

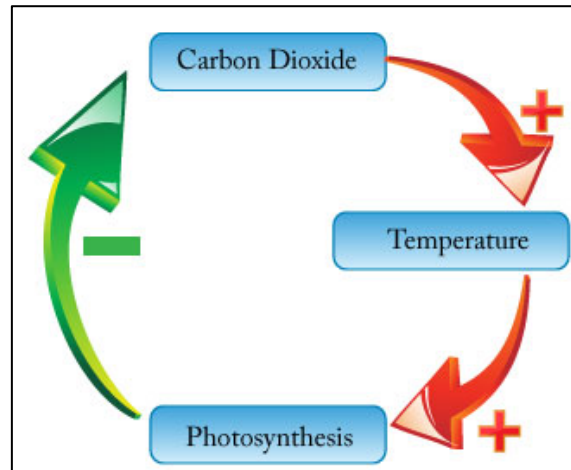
Feedback Loops

Components of Earth's climate system interact through feedback loops. Feedback loops circle from one system component through other components, and back to affect the first component. Before climate change, balancing feedback loops kept Earth's climate in equilibrium. The increase of greenhouse gases in the atmosphere has changed the balance. This significantly changes how the climate system works.

- This short video from NASA gives a clear explanation of the albedo effect, and how it can cause a reinforcing feedback loop (3:46)
<https://www.youtube.com/watch?v=cW4JTHz1aRg>

Feedbacks can be either “**reinforcing**” feedbacks or “**balancing**” feedbacks.

Balancing feedbacks dampen an effect or counteract any deviation from an equilibrium, and promote stability in the system:

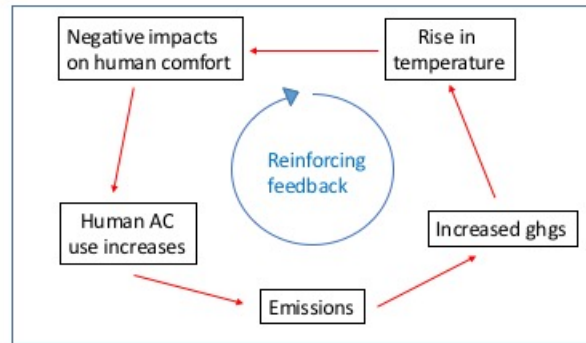


http://www.i-study.co.uk/IB_ES/IB_unit1_Environmental_systems_and_models.html

Balancing feedback: An increase in CO₂ leads to increased atmospheric temperatures. This in turn leads to higher rates of photosynthesis which results in more carbon dioxide being removed from the atmosphere. This counteracts the rise in temperature.

Note that the balancing feedback between CO₂ levels and the rate of photosynthesis only works up to a point. If it becomes too hot, plants will shut down to save water.

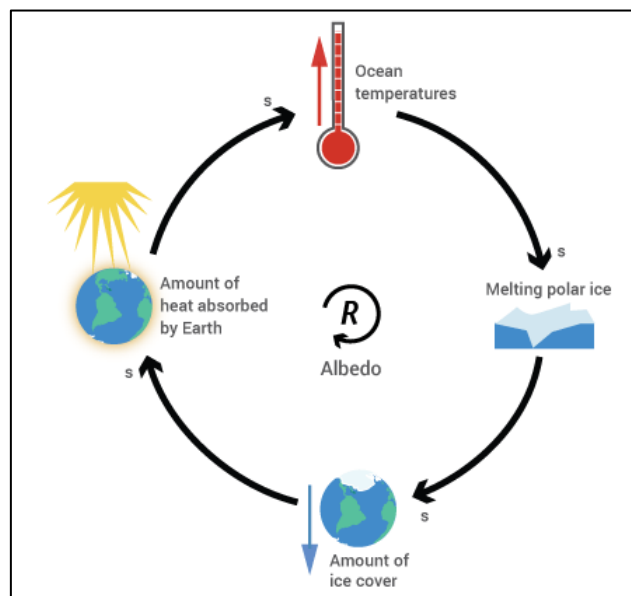
Reinforcing feedbacks strengthen an effect, as shown in the next diagram:



Reinforcing feedback: Emissions from human energy use cause a rise in greenhouse gases. This results in rising temperatures. Hotter conditions increase human discomfort. This causes humans to increase their use of air-conditioning. Increased AC use increases emissions.

The melting of land and sea ice at the poles is another example of a reinforcing feedback. A large proportion of the sunlight that hits ice bounces back to space because it is light-colored. We say that ice has a **high albedo** since it reflects a lot of the heat energy. This high albedo limits the amount of solar energy that is absorbed by the ice because a lot of the incoming energy is reflected.

As the Earth system gets warmer, the ice melts. This reveals land or water below. Both have a darker color than ice. The darker color – the lower albedo – means that less heat energy is reflected. This means that more of the sun's energy is absorbed. This leads to more warming, which leads to more ice melting – a reinforcing feedback.

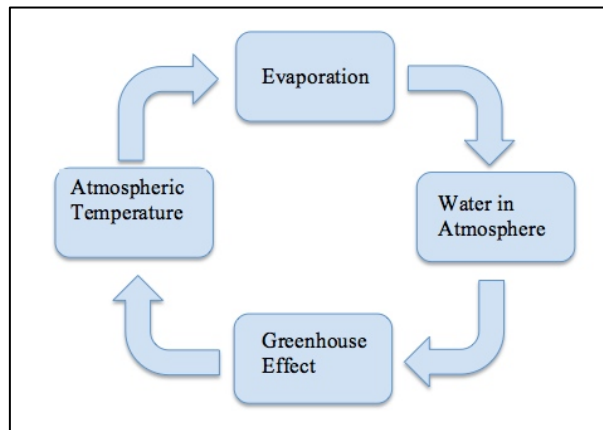


A reinforcing feedback from melting ice cover. Source: PBS

Water vapor is the most abundant greenhouse gas of all! Molecules of water vapor in the atmosphere cause another important reinforcing feedback. Warmer air can hold higher amounts of water vapor than colder air can. More water vapor in the air acts as a greenhouse gas, which causes



more heat energy to be absorbed. This leads to even higher temperatures. This is shown in the diagram below.



A reinforcing feedback from water vapor. Greater evaporation of water from land due to higher temperatures adds to water in the atmosphere. Water vapor is a greenhouse gas that absorbs solar energy, contributing to higher temperatures. Source: SERC

More information:

- How reinforcing climate feedbacks work (5:00) (Here called “amplifying” feedbacks)
<http://on.aol.com/video/how-climate-feedbacks-worsen-global-warming-516923291>