Introduction to Human-Induced Climate Change

Presentation to: Carilion Climate Change Workshop
5 October 2019.
Roanoke, Virginia USA

Carl E. Zipper
Virginia Tech
(retired).
**Presentation Goal:**

Describe scientific basis for human-induced climate change theory.

**Outline**

1. Well-documented scientific facts
2. The human-induced climate change theory
3. Is the theory is correct? What is the scientific evidence?
4. Climate feedbacks
**Fact 1:** Infrared (ir) absorbing “greenhouse gases” keep the earth warmer than it would otherwise be.

**GHGs:** Greenhouse gases are CO$_2$, CH$_4$, N$_2$O, O$_3$, Halocarbons, and H$_2$O.
Fact 1: Infrared (ir) absorbing gases are responsible for keeping the earth warmer than it would otherwise be.

Fact 2: Atmospheric concentrations of ir-absorbing GHGs, have changed historically, are increasing rapidly today.

Charts from: US Global Change Research Program, 4th National Climate Assessment 2017

Also: Halocarbons (classic refrigerants, CFCs, etc.) and Ozone ($O_3$)
Fact 1: ir-absorbing gases keep the earth warmer...
Fact 2: Atmospheric concentrations are increasing...
Fact 3: Earth climate is changing...

Annual Global Land and Ocean Temperature Anomaly (°F) vs. 1901-1960 Mean

1880 through 2016.

Arctic Sea Ice Extent, Annual Minima (2012 - record low)

2018

1979
Well-Documented Scientific Facts

**Fact 1:** ir-absorbing gases keep the earth warmer

**Fact 2:** Atmospheric concentrations are increasing

**Fact 3:** Earth climate is changing ..

---

Annual Global Land and Ocean Temperature

1880 through 2016.

https://earthobservatory.nasa.gov/world-of-change/DecadalTemp

---

Surface Temperature Change, 2005-14 vs. 1951-80.

Also: Glacial retreat, sea ice extent, sea level change, rainfall distributions, ocean heat, timing of spring onset, extreme weather event frequencies, etc.
Causes of Change: *Why* is global climate changing?

“Anthropogenic Climate Change Theory” (also known as “Greenhouse Theory”)

**Theory:** Anthropogenic greenhouse gas emissions are a major cause for the climate changes that have been observed over recent decades.

Is the theory correct? What is the scientific evidence?
1. Existence of a credible mechanism, grounded in scientific logic, combined with correspondence in time of changing climate with GHG concentration increases.
All continents, land surface, atmosphere, and ocean are warming. Such warming could not have occurred without "external forcing". IPCC scientists find no evidence that the sum of solar and volcanic forcings have produced such warming.
3. Pattern of warming is consistent with the greenhouse-theory mechanism, is inconsistent with explanations by skeptics:

*Nights have warmed more than days:* Infrared emission & absorption occurs both night and day. If increased solar output was cause, days would warm more than nights.

*The stratosphere has cooled:* If increasing solar output was cause, this would not occur.

*Warming has occurred over both land and oceans:* If human-induced heat, “urban heat effect”, etc. were responsible, this would not occur.

*The arctic has warmed more than other regions:* Evidence for “ice-albedo feedback.” Ice melting decreases albedo, increases solar absorption and infrared emissions.
4. Global climate models reproduce recent warming only by incorporating anthropogenic GHGs.

Source: IPCC, AR4 (2007), WG1 Fig. 9.5; WG1 TS Fig. 23
“Feedbacks”

“Ice-Albedo Feedback”

Increased Longwave (ir) Radiation

Emit Longwave (infrared, ir)

Reflect shortwave

Ice & snow loss increases ir for absorption.

Arctic/Antarctic

Permafrost, Boreal Forests, Tundra

Examples

As earth-system carbon & radiation dynamics change, greater risk of climate change beyond human control.

“Biosphere Feedback”

CO₂

CH₄

Frozen biomass does not biodegrade.

Arctic/ Antarctic

Temperate, Tropical, Arctic

Climate-induced ecosystem change

Introduction to Human-Induced Climate Change

Summary

1. Well-documented scientific facts
2. The human-induced climate change theory
3. Is the theory correct? What is the scientific evidence?
4. Climate feedbacks

Thank You!