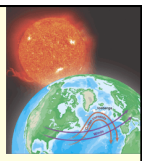


Global Climate Change-A:
Models, Evidence and Policy Implications

MES Winter 2011
February 16
Dr. Gerardo Chin-Leo

National Science Foundation Graduate Research Fellowship Program

- Awards for graduate work in sciences and technology
- $30k/y stipend, $10.5k/y for tuition + $1k travel
- Very competitive ~ 15% success rate
- Intellectual merit and broader impacts
  - Previous and proposed research
  - Articulate impacts of science on society

2

Global Climate Change A&B

- Modeling climate
- Role of CO_2 and biota (GAIA)
- Contemporary warming and GHG (CO_2&CH_4)
  - Data and evidence (geologic and modern)
- Role of ABC (Anthropogenic Brown Clouds) in rate of warming (Ramanathan&Yeng 2008)
- Interventions
  - Understanding the C-cycle and C sequestration
  - Fe-hypothesis and ocean fertilization
  - Geoengineering solutions (?)
- Making decision when outcomes are probabilistic
  - Type I and II errors

- Storms of my Grandchildren- Hanson
- Bedard. (2006) Car&Driver's magazine editorial on Al Gore's An Incovenient Truth
- Ramanathan&Feng. (2008). On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead. *Proceedings National Academy of Sciences (PNAS)*. 10(38): 14245-14250
- Schneider. (2001). Earth Systems: engineering and management. *Nature*. 409:417-421
- Morton. (2007). Is this what it takes to save the world? *Nature*. 447:132-136
- Chisholm. (2000). Stirring times in the Southern Ocean. (2000). *Nature*. 407:685-687

Strategy for Reading 1° Literature

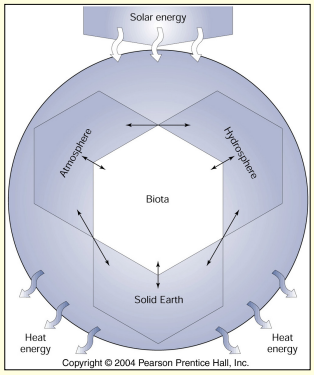
(e.g. Ramanathan & Feng 2008)

- WHAT? Outline conclusions (findings/results)
- WHY? Significance of the study and consequences of the findings
- VALIDITY. What is the evidence supporting each finding?
- HOW? Methods
- For each section identify terms/concepts that you do not understand.

CLIMATE. Meteorological conditions given by such variables as temperature, moisture, precipitation, wind velocity and atmospheric pressure that prevail in a certain region. Climate is determined through averages of these variables over time and space. "What you expect."

WEATHER. State of the atmosphere at a given time and place, described by variables such as temperature, moisture, precipitation, wind velocity and atmospheric pressure. "What you get."

Why it is so difficult to develop climate models?

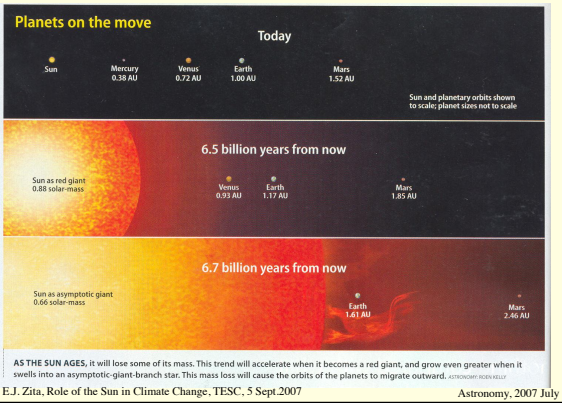


The Sun provides the energy that fuels climate. This energy is reflected, absorbed and transferred by the litho-, cryo-, hydro-, atmo- and bio-sphere determining climate.

Modeling climate is very complex because it is a dynamic, multi-component (tightly coupled) and non-linear (**+and- feedback loops**) system.

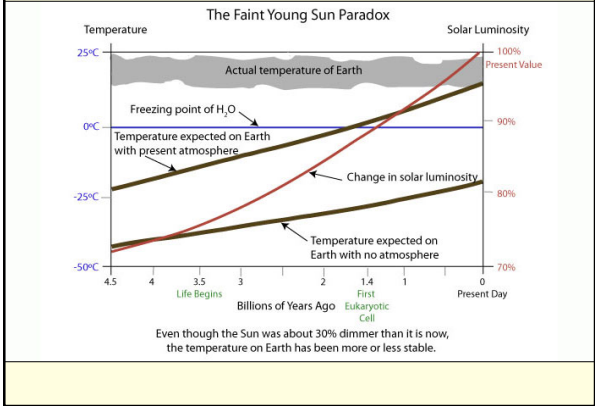
Some climate components can have both + and - effects. For example, clouds depending on altitude can have net warming or cooling effect.

Fate of the Sun and Earth

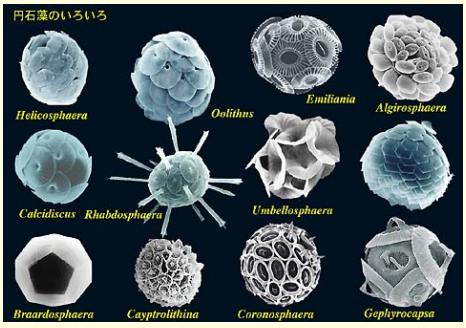


Dr. E.J. Zita, Role of the Sun in Climate Change, TESC, 5 Sept.2007

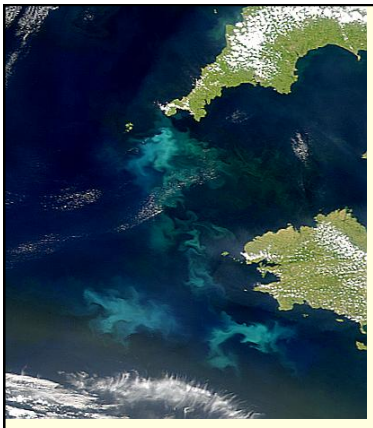
Astronomy, 2007 July



Even though the Sun was about 30% dimmer than it is now, the temperature on Earth has been more or less stable.



http://www.biol.tsukuba.ac.jp/~inouye/ino/etc/coccolithophorids.jpg



http://visibleearth.nasa.gov/view_rec.php?id=705

Marine productivity removes atmospheric CO_2 through sinking of organic matter to the deep sea. This C is removed from atmospheric circulation for ~ 1Ky (mixing time for deep sea water)

Organic matter buried in sediments represents a longer C removal (sequestration) time and has implications to climate regulation (strength of GH effect) and the accumulation and maintenance of atmospheric O_2.

"The GAIA hypothesis supposes that the atmosphere, the oceans, the climate, and the crust of the Earth are regulated at a state comfortable for life because of the behavior of living organisms." (Lovelock and Margulis, 1976)

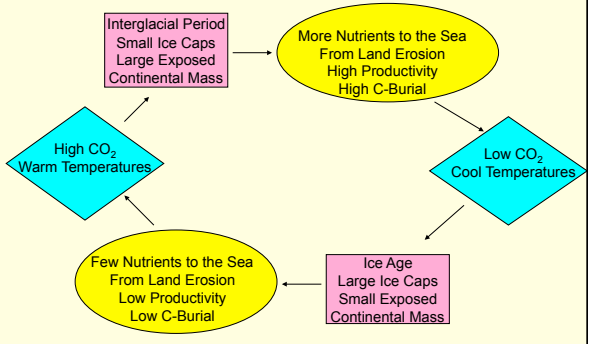
These are other GAIA definitions:

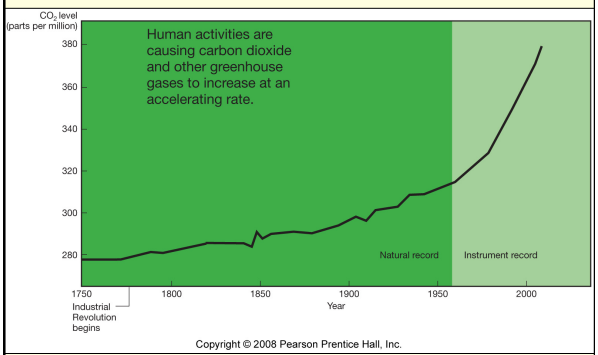
- INFLUENCIAL: Biota influences abiotic world (temp., chemical comp.)
- COEVOLUTIONARY: Biota influences the environment, which in turn influences evolution of Life.
- HOMEOSTATIC: Biota stabilizes abiotic world via negative feedback loops (e.g. thermostat).
- TELEOLOGICAL: Atmosphere kept in homeostasis by and for the biosphere.
- OPTIMIZING: Biota manipulates environment for purpose of creating favorable conditions

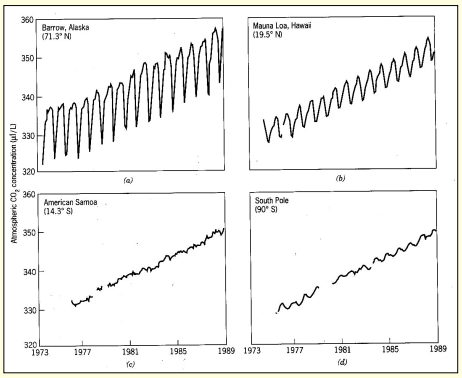
Observations leading to GAIA hypothesis and evidence of "GAIAN" mechanisms

- Comparative analysis of Mars and Earth atmospheres (Lovelock& Hitchcock '65)
- Evidence of homeostasis over Earth's history (Lovelock&Margulis 70s)
  - Constancy of composition (ocean, air) since Life established
  - Narrow temperature ranges compared to other planets
  - Influence of biota on abiotic environment
- Evidence of mechanisms
  - Greenhouse gases cycled by biota (CO_2, CH_4, H_2O) control climate
  - DMS dimethyl sulfide, a product of marine algae affect cloud formation and consequently the Earth's albedo
  - Constant composition of oceans and atmospheric gases through photosynthesis-respiration

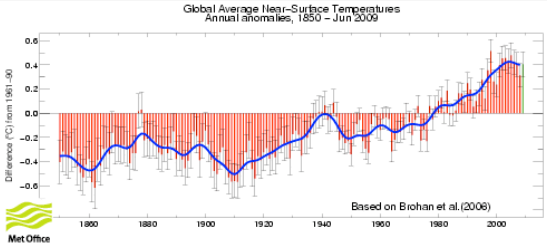
Feedback Loop Linking Glaciations, Atmospheric CO_2 and Phytoplankton C-burial.





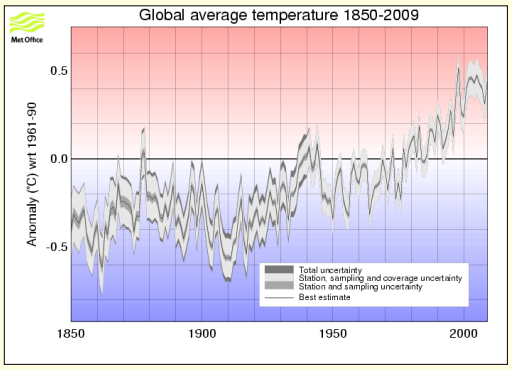


From: Introduction to Marine Biogeochemistry -Libes (1992)



http://www.metoffice.gov.uk/climatechange/science/monitoring/temperatures.html

-Data from monitoring stations on land, from ships and buoys at sea, and from remote sensing (satellites).
-Expressed as anomalies (change compared to a given 30 y period in this case the end of the 20th century).
-Determine uncertainties associated with the estimates (see Brohan et al. 2006).



http://www.metoffice.gov.uk/climatechange/science/monitoring/hadcrut3.html
For video of global temperature predictions see:
http://www.youtube.com/user/TheMetOffice#p/u/0/7KQ-cAqwtXs