Module 2: Activity 2

Making a Simple Predictive Model for Ground-Level Ozone

IT'S OUR AIR

SUMMARY

In this activity, students will use ozone and weather data to explore the relationship between ground-level ozone pollution and (1) maximum daily temperature, (2) average daily solar radiation, (3) average daily wind speed, and (4) daily precipitation. Students will make a simple predictive model based on the data. This activity will give students a window into the world of forecasting and a chance to engage in data analysis with real-world examples. Some previous knowledge of meteorology is recommended.

ESSENTIAL QUESTIONS

- What are some of the important factors that contribute to a high-ozone day?
- How can we predict which days will have high concentrations of ozone pollution?
- How can data be used to examine and solve real-world problems?

TIME NEEDED

This activity will take close to 90 minutes for AP classes and honors earth science classes. Academic earth science classes may need more time (see Teacher Tips for ways of modifying the activity).

North Carolina ESSENTIAL STANDARDS FOR EARTH/ENVIRONMENTAL SCIENCE

- EEn.2.5 Understand the structure of and processes within our atmosphere.
- EEn.2.5.5 Explain how human activities affect air quality

MAKING CONNECTIONS

This activity illustrates the importance of analyzing the relationships among multiple processes in a complex system – in this case, the atmosphere – which is an important scientific concept.

By giving students the opportunity to work with real ozone measurements and meteorological data, this activity gives students the chance to go beyond generalizations and begin to explore the subtleties, another important concept in science. In other words, just because sunshine is an important factor in ozone production doesn't mean that every sunny day will result in high concentrations of ground-level ozone. Students will learn that science is hard to reduce to short statements because in real life there are so many variables at play in any given situation. This activity also introduces the idea of studying data gathered in the past with the goal of forecasting future events. Although looking at only one year of data doesn't provide enough data to see long-term trends, it does provide enough data to allow students to discover some interesting and useful patterns.

Another connection to make is between air quality and health. Because poor air quality can create or exacerbate health problems, and because young people – especially those with asthma – can be more susceptible, it's important to understand how to forecast air quality.

BACKGROUND

One of the biggest air quality problems in North Carolina is ground-level ozone, a strong respiratory irritant that can cause serious health problems. In North Carolina, meteorologists at the Division of Air Quality forecast the air quality every day to help inform citizens how good or bad the air quality is expected to be. The forecast is communicated using the color-coded Air Quality Index (AQI). Knowing how much air pollution is in the air helps people take precautionary steps to protect their health, such as limiting outdoor activity during times when air pollution is higher. Although the way meteorologists forecast ground-level ozone is considerably more complex, this activity gives students a window into the process.

GROUND-LEVEL OZONE FORMATION

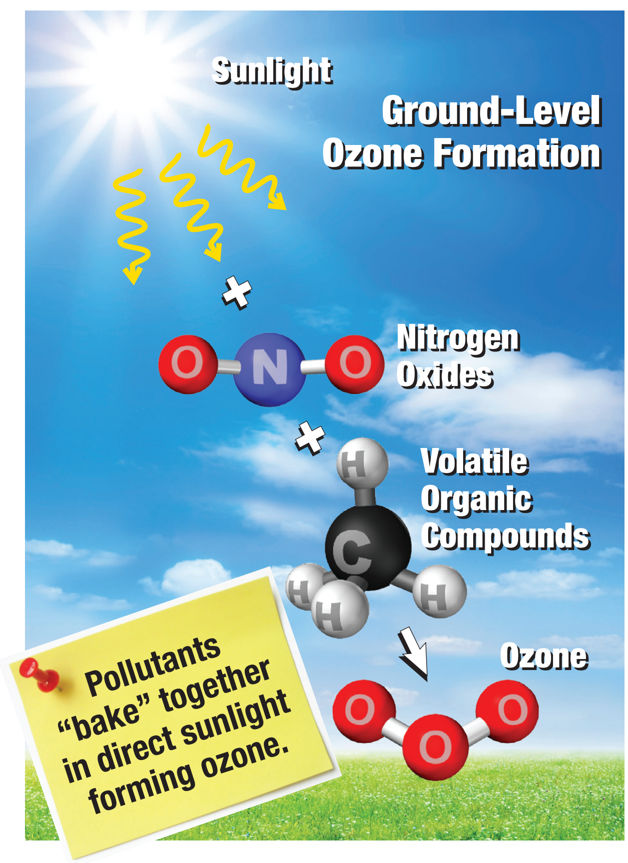
It's important to note that ground-level ozone (O_3) is not emitted directly from tailpipes or smokestacks. Ground-level ozone forms when nitrogen oxides (NO_x) react with volatile organic compounds (VOCs) in the presence of heat and sunlight. Nitrogen oxides are a byproduct of combustion; sources include vehicles and power plants that generate electricity through combustion. VOCs come from both anthropogenic sources such as cars and factories, and biogenic sources such as trees and other vegetation.

NO_x + VOCs + heat + sunlight $\rightarrow O_3$

As the equation illustrates, high concentrations of ozone depend on the presence of certain precursor pollutants and certain meteorological conditions. (See Activity 4 in Module1: "The Criteria Pollutants and a Closer Look at Ozone" for more information on ozone formation.)

In North Carolina, ground-level ozone is highest in the late spring and summer because this is when we receive the strongest solar radiation and the most hours of sunlight. Other meteorological factors that favor ozone formation include dry air, light winds, and warm temperatures. Poor air-quality episodes often share a common feature: a stagnant air mass with relatively little mixing or moving. The lack of mixing allows the ozone precursors (NO_x and VOCs) to accumulate over time in one place. Stagnant air masses are typically the result of a large area of high pressure, causing mostly sunny skies, hot and dry air, and light winds.

This activity gives students the opportunity to use real data to discover how weather influences ground-level ozone levels.



TRENDS IN OZONE POLLUTION IN NORTH CAROLINA

In North Carolina, air quality has been steadily improving over the last ten to fifteen years, thanks in large part to state and federal regulations and laws aimed at reducing emissions from power plants and vehicles. One example of this type of regulation is North Carolina's Clean Smokestacks Act of 2002, which set caps on annual emissions of nitrogen oxides and sulfur dioxide from power plants owned by utilities in North Carolina. (For more information on North Carolina's Clean Smokestacks Act and federal regulations such as the Clean Air Act, see the activity about regulations in Module 3.)

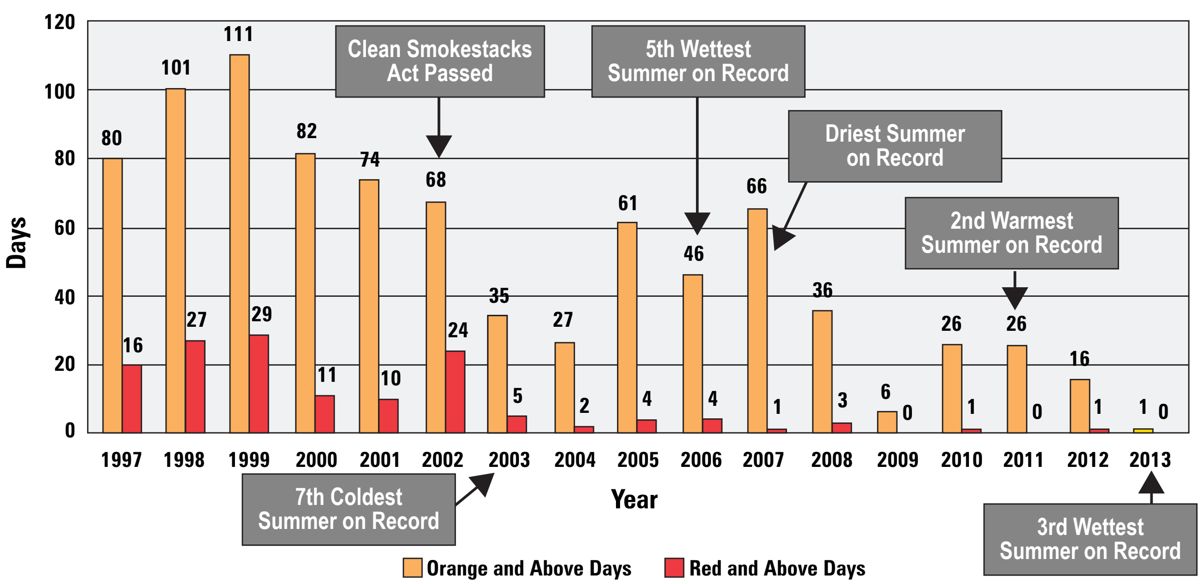
FORECASTING OZONE POLLUTION IN NORTH CAROLINA

Forecasts are predictions of the future that are based on data gathered in the past. Both this activity and the following one (Activity 3 in Module 2, "Forecasting Air Quality") allow students to use data from the past to make forecasts about the future.

Why is it important to forecast ozone pollution? Because breathing ozone can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases. Some of these health problems include chest pain, coughing, throat irritation, congestion and exacerbation of existing conditions such as bronchitis, emphysema and asthma. Repeated exposure can cause permanent problems. (There are several other It's Our Air activities with more information about the health problems caused by ground-level ozone. You can search for them by topic at www.itsourair.org/search-topic.)

Division of Air Quality meteorologists forecast ozone levels daily during ozone season, which is currently from April 1 to October 31. The forecast is communicated through the Air Quality Index (AQI) so that the public can use the information to protect their health. (See Activity 1 in Module 2, "What's an Air Quality Index?" for more information on the AQI, including where to find the AQI forecast.)

Professional meteorologists use sophisticated computer models that simulate chemical, physical and atmospheric processes to forecast ozone levels. In this activity, students will use several variables to put together a much, much simpler predictive model to forecast ozone levels.



Source: http://ncdc.noaa.gov and N.C. Division of Air Quality

MATERIALS

- Excel files containing ozone data (2012, Monroe, NC) and weather data (2012, Lilesville, NC), provided at http://itsourair.org/2-2-model-predict-ground-level-ozone-pollution
- Graph templates (provided)
- Calculators
- Computer lab (optional)

WARMUP

Review the Air Quality Index (AQI) if necessary. Review the AQI color codes for maximum eight-hour ozone levels: a measurement between 0 and 59 ppb is Code Green, between 60 ppb and 75 ppb is Code Yellow, and between 76-95 ppb is Code Orange. See Activity 1 in Module 2 ("What's an Air Quality Index?") for more information.

Review formation of ground-level ozone if necessary.

Review average daily solar radiation, which is measured in watts per meter squared (W/m^2). Several factors play into this measure, including the presence/absence of clouds, the hours of sunlight per day (more in spring/summer than fall/winter), and the angle at which the sun's rays are striking the Earth's surface (more direct in spring/summer, and more oblique in fall/winter). In summary, a sunny day will receive more average solar radiation than a cloudy day, while a sunny July day will receive more average solar radiation than a sunny April or October day due to the length of the day and the angle of the sun.

Ask students these questions in a class discussion:
- What are the ingredients for ozone formation at ground level? [Answer: NO_x, VOC, sunlight, heat]
- What time of year is ozone pollution likely to be a problem? [Answer: spring and summer]
- Why? [Answer: more sunlight; higher temperatures]
- Use the equation for ozone formation to brainstorm a list of factors that might affect ozone formation and discuss HOW they might affect ozone formation. [Answers: temperature, cloudy/sunny, amount of daylight, windy/still, wind direction, presence/absence of thunderstorms, long-term weather patterns such as drought, presence/absence of nitrogen oxide sources including motorized traffic and power plant emissions, etc.]
- Ask students how larger scale meteorological systems affect some of the weather factors discussed in the previous question. [Answers: High pressure systems result in sunny skies, dry air and light winds. Low pressure systems result in cloudy skies and precipitation. Fronts bring instability and change.]

Teacher Tips

Have the students count off from 1-4. Assign the 1's temperature, the 2's solar radiation, the 3's wind speed, and the 4's precipitation. After each student has filled out their data table and drawn a bar graph, randomly choose a 1, 2, 3, and 4 to explain their findings to the class. Once everyone has seen examples of each, divide the class into groups that each contain a 1, 2, 3, and 4 and give the groups time to answer the questions and create their own predictive models. Have the groups share their models, and let the students vote on the one they want to try on the model test in the Assessment section.

Depending on the level of your class, you can differentiate in several ways with this activity. You can have students go through the entire activity using data presented chronologically, or you can give students the pre-sorted data (provided) to make it easier and faster for them to fill out their data tables, or you can give students the data table answer keys and have them make their own bar graphs. (Note: In the pre-sorted files, data is sorted to make it easier to count up data points. For example, one file shows temperature in descending order so that all the days in the 80s will be together, making it easier to count how many days had temperatures in the 80s and to see how many of those had high ozone readings.)

If you want students to work directly with the data in the Excel spreadsheets and/or make bar graphs on a computer, consider doing the activity in a computer lab.

– Mark Townley

THE ACTIVITY

Have each student work independently in class (see Teacher Tips) to fill in the table and make a bar chart for one of the following: (1) maximum daily temperature, (2) average daily solar radiation, (3) average daily wind speed and (4) daily precipitation. The answers are included in the tables in brackets.

The data used to fill in these tables are provided in Excel spreadsheets that can be downloaded from at http://itsourair.org/2-2-model-predict-ground-level-ozone-pollution. The same data set is provided in two formats (chronological and pre-sorted) to provide two alternate ways to present the activity at different levels of difficulty (see Teacher Tips).

NOTE: The data set provided begins with April 2 (the second day of ozone season) because there was no ozone measurement recorded at the Monroe monitoring station on April 1.

COMPLETE DATA TABLES

Fill in the following table using the data provided by your teacher:

TABLE 1:
Maximum Daily Temperature vs. Percentage of Days at Code Green and Code Yellow (and Above)

Temperature Range (deg F)	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
50-59	[5]	[5]	[0]	[100]	[0]
60-69	[17]	[17]	[0]	[100]	[0]
70-79	[54]	[50]	[4]	[93]	[7]
80-89	[94]	[87]	[7]	[93]	[7]
90 and above	[43]	[28]	[15]	[65]	[35]
Add up column to check your math	213	187	26	NA	NA

TABLE 2:
Average Daily Solar Radiation vs. Percentage of Days at Code Green and Code Yellow (and Above)

Avg. Solar Radiation in W/m^2	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
0-49.9	[6]	[6]	[0]	[100]	[0]
50-99.9	[18]	[18]	[0]	[100]	[0]
100-149.9	[21]	[21]	[0]	[100]	[0]
150-199.9	[35]	[34]	[1]	[97]	[3]
200-249.9	[51]	[47]	[4]	[92]	[8]
250-299.9	[44]	[34]	[10]	[77]	[23]
300-349.9	[34]	[25]	[9]	[74]	[26]
350-399.9	[4]	[2]	[2]	[50]	[50]
Add up column to check your math	213	187	26	NA	NA

Fill in the following table using the data provided by your teacher:

TABLE 3:
Average Daily Wind Speed vs. Percentage of Days at Code Green and Code Yellow (and Above)

Avg. Wind Speed (mph)	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
0-1.9	[59]	[50]	[9]	[85]	[15]
2.0-3.9	[80]	[70]	[10]	[87.5]	[12.5]
4.0-5.9	[57]	[50]	[7]	[88]	[12]
6.0-7.9	[11]	[11]	[0]	[100]	[0]
8.0-9.9	[6]	[6]	[0]	[100]	[0]
Add up column to check your math	213	187	26	NA	NA

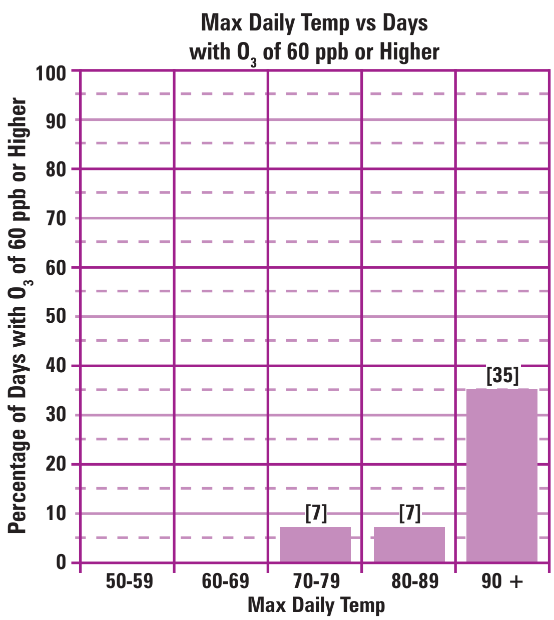
TABLE 4:
Daily Precipitation vs. Percentage of Days at Code Green and Code Yellow (and Above)

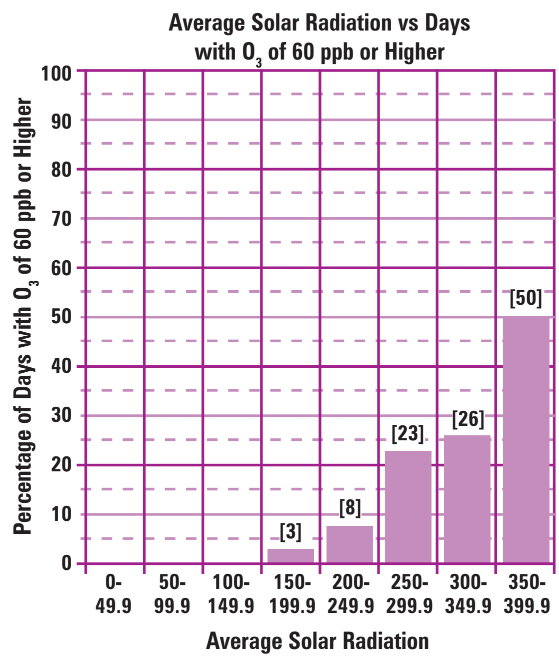
Rain?	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
No Rain	[126]	[107]	[19]	[85]	[15]
Some Rain	[87]	[80]	[7]	[92]	[8]
Add up column to check your math	213	187	26	NA	NA

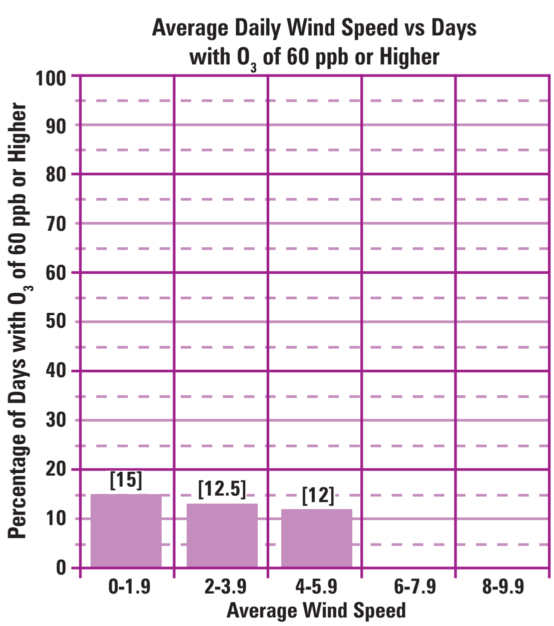
MAKE BAR GRAPHS

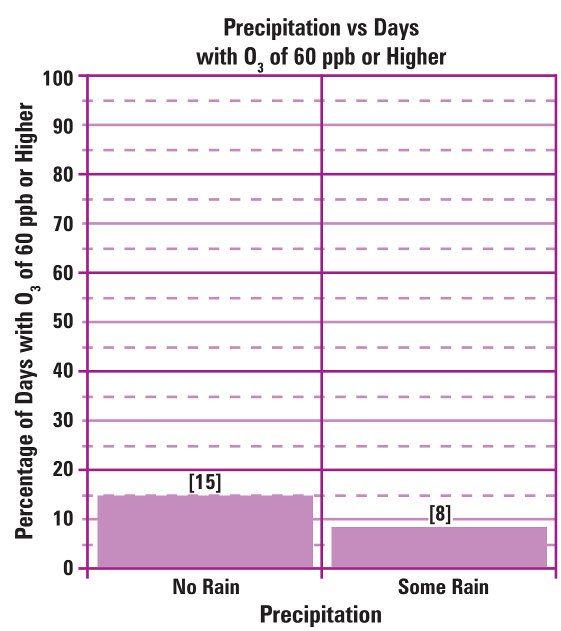
Using the graph templates provided, make a bar graph for each data table, showing the percent of days with ozone of 60 ppb or higher (Code Yellow) for each row of the table.

1. Label the y-axis "Percentage of Days with Maximum 8-Hour Ozone of 60 ppb or Higher," and mark it off from 0% to 100 % by 10's.
2. Label the x-axis (maximum temperature, average solar radiation, average wind speed, or precipitation) and mark it off using the data ranges in the first column of your table.
3. Draw a bar representing each row of your data table.









Forecasting Ozone

Have students work groups in class (see Teacher Tips) to answer the questions below and develop forecast models for forecasting Code Green and Code Yellow (and above) days for ozone.

Forecasting Code Green Days

Refer to the four bar graphs to answer the following questions:

1. What temperature ranges were most commonly associated with Code Green days? Why might this be? [Answer: 50-69 because ozone formation needs heat; cooler days are more likely to have experienced clouds/rain; and cooler days may be indicative of the presence of a fresh, clean air mass behind a recent cold front and/or from cleaner origins to the north, like Canada]
2. What range of wind speeds were most commonly associated with Code Green days? Why might this be? [Answer: higher than 6 mph, because wind can blow ozone away]
3. What range of solar radiation were most commonly associated with a Code Green days? Why might this be? [Answer: 0-149.99 W/m^2, because ozone formation depends on heat and sunlight]
4. Which is more likely to be associated with a Code Green day – a day with rain or a day with no rain? Why might this be? [Answer: a day with rain, because a day with rain is likely to be cloudy]
5. Although the data you have been working with is from the past, see if you can use it to forecast the future. Considering your answers to the above four questions, write a statement that describes a day you would forecast to be Code Green. Explain your reasoning. [Answer: A day with any one of the following characteristics Is likely to be Code Green: temperatures less than 70 or a high average wind speed or low solar radiation or some rain. Each of these conditions on its own tends to create conditions that inhibit ozone formation.]

Forecasting Code Yellow (and Above)

Refer to the four bar graphs to answer the following questions:

1. What range of maximum temperatures is most likely to be associated with a Code Yellow (or above) day? Why might this be? [Answer: temperatures above 90 because heat contributes to ozone formation; hot days are often sunny; and hot days may be indicative of a stagnant air mass that's been in place for a few days accumulating pollutants]
2. What range of wind speeds is most likely to be associated with a Code Yellow (or above) day? Why might this be? [Answer: 0-1.9 mph, because if there's not much wind ozone accumulates]
3. What range of solar radiation is most likely to be associated with a Code Yellow (or above) day? Why might this be? [Answer: 350-399.9 W/m^2, because high solar radiation means lots of sunlight, which contributes to ozone formation]
4. Which is more likely to be associated with a Code Yellow (or above) day – a day with rain or a day with no rain? Why might this be? [Answer: a day with no rain, because a day with no rain is sunny and sunlight contributes ozone formation]
5. Although the data you have been working with is from the past, see if you can use it to forecast the future. Considering your answers to the above four questions, write a statement that describes a day you would forecast to be Code Yellow (or above). Explain your reasoning. [Note: This question does not have a "right" answer – the goal of this question is to challenge students to look at their data, consider what they can learn from it, and produce a reasonable statement. Example answer: A day with temperatures above 90, average wind speeds less than 6 mph, average solar radiation above 200 W/m^2 and no rain is likely to be Code Yellow or above... because each of these characteristics is associated with a higher likelihood of a Code Yellow day, combining all four of them probably increases the likelihood.]

What's Missing?

What are some important factors in ozone formation that are not addressed in your predictive statements? [Answer: sources of nitrogen oxides and VOCs; other meteorological details such as movement of large air masses; wind direction; the timing and/or amounts of rain, cloud cover, etc.; how the different factors in this activity might interact]

WRAP UP AND ACTION

Develop a Class-Wide Model

As a class, discuss the predictive statements developed by students, and come to consensus on some simple predictive statements for forecasting Code Green days and Code Yellow (and above) days.

Make it clear that these predictive statements will not be 100 percent accurate, for many reasons: (1) this activity used only one year's worth of data in only one part of North Carolina, (2) this activity looked at only four variables, (3) this activity didn't consider sources of nitrogen oxides or VOCs, and (4) no model is without error.

As a class, make a list of other types of information that would help make a more accurate predictive model for ozone such as:

- the amounts of nitrogen oxides and VOCs present;
- the origin and movement of large air masses;
- wind direction;
- the timing and/or amounts of rain, cloud cover, etc.;
- how the different factors in this activity might interact;
- whether the previous day had high levels of precursor pollutants (NO_x and VOCs), some of which might linger.

As a class, discuss the value of models in using past data to predict future events, and also discuss the limitations of models. How can predictive models be assessed for accuracy? Can a model ever be 100 percent accurate? What can be done to increase the accuracy of a model?

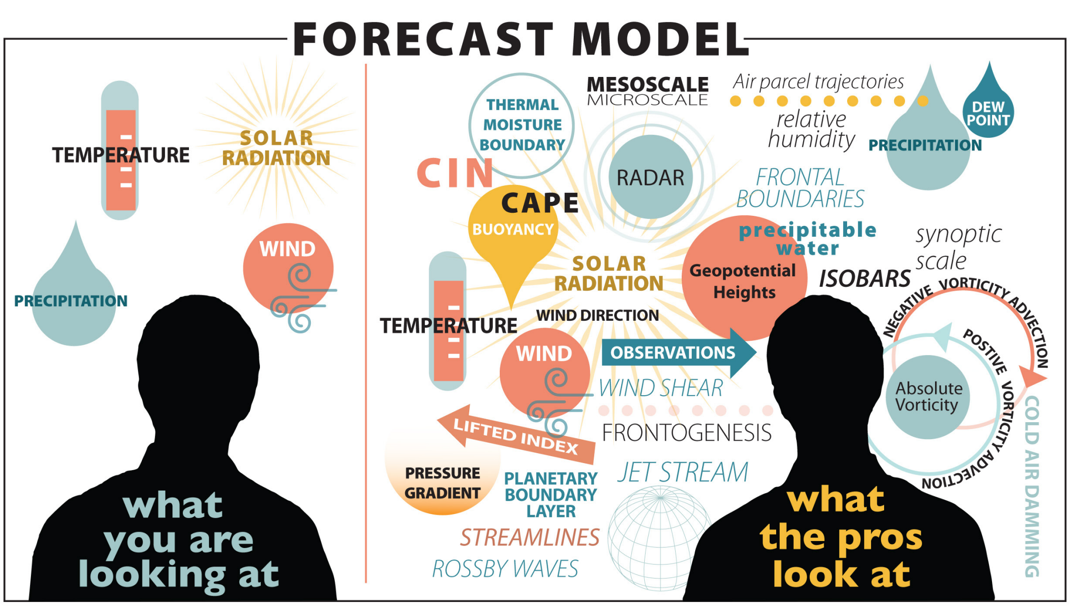
If you are not planning to do the following activity in this module ("Forecasting Air Quality"), show your class the video "What is IN the Air?" It reviews the AQI and air quality forecasting. It includes interviews with a doctor who studies the health effects of air pollution and with meteorologists at the Division of Air Quality.

ASSESSMENT

Validate the Model

Have the students look at a set of data points from the 2012 dataset to see how well their predictive statements would work. Here are a few examples:

Date	Maximum Temperature	Average Solar Radiation (W/m^2)	Average Wind Speed (mph)	Rain? (Yes/No)	Maximum 8-hr Ozone (ppb)
4/25/12	70.9	195.83	0.4	Yes	49.0
5/25/12	89.2	324.65	3.3	No	57.0
6/25/12	91.8	237.63	3.1	Yes	44.0
7/25/12	88.9	222.26	1.1	No	65.0



EXTENSIONS

If students notice a surprisingly low or high ozone concentration or other interesting occurrences/patterns in the data, encourage them to check the weather and other data for that day to see if they can explain it.

Go to http://www.epa.gov/airtrends/ozone.html to see how ozone air quality has trended in your community over the past 20 years. Point out that drier ozone seasons (2002 and 2007 in North Carolina) tend to have higher ozone concentrations than wetter ozone seasons, in part due to the fact that drier ozone seasons feature more sunny days in tandem with a favorable ozone-producing weather patterns such as high pressure overhead.

Consider analyzing data from your own community for this activity. Here's how:

1. Download Ozone Data

Collect ozone data for each day for the past ozone season for a particular monitoring station (preferably near your school) by going to http://www.epa.gov/airdata. Choose "ozone" under Air Quality Data Analyses, then click on the 8-hour average under "detailed raw ozone data." You want to have at least 20 ozone measurements of 60 ppb and higher per ozone season. Download it in an Excel file.

2. Request weather data from State Climate Office of North Carolina

The "Data Request Form" is located here:
http://www.nc-climate.ncsu.edu/services/request.php

You can specify the name of your city or county, or a particular station. If you want to specify a particular station, click on the link to the interactive map on the data request form. For period of interest, choose April 1-October 31 for the past year. You will not have to pay for data that is used for educational purposes.

3. Organize the data

You will receive your data as an Excel spreadsheet. Electronically cut and paste your ozone data into the spreadsheet. Use the "sort" function in Excel to make it easier to organize the data. First, sort by ozone and put all the ozone measurements of 60 ppb or higher in bold (select the cell and hold down control B or "apple" B). Then, for each graph, sort by the value you are graphing.

RESOURCES

Archived air quality data: http://www.epa.gov/airdata

State Climate Office of North Carolina:
http://www.nc-climate.ncsu.edu/

IT'S OUR AIR

Making a Simple Predictive Model for Ground-Level Ozone

Student Page #1

WORKSHEET FOR MAXIMUM DAILY TEMPERATURE

COMPLETE DATA TABLE

Fill in the following table using the data provided by your teacher:

TABLE 1:
Maximum Daily Temperature vs. Percentage of Days at Code Green and Code Yellow (and Above)

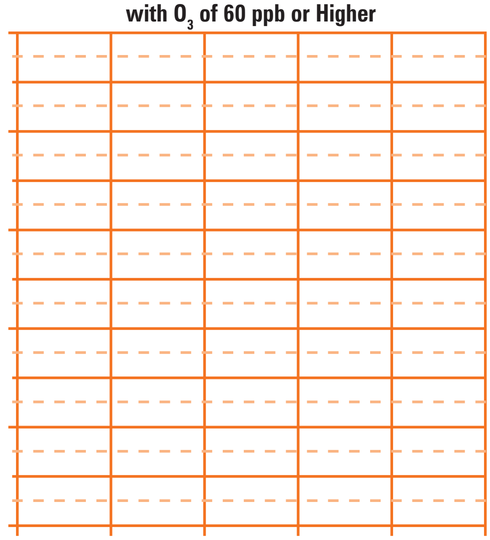
Temperature Range (deg F)	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
50-59					
60-69					
70-79					
80-89					
90 and above					
Add up column to check your math	213	187	26	NA	NA

MAKE A BAR GRAPH

Using the graph template at right, make a bar graph for the data table, showing the percent of days with ozone of 60 ppb or higher (Code Yellow) for each row of the table.

1. Label the y-axis "Percentage of Days with Maximum 8-Hour Ozone of 60 ppb or Higher," and mark it off from 0% to 100% by 10's.
2. Label the x-axis "Maximum Temperature," and mark it off using the data ranges in the first column of your table.
3. Draw a bar representing each row of your data table.

Max Daily Temp vs Days with O_3 of 60 ppb or Higher



IT'S OUR AIR

Making a Simple Predictive Model for Ground-Level Ozone

Student Page #2

WORKSHEET FOR AVERAGE DAILY SOLAR RADIATION

COMPLETE DATA TABLE

Fill in the following table using the data provided by your teacher:

TABLE 2:
Average Daily Solar Radiation vs. Percentage of Days at Code Green and Code Yellow (and Above)

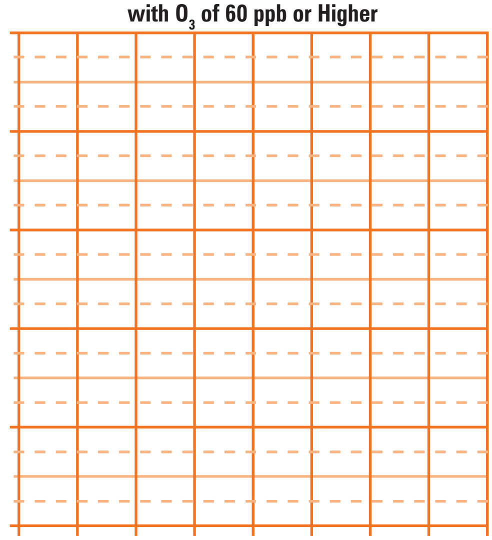
Avg. Solar Radiation in W/m^2	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
0-49.9					
50-99.9					
100-149.9					
150-199.9					
200-249.9					
250-299.9					
300-349.9					
350-399.9					
Add up column to check your math	213	187	26	NA	NA

MAKE A BAR GRAPH

Using the graph template at right, make a bar graph for the data table, showing the percent of days with ozone of 60 ppb or higher (Code Yellow) for each row of the table.

1. Label the y-axis "Percentage of Days with Maximum 8-Hour Ozone of 60 ppb or Higher," and mark it off from 0% to 100% by 10's.
2. Label the x-axis "Average Daily Solar Radiation," and mark it off using the data ranges in the first column of your table.
3. Draw a bar representing each row of your data table.

Average Solar Radiation vs Days with O_3 of 60 ppb or Higher



IT'S OUR AIR

Making a Simple Predictive Model for Ground-Level Ozone

Student Page #3

WORKSHEET FOR AVERAGE DAILY WIND SPEED

COMPLETE DATA TABLE

Fill in the following table using the data provided by your teacher:

TABLE 3:
Average Daily Wind Speed vs. Percentage of Days at Code Green and Code Yellow (and Above)

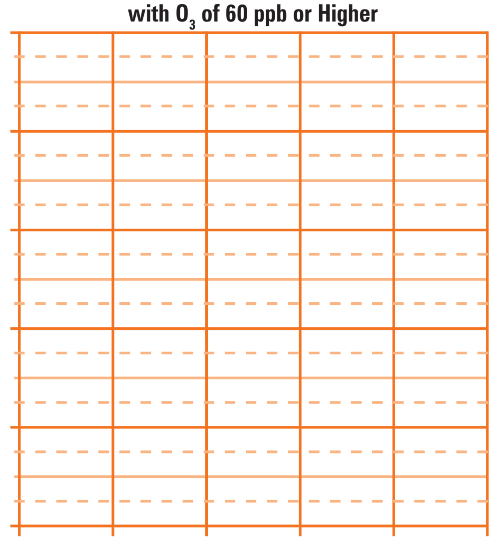
Avg. Wind Speed (mph)	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
0-1.9					
2.0-3.9					
4.0-5.9					
6.0-7.9					
8.0-9.9					
Add up column to check your math	213	187	26	NA	NA

MAKE A BAR GRAPH

Using the graph template at right, make a bar graph for the data table, showing the percent of days with ozone of 60 ppb or higher (Code Yellow) for each row of the table.

1. Label the y-axis "Percentage of Days with Maximum 8-Hour Ozone of 60 ppb or Higher," and mark it off from 0% to 100% by 10's.
2. Label the x-axis "Average Daily Wind Speed," and mark it off using the data ranges in the first column of your table.
3. Draw a bar representing each row of your data table.

Average Daily Wind Speed vs Days with O_3 of 60 ppb or Higher



IT'S OUR AIR

Making a Simple Predictive Model for Ground-Level Ozone

Student Page #4

WORKSHEET FOR DAILY PRECIPITATION

COMPLETE DATA TABLE

Fill in the following table using the data provided by your teacher:

TABLE 4: Daily Precipitation vs. Percentage of Days at Code Green and Code Yellow (and Above)

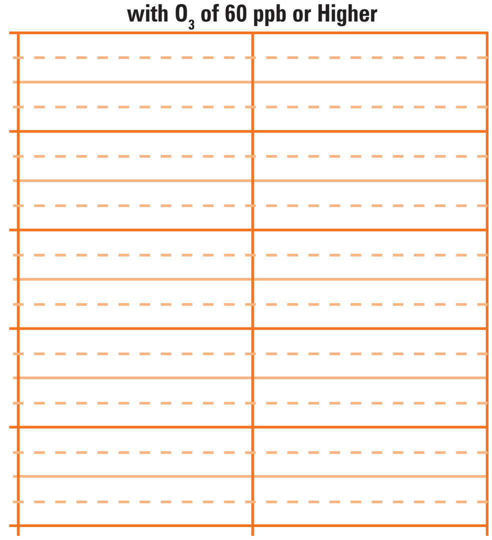
Rain?	Total # of Days	# of Days with Ozone 0-59.9 ppb (Code Green)	# of Days with Ozone 60 ppb or higher (Code Yellow or Above)	% of Total Days that were Code Green (Note: this column and the next should = 100)	% of Total Days that were Code Yellow or Above
No Rain					
Some Rain					
Add up column to check your math	213	187	26	NA	NA

MAKE A BAR GRAPH

Using the graph template at right, make a bar graph for the data table, showing the percent of days with ozone of 60 ppb or higher (Code Yellow) for each row of the table.

1. Label the y-axis "Percentage of Days with Maximum 8-Hour Ozone of 60 ppb or Higher," and mark it off from 0% to 100% by 10's.
2. Label the x-axis "Precipitation," and mark it off using the data ranges in the first column of your table.
3. Draw a bar representing each row of your data table.

Precipitation vs Days with O_3 of 60 ppb or Higher



IT'S OUR AIR

Making a Simple Predictive Model for Ground-Level Ozone

Student Page #5

WORKSHEET FOR FORECASTING OZONE

Forecasting Code Green Days

Refer to the four bar graphs to answer the following questions:

1. What temperature ranges were most commonly associated with Code Green days? Why might this be?
2. What range of wind speeds were most commonly associated with Code Green days? Why might this be?
3. What range of solar radiation were most commonly associated with a Code Green days? Why might this be?
4. Which is more likely to be associated with a Code Green day – a day with rain or a day with no rain? Why might this be?
5. Although the data you have been working with is from the past, see if you can use it to forecast the future. Considering your answers to the above four questions, write a statement that describes a day you would forecast to be Code Green. Explain your reasoning.

Forecasting Code Yellow (and Above)

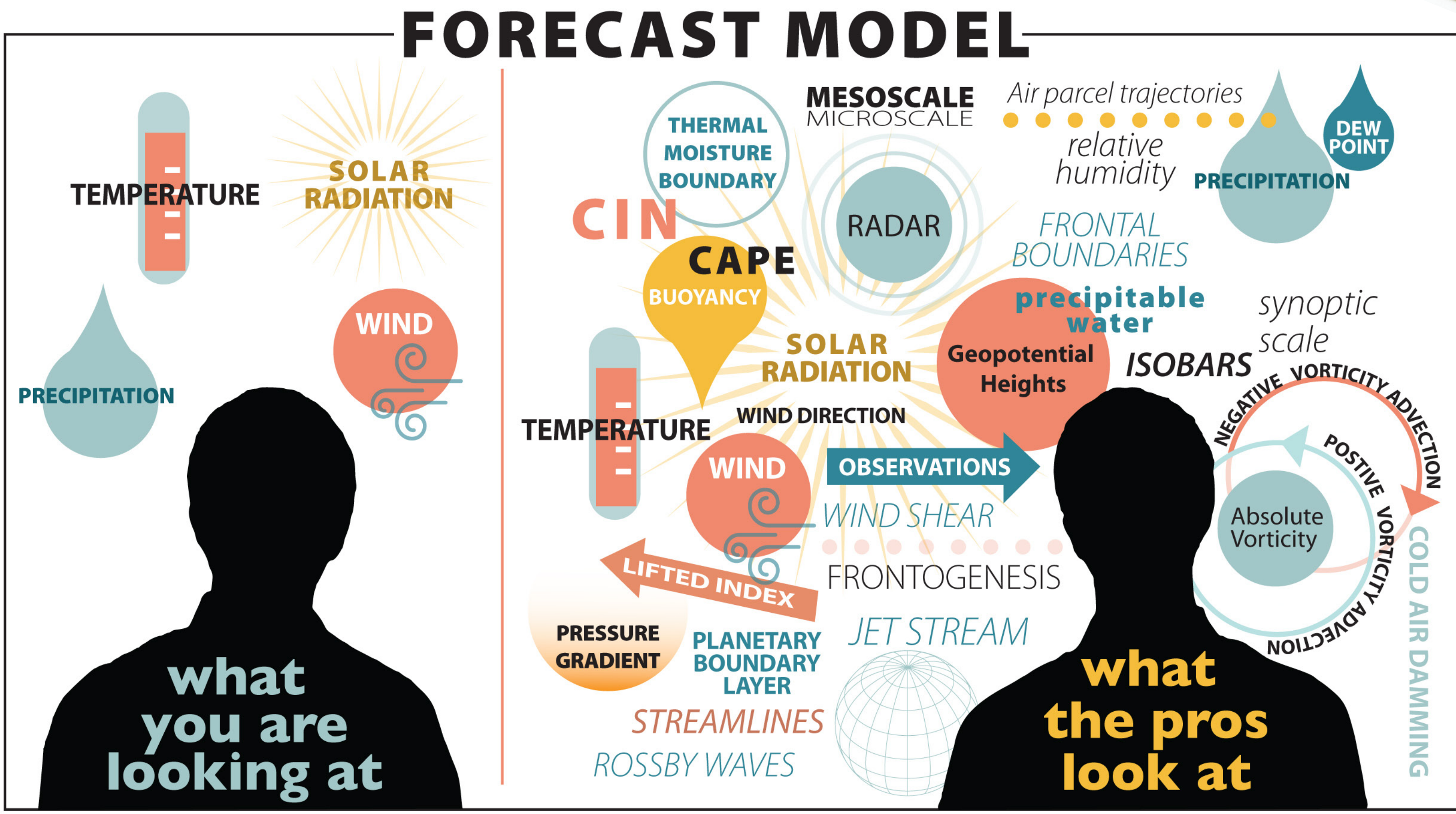
Refer to the four bar graphs to answer the following questions:

1. What range of maximum temperatures is most likely to be associated with a Code Yellow (or above) day? Why might this be?
2. What range of wind speeds is most likely to be associated with a Code Yellow (or above) day? Why might this be?
3. What range of solar radiation is most likely to be associated with a Code Yellow (or above) day? Why might this be?
4. Which is more likely to be associated with a Code Yellow (or above) day – a day with rain or a day with no rain? Why might this be?
5. Although the data you have been working with is from the past, see if you can use it to forecast the future. Considering your answers to the above four questions, write a statement that describes a day you would forecast to be Code Yellow (or above). Explain your reasoning.

What's Missing?

What are some important factors in ozone formation that are not addressed in your predictive statements?

Wrap Up


FORECAST MODEL
TEMPERATURE
SOLAR RADIATION
PRECIPITATION
WIND
what you are looking at
THERMAL MOISTURE BOUNDARY
MESOSCALE
MICROSCALE
Air parcel trajectories
relative humidity
PRECIPITATION
DEW POINT
CIN
RADAR
FRONTAL BOUNDARIES
CAPE
BUOYANCY
precipitable water
synoptic scale
SOLAR RADIATION
Geopotential Heights
ISOBARS
TEMPERATURE
WIND DIRECTION
NEGATIVE VORTICITY ADVECTION
WIND
OBSERVATIONS
POSTIVE VORTICITY ADVECTION
Absolute Vorticity
WIND SHEAR
LIFTED INDEX
FRONTOGENESIS
COLD AIR DAMMING
PRESSURE GRADIENT
PLANETARY BOUNDARY LAYER
JET STREAM
STREAMLINES
ROSSBY WAVES
what the pros look at