HAWS

HOME AUTOMATIC WEATHER STATION

USERS MANUAL

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VAISALA

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If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: 'How to Identify and Resolve Radio-TV Interference Problems.' This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 004-000-00345-4.

Table of Contents

NOTE: Program Names Are Capitalized

Introduction

Welcome to the weatherful world of HAWS! With HAWS you have the opportunity to operate an accurate, reliable weather station in your own home. Both professional and amateur meteorologists will enjoy the easy to understand programs and the speed with which important weather information can be accessed.

HAWS contains high quality sensors identical to those weather services in over 60 countries depend on every day. These sensors measure temperatures from +140°F to −130°F with ±0.4°F accuracy. Relative humidity (RH) is measurable from 0% to 100% with ±3% RH accuracy. Atmospheric pressure is measurable from 1060 millibars (MB) to 3 MB with ±0.5 MB accuracy.

Obtaining weather values from HAWS requires nothing more than loading a tape or disk and pressing a few keys on your Commodore computer. HAWS, along with this manual, provides the required information for understanding, monitoring and forecasting daily, local weather.

Designed as a curriculum guide as well as a program guide, this manual is arranged to maximize the educational potential of your Home Automatic Weather Station. Reading each chapter will provide you with important information about the weather values which the HAWS programs investigate, but IT IS NOT NECESSARY TO READ THE ENTIRE MANUAL TO SUCCESSFULLY RUN ANY OF THE PROGRAMS. HAWS users who want to go directly to a program without reading the background material pertaining to it should refer to the Table of Contents where all of the program names are listed in capital letters.

Weather, the state of the atmosphere at any given time, is controlled by a large number of factors. Essential ingredients of weather are: temperature, barometric pressure, wind, humidity, cloud formation, and precipitation. All of the programs described in this manual were written to help you obtain information about these parameters quickly and easily.

- DISPLAY offers continuous readings of temperature, air pressure, humidity, and continuous calculations of dew point, updated every 15 seconds. This program offers immediate access to weather values along with the opportunity to see how these values can vary from minute to minute.

- COMFACTOR, which estimates our comfort under various warm weather and dew point temperatures, is based on how we judge weather conditions with our senses. Instead of giving us numerical weather values, this program offers practical advice for coping with heat and humidity.

- CLOUDALT estimates the altitude of cumulus clouds (the thick clouds which often give us precipitation) through usage of relative humidity, temperature and dew point values. Watch how cloud altitudes can change with different environmental conditions.

- CHILLFACTOR helps us estimate our outdoor comfort during cold weather by considering temperature and wind speed. Use this program as a guide to protecting yourself from danger during cold, windy weather.

- CALC is a fun program which uses the HAWSCULATOR to convert temperature and pressure values from English to metric, and vice versa. The HAWSCULATOR also calculates dew point from temperature and relative humidity values.

- TREND collects pressure, temperature, relative humidity, and dew point values on disk or tape from 1 to 36 hours. Recording these values over time is an excellent way to learn about and predict the weather.

- GRAPH analyzes and plots the information gathered in TREND. Weather values gathered by HAWS are plotted on a graph with the high, low, mean, and average of each graph given numerically. Four separate graphical displays, one each for pressure, temperature, relative humidity, and dewpoint, are provided.

- PRINT, for those with printers, organizes the data collected in TREND and offers it in detail on print outs.

- FORECAST uses information gathered from TREND or inputted manually to predict approaching weather.

"User Programming" offers ideas for creating your own weather programs. You can design programs which will calculate heating, cooling, and growing degree days. Frost forecasting is another program idea you can work on. More ideas for creating programs will occur to you as you become more familiar with HAWS.

Calculating and analyzing chillfactor, hourly and diurnal trends, dew point, and comfort factor data is easy for everyone in the family. Don't worry if you're not a math or computer genius! HAWS takes care of the figuring for you and no programming knowledge is necessary. If you enjoy doing some programming, however, the section on User Programming presents you with many opportunities for experimentation.

HAWS is an excellent tool for meteorology students. The programs are designed to offer information as well as chances to investigate the relationships between weather parameters. For example, the programs: COMFACTOR, CLOUDALT, and CHILLFACTOR can be used with values provided directly by the HAWS sensor. Alternatively, to see what happens when any of the pertinent values are different from the current readings, run the programs without using HAWS. Enter your own hypothetical values and watch how the weather picture changes.

There's more to HAWS than just providing information about weather values. The data you collect can be used to check the efficiency of heaters, air conditoners, humidifiers, and other environment-related equipment. By maintaining careful records with TREND, GRAPH, and PRINT, we will discover how variations in the atmosphere occur with the seasons, with location, and with each year. Gather information about specific locales and keep records of how local conditions fit in with regional activity.

This manual is not intended to be a guide to using your Commodore Vic 20 or 64 computer. Commodore users will have no difficulty operating any of the HAWS programs, but if you are uncertain about tape, disk, or printing procedures, see your Commodore manual.

Be sure to follow installation and operation directions carefully to ensure the most accurate readings.

You are ready to start your own home weather station. Good day. Or is it? You tell us.

Abbreviations Used In This Manual

A	average value	(GRAPH)	N	no	
A	abort	(TREND)	PI	pressure in inches of mercury	
C	Celsius		PM	pressure in millibars	
DC	dew point Celsius		R	re-run program	(GRAPH)
DF	dew point Fahrenheit		RET	return	
F	Fahrenheit		RH	relative humidity	
H	high value	(GRAPH)	S	stop program	
L	low value	(GRAPH)	TC	temperature in Celsius	
M	median value	(GRAPH)	TF	temperature in Fahrenheit	
MB	millibars		Y	Yes	

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What's A HAWS Anyway?

Established in Helsinki, Finland in 1936 by Professor Vilho Vaisala, Vaisala develops and manufactures solutions for measurement problems in meteorology, environmental sciences, and industry.

The HAWS unit contains the same temperature, pressure, and humidity sensors as the Vaisala Radiosondes. These radiosondes are used by professional meteorologists in over 60 countries to obtain information about the upper atmosphere. Your Home Automatic Weather Station is not intended for gathering information at high altitudes, but for acquiring precise readings of local weather values. Below is a brief explanation of radiosondes for those of you who want to better understand the origin and potential of HAWS's sensors.

Radiosondes are small so that they can be carried aloft by gas-filled balloons. The devices are often carried 15 to 20 miles (24 to 32 kilometers) in altitude. While a balloon is aloft the radiosonde's sensors measure temperature, humidity, and air pressure. This information is transmitted to a receiving station on the ground by a miniature radio station in the radiosonde. By the time the radiosonde floats back to earth, weather stations are already using its readings in their reports.

Vilho Vaisala developed special-purpose capacitive transducers that are ideal for his unique radiosondes. Continuous research and development have brought Vaisala's radiosondes to new levels of accuracy for atmospheric measurement. Now we can all use Vaisala's instruments to obtain essential weather information. Vaisala is able to offer their sensors to HAWS users after years of technological advances which have made it possible to produce inexpensive, but excellent quality sensors.

Instrument Installation and Location

The HAWS unit should be positioned according to these instructions to ensure its accuracy and longevity.

HAWS can be placed indoors or outdoors. There are, however, several factors to consider when positioning the unit.

Indoors
If the unit is to be placed in a room with poor ventilation (where there is no noticeable air movement) it should be positioned with the probe tube facing down. The cover can be turned so that the connecting cable comes out on the same side as the probe. If there is no danger of anything touching the sensors, the protector tube can be removed with a twist and a pull.

Outdoors
HAWS will not give accurate readings if it is placed so that direct sunlight or heat from adjacent structures may influence it. The best outdoor location for HAWS is on the north side of a building, about two meters from the ground. It should hang horizontally with the probe tube's ventilation louvers on the underside. If it is not possible for the unit to be placed on the north side of the building, place it in the shadiest location possible.

While HAWS is made to withstand outdoor weather conditons, we recommend that you prevent precipitation from falling directly on the unit. Remember, however, that any rain protection device must be properly ventilated.

Never place the unit on a roof or in any other place where lightning can damage it. HAWS does not have overvoltage suppressors so it is a good idea to unplug it when there is a threat of an electrical storm. This precaution protects your computer from damage even when the unit has been carefully placed to avoid electrical discharge.

Each unit is accompanied by a mounting bracket and necessary mounting hardware. An installation diagram is provided along with the mounting bracket hardware. Be sure to follow the instructions provided in this diagram.

Extra Cable
A five meter (15 foot) cable is attached to HAWS. Any cable added to the original five meters may interfere with the performance of the unit and is not guaranteed by HAWS manufacturer. The capacitive attenuation of the longer cable can dull the sharp pulses it carries, and it may cause false inputs to the computer by picking up transients.

In low electronic noise environments cable lengths up to 15 meters (45 feet) have worked successfully. If you are going to add cable, use 9 wire, 9 x 0.22MM cable and join it at the connector end. Do not mix wires. Mixing wires may cause serious damage to HAWS and to your computer. If you do not have experience with this type of work, or if you do not have the necessary tools to do the job properly, let a professional electronics technician add the cable for you.

Connecting HAWS To Your Computer
There is a card edge connector on the end of the unit's cable which should only be inserted or removed from the USER PORT of your Commodore computer when the computer's power is OFF. Do not force the card edge connector into the USER PORT; it is keyed so that it fits into the port one way. If you have trouble plugging it in, turn it over and try again.

Using HAWS Unit For Both VIC 20 and Commodore 64
While different software is required to run HAWS on the VIC 20 and Commodore 64, the HAWS sensor is directly compatible with both. A "jumper" connector located on the circuit board inside the HAWS unit lets you run HAWS on either computer.

This "jumper" connector is set at the factory to allow you to run HAWS on the computer you specified. YOU ONLY HAVE TO TOUCH THIS "JUMPER" IF YOU WISH TO CONNECT HAWS FROM ONE COMMODORE COMPUTER TO THE OTHER.

To change the position of the "jumper" connector, carefully open the cover of your HAWS unit. Note that there is a flat cable connecting the cover and the box. Open the cover carefully so that you don't break that cable.

In the cover is a circuit board which is functioning as an interface between your computer and the HAWS sensors. Near the soldering terminals of the unit's cable is a small gray rectangular shaped plastic "jumper" on a brown stand. When using HAWS with VIC 20, this "jumper" must be next to the yellow wire terminal and next to the white wire terminal when using HAWS with a Commodore 64.

When changing "jumper" position, carefully remove the "jumper" with a pair of thin-nose pliers and re-insert it over the other two pins on that stand. Make sure that the cable from HAWS to the computer is not connected to your computer while switching the "jumper".

Keep This in Mind

Fasten "Constants" Label Here

Loading The HAWS Program
HAWS is the first of ten programs provided on tape and on the disk menu. It is a machine language program that allows data from the HAWS sensor to enter computer memory and be available for use with all the other programs and with programs written by the user. IT MUST BE LOADED FIRST, AFTER TURNING ON YOUR COMPUTER.

After you have loaded HAWS, you will be given the following choice:

1. LOAD CONSTANTS
2. LOAD HAWS
3. EDIT CONSTANTS (Commodore 64 only)

Each individual HAWS sensor has unique calibration constants that need to be loaded into memory the first time you use your HAWS unit. These constants are provided on a label which accompanies your HAWS unit. For safe keeping, fasten this label on this page in the space provided.

To load the constants: 1 RET. The constants appear individually in the order they appear on your list. Note that all constants on your list do not have to be entered into the computer. ENTER ONLY THOSE ASKED FOR. After entering each constant, press RET. If you make a mistake in entering any of the constants, do not worry. When the final constant has been entered and RET is pressed, the complete list is displayed. "Constants OK?" is on the screen. If you want the list to be accepted: Y and RET. If you need to make one or more corrections: N and RET. "Which One?" appears. Type the constant you wish to correct.

Example:

"Which One?"

Type: D1 RET

D1?

Type: the correct digits and RET

"Constants OK?" continues to appear until Y is typed.

For Tape Users . . . At this point you will be asked to save the constants on the program tape. Follow the instructions which are given on the screen. The constants are recorded on Side 2 of your tape. When the red HAWS flag appears on the screen, flip the tape back over to Side 1 to use the programs.

For Disk Users . . . To save the constants to the disk just press Y and RET once the complete list has been entered. When the red HAWS flag appears on the computer screen, you are ready to load a program. You can avoid accidentally writing over programs by putting a write protect tab on your program disk once the constants are saved to it. The tabs are short, adhesive strips. To protect a disk, place a tab over the square notch on the edge of the disk so that it is covered on the front and the back of the disk. As long as a tab is in place no data can be stored on the disk.

You will have to load and save the constants only once. In each subsequent session with HAWS you will choose option 2.

When you load HAWS by choosing option 2, a red HAWS flag is displayed in the lower left corner of the computer screen. This flag indicates that HAWS is installed. By installed we mean that the machine language program is loaded into the computer controlling the unit. HAWS must be installed for you to obtain its readings.

For Commodore 64 Users . . . Option 3 is available for editing constants that were entered previously. Type 3 and RET. The constants in memory are listed on the screen and correct values can be entered by following instructions on the screen.

HAWS programs offer opportunities for meteorology students to experiment with weather parameters. RUN a program and it asks if you want to use HAWS. "Yes" indicates that you want weather values to be supplied by the HAWS sensor. "No" indicates that you want to insert your own values into the program. By experimenting with weather parameters you will soon recognize how and why the weather changes.

A Few Last Points

- For disk users, LOAD "MENU", 8 must be typed to gain access to the programs. Bring the menu arrow parallel to the program you want to run by pressing the cursor down key. When the cursor is pointing to the desired program, press RET.
- To stop a program type S.
- To re-run a program without reloading it, press the space bar.
- HAWS software will only work on unexpanded Vic 20 or Commodore 64 machines.
- Remember that shutting your computer off while the program disk is in the disk drive may damage the disk. Shutting the disk drive off while the disk is in may also cause damage to the disk.

- Never attempt to adjust the HAWS unit so that its readings agree with a thermometer, barometer, or hygrometer. If HAWS's readings disagree with your other weather instruments, HAWS is probably correct. Atmospheric pressure varies with altitude, so in a two story building there is less pressure upstairs than downstairs (about 3 MB). HAWS pressure readings are actual barometric values at the location of the sensor, and are not adjusted to sea level.

- If you turn the computer power switch off while the HAWS sensor is plugged into the User Port, wait at least 30 seconds before turning the computer power switch back on. Otherwise, the first 15 to 20 pressure readings from the HAWS sensor after turning the computer back on may be inaccurate.

- When using the TREND program to collect and store data, it is a good idea to first run the DISPLAY program to check that the HAWS sensor and computer system are properly functioning. This precaution assures you that the time you invest in running TREND will result in the collection of high quality data.

Display

The DISPLAY program gives us information about four important weather parameters: temperature, atmospheric pressure, relative humidity, and dew point. The chapters immediately following this one explain these weather values in detail. To obtain readings of these values from HAWS's sensors:

RUN the DISPLAY program.

Enter the time in hours and minutes.

Example:

HR,MIN?

2,05 RET

Now, is it AM or PM?

1. AM 2. PM

Enter the number of the appropriate response and RET.

Scrolling around the border of the screen indicates that the unit is taking readings from its sensors. The scrolling usually begins a few seconds after the AM or PM is entered.

The current time appears along with the four weather parameters. Temperature and dew point are displayed in both Celsius and Fahrenheit. Air pressure readings are given in both inches of mercury and in millibars.

If HAWS detects changes in any of the four weather parameters while the DISPLAY program is running, the name of the parameter which has changed will inverse.

This program continues to display parameters indefinitely.

What's the Temperature?

All weather parameters are important, but few constantly affect our lives as powerfully as temperature. Our clothing, our housing, even our lifestyles reflect the influences of temperature. Many of us, however, confuse heat and temperature. Heat is a form of energy caused by molecular motion. Outdoor temperature is a unit measure of heat which varies with the amount of solar energy received at a location. Temperature is usually highest between 2 p.m. and 5 p.m. Once the maximum temperature is reached, cooling occurs rapidly until about 8 p.m. to 10 p.m. Daily minimum temperature occurs around sunrise.

Other strong influences on temperature include topography, altitude, and seasonal variations. Areas near large bodies of water usually experience fewer, and less dramatic, temperature changes than drier areas because water does not absorb or radiate energy as well as land. Unvegetated areas experience greater temperature variations than land with vegetation.

Temperature values change with altitude because the atmosphere gets colder farther away from earth. Since precipitation originates in clouds where temperature is lower than at ground level, it is possible to have snow or freezing rain when ground level temperatures are above freezing (32°F).

As air rises in the troposphere, its temperature usually decreases about 60°F per 1,000 feet of rising altitude. The decrease in temperature with rising altitude is referred to as the lapse rate. There are cases of temperature increasing with altitude, called inversions of lapse rate, or just inversions. Ideal conditions for inversions are cool, clear, mildly breezy nights when the ground radiates and loses heat more quickly than the air over it. On these nights air near the ground cools quickly while air several hundred feet up stays much the same.

HAWS expresses temperature in two scales; degrees Celsius (C), and degrees Fahrenheit (F). All HAWS program give temperature readings in both scales. To convert temperature measurements, see the HAWSCULATOR in the CALC program. To obtain current temperature readings at any time, run DISPLAY.

There are several excellent programs to help us observe temperature. TREND gathers temperature values for up to 36 hours at a time. GRAPH displays the gathered information for close analysis. For those with printers, PRINT offers all the collected data in detail.

Tons of Air and Lots of Pressure

Have you ever thought of yourself as living under a vast sea of air? We usually think of ourselves as living on top of the earth, not at the bottom of the atmosphere. We feel the solid earth below us and for some reason we consider the air above us to be weightless. Covering the circumference of the earth and reaching hundreds of miles above it, the atmosphere is actually 5 billion million tons of air circulating relative to the earth's surface. The air is divided into two main regions; lower (troposphere) and upper (stratosphere). Development of storms, fronts, and air masses, along with the mixing of air take place in the troposphere.

At sea level the atmosphere contains approximately 78 percent nitrogen, 21 percent oxygen, and one percent argon. Small quantities of carbon dioxide, helium, neon and krypton also move about us in the air. All weather processes occur within the atmosphere, therefore, they are all dependent on the gases listed above. Water vapor, dust particles, smoke, and salt from the sea are also in the atmosphere.

Air molecules move quickly and draw away from each other when they are heated; thus, heated air expands, its density decreases, and it rises above the cooler air around it. This perpetual process of warm air rising is one of the factors which causes weather to be in constant motion.

Air is also easily compressed. The air closest to the earth's surface is packed most densely because it is being compressed by the air above. When air is pushed down, however, it has a tendency to push back. This tendency to fight compression creates air pressure. Increased compression brings increased pressure. The pressure is not usually noticed by us because our bodies equalize external and internal pressure.

Pressure is expressed in several ways. "Inches of mercury" and "millimeters of mercury" are common scales of pressure measurement. "Pounds per square inch" reflects the understanding that pressure is a force per unit area, with one millibar being a force of 1,000 dynes per square centimeter. Standard sea level pressure is 14.7 pounds per square inch, 29.92 inches of mercury, 760 millimeters of mercury, or 1013.25 millibars. To convert pressure in inches of mercury to pressure in millibars, or vice versa, use the HAWSCULATOR in the CALC program.

Air pressure varies greatly with altitude. Packed down by all the air above the earth's surface, air around us is quite dense. As we ascend in the atmosphere, air becomes less compressed and pressure is reduced. Less compressed air also expands and cools as it converts its energy into energy of expansion. There is much less air pressure on the roof of a skyscraper than on the ground floor.

Air pressure will vary at any location when atmospheric disturbances occur. Such variations are usually limited to one pound per square inch, or less.

Momentary surface pressure is not a reliable indicator of the weather. Changes in pressure are one of the key indicators of what the weather has in store for us. These changes are created by differences in temperature and humidity (air moisture) within an air mass. When air masses with higher pressure move in, they usually bring good weather, while those with lower pressure may indicate poor conditions. Low pressure areas can contain powerful upcurrents and strong winds which often carry destructive storms. The lowest pressures with the fastest falls bring the most violent weather conditions. Moderately low pressure which falls slowly may bring tall clouds, but they do not always give precipitation.

Air pressure is read by HAWS and available to us through the DISPLAY program. By running DISPLAY we can find out what the air pressure is in millibars and in inches.

When barometric pressure is reduced to sea level, typical high pressure systems might be represented by 1024 MB or 30.25 PI. A typical low pressure system, or, storm, might be represented by 989 MB or 29.20 PI.

Barometric pressure rarely rises or falls by as much as one inch (33.864 millibars). When it does change that much, watch for a storm. More often than a sudden drop in barometric pressure, you will see a steady fall, which indicates a storm and that a low is developing. To analyze air pressure changes over an extended period of time, see TREND, GRAPH, and PRINT.

There is a daily (diurnal) variation of pressure due to the alternate heating and cooling of the atmosphere. The diurnal variation is small, about 1.5 MB from maximum to minimum every 24 hours. The other variation in pressure is caused by the passage of large pressure systems.

What's Relative About Humidity?

Relative Humidity (RH) simply tells us what percentage of the air is filled with water vapor at the current temperature. It does not tell us the absolute amount of water vapor in the air (absolute humidity). This may be easier to understand by considering a glass which is 25% full of liquid. The relative amount of liquid is obvious, but not the actual amount in ounces. If the relative humidity is 25%, we know that the air is filled to 25% of its holding capacity, but the actual amount of water vapor in the air is not specified.

Energy is required to evaporate water and hold it in vapor form. When the air is warm, there is more energy present, and the air is capable of evaporating and holding more moisture. As temperature decreases, the amount of water vapor the air can hold also decreases.

High temperatures accompanied by high relative humidity means sticky, uncomfortable weather. If the relative humidity is 75% to 80% on a summer day, many of us will feel uncomfortable and will want relief from the mugginess. On a winter day when the relative humidity is at this same level, however, the air will feel much drier.

Relative humidity varies greatly on a daily (diurnal) basis. A general rule to remember is that during the warmest part of the day relative humidity will be lowest (excluding days when there is precipitation).

To discover how we can estimate our comfort under various humidity and temperature conditions, see COMFACTOR.

Relative humidity is also given in DISPLAY and CLOUDALT. CALC uses relative humidity to find dew point. TREND also collects relative humidity information to be analyzed in GRAPH and PRINT.

A Few Points About Dew Point

The temperature at which a parcel of air becomes saturated (reaches 100% relative humidity) is the dew point. This is also the point at which condensation begins. From this information we can tell that dew point is directly related to the amount of water vapor in the air. When compared with the temperature of free air, the dew point temperature can be used to determine humidity conditions. Dew point temperature is also used in empirical formulas to discover cloud altitude, as well as when dew, frost, fog, or precipitation will appear.

The greater the difference between the current temperature and the dew point temperature of a particular air mass, the drier the air mass is. The closer the two temperatures are, the more likely it is that condensation will occur. We refer to the difference between the current temperature and the dew point as the spread. Relative humidity increases as the spread decreases. When temperature and dew point are the same, the relative humidity is 100%. If the dew point is above 60°F, the humidity is generally uncomfortable.

Air does not radiate heat as well as solid surfaces or as well as the earth; thus, solid surfaces and the earth cool faster than the air (especially at night). When air meets these surfaces, some of its energy is lost and the air cools. Dew often collects on objects during the night when they cool below the dew point, just as water droplets collect on a pitcher of ice water. Heavy dew collects on vegetation but usually does not appear on concrete or large solid objects because they gather great amounts of heat during the day and lose it slowly after sunset. Extreme temperatures are required for dew to gather on streets or houses.

Dew point is one of the four weather parameters which are automatically given in the DISPLAY program. With the HAWSCULATOR in the CALC program, it is easy to calculate dew point temperature by entering temperature and relative humidity values.

The COMFACTOR program uses dew point temperature and free air temperature to find what percentage of the average public will be uncomfortable in daily humidity conditions. HAWS also uses dew point in figuring the altitude of low clouds with the CLOUDALT program.

COMFACTOR

High temperatures accompanied by high humidity values can make most of us uncomfortable. COMFACTOR helps us predict if we will be comfortable outdoors during the hot weather by considering the dew point and the temperature on a Discomfort Index (DI). To understand the Discomfort Index, see Chart One.

The Discomfort Index is a good reference for judging comfort, but it may underestimate discomfort for strenuous physical activity during hot weather. When the temperature and humidity are high, be sure to use common sense in limiting activities.

Most of us experience less discomfort from heat or cold once we are exposed to it for a while. A person who is uncomfortable when the temperature first climbs to 90°F in the warm season will gradually become more comfortable in the heat as the season continues. As we gain more exposure to heat or cold we undergo actual physical changes which decrease the strain that excessive temperatures produce.

The COMFACTOR program will provide us with estimates of our comfort when temperatures are above 60°F.

Run the COMFACTOR program

YES, Use HAWS

The HAWS flag appears in the lower left corner of the screen to let you know that the HAWS machine language program is installed and that the HAWS data is available.

These readings are displayed on the screen:

Temp °F

Temp °C

Dewpt °F

Dewpt °C

RelHum %

A Discomfort statement based on these readings is also displayed on the screen. (See Chart One).

We can best discover how temperature and relative humidity affect dew point and comfort by entering our own values into the COMFACTOR program. Just enter N when asked if you want to use HAWS. Enter various combinations of temperature and relative humidity values. Notice that by pressing RET before entering your own temperature values, you can choose between using Celsius or Fahrenheit measurements.

Chart One: Discomfort Index

Discomfort Index Value	Description
0-70	Little or no discomfort
71-75	About 50% of us are uncomfortable
76-83	About 80% of us are uncomfortable
83-84	Danger for small children, those in poor health, and those unaccustomed to high heat and/or humidity
85-above	Danger Zone - almost everyone is uncomfortable

Cloud Altitude

When air cools and becomes saturated, condensation or sublimation (the transformance of water vapor to ice or ice to water vapor) triggers the development of clouds. Made of tiny droplets of water and/or ice crystals, clouds are supported by rising currents of air. Precipitation results when drops of water and/or ice crystals combine and grow. This growth of precipitation ingredients is speeded up when upward currents are involved. Light to moderate precipitation occurs when updrafts are mild. Stronger updrafts can support heavier, towering clouds which give us the greatest amounts of precipitation. These heavier clouds are usually 4,000 feet thick or thicker.

When air masses are unstable and ground level air is rising, the rising air will cool at a rate of 9.8°C per kilometer. This equals 5.5°F per 1000 feet of altitude. The dew point temperature decreases with the rising air at a rate of 1.7°C per kilometer (1.0°F per 1000 feet). When the rising air's temperature has cooled to the dropping dew point temperature, clouds will form at that altitude.

There are three basic types of cloud formations: high (at 16,500 to 45,000 feet), middle (6,500 to 16,500 feet), and low (ground level to 6,500 feet). Each type of cloud has its own altitude, its own purpose, its own anatomy, and its own name.

High Clouds
Cirrus, cirrocumulus, and cirrostratus are high clouds. Thunderstorm clouds are included in this high group, reaching altitudes of 40,000 feet or higher. Cirrus clouds, predominantly composed of ice crystals, are feathery and delicate in appearance. Because of their high altitudes, they often reflect hues of yellow and red before sunrise and after sunset. Wisps of cirrus are often called mares' tails.

Cirrocumulus look like lines, ripples, or small, white flakes. These relatively rare clouds are composed of supercooled water droplets or tiny ice crystals, or combinations of both.

Cirrostratus, which give the sky a milky appearance, are quite thin. They sometimes create a halo effect around the sun or the moon.

Middle Clouds
Altocumulus, altostratus, and nimbostratus are middle clouds. Altocumulus are layers or patches of solid cloud. Sometimes they appear as globules with dark shading.

Altostratus appear as veils of dark blue or gray. We can often see the sun or the moon through these thin clouds, but without the halo effect of the cirrostratus.

Nimbostratus are rainy, gray or dark, massive formations which often blot the sun out. Composed of suspended water droplets and falling raindrops or snowflakes,

nimbostratus produce continuous precipitation. They do not, however, produce hail, thunder, or lightning.

Low Clouds

Stratocumulus, stratus, cumulus and cumulonimbus are the low clouds. Stratocumulus look like patches or layers of flakes, or like globular masses. Usually made of small water droplets, they may produce hail and occasionally they will bring us snow. Stratus clouds look like fog but do not meet the ground. Tiny water droplets make up these uniform clouds.

Cumulus clouds, the most recognized formations, are thick and tall with horizontal bases and dome-like tops. Cumulus will grow as long as the air above them is not sinking at the same time it's warming. The rising air flow must also be moist. Cumulus reach their greatest depths in the early afternoon when surface air temperature is at its high. As the temperature cools, cumulus dissolve. Sparse cumulus indicate dry weather. Abundant cumulus indicate the possibility of showers.

Cumulonimbus have great vertical development and appear as heavy masses, mountains or towers. They can produce rain, lightning, thunder, snow, and hail. Cumulonimbus sometimes have ragged stratus clouds hanging below them.

CLOUDALT estimates the altitude of the base of cumulus clouds (up to 6,500 feet) by using ground level temperature and relative humidity values and the concept that cloud formation begins when rising air is cooled to its dew point value. To use CLOUDALT, run the program:

Yes, use HAWS

Temperature in degrees Fahrenheit and in degrees Celsius, dew point in Fahrenheit and Celsius, and Relative humidity will be given. Also on the screen we will see cloud altitude in kilometers and in feet.

You can run CLOUDALT using your own temperature and relative humidity values. Just press N when asked if you want to use HAWS. Enter any values of temperature and relative humidity. Remember, press RET before entering temperature values to choose between Celsius and Fahrenheit.

Fronts

Meteorologists watch the sky for cloud formations which indicate approaching cold or warm fronts. Fronts are zones separating air masses of differing character. Often called transition zones or boundary surfaces, they are usually narrow areas (50 to 500 miles wide) in which weather change is apparent. They are especially important in marking boundaries of air masses with differing temperatures.

Circulation brings differing air masses together, but the masses do not mix freely. The warmer air lies above the colder air and they form a mass that resembles a wedge. The layers of air do not just lie on top of each other; they press against each other in an attempt to reach equilibrium.

Developing fronts often serve as indicators of precipitation and condensation. As warm air is lifted over a front, precipitation or condensation will occur according to the stability of the air. When the air is unstable, massive clouds and heavy rain will result from the warm air's movement. When the air is stable, flat clouds and light rain will develop.

Cirrus clouds often tell us that a warm front is about one thousand kilometers away. As the front draws closer and the warm air is closer to the ground, the cirrus clouds become stratus clouds. When a warm front is approximately 480 kilometers away precipitation will usually fall. If no precipitation results at that point, cumulus clouds will generally appear.

A cold front occurs when cooler air pushes warmer air up. The warm air rises in a very steep slope and cools quickly. We are often surprised by how rapidly cold fronts replace warm air. When these fronts move quickly into moist air, heavy rain will fall for a short time and the wind will be gusty. The wind will then shift quickly and blow in cold air. The temperature will fall and the pressure will rise. Humidity is lowered as the cold front passes. Slowly moving cold fronts displace stable, warm air and bring gradual weather changes.

As we discussed in "Tons of Air and Lots of Pressure", cold air is denser and heavier than warm air and stays closer to the ground. Warm air bumping into cold air rises over the cold air; as this occurs the cold air slips below the warm air. The boundary between the two masses lies at an angle with the ground which becomes steeper with increasing altitude. Warm air climbs up the angle and often reaches tremendous heights. This rising of air over a front is referred to as frontal lifting.

Fog is a ground cloud of water droplets or ice crystals. Although fog can develop anywhere, it generally develops in coastal areas where moisture is plentiful. Fog forms when low air is cooled to its dew point, or when moisture accumulates in the air near the ground.

Weather observers look for several types of information about clouds: altitude, classification, direction, speed, and area of sky covered. This information is used to judge where air masses are, where they are going, and how they will affect the weather.

Air Masses

We've often heard weather forecasters telling us about approaching air masses; "A tropical air mass continues to bring hot humid air into our region," "A mass of arctic air will keep the cold air with us for at least another day." We listen and dress accordingly, but most of us don't understand what an air mass is.

A large body of air with approximately the same temperature, pressure, and humidity throughout is referred to as an air mass. Air masses can be thousands of square miles and have great depth. They are usually formed over large, uniform areas of land or water which have light wind movement. Source regions are the areas where air masses formed and where the masses got their temperature and moisture characteristics.

We often see four types of air masses identified on weather maps: polar continental (cP); polar maritime (mP); tropical continental (cT); and tropical maritime (mT).

Polar continental (cP) air masses are dry, cold and originate in the Arctic, Canada, and Alaska. When a polar continental air mass arrives in winter, we can expect the temperature to drop ten or more degrees in a short time. In the summer these air masses are welcomed as relief from the heat. Low humidity, clear skies, and northwesterly winds also accompany cP air masses in the summer.

Polar maritime (mP) air masses originate over the colder areas of the Atlantic and over the Northern Pacific. The masses from the Atlantic carry high humidity, cloudiness, and low to moderate temperatures. They usually travel into the northwestern United States, particularly in autumn and winter. The mP masses from the northern Pacific carry some precipitation, fog, and mild temperatures to the Pacific Coast.

Tropical continental (cT) air masses arrive from the southwestern United States and from Mexico in the summer. They are dry, warm, and occasionally produce drought if they cover an area over an extended period.

Tropical maritime (mT) air masses are familiar to the eastern United States in the summer. Bearers of summer's high humidity and high temperatures, these masses originate in the Caribbean Sea, the Gulf of Mexico, the mid-Pacific, and the Sargasso Sea area of the Atlantic. When these masses arrive in winter, they bring cloudiness and rain.

Some characteristics of air masses are modified as the masses travel. The longer a mass is influenced by the conditions of the new area it covers, the more its original parameters will become like those of the new area. The farther a mass travels from its source region, the more likely it is that its characteristics will be altered from their original values.

By listening to the meteorologists's description of approaching air masses we can predict what general temperature, pressure and humidity changes will occur. Use this information in addition to other weather knowledge to forecast for specific locales.

How the Wind Blows

Wind, air in horizontal motion, is an easily observable weather parameter which plays a vital role in the atmosphere. Wind is, however, a confusing forecasting tool for many amateur meteorologists. Regional wind variation, topography, altitude, and several other factors make forecasting by wind difficult.

The direction and velocity (speed) of wind are standard information tools which we will soon learn to use. First, however, we have to understand a few things about it.

When a pocket of air is wedged between areas of varying pressure, it moves away from the area of the greatest pressure. This movement from areas of higher pressure to areas of lower pressure occurs continuously as air attempts to gain equilibrium. If the difference between pressure areas is great, air is driven rapidly toward the area of lower pressure. If the difference between the pressure areas is slight, the air will move slowly.

Wind velocity increases with altitude. On the average, wind velocity at 33 feet in altitude is approximately twice what it is at 1.5 feet. At the altitude of 100 feet, wind velocity is 1.2 times what it is at 33 feet. Wind flowing close to the earth's surface is erratic and moves in spurts, or gusts. Gustiness is more prominent over areas that have many surface irregularities, such as cities and mountains. Both wind speed and wind direction are affected by irregular surfaces. As wind tumbles over and around obstacles many cross currents develop. It is interesting to note that wind meeting an obstacle is affected to five or six times the obstacle's altitude.

Wind velocity over land is generally higher during the day than at night. This is most noticeable during summer and on clear days. Velocity is usually greatest from 1 p.m. to 3 p.m., and lowest around sunrise.

In many regions meteorologists have discovered a seasonal change in the wind's velocity and direction. Generally, the velocity increases in winter and spring and decreases in summer and autumn. These velocity differences occur because temperature variations between high and low latitudes are greatest in winter and in spring. March, well known as the month for flying kites, usually carries winds with the greatest velocity. August winds usually have the lowest velocity. In some areas of the country, such as the Rocky Mountains, the Great Lakes, and the Pacific Coast, the average monthly wind velocity is difficult to predict.

We watch the wind by observing weather vanes (wind vanes). When the arrow of the weather vane points to the northeast, we are experiencing a northeast wind. Designed with no moving parts for convenience, durability, and economy, HAWS does not judge wind speed. We can, however, learn to estimate wind speed through observation. Chart Two presents guidelines for judging windspeed. The wind speed equivalents given in the chart are designed for simplicity and accuracy.

Small, hand-held, wind indicators can also be accurate when used carefully. One thing to be aware of when using a manual wind indicator is that they will only give the wind speed of the spot they are in. The Beaufort Wind Scale's guidelines allow us to judge the wind speed for a greater area.

Remember that no one weather factor will tell the complete story. Professional meteorologists need data from all over the country in order to provide accurate weather information. We must closely observe as many weather parameters as we can before making predictions.

Chart Two
Beaufort Wind Scale

Wind Effects	Approximate Speed Miles Per Hour	Approximate Speed Meters Per Second	Description
Wind felt on face; leaves rustle	4	2	Light Air
Leaves and twigs in constant motion; wind extends light flag	9	4	Gentle Breeze
Wind raises dust and loose paper; small branches move	16	7	Moderate Breeze
Small, leafy trees begin to sway; crested wavelets form on inland waters	22	10	Fresh Breeze
Large branches move; whistling in telegraph wires; difficult to control umbrellas	29	13	Strong Breeze
Entire trees sway; difficult to walk into wind	36	16	Moderate Gale

Chart Two (continued)

Wind Effects	Approximate Speed Miles Per Hour	Meters Per Second	Description
Twigs broken from trees; generally impedes walking; affects moving vehicles	43	19	Fresh Gale
Slight damage to buildings, shingles torn off, antennas damaged	49	22	Strong Gale
Rare inland; excessive building damage; trees uprooted	58	26	Whole Gale
Very rare; widespread damage occurs; wavetops change to spray	67	30	Storm
Extremely destructive to everything it meets	75	34	Hurricane

Wind Chill Factor

We've all seen a reading on the thermometer and gone outdoors only to find that the air feels much colder than the temperature indicated. When this happens we know that we've forgotten to consider wind chill factor. The wind chill factor may not always make a difference in your outdoor comfort, but it can make a big difference under many conditions. A 40°F day will feel like 28°F when the wind blows at 10 m.p.h., and a 30°F day with a 15 m.p.h. wind will feel like 9°F.

During the cold seasons wind velocity presents special health problems. Unfortunately, we do not have any natural insulation from the wind like most animals and birds. Instead, we try to protect ourselves by wearing various amounts of clothing as the weather changes. When we choose what clothing to wear, however, often we consider only temperature, not wind chill factor. Just as clothes dry faster when hung outside on a windy day, we lose our body heat faster when the wind blows unless we take extra precautions to protect ourselves.

When meteorologists give the wind chill factor, they are actually telling us about the cooling power of the wind. In addition to providing us with the wind chill factor in degrees Fahrenheit and in degrees Celsius, the HAWS CHILLFACTOR program gives us a practical guide to wind chill, called the K Scale (Chart Three).

Chart Three
K Scale

When K =	You Will Feel
0-50	Hot; dress in light materials and light colors
51-100	Warm; clothes should allow for air circulation
101-200	Pleasant; short sleeves, light materials
201-400	Cool; may require light jacket or long sleeves
401-600	Cold; hands may feel chilled; jacket with lining needed; keep head covered and dry
601-800	Very cold; wear several layers of clothing; stay covered and dry
801-1400	Frigid; keep extremeties well covered and dry; layer clothing; watch for gray or white skin patches which indicate frostbite
1401-2000	Danger; exposed flesh freezes within one minute
2001-2500	Intolerable; exposed flesh freezes within thirty seconds

The HAWS K Scale can be used year round as an indicator of comfort, but we rely on it most heavily during the cold season. Use K Scale in deciding how to dress for protection from wind and how long it is safe to remain outdoors.

To find the chill factor:

Run the CHILLFACTOR program

YES, use HAWS.

The current temperature will appear in both degrees Celsius and degrees Fahrenheit.

The lower half of the screen will present the first values of the Beaufort Wind Scale. (See Chart Two). To calculate wind chill factor, the program must be given the estimated wind speed. Observe the wind for at least one minute and choose the description on the Beaufort Wind Scale which most closely represents your observations. Press the space bar to look through the Wind Scale. When you find the most accurate description of your observation, RET.

The statement you chose is now registered as a K Scale value as well as the wind chill factor in degrees Celsius and in degrees Fahrenheit.

CHILLFACTOR also allows us to experiment with wind chill factors so that we can learn more about the relationship between wind speed and temperature. To experiment run CHILLFACTOR but do not use HAWS.

TEMP. (F) is requested.

To enter a Celsius value instead of a Fahrenheit value, RET. The F becomes a C. Enter a Celsius temperature value and RET. The temperature in both Celsius and Fahrenheit will appear on the upper half of the screen. The first values of the Beaufort Wind Scale appear on the screen. Wind speed selection is made by pressing the space bar until you come to the wind condition which coincides with your observation of wind conditions. Then press RET.

An enjoyable way to learn about the relationships between weather parameters is to experiment with the HAWSCULATOR.

The HAWSCULATOR can be used to calculate dew point and to convert temperature in Fahrenheit and in Celsius, and air pressure in inches of mercury (PI) and in millibars (PM).

To convert a Fahrenheit temperature to Celsius, bring the black cursor down the function column by pressing the space bar. When the cursor reaches TC, RET. Now the cursor is on the number one and TF is black. This indicates that you are entering a Fahrenheit temperature for conversion to Celsius. Use the space bar to bring the cursor to the first digit (or the negative sign) of the temperature you want to convert to Celsius. When the desired digit is reached, RET.

For two digit temperature readings, use the space bar to bring the cursor to the next digit and RET. If both digits of the temperature are the same (Example 77) RET twice at the digit. Now bring the cursor to = and RET. The temperature in Celsius is in the calculator display. RET to choose the next function.

Incorrect entries can be deleted from the calculator display by bringing the cursor to the arrow key.

To convert Celsius temperatures to Fahrenheit, bring the cursor to TF and enter the desired digits. Follow the instructions above to complete the conversion. The temperature in Fahrenheit is in the calculator display.

Now try converting pressure in inches of mercury (PI) to pressure in millibars (PM).

To find dew point, bring the cursor to the DP function, RET. The TF function is now black. Use the space bar to bring the cursor to the desired digits for temperature in degrees Fahrenheit, then to =, and RET. RH (relative humidity) is now black. Bring the cursor to each desired digits for relative humidity, then to =, and RET. The dew point temperature appears in °F in the calculator display.

TREND

The one thing that we can be sure of about weather is that change is on its way. Because change is only detectable over time, it makes sense to record weather values for extended periods and to analyze the collected data. TREND is our key to gathering precise data on air pressure, temperature, dew point, and relative humidity. TREND can be run for one hour or for any even number of hours up to, and including, 36 hours. By running TREND on a regular basis, sufficient data for analysis of long-term changes will be accumulated.

Eighteen readings, one approximately every 3⅓ minutes, are recorded if the program is run for one hour. When TREND is run for two to 36 hours, readings will be recorded nine times per hour, or once approximately every 6⅔ minutes.

TREND does not analyze information, it collects the unit's readings and stores them on tape or disk. Once the program is running, and before entering any information in TREND, remove the program disk or tape and insert a data disk or tape to store the TREND information. It is wise to always have a write protect tab on the program tape once the constants have been entered. When the write protect tab is in place, your programs are safe from accidental attempts to store data over them.

The program requests information on:

Date

Time

Hours

The date entered here will become the file name which you will use to subsequently retrieve this data for the GRAPH and PRINT programs.

Example: 082783

A maximum of seven digits may be entered as a file date. If several TRENDs are run on one date, differentiate between them by adding a letter after the date.

Example: 082783A

Once the date is entered, RET.

Next, enter the time the program is started:

Time: 8:25PM RET

A maximum of seven characters may be entered.

The next request is for the number of hours the program is to be run:

Hours? 12 RET

The only valid entries are 1 and every even number up to, and including, 36.

TREND offers an opportunity to change any inaccurate information:

INFO OK (Y,N)?

If No, the program will begin again. If Yes, the number of Total Readings to be recorded will appear on the screen.

Once Yes is entered, a series of numbers appears on the lower left of the screen to indicate that TREND is running. When the HAWS flag replaces these rolling numbers, a reading is being taken by the unit. Each time a reading is taken the number of Current Readings will increase by one. To find out how many readings are yet to be taken at any time, check the number of Current Readings against the number of Total Readings.

When all the readings have been taken, the word FINISHED appears on the screen. Remove the data disk or tape and insert the program disk or tape. Press S to complete the program.

To complete the TREND program before all readings are taken, press A (abort). The last stored reading will be duplicated as many times as there are remaining readings to be taken when A is pressed. When the duplication is complete, FINISHED appears on the screen.

With TREND we can maintain accurate daily records of maximum, minimum, mean, and average temperatures similar to those of professional meteorologists. Maximum temperatures usually occur between 2 p.m. and 4 p.m. local time. The day's minimum temperature usually occurs just before sunrise. To gather accurate, daily mean temperatures, start TREND before going to bed and leave it running until about 5 p.m. the next afternoon.

Perhaps the most interesting trends for us to watch are diurnal (daily). Diurnal weather is influenced by several factors: the sun's heat, air mass movement, and topography.

Atmospheric pressure has a diurnal variation resulting from the alternate heating and cooling of the atmosphere. This variation occurs because air is thinner during the hottest part of the day than it is during the cooler periods. The variation is only about 1.5 MB (.045 PI) from the maximum expansion of the atmosphere to the minimum contraction during any 24 hour period.

Soon after you begin taking daily readings with HAWS you will notice that the atmospheric pressure is usually highest at 10 a.m. and 10 p.m., and lowest at 4 a.m. and 4 p.m. The amount of change is approximately .04 (PI) in middle latitudes

and .15 (PI) in the tropics. The most dramatic change in diurnal temperature patterns takes place when there is a fluctuation in air mass or when heating or cooling take place under clear skies. Subtle variations in diurnal temperature patterns are seen regularly at certain locations. Temperature does not show a great diurnal change near the ocean, but inland areas experience a wide range of diurnal temperatures. Valleys also experience a great range of diurnal temperatures while hilltop temperatures are more stable.

Collecting daily maximum, minimum, and average values and comparing them with each month's average temperature will give you an insight into weather trends. These averages are available through the local National Weather Service Office or, the National Climatic Data Center, Federal Building, Asheville, N.C. 28801, phone (704) 259-0682.

As we gather more weather trend information a variety of fascinating weather phenomena will become evident. Be sure to watch for changes in weather parameters when: precipitation begins, there are cold or warm fronts, there are sea or lake breezes, there are thunderstorms or, there are regional winds (Santa Ana, Chinook). Also notice approaching intense low pressure areas, variable cloudiness (best results 10 a.m. - 3 p.m.), and fog formation at night.

It is also interesting to keep track of the number of daytime temperatures above 90 °F or below 32 °F. For minimum temperatures, the number of nocturnal temperatures below 32 °F or 0 °F is interesting. For Southern latitudes minimum temperatures considered might be 50 °F and 32 °F.

To discover the efficiency of heaters, air conditioners, humidifiers, and other environment related equipment, record indoor trends. Keep records of temperature and relative humidity readings to find out more about indoor environments.

You may want to begin a local network of HAWS users. By comparing weather parameters gathered by users in valley areas with users in hilly areas, or comparing user data gathered near the water with data gathered away from the water, you will gain more knowledge of all of the variables which affect the weather.

GRAPH

Full understanding of the relationships between variables often eludes us until we see them plotted on one or several graphs. GRAPH offers insight into the changes of air pressure, temperature, relative humidity, and dew point for one hour, or for every even number of hours up to, and including, 36 hours. GRAPH analyzes and plots collected TREND data on four graphs; one graph for each of the weather values.

The program requests:

File Date?

Before entering this information, remove the program disk or tape and insert the TREND disk or tape which contains the file you want to analyze. Enter the file date of the TREND to be analyzed and plotted.

Example: 082783 RET

Rolling numbers appear on the lower portion of the screen to indicate that TREND data is being analyzed.

Soon the first graph, Pressure, appears on the screen. If you want more information about the Pressure graph, press RET. At the top of the screen the H and L readings of the graph are given. RET again and the Y (divisions of the vertical axis) and X (divisions of the horizontal axis) values are given. The X values (Time) vary according to the amount of time TREND collected data. The Y values are dependent on the spread between the high and the low readings of each graph.

Remember that when all of the points on a graph are low it indicates that the plotted weather values did not vary much during the time TREND collected data. Do not confuse the low plot points with low readings.

Regardless of how many readings were collected in a TREND program and analyzed by GRAPH, only 18 points are plotted on each graph. The GRAPH program skips through the collected data and pulls one reading every division of X amount of time. To find the division of time in minutes, multiply the hourly division given on the graph by 60.

After obtaining the necessary X and Y information, RET again for the mean (M) and Average (A) values of the graph. The mean value is calculated by adding the high and the low values and dividing the sum by two. The average is calculated by adding all of the point values together and dividing the sum by the total number of points.

RET once again and the file date, starting time of the TREND plotted, and the number of hours TREND was run is displayed above the graph.

By pressing M (for metric) while the high and low, M, A, Y are displayed, or while Date and Time appear, all of the value information given above a graph is converted to metric. By pressing E (for English), this information is converted from metric to English.

RET once more and the file date, starting time of the TREND plotted, and the number of hours TREND was run is displayed above the graph. To move between the four graphs, press the space bar. Each graph has H, L, X, Y, M, A, file date, time, and hours information. The space bar brings the next graph to the screen, and RET brings us more information about an individual graph. Press the letter R at any time while running GRAPH and the original ("Date") screen appears.

PRINT

PRINT offers an excellent opportunity to study and permanently record collected TREND information. Each printout lists file date, time, the number of hours TREND was run, pressure (PI and PM), temperature (TF and TC), dew point (DF and DC) and relative humidity. The number of readings taken by TREND each hour varies according to the total number of hours TREND is to be run. Each line of readings is numbered, and each hour of readings is indicated by a double underscore. With these reference guides you should have no trouble finding any specific reading.

Be sure to carefully set up the paper in the printer for pagination before starting the program.

RUN PRINT. Type in the file date of the TREND you want to print and RET. "Date OK?" appears. To accept the file date, type Y, RET. If you want to correct the date, type N, RET.

When Y, RET is typed, the time, hours, and total readings of the TREND program are displayed on the screen and the printout starts.

FORECAST

The challenge and excitement of predicting the seemingly unpredictable is probably what makes meteorology a full time occupation for thousands and a part time amusement for many more. With HAWS you can obtain fast, accurate next day forecasts based on atmospheric pressure, temperature, and station altitude. Station altitude—the height of your unit (in feet) above sea level—is used along with barometric pressure from the HAWS sensor and temperature to convert the unit's pressure readings to sea level. Pressure values are always adjusted to sea level so that meteorologists from all over can directly compare readings. To find the altitude of your unit, call your town or city hall and give them your exact location. Local airports also have altitude information.

To obtain next day forecasts, enter the FORECAST program. You will then be asked if you want to use data from the TREND program:

Using TREND

(Y/N)?

IN ORDER TO GENERATE THE MOST ACCURATE FORECAST, WE RECOMMEND YOU RUN THE TREND PROGRAM FOR AT LEAST 12 HOURS PRIOR TO THE TIME A FORECAST IS REQUIRED.

Therefore:

Y RET

File Date?

093083 RET (Sept. 30, 1983 is only an example date)

The pertinent data from TREND is entered and analyzed.

Enter Altitude:

(ft)?

100 RET

The pressure adjusted to sea level appears on the screen. Press any key to continue:

Q RET

HAWS-U-CASTER comes up on the screen. Press return (RET) to see what the weather has in store.

The letters and numbers in the lowest slot of the HAWS-U-CASTER refer to Chart Four. This chart offers more forecast information.

To watch the HAWS-U-CASTER run again, RET.

To start FORECAST again without returning to the menu or rewinding the tape, press the space bar.

To stop the program, press S. For VIC 20 users, the HAWS program must then be re-loaded in order to run additional programs except for GRAPH and PRINT.

Chart Four

HAWS-U-CASTER FORECAST NOTES

	1	2
A	Stormy conditions	Increasing winds and colder
B	Squalls with clearing	Windy and colder
C	Showers within 12 hours from start of rise	Fair
D	Cloudy and warmer. If a warm front is approaching, showers are likely	Fair and windy
E	Storm approaching in the direction of the wind	Fair and colder
F	Fair and warmer. Rain within 2-3 days	Fair and warmer

NOTE:

No change on HAWS-U-CASTER means that general weather pattern will hold for the next day.

TILT means that HAWS-U-CASTER is unable to generate an accurate forecast with values encountered.

Instead of using TREND data to develop a next day forecast, you may wish to generate forecasts based on historical or hypothetical situations. The following example illustrates how this is done:

Using TREND

(Y/N)?

N RET

Enter Pressure

Value #1

(PI)?

30.3 RET

Note that PI is actual barometric pressure, i.e., not adjusted to sea level. If you wish to use pressure values adjusted to sea level such as obtained from radio or TV weather information, then enter a zero value for altitude.

Enter Temperature

(TF)?

70 RET

This is the temperature measured at the time Value #1 for PI was recorded.

Enter Altitude

(FT)?

100 RET

Sea level pressure should now be displayed on the screen.

Enter Pressure

Value #2

(PI)?

30.69 RET

Note that in order for HAWS-U-CASTER to forecast a significant weather change, Value #2 (which occurs in time after Value #1) has to vary either up or down by at least .08 PI from Value #1.

The HAWS-U-CASTER appears on the screen. Press return (RET) for weather forecast.

User Programming

Here are some important points to remember while programming HAWS:

1. You must be using an unexpanded VIC 20 or Commodore 64.
2. Load HAWS BEFORE you begin programming.
3. There are 2045 bytes (approximately 2K) available for programming on a VIC 20, or 38911 bytes (approximately 39K) on a Commodore 64.
4. The BASIC command SYS6144 on a VIC 20, or SYS49155 on a Commodore 64, verifies that the HAWS machine language program is intact in your computer, and it displays the HAWS flag in the lower left corner of your computer screen.
5. The BASIC command SYS6560 on a VIC 20, or SYS49560 on a Commodore 64, executes the machine language program. This program reads the sensors and returns its calculations to five specified variables.
6. The first line in your program MUST be:

   1 POKE52, 24: POKE56, 24: CLR: PI = 1: PM = 1: TF = 1: TC = 1: RH = 1 on a VIC 20, or CLR: PI = 1: PM = 1: TF = 1: TC = 1: RH = 1 on a Commodore 64.

   Where: PI = pressure in inches
   PM = pressure in millibars
   TF = temperature in Fahrenheit
   TC = temperature in Celsius
   RH = relative humidity

   The predefined variables will change when you execute SYS6560 on a VIC 20 or SYS49560 on a Commodore 64.

Here is an example of a program which will read the unit and print the values on the screen:

1 POKE52, 24: POKE56, 24: CLR: PI = 1: PM = 1: TF = 1: TC = 1: RH = 1 on a VIC 20, or CLR: PI = 1: PM = 1: TF = 1: TC = 1: RH = 1 on a Commodore 64.

10 REM LINE 20 VERIFIES THAT THE MACHINE LANGUAGE

15 REM PROGRAM HAS BEEN LOADED AND IS USABLE

20 SYS6144 on a VIC 20; SYS49155 on a COMMODORE 64.

30 REM LINE 40 EXECUTES THE MACHINE LANGUAGE

35 REM PROGRAM THAT READS THE SENSORS

40 SYS6560 on a VIC 20; SYS49560 on a COMMODORE 64.

50 PRINT " "

60 PRINT "PRESSURE (I) = ";PI

70 PRINT "PRESSURE (MB) = ";PM

```
 80 PRINT "TEMPERATURE (F) = ";TF
 90 PRINT "TEMPERATURE (C) = ";TC
100 PRINT "RELATIVE HUMIDITY (%) = ";RH
110 GOTO 20
```

Here is some additional information which will help you create programs to suit your weather-related needs.

Heating Degree Days

Heating degree days is a concept that can help us measure our heating fuel requirements, and, therefore, help us conserve fuel. Scientists have found that when the daily mean temperature falls below 65°F, most buildings must be heated if they are going to remain a comfortable 70°F inside. We can easily find daily mean temperature by adding the maximum and minimum Fahrenheit temperatures of a particular day together, and then dividing the sum by two. Each degree of mean temperature below 65°F is one heating degree day. When the daily mean temperature is 65°F or higher, there are zero heating degree days.

More fuel is needed to maintain 70°F in buildings with each additional heating degree day. When the daily mean temperature is 15°F, there are 50 heating degree days. When the daily mean temperature is 42°F, there are 23 heating degree days. Twenty-three heating degree days require less than half the fuel than 50 heating degree days. This difference will be reflected in your fuel bill. A month with 500 heating degree days will require twice as much fuel as a month with 250 heating degree days. Two equal numbers of heating degree days should require about the same amount of fuel whether or not they are accumulated during the same number of days.

The usefulness of heating degree days is judged by how we can use the idea to save money and fuel. If the efficiency of heating equipment remains constant, the fuel usage of a given house will be proportional to the number of degree days. To compare one heating system with another, assume that the efficiency of both systems is constant. Remember that the efficiency of heating equipment decreases during the warmer parts of the heating season; therefore, the fuel use per degree day is higher in the fall and spring than it is in the winter. This fluctuation in efficiency should be considered when comparing degree day data of cold climates with that of warm climates.

HAWS makes keeping accurate records easy. TREND together with GRAPH provides the high, mean, and average temperatures each day. By reading the graphs and recording the information, we can compare daily, weekly, monthly, and annual readings. With a printer and with the PRINT program, maintaining complete records is even easier. All pertinent TREND information is printed out in a convenient chart.

For illustrative purposes, monthly long term heating degree day averages are listed for the Boston Area:

July = 0	Nov. = 618	Mar. = 849
Aug. = 7	Dec. = 998	Apr. = 534
Sept. = 77	Jan. = 1,113	May = 236
Oct. = 315	Feb. = 1,002	Jun. = 42

Consult an almanac for more information about specific areas of the country.

Cooling Degree Days

During the warm months we can use a similar theory as described above to find air conditioning requirements. When we are concerned with maintaining a level of coolness, we count cooling degree days.

Instead of counting degree days when the mean daily temperature falls below 65°F, we count degree days when the mean daily temperature rises above 78°F. We know that to count degree days we must find the daily mean temperature by adding the maximum and minimum temperature's together and dividing by 2. By using the TREND program, however, we can let our computers do the figuring for us. Start TREND before going to bed at night and let it gather values until approximately 5 p.m. the next afternoon. Then, by using GRAPH, the data will be analyzed by your computer and plotted with low, mean, average and high temperature values computed.

When the daily mean temperature falls below 78°F, there are zero cooling degree days. Heating and cooling degree days do not cancel each other out. Totals for each type of degree days are accumulated independently.

Growing Degree Days and Frost Formation

Gardeners and farmers will appreciate the valuable help which HAWS can provide in predicting growing degree days and frost. Instead of guessing maximum and minimum daily temperatures, you can use TREND, GRAPH, and PRINT to collect and maintain accurate temperature information.

The growing degree day (GDD) is used to approximate when a certain crop will reach maturity. To calculate GDD, maintain records of the base temperature of each of your crops. Base and harvest temperatures may be obtained from your seed supplier or from your county agent. Run TREND to gather the maximum and minimum temperatures each day. Remember that the maximum temperature is usually reached between 2 p.m. and 4 p.m., and the minimum temperature comes just before sunrise. Use GRAPH to see exactly what the mean daily temperature is (maximum temperature + minimum temperature/2). When the mean temperature exceeds the base temperature of a certain crop, that crop will develop towards maturity for harvest.

Here are a few examples of base temperatures and a number of GDD for approximation of harvest time:

Chart Five

Growing Degree Days for Selected Crops and Locations

CROP	BASE TEMP.	UNITS TO MATURITY
(Wisconsin) peas	40	1300-1800
(Indiana) wheat	40	2100-2400
(Indiana) corn	50	2200-2800
(Arkansas) cotton	60	1900-2500

To predict frost, use DISPLAY to find the dew point at 7 p.m. When the wind is light the sky is clear and:

DF is 43 °F or higher, frost is highly unlikely

DF is 36-43 °F, frost is possible

DF is below 36 °F, frost is likely

Frost can also be predicted by estimating the night's minimum temperature. To do this, find the difference between the Celsius temperature and the Celsius dew point at either 1 p.m. (1300 hrs.) or 7 p.m. (1900 hrs). The formulas are:

$TC\ MIN = TC_{13} - \frac{1}{2}(TC_{13} - DC_{13}) - 6$

$TC\ MIN = TC_{19} - \frac{1}{2}(TC_{19} - DC_{19}) - 4$

Where:

13 = 1 p.m.

19 = 7 p.m.

Glossary

Absolute humidity: the actual amount of water vapor per unit of volume in the air.

Air mass: a wide body of air with considerable depth and the same general temperature, air pressure, and relative humidity throughout.

Air pressure: the force of the atmosphere's weight per unit area.

Altitude: height above a plane of reference expressed in definite units, usually above ground or above mean sea level.

Atmosphere: the mass of gases that surrounds the Earth.

Barometric pressure: air pressure as indicated by the weather instrument, the barometer.

Celsius temperature scale: the scale in which zero degrees is the melting point of pure ice and 100 degrees is the boiling point of pure water at standard atmospheric pressure.

Climate: meteorological data gathered over an extended period which tells us what conditions characterize a certain area.

Cloud: a mass of suspended water or ice particles floating in the atmosphere at various altitudes and appearing in many shapes.

Condensation: the point at which water vapor changes to liquid water.

Cooling degree days: a unit used to estimate air conditioning requirements of buildings during the warm months. The base 78 is subtracted from the daily mean temperature to obtain the number of cooling degree days.

Daily mean temperature: obtained by adding together the day's high and low temperatures and dividing the total by two.

Dew point (or dew point temperature): the temperature at which a particular air mass will have 100% relative humidity. Also, the temperature at which condensation occurs.

Diurnal: occuring every day; pertaining to a 24 hour period.

Evaporation: the conversion of liquid water to water vapor.

Fahrenheit temperature scale: the scale in which 32 degrees is the melting point of pure ice and 212 degrees is the boiling point of pure water at standard atmospheric pressure.

Heating degree days: a unit used to estimate fuel requirements of buildings during the heating season. Each degree of mean temperature below 65°F is considered as one heating degree day.

Inversion: temperature increases with altitude instead of decreasing with altitude as it normally does.

Parameter: a quality whose value varies depending on each specific case.

Relative humidity: the percentage of water vapor in the air to the amount the air could possibly hold at the same temperature.

Sea level: the level continuous with the ocean's surface at mean tide. Used in figuring altitude.

Sublimation: the conversion of ice to water vapor by heat, or the conversion of water vapor to ice by cooling.

Temperature: a definite scale measure of the amount of heat a substance contains.

Trend: the tendencies of weather as indicated by meteorological parameters such as temperature, pressure, dew point, and relative humidity, which are gathered and analyzed over short or long periods.

Weather: the atmospheric condition in regard to temperature, winds, precipitation, humidity and other meteorological phenomena. Refers to conditions at the moment, rather than to climate.

Wind: air in motion over the Earth's surface. Generally used in reference to horizontal air movement.

Wind chill factor: the relative discomfort resulting from the combination of temperature and wind.

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