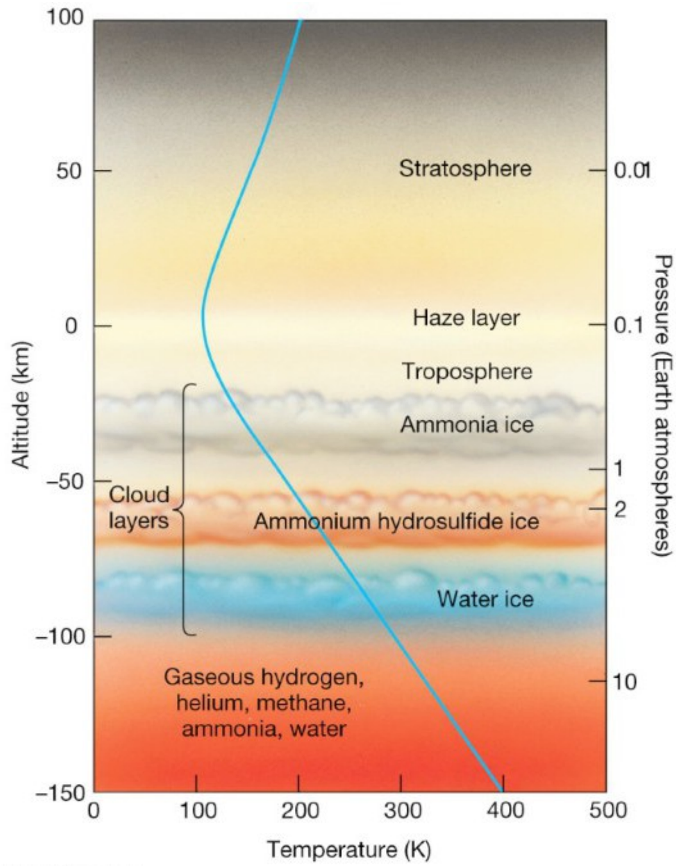
Is this the Greenhouse Effect at work?

Early in the 19th century, scientists began to speculate that the Earth, surrounded by the frigid vacuum of space, was habitable because its atmosphere contained special molecules like CO_2 and water vapor, molecules that can absorb heat rays emanating from the Earth and thereby trap its heat. That the Earth was warmer than one might expect was apparently confirmed when Kirchhoff's blackbody concept was adopted. Today it is considered a matter of course that the Earth's blackbody temperature is minus 18° Celsius, i.e., around 255 Kelvin, whereas its average temperature is 288 Kelvin. By the early 20th century, this temperature disparity started to be called The Greenhouse Effect.

NASA lists the predicted blackbody temperatures for the planets in our solar system at *Planetary Fact Sheets*. What's intriguing, though, is that through the efforts of NASA and other such agencies, we now have some insight into the atmospheres of these other solar system bodies.

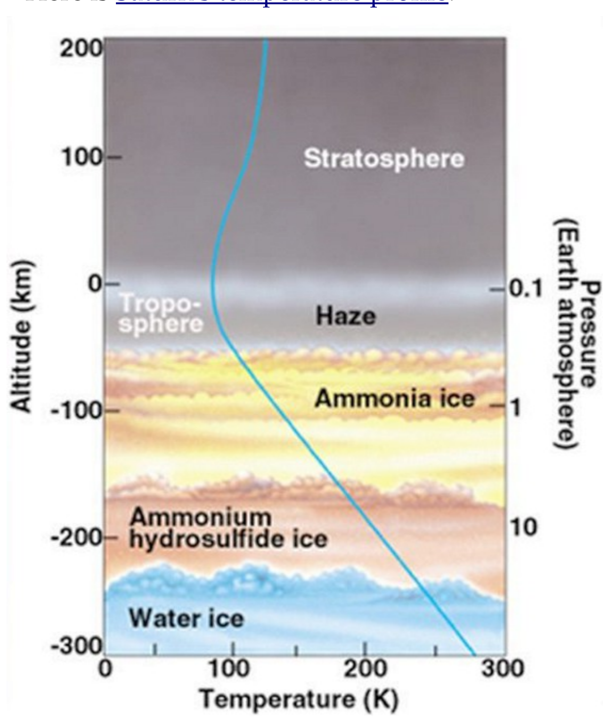
Here, for instance, is the atmospheric temperature profile for Jupiter.



Beginning around 1/10th the air pressure of the Earth at sea level, Jupiter's atmospheric temperature rises and easily exceeds its predicted blackbody temperature of 110 Kelvin. Notice as well that at 1/10th pressure, the atmosphere's temperature comes very close to the predicted 110 Kelvin.

Is this temperature increase with pressure the greenhouse effect at work?

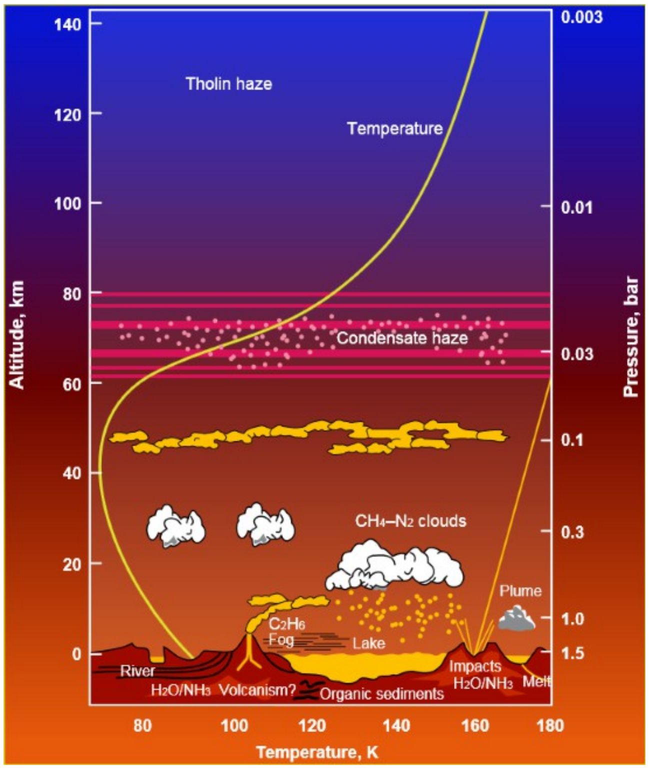
Here is Saturn's temperature profile.



At 0.1 bar, atmospheric temperature increases with pressure. And that temperature exceeds the blackbody prediction of 81 K for Saturn.

Is that the greenhouse effect at work?

Here is the atmospheric temperature profile for Saturn's moon Titan.



"Tholin haze" in this chart refers to the interaction of solar ultraviolet with Nitrogen and Methane molecules in Titan's upper atmosphere. This thick haze has a shadow effect on temperatures below, thus engendering progressive cooling with atmospheric depth – until a heating regime commences at 1/10th bar and proceeds to increase with pressure.

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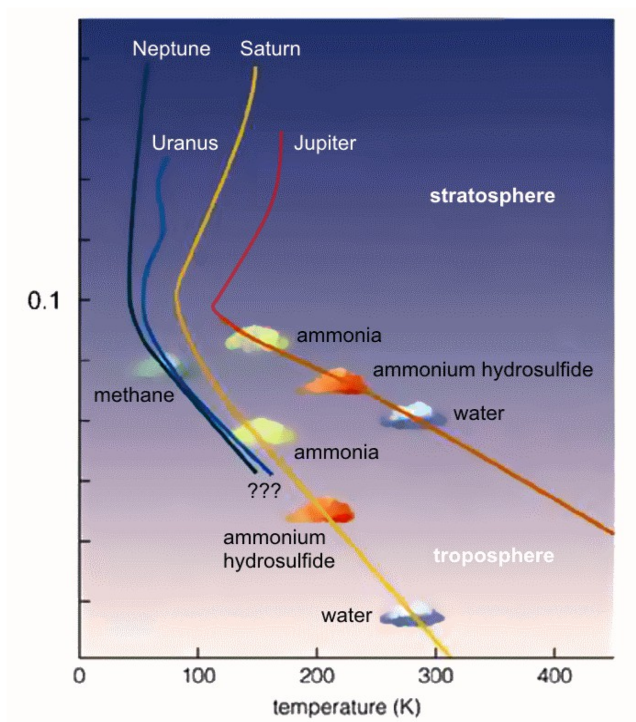
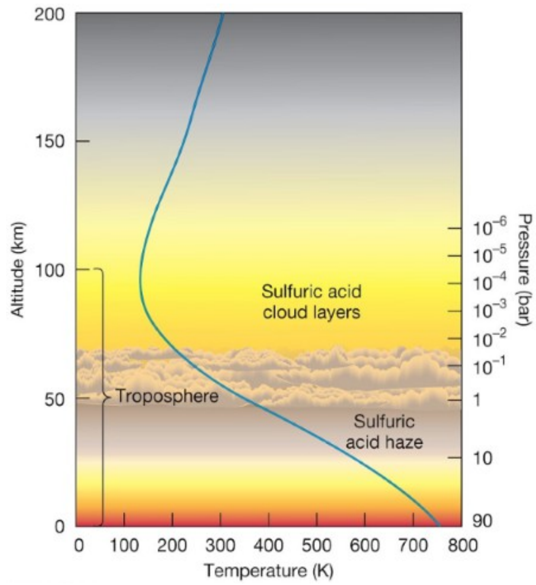
The next temperature profiles include Uranus and Neptune.



Beginning around 1/10th the pressure of the Earth at sea level, atmospheric temperature rises along with pressure and in both cases exceeds the blackbody prediction of 58.1 K and 46.6 K respectively.

Is that the greenhouse effect at work?

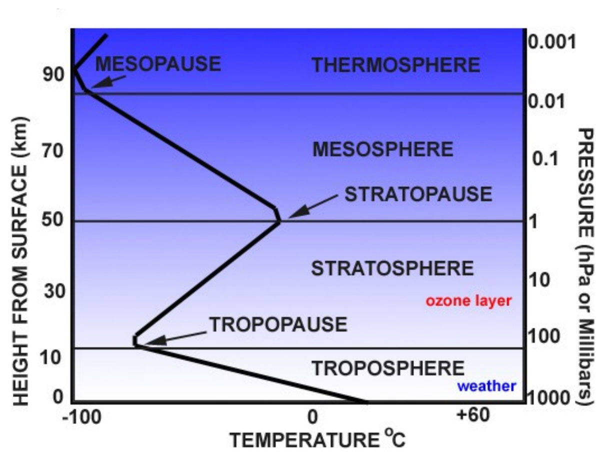
Here's the temperature profile for Venus.



In this case there's an exception to the rule of a temperature increase beginning around 1/10th of our sea level pressure. Perhaps this owes to weak stratospheric absorption, which allows the lower atmosphere's temperature to get more of a "running start" – as distinct from Titan's profile. Nevertheless, at a certain point atmospheric temperature rises along with pressure and far exceeds NASA's blackbody prediction of 226.6 Kelvin for Venus.

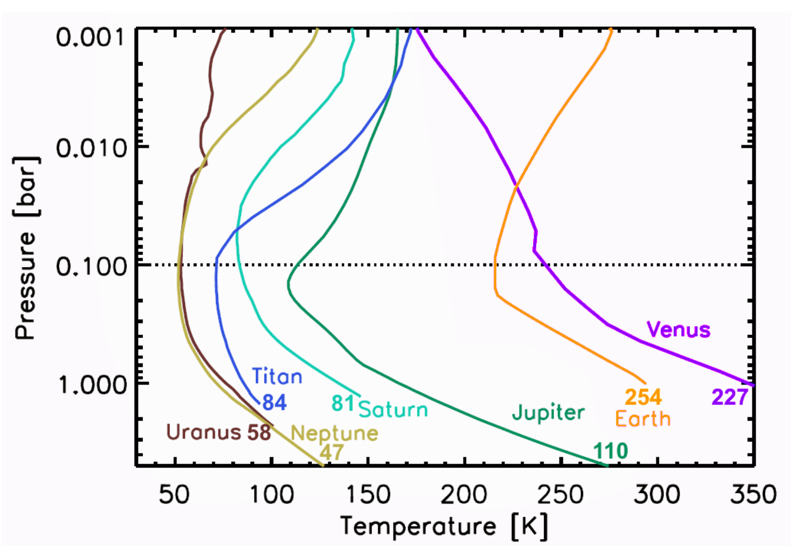
Is that the greenhouse effect at work?

Here's the temperature profile for Earth.



As usual, a temperature increase begins around 1/10th of sea level pressure and proceeds to exceed the 254 Kelvin blackbody prediction for the Earth.

Is that the greenhouse effect at work?



Summary

This chart is taken from the paper *Common 0.1 bar Tropopause in Thick Atmospheres Set by Pressure-Dependent Infrared Transparency*, by Tyler D Robinson of NASA and David Catling. I've inserted the blackbody prediction for each body so that you can compare it to actual temperatures at that pressure point. For example, Venus is 'supposed' to be 227 Kelvin but is 350 Kelvin at one atmosphere.

Since NASA's *Fact Sheets* provide no blackbody prediction for Titan, I extrapolated one myself, based on its albedo and solar irradiance at Saturn's distance. At any rate, you can see the pattern that emerges. To quote the NASA report,

> A minimum atmospheric temperature, or tropopause, occurs at a pressure of around 0.1 bar in the atmospheres of Earth, Titan, Jupiter, Saturn, Uranus and Neptune, **despite great differences in atmospheric composition**...

My emphasis. While the authors offer a few nods to the role of so-called greenhouse gases, it appears that the principal function of these gases is to impede the pressure-heating regime that's initiated at 0.1 bar. Titan's atmosphere, for instance, consists of a large quantity of greenhouse gases like ethane and methane. Yet its absorptive tholin stratosphere interrupts so much solar energy that Titan's final surface temperature suffers from what is called an "anti-greenhouse effect" – ironically brought about by "greenhouse gases". As we've seen already, the opposite kind of stratospheric scenario seems to prevail for Venus.

If scientists of the past had known that the temperature of ***every*** planet with a sufficient atmosphere rises along with atmospheric pressure, and ***always*** exceeds its predicted temperature, do you think they would have come up with a theory that attributed extra heating to the presence of certain trace gases that occupy less than 1 percent of the Earth's atmosphere? No, of course not. Yet today that old trace-gas heating construct has taken root so firmly that contrary evidence goes ignored.

Such obstinacy is clearly the Greenhouse ***Theory*** at work.

Alan Siddons