

POLICY BRIEF: Metaphoric language to increase climate literacy about extreme weather events in informal educational settings

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Summary

Values-based strategic communication for climate change includes a variety of evidence-based language tools that have been developed for use in informal educational settings. In this toolkit, metaphors help to educate the public on complex scientific topics, including climate change and extreme weather events. We developed evidence-based metaphors to explain six major types of extreme weather events: flooding, wildfires, sea level rise, heat waves, hurricanes, and unpredictable weather events. Participants ranked each set of metaphors based on their ability to explain the extreme weather event. Participants did not differ in their selected metaphors across demographic categories of different generations, ethnicities, religious identities, and/or gender identities.

Background

Increasingly alongside current climate change effects, the United States has seen an increase in severity, frequency, and unpredictability of wildfires, flooding, storm surge on coastlines, and other extreme weather events (Dangendorf et al., 2023; Ellis et al., 2022; Wahl et al.; 2015). Since extreme weather events occur on short timescales that can appear random or unconnected, it is difficult to explain why they are happening in local areas. Communicating the nuanced relationships between weather and climate remain a top priority for educators looking to promote climate literacy and action. Thus, we must continue to develop an effective way of explaining these rapidly changing events to the public in a way that encourages agency and efficacy (Geiger et al., 2017).

Communicating science in a way that allows people to understand the information, as well as the implications of what is being communicated, is necessary in order to educate the public on climate change. This can be done through framing, a widely used communication approach to address partisan socio-political topics (Borah, 2011). Framing uses individuals' backgrounds and "frames of mind" to communicate information in a way that results in a shared understanding of the topic. Individuals' subjective knowledge (what they believe to know about the topic) had a stronger influence than their objective knowledge (what they actually know about a topic) when choosing to engage in pro-environmental behavior. This relationship is mediated by their environmental emotions (Carmi et al., 2015).

Effective science communication must address the values, interests, and worldviews of an audience (Nisbet, 2009). Thus, values-based framing is part of a tested strategic communication

toolkit developed by the National Network for Ocean and Climate Change Interpretation to improve climate and ocean literacy and advocacy in informal educational settings. It follows a standardized formula, each piece of which is tested through surveys, interviews, and focus groups to maximize the efficacy of information delivery for public audiences. As shown in Figure 1, this formula starts with a cultural value (e.g., protection, responsible management), leverages a metaphor to explain a complex scientific phenomenon related to climate change, leads to a topic of interest (e.g., a focal species within an exhibit at a zoo), and ends with a community-level solution for acting on climate change (e.g., voting).

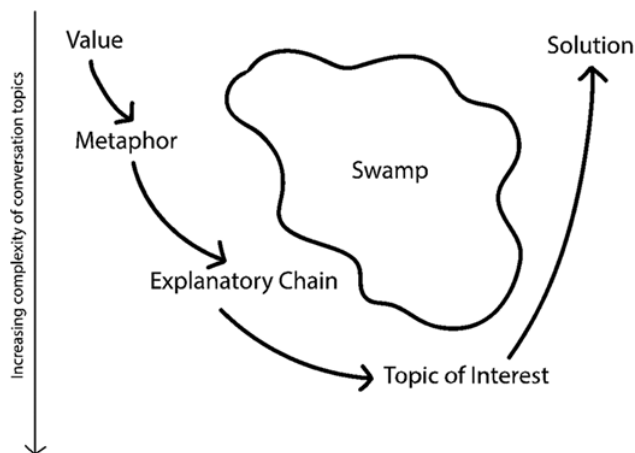


Figure 1. Using framing elements to navigate a positive climate communication around a swamp of unproductive cultural models (Bonanno et al., 2021).

Existing values-based framing strategies developed over the last decade by the National Network for Ocean and Climate Change Interpretation and the Frameworks Institute are a critical foundation for further work exploring effective metaphors for climate-related phenomena (Bales et al., 2015). In this policy brief, we detail research done by former Science Directors of NNOCCI, Dr. Richelle Tanner and Dr. Megan Ennes, that debuts additional evidence-based metaphoric language for describing extreme weather events. These tools are intended for audiences in informal science settings such as zoos, aquariums, and science centers.

Methodology

Initial metaphors were designed and tested internally by a team of researchers, science writers, and educators familiar with the existing NNOCCI toolkit and approach. Metaphors were explicitly designed to target a range of positive, neutral, and negative emotions with variations in length and detail of metaphoric language. Each extreme weather subject (flooding, wildfires, sea level rise, heat waves, hurricanes, and unpredictable weather events) had 3-5 metaphors developed for it. These were designed to be used in tandem with existing NNOCCI metaphors that explain basic climate change phenomena (e.g., warming, ocean circulation).

Communicator opinions were initially sought through a national survey sent primarily to informal educators, science writers, post-secondary students, and climate science professionals.

Participants were asked to rank each set of metaphors from best to worst on its ability to explain the extreme weather subject. Ten individuals were selected from this pool of communicators for individual audio interviews to determine elements of metaphoric language from the top-rated metaphors on the survey that were useful, positive, and/or needed to be changed to improve clarity. Edits were made to the metaphors displayed on the survey, and it was redistributed to a public audience. Public opinion was sought using a national survey (n = 307) administered through the survey platform, Prolific, which standardized response rates among race and gender demographic categories to match the national census. Again, participants were asked to rank each set of metaphors from best to worst on its ability to explain the extreme weather subject.

In addition to survey questions about selecting the best metaphors for each of six extreme weather subjects, we asked a suite of demographic questions to determine whether different subsets of the American population had different preferences for metaphoric language. We asked about generation, gender, ethnicity, and spiritual identity as adults and in their upbringing. Data were analyzed using the statistical software R. Weighted composite scores for each metaphor were calculated to compare responses. Kruskal-Wallis tests were used to analyze differences in responses determined by participant characteristics.

Key Findings

On average, the recommended tested metaphors displayed in Table 1 had a 46% selection rate as the top metaphor in that category. All metaphors contain language that indicates positive emotions, validating prior approaches that indicate this is an important component of effective science communication (Carmi et al. 2015).

Interestingly, there were no demographic differences in the selection of the top metaphor ($p > 0.05$), indicating greater concordance among members of the public in effective science communication than we anticipated. Thus, individuals of different backgrounds felt that the same metaphors were effective in expanding their knowledge of climate change. This suggests that the recommended metaphors listed in Table 1 are for use in broad informal educational settings, not just with audiences of a certain generation or religious affiliation. These findings align with previous NNOCCI work that developed metaphors broadly for the American public (Bales et al. 2015).

Subject	Recommended Tested Metaphor
Flooding	As the oceans warm, extra water evaporates from the ocean to the clouds. This extra water in the sky increases rainfall over land. Sometimes soil can't absorb this extra water fast enough. Soil is like a sponge: if it is too wet, it can't absorb more water. This results in runoff that can cause flooding.
Wildfires	When hot weather persists for a long time, the land and the plants that live there can dry out, becoming unlit matches waiting to be ignited. It only takes

	one spark to light an entire box of matches, just like it only takes one spark to ignite acres of dry shrubs.
Sea level rise	The ocean controls the circulation of heat and moisture through the climate system. When warmer temperatures turn ice into water worldwide, the volume of our oceans increases. We can think of "sea level rise" as overflowing an already-full glass of water, but wetlands as the paper towels soaking up an over-filled glass of water. Wetland waterways and plant communities soak up the effects of sea level rise to protect coastal human communities.
Heat waves	Heat waves can feel like a fever caused by climate change. Climate change can cause heat waves increasing the normal temperatures of an area just as a fever increases the normal body temperature.
Hurricanes	When hurricanes are amplified by climate change, it's like replacing your garden hose with a fire hose. The water comes out stronger, faster, and more unpredictably just like hurricanes amplified by climate change can be stronger, faster, and more unpredictable.
Unpredictable weather events	Unpredictable weather events due to climate change are as unpredictable as traffic conditions. When you don't know what's going on in front of you, it is hard to know when to slow or speed up. Since we cannot predict the change in weather patterns due to climate change, it can be difficult to prepare for unpredictable weather events.

Table 1. Top-selected metaphors in each extreme event subject area from the results of the public opinion survey. These are to be used in a values-based messaging framework, as shown in Figure 1 as step 2.

Suggested Applications

As stated above, these metaphors are designed to be used in conjunction with existing strategic communication tools in the NNOCCI framework (Fig. 1). Below, we provide example language to deploy these new metaphors within the existing NNOCCI framework:

Flooding

When we talk about flooding, it is important to connect the changing climate to changes in rain distribution. Here is an example of how the flooding metaphor can be used.

We can protect the habitats and ecosystems we call home by addressing the issue of climate change today (**NNOCCI Value**). Working together to reduce the risk of flooding, we safeguard the habitats we rely on and ensure future wellbeing for the entire community of life, including ourselves. As we burn coal, oil, and methane gas for energy production, excess carbon dioxide

is released into the atmosphere. This extra carbon dioxide acts as a heat trapping blanket (**NNOCCI Climate Change Metaphor**). The ocean and atmosphere touch over 70% of the planet. This can cause excess heat from the atmosphere to be transferred into the ocean. As the oceans warm, extra water evaporates from the ocean to the clouds. This extra water in the sky increases rainfall over land. Sometimes soil can't absorb this extra water fast enough. Soil is like a sponge: if it is too wet, it can't absorb more water (**Extreme Events Metaphor**). This results in runoff that can cause flooding. Communities can work together to increase their resilience to flooding in several ways (**Cue following Community Level Solutions**). One way to reduce flooding and urban heat, is through the reduction of paved areas and increase in green spaces. Another example would be supporting developers who construct buildings with rainwater tanks, green walls, or other building-scale infrastructure such as green roofs. Communities can also work together to ensure they work together to reduce flooding beyond their boundaries through programs such as wetland restoration, which have additional benefits in combatting rising carbon dioxide levels due to climate change. Working together, we can protect our habitats and communities and mitigate future impacts from the increase in flooding events due to climate change. (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2021, November).

Wildfires

When discussing wildfires, we want to connect how changes in climate can reduce rainfall in some areas leading to dryer, more fire prone communities. Here is an example of how the wildfire metaphor can be used.

Working together, we can protect our communities and local habitats from wildfire risk by addressing the issue of climate change today. When we work together to reduce the risk of wildfire, we can responsibly manage the habitats and ecosystems that share our communities (**NNOCCI Value**). As we burn coal, oil, and methane gas for energy production, excess carbon dioxide is released into the atmosphere. This extra carbon dioxide acts as a heat trapping blanket, which disrupts the climate and can lead to hotter weather in some areas (**NNOCCI Climate Change Metaphor**). When hot weather persists for a long time, the land and the plants that live there can dry out, becoming unlit matches waiting to be ignited. It only takes one spark to light an entire box of matches, just like it only takes one spark to ignite acres of dry shrubs (**Extreme Events Metaphor**). Thankfully, we can work together within our communities to protect the places and spaces we live in and care about (**Cue following Community Level Solutions**). Encourage your city to plant fire-resistant vegetation and engage in prescribed burns in public spaces. If you have an HOA, encourage them to include fire resistant plants in your community's list of approved plants- not only are these species less likely to catch fire, but they are also drought resistant and can reduce the need to water your lawn. Encourage others to learn about wildfires and how to reduce the amount of fuel on their properties. When we come together, we can reduce the impacts of wildfires on our communities to protect these spaces for all creatures who call it home.

Sea Level Rise

When discussing sea level rise, we want to connect rising temperatures to an increase in ocean volume, not just because of melting ice caps but also because of the physical properties of water expansion under heat. Here is an example of how the sea level rise metaphor can be used.

To minimize the impact of climate change on our coastal areas now and in the future, we need to responsibly manage the development and restoration of these areas (**NNOCCI Value**). Due to the burning of oil, coal, and methane gas for energy production and transportation, we produce excess carbon dioxide that enters the atmosphere. This buildup of extra carbon dioxide acts as a blanket, trapping heat within the atmosphere (**NNOCCI Climate Change Metaphor**). As the ocean and atmosphere touch, much of this excess heat is transferred to the water. The ocean controls the circulation of heat and moisture through the climate system. When warmer temperatures turn ice into water worldwide, the volume of our oceans increases. We can think of "sea level rise" as overflowing an already-full glass of water, but wetlands as the paper towels soaking up an over-filled glass of water (**Extreme Events Metaphor**). Wetland waterways and plant communities soak up the effects of sea level rise to protect coastal human communities. Our communities can work together to support wetland restoration and restrict new development in these areas (**Cue following Community Level Solutions**). We can also support coastal planning codes that plan for future sea-level rise to protect neighborhoods and towns from future harm. By planning for the future, we can help responsibly manage our resources and protect future generations, infrastructure, and ecosystems along our coasts.

Heat Waves

When discussing heat waves, we want to connect the increase in extreme heat conditions to rising temperatures. Climate change does not only impact the average global conditions, but some areas are also more prone to an increase in extreme conditions that are unpredictable in timing, frequency, and duration. Here is an example of how the heat wave metaphor can be used.

As our climate continues to change, we have a responsibility to protect our communities and local ecosystems from its impacts, such as increased heat (**NNOCCI Value**). Burning oil, coal, and methane gas for transportation and energy production produces carbon dioxide. This excess carbon dioxide enters the atmosphere, disrupting the climate and causing some areas to warm (**NNOCCI Climate Change Metaphor**). Warming is unevenly distributed around the world, with some places – particularly in urban areas – experiencing an increase in longer, more frequent heat waves. Heat waves can feel like a fever caused by climate change. Climate change can cause heat waves increasing the normal temperatures of an area just as a fever increases the normal body temperature (**Extreme Events Metaphor**). Thankfully, our communities can design solutions to protect the people and organisms who live there (**Cue**

following Community Level Solutions). Increasing access to green spaces can reduce urban heat illness and provide habitat for native plants and animals. Green roofs on homes and buildings can reduce energy consumption as well as provide cooling properties. Communities can also increase their public transportation to reduce energy consumption year-round, allowing for more of our energy to be used for creating cooler indoor spaces during heat waves. There are many ways our communities can plan for the future and protect people and habitats and mitigate the impacts of climate change.

Hurricanes

When discussing hurricanes, we want to connect the increase in hurricane severity and frequency to climate change. Here is an example of how the hurricane metaphor can be used.

Protecting our communities by addressing the issue of climate change is important for the people and organisms that call it home. When we reduce the impacts of hurricanes, we can safeguard the habitats we rely on and ensure the future wellbeing of the entire community of life, including ourselves (**NNOCCI Value**). As we burn coal, oil, and methane gas for energy production, excess carbon dioxide is released into the atmosphere. This extra carbon dioxide acts as a heat trapping blanket (**NNOCCI Climate Change Metaphor**). Much of the excess heat is absorbed by the ocean and can serve as fuel for hurricanes. When hurricanes are amplified by climate change, it's like replacing your garden hose with a fire hose. The water comes out stronger, faster, and more unpredictably just like hurricanes amplified by climate change can be stronger, faster, and more unpredictable (**Extreme Events Metaphor**). Communities can prepare for the impacts of hurricanes in many ways (**Cue following Community Level Solutions**). Working with city, state, and federal agencies, coastal ecosystem restoration can help reduce the impacts of hurricanes on coastal cities by providing a physical barrier to dampen the effects of storms. We can also support regional programs that require infrastructure and buildings to reduce the impact of flooding and wind on new development. To protect our communities, we can advocate for changes in insurance policies- for example, many companies will only allow homes to be rebuilt as they were rather than allowing for modifications to address hurricane impacts. By coming together, communities can protect the people and organisms that live there and reduce the impacts of storms for the future wellbeing of all.

Unpredictable Weather Events

When discussing unpredictable weather events, we want to maintain the distinction between weather (conditions now) and climate (30-year average of conditions) while connecting the increase in unpredictable weather to climate change. Here is an example of how the unpredictable weather event metaphor can be used.

To protect people and local habitats from climate change impacts, we need to responsibly manage our community responses to extreme weather events (**NNOCCI Value**). As we burn coal, oil, and methane gas for energy production, excess carbon dioxide is released into the

atmosphere. This extra carbon dioxide acts as a heat trapping blanket, which disrupts the climate and can lead to unpredictable weather events (**NNOCCI Climate Change Metaphor**). Unpredictable weather events due to climate change are as unpredictable as traffic conditions. When you don't know what's going on in front of you, it is hard to know when to slow or speed up. Since we cannot predict the change in weather patterns due to climate change, it can be difficult to prepare for unpredictable weather events (**Extreme Events Metaphor**). We can protect our communities now and in the future by working together to mitigate the impacts of unpredictable weather (**Cue following Community Level Solutions**). Together, we can support legislation that provides community programs for improving resilience through more green spaces, sustainable development, and emergency preparedness education. We can also advocate for changes in insurance policies- for example, many companies will only allow homes to be rebuilt as they were rather than allowing for modifications to address unpredictable weather. Support greener cities by advocating for public transit, more green spaces, and green infrastructure that will reduce energy use and improve living conditions for people, plants, and animals. With responsible management, we can mitigate the impacts of unpredictable weather due to climate change on all the organisms who call our community home.

These are just a few examples of how you can use framing to talk about extreme weather events. It is important to ensure that the community solutions you offer are relevant to the community you are addressing. Using each of these strategies together can lead to more hopeful conversations and an audience who feels empowered to make change (Ennes & Triana, 2024).

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