It's Foggy

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INTRODUCTION

I teach three Algebra 1B courses and three Physics courses, two of which are Honors classes. Most of the students in the Physics courses are eleventh graders, who are enrolled in the Space and Meteorology Program. By collaborating with the Meteorology teacher, use of this unit (mini lectures, laboratory explorations, and computer investigation), should be rewarding.

The goal of this curriculum unit is to understand concepts relating to fog. I am designing a two-week unit for maximum flexibility in teaching by identifying and modeling the aspects of fog. The unit will contain descriptive material concerning fog, which will provide a transition to the applied phase (laboratory activities). Careful attention will be given to student interest and student involvement. The curriculum unit will provide the kind of framework in science class to find connections with other meteorology topics. Hopefully, the unit will have a direct impact on the learning environment.

A great way to discover unique ideas, exceptional teaching skills, fortitude and foresight for the classroom is through activities in the curriculum unit that will increase student interest. The opportunity to develop and disseminate materials that would assist others will have significant impact on the overall classroom by incorporating the teacher's skills into the educational environment. The curriculum unit could be customized to focus on the particular needs and interest of teacher and student. Material will be used to keep skills current and give students practice with questions they would like encounter on semester examinations. Student's activities with software based science labs and science tools for exploration will be identified and used in the classroom activities.

The specific questions guiding the unit are:

1. What is fog?
2. What kind(s) of fog do we experience in Houston?
3. How is Houston's fog similar and different to the fog in California?
4. How does fog differ from smog?

"It's foggy today. I'll have to leave a little early from work." Then I thought, "What is fog?" "Lately I've thought about this wonderful occurrence." The author can relate to personal experiences such as, fog on a window. I often ask how does this fog occur. The main reason for teaching this unit is that fog is a common occurrence, which can have an impact on a person's daily activities: airplane schedule, going to wash and

recreational activities. Hopefully, the unit will have a direct impact on the learning environment.

Terms

- cloud
- dew point
- fog
- haze
- humidity
- mist
- relative humidity
- advection fog
- radiation fog
- upslope fog
- evaporation fog

Activity Index

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4.	Word Scramble – "It's Foggy"	Appendix C
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7.	UNISYS	Appendix E
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Activities

Students will perform the following activities.

1. Demonstrate how a cloud is formed. Have students perform J. Van Cleave's experiment "Cloud Maker" (pages 40-43).

2. Investigate how different kinds of fog forms. Read J. Williams (The Weather Book) and C. Ahrens (Meteorology Today) in order to complete the Table. Students will describe the formation of different kinds of fog. Duplicate copies of the chart, or use the overhead, and let the students write their answers on their paper.

3. List and categorize the different kinds of fog.

4. Define Terms. Have students circle the term in the Word Scramble "It's Foggy". Then have students define terms. See It's Foggy – Let the students fill in the Concept Web, then discuss.

5. Demonstrate how dew is formed. Have students perform the experiment "Dew Drops", J. Van Cleave's, Pages 48-51).

6. Use PowerPoint to create animated fog. Students will be able to determine if fog will exist by varying the temperature and dew point. One possible way – teacher will provide photo/pictures of fog. Student can follow procedure given in FOG.

7. By using UNISYS website weather.unisys.com, which was provided by Professor Lawrence, University of Houston Weather Station, students can complete the activity, "Will there be Fog?" Students will look at symbols and determine if fog or haze exists. Teachers may use www.weather.unisys.com to obtain other maps. A map is included in the Appendix. The teacher will provide background information and symbol definitions on the weather maps.

   Overview: By learning about mapping, the students can realize that weather can be summarized in map form, which is a truly international language for meteorology. The international collaboration that ensures the global transmission of weather observations is extended to the way in which weather maps are plotted. Synoptic charts, which portray a "snapshot" of the surface across a region, are the working material for many forecasters. Modern weather services provide automatically plotted surface charts, upon which the analyst (or a computer-driven machine) will draw a variety of lines. (Reynolds)

8. See Card Game – Match the ACT cards wit the F card to complete the statement. "FOG FACT"

Opportunities will be established to provide a link between other topics and this unit.

BACKGROUND INFORMATION

Though San Francisco has heavy fog, eighteen days per year, it is not the foggiest place on the West Coast. Cape Disappointment, Washington, located at the mouth of the Columbia River, has approximately 2,556 hours of fog per year. Moose Peal Lighthouse on Mistake Island, Maine, the foggiest area on the East Coast, averages 1, 580 hours of heavy fog each year. Located on the Appalachian Mountains area, West Virginia averages over 100 days of fog each year. Fog is a suspension of very small droplets in the air in contact with the surface of the Earth. Fog differs from clouds because it forms in the lower portion of the Earth's atmosphere. The Houston area is famous for radiation

and advection fog. Sometimes in Houston there may be fog and smog! Fog is usually formed by: 1) continual cooling of the air, or; 2) evaporating and mixing of vapor into the air.

According to international definition, fog is any condensation that reduces visibility to less than 1 kilometer (3,281 feet). Fog that does not greatly reduce visibility is called mist or haze. Fog forms from water that has evaporated from lakes, oceans, and rivers or from moist soil and plants. This evaporated water, called water vapor, expands and cools as it rises into the air. Air can hold only a certain amount of water vapor at any given temperature. This amount is called the holding capacity. As the temperature of the air decreases, so does its holding capacity. When the temperature drops so that the amount of water vapor in the air exceeds the holding capacity, some of the water vapor begins to condense (change into small droplets of water). Specifically, fog forms where warm air rises from the ground and is replaced by cold air. A look inside fog shows the cold air caused water vapor to condense in to tiny, visible water droplets. As these water droplets multiply, a cloud of fog is formed. Fog also forms when a warm front and a cold front meet, or when warm air travels over a cool surface like a lake or ocean. Fog disappears when the air temperature rises and the holding capacity increases.

Fog is composed of water vapor, which is merely water in a gaseous state. The change among the three phases (or states) of water- ice, liquid, and vapor (or solid, liquid, and gas) help create our weather by adding heat or taking heat from the surrounding air. As air cools its molecules-including water molecules-lose energy. Many water molecules condense, forming clouds or fog. Understanding how water acts as it evaporates into the air or condenses out of the air explains how dew, frost, fog, and clouds form. Fog is more likely to form on clear nights than on cloudy ones. The earth is always radiating away infrared energy into the atmosphere. After the sun goes down, solar energy is no longer warming the ground, but he infrared energy keeps sending heat upward. The ground cools. On cloudy nights, the clouds absorb infrared energy from the earth and radiate it back down. On clear nights, infrared energy is lost to space. The ground becomes colder. The cold ground cools the air next to it. If the air cools it to dew point, frost or fog forms. (Williams)

J. W. Williams (USA Today-The Weather Books) categorizes the basic types of fog in to the following: radiation, advection, upslope, sea smoke, or steam, and precipitation. Paul Joseph of The Wisconsin Weather Team classifies fog into four basic types: radiation, advection, evaporation, and upslope. C. Donald Ahrens (Meteorology Today) lists the main category as follows: radiation, or ground fog, advection, upslope, and evaporation (mixing). Linacre and Geerts considers seven kinds of fog; namely, hill mist or upslope fog, rain fog, radiation fog or ground fog, advection fog or sea fog, steam fog or sea smoke, ice fog, and smoke fog or smog.

Advection fog results from the movement (advection) of warm, moist air from south over a colder landmass. During the winter this is common when snow covers much

of the Midwest. The snow cools the bottom portion of the moist air mass often resulting in condensation. This type of fog can be widespread and very dangerous to air traffic. (Rubin and Duncan)

Advection fog develops from air traveling over a surface of a different temperature. One kind of advection fog, called sea fog, occurs when warm, moist air travels over a cold surface. Sea fog is most common along seacoast and lakeshores. Another kind of Advection fog, called steam fog, results from cold air passing over warm water. This advection fog is also called evaporation fog. Water vapor, evaporating continuously from the water surface, comes in contact with the cold air. When the air reaches its holding capacity, the excess water vapor condenses quickly into fog droplets that stream up from the water surface. Stream fog commonly appears on cold winter days over the Great Lakes and over the warm lakes in Florida. (See Figures1a and 1b) A common form of evaporation-mixing fog is the steam fog, which forms when cold air moves over warm water. This type of fog forms above a heated outside swimming pool in winter. As long as the water is warmer than the unsaturated air above, water will evaporate from the pool into the air. The increase in water vapor raises the dew point, and, if mixing is sufficient, the air above becomes saturate. The colder air directly above the water is heated from below and becomes warmer than the air directly above it. This warmer air rises and, from a distance, the rising condensing vapor appears as "steam." Over the ocean in Polar Regions, steam fog is referred to as arctic sea smoke.

Radiation fog occurs on calm, clear nights as the ground loses warmth through radiation in to the air. A layer of fog forms along the ground, as the air cools to the dew point, which defines the holding capacity of the air. The fog stays next to the ground because cold air is dense and tends to sink. Sometimes you will see fog only in the low-lying areas, such as bayous. Radiation fog is most common in the Sun Valley area in California, and into her deep valleys. Cooling close to the Earth's surface causes radiation fog. The Earth gives off long wave radiation, which on a clear night travels out into space. If the temperature drops to the dew point close to the ground, radiation fog can form. Radiation fog forming close to the ground is also knows as ground fog. (See Figure 2) Radiation fog may also be called valley fog. Additionally, high inversion fog (a radiation fog) is formed when fog no longer touches the ground, causing a strong inversion to exist above it. Fog usually occurs on nights when the sky is clear. During the day, air is kept warmed near the ground by a cloud layer, which insulates and prevents fog formation. (Dickinson)

Frontal fog forms along a front. A front is a boundary between tow air masses of different temperatures. Frontal fog is produced when raindrops fall from the warmer air mass into the colder one, when they evaporate. They thereby increase the water vapor in the cold air until the holding capacity is exceeded. Frontal fog develops below the boundary between tow air masses of different temperatures. Raindrops fall from the warmer air mass in to the colder one, evaporate, and turn in to fog. (See Figure 3)

There are other types of fog. The low cloud above the ground is also called stratus, or simply, high fog. Fog is simply a stratus cloud reaching to or forming on the ground. Stratus are grey clouds with generally rather uniform bases. Stratus are usually composed of water droplets, but can during very cold conditions, be made of ice crystals. (Lyons) A stratus cloud that lies on the ground is called ground fog, which usually forms late at night or early in the morning. (Day) Another frequent type of fog is hill fog, which occurs when layer cloud intersects a range of hills reducing visibility in these portions of the hills within the cloud to 1km (0.6 of a mile) or less. Hill fog often occurs in moist warm sectors of frontal depressions where the cloud base is low. (Reynolds)

A warm rain falling though a layer of cold, moist air can produce fog. Remember that the saturation vapor pressure depends on temperature: Higher temperatures correspond to higher saturation vapor pressures. When a warm raindrop falls into a cold layer of air, the saturation vapor pressure over the raindrop is greater than that of the air. This vapor pressure difference causes water to evaporate from the raindrops in to the air. If the moist air mixes with the cooler air, fog forms. Fog of this type is often associated with warm air riding up and over a mass of colder surface air. The fog usually develops in the shallow layer of cold air just ahead of an approaching warm front or behind a cold front, which is why this type of evaporation fog is also knows as frontal fog. Snow covering the ground is an especially favorable condition for frontal fog to form. The melting snow extracts heat from the environment, thereby cooling the already rain-saturated air.

Acid fog poses a threat to human health, especially to people with preexisting respiratory problems. It also adversely affects plants and structures subject to corrosion. In the Los Angeles basin during December 1982, acid fog reached a level of acidity comparable to that of vinegar. Another kind of fog is called advection – radiation fog that is formed when the ground becomes cold as a result of radiation cooling. The air-cools to its saturation port, which cause fog formation. In extremely cold arctic air, ice fog is produced. When ice crystal forms instead of droplets. As marine air moves over an ice or snow surface, ice fog forms.

Cold air crossing over warmer bodies of water cause evaporation fog around Wisconsin. As water evaporates, the moisture of the colder air immediately condenses it into clouds of fog. This is what looks like steam over Lake Michigan, inland lakes and rivers on a cold autumn or winter day.

Weather patterns that produce different types of fog are quite varied. Radiation fog occurs when air-cools at night without much wind or change in air mass, until the air reaches saturation. Radiation fog usually occurs at night and in the morning hours at any time of the year. Upslope fog a form of an advection fog, occurs mostly during cold months. (See Figure 4 and Figure 5) Radiation fog is more common in humid regions. Advection fog accompanies large-scale rain and snow systems throughout the continent,

and is found with smaller storms in humid regions; along the West Coast. Advection fog is seen at any time of the year; it occurs over the northern oceans most often in winter.

Fog is a reduction in visibility due to the atmosphere at the ground holding the maximum amount of water vapor that it can contain at that temperature. Visibility below about half a mile (1 km) is characteristic of fog, a term used to describe a cloud that has reached the ground. Most of the time, fog is composed of water droplets. When temperatures are much below freezing, ice crystals may form in sufficient quantity to mike ice fog. Typically, fog has a gray to somewhat light-blue appearance. (Musk) Haze, a natural phenomenon that causes a partial reduction in visibility, may occur after or before fog. Smog, a combination of smoke and fog, is partially from air pollution, which is a man-made condition caused by burning of fossil fuels and emission of harmful chemical pollutants into the atmosphere. Strictly speaking, a mixture of fog with smoke is smog. The term smog is often incorrectly applied to combination of haze and smoke.

In some developing countries, fog collection is very essential in the role of water planning. The collection of fog droplets by vegetation supports the vegetation and make contributions to acquifers. When the source of fog is clouds moving over the terrain, it occurs in the humid tropics. In Northern Chile, persistent fog provides water and maintains conditions of high humidity. The largest fog collection project in Chile is located above the fishing villages of Chungungo.

CONCLUSION

Below you will find a series of illustrations referred to in the texts, as well as the appendix, which contains illustrations that will help you explain these concepts to your students. (They can be made into overheads, for example.) You will also find handouts and activity sheets to accompany the activities in the lesson plans above.

It is my hope that this curriculum unit will provide the kind of framework in needed in a science class to interest students about fog and to find connections with other weather features.

ILLUSTRATIONS

Figure 1a

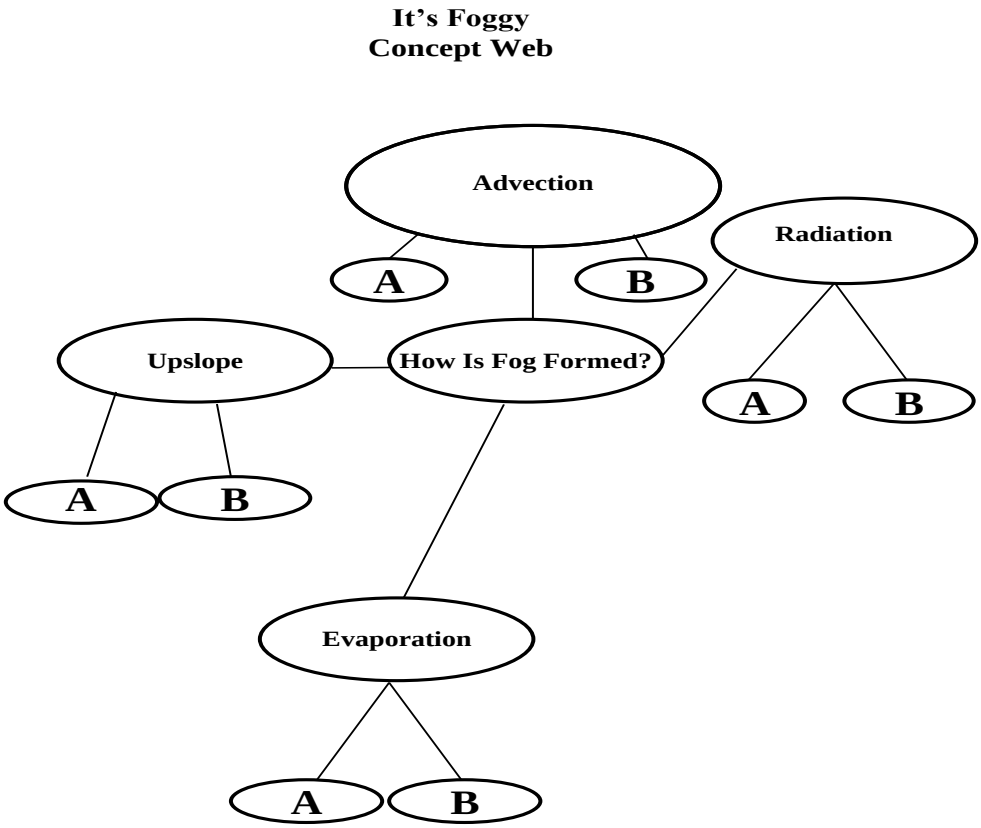


Figure 1b

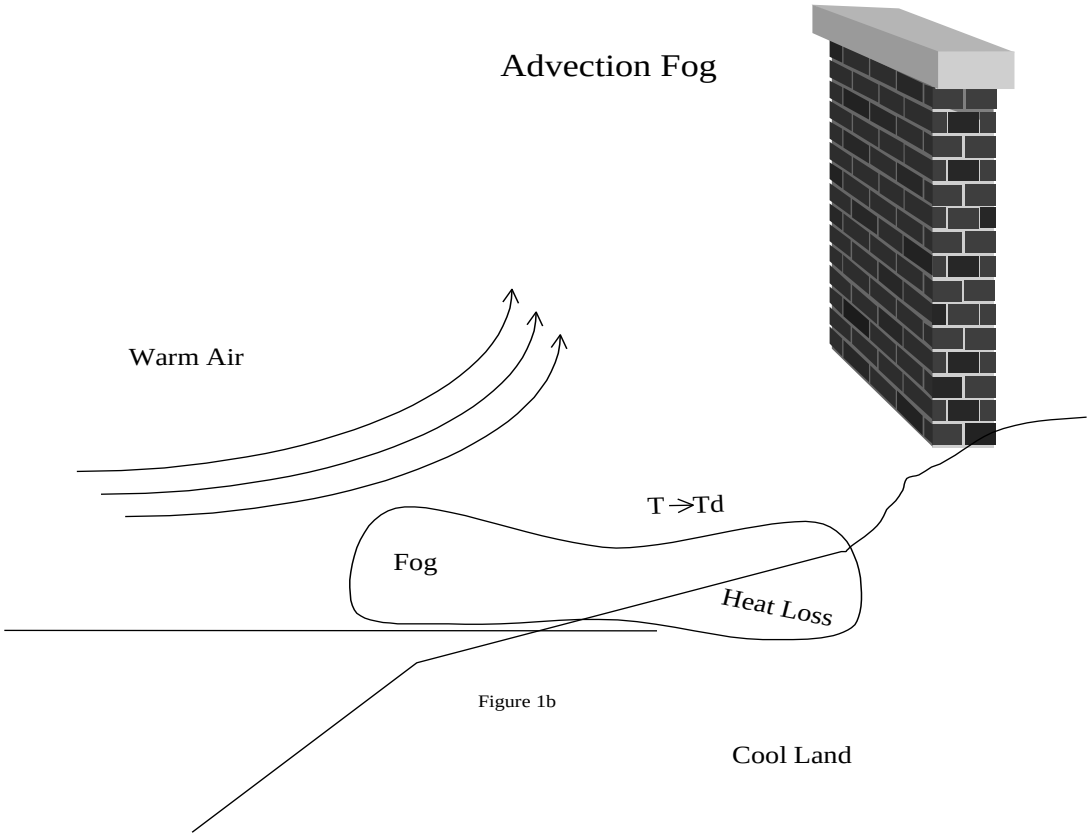
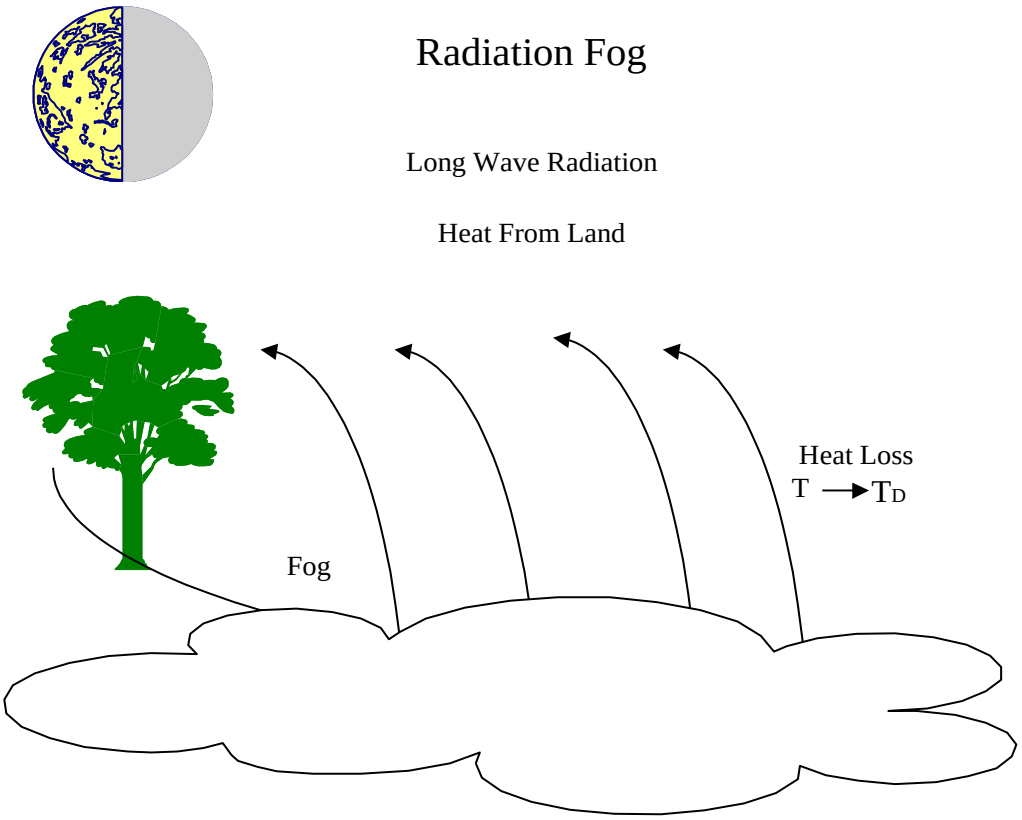


Figure 1b

Figure 2



Radiation Fog
•Clear night-radiation Fog
•Muggy night - dew point has close to temperature
•Clouds are greenhouse effect

Figure 3

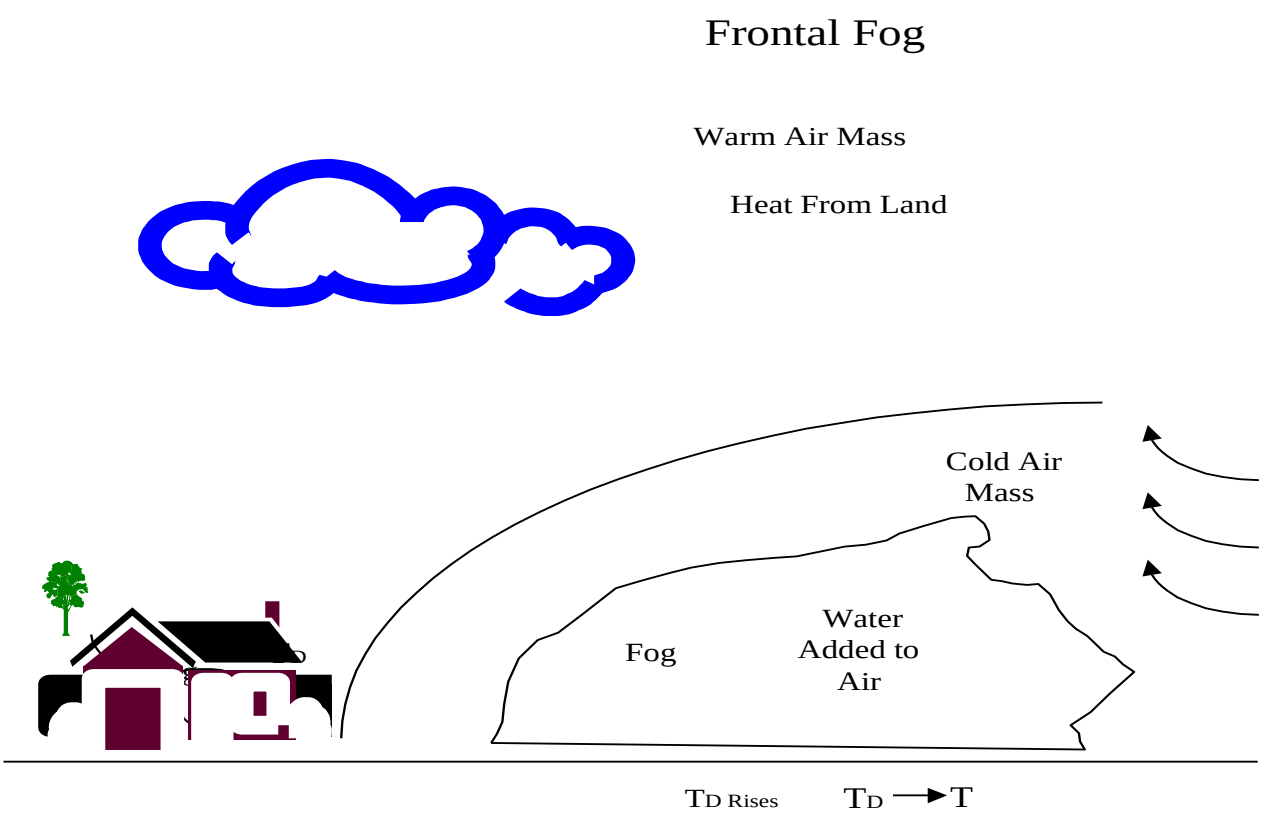

Frontal Fog
Warm Air Mass
Heat From Land
Cold Air Mass
Fog
Water Added to Air
TD Rises
TD → T
TD → TD
T → T
Later - Start
Start - Later
Eventually the two meet
Also because evaporation is a colling process
T → TD

Figure 4

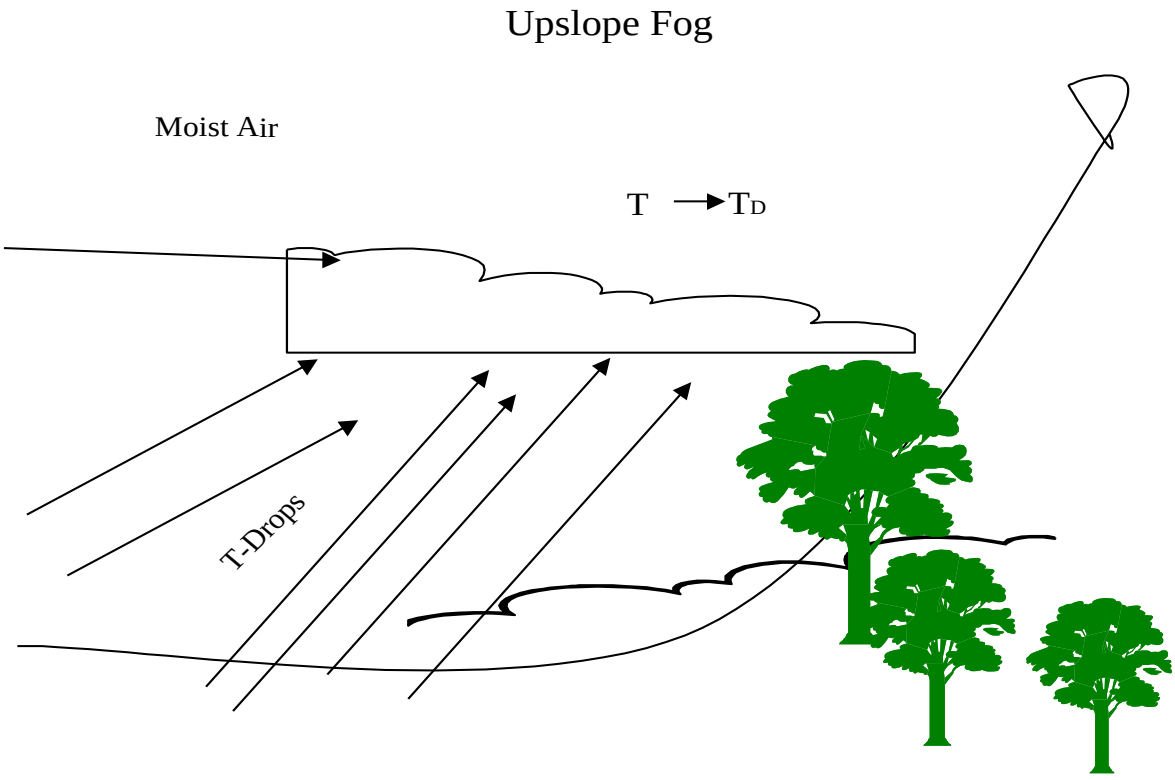
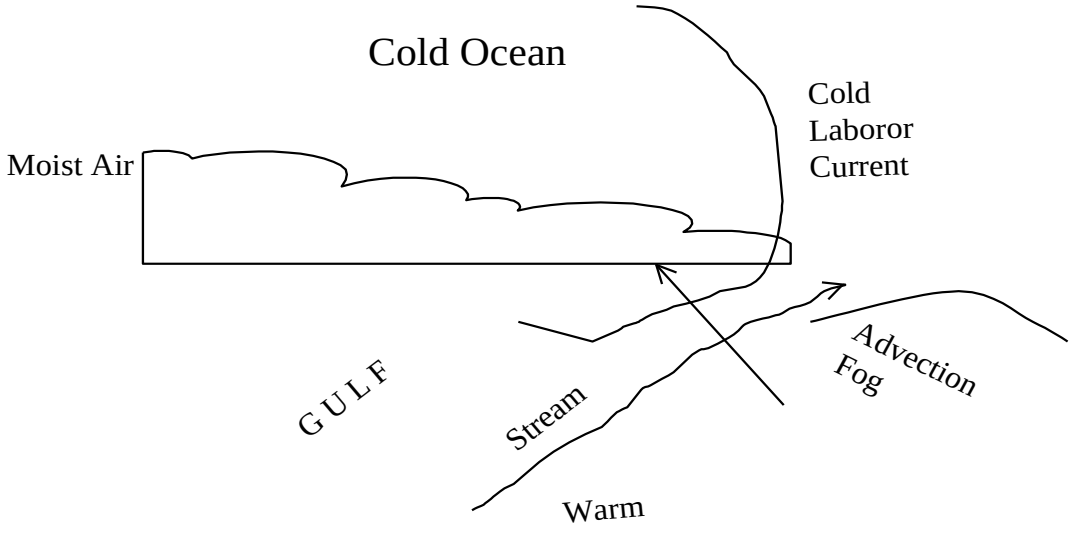


Figure 5


Cold Ocean
Cold
Laboror
Current
Moist Air
G U L F
Stream
Warm
Advection
Fog

APPENDICES

Below are charts, tables, and information to be utilized by the teacher, as well as handouts and worksheets to be utilized by the students.

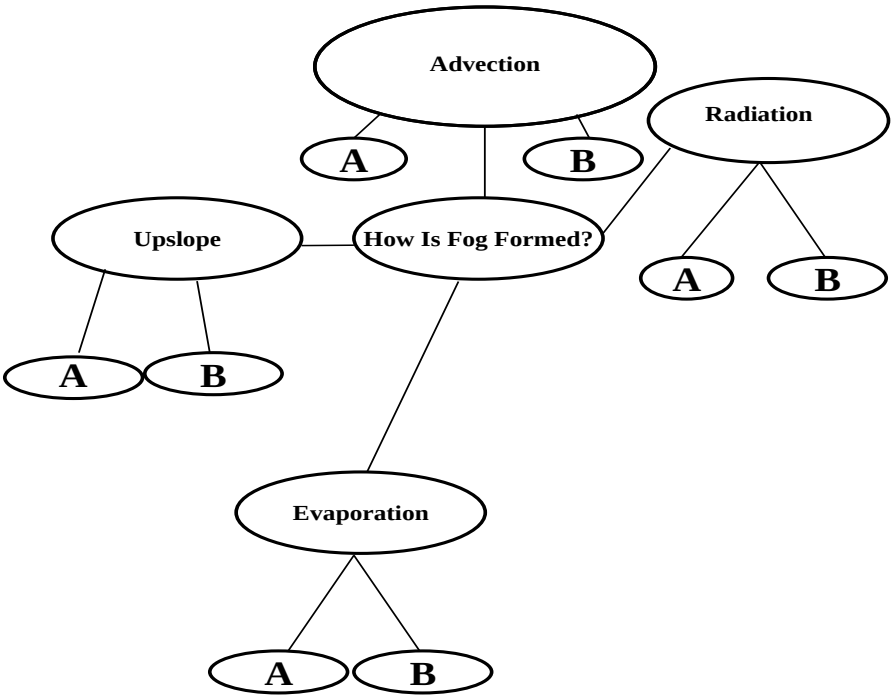
Appendix A

Types of Fog

TYPE	FORMATION	LOCATION
Radiation		▪ Central Valley Area of California ▪ Houston, Texas
Advection		▪ Pacific Coast (during summer) ▪ Atlantic Ocean (off the coast of Newfoundland) ▪ Southern or Central United States (Gulf of Mexico) ▪ England (gulf streams) ▪ Houston
Upslope		▪ Rockies (eastern side winter and spring)
Evaporation		▪ Yellowstone National Park ▪ Lake Michigan ▪ Wisconsin

Appendix B

It's Foggy
Concept Web



Directions
Complete the CONCEPT WEB
A = Additional Information
B = Location(s)

Appendix C

IT'S FOGGY
WORD SCRAMBLE

O	G	Y	O	F	S	F	S	W	M	B	C	T
F	O	A	T	U	B	G	R	O	U	N	D	H
U	F	V	D	E	M	T	A	O	M	G	C	E
P	E	W	A	V	B	U	D	L	N	A	K	P
S	C	X	B	A	E	G	I	C	U	T	D	R
S	I	X	C	P	A	C	A	W	P	O	A	C
D	E	W	P	O	I	N	T	I	S	N	Y	L
O	C	A	X	R	G	O	I	I	L	C	B	O
N	F	C	Y	A	H	S	O	G	O	A	G	T
C	O	Q	Z	T	I	E	N	C	P	N	P	Y
B	G	E	A	I	V	A	L	L	E	Y	E	G
C	B	T	D	O	M	S	D	E	A	C	G	C
I	L	C	E	N	C	M	Y	T	C	A	O	M
A	R	O	E	F	R	O	N	T	A	L	T	D
C	T	B	U	A	W	K	Y	B	I	M	R	A
Y	M	F	A	D	B	E	A	C	G	M	E	C

WORD LIST

DEW POINT	UPSLOPE	FRONTAL
ADVECTION	VALLEY	FOG
EVAPORATION	SEA SMOKE	STEAM FOG
RADIATION	GROUND	ICE FOG

Appendix D

Fog

Purpose: How to animate a fog lab.

Procedure:

1. Read over the lab you are presented with:
2. Turn on the computer and click "Start" (lower left hand corner)
3. Click "Programs"
4. Click "Microsoft PowerPoint"
5. Click "File" "New" "Blank Presentation"
6. Drop down menu appears for a New Slide
7. Then "Choose an Auto Layout"
8. Click "Blank" and select "OK"
9. To insert letters select "Text Box" and click inside of the PowerPoint Window where you want the text inserted. Begin typing text and it can be edited, spell checked and formatted. (use your Help for further instructions) or pictures select from the Tool Bar "Insert" "Picture" From: "Clip Art" or "File"
10. The selected "Clip Art" will be inserted in the slide.

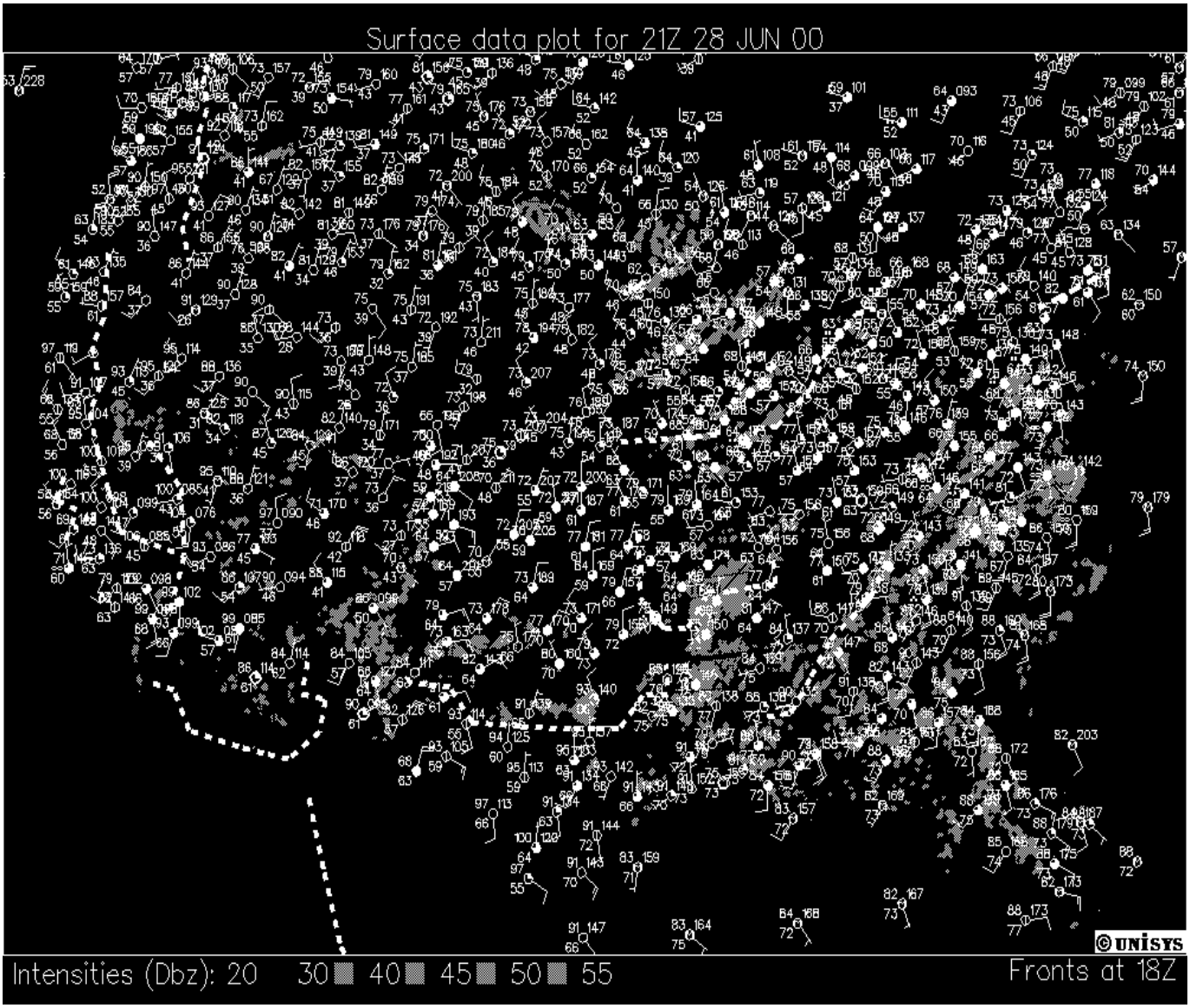
Other Additional Information

On the File menu, click New. To create a new, blank document, click the General tab, and then double-click the Blank Document icon. To create a document based on a template or wizard, click the tab for the type of document you want to create, and then double-click the name of the template or wizard you want. To create a new document based on the default template, click New.

Appendix E

For Weather symbols, refer to the following website:
http://weather.unisys.com/surface

Note: ∞ symbol for haze
═ symbol for fog



Appendix F

Fog Fact

FOGGY CARD GAME

ADVECTION OR GROUND	**F**
RADIATION	**F**
UPSLOPE	**F**
EVAPORATION	**F**
ROCKIES	**F**
CENTRAL USA	**F**

FOGGY CARD GAME (CONTINUED)

ACT

Another kind of fog is called _____ fog which is formed when the ground becomes cold as a result of radiation cooling. The air-cools to its saturation port, which cause fog formation. In extremely cold arctic air, ice fog is produced. When ice crystal forms instead of droplets. As marine air moves over an ice or snow surface, ice fog forms.

ACT

_____ fog poses a threat to human health, especially to people with preexisting respiratory problems. It also adversely affects plants and structures subject to corrosion. In the Los Angeles basin during December 1982, acid fog reached a level of acidity comparable to that of vinegar.

ACT

A warm rain falling though a layer of cold, moist air can produce fog. Remember that the saturation vapor pressure depends on temperature: Higher temperatures correspond to higher saturation vapor pressures. When a warm raindrop falls into a cold layer of air, the saturation vapor pressure over the raindrop is greater than that of the air. This vapor pressure difference causes water to evaporate from the raindrops in to the air. If the moist air mixes with the cooler air, fog forms. Fog of this type is often associated with warm air riding up and over a mass of colder surface air. The fog usually develops in the shallow layer of cold air just ahead of an approaching warm front or behind a cold front, which is why this type of evaporation fog is also knows as _____. Snow covering the ground is an especially favorable condition for _____fog to form. The melting snow extracts heat from the environment, thereby cooling the already rain-saturated air.

ACT

Over the ocean in Polar Regions, _____ fog is referred to as arctic sea smoke.

ACT

A common form of evaporation-mixing fog is the _____fog, which forms when cold air moves over warm water. This type of fog forms above a heated outside swimming pool in winter. As long as the water is warmer than the unsaturated air above, water will evaporate from the pool into the air. The increase in water vapor raises the dew point, and, if mixing is sufficient, the air above becomes saturate. The colder air directly above the water is heated from below and becomes warmer than the air directly above it. This warmer air rises and, from a distance, the rising condensing vapor appears as “steam.”

ACT

The low cloud above the ground is also called stratus, or simply, _____ fog.

ANNOTATED BIBLIOGRAPHY

http://southflorida.digitalcity.com\DCNews/krt-fog.htm

http://www.nws.noaa.gov/er/bgn/wxtalk/script22.txt

wysiwyg://51http://www.touchmj4.com/weather/fogtypes.htm
A brief description of the four basic types of fog. An excellent easy-to-understand weather guide explaining weather concepts.

http://www1.tor.ec.gc.ca/amp/fog/old/unnrf.html
General Information about radiation fog or ground fog is presented.

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An outstanding college-level textbook with information and tables, and photographs, which gives detailed information.

Bohren, C. F. Clouds in Glass of Beer Simple Experiments in Atmospheric Physics), New York John Wiley and Sons, Inc., 1987, pages 65-89.
This book answers questions about ordinary things. Experiments use simple material to introduce important ideas in atmospheric physics.

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Van Cleave, J. Weather (Mind Boggling Experiments You Can Turn Into Science Fair Projects), New York, John Wiley and Sons, Inc., 1995, 40-43, 48-51.
Experiments can be understood by someone with little basic science knowledge.

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An easy-to-understand Guide to USA's Weather.

Notes, Professor Lawrence, Houston Teacher Institute (University of Houston), March 7, 2000.
Lecture officers a close look at what goes on in fog information. Simple experiments were demonstrated