The X-factors of Climate

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This Science on a Sphere script was written with a target audience of families with young children (K-4th grade) in mind. However, easy modifications can be made to include a wider age range. For example, you can revise the audience questions to make them less targeted and make the explanations a little more technical to appeal to older groups. The directions in each section correspond to the script paragraph of the same letter.

Dataset Title:	Script:	Directions:
1. Blue Marble, 23° tilt	*(Introduce SOS according to your location's procedures, below is a sample introduction.)* A. Welcome to Science On a Sphere®! SOS was invented by Dr. MacDonald, current director of the NOAA Earth System Research Lab, as a new and more natural way to display scientific information. Four projectors are used to project images onto the sphere, each calibrated so that the images blend together and appear united. The sphere itself is made of carbon fiber and is suspended from the ceiling by wires. It is hollow and weighs a little over 50 pounds. B. Today, we are going to find out what factors determine the kind of climate a place has, and how to tell these climate zones apart. Before we begin, though, we all need to understand what climate means exactly. To give you an idea, let's say your family is going on vacation. As you are deciding what clothes to pack, you are basing your decisions on the destination's climate—the *general* weather conditions that people have come to expect after years and years. You don't know exactly what the high or low temperature will be, or if and when a storm will occur, but you have a general expectation: hot or cold, rainy or dry. For	A. *Point to the projectors, wires, and other objects as you reference them so audience members are not distracted by trying to find them themselves.*

	example, Seattle, Washington, has a mild, rainy climate—you need to pack a light jacket and an umbrella. Arizona on the other hand is hot and dry most of the time—better bring shorts and sun screen! If you think of plants as Earth's clothing, then Earth also dresses differently depending on what kind of climate a region has. Now that we all know what climate means, let's figure out the X-factors that cause it.	
2. Seasonal Blue Marble	A. This is a view of Earth that is cycled over a year, so it shows the different seasons. Different seasons are a characteristic of a temperate climate, while a tropical climate is known for having the same conditions throughout the year. We can see this for ourselves if we watch closely. B. Now, let's pretend that I am the sun. On this sphere, is the northern hemisphere or southern hemisphere closer to me? *(southern hemisphere)* So is the southern hemisphere getting more sunlight or less sunlight than the northern hemisphere? *(more sunlight)* Right, so because the southern hemisphere is getting more sunlight, is it winter or summer there? *(summer)* Exactly! Now that I have paused the animation to reflect the proper seasons, you can really see the differences, can't you? Just look how green the southern hemisphere is, while most of the northern hemisphere is covered in snow and ice! C. Sunlight is *unevenly* distributed at Earth's surface due to our planet's tilt. If the Earth weren't tilted 23°, there would be no change in seasons! This is exactly why the tropics stay basically the same—green and lush—*all* year; near the equator Earth's tilt is much less evident and so the tropics receive a *lot* of sunlight *all* year round (1,360 watts per square	A. *Tilt the dataset as soon as it begins playing so that the southern hemisphere is angled toward you.* A. ***Draw*** *a circle around a temperate climate zone, and a circle around a tropical zone to direct audience attention to these areas.* ***Clear*** *the drawings after a 2 year seasonal cycle is complete.* B. *After correct audience response, pause the animation to reflect summer in the southern hemisphere and winter in the northern hemisphere.* B. *Use the* ***pointer*** *(via* ***annotation****) to point out the seasonal differences between the hemispheres.*

	meter to be exact!). So, unequal amounts of sunlight throughout the year means seasons (temperate climate) and equal amounts mean no change (tropical climate).... we have found our first X-factor of climate: sunlight!	
3. Earth Topography and Bathymetry	A. This image of Earth emphasizes the different landscapes of the continents and oceans, such as tall mountains and deep ocean rifts. These features are formed after thousands and thousands of years as the plates that form Earth's crust shift around, a phenomenon called plate tectonics. B. We are going to focus on the mountain ranges in this display. How many of you have been hiking in the mountains before? Did you have to bring a jacket with you?/What did you notice as you climbed higher and higher? *(Yes./It gets colder up in the mountains.)* And why is it colder up there? You are getting closer to the sun the higher you climb, so you should be warmer, right? Wrong! It's all because of our atmosphere. Have you ever been in a crowded room and started to feel hot and stuffy because of all the body heat? Well, a similar situation occurs in our atmosphere. The particles and gases in the air are crowded together at Earth's surface. As you get higher and higher into the atmosphere, though, the particles and gases in the air spread further and further apart, making it cooler. What this means for climate is that, even during warming seasons, winter-like conditions can remain on land that is high above sea level. We can see evidence of this on the previous display...	A. *Use the **pointer** (via **annotation**) to point out any mountains and rifts that you mention.*
4. Seasonal Blue Marble (again)	A. ...see how even in June there is snow on the Himalayas? For most of the peaks in this range, that layer of snow is permanent—it	A. *Pause the dataset at June*

	never melts all year. B. We can even see snow in the Rockies in June. In fact, we depend on that snow to stay up in the mountains and melt slowly so it can replenish our water sources. C. And would you believe me if I told you that *Hawaii* gets snow every winter? It does!...on top of Mauna Kea, a tall mountain on the Big Island. So, even if it is the middle of summer or we are in a tropical place, conditions will be different high up in the mountains. That fact gives us our second X-factor of climate: altitude!	A./B. ***Zoom*** *into the Himalayas and Rockies to show snow cover* B. *Move the **pointer** (via **annotation**) around Hawaii, emphasizing how close it is to the equator.*
5. Linear IR Satellite (real time)	A. X-factor number three has to do with the movement of the air around us. If you can tell me what's moving the clouds in this image, then you already know what it is…(pause for any audience responses)… wind! We know there is wind outside when we see the tree branches swaying, or feel a cool breeze on our neck. There is wind blowing high up in the atmosphere too, scientists just have different ways of measuring it. One way is looking an infrared satellite image like this one, which shows us how clouds are moving. B. This image is produced by satellites that can sense the amount of infrared radiation—heat—that objects on and above Earth are giving off. Clouds give off very little heat compared to the ground, so they are easily sensed by the satellite. In this image the clouds are colored white. The brighter the white, the colder the cloud, which in turn means the higher the cloud is in the atmosphere. The high clouds are associated with severe weather. Temperatures at severe thunderstorm cloud tops can drop below	A. *You may want to lower the animation speed of the dataset so that the audience can more easily follow the movement of the clouds.* B. *Use the **pointer** (via **annotation**) to point out some of the brighter clouds.*

	-100°F! C. If we watch the bright clouds, we can see how the winds high in the atmosphere are moving. Clouds are pushed along with the wind, and the faster the clouds move, the stronger the wind. The areas of strongest winds, such as these, are called jet streams. D. There are two major jet streams that affect North American climate: the polar jet and the subtropical jet. As you can probably guess, these jet streams influence climate by either bringing colder polar air south or bringing warmer tropical air north. Here's an example: usually, during the winter, the polar jet dips down across the U.S. from the Rockies eastward, forming a feature called a longwave trough. This trough brings cold air down from the north and we get a typical winter season. Sometimes, however, the polar jet does not dip down very far, resulting in a shallow trough. Less cold polar air is brought down into the U.S., resulting in milder winters. This is exactly what we experienced last winter (2011-2012), which, if you recall, was a rather mild one! Now, there is one more X-factor to climate that we have yet to discuss, and it is pretty important since it covers around 71% of Earth's surface. Who can guess what I am talking about? *(The ocean)*	C. *Pause the dataset when you find a good visual example of the jet stream, then* ***draw*** *an arrow along it. Clear the arrow after a few seconds and resume play.* D. ***Draw*** *arrows illustrating cold air moving south and warm air moving north. Clear them after 2-3 seconds.* D. ***Draw*** *a normal longwave trough in red, then* ***draw*** *a shallow longwave trough in yellow to illustrate the differences.* D. *Use the* ***pointer*** *(via* ***annotation****) to point to the yellow trough as you relate the configuration of the polar jet to the past winter.*
6. Sea Surface Currents and Temp with Gray Land	A. The ocean is so important to climate because of the way it moves. This image shows surface ocean currents and temperature—reds are warm temperatures, blues are cold, and yellow and green are in the middle. B. Ocean currents cycle warm water from the tropics to the poles and cold water from the poles back to the tropics. If we didn't have	 B. *Move the* ***pointer*** *(via* ***annotation****) along the currents to show*

	currents like the Gulf Stream bringing warm water up the coast, then the Hamptons, NY would not be such a popular vacation destination! C. The Gulf Stream ocean current also helps moderate England's climate. In London, for example, the average low during January is just 34.5°F, while in Calgary, Alberta—which is the same distance north of the equator as London but is landlocked—January lows are around *4.8°F!* Brrrr! Clearly being next to a warm ocean current makes a big difference! D. Other significant warm ocean currents we can see on this map are the Kuroshio current along the western Pacific and the Agulhas current along the western Indian Ocean. So, let's recap really quickly: who can remember the four determining factors of climate that we just discussed? *(sunlight, altitude, wind, ocean currents)*	*the flow of warm water to the poles and cold water back to the equator* B. ***Draw** an arrow following the motion of Gulf Stream, if desired.* B. *Move your **pointer** (via **annotation**) over The Hamptons when you refer to it.* C. ***Place a map marker icon** ( ) over the approximate locations of London and Calgary. Connect both cities with a line to show how each city is located along the same line of latitude.* D. *Use the **pointer** (via **annotation**) to point out the Kuroshio and Agulhas current*
7. Earth with vegetation	Great! Now, let's pretend we didn't know any of that…as if we were aliens who just landed on planet Earth. How would we know that different places on Earth have different climates? Remember what I said at the beginning? The Earth "dresses" differently for different climates. A. Let's take New England and the Sahara Desert-Sahel region as an example. Looking at this map, what can you see that is different between these two regions? *(New England is green and the Sahara is brown…the environment is different.)* In other words, the plants that grow in New England are different from the plants that grow in the Sahara-Sahel. The plants are like Earth's clothes, they change depending on climate.	A. *Pause the dataset and move the sphere so that New England and the Sahara-Sahel are both in view.* A. *Move the **pointer** (via **annotation**) around these two regions, emphasizing the green area vs. the*

<table>
<tr><td></td><td></td><td>brown area (you may wish to draw and/or use zoom as well)</td></tr>
<tr><td>8. Land Cover Map with Ribbon of Labels</td><td>A. This image is kind of like a picture of Earth’s closet. These are all of Earth’s outfits! As we move from place to place we see that Earth’s outfit changes to match the climate.

B. If we coordinate the colors on the map to the colors on the labels we can learn which vegetation types correspond to the different climates of the world. So, what kinds of plants can you see growing in New England? (deciduous trees, forests) New England has a temperate climate, which, as we learned earlier, means that it experiences all 4 seasons. Now, if I told you that Japan also has a temperate climate, without peeking at the map, what kind of plants do you think we would find there? (Deciduous trees—same as New England.) Right, since the climates are the same, the same kinds of plants grow in both New England and Japan.

C. What about the Sahara-Sahel region? What do we see growing in this climate? (shrubs, barren) Where else in the world would we find this same kind of vegetation? (Other deserts: Mojave, Saudi Arabia, Australian Outback)

(If there is time: interactively go through other regions of the world and what kind of vegetation those climates have. Make sure that the climate-vegetation connection is clear.)

The balance between vegetation and climate is very fragile. If there is a change in climate it can upset and even destroy the native vegetation.</td><td>A. Move the pointer (via annotation) around the ribbon of labels (“outfits”) so that the audience can follow the analogy.
B. Before asking about New England’s vegetation, pause the animation so the audience can focus in on the dataset.
B. Move the pointer and/or draw (via annotation) around the green area in New England and the corresponding vegetation type in the ribbon of labels. Once the correct answer is given, turn the sphere to show Japan and move the pointer and/or draw (via annotation) around Japan.
C. Follow the procedure above for the discussion of the Sahara-Sahel vegetation.</td></tr>
<tr><td>9. Biosphere with Carbon Dioxide</td><td>A. This brings us to another influencing factor of climate that has come to the forefront over the past 50 years: greenhouse gases. Greenhouse</td><td>A. Pause the dataset once it loads (or have the animation set to</td></tr>
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concentra- tion measured at Mauna Loa	gases are present naturally in our atmosphere and help warm the Earth like a blanket; they reflect the heat given off by Earth back toward the surface. Without them, the average temperature of Earth would be about 0°F instead of 57°F. B. However, since industrial times, levels of these gases in our atmosphere, such as carbon dioxide, have increased more than normal cycles account for. This increase is mostly credited to human activities. Adding more greenhouse gases into the atmosphere is like adding an extra blanket around the earth—more heat gets trapped! Indeed, the greenhouse gas increase is correlated with a rise in average global temperature of about 0.74°C (1.3°F) since the late 19th century. This may not seem like much, but it is enough to begin to disrupt the climate-vegetation balance. C. This display tracks changes in Earth's vegetation. The green colors on the land represent plant life, and the light blue colors over the ocean represent marine phytoplankton (microscopic ocean plants). The changes in vegetation are linked to CO_2 changes. We can see the changes in CO_2 with time by looking at this graph, which charts the CO_2 levels measured at the NOAA lab in Mauna Loa, Hawaii from October of 1997 to September of 2006. D. Notice how, on a yearly basis, CO_2 levels are greater in winter than in summer. This is because during the summer there is more vegetation growing to absorb the CO_2 in the air, so rates drop. During the winter, however, fewer plants are around to take up the CO_2 in the air, and some plants die or decay, re-releasing their stored CO_2 into the atmosphere. This causes rates to go up in the winter. What is really important to notice is	*0) so that the audience is not distracted by the animation while you are explaining greenhouse gases.* C. *Resume play of the dataset.* C. *Use the **pointer** (via **annotation**) to point out the graph to the audience.* D. *Move the **pointer** (via **annotation**) along the upward (winter) and the downward (summer) segment of the graph as you distinguish between them.* D. ***Draw** a line through the graph showing the*

	that the *overall* trend in CO_2 levels is upward.	*upward trend.*
10. Earth at Night	A. So where does all the excess CO2 come from? Here's a clue. This is a display of all the nighttime lights of the world, developed from satellite sensors that detect light. Notice how industrialized the world has become. You can also see that we have a preference for certain climates: temperate and tropical climates seem to be the most populated, desert and polar the least. B. Humans now number over 7 billion, and with so many of us around, we play a big role in caring for the earth. The different climates that we see around the Earth today are so special because of a specific combination of X-factors: sunlight, altitude, wind, and proximity to ocean currents. Just as we would dress differently if we travelled to a new climate, the kind of plants that grow on Earth's surface differ between climates. We need to be aware of how our activities are also affecting climate so that we can help maintain the climate-vegetation balance and preserve ecosystems. *(Give your location's customary farewell. Below is a sample.)* Thank you all for coming, I hope you enjoyed this presentation of Science On a Sphere®. Please feel free to stick around for a few minutes and ask any questions.	A. *Move the* ***pointer*** *and/or* ***draw*** *(via* ***annotation****) around highly populated temperate/tropical regions and the sparsely populated desert/polar regions to show the difference between them.*