Chemical Engineering, Systems Thinking, and Climate Predictions

"There are no facts about the future, only predictions".

Most predictions are based on models – some intuitive, some developed from retrospective analysis, and some based on an understanding of the system that is in play.

There is a parallel between the techniques used in the development, design, and operation of a chemical process system and that used in the global warming/climate change 'science'

What follows is an attempt to expand the above premise.

Climate Change

"Change is what the climate is always doing and is the result of our planet's orbital eccentricities, axial wobble, solar brightness variation, and cosmic ray flux, There are also plausible terrestrial drivers of climate change too, including super volcanic events and tectonic movement, but these are not in the realm of anthropogenic (manmade) effects

The global mean temperature over which there has been so much obsession is only one part of climate (for example, how wet or dry the climate happens to be and is probably of far greater significance than a simple mean temperature). In fact it's not even clear that a global mean temperature is a particularly useful metric."

Steven Milloy

.Systems Thinking

The dictionary defines a system as an assemblage or combination of things or parts forming a complex or unitary whole.

Systems are everywhere:

- Relationships
- Financial/Business
- Organizational
- Scientific

The Earth's climate is a system – very complex with detail complexity as well as dynamic complexity.

Two kinds of systems – Escalating and Balanced

Really only balanced systems – all escalating eventually become balanced.

Another way to describe systems – Robust or Fragile

System boundaries are critical:
Interaction of elements of the system
Response to change in independent variables: exponential, linear, logarithmic,

Models

Models are devised to describe systems.

There are two general types of models:

Empirical – With the advent of mammoth computing capability, developing empirical models has become relatively easy – data is analyzed and correlated. If the first attempt doesn't succeed, more parameters are added until a correlation appears to have been achieved.

"Give me four adjustable parameters and I can simulate an elephant..
Give me one more and I can make his trunk wiggle"
John von Neumann

First principle models – these are developed by people who have studied in a field for many years and claim a fundamental understanding of the systems they are working with.

In either case, the models are basically the expert's assumptions about the system and how it works.
No matter how loudly the experts proclaim the merits of their model, there is only one way to validate a model and that is with unbiased experimental data.

No amount of retrospective data will validate a model.
Neither will popular acclaim by well-meaning advocates who don't have a clue about the science involved
Nor statements made by renowned scientists who have a vested interested in promoting their research and their political agenda.

Design/Operation

To simplify something accurately, you've got to understand it deeply"
Jonah Goldberg

The three keys to success –
Understand your process
Understand your process
Understand your process

Process Design/Operation:
- Experimental data – understand your process
- Construct model – identify key parameters and their interaction
- Validate model – controlled experiments
- Make predictions – use model
- Modify model - include new findings based on operating experience

Process Control Strategy

Understand Your Process

Key parameters:
- Temperature
- Pressure

Major Parts of the System:
- Sun
- Atmosphere
  - Composition
    - Dust
  - Temperature
  - Pressure
- Oceans (water)
  - Temperature
    - El Nino (1998)/La Nina (2007-08)
  - Composition
  - Level
  - Volcanoes – 10,000 – 200,000
- Earth
  - Structure
    - Inner Core – Solid, 5000-7000 K
    - Outer Core – Molten, 4000-6000 K
    - Mantle – Solid, 870C
    - Crust (Oceanic/Continental) – Solid

    Heat Loss at Core/Mantle Boundary 7.5-15 terawatts/year
    This is 1/3 of heat the radiates from the earth 42 terawatts/year
  - Volcanoes – 1500 Active
  - Glaciers

Key Questions

How good is your data?

"Is the U.S. Surface Temperature Record Reliable?"
Anthony Watts
SurfaceStations.org 2009
ISBN 13; 978-1-934791-29-5

"The report reveals a serious deterioration in the reliability of the U.S. temperature record due to siting decisions that violate NOAA's own rules. With only 11 per cent of surveyed stations being of acceptable quality, the raw temperature data produced by the USHCN stations are not significantly accurate enough to use in scientific studies or as a basis for public policy decisions.

Adjustments to the data by NOAA/NCDC and NASA add significant additional warming biases, which compound the errors present from localized site biases. With 89 per cent of the stations in the USHCN network having been shown not to meet NOAA's own criteria, the use data from adjacent stations to infill, adjust, or homogenize data likely results in a greater distribution of error through the network"

"The conclusion is inescapable: The U.S. temperature record is unreliable."

Warming and Cooling Periods over the last 2500 years

Roman Warming 500BC – 535 AD

Dark Ages 535AD – 900AD

Medieval Warming 900AD – 1300AD

Little Ice Age 1300AD – 1850AD

Modern Warming 1850AD - …..

Current world temperature

"No statistically significant warming over the past 15 years"
Phil Jones, Former head of East Anglica's Climate Research Unit

Carbon Dioxide/Water

"The most important players on the greenhouse stage are water vapor and clouds. Carbon dioxide has been increased to about 0.038% of the atmosphere (possibly from about 0.028% pre-Industrial Revolution) while water in its various forms ranges from 0% to 4% of the atmosphere and its properties vary by what form it is in and even at what altitude it is found in the atmosphere.

In simple terms the bulk of Earth's greenhouse effect is due to water vapor by virtue of its abundance. Water accounts for about 90% of the Earth's greenhouse effect -- perhaps 70% is due to water vapor and about 20% due to clouds (mostly water droplets), some estimates put water as high as 95% of Earth's total tropospheric greenhouse effect (e.g., Freidenreich and Ramaswamy, "Solar Radiation Absorption by Carbon Dioxide, Overlap with Water, and a Parameterization for General Circulation Models," *Journal of Geophysical Research* 98 (1993):7255-7264).

The remaining portion comes from carbon dioxide, nitrous oxide, methane, ozone and miscellaneous other "minor greenhouse gases." As an example of the relative importance of water it should be noted that changes in the relative humidity on the order of 1.3-4% are equivalent to the effect of doubling CO_2"

Steven Milloy

Which comes first, data or model?

Does coincidence prove causality?

Using retrospective data can be treacherous.

How good is your understanding of the system?

"The Sun is the primary driving force of climate.
The Sun provides Earth with a staggering amount of energy.
It drives weather, ocean currents and evaporation and provides the energy for life on Earth.
The Sun also prevents the oceans from freezing or boiling.
The solar driving and cosmic ray forcing of climate are seen globally on geological, archaeological, historical and modern time scales.

The 23 climate models of the IPCC **ignore or minimize** the role of the Sun.
All models failed to predict the cooling in the early 21st century.
None of the models predicted El Nino-La Nina events which transfer huge amounts of energy around the planet's surface"
Ian Plimer, "Heaven and Earth' pp.100-101

"The carbon cycle has been operating for at least 4000 million years and has been controlled by chemical reactions between water, air, and rocks.
It still is.
These reactions have stopped a runaway icehouse or a runaway greenhouse.

Supervolcanoes shape the Earth.
They induce extinctions, change ocean currents, change climate and add monstrous amounts of particles, CO2 and sulfur gases to the atmosphere.
Unseen submarine supervolcanoes have yet to be understood.
The loading and unloading of ice during past climate changes have been triggered by earthquakes and volcanoes.
We live in a period when volcanoes are quiet.

Orbital wobbles place the Earth at varying distance from the Sun.
Past climate changes have been influenced by orbital wobbles but the trigger for climate change and the influence of the Earth's orbital changes are not yet understood."

Ian Plimer "Heaven and Earth" pp.148-149

How well does your model do on predictions?

The IPCC has called upon climate models to support its hypothesis of anthropogenic global warming (AGW).
The claim is that the global mean temperature can be adequately simulated by combining the effects of greenhouse gases, aerosols, and such natural influences as volcanoes and solar radiation.

Close examination reveals that this so-called agreement is little more than an exercise in 'curve fitting' with the use of several adjustable parameters.

Current climate models can give a Climate Sensitivity (CS) of 1.5 degrees C to 11.5 degrees C for doubling of atmospheric CO2.
The wide variability is derived mainly from choosing different physical parameters that enter into the formation and disappearance of clouds.
The values of these parameters, many related to clouds, are simply chosen by 'expert opinion.'

Computer models do not consider solar dimming and brightening

Computer models do not accurately model the role of clouds

Computer models do not simulate a possible negative feedback from water vapor.

Computer models do not explain many features of the earth's observed climate.

Computer models cannot produce reliable predictions of regional climate change.

Conclusion : The climate models used by the IPCC do not depict the chaotic, open-ended climate. They cannot make reliable predictions and should not be used in formulating government policy.

Rising sea levels

Scientist have been forced to withdraw a study on projected sea level rise due to global warming after finding mistakes that undermine their findings

David Adam Guardian, February 21, 2010

Himalayan glaciers

Are not going to melt soon

Forty percent of the Amazon will be destroyed

Based on a report by an environmental pressure group (World Wildlife Fund)

Extreme weather related events

Chemical Engineering

Heat and Mass transfer

Unstready state

Evaporation rates and cloud formation

Competing forces of evaporation, convection, precipitation, and radiation create an energy balance in the climate system.

Heat sinks

The ocean currents transfer huge amounts of heat.
They are driven by wind and this is, in turn, driven by the Earth's rotation.
Changes in the shape of the shoreline, the Earth and the ocean floor can change currents.
The cool dense bottom currents of the ocean show that the Earth is far cooler than in past times.

The origin of El Nino is poorly understood.
Despite El Nino events being one of the greatest transfers of surface energy on Earth, they cannot be predicted by computer models.
El Nino events are not factored into models of future climate.

The oceans and the atmosphere are non-linear, chaotic and turbulent systems from bottom to top. We try to understand such systems with incomplete computer models

Material sinks

Carbon Distribution

Air - 800 billion tons
Oceans - 39,000 billion tons
Surface Rocks - 65,000,000 billion tons

The oceans store a vast amount of dissolved CO2 and the amount of CO2 in the air is correlated with global sea surface temperature.
A huge but unknown amount of CO2 is added to ocean water from submarine volcanoes.
The CO2 that is dissolved in ocean water is exchanged with and cycles through the atmosphere, life, soils, and rocks.
The oceans continually remove dissolves CO2 by shell formation, limestone formation, and chemical reactions with rocks and sediments.
The more CO2 dissolves in the oceans, the more CO2 is removed.
Water drives the carbon cycle.

Many of the major sources and sinks of carbon are ignored by the IPCC.

Properties of materials

Water
Carbon Dioxide
Henry's Law

Greenhouse gas – water vs. carbon dioxide

Given the present composition of the atmosphere, the contribution to the total heating rate **in the troposphere** (the portion of the atmosphere of most interest -- it is the region from the surface to basically the top of the active weather zone) is around **5% from carbon dioxide and around 95% from water vapor**.

However, **in the stratosphere**, the contribution is **about 80% from carbon dioxide and about 20% from water vapor**, although this makes a relatively small contribution to total greenhouse effect.

Comments from Skeptics

Ian Plimer, author of "Heaven and Earth"

> ***"We live in a time when the methodology of science is suspended. Reactions to human-induced global warming based on incomplete science can be extraordinarily costly, will distort energy policy, and make the poor poorer…in the case of the effect of carbon dioxide on climate, the correct solution to the non-problem of carbon dioxide is to have the courage to thoughtfully do nothing."***

Another Skeptic – Astrophysicist Nir Shariv

2 Feb 07 - Astrophysicist Nir Shariv, a prolific researcher and one of Israel's top young scientists, no longer accepts the logic of man-made global warming. "Like many others, I was personally sure that CO2 is the bad culprit in the story of global warming. But after carefully digging into the evidence, I realized that things are far more complicated than the story sold to us by many climate scientists or the stories regurgitated by the media.

Dr. Shariv's digging led him to the surprising discovery that there is no concrete evidence -- only speculation -- that man-made greenhouse gases cause global warming. Even research from the Intergovernmental Panel on Climate Change is bereft of anything here inspiring confidence.

Final Conclusion

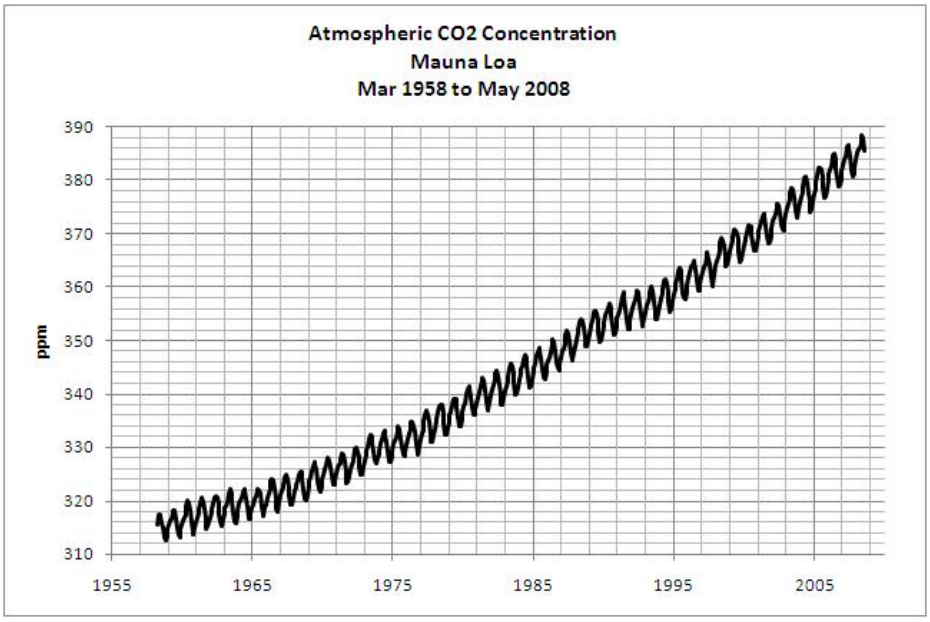
"As water vapor is the main greenhouse gas – huge amounts of energy are locked into oceans and large amounts of energy are transferred in the melting and evaporation. Compared to water – carbon dioxide is a trace gas in the atmosphere and is a minor component in the atmosphere and hydrosphere systems

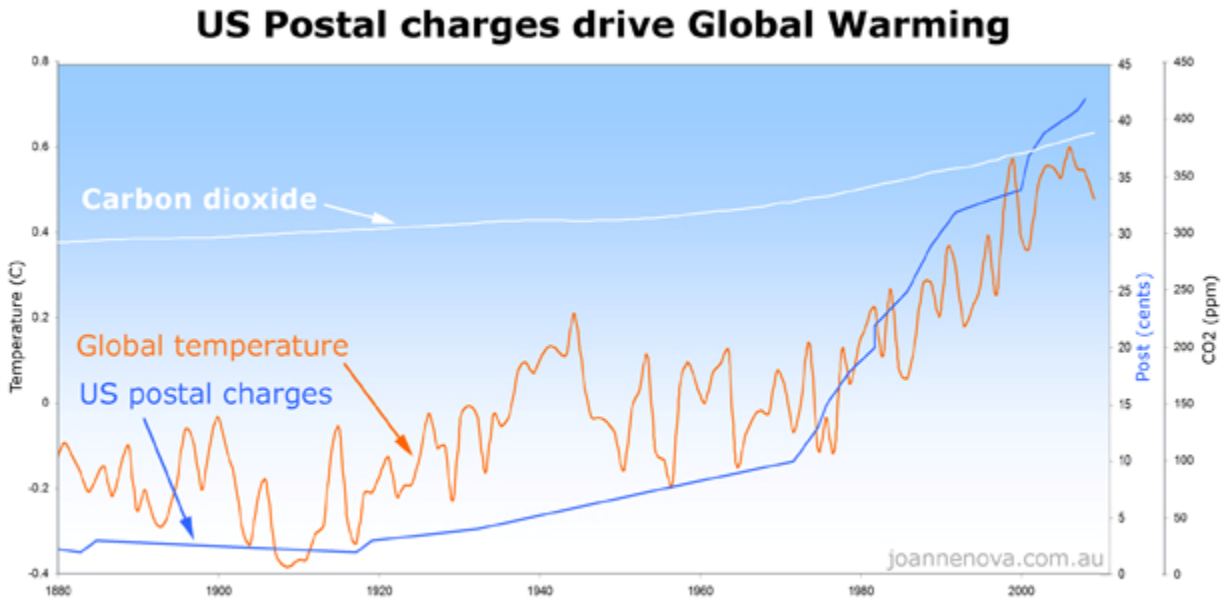
The carbon cycle is essentially driven by solar energy via the water cycle.

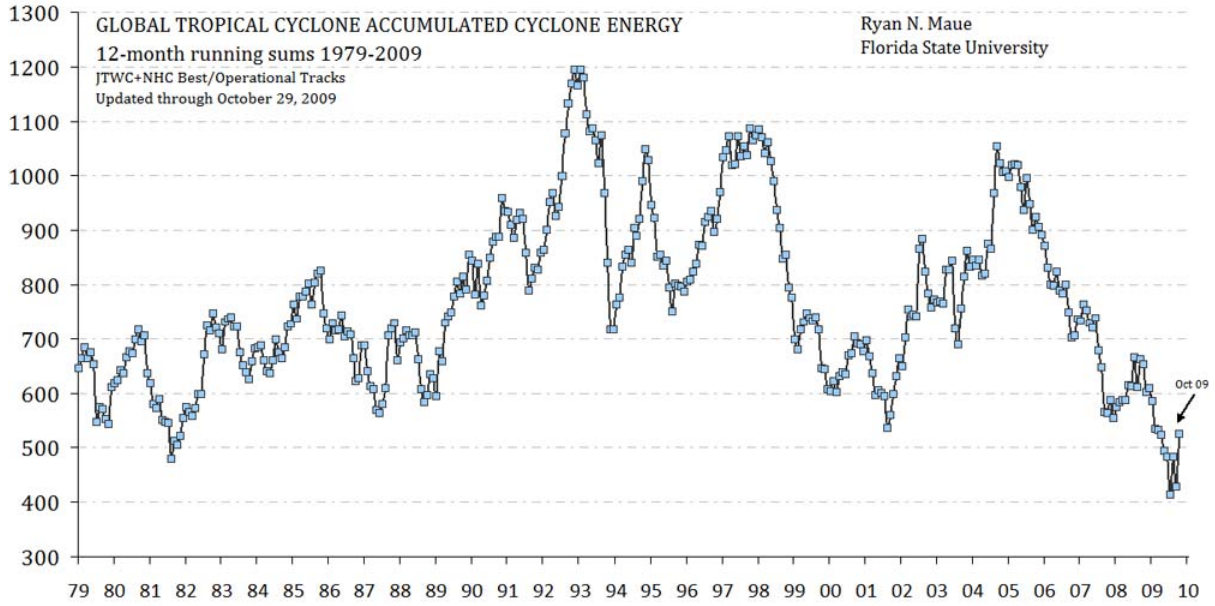
Contrary to popular belief – the carbon cycle does not control climate.
It is the water cycle that does and water vapor is the main greenhouse gas in the atmosphere.
Terrestrial water vapor fluxes represent one of the largest movements of mass and energy in the Earth's outer sphere – yet the relative contributions of non-biological water fluxes and those that are regulated solely by the physiology of plants is not well known."

Ian Plimer, "Heaven and Earth"

Appendix


Atmospheric CO2 Concentration
Mauna Loa
Mar 1958 to May 2008
ppm
390
380
370
360
350
340
330
320
310
1955
1965
1975
1985
1995
2005


US Postal charges drive Global Warming
Carbon dioxide
Global temperature
US postal charges
Temperature (C)
Post (cents)
CO2 (ppm)
joannenova.com.au
1880
1900
1920
1940
1960
1980
2000



The Earth has an average surface temperature of about 15C.
The tropics are some 10C degrees warmer.
In the atmosphere CO2 is a highly effective trap of energy in the infra-red wavelength of 14 to 16.5 microns – blocking the escape of heat radiation with wavelengths in this range reduces the radiating efficiency of the Earth by 15%.

If the atmosphere had no CO2 far more heat would be lost from Earth and the average surface temperature would be -3C.

The efficiency of the CO2 trap is essentially insensitive to the amount of CO2 in the atmosphere – all the CO2 does is slow down heat loss.
Atmospheric CO2 does not trap heat as insulation does.

If the current atmospheric CO2 content of 380ppmv were doubled to 760 ppmv, there would be a miniscule impact on the radiation balance and the temperature – an increase in air temperature of 0.5C is likely. This is hardly catastrophic!

Furthermore, the effects of the additional CO2 would be completely masked by other climate drivers such as the Sun and the Earth's orbit – and there would be great benefits derived from accelerated plant growth.

Heaven and Earth p366

Ignorance and Mistaken Hypotheses

If we want to operate in a complex system – we have to know not only what its current status is but what its status will be or could be in the future.
And we have to know how certain actions we take will influence the situation.

For this we need 'structural knowledge" – knowledge of how the variables in the system are related and how they influence one another.

The totality of such assumptions in an individual's mind – assumptions about the simple or complex links and the one-way or reciprocal influences between variables – constitutes that individual's 'reality model'.

A reality model can explicit – always available to an individual in a conscious form, or it can be implicit –with an individual himself unaware that he is operating on a certain set of assumptions and unable to articulate what those assumptions are.
Implicit knowledge is quite common (we usually call it intuition).

An individual's reality model can be right or wrong, complete or incomplete.
As a rule it will be both incomplete and wrong. – one would do well to keep that probability in mind – but that is easier said than done!!

People are most inclined to insist that they are right when they are wrong and when they are beset with uncertainty.
It happens that people prefer their incorrect hypotheses to correct ones and will fight tooth and nail rather than abandon an idea that is demonstrably false.
The ability to admit ignorance or mistaken assumptions is indeed a sign of wisdom and most individuals in the thick of complex situations are not, or not yet, wise.

Excerpted from "The Logic of Failure" (Recognizing and Avoiding Error in Complex Situations) by Dietrich Dorner, Perseus Books 1996

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