TRANSCRIPT FROM NOAA/GFDL EDUCATIONAL VIDEO:

CLIMATE MODELING 101 SERIES

GRID RESOLUTION; HOW DETAILED IS THE CLIMATE MODEL PICTURE?

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ANNOUNCER [KF]: From NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, a video from our Climate Modeling 101 series.

The topic: Grid Resolution; How detailed is the climate model picture?

For more information on this and other climate research topics, check out our web site at W-W-W dot G-F-D-L dot N-O-A-A dot "gov".

NARRATOR [KD]: If you had a nice digital photograph but couldn't afford to show it in all its detail, and instead had to divide it up into a relatively small number of fairly large boxes, you wouldn't see much of the original photo's detail. The average brightness and color of the area covered by each of the large boxes may be the same as in the original, but there's just not much detail in this kind of low resolution image. It simply contains less information.

But if you could afford to divide the photo into, say, four times as many boxes, you'd begin to recover a little bit more of the information that was in the original photograph. And every time you could afford to add still more boxes - so that each box represents a smaller area – more of the original image's detail would emerge.

Higher spatial resolution - in other words having smaller boxes and more of them – allows for a more detailed representation of information. That's true for 2-dimensional photographs and videos, as well as for 3-dimensional global climate models.

Because climate modeling is so computationally expensive - with many, many calculations needing to be done for each grid box, over and over again as the model marches forward in time – because of that computational expense - the grid resolution used in a climate model is largely determined by the amount of available computer power.

Ever since the kind of global climate models we're considering here were first invented, some of the world's largest supercomputers have been used to run climate model computer programs. As computer technology has advanced, state-of-the-art supercomputers have become larger and faster, allowing climate models to move to higher spatial resolution.

For example, back in the 1980s, GFDL's global climate model divided the Earth's ocean surface into a grid having 40 rows going from the North Pole to the South Pole, with each row in turn being divided into 96 boxes to span the globe from east to west. That's what could be done pushing a supercomputer of that era to its limits.

In the 1990s, faster computers allowed the horizontal resolution to be improved. Four ocean grid boxes fit into each one of the previous generation model's grid boxes.

In 2004, GFDL's workhorse climate model resolution improved again. 360 boxes were used to circle the Equator. This represents the grid from the GFDL model that appeared in several, recent, high profile assessment reports – like the 2007 Intergovernmental Panel on Climate Change reports, and the reports published by the U.S. Climate Change Science Program.

And recently, we at NOAA's Geophysical Fluid Dynamics Lab have been excited that we've developed an even higher resolution global climate model. In this new model, there are now 1440 grid boxes used to circle the Equator. That's a long way from the 96 used in back the 1980s.

But it's hard to see grid boxes this small when looking at the globe, so let's zoom into a region that contains the Gulf of Mexico. We can compare the new model's ocean grid with the previous generation GFDL model - And the model from the 1990s - And the one from the 1980s.

Here we've illustrated improvements in spatial resolution by showing the ocean model's horizontal grid, but similar improvements in resolution have taken place in the atmosphere, sea ice, and land components of successive generations of the GFDL global climate model. And there is finer resolution in the vertical as well as horizontal directions.

Here we see a depiction of a section of the east coast of the United States, showing the grid of the 2004 GFDL climate model. In this model, the atmosphere is divided into 24 vertical layers. Not all layers are the same thickness, with higher resolution near the surface. And the ocean is divided into 50 vertical levels – also with finer resolution near the surface.

[music – approx 5 seconds]

NARRATOR [KD]: But what are the benefits of a climate model having smaller grid boxes? - This higher resolution. Well, finer spatial resolution allows the new model to simulate certain smaller-scale physical processes that previous generations of our models could not. Higher spatial resolution provides a climate model with the capability to more accurately represent a wider range of the physical processes that together determine how the planet's climate system works and how it may change in the future.

Consider the Gulf Stream. In this map, drawn for Ben Franklin in the late 1700s, the Gulf Stream is depicted as a fairly wide and homogenous ocean current. It brings warm waters north along the east coast of the United States and then eastward towards Europe. This is a coarse resolution view of the Gulf Stream.

More modern observations have revealed that the Gulf Stream contains a variety of smaller scale details and variations. Meanders, eddies and rings form – especially along the edges of the Gulf Steam – and then dissipate.

These finer scale details can make a difference in the way heat, salt, and nutrients are transported. And you can see these sorts of features in this animation from GFDL’s new high resolution global climate model. All of what you see in this animation is being simulated spontaneously by the model itself- no observations from satellites or other sources are being fed into the model to force it to produce these details.

Like Ben Franklin’s map, the ocean component of coarser resolution global climate models can capture the big picture – their Gulf Streams move large amounts of heat northward and then eastward – but their inability to simulate the finer scale details, such as those seen here, can leave some climate questions unaddressed.

Other benefits that accompany higher resolution climate models include precipitation patterns that are simulated in crisper detail by the atmospheric model component – a factor than may benefit regional water resource management planning. Storms - including tropical storms - look more realistic. And there are other benefits.

But it’s not just about pretty pictures.

The additional computational expense associated with higher resolution models buys the opportunity to increase the realism of the simulations and to capture numerically more of the complexity that exists in the real climate system.

In addition to providing more regional detail, the use of higher resolution can lead to an improved simulation of the overall general circulation of the global atmosphere and oceans.

Combined with high quality observations, the climate models provide researchers an opportunity to learn more – to develop a better understanding of climate processes. This kind of scientific understanding contributes to improving our ability to understand and predict changes in the Earth’s environment - Knowledge that in turn is shared with policymakers and the public, so as to enhance society's ability to plan and respond.

ANNOUNCER [KF]: This educational video was created by the scientific research staff at NOAA’s Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey.

For more information about our climate research efforts, go to W-W-W dot G-F-D-L dot N-O-A-A dot “gov”.

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