Like Earth, Titan has a greenhouse effect. So does Venus, a whopping one, and so does Mars. Venus is the queen of the greenhouse effect. Ninety-nine point nine percent of the energy reaching the surface of Venus is retained by the greenhouse effect. Titan, though, comes in a close second. Ninety percent of the energy at the surface of Titan is held in by the greenhouse effect. On Earth it's about 60 percent, and on Mars it's down to 30. On Earth, Venus and Mars, the greenhouse effect is due to CO2 and water. Titan's greenhouse effect is the only one that's not from CO2; it's from nitrogen and methane. And that's kind of curious.

A greenhouse effect is due to optical properties of an atmosphere. It occurs when an atmosphere lets sunlight in and blocks infrared radiation from escaping. It's like an ideal blanket. An ideal blanket would let heat in and not let heat out. For Earth, heat in means sunlight and heat out means thermal radiation. Water and CO2 have those properties. They are clear in the visible - you can see right through water with visible radiation - but if you were looking in the infrared, water would be black. And so water and CO2 are greenhouse gases, and that causes the Earth to be warm. Without our atmosphere, if the Earth just sent out what it go it, the temperature on the Earth, instead of being plus 15 Celsius (59 Fahrenheit), would be minus 15 Celsius (5 Fahrenheit), which would be quite cold. Humans are altering the greenhouse effect, but there's also a greenhouse effect that's natural to this planet. And it lets light in and stops infrared radiation.

On Titan, the gases that are holding in the thermal radiation are nitrogen, methane and hydrogen. You might not think that nitrogen, methane and hydrogen would produce a greenhouse effect because they're symmetrical molecules. The greenhouse effect, it's infrared absorption, is due to non-symmetrical molecules. So then why do these gases have a greenhouse effect on Titan? They don't on Earth. Only the non-symmetrical molecules, like CO2 and H2O have a greenhouse effect, because they have a permanent dipole moment. Well, what happens on Titan the atmosphere is so dense that the molecules collide often, and when they collide, they get induced dipole moments, and they absorb during those collision events. This is kind of technical, but it illustrates how we can see something on another world that we would not see here on Earth. Since Titan's so cold and its atmosphere is so thick, the effect is 25 times larger on Titan than it is on Earth. We learn a lot about our atmosphere and our greenhouse effect by studying one that's completely different.

Even more interesting is that Titan is the only world in the solar system that has an anti-greenhouse effect. A greenhouse effect lets light in and stops infrared. But imagine a layer that stopped light from getting in and let infrared out, sort of an anti-blanket. Sort of like Gore-Tex. Gore-Tex lets water out, but not in. An anti-greenhouse effect does the same thing to heat. It lets heat out but doesn't let it in. And the haze on Titan
Today we call it the anti-greenhouse effect. People used to call it the "nuclear winter" effect. They think that if there was a nuclear war, the soot in the upper atmosphere would have the same properties as the haze on Titan. And people also think that a huge impact that killed the dinosaurs did it this way, by putting into the atmosphere this big load of soot that had an anti-greenhouse effect. We've never seen one and we don't wish to make one on this planet, but it's interesting to see a world that has one. Titan's the only one that does.

We can build a computer model of Titan that lets us simulate turning the haze up and down. If we turn the haze all the way down, the temperature skyrockets to a balmy 105 Kelvin (minus 168 C, minus 271 C), and if we turn the haze up, the temperature drops way down. So that's what controls the temperature. The anti-greenhouse effect on Titan is half as strong as the greenhouse effect. If there was no greenhouse effect, Titan's temperature would be 82 Kelvin. (minus 191 C, minus 312 F) The greenhouse effect would raise it to 105 Kelvin. The anti-greenhouse effect takes away half of the greenhouse effect. If we had an anti-greenhouse effect on Earth that took away half of our greenhouse effect, the average temperature of the Earth would be right at the freezing point. That would be cold.

See: Part I Part II Part IV