# Weather and Climate Variability Toolkit

USDA United States Department of Agriculture
National Institute of Food and Agriculture

Southeast Climate EXTENSION | Advancing Climate Extension in Agriculture

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# INTRODUCTION

The 4-H Weather and Climate Variability Toolkit is a collaborative effort between the Florida 4-H Program and the Southeastern Climate Consortium. This curriculum is the outreach education portion of a USDA grant titled "Climate Change to Climate Variability" and was developed to help address the well-documented need for science literacy education for United States youth as well as the need to increase climate literacy.

The objectives of this curriculum include the following:

1. Increase basic knowledge and understanding of weather and climate.
2. Increase awareness about careers related to the fields of weather and climate.
3. Improve attitudes and aspirations towards careers in science in general, and weather and climate specifically.
4. Increase ability to discern reliable sources of information on controversial topics (such as climate) from more unreliable or more biased sources of information.
5. Engage youth in experiential and inquiry-based activities while teaching subject matter related to weather and climate variability.

**Content**

- Science and technology content based on the National Science Education Standards and science, technology, social studies and mathematics content from Florida's Next Generation Sunshine State Standards
- 4-H Science Abilities (30 skills and abilities essential for scientific literacy)

**Context**

- The Essential Elements of Positive Youth Development, fundamental to 4-H
    - Mastering life challenges
    - Cultivating independence
    - Developing a sense of belonging within a group
    - Sharing a spirit of generosity toward others
- Reliance on trained, caring adult staff and volunteers as mentors, coaches, and facilitators.
- Perspective that youth are partners and resources in their own development
- Inquiry-based, hands-on, experiential approach to learning

## Delivery

These lessons are designed for multiple delivery modes, including club, classroom, afterschool, or camp settings. Throughout this curriculum, youth are encouraged to make connections to careers related to the fields of weather and climate.

The target audience for this curriculum is eight to twelve year olds (upper elementary school age). Resent research has shown that an $8^{th}$ grader's career aspirations are a more significant predictor of a youth's likelihood of pursuing a science degree than is academic performance in math and science.

This age group has unique learning characteristics with specific implications for facilitators. The following table lists some of these characteristics, but remember that not all characteristics will be observed in all youth at the same age. This information is provided to help you as you begin working with this age group.

| **General Characteristics of 8-12 year olds** | **Prompts for Facilitators** |
|---|---|
| Restless and active, with periods of fatigue | Emphasize active learning; provide time for processing and reflection |
| Like group activities | Emphasize group learning experiences and support a sense of belonging |
| Interested in sports and active games | Encourage fun and active learning experiences (limit lecture) |
| Need guidance from adults to stay on task in order to achieve best performance; desire to be independent, but still want and need parent's help (even if they don't admit it) | Work closely with youth to mentor and foster a sense of leadership and to provide a positive role model for learning and fun |
| Admire and imitate older boys and girls | Utilize teen leaders to help facilitate and serve as positive role models |
| Have interests that can change rapidly, jumping from one thing to another | Plan a variety of experiences during a single meeting or lesson. Use the activities as a main theme for the entire meeting or lesson and try to relate all the activities back to that theme to help embed the concepts taught |
| Beginning to think about what they want to do when they grow up | Provide plenty of examples of potential career opportunities during learning. Help them make the connection between careers that are available, and what the requirements are in order for them to pursue that career |
| Self-conscious and sensitive | Focus on developing individual strengths and provide opportunities for them to use their abilities and interests |
| Curious | Encourage questions and serve as a resource. Help them find answers in the library and online |
| Prefer to be in groups similar to themselves | Encourage the importance of similarities but also the value of differences within groups; relate how working with different people is important to their future career and personal lives |

## Facilitator Tips

*Think Safety*. Promote an environment that is inclusive where youth feel safe to have a voice and openly share ideas and questions. Remember to also account for physical safety issues including fire exits and traffic flow in the room. Provide plenty of space for group activities.

*Be Prepared*. Read through each lesson in advance and make sure you have all of the necessary supplies. Visuals are also important, and move outside whenever possible. If the space allows, designate a wall or white board as a "Wonder Wall." This wall is a place to write down questions, terms, and concepts as youth discover them. Any questions left at the end of the lesson can become homework for the next session.

*Provide Consistent Expectations for Behavior*. Practice active listening and model good communication by making eye contact and speaking clearly. Set ground rules and expectations for behavior at the beginning of the session.

*Engage Youth*. Youth learn best when they are actively engaged. Take advantage of their natural curiosity to explore new science concepts and terms. Remember that if you show enthusiasm, they will be more likely to mirror that enthusiasm.

*Develop Scientists*. Use scientific terms, such as "test, prediction, and record," as often as possible. Remind youth that science is part of our everyday lives.

*Limit Your Talking*. 4-H is about learning-by-doing. Alternate instruction with hands-on activity; a good rule of thumb is one hands-on activity for every 10 minutes of talking.

*Encourage Career Exploration*. Use every opportunity to make connections to careers related to weather and climate.

*Be Relevant*. Help youth make the connection between what they are learning and how it relates to the real world. The processing questions at the end of each lesson can help make those connections. Make sure you leave enough time to process each lesson.

This curriculum uses the Experiential Learning Model. 4-H Youth Development relies heavily upon the five steps of the experiential learning model to teach life skills. The sequential steps of the model help youth to identify what they have learned from a 4-H experience or activity and to apply that learning to other experiences or situations. The experiential learning process engages the learners in all phases of the activity, resulting in the ability to generalize this learning to new situations. The experiential learning model by Kolb (1984) and modified by 4-H includes five specific steps:

1. Participant(s) **experience** the activity--perform or do it.
2. Participant(s) **share** the experience by describing what happened.
3. Participant(s) **process** the experience to determine what was most important and identify common themes.
4. Participant(s) **generalize** from the experience and relate it to their daily lives.
5. Participant(s) **apply** what they learned to a new situation

When this model is used, youth both experience and process the activity. They learn from thoughts and ideas about the experience. Each step contributes to their learning.

Providing an experience alone does not create experiential learning. Experiences lead to learning if the participant understands what happened, sees patterns of observations, generalizes from those observations, and understands how to use the generalization again in a new situation. Advantages for facilitators using the experiential learning process in group settings include

- being able to assess youth's knowledge of or experiences with a subject and building upon it,
- serving as a coach using a variety of methods to involve youth in the experience, and
- learning together with youth in a cooperative way.

Benefits for youth participating in the experiential learning process, no matter what their individual learning style, include

- learning from each other by sharing knowledge and skills;
- working together, sharing information, and evaluating themselves and others;
- taking responsibility for their own learning, and
- relating experiences to their own lives.

**Getting Started**

The activity titled "Weather or Not," is a great way to introduce the topic of weather and climate variability. Print the weather terms and weather definitions on heavy paper or card stock. Distribute the weather terms cards to half the group. Distribute the weather definition cards to the other half. Ask the two groups to find their "matches" and introduce themselves. The materials for this activity are found in the appendices.

Southeast Climate
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**Project Skills**
Following directions

**Life Skills**
Learning to Learn, Critical Thinking, Problem Solving, Communicating

**Academic Standards**
SC.4.N.1.2; SC.4.L.17.4; SS.4.G.1.3; MA.5.A.4.1; SC.5.E.7.3; SC.5.E.7.5; SC.5.E.7.6; SS.5.G.4.2; SC.6.N.1.4 SE.6.E.7.6

**Grade Level(s):** 4-6

**Time**
To complete all the challenges, you will need approximately 5 hours. Challenge #3 (Cloud Journal) is a long-term activity that may be completed over the course of several weeks or months.

**Supplies Needed**
***Challenge #1***

- Straws
- Modeling clay
- Glass bottle
- Water
- Food coloring
- Empty 2-liter bottle
- Rocks
- Ruler
- Permanent marker
- Empty plastic jug
- Thermometers
- Gauze
- Rubber bands
- Protractor
- Ping pong balls
- Fishing line

# Unit 1 | How Do Scientists Measure and Study Weather?

**BACKGROUND**

*Weather* consists of short-term (minutes to days) variations in the atmosphere such as temperature, humidity, air pressure, cloudiness, precipitation, and wind. *Climate* is the distribution of weather over longer periods, such as months or years. Scientists record measurements of weather, which are called *observations*, on hourly, daily, monthly, annual, and decadal time scales. They look for sustained patterns in these weather observations (such as increase or decrease in temperature) over a minimum of 30 years to identify variations in climate. Before learning about climate, youth need to have a basic understanding of weather phenomena and some of the instruments that scientists use to measure and study weather.

**INTRODUCTION**

Ask the group, "How do scientists measure and study weather?" Record their answers on a flipchart or whiteboard. "Today, we are going to complete some challenges to learn about how scientists measure and study weather. Are you up for the challenges?"

**WHAT TO DO**

***Challenge #1*: *Measure and Observe the Weather***

Divide the youth into four groups and give each group a weather instrument. Ask the group members to share what they think the instrument is used to measure and how the measurement is taken. Allow them to share their predictions with the rest of the youth and then talk about the purpose of the instrument and demonstrate its proper use. Ask each group to take a measurement with the instrument and record what was measured and the measurement on a flipchart or whiteboard.

**Supplies Needed**

- Psychrometer
- Rain gauge
- Anemometer

***Challenge #2***

- Station images
- Where Should We Put Our Weather Station? worksheets
- Google image of camp location **or** location where this lesson is taught

***Challenge #3***

- Cloud Journal worksheets

***Challenge #4***

- Weather Map Symbols Guide
- Reading a Weather Map worksheets

***Challenge #5***

- Team Hurricane worksheets
- Team Tornado worksheets
- Access to the Internet

*Manufacture Your Own Weather Instruments*

You will find instructional resources for building a psychrometer, an anemometer, a rain gauge, and a thermometer under "Additional Resources" in the Unit 1 appendix. Instruct each group to build a different weather instrument than the one they worked with in Challenge #1. Ask them to take a measurement, record it on the flipchart or whiteboard, and then compare this measurement to the measurement taken earlier with the store-bought instrument. Are the measurements similar? Which is more accurate?

*Add Inquiry:* Design an experiment to test which weather instruments are more accurate. Teams can compare their store-bought and homemade instrument readings with readings available from FAWN, the Florida Automated Weather Network, at http://fawn.ifas.ufl.edu/. FAWN weather stations, which are located all over Florida, take hourly measurements and report them into the FAWN database. Many meteorologists and agriculture industry professionals use this network to accurately predict and monitor the weather.

***Challenge #2: Where Should We Put Our Weather Station?***

Ask the youth, "What are the best areas to place a weather station?" Record their answers and provide additional details if necessary. Divide the youth into groups and give each group a set of station images and a worksheet. The youth will examine the images and answer the questions on the first page of the worksheet. Lead a group discussion of their findings and reach consensus on the ranking of each station's location. Next, have the groups answer the questions on the second page of the worksheet and discuss their conclusions. Distribute the Google image of the appropriate camp (or wherever you are teaching this lesson, such as an extension office, park, school, or community center) and ask the groups to identify the two best possible locations for a weather station. Optional: have the youth go outside (with an adult) to select their top two locations for a weather station at your site.

The worksheets for this activity and the Google images of the camps are located in the Unit 1 appendix.

***Note:*** *If you choose to use a Google image of your teaching location, you must provide that image.*

***Challenge #3: Cloud Journal***

Clouds form when air rises. As the air rises, the pressure reduces, causing the air to expand and cool. When air rises, the air's temperature cools and may reach its *dewpoint temperature*, at which point it becomes saturated. Condensation occurs and the water vapor in the air condenses into tiny water droplets. As millions of droplets form, a cloud begins to take shape.

Ask the youth "What do you know about clouds?" Record their answers and provide more detail if necessary. Ask them if they are familiar with different types of clouds. Explain that they will be making and recording observations about clouds over the next several days/weeks/months. Distribute the Cloud Journal worksheets to the youth (one set to each person). The youth will record the location, date, and time they observe each type of cloud. This is a long-term assignment that engages the youth in the scientific practice of making and recording observations. They may compare their observations with those of other youth at predetermined intervals. Which clouds are the most common in Florida? Which clouds are the rarest? What time of year did they observe the various types of clouds? See "Additional Resources" in the Unit 1 appendix for a cloud ID chart.

The worksheets for this activity are located in the Unit 1 appendix.

***Challenge #4: Reading a Weather Map***

Meteorologists use symbols on surface weather maps to convey information about weather observations at a particular point in time. Some symbols represent precipitation; others represent the speed and direction of the wind, air temperature, air pressure, or fronts, among other observations. The weather maps in newspapers or on television weather forecasts are simplified versions of these surface maps. See "Additional Resources" in the Unit 1 appendix for background information on air masses and fronts.

Divide the youth into pairs and distribute the Weather Map Symbols Guide and the Reading a Weather Map worksheets to each pair. The youth will first examine the weather map for January 12, 2010, and answer the questions, using the symbols guide to help them interpret the information on the map. Lead a group discussion of their answers. Next, have the groups answer the questions on the weather map for June 26, 2012, the Tropical Storm Debby map, again using the symbols guide, and then lead a discussion of their answers.

The materials for this activity are located in the Unit 1 appendix.

***Challenge #5: Severe Storm Fact Tracker***

***Note:*** *It is recommended that before taking on this challenge, youth complete the "Fact and Opinion" activity and the "Evaluating Sources" activity in Unit 2. These activities will provide background for vetting and using information the youth find on the Internet.*

Print and cut out the "Weird but True" facts about storms. Ask for volunteers to read each description. Explain to the youth that because there are some really weird but true stories about storms, it is often hard to discern myth from fact. Divide the youth into two groups: Team Tornado and Team Hurricane, and divide each of those teams into two subgroups: the Fact Trackers and the M & M Busters. The Fact Trackers will answer the questions on the first and second pages of the worksheet, and the M & M Busters will "bust" the myths and misconceptions on the third page.

Distribute copies of the appropriate pages of the worksheets (Team Tornado or Team Hurricane) to each subgroup. Divide the question categories (e.g., formation, scale, occurrences) on the first page of the worksheet between the members of the Fact Trackers. They will individually search for the answers on the Internet and also identify the source(s) of their information. Divide the myths and misconceptions between the members of the M& M Busters and have them individually search for information on the Internet that disproves the statements. All subgroups will present their findings to the entire group.

See "Additional Resources" in the Unit 1 appendix for vetted sites for severe storm information. Youth may identify other sites as well.

The materials for this activity are located in the Unit 1 appendix.

**TALK IT OVER**

Sharing

- What surprised you most about these experiments and activities?

Processing

- What problems did you have with the instruments?
- What did you learn about weather that you didn't know before?

Generalizing

- How will learning about weather benefit you in the future?

Applying

- How would you teach someone else about what you learned today?
- Describe a time or situation when you might need to use what you learned today.
- What would you do differently if you did these experiments or activities again?

# Unit 2 | How Do You Become Climate Wise?

**Project Skills**
Following directions

**Life Skills**
Learning to Learn, Critical Thinking, Problem Solving, Communicating

**Academic Standards**
SC.4.N.1.8; SS.4.G.1.3; SC.5.N.1.6; SC.6.N.3.1; SC.6.E.7.6

**Grade Level(s) :** 4-6

**Time:** 1 hour

**Supplies Needed**
***Challenge #1***
- Fact or Opinion Cards

***Challenge #2***
- Super Science-Source Sleuth worksheets and screenshots

***Challenge #3***
- Weather or Climate cards

**BACKGROUND**

To become climate wise, youth need to know that although scientists may agree on the facts, they often disagree on how to interpret those facts. Youth also need to know that many conflicting opinions are presented in the media. To achieve an objective understanding of climate and climate variability, youth need to know how to differentiate between facts and opinions and how to identify credible sources of information. Another element of being climate wise is knowing the difference between a weather event and climate.

A scientific fact is a generally accepted reality (but still open to scientific inquiry); acceptance is based on replication, publication in an accredited journal, and peer review. Scientific facts are verifiable. An opinion is a belief, inference, interpretation, generalization, or judgment. Many common misconceptions are opinions. Opinions cannot be proven. Opinions are arguable. Both fact and opinion can be based on verifiable data; the interpretation must be evaluated as fact or opinion.

- Scientific writing is not necessarily objective.
- Like everyone else, scientists have opinions.
- Opinion is sometimes stated as fact.
- Hypotheses are not facts. (Some "theories" are actually hypotheses.)
- There is a difference between a personal theory and a scientific theory. A scientific theory is a tested, well-supported, and widely accepted explanation of nature; it is not simply a claim posed by an individual.
- "Facts" and opinions can be influenced by politics, sociology, and psychology.

## INTRODUCTION

Ask the group, "How do we know if a statement about climate is a scientific fact or someone's opinion? How do we tell whether a source of information can be trusted?" Record their answers on a flipchart or whiteboard. "Today, we are going to complete some challenges to learn how you can become climate wise. To be climate wise, you need to know how to be a detective to determine what is a scientific fact and what is an opinion. Are you up for the challenges?"

## WHAT TO DO

### *Challenge #1: Fact or Opinion?*

Instructions for this activity are included in the Unit 2 appendix. This activity is used with permission from ASK FL (Advancing Student Knowledge Through Teacher Education), a project of the University of South Florida Coalition for Science Literacy (CSL) and The Florida State University Center for Ocean-Atmosphere Prediction Studies (COAPS), funded by NASA for 3 years beginning April 15, 2010.

**Examples of Opinion Clues**

| Generalizations | Judgments | Must Be Proven |
|---|---|---|
| all | bad | is caused by |
| always | good | is responsible for |
| every | likely | results in |
| entire(ly) | unlikely | |
| only | significant (nonstatistical use) | |
| never | | |

***Note:*** *These words are clues—signals to the reader to be cautious. What appears to be a statement of fact may instead be a statement of opinion. Unfortunately, sometimes an extensive knowledge of climate science is needed to distinguish fact from opinion.*

### *Challenge #2: Evaluating Sources*

We know that not all information appearing in the media is factual and reliable. The same is true of "scientific sites" on the Internet. Every site has an agenda (e.g., to inform, to persuade, to present a point of view, to rally support, to create or change an attitude or belief), so it is up to the reader to determine the credibility of the site. Although most scientists agree on the facts related to climate change, they might not agree on how to interpret those facts, on what those facts could mean, or on which facts to present to the public. To become "climate literate," we must know how to "assess scientifically credible information about climate."

*Examples of Evaluation Criteria*

- Accuracy
- Authenticity
- Authority
- Currency/Timeliness
- Objectivity
- Presentation
- Reliability
- Usefulness/Relevance

Instructions for this activity are included in the Unit 2 appendix. This activity is used with permission from ASK FL (Advancing Student Knowledge Through Teacher Education), a project of the University of South Florida Coalition for Science Literacy (CSL) and The Florida State University Center for Ocean-Atmosphere Prediction Studies (COAPS), funded by NASA for 3 years beginning April 15, 2010.

### *Challenge #3: Weather vs. Climate*

The instructions and cards for this activity are included in the Unit 2 appendix. This activity is used with permission from ASK FL (Advancing Student Knowledge Through Teacher Education), a project of the University of South Florida Coalition for Science Literacy (CSL) and The Florida State University Center for Ocean-Atmosphere Prediction Studies (COAPS), funded by NASA for 3 years beginning April 15, 2010.

### TALK IT OVER

<u>Sharing</u>

- What surprised you most about these activities?

<u>Processing</u>

- What problems did you have with the activities?
- What did you learn about evaluating information that you didn't know before?

<u>Generalizing</u>

- How will learning about evaluating information benefit you in the future?

<u>Applying</u>

- How would you teach someone else about what you learned today?
- Describe a time or situation when you might need to use what you learned today.

**Project Skills:**
Following directions

**Life Skills:**
Learning to Learn, Critical Thinking, Problem Solving, Communicating

**Academic Standards**
SC.4.N.1.3; SC.4.N.1.7; SC.4.N.3.1; SC.4.P.8.1; SS.4.G.1.3; SC.5.E.7.5; SS.5.G.4.2; SC.6.N.3.4; SC.6.E.6.2; SC.6.E.7.1; SC.6.E.7.3; SC.6.E.7.4; SC.6.E.7.5; SC.6.E.7.6; SS.6.G.1.2

**Grade Level(s):** 4-6

**Time:** 3-4 hours

**Supplies Needed**

***Challenge #1***

- Rock core models
  - Light cover
  - Sand
  - Gravel
  - Colored glass beads
- Flags
- Magnifying glasses
- Sheets of paper
- Craft sticks
- Dendrochronology slips

***Challenge #2***

- ENSO Posters
- Clear plastic oblong container (18 x 4 x 4 in.)
- Water
- Mineral oil
- Blue food coloring
- Hair dryer
- Red oil-based paint (optional)
- Pacific Ocean map

***Supplemental Activity***

- Climate Explorers worksheet
- Access to the Internet

# UNIT 3 | How Do Scientists Study Climate and Climate Variability?

## BACKGROUND

*Climate* is the distribution of weather over longer periods, such as months or years. Scientists record measurements of weather, which are called observations, on hourly, daily, monthly, annual, and decadal time scales. They look for sustained patterns in these weather observations (such as increase or decrease in temperature) over a minimum of 30 years to identify variations in climate. To understand climate and climate variability, youth need to know how scientists look for clues about climate.

## INTRODUCTION

Ask the group, "How do scientists study climate and climate variability?" Record their answers on a flipchart or whiteboard. "Today, we are going to complete some challenges to learn about how scientists study climate and climate variability. Are you up for the challenge?"

## WHAT TO DO

### *Challenge #1: Clues About Climate*

Ask the youth, "What kinds of clues do scientists look for to learn about climate?" Record their responses, then tell them that they are all climatologists today. Scientists study rock, ice, and tree cores (or tree rings) to find clues about climate. Divide the youth into teams of three or four and give half of the teams rock core kits and the other half tree core kits. Follow the instructions below for the rock core kits and on the instruction sheet for the tree core kits; if time permits, ask the groups to switch kits. If time is short, allow the youth to share what they did and what they discovered.

*Dead Diatoms Do Tell Tales!*

Instructions for this activity are located within the Antarctica's Climate Secrets Flexhibit Lesson Plans, Activity 4A found in the Unit 3 appendix of this toolkit and are used with permission from ANDRILL's education coordinator. See "Additional Resources" in the Unit 3 appendix for information on obtaining the entire ANDRILL document.

*Tree Core Codes*

Ask the group, "Why might scientists study trees to find clues about climate?" and record their responses. Trees contain some of nature's most accurate evidence of the past. Their growth layers, appearing as rings in the cross section of the tree trunk, record evidence of floods, droughts, insect attacks, lightning strikes, and even earthquakes. Each year a tree adds new growth, called a tree ring, to its girth. A tree ring has two layers: a light-colored layer that is formed in the spring, and a dark-colored ring that is formed in the late summer. Tree growth depends upon local conditions such as water availability. Because the amount of water available to the tree varies from year to year, scientists can use tree ring patterns to reconstruct regional patterns of drought and climate variability. This field of study is known as *dendrochronology.*

During wet, cool years, most trees grow more, making the rings wider. During hot or drought years, rings are narrower. Modern dendrochronologists seldom cut down a tree to study its rings. Instead, they use a borer to extract a tree core.

Instructions for this activity are found in the Unit 3 appendix.

### *Challenge #2: Make Your Own El Niño in the Classroom*

*Climate Variability* - Changes can occur simultaneously over a wide variety of time scales (e.g., annual, interannual, multidecadal, and longer). Variations in climate modify the likelihood of different types of weather occurring, and the changes are likely to be different from region to region. It is important to understand that Earth's climate does not depend on the average of weather events, but instead depends on the likelihood of each type of weather. Therefore, it is useful to think of climate as the likelihood of each type of weather, which in turn brings us back to the concept of climate being the distribution of different types of weather.

Natural climate variations exist as part of the atmosphere, hydrosphere (water), geosphere (land surface), and cryosphere (ice) system. *Climate variability* is defined as the temporal variations of the atmosphere-hydrosphere-cryosphere-land surface system around a mean state (adapted from American Meteorological Society 2000). One well-known climate variation is *El Niño.* El Niño typically occurs over a period of 10 to 12 months before the ocean state either returns to a more average condition or changes further to a condition known as *La Niña.* El Niño and La Niña occur on an *interannual* time scale. Other natural climate variations occur on *multidecadal* (e.g., ocean cycling of heat) or even geologic time scales (e.g., ice ages). Natural climate variations can also occur on shorter time scales. One example is the *North Atlantic Oscillation*, which is a measure of the pressure difference between the Azores and Iceland. This oscillation alters the north-south pressure gradient over the North Atlantic Ocean, altering the strength and motion of wintertime storms off the northeast United States and tropical cyclones during the annual Atlantic hurricane season. The *El Niño–Southern Oscillation*, or ENSO, is the interannual variation in sea surface temperatures in the equatorial Pacific. ENSO has three phases: cold (El Niño), warm (La Niña), and neutral.

Before conducting the activity, display the ENSO posters and ask the youth what differences they see between El Niño and La Niña for each of the four seasons. What conditions are present on the

West Coast of the United States during El Niño and La Niña during each of the seasons? On the East Coast? In Florida?

The ENSO posters are included in the Unit 3 appendix of this toolkit.

How to display the posters:

Attach posters to the wall in the following order so that the seasons are side by side for comparison:

| | |
|---|---|
| El Niño Fall | La Niña Fall |
| El Niño Winter | La Niña Winter |
| El Niño Spring | La Niña Spring |
| El Niño Summer | La Niña Summer |

These maps are general representations of conditions during El Niño and La Niña. See "Additional Resources" in the Unit 3 appendix for more specific information.

Instructions for the "Make Your Own El Niño in the Classroom" activity, which is adapted from a NASA's Jet Propulsion Laboratory activity, are included in the Unit 3 appendix of this toolkit.

***Supplemental Activity: Climate Explorer***

Youth with access to the Internet can log on to the the AgroClimate website, an interactive website used by state climatologists, the agricultural industry, the forestry industry, and others interested in information about ENSO impacts on Florida's seasonal climate. The activity can be completed individually or with a partner; the worksheet leads the youth through the availabe options and introduces them to a wide range of information.

The worksheet can be found in the Unit 3 appendix.

**TALK IT OVER**

Sharing

- What surprised you most about these activities?
- What was the most difficult climate concept that you had to learn?
- Did you enjoy looking for climate clues?

Processing

- What problems did you have with the activities?
- What did you learn about climate that you didn't know before?

Generalizing

- How will learning about climate benefit you in the future?

Applying

- How would you teach someone else about what you learned today?
- Describe a time or situation when you might need to use what you learned today.
- What would you do differently if you did these activities again?

**Project Skills:**
Following directions

**Life Skills:**
Learning to Learn, Critical Thinking, Problem Solving, Communicating

**Academic Standards:**
SC.4.N.1.5; SC.4.N.3.1; SC.4.L.17.4; SS.4.G.1.3; MA.5.A.4.1; SC.5.E.7.3; SC.5.E.7.5; SC.6.N.1.4; SC.6.N.3.4; SC.6.E.6.1

**Grade Level(s):** 4-6

**Time:** 2-3 hours

**Supplies Needed**

***Challenge #1***

- Paper cups
- Scissors
- Bowl
- Sugar cubes
- Sand
- Food coloring
- Water

***Challenge #2***

- Outdoor thermometers

***Challenge #3***

- Red and blue markers
- July 4 Temperature and Precipitation Data
- Temperature and Precipitation Graphs
- Holiday Climatology Instructions

***Alternative Activity***

- Red and blue markers
- Birthday Climatology Instructions
- Birthday Climatology Temperature and Precipitation Graphs
- Access to the Internet

# Unit 4 | How Do Human Activities and Climate Interact?

**BACKGROUND**

*Climate* is the distribution of weather over longer periods, such as months or years. Scientists record measurements of weather, which are called *observations*, on hourly, daily, monthly, annual, and decadal time scales. They look for sustained patterns in these weather observations (such as increase or decrease in temperature) over a minimum of 30 years to identify variations in climate. Scientists study these variations in an attempt to understand the interaction of human activities and climate. This lesson will explore these interactions.

**INTRODUCTION**

Ask the group, "How do humans impact climate? How does climate impact humans?" Record their answers on a flipchart or whiteboard. "Today, we are going to complete some challenges to learn about how humans interact with climate. Are you up for the challenges?"

**WHAT TO DO**

***Challenge #1: Paper Cup Sinkhole***

Ask the youth, "What do you know about sinkholes? What causes sinkholes? What do sinkholes have to do with climate?" Record their responses. "We are going to make a model of a sinkhole to learn how they are formed."

Divide the youth into groups of four and give each group a paper cup and a pair of scissors. Make a hole in the bottom of the paper cup. Place the cup in a container (such as a cereal bowl). Place sugar cubes (simulating limestone) in the bottom of the cup. Cover the cubes with sand or soil. Fill the container that the cup is sitting in with colored water (simulating groundwater). Allow the cup to sit for 5 minutes and observe what happens (you may need to remove the cup after 5 minutes). The sugar cubes should begin to dissolve, forming a miniature sinkhole.

*Sinkholes* are natural formations found in areas where the underlying carbonate rocks can be dissolved by the circulation of groundwater. They are frequently found in areas of Florida where limestone is the underlying rock layer. Sinkhole formation is affected by changes in the level of groundwater, the composition of the water, and the type and depth of sediment on top of the limestone. Some types of sinkholes start developing a long time before the hole appears. Others occur more rapidly. Both natural environmental changes and human activities can influence sinkhole formation. Sea level changes could result in seawater infiltrating the groundwater. The salinity and acidity of the seawater could cause the underlying limestone to dissolve. During droughts, the groundwater level decreases. Both of these developments could affect the formation of sinkholes because the water supporting the upper layers of earth disappears and these layers sink into the holes that were created. These changes are related to climate. Changes to the landscape by humans, such as those resulting from drilling, pumping groundwater, loading water onto the surface, construction, mining, or even heavy traffic, can increase sinkhole formation rate and severity.

Sinkholes can be dangerous. They can be a safety concern for people and a threat to the foundations of buildings. Toxic materials can enter through sinkholes and pollute the groundwater. Sinkholes can appear suddenly, with no warning, and they can cause extensive damage.

### *Challenge #2: Heat Island Effect*

Ask the group, "What do you know about *heat islands*?" Record their responses. As urban areas develop, changes occur to the landscape. Buildings, roads, and other structures replace open land and vegetation. Surfaces that were once permeable and moist become impermeable and dry. These changes cause urban regions to become warmer than their rural surroundings, forming an "island" of higher temperatures in the landscape.

Heat islands occur on the surface and in the atmosphere. On a hot, sunny summer day, the sun can heat dry, exposed urban surfaces, such as roofs and pavement, to temperatures 50–90°F (27–50°C) hotter than the air, while the temperatures of shaded or moist surfaces—often in more rural surroundings—remain close to air temperatures. Surface urban heat islands are typically present day and night, but tend to be strongest during the day when the sun is shining.

Divide youth into groups of four or five and ask them to design an investigation to determine whether there are any heat islands at camp. Ask them to take temperature readings at several locations and record their measurements to see whether there are differences in temperature. Allow 10-15 minutes for the groups to make their measurements and then ask them to share their findings. Next, ask each group to brainstorm three strategies for mitigating the heat island effect at the camp. Examples include planting a shade tree in the parking lot, replacing pavement with ground cover or mulch, etc. Ask them to share their ideas.

### *Challenge #3: Holiday Climatology*

Climatologists create graphs (*climatologies*) using weather observations that have been collected over long periods of time (at least 30 years). The observations are collected from land-based weather stations, ships, buoys, and satellites passing over the Earth. Climatologists study these graphs to identify what are known as trends in the weather patterns. A *trend* is a long-term movement in a series of data points. Trends can go up or down, or move very little.

Tell the youth that they will create their own climatology graphs for July 4th (Independence Day). Divide the large group into three smaller groups and give each group a copy of the July 4 Temperature and Precipitation Data for Miami, Orlando, or Tallahassee. Also, give each group a copy of the Temperature and Precipitation Graphs and the Holiday Climatology worksheet. Explain or review how to read a bar graph (title, *x*-axis, *y*-axis, information in the bar itself) and the purpose of a bar graph (to compare data).

Ask the large group the following questions:

- Why might climatologists create temperature and precipitation graphs?
- What information might you learn from the temperature and precipitation graphs?

Direct the groups to follow the instructions, using the data sheet to find the information to create their bar graphs for their specific location. After the groups complete their graphs and answer the questions, discuss their findings in a large group. Record their answers on a whiteboard or flip chart. Determine if there are any similarities in the answers (greatest/smallest amount of rainfall in the same year, highest/lowest temperatures in the same year) across the locations.

The July 4th Temperature and Precipitation Data, the July 4th Temperature and Precipitation Graphs, and the Holiday Climatology worksheet can be found in the Unit 4 appendix.

***Alternative Activity: Birthday Climatology***

If youth have access to the Internet, they can create a Birthday Climatology for their birth date.

Tell the youth that they will create their own climatology graphs for their birthdays. Distribute the Birthday Climatology worksheet and the Birthday Climatology Temperature and Precipitation Graphs to each person. Everyone will receive the same precipitation graph. Distribute the min and max temperature graphs according to the following system: “Winter” to those having birthdays in December, January, and February; “Spring” to those having birthdays in March, April, and May; “Summer” to those having birthdays in June, July, and August; and “Fall” to those having birthdays in September, October, or November.

Explain or review how to read a bar graph (title, *x*-axis, *y*-axis, information in the bar itself) and the purpose of a bar graph (to compare data).

Ask the large group the following questions:

- Why might climatologists create temperature and precipitation graphs?
- What information might you learn from the temperature and precipitation graphs?

Direct the youth to follow the instructions, using the Activity Planner data tool to find the information to create their bar graphs for their specific locations. Note that the graphs cover the period from 2000 to 2012, so to complete the graphs, the youth will choose the “Last 10 Years” option under “How far do you want to go back?” on the website. After the youth complete their graphs and answer the questions, discuss their findings in a large group. Record their answers on a whiteboard or flip chart. Determine if there are any similarities in the answers (greatest/smallest amount of rainfall in the same year, highest/lowest temperatures in the same year) across the locations.

Instructions for using the data tool are included on the website http://climatecenter.fsu.edu/kids/tools/activity-planner

The Birthday Climatology Precipitation and Temperature Graphs and the Birthday Climatology worksheet can be found in the Unit 4 appendix.

**TALK IT OVER**

Sharing

- What surprised you most about these activities?

Processing

- What problems did you have with the activities?
- What did you learn about human activities and climate that you didn't know before?

Generalizing

- How will learning about the interaction of human activities and climate benefit you in the future?

Applying

- How would you teach someone else about what you learned today?
- Describe a time or situation when you might need to use what you learned today.
- What would you do differently if you did these activities again?

# Appendices

# Where Should We Put Our Weather Station?

Look at the three pictures of the weather stations and answer the following questions for each site.

| | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| What external factors could impact the observations? | | | |
| How might these factors affect the daily data? | | | |
| Rank the stations from best to worst (1 = best and 3 = worst). | | | |

After you have concluded the group discussion, answer the questions on the second page of the worksheet.

| | **Site 1** | **Site 2** | **Site 3** |
|---|---|---|---|
| What do you think would happen to the observations over time if the stations remained the same? | | | |
| How do you think those impacts would affect the climate record? | | | |
| Do you think the time the observation is taken at the weather station would affect the measurements? | | | |

Using what you have learned, let's examine possible locations for a weather station at this location.

# Where Should We Put Our Weather Station?

## Site #1

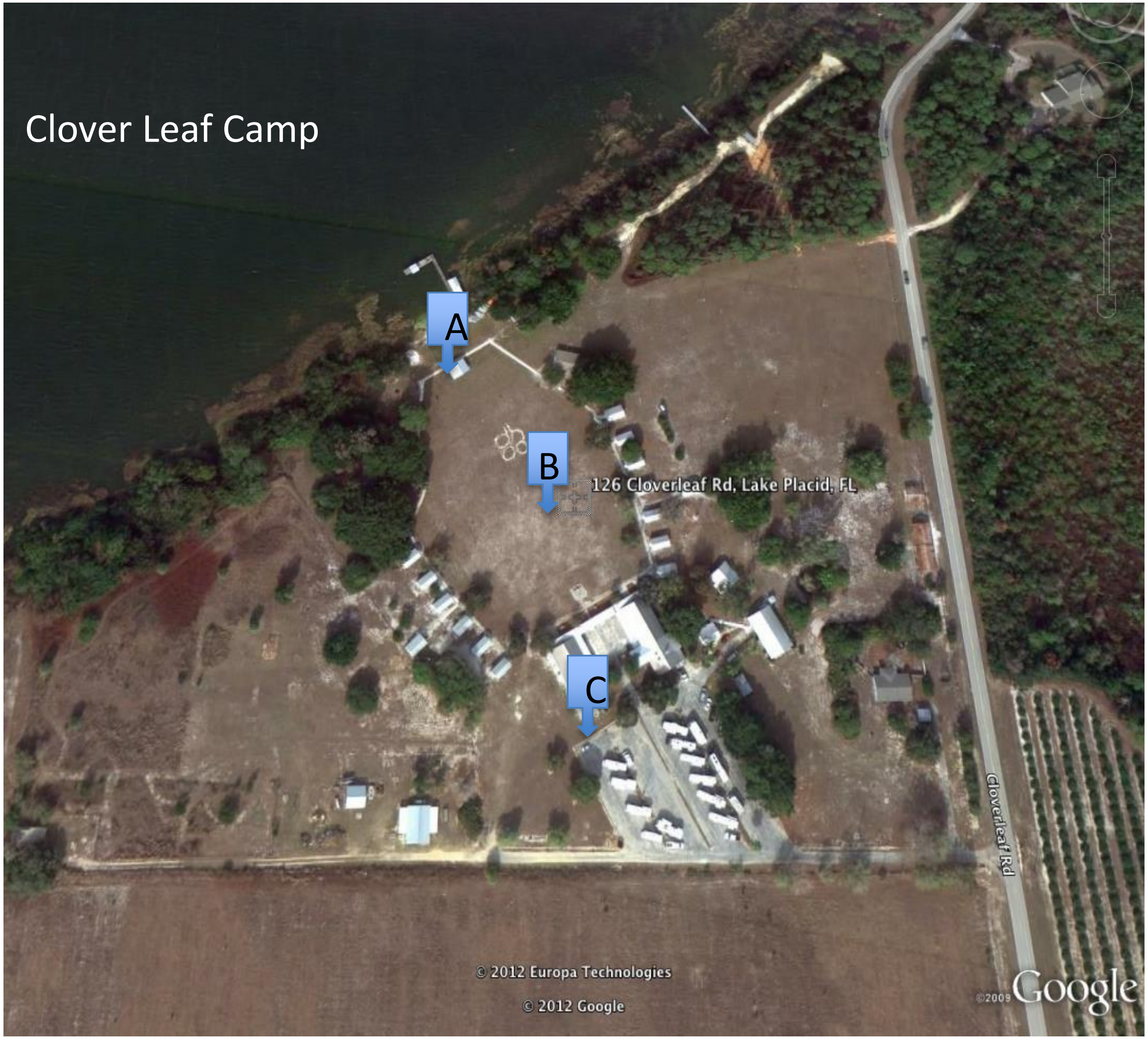
# Where Should We Put Our Weather Station?

## Site #2

# Where Should We Put Our Weather Station?

## Site #3

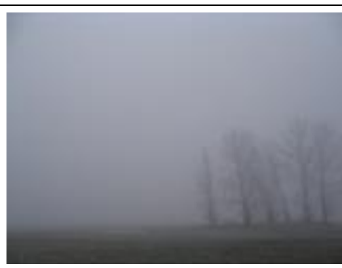

Cherry Lake Camp
A
D
C
B
3861 NE Cherry Lake Cir, Madison, FL
© 2012 Europa Technologies
© 2012 Google
©2009 Google

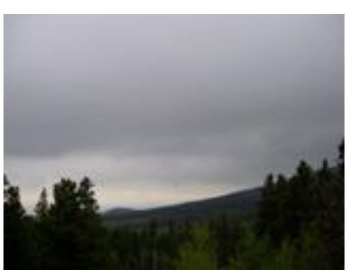

Clover Leaf Camp
A
B
126 Cloverleaf Rd, Lake Placid, FL
C
Cloverleaf Rd
© 2012 Europa Technologies
© 2012 Google
©2009
Google


Timpoochee Camp
4-H Camp Timpoochee
D
C
A
B
Timpoochee Ln
© 2012 Google
©2009 Google

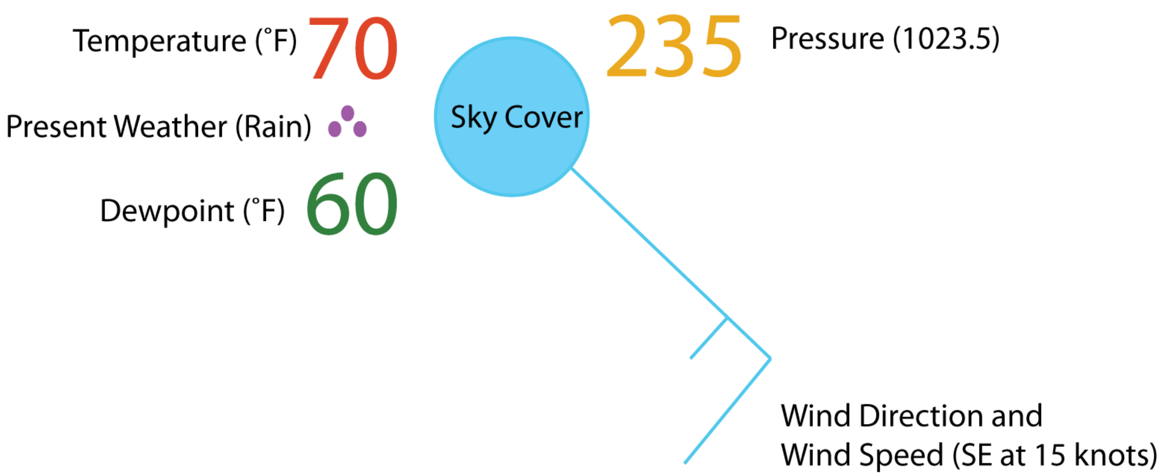
# Cloud Journal

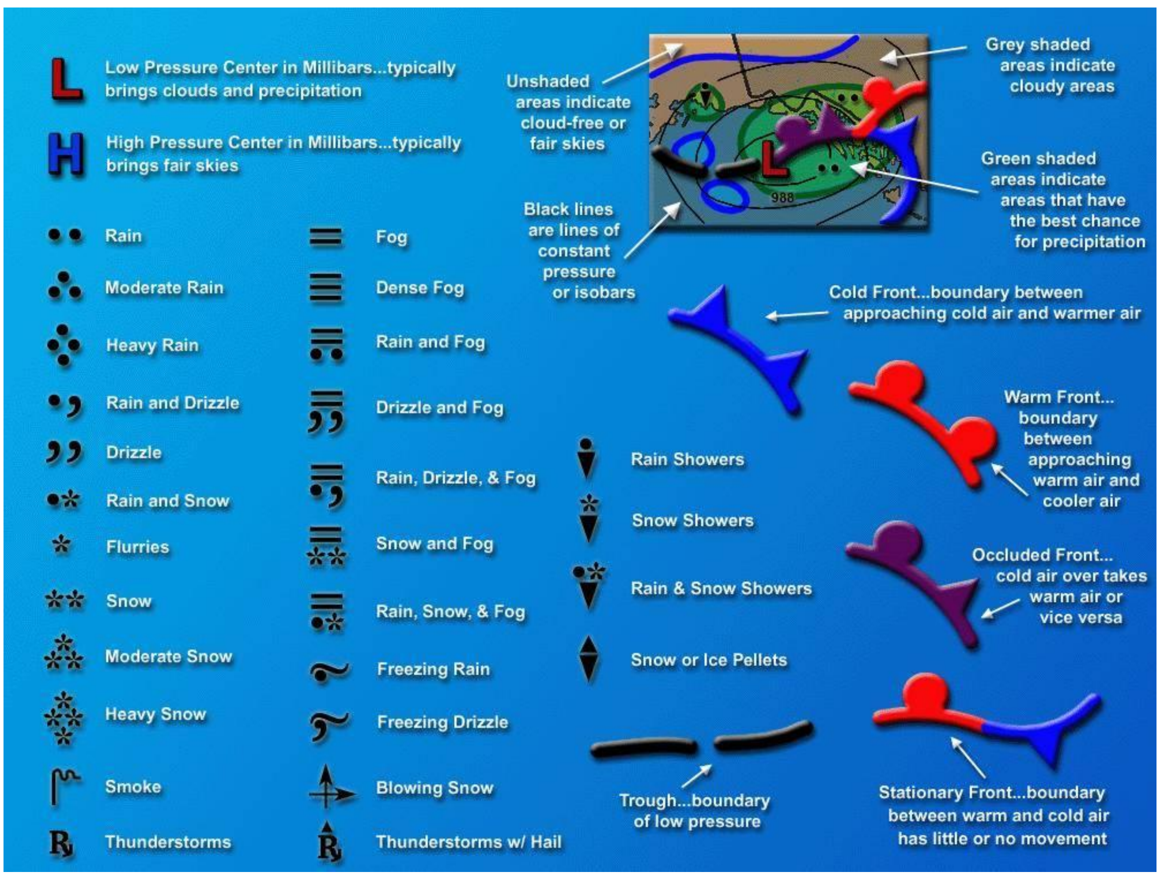
Directions: Record the location (where you were when you saw the cloud) and the date and time of your observations. Definitions from the AMS Weather Glossary: http://www.ametsoc.org/amsedu/wes/glossary.html#S

| | |
|---|---|
|  | **Cumulus**<br>Clouds that develop as a consequence of the updraft in convection currents; resemble huge puffs of cotton floating in the sky.<br>Location:<br>Date and time: |
|  | **Cirrus**<br>A high thin cloud occurring as silky strands and composed of ice crystals.<br>Location:<br>Date and time: |
|  | **Stratus**<br>Low clouds that occur as a uniform gray layer stretching from horizon to horizon. They may produce drizzle, and where they intersect the ground, they are classified as fog.<br>Location:<br>Date and time: |
|  | **Fog**<br>Location:<br>Date and time: |
|  | **Cirrostratus**<br>A high, thin, layered cloud composed of ice crystals that form a thin white veil over the sky.<br>Location:<br>Date and time: |

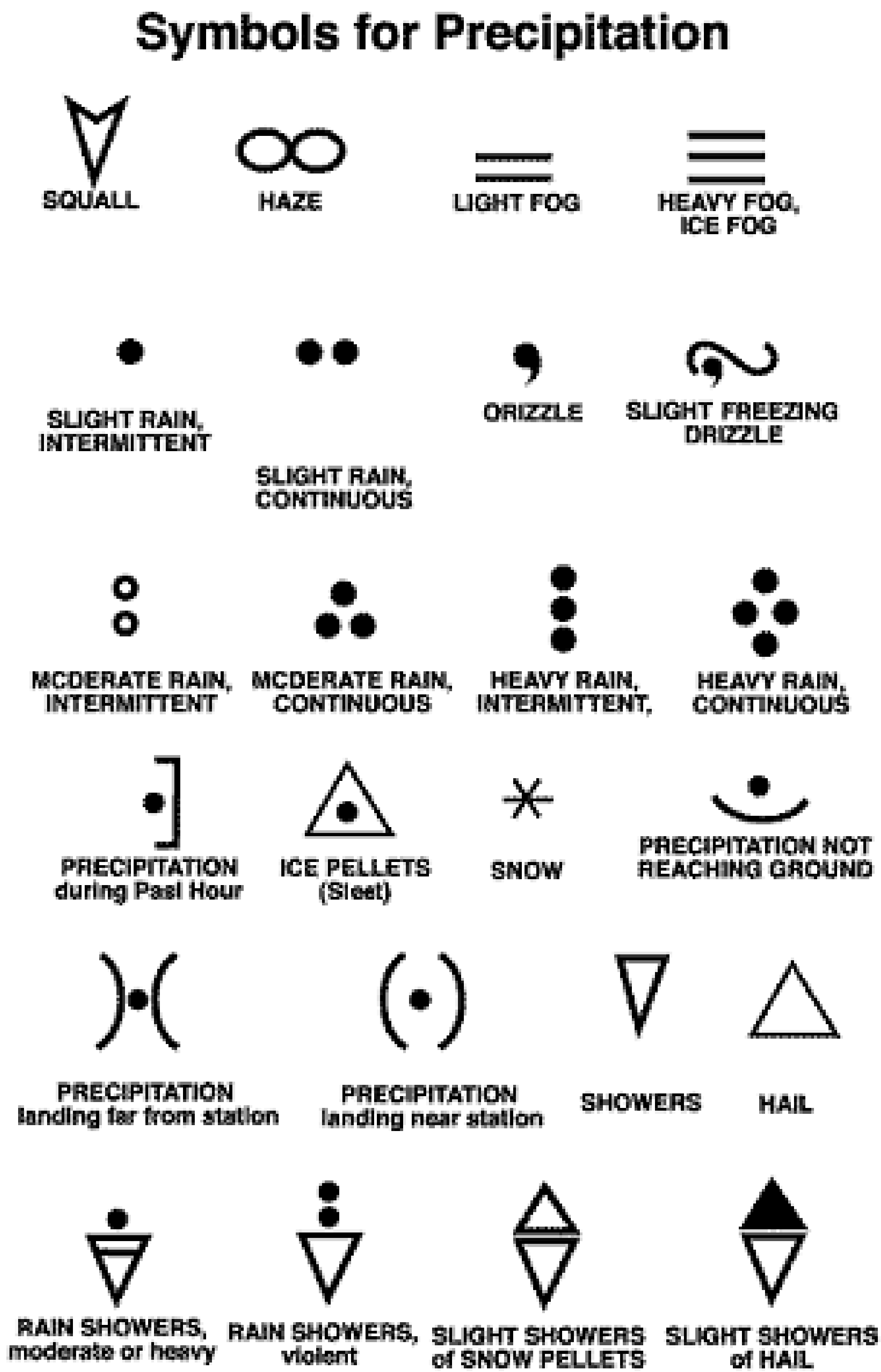
| | |
|---|---|
|  | **Rainbow**<br>An arc of concentric colored bands formed by refraction and internal reflection of sunlight by raindrops. (Observer must be looking at a distant rain shower with the sun at his/her back.)<br>Location:<br>Date and time: |
|  | **Contrails**<br>Cloud-like streamers frequently seen forming behind aircraft flying in clear, cold, humid air.<br>Location:<br>Date and time: |
|  | **Altocumulus**<br>Middle clouds consisting of roll-like patches or puffs forming a wavy pattern.<br>Location:<br>Date and time: |
|  | **Stratocumulus**<br>Low clouds consisting of large, irregular puffs or rolls arranged in a layer.<br>Location:<br>Date and time: |
|  | **Cumulonimbus**<br>Thunderstorm clouds that form as a consequence of deep convection in the atmosphere.<br>Location:<br>Date and time: |
|  | **Nimbostratus**<br>Low, gray, layered clouds that resemble stratus clouds but are thicker and yield more substantial precipitation.<br>Location:<br>Date and time: |

# Reading a Weather Map
## Weather Map Symbols Guide



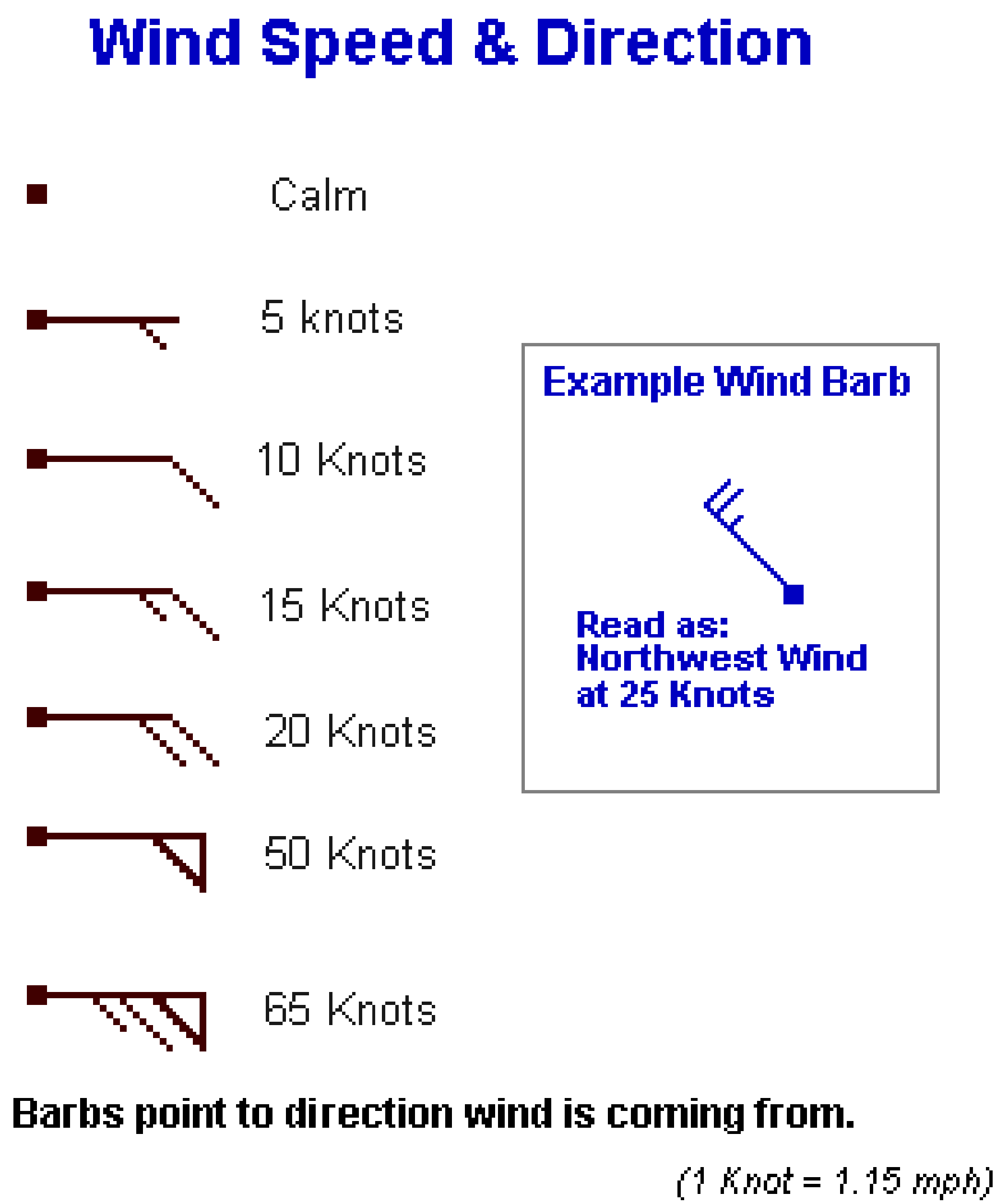




Source: NOAA


Symbols for Precipitation
SQUALL
HAZE
LIGHT FOG
HEAVY FOG, ICE FOG
SLIGHT RAIN, INTERMITTENT
SLIGHT RAIN, CONTINUOUS
DRIZZLE
SLIGHT FREEZING DRIZZLE
MODERATE RAIN, INTERMITTENT
MODERATE RAIN, CONTINUOUS
HEAVY RAIN, INTERMITTENT,
HEAVY RAIN, CONTINUOUS
PRECIPITATION during Past Hour
ICE PELLETS (Sleet)
SNOW
PRECIPITATION NOT REACHING GROUND
PRECIPITATION landing far from station
PRECIPITATION landing near station
SHOWERS
HAIL
RAIN SHOWERS, moderate or heavy
RAIN SHOWERS, violent
SLIGHT SHOWERS of SNOW PELLETS
SLIGHT SHOWERS of HAIL

Source: NASA

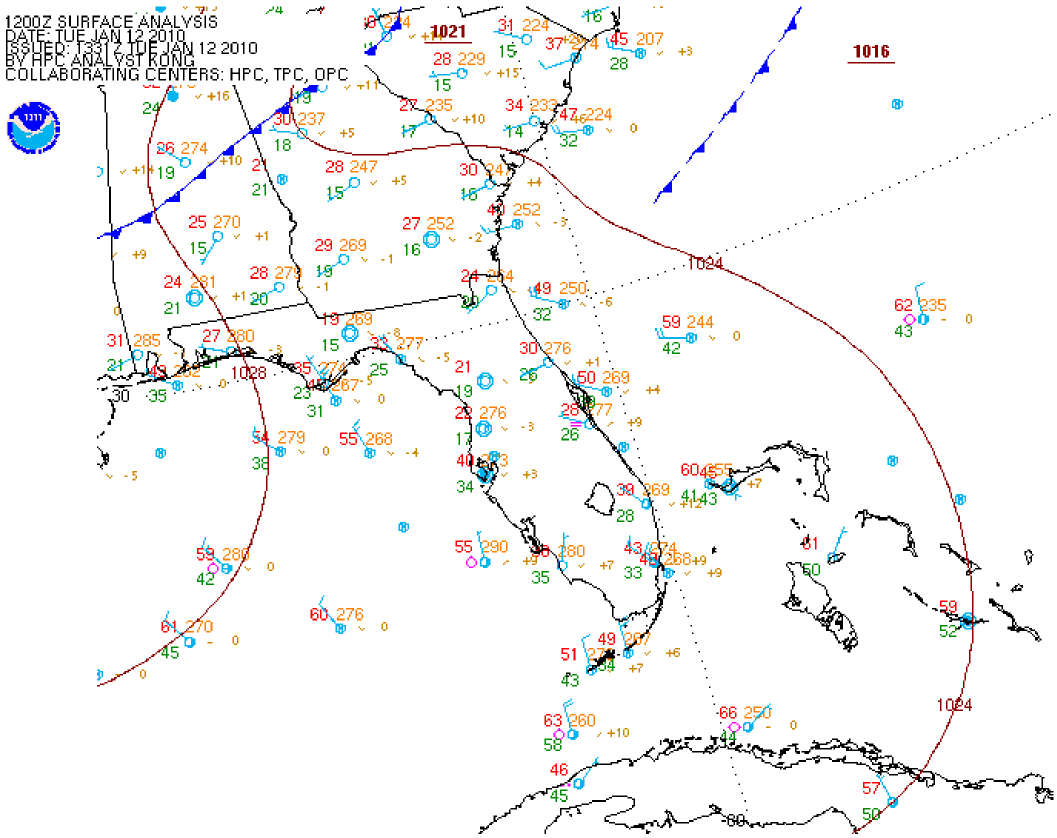

Source: National Science Foundation




Source: NOAA

Weather Symbols Summary, Symbols for Precipitation, Total Sky Cover, and Wind Speed & Direction downloaded on July 24, 2012, from http://weather.about.com/od/forecastingtechniques/ss/mapsymbols_2.htm

# Reading a Weather Map
# January 2010




Directions: Look at the surface weather map for January 12, 2010, and using the Weather Map Symbols Guide, answer the following questions:

1. What is the coldest temperature reported in Florida on this date?

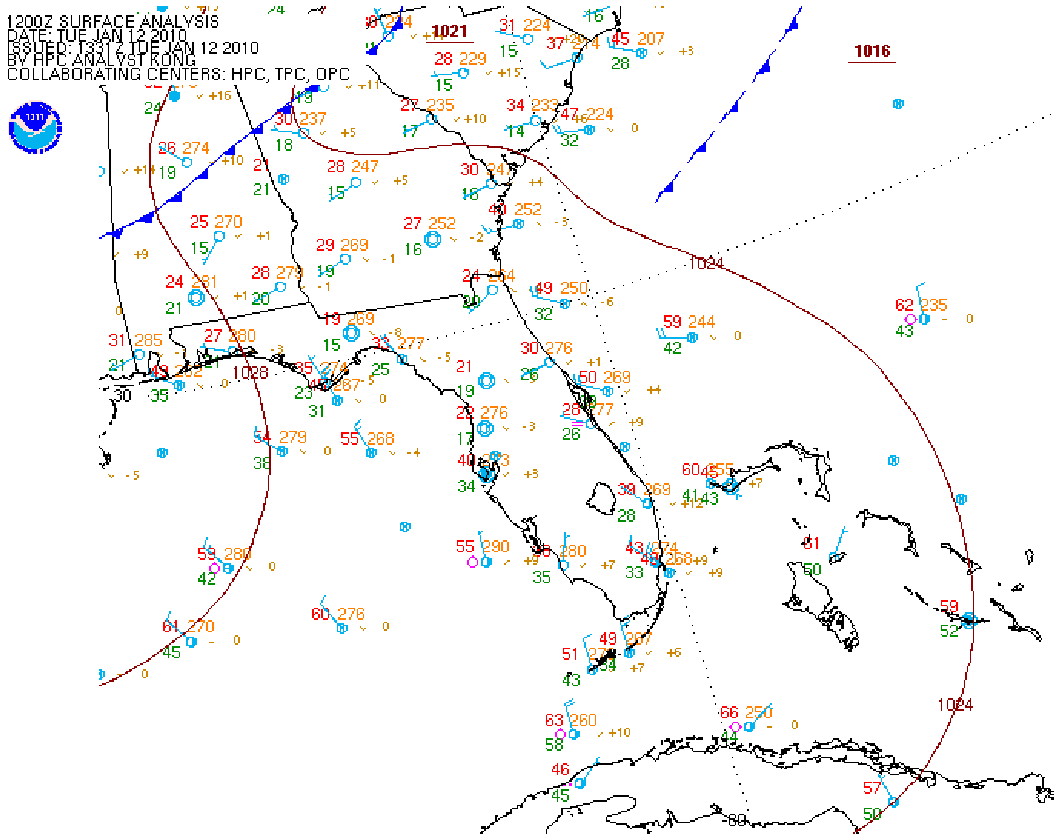
2. Where was the coldest temperature reported on the map?

3. What is the weather in Titusville?

4. What type of front is depicted on the map?

5. Where is the highest pressure reported and what was the observation?

# Reading a Weather Map
# January 2010 KEY




Directions: Look at the surface weather map for January 12, 2010, and using the Weather Map Symbols Guide, answer the following questions:

1. What is the coldest temperature reported in Florida on this date?
   19˚F

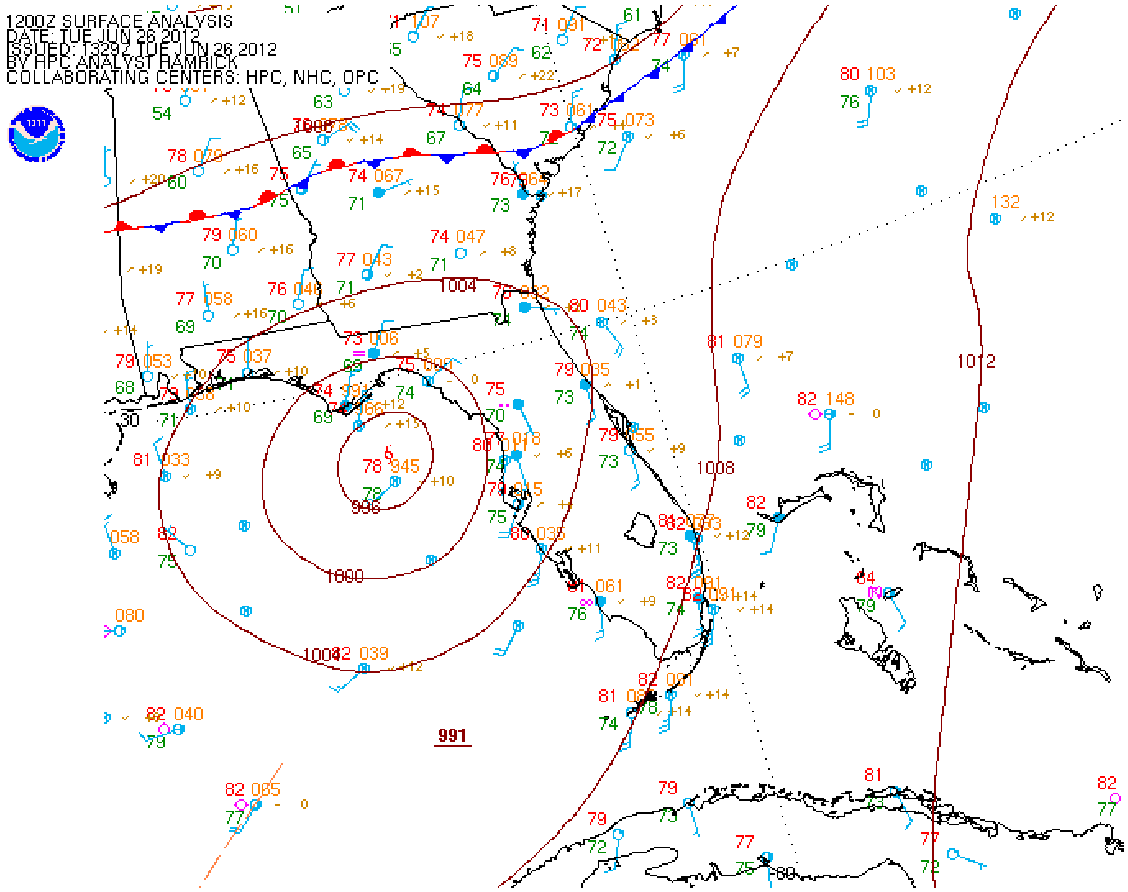
2. Where was the coldest temperature reported on the map?
   Tallahassee, FL

3. What is the weather in Titusville?
   Fog

4. What type of front is depicted on the map?
   Cold front

5. Where is the highest pressure reported and what was the observation?
   1028.5 in Mobile, AL

# Reading a Weather Map
# June 2012




Directions: Look at this surface map from Tropical Storm Debby in June of 2012, and using the Weather Map Symbols Guide, answer the following questions:

1. Draw the symbol used to identify Tropical Storm Debby (hint: the symbol isn't in the guide, but try to locate it on the map).

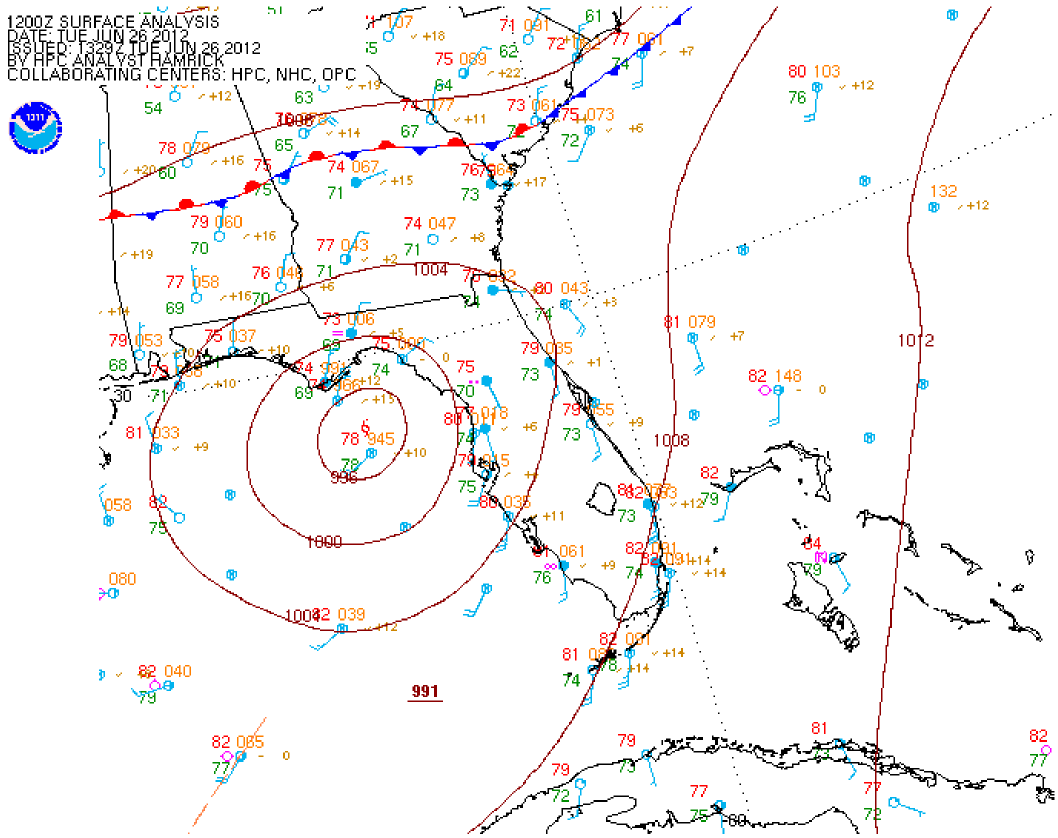
2. What kind of front is located across central Alabama and Georgia?

3. What is the present weather reported in Gainesville?

4. What is the current temperature in Tallahassee?

5. What is the wind speed and direction reported at Key West?

# Reading a Weather Map
# June 2012 KEY




1. Draw the symbol used to identify Tropical Storm Debby (hint: the symbol isn't in the guide, but try to locate it on the map).

2. What kind of front is located across central Alabama and Georgia?
   **Stationary front**

3. What is the present weather reported in Gainesville?
   **Rain**

4. What is the current temperature in Tallahassee?
   **73˚F**

5. What is the wind speed and direction reported at Key West?
   **South at 20 knots**

# Severe Storm Fact Tracker
## Weird but True

On July 1, 1955, nine-year-old Sharon Weron, of Sioux Falls, South Dakota, was riding her pony when a thunderstorm approached. As she hurried home, a tornado whipped her and her pony into the air and carried them over a thousand feet. She and the pony were unharmed.
(from *Freaks of the Storm, From Flying Cows to Stealing Thunder*, by Randy Cerveny, 2006. Thunder's Mouth Press, NY, p.38)

When tornadoes struck in Kentucky and southern Indiana on March 2, 2012, they picked up thousands of photographs, documents, and personal items and scattered them as far away as Ohio and West Virginia. A man in Pleasant Plain, Ohio, found a receipt with a New Pekin, Indiana, address from 160 miles away.
[from "Storm Victims Reunited with Far-Flung Personal Possessions", by Chris Kenning, reprinted in *USA Today* March 17, 2012 (downloaded July 16, 2012)]

During the 1926 Miami Hurricane, many new residents who were unfamiliar with hurricanes went outside during the eye. They ignored the warnings of those who knew that the worst part of the storm was about to hit, and over 100 people died.
(from *Freaks of the Storm, From Flying Cows to Stealing Thunder*, by Randy Cerveny, 2006. Thunder's Mouth Press, NY, p.169-70)

In 1876, the members of the Methodist Episcopal Church South in Swan Quarter, North Carolina, wanted to build a new church on a particular piece of property. The owner of that property, however, did not want to sell, so a small wooden church was built on another site. In September 1876, the day before the new church was to be dedicated, a hurricane struck the area, creating a massive storm surge. During the surge, the new church pulled loose from its brick pilings and floated down the street. It turned left and settled onto the lot that had been chosen originally. The owner deeded the lot to the congregation.
(from *Freaks of the Storm, From Flying Cows to Stealing Thunder*, by Randy Cerveny, 2006. Thunder's Mouth Press, NY, p.153-54)

# Severe Storm Fact Tracker
## Team Hurricane

Track down the facts about hurricanes, using the Internet as your source. Be sure to identify the source (name of the agency or organization) where you found the information. After you have completed your investigation, you will present your findings to the entire group. You may wish to include pictures, graphs, or other visual aids in your presentation.

**Formation**

- What is a hurricane (tropical cyclone)?

  Source(s):

- What conditions have to be present for a hurricane to form?

  Source(s):

- What causes hurricanes to "die"?

  Source(s):

- Why do hurricanes in the Northern Hemisphere rotate counterclockwise?

  Source(s):

**Scale**

- What is the Saffir-Simpson Hurricane Wind Scale?

  Source(s):

- What are the wind speeds for the five categories of the Saffir-Simpson Hurricane **Wind** Scale? (This scale was updated in 2012 and "Wind" was added to the name, so make sure you find the correct scale.)

  Source(s):

- How do scientists determine the intensity of a hurricane?

  Source(s):

**Occurrences**

- What time of year do most Atlantic hurricanes occur?

  Source(s):

- Is there any time of year when an Atlantic hurricane cannot occur? If so, when?

  Source(s):

- Is there any place on Earth that does not have hurricanes (also known as tropical cyclones or typhoons in some parts of the world)? If so, where?

  Source(s):

**Names**

- When is a tropical system given a name?

  Source(s):

- How are the names for Atlantic hurricanes chosen?

  Source(s):

# Severe Storm Fact Tracker
## Hurricane Myth and Misconception Busters

Use the Internet to help you bust these myths and misconceptions. Explain why each statement is incorrect. Be prepared to share your information with the entire group.

1. The upper floors of an apartment, condominium, or office building are a safe place to ride out a hurricane.

2. Friction over land kills hurricanes.

3. The biggest hurricanes are the most intense.

4. It's safe to go outside during the eye of a hurricane.

5. During a hurricane, the windows and doors on the storm side should be closed and the windows and doors on the lee side should be open.

6. Taping windows will protect them from flying debris.

7. If a hurricane passes over an oil slick, there will be oil in the rain.

8. Hurricane names can be used only once.

9. Hurricanes only form during the hurricane season (July through November).

10. Only coastal areas are at risk for hurricanes.

# Severe Storm Fact Tracker
## Team Hurricane KEY

Track down the facts about hurricanes, using the Internet as your source. Be sure to identify the source (name of the agency or organization) where you found the information. After you have completed your investigation, you will present your findings to the entire group. You may wish to include pictures, graphs, or other visual aids in your presentation.

**Formation**

- What is a hurricane (tropical cyclone)?
  ***A hurricane is a tropical cyclone that has a maximum sustained wind speed of 74 mph or greater. The term hurricane refers to tropical cyclones in the Northern Hemisphere that are east of the International Dateline to the Greenwich Meridian. A tropical cyclone is the generic term for a low-pressure system over tropical or subtropical waters.***
  Source(s): ***Atlantic Oceanographic and Meteorological Laboratory/National Hurricane Center***

- What conditions have to be present for a hurricane to form?
  ***Favorable environmental conditions that must be in place before a tropical cyclone can form include the following:***
  - ***warm ocean waters (at least 80˚F)***
  - ***an atmosphere that is potentially unstable***
  - ***a relatively moist air mass***
  - ***closeness to the equator***
  - ***a near-surface disturbance (cold front, tropical wave, convective line of storms)***
  - ***low wind shear environment***

  Source(s): ***National Hurricane Center/National Weather Service***

- What causes hurricanes to "die"?
  ***A tropical cyclone will begin to weaken over land because the storm lacks the moisture and heat source that the ocean provides. Other ways a tropical cyclone can weaken include entering an area that has increased wind shear and moving over cool or cold ocean waters.***
  Source(s): ***Atlantic Oceanographic and Meteorological Laboratory/National Hurricane Center***

- Why do hurricanes in the Northern Hemisphere rotate counterclockwise?
  ***Earth's rotation sets up an apparent force (called the Coriolis force) that pulls the winds to the right in the Northern Hemisphere (and to the left in the Southern Hemisphere).***
  Source(s): ***Atlantic Oceanographic and Meteorological Laboratory/National Hurricane Center***

## Scale

- What is the Saffir-Simpson Hurricane Wind Scale?
  ***A wind scale, from 1 to 5, that is based on the hurricane's present intensity. This scale addresses only wind speed and does not account for other hurricane-related impacts (storm surge, rainfall, and tornadoes).***
  Source(s): ***National Hurricane Center/National Weather Service***

- What are the wind speeds for the five categories of the Saffir-Simpson Hurricane **Wind** Scale? (This scale was updated in 2012 and "Wind" was added to the name, so make sure you find the correct scale.)
  - ***Category 5: Catastrophic Damage Will Occur (winds greater than or equal to 157 mph)***
  - ***Category 4: Catastrophic Damage Will Occur (winds 130-156 mph)***
  - ***Category 3: Devastating Damage Will Occur (winds 111-129 mph)***
  - ***Category 2: Extremely Dangerous Winds Will Cause Extensive Damage (winds 96-110 mph)***
  - ***Category 1: Very Dangerous Winds Will Produce Some Damage (winds 74-95 mph)***

  Source(s): ***National Hurricane Center/National Weather Service***

- How do scientists determine the intensity of a hurricane?
  ***There are many different techniques to measure the intensity of a hurricane. The Dvorak technique is used to estimate tropical cyclone intensity from satellite pictures.***
  ***Certain satellites can measure the size and strength of the wind field.***
  ***Hurricane hunters fly into the storms and take observations of the tropical cyclone.***
  Source(s): ***Atlantic Oceanographic and Meteorological Laboratory/National Hurricane Center***

## Occurrences

- What time of year do most Atlantic hurricanes occur?
  ***The peak of hurricane season is from mid-August to late October.***
  Source(s): ***National Hurricane Center***

- Is there any time of year when an Atlantic hurricane cannot occur? If so, when?
  ***The Atlantic hurricane season runs from June 1st through November 30th, and although the bulk of the hurricanes happen during this time period, there have been instances of tropical systems as early as March and as late as December. At least one storm has occurred in each month of the year.***
  Source(s): ***National Hurricane Center/Unisys Hurricane Maps/Coastal Service Center Hurricane Mapping Tool***

- Is there any place on Earth that does not have hurricanes (also known as tropical cyclones or typhoons in some parts of the world)? If so, where?
  ***Areas within 5° of latitude north and south of the equator have limited Coriolis force effect, which helps with the formation of tropical cyclones. Also, no tropical cyclones have impacted the West Coast of the United States because of the cold ocean water flowing from north to south via the ocean currents in the Pacific. There is a debate over whether the few storms that have formed in the Mediterranean Sea were either tropical cyclones or polar lows. It is also very rare for storms to form in the South Atlantic Ocean.***
  Source(s): ***Atlantic Oceanographic and Meteorological Laboratory/National Hurricane Center***

**Names**

- When is a tropical system given a name?
  ***A tropical system is given a name once it reaches Tropical Storm strength (winds greater than 39 mph).***
  Source(s): ***National Hurricane Center***

- How are the names for Atlantic hurricanes chosen?
  ***Prior to 1953, the storms were named according to the phonetic alphabet (Alpha, Baker, Charlie, etc). In 1953, the nation's weather service began using female names. In 1979, the practice was changed to include men's names. A separate set is used each year, beginning with the first name in the set. A set repeats every 6 years, unless a name is retired (if a storm is severe, deadly, or costly). The list of names is updated and maintained by the World Meteorological Organization (WMO). There are no names for Q, U, X, Y and Z. In the event there are more than 21 named storms, additional storms are named from the Greek alphabet.***
  Source(s): ***National Hurricane Center/National Weather Service***

# Severe Storm Fact Tracker
## Hurricane Myth and Misconception Busters KEY

Use the Internet to help you bust these myths and misconceptions. Explain why each statement is incorrect. Be prepared to share your information with the entire group.

1. The upper floors of an apartment, condominium, or office building are a safe place to ride out a hurricane.
   ***Wind speed increases with height, so it can blow out windows; storm surge can cause structural damage to the lower levels; it's more difficult to rescue people from the upper floors.***

2. Friction over land kills hurricanes.
   ***During landfall, the increased friction over land decreases the sustained winds and increases the gusts felt at the surface. After a few hours over land, the hurricane will weaken rapidly because moisture and heat sources provided by the ocean are no longer available.***

3. The biggest hurricanes are the most intense.
   ***There is very little association between intensity and size. Intensity is measured by maximum sustained winds or central pressure.***

4. It's safe to go outside during the eye of a hurricane.
   ***You have no way of knowing how long the light winds will last. Strong winds will return very quickly from the opposite direction.***

5. During a hurricane, the windows and doors on the storm side should be closed and the windows and doors on the lee side should be open.
   ***All windows should be closed and boarded up during a hurricane. The pressure differences between the outside and inside of a house do not build up enough to cause damage. The winds are highly turbulent, and debris can fly in through open windows.***

6. Taping windows will protect them from flying debris and breakage.
   ***Tape does not prevent the windows from breaking and offers no protection against flying debris. If the windows don't break, the tape has to be scraped off.***

7. If a hurricane passes over an oil slick, there will be oil in the rain.
   ***Hurricanes draw water vapor from a large area, much larger than the area covered by oil, and rain is produced in clouds circulating the hurricane.***

8. Hurricane names can be used only once.
   ***The names of hurricanes that are unusually destructive are retired. The World Meteorological Organization maintains six lists of names that are reused every six years.***

9. Hurricanes only form during the hurricane season (June 1 through November 30).
   ***Hurricanes sometimes form before or after the official hurricane season. The earliest observed hurricane was on March 7, 1908, and the latest observed hurricane was on December 31, 1954.***

10. Only coastal areas are at risk for hurricanes.
    ***The effects of hurricanes—strong winds, heavy rain, inland flooding, and tornadoes—can occur hundreds of miles from the coast.***

# Severe Storm Fact Tracker
## Team Tornado

Track down the facts about tornados using the Internet as your source. Be sure to identify the source (name of the agency or organization) where you found the information. After you have completed your investigation, you will present your findings to the entire group. You may wish to include pictures, graphs, or other visual aids in your presentation.

**Formation**

- What is a tornado?

  Source(s):

- What conditions have to be present for a tornado to form?

  Source(s):

- What causes the air to rotate?

  Source(s):

- Can tornadoes be predicted? Why or why not?

  Source(s):

**Scale**

- What is the Enhanced Fujita Scale?

  Source(s):

- What are the wind speeds for the six categories of the Enhanced Fujita scale?

  Source(s):

- When and how do scientists determine the strengths of a tornado?

  Source(s):

- Tornadoes are divided into three types, depending on their strength. What are those three types, and how is each defined?

  Source(s):

**Occurrences**

- What time of year do most tornados occur?

  Source(s):

- Is there any time of year when a tornado cannot occur? If so, when?

  Source(s):

- Where do most tornados occur?

  Source(s):

- Is there any place on Earth that does not have tornadoes? If so, where?

  Source(s):

# Severe Storm Fact Tracker
## Tornado Myth and Misconception Busters

Use the Internet to help you bust these myths and misconceptions. Explain why each statement is incorrect. Be prepared to share your information with the entire group.

1. A highway overpass is a safe place to take shelter if you are on the road and see a tornado approaching.

2. Opening windows to equalize air pressure will save a roof, or even a home, from destruction.

3. Mobile home parks attract tornadoes.

4. It's safer to try to outrun a tornado in a vehicle than to take shelter at home.

5. Tornadoes frequently "skip" houses.

6. The wider a tornado is, the stronger it is.

7. Tornadoes move exclusively in a northeasterly direction.

8. Tornadoes occur only in North America.

9. Tornadoes never strike big cities.

10. To keep from being sucked into the tornado, you can tie yourself to a well pipe, as they did in the movie *Twister*.

# Severe Storm Fact Tracker

## Team Tornado KEY

Track down the facts about tornados using the Internet as your source. Be sure to identify the source (name of the agency or organization) where you found the information. After you have completed your investigation, you will present your findings to the entire group. You may wish to include pictures, graphs, or other visual aids in your presentation.

**Formation**

- What is a tornado?
  ***A tornado is a violently rotating column of air descending from a thunderstorm and in contact with the ground.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- What conditions have to be present for a tornado to form?
  ***Most tornadoes are spawned from supercell thunderstorms, which are characterized by rotating updrafts and form in environments of strong vertical wind shear.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- What causes the air to rotate?
  ***Wind shear (the change in wind speed and/or direction with height).***
  Source(s): ***National Weather Service/Storm Prediction Center***

- Can tornadoes be predicted? Why or why not?
  ***Yes and no. Unlike hurricanes, tornadoes cannot be predicted/forecasted days in advance, nor are they as long-lived as tropical cyclone. Forecasters look for conditions that are favorable for the development of tornadoes, but at this time are not able to determine hours in advance which thunderstorm will produce a tornado. Forecasters work very hard to keep an eye out for severe weather and once they find a storm that is capable of producing a tornado, they will put out a tornado warning with as much lead time as possible.***
  Source(s): ***National Weather Service/Storm Prediction Center***

**Scale**

- What is the Enhanced Fujita Scale?
  ***The Enhanced Fujita Scale was developed by a forum of renowned meteorologists and wind engineers to make improvements on the original Fujita Scale, which has been used to assign tornado ratings, based on damage assessments of tornadoes, since 1971.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- What are the wind speeds for the six categories of the Enhanced Fujita scale?
  ***The EF Scale wind speeds are***
  - ***EF0 – 65-85 mph***
  - ***EF1 – 86-110 mph***
  - ***EF2 – 111-135 mph***
  - ***EF3 – 136-165 mph***
  - ***EF4 – 166-200 mph***
  - ***EF5- >200 mph***

  Source(s): ***National Weather Service/Storm Prediction Center***

- When and how do scientists determine the strengths of a tornado?
  ***Scientists and meteorologists determine the strengths of a tornado after the tornado has impacted an area by doing a storm survey. They are able to estimate the wind speed/strength of the tornado on the basis of the damage that is left in the wake of a tornado.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- Tornadoes are divided into three types, depending on their strength. What are those three types, and how is each defined?
  ***The three classes, or types, of tornadoes are***
  - ***Weak (EF0/EF1)***
  - ***Strong (EF2/EF3)***
  - ***Violent (EF4/EF5)***

  Source(s): ***National Weather Service/Storm Prediction Center***

**Occurrences**

- What time of year do most tornados occur?
  ***The main "tornado season" for the United States occurs from late winter through midsummer. The peak period for tornadoes in the southern plains is May into early June. On the Gulf Coast, the peak period is earlier during the spring; in the northern plains and upper Midwest, the peak period is in June or July. Tornadoes have also been reported with land-falling tropical cyclones.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- Is there any time of year when a tornado cannot occur? If so, when?
  ***Tornadoes can happen any day or night of the year. The earliest occurrence on modern record of a tornado was reported two minutes after midnight on Jan 1, 2011.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- Where do most tornados occur?

  ***Most tornadoes in the United States occur east of the Rocky Mountains in areas known as Tornado Alley (the central Plains) and Dixie Alley (southeastern United States) and in Florida.***
  Source(s): ***National Weather Service/Storm Prediction Center***

- Is there any place on Earth that does not have tornadoes? If so, where?
  ***Antarctica***
  Source(s): ***NOAA Satellite and Information Service, National Climatic Data Center***

# Severe Storm Fact Tracker
## Tornado Myth and Misconception Busters KEY

Use the Internet to help you bust these myths and misconceptions. Explain why each statement is incorrect. Be prepared to share your information with the entire group.

1. A highway overpass is a safe place to take shelter if you are on the road and see a tornado approaching.
   ***The overpass acts as a wind tunnel and may also collect debris. Cars parked under the overpass create a roadblock, which is dangerous for emergency vehicles trying to get through.***

2. Opening windows to equalize air pressure will save a roof, or even a home, from destruction.
   ***Opening windows allows damaging winds to enter the structure and does not equalize the pressure.***

3. Mobile home parks attract tornadoes.
   ***There are thousands of mobile homes, so there is a great likelihood that mobile home parks will be hit. Also, mobile homes offer little protection, so when a park is hit by a tornado there is the possibility of more extensive damage.***

4. It's safer to try to outrun a tornado in a vehicle than to take shelter at home.
   ***Tornadoes can move at speeds up to 70 mph and shift directions erratically and without warning.***

5. Tornadoes frequently "skip" houses.
   ***Sometimes the damage path of a tornado will result in several buildings being demolished, followed by others that are lightly damaged, followed by several more being demolished. The reason for this may be that some of the buildings are better constructed, or that the orientation of the building made some parts of if more vulnerable to the winds. Also, small eddies in the tornado's path can add to or detract from its circulation.***

6. The wider a tornado is, the stronger it is.
   ***The size and shape of a tornado are not conclusive indicators of its strength. Small tornadoes can cause violent damage and large ones can cause only weak damage.***

7. Tornadoes move exclusively in a northeasterly direction.
   ***Tornadoes typically move from the northwest to northeast, but they have been known to move in any direction.***

8. Tornadoes occur only in North America.
   ***Tornadoes occur in many parts of the world.***

9. Tornadoes never strike big cities.
   ***Tornadoes can strike anywhere, and several large cities have experienced tornadoes (Dallas, Oklahoma City, Wichita Falls, Miami, Salt Lake City).***

10. To keep from being sucked into the tornado, you can tie yourself to a well pipe, as they did in the movie *Twister*.
    ***Although the tornado probably will not dislodge a pipe buried deeply in the ground, you'll probably be whipped around at the end of the rope or be pulled from the rope.***

# Additional Resources: Unit 1

How Do Scientists Measure and Study Weather

## Manufacture Your Own Weather Instruments

Instructions for building a psychrometer, an anemometer, a rain gauge, and a thermometer can be found, in the *Forces of Nature 4-H Camp Kit* from Utah Extension's Aggie Adventures Camp Kit http://www.utah4-h.org/htm/resource-library/kits/set-guides-request-form, or from the book *Weather Projects for Young Scientists: Experiments and Science Fair Ideas* by Mary Kay Carson.

## Cloud Journal

NASA has a very nice cloud ID chart that can be printed or viewed online at http://science-edu.larc.nasa.gov/SCOOL/Cloud_ID.php

## Reading a Weather Map

Background information on air masses and fronts can be found on NOAA's National Weather Service "Jetstream – Online School for Weather" site

http://www.srh.noaa.gov/jetstream/synoptic/airmass.htm

## Severe Storm Fact Tracker

The following are vetted sites for severe storm information.

## Tornado Websites

http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadosafety.html

http://www.nssl.noaa.gov/edu/safety/tornadoguide.html

http://www.nws.noaa.gov/om/brochures/tornado.shtml

http://www.spc.noaa.gov/faq/tornado/

http://www.noaawatch.gov/themes/severe.php

http://www.ucar.edu/communications/factsheets/Tornadoes.html

http://www.ncdc.noaa.gov/oa/climate/severeweather/tornadosafety.html

## Hurricane Websites

http://www.noaanews.noaa.gov/stories2004/s2303.htm

http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqHED.html

http://www2.ucar.edu/news/backgrounders/hurricanes-typhoons-cyclones

http://www.comet.ucar.edu/nsflab/web/hurricane/311.htm

# Fact or Opinion

Southeast Climate EXTENSION | Advancing Climate Extension in Agriculture
USDA United States Department of Agriculture National Institute of Food and Agriculture

# Activity: Fact and Opinion

**Objective**: Participants will correctly identify fact and opinion statements related to climate change.

**Materials**:

- Cards printed before the workshop with the facts and opinions provided herein, one statement per card
- Sticky notes
- Heading cards
- Whiteboard

**Procedure:**

- Divide the group into pairs.
- Distribute the cards containing examples of facts and opinions about climate change that have been taken from news articles, websites, movies, etc. Each pair receives four cards, a mix of fact and opinion. (Some statements will be duplicated and distributed across pairs.)
- Instruct the pairs to identify each statement as fact or opinion. Ask them to record their decisions on sticky notes and place the notes on the backs of the cards. In addition, instruct them to take notes as to why they categorized a statement as fact or opinion.
- Mount two "heading" cards (one with the heading "Fact" and the other with the heading "Opinion") on the wall/whiteboard. As participants finish identifying their statements, they post the cards under the appropriate headings.
- Read each statement to the large group. Ask the pair(s) who identified the statement as fact or opinion to give its (their) reasoning. If there is disagreement, the large group discusses the statement. Scientists comment as needed.
- During the discussion, ask for "clues" that signal whether a statement is fact or opinion; a facilitator records the clues on the whiteboard.
- Facilitate a discussion that leads to group agreement on a definition of "scientific fact" and a definition of "opinion."
- Ask if anyone would like further clarification about the difference between scientific fact and opinion.

**Facilitator Notes:**

**Examples of Opinion Clues**

| Generalizations | Judgments | Must Be Proven |
|---|---|---|
| all | bad | is caused by |
| always | good | is responsible for |
| every | likely | results in |
| entire(ly) | unlikely | |
| only | significant (nonstatistical use) | |
| never | | |

*Note: These words are clues—signals to the reader to be cautious. What appears to be a statement of fact may instead be a statement of opinion. Unfortunately, sometimes an extensive knowledge of climate science is needed to distinguish fact from opinion.*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**Facts and Opinions for Cards:**

*Note: The fact statements used in this activity are scientific facts (not true/false statements).*

| Fact | Opinion |
|---|---|
| Climate change is real. | All climate change is caused by humans. |
| Sea level along Florida's coasts is rising. | Climate change is bad for humans. |
| Arctic ice cover is retreating. | All climate change is reversible (solvable). |
| Most Alpine glaciers are retreating. | The entire world is warming. |
| Temperature can increase at one location and decrease at another. | A warming globe results in stronger/more frequent hurricanes. |
| Changes in land use can affect climate. | Global warming is responsible for tornadic activity in 2011. |
| The ocean absorbs carbon dioxide. | The net damage costs of climate change are likely to be significant and to increase over time. |
| The sun heats Earth's surface unevenly. | All sinkholes are caused by changing climate. |
| Sea level differs across the globe. | All greenhouse gases are bad. |
| Humans can adapt to a changing environment. | Earth is accurately modeled by a greenhouse. |
| $CO_2$ concentration in the atmosphere and ocean is observed to be increasing when averaged over a year or more. | $CO_2$ is likely responsible for global warming. |
| The average annual energy output by the sun can be linked to the number of sunspots. | If satellites cannot detect increased energy output from Earth, then Earth can't be warming. |
| Human-made substances can reduce ozone concentration. | The ozone hole is entirely human-made. |
| Melting of floating ice does not raise the sea level. | Climate change will have only negative impacts on human health. |


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Climate change is real.

Sea level along Florida’s coasts is rising.

All climate change is caused by humans.

Climate change is bad for humans.

Arctic ice cover is retreating.

Most Alpine glaciers are retreating.

All climate change is reversible (solvable).

The entire world is warming.

Temperature can increase at one location and decrease at another.

Changes in land use can affect climate.

A warming globe results in stronger/more frequent hurricanes.

Global warming is responsible for tornadic activity in 2011.

The ocean absorbs carbon dioxide.

The sun heats Earth's surface unevenly.

The net damage costs of climate change are likely to be significant and to increase over time.

All sinkholes are caused by changing climate.

Sea level differs across the globe.

Humans can adapt to a changing environment.

All greenhouse gases are bad.

Earth is accurately modeled by a greenhouse.

$CO_2$ concentration in the atmosphere and ocean is observed to be increasing when averaged over a year or more.

The average annual energy output by the sun can be linked to the number of sunspots.

$CO_2$ is likely responsible for global warming.

If satellites cannot detect increased energy output from Earth, then Earth can't be warming.

Human-made substances can reduce ozone concentration.

Melting of floating ice does not raise the sea level.

The ozone hole is entirely human-made.

Climate change will have only negative impacts on human health.

# Evaluating Sources

# Activity: Evaluating Sources

**Objective**: Participants will apply sound criteria in evaluating climate-change websites.

**Materials**:
- Whiteboard or flip chart
- The SUPER Science-Source Sleuth worksheets
- The SUPER Science-Source Sleuth keys

***Option 1 – Using the screen shots provided with this guide, prepare in advance:***
- Greenpeace International screen shot for projection
- Handouts of the four screen shots for evaluation, one web page per group, multiple groups per web page as needed
- The four screen shots for projection

***Option 2 – Prior to the workshop, identify web pages containing statements about climate change or global warming that can be evaluated using the criteria. Create answer keys for these web pages. Access the web pages online during the workshop.***
- Ensure that live Internet access will be available for Facilitator and participants.
- Websites presenting climate information include but are not limited to:

| | |
|---|---|
| NASA | climate.nasa.gov |
| EPA | epa.gov/climatechange |
| NWF | nwf.org/Global-Warming |
| UCS | ucsusa.org/global_warming |

**Procedure**:

- Using either a projection of the home page of the Greenpeace website or an up-to-date screen shot and the following prompts, elicit criteria for evaluating the site from participants and capture on a whiteboard or flip chart.
  - What do you look for when you evaluate a source?
  - Does this web page show an agenda (political, economic)?
  - What features of the web page provide factual climate information versus opinions?

  Use the criteria in The SUPER Science-Source Sleuth worksheet to further prompt the group (e.g., What aspects of the language on a site do you consider?)
- Break large group into groups of 4-5 participants.
- Provide each group with either a screen shot from a website or a URL and The SUPER Science-Source Sleuth worksheet. The screen shots are examples that meet the criteria to varying degrees.
- Instruct the groups to select one person per group to present the group's results to the whole group.
- Give the groups 15 minutes to review the content of the screen shot or web page and make notes on their worksheet in response to the criteria.
- Ask the reporter for each group to present the results for whole-group discussion.
- Project the screen shot or web page for the entire group as it is being discussed.
- Prompt participants to discuss how this activity could be modified for use in their classrooms.
- Distribute The SUPER Science-Source Sleuth keys at the conclusion of the activity.


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# Impacts

No one knows how much warming is "safe". What we do know is that climate change is already harming people and ecosystems. Its reality can be seen in melting glaciers, disintegrating polar ice, thawing permafrost, dying coral reefs, rising sea levels, changing ecosystems and fatal heat waves.

And it is not only scientists that are witnessing these changes. From Inuit in the far north to islanders near the equator - people are already struggling with the impacts of climate change.


**Extreme weather**
Flooded village in southern France, close to a nuclear power station. Earlier in 2003 the same area experienced a long drought. Climate change means more extreme weather like flooding and droughts.

But all of this is only the beginning. We are already experiencing dangerous climate change...we need to act to avoid catastrophic climate change. While not all regional effects are yet known, here are some likely future effects if we allow current trends to continue:

## What we do

- Climate change
- Climate impacts
- Ocean circulation
- Extreme weather
- Sea level rise
- Health, food and water
- Habitat loss
- Global Melting



## More information on nuclear energy:


Chernobyl, 25 years later
Publication

Fukushima - latest updates
Topic

No more Chernobyls
Topic

## Relatively likely and early effects of small to moderate warming

- Sea level rise due to melting glaciers and the thermal expansion of the oceans as global temperature increases
- Massive releases of greenhouse gases from melting permafrost and dying forests.
- A high risk of more extreme weather events such as heat waves, droughts and floods. Already, the global incidence of drought has doubled over the past 30 years.
- Severe impacts on a regional level. For example, in Europe, river flooding will increase over much of the continent, and in coastal areas the risk of flooding, erosion and wetland loss will increase substantially.
- Natural systems, including glaciers, coral reefs, mangroves, arctic ecosystems, alpine ecosystems, boreal forests, tropical forests, prairie wetlands and native grasslands, will be severely threatened.
- An increase in existing risks of species extinction and biodiversity loss.
- The greatest impacts will be on the poorer countries least able to protect themselves from rising sea levels, spread of disease and declines in agricultural production in the developing countries of Africa, Asia and the Pacific.
- At all scales of climate change, developing countries will suffer the most.


Flames consume huge areas of forest in Montalvao, Portugal. Portugal declared a national disaster after the worst forest fires in more than two decades killed nine people, torched thousands of hectares of forest and destroyed homes in 2003.

## Longer term catastrophic effects if warming continues

- Greenland and Antarctic ice sheet melting. Unless checked, warming from emissions may trigger the irreversible meltdown of the Greenland ice sheet in the coming decades, which would add up to seven meters of sea-level rise, over some centuries; there is new evidence that the rate of ice discharge from parts of the Antarctic mean that it is also at risk of meltdown.
- The Atlantic Gulf Stream current slowing, shifting or shutting down, having dramatic effects in Europe, and disrupting the global ocean circulation system;
- Catastrophic releases of methane from the oceans leading to rapid increases in methane in the atmosphere and consequent warming.

Never before has humanity been forced to grapple with such an immense environmental crisis. If we do not take urgent and immediate action to stop global warming, the damage could become irreversible.

Greenpeace briefing paper: IPCC's Third Assessment Report (pdf)

World Bank, Pentagon: global warming red alert

[redacted]

### The problems...

- › Climate Impacts Topic
- › Coal Topic
- › Rainforest destruction Background

### ... and the solutions.

- › Climate science Topic
- › Energy [R]evolution Topic
- › Making IT industry climate leaders Topic

**NASA** http://climate.nasa.gov/keyIndicators/index.cfm#co2

National Aeronautics and Space Administration

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# GLOBAL CLIMATE CHANGE

Vital Signs of the Planet

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## KEY INDICATORS

CARBON DIOXIDE CONCENTRATION | GLOBAL SURFACE TEMPERATURE | ARCTIC SEA ICE | LAND ICE | SEA LEVEL

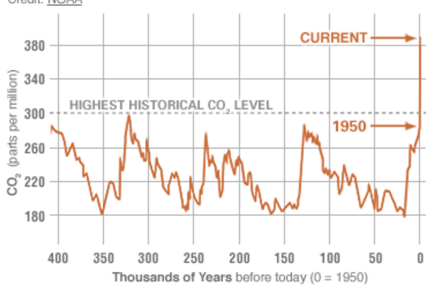
# Carbon Dioxide Concentration

download data

Data updated 5.12.11

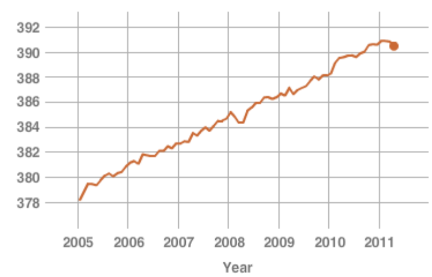
### PROXY (INDIRECT) MEASUREMENTS

Data source: Reconstruction from ice cores.
Credit: NOAA




### DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (corrected for average seasonal cycle) - - Credit: NOAA




### WHAT DOES THIS MEAN?

Carbon dioxide ($CO_2$) is an important greenhouse gas released through natural processes such as respiration and volcano eruptions and through human activities such as deforestation and burning fossil fuels. The chart on the left shows the $CO_2$ levels in the Earth's atmosphere during the last three glacial cycles, as reconstructed from ice cores. The chart on the right shows $CO_2$ levels in recent years, corrected for average seasonal cycles.

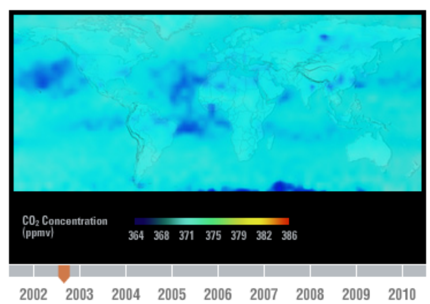
The time series at right shows global distribution and variation of the concentration of mid-tropospheric carbon dioxide in parts per million (ppmv) at an altitude range of 3-13 km (1.9 to 8 miles).

**NASA missions that help monitor CO2:**
**AIRS • Orbiting Carbon Observatory (launch 2013)**

### TIME SERIES: 2002-2009

Data source: (Atmospheric Infrared Sounder) AIRS
Credit: NASA

SEPTEMBER
2002



# Temperature Changes

Surface Temperature Change | Tropospheric Temperature Change | Stratospheric Temperature Change | Recent Scientific Developments

Temperatures are changing in the lower atmosphere - from the Earth's surface all the way through the stratosphere (9-14 miles above the Earth's surface). Scientists are working to document temperature trends and determine their causes.

## Surface Temperature Change

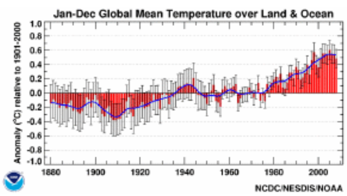



*Figure 1: Annual Average Global Surface Temperature Anomalies 1880-2008. Courtesy NOAA (Surface temperature records such as the one shown here have been quality controlled to remove the effects of urbanization at observing stations in and around cities).*
*Click on Thumbnail for full size image.*

Records from land stations and ships indicate that the global mean surface temperature warmed by about 0.9°F since 1880 (see Figure 1). These records indicate a near level trend in temperatures from 1880 to about 1910, a rise to 1945, a slight decline to about 1975, and a rise to present (NRC, 2006). The Intergovernmental Panel on Climate Change (IPCC) concluded in 2007 that warming of the climate system is now "unequivocal," based on observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007).

According to the National Oceanic and Atmospheric Administration's (NOAA) 2008 State of the Climate Report and the National Aeronautics and Space Administration's (NASA) 2008 Surface Temperature Analysis:

- Since the mid 1970s, the average surface temperature has warmed about 1°F.
- The Earth's surface is currently warming at a rate of about 0.29°F/decade or 2.9°F/century.
- The eight warmest years on record (since 1880) have all occurred since 2001, with the warmest year being 2005.

Additionally (from IPCC, 2007):

- The warming trend is seen in both daily maximum and minimum temperatures, with minimum temperatures increasing at a faster rate than maximum temperatures.
- Land areas have tended to warm faster than ocean areas and the winter months have warmed faster than summer months.
- Widespread reductions in the number of days below freezing occurred during the latter half of the 20th century in the United States as well as most land areas of the Northern Hemisphere and areas of the Southern Hemisphere.
- Average temperatures in the Arctic have increased at almost twice the global rate in the past 100 years.

The IPCC has concluded that most of the observed warming in global average surface temperature that has occurred since the mid-20th century is very likely a result of human activities (IPCC, 2007). During the first half of the last century, there was likely less human impact on the observed warming, and natural variations, such as changes in the amount of radiation received from the sun, likely played a more significant role.

**Related Links**

- EPA: Future Temperature Changes
- USGCRP: Product 1.1 - Temperature Trends in the Lower Atmosphere Steps for Understanding and Reconciling Differences
- NASA: Global Institute for Space Studies Surface Temperature Observations
- NOAA 2008 State of the Climate

**United States Surface Temperature Trends**

Observations compiled by NOAA's National Climatic Data Center indicate that over the past century, temperatures rose across the contiguous United States at an average rate of 0.11°F per decade (1.1°F per century). Average temperatures rose at an increased rate of 0.56°F per decade from 1979 to 2005. The most recent eight-, nine-, and ten-year periods were the warmest on record.

Warming occurred throughout most of the U.S., with all but three of the eleven climate regions showing an increase of more than 1°F since 1901. The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**NWF http://www.nwf.org/Global-Warming/What-is-Global-Warming/Global-Warming-is-Happening-Now.aspx**

NATIONAL WILDLIFE FEDERATION

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# WHAT IS GLOBAL WARMING?

HOW GLOBAL WARMING IS IMPACTING POLAR BEARS >>

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  - Global Warming is Human Caused
  - Global Warming is Accelerating
  - Global Warming is Affecting Weather
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## Global Warming is Happening Now

No longer is global warming something only facing future generations. Changes to our climate are being documented all across the planet today. People, animals, and plants are already feeling the heat.

### Temperatures are increasing

The most striking evidence of a global warming trend is closely scrutinized data that show a relatively rapid and widespread increase in temperature during the past century. The 10 warmest years on record occurred during 1997-2008, according to NASA's Goddard Institute for Space Studies.

The rising temperatures observed since 1978 are particularly noteworthy because the rate of increase is so high and because, during the same period, the energy reaching the Earth from the Sun had been measured precisely enough to conclude that Earth's warming was not due to changes in the Sun.


### Sea levels are rising

Global sea level has increased by roughly 8 inches over the past century, and the rate of increase is accelerating. Global warming causes sea-level rise in two ways: (1) Ocean water is expanding as it warms. (2) Land-based ice in glaciers and ice sheets is melting.

Sea-level rise has been happening even faster than scientists anticipated a few years ago. If recent projections are accurate, 2-3ºF warming could bring about 3 feet of global sea-level rise by 2100, displacing approximately 56 million people in 84 developing countries around the world. Coastal habitats also face major changes as low-lying areas are inundated with saltwater.

### Sea ice is melting

Declining sea ice is one of the most visible signs of global warming on our planet. Since 1979, Arctic sea ice extent in September (when the annual minimum is reached) has declined by over 30 percent, according to the National Snow and Ice Data Center. The ice extent has been declining in other seasons, too. Despite slightly larger ice extents in 2009, recent observations indicated that the ice is thinner and much younger (less multiyear ice) than it used to be.

Covering an average of 9.6 million square miles, these areas of ice floating on ocean waters play an important role in regulating our climate, by reflecting some sunlight back to space, and in the life cycles of many polar species, such as polar bears, seals, and walruses.

**Take Action**


**Stop the Attack on Wildlife**

Our nation's most important wildlife conservation laws are under attack. **Speak Up TODAY >>**

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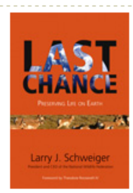
  June 07, 2011 01:32:56 pm
- Tar Sands – EPA Says State Dept Did Inadequate Risk Review
  June 07, 2011 11:40:11 am




**Last Chance: Preserving Life on Earth** Written by National Wildlife Federation president Larry Schweiger, it



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**UCS** http://www.ucsusa.org/global_warming/

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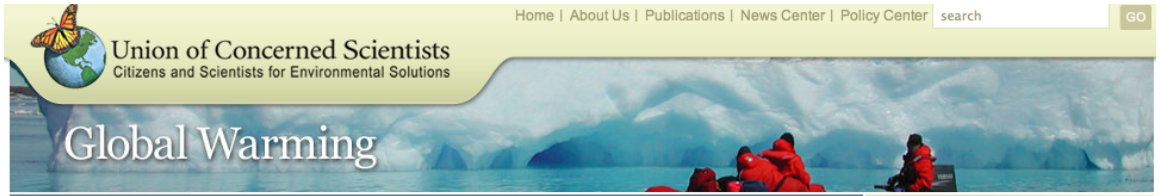


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## Global Warming

**The Earth is warming** and human activity is the primary cause. Climate disruptions put **our food and water supply** at risk, endanger **our health**, jeopardize **our national security**, and threaten other **basic human needs**. Some impacts—such as record high temperatures, melting glaciers, and severe flooding and droughts—are already becoming increasingly common across the country and around the world. So far, our national leaders are failing to act quickly to reduce heat-trapping emissions.

However, there is much we can do to **protect the health and economic well-being of current and future generations from the consequences of the heat-trapping emissions** caused when we burn coal, oil, and gas to generate electricity, drive our cars, and fuel our businesses.

**Our country is at a crossroads:** the United States can act responsibly and **seize the opportunity to lead** by developing new, innovative solutions, as well as immediately putting to use the many practical solutions we have at our disposal today; or we can choose to do nothing and deal with severe consequences later. At UCS we believe the choice is clear. **It is time to push forward toward a brighter, cleaner future.**

### What is Global Warming?

When CO2 and other heat-trapping emissions are released into the air, they act like a blanket, holding heat in our atmosphere and warming the planet. Overloading our atmosphere with carbon has far-reaching effects for people everywhere. Learn more

**Highlights**

- Attack on the Clean Air Act
- Steps the EPA Must Take to Reduce Global Warming Emissions
- **Campaign:** The Weight of the Evidence
- **Analysis:** *Climate 2030: A National Blueprint for a Clean Energy Economy*

### Global Warming Science & Impacts

What does the science say about global warming and what are the connections between climate data and the changes we see around us—and those we expect to see in the future? Learn more

### Global Warming Contrarians

Why has it been so difficult to achieve meaningful solutions? Media pundits, partisan think tanks, and special interest groups funded by fossil fuel and related industries raise doubts about the truth of global warming. These deniers downplay and distort the evidence of climate change, demand policies that allow industries to continue polluting, and attempt to undercut existing pollution standards. UCS fights misrepresentations of global warming, providing sound, science-based evidence to set the record straight. Learn more

**YOU *can* HELP**

**Use Best Available Technologies to Curb Global Warming**

Urge your governor to protect the public's health and the environment by ensuring that polluting facilities use the best available technologies to cut global warming emissions.

GET INVOLVED

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- Attack on the Clean Air Act
- The Clean Air Act
- California's Proposition 23 - The Dirty Energy Proposition


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# The SUPER Science-Source Sleuth

Use the criteria in the first column to investigate the website. Use the space in the second column to record your clues.

| Criteria | Notes |
|---|---|
| Language<br>• Errors in spelling and/or grammar<br>• positive/negative<br>• reasonable/sensationalist<br>• scientific terms/“buzz” words | |
| Graphics<br>• readable<br>• labeled<br>• source identified<br>• data quality documented<br>• content explained | |
| Factual statements<br>• referenced<br>• verifiable | |
| Opinion statements<br>• identified as opinion, not stated as fact | |
| Author and affiliations<br>• identified<br>• credible | |
| Presentation<br>• appealing design<br>• logical organization | |
| Usefulness<br>• addresses topic<br>• comprehensive/superficial<br>• appropriate for audience<br>• links provided and functioning | |
| Currency<br>• recency<br>• frequency of updates | |


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# The SUPER Science-Source Sleuth

KEY: GREENPEACE SCREEN SHOT

Use the criteria in the first column to investigate the website. Use the space in the second column to record your clues.

| Criteria | Notes |
|---|---|
| Language<br>• Errors in spelling and/or grammar<br>• positive/negative<br>• reasonable/sensationalist<br>• scientific terms/"buzz" words | • Negative (people are already struggling; experiencing dangerous climate change; need to act to avoid catastrophic climate change)<br>• Sensationalist (Never before has humanity been forced to grapple with such an immense environmental crisis. If we do not take urgent and immediate action to stop global warming, the damage could be irreversible.)<br>• Buzz words: meltdown, catastrophic |
| Graphics<br>• readable<br>• labeled<br>• source identified<br>• data quality documented<br>• content explained | • Images clear<br>• NA<br>• Yes (Greenpeace)<br>• NA<br>• Yes (however, not clear that the occurrences are related to climate change, using weather events to imply climate change) |
| Factual statements<br>• referenced<br>• verifiable | • No references<br>• Yes, some are (thawing permafrost, rising sea level) |
| Opinion statements<br>• identified as opinion, not stated as fact | • All are stated as fact. |
| Author and affiliations<br>• identified<br>• credible | • No<br>• NA |
| Presentation<br>• appealing design<br>• logical organization | • Somewhat cluttered<br>• Yes |
| Usefulness<br>• addresses topic<br>• comprehensive/superficial<br>• appropriate for audience<br>• links provided and functioning | • Yes, in their view<br>• Covers a number of topics, but lacks scientific depth<br>• Not for those looking for factual information on climate/climate change<br>• IPCC's Third Assessment Report<br>• World Bank, Pentagon "global warming red alert" |
| Currency<br>• recency<br>• frequency of updates | • Referencing IPCC's 3rd assessment report (4th was published in 2007), photographs not dated<br>• Not provided |


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# The SUPER Science-Source Sleuth

KEY: NASA SCREEN SHOT

Use the criteria in the first column to investigate the website. Use the space in the second column to record your clues.

| Criteria | Notes |
|---|---|
| Language<br>• Errors in spelling and/or grammar<br>• positive/negative<br>• reasonable/sensationalist<br>• scientific terms/"buzz" words | • No<br>• Positive<br>• Reasonable<br>• Scientific terms ($CO_2$, units defined) |
| Graphics<br>• readable<br>• labeled<br>• source identified<br>• data quality documented<br>• content explained | • Yes<br>• Yes<br>• Yes<br>• Yes for some (right top graph)<br>• Yes |
| Factual statements<br>• referenced<br>• verifiable | • Yes<br>• Yes, can go to credited source or other source that would support science presented |
| Opinion statements<br>• identified as opinion, not stated as fact | • None present |
| Author and affiliations<br>• identified<br>• credible | • No author; affiliation for site is clear<br>• NA for author; yes for affiliation |
| Presentation<br>• appealing design<br>• logical organization | • Yes, very sharp layout<br>• Yes, topics easy to find, good menus, etc. |
| Usefulness<br>• addresses topic<br>• comprehensive/superficial<br>• appropriate for audience<br>• links provided and functioning | • Yes<br>• Yes, actual observations presented, defined, and downloadable<br>• Yes<br>• Yes |
| Currency<br>• recency<br>• frequency of updates | • Yes, data present up through early 2011<br>• Updated 5.12.11 |


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# The SUPER Science-Source Sleuth

KEY: EPA SCREEN SHOT

Use the criteria in the first column to investigate the website. Use the space in the second column to record your clues.

| Criteria | Notes |
|---|---|
| Language<br>• errors in spelling and/or grammar<br>• positive/negative<br>• reasonable/sensationalist<br>• scientific terms/"buzz" words | • Minimal<br>• Positive<br>• Reasonable<br>• Scientific terms (units specified, anomalies, trends, other statistical terms |
| Graphics<br>• readable<br>• labeled<br>• source identified<br>• data quality documented<br>• content explained | • Small graphic, but can be enlarged<br>• Clearly labeled<br>• Yes<br>• Yes<br>• Yes |
| Factual statements<br>• referenced<br>• verifiable | • Yes (IPCC, NOAA, NRC)<br>• Yes |
| Opinion statements<br>• identified as opinion, not stated as fact | • Some presented as fact (e.g. last sentence) |
| Author and affiliations<br>• identified<br>• credible | • Author no, affiliation yes<br>• Author NA, affiliation yes |
| Presentation<br>• appealing design<br>• logical organization | • No. Very cluttered, sidebars overlay other text, text wrap issues<br>• Flow hard to follow. On first glance, hard to decide where to focus attention. |
| Usefulness<br>• addresses topic<br>• comprehensive/superficial<br>• appropriate for audience<br>• links provided and functioning | • Yes<br>• Comprehensive (lots of stats)<br>• Yes<br>• Yes |
| Currency<br>• recency<br>• frequency of updates | • Pretty good, refers to latest reports, trend graph slightly outdated (thru 2008)<br>• NA – partial screen shot |


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# The SUPER Science-Source Sleuth

KEY: NWF SCREEN SHOT

Use the criteria in the first column to investigate the website.   Use the space in the second column to record your clues.

| Criteria | Notes |
|---|---|
| Language<br>• errors in spelling and/or grammar<br>• positive/negative<br>• reasonable/sensationalist<br>• scientific terms/“buzz” words | • No<br>• Negative (headings, menu bar text)<br>• Sensationalist, hyped<br>• Scientific (units, sea level rise) |
| Graphics<br>• readable<br>• labeled<br>• source identified<br>• data quality documented<br>• content explained | • NA (image is clear)<br>• No<br>• Yes, photographer named<br>• NA<br>• No (polar bears appear to be struggling, contributing to sensationalist tone) |
| Factual statements<br>• referenced<br>• verifiable | • Two are referenced<br>• Not guaranteed (10 warmest years on record did not occur from 1997-2008). Also what record are they referring to? Surface temperatures? Top of atmosphere temperatures? |
| Opinion statements<br>• identified as opinion, not stated as fact | • Yes, opinions related to Sun’s radiation effect on the Earth are still under debate in the scientific community. |
| Author and affiliations<br>• identified<br>• credible | • Author no, affiliation yes<br>• Author NA, affiliation questionable due to clear agenda, sensationalism |
| Presentation<br>• appealing design<br>• logical organization | • Yes<br>• Yes |
| Usefulness<br>• addresses topic<br>• comprehensive/superficial<br>• appropriate for audience<br>• links provided and functioning | • Yes<br>• No (statements made out of context, no direct references to allow verification)<br>• Not as a scientific source of information<br>• Yes |
| Currency<br>• recency<br>• frequency of updates | • 2008/2009 the most recent dates on site<br>• No info provided |


Developed with funds from NASA Innovations in Climate Education Grant NNX10AB61A

# The SUPER Science-Source Sleuth

KEY: UCS SCREEN SHOT

Use the criteria in the first column to investigate the website. Use the space in the second column to record your clues.

| Criteria | Notes |
|---|---|
| Language<br>• errors in spelling and/or grammar<br>• positive/negative<br>• reasonable/sensationalist<br>• scientific terms/"buzz" words | • No<br>• Negative<br>• Sensationalist<br>• Buzz words (at a crossroads),<br>• Some science terms |
| Graphics<br>• readable<br>• labeled<br>• source identified<br>• data quality documented<br>• content explained | • Image is clear<br>• No<br>• No<br>• NA<br>• No (photo of mom, little girl, baby, and dog gazing at "global warming in action" adds to sensationalist tone) |
| Factual statements<br>• referenced<br>• verifiable | • No (not in links)<br>• Some. Human activity being primary cause is in the IPCC4 report. |
| Opinion statements<br>• identified as opinion, not stated as fact | • By very name, the UCS implies that they are objective (like a political action committee); others "jeopardize our national security" |
| Author and affiliations<br>• identified<br>• credible | • No author, Yes affiliation<br>• No. Sensationalist/alarmist tone. They rely on their name to make you believe they are credible |
| Presentation<br>• appealing design<br>• logical organization | • Okay, but erratic use of bold text is distracting and ineffective<br>• Yes |
| Usefulness<br>• addresses topic<br>• comprehensive/superficial<br>• appropriate for audience<br>• links provided and functioning | • Not really. Few scientific facts even provided<br>• Superficial – discussion of $CO_2$ emissions<br>• No<br>• Yes, but links are all internal to page (not to outside sources) |
| Currency<br>• recency<br>• frequency of updates | • Unable to judge. No dates of any kind provided in materials. Note: 2010 copyright at bottom of actual page)<br>• Not provided. |


Developed with funds from NASA Innovations in Climate Education Grant NNX10AB61A

# Weather vs. Climate

Southeast Climate
EXTENSION | Advancing Climate Extension in Agriculture
USDA United States Department of Agriculture
National Institute of Food and Agriculture

# Activity: Weather vs. Climate

**Objective**: Participants will develop criteria for differentiating between weather and climate and use their criteria to compose definitions of the terms *weather* and *climate*.

**Materials**: Whiteboard

Facilitator prepares weather and climate event cards from the content detailed in the chart that follows. For each group of 3-5 participants, prepare 10 cards—5 containing weather events and 5 containing climate events. There will be overlap in assigned cards, but develop the sets such that no two groups receive an identical *set* of cards. Each card will be printed with one weather or climate event on one side but will not be labeled “weather” or “climate.” A description, explanation, definition, or example will be printed on the other side to help facilitate understanding of the events.

**Procedure**:

- Divide the large group into groups of 3-5 participants.
- Give each group a set of cards, prepared as described above using the content that follows.
- Ask each group to examine the contents of each card and determine whether the event is a climate event or a weather event. Advise the groups to keep the cards visible as they sort to help them discern consistencies in the categories. Ask them to look for similarities across the descriptions on the cards and to develop criteria for distinguishing between climate and weather as they sort.
- Ask each group to write a definition of weather and a definition of climate based on their criteria.
- Ask one group to present their definition of weather. Write the definition on the whiteboard. Ask other groups if they have additions or changes to make to the definition.
- Ask another group to present their definition of climate. Repeat the procedure to arrive at a definition of climate.

**Prompts**:

- How did you determine the classifications of “weather” and “climate”?
- How did you consider time?
- How did you consider space?
- Which concepts were the most troublesome to categorize?
- Do the events on the cards act in one or more of Earth’s spheres?

**Facilitator Notes:**

- Weather is typically an event.
- Weather events typically last less than a day; however, some weather events can remain over a region for more than a week.
- Weather is defined as short-term variations in the atmosphere (minutes to days).
- A snow pack is a long-term total accumulation and hence climate; day-to-day changes in the snow pack would be weather.
- Climate is an outcome or statistic based on many events.
- Climate is typically on seasonal or longer scales.
- Climate is defined as the distribution of weather events over time (period of months or more).
- The definition of climate is evolutionary.
- Climate can be applied to any spatial scale (e.g., from a weather station to a global statistic).


Developed with funds from NASA Innovations in Climate Education Grant NNX10AB61A

## Content for Sorting Cards

| Weather Cards | |
|---|---|
| Event (side one) | Description, Explanation, Definition, or Example (side two) |
| Hurricane | A hurricane making landfall along the West Coast of Florida at 2:00 p.m. on Saturday |
| Thunderstorm | An afternoon thunderstorm |
| Sea Breeze | Onset of the sea breeze over land during the afternoon |
| Heat Wave | A heat wave in New York City lasting four days |
| Freeze | An overnight freeze that damages orange crops in central Florida |
| Cold Front | A cold front, or boundary between two types of air masses with different characteristics (i.e., temperature, humidity), passing through the Tampa Bay area during the afternoon, with temperatures falling from the 90s in the morning to the 60s in the evening |
| Tornado | A tornado staying on the ground for four hours and tracking 180 miles |
| Clear Sky | A clear nighttime sky in the summer |
| Fog | An overnight fog |
| Dust Storm | A dust storm that crosses the Sahara Desert over the course of three days |

| Climate Cards | |
|---|---|
| Event (side one) | Description, Explanation, Definition, or Example (side two) |
| Drought | The drought associated with the Great Dust Bowl in the 1930s (an extended period during which there is an extreme deficit in precipitation) |
| ENSO | A year-to-year variation in sea surface temperature and winds observed in the tropical Pacific Ocean roughly every four to six years |
| Ice Age | A geological period during which Earth exhibited a reduced global temperature and an increased presence of large glaciers and ice sheets |
| Snowpack | Accumulated snowfall on the ground over a given month or season; term typically used in alpine regions |
| Monsoon | A seasonal pattern of changes in the atmospheric circulation patterns (wind patterns) and precipitation |
| Bermuda High | A large, semi-permanent pressure pattern located over the tropical center of the Atlantic Ocean |
| Seasons | Typically a three-month period: spring, summer, winter, and fall |
| Annual Rainfall | The amount of precipitation measured over the course of a year |
| Decadal Increase in $CO_2$ | $CO_2$ concentration in the atmosphere, measured in Hawaii, has exhibited an increasing trend over the past several decades |
| Polar Ice Cap | The area and volume of sea ice in the Arctic region vary from year to year |


Developed with funds from NASA Innovations in Climate Education Grant NNX10AB61A

| | | |
|---|---|---|
| Hurricane | Heat Wave | Tornado |
| Thunderstorm | Freeze | Clear Sky |
| Sea Breeze | Cold Front | Fog |

A tornado staying on the ground for four hours and tracking 180 miles

A heat wave in New York City lasting four days

A hurricane making landfall along the West Coast of Florida at 2:00 p.m. on Saturday

A clear nighttime sky in the summer

An overnight freeze that damages orange crops in central Florida

An afternoon thunderstorm

An overnight fog

A cold front, or boundary between two types of air masses with different characteristics (i.e., temperature, humidity), passing through the Tampa Bay area during the afternoon, with temperatures falling from the 90s in the morning to the 60s in the evening

Onset of a sea breeze over land during the afternoon

Dust Storm

Ice Age

Bermuda High

Drought

Snowpack

Seasons

ENSO

Monsoon

Annual Rainfall

A large, semi-permanent pressure pattern located over the tropical center of the Atlantic Ocean

Typically a three-month period: spring, summer, winter, and fall

The amount of precipitation measured over the course of a year

A geological period during which the Earth exhibited a reduced global temperature and an increased presence of large glaciers and ice sheets

Accumulated snowfall on the ground over a given month or season; term typically used in alpine regions

A seasonal pattern of changes in the atmospheric circulation patterns (wind patterns) and precipitation

A dust storm that crosses the Sahara Desert over the course of three days

The drought associated with the Great Dust Bowl in the 1930s (an extended period during which there is an extreme deficit in precipitation)

A year-to-year variation in sea surface temperature and winds observed in the tropical Pacific Ocean roughly every four to seven years

Decadal Increase in $CO_2$

Polar Ice Cap

$CO_2$ concentration in the atmosphere, measured in Hawaii, has exhibited an increasing trend over the past several decades

The area and volume of sea ice in the Arctic region vary from year to year

# Antarctica's Climate Secrets Flexhibit Lesson Plans, Activity 4A

Southeast Climate EXTENSION | Advancing Climate Extension in Agriculture

USDA United States Department of Agriculture National Institute of Food and Agriculture

# Tiny Clues to Antarctica's Past

## Life at the bottom of the marine food chain

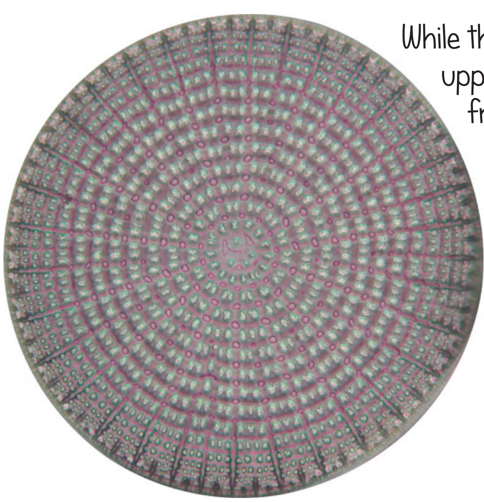
**Diatoms** are one of the most abundant organisms in the world: these single-celled algae live wherever they have access to both moisture and sunlight. Individual diatoms are too small to be seen except under powerful microscopes. However, the number of diatoms in one area of the ocean sometimes gets so large that cameras on Earth-orbiting satellites can see them. Diatoms are one group of a larger set of organisms called **phytoplankton**.

Diatoms are extremely important for wildlife in Antarctica because they form the base of the food chain. Small shrimp-like animals called **krill** eat diatoms, and just about everything else in the Southern Ocean eats krill!

*Krill eat diatoms. As the diatoms pass through a krill's digestive system, large numbers of them get "packaged" into fecal pellets that settle to the ocean floor. Diatoms' cell walls are made of glass, so they aren't damaged by passing through a krill.*

## Diatoms' glassy skeletons

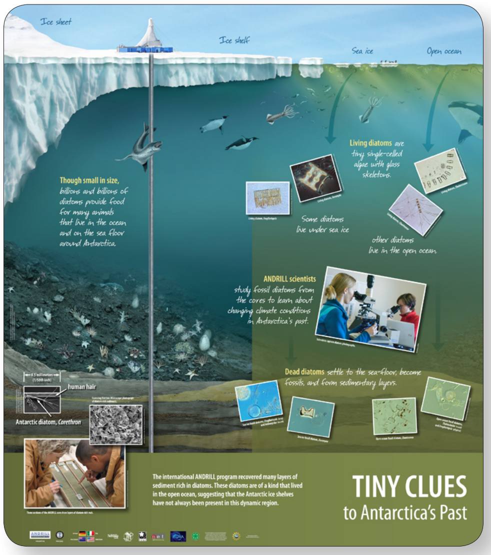
Like any type of organism that gets its energy from the sun, diatoms have cell walls to protect their insides. Diatoms extract silica – the material you know as glass – from the water around them and use it to build their cell walls. These rigid cell walls can be thought of as glass "skeletons." Each species of diatom has a unique structure for its skeleton. Many of the patterns are complex and beautiful. These unique patterns make it possible for scientists who study them to identify diatom species from small fragments of their cell walls.



George Swann

While they are alive, marine diatoms float in the uppermost layers of the ocean, using energy from sunlight for photosynthesis. After diatoms die or pass through the digestive system of a krill, their skeletons sink to the seafloor. There, they might remain whole, they might be crushed by other sediments, or they might be ground into bits by the friction from an ice sheet moving over them.

## Unit 4 Banner




Explore and discuss the *Tiny Clues to Antarctica's Past* banner. Electronic versions of the banners are available at **http://www.andrill.org/flexhibit.**

## Unit 4 Podcasts

The following short videos complement this unit. They can be viewed or downloaded from **http://www.andrill.org/flexhibit**.

- Diatom Tour
- Microorganism Tour

## Activities in this unit. . .



Prepare four artificial rock cores using glass seed beads as model diatoms. Sample the cores and decipher the diatoms' stories to infer the rock's history.



Use buttons to represent forms of diatoms that grow in chains. Sample a core and count the different forms to illustrate how they indicate the presence or absence of sea ice.

# Dead Diatoms Do Tell Tales!

You probably already know that scientists who study fossils are called **paleontologists**. Though some paleontologists study large fossils such as dinosaur bones or ancient seashells, many examine tiny fossils that can only be seen under a microscope. These scientists are called **micropaleontologists**, and diatom skeletons are one of the kinds of fossils they study.

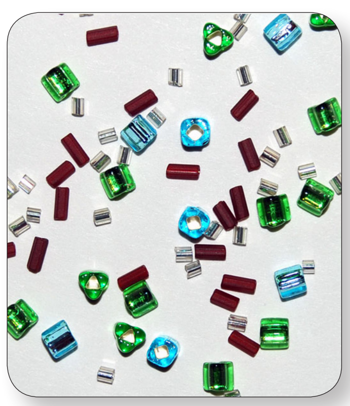
Scientists who study past environments are pleased when they discover fossil diatoms in their sedimentary rock samples. The types, numbers, and conditions of diatom skeletons tell something about the environment that existed when they were deposited. Diatom species that lived for relatively short time spans can also provide important clues about the age of sediments.

## Preview

In this activity, you'll use glass seed beads to represent fossil diatom skeletons. Like diatoms, seed beads are small, and both items are made of glass. You'll prepare four artificial rock cores with sediments and seed beads. Once the cores are prepared, you and others will take samples of the sediments and use a magnifying glass to find and identify the model diatoms. Just as micropaleontologists do, you'll separate the "diatoms" from the rocks, check to see if they've been broken or crushed, and identify the species they represent. You'll read the dead diatoms' tales to infer what type of environment existed when they died.

### Three Environments that Preserve Fossil Diatoms

After diatoms die, their skeletons sink and accumulate on the ocean floor. If this happens in an ice-free **open ocean**, most of the skeletons remain whole and unbroken, even after they are buried by other layers and compressed into rock. During times that Earth's climate is cooler, **ice sheets** expand off the continent over the former seafloor. The motion of ice and rocks grinding over diatoms crushes them into small fragments. Under an **ice shelf**, broken diatoms from the base of the ice sheet are deposited in layers with other sediments.



*Different colors of glass seed beads represent different diatom species.*

## Time

- 2–3 hours

## Tools & Materials

- Core Log Sheet (page 155)
- Clear plastic fluorescent bulb guard (two 10-inch pieces split in half lengthwise)
- Duct tape
- Coarse sand (3 cups)
- Dark sand (¼ cup)
- White sand (¼ cup)
- Orange or red sand (¼ cup)
- Gravel (15-20 pieces)
- Four different colors of glass seed beads (1½ teaspoons each)
- Heavy-duty plastic zipper-style bags (4)
- Paper plates (6)
- Magnifying glasses (2-3)
- Craft sticks (4)
- Fine-tipped paintbrushes (2-3)
- Clear-drying white glue
- Permanent marker
- Scissors
- Hammer
- Safety glasses or goggles
- Colored markers
- Large sheet of construction paper or poster board

- Items found in this book
- Items included in the Flexhibit Kit, available from **http://www.andrill.org/flexhibit.**
- + Additional items

# Prepare

## Part 1 – Break some beads!

Diatom skeletons can be broken apart in nature. Glass beads can also be broken — with a hammer!

1. Assign each of your four colors of beads to one of the four diatom names below. Read the pronunciations aloud to learn how to say their names. Write the color of bead you'll use to represent each type of diatom on this chart.

| Diatom Name | Pronunciation | Bead Color |
|---|---|---|
| *Thalassiosira* | thuh-**lass**-ee-oh-seer-uh | |
| *Chaetoceros* | ka-**tah**-seer-us | |
| *Fragilariopsis curta* | frah-jill-airy-**op**-sis **ker**-tuh | |
| *Fragilariopsis* species | frah-jill-airy-**op**-sis | |

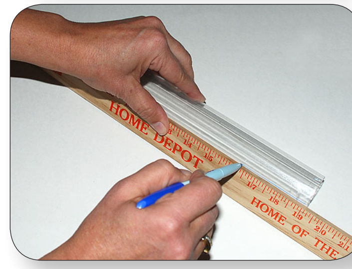
2. Put your *Thalassiosira* beads in a heavy zipper-type plastic bag.
3. Lay the bag on a hard surface such as a concrete floor or sidewalk. Shake it gently to spread the beads into a single layer.
4. Put on safety glasses or goggles to protect your eyes.

5. Tap the hammer on about two-thirds of the beads, so that many (but not all) of them are broken.
6. Pour the contents of the bag onto a paper plate. Shake the plate gently to help separate the bead fragments by size.
7. View the beads with a magnifying glass. Use a fine-tipped paintbrush to sort the pieces into three piles: whole beads, large pieces, and small fragments. Your sorting doesn't need to be perfect, just good. You should end up with about the same amount of each of the three sizes. If necessary, return some of the whole beads to the plastic bag to break more of them.

8. Repeat this breaking and sorting process two more times, once each for your *Chaetoceros* and *Fragilariopsis curta* beads.
9. For your *Fragilariopsis* species beads, only tap the hammer on about one-quarter of the beads so you keep most of them whole. Use gentle shaking and the paintbrush to separate them on their paper plate into the three sizes.

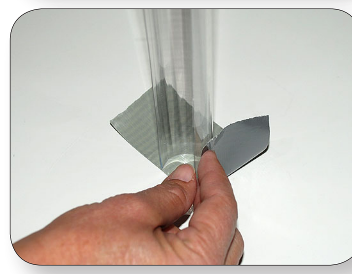
## Part 2 – Prepare a key to your model diatoms

1. Prepare a page-sized piece of poster board or construction paper with a chart like this.

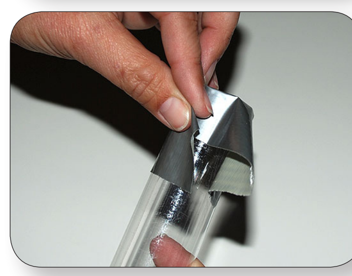



| Example of Beads | Diatom Name | Pronunciation | Environment where they lived |
|---|---|---|---|
| | *Thalassiosira* | thuh-**lass**-ee-oh-seer-uh | Open ocean |
| | *Chaetoceros* | ka-**tah**-seer-us | Open open |
| | *Fragilaropsis curta* | frah-jill-airy-**op**-sis **ker**-tuh | Sea ice |
| | *Fragilariopsis* species | frah-jill-airy-**op**-sis **spee**-sees | Open ocean |

2. Glue two or three of the beads that represent each type of diatom into the **Example of Beads** column and set the chart aside to dry
3. Prepare another page-sized chart like this.



| Condition of Beads | Relative Number of Beads | Depositional Environment |
|---|---|---|
| Whole | Many | Open Ocean |
| Broken | Some | Under an Ice Shelf |
| Crushed | Few | Under an Ice Sheet |



## Part 3 – Prepare holders for four artificial rock cores

1. Cut two 10-inch lengths of the clear plastic tube.
2. Use a ruler to mark two straight lines, on opposite sides, along the length of each tube.
3. Cut each tube in half lengthwise. You will end up with four half-cylinders.

4. Use eight 4-inch pieces of duct tape to close both ends of the half-cylinders as shown in the photos.
5. Using a permanent marker, label the duct tape at one end of the holder as the TOP of the core and the other end as the BOTTOM.
6. Add an additional piece of duct tape to the side of each core holder to label them as Core 1, Core 2, Core 3, and Core 4.

### Which way is "UP"?

When working with rock cores, the standard practice is to always keep the TOP of the core to the left. That way, everyone knows that the older rock is at the right end (BOTTOM) of the core and the rock gets younger as you move to the left.

## Part 4 – Make some model cores

### Preparing the sand

1. Add just enough water to your sand so it sticks together — you want a consistency like what you'd use for building sand castles.
2. Add moist sand along the length of all four core holders so each trough is about ½ to ⅔ full. Press the sand gently to make a flat surface.

### Making Core 1

1. Take about one-quarter of each color of the **Crushed** bead fragments and sprinkle them along the surface of the sand.
2. Smooth the surface gently so that most of the bead fragments are covered but are still within the top several grains of the surface.
3. Put 8-10 pieces of gravel on the core's surface. Press them flat into the sand so the surface looks like a cut core.

### Making Core 2

1. Use a spoon to move some of the sand in the core holder out of the way. (Anywhere along the length of the core is fine.) Add a spoonful or two of another color of sand to make a new layer that crosses the core from side to side. Repeat this process two or three times to give this core a layered appearance.
2. Sprinkle about half of the **Broken** bead fragments of the four species in separate horizontal layers across the surface of this core. Add about half of the remaining **Crushed** bead fragments to this core as well.
3. Smooth the surface gently so that the bead fragments are covered by sand but are still within the top several grains of the surface.

4. Add 2-3 small pieces of gravel along the bottom of the layers you made and press them flat into the sand. These represent the larger rocks that settled first after an underwater landslide.

### Making Core 3

1. Make a thick horizontal layer of the **Whole** *Fragilariopsis species* beads crossing the surface of Core 3. Use about ¾ of your supply.
2. Sprinkle about ¾ of the **Whole** *Thalassiosira*, *Chaetoceros*, and *Fragilariopsis curta* beads in separate horizontal layers across the surface of the core.
3. Add about half of the remaining **Broken** beads and **Crushed** beads to the surface. This core surface should be almost covered with beads.

### Making Core 4

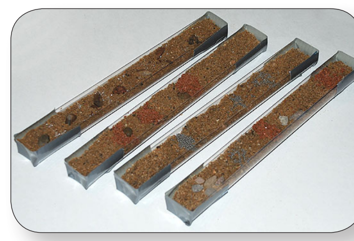
1. Sprinkle your remaining **Crushed** bead fragments along the surface of Core 4. Smooth the surface lightly and add 4-5 pieces of gravel to the bottom third of the core. Press them flat into the sand.
2. Add a thin layer or two of another color of sand across the middle third of the core. Sprinkle your remaining **Broken** bead pieces in separate horizontal layers across this section. Smooth the surface lightly and add two or three small pieces of gravel along the bottom of the sand layers.
3. Sprinkle your remaining **Whole** beads in separate layers across the top third of the core.

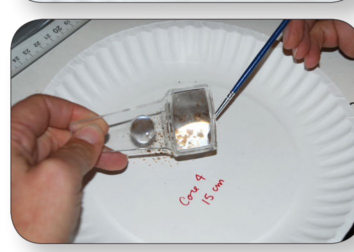
## Part 5 – Sample the cores

1. Place your prepared cores next to metric rulers. Line up the bottom of each core with the bottom of the ruler.
2. Choose a place in one of the four cores where you'll take a sample. Write the core number and the distance from the bottom of the core on a paper plate.
3. Use a craft stick to gather a small sample of sediments from the surface of the core. Gather enough to cover the bottom half-inch (1 cm) of the craft stick. Put the sediments on your paper plate.
4. Gently shake the plate or use a small paintbrush to spread the sample out. Use a magnifying glass to examine any diatoms you find.

### Studying diatoms

Micropaleontologists who study diatoms learn how to recognize different diatom species by the shape and patterns preserved in small fragments of their skeletons. You'll use color to help you recognize the model diatoms in the artificial cores you make.





5. Compare the diatoms you find in your sample to your two charts. Write the answers to the following questions directly onto your paper plate.
    - What types of diatoms did you find? What environment did those diatoms live in?
    - On the whole, how would you describe the number of diatoms in your sample – Many? Some? or Few?
    - In general, what condition are the diatoms in – Whole? Broken? or Crushed?
    - What environment would you infer was there when they were deposited – an ice sheet? an ice shelf? open ocean?
6. For samples from Core 4, transfer your data to the appropriate spot on the Core Log Sheet.

# Core Log Sheet

| Initials of Sampler | Distance from Bottom of core (cm) | Relative number of diatoms in sample (Many, Some, Few) | Condition of diatoms (Whole, Broken, or Crushed) | Environment in which diatoms were deposited |
|---|---|---|---|---|
| | 25 | | | |
| | 24 | | | |
| | 23 | | | |
| | 22 | | | |
| | 21 | | | |
| | 20 | | | |
| | 19 | | | |
| | 18 | | | |
| | 17 | | | |
| | 16 | | | |
| | 15 | | | |
| | 14 | | | |
| | 13 | | | |
| | 12 | | | |
| | 11 | | | |
| | 10 | | | |
| | 9 | | | |
| | 8 | | | |
| | 7 | | | |
| | 6 | | | |
| | 5 | | | |
| | 4 | | | |
| | 3 | | | |
| | 2 | | | |
| | 1 | | | |
| | 0 | | | |

# Ponder. . .

Once you've gathered the Core Log information for Core 4, use it to tell the tale of the changing depositional environment. Start your story at the time rocks at the bottom of the core were deposited. Describe the environments that existed through time to produce the sediments and diatoms you found in the core.

# Practice

## Got the Big Idea?

The types, numbers, and conditions of fossil diatoms found in rock cores are indicators of past environments.

## Check your core interpretations

**Core 1** – Samples of this core show very few diatoms among the sand grains. Of the diatoms that are present, most have been crushed into small fragments. Along with the mixed sizes of sediments, this indicates that this portion of the core was deposited beneath an ice sheet.

**The presence of none or a few diatom fragments tells that rocks were deposited under an ice sheet.**

**Core 2** – Samples from this layered core show a noticeable number of diatoms among the sand grains. Most of the diatoms are broken, indicating that an ice sheet moved over them at some point. Later, they were arranged in layers by underwater landslides that occur under an ice shelf.

**The presence of some diatoms that have been broken and deposited in layers tells that rocks were deposited under an ice shelf.**

**Core 3** – Samples of Core 3 contain many diatoms, and most of them are whole. The diatoms weren't exposed to grinding and friction, indicating that they were deposited in the open ocean.

**The presence of many diatoms that are whole tells that rocks were deposited in the open ocean.**

**Core 4** – This core represents rocks from unknown environments. Depending on the section you chose, these samples may represent any one of the environments described above.

## Get ready to present

Come up with an introductory comment or a question to invite people to look for model diatoms in the cores. Read over the unit introduction and the activity Preview to be sure you can give a simple explanation of what diatoms are. Consider which pictures or text on the "Tiny Clues" banner might help you explain your topic.

You may want to set up your station with samples from Cores 1, 2, and 3 already on paper plates. This will allow you to demonstrate the use of a magnifying glass to look for diatoms in the samples.

## Present

Tell visitors what diatoms are. Let visitors know that they can take a sample of the cores to look for model diatoms. When they find model diatoms in their sample, have them match what they found to the diatom key, then figure out what the condition of the diatoms tells. Some people may enjoy trying out the pronunciations of the different diatoms.

For visitors who are interested and engaged, you can tell the environmental history represented by diatoms in Core 4. Start at the bottom section of the core and tell its story, then move up to the next section, and so on. Point out that scientists (and you!) are anxious to learn how the rock record of Antarctica fits into global climate history.

# Tree Core Codes

Directions: Give each group a tree cookie. Ask them to look for evidence of flood or drought. Once the groups have analyzed their tree cookies, give them two paper strips that represent tree cores. Tell them that

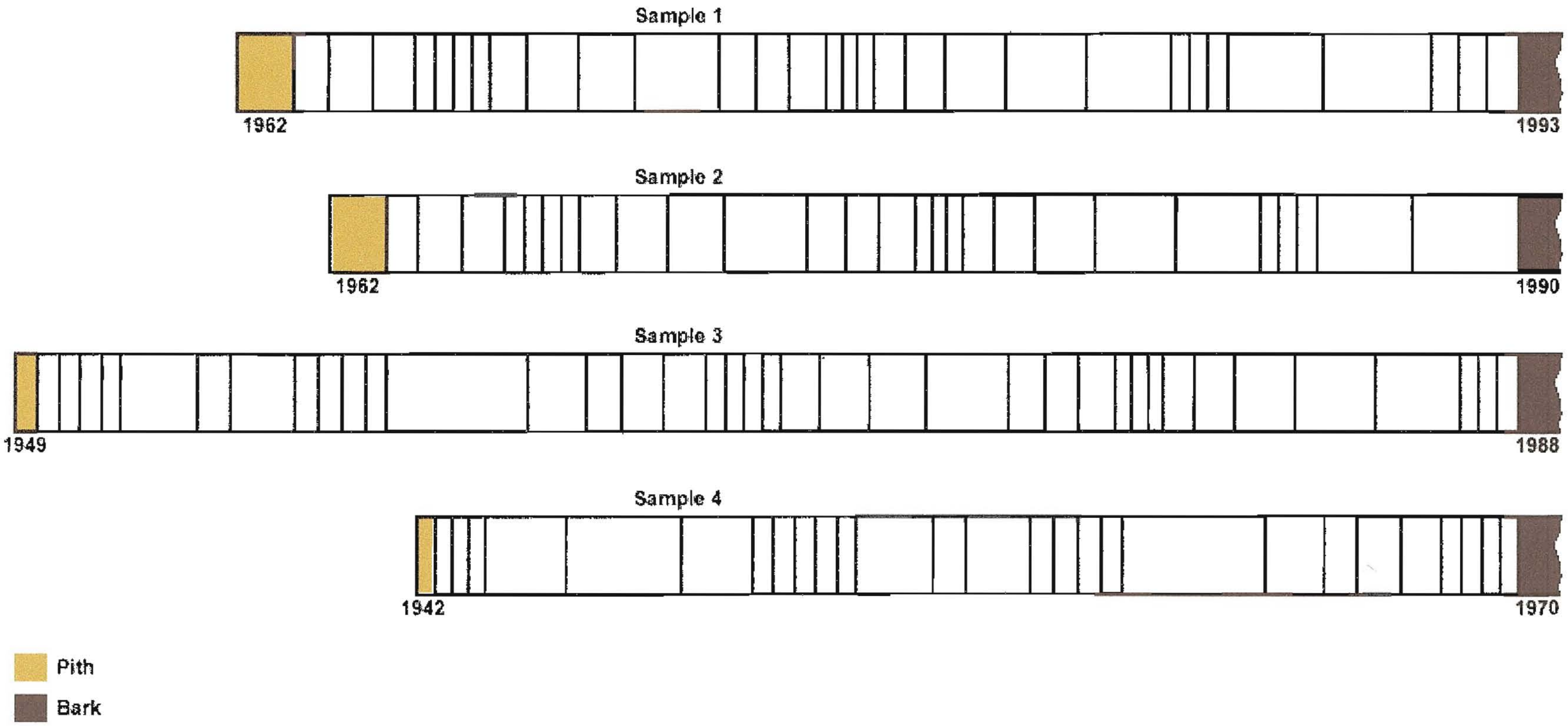
- sample 1 was taken from a living tree in July 1993,
- sample 2 was taken from a tree on a Christmas tree farm,
- sample 3 was taken from a log found in a nearby forest, and
- sample 4 was taken from a beam that was removed from the Camp Timpoochee Auditorium.

Ask them to determine the age of each tree (how many years it had been growing) by counting the rings, and then have them design a chart, such as the chart below, to record their answers.

| Sample | Age of tree | Year cut or cored | Year growth began |
|---|---|---|---|
| **1** | 31 years | 1993 | 1962 |
| **2** | 28 years | 1990 | 1962 |
| **3** | 39 years | 1988 | 1949 |
| **4** | 28 years | 1970 | 1942 |

Next, ask them if they notice any patterns. Try to line up their paper strips so that the patterns match. Ask them:

- What type of weather occurred in 1985? ***Dry or drought***
- What years were drought years? ***1942-45; 1949-53; 1957-60; 1966-69; 1977-79; 1985-87.*** Which years were wet or rainy years? ***1946-48; 1954; 1956; 1961-65; 1971-73; 1982-85; 1988-89.***
- Is it more important to sample trees that are older or younger? Why or why not? ***Older trees will provide data for a longer time frame and they will also provide data when there may not be any other rainfall data for that year in that location. Typically, a combination of both older and younger trees is preferred to help match datasets.***


Sample 1
1962
1993
Sample 2
1962
1990
Sample 3
1949
1988
Sample 4
1942
1970
Pith
Bark

# Make Your Own El Niño in the Classroom

Adapted from http://sealevel.jpl.nasa.gov/files/archive/make-your-own-el-nino.html

Purpose: Hands-on demonstration of the El Niño effect, trade winds, and upwelling

Materials:

- Clear plastic oblong container (approximately 18"x4"x4"; smaller will work; food containers are ideal)
- Water
- Baby oil (enough to create a ¼- to ½-inch layer in the container)
- Blue food coloring
- Hair dryer
- Red oil-based paint (optional)
- Pacific Ocean map

Set-up time: Less than 5 minutes

Preparation:

- Fill the container with water to within 1 inch of the top.
- Add 2-3 drops of blue food coloring to the water to create the "ocean." (Some of the food coloring will settle to the bottom, which is fine because this will show the upwelling.)
- If using the red oil-based paint, mix it with the baby oil in a bowl until the oil is evenly colored. (The red paint isn't necessary to the success of the experiment.)
- Gently pour the oil over the surface of the water. (It's okay if it mixes a bit at first because the oil and water will separate.)
- Set the container on the map of the Pacific Ocean and mark East (Indonesia) and West (South America).
- Plug in the hair dryer, being careful to avoid any water spills.

Explanation:

The liquids in the plastic container represent a cross-sectional slice of the Pacific Ocean near the equator. The oil (possibly colored red) represents the warm layer of surface water that has been heated by the sun. The blue water represents the colder water below the surface warm layer. (The boundary layer between the two layers is called the *thermocline*.) The hair dryer will represent the trade winds.

Action (Stage 1):

Ask a student to turn on the hair dryer (no heat is needed), starting on the medium setting. (If the hair dryer is low wattage, you may have to use the high setting.) Instruct the student to hold the hair dryer steady at the East end of the container, about 3-4 inches above the water, and direct the “wind” across the surface of the oil-topped water from the East to the West.

Prompt: What effect does the wind have on the “warm” (oil) and “cold” (blue) water?

Response: The “warm” water piles up in the West as it is blown by the “trade winds.” This is the normal condition for the equatorial Pacific Ocean.

Prompt: Where is the warm water located on the globe?

Response: Warm water is located in the tropics (typically along the equator, between 30°N and 30°S) and in currents such as the Gulf Stream that carry the warm water from the tropics.

Prompt: What will happen to the air above the warm water in terms of how much moisture the air can hold?

Response: Warm air can hold more water vapor than cold air, so warm air will have a higher dew point. The *dew point temperature* is defined as the temperature to which the air has to cool to become saturated. Once it is saturated, the air will condense and form clouds. There are only two ways to saturate the air: (1) add more water vapor to the air or (2) cool the air until its temperature is closer to the dew point temperature. The greater the moisture content, the higher the potential is to produce greater amounts of precipitation.

For example:

Air Parcel 1: Temperature = 31˚F, Dew point = 28˚F
Air Parcel 2: Temperature = 89˚F, Dew point = 43˚F

Air Parcel 2 contains more water vapor than Air Parcel 1 because of its higher dewpoint, but Air Parcel 1 has a higher relative humidity because not as much cooling is needed for the temperature to reach the dew point. *Relative humidity* is a measure of the amount of water vapor contained in the air, divided by the maximum amount the air can hold, expressed as a percent. A relative humidity of 50% means the air contains ½ of the water vapor it can actually hold.

In this example, Air Parcel 1 is more likely to become saturated.

If both air parcels were to become saturated, then Air Parcel 2 would have the potential for more precipitation.

Optional activity: Have the youth design an experiment to test the relative moisture-holding capabilities of warm and cold air.

You may notice that the sediment of the blue food coloring moves upward toward the surface at the East end. (This will only happen if there is sediment.) This is upwelling, which, in the Pacific Ocean, brings nutrient-rich bottom waters to the surface. Plankton feed on the nutrients, and fish feed on the plankton, so these areas of the Pacific tend to be rich in fish and other sea life.

Action (Stage 2):
Ask the student to turn off the "trade winds."

Prompt: What happened when the trade winds stopped?

Response: You may need to repeat the experiment several times to observe the motion that occurs when the trade winds stop. Note that in your model the "upwelling" seen while the trade winds were blowing is no longer present, so no nutrient-rich water surfaces to feed marine life. Now a thick layer of warm water (oil) covers the surface in the East, cutting off the upwelling of nutrient-rich cold water.

Link to JPL El Niño poster:

http://sealevel.jpl.nasa.gov/gallery/posters/?ImageID=5

Link to NASA animation of sea surface heights showing two decades of El Niño and La Niña events:

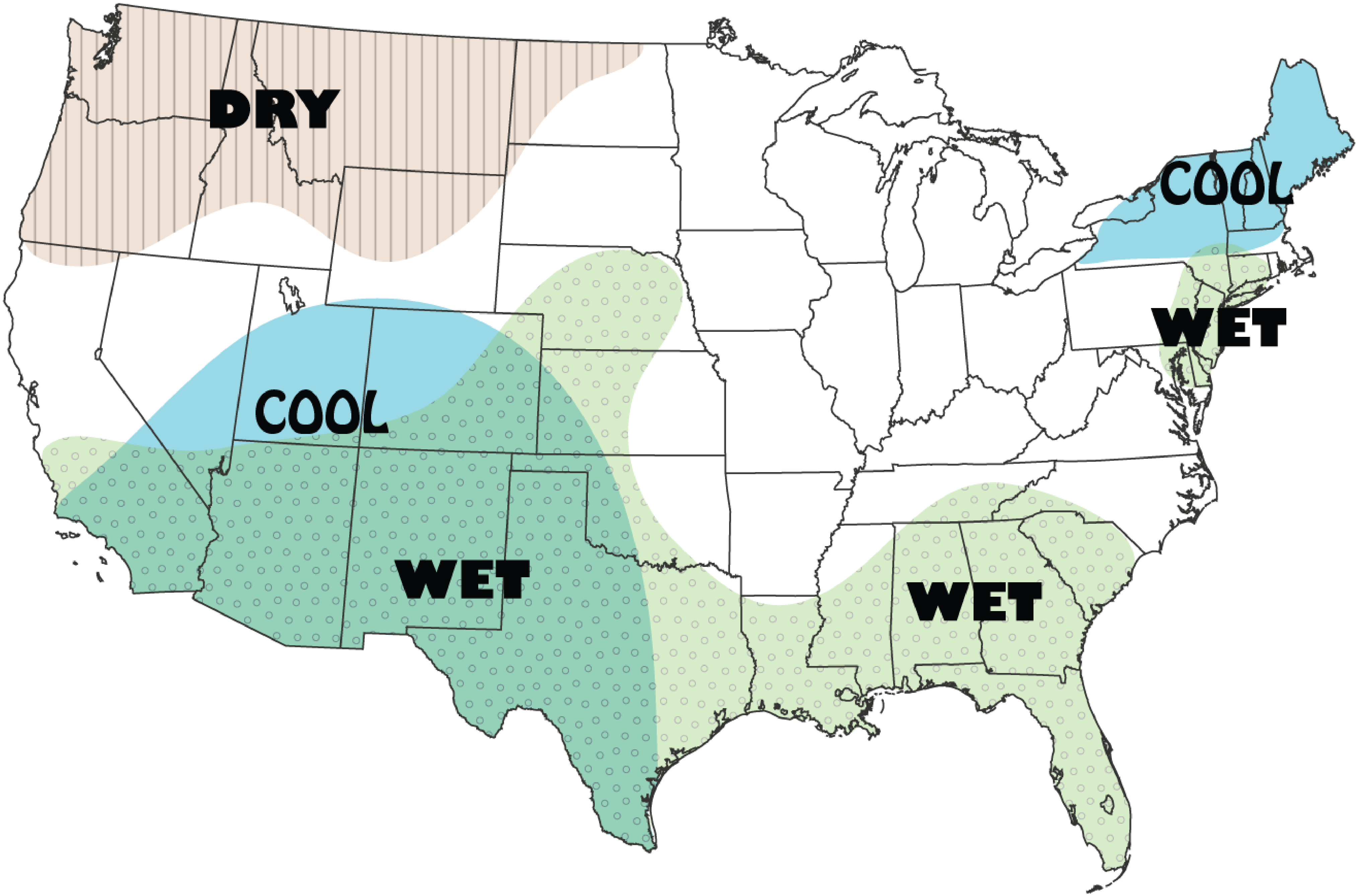
http://www.nasa.gov/mission_pages/hurricanes/features/PacificOceanSeaSurfaceHeights.html

Link to NASA information on El Niño and La Niña:

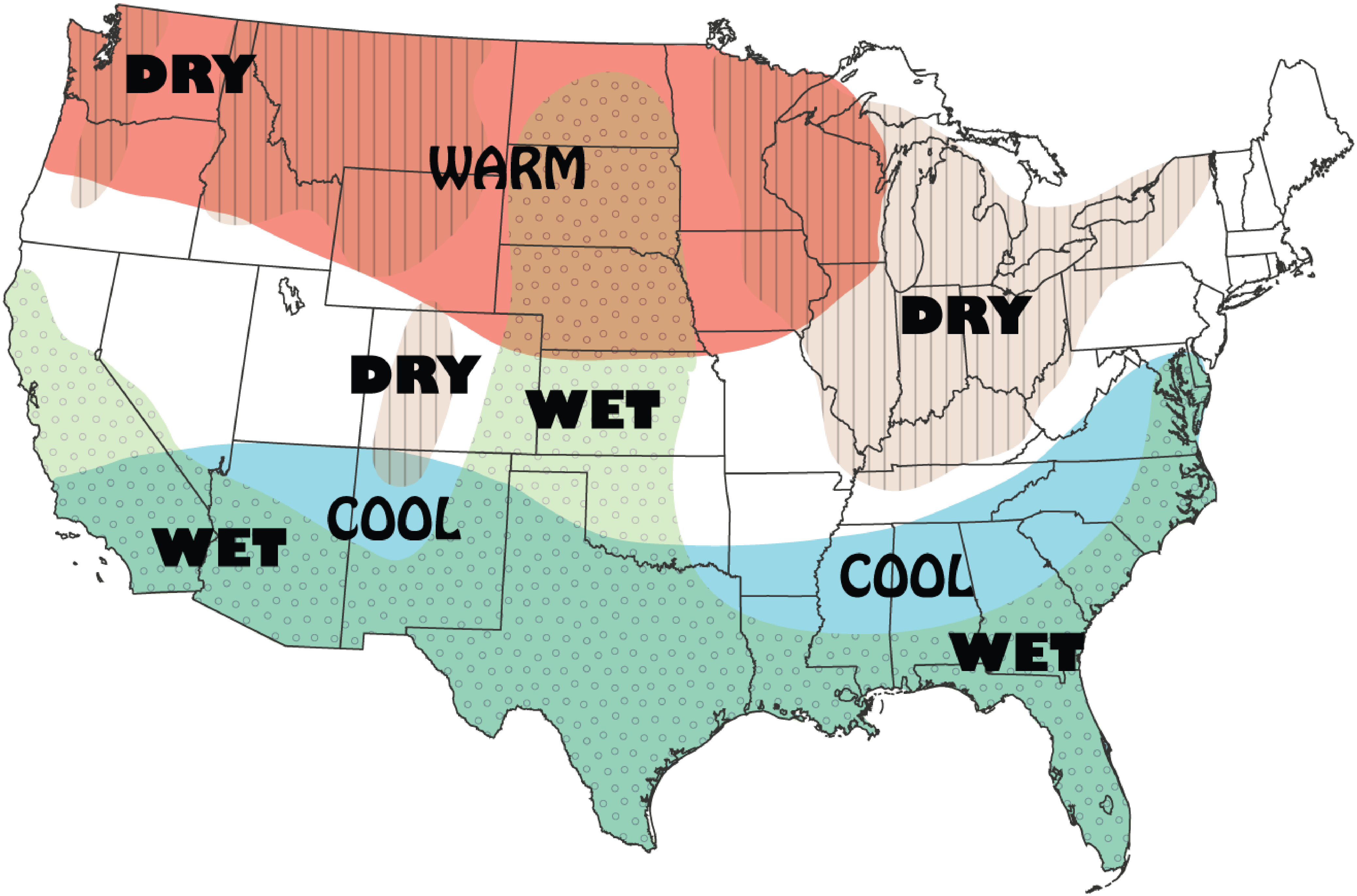
http://kids.earth.nasa.gov/archive/nino/intro.html

# ENSO Poster

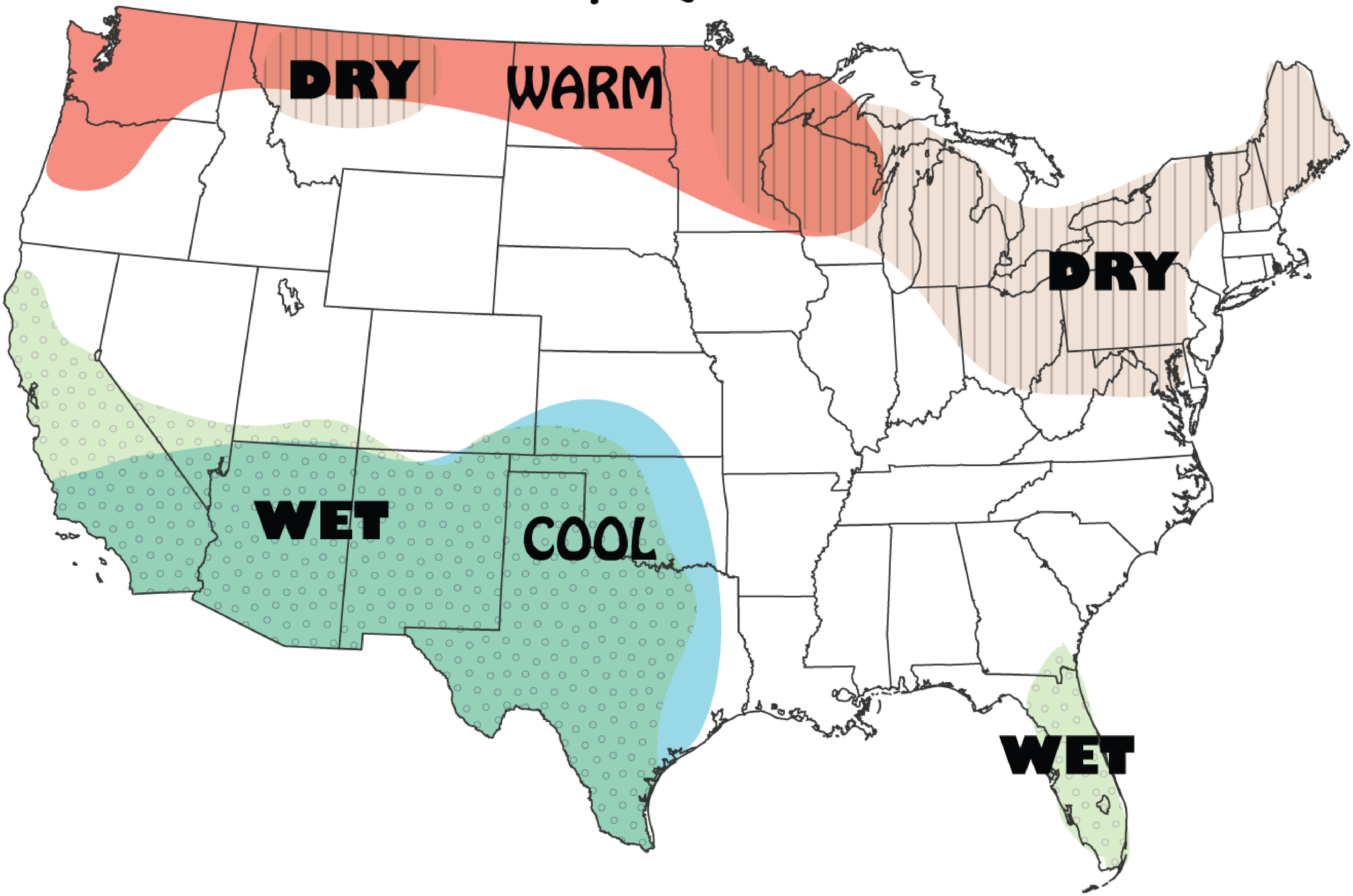
# Effects of El Niño Fall on U.S. Weather



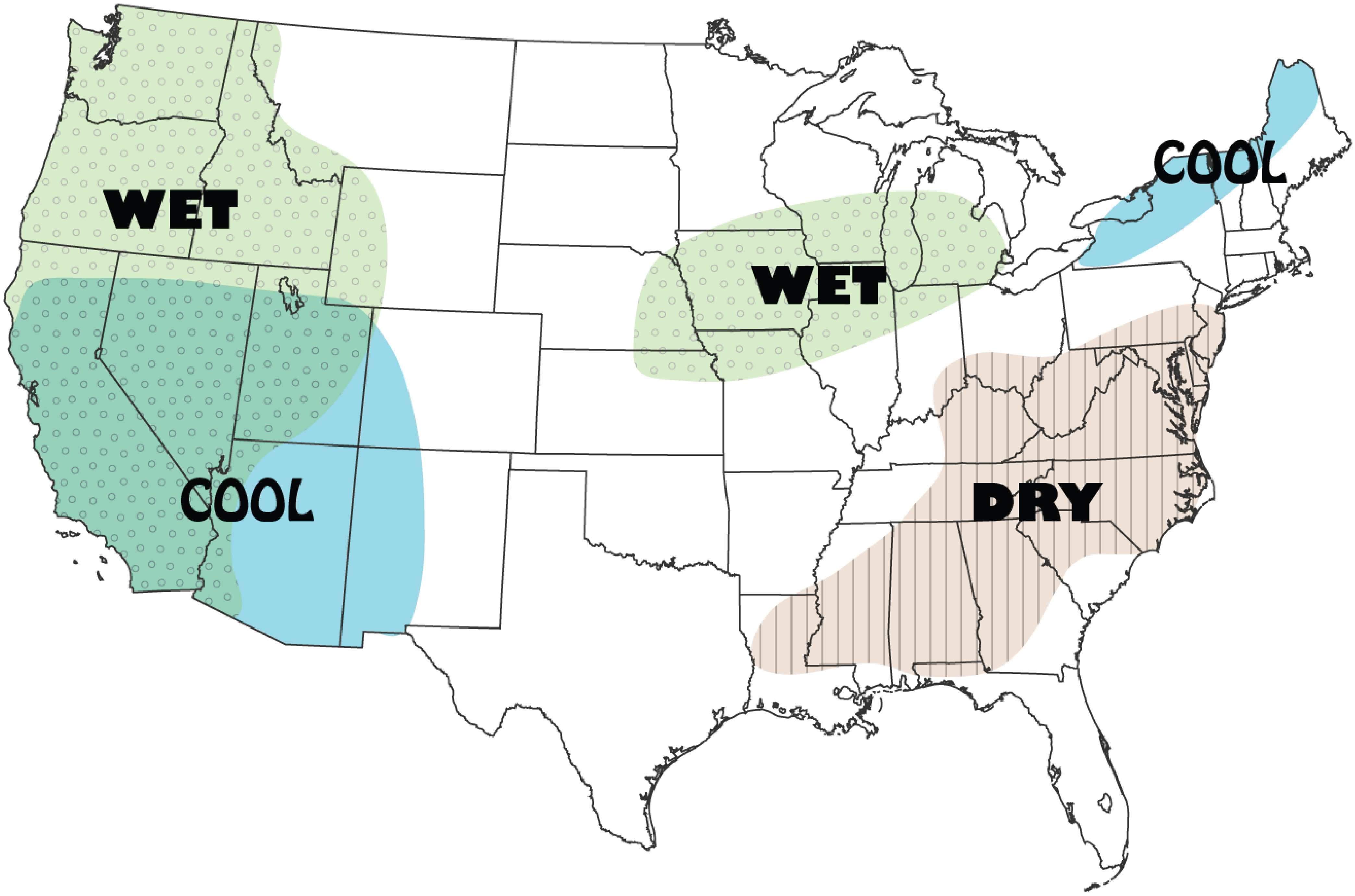
# Effects of El Niño Winter on U.S. Weather



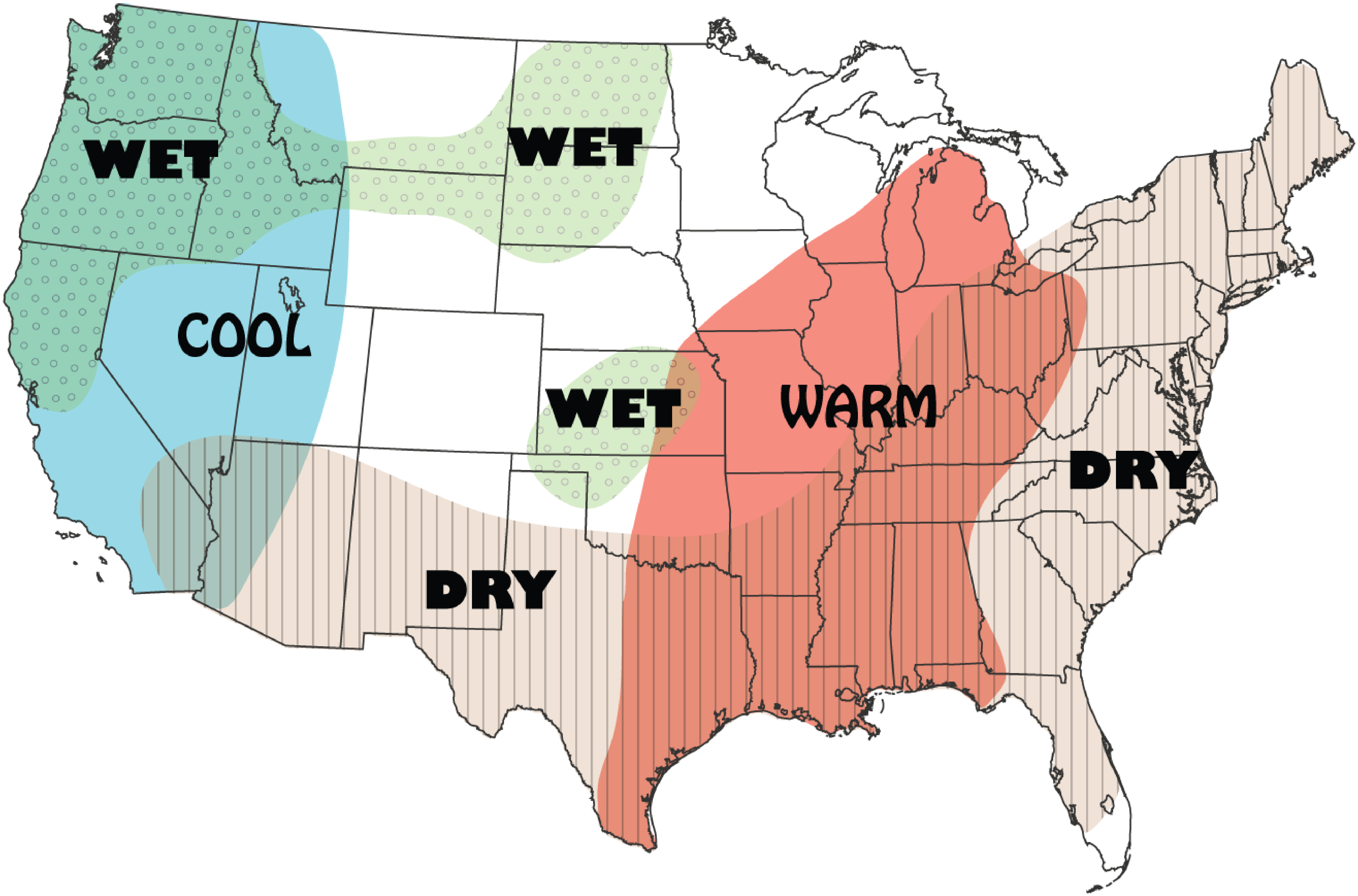
# Effects of El Niño Spring on U.S. Weather



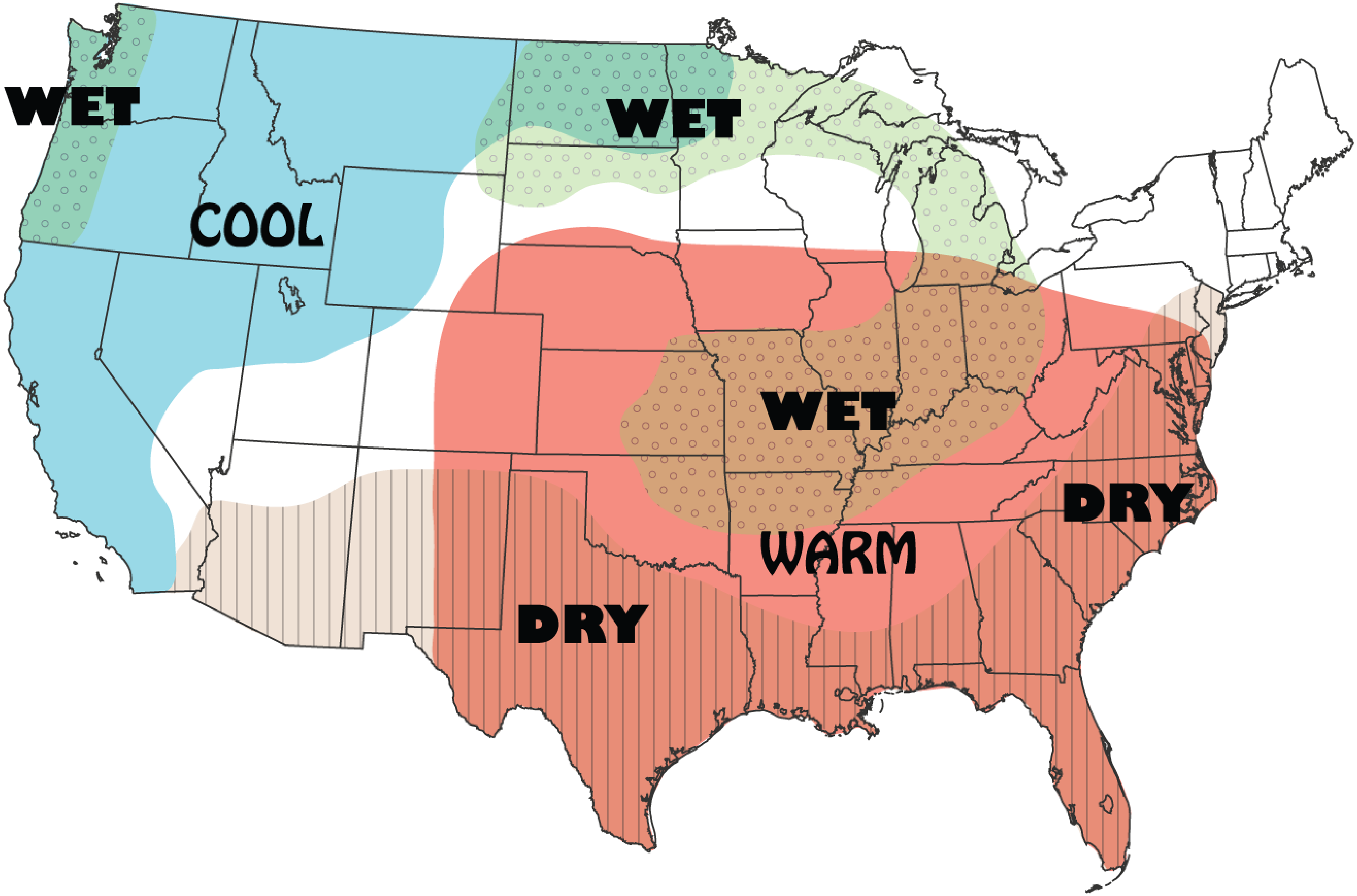
# Effects of El Niño Summer on U.S. Weather



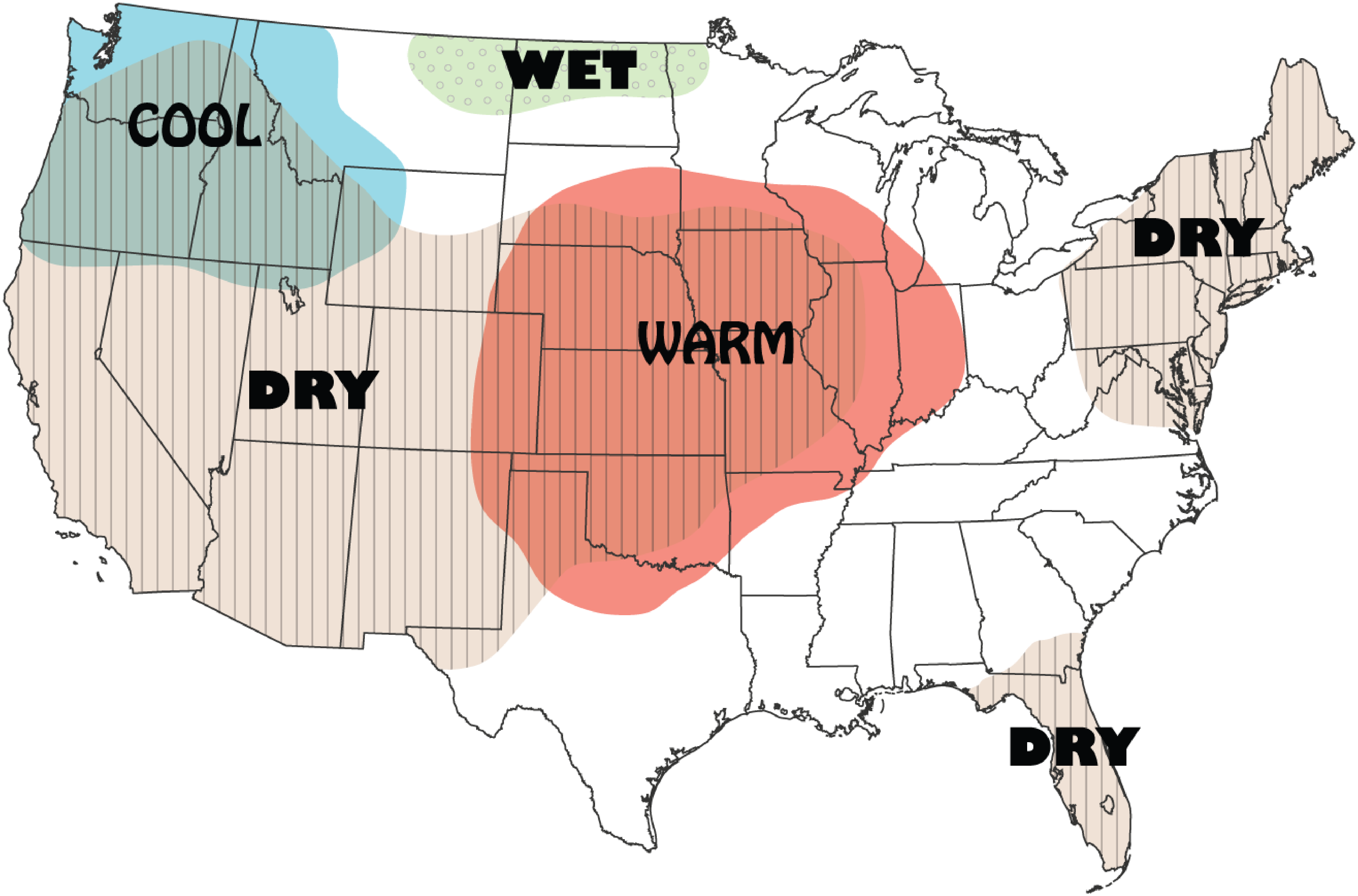
# Effects of La Niña Fall on U.S. Weather



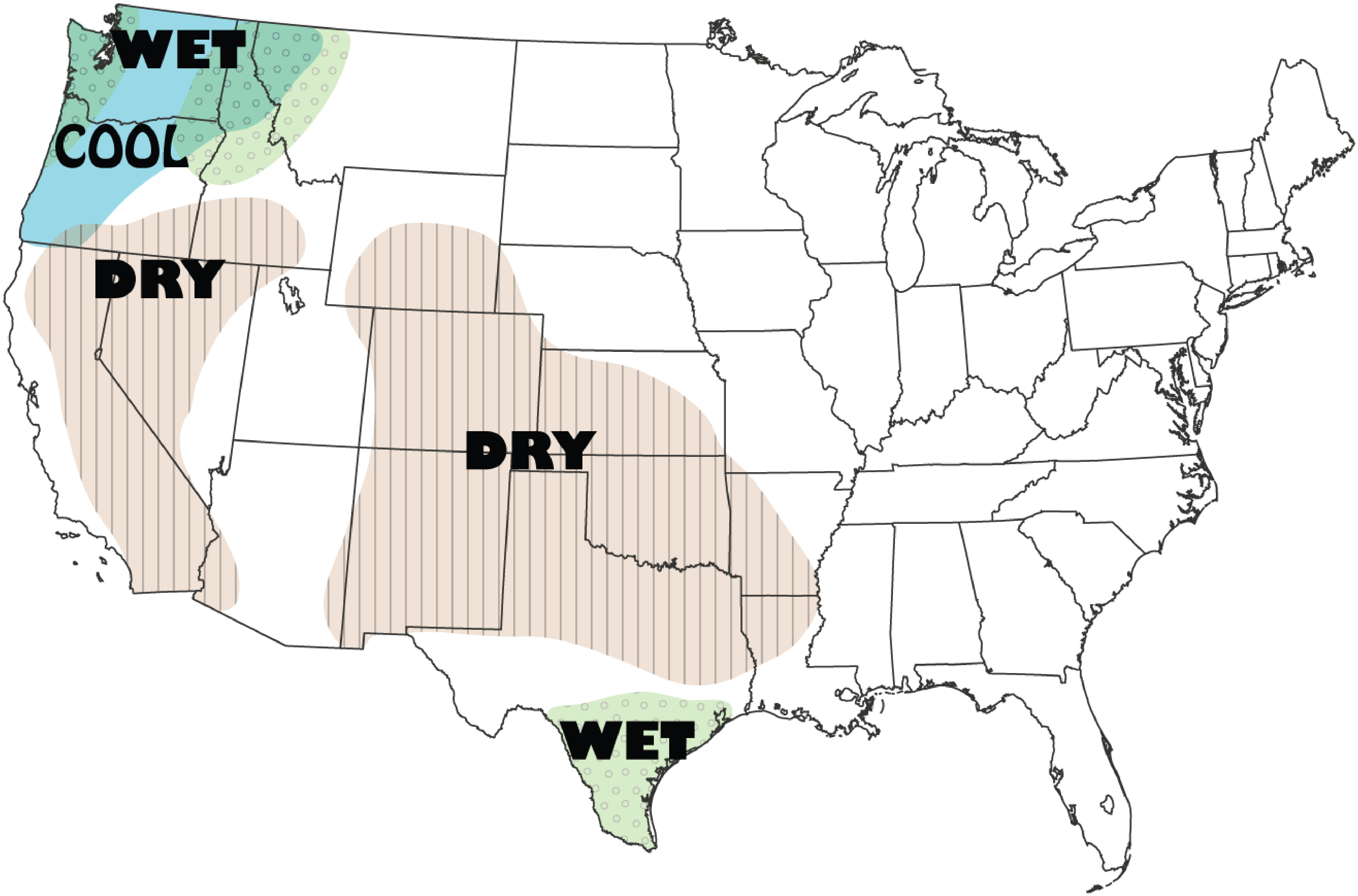
# Effects of La Niña Winter on U.S. Weather



# Effects of La Niña Spring on U.S. Weather



# Effects of La Niña Summer on U.S. Weather



# Climate Explorers

Directions: Use the URL below to access the AgroClimate site and then follow the instructions to explore the site and answer the questions.

http://agroclimate.org/tools/climate_tool/

All tools on this site default to the current phase of the ENSO cycle (Neutral, El Niño, or La Niña).

1. From the map, select the state and county of interest. If there is no station in the county, surrounding counties will be displayed and you can choose a station from among those. Click on the blue marker to select your station.

2. Verify in the toolbox on the left that your station has been selected.

3. Select **Total Rainfall** from the options on the left. The graphic shows the current long-term ENSO phase climatology compared to the current year of data (in red). The *deviations* are shown in a table at the top of the display. A *deviation* is the difference (positive or negative) between the value of an observation and the *average* of the dataset. The *average* is the "middle" or "typical" value of a dataset. You can hold your mouse over the bars on the graph to see the actual totals, which will appear at the top of the bars.

   a. How do the observed rainfall compare to the ENSO phase climatology for 2012?

4. From the tabs at the top of the graph, select **Last 5 Years**. The monthly rainfall data from 2007 to 2011 are displayed on the graphic. The gray bars represent the actual observed values, and the colored line, the *trend line,* displays the average totals. The color of the line depends on which ENSO phase is selected on the left. The line defaults to the current phase of ENSO and the bars default to 2011.

   a. How do the observed rainfall totals compare with the averages from the current phase of ENSO?

   b. Select another phase of ENSO. How do they compare?

   c. Try the same comparison with the third phase of ENSO. What are the results?

   d. Now, click on **All Years** and look at how the data compare with the averages from all of the years of data.

5. *Optional activity*: From the table select another year of data and answer the questions in step 4.

6. Select **Probability Distribution** from the tabs at the top of the graphic and **All Years** from the left. A *probability distribution* shows the probability of a range of values for a certain variable, in this case, inches of rainfall. *Probability* is the chance, or likelihood, that a certain event will occur. The data displayed represent all of the January data for the entire period of record for the station, arranged by *bin*. A *bin* is a range of values, such as 0-1 inches.

    a. Which bin(s) has (have) the highest probability of occurrence?

    b. Which bins have the lowest probability of occurrence?

7. *Optional activity*: Now that you've identified those bins, select another month and answer the same questions.

8. Using the same months, examine how the probabilities change depending on the phase of ENSO by selecting each ENSO phase (Neutral, El Niño, and La Niña) and seeing which bins have the highest and lowest probabilities.

9. Now we will look at the *probability of exceedance* of the rainfall. A *probability of exceedance* curve gives the probability that a certain amount of rainfall will be exceeded. Select **Probability of Exceedance** from the tabs and then click on the **Compare ENSO Phases** option on the left. All of the curves for January for Neutral, El Niño, and La Niña are displayed.

| *Month* | *All High* | *All Low* | *Neutral High* | *Neutral Low* | *El Niño High* | *El Niño Low* | *La Niña High* | *La Niña Low* |
|---|---|---|---|---|---|---|---|---|
| *January* | | | | | | | | |
| *July* | | | | | | | | |

a. What is the first thing you notice about the curves?

b. From the *y*-axis, determine the rainfall values at 60% for each phase.

c. Now, select a different month and explain how, if at all, the lines have changed from January.

d. Determine the rainfall values at 60% for each phase.

10. *Optional activity*: You may pick a different location and repeat the activity for rainfall, or keep the same location and complete the activity using average minimum temperature or average maximum temperature information.

Discussion Questions:

1. How could you use the information on this website to determine what crop to plant at a certain time to maximize yield?

2. Suppose you are planning an outdoor event for a particular time of year. What impact could you expect in a La Niña year?

# Climate Explorers KEY

Directions: Use the URL below to access the AgroClimate site and then follow the instructions to explore the site and answer the questions.

http://agroclimate.org/tools/climate_tool/

All tools on this site default to the current phase of the ENSO cycle (Neutral, El Niño, or La Niña).

1. From the map, select the state and county of interest. If there is no station in the county, surrounding counties will be displayed and you can choose a station from among those. Click on the blue marker to select your station. ***Note: DeFuniak Springs in Walton County is used for this example; the default phase for the key is neutral.***

2. Verify in the toolbox on the left that your station has been selected.

3. Select **Total Rainfall** from the options on the left. The graphic shows the current long-term ENSO phase climatology compared to the current year of data (in red). The *deviations* are shown in a table at the top of the display. A *deviation* is the difference (positive or negative) between the value of an observation and the *average* of the dataset. The *average* is the "middle" or "typical" value of a dataset. You can hold your mouse over the bars on the graph to see the actual totals, which will appear at the top of the bars.
   a. How does the observed rainfall compare to the ENSO phase climatology for 2012? ***February and June were above normal, while the rest of the monthly totals were below normal. May was the most below normal.***

4. From the tabs at the top of the graph, select **Last 5 Years**. The monthly rainfall data from 2007 to 2011 are displayed on the graphic. The gray bars represent the actual observed values, and the colored line, the *trend line,* displays the average totals. The color of the line depends on which ENSO phase is selected on the left. The line defaults to the current phase of ENSO and the bars default to 2011.
   a. How do the observed rainfall totals compare with the averages from the current phase of ENSO? ***The observations seem to have a similar trend, although most months were below the averages.***
   b. Select another phase of ENSO. How do they compare? ***(El Niño was selected for the key.) The observations again have a similar trend, and the observed values were below the averages for El Niño, except July and September, when they were above.***
   c. Try the same comparison with the third phase of ENSO. What are the results? ***(La Niña was selected for the key.) The totals for January, February, and March were very close to the average for La Nina; September was above average.***
   d. Now, click on **All Years** and look at how the data compare with the averages from all of the years of data. ***The rainfall follows the same trend of a wet winter, dry spring, wet summer, and dry fall, but only two months had above average rainfall, and the other months were slightly below or well below average. Note: This pattern is typical for North Florida, but not for Central or South Florida.***

5. *Optional activity*: From the table select another year of data and answer the questions in Step 4.

6. Select **Probability Distribution** from the tabs at the top of the graphic and **All Years** from the left. A *probability distribution* shows the probability of a range of values for a certain variable, in this case, inches of rainfall. *Probability* is the chance, or likelihood, that a certain event will occur. The data displayed represent all of the January data for the entire period of record for the station, arranged by *bin*. A *bin* is a range of values, such as 0-1 inches.
   a. Which bin(s) has (have) the highest probability of occurrence? ***3-4" (19%)***
   b. Which bins have the lowest probability of occurrence? ***0-1" and 9-10" (1%)***

7. Now that you've identified those bins, select another month and answer the same questions. ***(July was selected for the key.) more than 10" (24%) and 0-1" and 1-2"(0%)***

8. Using the same months, examine how the probabilities change depending on the phase of ENSO by selecting each ENSO phase (Neutral, El Niño, and La Niña) and seeing which bins have the highest and lowest probabilities.

9. Now we will look at the *probability of exceedance* of the rainfall. A *probability of exceedance* curve gives the probability that a certain amount of rainfall will be exceeded. Select **Probability of Exceedance** from the tabs and then click on the **Compare ENSO Phases** option on the left. All of the curves for January, for Neutral, El Niño, and La Niña are displayed.

| ***Month*** | ***All High*** | ***All Low*** | ***Neutral High*** | ***Neutral Low*** | ***El Niño High*** | ***El Niño Low*** | ***La Niña High*** | ***La Niña Low*** |
|---|---|---|---|---|---|---|---|---|
| *January* | ***3-4*** | ***0-1<br>9-10*** | ***3-4*** | ***0-1*** | ***5-6*** | ***0-1*** | ***4-5*** | ***9-10*** |
| *July* | ***More than 10*** | ***0-1<br>1-2*** | ***More than 10*** | ***0-1<br>1-2*** | ***6-7*** | ***2-3<br>1-2*** | ***More than 10*** | ***0-1<br>1-2<br>2-3*** |

   a. What is the first thing you notice about the curves? ***The El Niño curve is higher than the other two.***
   b. From the *y*-axis, determine the rainfall values at 60% for each phase. ***Neutral – 3.5", La Niña – 3.5", El Niño – 4.5"***
   c. Now, select a different month and explain how, if at all, the lines have changed from January. ***(July was selected for the key.) The La Niña curve is now higher than the other curves and the shapes of all the curves are different.***
   d. Determine the rainfall values at 60% for each phase. ***El Nino – 6.5", Neutral – 7.25", La Nina – 8.5"***

10. *Optional activity*: You may pick a different location and repeat the activity for rainfall, or keep the same location and complete the activity using average minimum temperature or average maximum temperature information.

Discussion Questions:

1. How could you use the information on this website to determine what crop to plant at a certain time to maximize yield?

2. Suppose you are planning an outdoor event for a particular time of year. What impact could you expect in a La Niña year?

# Additional Resources: Unit 3

How Do Scientists Study Climate and Climate Variability?

## Dead Diatoms Do Tell Tales!

The full document *Antarctica's Climate Secrets Flexhibit Lesson Plans* can be found at http://www.andrill.org/flexhibit/flexhibit/materials/activities/index.html

## Make Your Own El Niño in the Classroom

More specific information about conditions during El Niño and La Niña can be found at http://agroclimate.org/tools/climate_tool/

# Holiday Climatology

## *Speak Like a Climatologist*

climatology = multiyear record of temperatures and precipitation

data = daily observations of temperature and precipitation

max = maximum, the highest or largest

min = minimum, the lowest or smallest

trace = an amount of precipitation too small to measure

## *Draw a Temperature Bar Graph*

Directions: Follow steps 1-4 below to create your temperature bar graphs. Place a check mark in the box next to the number after you have finished each step.

*Pointers:*

- The years are located on the x-axis (x to the left).
- The temperature ranges are located on the y-axis (y to the sky).
- The marks on the y-axis are in units of one degree.
- The highest maximum and the lowest minimum temperatures can occur during more than one year!

☐ 1. Look at the maximum temperature data for **July 4th** for your location. For each year on the **Maximum Temperature graph** draw a bar for the maximum temperature.

☐ 2. Find the year(s) of the highest maximum temperature and color the bar(s) red.

☐ 3. Now look at the minimum temperature data for **July 4th** for your location. For each year on the **Minimum Temperature graph**, draw a bar for the minimum temperature.

☐ 4. Find the year(s) of the lowest minimum temperature and color the bar(s) blue.

## *Draw a Precipitation Bar Graph*

Directions: Follow steps 1-3 below to create your precipitation bar graph. Place a check mark in the box next to the number after you have finished each step.

*Pointers*:

- The years are located on the x-axis (x to the left).
- The precipitation amounts, in inches, are located on the y-axis (y to the sky).
- The marks on the y-axis are in units of one-tenth of an inch.
- The largest number of inches of precipitation or the smallest number of inches of precipitation can occur for more than one year!
- The amount of precipitation on a specific day can be "zero" or "trace"! If the data entry is "trace" for a year, draw a small bar, less than one-half inch, for that year on your graph.

☐ 1. Look at the precipitation data for **July 4th** for your location. For each year on the graph, draw a bar for the number of inches of precipitation.

☐ 2. Find the year(s) having the largest number of inches of precipitation and color the bar(s) red.

☐ 3. Find the year(s) having the smallest number of inches of precipitation and color the bar(s) blue. Remember, this number can be "zero" or "trace."

## *Think Like a Climatologist*

What maximum temperature occurs most often?

What minimum temperature occurs most often?

What precipitation amount occurs most often?

On the basis of the temperature and precipitation data you have collected, would you plan for an indoor activity or an outdoor activity for July 4th at this location?

Station: MIAMI INTL AP

| Date | Max Tempera | Min Tempera | Precipitation |
|---|---|---|---|
| 7/4/2000 | 88 | 77 | 0.19 |
| 7/4/2001 | 88 | 75 | 0.02 |
| 7/4/2002 | 88 | 74 | 0.34 |
| 7/4/2003 | 89 | 78 | 0.21 |
| 7/4/2004 | 89 | 78 | 0.37 |
| 7/4/2005 | 91 | 81 | Trace |
| 7/4/2006 | 89 | 78 | 0.00 |
| 7/4/2007 | 90 | 73 | 0.47 |
| 7/4/2008 | 90 | 74 | 0.26 |
| 7/4/2009 | 90 | 78 | 0.08 |
| 7/4/2010 | 89 | 73 | 1.22 |
| 7/4/2011 | 90 | 76 | 0.62 |
| 7/4/2012 | 92 | 80 | 0.00 |

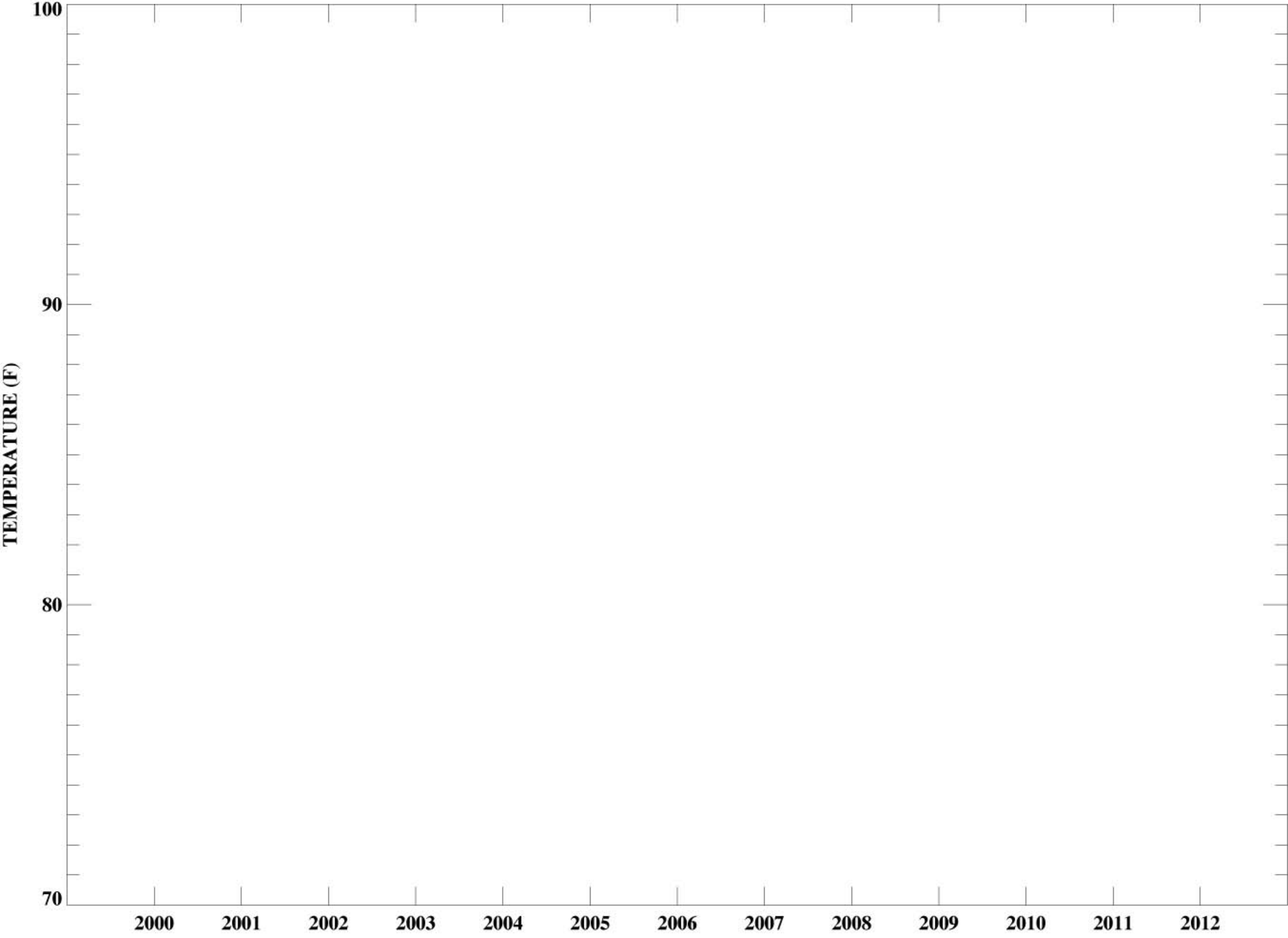
Station: ORLANDO INTL AP

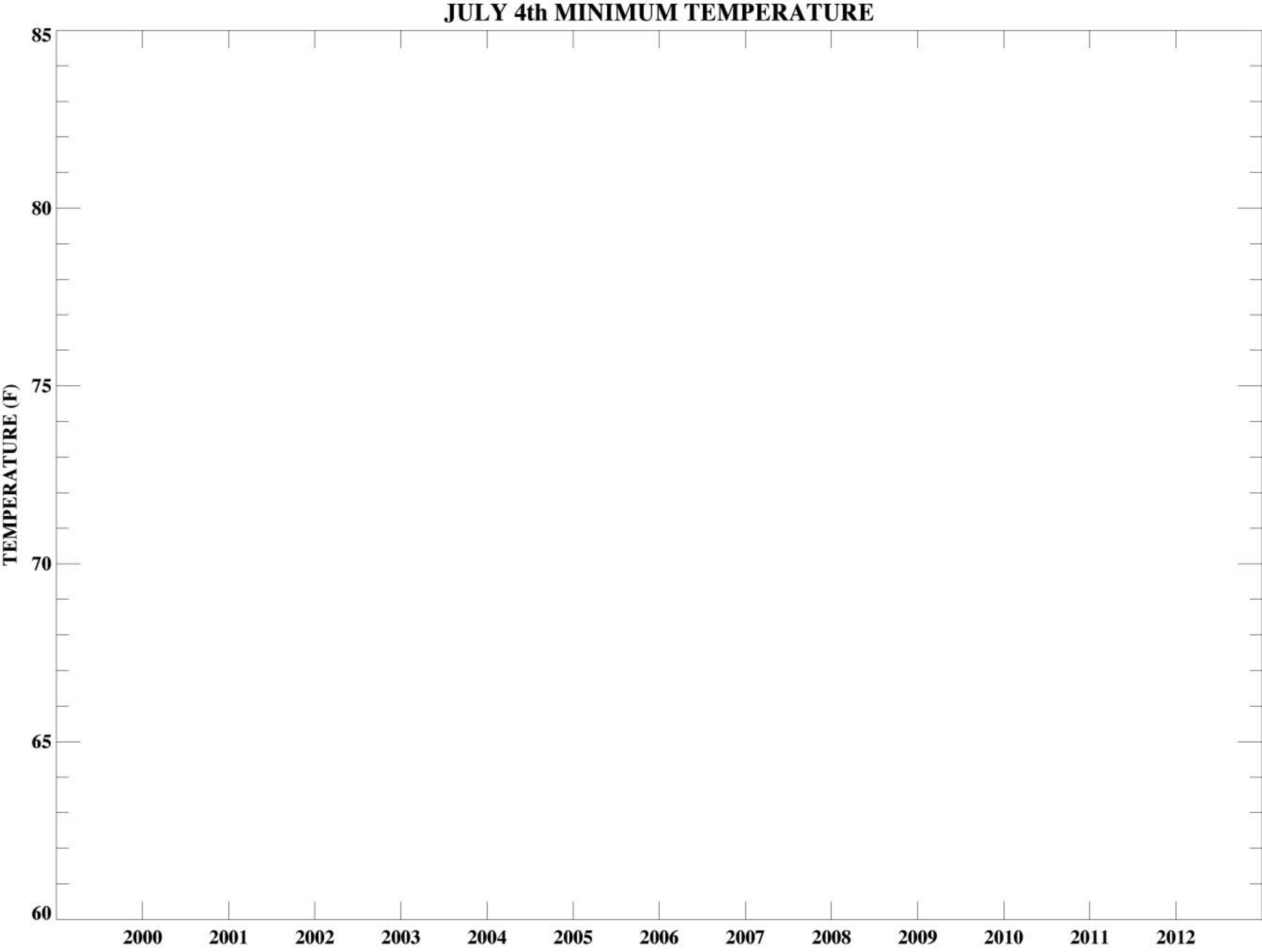
| Date | Max Tempera | Min Tempera | Precipitation |
|---|---|---|---|
| 7/4/2000 | 90 | 72 | 0.00 |
| 7/4/2001 | 91 | 74 | Trace |
| 7/4/2002 | 87 | 73 | 0.07 |
| 7/4/2003 | 92 | 74 | Trace |
| 7/4/2004 | 93 | 72 | 0.04 |
| 7/4/2005 | 93 | 75 | 0.09 |
| 7/4/2006 | 89 | 74 | 0.19 |
| 7/4/2007 | 88 | 73 | 0.49 |
| 7/4/2008 | 88 | 71 | 0.46 |
| 7/4/2009 | 92 | 76 | 0.51 |
| 7/4/2010 | 85 | 73 | 0.52 |
| 7/4/2011 | 94 | 74 | 0.00 |
| 7/4/2012 | 92 | 72 | 0.18 |

Station: TALLAHASSEE RGNL AP

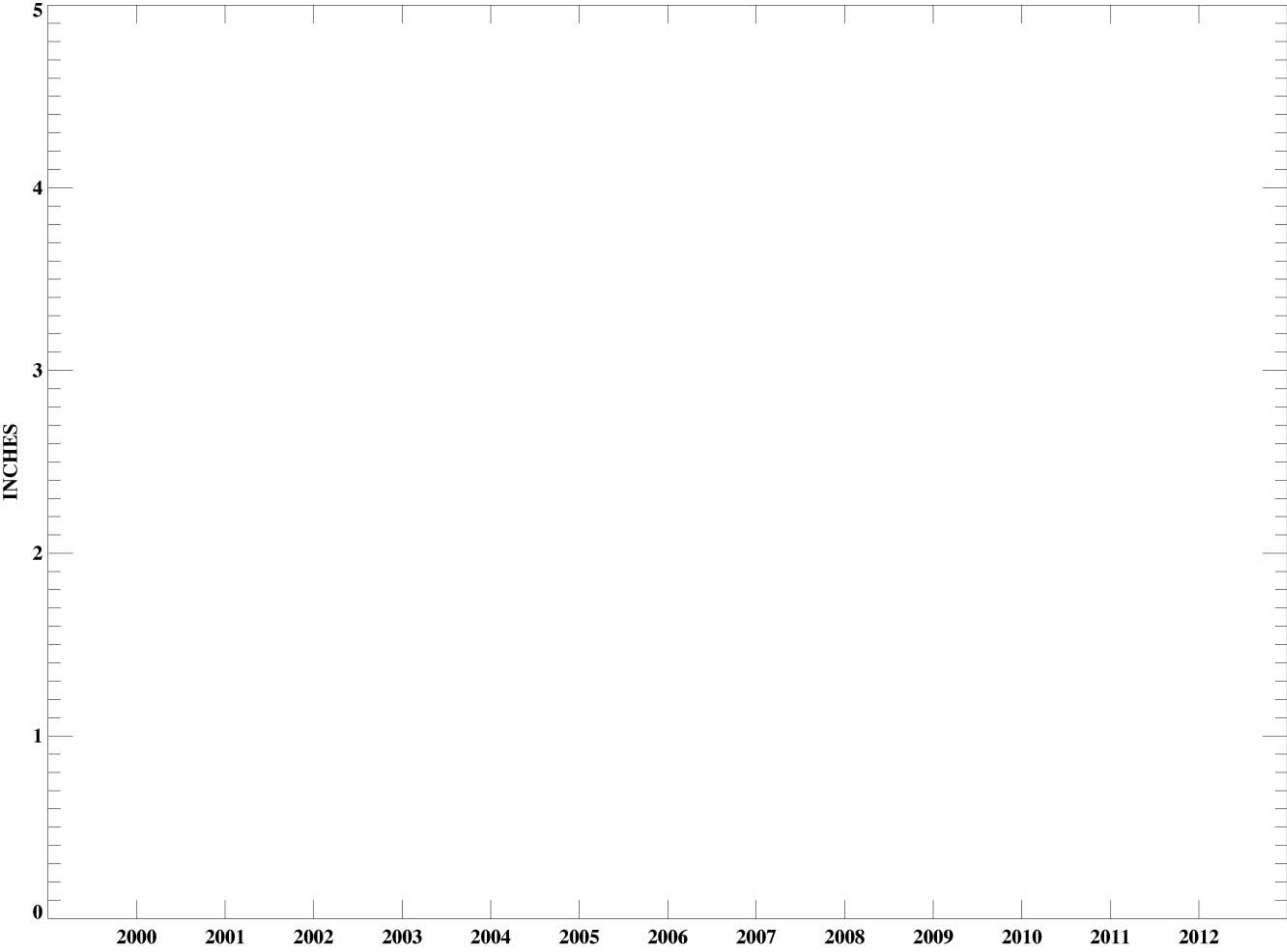
| Date | Max Tempera | Min Tempera | Precipitation |
|---|---|---|---|
| 7/4/2000 | 95 | 66 | 0.00 |
| 7/4/2001 | 93 | 70 | 0.08 |
| 7/4/2002 | 91 | 69 | 0.04 |
| 7/4/2003 | 85 | 72 | 0.82 |
| 7/4/2004 | 88 | 71 | 1.73 |
| 7/4/2005 | 93 | 74 | 0.04 |
| 7/4/2006 | 96 | 71 | 0.00 |
| 7/4/2007 | 89 | 73 | Trace |
| 7/4/2008 | 92 | 68 | Trace |
| 7/4/2009 | 97 | 67 | 0.00 |
| 7/4/2010 | 87 | 74 | 0.01 |
| 7/4/2011 | 97 | 71 | 0.16 |
| 7/4/2012 | 89 | 73 | 0.19 |

# JULY 4th MAXIMUM TEMPERATURE




JULY 4th MINIMUM TEMPERATURE
TEMPERATURE (F)
85
80
75
70
65
60
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

JULY 4th PRECIPITATION



# Birthday Climatology

## *Speak Like a Climatologist*

climatology = multiyear record of temperatures and precipitation

data = daily observations of temperature and precipitation

max = maximum, the highest or largest

min = minimum, the lowest or smallest

trace = an amount of precipitation too small to measure

## *Draw a Temperature Bar Graph*

Directions: After you have obtained your data from the website, follow steps 1-4 below to create your temperature bar graphs. Place a check mark in the box next to the number after you have finished each step.

*Pointers:*

- The years are located on the x-axis (x to the left).
- The temperature ranges are located on the y-axis (y to the sky).
- The marks on the y-axis are in units of one degree.
- The highest maximum and the lowest minimum temperatures can occur during more than one year!

☐ 1. Look at the maximum temperature data for **your birthday** for your location. For each year on the **Maximum Temperature graph** draw a bar for the maximum temperature.

☐ 2. Find the year(s) of the highest maximum temperature and color the bar(s) red.

☐ 3. Now look at the minimum temperature data for **your birthday** for your location. For each year on the **Minimum Temperature graph**, draw a bar for the minimum temperature.

☐ 4. Find the year(s) of the lowest minimum temperature and color the bar(s) blue.

## *Draw a Precipitation Bar Graph*

Directions: Using the data you obtained from the website, follow steps 1-3 below to create your precipitation bar graph. Place a check mark in the box next to the number after you have finished each step.

*Pointers*:

- The years are located on the x-axis (x to the left).
- The precipitation amounts, in inches, are located on the y-axis (y to the sky).
- The marks on the y-axis are in units of one-tenth of an inch.
- The largest number of inches of precipitation or the smallest number of inches of precipitation can occur for more than one year!
- The amount of precipitation on a specific day can be “zero” or “trace”! If the data entry is “trace” for a year, draw a small bar, less than one-half inch, for that year on your graph.

☐ 1. Look at the precipitation data for **your birthday** for your location. For each year on the graph, draw a bar for the number of inches of precipitation.

☐ 2. Find the year(s) having the largest number of inches of precipitation and color the bar(s) red.

☐ 3. Find the year(s) having the smallest number of inches of precipitation and color the bar(s) blue. Remember, this number can be “zero” or “trace.”

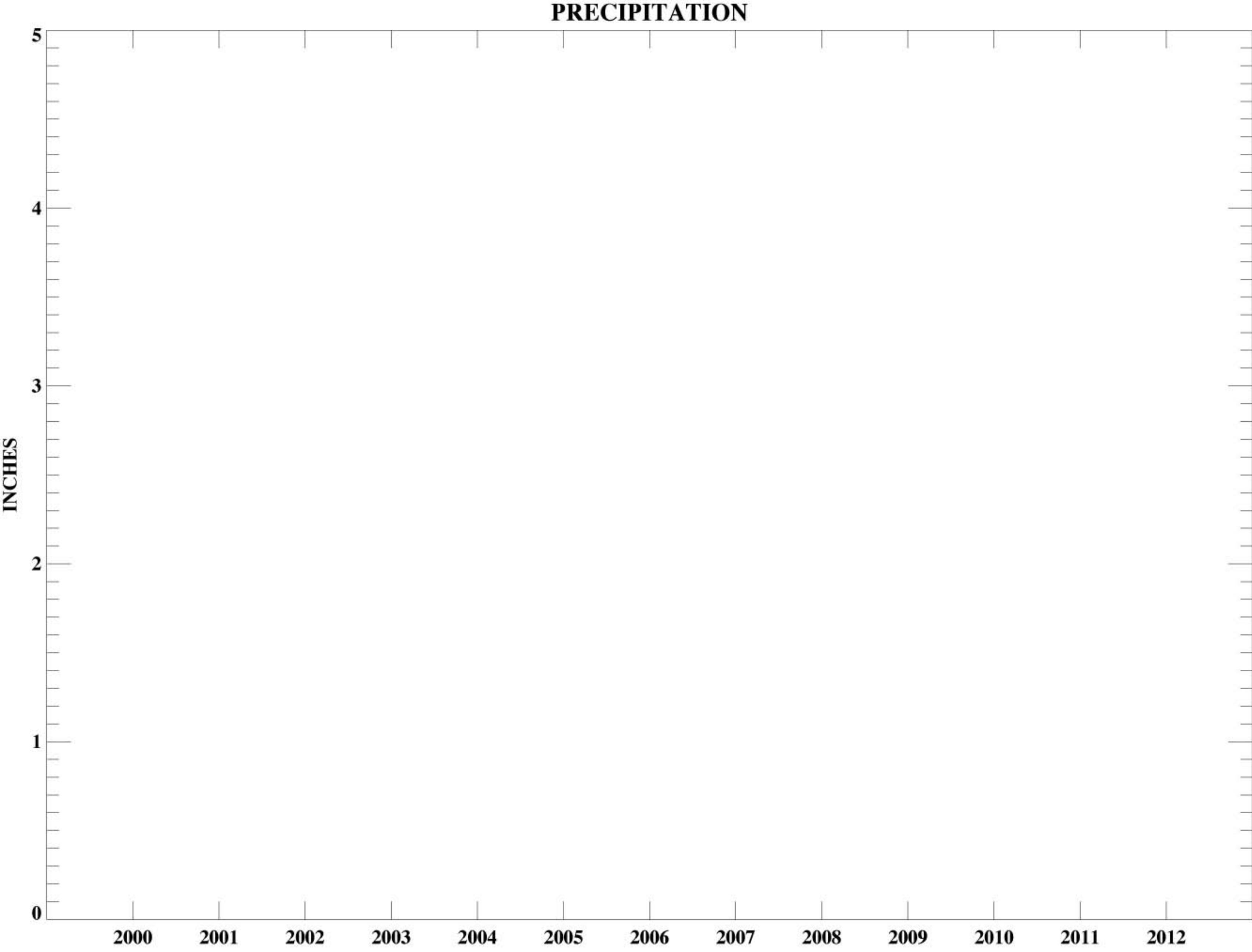
## *Think Like a Climatologist*

What maximum temperature occurs most often?

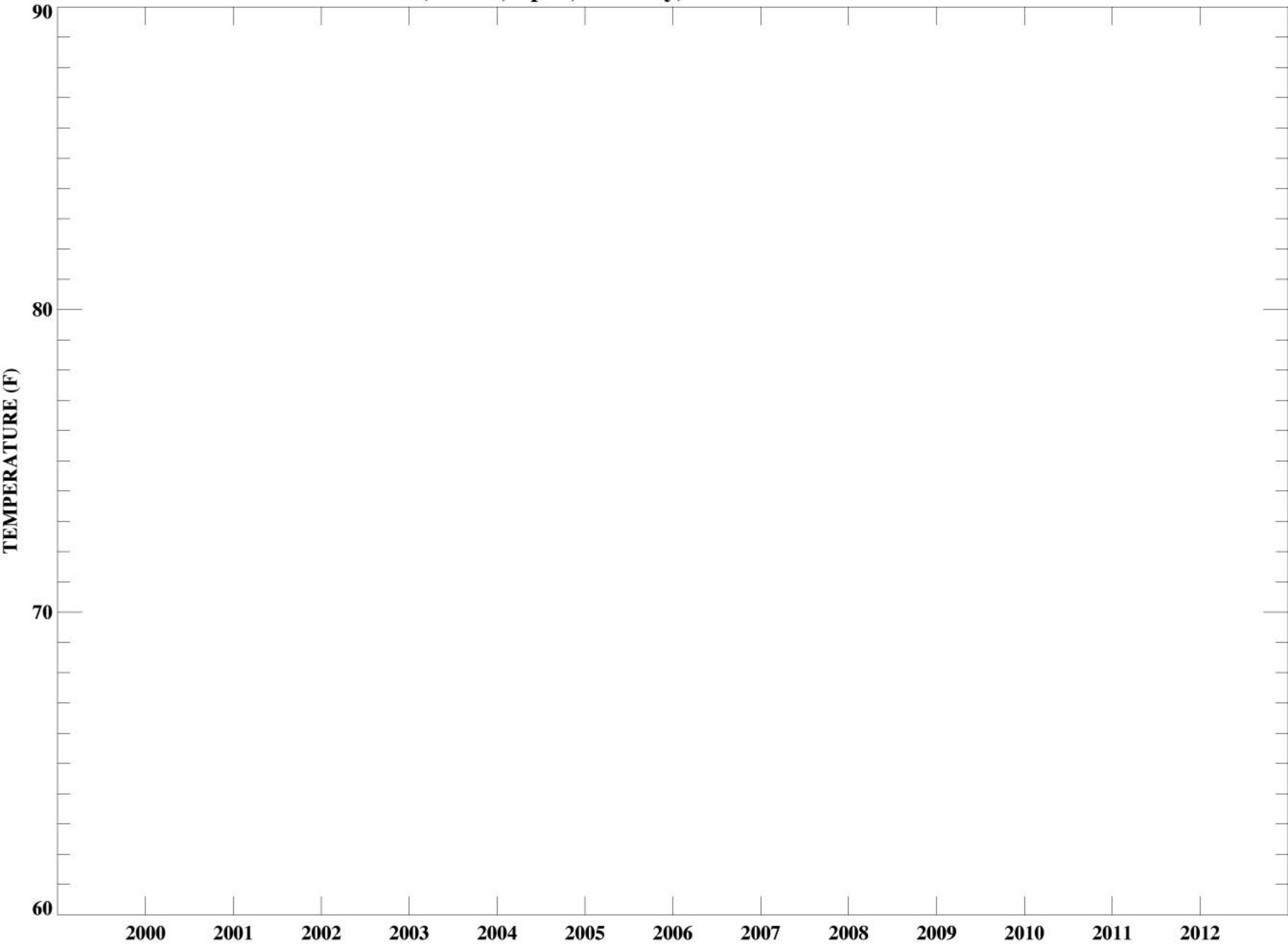
What minimum temperature occurs most often?

What precipitation amount occurs most often?

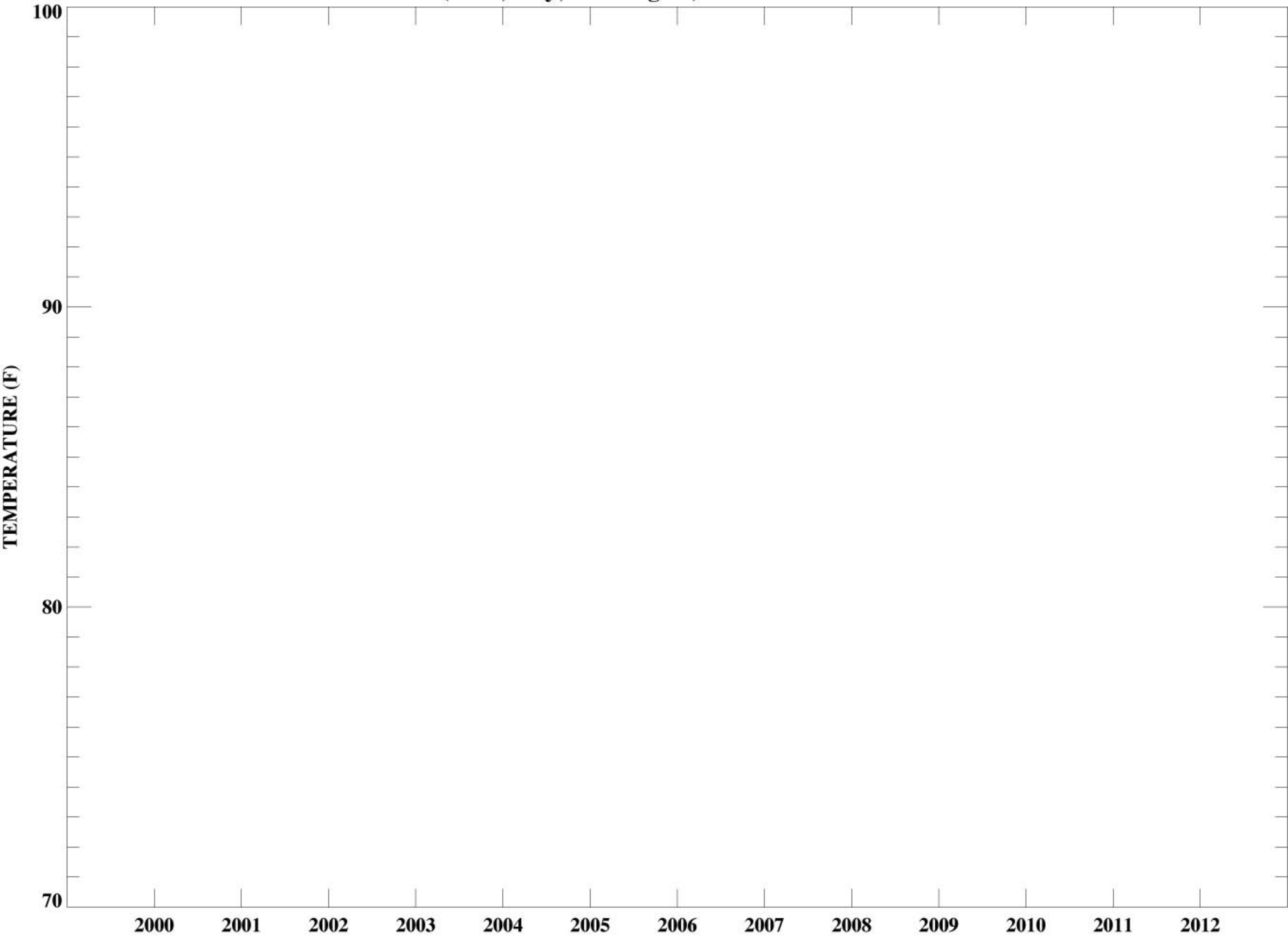
On the basis of the temperature and precipitation data you have collected, would you plan for an indoor activity or an outdoor activity for your birthday at this location?


PRECIPITATION
INCHES
0
1
2
3
4
5
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

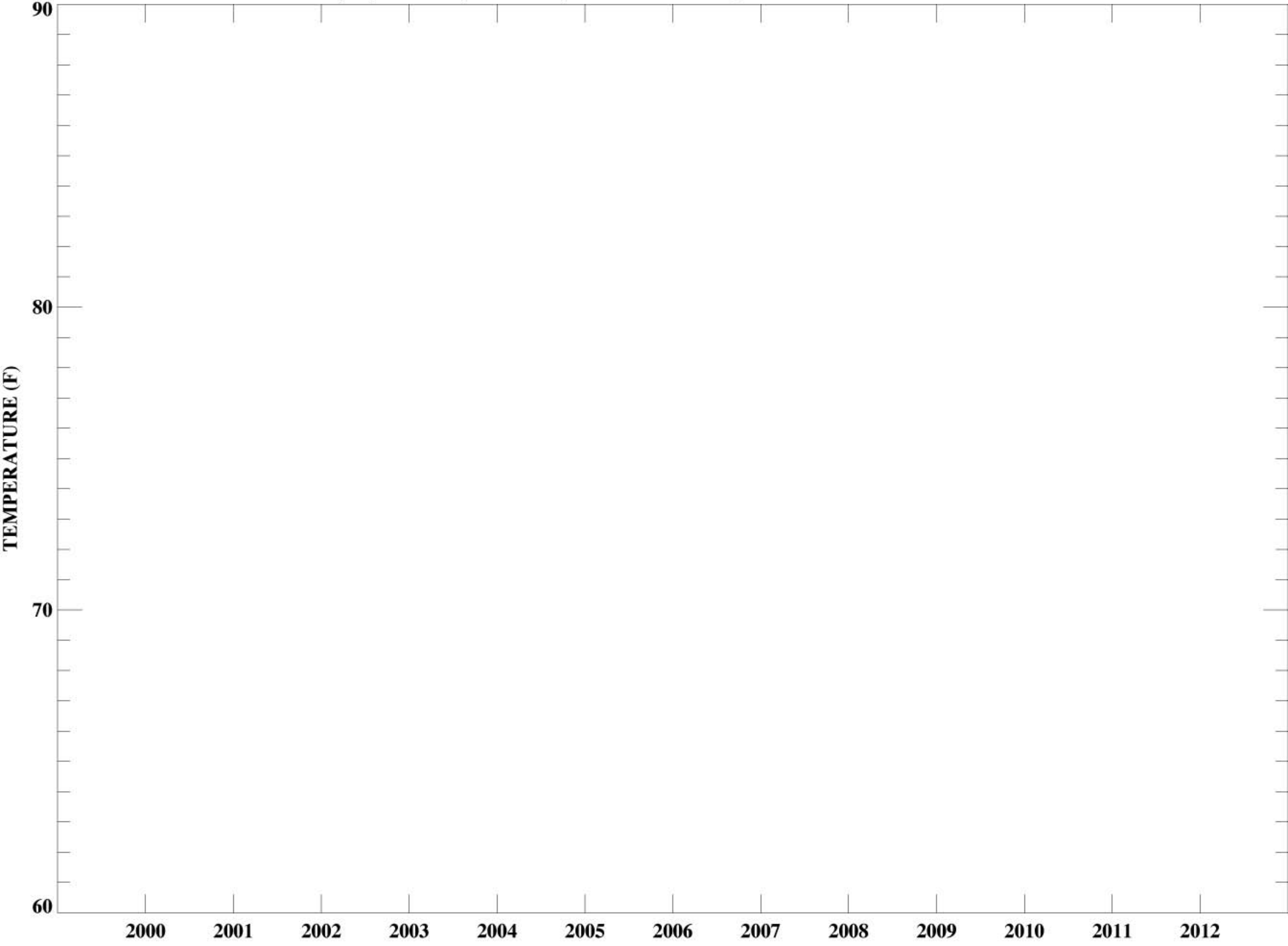
SPRING (March, April, and May) MAXIMUM TEMPERATURE



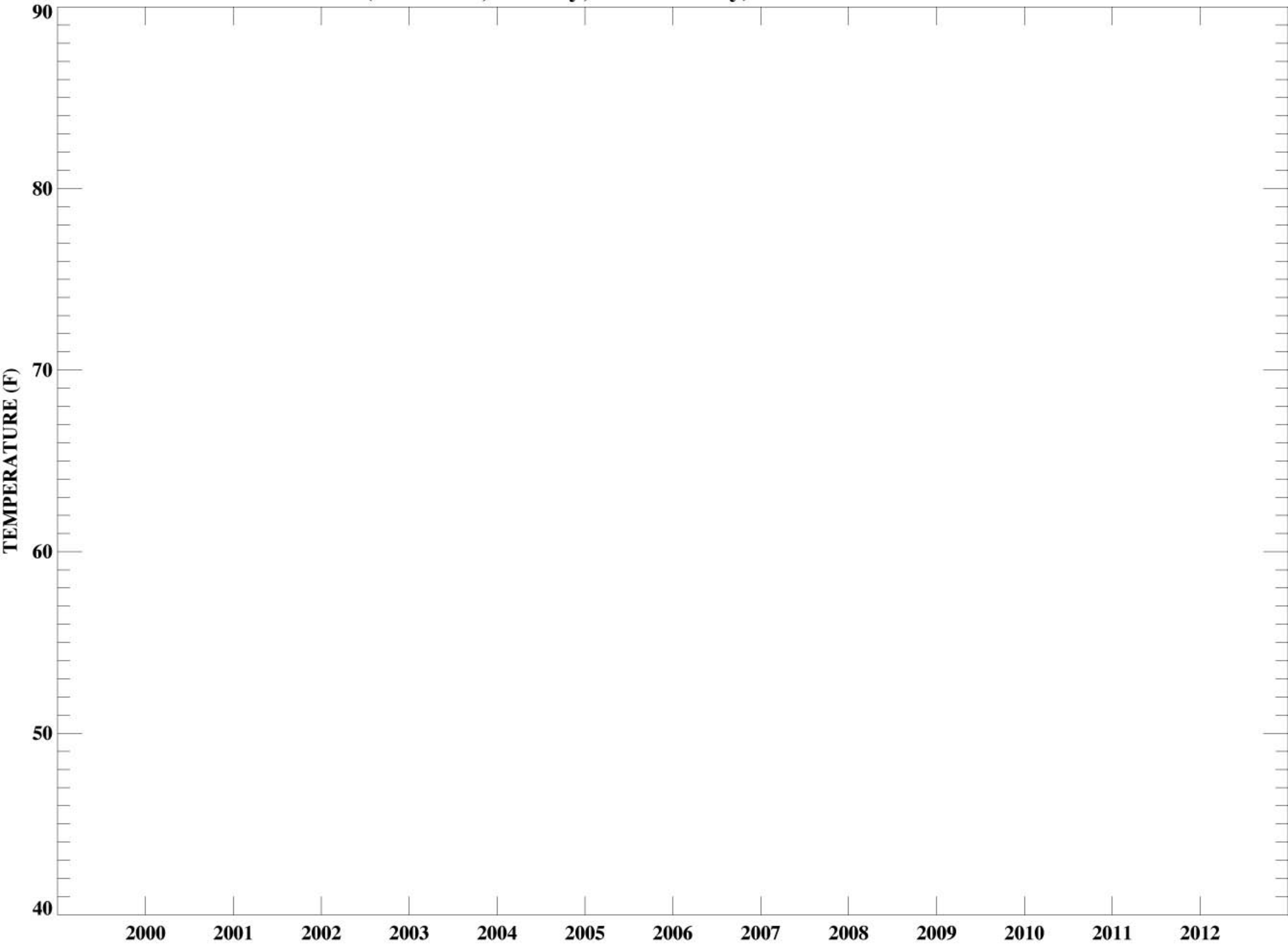
SUMMER (June, July, and August) MAXIMUM TEMPERATURE

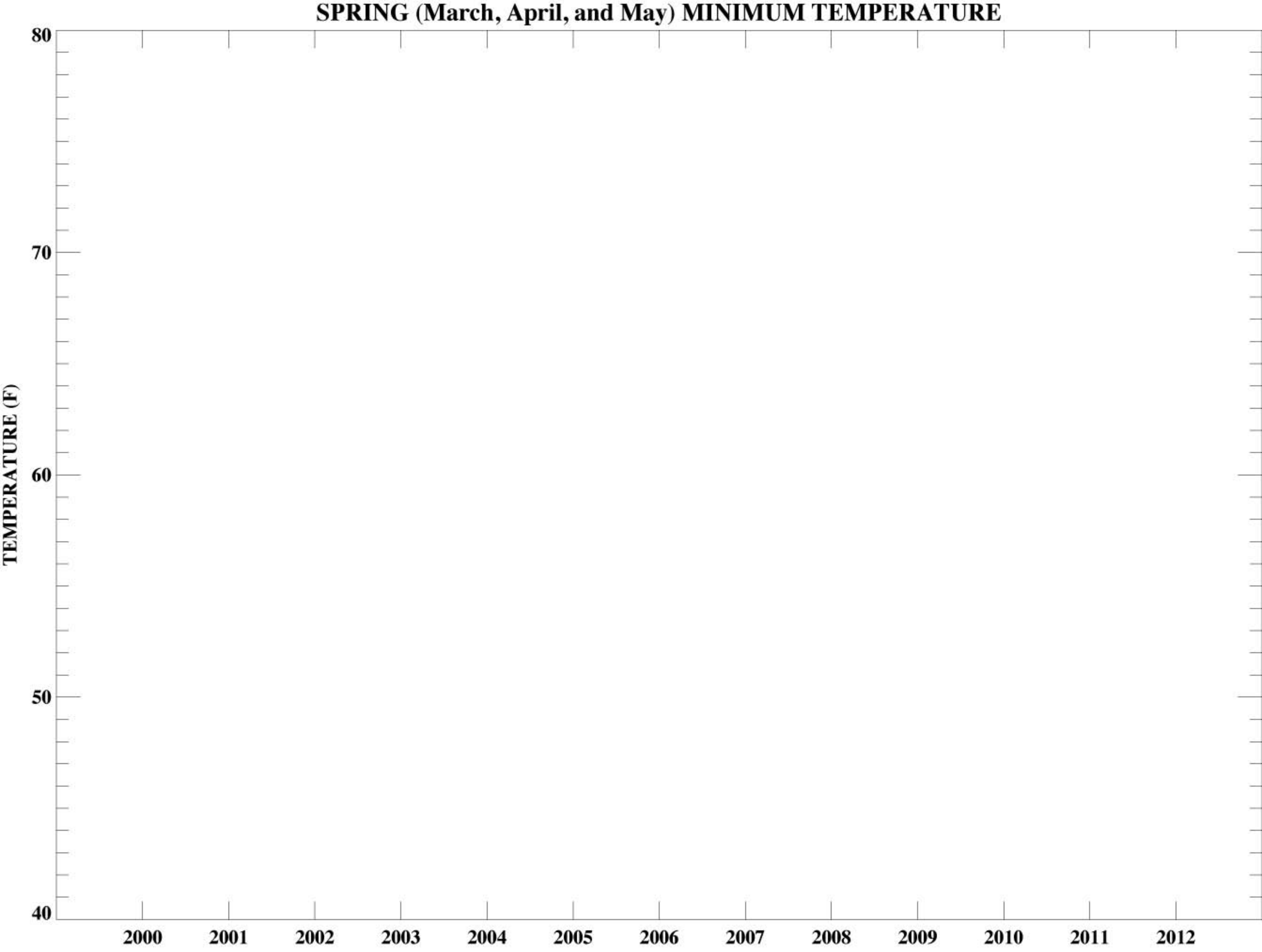


FALL (September, October, and  November) MAXIMUM TEMPERATURE

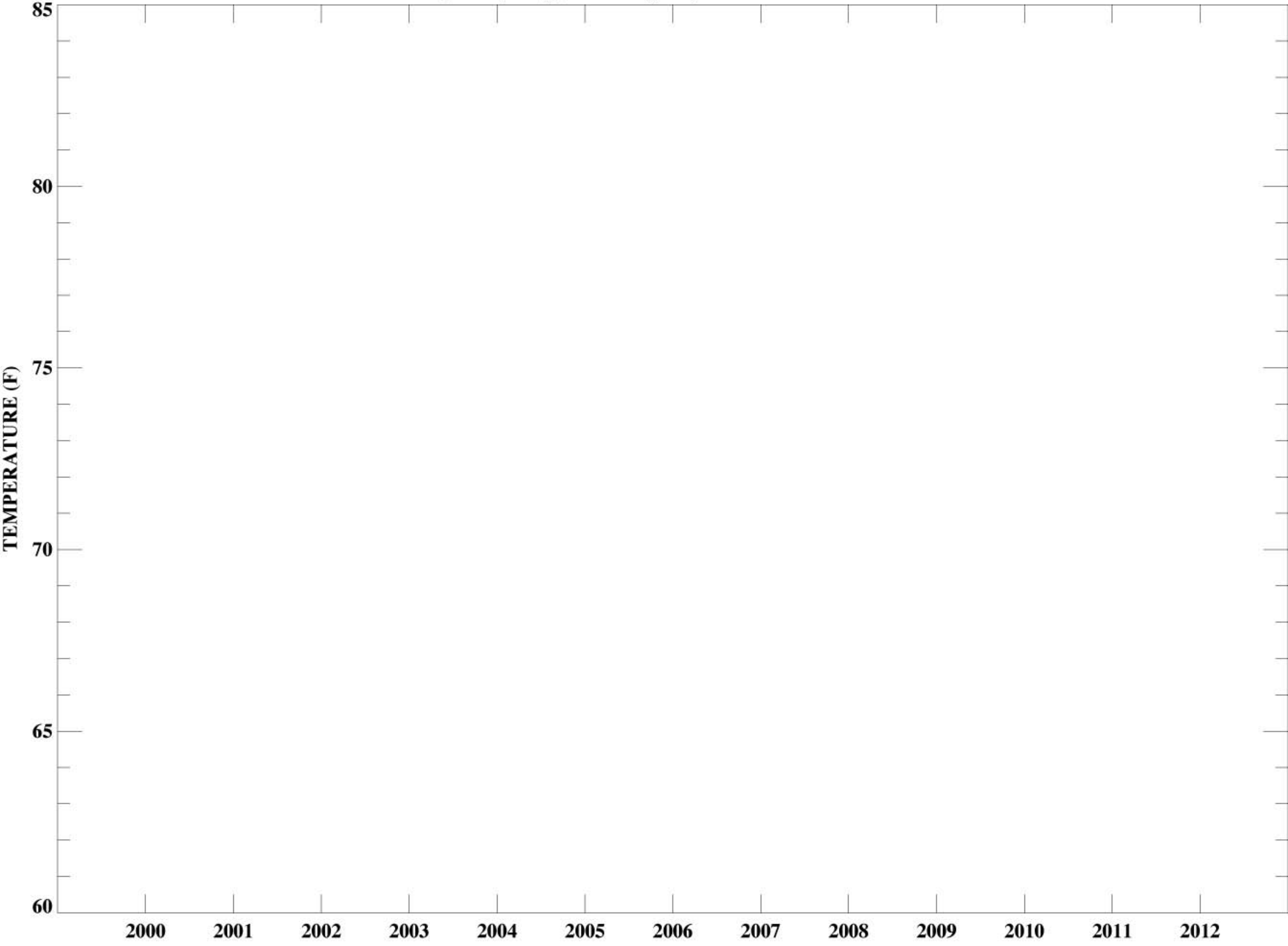


WINTER (December, January, and February) MAXIMUM TEMPERATURE

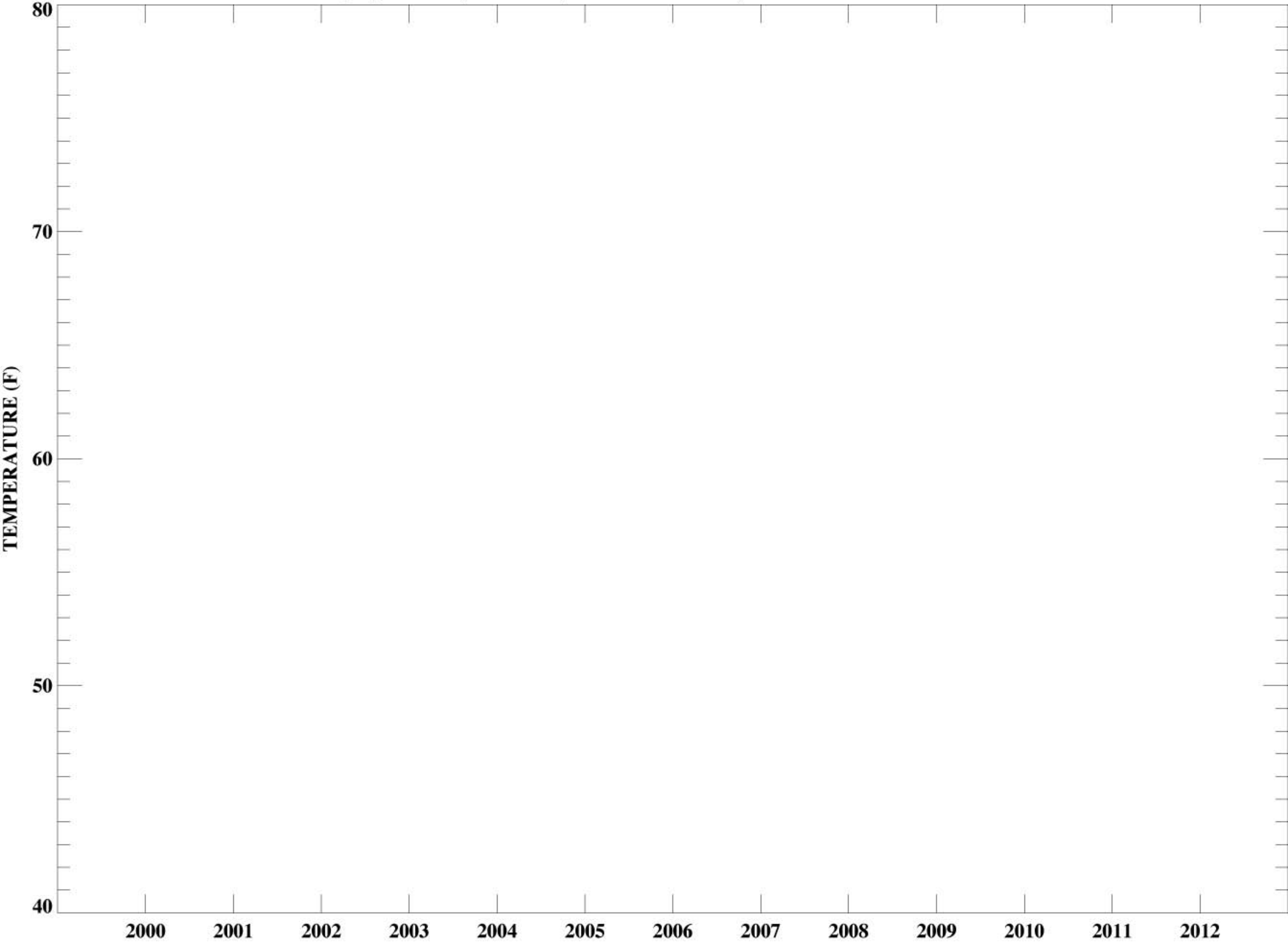



SPRING (March, April, and May) MINIMUM TEMPERATURE
TEMPERATURE (F)
80
70
60
50
40
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

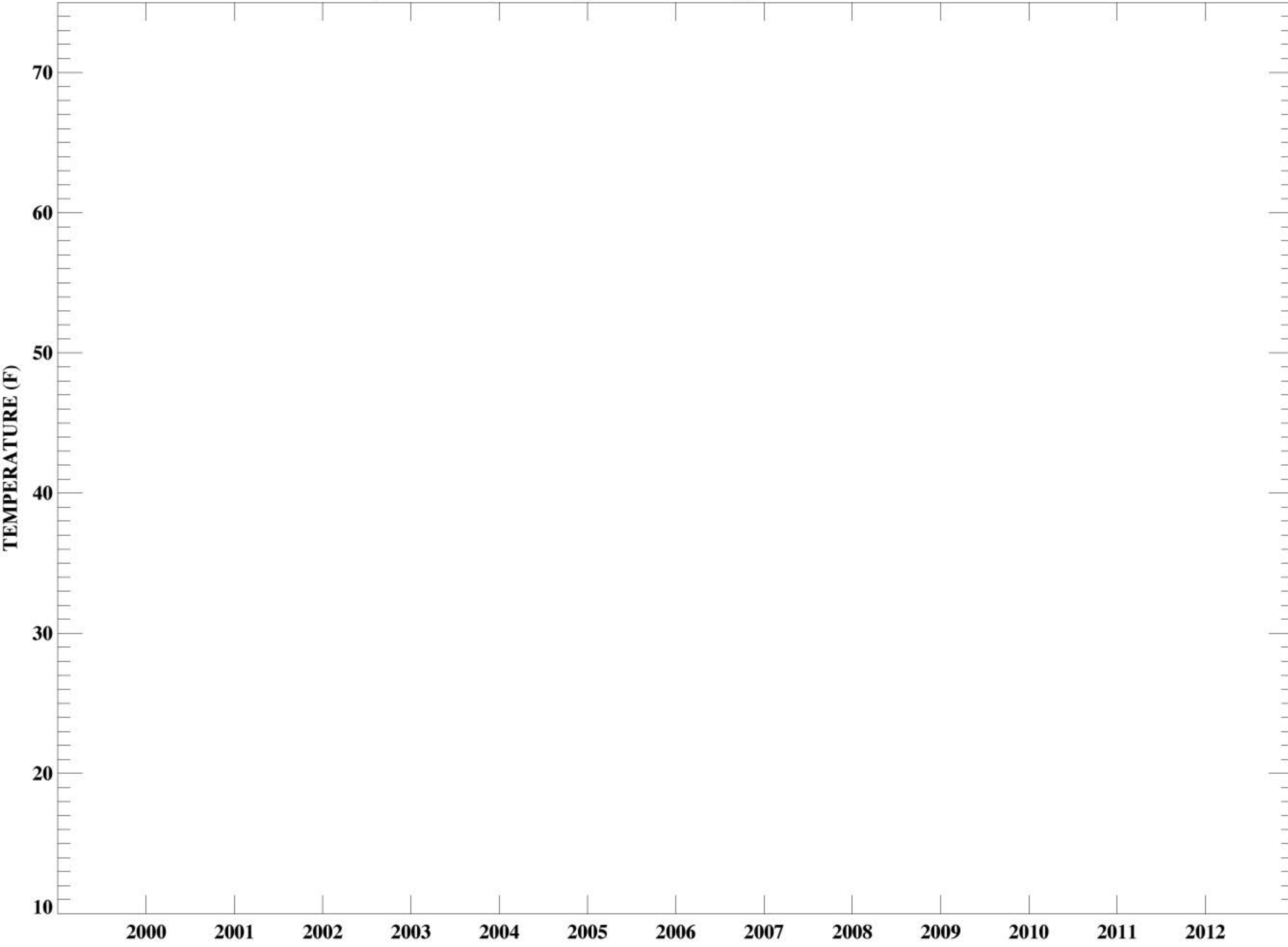
SUMMER (June, July, and August) MINIMUM TEMPERATURE



FALL (September, October, and November) MINIMUM TEMPERATURE



WINTER (December, January, and February) MINIMUM TEMPERATURE



| | | |
|---|---|---|
| Anemometer | | Barometer |
| Barometric pressure | | Cold front |
| Coriolis effect | | Drought |

| | | |
|---|---|---|
| Flood | | Front |
| Heat index | | High pressure system |
| Humidity | | Jet stream |

| | | |
|---|---|---|
| Lightning | | Low pressure system |
| Millibars | | Temperature |
| Warm front | | Water vapor |

| | | |
|---|---|---|
| Wind speed | | Psychrometer |

| | | |
|---|---|---|
| An instrument that measures the speed or force of the wind. | | An instrument used to measure atmospheric pressure. |
| The pressure exerted by the atmosphere at a given point. The measurement can be expressed in millibars or in inches or millimeters of mercury. | | The leading edge of an advancing cold air mass that is running under and displacing the warmer air in its path. |
| A force per unit mass that arises solely from Earth's rotation, acting as a deflecting force. It is dependent on the latitude and speed of the moving object. | | Abnormal dry weather for a specific area that is sufficiently prolonged for the lack of water to cause serious hydrological imbalance. |

| | | |
|---|---|---|
| High water flow or an overflow of rivers or streams from their natural or artificial banks, inundating adjacent low-lying areas. | | The transition zone or interface between two air masses of different densities, which usually means different temperatures. |
| The combination of air temperature and humidity that gives a description of how the air feels. | | An area of relative pressure maximum that has diverging winds and a rotation opposite to the Earth's rotation. |
| The amount of water vapor in the air. | | An area of strong winds concentrated in a relatively narrow band in the upper troposphere that flows from west to east. |

| | | |
|---|---|---|
| A sudden and visible discharge of electricity produced in response to the build up of electrical potential between cloud and ground, between clouds, within a single cloud, or between a cloud and surrounding air. | | An area of relative pressure minimum that has converging winds and rotates in the same direction as the Earth. |
| The standard unit of measurement for atmospheric pressure used by the National Weather Service. | | An instrument used to measure the water vapor content of the atmosphere. |
| The measure of molecular motion or the degree of heat of a substance. | | The leading edge of an advancing warm air mass that is replacing a retreating relatively colder air mass. |

| | | |
|---|---|---|
| Water in gaseous form. | | The rate of the motion of the air on a unit of time, measured in miles or knots per hour. |
| | | |
| | | |

# Weather Terms

# Key

| Term | Definition |
|---|---|
| anemometer | An instrument that measures the speed or force of the wind. |
| barometer | An instrument used to measure atmospheric pressure. |
| barometric pressure | The pressure exerted by the atmosphere at a given point. The measurement can be expressed in millibars or in inches or millimeters of mercury. |
| cold front | The leading edge of an advancing cold air mass that is running under and displacing the warmer air in its path. |
| Coriolis effect | A force per unit mass that arises solely from Earth's rotation, acting as a deflecting force. It is dependent on the latitude and speed of the moving object. |
| drought | Abnormal dry weather for a specific area that is sufficiently prolonged for the lack of water to cause serious hydrological imbalance. |
| flood | High water flow or an overflow of rivers or streams from their natural or artificial banks, inundating adjacent low-lying areas. |
| front | The transition zone or interface between two air masses of different densities, which usually means different temperatures. |
| heat index | The combination of air temperature and humidity that gives a description of how the air feels. |
| high pressure system | An area of relative pressure maximum that has diverging winds and a rotation opposite to the Earth's rotation. |
| humidity | The amount of water vapor in the air. |
| jet stream | An area of strong winds concentrated in a relatively narrow band in the upper troposphere that flows from west to east. |

| | |
|---|---|
| lightning | A sudden and visible discharge of electricity produced in response to the build up of electrical potential between cloud and ground, between clouds, within a single cloud, or between a cloud and surrounding air. |
| low pressure system | An area of relative pressure minimum that has converging winds and rotates in the same direction as the Earth. |
| millibar | The standard unit of measurement for atmospheric pressure used by the National Weather Service. |
| psychrometer | An instrument used to measure the water vapor content of the atmosphere. |
| temperature | The measure of molecular motion or the degree of heat of a substance. |
| warm front | The leading edge of an advancing warm air mass that is replacing a retreating relatively colder air mass. |
| water vapor | Water in gaseous form. |
| wind speed | The rate of the motion of the air on a unit of time, measured in miles or knots per hour. |

Adapted from The Weather Channel weather glossary:
http://www.weather.com/glossary/a.html

# Weather and Climate Variability Toolkit Glossary

*Climate* - The distribution of *weather* over longer periods, such as months or years.

*Climate variability* - The temporal variations of the atmosphere-hydrosphere-cryosphere-land surface system around a mean state.[1]

*Climatology* – The study of climate or a description of weather observations that have been collected over long periods (at least 30 years). The observations are collected from land-based weather stations, ships, buoys, and satellites passing over the Earth.

*Dendrochronology* - The study of past climate through tree ring patterns that allows scientists to reconstruct regional patterns of drought and climate variability.

*Dew point temperature* - The temperature to which the air has to cool to become saturated.

*El Niño* – The anomalous warming of the surface ocean waters in the eastern tropical Pacific (10 degrees above and 10 degrees below the equator) occurring every 3 to 7 years and associated with changes in weather patterns worldwide.

*ENSO (El Niño–Southern Oscillation)* – An episode of anomalously high sea surface temperatures in the equatorial and tropical eastern Pacific; associated with large-scale swings in surface air pressure between the western and central tropical Pacific.[2]

*Heat island* - An area of higher temperatures in the landscape, most commonly associated with urban centers (cities).

*Interannual* - Refers to processes that occur on a time scale of more than 1 year but usually less than 10 years.

*La Niña* – The anomalous cooling of the surface ocean waters in the eastern tropical Pacific (10 degrees above and 10 degrees below the equator) occurring every 3 to 7 years and associated with changes in weather patterns worldwide.

*Multidecadal* – Involving multiple decades.

*North Atlantic Oscillation* - A large-scale fluctuation in atmospheric pressure between the subtropical high pressure system located near the Azores in the Atlantic Ocean and the subpolar low pressure system near Iceland. Variations in this north-south pressure pattern can alter the strength and frequency of low pressure centers (cyclones) crossing the North Atlantic.

*Observation* - The act of measuring with an instrument, or the measurements of *weather* on hourly, daily, monthly, annual, or decadal time scales.

*Relative humidity* - A measure of the amount of water vapor contained in the air, divided by the maximum amount the air can hold, expressed as a percent.

*Sinkhole* - Natural formation found in areas where the underlying carbonate rocks can be dissolved by the circulation of groundwater.

*Thermocline* – A layer of water in which there is an abrupt change in temperature separating the warmer surface water from the colder deep water. [3]

*Weather* - Short-term (minutes to days) variations in the atmosphere such as temperature, humidity, air pressure, cloudiness, precipitation, and wind.

[1] adapted from American Meteorological Society 2000

[2] AMS online

[3] NOAA/CPC

**4-H Weather and Climate Variability Toolkit**
**Next Generation Sunshine State Standards At a Glance**

| Grade | Subject | Benchmark Code | Benchmark | Unit 1 | Unit 2 | Unit 3 | Unit 4 |
|---|---|---|---|---|---|---|---|
| 4th Grade | Science | SC.4.N.1.2 | Compare observations made by different groups using multiple tools and seek reasons to explain the difference across groups. | ● | | | |
| | | SC.4.N.1.3 | Explain that science does not always follow a rigidly defines method but that science does involve the use of observations and empirical evidence. | | | ● | |
| | | SC.4.N.1.5 | Compare the methods and results of investigations done by other classmates. | | | | ● |
| | | SC.4.N.1.7 | Recognize and explain that scientists base their explanations on evidence. | | | ● | |
| | | SC.4.N.3.1 | Explain that models can be 3-dimensional, 2-dimensional, and explanation in your mind, or a computer model | | | ● | ● |
| | | SC.4.N.1.8 | Recognize that science involves creativity in designing experiments. | | ● | | |
| | | SC.4.L.17.4 | Recognize ways plants, animals, humans can impact the environment. | ● | | | ● |
| | | SC.4.P.8.1 | Measure and compare objects and materials based on their physical properties including: mass, shape, volume, color, hardness, texture, odor, taste, attraction to magnets. | | | ● | |
| | Social Studies | SS.4.G.1.3 | Explain how weather impacts Florida | ● | ● | ● | ● |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5th Grade | Math | MA.5.A.4.1 | Construct and describe a graph showing continuous data, such as a graph of a quantity that changes over time. | | | | ● |
| | Science | SC.5.E.7.3 | Recognize how air temperature, barometric pressure, humidity, wind speed and direction, and precipitation determine the weather in a particular place and time. | ● | | | ● |
| | | SC.5.E.7.5 | Recognize that some of the weather-related differences, such as temperature and humidity, are found among different environments, such as swamps, deserts, and mountains. | ● | | ● | ● |
| | | SC.5.E.7.6 | Describe characteristics (temperature and precipitation) of different climate zones as they relate to latitude, elevation, and proximity to bodies of water. | ● | | | |
| | | SC.5.N.1.6 | Recognize and explain the difference between personal opinion/interpretation and verified observation | | ● | | |
| | Social Studies | SS.5.G.4.2 | Use geography concepts and skills such as recognizing patterns, mapping, graphic to find solutions for local, state, or national problems. | ● | | ● | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6th Grade | Science | SC.6.N.1.4 | Discuss, compare, and negotiate methods used, results obtained, and explanations among groups of students conducting the same investigation. | ● | | | ● |
| | | SC.6.E.6.1 | Describe and give examples of ways the Earth's surface is build up ad torn down by physical and chemical weathering, erosion, and deposition. | | | | ● |
| | | SC.6.N.3.4 | Identify the role of models in the context of sixth grade science benchmarks. | | | ● | ● |
| | | SC.6.N.3.1 | Recognize and explain that a scientific theory is a well-supported and widely accepted explanation of nature and is not simply a claim posed by an individual. Thus the use of the term theory in science is very different than how it is used in everyday life. | | ● | | |
| | | SC.6.E.6.2 | Recognize that there are a variety of different landforms on Earth's surface such as coastlines, dunes, rivers, mountains, glaciers, deltas. And lakes and relate these landforms as they apply to Florida. | | | ● | ● |
| | | SC.6.E.7.1 | Differentiate between radiation, conduction, and convections, the three mechanisms by which heat is transferred through Earth's system. | | | ● | |
| | | SC.6.E.7.3 | Describe how global patterns such as the jet stream and ocean currents influence local weather in measurable terms such as temperature, air pressure, wind direction and speed, and humidity and precipitation. | | | ● | |
| | | SC.6.E.7.4 | Differentiate and show interactions among the geosphere, hydrosphere, cryosphere, atmosphere, and biosphere. | | | ● | |
| | | SC.6.E.7.5 | Explain how energy provided by the sun influences global patterns of atmospheric movement and the temperature differences between air, water, and land. | | | ● | |
| | | SC.6.E.7.6 | Differentiate between weather and climate | ● | ● | ● | ● |
| | Social Studies | SS.6.G.1.2 | Analyze the purposes of map projections and explain the applications of various types of maps | | | ● | |

## Websites for Additional Information on Weather and Climate

National Earth Science Teachers Association (NESTA)

Windows to the Universe

http://www.windows2universe.org/

UCAR (University Corporation for Atmospheric Research) and NCAR (National Center for Atmospheric Research)

Kids' Crossing

http://www.eo.ucar.edu/kids/index.html

National Weather Service

JetStream – Online School for Weather

http://www.srh.noaa.gov/jetstream/

NOAA Education Resources

http://www.education.noaa.gov/

NASA, NOAA, NSF, managed by UCAR

The GLOBE Program

http://www.globe.gov/

NASA

Educator Resources

http://www.nasa.gov/audience/foreducators/index.html