

Waves Screen

Adjust the greenhouse gas concentration and observe the effects on the infrared waves and surface temperature. Measure the energy balance at the top of the atmosphere.

MEASURE the energy entering and exiting the the atmosphere

OBSERVE temperature qualitatively

ADJUST greenhouse gas concentration

EXPLORE atmosphere at different time periods

ADD cloud to model albedo

Photons Screen

Observe sunlight and infrared energy represented as photons. Experiment with greenhouse gas concentration, and measure the energy flux throughout the atmosphere.

MEASURE energy flux at various altitudes

SELECT temperature units

VIEW additional photons to better observe density

EXPLORE atmosphere at different time periods

Layer Model Screen

Model greenhouse gases as infrared absorbing layers. Control solar intensity, surface albedo, and infrared absorbance and observe the impact on photon behavior and the temperature.

The screenshot shows the PhET Layer Model simulation interface. The main window displays a cross-section of the atmosphere with a surface and three layers. The top layer is labeled '255.2 K', the middle layer '303.5 K', and the bottom layer '335.9 K'. The interface includes a control panel on the right with sliders for 'Solar Intensity' (set to 'Our Sun'), 'Surface Albedo' (set to 0.9), and 'Infrared Absorbance' (set to 100%). A 'Sunlight' panel shows 'Solar Intensity' and 'Surface Albedo' sliders. An 'Infrared' panel shows 'Absorbing Layers' (set to 2) and 'Infrared Absorbance' (set to 100%). The bottom panel includes 'Temperature Units' (K, °C, °F), 'More Photons', 'Energy Balance', and 'Flux Meter' checkboxes. The PhET logo is visible in the bottom right corner.

MEASURE the temperature at each layer

ADJUST solar intensity and surface albedo

ADD infrared absorbing layers to atmosphere

SELECT temperature units

CHANGE infrared absorbance

Suggestions for Use

Sample Challenge Prompts

- Describe the effect of greenhouse gases on infrared radiation and surface temperature.
- Explain how the Energy Balance changes in response to the greenhouse gas concentration.
- Measure the Energy Flux throughout the atmosphere. What factors affect the energy flux?
- Compare the behavior of the infrared absorbing layers to the greenhouse gases in the atmosphere.
- Determine all of the factors that affect the surface temperature.

Microscopic Model

- Use [Molecules and Light](#) to build a microscopic model of the greenhouse effect. Compare the behavior of greenhouse gases to other atmospheric gases.
- Use the Photon Absorption tab of the [legacy version](#) of Greenhouse Effect to build a model atmosphere and observe how infrared and visible photons interact with the molecules.

Customization Options

Query parameters allow for customization of the simulation, and can be added by appending a '?' to the sim URL, and separating each query parameter with an '&'. The general URL pattern is:

```
...html?queryParameter1&queryParameter2&queryParameter3
```

For example, in Greenhouse Effect, if you only want to include the 1st and 2nd screens (`screens=1,2`), with the 2nd screen open by default (`initialScreen=2`) use:

https://phet.colorado.edu/sims/html/greenhouse-effect/latest/greenhouse-effect_all.html?screens=1,2&initialScreen=2

To run this in Spanish (`locale=es`), the URL would become:

https://phet.colorado.edu/sims/html/greenhouse-effect/latest/greenhouse-effect_all.html?locale=es&screens=1,2&initialScreen=2

⚙ Indicates this customization can be accessed from the Preferences menu within the simulation.

Query Parameter and Description	Example Links
⚙ <code>defaultTemperatureUnits</code> - determines default temperature units, F, K, C (default).	<code>defaultTemperatureUnits=K</code> <code>defaultTemperatureUnits=F</code>
<code>screens</code> - specifies which screens are included in the sim and their order. Each screen should be separated by a comma. For more information, visit the Help Center .	<code>screens=1</code> <code>screens=3,2</code>
<code>initialScreen</code> - opens the sim directly to the specified screen, bypassing the home screen.	<code>initialScreen=1</code> <code>initialScreen=3</code>
⚙ <code>locale</code> - specify the language of the simulation using ISO 639-1 codes. Available locales can be found on the simulation page on the Translations tab . Note: this only works if the simulation URL ends in “_all.html”.	<code>locale=es</code> (Spanish) <code>locale=fr</code> (French)
<code>audio</code> - if muted, audio is muted by default. If disabled, all audio is permanently turned off.	<code>audio=muted</code> <code>audio=disabled</code>
<code>allowLinks</code> - when <code>false</code> , disables links that take students to an external URL. Default is <code>true</code> .	<code>allowLinks=false</code>
<code>supportsPanAndZoom</code> - when <code>false</code> , disables panning and zooming using pinch-to-zoom or browser zoom controls. Default is <code>true</code> .	<code>supportsPanAndZoom=false</code>

Model Simplifications

- The simulation takes time to reach equilibrium. Note that the atmosphere may reach radiative balance before the surface temperature stabilizes. For best results, allow the system to reach equilibrium before starting a new experiment.
- The simulation models the drivers of greenhouse effects, not the effects of climate change. Small changes in the concentration of greenhouse gases, however, can lead to large effects.
- The model illustrates the core concept of the greenhouse effect. It shows only two types of radiation – sunlight (visible) and infrared. It does not model wavelength-specific absorption and emission. The model does not explicitly include specific greenhouse gases. Increasing the greenhouse gas concentration increases the probability that infrared radiation is absorbed.
- When photons are absorbed by a greenhouse gas or infrared absorbing layer they will briefly disappear and reappear when emitted. When emitted, a photon has an equal probability of being directed to the surface or sent out toward space.
- We limit the direction of the emitted IR photons to make them easier to track. IR photons are roughly orthogonal to the ground when first emitted. They are randomly deflected up to 60° when emitted by the greenhouse gases or an infrared absorbing layer.

- We model the sunlight as being completely in the visible spectrum. In reality, the blackbody spectrum of the sun peaks in the visible range, but also includes infrared and other wavelengths.
- The wave representation uses stroke weight and opacity to indicate intensity. The thicker and more opaque the wave, the more intense the radiation.
- The ratio of visible to IR photons is 5:1 which is not literally accurate, but conveys the right idea.
- Haze is used as a visual indication of greenhouse gas concentration, though in reality greenhouse gases are colorless.
- The cloud is used to model albedo. The ground on the Waves and Photons screens has an albedo of 0.2. Adding the cloud will increase the albedo to 0.3 to match the average albedo of Earth.
- The cloud does not contribute any additional water vapor to the atmosphere and has no effect on the greenhouse gas concentration.
- The model is calibrated to match average surface temperatures from the given time periods. The cloud is always enabled so that the temperatures match the real average for those years.
- When providing the actual concentration of greenhouse gases during the various time periods, we do not include water vapor. Water vapor is the most abundant greenhouse gas in the atmosphere, but it is a condensable gas and its concentration depends on the temperature of the atmosphere. This makes water vapor the only greenhouse gas whose concentration increases because the atmosphere is warming, and causes it to warm even more.
- Differences in Energy Flux at different greenhouse gas concentrations or time periods will be more noticeable closer to the surface. This is because the density of greenhouse gases in the atmosphere decreases with altitude.
- On the Layer Model screen, layer temperature will not be displayed until the first photon is absorbed.
- Due to the range of solar intensity and surface albedo, there is a wider range of surface temperatures possible on the Layer Model screen.

See all published activities for Greenhouse Effect [here](#).

For more tips on using PhET sims with your students, see [Tips for Using PhET](#).