

HURRICANE

Information for the Teacher

This hurricane simulation activity and STELLA model were adapted from materials developed by Jan Mons and Cathy Eaton of the *Glynn's Integration of Systems Thinking Project* in Brunswick, Georgia. The activity is a simulation in several senses. First, the STELLA hurricane model is used to produce the path of the storm as well as the strength and the extent of the hurricane. Second, teams of students act as officials of the National Hurricane Center to issue tropical storm and hurricane advisories depending on the strength of the storm and predicted landfall. Third, by simulating hurricanes in three years (1996, 97 and 98) during which sea surface temperatures varied, students are able to see for themselves that higher sea surface temperatures result in storms of higher intensity.

Most people have no idea of the many factors involved in hurricane prediction. While participating in this activity packet, students will assume the roles of National Hurricane Center personnel. Using the computer simulation, students will make decisions very similar to the decisions made by the people involved in hurricane prediction. The intent is to help students become aware of the many elements that must be considered as a hurricane approaches the area. Although there is no way to control the course and strength of a hurricane, students can learn the importance of processing all of the available information and making informed decisions.

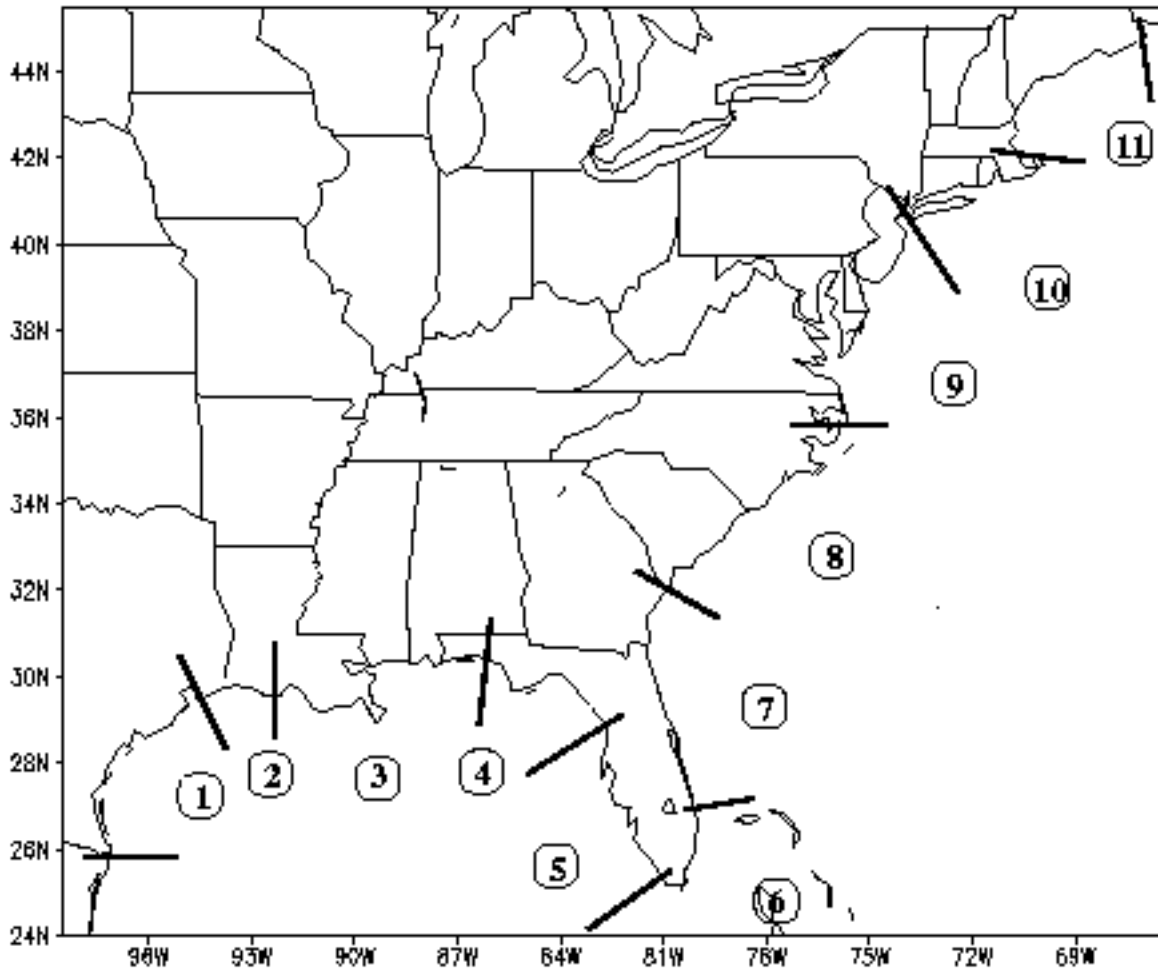
Hurricane Background Information

If your textbook has inadequate information about hurricanes, we have provided information sheets that you may use with your students. See Appendix A.

The STELLA Model – Background and Directions

This is an empirical model in which several parameters have been “tuned” to produce realistic looking hurricane paths. The movement of the simulated hurricane depends on the initial heading (longitude, latitude), a turning day, and the final heading (longitude, latitude). It also depends on the Coriolis force which accelerates the hurricane in a 90 degree clockwise direction from its current path with a magnitude proportional to the current velocity of the hurricane.

The initial heading and final heading are associated with eleven sections of the United States coastline. Researchers at the University of Colorado led by Dr. William Gray are starting to determine landfall probabilities which they will specify according to these eleven coastal regions.



Currently the model requires the student to enter a code supplied by the teacher. The teacher may decide whether or not to tell the students that this code refers to a specific landfall region. In a future version of the model, the region will be determined according to probabilities computed by these researchers.

Hurricane intensity is related to the amount of time that the storm spends over relatively warm water versus relatively cool water. The change in hurricane wind strength depends on three factors:

- A) the difference between the current SST and the convection threshold of 27 degrees Celsius
- B) the difference between the current SST and the previous SST along the hurricane path
- C) a random factor

Once the hurricane reaches land (indicated in the model by a SST of 0 degrees), wind strength decreases by 1/4 of the current value each day.

To account for the random factor, the model uses a random number generator for which the student sets the random number seed. **Students should set the random number seed (rseed) on the model so that they can reproduce results if their simulation is interrupted. The teacher may assign a decimal between 0 and 1 to each student group.**

Sea surface temperature contour maps (see Student Packet) represent the state of the ocean for August, September and October of 1996, 1997, and 1998. The data used for the maps are contained in converters built into the model. Which converter used depends on the year and month selected by the student. The coolest year was 1996 and the warmest year was 1998. Students should see greater wind speeds in 1998 hurricanes than in 1997 or 1996 hurricanes. **It is recommended that the teacher assign each group a specific starting date so that each group's hurricane will be using data from a different map. If a hurricane starts within the last 10 days of the month, data from the next month's map will also be used.**

HURRICANE LESSON PLANS

*** SPECIAL NOTE: You will need to schedule the computer lab for day 2 of this 3 day learning environment.*

DAY 1

PURPOSE:

To review the elements of a hurricane and to practice hurricane plotting, to discuss the services of the National Hurricane Center, and to practice completing Hurricane Advisory forms.

MATERIALS:

Hurricane tracking maps (1 for each student pair)

Data tables of hurricanes Andrew and Hugo (1 for each student pair)

Transparency of hurricane tracking map (1 for the teacher)

National Hurricane Center Advisory forms (Tropical Storm and Hurricane) (1 for each student pair)

Transparency of hurricane Andrew or Hugo data table (1 for the teacher)

Hurricane Watch/Warning overlay transparencies (1 for each student pair and 1 for the teacher)

Warning and Watch Overlay Guidelines (1 for each student pair)

PROCEDURES:

1. With the class review the elements of a hurricane. Briefly review how a hurricane forms and moves across the Atlantic Ocean. Ask students if they have ever watched hurricane reports on television. Ask students to tell you the type of information that is reported. (Most reports include the current position of the storm [latitude, longitude, and distance from some city,] wind speed, total size [diameter] of the hurricane, barometric pressure at the center, the direction in which the storm is currently moving, and whether the storm is any threat to land.) Remind students that if a storm were divided into quadrants, the Northwest quadrant of the storm is the most dangerous. Also, discuss the importance of coastal area residents' being able to plot hurricanes as they travel across the Atlantic.

2. Have students work in pairs to practice their hurricane tracking skills. Pass out a hurricane tracking map and the data table for hurricane Hugo to each pair. Review how to plot a hurricane's path. Using a transparency of a hurricane tracking map, plot the first several pairs of coordinates for the hurricane. When you feel that students are clear on what is expected, allow them to continue plotting the hurricane until it makes landfall. When students have finished plotting the hurricane, compare their tracks with the one you have completed on the transparency. Clarify any misunderstandings that may exist. Once this comparison/discussion is complete, students should plot the data for hurricane Andrew.
3. Ask students if they have ever heard of the National Hurricane Center (NHC) in Coral Gables, Florida. Point out to students that it is this agency that officially tracks Atlantic hurricanes and is responsible for notifying coastal areas of pertinent hurricane information (wind speed, location, forward speed, barometric pressure at the center of the storm, projected path, and distance from any body of land). The NHC is also the agency that sends reconnaissance planes into hurricanes to collect data about the storm.
4. Discuss the paths of the two hurricanes and compare the location of landfall for each hurricane. Show students a map containing plots of many hurricanes.
5. Explain to students that for the next several days they will be the National Hurricane Center. Tell them that they will be collecting, recording and computing data concerning several Atlantic hurricanes. Introduce the National Hurricane Center Advisory form that students will be responsible for completing. Go over this form and explain each of the entries that NHC teams will be making.
6. Using the data table transparencies from Andrew or Hugo, have students practice completing the National Hurricane Center Advisories forms. Students should use the Watch/Warning Overlay to assist in determining distance from land, direction of the storm, projected path, and the need for a warning or a watch. You may want to model the use of this overlay using the overhead projector. You may wish to go over the Warning and Watch Overlay Guidelines at this time.

7. Spend the last several minutes of the class period assigning students to their working groups. It is each of these groups which will play the role of the National Hurricane Center.
8. Sample Group Assignment: (from Leslie Backus at Montgomery Blair High School)

Each member of the group must have all answers to all questions by due date.

Resources:

NOAA booklets, textbook, newspaper, readings, videos, computer program

Questions:

- A. What conditions are needed for a hurricane? Describe how it forms.
- B. Describe its structure and the 5 classes (categories).
- C. What are a storm's usual paths? Describe the usual chronology for one.
- D. Describe the effects of a hurricane on: the natural world, material things, human beings (fatalities, injuries, psychological).

Include: wind, water, storm surge, rain.

- E. Discuss forecasting and tracking.

Include: names (system), definitions of: tropical wave, depression, storm, hurricane.

- F. List safety precautions and rules:

Beginning of season

During a watch

During a warning

During the storm

HURRICANE LESSON PLANS

DAY 2

PURPOSE:

To run the hurricane model and complete the advisory forms.

MATERIALS:

Computers (1 for each student team)

Hurricane model loaded on each computer

Tracking maps and overlay transparencies (1 for each student team)

Blank data tables (2 for each student team)

Blank Advisory forms (several for each student team)

Calculators (1 for each student team)

Metric rulers (1 for each student team)

PROCEDURES:

1. Introduce the “Hurricane” model by reminding students that the National Hurricane Center gets information from a variety of sources including satellite imagery and the hurricane reconnaissance planes that fly into the storms. This information is fed into a central computer that compiles it into the data table that appears on the monitor. This information is then sent on to interested parties including local weather stations and Emergency Management Agencies at susceptible locations in areas of coastal U.S. Remind students that the data must be as accurate as possible, but it is not the responsibility of the National Hurricane Center to recommend any emergency actions.
2. Assign each group its own:

Starting Month (August, September or October)

Starting Day (1-30 or 31)

Year (1996-1998)

Used to provide an opportunity for observations based on: storm intensity at landfall, sea surface temperatures and time

Code (6-11)
rseed (0-1)

of year

Used to vary the location of landfall

Used to allow duplication of results if
needed.

3. Take the students to the computer lab to run the “Hurricane” model. (As groups of students go into the lab, you may want to assign every other computer or every third computer. This way, things won’t get quite as crowded.) This model will generate tables of information that the students need in order to plot each hurricane and to be able to post their National Hurricane Center advisories. Because of the limited space available and the total number of students, students in each group will have specific roles. They are as follows:
 - A. Two students in each group will be responsible for actually running the model on the computer. One of these students will be responsible for completing a hard copy of the data table.
 - B. One student will be responsible for completing the NHC Advisory form.
 - C. Two students are to plot the positions of the hurricane and compute distance traveled and forward speed of the storm.

Each NHC group will probably have time to run only one hurricane in a class period.

HURRICANE LESSON PLANS

Day 3

PURPOSE:

To process the “Hurricane” run from Day 2

MATERIALS:

Data table from Day 2

Hurricane tracking maps from Day 2

SST contour maps that match each group’s hurricane starting date

PROCEDURES:

1. Students are to work in their groups from Day 2. Allow groups about ten to fifteen minutes to discuss the “Hurricane” run using their data tables. They are to review their actions from the previous day and create a “Jot List” of suggestions to share with the rest of the class. This list should include any problems that they encountered but could not solve and any procedures that they used that made the hurricane tracking and advisory posting easier.
2. After about ten minutes, begin a full class discussion of the “Hurricane” run from Day 2. Discuss each group’s list of problems and suggestions. If students had a problem, allow the class an opportunity to brainstorm possible solutions to the problem.
3. Using a transparency of the hurricane tracking map, plot the location of the landfall of each hurricane that was tracked in the computer lab on Day 2. Record the starting date of each hurricane and the wind speed and category when it hits land.
4. Lead a discussion in which the students try to determine why the simulated hurricanes vary in intensity. Pass out the appropriate SST contour maps to each group.
5. Sample Group Assignment (see Student Packet for assignment sheet)
 - A. Record your observations from the hurricane simulation activity.
 - B. State your hypothesis about the factors which influence the strength of a hurricane.
 - C. List the variables involved in the experiment to test your hypothesis:

Control Variables:

Experimental Variable:

- D. Describe how you would conduct the experiment. Tell how you would systematically change slider values and collect results.
 - E. Explain how you will analyze your results.
6. Possible hypotheses and variables:
- A. Hurricanes that start in August are stronger than those that start in October.
Control variables: Starting Day, Year, Code, rseed
Experimental variable: Starting Month
 - B. Hurricanes lessen in intensity as the landfall region moves north.
Control variables: Starting Month, Starting Day, Year, rseed
Experimental variable: Code
 - C. The random factor has a significant impact on a hurricane's intensity.
Control variables: Starting Month, Starting Day, Year, Code
Experimental variable: rseed