00602	.04158	.09212	.13411	.16092	.17562	.18295	.18637	.18790	.18856
2.00	.01168	.08918	.21335	.32626	.40876	.45651	.48148	.49440	.50024	.50286
3.00	.01380	.11125	.27899	.44572	.57062	.64938	.69364	.71654	.72769	.73287
4.00	.01440	.11903	.30592	.49963	.65122	.75109	.83961	.84112	.85704	.86468
5.00	.01456	.12141	.31548	.52100	.68597	.79773	.86517	.90257	.92202	.93163
6.00	.01459	.12208	.31856	.52969	.69959	.81724	.88956	.93048	.95221	.96314
7.00	.01460	.12226	.31949	.53127	.70457	.82487	.89959	.94240	.96546	.97729
8.00	.01460	.12233	.31976	.53209	.70629	.82769	.90351	.94726	.97103	.98334
9.00	.01460	.12231	.31983	.53234	.70686	.82868	.90497	.94915	.97328	.98584
10.00	.01460	.12232	.31985	.53241	.70704	.82902	.90550	.94987	.97415	.98685

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	9	19	40	35	3b	11
EXPECTED	.04608	.82761	3.90776	10.53877	20.46072	31.08585	37.40571	32.85693	12.87057

CHI-SQUARE= 6.65256 CELLS USED= 6(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)
EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90
CUMULATIVE PROBABILITY	.00031	.00582	.03188	.10213	.23458	.44578	.69515	.91420	1.00000
SECTOR PROBABILITY	.00031	.00552	.02605	.07026	.13640	.20774	.24937	.21905	.08580

Table A14. Observed and Expected (Gamma) Cell Counts, VAFB Winter, Jimsphere, 12 km, Wavelength Range, 90–420 m Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lu} * Lu

B |u'| * |u'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	2	1*	5	E	3	I	1	0	0	0	I	0	0	0	0	0	0	0	0	0
2	0	3	7	8	9	11	5	3	2	1	I	0	0	0	0	0	0	0	0	0
3	0	0	2	4	2	10	5	4	2	0	1	0	0	0	0	0	0	0	0	0
4	0	I	0	3	5	6	6	0	0	1	I	0	0	0	0	0	0	0	0	0
5	0	0	0	I	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	I	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

P = .3348 γ_1 = 2.0788 γ_2 = 4.7338 η = .5052

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.42	3.97	7.m	E.37	6.55	4.27	2.47	1.32	.66	.32
2.00	.31	3.57	8.53	10.69	9.5s	6.94	4.39	2.52	1.35	.68
3.00	.10	1.44	4.18	6.2?	6.37	5.21	3.65	2.28	1.31	.71
4.00	.03	.46	1.60	2.78	3.66	B.99	2.31	1.58	.98	.56
5.00	.01	.13	.54	1.08	1.44	I.48	1.26	.93	.62	.38
6.00	.00	.03	.17	.38	.57	.65	.61	.49	.35	.23
7.00	.00	.01	.OS	.13	.21	.27	.27	.24	.18	.13
0.00	.00	.00	.01	.OC	.07	.10	.11	.11	.09	.07
9.00	.00	.00	.00	.01	.OB	.04	.04	.05	.04	.03
10.00	.00	.00	.00	.00	.01	.01	.02	.02	.02	.02

CHI-SQUARE= 8.80593 CELLS USED= 7(I.E. ,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
I.00	.00282	.02926	.08150	.13730	.18099	.20947	.22597	.23477	.23920	.24132
2.00	.00489	.05513	.16426	.29134	.39871	.47347	.51926	.54489	.55831	.56498
3.00	.00555	.06537	.20239	.37079	.52062	.63012	.70022	.74104	.76319	.77457
4.00	.00572	.06860	.21630	.40322	.57482	.70428	.78981	.84116	.86982	.88495
5.00	.00578	.06950	.22079	.41492	.59612	.73542	.82932	.88089	.91971	.93739
6.00	.00577	.06973	.22213	.41880	.60384	.74749	.84547	.90631	.94150	.96074
7.00	.00577	.06979	.22251	.42002	.60647	.75190	.85169	.91413	.95055	.97068
(1.00	.00578	.06981	.22261	.42038	.60732	.75343	.85399	.91714	.95418	.97472
9.00	.00578	.06981	.22263	.42049	.60759	.75395	.85480	.91826	.95556	.97633
10.00	.00578	.06981	.22264	.42052	.60767	.75411	.85508	.91866	.95607	.97695

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees **Sample Size: 150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	1	2	11	26	40	53	17
EXPECTED	.00976	.26735	1.67538	5.66824	13.51680	25.17894	37.87198	42.69010	23.32185

CHI-SQUARE= 4.84268 CELLS USED= 5(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	PO.	30.	YO.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00007	.00185	.01302	.05080	.14092	.30878	.55992	.84452	1.00000
SECTOR PROBABILITY	.00007	.00178	.01117	.03779	.09011	.16786	.25115	.28460	.15548

Table A15. Observed and Expected (Gamma) Cell Counts, VAFB Winter, Jimsphere, 12 km, Wavelength Range, 90–420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * Lv$

B |v'| * |v'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	7	14	12	5	9	3	2	0	0	0	1	0	0	0	0	0	0	0	0	0
2	0	3	11	13	8	Y	5	2	0	0	I	0	0	0	0	0	0	0	0	0
3	0	0	3	9	3	8	4	2	0	0	I	0	0	0	0	0	0	0	0	0
C	0	I	2	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	I	0	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3205 γ_1 = 1.6875 γ_2 = 3.0769 η = .4858

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	0.00	9.00	10.00
1.00	2.02	10.42	14.10	11.65	7.55	4.25	2.18	1.05	.49	.22
2.00	1.04	6.71	11.17	10.93	8.11	5.09	2.86	1.40	.73	.34
3.00	.29	2.39	4.89	5.65	4.83	3.41	2.11	1.19	.62	.31
4.00	.07	.72	1.78	2.91	2.35	1.86	1.27	.78	.44	.23
5.00	.02	.20	.58	.92	1.01	.83	.67	.45	.27	.15
6.00	.00	.05	.18	.32	.40	.39	.32	.23	.15	.09
7.00	.00	.01	.05	.11	.15	.16	.IY	.11	.08	.05
8.00	.00	.00	.01	.03	.05	.06	.06	.05	.04	.03
9.00	.00	.00	.00	.01	.02	.02	.Of	.02	.02	.01
10.00	.00	.00	.00	.00	.01	.01	.01	.01	.01	.01

CHI-SQUARE= 7.99917 CELLS USED= 8(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	0.00	9.00	10.00
1.00	.01347	.08292	.17692	.25459	.30492	.33323	.34777	.35479	.35802	.35947
2.00	.02038	.13454	.30300	.45353	.55796	.62022	.65382	.67072	.67879	.68250
3.00	.02233	.15241	.35338	.54159	.67820	.76317	.81083	.83565	.84788	
4.00	.02281	.15769	.37051	.57479	.72706	.82439	.88049	.91048	.92563	.93296
5.00	.02292	.15913	.37585	.58624	.74528	.84853	.90908	.94204	.95900	.96735
6.00	.02294	.15950	.37742	.58998	.75165	.85753	.92021	.95472	.97269	.98164
7.00	.02294	.15960	.37786	.59111	.75379	.86073	.92437	.95962	.97812	.98741
0.00	.02295	.15962	.37798	.59146	.75448	.86183	.92587	.96146	.98021	.98967
9.00	.02295	.15962	.37801	.59156	.75470	.86220	.92640	.96213	.98099	.99055
10.00	.02295	.15963	.37802	.59158	.75476	.86232	.92658	.96237	.98128	.99087

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	1	6	16	23	38	40	23
EXPECTED	.04473	.63987	2.68414	8.95148	13.86415	23.19648	33.45749	40.23577	28.92810

CHI-SQUARE= 6.07990 CELLS USED= 8(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00030	.00456	.02246	.06880	.16123	.31587	.53892	.80716	1.00000
SECTOR PROBABILITY	.00030	.00426	.01789	.04634	.09243	.15464	.22305	.26824	.19284

Table A16. observed and Expected (Gamma) Cell Counts, **VAPB** Winter, Jimsphere, 12 **km,** Wavelength Range, **420–2470 m** Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lu} * LU

B |u'| * |u'|

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	3	e	3	4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E	0	4	6	6	12	3	I	6	0	1	0	0	1	0	0	0	0	0	0	0
3	0	0	7	6	8	10	7	I	E	I	1	0	0	0	0	0	0	0	0	0
4	0	0	3	4	3	5	5	2	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	2	6	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	2	2	0	0	P	0	0	1	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	1,	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	I	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eo	0	0	0	0	0	0	0	0	0	0	0	0	0				0	0	0	0

Expected Cell Count

P = .2802 γ_1 = 2.6077 γ_2 = 4.5529 η = .3702

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.30	2.48	4.53	4.58	3.44	2.16	1.21	.62	.30	.14
2.00	.46	9.22	8.64	9.70	7.99	5.46	3.29	1.81	.93	.46
3.00	.26	2.69	6.22	7.82	7.11	5.31	3.96	2.04	1.12	.58
4.00	.11	1.26	3.28	4.57	9.57	3.71	2.60	1.65	.96	.53
5.00	.04	.51	1.47	2.27	2.47	2.17	1.69	1.11	.69	.40
6.00	.01	.19	.60	1.01	1.20	1.13	.92	.66	.43	.26
7.00	.00	.06	.23	.42	.54	.55	.47	.36	.25	.16
8.00	.00	.02	.08	.17	.83	.25	.23	.18	.13	.09
9.00	.00	.01	.03	.06	.09	.11	.10	.09	.07	.05
10.00	.00	.00	.01	.0P	.04	.0'	.03	.04	.03	.02

CHI-SQUARE= 9.00922 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00200	.01852	.0487	.07924	.10214	.11653	.12459	.12874	.13076	.13170
2.00	.00503	.04969	.1374	.23271	.30890	.33968	.38965	.4058	.41411	.41810
3.00	.00674	.06931	.1986	.34592	.46953	.55569	.60871	.6385	.65429	.66215
4.00	.00745	.07840	.2295	.40731	.56130	.67225	.74264	.7834	.80561	.81699
5.00	.00770	.08202	.2429	.43584	.60639	.73173	.81304	.8612	.89795	.90197
6.00	.00778	.08334	.2482	.44709	.62644	.75934	.84676	.8993	.92894	.94471
7.0	.00781	.08379	.2502	.45266	.6348	.77135	.86191	.9168	.94813	.96496
0.00	.00781	.08394	.250	.45446	.6381	.77632	.86839	.9245	.95672	.9715
9.00	.00782	.08398	.251	.45511	.6393	.77830	.87106	.9278	.96042	.97817
10.00				.45534		.77906			.96198	.97989

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	10	24	27	44	36	6
EXPECTED	.08302	1.12979	4.85563	11.82046	21.28081	31.02032	38.82254	41.84680	41.15283

CHI-SQUARE= 5.47256 CELLS USED= 6(I.E. ,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLEATIVE PROBABILITY	.00042	.00095	.00032	.10018	.20005	.46085	.77034	.98065	1.00000
SECTOR PROBABILITY	.00042	.00753	.03237	.07006	.14187	.20680	.24548	.21231	.07435

Table A17. Observed and Expected (Gamma) Cell Counts, VAPB Winter, Jimsphere, 12 km, Wavelength Range, 420-2470 m Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lv} * Lv

B |v'| * |v'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	3	8	2	1	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	3	6	8	9	6	3	4	0	3	0	0	0	0	0	0	0	0	0	0
3	0	0	6	6	8	4	4	2	2	1	1	1	0	0	0	0	0	0	0	0
4	0	0	1	5	4	4	3	1	2	1	1	0	0	0	0	0	0	0	0	0
5	0	0	2	1	6	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2898 γ_1 = 2.5709 γ_2 = 4.7895 η = .3956

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.22	2.15	4.38	4.77	3.80	2.50	1.45	.78	.39	.19
2.00	.31	3.43	7.89	9.61	8.42	6.05	3.80	2.17	1.15	.58
3.00	.16	2.06	5.41	1.41	7.21	5.68	3.87	2.37	1.35	.72
4.00	.06	.9[illegible]	e.72	4.17	4.48	3.09	2.04	1.07	1.13	.64
5.00	.02	.35	1.17	1.99	2.34	2.19	1.74	1.23	.79	.47
6.00	.01	.12	.46	.86	1.10	1.11	.95	.71	.*9	.SI
7.00	.00	.04	.17	.34	.48	.52	.47	.38	.27	.18
8.00	.00	.01	.06	.13	.20	.23	.22	.19	.14	.10
9.00	.00	.00	.02	.05	.08	.10	.10	.09	.07	.05
10.00	.00	.00	.01	.02	.03	.04	04	.04	.03	.OS

CHI-SQUARE= I.81358 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00147	.01580	.04498	.07682	.10212	.11878	.12848	.13365	.13625	.13750
2.00	.00354	.04077	.12253	.21843	.29989	.35885	.39185	.41147	.42174	.42685
3.00	.00463	.05561	.17342	.31874	.44829	.54310	.60389	.63933	.65858	.66847
4.00	.00505	.06214	.19807	.37118	.53057	.65103	.73072	.77861	.80538	.81953
5.00	.00519	.06462	.20834	.39470	.56972	.70477	.79604	.85210	.88412	.90140
6.00	.00524	.06547	.21223	.40429	.58665	.72911	.82671	.88752	.92278	.94211
7.00	.00525	.06575	.21361	.40796	.59351	.73944	.84020	.90354	.94063	.96118
8.00	.00525	.06584	.21408	.40929	.59615	.74360	.84585	.91045	.94851	.96973
9.00	.00526	.06586	.21423	.40976	.59712	.74522	.84813	.91332	.95186	.97343
10.00	.00526	.06587	.21428	.40992	.59747	.74583	.84901	.91448	.95324	.97498

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees **Sample Size: 150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	0	6	24	27	39	41	11
EXPECTED	.03281	.72853	3.63240	9.89086	19.41426	30.35837	38.21277	34.83982	12.89018

CHI-SQUARE= 3.19877 CELLS USED= 6(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	SO.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00022	.00508	.02929	.09523	.22466	.42705	.68180	.91407	1.00000
SECTOR PROBABILITY	.00022	.00486	.02422	.06594	.12943	.20239	.25475	.23227	.08593

Table **A18.** Observed and Expected **(Gamma)** Cell Counts, VAFB Transition, Jimsphere, **12 km,** Wavelength Range. **90-420 m**
Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * Lu$

B |u'| * |u'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	2	4	4	2	3	0	1	1	1	0	0	0	0	0	0	0	0	0	0
2	0	1	7	4	9	5	10	6	1	1	0	1	0	0	0	0	0	0	0	0
3	0	0	4	0	1	4	10	6	0	2	2	2	0	0	0	0	0	0	0	0
4	0	0	2	1	5	4	2	3	2	3	1	0	1	0	0	0	0	0	0	0
5	0	2	0	0	2	4	4	1	3	2	1	0	0	0	0	0	0	0	0	0
6	0	0	0	0	2	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
e	o	o	o	o	o	o	~	o	i	o	o	o	o	o	o	o	o	o	o	o
9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2768 γ_1 = 2.6824 γ_2 = 5.9186 η = .4111

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.03	.61	2.11	3.38	3.62	3.05	2.18	1.39	.82	.45
2.00	.04	1.02	3.91	6.91	8.09	7.38	5.65	3.85	2.39	1.38
3.00	.02	.61	2.63	5.18	6.68	6.63	5.50	9.01	2.65	1.62
4.00	.01	.26	1.20	2.79	3.95	4.26	3.81	2.97	2.09	1.35
5.00	.00	.10	.53	1.27	1.97	2.50	2.21	1.84	1.37	.94
6.00	.00	.03	.20	.52	.88	1.11	1.14	1.01	.80	.58
7.00	.00	.01	.07	.20	.36	.49	.54	.51	.43	.32
0.00	.00	.00	.02	.07	.14	.21	.24	.24	.21	.17
9.00	.00	.00	.01	.02	.05	.0e	.10	.11	.10	.08
10.00	.00	.00	.00	.01	.02	.03	.04	.05	.05	.04

CHI-SOUMI" 7.88411 CELLS USED* 4(I.E. .CELL COUNTS GREATER THAN OR EQUAL *10* 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00019	.00426	.01833	.04088	.06504	.08538	.09990	.10920	.11467	.11768
2.00	.00046	.01131	.05143	.12002	.19812	.28752	.31977	.35471	.37611	.38834
3.00	.00061	.01550	.07313	.17624	.29888	.41248	.50137	.56303	.60209	.62514
4.00	.00067	.01731	.08345	.20516	.35415	.49615	.61047	.69196	.74495	.77702
5.00	.00069	.01798	.08762	.21782	.37992	.53725	.66629	.76004	.82217	.86049
6.00	.00069	.01820	.08916	.22283	.39079	.55550	.69214	.79262	.86008	.90224
7.00	.00069	.01827	.08969	.22468	.39507	.56308	.70330	.80719	.87748	.92180
8.00	.00069	.01829	.08986	.22533	.39666	.56602	.70788	.81337	.88508	.93053
9.00	.00069	.01830	.08991	.22555	.39723	.56714	.70968	.81589	.88827	.93428
10.00	.00069	.01830	.08993	.22562	.39743	.56755	.71036	.81688	.88957	.93584

Observed and Expected **(Gamma)** Counts within Equal Area Sectors

Sector Size: ***10*** Degrees Sample Size: **150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	2	7	9	33	30	56	13
EXPECTED	.00335	.16581	1.36838	5.33541	13.83897	27.13013	41.17909	43.56314	17.41773

CHI-SQUARE= 11.18728 CELLS USED= 6(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00002	.00113	.01024	.04581	.13807	.31893	.59346	.88388	1.00000
SECTOR PROBABILITY	.00002	.00111	.00911	.03557	.09226	.18087	.27453	.29042	.11612

Table A19. Observed and Expected *(Gamma)* Cell Counts. **VAFB** Transition, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized $|v'|$ or L_v

Observed **and** Expected **(Gamma)** Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * Lv$

$B|v'| * |v'|$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5	15	7	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	12	11	11	7	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
3	1	5	5	9	6	3	3	3	2	0	0	0	0	0	0	0	0	0	0	0
4	0	2	2	2	3	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
5	0	1	2	4	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3755 $\quad \gamma_1$ = 2.2247 $\quad \gamma_2$ = 3.4086 $\quad \eta$ = .4648

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.72	8.99	8.72	5.53	2.88	1.32	.57	.23	.09	.04
2.00	2.62	10.88	13.09	9.93	5.95	3.10	1.47	.65	.28	.11
3.00	1.06	5.57	8.31	7.55	5.26	3.11	1.64	.80	.36	.16
4.00	.33	2.19	3.96	4.24	3.40	2.26	1.32	.70	.35	.16
5.00	.09	.75	1.62	2.01	1.83	1.37	.88	.51	.28	.14
6.00	.02	.23	.60	.85	.E7	.72	.51	.33	.19	.10
7.00	.01	.07	.20	.33	.38	.35	.27	.19	.12	.07
8.00	.00	.02	.07	.12	.15	.16	.13	.10	.07	.04
9.00	.00	.01	.02	.04	.06	.07	.0e	.05	.03	.OP
10.00	.00	.00	.01	.01	.02	.03	.03	.02	.02	.01

CHI-SQUARE= 8.18239 CELLS USED= 10(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01814	.07807	.13617	.17303	.19212	.20093	.20472	.20628	.20690	.20715
2.00	.03564	.16811	.31348	.41656	.47534	.50480	.51836	.52426	.52672	.52771
3.00	.04271	.21231	.41311	.56656	.66044	.71061	.73509	.74629	.75118	.75323
4.00	.04495	.22911	.45634	.63808	.75463	.81988	.85320	.86910	.87631	.87945
5.00	.04557	.23472	.47273	.66788	.79664	.87101	.91021	.92953	.93857	.94264
6.00	.04573	.23644	.47843	.67925	.81384	.89303	.93566	.95716	.96746	.97220
7.00	.04577	.23694	.48029	.68332	.82045	.90196	.94640	.96914	.98022	.98540
8.00	.04578	.23708	.48087	.68470	.82286	.90541	.95073	.97412	.98563	.99109
9.00	.04578	.23711	.48104	.68515	.82371	.90670	.95241	.97612	.98786	.99347
10.00	.04578	.23712	.48109	.68530	.82400	.90716	.95304	.97690	.98875	.99444

Observed **and** Expected **(Gamma)** Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	8	15	19	33	44	28	2
EXPECTED	.27069	2.56744	7.94353	15.77473	24.28909	30.89946	32.50697	25.98669	9.78140

CHI-SQUARE= 5.55562 CELLS USED= 6(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00180	.01892	.07188	.17704	.33897	.54497	.76168	.93479	1.00000
SECTOR PROBABILITY	.00180	.01712	.05298	.10516	.16193	.20600	.21671	.17311	.06521

Table A20. Observed and Expected (Gamma) Cell Counts, VAFB Transition, Jimsphere, 12 km, Wavelength Range, 420–2470 m, Non-dimensionalized $|u'|$ and L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lu} * L_u$

$B\|u'\| * \|u'\|$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5	8	3	6	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0
2	0	5	10	8	7	5	6	3	1	0	0	1	0	0	0	0	0	0	0	0
3	0	0	6	6	4	8	3	0	0	0	0	1	1	0	0	0	0	0	0	0
4	0	0		8	4	7	1	0	1	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	2	5	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .2119 γ_1 = 2.4196 γ_2 = 4.3057 η = .2826

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.48	3.30	5.W	5.62	4.19	2.65	1.50	.78	.39	.18
2.00	.65	5.12	9.56	10.18	8.14	5.48	3.29	1.81	.84	.46
3.00	.38	3.25	6.60	7.83	6.57	4.73	3.01	1.76	.%	.50
4.00	.17	1.57	3.48	4.33	4.00	3.07	2.08	1.28	.73	.40
5.00	.07	.67	1.60	2.14	2.11	1.78	1.23	.EO	.48	.27
6.00	.02	.a	.68	.97	1.02	.88	.66	.45	.28	.17
7.00	.01	.10	.27	.42	.46	.42	.33	.24	.16	.10
8.00	.00	.04	.10	.1t	.20	.19	.16	.12	.08	.05
9.00	.00	.01	.0b	.07	.08	.08	.07	.06	.0y	.03
10.00	.00	.00	.01	.03	.03	.04	.03	.03	.02	.01

CHI-SQUARE= 1.12193 CELLS USED= 8(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00302	.02501	.06289	.10033	.12827	.14592	.15590	.16IIC	.16370	.16492
2.00	.00736	.06352	.16511	.27041	.35265	.40684	.43872	.45603	.46487	.46919
3.00	.00989	.08771	.23333	.38948	.51551	.60122	.65320	.68224	.69750	.70514
4.00	.01102	.09932	.26813	.45317	.60589	.71208	.77790	.81547	.83562	.84592
5.00	.01147	.10422	.28109	.48302	.64983	.76750	.84152	.88440	.90775	.91986
6.00	.01163	.10614	.29012	.49593	.66955	.79308	.87150	.91738	.94262	.95584
7.00	.01168	.10684	.29264	.50122	.67793	.80425	.88490	.93236	.95862	.97249
8.00	.01170	.10710	.29358	.50330	.68134	.80896	.89065	.93889	.96570	.97990
9.00	.01171	.10718	.29393	.50410	.68269	.81087	.89305	.94166	.96873	.98311
10.00	.01171	.10721	.29405	.50439	.68322	.81162	.89402	.94281	.97001	.98447

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	9	24	35	32	38	9
EXPECTED	.12377	1.64281	5.73031	12.15244	20.15559	28.53286	34.73003	32.96639	13.96580

CHI-SQUARE= 5.76571 CELLS USED= 8(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00083	.01178	.04998	.13100	.26537	.45559	.68712	.90689	1.00000
SECTOR PROBABILITY	.00083	.01095	.03820	.08102	.13437	.19022	.23153	.21978	.09311

Table A21. observed and Expected (Gamma) Cell Counts, VAFB Transition, Jimsphere, 12 km, Wavelength Range, 420–2470 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Counts within Square8

Observed Cell Count

sample Size = 150

$B_{Lv} * Lv$

B |v'| * |v'|	1	a	3	4	5	6	7	a	9	10	11	12	13	14	15	16	17	18	19	20
1	4	13	5	4	1	3	0	a	0	0	0	0	0	0	0	0	0	0	0	0
a	1	a	7	12	3	5	a	a	0	0	0	0	0	0	0	0	0	0	0	0
3	0	11	12	5		2	2	0	1	0	0	0	0	0	0	0	0	0	0	0
	0	0	6	5	5	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0
5	0	0	7	4	2	1	0	1	0	0		0	0	0	0	0	0	0	0	0
e	0	0	3	6	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

P = .2063 γ_1 = 2.4816 γ_2 = 3.3918 n = .2412

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	1.56	5.70	6.25	4.49	2.62	1.36	.65	.29	.13	.05
2.00	2.52	9.90	11.77	9.14	5.N	3.17	1.81	.77	.35	.15
3.00	1.62	6.91	8.96	7.55	5.11	3.02	1.63	.a3	.40	.18
4.00	.79	3.65	5.14	C.67	3.39	2.13	1.22	.65	.33	.16
5.00	.3%	1.68	2.56	2.50	1.93	1.29	.78	.44	.23	.12
6.00	.13	.71	1.17	1.22	1.00	.71	.45	.28	.14	.08
7.00	.05	.29	.50	.56	.49	.36	.24	.15	.09	.05
0.00	.02	.11	.21	.25	.22	.17	.12	.08	.05	.03
9.00	.01	.04	.0e	.10	.10	.08	.06	.04	.0a	.01
10.00	.00	.02	.03	.04	.04	.04	.03	.02	.01	.01

CHI-SQUARE= 16.89024 CELLS USED= 8(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 51

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01041	.04419	.09003	.11048	.13747	.14691	.15082	.15277	.15361	.15396
c.00	.02721	.13118	.25176	.34212	.39788	.42803	.44306	.45011	.45348	.45496
1.00	.03800	.18804	.36788	.50903	.59881	.64912	.67503	.68759	.69341	.69601
4.00	.04325	.21763	.43172	.60406	.71641	.78095	.81501	.83192	.83985	.84362
5.00	.04549	.23108	.46226	.65125	.77648	.84962	.88888	.90871	.91838	.92273
0.00	.04638	.23672	.47571	.67284	.80474	.88060	.92485	.94644	.95698	.96195
7.00	.04670	.23896	.48131	.68218	.81733	.89758	.94144	.96402	.97512	.98040
0.00	.04682	.23982	.48358	.68606	.82270	.90413	.94880	.97189	.98331	.98876
9.00	.04686	.24014	.48443	.68763	.82493	.90690	.95196	.97532	.98690	.99145
10.00	.04688	.24025	.48476	.68824	.82583	.90804	.95329	.97677	.98843	.99303

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	8	34	17	27	31	22	10
EXPECTED	.02250	5.43818	12.17956	18.90127	24.57522	28.35350	28.72930	22.87175	8.13043

CHI-SQUARE= 16.53787 CELLS USED= 7(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00548	.04172	.12292	.24893	.41277	.60179	.79332	.94580	1.00000
SECTOR PROBABILITY	.00548	.03624	.08120	.12601	.16383	.18902	.19153	.15248	.05420

Table A22. Observed and Expected (Gamma) Cell Counts, VAFB Summer, Jimsphere, 12 km, Wavelength Range, 90-420 m
Non-dimensionalized |u'| or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lu} • Lu

B |u'| * |u'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	3	1	6	5	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	5	8	10	14	4	4	1	1	0	0	0	0	1	0	0	0	0	0	0
3	0	2	1	3	1	0	9	6	3	3	1	2	1	0	0	0	0	0	0	0
4	0	0	1	2	2	5	3	2	1	3	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	2	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	1	0	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3090 γ_1 = 2.5139 γ_2 = 5.0005 η = .4358

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.17	1.97	4.37	5.07	4.21	2.87	1.72	.94	.48	.24
2.00	.22	2.85	7.26	9.52	8.81	6.59	4.28	2.52	1.37	.70
3.00	.10	1.58	4.64	6.93	7.20	5.96	4.23	2.68	1.56	.85
4.00	.04	.64	2.18	3.69	4.28	3.90	3.01	2.06	1.29	.75
5.00	.01	.23	.88	1.67	2.15	2.14	1.80	1.32	.88	.54
6.00	.00	.07	.32	.68	.96	1.05	.95	.75	.53	.35
7.00	.00	.02	.11	.26	.40	.47	.46	.39	.30	.20
8.00	.00	.01	.04	.09	.16	.20	.21	.19	.15	.11
9.00	.00	.00	.01	.03	.06	.08	.09	.09	.07	.06
10.00	.00	.00	.00	.01	.02	.03	.04	.04	.03	.03

CHI-SQUARE= 5.80508 CELLS USED= 61(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00117	.01428	.04344	.07722	.10529	.12444	.13593	.14222	.14545	.14703
2.00	.00263	.03471	.11227	.20950	.29628	.33939	.39942	.42248	.43485	.44112
3.00	.00331	.04583	.15429	.29774	.43252	.53535	.60356	.64450	.66720	.67925
4.00	.00356	.05033	.17333	.34141	.50472	.63355	.72185	.77653	.80709	.82484
5.00	.00363	.05191	.18075	.35998	.53759	.68071	.78098	.84448	.88172	.90229
6.00	.00365	.05241	.18339	.36715	.55120	.70131	.80792	.87643	.91724	.94014
7.00	.00365	.05256	.18427	.36975	.55646	.70972	.81941	.89052	.93330	.95757
8.00	.00366	.05261	.18455	.37064	.55839	.71298	.82407	.89645	.94024	.96524
9.00	.00366	.05262	.18463	.37094	.55907	.71420	.82588	.89884	.94312	.96851
10.00	.00366	.05262	.18466	.37103	.55930	.71464	.82657	.89977	.94428	.96985

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	3	5	17	28	48	44	5
EXPECTED	.01551	.43428	2.56805	7.90330	17.38792	29.41591	39.41712	37.90742	14.80870

CHI-SQUARE= 10.60759 CELLS USED= 61(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00010	.00300	.02012	.07335	.18913	.38524	.64802	.90074	1.00000
SECTOR PROBABILITY	.00010	.00290	.01713	.05322	.11578	.19611	.26278	.25272	.09926

Table *A23.* Observed and Expected **(Gamma)** Cell Counts, **VAFB** Summer, Jimsphere, 12 km, Wavelength Range, 90–420 m
Non-dimensionalized $|v'|$ or L_v

Observed and Expected **(Gamma)** Counts within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * Lv$

B |v'| • |v'|	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0	12	5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	11	7	5	a	3	3	0	0	0	1	0	0	0	0	0	0	0	0	0
3	0	a	10	e	7	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0
4	0	2	1	0	6	1	I	I	0	0	0	0	0	0	0	0	0	0	0	0
5	0	2	2	2	2	1	I	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	I	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
e	0	0	I	0	I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3368 γ_1 = 2.4416 γ_2 = 3.3521 η = .3947

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	2.21	7.07	6.77	4.27	2.20	1.01	.43	.18	.07	.03
2.00	2.89	10.96	12.44	9.12	5.35	Z.N	1.29	.57	.24	.10
3.00	1.48	6.74	9.09	7.74	5.17	2.97	1.54	.74	.34	.15
4.00	.58	3.10	4.89	4.77	3.59	2.29	1.30	.68	.33	.IS
5.00	.20	1.23	2.24	2.98	2.07	1.46	.90	.51	.27	.13
6.00	.06	.45	.93	1.15	1.06	.82	.55	.33	.19	.10
7.00	.02	.15	.36	.49	.50	.42	.30	.20	.12	.07
8.00	.01	.05	.13	.20	.22	.20	.15	.11	.07	.04
9.00	.00	.02	.OS	.OB	.09	.09	.07	.OS	.04	.02
10.00	.00	.00	.02	.03	.04	.04	.03	.03	.02	.01

CHI-SQUARE= 9.32636 CELLS USED= 9(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.01471	.06183	.10696	.13544	.15013	.15688	.15975	.16092	.16138	.16156
8.00	.03399	.15421	.28229	.37154	.42189	.44693	.45838	.46333	.46538	.46620
3.00	.04388	.20901	.39768	.53851	.62331	.66814	.68985	.69972	.70400	.70579
4.00	.04772	.23349	.45477	.62741	.73613	.79620	.82657	.84096	.84745	.85027
5.00	.04902	.24298	.47921	.66835	.79090	.86068	.89706	.91485	.92312	.92682
6.00	.04943	.24636	.48877	.68557	.81521	.89043	.93047	.95047	.95999	.96435
7.00	.04955	.24748	.49228	.69236	.82534	.90334	.94539	.96670	.97701	.98181
8.00	.04958	.24785	.49351	.69491	.82935	.90868	.95175	.97379	.98455	.98961
9.00	.04959	.24796	.49393	.69583	.83088	.91080	.95438	.97677	.98778	.99300
10.00	.04960	.24799	.49406	.69616	.83145	.91162	.95542	.97800	.98913	.99444

Observed and Expected **(Gamma)** Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: **150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	1	12	16	27	34	30	29	1
EXPECTED	.51017	4.08583	10.85150	18.95504	26.28489	30.68856	29.88631	21.78320	6.95448

CHI-SQUARE= 3.35038 CELLS USED= 6(I.E..CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	10	20	30	40	50	60	70	80	90
CUMULATIVE PROBABILITY	.00340	.03064	.10298	.22935	.40458	.60917	.80842	.95364	1.00000
SECTOR PROBABILITY	.00340	.02724	.07234	.12637	.17523	.20459	.19924	.14522	.04638

Table A24. Observed and Expected (Gamma) Cell Counts, VAPB Summer, Jimsphere, 12 km, wavelength Range, 420–2470 m, Non-dimensionalized $|u'|$ or L_u

Observed and Expected (Gamma) Counts within Squares

Observed Cell Count

Sample Size = 150

B_{Lu} • Lu

B | u' | * | u' |	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	8	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	11	11	9	10	6	1	1	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	9	9	7	3	0	1	2	0	0	0	0	0	0	0	0	0	0	0
4	0	1	2	9	5	3	2	2	0	0	0	1	0	0	0	0	0	0	0	0
5	0	0	1	2	4	2	~	1	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	2	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0
7	0	0	1	4	1	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 7	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0
1 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1 9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3578 γ_1 = 2.6448 γ_2 = 3.8826 η = .4335

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	93	4 39	5 34	3 95	2 29	1 15	53	23	10	.04
2.00	1 37	7 66	11 08	9 54	6 30	3 54	1 79	84	37	.16
3.00	71	4 85	8 41	8 47	6 41	4 05	2 27	1 16	56	.25
4.00	27	2 21	4 54	5 28	4 53	3 20	1 97	1 10	57	.28
5.00	09	86	2 05	2.72	2 62	2 05	1 38	84	47	.24
6.00	03	30	82	1 24	1 33	1 14	84	55	33	.18
7.00	01	10	31	52	61	58	46	33	21	.12
8.00	00	03	11	20	26	27	23	18	12	08
9.00	00	01	04	07	11	12	11	09	07	04
10.00	00	00	01	03	04	05	05	04	03	.02

CHI-SQUARE. 6 41015 CELLS USED= 8(I E ,CELL COUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00622	03552	.07113	.09746	.11271	.12040	12393	12547	.12611	.12637
2.00	.01532	.09567	.20512	29503	.35228	.38358	39907	.40621	40934	.41067
3.00	.02009	.13276	.29827	.44467	.54462	60292	63352	.64841	65526	.65827
4.00	.02191	.14934	.34510	.52673	.65686	.73646	,78019	.80242	.81307	.81795
5.00	.02250	.15565	.36506	.56484	.71243	.80569	.85866	88649	.90027	.90677
6.00	.02268	.15782	.37273	.58077	,73724	83813	.89672	.92824	94423	.95196
7.00	.02273	.15852	.37547	.58696	.74752	.85226	.91394	.94764	.96502	.97359
8.00	.02274	.15873	.37640	.58924	.75155	85809	.92132	.95620	.97440	.98348
9.00	.02275	.15879	.37670	.59003	.75305	.86039	.92436	95983	.97847	.98784
10.00	.02275	.15881	.37679	.59030	.75360	.86126	.92556	.96132	,98018	,98970

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees Sample Size: 150

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	8	13	31	36	31	26	5
EXPECTED	.18233	2.27353	7.98986	16.80820	26.36406	33.12780	33.13930	23.46334	6.65151

CHI-SQUARE= 2.74946 CELLS USED= 7(I.E..CELL COUNTS GREATER THAN OR EQUAL 10 5)

EXPECTED DISTRIBUTION

ANGLE	10.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00122	.01637	.06964	.18169	.35745	.57831	.79923	.95566	1.00000
SECTOR PROBABILITY	.00122	.01516	.05327	.11205	.17576	.22085	.22093	.15642	.04434

Table A25. Observed and Expected (Gamma) Cell Counts, VAFB Summer, Jimsphere, 12 km, Wavelength Range, 420–2470 m Non-dimensionalized $|v'|$ or L_v

Observed and Expected (Gamma) Count8 within Squares

Observed Cell Count

Sample Size = 150

$B_{Lv} * Lv$

$B|v'| * |v'|$

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	4	9	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	3	8	2	5	2	4	2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	4	13	6	10	5	4	1	0	1	0	0	0	0	0	0	0	0	0	0
4	0	1	6	4	5	4	3	2	0	2	0	1	0	0	0	0	0	0	0	0
5	0	0	2	4	3	3	1	3	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	5	2	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
io	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Expected Cell Count

ρ = .3390 γ_1 = 2.9615 γ_2 = 4.1560 η = .4016

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.43	2.49	3.47	2.81	1.75	.93	.45	.20	.09	.04
2.00	.86	5.71	9.19	8.51	5.95	3.50	1.84	.89	.41	.18
3.00	.55	4.32	8.11	8.62	6.80	4.46	2.58	1.36	.67	.31
4.00	.25	2.25	4.88	5.90	5.21	3.78	2.39	1.37	.73	.36
5.00	.09	.97	2.41	3.21	3.22	2.56	1.76	1.09	.62	.33
6.00	.03	.37	1.05	1.60	1.73	1.50	1.12	.74	.45	.26
7.00	.01	.13	.42	.71	.84	.79	.64	.45	.29	.18
8.00	.00	.04	.16	.29	.38	.39	.33	.25	.17	.it
9.00	.00	.01	.06	.12	.16	.18	.16	.13	.io	.06
10.00	.00	.00	.02	.04	.07	.08	.08	.07	.05	.04

CHI-SOUARE' 5.56650 CELLS USED= 6(I.E., CELLCOUNTS GREATER THAN OR EQUAL TO 5)

Expected Cumulative Probability

	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
1.00	.00288	.01949	.04259	.06135	.07301	.07921	.08219	.08353	.08410	.08434
2.00	.00860	.06331	.14765	.22315	.27446	.30401	.31928	.32658	.32989	.33132
3.00	.01230	.09580	.23420	.36718	.46383	.52313	.55560	.57198	.57976	.58329
4.00	.01395	.11245	.28337	.45566	.58704	.67153	.71993	.74544	.75806	.76400
5.00	.01457	.11955	.30652	.50067	.65349	.75505	.81521	.84799	.86474	.87288
6.00	.01478	.12225	.31623	.52103	.68538	.79695	.86457	.90231	.92207	.93192
7.00	.01484	.12320	.31999	.52953	.69949	.81635	.88823	.92898	.95071	.96173
8.00	.01486	.12352	.32136	.53286	.70536	.82481	.89891	.94136	.96425	.97601
9.00	.01487	.12362	.32184	.53411	.70768	.82832	.90352	.94685	.97038	.98257
10.00	.01487	.12365	.32200	.53456	.70857	.82972	.90543	.94920	.97306	.98549

Observed and Expected (Gamma) Counts within Equal Area Sectors

Sector Size: 10 Degrees **Sample Size: 150**

	1	2	3	4	5	6	7	8	9
OBSERVED	0	0	5	24	26	35	33	26	1
EXPECTED	.16875	2.36625	8.62914	18.19024	28.08763	34.24971	32.55081	20.91976	4.63765

CHI-SOUARE- 4.79338 CELLS USED- 6(I.E.,CELL COUNTS GREATER THAN OR EQUAL TO 5)

EXPECTED DISTRIBUTION

ANGLE	io.	20.	30.	40.	50.	60.	70.	80.	90.
CUMULATIVE PROBABILITY	.00112	.01690	.07443	.19570	.38295	.61128	.82828	.96775	1.00000
SECTOR PROBABILITY	.00112	.01578	.05753	.12127	.18725	.22833	.21701	.13947	.03225