BRIDGING SCIENCE AND JOURNALISM CURRICULUM PACKET

This curriculum packet includes lesson plans for high school science teachers to help their students make the connection between science and journalism. This packet is plug and play - meaning that one can decide to use all lesson plans or just a few. The choice is up to you!

Each lesson plan includes:

- Overview of the activity
- NGSS standards the lesson matches to
- Student learning objectives
- Instructions for the activity (and relevant answer keys if needed)
- Lesson outcomes
- Assessment options

This curriculum aims to help students build their creative and critical thinking, problem solving, communication and writing skills while exploring aspects of science phenomena in San Diego while using journalistic and scientific approaches to complete each lesson.

The lesson plans included are:

- Geoscience
- Storytelling with Science
- How to Think Like a Journalist
- Engineering a Sensor
- Mapping with Science Data

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This project is part of the Center for Science and Media at San Diego State University in the School of Journalism and Media Studies. The Center for Science and Media is a collaboration of the School of Journalism and Media Studies with the College of Sciences in the areas of research, public service, and curriculum. The Center's mission is to educate the public about science, through the strategic and ethical use of media.

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GEOSCIENCE: The Atmosphere System

A Multidisciplinary View of Air Chemistry and Life

Lesson Plan Created by
Kevin Robinson, San Diego State University Department of Geological Sciences

ABOUT

The goal of this “critical and creative thinking” lesson is to develop a “systems’ understanding of some of the complex interactions that determine the nature of Earth’s atmosphere and a basic understanding of the role that humans play. Earth processes operate over a variety of time frames. Some have shaped the atmosphere over geologic time (millions of years) to create our beloved environment. Others show off their short term influence with quick results. A natural short term influencer can be a moderate sized explosive volcanic eruption which can change global heat flow for several years. Humans are also a short term force (a continual force) and have produced a measurable system change in 100 years (a hundred years is short, a million is long). Unlike a single volcanic eruption, the human force is ongoing. This lesson is to serve as a launching point for individualized student investigation. Some research questions are proposed for the teacher as a starting point.

NGSS STANDARDS

Practices: Asking Questions and Defining Problems, Engaging in Argument from Evidence.

Disciplinary Core Ideas: ESS1C-The History of Planet Earth, ESS2A-Earth Materials and Systems, ESS3D-Global Climate Change, ESS3C-Human Impacts on Earth Systems

Cross Cutting Concepts: Patterns, Cause and Effect, Scale Proportion and Quantity, System and System Models, Energy and Matter, Structure and Function, Stability and Change, Interdependence of Science, Engineering, and Technology, Influence of Science, Engineering, and Technology on Society and the Natural World

LEARNING OBJECTIVES
Students will be able to:

- Develop a working knowledge of the evolving ocean-atmosphere system and note its chemistry and relation to climate, pollution, and environmental health.
- Explore the complexity of processes that force Earth's atmosphere to change over different time frames and define how this relates to carbon cycling.
- Realize our human contribution in the whole Earth system.

ACTIVITIES

- Complete Worksheet 1 and 2: Earth System Connections
- Complete Critical Thinking Assignment (Optional): Students can research the ideas discussed in the following lesson and through further study of the Earth's Atmosphere System.
- Students should describe and relate their understanding in words and/or images as an educational news story, motivational narrative, or visual compilation.

Instructions

1. Provide the students with the reading included in this lesson plan.
2. Have the students complete worksheets 1 and 2 (can be done in the same session or follow-up session) and turn them into the teacher for review and a grade.

   OPTIONAL:

   Critical Thinking Assignment

   1. Students research the ideas from the reading and do further study using the links and search terms below.

   2. Students describe and relate their understanding of the reading in words or images and provide that to the teacher for review and a grade.

      Search Terms: connections between the atmosphere, hydrosphere, geosphere and biosphere, atmospheric systems, system sciences and the atmosphere, biosphere-atmosphere interactions, geosphere-atmosphere interactions, hydrosphere atmosphere interactions, understanding the atmosphere from an earth systems perspective, the carbon cycle, the atmosphere of the Anthropocene, particulate pollution, air particulate chemistry, air pollution and human health.

      Search strategies could include searching for websites and images as well as Google Scholar for periodical or journal references

See Addendum for Pollution and Atmospheric Chemistry

- Students can continue to research pollution and atmospheric chemistry (see worksheet 3)

OUTCOMES

The students will be able to:

- Complete the “Connections Worksheets”. For each connection, write a short description of the processes involved.
- Provide a multidisciplinary understanding of the evolving atmosphere with knowledge of geologic, and historic rates of change.
- Show a developed “diversity of thought” from an individual perspective.
- Create a news story, motivational narrative, essay, poster, video, poem, painting, or song of their choice to describe the connections from the worksheet.

ASSESSMENT:

Students will be evaluated based on the completion of worksheets and a written and/or creative summary of the atmosphere system. Further assessment can be determined by the teacher.

Earth's Atmosphere System

One of the big realizations in the study of our atmosphere is that a true Earth Systems understanding is essential. This was apparent in the 1960s when meteorologists began to integrate ocean science data in their weather models. Since then, we know much more about the global processes involved in determining atmospheric chemistry and physics. Such "systems" learning involves several domains of science that were at one time studied independently. A systems approach involves multidisciplinary perspectives and requires knowledge integration. Geology, chemistry, physics, biology, engineering, and life science as well as social science are components to understand and are also directions for investigation. The atmosphere of planet Earth is directly tied to the biosphere, hydrosphere, geosphere, and the ecosystems and environments that together they create and how they interact with each other. The rate and intensity of the variety of processes drives weather, climate, and life changes over time.

Ocean-Atmosphere System. The atmosphere can't be separated from the ocean-atmosphere system. It is most influenced by the transfer of heat and mass in the water cycle. One meter off the top of the entire ocean is evaporated into the atmosphere every year. This is how geological processes like weathering, erosion, sedimentation, and spectacles like the Grand Canyon can form over millions of years. In 5,000-10,000 years, you could evaporate all the water in the ocean. In 5 million years, global evaporation could produce rain equivalent to 1,000 oceans. Small changes in the ocean-atmosphere system over many thousands of years can trend Earth toward an Ice Age or to a hotter and steamier epoch. But even smaller changes can make more rain or wind, and change the depth of seasons and paths of storms. Though the water vapor in the atmosphere is small (1-4%) it is a big factor in the global climate story. A hotter world means more rain and increased rates of weathering and erosion. It also means more flooding.

Geosphere

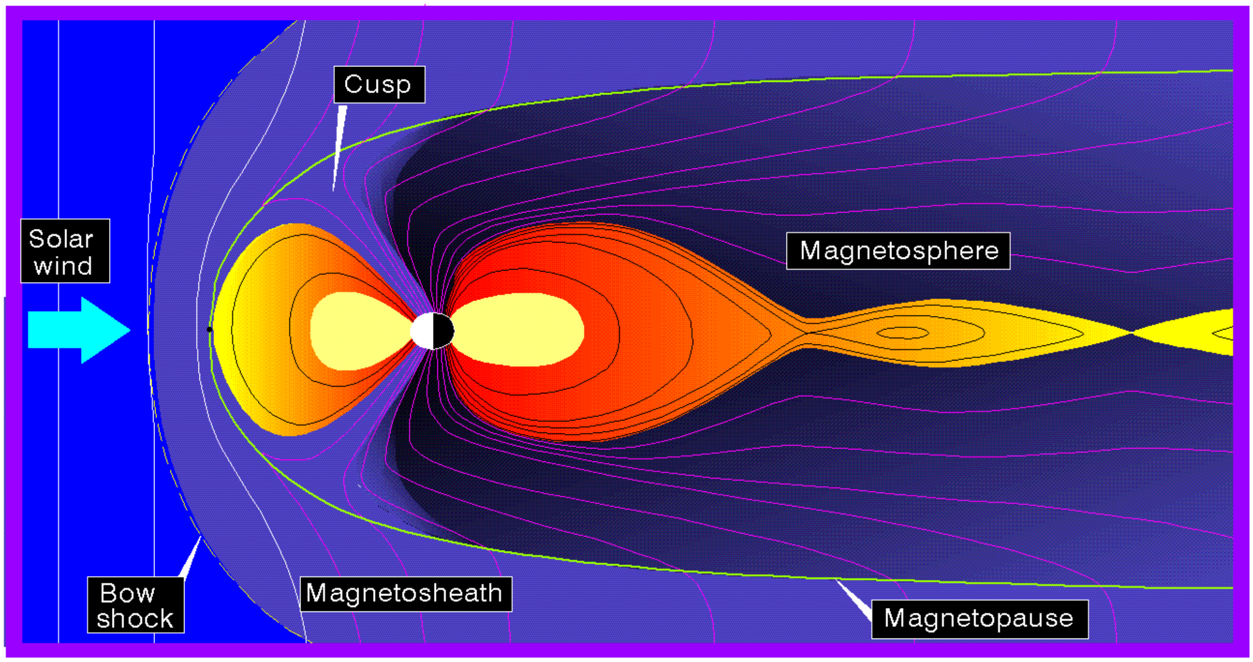


Fig 1: The magnetic field that is generated deep inside the Earth is the reason we still have an atmosphere.
(Image Source: NASA https://image.gsfc.nasa.gov/poetry/magnetism/magnetism.html)

The geosphere system consists of the solid earth and the processes related to its formation (tectonics/magma), its behavior (convection/magnetism) as well as the processes of weathering, erosion and sedimentation. Geosphere processes like seafloor spreading and weathering remove carbon (sequester) from the environment. Weathering of calcium rich rocks enables more carbonate ($CaCO_3$) minerals to form. Hydrothermal alteration of ocean crust via sea-floor spreading also removes carbon. Rocks and minerals that form carbonate and organic mud rocks (shale) pull the carbon out of the environment for long term sequestration (millions of years). Oil shale is a dominant source rock for petroleum and gas. The rocks that form in the ocean that are partly made up of carbon (limestone, shale) are almost always formed with involvement of the biosphere.

The inside of planet Earth (outer core) produces a strong geomagnetic field that protectively surrounds our planet (Fig 1). The hot convecting metal interior is the main reason why we have an atmosphere. Mars (⅕ size of Earth) likely once had molten metal core that protected an atmosphere for its first billion years. Upon solidification, the magnetic dynamo effect dissipated and Mar's precious gases (and water) were lost. After this stage, the buffer from heat and cold no longer exists. The resulting loss of water vapor and hydrosphere on Mars 3.5 billion years ago left a parched and virtually dead world.

Another one of the geosphere feedbacks to the atmosphere is the release of volcanic gases, both Carbon Dioxide and Sulfur Dioxide. Over geologic time, variations and cycling of carbon contributes to slowly changing concentrations and correlates with hot or cold geologic periods . During tectonic upheavals, volcanic emissions can have a major long-term effect (thousands to millions of years) with CO2 causing intense global warming and environmental disruption including mass extinctions (e.g. Permian, and Triassic). These were times of major tectonic rearrangement, and though they did not happen instantaneously, they are still seen to be focused over a more narrow time frame compared to the typical rates of tectonic change. Generally it is slow changes over time to the system that produces the long term changes in atmospheric Carbon Dioxide. As we know, CO2 warms the planet (holding heat from infrared radiation) just as a decrease in CO2 results in a cooler planet.

Volcanoes also have the ability to change the atmosphere and its heat flow much faster. A large-volume, ash and gas rich eruption can have a rather sudden (months-years) effect on climate. In this case it is not the CO2 that causes the change it is the Sulfur Dioxide (SO2). This volcanic gas can be injected high into the stratosphere where it persists as crystals of sulfate for several years. In 1991, Mt. Pinatubo in the Philippines produced the largest eruption of the 20th Century and showed scientists how the cooling can happen (0.5C over two years). A bigger event like that in 1815 at Mt. Tambora can cause 2-3C changes. This might seem like a small change but that eruption is credited with producing the "year without a summer" in 1816. Figure 2 shows the temporal relationship between large sulfur rich eruptions and global temperatures.

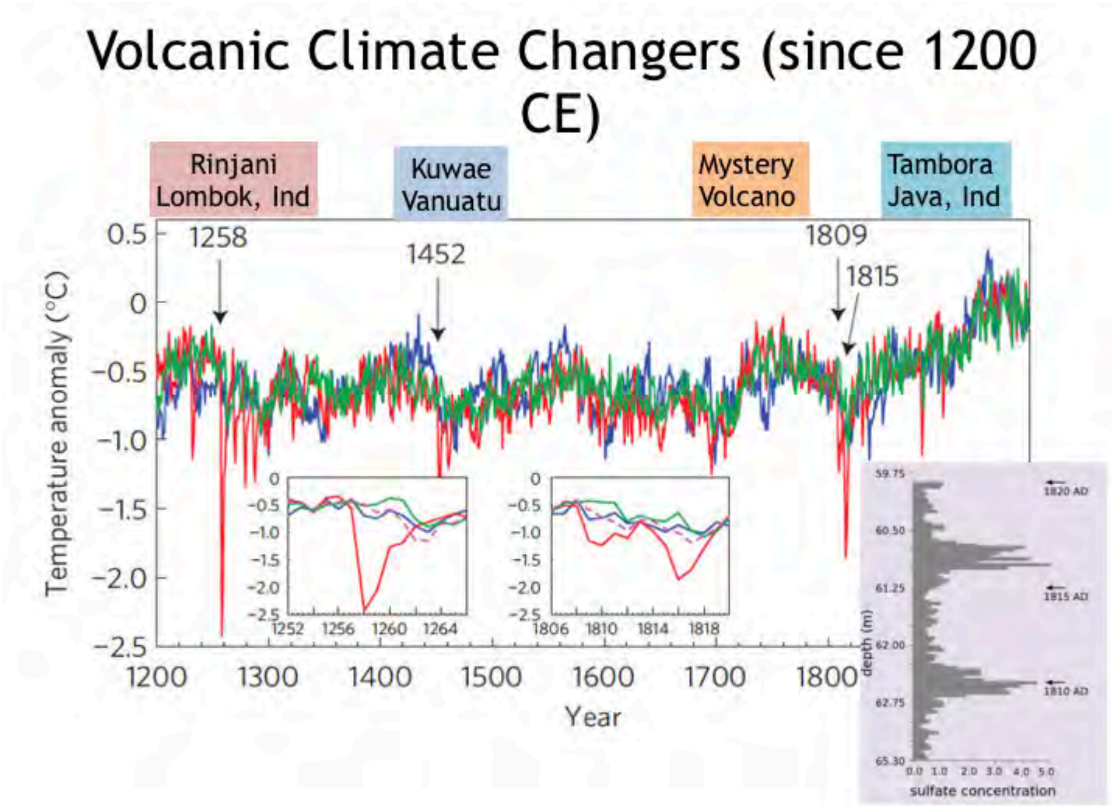


Fig 2: Data from Tree Rings, Ice cores and ocean sediment can tell us about past climates. Recent studies have shown how historic volcanic eruptions have quickly altered climate for a short period of time (2-5 years). The key driver of short term, volcanic related climate change is the gas Sulfur Dioxide, which after emission mixes with water vapor to form sulfate crystals high in the atmosphere (Stratosphere). These crystals block sunlight resulting is rather sudden cooling (and drying) of the globe. This has led some modernist scientists to propose a "anthropogenic" solution to global warming. Put a bunch of man-made sulphates high into the atmosphere and geoengineer a cooler world. But without knowing all the potential feedback this is at least a risky solution. We don't yet know what all could go wrong. (The small inset shows elevated sulfate signals in the polar ice cores. Image compilation by Kevin Robinson)

Biosphere

Life changes the air. The make-up of the atmospheric changes in response to inputs from the biosphere. For a couple billion years after processes formed a primitive atmosphere, evolutionary changes brought along a new type of organism that began to produce Oxygen during photosynthesis. Figure 3 shows the great oxygenation event (GOE). Prior to about 2.5 billion years ago, the planet was anaerobic (without O2) when single cell archaea (prokaryotic) organisms survived by reducing molecules like Methane or Sulfide. The earliest atmosphere held 1,000 times more CO2 than today. At 2.5 billion years, a big change occurred due to the evolution of organisms that could reduce atmospheric Carbon Dioxide through photosynthesis producing a new gas in the evolving atmosphere, Oxygen. Later (1 billion yrs ago) organisms would adapt to utilize this O2 in the process of respiration.

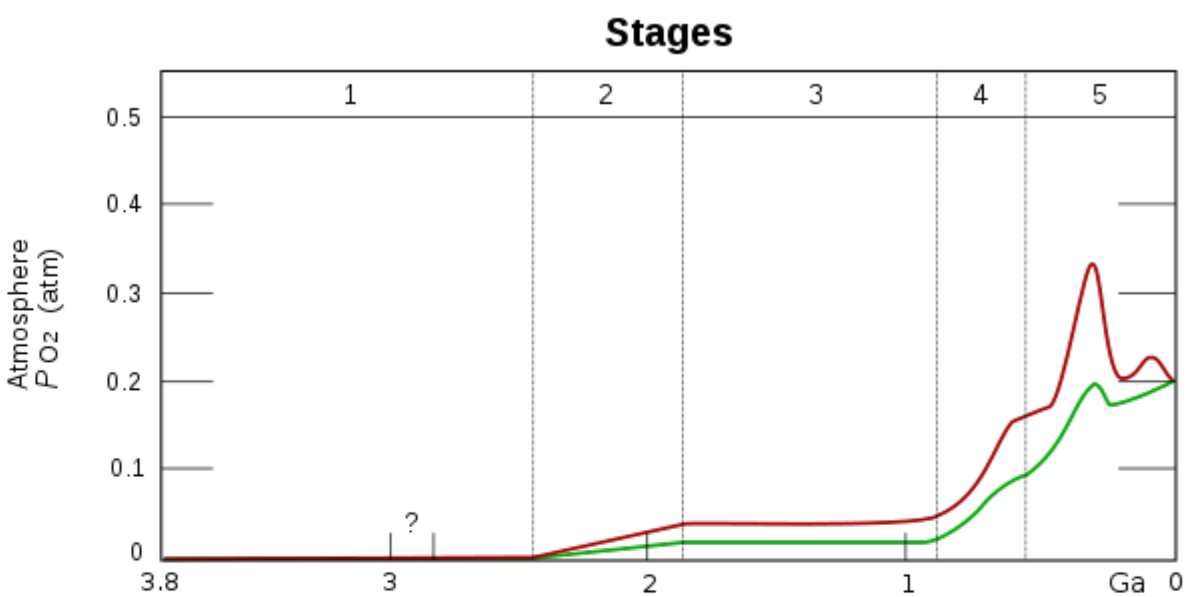


Fig 3: Early evolution of the atmosphere, note the great Oxygenation Event at 2.5 billion years ago. Note how long ago Oxygen begins to rise. (Image Source: Wikipedia user Loudubewe under CC3.0)

Plants store carbon. The biosphere removes carbon dioxide from the atmosphere in two distinct ways. On land the storage of this carbon is in the wood of trees, roots and soil. Figure 4 shows the largest rainforest and land based “carbon-sink” on Earth. The storage cycle of this “tree” carbon is generally of moderate duration (100-1000 years) so it is important in the short-term carbon cycle. In the case of a rapidly covered swamp (buried by sediment during sea level rise), carbon can be stored for geologic time in the form of coal. Coal formation was abundant in the distant past (100’s of millions of years ago) but does not currently play a large role in carbon storage.

Fig 4: Global rainforest systems contribute to carbon removal and in the process give us Oxygen. (Image Source: Google Earth Image)

Ocean productivity is key to long term carbon storage. What currently plays the most important role in long term carbon storage (over geologic time) is ocean productivity (Fig 5). Certain plankton and calcifers, including coral, build shells with carbon ($CaCO_3$) to form a rock called limestone. Plankton and other sea life can also store carbon in their body tissues that can sink, to be incorporated into organic mud on the ocean floor (shale). These processes remove carbon more permanently from the environment (air/water). Thus ocean productivity and calcification should be thought of as essential to help counteract the rapid rise in carbon dioxide from human emissions. Earth's biosphere plays a vigorous role in regulating and cycling of gases in the atmosphere. These gases are almost immediately exchanged with the ocean waters. Images of the Earth from January to June show a major change in vegetated area on land, from the snow-covered lands that absorb less CO_2 in January to the summer growing season when plant growth actively and efficiently removes atmospheric carbon by photosynthesis (Fig 6).

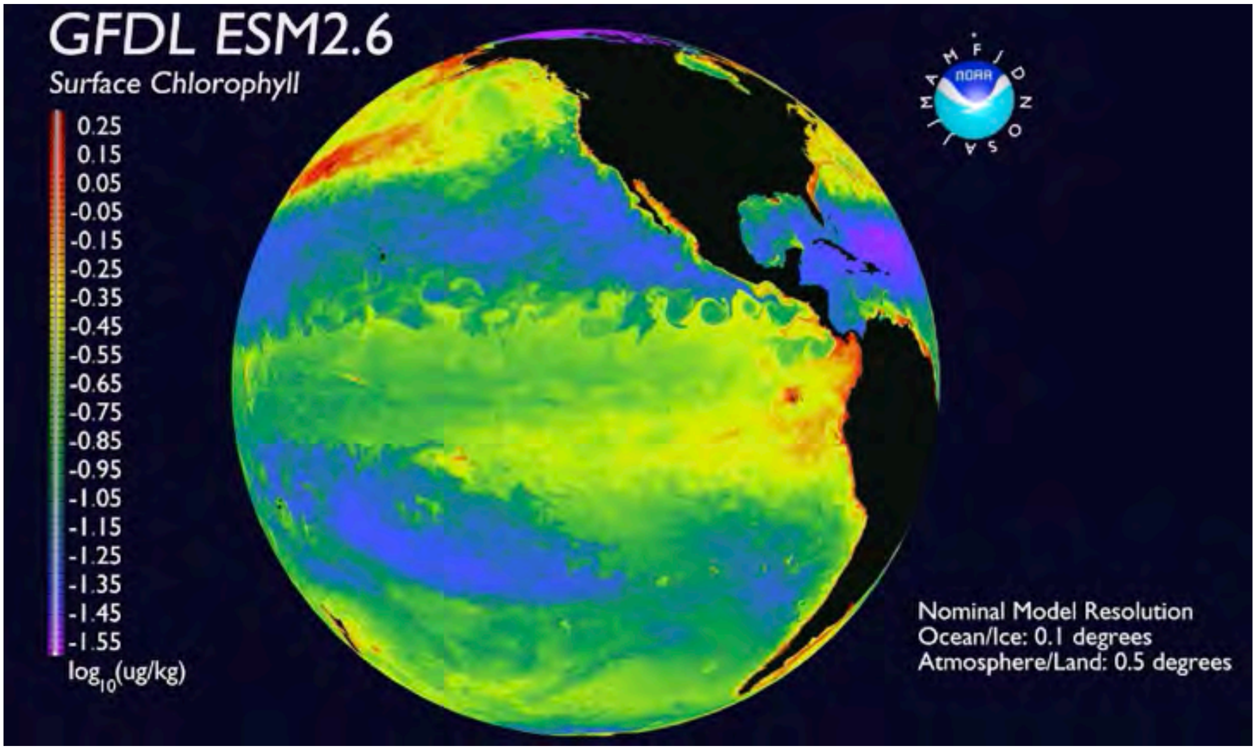
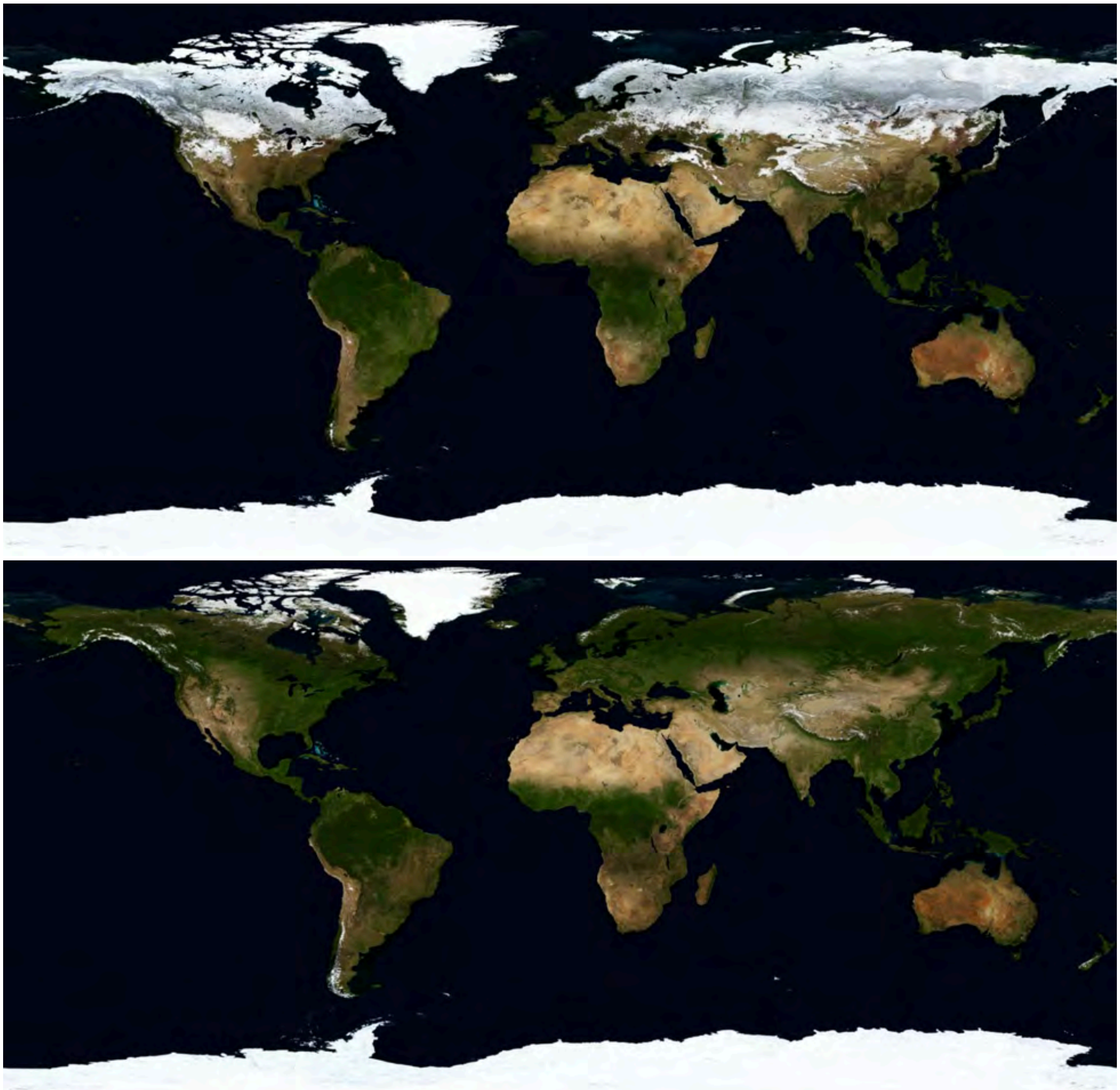


Fig 5: Visualization of ocean productivity (Chlorophyll) from space shows phytoplankton blooms which relate to nutrients brought up from the ocean bottom by upwelling currents. Photosynthesis removes and stores Carbon while adding Oxygen. Roughly half of the Oxygen we breathe derives from ocean productivity. Most of the long term carbon storage involves ocean productivity. (Image Source: NOAA)

Fig 6: Seasonal change on Earth (January-top, June-bottom), note the big change in the northern hemisphere. (Image Source: NASA composite imagery)



Cycles of this vegetative carbon removal can be seen in a two year graph of average global CO2 values (from Scripps Institution station on Mauna Loa). Due to the radical seasonal fluctuation in photosynthetic activity over the continents in the northern hemisphere, global CO2 levels fall during spring and summer as plant growth flourishes. In the fall and winter, CO2 levels build back up again to reach their peak (following a 2 month lag) in May. It is during this time in spring that the yearly CO2 levels reach their peak (Fig 7).

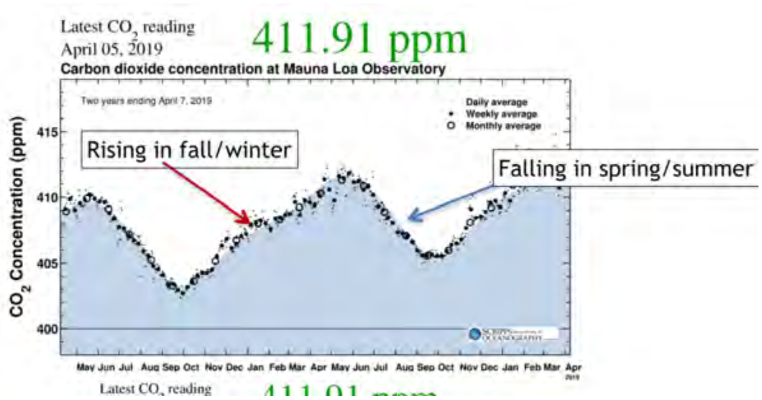


Fig 7: Seasonal CO2 changes (Image Source: Scripps Institute of Oceanography)

Variations in global environments and the evolving life forms have ultimately led to the current system of mass exchange (CO2). For hundreds of millions of years organisms in the ocean and coastal environments have trapped and stored this carbon in deposits of organic shale or limestone, and as coal, oil and natural gas. It was only about 200 years ago that humans started burning (en masse) this long trapped carbon as fuel. Our human system also adds large amounts of CO2 by making cement from limestone. The rate of increase in CO2 has continually increased and now rises by 4ppm per year.

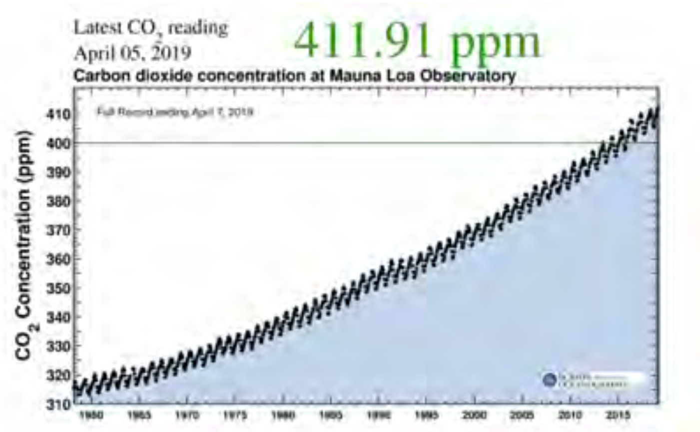


Fig 8: Fifty-year CO2 changes
(Image Source: Scripps Institute of Oceanography)

The sawtooth pattern related to seasonal fluctuation can be seen in this 50 year image (Fig 8) and is superimposed on the overall rising trend. The basic system physics is that humans release more CO2 than the environment can absorb. This rate of increase is due to the fact that the environment and life cannot utilize and store the carbon as fast as its being produced. The current rate of anthropogenic increase is 100-1000 times faster than the prehuman rate of change. Life has always played a role in changing the atmosphere. What is presently different is that one form of life (humans) now dominates the CO2 production process while also reducing the environment's ability to sequester carbon.

Anthropocene

Humans are leaving a mark. There is no doubt that humans have altered the chemistry of the atmosphere. The rate of change that scientists observe and describe is alarming (compared to geologic rates). These findings come from thousands of scientists working in multiple disciplines over many decades. The science involves historic as well as prehistoric assessments. The biggest factor everyone recognizes is that the exponential rise in human population marks a change in different parts of the system which is recorded by the layers deposited over this time frame.

Our population has increased by more than 4 billion since 1960. Currently there are about 7.8 billion of us and it is estimated that over 110 billion humans have lived in the last 50,000 years. We started burning fossil fuels in earnest during the industrial revolution and noticeable changes are seen in the sedimentary record beginning in the late 1800’s. Volcanoes are the single biggest source of atmospheric CO2 next to humans. The largest volcanic events in geologic history have altered the course of evolution. We surpassed that force of nature in 1875. In the early 1900’s, the CO2 had ramped up and was increasing at 1 ppm/yr. The rate has recently risen to 4ppm/yr. Humans now pump 20-30 times as much CO2 into the atmosphere as all volcanoes.

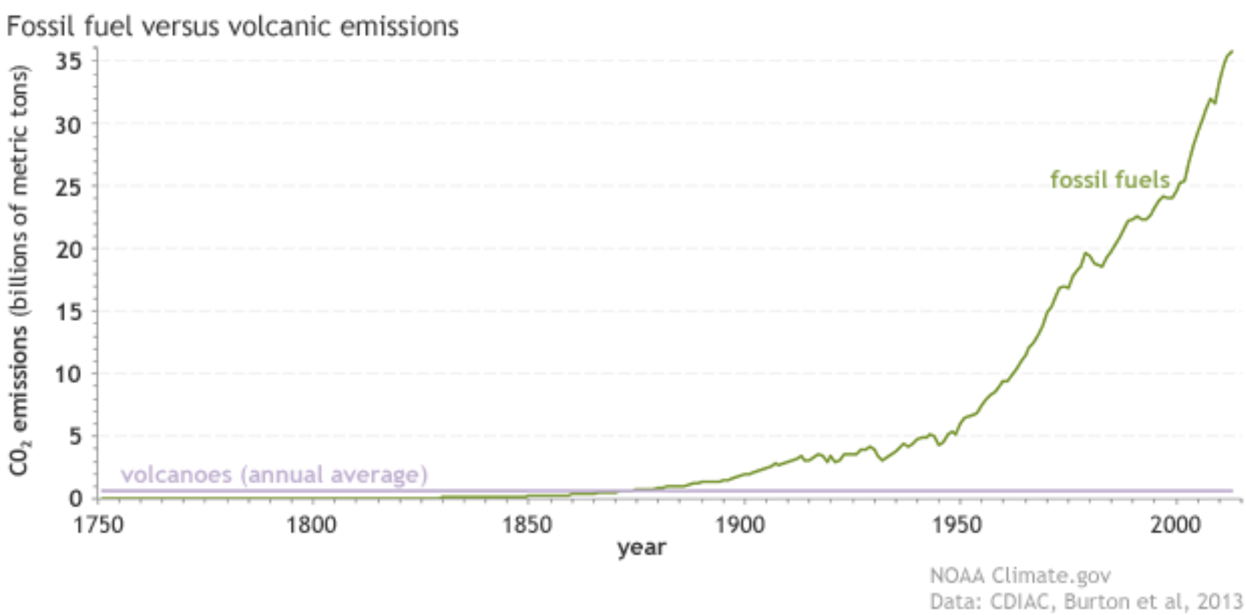


Fig 9: It was about the year 1875 that human CO2 flux exceeded that of “natural” volcanic gas emissions. (Image Source: NOAA)

These measurable changes have occurred in recent geologic time (Holocene layers as old as 11,700 yrs). Science observations around the world can define biological, chemical, and isotopic changes in the atmosphere, oceans, sediments, tree rings, and ice core that track our presence on Earth. A new geologic epoch for the onset of this global human sedimentary layer has been proposed (but not yet made official by geologists). It will be called the Anthropocene, or the Age of Humans. The exact timing of when the new epoch should begin is currently being debated. (based on changes in CO_2, chemical pollution, radioactivity).

Increasing rates. Global resource use and our average carbon footprint has risen at a faster rate than the population. Our rapid population increase has also stressed the environment to make it less able to store carbon. In many places the carbon sinks, like rain forests and mangrove swamps, are being destroyed at a high rate. The environment is changing. The chemistry of the atmosphere and our anthropogenic footprint is altering the rate at which the changes happen. Atmospheric chemistry is changing 2-3 orders of magnitude (X100-1000) more rapidly than in early human history. The carbon dioxide concentration is a relatively small part of the air and currently measures only 420 parts per million but in 1875 it was 275 ppm (50% increase). So why is a concentration in parts per million such a big deal. The problem is that CO_2 absorbs some of the infrared radiation (heat) that radiates from the Earth out into space every night. The extra heat that the CO_2 holds (infrared) is rather small on a daily basis. But that tiny amount gets added up 24 hours a day, 7 days a week, 365 days a year, for 150 years. (Do a compound interest calculation if you made 1% a day vs 1% a year). This change in atmospheric heat results in changes to global heat flow, evaporation, weather, climate and environmental systems.

The CO_2 is building up faster and faster but the Earth's ability to absorb it is slowing down. Humans add carbon to the atmosphere and also make changes to the carbon removal systems which results in even more carbon building up in the atmosphere. Like carbon-absorbing rain forests and soils on land, the primary productivity of phytoplankton in the ocean is vitally important. Some plankton create limestone shells with the CO_2 ($CaCO_3$) and other organic carbon is sequestered in biomass that falls to the ocean floor to be stored as organic mud or shale. Carbon acidification of the oceans and the petrochemicals materials that pollute the water have the potential to reduce primary productivity and greatly inhibit the amount of carbon that the oceans and marine life can absorb.

Bad chemicals. The Anthropocene has also introduced particulates (often toxic) into the air which have been proven to have negative effects on life. There were many aerosol pesticides (DDT, Parathion, Malathion, and others) that were banned beginning in the 1970's because of their harmful effects not just on humans but on entire ecosystems. Even today there are many agricultural chemicals that are known to be indiscriminately toxic and pose harm to not only birds, bees, and butterflies but to the very ecosystem that the plants depend on…...the soil. There is still a toxic plume of DDT in the Pacific Ocean off Southern California left over from the 20th century production in Long Beach.

Changes underway. The human participation in the Earth system cannot be ignored and this was recognized decades ago. Since then, the EPA has been established, the Clean Air Act, the Clean Water Act, the Montreal Protocol all have been passed, and more is still being done. We are constantly altering our behavior based on new science understanding.

EXAMPLE: A 20th Century Learning Experience, atmospheric geochemistry of the Anthropocene

> One award winning 20th century scientist, unknowing played a large negative role for the whole Earth system. The effects were realized long after his death. I'm sure he was a nice guy and if he did not invent these chemical breakthroughs someone else would have. His name was Thomas Midgley. In the 1920's he developed "chlorofluorocarbons" for refrigeration which have since the 1970's have been known to destroy the Earth's ozone layer. An understanding of the extreme consequences from Earth losing its ozone led to the landmark environmental agreement called the "Montreal Protocol" in the early 1980's. For the auto industry Midgley developed a cure for engine knocking by adding Lead to gasoline. The lead in gasoline helped engines run smoother. Unknowingly we began to pump millions of tons of Lead into the atmosphere by using what was called "ethyl" gasoline. Midgley eventually suffered from lead poisoning himself. In the 1960's, Understanding of this global contamination problem helped pave the way for the "Clean Air Act". It was discovered by a scientist named Clair Patterson who was trying to develop a technique for age dating the Earth with Uranium and Lead isotopes. He realized that his lab and everything else (air, water, soil, and human bodies) were contaminated from the atmospheric "exhaust" lead which had been accumulating in the environment for nearly 5 decades. The rise of atmospheric Lead levels accelerated after WWII during the great population acceleration.

(There are many other examples of "global" anthropogenic geochemical markers in the sedimentary record. In addition to marking the onset of leaded gasoline, the "ice core" layers also mark the later (1945) initiation of atmospheric nuclear testing.)

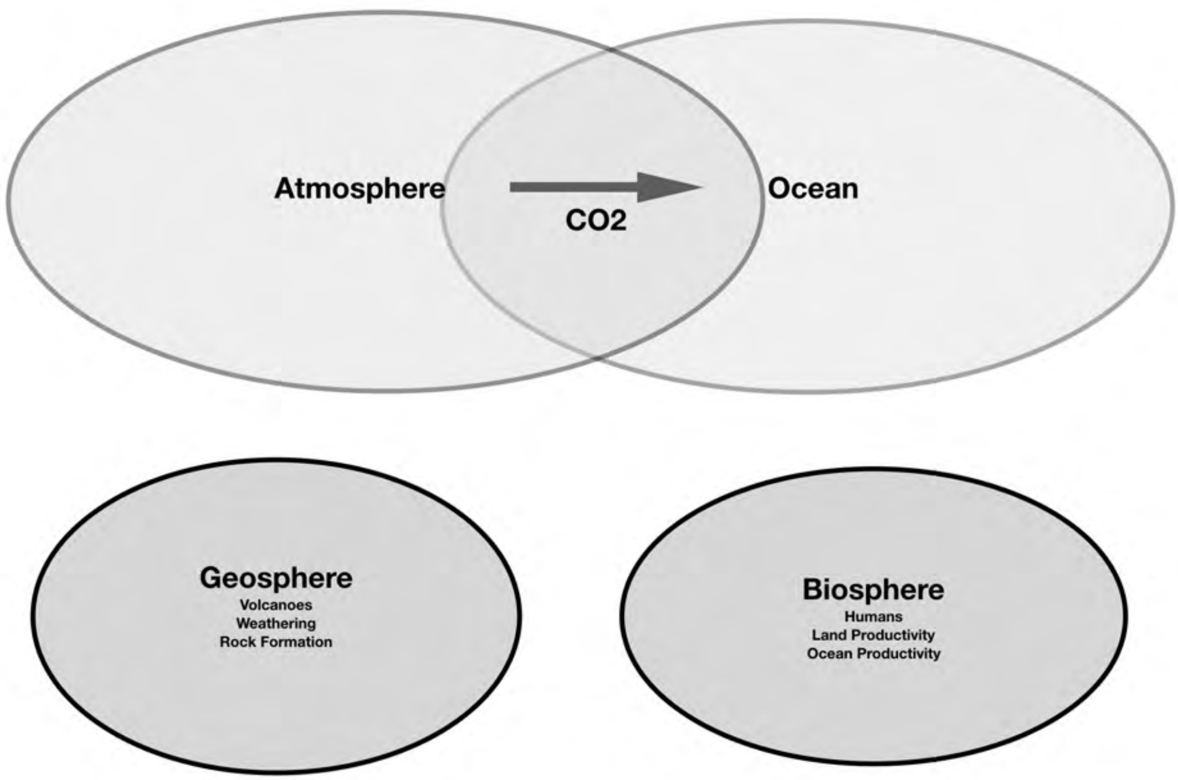
For Further Study - See Addendum

- Air pollution and the atmosphere system (See also: Connections worksheet 3)
- Mapping Science Data Lesson

<u>Earth Systems:</u> Connections Worksheet 1: Brainstorm

When humans were not separate from the biosphere (playing a much smaller and insignificant role).

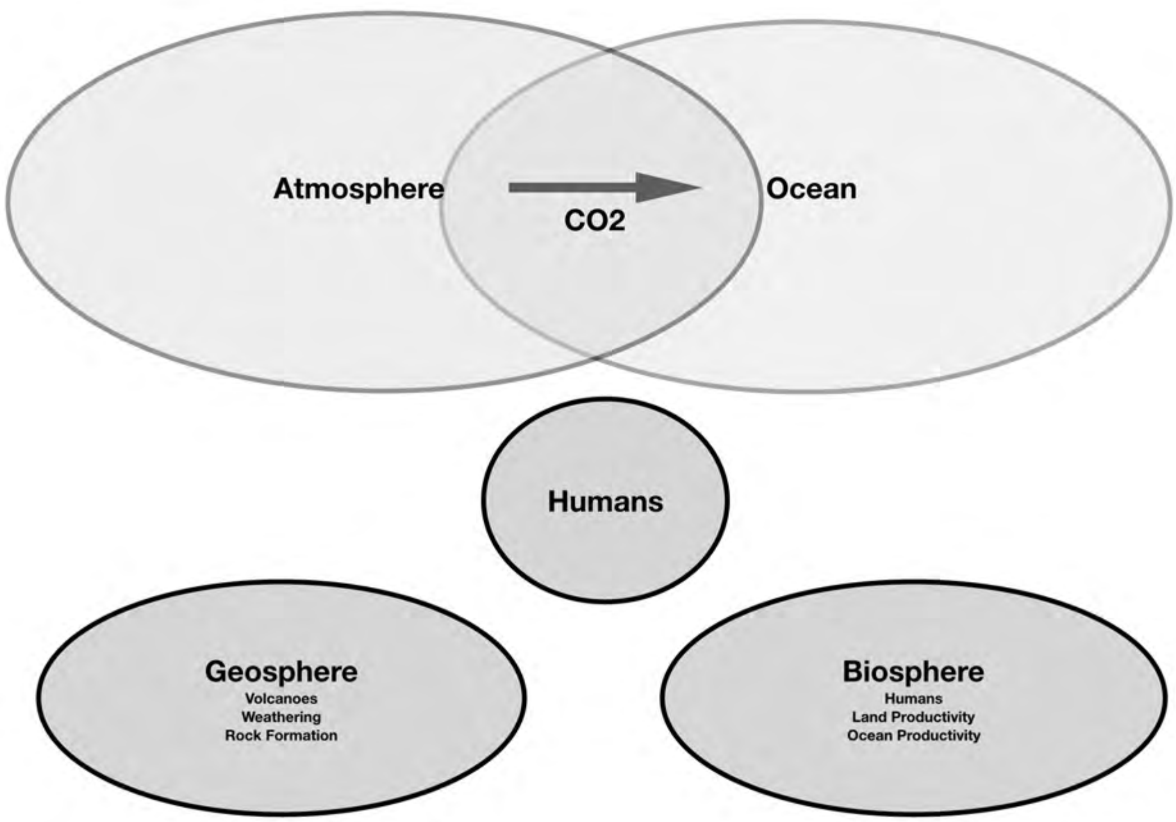
Paths should be labeled to show the flow of Carbon. One of the vital links is shown as a large percentage of atmospheric CO_2 gets dissolved in the ocean. Numbered directional arrows can go both ways and have different sizes (two separate arrows). Your arrows should show flow between the ocean-atmosphere and biosphere, the ocean-atmosphere and geosphere, the biosphere and geosphere. For each arrow write a short description of the processes involved.



<u>Earth Systems:</u> Connections Worksheet 2: Brainstorm

When humans were so numerous that they started to play an independent role.

Your “numbered” flow paths should be labeled to show the movement of Carbon just as they did in Worksheet 1. Arrows can go both ways and have different sizes, and they can also merge. For instance the burning of fossil fuels relates to humans extracting them and then burning them. The arrow from the geosphere would curve to intersect with an arrow from the human sphere that then connects to the ocean-atmosphere. Your arrows should show flow between all the spheres. For each numbered arrow write a short description of the processes involved. It obviously will also show the integral part that humans play to change the flow of the system. How does the diagram change when humans are included? The only way an arrow would ever go to the human bubble is if we developed the large-scale capability to sequester carbon either by industrial applications, ocean fertilization, or reforestation on a global scale.



The following addendum helps bridge the geoscience module with the Mapping Science Data Lesson.

Addendum: For Further Study (see Mapping Science Data Lesson)

Pollution and the Atmosphere System

The only natural sources of air pollution are wind-blown dust and smoke. Both of these can have a human element or cause. All the other forms of pollution are only created by humans. Air pollution can take many forms and the chemistry can be complex. Air pollution can be gases, aerosols, or particulates. Some people argue that CO2 should be considered a pollutant. In some cases there can be air pollution that becomes soil or water pollution. One example that is still just as pertinent today as it was in the 20th century is that of biocide applications in agricultural communities.. Whether they be pesticides, fungicides, algicides, or herbicides they are all designed to kill, and many are applied via aerosol sprays that can pollute the nearby air and be incorporated into the soil. We know little about long term human health impacts but past experience tells us we find out the negative consequences eventually. Later tilling of the soil can introduce dust that is laden with toxins into the blowing wind farming communities throughout the world must deal with these forms of air pollution.

Another example of the transfer of ground and water pollution to the atmosphere was seen in the aftermath of Hurricane Harvey in Houston. Flooded chemical plants and other sources input toxins into the muddy floodwaters that covered the city. Neighborhoods were underwater for weeks. When the water finally drained away there was a thick layer of fine grained mud left everywhere. As this dried out, winds were able to entrain clay and silt particles into the air and create toxic dust clouds. Each major regional flood that occurs brings this as an after effect for months and years.

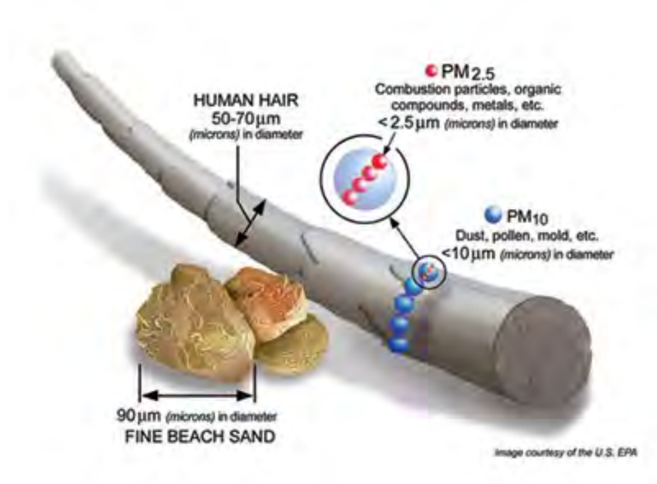
There are several good examples of toxins, now banned, that were a big problem in the past and there are many that appear to be a problem today. Unfortunately the categories of air pollution that are tracked by the EPA (https://www.epa.gov/air-trends) do not include all the various chemicals that are present. The particulates are NOT generally known about in detail and only in very specific studies does the chemistry of the particulates become apparent.

The largest source of air pollution comes from burning fossil fuels. This includes all forms of combustion and industrial processing. These can have identified point sources or can be pervasive in areas of high population density. Cities have been identified to have the highest levels of general air pollution. The categories of air pollution that are identified and tracked by the EPA include; Carbon Monoxide, Lead, Nitrogen Dioxide,

Ozone, Particulate Matter (PM10), Particulate Matter (PM2.5), and Sulfur Dioxide. Though all are considered harmful to human health the small particulates (PM2.5) are especially harmful because these small particles can be drawn deep into the lungs of humans and do the most harm.
Look at the EPA website to learn more https://www.epa.gov/air-trends

Questions for thought:

- What types of pollution does this data include?
- Does the pollution data include the chemistry of the particulates?
- What is not included in national air pollution data?
- What toxic metal is currently monitored in air pollution?
- Does data show the national air quality trends to be going up or down over the last 20 years?



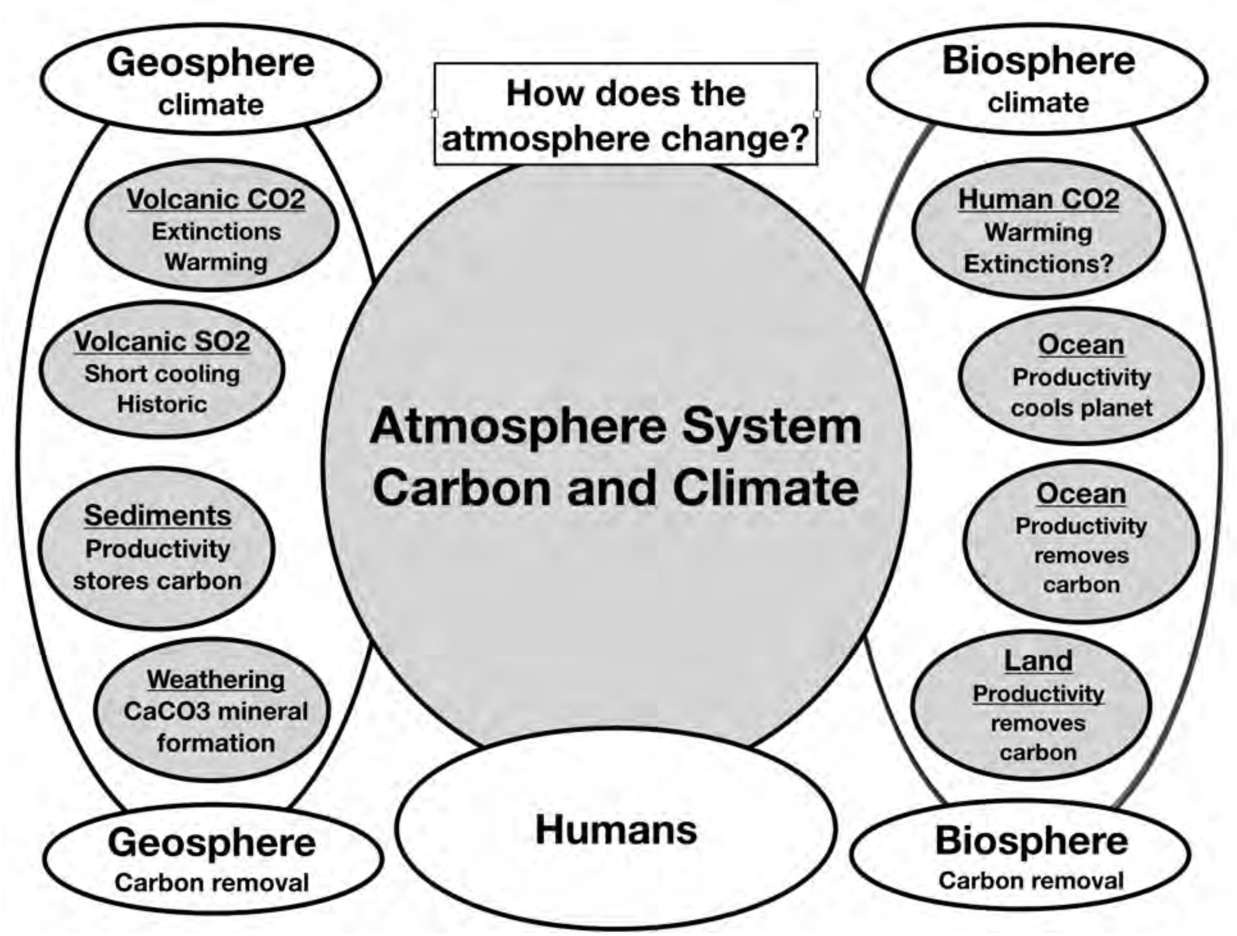
- In which regions does the data show an uptick in the last few years?
- What is particulate matter?
- Do we know all there is to know about particulate pollution?

Continued Research in Depth: What is in the air?
- Research “the chemistry of particulate air pollution (PM 2.5 & 10)
- Research the health effects of air pollution and show case study documentation
- Research and report on local air pollution by acquiring data for direct investigation (see MAPPING DATA Lesson)

<u>Earth Systems:</u> Connections Worksheet 3: Brainstorm

Some of the various roles of the geosphere and biosphere in storing carbon, and regulating climate are shown on the diagram below. Review these. Worksheets 1 and 2 looked at the carbon cycle and how humans have changed the pre-industrial status quo with lots of extra carbon dioxide.

On this worksheet brainstorm how human pollution (air and water) and other activities might force changes to climate as well as carbon storage (removal). From the human sphere at the bottom create numbered paths. List and describe those below the diagram. Diagram and label the forces which can change the system in regards to pollution and anthropogenic environmental change.



Further Thought: Pollution and Atmosphere System Interactions (with Connections Worksheet 3)

- How does pollution change the Geosphere, Biosphere, and Ocean-Atmosphere Systems?
- What does human-related air pollution (fires, industrial, transportation, dust) do to change the dynamics of the atmosphere?
- What pollutants (gases, aerosols, and particulates) can cause warming?
- What pollutants (gases, aerosols, and particulates) can cause cooling?
- What interactions can pollutants have on environmental systems and carbon storage (and ecosystems)?

Air Pollution Map Resources: For research and continued learning

National Weather Service
https://www.weather.gov/gis/NWS_KMLFiles
EPA/ArcGIS-Interactive Air Quality Monitoring Data
https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=5f239fd3e72f424f98ef3d5def547eb5&extent=-146.2334,13.1913,-46.3896,56.5319
Air Emission Resources EPA-Where You Live
https://www3.epa.gov/air/emissions/where.htm
California Air Resources Board Maps
https://ww3.arb.ca.gov/maps/maps.htm
Real-Time Air Quality Monitoring Data-USA
https://files.airnowtech.org/airnow/today/airnow.kml
Canada National Pollution Release Inventory (NPRI) https://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=1D892B9F-1&wbdisable=true
Air Quality-Google Outreach
https://www.google.com/earth/outreach/special-projects/air-quality/
AirNow-Current Air Quality Conditions (Map Tool)
https://www.airnow.gov
Google Earth Tool for Studying Air Quality https://www.enviroware.com/the-google-earth-tool-for-studying-air-quality/
Europe Air Quality KMZ/KML files (Drag/Import into Google Earth) https://www.enviroware.com/google-earth-environmental-data-files/
Environmental Defense Fund-Sensors and Air Quality
https://www.edf.org/airqualitymaps
EDF Air quality Oakland California-interactive map https://www.edf.org/airqualitymaps/oakland/pollution-and-health-concerns-west-oakland
World Health Organization
https://www.who.int/airpollution/en/