P.3 "HOUR-BY-MONTH" CLIMOGRAMS AS A PLANNING, DECISION-AID, AND EDUCATIONAL TOOL IN THE VISUALIZATION, SUMMARIZATION, AND INTERPRETATION OF VISIBILITY AND CEILINGS' DATA

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1. INTRODUCTION

Cloud ceiling and visibility conditions are two critical meteorological elements that govern the conduct of aircraft operations. For safety reasons, regulations exist that determine proper piloting behavior in instances of less than optimal ceiling and visibility conditions. Two examples of these are "VFR" ("Visual Flight Rules") and "HVFR" ("High Visual Flight Rules"). Two other elements that significantly affect visibility, but not ceilings, are Fog and Haze. In terms of diurnal and seasonal climatic variability, VFR, HVFR, Fog, Haze, and other measures can have wide-ranging climatological frequencies, both on a single and multi-station basis.

To facilitate effective long-range planning, scheduling, and decision-making for proposed operations in which ceiling and visibility conditions might have an impact, it would therefore be useful to have climatic summarizations on a monthly and hourly basis. In years past, such sources invariably consisted of cumbersome multi-page tables, generally for a subset of hours. Given the relatively recent advent of powerful desktop computers and their graphics' capabilities, a more viable treatment is graphical – transforming multi-tabular data into concise single-page visual layouts that give a quick comprehensive feel for a given parameter's seasonal and diurnal variation. The charts' purpose can be purely descriptive also, but in either case, the raw data are usually more effectively conveyed visually. Such graphical products also lend themselves to presentation on the worldwide web, itself a comparatively new.

The purpose of the following is to illustrate the use of hour by month climograms as a means of visualizing single-station Flying Weather, Fog, Haze, and Ceilings' data. Analogous in concept to the topographic map, month of the year comprises the y-axis, hour of the day the x-axis. Upon the grid, variables such as percent of time with VFR, Fog, etc., are contoured. Off-hour data not represented explicitly in the original data sets can be estimated using various smoothing and interpolation algorithms. Multiple overlain contours can depict multiple variables simultaneously, and color schemes can impart a more conceptual feel for the variable(s) and their magnitudes. In addition, sunrise/sunset demarcation curves can be overlain, lending additional perspectives to the parameters' contour/coloring patterns. Most importantly, the diurnal and seasonal climatological variability is depicted in its entirety on a single-page chart.

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Such decision-aid products, representing other parameters such as winds and temperature, have been created for several Naval Air commands, as well as a National Weather Service Forecast Office.

2. METHODS AND PROCEDURES

Six different climograms types related to ceilings and/or visibility are exhibited for a sampling of stations: the already mentioned VFR, HVFR, Fog, and Haze types, those for MVFR ("Mid-VFR") Flying Weather, and a "Highly-Restricted Visibilities and Ceilings" Flying Weather category. A seventh purely descriptive type depicts the percent of time with ceilings (Broken and Overcast cloud cover) and the median heights of those ceilings. Data source is the International Station Meteorological Climate Summary (ISMCS), Version 3.0, published on a CD-ROM by the NOAA National Climatic Data Center (NCDC).

3. RESULTS

3.1 - VFR Climograms

3.1.1. - Los Angeles Int'l Airport (LAX)

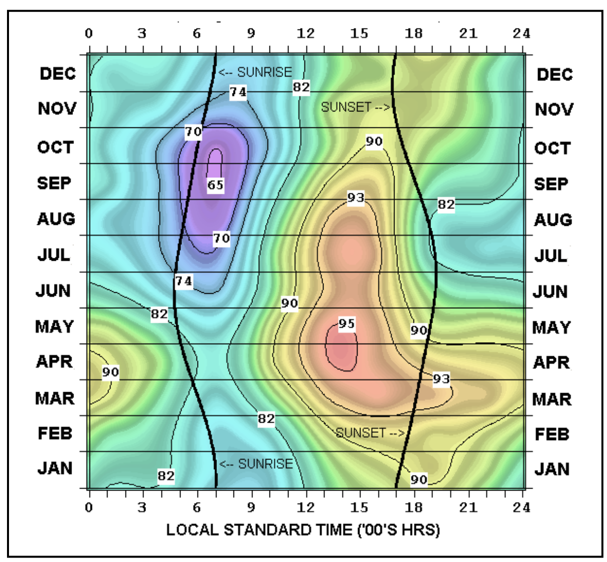

Figure 1. Percent of Time with Visual Flight Rules ("VFR") Conditions at Los Angeles Int'l Airport, CA. - (Ceilings>= 1000 ft. and Visibilities >= 3 mi.)

Figure 1 is a VFR climogram for Los Angeles International Airport (LAX). VFR is defined here as ceilings greater than or equal to1000 feet and visibilities greater than or equal to 3 miles. The contours depict a wide range of percent frequencies, from the mid 60's (violet shadings) to the mid 90's (orange-brown shadings). The generally larger area of high magnitude contours (90's) in March and April, extending beyond sunset, probably reflects the drier lower atmospheric conditions during these transition months. In contrast, the relatively low magnitude areas for August to October covering the sunrise and early morning hours likely reflect the effects of radiative cooling during the progressively lengthening nights of this late summer to early autumn period. Later on in November and December when drier offshore flow becomes more prevalent (including Santa Ana episodes), VFR incidence becomes more frequent again in the early morning hours after sunrise.

3.1.2. - Bakersfield Airport, CA.

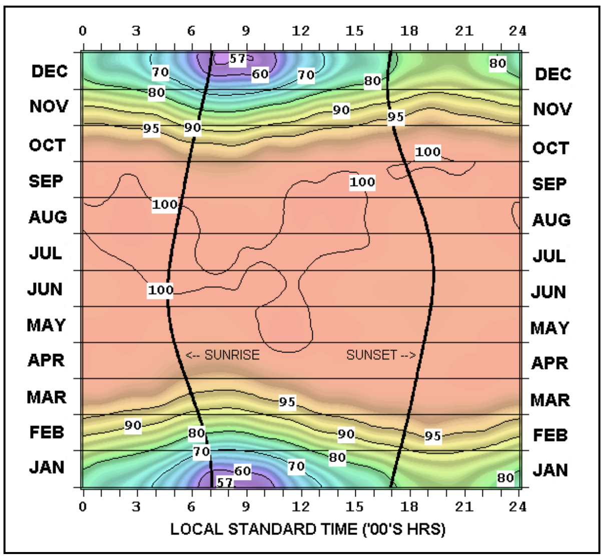

Figure 2. Percent of Time with Visual Flight Rules ("VFR") Conditions at Bakersfield Airport, CA. - (Ceilings>= 1000 ft. and Visibilities >= 3 mi.)

Figure 2 is a VFR climogram for Bakersfield Airport, CA., located at the southern end of the great Central Valley. The contour pattern is decidedly different than LAX's, with even more contrasts in magnitudes, but much higher overall VFR incidence. Lowest percent magnitudes, in the high 50's, cover the sunrise to early morning hours for late December and early January (light violet shadings), reflecting Fog to a considerable extent (see Figure 21) and low ceilings' incidence. In contrast, VFR incidence is almost exclusively 95 percent or higher over April to October for all hours of the day, an irregular swath of 100 percent incidence also visible covering various contiguous hours over May to September.

3.1.3. - Asheville WSO, NC.

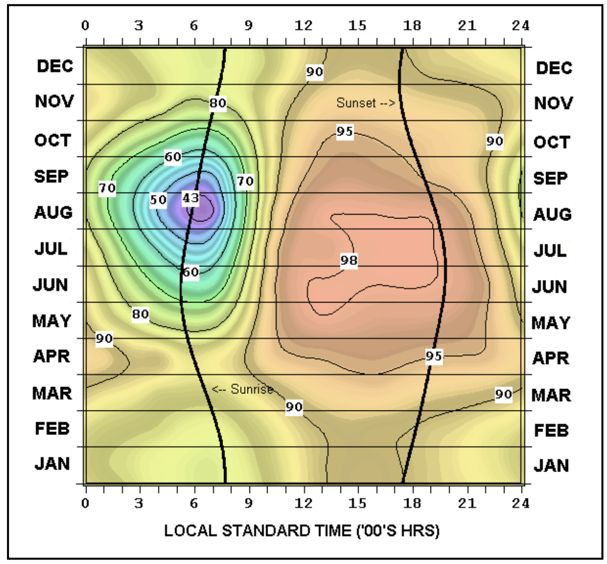

Figure 3. Percent of Time with Visual Flight Rules ("VFR") Conditions at Asheville WSO, NC. - (Ceilings>= 1000 ft. and Visibilities >= 3 mi.)

Figure 3 is a VFR Climogram for Asheville, NC., home of the NOAA National Climatic Data Center. Most noticeable is the small area of decidedly lower percent VFR incidence (in the 40's), confined mostly to August, a few hours either side of sunrise. Somewhat like LAX, this is likely due to the longer August nights compared to June and July. Asheville winds are typically quite light during the pre-sunrise hours in August, the climatological incidence of calms greater than 40 percent [NCDC, 1995]. The area of maximum VFR incidence (98 percent isopleth) encompasses the majority of the afternoon hours from June into early August.

3.1.4. - Rio de Janeiro, Brazil.

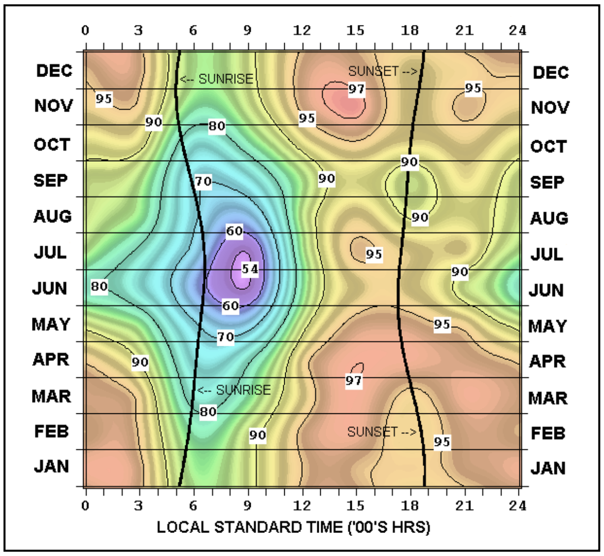

Figure 4. Percent of Time with Visual Flight Rules ("VFR") Conditions at Rio de Janeiro, Brazil - (Ceilings>= 1000 ft. and Visibilities >= 3 mi).

Figure 4 is VFR climogram for Rio De Janeiro, Brazil. Apart from the contour configurations, a noticeable feature is the concave rather than convex sunrise and sunset demarcation lines, this, of course, reflecting Rio de Janeiro's location in the Southern Hemisphere. Thus, the area of minimum percent incidence (violet area covering the early post sunrise hours in June and July) is a wintertime feature, likely due to the longer nights at that season, associated with the still moist, tropical that are predominant. In general, maximum incidence (>95 percent) covers wide areas of the afternoon hours, the only exception being those for June to early October..

It's evident from the above four VFR charts that the single-page layout scheme summarizes quite well the main diurnal and seasonal climatological VFR features. While it is highly unlikely that these particular stations would ever be compared for some operational planning or decision-making purpose related to VFR, the advantage of single-page layouts like these for genuine multi-station comparisons seems even more convincing.

3.2. *- HVFR ("High VFR") Climograms*

Another common Flying Weather designation is HVFR or "High VFR". This is more stringent condition, the ceiling cutoff altitude raised significantly, in this case to 3000 feet, the visibility limit remaining at 3 miles.

3.2.1. - Los Angeles Int'l Airport (LAX)

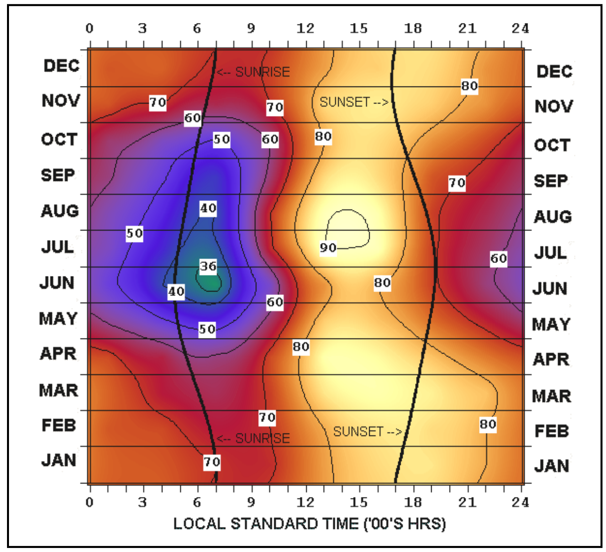

Figure 5. Percent of Time with High Visual Flight Rules ("HVFR") Conditions at Los Angeles Int'l Airport (LAX) - (Ceilings>= 3000 ft. and Visibilities >= 3 mi).

Figure 5 is a HVFR climogram for Los Angeles International Airport (LAX). Aside from the significantly higher frequencies in the afternoons (>80%) and lower ones for the nocturnal hours of late Spring to early Fall <60 %), the contours exhibit a somewhat different configuration than that for VFR, especially with regards to extremes. The minimum isopleth (36 percent) covers the roughly 0700 LST to 0800 LST period in late June, part of the locally well-known "June-gloom" phenomenon. The maximum contour (90%) includes the early afternoon hours in mid-July to mid-August.

3.2.2. - Asheville WSO, NC.

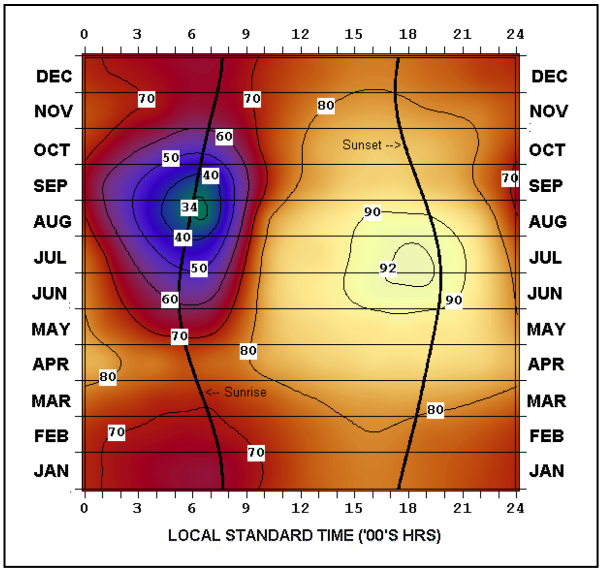

Figure 6. Percent of Time with High Visual Flight Rules ("HVFR") Conditions at Asheville WSO, NC. - (Ceilings>= 3000 ft. and Visibilities >= 3 mi).

Figure 6 is a HVFR climogram for Asheville WSO, NC. The general configuration is much the same as for its VFR chart, and it also resembles LAX's to an appreciable extent, although the extreme minimum contour for Asheviile (34 percent) occurs later in August, and the maximum isopleth (92 percent) is situated slightly earlier in the summer and later in the afternoon.

3.2.3. – Sioux City WSO, IA

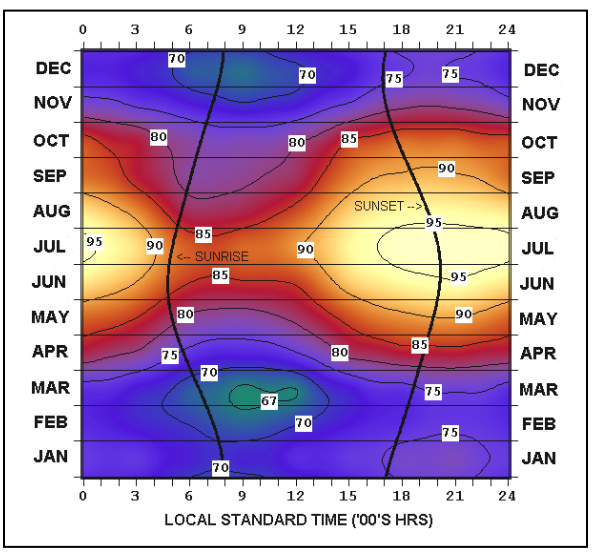

Figure 7. Percent of Time with High Visual Flight Rules("HVFR") Conditions at Sioux City, WSO, IA. - (Ceilings>= 3000 ft. and Visibilities >= 3 mi).

Figure 7 is a HVFR climogram for Sioux City WSO, Iowa. The contour orientations seems more horizontal (seasonal) than vertical (diurnal), with a maximum 95% contour situated almost exclusively in July for the late afternoon hours through midnight. The minimum 67% contour, curiously, is situated over the first half of March for the hours 0900 LST to 1100 LST, possibly the result of mid-morning melting, evaporation, and condensation aloft of the winter's snowmelt, producing a slight decrease in sub-HVFR cloud ceiling frequencies.

3.2.4. - Agana, Guam

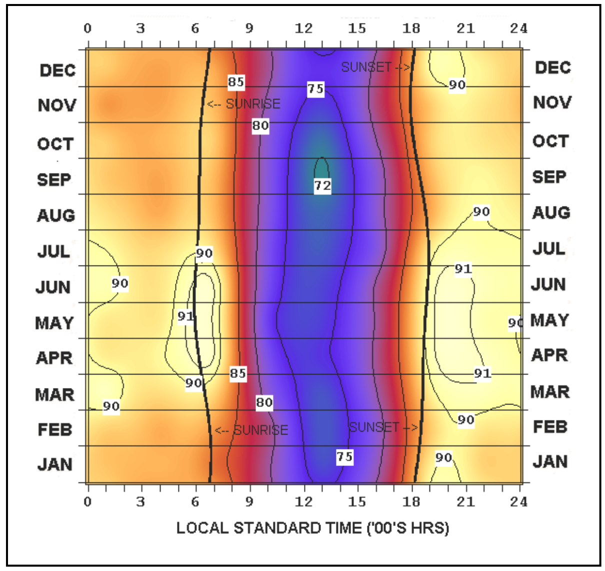

Figure 8. Percent of Time with High Visual Flight Rules ("HVFR") Conditions at Agana, Guam - (Ceilings>= 3000 ft. and Visibilities >= 3 mi).

Figure 8 is a HVFR climogram for Agana Naval Air Station, Guam (now closed). The pattern of isopleths departs significantly from the other three charts in that the minimum contours (<=75 percent) are an afternoon feature - overlaying the hours 1200 LST to 1600 LST for all months of the year except December. Guam's tropical trade-wind climate consists essentially of two seasons, a dry season covering mid-January to mid-May, and a wet season, covering essentially mid-July to mid-November [NCDC, 1995]. The minimum 72% contour is centered at about 1300 LST in September, the maximum 91% contours situated quasi-symmetrically about the sunrise demarcation line for April-June, and over the post-sunset hours 1900 LST to 2200 LST, for April-June also. The Agana overall contour pattern reflects the low latitude of the station (13.5 N) and the consequent slight variation in sunrise and sunset times over the course of the year. This in turn produces only slight contrasting variation in daytime warming and nocturnal cooling, affecting the climatological contrasts of HVFR.

3.3. - MVFR ("Mid VFR") Climograms

A third common VFR type is Mid-VFR or "MVFR". This measure differs from VFR and HVFR in that it is derived from the arithmetic difference of HVFR less VFR. Thus, if VFR incidence for a given month and hour is 85% and HVFR is 65%, MVFR incidence is 85% less 65% or 20%. A relatively high incidence of MVFR might occur in cases in which cloud ceilings tend to be higher than 1000 feet, but still lower than 3000 feet, as might be the case during summertime mornings when solar heating is just underway. As the day progresses and ceilings' levels continue to elevate to levels higher than 3000 feet, the VFR-HVFR climatological statistic becomes less in magnitude. Two climogram examples are provided - LAX and Asheville.

3.3.1. – Los Angeles Int'l Airport (LAX)

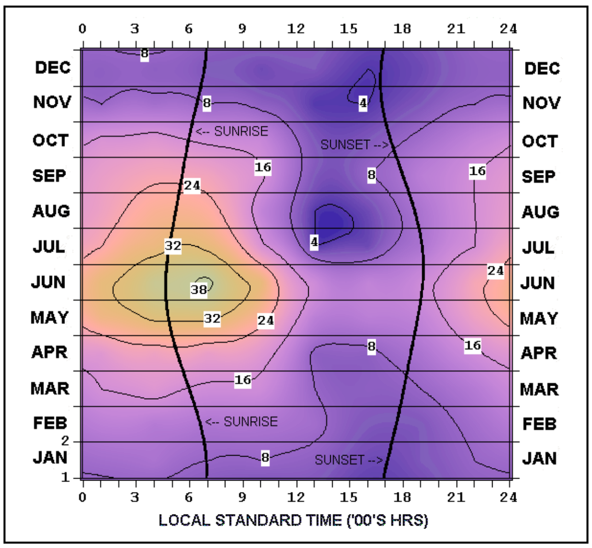

Figure 9. Percent of Time with Mid-Visual-Flight Rules ("MVFR") Conditions at Los Angeles Int'l Airport (Ceilings>1000 ft and <3000 ft; Visibilities >= 3 mi).

Figure 9 is the MVFR climogram for LAX. The 38% maximum contour situated in early June at about 7AM reflects the 74% VFR percentage at that hour (see Figure 1) subtracted by the 36% percentage figure for HVFR at the same time (See Figure 5). Thus for the early morning hours during this "June-gloom" period, while ceilings are above 1000 feet (and visibilities >= 3 miles) an appreciable amount of the time (74%), they are still less than 3000 feet, 38% of the time. By 3PM, however, in early June, the MVFR figure has been reduced to something between 8 and 16% (actually 13% from the actual data table) reflecting a 93% figure for VFR and an 80% one for HVFR. This, of course, reflects the raised cloud ceilings, owing to the progressive diurnal heating from below. Minimum MVFR incidence (4% contour) covers roughly mid-July and most of August from roughly 1300 LST to 1500 LST, and November to mid-December for a few hours just before sunset.

3.3.2. - Asheville, NC.

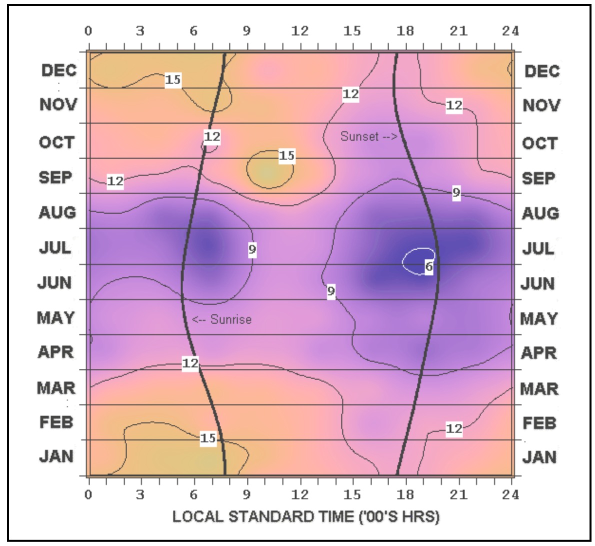

Figure 10. Percent of Time with Mid-Visual-Flight Rules ("MVFR") Conditions at Asheville, NC. - (Ceilings>1000 ft and <3000 ft; Visibilities >= 3 mi).

Figure 10 is the MVFR Climogram for Asheville. Unlike LAX, there are no maximum contours that stand out. Interestingly, the relative minimum areas (isopleths at 9 percent or less) that make of the early morning hours over June to August and the afternoon to evening hours over April to August are attributable to different physical causes. The former is due to the generally low ceilings and visibilities owing to the calms and fog (See Figure 17) at that season (VFR percentages in the 40's – see Figure 3), HVFR in the 30's. – see Figure 6.). The latter, including the modest magnitude 6% relative minimum contour covering the immediately preceding hours just before sunset in late June and early July, has a similar explanation as LAX"s (VFR percentages in the high 90's, HVFR in the low 90's), namely the cumulative effects of diurnal heating on cloud base altitudes.

It should be mentioned that cloud cover which has become "Scattered" or absent (together with visibilities >=3 miles) would qualify as both VFR and HVFR, with the MVFR figure equaling 0%.

3.4. – Highly Restricted Ceilings and Visibilities Climograms

Another type of climogram is utilized to depict the incidence of highly restricted ceilings and/or visibilitiy conditions, in this example ceilings <=200 ft and visibilities <=3/4 mile. While this combination of very poor flying weather conditions is confined almost exclusively to the hours just around sunrise, there are interesting station-to-station variations in seasonal affinities that will be shown in the charts to follow.

3.4.1. – Los Angeles, Int'l Airport (LAX)

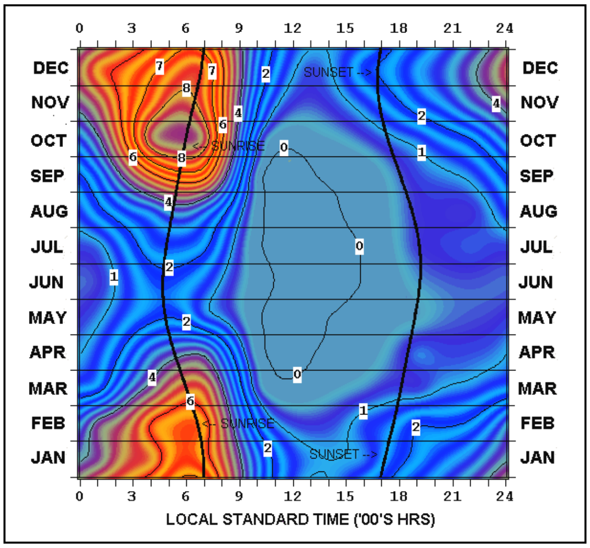

Figure 11. Percent of Time with Highly Restricted Ceilings and Visibility conditions at Los Angeles Int'l Airport (LAX) - (Ceilings><=200 ft and Visibilities >=3/4 mile.

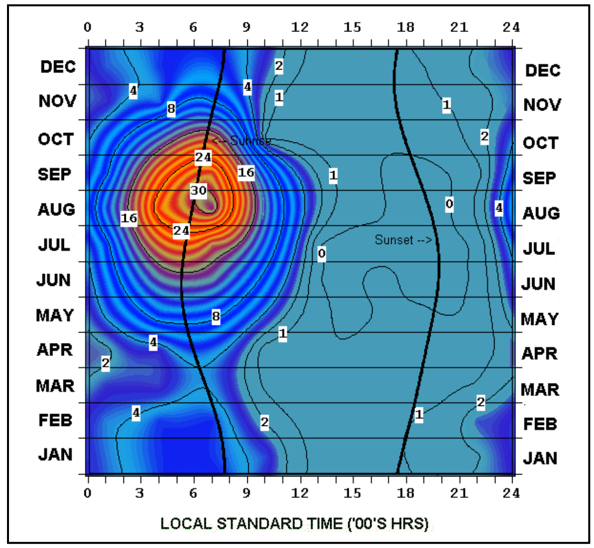

Figure 12. Percent of Time with Highly Restricted Ceilings and Visibility conditions at Asheville, NC.-(Ceilings<=200 ft and Visibilities >=3/4 mile.

Figure 11 is a climogram of the Highly Restricted Ceilings and Visibilities condition at Los Angeles Int'l Airport. Maximum frequency (8% isopleth) is confined to October and November, several hours at most before sunrise and an hour at most after. This phenomenon seems to be related to nocturnal cooling episodes in early autumn, in which relatively dense fog occurs. In general, Fog incidence at LAX is at a climatological maximum at this time of year (see Figure 15).

3.4.2. – Asheville, NC

Figure 12 is a climogram of the Highly Restricted Ceiling and Visibility condition at Asheville, NC. There is a decided maximum (30% isopleth), encompassing nearly all of August just after sunrise. Similar to LAX, this is predominantly a Fog feature (see Figure 17 for Asheville's Fog climogram).

3.4.3 – Boston WSO, MA.

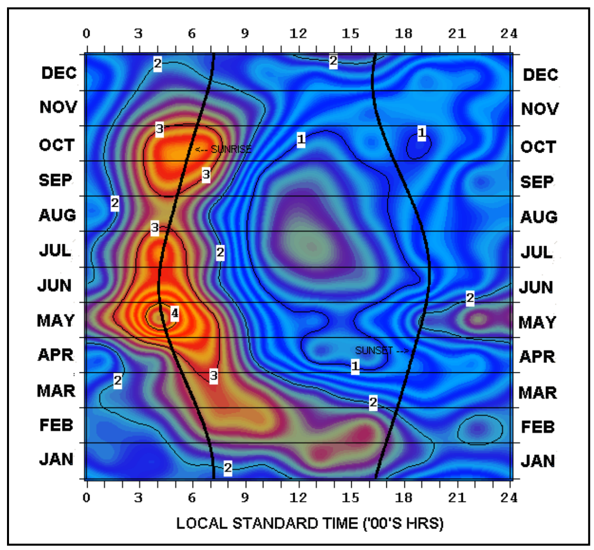

Figure 13. Percent of Time with Highly Restricted Ceilings and Visibilty conditions at Boston, MA (Ceilings><=200 ft and Visibilities >=3/4 mile.

Figure 13 is a climogram of the Highly Restricted Ceilings and Visibility condition at Boston WSO. While the maximum frequency contours are not high in magnitude (3-4%), there is a "two-pronged" feature, one straddling the sunrise demarcation line in September and October, the other in May. The 3 percent isopleth also spreads out from this latter "pole" forward into July and backwards into April.

3.4.4. – BakersfieldAirport, CA.

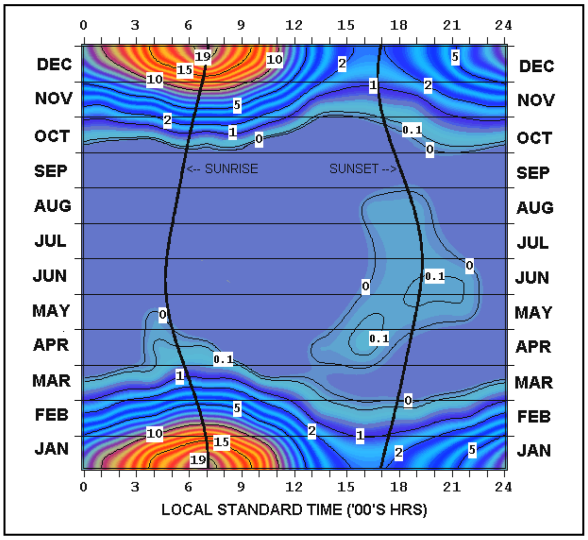

Figure 14. Percent of Time with Highly Restricted Ceilings and Visibilty conditions at Bakersfield, CA (Ceilings><=200 ft and Visibilities >=3/4 mile).

Figure 14 is a climogram of the Highly Restrictive Ceilings and Visibilities condition for Bakersfield, CA. Yet another differently placed “pole” of maximum magnitude isopleths is displayed, in this case a 19 percent contour that centers on the sunrise curve over December and January. This of course again relates to the Fog (see Figure 21) that tends to form in the enclosed San Joaquin Valley during wintertime when circulation patterns are favorable (or unfavorable, operations-wise).

Aside from December and January morning hours, however, this condition is generally infrequent and almost non-existent in the Spring, Summer, and early Fall (September).

It should be mentioned that the particular ceilings and visibility combinations used here to define VFR, HVFR, MVFR, and the Highly Restricted Flying weather conditions above for the various charts are by no means universal. However, relatively slight variations from the above criteria would most likely yield seasonal/diurnal contour patterns that are similar in configuration if not exact magnitudes.

***3.5. -** Fog and Haze*

Obviously, Fog and Haze are two conditions that may affect visibility and flight operations. With Fog, ceilings normally should not enter into consideration because Fog extends from the surface upward, and the ceilings, by definition, are absent. The ISMCS product does not explicitly quantify the visibility mileage necessary define Fog, although a definition familiar to the writer is a visibility is less than 7 miles, combined with dry bulb/dewpoint spread below a certain threshold. Thus, the fact that Fog can be observed when visibilities are between 4 to 6 miles indicates that it may not necessarily be a Flying Weather restricting condition. A known haze definition has visibilities less than 7 miles, but dry bulb/dewpoint spreads above the Fog threshold. Using this criterion, like Fog, if visibilities are between 4 and 6 miles there may be no Flying Weather restricting condition if ceilings are also greater than a specified altitude level,

3.5.1. - Fog and Haze Climograms for Los Angles Int’l Airport (LAX)

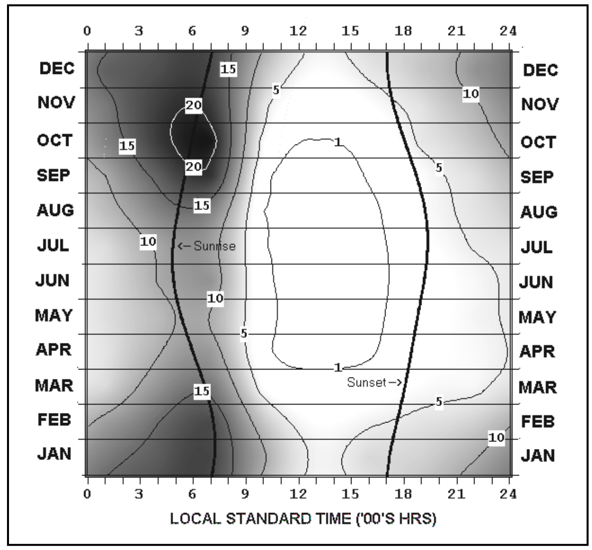

Figure 15. Fog Climogram for Los Angeles Int’l Airport (LAX)

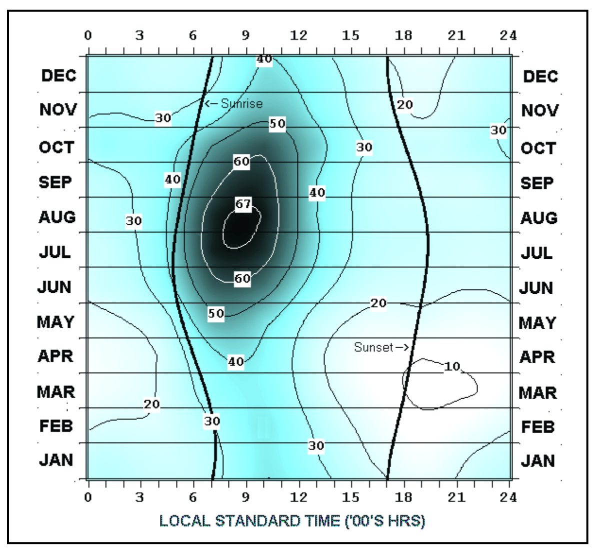

Figure 16. Haze Climogram for Los Angeles Int’l Airport (LAX)

Figures 15 and 16 above depict the percent incidence of Fog and Haze at LAX. Maximum incidence of Fog

(20 percent isopleth) is an October to mid-November phenomenon, the enclosed area centered on the sunrise demarcation line, extending a couple of hours either side of it at the widest. This maximum Fog positioning corresponds quite well with the minimum area exhibited in the LAX highly restricted visibility chart (Figure 11), indicating that the latter is related to denser fog episodes. The Haze climogram shows a decided maximum (67%) covering roughly mid-July through August at around 0800 LST to 0900 LST, probably relating to cases in which visibilities are still less than 7 miles, but dry bulb/dewpoint spreads are past the Fog threshold.

3.5.2. - Fog and Haze Climograms for Asheville, NC

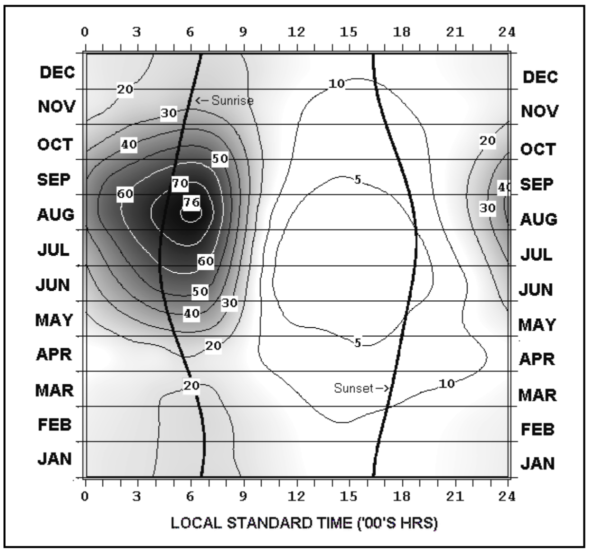

Figure 17. Fog Climogram for Asheville, NC.

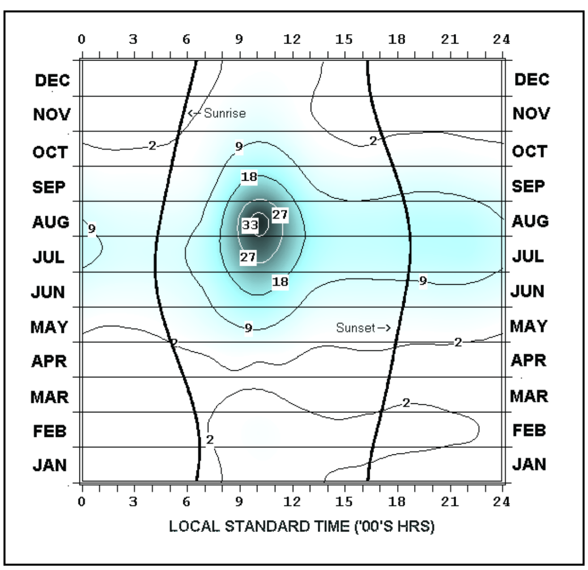

Figure 18. Haze Climogram for Asheville, NC.

Figures 17 and 18 depict the percent incidence of Fog and Haze at Asheville. The outstanding feature of the Fog chart is the 76 % maximum contour, centered around 7AM in August. This feature corresponds very well with the positioning of the VFR and HVFR minimum contours, (Figures 3 and 6, respectively) indicating that those minima are Fog-induced. The Haze maximum (33 percent) contour is also positioned in August, a few hours later around 0900 LST to1000 LST, reflecting accumulated post-sunrise insolation; dry Bulb/dewpoint spreads have increased into the Haze realm, visibilities, however, still less than 7 miles. Other than this August early-morning maximum, Haze incidence in Asheville is very infrequent compared to LAX, likely because prevailing winds in Asheville are northwesterly [NCDC, 1995] – or continental, whereas LAX's are onshore from the Pacific Ocean, a few miles to the west.

3.5.3. - Fog and Haze Climograms for Boston, MA .

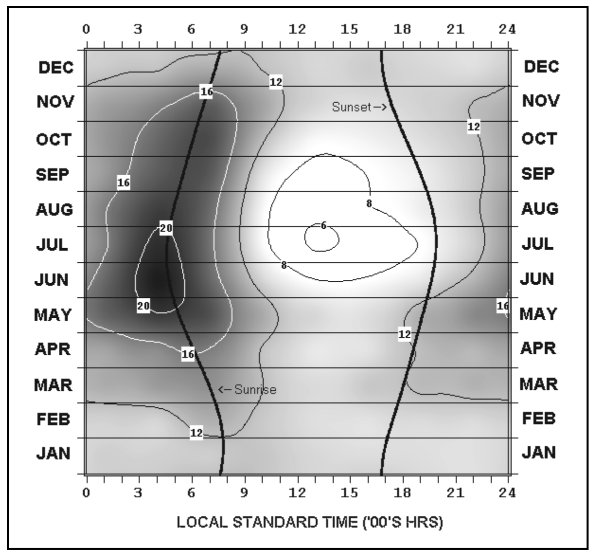

Figure 19. Fog Climogram for Boston, MA.

Figure 19 (above) and Figure 20 (below) depict the incidence of Fog and Haze, respectively, at Boston, MA. In contrast with LAX and Asheville, Fog incidence at Boston exhibits a late Spring to mid-summer maximum (20 percent contour), essentially straddling the sunrise demarcation line. This coincides somewhat with the relative maximum incidence of highly restricted ceilings/ visibility chart in Figure 13. In the Fog chart, a broader area enclosed by the 16% contour covers much of the pre-sunrise hours, especially for April through November.

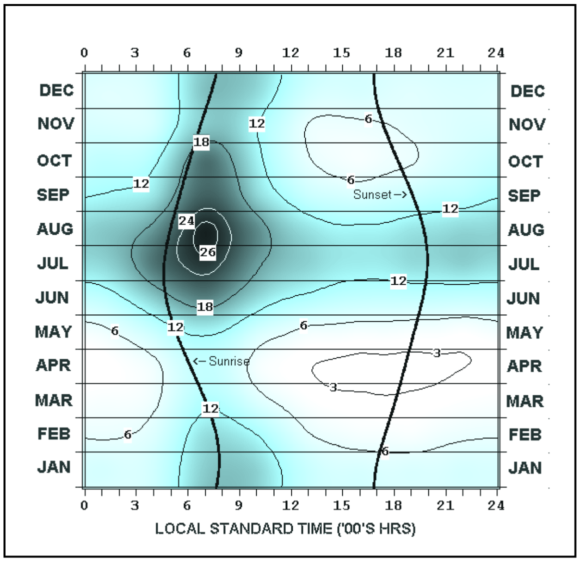

Figure 20. Haze Climogram for Boston MA.

The Haze chart shows a maximum isopleth (26 percent) covering roughly mid-July through August, several hours after sunrise, a 12% area encompassing all hours in July and August.

3.5.4. - Fog and Haze Climograms for Bakersfield, CA.

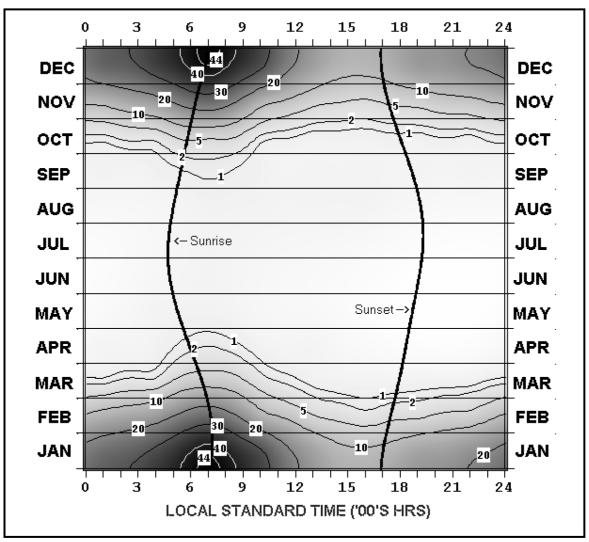

Figure 21. Fog Climogram for Bakersfield Airport, CA.

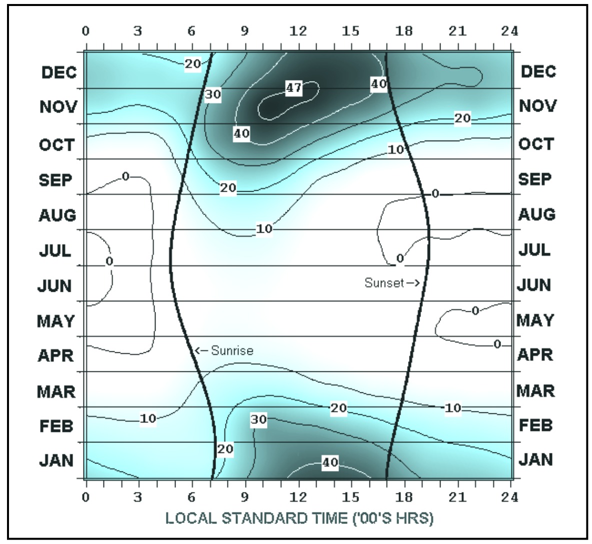

Figure 22. Haze Climogram for Bakersfield Airport, CA.

Figures 21 and 22 are Fog and Haze climograms, respectively, for Bakersfield, CA . The Fog chart's pattern is very similar to that of the VFR chart (Figure 2), and the Highly Restricted Ceilings and Visibilities graph (Figure 14) reinforces the obvious that dense fog is the factor that produces the very poor Flying Weather conditions around sunrise in December and January. The Haze climogram's maximum (47%) contour is curiously placed in November over the late morning hours, the broader 40 percent isopleth covering most of the daytime hours for November and December, also obliquely. The cause of this is not totally clear. Perhaps to some extent it reflects pollutants trapped at the south end of the San Joaquin Valley, (wildfire smoke debris or pollutants from the Bay area?), these having a seasonal proclivity to accumulate in the lower atmosphere in the Bakersfield vicinity.

3.6. - *Percent of Time with Ceilings/Median Ceilings' Heights' Climograms*

The last climogram type to be illustrated is the "Percent of Time with Ceilings/Median Ceilings Heights". Its purpose is purely descriptive, but restricted flying weather insights can certainly be gleaned from inspection of the patterns. Seven stations' charts are presented, a number having interesting features.

Again, cloud ceilings are defined as broken or overcast sky cover conditions, and median ceiling heights are the 50th percentile ranked magnitudes of those broken or overcast cases' ceilings' altitudes. "Percent of Time with Ceilings" is depicted by a violet (relatively low incidence) to red (relatively high incidence) coloring scheme, "Median Ceilings' Heights" are overlain with dashed contours.

3.6.1. - Los Angeles Int'l Airport (LAX)

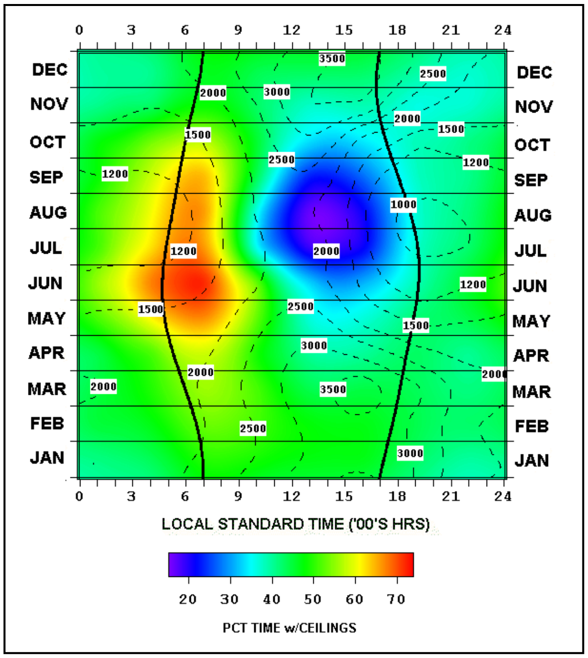

Figure 23. Ceilings' Climogram for Los Angeles Int'l Airport (LAX)

Figure 23 is a Ceilings' climogram for Los Angeles Int'l Airport (LAX). The frequency of ceilings' (Broken and Overcast cloud cover) has both the maximum and minimum incidence in summer. Highest frequency (reddest area, corresponding to 70% or greater) is located just after sunrise in June (the "June gloom" feature). Minimum incidence (dark-blue area corresponding to 20% or less) is positioned over the early afternoon hours, principally in July and August. This latter feature may be due, at least in part, by the strengthened and lowered subsidence inversion aloft in mid-summer, cloud thicknesses less than in June with a more certain burnoff to scattered or clear conditions likely The maximum median ceilings height contour (3500 ft) is seen for March in the mid to late afternoon hours, (drier atmospheric conditions with diminishing incidence of low ceilings) and mid- November through December (also generally drier atmospheric conditions due to increased offshore flow). Interestingly, the lowest median contour (1000 ft) is concentrated in July and August for those several hours just after sunset, the median heights showing a gradually rise overnight to 1200 ft . This might reflect the predominant (drier) offshore flow during the overnight hours, with some evaporation of cloud bases.

Figure 24 is an alternative depiction of Figure 23. The percent incidence colorings are replaced by solid contours, the dashed ceilings isopleths remaining unchanged in format.

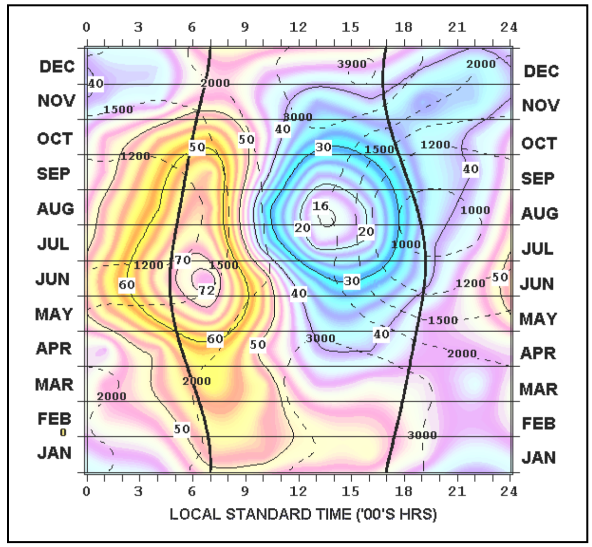

Figure 24. Ceilings' Climogram for Los Angeles Int'l Airport (LAX) – Alternative presentation form

3.6.2. – Asheville, NC

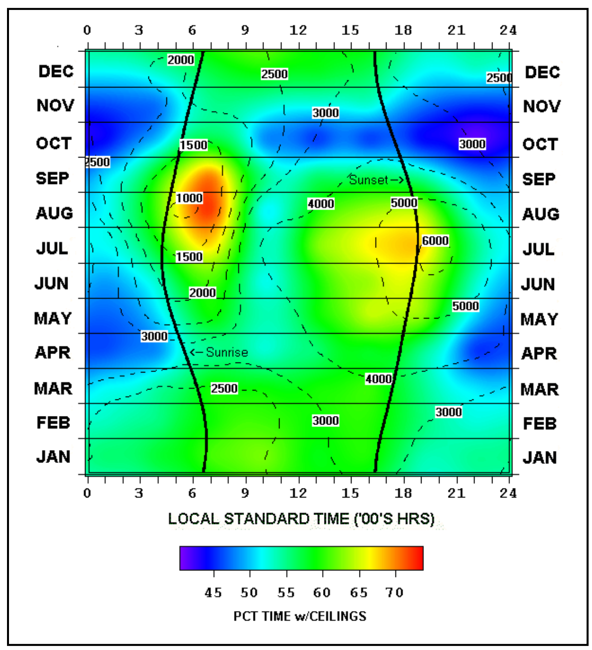

Figure 25. Ceilings' Climogram for Asheville, NC

Figure 25 is a Ceilings' climogram for Asheville. Maximum incidence of ceilings (red area, representing near, equal, or greater than 70%) is situated over roughly mid-July to late September, corresponding median ceilings' heights in the 1000 ft to 1500 ft range (dashed contours). This singular feature, of course, was previously seen in the VFR (Figure 3), HVFR (Figure 6), Highly Restricted Visibilities/Low Ceilings (Figure 12), and Fog (Figure 17) charts.

A secondary maximum area (yellow-orange to orange area – corresponding to roughly mid to high 60's' percentages) is seen for the late July afternoon hours, this, however, associated with median ceilings' heights much higher (5000 ft to 6000 ft). Lowest frequency of ceilings in Asheville (40 to 45 percent – darkest blue areas) are confined to October and November for the post sunset hours through about 2AM. Median ceiling heights range from 3000 feet (early evening hours) to 2000 feet (post midnight hours).

3.6.3. - Ft. Myers FL..

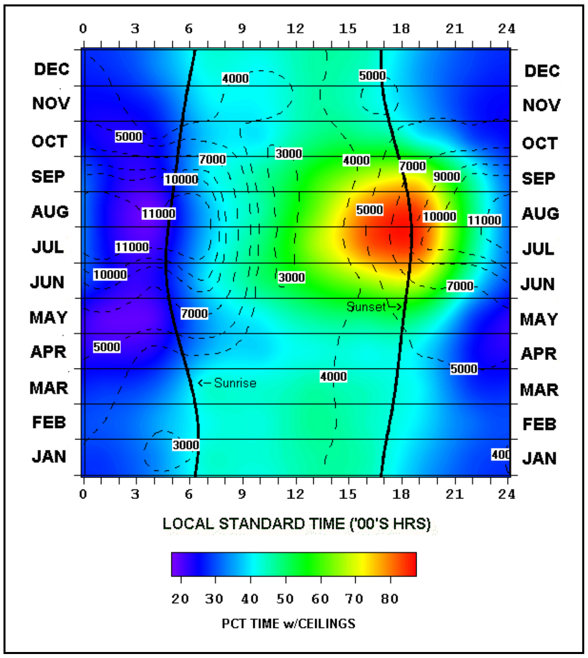

Figure 26. Ceilings' Climogram for Ft Myers, FL,

Figure 26 is the Ceilings climogram for Fort Meyers, FL, located in a high thunderstorm frequency area of the country, most of the occurrences in July and August.

Ceilings' percentages in the post-sunset hours before sunrise are generally between 20-40 percent (blue shadings) with median ceilings at 5000 feet and above. The circular red feature depicting frequencies of roughly 75% percent or greater, reflects the occurrence of late-afternoon early evening thunderstorms, either locally or regionally (the latter storms still close enough for their cloud expanses to affect local ceiling observations). From late June to mid-September the daytime pattern of median ceiling height contours shows a consistent progression. Median heights just after sunrise are quite high (10000 ft) likely reflecting residual cloud cover debris from the previous day's thunderstorms. As the morning progresses, the median values drop off rapidly, an elongated 3000 foot contour region, a few hours wide, visible for the late morning hours. This probably reflects the early development of cumuli, the clouds becoming expansive and frequent enough such that their base altitudes become the climatological median ceiling height.

As the day wears on, accumulated lower atmospheric heating causes the cloud bases to raise further, the first appearance of the red region (about 1500 LST) reflecting the onset of thunderstorms (ceiling frequencies passing 80%). After 2000 LST, frequencies decrease to green (~50% to 60% levels), median ceilings remaining high (10000-11000 foot levels), but with the percentages dropping off rapidly to blue (<30 percent) levels by midnight.

3.6.4. – Minneapolis-St. Paul, MN

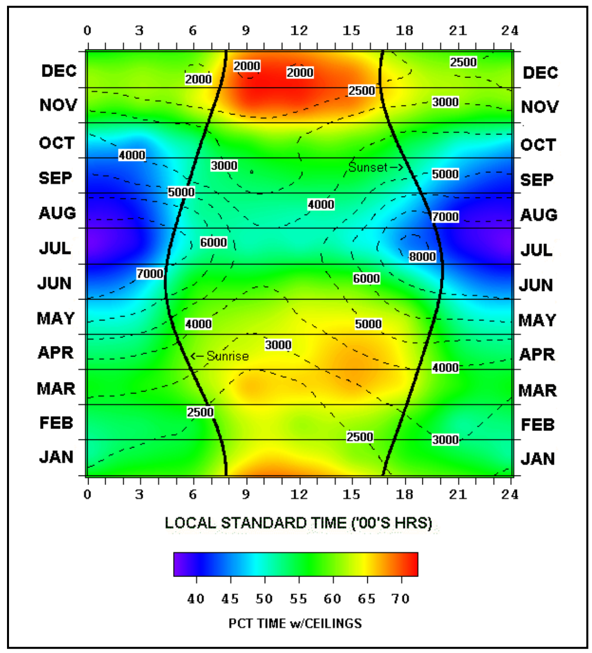

Figure 27. Ceilings' Climogram for Minneapolis, MN.

Figure 27 is the Ceilings' climogram for Minneapolis-St. Paul. Prominent is a red high frequency area covering essentially November and December for the daylight hours. Percent incidence ranges from the mid 60's to the low 70's, the median ceilings' heights generally 2000-2500 feet. This is the characteristic dull, low cloudiness that often affects Minneapolis during the transition to mid-winter, January bringing more episodes of arctic outbreaks, with bitter cold and somewhat less dreary, low cloudiness. A secondary maximum area of relatively high frequencies covers March from about 0900 LST to sunset (median ceiling heights lifting from about 2500 to near 4000 feet), and in April for the afternoon hours (median ceilings rising from about 3000 to 5000 feet. Similar to Sioux City (See Figure 7), the March feature might be a subtle reflection of evaporated snowmelt condensing as cloud. Since April afternoons have the highest mean wind speed of the year in Minneapolis-St. Paul [NCDC, 1995], perhaps this relative frequency maximum is a reflection of increased convection and turbulent mixing, moist air from near ground level being carried up higher to condense as clouds.

3.6.5. - San Francisco WSO.

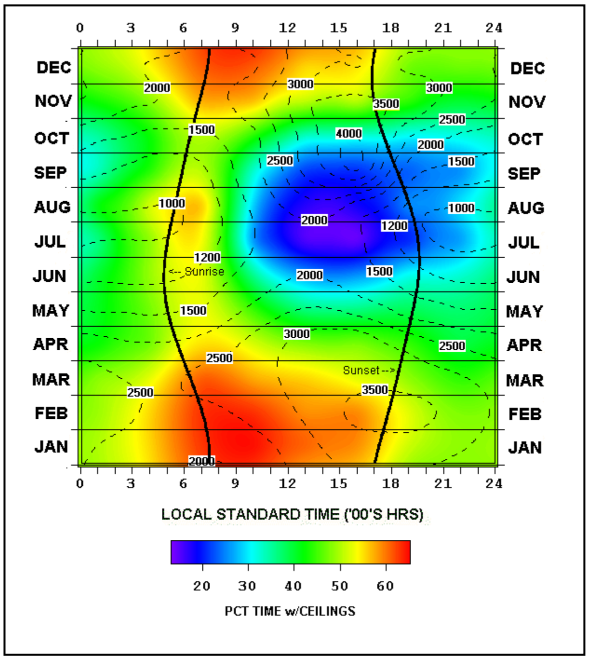

Figure 28. Ceilings' Climogram for San Francisco WSO, CA.

Figure 28 is the Ceilings' climogram for San Francisco WSO. In general, maximum ceilings' incidence (orange and red areas – reflecting high 50's to low 60's percent frequencies) is situated over the December to March daytime hours, and also for a number of pre-sunrise hours as well. This is coincident with the rain season and all the associated weather than promotes broken and overcast sky conditions. Median ceiling heights during these times exhibit a morning to afternoon increase, typically from at or less than 2500 feet just after sunrise to above 3000 feet in the afternoons, sometimes greater than 3500 feet (February from about 1500 LST to 2100 LST).

Summer brings expansion of the North Pacific High and the strengthening subsidence inversion, low morning cloudiness, and mostly sunny conditions for the afternoons. This shows up as a wide expanse of 1200 foot or less median height contours covering the early morning hours from June into September, and the evening hours from June to August. A small, orange-colored feature of mid-50's percent frequencies covers 0600 LST and 0700 LST in August.

Another large area of low ceilings' frequencies (blue shadings – indicative of upper 20's to low teens' percentages) is seen for June to early October from 0900 LST to nearly midnight, although the corresponding median heights, while failing to reach 2000 feet in the early afternoons of July become higher as the summer progress. Late September and early October have the warmest afternoon temperatures of the year in San Francisco [NCDC, 1995] , the sea-breeze typically less intense than in summer, this likely reflected by the relative maximum 4000 foot median ceiling contour overlaying 1500 LST to1600 LST for this period. Percent ceilings' frequencies are still quite low, however, in the 20's.

3.6.6. - La Guardia Int'l Airport, NY

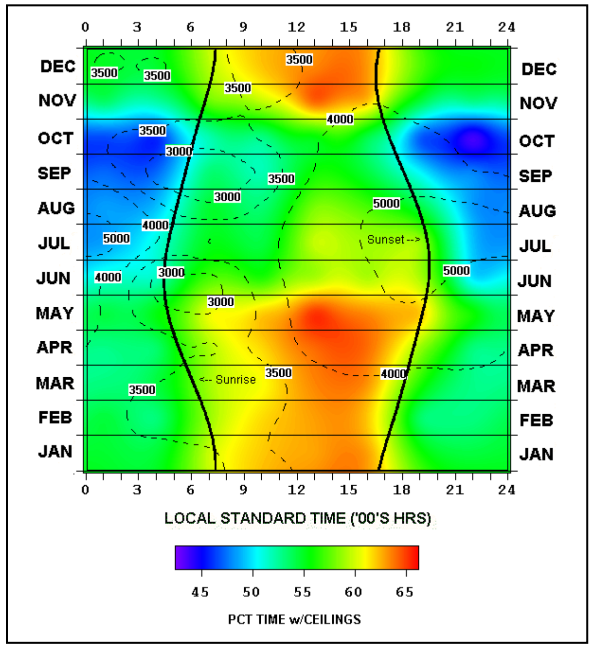

Figure 29. Ceilings' Climogram for La Guardia Int'l Airport, NY.

Figure 29 is the Ceilings' Climogram for New York La Guardia Int'l Airport. A relatively symmetrical pattern of ceilings' frequencies (colorings) and median heights (contours) is seen, with comparatively slight variation, for each, diurnally and seasonally. The range of median height contours is just 2000 feet (3000 feet to 5000 feet).

Maximum ceilings' frequencies (orange to red areas, corresponding to values in the low to mid 60's) cover roughly the mid-morning to late afternoon hours for the months November to May, median ceiling heights for those times ranging from about 3500 to 4000 feet.. Minimum ceilings' frequencies (blue areas - corresponding to percentages less than 50 percent) cover most of the nocturnal hours over July through October.

Visible are two ellipsoid-shaped minimum (3000 ft) median height areas, the first positioned over mid-May to mid-June for the hours 0400 LST to 0900 LST, the other essentially confined to September for 0300 LST to 1000 LST.

The maximum median heights' isopleth (5000 feet) is a June to August feature, covering the late afternoon hours for all three months and extending well into the evening hours, especially for July,

3.6.7. - Goodland, Kansas

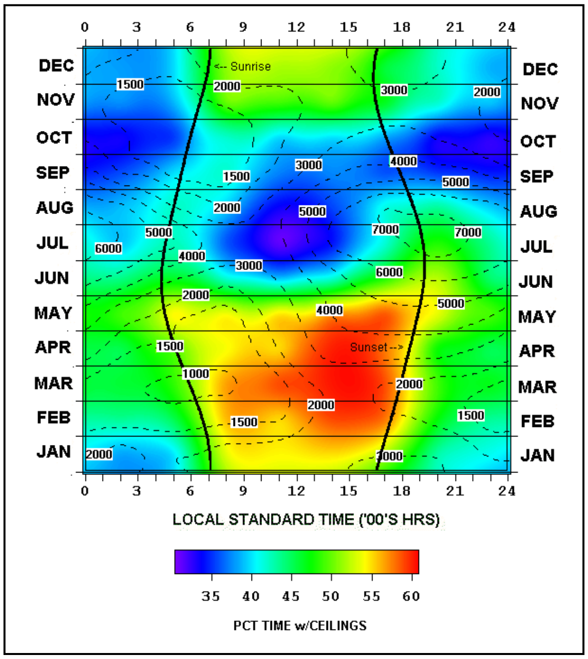

Figure 30- Ceilings Climogram for Goodland, KS

Figure 30 is the Ceilings' climogram for Goodland, Kansas. Goodland, located on the high plains of the northwestern corner of the state has a somewhat complex pattern of median ceiling height contours. The orientations, especially for the midnight to late morning hours from February to June, and from September to December, are oblique, reflecting a combination of both diurnal and seasonal influences. The most horizontal (diurnal) orientation is seen for July and August.

Maximum ceilings' frequencies (orange and red areas), corresponding to 55% to 62% incidence, covers nearly all the afternoon hours over February to May, the red-orange coverage in March also extending over nearly all of the forenoon hours as well.

The absolute minimum 1000-foot median ceiling isopleth also overlays March from about 0400 LST to 0900 LST. This might be attributable in part to early morning low cloud formation, the result of snowmelt, evaporation, and condensation aloft. March average snowfall for March (10 inches) is the highest of any month for Goodland [NCDC, 1995]. In addition, owing to the east-west upslope terrain in northwestern Kansas, Goodland can be subject to low cloudiness, fog, and drizzle during episodes of easterly component winds. This undoubtedly also contributes to a lowering effect on the median contours for those seasonal/diurnal times of the year that are most frequently affected by upslope easterlies. The orange-red afternoon coloring likely reflects increased windiness and convection, promoting cloud formation, but with higher ceilings.

Highest median ceiling contours (7000 feet) are seen mostly for July, covering the hours 1600 LST to 2100 LST. Minimum frequency of ceilings (violet coloring, indicating <35 percent incidence) occurs in July for roughly 1000 LST to Noon, the frequency, however, increasing to 45-50% (green coloring), to go with the already mentioned 7000 foot ceilings later in the day,

4. SUMMARY AND CONCLUSION

The foregoing described and illustrated "Hour-by-Month" Climograms as tool for depicting on single page layouts the diurnal and seasonal climatological variation of various types of Flying Weather conditions, Fog and Haze, and the frequency of ceilings (Broken and Overcast sky conditions) combined with median ceilings' heights. Such a visual presentation mode effectively summarizes large amounts of data (e.g., for a given station there are some 288 month/hour data points) and permits quick-study insights to be gained that would not likely be possible in such a manner with tabular inspections. Visual impressions are also likely retained longer in the mind than information picked up from tables. Another, perhaps even greater, advantage is realized when multi-station comparisons are needed on the fly, and by extension, in this regard, an ultimate application of "Hour-by-Month" climograms might be construction of a reference "atlas".

5. REFERENCES

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NOAA National Climatic Data Center (NCDC), 1995. International Station Meteorological Climate Summary (ISMCS), Version 3.0 – CD-ROM