Integrating Data Computation and Visualization to Build Model-based Water Literacy

Learning Goals and NGSS Connections

2020

Next Generation Science Standards and the Scientific Practices

BOX S-1

THE THREE DIMENSIONS OF THE FRAMEWORK

1 Scientific and Engineering Practices

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

2 Crosscutting Concepts

1. Patterns
2. Cause and effect: Mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: Flows, cycles, and conservation
6. Structure and function
7. Stability and change

3 Disciplinary Core Ideas

Physical Sciences
PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

Life Sciences
LS1: From molecules to organisms: Structures and processes
LS2: Ecosystems: Interactions, energy, and dynamics
LS3: Heredity: Inheritance and variation of traits
LS4: Biological evolution: Unity and diversity

Earth and Space Sciences
ESS1: Earth's place in the universe
ESS2: Earth's systems
ESS3: Earth and human activity

Engineering, Technology, and Applications of Science
ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Washington, D. C.: National Academies Press.

CompHydro Learning Goals

Hydrologic (H)

1. Students will be able to explain the impacts of too much water in a place at one time on people and the ecosystem.
2. Students will be able to quantify precipitation rates and total amounts for intense rainfall events.
3. Students will be able to describe sources of variability in measured precipitation rates across space, use interpolation to estimate rates between gages, and appreciate the limitations of these estimates.
4. Students will be able to explain ways that human activity (climate change, pollution, urban heat island) might influence the frequency and/or severity of intense precipitation events.
5. Students will be able to identify watersheds and watershed divides on maps and in real landscapes, and demonstrate the topography-driven pathways water takes across the landscape.
6. Students will be able to explain the forces that move water reaching the land as precipitation, including gravity, pressure, matric or surface tension [and osmosis], and how these determine the pathways and rates of movement.
7. Students will be able to calculate the amounts of water following different pathways – surface runoff, infiltration, evapotranspiration, percolation - in order to explain differences in runoff following intense rain events.
8. Students will be able to analyze the significance of human modifications to the urban landscape – impervious surfaces and associated drainage systems, changed topography, changed vegetation – for altering the pathways of water movement and resultant runoff.
9. Students will be able to support and critique arguments about the efficacy of different mitigation strategies for reducing runoff using scientific principles and evidence, data and computational literacy.

Data (D)

1. **Variability:** Students will be able to recognize and quantify variability in data, explain and manage or reduce sources of variability, and qualify their confidence in estimates in light of underlying variability.
2. **Plotting and Interpolation of Data:** Students will be able to plot precipitation gage locations and data on a map and interpolate data in order to contour rainfall amounts.
3. **Data Processing and Manipulation**: Students will be able to select appropriate data, and make accurate calculations or manipulations of the data in order to answer their questions/serve their purpose. This includes being able to use and convert between common precipitation and runoff parameters (including rain, runoff and stream flow rates, runoff ratios).
4. **Developing Questions**: Students will be able to develop testable questions from data.
5. **Visualization:** Students will be able to create and interpret key visualizations used in watershed hydrology, including 3D shape of watersheds from plan and cross-section views of contour maps, and hydrographs.
6. **Patterns, Noise and Complexity:** Students will be able to find trends or patterns in noisy data and recognize the tradeoff in terms of effort and complexity in gathering or using more data.
7. **Comparing Models to Observations:** Students will be able to perform and adjust several runs of a model to work toward modeled and observed agreement.

Computation (C)

1. **Quantitative Reasoning:** Students are comfortable with the computations needed to quantify phenomena in nature, identify and quantify trends and patterns, and distinguish variability and error.Students will be able to explain how increases in data decrease uncertainty in interpolation but may also introduce complexity.
2. **Design & Modeling:** Students can parameterize variables and identify the important constraints.Students will be able to consider the importance of boundary assumptions and parameter estimation in models.Students can deal with the scale of phenomena in time and space through discretization, and recognize the consequences of using different sized time intervals or spatial cells.
3. **Problem-solving**: Students can use iterative and recursive approaches to problem solving. Students will be able to perform and adjust several runs of a model to test ideas about flood mitigation, while understanding the limitations of the models.
4. **Simulation:** Students will be able to compare model runs of hydrographs and water budgets to known hydrographs and budgets.Students will be able to identify and describe benefits and challenges of using computers to analyze data.
5. **Data Visualization:** Students can use different levels of abstraction in visualizing data.