NOAA Technical Memorandum NWS SR-171

PP-TOOLS: A CLIMATOLOGICAL FORECAST AID FOR AVIATION FORECASTERS

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November 1995

Preface

Copies of the PP-Tools program have been distributed to all Southern Region offices and to each of the other NWS regions. Inquiries should be directed to the appropriate Regional Headquarter's representative on the NWS Local Applications Working Group (most likely in either Scientific Services Division or Systems Operations Division).

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1. INTRODUCTION

PP-Tools is a computer program that serves as a climatological forecast aid for the aviation forecaster. The objective of the program is to provide the aviation forecaster with interactive access to up to 30 years of climatological "experience" for user-specified stations. This information is intended to supplement other forecast information with the ultimate goal of helping the forecaster issue the best possible terminal forecast.

The objective of this paper is to provide an overview of PP-Tools and then provide a more detailed discussion of the program's main features, including examples of program output and how the data might be used for various forecast situations.

2. OVERVIEW OF PP-TOOLS

PP-Tools is a full-featured Windows program with the familiar user interface that includes pull-down menus, toolbar, status line, and online help.

The program is first used to process up to 30 years of CD-ROM climate data for user-selected stations into a relatively small database. This database is then used to provide interactive access to tables of persistence probability as well as climatological charts of wind, IFR events, thunderstorms, precipitation events, temperature/relative humidity, and opaque sky cover. The program also allows viewing and editing of text files.

The user-friendly Windows interface makes the program extremely easy to use. The status line at the bottom of the screen provides a brief description of every menu option and every toolbar icon. The program's extensive online help answers just about any remaining questions with topics ranging from extracting the CD-ROM data to using and understanding persistence probability tables and the climatological graphic products.

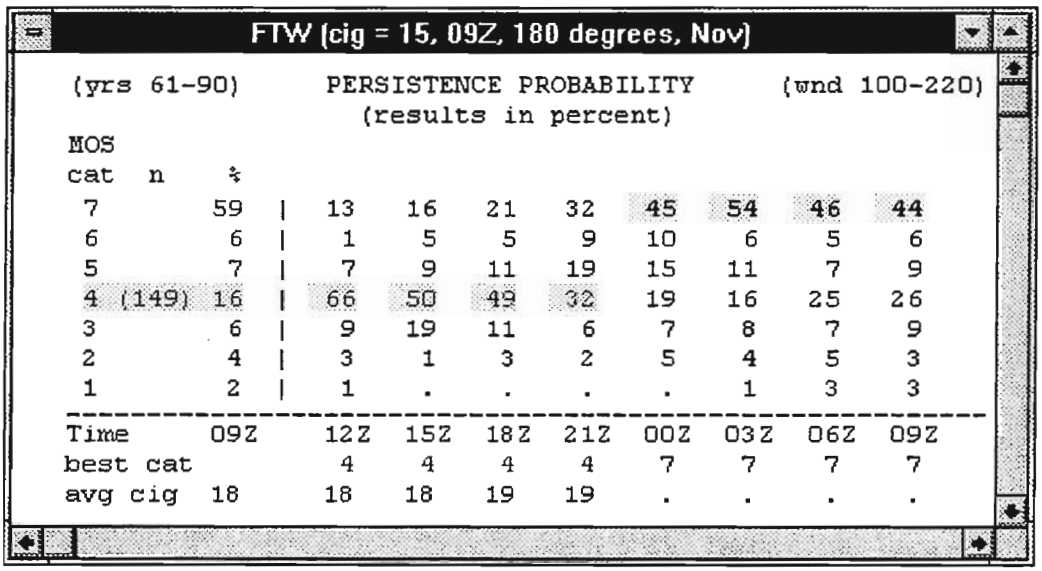
The two main features of the program are persistence probability tables and the climatological charts. These topics will now be discussed in more detail.

3. PERSISTENCE PROBABILITY

Persistence probability (PP) is a climatological forecast tool that can lead to a significant improvement in aviation terminal forecasts. PP tables give the forecaster immediate access to the equivalent of up to 30 years of aviation forecast experience.

As the name suggests, persistence probability is basically the "probability" that a particular ceiling or visibility condition will "persist". More specifically, given an initial ceiling or visibility condition, persistence probability can be expressed as a table of probabilities of all possible ceiling or visibility conditions at 3-hour intervals following the initial hour.

PP tables are produced when the user selects the appropriate menu or toolbar item and then completes the dialog box by specifying a particular station, month, hour, wind direction, and initial ceiling or visibility. For ease of use, the dialog box items default to the last-used station, current month and hour, and the last-used wind direction. Figure 1 shows an example of a PP-Table for ceiling conditions.



FTW (cig = 15, 09Z, 180 degrees, Nov)

(yrs 61-90) PERSISTENCE PROBABILITY (wnd 100-220)
(results in percent)

MOS cat	n	%								
7		59	13	16	21	32	45	54	46	44
6		6	1	5	5	9	10	6	5	6
5		7	7	9	11	19	15	11	7	9
4	(149)	16	66	50	49	32	19	16	25	26
3		6	9	19	11	6	7	8	7	9
2		4	3	1	3	2	5	4	5	3
1		2	1	.	.	.	.	1	3	3
Time		09Z	12Z	15Z	18Z	21Z	00Z	03Z	06Z	09Z
best cat			4	4	4	4	7	7	7	7
avg cig		18	18	18	19	19	.	.	.	.

Figure 1. Example of PP Table for ceiling.

The PP table in Figure 1 is for Fort Worth with initial conditions specified as: ceiling 1500 feet at 09Z with a South wind in November. The table provides important information about (1) the initial conditions and (2) the subsequent 3 to 24-hour periods at 3-hour intervals.

3a. Information about initial conditions

For the initial hour, the MOS category and the number of cases in the database that met the specified criteria are highlighted in yellow. Also highlighted is the frequency of occurrence of this condition, expressed as a percentage of all categories for this hour and wind direction. Similar frequencies are listed for the other MOS categories for this hour and wind direction. This frequency information shows whether the initial condition is a common or perhaps rare occurrence. The average ceiling associated with the initial MOS category is also indicated.

For the example shown, the initial MOS category 4 ceiling condition was found in the database 149 times for the specified conditions. The frequency of occurrence is 16%, so this event would not be considered unusual or rare. In fact, this category 4 ceiling is the most likely occurrence other than category 7 events, and the average ceiling for all such cases is 1800 feet. The percentage information also shows that the likelihood of IFR conditions for this hour and wind direction is 12% (adding frequencies for categories 1, 2 and 3).

3b. Information about conditions beyond the initial hour

For each of the subsequent 3 to 24-hour periods following the initial conditions, percentage frequencies of occurrence (probabilities) are listed for each possible MOS category, and the "best" MOS category is highlighted in yellow. The average ceiling that was associated with this category is specified. This information essentially tells the forecaster the likelihood of a particular ceiling and the average height of the ceiling when it occurs.

For the example in Figure 1, the table shows the category 4 ceiling as the most likely category through 21Z with average ceiling heights of 1800 to 1900 feet. The table shows that category 7 conditions are most likely at 00Z and later.

The percentage values for each of the 3-hour forecast periods provide important information about the relative frequencies of the various categories, and this gives the forecaster an indication of how much confidence to have in the data. For the example, the percentages are fairly high for category 4 conditions through 18Z, and for category 7 conditions at 00Z and beyond. However, at 21Z the percentage of category 4 events is the same as for category 7.

The percentage values can also help the forecaster avoid forecasting events that are not likely to occur. For the example data, the initial hour is 09Z, and the forecaster might be thinking about IFR conditions at 12Z. But would this be a wise forecast? Probably not, since the probability of MVFR conditions (category 4) is 66%, or about 5 times greater than the sum of the probabilities for IFR categories 1, 2 and 3 at 12Z.

3c. Using PP data against itself

One of the most powerful uses of persistence probability is the use of the data against itself. This is when the forecaster looks ahead in time to an expected condition and then uses the PP data to determine (1) the average ceiling or visibility for the expected category and (2) the most likely change in the conditions over the forecast period. This application of PP tables might be used to help answer the following forecast questions:

- It's VFR at 00Z, but the gradient has increased and low ceilings appear likely. When is the ceiling most likely to form? What will be the initial ceiling height? How long will the ceiling last?

Figure 2 shows a PP table depicting initial conditions for such a forecast situation. The data is for San Antonio at 00Z in April with a South wind.

SAT (cig = none, 00Z, 180 degrees, Apr)

(yrs 61-90) PERSISTENCE PROBABILITY (wnd 100-220)
(results in percent)

MOS cat	n	%								
7	(648)	72	87	61	48	42	45	59	70	79
6		6	1	1	2	2	3	5	5	6
5		10	2	3	3	5	4	7	12	8
4		9	8	21	23	24	33	27	11	6
3		2	1	11	18	18	11	2	1	1
2		1	.	2	5	6	4	0	0	0
1		.	.	0	1	3	0	.	.	.
Time		00Z	03Z	06Z	09Z	12Z	15Z	18Z	21Z	00Z
best cat			7	7	7	7	7	7	7	7
avg cig		.	.	.	.	.	.	.	.	.

Figure 2. PP table for San Antonio, no ceiling, 00Z, South wind, April

The PP table indicates category 7 as the most likely category through 24 hours. But as previously stated, the gradient has increased and a ceiling is expected. By examining the table, the probabilities of category 4 increase to 21% at 06Z and remain fairly high through 18Z. So the ceiling might be expected to begin around the 06Z time period. But what would be the initial height of the ceiling? A new PP table could be generated as before by specifying the new time and some arbitrary category 4 ceiling. But there is a quicker way.

A special "magnifying glass" cursor makes it simple to look ahead in time as described above. Simply place the magnifying glass cursor over the time and MOS category of interest and click. A new PP table will instantly be produced, and the initial time and MOS category of the new table will correspond to the point at which the mouse button was pressed. The remainder of the criteria will be the same as the original PP table.

For the example data, the magnifying glass cursor is placed over category 4 and 06Z, and then the mouse button is pressed, producing the new table shown in figure 3.

SAT (cig = cat 4, 06Z, 180 degrees, Apr)

(yrs 61-90) PERSISTENCE PROBABILITY (wnd 100-220)
(results in percent)

MOS cat	n	%							
7		47	5	6	9	26	43	62	58	25
6		4	1	1	2	5	7	5	3	4
5		4	3	3	5	8	20	14	6	4
4	(240)	27	58	50	56	52	25	15	25	47
3		15	29	31	22	8	3	3	6	16
2		3	4	8	5	1	2	2	1	4
1		1	.	1	0	.	.	.	1	0
Time		06Z	09Z	12Z	15Z	18Z	21Z	00Z	03Z	06Z
best cat			4	4	4	4	7	7	7	4
avg cig		14	14	15	16	20	.	.	.	14

Figure 3. PP table for San Antonio, category 4 ceiling, 06Z, South wind, April

The new table now provides some answers to the remaining forecast questions. The average ceiling height for category 4 conditions at 06Z is 1400 feet. And looking at the data following 06Z, it looks like the ceiling most often remains 1400-1600 feet until lifting to 2000 feet by 18Z. The data further indicates VFR conditions at 21Z and also the ceiling forming again at 06Z.

Another forecast situation when persistence probability data might be used against itself is as follows:

- It's VFR at 15Z with a South wind. But a cold front will move through by 18Z and IFR conditions are expected to be widespread behind the front. What does climatology indicate for IFR ceiling heights at 18Z and beyond? And how might these conditions be expected to change?

These questions would be answered as in the previous example. We would generate a new PP table, specifying a North wind and an initial ceiling height that might be expected for the situation. The new table should then provide the necessary information. The only difference in this and the previous example is that the wind direction has changed, and for this reason, the magnifying glass cursor method of generating a new table cannot be used.

These are only a couple of examples of this powerful use of persistence probability data. The important point is that the data is very accessible, and the forecaster is able to answer many difficult forecast questions very quickly.

4. CLIMATOLOGICAL CHARTS

In order to make the best possible forecast for a particular location, it is essential that the forecaster be thoroughly familiar with local climatology. PP-Tools makes this aviation-related climatological data readily available.

The best was to study PP-Tools climatology for a station is to first select the station, and then view all statistical charts. This can be accomplished by first clicking "Select station" and then the "View all statistics" icons on the toolbar, or by making similar selections from the PP data menu. The following charts will then be displayed for viewing...

1. Wind summary (figure 4) -- This chart shows wind roses (Bomar, 1983) for each season and the year. The wind rose depicts the relative frequency of wind direction on a 16-point compass. Each ring on the wind rose represents a frequency of 10 percent of the total. The range of mean hourly wind speed for each time period is also indicated.

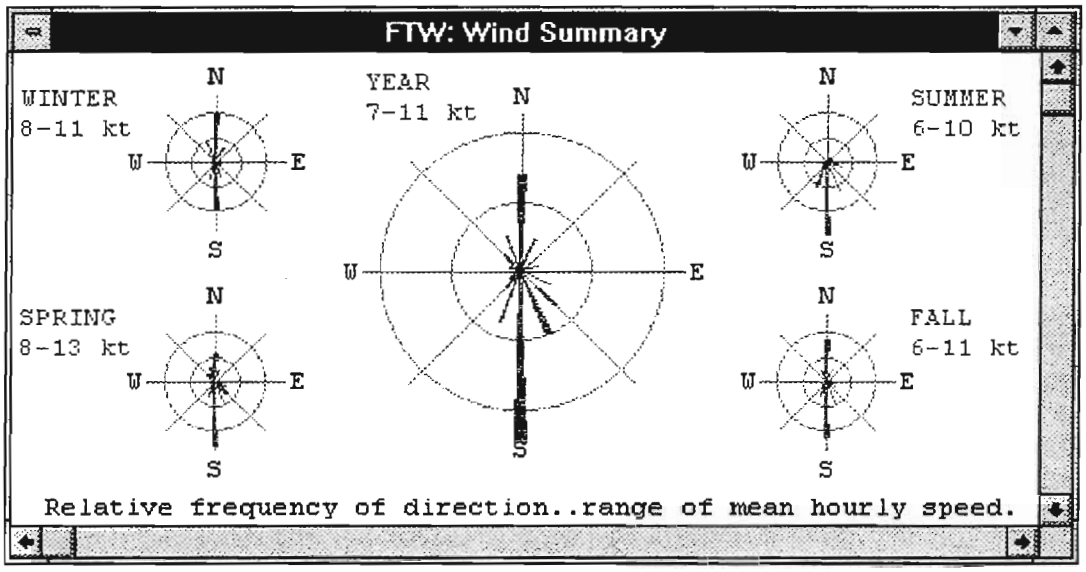


Figure 4. Wind Summary

For ease of viewing, the remaining climatological charts will be displayed on the following pages so that the descriptions and chart examples appear on the same page...

2. Wind (figures 5 & 6) -- These charts show the hourly and monthly distribution of wind speed (knots) in yellow. The frequency of sustained wind speed in excess of 20 knots is expressed as a percentage and is colored brown. A wind rose is also displayed. The graphics (and the other graphics that follow) have buttons that allow the user to quickly change months or toggle to or from the annual distribution.

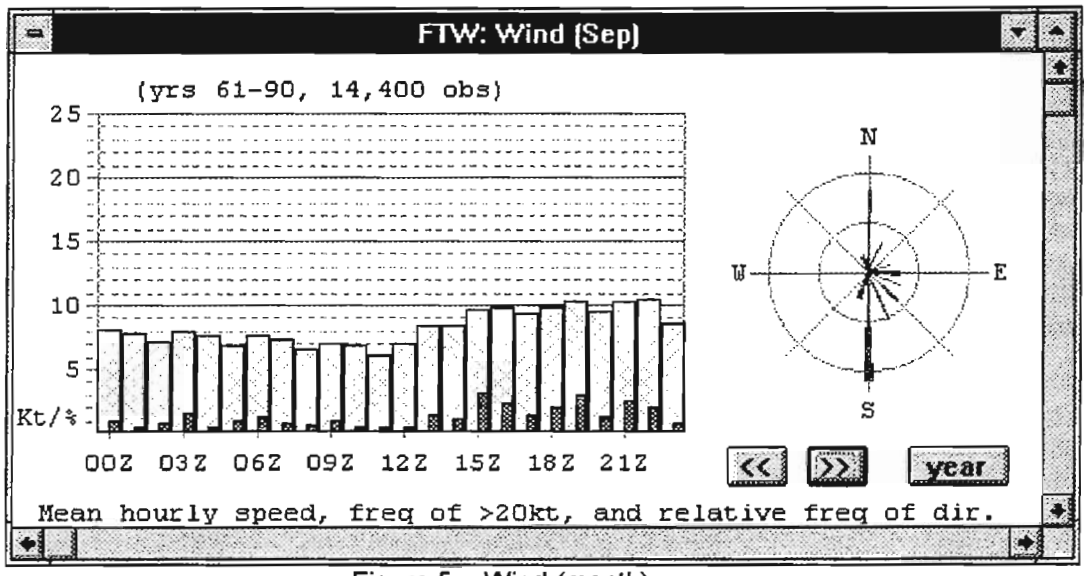


Figure 5. Wind (month)

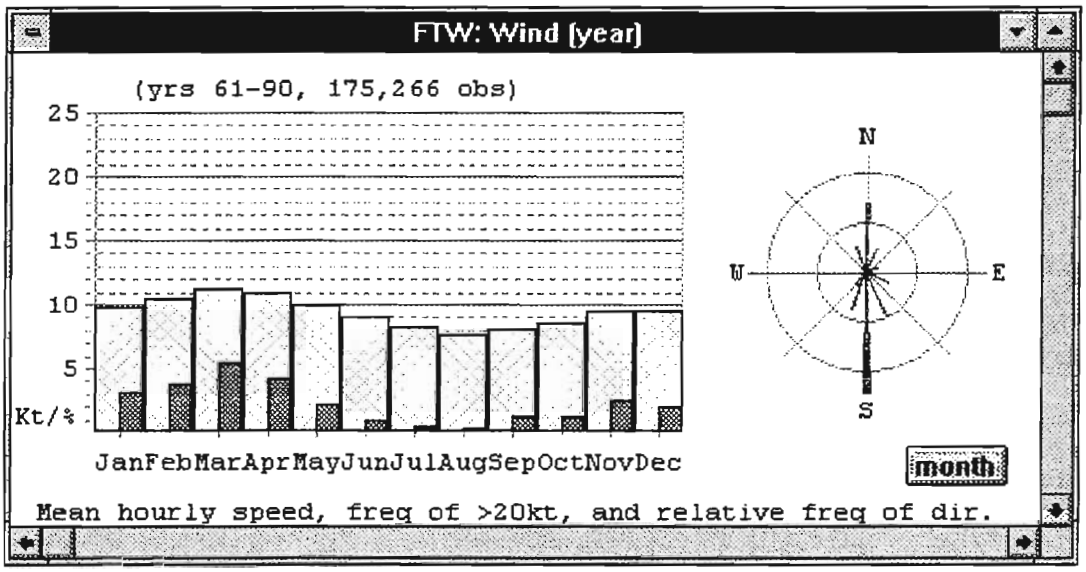


Figure 6. Wind (year)

3. IFR (figures 7 & 8) -- These charts show frequency distributions of IFR (instrument flight rule) events by hour and month. Each bar on the graph represents the sum of ceiling events (shown in blue) and visibility events (shown in yellow).

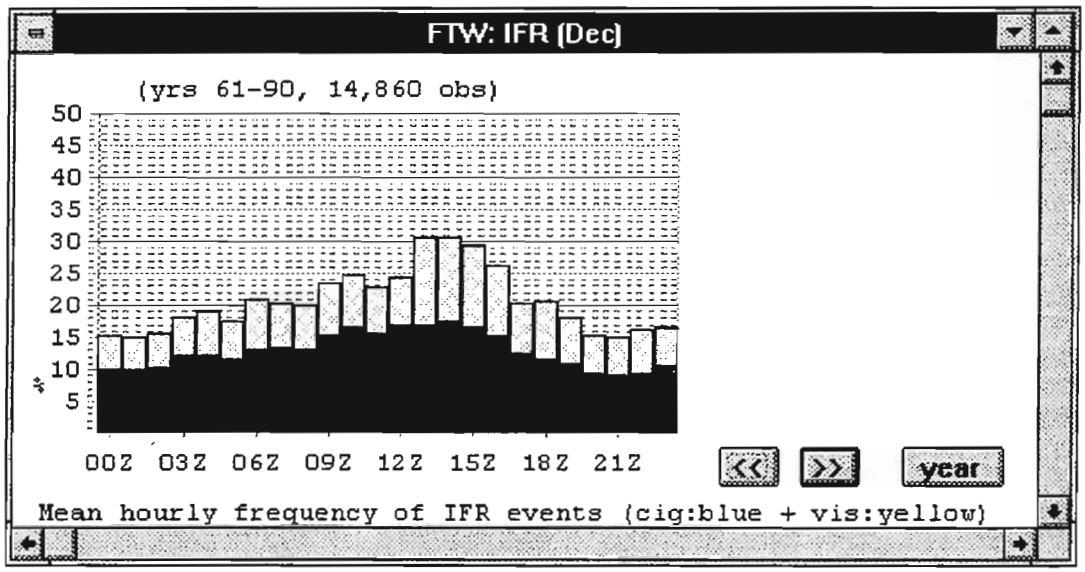


Figure 7. IFR (month)

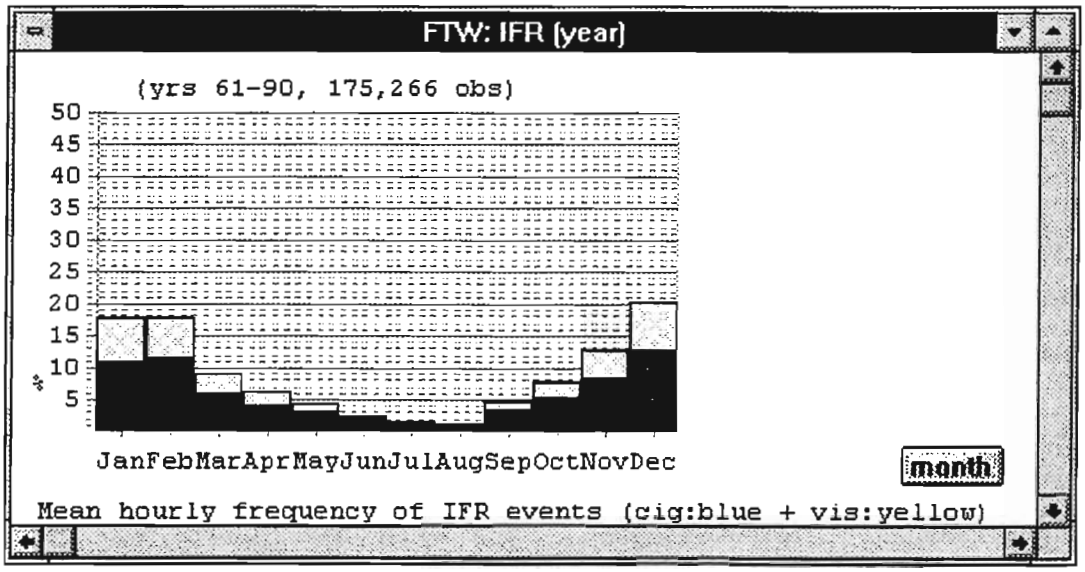


Figure 8. IFR (year)

4. Thunderstorms (figures 9 & 10) -- These charts show frequency distributions of thunderstorm events by hour and month. Each bar on the graph represents the percentage sum of non-severe and severe thunderstorm events that were reported on hourly observations during the period of record. Severe events are indicated in purple. The percentage frequency of hail events is also shown and is colored yellow. NOTE: Severe thunderstorm and hail events are comparatively rare and will therefore almost never appear in the monthly distribution for the year. Their absence on the chart should not be interpreted as no occurrence.

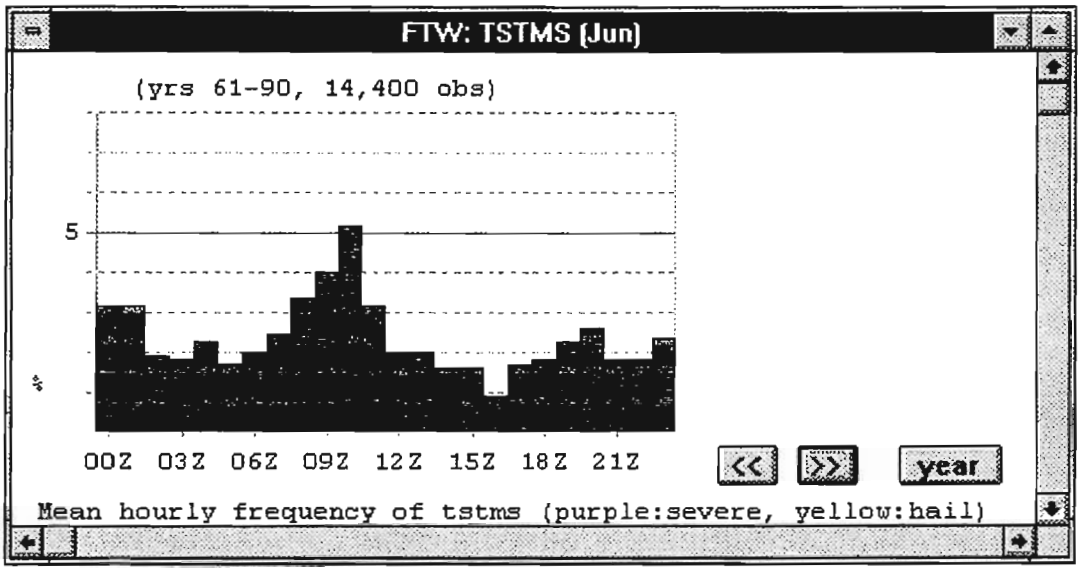


Figure 9. Thunderstorms (month)

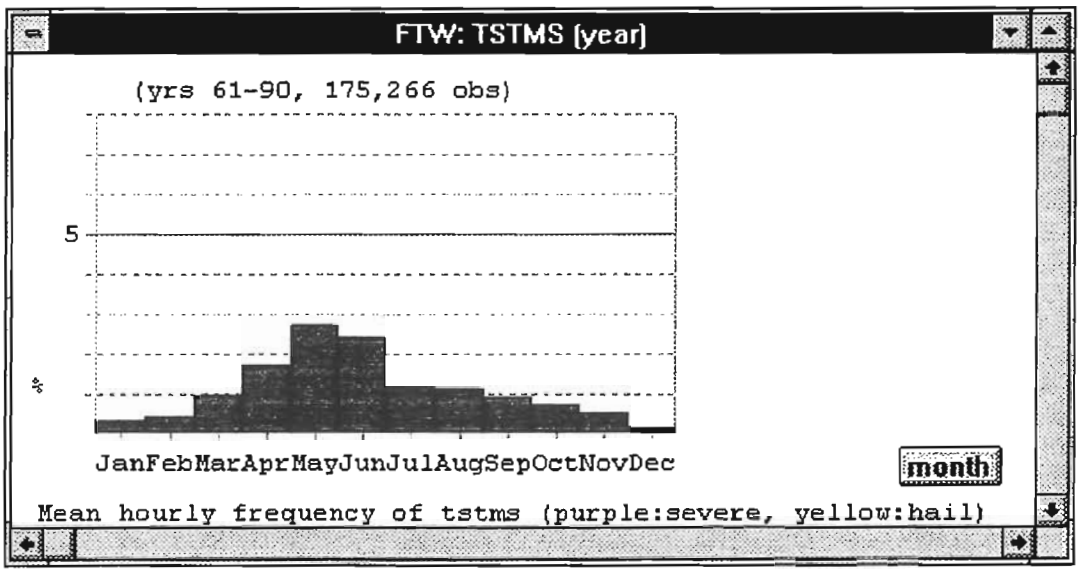


Figure 10. Thunderstorms (year)

5. Precipitation events (figures 11 & 12) -- These charts show the frequency distribution of precipitation events by hour and month. Each bar represents the sum of liquid (green) and frozen (purple) events. IMPORTANT: the distribution of precipitation events gives no indication whatsoever about precipitation amounts.

These charts also include frequency distributions of thunderstorm events in red. This allows viewing the association of precipitation events with thunderstorm events. If the difference in percentages is considerable, then a routine forecast that calls for thunderstorms may be inappropriate.

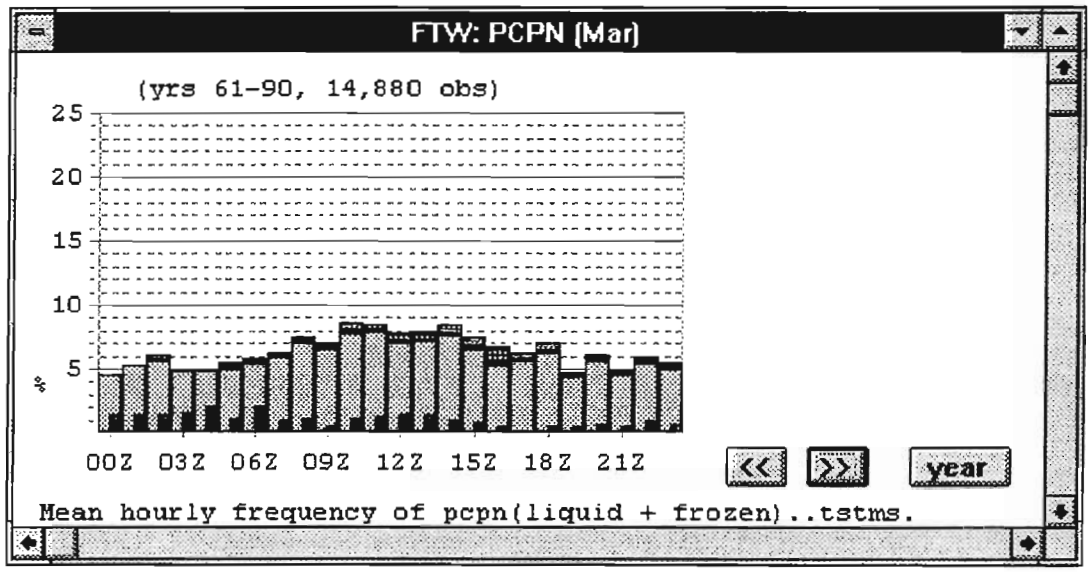


Figure 11. Precipitation occurrence (month)

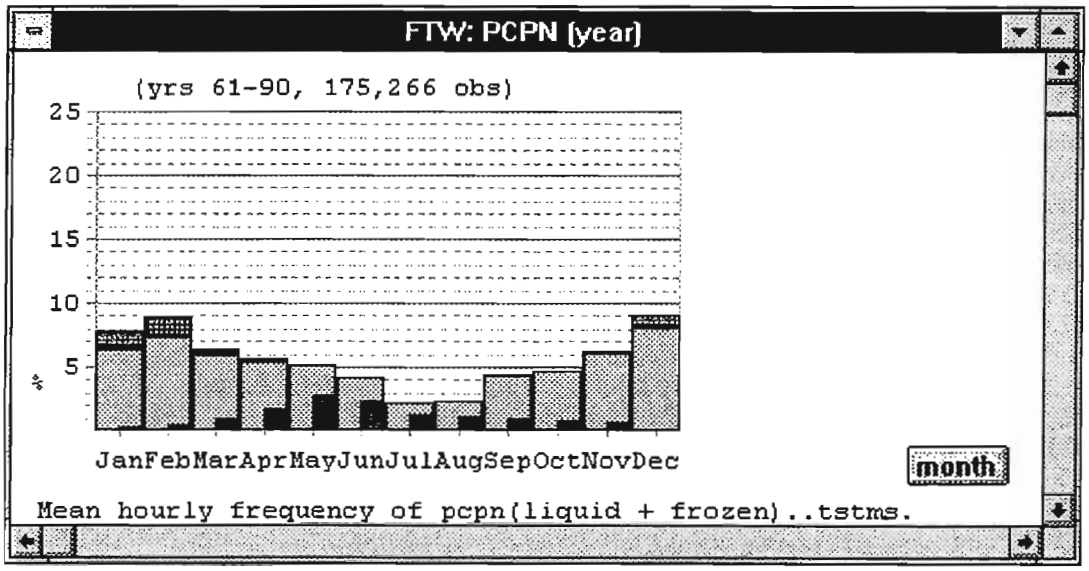


Figure 12. Precipitation occurrence (year)

6. Temperature/relative humidity (figures 13 & 14) -- These charts show the mean hourly or mean monthly temperature and relative humidity. NOTE: these graphs are based on hourly observations, so average daily maximum or minimum temperatures will be slightly different.

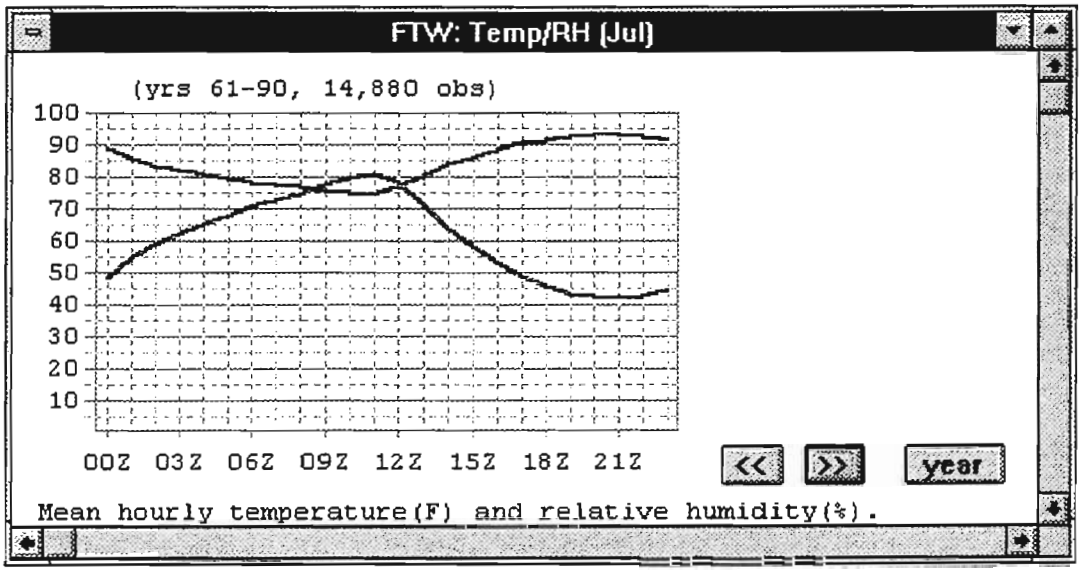


Figure 13. Temperature/relative humidity (month)

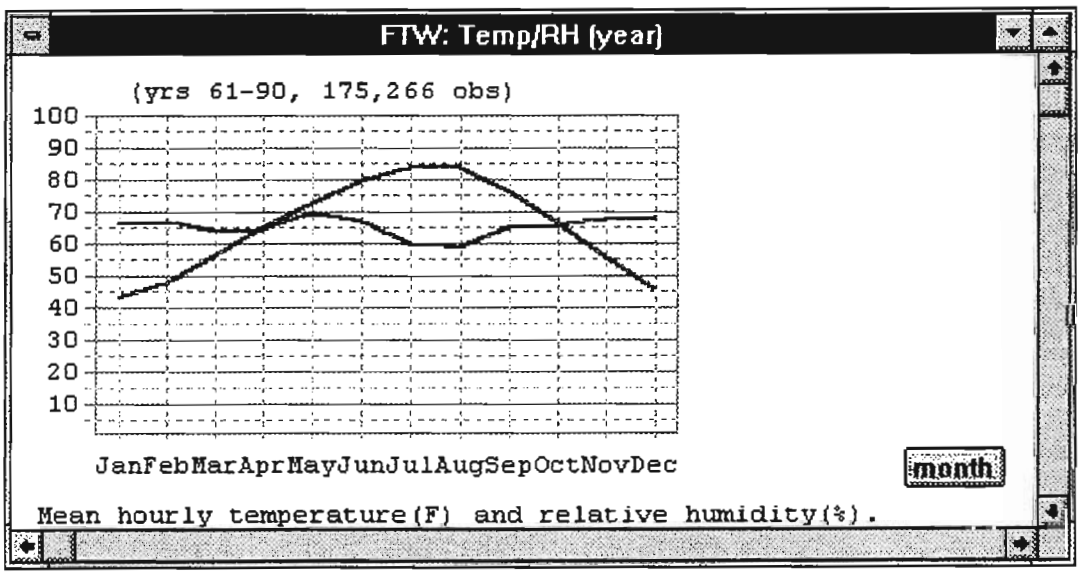


Figure 14. Temperature/relative humidity (year)

7. Opaque sky cover (figures 15 & 16) -- These charts show the mean hourly and monthly sky cover, expressed in tenths.

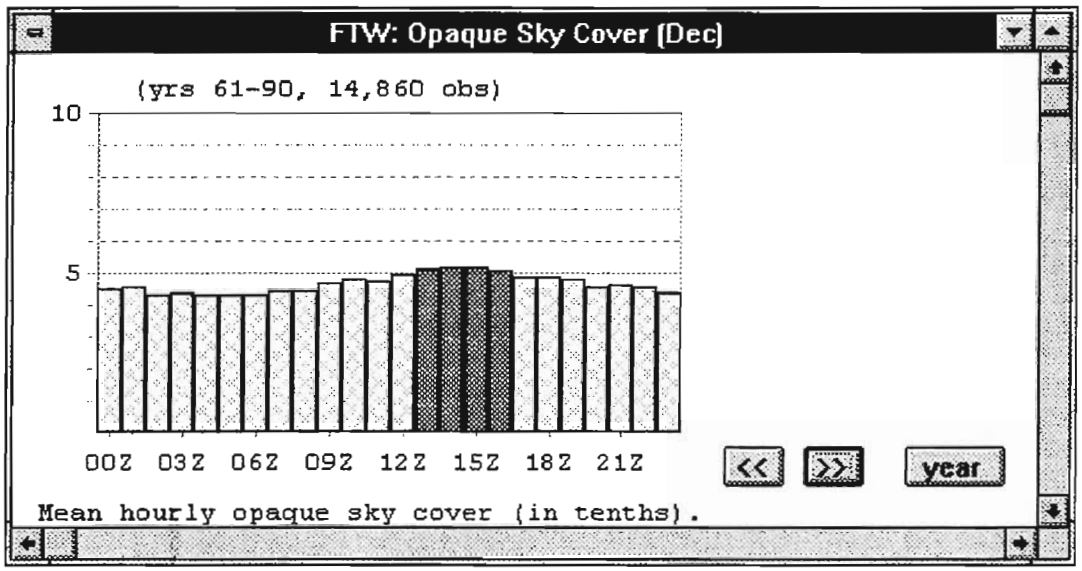


Figure 15. Opaque sky cover (month)

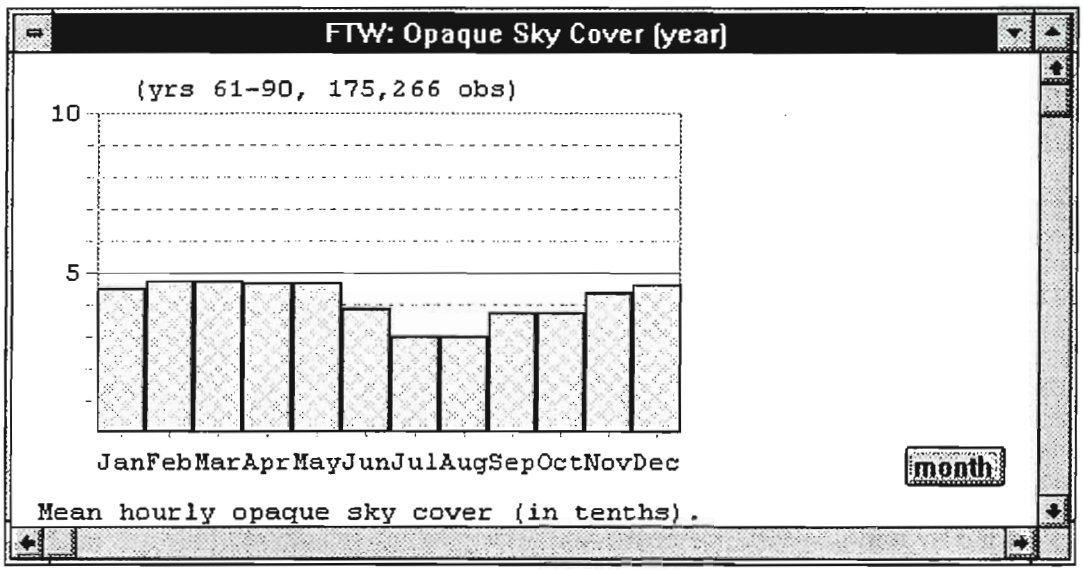


Figure 16. Opaque sky cover (year)

5. PROGRAM HARDWARE AND SOFTWARE REQUIREMENTS

PP-Tools requires a 386 (or higher) computer with 4 megabytes (mb) of random access memory, a hard disk, and a mouse. In order to create the local database, a CD-ROM drive is required. The hard drive must have more than 28 mb available for temporary storage of data extracted from the CD-ROM. The permanent storage requirements for the local database are just under 400 kilobytes per station. Permanent storage requirements for a 10-station database would therefore be less than 4 mb. A printer is optional.

The computer operating system must be capable of running Windows 3.1 applications. To produce the local database, the user must have access to the SAMSON (Solar and Meteorological Surface Observational Network) CD-ROM series. National Weather Service (NWS) regional offices have already made this CD-ROM data available to many NWS forecast offices. The data is also available from the National Climatic Data Center.

6. BUILDING THE PP-TOOLS DATABASE

The PP-Tools database is created by first using software on the SAMSON CD-ROM to extract up to 30 years of hourly climate data to the hard drive. This data extraction process typically takes about 10 minutes per station and creates a temporary data file on the hard disk of about 28 mb. Step-by-step instructions for this process are contained in the online help of PP-Tools.

The next step is to use PP-Tools to process the extracted data. Detailed instructions for this step are also contained in the online help. Processing the extracted data takes about one hour on a 486 computer, and the process creates two files: nnn.CIG and nnn.VIS. The combined size of the two files is less than 400 kilobytes. The 28 mb file can then be deleted. At this point the data is ready for use by PP-Tools.

7. CONCLUDING REMARKS

The PP-Tools program makes up to 30 years of aviation-related climate data available to the forecaster and can make a significant contribution to the terminal forecast process. The program is intended to supplement other forecast techniques, and the program's potential application is for all NWS forecasters, whether they be interns just learning the forecast process or forecasters with many years of experience.

REFERENCES

Bomar, George W., 1983: *Texas Weather*, University of Texas Press, 265 pp.

NOTE: Specific references on persistence probability were not available to the author. However, it is important to note that the PP-Tools program is based on the author's experience with persistence probability as used in the U.S. Air Force during the period 1969-1972.