Milestones in Meteorology

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This Science On a Sphere® script was written with a target audience of families with middle school- through junior high school-aged children in mind. If you need to appeal to a younger group, you may wish to modify questions to make them more targeted and make explanations less technical. 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 Laboratory, 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. This is a beautiful image of our planet from space, called the Blue Marble. It was created by NASA from lots and lots of different satellite images. It took four months to compile the Blue Marble imagery, because the images of the land and ocean could only be used when there were no clouds around. Then, afterward, the clouds were added on top. C. Even though this is a still image of Earth, we know that our planet is an ever-changing, complex place. This can at times be frustrating, because we humans, we like control, don't we? Take the weather, 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.*

instance. How many of you have ever been frustrated with the weather? *(pause for any audience reaction/response)* Wouldn't it be great if we could control it? No blistering heat waves, no rain on the 4th of July parade, snow on Christmas. . . we wish!

D. So, since we can't really *control* the weather, what's the next best thing? Predicting it—then at least we know what's coming! Meteorology, the science of weather forecasting, dates all the way back to ancient Greece when the Greek philosopher, Aristotle, wrote a book called *Meteorology,* which included his theories on the water cycle and certain weather phenomena. *(**__Note for the presenter__: Aristotle's use of the term "meteorology" does not hold the same meaning that we give it today, but rather was meant as the study of general earth science.**)*

E. Obviously, we have come a *long* way since Aristotle. Instead of a few weather theorists living here and there, trained meteorologists are now employed at weather bureaus around the world. In the U.S.A., for example, we have the National Weather Service, which is a part of NOAA. The National Weather Service (NWS) is an organized network of meteorologists dedicated to forecasting the weather and issuing warnings to better protect us and our economy. ***__(**Note for the international presenter:__*** *feel free to substitute your national weather agency in lieu of the NWS/NOAA, if desired.**)* The practice of forecasting is still far from perfect, but accuracy is increasing every day thanks to improvements in knowledge and technology. The past forty years in particular have been a time of major milestones in the field of meteorology. Today we're going to take a journey through those years to discover how the practice of meteorology evolved as new tools were developed. We may even pick up some of our own forecasting skills!

	F. So, let's all go back forty years. It's 1972: Richard Nixon is President, bell-bottomed pants are in fashion, and gas is only 36 cents a gallon! A few years later, in the mid-1970s, we are witness to our first major milestone in weather forecasting . . .any guesses as to what this milestone might be? Maybe some of the adults here today can recall what I'm talking about? It's the same technology that created this Blue Marble imagery. . . *(satellites)* Right! In 1975 the first Geostationary Operational Environmental Satellites, GOES, were launched . . .and just look how many (*about 400*) we have orbiting the Earth now. . .	
2. All Satellites	A. All of these satellites are used to give meteorologists important weather information. There are two main types of satellites found in this picture: polar-orbiting and geostationary. Who can tell me which kind this is? *(geostationary)* Exactly! *Geostationary* satellites are easy to pick out because they appear still, hovering above the same point on Earth. In order for them to do this, they must move 6 - 7 times faster than the Earth rotates since they are high above the Earth with a big orbital path. The NOAA GOES satellites orbit 22,300 miles above Earth. To the scale of SOS, if you were a geostationary satellite you would be standing about 18 feet away from the sphere's surface. B. The GOES satellites are very handy because they give meteorologists continuous footage of the same spot all day, every day. However, since the GOES satellites are so far from Earth's surface, they can't give us very high resolution images. In other words, if we zoom in very much on a GOES image, it gets pretty blurry. They also, unfortunately, cannot see the poles. But that's why we have POES—polar-orbiting satellites. These satellites do exactly what their name says: they orbit	A. ***Draw** a circle around a geostationary satellite.* B. *Tilt the sphere to show the poles and the POES satellites that are orbiting around them.*

	around the north and south poles. Because they are always moving, polar-orbiting satellites can't give us continuous footage of the same spot, but they *do* give us a view of the poles. POES images are also much higher resolution since they are only 450 miles above Earth's surface. Combining the GOES and POES images gives forecasters a powerful view of the sky.	
3. Enhanced IR Satellite (Real Time)	A. Here is one such view. We are looking at infrared satellite imagery: something all meteorologists depend on. This display takes data mainly from GOES satellites, but uses POES data over the poles, which is why the poles are a little patchy. Satellites sense the amount of infrared radiation—heat—that objects on and above Earth are giving off. It is easy for the satellite to pick out the clouds in the air since they are so much colder than the ground. Then, the clouds are enhanced with color based on their temperature: white meaning cold, purple meaning colder (usually about -50°C/-58°F), and teal meaning coldest (usually about -60°C/-76°F). Since the temperature of a cloud is directly related to its height, the teal clouds are the tallest clouds. Tall clouds often produce severe weather. B. When forecasting, meteorologists use infrared satellite imagery like this to see if clouds are coming their way. They can tell which direction the clouds are moving by looking at the winds high in the atmosphere, which you can see here. C. So, let's start the animation over again and try our hand at forecasting. Here is a good patch of high, stormy clouds. Where do you think these clouds are headed?	A. *Briefly tilt the sphere to show the patchiness of the poles.* A. *Use the **Pointer** (via **Annotate**) to point out clouds of different colors/heights as you mention them.* B. *Move your cursor parallel to the upper-level flow to illustrate the winds.* C. *Restart the dataset; pause it when you see a large area of clouds develop and move the **Pointer** or **draw** (via **Annotate**) around the clouds.*

		You may wish to draw an arrow representing the wind direction to help the audience determine where the clouds will go.
4. GLAPS Radar Reflectivity (dBz)	A. Let's return to our timeline. The 1970s brought along another big development in meteorology: an organized network of weather radars. We see weather radar images all the time when we watch the TV forecast. Weather radar is an essential tool for forecasting which, unlike satellite, is ground-based. B. Radar was around before the 1970s, but initially it was invented and used for military purposes. During WWII, army scientists noticed that the radars they were using could also detect rain and snow. After the war, research on using radar for meteorological purposes began, and a solid network of weather radars was finally established around the same time that weather satellites made their debut. C. This is a map of U.S. radar reflectivity (radar echoes) in real time. Radars work by sending out pulses of radio waves. When these waves run into something in the air—usually a form of precipitation such as rain, sleet, or snow—they are scattered back to the radar. The backscattered waves—or echoes—can tell meteorologists how far away the precipitation is from the radar, and if the precipitation is heavy or light. Then, the radar image that we see here and so often on the news, is created. It shows the area of precipitation and it is color-coded based on the intensity of the rain, sleet, snow etc. Green echoes usually signify light precipitation, yellow moderate, and red intense. The shape of the radar image	A. *Pause the dataset once it loads (or have the animation set to 0) so that you can give your explanation without the audience being distracted by the animation.* C. *Resume play of the dataset.* C. *As you describe the meaning of the color code, pause the dataset when a good radar echo example appears.* ***Zoom*** *into the radar echo to better show the colors. Resume play after a few seconds.*

	is also important to meteorologists, because it can tell them what kind of storm it is, which way the storm is moving, and if tornadoes are likely. D. *(**__Note for the presenter__: have a section of the dataset which displays a good variety of radar echo intensities preselected before announcing the radar activity. **)* Now you are going to be the meteorologist. Can you see any precipitation on this map? Is that an area of light, moderate, or intense precipitation (or a mix of intensities)? Do you think this type of rain intensity is associated with strong thunderstorms?	D. *Pause the dataset at the beginning of your preselected section. **Zoom** into the various radar echoes present on the dataset as you ask the audience to decide on the levels of intensity.*
5. Hurricane Isaac Radar over Satellite 8/20 - 9/3/12	A. When we combine both satellite and radar data, we can really see the connection between clouds and rainfall. Meteorologists often layer satellite images with radar for that reason. As you can see, the most intense rainfall is occurring under the brightest, tallest clouds, the clouds that were teal-colored in the enhanced infrared satellite image we saw earlier. B. So, with the development of satellites and weather radars, the 1970s was a pretty exciting time for meteorologists. But forecasting is about more than simply whether or not it is going to rain. When we get dressed in the morning, what do we want to know when deciding between pants and shorts, t-shirt or sweater? *(the temperature)* Right! Forecasters also predict the high and low temperatures we can expect to feel during the day. Moving forward in time about twenty years to the late 1990s, another milestone occurred that has since made temperature forecasts increasingly precise: automated weather stations (called Automated Surface Observing System—ASOS—by the NWS).	A. *This clip is pre-programmed for layering. You may wish to slow the animation speed prior to your presentation if you feel it is too fast.* A. *Move your **Pointer/draw** (via **Annotate**) around the areas of heaviest rainfall and brightest clouds.*
6. GLAPS SFC	A. This image is a compilation of surface wind	A. *Use the **Pointer** (via*

Temp (F) and Wind (kt)	and temperature measurements reported from automated weather stations. It is color-coded for temperature, with green being cooler temperatures and red being hotter temperatures. These shifting line segments are called wind barbs. They are pointing in the direction the air is moving; the little lines sticking out from the end of the wind barb indicate wind speed—more lines means higher speed. B. Automated weather stations are so helpful to weather forecasters because they operate by themselves day or night, rain or shine, taking scheduled measurements of air temperature, humidity, wind speed and direction, visibility, and more. Before the nationwide implementation of automated weather stations by the NWS in the late 1990s, the newbie at the weather office would have to go outside and take all those measurements by hand, which took a lot longer and was less accurate. C. Meteorologists use maps like this to see how warm and cold air at the surface are moving due to the winds, which can influence the next day's temperatures. Winds from the south bring up the warmer tropical air, while winds from the north bring down the colder polar air. D. Now we are going to make our own temperature forecast using this map! *(**__Note for the presenter__: have a location and corresponding 24-hr section of the dataset preselected before announcing the temperature forecasting activity. **)* Let's say we are forecasting for <u>(your preselected location)</u> Watch the area around <u>(your preselected location)</u> closely. . . which way are the winds pointing, for the most part? So, looking at this pattern of winds, are you going to forecast warmer or colder than average temperatures for the next day?	***Annotate**) to point out a wind barb(s) as you mention them. You may also wish to **zoom** into the wind barb to show detail.* C. ***Draw** arrows pointing north to represent winds bringing up tropical air; **draw** arrows pointing south to represent winds bringing down polar air.* D. *Pause the dataset at the beginning of your preselected section once you announce the temperature forecasting activity.* D. ***Place a map marker icon** () over the location where you want your*

	(***<u>Note for the presenter</u>*: *If the audience is having trouble, remind them that southerly winds bring warm air from the south, northerly winds bring cold air from the north.)* Great job, I think we have some budding meteorologists in here! So, at this point on our journey through forecasting history, meteorologists had radar, satellite, and automated weather station reports, all of which helped immensely to improve forecasts. But as forecasts covering the next few days became more accurate, people became more curious. . . they wanted to know what the weather would be like for the next week, and even the next month! Unfortunately, radar, satellite, and automated weather station reports aren't as helpful for long-term forecasts. So, as we follow our timeline into the 21st century, what's next for meteorology?. . .	*audience to forecast the temperature*. D. *Once you tell the audience to watch the area closely, slowly flip through the first few frames in your subsection. This will help the audience determine wind direction.* D. *To give a hint to the correct answer,* ***draw*** *an arrow in the general direction of the winds around your selected location.* D. *Once the correct answer is given, pause the animation at the last frame of your section and use the* ***Pointer*** *(via* ***Annotate****) to emphasize the resulting temperatures (hotter if warm air was blown in or cooler if cold air was blown in).*
7. GFS Model—6- hour precipitation and MSLP	A. . . . computer weather models, like this one here! Use of computer models for everyday weather prediction only really became possible in the early 2000s because of significant improvements in computing power. Before that, the calculations would have taken so long that by the time the model gave a forecast, the day it was forecasting for would already have been over! B. At the core of any computer weather model is a series of numerical equations. The *current*	A. *Pause the dataset once it loads (or set the animation to 0 beforehand) so the animation does not distract from your explanation of computer weather modeling.*

	weather conditions are entered into the equations, calculations are made by the computer, and the *forecasted* weather is outputted.	
	C. This model is the Global Forecast System model, or GFS. The GFS can be programmed to forecast for several different atmospheric phenomena; here it is predicting rainfall amounts and the movement of atmospheric pressure systems 186 hours (7.75 days) into the future. Areas of predicted rainfall are colored, with green signifying the least amount of rainfall, red the most. The black lines are lines of constant atmospheric pressure, showing meteorologists where high- and low-pressure systems are predicted to move. You probably have heard the TV weatherperson talk about high-pressure and low-pressure systems before. High-pressure systems, like this one, are associated with sinking air and fair weather; winds around high-pressure systems circulate clockwise (in the Northern Hemisphere). Low- pressure systems, such as this one, are associated with rising air, which usually leads to clouds and rainfall; winds around low-pressure systems circulate counter-clockwise (in the Northern Hemisphere). By looking at the GFS and other weather models, meteorologists can get a pretty good idea of what weather conditions are coming their way. Models can also alert meteorologists to potential severe weather threats, such as tornadic thunderstorms and hurricanes. Meteorologists respond by watching threatened areas more closely, improving forecasts and warnings.	C. *Resume play as you announce the dataset.* C. *Pause the dataset as you explain what low- and high-pressure systems are.* ***Place an* H *icon*** *in the center of a high-pressure system and* ***an* L *icon*** *in the center of a low-pressure system. (Pick a low-pressure system that has a noticeable area of rainfall associated with it.)*
	D. Let's try out the model ourselves. *(*****<u>Note for the presenter</u>****: have a location preselected before beginning this activity. **)* This time let's say we live in *<u>(your preselected location)</u>* and want to see what weather the GFS model is predicting a week from now. Watch the *<u>(your</u>*	D. *Clear any* **H** *or* **L** *icons you placed and restart the dataset.* D. ***Place a map marker icon*** ( )

	preselected location) area closely. Here are the day seven predictions. . . does it look like rain/low pressure or sunshine/high pressure?	*over the location you have selected for the model forecast activity.* D. *Pause the dataset when it reaches hour 186 (the last frame) so that the audience can determine the GFS predictions for the location you have selected (you may wish to **zoom** into the location to show detail).*
8. Facebook with Status Layer	A. Now, what in the world is this? This, ladies and gentlemen, is the world according to Facebook friendships. And what in the world does Facebook have to do with weather forecasting? Well, jumping to current day on our journey through time we find that social media is the newest advancement in weather forecasting. B. No, I am not off my rocker, I can explain. Yes, meteorologists today have a lot of tools at their fingertips: radar, satellite, automated weather reports, computer models. . . but nothing can replace real, *human* observations. Sure, satellite images can show us the location and height of clouds, but we really can't know for sure what is going on underneath them. And radar usually works pretty well, but sometimes it can't tell the difference between rain, fog, or even a tall building. C. Meteorologists obviously don't have eyes everywhere and sometimes need a better idea of what is *really* going on around them. Solution: social media sites like Facebook, where people often post statuses and even pictures about the weather they are seeing. Often, social media sites turn into an	

	unofficial weather observation network composed of hundreds of people! Never before have forecasters had so many up-to-the-minute *human* weather observations, providing more detailed and localized information than any computer could. And thanks to Facebook, meteorologists and the NWS can also reach a larger share of the public with important weather information. You can imagine how valuable this social media relationship is during severe weather outbreaks. D. If you still don't believe me, I'll show you! Take a look at some of these real-life examples of weather-related Facebook posts from around the world. E. The benefits of Facebook aren't equally shared though; which countries do you notice are missing out? *(China, much of Africa, Russia etc.)*	D. *Turn on the Facebook Status PIP layer. Rotate the sphere slowly as you describe the posts from around the world.* E. *Use the **Pointer** (via **Annotate**) to point out the countries that are missing from the map as the audience calls them out.*
9. Blue Marble and Nightlights	As you can see, the Earth is an incredible but complex place to live. Weather is a part of the Earth system, and throughout human civilization it has perplexed and frustrated many. Now, however, thanks to improvements in technology, we are better able to understand how the weather works. As we discovered in our journey through time, incredible strides have been made in the field of meteorology over the past forty years, including the development of organized radar and satellite networks, implementation of automated weather stations, and introduction of computer weather models. Today, even Facebook is helping weather forecasters. All of these improvements have led to a safer society that is better prepared for whatever weather comes their way.	

	(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.	