Stormy weather and where are we?
Convection and GPS receivers

Part I – Convection
NSESs addressed
Energy In The Earth System
Heating of earth's surface and atmosphere by the sun drives convection within the atmosphere and oceans, producing winds and ocean currents (p.189).

Objective 1
Students will investigate one of the physical principles, convection, underlying the movement of air and water which can result in the formation of storms. (Convection current lab – hot/cold water mixing)

Exploration
Chemco's ship carrying industrial chemicals encountered a storm during its voyage from Seattle to Los Angeles. Unfortunately, a large cargo box on the ship's deck holding barrels of toxic chemicals broke loose during the storm and was lost at sea. Although Chemco claims that the cargo box is waterproof and will not leak for years, it must be recovered as soon as possible. But before you attempt recovery of the cargo you will investigate principles underlying the movement of fluids, including air and water.

What causes the air to move, eventually leading to strong winds and storms such as the one encountered by Chemco's ship? To help you answer this question, you will begin by mixing different types of liquids and observe what happens.

You will need:
1. Six transparent cups, two with holes near the top, two with holes near the bottom, and two with holes near the top and the bottom.
2. Masking or scotch tape.
3. Transparent box
4. Tap water
5. White paper
6. Two 250 ml beakers
7. Red and blue food coloring
8. Hot plate

9. Thermometer
10. Tongs or insulated pads to hold hot liquids
11. Ice cubes
12. 50 pennies or washers for weights
13. Salt
14. Balance
15. Centimeter ruler

Prepare a chart similar to the one below to record your observation for the first investigation. You will need to make different charts for the other investigations.

	Start of investigation	1 min	5 min
Temp in cup			
Description of the position of the colored water as it leaves the cup			
Temp in box			

Investigation 1

1. Take a small piece of tape, 3 cm will do, and fold about 1 cm of the tape back onto the strip. This 1 cm fold will allow you to easily remove the entire strip from the inside of the cup when it has water in it. Now make one more strip like the one you just made. Get one cup with a hole near the top and one cup with a hole near the bottom and put the pieces of tape you just prepared over the holes.
2. Put enough tap water into your transparent box to cover the holes in each cup.
3. Heat up water on your hot plate until it is about 60 degrees Celsius. Put one or two drops of red food dye into the water. Pour the warm water into the cups you previously prepared with tape.
4. Put the cups into the transparent box one at a time by having your partner hold the cup it place while you add enough pennies or washers to make cup sink and stay on the bottom. Measure and record the temperature of the water in the box and in the cup. Being careful to not disturb the water in the cup or the box, remove the tape from each of the cup's hole with your fingers (or tweezers if the water is too warm).

5. Place a piece of white paper behind your box to make it easier to watch the movement of the colored water. Observe the movement of the water out of the cup and write your observations in the data table. Make a sketch of the water movement.
6.

Investigation 2

1. Repeat investigation 1 using water cooled to 5-10 degrees Celsius and blue dye in the cups.
2. Predict how the blue water will flow out of the cups.
3. Make a new data table and again sketch the movement of the colored water.

Investigation 3

1. Repeat investigation 2 using tap water and blue dye in one cup and tap water and red dye in the other cup. Make sure that the water in the cups and in the box is the same temperature.
2. Predict how the water will flow out of each cup.
3. Make a new data table and again sketch the flow of the colored water from each cup.

Investigation 4

1. Repeat the previous investigations but use two cups with each with two holes. Put warm water with red dye in one cup and cold water and blue dye in the other cup. When you put the cups in the box make sure the holes in each cup are facing each other.
2. Predict how the water will flow out of each cup.
3. Predict what will happen when the warm and cold water meet one another.
4. Make a new data table and again sketch the movement of the water in each cup.
5. Repeat the experiment but this time place the cups on opposite ends of the box. Predict how the water will flow out of each cup and where the warm and cold water will be after 10 minutes.

Analysis and concept formation

1. Describe the movement pattern of the warm water (dyed red) by comparing the flows in experiment 1 and 4.
2. Describe the movement pattern of the cold water (dyed blue) by comparing the flows in experiment 2 and 4.

3. What do you think it was necessary to do experiment 3?
4. In experiment 3, why do you think that the colored water, both blue and red, moved in all directions in contrast to a more directed movement in experiment 1 and 2.
5. You may remember from previous observations that wood usually floats on water. In fact, matter, including fluid, that is less dense than water, is pushed up or buoyed up by the surrounding water. What inferences can you draw about the densities of the warm and cold water compared to the tap water in the box in your experiments?

In this experiment the rising of the warm water and the sinking of the cold water is a model for understanding a process called convection.

Concept application

1. On a warm sunny day, certain areas of the earth's surface absorb more heat from the sun than other areas. Because of this uneven heating, the air over the warmer areas becomes warmer and therefore less dense than the air surrounding it. What will happen to this warm air? If you were a bird or on a hang glider what would you experience if you encountered this warm air?
2. Usually the temperature of the air decreases as you move up from the ground. What will eventually happen to the temperature of the warm air in question one? As a result of this change, what will happen to its density? Which direction will the air move now?

?Insert graphic comparing model of convection in experiments to atmospheric process?

?Using the graphic above, describe the differences between the model you used in the investigations and what occurs in the atmosphere?

Summing up

The transfer of heat by the movement of a fluid such as water or air is called convection. Convection happens naturally in the atmosphere and in bodies of water like lakes and the oceans. In the atmosphere, air molecules over warmer areas of the earth's surface are heated up. The heated air expands and becomes less dense than the surrounding cool air. This less dense, warm air is buoyed upward and begins rising up into the atmosphere. As this air rises in the atmosphere, it encounters cooler air and eventually it will cool

down. At the same time that the warm air is rising, the cooler surrounding air flows toward the earth's surface to replace the warm rising air. This cooler air becomes heated, and therefore less dense, and begins to rise. In meteorology, this cycle and vertical exchange of heat is called convection.

Part II of Module 1 - GPS receivers

NSES addressed

Objectives
1. Students will learn how to use a GPS receiver to determine their latitude and longitude on a map.
2. Students will demonstrate how to locate a position through triangulation.

Exploration
Navigators aboard Chemco's ship can determine the ship's latitude and longitude using a Global Positioning System receiver. In the following investigations you will learn how this system works.

Materials
Paper and pencil
Graph paper
Compasses for drawing arcs
Metric ruler

Investigation 1

On you paper mark two different points about 3 centimeters apart. Place your compass point on one these points and draw a circle with a diameter of about 2 centimeters. Do the same thing with the other point.

- How many places did the circles intersect?

Suppose the two starting points were places on the earth where the exact latitude and longitude was known. You could think of these points as corner buildings on streets where different roads cross one another. Pretend that you were standing on one of the two places where the circles crossed. If someone in one of the corner buildings wanted to know which place you

were standing on, could they know for sure which one without looking at you? Why or why not?

To resolve this problem take your compass point and place it about two centimeters away from the centers of the other circles. Draw a third circle around this point. Notice that the three circles only intersect in one place.

- To determine your position accurately how many reference points do you need information from, such as distance information?

On your paper draw three Xs (but not in a straight line). Place a dot about five centimeters from each of three Xs. Now draw a line from each X to the dot and measure the length of the line.

- If a radio signal was sent from each X to the dot, which one of the lines would the signal take the least amount of time to reach the dot? The most amount of time?

Investigation 2
On your graph paper draw a grid as shown in figure 1. Use the table below to plot the position of three ships that were in contact with Chemco's ship during the storm. Each ship received a distress signal from Chemco's ship and the number of milliseconds (ms) it took the signal to reach each ship is listed in the third column of the table.

Can you find the location of Chemco's ship?

Ship name	X, Y coordinates	Time in milliseconds (ms) it took the distress signal from Chemco's ship to reach the receiving ships
Ascension	3, 3	4 ms
Bautista	7, 6	3 ms
Cordell	13, 3	5 ms

Concept formation
Measurement of signal travel times is the basis for radar and the Global Positioning System (GPS). How many signals are required to accurately

loacte your map position using the GPS? Whatever your answer was to the last question, why wouldn't one signal less be correct? Demonstrate on the graph paper why your answer is correct.

The process you used to determine location using the GPS is called triangulation. Why do you think this is this an appropriate term to describe this process?

Concept application

Based on investigation 2 create a similar problem for other groups in the class to solve. Do not use the same numbers that were used in the table for investigation 2.