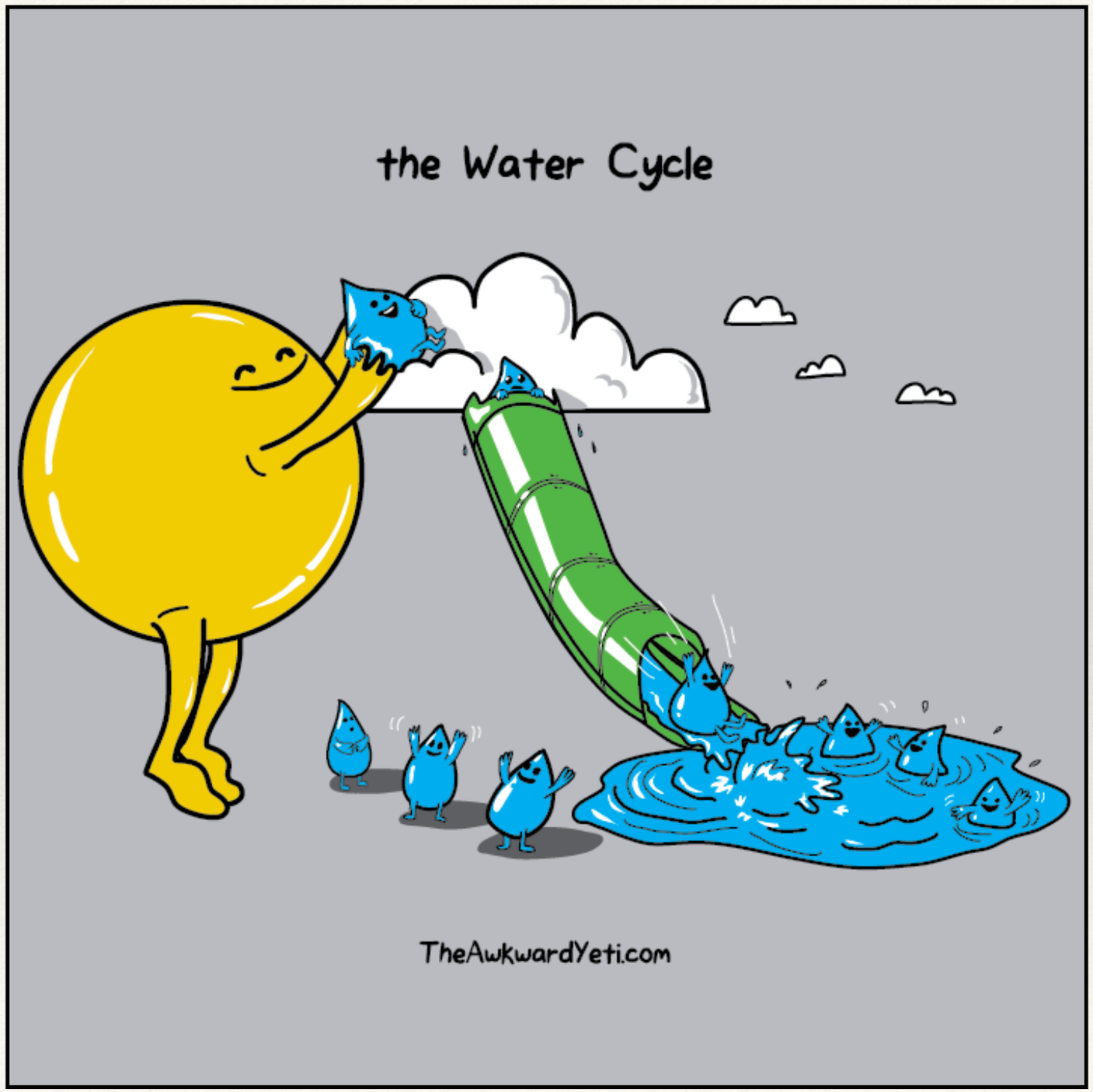
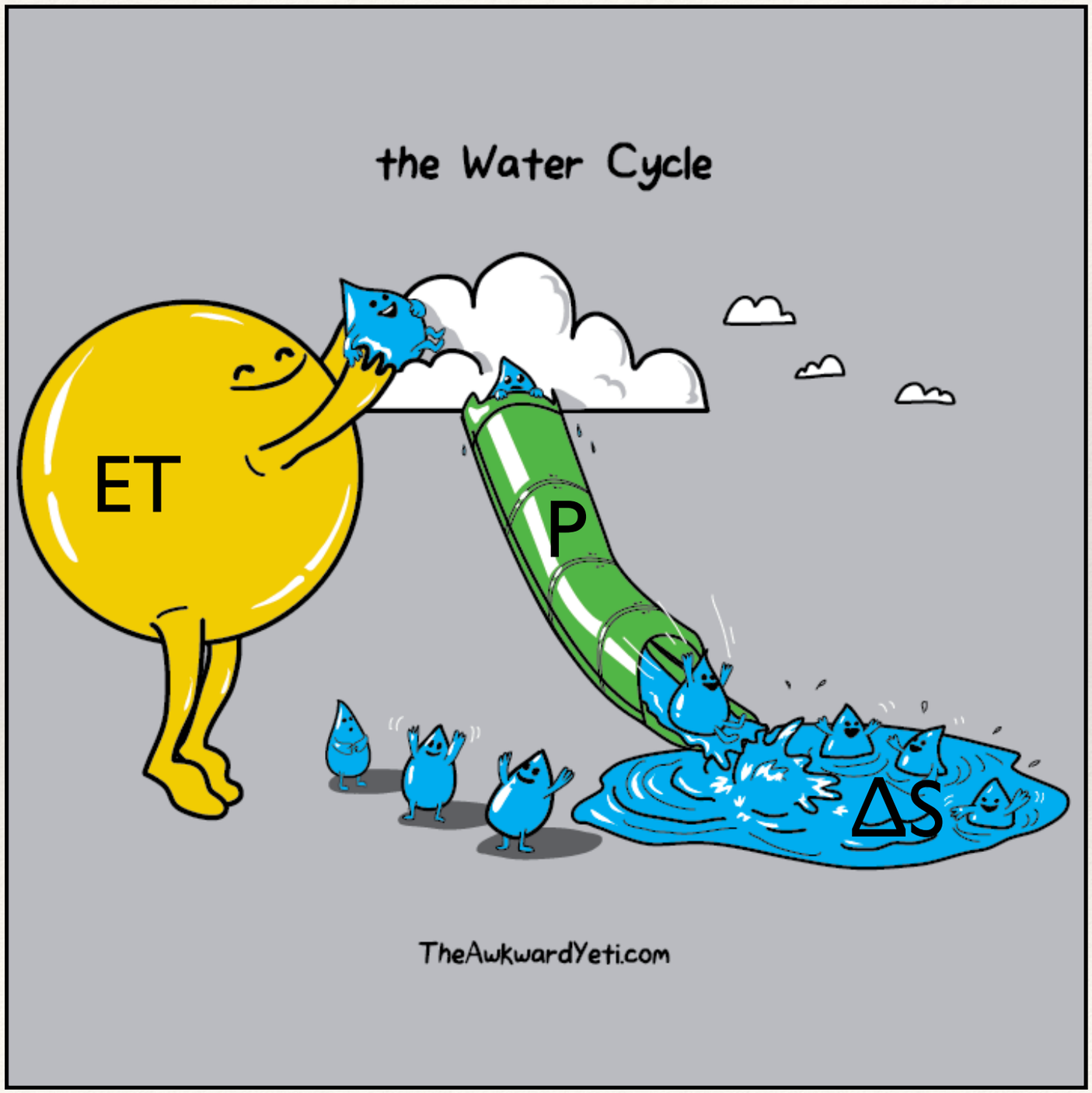
This is a model



What is a model?

- Scientific modeling is a scientific activity, the aim of which is to make a particular part or feature of the world easier to understand, define, quantify, visualize, or simulate. (en.wilkipedia.org/wiki/Scientific_modelling)
- Models of theory (process, physically based)
- Models of data (derived from observations, statistics)

Mathematical Representation of this model



Precipitation = Evapotranspiration + Change in Storage

$$P = ET + \Delta S$$

(at global scales ΔS includes streamflow since that water is still "stored" in the earth)

Water balance can tell you a lot

What are models?

- A set of ideas that describe a process/phenomena
- A simplified representation of some aspect of the world
  - Uses
    - understanding a pattern, process, phenomena in the world - especially when there are many interacting elements/controls on this phenomena
    - estimation of what might happen to a phenomena in the future (or if something changes) “what if” scenarios

Pollution abatement

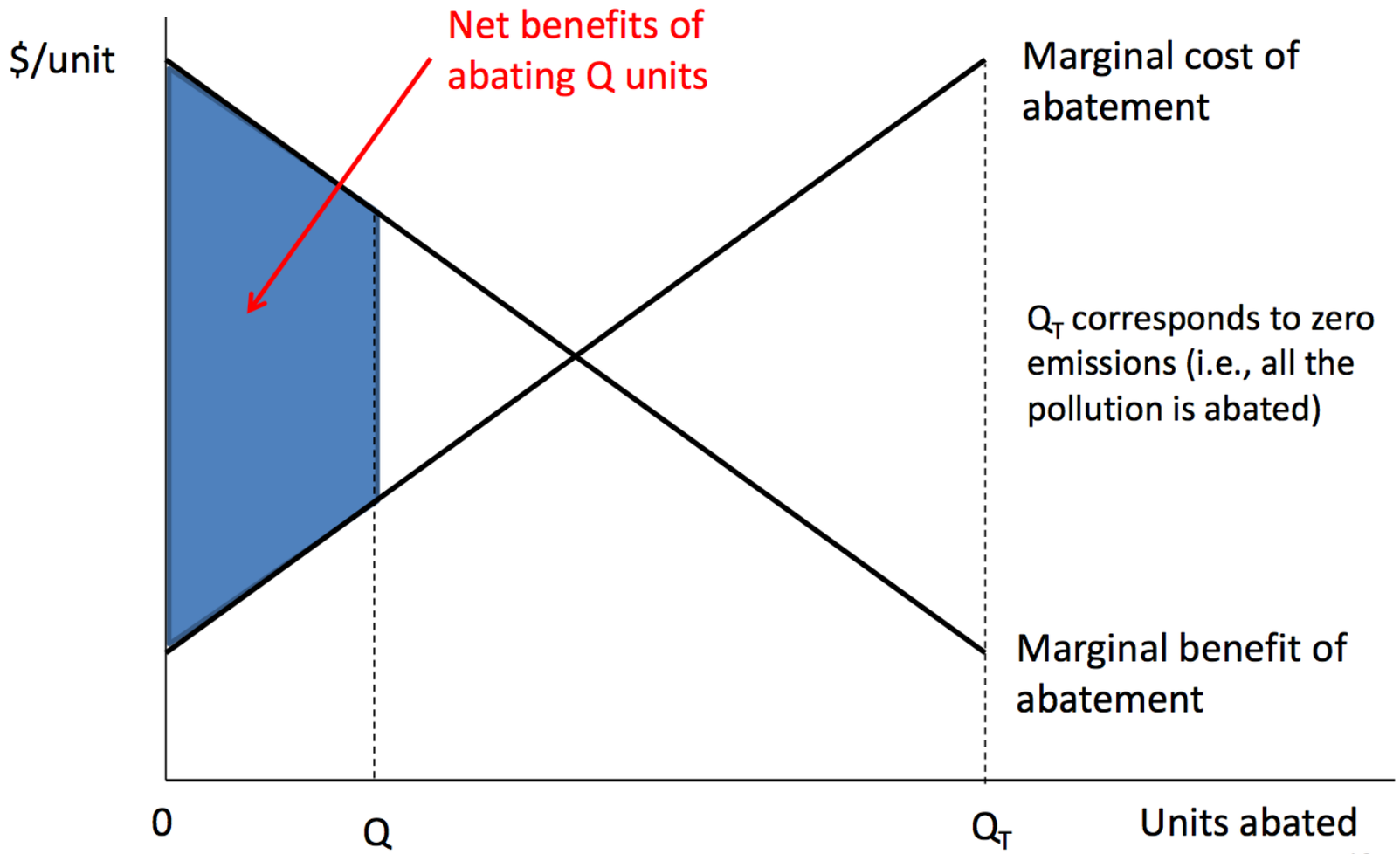
- Pollution abatement – reductions in the emissions of a pollutant
- Marginal cost of abatement – the costs of eliminating another unit of emissions
- Marginal benefit of abatement – the benefits of eliminating another unit of emissions

- Three stages of pollution abatement
  - end-of-pipe treatment
  - changes in production processes
  - reductions in output

Models for understanding (understanding why there are tradeoffs)

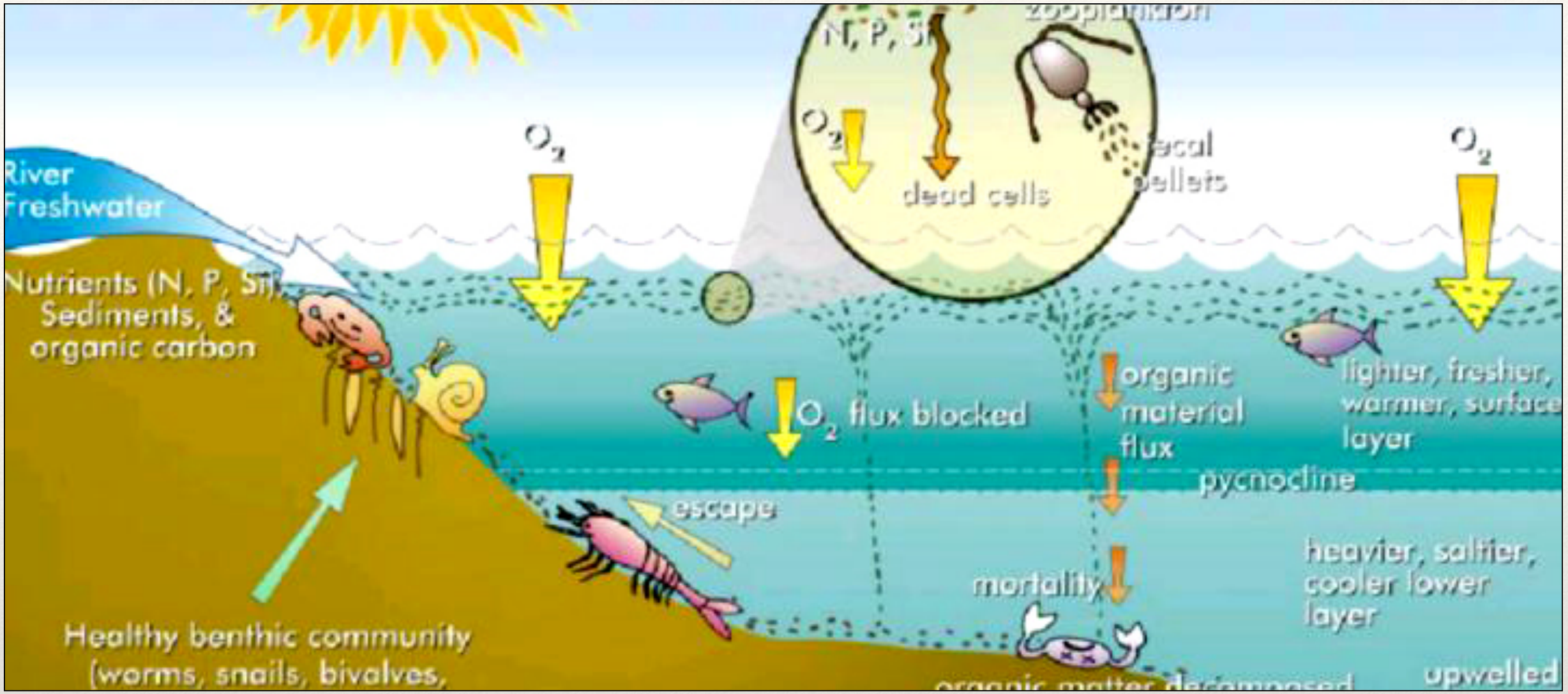
How to think about why there might be different strategies for abatement (where? when?)

Net benefits of pollution abatement



Models for understanding (understanding why there are tradeoffs)

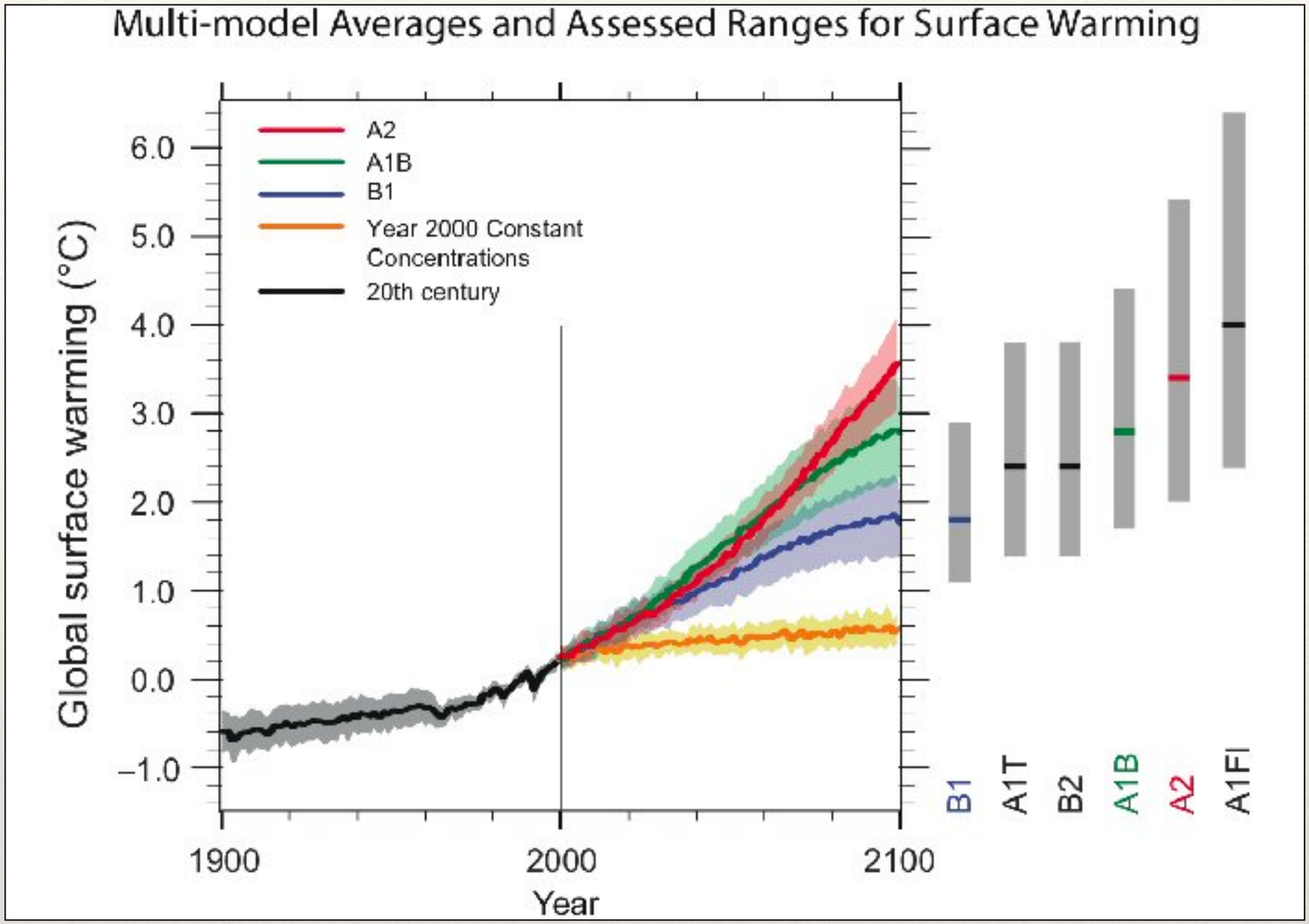
Why there might be an "optimal" choice for amount of pollutant abatement



US EPAL http://www.newworldencyclopedia.org/entry/File:Eutrophication.jpg

Models for understanding (big #'s, little #'s as controls on phenomena)

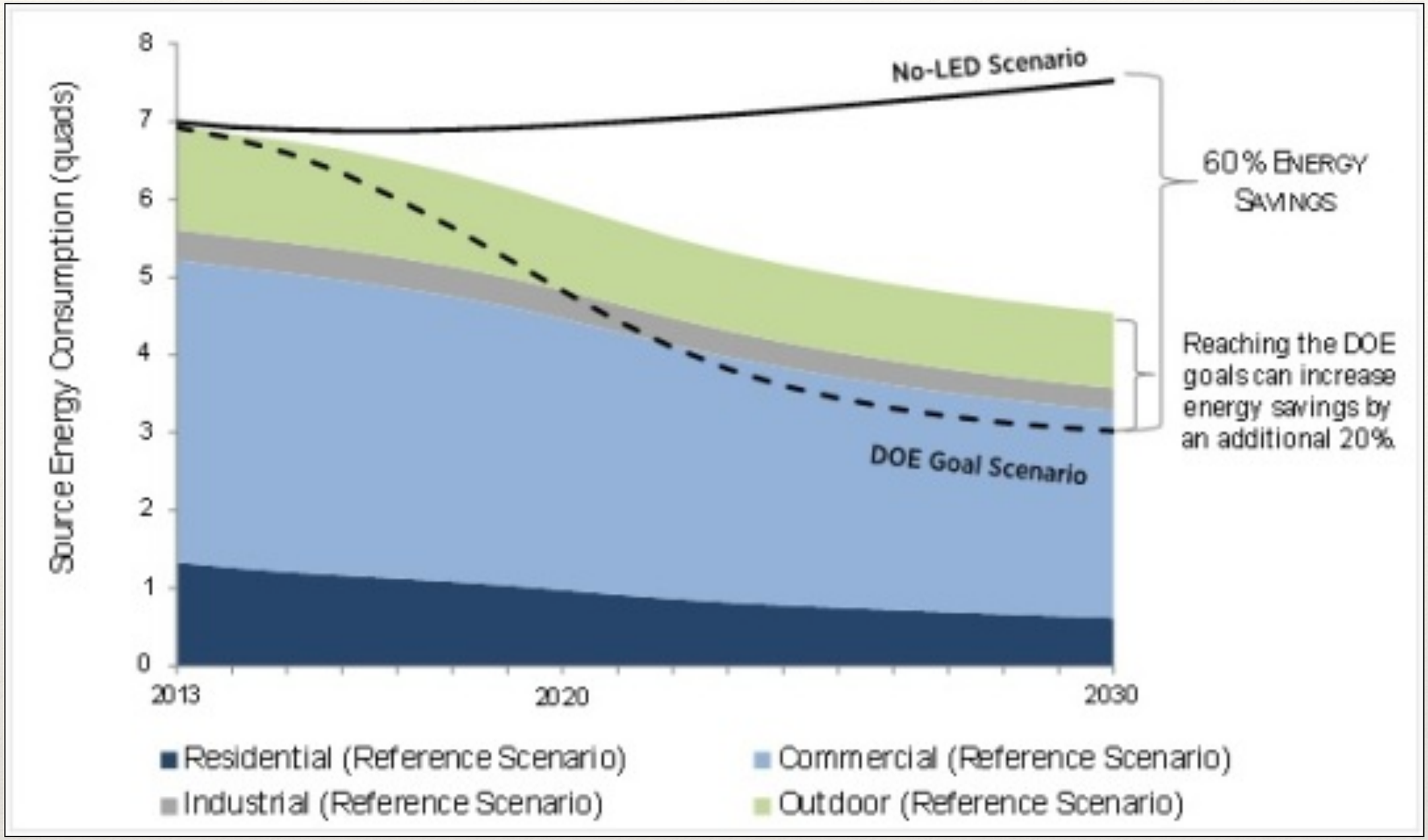
In a particular place (Baltimore Harbor), would temperature often be a limiting factor in eutrophication?
(so at what times of year, would N-export matter less?)



http://narccap.ucar.edu/about/figures/IPCCProjections.jpg

Models for estimation

Estimate of global temperatures over the next 100 years



http://www.lightnowblog.com/2014/10/forecasted-energy-savings-from-led-lighting/

Models for estimation

Estimate of energy savings from LED adoption

GOALs: Modeling for Problem Solving in Environmental Science

- There is something you need to know in order to solve the problem
  - Answer to a question -
    what if?
    how much?
    which alternative?
  - Test of a hypothesis
- **Start by clearly defining what that question is!!**
- Examples?

Modeling for Problem Solving in Environmental Science

- Models for communication
- Similar to question driven -
  - what specifically do you want the model to communicate/illustrate?

Alaska's Tonsina Glacier is shown in this photo, in a valley formed by repeated cycles of glacial advance and retreat. The glacier is currently thinning and retreating.

Goal: Help public understand why, even if temperature warms - glaciers might grow (due to increasing snowfall) - but a threshold temperature might be reached where glacier will shrink

Run glacier_an.jar

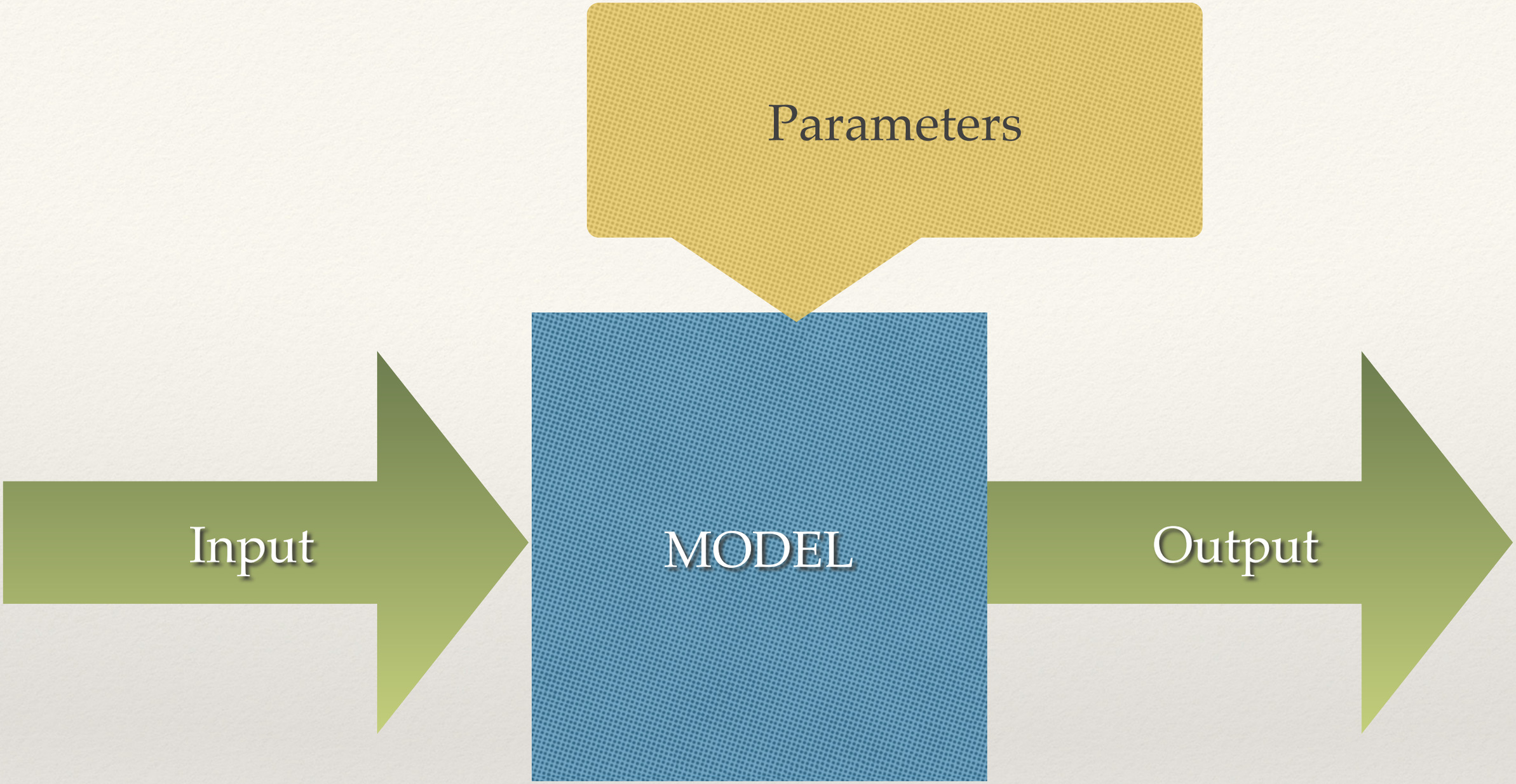
(You will need java installed on your machine if you want to play (not necessary)

Example:Glaciers

Goal: Help public understand why, even if temperature warms - glaciers might grow (due to increasing snowfall) - but a threshold temperature might be reached where glacier will shrink

Goals

- *There is something you need to know in order to solve a problem (or come up with a strategy) - to achieve your goal*
- Communicate something about the world



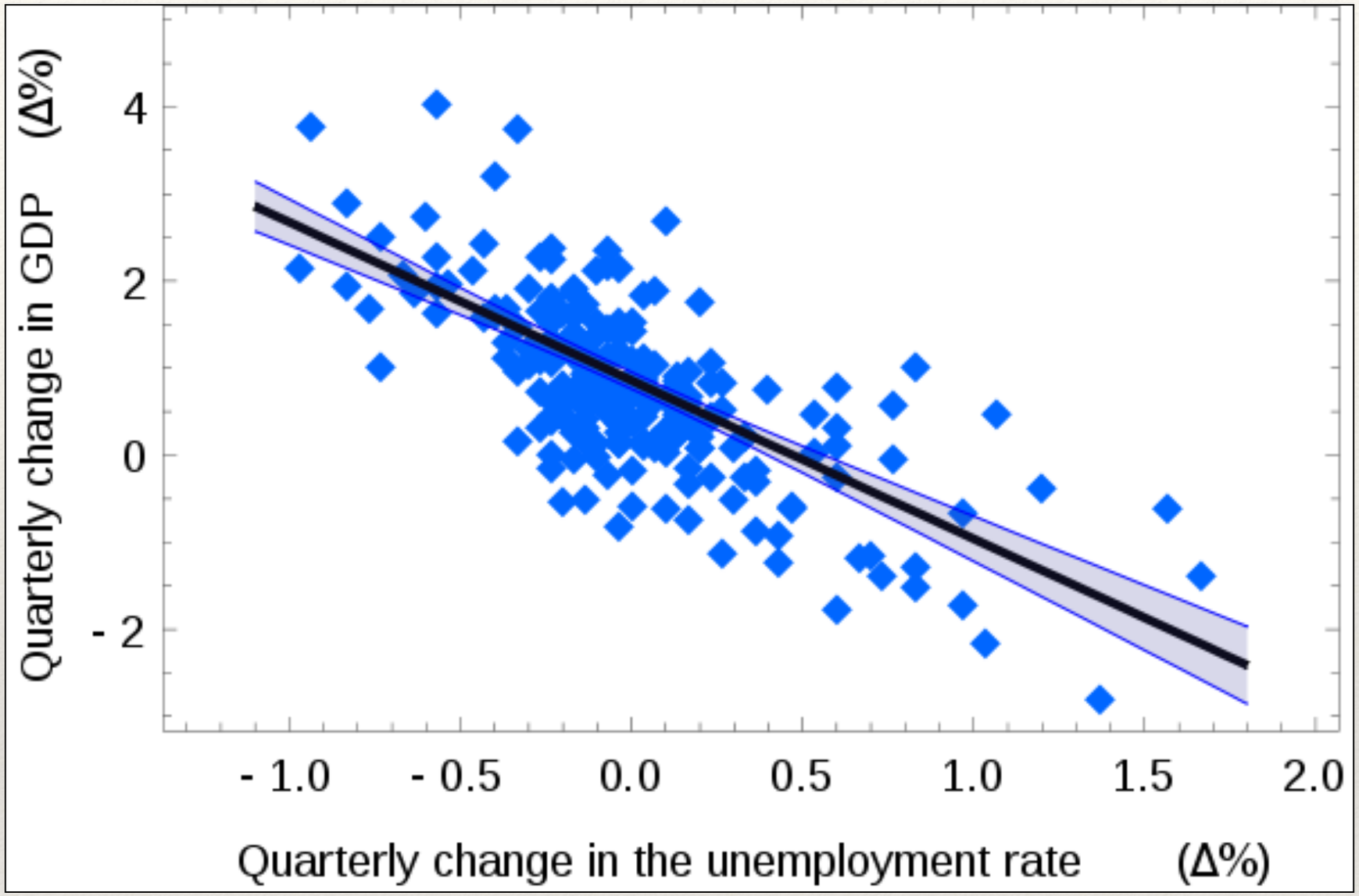
Basic components of models

Inputs: Varying; think x of a x vs. y regression

Parameters: single values that influence relationships in the model

Outputs: what you want to estimate

The US "changes in unemployment – GDP growth" regression with the 95% confidence bands.



Simple model

Input: Change in unemployment rate
Output: Change in GDP
Parameters: Slope and intercept of the line

STEPS: Modeling for Problem Solving in ES

1. **Clearly define your goal (a question you want to answer, hypothesis you want to test, prediction you want to make) - as precisely as possible**
2. Design or Select your model
3. Implement the model
4. Evaluate the model and quantify uncertainty
5. Apply the model to the goal
6. Communicate model results

Goals

- The goal will help you to define the core pieces of a model
- Often helpful to start at the end: Outputs
- Example:
  - Problem: which piece of land should be purchased to maximize biodiversity?
  - Outputs
    - monetary costs and benefits of different options in 2015 dollars, including “non-market” benefits

Goals

- Example
  - Problem: how will forest carbon sequestration change if fire frequency increases with warming
- Outputs
  - carbon sequestration for different fire frequencies

STEPS: Modeling for Problem Solving in ES

1. **Clearly define your goal (a question you want to answer, hypothesis you want to test, prediction you want to make) - as precisely as possible**
    a. **List input and outputs**
2. Design or Select your model
3. Implement the model
4. Evaluate the model and quantify uncertainty
5. Apply the model to the goal
6. Communicate model results

In-class Exercise

- A foundation is offering to provide funding to support model development; the foundation will hold a competition to choose which project offers the most convincing case for **a need** for model development
- Criteria for selection would be:
  - model development will contribute information needed to solve a problem
- Brainstorm about potential projects (Breakout Room Groups);
  - What question will be answered
  - Why this question is important
  - What will input and outputs be