A Better Way to Read & Think About the Next Generation Science Standards

John White
DataStreme LIT – North Carolina

The AMS DataStreme courses inherently address STEM topics. The Next Generation Science Standards (NGSS), which include weather and climate among the NGSS Disciplinary Core Ideas (DCI), also anticipate "developing and using models." And the NGSS "Crosscutting Concepts" include "Systems and System Models."
Among the NGSS DCI bullets supporting the "Weather and Climate" DCI is this entry (http://www.nextgenscience.org/msess2-earth-systems):

ESS2.D: Weather and Climate

- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6)
- Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5)
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)

The second bullet in the core ideas about weather and climate seems to contradict the emphasis on models elsewhere in the NRC's *A Framework for K-12 Science Education*. This poster provides a simple explanation of modeling in an atmospheric context.

To borrow a phrase from The Beatles, many folks "wake up, roll out of bed,…" and check the sky. They're looking to see if it's sunny or cloudy or raining. Anticipating the day's weather based on what they're observing, they're applying the first step in a modeling process.
Let's walk through an example of how this process might work.

Begin scrutinizing the poster schematics from the upper left. At observing sites around the world, weather "observers" (often automated observing sites in modern meteorology) collect weather information, and analysts use standard weather map symbols to plot weather maps. We know how to analyze and interpret weather maps to facilitate understanding and assessing future weather. However, in addition to traditional weather observing, there are various types of specialized data such as the depicted vertical wind profiles collected with (as shown) boundary layer wind profilers. Analyzing these data, one can define a diurnal low-level jet in the wind field; applying the knowledge of the wind field's structure can help assess the transport of pollutants, and an air quality meteorologist may develop a conceptual model of this transport process as a diagram of the physical world (a model).

Proceeding from a conceptual to a quantitative model requires nothing more than breaking down the processes involved into the component parts, illustrated in the "AQ Model Process." When you combine the various components of the model and couple them in a 3-dimensional framework, you've built "THE model."

Of course, there are many discreet steps in the actual modeling process; but fundamentally it consists of what's shown here: having a concept of how something works and applying the sciences' understanding to develop the quantitative descriptions that can then be mathematically manipulated.

It's important that we understand what models tell us. Dr. Harvey Jeffries (UNC-CH), in a presentation to air quality managers offered the perspective shown in his "Model Vindication Statement" to help them understand and apply some specific AQ modeling results:

> “This model is as well-formulated as any model I know and it uses inputs and assumptions more likely than any other set, and therefore, until additional information becomes available that will change the model's formulation or the inputs, it makes sense to act as if this model's forecasts are accurate."

He then admonishes us that "[s]uch a claim must be supported with evidence and arguments."

Thus is the nature of science.

But, wait! There's more…

In the real world, models are used to inform policy, regulations, taxes, and more. Recognizing how these non-science activities depend on science-based models informs how we develop models and helps us appreciate that we must present valid model results. (Caution: refer to Harvey's "Model Vindication Statement.")

The process demands critical thinking. Examples of mature models include how we categorize clouds and the resulting patterns of precipitation. There are other models science endeavors to build to maturity: the North Atlantic Oscillation, for example, is a challenge.

Our success at modeling features such as pollutant concentrations and the performance of AQ advisory color codes is one common example of that the success of explicit modeling efforts. Another terrific success was the accurate prediction of the formation and path of Hurricane Sandy.

Understanding the modeling process will allow you to put those critical thinking skills to work in assessing how you think about the Next Generation Science Standards' assertion that "weather can only be predicted probabilistically."