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Panel: A Meaningful Discussion about Climate Change

**Thoughts on Science and Climate**

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Author's Note:

In the following text, blue represents what was said, and indented black what was shown on slides.

With the various hats that I wear scientifically, professionally, politically, and as a parent of four, I am often asked “Do you believe in climate change?” It is hard for me to know how to approach that question; belief is not a word that I commonly associate with science.

We read and hear today in almost every news venue that the “debate is over” regarding anthropogenic forcing of global warming. The August 13<sup>th</sup>, 2007, issue of *Newsweek* carries a cover story in which lead author Sharon Begley calls greenhouse doubters “deniers.” Denier is a word often associated with many things—religion, addiction, old age, weight, athletic prowess—but rarely, in my experience, with science.

I am going to spend the next few minutes using a series of simple definitions, all from Webster's online dictionary, to provide a common baseline for how we might frame the climate conversation (I'm avoiding for now the use of the word “debate” so as not to be considered a denier!) as we go forward.

Main Entry: **be·lieve**

**1 a:** to have a firm religious **faith** **b:** to accept as true, genuine, or real

**2:** to have a firm conviction as to the goodness, efficacy, or ability of something

**3:** to hold an opinion

Main Entry: **<sup>1</sup>faith**

**2 b (1):** firm belief in something for which there is no proof **(2):** complete trust

**3:** something that is believed especially with strong conviction

Main Entry: **sci·ence**

**1:** the state of knowing

**3 a:** knowledge or a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through **scientific method**

**b:** such knowledge or such a system of knowledge concerned with the physical world

**Scientific method.** Principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses

**Belief** and **science** have collided many times in the past. Galileo was required to recant his heliocentric ideas because Pope Urban VIII and the vast majority of Church officials did not believe that the Earth revolved around the sun.

**“The proposition that the sun is in the center of the world and immovable from its place is absurd, philosophically false, and formally heretical; because it is expressly contrary to Holy Scriptures.”**

The Pope, speaking on behalf of the church, was **passionate** about a **belief** that we now understand to have been under-informed by scripture.

I am **passionate** about many things in life: my family, global energy, the environment. Everyone has passions.

Main Entry: **pas·sion**

the emotions as distinguished from reason b: intense, driving, or overmastering feeling or conviction 5b: a strong liking or desire for or devotion to some activity, object, or concept

As we look back across the centuries, with the benefit of technology and scientific understanding, many explanations for the order of the physical world that were based in beliefs, faith, and passion have been shown to be incorrect. Such is understanding and progress. Nothing indicates that this trend will change in the future as our descendents look back on what we “believe” today.

**Passion**, in my judgment, has never made a cozy bedfellow with **reason** or **objectivity**. How many parents could bury their passion for a child and hand a child known to be guilty of a capital crime over to the authorities? Passion can override **reason** and **objectivity**.

Main Entry: <sup>1</sup>**rea·son**

**1 c:** a sufficient ground of explanation or of logical defense; *especially*: something (as a principle or law) that supports a conclusion or explains a fact <the *reasons* behind her client’s action>

**2 a (1):** the power of comprehending, inferring, or thinking especially in orderly rational ways

Main Entry: <sup>1</sup>**ob·jec·tive**

**3 a:** expressing or dealing with facts or conditions as perceived without distortion by personal feelings, prejudices.

Before I became a PowerPoint Czar and Email King, I actually earned a living by working on a multidisciplinary team building some of the early 3D computer models of oil fields. It was great fun to try to model what was in between the limited **data**.

Main Entry: **da·ta**

**1:** factual information (as measurements or statistics) used as a basis for reasoning, discussion, or calculation

**3:** information in numerical form that can be digitally transmitted or processed

Eric Barron shared with me his brief thoughts on climate **data** and also data that are needed to reduce uncertainty in climate modeling.

#### Climate Data

- Historical sources that can be indirectly tied to temperature, such as harvest times and records of mountain glacier lengths
- Annual banding records that can be indirectly tied to temperature, including
  - Tree rings
  - Corals
  - Ice cores
  - Lake sediments
- Supporting information that may lack fine temporal resolution, such as borehole temperature data in which the downhole diffusion of temperature can be reconstructed

#### Data to Reduce Uncertainty

- More data from the Southern Hemisphere: reduce the dependency on data from NA and Europe.
- Improved data from the oceanic regions, enabling a more comprehensive analysis
- Reassessment of older data sets, which may not have been subjected to the scrutiny of more recent data sets
- Analysis of the biological, chemical, and physical connections of proxy sources to temperature and climate
- Exploration of statistical techniques; the notion of “error bars” may not be appropriate for analysis of disparate proxy data sets. (NRC, 2006)

There was a phrase we often repeated on our 3D modeling team: **“We are certain of only one thing—our model is wrong!”** Modeling was a process of wrongness minimization. The wrongness was always brought home when we drilled a new well, cut a new core, acquired new logs, took a DST, etc. Addition of new data always increased complexity. The physical world is not a simple place; it is difficult to **model**.

Main Entry: <sup>1</sup>**mod·el**

**12:** a system of postulates, data, and inferences presented as a mathematical description of an entity or state of affairs; *also*: a computer simulation based on such a system <climate *models*>

Models are fantastic tools that force us to clean the data, typically contain and honor known data, and attempt to explain and describe a physical system mathematically. But **models** are not **data**, and to be valuable, models must be testable and reproducible.

In the June 2006 issue of *Eos*, Ira Sasowsky was cautious:

“A particular concern is the lack of documentation of computer model methods and analyses.... Published documentation of code methods and tests does not exist, leaving no basis for reviewers to assess the methods and the results of the research paper....

Because reproducibility is a fundamental element of the scientific method, model documentation should be sufficiently detailed so that other researchers in the field could reproduce the published results....”

There was a time when I built very large databases that incorporated log **data**, quantified core data, seismic data, production tests, and the like. A program called SAS Insight allowed us to interact with the data and explore them for relationships of correlation. I often used the relationships to create predictive algorithms to forecast something from something else: for example, permeability **correlated** well with porosity.

Main Entry: **cor·re·la·tion**

a relation existing between phenomena or things or between mathematical or statistical variables which tend to vary, be associated, or occur together in a way not expected on the basis of chance alone

I used to make statements of causation now and then. For a given pore type, increased cementation **causes** permeability reduction. It turns out, in carbonate systems, permeability is complex and related to many things, including pore type, pore structure, facies, percentage and type of secondary cement, and the like. As is often the case in the physical world, the relationship between X and Y is not straightforward, and proving causation is very difficult.

### **Correlation Des not Imply Causation**

1. **Correlation**—X is related to Y
2. **Causation**—a change in X causes a change in Y
3. **Common Response**—both X and Y change in common to some third, unseen variable
4. **Confounding**—the effect of X and Y is mixed up with the effects of other explanatory variables on Y. To establish causation, a carefully controlled, designed experiment must be run.

Let's examine each of these in the context of Climate Change.

**Correlation.** Increases in global temperature show a trend similar to that of increases in atmospheric CO<sub>2</sub>, sometimes trailing and sometimes leading.

**“The degree of warming is linked to the total volume of CO<sub>2</sub> in the atmosphere. The pre-industrial levels of CO<sub>2</sub> were about 280 ppm and current levels are rising through 380 ppm.**

Any approach to reducing the growth of the levels of greenhouse gases in the atmosphere **must include either reducing the emissions of CO<sub>2</sub> to the atmosphere or enhancing the sinks for CO<sub>2</sub>.**”

—Source: NPC, 2007

**Causation.** An increase in CO<sub>2</sub> causes global warming.

“Global warming is now well documented and accepted by scientists as fact. The average global surface temperature has increased by approximately 0.5–1.0°F (0.3–0.6°C) over the last century. This warming is largely attributed to the increase of greenhouse gases caused by humans **artificially** increasing the concentration, mainly of carbon dioxide and methane in the Earth’s atmosphere.

—Source: Stanford Solar Center, <http://solar-center.stanford.edu/sun-on-earth/glob-warm.html>

**Common Response.** Earth temperature is related to CO<sub>2</sub> levels and solar activity.

Many psychological studies have shown that children who watch violent television are more likely to exhibit violent behavior. The general trend shows that a child’s “level” of violence is positively correlated to the amount of violent television programs a child has seen. The violent television itself is not necessarily what caused the violent behavior. It is possible that children who behave violently for other reasons are especially fond of watching violent television. The correlation between the two events is just not enough information to conclude anything about cause and effect.

**Confounding.** Global warming is caused, in part, by the interplay between several forcing factors, among which are solar activity, CO<sub>2</sub>, methane, aerosols, and concentration of other GHG’s.

Robert Charlson, U. Washington, June 2007 Nature Reports Online as reported in News of the Week, *Science*, July 6, 2007

The good correlation between the observed 20th century temperature anomaly and the models that use natural and anthropogenic forcing *versus* the poor correlation between the observed temperature anomaly and the models that use only natural forcing, Charlson et al. argue, “conveys a lot more confidence than can be supported in actuality.” IPCC authors concede the group has a point. Greenhouse gas changes are well known, but not so the counteracting cooling of pollutant hazes, called aerosols.

Is the debate over?

“Few **credible** scientists now doubt that humans have influenced the documented rise in global temperatures since the Industrial Revolution.”

—Julie Brigham-Grette et al., *Eos*, v. 87, no. 36, September 5, 2006

“If the evidence for anthropogenic forcing of global warming were truly as compelling as AGU has stated, no controversy would today exist.”

—Kevin Corbett, *Eos*, October 24, 2006

### What is research?

Main Entry: <sup>1</sup>**re·search**

Function: *noun*

**1** : careful or diligent search

**2** : studious inquiry or examination; *especially* : **investigation or experimentation aimed at the discovery and interpretation of facts, revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws**

**3** : the collecting of information about a particular subject

As scientists we must protect the right of scientific challenge and debate. It is what pushes us to defend our ideas and to discover in the process. That is research. That is science. It demands debate. The debate is never over in science. It is precisely this debate that causes science to advance. Debate is as important to science as the first amendment is to a democracy. Let us celebrate the scientific process and the different ways we each view a given problem.

If an hypothesis withstands the challenge of further data collection, independent testing and peer review, it will survive to become a theory. I use the word theory in the scientific sense, not in the Sherlock Holmesian (I have a theory...) or media (There is a new theory out on...) sense. Each new piece of data adds to and strengthens a well-founded theory.

The theory of evolution, now being tested at the bacterial scale, is a wonderful example of the scientific process. Even though much remains to be learned, few question the need and right to continue to test the theory of evolution, which is holding up marvelously, by the way.

Climate change is documented in the rock record at many scales, explained by reasonable physical processes, and supported by certain principles and laws. It continues to be tested.

The hypothesis of anthropogenic forcing of global warming is being tested today. Largely indirect measurements of temperature correlate reasonably well with measurements of CO<sub>2</sub> for the past 600,000 years or so, but the system is complex, multivariate, and nonlinear and difficult to model.

In summary, in terms of anthropogenic forcing of climate change, I am neither a believer nor a denier. Those words are best used in other contexts. I am a scientist (hopefully a

credible one), and I reserve the right to change my mind as data and my understanding evolve.

Causation is difficult to prove. Data are being collected, models are being run, much is being learned, and much remains to be learned.

I think that there are many good reasons to reduce emissions, above and beyond the climate conversation. No one wants to breathe bad air. In terms of large-scale CO<sub>2</sub> reductions, the problem is immense, and infrastructure costs will run into the trillions of dollars. The energy, economy, and environment tapestry is intricate, and we must guard against poorly considered policy that could have severe, unintended consequences.