# BIG DATA

## SMALL DEVICES

### INVESTIGATING THE NATURAL WORLD ·····USING····· REAL-TIME DATA

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# CONTENTS


ABOUT THE AUTHORS ..... vii
ACKNOWLEDGMENTS ..... ix
PREFACE ..... xi
INTRODUCTION ..... 1

## PART 1: USING REAL-TIME DATA IN THE CLASSROOM

PAGE 3

1

### WHAT ARE REAL-TIME DATA?

5

Accessing Real-Time Data for Student Investigations ..... 6
Using Crosscutting Concepts with Real-Time Data ..... 8
Summary ..... 15
References ..... 15

2

### TECHNOLOGY TIPS AND TRICKS

17

Accessing Your School's Network ..... 17
Operating Systems ..... 18
Responsive Design ..... 19
Native Apps ..... 20
Using Apps for Accessing Real-Time Data ..... 21
Using QR Codes ..... 22
A Note About Time ..... 23
Managing Devices ..... 24
Graphing Data ..... 25
Summary ..... 26
References ..... 26

3

### CONDUCTING INVESTIGATIONS WITH REAL-TIME DATA

27

Levels of Inquiry ..... 27
Distinguishing Between Investigations and Experiments ..... 29
Science and Engineering Practices ..... 30
Summary ..... 40
References ..... 41

4

### DATA TYPES, REPRESENTATION, AND ANALYSIS

43

Understanding the Different Types of Data ..... 46
How Scientists Communicate About Their Data ..... 58
Exceptions to the General Rules for Summarizing Data ..... 60
Summary ..... 63
Reference ..... 63

## PART 2: SAMPLE ACTIVITIES USING REAL-TIME DATA

PAGE 65

INTRODUCTION ..... 67
AVOIDING ASSUMPTIONS ..... 68
USING GATHERED RESOURCES IN THE CLASSROOM ..... 69
REFERENCES ..... 69


### INVESTIGATIONS USING REAL-TIME ATMOSPHERE DATA

71

References ..... 74
Air Quality ..... 75
Climate From Pole to Pole ..... 81
Extreme Weather ..... 85
Weather Mapper ..... 90
Weather Stories ..... 96
Wind Beneath Our Wings ..... 102


### INVESTIGATIONS USING REAL-TIME BIOSPHERE DATA

111

References ..... 113
Animal Behavior Ethograms ..... 114
Emerging or Developed? ..... 120
This Land Is Our Land ..... 126
Wildfire! ..... 132


### INVESTIGATIONS USING REAL-TIME GEOSPHERE DATA

141

Reference ..... 143
Convergent or Divergent? ..... 144
Radon Mapper ..... 150
Tectonic Plate Shuffle ..... 156
Volcano Risk ..... 163


### INVESTIGATIONS USING REAL-TIME HYDROSPHERE DATA

171

References ..... 173
Catch the Wave! ..... 174
Dissolved Oxygen and Water Quality ..... 180
Oceans and Climate ..... 186
Tides of Change ..... 192




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## 9

## INVESTIGATIONS USING REAL-TIME CELESTIAL SPHERE DATA

201

Reference ..... 202
Photoperiods ..... 203
Solar Terminator ..... 209
Tonight's Sky ..... 215
Hiding Out ..... 221

# PART 3: GOING FURTHER

PAGE 229

## 10

## BEYOND THE DATA

231

Challenging the Skeptics ..... 233
Earthquake! ..... 234
Hurricane "Me" in the News ..... 235
National Park Travel Guides ..... 236
Stratospheric Ozone ..... 237
We Are the World ..... 238

## 11

## REAL-TIME CITIZEN SCIENCE

239

Established Citizen Science Projects ..... 241
Citizen Science Project Collections ..... 242
Building Your Own Project ..... 244
References ..... 247

**ACTIVITY REFERENCES** ..... 249
**INDEX** ..... 251

# INTRODUCTION

Smartphones and tablets are now in the hands of even our youngest learners. As teachers, we are encouraged to use bring-your-own-technology (BYOT), but often are not sure how to transform smartphones and tablets into a valuable learning tool for meaningful instruction.

One answer lies in using a number of free smartphone and tablet apps that provide "real-time" data to explore Earth and environmental science concepts. These are data collected and made available in real time, or nearly so. Real-time data can be found on websites such as the U.S. Geological Survey (USGS), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), NASA, and the National Weather Service (NWS). These are all government agencies that provide free data products such as weather and earthquake information, streamflow data, toxic waste information, times of celestial events, and planetary data. These data are free, and a multitude of apps have been developed that access and visualize them, in most cases at no cost. Students can access this information on websites; however, allowing students to investigate concepts using their smartphones in app-based activities allows them to be more engaged in science investigations and teaches them how to turn the technology they carry with them all the time into a useful learning tool.

Using real data in classroom investigations aligns with the following *Next Generation Science Standards* (*NGSS*) science and engineering practices:

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Developing and using models
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Using mathematics and computational thinking
- Obtaining, evaluating, and communicating information

The *NGSS* crosscutting concepts involved in real-time data investigations include the following:

- Patterns
- Cause and effect: Mechanism and explanation
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter: Flows, cycles, and conservation
- Structure and function
- Stability and change

This book is designed to help the classroom Earth and environmental science teacher develop student investigations that use real-time data. It includes information on the technology and classroom implementation aspects of accessing and using data for meaningful learning. Sample lesson plans are included that showcase specific data and the apps that include them. But more importantly, this book provides the classroom teacher with a set of tools to develop investigations with any online-accessible data. Finally, exploring real-time data is not limited to independent experiences—collecting and sharing data with others can promote collaborative scientific investigations. With the use of multiple web-based applications and apps for personal devices, opportunities exist for everyone to participate in citizen science programs.




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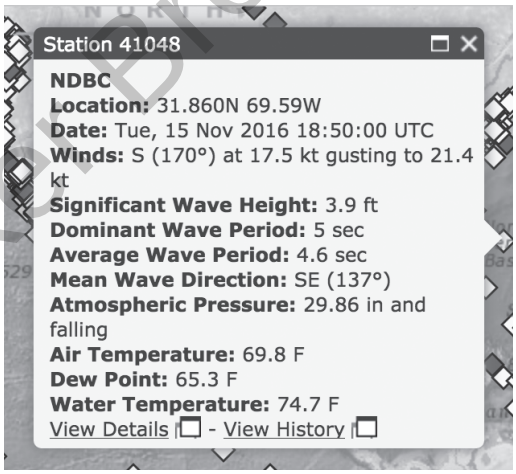
# WHAT ARE REAL-TIME DATA?

Every time an earthquake happens anywhere on our planet, the U.S. Geological Survey (USGS) records its location, magnitude, and depth. This information is available immediately through the USGS website. Most people are familiar with the data provided by the National Weather Service. Through its website, information about surface and atmospheric conditions such as barometric pressure, wind speed, wind direction, and humidity are updated hourly and available in real time.

The National Data Buoy Center (NDBC), a division of the National Oceanic and Atmospheric Administration (NOAA), provides data from hundreds of buoys in every ocean and other major body of water in the world (Figure 1.1), including latitude, longitude, wind speed, wave height, air temperature, water temperature, and wave period. These data are updated hourly for most stations and posted online in real time. As conditions change, data are updated and made immediately accessible to anyone, anywhere.

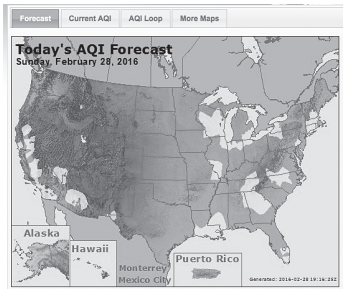
**Figure 1.1.** Example of NDBC buoy data




*Source:* National Data Buoy Center, *www.ndbc.noaa.gov.*

Other data collected by various government agencies and distributed via the web in real time include stream quality, groundwater levels, toxic waste amounts, ozone levels, tide tables, Moon phase, and sunrise and sunset times. Because these data are provided by

# TEACHER NOTES: AIR QUALITY

| | | | |
|---|---|---|---|
| **Learning Goal** | Students will explore the relationship between tropospheric ozone and temperature and how human populations affect ozone levels. | | |
| **Disciplinary Core Ideas** | • Weather and climate<br>• Human impacts on Earth systems | | |
| **Science and Engineering Practices** | • Analyzing and interpreting data<br>• Engaging in argument from evidence | | |
| **Crosscutting Concepts** | • Energy and matter: Flows, cycles, and conservation<br>• Stability and change | | |
| **Background Information** | Tropospheric ozone is a gas that occurs naturally in the atmosphere in small amounts. It is also produced by photochemical reactions when sunlight interacts with pollutants such as nitrous oxides ($NO_x$), carbon monoxide (CO), and volatile organic compounds (VOCs) produced by automobiles, industry, and other human activities. High levels of ozone in the troposphere present a health risk to humans and other organisms. In people, respiratory problems are more likely to occur when ozone levels are elevated, which can be especially problematic for people with asthma. Because sunlight and heat increase ozone formation, ozone levels are often higher in summer than in winter. Also, because it is formed from pollutants such as CO, $NO_x$, and VOCs, ozone levels are usually higher in high-population areas than in rural areas. | | |
| **DATA AND TECHNOLOGY** | | | |
| **Online Sources** | • AIRNow website (*www.airnow.gov*) for air-quality data<br>• Weather Underground website (*www.wunderground.com/history)* for climate data<br>• QR Codes: See Table 5.1 (p. 108). | | AIRNow website screenshot<br>  <br><br>*Source: www.airnow.gov.* |
| **App and Device Sources** |  | *Weather History Explorer* app for weather history data<br>Device platforms: Android, iOS | |
| |  <br> | *AIRNow* app for air-quality data<br>Device platforms: Android, iOS | |

| DATA AND TECHNOLOGY (*continued*) | |
|---|---|
| **Technology Notes** | Although there are dozens of apps that provide current air-quality data, the authors found no apps that provide historical data. The EPA *AIRNow* app provides current data. To find historical data, students should access the EPA AIRNow website through a browser on a computer or their device. This should not present much of a problem, because the data are easy to access through the website. |
| **About the Data** | **Data Sampling:** You might need to help students determine how to sample fairly. For instance, students might pick a particular day of the month to sample at a particular time or if there are multiple measures each day, they might calculate the mean (average) temperature for the day.<br><br>**Data Type:** Temperature and ozone level are interval–ratio (measured) types of data.<br><br>**Data Issues:** More-astute students might notice that the months being different lengths could cause minor data variation on the horizontal axis. One solution to this is to divide the number of days in a year by 12 and then measure at the same point in each of those periods. This will result in 12 evenly spaced measures; note they will be on different dates of each calendar month. |
| **USING AND ADAPTING THE ACTIVITY** | |
| **About the Activity** | Ozone levels are reported using an air quality index (AQI) that corresponds to actual ozone levels. The EPA AQI of 100 represents ozone levels of 0.075 parts per million (ppm) averaged over an 8-hour period. Levels of 0.070 ppm are considered the standard for EPA regulations. Students will need to understand that the method of data sampling will present outliers, because air quality is also affected by weather conditions such as wind, sky cover, and precipitation, which affect the availability of pollutants and/or the amount of sunlight available for photochemical reactions. |
| **Scaling Down** | Use a jigsaw activity by having students work in pairs, with each pair collecting one data point and sharing with the class. You can also use an app and track data over long periods of time, starting early in the year. Have students collect daily data and record it on a class weather calendar to correlate temperature and ozone only, without comparing it to less-populated areas. By the end of a full semester, the amount of data collected will be sufficient for analysis. |







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| USING AND ADAPTING THE ACTIVITY (*continued*) | |
|---|---|
| **Scaling Up** | Have students collect other weather data, such as precipitation or wind speed. Then, they can compare data from sunny dates to data from rainy dates as an additional variable in producing photochemical ozone, or explore the role of wind in reducing pollutants. Students can also collect data related to population density for urban areas. |
| **Extending** | **Ozone Monitoring:** Students in urban areas can use ozone test strips to monitor ozone levels near their school.<br><br>**Ozone Up High:** If it is the same molecule, why is ozone considered bad low in the atmosphere but good when up high in the atmosphere? Students can investigate stratospheric ozone using the NASA app *Earth Now,* and compare stratosphere and troposphere ozone levels.<br><br>**Enrichment Using Data:** Have students construct a meteogram for temperature and ozone level (with the time variable on the horizontal axis) to examine variation over the year. |

| ASSESSMENT NOTES |
|---|
| Although ozone levels vary seasonally, they will be higher in the summer than at other times of the year because of increased ultraviolet light levels. Generally, trend lines should show a greater correlation between ozone and temperature in urban areas than in rural ones. |