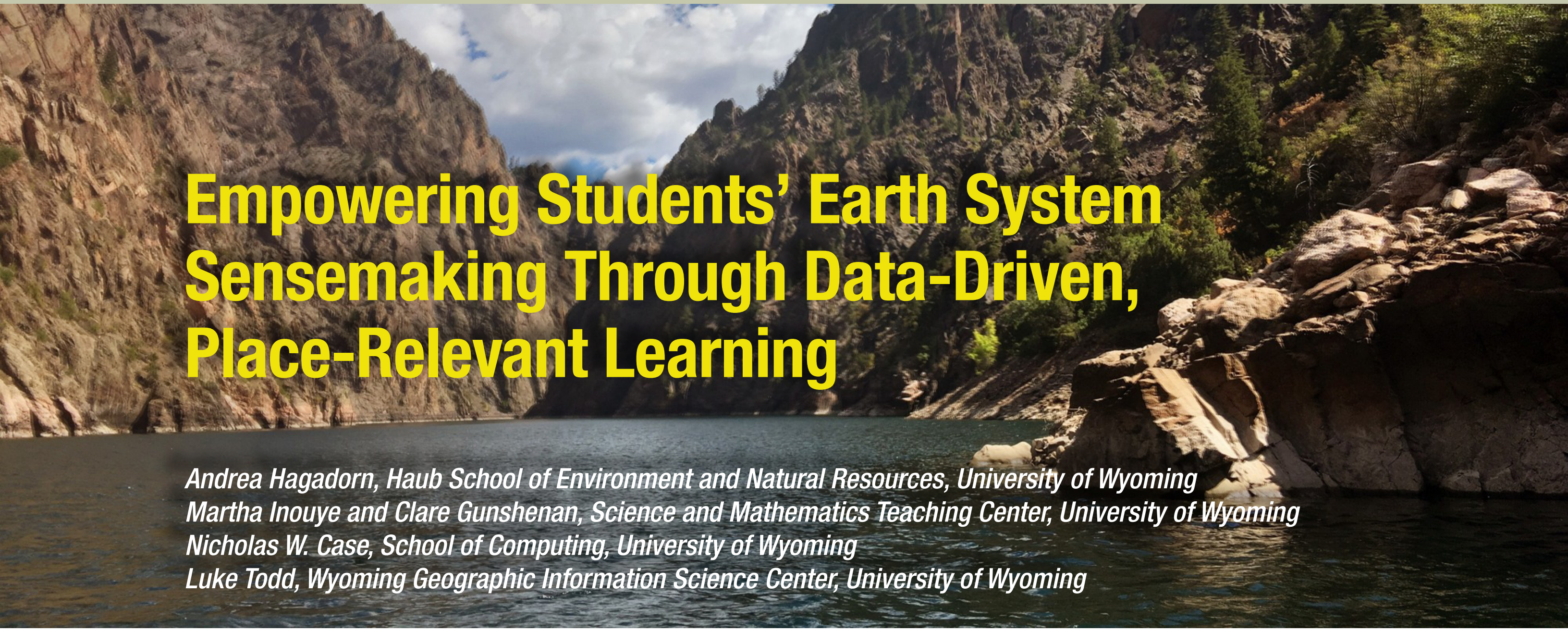
Empowering Students' Earth System Sensemaking Through Data-Driven, Place-Relevant Learning

Andrea Hagadorn, Haub School of Environment and Natural Resources, University of Wyoming
Martha Inouye and Clare Gunshenan, Science and Mathematics Teaching Center, University of Wyoming
Nicholas W. Case, School of Computing, University of Wyoming
Luke Todd, Wyoming Geographic Information Science Center, University of Wyoming



Crystal Reservoir, Curecanti National Recreation Area Photo Credit: National Park Service

Abstract

As water reservoirs in the western United States reach historic lows, students are increasingly confronted with complex environmental challenges stemming from water scarcity that directly affect their lives and communities. This article highlights how three high school teachers used a free online platform called WY-Adapt—which includes more than ten interactive dashboards featuring temperature, precipitation, snowpack, streamflow, and real-time sensor data—to help students explore past climate trends and future projections and connect them to changes in their own communities. These teachers turned complex, place-relevant climate data into meaningful learning experiences that supported student sensemaking around NGSS-aligned ideas connected to evidence-based forecasts of Earth's systems and relationships among Earth's systems and human activity. Their classroom examples and insights illustrate how tools like WY-Adapt can support data-driven, place-relevant, and sensemaking-focused learning.

Introduction

Reservoirs, natural and artificial water bodies used to store and regulate water, have reached record lows across the western United States, prompting water restrictions in communities from Wyoming to California (Albrecht et al., 2024; USBR, 2025). Students are living through these environmental changes and need access to tools to help them interpret real-world data to explore the changes and their impacts. Often, middle and high school students have little exposure to the data-driven, computer-based models climate scientists use, or to resources that support using these models for sensemaking (Forbes et al., 2020). This means they also lack access to locally relevant Earth system data, models, and stories that are essential to learning about the Earth's climate. Using grade-level accessible and place-relevant data from current computer-based models can help solve this problem by allowing students to visualize regional changes and connect them to their daily lives and communities.

This article shares one approach to integrating current and local data in learning, using data from Wyoming Anticipating the Climate-Water Transition (WyACT), a National Science Foundation-funded project that aims to engage communities in planning around changing water. As part of this effort, researchers are developing datasets and models that explore trends in precipitation, temperature, snowpack, and soils, and are working to make these cutting-edge data more accessible to a wide range of users, namely through a data visualization platform called WY-Adapt (WyACT, 2026c). The platform includes over ten interactive data dashboards that

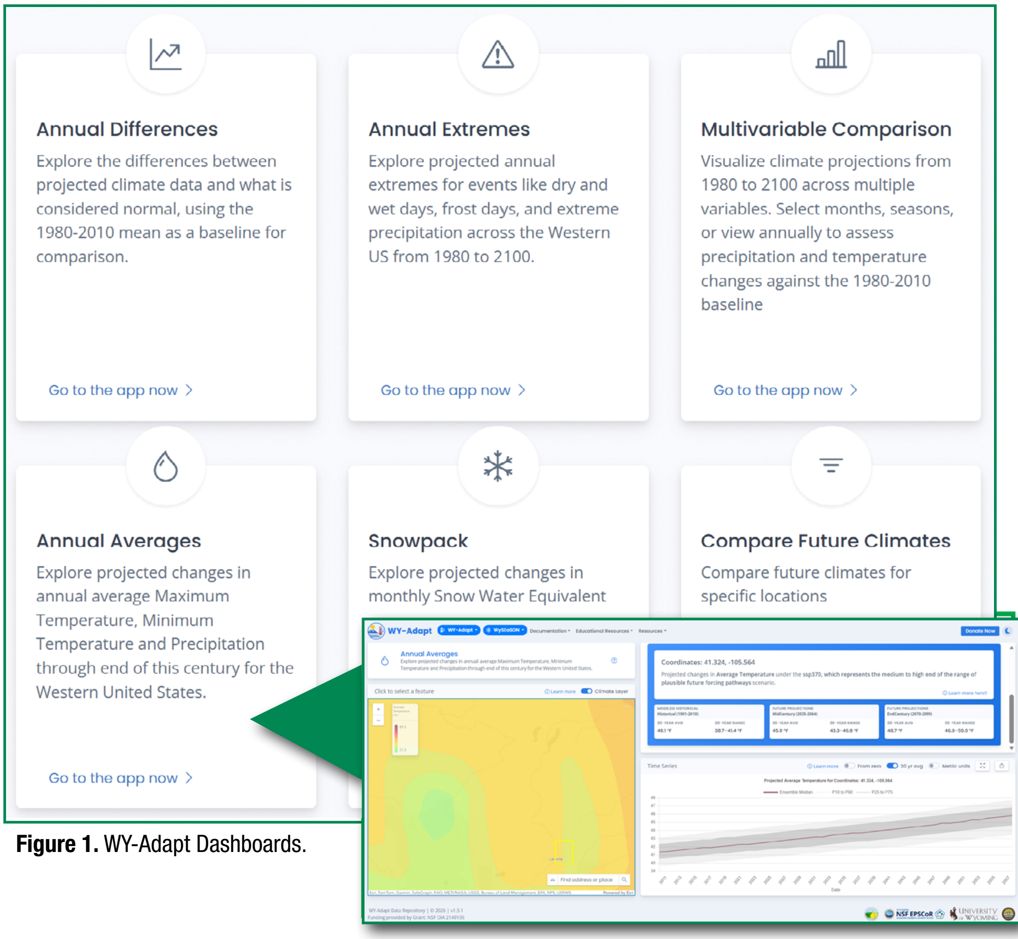
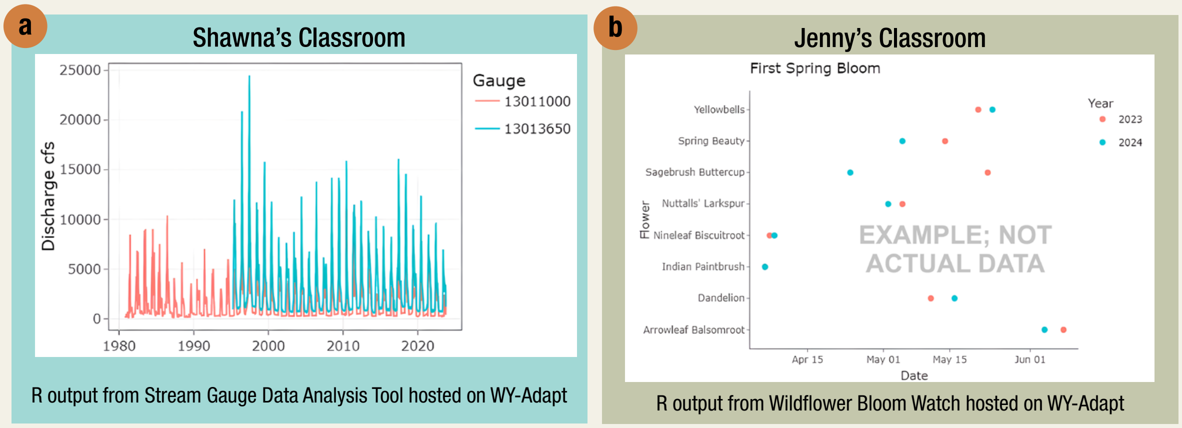


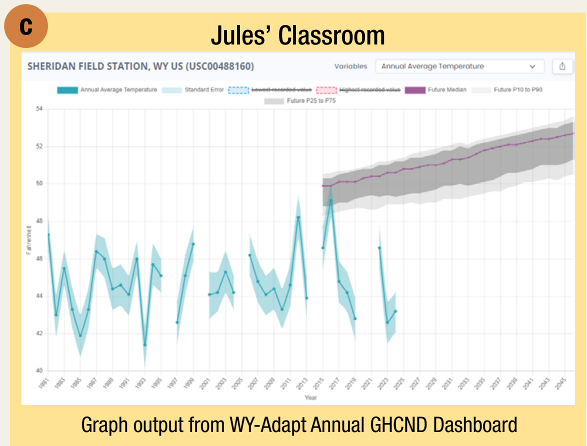
Figure 1. WY-Adapt Dashboards.

show local and regional projected temperature and precipitation trends, snowpack and hydrologic data, real-time monitoring of lakes and meteorologic data, and more (see Figure 1). Through WyACT's Teacher Researcher Knowledge Exchange program (hereafter called "the Knowledge Exchange"), K-12 educators collaborate with these researchers to translate their complex data into accessible classroom and field learning experiences. These educators have had particular success developing learning progressions where students use the WY-Adapt platform to make sense of environmental changes in their communities. This article introduces three high school-level examples where teachers integrated WY-Adapt into Earth system-connected learning (see Table 1 for a range of dimension connections).

Table 1. Possible NGSS dimension connections to the WY-Adapt platform. All dimensions are shared at the high school level. SEP (NGSS, 2013b), CCC (NGSS, 2013c), and DCI (2013a) connections come from NGSS dimension appendices.

Dimensions	Potential Learning Connections
Crosscutting Concepts (CCCs)	
Systems and system models	Students can target different dashboards to make sense of different components, inputs, and outputs of local and regional systems, and use these to make predictions about system function.
Stability and change	Students can deeply explore ideas of quantifying and modeling change and rates of change across dashboards
Cause and effect	Students can identify dashboard data as observational and modeled data (i.e., forms of empirical data), in order to identify causation, correlation, and specific causes and effects.
Science & Engineering Practices (SEPs)	
Analyzing and interpreting data	Students can access, analyze, and interpret modeled and observed data, as visualized on dashboards, in order to: • make valid and reliable scientific claims, and/or • identify and consider data limitations (e.g., measurement error, sample selection, model limitations).
Developing and using models	Students can use the climate models in dashboards to: • illustrate and/or predict the relationships between systems or between components of a system, and/or • compare multiple types of models in terms of how they predict phenomena, what mechanisms they suggest, and the merits and limitations of each.
Constructing explanations and evaluating design solutions	Students can use a range of dashboards to construct and revise explanations that: • integrate valid and reliable evidence from multiple sources (e.g., dashboard data and students' own investigations), • connect evidence to phenomenon explanations, including possible unanticipated effects, and/or • assess the extent to which model data and related reasoning might support an explanation or conclusion.
Disciplinary Core Ideas (DCIs)	
ESS3.A - Natural resources **ESS3.B** - Natural hazards **ESS3.C** - Human impacts on Earth systems **ESS3.D** - Global climate change	Students can explore dashboards to make sense of: • relationships between humans, natural resources, decision making, and model projections (ESS3.1 and ESS3.B), • relationships between Earth and human activity (ESS3.C). and/or • the role of climate models in anticipating and responding to local and regional changes (ESS3.D)





Dashboard Snapshots

Figure 2. Snapshots of WY-Adapt dashboards used in classroom examples. Panel (a) references a Stream Gauge R script (TRKE, 2024b), which can be found on WY-Adapt's Knowledge Exchange TRKE project page, as can a number of the resources Shawna and her collaborators used (TRKE, 2025b) for her learning progression. Panel (b) references a Wildflower Watch R script (TRKE, 2024a), which can be found on WY-Adapt's Knowledge Exchange project page. Panel (c) references the Annual GHCND Dashboard (WyACT, 2026a), which can be found on the main WY-Adapt webpage, as can a number of the resources Jules used for her learning progression (TRKE, 2025a)

Using Place-Relevant Data in the Classroom

The Knowledge Exchange's 2024-2025 cohort included 31 participants who explored WY-Adapt as a data-rich resource for investigating questions related to changing water availability. As evidenced in Table 1, there are a myriad of ways in which WY-Adapt can be used with students to address the Next Generation Science Standards and their three dimensions. The next sections highlight three classroom-tested examples that illustrate ways these dimensions might be integrated. Each example is housed in the Educational Resources section of WY-Adapt (TRKE, 2026c), and dashboard snapshots can be found in Figure 2.

Example 1: Using WY-Adapt to Spark Student Questions

Shawna Mattson (Table 2) is a high school science teacher who used WY-Adapt as an access point in a two-week mini unit to help her 9th grade students generate deeper questions about and connections to their home watershed. Students engaged with WY-Adapt across four class periods, supported by pre-prepared data visualizations of several decades of U.S. Geological Survey streamflow data (USGS, n.d.) from their local stream gauge, following the steps in the Stream Gauge Data Analysis Tool (TRKE, 2024b).

Students were asked, "How does the city of Green River impact the health of the Green River?" They recorded their initial ideas, then engaged with the visualized streamflow data and the WY-Adapt Current Conditions dashboard (WyACT, 2026b) to come up with more connections and further questions. Additional prompts like, "What streams and tributaries flow into our watershed?" and "Where does the water go?" helped students to focus their data explorations on the ways their watershed operates as a system with components upstream and downstream of their community. Ultimately, students used their explorations to come up with their own questions about water's movement and role in their home watershed.

These ideas were used in further classroom investigation of climate, hydrosphere, and human interactions connected to HS-ESS3-6 (see Table 2). **Shawna's three-dimensional learning outcome was: Students use digital tools like WY-Adapt to spark their ideas and questions about their home watershed— they interpret a static data output, then investigate their own interests and questions about the system and its components by navigating the interactive platform.** Reflecting on this implementation, Shawna shared that her students will often look at an infographic or a piece of data and freeze because they don't know where to start. Using WY-Adapt has helped her students build confidence in their data literacy and ability to grapple with big data. Starting local helped students to focus, then be able to zoom out and explore the bigger data without being daunted.

Table 2. Shawna's target Next Generation Science Standard, its dimensions, and how they integrated in her use of WY-Adapt.
In the right column, Crosscutting Concept text is indicated with italics. Science & Engineering Practice text is indicated with bolding. Disciplinary Core Idea text is indicated with underlines.

HS-ESS3-6: Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	
Crosscutting Concept	**WY-Adapt in the 3D Classroom**
Systems and System Models: When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	Shawna used WY-Adapt in tandem with other platforms to help her students explore their local watershed. They began by **interpreting static streamflow graphs that compiled years of data** from their local watershed, then **used WY-Adapt dashboards to explore** upstream and downstream areas *(i.e., watershed system components)* **to identify their own interests and questions.** To guide their exploration, Shawna posed the following questions: • What streams and tributaries *flow into* our watershed? • Where does the water *go*?
Science & Engineering Practice	
Asking Questions & Defining Problems: Ask questions that arise from examining models to clarify relationships.	
Disciplinary Core Idea	
ESS3.D: Global Climate Change: Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	

Examples 2 and 3: Using WY-Adapt to Promote Data Analysis & Interpretation for Claims

Two other teachers from separate high schools took different approaches to embedding WY-Adapt in their classrooms. Jenny Edwards and Jules Craft each had their high school students access, analyze, and interpret climate data on WY-Adapt to make sense of trends in locally relevant places. For Jenny, this supported students in making predictions about climate-driven changes in their school's pollinator garden and how those changes might impact migrating birds in the context of HS-ESS2-2 (see Table 3). For Jules, this was a part of a student assessment in an ecology unit targeting HS-ESS3-5 (see Table 4).

Table 3. Jenny's target Next Generation Science Standard, its dimensions, and how they integrated in her use of WY-Adapt.
In the right column, Crosscutting Concept text is indicated with italics. Science & Engineering Practice text is indicated with bolding. Disciplinary Core Idea text is indicated with underlines.

HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems	
Crosscutting Concept	**WY-Adapt in the 3D Classroom**
Stability & Change: Feedback (negative or positive) can stabilize or destabilize a system.	During a phenology unit, Jenny's class used WY-Adapt's Annual Averages dashboard to access climate data (e.g., temperature and precipitation). They **compared these data with their own** *weekly observations of changes* in leaves, flowers, and wildlife (i.e., phenology) along a Wildflower Watch transect in their native species school garden. They **visualized these data with an R script,** allowing them to *plot changes over time and connect these with* the climate data trends. They shared this R script on WY-Adapt's TRKE project page.
Science & Engineering Practice	
Analyzing & Interpreting Data: Analyze data using computational models in order to make valid and reliable scientific claims.	
Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems: Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. **ESS2.D: Weather and Climate:** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	

Jenny's 11th and 12th grade environmental science class (Table 3) used WY-Adapt's Annual Averages dashboard to compare local climate model data with the seasonal phenology observations they and their peers have collected over multiple springs in their school pollinator garden. To identify trends, the students visualized their monitoring data with a [Wildflower Bloom Watch R script](#) (TRKE, 2024a). Comparing their phenology observations to modeled climate data helped Jenny's students make sense of potential climate impacts in their schoolyard and broader local environment. The monitoring in this unit spanned the spring semester, though the WY-Adapt data analysis and visualization portions of the unit lasted four class periods.

Jenny's learning outcome for this progression was: Students organize and explore data in R, then interpret R outputs to identify phenology trends at their school and make inferences about ways that climate trends might impact local phenology trends. Reflecting on this implementation, Jenny shared that WY-Adapt is an incredible asset to her students and classroom, and using researcher methodologies in the field of phenology has provided an authentic data collection piece and revitalized the use of a native species biodiversity garden at her school. By comparing student-collected phenology data with climate data, her students were able to contextualize potential impacts of climate change in their local environment.

Table 4. Jules' target Next Generation Science Standard, its dimensions, and how they integrated in her use of WY-Adapt.
In the right column, Crosscutting Concept text is indicated with italics. Science & Engineering Practice text is indicated with bolding. Disciplinary Core Idea text is indicated with underlines.

<table>
<tr><td colspan="2">HS-ESS3-5: Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems</td></tr>
<tr><td>Crosscutting Concept</td><td rowspan="6">WY-Adapt in the 3D Classroom
The ecosystem impact assessment asked students to describe how the climate in the Goose Creek watershed has changed in the past 50 years, and could continue to change in the next 50 years. Her students used WY-Adapt to find climate data, such as average temperature and rainfall, for certain time ranges, as well as modeled possible futures to inform their conclusions.</td></tr>
<tr><td>Stability & Change: Change and rates of change can be quantified and modeled over very short or very long periods of time.</td></tr>
<tr><td>Science & Engineering Practice</td></tr>
<tr><td>Constructing Explanations: Construct an explanation based on valid and reliable evidence and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.</td></tr>
<tr><td>Disciplinary Core Idea</td></tr>
<tr><td>ESS3.D: Global Climate Change
Though the magnitudes of human impacts are greater than ever, so too are human abilities to model, predict, and manage current and future impacts.</td></tr>
</table>

Jules' 10th grade class (Table 4) used WY-Adapt climate data, such as average temperature and precipitation, to analyze how their local watershed has changed over the past 50 years, zooming in and out on the graph and considering how the map colors shifted over time. They similarly used WY-Adapt model projections to make predictions about how the watershed could continue to change and the impacts these changes would have on ecosystems and other Earth systems. They completed these investigations over two 50-minute class periods as part of their ecosystem impact unit's summative assessment, though they also engaged with WY-Adapt more generally throughout the unit. This progression allowed students to make place-relevant and data-informed connections between Earth systems and the biosphere in their sensemaking.

Jules' learning outcome for this progression was: Students interpret data from the WY-Adapt dashboards to a) draw conclusions and make predictions, and b) connect these conclusions and predictions to the past and possible future stories of their home watershed. Reflecting on this implementation, she shared that allowing students 10 minutes to just play around on the WY-Adapt site was very interesting. They turned on and off layers of the map, toggled through past and future years to see what changes had happened or might still occur in their homes. It was eye-opening for them, and it also helped them make more relevant use of the information once the assessment was underway.

Resources for Integrating WY-Adapt into Your Context

These three examples illustrate a few ways in which teachers have used WY-Adapt to support data-driven and place-relevant learning focused on sensemaking. There are many other ways to incorporate WY-Adapt into your classroom, some of which teachers have already planned and shared on the WY-Adapt

Knowledge Exchange educational resource page (TRKE, 2026a). The Knowledge Exchange resource page also features data-inspired check-ins and other small activities (TRKE, 2026b) where WY-Adapt dashboards support inquiry, discussion, and student engagement. Complementing these resources, a set of WySEaSON dashboards (WyACT, 2026d) share socio-environmental system data and make connections between data, environmental change, and real-world local impacts. You might integrate these social and biophysical dashboards and educational resources into your classrooms to support a range of learning experiences rooted in place, data, and sensemaking.

Why Place-Relevant, Data-Driven Sensemaking Matters

In today's information-rich world, the ability to actively explore Earth system data, make sense of complex climate phenomena, and connect those changes to local realities is essential—not just for scientists, but for all students preparing to navigate an uncertain future. When students engage with tools like WY-Adapt, they participate in sensemaking, data-driven investigation, and place-relevant learning that deepens their understanding by connecting scientific concepts to their lived experiences.

Tools like WY-Adapt enable educators to bring current Earth science phenomena and data into the classroom in ways that tightly align with science practices and crosscutting concepts. Especially impactful is the opportunity these dashboards provide for students to engage with and manipulate complex, current models in support of their own sensemaking. By grounding instruction in local and relevant data and models, teachers are not just preparing students for higher education and careers—they are also preparing students with lifelong learning skills that equip them to take on real-world challenges. Encouraging these skills empowers students to critically engage with data and make sense of our complex world. The classroom-tested examples shared in this article represent only three approaches for weaving standards, three-dimensional learning, and rich model data into Earth science learning. Endless other approaches will fit your context and standards, so explore the relevant topics your students care about and use tools like WY-Adapt to bring complex Earth system subjects to life.

Acknowledgements

We would like to thank the 31 teachers, nonformal educators, and university researchers who participated in the Teacher Researcher Knowledge Exchange's second cohort, especially Jenny Edwards, Jules Craft, and Shawna Mattson, who provided insight into WY-Adapt's use in the classroom. Additionally, thank you to the WY-Adapt developers in the Wyoming Geospatial Information Science Center (WyGISC) at the University of Wyoming who have worked for years to make this platform accessible and responsive to Wyoming teachers' needs and interests.

Funding Details: This material is based upon work supported by the National Science Foundation under Grant 2149105.

Disclosure Statement: The authors report there are no competing interests to declare.

Data availability statement: The data that supports the findings of this study are available from the corresponding author upon reasonable request.

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About the Authors

Andrea Hagadorn is a Master's student in the Environment, Natural Resources, and Society program at the University of Wyoming. She previously served as an Air Force Intelligence Officer for ten years, earning a B.S. in Geospatial Science. Andrea currently supports the Teacher Researcher Knowledge Exchange (TRKE) program, part of the NSF-funded Wyoming Anticipating the Climate-Water Transition program at the University of Wyoming. Andrea can be reached at ahagador@uwyo.edu.

Martha Inouye (ORCID: 0000-0003-4925-1321) is a Research Scientist in the Science and Mathematics Teaching Center at the University of Wyoming. Her work focuses on the development and facilitation of K-12 science teacher professional learning. She co-leads the TRKE program. Martha can be reached at minouye@uwyo.edu.

Clare Gunshenan (ORCID: 0000-0002-1654-7401) is an Outreach Educator in the Science and Mathematics Teaching Center at the University of Wyoming. She co-leads the TRKE program. Clare can be reached at cgunshen@uwyo.edu.

Nicholas W. Case (ORCID: 0000-0001-6440-0693) is an Assistant Lecturer in the Applied Software Development program under the School of Computing at the University of Wyoming. Specializing in .NET and ArcGIS JavaScript API 4.x, he focuses on creating interactive GIS web applications and spatial data analysis. Nicholas can be reached at ncase2@uwyo.edu.

Luke Todd is a Geospatial Analyst with the Wyoming Geographic Information Science Center at the University of Wyoming. Luke can be reached at luke.todd@uwyo.edu.