CLIMATE CHANGE: THE SCIENCE

Robert Mark Simpson

University of Tennessee at Martin

NACTA Workshop 2019

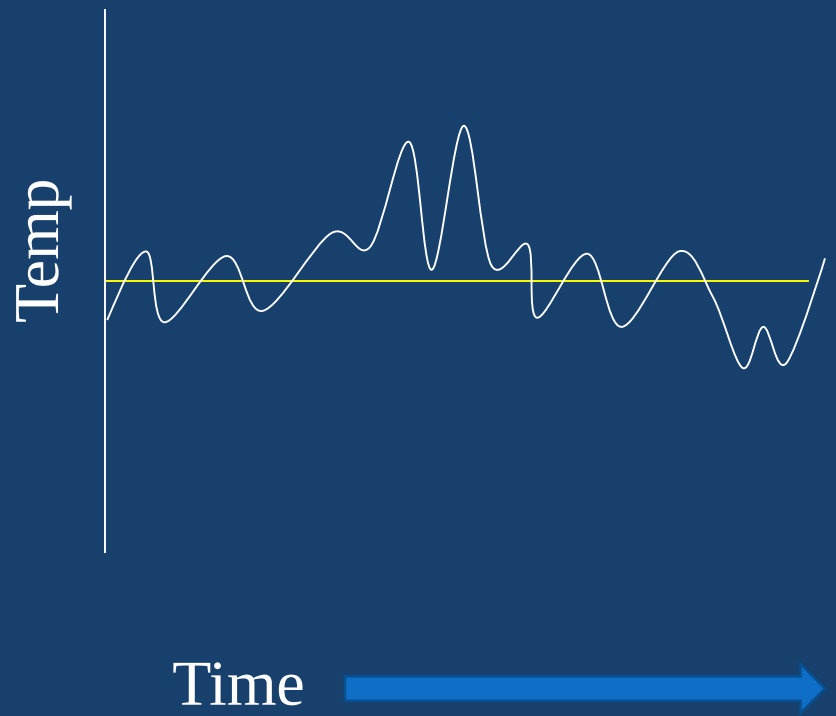
Murray State University
Murray, Kentucky

THE SCIENCE BEHIND CLIMATE CHANGE

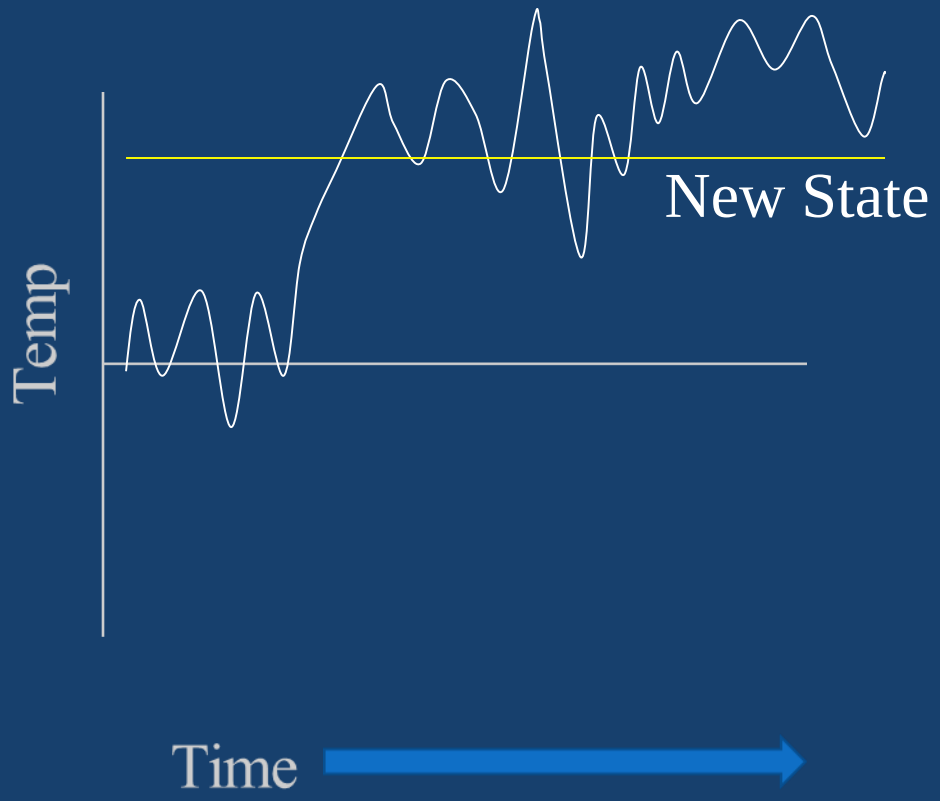
http://www.justfacts.com/globalwarming.asp

CLIMATE VARIABILITY VS CLIMATE CHANGE

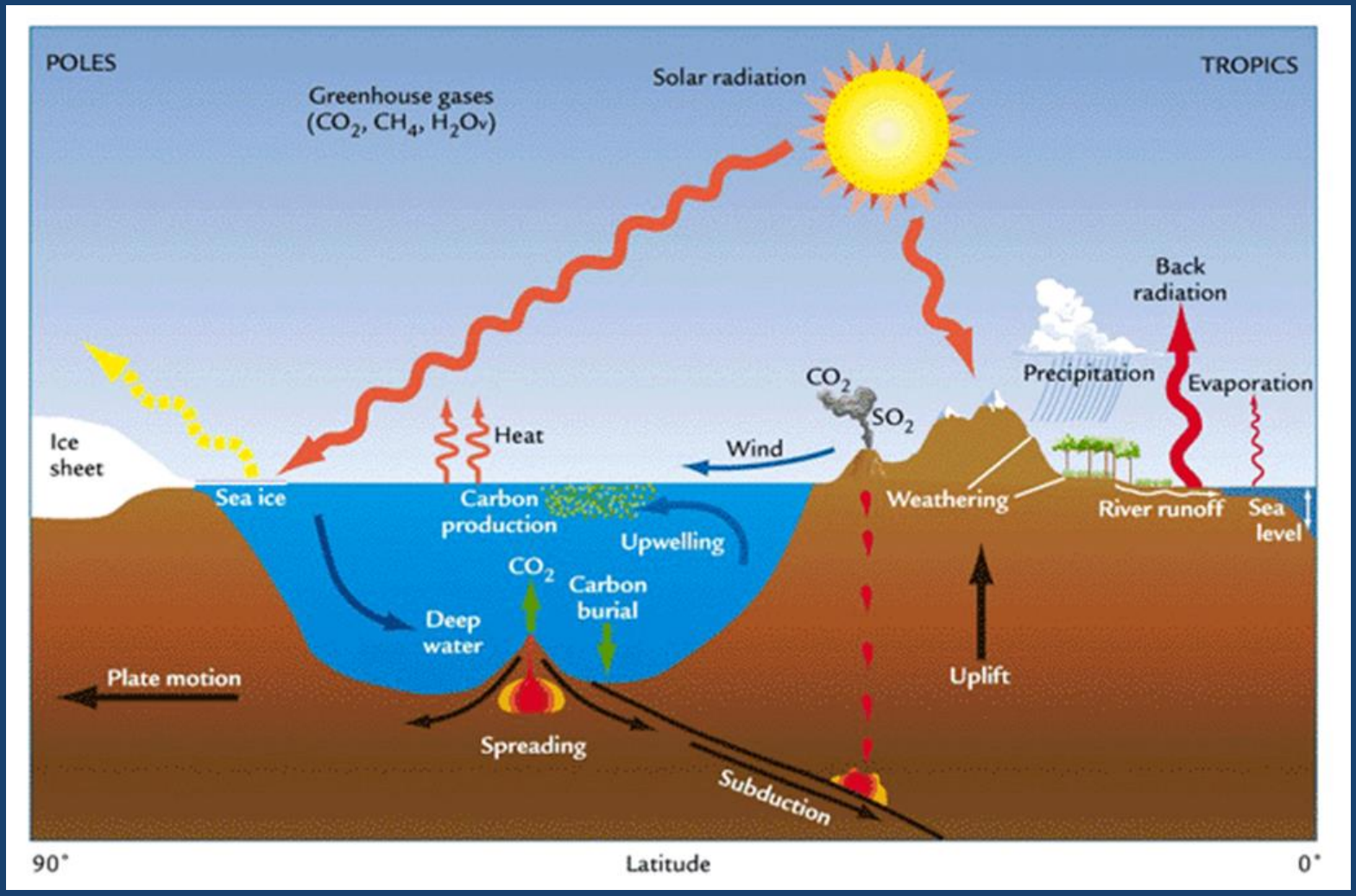
- Equilibrium – Climate Variability!



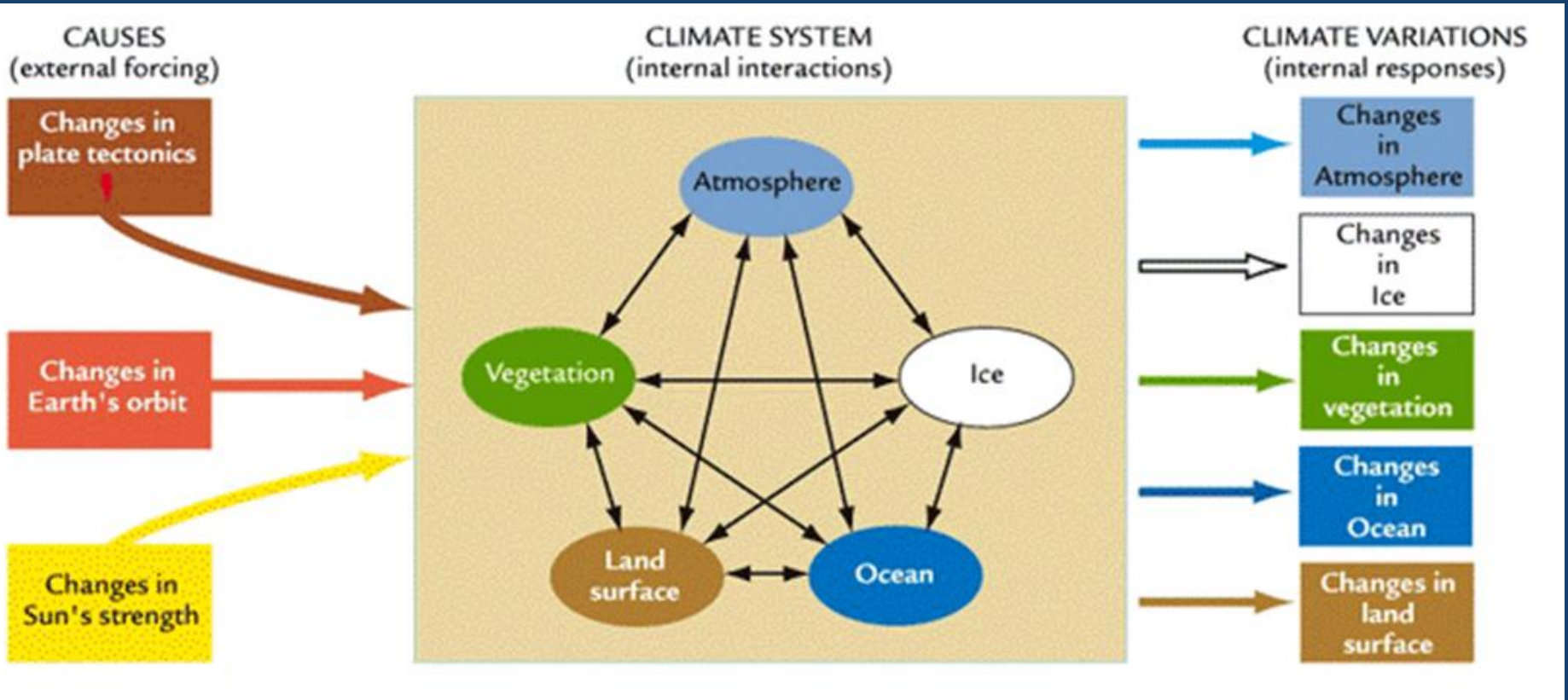
- Moving to a new "state" – Climate Change!



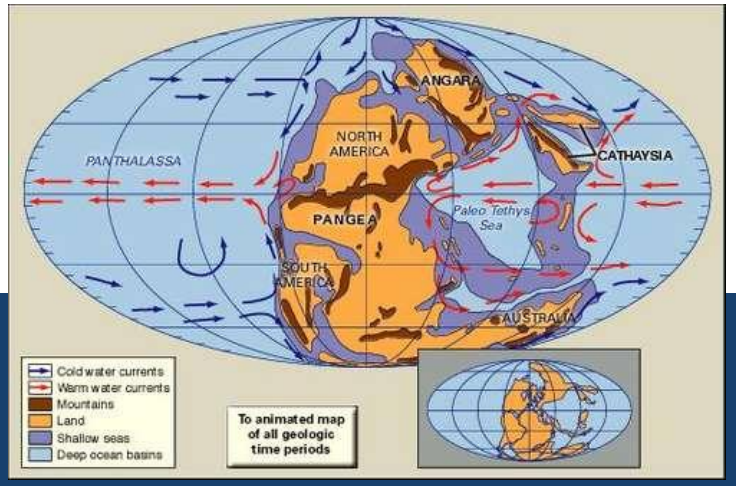
The Systems in the Earth's Climate



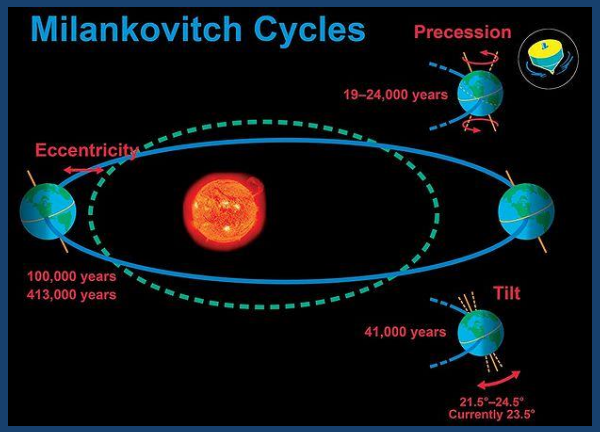
CLIMATE CHANGE AND FEEDBACKS!

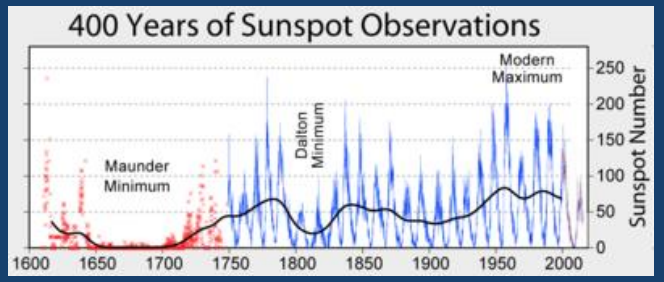


CAUSES OF CLIMATE CHANGE



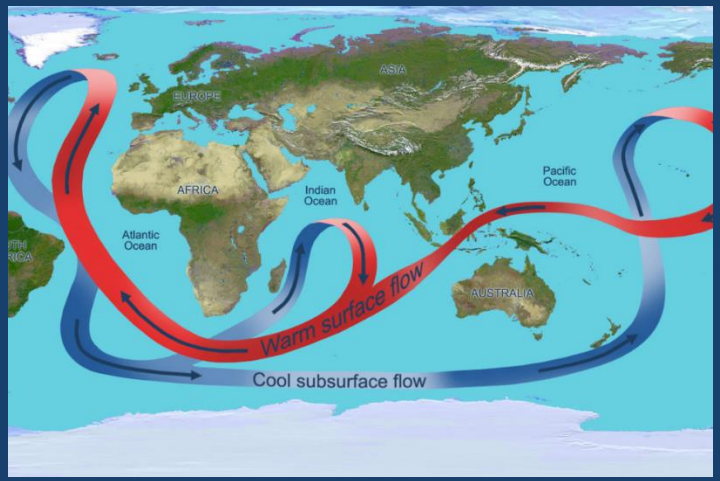
- **Natural Causes**
  - The Arrangement of the Continents
  - The Milankovitch Cycles
    - Eccentricity of the orbit – 400,000 years
    - Variation in the Angle of the Earth's Axis Tilt - 43,000 years
    - Wobble of the Earth's Axis – 26,000 years
  - Sunspot Cycles
    - Maunder Minimum
      - Responsible for the "Little Ice Age"???
      - Inter-decadal Climate Variations





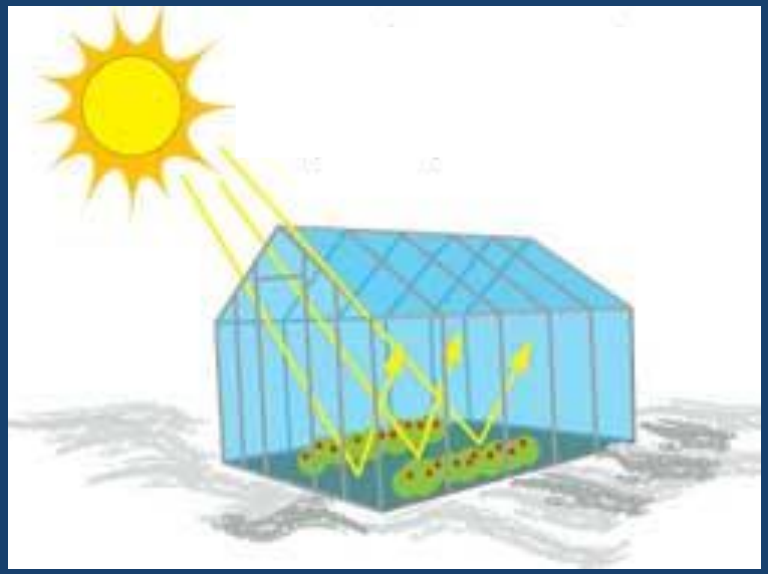
CAUSES OF CLIMATE CHANGE

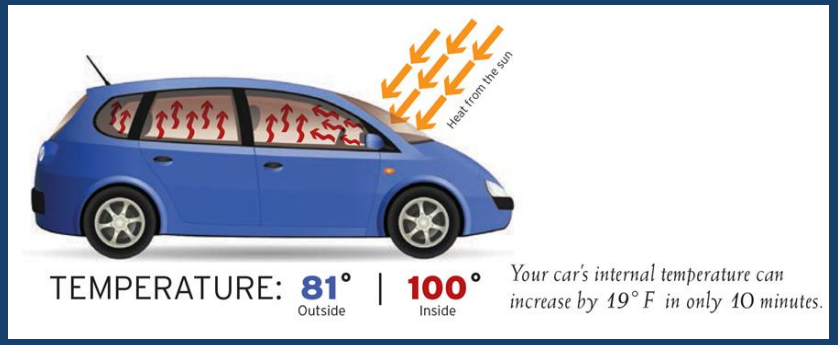
- Volcanic Eruptions and Meteor/Asteroid Impacts
  - Increases Particulate Matter
  - Changes Atmospheric Composition
  - Alters vegetation cover
- Deep Oceanic Circulation Patterns
  - Tied to very long-term climate change
  - Can be affected by short-term climate changes
- Oceanic oscillations in temperature
  - Pacific Decadal Oscillation (PDO)
  - Atlantic Multi-decadal Oscillation (AMO)



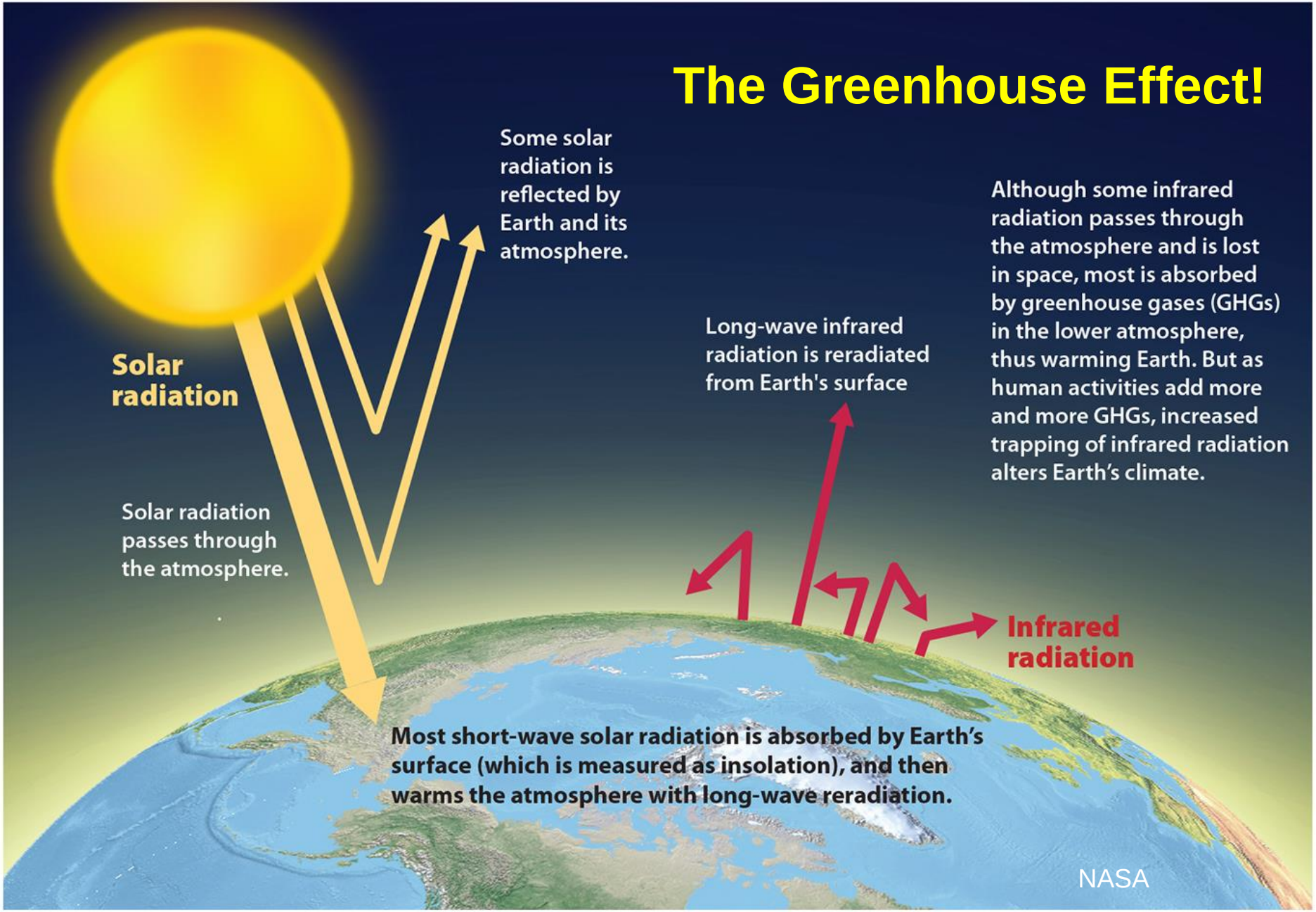
THE GREENHOUSE EFFECT AND ATMOSPHERIC WARMING

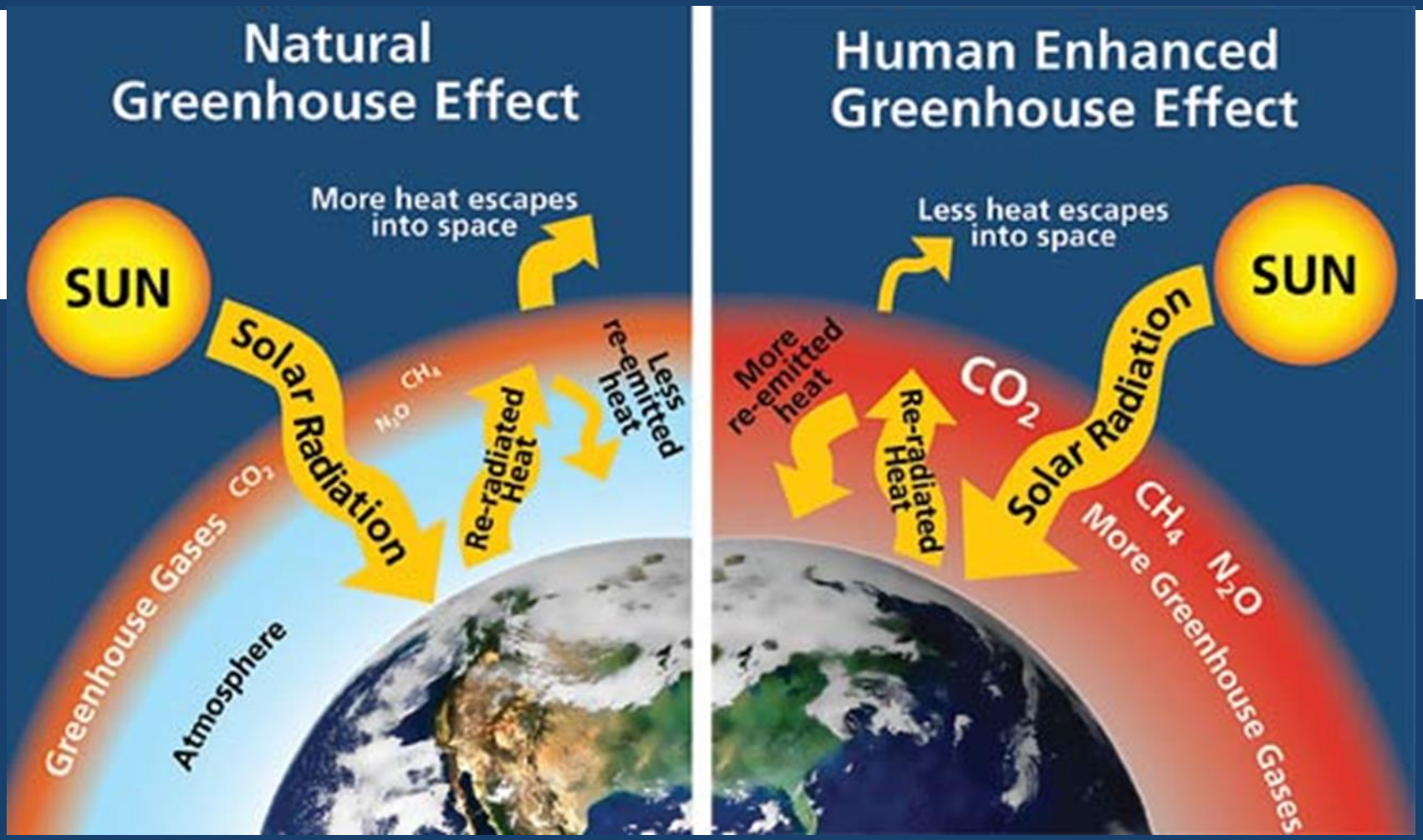
- This term is a misnomer because:
  - A real greenhouse *traps* heat energy inside the greenhouse





Your car is an excellent greenhouse!


The Greenhouse Effect!
Some solar radiation is reflected by Earth and its atmosphere.
Solar radiation
Solar radiation passes through the atmosphere.
Long-wave infrared radiation is reradiated from Earth's surface
Although some infrared radiation passes through the atmosphere and is lost in space, most is absorbed by greenhouse gases (GHGs) in the lower atmosphere, thus warming Earth. But as human activities add more and more GHGs, increased trapping of infrared radiation alters Earth's climate.
Infrared radiation
Most short-wave solar radiation is absorbed by Earth's surface (which is measured as insolation), and then warms the atmosphere with long-wave reradiation.
NASA

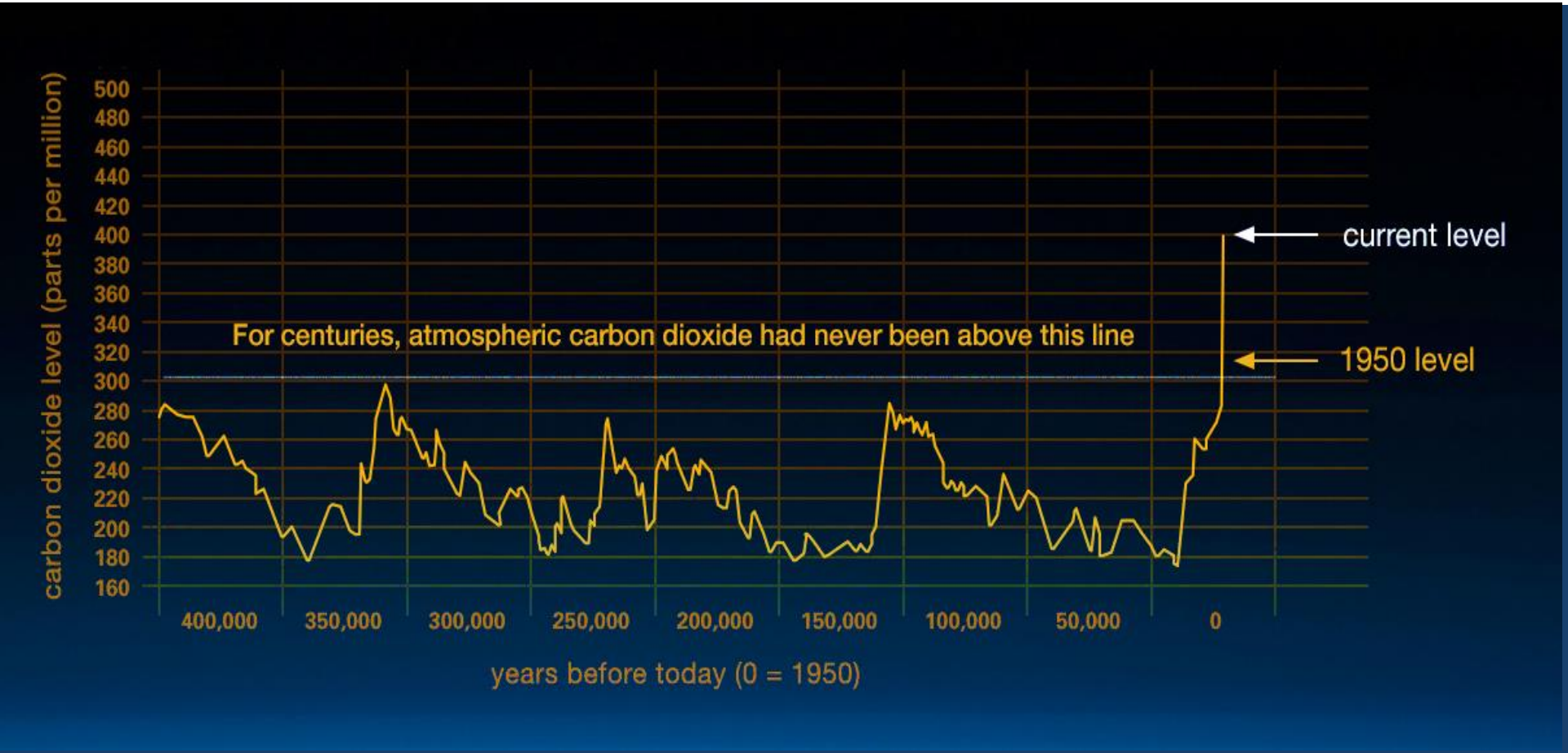


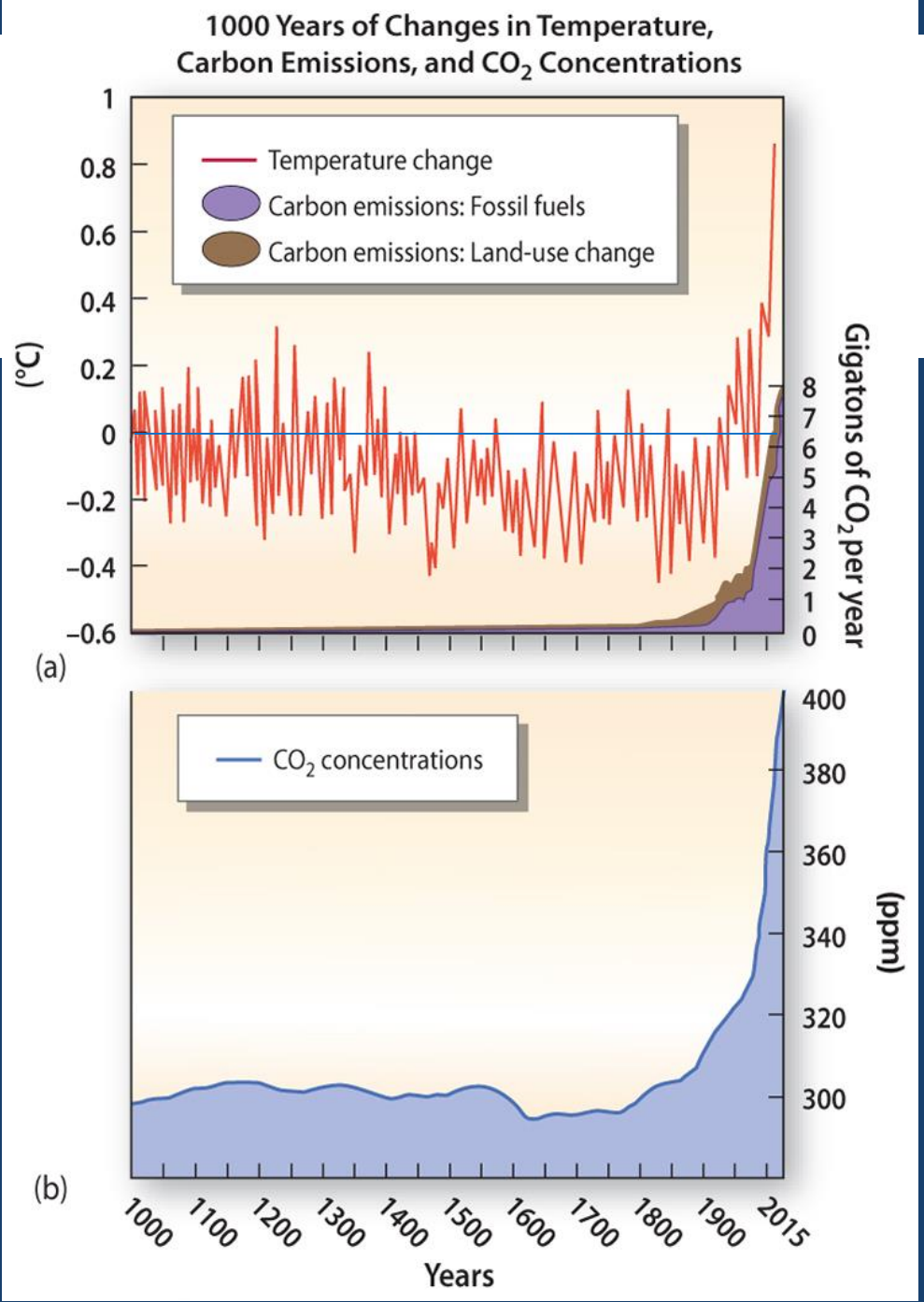
- The atmosphere merely absorbs the energy emitted by the earth's surface
- Without the greenhouse "effect", Global average temp ~ 0^oF or -18^oC

THEN ALONG COMES THE HUMAN BEING…

- Agriculture and Domestication of Animals
  - Discovering fire!
  - Turning over of soil – releases some carbon dioxide
  - Use of irrigation – draws down groundwater
    - Reduces evaporation into the air as a long-term result
- Industrial Development
  - Land cover removal (forest and grasslands) changing the albedo of the surface
  - Introduction of particulate matter
  - Introduction of greenhouse gases (particularly carbon forms) at rates much faster than the carbon was sequestered into the ground naturally
- Sheer population growth
  - From 1 to 7.7 billion people since the start of the Industrial Revolution

THE REALLY LONG VIEW…

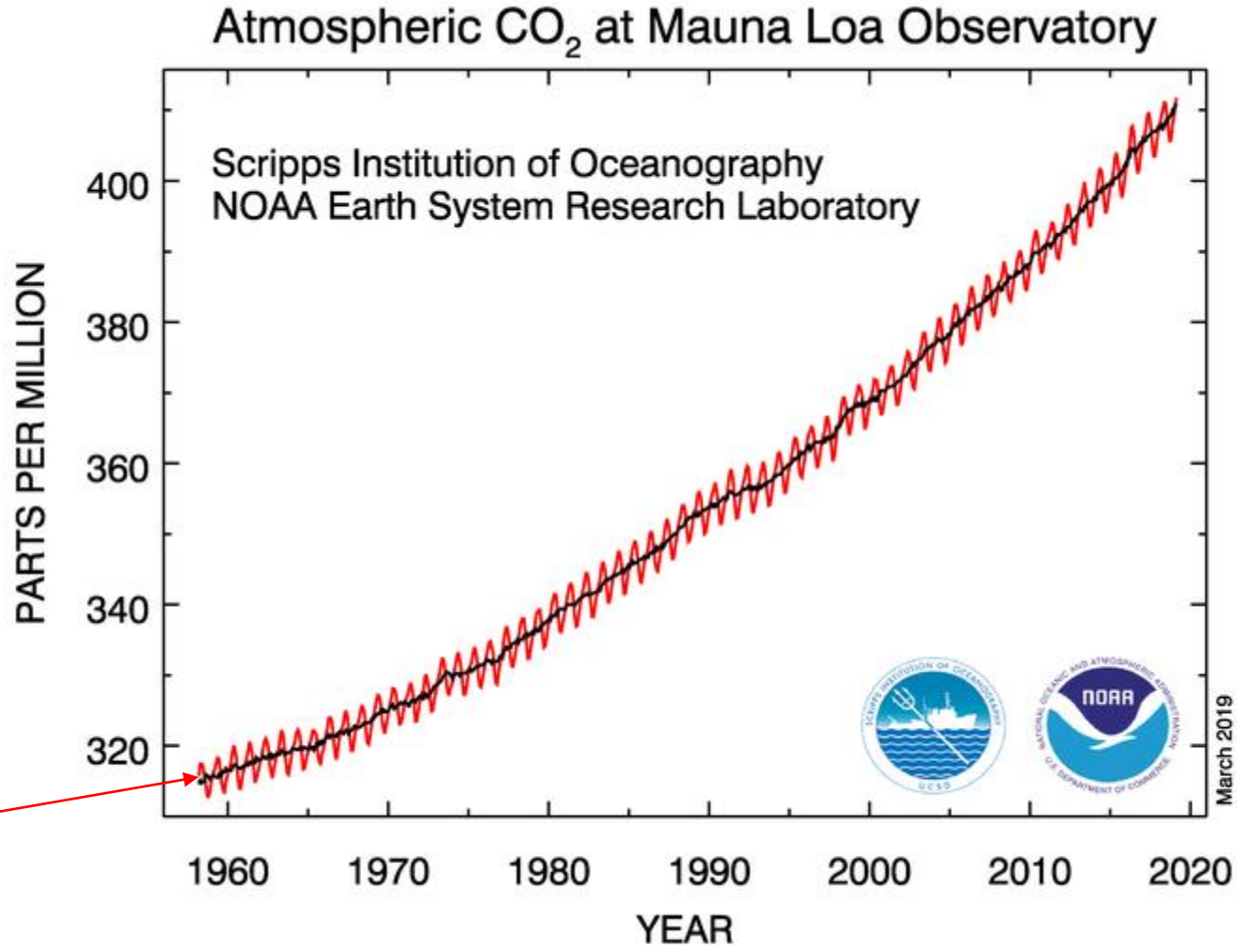




MORE RECENTLY…

- Over the long-haul, it has been warmer than now (though not by much)
- The take-aways from these graphs are:
  - Carbon Dioxide levels have been relatively consistent for the last 1,000 years (and before that) but have spiked only in the last 60.
  - The previous graphs show that we have never had this *rapid* warming before, even though the average temperature is the same as it was around the Medieval Optimum.

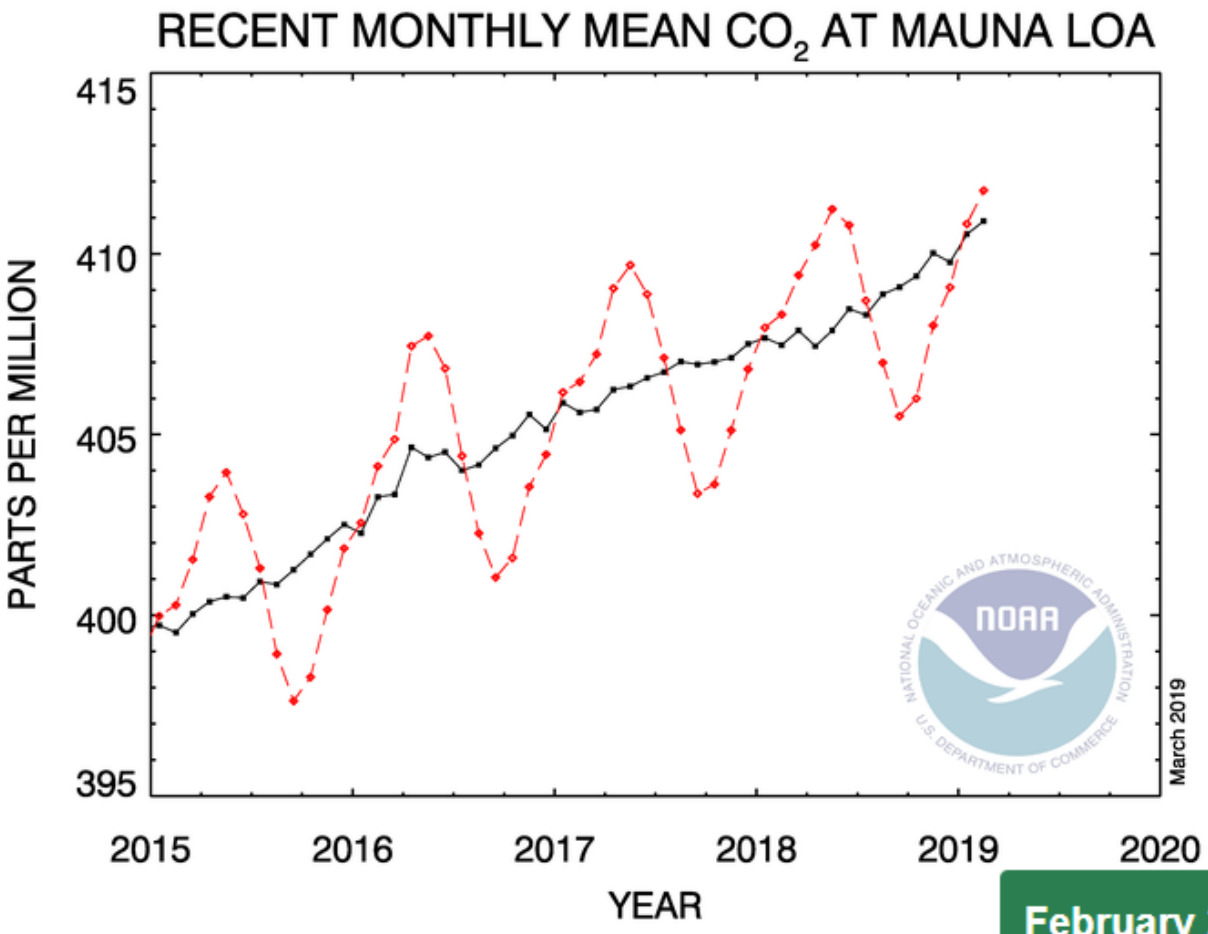
UPON CLOSER INSPECTION…



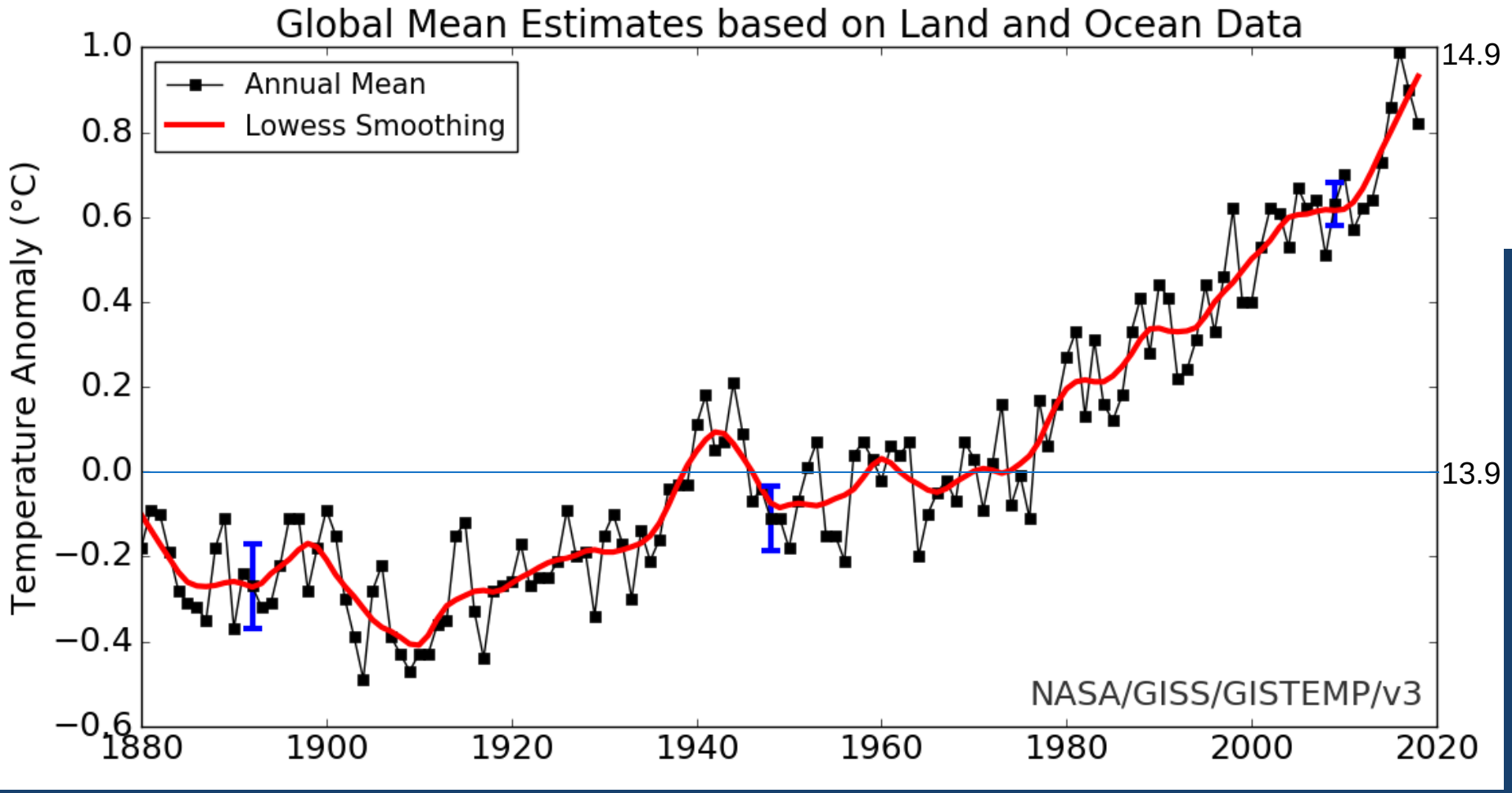
I was born here

CO_2 increased by 30% since I was born!

MOST RECENTLY (TO FEBRUARY 2019)

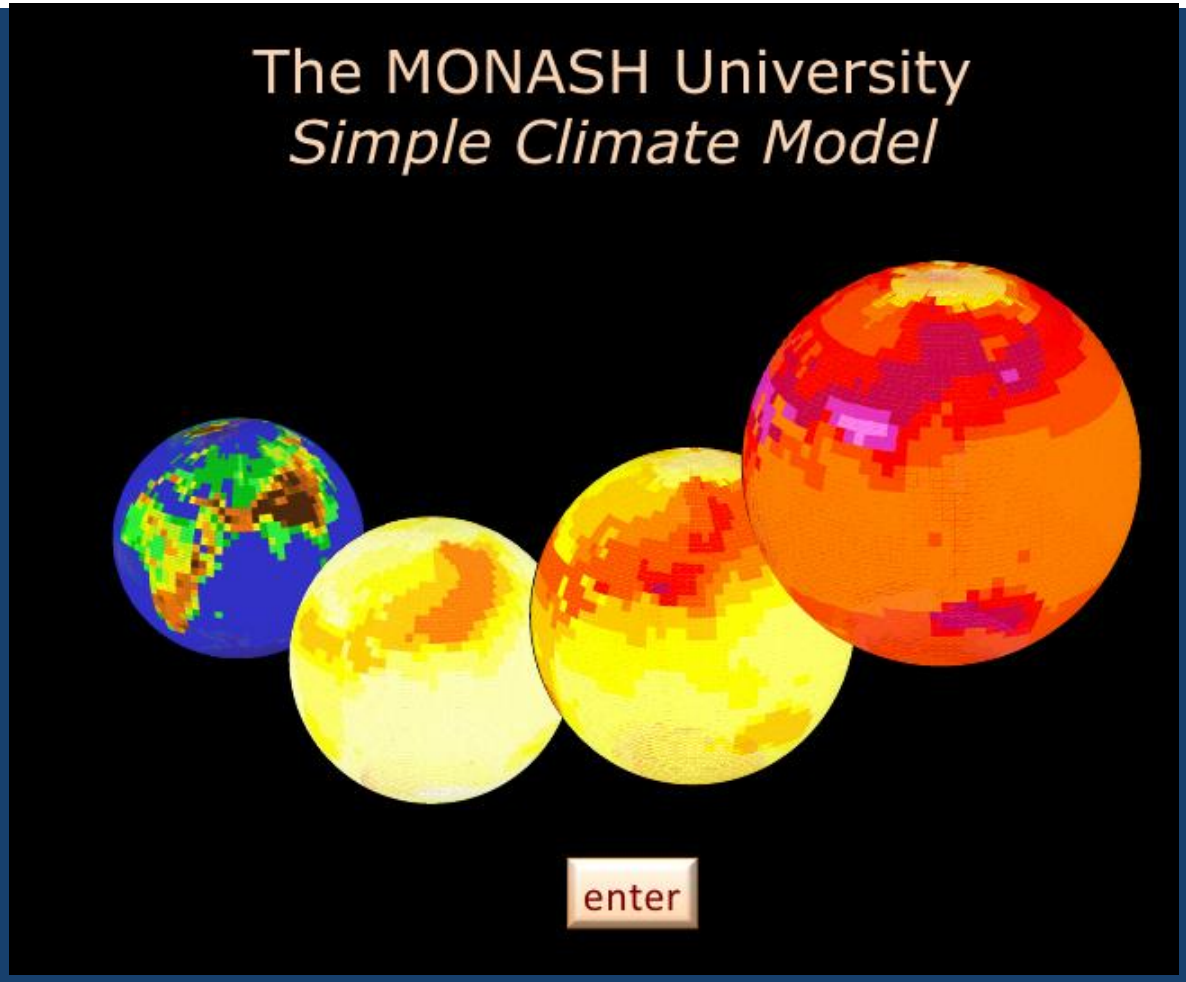


February 2019: 411.75 ppm
February 2018: 408.32 ppm
Last updated: March 5, 2019

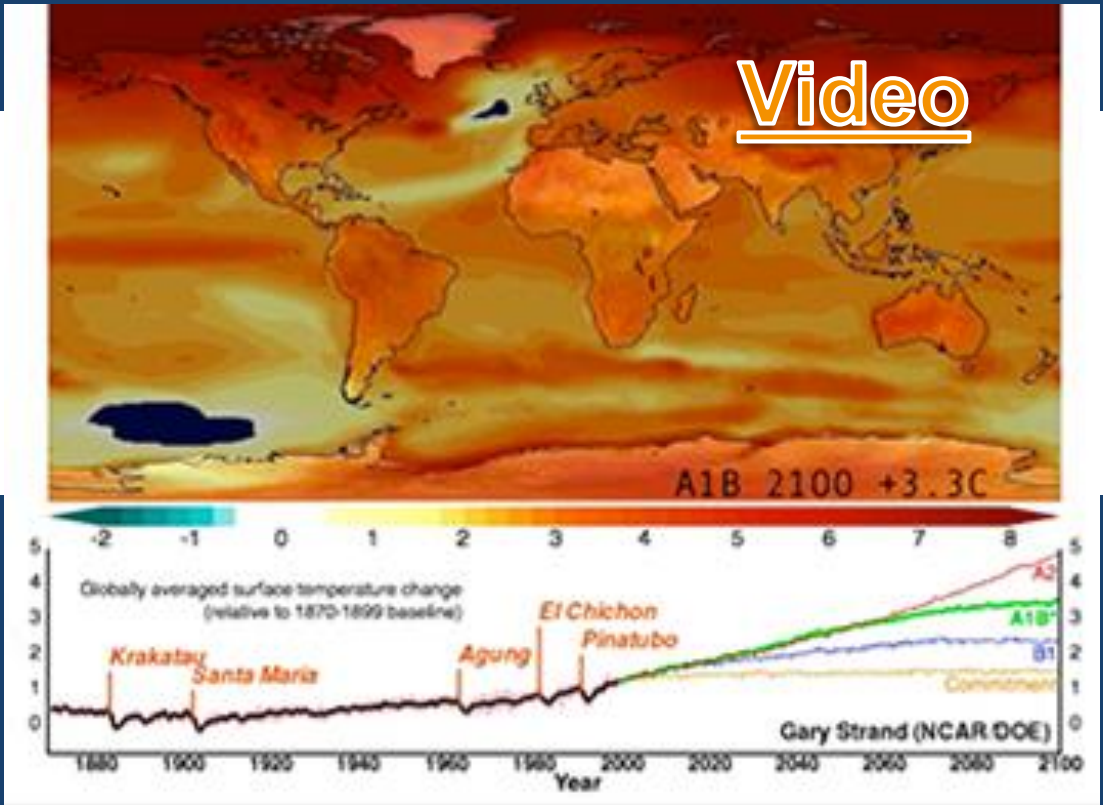


Relative to the 1901-2000 average. Source: NOAA
Global Average Temperature now: 58.62°F (14.9°C) – GISS
Global Average Temperature 1901-2000 56.9°F (13.9 °C) - NCEI

A SIMPLIFIED CLIMATE MODEL



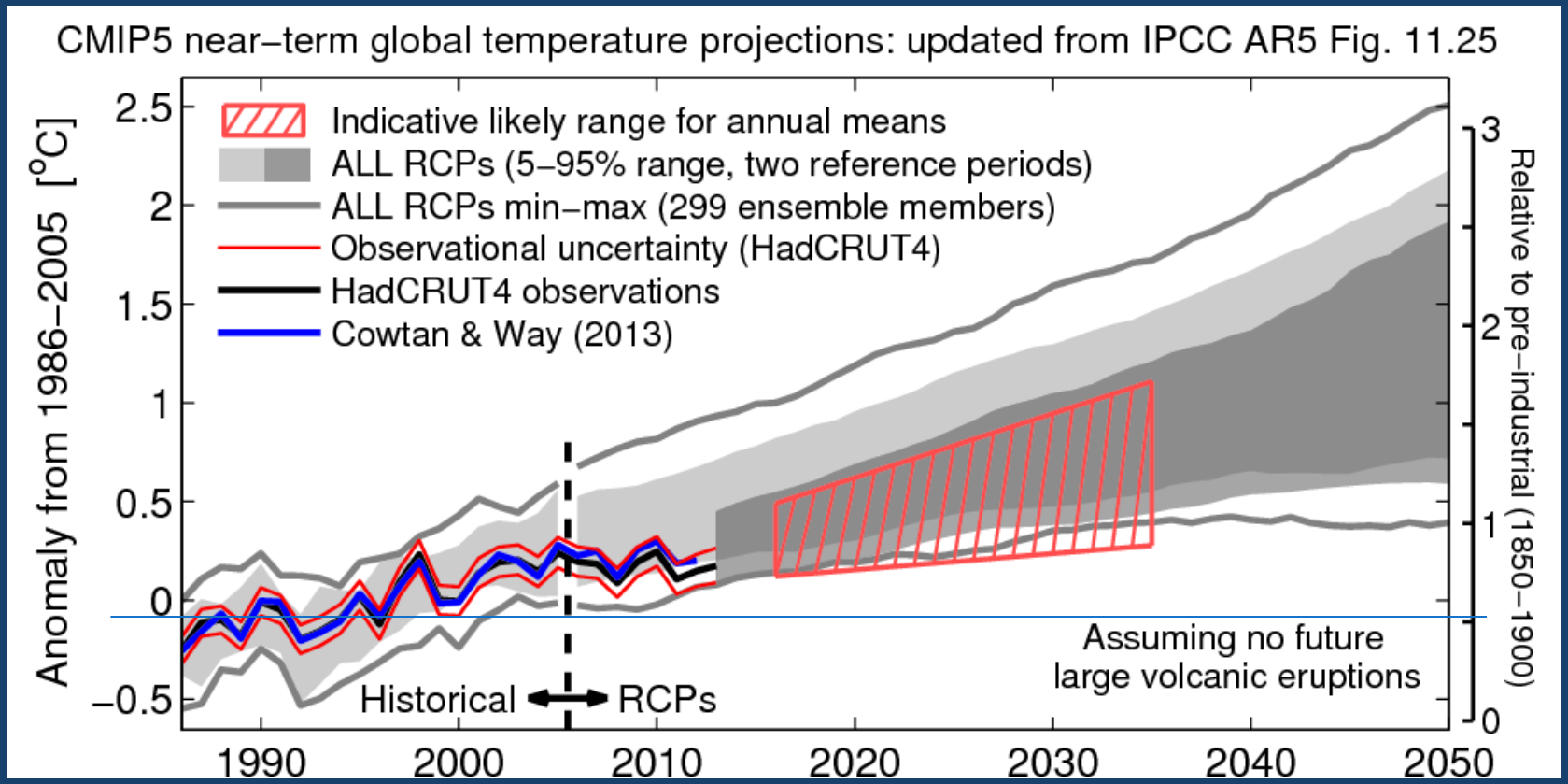
Climate Change Simulations: Possible Future Outcome



Climate Change Simulation, 1870–2100

NCAR/UCAR
National Center for Atmospheric Research
University Corporation for Atmospheric Research

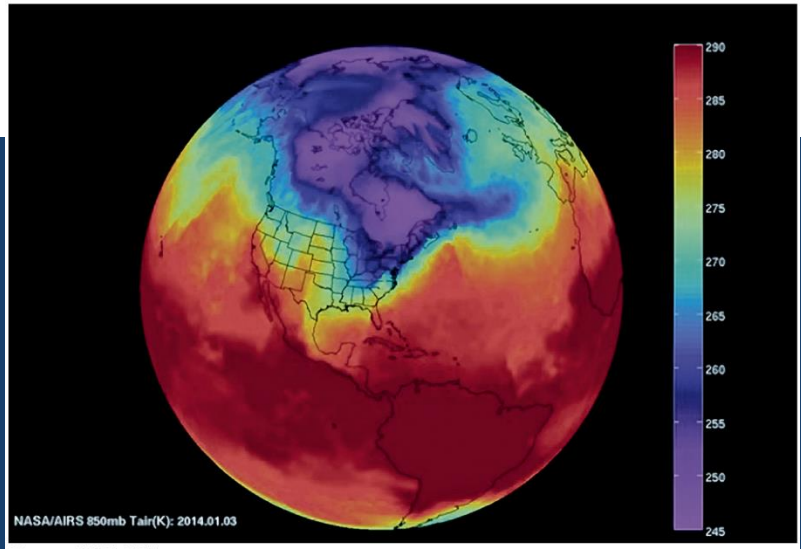
THE LATEST MODEL TREND (IPCC AR5)



RCP = Representative Concentration Pathways

LINKING CLIMATE CHANGE TO EXTREME WEATHER

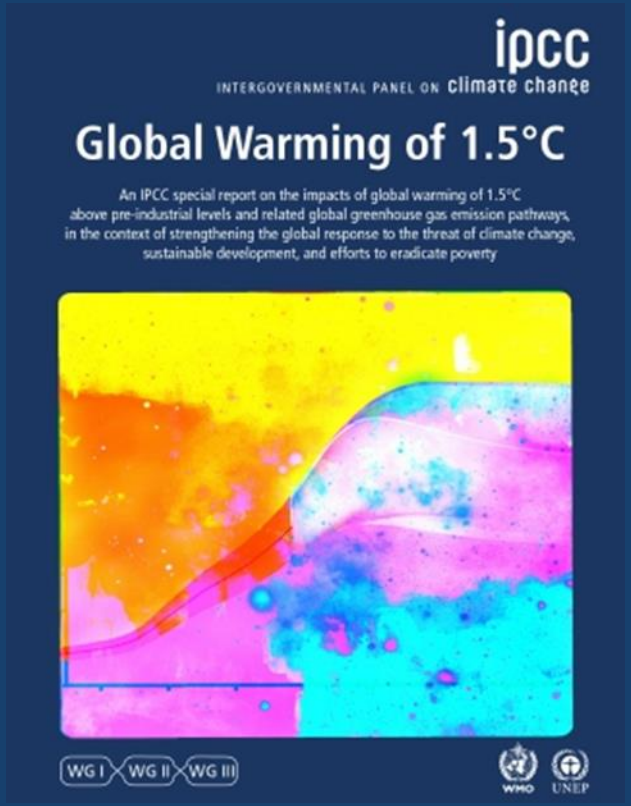
- The Hurricane Seasons of 2004;2005; 2017; 2018
- The Tornado Outbreak of 2011
- The Flash Drought of 2012
- "Super-storm Sandy" of 2012
- The "Polar Vortex" of 2014 and 2019
- Wildfires in the western US (name your year)
- The second year in a row, Tennessee had the record highest February precipitation



[Source: NASA/JPL]

THE UN REPORT ON CLIMATE CHANGE OCTOBER 9, 2018

- Must limit average temperature rise to 1.5°C (2.7°F) by 2030
- Achieved by reducing carbon emissions by 40% - to 50% by then!
  - Do-able within the laws of physics and chemistry
  - Do-able within the laws of politics and economics?
- Why is this necessary?
  - We may reach a tipping point
  - Sustainability at current levels of development demand it
  - International Security may require it!



THANK YOU!