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AN IMPROVED DIAGNOSTIC MODEL FOR ESTIMATING
WIND ENERGY

By
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SRI International
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SUMMARY

The purpose of the computer model COMPLEX is to determine whether a specific site has sufficient wind energy to merit installation of wind-measuring equipment and collection of data over a representative period of time. The model has been developed at SRI International under sub-contract to Pacific Northwest Laboratory as part of the Department of Energy (DOE) Wind Energy Program (Wendell et al. 1981).

Two previous reports (Bhumralkar et al. 1980, Endlich et al. 1980) described the rationale for the model and gave examples of its application. In addition, the latter report included program listings and instructions for users of the model. The present report describes further changes that have been made to improve the model's accuracy and to simplify the computations. The method for computing nondivergent winds has been reformulated to avoid the objection that earlier versions had neglected certain minor terms in the equations used. Program listings are given in the Appendix.

The accuracy of the new model has been determined for three localities that were studied previously. The results are compared in the following tabulation:

COMPARISON OF NEW AND EARLIER RESULTS

Site	Annual Average Wind Speed ($m\ s^{-1}$)				
	Measured	Model		Improvement	Error Remaining
		Previous	New		
Clayton, New Mexico	7.6	5.8	6.2	0.4	1.4
San Geronio, California	8.0	7.2	7.7	0.5	0.3
Block Island, Rhode Island	7.5	7.0	7.5	0.5	0.0

The values shown are annual average wind speeds for 1977 (additional comparisons appear in Section III). The increased accuracy is comparable for all three sites; the overall performance of the model is improved to a modest degree.

The model represents a quantitative, objective method for using historical weather reports and terrain height information to assess potential wind energy. The high cost of wind turbines requires that actual measurements be used to verify the economic potential at specific sites identified by model computations as being promising.

ABSTRACT

Because wind data are available only at scattered locations, a quantitative method is needed to estimate the wind resource at specific sites where wind energy generation may be economically feasible. This report describes a computer model that makes such estimates. The model uses standard weather reports and terrain heights in deriving wind estimates; the method of computation has been changed from what has been used previously. The performance of the current model is compared with that of the earlier version at three sites; estimates of wind energy at four new sites are also presented.

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I. INTRODUCTION

There are many localities where winds may be strong enough to make the installation of wind turbines economically feasible. Wind data from the National Weather Service (NWS) network are available only at scattered locations (frequently airports), most of which are not exceptionally windy. Therefore, quantitative methods are needed that use the NWS data to estimate the winds at the sites of interest. Sherman (1978)* developed a method to do this using the continuity equation. At SRI, Bhumralkar et al. (1980) extended this method using a terrain-following coordinate system. The terrain heights, variable from point to point, form the base of the mesh.

Ludwig and Byrd (1980) introduced the use of an eigenvector analysis to represent a long series of wind reports from the closest NWS stations. The wind flow model COMPLEX is run for the mean wind components at the stations and for each of the principal eigenvectors. In each run the initial winds at all mesh points are estimated. These initial winds are adjusted to be nondivergent, thereby introducing the effects of the terrain on the velocity field (viz. the flow tends to speed up over higher terrain and pass around obstacles in a realistic manner).

Improvements to the method were made by Endlich et al. (1982); these included use of the geostrophic wind to represent the flow in the upper part of the boundary layer. The simulated wind statistics were compared to measured data at seven sites. These comparisons showed generally good agreement; however, two deficiencies in the technique were isolated. The research reported here remedies these deficiencies.

The first deficiency was most apparent in dealing with data from the area surrounding Clayton, New Mexico, where the afternoon boundary layer is more than 2 km deep. In the model, the geostrophic wind (computed from surface pressure data for the locality) was used to estimate the initial winds at the top of the boundary layer (which is the top of the model domain). When the boundary layer is unusually deep, this approach produced too-low wind speeds at levels near the surface. This has been changed by limiting to 1 km or less the height at which the geostrophic wind is applied.

The second deficiency in the previous technique was in the mathematical formulation of the equations used to compute the nondivergent winds. These equations had first been used by Sherman (1978) in a

*References are listed at the end of the report.

Cartesian (x,y,z) coordinate system. To facilitate use of this technique over complex terrain, Bhumralkar et al. (1980) adapted the equations for a terrain-following coordinate system (x,y,σ) . In the process, some minor terms in the (x,y,σ) form of the equations were ignored. Because these terms are important only in a few regions where the terrain is uncommonly steep, they are not of general significance. Nevertheless, it is desirable to avoid this simplification, and we have done so by using a different method to compute the nondivergent winds.

The computational concept is to test each elemental volume defined by the grid mesh to determine whether inflow and outflow are equal. If so, the local flow is nondivergent; if not, the wind components are altered slightly to produce nondivergence. The volume elements have sigma surfaces as their upper and lower boundaries, and it is assumed that the flow is parallel to these surfaces. The alterations to the winds are also controlled to preserve the vertical component of vorticity. The computational technique is explained in Section II. The new computer program that includes these changes is named COMPLEX-2; it replaces the earlier program COMPLEX.

The COMPLEX-2 program has been applied to the 1977 data for San Geronio, California; Clayton, New Mexico; and Block Island, Rhode Island. In Section III, the new results are compared with those achieved using COMPLEX. Section IV presents wind energy estimates for four new sites: Goodnoe Hills, Washington; Meade, Kansas; Pacheco Pass, California; and Stratton Mountain, Vermont. Section V gives a summary and the conclusions of this research. A listing of most of the programs is included as the Appendix to this report. The use of the complete package of programs for applying terrain and weather data is unchanged (except for the substitution of COMPLEX-2 for COMPLEX) from the procedure described in Appendices A and B of Endlich et al. (1980).

II. NEW PROCEDURES

A. Application of the Geostrophic Wind

As noted in Section I, study of our previous results indicated that a more realistic estimate of winds in regions of interest could be obtained by changing the application of the geostrophic wind. Previously, the geostrophic wind was assumed to apply at the boundary layer top, which may range from 300 to 2000 m above ground level. Also, winds from standard weather stations were analyzed at anemometer height (conventionally 6 m in recent years). Between the anemometer height and the top of the boundary layer, winds were interpolated by applying a logarithmic wind profile with height. This procedure produces smooth changes of both wind speed and direction with height, with the largest shear near the ground. In the new version, we specify that the geostrophic wind applies at a certain height (called GTHK in Subroutine INWND) unless the boundary layer top at that point is less than GTHK; in that case, the geostrophic wind applies at the lower height. The result is that the principal terrain effects on the wind profile are concentrated in the layer immediately above the terrain, rather than allowing these effects to be stretched over a deep layer (e.g. the afternoon boundary layer at Clayton). Experimentation with this concept indicates that GTHK is site-dependent; it should be largest where terrain is rough and where heating is very strong. We have used a range of values from 500 to 850 meters.

B. Solution for Nondivergent Winds

The use of terrain-following coordinates (sigma surfaces) has been explained in our earlier reports. A volume element of the grid mesh is shown in Figure 1. The upper and lower surfaces of the elements are (constant) σ surfaces; the vertical separation between them is known over the mesh. We assume there is no flow through the sigma surfaces. [This assumption is analagous to the use by Sherman (1978) and Rhumralkar et al. (1980) of an empirical coefficient to keep vertical wind components very small.] Thus, the flow into or out of a volume element takes place through the vertical faces; i.e., it is due entirely to the horizontal u and v wind components. The flux through a face is equal to the u component (or v component, as appropriate) multiplied by the vertical separation Δz between σ_1 and σ_2 . (In general, this vertical separation varies from point to point.) Let $u^* = u\Delta z$ and $v^* = v\Delta z$ so that the winds are weighted by the vertical separation. Then, for a volume element, the divergence is

$$D = \partial u^* / \partial x + \partial v^* / \partial y \quad . \quad (1)$$

FIGURE 1. Volume elements of the grid mesh. The wind components in the x-direction (arrows) indicate net outflow. For nondivergence this must be compensated by net inflow in the y-direction (not shown).

Similarly, the vertical component of vorticity is

$$\xi = \partial v^* / \partial x - \partial u^* / \partial y \quad . \quad (2)$$

The concept of making the local flow nondivergent by altering wind components is that given by Endlich (1967) and several other investigators, including Liu and Goodin (1976), Chen (1980), and Goodin et al. (1980). The basic idea is as follows: Suppose that there is net convergence into a volume element owing to greater inflow than outflow. This can be corrected by decreasing the wind components on inflow faces and increasing those on outflow faces. The changes to wind components needed to produce nondivergence in a volume element are usually quite small, and the formulas have been given in the references noted above. These changes tend to disturb the original vorticity; therefore, additional changes are made to neighboring wind components to restore the original vorticity for that element. Volume elements are treated in sequence and 10 to 15 passes through the grid are required to reduce the divergence (whether positive or negative) to very small magnitudes while retaining the original vorticity field.

In using this technique in the COMPLEX-2 program, the flow in any layer can be made nondivergent independently of the flow in neighboring layers. Thus, the layers of the grid mesh can be treated in sequence. This makes the computations simpler than the three-dimensional relaxation process previously used in COMPLEX. The subroutine that performs these computations is called BAL5; a listing is included in the Appendices.

C. Specifying the Boundary Layer Top

The use of a boundary layer top that varied in height above terrain from point to point has been described by Endlich et al. (1980). These heights were computed in an iterative manner, based on three parameters specified by the user:

- the average thickness of the boundary layer in the area of interest (obtained from climatological data given by Holzworth 1972)
- the desired slope of the boundary layer top
- the minimum thickness over mountain peaks (if any are present).

This formulation generally worked well; however, it was not able to reproduce some features of the boundary layer top. In particular, in the vicinity of coastlines, the boundary layer top has a general slope from ocean to lower values over land at night, with the reverse situation (higher values over land than ocean) in the daytime. To provide greater flexibility, we have introduced two additional parameters that permit one to specify west-to-east and south-to-north gradients in the slope of the boundary layer top. The parameters are included in the iterative computation. The computer code for this subroutine (SETBLT) is included in the Appendix.

III. EVALUATION OF NEW PROCEDURES

Three sites were selected to compare results obtained with the old and new models: San Gorgonio Pass, California; Clayton, New Mexico; and Block Island, Rhode Island. These three sites represent a variety of weather regimes. Maps for these sites, showing the local weather stations and major terrain features, are included in Endlich et al. (1980). In that report, we described the use of the COMPLEX program to determine hub-height winds for the typical weather patterns (eigenvectors) at these sites, and to calculate the wind speed and direction at three-hour intervals for the year 1977. In the present study, we replaced COMPLEX with the new program COMPLEX-2 and repeated the computations. The values of various parameters used in the computations are given in Table 1.

A. San Gorgonio, California

The measuring site at the eastern end of the San Gorgonio Pass is close to rugged terrain and subject to strong thermal contrasts between the Los Angeles Basin and the interior desert. Weather reporting stations are all distant from the site.

In making the initial flow nondivergent, the BALWIND program makes changes in u or v wind components as large as 4 m s^{-1} in some areas of the grid. This is caused by the roughness of the terrain and the variations in boundary layer thickness. The measured annual wind speed at the PNL measuring site for 1977 was 8.0 m s^{-1} ; the COMPLEX-2 model predicts 7.7 m s^{-1} , compared to 7.2 m s^{-1} predicted by COMPLEX. The breakdown by seasons (Figure 2) shows that in winter the new simulated speeds are considerably higher than measured, and that the error is increased slightly in comparison with the earlier simulations. (Most of these speeds are below the cut-in threshold of approximately 6 m s^{-1} for large wind generators.) In spring, the simulated speeds are lower than measured by several meters per second, and the measured evening speed maximum is not well represented. The daytime speeds are greater (and more accurate) than the earlier results. In summer there is also improvement in the simulations for the daytime hours, while in autumn the results are similar to the previous ones. Figure 3 shows that there is somewhat improved accuracy in the new frequency distributions at the upper end of the speed range in comparison to the previous results.

In summary, the results for San Gorgonio show that the new model is somewhat more accurate than the old model on an overall basis and that the exceptionally strong winds of spring (presumably resulting from thermal gradients intensified by the high mountains on both sides of the

TABLE 1. Wind Measuring Sites, Grids, Boundary Layer Parameters for the Day/Night, and Data Stations

Site	Grid Sizes (km)	Day/Night Boundary Layer						Height Where Geostrophic Wind Applies (m)	Data Stations and Year
		Average Thickness (m)	Slope Factor	Minimum Thickness (m)	West/East Gradient (m)	South/North Gradient (m)	Thickness at Site (m)		
San Geronio, CA 33.93°N, 116.58°W, 345 m ASL	10.0,2.5	1200/500	0.7/0.7	300/250	600/-200	400/-50	1316/539	500	Daggett, CA LA International Airport, CA Sandberg, CA Yuma, AZ (1977)
Clayton, NM 36.44°N, 103.20°W, 1533 m ASL	8.0,2.0	2600/450	1.2/1.0	500/250	-300/-50	0/-50	2594/440	500	Dodge City, KS Amarillo, TX Tucumcari, NM Pueblo, CO (1977)
Block Island, RI 47.17°N, 71.57°W, 9 m ASL	9.0, 3.0	1000/700	2.0/-1.0	300/300	-100/0	100/-50	906/850	500	Windsor Locks, CN Providence, RI Bridgeport, CN JFK International Airport, NY (1977)
Goodnoe Hills, WA 45.75°N, 120.56°W, 805 m ASL	6.0,1.5	1200/600	0.8/0.6	400/350	100/-50	0/0	1155/508	800	Pendleton, OR Portland, OR Dallesport, WA Yakima, WA (1964)
Meade, KS 37.30°N, 100.31°W, 759 m ASL	8.0,2.0	1600/450	1.1/0.9	500/350	-200/0	0/0	1598/452	500	Dodge City, KS Wichita, KS Amarillo, TX (1977)
Stratton Mtn, VT 43.09°N, 72.93°W, 1170 m ASL	5.0,1.25	1300/650	0.6/0.2	450/400	-50/0	50/-50	974/400	500	Worcester, MA Concord, NH Albany, NY Burlington, VT (1977)
Pacheco Pass, CA 37.07°N, 121.22°W, 458 m ASL	5.0,1.25	1100/700	0.9/0.7	450/400	200/-50	200/-50	1084/653	850	Fresno, CA Stockton, CA San Francisco, CA Salinas, CA (1964)

FIGURE 2. Seasonal and diurnal wind-speed curves for San Geronio, California, 46 m above ground, as simulated by the wind flow model and as measured at the site.

FIGURE 3. Frequency distributions of wind speed and direction for San Geronio, California, for model simulations and site measurements.

pass) are not well reproduced using the data from the widely scattered weather stations in the area. Probably the simulations would be different if weather reports from a station in the desert were available.

B. Clayton, New Mexico

The earlier results for Clayton gave an annual wind speed 1.8 m s^{-1} lower than the measured average speed of 7.6 m s^{-1} . (The measured data were incomplete and we used those data available to derive this estimate.) Because the terrain in the immediate area of Clayton is relatively flat, the corrections made to the initial winds to produce non-divergence (using the program COMPLEX-2) are all less than 0.2 m s^{-1} . Thus, this portion of the simulation is not of critical importance.

On the other hand, we expected that changing the application of the geostrophic wind (discussed in Section II-A) would lead to an improved simulation. As shown in Figure 4, this proved to be true only to a limited extent: The new results are closer to the measured values, but substantial errors remain. (The remaining error in annual average wind speed is 1.4 m s^{-1} .) In all seasons except summer, the model wind speeds are too low, particularly for the afternoons. We do not envision any further changes to BALWIND that would substantially alleviate this error; we believe that the residual error results from the lack of a weather reporting station close enough to Clayton to reveal local influences on the winds. A station to the west, toward the Rocky Mountains, would be particularly valuable. Figure 5 shows that the new frequency distribution of speeds is somewhat more accurate than the earlier results.

C. Block Island, Rhode Island

The previous simulation for 1977 at Block Island gave an annual average wind speed of 7.0 m s^{-1} ; the new simulated value is 7.5 m s^{-1} , which agrees exactly with the measured value. Seasonally, the main error is in the fall, when the simulated speeds are too low (Figure 6). The measured speeds have maximum values in the late afternoon or evening, whereas the simulated speed maxima occur in midafternoon. The frequency distribution of speeds (Figure 7) shows that the simulations have more high speeds (greater than 12 m s^{-1}) than found in the measured values. It is worth noting that the weather stations from which data are taken are all on the mainland and do not adequately reflect the oceanic influences that affect Block Island.

D. Summary

The results described above for the three sites show that the new program (COMPLEX-2) performs satisfactorily. It is somewhat more accurate than the previously used program COMPLEX, and can serve as a replacement for it. Other advantages in using COMPLEX-2 are improved computational efficiency and avoidance of certain mathematical

FIGURE 4. Seasonal and diurnal wind-speed curves for Clayton, New Mexico, as simulated by the wind flow model and as measured at the site.

FIGURE 5. Frequency distributions of wind speed and direction for Clayton, New Mexico, for model simulations and site measurements.

FIGURE 6. Seasonal and diurnal wind-speed curves for Block Island, Rhode Island, as simulated by the wind flow model and as measured at the site.

FIGURE 7. Frequency distributions of wind speed and direction for Block Island, Rhode Island, for model simulations and site measurements.

simplifications that are used in COMPLEX. Program COMPLEX-2 applies the geostrophic wind at a different height above ground than did COMPLEX. This usage produced an improvement of 0.4 to 0.5 m s⁻¹ in the simulated annual average wind speeds. Use of the new program gives improved estimates of overall frequencies of speeds, as well as annual average speeds. On the other hand, when using widely scattered standard weather reports for initial conditions, COMPLEX-2 does not capture local winds that are probably the result of thermal influences, as in the case of the strong springtime winds at San Corgonio Pass. Diurnal patterns are not represented very well for the same reason.

IV. APPLICATION TO NEW SITES

A. Goodnoe Hills, Washington

The location of the wind measuring site (now occupied by three Boeing MOD-2 wind generators) is shown in Figure 8, along with the locations of the nearest weather stations. The site is at an elevation of 805 m (2640 ft) on the crest of hills north of the Columbia River. The weather data for 1964 were chosen for the model simulations because reports from Dallesport and Yakima (both reasonably close) were available for that time. Information about the computer runs is given in Table 1.

FIGURE 8. Location of Goodnoe Hills, Washington, and nearest weather stations.

The geostrophic winds for this site were computed from sea-level pressure reports from Yakima, Dallesport, and Pendleton. Figure 8 shows that these three stations form a regular triangle and that the site is located fairly close to the center of the triangle. Thus, the stations are well distributed. The geostrophic vectors (computed in Program GEOCAL) are generally rather strong but are otherwise in good agreement with the observed surface winds at the three stations. Thus, the geostrophic winds are suitable for use in Program BALWIND. The mean geostrophic wind for the year 1964 is from 297° at 11.6 m s^{-1} . This relatively strong wind is a major factor in producing high wind speeds in the simulation for the site.

For the parameter GTHK (the height above ground where the geostrophic wind applies), we initially chose a value of 500 m, at the lower end of the expected range. The simulations produced an annual average wind speed greater than 9 m s^{-1} , which was obviously too strong when compared to the regional analysis for this area given by Elliott and Barchet (1980). The simulation was repeated with GTHK set at 800 m, toward the upper end of the expected range, and this produced values shown below that we believe to be fairly accurate.

The nondivergent calculation changes u or v components up to 2.0 m s^{-1} . The results are shown in Figure 9. The simulated annual average wind speed is 8.3 m s^{-1} . (There are no site measurements for comparison for the year 1964.)

Because the night-to-day and day-to-night transitions occur abruptly in the model, we have fitted the diurnal points in Figure 9 with smooth curves to remove this effect. The wind speed distribution (Figure 10) shows that 35% of the winds are higher than 10 m s^{-1} ; thus, the results show that this site is quite windy. The strongest winds of the simulation are predominantly from the west to northwest.

B. Meade, Kansas

The terrain around Meade is flat and the site is at an elevation of 759 m (2490 ft). The site and nearest weather stations are shown in Figure 11. The Dodge City station is only 60 km (36 mi) from the site, which is relatively close. The parameters used in the simulations are given in Table 1.

To obtain the geostrophic winds for this site, we used the triangle of stations consisting of Dodge City, Amarillo, and Wichita. Figure 11 shows that the center of this triangle is somewhat to the southeast of the site. The time history of geostrophic winds (calculated in Program GEOCAL) was generally in good agreement with the measured surface winds. The mean annual geostrophic wind vector is from 190° at 6.1 m s^{-1} . We selected a value of 500 m (corresponding to uniform terrain) for GTHK, and this produced the results shown below.

FIGURE 9. Seasonal and diurnal wind-speed curves for Goodnoe Hills, Washington, as simulated by the wind flow model.

FIGURE 10. Frequency distributions of wind speed and direction for Goodnoe Hills, Washington, for model simulations.

FIGURE 11. Location of Meade, Kansas, and nearest weather stations.

Because the terrain is regular and the boundary layer top has a gradual slope, the initial winds are altered to only a slight extent (less than 0.3 m s^{-1} at any grid point) in making the flow nondivergent. The results of the simulations for 1977 are shown in Figure 12. The simulated annual average wind speed 46 m above the ground is 7.9 m s^{-1} with the highest speeds in spring. Figure 13 shows the cumulative frequency diagram. Wind speeds are greater than 10 m s^{-1} approximately 28% of the time, and the strongest winds are predominantly from the southwest. The simulations indicate that this site is a moderately windy one, in agreement with the analysis by Edwards et al. (1981).

C. Stratton Mountain, Vermont

Stratton Mountain is a prominent peak in southern Vermont. The wind-measuring site is at an elevation of 1177 m (3860 ft) on a ridge just north of the summit. Data from four weather stations (Figure 14) were available for 1977 from this region (see Table 1). Naturally, all of them are at elevations considerably lower than the site. The parameters used in the simulations are given in Table 1. We selected values of boundary layer thickness and slope similar to those used previously (Endlich et al., 1980) for Mt. Tom, near Holyoke, Massachusetts.

FIGURE 12. Seasonal and diurnal wind-speed curves for Meade, Kansas, as simulated by the wind flow model.

FIGURE 13. Frequency distributions of wind speed and direction for Meade, Kansas, for model simulations.

FIGURE 14. Location of Stratton Mountain, Vermont, and nearest weather stations.

The geostrophic winds at Stratton Mountain were computed using pressure reports from Burlington, Albany, and Concord (there were many missing reports at Worcester). Figure 14 shows that the center of this triangle (which is the point where the pressure gradient is most representative) is somewhat to the north of the site. The time series of geostrophic winds for 1977 has values that are in good agreement with the measured surface winds at the three stations; hence, the geostrophic winds are satisfactory. The annual average geostrophic wind vector is from 280° at 16.1 m s^{-1} . This high value is believed to be reasonable for this site because storms pass by at all times of year. Since the thermal influences at the site are not believed to be particularly strong, we used a value of 500 m for the parameter GTHK. Alterations to original u or v wind components to make the flow nondivergent are as large as 2 m s^{-1} .

Figure 15 shows the results of the simulations. The annual average wind speed is 12.2 m s^{-1} , and the highest speeds occur in the winter as storms pass by. We believe that these values are reasonable in comparison to measurements at Mt. Washington, New Hampshire. On this mountain (a 1910-m peak) measurements over many years show an annual average wind speed of 16 m s^{-1} . The cumulative frequency curve for Stratton Mountain (Figure 16) shows that speeds greater than 10 m s^{-1} occurred approximately 54% of the time, indicating that the site is extremely windy. The analysis by Pickering et al. (1980) indicates much lower speeds, e.g., an annual average of approximately 8.0 m s^{-1} for southern Vermont. Very probably their regional estimates do not apply specifically to the highest peaks (such as Stratton Mountain) where wind speeds would be greatest. It is also worth noting that because of its elevation, the site is subject to significant amounts of snow and ice that interfere with wind measurements and would undoubtedly have large adverse effects on wind generators.

D. Romero Overlook, California

The Romero Overlook site is north of the Pacheco Pass at an elevation of 458 m (1504 ft). This pass through low mountains joins the coastal valleys (subject to marine air) with the interior San Joaquin Valley (hot and dry in summer). The location of the site in relation to the nearest weather stations is shown in Figure 17, and the parameters used in the model simulations are shown in Table 1. Weather data were selected for 1964.

We used the triangle formed from Salinas, Fresno, and Stockton in computing geostrophic winds. Inspection of the weather reports for these stations showed that the sea-level pressure values at Salinas were generally several millibars higher than those at the other two stations (both of these are in the thermal low produced by the heating of the San Joaquin Valley). Because of the large pressure differential, the geostrophic winds have very large northwesterly components: for example, computed speeds greater than 30 m s^{-1} are frequent in summer. The annual average geostrophic wind vector is from 328° at 20.5 m s^{-1} . This extremely high value is dictated by the pressure reports. We made simulations using a relatively large value of 850 m for CTHK because of the rough terrain and large thermal influences.

The model results are shown in Figure 18. The simulated annual average wind speed is 9.9 m s^{-1} , with strongest winds in the summer. The hourly simulated speeds at the site in July are as large as 24 m s^{-1} . These values are much stronger than those shown for this area by Simon et al. (1980), who give an estimated annual average speed in the range from 7.5 to 8.0 m s^{-1} . The simulations are believed to be inaccurate because of the exceptionally strong geostrophic speeds, as mentioned earlier. Figure 19 shows the cumulative frequency diagram, with simulated wind speeds greater than 10 m s^{-1} approximately 8% in 1981. The most frequent direction of strong winds is from the northwest to north.

FIGURE 15. Seasonal and diurnal wind-speed curves for Stratton Mountain, Vermont, as simulated by the wind flow model.

FIGURE 16. Frequency distributions of wind speed and direction for Stratton Mountain, Vermont, for model simulations.

FIGURE 17. Location of Romero Overlook, California, and nearest weather stations.

This simulation for Romero Overlook has revealed a weakness in the use of the surface geostrophic wind to represent the wind at the top of the boundary layer. This weakness is believed to be due to the strong and persistent temperature gradients from Salinas to the heated interior valley that accompany the strong pressure differences of the warmer months of the year. The temperature gradient can be interpreted in terms of a thermal wind, i.e., as a shear of the geostrophic wind. The shear vector is parallel to the isotherms with cold air to the left, and in summer it is of appreciable magnitude and is directed to the north. Therefore, for a large part of the year the geostrophic wind vector at the top of the boundary layer is substantially weaker than the values we used.

In retrospect we see that a simple method would correct for the thermal wind, as follows. The thermal wind can be computed at three-hour intervals using the surface temperature values for the same three stations used to compute geostrophic winds. Then it can be assumed that the thermal shear exists over a certain vertical interval, such as 500 m. This gives a shear vector that can be subtracted from the

FIGURE 18. Seasonal and diurnal wind-speed curves for Romero Overlook, California, as simulated by the wind flow model.

FIGURE 19. Frequency distributions of wind speed and direction for Romero Overlook, California, for model simulations.

surface geostrophic vector to give the geostrophic wind vector aloft. This corrected value represents the initial geostrophic wind in the upper layer of the model. In the output of wind statistics, this correction would only be important at places such as Romero Overlook and probably also San Gorgonio Pass where temperature gradients are strong and persistent. However, the amount of computation involved to obtain thermal winds is small, so the calculation could be made a standard feature of the GEOCAL program.

E. Application of the Technique

In earlier SRI studies, the programs were written in FORTRAN IV for a CDC 6400 computer. The programs TERRAIN and GRIDHT, which process terrain heights (obtained on magnetic tape from the National Cartographic Information Center), use machine-dependent procedures in READ and WRITE statements. These procedures cannot be easily translated for other computers. Therefore, in making computations for the four sites discussed above, these two programs were run on the CYBERNET system, which simulates the KRONOS operating system of the CDC 6400. The remainder of the programs (viz. GEOCAL, XFORM, COMPLEX-2, REWND, and WINDY) were run on SRI's VAX-11/782 computer, which has replaced the CDC 6400 at SRI. Only minor changes to these programs were needed to make the transfer feasible. A block diagram of these programs and listings for each of them are given in the Appendices.

Detailed information for potential users of the wind energy programs is given in Endlich et al. (1980) and will not be repeated here. A user interested in only a few sites might find it more efficient to obtain terrain height values by hand from appropriate maps than to obtain terrain tapes and modify the program for another computer, as mentioned above. The process of obtaining terrain heights by hand can be facilitated by computing the latitude and longitude of the grid points using the standard FORTRAN code provided for this purpose in Program GRIDHT.

The wind analysis methodology depends on the time history of the geostrophic winds at the site of interest. In principle, there is no difficulty in this, because the geostrophic wind is given directly by the local pressure gradient. This gradient can be calculated from values of sea-level pressure at the three weather stations closest to the site. (As mentioned earlier, this computation is made by program GEOCAL.) In practice, the geostrophic wind speeds computed by GEOCAL should be inspected to ensure that they are reasonable. Calculated geostrophic wind speeds that are consistently very much higher or lower than the nearest observed winds direct suspicion on the appropriateness of the surface geostrophic wind in representing the wind at the top of the boundary layer. For a site similar to Romero Overlook where there are strong and persistent low-level temperature gradients, the surface geostrophic wind should be corrected with the thermal wind; however, the

computer code to do this has not been formulated yet. At most sites, the surface geostrophic winds are suitable for the application that has been made.

F. Summary

The revised wind flow model has been applied to four new sites. In comparison to regional analyses (cited earlier), the results of the simulation appear to be reasonable, with the exception of Romero Overlook, where the estimates are too strong. It is probable that this is due to the neglect of strong and persistent thermal winds in this particular area. It would be desirable to compare the 1977 simulations for Meade and Stratton Mountain to the 1977 measurements at these sites; however, such a comparison is beyond the scope of this study. Although the simulation for Goodnoe Hills is for 1964, the results should agree in general with 1977 measurements for this site. Such comparisons can be made at a later time.

V. SUMMARY AND CONCLUSIONS

The SRI methodology for estimating winds for wind energy applications uses a series of computer programs described and listed in an earlier report (Endlich et al. 1980). In the previous research, the Program COMPLEX was used to make an initial wind analysis on a three-dimensional grid (bounded by the terrain and the boundary layer top) and to account for terrain effects by making the initial flow nondivergent. In the present research, this program has been replaced by the Program COMPLEX-2, which performs the same functions in a different manner. Other elements of the procedure are unchanged.

Program COMPLEX-2 has several advantages:

- It is more accurate in estimating winds: Annual average wind speed estimates for the three sites on which it was tested and compared with previous results were improved by 0.4 to 0.5 m s⁻¹, a modest amount.
- The mathematical formulation avoids certain simplifications that were used previously, thereby removing possible criticism of this usage in the earlier methodology.
- The computations used to obtain nondivergent winds are simpler and more efficient than those used previously.
- The revised Subroutine SETBLT affords greater flexibility: It allows one to establish a boundary layer top that depends on parameters for a west-to-east and a north-to-south gradient in top height, as well as using the previous parameters for average boundary layer thickness and slope of the top.

A user interested in applying the programs to a small number of sites may find that it is more efficient to read terrain heights at grid points from appropriate maps than to adapt Program TERRAIN (which was written for a CDC 6400 computer) to a different computer.

Any simulations made should be checked against independent estimates such as the regional studies cited earlier. The present experiments have shown that the accuracy of the results is sensitive to the values of the parameters that are listed in Table 1 and to the distribution of weather reports with respect to the site. A fairly even distribution of at least three weather stations within a distance from the site of 100 km would be desirable, but is seldom realized. The geostrophic winds (computed in Program GEOCAL) should be compared with the concurrent observed winds and if there are consistent large differences,

it is likely that strong and persistent thermal winds are present. Neglect of these may adversely affect the simulations. A method to compute and use thermal winds has been formulated, and we plan to test it in any further simulations.

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APPENDIX

FIGURE A-1 BLOCK DIAGRAM OF THE WIND ENERGY COMPUTER PROGRAMS

Program GEOCAL

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        WRITE (3,1)
        WRITE (3,20)
        DO 49 K=1,10
            WSS(K)=0.0
            WDS(K)=0.0
            SPS(K)=0.0
49      CONTINUE
        IS=0
        NRW=0
C
        DO 50 I=1,NSTA
            P180=ACR*ALAT(I)
            P180S(I)=SIN(P180)
            P180C(I)=COS(P180)
            STANS(I)=ISTA(I)
50      CONTINUE
        C1=1.0
        RHO=1.1
        C2=100.0/(RHO*1.11)
        IOK=' NO'
        STLT1=ALAT(IU1)
        STLN1=ALON(IU1)
        STLT2=ALAT(IU2)
        STLN2=ALON(IU2)
        STLT3=ALAT(IU3)
        STLN3=ALON(IU3)
        AVLAT = ( 0.333 *(STLT1 + STLT2 + STLT3))/57.2958
        AVLON = ( 0.333 *(STLN1 + STLN2 + STLN3))/57.2958
        FC = 14.584 * SIN(AVLAT)
        COSLAT=COS(AVLAT)
        DENOM = (STLT2 -STLT1) * (STLN3 - STLN1) - (STLT3 -STLT1) *
+             (STLN2 - STLN1)
100 READ(1,60,END=200) IYR,IMO,IDA,IHOUR,
1 ((IWS(J,I),J=1,3),ISP(I),IWD(I),I=1,4)
C
C      SPECIAL FIX FOR STRATTON VT. DATA
C
C*****
C      IF(IHOUR.EQ.0) GO TO 100
C      IF(IHOUR.GT.0 .AND. IHOUR.LT.23) IHOUR=IHOUR-1
C*****
C      PROCESS ONE RECORD OF DATA.
C      320 BYTES PER RECORD (4 STATIONS).
C
C
110 DAY=30.5*(IMO-1)+IDA
    IGH=IHOUR+IGMT(JS)
C
C      CHANGE THE DATES TO BE CONSISTENT WITH THE GMT TIMES.
C
    IF (IGH.LE.24) GO TO 111
    IGH=IGH-24
    IDA=IDA+1
    IF (IDA.LE.MODA(IMO)) GO TO 111
    IDA=1
    IMO=IMO+1
    IF (IMO.LE.12) GO TO 111
    IMO=1
    IYR=IYR+1
111 IDATE=IYR*10000+IMO*100+IDA
    IF(IDATE.LE.0) GO TO 200
C
C      SKIP NON-3-HOURLY OBSERVATION.
C
    IF (JMOD(IGH,3).NE.0) GO TO 100
    IF (IGH.NE.IGHS) GO TO 180
112 CONTINUE
C
C      PROCESS DATA FOR EACH STATION.
C

```

```

DO 175 I=1,4
  ISITE=ISTA(I)
  JS=I
  STAN(JS)=ISITE
  IOK=' NO'
  IDATES=IDATE
  IGHS=IGH
C   WIND SPEED
  CALL SIGNCHK(WS(JS),IWS(1,I))
  IF (WS(I).EQ.-9.) THEN
    WS(JS)=WSS(JS)
    PRINT 16, ISITE,IDATE,IGH
  END IF
C   WIND DIRECTION
  IF (IWD(I).LE.0) THEN
    WD(JS)=WDS(JS)
    PRINT 17, ISITE,IDATE,IGH
  ELSE
    WD(JS)=IWD(JS) * 10.0
  END IF
C   PRESSURE
  IF (ISP(I).LE.0) THEN
    SPP(JS)=SPS(JS)
    PRINT 18, ISITE,IDATE,IGH
  ELSE
    SPP(JS)=ISP(JS)*0.1
    IF (SPP(JS).LT.500.0) SPP(JS)=SPP(JS)+1000.0
  END IF
C   SKY COVER (NOT USED)
C   IF (OPQ(I).EQ.1H ) GO TO 145
C   IF (OPQ(I).EQ.1HX) GO TO 150
C   GO TO 155
C 145 OC(JS)=OCS(JS) $ WRITE (6,19) ISITE,IDATE,IGH
175 CONTINUE
C
C   CALCULATE THE STABILITY INDICES.
C
DO 160 J=1,NSTA
  SP180=P180S(J)
  CP180=P180C(J)
  CALL STABLE (IHOURL,SAL,SI(J),WS(J),OC(J))
C
C   CONVERT WIND SPEED UNITS FROM KTS TO M/S.
C
WS(J)=WS(J)*0.5148
ANGLE=ACR*WD(J)
U(J)=-WS(J)*SIN(ANGLE)
V(J)=-WS(J)*COS(ANGLE)
160 CONTINUE
C
C   CALCULATE THE GEOSTROPHIC WINDS.
C
  CALL GWINDS (UG,VG)
C
  NNSTA=NSTA-1
  WRITE (2,61) IDATE,IGH ,NSTA,UG,VG
  DO 65 L=1,NSTA
    WRITE (2,62) STAN(L),SPP(L),WD(L),WS(L),OC(L),U(L),V(L),SI(L)
  65 CONTINUE
  NRW=NRW+1
  IF (IDA.NE.15) GO TO 165
  WRITE (3,21) IDATE,IGH,(STAN(L),U(L),V(L),SI(L),L=1,NSTA),UG,VG
  WRITE (3,9) (SPP(L),L=1,NSTA)
C
C   SAVE THE 3-HOURLY OBSERVATIONS.
C
165 DO 170 J=1,NSTA
  SPS(J)=SPP(J)
  WDS(J)=WD(J)
  WSS(J)=WS(J)
C   OCS(J)=OC(J)          DID NOT USE THIS PARAMETER

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```

        STANS(J)=STAN(J)
        US(J)=U(J)
        VS(J)=V(J)
        SIS(J)=SI(J)
170  CONTINUE
        UGS=UG
        VGS=VG
        IS=0
        IOK='YES'
        GO TO 100
180  IS=1
        IF (IOK.EQ.'YES') GO TO 112
        WRITE (2,61) IDATES,IGHS,NSTA,UGS,VGS
        DO 66 L=1,NSTA
        WRITE (2,62) STANS(L),SPS(L),WDS(L),WSS(L),OCS(L),US(L),VS(L),SIS(L)
66   CONTINUE
        NRW=NRW+1
        IF (IDA.NE.15) GO TO 112
        WRITE (3,21) IDATES,IGHS,(STANS(L),US(L),VS(L),SIS(L),L=1,NSTA),
1UGS,VGS
        GO TO 112
200  WRITE (3,21) IDATE,IGH ,(STAN(L),U(L),V(L),SI(L),L=1,NSTA),UG,
1VG
        ENDFILE 2
        WRITE (3,8) NRW
        STOP 200
        END
        SUBROUTINE GWINDS (UGS,VGS)
        COMMON /DAT/ PRS(10),STLAT(10),STLON(10),IU1,IU2,IU3,C1,C2,FC,
1AVLAT,AVLON,DENOM,STLT1,STLT2,STLT3,STLN1,STLN2,STLN3,COSLAT
        PR1 = PRS(IU1)*C1
        PR2 = PRS(IU2)*C1
        PR3 = PRS(IU3)*C1
C* CORIOLIS FORCE IN UNITS 10 -5 SEC -1
C* DENSITY IN UNITS 10 -3 G/CM3, PRESSURE IN MB
        DPDLT = (( STLN2 -STLN1) * (PR3 - PR1) - (STLN3 - STLN1) *
+ (PR2 - PR1))/(-DENOM)
        DPDLN = (( STLT2 -STLT1) * (PR3 -PR1) - (STLT3 - STLT1) *
+ (PR2 - PR1))/DENOM
        UGS = -(C2/FC) * DPDLT
        VGS = (C2/FC) * (DPDLN/COSLAT)
C* SPEED UNITS ARE M PER SEC
        RETURN
        END
        SUBROUTINE SIGNCHK(WS,IWS)
C
C   SUBROUTINE FOR DECIPHERING THE VARIOUS SYMBOLS FOR WIND SPEED
C
        DIMENSION IP1(10),MIN(10),NUM(10),SNUM(10),IWS(3)
        CHARACTER*1 AST,IWS,IP1,MIN,SNUM
        DATA IP1/'A','B','C','D','E','F','G','H','I','/'
        DATA MIN/'J','K','L','M','N','O','P','Q','R','/'
        DATA NUM/1,2,3,4,5,6,7,8,9,0/
        DATA SNUM/'1','2','3','4','5','6','7','8','9','0'/
        DATA AST/'*'/
C
        IF(IWS(3).EQ.AST) THEN
            WS=99.
            RETURN
        END IF
        WS1=0.
        WS2=0.
        WS3=0.
        DO 10 K=1,10
            IF(IWS(3).EQ.IP1(K)) THEN
                WS1=NUM(K)
                DO 20 L=1,10
                    IF(IWS(2).EQ.SNUM(L)) WS2=NUM(L)*10.
                    IF(IWS(1).EQ.SNUM(L)) WS3=NUM(L)*100.
                20 CONTINUE
            10 CONTINUE

```

```

20      CONTINUE
        WS=WS1 + WS2 + WS3
        RETURN
      ELSE IF(IWS(3).EQ.MIN(K)) THEN
        WS1=NUM(K)
        DO 30 L=1,10
          IF(IWS(2).EQ.SNUM(L)) WS2=NUM(L)*10.
          IF(IWS(1).EQ.SNUM(L)) WS3=NUM(L)*100.
30      CONTINUE
        WS=(WS1 + WS2 + WS3) * -1.0
        RETURN
      ELSE IF(IWS(3).EQ.SNUM(K)) THEN
        WS1=NUM(K)
        DO 40 L=1,10
          IF(IWS(2).EQ.SNUM(L)) WS2=NUM(L)*10.
          IF(IWS(1).EQ.SNUM(L)) WS3=NUM(L)*100.
40      CONTINUE
        WS=WS1 + WS2 + WS3
        RETURN
      ELSE
        CONTINUE
      END IF
10     CONTINUE
      IF(IWS(3).EQ.'0'.AND. IWS(2).EQ.'0') THEN
        IF(IWS(1).EQ.'0') THEN
          WS=-9.
          RETURN
        END IF
      END IF
      PRINT 1, IWS
      WS=-9.
1     FORMAT(1H ,' ILLEGAL CHARACTHER IN WIND SPEED FIELD ',3A1)
C
      END
      SUBROUTINE STABLE (J,SAL,SI,WSP,OC)
C
      DIMENSION IX(15),HCOS(24)
      COMMON /CSTAB/SP180,CP180,DAY
      DATA HCOS/-0.9695,-0.866,-0.7071,-0.5,-0.2588,0.0,0.2588,0.5,
1     0.7071,0.866,0.9659,1.0,0.9659,0.866,0.7071,0.5,0.2588,0.0,
2     -0.2588,-0.5,-0.7071,-0.866,-0.9659,-1.0/
      DATA IX/1,2*2,1,2,3,2,4*3,4,3,2*4/
      I=J
      CC=OC*0.1
      IJ=4
C
C     CALCULATE THE SIN OF THE SUNS ELEVALTION ANGLE (SAL)
C
      XT=-.43378 * COS(0.0172142 * (10.0+DAY))
      XS=XT/SQRT(1.0+XT*XT)
      XC=XS/XT
      XSP=XS * SP180
      SCP=XC * CP180
102    HC=HCOS(I)
      SAL=XSP + HC *XCP
C
C     IS IT OVERCAST (CC .GE. 0.9)
C
      IF (CC .GE. 0.9) GO TO 310
C
C     IS IT NIGHT (SAL .LT. 0)
C
      IF (SAL .LT. 0.0) GO TO 305
C
C     CALCULATE DAYTIME STABILITY
C
      IS THE SUN WITHIN 15 DEGREES OF HORIZON (SAL .LT. 0.26)
      IF (SAL .LT. 0.26) GO TO 310

```


Program XFORM


```

PROGRAM XFORM
C
C THIS PROGRAM CALLS OTHER ROUTINES FOR MAJOR OPERATIONS
C PROGRAM MODIFIED TO RUN ON VAX 11/782
C
C DIMENSION X(1000,20),XM(20),NBR(6),TEMP(20),A(20)
C 1 ,D(20),Z(20,20),WK(20)
C
C NVAR = NUMBER OF VARIABLES (TWICE NUMBER OF WINDS
C (INCLUDING GEOSTROPHIC)
C NREC = NUMBER OF RECORDS (HOURS OF DATA)
C NSITE = NUMBER OF SITES (NVAR/2)-1
C
C READ (*,31) NRECS
31 FORMAT(BZ,3I4)
PRINT 32, NRECS
32 FORMAT(1X,' NRECS= ',I4)
READ (1,16) IDATE,IHR,NSITE,UG,VG
16 FORMAT(BZ,3I8,2F8.2)
REWIND 1
NVAR=2*(NSITE+1)
PRINT 1601, NVAR,NSITE
1601 FORMAT(1X,' NVAR= ',I6,' NSITE= ',I6)
C
C SETTING CONTROL PARAMETER FOR MATRIX OPERATING ROUTINES
C IN SUB1
C
C NBR(1)=NVAR
C NBR(2)=NRECS
C NBR(3)=732
C NBR(4)=1
C NBR(5)=1
C NBR(6)=0
C IX=732
C
C SUB1 READS INPUT DATA, CALCULATES EIGENVECTORS, INNER PRODS. ETC.
C
C CALL SUB1(X,XM,NBR,NVAR,NSITE,NRECS,IX,A,D,Z,WK,TEMP)
C STOP
C END
C SUBROUTINE SUB1(X,XM,NBR,NVAR,NSITE,NRECS,IX,A,D,Z,WK,TEMP)
C
C DIMENSION X(732,NVAR),XM(NVAR),NBR(6),TEMP(NVAR),
C 1 VCV(100),A(20),D(NVAR),Z(NVAR,NVAR),WK(20),
C 2 SUMU(10),SUMV(10),ISTAB(10),PV(20)
C
C REAL ISTAB
C
C THIS SUBROUTINE READS INPUT WIND AND STABILITY DATA, CALCULATES
C COVARIANCE MATRIX, OBTAINS EIGENVECTORS OF COVARIANCE MATRIX, AND
C CALLS A ROUTINE TO OBTAIN TRANSFORMED DATA.
C
C MATSUB=NO. OF SUBMATRICES READ--GENERAL 4/YEAR
C
C MATSUB=NRECS/732+1
C MATSUB=4
C MVP=NSITE+1
C NCASES=0
C IPRINT=0
C DO 150 NN=1,MATSUB
C
C AT 8 OBS/DAY THERE ARE 2928 OBS/LEAP YEAR. 2928/4=732
C
C DO 100 L=1,732
116 READ (1,18,END=99) IDATE,IHR,NSITE,UG,VG
DO 101 K=1,NSITE
READ (1,17) DUM1,DUM2,DUM3,DUM4,DUM5,SUMU(K),SUMV(K),
ISTAB(K)

```

```

1
101      CONTINUE
18      FORMAT(BZ,3I8,2F8.2)
17      FORMAT(BZ,8F8.2)
      IF(L.LE.10) PRINT 1600, IDATE,IHR,NSITE,(SUMU(J),SUMV(J),ISTAB(J),
1 J=1,NSITE),UG,VG
1600     FORMAT(1H0,I6,I2,I3,/, (3F10.2))
      NCASES=NCASES+1
      IF(NCASES.GT.NRECS) GO TO 116
      SUMU(MVP)=UG
      SUMV(MVP)=VG
      DO 100 I=1,MVP
C
C      ENTERING WIND DATA INPUTS IN MATRIX X
C
      NPI=2*(I-1)+1
      NPIP1=NPI+1
      X(L,NPI)=SUMU(I)
      X(L,NPIP1)=SUMV(I)
C
      IPRINT=IPRINT+1
100     CONTINUE
      IF(NN.LT.MATSUB) GO TO 102
99      CONTINUE
      IF(NCASES.LT.NRECS) GO TO 86
102     CONTINUE
      CALL BECOVM(X,IX,NBR,TEMP,XM,VCV,IER)
C
C      BECOVM IS AN IMSL ROUTINE (REFER TO IMSL MANUAL FOR DESCRIPTION)
C
      NBR(4)=NBR(4)+1
      NBR(4)=NN+1
150     CONTINUE
C
C      PRINTING MEANS AND NUMBER OF INPUT DATA SETS
C
      PRINT 12,(XM(I),I=1,NVAR)
12      FORMAT(1H0,'VECTOR OF MEANS ',8E12.5)
      PRINT 88, NCASES
88      FORMAT(1H0,'NUMBER OF CASES ',I5)
C
C      OBTAINING (FROM SYMMETRIC STORAGE) AND PRINTING THE VARIANCE/
C      COVARIANCE MATRIX (VCV) AND THE ERROR PARAMETER
C
      DO 10 I=1,NVAR
      DO 1000 K=1,NVAR
1000    A(K)=0.
      DO 111 J=1,NVAR
          IF(J.GT.I) K=(J*(J-1)/2)+I
          IF(J.LE.I) K=(I*(I-1)/2)+J
111    A(J)=VCV(K)
10      PRINT 14,(A(K),K=1,NVAR)
14      FORMAT(1H0,'COVARIANCE MATRIX ', 8E12.5)
      PRINT 15, IER
15      FORMAT(1H0,'ERROR PARAMETER IS = ',I5)
C      COVARIANCE MATRIX HAS BEEN WRITTEN, NOW DO EIGENVECTORS
C
      N=NVAR
      IZ=NVAR
      IJOB=1
      CALL EIGRS(VCV,N,IJOB,D,Z,IZ,WK,IER)
C
C      EIGRS IS AN IMSL ROUTINE (REFER TO IMSL MANUAL FOR DESCRIPTION)
C
C      PRINTING AND WRITING TO A FILE EIGENVECTORS
C
      DO 16 I=1,N
16      PRINT 32, (Z(I,J),J=1,N)
32      FORMAT(1H0,'MATRIX OF EIGENVECTORS ',8E12.5/26X,8E12.5)
      DO 310 I=1,N
          WRITE(2,3001), I
          PRINT 3001,I

```

```

C
C      RADIATION AND CLOUD AMOUNT EFFECT (XSOL=INSOLATION)
C
      XSOL=(1.0 - 0.5 *CC) * SAL
      IF(XSOL .GT. 0.30) GO TO 120
      IRAD=3
      GO TO 200
120    IF(XSOL .GT. 0.55) GO TO 130
      IRAD=2
      GO TO 200
130    IRAD=1
C
C      WIND SPEED EFFECT
C
200    IF(WSP .GT. 3.0) GO TO 210
      IWS=1
      GO TO 300
210    IF(WSP .GT. 6.0) GO TO 220
      IWS=2
      GO TO 300
220    IF(WSP .GT. 10.0) GO TO 230
      IWS=3
      GO TO 300
230    IF(WSP .GT. 12.0) GO TO 240
      IWS=4
      GO TO 300
240    IWS=5
300    IEX=(IWS-1) * 3 + IRAD
      IJ=IX(IEX)
      GO TO 310
C
C      CALCULATION OF NIGHTTIME STABILITY
C
305    IF(WSP .GT. 6.0) GO TO 310
      IF(CC .GE. 0.5 .AND. WSP .GT. 3.0) GO TO 310
      IJ=5
310    SI=IJ
C
C      RETURN
C      END
C
C      PRINTING AND WRITING TO A FILE EIGENVECTORS (X100 TO CONVERT TO
C      CM/SEC)
C
3001  FORMAT(8X,I2)
      DO 310 J=2,N,2
          JMONE=J-1
          UCMPS=100. * Z(JMONE,I)
          VCMPS=100. * Z(J,I)
          WRITE(2,3002) UCMPS,VCMPS
          PRINT 3002, UCMPS,VCMPS
          FORMAT(2F10.2)
3002  CONTINUE
310    I=N+1
      WRITE(2,3001) I
      PRINT 3001, I
      DO 320 J=2,N,2
C
C      PRINTING AND WRITING MEAN VECTORS (X100 TO CONVERT TO CM/SEC)
          JMONE=J-1
          UCMEAN=100. * XM(JMONE)
          VCMEAN=100. * XM(J)
          WRITE(2,3002) UCMEAN,VCMEAN
          PRINT 3002, UCMEAN,VCMEAN
320    CONTINUE

```

```

C
C      PRINT EIGENVALUES
C
      DSUM=0.0
      DO 325 K=1,NVAR
          DSUM=DSUM+D(K)
325  CONTINUE
      DSUM=0.01*DSUM
      PRINT 112, (D(K),K=1,NVAR)
112  FORMAT(1H0,'EIGENVALUES ARE ',8E12.5)
      DO 326 K=1,NVAR
          PV(K)=D(K)/DSUM
326  CONTINUE
      PRINT 113, (PV(K),K=1,NVAR)
113  FORMAT(1H0,'PERCENT VARIANCE ',12F8.3)
      PRINT 15,IER
C
C      EIGENVECTOR MATRIX HAS BEEN WRITTEN, NOW DO INNER PRODUCTS
C
      REWIND 1
C
C      SUB2 CALCULATES INNER PRODUCTS OF INPUT DATA SETS WITH EIGENVECTORS
C
      CALL SUB2(Z,NVAR,NSITE,XM,NRECS)
      GO TO 114
86   PRINT 115, NCASES,NRECS
115  FORMAT(1H1,'NCASES =',I8,' NRECS =',I8,' RUN ABORTED ')
114  CONTINUE
      RETURN
      END
      SUBROUTINE SUB2(Z,NVAR,NSITE,XM,NRECS)
C
C      Z=MATRIX OF EIGENVECTORS OF DATA COVARIANCE MATRIX
C      NVAR=NUMBER OF ELEMENTS IN INPUT DATA SETS (WIND COMPONENTS)
C      XM=MEANS OF INPUT DATA
C      NRECS=NUMBER OF INPUT DATA SETS
C      NSITE=NUMBER OF SITES USED
C      SUMU,SUMV=OBSERVED WIND COMPONENTS
C
      DIMENSION ISTAB(10),Z(NVAR,NVAR),XM(NVAR),C(20),SUMU(10)
      1 ,SUMV(10),XD(20)
C
      REAL ISTAB
C
      DATA C/20*-999./
      NCASES=0
      DO 150 L=1,NRECS
C
C      READING INPUT DATA--DATE, HOUR (LOCAL TIME) AND NSITE GROUPS
C      OF THREE (U,V,STABILITY CLASS), FINAL PAIR OF DATA ARE GEOSTROPHIC
C      U AND V
C
      READ(1,10,END=99) IDATE,IHR,NSITE,UG,VG
      DO 100 K=1,NSITE
          READ(1,11) DUM1,DUM2,DUM3,DUM4,DUM5,SUMU(K),SUMV(K),ISTAB(K)
100  CONTINUE
      10  FORMAT(BZ,3I8,2F8.2)
      11  FORMAT(BZ,8F8.2)
      NSP1=NSITE+1
      SUMU(NSP1)=UG
      SUMV(NSP1)=VG
      NCASES=NCASES+1
      DO 101 I=1,NSP1
          J=2 * (I-1)+1
          JP1=J+1
C
C      GETTING DEVIATION FROM MEAN FOR EACH INPUT WIND DATUM
C
      XD(J)=SUMU(I)-XM(J)
      XD(JP1)=SUMV(I)-XM(JP1)
101  CONTINUE

```

```

C      COMPUTE INNER PRODUCTSS. C(K)=INNER PRODUCT OF INPUT WIND DATA
C      (DEVIATIONS FROM MEAN) SET WITH KTH EIGENVECTOR
C
      DO 120 K=1,NVAR
          TERM=0.
          DO 130 J=1,NVAR
              TERM=TERM+XD(J)*Z(J,K)
130          CONTINUE
          C(K)=TERM
120      CONTINUE
      CONTINUE

C      WRITE DATE, HOUR, INNER PRODUCTS AND STABILITIES
C
      WRITE(3,30) IDATE,IHR,NVAR,NSITE
      WRITE(3,31) (C(J),J=1,NVAR)
      WRITE(3,31) (ISTAB(J),J=1,NSITE)
30      FORMAT(4I8)
31      FORMAT(10F8.2)
32      FORMAT(10I8)


      IF(L.LT.30) PRINT 75,(C(LF),LF=1,NVAR)
75      FORMAT(1X,10F10.2)
150     CONTINUE
      PRINT 18,NCASES
18      FORMAT(1H0,'NUMBER OF DAYS READ = 'I5)
99      ENDFILE 3
      REWIND 3
      RETURN
      END

```


Program COMPLEX - 2


```

      PROGRAM COMPLEX-2
C* THIS FORM OF COMPLEX IS FOR WIND ENERGY, MAY '82
C* * * * * PROGRAM TO COMPUTE TOPOGRAPHICALLY INDUCED WINDS
C* THIS FORM USES DIRECT VECTOR ALTERATIONS IN SUBROUTINE BAL5.
C
      DIMENSION B(21,21),LPRNT(10)
      COMMON/RARS/RHS(21,21,10)
      COMMON/CSFC/SFCHT(21,21),SIGMA(10),SIGMAH(10),X(32),Y(32)
      COMMON/UARS/U(21,21,10),UA(21,21,10),V(21,21,10),VA(21,21,10)
      COMMON/WARS/W(21,21,10),WA(21,21,10)
      COMMON/PARMS/ZTOP,DS,DSIGMA,NLVLM1,XHT1,XHT2,X1,Y1,
1 X2,Y2,UG,VG,RATIO,TDSI
      COMMON /CVOS/ IB,JB,IZ,JZ,IV,DSI,IXZ,JYZ
      COMMON/CTOP/ MI,NI,MR,NR,NGRID,HTOP
      COMMON/LIMITS/NCOL,NROW,NLVL,NCOLM1,NROWM1
      COMMON /BLHT/ BLT(21,21),HSITE, AVTHK, SLFAC,STHK,BLGRX,BLGRY
      COMMON /SITE/ IXS, JYS, THSITE, IGRID
      COMMON /C3/ IP1,IP2,JP1,JP2,ICNT
      DIMENSION SIGMA1(10)
      INTEGER DNI
      DATA NIT/10/
C      DATA SIGMA1/.00,.11,.22,.33,.44,.55,.66,.77,.88,1.0/
      DATA SIGMA1/.00,.04,.09,.15,.23,.33,.45,.60,.78,1.0/
      DATA NLVL,NROW,NCOL/10,19,21/
C      DATA SIGMAH/.00,.055,.11,.165,.22,.275,.33,.385,.44,.495/
      DATA SIGMAH/.00,.02,.04,.065,.09,.12,.15,.19,.23,.28/
      DATA IP1,IP2,JP1,JP2,ICNT/1,21,1,21,1/
C* IN ALL ARRAYS POINT (1,1) IS AT SW CORNER. X INCREASES TO EAST, Y
C TO N. INDICES ARE I,J,K -(COL,ROW,LYR) WITH LIMITS NCOL,NROW,NLVL
C* UNITS USED IN COMPUTATION ARE CM, G, SEC.
1  FORMAT(4I5,F10.2)
2  FORMAT (/ ' FINAL RESULTS' /11X,'K          UA          VA          W
+      REL. HTS.' /)
3  FORMAT(2X,I10,2X,2F10.2,F11.3,F10.1)
4  FORMAT(10X,'TOTAL TIME =',E12.3)
5  FORMAT (2X,I10,2X,3F10.2,F11.3,F10.1)
7  FORMAT(2X,5E12.3)
8  FORMAT(6I5,2F10.2)
9  FORMAT (2I5,2F10.2,I5,F10.0,F5.1,F8.0)
      RTB=SECNDS(0.0)
      READ(*,1) JSITE
      PRINT 9011,JSITE
      READ(*,1) NWIND,NGRID
      PRINT 9012,NWIND,NGRID
      READ(*,1) IXZ,JYZ,IXSS,JYSS,HSITE
      PRINT 9015, IXZ,JYZ,IXSS,JYSS,HSITE
      READ(*,8) MI,NI,MR,NR,IZ,JZ,DSI,DSR
      IB = ((IXZ-1)*IZ +2) -IXSS
      JB = ((JYZ -1) * JZ +2) -JYSS
C* (IB-1)= FINE GRID X UNITS FROM SW CORNER COARSE GRID TO SW CORNER
C OF FINE GRID
      PRINT 9013, MI,NI,MR,NR,IB,JB
      PRINT 9014,IZ,JZ,DSI,DSR
      HSITE=30.48*HSITE
      NLVLM1=NLVL-1
C
      READ(*,9022) AVTHK, SLFAC, STHK, DNI, BLGRX, BLGRY
      PRINT 9025, AVTHK, SLFAC, STHK, DNI, BLGRX, BLGRY
      AVTHK = 100.0 * AVTHK
      STHK = 100.0 * STHK
      BLGRX = 100.0 * BLGRX
      BLGRY= 100.0 * BLGRY
C* READ PRINT INDICATORS. TO PRINT LEVEL K USE LPRNT(K) = 1.
      READ(*,9030) (LPRNT(K),K=1,NLVL)
      PRINT 9035
      PRINT 9030, (LPRNT(K),K=1,NLVL)
      READ(*,9060) NREL, RATIO, IPNCH
      PRINT 9062, IPNCH
C OBTAIN HEIGHT OF TERRAIN(SFCHT) FOR BOTH GRIDS
      CALL TOPO(0)

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C LOOP THRU NWIND SETS.
DO 1050 IWIND = 1,NWIND
PRINT 9016, IWIND, NWIND
IXS=IXZ
JYS=JYZ
NCOL=MI
NROW=NI
DS=DSI
C LOOP THRU NGRID SYSTEMS.
RTD=SECNDS(RTB)
PRINT 7,RTB,RTD
DO 1040 IGRID = 1,NGRID
DO 18 K=1,NLVL
IF(IGRID.EQ.1) SIGMA(K)=SIGMA1(K)
IF(IGRID.EQ.2) SIGMA(K)=SIGMAH(K)
18 CONTINUE
IF(IGRID.EQ.1) GO TO 10
C CHANGES FOR FINE GRID
PRINT 9040
DS=DSR
NCOL=MR
NROW=NR
IXS=IXSS
JYS=JYSS
10 CONTINUE
DS=DS*1.0E5
NCOLM1=NCOL-1
NROWM1=NROW-1
TDSI = 1./(2.0*DS)
C ESTABLISH GRID COORDINATES
X(1)=0.0
DO 12 I = 1,NCOLM1
X(I+1) = X(I) + DS
12 CONTINUE
Y(1)=0.0
DO 13 J = 1,NROWM1
Y(J+1) = Y(J) + DS
13 CONTINUE
C SET BL TOP AND SIGMA SURFACES
CALL TOPO(IGRID)
C PRINT + PLOT SURFACE HEIGHT
PRINT 171
171 FORMAT (1H1,' TERRAIN HEIGHT, M, 1ST ROW IS TO NORTH//')
DO 53 JP = 1,NROW
DO 53 IP = 1,NCOL
B(IP,JP) = .01 * SFCHT(IP,JP)
53 CONTINUE
DO 54 JP = 1,NROW
JR = NROW+ 1 -JP
54 PRINT 9100, ( B(IP,JR),IP=1,NCOL )
55 CONTINUE
C * * * *PLOT GEOMETRIC HEIGHTS OF SELECTED SIGMA SURFACES
DO 511 K = 1,NLVL
IF (LPRNT(K) .NE. 1) GO TO 511
DO 627 JP = 1,NROW
DO 627 IP = 1,NCOL
B(IP,JP) = .01 * RHS(IP,JP,K)
627 CONTINUE
PRINT 571,K
571 FORMAT (1H1,' HEIGHT ABOVE TERRAIN, M, LVL='I3/)
DO 628 JP=1,NROW
JR = NROW+ 1 -JP
628 PRINT 9100, ( B(IP,JR),IP=1,NCOL )
511 CONTINUE
C* READ AND ANALYZE WIND DATA USING INWND
IF (IGRID .EQ. 1 .AND. IWIND .EQ. 1) CALL INWND(0)
C* MAKE INITIAL WIND ANALYSIS ON MESH
CALL INWND(IGRID)
C * * * *PLOT OBSERVED VELOCITY COMPONENTS AT SELECTED LEVELS * *
DO 211 K = 1,NLVL
IF (LPRNT(K) .NE. 1) GO TO 211
PRINT 271,K

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271  FORMAT(1H1,'  U COMPONENT CM PER SEC, LVL = 'I4/)
    DO 56 JP =1,NROW
    JR = NROW+ 1 -JP
56   PRINT 9100, (  U(IP,JR,K),IP=1,NCOL )
211  CONTINUE
    DO 212 K =1,NLVL
    IF (LPRNT(K) .NE. 1) GO TO 212
    PRINT 272,K
272  FORMAT(1H1,'  V COMPONENT CM PER SEC, LVL = 'I4/)
    DO 58 JP =1,NROW
    JR = NROW+ 1 -JP
58   PRINT 9100, (  V(IP,JR,K),IP=1,NCOL )
212  CONTINUE
214  RTX=SECNDS(RTD)
    PRINT 7,RTB,RTD,RTX
    IF (IGRID .GT. 1) GO TO 226
    DO 220 K =2,NLVL
    DO 220 I =2,NCOLM1
    DO 220 J =2,NROWM1
    HSIZE=SFCHT(I+1,J) + RHS(I+1,J,K)
    HSIW=SFCHT(I-1,J) + RHS(I-1,J,K)
    HSIJ=SFCHT(I,J+1) + RHS(I,J+1,K)
    HSIK=SFCHT(I,J-1) + RHS(I,J-1,K)
    DHDX=(HSIZE - HSIW) * TDSI
    DHDI=(HSIJ - HSIK) * TDSI
    W(I,J,K)=U(I,J,K) * DHDX + V(I,J,K) * DHDI
220  CONTINUE
226  CONTINUE
    IF (IGRID .EQ. 1) PRINT 9050
    IF (IGRID .GT. 1) PRINT 9055
    PRINT 9020
9020  FORMAT (/ ' ORIGINAL U, V, W, REL. HTS AT SITE'/)
    PRINT 3,(K, U(IXS,JYS,K), V(IXS,JYS,K), W(IXS,JYS,K),
2     RHS(IXS,JYS,K),K=1,NLVL)
    DO 213 K =1,NLVL
    IF (LPRNT(K) .NE. 1) GO TO 213
    PRINT 273,K
273  FORMAT(1H1,'  W, CM/SEC TIMES 10, LVL = 'I3/)
    DO 60 JP = 1,NROW
    DO 60 IP = 1,NCOL
    B(IP,JP) = 10.* W(IP,JP,K)
60   CONTINUE
    DO 65 JP = 1,NROW
    JR = NROW+ 1 -JP
65   PRINT 9100, ( B(IP,JR),IP=1,NCOL )
213  CONTINUE
C CALL SUBROUTINE TO MAKE WINDS NONDIVERGENT
    CALL BAL5(NIT)
    DO 605 I=1,NCOL
    DO 605 J=1,NROW
    DO 605 K=1,NLVL
        UA(I,J,K)=U(I,J,K)
        VA(I,J,K)=V(I,J,K)
        WA(I,J,K)=W(I,J,K)
605  CONTINUE
C * * * * *PLOT ADJUSTED VELOCOTY COMPONENTS  AT SELECTED LEVELS
    DO 611 K =1,NLVL
    IF (LPRNT(K) .NE. 1) GO TO 611
    PRINT 671,K
671  FORMAT (1H1,'  ADJUSTED U COMPONENT, CPS,  LVL='I3/)
    DO 622 JP=1,NROW
    JR = NROW+ 1 -JP
622  PRINT 9100, (  UA(IP,JR,K),IP=1,NCOL )
611  CONTINUE
    DO 612 K =1,NLVL
    IF (LPRNT(K) .NE. 1) GO TO 612
    PRINT 672,K
672  FORMAT (1H1,'  ADJUSTED V COMPONENT, CPS,  LVL='I3/)
    DO 624 JP=1,NROW
    JR = NROW+ 1 -JP
624  PRINT 9100, (  VA(IP,JR,K),IP=1,NCOL )

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612  CONTINUE
      IF (IGRID .EQ. 1) PRINT 9050
      IF (IGRID .GT. 1) PRINT 9055
      PRINT 2
      PRINT 3, (K, UA(IXS, JYS, K), VA(IXS, JYS, K), W(IXS, JYS, K),
+      RHS(IXS, JYS, K), K=1, NLVL)
      RTE=SECNDS(RTX)
      RTT=SECNDS(RTB)
      PRINT 4, RTT
      PRINT 7, RTB, RTD, RTX
      IF (IGRID .NE. NGRID) GO TO 1040
C*  COMPUTE WINDS AT HUB HT, PUT IN UA(I,J,1).  USE INTERP BETWEEN
C  LEVELS OR DOWNWARD LOG EXTRAPOLATION.
      HUBHT = 4570.0
      DO 900 I = 1, NCOL
      DO 900 J = 1, NROW
      IF (RHS(I, J, 2) .LT. HUBHT) GO TO 855
      Z3 = ALOG(RHS(I, J, 3))
      Z2 = ALOG(RHS(I, J, 2))
      ZHB= ALOG(HUBHT)
      UA(I, J, 1) = ((UA(I, J, 3) - UA(I, J, 2)) / (Z3 - Z2))
+      * (ZHB - Z2) + UA(I, J, 2)
      VA(I, J, 1) = ((VA(I, J, 3) - VA(I, J, 2)) / (Z3 - Z2))
+      * (ZHB - Z2) + VA(I, J, 2)
      GO TO 900
855  CONTINUE
      KUP = 3
      IF (RHS(I, J, 3) .GE. HUBHT) GO TO 860
      KUP = 4
      IF (RHS(I, J, 4) .GE. HUBHT) GO TO 860
      KUP = 5
      IF (RHS(I, J, 5) .GE. HUBHT) GO TO 860
860  CONTINUE
      KLWR = KUP - 1
      UA(I, J, 1) = UA(I, J, KLWR) + (HUBHT - RHS(I, J, KLWR))
+      * (UA(I, J, KUP) - UA(I, J, KLWR)) / (RHS(I, J, KUP) - RHS(I, J, KLWR))
      VA(I, J, 1) = VA(I, J, KLWR) + (HUBHT - RHS(I, J, KLWR))
+      * (VA(I, J, KUP) - VA(I, J, KLWR)) / (RHS(I, J, KUP) - RHS(I, J, KLWR))
900  CONTINUE
C*  WRITE RESULTS- SITE, E. VECTOR NO, U, V, DAY-NITE INDICATOR, AV. B L
C  THICKNESS, SLOPE, MIN. THICKNESS
      IF (IPNCH .GT. 0)
+      WRITE(5, 9) JSITE, IV, UA(IXS, JYS, 1), VA(IXS, JYS, 1), DNI, AVTHK,
+      SLFAC, STHK
      PRINT 9045
      DO 910 JP = 1, NROW
      JR = NROW + 1 - JP
910  PRINT 9100, (UA(IP, JR, 1), IP=1, NCOL)
      PRINT 9046
      DO 915 JP = 1, NROW
      JR = NROW + 1 - JP
915  PRINT 9100, (VA(IP, JR, 1), IP=1, NCOL)
      PRINT 9065
9065  FORMAT (// ' PRINT FINAL OUTPUT CARD')
      PRINT 9, JSITE, IV, UA(IXS, JYS, 1), VA(IXS, JYS, 1), DNI, AVTHK, SLFAC, STHK
1040 CONTINUE
1050 CONTINUE
9011 FORMAT (// ' SITE NUMBER = 'I5)
9012 FORMAT (// ' NO. WIND SETS = 'I5, ' NO. GRIDS = 'I5)
9013 FORMAT (// ' COARSE GRID E-W 'I5, ' S-N 'I5, ' FINE GRID E-W 'I4, ' S-N
+ 'I4, ' DISTANCE, X 'I4, ' Y 'I4)
9014 FORMAT (// ' RATIO, COARSE - FINE, IZ 'I5, ' JZ 'I5, ' COARSE INCR 'F6.1
+ ' FINE INCR 'F6.1)
9015 FORMAT (// ' SITE, COARSE GRID X 'I5, ' Y 'I5, ' SITE, FINE GRID X 'I5, '
+ Y 'I5, ' SITE ELEVATION, FEET = 'F8.1)
9016 FORMAT (1H1, // ' WIND SET NO. 'I5, ' OF 'I5 //)
9022 FORMAT (F10.1, F10.2, F10.1, I5, 2F7.1)
9025 FORMAT (// ' AVER. BNDY. THICKNESS IN M = 'F8.1,
+ ' SLOPE FACTOR FOR BL TOP = 'F6.1, ' MIN. THICKNESS = 'F8.1,
+ // ' DAY1 NITE2 INDICATOR = 'I3, ' B LYR GRADIENT TO EAST, M = 'F7.1
+ ' TO NORTH = ' F7.1 //)

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9030 FORMAT (12I5)
9035 FORMAT (/ ' INDICATORS, LPRNT(K), FOR PRINTING FIELDS' /)
9040 FORMAT (1H1, ' BEGIN COMPUTATIONS FOR FINE GRID' /)
9045 FORMAT (1H1, ' U COMP. AT HUB HT.' /)
9046 FORMAT (1H1, ' V COMP. AT HUB HT. CPS' /)
9050 FORMAT (1H1, ' COARSE GRID' /)
9055 FORMAT (1H1, ' FINE GRID' /)
9060 FORMAT (15,E10.1,15)
9062 FORMAT (/ ' IPUNCH=' I3)
9100 FORMAT (/5X,22F5.0)
STOP
END
SUBROUTINE INWND(NUM)
C* THIS IS A MODIFIED VERSION OF VOBSE. IT USES ANEMOM. WINDS AND
C GEOSTROPHIC WINDS AT UPPER BNDY. IT INTERPOLATES LOGARITHMICALLY.
C FOR FINE GRID IT INTERPOLATES FROM COARSE GRID OUTPUT.
C* LAST REVISION MAY 1982
C
COMMON/LIMITS/NCOL,NROW,NLVL,NCOLM1,NROWM1
COMMON /CVOS/ IB,JB,IZ,JZ,IV,DSI,IXZ,JYZ
COMMON/RARS/RHS(21,21,10)
COMMON/UARS/U(21,21,10),UA(21,21,10),V(21,21,10),VA(21,21,10)
COMMON/WARS/W(21,21,10),WA(21,21,10)
COMMON/CSFC/SFCHT(21,21),SIGMA(10),SIGMAH(10),X(32),Y(32)
COMMON/PARMS/ZTOP,DS,DSIGMA,NLVLM1,XHT1,XHT2,X1,Y1,
1 X2,Y2,UG,VG,RATIO,TDSI
COMMON/CTOP/ MI,NI,MR,NR,NGRID,HTOP
COMMON /BLHT/ BLT(21,21),HSITE, AVTHK, SLFAC,STHK,BLGRX,BLGRY
DIMENSION A(21,21),B(21,21),C(21,21)
DIMENSION UX(625),VX(625),Z(625),IS(3850),XG(10),YG(10)
DIMENSION XS(10),YS(10),US(10),VS(10),ZS(10),ES(10),YX(60),XX(60)
DATA WGHT,AHS,LL4/2.0,150.0,4/
DATA ESS/304.8/
2 FORMAT(4X,13F4.0)
3 FORMAT(4X,-2P13F5.0)
4 FORMAT(110,2F10.1)
5 FORMAT(3F10.2)
6 FORMAT(4X,-2P14F6.2)
7 FORMAT(1H )
8 FORMAT(4X,-5P3F10.2)
9 FORMAT(2X,'EIGENVECTOR NO',I3)
PRINT 9001
9001 FORMAT (/ ' BEGIN SUBROUTINE INWND' /)
IF (NUM.GT.0) GO TO 100
IT=NROW*NCOL
DSS=DS
YMIN=Y(1)
XMIN=X(1)
YD=DSS
XD=YD
YMAX=(NROW-1)*DSS+YMIN
CALL BOUNDS(0,NROW,NCOL,YMAX,XMIN,YD,XD,YX,XX)
READ(*,5) SLAT, SLNG
PRINT 9007, SLAT, SLNG
C READ IN NO OF DATA POINTS AND AVER ANEM HT.
READ(*,4) NSTA,ANHT,GTHKM
PRINT 9003, NSTA,ANHT,GTHKM
ANHT=100. * ANHT
GTHKM=100. * GTHKM
C* READ LAT YS, LONG XS OF STATIONS (DEG) AND CONVERT TO XS YS (CM)
C MEASURED FROM SW CORNER OF COARSE GRID
READ(*,9015) (YS(J), XS(J),J=1,NSTA)
PRINT 9004
PRINT 9015, (YS(J), XS(J),J=1,NSTA)
DO 15J=1,NSTA
XS(J) = (XS(J) - SLNG)*(111.0 *COS(SLAT/57.295))
YS(J) = (YS(J) - SLAT)*111.0
XS(J) = XS(J) + IXZ * DSI
YS(J) = YS(J) + JYZ * DSI
XG(J) = XS(J)/DSI
YG(J) = YS(J)/DSI
XS(J) = XS(J) * 100000.0
YS(J) = YS(J) * 100000.0

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```

15 CONTINUE
  PRINT 9008
  PRINT 9011, (XS(J), YS(J), XG(J), YG(J), J=1, NSTA)
C  INITIATE SUBROUTINE NET (GRID POINT ANALYSIS)
  CALL NET(NSTA, NSTA, WGHT, NSTA, NROW, NCOL, YS, XS, VS, US, ZS, YX, XX, VX, UX,
1    Z, IS)
  GO TO 300
100 IF (NUM.GT.1) GO TO 200
C  READ IN WIND COMPONENTS FOR EACH DATA POINT.
  READ(*,4) IV
  PRINT 9, IV
  READ(*,9015) (US(J), VS(J), J=1, NSTA)
  PRINT 9015, (US(J), VS(J), J=1, NSTA)
  READ(*,5) UGEOS, VGEOS
  PRINT 9006, UGEOS, VGEOS
C  WRITE (10) VS, US
  DO 27 J=1, NSTA
27 ZS(J)=SQRT(US(J)*US(J)+VS(J)*VS(J))
C* USE NET TO GET GRID, PT SURFACE WIND ANALYSIS
  CALL NET(1,1,0.05, NSTA, NROW, NCOL, YS, XS, VS, US, ZS, YX, XX, VX, UX, Z, IS)
  CALL NET(2,1,0.05, NSTA, NROW, NCOL, YS, XS, VS, US, ZS, YX, XX, VX, UX, Z, IS)
  PRINT 9020
  PRINT 9016, (UX(L), L=1, IT)
  PRINT 9021
  PRINT 9016, (VX(L), L=1, IT)
C PT. L =1 IS IN THE NW CORNER OF UX AND VX
  9016 FORMAT (/5X,21F5.0)
C* MAKE A LOG INTERP BETWEEN ANEM HT AND GEOS WINDS.  SFC WINDS=0.
  DO 50 J =1, NROW
  DO 50 I =1, NCOL
    IR = (NROW-J) * NCOL + I
    ANHTE=ANHT
C* ASSIGN EFFECTIVE ANEM. HT FOR LOWEST POINT
C  ANHTE= ANHT * (RHS(I,J,NLVL) / AVTHK)
C  IF (ANHTE.GT.ANHT) ANHTE=ANHT
    ANHTL=ALOG(ANHTE)
C  ASSIGN GEOS WIND TO BLT(RHS) OR TO GTHKM, WHICHEVER IS LOWER
    GTHK=RHS(I,J,NLVL)
    IF (GTHK.GT.GTHKM) GTHK=GTHKM
    BD=1.0 / (ALOG(GTHK) - ANHTL)
    USHR= (UGEOS - UX(IR))
    VSHR= (VGEOS - VX(IR))
    DO 40 LV = 2, NLVL
      BN= ALOG(RHS(I,J, LV)) - ANHTL
      U(I,J, LV)= UX(IR) + USHR*BN*BD
      V(I,J, LV)= VX(IR) + VSHR*BN*BD
40 CONTINUE
50 CONTINUE
  GO TO 250
200 CONTINUE
C  INTERPOLATES VALUES OF FINE GRID FROM VALUES OF COARSE GRID.
  IZ1=IZ-1
  XD=(IB-1.0)/IZ
  YD=(JB-1.0)/JZ
  IG=XD
  JG=YD
  ID=(XD-IG)*IZ+0.00001+ 1
  IE=IB+NCOL-1
  JE=JB+NROW-1
  IBB=IG*IZ+1
  IEE=(IE+IZ-2)/IZ
  IEE=IEE*IZ+1
176 FORMAT(2X,5I10,2F10.2)
  L1=NLVL+1
  K=0
  DO 180 KX=1, L1, 2
    K=K+1
    KY=KX
    IF (KX.EQ.L1) KY=KX-1
    DO 170 I=IBB, IEE, IZ
      I0=(I-1)/IZ+1
      IX=I-IBB+1

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DO 170 J=JB,JE
  JX=J-JB+1
  Y1=(J-1.0)/JZ+1.0
  J1=Y1
  J2=J1+1
  FJ=Y1-J1
  A(IX,JX) =FJ*(UA(I0,J2,K)-UA(I0,J1,K))+UA(I0,J1,K)
  B(IX,JX) =FJ*(VA(I0,J2,K)-VA(I0,J1,K))+VA(I0,J1,K)
  C(IX,JX) =FJ*(WA(I0,J2,K)-WA(I0,J1,K))+WA(I0,J1,K)
170 CONTINUE
  IX=0
DO 175 IYT=IBB,IEE,IZ
  IY=IYT-IBB+1
  IX=IX+1
DO 175 IYY=1,IZ1
  IX=IX+1
  FJ=IYY*1.0/IZ
DO 175 JX=1,NROW
  A(IX,JX) =FJ*(A(IY+IZ,JX)-A(IY,JX))+A(IY,JX)
  B(IX,JX) =FJ*(B(IY+IZ,JX)-B(IY,JX))+B(IY,JX)
  C(IX,JX) =FJ*(C(IY+IZ,JX)-C(IY,JX))+C(IY,JX)
175 CONTINUE
  MID=NCOL+ID-1
DO 177 JX=1,NROW
  IX=0
DO 177 IY=ID,MID
  IX=IX+1
  U(IX,JX,KY)=A(IY,JX)
  V(IX,JX,KY)=B(IY,JX)
  W(IX,JX,KY)=C(IY,JX)
C   IF (JX.EQ.1.AND.K.EQ.4) PRINT 176,MID,JX,IY,IX,K,U(IX,JX,K)
C   2      ,A(IY,JX)
177 CONTINUE
180 CONTINUE
DO 240 K=2,NLVL,2
  KP1=K+1
  IF (K.EQ.NLVL) KP1=K
DO 240 JX=1,NROW
DO 240 IX=1,NCOL
  IF (K.GT.2) GO TO 235
C* USE LOG EXTRAPOLATION FOR LEVEL 2
  Z5 = ALOG(RHS(IX,JX,5))
  Z3 = ALOG(RHS(IX,JX,3))
  Z2 = ALOG(RHS(IX,JX,2))
  U(IX,JX,2) =((U(IX,JX,5)-U(IX,JX,3))/(Z5-Z3))*(Z2-Z3)+U(IX,JX,3)
  V(IX,JX,2) =((V(IX,JX,5)-V(IX,JX,3))/(Z5-Z3))*(Z2-Z3)+V(IX,JX,3)
  W(IX,JX,2) =((W(IX,JX,5)-W(IX,JX,3))/(Z5-Z3))*(Z2-Z3)+W(IX,JX,3)
  GO TO 240
235  U(IX,JX,K)=0.5*(U(IX,JX,K-1)+U(IX,JX,KP1))
     V(IX,JX,K)=0.5*(V(IX,JX,K-1)+V(IX,JX,KP1))
     W(IX,JX,K)=0.5*(W(IX,JX,K-1)+W(IX,JX,KP1))
240 CONTINUE
250 CONTINUE
  PRINT 9002
300 RETURN
9002 FORMAT (/ ' END OF SUBROUTINE INWND' /)
9003 FORMAT (/ ' THE NUMBER OF INPUT WINDS = 'I3,' ANEM. HT. (M) = '
1 F5.1,' MIN. GTHK= ',F6.1/)
9004 FORMAT (/ ' LATITUDE AND LONG OF STATIONS' /)
9006 FORMAT (/ ' GEOSTROPHIC WIND, CPS, U COMP. ='F8.1,' V COMP.
+ ='F8.1/)
9007 FORMAT (/ ' THE SITE IS AT LAT ='F9.3,' AND LONG='F9.3)
9008 FORMAT (/ ' X AND Y OF STATIONS IN CM AND IN GRID UNITS FROM SW
+CORNER')
9011 FORMAT (/4X,2F11.0,8X,2F10.1)
9015 FORMAT (2F10.2)
9020 FORMAT (1H1,' U COMPONENT AT SFC, CM S-1' /)
9021 FORMAT (1H1,' V COMPONENT AT SFC, CM S-1' /)
END
SUBROUTINE TOPO(NUM)

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C
CC  READ AND COMPUTE TOPOGRAPHY AT GRID POINTS
C*  LAST REVISION 7/27/79
C
COMMON/LIMITS/NCOL,NROW,NLVL,NCOLMI,NROWMI
COMMON/CTOP/ MI,NI,MR,NR,NGRID,HTOP
COMMON/RARS/RHS(21,21,10)
COMMON/CSFC/SFCHT(21,21),SIGMA(10),SIGMAH(10),X(32),Y(32)
COMMON /BLHT/ BLT(21,21),HSITE, AVTHK, SL=AC,STHK,BLGRX,BLGRY
DIMENSION XF(23,34),YF(23,34)
2  FORMAT(11F6.0)
3  FORMAT(4X,-2P14F5.0)
4  FORMAT(/,5X,21F5.0)
6  FORMAT(4X,-2P19F5.0)
PRINT 9001
9001 FORMAT (/ ' BEGIN SUBROUTINE TOPO' )
IF (NUM.GT.0) GO TO 10
C  READS TERRAIN HEIGHT VALUES AT GRID POINTS IN FEET
C  COARSE GRID.
N2=NI+1
M2=MI+1
PRINT 9006
PRINT 9003
DO 8 J=2,N2
READ(*,2) (XF(I,J),I=2,M2)
8  CONTINUE
DO 118 J = 2,N2
JR = N2 + 2 -J
PRINT 4, (XF(I,JR),I =2,M2)
118 CONTINUE
IF (NGRID.LT.2) GO TO 150
C  FINE GRID (IF NGRID EQ 2)
M2=MR+1
N2=NR+1
PRINT 9004
DO 9 J=2,N2
READ(*,2) (YF(I,J),I=2,M2)
9  CONTINUE
DO 119 J = 2,N2
JR = N2 + 2 -J
PRINT 4, (YF(I,JR),I =2,M2)
119 CONTINUE
GO TO 150
10 J=1
DO 12 JX=1,NROW
I=1
J=J+1
DO 12 IX=1,NCOL
I=I+1
IF (NUM.GT.1) GO TO 11
SFCHT(IX,JX)=XF(I,J)
GO TO 12
11 CONTINUE
SFCHT(IX,JX)=YF(I,J)
12 CONTINUE
C  CONVERTS TERRAIN HEIGHT VALUES AT GRID POINTS TO CENTIMETERS.
DO 22J=1,NROW
DO 22I=1,NCOL

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22 SFCHT(I,J)=30.48*SFCHT(I,J)
25 CONTINUE
C** SET BNDY LAYER TOP.
    CALL SETBLT
C DENOTE GEOMETRIC HEIGHT ABOVE TERRAIN BY RHS
    DO 67 J=1,NROW
    DO 67 I=1,NCOL
    DO 67 K=1,NLVL
        ZVAR = BLT(I,J) - SFCHT(I,J)
    67 RHS(I,J,K)=SIGMA(K)*ZVAR
    150 PRINT 9002
9002 FORMAT (/' END OF SUBROUTINE TOPO'/)
9003 FORMAT (/' TERRAIN HTS, COARSE GRID, FEET'/)
9004 FORMAT (/' TERRAIN HTS, FINE GRID, FEET'/)
9006 FORMAT (/' PRINTOUT IS REVERSE OF INPUT - HAS NORTH ROW 1ST'/)
    RETURN
END
SUBROUTINE SETBLT
C** THIS SUBROUTINE SETS THE HEIGHT OF THE BNDY LAYER TOP. AVTHK IS
C AVER. BL THICKNESS OVER AREA. SLFAC CONTROLS THE SLOPE, IF 0 THE
C TOP IS FLAT, IF 1 THE BL TOP FOLLOWS THE TERRAIN. HSITE IS HT OF
C THE SITE, STHK IS THE SMALLEST BL THICK ALLOWED.
C BLGRX IS B Lyr HT GRADIENT TO E.
C BY R ENDLICH, MAY 82.
C* LAST REVISION JUNE '82
    DIMENSION B(21,21)
    COMMON/LIMITS/NCOL,NROW,NLVL,NCOLMI,NROWMI
    COMMON /SITE/ IXS, JYS, THSITE, IGRID
    COMMON /BLHT/ BLT(21,21),HSITE, AVTHK, SLFAC,STHK,BLGRX,BLGRY
    COMMON /CSFC/ SFCHT(21,21),SIGMA(10),SIGMAH(10),X(32),Y(32)
    PRINT 9001
    THK = AVTHK
    IF (IGRID .GT. 1) THK = THSITE
    BLX=BLGRX
    BLY=BLGRY
    IF(IGRID.GT.1) THEN
        BLX=BLGRX/4.0
        BLY=BLGRY/4.0
    END IF
    ITER = 0
10  ITER = ITER + 1
    SUM1 = 0.0
    Q1 = 0.0
    DO 50 I = 1,NCOL
    DO 50 J = 1,NROW
        BLT(I,J) = THK + (SLFAC * SFCHT(I,J)) + (1.0 -SLFAC) *HSITE
C ADD EASTWARD GRADIENT TO BLT FROM COL. 10
        BLT(I,J)= BLT(I,J)+ (I-10)*(BLX/FLOATJ(NCOL))
C ADD NORTHWARD GRADIENT FROM ROW 10
        BLT(I,J)= BLT(I,J) + (J-10)*(BLY / FLOATJ(NROW))
        IF (SFCHT(I,J) .GT. (BLT(I,J)- STHK )) BLT(I,J) = SFCHT(I,J)
        + STHK
        SUM1 = SUM1 + (BLT(I,J) - SFCHT(I,J))
    50  Q1 = Q1 + 1.0
    CONTINUE
    IF(IGRID.GT.1) GO TO 51
    ATH = SUM1/Q1
    THK = THK + (AVTHK - ATH)
    THSITE = BLT(IXS,JYS) - SFCHT(IXS,JYS)
    PRINT 9010, AVTHK,ATH, THSITE
    DIFF = ABS(AVTHK - ATH)
    IF (ITER .GT. 9) GO TO 52
    IF (IGRID .EQ. 1 .AND. DIFF .GT. 100.0) GO TO 10
51  CONTINUE
    IF(IGRID.EQ.1) GO TO 52
    ATH=SUM1/Q1
    THSITE2=BLT(IXS,JYS) - SFCHT(IXS,JYS)
    THK=THK + (THSITE - THSITE2)
    DIFF2=ABS(THSITE - THSITE2)
    PRINT 9010, AVTHK,ATH,THSITE2
    IF(ITER.GT.9) GO TO 52
    IF(DIFF2.GT.100.0) GO TO 10

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52  CONTINUE
    DO 55 JP = 1,NROW
    DO 55 IP = 1,NCOL
        B(IP,JP) = .01 * BLT(IP,JP)
55  CONTINUE
    PRINT 9115
    DO 60 JP = 1,NROW
    JR = NROW+ 1 -JP
60  PRINT 9100, ( B(IP,JR),IP=1,NCOL)
    DO 65 JP= 1,NROW
    DO 65 IP= 1,NCOL
        B(IP,JP)= .01*(BLT(IP,JP) -SFCHT(IP,JP))
65  CONTINUE
    PRINT 9020
    DO 70 JP= 1,NROW
    JR= NROW +1 -JP
70  PRINT 9100, (B(IP,JR),IP=1,NCOL)
    PRINT 9002
9001 FORMAT (1H1,' BEGIN SUBROUTINE SETBLT'//)
9002 FORMAT (1H1,' END OF SUBROUTINE SETBLT'//)
9010 FORMAT (1H1,' INITIAL AV. THICKNESS, CM='F10.1,
+ ' ACTUAL AV. THICKNESS ='F10.1,
+ ' SITE THICKNESS ='F10.1//)
9020 FORMAT(1H1,'BNDY LAYER THICKNESS IN M'//)
9100 FORMAT (/5X,22F5.0)
9115 FORMAT (1H1,' HEIGHT OF BNDY LAYER TOP, M '//)
    RETURN
    END
    SUBROUTINE BOUNDS(MER,MT,NT,YMAX,XMIN,YD,XD,Y,X)
    DIMENSION Y(1),X(1)
    DO 10 M=1,MT
    YM=YMAX+(1-M)*YD
    Y(M+MT)=YM
10  Y(M)=YM
    DO 20 N=1,NT
    XN=XMIN+(N-1)*XD
    X(N+NT)=XN
20  X(N)=XN
    RETURN
    END
    SUBROUTINE NET(KQ,IDS,WIN,JJ,M9,N9,YS,XS,VS,US,HS,Y,X,V,U,H,IS)
C
C  MAKES GRID PT ANALYSES FROM STATION DATA
C
    DIMENSION DS(150),JS(150),IQ(150)
    DIMENSION YS(1),XS(1),VS(1),US(1),HS(1)
    DIMENSION Y(1),X(1),V(1),U(1),H(1),IS(1)
    DATA KSW,ALPH,UNIL/4,2.5,5000.0/
    DATA DYI,DCK/1.0E12,3.2E7/
    IF(KQ.GT.2) GO TO 18
    KQ5=KQ-1+KSS5
    L=0
    M=L
    I=0
75  M=M+1
    IF (M-M9)77,77,100
77  N=0
    YLM=Y(M)
80  N=N+1
    IF (N-N9)81,81,75
81  L=L+1
    NOD=0
    K=NOD
    XLN=X(N)
    IF (KQ-1)82,82,83
82  U(L)=0.0
    V(L)=U(L)
    H(L)=V(L)
    NOD=0
    DVH=0.0
    DUH=DVH
    DHH=DUH
    DNH=DHH
    GO TO 84

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83 DYVH=Ø.Ø
DYUH=DYVH
DYHH=DYUH
DXVH=DYHH
DXUH=DXVH
DXHH=DXUH
DYYH=DXHH
DXXH=DYYH
DXYH=DXXH
DYH=DXYH
DXH=DYH
W=WIN
DNH=W
NOD=1
K=Ø
DHH=H(L)*W
DUH=U(L)*W
DVH=V(L)*W
84 K=K+1
IF (K-KS)85,85,9Ø
384 I=I+KS-K
GO TO 9Ø
85 I=I+1
IF (NOD-KQ5)86,384,384
86 J=IS(I)
IF (J)84,84,87
87 IF (ABS(US(J)).GT.UNIL)GO TO 84
XSJ=XS(J)
YSJ=YS(J)
USJ=US(J)
VSJ=VS(J)
HSJ=HS(J)
DYS=YSJ-YLM
DXS=XLN-XSJ
DYS2=DYS*DYS+DXS*DXS
DXS2=Ø.5*DYS2
IF (IDS.EQ.Ø)GO TO 385
USK=USJ
VSK=VSJ
IF (KQ.EQ.1)GO TO 388
USK=USJ+U(L)
VSK=VSJ+V(L)
388 DXS1=USK*USK+VSK*VSK+Ø.Ø1
DXS2=(USK*DYS-VSK*DXS)
DXS2=DXS2*DXS2/DXS1
385 W=DYL/(DYS2+DXS2*ALPH+DYL)
NOD=NOD+1
DNH=DNH+W
HSJ=HSJ*W
USJ=USJ*W
VSJ=VSJ*W
DHH=DHH+HSJ
DUH=DUH+USJ
DVH=DVH+VSJ
IF (KQ-1)89,84,89
89 DYH=DYH+DYS*W
DXH=DXH+DXS*W
DXYH=DXYH+DXS*DYS*W
DXXH=DXXH+DXS*DXS*W
DYYH=DYYH+DYS*DYS*W
DXHH=DXHH+HSJ*DXS
DYHH=DYHH+HSJ*DYS
DXUH=DXUH+USJ*DXS
DYUH=DYUH+USJ*DYS
DXVH=DXVH+VSJ*DXS
DYVH=DYVH+VSJ*DYS
GO TO 84
9Ø CONTINUE
IF (KQ-1)94,91,94
91 IF (NOD-2)8Ø,92,92
92 IF (DNH)8Ø,8Ø,93

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93 DNH=1./DNH
   H(L)=DHH*DNH
   U(L)=DUH*DNH
   V(L)=DVH*DNH
   GO TO 80
94 IF (NOD-3)80,80,95
95 D=DYH*DYH-DNH*DYYH
   E=DXYH*DYH-DXH*DYYH
   A=DXH*DYH-DNH*DXYH
   B=DXXH*DYH-DXH*DXYH
   BDAE=B*D-A*E
   IF (BDAE)97,80,97
97 BI=1./BDAE
   C=DXHH*DYH-DHH*DXYH
   F=DYHH*DYH-DHH*DYYH
   CU=DXUH*DYH-DUH*DXYH
   FU=DYUH*DYH-DUH*DYYH
   CV=DXVH*DYH-DVH*DXYH
   FV=DYVH*DYH-DVH*DYYH
   H(L)=(B*F-C*E)*BI
   U(L)=(B*FU-CU*E)*BI
   V(L)=(B*FV-CV*E)*BI
   GO TO 80
100 CONTINUE
   RETURN
18 CONTINUE
   KS=KQ
   KSS5=IDS
   DLCK=DCK*DCK
   JCT=150
   JS(JCT)=-1
   DS(JCT)=DLCK
   JC2=JCT-2
   L=0
   M=L
   I=0
20 M=M+1
   N=0
   YLM=Y(M)
25 N=N+1
   L=L+1
   J=0
   JT=JJ
   XLN=X(N)
   XLCK=DLCK
29 JC=0
   J=JC
30 J=J+1
   DYS=YS(J)-YLM
   DXS=XLN-XS(J)
   DLS=DYS*DYS+DXS*DXS
   IF (DLS-XLCK)32,33,33
32 JC=JC+1
   IF (JC.LT.JCT)GO TO 31
   XLCK=XLCK*.75
   GO TO 29
31 DS(JC)=DLS
   JS(JC)=J
   IYS=0
   IXS=1
   IF (DXS.LT.0)IXS=2
   IF (DYS.LT.0)IYS=2
   IQ(JC)=IYS+IXS
33 IF (J-JT)30,34,34
34 KP=0
   K=0
   ISW=1
   JQ=ISW
   JX=JC
   IF (KSW.LT.1)ISW=2

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35 K=K+1
   SIL=DLCK
   J=0
   I=I+1
   KP=KP+1
   JC=JCT
40 J=J+1
   IF (J.LE.JX)GO TO (41,42)ISW
   GO TO 45
41 IF (IQ(J).NE.JQ)GO TO 40
42 IF (DS(J)-SIL)44,40,40
44 SIL=DS(J)
   JC=J
   GO TO 40
45 DS(JC)=DLCK
   IS(I)=JS(JC)
   JQ=JQ+1
   IF (JQ.GT.4)JQ=1
   IF (KP.EQ.KSW)ISW=2
   IF (JC.LT.JCT)GO TO 49
   IF (KP.GT.KSW)GO TO 49
   K=K-1
   I=I-1
   GO TO 35
49 IF (K-KS)35,50,50
50 IF (N-N9)25,55,55
55 IF (M-M9)20,60,60
60 CONTINUE
   RETURN
   END

```

```

      SUBROUTINE BAL5(NITER)
C      BALANCE DIVERGENCE TO DD AND VORTICITY TO VT
C*   SCALED TO GIVE UNITS 10-6 SEC-1. W SPD IN MPS.
C*   THIS VERSION USES FLUX METHOD
C   COMPUTE NON-DIV WINDS FOR WINDS WEIGHTED BY THICKNESS OF LAYER.
C   ASSUME SIGMADOT =0. SOLUTION FOR COMPLEX TERRAIN BASED ON DIRECT
C   VECTOR ALTERATIONS. INDICES IN 2D ARRAYS A(J,K) ARE J=ROW, K= COL
C   WITH A(1,1) IN NW CORNER. INDICES REFER TO NW CORNER OF EACH BOX.
C   BY R. ENDLICH MAY '82.
      DIMENSION VT(21,21),DI(21,21),VO(21,21),U1(21,21),V1(21,21)
      DIMENSION UN(21,21),VN(21,21),THK(21,21),RHN(21,21,10)
      COMMON /CSFC/SFCHT(21,21),SIGMA(10),SIGMAH(10),X(21),Y(21)
      COMMON /UARS/U(21,21,10),UA(21,21,10),V(21,21,10),VA(21,21,10)
      COMMON /PARMS/ZTOP,DS,DSIGMA,NLVLM1,XHT1,XHT2,X1,Y1,X2,Y2,UG,VG
      1 ,RATIO,TDSI
      COMMON /CVOS/IB,JB,IZ,JZ,IV,DSI,IX1,JYZ
      COMMON /CTOP/MI,NI,MR,NR,NGRID,HTOP
      COMMON /LIMITS/NCOL,NROW,NLVL,NCOLM1,NROWM1
      COMMON /RARS/RHS(21,21,10)
      COMMON /C3/ KP1,KP2,JP1,JP2,ICNT
      PRINT 9002
      GS = DS * 1.0E-07
C   GRID SPACING IS IN KM TIMES 0.01, (100'S KM). DS IN CM.
      GSI = 10.0/GS
C   FOR THIS RECTANGULAR GRID USE CS(J)=SEC(J)=TNG(J)=1.0.
      CSJ = 1.0
      SECJ = 1.0
      TNGJ=1.0
C   TRANSFER WINDS TO 2D ARRAYS
C   ARRAYS U,V AND RHS WRITTEN (COLS,ROWS,LEVAL) NOW CONVER TO ARRAYS UN,
C   VN AND RHN AS 2 DIMENSIONAL ARRAYS WRITTEN (ROWS,COLS).
C
      DO 25 L=1,NLVL
      DO 25 J=1,NROW
      DO 25 I=1,NCOL
         JR=NROW + 1 - J
         RHN(JR,I,L)= RHS(I,J,L)

```

```

25  CONTINUE
    DO 800 L=2,NLVL
        DO 35 J=1,NROW
            DO 35 I=1,NCOL
                JR=NROW + 1 - J
                KR=I
                UN(JR,KR)= U(I,J,L)
                VN(JR,KR)= V(I,J,L)
35      CONTINUE
        CALL SETDBLARRY(0.0,DI ,21,21)
        CALL SETDBLARRY(0.0,VT ,21,21)
        CALL SETDBLARRY(0.0,VO ,21,21)
C  COMPUTE LAYER THICKNESS AND MULTIPLY WIND COMPONENTS
    DO 40 J =1,NROW
        DO 40 K =1,NCOL
            LA = L +1
            IF (LA .GT. NLVL) LA = NLVL
            HTA = RHN(J,K,LA) * 0.01
            LB = L -1
            IF (LB .LT. 1) LB =1
            HTB = RHN(J,K,LB) * 0.01
            THK(J,K) = 0.5 *(HTA -HTB) * 0.01
C  UNITS OF THICKNESS ARE HUNDREDS OF M FOR CONVENIENCE
C  CHANGE SPEED TO MPS
            U1(J,K)= UN(J,K)*.01
            V1(J,K)= VN(J,K)*.01
            UN(J,K) = U1(J,K) * THK(J,K)
            VN(J,K) = V1(J,K) * THK(J,K)
40    CONTINUE
C  PRINT 9520
    DO 45 J =1,NROW
C 45  PRINT 9102, (THK(J,K),K=1,NCOL)
C  COMPUTE ORIGINAL DIVERGENCE AND VORTICITY
    DO 170 J =1,NROWM1
        DO 170 K =1,NCOLM1
            UE = 0.5 * (UN(J,K+1) + UN(J+1,K+1))
            UW = 0.5 * (UN(J,K) + UN(J+1,K))
            VNO = 0.5 * (VN(J,K+1) + VN(J,K))
            VSO = 0.5 * (VN(J+1,K) + VN(J+1,K+1))
            UC = 0.5 * (UE + UW)
            VC = 0.5 * (VNO + VSO)
            DUE = GSI * SECJ * (UE - UW)
            DVN = GSI * (VNO - VSO)
            DI(J,K) = DUE + DVN - VC*TNGJ/6.37
            VE = 0.5 * (VN(J,K+1) + VN(J+1,K+1))
            VW = 0.5 * (VN(J,K) + VN(J+1,K))
            UNO = 0.5 * (UN(J,K+1) + UN(J,K))
            USO = 0.5 * (UN(J+1,K) + UN(J+1,K+1))
            DVE = GSI * SECJ * (VE - VW)
            DUN = GSI * (UNO - USO)
            VT(J,K)= DVE-DUN + UC*TNGJ/6.37
170  CONTINUE
C  PRINT 9570
    DO 173 J =1,NROW
C 173 PRINT 9100, (VT(J,K),K=1,NCOL)
C  PRINT 9571
    DO 172 J =1,NROW
C 172 PRINT 9100, (DI(J,K),K=1,NCOL)
C  FOR NONDIVERGENCE SET DDJK=0.0
    DDJK = 0.0
    LG = 0
    RA = 0.4
210  LG = LG+1
    DO 500 J =1,NROWM1
        DO 500 K =1,NCOLM1
            UE = 0.5 * (UN(J,K+1) + UN(J+1,K+1))
            UW = 0.5 * (UN(J,K) + UN(J+1,K))
            VNO = 0.5 * (VN(J,K+1) + VN(J,K))
            VSO = 0.5 * (VN(J+1,K) + VN(J+1,K+1))
            UC = 0.5 * (UE + UW)
            VC = 0.5 * (VNO + VSO)

```

```

DUE = GSI * SECJ * (UE - UW)
DVN = GSI * (VNO - VSO)
DI(J,K) = DUE + DVN - VC*TNGJ/6.37
CUJK = .05 * GS * CSJ*(DDJK - DI(J,K)) * RA
CVJK = .05 * GS * (DDJK - DI(J,K)) * RA
UN(J,K+1) = UN(J,K+1) + CUJK
UN(J+1,K+1) = UN(J+1,K+1) + CUJK
UN(J,K) = UN(J,K) - CUJK
UN(J+1,K) = UN(J+1,K) - CUJK
VN(J,K+1) = VN(J,K+1) + CVJK
VN(J,K) = VN(J,K) + CVJK
VN(J+1,K) = VN(J+1,K) - CVJK
VN(J+1,K+1) = VN(J+1,K+1) - CVJK
VE = 0.5 * (VN(J,K+1) + VN(J+1,K+1))
VW = 0.5 * (VN(J,K) + VN(J+1,K))
UNO = 0.5 * (UN(J,K+1) + UN(J,K))
USO = 0.5 * (UN(J+1,K) + UN(J+1,K+1))
DVE = GSI * SECJ * (VE - VW)
DUN = GSI * (UNO - USO)
VO(J,K) = DVE - DUN + UC*TNGJ/6.37
CVJK = .05 * GS * CSJ*(VT(J,K) - VO(J,K)) * RA
CUJK = .05 * GS * (VT(J,K) - VO(J,K)) * RA
UN(J,K) = UN(J,K) - CUJK
UN(J,K+1) = UN(J,K+1) - CUJK
UN(J+1,K) = UN(J+1,K) + CUJK
UN(J+1,K+1) = UN(J+1,K+1) + CUJK
VN(J,K+1) = VN(J,K+1) + CVJK
VN(J+1,K+1) = VN(J+1,K+1) + CVJK
VN(J,K) = VN(J,K) - CVJK
VN(J+1,K) = VN(J+1,K) - CVJK
500 CONTINUE
IF (LG .GT. NITER) GO TO 540
DO 530 J=2,NROWM1
DO 530 K=2,NCOLM1
IF (ABS(DDJK - DI(J,K)) .GT. 1.0) GO TO 210
IF (ABS(VT(J,K) - VO(J,K)) .GT. 1.0) GO TO 210
530 CONTINUE
540 CONTINUE
C PRINT 9570
C PRINT 9580
C DO 510 J=1,NROW
C 510 PRINT 9100, (VO(J,K),K=1,NCOL)
C PRINT 9200, LG
C PRINT 9571
C PRINT 9580
C DO 520 J=1,NROW
C 520 PRINT 9100, (DI(J,K),K=1,NCOL)
SUM1=0.0
SUM2=0.0
DO 1040 J =1,NROW
DO 1040 K =1,NCOL
UN(J,K) = UN(J,K)/THK(J,K)
VN(J,K) = VN(J,K)/THK(J,K)
U1(J,K) = U1(J,K) - UN(J,K)
V1(J,K) = V1(J,K) - VN(J,K)
SUM1=SUM1 + U1(J,K)
SUM2=SUM2 + V1(J,K)
1040 CONTINUE
SUM1=SUM1/(NROW*NCOL)
SUM2=SUM2/(NROW*NCOL)
C NORMALIZE ORIG. AVERAGE VALUES
DO 1045 J=1,NROW
DO 1045 K=1,NCOL
UN(J,K)=UN(J,K) + SUM1
VN(J,K)=VN(J,K) + SUM2
1045 CONTINUE
IF(ICNT.GE.5) GO TO 8888
PRINT 1145
1145 FORMAT(' U COMP. DIVERGENT ')
DO 1160 J=1,NROW
1160 PRINT 9150, (U1(J,K),K=1,NCOL)

```

```

9150  FORMAT(2X,31F4.1)
      PRINT 1155
1155  FORMAT(' V COMP. DIVERGENT ')
      DO 1170 J=1,NROW
1170  PRINT 9150, (V1(J,K),K=1,NCOL)
C
C* CHANGE BACK TO 3D ARRAYS AND CM S-1
C
      DO 580 J=1,NROW
      DO 580 K=1,NCOL
          JR=NROW + 1 - J
          U(K,JR,L)= UN(J,K) * 100.
          V(K,JR,L)= VN(J,K) * 100.
580  CONTINUE
800  CONTINUE
      PRINT 9003
8888 CONTINUE
9002 FORMAT (// ' BEGIN SUBROUTINE BAL5 '//)
9003 FORMAT (// ' END OF SUBROUTINE BAL5 '//)
9100 FORMAT (/2X,31F4.0)
9102 FORMAT (/2X,31F4.1)
9200 FORMAT (/ ' NUMBER OF ITERATIONS ='I5)
9520 FORMAT (1H1, ' LAYER THICKNESS IN HUNDREDS OF M'//)
9560 FORMAT (15H DIVERGENT WIND//)
9561 FORMAT (19H NCN DIVERGENT WIND//)
9565 FORMAT (1H1,12H U COMPONENT)
9566 FORMAT (1H1,12H V COMPONENT)
9581 FORMAT (16H ANALYZED VALUES//)
9570 FORMAT (1H1,30H RELATIVE VORTICITY 10-6 SEC-1)
9571 FORMAT (1H1,22H DIVERGENCE 10-6 SEC-1)
9580 FORMAT (16H BALANCED VALUES//)
      RETURN
      END
      SUBROUTINE SETDBLARRY(VALUE,ARRAY,NUM1,NUM2)
C
C      INITIALIZES ALL ELEMENTS OF ARRAY TO VALUE
C      REVISION SEPT. 1978
C
      DIMENSION ARRAY(NUM1,NUM2)
      DO 10 I=1,NUM1
      DO 10 J=1,NUM2
          ARRAY(I,J)=VALUE
10  CONTINUE
      RETURN
      END

```


Program REWND


```

C      PROGRAM REWND
C
C      THIS PROGRAM CALCULATES HOURLY WINDS FROM EIGENVECTOR SOLUTIONS
C      AND HOURLY TRANSFORMED OBSERVATIONS AT SURROUNDING SITS.
C
C      PROGRAM MODIFIED TO RUN ON A VAX 11/782
C
C      DIMENSION ITYPE(24),USOL(5,20),VSOL(5,20),UMN(5),VMN(5),
C      1 A(20),NNDAY(5),ISTAB(10),AVTHK(5),SFAC(5),STHK(5)
C      REAL ISTAB
C
C      READ(8,3) NEIG,NTYPE
C      3      FORMAT(2I5)
C
C      NUMBER OF TYPES OF SOLUTION (NTYPE).
C      NUMBER OF EIGENVECTORS TO BE USED (NEIG).
C      NUMBER OF VARIABLES (NVAR).
C      NUMBER OF SITES (NSITE=NVAR/2).
C
C      READ(3,20) IDATE,IHOUR,NVAR,NSITE
C      20      FORMAT(4I8)
C      PRINT 3333, IDATE,IHOUR,NVAR,NSTE
C      3333      FORMAT(1X,5I10)
C
C      READING TAPE TO GET NVAR=NO. OF VARIABLES
C      WHICH IS = TOTAL NO. OF EIGENVECTORS, BUT NOT NECESSARILY
C      TO NUMBER USED TO CONSTRUCT WINDS (NEIG).
C
C      BACKSPACE 3
C      INVEIG=NVAR-NEIG+1
C
C      READING COMPLEX SOLUTIONS FOR EIGENVECTORS (J) AND MEANS AS
C      DERIVED FOR EACH TYPE (I) OF MIXING DEPTH.
C
C      2      READ(8,10000) JSITE,IV,UDUM,VDUM,NTDAY,AVA,SLS,STS
C      10000      FORMAT(2I5,2F10.2,I5,F10.0,F5.1,F8.0)
C
C      BLANK RECORD STOPS READING
C
C      IF(JSITE.LE.0) GO TO 7
C      AVTHK(NTDAY)=AVA
C      SFAC(NTDAY)=SLS
C      STHK(NTDAY)=STS
C      NNDAY(NTDAY)=NTDAY
C
C      JSTE=SITE IDENTIFIER (NOT USED)
C      IV=EIGENVECT NO. (=0 FOR MEANS)
C      UDUM,VDUM=COMPLEX MODEL SOLUTIONS FOR THIS EIGENVECT NO. AND
C      SOLUTION TYPE (NTDAY)
C      NTDAY=CASE TYPE E.G. DAY=1, NIGHT=2
C      AVTHK,SFAC,STHK=AV. MIX. LAYER THICKNESS (M), SLOPE, FACTOR
C      AND MINIMUM LAER THICKNESS(M) USED FOR THIS CASE--NOT USED.
C      SOLUTIONS FOR VARIOUS CASE TYPES AND EIGENVECTORS ASSIGNED
C      TO ARRAYS BELOW
C
C      IF(IV.EQ.0) GO TO 5
C      USOL(NTDAY,IV)=UDUM
C      VSOL(NTDAY,IV)=VDUM
C      GO TO 6
C
C      COMPLEX MODEL SOLUTIONS FOR MEAN INPUTS
C
C      5      UMN(NTDAY)=UDUM
C      VMN(NTDAY)=VDUM
C      6      GO TO 2
C      7      CONTINUE
C
C      DEFINE TYPE OF MIXING FOR EACH HOUR OF THE DAY
C
C      READ(8,20000) (ITYPE(IHR),IHR=1,24)

```

```

2000  FORMAT(24I3)
      NCASE=1
      PRINT 1001
1001  FORMAT(1H1,'EIGVECT. ',3X,'TYPE',5X,'U',9X,'V',2X,
1      'D/N IND',4X,'AV THK',5X,'SLOPE',3X,'MIN THK')
      DO 1100 I=1,NTYPE
          PRINT 1002, I,UMN(I),VMN(I),NNDAY(I),AVTHK(I),SFAC(I),
1          STHK(I)
1002  FORMAT(1X,'MEAN ',I8,2F10.3,I5,6X,F9.1,3X,F6.2,F7.1)
          DO 1100 J=INVEIG,NVAR
              PRINT 1003, J,I,USOL(I,J),VSOL(I,J)
              FORMAT(1X,I5,I7,2F10.3)
1003
1100  CONTINUE
      PRINT 1004,((K),K=1,24),(ITYPE(L),L=1,24)
1004  FORMAT(1H0,'CASE TYPES',/,1X,'HOUR=',24I3,/,1X,'TYPE',24I3)
C
C      READING THE INNER PRODUCTS (A) OF THE OBSERVED DATA SETS
C      AND THE EIGENVECTORS FOR EACH DATE (IDATE) AND HOUR (IHOUR)
C
30  READ(3,20,END=99) IDATE,IHOUR,LVAR,LSITE
      READ(3,21) (A(J),J=1,NVAR)
      READ(3,21) (ISTAB(J),J=1,NSITE)
21  FORMAT(10F8.2)
C
C      SELECTING SOLUTION TYPE APPROPRIATE TO THE HOUR
C
C      CORRECTION FOR HOUR=0
C
      IF(IHOUR.EQ.0) THEN
          II=ITYPE(24)
      ELSE
          II=ITYPE(IHOUR)
      END IF
C
C      GETTING U,V COMPONENTS FOR MEAN SOLUTIONS
C
      U=UMN(II)
      V=VMN(II)
C
C      SUMMING WEIGHTED (*A) SOLUTIONS FOR EACH EIGENVECTOR
C
      DO 35 K=INVEIG,NVAR
          U=U+A(K)*USOL(II,K)
          V=V+A(K)*VSOL(II,K)
35
C
C      GETTING SPEED AND DIRECTION
C
      S=SQRT(U*U + V*V)
      IF(S.EQ.0.0) GO TO 40
      D=ATAN2(V,U) * 57.2719
      GO TO 45
40  D=270.0
45  D=270.0-D
      IF(D.LT.0.) D=D+360.0
      D=AMOD(D,360.)
      XJ=IDATE
      HOUR=IHOUR
C
C      WRITING RECONSTRUCTED WIND INFORMATION. PRNT RESULTS
C      ONCE PER 100 CASES (3-HR DATA) FOR INSPECTION
C
      WRITE(2,801) XJ,HOUR,U,V,S,D
      FORMAT(6F10.2)
      IMPRNT=JMOD(NCASE,15)
      IF(IMPRNT.EQ.1) PRINT 3005, NCASE,IDATE,IHOUR,U,V,S,D,(A(KK),KK=1,NVAR)
3005  FORMAT('O','CASE =',I8,'DATE =',I10,' HOUR =',I8,/,
1      ' U =',F10.3,' V =',F10.3,/,1X,'SPEED=',F10.3,' DIRECT=',F10.3,
2      /,1X,'COEFFICIENTS',12F9.3)
      NCASE=NCASE+1
      GO TO 30

```

```

C      WRITE END FILE ON TAPE, PRINT NUMBER OF CASES TREATED,
C      REWIND TAPES AND END
C
99      ENDFILE 2
      PRINT 9000, NCASE
9000    FORMAT(1X,'EOF FILE 2',5X,'NO. OF CASES =',2X,I6)
      REWIND 2
      REWIND 3
999      CONTINUE
      STOP
      END

```


Program WINDY


```

PROGRAM WINDY

C
C CALCULATES RUN DURATIONS IN SPECIFIC CATEGORIES AND SEASONAL
C AND HOURLY AVERAGE SPEEDS.
C
C PROGRAM MODIFIED TO RUN ON A VAX 11/782
C
C DIMENSION LOWS(80),MIDS(80),MOSTS(80),SPDS(24,4),XN(24,4)
C 1,SEA(4),SON(4),SEASUM(4),SEANO(4)
C CHARACTER*3 SEA,SON,ALL
C
C DATA ALL/'ALL'/
C DATA SEA/'DEC','MAR','JUN','SEP'/
C DATA SON/'FEB','MAY','AUG','NOV'/
C SPAST=4.
C N=0
C USED=0.0
C USED IS A COUNTER FOR NO. OF HRS USED IN COMPUTATIONS
C
C SETTING RUNS AND SUMS=0.
C
C DO 50 I=1,79
C     LOWS(I)=0
C     MIDS(I)=0
C     MOSTS(I)=0
50 CONTINUE
C DO 52 I=1,4
C     SEASUM(I)=0.0
C     SEANO(I)=0.0
52 CONTINUE
C DO 55 J=1,4
C DO 55 I=1,24
C     SPDS(I,J)=0.0
C     XN(I,J)=0.0
55 CONTINUE
C NMID=0
C NLO=0
C NHI=0
C
C JULIAN=JULIAN DATE AT START OF RUN THEN CONVERTED TO DAYS
C SINCE DEC 1.
C
C SPLOW=LOWEST SPEED AT WHICH GENERATOR OPERATES (M/S)
C SPHI,TOPSPD=RANGE OF MAXIMUM GENERATED POWER (M/S)
C UNITS=FACTOR TO CONVERT GIVEN UNITS TO M/S
C AT=TIME INTERVAL, HRS, BETWEEN RECORDED DATA
C K--PROGRAM USES EVERY KTH RECORD FOR CALCULATIONS
C INCT=K*AT, IS INTERVAL HRS BETWEEN RECORDS ACTUALLY USED
C FOR COMPARISONS USE K=3, INCT=3, FOR REAL HOURLY DATA
C AND K=1. INCT=3 FOR MODEL (3 HR) DATA
C
C READ(*,5000) JULIAN,SPLOW,SPHI,TOPSPD,UNITS,INCT,K
5000 FORMAT(BZ,I3,4F7.2,2I3)
C IF(INCT.EQ.0) INCT=1
C PRINT 5001, JULIAN,SPLOW,SPHI,TOPSPD,UNITS,INCT,K
5001 FORMAT(1H1,'JULIAN = ',I3,' SPLOW = ',F7.2,' SPHI = ',F7.2,
1 ' TOPSPD = ',F7.2,' UNITS = ',F7.2,' TIME STEP = ',I3,
2 ' K = ',I3)
C JULIAN=JULIAN+31
C
C 100 READ(1,4000,END=86) CASE, HOUR,U,V,S,D
4000 FORMAT(BZ,6F10.2)
C
C HOUR CORRECTION FOR 0 HOUR
C
C IF(HOUR.EQ.0.0) HOUR=24.0
C IF(K.EQ.1) GO TO 125
C N=N+1
C IF(MOD(N,K).NE.1) GO TO 100
125 CONTINUE

```

```

C      MISSING SPEED=99.9
      IF(S.EQ.99.9) PRINT 6007, CASE, HOUR
      IF(S.EQ.99.9) GO TO 100
6007   FORMAT(IX, 'MISSING ', 2F8.0)
C
C      GETTING HOUR INDEX (IH) AND SEASON INDEX (LSEA--1=DEC-FEB,...4,=
C      COUNT NO. OF HOURS USED
C
      USED=USED+1.0
      IH=HOUR
      S=UNITS*S
      SPAST=S
      ICASE=CASE
      LLL=ICASE/100
      LLL=MOD(LLL,100)
      LSEA=LLL/3 + 1
      IF(LSEA.EQ.5) LSEA=1
      SEASUM(LSEA)=SEASUM(LSEA) + S
      SEANO(LSEA)=SEANO(LSEA) + 1.0
      SPDS(IH,LSEA)=SPDS(IH,LSEA) + S
      XN(IH,LSEA)=XN(IH,LSEA) + 1.0
C
C      GETTING RUN CATEGORIES AND INCREMENTING
C
      IF(S .GE. SPLOW) GO TO 130
      NHI=0
      NMID=0
      NLO=NLO+1
      GO TO 200
130    NMID=NMID+1
      NLO=0
      IF(S.GT.SPHI .AND. S.LT.TOPSPD) GO TO 140
      NHI=0
      GO TO 210
140    NHI=NHI+1
      GO TO 210
200    J=1 + (NLO-1)*INCT
      IF(J.GT.79) J=79
      LOWS(J)=LOWS(J)+1
      GO TO 100
210    J=1 + (NMID-1)*INCT
      IF(J.GT.79) J=79
      MIDS(J)=MIDS(J)+1
      IF(NHI.EQ.0) GO TO 100
      J=1 + (NHI-1)*INCT
      IF(J.GT.79) J=79
      MOSTS(J)=MOSTS(J)+1
      GO TO 100
80     CONTINUE
      PRINT 6009, USED
6009   FORMAT(//, ' NO. OF OBSERVATIONS =', F9.0, //)
C
C      PRINT RUN DURATIONS, CALCULATE AND PRINT AVERAGE SPEEDS.
C
      PRINT 6000
6000   FORMAT(1H0, 'RUN DURATION'.3X, 'LT', 5X, 'GE', 3X, 'BETWEEN', /,
1       1 3X, '(HOURS)', 4X, 'SPLOW', 1X, 'SPHI-TOPSPD',
2       2 ' NORMALIZED TO A YEAR')
      INSTRT=INCT+1
      DO 300 I=INSTRT, 79, INCT
          J=I-INCT
C      GETTING NUMBER OF TIMES THAT MAXIMUM RUN LENGTH=J FOR
C      THREE CRITERIA
          LOW=LOWS(J)-LOWS(I)
          MID=MIDS(J)-MIDS(I)
          MOST=MOSTS(J)-MOSTS(I)
C      NORMALIZE HOURS TO A YEAR OF 3 HRLY OBSERVATIONS
          XL=LOW
          XM=MID
          XT=MOST
          PLOW=8.0 * 365. * XL/USED

```

```

        PMID=8.0 * 365. * XM/USED
        PMOST=8.0 * 365. * XT/USED
        PRINT 6001, J, LOW, MID, MOST, PLOW, PMID, PMOST
6001  FORMAT(4X, I2, 0X, I4, 2X, I4, 4X, I4, 3(4X, F8.0))
300  CONTINUE
        PRINT 6005
6005  FORMAT(////, 1H0 'SEASONAL MEANS--')
        DO 325 I=1, 4
            AVER=SEASUM(I)/SEANO(I)
            PRINT 6006, SEA(I), SON(I), AVER
6006  FORMAT(10X, A3, ' THROUGH ', A3, F6.2, ' M/S')
325  CONTINUE
        DO 375 LSEA=1, 4
            SUM=0.0
            ZNUM=0.0
            PRINT 6002
6002  FORMAT(////, 1H0, 'HOURLY MEANS--', /, 4X, 'HR', 3X, 'MEAN (M/S)')
            PRINT 6008, SEA(LSEA), SON(LSEA)
6008  FORMAT(1X, ' ', A3, ' THROUGH ', A3)
            DO 350 IH=1, 24
                SUM=SUM+SPDS(IH, LSEA)
                ZNUM=ZNUM+XN(IH, LSEA)
                IF(XN(IH, LSEA).EQ.0.) GO TO 225
                SPEED=SPDS(IH, LSEA)/XN(IH, LSEA)
                GO TO 230
            225  SPEED=-99.9
            230  CONTINUE
                PRINT 6003, IH, SPEED
6003  FORMAT(4X, I2, F10.3)
350  CONTINUE
            SUM=SUM/ZNUM
            PRINT 6004, ALL, SUM
6004  FORMAT(1H0, ' ', A3, F10.3)
375  CONTINUE
        STOP
        END

```


Program SPSS

RUN NAME	FREQUENCIES,CROSSTABS PACHECO PASS
VARIABLE LIST	CASENO,HOUR,DUM1,DUM2,SPEED,DIRECT
VAR LABELS	DIRECT,DIRECTION--22.5 DEGREE BINS/SPEED, SPEED--IN METERS PER SECOND/
INPUT MEDIUM	DISK
INPUT FORMAT	FIXED(6F10.2)
N OF CASES	UNKNOWN
MISSING VALUES	SPEED(99.9)/DIRECT(999.)
COMPUTE	SPEED2=SPEED
COMPUTE	SPEED2=TRUNC(SPEED2/200)
COMPUTE	DIRECT2=TRUNC((DIRECT+11.25)/22.5+1)
ASSIGN MISSING	DIRECT2(-1)
IF	(DIRECT2 GT 16) DIRECT2 = 1
COMPUTE	SPEED4=TRUNC(SPEED/100)
ASSIGN MISSING	SPEED2,SPEED4(-1)
RECODE	SPEED4(0 THRU 3=1)(4 THRU 7=2) (8 THRU 11=3)(12 THRU 15=4)(16 THRU HI=5)
VAR LABELS	SPEED2,SPEED--2 METER PER SECOND BINS/ SPEED4,SPEED--4 METER PER SECONDS BINS/ DIRECT2,DIRECTION--22.5 DEGREE BINS/
VALUE LABELS	SPEED4(1)0 - 3.99(2)4-7.99(3)8-11.99 (4)12-15.99(5)16 AND OVER/
TASK NAME	FREQUENCY SPEED--2 METER BINS
FREQUENCY	INTEGER=SPEED2(0,30)
OPTIONS 8	
TASK NAME	CROSS TAB SPEED--BINS OF 4 BY DIRECT
CROSSTABS	VARIABLES=SPEED4(1,5), DIRECT2(0,16)/ TABLES=SPEED4 BY DIRECT2
STATISTICS	ALL
FINISH	