Skeleton of a Conclusion:

Claim

Evidence

Mathematical Model

with Reasoning about the Constant, the Pattern, and General Equation

Prediction

Confidence *with Justification*

\+ Limitations

Skeleton of a Conclusion:

I. Claim

Clearly state your conclusion.

I. Evidence

Explain how the data you cite supports your claim.

I. Mathematical Model with Reasoning

Communicate the mathematical model that behaves the same as the system you investigated. Along with the model you need to describe your reasoning about 1) what the A-value represents in the real world and 2) why the pattern makes sense. Be sure to also include 3) the generalized equation (in all words).

I. Prediction

Communicate how the system you behave for the scenario presented at the beginning of the experiment.

I. Justification

Explain your thinking for your confidence in using your data to predict the future behavior of the system.

I. Limitations

Evaluate the limitations of either your procedure to collect data or of the model your created of the system you investigated.

Exemplar Conclusion from Past Experiment:

After investigating speeding up of a ball down a ramp in order to determine a mathematical model for constant acceleration, I conclude that there is a quadratic relationship between the distance the object moves and the time is has moved. My evidence for this claim is that all five of my data points over a 3 m range all fit on a single best-fit curve that is quadratic.

This system of an accelerating object from rest can be mathematically modeled as:

$$\text{Distance Travelled} = 0.3\ \text{m/s /s} * \text{time}^2$$

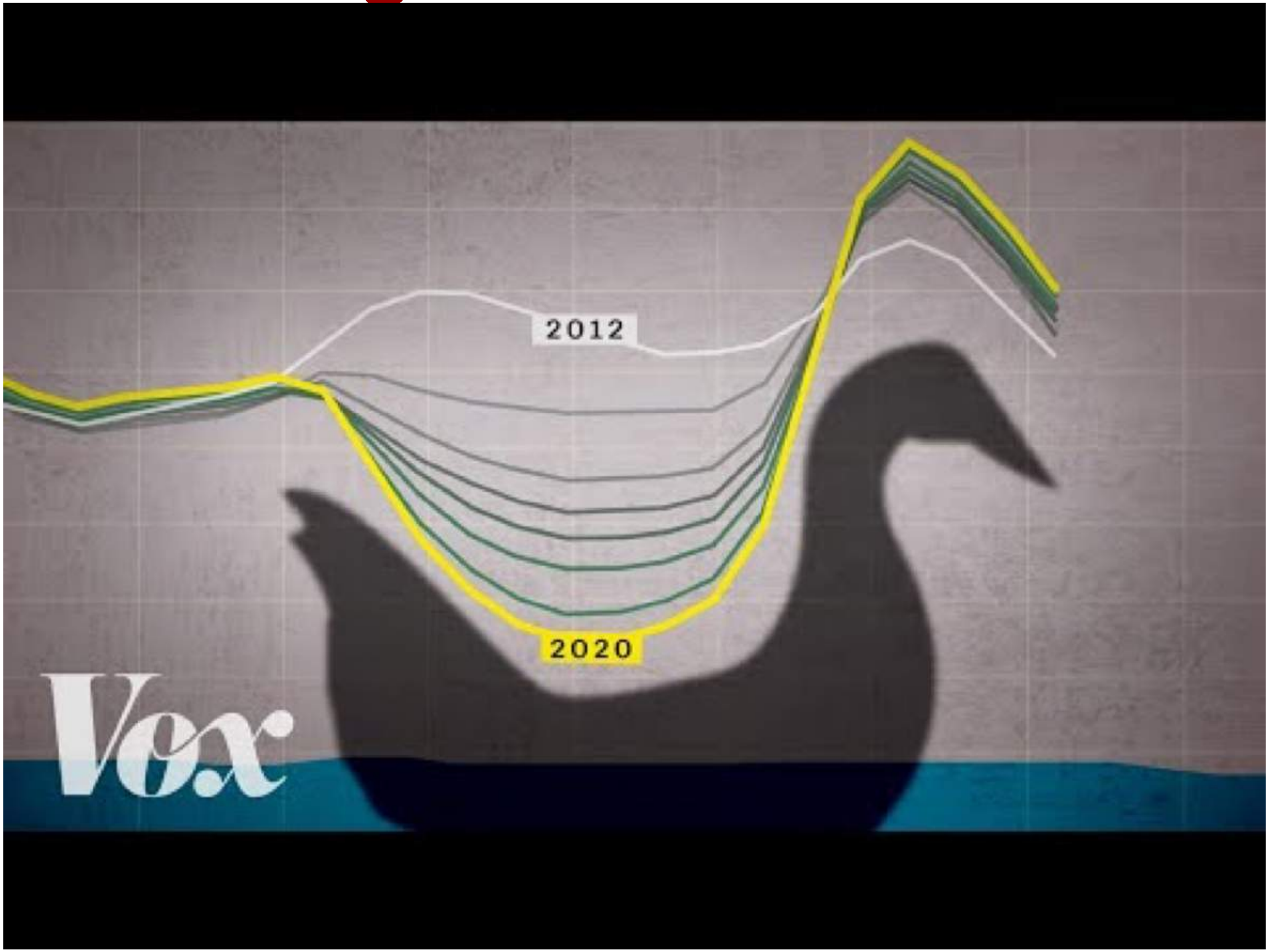
where the 0.3 m/s /s is how much the ball is speeding up each second.
It makes sense that the pattern is quadratic because time affects both how long the ball has rolled and how much it has speed up. So in general for an object accelerating from the model will be

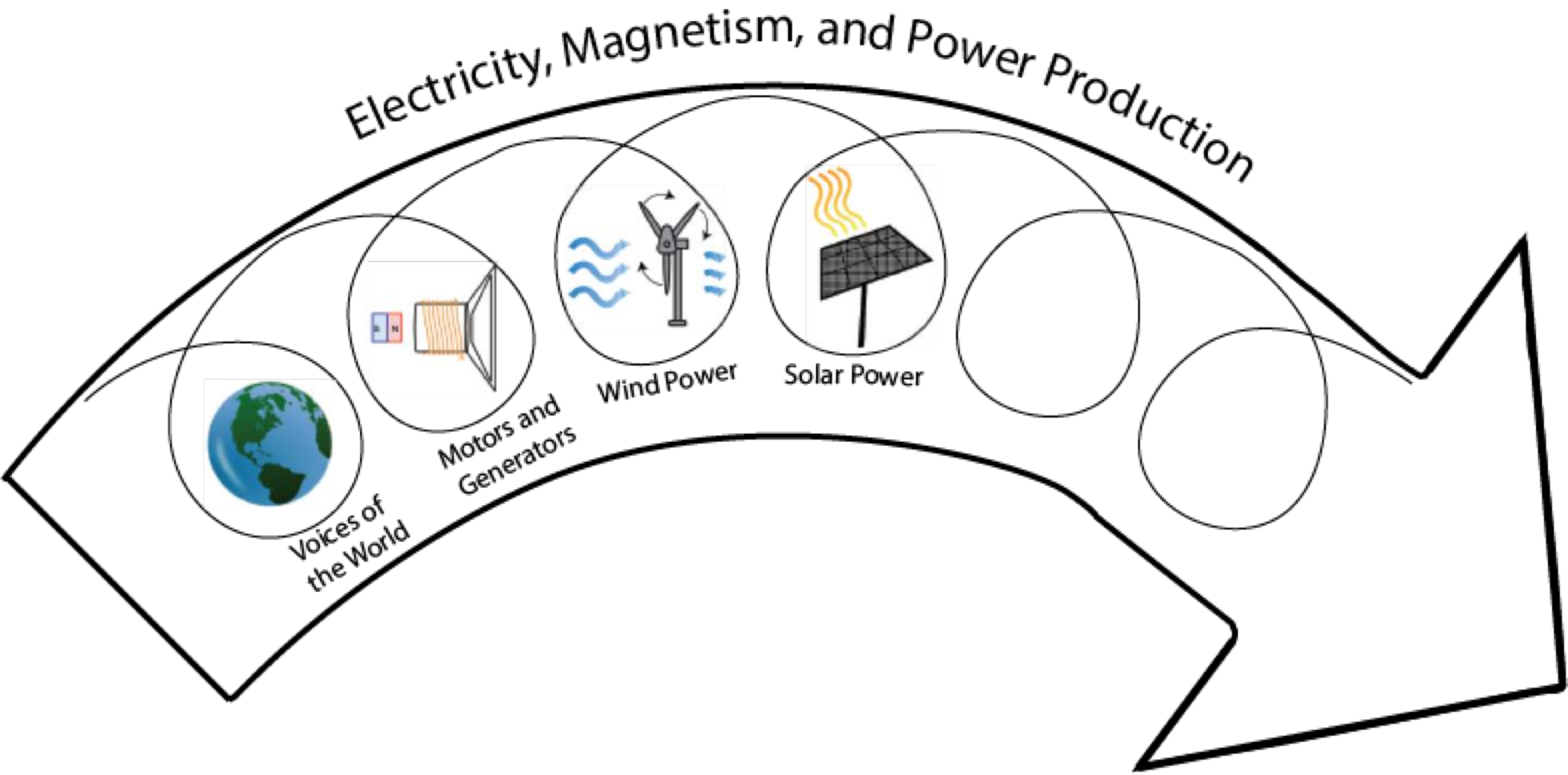
$$\text{Distance Travelled} = \tfrac{1}{2}\ \text{acceleration} * \text{time} \times \text{time}$$

Using data from the 30 cm high ramp groups, I predict for a ball rolling for 4 seconds that it will travel a distance of 4.80 (+/- 0.05) m. My confidence for this prediction is only medium-high, since the best-fit line hits near the center of most of my data points but the prediction is outside their data range.

One limitation of our procedure was that our ramp was not straight, now that I understand acceleration better I can reason that where the ramp was bowed down the ball would accelerate faster than where is was slightly bowed up, which would make for data points respectively above and below the best fit curve.

Challenges with Solar Cells




Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power
Solar Power

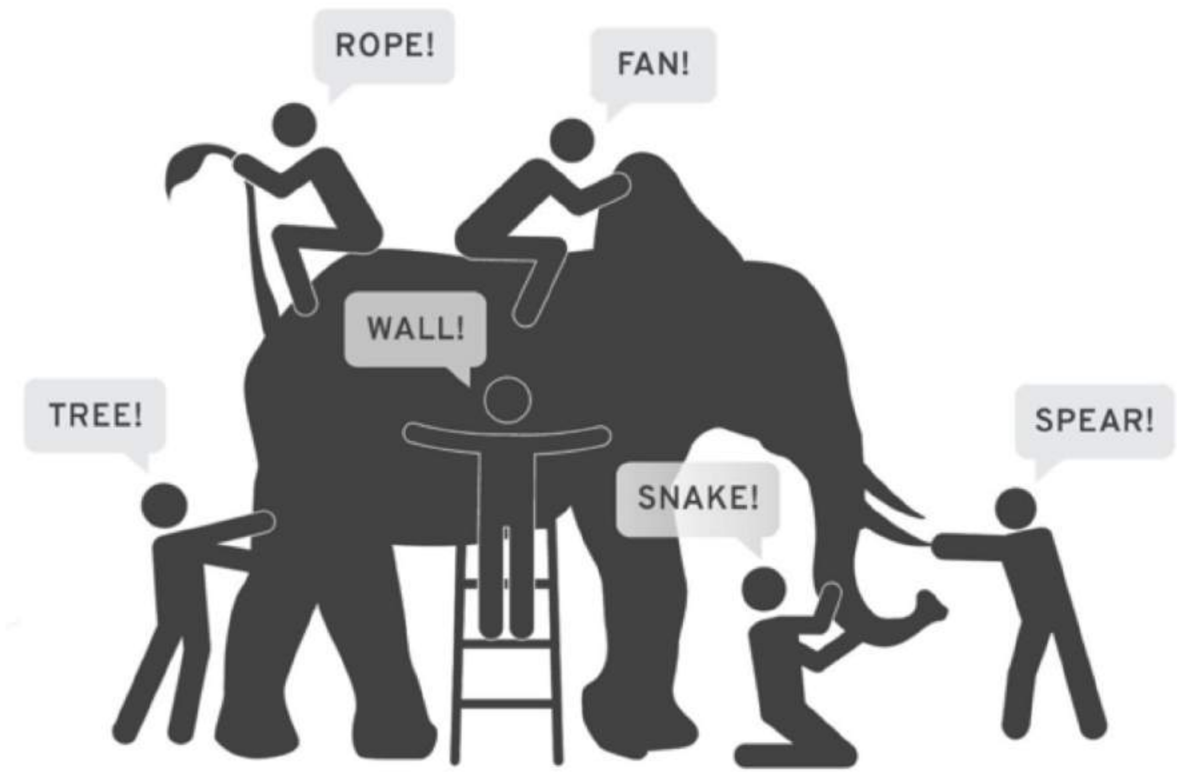
Our Evolving Understanding of the Nature of Light

Activity: 6Extension - Wave / Particle Duality

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Our Evolving Understanding of the Nature of Light

Activity: 6Extension - Wave / Particle Duality



We have to remember that what we observe is not nature in itself, but nature exposed to our method of questioning.

— Werner Heisenberg

Electricity, Magnetism, & Power Production - Day 12

Agenda:

Understanding the Earth System to inform our Climate Rubric

Using our Inner Scientist to look at Data

Due Next Class

Due This Class

Warm Up Question:

Go to bit.ly/climatesim

Write the following:
- 3 things you notice
- 2 things you wonder

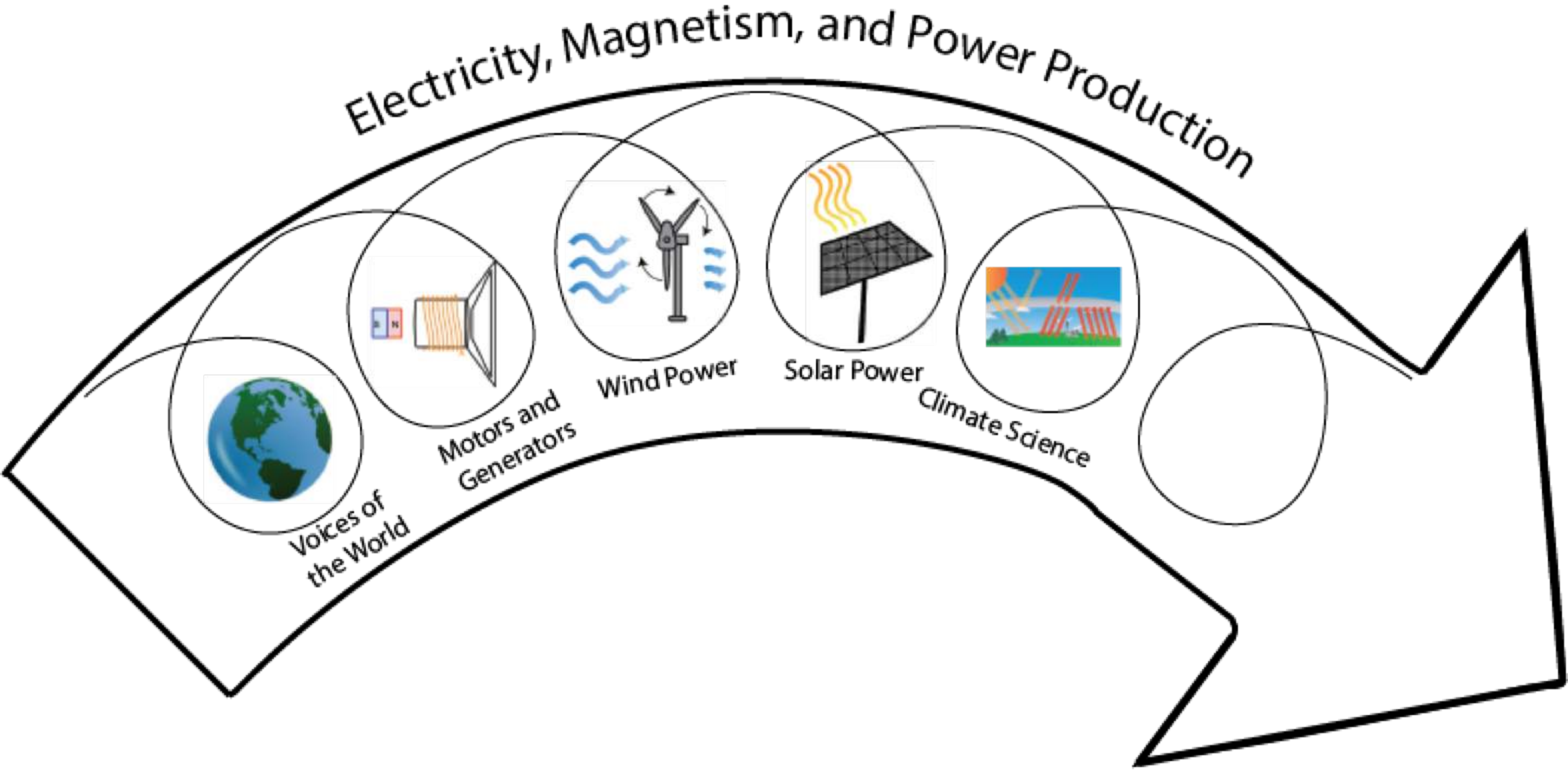
I notice…
I wonder...

Teacher Note: Resources & Background on climate science and climate change

The Framework for K-12 Science Education (which the NGSS was based upon) is an excellent, short resource for background information.

See ESS2.D: WEATHER AND CLIMATE pages 186-191

and ESS3.D: GLOBAL CLIMATE CHANGE pages 196-199


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power
Solar Power
Climate Science

What is Climate vs Weather?

Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Climate is longer term and location sensitive; it is the range of a region's weather over 1 year or many years.

-- The Framework for K-12 Science Education

Simply put: ***weather*** is how it is outside *right now*, ***climate*** is *how it is supposed to be*

Timescales for Climate vs. Weather

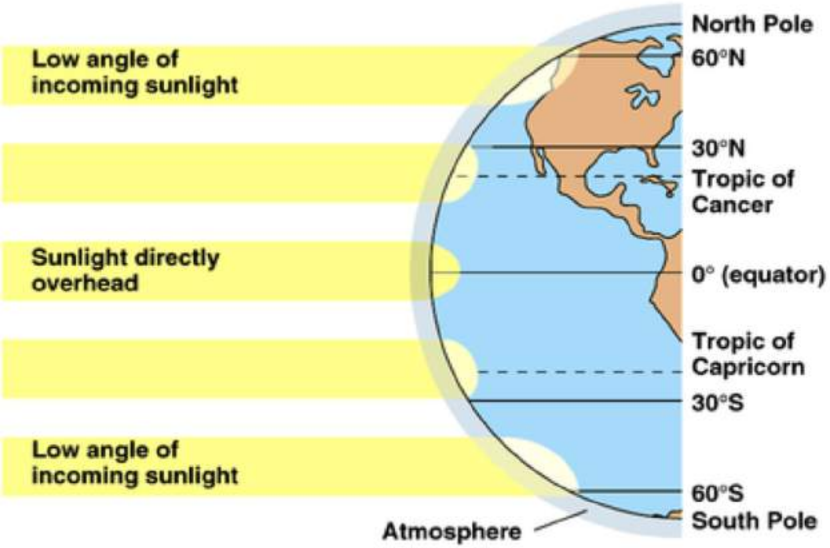
Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time scales—from days, weeks, and months for weather to years, decades, centuries, and beyond—for climate.

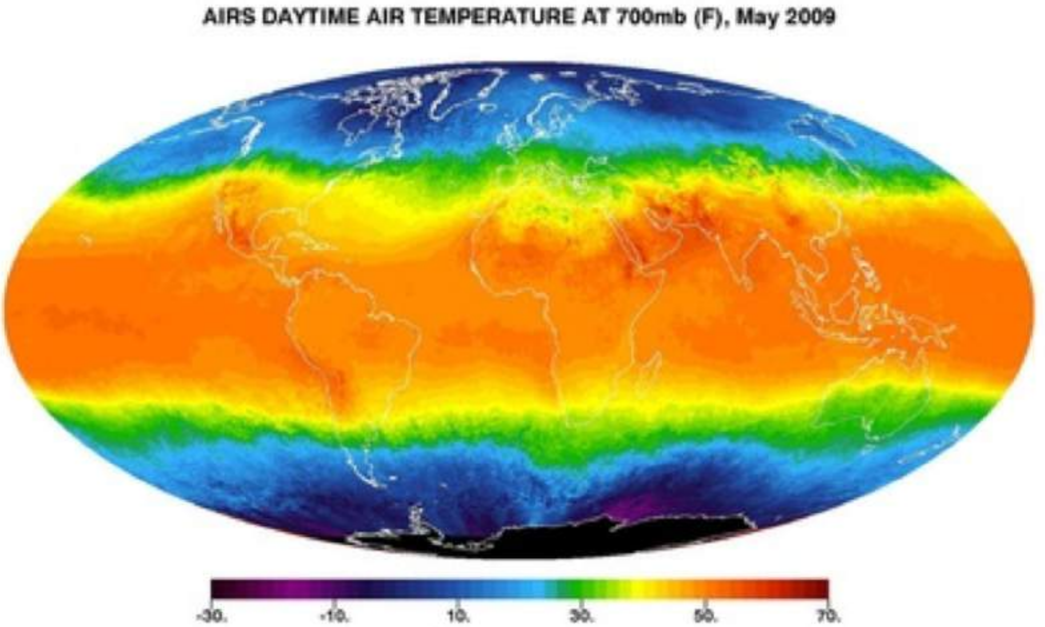
-- The Framework for K-12 Science Education

You can get surprisingly far with 3 simple factors affecting Atmospheric Circulation

1. The differential intensity of sunlight over the earth

Think: different optimal angles for a solar cell





You can get surprisingly far with 3 simple factors affecting Atmospheric Circulation

1. The differential intensity of sunlight over the earth

    Think: different optimal angles for a solar cell

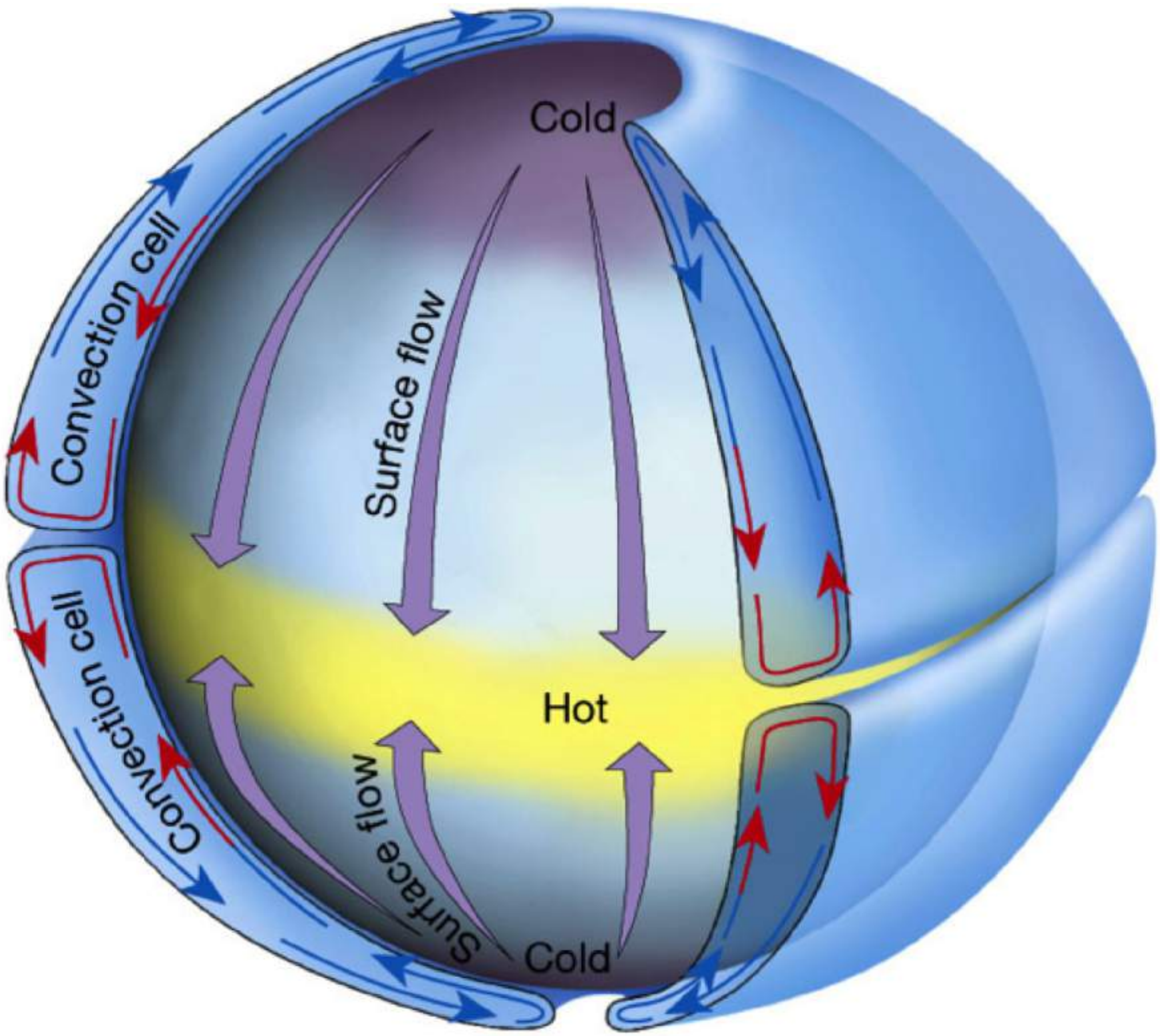
2. The earth's surface varies

    Think: water vs. land vs mountain ranges

3. The fact the earth is ***really big*** and spinning

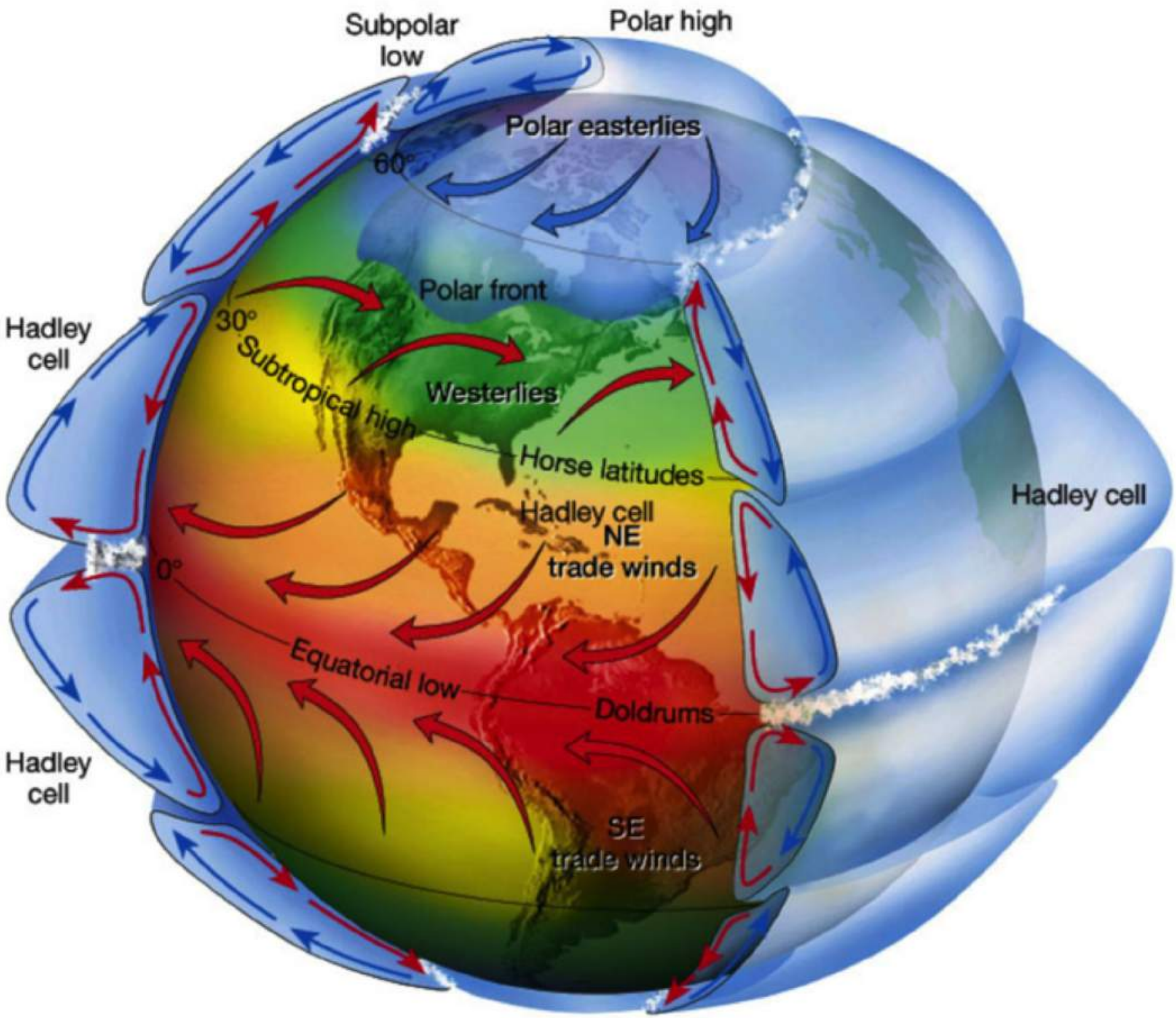
    Think: it is not going to be simple

A bit Oversimplified: Air at the equator warms, rises, and is pushed from the following air behind it to the poles, where it cools, sinks and flows back to the equator to repeat

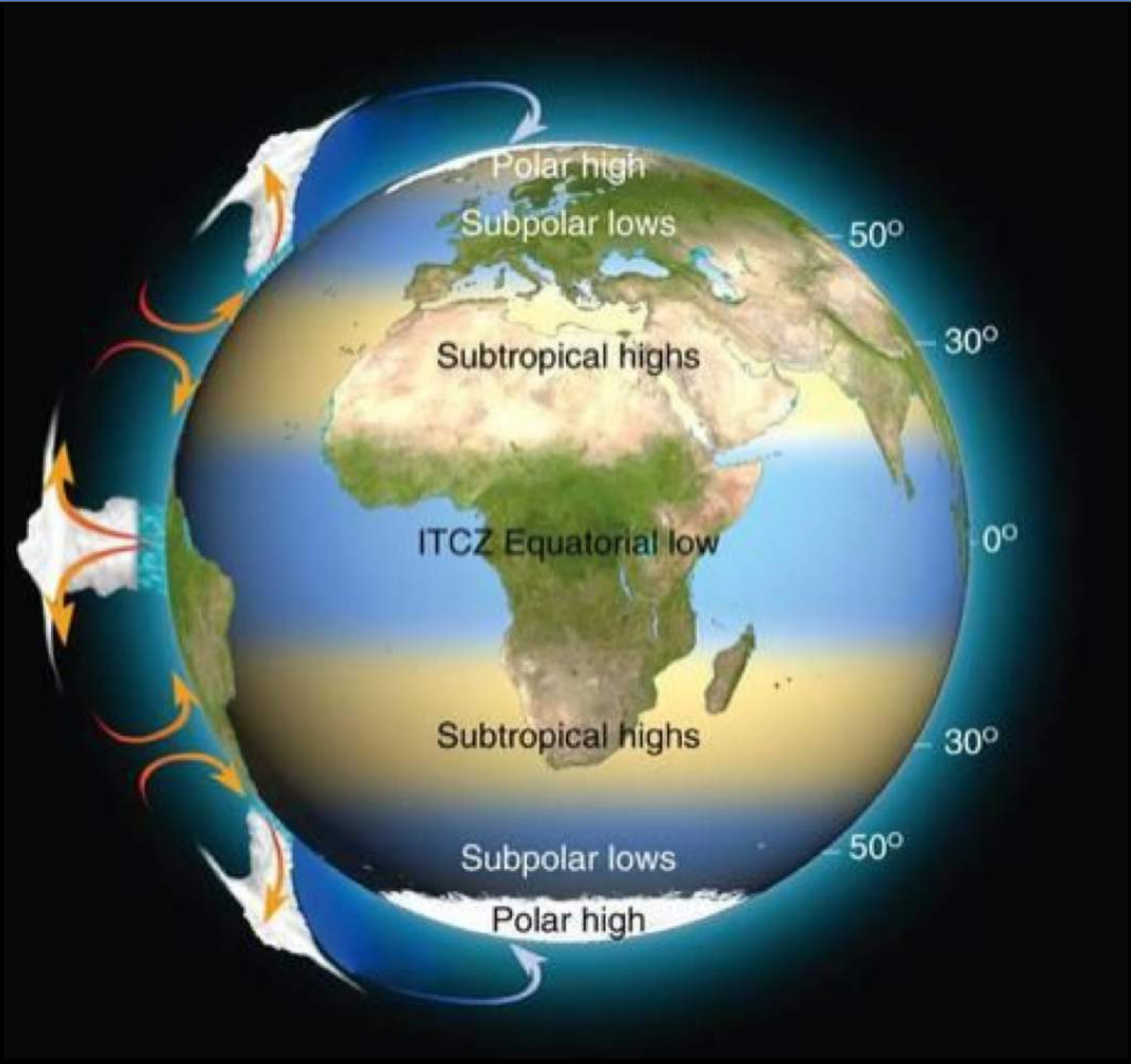


Simple, single cell atmospheric convection in a non-rotating Earth. "Single cell" being either a single cell north or south of the equator. Figure 7.5 in *The Atmosphere, 8th edition*, Lutgens and Tarbuck, 8th edition, 2001

Remember the earth's surface varies and it is ***really big*** and spinning

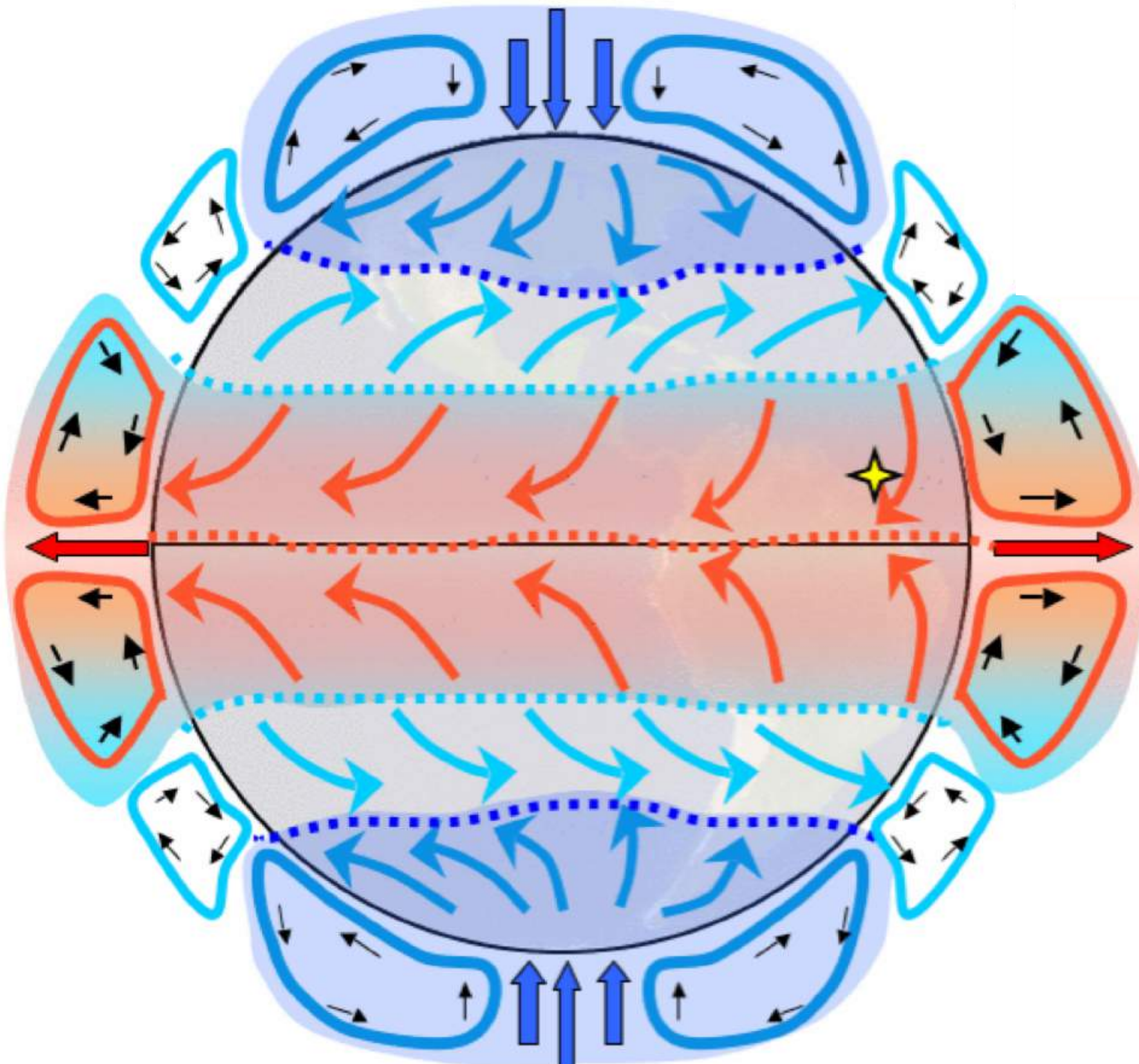


Idealized, three cell atmospheric convection in a rotating Earth. "Three cell" being either three cells north or south of the equator. The deflections of the winds within each cell is caused by the Coriolis Force.



Source: serc.carleton.edu

A Peak at an animated representation.



Source: http://montessorimuddle.org/

A Peak at another representation.
Why is Oregon so mild in winter vs Minnesota at the same latitude?

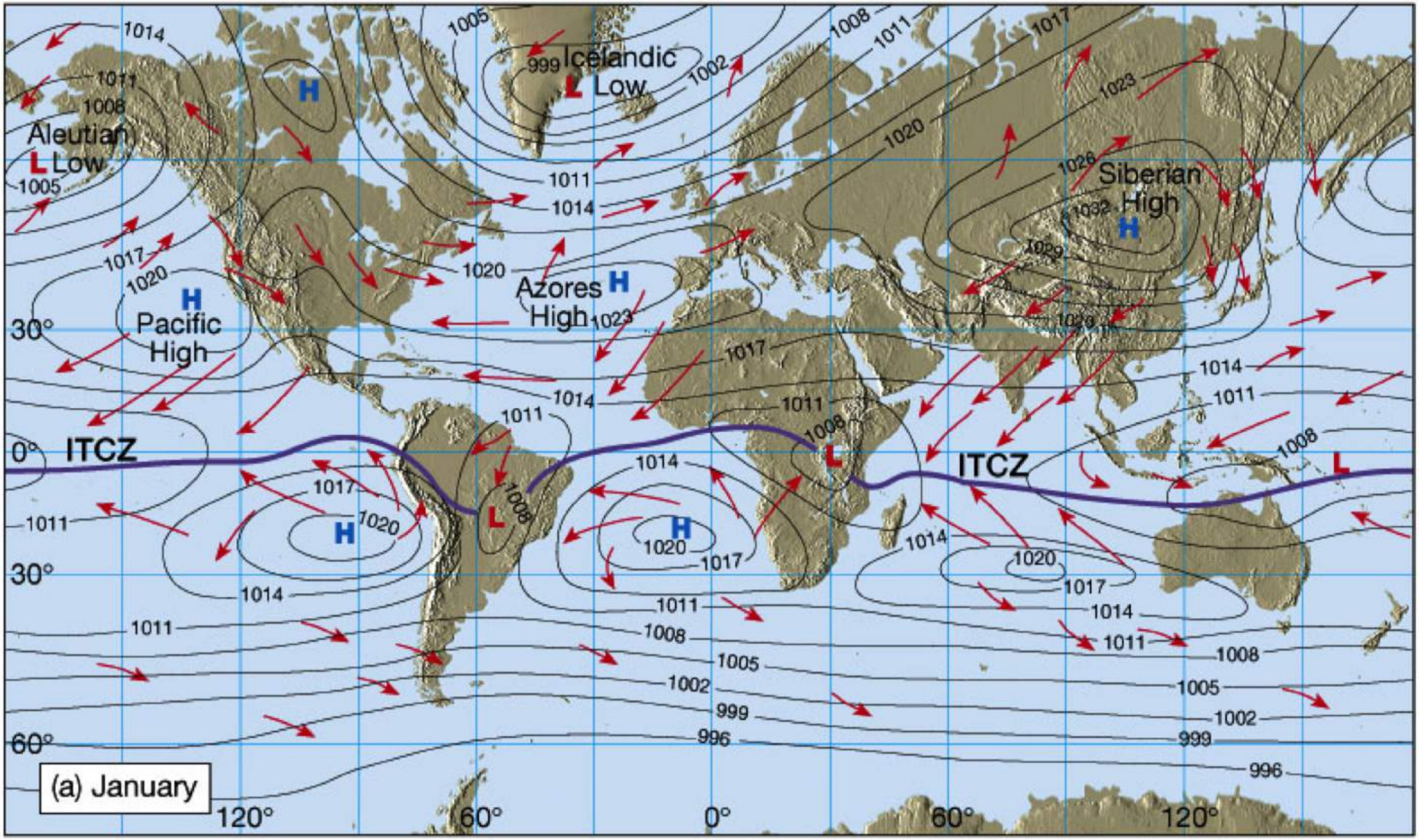


Figure 7.9 in *The Atmosphere, 8th edition*, Lutgens and Tarbuck, 8th edition, 2001.

A Peak at another representation.
Why is Oregon so mild in summer vs. Minnesota at the same latitude?

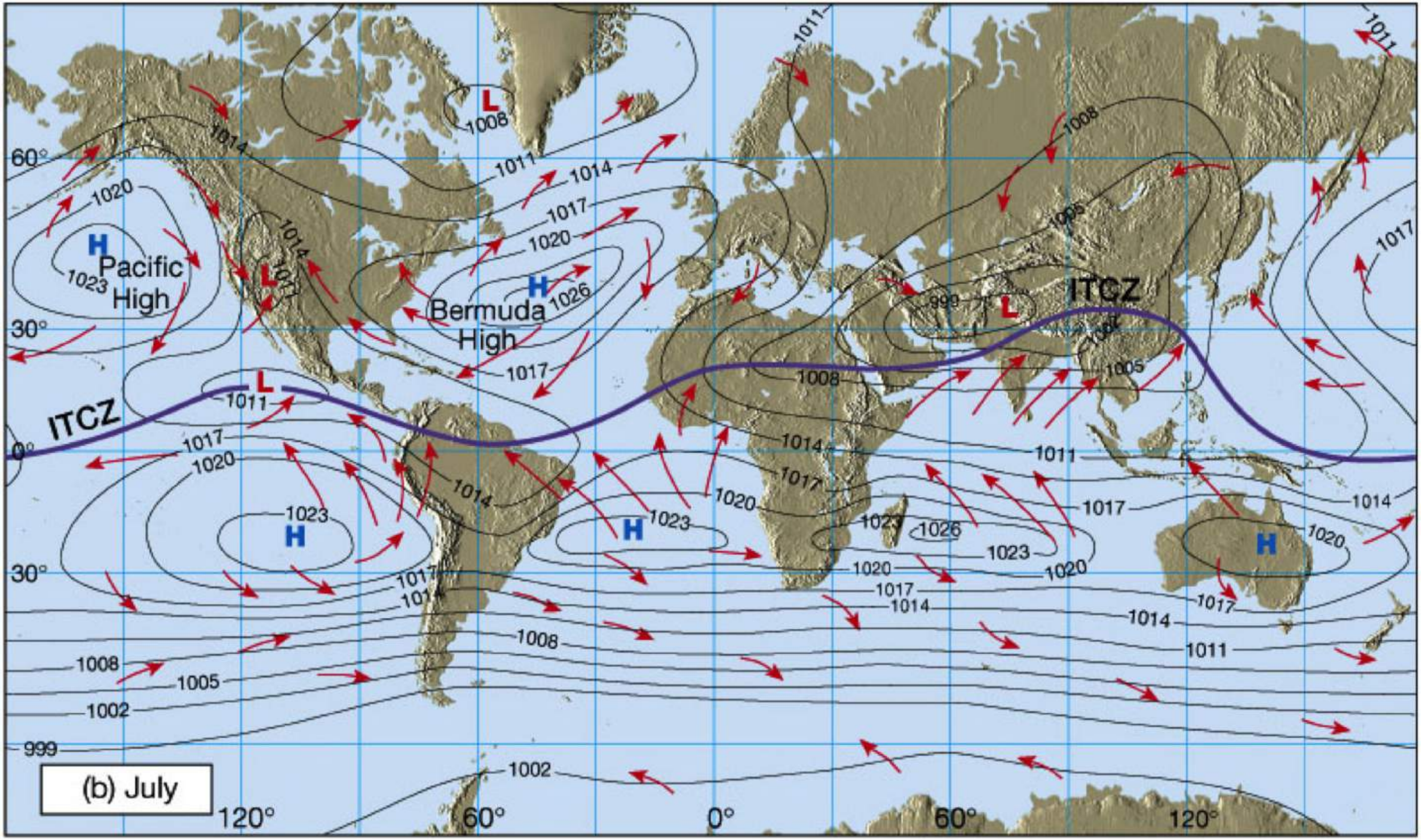
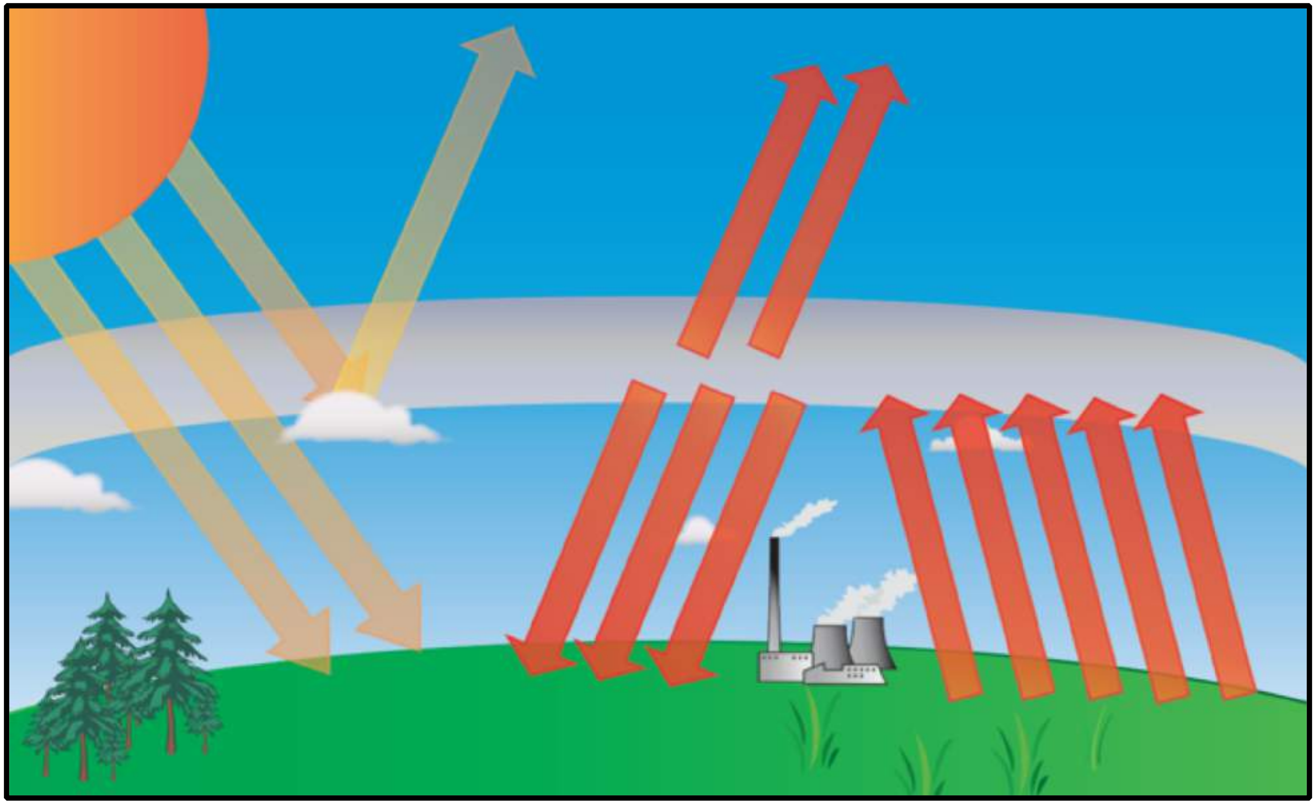


Figure 7.9 in *The Atmosphere, 8th edition*, Lutgens and Tarbuck, 8th edition, 2001.

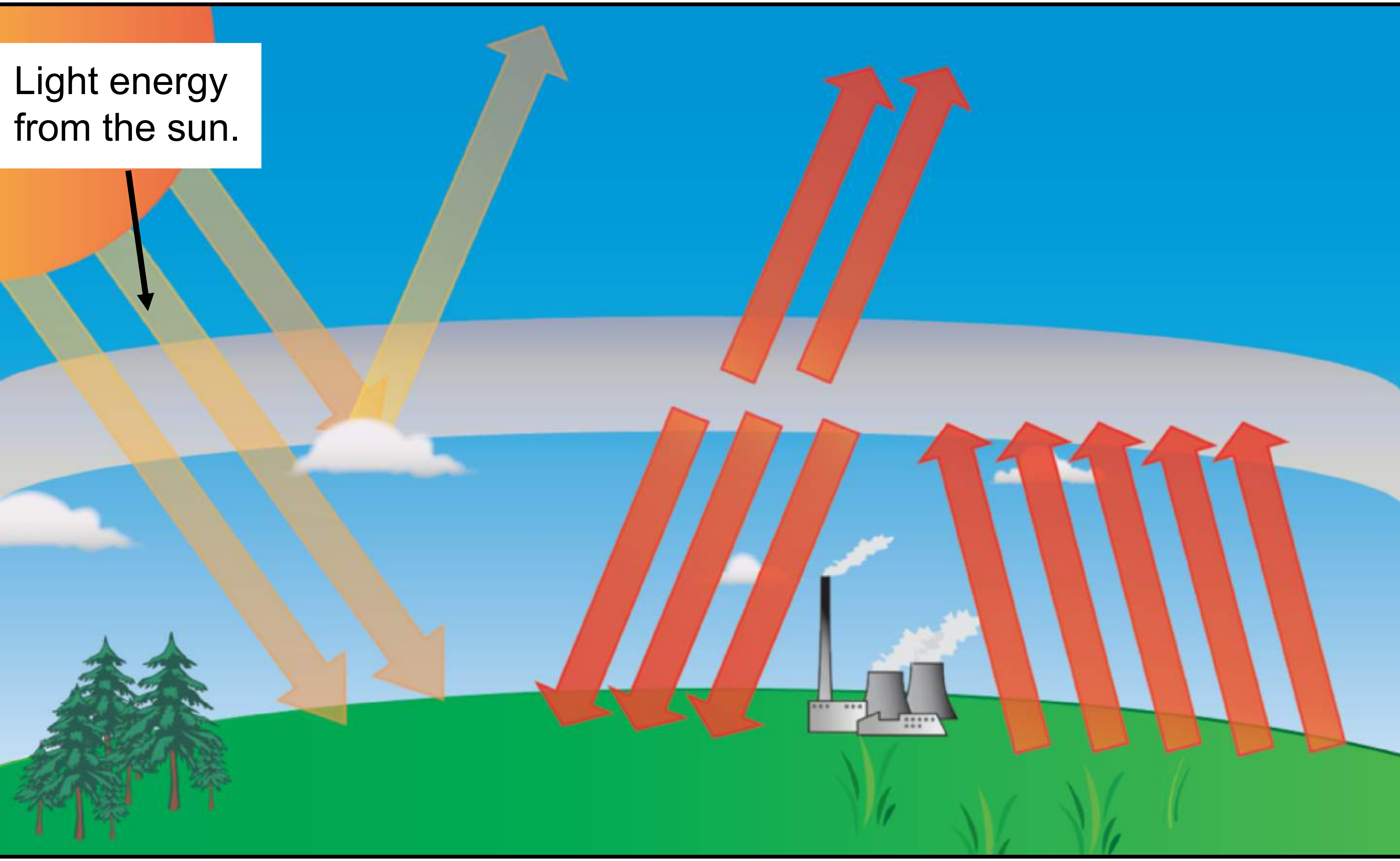
Earth System through Sankey Diagrams

Annotate your Sankey Diagram in your Packet

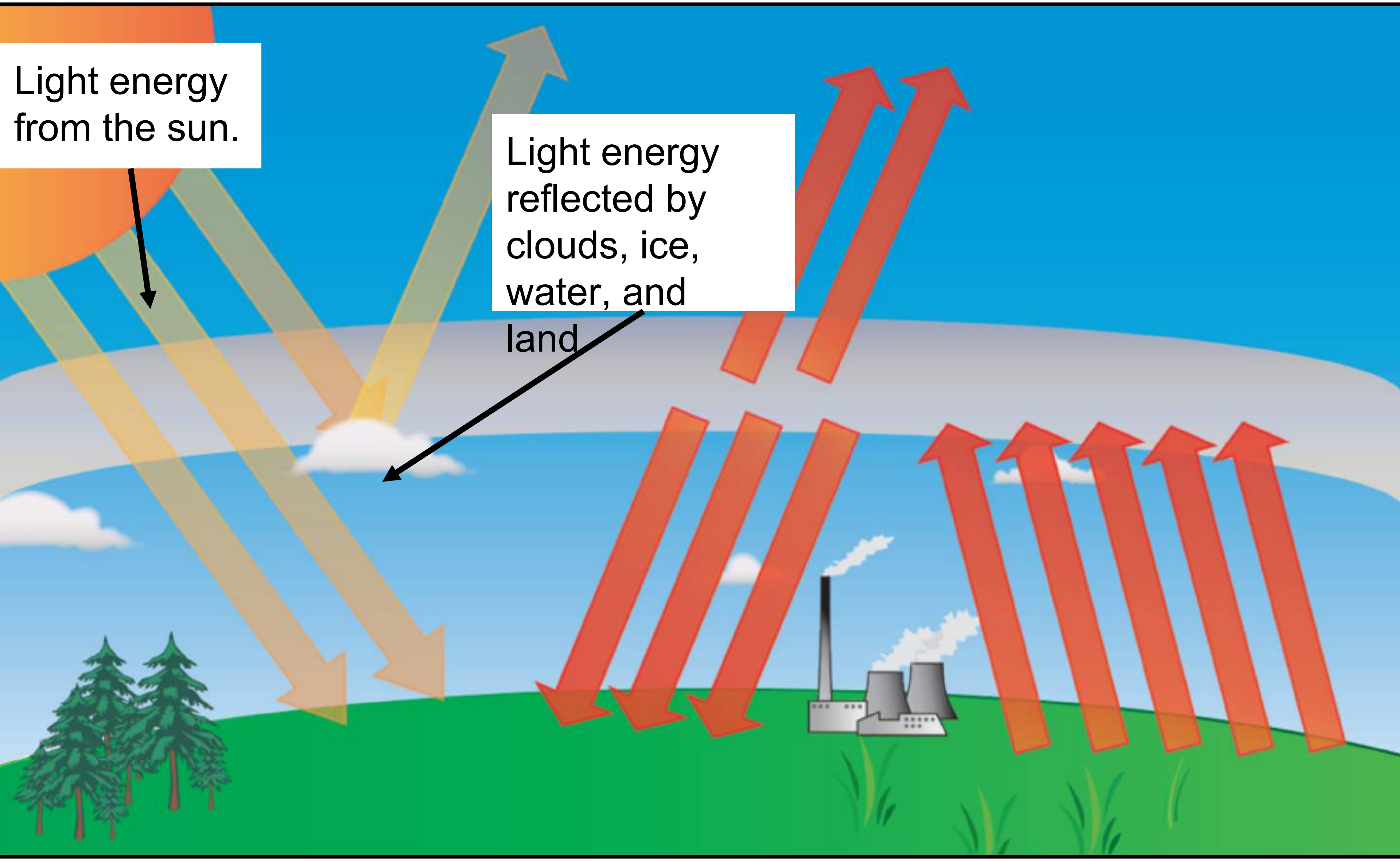
Often diagrams can better represent and express what is happening:



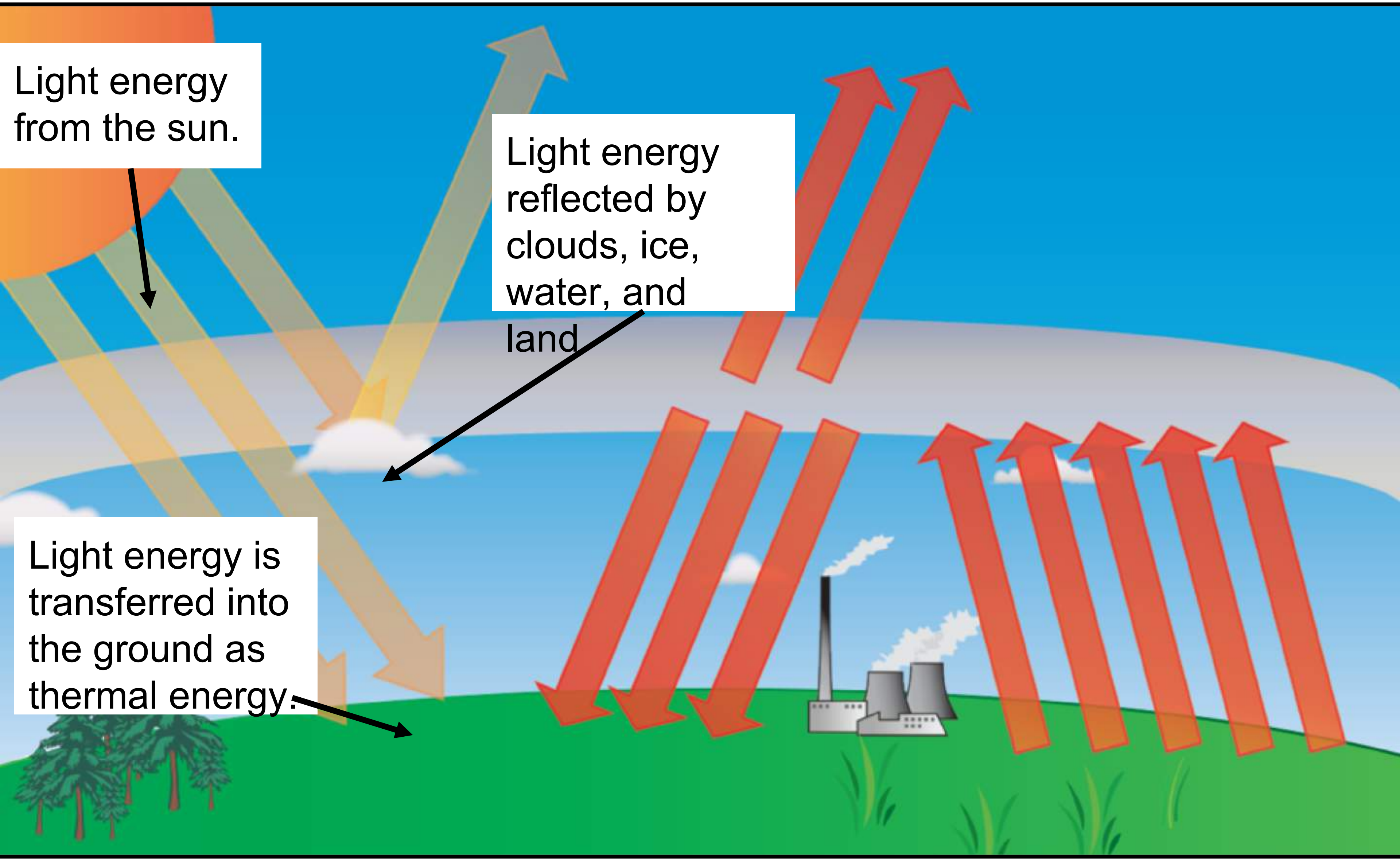
Earth System through Sankey Diagrams



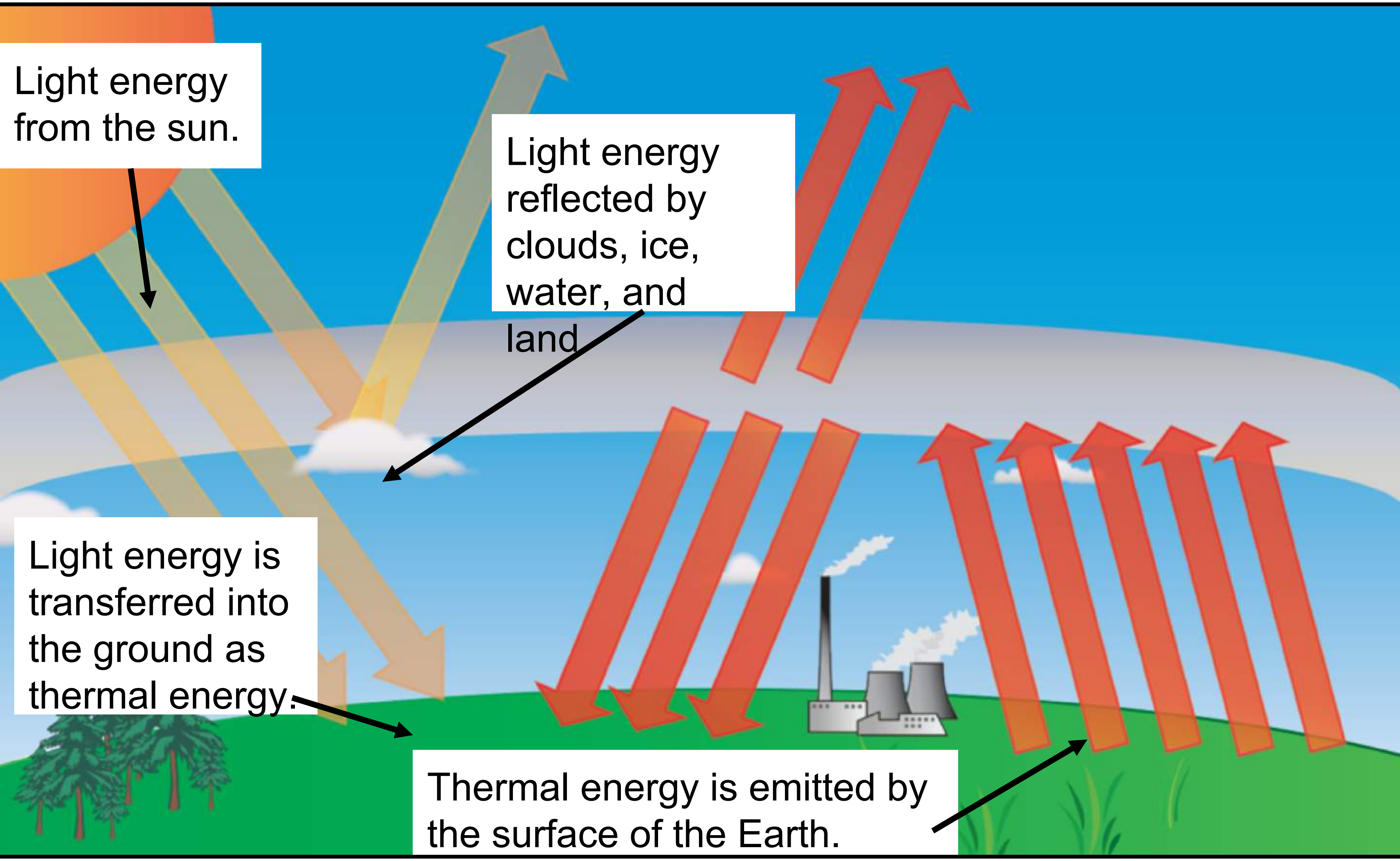
Earth System through Sankey Diagrams



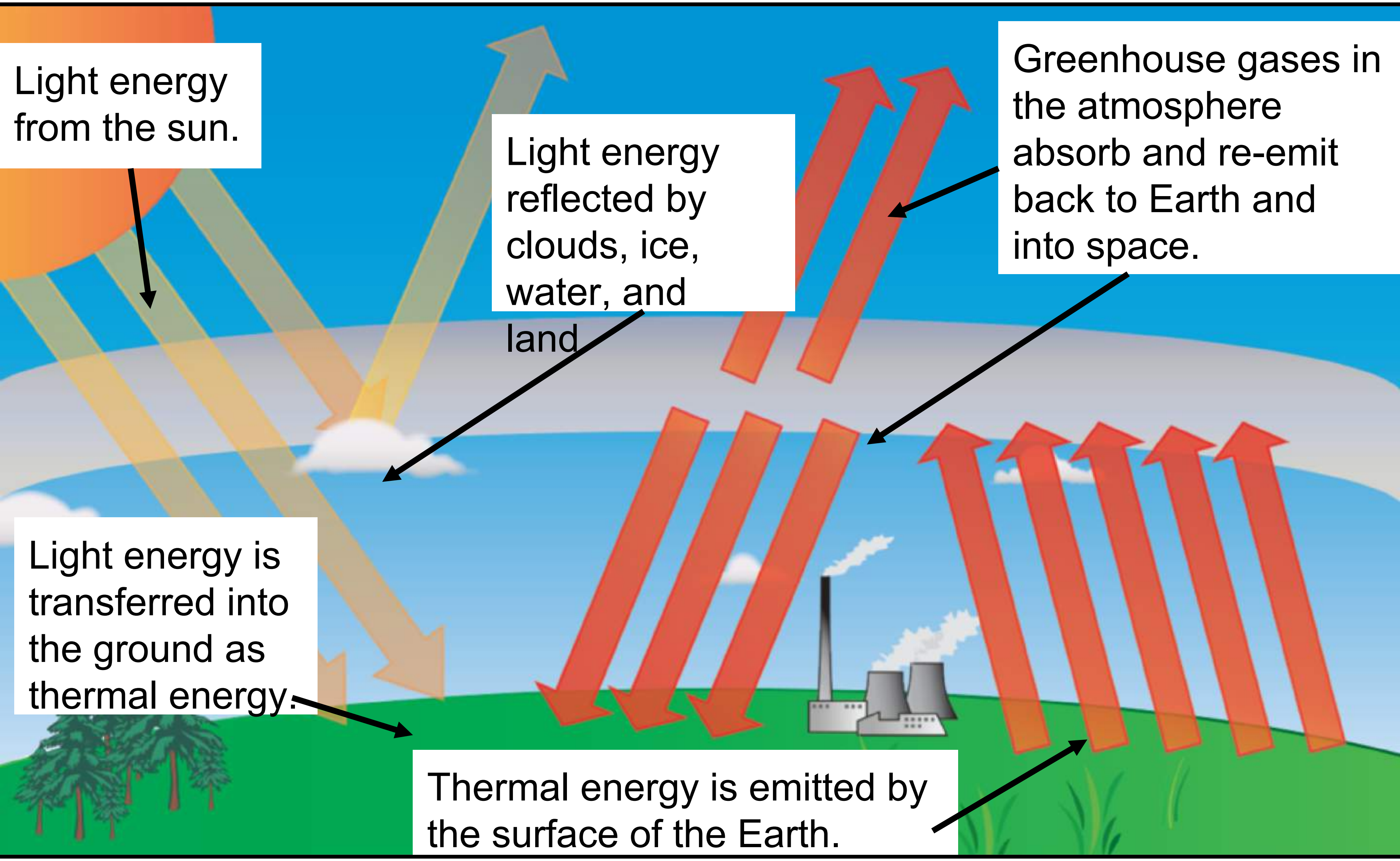
Earth System through Sankey Diagrams



Earth System through Sankey Diagrams



Earth System through Sankey Diagrams



Understanding Energy in the Earth System

At its very simplest is it is about

E_{in} versus E_{out}

One level more thoughtful is looking at the rate of Energy Transfer

$$\frac{E_{in}}{\text{unit time}} \quad \text{versus} \quad \frac{E_{out}}{\text{unit time}}$$

Now at this point we really should add:

$$\frac{E_{in}}{\text{unit time}} \searrow \quad E_{\text{Stored in Earth}} \quad \nearrow \frac{E_{out}}{\text{unit time}}$$

Energy in the Earth System: Warming Climate

E_{in}

E_{out}

$E_{\text{Stored in Earth}}$

Energy into the Earth system increased

System

E_{in}

E_{out}

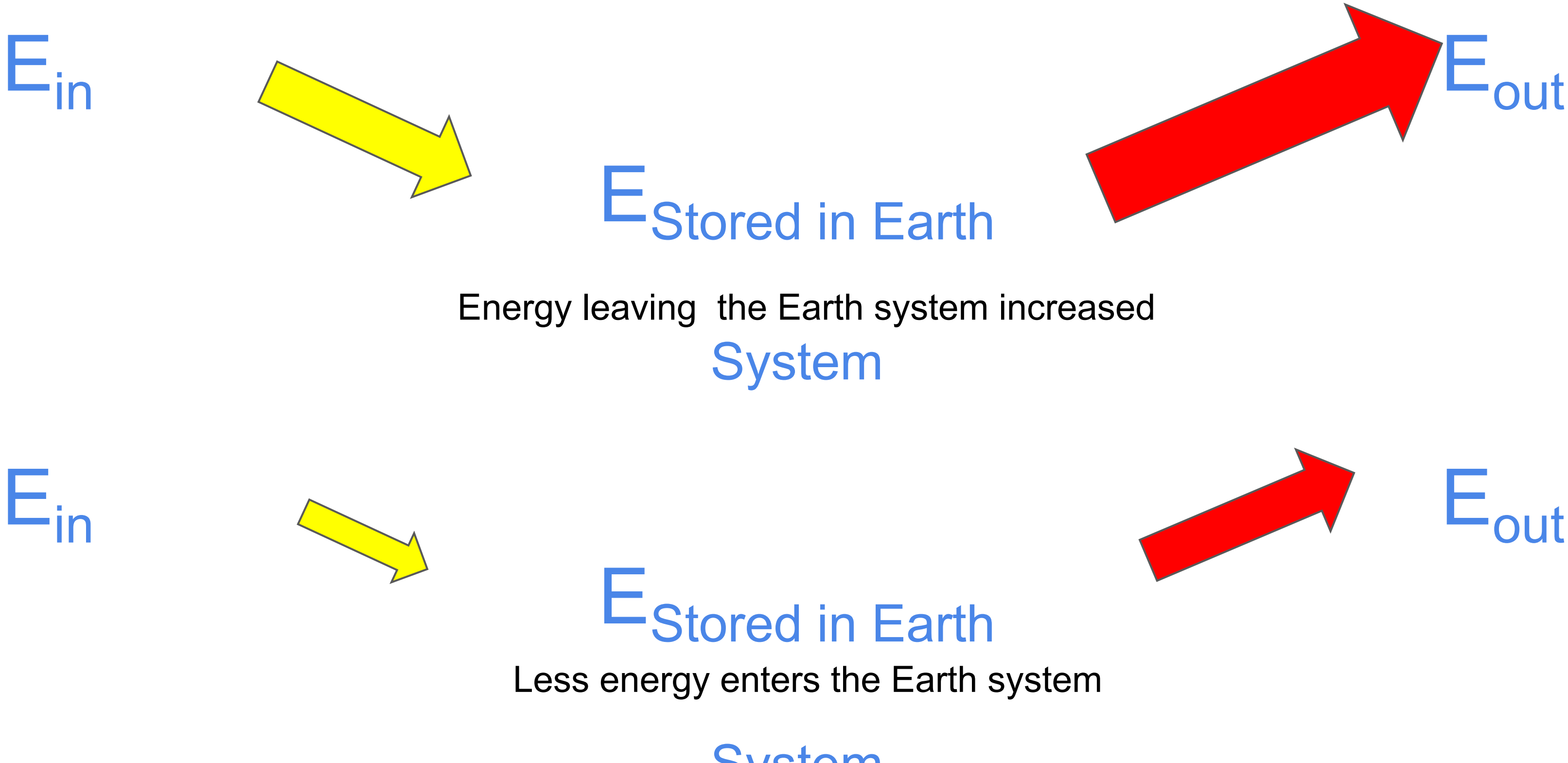
$E_{\text{Stored in Earth}}$

Less energy left the Earth system

System

In a warming climate the Earth system gains energy because the energy in is greater than the energy out.

Energy in the Earth System: Cooling Climate



In a cooling climate the Earth system loses energy because the energy in is less than the energy out.

Earth System through Sankey Diagrams

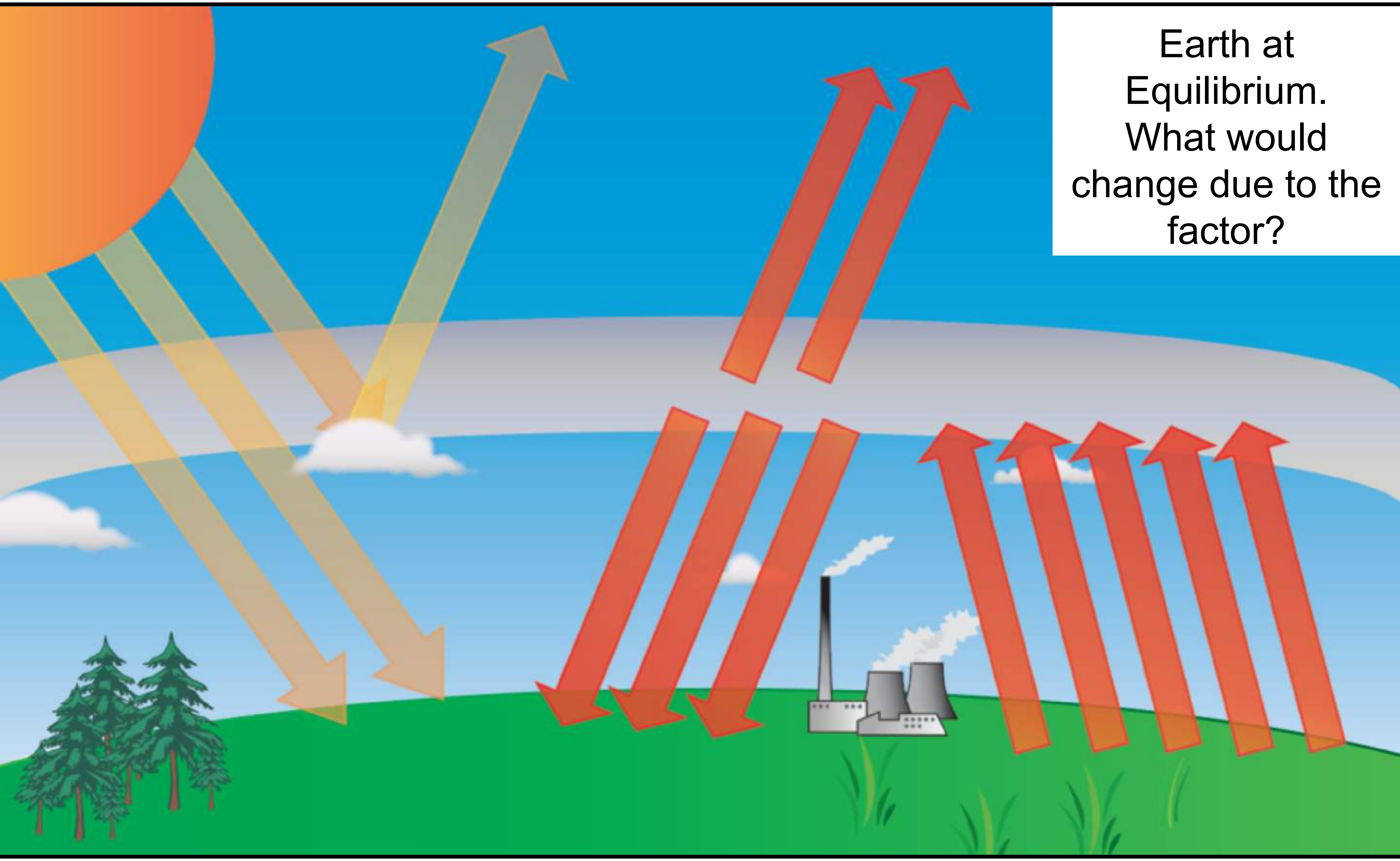
Let's investigate these 10 factors by their primary/initial effect and the timescale of the effect they have on the Earth system:

A. Atmospheric composition
B. Volcanic activity
C. Circulation of the Oceans
D. Deforestation
E. Earth's orbit and the orientation of its axis
F. Circulation of the Atmosphere
G. Glaciation
H. Human activities
I. Increase in sun's energy output
J. Decrease in sun's energy output

Earth System through Sankey Diagrams

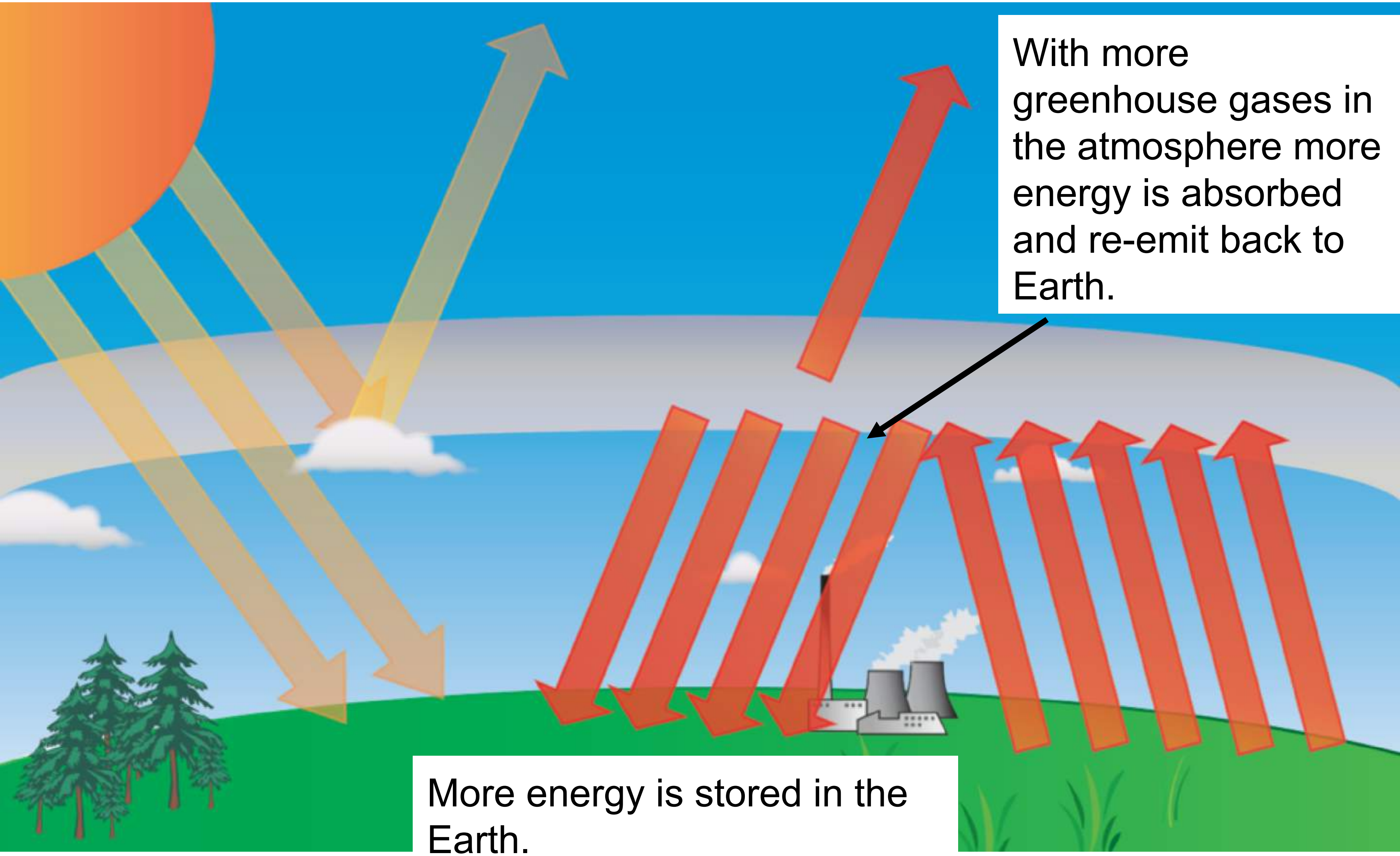
See interactive arrows in
[6Activity - Sankey Manipulative Diagram for Climate Change Graphic]

Factor: Atmospheric Composition



Earth at Equilibrium. What would change due to the factor?

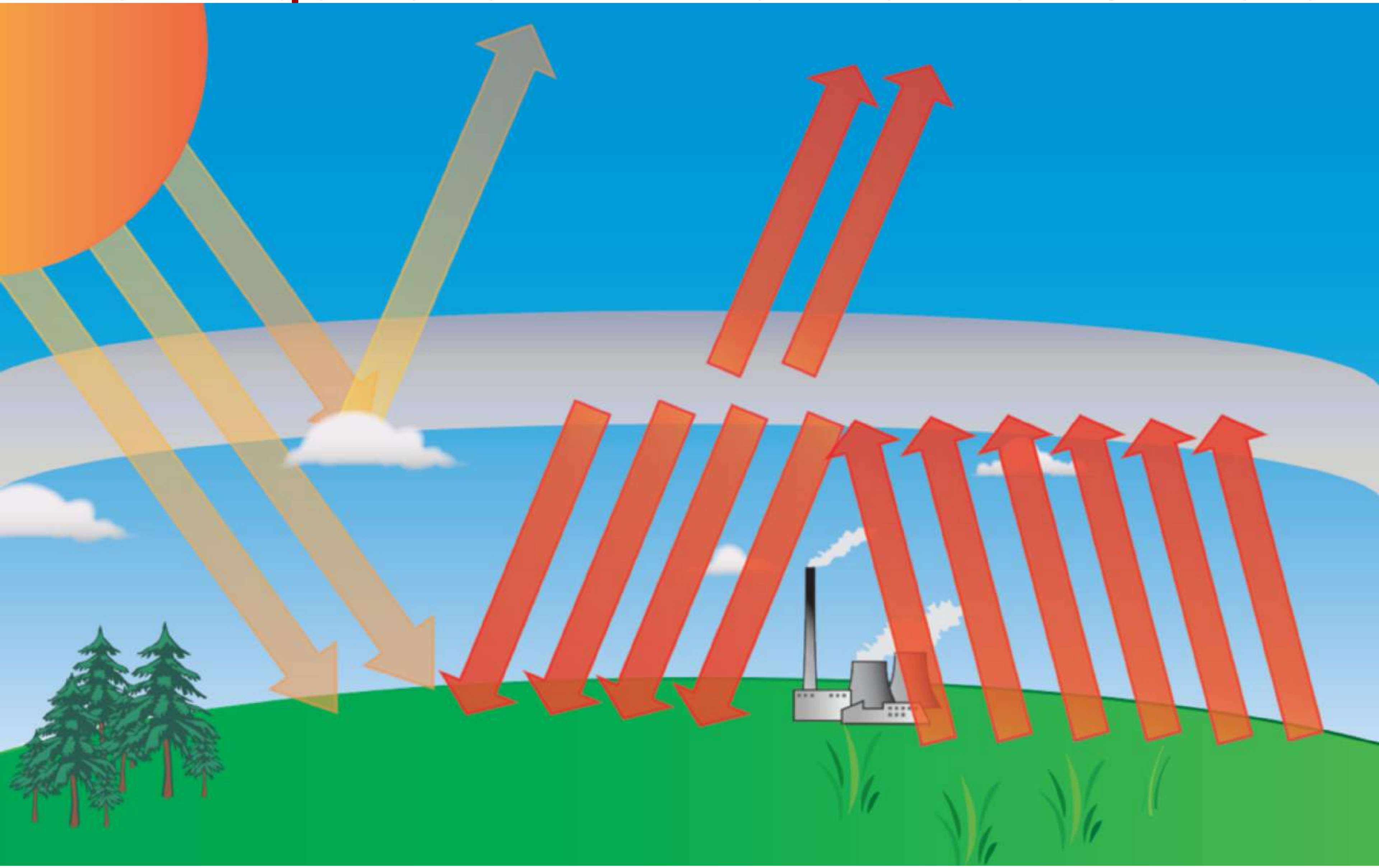
Increased Atmospheric Composition



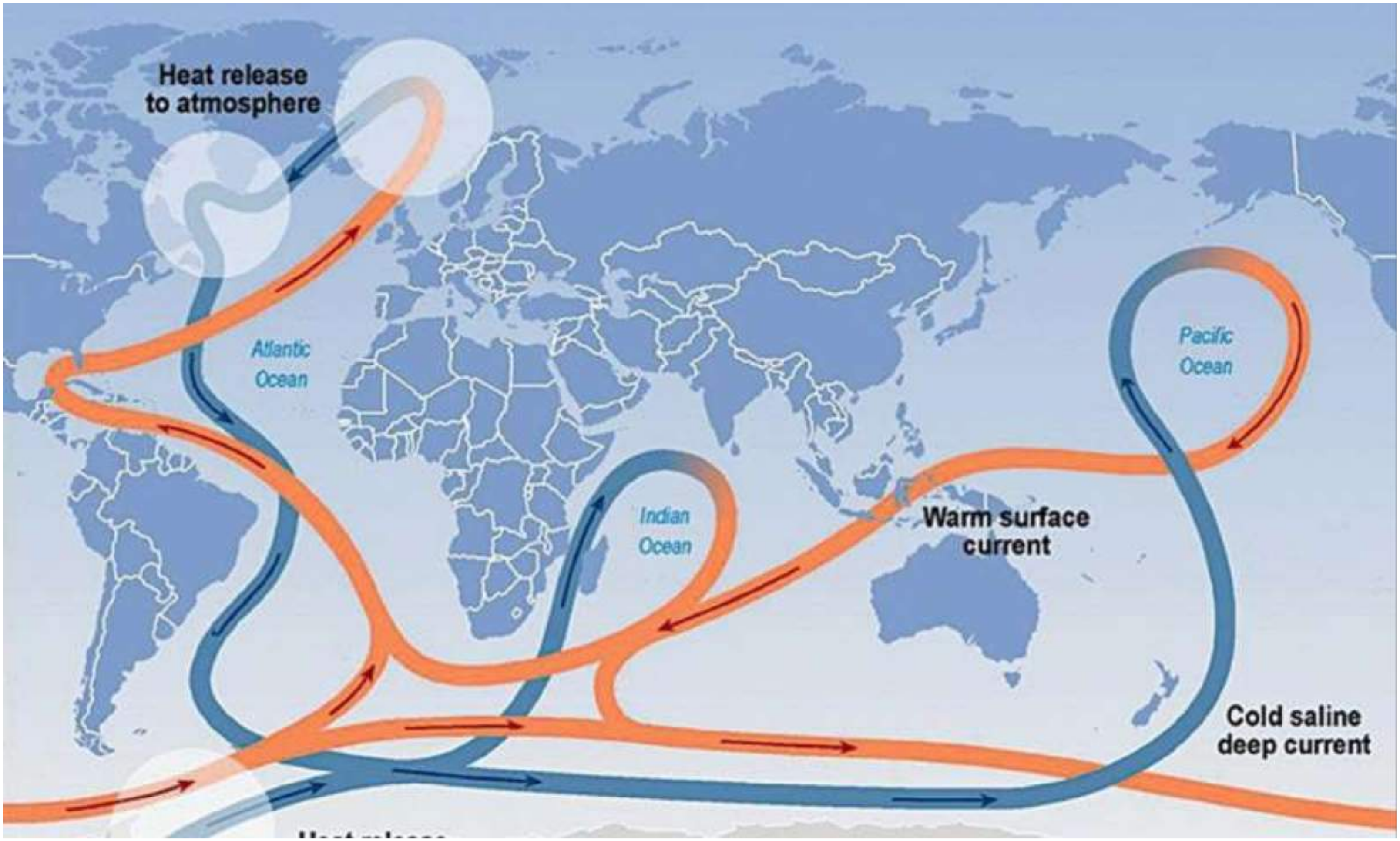
With more greenhouse gases in the atmosphere more energy is absorbed and re-emit back to Earth.

More energy is stored in the Earth.

New Equilibrium with a Warmer Climate

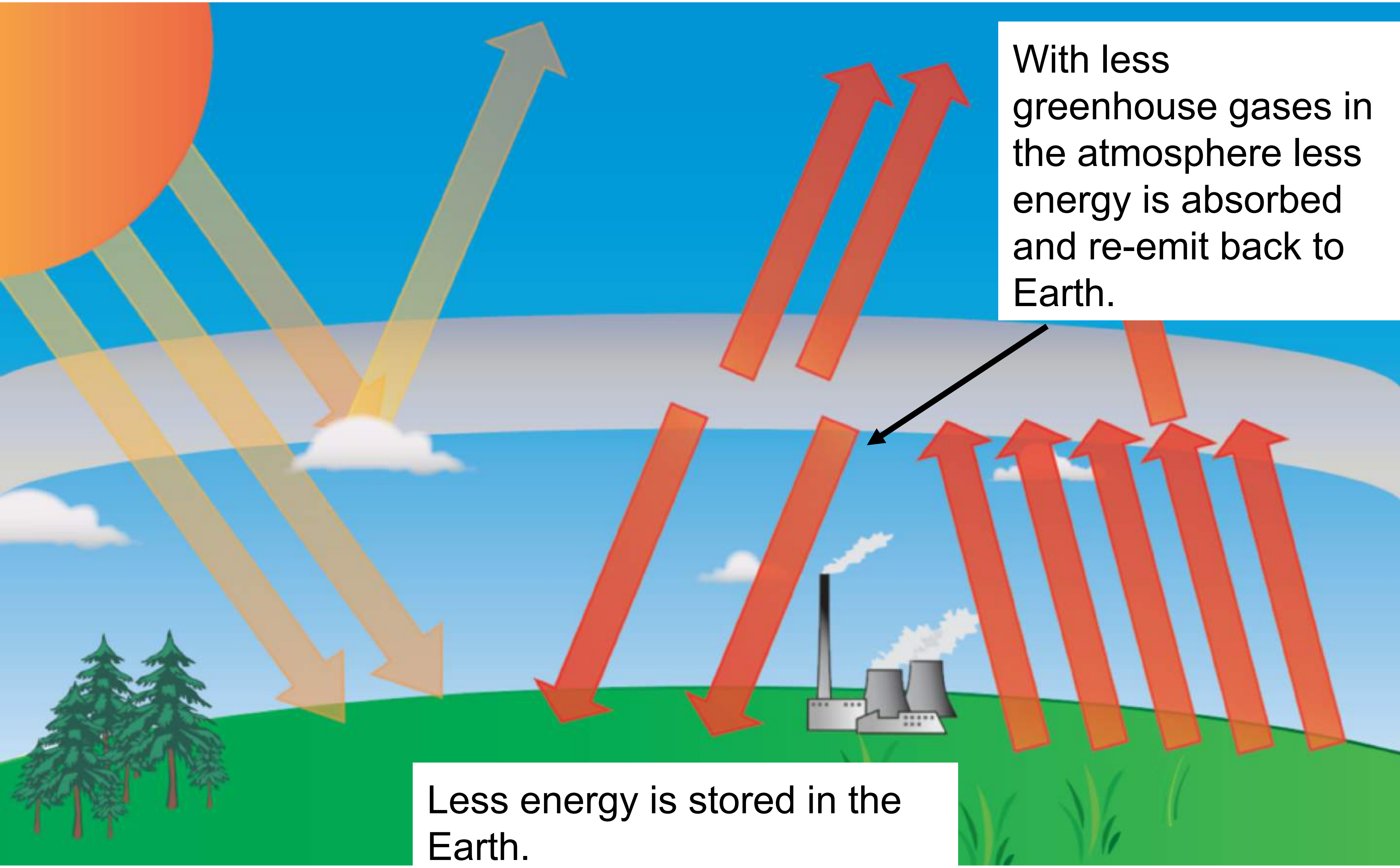


Factor: Circulation of the Oceans

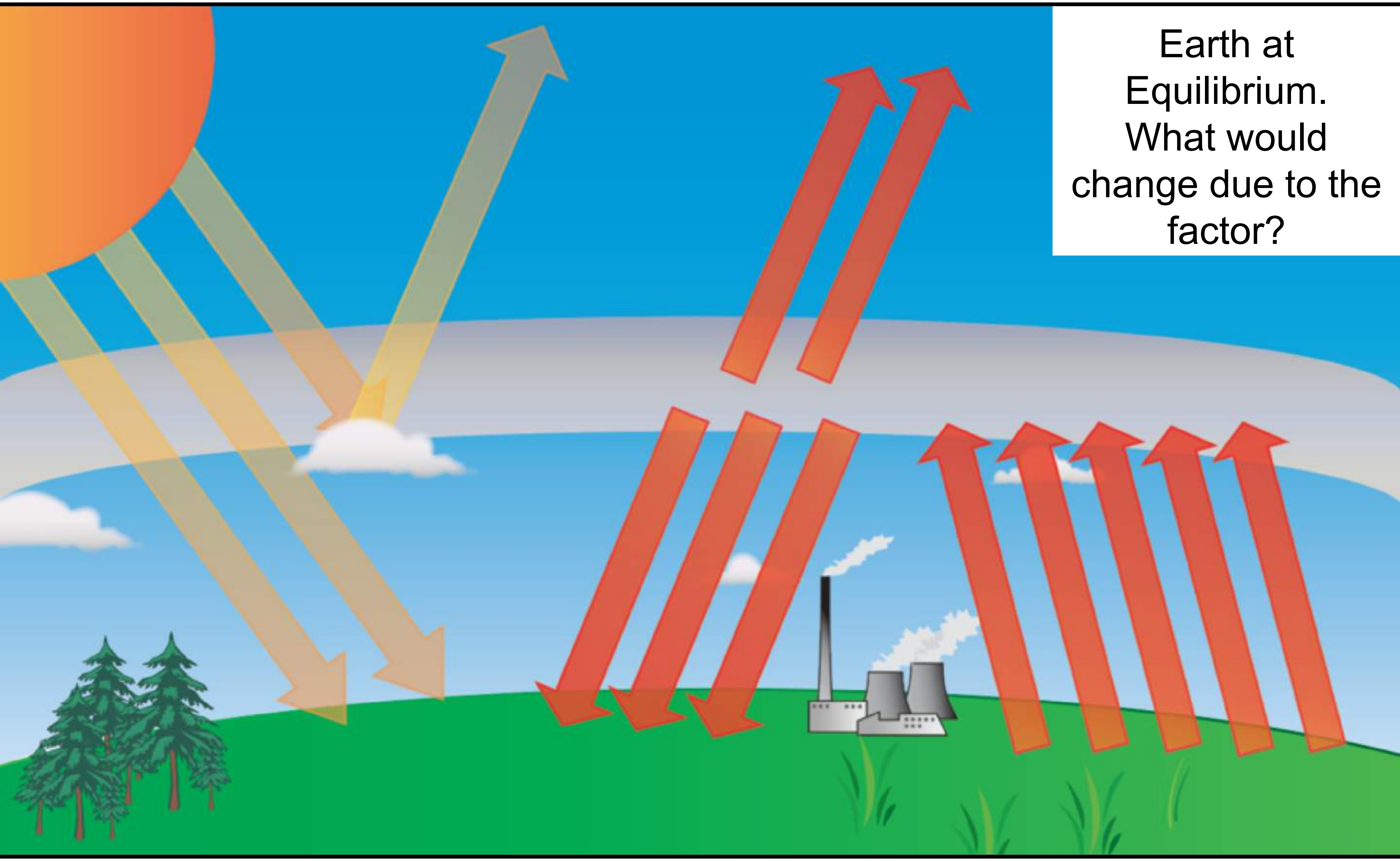


When it comes to regulating global climate, the circulation of the Atlantic Ocean plays a key role. The constantly moving system of deep-water circulation, sometimes referred to as the Global Ocean Conveyor Belt, sends warm, salty Gulf Stream water to the North Atlantic where it releases heat to the atmosphere and warms Western Europe. The cooler water then sinks to great depths and travels all the way to Antarctica and eventually circulates back up to the Gulf Stream. Credit: Intergovernmental Panel on Climate Change
Read more at: https://phys.org/news/2018-04-atlantic-ocean-circulation-weakest-years.html#jCp

Decreased Atmospheric Composition

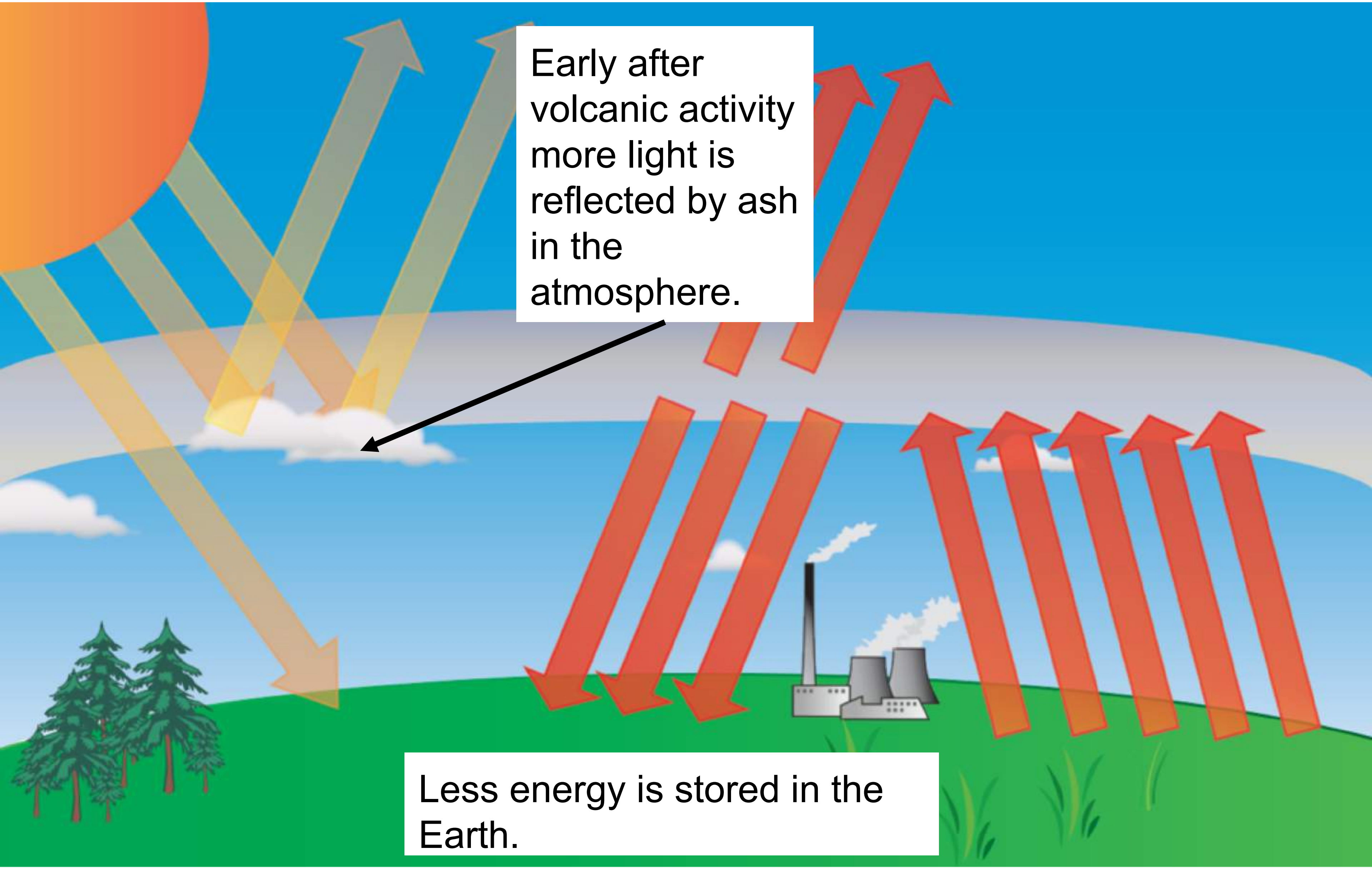


Factor: Volcanic Activity

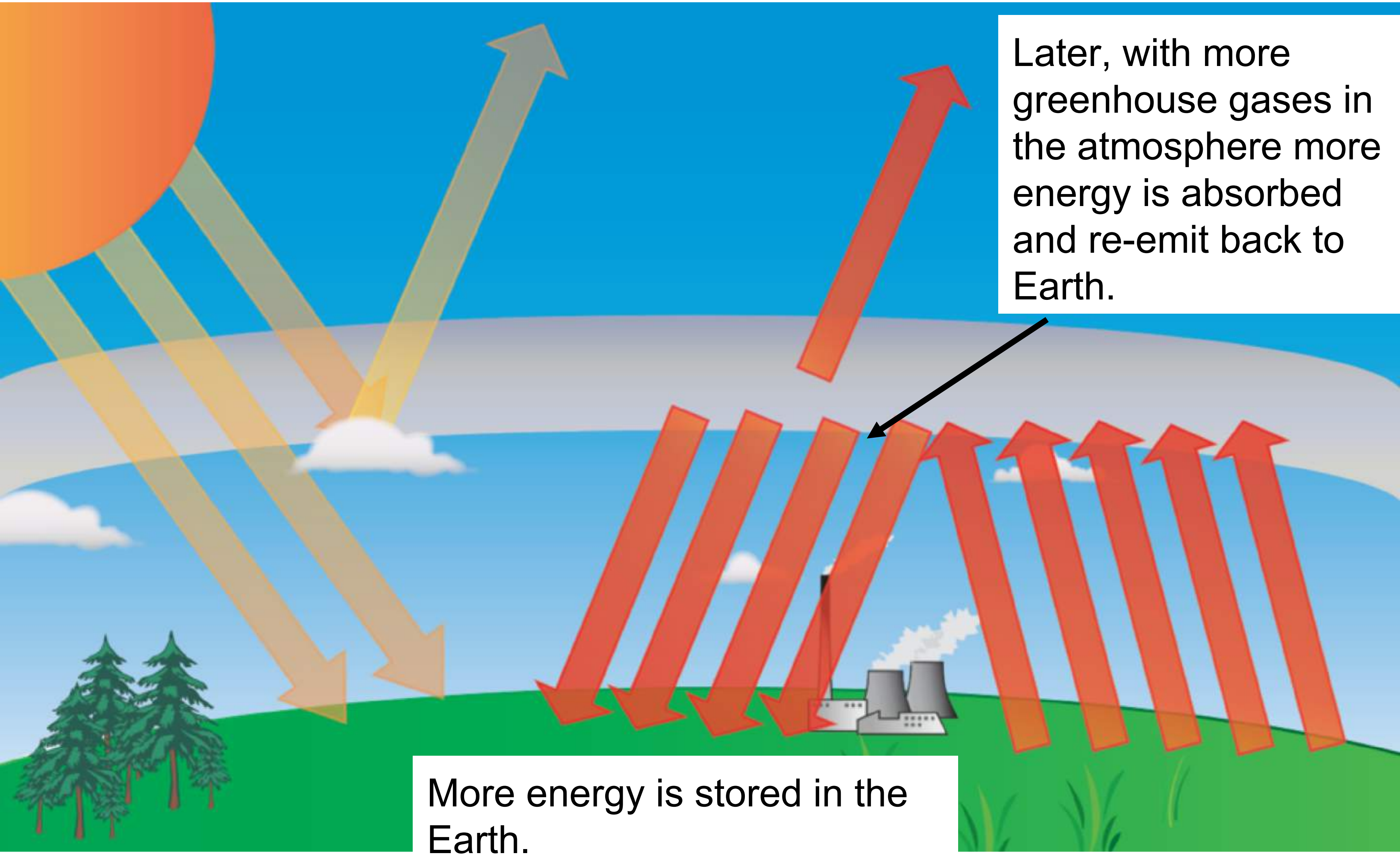


Earth at Equilibrium. What would change due to the factor?

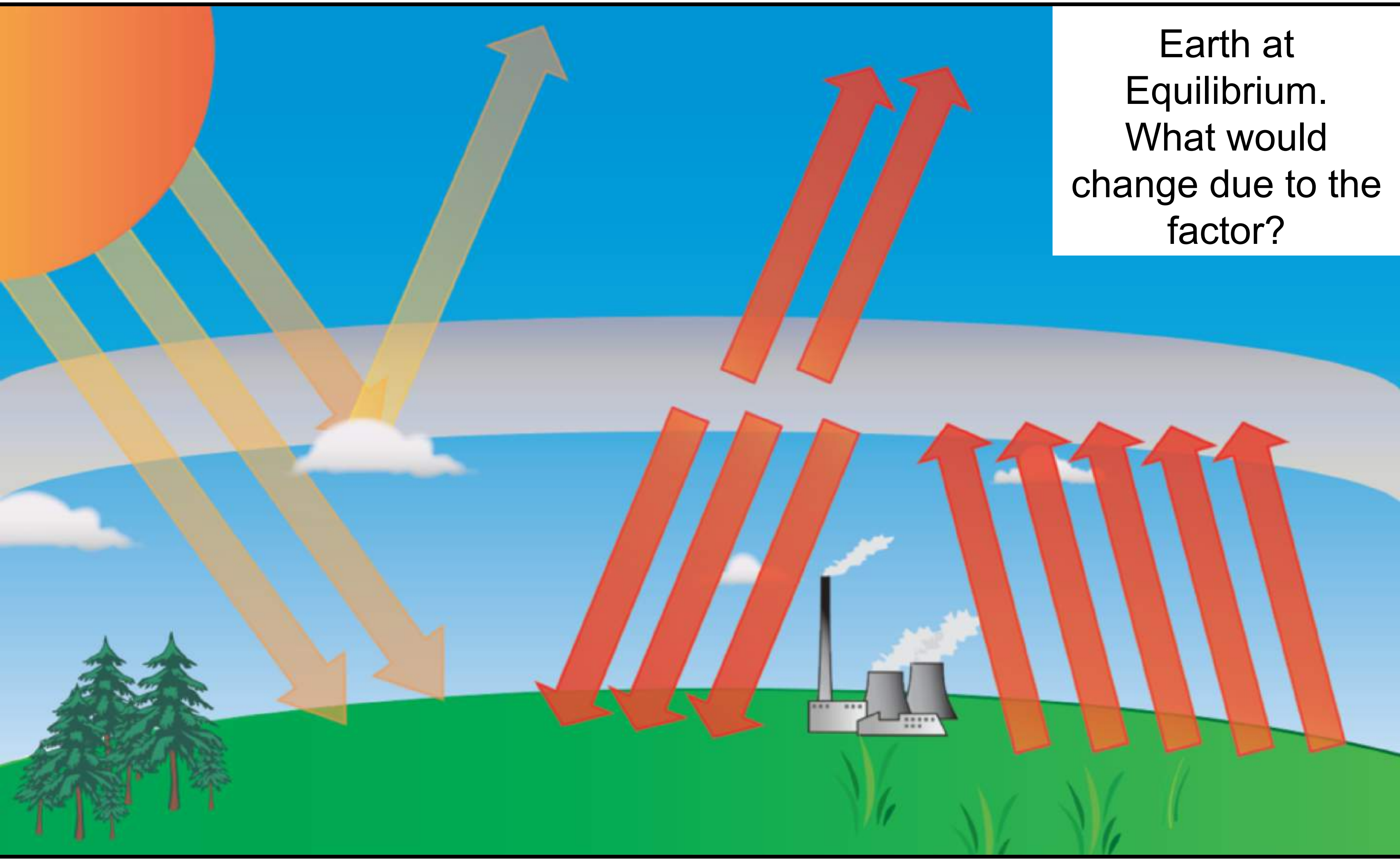
Factor: Volcanic Activity Early



Factor: Volcanic Activity Long Term

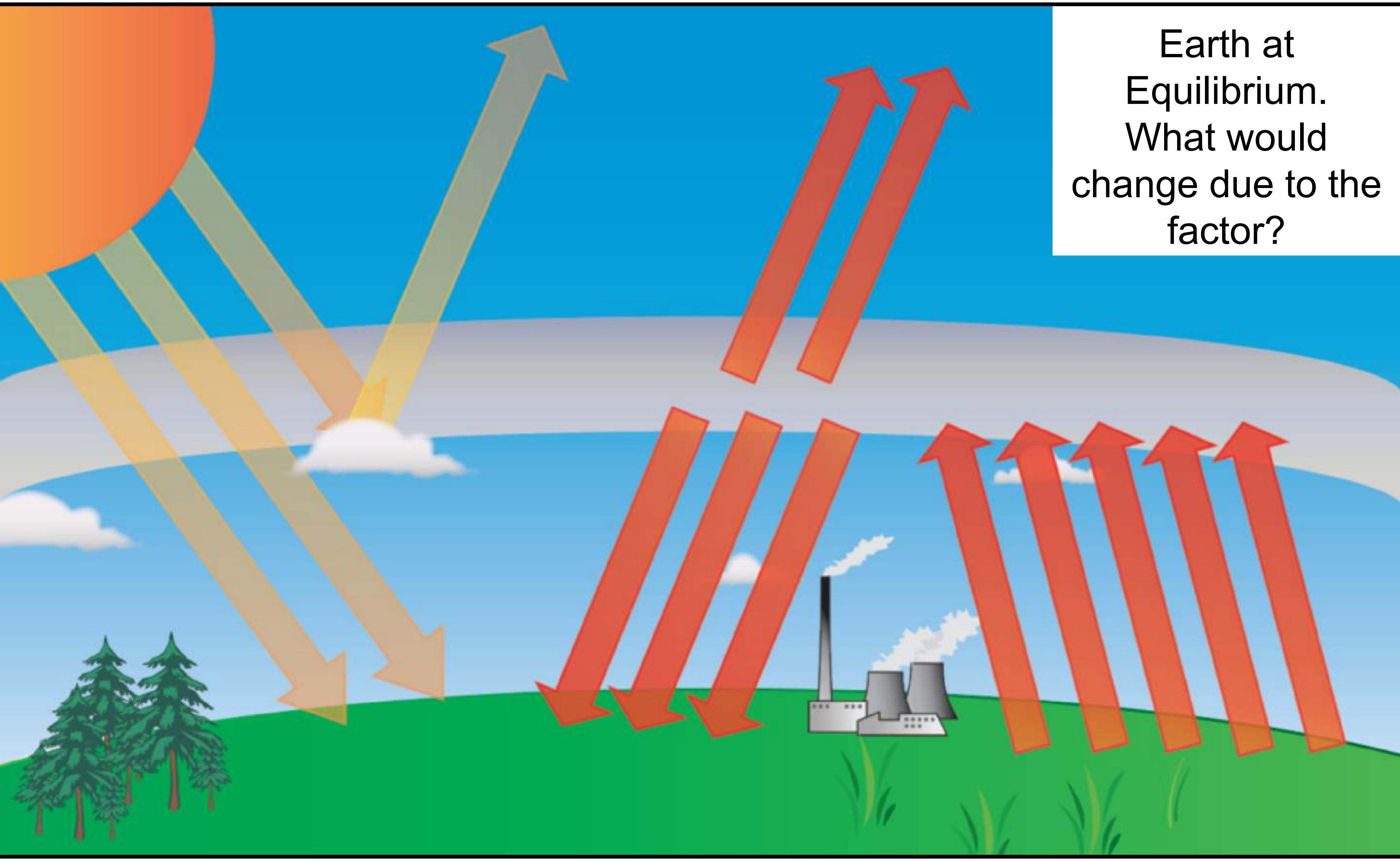


Factor: Circulation of the Oceans



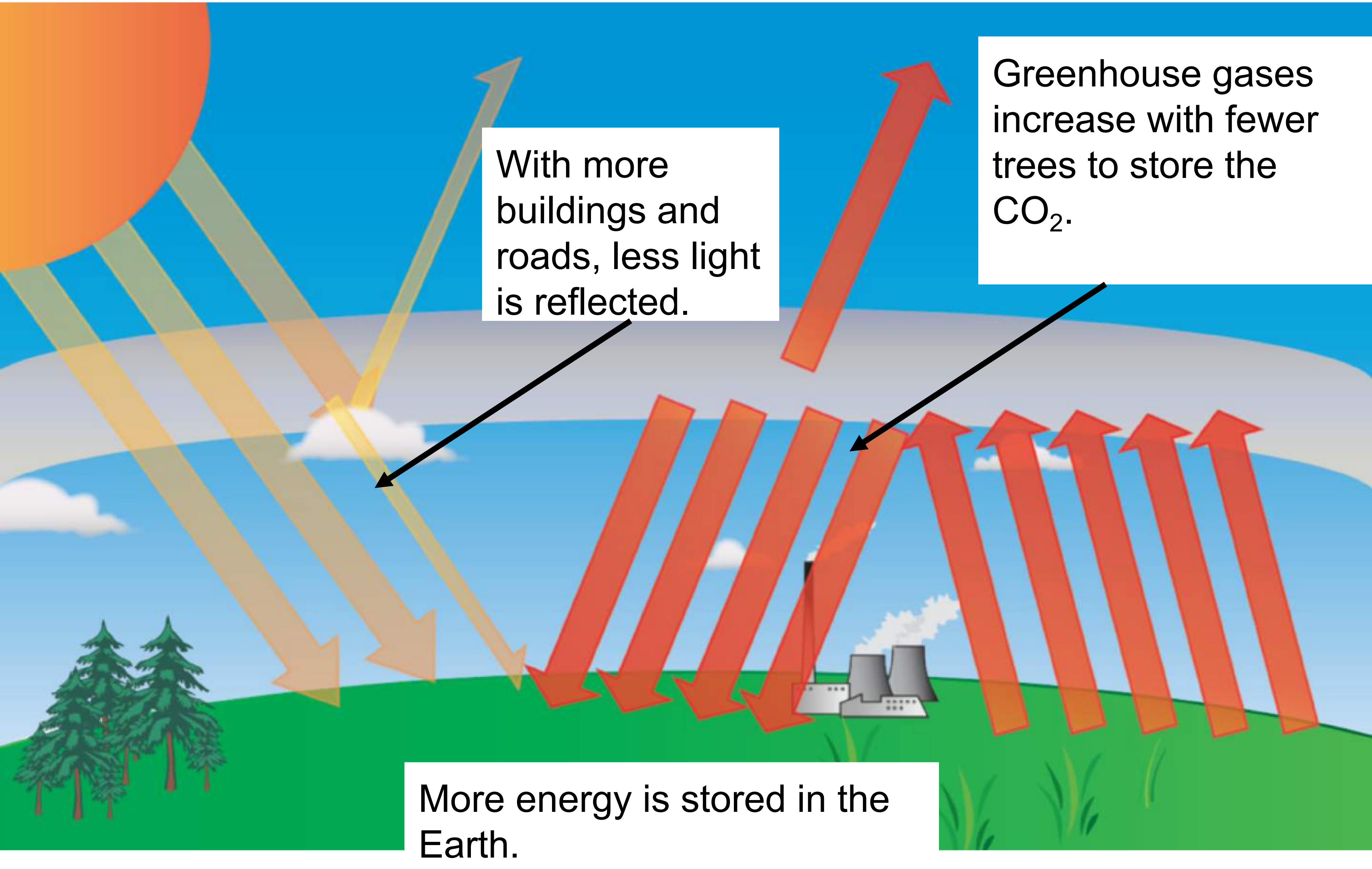
Earth at Equilibrium. What would change due to the factor?

Factor: Deforestation

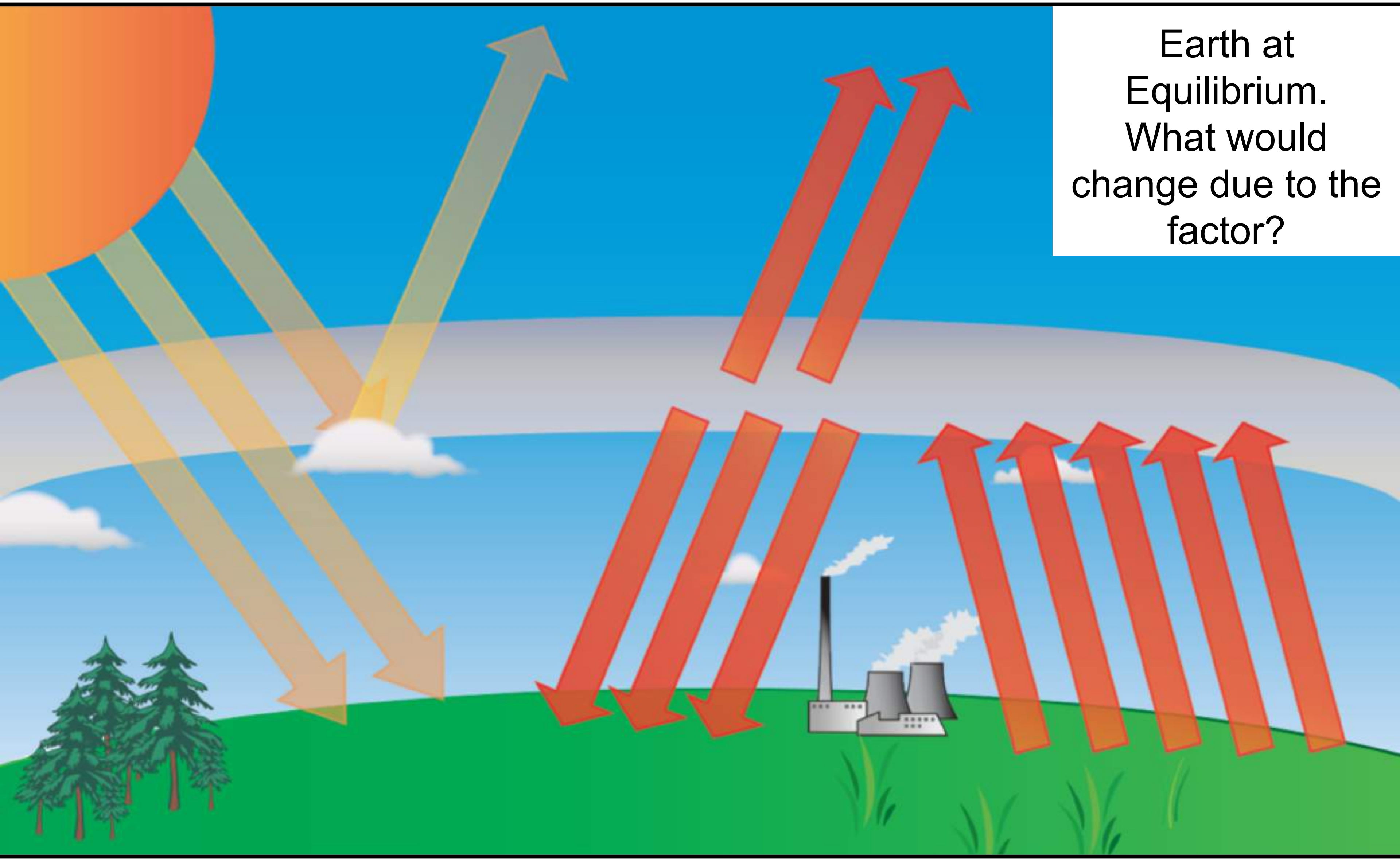


Earth at Equilibrium. What would change due to the factor?

Factor: Deforestation

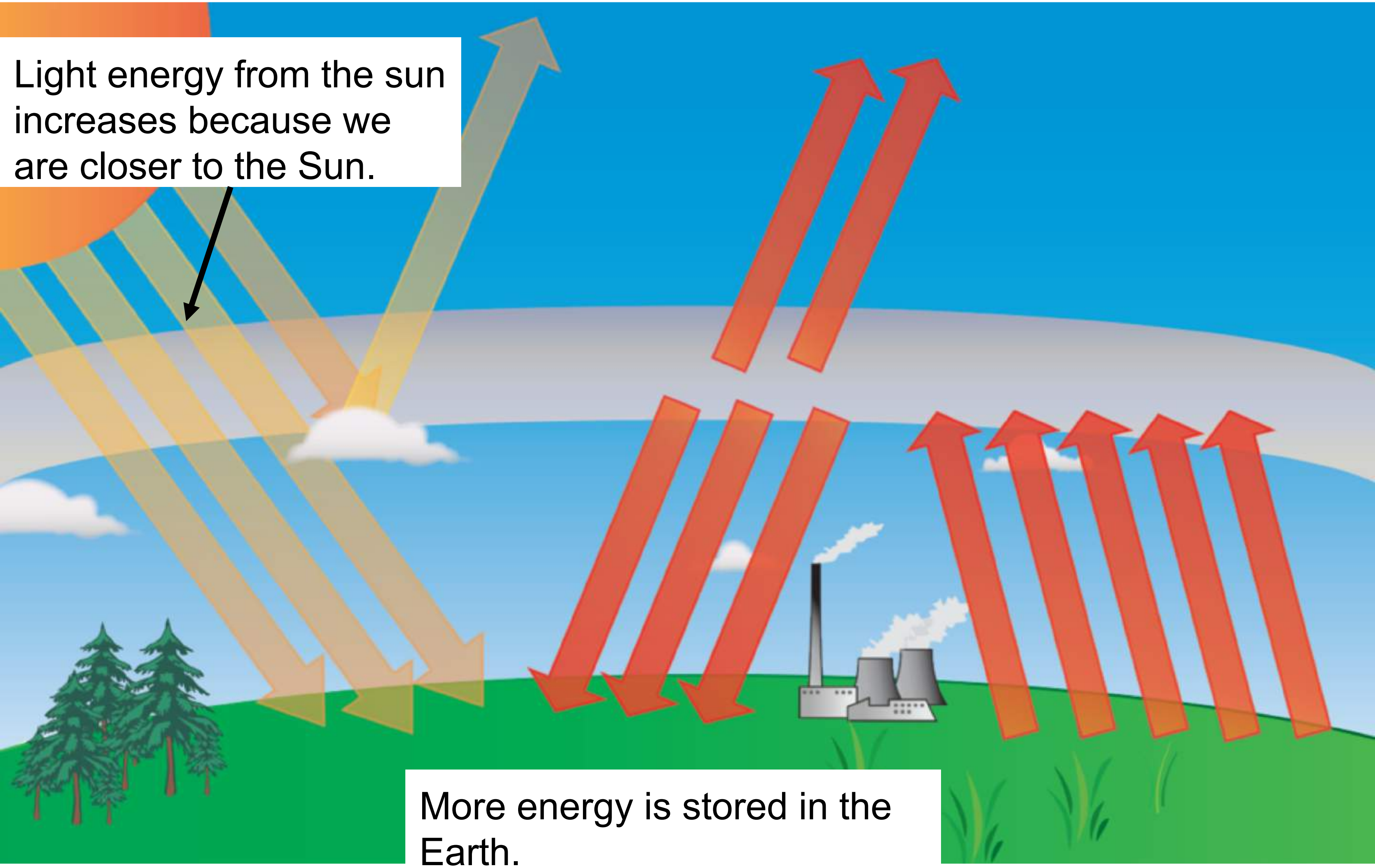


Factor: Earth’s Orbit and the Orientation of its Axis



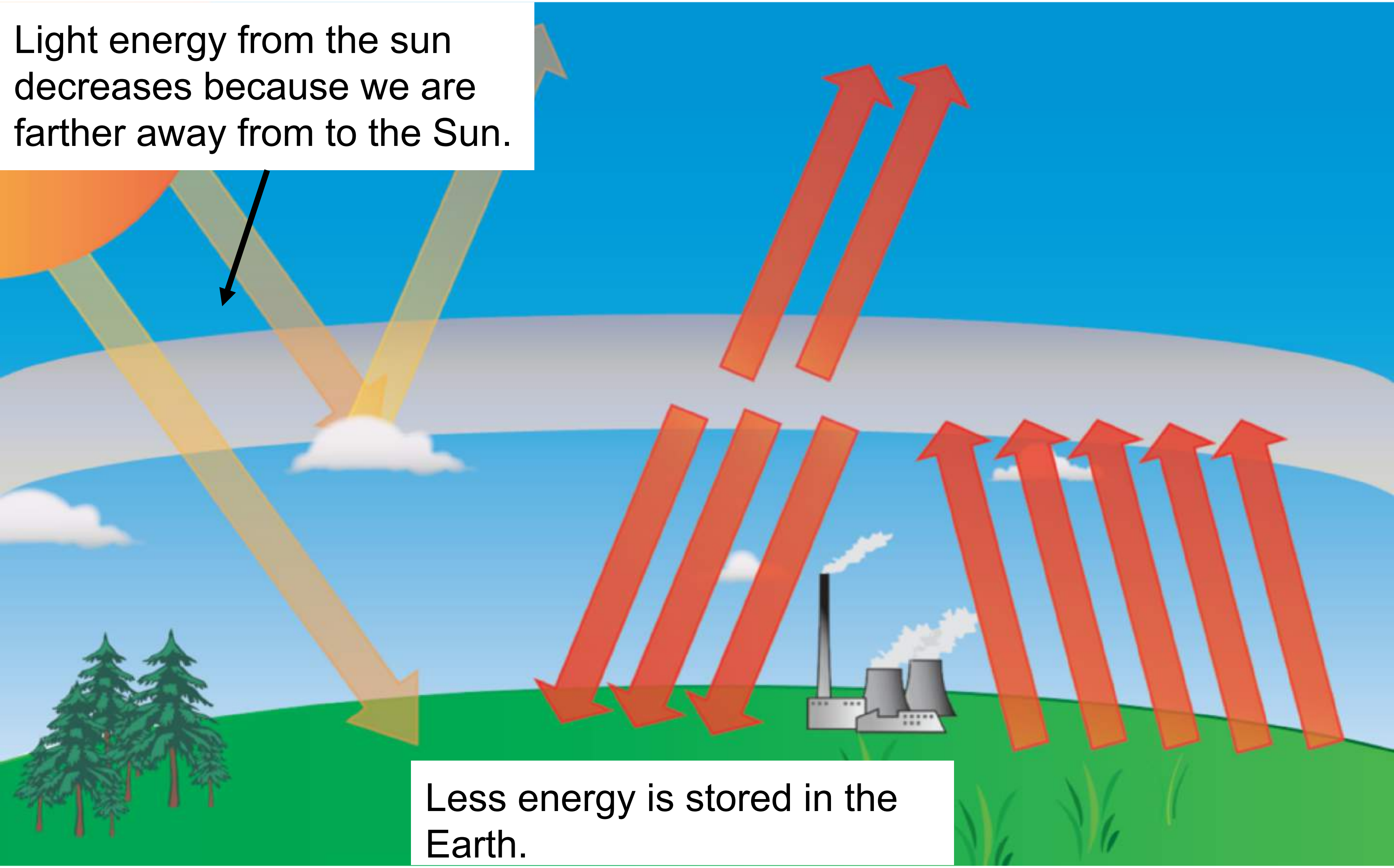
Earth at Equilibrium. What would change due to the factor?

Earth’s Orbit: Closer to the Sun



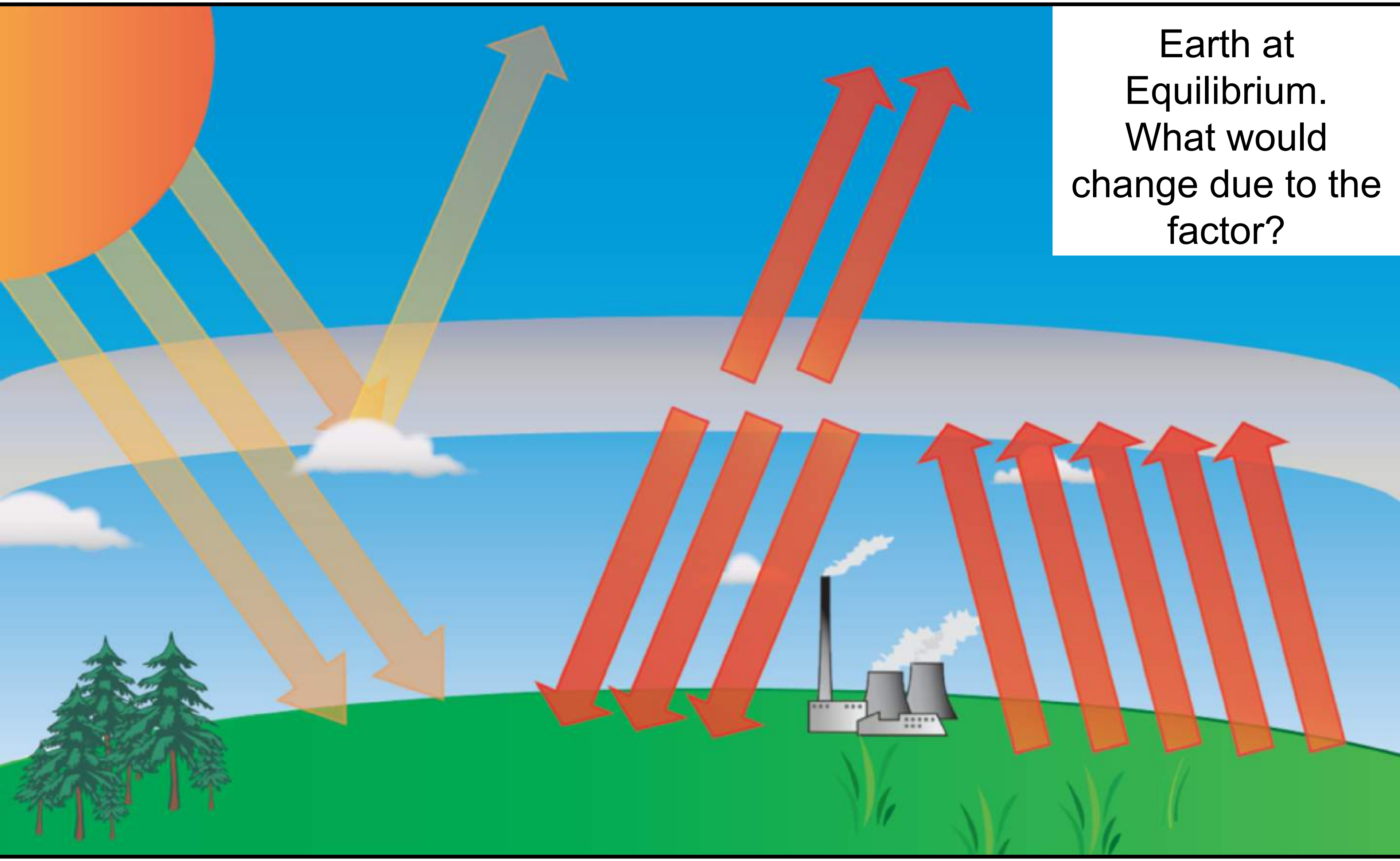
Earth’s Orbit: Further from the Sun

Light energy from the sun decreases because we are farther away from to the Sun.



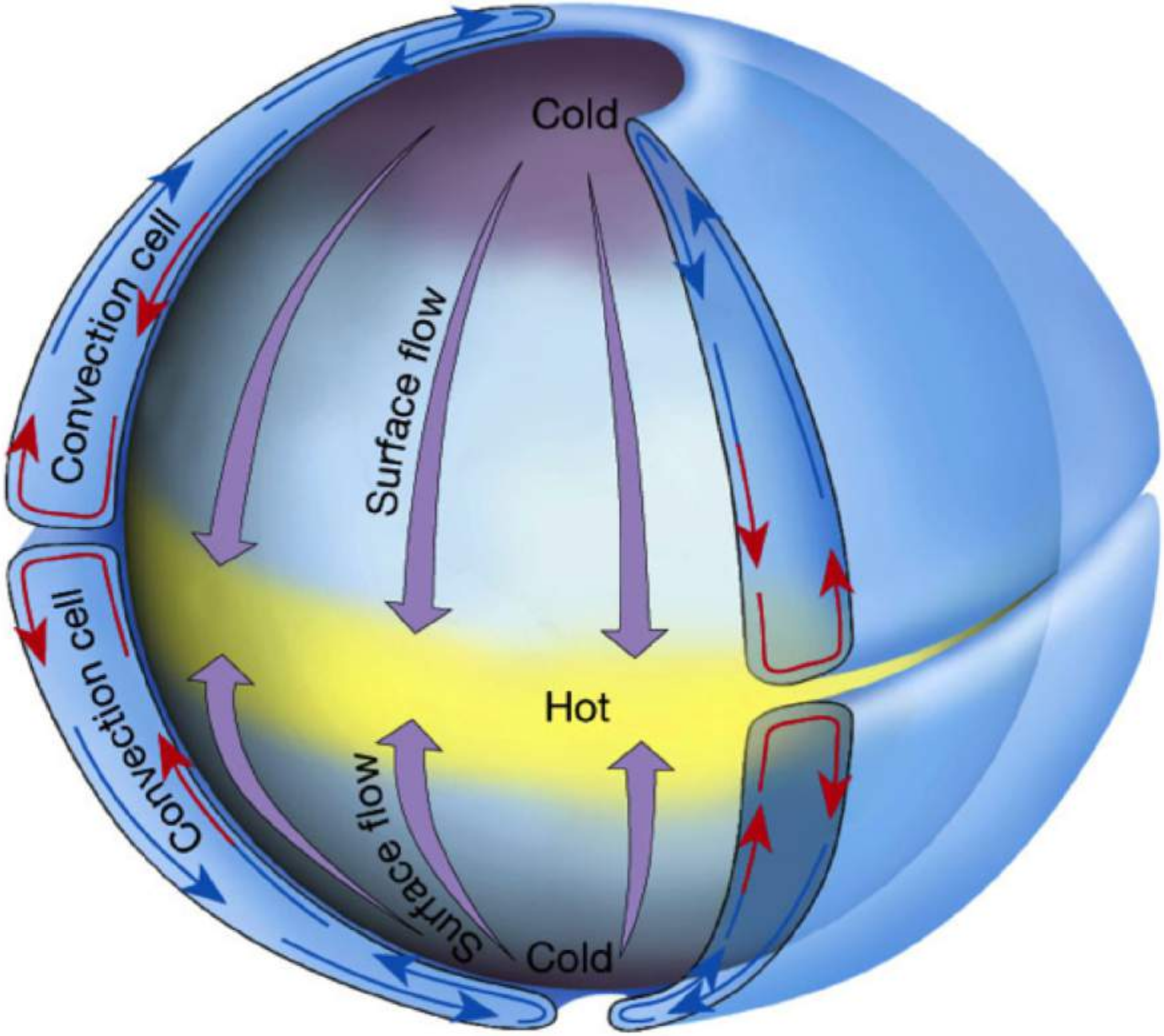
Less energy is stored in the Earth.

Factor: Circulation of the Atmosphere

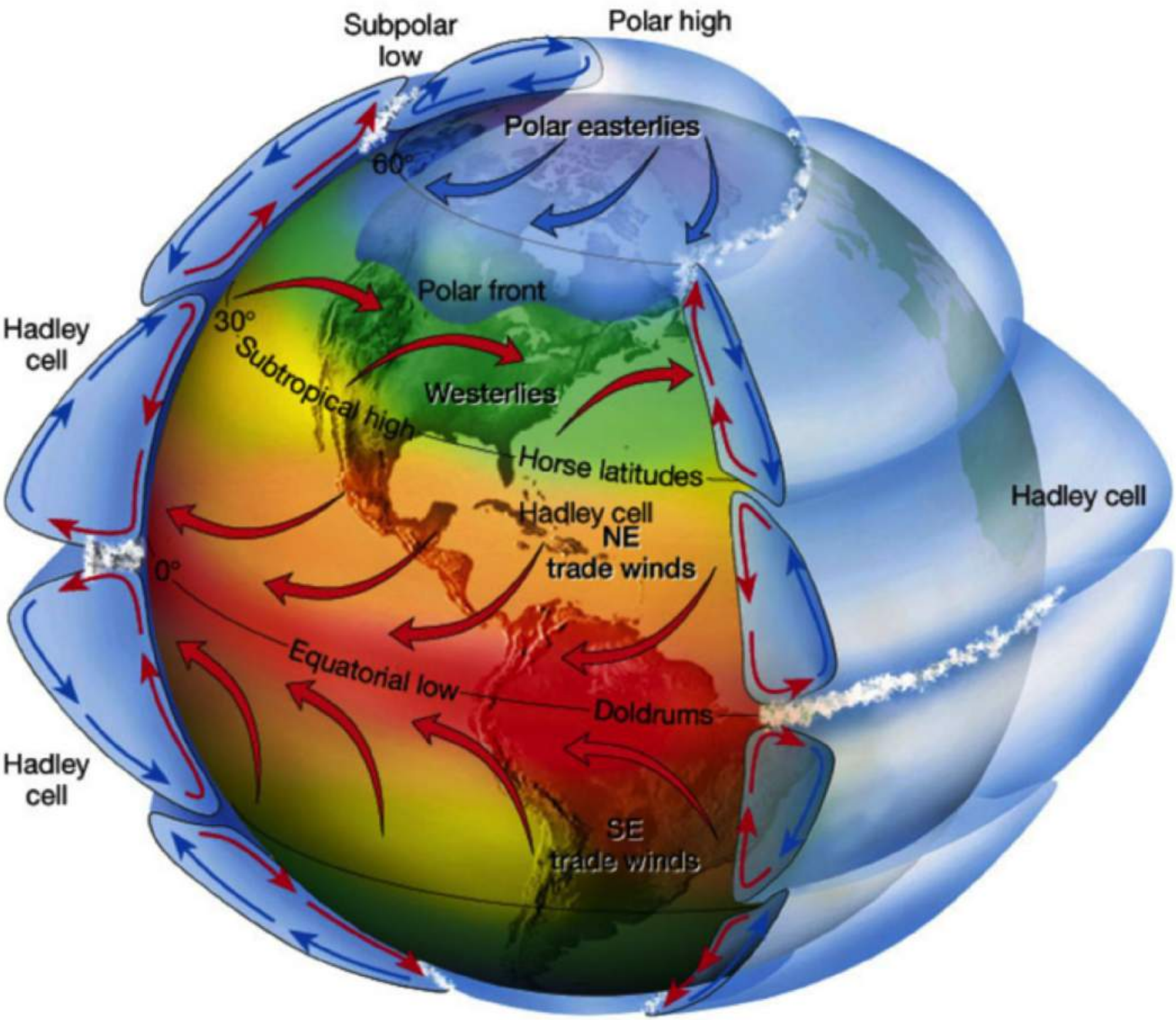


Earth at Equilibrium. What would change due to the factor?

Factor: Circulation of the Atmosphere

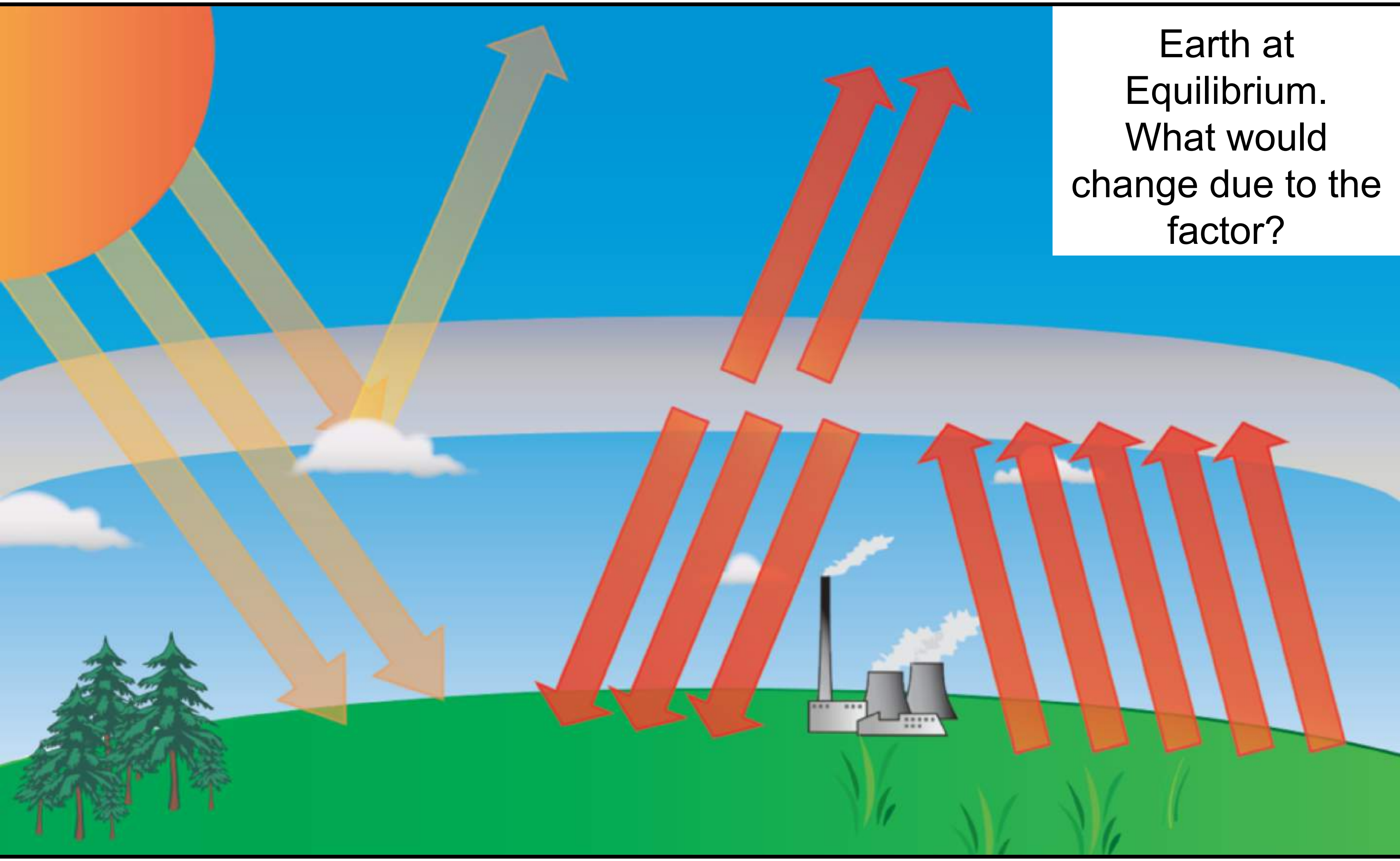


Remember the earth's surface varies and it is ***really big*** and spinning



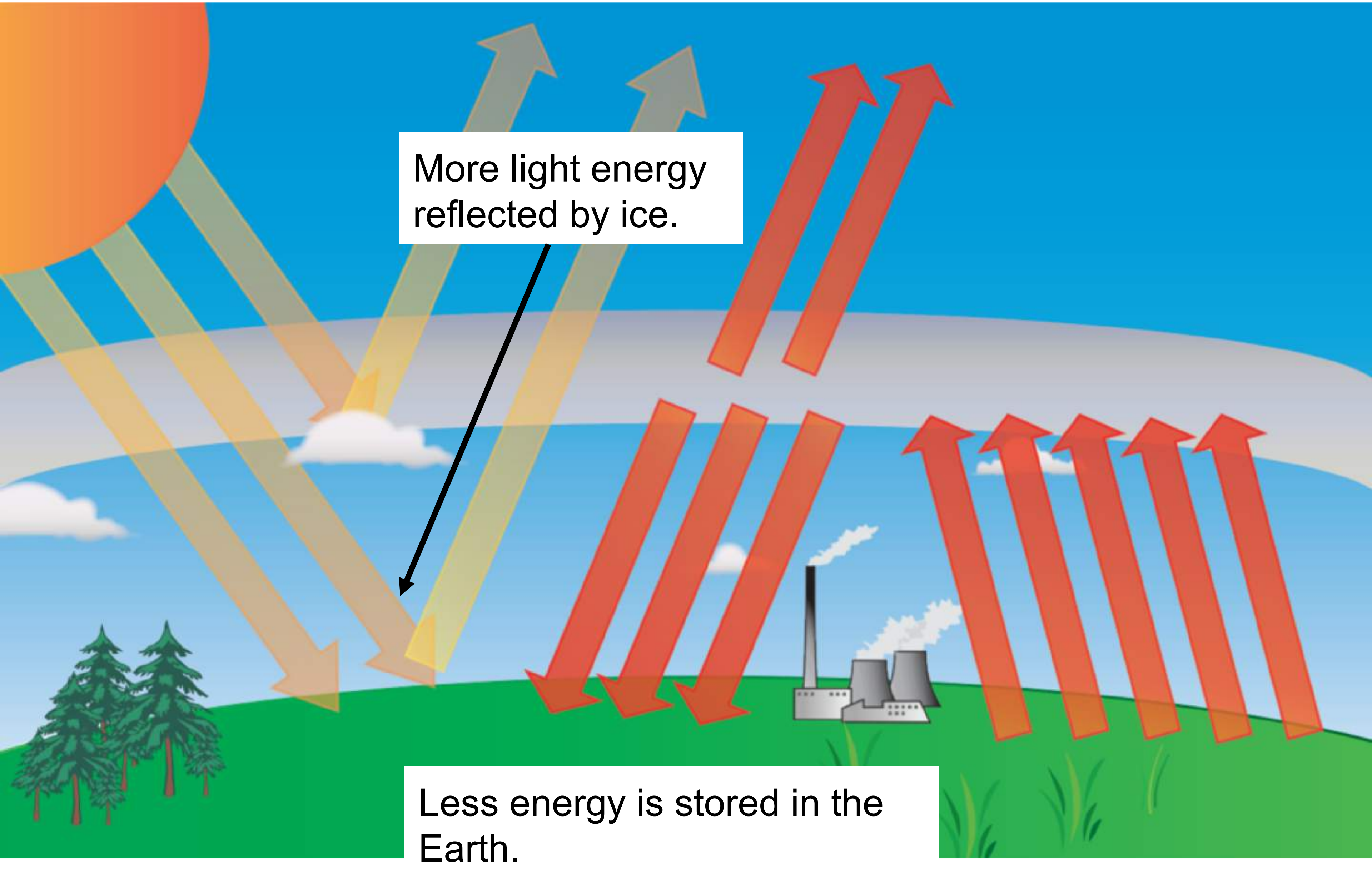
Idealized, three cell atmospheric convection in a rotating Earth. "Three cell" being either three cells north or south of the equator. The deflections of the winds within each cell is caused by the Coriolis Force.

Factor: Glaciation

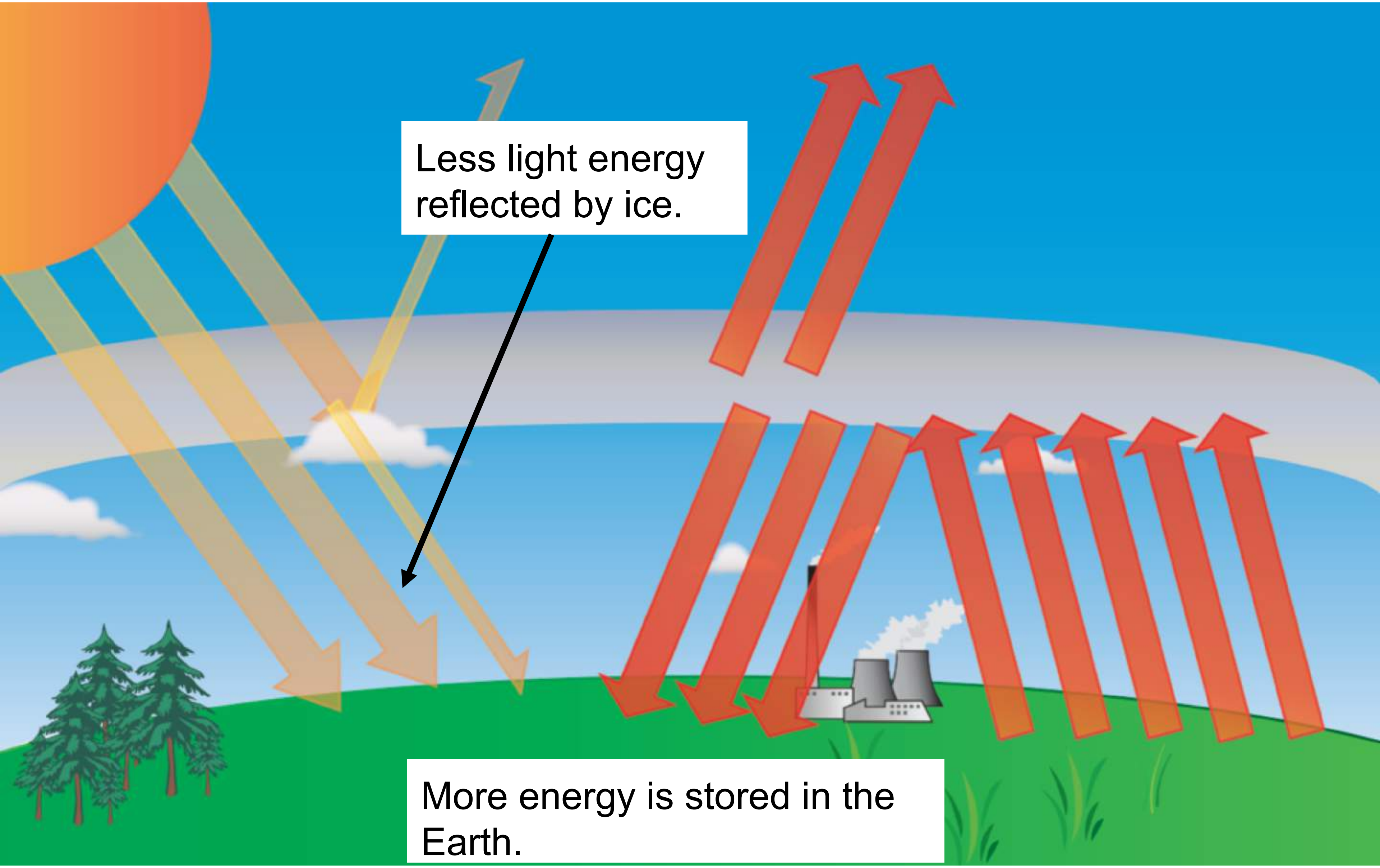


Earth at Equilibrium. What would change due to the factor?

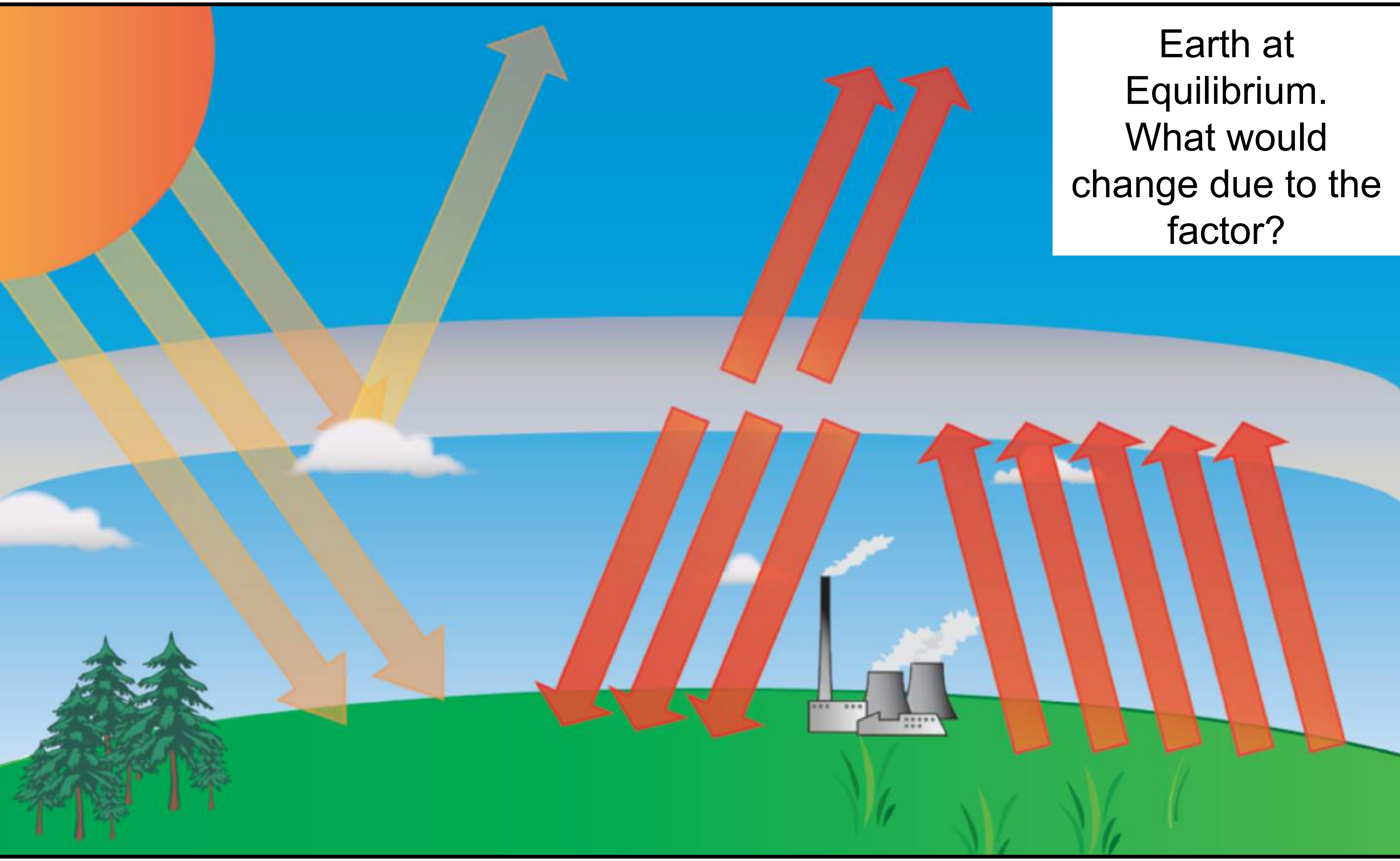
Increased Glaciation



Decreased Glaciation

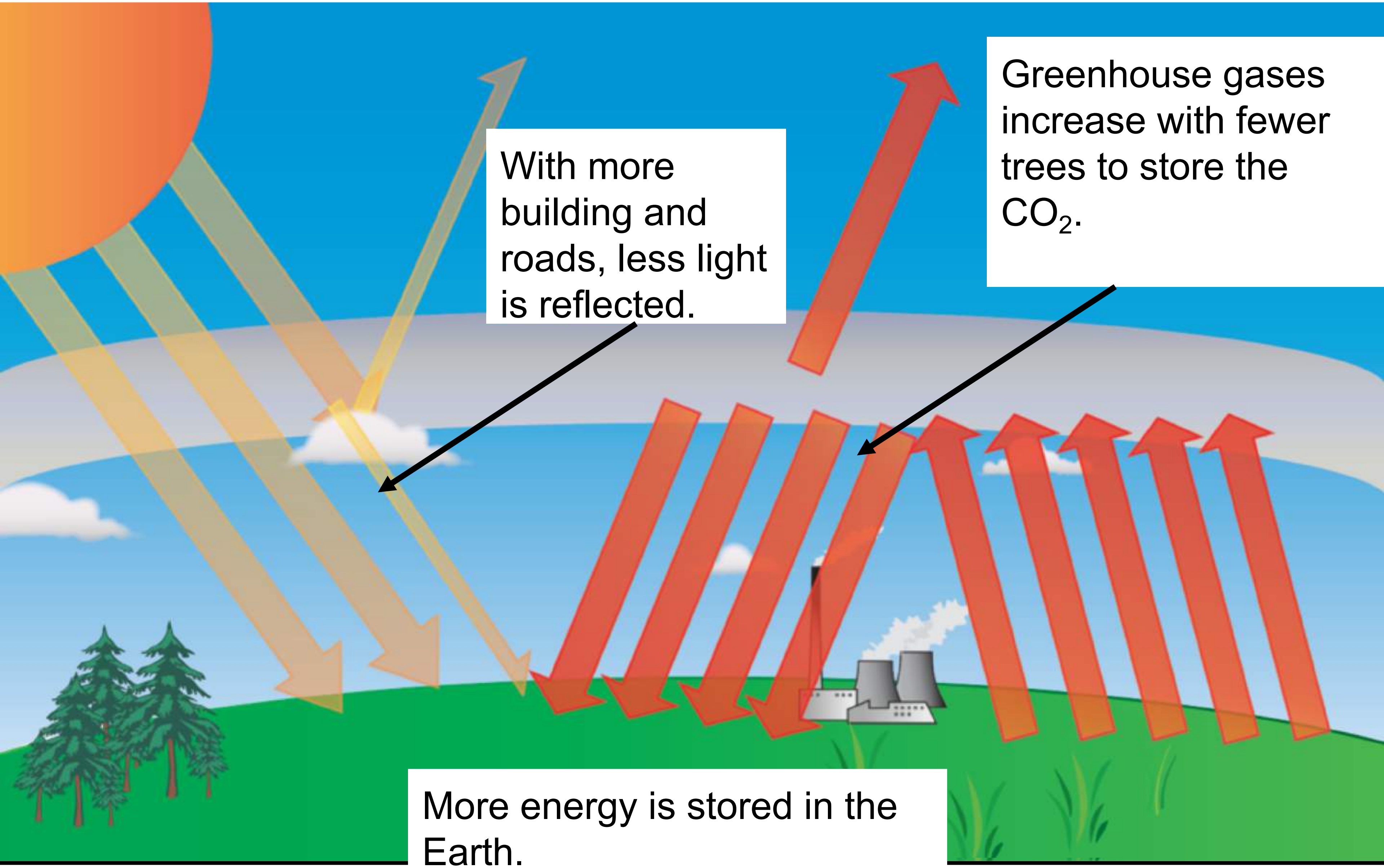


Factor: Human activities

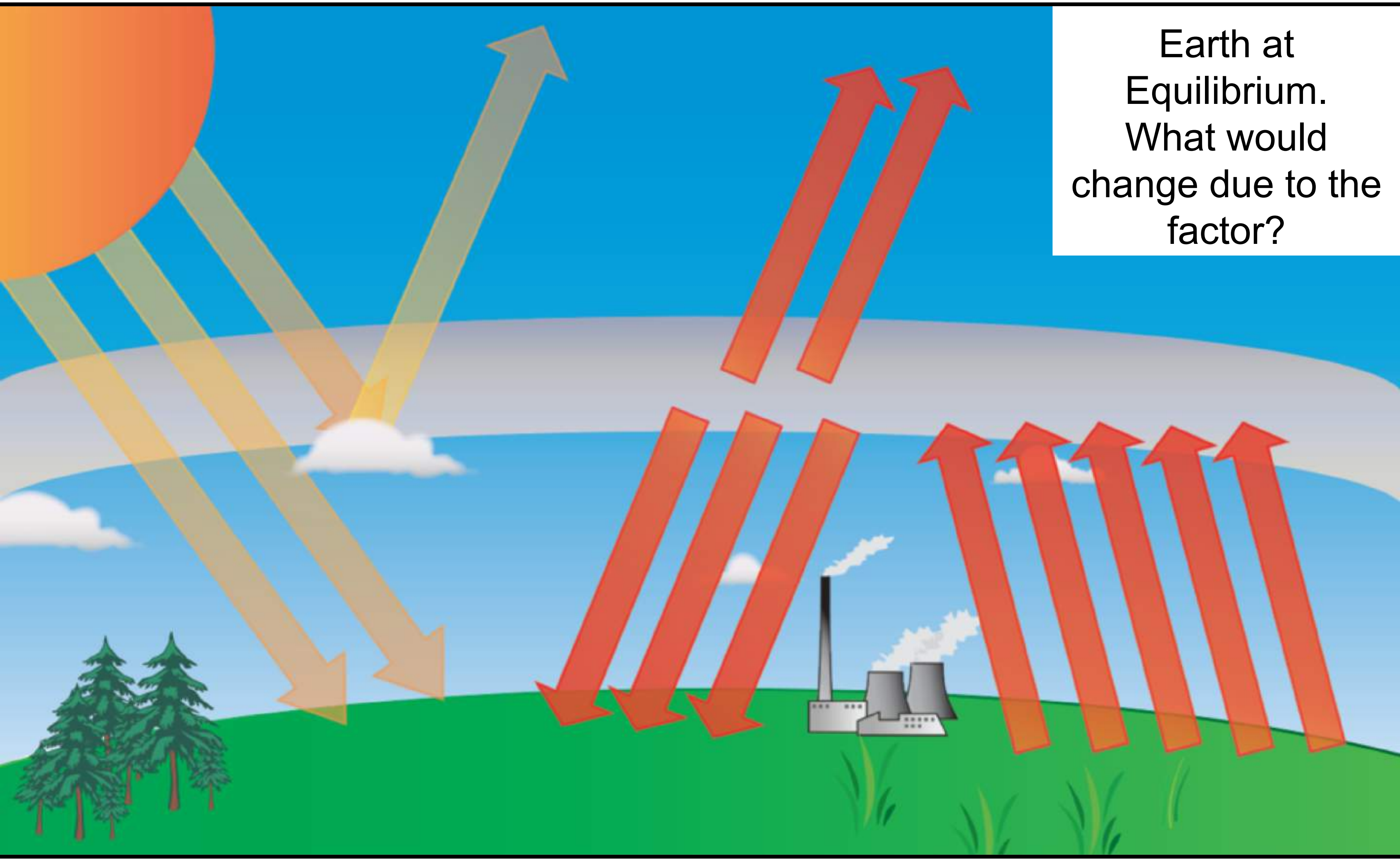


Earth at Equilibrium. What would change due to the factor?

Factor: Human activities

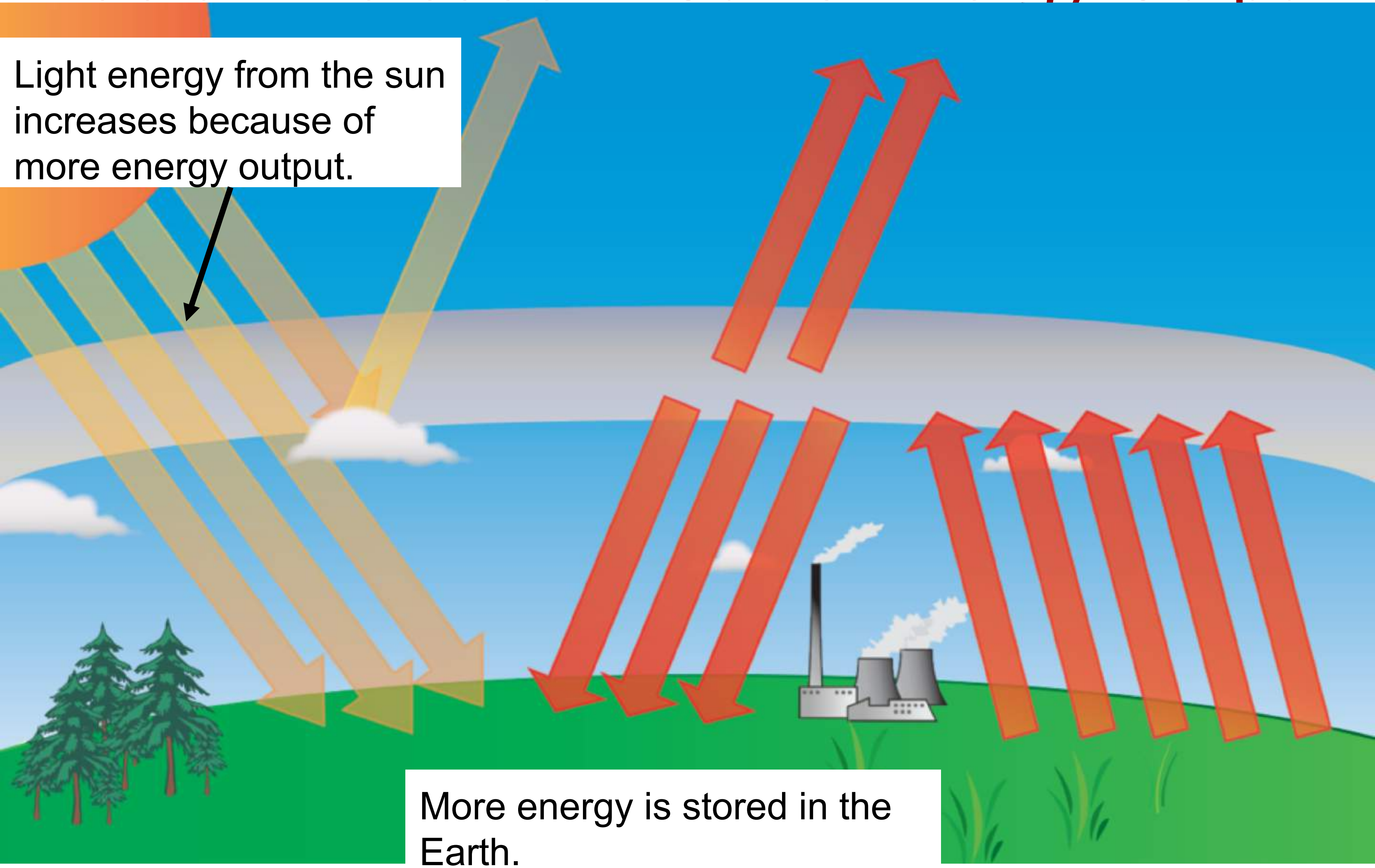


Factor: Increase in Sun's Energy Output



Earth at Equilibrium. What would change due to the factor?

Factor: Increase in Sun's Energy Output

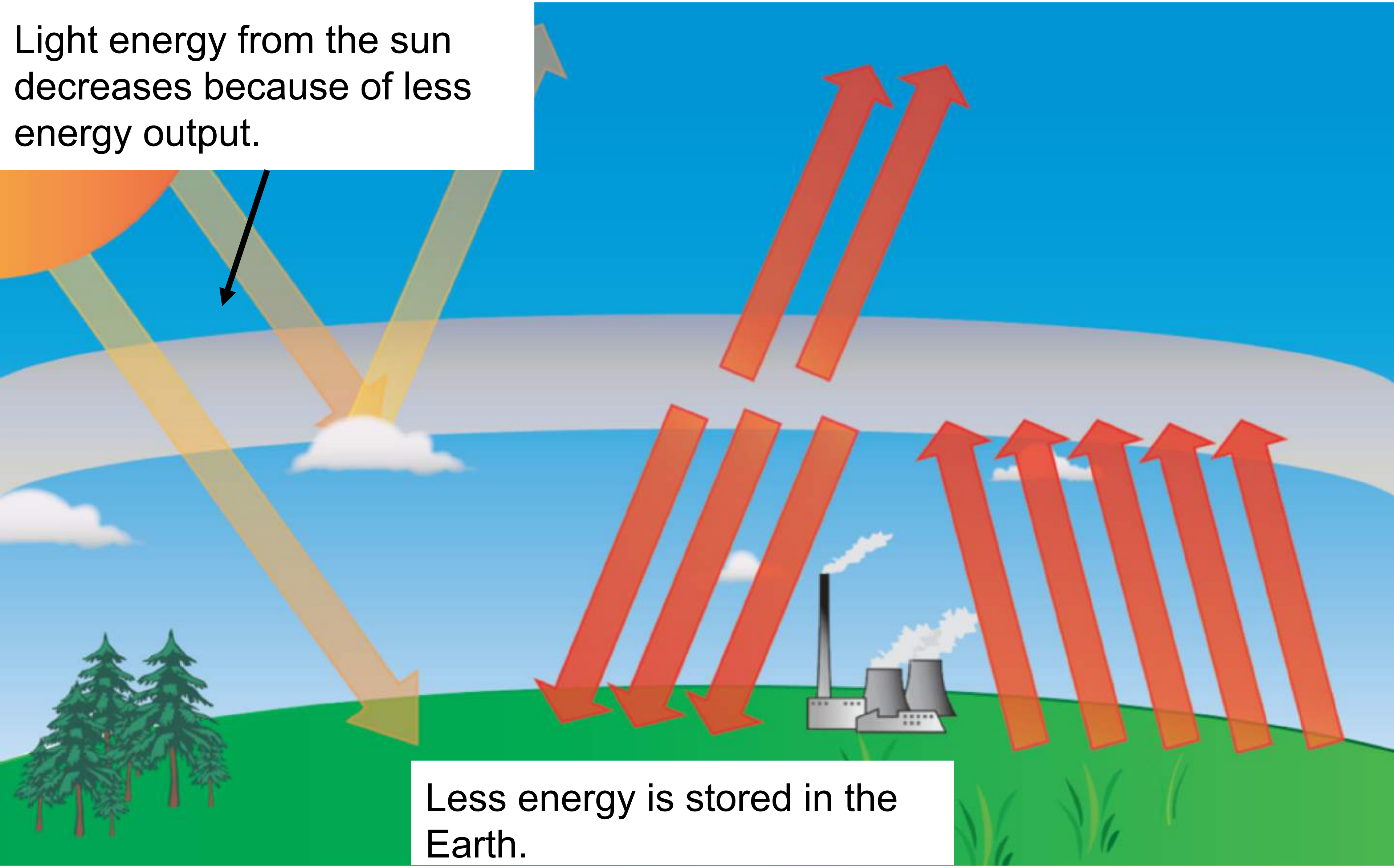


Light energy from the sun increases because of more energy output.

More energy is stored in the Earth.

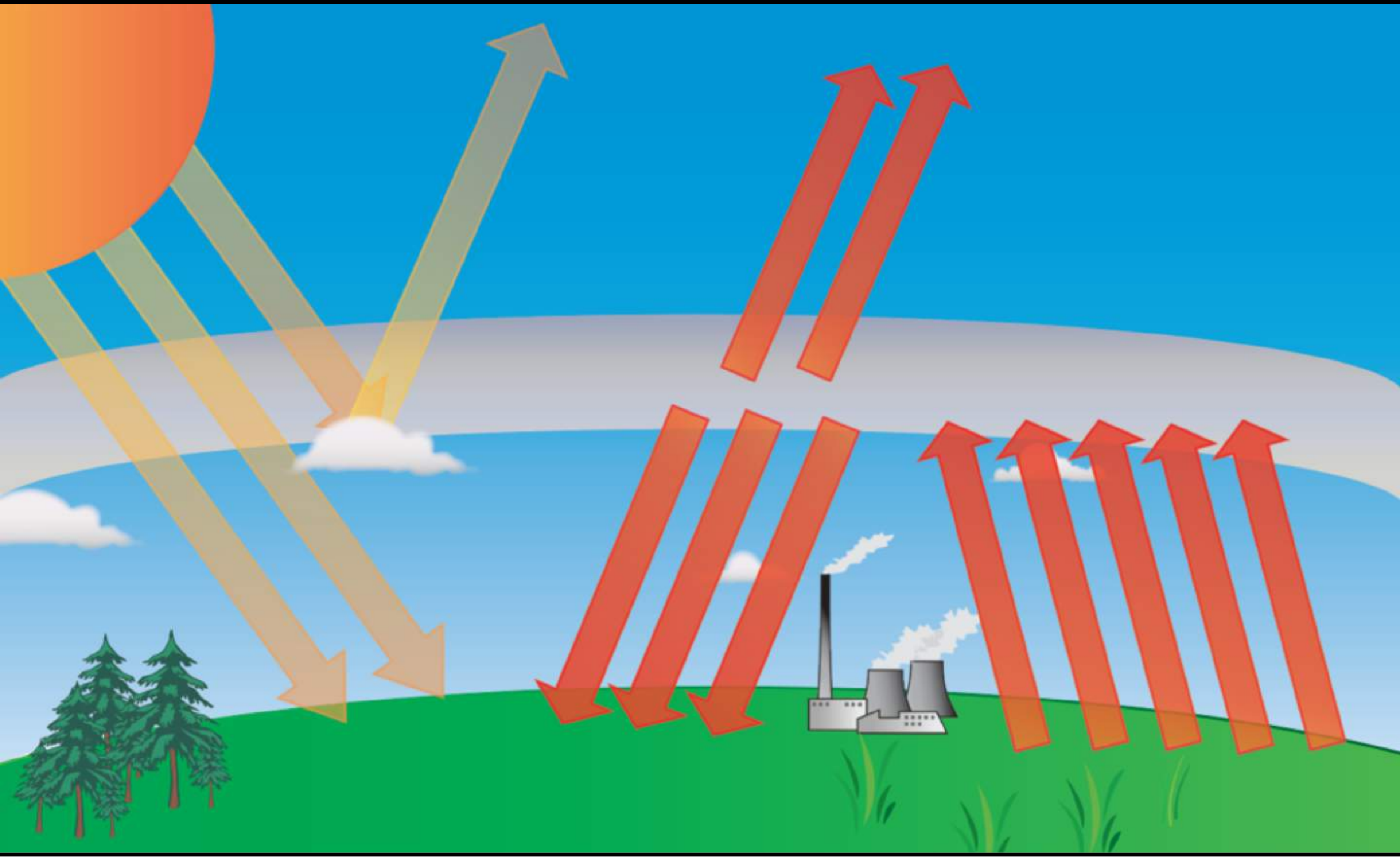
Factor: Decrease in Sun's Energy Output

Light energy from the sun decreases because of less energy output.

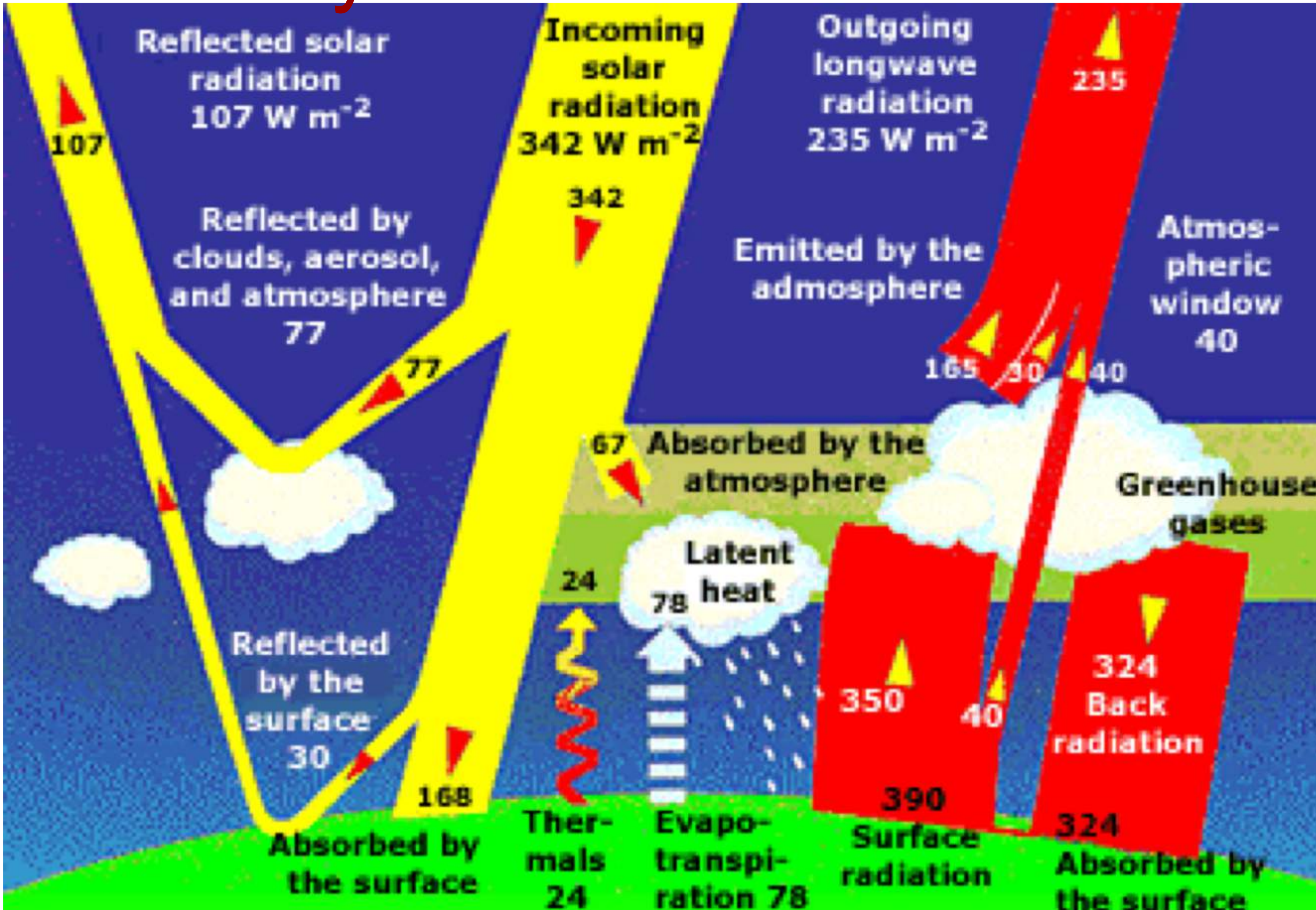


Less energy is stored in the Earth.

Our Simple but Pretty Good Diagram



What do you notice? wonder about?

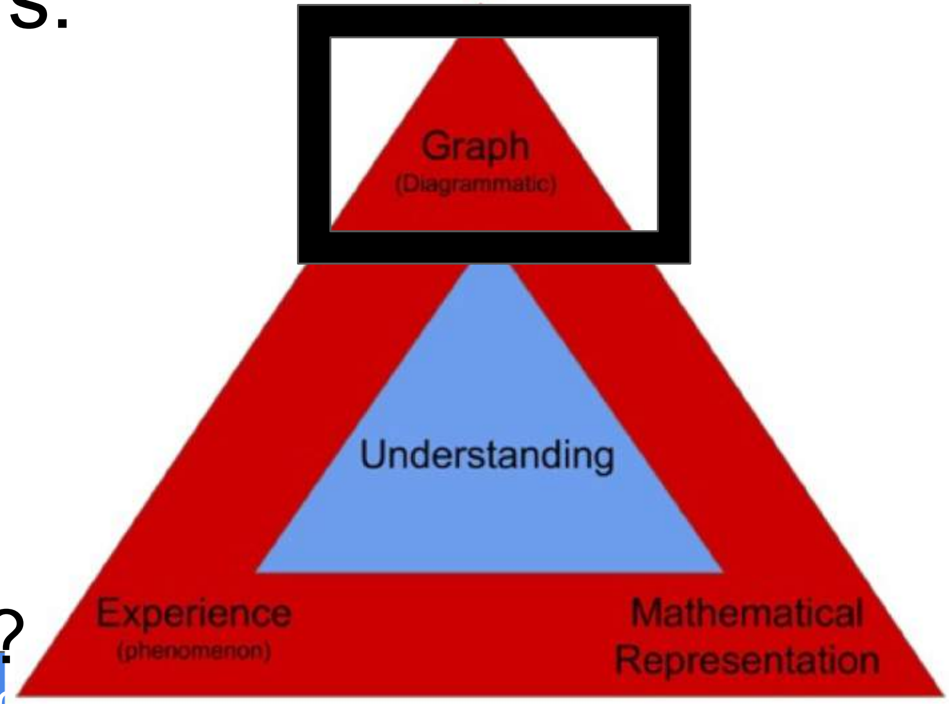


Let's Be Playful with our Inner Scientist

We have been building our critical thinking and analysis toolbox all year. Climate data is so complex you will need to use all you got.

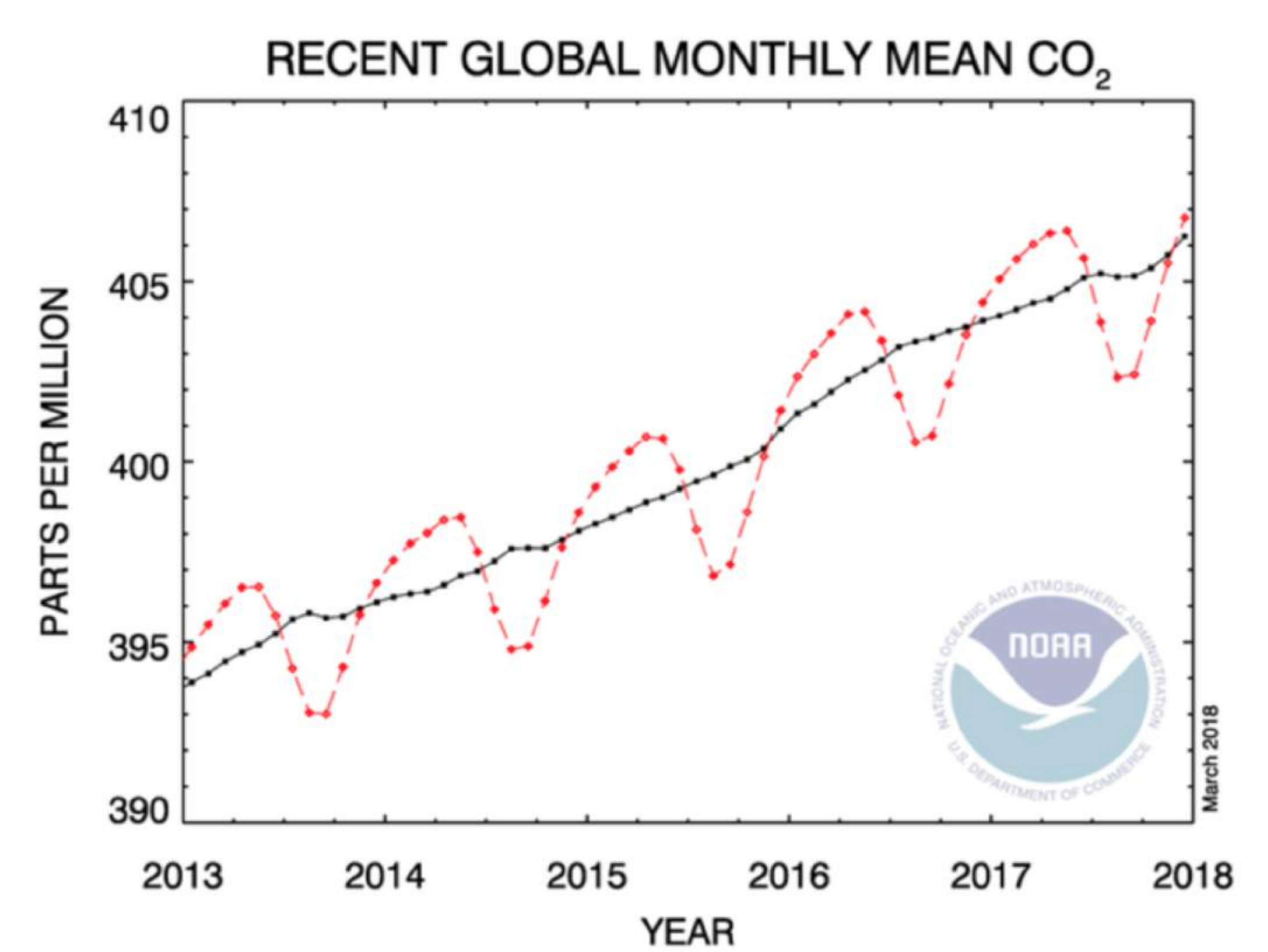
Helpful discussion starters:

- I notice…
- I see a pattern with…
- I wonder…
- What is the system?
- How does this connect to other things we know?



U.S. Department of Commerce / National Oceanic & Atmospheric Administration / NOAA Research

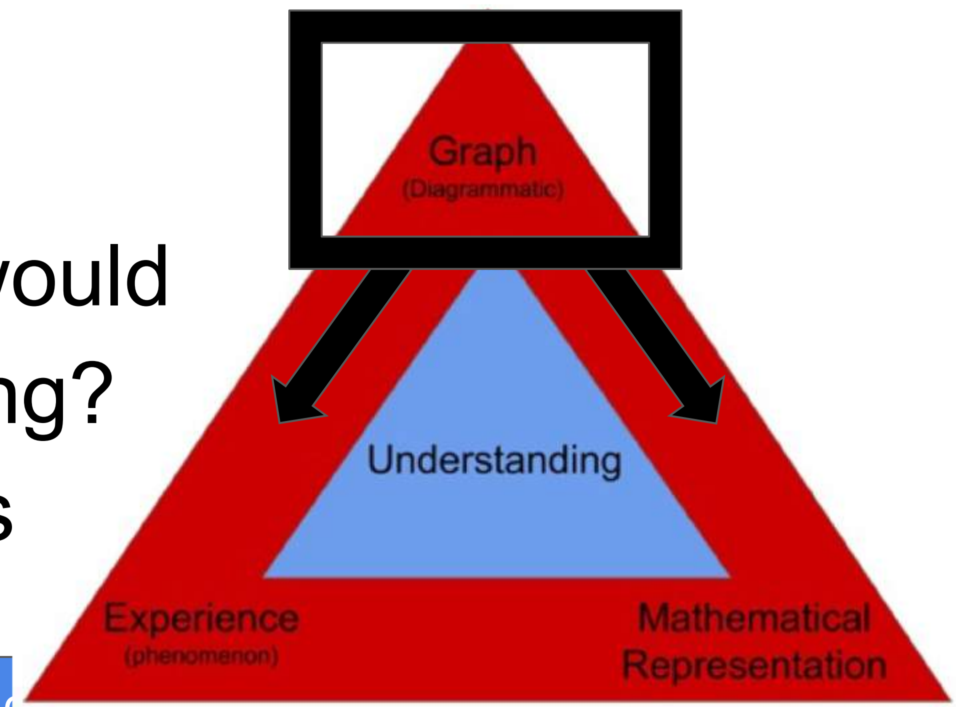
Earth System Research Laboratory
Global Monitoring Division



Let's Be Playful with our Inner Scientist

Let us move around the Triangle

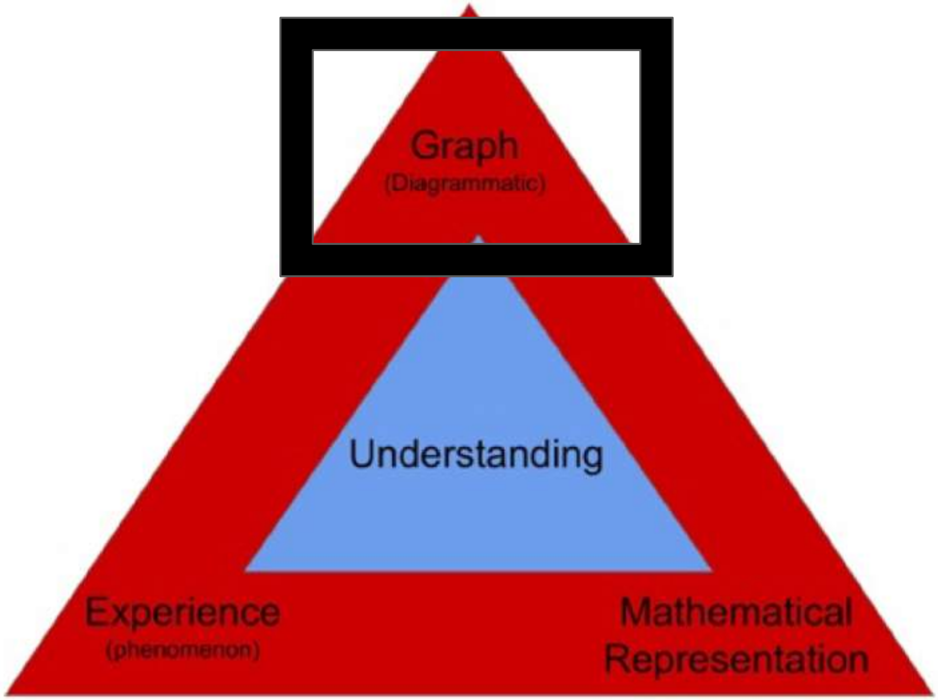
1. What is the overall trend?
2. What is happening on earth that could explain why the data cyclical?
3. Can you estimate a mathematical model?
4. What is the value in creating a model?
1. What other models would you think of creating?
6. What other questions do we have?



Let’s Be Playful with our Inner Scientist

Let us move around the Triangle

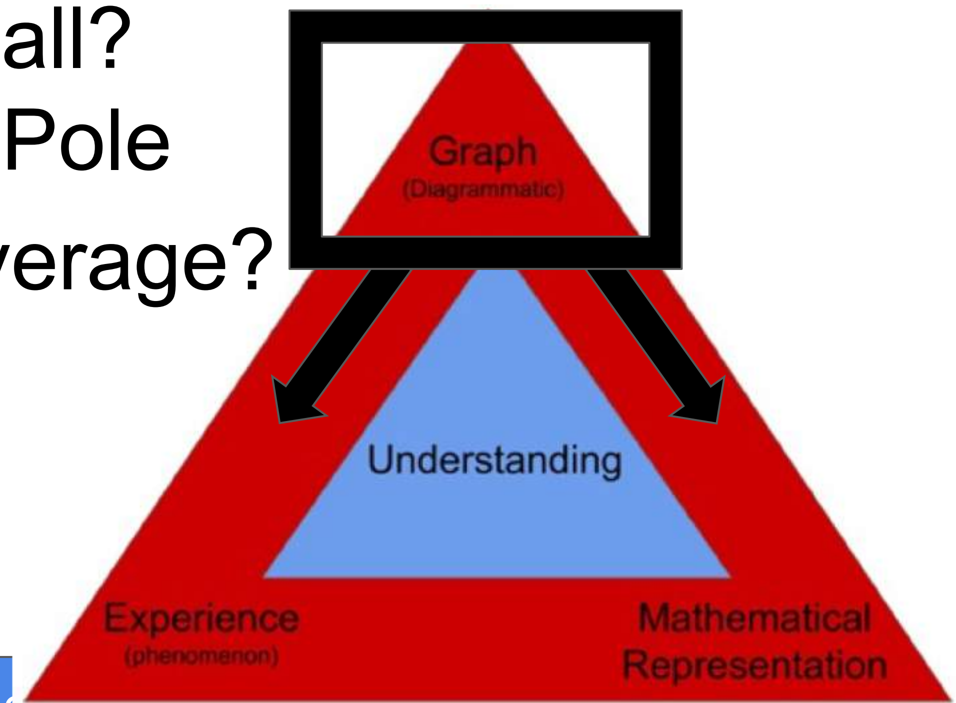
Let get a bit more complex.



Let's Be Playful with our Inner Scientist

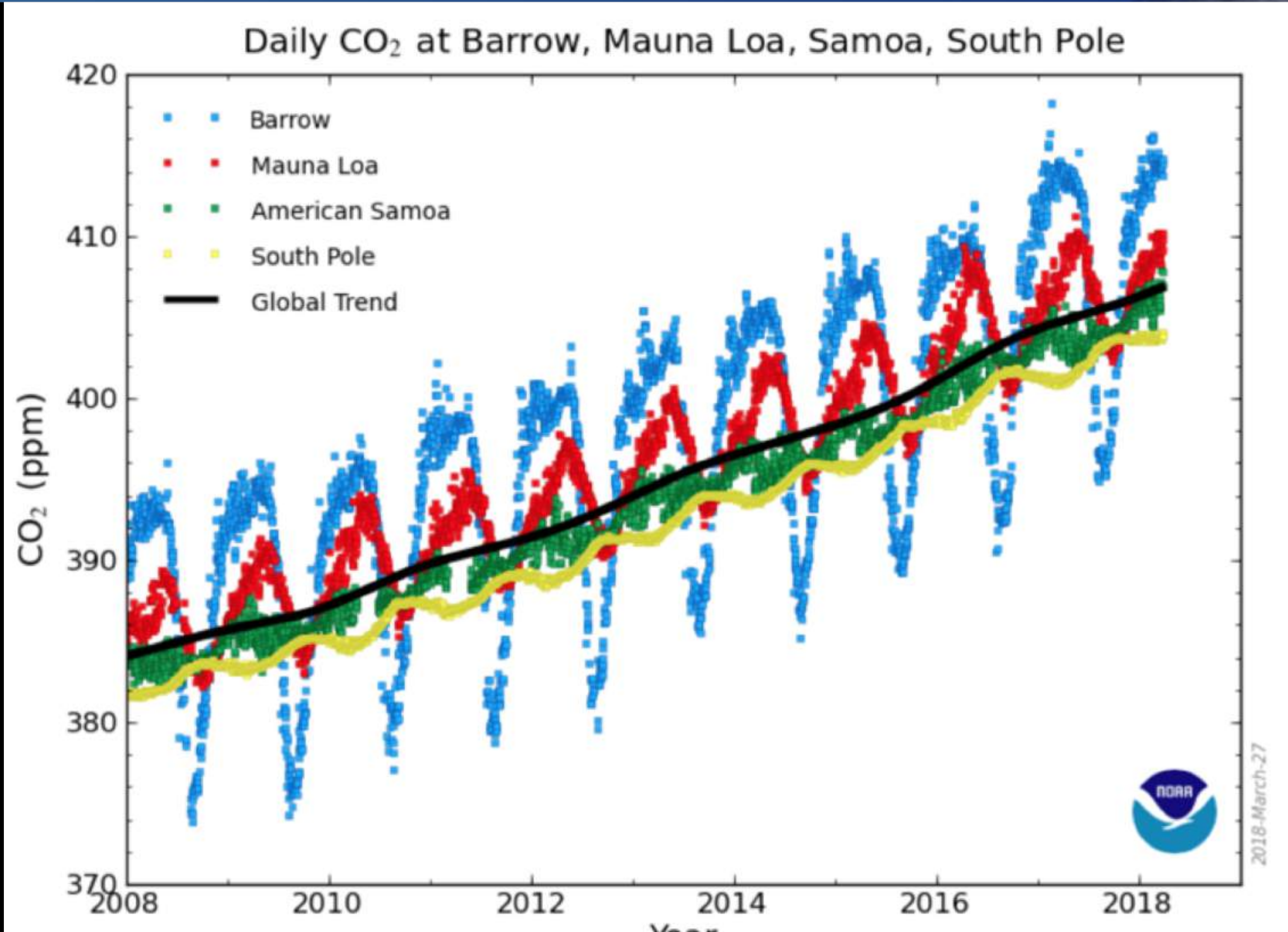
Let us move around the Triangle

1. How is this graph different?
2. How is this graph similar?
3. Where is Barrow?
4. Why is Barrow's oscillations so big and American Samoa small?
5. Why does the South Pole always stay below average?



U.S. Department of Commerce / National Oceanic & Atmospheric Administration / NOAA Research

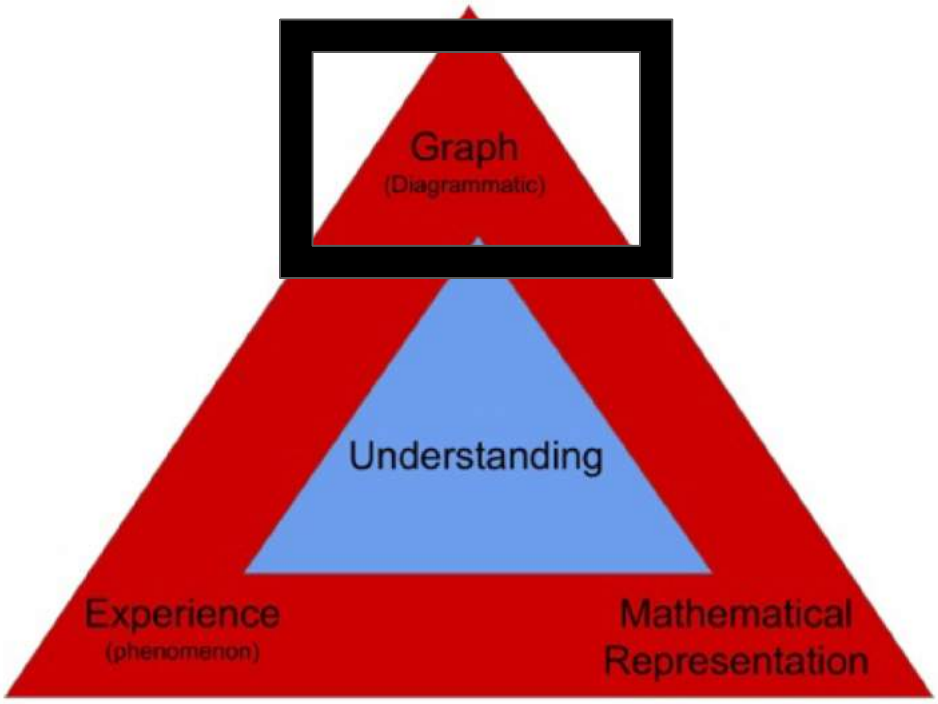
Earth System Research Laboratory
Global Monitoring Division



Let's Be Playful with our Inner Scientist

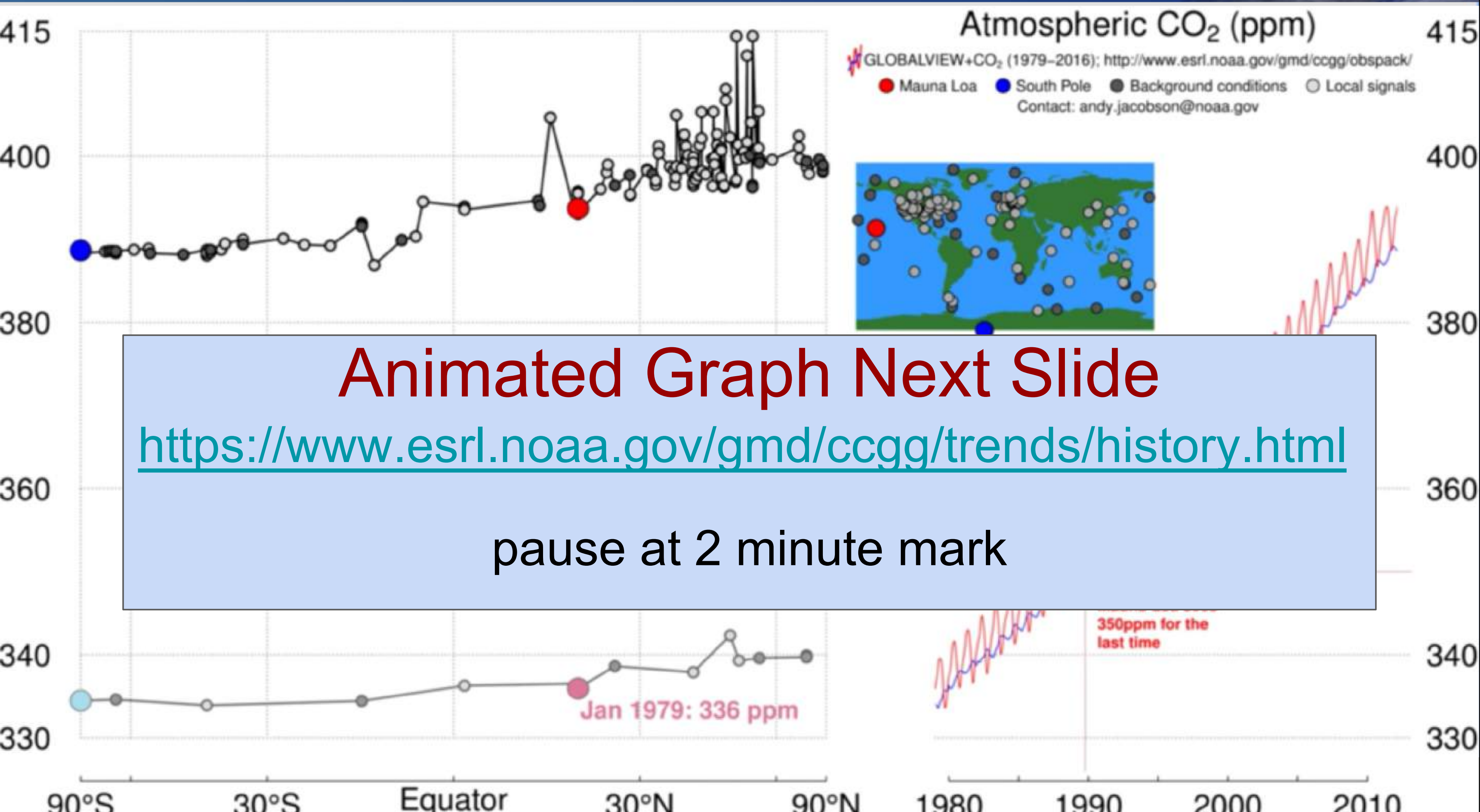
Let us move around the Triangle

Let's get a a lot more complex.



U.S. Department of Commerce / National Oceanic & Atmospheric Administration / NOAA Research

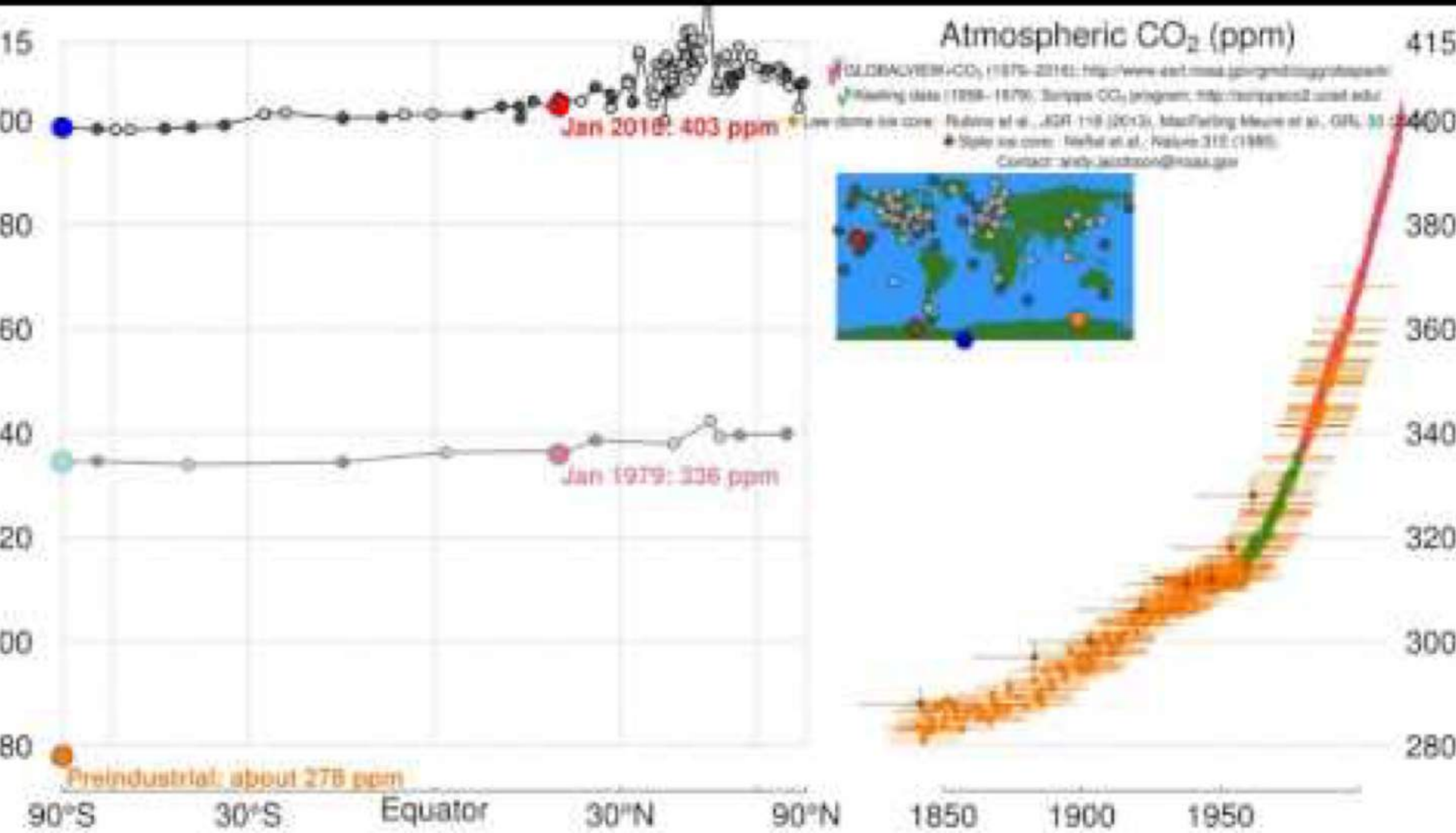
Earth System Research Laboratory
Global Monitoring Division



Animated Graph Next Slide

https://www.esrl.noaa.gov/gmd/ccgg/trends/history.html

pause at 2 minute mark



Atmospheric CO_2 (ppm)
Jan 2016: 403 ppm
Jan 1979: 336 ppm
Preindustrial: about 278 ppm
90°S
30°S
Equator
30°N
90°N
1850
1900
1950
415
400
380
360
340
320
300
280

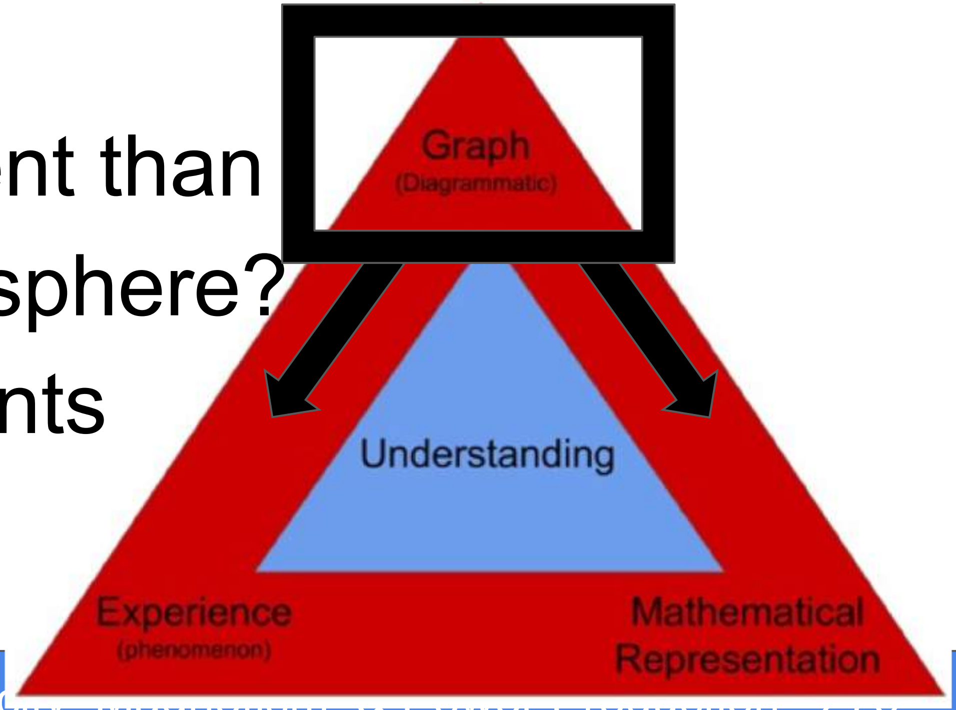
Let’s Be Playful with our Inner Scientist

Let us move around the Triangle

At the 2 minute mark:

1. How is this graph different?
2. How is this graph similar?
3. Why is this graph named the “pump handle”?
4. Why is the northern hemisphere different than the southern hemisphere?

1. Why are measurements usually taken away from cities?

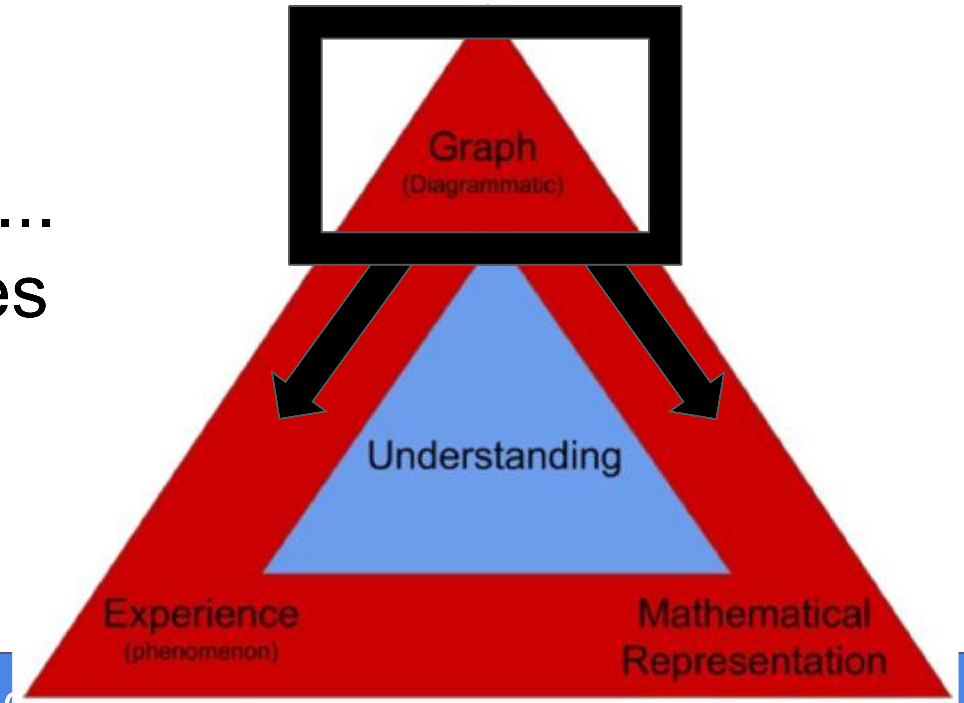


Let’s Be Playful with our Inner Scientist

Last One

Helpful discussion starters:

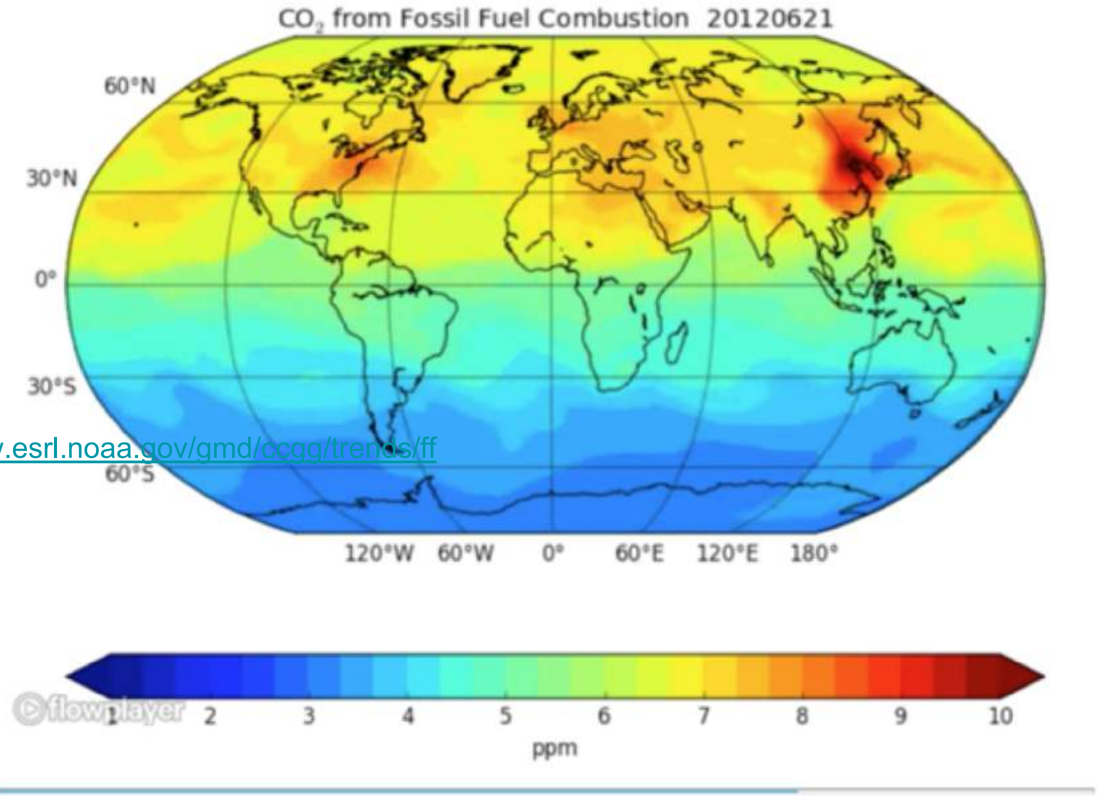
- I notice…
- I see a pattern with…
- I wonder…
- Who is...
- How does this connect to...
- What other questions does this raise?



National Oceanic and Atmospheric Administration

Animated CO_2 Emission Graph (must use link)

https://www.esrl.noaa.gov/gmd/ccgg/trends/ff.html



https://www.esrl.noaa.gov/gmd/ccgg/trends/ff.html

Carbon Dioxide from Fossil Fuel Combustion

Electricity, Magnetism, & Power Production - Day 13

Agenda:

Finish Understanding Earth Systems

Warm Up Question:

Due Next Class

6Q3 - Quiz on the Basic Physics of Climate Science

Due This Class

Finish where we left off with understanding Earth Systems

Electricity, Magnetism, & Power Production - Day 14

Agenda:

Quiz on Understanding
    Earth Systems

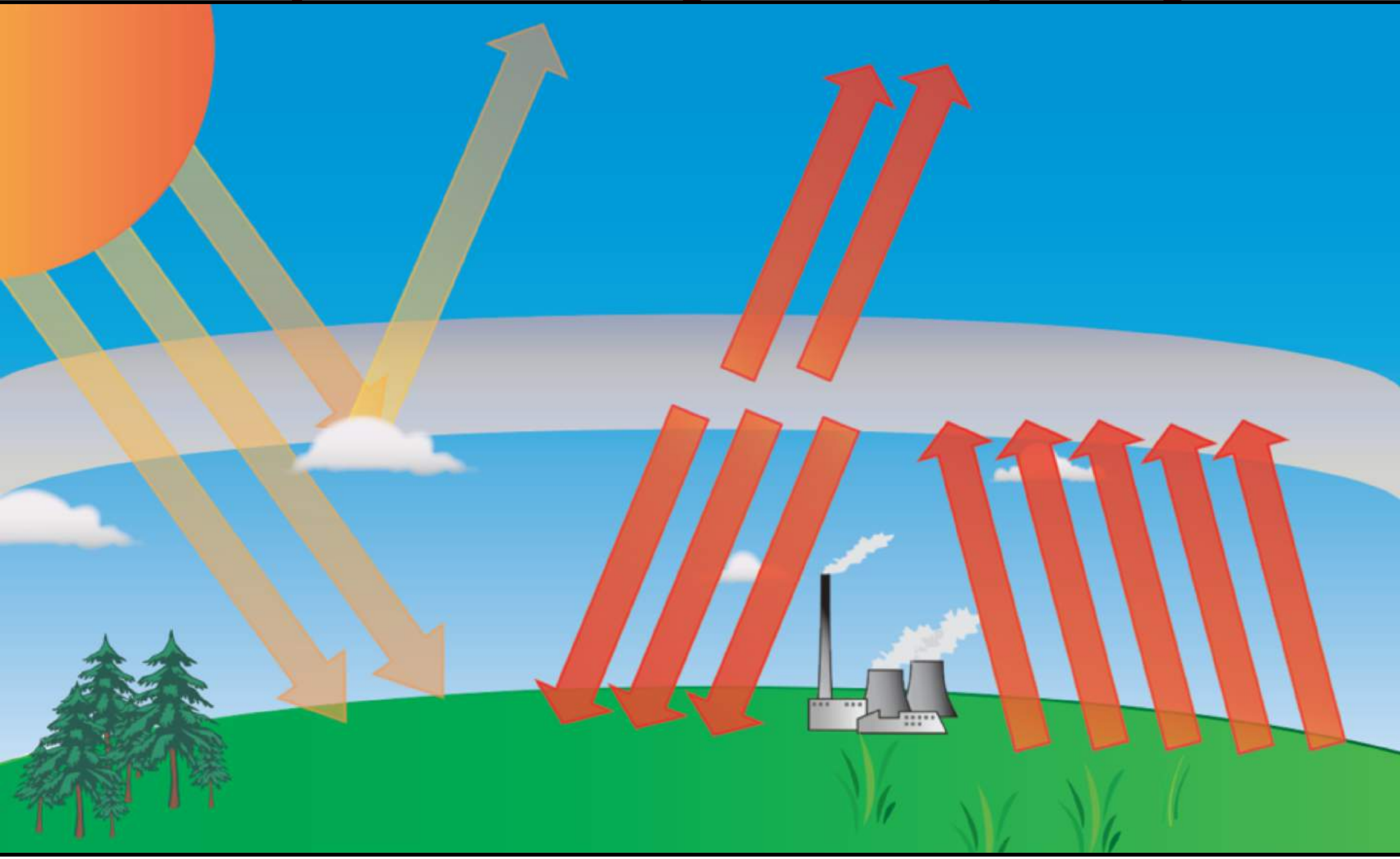
Applying Our
    Understanding to Make
    Our Rubric

Due Next Class

Due This Class

Warm Up Question:

Earth System through Sankey Diagrams



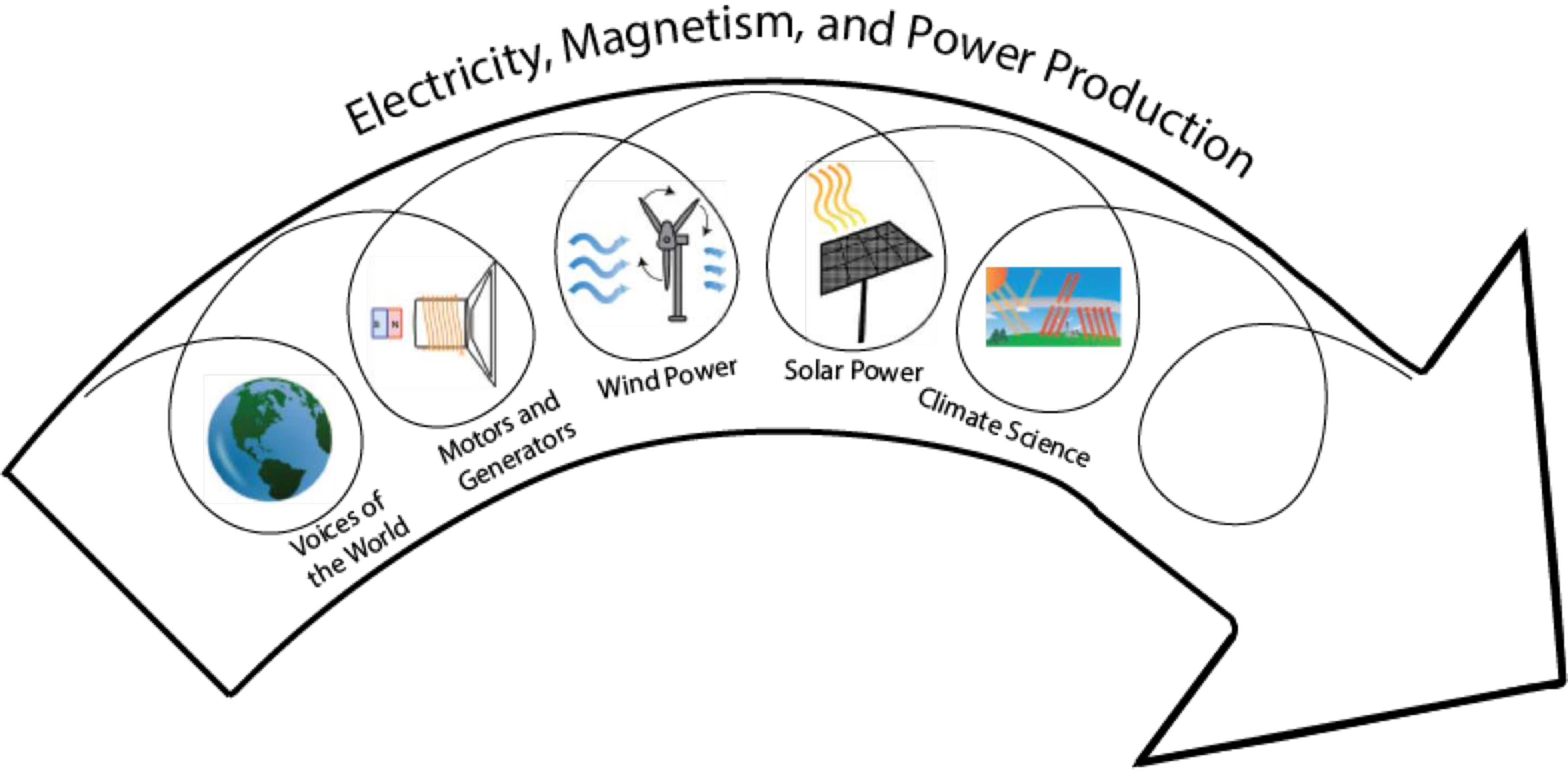
6Q3 - Quiz on the Basic Physics of Climate Science

Philosophical Chairs: The Questions of Nuclear?

Philosophical Chairs for Climate Impact Rubric

For each energy source

1. Stand next to the number 1-5 that you think best represents the Climate/Environmental impact of that source.
2. Each group present two important reasons.
3. Now if persuaded move to the number.
4. Explain why you moved.
5. Any one now want to move?
6. Count which number has highest or should we average them?


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power
Solar Power
Climate Science

Electricity, Magnetism, & Power Production - Day 15

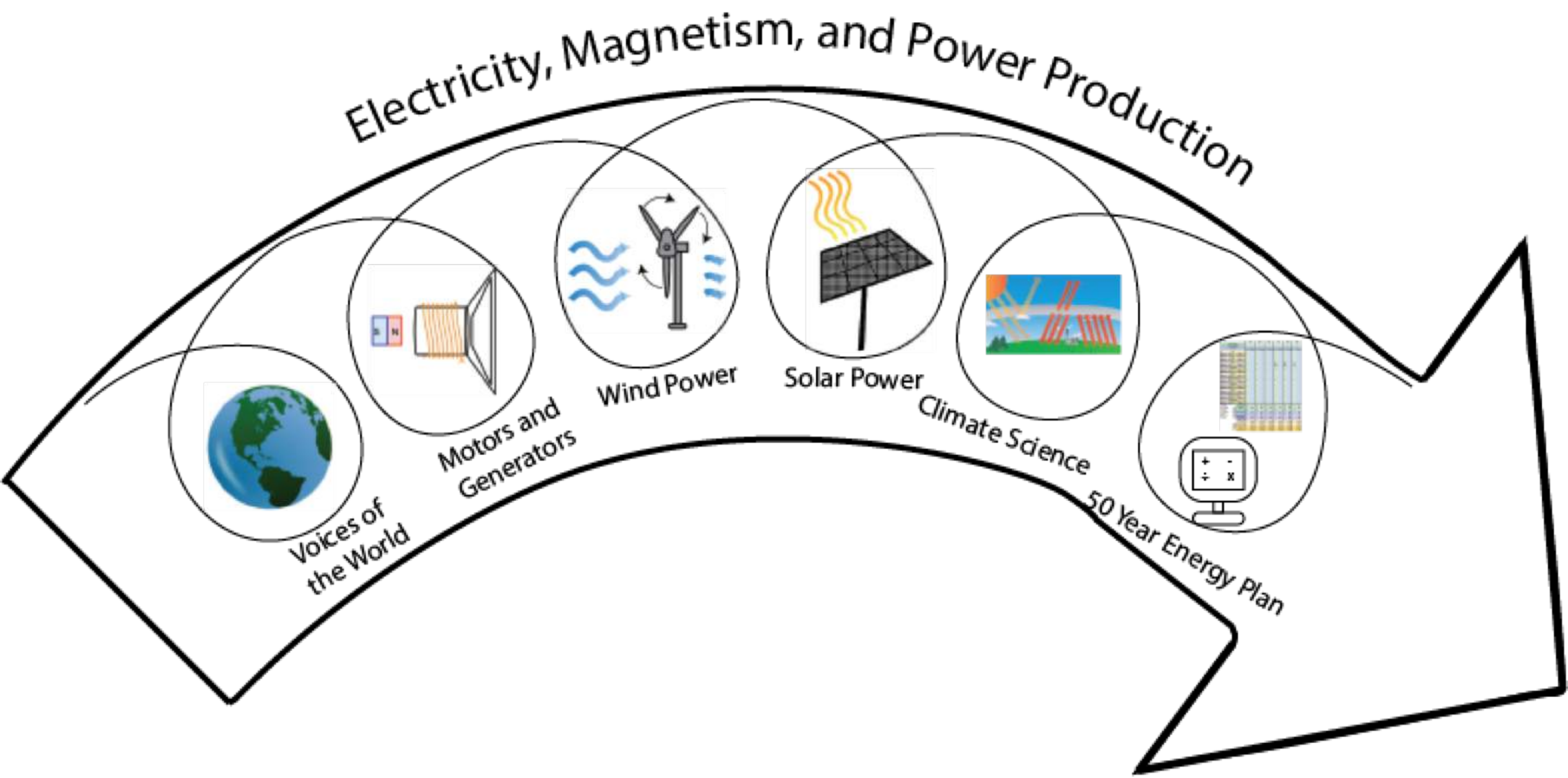
Agenda:

Starting your 50 Year Energy Plan

Warm Up Question:

Due Next Class

Due This Class



Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power
Solar Power
Climate Science
50 Year Energy Plan

Starting Your 50 Year Energy Plan

	Land Use	Air CO2	Cost	Reliability	Max %	Max Rate	2010s		2020s		2030s		2040s		2050s		2060s	
% Energy Needed (% of current energy use)							100		105		110		115		120		125	
Expected % Growth (% change)							20		15		15		10		10		5	
							%**	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth
Hydro (already Maxed)	5	2	2	4	43	0	43		43		43		43		43		43	
Coal	3	5	1	5	34	0	34		34		34		No Coal After 2035		No Coal After 2035		No Coal After 2035	
Natural Gas	3	4	1	5	30	6	12		12		12		12		12		12	
Nuclear	2	1	4	5	100	2	3		3		3		3		3		3	
Biomass	4	2	3	3	12	2	3		3		3		3		3		3	
Wind	4	1	3	2	30	4	5		5		5		5		5		5	
Geothermal	4	1	2	5	30	8	0		0		0		0		0		0	
Solar	3	1	4	2	30	6	0		0		0		0		0		0	
Wave	3	1	5	4	30	10	0		0		0		0		0		0	
Smart Grid Technology	1	1	5	5	12	2	0		0		0		0		0		0	
Energy Storage	1	1	5	5	20	2	0		0		0		0		0		0	

		2010s		2020s		2030s		2040s		2050s		2060s	
Constraints	Energy Needs Check	100 of 100	👍	100 of 105	👎	100 of 110	👎	66 of 115	👎	66 of 120	👎	66 of 125	👎
	% Growth Check	0 of 20	👍	0 of 15	👍	0 of 15	👍	0 of 10	👍	0 of 10	👍	0 of 5	👍
	Reliability Check Score must be above 3	4.4	👍	4.4	👍	4.4	👍	4.0	👍	4.0	👍	4.0	👍
Criteria	Environmental Impact / Land Use	3.9	😕	3.7	😕	3.6	😕	2.5	😁	2.4	😁	2.3	😁
	Climate Impact / Air Quality	3.2	😭	3.0	😭	2.9	😭	1.3	😁	1.2	😁	1.2	😁
	Start Up Cost / Maintenance	1.7	😁	1.6	😁	1.5	😁	1.2	😁	1.1	😁	1.1	😁

*Note: Large Hydro and Coal do not contribute to % growth
**Note: 2010s values came from 2009-2011 average energy source percentages

Reviewing and Redefining Our Problem

(Look at your 6CER - Section 1 - Exploring Our Engineering Challenge)

Problem Statement:

We as the Energy Plan Commission seek to create a 50 Year Energy Plan that must address the energy needs of Oregonians for the State of Oregon.

Constraints: What we must accomplish

1. *Meet the energy needs of the state for the next 50 years*
2. *Stay within the projected growth each decade*
3. *Provide reliable power*
4. *Be off coal by 2035*

Criteria: How we judge our plan

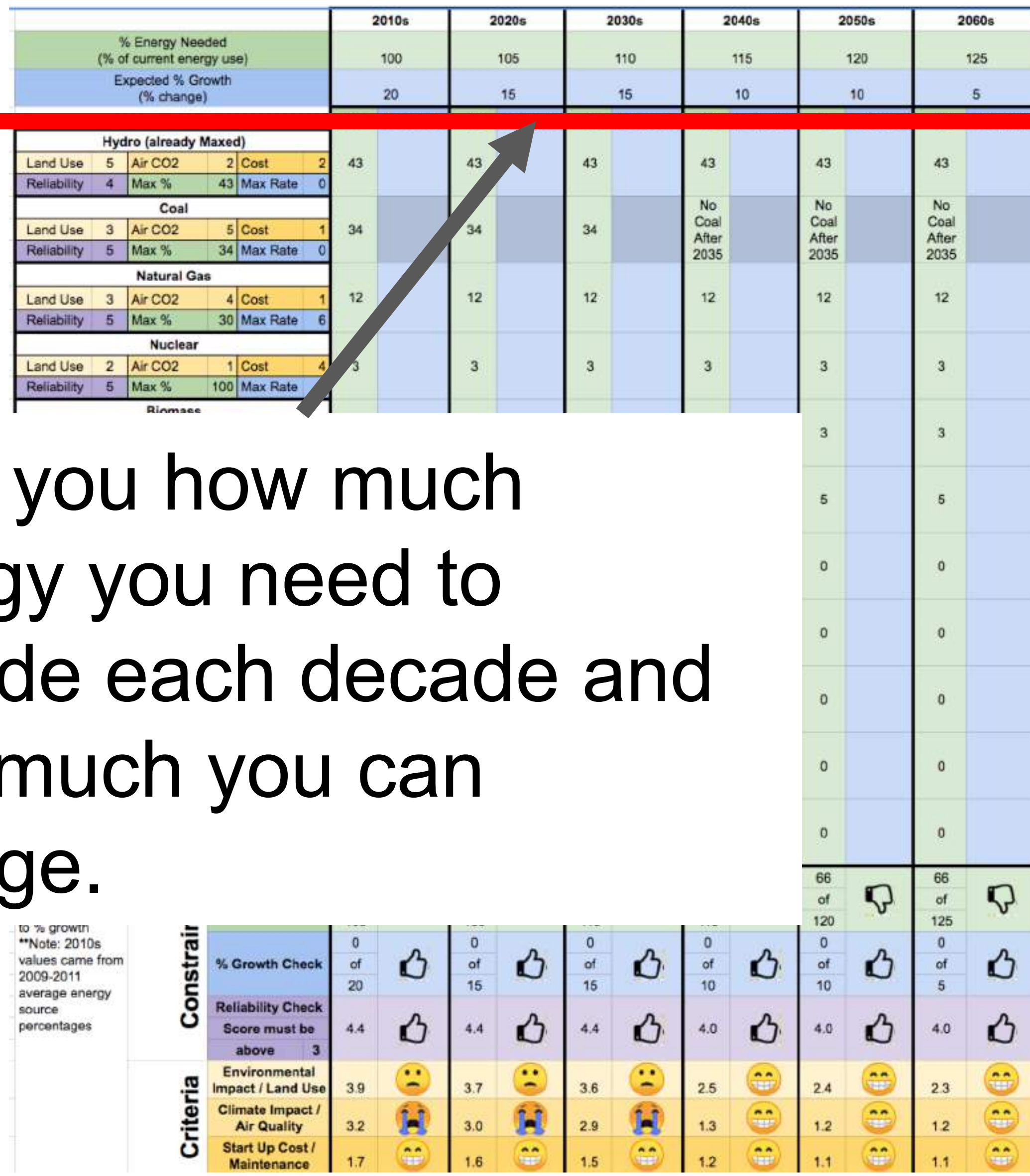
1. *Environmental Impact / Land Use*
2. *Climate Impact / Air Quality*
3. *Start Up Cost / Maintenance*

Overview of the Program

						2010s		2020s		2030s		2040s		2050s		2060s	
% Energy Needed (% of current energy use)						100		105		110		115		120		125	
Expected % Growth (% change)						20		15		15		10		10		5	
						%**	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth
Hydro (already Maxed)																	
Land Use	5	Air CO2	2	Cost	2	43		43		43		43		43		43	
Reliability	4	Max %	43	Max Rate	0												
Coal																	
Land Use	3	Air CO2	5	Cost	1	34		34		34		No Coal After 2035		No Coal After 2035		No Coal After 2035	
Reliability	5	Max %	34	Max Rate	0												
Natural Gas																	
Land Use	3	Air CO2	4	Cost	1	12		12		12		12		12		12	
Reliability	5	Max %	30	Max Rate	6												
Nuclear																	
Land Use	2	Air CO2	1	Cost	4	3		3		3		3		3		3	
Reliability	5	Max %	100	Max Rate	2												
Biomass																	
Land Use	4	Air CO2	2	Cost	3	3		3		3		3		3		3	
Reliability	3	Max %	12	Max Rate	2												
Wind																	
Land Use	4	Air CO2	1	Cost	3	5		5		5		5		5		5	
Reliability	2	Max %	30	Max Rate	4												
Geothermal																	
Land Use	4	Air CO2	1	Cost	2	0		0		0		0		0		0	
Reliability	5	Max %	30	Max Rate	8												
Solar																	
Land Use	3	Air CO2	1	Cost	4	0		0		0		0		0		0	
Reliability	2	Max %	30	Max Rate	6												
Wave																	
Land Use	3	Air CO2	1	Cost	5	0		0		0		0		0		0	
Reliability	4	Max %	30	Max Rate	10												
Smart Grid Technology																	
Land Use	1	Air CO2	1	Cost	5	0		0		0		0		0		0	
Reliability	5	Max %	12	Max Rate	2												
Energy Storage																	
Land Use	1	Air CO2	1	Cost	5	0		0		0		0		0		0	
Reliability	5	Max %	20	Max Rate	2												
Constraints	Energy Needs Check					100 of 100	👍	100 of 105	👎	100 of 110	👎	66 of 115	👎	66 of 120	👎	66 of 125	👎
Constraints	% Growth Check					0 of 20	👍	0 of 15	👍	0 of 15	👍	0 of 10	👍	0 of 10	👍	0 of 5	👍
Constraints	Reliability Check Score must be above				3	4.4	👍	4.4	👍	4.4	👍	4.0	👍	4.0	👍	4.0	👍
Criteria	Environmental Impact / Land Use					3.9	🙁	3.7	🙁	3.6	🙁	2.5	😁	2.4	😁	2.3	😁
Criteria	Climate Impact / Air Quality					3.2	😭	3.0	😭	2.9	😭	1.3	😁	1.2	😁	1.2	😁
Criteria	Start Up Cost / Maintenance					1.7	😁	1.6	😁	1.5	😁	1.2	😁	1.1	😁	1.1	😁

*Note: Large Hydro and Coal do not contribute to % growth
**Note: 2010s values came from 2009-2011 average energy source percentages

Overview of the Program



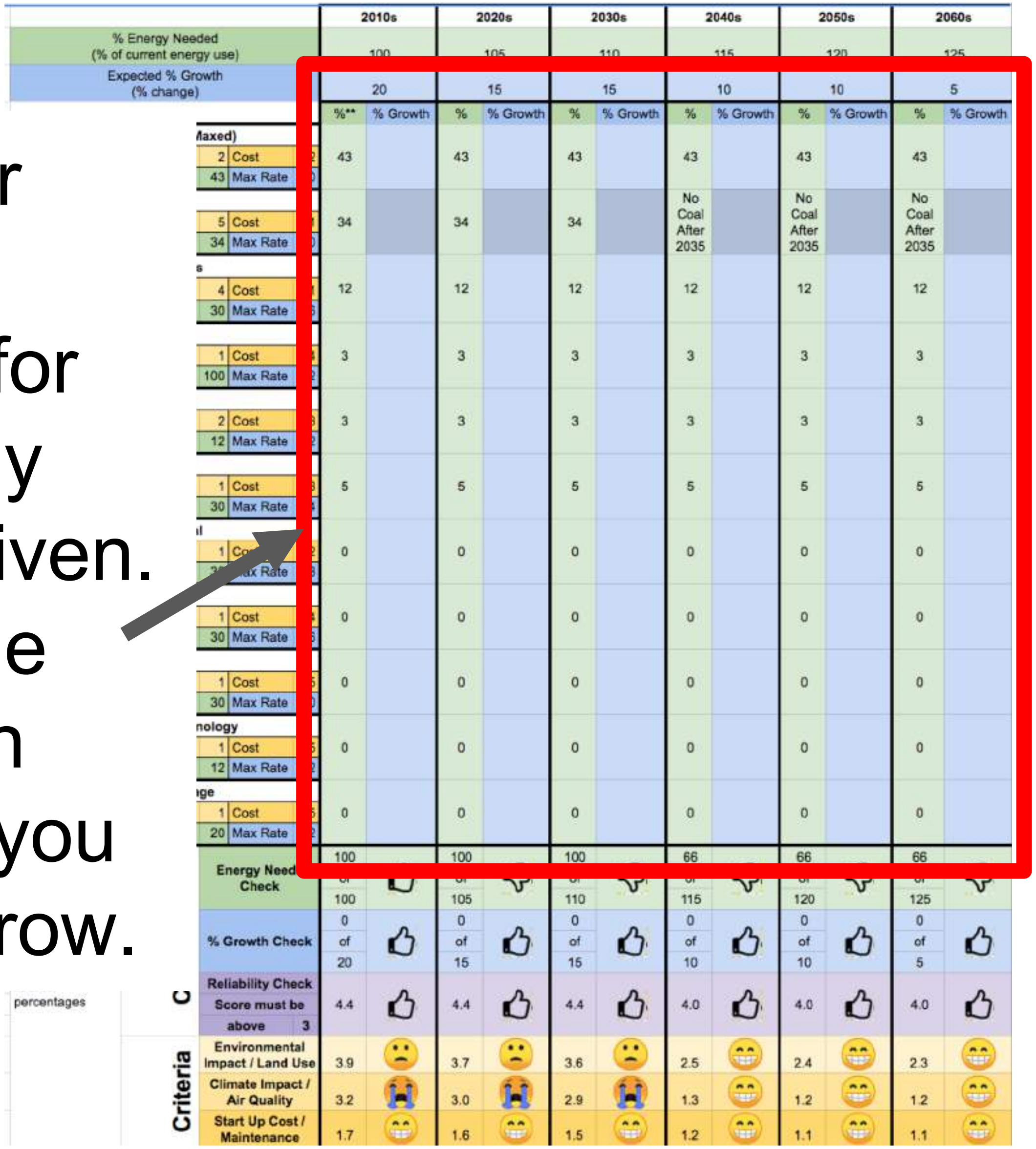
	2010s	2020s	2030s	2040s	2050s	2060s
% Energy Needed (% of current energy use)	100	105	110	115	120	125
Expected % Growth (% change)	20	15	15	10	10	5
Hydro (already Maxed): Land Use 5, Air CO2 2, Cost 2, Reliability 4, Max % 43, Max Rate 0	43	43	43	43	43	43
Coal: Land Use 3, Air CO2 5, Cost 1, Reliability 5, Max % 34, Max Rate 0	34	34	34	No Coal After 2035	No Coal After 2035	No Coal After 2035
Natural Gas: Land Use 3, Air CO2 4, Cost 1, Reliability 5, Max % 30, Max Rate 6	12	12	12	12	12	12
Nuclear: Land Use 2, Air CO2 1, Cost 4, Reliability 5, Max % 100, Max Rate	3	3	3	3	3	3
Biomass					3	3
					5	5
					0	0
					0	0
					0	0
					0	0
					0	0
					66 of 120	66 of 125
Constraints: % Growth Check	0 of 20	0 of 15	0 of 15	0 of 10	0 of 10	0 of 5
Reliability Check Score must be above 3	4.4	4.4	4.4	4.0	4.0	4.0
Criteria: Environmental Impact / Land Use	3.9	3.7	3.6	2.5	2.4	2.3
Climate Impact / Air Quality	3.2	3.0	2.9	1.3	1.2	1.2
Start Up Cost / Maintenance	1.7	1.6	1.5	1.2	1.1	1.1

to % growth
**Note: 2010s values came from 2009-2011 average energy source percentages

Tells you how much energy you need to provide each decade and how much you can change.

Overview of the Program

Create your plan here. Current % for each energy source is given. Edit the blue column with how much you want it to grow.



	2010s		2020s		2030s		2040s		2050s		2060s	
% Energy Needed (% of current energy use)	100		105		110		115		120		125	
Expected % Growth (% change)	20		15		15		10		10		5	
	%**	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth
laxed) 2 Cost, 43 Max Rate	43		43		43		43		43		43	
5 Cost, 34 Max Rate	34		34		34		No Coal After 2035		No Coal After 2035		No Coal After 2035	
s 4 Cost, 30 Max Rate	12		12		12		12		12		12	
1 Cost, 100 Max Rate	3		3		3		3		3		3	
2 Cost, 12 Max Rate	3		3		3		3		3		3	
1 Cost, 30 Max Rate	5		5		5		5		5		5	
l 1 Cost, Max Rate	0		0		0		0		0		0	
1 Cost, 30 Max Rate	0		0		0		0		0		0	
1 Cost, 30 Max Rate	0		0		0		0		0		0	
nology 1 Cost, 12 Max Rate	0		0		0		0		0		0	
ge 1 Cost, 20 Max Rate	0		0		0		0		0		0	
Energy Need Check	100 of 100		100 of 105		100 of 110		66 of 115		66 of 120		66 of 125	
% Growth Check	0 of 20		0 of 15		0 of 15		0 of 10		0 of 10		0 of 5	
Reliability Check Score must be above 3	4.4		4.4		4.4		4.0		4.0		4.0	
Environmental Impact / Land Use	3.9		3.7		3.6		2.5		2.4		2.3	
Climate Impact / Air Quality	3.2		3.0		2.9		1.3		1.2		1.2	
Start Up Cost / Maintenance	1.7		1.6		1.5		1.2		1.1		1.1	

Overview of the Program

	2010s	2020s	2030s	2040s	2050s	2060s
% Energy Needed (% of current energy use)	100	105	110	115	120	125
Expected % Growth (% change)	20	15	15	10	10	5

Source	Land Use	Air CO2	Cost	Reliability	Max %	Max Rate
Hydro (already Maxed)	5	2	2	4	43	0
Coal	3	5	1	5	34	0
Natural Gas	3	4	1	5	30	6
Nuclear	2	1	4	5	100	2
Biomass	4	2	3	3	12	2
Wind	4	1	3	2	30	4
Geothermal	4	1	2	5	30	8
Solar	3	1	4	2	30	6
Wave	3	1	5	4	30	10
Smart Grid Technology	1	1	5	5	12	2
Energy Storage	1	1	5	5	20	2

Source	2010s %	2010s % Growth	2020s %	2020s % Growth	2030s %	2030s % Growth	2040s %	2040s % Growth	2050s %	2050s % Growth	2060s %	2060s % Growth
Hydro			43		43		43		43		43	
Coal					34		No Coal After 2035		No Coal After 2035		No Coal After 2035	
Natural Gas			12				12					
Nuclear			3		3		3					
Biomass			3		3		3					
Wind			5		5		5					
Geothermal			0		0		0					
Solar			0		0		0					
Wave			0		0		0					
Smart Grid Technology			0		0		0					
Energy Storage			0		0		0		0		0	

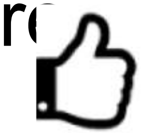
		2010s		2020s		2030s		2040s		2050s		2060s	
Constraints	Energy Needs Check	100 of 100	👍	100 of 105	👎	100 of 110	👎	66 of 115	👎	66 of 120	👎	66 of 125	👎
	% Growth Check	0 of 20	👍	0 of 15	👍	0 of 15	👍	0 of 10	👍	0 of 10	👍	0 of 5	👍
	Reliability Check Score must be above 3	4.4	👍	4.4	👍	4.4	👍	4.0	👍	4.0	👍	4.0	👍
Criteria	Environmental Impact / Land Use	3.9	🙁	3.7	🙁	3.6	🙁	2.5	😁	2.4	😁	2.3	😁
	Climate Impact / Air Quality	3.2	😭	3.0	😭	2.9	😭	1.3	😁	1.2	😁	1.2	😁
	Start Up Cost / Maintenance	1.7	😁	1.6	😁	1.5	😁	1.2	😁	1.1	😁	1.1	😁

Note: Large Hydro and Coal do not contribute to % growth
**Note: 2010s values came from 2009-2011 average energy source percentages

All of the energy sources and their criteria scores and numbers that limit their growth.

Overview of the Program

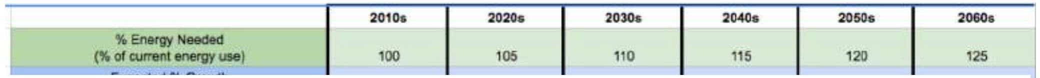
	2010s		2020s		2030s		2040s		2050s		2060s	
% Energy Needed (% of current energy use)	100		105		110		115		120		125	
Expected % Growth (% change)	20		15		15		10		10		5	
	%**	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth	%	% Growth

The constraints are checked here. You must have all of these be a  by the end of your 50 Year Plan.

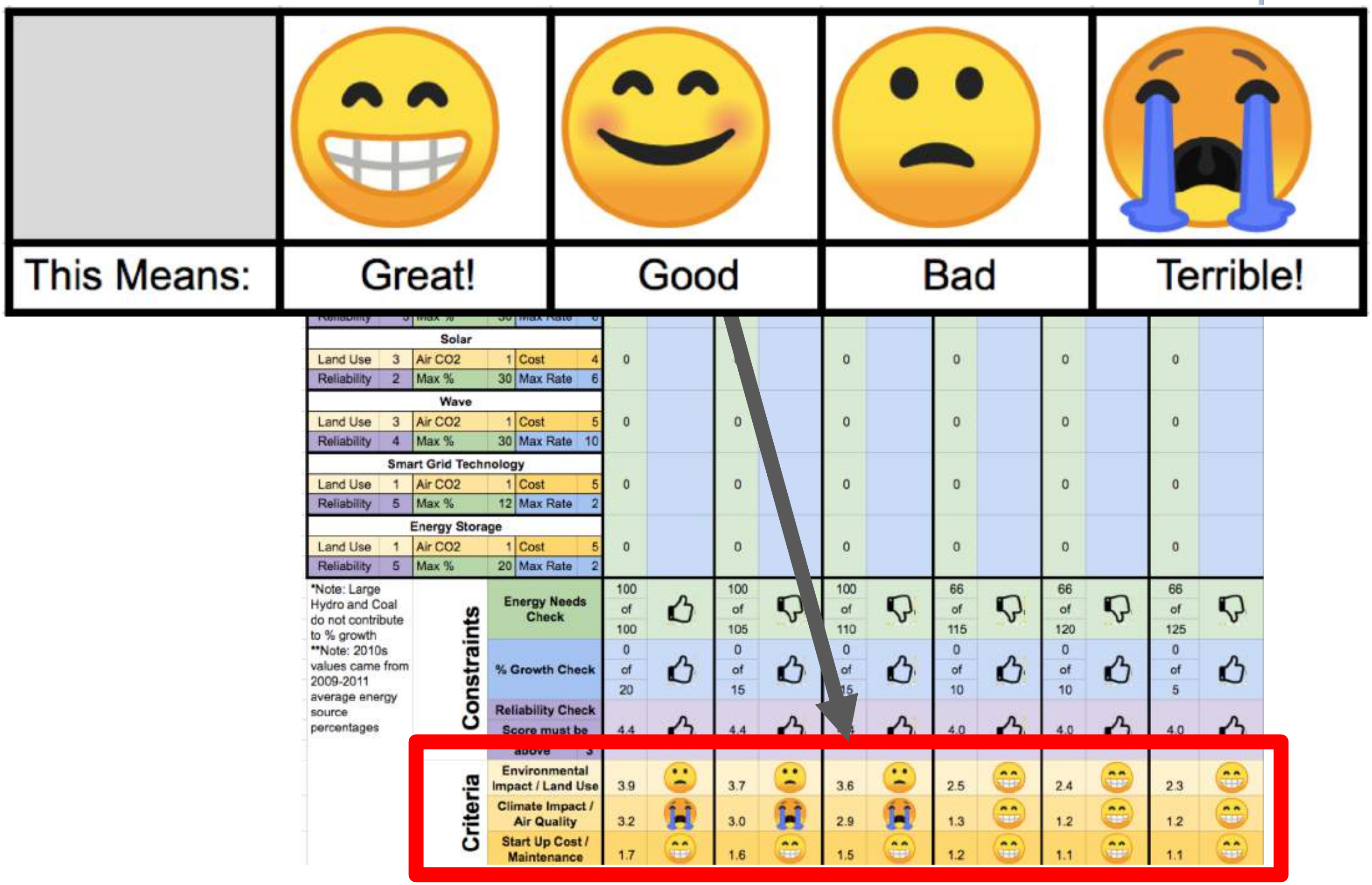
				2010s %	2010s % Growth	2020s %	2020s % Growth	2030s %	2030s % Growth	2040s %	2040s % Growth	2050s %	2050s % Growth	2060s %	2060s % Growth
Wind	Land Use 4	Air CO2 1	Cost 3	5		5		5		5		5		5	
	Reliability 2	Max % 30	Max Rate 4												
Geothermal	Land Use 4	Air CO2 1	Cost 2	0		0		0		0		0		0	
	Reliability 5	Max % 30	Max Rate 8												
Solar	Land Use 3	Air CO2 1	Cost 4	0		0		0		0		0		0	
	Reliability 2	Max % 30	Max Rate 6												
Wave	Land Use 3	Air CO2 1	Cost 5	0		0		0		0		0		0	
	Reliability 4	Max % 30	Max Rate 10												
Smart Grid Technology	Land Use 1	Air CO2 1	Cost 5	0		0		0		0		0		0	
	Reliability 5	Max % 12	Max Rate 2												
Energy Storage	Land Use 1	Air CO2 1	Cost 5	0		0		0		0		0		0	
	Reliability 5														
Constraints	Energy Needs Check			100 of 100	👍	100 of 105	👎	100 of 110	👎	66 of 115	👎	66 of 120	👎	66 of 125	👎
	% Growth Check			0 of 20	👍	0 of 15	👍	0 of 15	👍	0 of 10	👍	0 of 10	👍	0 of 5	👍
	Reliability Check Score must be above 3			4.4	👍	4.4	👍	4.4	👍	4.0	👍	4.0	👍	4.0	👍
Criteria	Impact / Land Use			3.9		3.7		3.6		2.5		2.4		2.3	
	Climate Impact / Air Quality			3.2		3.0		2.9		1.3		1.2		1.2	
	Start Up Cost / Maintenance			1.7		1.6		1.5		1.2		1.1		1.1	

*Note: Large Hydro and Coal do not contribute to % growth
**Note: 2010s values came from 2009-2011 average energy source percentages

Overview of the Program



The criteria are factored in here.



Exploring the Program

Play with the Program for a little bit...

Constraints: What we must accomplish

1. *Meet the energy needs of the state for the next 50 years*
2. *Stay within the projected growth each decade*
3. *Provide reliable power*
4. *Be off coal by 2035*

What do you have to do to in a decade to get three ?

Constraints

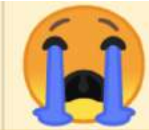
Energy Needs Check	100 of 100	
% Growth Check	20 of 20	
Reliability Check Score must be above **2.5**	2.9	

Exploring the Program

Play with the Program for a little bit...

Criteria: How we we judge our plan

1. *Environmental Impact / Land Use*
2. *Climate Impact / Air Quality*
3. *Start Up Cost / Maintenance*

Criteria	**Environmental Impact / Land Use**	3.4		4.0	
	Climate Impact / Air Quality	2.8		2.8	
	Start Up Cost / Maintenance	2.8		1.3	

What in the program decides what emoji you get?

				
This Means:	Great!	Good	Bad	Terrible!

Some Strategy Tips Before you Start

- Look back at the first paragraph in your essay. Use that to help determine your strategy.
  - Prioritize the criterion that you value the most.
- Just start with your first thoughts, then iterate to improve the plan. (Your first plan should not be your best plan)
- You do not necessarily need to spend all of the % Growth every decade.

50 Year Energy Plan

Go and complete your 50 Year Plan.

You should complete at least three plans. This will help you improve your plan and strategy.

Evaluating Competing 50 Year Energy Plans

Evaluating Competing 50 Year Energy Plans			
What are the strengths and weaknesses of your plan in terms of the criterion?		What are the strengths and weaknesses of the competing plan in terms of the criterion?	
Describe the overall strategy of your plan.		Describe the overall strategy of the competing plan.	
Strengths	Weaknesses		

Once you finalize your plan, be thoughtful in your description of it

Evaluating Design Solutions

Our focus next class

te the problem and evaluate your design so on against others. In this there will be fo 4) sections.

1. Exploring Our Engineering Challenge (Claim)
2. Evaluating Competing 50 Year Plans (Evidence)
3. Reasoning about the Best Design (Reasoning)
4. Limitations of your Plan

Electricity, Magnetism, & Power Production - Day 16

Agenda:

Refine your 50 Year Energy Plan

Evaluating Competing Plans

Reasoning about the Best Design

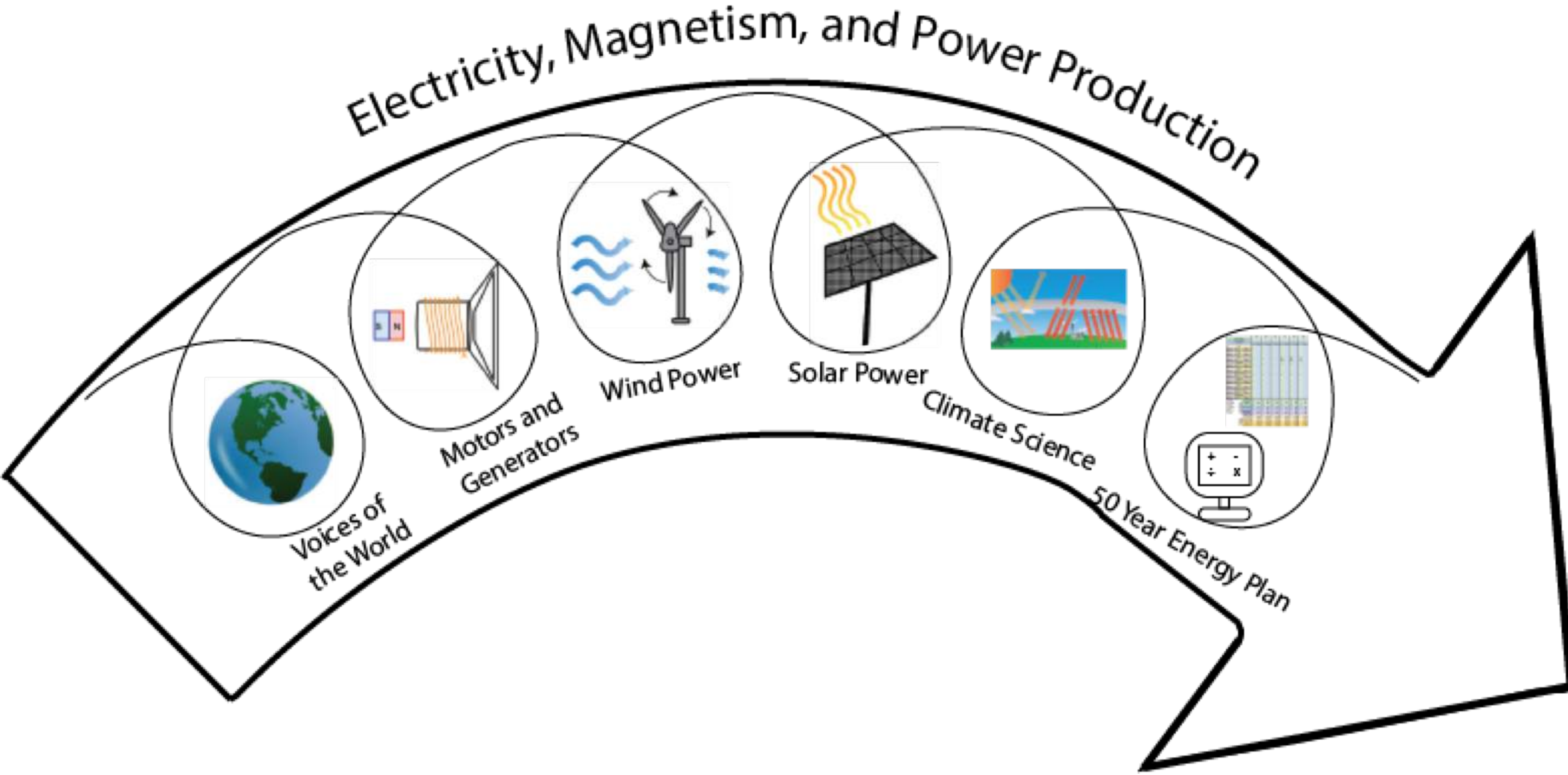
Reflecting on Limitations

Warm Up Question:

In terms of our 50 year energy plan, how would you convince someone that one plan was better than the other?

Due Next Class

- Graphic Organizers for Competing Plans and Best Design / Reasoning about the Best Design


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power
Solar Power
Climate Science
50 Year Energy Plan

Evaluating Design Solutions

At the Start of Class: Our focus

te the problem and evaluate your design so on against others. In this there will be fo 4) sections.

1. Exploring Our Engineering C allenge (Claim)
2. Evaluating Competing 50 Year Plans (Evidence)
3. Reasoning about the Best Design (Reasoning)
4. Limitations of your Plan

Evaluating Competing 50 Year Energy Plans

Evaluating Competing 50 Year Energy Plans			
What are the strengths and weaknesses of <u>your</u> plan in terms of the criterion?		What are the strengths and weaknesses of the <u>competing</u> plan in terms of the criterion?	
Describe the overall strategy of <u>your</u> plan.		Describe the overall strategy of the <u>competing</u> plan.	
Strengths	Weaknesses	Strengths	Weaknesses

Time to consider other solutions.

Evaluating Design Solutions

Decisions need to be made,
what is our best option?

te the problem
on against
others. In this there will be fo 4) sections.

1. Exploring Our Engineering C llenge (Claim)
2. Evaluating Competing 50 Ye Plans (Evidence)
3. Reasoning about the Best Design (Reasoning)
4. Limitations of your Plan

Reasoning about the Best Design

Reasoning about the Best Design		
Claim: Restate your claim about which criterion is most important (see introduction paragraph) and state which plan best fulfills that priority.		
Most Important Criterion	Important Difference Between Plan A and Plan B	What energy resource / strategy did the plan use to achieve that difference?
Very Important Criterion	Important Difference Between Plan A and Plan B	What energy resource / strategy did the plan use to achieve that difference?
Really Important Criterion	Important Difference Between Plan A and Plan B	What energy resource / strategy did the plan use to achieve that difference?
Concluding statement: Summarize (in terms of the priority of the criteria) why your chosen solution (plan A or B) is better.		

Evaluating Design Solutions

As always in science and engineering let's reflect on the limitations of our plan.

municate the problem
n solution against
be four (4) sections.

1. Exploring Our Engin ing Challenge (Claim)
2. Evaluating Competi 50 Year Plans (Evidence)
3. Reasoning about the est Design (Reasoning)
4. Limitations of your Plan

Limitations of Your Plan

Limitations of Your Plan		
What challenges do you envision in implementing your solution? Have you made any assumptions?	What problems may still remain if your proposed plan is implemented?	What technological breakthroughs might change your plan design? How might it change?

What else do you want to include in your essay?	

Electricity, Magnetism, & Power Production - Day 17

Agenda:

In class essay

Warm Up Question:

Due Next Class

Due This Class

Finishing your in class essay