P6.6 DIURNAL AND SEASONAL WIND VARIABILITY FOR SELECTED STATIONS IN CENTRAL AND NORTHERN CALIFORNIA CLIMATE REGIONS

Charles J. Fisk *
NAVAIR-Point Mugu, CA

1. INTRODUCTION

Utilizing three-chart sets of hour-by-month climograms analogous to topographic maps, the diurnal and seasonal wind variability of seventeen California localities in the central and northern portions of the state are surveyed and analyzed. This is a followup to a similar study done a year ago for sixteen stations mostly south of the Transverse Ranges [Fisk, 2008].

The layouts are intended to provide quick-study visual overviews of the stations' diurnal and seasonal wind character, the information possibly useful for general planning and scheduling endeavors in which decision-making lead-times are not necessarily emergency and precision is not paramount. They can also be used in a more "pure" climatological context, the features interpreted and compared for their own sake.

Climograms such as these have been produced for a number of Naval Air Station commands as well as a National Weather Service Forecast office. Diurnal and seasonal variation for other parameters such as mean temperature, percent of time with fog, etc., have been graphed in similar layout schemes.

The wind variability charts are "Mean Vector Wind/Constancy", "Prevailing Winds", and "Mean Scalar Wind Speeds/Percent of Time with Calms". For each layout, calendar month replaces the North/South or Y-axis, and hour of the day the East-West or X-axis. The various points on the graph represent wind climatological statistics for individual hours, by month, and areas with similar properties are contoured/colored to further illuminate their features. Sunrise/Sunset demarcation traces are also overlain. The station selection makes use of the NOAA Western Regional Climate Center's California Climate Region delineation (Figure 1). The WRCC regions included in this study are the Central Coast ("F"), the San Joaquin Valley ("G"), the Sierra ("D"), the Sacramento Delta ("E"), the North Coast ("A"), North Central ("B"), and Northeast ("C").

The original raw data were downloaded from the NCDC Integrated Surface Hourly ("ISH"} online site, the periods of record generally dating back to1973 or earlier - in one case to 1932 (San Francisco). Climatological statistics for each hour of the day, by month, (288 total data points) were used to construct the graphs.

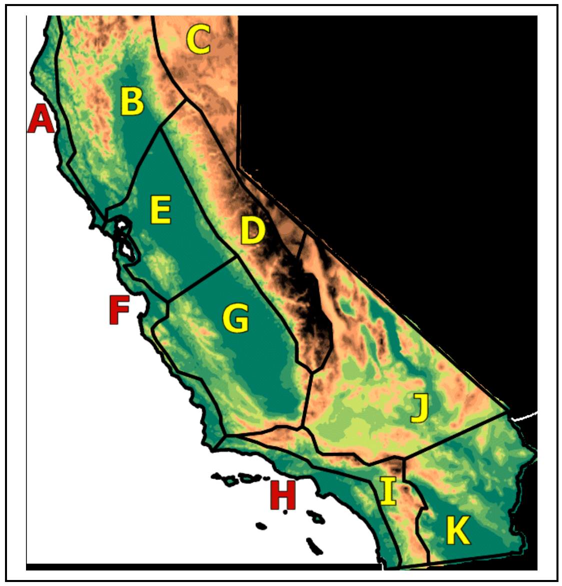

Figure 1. NOAA Western Regional Climate Center (WRCC) California Climate Regions [WRCC, 2007]

2. METHODS AND PROCEDURES

As in the previous study, the station-by-station sections present the three graph types along with some written interpretations of their features, but as before, the large number of charts presented (in this case 51) and space constraints necessitates that the explanations be relatively brief and occasionally speculative.

In any case, visualization of climate information as it is done here is intended to serve as a viable alternative to lengthy written summarizations and/or voluminous tabulations.

2.1 - "Mean Vector Wind" and Vector Wind "Constancy"

The mean vector wind and vector wind "constancy" characterize overall wind direction and persistence. Calculation is performed by decomposing individual wind observations into their north/south and east/west components, adding the components, and then recombining their arithmetic averages into a single overall "mean vector wind" or "resultant wind". Since individual wind directions almost always show variability from observation to observation, resultant wind speeds will be somewhat less that the corresponding mean scalar wind speeds (mean wind speed irrespective of

* *Corresponding author address:* Charles J. Fisk, NAVAIR, Point Mugu, CA. 93042: e-mail: charles.fisk@navy.mil

direction). The ratio of the former to the latter multiplied by 100 measures vector wind "constancy". Constancy values can range from 100 (individual wind observations unvarying in direction but not necessarily in speed) to 0 (individual wind observations canceling each other out exactly when added vectorially. As the charts illustrate, mean vector wind directions, speeds, and constancies for a given station can vary considerably on an hour-by-hour basis climatologically, owing to diurnal, seasonal, and local topographical influences.

Mean vector winds are depicted in their climogram as arrows, oriented in the direction of flow, the lengths proportional to speed. Constancy values are depicted by color shadings.

2.2 - "Prevailing Winds"

"Prevailing Winds" are the most frequently observed 16-point compass wind directions. The climogram depicts for each hour, by calendar month, its direction and mean speed, the arrows also oriented in the direction of flow with their lengths proportional to mean speed. Occurrence frequencies are represented as superimposed color shadings/contour lines.

Prevailing winds information, of course, is less inclusive than that of the mean vector wind, as information on just one direction is considered. However, its interpretation is somewhat more intuitive, and in this regard the two charts complement each other.

Prevailing wind frequencies that are high in magnitude, say >30 percent, are generally associated with mean vector winds of a similar directional orientation accompanied by a high constancy value.

2.3 **-** "Mean Scalar Wind Speed/Percent of Time with Calms"

"Mean Scalar Wind Speed" and "Percent of Time with Calms" are depicted for each hour and month as solid contours/color for the former and dashed contours for the latter.

3. RESULTS

3.1 - "Central Coast" Stations

Five stations from the "Central Coast" region are analyzed for their wind variability: Santa Maria Municipal Airport , San Luis Obispo Airport, Salinas Airport, Monterey, and San Francisco WSO.

3.1.1 **–***Santa Maria Municipal Airport - Lat: 34° 54' N; Lon: 120° 27' W; Elev: 269 ft*

Santa Maria is located in a ten-mile wide valley, open to the Pacific Ocean about 15 miles to the west. A symmetric pattern of relative constancy magnitudes is indicated, the most notable feature being the red\orange area of high constancy northwesterly vectors covering most of the daylight hours and some of the near post-

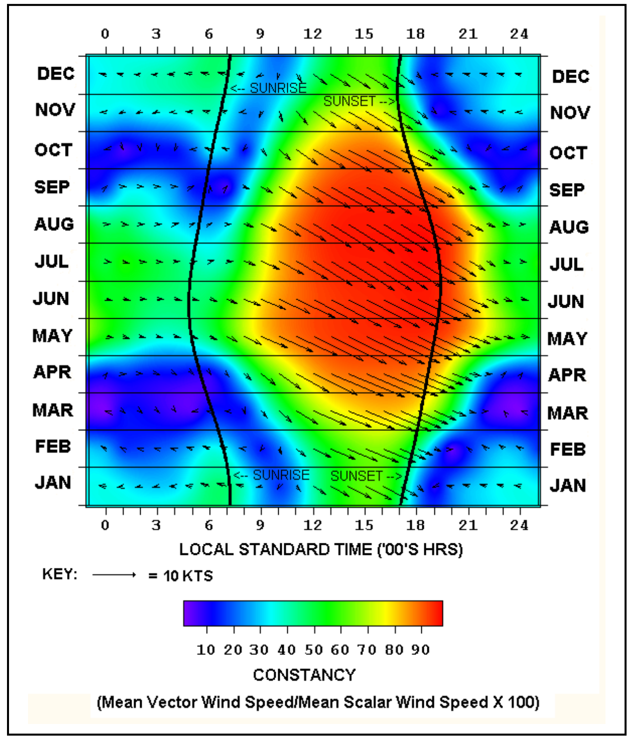

Figure 1. Mean Vector Wind/Constancy Chart for Santa Maria Municipal Airport, CA.

sunset ones, especially for the months May to September. This likely reflects a combination of the sea-breeze and in some cases post-frontal northwesterly episodes. Constancy magnitudes for the hours 0900 LST to 2000 LST, inclusive, within these five months (60 data points), range as high as 96, the overall subset average, 90. The low-constancy blue/violet shaded areas (magnitudes generally less than 20) oriented vertically depict diurnal transition periods (e.g., September-December early post-sunrise hours). Low constancy bands that are slanted more horizontally can indicate seasonal transition periods, but in the case of Santa Maria, at least, the horizontal blue-shaded areas (e.g., those covering the March and April pre-sunrise hours) reflect more the presence of light and variable wind character. Overall resultant wind statistics for Santa Maria taking all observations as a unit are: resultant direction: 296.65 degrees (WNW), resultant speed 3.68 knots, and constancy 56.38.

Not surprisingly, the Prevailing Winds chart (Figure 2) also displays a strong tendency for northwesterlies. Occurrence frequencies are greater than 40 percent for virtually all the noon to sunset hours for the months April to October, a narrow area just preceding sunset during April, May, and June indicating 54 percent or greater incidence, an exceptionally high statistic when one considers that a completely uniform around-the-compass wind climatology would have just 6.25 percent frequencies for each 16-point direction (assuming no calms). Nearly all the depicted directions on the chart, irrespective of magnitude, are either northwesterly or

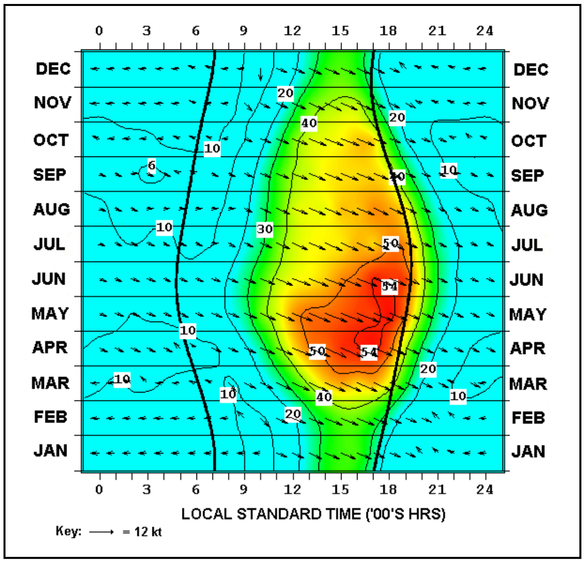

Figure 2. Prevailing Winds' Chart for Santa Maria, CA. Municipal Airport

easterly.

The Mean Scalar Wind and Percent of Time with Calms chart (Figure 3) shows a large contrast in mean wind speeds and percent of times with Calms. Most of the wind speeds for the hours before sunrise, especially over May to October are quite light, averaging 3 knots or less. A 54 percent isopleth (dashed) of Calms' incidence is seen for 2300 LST to 0100 LST in late August and September, corresponding to mean speeds of 2 knots or less. Mean speeds in the mid-afternoon hours for late-April through May are a relatively hefty 14 knots, the overall Santa Maria mean scalar speed 6.49 knots.

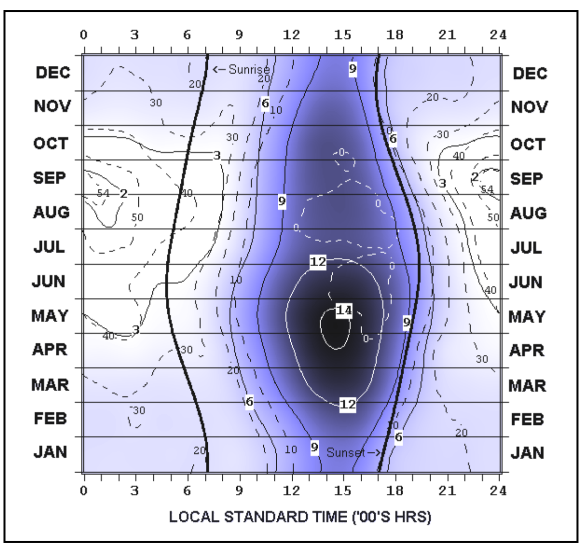

Figure 3. Mean Scalar Wind Speeds and Percent of Airport for Santa Maria, CA.

3.1.2 – *San Luis Obispo Regional Airport – Lat: 35°14' N; Lon: 120° 39'; Elev: 212 ft.*

San Luis Obispo is a coastal station located about 30 miles north of Santa Maria and roughly halfway between Los Angeles and San Francisco. The Mean Vector Wind chart (Figure 4) displays many of the same features as Santa Maria's, namely the prominent (red/orange) area of high constancy northwesterly vectors for much of the late morning to early evening hours, especially over May to September ; also the blue/violet areas of mostly light and mixed-direction vectors covering most of the nocturnal and early morning hours, particularly for October to April. Using the same subset of 60 hours that was focused on for Santa Maria, constancy magnitudes for the hours 0900 to 2000 LST, inclusive, as part of the five months period May to September, ranged as high as 94, the overall average 85.

Overall wind constancy for San Luis Obispo is 66.06, the associated resultant direction 299.74 degrees (WNW), and magnitude 3.92 knots.

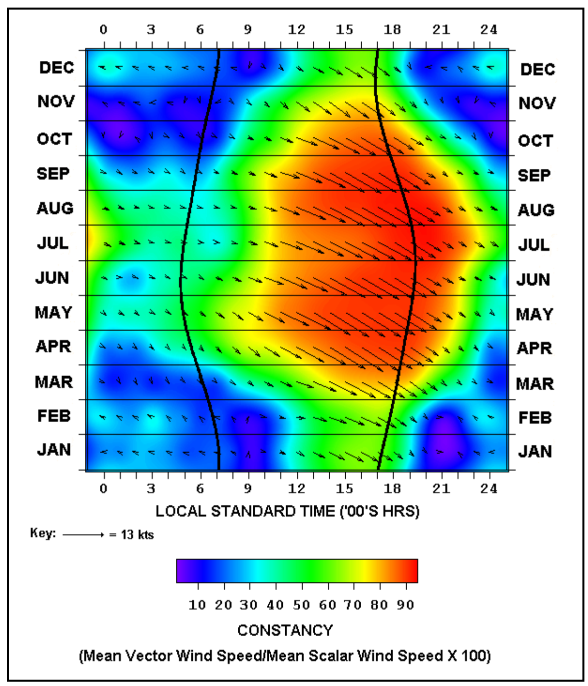

Figure 4. Mean Vector Wind/Constancy Chart for San Luis Obispo, CA. Regional Airport

San Luis Obispo's prevailing winds patterns (Figure 5) are similar to Santa Maria's, but the area of 40 percent incidence is less extensive, and the extreme maximum isopleths are shifted into July and August. For these two months, a 53 percent maximum frequency contour overlays the west-northwesterlies resident for the hours 1600 LST and 1700 LST.

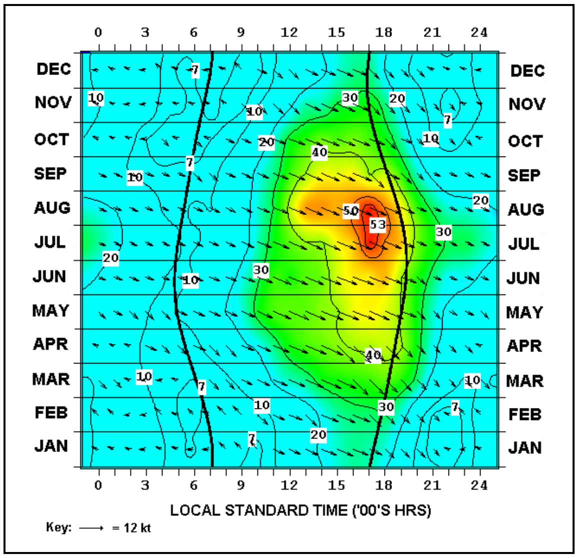

Figure 5. Mean Vector Wind/Constancy Chart for San Luis Obispo Regional Airport

From the Mean Scalar Wind Speed/Percent of Time with Calms chart (Figure 6), the 14-knot mean speed isopleth area is similarly situated as Santa Maria's (most afternoon hours in April and May), but the area of mean speed minima is broader and rearranged to the immediately preceding sunrise hours from July through November, and the late evening hours prior to midnight from October to November. Percent incidence of calms exceeds 60 percent during these intervals, a 64 percent isopleth visible for the October and November pre-sunrise hours. Mean scalar wind speed for San Luis Obispo is 5.93 knots, a bit less than Santa Maria's.

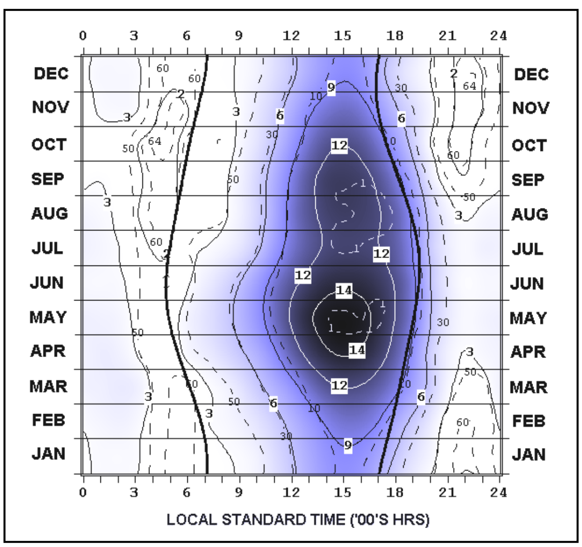

Figure 6. Mean Scalar Wind Speeds and Percent of Time with Calms Chart for San Luis Obispo Regional Airport

3.1.3 ***–****Salinas Municipal Airport) Lat: 36° 40' N; Lon: 121° 36' W; Elev: 85 ft.*

Salinas is located at the mouth of the river that bears the same name, a short distance from the Pacific Ocean. The valley itself slowly ascends some 90 miles to the southeast into the Paso Robles vicinity.

In the Mean Vector Wind/Constancy chart (Figure 7), the outstanding feature again is the prominent red shaded area of high constancy northwesterly vectors, but there are also clearly defined narrow blue bands of low constancies, oriented symmetrically both quasi-horizontally and vertically. These identify diurnal and seasonal transition periods between the northwesterly onshore and southeasterly down-valley flow.

During roughly May to August, the net mean vector flow is onshore for all hours of the day, especially so during the afternoon sea-breeze time, but during the colder months November to February, offshore flow is prevalent, especially for the intervals a few hours either side of sunrise. The southeasterly vectors for some of these hours exhibit constancy magnitudes in the low 80's, not a great deal less than those for the late-afternoon mid-summer northwesterlies, the latter showing figures frequently in the low 90's.

This "back-and-forth" between wind regimes reduces Salinas' overall wind constancy to 34.44, the associated resultant direction 284.44 degrees (WNW), and magnitude 2.39 knots.

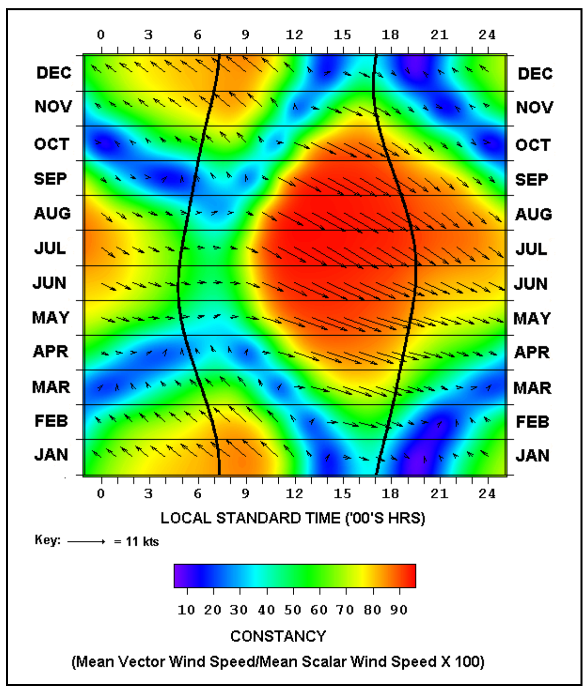

Figure 7. Mean Vector Wind/Constancy Chart for Salinas Municipal Airport

In the Prevailing Winds chart (Figure 8), maximum incident northwesterly onshore flow is evident for noon LST in July and August (the vectors located inside the 45 percent isopleth), a separate secondary maximum for southeasterly offshore flow (36 percent) also shown for roughly 0900 and 1000 LST over December to February. Prevailing wind directions are frequently westerly as well, particularly during the nocturnal hours of the warmer months of the year, at lower frequencies and reduced mean speeds, however.

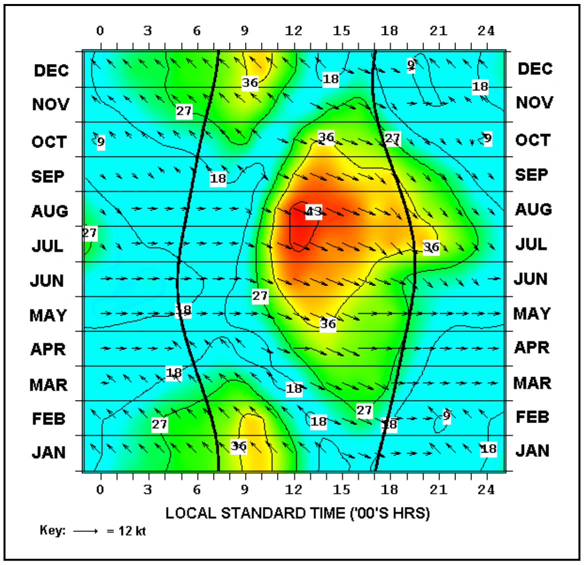

Figure 8. Prevailing Winds Chart for Salinas Municipal Airport

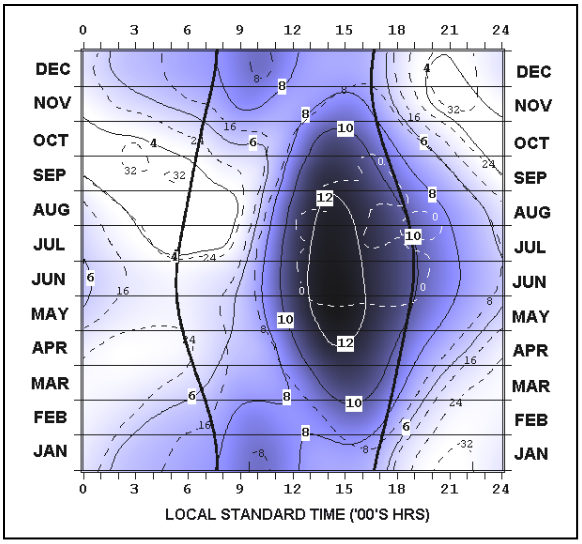

Figure 9. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Salinas Municipal Airport

From the Mean Scalar Wind Speeds/Percent of Time with Calms chart (Figure 9) maximum mean speeds are not quite at the level of those of Santa Maria and San Luis Obispo, the 14 knot isopleth absent. Instead, a fairly broad 12-knot contour is present, encompassing roughly the early afternoon hours from April through August. Missing also, however, are the extremely light wind speed contours that were indicated for the other two stations, undoubtedly attributable to the less sheltered, Salinas area topography that promotes the down-valley flow.

Maximum calms' incidence shows up as two minor 32 percent isopleths encompassing a few of the September and early October pre-sunrise hours.

Mean overall wind speed at Salinas is 6.95 knots, higher than either Santa Maria (6.49 knots) or San Luis Obispo (5.93 knots).

3.1.4 – Monterey Peninsula - Lat: 36° 35' N; Lon: 121° 51' W; Elev: 253 ft.

Figure 10 is the Mean Vector Wind/Constancy Chart for Monterey, located on the southeastern end of Monterey Bay about 10 miles west of Salinas. The familiar oval-shaped red/orange high constancy area in again apparent, Monterey's feature, like that for Salinas, somewhat stretched into the post-sunset hours, especially in June and July.

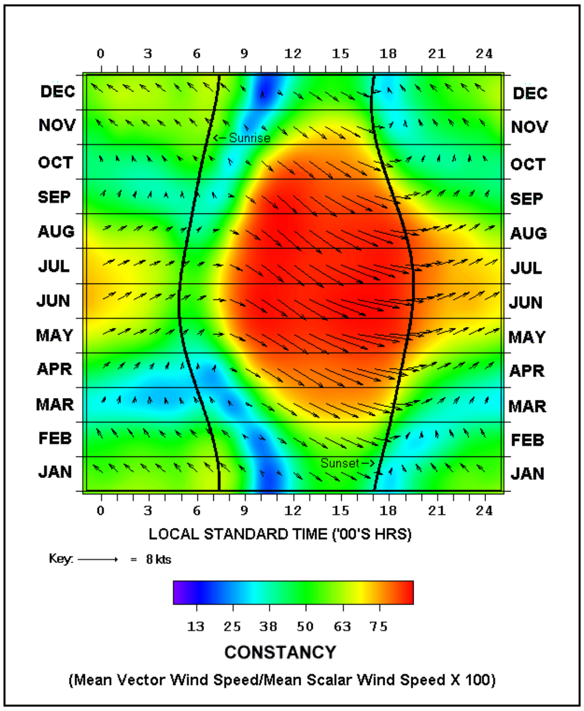

Figure 10. Mean Vector Wind/Constancy Chart for Monterey, CA.

Highest Constancy statistic is 86, somewhat lower than that for Santa Maria, San Luis Obispo, and Salinas. Resultants for the high constancy hours are generally northwesterly, becoming more westerly and lesser in magnitude as sunset approaches, then light southwesterly after sunset, remaining so through sunrise.

The positioning of the blue (low) constancy bands reflect both diurnal and seasonal transitional periods, the former most apparent for the forenoon hours a few hours after sunrise in November to March, and the latter for the pre-sunrise hours in March (light southeasterly orientations transitioning to southwesterly ones)

Overall resultant wind is 279.59 degrees (W) at 2.43 knots, the constancy 45.98.

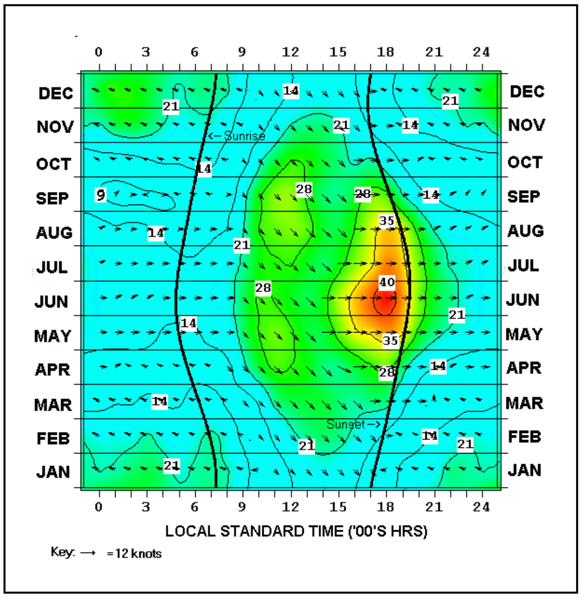

Figure 11.- Prevailing Winds' Chart for Monterey, CA.

The Prevailing Winds chart (Figure 11) shows northwesterlies as the most prevalent direction for most of the warmer months' early afternoon hours, the orientation then becoming westerly at higher frequencies through sunset. The maximum 40 percent contour overlays those westerlies resident for 1600 LST-1700 LST in June.

From Figure 12, the Monterey maximum mean speed contour (10 knots) is a bit lower still than that for the previous three stations, covering a few hours in May (approximately 1300 LST to 1500 LST). Greatest calms' incidence (40 percent contour) is seen in September as an elongated swath covering roughly 0200 LST to 0800 LST. Overall mean scalar wind speed for Monterey is 5.28 knots.

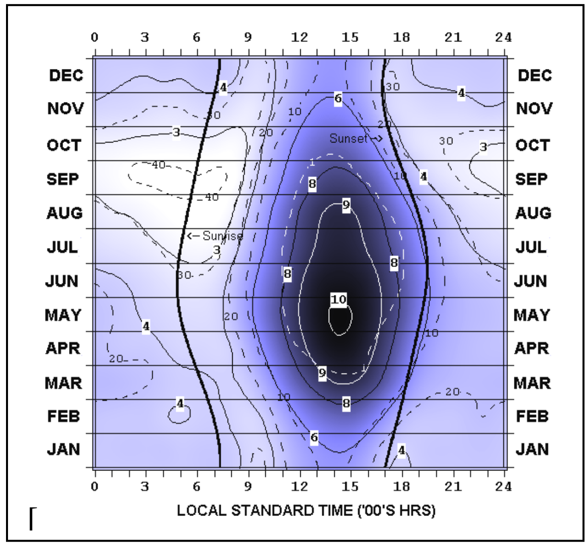

Figure 12. . Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Monterey, CA.

3.1.5 –San Francisco WSO- Lat: 34° 37' N; Lon: 122° 23' W; Elev: 21 ft.

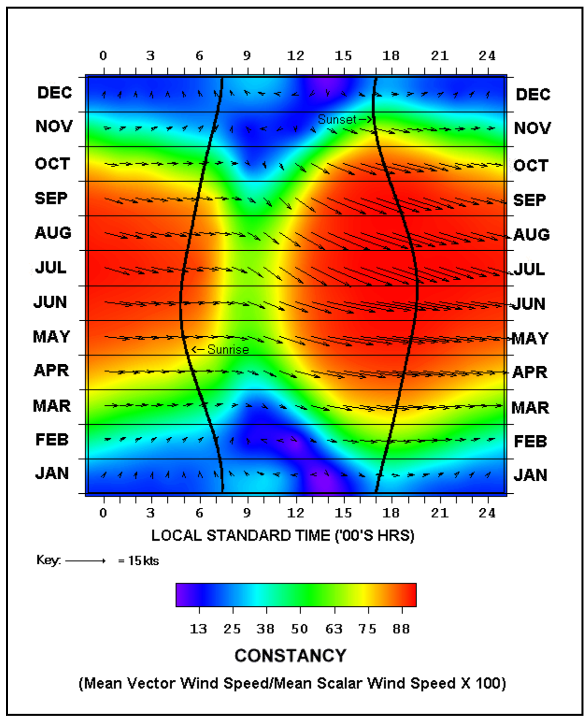

Figure 13. Mean Vector Wind/Constancy Chart for San Francisco WSO, CA.

Figure 13 is the Mean Vector Wind/Constancy chart or San Francisco WSO. Another symmetric pattern of mean vector orientations and constancies is present, a result of San Francisco's relatively exposed location to the Pacific. In general, the non-winter months' afternoon vectors are west-northwesterly to northwesterly, and constancy magnitudes for April to September are at red 75+ magnitude levels for virtually every hour from 1300 LST to 0700 LST, inclusive, the mean constancy figure for those 114 hours, roughly 40 percent of the entire 288 hours' set, 86.5.

Resultant winds over the colder months are relatively non-persistent (blue low constancy shadings for all hours), suggestive of a generally variable wind character.

Overall mean vector wind constancy for San Francisco is 63.81, the resultant direction 281.91 (WNW), and speed 5.92 knots.

From Figure 14, the maximum prevailing wind frequencies are indicated for the late afternoon hours in May and June (inclusion within the 45 percent isopleth).

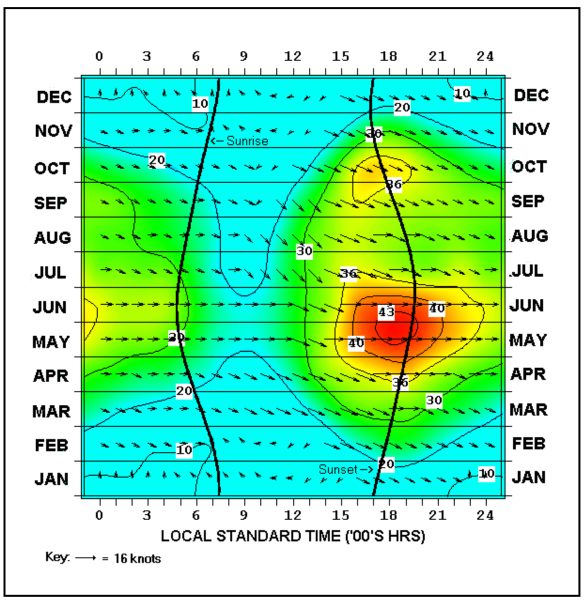

Figure 14. Prevailing Winds' Chart for San Francisco WSO

.

In Figure 15, an18-knot maximum mean speed contour is positioned in June and July for roughly the hours 1400 LST-1600 LST. The 15 knot area is also quite extensive, covering at least several afternoon hours in each of the months May to August, inclusive. At the low-end, a 5-knot minimum contour includes, at the widest, the hours 0300 LST-0800 LST in November, superimposed within that isopleth the barely discernable 22-percent maximum calms' contour, centered about sunrise. Overall mean scalar wind speed at San Francisco is 9.28 knots, significantly higher than that for Santa Maria, San Luis Obispo, Salinas, and Monterey.

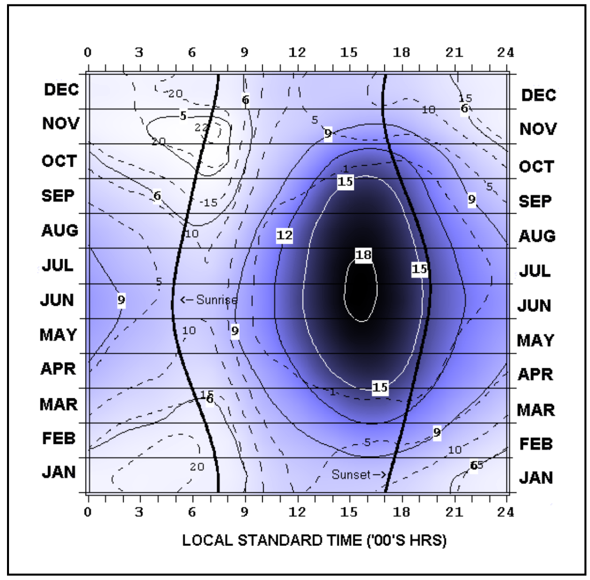

Figure 15. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for San Francisco WSO

3.2 - "San Joaquin Valley" Stations

Three stations from the "San Joaquin Valley" region are analyzed for their wind variability: Bakersfield WSO, Paso Robles Municipal Airport, and Fresno WSO

3.2.1 - Bakersfield – Lat: 35° 25'; Lon: 119° 3'; Elev: 495 ft.

Bakersfield, located at the south end of the San Joaquin Valley, about 260 miles from Sacramento, displays clearly delineated areas of high and low vector wind persistence (Figure 16).

Over October to March during the nocturnal (sunrise to sunset) hours, the resultants are mostly light easterly and northeasterly, but for April to September they are higher in magnitude and north to northwesterly. For November through June there is a prominent one to three hour wide violet-colored low constancy band running just after the sunrise trace and extending parallel to it, marking a transitional period between the nocturnal and daytime regimes. The orange to red highest constancy area, encompassing April to October, and extending at its widest from 1100 LST to 2100 LST in July, is associated with strong northwesterlies (actually a seabreeze) a diurnal circulation feature of the San Joaquin Valley.

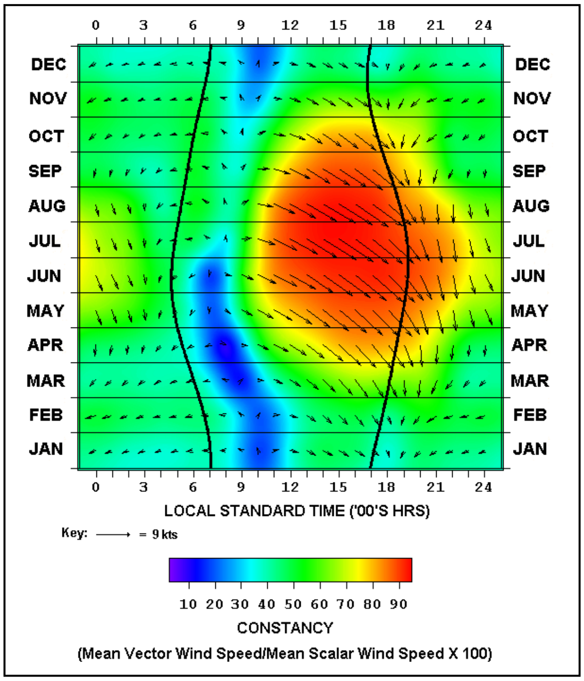

Figure 16. Mean Vector Wind/Constancy Chart for Bakersfield WSO, CA.

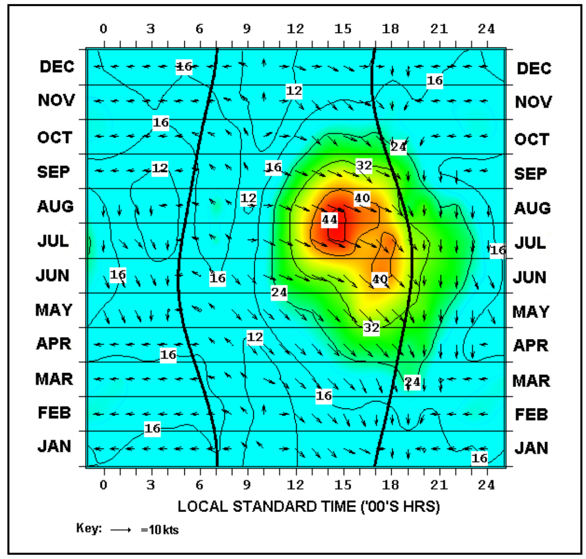

Figure 17. Prevailing Winds Chart for Bakersfield WSO, CA.

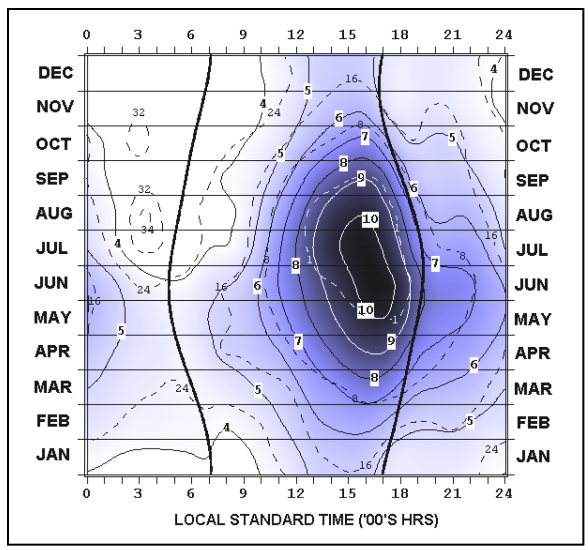

Figure 18. Mean Scalar Wind Speeds and Percent of Times with Calms Chart for Bakersfield WSO

Overall mean vector wind constancy for Bakersfield is 41.53, associated with a resultant direction of 334.17 degrees (NNW), and mean speed 2.27 knots.

In the Prevailing Winds chart (Figure 17), a relatively narrow area of 44 percent isopleths encompassing roughly mid-July to mid-August for the hours 1400 LST to 1500 LST identifies the time-of-year with the most prevalent individual wind direction (northwesterly). A broader 40 percent swath incorporates an additional hour or two on either side of this area, a second area covering 1700 LST and 1800 LST for June and July (north-northwesterly prevailing direction) also evident. Mean speeds for all these hours are around 10 knots. Prevailing wind frequencies are significantly less for most of the rest of the chart, typically less than 16 percent, a general dichotomy evident between the northerly to northwesterly flow for all hours during the summer months and the more easterly flow for the others, particularly during the nocturnal hours.

The Mean Scalar Wind Speeds/Percent of Time with Calms chart (Figure18) shows a maximum mean speed contour (10 knots) covering roughly mid-May to mid-August for the mid- to-late afternoon hours, extending to a couple of hours before sunset. At the lightest, mean speeds are 4 knots or less for most pre-sunrise hours from July through January, the maximum percent of time with calms isopleth (34 percent) confined to 0300 LST-0400 LST for August. Mean scalar wind speed at Bakersfield is 5.47 knots.

__3.2.2 –__Paso Robles Municipal Airport – Lat: 35° 40'; Lon: 120° 38'; Elev: 836 ft.

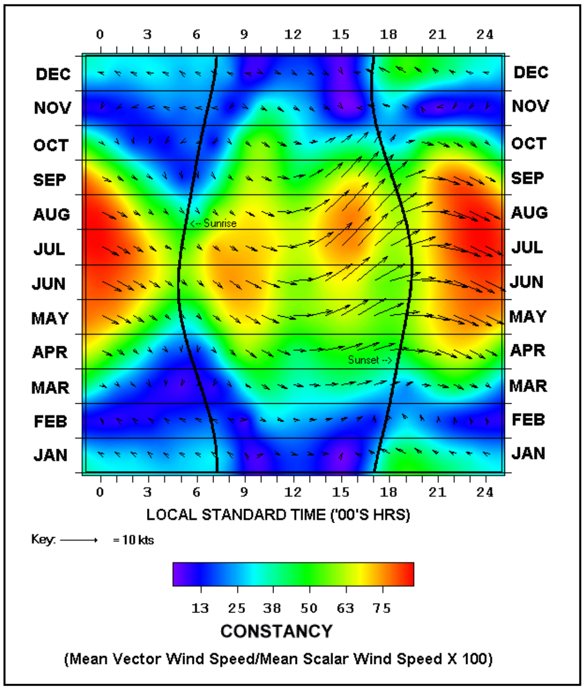

Figure 19. Mean Vector Wind/Constancy Chart for Paso Robles Municipal Airport, CA.

Paso Robles is located about 30 miles north of San Luis Obispo, inland of the Santa Lucia coastal range but just to the east of the canyons that cut through it. The local terrain variations in the Paso Robles vicinity produce numerous microclimates that impact the wine-growing industry, a major economic segment of the area.

Examining the mean vector wind chart for the Municipal Airport (Figure 19), three contiguous areas of relatively high constancy (orange or red coloring) flow are seen. The first covers the early morning hours (roughly 0800 LST-1000 LST) over May to June, the vectors northwesterly at light magnitudes. Another area of southwesterly vectors at relatively high magnitudes covers July to September for the mid-afternoon hours. The third, broadest, and highest constancy area (magnitudes as high as 86) surrounds the May to September post sunset hours, the flow northwesterly again at progressively decreasing magnitudes. Mean vector flow for most of the other months, especially November to February, is light, at low (blue) constancy levels.

Schukratf [2007] describes the Paso Robles area as being influenced, especially during summer afternoons, by southwesterly to west-southwesterly marine-layer flow through breaches in the Santa Lucia Range, particularly the Templeton Gap, and in the more northerly reaches, by west to northwesterly flow up the Salinas River Valley. Elements of each of these flow types is shown in Figure 19 for the airport station, a major effect being a typically large diurnal temperature decline in the afternoons and evenings. Mean daily temperature ranges, as a result, are the largest of any area in California [Paso Robles Wine Country Alliance, 2008].

Overall resultant wind at Paso Robles Airport is 265.19 degrees (W) at 2.03 knots, the constancy 35.44.

From Figure 20, the most prominent prevailing wind feature is the relatively frequent and strong south-westerlies - especially for July and August in the late afternoons. A 34-percent contour overlays these months at 1600 LST in July and 1600 LST-1700 LST in August, the mean speeds for these hours: 15 knots). After sunset, a secondary relative maximum frequency area (25 percent contour) of west-northwesterlies and northwesterlies at reduced mean speeds (~7 knots) is also shown. Possibly the airport may be subject to southwesterly followed by northwesterly marine-layer intrusions on the same day.

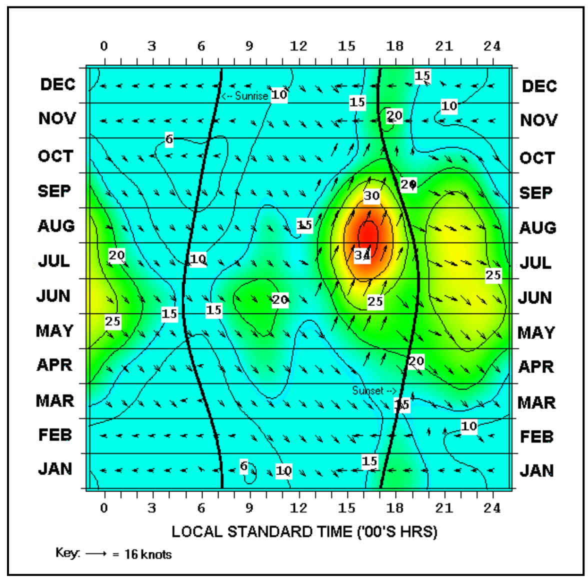

Figure 20. Prevailing Winds Chart for Paso Robles Municipal Airport, CA.

From the Mean Scalar Wind Speeds/Percent of Time with Calms chart (Figure 21). Paso Robles Airport post midnight-pre sunrise wind speeds are normally quite light, especially for July through January, the 3 knot isoline much in evidence, the 2 knot contour visible covering August-October, a couple of hours either side of sunrise.

The 60 percent contour of calms' incidence overlays the 2-knot mean speed isopleth almost exactly, and a small 65 percent contour is also evident for mid-September to mid-October just after sunrise.

In contrast, maximum mean wind speeds for May-August in the late to mid-afternoon are 12 knots, a 14-kont contour shown including June to mid-July for about 1600 LST to 1700 LST. Overall mean speed at Paso Robles is 5.71 knots.

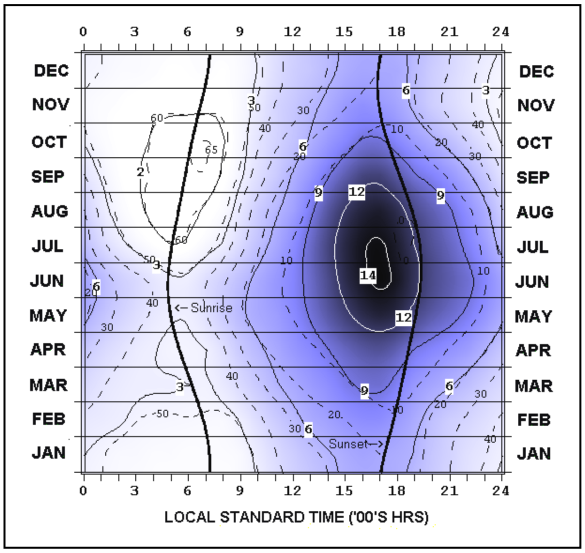

Figure 21. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Paso Robles Municipal Airport, CA.

3.2.3 –Fresno WSO AP – Lat: 36° 46'; Lon: 119° 43'; Elev: 328 ft.

Fresno WSO AP is located on flat terrain approximately halfway up the San Joaquin Valley, and about 150 miles from Sacramento. From Figure 22, a broad area of high (reddish) constancy areas covers roughly May to September from roughly 1400 LST to 0400 LST, the vectors west to northwesterly. Constancy figures are as high as 96. This, of course, likely reflects the onshore flow originating from the distant San Francisco Bay vicinity, the trajectory having been forced southward by the topographical orientation of the Central Valley. This flow regime, however, is essentially absent over November to February, the resultants light easterly at very low constancies. Seasonal transition zones, indicated by quasi-horizontal areas of low (blue) constancies are also visible over February, March, and November; and more diurnal (vertically-oriented) low persistence zones (either reflecting transition periods, or light and variable wind character) are also seen encompassing the late afternoon and early evening hours of January and December, and several hours after sunrise for the months May through October.

Mean vector wind constancy at Fresno is 39.26, associated with a mean resultant direction 305.00 degrees (NW) and speed 2.16 knots.

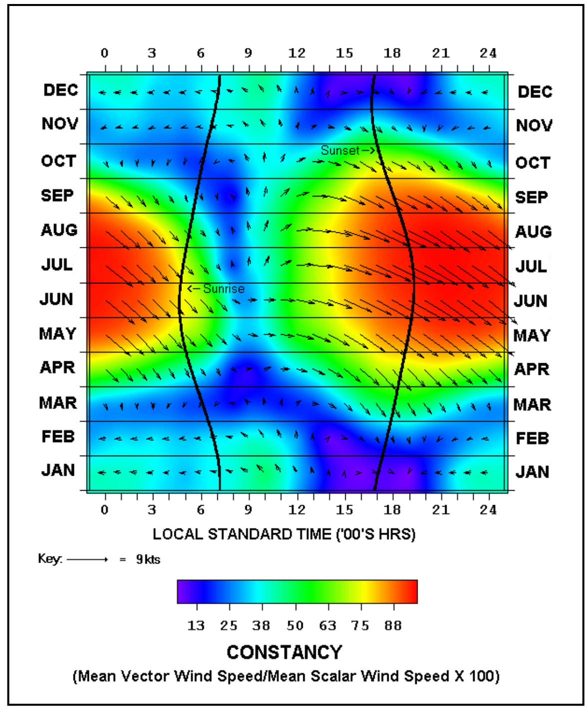

Figure 22. Mean Vector Wind/Constancy Chart for Fresno WSO AP, CA.

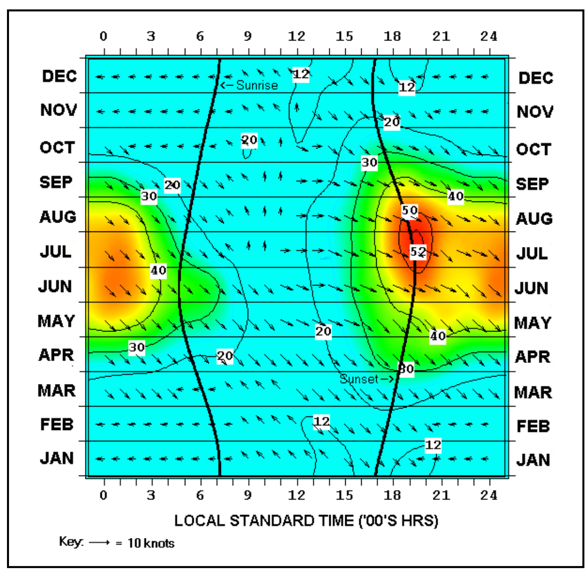

Figure 23. Prevailing Winds Chart for Fresno WSO AP, CA.

The Prevailing Wind chart's features (figure 23) are much the same, the most frequent wind directions (almost all northwesterlies) seen for May to August, especially for the late afternoons and evenings. Again this probably relates to flow from the San Francisco Bay area, although the mean speeds are lighter, nearly all of them less than 10 knots. A pronounced maximum in frequency (50 percent) is noted for July-August for 1800 LST and 1900 LST, the latter hour in July indicating a better than 52 percent climatological frequency of northwesterlies. Frequencies are greater than 40 percent for most of the nocturnal hours over May-August, again reflecting incidence of mostly northwesterlies.

For some of the early morning hours (e.g., 0900 LST to 1100 LST) in July to March, prevailing wind directions are light southerly or southeasterly, compared to the more northwesterly orientations at these same hours during the other months. Nocturnal directions (sunset

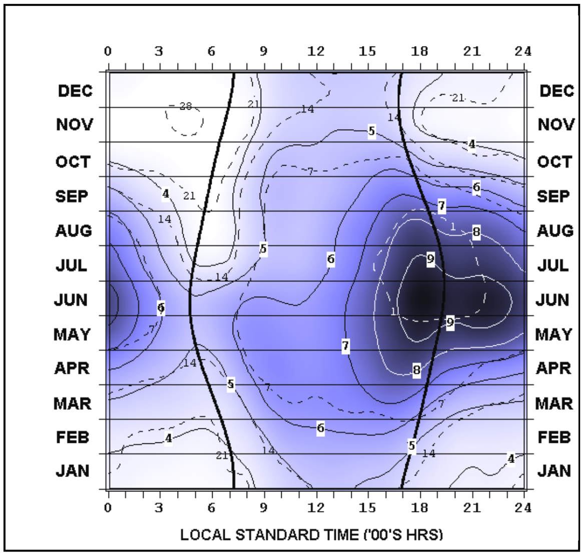

Figure 24. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Fresno WSO AP, CA.

to sunrise) are generally light easterly over November-February.

From Figure 24, the maximum wind speed contour (9 knots) compared to Bakersfield and Paso Robles, is lesser in magnitude, oriented more horizontally (confined mostly to June), and extended well into the post- sunset hours. This lag might be attributable to Fresno's relatively exposed but nonetheless distant location from the San Francisco Bay area, the maximum seabreeze "pulse" delayed. Highest mean wind speed for any individual hour at Fresno is 9.88 knots for June at 1800 LST.

The maximum area of Calms incidence (28 percent contour) is positioned in November for the hours 0300 to 0500 LST. Overall mean wind speed for Fresno is 5.50 knots.

3.3 - "Sacramento Delta" Stations

Three stations from the "Sacramento Delta" region are analyzed for their wind variability: San Jose Airport, Stockton WSO, and Sacramento WSO.

3.3.1 – San Jose – Lat: 37° 22'; Lon: 121° 56'; Elev: 62 ft

.

San Jose is located in the Santa Clara Valley at the southern end of the San Francisco Bay area, about 50 miles from San Francisco proper. Protected on three sides by mountains, its mean vector winds exhibit a considerably lighter character than say, San Francisco.

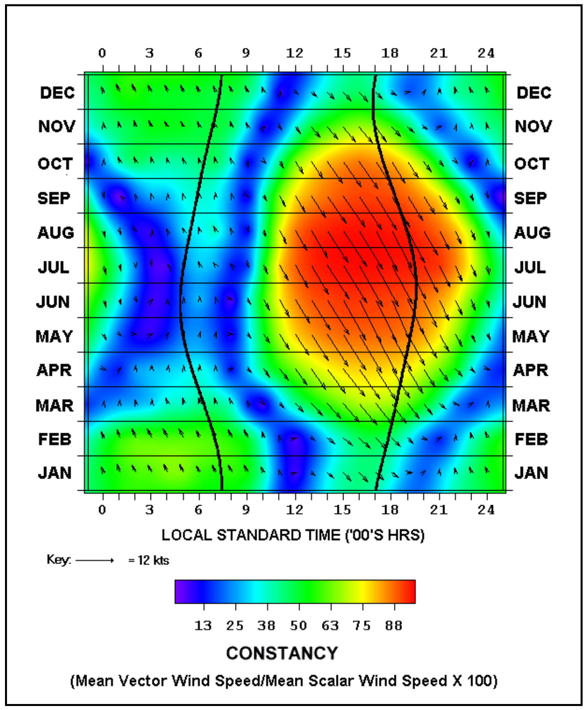

Figure 25. Mean Vector Wind/Constancy Chart for San Jose Airport, CA.

The symmetric red/orange high constancy area includes hourly mean vectors that are exclusively north-northwesterly, the clearly evident low (blue) constancy bands marking transitional periods between these and the light southeasterlies that characterize most of other hours on the early-morning and nocturnal "sides". Constancy magnitudes for some of the July and August late afternoon vectors are as high as 95.

Overall San Jose mean vector wind direction is 324.31 (NW), speed 2.61 knots, and constancy 44.02

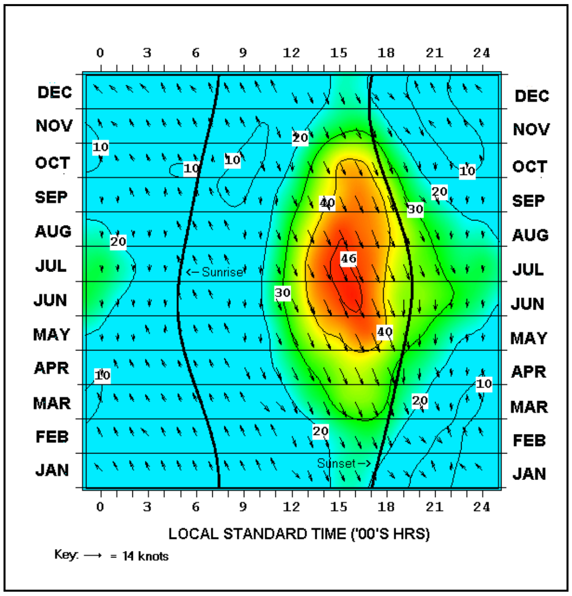

Figure 26. Prevailing winds Chart for San Jose, CA.

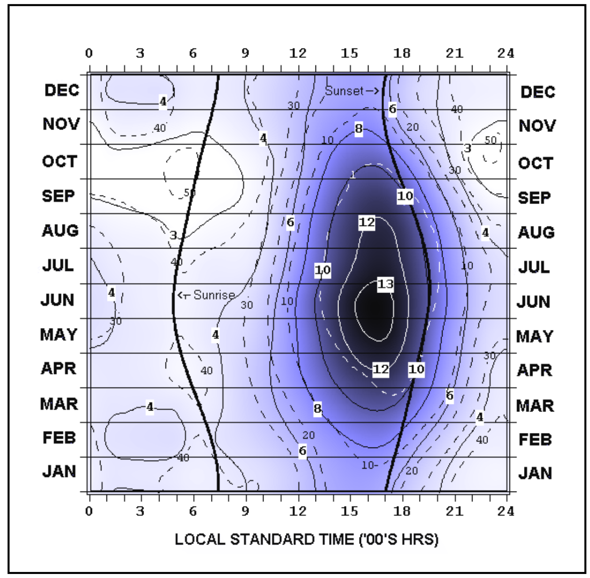

Figure 27. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for San Jose, CA.

The Prevailing Winds chart (Figure 26) shows high frequency isopleths reflecting the north-northwesterly sea-breeze for the summer afternoon and early evening hours. A few mid-afternoon hours in June, July, and August have frequencies exceeding 46 percent, the 40 percent contour, covering five mid-afternoon hours each in June, July, and August. For most of the other hours, prevailing winds are more modest in frequency (mostly less than 20 percent), the directions for the nocturnal hours in non-summer light southeasterly.

In the Mean Scalar Wind Speed/Percent of Time with Calms chart (Figure 27) the area of maximum mean speeds (13 knot contour) is situated over late May and June for roughly the hours 1500 LST-1700 LST. Maximum incidence of Calms (50 percent dashed isoline) covers roughly mid-September and all of October for the two or three hours immediately preceding Sunrise, another minor 50 percent contour visible for the hours just preceding midnight for portions of October and November.

Overall mean scalar wind speed for San Jose is 5.92 knots

3.3.2 - Stockton Municipal Airport – Lat: 37°54' N; Lon: 121° 14' W; Elev: 36 ft.

Stockton is located about 55 miles inland of San Jose, surrounded by the agricultural lands of the California Central Valley along with the various waterways and rivers that make up the California Delta.

The Stockton Mean Vector Wind/Constancy chart (Figure 28), in contrast with San Jose's, exhibits a considerably more horizontal (seasonal) constancy layout, a function of its more exposed topographical setting. The red/orange high constancy expanse is larger, covering most of the hours from early morning to near midnight for the months May to September (the vectors almost all northwesterly), and the blue-violet low constancy bands are almost exclusively horizontal except for the early afternoon hours for December and January. Constancy magnitudes in the red/orange areas range from the low 80's to as high as 91, those in the violet areas of December-January around 10.

Overall mean vector wind direction for Stockton is 286.50 degrees (WNW) at 3.32 knots, the constancy 47.73.

The maximum frequency contours for the Prevailing Winds chart (Figure 29) are post-sunset, a small area of 50 percent isopleths positioned for the three-to-four contiguous hours immediately following sunset in May and June, probably, like Fresno, related to Stockton's relatively removed but still exposed downwind location from the Bay. Prevailing wind directions for these high frequency cases are almost all westerly.

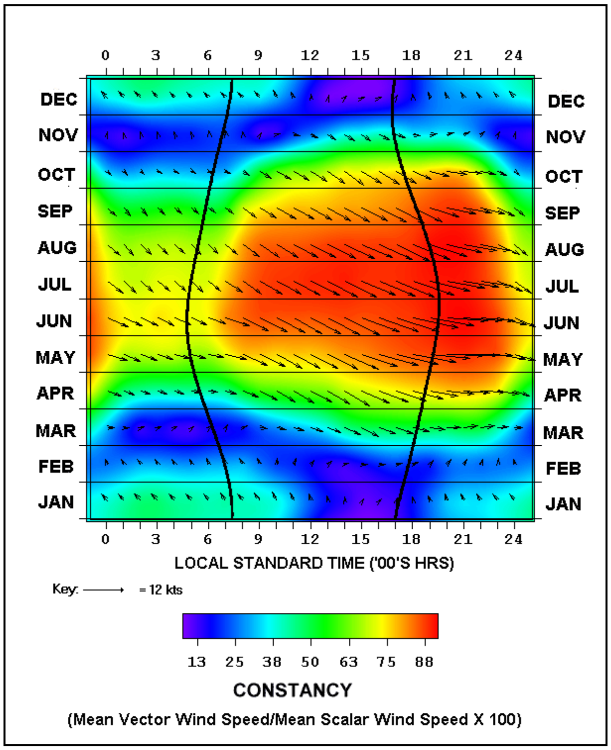

Figure 28 - Mean Vector Wind/Constancy Chart for Stockton, CA.

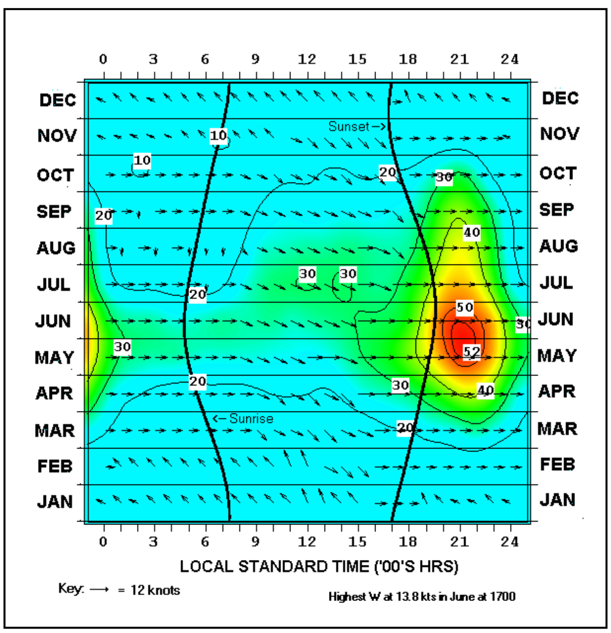

Figure 29. Prevailing Winds Chart for Stockton, CA.

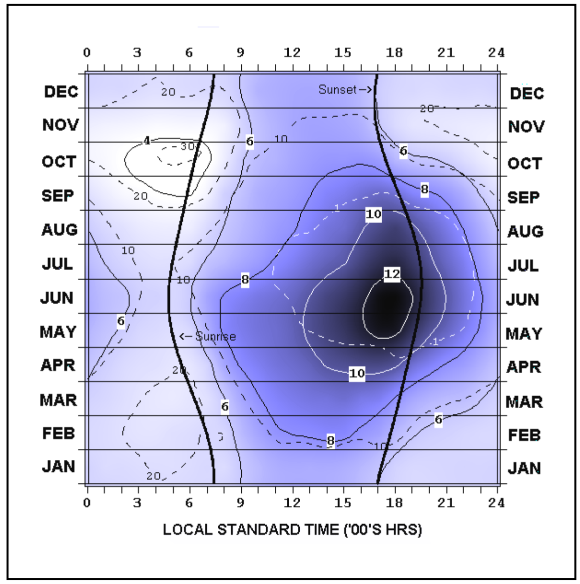

Figure 30. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Stockton, CA.

Maximum mean wind speeds (Figure 30) are seen for May and June in the late afternoon, as indicated by the 12-knot contour overlaying that diurnal period. Minimum mean speeds (4-knot isoline) cover mostly the immediately preceding sunrise hours in September and October, the 30 percent maximum contour for Calms also contained within, restricted to October.

Overall mean scalar wind speed is 6.96 knots, a full knot higher than that for San Jose (5.92 knots).

3.3.3 –Sacramento WSO – Lat: 38° 31' N; Lon: 121° 30' W; Elev: 16 ft.

Sacramento, capital of California, is located about 40 miles just north of east from Stockton, at the confluence of the Sacramento and American Rivers.

From Figure 31, mean vector winds during the high sun season are southerly to southwesterly , an effect of marine-layer onshore flow turning northward up the Sacramento Valley. Sacramento summertime flow is further influenced by the thermal low that typically forms in the Central Valley, and the general north-south orientation of the Valley [Zaremba and Carrol,1999]. The red/orange high constancy area is less extensive than Stockton's, but a few individual hourly magnitudes are in the low 90's, the absolute maximum, 94. The layout of the blue (low) constancy areas in horizontal fashion for all the hours of the day in November to February reflects the relatively variable wind character during the colder season in Sacramento.

Overall mean vector wind direction for Sacramento is 208.39 degrees (SSW), the speed, 2.82 knots, and constancy 41.22.

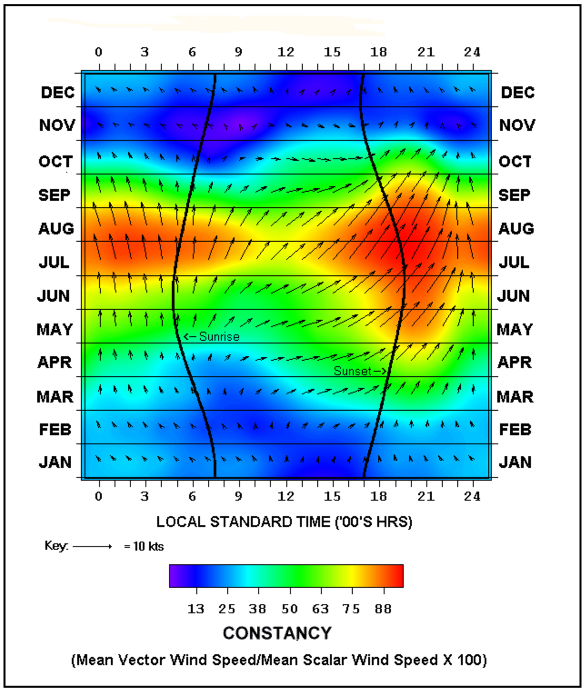

Figure 31 - Mean Vector Wind/Constancy Chart for Sacramento, CA.

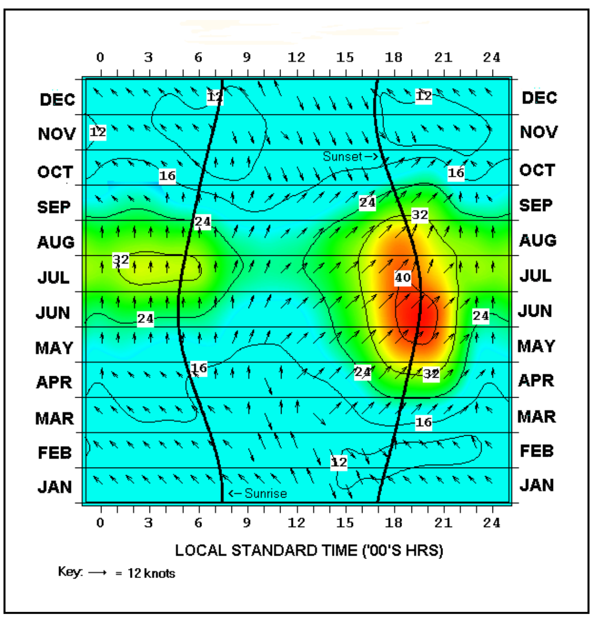

Figure 32. Prevailing Winds Chart for Sacramento, CA..

The Prevailing winds' chart (Figure 32) shows a 40 percent or greater incidence of southwesterlies for those May to July hours immediately preceding and following sunrise. Nocturnal prevailing directions are mostly

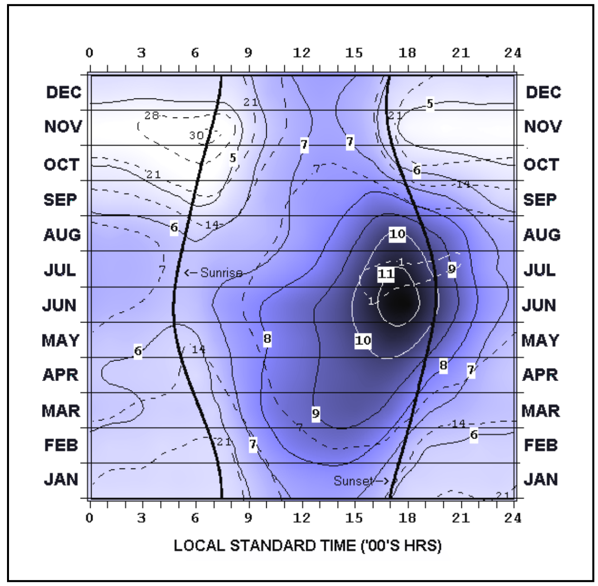

Figure 33 – Mean Scalar Wind Speed/Percent of Time with Calms' Chart for Sacramento, CA..

southerly during summer, a distinct secondary maximum contour area (32 percent) evident for July, enclosing the prevailing wind vectors encompassing the hours 0100 LST-0700 LST. During the colder months prevailing nocturnal flow is mostly light southeasterly.

The Mean Scalar Winds/ Percent of Time with Calms chart (Figure 33) shows an 11-knot area of maximum mean speeds confined to a few hours just before sunset, essentially for June. October and November have the lightest mean wind speeds, the minimum 5-knot contour enclosing most of the nocturnal hours for each, with daytime mean speeds equivalent to or less than those at comparable hours for the other calendar months. The 30 percent maximum percent incidence of calms appears as a small circular dashed contour centered around sunrise in early November. Overall Sacramento mean scalar wind speed is 6.84 knots.

3.4 – "Sierra" Stations

Two stations are analyzed from the general "Sierra" region: Bishop, and Blue Canyon.

3.4.1 – Bishop (Eastern Sierra Regional) Airport – Lat: 37° 22' N; Lon: 118° 22' W; Elev: 4124 ft.

Bishop is located at the northern end of the Owens Valley immediately east of the Sierra Nevada. In the WRCC classification scheme, it is actually just outside the "Sierra" region in the "Mohave", but since it was not considered in the previous Southern California analysis, and its patterns are interesting, it is included here.

Bishop's Mean Vector Wind Constancy features (Figure 34) resemble those of many of the Southern California Basin and Range desert stations, namely the presence of the broadest, highest constancy areas for the nocturnal and early morning hours. A prominent red-orange area of high constancy (70's to low 80's magnitude) northwesterly vectors is present for most of the May through January post midnight hours through roughly 0900 PST, possibly reflecting persistent downslope flow from the Sherwin Grade vicinity, to the northwest of Bishop. In contrast, resultant wind persistence is generally low during the daytime hours for November-April, as depicted by the blue-violet low constancy features, the other contiguous months May to October, displaying southerly resultants at moderate (green) to high (red-orange) constancy levels (maximum: 78). The "ring" feature covering the relatively high constancy southerly resultants for the early afternoons in July and August is not unlike that displayed for Palm Springs [Fisk, 2008].

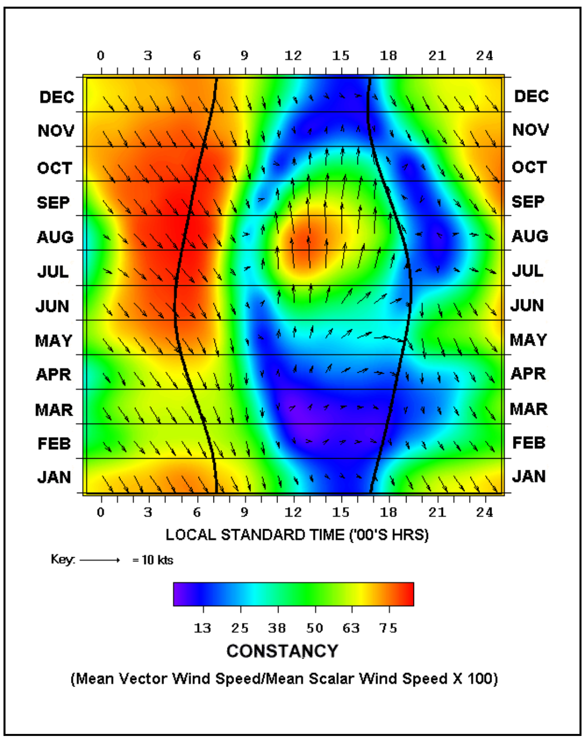

Figure 34. Mean Vector Wind/Constancy Chart for Bishop, CA.

.

Overall resultant wind for Bishop is 297.07 degrees (WNW) at speed 1.09 knots. Constancy is just 14.64, reflecting the wide variation in mean vector orientations clearly shown in the chart.

The Prevailing Winds chart (Figure 35) indicates mostly southerly prevailing winds for the non-winter months during the daytime hours, northerlies during winter. Northwesterlies at lighter mean speeds seem to comprise most of the post midnight hours through early morning for most months, but there is a greater northerly/northwesterly mix for the post sunset hours through midnight. The small-feature maximum 34 percent isopleth overlays the 1900 LST and 2000 LST prevailing Northerlies for May, and a lesser magnitiude, but broader 28 percent contour expanse includes the prevailing southerlies for the early afternoons in July-September, along with a few other hours for the late-afternoon in October. The low daytime constancies that appear in Figure 34 probably reflect a "clash" between these diametrically opposed northerlies and southerlies.

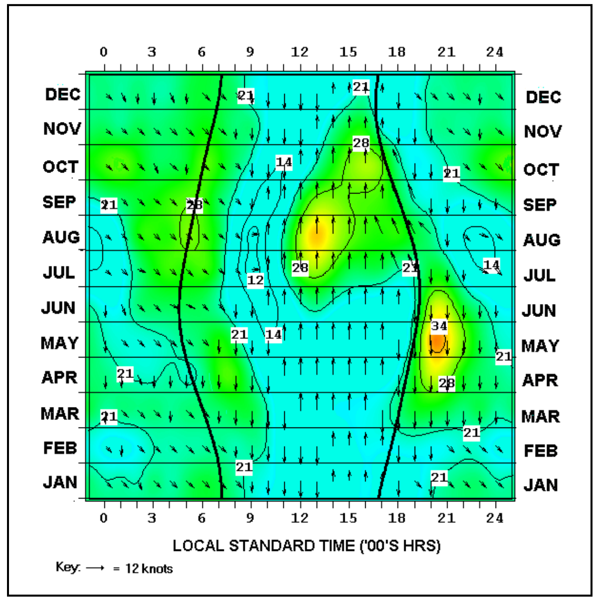

Figure 35. Prevailing Winds Chart for Bishop, CA.

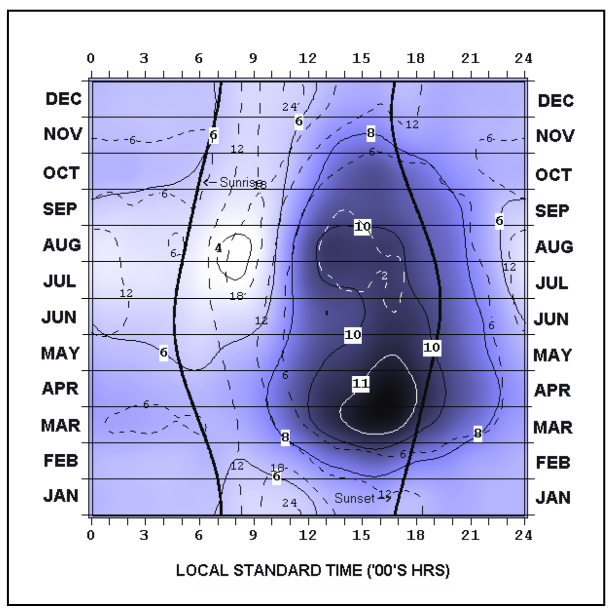

Figure 36. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Bishop, CA.

From Figure 36, the maximum mean speed isopleth is a Spring feature, the 11 knot contour covering the March and April afternoon hours, especially for the former. The minimum 4 knot isopleths is positioned in July and August just a few hours after sunrise. Curiously, the maximum percent of time Calms contour (24 percent), lies just before Noon for December and part of January. Mean overall wind speed at Bishop is 7.48 knots,

3.4.2 – Blue Canyon Airport – Lat: 39° 17 N; Lon: 120 °42' W; Elev: 5282 ft.

Blue Canyon is located between Sacramento and Lake Tahoe, not far west from Emigrant Gap.

The most noticeable vector orientation feature from the Mean Vector Wind/Constancy chart (Figure 37) is the prevalence of southerly oriented vectors for all the post-sunrise pre-sunset hours, the vectors southeasterly for the first few hours just after sunrise, south to southwesterly for the others. The orange to red high constancy area (in the case of Blue Canyon, representing values >70, approximately – maximum: 83) is widest for July and August, overlaying the daytime south-southwesterly to southwesterly vectors, and the light easterly nocturnal ones. There is a faint trace of a relative constancy minimum, shown by the light bluish "sliver" running parallel to sunset over April to November just to the nocturnal side. Outside of the summer months, most of the nocturnal vectors are light southeasterly. Given the surrounding mountainous terrain, the Blue Canyon mean vector pattern likely reflects the alternating predominance of upslope and downslope flow.

Overall resultant wind at Blue Canyon is 170.55 degrees (S) at speed 1.60 knots. Constancy is 37.63.

The prevailing winds chart (Figure 38) shows a somewhat differing pattern of vector orientations. Most of the nocturnal vectors, especially for the colder months of the year, are light northeasterly, not southeasterly. Conforming to the mean vector wind pattern, however, the warmer months of the year, from about 0900 LST on, exhibit a progression of southerly to southwesterly to westerly prevailing wind directions. The maximum frequency isopleth (36 percent), another very localized feature, covers 0900 LST and 1000 LST in August.

Most of the other contours are at 18 percent levels or less, the minimum isopleth (12 percent) matching up well in placement with the minimum constancy feature in Figure 37.

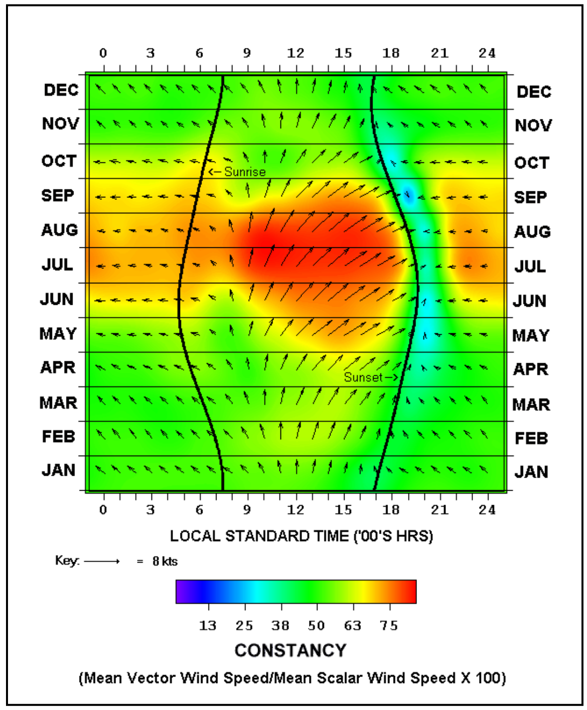

Figure 37. Mean Vector Wind/Constancy Chart for Blue Canyon, CA.

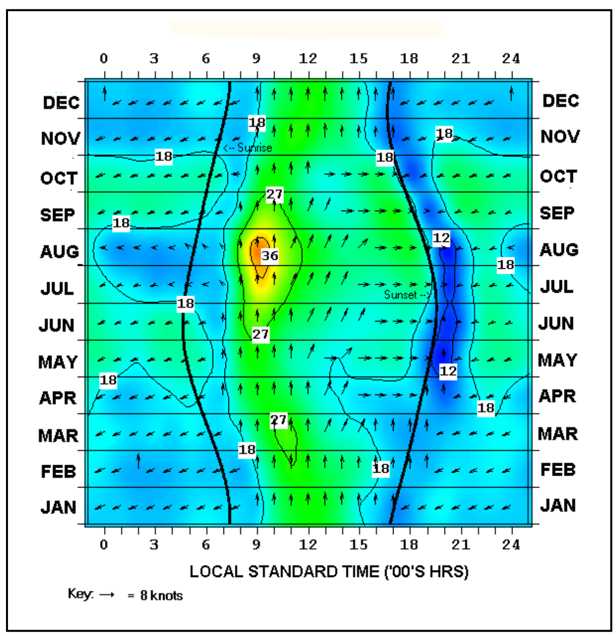

Figure 38. Prevailing Winds Chart for Blue Canyon, CA.

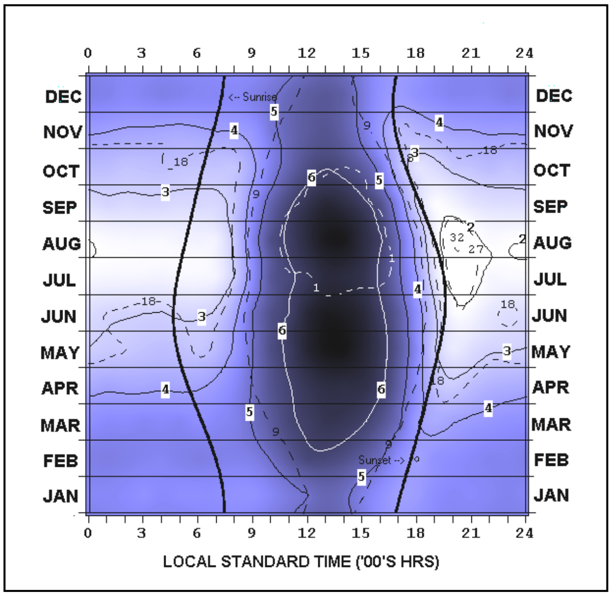

Figure 39. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Blue Canyon, CA.

From Figure 39, mean wind speeds at Blue Canyon are relatively light, a broadly positioned 6 knot maximum contour covering the late-morning to late afternoon hours for March to October, inclusive. The nocturnal and early morning hours over June to September have means typically at 3 knots or less, and a 2-knot contour includes several July and August hours immediately after sunset. The maximum calms' percent contour (32 percent) is also enclosed within this latter feature, representing a single hour (2000 LST for August). Overall Blue Canyon mean wind speed in 4.25 knots.

3.5 - "North Central" Stations

Two stations are included for analysis from the North Central region, Redding and Ukiah

3.5.1 - Redding Municipal Airport – Lat: 40° 31′ N; Lon: 122° 18′, W; Elev: 505 ft

Redding is located at the northwestern end of the Central Valley about 150 miles northwest of Sacramento.

A few notable exceptions notwithstanding, the Redding mean vector wind chart depicts mostly low (blue to violet) constancy levels, indicative of a quite variable climatological wind regime. Median constancy for the individual 288 hours is just 27.

The major exception to this is the oval shaped area of high (red) constancy southeasterly vectors (constancies as high as 80), principally covering August and September, for the 1300 LST to sunset periods. This may be a combination of upslope valley winds, "reinforced' by flow from the distant San Francisco Bay area, the latter having been turned northward by the Sacramento Valley topography. Such an effect would be most prominent in summer, as it is for Redding in the chart. Southerly vectors are also present for the afternoon hours in February through June along with September, but at considerably lower constancies.

The other noticeable exception is for the September through November mid-evening through mid morning hours (roughly 2100 LST through1000 LST, inclusive), the mean vectors almost exclusively northwesterly to northerly, at relatively high (for Redding) "green" constancy levels, the overall mean for these hours, 42 .

Overall resultant wind for Redding is 268.81 degrees (W) at speed 0.38 knots. Constancy is just 5.12, the lowest figure of any of the 33 California stations considered in this paper and its predecessor [see Fisk, 2008].

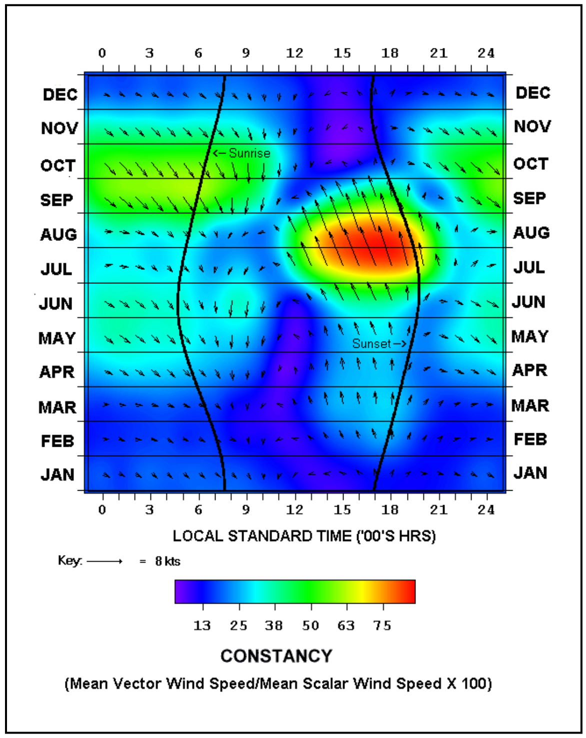

Figure 40. Mean Vector Wind/Constancy Chart for Redding, CA.

The Prevailing Winds chart (Figure 41) shows a fairly large number of light northwesterlies confined to the nocturnal hours, and there is also an assortment of season-dependent northerlies, southeasterlies, or southerlies covering the daytime hours. A 35-percent frequency isopleth overlays a number of prevailing southerly and southeasterly cases that occur for the late afternoons in July and August, and a secondary 30-percent contour is associated with prevailing northwesterlies and northerlies that were identified for 0700-1000 LST in October, and 1000 LST in November.

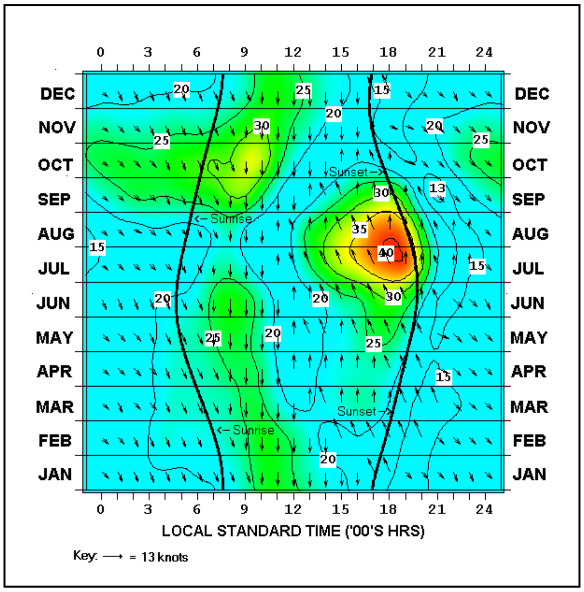

Figure 41. Prevailing Winds' Chart for Redding Municipal Airport, CA.

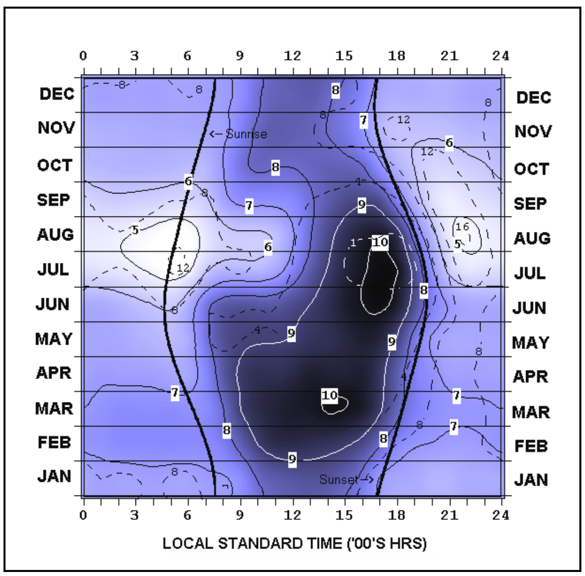

Figure 42. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Redding, CA.

The Mean Scalar Wind/Percent of Time with Calms chart (Figure 42) shows two 10-knot maximum contours, a larger one situated for the late afternoons in July and August, and a smaller one encompassing a few mid-afternoon hours in March. Lowest mean speeds, depicted by the 5 knot contour, are noted in July and August for a few hours either side of sunrise, and in August for around 0800 LST-1000 LST. The 16 percent minimum calms' incidence contour is also situated within this later area. Mean overall wind speed at Redding is 7.32 knots.

3.5.2 - *Ukiah – Lat: 39° 9' N; Lon: 123° 13' W; Elev: 610 ft*

Ukiah is located in a valley of the same name in southern Mendocino County, about 30 miles inland from the Pacific Ocean, separated by the Pacific Coast Range.

The Mean Vector Wind/Constancy chart (Figure 43) shows mostly light magnitude vectors at moderate to low constancies (median value: 28) . The only exception to this is an orange/red locally high constancy expanse (figures as high as 67) positioned for the late afternoons, particularly in May and June, The associated mean vectors turn dramatically from west/ northwesterly orientation to more northerly ones just before sunset. Not unlike Paso Robles, this likely reflects marine air intrusions that enter the valley through topographical breaks when diurnal pressure gradients are sufficiently favorable in the mid-afternoons. The Eel River runs north out of Ukiah, so perhaps most of the marine layer flow is upslope through the valley later on. A few hours after sunset, however, the vectors again assume the light and non-persistent character that mark most of the other hours, climatologically.

Overall vector wind constancy for Ukiah is 17.50, resultant direction: 296.64 (WNW) and resultant speed 0.61 knots.

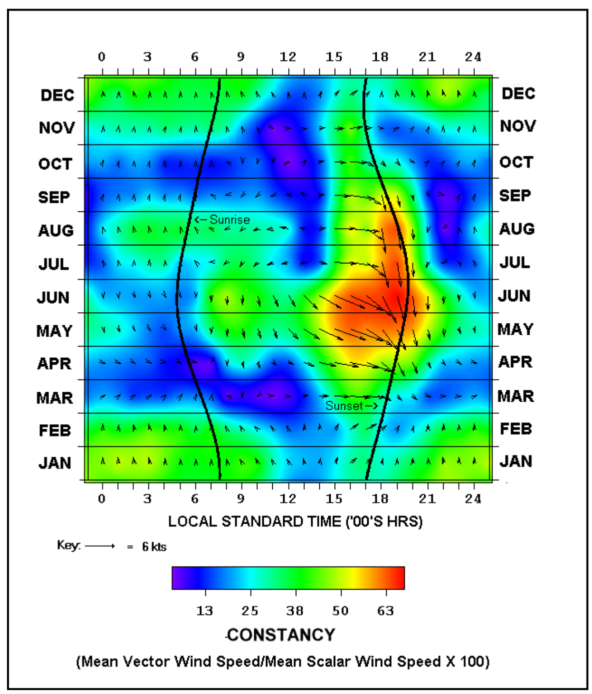

Figure 43. Mean Vector Wind/Constancy Chart for Ukiah, CA.

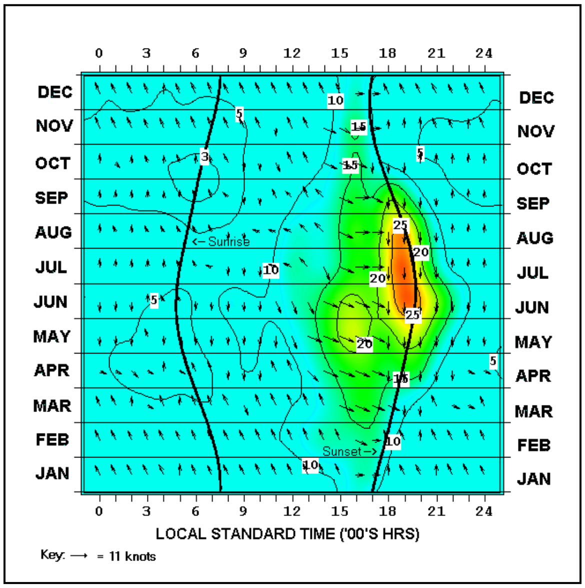

Figure 44. Prevailing Winds Chart for Ukiah, CA.

The prevailing wind chart also shows very clearly Ukiah's light and non-predominant wind character for most hours of the day. Again, the exception is the late afternoons for roughly March through September, which the prevailings becoming consistently northwesterly to westerly for 1400 LST-1500 LST, and then just before sunset, especially in May to August, northerly at the higher observed frequencies (within the 25 percent frequency isopleth). Just a couple of hours after sunset, however, they are back to their non-descript frequency levels. Overall Ukiah mean percent frequency is just 9 percent.

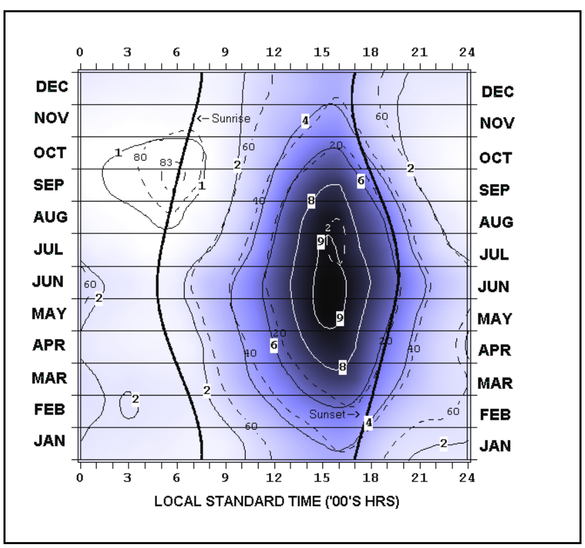

Figure 45. Mean Scalar Wind Speeds and Percent of Time with Calms' Chart for Ukiah, CA.

From Figure 45, mean speeds for these above mentioned late afternoon periods are roughly 6 to 9 knots, the maximum 9-knot contour region leading the maximum constancy and percent frequency areas by several hours,

Another interesting feature of the chart is the exceptionally high frequency of Calms, especially around sunrise in September and October, percentages in excess of 80 percent. Indeed, as the overall figure is 50 percent; "Calms" are by far Ukiah's "prevailing" wind. Overall mean wind speed for the station is 3.46 knots.

3.6- *"North Coast" Stations*

One station is included from the North Coast region: Arcata

3.6.1 - *Arcata Airport – Lat: 40° 59' N; Lon: 124° 07' W; Elev: 221 ft*

Arcata is located adjacent to the Arcata Bay (northern) portion of Humboldt Bay, about 275 miles north of San Francisco. Eureka, the seaport for the area, is located five miles to the south.

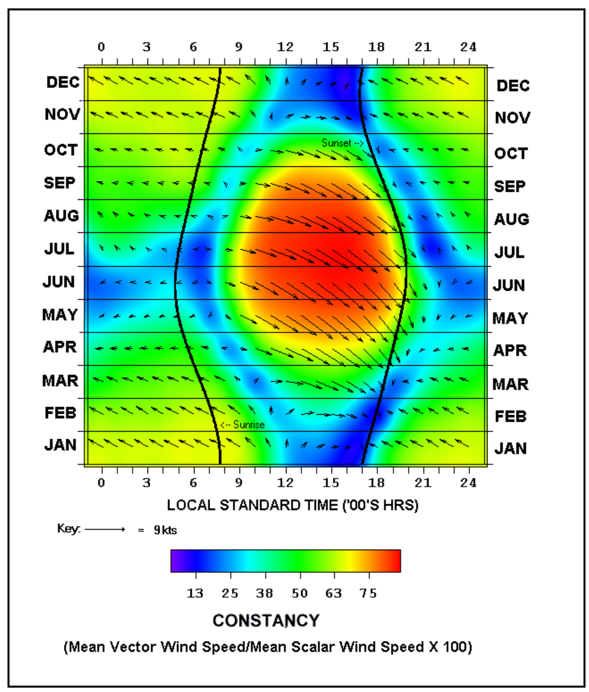

Figure 46. Mean Vector Wind/Constancy Chart for Arcata, Airport, CA..

Arcata's Mean Vector Wind/Constancy chart (figure 46), displays the familiar, highly symmetric arrangement of constancy features that are the trademark of most California stations that lie immediately adjacent to the Pacific. The red/orange constancy maximum feature, covering essentially the mid-morning to late afternoon hours for the months May to September, inclusive, depicts the persistent west-northwesterly to north-westerly onshore resultant flow that predominates at those times. Most of the offshore mean vector flow is southeasterly, at lesser (green to yellow) constancy levels, the transition between the two, resolved, in typical fashion, by the narrow blue/violet bands. The stronger southeasterly resultant flow seen for the colder months might be a reflection of the greater frequency of Pacific Storms offshore and their counterclockwise circulations.

Overall mean resultant wind for Arcata is 316.05 degrees (NW) at 0.63 knots, the constancy figure quite low at 11.24, likely due to the opposing nature of the northwesterly and southeasterly flow regimes, and the greater number of southeasterly cases, the latter almost offsetting the generally lesser individual magnitudes.

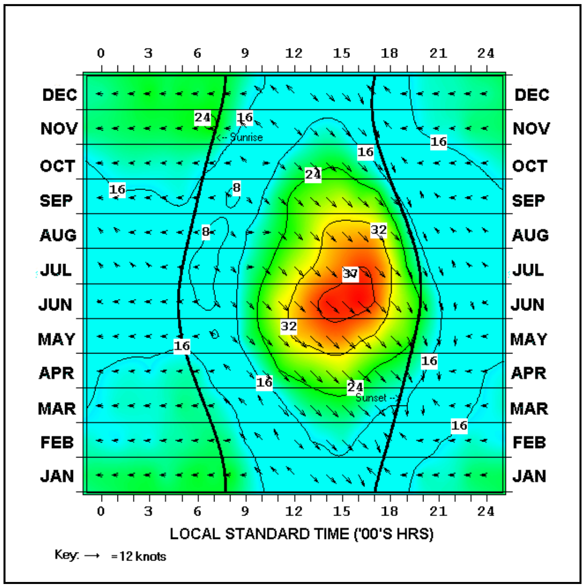

Figure 47. Prevailing Winds Chart for Arcata, CA.

The Prevailing Winds chart (Figure 47) looks quite similar, feature-wise. The frequency maximum (32 percent isopleth) is confined mostly to the late afternoon hours in June, and judging from the coloring (green as opposed to light blue), the nocturnal prevailing southeasterlies are somewhat more frequent during the colder months (November to January in particular) than they are for similar hours during the other months. Median resultant direction for the 288 individual hourly climatological cases is 123 degrees.

The Mean Scalar Wind Speed/Percent of Time with Calms chart (Figure 48) shows the maximum mean speed isopleth (11 knots) confined essentially to May for the hours 1300 LST to 1600 LST. Greatest likelihood of Calms occurs just before sunrise from late August to mid-September, a 53 percent contour seen. Mean overall wind speed at Arcata is 5.62 knots.

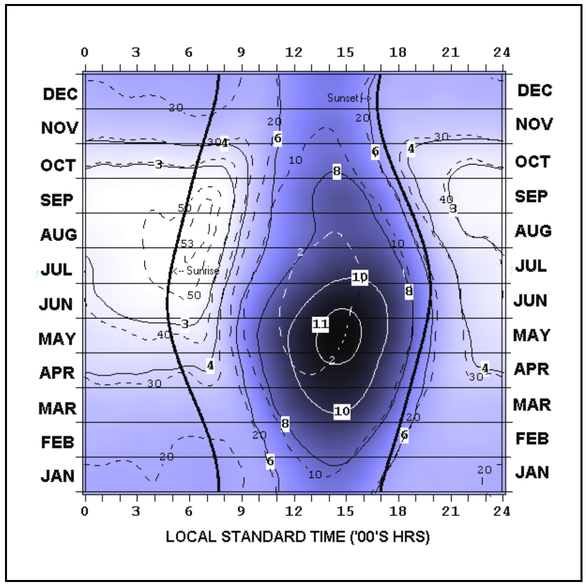

Figure 48. Mean Scalar Wind Speeds/Percent of Times with Calms Chart for Arcata, CA.

3.7- *"Northeast" Stations*

One station is included from the Northeast region: Alturas

3.7.1 - *Alturas – Lat: 41° 29' N; Lon: 120° 33' W; Elev: 4370 ft*

Alturas is located in the semi-arid sparsely populated far northeastern corner of the state, along the north fork of the Pit River.

The Mean Vector Wind Constancy Chart (Figure 49), one major exception aside, is relatively featureless. The exception is the red-orange maximum constancy area (magnitudes in the 60's to low 70's), covering July-August for the afternoon hours, and associated with vectors just slightly south of west in orientation. Although Alturas is many miles inland, perhaps this feature is a resultant expression of Pacific onshore flow that has made its way up the Sacramento valley and then further northeastward into the Alturas vicinity. A lesser feature, noticeable for the colder months of the year, particularly November to February, has mostly southerly resultants for the daytime hours, southwesterly ones, especially in the afternoons, for the other months. Overall mean vector wind direction is 256.83 degrees (WSW) at 1.37 knots, the constancy 27.34.

The Prevailing Winds chart (Figure 50) is also fairly featureless except for the highly localized 40 percent plus occurrences of prevailing westerlies for the late afternoons of July. Overall mean frequency, however, of the prevailing winds is just 13 percent.

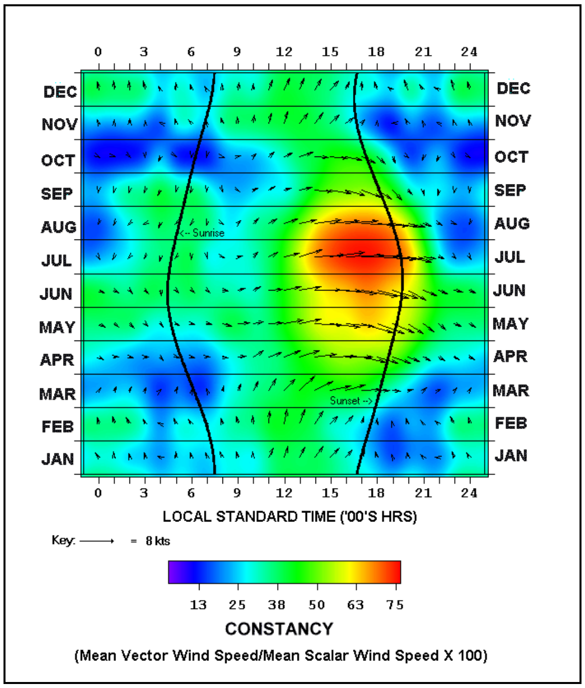

Figure 49. Mean Vector Wind/Constancy Chart for Alturas, CA.

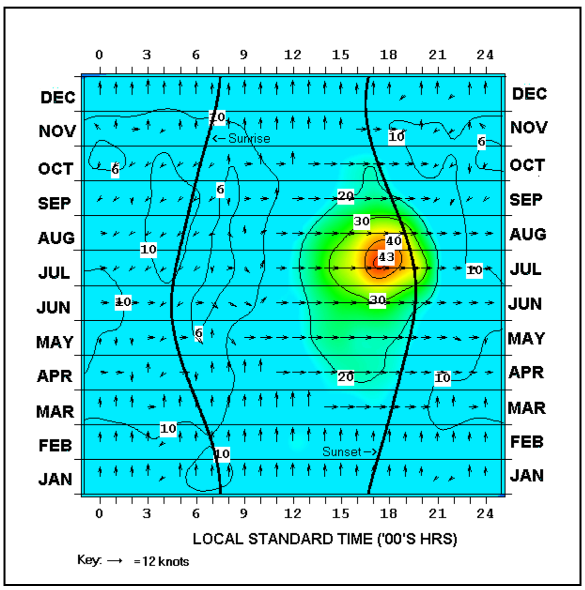

Figure 50. – Prevailing Winds Chart for Alturas, CA.

The Mean Scalar Wind Speed/Percent of Time with Calms' chart (Figure 51) shows a maximum mean speed 10 knot contour positioned essentially for the late afternoon hours in June and July. A maximum percent of Calms isopleth (65 percent) is seen covering the few hours just after sunrise, from late July through mid-September. Mean wind speed in Alturas is 5.01 knots.

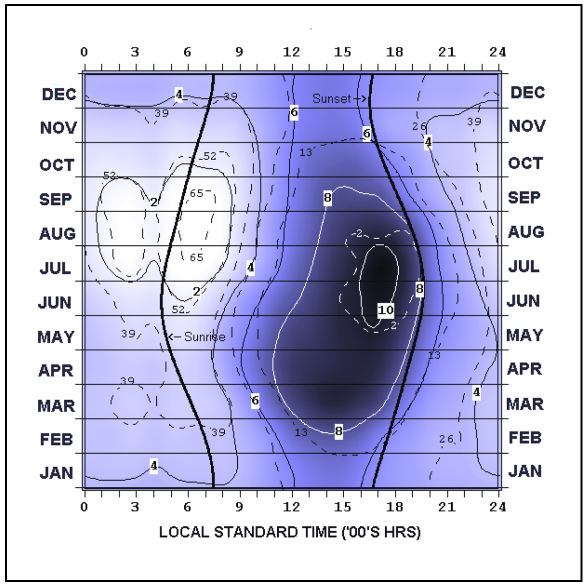

Figure 51. Mean Scalar Wind Speed/ Percent of Time with Calms' Chart for Alturas, CA.

4. SUMMARY

Using a three-chart scheme of hour-by-month climograms analogous to topographic maps, the diurnal and seasonal wind variation of seventeen central and northern California stations were analyzed, similar to that done previously for sixteen stations located in the southern areas of the state [Fisk, 2008].

Most of the stations, especially the coastal ones, showed the influences of Pacific diurnal onshore flow, indicated by the high constancy and high frequency west to northwest mean vector and prevailing wind orientations, respectively, present for most months. Attributable in large part to the open nature of San Francisco Bay, this signal was also evident to a noticeable but lesser extent for the more interior Central Valley stations.

Nonetheless, while many of stations' features were similar on a chart-by-chart basis, there were also very discernable differences, the more important of these explainable on plausible physical levels.

The climogram methodology utilized here allowed the voluminous station data to be presented in concise (single page) fashion, the graphs conveying the differing types of wind variability information in a comprehensive, intuitive way not likely surpassable in effectiveness via written or tabular means.

5. REFERENCES

"Alturas, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Alturas

"Arcata, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Arcata

Fisk, C.J., 2008: "Diurnal and Seasonal Wind Variability for Selected Stations in Southern California Climate Regions", 20th Conference on Climate Variability and Change, American Meteorological Society, 20-24 January 2008, New Orleans
http://ams.confex.com/ams/pdfpapers/135164.pdf

"Fresno, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Fresno

NOAA Western Regional Climate Center, Desert Research Institute, 2007: "California Climate Tracker" page (includes California Climate Regions' Map)
http://www.wrcc.dri.edu/monitor/cal-mon/index.html

NOAA National Climatic Data Center. 1995: "International Station Meteorological Climate Summary Version 3.0"

Paso Robles Wine Country Alliance, 2008: "Paso Robles Climate"
http://www.pasowine.com/pasorobles/climate.php

"Redding, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Redding,_California

"Salinas, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Salinas,_California

Schukraft, Donald, CCM, 2007: (Letter to Director, Regulations and Rulings Division, Alcohol and Tobacco Tax and Trade Bureau – concerning "Paso Robles Westside AVA Petition")
http://www.ttb.gov/nprm_comments/ttbnotice71/0710122.pdf

STI ERsys: 2008: "Travel Distance Table –Sacramento, CA."
http://www.ersys.com/usa/06/0664000/distance.htm

"Stockton, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Downtown_Stockton

"Ukiah, California – From Wikipedia, the Free Encyclopaedia"
http://en.wikipedia.org/wiki/Ukiah,_California

Zaremba, L. L., and Carroll, J. J., 1999: "Summer Wind Flow Regimes over the Sacramento Valley" Journal of Applied Meteorology, Vol. 38, Issue 10, pp 1463-1473 (from AMS Journals Online).