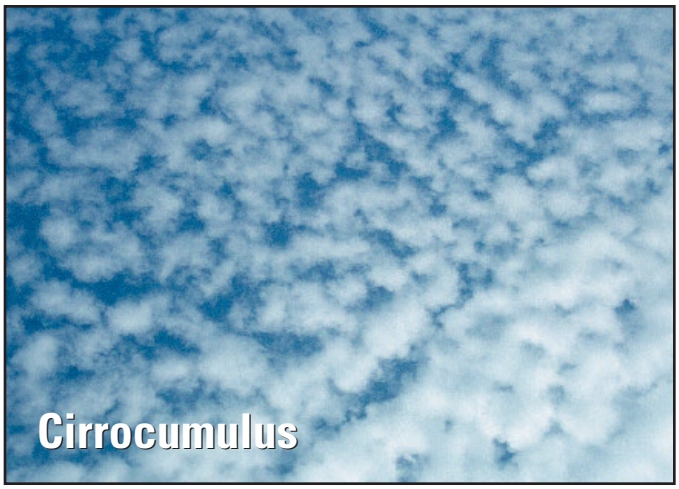
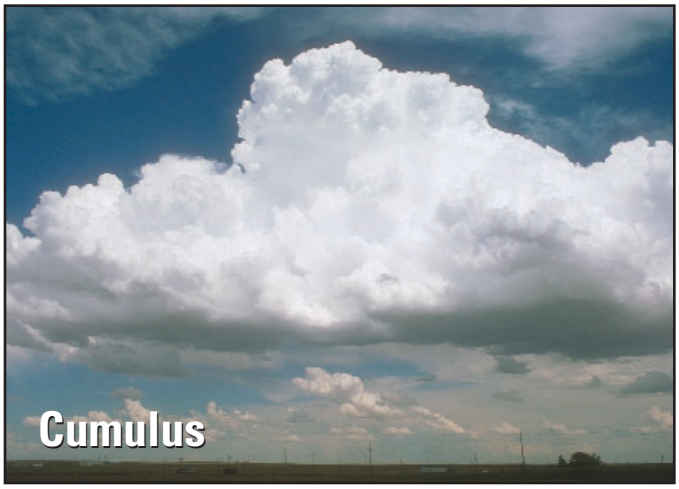
Atmospheric Science Explorers

Altitude: 25,000–35,000 ft.
ice crystal clouds which look like horse tails



Altitude: 25,000–30,000 ft.
ice crystal clouds in small cumulus puffs

Altitude: 7,000–23,000 ft.
puffy clouds which look like fish scales;
may have dark undersides



Altitude: 3,000–10,000 ft.
fair weather clouds which develop vertically

Altitude: 3,000–75,000 ft.
thunderheads which extend from low altitudes to high altitudes

Altitude: Surface (fog)–5,000 ft.
thick, gray clouds which blanket the sky

These cloud heights can vary by location and time of year.

Heat Up, Rise Up

How does a thermometer measure temperature? This simple thermometer will show you and give you the temperature too.

Gather the following materials:
- empty glass soda bottle (8–12 oz., .25 liters, etc.)
- red food color
- 2 transparent straws
- non-hardening clay or gum
- clear tape
- thermometer

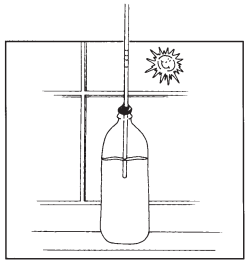
Here's how to do it:
1. Fill the bottle 2/3 full of colored water. The air space above the water is **VERY** important.
2. Stick one straw inside the other and tape them together. This seal needs to be airtight.
3. Put the straw in the bottle so that the bottom of the straw is about 2 inches (5 centimeters) below the water level.
4. While holding the straw at this point seal the mouth of the bottle with clay (or gum). Use enough clay to be sure that it forms an airtight seal between the straw and bottle.
5. Place your thermometer in a sunny window and watch the water level go up the straw. Put it in the refrigerator or freezer and watch the level go down.

What's going on

The water level in the straw changes because air expands as it is heated and contracts as it is cooled. Your thermometer works not because the water expands (it does a tiny amount), but because the air above the water expands and contracts. As the air expands it pushes on the water in the bottle. The water has nowhere to go but up the straw. If your thermometer isn't working it could be because your clay seal isn't airtight. If the clay seal is not airtight, the air will expand and leak out the top instead of pushing on the water.

There's more

To make your thermometer accurate, you need to compare it to a real thermometer. Place both side-by-side and leave them for 10 minutes. (It takes some time for your thermometer to register a change.) Mark your straw with a line and write the real temperature on that line. Repeat this process for lots of different temperatures.



Rise Above It All

What does hot air have to do with clouds? Why does hot air rise? How can water and air act in the same way? In this experiment, you'll learn how clouds rise above it all.

Gather the following materials:
- a large glass or plastic jar
- a smaller glass jar (like a baby food jar) that will fit inside the large jar
- red and yellow food coloring
- string
- water

Here's how to do it:
1. Start some water boiling, enough to fill the small jar.
2. While the water is heating up, tie the string around the small jar, below the neck. Tie it tight so that it won't slip off. Leave a string tail long enough to lower the small jar into the larger one. Practice putting the small jar into the larger jar.
3. Get some water from the refrigerator and pour it into the large jar. The water should fill 2/3 of the large jar. Add 2–3 drops of yellow food coloring.
4. When the water boils, pour it into the small jar and add red food coloring—red since this water is hot.
5. Using the string, gently lower the small jar into the large jar.

What's going on

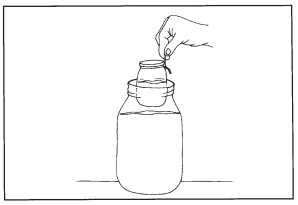
If everything went well, you saw the red water rise through the yellow water, and now you've got a layer of orange water on top of a layer of yellow water. Why did the red (hot) water rise through the yellow (cold) water? Because hot water is less dense than the cold water. Hot air does the same thing; it rises through cold air. This is how clouds start to form.

Air near the ground gets hot when the sun shines. Air a few hundred yards above the ground is not as hot. So, the hot air rises through the cold air. This hot air can rise for many miles, but as it rises it also cools. When it has cooled enough (see How Cold is Cold Enough) then it will form a cloud.

There's more

If you want to see hot air near the ground, look for heat waves shimmering above car roofs during the summer. What color car makes the most heat waves? Mirages form in areas where the air near the ground is much warmer than the air just a few yards above the ground.

Try filling the small jar with cold water and lowering it into a large jar filled with hot water. What happens? This is called a temperature inversion, and no clouds will form if there is a temperature inversion. Why?



How Wet is the Air?

The air is filled with invisible water vapor, but how much? This tool will allow you to measure and find out.

Gather the following materials:
- pint-sized milk carton, empty and clean
- water
- two small thermometers
- cotton shoelace, gauze, or cotton ball
- string
- clear tape

Here's how to do it:
1. Cut a piece of shoelace 1 inch long (2.54 centimeters) and pull it (or gauze or cotton ball) over the bulb of one thermometer. Tie the shoelace in place so it won't fall off. Tape the thermometer to one side of the carton and get the shoelace wet.
2. Tape the second thermometer to another side of the carton.
3. Punch two holes in the top of the carton (where the expiration date is stamped). Thread a long piece of string through these holes and tie the ends together to form a large loop.
4. Go outside and swing the carton overhead while holding onto the string. Do this for one minute.
5. Quickly look at the temperatures on the two thermometers. Write them down.

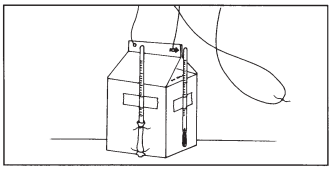
What's going on

The temperature of the thermometer with the wet bulb is always lower than the temperature of the thermometer with the dry bulb. This is because water is evaporating from the wet bulb thermometer and cooling it down.

The difference between the two temperatures gives a clue to the amount of water in the air. **The bigger the difference the drier the air.** The relative humidity is 100% when it is raining and almost 0% in the driest deserts.

There's more

Use the chart given here to calculate the relative humidity of the air. If you have room and can safely swing the apparatus, try measuring the humidity in the bathroom before and after you take a shower.



Dry-Bulb Temperature minus Wet-Bulb Temperature

Dry-Bulb Temperature (°F)	1	2	3	4	5	6	7	8	9	10	15	20	25
30	89	78	67	56	46	36	26	16	6				
35	91	81	72	63	54	45	36	27	19	10			
40	92	83	75	68	60	52	45	37	29	22			
45	93	86	78	71	64	57	51	44	38	31			
50	93	87	80	74	67	61	55	49	43	38	10		
55	94	88	82	76	70	65	59	54	49	43	19		
60	94	89	83	78	73	68	63	58	53	48	26	5	
65	95	90	85	80	75	70	66	61	56	52	31	12	
70	95	90	86	81	77	72	68	64	59	55	36	19	3
75	96	91	86	82	78	74	70	66	62	58	40	24	9
80	96	91	87	83	79	75	72	68	64	61	44	29	15
85	96	92	88	84	80	76	73	70	66	62	46	32	20
90	96	92	89	85	81	78	74	71	68	65	49	36	24
95	96	93	89	86	82	79	76	72	69	66	52	38	28

How Cold is Cold Enough?

When hot air rises it cools, but how cool does it need to get before it forms a cloud? To solve the problem, try this.

Gather the following materials:
- a steel can (like a soup can)
- a thermometer that can get wet and fits inside the can
- some crushed ice

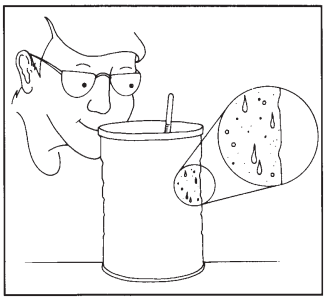
Here's how to do it:
1. Peel the paper from the can.
2. Put the thermometer in the can and add enough water to fill the can 1/2 full. (If condensation forms on the outside of the can, you'll have to pour out the water and start with warmer water.)
3. This step takes patience. The idea is to cool the water slowly by adding only a few small pieces of ice at a time. Stir and wait for the ice to melt before adding more ice. When water starts to condense on the outside of the can then you read the thermometer. If the water temperature is 32°F (0°C) and you still haven't got any condensation on the outside then you will have to add salt and ice to get the water to cool below freezing.
4. The temperature is the dew point of the air.

What's going on

You've probably already noticed that on a hot summer day water collects on the outside of a cold drink. This water comes from the air. In the air water is in the form of a gas called water vapor. If you cool the air then the water in it condenses to form liquid water. By adding ice slowly and writing down the temperature at which the water vapor in the air started to condense, you've figured out how cold the air has to get before it will form a cloud. The temperature at which water vapor will condense is called the dew point.

There's more

As air rises, it naturally cools off. A parcel of air will cool 5.4°F (3°C) for every 1,000 feet (304 meters) it rises, until it reaches its dew point temperature. Then the cooling rate slows down, as condensation releases heat and forms clouds. With the temperature and the dew point, you can predict the altitude of the base of the clouds. Let's imagine the temperature on the ground is 70°F (21°C), and the dew point is 54°F (12°C). The difference in temperature is 16°F. Since the temperature drops 5.4°F per 1,000 feet then in about 3,000 feet (912 meters) the temperature will have dropped to the dew point. So you'd guess that the cloud bottoms would form about 3,000 feet above the ground.



Office of Education and Outreach
NCAR • UCAR • UOP
P.O. Box 3000, Boulder, CO 80307-3000
Phone: (303) 497-1174 E-mail: EO@ucar.edu
Web: http://www.ucar.edu