How do scientists use technology to continually improve estimates of when and where natural hazards occur?

What if you could predict an earthquake?

What would make a good prediction? Knowing where, when, and the magnitude of the quake would make it possible for people to evacuate.

A Good Prediction

Scientists are a long way from being able to predict earthquakes. A good prediction must be detailed and accurate. Where will the earthquake occur? When will it occur? What will be the magnitude of the quake? With a good prediction authorities could get people to evacuate. An unnecessary evacuation is expensive and causes people not to believe authorities the next time an evacuation is ordered.

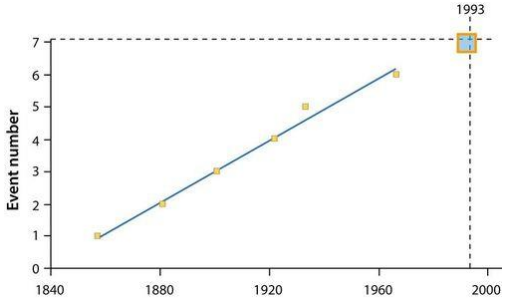
The probabilities of earthquakes striking along various faults in the San Francisco area between 2003 (when the work was done) and 2032.

Where?

Where an earthquake will occur is the easiest feature to predict. How would you predict this? Scientists know that earthquakes take place at plate boundaries and tend to happen where they've occurred before (Figure above). Fault segments behave consistently. A segment with frequent small earthquakes or one with infrequent huge earthquakes will likely do the same thing in the future.

When?

When an earthquake will occur is much more difficult to predict. Since stress on a fault builds up at the same rate over time, earthquakes should occur at regular intervals (Figure below). But so far scientists cannot predict when quakes will occur even to within a few years.



Around Parkfield, California, an earthquake of magnitude 6.0 or higher occurs about every 22 years. So seismologists predicted that one would strike in 1993, but that quake came in 2004 - 11 years late.

Earthquake Signs

Signs sometimes come before a large earthquake. Small quakes, called foreshocks, sometimes occur a few seconds to a few weeks before a major quake. However, many earthquakes do not have foreshocks, and small earthquakes are not necessarily followed by a large earthquake. Ground tilting, caused by the buildup of stress in the rocks, may precede a large earthquake, but not always. Water levels in wells fluctuate as water moves into or out of fractures before an earthquake. This is also an uncertain predictor of large earthquakes. The relative arrival times of P-waves and S-waves also decreases just before an earthquake occurs.

Folklore tells of animals behaving erratically just before an earthquake. Mostly, these anecdotes are told after the earthquake. If indeed animals sense danger from earthquakes or tsunami, scientists do not know what it is they could be sensing, but they would like to find out.

Earthquake prediction is very difficult and not very successful, but scientists are looking for a variety of clues in a variety of locations and to try to advance the field.

See more at

http://science.kqed.org/quest/video/earthquakes-breaking-new-ground/

It's been twenty years since the Loma Prieta Earthquake ravaged downtown Santa Cruz and damaged San Francisco's Marina District and the Bay Bridge. QUEST looks at the dramatic improvements in earthquake prediction technology since 1989. But what can be done with ten seconds of warning?

Find out more by listening to this audio report at:

http://science.kqed.org/quest/audio/predicting-the-next-big-one/

Lesson Summary

- A good prediction must indicate when and where an earthquake will take place with detail and accuracy.
- Fault segments tend to behave the same way over time.
- Signs that an earthquakes may occur include foreshocks, ground tilting, water levels in wells and the relative arrival times of P and S waves.

Think Like a Seismologist

1. What magnitude was the 2010 Haiti earthquake?

2. How did scientists recognize that the fault was active?

3. What evidence led to the prediction?

4. What can not be predicted?

5. What type of fault is at the Hayward Fault?

6. Why are earthquakes so hard to predict?

7. Why is it easier to predict where a quake will occur than when?

8. Describe some of the signs that scientists use to predict earthquakes.

9. It's now nine years after the map of earthquake probabilities in the San Francisco Bay area was made. What do you think the fact that no large earthquakes have struck those faults yet does to the probability that one will strike by 2032?

What is one of the deadliest science jobs?

No one can predict exactly when a volcanic eruption will take place. There are clues, but no one knows exactly when. Sometimes a volcano will erupt when scientists are studying it. Volcanologists have a high fatality rate among scientists because forecasting eruptions is so difficult.

Predicting Volcanic Eruptions

Volcanic eruptions can be devastating, particularly to the people who live close to volcanoes. Volcanologists study volcanoes to be able to predict when a volcano will erupt. Many changes happen when a volcano is about to erupt. Even so, eruptions are very difficult to predict.

History of Volcanic Activities

Scientists study a volcano's history to try to predict when it will next erupt. They want to know how long it has been since it last erupted. They also want to know the time span between its previous eruptions. Scientists watch both active and dormant volcanoes closely for signs

that show they might erupt.

Mount Rainier in Washington State is currently dormant. The volcano could, and probably will erupt again.

Earthquakes

Earthquakes may take place every day near a volcano. But before an eruption, the number and size of earthquakes increases. This is the result of magma pushing upward into the magma chamber. This motion causes stresses on neighboring rock to build up. Eventually the ground shakes. A continuous string of earthquakes may indicate that a volcano is about to erupt. Scientists use seismographs to record the length and strength of each earthquake.

Slope Tilt

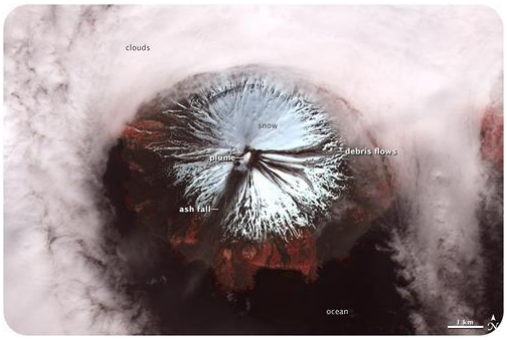
All that magma and gas pushing upward can make the volcano's slope begin to swell. Ground swelling may change the shape of a volcano or cause rock falls and landslides. Most of the time, the ground tilting is not visible. Scientists detect it by using tiltmeters, which are instruments that measure the angle of the slope of a volcano.

Gases

Scientists measure the gases that escape from a volcano to predict eruptions. Gases like sulfur dioxide (SO_2), carbon dioxide (CO_2), hydrochloric acid (HCl), and water vapor can be measured at the site. Gases may also be measured from satellites. The amounts of gases and the ratios of gases are calculated to help predict eruptions.

Remote Monitoring

Satellites can be used to monitor more than just gases (Figure below). Satellites can look for high temperature spots or areas where the volcano surface is changing. This allows scientists to detect changes



accurately and safely.

Mount Cleveland, in Alaska, is monitored by satellite.

Costs and Benefits of Predictions

No scientist or government agency wants to announce an eruption and then be wrong. There is a very real cost and disruption to society during a large-scale evacuation. If the scientists are wrong, people would be less likely to evacuate the next time scientists predicted an eruption. But if scientists predict an eruption that does take place, it could save many lives.

Lesson Summary

- Volcanologists use several lines of evidence to try to forecast volcanic eruptions.
- Magma moving beneath a volcano will cause earthquakes and slope deformation. Gases may be released from the magma out of the volcano vent.
- Deciding whether to call for an evacuation is very tricky.

Think Like a Volcanologist

PRACTICE

Use the resource below to answer the questions that follow.
Mount Pinatubo: Predicting a Volcanic Eruption at

`http://www.teachersdomain.org/asset/ess05_vid_pinatubo/`

1. What does the measurement of sulfur dioxide tell scientists?

2. How many seismic stations were established around the mountain?

3. What did the seismic stations measure?

4. What evidence was there for a potential eruption?

5. What finally triggered the evacuation from the island?

6. When did the first eruption occur? How soon after the evacuation?

7. When did the massive eruption occur?

REVIEW

8. What are the signs that magma is moving beneath a volcano?

9. How is a volcano monitored remotely?

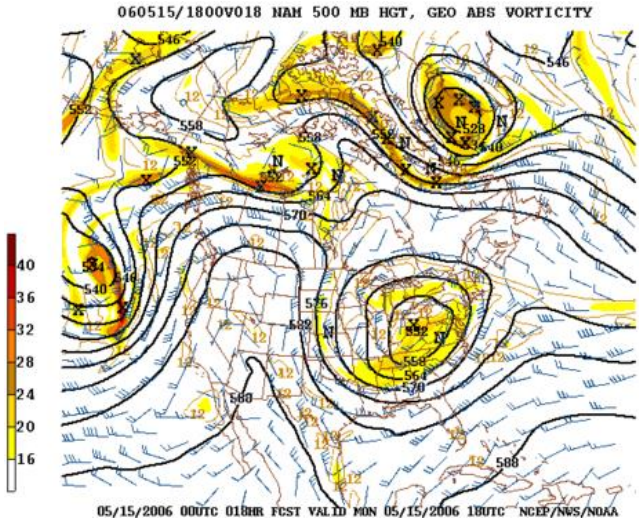
10. Why is it helpful for scientists to be able to predict volcanic eruptions?

Does a picnic bring rain?

Weather forecasts are better than they ever have been. According to the World Meteorological Organization (WMO), a 5-day weather forecast today is as reliable as a 2-day forecast was 20 years ago. Now there's no excuse to be rained out on a picnic!

The most accurate weather forecasts are made by advanced computers, with analysis and interpretation added by experienced meteorologists. These computers have up-to-date mathematical models that can use much more data and make many more calculations than would ever be possible by scientists working with just maps and calculators. Meteorologists can use these results to give much more accurate weather forecasts and climate predictions.

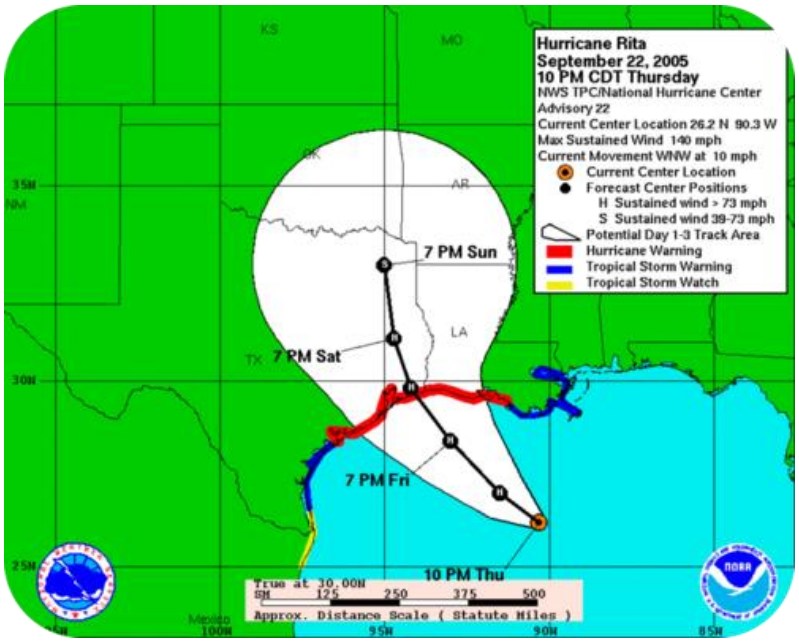
In Numerical Weather Prediction (NWP), atmospheric data from many sources are plugged into supercomputers running complex mathematical models (Figure below). The models then calculate what will happen over time at various altitudes for a grid of evenly spaced locations. The grid points are usually between 10 and 200 kilometers apart. Using the results calculated by the model, the program projects weather further into the future. It then uses these results to project the weather still further into the future, as far as the meteorologists want to go. Once a forecast is made, it is broadcast by satellites to more than 1,000 sites around the world.



A weather forecast using numerical weather prediction.

NWP produces the most accurate weather forecasts, but as anyone knows, even the best forecasts are not always right.

Weather prediction is extremely valuable for reducing property damage and even fatalities. If the proposed track of a hurricane can be predicted, people can try to secure their property and then evacuate (Figure below).



By predicting Hurricane Rita's path, it is likely that lives were saved.

Lesson Summary

- Meteorologists use computers to crank data through mathematical models to forecast the weather.
- Numerical weather prediction calculates what will happen to conditions horizontally and vertically over an area.
- Weather forecasts can go further into the future than ever.

Think Like a Meteorologist

PRACTICE

Use this resource to answer the questions that follow.

`http://www.youtube.com/watch?v=dqpFU5SRPgY`

1. Why is weather difficult to predict?

2. What is the afternoon constellation? What does it do?

3. What are the basic shapes of clouds?

4. What is fog?

5. Why is it important to study clouds?

6. What will Cloudsat do? Why is this an improvement?

REVIEW

7. What is numerical weather prediction?

8. Even with numerical weather prediction, meteorologists have a difficult time predicting the path of a hurricane more than a day or two into the future. Why?

9. One popular online weather prediction site goes 10 days out and another goes 15 days out. Why the discrepancy?

Social, Economic, and Environmental Issues Affect Decisions about Human-Engineered Structures

Use the Internet to investigate and report on a local human engineered structure that is being built (dams, homes, bridges, roads). What kind of **social**, **economic** and **environmental** issues affect the decisions about where these structures are built? Share what you find with a friend.

Glossary

- **Atmosphere**: is the layer of gases that may surround a planet of sufficient mass
- **Biomass**: Total mass of organisms at a trophic level.
- **Biomass production**: Use of organic matter (biomass) from plants to create electricity.
- Biosphe**re**: the global ecological system integrating all living beings and their relationships.
- **Feedback Loops**: is a process in which information about the past or the present influences the same phenomenon in the present or future. As part of a chain of cause-and-effect that forms a circuit or loop, the event is said to "feed back" into itself.
- **Geosphere**: the solid part of earth including the surface
- **Geothermal power**: Electricity derived from the natural flow of heat from the earth's core.
- **Hydropower**: Electricity derived from the energy of moving water.
- **Hydrosphere**: the combined mass of water found on, under, and over the surface of a planet
- **Natural Hazards**: a threat of a naturally occurring event that will have a negative effect on people or the environment
- **Nonrenewable resource:** Natural resource that is used up faster than it can be made by nature.
- **Renewable resource**: Natural resource that can be replaced as quickly as it is used.
- **Resources**: A useful material that is found in nature sustainable resource: Resources that is used in a way that meets the needs of the present without keeping future generations from meeting their needs.
- **Solar power**: Electricity derived from the sun.
- **Wind power**: Electricity derived from the wind.