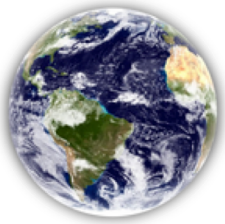
Wind, Water & Mountains: 'Ingredients' of Regional Climate



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This Science On a Sphere script is written as an SOS introductory lecture and participation activity for 6-10th grade students which should take place before completing the lesson plan: "Wind, Water & Mountains," in the classroom following. **Materials needed for SOS demo**: An "SOS student worksheet" for every student, copies of location pictures 1-6 (at least 1 copy per 6 students for final activity), writing utensils.

Content addresses Next Generation Science Standard **MS-ESS2-6:**

> **Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. [Clarification Statement: Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean convection cycle, which is constrained by the Coriolis effect and the outlines of continents. Examples of models can be diagrams, maps and globes, or digital representations.] [Assessment Boundary: Assessment does not include the dynamics of the Coriolis effect.]**

Dataset	Script	Directions
Blue Marble	*(After a short introduction to SOS technology…)* Have you ever wondered what it would be like to live in another part of the world for a while? Some of you may have first-hand experience, others dream of exotic locales – whether ice-covered or tropical, desertic or mountainous. Today we're going to figure out how to determine the expected climate of a region without Google-ing it. That is, taking a look at the factors or environmental 'ingredients' that determine a location's climate.	
Köppen Climate Classifications	A. What do you think the places 'painted' in the same color have in common? B. This is a climate classification map, which was first made in 1884. It is based on the idea that native vegetation is the best expression of climate. So that must mean that not only	*A. Allow input from the audience on everything from vegetation, climate, weather, latitude, and elevation,*

	do these places have similar sunshine and rainfall but also the same plant species – basically they should look and feel the same. C. As you can see, around the equator they are colored mostly blue or dark blue and around the poles are the same color of green. Today we're going to explore different ingredients of Earth's climate like ocean and atmospheric circulation in order to investigate the differences between the places depicted in different colors on this map. D. For the purpose of comparison and learning more about exotic locations, I've chosen 6 around the world. I'm going to ask you to fill out the worksheet as we go along. Now, I'm going to give you a number that corresponds to a place: 1 - 6 that is marked on the globe. Please circle it on your paper.	*etc. If they only think of a few, say "what else?"* *D. Assign numbers to students into groups of 3-5. Put students sitting next to one another in the same group so they may discuss answers together.* ***Circle on paper #1 circle: 1-6***
Earth with Vegetation With 1-6 pushpins	A. Here are the 6 locations on the Earth with red pushpins. We will compare these places in all of the datasets. As we go over the ingredients of regional climate, I'll ask you to record what you see. We'll compile the factors together and write a few sentences about the approximate climate of your location. Don't worry about reading the text on your worksheet. That is to help you later in writing your paragraphs, just circle the bold lines as we go along.	
Real-Time IR Sat- Enhanced Color With 1-6 pushpins	A. First, let's talk about how weather is different from climate. This is a sequence of images of real-time *weather* for the past month. These are images created using an infrared instrument on a GOES satellite. When we look at things in infrared we are able to detect their temperature. Clouds are much colder than the land, so we are able to detect the presence of clouds. The tallest, coldest clouds, which are higher up in the atmosphere appear in teal and purple, whereas the white and grey clouds are low, closer to the Earth and warmer. You can also see the direction the air moves or the atmospheric circulation around the globe. Can you point out any specific examples of the direction of air movement? Like here… or here? B. There are what we call wind belts in the atmosphere. Generally we can see that the air moves west to east like they do where we live or east to west like near the equator, the direction of the wind we call the prevailing wind. We can also pick out local weather by clouds that rotate. When	A. *Allow discussion of circular motion and notice of westerly vs. easterly flow, a foreshadowing moment.* *B. User a laser pointer to highlight westerly and easterly belts as well as low pressure systems.*

	you see clouds rotating in a counter-clockwise direction in the northern hemisphere you can bet there is likely stormy weather there. I see the weather is different today in our 6 locations, some are cloudy maybe even rainy, and others are dry and clear. C. Weather and climate are different. I like to say that climate is what determines which clothes you buy and weather determines which clothes you actually wear each day. For example, climate might tell us that the average high for January in Denver is 43 degrees but some days might be 60 and sunny and other days might be 15 and clear, then snowy, cloudy the next. In other words, climate is what you expect; weather is what you get.	
Real-Time Land Surface Temperature With 1-6 pushpins Overlay lat/long	A. So, let's start predicting what climate we can expect at these special exotic destinations. Our first ingredient to climate is latitude. Latitude plays a VERY important role in climate for a couple of different reasons. Not the least of which, latitude clues us in to how much direct sunlight a location gets on any given day and what its seasons might look like, this is because the Earth is tilted at 23.5 degrees. For instance, when looking at this animation we see the temperature on the land throughout the year. Blue is cold and orange is hot. During December when the Southern Hemisphere is pointed towards me, if I'm the sun, the tropic of Capricorn is receiving direct sunlight and therefore the southern hemisphere is warmer. When we look at the Northern Hemisphere we see that it's much colder as it's pointed away and experiences winter. The opposite is true during June. When the sun is directly over the Tropic of Cancer, the northern hemisphere receives more sunlight and therefore experiences summer. Now, in between 23.5 degrees north and south, what kind of temperature change do you see throughout the year? B. Now, record what seasons the location you picked has. Either it has limited seasons in the tropics or it experiences summer in June like the Northern Hemisphere or experiences summer in December like the Southern Hemisphere. Please circle one as it relates to your location.	*A. Overlay lat/long coordinates in white and rotate around to compare the latitudes of the 1-6.* *B. Pause during northern hemisphere summer & compare. Pause during northern hemisphere winter & compare.* ***On paper #2 circle: Northern Hemisphere, Southern Hemisphere or Tropical seasons.***
Latitude Longitude Layers	A. Next we want to decide how latitude determines whether your climate is mostly cold, seasonal or mostly hot. If your location is above 60 degrees north or south, it is Polar, remember those places were mostly blue in the last	A. *Tilt the earth so that each of the approximate latitudes can be assessed.* ***On paper #3***

With 1-6 pushpins	dataset, which means they are pretty cold all year. If your location is between 30 and 60 degrees north or south, it's considered to be in the mid-latitudes; these places in the last dataset went from blue and cold in the winter to orange and hot in the summer. You get 4 distinct seasons in the mid-latitudes. If this relates to you circle mid-latitudes. Lastly, if your location is between the equator and 30 degrees its in the tropics or subtropics. Do you remember what they looked like in the temperature dataset? These places tend to be warm all year round and have fewer seasonal changes. Circle Tropical and sub-tropical.	***circle: Polar, Mid-latitude or Tropical/Sub-tropical***
Topo w Black Ocean Mask With 1-6 pushpins Rain Shadow layer General Circulation Overlay	A. Next we're going to talk about another ingredient to regional climate, elevation. As you might remember, the higher you go up in the first layer of the atmosphere, the colder it gets. That's why we all head to the high-country of the Rockies in the summer. It stays pretty cool up there even in the summer. Weather can also be more extreme at high elevations, with more wind and rain or snow. You should be able to tell by the color & texture of this map where the high elevations are. We are going to generalize a bit. You have three choices: High, Medium, or Low. High places will pretty much always be colder than medium or low places. **B.** Mountains can also cause differences in rainfall. There are two sides to a mountain. The leeward and windward. Windward is the side upwind leeward is downwind. When you combine the prevailing wind with a mountain range you can get vastly different climates on the either side. On the windward side of the mountain, you can get very lush vegetation due to abundant precipitation, because the air rises to get over the mountain, causing the air to cool, form clouds and precipitate. On the leeward side you will often see a desert because the air has lost its moisture on the windward side. **C.** So let's add the prevailing wind directions to this topographical map and see if we can detect any places where we might see a rain shadow. You may remember from the weather dataset that wind and weather move in different directions. Who here circled High for the last question? Great, let's look at #4. The wind appears to be moving to the west. If there is in fact a rain shadow effect,	A. **On paper #4 circle: High, medium or low elevation** B. *Turn on the rain shadow effect layer and explain.* *C. Turn on the General Circulation overlay*

	which there probably is given that this is the tallest mountain range in the world, then which side of the Himalayas would we likely see lush, green vegetation? Left or right? Does anyone else suspect a rain shadow effect?	
Earth with Vegetation With 1-6 pushpins	**A.** On the leeward side of the Himalayas we can distinctly see an arid or dry climate as it looks yellow and not green there we can see the same effect in the U.S. with the Rocky Mountains and Sierra Nevadas. When the wind moves oppositely, like the western side of Madagascar, we see a rain shadow on the opposite side. If your location is in a rain shadow, circle it. If not, circle no.	*A. Overlay General Circulation and look at each location for windward/leeward, large mountains or brown vegetation as clues.* ***On paper #5 circle: In a Rain Shadow or not.***
Annual Precip With 1-6 pushpins	A. As long as we are on the subject of rainfall, let's look at a map that shows the global annual average of precipitation. Many factors affect the amount of rain a location gets, like the rain shadow effect, latitude and proximity to water but for now let's just look at the results. Brown and yellow are arid or drier places whereas green have average precip while blue are wet. According to this map and the color bar legend, estimate whether your location is wet, dry or average. Average would be around the middle of the color bar (green) or 1500 mm. Please circle wet, dry or average.	*A. Allow time to determine the rainfall at each location 1-6. Give examples if necessary.* ***On paper #6 circle: wet, dry or average.***
Sea Surface Currents with grey land With 1-6 pushpins	A. This dataset highlights the next ingredient: Sea surface currents. What you're seeing here is one of the Earth's grand mechanisms for heat transport – currents on the surface of the ocean. They take water from the equator (where there is an abundance heat) and move it towards the poles (where there is a shortage of heat). These currents are driven by wind and the rotation of the Earth. Without them, the Earth would have a lot more ice and fewer places for people to live. All places around the world, whether inland or coastal are affected by the ocean. Now let's see how proximity to the ocean affects land temperature.	*A. Tilt the earth and point out the North Atlantic.*
GLAPS day/night temp comparison With 1-6	A. The closer you are to the ocean, the more it regulates your climate. We call this ingredient: Proximity to water. This dataset is a model of temperature for June 10th, 2013. We are comparing daytime to nighttime temperatures. B. Do you see a difference between coastal and continental	*B. Don't push play, just toggle the two frames*

pushpins	places when comparing day to night temps? There is a pretty good example in Australia at #6. Look closely at the color bar. Talk with the person next to you about what you see. C. If you have #4, we don't see what we would expect to see. This probably means that the extreme elevation in #4 that makes it pretty cold whether day or night. Skip this question if you have #4. D. Water has a high heat capacity, which means it takes a lot of energy to warm it up and to cool it down. Therefore, places near the ocean tend to have milder climates – less of a day and night temperature difference – the highs and lows for the day aren't far apart, whereas places far inland tend to have more extreme climates - larger difference between day and night temperature – meaning the highs and lows are further apart. Circle coastal - less temp difference or continental- large temp difference.	*slowly between day and night, pointing out the drastic color changes of continental regions and allow a pair-share discussion happen.* D. **On paper #8 circle: less temp difference or large temp difference**
NASA Sea Surface Temperature With Ocean Currents Overlay With 1-6 pushpins	A. Lastly, let's put together proximity to water and sea surface currents. This is a model of sea surface temperature, which shows us where the water is warm in red and cold in blue. When we look closely, we can see where there are warm or cold currents just by looking at the temperature of the ocean near the coasts. There's a general rule of thumb for currents. They tend to be warmer on the east coasts of all continents and colder on the west coasts. B. For example, you can see this is true of the east and west coast of the U.S. I bet you thought summertime surfing in California was warmer than surfing in New Jersey but that's not the case! If we look at South America, we see the same phenomenon. C. If your location is in fact coastal, it could be slightly warmer or cooler depending on the current that runs near it. So let's identify the current that affects your coastal community. If there is an ocean current near your location then please circle warm or cold and write the name of it. If your location is continental, then you can skip this step. If you have #1, the current is cold and is called the Alaskan Coastal Current.	*A. Tilt the sphere to show both Japan and the west coast of the U.S. and pause during the summer (when the red moves furthest north).* *B. Rotate the sphere to compare east and west coasts of the U.S. at the same time and rotate up to show South America.* *C. Turn on the Ocean Currents overlay. Point out the names of the currents and the color of the arrow**. On paper #9: Write the name and circle warm or cold.***
Global Vegetation	A. Finally, let's bring a little life into this discussion to conclude our investigation of exotic locations. As you know, climate determines life and vegetation of a region.	*A. Let the dataset play in the background while you pass around sets of*

With 1-6 pushpins		What we see here is the global vegetation on the Earth throughout the year. If you grew up in Colorado, you may desire to live somewhere tropical. And what makes a place tropical is plentiful rain and sunshine. In your small group, please look at these pictures and choose which one is your location, write down the Biome or the life zone it falls in, on your worksheet. It should be fairly obvious, but fun nonetheless! I will tell you the name of your place after.	*the location pictures of 1-6.* ***On paper #10: Write biome of their location*** *as well as discuss which picture is which location with their group.*

To Conclude: Today we have investigated the climate of 6 exotic locations by looking at the ingredients of regional climate. Can you remember one of those ingredients? Latitude, prevailing wind, proximity to water, elevation, and ocean currents. One group at a time, tell me which number you had and which picture you think is your location and why. (Announce the location name at the end of each share).

1 (Tundra) is Barrow, AK

2 (Tropical Forest) is Port Spain, Trinidad

3 (Savanna) is Brasilia, Brazil

4 (Mountains – mixed vegetation) is Lhasa, Tibet, China

5 (Temperate Forest) is Nagasaki, Japan

6 (Desert) is Alice Springs, Australia

In Class Assessment: The students write a paragraph about their location's climate. Read them the example or have the teacher read it to them and help them finish their paragraph in class. **Also recommended for post-SOS regional climate: Wind, Water & Mountains: Ingredients of Regional Climate stations activity.**

Example Paragraph: Boulder, Colorado is in the northern hemisphere, which means it has winter in December and summer in June. It is in the mid- latitudes, which means it has 4 seasons. Boulder is in a rain shadow as it falls on the leeward side of the Rocky Mountains. Boulder receives less than average annual precipitation. Boulder is continental and not near the ocean; therefore, its day/night temperature differences are more than that of the places that are coastal. Boulder is much higher than sea level so it's colder than places lower in elevation at the same latitude. Boulder falls in the mountains and temperate grasslands biome.