**RISING WATERS**

**Segment A: Conditions for Precipitation**

***A-1 SOS Visual: Blue Marble with Clouds***

Have you ever wondered what the right conditions are for rain? Let’s explore that question by taking a look at the earth.

This is the view we would have if we were astronauts out in space.  These are the true colors of the earth – white clouds, tan and green continents, and dark blue waters. The oceans cover about seventy percent of the world and are the source of precipitation.  The atmosphere, land, and oceans form a global climate system.  We feel that climate system locally in the form of weather.

But what drives the weather?  What makes it do what it does?

***A-2 SOS Visual: NASA Sea Surface Temperatures***

This picture shows the temperature of the sea surface. The red colors show the warmest water in the tropics and the blue shown at the poles are the coldest places. You can see that the earth is unevenly heated.  The uneven heating plus the rotation of the earth sets the wind and sea currents in motion. In fact, uneven heating is the fundamental cause of all weather.

Weather affects us every day.  What we decide to wear, the activities we choose, and how we travel to those activities is all determined in part by the weather. Weather is what happens in the short term, over the next several days.  Today it might be sunny, and tomorrow it might rain.

Meteorologists use many pieces of data to observe and predict the weather. Let’s look at one of those, something called total precipitable water, as measured over the last year.

***A-3 SOS Visual: Real-time Total Precipitable Water***

Total precipitable water represents the moisture in the air.  Essentially, this is how much water the atmosphere holds that could turn into rain if conditions are right.  Focus on the green color which is where the total precipitable water is greatest or where the air is wettest.

Warm air can hold more moisture than cold air.  So the green areas, where the air is wettest, are located around the equator, where it's hot and the oceans are warm and plentiful. Here, high levels of evaporation mean the hot air accumulates high amounts of moisture.

This is *also* why it rains a lot in the rain forest.  It's warm there.  At the poles, the air is generally too cold to hold enough moisture for it to rain or snow much.  For example, Antarctica is one of the driest places in the world. The snow and ice that has accumulated there over hundreds of thousands of years just doesn't melt.

***A-4 SOS Visual: Real-time Infrared Satellite Over Land***

Another way meteorologists look at weather patterns is by studying infrared satellite images of cloud cover. This is a picture of cloud cover over the last month. The lowest clouds are a very light gray and the highest clouds are bright white.

The bright white clouds that look most like cotton balls are high Cumulonimbus clouds, or thunderstorms.  They're associated with the most severe weather.  Notice that you see many of these clouds around the equator.  That's because it’s warm there, so the wet atmosphere produces more rain.

There are some exceptions to this. Deserts for example often have warm air. The dry conditions in these areas however are because of their unique geographic location, where weather patterns and the flow of moisture are hampered.

***A-5 SOS Visual: Blue Marble without Clouds***

Let’s take another look at the earth, this time without clouds. Look at where the green areas are on the continents. These are the places with the most trees and vegetation, where rainfall is plentiful enough to keep the vegetation alive. You might notice that these areas are the same places where we saw the most total precipitable water and cumulonimbus clouds.

We’ve seen in this segment that infrared satellite images and total precipitable water data are two of the tools meteorologists use to predict rainfall. And that warmer air is an important factor for making the right conditions for rain.

**RISING WATERS**

**Segment B: Current and Future Precipitation Trends**

***B-1 SOS Visual: Blue Marble without Clouds***

Most people talk about the weather, a lot. We watch the weather to see if we need an umbrella or to figure out what to wear from day to day. But did you know there’s a difference between weather and climate? Climate is the synthesis of all weather events on record. Records of climate over time show patterns. Virtually all climate scientists agree that the planet is warming based on temperature data from the atmosphere, ground, and oceans, combined with evidence of melting ice and rising sea levels.

A warmer atmosphere will likely mean more extreme weather. Scientist are predicting that the wetter places will be wetter and the drier places drier. Look at the places on the continents where we see green. These are areas where there is enough water for a lot of vegetation. In other words, these are the wet places where we can expect more precipitation and perhaps more flooding.

***B-2 SOS Visual: IPCC Temperature Anomaly (computer model)***

This computer model looks at temperature change from the year 1870 through 2100. The temperatures you'll see are all compared to temperatures in 2000. Blue tones represent temperatures cooler than those in 2000, while yellow and red tones represent temperatures warmer than those in 2000.  The model will run a few times so you have a chance to take it in.

Every computer model is tested, in part, by how well the model predicts what has already happened or what is already known. If it predicts the past well, then we have confidence that it might also predict what will happen in the future.

According to this computer model, whose predictions fall somewhere in the middle of other models, global mean warming is predicted to reach about 5 degrees Fahrenheit above present levels by 2100.  Warming in North America alone is predicted to reach almost 9 degrees Fahrenheit higher.  Notice that the continents warm more than the oceans. This is because it takes longer to heat water than land.  It also takes water longer to cool down.  The coastlines are slower to heat than the interiors of the continents because they are buffered somewhat by their proximity to the ocean.

Warm air is capable of holding more moisture than cold air. So, higher temperatures allow for more rain producing moisture to enter the atmosphere. This is because, as the world’s oceans heat up - even a little, the water molecules near the sea surface become more energetic and tend to evaporate into the atmosphere more readily.  Thus, the air gains water vapor, or clouds.  The effect gets stronger for each additional degree of warming.  At the same time, higher temperatures evaporate water out of the parched terrain where it hasn’t been raining.  So, the net effect for the future is that, in general, the wet places will be wetter and the dry places drier.

***B-3 SOS Visual: Shots of the ocean and shore with people and shoreline structures***

Another way in which we expect wetter conditions is along our coastlines due to sea level rise.Sea level can rise in two different ways with respect to climate change. The first is the expansion of the sea water as the oceans warm due to an increasing global temperature. Things expand when they are heated, like the expansion of a wooden door in the summer causes the door to stick.

The second way that sea level is expected to rise is due to the melting of land-based glaciers which then adds water to the ocean.

What does a rise in sea level mean to us?

***B-4 SOS Visual: Sea Level Rise***

Sea level has been rising throughout the 20th century at a rate of about 1.5 to 2 mm per year as measured by long term records.  In the 21st century, sea level rise is already 3 mm per year. For your reference, a dime is roughly the thickness of a millimeter.

Climate scientists agree that sea level is projected to rise at an even greater rate in this century.

This picture shows the sea level rising by 1 meter or about 3 feet above current sea level by 2100, so it’s close to what most scientists are currently projecting. The land that would be covered by water is first shaded black, then red to show the decrease in land as the waters rise.

So we’ve seen in this segment that scientists are predicting a warmer climate that could create wetter conditions in certain parts of the world in two different ways: through increased rainfall intensity and through rising sea level.

**RISING WATERS**

**Segment C: The Impact of Flooding on People**

***C-1 SOS Visual: Blue Marble without Clouds***

Did you know that flooding is the world’s most common, costly, and deadly natural disaster? More people will become vulnerable to the impact of flooding because of an increase in both the frequency of flooding in some areas and population growth. Currently, there are places where people are already facing more evacuations, road closures, damage to houses and businesses, or worse.

A warmer climate is predicted to create wetter conditions in two different ways: through increased rainfall intensity in some places and through rising sea level.  We're going to look at how this might affect people.

***C-2 SOS Visual: Surface of Earth and Nighttime Lights***

Here, you are seeing the earth at night, as if the whole earth were dark at one time.  Areas of high population and economic development are generally covered with white lights. The difference in population between the eastern and the western parts of the United States is clearly visible.

Areas along coastlines and major waterways tend to be well populated. Early industry settled along rivers.  Communities formed and grew around that industry and along those same rivers.

There are about 7 billion people living on Earth and that population is roughly visible here.  Current projections show that the population is expected to reach around 9 billion in the year 2050.  So, there will be many more people along the coastlines and rivers and more white lights around cities in the future, exposing more people to the risks of flooding.  Let's take a look at where flooding has happened globally over one decade.

***C-3 SOS Visual: Global Flooding (overlay on earth at night)***

All of the bright orange dots represent places that have experienced major flooding from 2000-2009.  Each of these dots represents a large flood that has caused significant damage or fatalities.

The flood areas are overlaid on the lights at night, to give a sense of how people have been affected.  Flooding affects people who live, work and travel near waterways.

When it comes to floods, the character of the precipitation is what counts.  How often is rain concentrated in short, intense bursts that produce flash floods, or in multi-day torrents that can cause much more severe flooding over entire regions?  Or is the rain falling and snow melting in more gentle, non-destructive ways?  Heavy rain is the most common cause of flooding but there are other causes such as snow melt, ice jams, and tidal surges to name a few.

Over the last century, data indicates more intense rain events have occurred and models predict that this trend will continue.  As our population increases, more people will be vulnerable to the impacts of flooding.

***C-4 SOS Visual: Shots of life along waterways and shorelines / Shots of flooding***

People have lived along waterways since the very beginning and it's safe to assume that we'll continue to do so.  If, as the data suggests, global flooding will increase in the future, then what can we do to support human resiliency in the face of flooding?  Increased awareness about the risks of flooding and preparation can help any community that experiences flooding. This might include preserving floodplains, monitoring river levels and alerting others, and preparing and following an emergency plan and evacuation instructions. If the past is any indication of the future, then it's our collective imagination and capacity for innovation and action that makes us resilient.