How do we Predict Future Climate?

Climate is the average weather pattern in an area over a long time period. And Earth's climate is changing rapidly, impacting life around the world. Changes in precipitation patterns are expected to cause some regions to have increased droughts, and others increased flooding. These changes could alter freshwater supplies, reduce crop yields and damage forests. They could also impact ecosystems, harming both humans and animals. It is necessary to understand and attempt to predict these changes, so we can be better prepared.

Drought may have impacts on agriculture. Credit: USDA

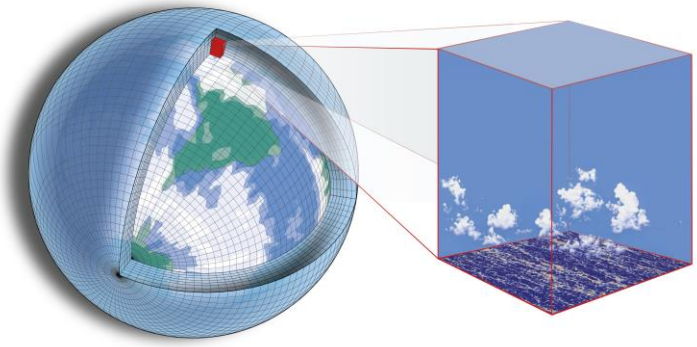
*Scientists use computer programs called **climate models** to understand how our planet is changing. **Climate modeling** is a way to predict the future and try to understand the impact of different choices we make on the planet.*

Why is NASA data important for climate models?

The best way for scientists to see the big picture of our planet's climate—as it's happening and where it's happening—is using Earth-observing satellites that provide a zoomed-out view of Earth, covering the oceans and lands.

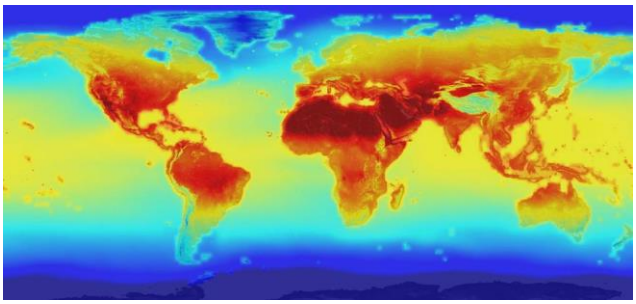
NASA is a leader in making space-based measurements of climate variables, including precipitation, water vapor, and temperature, over long periods of time. Long records of these variables develop and inform climate models.

Climate Models are computer programs that scientists use to understand how our planet is changing and predict future climate patterns. These computer programs are made up of a number of mathematical equations that describe the many physical and chemical relationships among Earth's systems including the land, atmosphere, ocean and ice.



Climate models divide the atmosphere into a 3-D grid. Each grid piece is represented by mathematical equations that describe the materials in it and the way energy moves through it. Credit: Schneider et al., Nature Climate Change

Models allow us to simulate experiments that we cannot do in the real world and help us understand how different factors can affect Earth's climate—like the impact of a volcanic eruption or a sudden change in the temperature of the oceans.



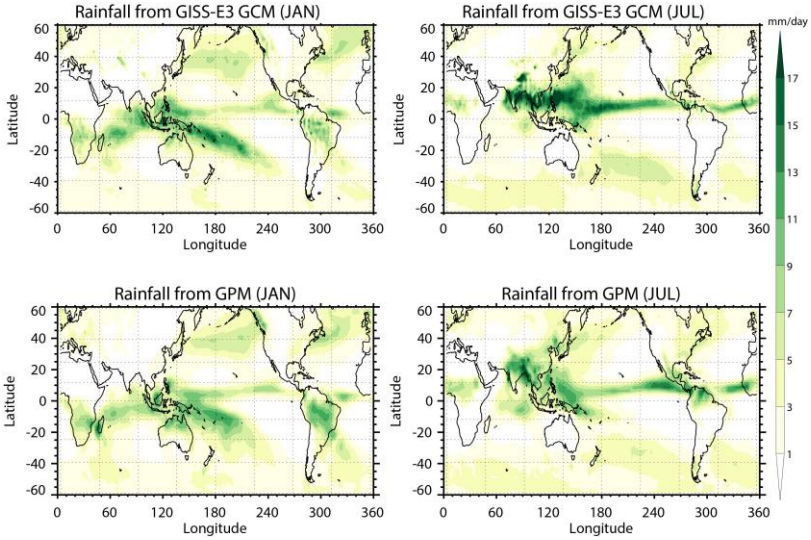
NASA climate forecast showing how global temperature might change up to year 2100 under different greenhouse gas emissions scenarios. Credit: NASA

In other words, climate models work like a laboratory within a computer. They allow scientists to test and study how different factors interact to influence a region's climate.

For example, say a scientist wants to know what would happen to Earth's climate if the oceans became hotter by 1 degree Celsius. Using a climate model, a scientist could simulate changing the ocean temperature within the computer program. The model would then calculate how a warmer ocean would interact with other Earth systems to cause large changes in Earth's climate, such as changes in worldwide rainfall patterns. Models can also show how small changes can have long-term effects. The model could help scientists understand how a small change in ocean temperature would affect Earth's climate 10, 100, or even 1,000 years from now.

How do we tell if a model is working correctly?

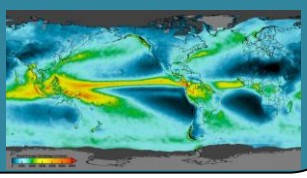
A climate model needs to capture Earth's systems, producing similar rainfall and wind patterns and ocean currents as what we observe from satellites and other instruments in real life. If a climate model cannot accurately produce Earth's systems such as rainfall patterns at present, then it is less likely that a climate model will be able to predict future changes in rainfall and its influence on other components such as soil moisture. Therefore, scientists "run" climate models in the past to check that their model can mimic what we observed in real life to make sure their model is working correctly in order to make predictions that are more reliable.



Rainfall from the NASA GISS-E3 climate model over January and July (top images) compared to observed rainfall from GPM (bottom images). Credit: Greg Elsaesser (NASA GISS)

How does the GPM mission help develop models?

The GPM mission provides over 20 years of precipitation data covering nearly the entire globe. Having a long precipitation record from GPM not only helps understand patterns and trends of precipitation globally but helps to advance our understanding of the water and energy cycles. Knowing how water and energy interact in the climate helps develop the equations that make up a model. Additionally, GPM data are used to check if a climate model can show similar precipitation patterns so that a model's predictions are more reliable.



Global precipitation from 2000-2019 observed by GPM.

Climate Models and Decision-making

There are a range of government and private organizations that use satellite observations and other instruments for climate modeling activities including NASA GMAO, NASA GISS, and NWS CPC— to name a few.

Models can be powerful tools to predict climate and help us to be better prepared, which can be useful in many industries including agriculture, energy, transportation, water resources, and health. They can help address questions and plan for the future, such as how to make our water resources more resilient, where to safely build homes, and which crops will grow best in a changing climate.

Learn more about NASA and Climate Models!

References and Resources:
- NASA Climate
- NASA GISS
- NOAA Climate
- NASA GMAO