Climate Understanding and Response

This presentation is a summary of the known science of climate change with ideas for mitigation and behavior.

This is intended for people who might appreciate a summary, for anyone who does not totally understand Climate Change, and for people who may not realize our climate is changing.

I write this with the hope that greater understanding will lead to more proactive, collective action.

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Posted for the 50th Earth Day

What is Global Warming?

Why is there such concern over global warming of just a few degrees?

Climate temperature is not the same as weather temperature.

Climate temperature is the average (mean) global temperature,

which has only varied by 16 C^o (29 F^o) in the past 800,000 years.

During the last ice age, 20,000 years ago, mean surface temperature was only 12 C^o below our current temperatures. Glaciers thousands of feet thick covered most of North America, and sea level was hundreds of feet below current sea level.

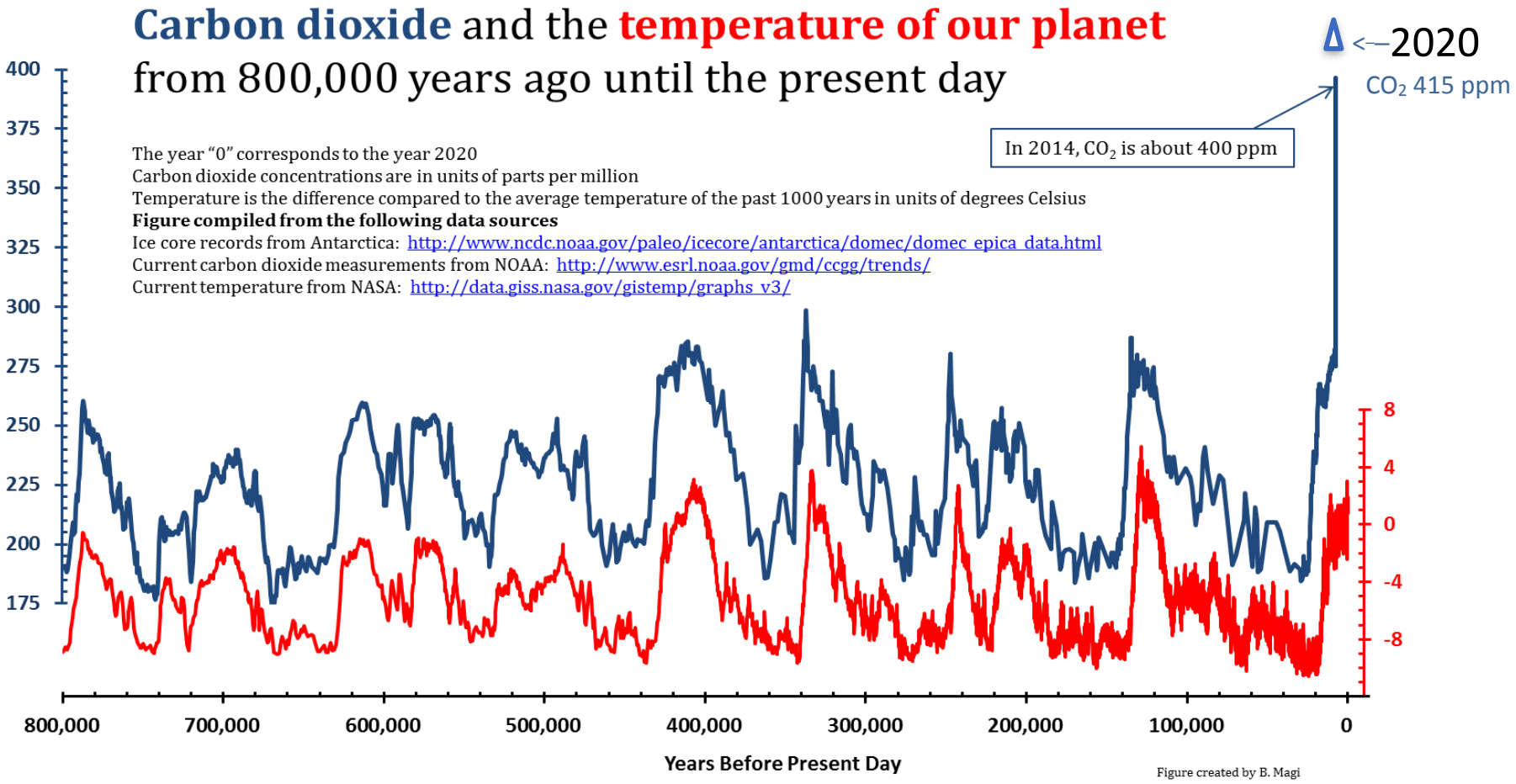
At the peak of the last interglacial period, carbon dioxide (CO_2) concentration was 280 parts per million (ppm), mean surface temperature was only 4 C^o above our current temperature, and sea level was 24 feet above current levels.

Aren't we experiencing a natural climate cycle?

Milankovitch Cycles, which include: the path of the Earth's orbit around the Sun, the tilt of Earth's axis relative to the Sun, and the wobble of the Earth on its axis, explain most of the temperature and CO_2 cycles prior to fossil fuel combustion.

These cycles of temperature can not account for the current concentration of greenhouse gases.

Ice Core Data Showing Carbon Dioxide (CO_2) Concentration and Global Mean Surface Temperature for 800,000 years



CO_2 concentration has not been below 175 ppm nor above 280 ppm for more than 800,000 years until fossil fuel combustion. The current concentration of CO_2 is 415 ppm.

What are Greenhouse Gases?

Carbon is the basic element of all living things.
Fossil fuels are a product of previously living organisms that have been under high pressure and heat for millions of years deep within the earth.

The fossil fuels are coal, oil, and natural gas (which is 85% methane).
When any of these fossil fuels are burned they emit CO_2.

Greenhouse gases (GHGs) are gases that trap heat from infrared solar radiation.
The rest of the gases in the atmosphere (more than 99%) do not absorb any solar radiation.

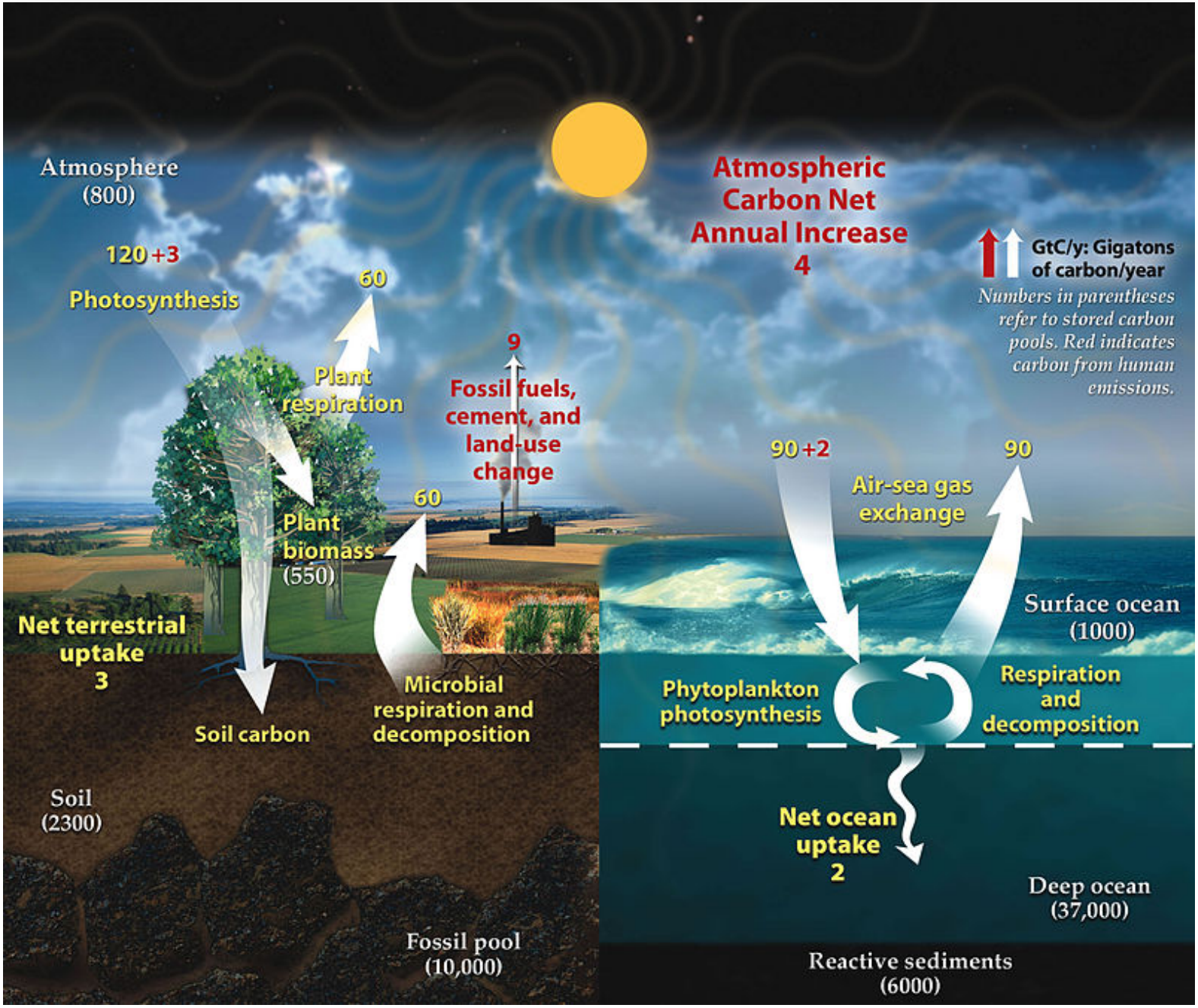
The primary GHGs are water vapor (H_2O), CO_2, methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and the chlorofluorocarbons. Current total concentration of all GHGs is 454 ppm.

H_2O does not behave like a GHG because clouds reflect solar radiation, and it precipitates quickly from the atmosphere.

91% of total GHG volume is CO_2.

CH_4 concentration has not been below 350 parts per billion (ppb) nor above 800 ppb for more than 800,000 years until fossil fuel combustion.
The current concentration of CH_4 is 1,870 ppb.
CH_4 absorbs solar radiation roughly 30 times more intensely than CO_2.
CH_4 accounts for 0.4% of GHG volume (1.87 ppm/454 ppm x 30)
but 12% of atmospheric warming.

Carbon Dioxide in the Atmosphere



Another reason we know the CO_2 concentration above 280 ppm is caused by burning of fossil fuels

99% of the carbon in CO_2 in the atmosphere is Carbon-12 (^{12}C).
1% of the atmospheric carbon is Carbon-13 (^{13}C).
^{14}C is the radioactive isotope of carbon which is formed when a small percentage of nitrogen atoms are struck by cosmic neutrons that change the nitrogen atoms into ^{14}C.
^{14}C exists only in trace amounts in the atmosphere,
but its level of production has remained a constant.

Because all fossil fuels have been underground for millions of years,
all of their carbon has decayed to the stable element ^{12}C.
The carbon in CO_2 that comes from burning of fossil fuels is all ^{12}C.

^{14}C's long half-life of 5,700 years enables us to track the ratios of the three carbon isotopes over time.

The ratios of both $^{12}C/^{13}C$ and $^{12}C/^{14}C$ are both increasing at a rate that correlates with the increase in CO_2 concentration.

This increasing proportion of ^{12}C can only be explained by emissions from burning of fossil fuels.

Effects of Increasing Concentration of GHGs

Oceans absorb most atmospheric CO_2.
CO_2 levels in the ocean are rapidly increasing.

CO_2 when mixed with sea water, produces carbonic acid (H_2CO_3). The H_2CO_3 dissipates quickly, but it makes the oceans more acidic.

<u>Ocean acidification is currently occurring 25 to 100 times faster than in the past one million years.</u>

Acidic oceans do not support formation of calcium carbonate ($CaCO_3$), which is the basic component of corals, shellfish, and vertebrae.

Oxygen (O_2) levels are decreasing in the oceans, contributing to more and larger marine dead zones.

Production of the basic building block of the ocean food chain, phytoplankton, is in decline in the lower oceans.

Effects of Higher Global Mean Surface Temperatures

Surface ocean currents are slowing and meandering more.
Jet streams are slowing and meandering more.
Both are causing climates to shift and weather patterns to become more extreme.

Oceans absorb most of the atmospheric increase in temperature.
Warming oceans hold less oxygen, also contributing to more and larger marine dead zones.

Melting ice and warming permafrost are exposing methane clathrate
and releasing vast deposits of CH_4 at a faster rate than ever before.

Floating ice melts sooner than ice on land.
When sea ice melts, the exposed water absorbs the solar radiation that the ice used to reflect.
As oceans warm, their volume increases, raising sea level.
When floating ice (Arctic) melts it raises sea level only slightly.
Melting Antarctic ice and Greenland ice will raise sea level quickly.

Sea level rise has always followed rise in surface temperatures.
The last time CO_2 concentration was 415 ppm was 10 million years ago.
Sea level was 100 feet above current level.

Current warming is too rapid for many species to adapt or evolve,
increasing the rate of: species extinctions, loss of biodiversity,
loss of traditional food sources,
loss of habitat, and
climate migration.

Incentives to Change Energy Sources

Solar, wind, geothermal, hydro, and nuclear power
will have lower total cost than our current sources of energy.

Local energy sources, including Small Modular Nuclear
Reactors, with local grids will be more efficient,
be less susceptible to wide-area blackouts,
and provide better national security.

Renewable energy will create clean new sustainable jobs.

A healthier energy economy will help to promote more sustainable
environmental practices and a circular economy.

We have the technology to replace fossil fuels now.

Why are we responding so slowly?

Most people do not grasp the urgency or the severity of what is happening.
Most people are not observing the changes happening in nature.

Changing from a hydrocarbon economy will be expensive.

Current natural gas prices, that fail to account for the liabilities and perils of their use, make energy alternatives financially impractical.

Inexpensive ethane, which comes primarily from natural gas, makes virgin plastics cheaper than most sustainable alternatives and cheaper than recycled plastics.

Fiscal policy incentivizes fossil fuel production without addressing climate effects.

Leakage of methane will be expensive to stop.

Too many people are denying science and evidence.

Internet noise is loaded with false claims about climate and fossil fuels.

Political, religious, and social beliefs outweigh facts.

How you can help

Use your influence to persuade civic and business leaders
to drastically reduce fossil fuel combustion, ASAP.

Preserve natural resources.
Restore wetlands and forests Plant trees!
Promote stainable agriculture and native species.
Replace lawns that need mowing with cover crops and wild flowers.
Reduce impervious surfaces.
Conserve water.
Eliminate toxic herbicides, pesticides, and fertilizers.
Protect against erosion.
Move to a more circular economy and lifestyle.
Reduce first, then Reuse, then Recycle.
Focus on solutions.
Set a good example.
Evoke peer pressure.
Promote sustainable population growth.

Take responsibility for the long-term effects of
everything you can control.

Reduce Your Carbon Footprint

The wealthiest 10% of global population emits 45% of global CO_2.
The poorest 50% emit only 13% of global CO_2.

Ask your electricity supplier for an energy audit.
Buy electricity from renewable energy sources. You have a choice!
Buy natural gas from biogas sources.
Reduce energy consumption.
Lower furnace and water heater settings, raise AC settings.
Increase insulation, seal building air leaks.
Eliminate unnecessary lighting, heating, and cooling.
Use all LED lighting.
Convert to solar, geothermal, and electric heat pumps from renewable sources.
Buy sustainable locally-grown and locally-raised food.
Reduce your automobile hydrocarbon fuel consumption.
Drive electric cars and charge batteries or fuel cells with renewable energy.
Avoid air travel.
Use electric public transportation.
Avoid flash fashions.

Avoid unnecessary single-use plastics.
Reduce demand for hydrocarbon polymers.
Promote extended producer responsibility for recycling.

Today will be remembered in history as the time when we first understood the effects of greenhouse gases and recognized our ability to make a difference.

Will we sleep walk into catastrophe, or will we respond to the challenge and mitigate the suffering of future generations?