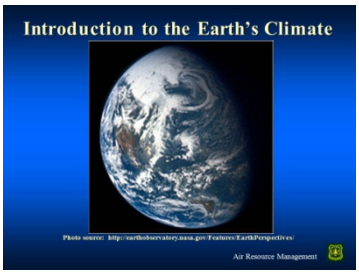
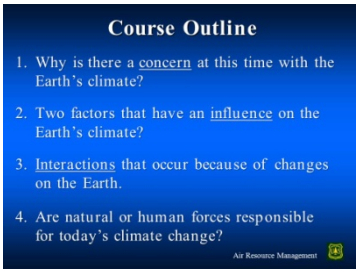
Slide 1



Hello – My name is Melanie Pitrolo. I am an air resource management specialist and my duty station is in Asheville, North Carolina. This is the first lesson in a series to fulfill the Agencies goal to train Forest Service staff on climate change.

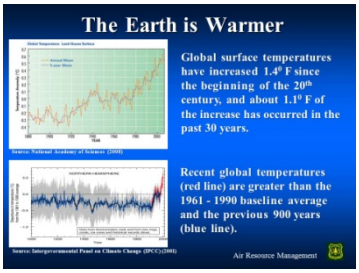
Slide 2



In this lesson we will learn; Why is there a concern at this time with the Earth's climate; Two factors that have an influence on the Earth's climate; Interactions that occur because of changes on the Earth; Are natural or human forces responsible for today's climate change?

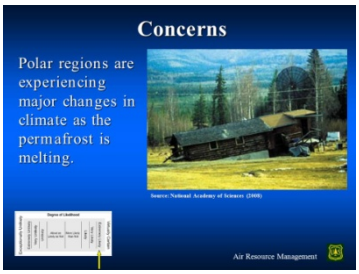
Slide 3

Why is there a concern at this time with the Earth's climate?



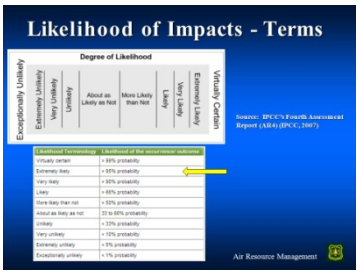
The Intergovernmental Panel on Climate Change (or IPCC) has concluded it is "unequivocal" the Earth's average temperature is rising. Global surface temperatures have increased 1.4^0 F since the beginning of the 20^{th} century, and about 1.1^0 F of the increase has occurred in the past 30 years. Recent global temperatures (seen here as the red line on the bottom graph) are greater than the 1961 – 1990 baseline average and the previous 900 years, which is shown as the blue line.

Slide 4



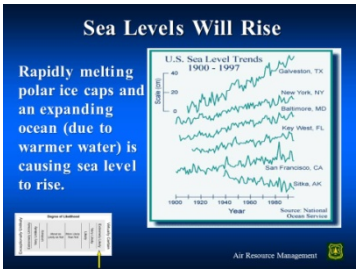
The recent changes seen in the climate have been of concern to many people. For example, permafrost in the polar regions has melted and it is **extremely likely** the permafrost will continue to melt and result in further sinking of the land. This will present substantial challenges to engineers attempting to preserve and maintain infrastructures, and minimize damage to roads, runways, and water and sewer systems.

Slide 5



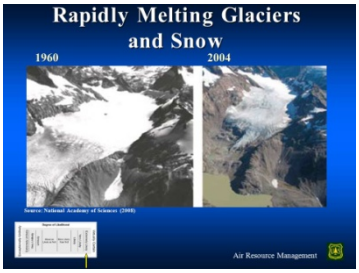
Uncertainty is always present in scientific findings. The IPCC agreed to use specific words or terms whenever they relate to the probability (or certainty) that a finding was to occur. For example, in the last slide I said it is **extremely likely** the thawing of permafrost will continue. A statement that is "extremely likely" is defined to have a likelihood of occurring between greater than 95 percent and less than 99 percent.

Slide 6



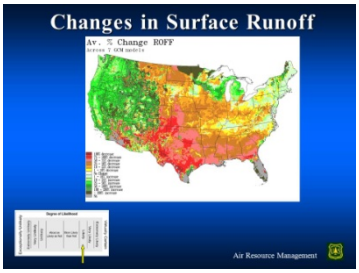
The scientific consensus has concluded it is **extremely likely** the Earth's sea levels will continue to rise. First, the ocean temperature is getting warmer and this causes it to expand, and many coastal areas may experience increases in sea level height. A second reason is because land-based polar ice caps are rapidly melting and the additional water to the oceans is causing sea level to rise. Some coastal areas (such as Sitka, AK) may not observe a sea level rise because either the continent is rebounding from the lost weight of the glacier or the geological uplifting from plate tectonics.

Slide 7



Rapidly melting mountain glaciers and snow is **extremely likely** to continue and this could result in water shortages for people depending on the slow release of these essential water sources in the western United States.

Slide 8



General circulation models (GCM) are predicting changes in precipitation and temperature patterns. This is **likely** to change the average percent run off of precipitation in some areas of the United States.

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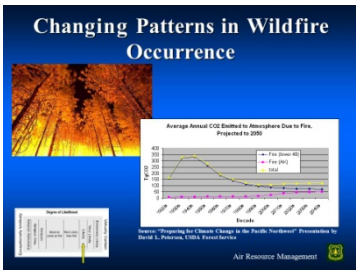
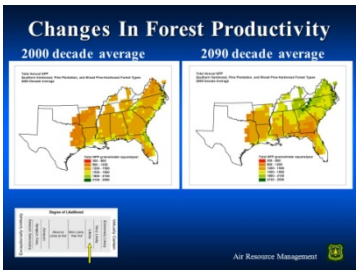
Some diseases transmitted by food, water, and insects are **likely** to increase. For example, mosquitoes are known to transmit West Nile Virus. An increase in temperature, precipitation, or extreme weather events have all been linked to expanding the mosquito habitat and consequently the number of mosquitoes.

Slide 10



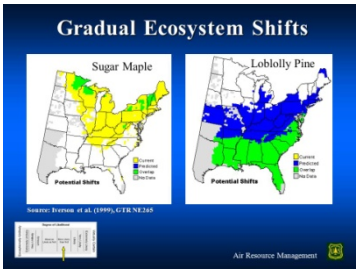
I mentioned the permafrost in northern latitudes has been melting, and in the future the forest floor of the boreal forest will become dryer as there is an increase in air temperature. Therefore, scientists have predicted there is **likely** to be an increase in the number of wildfires in the remote areas of Alaska.

Slide 11



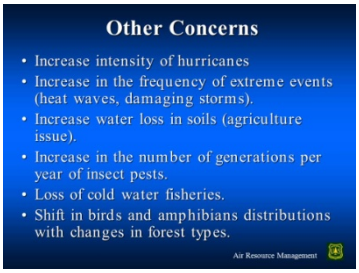
Changes in the net primary productivity (or NPP), a measure of forest productivity, is **likely** to change in the future. For example, portions of western North Carolina are predicted to increase in net primary productivity for the decade averages for the year 2000 and 2090.

Slide 12



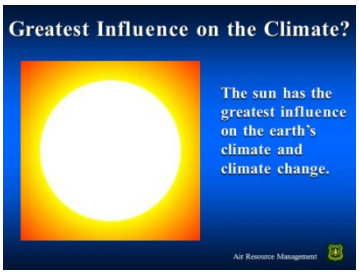
More likely than not, climate change may result in the gradual shift in the location of forest trees and communities. For example, northern species such as sugar maple may become less abundant in the eastern United States as the species migrates further into Canada; while southern species such as loblolly pine may be found north of its current distribution.

Slide 13



Other climate change related concerns also include; Increase intensity of hurricanes; Increase in the frequency of extreme events (heat waves, damaging storms); Increase water loss in soils (agriculture issue); Increase in the number of generations per year of insect pests; Loss of cold water fisheries; Shift in birds and amphibians distributions with changes in forest types.

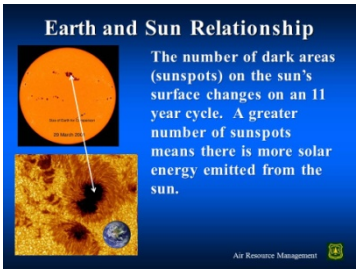
Slide 14



So, what do you think is the greatest influence on the Earths' climate? You would be correct if you answered the sun. The **average** distance between the sun and earth is about 93 million miles. The sun's **average** luminosity (rate of energy release) is 3.9 x 10^{26} Watts, and on **average** the earth receives 1387 Watts on every square meter of surface.

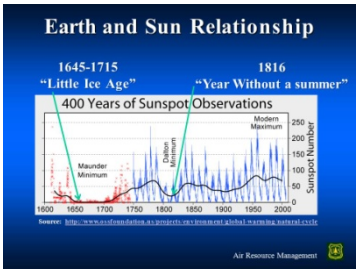
To understand our climate, we will examine two natural factors that have a tremendous influence our climate. First, we will examine influences on the amount of sun's energy that reaches the earth's atmosphere. The second factor to examine is what influence the earth's atmosphere has on sun's energy once it is reflected or released by the earth's surface.

Slide 15



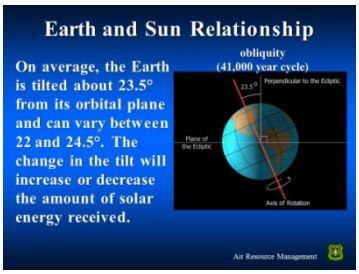
Overtime, the amount of energy released from the sun changes. The number of dark areas, called sunspots, on the sun's surface changes on approximately an 11 year cycle. A greater number of sunspots means there is more solar energy emitted from the sun.

Slide 16



In this chart, notice how the blue peaks are on approximately an 11 year cycle. There are few peaks with red "x"s because there were fewer sun spots between 1645 and 1715 and then again in 1816. The first time period time is referred to as the Little Ice Age. The Little Ice Age brought colder winters to parts of Europe and North America. Farms and villages in the Swiss Alps were destroyed by encroaching glaciers during the mid-17th century. Canals and rivers in Great Britain and the Netherlands were frequently frozen deeply enough to support ice skating and winter festivals. In the winter of 1780, New York Harbor froze, allowing people to walk from Manhattan to Staten Island. Sea ice surrounding Iceland extended for miles in every direction, closing harbors to shipping. Iceland also suffered failures of cereal crops, and people moved away from a grain-based diet. In North America, Native Americans formed leagues in response to food shortages. There were reports of heavy snowfalls in the winters of 1665, 1744 and 1886.

Slide 17



The Earth rotates about an axis and this controls the diurnal (day-night) cycle and also controls how much solar energy the earth intercepts during the year. If the northern hemisphere is tilted toward the sun (summer) then it will receive more solar radiation than the southern hemisphere, which would be experiencing winter. On average, the Earth is tilted about 23.5° from its orbital plane and the axis tilt, or obliquity, varies over time. This tilt can vary between 22 and 24.5°. The distance between the Earth and sun will change over a period of 41,000 years, which will increase or decrease the amount of solar energy received. Increased obliquity can cause summers to be warmer and winters to be colder. We are currently in a decreasing phase, which under normal circumstances will cool the climate system.

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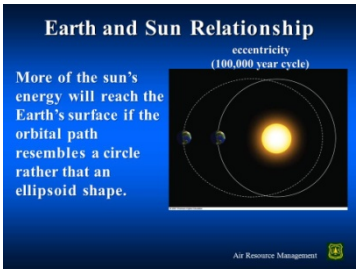

The distance between the sun and earth does vary by season and over about 100,000 years. The Earth orbits the sun in an elliptical shape and this is referred to as the eccentricity. Eccentricity is a measure of how far from circular the Earth's orbit is around the sun and this controls how much solar energy the earth intercepts during the year. As the earth's eccentricity increases then we spend less time close to the sun in the span of a single year and get less solar energy on an annual basis. This condition tends to cool the earth.

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The earth is not perfectly round so the gravitational pull tugs the axis over time creating a wobble cycle that takes 26,000 years to complete. The movement is like a top and is called the precession. This gyroscopic wobble of the earths axis is driven by tidal forces which are influenced by the sun and our moon. Currently the southern hemisphere is at an orbital position that is closest to the sun, so they are enjoying warmer summers and cooler winters.

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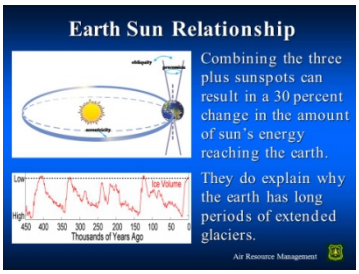
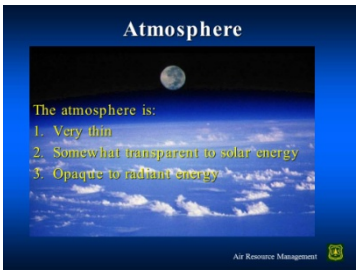


Combining the three orbital characteristics plus sunspots can result in a 30 percent change in the amount of sun's energy reaching the earth. These do explain why the earth has long periods of extended glaciers, but they do not explain the recent temperature increase. Currently, the earth should be cooling.

Slide 21



Now, let's talk about the atmosphere and it's influence on the Earth's climate. The Earth's atmosphere is about 60 miles thick while the radius of the earth is much greater at about 4000 miles in diameter. The atmosphere is somewhat transparent and this allows about 70% of the sun's energy (solar radiation) to reach the earth's surface. The atmosphere is also opaque because the energy emitted from the earth's surface is reflected by the atmosphere back towards the earth's surface.

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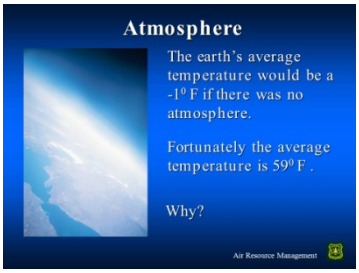
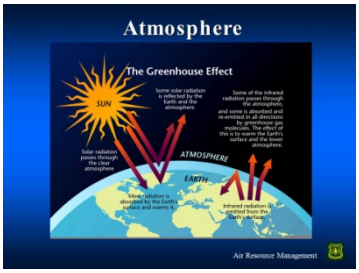


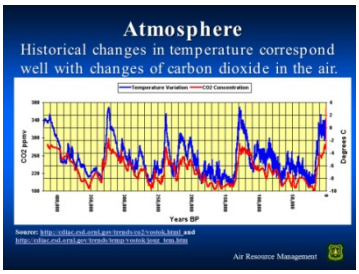
If there was no atmosphere then the average temperature of the earth would be freezing and could not support life as we know it today. So, why is the global average temperature about 59^0 F?

Slide 23



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. 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 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 **water vapor**, 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.

Slide 24



This graphic shows 400,000 years of Antarctic changes in carbon dioxide and temperature estimated from ice core samples. Careful examination of the graphic reveals carbon dioxide increases proceeded the temperature increases. The carbon dioxide increases most likely resulted from environmental conditions becoming favorable for an increase in global photosynthesis, especially phytoplankton in the oceans.

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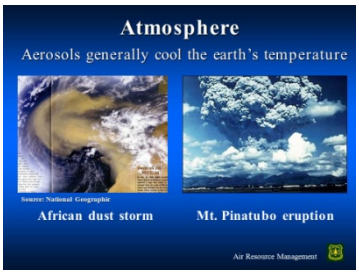

Aerosols are suspended liquid or solid particles that can cause the atmosphere to cool. The large (diameter > 20 µm) aerosols settle to ground; while the smallest (diameter < 0.1 µm) aerosols have little impact on the earth's climate. Aerosols that have a diameter between 0.1 – 1.0 µm have the greatest influence on the earth's climate and these include:

1. Bursting water bubbles, i.e. sea salt,
2. Mineral dust dispersed by the wind,
3. Ash from volcanoes,
4. Soot from forest fires,
5. Spores and pollen, and
6. Conversion from gas -- for example sulfur dioxide released from volcanoes to sulfate aerosols

Aerosols generally cool the climate by increasing albedo and serving as cloud condensation nuclei (i.e. they help form clouds). The term albedo refers to reflecting solar energy back to space before the solar energy can be absorbed by the earth's surface.

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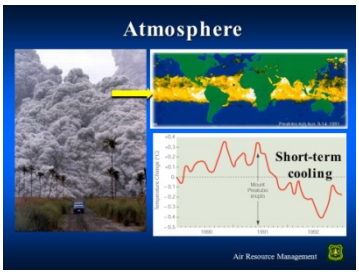

Volcanoes can inject into the stratosphere large amounts dust and gases (especially sulfur dioxide) that become aerosols. The stratosphere is located between about 6 miles and 30 miles above the Earth's surface. The aerosols can remain in the stratosphere for many months and serve as condensation nuclei and form clouds. The effect on climate is dependent on size of the aerosol particles. Small particles (< 1 µm) reduces net solar radiation and can cool the earth; while net warming occurs for larger (2 µm) particles because they absorb terrestrial radiation (long-wave infrared). The volcanic release from Mount Pinatubo resulted in the average global temperature decreasing in 1991 and a portion of 1992.

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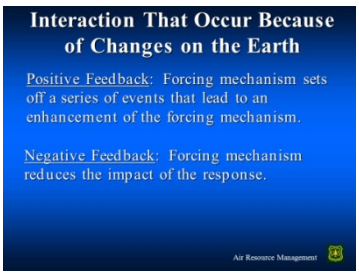

We have been examining two factors that influence the Earth's climate. At times in the Earth's history, changes in the amount of solar energy or changes in the components in the atmosphere have led to an increase or decrease in the Earth's temperature. Scientists use the terms positive feedback and negative feedback to communicate how a forcing mechanism has an influence on the environment. A positive feedback is defined as a forcing mechanism sets off a series of events that lead to an enhancement of the forcing mechanism; while a negative feedback is a forcing mechanism that reduces the impact of the response. You will understand these two terms with the following example.

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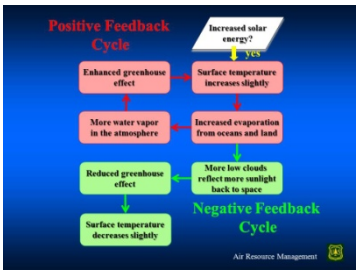

Let's begin with a time period where there is a gradual increase in solar energy reaching the earth. This would have resulted in a gradual increase in the Earth's temperature and the increase in the surface temperature will act as a forcing mechanism. The gradual global temperature increase would have increased the evaporation rate from the oceans and land. The increase of water vapor in the atmosphere would then trap the heat released from the earth surface and resulted in an enhanced greenhouse effect with the temperature having a further slight increase. Now think about what has been described. Is this a positive or negative feedback cycle? You are correct if you said it was a positive feedback cycle. There is also another possible scenario that can occur and perhaps at the same time as positive feedbacks. The slight increase in temperature that increased the evaporation from the oceans and land could result in the formation of more cumulus clouds in the lower atmosphere. Cumulus type clouds will reflect solar energy back into space before the energy can reach the Earth's surface. This will result in a reduced greenhouse effect and a cooling of the Earth's surface. This second scenario is a simple explanation of a negative feedback cycle.

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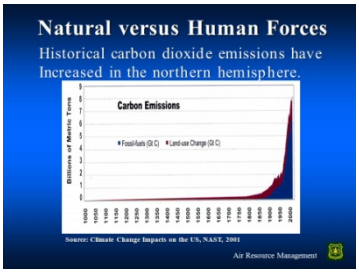
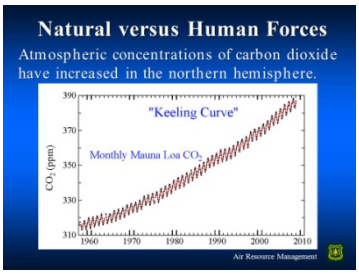


Climate researchers have an interesting challenge because they cannot perform controlled studies (i.e. experimental manipulation) of the amount of energy released from the sun, or greenhouse gases in the Earth's atmosphere because we have only one sun and Earth in our solar system. Instead they have to rely upon computer models, called global circulation models, that approximate the physical, hydrologic, and biological systems of the Earth and how these interact and affect the Earth's climate. The global circulation models need to account for all known factors that have a positive or negative feedback on the Earth's climate. This presentation has focused on how natural factors influence the Earth's climate, but we need to keep in mind the global circulation models also need to account for how human activities may also influence the climate. Prior to the industrial revolution, changes in land use (especially the conversion of forests to agriculture or cities) slowly increased the amount carbon dioxide released into the atmosphere. Beginning in about 1860, the industrial revolution resulted in an exponential increase in carbon dioxide

emissions from the combustion of fossil fuels to meet our energy demands for the purpose of increasing the amount of commodities produced and also improving the standard of living for people living in developed countries like the United States.

Slide 30



Carbon dioxide can remain in the atmosphere 50 to 200 years and it is possible that some carbon dioxide released during the beginning of the industrial revolution is still present in today's atmosphere.

In 1958, Dr. Charles David Keeling began monitoring atmospheric concentration of carbon dioxide at Mauna Loa Observatory, Hawaii. At this remote site, the carbon dioxide concentration have steadily increased from 315 parts per million to 385 parts per million in June, 2008. Please note in this graphic that there is approximately a 5 part per million seasonal variation due to carbon dioxide uptake changes from world's vegetation that is mostly found in Northern Hemisphere.

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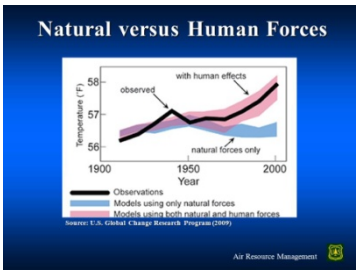
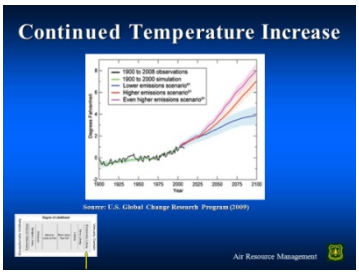


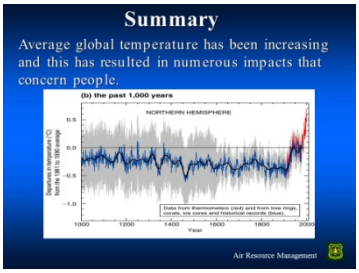
We began this presentation by noting the average global temperature has been increasing. Climate scientists have used general circulation models to ask if the increase in temperature is due to natural forces alone, or do human influences also contribute to the observed temperature increase. Modeling scenarios that include only natural forcing under-predict the average global temperatures observed recently. This is shown as the blue area on the graphic in comparison to the measured average global temperature shown as the black line. You will note that the modeling results displayed as the red area have good agreement with the average global temperature, and the improved modeling results were achieved when the emissions of greenhouse gases and other human activities were included with natural forces as inputs into the general circulation models.

Slide 32



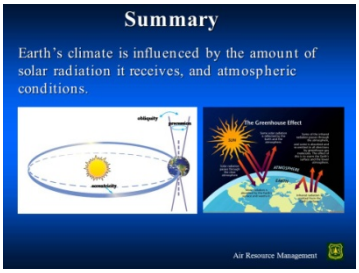
Therefore, there is a legitimate concern today and it is **extremely likely** that global temperatures will continue to increase.

Again, general circulation models do simulate the temperature increase that has been observed between 1900 and 2000. This can be seen in this graphic when you compare the monitoring results shown as the black line with the model predictions displayed as the green line. However, the amount of change in global temperature in the future **depends on us** and how much more forested land we convert to other uses, and especially on the amount of greenhouse gases we continue to release into the atmosphere from the combustion of fossil fuels.



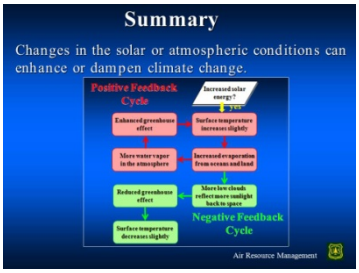
Slide 33

In summary, this first lesson we have learned the average global temperature has been increasing and this has resulted in numerous impacts that concern people.



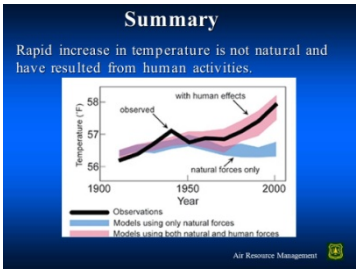
Slide 34

In summary, this first lesson we have learned the Earth's climate is influenced by the amount of solar radiation in receives, and atmospheric conditions.



Slide 35

In summary, this first lesson we have learned the changes in the solar or atmospheric conditions can enhance or dampen climate change.



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In summary, this first lesson we have learned the rapid increase in temperature is not natural and have resulted from human activities.