

Systems

*'a set of connected things or parts forming a complex whole, in particular.
a set of things working together as parts of a mechanism or an interconnecting network.'*

We will have studied several systems over the course of the year including, the water cycle, the carbon cycle, and the energy system associated with the greenhouse effect. We are now going to model these systems focusing in on the **parts of the system** and **how these parts are connected**. We will also look at **what outside factors are influenced by, or influence, the system**.

Ultimately (in MP7), we will look at the relationships between these systems and their effect on Earth's temperature (as a parameter of climate and climate change).

Target	1	2	3	4
LE 5.7 Preparedness	Does not complete formative or summative in an effortful and timely manner, is not engaged, does not arrive on time with class materials ready to learn, does not communicate when issues arise	Completes formative or summative in an effortful or timely manner, is sometimes engaged, sometimes arrives on time with class materials ready to learn, sometimes communicates when issues arise	Completes formative or summative in an effortful and timely manner, remains engaged, arrives on time with materials ready to learn, communicates when issues arise	Completes formative or summative in an effortful and timely manner, remains engaged, arrives on time with materials ready to learn, communicates when issues arise, and is reflective on strengths and challenges within your preparedness skill
LE 7.4 Connections	Recognizes that multiple ideas may be connected	Recognizes that connecting multiple ideas may provide deeper meaning	Recognizes connection between multiple ideas, systems or solutions to construct meaning	Connects multiple ideas, systems or solutions that provoke meaning in novel ways (i.e. demonstrating empathy by synthesizing complexity, metaphoric thinking, applying patterns)
Hydro 9	I can label a water cycle		I can develop a model to describe the cycling of water in place/form on Earth	I can incorporate the relationships between the water cycle and Earth's temperature
MP7	I can model how water, carbon and energy cycle/flow within and between the Earth's spheres	(1 plus) I can model how external factors can amplify or dampen the change within a system	(2 plus) I can model/explain the relationships between external factors and the flow of matter and of heat energy within Earth's systems resulting in changes in Earth's temperature	(plus) human impact

Parts of Speech

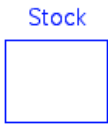
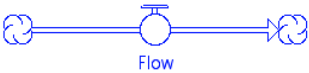

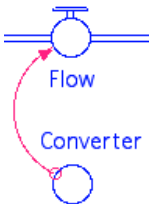
Part of Speech	Definition	Example:
Noun		
Verb		

Practice Identifying: *Circle noun, underline the verb*

Water flows from Little Elmore Pond into the North Branch.

Introduction to Systems Modeling

Standard Symbols and Definitions/Descriptions

System Model Component	Icon / Symbol	Meaning
Stock		(NOUN) the stock is the <u>something</u> that accumulates or depletes
Flow		(VERB) the flow shows the <u>transfer or transform</u> of one stock to another
Converter		A converter influences/effects a flow OR is influenced by a stock/flow/other converter.
Connector		The connector (the arrow) represents the influence of one component on another within the system: Converter effects Flow Converter effects Converter Flow effects Converter Stock effects Converter

The **something ...**

There can only be **one something** flowing through the system. We'll call that the '**currency**'.

The **stock is the amount of the 'currency'....**

It is the '**currency**' that **accumulates** or **depletes** as a consequence of the **flow** into or out of the stock.

So, the **flow** moves the 'currency' **from stock to stock** by changing the 'currency's place (transfer) and/or form (transform).

This is expressing the Laws of Conservation of Matter/Energy (matter/energy cannot be created or destroyed but can be transferred/transformed).

Example...

evaporation (flow) moves water (currency) from a lake/liquid to atmosphere/gas

So, each stock connected by some flow must have in it the 'currency' in some place or form.

If a stock does NOT contain the 'currency' in some place or form, it is not a stock of the system you are focusing on... It can/might be a converter.

Start with a paper version of a system model of the water cycle..... (slideshow)

this will be part of MP7 Summative Part 2

Now that you have a systems model of part of the water cycle, finish it – using either Stella OR the paper version (or any software that can draw a box, an arrow, and write text). Incorporate the following **stocks**, **flows**, and **converters** into your model.

(in the first row in the table) Identify which are ‘stocks’, ‘flows’, and ‘converters’.
Once you have identified the ‘stocks’, what is the ‘currency’? _____

<u>Stock</u> ‘ (“currency” = _____)
Liquid water in atmosphere (clouds)
Water vapor (gas state) in atmosphere
Water (l) in oceans
Water (l) in lakes, ponds, rivers (surface water)
Groundwater (l)
Water as snow and ice (s) (on land)
Ice caps (s) (ocean)
Water (l) in trees

Evaporation
Condensation
Freezing
Melting
Precipitation (raining / snowing)
Flowing (run-off / flow)
Percolating / infiltrating
Transpiration
Plant Uptake

Earth’s temperature
Albedo
Greenhouse Effect

- Make a system model of the water cycle using the stocks and flows above.
 - Starting with the stocks, lay them out to represent (approximately) where they physically would be. The stocks can only be used once – *except if you are laying out your system model on top of an already sketched water cycle.*
 - Then, add the flows, representing how the water moves from place to place and/or form to form. The flow is represented by an arrow connecting where in place/form the water starts and where in place/form the water ends. The flows may be used more than once. In Stella, if you use the flow more than once, you’ll need to add a ‘1’ or ‘2’ or ‘3’ ... to the title box.
- Add the converters and their connectors.
 - Each converter can only be represented once. There may be multiple connections to/from each converter.
 - Add the ‘+’ and ‘-’ beside the end of the connectors to indicate whether the changes in the converter and its connected flow/converter/stock are in the same direction or opposite.
- If you are using Stella, (or any other software), don’t forget to save your project to your U: drive.

Stella is software package designed to model systems. We will use it as a tool to help model the water cycle, carbon cycle, Earth's energy system, and the relationships between these systems.

The Water Cycle

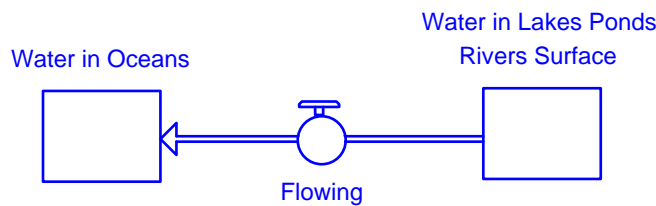
The 'currency' is _____

So, each of the stocks connected by some flow must contain _____ in some form or place.

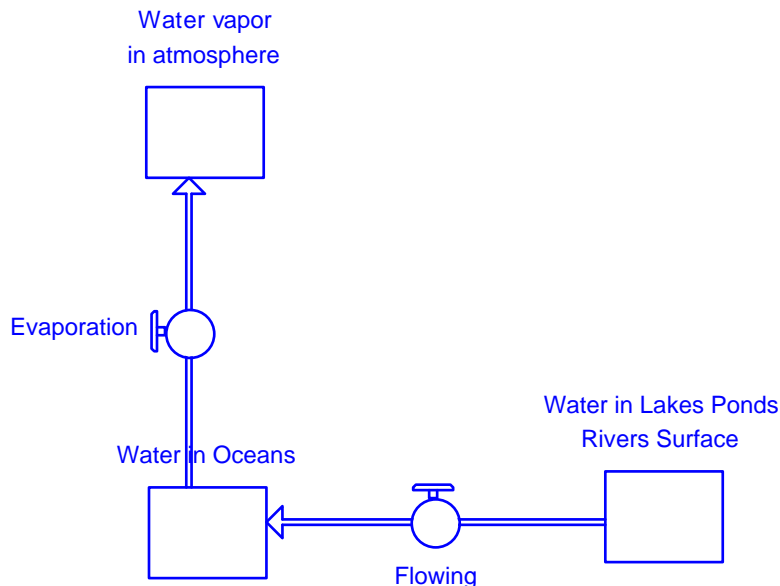
1. Make a new **Stock** and title it **Water in Lakes Rivers Ponds Surface**. Make sure your title includes the 'currency' as a check to make sure it is the 'currency' that is flowing between stocks.
2. Make a second **Stock** and title it **Water in Oceans**



3. Now select the Flow icon from the tool bar and connect **Water in Lakes Rivers Ponds Surface** and **Water in Oceans**. Title the new flow **Flowing**.



4. Make a third **Stock** and title it **Water vapor in atmosphere**. Connect this stock to **Water in Oceans** with a flow titled **Evaporation**.

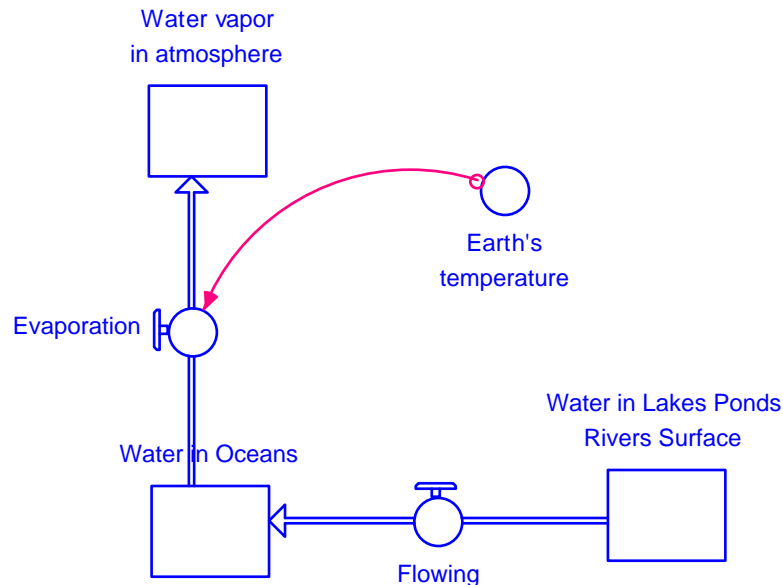


- Now think of something, (*that is NOT a component of the system*), that is affecting the rate of the flows. A simple thing might be **Earth's temperature** affecting the rate of **Evaporation**. Create a converter and title it **Earth's temperature**. Select the connector to connect **Earth's temperature** to **Evaporation** to represent that Earth's temperature influences evaporation.

Add the '+' / '-' following example in class.....

Considering the elements at the end of each arrow...

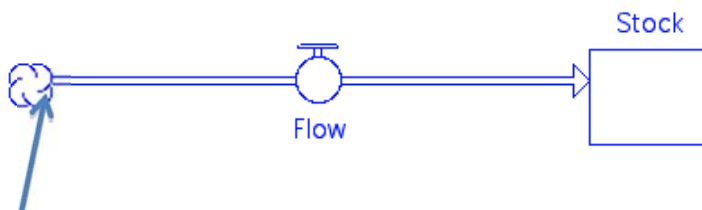
- If the elements change in the same direction, (an increase in one leads to an increase in the other, or a decrease in one leads to a decrease in the other), put a '+' by the arrow.
- If the elements change in opposite directions, (an increase in one leads to a decrease in the other, or a decrease in one leads to an increase in the other), put a '-' by the arrow.



Now, delete the Earth's temperature converter.... As it is not in a very convenient spot for the final Stella model diagram....

- To put a "bend" in your flow arrows, start your arrow... drag to where you need the bend, then press the 'Shift' key, and drag in the new direction.
- Save your document to your U: drive.

The 'cloud' in STELLA:



The cloud-like symbol indicates the limit (edge/cutoff) of your model. It is a way to represent that the parts of the system represented are only a "piece of the pie" and that "piece" is connected to other stocks and flows that are not being considered.

If we were done with our model of the water cycle, we would add a cloud on the 'water on the surface of the land' side, and on the 'water in oceans' side....

But we are **not** done!

this will be part of MP7 Summative Part 2

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Water vapor (gas state) in atmosphere	Condensation	Albedo
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Water (l) in lakes, ponds, rivers (surface water)	Melting	
Groundwater (l)	Precipitation (raining / snowing)	
Water as snow and ice (s) (on land)	Flowing (run-off / flow)	
Ice caps (s) (ocean)	Percolating / infiltrating	
Water (l) in trees	Transpiration	
	Plant Uptake	

4. Make a model of the complete system by making the system into a complete cycle using the stocks and flows above.
 - a. Starting with the stocks, lay them out to represent (approximately) where they physically would be. The stocks can only be used once – except if you are laying out your system model on top of an already sketched water cycle.
 - b. Then, add the flows, representing how the water moves from place to place and/or form to form. The flow is represented by an arrow connecting where in place/form the water starts and where in place/form the water ends. The flows may be used more than once. In Stella, if you use the flow more than once, you’ll need to add a ‘1’ or ‘2’ or ‘3’ ... to the title box.

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