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THE LIMITATIONS OF THE CORRELATION METHOD

FOR

DETERMINING THE WIND INFLUENCE UPON MISSILES

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U. S. ARMY ORDNANCE MISSILE COMMAND

REDSTONE ARSENAL, ALABAMA

18 DECEMBER 1961 REPORT NO. RR-TR-61-35

THE LIMITATIONS OF THE CORRELATION METHOD FOR DETERMINING THE WIND INFLUENCE UPON MISSILES

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ABSTRACT

The correlation method utilizing the linear inter and intra-level correlation coefficients is limited by its nature for two reasons. Firstly, there is evidence that the relationship is non linear, but actually the linear part only is used. Secondly, the simultaneous occurrence of wind data in the individual case is not sufficiently considered by the correlation method.

A comparison with a newly developed "characteristics method" is performed. The latter proves superior to the correlation method.

It can be shown that the knowledge of the wind velocity at the jet stream layer is an essential parameter to successfully approach the individual profile analytically. For good achievements, the correlation method is restricted to the utilization of parameters from the jet stream layer. This is a further limitation. In contrast, the characteristics method promises successful application for a variety of parameter selections, even from the lower stratosphere. This is explainable by the connection of the individual profile with certain weather types whose reflections are found at all levels.

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I. INTRODUCTION

The representation of the wind profile in missile ballistics has been a topic since missile development began. It was not until recent years, however, when the accuracy of target hitting required a careful analysis of this problem.

The problem consists of two parts, namely the proper consideration of the wind influence for design purposes, and availability of information at the firing date.

Climatology is usually taken as the basis for design criteria. Information at the firing date may constitute no problem in times of peace, while during times of war ordinarily a prediction problem arises. It exceeds the intended frame of this report to discuss the various prediction tools. Briefly, climatology can solve both outlined problems to furnish design criteria and serve as prediction basis.

It is generally accepted that basic climatology in form of monthly mean values may eliminate the wind-drift effect on the missile as a first approximation with some success. Higher accuracy in target hitting in the particular case, however, requires an improved method.

One way of better approximation of the wind data in the individual case of firing has been shown by Court (2), Bieber (1) Trembath (7) and others by development of the correlation method. By its application the basic climatological data are stratified by utilization of the inter-and intra-level correlation coefficients of the wind velocity, usually zonal and meridional components.

The direct relation between the mean value matrix, the correlation matrix and the influence matrix of the flying body is indeed tempting to proceed on this way.

Otherwise, the correlation method by its nature cannot represent the individual profile adequately. The limitations and comparison with other advanced methods is therefore the objective of this report.

II. LIMITATIONS OF THE CORRELATION METHOD

II. A. The Meaning of the Linear Correlation Coefficient

There are two major objections to the correlation method. The first is the use of the linear correlation coefficient. There is evidence that the relations of wind components between various levels are nonlinear while in the correlation method only the linear portion is used. It is entirely understandable why this restriction is accepted. Statistical methods considering nonlinear influences are either not available or so complicated that their application is uneconomical.

The second objection lies in the meaning of the linear correlation coefficient. A correlation coefficient of 0.4 still means that only 16 percent (i.e., 0.4 times 0.4) of the data are related. For instance, study the relation of the zonal wind components between one level and another. If this coefficient is 0.4, then for any positive departure from the mean value (reference period) at the originating level a positive departure occurs simultaneously at the respective level in 16 percent of the data. In 84 percent, the departures from the mean value in the second level may be dominated by other events than the departure from the mean at the originating level. A correlation coefficient of $\geq |0.7|$ should be required to guarantee that at least 50 percent of the data are related. Examining publications of the correlation matrices, one recognizes how rarely those correlation coefficients appear.

II. B. The Simultaneous Occurrence of Wind Data

Still another feature of the correlation method may be discussed. The correlation coefficients between height levels are developed from data of two height levels while the wind profile contains numerous levels simultaneously. The simultaneous occurrence of departures from the reference point must be studied. Theoretically, the probability of having, for instance, a positive departure from the mean value for two simultaneous levels, each having a correlation coefficient of 0.4 to the basic height level, is only 16 percent times 16 percent which is approximately 3 percent.*)

This figure is usually exceeded, being increased by persistence. The actual probability will lie between the minimum of 3 percent without persistence and the maximum of 16 percent with full persistence. The probability will more likely be below the maximum of 16 percent. However, the probability for the likeness of the recomputed wind profile by the correlation method with the actually observed individual case will be smaller than the lowest correlation coefficient in the series. Although this does not reflect the complete true figure of evaluating the dissimilarity between the individual and the theoretical wind profile, it implies the limitations of the correlation method. An example may further explain the meaning of the simultaneous occurrence of departures from the reference point.

Assumed, at some level the wind velocity (direction and speed) would coincide with the monthly mean velocity. Consequently, due to the correlation concept, it is expected that the monthly mean profile for zonal and meridional wind component constitutes the profile in this event. Figures 1a and 1b demonstrates for the zonal and meridional wind component, respectively, the range between which actual wind observations can be found. The sample has been assembled from wind observations at Patrick AFB, Florida, during the January months from 1951 to 1957. The six cases have in common the observed wind velocity with the value of the monthly average at 12 km. The range is expressed by the envelope for the respective maximum or minimum wind component data of the six sample cases. An individual date, e.g. 18 January 1956, may lie between those extreme values. Figures 1a and 1b indicate therefore the field of variation, and the divergence between the actual profile and the profile expected from the correlation method. It may be emphasized that the presented sample of figures 1a and 1b delineates a sample of average profile conditions for which one ought to expect the best performance of statistical methods derived from averages.

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*) Footnote:

The probability of two simultaneous events follows by multiplication of the probability of both events.

Figure 2 illustrates the departure between observed profile (25 January 52) and the analytical profile by the correlation method in an extreme case. Although the correlation method yields a better approach to the observed conditions than the monthly mean profile the dissimilarity of the observed and analytical profile is obvious. The agreement at 12 km is forced because it was part of the assumption. Since the stratification parameter at 12 km refers to an extreme, the presented analytical profile illustrates the maximum deviation from the monthly mean profile which can be obtained by the correlation system. Obviously the adjustment is insufficient.

Other levels for determination of the profile can be added, for instance, at 5 km and 20 km. This may lead to further improvement. The net gain may still be doubtful. In a recent article Striebel and Bieber (6) came to the conclusion that "very little is gained by considering the most sophisticated or 'Best Linear Prediction' as opposed to the simplest".

At the same time additional (independent) observations of the actual profile are known. Consequently the number of unknown observations within the profile is decreased. Then probably simpler methods are available or the correlation method is no longer necessary because the profile required for missile firing is known.

III. COMPARISON WITH OTHER SYSTEMS

III. A. Mode of Comparison

A special computation of the departure of the missile from the target due to atmospheric effects by application of the various systems would best indicate the differences between methods. However, this comparison would be limited to the special type of missile for which it is derived, and figures would vary for various missile types. Therefore, the comparison of errors in this report may be based upon a general measurement expressing the goodness of fit. It can be assumed that the closer the observed profile is approached by analytical means, the smaller the departures of the missile from the target due to the wind influence will be. In principle, one ought to apply a weighting function to the differences between the observed and computed (theoretical) profile. A first survey, however, may neglect this weighting function.

The comparison of the systems is based upon two measures. First, the mean squared difference between the computed (analytical) wind profile (zonal and meridional component) and the observed wind profile is used. This mean squared difference is known as "left variance" and represents a measure to evaluate the discrepancy between the assumed and actual profile. It permits an evaluation of the divergence of analytical and observed profile without any consideration of the fact that, although the profiles diverge, the positive and negative departures from one another may balance.

The analytical profile may be a good approach, and may serve the intended purpose, although the mean squared difference yields a relatively high value. Therefore, a second measurement for evaluation is given in the algebraic sum of the differences between the observed and analytical profile divided by the number of respective levels. This sum is called the "mean integral departure".

III. B. The Characteristics Method

The deficiency and limitation of the correlation method to the development of a system which uses the wind profile on a particular day and derives characteristic coefficients for classification. The details are published in a separate report (4). It may be sufficient here to know that mathematical characteristics are derived either by curve fitting of the direction and speed profile or the zonal and meridional components. This depends upon the intended mission of the system.

The characteristics method causes some complication in relating the wind profile to the influence matrix but principally this problem can be solved. It is emphasized, however, that the simplicity of the method with listings in tabular form can prove advantageous in the tactical field application during wartime. While writing this report, a new method by James and Harris (5) for calculating the wind compensation was noted. This method disposes of the matrix system and employs the integrated wind profile instead. The developed "characteristics method" would ideally give the input data for this method.

It may be emphasized, in addition, that the new characteristics method can be modified so that the integral effect of the wind upon a special missile type is eliminated by one coefficient (characteristics), in other words, the integral departure is zero without the mean squared difference being zero. This set of characteristics, however, would be limited to one missile type only.

III. C. Comparison of Residuals

III. C. 1. Sample Selection

Patrick Air Force Base, Florida, in January with data from 1951 - 1957 served as the pilot station. Three levels for the stratification parameter have been selected at which the observed wind data met certain group conditions described below. The 3 km level was chosen to show the influence of a tropospheric layer above the ground layer. The 12 km level may unveil conditions created by the jet stream layer, and the 20 km level renders results influenced by lower stratospheric conditions. The test samples at these three levels constitute three depicted subgroups of data.

Subgroup (a) represents data in which the observed wind velocity at the level coincides with the monthly average wind velocity. In that case the monthly mean profile method and the correlation method led to the same wind profile.

The second subgroup (b) comprises data in which the zonal component of the observed wind coincides with the zonal component of the monthly mean velocity at that particular level, but the meridional component of the observed wind velocity differs from the meridional component of the monthly mean wind velocity at the particular level. A one-parameter model for the correlation method, using the intra-level correlations, would yield the same result as the mean monthly profile, but a two-parameter model (zonal and meridional component) would improve the agreement between analytical and observed profile when applying the correlation method.

The third and last test group (c) consists of cases in which the wind velocity at the particular levels took extreme values for westerly winds. This subgroup displays maximum possible benefit in the utilization of the correlation method compared with the mean profile method. Although this group selection is not a random data selection, it fills the purpose of evaluation. It favors the correlation method in so far as it is known that the correlation method should be better for the extreme cases compared with the mean profile method. If a further improvement would become evident by employing the characteristics method, the conclusion could be drawn that the characteristics method excells the correlation method.

Otherwise, if one assumes that mean conditions would be best met by the correlation method, one finds a sample thereof. Thus, the selection of the test samples is a handicap for the characteristics method rather than any favorable selection. Four terms of the polynomial series for direction and two terms of the Fourier series for speed constitute the analytical profile. For the component analysis four polynomial terms are utilized.

III. C. 2. Detailed Listings of Sample Data

Results of the comparison of residuals are exhibited by Tables 1A and 1B. It ought to be mentioned that the characteristics method, besides the sample selection, is hampered in this comparison by comparing zonal and meridional component of the wind velocity. The curve fitting process for deriving the characteristics was performed for both wind direction and speed data. If it were known that zonal and meridional components only are needed, then a direct curve fitting process of the profiles of wind components rather than speed and direction would further improve the closeness of fit in case of the characteristics method, and the result would even more delineate the superior qualities of the characteristics method. This will be shown later in the summary result (Table 3).

Table 1A contains the comparison between monthly mean profile (MM), correlation (CO) and characteristics method (CHA) for the mean squared difference and detailed subgroups. The table is self-explanatory. The first columns contain the group selection and the others the resulting differences of the analytical profile.

It is noticeable that the three listed figures under MM, CO and CHA for the combined zonal plus meridional components show practically no difference for subgroup (a). Since the correlation method and the monthly mean deliver identical profiles, as described in the previous section, the identical figure for both systems is understandable. No improvement with the characteristics method is accomplished, as the figure in the first column under CHA delineates. The analytical profiles for group (a) at 3, 12 and 20 km were obtained by averaging the computed characteristics within the entire subgroup. This resembles the computation of the monthly mean profile by mixing of several profile types and disregards fully the potential of the characteristics method.

Inspection of the characteristic coefficients revealed that this first subgroup was not uniform and homogeneous as it appeared for the correlation method. This is no way to recognize any divergence of the profiles by the correlation method, except in turning to a more sophisticated model of multiple stratification parameters.

The characteristics method, however, showed that the sample for the first subgroups consists of profiles whose distinction is as follows: In the 3 km level group one profile proved to be different from the others. In the 12 km group classification into two parts was obvious, and in the 20 km group even 3 profile types seemed present. Utilizing these features, and computing mean coefficients for those subparts reduced the error as listed by the figure in parenthesis under CHA. It may be added that only a restricted number of coefficients (namely four) was used for the characteristics method.

Subgroup (b) displays a similar result. The figures for the monthly mean profile and the correlation method differ only slightly from one another, although this subgroup (b) employs a second stratification parameter, the meridional component at the level selection. This introduction of the second condition is already sufficient to render visible improvements for the characteristics method. It can be best recognized in Table 2 below, where the groups (b) and (c) have been summarized and the difference is expressed in percentage of the difference for the mean profile MM.

TABLE 2

Summary of Reduction in Groups b and c for the Correlation Method and the Characteristics Method

Level Selection	Group	CO	CHA
3 km	b	101%	72%
	c	68	42
12 km	b	84	69
	c	54	32
20 km	b	101	50
	c	93	62

Consider first group b. The correlation method displays its best response for the 12 km level selection, where the maximum profile speed occurs. Surprisingly, the largest difference reduction for the characteristics method with regard to the correlation method is accomplished for the 20 km level selection. There is, however, no statistical significance between the figures of the 3 level selections in case of the characteristics method due to the small sample size. The differences may be caused by excellent profile fits of single cases, like direction 10, speed 10 and direction 14, speed 10 at the 20 km level selection. (See detailed table 1A).

However, the last subgroup (c), which comprises the extreme cases, indicates a noticeable improvement by the correlation method for 3 km and 12 km level selection. The smallest differences are obtained for level selection in the jet stream layer. Caution is again necessary with the interpretation, as knowledge of the wind velocity at a level of extreme speed and variation contributes to the reduction compared with the difference of the mean profile.

Again, the characteristics method proves best and yields even response for level selection in the stratosphere. With some caution an explanation in physical terms may be stated as follows: It is a well-known fact that correlations between stratosphere and troposphere are generally poor. Thus, level selection at the 20 km level contributes little to actual wind profile representation by the correlation method. The derived correlation is too complex to respond in case of individual samples.

This is different for the characteristics method. The wind profile seems to depend upon weather systems which may still have relations to stratospheric effects, as reflected in departures from the mean condition at 20 km. Therefore, a classification of the vertical profile appears possible and is expressed by the reduction of the characteristics method compared to the mean profile.

Table 1B contains the comparison between the three discussed methods with regard to the mean integral departure. The result resembles the derived details of Table 1A, and shall not be further described here.

III. C. 3. Summary of Results

The detailed presentations of Tables 1A and 1B may now be summarized for a better review. It is understandable that the figures would differ somewhat from the presented values of tables 3, if the complete set of data in January were applied. Nevertheless, the chosen groups permit an objective evaluation of the question of the superior method.

The mean squared difference (table 3A) is discussed first. The column under MM displays the mean squared difference for the monthly mean profile prediction of the three level groups 3 km, 12 km, and 20 km. The 12 km value appears largest, which is an effect of sample selection. The mean squared difference were equal for the complete set of January data. Again, the mean squared difference for the mean profile method is taken as reference of comparison, and is defined to be 100%.

The correlation method (column with heading CO) delineates a considerable reduction of the mean squared difference for the 12 km group, while the 3 km and 20 km groups show little response. This is, as mentioned, not only a consequence of better relation of the profile to the jet stream layer, but partly a result of reduction of the difference by knowledge of the wind velocity in layers of maximum wind and variability. Therefore, a considerable part of the departure is eliminated if the wind velocity at jet stream layer is known.

The characteristics method (CHA) is represented by three columns in Table 3. The first figure under column 1 summarizes the result employing the alike group divisions of the monthly mean and correlation method. Column 2 utilizes the potential of the characteristics method and splits the first group (a) into subparts as feasible to the characteristics, and described in the previous section. The last column (3) displays the result from curve fitting of the zonal and meridional component. Contrary to the correlation method, the characteristics method responds also to knowledge of the wind in other layers, as the result for the 3 km and 20 km group demonstrates (column CHA). Again, the best approach is obtained with stratification parameters from the jet stream layer (12 km level). The difference from other levels, however, is far less than with the correlation method. In the additional columns the results of the characteristics method are similar, but show reduced magnitudes due to better fitting.

The last column of table 3A indicates the mean squared difference under the assumption that no wind exists, in other words: neglection of the wind influence at all. It can be seen that for the selected sample cases the employing of the mean wind profile as predictor would have decreased the difference already considerably.

This conclusion holds only for the particular example given in this report. It cannot be generalized for all climatic regimes. Therefore, some caution is justified with respect to the absolute values displayed by tables 3.

Table 3B exhibits the result with consideration of the mean integral departure. The results resemble that derived for table 3A and are not repeated here.

IV. CONCLUSION

The correlation method utilizes the inter-and intra-level correlation coefficient to appraise the wind influence upon a missile. It has been discussed in this report that the non-linear part of the wind relation is generally neglected and that the correlation coefficients for sufficient efficiency should be at least 0.7. Else the coefficient is too weak to properly represent the wind profile and express its instantaneous occurrence. At the present state the wind profile is composed of horizontally derived variates and the simultaneous occurrence of wind data is generally neglected. Besides these physical reasons demanding the development of a new method, the correlation method by its complex matrix employment is very elaborate and needs bigger computer facilities for operational work.

The second part of the report elaborates on the comparison of the correlation method with two other systems, the monthly mean profile and a recently developed "characteristics method".

Sample cases of days in January at Patrick AFB (Florida) have been selected with the following assumptions:

(a) The observed wind velocity at a certain level coincides with the monthly mean velocity.

(b) The zonal component of the wind velocity at a certain level coincides with the zonal component of the monthly mean velocity.

(c) The observed wind speed takes an extreme for westerly winds of the zonal component.

Three levels were chosen for the above conditions, 5 km in the lower troposphere, 12 km in the jet stream layer, and 20 km in the stratosphere. Although the selection of the test samples cannot render final figures which would be representative for the complete set of January data, it permits a survey of the trend of the differences to eliminate the wind influence

It can be seen from tables 1A and 1B that the correlation method responds best for level selections in the jet stream layer, while for stratospheric levels, such as 20 km, this method is practicsily useless. This was expected, as correlation between stratosphere and troposphere is very complex and cannot simply be expressed by level wind correlations. Level selection in the lower troposphere helps only partly to account for the wind influence over the accomplishments of the mean profile method.

The characteristics method follows the same tendency as the correlation method since jet stream layer reference proves to be the best stratification parameter. A noticeable reduction of the departures in comparison to the mean profile method, however, can be obtained with other level selections too. This is explainable by the fact that the wind profile as such is connected with certain types of weather situations with typical values at all levels. Such individual types can be represented by the characteristics method, but obviously are lost by the correlation method.

V. REFERENCES

1. Bieber, R. E.
   Missile Structural Loads by Nonstationary Statistical Methods
   Lockheed Missile and Space Division Technical Report
   LMSD 49 703 (1957)

2. Court A.
   Vertical Correlations of Wind Components
   Scientific Report No. 1, Contract AF 19 (604) - 2060 (1957)

3. Essenwanger, Oskar
   The Wind Profile in Atmospheric Ballistics Problems
   Manuscript to be published in a scientific magazine.

4. Essenwanger, Oskar
   On the Mathematical Characteristics of Individual Wind Profiles
   Manuscript to be published in ABMA Reports (1961)

5. James, R. L. and Harris, R. J.
   Calculation of Wind Compensation for Launching of Unguided
   Rockets; NASA Technical Note D-645 (1961) p 1 - 52. (1961)

6. Striebel, C. T. and Bieber, R. E.
   Prediction of Upper Air Winds Over Cape Canaveral
   Bull. Am. Meteor. Soc. Vol 42 p 522 - 526 (1961)

7. Trembath, N. W.
   Control System Design Wind Criterion
   Electronics Laboratory, Space Technology Laboratory (1958)

TABLE 1A

Comparison Between Monthly Mean Profile Method (MM), Correlation Method (CO), and Characteristics Method (CHA). Mean Squared Difference in $(m/sec)^2$

Level Selection	Group	Sub Group dd	v	n	Methods MM Zon.	MM Merid.	CO Zon.	CO Merid.	CHA Zon.	CHA Merid.	MM Combined	CO Zon. + Merid.	CHA Zon. + Merid.		No Wind Assumption Zon.	No Wind Assumption Merid.
3 km	a	12	9	7	55	33	55	33	54	36	88	88	90	(53)	408	34
	b	11	9	2	72	32	72	31	56	24	104	103	80		579	28
		13	10	2	75	33	75	30	43	32	108	105	75		728	31
		14	10	2	155	130	155	140	118	87	285	195	205		722	140
	c	11	28	1	118	117	51	133	34	69	235	184	103		849	96
		12	20	1	129	33	85	33	48	43	162	118	91		786	29
		12	21	1	123	70	58	70	22	38	193	128	60		897	61
		13	26	1	382	75	199	79	77	111	457	278	188		1445	63
12 km	a	12	36	6	39	34	39	34	47	42	73	73	89	(54)	462	30
	b	11	39	2	65	64	65	40	25	67	129	105	92		638	52
		13	39	2	54	119	54	96	35	81	173	150	116		489	126
	c	12	66	1	289	67	116	65	53	58	356	181	111		1311	51
		12	67	1	250	15	157	15	49	30	265	172	79		1120	35
		12	71	1	222	34	93	35	52	21	256	128	73		1327	239
		12	72	1	186	135	95	135	33	137	321	230	170		1051	15
		11	79	1	305	266	96	141	64	67	571	237	131		977	137
20 km	a	12	6	9	109	56	109	56	100	62	165	165	162	(135)	634	69
	b	10	10	1	82	90	82	120	12	34	172	202	46		300	101
		11	8	5	52	67	52	78	47	42	119	130	89		387	60
		13	8	4	74	42	74	35	25	32	116	109	57		240	48
		14	10	1	129	97	129	61	6	4	226	190	10		174	111
	c	12	25	1	235	31	150	32	70	24	266	182	94		1096	32
		11	16	2	103	53	90	50	83	34	156	140	117		694	48
		12	15	5	88	67	89	68	54	44	155	157	98		395	72
		13	13	1	65	38	67	35	24	53	103	102	77		674	30

dd = wind direction in 16 points, v = wind speed, n = number of observations

TABLE 12

Comparison Between Monthly Mean Profile Method (MM), Correlation Method (CO), and Characteristics Method (CHA). Mean Integral Departure in m/sec

Level Selection	Group	Sub Group dd	v	n	Methods MM Zon.	MM Mer.	CO Zon.	CO Mer.	CHA Zon.	CHA Mer.	MM Comb.	CO Zon. + Mer.	CHA Zon. + Mer.		No Wind Assumption Combined
5 km	a	12	9	7	2.0	2.7	2.0	2.7	2.0	2.7	2.3	2.3	2.3	(1.5)	9.6
	b	11	9	2	4.5	2.5	4.5	2.4	2.0	3.5	3.5	3.4	3.2		11.2
		13	10	2	3.9	1.7	3.9	1.6	1.7	0.2	2.8	2.8	1.0		11.6
		14	10	[illegible]	6.0	6.5	6.0	6.4	6.0	4.7	6.2	6.2	5.4		12.6
	c	11	28	1	5.7	6.7	1.0	7.6	.8	1.2	6.2	4.3	1.0		14.6
		12	27	1	[illegible]	2.6	0.4	2.6	.2	.5	4.0	1.5	.4		12.4
		12	21	1	6.8	4.0	2.1	4.0	.2	.2	5.4	3.0	.2		13.8
		13	36	1	10.7	1.1	5.2	1.4	.1	.8	5.9	3.3	.4		14.6
10 km	a	12	36	6	1.3	1.7	1.3	1.7	1.3	2.0	1.5	1.5	1.6	(1.0)	9.1
	b	11	39	2	2.0	3.5	2.0	1.1	0.6	0.5	2.7	1.6	0.5		11.1
		13	39	2	1.8	4.2	1.8	4.2	2.0	4.2	3.0	3.0	3.0		11.6
	c	12	66	1	11.4	4.8	4.2	4.5	1.2	4.9	8.1	4.4	3.0		16.5
		12	67	1	3.7	.2	3.7	.0	1.1	.5	2.0	1.8	.8		13.3
		12	71	1	7.2	1.8	1.1	2.0	3.0	1.7	4.5	1.6	2.4		20.2
		12	72	1	4.4	2.4	4.2	2.6	.4	1.8	3.4	3.4	1.1		10.6
		11	79	1	12.5	11.1	3.8	6.7	.9	.1	11.8	5.2	.5		12.2
20 km	a	12	6	9	4.1	3.0	4.1	3.0	4.4	3.5	3.5	3.5	3.9	(3.5)	10.7
	b	10	10	1	4.5	1.1	4.5	4.0	1.2	.0	2.8	4.2	.6		7.1
		11	8	5	2.7	5.8	2.7	5.0	2.7	3.6	4.2	3.8	3.2		10.7
		13	8	4	3.4	4.0	3.4	3.5	2.3	2.9	3.7	3.4	2.6		9.1
		14	10	1	5.1	6.9	5.1	4.2	.4	.2	6.0	4.6	.3		9.7
	c	12	25	1	12.6	.9	9.1	1.0	.2	.7	6.8	5.1	.4		15.6
		11	16	2	3.9	2.4	3.9	2.4	3.9	2.4	3.1	3.1	3.1		11.5
		12	15	5	2.2	3.6	3.2	2.7	2.9	2.0	2.9	3.4	2.4		13.1
		13	13	1	1.8	1.4	1.1	.4	.2	.2	1.6	.8	.2		10.5

dd = wind direction in 16 points, v = wind speed, n = number of observations

TABLE 3

Summary of Comparison Between Monthly Mean Profile (MM) Correlation (CO) and Characteristics (CHA) Method. The Last Column Indicates the Difference by Assumption of No Wind.

A) Mean Squared Difference

Level Selection		n	MM	CO	CHA 1	CHA 2	CHA 3	Negl.
3 KM	Mean Squared Difference	17	156	137	105	90	77	693 m^2 sec^{-2}
	Percentage	-	100	88	67	58	50	444%
12 KM	Mean Squared Difference	15	187	126	101	87	79	788 m^2 sec^{-2}
	Percentage	-	100	67	54	46	42	420%
20 KM	Mean Squared Difference	29	152	149	106	98	91	553 m^2 sec^{-2}
	Percentage	-	100	98	70	65	60	365%

B) Mean Integral Departure Per Profile

Level Selection		n	MM	CO	CHA 1	CHA 2	CHA 3	Negl.
3 KM	Integral Departure	17	3.7	3.1	2.2	1.8	1.7	11.4 m sec^{-1}
	Percentage	-	100	85	60	50	47	308%
12 KM	Integral Departure	15	3.3	2.2	1.6	1.5	1.2	11.5 m sec^{-1}
	Percentage	-	100	67	49	45	35	345%
20 KM	Integral Departure	29	3.7	3.6	2.8	2.7	2.3	10.5 m sec^{-1}
	Percentage	-	100	97	77	73	64	287%

CHA (1) Grouping alike MM and CO
CHA (2) Grouping with Subparts in group a (see text)
CHA (3) Curve fitting of profiles in zonal and meridional component

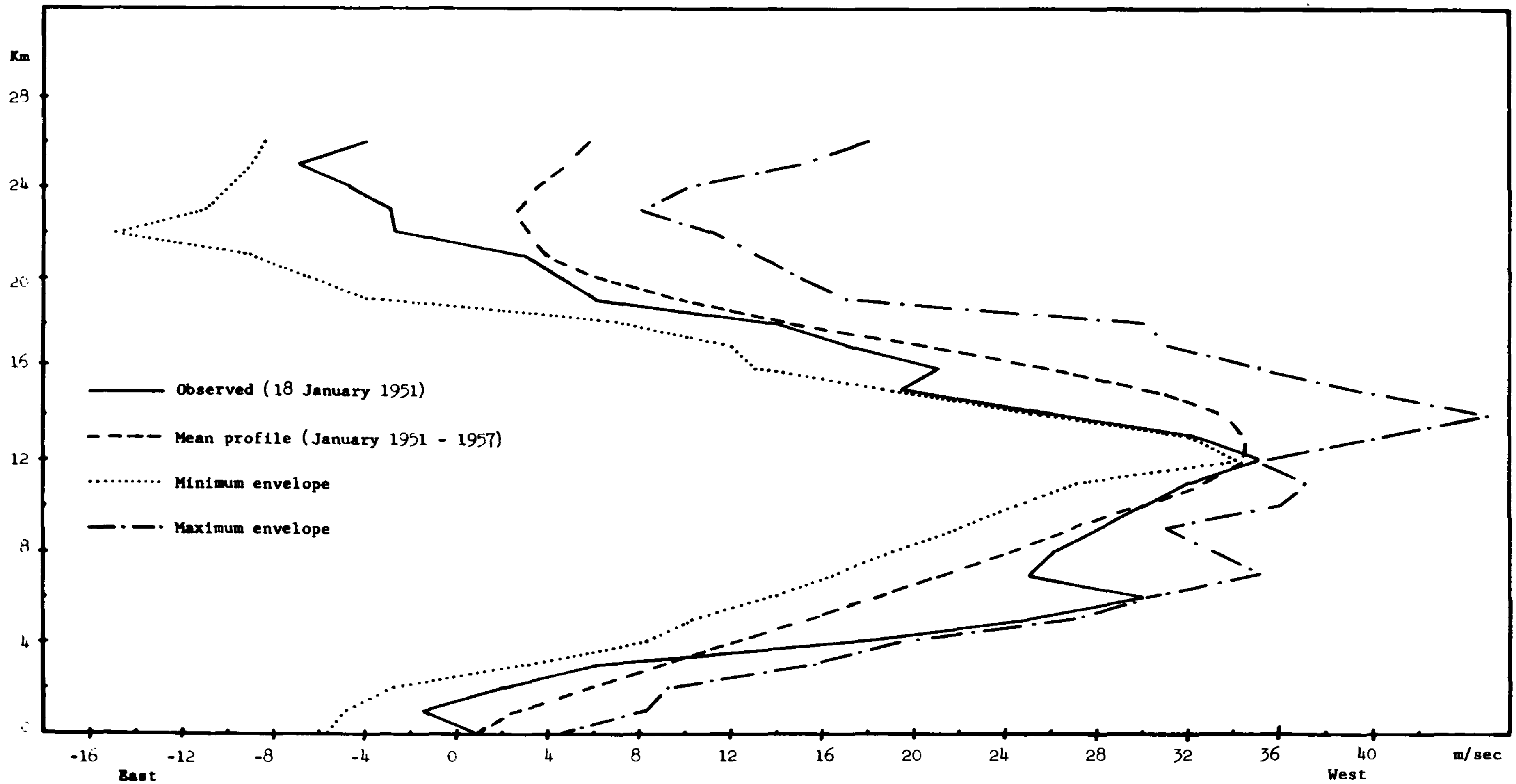

Figure 1A	Empirical boundaries of zonal wind speed for selected profiles of 34.5 m/sec zonal and -1.6 m/sec meridional speed at 12 Km, January 1951 - 1957 at Patrick AFB

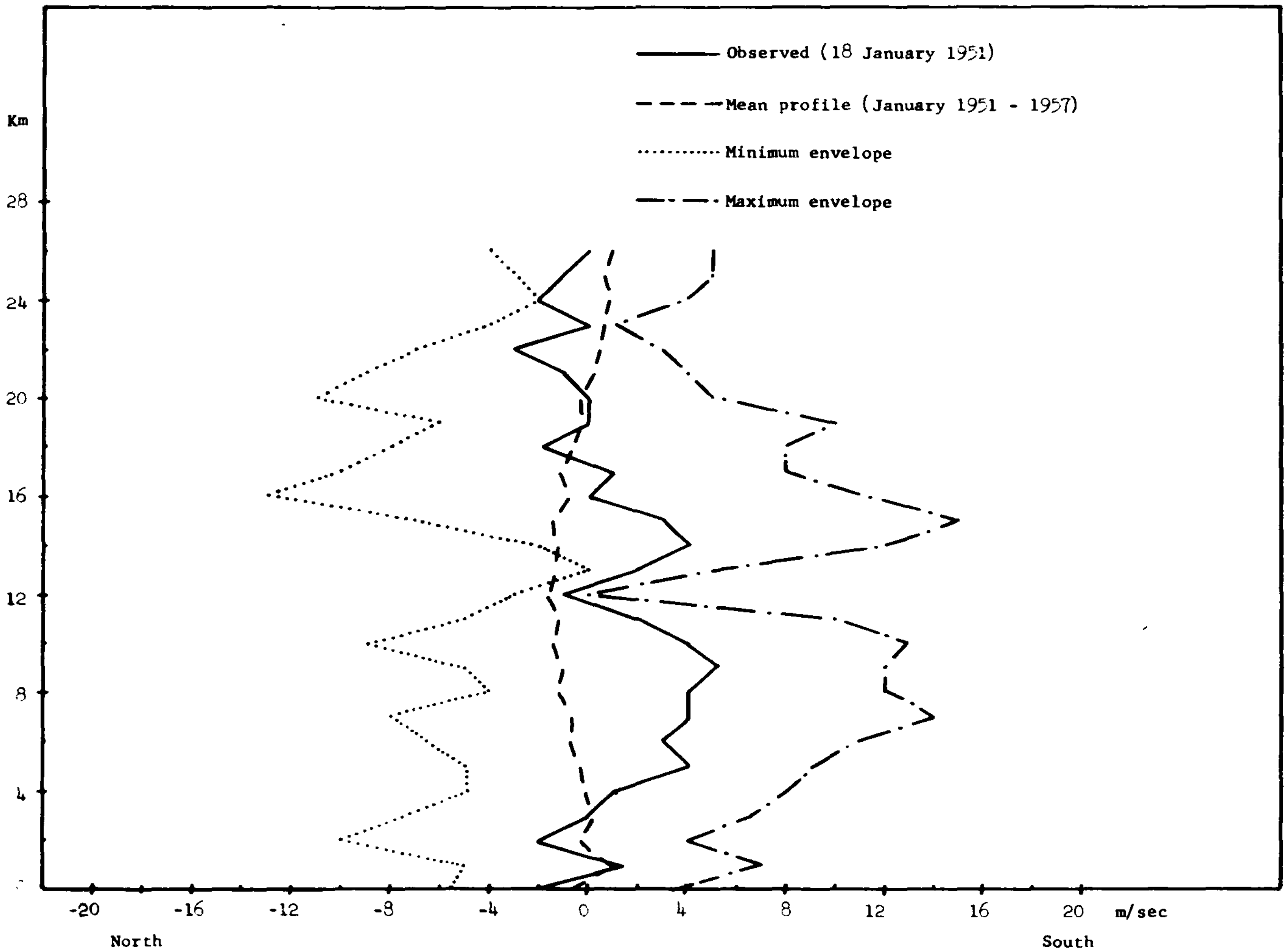

Figure 1B	Empirical boundaries of meridional wind speed for selected profiles of 34.5 m/sec zonal and -1.6 m/sec meridional speed at 12 Km, January 1951 - 1957 at Patrick AFB

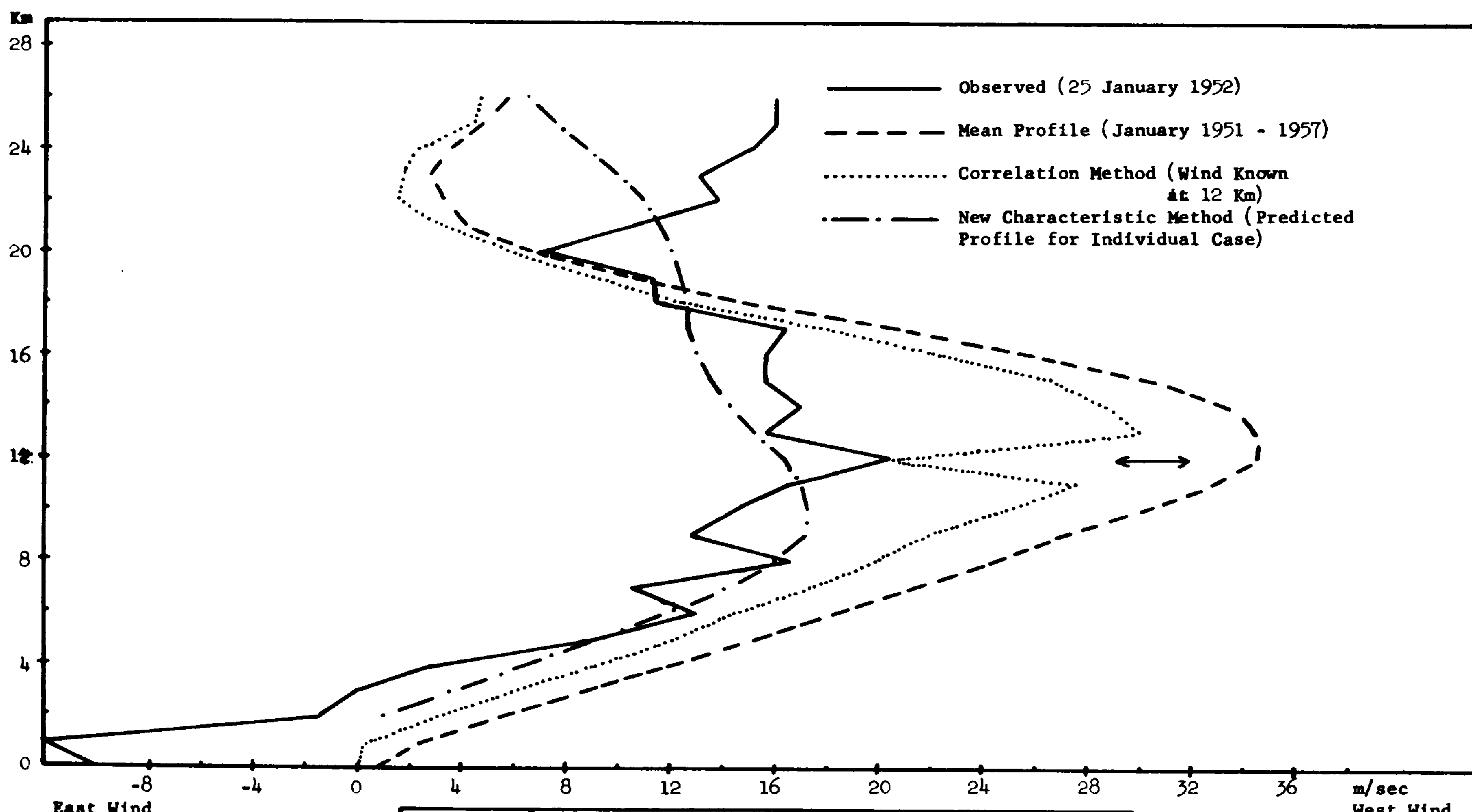

Fig. 2	Zonal Wind Component 25 January 1952 Patrick AFB

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APPROVAL:

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