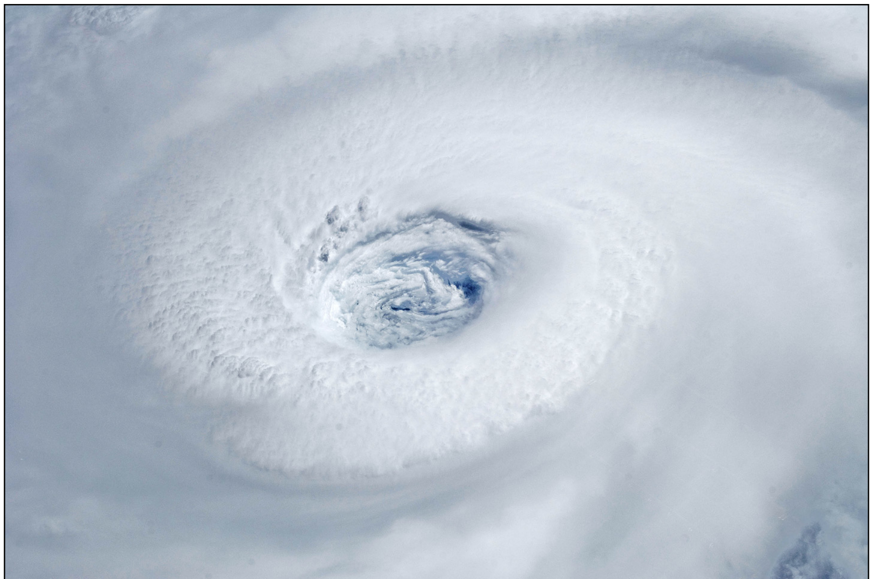
HURRICANE!



Astronauts aboard the International Space Station took this digital photograph of the eye of Hurricane Igor at 10:56 Atlantic Daylight Time on September 14, 2010. The storm was a category four hurricane on the Saffir-Simpson scale of intensity. At the time of the image, Igor was centered in the Atlantic Ocean near 18° N 52° W and slowly moving west-northwest at 11 kilometers (7 miles) per hour, according to the U.S. National Hurricane Center. Maximum sustained winds of 213 km (132 mi.) per hour, with gusts to 259 km (161 mi.) per hour.

INTRODUCTION

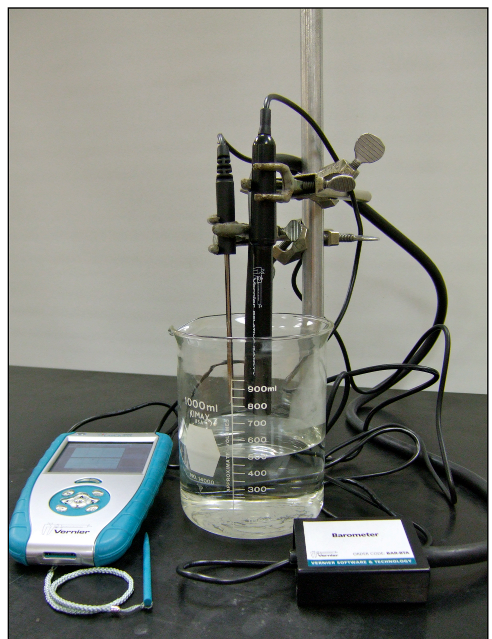
According to census data, more than 50% of the US population lives within 50 miles of an ocean coastline. We are acutely aware of the catastrophic effects a severe storm can have on our own coastal cities, but hurricanes are not an exclusively American concern. Globally, 44% of the population lives within 150 km of a coastline. The potential for devastation on a large scale is a very real social and economic concern. Atmospheric scientists have been studying the formation of these large storms for literally decades, to develop a way to predict when and where storms will form, and with what intensity. Understanding the principles of heat transfer and energy exchange which create favorable conditions is not very difficult, but predicting when a storm will form, what path it will follow, and how strong it will become is a much more complicated problem because of the number of variables involved.

OBJECTIVES

- Measure and record atmospheric data for indoor and outdoor locations
- Compare temperature and humidity conditions over regions of warm and cold water
- Explain the basic mechanisms of hurricane formation
- Analyze existing data for trends in frequency and severity
- Apply the scientific method to a complex problem with multiple variables and outcomes

EQUIPMENT

- Vernier LabQuest
- Barometer
- Temperature Probe
- Relative Humidity Sensor
- Ring stand and clamps
- Thermometer
- Beakers
- Hot water and ice water



Do not submerge the probes below the water line. Both probes should be in the air just above the water.

EXPERIMENTAL PROCEDURE

- Connect the barometer, temperature probe, and humidity sensor to the LabQuest, and switch it on. Under the **Sensor** menu of the **Meter** tab, select **Data Collection**. Make the collection **Length** = **5 minutes**, and the **Rate** = **10 samples per minute**.
- Take the LabQuest with the attached sensors outside, and collect data for 5 minutes. Make sure to save the run by tapping the **File Cabinet** icon when data collection is complete. Bring the equipment back to the classroom, and repeat the measurements indoors. Again, make sure to save the trial.
- For both data sets, record the average (mean) pressure, temperature, and humidity. Under the **Analyze** menu of the **Graph** tab, choose **Statistics** to display the mean values for each.
- While your lab partners are collecting these data, prepare two beakers: Fill one beaker with 500ml of ice water. Fill the second beaker with 500ml of very hot tap water. Use a standard thermometer to measure the temperature of each beaker (we do not need the LabQuest precision for the water temperatures, but we do want to illustrate the difference between the hot and cold water).
- Arrange the beakers as shown in the figure so that you can clamp both a temperature and a humidity sensor over the surface of the water.

- When the sensors are in place, begin data collection. Collect data for the pressure, temperature and humidity above the hot water beaker, then collect data for the conditions above the ice water beaker. Make sure to save each data run.
- When you have both data sets, record the mean temperature and humidity for each beaker.

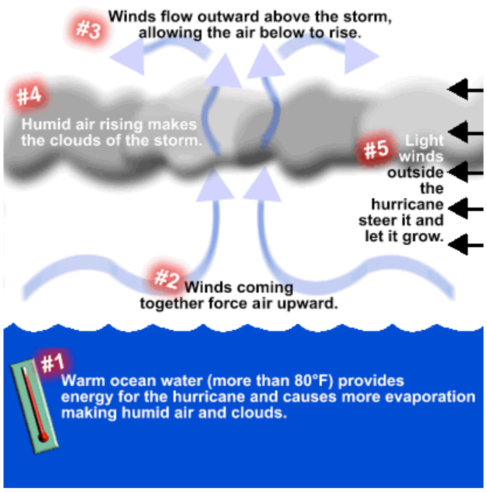
Data & Analysis

If you have not already, record your data in your lab notebook.

	Water Temperature (°C)	Average Pressure (kPa)	Average Temperature (°C)	Average Relative Humidity (%)
Outdoors	---------			
Indoors	---------			
Ice Water				
Hot Water				

1. Compare indoor and outdoor conditions. Note what the weather is like outside (sunny or rainy, windy or calm). Average atmospheric pressure is 101.3 kPa. Are indoor and outdoor pressures about equal? Higher or lower than average pressure? Clear weather is associated with high pressure, and stormy weather is associated with low pressure. Is your data consistent with this?
2. Compare temperature and humidity conditions above the hot and cold water surfaces. It should be obvious where the temperature is higher, but where is the humidity the highest? Why? (Hint: Think about what temperature means to the energy of the water molecules, and where it might be easier for those molecules to escape into the atmosphere.)
3. Use these observations to think about where hurricanes form. Do they form at high or low latitudes? Why? Explain basic hurricane mechanics in terms of **heat transfer** and **energy exchange**.
4. The table below shows global hurricane data for the past 35 years. For the most recent data (2005–2010), complete the table by calculating the percentage of storms at the Category 4 and 5 level:

$$\% \ severe = \left(\frac{total\ number\ cat\ 4\ \&\ 5\ storms}{total\ number\ of\ hurricanes} \right) \times 100$$



Region	Total Number of Hurricanes			Total Number of Category 4 & 5 Storms			% of Storms at Categories 4 & 5		
	1975–1989	1990–2004	2005–2010	1975–1989	1990–2004	2005–2010	1975–1989	1990–2004	2005–2010
East Pacific Ocean	144	140	39	36	49	10	25.0	35.0	
West Pacific Ocean	340	283	82	85	116	40	25.0	41.0	
North Atlantic	80	100	49	16	25	16	20.0	25.0	
Southwestern Pacific	83	79	26	10	22	11	12.0	27.8	
North Indian Ocean	13	28	11	1	7	6	7.7	25.0	
South Indian Ocean	128	147	46	23	50	18	18.0	34.0	
Global Totals	**788**	**777**	**253**	**171**	**269**	**101**	**21.7**	**34.6**	**39.9**

5. Keeping in mind that the last time interval is only **five years** (notice that the first two data intervals are **15 years** each), have the **total number** of hurricanes changed significantly? What about the total number of severe storms? Has the *percentage* of severe storms increased or decreased? Is the trend the same for every region?
6. If you were an atmospheric scientist studying this data, what hypothesis could you offer explain the trend you observe? What additional data or information would you want to collect to test your hypothesis? Keeping in mind that correlation is not the same as causation, can you think of a way to prove your hypothesis conclusively? Or maybe *disprove* it?