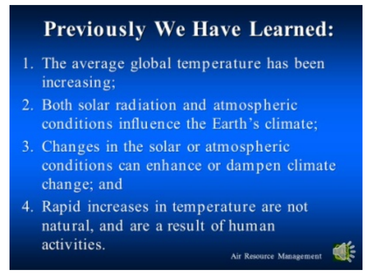
Slide 1

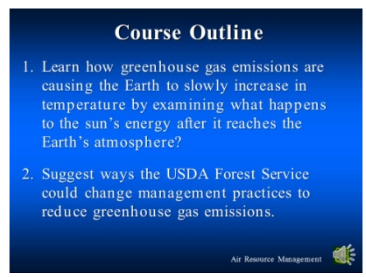
Hello. My name is Melanie Pitrolo, and I'm an air quality specialist with the USDA Forest Service. For the second year in a row, the Air Resource Management team for the southern region of the Forest Service will present a lesson on the earth's changing climate. Bill Jackson has prepared the slides, and I will serve as narrator. This series of lessons serves to fulfill the Agency's goal to train Forest Service staff on climate change.

Slide 2



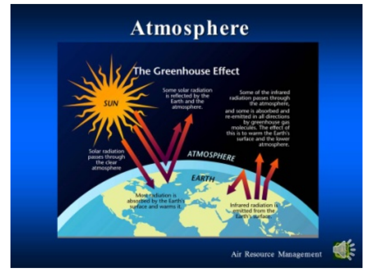
During the first lesson on climate change, we learned that Average temperatures across the globe have been increasing; We also learned that the sun's energy as well as atmospheric conditions influence the earth's climate, and changes in these conditions can both enhance and dampen climate change impacts; Finally, we learned that the rapid increases in observed temperatures are not natural, and in fact are the result of human activities.

Slide 3



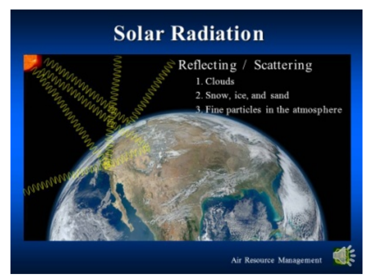
So in this lesson, we are going to delve a little deeper into why human activities are causing increases in global temperature. Specially, we will: First learn how greenhouse gas emissions are causing the Earth to increase in temperature by examining what happens to the Sun's energy after it reaches the Earth's atmosphere? And then we will suggest practical ways that the USDA Forest Service could change management practices to reduce greenhouse gas emissions.

Slide 4



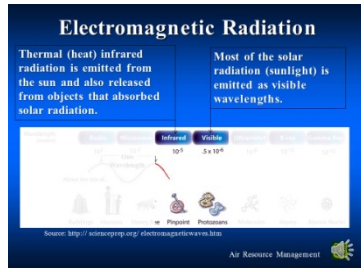
As we discussed last time, the sun emits solar radiation that reaches the earth. About 30% of the incoming solar radiation is reflected back to space; while the remaining 70% of the incoming solar radiation is absorbed by the earth's surface. The earth's atmosphere acts like glass in a greenhouse – it allows solar radiation to penetrate and warm the surfaces, and hinders the heat from leaving the Earth. The earth's surface is warmed by the solar radiation and then it releases the energy (heat) as infrared radiation. Some of the infrared radiation is emitted into space, but most of it is absorbed and re-emitted in all directions by "greenhouse" gases. In today's atmosphere, the main greenhouse gases include **<u>water vapor</u>**, carbon dioxide (CO_2), methane (CH_4), nitrous oxides (N_2O), and certain chlorofluorocarbons (CFC). The amount of greenhouse gases in the atmosphere play a critical role in determining global temperature, and historically the amount of carbon dioxide in the atmosphere has had the greatest influence on the earth's climate. The next several slides will focus on what happens to the solar radiation emitted from the sun.

Slide 5



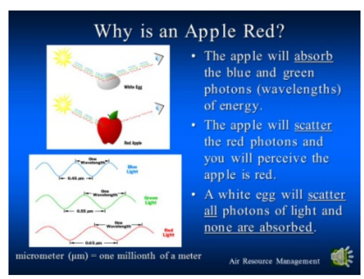
So as just mentioned, 30% of the incoming solar energy does not reach the earth's surface. What causes this? First, thick clouds covering large areas in the lower atmosphere will reflect solar energy back into space. These types of clouds are frequently found above polar oceans and in subtropical regions, such as the southern United States, Second, fresh snow and ice found in the polar regions, glaciers in mountainous areas, and fresh snow covering the northern and southern hemispheres during the winter months cause reflection of the incoming solar radiation. Additionally, sand – found in desert regions on Earth – can reflect solar energy. Finally, fine particulate found in the atmosphere can cause scattering of solar radiation. I should also note the three items listed above can also absorb solar radiation depending on their color. For example, a dark cloud or old, dirty snow will absorb rather than reflect solar radiation.

Slide 6



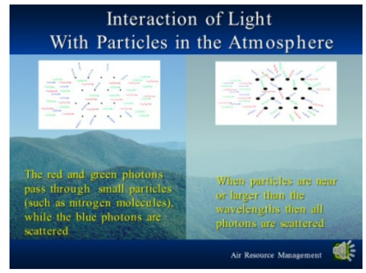
Before continuing to explore what happens to the Sun's energy that reaches Earth's atmosphere, we need some additional understanding about the sun's energy. The Sun emits solar radiation across most of the electromagnetic radiation spectrum. Electromagnetic radiation is classified into different types based upon the wavelength, or the distance between the peaks. Typically, the units of measure are micrometers or 1 millionth of a meter in length. Long wavelengths have a low frequency and are not harmful, while the shortest wave lengths have high frequencies that can be harmful to humans and other biota. The longest wavelengths are radio waves while the shortest are gamma rays. The electromagnetic radiation emitted from the Sun that reaches Earth include radio waves, infrared, and visible light. The Sun also emits microwaves, ultraviolet, and x-rays, but most of these do not reach the surface because they are absorbed by water vapor, molecular oxygen, or ozone found in the upper atmosphere. In this presentation we are going to focus on the infrared and visible wavelengths found in the middle of the electromagnetic radiation spectrum. Half of the solar radiation is emitted as visible wavelengths, or sunlight, that allow us to see objects. Fires, lamps, flashlights and others items also produce visible wavelengths of light. Infrared radiation is emitted from the Sun and also released from objects that absorb solar radiation. The infrared radiation is what causes the Earth to warm.

Slide 7



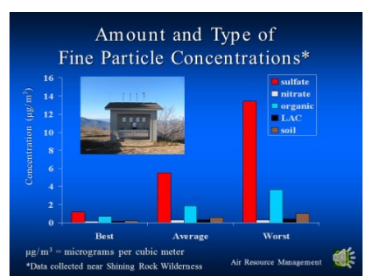
Everyday we experience the effects of how visible wavelengths of energy interact with objects when we view colors in our environment. We all know that an egg is white, and that this apple is red. Why is that? The visible wavelength can be divided into blue, green and red wavelengths or photons of energy. The visible light spectrum ranges between 0.4 micrometers for the shorter blue photons to about 0.7 micrometers for the longer red photons. Surface molecules of objects both absorb and reflect photons of visible light. White light, which is composed of all of the 'colors' of photons, strikes an object. When the white light strikes the red apple, surface molecules of the apple will capture or absorb all of the visible light photons except red. Therefore, you see that the apple is red. At the same time, when the white light strikes the egg, none of the visible light photons are absorbed - the egg looks white because it has scattered all of the three types of photons – blue, green and red – are scattered toward your eye. This is why white or light colored objects such as clouds, snow, ice or sand can reflect the Sun's energy from Earth and back into space.

Slide 8



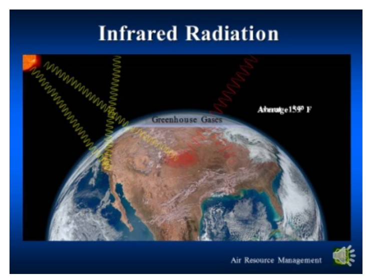
Remember, I told your earlier that some of the scattering or reflecting of solar energy back into space is attributable to fine particles in the atmosphere. These two figures show the same mountainous scene in western NC. The figure on the left shows the scene with few fine particles in the atmosphere, and the farthest peak – about 50 miles away – is clearly visible. That same peak cannot be seen in the figure on the right because of the large amounts of fine particles simulated in that image. Atmospheric visibility is influenced by scattering and absorption by light particles and gases. The particles absorb, refract, reflect and diffract light. When white light (consisting of all of the colored photons) passes through pollution-free air, the red and green photons pass by the much smaller gas molecules, such as nitrogen. The smaller blue photons are about the same size as the gas molecules and therefore are scattered. This is why you see a blue sky on a clear day. Remember we learned earlier that wavelengths of light range in size from 0.4 up to 0.7 millimeters. When the air contains particles of air pollution that are near to or larger than the largest wavelength of all light, then all of the photons are scattered and a whitish haze will occur. Additionally, a portion of the visible wavelength of solar radiation is scattered back toward space before reaching the Earth's surface.

Slide 9



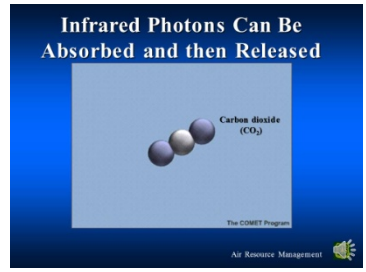
Reductions in the visibility of scenic views is a common occurrence in the summer months, especially in the eastern United States. Our Agency participates with other agencies including the National Park Service and EPA to sample the amount and type of fine particles in the atmosphere.Carefully look at this chart for data collected from the southeastern United States. The Y-axis on the left shows how much of each of five types of fine particles – sulfates, nitrates, organic and inorganic carbon, and soils – are present in the atmosphere on the best, average, and worst visibility days. The results show sulfates, the red bars, are the primary fine particle in the atmosphere. Sulfates originate as sulfur dioxide gas typically emitted usually from coal-fired power plants. In addition to sulfates' effects on visibility, researchers have found that global concentrations of sulfates in the atmosphere have an important influence on the global temperature. During periods of lower sulfate concentrations in the atmosphere the global temperatures increased. In the US and Europe, reductions of sulfates in the atmosphere began in the 1970s and continue today in order to improve the air we breath, improve scenic views, and reduce the adverse impacts from acidic deposition to ecosystems. However, starting about 1980, there has been a significant increase in the burning of coal at facilities in Asia, especially China, where there is little or no air pollution control devices to reduce sulfur dioxide emissions. Some scientists have attributed the smaller than expected amount of observed global temperature increases between 1998 and 2008 to both the cooling effects of the increase in sulfur dioxide released in the atmosphere from Asia and natural factors, such as a reduction in the amount of solar energy released by the sun during this 11 year period.

Slide 10



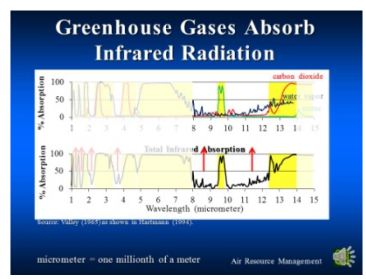
So we return again to where we left off. In the previous slides, we have learned why about 30 percent of the visible wavelengths of solar radiation is reflected or scattered back into space by clouds, snow, ice, desert sand and fine particles, especially sulfates, in the atmosphere. About half the incoming solar radiation is in the visible wavelengths; while, slightly less than half of the remaining solar radiation reaching Earth's surface is infrared radiation. We cannot see infrared radiation, but can feel it's warmth when we allow the sun to shine upon us. About 70 percent of the short wave, visible electromagnetic radiation reaches Earth. When it reaches the Earth's surface, the visible wavelengths are slowed down and re-emitted into the atmosphere as long-wave, infrared radiation. If there were no greenhouse gases nor the thin, high level clouds containing ice reflecting radiation back toward the Earth, then Earth would be freezing and could not sustain life. However, Earth does have greenhouse gases and high level clouds. While a portion of the infrared radiation is emitted into space, the remainder is absorbed and then released where it can be absorbed by other greenhouse gas molecules. This results in a gradual heating of the lower atmosphere to a comfortable global average temperature of 59^0 F that sustains life on Earth.

Slide 11



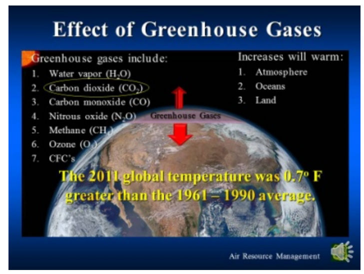
Carbon dioxide is one of the greenhouse gases. It consists of three atoms with one carbon atom in the middle and an oxygen atom bonded to each side. When its atoms are bonded together, the carbon dioxide molecule can absorb the much smaller photons of infrared radiation and starts to vibrate. Eventually, the vibrating molecule will release the infrared photon, and it will likely be re-absorbed by yet another greenhouse gas molecule. This absorption-release-absorption cycle serves to keep the heat near the surface and effectively insulating the Earth's surface from the cold of space. In contrast, the red apple absorbs the green and blue photons and those photons become a part of the apple and are not released. Most greenhouse gas molecules are composed of three or more atoms, bound loosely enough together to be able to vibrate with the absorption of heat. Nitrogen and oxygen are the major components of the atmosphere and both are two-atom molecules. These are too tightly bound together to vibrate and thus they do not absorb infrared protons nor contribute to the greenhouse effect.

Slide 12



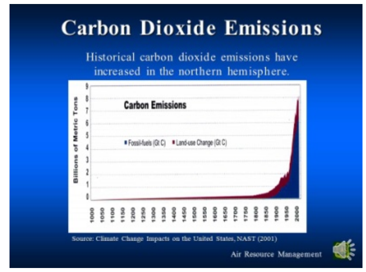
The bottom graphic shows the percentage of infrared radiation that is absorbed by greenhouse gases. There are wavelengths (shown in the white areas with red arrows) where greenhouse gases absorb only a small portion of the infrared radiation. Each greenhouse gas has a unique pattern of energy absorption of radiation. A particular greenhouse gas may absorb infrared radiation in some wavelengths, but not in others. Now look at the top graphic and you will see the infrared absorption curves first for water vapor, then ground-level ozone, and finally carbon dioxide. Water vapor is by far the most important greenhouse gas contributing to the insulating effect at the Earth's surface. It accounts for between 36 and 66 percent of the temperature when the sky is clear and between 66 and 85 percent when including the clouds. Notice that water vapor absorbs nearly 100 percent of the infrared wavelengths between 5 and 7 micrometers and several other wavelengths. Now compare the upper and lower graphics between 8 and 14 micrometers and notice that water vapor has a low amount of absorption of infrared radiation in these wavelengths. This are provides a "window" for infrared radiation to pass through the atmosphere and into space. However, the region between about 9.5 and 10 micrometers is a region where ground-level ozone absorbs infrared radiation. Ground-level ozone is naturally occurring, but the combustion of fossil fuels can increase concentrations, especially near urban areas in summer months. Around 4 micrometers and above 13 micrometers, carbon dioxide absorbs most of the infrared radiation while water vapor absorbs less. Carbon dioxide is not as strong a greenhouse gas as water vapor, but it is the second most important greenhouse gas. One reason is that carbon dioxide has been estimated to remain in the atmosphere for 30 to 95 years; while water vapor and ground-level ozone have lifespans of about a week.

Slide 13



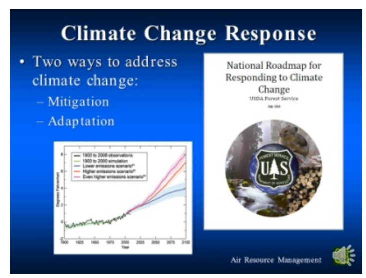
Besides water, ground-level ozone and carbon dioxide, naturally occurring greenhouse gases also include carbon monoxide, nitrous oxide, and methane. Between the last major ice age and about 1860 (just before the industrial revolution), these six greenhouse gases maintained an atmospheric balance such that the amount of infrared radiation trapped near the surface and released into space kept Earth's temperature at an average of 59 degrees Fahrenheit. The seventh listed greenhouse gas, chlorofluorocarbons or CFCs, are man-made compounds that were first released into the atmosphere from industry in the 1940s. The atmosphere, oceans and lands will continue to warm as carbon dioxide and other greenhouse gas concentrations increase in the atmosphere. This is because there will be **less** infrared radiation released into space and **more** heat be trapped near Earth's surface. Increases in global temperatures are continuing, with a 0.7 degree Fahrenheit increase in 2011 global temperatures in comparison to the average temperature for 1961 – 1990. The combustion of fossil fuels and other human activities will continue to cause a reinforcement (or positive feedback) of the greenhouse effect, especially if countries in Asia continue to install sulfur dioxide pollution control devices in order to protect their citizen's health and the environment.

Slide 14



This graph shows that prior to the industrial revolution, changes in land use (especially the conversion of forests to agriculture or cities) slowly increased the amount carbon released into the atmosphere. Beginning in about 1860, the industrial revolution resulted in an exponential increase of carbon dioxide emissions from the combustion of carbon that had previously been stored in fossil fuels, like coal. We burn fossil fuels to meet our energy demands for the purpose of increasing the amount of commodities produced and also to improve the standard of living for people living in developed countries like the United States. Global atmospheric concentrations of carbon dioxide have increased not only because carbon has been released from the prior storage in fossil fuels deep in the Earth, but also because once carbon dioxide is formed it can remain in the atmosphere for many decades. As an Agency, we need to recognize that our activities also contribute to increasing the amount of carbon dioxide and other greenhouse gases in the atmosphere.

Slide 15

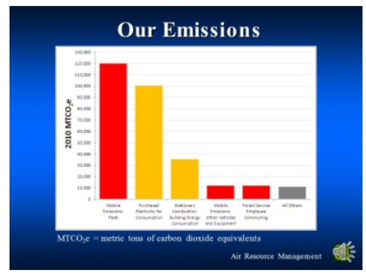


There are two main policy responses to climate change: mitigation and adaptation. Climate change mitigations are actions we can take to <u>decrease the intensity</u> of infrared radiation being trapped near the Earth's surface. On the other hand, adaptation involves implementing management actions to <u>tolerate</u> the effects of a changing climate. In simple terms, adaptation seeks to lower the risks posed by the consequences of climate change, while mitigation addresses the root cause - which we have learned is increased amounts of greenhouse gases in the atmosphere. Both approaches will be necessary, because even if greenhouse gases are reduced dramatically, adaptation will still be needed to deal with the global changes that have already been set in motion. Climate change adaptation strategies are being developed by the USDA Forest Service, and will be discussed in future lesson. We will spend the remainder of this lesson talking about ways that the Forest Service can mitigate climate change.

Slide 16

Most climate change mitigation involves either reducing the amount of greenhouse gases released from where they are emitted, or by increasing the amount of carbon absorbed and stored by vegetation or the oceans. The first step in reducing emissions is actually knowing what the baseline – or current – emissions are. In February 2011 the Forest Service released the Greenhouse Gas Inventory Report, which detailed the amount of greenhouse gas emissions attributed to our work. Second, we can implement cost-effective greenhouse gas emission reductions.

Slide 17

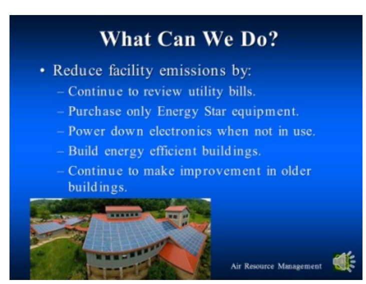


Based upon the February 2011 USDA Forest Service Greenhouse Gas Inventory Report, the greatest amount of greenhouse gases are emitted from our vehicles and other equipment that burn gasoline, jet fuel, or diesel fuel. These are shown on the graphic for the red bars beginning with the words "Mobile" or "Forest Service Employee Commuting." Of course this makes sense because many of us need to travel from our homes and duty stations to locations in the National Forests and elsewhere to perform work. Various types of fossil fuel consuming equipment are utilized for harvesting timber, building and maintaining roads, and improving watershed conditions. Another important source of greenhouse gas emissions is electricity. The electricity we use is purchased from the nation's power grid. Electricity is used to run our computers and other equipment, for lighting in our offices and developed sites, and especially for cooling and heating our buildings. The "Stationary Combustion …" source bar shows the direct emissions of greenhouse gases from on-site combustion of fuels for heating, such as from burning fuel oil, liquefied petroleum gas, natural gas, or even coal. So we can see that the majority of greenhouse gas emissions from Forest Service activities are from mobile sources, electricity consumption, or combustion of fossil fuels. This is unsurprising, given what we have already learned about greenhouse gases. In fact, EPA tracks greenhouse gas emissions on a national scale, and for their most recent inventory 72% of all greenhouse gas emissions in the US were from these same three sectors.

Slide 18

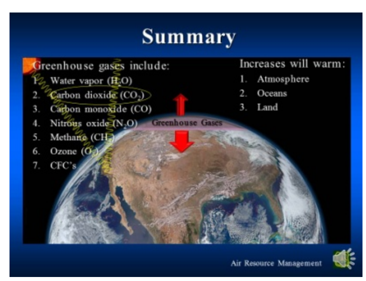
Given that so much of our emissions come from mobile sources, it would be appropriate to focus mitigation efforts on this sector. We can reduce mobile emissions by: Driving sensibly and within the speed limit. Not only will we be safer, but driving at a slower speed and with less rapid acceleration and braking also reduces the amount of fossil fuels we consume. You can assume that each 5 mile increment you drive over 50 miles per hour is like paying an additional 27 cents per gallon, and increases your greenhouse gas emissions by up to 15%. We need to continue to think about ways to carpool and reduce the number of vehicles going to the same location. For example, in Region 8, the fire staff has started conducting annual training sessions for numerous classes at one location. This allows District and Supervisor Office staff to car pool to the session. Also, we need to continue to evaluate how many and the types of vehicles that are needed to perform our work. For example, some communities and states have a compressed natural gas infrastructure that we may be able to utilize, or we may be able to add gasoline/electric hybrid vehicles to our mix. As we design new offices then it may be worthwhile consider installing a solar power station if we can utilize the gas-electric vehicles that have recently entered the market. Even just buying more fuel efficient gasoline-powered vehicles can make a big impact – the annual difference between choosing a car that gets 30 mpg and another one that gets 30 mpg adds up to nearly $1000 in fuel savings and subsequent reductions in greenhouse gas emissions. One final way to reduce greenhouse gas emissions from vehicles and equipment is for us to use biofuels, which could include purchasing gasoline that contains ethanol, or for diesel vehicles and equipment we should seek to use biodiesel. We should also seek ways to encourage contractors to use biodiesel when it can be utilized at a project site. Remember, biofuels do not release carbon that had previously been stored in the Earth as oil or gas.

Slide 19



Remember that the other main sources of greenhouse gas emissions were electricity consumption and fossil fuel combustion. We can reduce greenhouse gas emissions associated with those sectors by: Continuing to evaluate energy use by reviewing utility bills in order to identify the facilities with the highest costs, and focus efforts to reduce energy usage at those locations. Purchasing Energy Star compliant equipment will reduce our electrical consumption. EPA estimates that in 2010, Americans saved $20 Billion Dollars on their utility bills with the help of Energy Star, and prevented the equivalent of greenhouse gas emissions from 38 million vehicles. For the Forest Service, based on the most recent data, less than 35 percent of all of our laptops, desktops, plotters and monitors were Energy Star compliant. Speaking of electronics – did you know that total electricity consumed by idle electronics equals the annual output of 12 power plants? Save energy and reduce greenhouse gas emissions at work by setting your computer, monitor and other office equipment to power down when not in use. Also, make sure you unplug chords – including for cell phones – when not in use. New buildings should be at least 30 percent more efficient than local building codes require. Evaluate if biomass, geothermal, solar, or wind generation would be a good choice to supplement energy requirements. Also, windows that can be opened may reduce demand for electricity in the spring and fall if air conditioners typically operate during those seasons. Upgrades to older building may include increasing the amount of insulation in walls and ceiling, installing motion detectors in rooms used periodically throughout the day, and replacing lights that meet modern efficiency standards. If available, switching from diesel fuel to natural gas will lower the amount of greenhouse gas emissions from a boiler.

Slide 20



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Slide 21

End of Lesson Two; What happens to the Sun's energy after it reaches the Earth's atmosphere?