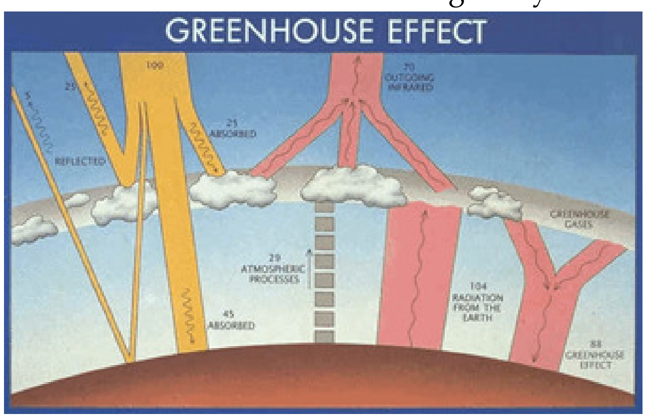
Radiative Equilibrium or Radiative Poppycock?
by Alan Siddons, August 2008

What animates global warming concerns is an imaginary law of physics called "radiative equilibrium". Energy out must equal energy in, this “law” says. Which does sound plausible on the face of it. In this view, however, if the light emitted by a heated object is suppressed in some way, its radiant energy will increase past the level of radiant input until it breaks through the barrier... in obedience to this “law”.

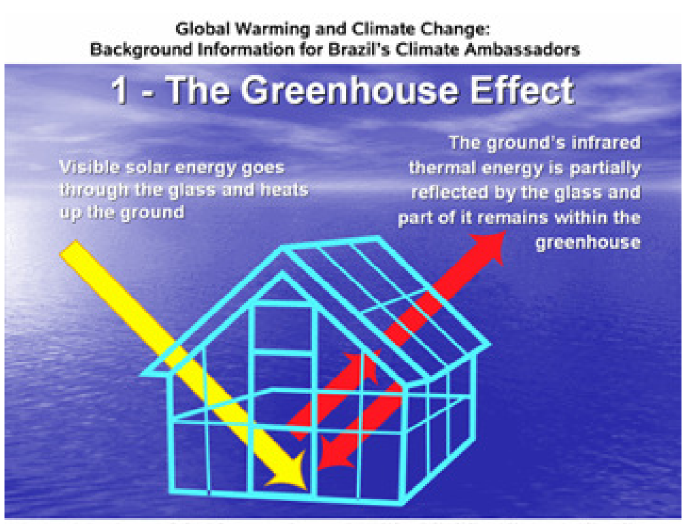
This notion originates from a long-ago misconception about how glass greenhouses work, thus the family name this "effect" goes by. It was believed that glass blocked the passage of "dark radiation" (infrared) and kept storing energetic photons inside it. Once those photons had accumulated enough power to overcome the glass barrier, radiative equilibrium was achieved. So this is the scenario: sunlight enters, heat is generated and dark light is emitted. This dark light is amplified because of the blockage and finally exits at the same magnitude as the entering sunlight. But only after the light "trapped" inside has raised the greenhouse's temperature. Since the barrier will keep raising the temperature until the barrier is broken, increasing the barrier's strength will get you any amount of internal heat you want. (If only that were true…)

It is 19th century poppycock. And here’s a telltale sign of it: Why do you always see a "layer of greenhouse gases" depicted *overhead* in illustrations about the “greenhouse effect”, when in fact these molecules are at their densest concentration right at your feet?



What these illustrations show you is the theory's genetic lineage. That "layer of greenhouse gases" is merely a pane of greenhouse glass in another guise. ***There is no such “layer”***.

It started from a misconception about glass nearly 200 years ago and has stayed that way.



In reality, greenhouses merely suppress ***convective*** heat-loss, preventing the heated air from dissipating. It is ***air*** that's trapped, not radiation; glass's response to infrared (IR) has nothing to do with it. Clear plastic bags will do just as well or even panes of polished salt crystals, which don't absorb IR at all. This is why polished salt crystals are used as windows in laboratory IR spectroscopy. Also, any infrared radiation ***absorbed*** by the glass is immediately ***re-radiated*** (scattered in all directions) by that glass — ***it does not constitute a radiative barrier.***

Thermal Infrared image of a house, clearly showing radiation passing through glass windows.

PLEASE NOTE: *None of what is described below actually occurs in reality.*

Bigelow Laboratory for Ocean Sciences
In a greenhouse, visible light (e.g., from the Sun) easily penetrates glass or plastic walls, but heat (in the form of infrared radiation) does not. The greenhouse effect refers to the physical process by which atmospheric gases allow sunlight to pass through but absorb infrared radiation thus acting like a blanket trapping heat.
http://www.bigelow.org/virtual/handson/greenhouse_make.html

The U.S. government's Environmental Protection Agency
The energy that is absorbed is converted in part to heat energy that is re-radiated back into the atmosphere. Heat energy waves are not visible, and are generally in the infrared (long-wavelength) portion of the spectrum compared to visible light. Physical laws show that atmospheric constituents—notably water vapor and carbon dioxide gas—that are transparent to visible light are not transparent to heat waves. Hence, re-radiated energy in the infrared portion of the spectrum is trapped within the atmosphere, keeping the surface temperature warm. This phenomenon is called the "greenhouse effect" because it is exactly the same principle that heats a greenhouse http://www.epa.gov/ne/students/pdfs/activ13.pdf

Fort Lewis College, Colorado
This partial trapping of solar radiation is known as the greenhouse effect. The name comes from the fact that a very similar process operates in a greenhouse. Sunlight passes relatively unhindered through glass panes, but much of the infrared radiation reemitted by the plants is blocked by the glass and cannot get out. Consequently, the interior of the greenhouse heats up, and flowers, fruits, and vegetables can grow even on cold wintry days.
http://physics.fortlewis.edu/Astronomy/astronomy%20today/CHAISSON/AT307/HTML/AT30702.HTM

Glass is transparent to sunlight, but is effectively opaque to infrared radiation. Therefore, the glass warms up when it absorbs some of the infrared radiation that is radiated by the ground, water, and biomass. The glass will then re-radiate this heat as infrared radiation, some to the outside and some back into the greenhouse. The energy radiated back into the greenhouse causes the inside of the greenhouse to heat up.
http://www.planetconnecticut.org/teachersadministrators/pdfs/lesson1.pdf

United Nations Framework Convention on Climate Change
Greenhouse gases make up only about 1 per cent of the atmosphere, but they act like a blanket around the earth, or like the glass roof of a greenhouse -- they trap heat and keep the planet some 30 degrees C warmer than it would be otherwise.
http://unfccc.int/essential_background/feeling_the_heat/items/2903.php

NASA
The "greenhouse effect" is the warming of climate that results when the atmosphere traps heat radiating from Earth toward space. Certain gases in the atmosphere resemble glass in a greenhouse, allowing sunlight to pass into the "greenhouse," but blocking Earth's heat from escaping into space.
http://www.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/green.htm

NASA
Why is this process called "The Greenhouse Effect?"
Because the same process keeps glass-covered greenhouses warm. The Sun heats the ground and greenery inside the greenhouse, but the glass absorbs the re-radiated infra-red and returns some of it to the inside.
http://www-istp.gsfc.nasa.gov/stargaze/Lsun1lit.htm

Light passes through the glass into the greenhouse and heats things up inside the greenhouse. The glass is then opaque to the infrared energy these heated things are emitting, so the heat is trapped inside the greenhouse.
http://home.howstuffworks.com/question238.htm

NASA
A real greenhouse is made of glass, which lets visible sunlight through from the outside. This light gets absorbed by all the materials inside, and the warmed surfaces radiate infrared light, sometimes called "heat rays", back. But the glass, although transparent to visible light, acts as a partial barrier to the infrared light. So some of this infrared radiation, or heat, gets trapped inside.
http://www-airs.jpl.nasa.gov/News/Features/FeaturesClimateChange/GreenhouseEffect/

Dept of Atmospheric and Oceanic Science at the University of Maryland
A real greenhouse is enclosed by glass walls and ceilings. Glass is highly transparent in the visible wavelengths of the sun, so sunlight freely passes into the greenhouse. However, glass is highly absorbing in the infrared wavelengths characteristic of emission by earth's surface. Therefore, the infrared radiation emitted by the surface is efficiently absorbed by the glass walls and ceiling, and these surfaces, in turn, radiate energy back into the interior of the greenhouse, as well as outward to the environment. But clearly, a large portion of the infrared radiation from the surface does not pass outward from the greenhouse, and the equivalent energy is contained within the greenhouse environment.
http://www.atmos.umd.edu/~owen/CHPI/IMAGES/grnhs1.html

Greenhouse gases like water vapour, carbon dioxide, methane and nitrous oxide trap the infrared radiation released by the Earth's surface. The atmosphere acts like the glass in a greenhouse, allowing much of the shortwave solar radiation to travel through unimpeded, but trapping a lot of the longwave heat energy trying to escape back to space. This process makes the temperature rise in the atmosphere just as it does in the greenhouse. This is the Earth's natural greenhouse effect and keeps the Earth 33°C warmer than it would be without an atmosphere, at an average 15°C. In contrast, the moon, which has no atmosphere, has an average surface temperature of -18°C.
http://www.enviropedia.org.uk/Climate_Change/Greenhouse_Effect.php

University of Alaska-Fairbanks, Physics Department
Greenhouse gases act as a blanket
Some of you may wonder how a green house takes solar energy and turns it into thermal energy. A good example of this is something you can observe every day in the summer in you own car. It happens when you leave you car in a sunny parking lot with the windows up. The solar energy is passing through the glass and is heating the cars interior. What's really happening is the short wave infrared waves are going in and are turning into long wave infrared waves, which cannot escape.
http://ffden-2.phys.uaf.edu/102spring2002_Web_projects/C.Levit/web%20page.html

Web Site Funded by the U.S. Agency for International Development with the assistance of Canada International Development Agency
On a clear day, most of the energy arriving from the sun in a form of short wave length radiation passes through the atmosphere to warm the earth's surface. This energy must be got rid of to maintain the earth's energy balance. It escapes in the form of longer wavelength infrared radiation. But if the infrared radiation could escape directly to space, then the earth's surface would be 30 degrees colder than it is today. It would be uninhabitable.

Fortunately, much of this infrared radiation is absorbed in the atmosphere by the so-called greenhouse gases, making the world much warmer than it would be without them. These gases act rather like the glass in a greenhouse, which allows sunlight to enter, provides shelter from the wind and prevents most of the infrared energy from escaping, keeping the temperature warm. http://www.climate.org.ua/ghg/ghgeffect.html

State of Utah Office of Education
On a global scale, carbon dioxide, water vapor, and other gases present in the atmosphere are similar to the glass in a greenhouse. Ultraviolet radiation from the sun (having a short wavelength) can pass through the glass. Once inside the greenhouse, the ultraviolet radiation is absorbed by soils, plants, and other objects. Upon absorption, it becomes infrared radiation or heat energy having a shorter wavelength. Because of this, infrared radiation cannot escape through the windows. The windows act like a large blanket in which they reradiate the infrared energy back into the greenhouse. This phenomenon naturally causes the overall temperature within the greenhouse to increase.
http://www.usoe.k12.ut.us/curr/science/core/earth/sciber9/Stand_6/html/1e.htm

G.H.P. Dharmaratna, Director General Department of Meteorology
In order to understand the greenhouse effect on earth a good place to start is in a greenhouse. A greenhouse is kept warm because energy coming in from the sun (in the form of visible sunlight) is able to pass easily through the glass of the greenhouse and heat the soil and plants inside. But energy which is emitted from the soil and plants is in the form of invisible infrared radiation; this is not able to pass as easily through the glass of the greenhouse. Some of the infrared heat energy is trapped inside; this is the main reason why a greenhouse is warmer than outside.
http://www.lankajalani.org/Publications/Paper%20-%20Impacts%20of%20Climate%20Change.doc

Weather-Climate.org
This warming effect is called the "greenhouse effect" because it is the same process as that which occurs in a greenhouse on a sunny day. The glass is transparent to short-wave radiation but absorbs the outgoing long-wave radiation, causing a rise in temperature inside the greenhouse.
http://www.weather-climate.org.uk/04.php

Eduhistory.com

The glass used for a greenhouse acts as a selective transmission medium for different spectral frequencies, and its effect is to trap energy within the greenhouse, which heats both the plants and the ground inside it. This warms the air near the ground, and this air is prevented from rising and flowing away. This can be demonstrated by opening a small window near the roof of a greenhouse: the temperature drops considerably. Greenhouses thus work by trapping electromagnetic radiation and preventing convection.

http://www.eduhistory.com/greenhouse.htm

Northwestern University, Evanston, Illinois

Overview: Carbon Dioxide is identified as "greenhouse gas" because of its ability to trap heat within earth's environment. ...Explain that the greenhouse effect works in a somewhat similar -- but not entirely the same -- way (see teacher notes and background supplement sheet for more information). The sun's rays pass through the atmosphere and warm the surface. The earth emits some of this energy back into space (like heat from a campfire). But gases such as carbon dioxide and water vapor (in clouds) absorb much of this energy and send it back to earth. People have come to call this process the "greenhouse effect" because it reminds them of how actual greenhouses, which are made out of glass and grow plants, let the sun's rays in while trapping much of the radiation that would otherwise escape.

http://www.letus.northwestern.edu/projects/gw/pdf/C09.pdf

Remember: None of the above scenarios actually occur. Yet all believe it does ...

Atmospheric pressure, gravity and temperatures

Every planet with sufficient gravity to hold onto a substantial atmosphere shows a temperature gradient like the earth's, warmer as you approach the surface - and always far warmer than radiative physics allows. Every planet. Despite evidence now available to us, however, trace gas heating theory has a firm grip on the minds of skeptic and believer alike. Decades more look likely to pass before this 19th century conjecture is finally abandoned.

It is widely believed that without the "greenhouse effect" our planet's near-surface temperature would be about **-**18° Celsius, so we have "greenhouse gases" to thank for an average of +15°C instead. Water vapor, carbon dioxide and other such trace gases all combine to raise the air's temperature 33 degrees C.

But is this true?

Actually, all we're going on are these few facts:

1) that our atmosphere is warmer than radiant energy calculations predict, and

2) that the air contains trace gases that react to infrared.

So we have assumed that these two things must be related.

Real world evidence challenges that assumption, however. With 1 bar being the earth's air pressure at sea level, the graph below depicts temperature changes between 0.1 and 1 bar of pressure on earth and five other planets.

In the graphic below, most figures are from NASA's *Planetary Fact Sheets*

http://nssdc.gsfc.nasa.gov/planetary/planetfact.html

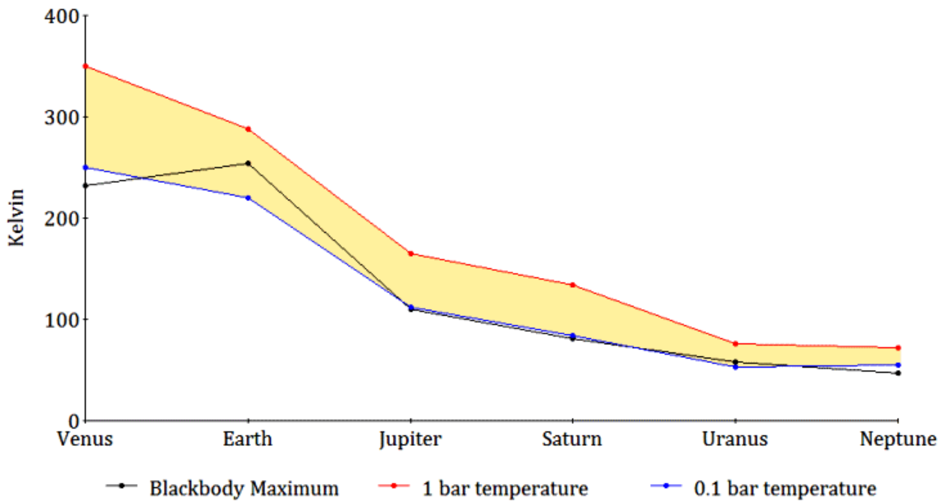


Chart 1: Atmospheric pressure vs Planetary Temperatures

So from 0.1 to 1 bar...

Venus rises 100°C.
Earth rises 68°.
Jupiter rises 53°.
Saturn rises 50°.
Uranus rises 23°.
Neptune rises 17°.

Yet...
Venus receives 2,614 watts per square meter from the sun.
Earth receives 1,368 watts from the sun.
Jupiter receives 50.5 watts from the sun.
Saturn receives 14.9 watts from the sun.
Uranus receives 3.7 watts from the sun.
And Neptune receives a piddling 1.5 watts from the sun.

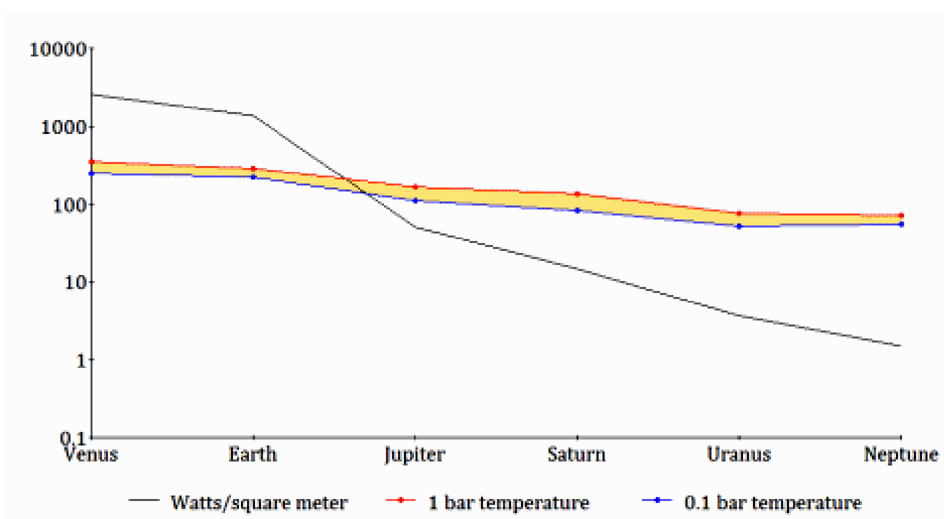


Chart 2: Solar irradiance vs Planetary Temperatures

The solid grey line shows the solar irradiance each planet receives, expressed in Watts per square meter. Notice in particular that although it collects **only 1.5 Watts per square meter** — 0.058% of what Venus receives — Neptune's atmosphere, at a mere one bar of pressure, manages to raise the planet to 154% of the temperature that a purely radiative (blackbody) model would predict.

What trait do these planets share? Just the presence of an atmosphere dense enough to reach 1 bar of pressure. Jupiter's enormous pressure doesn't stop there. It continues until the temperature is *far higher* than Earth's - and it also does this with hydrogen and helium, which are not greenhouse gases. Measurements indicate that Saturn, too, having only 15 watts to deal with compared to Earth's 1,368, falls short of Earth by only 15 degrees.

The ***rate*** of heating is an intriguing feature here. For instance, Earth climbs from 220 Kelvin to 288K, making for a rate of 1.3K (288/220), while Saturn goes from 84 to 134, a rate of 1.6. A planet's overall density appears to be a key factor, for comparing 1 bar heating rates to densities relative to Earth reveals an inverse relationship.

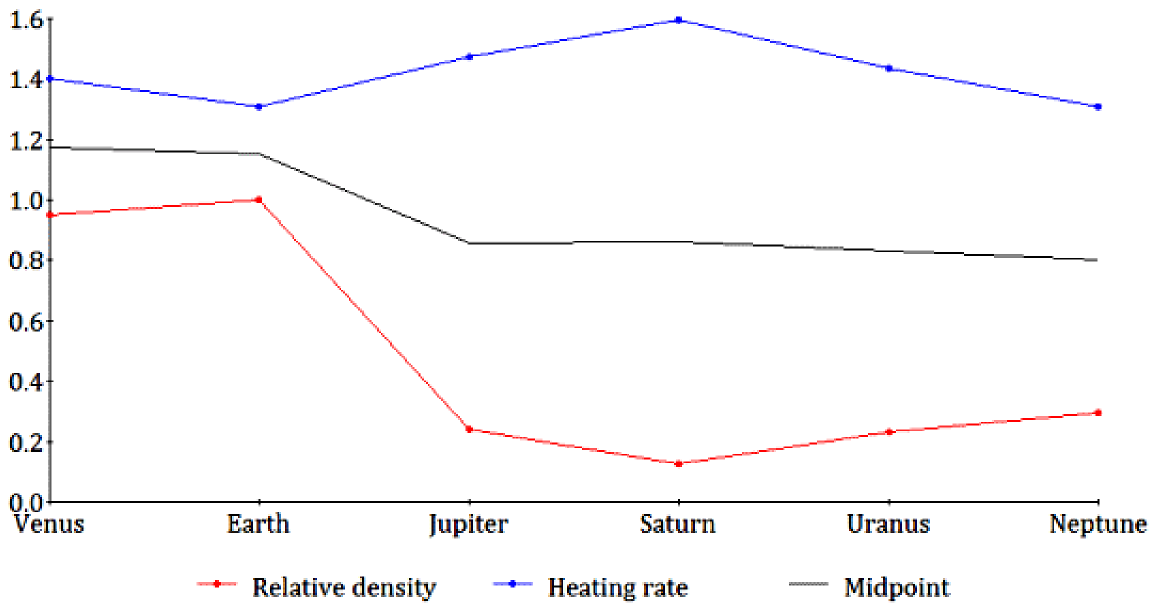


Chart 3: Planetary heating ratios of gas to solid/liquid

It seems, as a general rule, that the greater the ratio of gas to solid and liquid, the greater the heating rate. But it should also be pointed out that the rates for Earth and Neptune are identical. Loss of solar energy does play a role, as the falling midpoint line suggests.

Conclusion

One last detail about the first chart. Notice that ***in every case*** the temperature of a planet even at **1** earth-atmosphere is higher than a blackbody temperature prediction. The reason for this discrepancy seems obvious. A blackbody equation only calculates for **radiant** energy; it ignores the inherent thermal impact of an atmosphere. How such heating is accomplished is a matter of conjecture at this stage of our understanding. Possibly gas expansion on the sunlit side of a planet and contraction on the shadow side inducing an atmospheric pumping effect that gets convection currents going; thus cool descending air — encountering pressure — will acquire a higher temperature, the result that always occurs when gases are compressed.

But by whatever means atmospheric pressure due to gravity generates heat by itself, the observational evidence clearly indicates that it does, without the need for so-called "greenhouse gases" or the magical "re-radiation" of earth's IR from carbon dioxide.

Venus	Earth	Jupiter	Saturn	Uranus	Neptune	
2,613.9	1,368	50.5	14.9	3.71	1.51	Irradiance
231.7	254.3	110	81.1	58.2	46.6	Blackbody
350	288	165	134	76	72	1 bar
250	220	112	84	53	55	0.1 bar
100	68	53	50	23	17	Delta
1.40	1.31	1.47	1.60	1.43	1.31	Rate of rise

Post-script: Water vapour - a greenhouse gas?

Dry air is cheaper to heat than moist air, thus clearly indicating that moist air gives up its retained heat more easily. This has been pointed out before and is the principle behind our bodies sweating to try and cool down. It's a heat-loss mechanism because water vapor ***absorbs*** and ***releases*** heat quite readily. Shifting this principle to an industrial context gives you steam engines, of course. Thinking that ***heat absorption*** implies ***insulative trapping*** is backwards thinking and quite breathtaking in its implications.

Most of the warming in the climate models comes from the assumption that water vapor and precipitation increase as temperatures warm, a strong positive feedback. Water vapor is a far more important greenhouse gas than CO_2. However, that assumption has been shown in observations and peer-reviewed research to be wrong, and in fact water vapor and precipitation act as a negative feedback that reduces any small greenhouse warming from carbon dioxide. http://www.energytribune.com/articles.cfm?aid=970

So what does all this mean? Put it together. It means that contrary to advertised, water vapor is a major "***anti-greenhouse gas***" — a term that has to be put in quotes because assuming that carbon dioxide is in any way a warming agent is also wrong, as is the whole "science of radiative forcing."

Not only will the trace gases need more energy to reach the same temperature as the air that contains them, they will radiate it in all directions instantly and at the speed of light and thus increase the efficiency of the air mass in cooling it, not warming it, in line with the first and second laws of thermodynamics.

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