

Climate Science Investigations (CSI): Using Evidence-Based Argumentation To Address Skeptics' Claims

Project Funded through NASA's Innovations in Climate Education (NICE) Program (2011 – 2014)

Principal Investigator: Julie Lambert, Ph.D., Florida Atlantic University

Co-Investigators: Brian Soden, Ph.D., University of Miami and Robert Bleicher, Ph.D., California State University Channel Islands

Curriculum and Research Coordinator: Alana Edwards

Research Assistant: Anne Henderson

OVERVIEW OF CLIMATE SCIENCE INVESTIGATIONS: SOUTH FLORIDA

Objective:

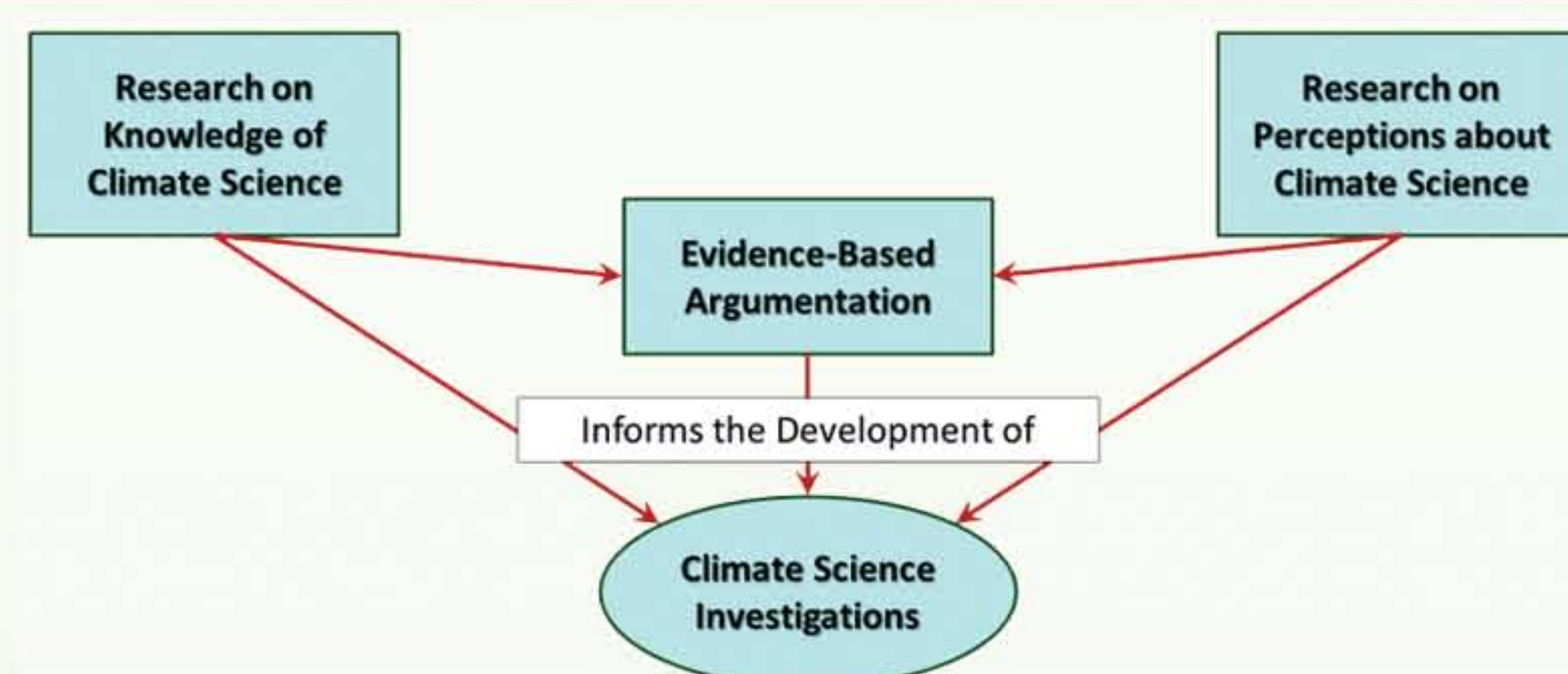
Develop and pilot online interactive modules that teach high school and undergraduate students how to analyze and use NASA data to address the public's commonly held misconceptions about climate change.

Estimated Instructional Time: Approximately 9 weeks

Pilot Audiences:

- High School — Environmental Science Courses in Broward, Miami-Dade, Monroe, and Palm Beach Counties
- Undergraduate — Weather and Climate Courses at the University of Miami

A FRAMEWORK FOR CSI INFORMED BY EDUCATIONAL RESEARCH



RESEARCH ON PRESERVICE TEACHERS' KNOWLEDGE AND PERCEPTIONS ABOUT CLIMATE SCIENCE

Pre-Assessments

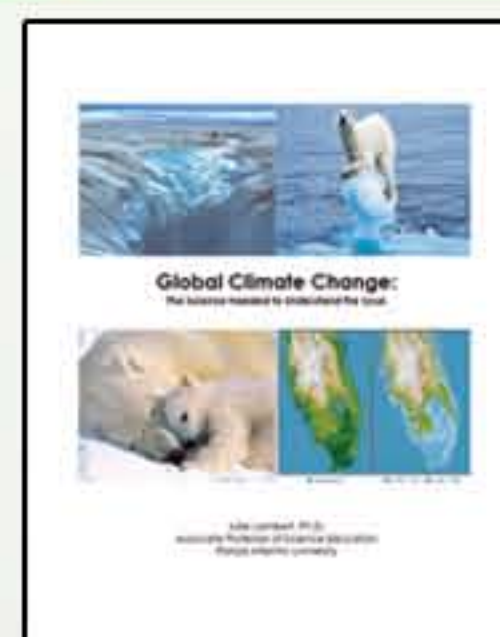
- Inventory of Perceptions about Climate Change (IPCC)
- Climate Science Inventory of Knowledge (CSIK)

Climate Change Instruction

- Climate Change Study Guide
- Series of Lessons & Investigations
- <http://www.coe.fau.edu/faculty/lambert/>

Post-Assessments

- Inventory of Perceptions about Climate Change (IPCC)
- Climate Science Inventory of Knowledge (CSIK)



Lambert, J. & Bleicher, R. (2013). Climate change in the preservice teacher's mind. Journal of Science Teacher Education. <http://link.springer.com/content/pdf/10.1007%2F10972-013-9344-1.pdf>

Lambert, J., Undgren, J., & Bleicher, R. (2012). Assessing elementary science methods students' understanding about global climate change. International Journal of Science Education. 34(7-8), 1167-1188.

Inventory of Perceptions about Climate Change (IPCC)

Paired Samples t-test Results for the IPCC (n= 97)

		Mean	SD	SEM	t	p*
Science (evidence, causes, and consequences)	Pre	58.26	7.61	0.814	6.921	.000
	Post	63.89	8.93			
Actions (solutions to mitigate climate change)	Pre	20.98	2.71	0.332	7.496	.000
	Post	23.48	3.05			
Concern	Pre	1.84	0.89	0.118	6.014	.000
	Post	2.55	1.11			
Skepticism (influence of media, politics, and oil companies; consensus of scientists)	Pre	15.88	2.56	0.362	3.686	.000
	Post	17.21	3.36			
Self-Reported Knowledge	Pre	10.78	3.09	0.398	15.490	.000
	Post	16.95	3.09			
Interest	Pre	3.70	0.99	0.116	2.842	.005
	Post	4.03	1.07			

*Level of significance, $p \leq 0.05$, Reliability = 0.92 using the Cronbach alpha statistical test.

Climate Science Inventory of Knowledge (CSIK)

		Mean	N	SD	SEM	t	p*	Cohen Effect Size d (f)
Overall Knowledge	Pre	13.817	104	5.563	.546	20.675	.000	2.32 (0.76)
	Post	31.414	104	9.157	.898			
Greenhouse Effect	Pre	1.778	135	1.342	.116	14.984	.000	1.55 (0.61)
	Post	4.585	135	2.180	.188			
Carbon Cycle	Pre	1.272	136	.847	.072	11.330	.000	1.27 (0.54)
	Post	2.993	136	1.723	.148			
Forcing	Pre	5.630	127	2.449	.217	19.474	.000	2.08 (0.72)
	Post	12.330	127	3.840	.341			
Impacts	Pre	4.885	130	2.394	.210	16.789	.000	1.60 (0.63)
	Post	9.139	130	2.898	.254			

*Level of significance, $p \leq 0.05$, Reliability = 0.92 using the Cronbach alpha statistical test.

CSI: SOUTH FLORIDA

CLIMATE SCIENCE INVESTIGATIONS: SOUTH FLORIDA

[Home](#) [About](#) [FAQ](#) [References](#) [Resources](#)

The Nature of Science

Weather and Climate

Energy - The Driver of Climate

Temperature Over Time

Causes of Climate Change

Impacts of Climate Change

What We Can Do

Addressing Climate Skeptics' Claims

EVIDENCE-BASED SCIENTIFIC ARGUMENTATION

The Difference Between an Argument and Argumentation

- Scientific Argument – a series of propositions (Nussbaum, Sinatra, & Owens, 2012).
- Scientific Argumentation – social process where two or more individuals construct and critique arguments (Kuhn & Udell, 2003; Nussbaum, 2002).

Research on Argumentation Over Past Decade

Goal is to support the use of argumentation as an instructional practice.

- Development of new curricula (Krajcik, McNeill, & Reiser, 2008; and Stewart, Cartier, & Passmore, 2005)
- Technology-enhanced learning environments (Clark & Sampson, 2008; Linn, Davis, & Bell, 2003; Sandoval & Reiser, 2004; and Toth, Suthers, & Lesgold, 2002)
- Instructional strategies (Kuhn & Reiser, 2006; and Osborne, Erduran, & Simon, 2004)

Even with these curricula and instructional strategies, teachers have difficulty using argumentation as an instructional practice (Osborne, MacPherson, Patterson, & Szu, 2012).

NATURE OF SCIENCE

Core Science Concepts

- Nature of Scientific Inquiry
- Role of Skepticism in Science
- Evidence-Based Argumentation
- Scientific Consensus and Certainty

Examples of Skeptics' Overarching Claim

There is no scientific consensus about causes of climate change.

Examples of Skeptic's Sub-claims

Hurricanes aren't linked to global warming. (Example of ongoing research)

Scientists ...	Detectives ...
ask questions.	conduct inquiries.
make systematic observations.	set up surveillance.
propose hypotheses.	follow their intuition and instinct (based on experience) to come up with likely scenarios.
collect, analyze, and interpret data.	(with help from forensic scientists) collect, analyze, and interpret evidence.
construct explanations, using evidence and reasoning to justify these explanations.	infer or deduce what happened based on the evidence collected.
evaluate or critique others' explanations.	investigate other leads to exclude all other possibilities and suspects.
communicate their research methods and results to other scientists and the public.	turn over their evidence and findings to prosecutors and the courts.

WEATHER AND CLIMATE

Core Science Concepts

- Difference Between Weather and Climate
- Types of Climate
- Extreme Weather Events

Examples of Skeptics' Overarching Claim

Extreme weather events (such as precipitation and flooding, drought, heat waves) are not increasing, but just part of a normal cycle.

Examples of Skeptic's Sub-claims

- Scientists can't even predict the weather.
- Record high snow cover was set in 2008-2009.



ENERGY: THE DRIVER OF CLIMATE

Core Science Concepts

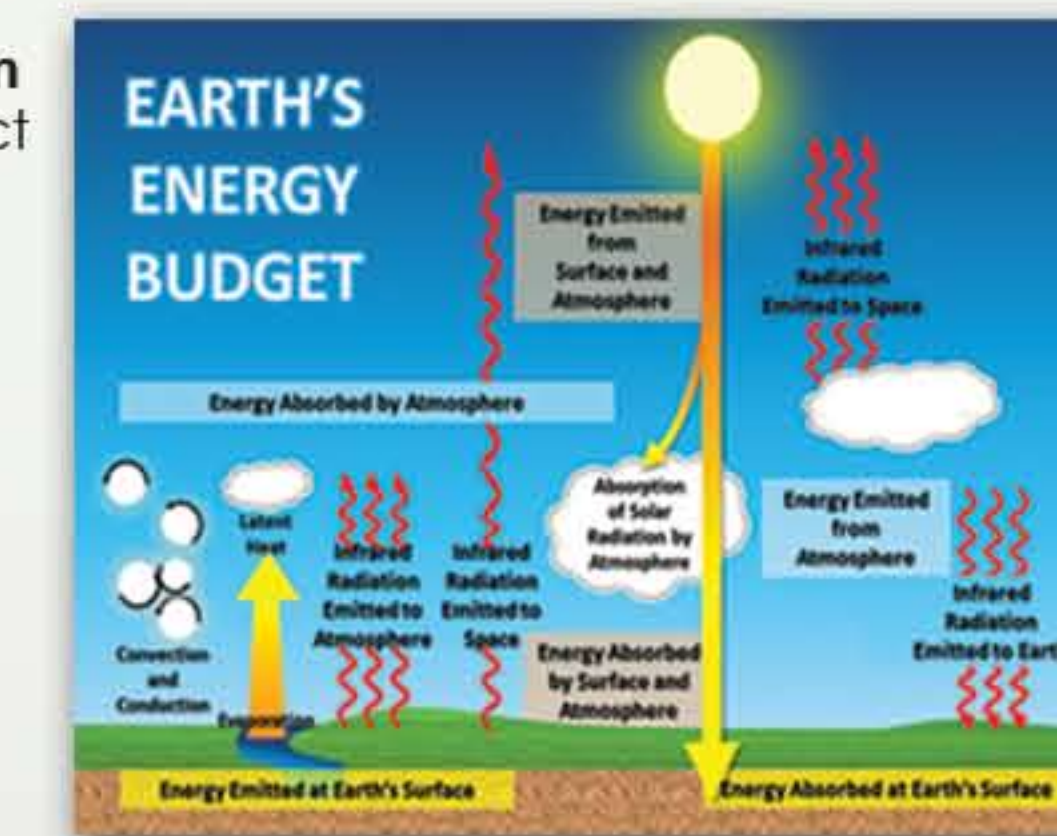
- Electromagnetic Radiation
- Heat Transfer
- Greenhouse Effect
- Composition and Structure of the Atmosphere
- Difference Between Natural and Amplified Greenhouse Effect
- Temperature and Radiation
- Earth's Energy Balance

Examples of Skeptics' Overarching Claim

The explanation of the greenhouse effect contradicts the second law of thermodynamics.

Examples of Skeptic's Sub-claims

- CO2 is a pollutant.
- Water vapor is the most powerful greenhouse gas.
- The greenhouse effect has been falsified.



TEMPERATURE OVER TIME

Core Science Concepts

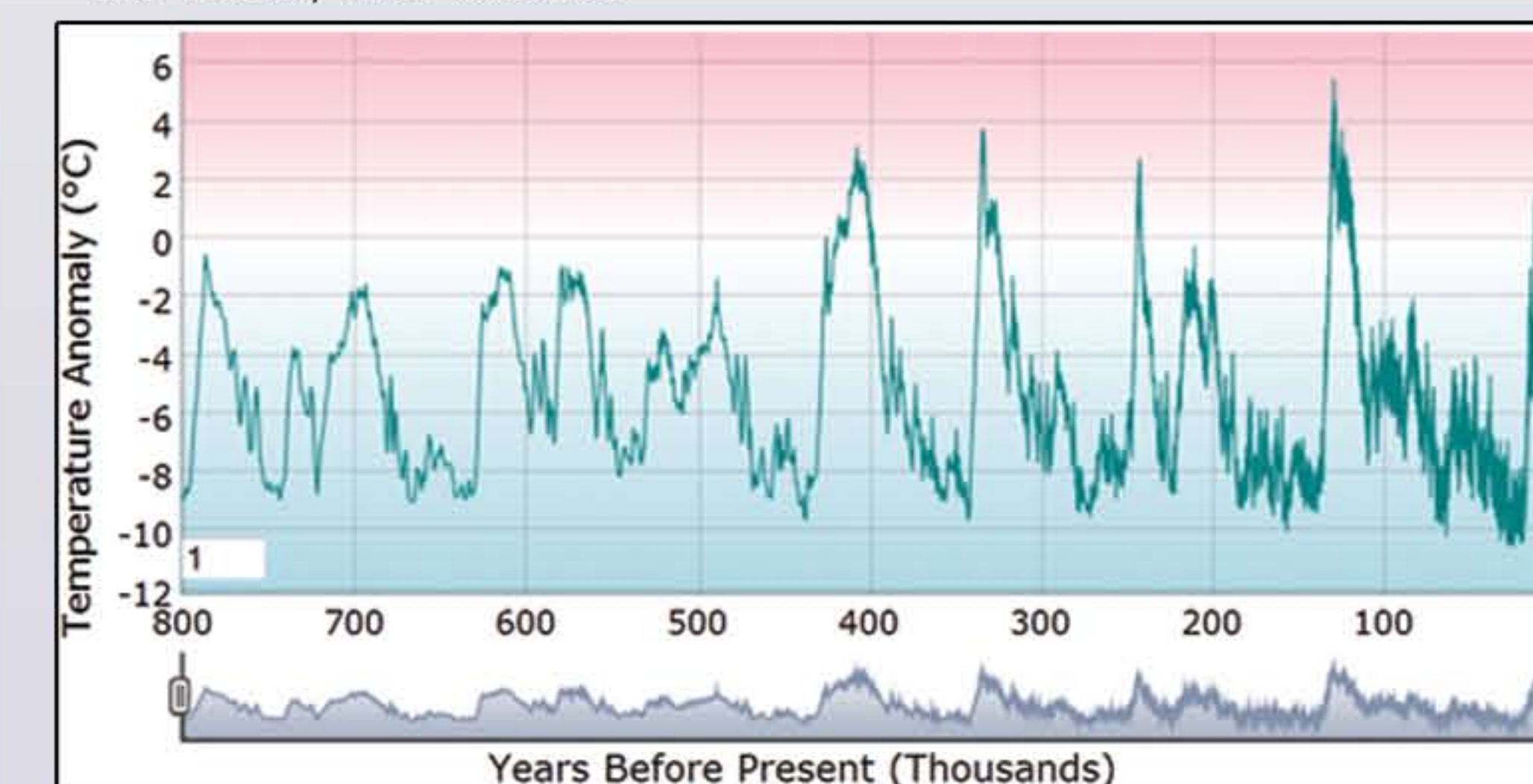
- Factors that Affect Temperature (Latitude, Angle of Solar Radiation, Seasons, Water, Ocean Currents, Elevation)
- Methods for Studying Past Temperature
- Temperature Change Over Geologic Time, Past 2,000 Years, and Since the Industrial Revolution.

Examples of Skeptics' Overarching Claim

Earth's climate (global average temperature) has changes in the past and recent changes are NOT unusual.

Examples of Skeptic's Sub-claims

- The temperature record is unreliable.
- It is cooling. We're heading into an ice age.
- An ice age was predicted in the 1970s.
- The Medieval Warm Period was warmer.
- The "Hockey Stick" is broken.



CAUSES OF CLIMATE CHANGE

Core Science Concepts

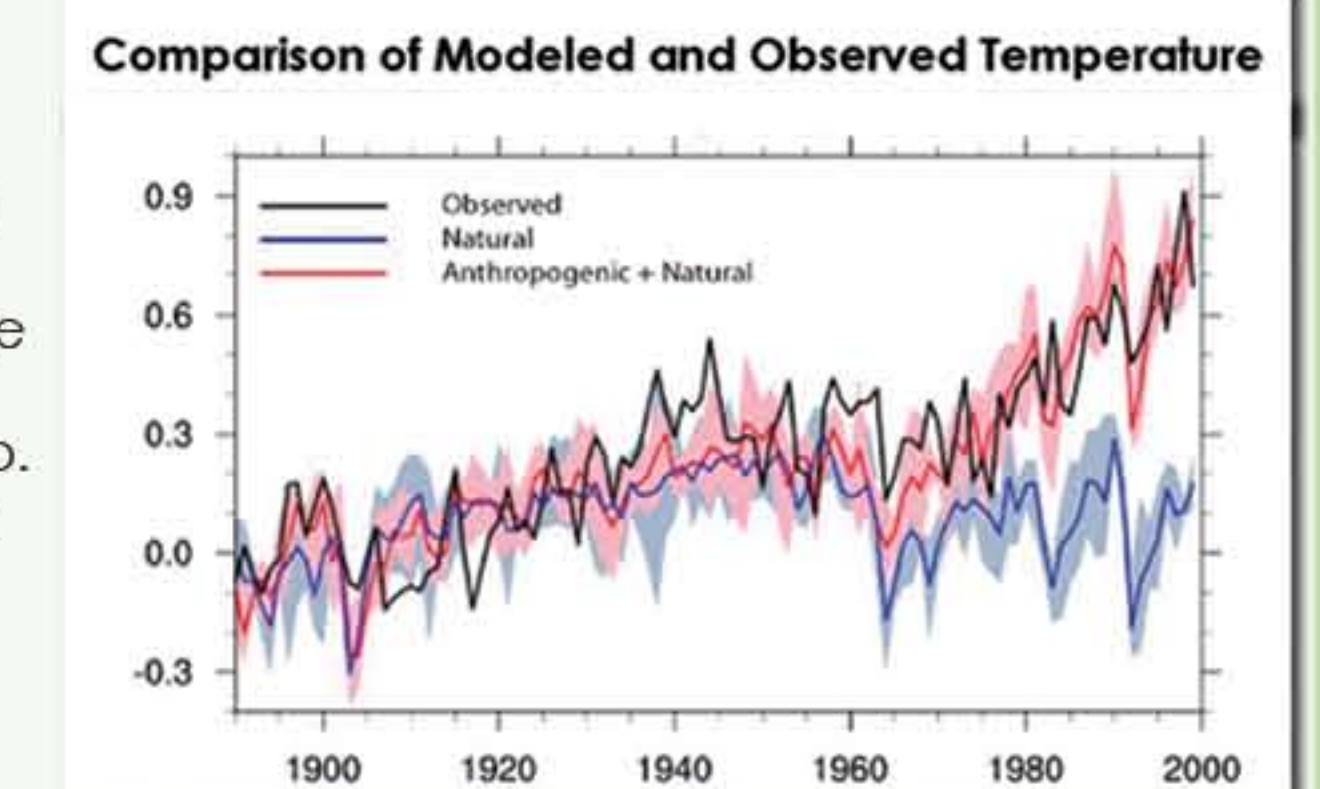
- Natural Causes, (Milankovitch Cycles, Volcanic Eruptions, Solar Activity, ENSO)
- Anthropogenic Causes (Fossil Fuel Combustion, Changes in Land-Use, Cement Production)
- Radiative Forcings
- Climate Feedbacks
- Carbon Cycle
- Global Climate Models

Examples of Skeptics' Overarching Claim

Natural variability is causing recent changes in temperature, not human activity.

Examples of Skeptic's Sub-claims

- CO2 is plant food and CO2 is not a pollutant.
- There is no correlation between CO2 and temperature.
- Human CO2 is a tiny percentage of CO2 emissions.
- It is the sun. It is not us. It is El Niño.
- Volcanoes emit more CO2 than humans.
- Models are unreliable.
- There is no empirical evidence. There's no consensus.



IMPACTS OF CLIMATE CHANGE

Core Science Concepts

- Observed and Projected Impacts for Different Emission Scenarios (Global Mean Temperature Increase, Land and Sea Ice Melt, Sea Level Rise)
- Changes to Hydrologic Cycle, Ocean Currents, Ocean Chemistry, Ecosystems and Species Diversity, Human Health

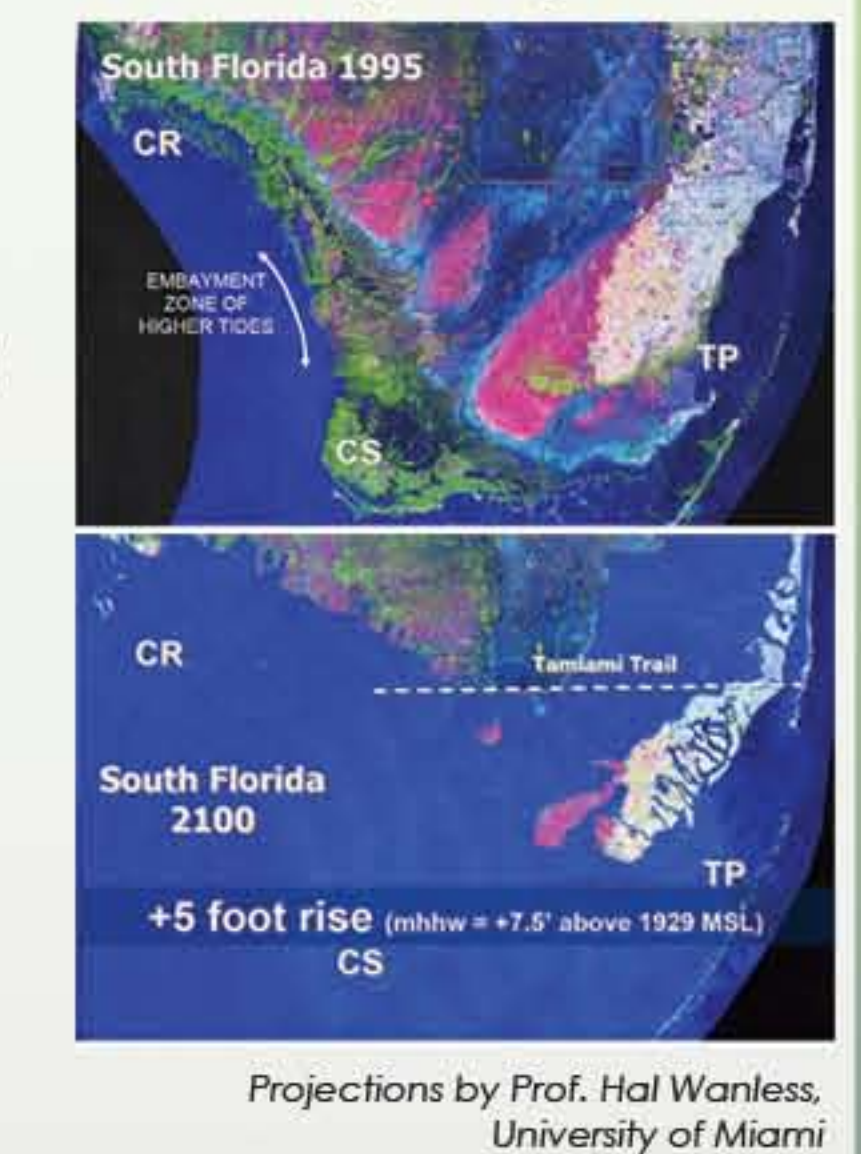
Examples of Skeptics' Overarching Claim

There is not enough evidence that Earth is warming.

The impacts of a few degrees of global warming would NOT be that harmful to life (including humans) on Earth. Warming could even be good.

Examples of Skeptic's Sub-claims

- Antarctica and Greenland are gaining ice.
- Glaciers are growing.
- Arctic ice melt is a natural cycle.
- Sea level rise is exaggerated.
- Earth has not warmed as much as expected.
- Ocean acidification is not serious. (Corals are resilient to bleaching.)
- Animals and plants can adapt. (Polar bears numbers are increasing.)



Projections by Prof. Hal Wanless, University of Miami

WHAT WE CAN DO

Core Science Concepts

- Mitigation, Adaptation
- Renewable Energy
- Stabilization Wedges
- Energy Consumption
- Environmental Policy

Examples of Skeptics' Overarching Claim

Humans cannot reduce the effects of global warming even if it is happening. It is too late to stop global warming, so we should adapt.

Examples of Skeptic's Sub-claims

- CO2 limits will harm the economy.
- Renewable energy is too expensive.
- It is too hard. It is not urgent.

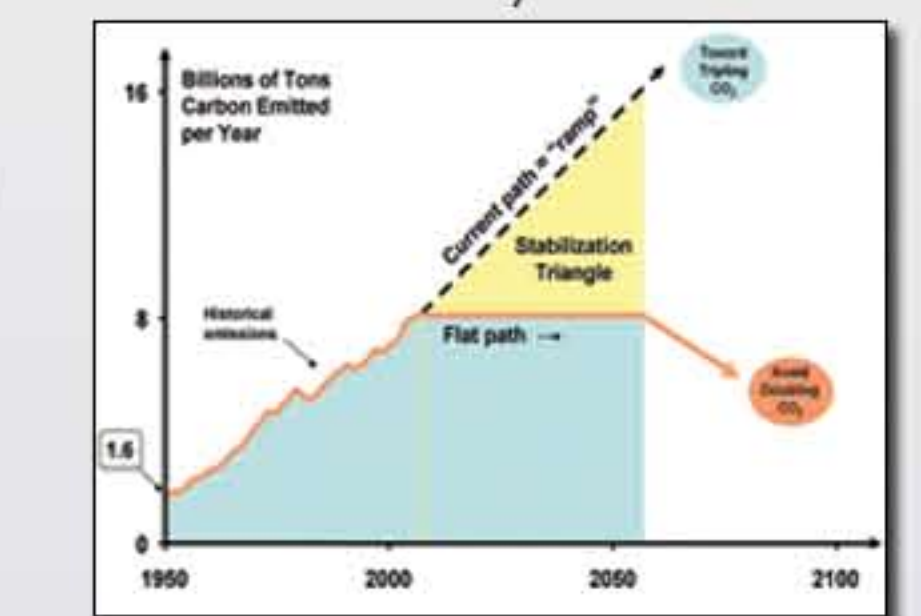
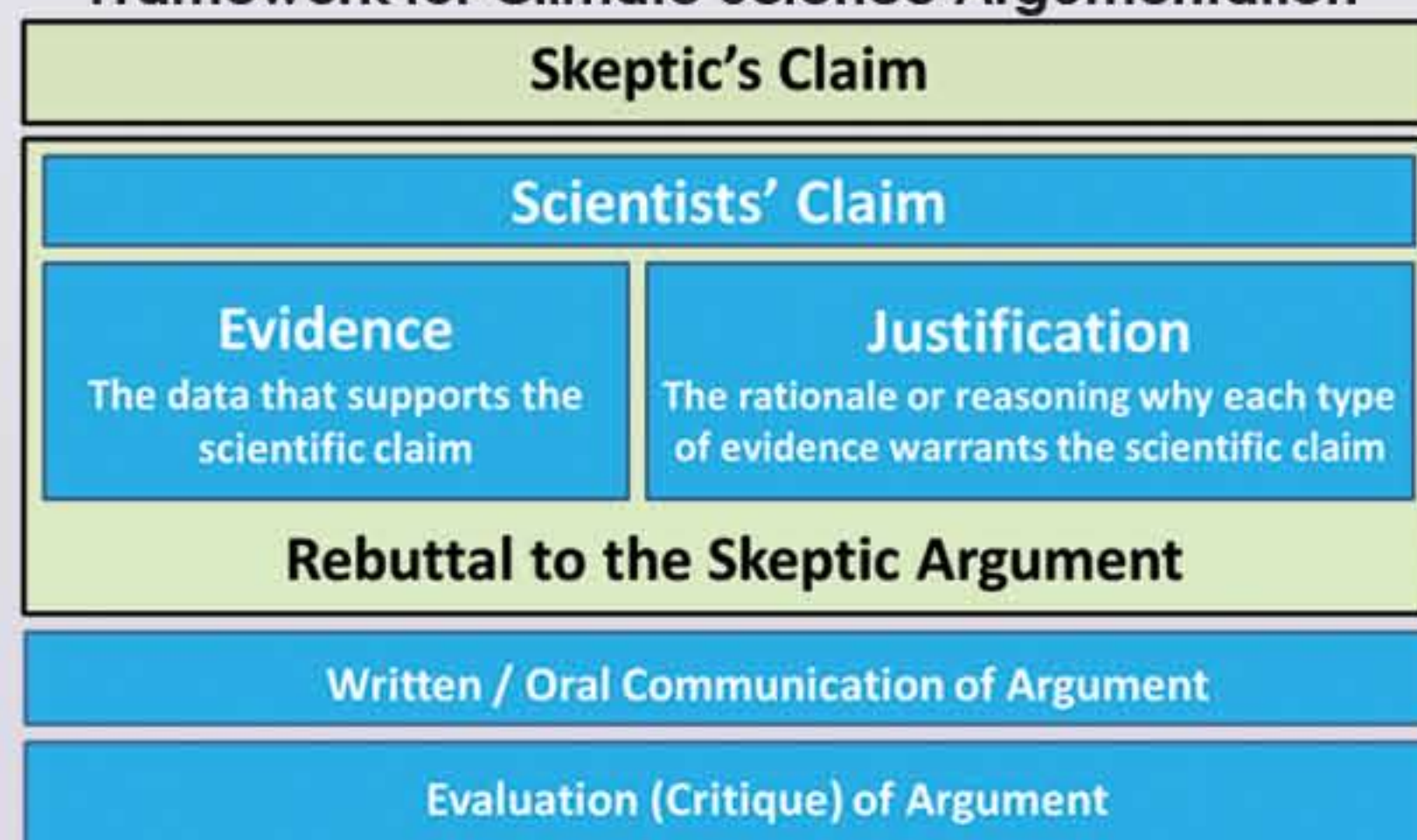


Image Source: <http://cmi.princeton.edu/>

ADDRESSING CLIMATE SKEPTICS' CLAIMS

Framework for Climate Science Argumentation



Adapted from Toulmin's Argument Pattern (1958)