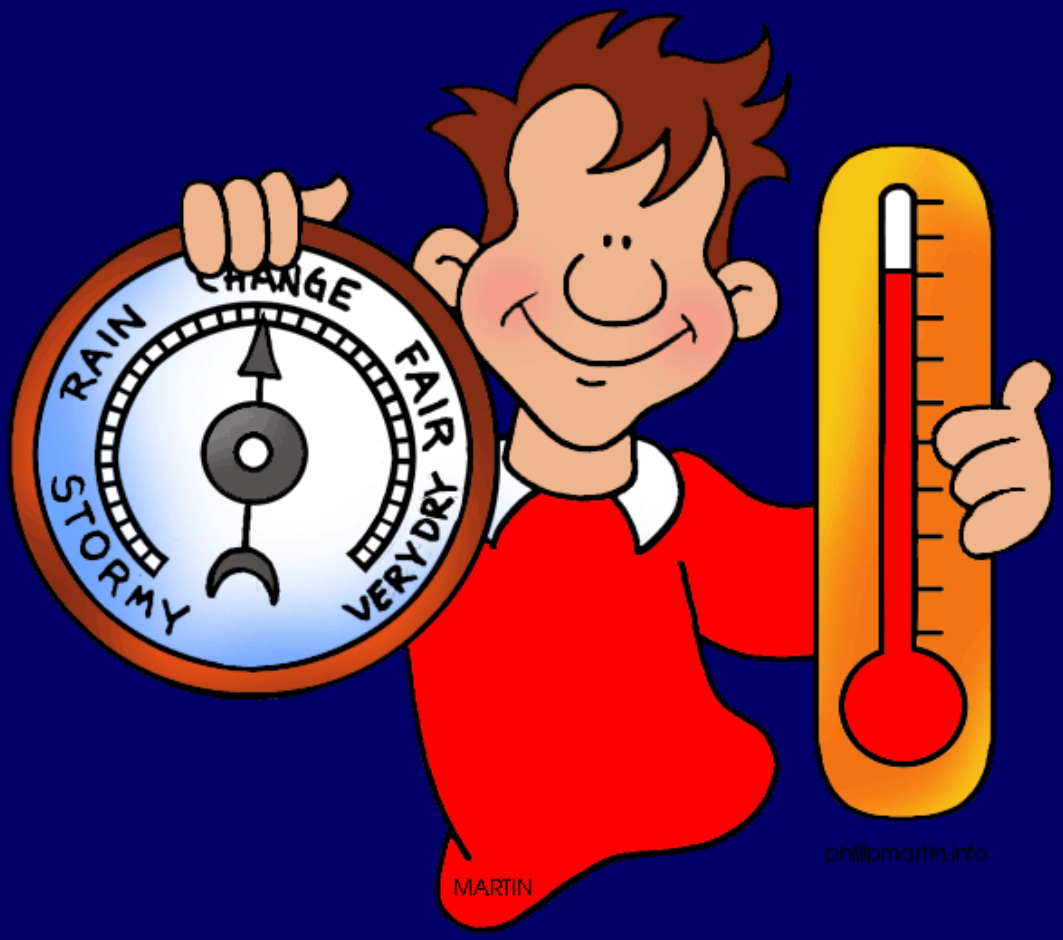
Weather Analysis



Essential Standard 2.5

Understand the structure of and processes within our atmosphere.

Learning Objective 2.5.4

Predict the weather using available weather maps and data including surface and upper atmospheric winds, and satellite imagery.

I Can Statements

At the end of this lesson, you should be able to say, with confidence:

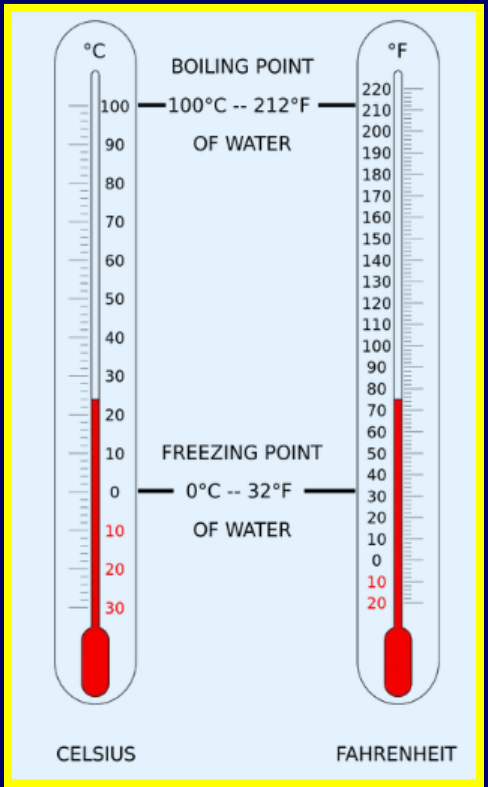
- I can name the devises used on the ground to measure temperature, air pressure, wind, rain, and humidity.
- I can explain what heat waves are and why they are more dangerous in urban areas.
- I can explain how the national weather service collects data and uses it to help predict the weather.
- I can read a weather map and determine the current weather and future weather.

Meteorology

Meteorologists measure the atmospheric variables of temperature, air pressure, wind, and relative humidity to make accurate weather forecasts.

Temperature

The most common weather device is the thermometer which is used to measure temperature.



In the United States, the common unit used for measuring temperature is Fahrenheit, ^{o}F.

But in science and the rest of the world, the metric unit for temperature is Celsius, ^{o}C.

Converting Temperature Units

To be precise, you can use equations to convert temperature readings between Celsius and Fahrenheit.

EQUATION

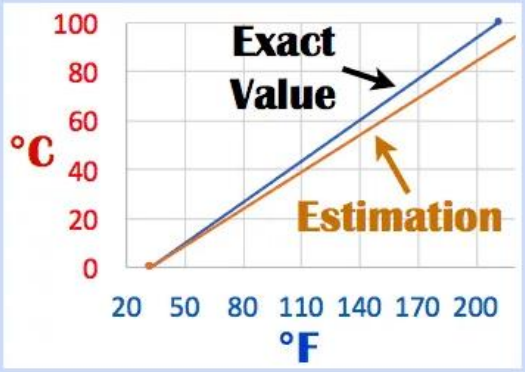
$[°F] = [°C] \times 1.8 + 32$

or

$[°F] = [°C] \times \frac{9}{5} + 32$

EASY ESTIMATION

$[°F] = [°C] \times 2 + 32$



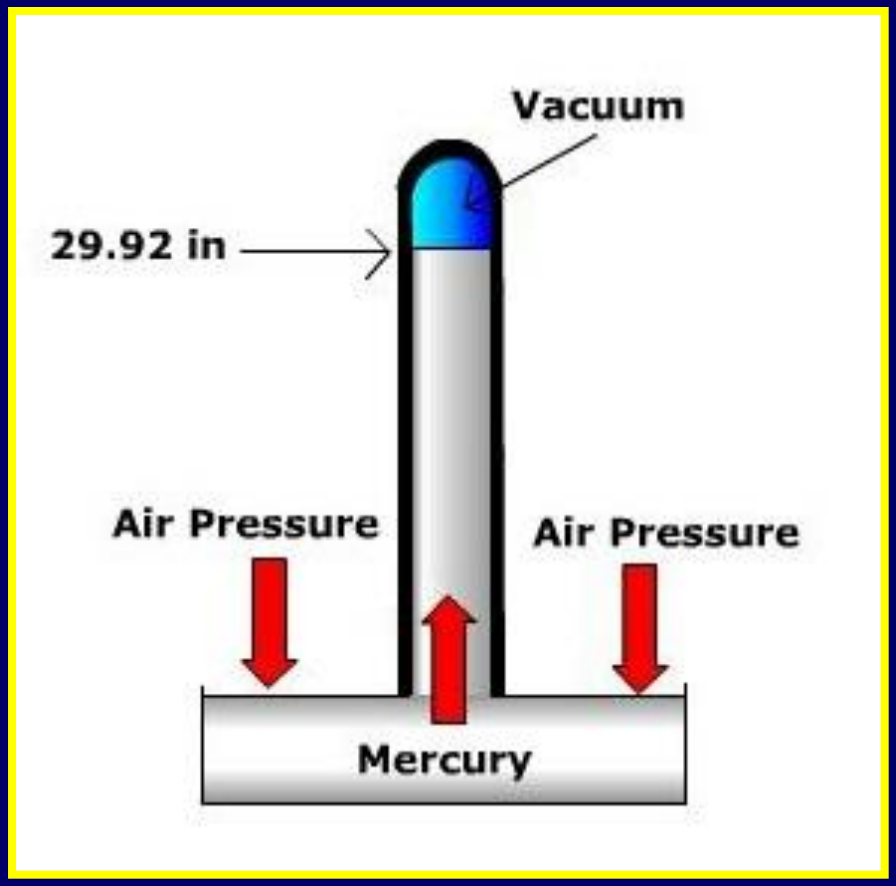
But you can also estimate, if precision is not necessary.

$^{o}F = {}^{o}C \times 2 + 32$

$^{o}C = {}^{o}F \div 2 - 32$

Air Pressure

Air pressure is measured using barometers. Some barometers use mercury.



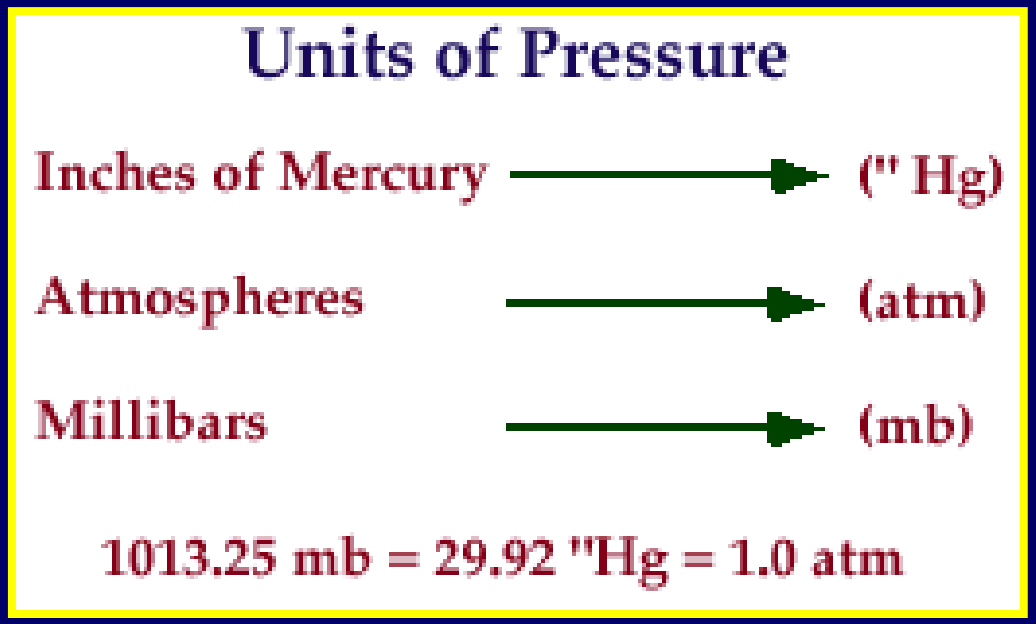
Inside an inverted glass tube is a vacuum, which exerts no pressure on the mercury, allowing the mercury to expand and contract freely.

Atmospheric pressure pushes down on the surface of the mercury causing it to rise inside a glass tube.

The height of the mercury in the tube, reflects the pressure exerted by the surrounding air.

Air Pressure Units

Weather stations and aviation use inches of mercury, (“Hg), as the unit for measuring air pressure.

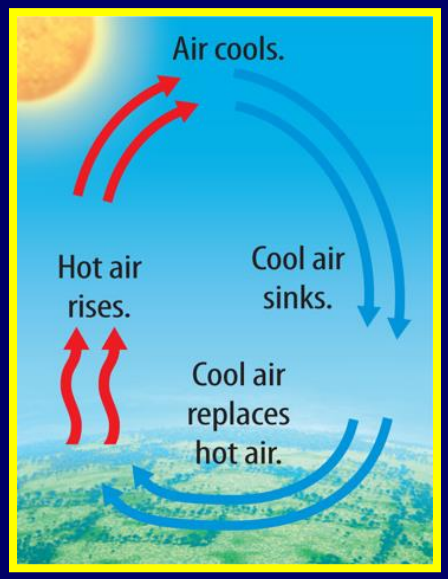


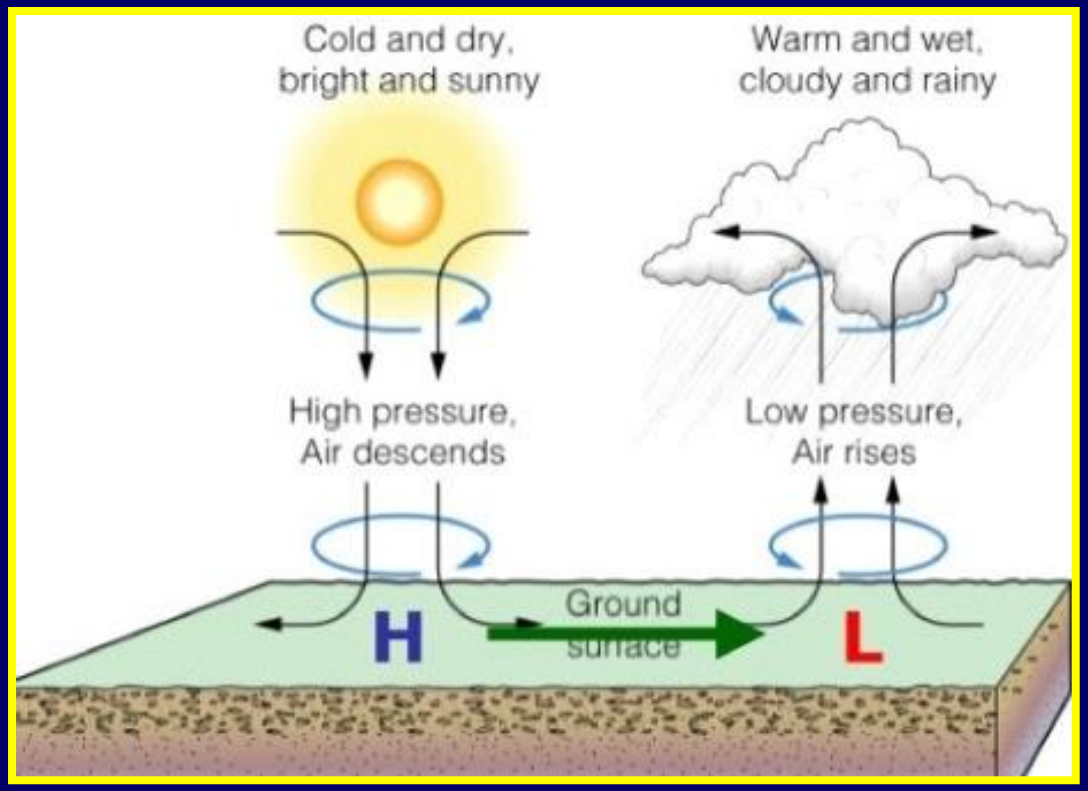
Meteorologists use Millibars, mb. At sea level, the air pressures is 1013.25 mb.

The common (everyday person) unit for measuring mercury is atmospheres (atm). At sea level, that air pressure is 1 atm.

High Pressure Systems

Remember that when air cools, it becomes more dense and sinks, creating areas of high pressure.



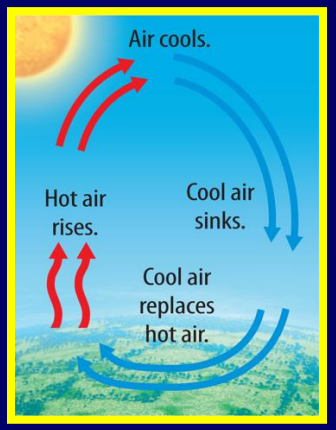


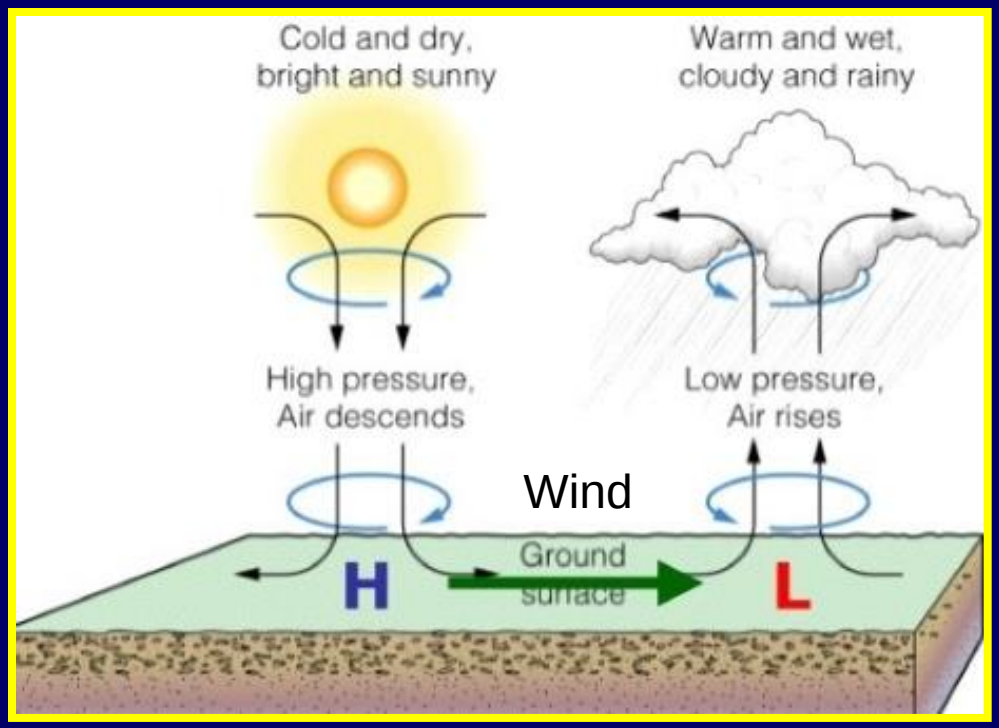
High pressure systems are associated with cool, dry, bright and sunny weather.

Low Pressure Systems

Hot air expands, becomes less dense and rises, creating areas of low pressure.

As the air rises, water vapor cools and condenses to form clouds or rain.





Low pressure systems are associated with clouds and rain.

Changes in Pressure

Changes in air pressure can help predict the weather.

When air pressure drops, clouds and rain are on the way.

A large drop in air pressure signifies stormy weather ahead.

When air pressure increases, fair weather is on the way.

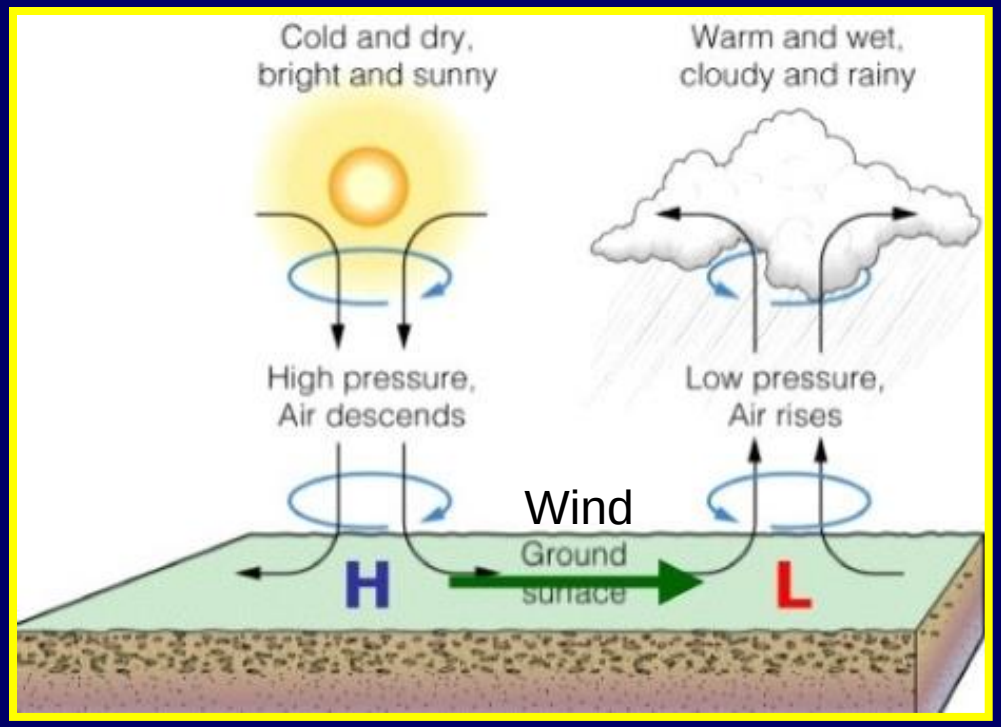
Wind

Anemometers are used to measure wind speed.

The simplest type of anemometer has cupped arms that rotate as the wind blows.

Wind and Pressure

Recall that wind is caused by air moving from areas of high pressure to areas of low pressure.



An increase in wind speed can signify a drop in pressure and associated cloudy, rainy weather.

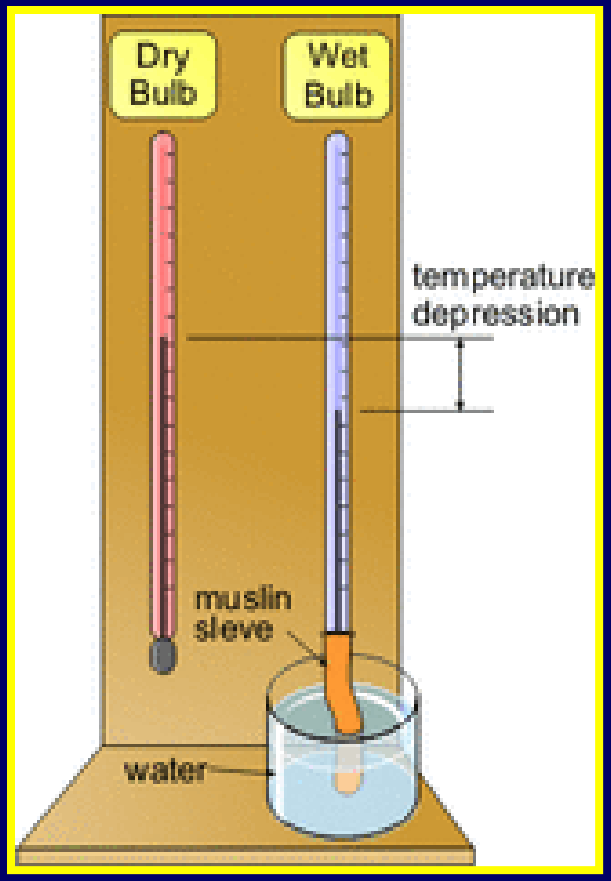
Rain Gauge

Rain gauges are used to measure the amount of precipitation in a particular area.

A rain gauge can’t help predict the weather, it just collects precipitation after the fact.

Humidity

Hygrometers measure relative humidity using wet and dry bulb thermometers.



As water evaporates from the wet bulb, the bulb cools, creating a temperature difference between the wet bulb and the dry bulb.

Relative Humidity

This temperature difference is used in conjunction with a relative humidity chart to determine the relative humidity.

Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

Recall that when the relative humidity reaches 100% that the air is saturated with water vapor and cannot hold any more, so condensation begins.

Relative Humidity

When there is no difference between the wet bulb temperature and the dry bulb temperature, it means that evaporation is unable to occur.

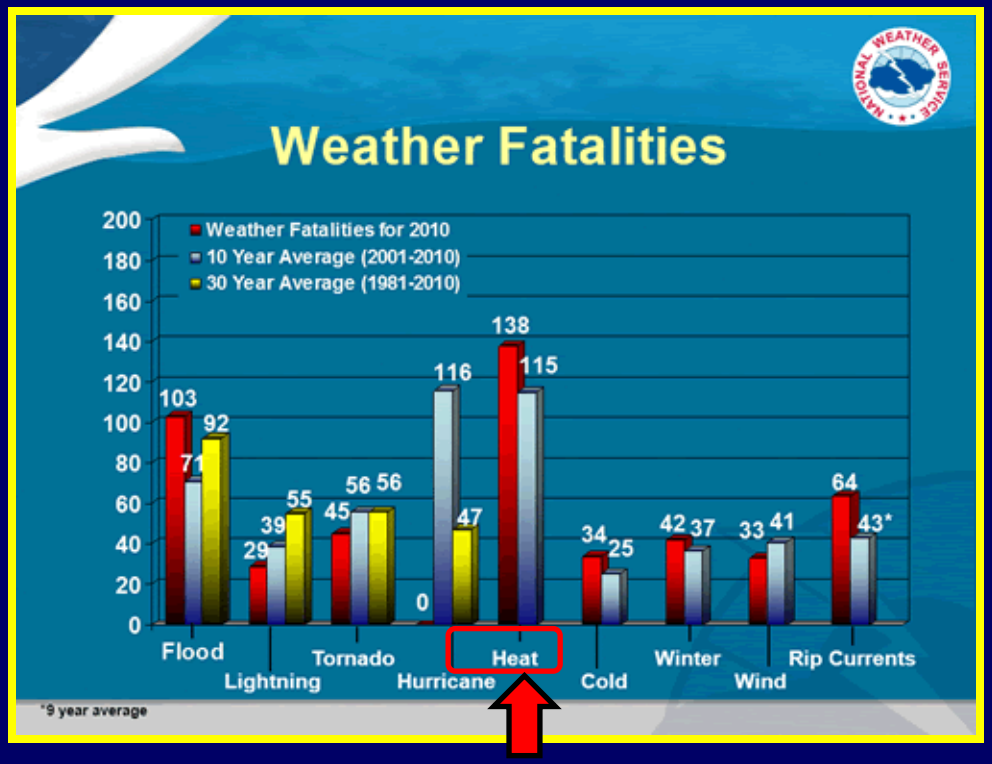
Relative Humidity (%)

Dry-Bulb Temperature (°C)	Difference Between Wet-Bulb and Dry-Bulb Temperatures (C°)															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
−20	100	28														
−18	100	40														
−16	100	48														
−14	100	55	11													
−12	100	61	23													
−10	100	66	33													
−8	100	71	41	13												
−6	100	73	48	20												
−4	100	77	54	32	11											
−2	100	79	58	37	20	1										
0	100	81	63	45	28	11										
2	100	83	67	51	36	20	6									
4	100	85	70	56	42	27	14									
6	100	86	72	59	46	35	22	10								
8	100	87	74	62	51	39	28	17	6							
10	100	88	76	65	54	43	33	24	13	4						
12	100	88	78	67	57	48	38	28	19	10	2					
14	100	89	79	69	60	50	41	33	25	16	8	1				
16	100	90	80	71	62	54	45	37	29	21	14	7	1			
18	100	91	81	72	64	56	48	40	33	26	19	12	6			
20	100	91	82	74	66	58	51	44	36	30	23	17	11	5		
22	100	92	83	75	68	60	53	46	40	33	27	21	15	10	4	
24	100	92	84	76	69	62	55	49	42	36	30	25	20	14	9	4
26	100	92	85	77	70	64	57	51	45	39	34	28	23	18	13	9
28	100	93	86	78	71	65	59	53	47	42	36	31	26	21	17	12
30	100	93	86	79	72	66	61	55	49	44	39	34	29	25	20	16

At this point, the relative humidity will be 100% and rain or snow is very likely.

Heat and Humidity

Recall that hot air can hold more vapor, so the relative humidity can become very high during hot weather.

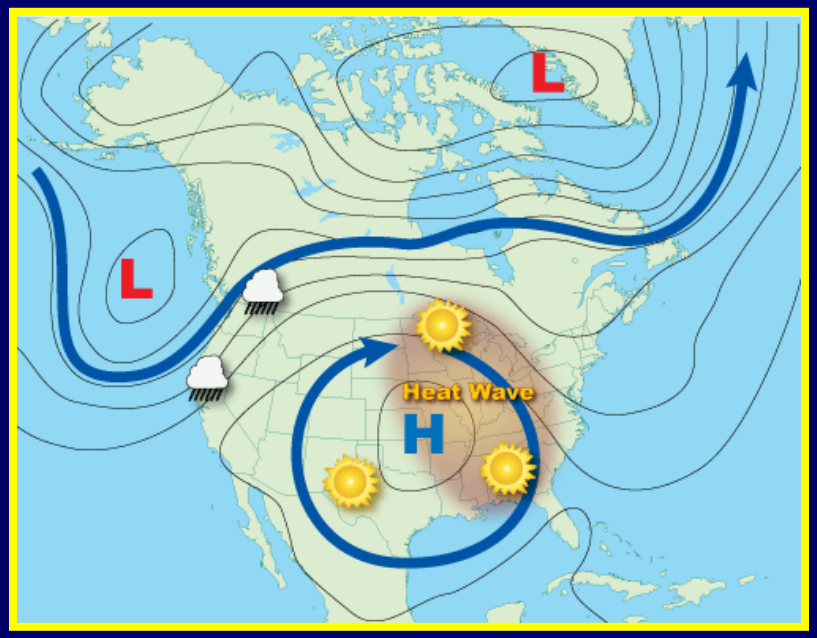


The higher the relative humidity, the harder it becomes for sweat to evaporate and lower body temperatures.

Heat is the number one cause for weather related fatalities.

Heat Wave

Heat waves occur when there are several days of unusually hot weather.

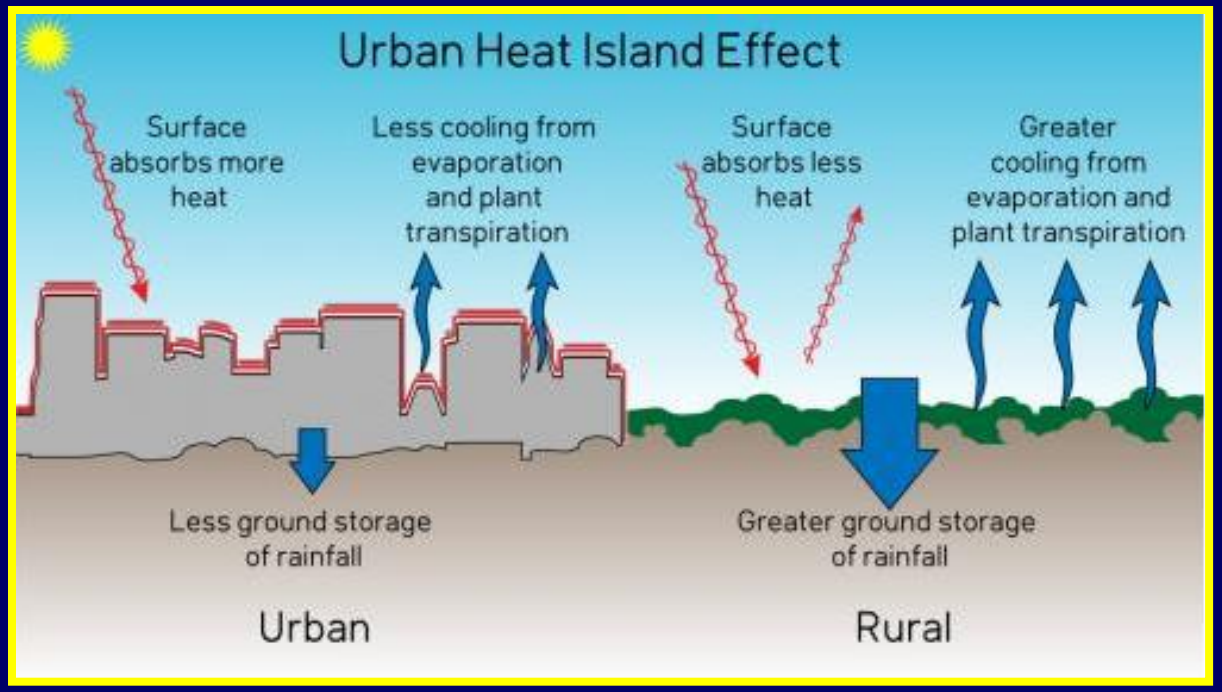


Heat waves generally occur when a high pressure system gets blocked from moving.

Air continues to descend and is heated near the ground but is then prevented from rising and cooling.

Urban Heat Islands

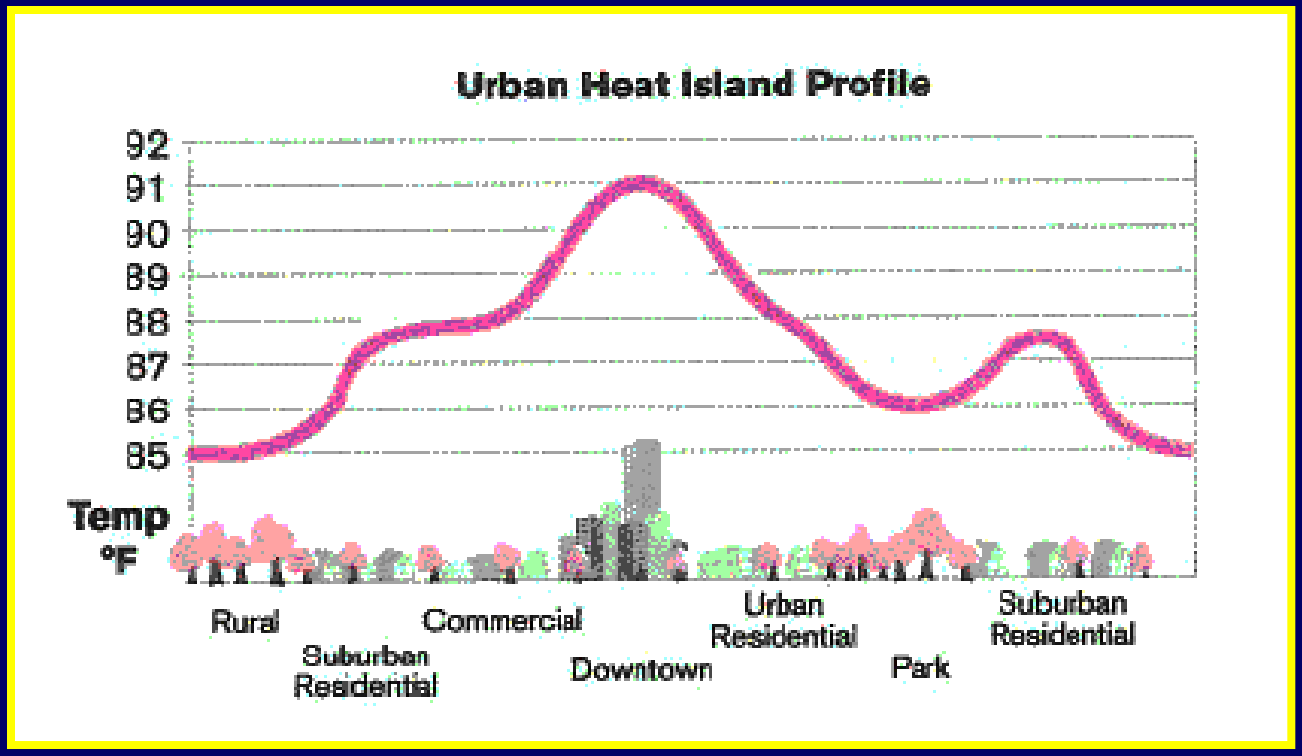
Most heat-related deaths occur in cities. Brick and mortar buildings, asphalt streets, and tar roofs absorb a lot of heat.



With little plant cover, there is not much cooling effect from evaporation or transpiration.

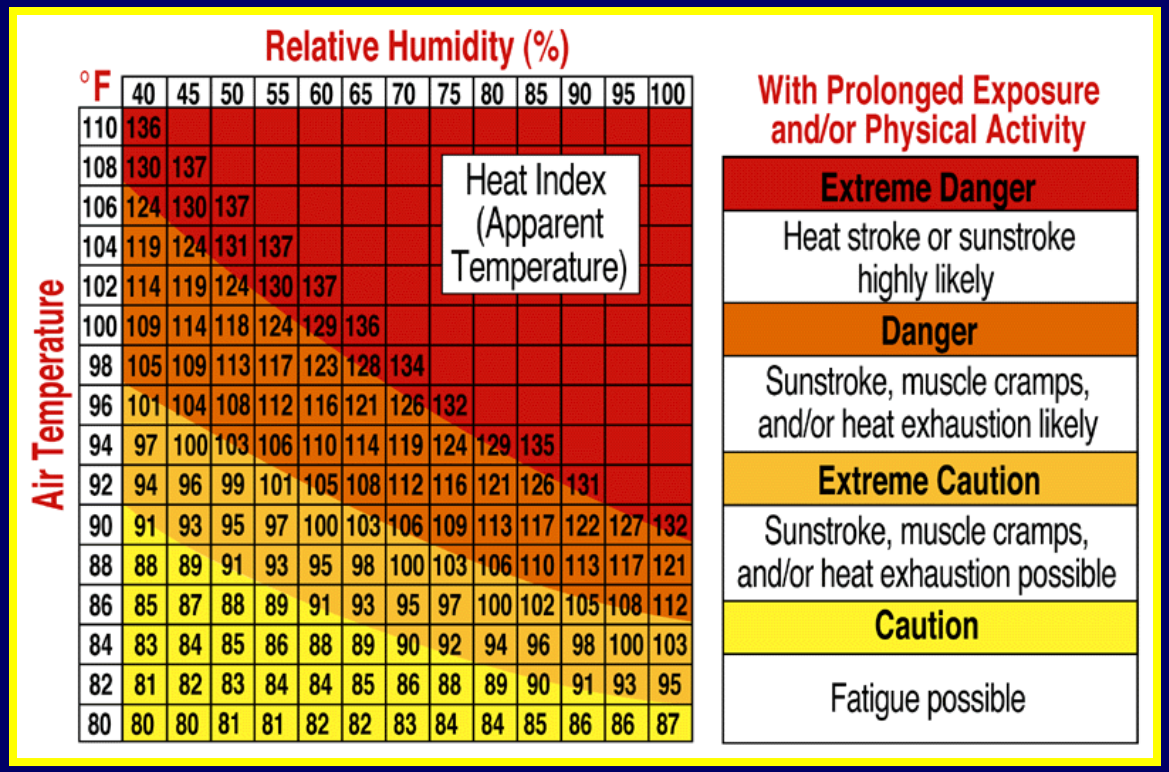
Urban Heat Islands

Temperatures in urban areas can be warmer than rural areas by several degrees both day and night. This is commonly called the urban "heat island" effect.



Heat Index

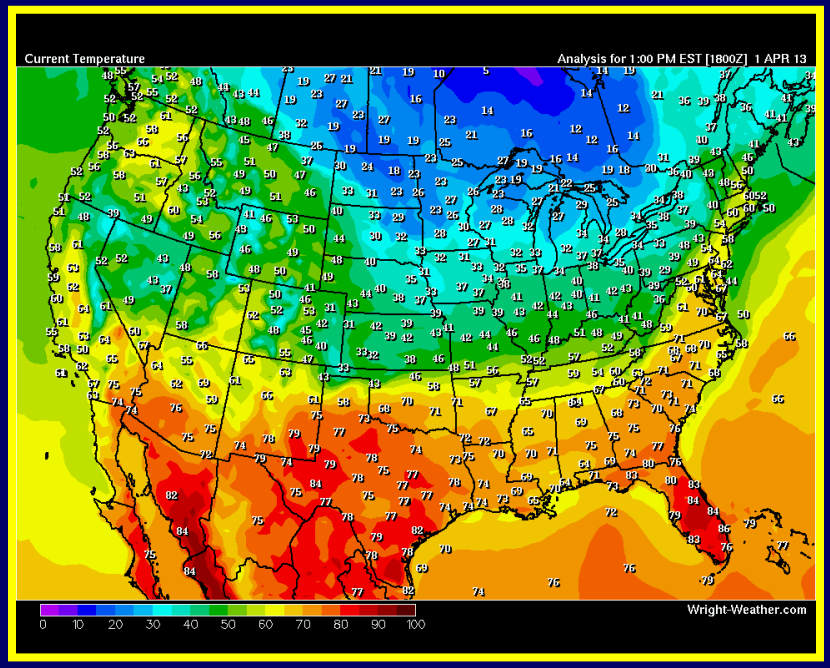
The National Weather Service uses the Heat Index (HI) to compute the "apparent temperature," which is a measure of how hot it feels to people at a certain combination of temperature and humidity.



High temperatures along with a high relative humidity increase the chances of heat or sunstroke.

National Weather Service

In order to analyze weather data and make forecasts, data must be gathered from many different locations at the same time.



The National Weather Service has established over 1,700 official sites that gather ground data.

Weather Balloons

Because the weather we experience is largely a result of changes that place high in the troposphere, data also has to be gathered at heights up to 3,000 km.

Radioscondes are balloons that contain sensors to measure data and send it back by radio signals to ground stations.

Weather balloons are usually sent up twice a day.

Doppler Radar

Doppler radar is used to help track rain.

Radar systems send out electromagnetic waves that bounce off large raindrops, scatter, and are then received by antenna and projected onto a screen.

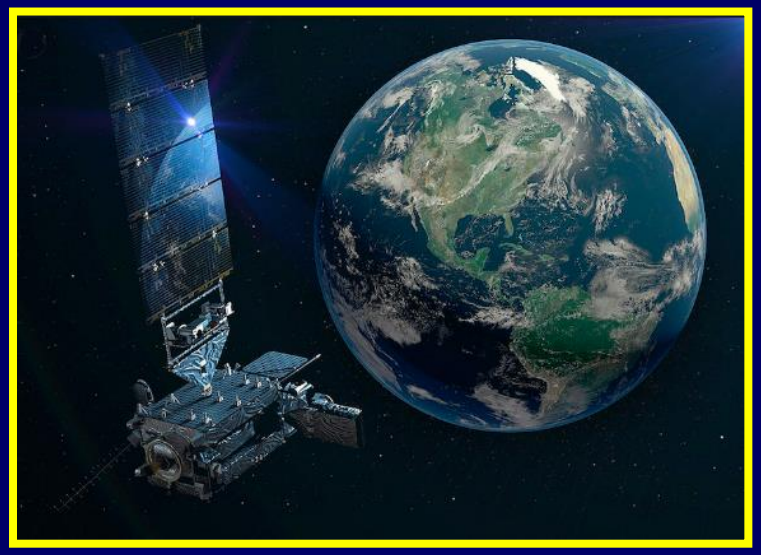
Orbiting Satellites

Orbiting Earth from pole to pole, 14 times a day, is a series of satellites called the Joint Polar Satellite System, JPSS.

There satellites are capable of collecting weather data, ocean data, plant life data, as well as detecting changes in volcanic activity and wildfire activity.

Stationary Satellites

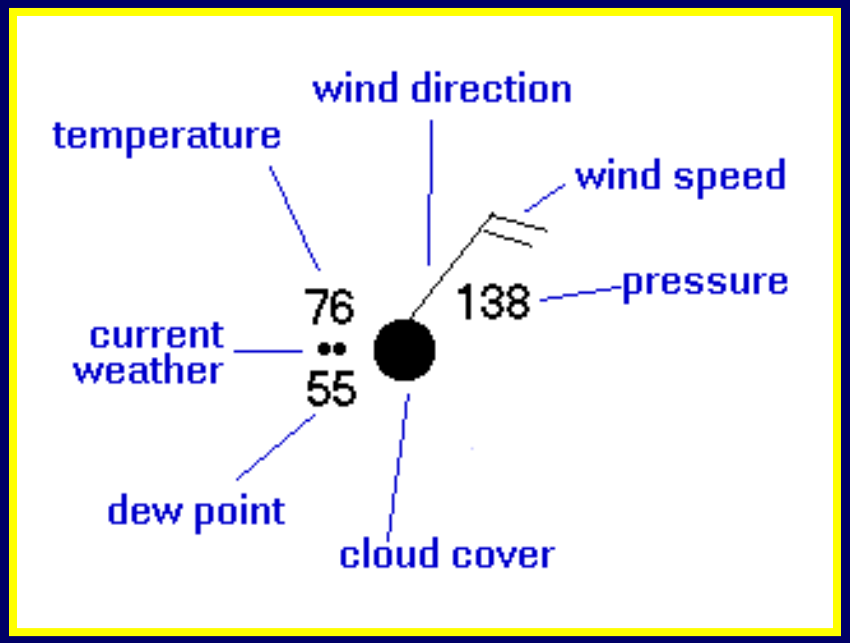
There are also a series of stationary satellites called Geostationary Operational Environmental Satellites, GOES.



There satellites can also collect weather data but can also monitor Solar activity, smog, smoke, and ash, lightning strikes, and pick up GPS distress beacons to aid in search and rescue missions in the middle of the ocean.

Weather Symbols

Once the data is collected, the weather stations use station models to show weather data for a particular area at a particular time.

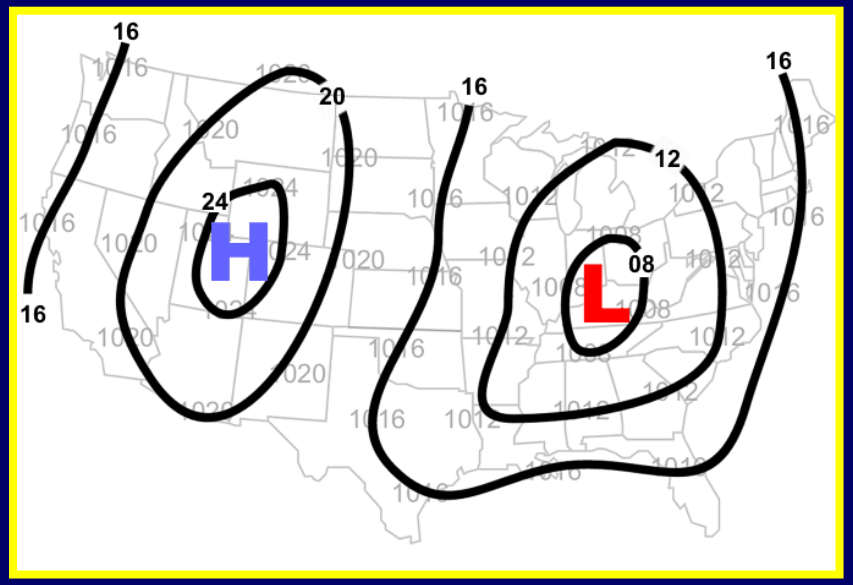


Where and how the data is represented on the model is standard all over the United States.

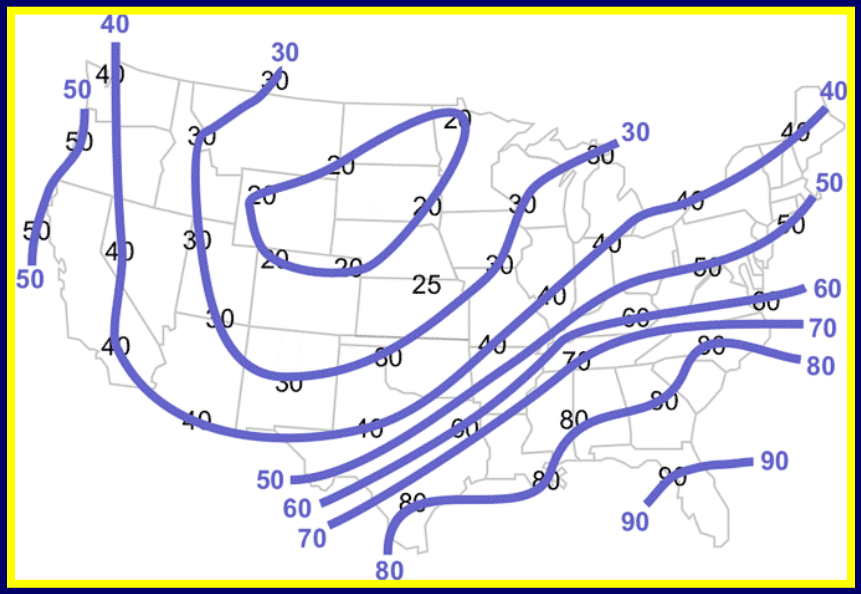
A meteorologist can look at a model and gain a lot of information all at once.

Isobars & Isotherms

To plot the data nationwide, meteorologists use lines that connect points of equal or constant values. Lines of equal pressures are called isobars and lines of equal temperature are called isotherms.



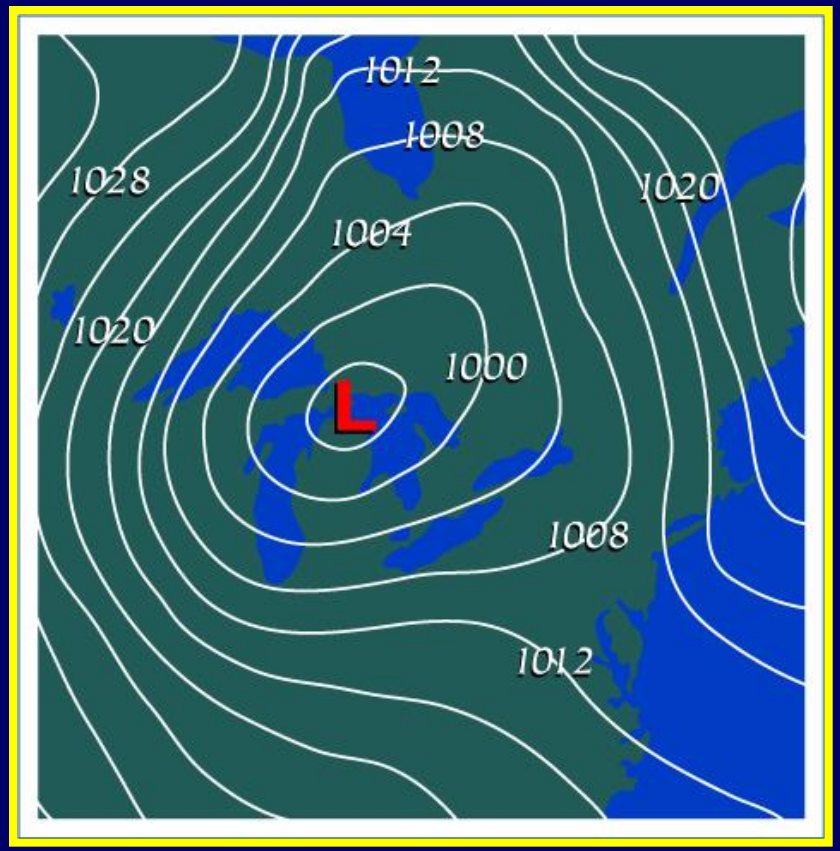
Surface Pressure Isobars



Surface Temperature Isotherms

Winds

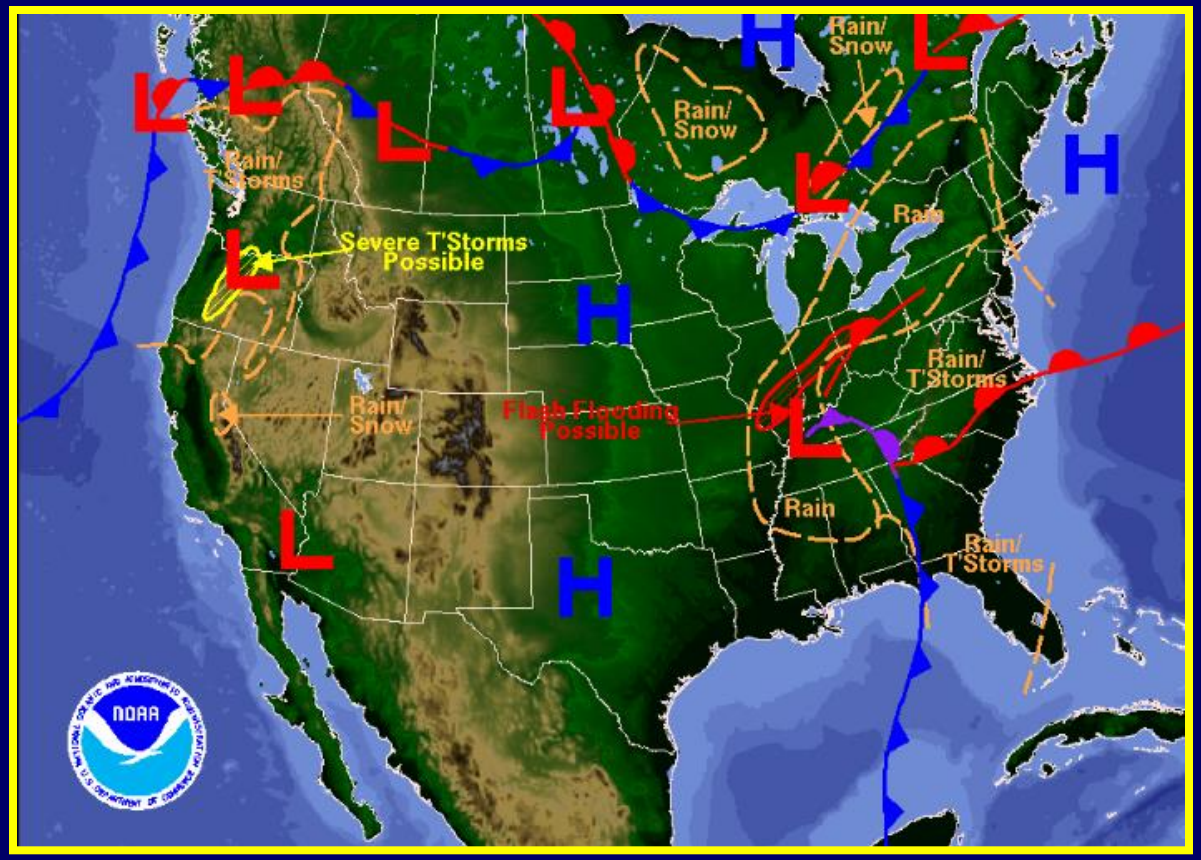
Just as you can make inferences about elevation based on the lines on contour maps, you can also make inferences by studying isobars on a map.



Isobar lines that are closer together indicate a large pressure difference over a small area which result in strong winds.

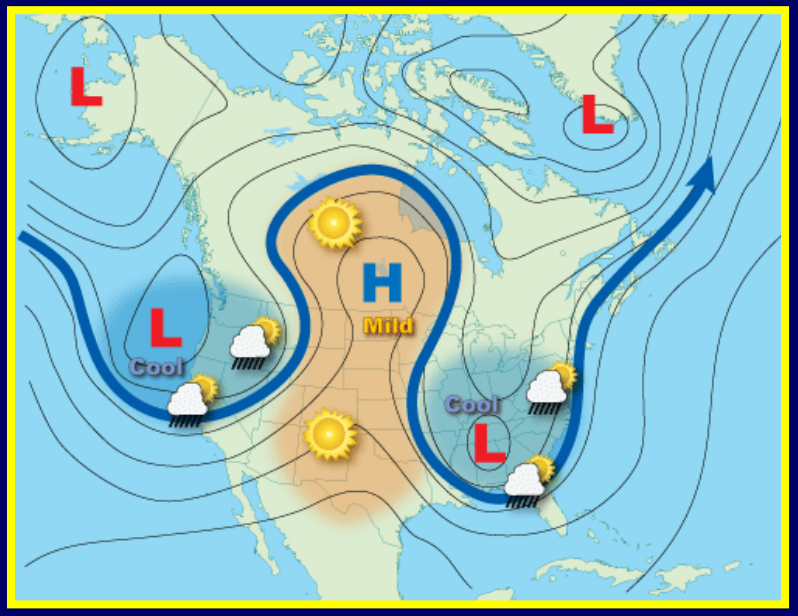
Weather Maps

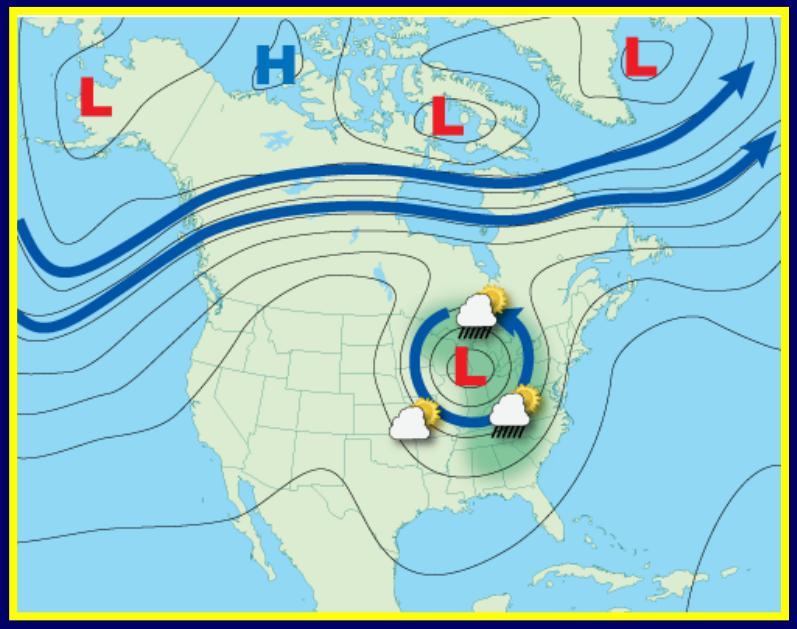
Weather maps are used to show the general public what is going on with the weather.



Pressure Systems

High pressure systems, H, are associated with clear, dry, sunny, calm weather.





Low pressure systems, L, are associated with cloudy, rainy, and stormy weather.

Fronts

Recall that fronts occur where two or more air masses with different temperatures meet and usually lead to rain, snow, or thunderstorms.

A warm front is represented, on a weather map, by red semi-circles on the side to which the front is moving.

Warm fronts are associated with cloudiness, gentle rains, and warmer temperatures as the front passes.

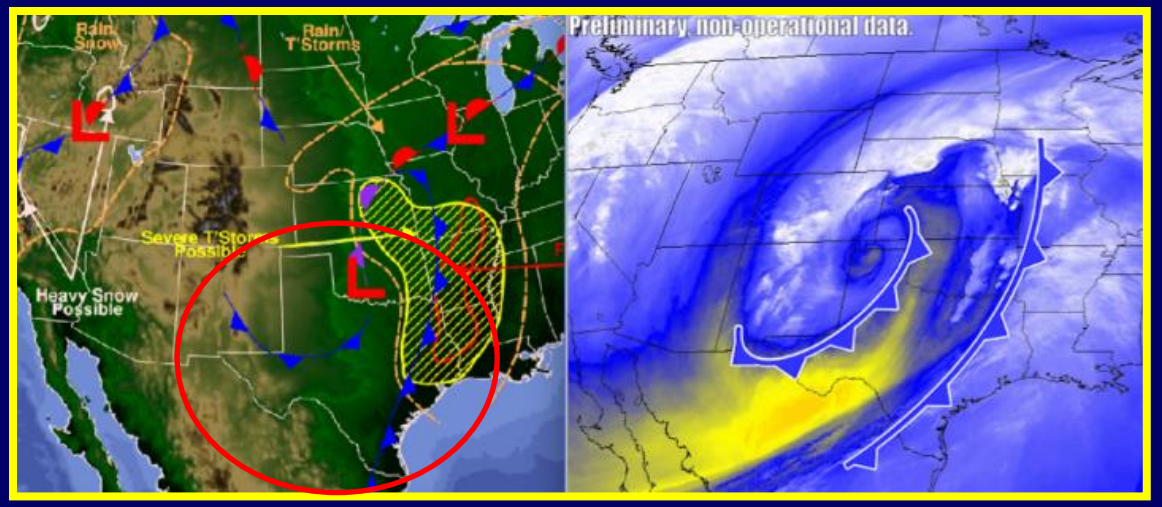
Fronts

Cold fronts are associated with more thunderstorms and snow storms, followed by colder weather once the front passes.

Cold fronts are represented on a weather map by blue triangles pointing in the direction the cold front is moving.

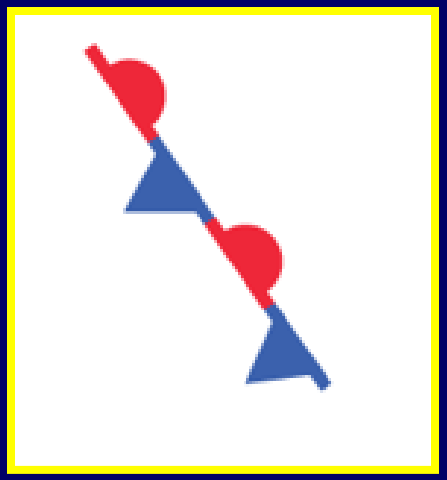
The weather map shows two cold fronts moving through Texas.

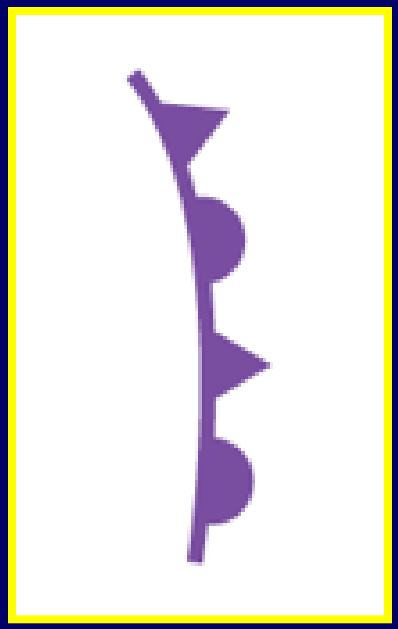
An image collected from a GOES satellite shows atmospheric water vapor from the same afternoon.



Fronts

Stationary fronts occur when a cold and warm front meet but neither one moves, so there is a long period of rain.

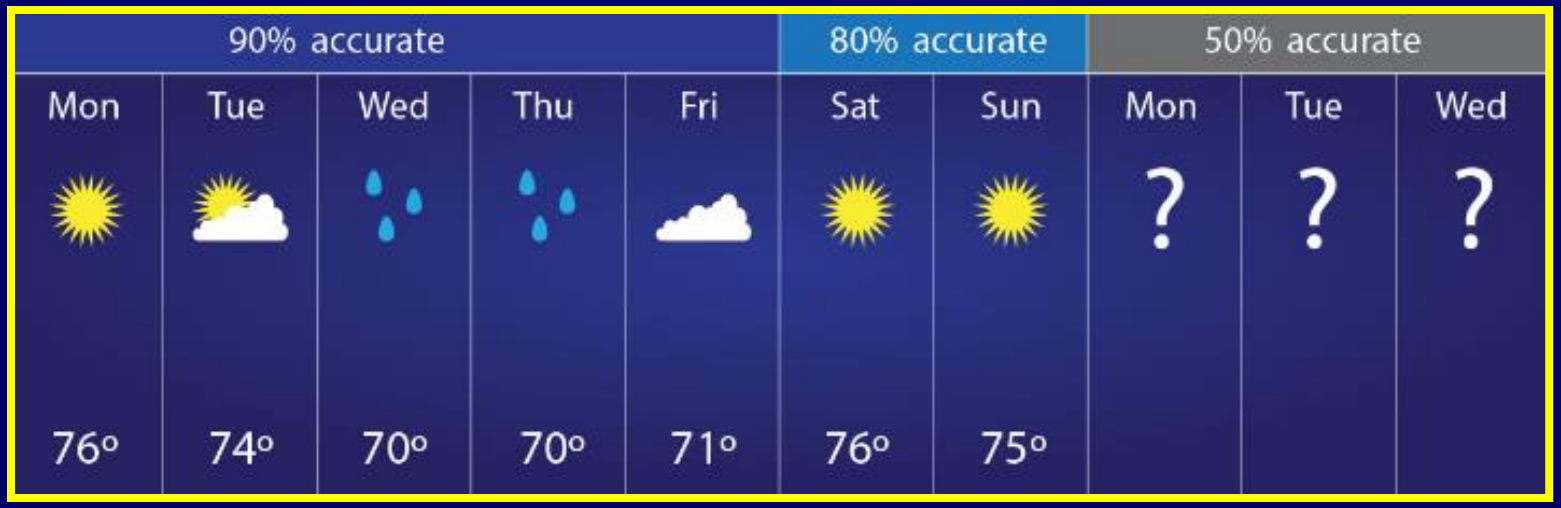




An occluded front occurs when a cold front catches up with a warm front and usually brings dry air.

Reliability of Weather Forecasts

With the help of satellites, meteorologists can see weather patterns on parts of the globe before they move into another area, making short term weather predictions extremely accurate.



But because so many factors are involved in determining the weather, long term forecasts are less accurate.

The End