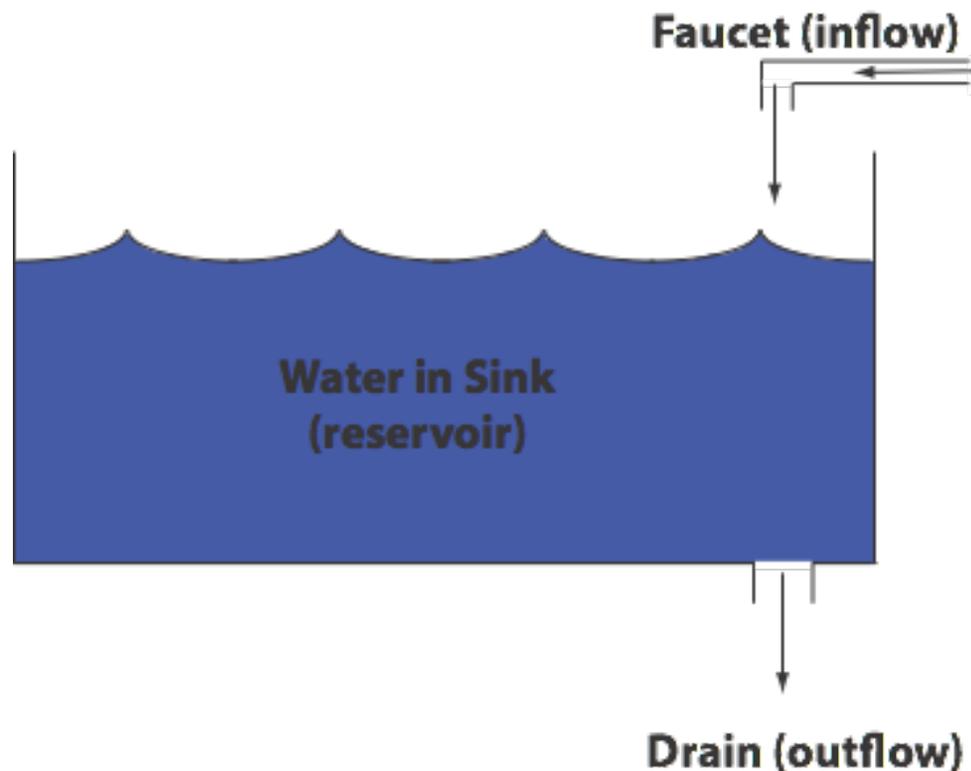


Systems Thinking – Modeling a System

A simple example of a dynamic system – a bathtub

- The balance between the inflow through the faucet and the outflow through the drain determines how much water accumulates in the tub.



Is this system open or closed?

Examples in the Earth System

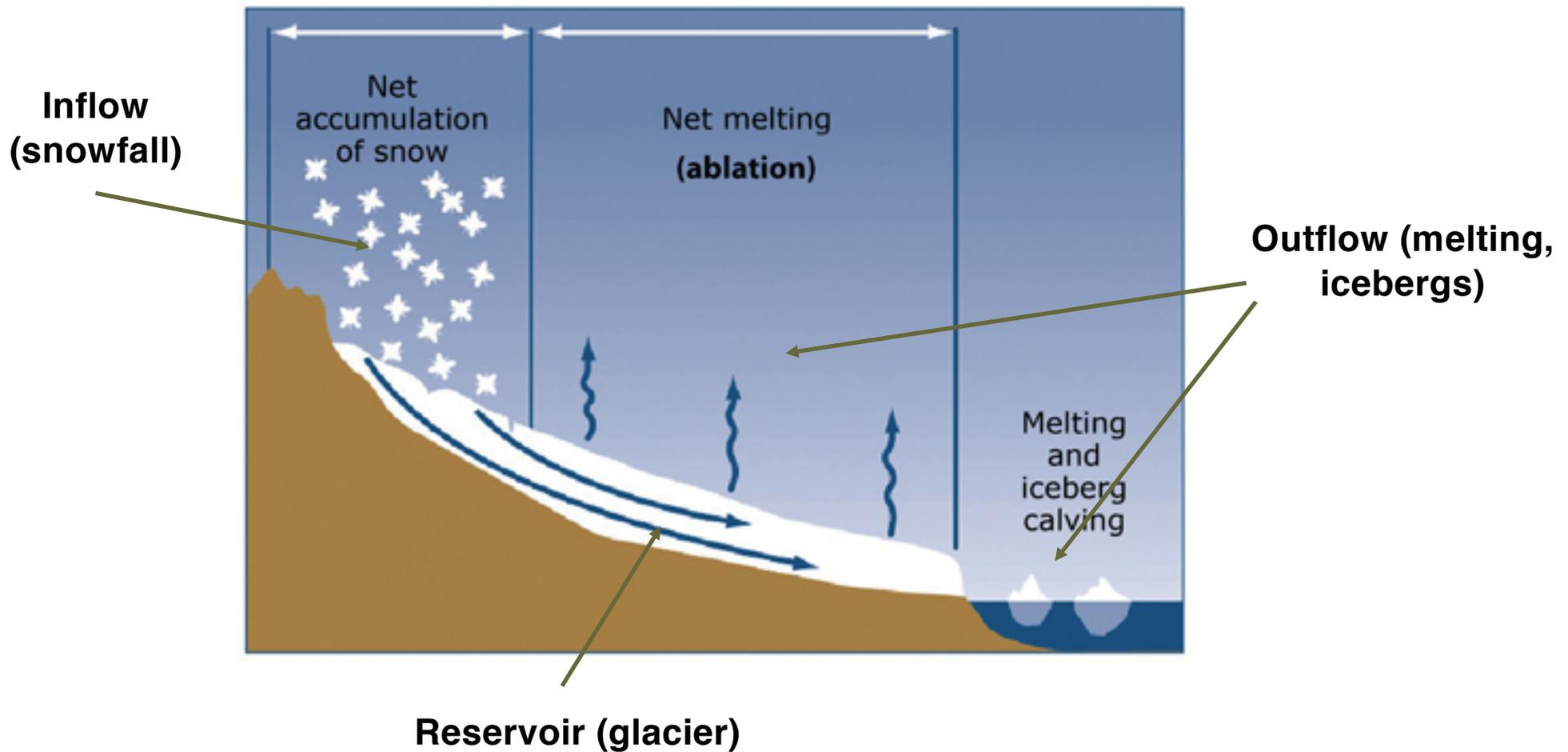


Inflow (runoff, precipitation)

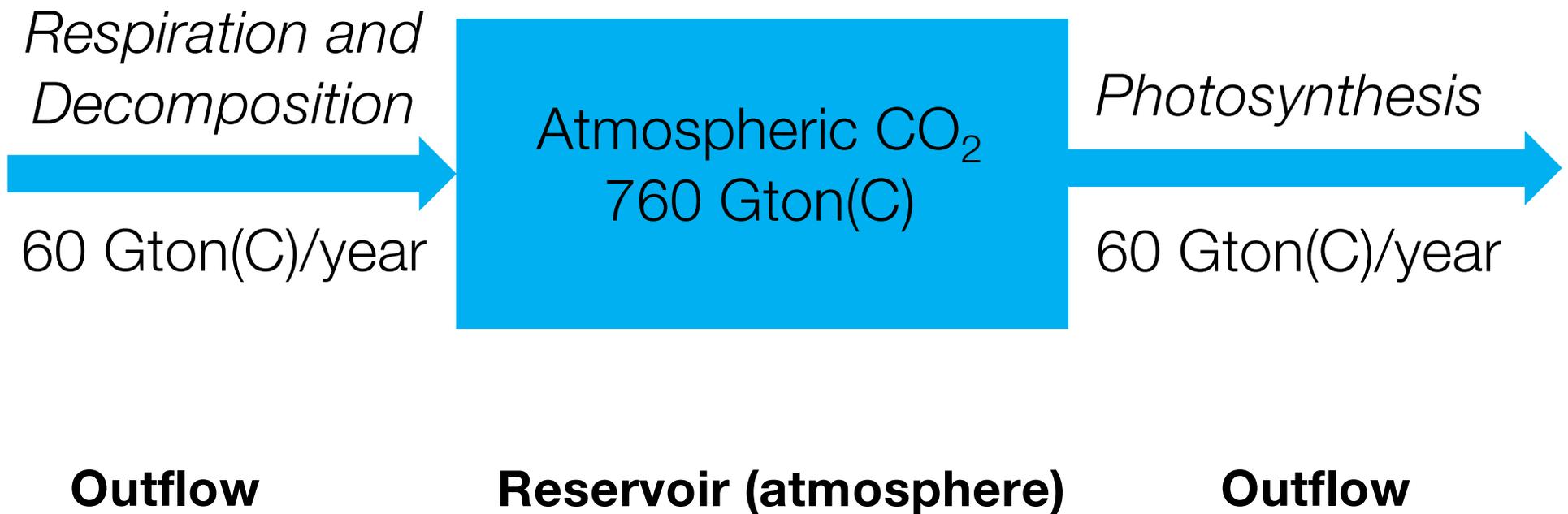
**Outflow
(stream outlet)**

Reservoir (pond)

Examples in the Earth System



Examples in the Earth System



Examples in society

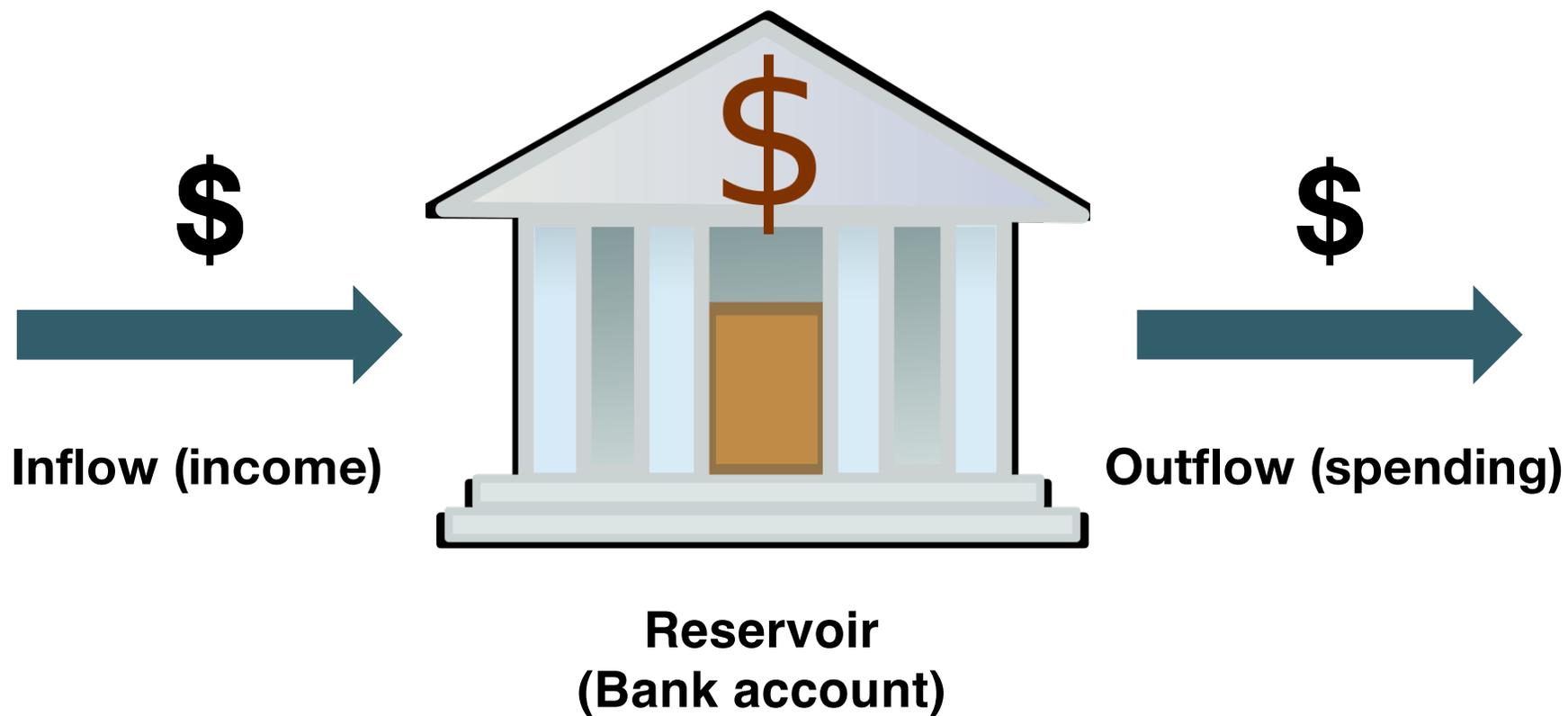
Inflow (entrance)

Outflow (exit)



**Reservoir
(parking lot)**

Examples in society

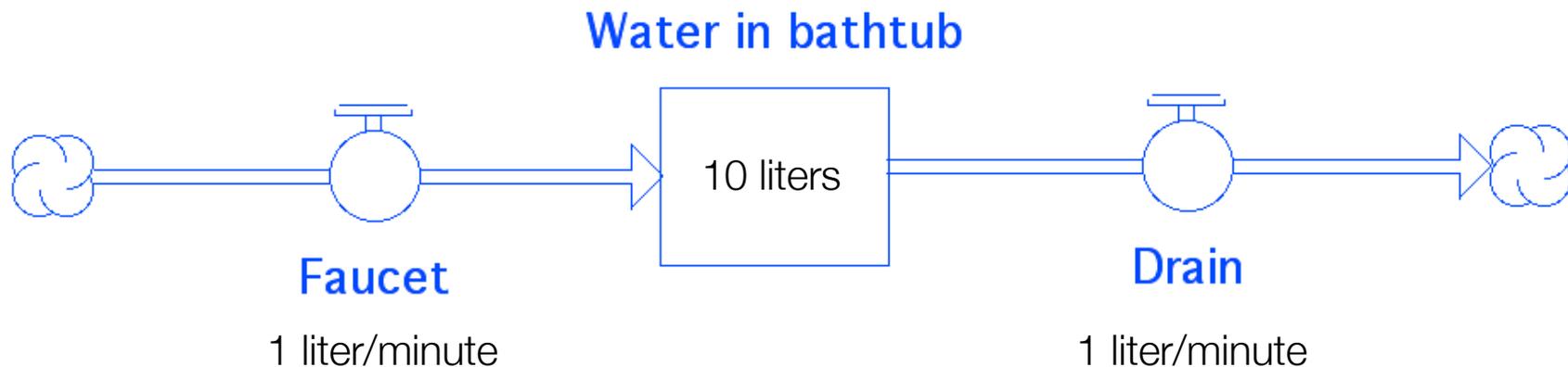


Why use a systems model?

- **Systems diagrams** are useful for *showing* relationships in a system:

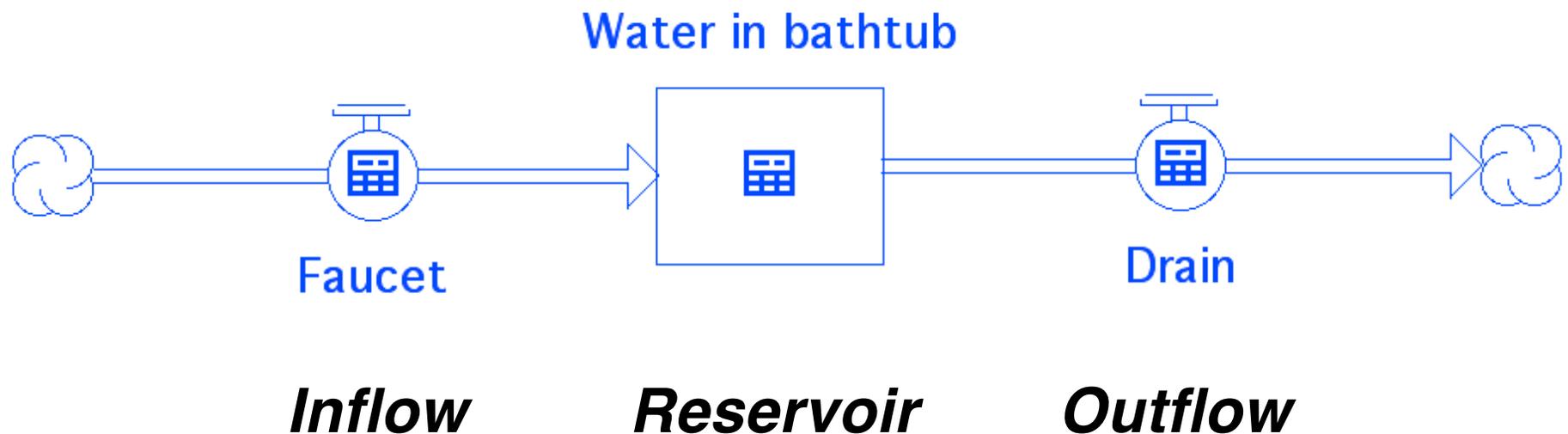


- **Systems models** are useful for *quantifying* relationships in a system, and allowing system behavior to be *explored* experimentally:

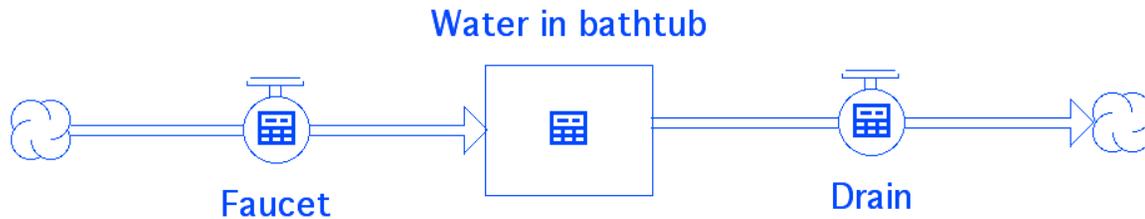


Systems model of the bathtub

- STELLA is a software package that allows the user to build icon-based dynamical systems models
- The goal is to take the systems diagram of a bathtub and simulate in a STELLA model
- A STELLA model of the bathtub system includes a reservoir for the bathtub, and two flows that represent the faucet and drain



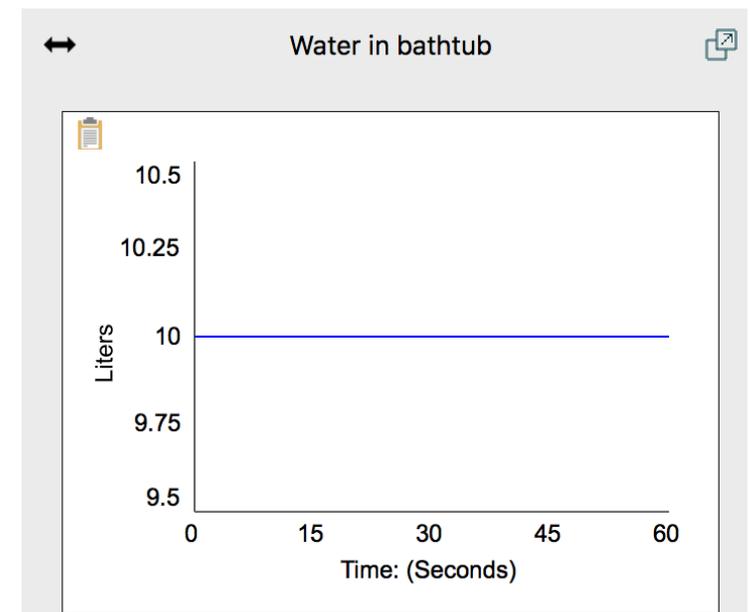
Unit 3 Bathtub Model



Model: icon-based representation of the system

```
Water_in_bathtub(t) = Water_in_bathtub(t - dt) + (Faucet - Drain) * dt
INIT Water_in_bathtub = 10
INFLOWS:
  Faucet = 1
OUTFLOWS:
  Drain = 1
```

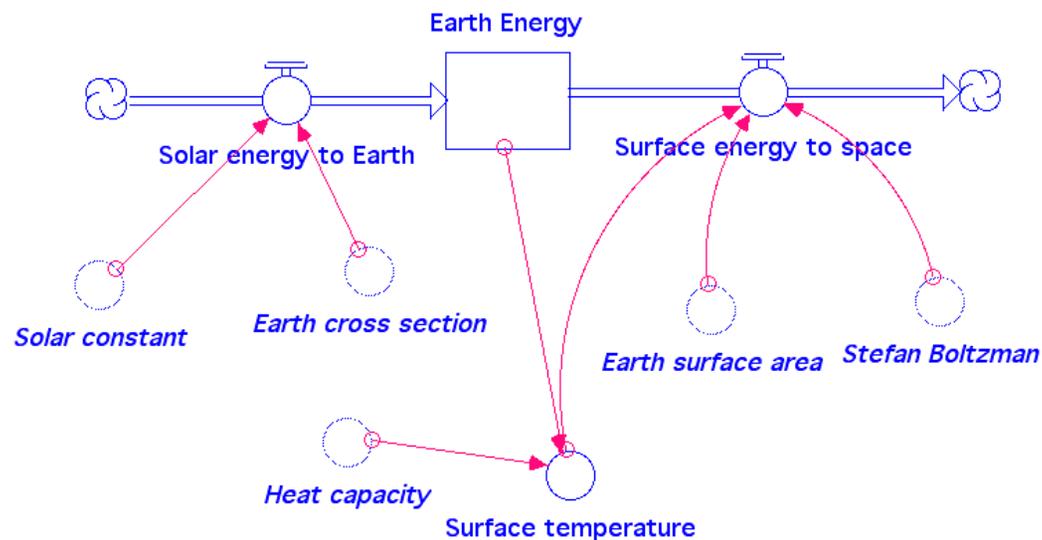
Equation: mathematical representation of the system - STELLA does the calculations for us



Output: graph of the system model output as it runs - in this case, the change in the water in bathtub with time

Systems modeling

- The bathtub model is simple enough that we could just do the calculation of flows and reservoir size with each time step by hand
- BUT, when a system is more complicated, a systems model becomes necessary to keep track of everything
- For example, below is a systems model for the Earth's energy balance (i.e., inflow of energy from the Sun, the Earth reservoir of energy, and outflow of energy back to space)



Inflow

Reservoir

Outflow