LAB MODULE 8: AIR MASSES AND WEATHER SYSTEMS

Note: Please refer to the GETTING STARTED lab module to learn how to maneuver through and answer the lab questions using the Google Earth (🌐) component.

Key Terms

You should know and understand the following terms:

<table>
<thead>
<tr>
<th>Air mass</th>
<th>Cold front</th>
<th>Occluded Front</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continental (c)</td>
<td>Downburst</td>
<td>Stationary Front</td>
</tr>
<tr>
<td>Maritime (m)</td>
<td>Front</td>
<td>Thunderstorm</td>
</tr>
<tr>
<td>Arctic or Antarctic (A)</td>
<td>Mesocyclones</td>
<td>Tropical Cyclones</td>
</tr>
<tr>
<td>Polar (P)</td>
<td>Microburst</td>
<td>Warm Front</td>
</tr>
<tr>
<td>Tropical (T)</td>
<td>Mid-latitude cyclone</td>
<td>Weather</td>
</tr>
</tbody>
</table>

LAB LEARNING OBJECTIVES

After successfully completing this module, you should be able to the following tasks:

- Identify and describe air masses and their associated moisture and temperature conditions
- Describe fronts and frontal systems
- Identify the evolution and migration of a mid-latitude cyclone in the US
- Identify the mechanisms producing thunderstorms, tornados, and hurricanes
- Interpret maps showing the geographical distributions of severe weather systems
INTRODUCTION

This lab module explores air masses, fronts and mid-latitude cyclonic weather systems. Topics include the following: continental and maritime air masses; stationary, cold, warm and occluded fronts; and the patterns and processes of mid-latitude cyclones and severe weather storms. The modules start with four opening topics, or vignettes, which are found in the accompanying Google Earth file. These vignettes introduce basic concepts of weather and severe weather systems. Some of the vignettes have animations, videos, or short articles that will provide another perspective or visual explanation for the topic at hand. After reading the vignette and associated links, answer the following questions. Please note that some links might take a while to download based on your Internet speed.

Expand the INTRODUCTION folder and then select Topic 1: Weather.

Read Topic 1: Weather.

Question 1: Briefly describe the likely weather conditions evident in the picture.

Read Topic 2: Air Masses.

Question 2: The vignette states why there is no mA classification. Additionally, there is no continental equatorial (cE) classification. What is the primary reason that a cE air mass classification does not exist (Hint: it is the opposite reason of mA)?

Read Topic 3: The Evolution and Weather Conditions of Fronts.

Question 3: Compare the density and speed of cold air (from the cold front) to warm air (from the warm front)

Read Topic 4: Human Interaction: Tornado Alley.

Question 4: Why do areas located between 30°N to 50°N provide favorable conditions for tornado generation?

Collapse and uncheck the INTRODUCTION folder.
GLOBAL PERSPECTIVE

As noted in the vignette, air masses are not randomly distributed across the globe; in fact the geographic origin (source region) of air masses determine each of the six potential air mass types – continental Arctic (cA), continental polar (cP), continental tropical (mT), maritime polar (mP), maritime tropical (mT), and maritime equatorial (mE).

As air masses move around the Earth due to weather conditions, they can gain or lose moisture, or increase or decrease in temperature. For example, a maritime polar (mP) air mass moving across a continent could lose much of its moisture and become a continental polar (cP) air mass.

In this exercise, you will describe the spatial patterns of air masses as they relate to various locations throughout the world.

- Verify that **Labels** (under **Borders and Layers**) is selected in the **Layers** panel.
- Expand the **GLOBAL PERSPECTIVE** folder and select the **Air Mass** folder.
- Select the **Air Mass** folder.
- Select and double-click **Location A**.
  - **Question 5**: Name of City: ____________________
  - **Question 6**: Principal air mass:____________________
  - **Question 7**: Identify the air temperature (as very cold, cold, warm, or very warm) and the air humidity (as moist or dry) for the source region of this air mass.

- Select and double-click **Location B**.
  - **Question 8**: City name: ____________________
  - **Question 9**: Principal air mass:____________________
  - **Question 10**: Identify the air temperature (very cold, cold, warm, or very warm) and the air humidity (moist or dry) for the source region of this air mass.

- Select and double-click **Location C**
  - **Question 11**: Island name: ____________________
**Question 12**: Principal air mass:__________________

**Question 13**: Identify the air temperature (very cold, cold, warm, or very warm) and the air humidity (moist or dry) for the source region of this air mass.

Select and double-click **Location D**.

**Question 14**: Island name: ________________

**Question 15**: Principal air mass:__________________

**Question 16**: Identify the air temperature (very cold, cold, warm, or very warm) and the air humidity (moist or dry) for the source region of this air mass.

Collapse and uncheck the **GLOBAL PERSPECTIVE** folder.

**FRONTS**

Fronts are synoptic scale features, meaning they are usually regional or continental in scale, in the order of several hundred to 1000 km (621 miles) or more in length. Synoptic scale weather maps, known as surface weather analysis, use various symbology from known data (pressure, temperature, cloud cover) to determine weather fronts.

On weather maps, the cold front boundary is designated by a blue line of triangle *pips*, while warm front boundaries are represented by a red line of half-circle pips. Occluded fronts are shown in purple (red+blue) of alternating triangle and half-circle pips. In all these cases, the side of the line on which the symbol appears indicates the direction of movement of the frontal zone. For stationary fronts, the direction of movement is static, and thus, is represented by the alternation of blue triangles and red half circles shown in opposing directions.

Expand the **FRONTS** folder.

Select and double-click **Cold front**.
This symbol depicts a cold front stretching from northern Minnesota to western Nevada.

**Question 17:** In which general direction is the front moving?

Select and double-click **Location E** and check **Location F**.

**Question 18:** At which location would you expect the air temperature to be warmer?

**Question 19:** Which location would be experiencing thunderstorms?

Uncheck **Cold front**.

Uncheck **Location E**.

Select and double-click **Warm front**.

This symbol depicts a warm front stretching from northern Minnesota to eastern Kentucky.

Check **Location G**.

**Question 20:** In which general direction is the front moving?

**Question 21:** At which location (F or G) would you expect the air temperature to be warmer?

**Question 22:** Would there be rainfall at Location G? If so, briefly describe the intensity (how “hard” it is raining) and duration.

Collapse and uncheck the **FRONTS** folder.

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**MID-LATITUDE CYCLONES**

Mid-latitude cyclones are organized low pressure systems that have cold and warm fronts. The development of mid-latitude cyclones is part of the process known as *cyclogenesis*.

Expand the **MID-LATITUDE CYCLONES** folder.

Double-click **Migration**.
This animation shows the development and migration of a mid-latitude cyclone, as well as satellite imagery (Note: The satellite imagery section might take a few minutes to upload).

Now, you will go through the cyclogenesis of a mid-latitude cyclone on Google Earth.

 sede Click **Back to Google Earth**.

 Select and double-click **Day 1**

 This map shows a typical initial development of a mid-latitude cyclone. The center of the system has the lowest pressure, which is located along the jet stream (blue arrows). The system travels in an easterly direction along the jet stream, with the warm front leading, followed by the cold front. The stage of cyclogenesis is the **open stage**.

 Uncheck **Day 1**.

 Select and double-click **Day 2**.

 The system continues moving eastward along the jet stream. The cold front is traveling faster than the warm front and the distance between the two fronts is decreasing. With the distance between the fronts becoming smaller, cooler air starts to push the warmer air, and the warmer air begins to move upwards. The stage of cyclogenesis is the **mature stage**.

 Uncheck **Day 2**.

 Select and double-click **Day 3**.

 Now, the cold front has caught up with the warm front and forms an occluded front. The warmer air is now aloft (above the surface) and precipitation may occur. This stage of cyclogenesis is the **occluded stage**.

 **Question 23**: In which direction is the air circulation in a developing mesocyclone?

 **Question 24**: Where is the origin of the cold mass and warm air mass in these examples?

 **Question 25**: Why does the cold front move faster than the warm front?

 **Question 26**: Why does the center of the system track along the jet stream?
**Question 27:** Where does the heaviest rainfall occur - along the cold front or the warm front?

**THUNDERSTORMS AND TORNADOS**

**Thunderstorms**

Thunderstorms are formed when parcels of *unstable* (warm, moist) air are lifted rapidly and vertically from the ground. Lifting mechanisms include convective lifting from the unequal warming of the ground, orographic lifting from air forced over a mountain or similar terrain, or frontal lifting from the leading edge of a cold or warm front. Rapid ascension of unstable air creates strong *updrafts* (upward moving air) and intense adiabatic cooling (that is, cooling without interacting with the surrounding air). When the updrafts reach the maximum altitude (usually in the troposphere, or over 12 km (40,000 feet) from the Earth’s surface), they change direction and become downdrafts, and precipitate.

Typical thunderstorms have weak updrafts and weak downdrafts. Thunderstorms that produce flash floods have strong updrafts but weak downdrafts. Thunderstorms that produce *downbursts* (or *microbursts*) of downward, divergent air have weak updrafts but strong downdrafts. When strong updrafts and downdrafts are present severe thunderstorms known as supercells are formed. Associated with these thunderstorms are the anvil shaped cumulonimbus clouds, heavy rains or hail, thunder and lightning, gusts of wind, *mesocyclones* (strong vertical updrafts that rotate and form a vortex of air), and sometimes tornadoes.

**Question 28:** At what stage(s) does updraft develop?

**Question 29:** At what stage(s) does a cP advance into a mT occur, followed by condensation and cloud formation?

**Question 30:** At what stage(s) does the atmosphere cool and stabilize?

**Tornadoes**
Tornadoes form as a result of strong updrafts combined with wind shear (the difference in wind direction and speed with altitude). The combination changes the rotation of air from a horizontal axis to a vertical axis. When the funnel reaches the ground, it has evolved into a tornado.

Double-click Tornado Formation for the animation of the evolution of a tornado and practice categorizing tornadoes using the Enhanced Fujita Scale.

**Question 31:** What does an area look like when it is hit by a EF2 tornado?

**Question 32:** What does an area look like when it is hit by a EF4 tornado?

Select Tornado Tracks and Icons.

The following tornado data is from the NOAA National Weather Service. Tornados have been classified by the original Fujita Scale (the tornado scale used until 2007); classification ranges from F0 to F5.

Uncheck Tornado Tracks and Icons.

Expand Tornadoes by F-scale.

Select and double-click F0.

F0 are the weakest tornados, and have the least amount of damage. They are also the most common.

**Question 33:** Does your state (or the location provided by your instructor) have an F0 tornado?

Unselect F0. Double-click F1. Note the geographic distribution of tornadoes at this strength.

Repeat F2-F5.

**Question 33:** How has the frequency and location of tornados changed as the strength increases?

Collapse and uncheck Tornadoes by F-scale.

Expand Tornadoes by Month. Select and examine each month.

**Question 34:** Which couple of months has the most tornadoes?

**Question 35:** What conditions do you think promote such high numbers?
Condense and uncheck the folder **THUNDERSTORMS AND TORNADOS**.

**TROPICAL CYCLONES**

Tropical cyclones have different names, depending on where they develop. In the Atlantic and eastern Pacific Oceans, they are called *hurricanes*. In the Indian Ocean they are known as *cyclones* and in the eastern Pacific they are identified as *typhoons*.

Tropical cyclones are storm systems of low pressure surrounded by a complex spiral of thunderstorms. Unlike mid-latitude cyclones, tropical cyclones do not form in regions with fronts. Rather, hurricanes develop where the atmosphere is relatively homogenous - but with a high pressure aloft to “cap” the low pressure storm. These storm systems rely on energy from warm water to develop, and as such, form in low latitudes.

Expand **TROPICAL CYCLONES**.

Expand **Historical Hurricane Tracks**.

Select **Legend** and select and double-click **Atlantic: 2000-2012**.

**Question 36:** Explain the general pathway of hurricanes in the Atlantic Ocean.

Uncheck **Atlantic: 2000-2012**.

Select and double-click **Eastern North Pacific 2000-2012**.

**Question 37:** Explain the general pathway of typhoons in the Pacific Ocean.

Collapse and uncheck **Historical Hurricane Tracks**.

Expand and double-click **Hurricane Katrina**. To close the citation, click the X in the top right corner of the window.

Select and double-click **Katrina Landfall Video**. Watch the time lapse of Hurricane Katrina as it hits Louisiana.

Select and double-click **Tracks** and view the pathway of this hurricane from the Caribbean Sea to North America.

Select **Hurricane**.
**Question 38**: Geographically, where was Hurricane Katrina the largest (an H5 – shown as a red circle)?

**Question 39**: What happened to the Hurricane once it hit land?

 Collapse and uncheck Hurricane Katrina.

 Select and double-click Hurricane Sandy.

 Hurricane Sandy is considered the largest hurricane ever recorded in the Atlantic basin, measuring in at over 1100 miles (1800 km) in diameter.

 **Question 40**: True or False: The storm system that hit New Jersey and the surrounding area on October 29 was a tropical cyclone.

 **Question 41**: Explain your answer in the previous question.