







Graph shows that over the last 800 thousand years, the CO2 level was never above 300 ppm, which caused a temperature rise of about 10°C in the Arctic. Current CO2 level of 401 ppm does not include other GHGs, which are shown in the next slide.



http://www.esrl.noaa.gov/gmd/aggi

The NOAA Annual Greenhouse Gas Index (AGGI) measures the commitment society has already made to living in a changing climate. It is based on the highest quality atmospheric observations from sites around the world. Its uncertainty is very low.

The AGGI in 2015 was 1.37, which means that we've turned up the warming influence by 37% since 1990.

It took ~240 years for the AGGI to go from 0 to 1, i.e., to reach 100%, and 24 years for it to increase by another 37%.

In terms of CO_2 equivalents, the atmosphere in 2015 contained 485 ppm, of which 399 is CO_2 alone. The rest comes from other gases.

 CO_2 is by far the largest contributor to the AGGI in terms of both amount and rate of increase.

Note: The IPCC suggests that a constant concentration of CO_2 alone at 550 ppm would lead to an average increase in Earth's temperature of $\sim 3^{\circ}$ C (5.4° F).



CO2 causes about 2/3 of the heating, methane a sixth, and other gases a sixth. Notes:

http://www.esrl.noaa.gov/gmd/aggi

The Radiative Forcing on the left axis shows the actual instantaneous heating impacts of the GHGs.

The AGGI index on the right axis is arbitrarily set at one in 1990.

http://www.esrl.noaa.gov/gmd/aggi/aggi.html

Figure 4 shows radiative forcing for the major gases, carbon dioxide, methane, and nitrogen oxide, chloroflurocarbon refrigerants, and a set of 15 minor long-lived halogenated gases (CFC-113, CCl_4 , CH_3CCl_3 , HCFCs 22, 141b and 142b, HFCs 134a, 152a, 23, 143a, and 125, SF₆, and halons 1211, 1301 and 2402). Except for the HFCs and SF₆, which do not contain chlorine or bromine, these gases are also ozone-depleting gases and are regulated by the Montreal Protocol.

As expected, CO_2 dominates the total forcing with methane and the CFCs becoming relatively smaller contributors to the total forcing over time. The five major greenhouse gases account for about 96% of the direct radiative forcing by long-lived greenhouse gas increases since 1750. The remaining 4% is contributed by the 15 minor halogenated gases.

Global Carbon Budget

The International Panel on Climate Change (IPCC) said in 2013: For a probability >66% of limiting global warming to less than 2°C, **cumulative CO₂ emissions must be less than 3 trillion tons CO₂**. (which still results in maximum CO₂ concentrations reaching **421 ppm**)*

Since 1.8 trillion tons CO₂ was already emitted by 2014**, Maximum remaining emissions budget = 1.1 trillion tons CO₂. Only 30 years left at current rate or 20 years at current rate of 2.5% annual increases. Emissions must be zero by 2034.

* "Umiting the warming caused by anthropogenic CO₂ emissions alone with a probability of >33%, >50%, and >66% to less than 2°C since the period 1861–1880, will require cumulative CO₂ emissions from all anthropogenic sources to stay between 0 and about 1560 GtC, 0 and about 1210 GtC, and 0 and about 1000 GtC since that period respectively. These upper amounts are reduced to about 880 GtC, 840 GtC, and 800 GtC respectively, when accounting for non-CO2 forcings as in Model RCP2.6. An amount of 531 [446 to 616] GtC, was already emitted by 2011." From IPCC WGI ARS, Approved Summary for Policymakers, p. SPM-20-22 (9/27/2013) ** Le Quéré et al. 2015

When the country negotiators saw the IPCC Carbon Budget, they realized they would have to make much more drastic cuts than they wanted (plus there are a lot of equity issues in how to divide up the remaining "budget," so they rejected including a Carbon Budget in the 2015 Paris Agreement, opting instead for a 2°C target (plus 1.5°C as an "aspirational" goal).



Another graphic, based on wanting to have an 80% chance of <2°C (instead of the IPCC 66% chance), shows we have already emitted more than enough to exceed 1.5°C and only have 8 years of emissions left before exceeding 2°C.



<u>*RL Miller*</u> article at http://www.takepart.com/article/2013/09/27/ipcc-report-climatechange-bill-mckibben-new-math



The data shows that emissions are currently **<u>above</u>** the path of the top red line, the worst predictions included in the IPCC models.



www.ClimateScoreboard.org



Emission scenarios for approximately 88–92% chance of not exceeding 2°C. Both plots illustrate 'orthodox' mitigation pathways with (a) C+ for CO2 only (twenty-first century cumulative emissions: 2741 GtCO2) and (b) B6 for Kyoto gases (twenty-first century cumulative emissions: 3662 GtCO2e). Blue line, Annex 1; red line, non-Annex 1; dotted line, total including deforestation. **Anderson K , Bows A Phil. Trans. R. Soc. A 2011;369:20-44**



Climate model . Photograph: Goddard Space Flight Center Scientific Visualization Studio/NASA

Jim: Better move to Canada if you want to survive.

Tipping Points Happening Now

- Loss of Arctic Sea Ice increases Arctic Ocean heating, which decreases Arctic Sea Ice
 a positive feedback loop
- Arctic Heating increases emissions of methane from Arctic methane hydrate deposits, which increases global temperatures, which produces more emissions of methane from Arctic methane hydrates - a positive feedback loop
- Loss of glaciers and snow decreases sun reflections, increases solar heat absorption, which increases global temperatures, which decreases glaciers and snow - a positive feedback loop



What Can We Do?

Typical Approaches to Sustainability Are Important But Not Enough.



We have to remove the excess carbon to save humanity and the other living creatures.



This chart shows how many ways of reducing carbon are profitable (i.e. insulation, lighting, water heating, etc. have quick payback of over \$150 per ton of carbon saved. Planting trees only costs 10-15 per ton of carbon. Carbon Capture and Sequestration (CCS) only costs \$20-30 per ton.



But Most Technologies to Reverse Global Warming Are Not at the Scale Required. This analysis from McLaren shows that only Ocean Seaweed Forests can scale up to the size needed to both negate current fossil fuel emissions and remove the 2 trillion tons of excess carbon already emitted. (The blue circles on the right show cost estimates over \$200 per ton for chemical "trees" to capture carbon, but prices are coming down now.)

But Seaweed Forests can make money since they replace fossil fuels, and our projected cost of permanent safe sequestration is less than \$20 per ton.



The red line shows the disaster on the current path of fossil fuels, plus some solar and wind renewables.

The green line shows a path back to a human-friendly climate. Hopefully, we can do it faster, if we get enough funding.



California is a totally different picture. It shows a path toward a human-friendly climate. Note that it also includes carbon sequestration on the land (both trees and soil carbon). However, it will not remove the trillions of tons of legacy carbon from previous fossil fuels. Ocean Forests are needed for that.



This graph shows that until California passed AB 32 in 2006, it was also on the red line path to climate catastrophe, like the rest of the world. But AB 32 mandated California's total emissions (not just CO2, but all GHG emissions) equal 1990 levels by 2020. Current projections show that California currently projects being under that target.

In August 2016, the California legislature passed SB 32, which mandates California's total emissions equal 40% below 1990 levels by 2030.

In addition, Governor's Executive Orders in 2005 and 2015 state a goal of 80% below 1990 levels by 2050.



California's plan addresses all major sources of GHG Emissions. High GWP is high global warming potential gases including chloroflurocarbon refrigerants, long-lived halogenated gases (CFC-113, CCl_4 , CH_3CCl_3 , HCFCs 22, 141b and 142b, HFCs 134a, 152a, 23, 143a, and 125, SF_6 , and halons 1211, 1301 and 2402).



A slide from E3 consultants, based on the CARB discussion draft of the Scoping Plan Update.

How Everyone Can Help

- · What governments can do: set prices/caps on carbon emissions, etc.
- · What companies can do: efficiency, zero waste, zero emissions, etc.
- · What environmental organizations can do: educate, organize, etc.
- · What community organizations can do: educate, organize, etc.
- · What individuals can do:
- ✓ Become educated on the complex interacting issues
- ✓ Become aware of one's own values vs. new values needed
- ✓ Become aware of the impact of one's own behavior
- ✓ Become educated on solutions
- ✓ Change one's own behavior
- ✓ Become politically active in supporting solutions at all levels
- ✓ Organize actions with others, join key organizations
- ✓ Lead humanity to sustainability

How You Can Help

Keep Informed

Sierra Club list: www.SierraClubCalifornia.org: Sign up at <u>Take Action</u> for SCC Action Alerts List (< 1 email/week)

EXPRESS your Opinions - politicians count on APATHY

Comment on and Support National and Local Legislation and Regulations

Support Earth Day and other educational and action events in your community, www.350.org, EarthDay.net

Help your business and organizations, church, etc. go GREEN!



Go GREEN yourself!

Help your family go green!

- Take personal action to reduce emissions by 80% ASAP.
- Stop driving solo: transit, walk, bike, telecommute, car pool
- Stop using fossil fuels: Get a plug-in electric or plug-in hybrid car
- No more air flights (except emergencies).
- Conserve energy at home
- · Grow your own food, buy local organic produce, stop beef
- 4 R's: Reduce (buy less), Reuse, Recycle, Re-buy (buy recycled products in your own canvas bag)
- Go carbon neutral with offsets for any remainder: www. B-E-F.org
- Invest only in environmentally responsible investments

"The greatest threat to our planet is the belief that someone else will save it."

-- Sir Robert Swan



Responses to Skeptics

- 1. Big Climate Effects Already Happening in U.S. and Around the World
- Current high CO₂ level has not yet increased land temperatures because the ocean has absorbed most of the heat.
- Impact of CO₂ emissions from volcanoes is less than 1% of the human CO₂ emissions.
- 4. Radiation from the sun is actually decreasing, but earth temperatures are increasing because the human CO₂ emissions overwhelm the sun's effect.
- 5. What to do?
 - Crash replacement of all energy from fossil fuels.
 - Stop building any more fossil fuel plants.
 - Sequester CO2 with algae in the ocean.

This set of 7 slides provides science data-based responses to several main objections raised by "climate skeptics."

https://www.skepticalscience.com/argument.php has one line responses (plus data) to 193 climate skeptics' arguments.



If there were no warming, the record high temperatures each year would equal the record low temperatures, as shown in the upper left.

The lower left shows that in the 1950s record highs slightly exceeded record lows, but recently, record highs are 90%, but record lows are only 10% of record temperatures each year in the US.



This pattern of record floods in some places and record droughts in other places has continued.



Because the Earth's oceans have absorbed 90% of the heat, the land temperatures have risen more slowly than the GHG emissions, but that is starting to change now.



The bottom blue line shows radiation from the sun is actually decreasing, but earth temperatures are increasing, so increased sunlight is not warming the earth.



The measured increases in CO2 in the atmosphere reflect the emissions from human burning of fossil fuels, not natural causes (such as volcanos, which are a very minor contribution (less than 1% compared to human emissions).



The top black line shows the observed temperature increase. Only the human caused GHGs can explain the observed temperature increases.

This chart also shows that solar radiation, ozone, and volcanoes are minor contributors, compared to the GHGs and the observed temperatures.

The Sulfate emissions, primarily from coal and high sulfur bunker fuel from ocean shipping, have countered the GHG effects and decreased global warming. However, as these high sulfur fuels are phased out to protect human health, the global warming impact of GHGs will dramatically increase, leading us toward dangerous irreversible tipping points.