topic VII

What Causes Weather?

Time Emphasis: 16 days

TOPIC OUTLINE

INVESTIGATION		A-1a	B-1a	C-1a	C-1b	C-3a	C-3b	C-4a	LTI -#12	FE -# 5
Estimated Time (Periods)		1	3	1	1	D	1	1		

A. Atmospheric variables

A-1 Local atmospheric variables

What Are Some Relationships Between Atmosphere Variables That Can Be Observed Locally?

		A-1a	B-1a	C-1a	C-1b	C-3a	C-3b	C-4a	LTI -#12	FE -# 5
A-1.1 Probability of occurrence	A-1.11	■								
A-1.2 Temperature variations	A-1.21	■								
A-1.3 Pressure variations	A-1.31	■								
A-1.4 Moisture variations	A-1.41	■								
	A-1.42	■								
A-1.5 Air movement	A-1.51	■								
A-1.6 Atmospheric transparency	A-1.61								■	
	A-1.62									
A-1.7 Other variables	A-1.71	■								

B. Synoptic weather data

B-1 Synoptic analysis

What Airmass Characteristics Can Be Determined From Synoptic Observations?

		A-1a	B-1a	C-1a	C-1b	C-3a	C-3b	C-4a	LTI -#12	FE -# 5
B-1.1 Airmass characteristics	B-1.11									
	B-1.12		■							
	B-1.13		■							
	B-1.14		■							
	B-1.15		■							
	B-1.16		■							
B-1.2 Airmass source regions	B-1.21		■							
B-1.3 Airmass tracks	B-1.31		■							

C. Atmospheric energy exchanges

C-1 Input of moisture and energy

How Does the Atmosphere Acquire Moisture and Energy?

		A-1a	B-1a	C-1a	C-1b	C-3a	C-3b	C-4a	LTI -#12	FE -# 5
C-1.1 Evaporation and transpiration	C-1.11			■						
	C-1.12									
	C-1.13			■						
	C-1.14									
C-1.2 Vapor pressure	C-1.21				■					
	C-1.22				■					
	C-1.23			■						
C-1.3 Saturation vapor pressure	C-1.31						■			
	C-1.32				■					
C-1.4 Other input energy	C-1.41				■					
	C-1.42									
	C-1.43									

	INVESTIGATION		A-1a	B-1a	C-1a	C-1b	C-3a	C-3b	C-4a	LTI -#12	FE -# 5
	Estimated Time (Periods)		1	3	1	1	D	1	1		
TOPIC OUTLINE	C-2 Moisture and energy transfer		*How Are Moisture and Energy Transferred in the Atmosphere?*								
	C-2.1 Density differences	C-2.11									
		C-2.12									
		C-2.13									
		C-2.14									
		C-2.15									
	C-2.2 Wind speed and direction	C-2.21									■
		C-2.22									
		C-2.23									
	C-2.3 Adiabatic changes	C-2.31					■				
	C-3 Release of moisture and energy within the atmosphere		*How Are Moisture and Energy Released Within the Atmosphere?*								
	C-3.1 Condensation and sublimation	C-3.11					■	■			
		C-3.12									
		C-3.13									
	C-3.2 Cloud formation	C-3.21					■				
	C-4 Release of moisture and energy from the atmosphere		*How Are Moisture and Energy Released From the Atmosphere?*								
	C-4.1 Precipitation	C-4.11									
	C-4.2 Wind-water interaction	C-4.21							■		■
PROCESS OF INQUIRY OBJECTIVES	Mathematical Skill	PIO-1	■	■							
	Measurement Skill	PIO-2		■	■	■		■	■	■	■
	Creating Models	PIO-3		■	■	■	■	■			
	Analysis of Error	PIO-4						■			
	Data analysis	PIO-5		■	■	■		■	■		■
TITLES	Multimedia: Check Multimedia Section of Supplement for reference to this topic.		Weather Watch Analysis	The Synoptic Weather Map	Evaporation	Vapor Pressure	Adiabatic Cooling & Cloud Formation	Dew Point - Cumulus Cloud Formation	Air-Water Interactions	Haze	Beach

VII-A-1a: WEATHER WATCH ANALYSIS

(Continuation of LTI #1 - Weather)

QUESTION:

What relationships between atmospheric variables can be determined from local observations?

MATERIALS:

Weather watch data, U.S. weather maps for the time period of the weather watch data.

SUGGESTED APPROACH:

1. The major portion of this investigation should be spent in discussion, since the students should have been looking for relationships between factors during the time the data were collected. Ask them which factors they think are related; be sure that they can demonstrate to each other that their hypotheses are reasonable, based on the data; encourage students to challenge each other.

2. List on the board all the relationships that are suggested. Have the students indicate which relationships are strong (almost always true) and which are weak (sometimes not true); if possible, estimate a percentage probability. Also, have them indicate whether the relationships are direct or inverse.

3. Lead the students in a discussion of why the factors listed are related in the manner described. Clarify their ideas with leading questions.

4. Distribute weather maps for the period covered by the weather watch. Ask students to study the weather maps and to look for any symbols which seem to be correlated to their local weather data. Discuss any correlations that have been found.

5. Ask students how the results of this investigation could be used to aid them in predicting weather. Give them some sample sets of data (taken from the weather watch). Ask them to predict the next day's weather; then give them the date for the initial data and have them check their predictions.

PRECAUTIONS:

The clarity of the relationships between weather factors depends on locality, season, and type of weather conditions. A stagnant situation, in which pressure patterns remain nearly fixed day after day, produces little change in weather and thus, relationships are almost impossible to detect. This is why it is important for students to look first at the period of time during which marked changes have taken place.

TYPICAL RESULTS:

If data have been collected over a period of at least 2 months, there should be a number of weeks during which marked changes in weather took place and students should be able to clearly establish relationships between changes in pressure, wind direction, changes in temperature, cloudiness, and precipitation.

MODIFICATIONS:

1. Have some of the students carry out a statistical investigation of the weather factor relationships. A good description of how to do this is given in *Investigating the Earth,* Teacher's Guide, pp. 234-235.

2. Capitalize on student ability to make predictions by having them make daily forecasts for the local school district. Encourage them to keep a record of their successes and to analyze any failures carefully so that future mistakes can be avoided or reduced.

3. If for some reason, a weather watch has not been maintained, this investigation can be done by using "canned" data taken from previous years, newspapers, or U.S. weather bureau data. (Order the *Local Climatological Report* for your nearest weather bureau station.)

4. Exchange weather watch data with other schools in the State and/or Nation. Analyze any similarities and differences.

REFERENCES:

Investigating the Earth, p. 193; Teacher's Guide, pp. 232-237, 253.
Our Planet in Space, pp. 226-233, 241-246, 248-249, 258-259, 264-274, 324-325.

VII-A-1a: WEATHER WATCH ANALYSIS

(Continuation of LTI #1 - Weather)

QUESTION:

What relationships between atmospheric variables can be determined from local observations?

INTRODUCTION:

In the weather watch, you have made and graphed daily observations of the more important weather variables. Since the beginning of the watch, you have learned many concepts that can now be applied to these weather factors. In this investigation, you will analyze the data for relationships between the various weather factors, and compare local data with U.S. weather maps for the same time period.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. determine which of the variables are related and whether the observed relationship is inverse or direct.

2. predict the effects of a change in one of the variables on the other variables.

3. summarize the events that usually precede precipitation.

4. summarize the events that usually precede fair weather.

METHOD:

1. Study the weather watch data carefully, especially those weeks during which marked changes occurred in the local weather.

2. List all factors that seem to be related and indicate whether the relationship is direct or inverse. Also, make an estimate of the strength of the relationship (whether it is: always true, sometimes true, or rarely true); you might express this in terms of the percentage probability.

3. Obtain U.S. weather maps for several of the weeks during which marked changes occurred in the local weather. Study the maps, and attempt to correlate them with your local data. Describe your observations.

4. Compare your findings with those of other students to determine areas of agreement and disagreement in your interpretations.

5. Obtain a sample set of data from the teacher. Describe a weather prediction for the next day. Check your prediction against what actually happened. Determine your accuracy. List some factors which could have made your prediction more accurate.

QUESTIONS:

(A-1.11) 1. What frequency of occurrence would lead you to the identification of the existence of a relationship between two weather variables?

(A-1.21) 2. What is the relationship between cloud cover and temperature?

(A-1.31) 3. What is the relationship between air pressure and temperature?

(A-1.41) 4. What is the relationship between dew point temperature and air temperature?

(A-1.42) 5. As the difference between dew point temperature and air temperature decreases, what is the probability of precipitation?

(A-1.51) 6. What is the relationship between wind speed and atmospheric pressure?

(A-1.71) 7. How do other weather variables seem to be related?

8. What weather events usually precede precipitation?

9. What weather events usually precede clearing?

Difficult (3)

VII-B-1a: THE SYNOPTIC WEATHER MAP

QUESTION:

What airmass characteristics can be determined from synoptic observations?

MATERIALS:

Student handout sheets, U. S. Weather Map Series (weekly set for each group of students).

SUGGESTED APPROACH:

1. Initiate a discussion about the extension of observation of weather from the local area to an area of continental size. Relate the discussion to the lead question.

2. Students already should have developed some awareness of weather variables and how they are measured. In this investigation they will see how this information is used to present a "bird's eye view" of an entire weather system on a synoptic weather map and how this weather map can be used to make short-term predictions of future weather conditions.

3. Very little prelab discussion is necessary. Indicate to students that this is an exercise in the interpretation of various "fields," similar to the work done in an earlier topic. Indicate that irregularities, "anomalies," may be observed in the field patterns.

4. Some class time might be spent getting the students started. This will vary according to individual student ability.

5. During postlab discussion, develop the ideas that this synoptic weather map can be used to identify major weather patterns,such as: airmasses, cyclones, anticyclones, interfaces between airmasses (fronts), and areas of associated bad weather.

6. Have the students examine a series of daily U.S. weather maps and determine the speed and direction that weather systems move across the country.

7. Have students attempt short-range predictions.

TYPICAL RESULTS:

1. The student maps, when completed, should appear similar to those on Supplementary Sheets #2 and #3.

2. The students should be able to realize from viewing their three completed maps that "some kind of irregularity" exists in the same location on all three maps (i.e., northerly trending isotherms, sharp "V's" in isobars, and abrupt changes in wind direction).

3. The students should make the following observations and inferences from a study of their maps. This may be summarized and reviewed in postlab session.

   Map I - Barometric Pressure:

   (1) Uniform HIGH pressure area over the Utah area; another over Miami.

   (2) LOW center near Cincinnati.

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(3) Isobars develop a "V" pattern resembling a gully or trough from Galveston to Cincinnati and from Hatteras to Cincinnati. Isobars change direction abruptly in these regions.

(4) Pattern around the Low is not as circular as around the High.

Map II - Surface Wind Patterns:

(1) A definite streamline pattern is observable.

(2) Air appears to be converging on the Cincinnati area, approaching in a somewhat counterclockwise pattern.

(3) Air appears to be diverging from the Utah (Salt Lake City) area in a somewhat clockwise pattern.

(4) An abrupt change in wind directions appears in the Galveston-Little Rock-Cincinnati region.

Map III - Surface Temperature Patterns:

(1) Large temperature change (steep gradient) near Richmond-Hatteras.

(2) N-S isotherm in Galveston-Little Rock-Cincinnati area.

(3) General trend toward cooler temperatures inland, warmer temperatures along coastline, typical of late fall or early spring.

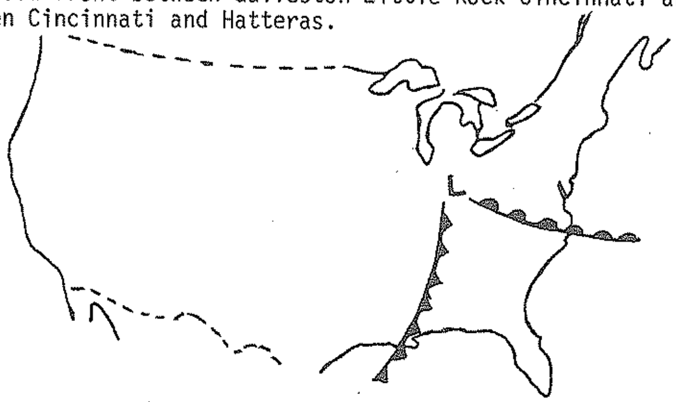
Map IV-- Sky Conditions and Precipitation Patterns:

(1) Precipitation is occurring in an observable area between Galveston-Little Rock-Cincinnati and Richmond-Hatteras.

(2) Generally cloudy skies prevail in adjacent areas.

(3) The Salt Lake City area and the southwest are clear.

(4) Inferences drawn from the temperature, pressure, and wind anomalies, coupled with locations of precipitation areas, lead to the identification of a cold front between Galveston-Little Rock-Cincinnati and a warm front between Cincinnati and Hatteras.



MODIFICATIONS:

1. The teacher may wish to have the students analyze the completed maps (i.e., reproduce Supplementary Sheets #3 and #4 for student use) and not become involved with drawing their own.

2. The teacher may wish to use data from a more current weather map and relate it to the weather the student is now experiencing.

REFERENCES:

Investigating the Earth, pp. 193-202; Teacher's Guide, pp. 235-247.

VII-B-1a: THE SYNOPTIC WEATHER MAP

QUESTION

What airmass characteristics can be determined from synoptic observations?

INTRODUCTION:

We experience a great variety of weather conditions in the area where we live as we carry on our daily lives. How are these weather events associated with those occurring elsewhere in the country? One of the best ways to look at a large system, when we are capable of directly viewing only a very small part of it, is to observe a model.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. plot weather data on a blank map and construct an isoline model for appropriate variables.

2. identify major weather patterns, such as airmasses, cyclones, anticyclones, fronts, and storm areas if they exist on a weather map.

3. make short-range weather forecasts when provided with a series of daily weather maps.

METHOD:

PART I

1. Label your four maps as follows: Map I - Barometric Pressure Patterns; Map II - Surface Wind Patterns; Map III - Surface Temperature Patterns; Map IV - Sky Conditions and Precipitation Patterns. Use the information plotted on the base map to draw each individual map as indicated below.

2. On Map I, draw equal barometric pressure lines (isobars). Use a 4 millibar interval between lines, starting with 100.0 millibars. If any major irregularities in the lines appear, do not alter them.

3. On Map II, draw a short arrow through each circle indicating the direction of wind movement at that city. Draw stream-lines (longer arrows representing the direction air would move) for the general map area. Do not smooth out any abrupt changes.

4. On Map III, lightly sketch in equal temperature lines (isotherms), using a 5 degree interval between lines. When you are satisfied that the lines are correct, darken them with pencil or ink. The lines should follow the measured temperatures with a minimum amount of "interpreted" variations. Irregularities should not be smoothed out!

5. On Map IV, draw a boundary line enclosing the partly cloudy area and draw vertical lines throughout the area. Draw a line enclosing the cloudy or foggy area and crosshatch the entire area. Draw a line enclosing the area where it is raining, and shade the area with your pencil.

6. Examine the four maps carefully and compare them to each other. Describe the patterns that you are able to observe.

PART II

7. Examine a series of U.S. daily weather maps. Try to locate well-defined "Highs" and "Lows." On a blank map of the United States, draw small circles representing the daily positions of a "High" as it moves across the United States. Label the interior of each circle with an (H) and connect them with a smooth dotted line representing the apparent path of this system. Repeat the procedure, using small squares, for the "Low" pressures.

8. Observe the general direction of movement of these systems across the country, and, using the scale of the map, calculate the average number of miles per day that the systems move.

9. Examine the first two or three daily maps in a series (not the same series used previously), and write a weather forecast for your area for the next 2 days. When completed, turn to the next two maps of the series and check the accuracy of your prediction.

QUESTIONS:

1. What characteristics can be used to identify the airmasses on your map?

(B-1.12) 2. What are the characteristics of the temperature field within the airmasses?

(B-1.13) 3. What is the pattern of air movement (wind direction) in the airmass located in the east?

(B-1.14) 4. What is the pattern of air movement (wind direction) in the airmass located in the west?

(B-1.15) 5. With respect to the position of major airmasses, where is precipitation occurring?

(B-1.16) 6. With respect to the airmasses, where are the atmospheric conditions most likely unstable?

(B-1.31) 7. What is the average rate and direction of movement of an airmass across the U.S.? How could this information be used for weather forecasting?

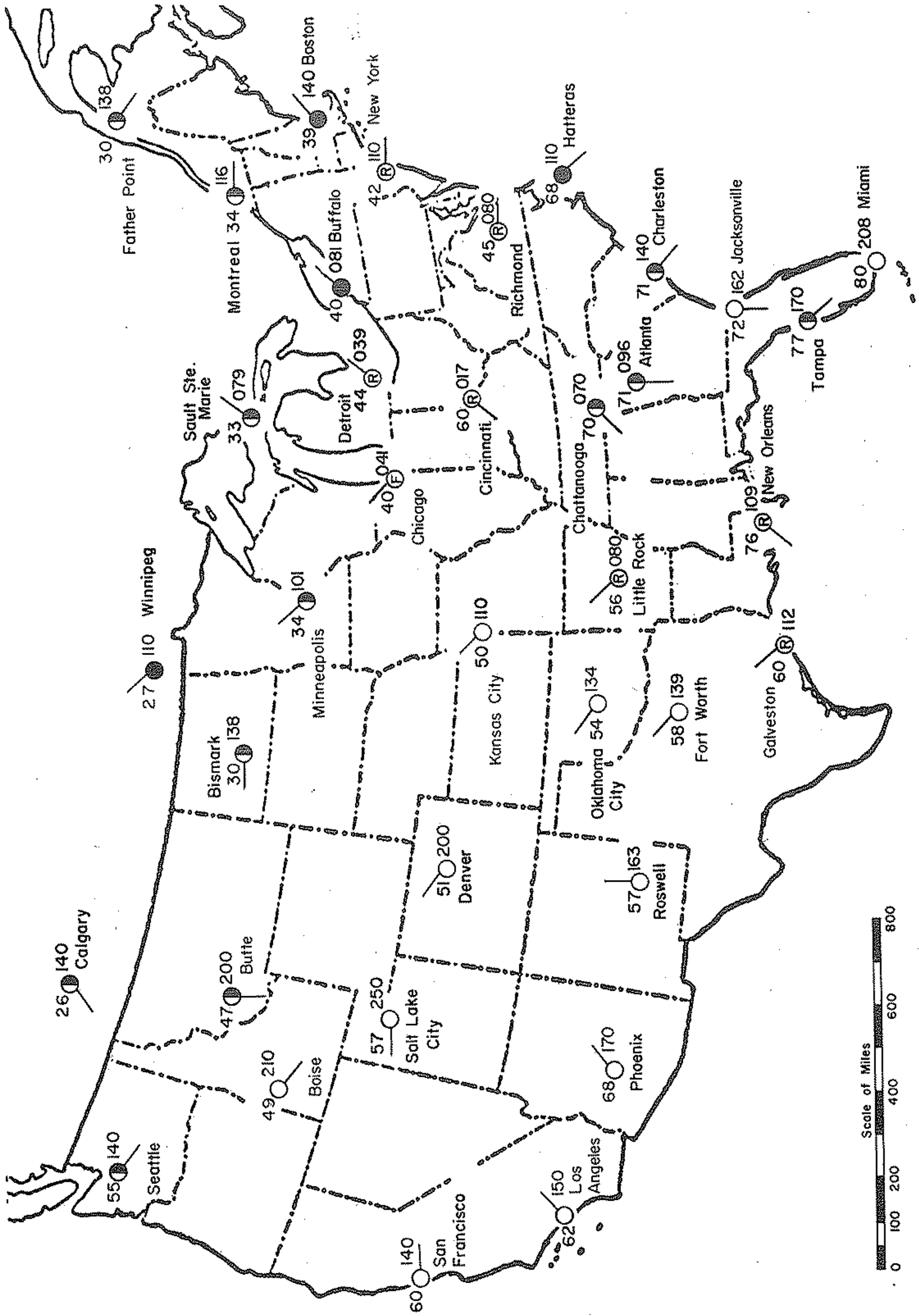
(B-1.21) 8. How do the properties of the airmasses compare to their apparent point of origin?

9. All the surface air in the eastern part of the U.S. seems to be converging on one area. What happens to it once it gets there?

10. The surface air in the western part of the U.S. seems to be moving out of one area. Where is the air to replace it coming from?

11. Observe the way the isotherms bend on your temperature maps as they cross from water to land. Which is warmer, the land or the water? What time of the year would you infer this to be? Explain.

WEATHER DATA MAP OF THE U. S.



MAP KEY

Temperature Reading—51

250 — Barometric Pressure (250=1025.0 mb.)

Wind direction, circle is head of arrow — (R) — Circle Indicates: cloud cover

◐= ½ Overcast; ●= Complete overcast;

○= Clear skies; Ⓡ= Rain; Ⓕ= Fog

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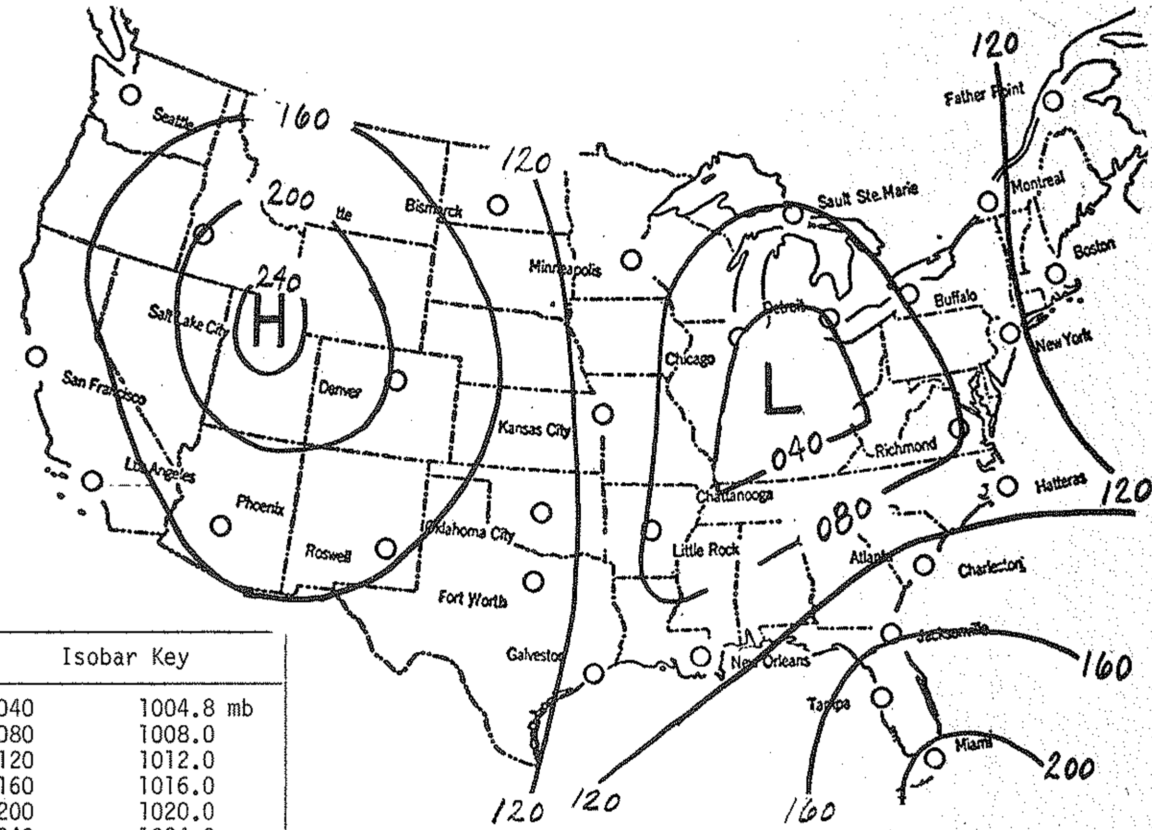
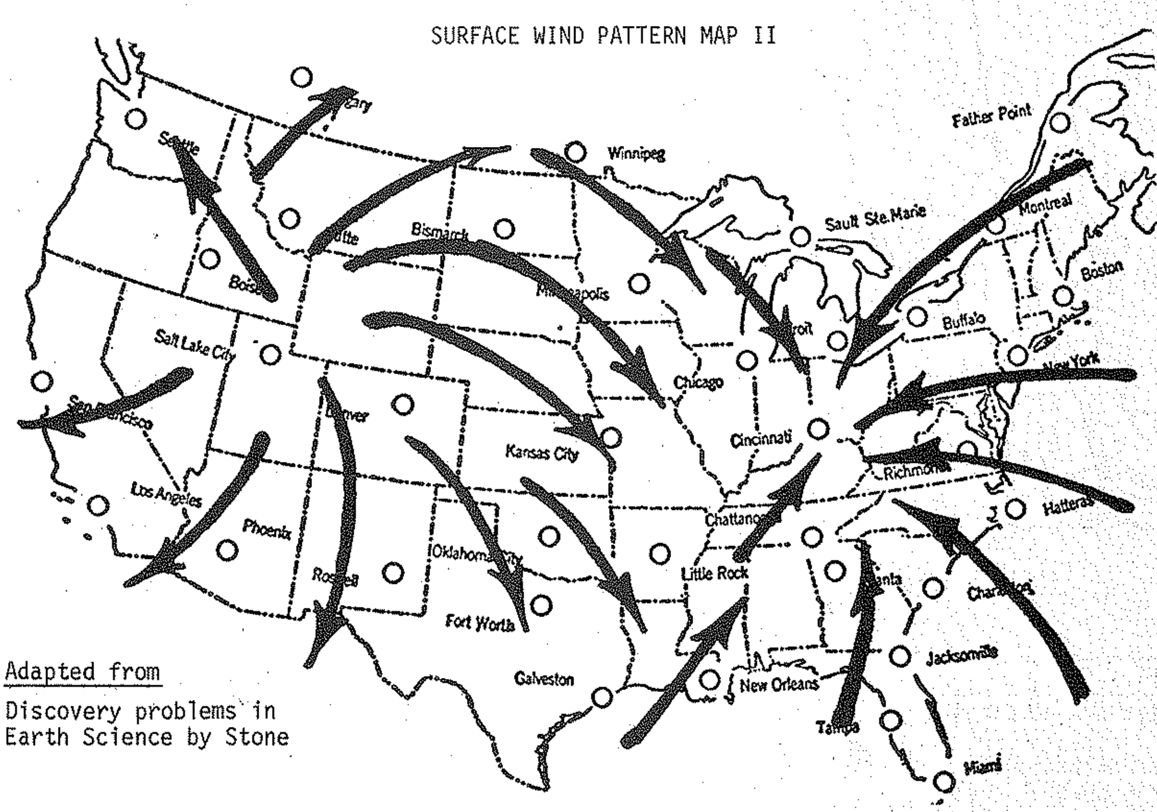
ATMOSPHERIC PRESSURE MAP I



Isobar Key	
040	1004.8 mb
080	1008.0
120	1012.0
160	1016.0
200	1020.0
240	1024.0

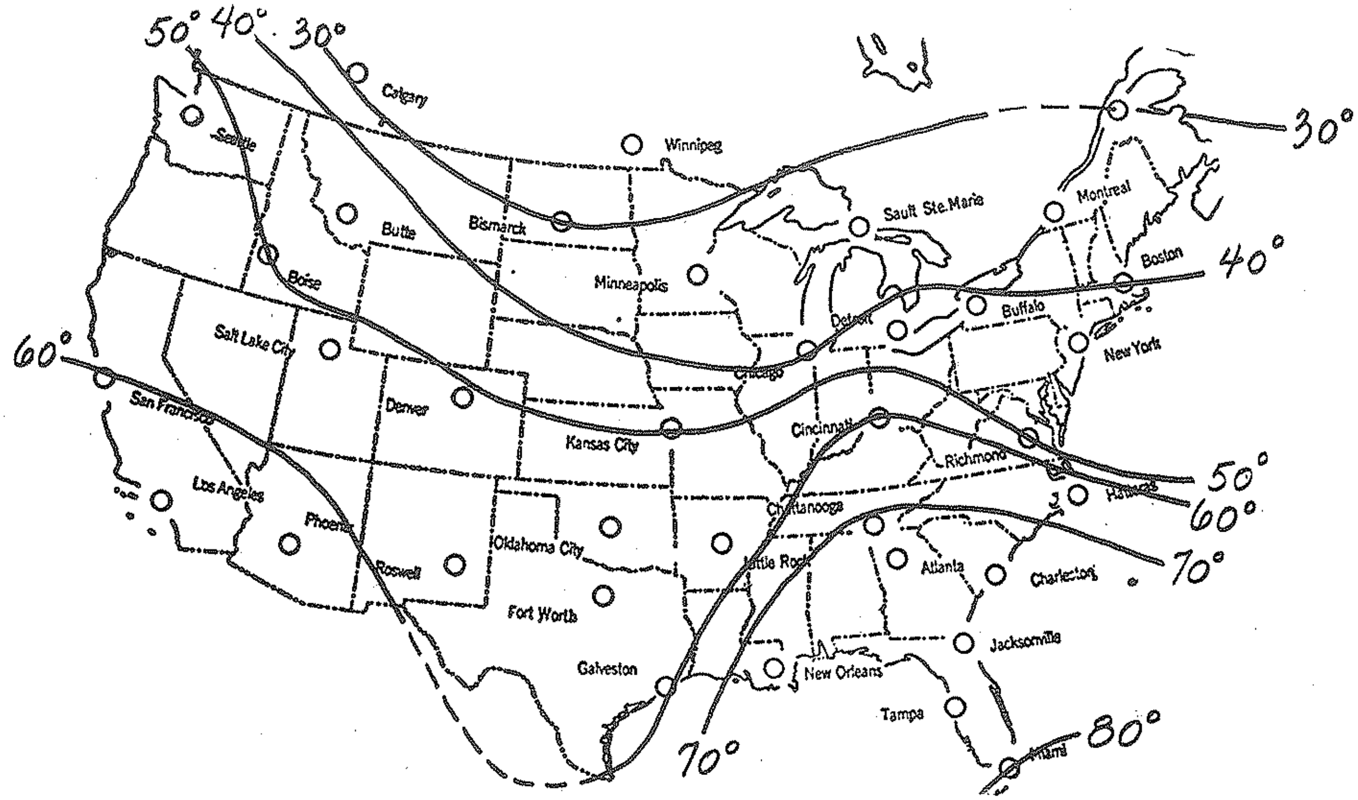
SURFACE WIND PATTERN MAP II



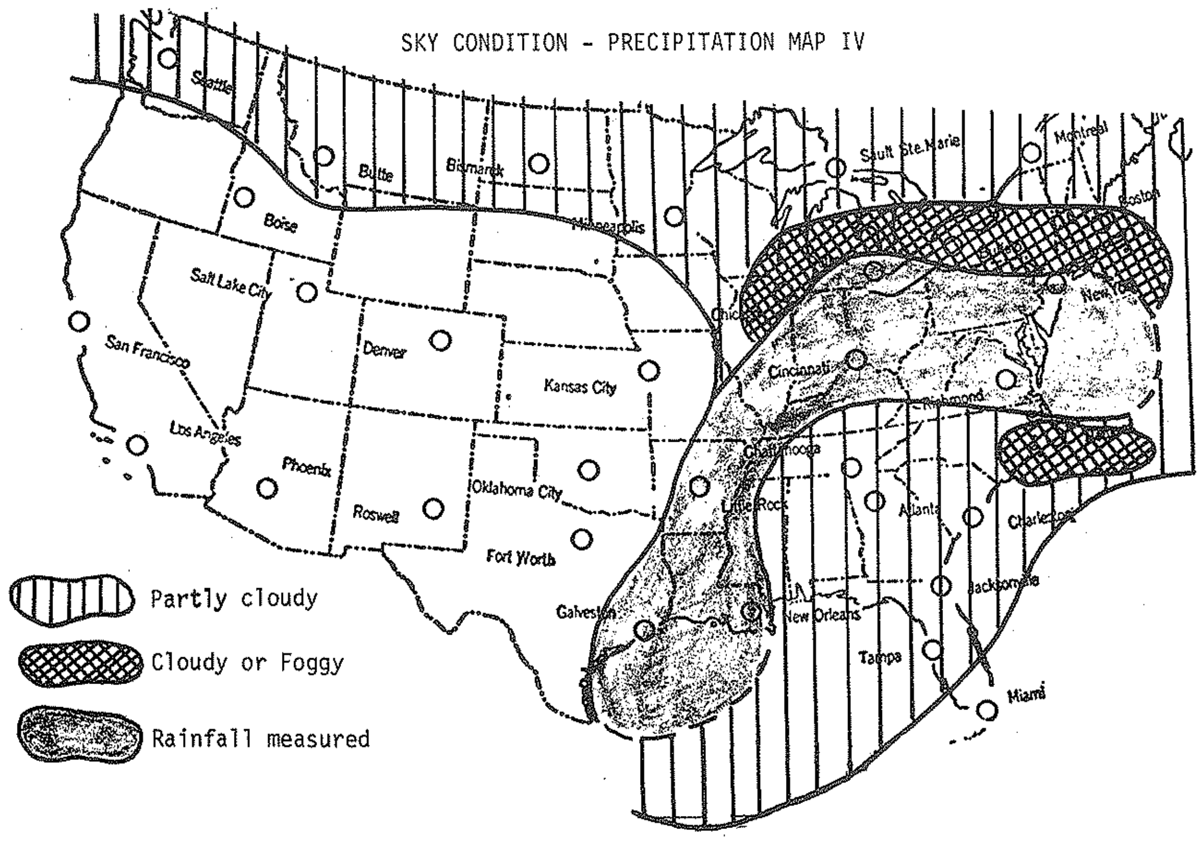
Adapted from

Discovery problems in Earth Science by Stone

SURFACE TEMPERATURE MAP III



SKY CONDITION - PRECIPITATION MAP IV



VII-C-1a: EVAPORATION

QUESTION:

How does the atmosphere acquire moisture and energy?

MATERIALS:

The needs will depend entirely on the procedures designed by the students. A variety of beakers, petri dishes, thermometers, heat lamps, meter sticks, balances, fan, etc. will probably be requested. Suggest that any unusual items be brought in by the students or requested well in advance of class.

SUGGESTED APPROACH:

1. Have the students consider the question, "What factors affect the rate of evaporation?" Make a list of their suggestions; the list should include surface area exposed to air, movement of air, water temperature, humidity of air, air temperature. Assign one factor to each student or small group of students.

2. Instruct students to design a procedure that will test the effect of their factor on the rate of evaporation. Remind them that they are making models of the earth's atmospheric engine and that realistic temperature ranges, wind speeds, etc., should be used. Discuss with them the necessity for keeping all variables constant, except the one being studied.

3. Have students carry out their procedures. This can be done either in class or at home.

4. Lead the students in a discussion of their procedures, data, and interpretations. Help them to explain the reasons behind each of the effects.

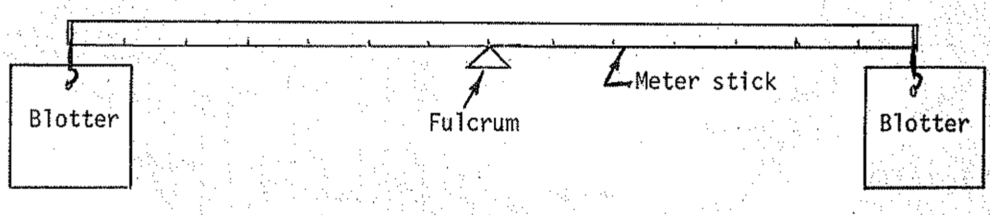
PRECAUTIONS:

1. If you expect the investigation to be completed during one class period, complete steps one and two during the preceding class or as homework.

2. Commercial evaporation kits use sponges which are very difficult to cut into identical pieces. Also, some of the plastic balances melt when a heat lamp is used as a heat source. Simple wooden balances, constructed from meter sticks, or triple beam balances can be used in place of the plastic balances. Paper blotter materials cut into 6 or 8 inch squares can be used in place of the sponges.

TYPICAL RESULTS:

The students may design apparatus similar to that in the diagram below:



Possible techniques for usage are:

1) Surface Area - Cut four equal-sized blotters; dip each in a container of water.

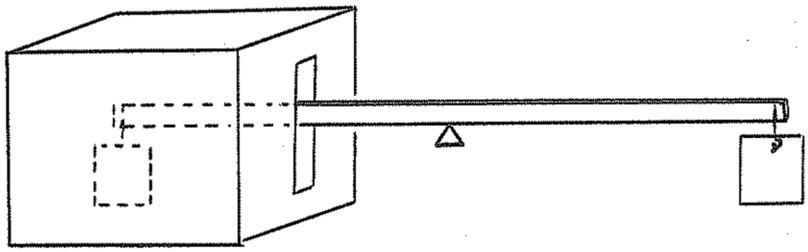
Hang two blotters, one suspended below the other on one end of the balance. On the other end, hang two blotters positioned back to back so that only two sides are exposed to the air. Adjust the fulcrum until a balance is obtained. Observe over a period of time, and determine which way the balance tips. The side that goes up will be the one with the greater evaporation.

2) Air Movement - Balance identical, soaked blotters on the ends of the meter stick. Adjust a fan so that it blows air past only one of the blotters. Observe the results.

3) Water Temperature - Dip one blotter in hot water, the other in cold. Set up the apparatus and observe the results.

4) Air Temperature - Balance identical, soaked blotters on the meter stick. Direct a light bulb toward one and observe.

5) Humidity - Cut a 1-inch slot in the side of an approximately 1-foot cube cardboard box. (See diagram.) Moisten the interior walls of the box, and position the balance so that one end extends through the slot. Close the box top and observe.



<u>REFERENCES:</u>

Our Planet in Space, pp. 261-262
Investigating the Earth, p. 181; Teacher's Guide, pp. 223-225.

VII-C-1a: EVAPORATION

QUESTION:

How does the atmosphere acquire moisture and energy?

INTRODUCTION:

What makes water evaporate? What factors affect the rate of evaporation? In this investigation, you will design your own experiment to test the effects of these factors on the evaporation rate.

OBJECTIVES:

When you finish this investigation, you should be able to:

1. describe a group of variables that would effect rate of evaporation.
2. design a procedure that can be used to test the effect of each factor on rate of evaporation.
3. carry out the designed procedure, collect data, and report the discovered effect on evaporation rate.
4. compare your data with that of students working with the same factor.
5. discuss the effects of the other factors with students working with them.

QUESTIONS:

(C-1.11) 1. How can water get into the atmosphere?

(C-1.23) 2. What is the effect of each of the factors that were investigated on the evaporation rate of equal volumes of water?

(C-1.13) 3. What is the relationship between energy and evaporation?

(C-1.13) (C-1.23) 4. What would be the characteristics of a good drying day (rapid evaporation)?

Easy (1)

VII-C-1b: VAPOR PRESSURE

QUESTION:

How does the atmosphere acquire moisture and energy?

MATERIALS:

One set of apparatus as shown on the student sheet for each group of three students, food coloring.

SUGGESTED APPROACH:

1. Discuss with students the concept of vapor pressure and how it could be investigated.
2. Suggest the use of this apparatus although other approaches might be used.
3. Have the students determine the relative vapor pressures of water at various temperatures. (Temperatures above or below room temperature can be achieved by placing the bottle in a hot water or ice bath and allowing a few minutes for the bottle to adjust to the temperature of the bath.)

PRECAUTIONS:

1. The ends of the glass tubing must be reduced to a small diameter (about 0.5 mm., see detail drawing) in order for the apparatus to work properly.
2. The glass tubing should be well supported to reduce the possibility of breakage.
3. Be sure to use a dry bottle for each trial; wiping will not dry the bottles enough they must be allowed to stand open for several hours in sunlight or must be heated to drive off the moisture.
4. The amount of vapor pressure that can be observed will depend on the vapor pressure in the room (i.e., with high room humidity, little change in vapor pressure will be observed).

TYPICAL RESULTS:

1. Students should see the water level (vapor pressure) rise rapidly and then level off as saturation is approached.
2. A higher temperature environment (i.e., a warm water bath) should result in higher leveling-off point (i.e., higher saturation vapor pressure).

MODIFICATIONS:

1. Use this exercise as a teacher demonstration.
2. Have a small group of students do the exercise as a demonstration.

VII-C-1b: VAPOR PRESSURE

QUESTION:

How does the atmosphere acquire moisture and energy?

INTRODUCTION:

Vapor pressure is that part of air pressure that is caused by water vapor in the air. As water evaporates, the number of molecules of water per unit volume of space increases, and this exerts a greater pressure. (If the water reaches the maximum number per unit volume, saturation vapor pressure exists.) How will the rate of evaporation change as the vapor pressure increases? What factors affect the saturation vapor pressure?

OBJECTIVES:

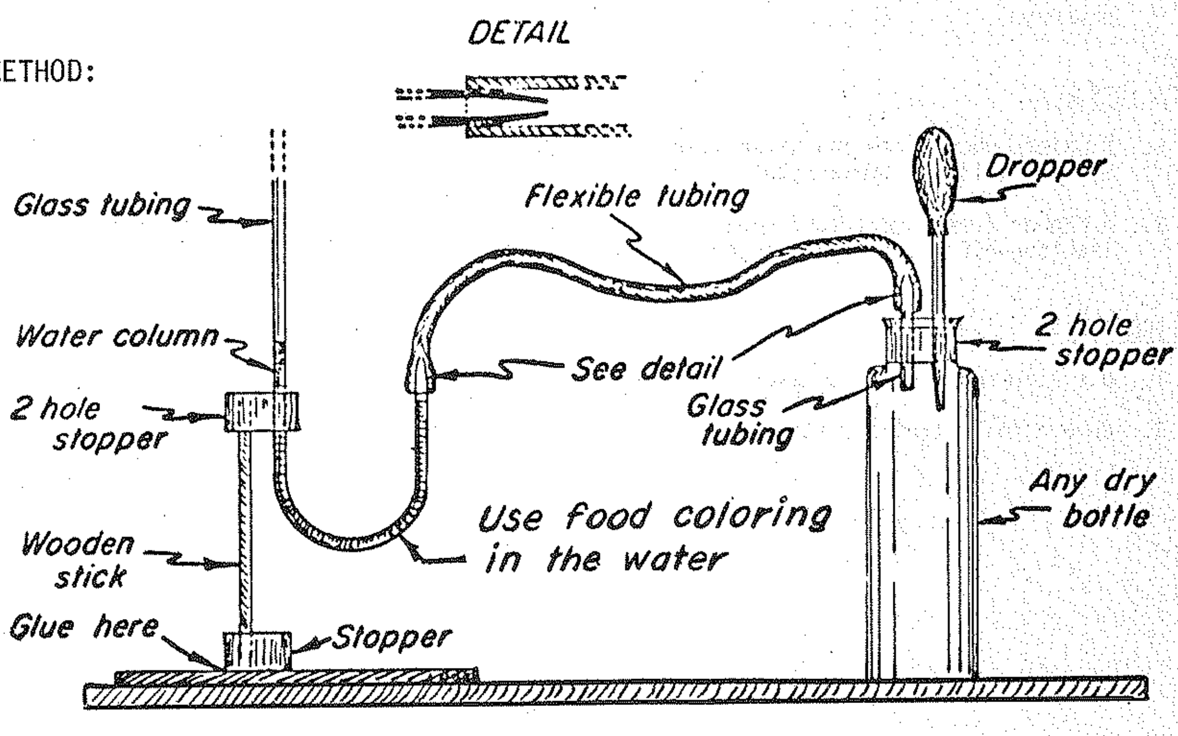
When you finish this investigation, you should be able to:

1. measure the relative saturation vapor pressure for a given set of conditions using the apparatus provided.

2. describe the relationship between saturation vapor pressure and temperature.

3. identify similarities and differences between the experimental model and the earth's atmosphere.

METHOD:



1. Set up the apparatus as shown in the diagram.

2. Place a metric scale behind the glass tube so that readings can be made as the water level changes.

3. Remove the dropper, fill it with water, insert it in the stopper and measure and record the height of the water level.

4. Squeeze the water into the bottle.

5. Take readings of the water level every 10 seconds and record on a data table.

6. Place another dry bottle on the apparatus, and position it in a warm water bath. Repeat the procedure.

7. Place another dry bottle in an ice bath and repeat.

8. Graph the data for each exercise.

QUESTIONS:

1. Why does the water column rise? Is the column being pulled or pushed? By what? How do you know?

2. What is the pattern of change in the water levels with time?

(C-1.21) 3. In an air-water environment (e.g., air over a lake), where would you expect the vapor pressure to be highest?

(C-1.22) 4. Describe the relationship between the vapor pressure and the rate at which evaporation occurs.

(C-1.32) 5. Describe the relationship between saturation vapor pressure and air temperature.

(C-1.32) (C-1.41) 6. What would be the probable pattern of the average saturation vapor pressure between the equator and the poles?

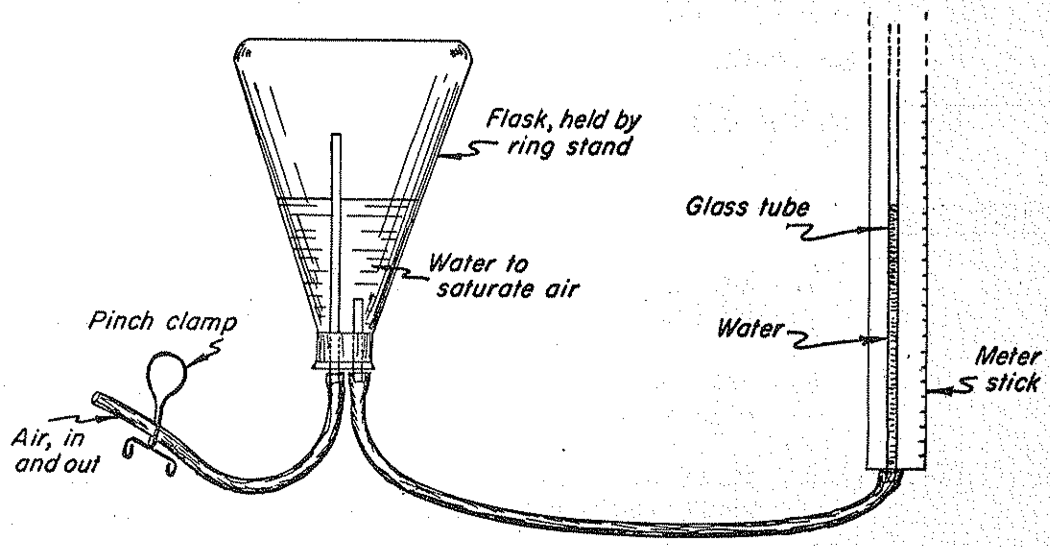
VII-C-3a: ADIABATIC COOLING AND CLOUD FORMATION

QUESTION:

How are moisture and energy released within the atmosphere?

PURPOSE:

The formation of clouds requires saturated moist air and a condensation surface. Saturation is achieved when the air is cooled adiabatically by decreasing the pressure and allowing it to expand (adiabatic process). Condensation surfaces, or nuclei, are usually particles of dust, smoke, salt, pollen, etc. This demonstration can be used to show that a cloud results only when both condensation nuclei and reduced pressure are present.



PROCEDURE:

1. Set up the apparatus as shown in the diagram. Force air into the flask until the water in the glass tube is to the top of the meter stick. Close the pinch clamp.
2. Open the pinch clamp suddenly. Observe the pressure drop as shown by the decreasing water level in the glass tube. Observe the air in the flask (no cloud should form).
3. Open the flask and allow some smoke from a candle to enter. Close the flask, return it to its original position and force the water level in the tube to the top of the meter stick. Close the pinch clamp.
4. Open the pinch clamp suddenly. Observe the pressure and the air in the flask (pressure falls, a cloud forms).

PRECAUTIONS:

1. Swirl the water in the flask before carrying out the demonstration. This is necessary to saturate the air with water vapor.
2. A black card behind the flask will make the cloud more visible.

MODIFICATIONS:

1. If possible, introduce a thermometer into the flask in such a way that its bulb is in the air. This would allow you to measure the temperature change that results from the pressure changes and actually prove that cooling occurs.

2. To show that air expands when pressure decreases, blow a little air into a small balloon and tie it shut. Place the balloon inside a bell jar. Evacuate the bell jar with a suction pump. Watch the balloon expand.

3. To illustrate the cooling of air as it expands under decreased pressure, inflate an inner tube to a high pressure. Let it rest for about 15 minutes so that its temperature will become equal to the room temperature. Measure room temperature. Open the valve of the inner tube and measure the temperature of the escaping air.

4. Obtain a large, strong bottle. Put half an inch of water in the bottle and seal the bottle tightly. Insert a glass tube through a hole in the stopper, and connect the glass tube to a bicycle pump by means of rubber tubing. Pump air into the bottle until moderate pressure is built up. Clamp the tube to prevent the escape of air and to retain the pressure. Allow the bottle to stand for several minutes until the air in the bottle is saturated with water vapor. Release the pressure suddenly by opening the clamp. Watch the cloud form in the bottle.

QUESTIONS:

1. Why does the water in the glass tube fall when the pinch clamp is opened?

2. Why didn't a cloud form the first time?

(C-2.31) 3. What must be happening to the air in the flask when the pinch clamp is suddenly opened? What is the evidence?

(C-3.11) 4. What conditions seem to be necessary for the formation of clouds?

(C-3.21) 5. Describe the composition of a typical cloud droplet.

REFERENCES:

Investigating the Earth, pp. 184-190; Teacher's Guide, pp. 226-230, 250-252.
Our Planet in Space, pp. 269-275, 288-291.
What Makes Clouds Form? EBF-AGI.

Easy (1)

VII-C-3b: DEW POINT - CUMULUS CLOUD FORMATION

QUESTION:

How are moisture and energy released within the atmosphere?

MATERIALS:

Shiny metal can, sling psychrometer, thermometer, crushed ice, water.

SUGGESTED APPROACH:

1. Briefly discuss with the students what conditions are necessary for cloud formation. Remind them that cumulus clouds form from rising air and ask them what information they would have to know to be able to calculate the base altitude for such clouds.

2. Have the students measure the dew point directly by determining the temperature at which condensation first appears on the outside of a metal can containing water and crushed ice. They should repeat this measurement several times and average their results.

3. Have the students measure dew point indirectly by using a sling psychrometer and a dew point temperature chart such as the one on the Earth Science Reference Tables.

4. Have the students plot the surface air temperature on the temperature vs. altitude graph. (See Supplemental Sheet.) The fact that rising air cools at the rate of 10°C/km. will determine the temperature of the air at 1 km. A line through these points will show the temperature of rising air at any altitude.

5. Have the students plot the observed dew point on the temperature vs. altitude graph. Since the dew point decreases at a rate of 2°C./km., the dew point at 1 km. can be determined. A line through these points will show the dew point at any altitude.

6. The point at which these two lines cross determines the altitude at which the dew point is equal to the air temperature and where the base of the cumulus cloud would be.

7. Call the U. S. weather bureau for the official dew point, cloud height, and air temperature.

8. Lead the students in a brief discussion of their data relative to the official value of the weather bureau. Analyze any apparent sources of error.

9. Discuss why both air temperature and dew point temperature decrease with altitude.

PRECAUTIONS:

1. If the students add ice to the water too quickly, the value they obtain for the dew point will be too low since the temperature will fall past the dew point too quickly.

2. Try to carry out the investigation on a day when there are fair-weather cumulus clouds. If there are no clouds or the "wrong" kind of clouds, use the data to predict the height at which clouds would form if all the necessary conditions were met. Since this investigation will be done during the winter months, this situation is very likely to occur.

3. Try to do the investigation outdoors on a day when the dew point is above 0°C.

TYPICAL RESULTS:

If outdoor data are used, students should be able to predict cloud base height to within a few hundred meters. If the investigation is done indoors, it will help if the windows are opened wide previous to class and kept open during class. Indoor data produce variable results.

MODIFICATIONS:

Have the students use the wet adiabatic rate (6°C/km.), above the intersection of the air temperature-dew point lines, to find out at what altitude the clouds would be composed of ice crystals.

REFERENCES:

Investigating the Earth, pp. 184-187, 200, 574; Teacher's Guide, pp. 226-229, 242-244.
Our Planet in Space, 262-263, 268-269, 288-291.
The Earth Sciences, pp. 250-252.

VII-C-3b: DEW POINT - CUMULUS CLOUD FORMATION

QUESTION:

How are moisture and energy released within the atmosphere?

INTRODUCTION:

Have you seen the sky filled with cumulus clouds and noticed that their flat bases all seem to be the same distance from the ground? The water droplets that form these clouds come from the cooling of warm, moisture-laden air as it rises from the ground. Why do the clouds begin to form at the same level? What must be true about the temperature at that level? In this investigation, you will measure the air temperature and dew point, and use these temperatures to determine the height at which cumulus clouds would form in the sky above you.

OBJECTIVES:

When you have finished this investigation, you should be able to:

1. determine the dew point temperature using the psychrometer and shiny can methods.

2. determine the base altitude of cumulus clouds from dew point and air temperature data.

3. measure and record the dew point temperature indirectly by using a sling psychrometer and the dew point temperature chart in your Earth Science Reference Tables.

4. compare your data with those of other students to determine variations.

5. find the base height at which cumulus clouds begin to form by plotting your dew point and temperature data on the supplementary sheet provided.

6. compare your base height determination with the official weather bureau value and analyze the reasons for any differences.

QUESTIONS:

(C-3.11) 1. Why does water vapor condense at the dew point temperature?

2. How do your values for dew point temperature obtained from the can compare with those from the sling psychrometer? If they were different, what could be the reason(s)?

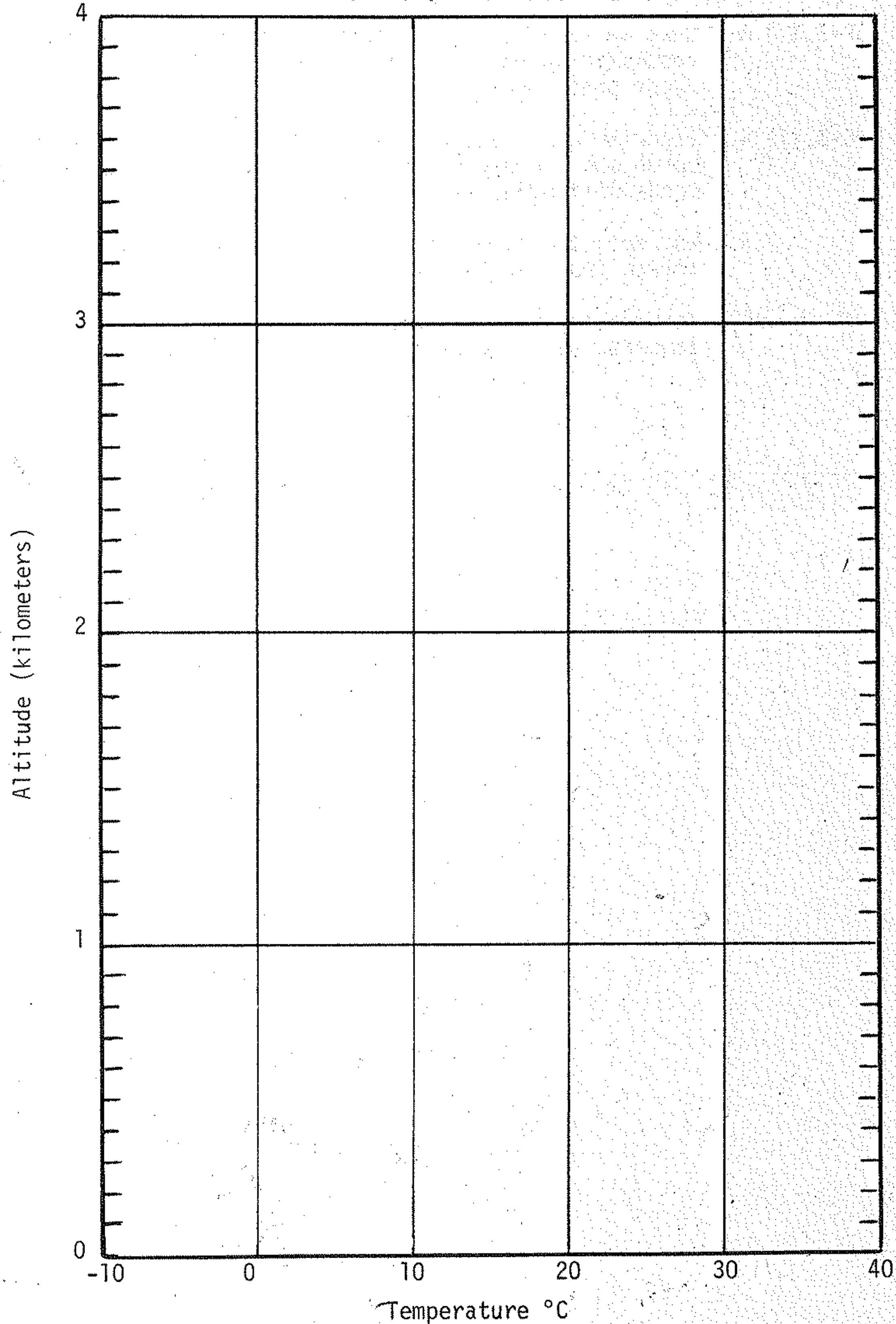
(C-1.31) 3. What would be the relationship between evaporation and condensation when the air is saturated? (Saturation vapor pressure.)

(C-3.11) 4. Describe what happens when the dry adiabatic cooling curve and the dew point lowering curve meet, providing condensation nuclei are present.

5. Why does the base altitude of fair-weather cumulus clouds change from day to day?

6. What would happen to the air temperature and dew point temperature of descending air?

ALTITUDE VS. TEMPERATURE GRAPH



Easy (1)

VII-C-4a: AIR-WATER INTERACTION

QUESTION:

How are moisture and energy released from the atmosphere?

MATERIALS:

World wind map and world ocean current map (supplementary sheet).

SUGGESTED APPROACH:

1. Briefly discuss with students the cause of wind. Ask them to suggest a few effects wind may have on the earth's surface, and have them briefly trace the energy transfers which are prerequisites to these effects.

2. The remainder of this exercise can best be accomplished as a homework assignment.

   A. Have the students compare the world wind and ocean current maps for similarities and differences.

   B. Have the students examine some local effects of wind which indicate a transfer or release of energy from the atmosphere to the earth's surface. Some possibilities are:

      1) Attach about four balloons to a flag pole at various heights. Normally the balloons will indicate faster air movement near the top than near the ground, due to friction of the air with the ground. It will also be apparent that friction turns winds.

      2) Observe "tree flags." Most trees have longer limbs on one side than on the other, and this shows the direction of the prevailing wind.

      3) Observe waves on a body of water. Observe wind direction and relate it to the direction of the wave movement.

      4) Observe an area of sand; carefully locate any ripple marks or dunes. At the same time, observe wind direction. Keep records for several days, note any changes in the location of the ripple marks or dunes and relate these to the wind. (The same results can be seen observing snow.)

3. After completion of the assignment, lead the students in a discussion of the observed wind effects; help them relate these to energy transfer and trace the path of this transfer.

REFERENCES:

Investigating the Earth, pp. 164-172, 234-240; Teacher's Guide, pp. 206-209, 218-219.
Our Planet in Space, pp. 226-232, 235-237, 313-317, 309-310, 419-434.
Exploring Earth Sciences, pp. 66-67, 107, 298, 378.
Focus on Earth Science, pp. 182-187, 230, 306-313.

VII-C-4a: AIR-WATER INTERACTION

QUESTION:

How are moisture and energy released from the atmosphere?

INTRODUCTION:

Man's development has been closely associated with wind. For example, anthropologists have been able to trace man's migration patterns from one land mass to another by observing the paths that crude sailing vessels follow.

The effects of wind on man have not all been positive. Hurricanes and tornadoes cause property damage and may result in human death.

What causes the wind? Where does the energy to move the air come from? What are the effects of this energy on the earth?

OBJECTIVES:

When you finish this investigation, you should be able to:

1. cite several evidences of the release or transfer of energy from the atmosphere to the earth's surface.

2. analyze such release or transfer in terms of kinetic and potential energy and the conservation of energy.

METHOD:

1. Compare the map of worldwide winds with the map of worldwide ocean currents and describe the probable associations between them.

2. Observe the effects of wind on objects in your local environment; find some effects that you think are caused by wind; then observe the wind's direction and see if any correlation is evident.

3. Discuss your findings with other students.

QUESTIONS:

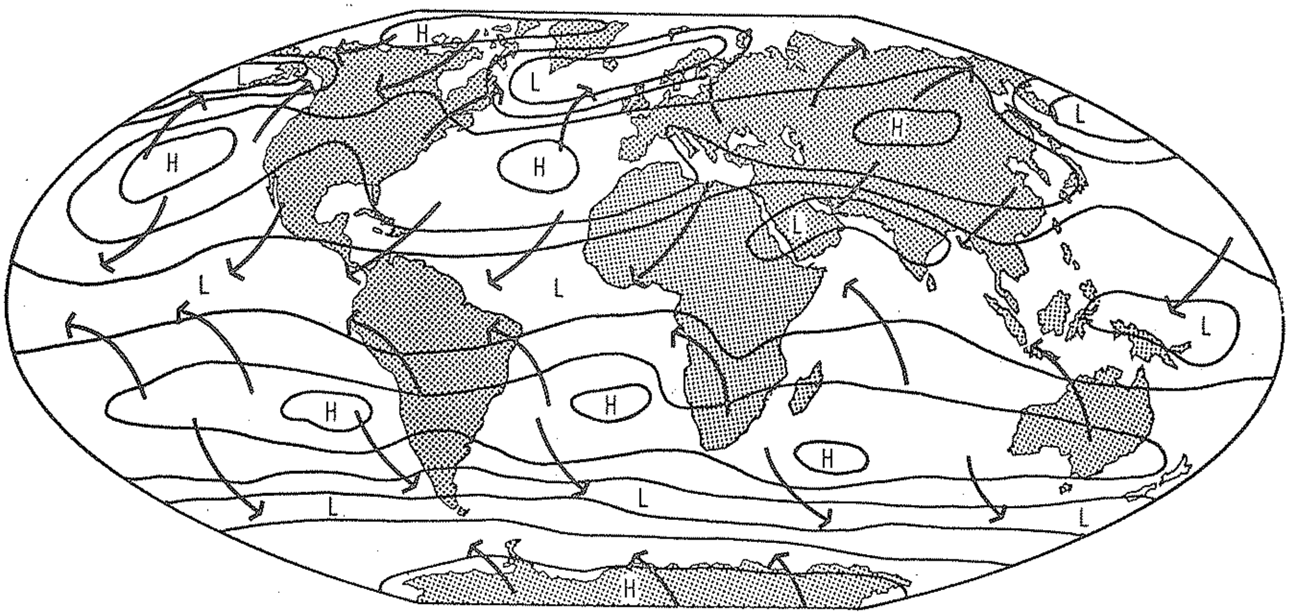
1. What wind effects were you able to observe?

2. How did you know they were due to the wind?

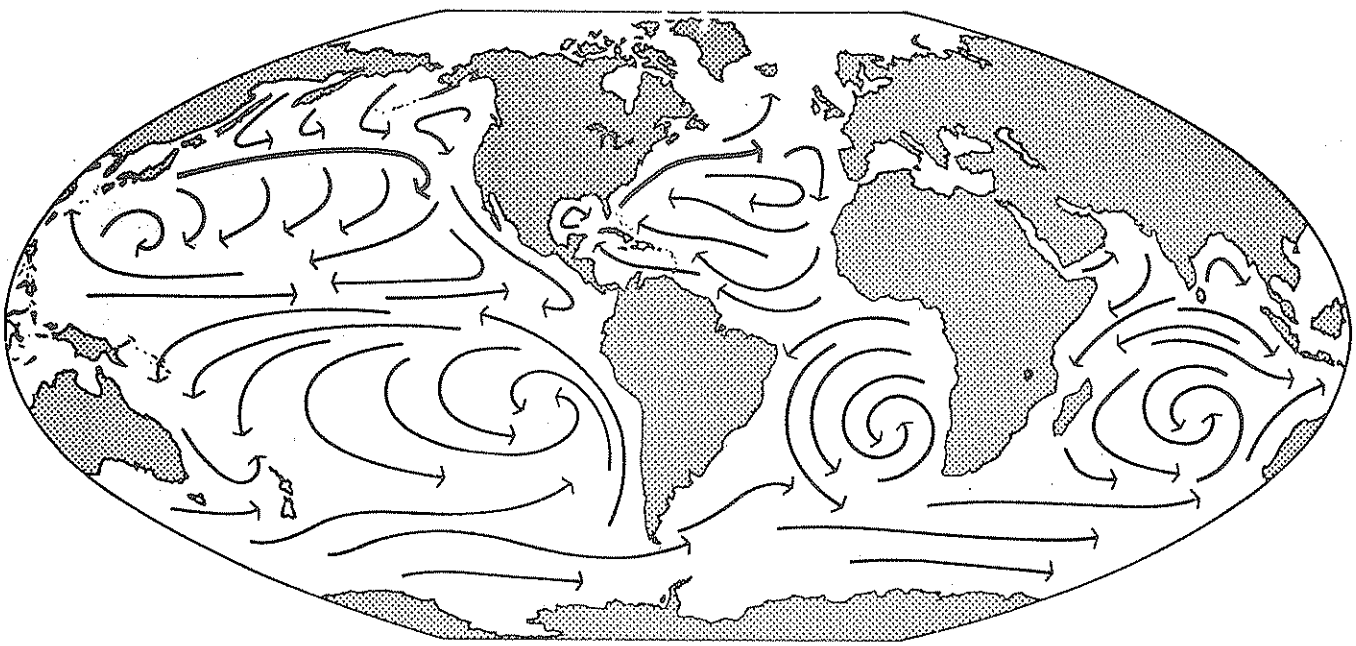
(C-4.21) 3. Choose at least one of your "effects," and describe the energy transfers that took place, identifying both those that were potential and kinetic energy.

SUPPLEMENTARY SHEET

(Wind Patterns - Ocean Currents)



Generalized Wind Pattern Map



Generalized Ocean Current Map

ADAPTED FROM:

Investigating the Earth, Teacher's Guide