Introduction to Earth's Climate System

Basic Systems Dynamics

MODULE 2.3

2.3 Basic Systems Dynamics

Video Lesson Goals:

» Define stock, flow, and feedback.

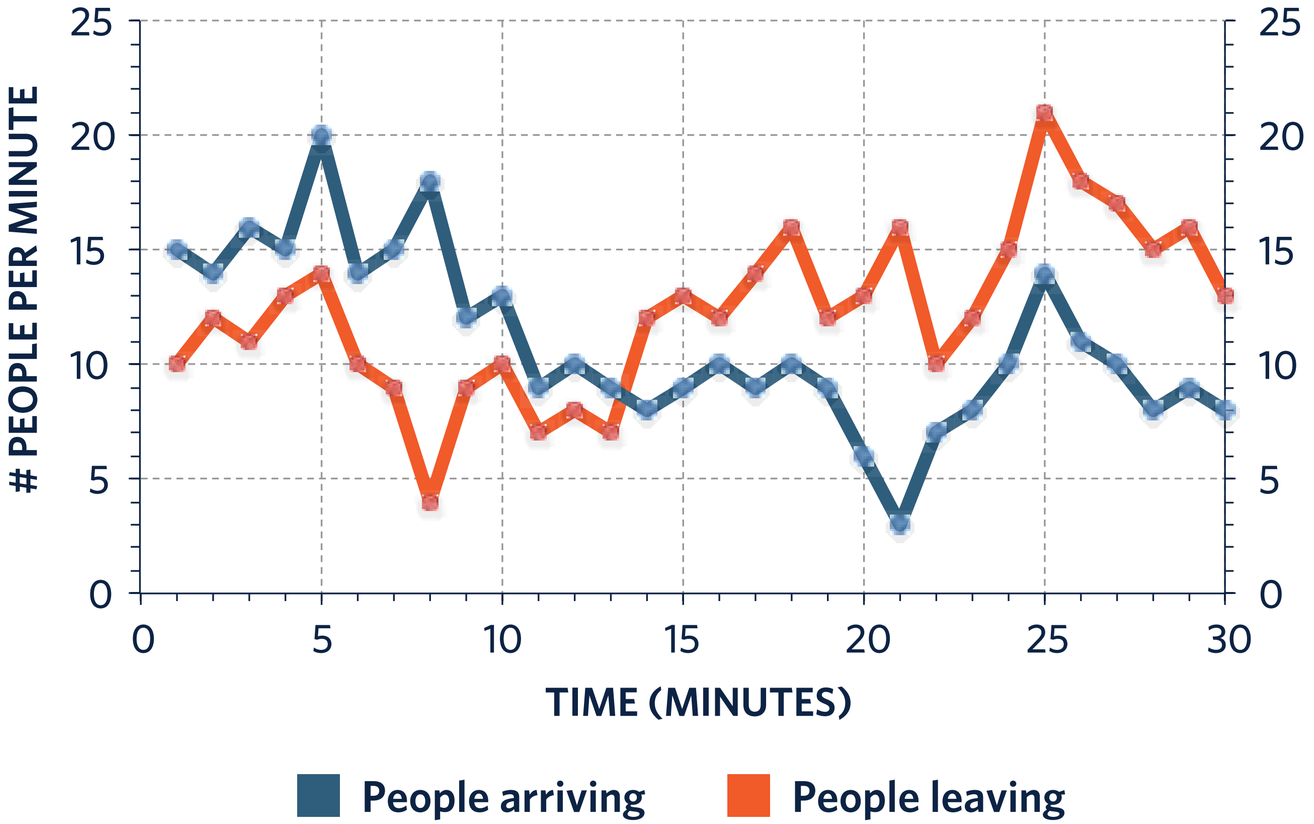
» Explain how the combined history of inflows and outflows determines a stock

» Predict what happens to stocks and flows of energy and materials when a system is perturbed

» Construct examples of both amplifying and stabilizing feedbacks

Party Dynamics

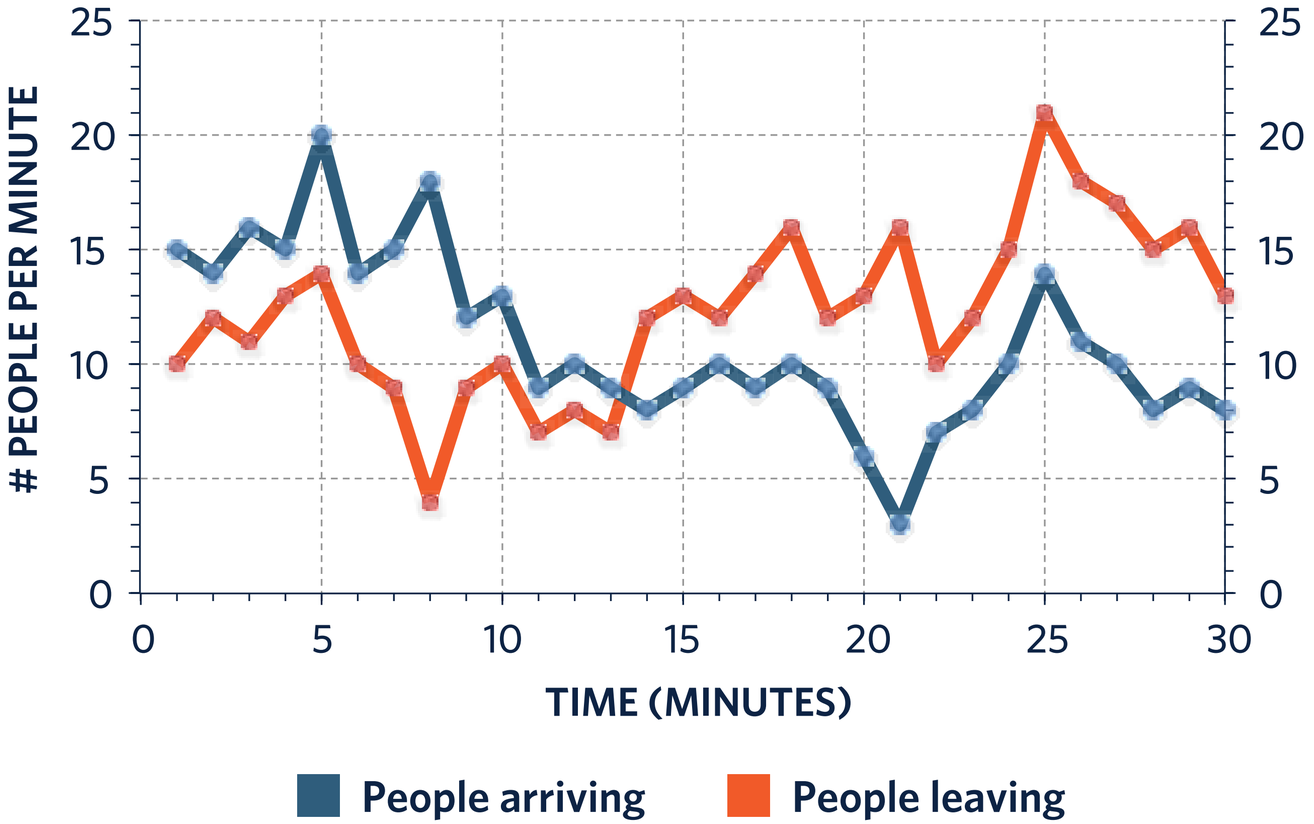
Party Dynamics:
During which minute did the most people ARRIVE?



A. Minute 5
B. Minute 8
C. Minute 13
D. Minute 25
E. Cannot be determined

AFTER CRONIN AND GONZALEZ, 2007

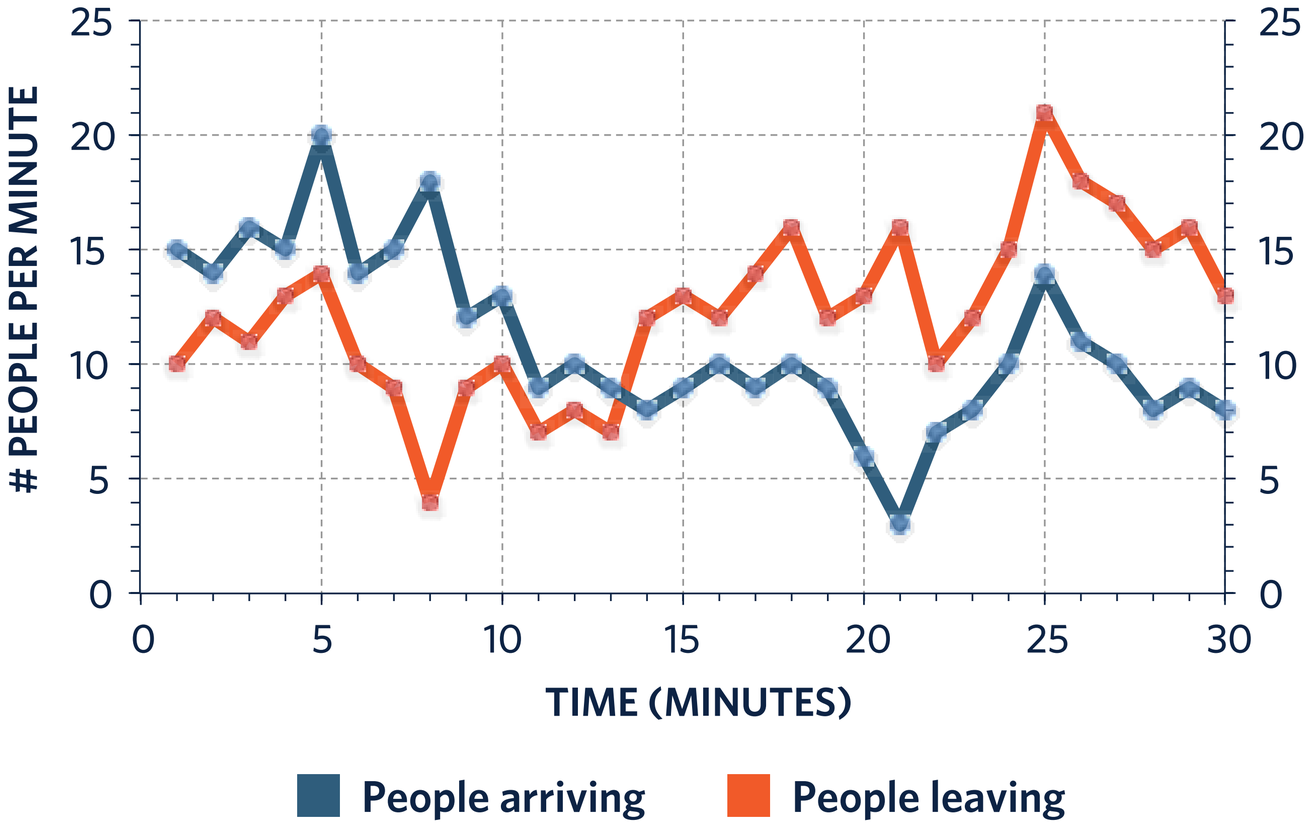
Party Dynamics:
During which minute did the most people LEAVE?



A. Minute 5
B. Minute 8
C. Minute 21
D. Minute 25
E. Cannot be determined

AFTER CRONIN AND GONZALEZ, 2007

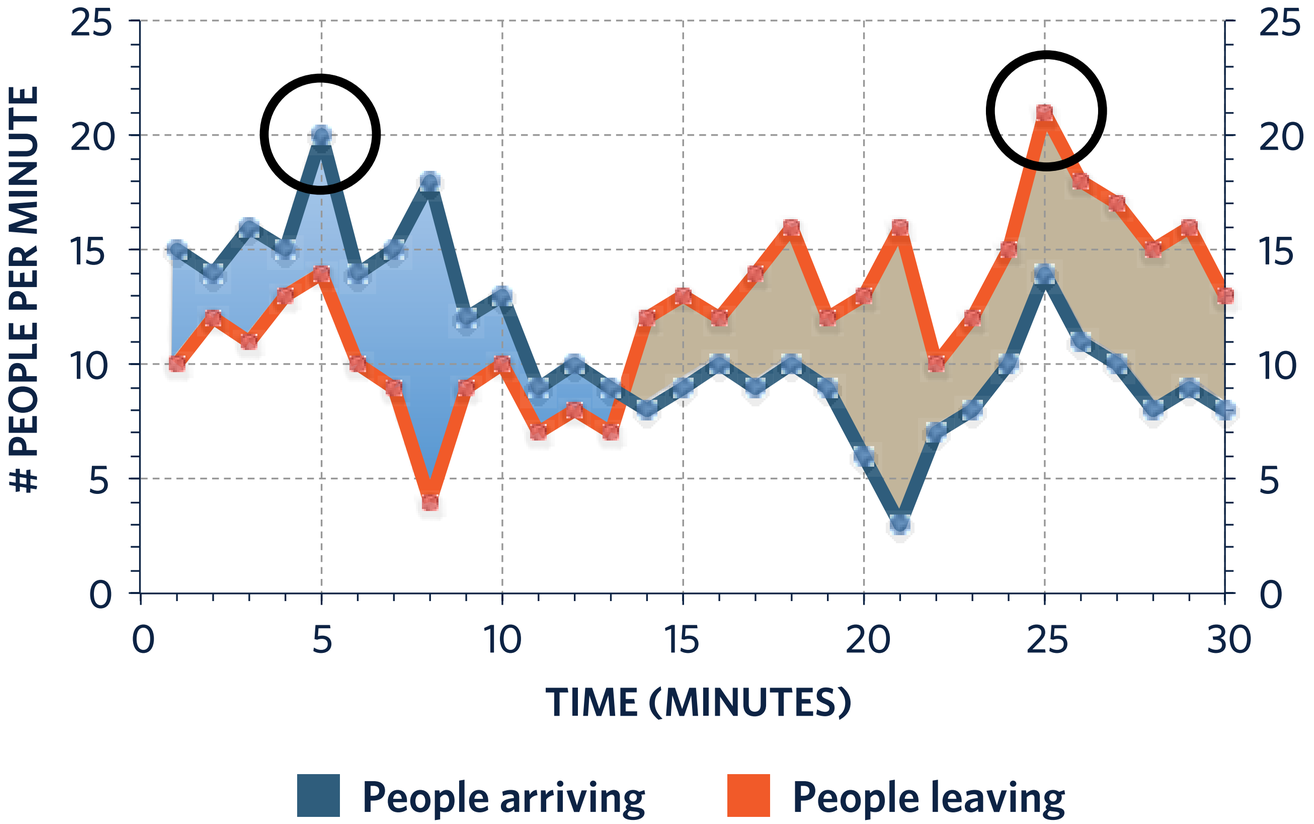
Party Dynamics:
During which minute were the FEWEST people at the party?



A. Minute 1
B. Minute 13
C. Minute 21
D. Minute 30
E. Cannot be determined

AFTER CRONIN AND GONZALEZ, 2007

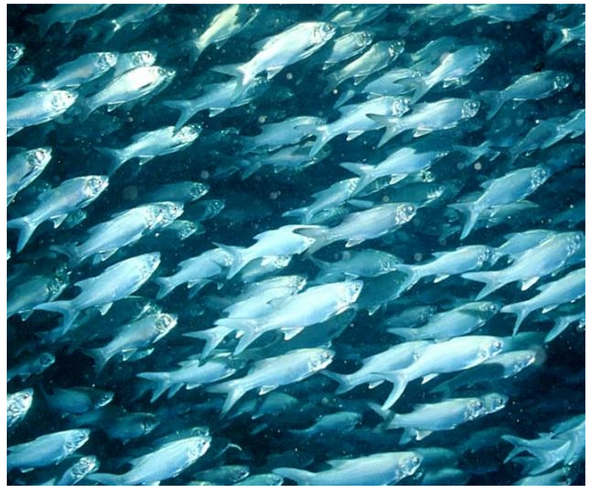
Party Dynamics



AFTER CRONIN AND GONZALEZ, 2007

Systems dynamics: Stock & Flow

STOCK: Amount or quantity of something residing in a particular place at a particular time

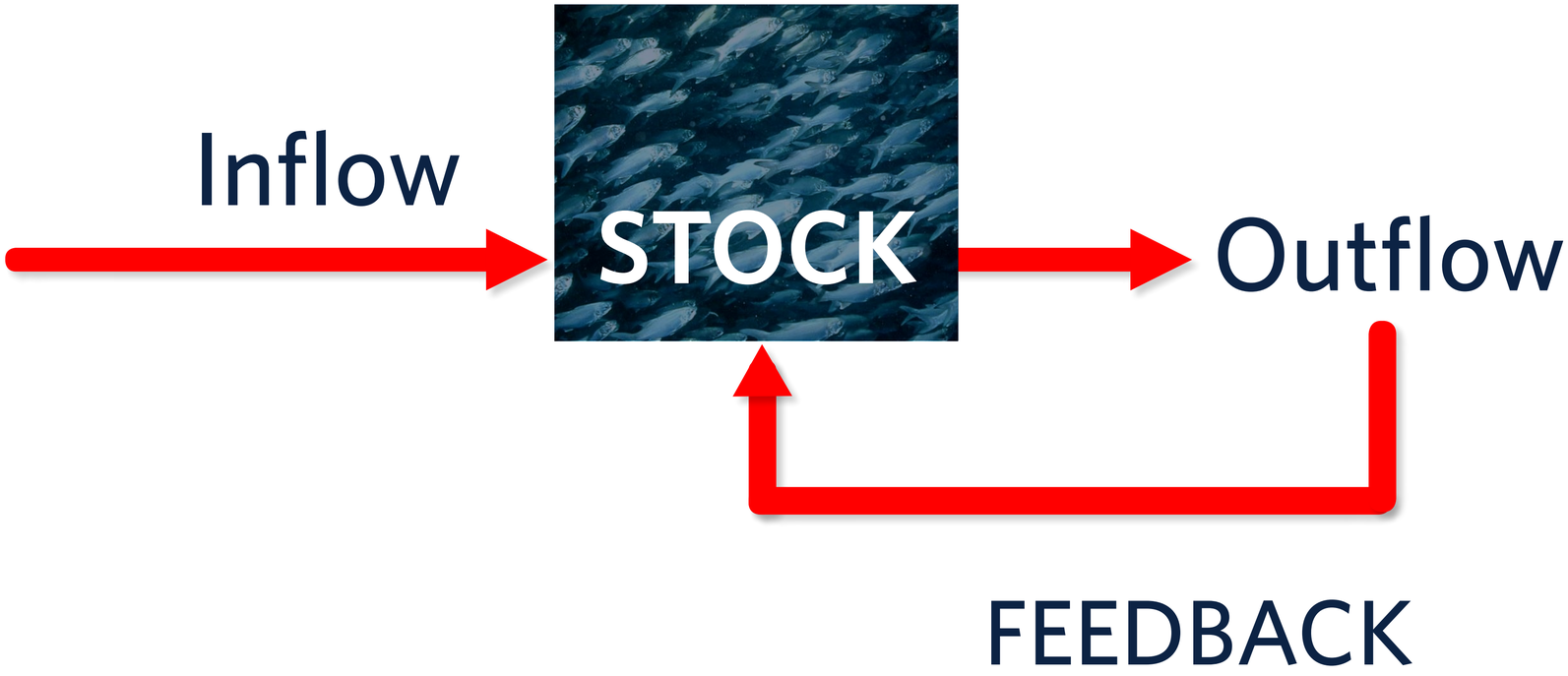


apples in a basket, water in a glacier, fish in the sea, people at a party, CO_2 in the atmosphere, knowledge in your brain, political capital…

APPLES: STEENBERGS; FISH: NOAA; PEOPLE: JAMES CRIDLAND

Systems dynamics: Stock & Flow

FLOW: The rate at which stuff adds or subtracts from a stock.



apples picked per hour, water melted per month, fish born per year, knowledge lost per decade...

Feedbacks link stocks & flows

AMPLIFYING FEEDBACK: Response to the perturbation pushes the system farther in the same direction as the perturbation.

Inflow from snow

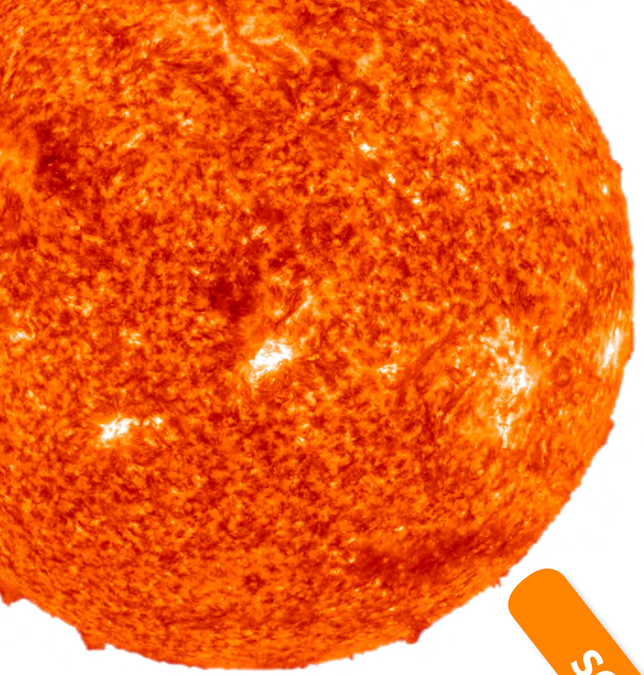
What if…temperature cools?
What if…temperature warms?

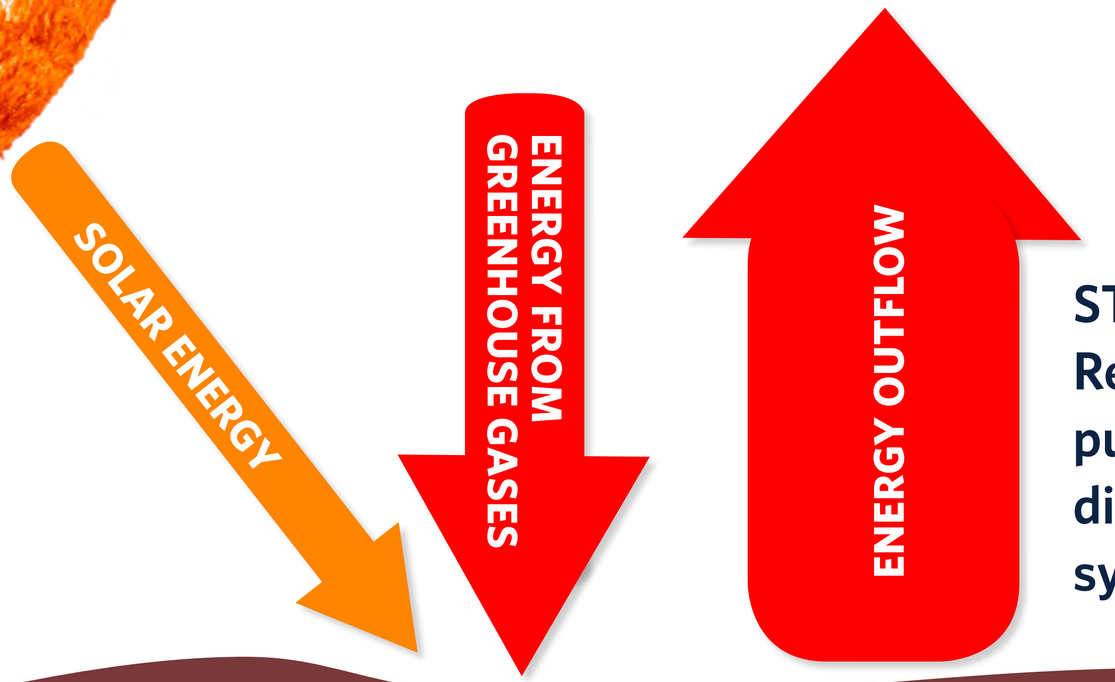
STOCK OF ICE

Outflow from melt

Feedbacks link stocks & flows

Climate feedbacks both respond to temperature changes and, in turn, influence temperature





STABILIZING FEEDBACK:
Response to the perturbation pushes the system in the opposite direction and acts to bring the system toward equilibrium again.

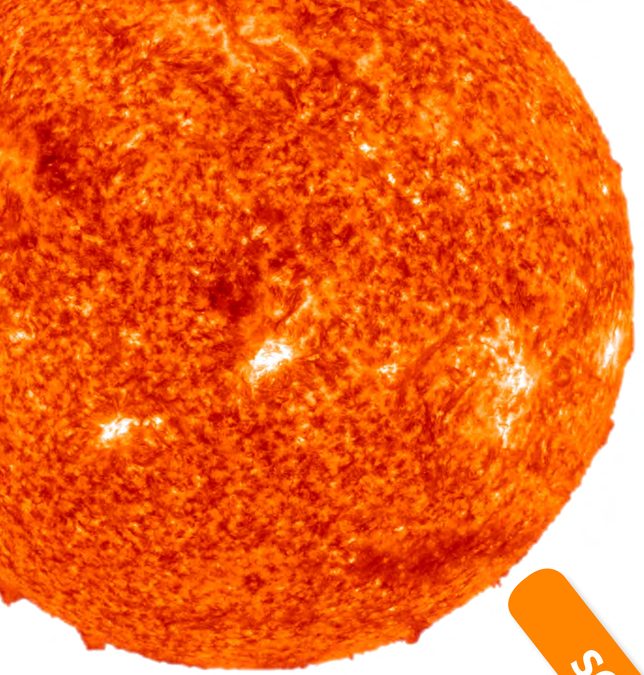
Energy inflows **Outflow via radiation depends on temperature**

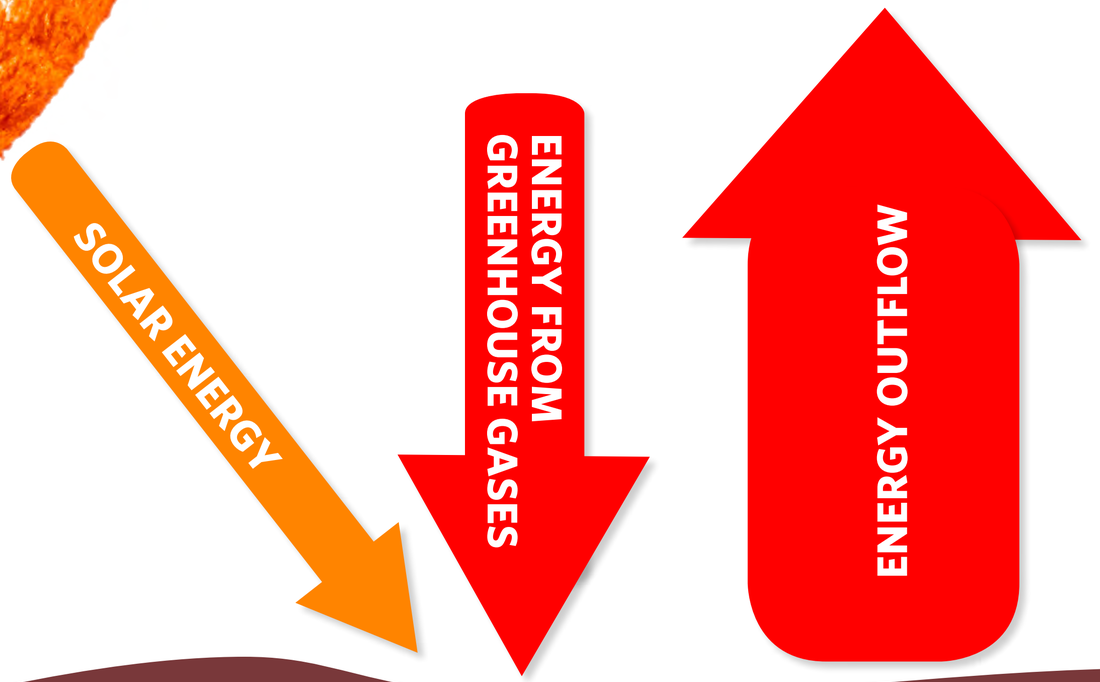
EARTH'S SURFACE

NASA

Feedbacks link stocks & flows

Climate feedbacks both respond to temperature changes and, in turn, influence temperature





Energy inflows

Outflow via radiation depends on temperature

EARTH'S SURFACE

NASA

Key Points

» In Earth's dynamic climate system, there are stocks of matter and energy, flows of matter and energy, and feedbacks.

» If inflows and outflows are equal, a stock won't change over time. If inflow > outflow, the stock will grow. If outflow > inflow, the stock will shrink over time.

» Amplifying feedbacks push the system in the same direction as a perturbation. These are the "runaway", destabilizing processes that can cause big changes.

» Stabilizing feedbacks counteract perturbations and keep a system from changing very fast. They help move the system toward equilibrium – perhaps a new equilibrium state, but a stable state nonetheless.

» We've encountered one amplifying feedback involving ice and its reflectivity, and one stabilizing feedback involving emission of radiation by Earth's surface. We'll encounter more feedbacks later.