Los Alamos Study Group

Nuclear Disarmament • Environmental Protection • Social Justice • Economic Sustainability

The Eleventh Hour: Greenhouse Gases & Runaway Warming

Andrew Ash - July 5, 2017

Greenhouse Gases: It's Not Just Carbon Dioxide

Greenhouse gases (GHGs) regulate the climate by trapping heat in the Earth's atmosphere. This is facilitated by the absorption & emission of infrared radiation through a process known as the *Greenhouse Effect.*

- GHGs are essential to supporting life on Earth. However, due to human activity, atmospheric GHG concentrations now greatly exceed their natural levels.

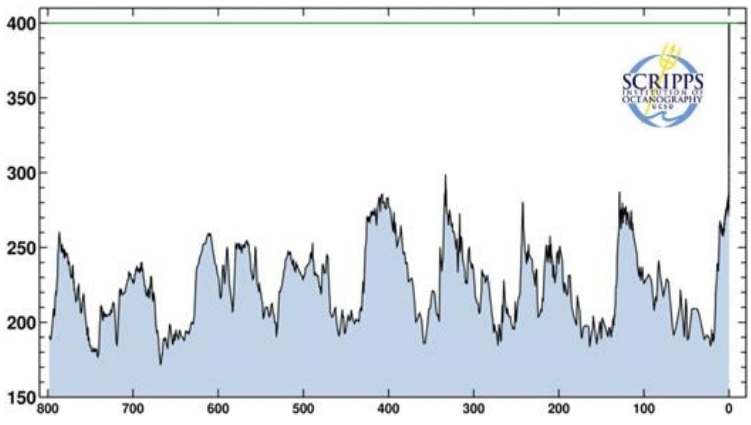
Global Warming Potential (GWP) Relative to CO_2		
Gas	over 20 years	over 100 years
Carbon Dioxide (CO_2)	1	1
Methane (CH_4)	84-86	28-34
Nitrous Oxide (N_2O)	264-268	265-298
HFC-134a	3,710-3,790	1,300-1,550

IPCC

Unchartered Territory

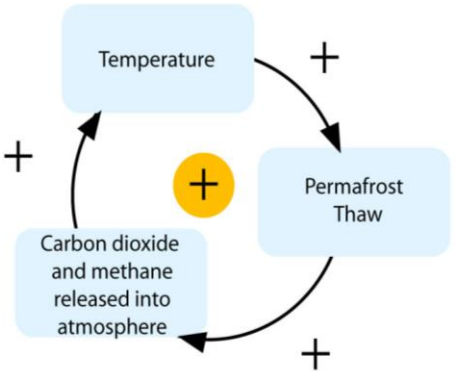
- GHG concentrations are now much higher than at any previous time in human existence.
- Since the dawn of the Industrial Revolution in the early 1800s, global methane concentrations have nearly tripled.
- For the past 800,000 years, carbon dioxide levels were locked between 180-290 parts per million (ppm). Today, CO_2 concentrations exceed 405 ppm, their highest point in over 15 million years.
- Rapid increases in CO_2 have been linked to periods of mass extinction. The worst extinction event in Earth's history was likely the result of rapid warming and ocean acidification due to dramatic spikes in CO_2 and/or methane.

Historic CO_2 Concentrations (ppm)



Uncontainable Feedback Loops:

- A positive feedback loop occurs when two or more functions reinforce each other. Feedback loops are critically important because they can trigger rapid changes in temperature.
- Example: As temperatures rise, permafrost melts and methane is released into the air. The excess methane exacerbates existing climate change, which causes even more permafrost to melt. This cycle repeats itself, and the feedback loop's strength is amplified.



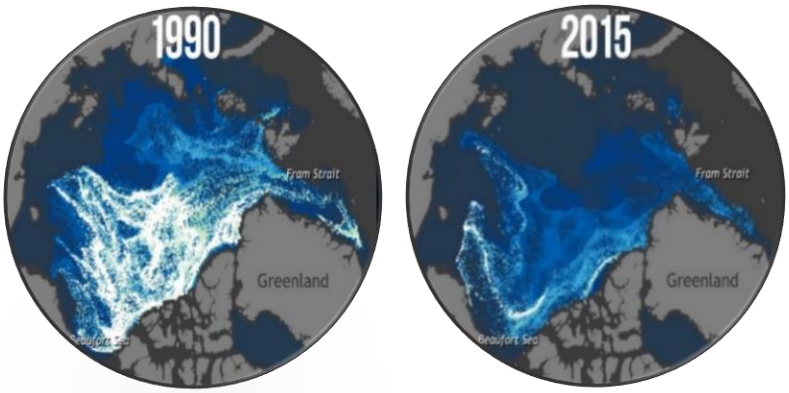
Narrow Horizon for Corrective Action:

- Due to the nature of positive feedback loops, the impacts of climate change could transpire at an accelerating, non-linear rate. As such, the window of opportunity for preventing catastrophic climate change is closing rapidly.
- Natural GHG sinks are becoming overstressed, indicating that our GHG budget has been virtually exhausted.
- Roughly a quarter of anthropogenic warming is masked by short-lived aerosols and precursors, which block solar radiation. The long-term effects of climate change will therefore be more profound than they currently appear.
- Large quantities of GHGs are currently shielded by permafrost and land ice. Once these gases are released into the air, global warming could become uncontrollable.
- Ocean acidity levels have already increased 26% in the past 200 years. Additional acidification could completely destabilize vulnerable marine ecosystems.
- Carbon dioxide, nitrous oxide, and other GHGs can last in the atmosphere for hundreds of years. As such, the effects of climate change will persist well into the future, even if aggressive actions are taken today.

Emergency Threats

- Climate change will disproportionately affect the world's most vulnerable populations, furthering political instability throughout volatile regions of the globe.
- Over 90% of Earth's excess heat is going into the ocean, where the effects of warming can take hundreds of years to reverse.
- The early effects of climate change have been characterized by a series of political, economic and environmental stressors. Primary threats include:
  - Rising sea levels, coastal flooding, infrastructure decay and mass migration of climate refugees.
  - Intensified storms and natural disasters; prolonged droughts, added stress on local water supplies and heightened risk of forest fires.
  - Ocean acidification, compromised marine ecosystems, famine and increased chance of war over scarce resources.

Polar Ice Melt: 1990-2015

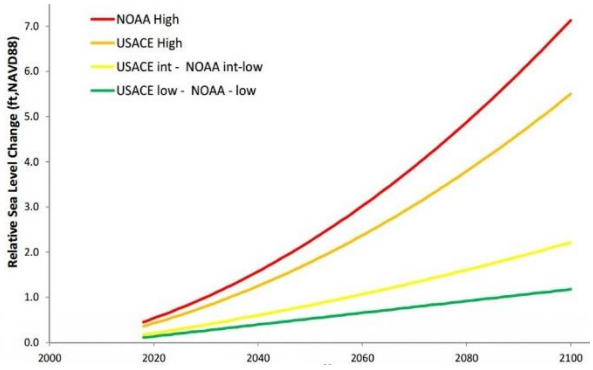


Worsening Forecasts:

- The exact magnitude of future climate change remains uncertain and will largely depend on the scale of ongoing mitigation efforts
- Delayed mitigation efforts in the present will necessitate steeper emissions reductions going forward. In 2005, a *3% annual reduction* in carbon emissions would have resulted in a less dangerous CO_2 concentration of 350ppm by 2100. Waiting until 2020 to cut emissions would require a *15% annual reduction* rate to achieve that same goal.

Crisis Scenarios

- Even under the most aggressive mitigation plans, sea levels are projected to rise at least one meter by 2100.
- Sea-level rise will cause large coastal population centers to become uninhabitable, forcing millions of displaced climate refugees to move inland and compete for dwindling resources.



Army Corps of Engineers

- Under a 0.5 meter rise in seas:
  - New York City could witness **2.9 million** people displaced and **$2.1 trillion** in assets at risk.
  - Miami, Florida could witness **4.8 million** people displaced and **$3.5 trillion** in assets at risk.
  - Calcutta, India could witness **14 million** people displaced and **$2 trillion** in assets at risk.
  - Guangzhou, China could witness **10 million** people displaced and **$3.4 trillion** in assets at risk.

Conclusions

- The time-horizon for addressing climate change is extremely narrow and an emergency level response will be needed to prevent a climate catastrophe.
- Past observations of climate change are not indicative of the future consequences. The effects of climate change will continue to worsen over time as feedback loops strengthen and aerosols are removed from the atmosphere.
- Atmospheric GHG concentrations cannot simply plateau, they will need to be substantially reduced. Doing so will require both *energy transformation* and *conservation*.
- Climate change is largely irreversible over millennia.

References

Atkin, Emily. (2015, April). *Too Much Carbon Dioxide May Have Caused Earth's Worst Mass Extinction.* ThinkProgress
Climate Central. (2016, March). *Arctic Sea Ice Extent Threatening to Set Record Low*. Princeton, NJ
CSIRO. (2017, May). *Cape Grim Greenhouse Data.* Cape Grim, Tasmania, Australia.
Environmental Defense Fund. (2017). *Climate change's effects plunder the planet.* New York, NY
Gillis, Justin. (2017, June). *Carbon in Atmosphere Is Rising Even as Emissions Stabilize.* The New York Times. New York, NY
Hanson J, Karecha P, Sato M, Mason Delmotte V, Ackerman F, et al. (2013). *Assessing "Dangerous Climate Change": Required Reduction of Carbon Emissions to Protect Young People, Future Generations and Nature.* PLoS ONE
Intergovernmental Panel on Climate Change. (2013). *5th Assessment Report.*
Lubin, Gus, Nudelman, Mike. (2014, April). *Rising Sea Levels Could Cause Staggering Damage To These Cities.* Business Insider. New York, NY
Jones, Nicola. (2017, January). *How the World Passed a Carbon Threshold and Why It Matters.* Yale School of Forestry & Environmental Studies. New Haven, CT
Scripps Institution of Oceanography. (2016). *Lastest CO2 reading.* San Diego.
St. Joseph Environmental Science. (2010, September). *A Nitrogen Cycle activity & the Positive Feedback Loop of Global Warming*.
U.S. Army Corps of Engineers. (2015, January). *North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk.*