

Ups and Downs

What Causes Tides / Grades 9-12 / Earth Science

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Focus Question

What causes tides and tidal currents?

Learning Objectives

- Students will explain and model forces that cause and affect tides.
- Students will analyze variations in tidal patterns and water levels in selected areas, and infer and discuss some conditions that may have influenced these variations.
- Students will describe how tides affect our lives and explain the importance of monitoring tides.

Links to Overview Essays and Resources Useful for Student Research

http://oceanservice.noaa.gov/education/tutorial_tides - Tides and Water Levels Tutorial and Subject Review

<http://www.edusite.com/sci/tides.htm> - Links to Internet sites with information about tides

Materials

- *(optional)* Access to the Internet and NOAA's Tides Online Web page (<http://tidesonline.nos.noaa.gov/>); if Internet access is not available, prepare copies of Appendices A, B, and C, at the bottom of this lesson plan, one copy for each student or student group. Click the following links for printable versions of:

[Appendix A](#), [Appendix B \(pt.1\)](#), [Appendix B \(pt.2\)](#), [Appendix C \(pt.1\)](#), [Appendix C \(pt.2\)](#)

- Copies of "Tides and Water Levels Student Worksheet," at the bottom of this lesson plan, one copy for each student or student group. [Click here for a printable version of the student worksheet.](#)
- Materials for constructing models of the Earth-moon-sun system (optional, depending upon students' approach to Part 2 of the learning procedure)

Audio/Visual Materials

- Optional, depending upon students' approach to Part 2

Teaching Time

- Part 1 (Researching and Exploring Tides): One or two 45-minute class periods [Note: If the Internet is not accessible, Subject Review questions may be addressed as a classroom discussion using Background Information and information from the Tides and Water Levels Tutorial (http://oceanservice.noaa.gov/education/tutorial_tides/tides01_intro.html). Data for answering questions on the "Tides and Water Levels Student Worksheet" can be found in Appendices A, B, and C]
- Part 2 (Explaining Tidal Phenomena): Two or three 45-minute periods, plus time outside of class for research and preparation

Seating Arrangement

- Part 1: as appropriate for working with Internet resources or for class discussion
- Part 2: groups of four or more students

Maximum Number of Students

32

Key Words

Tide
 Tidal current
 Ebb
 Flood
 Spring tide
 Neap tide
 Perihelion
 Aphelion
 Perigee
 Apogee
 Lunar cycle

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Background Information

Tides are the periodic rising and falling of ocean waters caused by the gravitational forces of the sun and moon. The vertical motion of tides is accompanied by a horizontal movement of ocean waters called tidal currents. Oceanographers say that tides rise and fall, while tidal currents ebb (during a falling tide) and flood (during a rising tide).

For a simple explanation of tides, it is sufficient to consider only the effects of the moon (the magnitude of the moon's effect is about twice that of the sun, since the moon is closer to the Earth). At any point in a day, one side of the Earth will be closer to the moon than the opposite side. Ocean waters on the closer side of the Earth will experience a greater gravitational pull from the moon than waters on the opposite side of the earth (tide generating forces vary inversely as the cube of the distance from the tide generating object). This causes a "bulge" in the waters closest to the moon, and creates a high tide. At the same time, inertial forces on the opposite side of the Earth causes a similar "bulge" creating another high tide. Low tides occur at longitudes that are 90° from the longitudes of locations that are experiencing high tides. The sun also exerts a gravitational force on ocean waters. Depending upon the positions of the sun and moon relative to the Earth, the sun's gravity may enhance or diminish the tidal effect caused by the moon. When the sun and moon are aligned (at the time of full moon or new moon), their gravitational forces act in the same direction and produce more pronounced high and low tides that are called spring tides. When the sun and moon are at right angles relative to the earth, the gravitational force of the sun partially cancels out the gravitational force of the moon. The result is less pronounced high and low tides that are called neap tides. The magnitude of tides is also affected by the actual distances between the sun, moon, and Earth: Gravitational attraction is increased when the Earth is closest to the sun (perihelion) or moon (perigee). For more information on the causes and types of tides, visit: http://oceanservice.noaa.gov/education/tutorial_tides

For centuries, people who live and work near seacoasts have understood the importance of being able to predict tides and tidal currents. Low tides may prevent ships from entering harbors, while high tides may make it impossible for ships to pass beneath bridges. Tidal currents may significantly increase the speed of a vessel, or may carry it into dangerous waters. Recreational boaters who anchor near shore may find themselves stranded by a falling tide. Fishermen throughout the world have learned that catches are likely to be much larger during certain portions of the tidal cycle than others.

Many people who live thousands of miles from any ocean also pay close attention to the same lunar cycles that produce tides. Traditional agricultural practices often prescribe planting and harvesting during times when the moon is at a specific location relative to the Earth. Some traditional forestry practices link lunar cycles with specific properties of wood including strength, resistance to decay, and resonance for musical instruments. Lunar cycles have also been linked with many aspects of human biology, behavior, and folklore including crime, suicide, mental illness, birthrates, fertility, werewolves, and vampirism. The first part of this lesson is intended to:

- introduce students to tides and tidal currents, and improve their understanding of how these phenomena are measured and predicted; and
- introduce students to some of the data available from oceanographic monitoring programs that can be used by anyone who wants to study the Earth's oceans.

In the second part of this lesson, students will design and prepare educational materials that can be used to explain the fundamental tidal phenomenon as part of introductory middle school oceanography lessons.

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Learning Procedure

[Note: This lesson is based, in part, on an activity created by Claire Silva, Biology Teacher]

Part 1: Researching and Exploring Tides

1. Direct students to the Tides and Water Levels Tutorial and the Tides Subject Review at: http://oceanservice.noaa.gov/education/tutorial_tides. If you choose to have students work in groups, you may want to assign different tutorial sections to each student. Have each student or student group answer questions in the Tides Subject Review. To save class time, you may want to assign this portion of the lesson as homework.
2. Review students' answers to questions in the Tides Subject Review. Lead a brief discussion of ways in which knowledge of tides can be useful and important.
3. Have each student or student group answer questions on the "[Student Worksheet](#)" using data from <http://tidesonline.nos.noaa.gov> or from Appendices [A](#), [B1](#), [B2](#), [C1](#), and [C2](#).

Part 2: Explaining Tidal Phenomena

Have students or student groups prepare visual materials that could be used to explain tides and tidal currents to a 5th or 6th grade science class. Appropriate materials may include physical models (e.g., mobiles), visual media (e.g., Powerpoint® presentations; computer animations), theatrical presentations (e.g., drama; music; dance), or publications. Materials produced should support explanations about:

- The influence of the sun and moon
- Spring and neap tides
- Tidal magnitude at perigee, apogee, perihelion, and aphelion

Encourage (and give credit for) creativity! These presentations offer cross-curricular opportunities, particularly with social studies, English language arts, and fine arts. Whatever media students choose to work with, their final presentation should be accompanied by a list of sources for the information they present. A good starting point for this activity is the Roadmap to Resources: Tides & Water Levels (http://oceanservice.noaa.gov/education/tutorial_tides/supp_tides_roadmap.html), which provides links to many other sources of data and information about tides.

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The Bridge Connection

The Bridge is a growing collection online marine education resources. It provides educators with a convenient source of useful information on global, national, and regional marine science topics. Educators and scientists review sites selected for the Bridge to insure that they are accurate and current.

www.vims.edu/bridge - Click on "Ocean Science Topics" in the navigation menu to the left, then "Physics." There are many resources on tides and currents in these pages.

The "Me" Connection

Have students write a short essay on why knowledge about tides and water levels is (or might be) important in their own lives.

Extensions

The rise and fall of ocean tides involve huge amounts of energy. Have students or student groups prepare a report on how this energy could be captured in a form that could be used by humans. Reports should include a plausible mechanism for converting tidal motion into useful energy, a strategy for transporting captured energy to potential users, and a rough estimate of the energy that might be available from tidal sources. A keyword search on "tide energy" will produce lots of starting points.

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Resources

http://oceanservice.noaa.gov/education/tutorial_tides/supp_tides_roadmap.html – NOAA's National Ocean Service Web site's Roadmap to Resources about tides and water levels, with links to many other sources of tide data and background information

<http://www.navmetocom.navy.mil> – Naval Meteorology and Oceanography Command Web site with information on waves and tides and other oceanography topics

<http://www.edusite.com/sci/tides.htm> – Links to educational resources on ocean science topics

<http://www.internet4classrooms.com/tide.htm> – Links to internet resources dealing with tides

<http://school.discovery.com/curriculumcenter/oceans> – Discovery Channel School resources on ocean science topics

National Science Education Standards

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Motions and forces

Content Standard D: Earth and Space Science

- Energy in the earth system

Content Standard E: Science and Technology

- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Natural and human-induced hazards

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Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1. The Earth has one big ocean with many features.

- Fundamental Concept c. Throughout the ocean there is one interconnected circulation system powered by wind, tides, the force of the Earth's rotation (Coriolis effect), the Sun, and water density differences. The shape of ocean basins and adjacent land masses influence the path of circulation.
- Fundamental Concept d. Sea level is the average height of the ocean relative to the land, taking into account the differences caused by tides. Sea level changes as plate tectonics cause the volume of ocean basins and the height of the land to change. It changes as ice caps on land melt or grow. It also changes as sea water expands and contracts when ocean water warms and cools.

Essential Principle 6. The ocean and humans are inextricably interconnected.

- Fundamental Concept f. Coastal regions are susceptible to natural hazards (such as tsunamis, hurricanes, cyclones, sea level change, and storm surges).

Essential Principle 7. The ocean is largely unexplored.

- Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.
- Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.
- Fundamental Concept e. Use of mathematical models is now an essential part of ocean sciences. Models help us understand the complexity of the ocean and of its interaction with Earth's climate. They process observations and help describe the interactions among systems.

- Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

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Ups and Downs

Student Worksheet - Analyzing Real-time Water Level Data from Monitoring Stations

NOAA Tides and Currents, managed by the Center for Operational Oceanographic Products and Services (CO-OPS), provides access to NOAA's vast collection of oceanographic and meteorological data (historical and real-time), predictions, and "nowcasts" and forecasts. Tides Online provides an easy way to view recent data from the National Water Level Observation Network, a network of 175 continuously operating water-level stations throughout the USA.

1. Open the Tides Online Web page at <http://tidesonline.nos.noaa.gov/>. Click "State Maps," then on "MA" (Massachusetts) and select "Woods Hole." If at any point there are no data available, hypothesize on what might have caused this error. Is there unusual or severe weather at the monitoring station?
2. How many high and low tides did Woods Hole, MA experience in the last lunar day? What type of tidal pattern did Woods Hole experience? What are the tidal heights in Woods Hole, MA?
3. How do the observed and predicted data compare? What may have caused any differences between the observed and predicted data for Woods Hole, MA?
4. Click the Back button twice on your browser or return to <http://tidesonline.noaa.gov/geographic.html>. "Click" on AL (Alabama) and select Dauphin Island, AL.
5. How many high and low tides did Dauphin Island, AL experience in the last lunar day? What type of tidal pattern did Mobile experience? What are the tidal heights in Dauphin Island, AL?
6. How do the observed and predicted data compare? What may have caused any differences between the observed and predicted data for Dauphin Island, AL?
7. Click the Back button twice on your browser or return to: <http://tidesonline.noaa.gov/geographic.html>. "Click" on WA (Washington) and select Seattle, WA.
8. How many high and low tides did Seattle, WA experience in the last lunar day? What type of tidal pattern did Seattle experience? What are the tidal heights in Seattle, WA?

9. How do the observed and predicted data compare? What may have caused any differences between the observed and predicted data for Seattle, WA?

Conclusion questions:

1. Summarize what causes tides. Discuss the effects of tidal forces and how bulges are formed.
2. Explain why humans are interested in monitoring tides. What impact do tides have on human life? What impact might tides have on other organisms?
3. Discuss how tides are monitored. Describe the old and new methods of monitoring tides.
4. Compare and contrast the tidal patterns of Cape Cod, MA, Dauphin Island, AL, and Seattle, WA. What is the tidal pattern in your area?

Further Exploration:

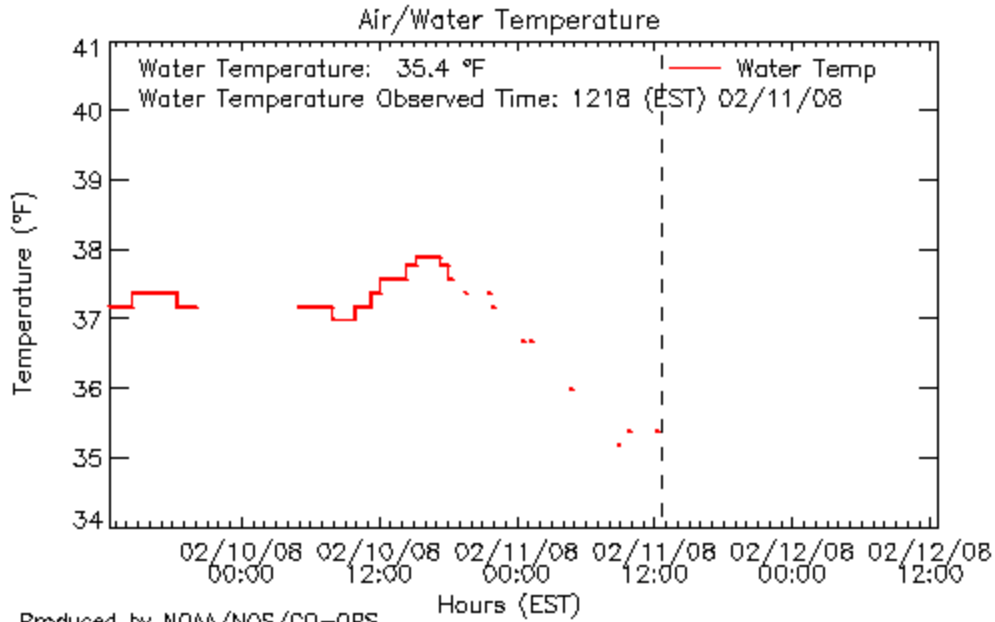
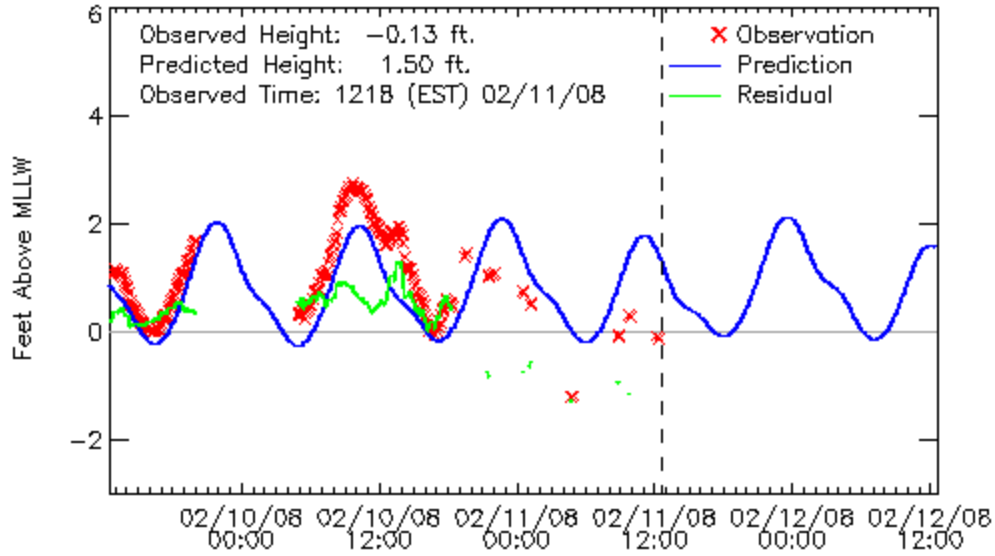
Using the NOS Web site at <http://tidesonline.nos.noaa.gov/geographic.html>, select a tidal gauge that is located near your area. Monitor the tidal gauge for one month and record tidal fluctuations. Note any deviation from the predicted and observed tidal levels. What do you think causes this deviation?

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Appendix A

Water Level and Temperature Data for Monitoring station # 8447930, Woods Hole, MA

8447930 Woods Hole, MA
Water Levels



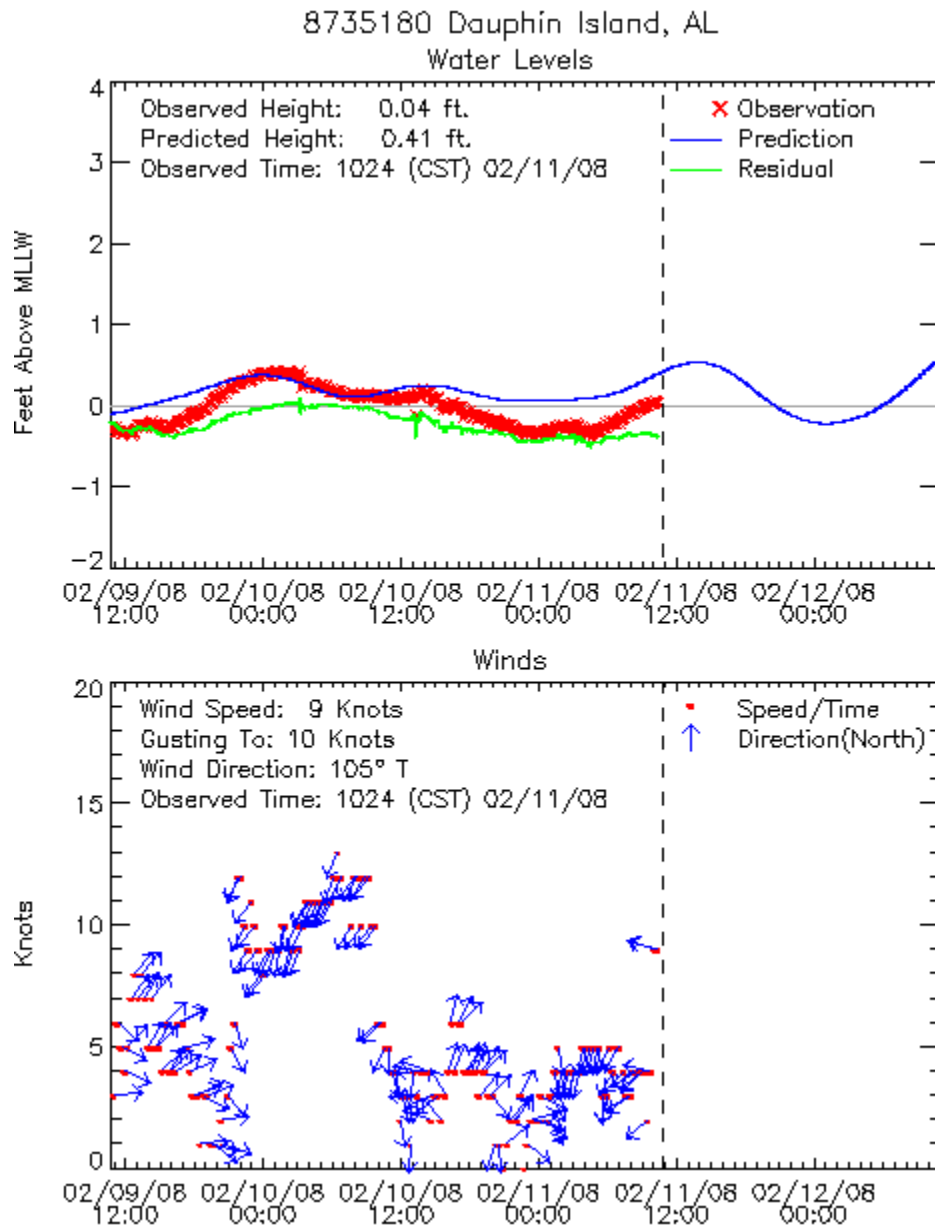
Produced by NOAA/NOS/CO-OPS

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Appendix B (pt. 1)

Water Level and Wind Data for Monitoring station #8735180 Dauphin Island , AL

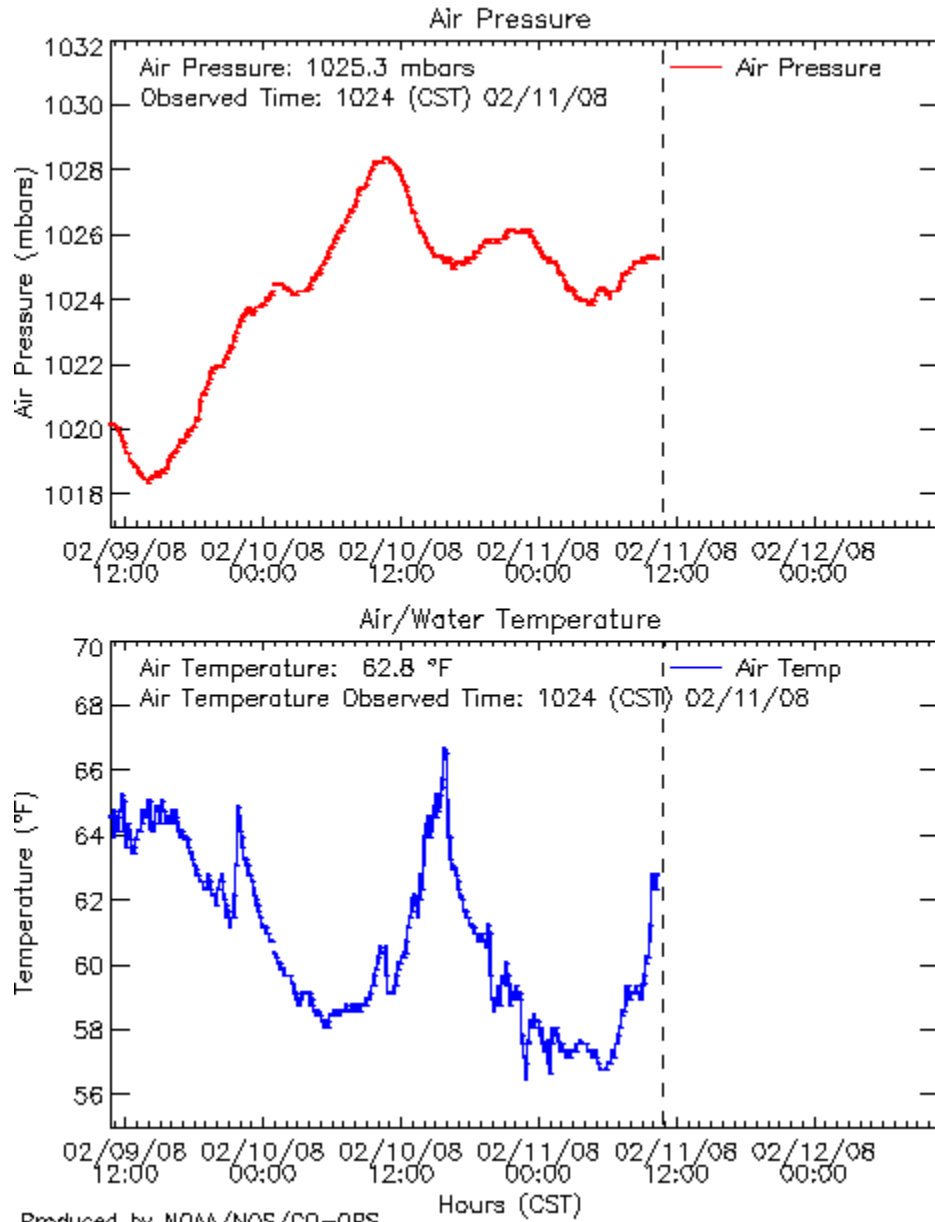


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Appendix B (pt. 2)

Air Pressure and Temperature Data for Monitoring station #8735180 Dauphin Island, AL

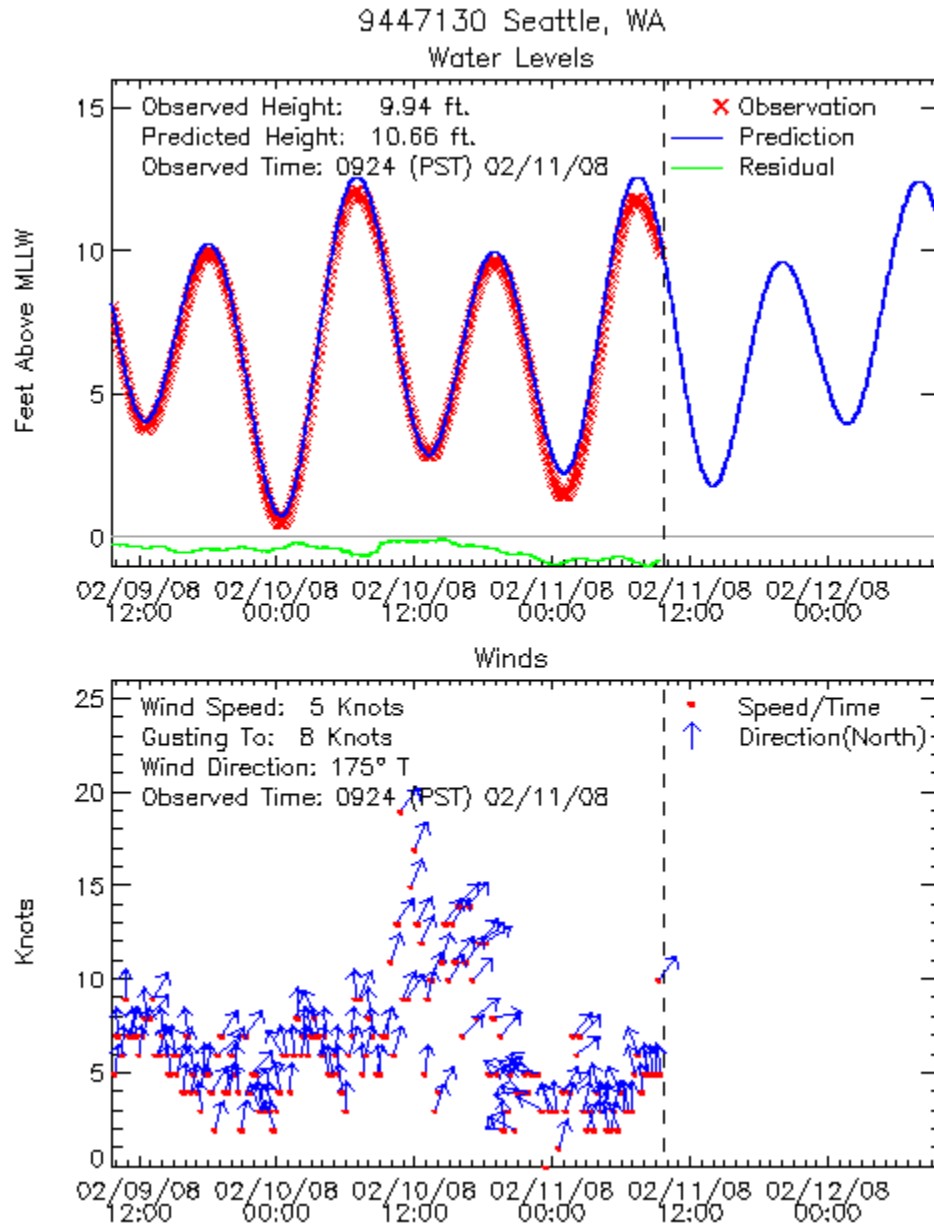


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Appendix C (pt. 1)

Water Level and Wind Data for Monitoring station # 9447130 Seattle, WA

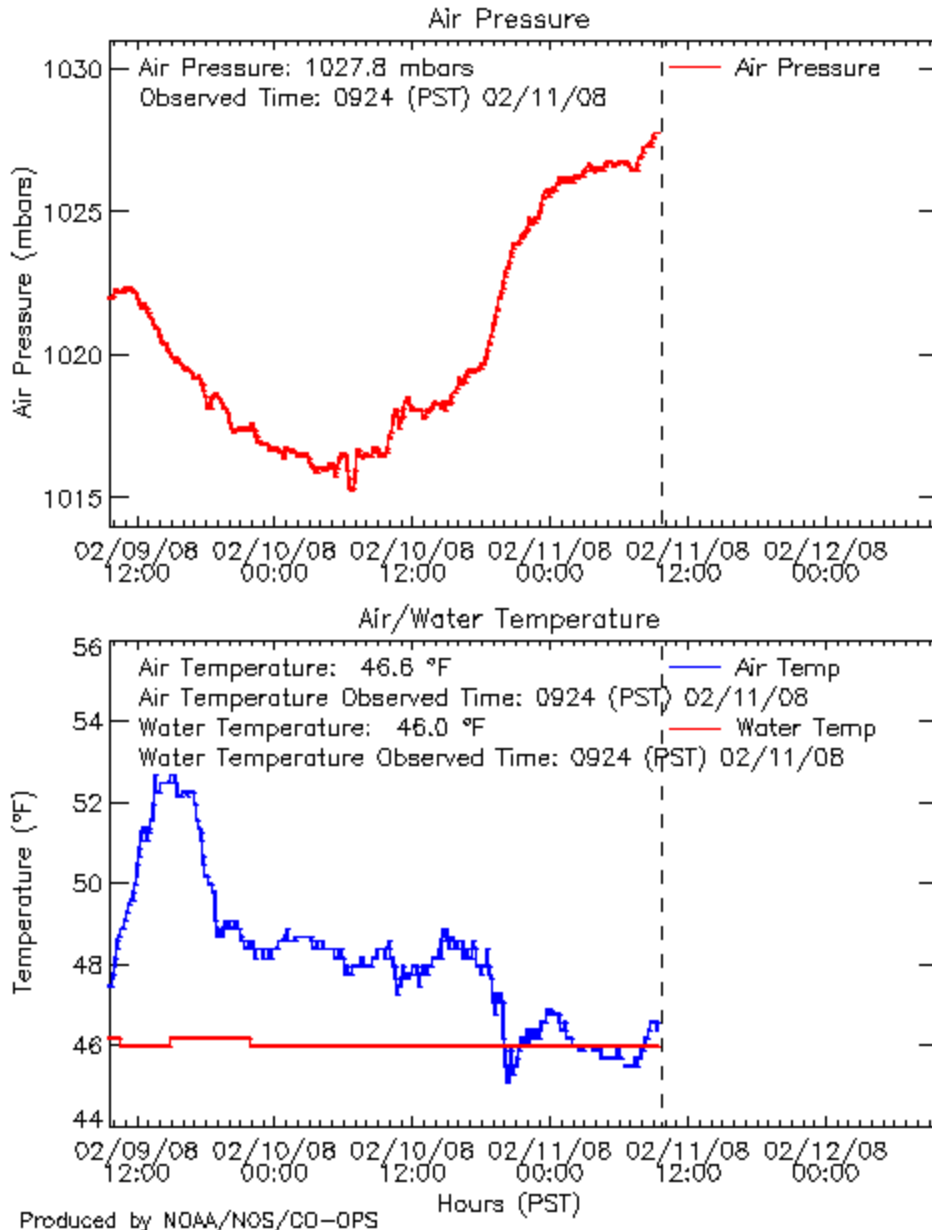


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Appendix C (pt. 2)

Air Pressure and Temperature Data for Monitoring station # 9447130 Seattle, WA



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