Climate Change – A Science Enterprise

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1. What is climate?
2. What makes climate and what makes it change?
3. What do the data tell us?
4. What do the models tell us?

IPCC – AR5: Warming of the climate system is unequivocal, and we are 95% certain that human activity have caused most of the warming over the past 60 years. (WG I)

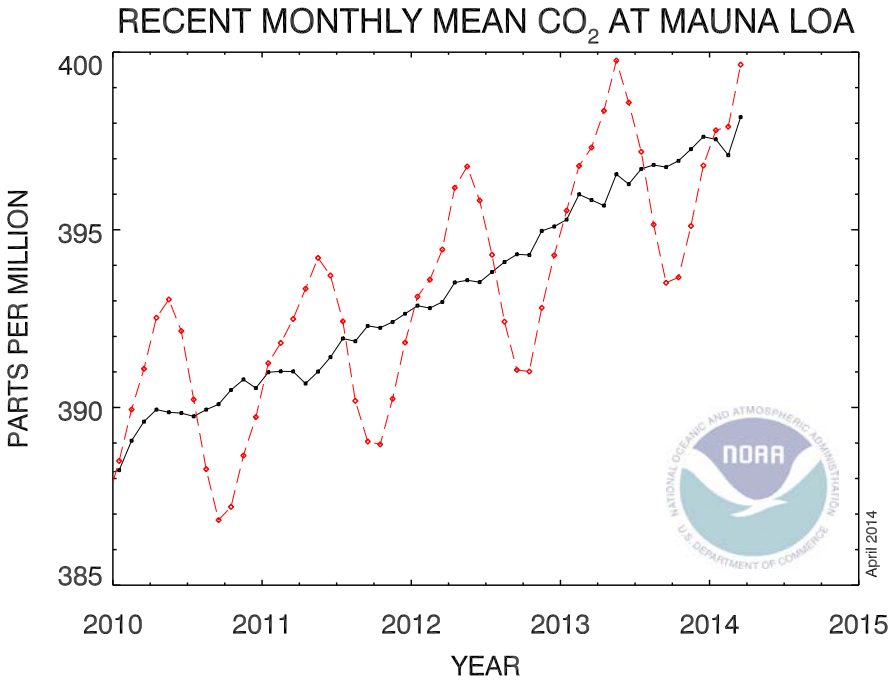
Some Working Definitions*

- **Global Warming** – the idea that atmospheric temperatures are increasing over time in an unnatural way due to human impacts
- **Global Climate Change** – an examination of changes in the Earth's climate system that may involve atmospheric temperature or a host of other environmental measurements in the atmosphere, biosphere, cryosphere, hydrosphere, and pedasphere
- **Anthropogenic Forcings** – changes in the climate system due to human impacts on Earth
- **Natural Forcings** – changes in the climate system due to astronomical or geophysical impacts not of human origin
- **Climate –** the long-term (minimum, 30 years) established patterns of **representative** weather, water, and surface features (including the biosphere) in an area.

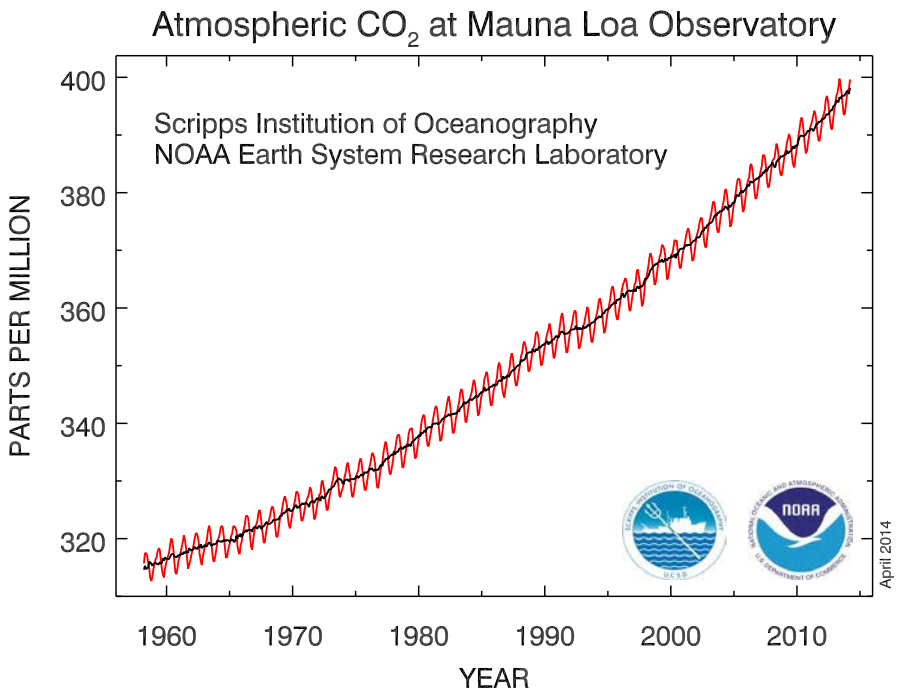
*In 30 years as a working meteorologist and climatologist, I've developed these conceptual practical working definitions; they have a scientific basis as reviewed in literature by, for example, the IPCC

How do we know what we know? Evidence for Change!

Red line – monthly average data



Black line – running mean



Some (More) Working Definitions*

- **Climate Change** understanding requires a long-term lens of understanding of science as a process – one that is ***tentative***, and informed by ***evidence***.

- Long-term temperature ***anomalies*** are one way to measure this long-term lens of change.
- Anomaly = departure from the mean or median. Shown as + or – compared to "0" (which represents the "norm").

Science is Hard!

National Science Foundation: Science Hard

NEWS · Science & Technology · Science · Government · ISSUE 45·01 ISSUE 38·21 · Jun 5, 2002

INDIANAPOLIS—The National Science Foundation's annual symposium concluded Monday, with the 1,500 scientists in attendance reaching the consensus that science is hard.

the ONION
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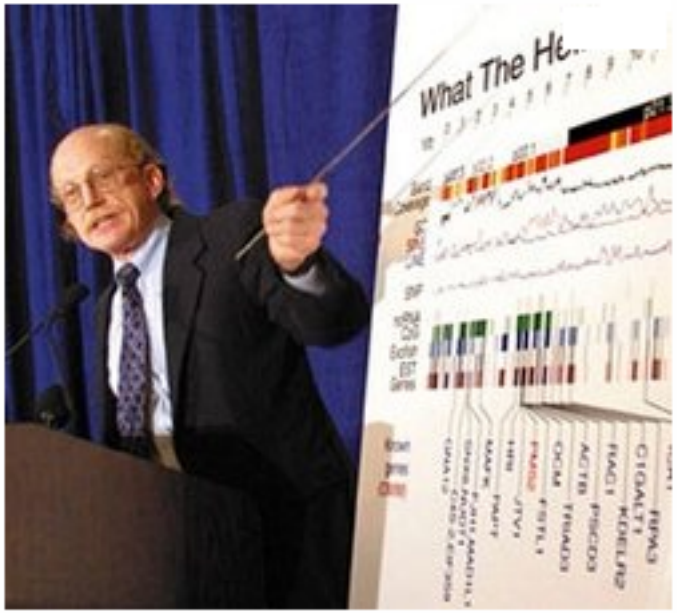
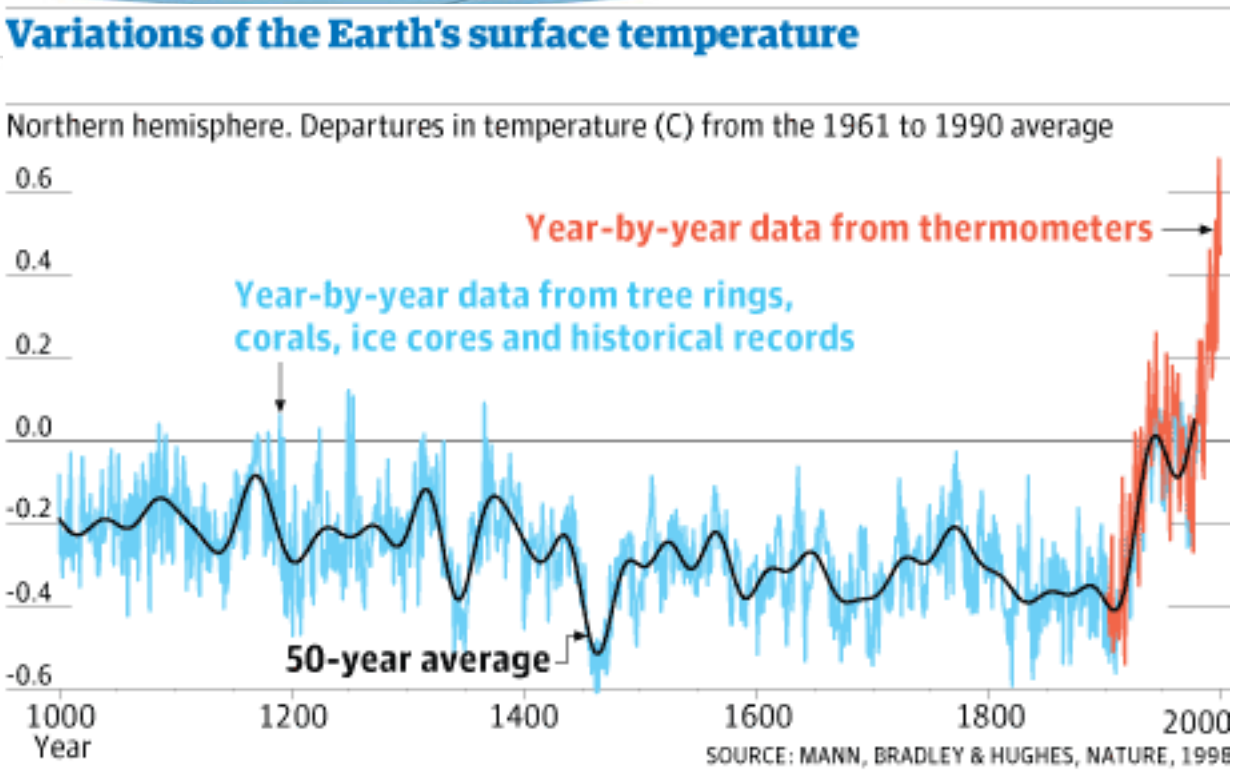


Farian explains the NSF findings.

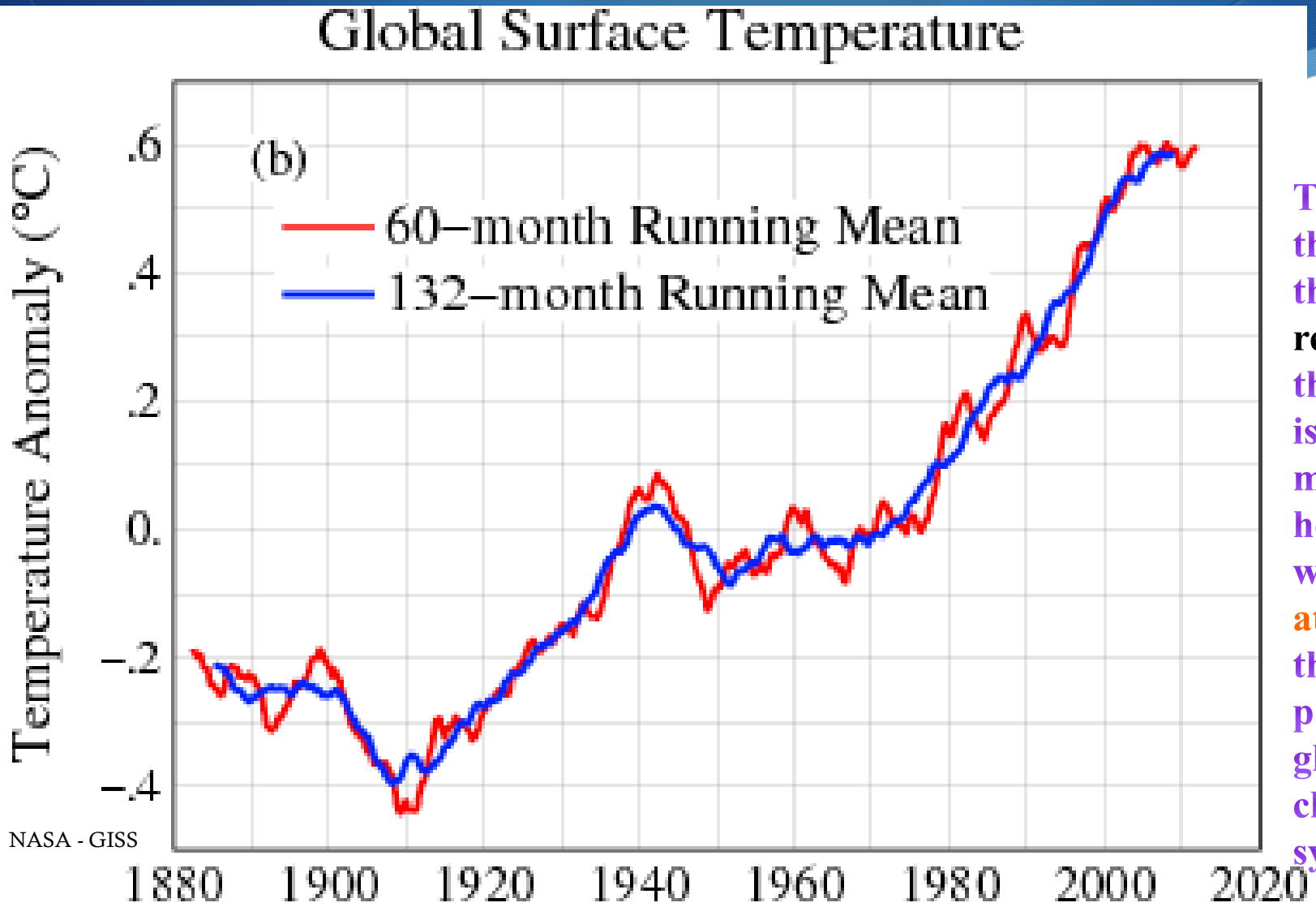
"For centuries, we have embraced the pursuit of scientific knowledge as one of the noblest and worthiest of human endeavors, one leading to the enrichment of mankind both today and for future generations," said keynote speaker and NSF chairman Louis Farian. "However, a breakthrough discovery is challenging our long-held perceptions about our discipline—the discovery that science is really, really hard."

How Do We Know What We Know?

- Proxy Data
  - Tree Rings
  - Corals
  - Ice Cores
  - Sediment Cores
  - Pollen Records
  - Fossils
  - Radiocarbon and other isotope decay dating
- Combined Reconstruction



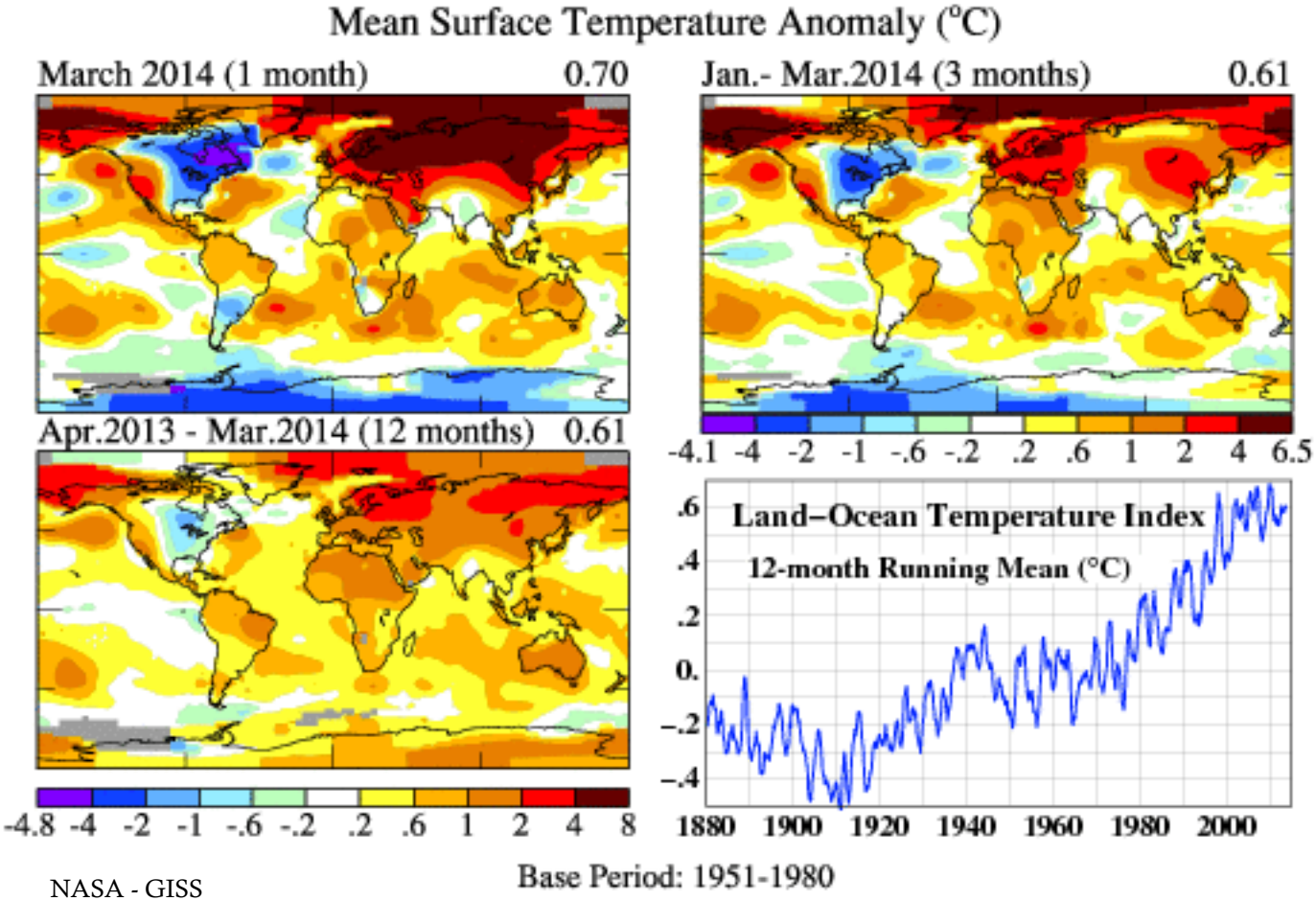
I thought temperature stopped warming in 1998?



The role of the oceans, the 3 polar regions, and the biosphere is not measured here! Along with the atmosphere – this is all part of the global climate system.

Yeah, but what about last winter?

- Snowmageddon 1, 2, 3, 4 & 5! And snowpacolypse! And Snowzilla!
- Record Cold and Snow in Eugene, too!
- Media hype?
- Look at the patterns and decide…



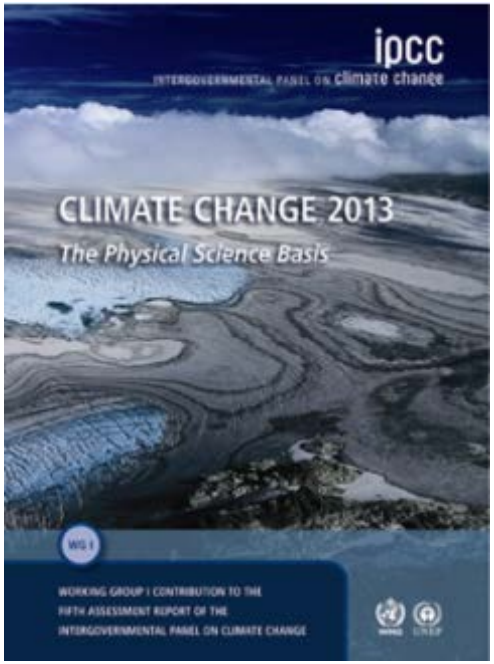
Ok. I see the evidence. What about these climate models?

- **Climate models** are *similar to* weather prediction models. Both are based on the Navier-Stokes equations of fluid dynamics (physics!)
  - **Conservation of mass**
  - **Conservation of momentum**
  - **Conservation of heat**
  - **Conservation of water substance**
  - **Equation of state**

- **Weather prediction models** are limited to about 7-14 day skillful predictions at the present time, but climate models can make projections for centuries
  - **An initial value problem in physics + chaos theory**
  - **Must make assumptions, however, about human behavior to obtain skillful projections – so make multiple *scenarios***
  - ***Calibrations* – start model forecasts in the year 1900 based on observations – can they reproduce faithfully climate patterns 100 years later (in 2000)? Yes, they can!**

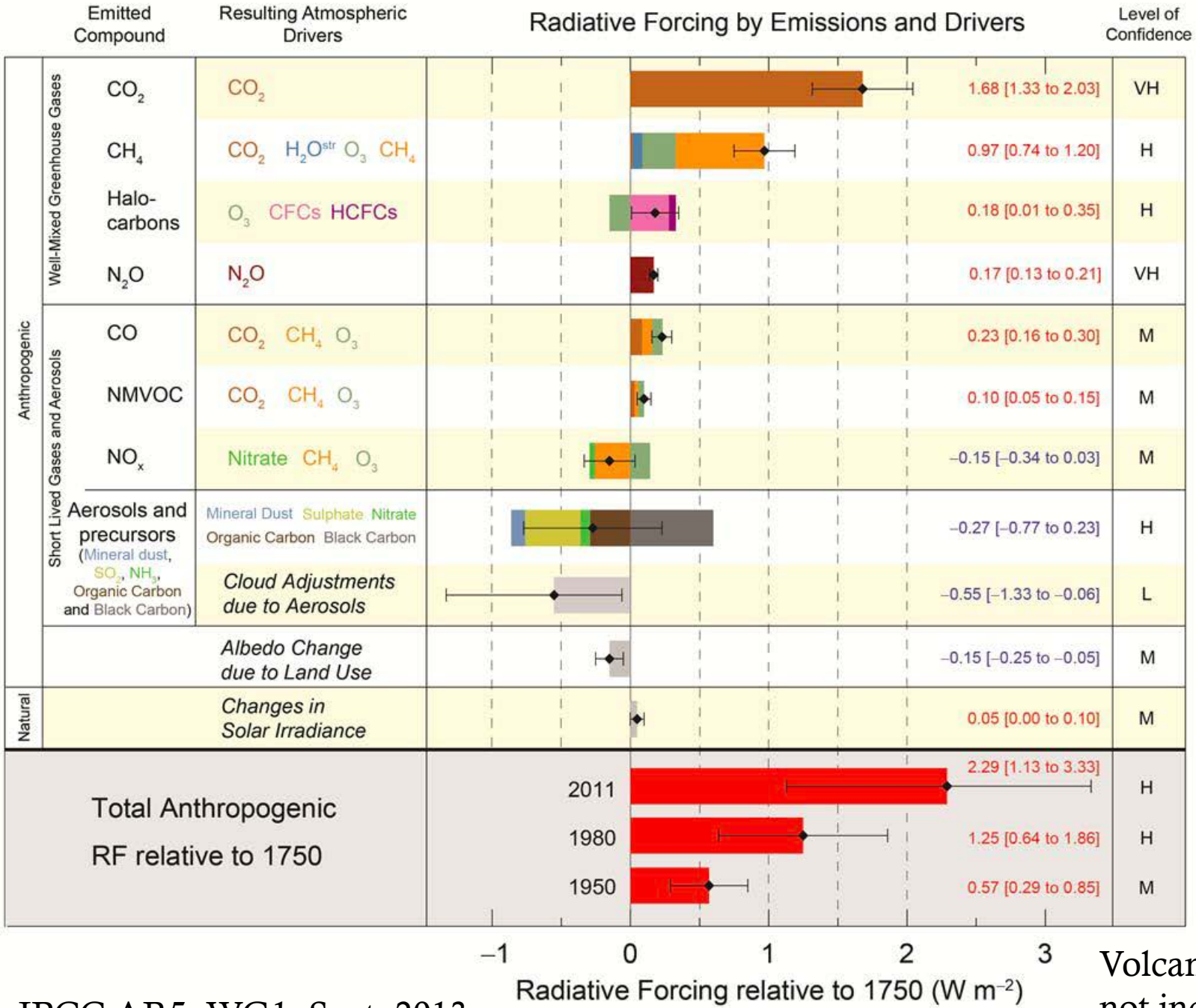
Climate Models

- **Climate models** construct future climate states that are *representations of the future*, in a statistical sense of what is likely given these interactions with the atmosphere:
  - **Ocean interactions**
  - **Biosphere interactions**
  - **Cryosphere interactions**
  - **Scientific uncertainty was quantified in great detail in 2007 by the IPCC and in 2013-14 that uncertainty has been further clarified**
- **Note ties to chemistry, biology, physics, technology, engineering, mathematics, statistics!**



What Does Physics Tell Us?

- **Warming processes (positive feedbacks):**
  - **Increased CO_2 → Increases absorption of infrared radiation (IR)**
    → enhancement of "greenhouse effect"
  - **Increased greenhouse gases (GHG) other than CO_2 – many more potent than CO_2 → "greenhouse effect" enhancement [methane, ozone, NO_x, HCFC, …]**
  - **Reduction of ice → increases energy absorbed by Earth**
  - **Land use changes (deforestation, urbanization) → increase energy absorption**
- **Cooling processes (negative feedbacks):**
  - **Volcanic effects and other aerosols (pollutants) → reduction of solar radiation input at surface**
  - **Clouds reduce incoming solar energy (but may enhance IR)**
  - **Increased vegetation provides cooling**



IPCC AR5, WG1, Sept. 2013

Volcanic forcing not included

What About the Future?

Actually, climate models are a little more helpful

Good References

- IPCC
  - **www.ipcc.ch - 3 new major reports published since fall 2013!**
- US National Academy of Sciences (do a search on their page)
  - http://www.nationalacademies.org/publications/
- Skeptical Science (John Cook, Australia)
  - http://www.skepticalscience.com/
- Climate Literacy Educational Awareness Network (CLEAN)
  - http://cleanet.org/index.html
- EarthFix (Oregon Public Broadcasting)
  - http://earthfix.opb.org/
- LCC Science Division – become well-informed!