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The layer model

This is an algebraic calculation of the effect of an infrared (IR) absorber, a pane of glass essentially, on the mean temperature of the surface of the Earth. By solving the energy budgets of the Earth's surface and the pane of glass, the reader can see how the pane of glass traps outgoing IR light, leading to a warming of the surface. The layer model is not an accurate, detailed model suitable for a global warming forecast, but the principle of the greenhouse effect cannot be understood without understanding the layer model.

The bare rock model

The temperature of the surface of the Earth is controlled by the ways that energy comes in from the Sun and shines back out to space as IR. The Sun shines a lot of light because the temperature at the visible surface of the Sun is high and therefore the energy flux $I = \varepsilon\sigma T^4$ is a large number. Sunlight strikes the Earth and deposits some of its energy into the form of vibrations and other bouncings around of the molecules of the Earth. Neither the Earth nor the Sun is a perfect blackbody, but they are both almost blackbodies, as are most solids and liquids. (Gases are terrible blackbodies as we will learn in Chapter 4.) The Earth radiates heat to space in the form of IR light. Earth light is of much lower frequency and of lower energy than sunlight.

We are going to construct a simple model of the temperature of the Earth. The word ***model*** is used quite a bit in scientific discussions, to mean a fairly wide variety of things. Sometimes the word is synonymous with "theory" or "idea," such as the Standard Model of Particle Physics. For doctors, a "model system" might be a mouse that has some disease that resembles a disease that human patients get. They can experiment on the mouse rather than experiment on people. In climate science, models are used in two different ways. One way is to make forecasts. For this purpose, a model should be as realistic as possible and should capture or include all of the processes that might be relevant in Nature. This is typically a mathematical model implemented on a computer, although there's a nifty physical model of San Francisco Bay you should check out if you're ever in Sausalito. Once such a model has been constructed, a climate scientist can perform what-if experiments on it that could never be done on the real world, to determine how sensitive the climate would be to changes in the brightness of the Sun or properties of the atmosphere, for example.

The simple model that we are going to construct here is not intended for making predictions, but is rather intended to be a toy system that we can learn from. The model will demonstrate how the greenhouse effect works by stripping away lots of