Climate Change
Water we worried about?

No Models.
No Predictions.
Just a simple collection of data facts and the one thermodynamic implication that should be understood by all.

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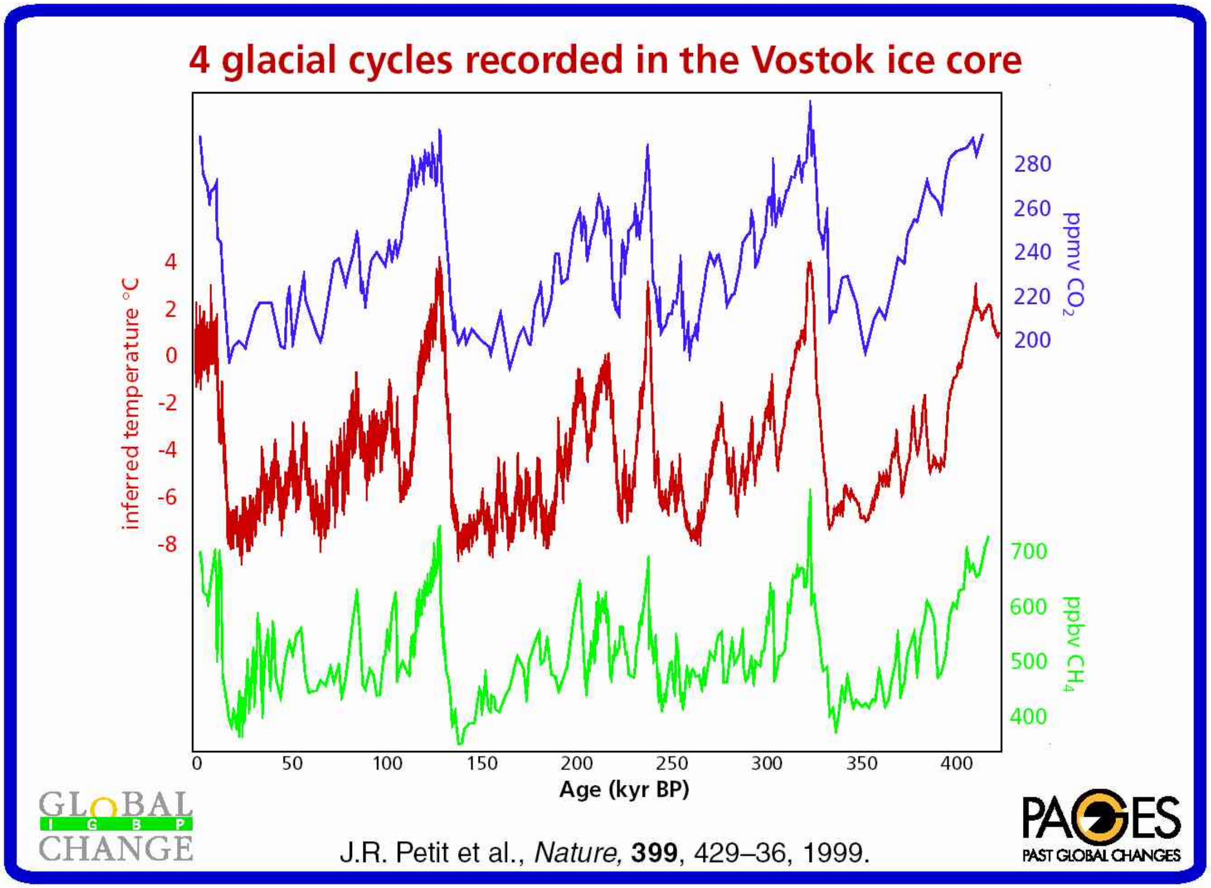
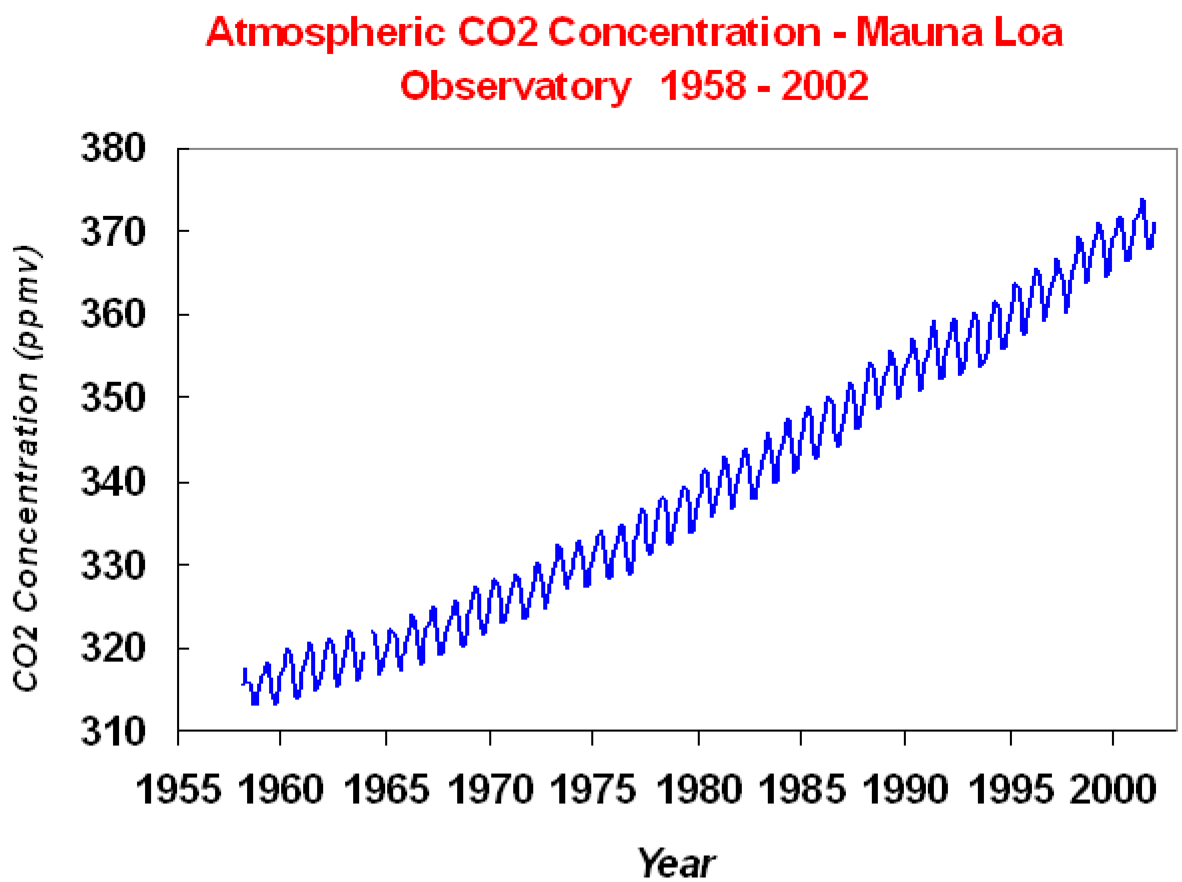


Message #1: Earth has been in a steady 100,000-yr cycle of glaciation and recession for at least the last half-million years. The coming and going of "ice ages" on Earth is no mystery. This steady pattern results from the Milankovitch Cycles, the most significant of which is the 100,000-yr Eccentricity Cycle of the Earth's elliptical path around the sun. The blue and green data are real data from gas bubbles trapped in Antarctic ice that has been cored and analyzed. The Vostok ice coring project is complete; the total core length was over 3 kilometers long. As the reader can see, CO2 ranged over the last half million years between 200 -300 ppm.

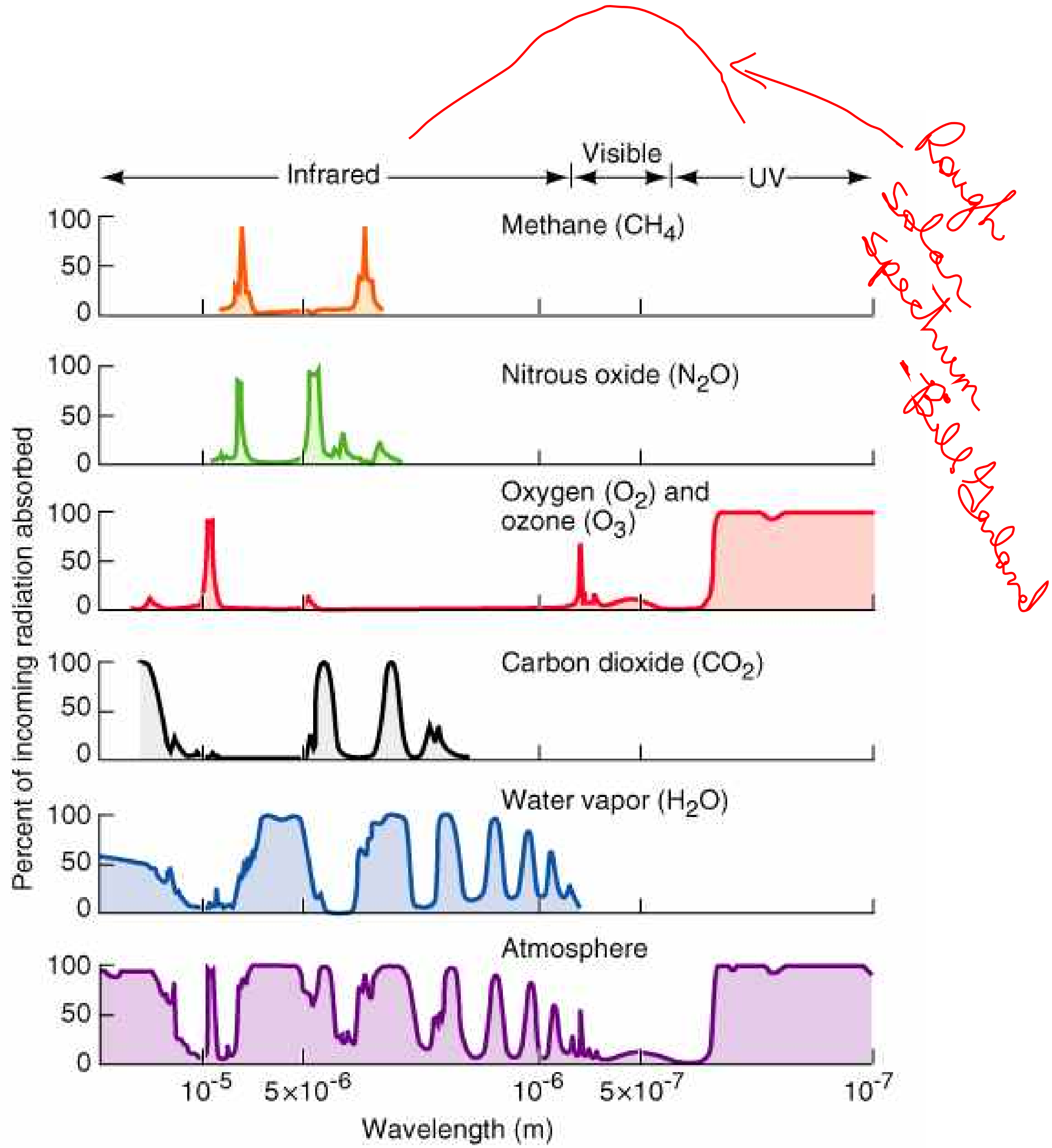


Message #2: Modern man has taken carbon dioxide above its known, recent natural range of 200 – 300 ppm due to the combustion of fossil fuels. As of 2005 we are approaching 380 ppm, a level that is 25-30% over the natural CO_2 maximums of the last half-million years.

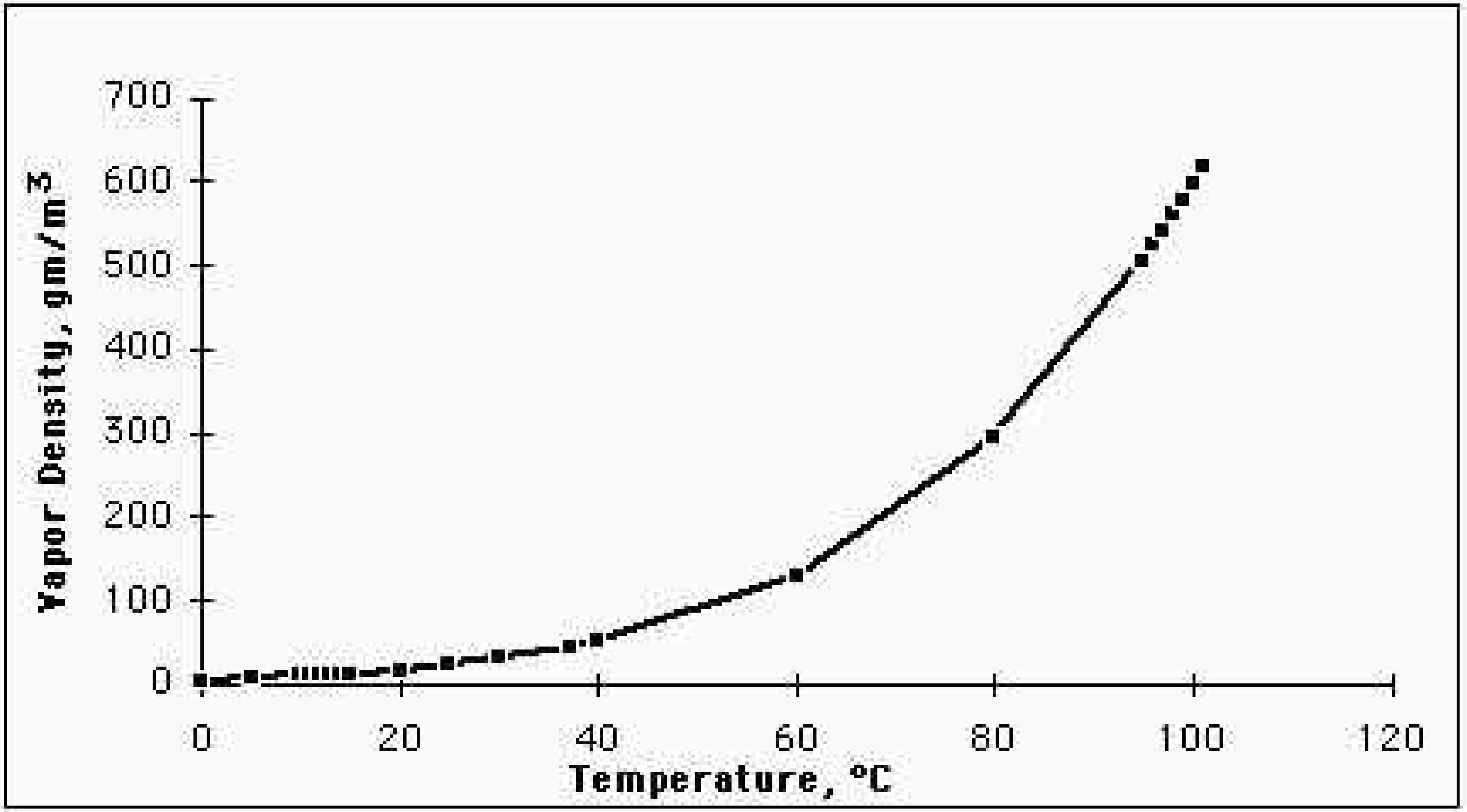
Message #3: CO2 does absorb and re-emit IR (i.e., heat) around a specific and unique IR wavelength (centered at 4E-6 m) at which most other greenhouse gasses do not absorb and re-emit. CO2 is a few percent of the overall greenhouse effect.

Message #4: More CO2 can only mean ***a little more*** heat is being trapped at λ = 4E-6 m than would have been trapped without more CO2. It is an obvious fact.

Message #5: Water vapor is the primary "greenhouse gas." Water, both as vapor and as clouds (providing a blanket effect), provides most of the Earth's essential greenhouse effect. As seen in the data to the right, water vapor is certainly the primary greenhouse gas.



Saturation Mass Density of Water Vapor in Air



Message #6: A look at basic equilibrium thermodynamics for water vapor. Warmer air holds more water vapor before reaching saturation than cooler air can hold. Still warmer air can hold yet more water vapor. The equilibrium thermodynamics of the relationship between dry air and water vapor enables warmer air to stably contain more water vapor.

Message #7: Review of CO_2 facts.

We know anthropogenic fossil fuel use has increased atmospheric CO_2 levels outside the CO_2 range that had been seen on Earth for the immediately previous half-million years.

CO_2 is a lesser but undeniable greenhouse gas.

It can only be a fact that a small amount of additional heat energy is being trapped in our atmosphere due to the additional CO_2 than would have been trapped without that additional CO_2.

If we have a 25-30% increase in a greenhouse gas that is a few percent of the total greenhouse gas effect, we might reasonably approximate that we have an increase on the order of one percent in overall greenhouse effect.

Is that additional percent significant all by itself? Some would argue that it is not. They are probably correct.

However, the situation is somewhat more complicated . . .

Message #8: Anthropogenic CO2 is adding about a percent in overall greenhouse effect. Recall now that water vapor is the primary greenhouse gas. Water, as both vapor and cloud, represents most of the overall greenhouse effect. And recall the basic equilibrium thermodynamic behavior of water vapor, i.e., that slightly warmer air can hold more water vapor. In series then: anthropogenic CO2 is trapping a little more heat and, therefore, slightly warming the system, slightly warmer air can hold more water vapor, more water vapor does trap more heat, more trapped heat does warm the air, warmer air can hold more water vapor, more water vapor traps more heat, more heat warms the air, etc. etc. etc. . . .

This is the **positive water vapor feedback** of Earth's atmosphere.

It is "positive" because it is self reinforcing. Warmth begets vapor which begets warmth which begets vapor etc.

Thus, the climate change problem is not really about the additional heat that the additional CO2 can cause to be trapped all by itself. **The climate change problem is about what water vapor can do in response.**

The Earth's atmosphere is very well mixed. With the oceans as a source, water vapor in the Earth's atmosphere is certainly not source limited. Equilibrium thermodynamics usually reign in any well-mixed system that is not source limited.

Message #9: The bigger, longer-term balance.

Global average water vapor saturation in the Earth's troposphere is about 50%; some air is dry, some air is fully saturated, some columns of air are rising and producing condensation through adiabatic cooling, elsewhere dry air masses are moving offshore and beginning the process of re-absorbing water vapor from the oceans; all together, the average level of water vapor content in this ocean-source, well-mixed system is about 50% relative saturation. As the Earth accumulates a little additional warmth because of the additional greenhouse gas effect from anthropogenic CO2, how will water vapor respond? Is there any reason why the 50% average saturation would not be maintained? That is the main question puzzling climate modelers. Assumptions on this matter are the reason for varying climate model predictions. Hypotheses like the "Iris Theory" (i.e., that increased water vapor leads to increased tropospheric cloud cover which leads to reduction in incoming solar insolation, the system operating naturally like the iris of an eye) have been postulated. Clouds are an interesting case as they serve both a blanket role, adding to the overall greenhouse effect, and a reflector role. We just don't have enough experience or data history to know how the water vapor system will respond.

If there is some degree of positive water vapor feedback, how far can it proceed? Can it become a complete runaway? The answer to the second question is a fairly confident "no." It is generally believed that the system can not run away. The paleoclimatalogical record includes rapid warming events (e.g., the Permian-Triassic boundary) in the past that always stabilized. The P-T transition, and several others in Earth's history, seem relatively wide to be bounded by an Iris-type theory. Mechanical responses are believed capable of eventually reversing the thermodynamics-based warming. These responses are 1. tropospheric dust, smoke and soot loading from a dry surface providing additional condensation nucleii which aids precipitation and 2. that moisture moves from a warmer, moister troposphere to the stratosphere and forms a relatively stable stratospheric ice fog. Such an ice fog would reflect would-be incoming solar insolation and bring cooling. The stratospheric ice fog event is basically the Iris Theory on steroids and moved up to the stratosphere. The high ice fog would be slower in initial response, much longer lasting and slower in decline. The stratospheric ice fog-based cooling could be significant in its own right; it could be as deep or deeper than recent ice ages. Such a deep cooling would also eventually reverse as reduced solar insolation leads to reduced tropospheric mixing. The cooler, lesser-mixed upper troposphere would dry and begin drawing moisture back from the stratosphere. There is a balance. Mechanical responses limit thermodynamic drivers to warming while thermodynamics (the dry troposphere drawing moisture back from an icy stratosphere) reverses cooling.

In conclusion, the Earth's atmosphere is a complex system dominated by water vapor. How warm Earth will get due to anthropogenic CO2 emissions will be determined by the water vapor response. Thermodynamics of water vapor seem favorable to some degree of self-sustaining warming. The primary mechanical response(s) that could or would eventually reverse the thermodynamic forcing have been identified. The system might maintain itself in a relatively amiable range through cloud-based, iris-like effects. We should hope for such. Alternatively, water vapor might drive a warming to the point of creation of a more extreme stratospheric ice fog. How hot could it get? How cold can it get in a stratospheric ice fog reversal? On what time scales? How will such forcings be timed to coordinate with or work against the Milankovitch Cycles to be either exacerbated or muted? Are we starting a perturbation that might have amplitudes of oscillation outside the range that modern humans could survive en masse? Possibly. Are we starting events that could lead to conditions that are significantly outside the range of experience of our ancestors? Possibly. Large climate shifts such as the P-T transition are usually also moments of significant global extinction.