G.R.O.W.

Getting Real On-farm Weather Field Observation Methods

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Local Weather Observations

1.0 INTRODUCTION: Local weather has a direct influence on you. Recording weather conditions over time gives you a perspective about the climate conditions in the study area. Weather changes, so the more observations and data you have, the better you can characterize the local weather. However, you have limited time to make observations and measurements, try to make your weather observations at 9 AM each morning. This will make your data conform to conventional practices of most weather observers.

1.1 Sources of Weather Data: You can get daily weather data from the newspapers, radio, TV or Internet. In most cases, the weather observation station is NOT the same as your study site. In that case, you need to consider making local weather observations and measurements. You may still need to rely on the nearest weather observation station for data to help calibrate or validate your field observations.

1.2 Basic Weather Observation Terms: The basic weather observations are defined and summarized in the table below.

Basic Weather Observation Terms	
Temperature	The measurement of the amount of heat that is present.
Thermometer	An instrument used to measure temperature.
Your Description (Sensible Temperature)	This is the temperature you feel. It is your opinion and is not a measurement. It may be different than the temperature on a thermometer.
Estimated by Insects	The estimated temperature by observing insect activity. (See the “Insect Temperature Reference Table.”)
Measured Temperature	The temperature measured on the thermometer. It is also called the “dry bulb temperature.”
Pressure	The measurement indicating rising (lifting) or subsiding (sinking) air.
Barometer	An instrument used to measure atmospheric pressure.
Wind	The horizontal movement of air.
Anemometer	An instrument used to measure wind velocity.
Wind Speed	How fast the air is moving horizontally at the Earth’s surface.
Wind Direction	The direction the wind is coming from. Turn so you feel the wind blowing directly on your face.
Relative Humidity	The ratio of water vapor in the air to the amount that could be present if the air was saturated.
Hygrometer	An instrument used to measure relative humidity.
Clouds	Masses of very small water droplets or ice crystals suspended in air.
Cloud Type	Clouds are generally grouped by the altitude where they are found (low, middle, high). They are also named by their shape or form (cumulus, stratus, cirrus, cumulonimbus). Use the Cloud reference table to get the cloud letter codes and names.
Cloud Height	Tells how high the lowest cloud layer is above the ground.
Cloud Cover	Tells how much of the sky is covered with clouds.
Precipitation	The form and relative intensity of water (liquid or solid) falling from the sky. (See the terms in the Precipitation Terms reference table.)
Rain gauge	An instrument used to measure the amount of rainfall.

2.0 BASIC WEATHER OBSERVATIONS

2.1 Temperature: The standard practice is to measure air temperatures in the shade about 1.5 m / 4.5 ft above the ground. The typical diurnal temperature pattern shows lowest daily temperatures occurring just before dawn. The highest temperatures are typically at mid-afternoon.

2.1.1 Measured Using Thermometers:

- **Dry bulb temperature** is what most people think about when they hear the word "temperature." This is the amount of heat contained in air that is not saturated (i.e. relative humidity is not 100%).
- **Wet bulb temperature** is the temperature from a special thermometer with a saturated cloth wick. It provides the basis for calculating relative humidity.

2.1.2 Estimated Using Insects: All living organisms exist and function within a range of temperatures. If the temperatures exceed the maximum / minimum tolerance range, the organism dies. As the temperatures approach the tolerance limits, many animals reduce their activity to alleviate the environmental stress on their bodies. Some researchers have found specific examples of insect behavior corresponding to specific temperatures. Some of these "insect thermometers" are given in the table on the next page.

INSECT TEMPERATURE REFERENCE TABLE
(From Natural History after studies by Cleve Hallenbeck)

Katydid Calls

Sound	Temp	
Kay Tee Did It	24.4 °C	76 °F
Kay Tee Didn't	23.3 °C	74 °F
Kay Tee Did	21.1 °C	70 °F
Kate Didn't	19.4 °C	67 °F
Kate Did	17.7 °C	64 °F
Katy	16.7 °C	62 °F
Kate	14.4 °C	58 °F
(No call)	12.8 °C	55 °F

Cricket

Chirps / min	Temp	
194	29.4°C	85 °F
172	26.7°C	80 °F
151	23.9°C	75 °F
129	21.1°C	70 °F
108	18.3°C	65 °F
86	15.6°C	60 °F
65	12.8°C	55 °F
43	10°C	50 °F
22	7.2°C	45 °F
0	4.4°C	40 °F

Black Field Cricket

Step 1. Count the number of cricket chirps for 14 seconds.
Step 2. Add the count to 40.
Step 3. The result is the temperature reading in °F

All Insects

Quiet	> 40.6°C	> 105 °F
	4.4°C	< 40 °F
Helpless	1.7°C	35 °F
Dormant	0°C	32 °F

Some Other Insects

Bees stay still	39.4°C	>103 °F
Cicadas start to sing	28.9°C	84 °F
Ants stay home	12.2°C	54 °F

2.2 Barometric pressure: Barometer is derived from the Greek words *baros* (weight) and *metron* (measure). So a barometer, literally, is weighing the atmosphere. Atmospheric pressure indicates vertical air movements and cloud cover conditions associated with rising (low pressure, cloudy skies) and sinking air (high pressure, clear skies). Differences in pressure cause wind, which moves from high pressure to low pressure. More significant than the actual pressure measurement is the air pressure trend (change over time). This combined with wind direction and cloud types (all observed over time) provides the basis for weather forecasting.

There are some basic sources for barometric pressure information. Be careful using these sources. They are often reported using a city name. It may or may not be in the same location as the weather station reporting the data. Your location may or may not correspond to the city or the weather station locations. Local topography can affect the specific pressure measurements.

- **Daily weather reports** (via radio, TV): Not all weather reports are the same. So look for one that actually reports the barometric pressure in relative or absolute terms.
- **Internet Weather Sites:** Various government and commercial weather sites are on the Internet. Government sites tend to be free. Commercial sites offer basic information free, but charge for advanced information services.

Nan Weather	http://www.tutiempo.net/en/Weather/Nan/VTCN.htm
	http://www.weatherunderground.com/global/stations/48331.html
	http://wwwa.accuweather.com/index-world-forecast.asp?partner=accuweather&myadc=0&traveler=0&zipcode=ASI|TH|TH031|NAN|
Nan Climate	http://www.tutiempo.net/en/Climate/Nan/483310.htm
	http://www.worldclimate.com/cgi-bin/grid.pl?gr=N18E100
	http://www.weatherbase.com/weather/weather.php3?s=013384&refer=
Thawangpha weather	http://www.fallingrain.com/world/TH/4/Tha_Wang_Pha.html
	http://wwwa.accuweather.com/index-world-forecast.asp?partner=accuweather&myadc=0&zipcode=ASI|TH|TH031|THA%20WANG%20PHA|
Thawangpha Climate	http://www.tutiempo.net/en/Climate/THA_WANG_PHA/483150.htm
Thai Meteorology Dept	Daily forecast: http://www.thaimet.tmd.go.th/Html/News/Eng/English1_1.pdf
	Home page: http://www.tmd.go.th/index_eng.php
World Meteorology Organization	Thailand Weather: http://www.worldweather.org/089/m089.htm

- **Barometer:** You can make or purchase a barometer to keep at home or at the study site. To get full benefit of the purchased barometer data you record, you need to calibrate your barometer. This means getting an actual barometric pressure reading from a nearby official weather station or airport. If you use a radio / TV source or the weather station is far from you, the calibration (and your data) will be less precise. However, the pressure trend is more useful. An uncalibrated barometer will give you the ability to determine the relative rate of pressure change. This information refines your ability to predict weather changes.

2.2.1 Making a Water Bottle Barometer: Here is a simple barometer you can make to get "relative" barometric pressure readings.

Materials: A bowl, water, plastic bottle, index card, tape, and marker. The bowl should be deep enough to hold the bottle upright. The bottle should fit into the bowl vertically (with the mouth of the bottle down in t he bowl), but fit loosely without toppling over.**Procedures:**
Step 1. Fill the bowl ½ full with water.
Step 2. Fill the bottle ¾ full with water.
Step 3. Cover the mouth of the bottle with your thumb. Invert the bottle. Put it into the bowl. Be sure the mouth of the bottle is under water. Remove your thumb. Let the water in the bottle settle.
Step 4. Vertically center the index card on the water level in the bottle. Half the card should be above the water line and half below.
Step 5. Use the marker to draw an "Index" (reference) water line. Write a "+" (plus) and the word "high" above the water line. Write a "-" (minus) and the word "low" below the water line. .

2.2.2 Interpreting Barometric Measurements:

- Air pressure pushes down on the surface of the water in the bowl. The force is sufficient to keep the water in the bottle. Remember, standard atmospheric pressure is about 1.0335123 kilogram-force/square centimeter or 14.7 pound-force/square inch (PSI).
- Changes in air pressure (from the time you set up your barometer) will cause the water level in the bottle to change. Higher air pressure pushes water up into the bottle. Lower air pressure lets water flow out of the bottle.
- Your barometer only shows relative air pressure changes (up = higher than before you set up the barometer; down = lower than before the set up). You don't really know the exact barometric pressure measurement.
- The simplistic interpretation of your home made barometer results are:
  Lower Pressure = warmer, cloudier, wetter weather.
  Higher Pressure = cooler, clearer, drier weather.

2.3 Wind velocity: Wind velocities affect the environment and living organisms. Generally, heat and moisture are moved around the planet by wind. Surface ocean currents are driven by wind. Generally, winds tend to blow stronger in the afternoons than in the mornings.

Of particular importance for humans is the effect of wind-chill. Linked with high relative humidity, wind can effectively make you feel colder than the measured temperature. In extremely cold conditions, this can pose health risks and ultimately be life threatening.

You can make a subjective visual estimation of wind velocities using the Beaufort Scale of Wind Effects on Land. Admiral Sir Francis Beaufort of the British Royal Navy developed the scale in 1805. Originally the wind effects were for sailing ships. It has been revised and modified over time, and also adapted to land. Although it is subjective, the functional definitions for the "Wind Effects on Land" are fairly detailed and definitive. Wind speed measuring devices give an objective measurement. The price varies directly with the complexity and technology used. Two devices are included here, both relatively low tech. The first device is home made. The second, the Dwyer Wind Gauge, can be purchased.

2.3.1 The Beaufort Wind Scale: To use the wind scale, follow these 4 simple steps.

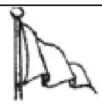
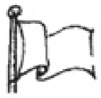
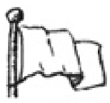
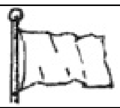
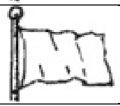
Step 1. Make a careful observation of the effect of the wind on your immediate surroundings.

Step 2. Match your local observation to the written descriptions in the left column of the chart.

Step 3. Follow the row across to the right in the chart to get the official WMO (World Meteorological Organization wind velocity term for your observed local wind velocity.

Beaufort Wind Table for Land Effects

MEWS weather observers should set up a flag near their operating position. Use the Description and flag references to estimate the wind speed. Report the range of wind speeds from the chart rather than a specific number.

Description	Flag	WMO term	Mph	Km/ hr	Knots	Force	Psu lbs/sq ft (Kg/sq m)
			Report wind speed in knots to flight crews				
Calm; smoke rises vertically	---	Calm	<1.0	<1.5	<0.9	0	0.006266 (0.003059)
Smoke indicates wind; flag hangs limp, wind vanes do not move		Light Air	1-3	1.5-6	1-3	1	0.02924 (.01428)
Wind felt on face, leaves rustle, flag stirs, wind vanes move		Light breeze	4-7	6-12	4-6	2	0.142 (0.6934)
		5 Knots maximum tailwind for helicopter take-off					
Leaves and twigs in constant motion; flag occasionally extends		Gentle Breeze	8-12	12-20	7-10	3	0.3759 (1.835)
		10 Knots ideal for helicopter flight operations					
Dust and paper fly; small branches move; Flag flaps		Mild Breeze	13-18	21-29	11-16	4	0.8145 (3.977)
small leafy trees begin to sway; white crested wavelets appear on lakes/ponds; Flag ripples		Fresh Breeze	19-24	30-39	17-21	5	1.504 (7.342)
		20 Knots maximum gusts for helicopter flight operations					
Large branches move; wires whistle; umbrellas hard to use; Flag snaps		Strong Breeze	25-31	40-50	22-27	6	2.485 (12.13)
Whole trees sway; hard to walk; Flag extended		Near Gale	32-38	51-61	28-33	7	3.822 (18.66)
Twigs and small branches broken; cars veer on roads; Flag tatters		Gale	39-46	62-74	34-40	8	5.597 (27.33)
Slight structural damage occurs (roof shingles blow off)		Strong Gale	47-54	75-87	41-47	9	7.769 (37.93)
		45 Knots maximum winds for helicopter flight operations					
Trees broken or uprooted, considerable damage to buildings		Storm	55-63	88-101	48-55	10	10.53 (51.39)
Wide spread damage caused	---	Violent Storm	64-72	02-114	56-63	11	13.78 (67.3)
	---	Hurricane	>73	>115	>63	12	>13.78 (>67.3)

Disclaimer: Use of the pressure data to calculate tower/antenna wind loads is at your own risk. The RTC-TH and HSØZHM assume no liability for the use of this data. Pressure values are the upper limits for a wind category.

Step 4. Continue across the row to the right to get the estimated numerical wind velocity in miles per hour (mph), kilometers per hour (kph), or the wind Force Number (used in special fields to describe wind velocities).

2.3.2 Soap Bubble Method: Use this method for calm to light air (0-6 kph / 0-3 mph)
Step 1. Mark off a convenient distance on level ground away from buildings or trees. About 3 meters or 10 ft will do. Be sure you can see the start and end points clearly. One person needs to stand at each end.
Step 2. The upwind person should mix a thick solution of red colored Kool-Aid in a cup.
Step 3. The downwind person uses a stopwatch or a watch with a second hand to time the soap bubbles. Tell the upwind person to start making soap bubbles. Then the downwind person measures the time it takes for the first bubbles to reach the end point.

2.3.3 Making Wind a Home Made Wind Speed Indicator: You can make a simple wind speed indicator to take actual field measurements.
Materials Needed: Semi-circular protractor, a ping-pong ball, 20 cm / 8 in of strong thread, transparent tape, scissors, and a marking pen.

Procedures:
Step 1. Tape one end of the thread firmly to the Ping-Pong ball.
Step 2. Tie the other end of the thread to the center of the protractor base line. (Note: The protractor base will be the top when you use the wind speed indicator. The ping-pong ball should hang down so the thread crosses the protractor scale. The wind speed will be indexed to the degree scale on the protractor.
Step 3. To calibrate the wind speed indicator, find an open area without traffic. Be sure it is a calm day---or do this early in the morning when the winds tend to be calm. Have a friend drive while you ride in the car. Open the window. Start slowly. Have the driver hold a steady speed at 5 mph. Watch the indicator string on the ping-pong ball and record the angle on the protractor scale. Repeat this for each speed increment in the table.

Protractor Angle	Wind Speed		Protractor Angle	Wind Speed	
	kph	mph		kph	mph
	0	0		48	30
	8	5		56	35
	16	10		64	40
	24	15		72	45
	32	20		80	50
	40	25		88	55

Step 4. You can repeat the calibration procedure to verify the results. The table below is a rough check to validate your results.

Protractor Angle	Wind Speed		Protractor Angle	Wind Speed	
	kph	mph		kph	mph
90°	0	0	50°	48	30
	8	5	40°	56	35
	16	10	30°	64	40
80°	24	15		72	45
70°	32	20	20°	80	50
60°	40	25		88	55

2.3.4 Wind Velocity Measurements Using the Home-made Wind Speed Indicator:

Step 1. Hold the wind speed indicator by one end of the protractor base so the base is at the top is parallel to the ground. The ping-pong ball indicator string should line up at 90° if the wind is not blowing.

Step 2. Point the wind speed indicator directly into the wind. Stand to one side. This way your body will not disturb the airflow over the wind speed indicator. Read the angle of the farthest downwind position of the indicator string. Record it in your field notebook.

Step 3. Take a total of at least three measurements to average the results. The wind is not always blowing steadily. You can report the average wind speed and the maximum “gust” during the time of your observations.

Step 4. Use the calibration table to convert the indicator string angle to the estimated wind speed. Record the data in your field notebook.

Discussion: Actual calibration of your home made wind speed indicator should be done using a purchased wind speed indicator or anemometer. Local site conditions (e.g. proximity to buildings, vegetation, etc.) and general site topography (e.g. landforms) will affect wind speed measurements.

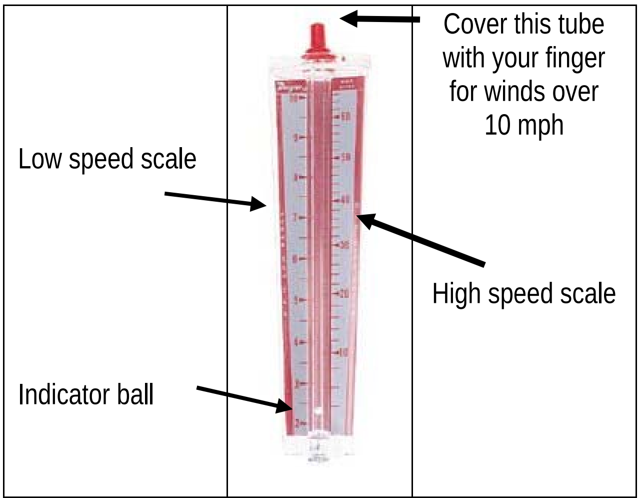
2.3.5 The Dwyer Wind Gauge is a portable and reliable tool to measure wind speed in the field. This is a hand held instrument. As the wind blows, the white indicator ball in the tube moves up with high wind speeds, and drops down with low wind speeds. Because the wind does not blow at a constant velocity, you have to subjectively judge when to read and record the position of the indicator ball. With practice, you gain proficiency using the device.

If you take several readings, carefully noting the maximum and the minimum wind speeds during the measurement interval, you can mathematically calculate the average wind speed. This would be a more accurate depiction of the wind speed.

Step 1. Find a clear open area away from buildings and other structures that might block or amplify the wind.

Step 2. Stand facing into the wind. Hold the Dwyer wind meter perpendicular to the ground with your arm fully extended.

Step 3. Watch the tiny white ball in the Dwyer wind meter. If the ball stays within the scale 0-10 mph, read the wind velocity based on the position of the white indicator ball. If the ball is off scale at the top, place a fingertip over the red plastic pipe at the top of the wind gauge. Then read the position of the white indicator ball.



Dwyer Wind Gauge

Step 4. Repeat Steps 2 & 3 until you have taken at least 3 measurements. Watch for the maximum and minimum wind speeds. Use the table below to record your data.

Step 4. Calculate the average wind speed. Add the three measurements together. Divide the sum by 3 to get the average wind speed.

DWYER WIND GUAGE DATA LOG				
Location:			Date:	Time:
Recorded by:				Wind Direction:
Obs #	Wind Speed	Max	Min	Use this area for your calculation.
1				
2				
3				
Total				
Average				

[Note: If the wind speed gauge you are using is marked in mph (miles per hour) use the conversion table below to report the wind speed in other units).

Wind Speed Conversion Table								
mph	km/h	knots	mph	km/h	knots	mph	km/h	knots
1	1.61	0.869	9	14.48	7.821	45	71.42	39.10
2	3.22	1.738	10	16.09	8.69	50	80.47	43.45
3	4.83	2.607	15	24.14	13.03	55	88.51	47.79
4	6.44	3.476	20	32.19	17.38	60	96.56	52.14
5	8.05	4.345	25	40.23	21.72	65	104.60	56.48
6	9.66	5.214	30	48.28	26.07	70	112.70	60.83
7	11.27	6.083	35	56.33	30.41	75	120.70	65.17
8	12.87	6.592	40	64.37	34.76	80	128.70	69.52

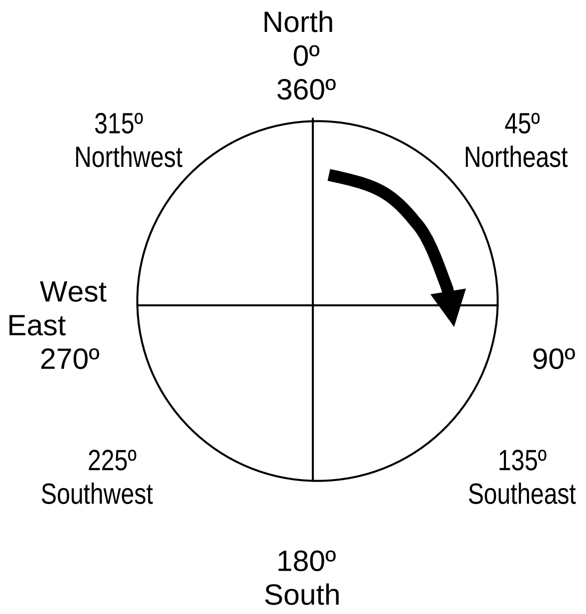
Report wind speeds in knots to air crews.	
Wind Speed Guidelines for Helicopter Flight Operations	
10 knots / 18.5 km/h ideal; OK to fly	Above 45 knots / 83 km/h; No Flights
Gusts above 20 knots / 37 km/h; No Flights	Max tailwind 5 knots / 6 km/h; No take off.
Advise air crews when wind velocities approach guideline limits.	

2.4 Wind Direction is an important weather variable. Keeping records of the change in wind direction over time can help forecast the weather. The key factor to watch for is the pattern of change in the wind direction to see if the winds are veering or backing (see the table on the next page). Winds are named for the direction from which they come. Thus, a north wind is blowing from the north going to the south.

You can measure the wind direction using a magnetic compass (very handy when moving around to different locations in the field) or make a wind tell-tale (if you have a fixed weather observation station.

Winds usually are not constant. The wind direction can vary as you are trying to measure it. So take several measurements and average the results. Remember it is not so important to know the exact wind direction. It is more important to detect the pattern of change over time.

2.4.1 Measuring Wind Direction with a Magnetic Compass

	To Measure Wind Direction: Imagine you are standing in the middle of the circle in the picture on the left. Step 1. Stand facing the wind (looking into the direction from which the wind is blowing). Step 2. Aim the magnetic compass directly into the wind, but keep the compass level so the needle swings freely. Step 3. Read off the azimuth angle in degrees ranging from 0º (starting at North) going clockwise around the circle. Step 4. Change the azimuth number into the name of the direction using the table below. Ultra precision is not needed. The general direction is good enough.
Veering Winds	Backing Winds
A veering wind that turns clockwise with height. It is associated with dynamic lifting because a south wind transports warmer air to the north. The magnitude of warm air lifting is a function of wind speed and the pre-existing thermal gradient. Weak winds will result in weak lifting. Winds often veer ahead of cold fronts (in the warm sector of a mid-latitude cyclone).	A backing wind is a wind that turns counter-clockwise with height. A backing wind is associated with cold air advection (sinking cooler air). Winds back behind cold fronts.

2.4.2 Making a Wind Tell-Tale: You can make a simple wind tell-tale to take actual field measurements of wind direction.

Materials: A piece wood 3" x 3"; a wire rod 6" long, a piece of yarn 6" long, a magnetic compass. (The dimensions are variable depending on the size you want instrument you want. This set is designed to be pocket-sized for portability.)

Procedures:

Step 1. Lay the wood flat on a table top.
Step 2. Draw 2 straight lines diagonally across the piece of wood from corner to corner to find its center.
Step 3. Lay the wood so one corner points away from you. Label the corners N, E, S, and W in a clockwise direction. (You can add indicators half way between the cardinal directions to indicate NE, SE, SW, and NW if you like.)
Step 4. Drill a small hole in the center and mount the wire rod perpendicular to the wood base.
Step 5. Tied the yarn to the top of the wire rod so it can hang freely for it full length.

2.4.3 Measuring Wind Direction with a Wind Tell-Tale:
Step 1. Find a clear open area away from buildings and other structures that might block or amplify the wind.
Step 2. Set up the wind tell-tale and orient it using a magnetic compass. Get the corner of the Wind Tell-tale labeled “N” to point to the North. (**Note**: If you use a magnetic compass and do NOT correct for magnetic declination, be sure to record your wind direction data as “magnetic” north directions. If you adjust for magnetic declination, then indicate your wind direction data is relative to “True” north. Be careful when making corrections for magnetic declination. This is a common source of errors in data records.)
Step 3. Step back and let the wind blow freely over the instrument.
Step 4. Look at the tell-tale yarn as it trails in the wind. Draw in imaginary line along the length of the tell-tale directly across the wooden base to the opposite side to read the wind direction. (**Note**: Remember, winds are named for the direction FROM which they come.)

2.4.4 Wind-chill Index: High wind speeds combined with low temperatures effectively reduce the sensible temperature. When cold air flows over your body, it removes from you heat by conduction. These conditions make you feel colder than the temperature you see on the thermometer. Cold, windy conditions can pose a threat to your survival.

The table below summarizes the wind-chill effects for various temperature and wind speeds. The risk categories are also shown at the bottom of the table. When working outdoors in cold, windy conditions, be very aware of the potential for wind-chill hazards. Under these conditions, it is best to work in teams with at least one person designated to monitor the wind-chill conditions AND to watch the other team members for signs of frostbite.

Wind Chill

Wind Velocity (km/h)	Measured Air Temperature (°C)									
0	5	0	-5	-10	-15	-20	-25	-30	-35	-40
5	4	-2	-7	-13	-19	-24	-30	-36	-41	-47
10	3	-3	-9	-15	-21	-27	-33	-39	-45	-51
15	2	-4	-11	-17	-23	-29	-35	-41	-48	-54
20	1	-5	-12	-18	-24	-31	-37	-43	-49	-56
25	1	-6	-12	-19	-25	-32	-38	-45	-51	-57
30	0	-7	-13	-20	-26	-33	-39	-46	-52	-59
35	0	-7	-14	-20	-27	-33	-40	-47	-53	-60
40	-1	-7	-14	-21	-27	-34	-41	-48	-54	-61
45	-1	-8	-15	-21	-28	-35	-42	-48	-55	-62
50	-1	-8	-15	-22	-29	-35	-42	-49	-56	-63
55	-2	-9	-15	-22	-29	-36	-43	-50	-57	-63
60	-2	-9	-16	-23	-30	-37	-43	-50	-57	-64
65	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65
70	-2	-9	-16	-23	-30	-37	-44	-51	-59	-66
75	-3	-10	-17	-24	-31	-38	-45	-52	-59	-66
80	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67

Travel can be dangerous

Use heated vehicles; temporary shelters unsuitable and dangerous.

Starts danger of frostbite and possible death.

Frostbite in 30 minutes

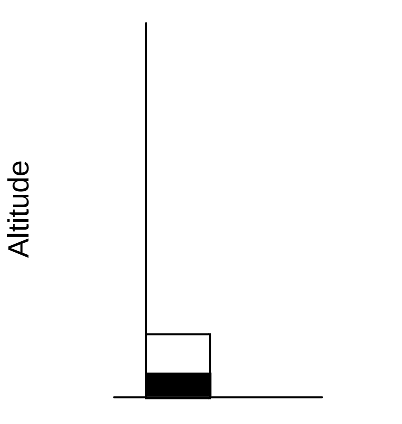
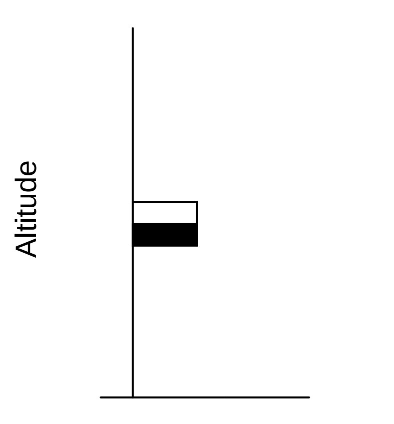
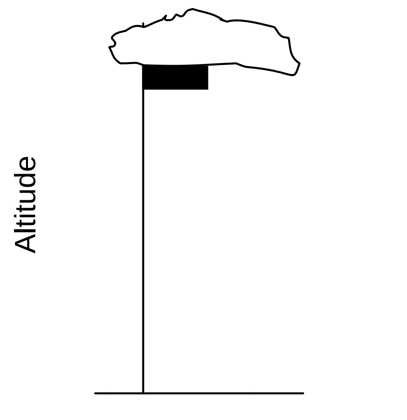
Frost-bite in 10 minutes

Frostbite within 5 minutes

Adapted by G.K. Lee for RTC-TH M.E.W.S.

2.5 Moisture is any form of water in the atmosphere. Water can take the form of a solid, liquid, or gas at normal atmospheric temperatures and pressures. Gaseous water (water vapor) is most commonly reported as relative humidity in weather reports. Solid and liquid water is reported as precipitation. You can get these data from local radio and TV weather reports. However, the actual weather station recording the data may not be in the local area of your study site. In that case, you need to make on-site measurements.

2.5.1 Relative Humidity is the measurement of the moisture in the air stated as a ratio to the amount of moisture that could be held if the air were saturated. Air temperature affects relative humidity. Warm air can hold more moisture than cold air. Since air temperature decreases with altitude, relative humidity can increase as air rises from the surface. . Liquid water at the surface can be changed to a gas (evaporated). If the air is lifted and cooled sufficiently, condensation occurs. The water vapor changes from gas back to liquid. This is a simplified explanation of cloud formation. Generally, as the air rises and cools, the actual amount of moisture in the air remains the same. The water holding capacity of the air is decreased, so the relative humidity increases.

Air at the surface	Air rising from the surface	Air at the LCL
		
Air at the surface starts off at a given temperature and given amount of moisture = a certain relative humidity.	As it rises, the air temperature decreases reducing the ability of the air to hold water; the relative humidity increases.	At the Lifting Condensation Level (LCL), the air becomes saturated (relative humidity = 100%). Clouds can begin to form

Three key terms are involved here: Saturation, Dew Point Temperature, and the Lifting Condensation Level (LCL). Saturation is when the relative humidity equals 100%. The Dew Point Temperature (Dew Point) is the temperature at which saturation occurs. The LCL is the altitude above sea level where rising air is cooled to the Dew Point so that Saturation occurs.

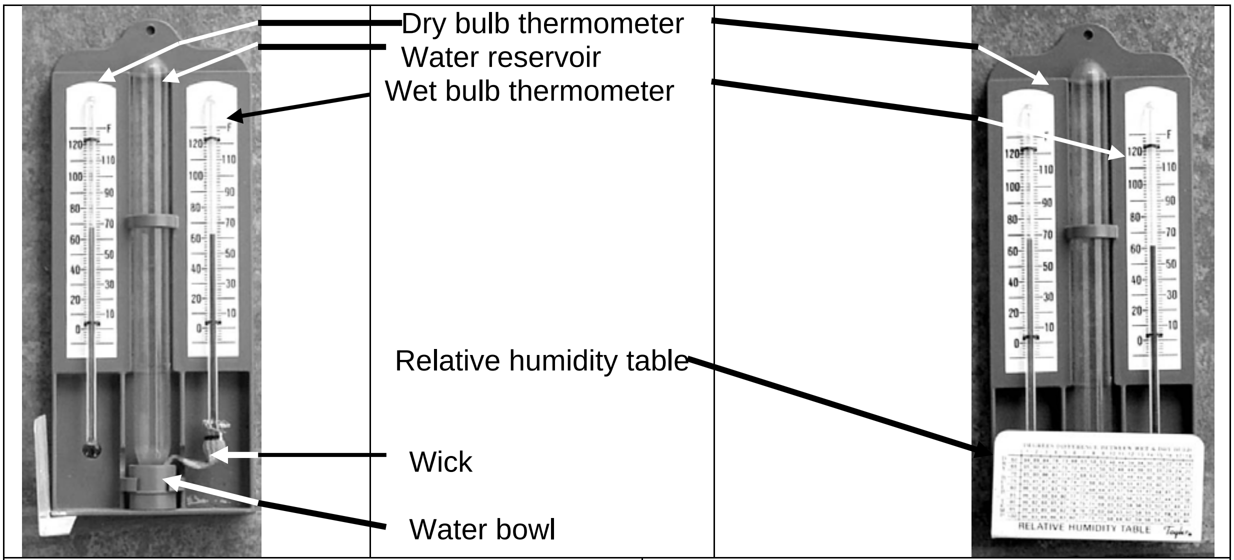
Each day, and sometimes each hour, the temperature and relative humidity of the air at the surface varies. Thus, saturation, the dew point, and the LCL are not constant and change each day / hour.

If you are not able to make repeated weather observations throughout the day, you should plan to make your weather observations each morning at 9 AM local time. This is the standard practice for weather observers around the world. Following this practice lets you correlate your local weather observations with other available records.

2.5.2 The Hygrometer is an instrument for measuring relative humidity. There are various models available. These instructions are for a hygrometer with two thermometers: a dry bulb and a wet bulb. It is not very portable. It would normally be permanently attached to a wall. If it is outdoors, it should be placed in the shade.

The water reservoir supplies water to saturate a cloth wick wrapped around the base of the wet bulb thermometer. As the water from the cloth wick is evaporated, heat is removed from the wick, lowering the temperature. It is important to keep an ample water supply in the instrument. Clean water must be used to avoid contaminating the wick. Mineral encrustations on the wick will affect the evaporation rate and lead to erroneous readings.

Regular monitoring of the hygrometer should be coordinated with the other weather observations. If only one observation can be done each day, standardize the readings to 9 AM local time each morning.



Dry Bulb – Wet Bulb Thermometer with open case showing the water bowl and wick.	Dry Bulb – Wet Bulb Thermometer with closed case showing relative humidity table.

Procedure:

Step 1. Fill the water reservoir with CLEAN, FRESH water.

Step 2. Be sure the wick on the wet bulb is clean and thoroughly wet.

Step 3. Set up the hygrometer in a shady location. [**NOTE**: Watch the wet bulb thermometer carefully. When the temperature stops decreasing, get the wet bulb temperature.]

Step 4. Record the dry and wet bulb temperatures using a standard format (see the sample below).

Step 5. Calculate the difference between the two temperatures. (**Note**: Subtract the wet bulb temperature from the dry bulb temperature. Usually, the wet bulb temperature will be lower.)

Step 6. Get the Relative Humidity Table (see next page).

Step 7. Find the difference between dry and wet bulb temperatures along the horizontal scale of the chart.

Step 8. Find the dry bulb temperature along the vertical scale of the chart.

Step 9. Find the intercept of these two in the center of the chart. This is the relative humidity; record this on your worksheet.

<table>
<tr><td colspan="3">Location:</td><td>Date:</td></tr>
<tr><td colspan="3">Recorded by:</td><td>Time:</td></tr>
<tr><td>Measurement</td><td>Hygrometer</td><td colspan="2" rowspan="5">Step 1. Read and record the wet bulb temperature in row B.
Step 2. Read the record the dry bulb temperature in row A.
Step 3. Subtract the wet bulb temperature (B) from the dry bulb temperature (A); write the result in row C.
Step 4. For the hygrometer, use the psychometric table to find the relative humidity. For the sling psychrometer, use the sliding scale on the instrument.</td></tr>
<tr><td>A. Dry Bulb Temperature</td><td></td></tr>
<tr><td>B. Wet Bulb Temperature</td><td></td></tr>
<tr><td>C. Dry-Wet Bulb Temp.</td><td></td></tr>
<tr><td>Percent Relative Humidity</td><td></td></tr>
</table>

Relative Humidity Chart for °C Temperatures

Dry Bulb Temperature (Air Temperature °C)	Dry Bulb Temperature minus Wet Bulb Temperature in °C																	
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
-20	70	41	11															
-17.5	75	51	26	2														
-15	79	58	38	18														
-12.5	82	65	47	30	13													
-10	85	69	54	39	24	10												
-7.5	87	73	60	48	35	22	10											
-5	88	77	66	54	43	32	21	11	1									
-2.5	90	80	70	60	50	42	37	22	12	3								
0	91	82	73	65	56	47	39	31	23	15								
2.5	92	84	76	68	61	53	46	38	31	24								
5	93	86	78	71	65	58	51	45	38	32	1							
7.5	93	87	80	74	68	62	56	50	44	38	11							
10	94	88	82	76	71	65	60	54	49	44	19							
12.5	94	89	84	78	73	68	63	58	53	48	25	4						
15	95	90	85	80	75	70	66	61	57	52	31	12						
17.5	95	90	86	81	77	72	68	64	60	55	36	18	2					
20	95	91	87	82	78	74	70	66	62	58	40	24	8					
22.5	96	92	87	83	80	76	72	68	64	61	44	28	14	1				
25	96	92	88	84	81	77	73	70	66	63	47	32	19	7				
27.5	96	92	89	85	82	78	75	71	68	65	50	36	23	12	1			
30	96	93	89	86	82	79	76	73	70	67	52	39	27	16	6			
32.5	97	93	90	86	83	80	77	74	71	68	54	42	30	20	11	1		
35	97	93	90	87	84	81	78	75	72	69	56	44	33	23	14	6		
37.5	97	94	91	87	85	82	79	76	73	70	58	46	36	26	18	10	3	
40	97	94	91	88	85	82	79	77	74	72	59	48	38	29	21	13	6	
42.5	97	94	91	88	86	83	80	78	75	72	61	50	40	31	23	16	9	2
45	97	94	91	89	86	83	81	78	76	73	62	51	42	33	26	18	12	6
47.5	97	94	92	89	86	84	81	79	76	74	63	53	44	35	28	21	15	9
50	97	95	92	89	87	84	82	79	77	75	64	54	45	37	30	23	17	11

- Use the hygrometer to get the Dry Bulb and the Wet Bulb Temperature. Example, Dry Bulb = 30°C, Wet Bulb = 28°C.
- Subtract the Wet Bulb temperature from the Dry Bulb temperature. Example, 30°C – 28°C = 2°C. Find the column for 2°C across the top of the chart.
- Locate 30°C in the Air Temperature column at the left side of the chart.
- Find the intersection of the column and row to get the % relative humidity. For the example of 2°C and 30°C, the relative humidity is 86%.

2.5.3 Heat Stress Index: During the summer, if you know the air temperature and the relative humidity, you can use the table below to determine the Heat Stress Index. Every living organism has a range of temperatures it can tolerate. When the temperatures get to the extremes, either too high or too low, the organism may die. If the temperatures are too high, people are subjected to heat stress related discomfort, illness, and possibly death.

Generally, higher relative humidity conditions effectively make you feel warmer than the measured temperature shown on a thermometer. This is due to the fact that your body uses evaporation to cool itself. When the relative humidity is high, evaporation is slowed. This effectively reduces the ability of your body to cool itself. As you internal temperature rises, so does your discomfort level.

To avoid the dangers of heat stress illness, do the obvious: stay out of the sun and minimize physical activity. Can you understand why drinking an iced beverage is not an effective practice to keeping yourself cool?

Heat Stress Index (Sensible Temperature)

Air Temp	Relative Humidity								
	10%	20%	30%	40%	50%	60%	70%	80%	90%
46°C	44°C	49°C	57°C	66°C					
43°C	41°C	44°C	51°C	58°C	56°C				
41°C	38°C	41°C	45°C	51°C	57°C	65°C			
38°C	35°C	37°C	40°C	43°C	49°C	56°C	62°C		
35°C	32°C	34°C	36°C	38°C	42°C	46°C	51°C	58°C	
32°C	29°C	31°C	32°C	34°C	36°C	38°C	41°C	45°C	50°C
29°C	27°C	28°C	29°C	30°C	31°C	32°C	34°C	36°C	36°C
27°C	24°C	25°C	26°C	26°C	27°C	28°C	29°C	30°C	31°C

Danger Level	I Caution	II Extreme Caution	III Danger	IV Extreme Danger	---
Heat Index	27-32°C	32-40°C	40-54°C	Above 54°C	Relative humidity rarely observed
Heat Syndrome	Fatigue possible with prolonged exposure and/or physical activity	Sunstroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity	Sunstroke, heat cramps, or heat exhaustion likely; heat stroke possible with prolonged exposure and/or physical activity	Heat / sunstroke highly likely with continued exposure	Generally not applicable but conditions would be extremely dangerous

- Use a hygrometer placed in a shaded position about 1.2 m / 5 ft above the ground.
- Air Temperature is read from the Dry Bulb Thermometer.
- Relative Humidity is calculated using the Relative Humidity Table. This requires the following data: Air Temperature and the Temperature Difference between the Dry and Wet Bulb readings.

2.5.4 Precipitation is any solid or liquid water falling from a cloud. Precipitation is often measured using a rain gauge (except for snow, which is recorded by depth on the ground). The rain gauge should be placed in an open area, preferably over a grassy surface so rain drops won't splash into the collector. You should check the rain gauge at about 9am each day for a 24-hour period.

2.5.4.1 MAKE A SIMPLE RAIN GAUGE: You can make a simple rain gauge using empty plastic bottles.

Materials: a large empty plastic bottle (about 1 liter); a smaller plastic bottle (less than 1 liter; it must fit inside the larger bottle); a pair of scissors.

Procedures:

Step 1. Cut the top off a large bottle about two thirds of the way up.

Step 2. Turn the top upside down and put it into the bottom part like a funnel.

Step 3. Cut the top off the smaller bottle to make a collecting cup. (The height is determined by the space inside the larger bottle. The collector cup should fit under the "funnel" opening of the larger bottle to catch the rain.)

Step 4. Place the small bottle inside the bottom part of the large bottle.

Step 5. Place the rain gauge in an open space and away from trees and buildings. You can set it on the ground. But make sure it doesn't tip over or get blown over by the wind. Or you can mount it to a pole no more than 1 m / 3 ft above the ground.

Step 6. The rain gauge must be checked daily at the same time each day. Weather observers use a standard time of 9 am local time. Dew can collect inside the rain gauge and lead to false readings. So don't let the dew accumulate between your rain gauge readings.

2.5.4.2 Measuring Rainfall

Step 1. Carefully pour the water from the rain gauge collecting container into a graduated cylinder.

Step 2. Be sure the graduated cylinder is placed on a flat, level surface.

Step 3. Carefully view the level of the water in the cylinder. Take the reading at lowest point at the center of the cylinder (not at the walls of the cylinder).

Step 4. If there is a lot of water, measure the water in increments by emptying the graduated cylinder and refilling it until you have measured all of the collected water.

Step 5. All up all the incremental measurements and add them together. Record the rainfall amount.

2.6 CLOUD OBSERVATIONS:

2.6.1 Cloud Identification: Clouds are classified on the basis of their altitude (height above the ground) and their general shape. Fog can be considered clouds that are low to the ground. [**Note**: There are some significant differences how fog and clouds are made. But their physical appearance is similar.] Clouds classified on the basis of their altitude and shape.

There are 3 general altitude groups: low (ground level to 6,500-7,000 feet), middle (6,500-7,000 to 20,000 feet) and high (20,000-40,000+ feet). Some clouds extend vertically across these layers. The vertical development is so significant these clouds are put into a separate category.

The basic terms for cloud shape include: ***cumulus*** (Latin for "heap") usually found from 4,000-5,000 feet; ***cirrus*** (Latin for "curl") found above 18,000-20,000 feet and often signal an approaching storm; ***stratus*** (Latin for "spreading out" or "layered") found at low altitudes (2,000-7,000 feet) often signaling bad weather is coming; ***nimbus*** (Latin for "rain") low clouds that bring rain. There are also combination terms that modify the basic terms: ***alto*** (Latin for "high") can be combined to form ***altostratus, altocumulus*** which are middle altitude clouds with a stratus or cumulus form.

RTC-TH MEWS Simplified Cloud Identification Chart			
High **12,000 m to 6,000m**	 Cirrus	 Cirrostratus	**Vertically Developed** **12,000m to 500m**
	 Cirrocumulus	 Contrails	
Middle **6,000m to 2,000 m**	 Altostratus	 Altocumulus	 Cumulonimbus
Low **2,000m to Surface**	 Stratus	 Stratocumulus	
	 Nimbostratus	 Fog (ground level)	 Cumulus

Estimating Cloud Base Height: Identify cloud type; report Low clouds as 2000m, use lower limit for other cloud types.

Flight Advisories: Report flight advisory to air crews for the following conditions.

Low Clouds near or at l60m AGL (day); 500m AGL (Night). No flights if below these minimum limits.

Reduced Visibility: Smoke, dust, haze, fog reducing visual range to 3.2 km (Day) or 5 km (Night); No flights if below these minimum limits.

Severe Weather: Thunderstorms, lightning, heavy rain, excessive winds, or other weather extremes.

CLOUDS					
Code	**Name**	**Description**	**Altitude** m	**Altitude** ft	Class
Ci	Cirrus	Delicate, wispy, feathery; streaky, stringy; slow moving; doesn't block the sun; mares tails—large ice crystals extending down	6,000 to 12,000	20,000 to 40,000	HIGH **(ice)**
Cc	Cirrocumulus	Thin sheets or closely packed small puffs without shadows; "mackerel" sky			
Cs	Cirrostratus	Whitish veil, usually fibrous; makes halo around the sun or moon.			
Ac	Altocumulus	Layer of separate cloud masses; fit closely in geometric pattern; blue sky visible between masses; white or gray on shaded side; associated with bad weather.	2,000 to 6,000	6,500 to 20,000	MIDDLE
As	Altostratus	Extensive, eve, gray layer over entire sky; gray, smooth bottom; sun is a bright spot; associated with bad weather.			

CLOUDS					
Code	**Name**	**Description**	**Altitude** m	**Altitude** ft	Class
St	Stratus	Dense, dark gray layer; uniform base	Ground to 2,000	Ground to 6,500	LOW
Ns	Nimbostratus	Dense, dark gray layer with precipitation (rain or snow); thick enough to block the sun			
Sc	Stratocumulus	Distinct gray masses (long rolls, right angles to the wind and cloud motion) with patches of open sky, flat tops; often associated with fair or clearing weather; but snow flurries or rain are possible from individual cloud masses.			
Cu	Cumulus	White, wooly mass, flat base, lumpy top; gray or dark on shaded side or bottom; small clouds associated with fair weather.	300 to 1,525	1,000 to 5,000	VERTICAL
Cb	Cumulonimbus	White, anvil shaped top; very dark base; vertical dimension greater than horizontal; heavy rainfall, thunder, lightning, gusty winds, hail possible; strong updrafts	300 to 12,000	1,000 to 40,000	

FOG		
Code	**Name**	**Description**
Fr	Radiation Fog	Often associated with a temperature inversion; bottom layer of air (closest to ground) cools below the dew point.
Fa	Advection Fog	Warm, moist air moves over a cold surface (snow, ice, or cool ocean current) and cools below the dew point.
Fo	Orographic Fog	Warm, moist air is forced upslope and is cooled below the dew point.
Fe	Evaporation Fog "Steam Fog" "Sea Smoke"	Evaporation adds water vapor to air that is already cool and near saturation (high relative humidity); cool air passing over warm water increases the relative humidity so that evaporation adds the needed water vapor to attain saturation.
Note: Fog is sometimes called "clouds close to the ground." Sometimes it is considered precipitation (as is the case with this observation form).		

Procedure:
Step 1. Look up and observe the general appearance of a cloud.

Step 2. Try to recognize its basic shape: puffy (***cumulus***), thin and flat (***stratus***), or thin, wispy and curly (***cirrus***). Compare its appearance to the examples and the text descriptions in the accompanying materials.

Step 3. Try to estimate its height---low, medium, or high.

[**Note:** Keep good observation records. Some types of clouds will often appear before a storm arrives. This can be a very useful weather prediction method.

2.6.2 Calculating the Dew Point Temperature: The ***dew point temperature*** is the temperature at which the relative humidity equals 100% (***saturation***). This is important because this is the temperature when water vapor (the gaseous form of water) begins to change to a liquid form; in other words, ***condensation*** begins at the dew point. The air temperature and relative humidity at any given time on any given day is different. So the dew point temperature will also be different from hour to hour or day to day.

You can use this information in a number of ways: 1) to estimate the height of the low clouds; 2) estimate when condensation will form (and get your camping gear wet over night); 3) estimate if your hike or climb will get into the cloud layer on a mountain (which helps you to prepare the proper clothing and equipment).

Step 1. Get the dry and wet bulb temperatures. Record the time of day.

Step 2. Calculate the wet bulb depression by subtracting the wet bulb temperature from the dry bulb temperature.

Step 3. Get the dew point temperature reference table. Look up the dry bulb temperature on the left hand column.

2.6.3 Estimating Cloud Base Height: Air lifted from the Earth's surface is usually not saturated (relative humidity is less than 100%). As it rises, it cools adiabatically (cooling by expansion) at a rate of 9.78°C/1000 m. If you know the temperature and relative humidity conditions at the surface (your location), you can estimate the height of the clouds over your location.

Step 1. Measure the air temperature and relative humidity for your location.

Step 2. Calculate the dew point temperature.

Step 3. Subtract the dew point temperature from the dry bulb temperature.

Step 4. Divide the result (the wet bulb depression) by 9.78.

Step 5. Multiple the results by 1000 to get the estimated height (in meters) of the base of the clouds overhead.

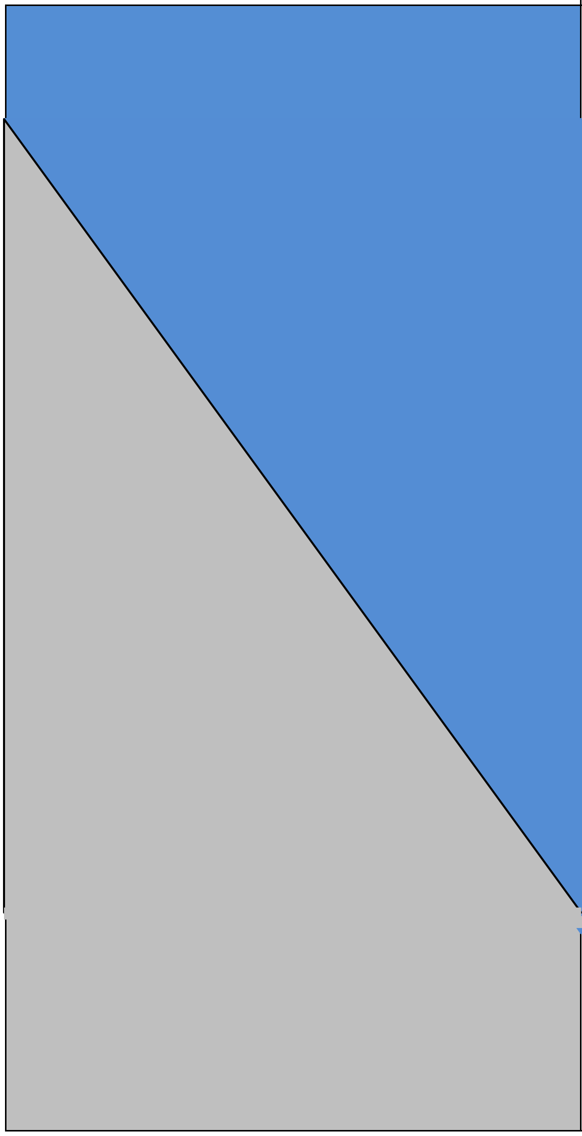
DEW POINT TEMPERATURE CHART (°C)

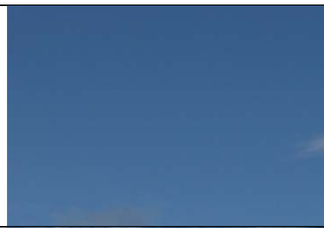
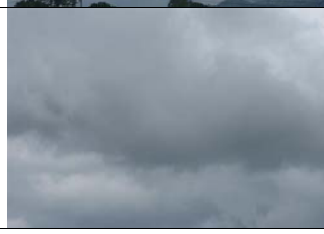
Dry Bulb Temperature (Air Temperature °C)	Dry Bulb temperature minus Wet Bulb temperature in °C															
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0
-20	-25	-33														
-17.5	-21	-27	-38													
-15	-19	-23	-28													
-12.5	-15	-18	-22	-29												
-10	-12	-14	-18	-21	-27	-36										
-7.5	-9	-11	-14	-17	-20	-26	-34									
-5	-7	-8	-10	-13	-16	-19	-24	-31								
-2.5	-4	-6	-7	-9	-11	-14	-17	-22	-28	-41						
0	-1	-3	-4	-6	-8	-10	-12	-15	-19	-24						
2.5	1	0	-1	-3	-4	-6	-8	-10	-13	-16						
5	4	3	2	0	-1	-3	-4	-6	-8	-10	-48					
7.5	6	6	4	3	2	1	-1	-2	-4	-6	-22					
10	9	8	7	6	5	4	2	1	0	-2	-13					
12.5	12	11	10	9	8	7	6	4	3	2	-7	-28				
15	14	13	12	12	11	10	9	8	7	5	-2	-14				
17.5	17	16	15	14	13	12	12	11	10	8	2	-7	-35			
20	19	18	18	17	16	15	14	14	13	12	6	-1	-15			
22.5	22	21	20	20	19	18	17	16	16	5	10	3	-6	-38		
25	24	24	23	22	21	21	20	19	18	18	3	7	0	-14		
27.5	27	26	26	25	24	23	23	22	21	20	16	11	5	-5	-32	
30	29	29	28	27	27	26	25	25	24	23	19	14	9	2	-11	
32.5	32	31	31	30	29	29	28	27	26	26	22	18	13	7	-2	
35	34	34	33	32	32	31	31	30	29	28	25	21	16	11	4	
37.5	37	36	36	35	34	34	33	32	32	31	28	24	20	15	9	0
40	39	39	38	38	37	36	36	35	34	34	30	27	23	18	13	6
42.5	42	41	41	40	40	39	38	38	37	36	33	30	26	22	17	11
45	44	44	43	43	42	42	41	40	40	39	36	33	29	25	21	15
47.5	47	46	46	45	45	44	44	43	42	42	39	35	32	28	24	19
50	49	49	48	48	47	47	46	45	45	44	41	38	35	31	28	23

- Use the hygrometer to get the Dry Bulb and the Wet Bulb Temperature. Example, Dry Bulb = 30°C, Wet Bulb = 28°C.
- Subtract the Wet Bulb temperature from the Dry Bulb temperature. Example, 30°C – 28°C = 2°C.
- Find the column for 2°C across the top of the chart. Locate 30°C in the Air Temperature column at the left side of the chart. Find the intersection of the column and row to get the Dew Point Temperature. For the example of 2°C and 30°C, the Dew Point Temperature is 27°C.
- Divide 27°C by 10°C = 2.7 X 1000 m = 2700 m (the altitude of the bottom of the clouds)

2.6.4 Cloud Cover: The amount of clouds covering the sky affects how much sunlight gets to the Earth's surface. This has significance to famers because it affects surface temperatures and dissolved oxygen levels in fish ponds. Cloudy days can mean lower temperatures. Cloudy nights can be warmer than clear nights.

Use the table below to estimate the amount of cloud cover over your area.



Sky Condition: Cloud Cover Terms	
Clear Sky is blue with no clouds or very few small clouds.	
Scattered Sky is blue, but small patches of clouds are present.	
Broken Large patches of clouds, but patches of blue sky can be seen between the clouds.	
Cloudy The sky is covered mostly with clouds and a few blue patches.	
Overcast Clouds cover the sky; no patches of blue can be seen.	

3.0 WEATHER FORECASTING: Although radio / TV weather reports are readily available, they have three primary shortcomings:

- They tend to be general wide area forecasts that may not apply to the specific local conditions at your site.
- The weather station data used may be distantly located to your site.
- Local terrain conditions could vary significantly over a short distance so that even a nearby weather station data may not always apply to your site.

For these reasons, you would be wise to learn to observe the sky conditions overhead and have an idea of the impending weather. There are numerous cases of families on a picnic deciding to take a walk or a hike only to find themselves stranded due to rapidly changing weather conditions. Mountainous areas are well-known for fast changes of weather.

There are two basic simplified weather forecasting methods presented in this paper: Wind and Cloud Method and the Barometer (Pressure) and Wind Method. (Note: If needed, review the previous sections of this paper for details on how to measure wind speed, wind direction, and how to identify clouds.)

3.1 WIND AND CLOUD FORECASTING METHOD: Follow these basic steps to a simple weather forecast using the following steps:

Step 1. Determine the true wind direction. (**Note**: This requires adjusting local magnetic compass measurements for the proper magnetic declination.)

Step 2. Watch for the pattern of change in the wind direction over time.

Step 3. Identify the cloud formations. Keep a log and watch for changes over time.

<table>
<tr><th>Fair Weather</th><th>Changing Weather</th><th>Stormy Weather</th></tr>
<tr><td rowspan="2">Cumulus</td><td>Cirrus
Cirrostratus
Cirrocumulus</td><td>Altocumulus
Altostratus
Cumulonimbus
Nimbostratus</td></tr>
<tr><td colspan="2">Stratus
Stratocumulus</td></tr>
</table>

Step 4. Determine if the cloud density (overall cloud coverage of the sky) is increasing or decreasing.

- Thickening clouds can indicate wet weather is on the way.
- Thinning clouds or breaks in clouds can indicate clearing is on the way.

Step 5. Determine if the cloud height is increasing or decreasing. (Note: Cloud types are grouped by altitude; low, middle, high.)

- Decreasing clouds heights can indicate wet weather is on the way.
- Increasing cloud heights can indicate a break in weather; clearing on the way.

Step 6. Combine the cloud identification and wind direction change information and use the Wind and Cloud Forecasting Summary Table below for a simplified forecast.

3.2 PRESSURE AND WIND FORECASTING METHOD:

Step 1. Watch for changes in barometric pressure.

- Rising pressure indicates a trend toward fair weather.
- Steady pressure (little or no change) indicates present weather condition will continue.
- Falling pressure indicates a trend toward stormy weather.

Step 2. Determine the rate of change in barometric pressure. The common terms used are:

- Slowly = less than 3 mb change in 3 hours (0.885 in Hg / 3 hrs)
- Moderately = 3-6 mb change in 3 hours (0.885 to 0.177 in Hg/3 hrs)
- Fast (rapidly) = more than 6 mb change in 3 hr (more than 0.177 in Hg/3hrs)
- Steady = little or no change

Step 3. Determine the true wind direction. (**Note**: This requires adjusting local magnetic compass measurements for the proper magnetic declination.)

Step 4. Watch for the change in wind direction over time.

Step 5. Combine the barometric pressure measurement, the rate of change in barometric pressure, with the change in wind direction. See the summary table below for a simplified forecast.

WIND AND CLOUD WEATHER FORECASTING SUMMARY TABLE

Equipment needed to complete this form	Optional equipment
[ ] Magnetic compass [ ] Cloud chart [ ] Pen / Pencil	[ ] binoculars [ ] camera [ ] sketch pad

Time of Observations			**Wind Dir.**	**Cloud Type**	**Your Forecast**	
Morning	0600	6 am			Time:	
Mid-morning	0900	9 am			**Forecast:**	
Noon	1200	12 pm				
Mid-afternoon	1500	3 pm				
Evening	1800	6 pm				

Note: Wind direction is the direction the wind comes from; W = blowing from the west.

Cloud-Wind Forecasting Summary Table (Adapted for the western US)

Clouds		**Wind Shift**	**Weather Forecast**	
W of Mtns	**E of Mtns**		**W of Mtns**	**E of Mns**
Stratus Stratocumulus	None	NW to W to SW	Rain possible from coast to mtns.	Fair
Stratocumulus Stratus; (SE winds)	-----	SE to S	Rain possible from coast to mtns	Fair
Cumulus or Clear; (S winds)	-----		Fair	
Clear skies		NE to E	Fair	

Brief Summary of Cloud Types and Conditions

Cumulus	Cirrus	Stratus	Nimbostratus
Rain possible especially on hot summer days and clouds get thick and dark.	Storm coming in the next 24-48 hours.	Bad weather approaching when clouds are stretched out in calm flat layers; drizzly rain	Rainstorm likely when dark gray clouds are low, cover the sky widely; drizzly rain

Stratocumulus	Altocumulus	Altostratus
Widespread, drizzly rain.	Settled weather conditions.	Changing weather.

PRESSURE – WIND WEATHER FORECASTING SUMMARY TABLE

Equipment needed to complete this form	Optional equipment
[ ] Magnetic compass [ ] Cloud chart [ ] Pen / Pencil	[ ] binoculars [ ] camera [ ] sketch pad

Time of Observations			**Barometer**	**Wind Dir.**	**Your Forecast**	
Morning	0600	6 am			**Time:**	
Mid-morning	0900	9 am			**Forecast:**	
Noon	1200	12 pm				
Mid-afternoon	1500	3 pm				
Evening	1800	6 pm				
Wind direction change		☐ Veering ☐ Backing				

Note: Wind direction is the direction the wind comes from; W = blowing from the west.

FORECASTING BY BAROMETER & WIND DIRECTION DATA

Sea Level Press In Hg	Wind Dir	Forecast
30.1 to 30.2 Steady	SW to NW	Fair with slight temperature changes for 1 or 2 days.
30.1 to 30.2 Rising fast		Fair followed in 2 days by warmer temperatures and rain.
30.1 to 30.2 Falling slowly		Warmer with rain in 24 to 36 hrs.
30.1 to 30.2 Falling fast		Warmer with rain in 18 to 24 hrs.
30.2+ Stationary		Continued fair with no decided temperature change.
30.2+ Falling slowly		Slowly rising temperature and fair for 2 days.
30.1 to 30.2 Falling slowly	S to SE	Rain within 24 hrs.
30.1 to 30.2 Falling fast		Wind increasing in force with rain within 12 to 24 hrs.
30.1 to 30.2 Falling slowly	SE to NE	Rain in 12 to 18 hrs.
30.1 to 30.2 Falling fast		Increasing wind with rain in 12 hrs.
30.1+ Falling slowly	E to NE	Summer: light winds, rain may not fall for several days Winter: rain within 24 hrs.
30.1+ Falling fast		Summer: rain probable within 12 to 24 hrs. Winter: rain or snow with increasing winds from NE.
30.0 or less Falling slowly	SE to NE	Rain will continue 1 to 2 days.
30.0 or less Falling fast		Rain with high wind; clearing and cooler in 24 hrs.
30.0 or less Rising slowly	S to SW	Clearing within a few hours; continued fair for several days.
29.8 or less Falling fast	S to E	Severe storm of wind and rain or snow imminent; clearing and colder in 24 hrs.
29.8 or less Falling fast	E to N	Severe NE gales and heavy rain or snow followed by winter cold wave.
29.8 or less Rising fast	Going to W	Clearing and colder.

Notes on Barometer changes

Slowly = under 3 mb/3 hours (0.885 in Hg/3 hrs)
Moderately = 3-6 mb/3 hours (0.885 to 0.177 in Hg/3 hrs)
Fast (rapidly) = over 6 mb/3 hr (more than 0.177 in Hg/3hrs)
Steady = little or no change

Pressure Conversions

Inches Hg to Mb		Mb to Inches Hg	
30.2	1023.7	1023	30.1785
30.1	1020.3	1019	30.0605
30.0	1016.9	1016	29.9720
29.8	1010.1	1009	29.7655

3.3 SOME WEATHERWISE SAYINGS: Over time, consistent observations persisted to the point that popular sayings were devised.

- Rainbow in the morning, sailors take warning; Rainbows at night, sailors delight.
- Winds that swing with the sun and winds that bring the rain are one. Winds that swing around the sun, keep the rainstorm on the run.

4.0 SUMMARY

The Geographic Systems Model (with the attendant environmental checklists) and the General Systems Matrix help to guide studies of our complex environment. The basic components were briefly described with notes indicating key linkages between the checklists.

It takes practice to thoroughly review a study site. Repeated practice in using the checklists hones your observation skills over time. It doesn't happen overnight, and it certainly doesn't come easy. Usually no one person will be able to carry the full load alone. Teamwork helps. Brainstorming and open communication (constructive discourse) brings forth the synergy of a team effort.

The notes in any one cell of the summary table on the next page are necessarily brief. But having this summary fit on one page helps give you the big picture in a single glance. However, you must supplement the notes in the table with the details of this paper AND the text readings---as a start. This is only the opening shot in a larger battle you will wage in the quest of finding the salient facts. Pay particular attention to the cross-reference notes linking one checklist item to other checklists. The Geographic Systems Model is highly interconnected. The myriad and multiple interconnections is a significant challenge for students of the environment.

Be fully prepared to not find the "single" correct answer at the end of your quest (assuming it has an end---they usually are ongoing sagas). The most likely end will be a range of solution alternatives forcing you to make hard choices resulting in short term gains at the expense of long-range goals, or making sacrifices today for uncertain future long term gains. Nothing is guaranteed. Conditions are in flux and continue to change, even as you observe and measure them

NOTE: The attached Weather Observation Log forms are used for the RTC-TH EmComm MEWS program (Emergency Communications Mobile Emergency Weather Station).

. Although the purpose of MEWS is different from GROW, many of the observations are similar. The use of the MEWS Observation Log form gives you a systematic form to record weather observations on your farm. It also gives you an opportunity to develop weather observation skills adaptable for use in times of emergency. The fundamental idea in the RTC-TH community-based education program is integration of knowledge and skills applied widely to various aspects of life.

RTC-TH M.E.W.S. Weather Observation Log

M.E.W.S. Mobile Emergency Weather Station – RTC Thailand

Ready to serve and sustain our community.

1. Header					
Location					
Lat ° ' " N		Long ° ' " E			
Lat N		Long E		Elev m AMSL	
Date		Weather Observations Time			
		Sunrise	Mid-Afternoon	Sunset	
Local time 24-hr format	Hour→				
Observer (initial; see back)					

				Sunrise	Mid-Afternoon	Sunset
2. Temperature / Relative Humidity	2.1	Air (Dry bulb)	Thermometer in shade; 1.5 m above ground	°C	°C	°C
	2.2	Wet Bulb		°C	°C	°C
	2.3	Difference	Subtract 2.2 from 2.1;	°C	°C	°C
	2.4	Rel. Humidity	Use 2.1, 2.3; R H Table	%RH	%RH	%RH
	2.5	Dew Point	Use 2.1, 2.3; Dew Pt Table	°C	°C	°C
	2.6	Heat Stress	Use 2.1, 2.4 ; HSI Table	Heat Stress °C	Heat Stress °C	Heat Stress °C
			Danger Level (if any from Heat Stress Index table)	□Cautn □Danger □ Ex Cautn □Ex Dangr	□Cautn □Danger □ Ex Cautn □Ex Dangr	□Cautn □Danger □ Ex Cautn □Ex Dangr
	2.7	Wind Chill	Use 2.1, 3.1; Wind Chl Tbl	Wind Chill. °C	Wind Chill. °C	Wind Chill. °C
			Danger Level (if any from Wind Chill chart)	□Trvl Dngr □Frstbte10 □TShltr Dgr □Frstite30 □Frostbite □Frstbte5	□Trvl Dngr □Frstbte10 □TShltr Dgr □Frstite30 □Frostbite □Frstbte5	□Trvl Dngr □Frstbte10 □TShltr Dgr □Frstite30 □Frostbite □Frstbte5
3. Wind Speed / Direction	3.1	Report wind speed in ***knots to air crews;*** km/h to all others.				
		Average	Get 3 readings & average	km/h knts	km/h knts	km/h knts
		Gusts	Record highest gust	km/h knts	km/h knts	km/h knts
		Wind Speed Guidelines for Helicopter Flight Operations				
		10 knots / 18.5 km/h ideal; OK to fly		Above 45 knots / 83 km/h; No flights.		
		Gusts above 20 knots/ 37 km/h; No flights		Max tailwind 5 knots/ 6 km/hr; No take off		
	3.2	Steady Wind Direction	Circle direction steady **wind comes FROM**	N NE S SW E SE W NW	N NE S SW E SE W NW	N NE S SW E SE W NW
		Variable Wind Direction	Circle 1 or more directions **wind comes FROM**	N NE S SW E SE W NW	N NE S SW E SE W NW	N NE S SW E SE W NW
4. Sky Conditions	4.1	Cloud Cover	Use Definitions in Cloud Cover Table	□ Clear □ Cloudy □ Scattered □ Overcast □ Broken	□ Clear □ Cloudy □ Scattered □ Overcast □ Broken	□ Clear □ Cloudy □ Scattered □ Overcast □ Broken
	4.2	Use local mountain of known elevation (above mean sea level) and report clouds above, at, or below mountain top.				
		Cloud Base Ht (Loc Rel)	Relative to local Mtn m AMSL	□ Clouds above mtn □ Clouds at mtn top □ Clouds below mtn	□ Clouds above mtn □ Clouds at mtn top □ Clouds below mtn	□ Clouds above mtn □ Clouds at mtn top □ Clouds below mtn
		m	DewCal (2.1-2.5)/9.8x1000m	m AGL	m AGL	m AGL
		*Min. flight altitudes: **Day** = 160m AGL; **Night** – 500 m AGL; **Low cloud ceiling** = No flights.*				
	4.3	Cloud Type	High / Middle / Low; Vertically Developed	□ Cirrus □ Altostrat □ Altocum □ Stratus □ Nimstrat □CuNim □ Cumul	□ Cirrus □ Altostrat □ Altocum □ Stratus □ Nimstrat □CuNim □ Cumul	□ Cirrus □ Altostrat □ Altocum □ Stratus □ Nimstrat □CuNim □ Cumul
	4.4	Rainfall	Measure at 0900 hrs each morning. Report amount for last 24 hrs.			mm
	4.5	Visual Range (Visibility)	Name of 3.2 km mark	□ more □ less than □ Rain □ Fog □ Haze □ Smoke	□ more □ less than □ Rain □ Fog □ Haze □ Smoke	□ more □ less than □ Rain □ Fog □ Haze □ Smoke
			Name of 5 km mark	□ more □ less than □ Rain □ Fog □ Haze □ Smoke	□ more □ less than □ Rain □ Fog □ Haze □ Smoke	□ more □ less than □ Rain □ Fog □ Haze □ Smoke
		*Helicopter minimum visibility: **Day** = 3.2 km / 2 miles; **Night** = 5 km / 3 miles; **Low visibility** = No flights*				
	4.6	Severe Weather	Thunderstorms	□ Yes □ No	□ Yes □ No	□ Yes □ No
			Lightning – Flash, count secs to boom / 3	N NE E SE S SW W NW □ Yes km	N NE E SE S SW W NW □ Yes km	N NE E SE S SW W NW □ Yes km
			Warn air crews of any severe weather in your area.			

All weather observers write their initials and clearly print their name using block letters			

M.E.W.S. Summary Weather Observation Log Instructions

Header

Location: Local Place Name

Latitude, Longitude from GPS, survey records or map measurement.

Elevation: Survey records or map measurement (GPS elevations are not reliable).

1. Header	RTC-TH M.E.W.S. Weather Observation Log				
	Location				
	Lat ° ' " N		Long ° ' " E		Elev m AMSL
	Lat N		Long E		
	Date		Weather Observations Time		
			Sunrise	Mid-Afternoon	Sunset
	Local time 24-hr format	Hour →			
	Observer (initial; see back)				

Ready to serve and sustain our community.

Date/Hour: Use local Thai standard time in 24 hour format. **Observer:** initials in box. Full name (print clearly) on top/back of form

Temperature / Relative Humidity

2.1 Air (Dry Bulb) Temp: Read thermometer kept in the shade, 1.5 m above the ground.

2.2 Wet Bulb Temp from hyrgrometer kept in the shade, 1.5 m above the ground.

2.3 Difference between Dry and Wet Bulb temperatures.

2. Temperature / Relative Humidity					
2.1	Air (Dry bulb)	Thermometer in shade; 1.5 m above ground	°C	°C	°C
2.2	Wet Bulb		°C	°C	°C
2.3	Difference	Subtract 2.2 from 2.1;	°C	°C	°C
2.4	Rel. Humidity	Use 2.1, 2.3; RH Table	%RH	%RH	%RH
2.5	Dew Point	Use 2.1, 2.3; Dew Pt Table	°C	°C	°C
2.6	Heat Stress	Use 2.1, 2.4; HSI Table	Heat Stress °C	Heat Stress °C	Heat Stress °C
		Danger Level (if any from Heat Stress Index table)	□Cautn □Danger □Ex Cautn □Ex Dangr	□Cautn □Danger □Ex Cautn □Ex Dangr	□Cautn □Danger □Ex Cautn □Ex Dangr
2.7	Wind Chill	Use 2.1, 3.1; Wind Chl Tbl	Wind Chill °C	Wind Chill °C	Wind Chill °C
		Danger Level (if any from Wind Chill chart)	□Trvl Dngr □Frstbte10 □TShitr Dgr □Frstite30 □Frostbite □Frstbte5	□Trvl Dngr □Frstbte10 □TShitr Dgr □Frstite30 □Frostbite □Frstbte5	□Trvl Dngr □Frstbte10 □TShitr Dgr □Frstite30 □Frostbite □Frstbte5

2.4 Relative Humidity: Use Dry Bulb Temp (2.1), Difference (2.3) and Relative Humidity table to find % Relative Humidity.

2.5 Dew Point Temperature: Use Dry Bulb Temp (2.1), Difference (2.3) and Dew Point Temp table to find Dew Point Temp.

2.6 Heat Stress Temperature: Use Dry Bulb Temp (2.1), % Relative Humidity (2.4) and Heat Stress Index Table to find Heat Stress Temperature and relevant advisory warning.

2.7 Wind Chill: Use the Dry Bulb Temp (2.1) and Wind Speed (3.1) and Wind Chill Table to find the Wind Chill Temperature and relevant advisory warning.

Wind Speed / Direction

3.1 Average and Gust Wind speeds: Use Beaufort Table or direct measurements 3 times and average results. Gusts are short, strong blasts of wind. *Report wind speeds in knots to air crews. Advise air crews when wind speeds are close to affecting helicopter flight operations.*

3. Wind Speed / Direction					
	Report wind speed in *knots to air crews*; km/h to all others.				
3.1	Average	Get 3 readings & average	km/h knts	km/h knts	km/h knts
	Gusts	Record highest gust	km/h knts	km/h knts	km/h knts
	Wind Speed Guidelines for Helicopter Flight Operations				
	10 knots / 18.5 km/h ideal; OK to fly			Above 45 knots / 83 km/h; No flights.	
	Gusts above 20 knots/ 37 km/h; No flights			Max tailwind 5 knots/ 6 km/hr; No take off	
3.2	Steady Wind Direction	Circle direction steady wind comes FROM	N NE S SW E SE W NW	N NE S SW E SE W NW	N NE S SW E SE W NW
	Variable Wind Direction	Circle 1 or more directions wind comes FROM	N NE S SW E SE W NW	N NE S SW E SE W NW	N NE S SW E SE W NW

3.2 Steady or Variably blowing winds. If steady, circle letter for direction. If variable, circle all appropriate letters for directions.

Sky Conditions

4.1 Cloud cover: Look at the sky and follow the definitions for each cloud cover classification.

4.2 Cloud Base Height: If relative to a local mountain, give its name and elevation above mean sea level. Note Local Relief in meters. If using the Dew Point method, subtract Dew point temp (2.5) from Dry temp (2.1) and divide result by 9.8, multiply quotient by 1000m. *Advise air crews when cloud base height (ceiling) are close to affecting helicopter flight operations.*

4.3 Cloud Type: Check the appropriate box based on cloud description in the guide book

4. Sky Conditions						
4.1	Cloud Cover	Use Definitions in Cloud Cover Table		□Clear □Cloudy □Scattered □Overcast □Broken	□Clear □Cloudy □Scattered □Overcast □Broken	□Clear □Cloudy □Scattered □Overcast □Broken
4.2	Use local mountain of known elevation (above mean sea level) and report clouds above, at, or below mountain top.					
	Cloud Base Ht (Loc Rel) m	Relative to local Mtn m AMSL		□Clouds above mtn □Clouds at mtn top □Clouds below mtn	□Clouds above mtn □Clouds at mtn top □Clouds below mtn	□Clouds above mtn □Clouds at mtn top □Clouds below mtn
		DewCalc (21-2.5)/9.8x1000m		m AGL	m AGL	m AGL
	Min. flight altitudes: Day = 150m AGL; Night = 500 m AGL; Low cloud ceiling = No flights.					
4.3	Cloud Type	High	Vertically Developed	□Cirrus □CuNim	□Cirrus □CuNim	□Cirrus □CuNim
		Middle		□Altostrat □Altocum	□Altostrat □Altocum	□Altostrat □Altocum
		Low		□Stratus □Nimstrat □Cumul	□Stratus □Nimstrat □Cumul	□Stratus □Nimstrat □Cumul
4.4	Rainfall	Measure at 0900 hrs each morning. Report amount for last 24 hrs.				mm
4.5	Visual Range (Visibility)	Name of 3.2 km mark		□more □less than □Rain □Fog □Haze □Smoke	□more □less than □Rain □Fog □Haze □Smoke	□more □less than □Rain □Fog □Haze □Smoke
		Name of 5 km mark		□more □less than □Rain □Fog □Haze □Smoke	□more □less than □Rain □Fog □Haze □Smoke	□more □less than □Rain □Fog □Haze □Smoke
	Helicopter minimum visibility: Day = 3.2 km / 2 miles; Night = 5 km / 3 miles; Low visibility = No flights					
4.6	Severe Weather	Thunderstorms		□Yes □No	□Yes □No	□Yes □No
		Lightning	Flash, count secs to boom / 3	N NE E SE S SW W NW □Yes km	N NE E SE S SW W NW □Yes km	N NE E SE S SW W NW □Yes km
		Warn air crews of any severe weather in your area.				

4.4 Rainfall: Measure water in rain gauge each day at 0900 hrs. Rain gauge should be in open area, away from tall objects, with top of gauge 50 cm above ground to avoid splash water from entering gauge.

4.5 Visual Range: Pick landmarks 3.2 km and 5 km from your observation site. Report when visual range is more or less than the known distances to these landmarks. *Advise air crews when visual range is close to affecting helicopter flight operations.* Check appropriate boxes for reasons of reduced visibility.

4.6 Severe Weather: Primary concerns and thunderstorms and lightning. Check the appropriate boxes. If lighting, watch for flash, count seconds until you hear the thunder, divide by 3 = approximate distance in km. Circle direction to storm.