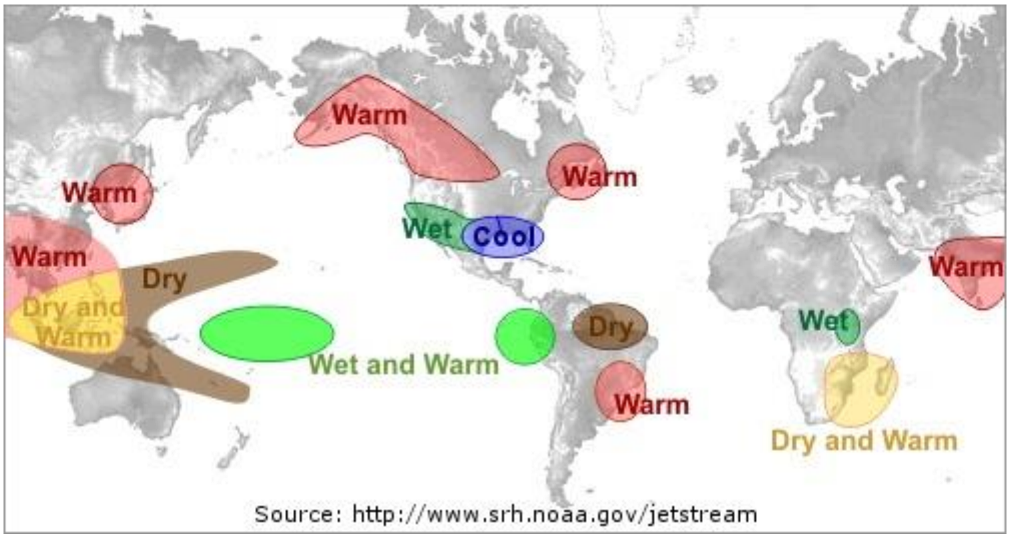
Unit 5 Background Information: Water, Atmosphere & Land

Short-Term & Long-Term Climate Change

El Nino-Southern Oscillation (ENSO) provides an example of *short-term climate change*. It occurs irregularly at 2-7 year intervals and was first recognized by fishermen off the coast of Peru. During an El Nino event unusually warm ocean currents in the eastern Pacific result in heavy rains and flooding in some parts of the world (e.g. South America), and droughts in other parts of the world (e.g. Australia). La Nina is essentially the opposite of El Nino. During a La Nina event ocean currents cool and the aforementioned climate patterns reverse. The atmospheric component of ENSO is called Southern Oscillation and it refers to a change in air pressure that occurs over the tropical Pacific.

Figure: El Nino December-February



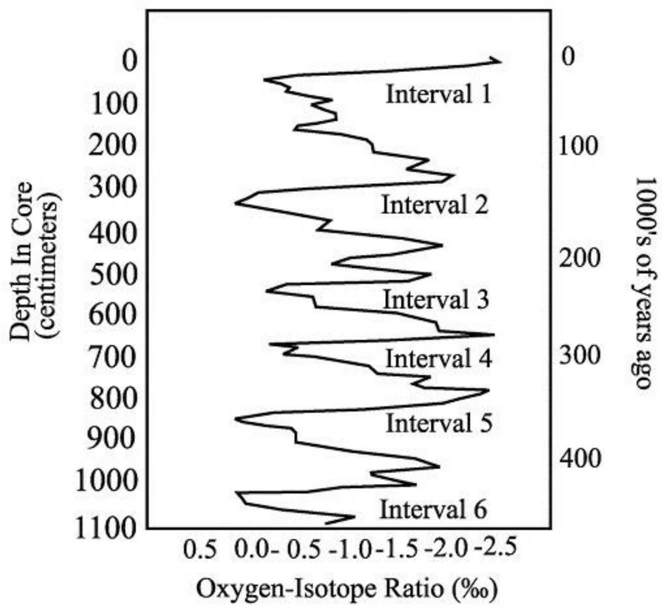
Milankovitch cycles help explain *long-term patterns of climate change*. The Milankovitch Theory explains long-term climate patterns using cyclic variations in three elements of Earth-sun geometry: eccentricity, obliquity and precession. Orbital eccentricity refers to *changes in Earth's orbit* around the sun. This affects the distance between Earth and the sun during the period of its revolution. Earth's orbit ranges from an elliptical orbit to a more circular orbit in a cycle that takes between 90-000 to 100,000 years to complete.

Obliquity refers to *changes in the tilt of earth's axis* between 22.1 and 24.5 degrees. As the tilt of Earth's axis increases the difference between seasons intensifies. It takes roughly 40,000 years to complete one cycle.

Precession is a *change in the direction of Earth's axis of rotation* similar to that of a top as its spin begins to slow. This influences the dates at which the Earth is closest to and farthest away from the sun. Changes in precession increase the contrast between seasons in one hemisphere and decrease the contrast between seasons in the opposite hemisphere.

Together, these three cycles of variation in Earth-sun geometry can be used to explain long-term patterns of climate change like the ice ages.

Figure: Ice Ages

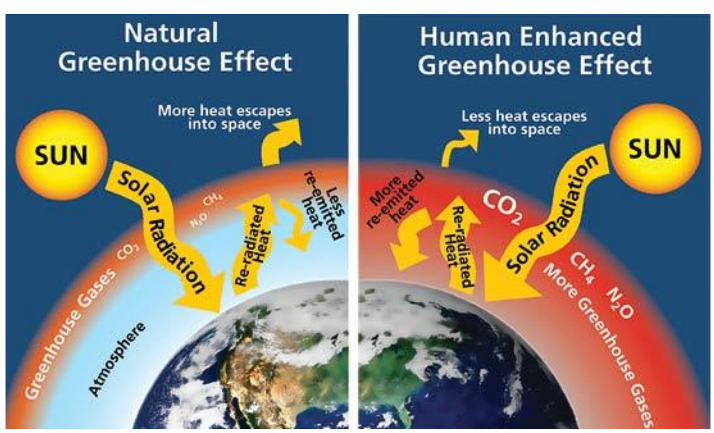


Sawtooth cycles from Broecker and van Donk, showing core depth & age versus oxygen isotope ratio. Note how graph shows that during ice age intervals the buildup is slow and jagged while the end is abrupt

The Greenhouse Effect

Gases in the atmosphere function like a greenhouse by trapping heat from the. As solar radiation heats the earth, the planet warms and emits radiation out into the atmosphere in the form of infrared light. The absorption of radiation coming from the Earth by greenhouse gasses and subsequent re-radiation of that energy back to Earth is called the *greenhouse effect*. It is important to note that life on Earth would be impossible without the heat-trapping effects of greenhouse gases in the atmosphere (the average temperature would be ~0^{o} F). Greenhouse gasses include: water vapor, carbon dioxide, methane, nitrous oxide, and ozone. These gases differ in their concentration, their ability to absorb radiation and in the amount of time they spend in the atmosphere. Natural sources of these gases include volcanism, cellular respiration, denitrification and evaporation. Anthropogenic sources of greenhouse gasses include fossil fuel combustion, agriculture, deforestation, landfills and industrial chemicals. In the United States, fossil fuel combustion for electricity generation and transportation are responsible for producing most of our carbon, nitrogen, and ozone emissions. Agriculture and natural gas exploration produce most of our methane emissions. Our goal is to reduce greenhouse gas emissions, and achieving this aim will require significant changes in manufacturing, agriculture, energy generation and transportation.

Figure: Greenhouse Effect



Greater concentrations of greenhouse gases mean more solar radiation is trapped within the Earth's atmosphere, making temperatures rise. Source: W. Elder, NPS.

Human Impact on Natural Resources

Like every other organism, humans alter the environment in which they live. As the human population grows and countries industrialize our impact on the environment expands. Human activity impacts the water, the air, and the land and the consequences can be far reaching and severe.

Common sources of water pollution include human wastewater, agriculture, industry, mining, development, and pharmaceuticals. In the United States we have infrastructure in place to treat our wastewater. Septic tanks and sewage treatments plants are used to remove contaminants before releasing water back into the environment. However, there are instances in which the older components of our infrastructure are overwhelmed and large quantities of untreated sewage are released into the environment. This occurs because some of our old wastewater treatment plants receive water from storm drainage systems in addition to the wastewater received from households. Large storms can overwhelm the plant's capacity and cause it to release untreated sewage directly into a nearby body of water. According to the EPA, sewage overflows happen about 40,000 times per year in the United States.

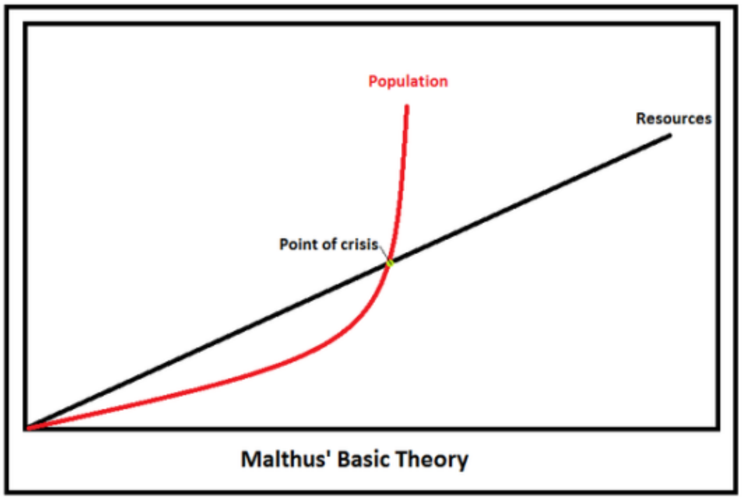
Air pollution comes from natural and anthropogenic sources. Natural sources include volcanoes, plants, lightening, and forest fires. Anthropogenic sources include: fossil fuel combustion, industrial processes and agriculture. In the United States the Clean Air Act lists six criteria air pollutants: sulfur dioxide, nitrogen oxides, carbon monoxide, particulate matter, tropospheric ozone and lead. The effects of these pollutants include respiratory irritation, tissue damage, acid rain, ozone, and climate change. The extraction and combustion of fossil fuels is responsible for much of the air pollution we generate, and once in the atmosphere these pollutants can be carried anywhere in the world.

Humans use land for a variety of purposes including agriculture, development, industry and waste disposal. The goal of effective land management is to maximize the benefits of these activities while minimizing their harmful effects on the environment. To illustrate, in the United States we use landfills to dispose of most of our waste. Landfills improve our quality of life by removing waste from our homes and helping to prevent the spread of disease. Although landfills are designed to prevent the environment from becoming contaminated with our waste, there is still a risk that the surrounding soil and water will become contaminated by leachate from the landfill. In fact, according to the EPA, almost all landfills have released leachate into the environment. Land use practices involve trade-offs, and we have to consider potential environmental consequences alongside any perceived improvements in our quality of life.

Population Growth & Food

In the late eighteenth century Thomas Malthus pointed out that the human population was growing faster than its ability to produce food. According to Malthus "the power of population is so superior to the power of the earth to produce subsistence for man that premature death must in some shape or other visit the human race." He illustrated the point with a graph.

Figure: Malthus' Theory



Malthus recognized food a major limiting factor to the number of people the Earth can support. In spite of advances in technology that have allowed us to produce more food per acre of land than ever before, there are still people who do not receive adequate nutrition. Roughly eight million people starve to death every year and many more millions are classified as undernourished or malnourished. Poverty is recognized as the primary cause of our food problem. Enough food is produced to feed everyone, but not everyone can afford to buy the food they need. In stark contrast to people with inadequate diets, the World Health Organization estimates that more than one billion people are over-nourished. In 2004 the International Obesity Task Force released a study stating that a quarter of the world's population was overweight, five percent of which was obese. The food problem is complex, and solutions must be sought at every level in politics, economics, and agriculture. Each stakeholder is critically important to ensuring that every person has access to adequate diet.

Sources

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