

No. 25-170

IN THE

Supreme Court of the United States

SUNCOR ENERGY (U.S.A.), INC., ET AL.,
Petitioners,

v.

COUNTY COMMISSIONERS OF BOULDER COUNTY, ET AL.,
Respondents.

*On Writ of Certiorari to the Supreme Court of
Colorado*

**BRIEF FOR *AMICUS CURIAE* NATURAL
RESOURCES DEFENSE COUNCIL IN
SUPPORT OF RESPONDENTS**

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INTEREST OF *AMICUS CURIAE*¹

The Natural Resources Defense Council (NRDC) is a national non-profit membership organization whose mission includes advocating for evidence-based decisionmaking to protect people and the environment. Science informs all aspects of our work, from identifying environmental and public health problems to forging effective solutions. Accordingly, NRDC has a longstanding organizational commitment to developing scientific expertise. Over 60 members of our staff have advanced scientific degrees and our scientists have published more than 70 articles in peer-reviewed scientific journals since 2020. Since its founding in 1970, NRDC has litigated hundreds of environmental cases, many of which concern laws and regulations pertaining to greenhouse gas emissions. Here, as in all such cases, NRDC has a strong interest in ensuring that the Court relies on accurate, robust, and credible climate science. Although the merits of Boulder’s claims are not presently before the Court, Petitioners repeatedly claim that the climate change harms affecting Boulder cannot be traced to their sources. In doing so, Petitioners overlook an extensive body of established climate science that draws these causal lines. NRDC submits this brief to correct the record and provide the Court with an overview of these scientific capabilities.

¹ Pursuant to Rule 37.6, counsel for *Amicus Curiae* certifies that this brief was not authored in whole or in part by counsel for any party, and that no person or entity other than counsel for *Amicus* has made a monetary contribution to the preparation and submission of this brief.

SUMMARY OF ARGUMENT

Throughout their Opening Brief, Petitioners incorrectly state that greenhouse gas emissions cannot be traced to their sources, and that the climate change harms affecting Boulder cannot be attributed to those sources. *See* Pet. Br. 28, 36–37. In doing so, they improperly—and erroneously—prejudge whether Boulder’s claims will succeed on the merits, an issue not before this Court.

As a scientific matter, Petitioners are both incorrect and a decade or more behind the consensus of the leading national and international bodies of climate experts. Peer-reviewed studies have identified and quantified the contribution of specific causal factors—including specific categories of emissions, such as those from fossil fuel producers—to observed changes in the climate system.

The effects of climate change are already far-reaching. “Global temperature has increased faster in the past 50 years than at any time in at least the past 2,000 years.” U.S. Global Change Rsch. Program, Fifth National Climate Assessment 1-17 (2023), <https://tinyurl.com/5sr45k88> (hereinafter Fifth-NCA). The United States is warming even faster than the global average. *Id.* 1-40. Alongside this warming, extreme weather events, such as heat and heatwaves, droughts, heavy precipitation events, and wildfires, have become increasingly severe or frequent. *Id.* at 1-16.

Climate attribution science—the branch of climate science that identifies and quantifies the contribution of specific causal factors to observed changes in the climate system—has advanced significantly. While in

2007 the Intergovernmental Panel on Climate Change (“IPCC”)—the leading global authority on climate science—could conclude only that human greenhouse gas emissions “very likely” caused global warming, in 2023 the IPCC concluded that human greenhouse gas emissions “have unequivocally caused global warming.” *Compare* IPCC, Summary for Policymakers, in Synthesis Report, Fourth Assessment Report 5 (2007), <https://tinyurl.com/yc7bj6zt>, with IPCC, Summary for Policymakers, in Synthesis Report, Sixth Assessment Report 4 (2023), <https://tinyurl.com/546wpt8j> (hereinafter Sixth-IPCC-SR). Two preeminent national climate expert bodies—the National Academies of Science, Engineering, and Medicine (“National Academies”), and the U.S. Global Change Research Program (“USGCRP”)—are in accord. *See* National Academies, Effects of Human-Caused Greenhouse Gas Emissions on U.S. Climate, Health, and Welfare 9–10 (2025), <https://tinyurl.com/4rrv8x4d> (hereinafter NAS-2025); Fifth-NCA at 3-5.

Climate attribution science has also progressed substantially in its ability to show how human greenhouse gas emissions have contributed to the increasing severity or frequency of extreme weather events and resulting economic, property, and public health harms. *See* Fifth-NCA at 3-18 (“The science of evaluating the effects of human-caused climate change on extreme weather and climate events has advanced significantly. Human influence has changed the frequency and intensity of some types of extreme events, and it is now possible to quantify the influence of anthropogenic climate change on certain types of specific extreme events.”). For example, attribution studies have shown that human greenhouse gas

emissions have increased the likelihood of heatwaves. See Nicholas J. Leach et al., *Heatwave Attribution Based on Reliable Operational Weather Forecasts*, 15 *Nature Commc'ns*, no. 4530, May 30, 2024, at 1, <https://tinyurl.com/543fmfw7> (concluding that human emissions made the 2021 Pacific Northwest heatwave at least 8 times more likely (with a range of 2–50 times more likely)). Studies have also shown how human emissions have contributed to the resulting harms of extreme heat events. See A.M. Vicedo-Cabrera et al., *The Burden of Heat-Related Mortality Attributable to Recent Human-Induced Climate Change*, 11 *Nature Climate Change* 492, 492 (2021), <https://tinyurl.com/yfbv3xzs> (concluding that from 1991–2018, anthropogenic climate change caused 37% of warm-season heat-related deaths (with a range of 20.5%–76.3%)).

Attribution science has also demonstrated how the greenhouse gas emissions of particular entities, like major fossil fuel producers, have contributed to climatic changes and resulting harms. Such studies have not only traced the greenhouse gas emissions of particular entities that have led to these climatic conditions, see Richard Heede, *Tracing Anthropogenic Carbon Dioxide and Methane Emissions to Fossil Fuel and Cement Producers, 1854–2010*, 122 *Climatic Change* 229 (2014), <https://tinyurl.com/mfu56rtc>, but have also quantified those entities' contributions to specific extreme weather events, see, e.g., Yann Quilcaille et al., *Systemic Attribution of Heatwaves to the Emissions of Carbon Majors*, 645 *Nature* 392, 392, 395–96 (2025), <https://tinyurl.com/45c5jcck> (concluding that 180 major fossil fuel and cement producers “substantially contributed” to making 213 historical heatwaves from 2000–2023 “more likely and

more intense” and individual entities’ contributions were “high enough to enable the occurrence of 16–53 heatwaves that would have been virtually impossible in a preindustrial climate”).

These studies do not represent outliers or fringe positions. Established scientific experts have long recognized that attribution science can identify and quantify human contribution to observed changes in the climate system. The National Academies released a landmark report recognizing the capabilities of attribution science in 2016 and issued a subsequent report recognizing substantial advances in the field just three weeks ago. *See* Nat’l Academies, *Attribution of Extreme Weather Events in the Context of Climate Change* (2016), <https://tinyurl.com/mvy3s8rb> (hereinafter NAS-2016); Nat’l Academies, *Attribution of Extreme Weather and Climate Events and Their Impacts* (2026) <https://tinyurl.com/2sdww5eu>, (hereinafter NAS-2026). And the IPCC and USGCRP rely extensively on attribution science to inform their conclusions about observed changes in the climatic system, including global warming, worsening extreme weather events, and resulting harms. *See generally* IPCC, *Chapter 11: Weather and Climate Extreme Events in a Changing Climate*, in *The Physical Science Basis, Sixth Assessment Report* (2021), <https://tinyurl.com/2s37b65f> (hereinafter Sixth-IPCC-Chapter11); Fifth-NCA at 3-5 to 3-37.

The Court should disregard Petitioners’ mischaracterization of the science and affirm the Colorado Supreme Court’s decision if it does not dismiss for lack of jurisdiction. Boulder should have an opportunity to proceed to the merits of its case and

show that its harms are attributable to Petitioners' greenhouse gas emissions.

ARGUMENT

I. Global warming and worsening extreme weather events are already harming states and communities.

The alleged injury at the core of Boulder's lawsuit—that it has experienced concrete harms caused by climate change—is consistent with broader findings that scientists have observed and documented for years. The scientific record shows that the effects of climate change are already far-reaching. Present-day levels of greenhouse gases in the atmosphere are higher than at any time in at least the past 800,000 years. Fifth-NCA at 1-17. Carbon dioxide concentrations have now reached approximately 430 parts per million (ppm), compared to a pre-industrial baseline of approximately 280 ppm. NASA, *Carbon Dioxide – Earth Indicator* (June 2026), <https://perma.cc/CZ4H-CQTB>; Fifth-NCA at 2-6.

These unprecedented levels of atmospheric greenhouse gas concentrations have been accompanied by unprecedented rates of global warming. “Global temperature has increased faster in the past 50 years than at any time in at least the past 2,000 years.” Fifth-NCA at 1-17. And the continental United States has been warming 60% faster than the global average. *Id.* at 2-4. Since 1970, temperatures in the contiguous United States have risen by 2.5°F and temperatures in Alaska have risen by 4.2°F. *Id.* at 2-11.

Global warming has been linked to other observed changes in the climate system as well. These include

increases in the frequency and intensity of hot extremes and decreases in the frequency and intensity of cold extremes over 80% of global land surface, including in the United States. NAS-2026 at 48–49. The western United States has been particularly afflicted “by extreme heat since the 1980s, experiencing a larger increase in days over 95°F, as would be expected given the greater warming in that region relative to” the eastern United States. Fifth-NCA at 2-17. In recent decades, multiday heatwaves have become hotter, more frequent, longer lasting, and have harmed a larger geographic area. *Id.* “[T]he average number of heatwaves has doubled since the 1980s, and the length of the heatwave season has increased from about 40 days to about 70 days.” *Id.*

Global warming has also led to global sea level rise due to melting glaciers and ice sheets and thermal expansion from ocean warming. IPCC, *Summary for Policy Makers, in The Physical Science Basis, Contribution of Working Group I to the Sixth Assessment Report* 11 (2021), <https://tinyurl.com/29aa8w47> (hereinafter Sixth-IPCC-WGI). “The rate of sea level rise in the 20th century was faster than in any other century in at least the last 3,000 years.” Fifth-NCA at 1-17; *see also* Sixth-IPCC-WGI at 8 (stating same with “high confidence”).

Global warming has also caused more frequent and intense precipitation events. Warming increases the vapor pressure deficit—a measure of the difference between the amount of moisture in the air and the amount of moisture that the air could hold at saturation. *See* Fifth-NCA at 3-21 to 3-22. At higher temperatures, the atmosphere can hold more water

vapor, which in turn results in heavier precipitation events. *See id.* Accordingly, “[t]he frequency and intensity of heavy precipitation events have increased across much of the United States.” *Id.* at 2-19; *see id.* at 3-22; NAS-2026 at 54. The IPCC similarly concluded that in the United States “there is an overall increase in one-day heavy precipitation, both in terms of intensity and frequency.” Sixth-IPCC-Chapter11 at 1560. In the southwest United States, total precipitation falling on the heaviest 1% of days has increased by 17%. Fifth-NCA at 2-19 & fig. 2.8.

Global warming also leads to increased drought, “primarily through warming-induced increases in evaporative demand and surface water losses” as the air pulls water from moisture in the soil, vegetation, and bodies of water. Fifth-NCA at 3-32. This can result in agricultural drought—which occurs when moisture in the soil is depleted and cannot support agricultural yields—or hydrological drought—which occurs when surface and subsurface water supplies are depleted. *See id.* at 2-19. Rising global temperatures increase the intensity, frequency, and duration of droughts and “are already amplifying hydrological drought severity in California, the Pacific Northwest, the Colorado River Basin, and across southwestern North America.” *Id.* at 3-32, 2-25.

Wildfires have also become more severe. High vapor pressure deficit “is strongly associated with the hot and dry weather conditions conducive to the intensification and spread of wildfires, as well as with drier” vegetation that fuels wildfires. Fifth-NCA at 3-32. “In recent decades, warmer temperatures, declines in humidity, and increases in [vapor pressure deficit] have caused large-scale increases in fire weather and

areas burned by wildfire” in the western United States. *Id.*; see also NAS-2026 at 61 (“In the western United States . . . both the area and the severity of wildfires and their associated damages have increased in the last four decades.”).

The resulting harms of these more severe or frequent extremes are also increasing across the country. These include “increases in heat-related illnesses and death, costlier storm damages, longer droughts that reduce agricultural productivity and strain water systems, and larger, more severe wildfires that threaten homes and degrade air quality.” Fifth-NCA at 1-17.

The severe impacts discussed above are not theoretical or purely a prediction of things to come. They are observed phenomena that are already taking a toll on states and communities across the country. For that reason, Boulder’s allegations in this lawsuit, if proven at trial, would put it among the many communities already recognized to be experiencing increasingly severe or frequent extreme weather events linked to climate change.

II. Climate attribution science can identify the causes of climate change and quantify their role in observed climate change harms.

Just as science corroborates the present-day reality of extreme weather events, it also provides credible methodologies for establishing their cause. As elaborated further in the sections to follow, such methodologies have been used to demonstrate the causal link not just between particular types of weather events and human greenhouse gas emissions generally, but also between particular types of

weather events and greenhouse gas emissions from particular sources. If given the opportunity to proceed to the merits of its case, Boulder could draw on these methodologies to demonstrate the causal links it alleges between the climatic harms it is experiencing and Petitioners' emissions.

Attribution science is the branch of climate science that identifies and quantifies the contribution of specific causal factors to observed changes in the climate system and extreme weather events. It can identify and quantify the extent to which human contributions—like greenhouse gas emissions, aerosols, and land-use changes—have distorted the climate system. Attribution science allows scientists to study questions such as: How much of the observed global warming or sea level rise has been caused by human emissions? Or, to what extent have human emissions made wildfires more severe or frequent? Attribution science does not assert that human activity is the sole cause of any particular weather event or the damage resulting from that event, but rather, analyzes the extent to which human activity contributed to making the event more likely, severe, or damaging.

Climate attribution science relies on counterfactual modeling, which is standard across many other scientific disciplines, including epidemiology. *See* NAS-2016 at 29, 34. Scientists compare the actual event against modeled scenarios of what might have occurred in a world without human contributions like greenhouse gas emissions. By running simulations with and without human contributions, researchers can isolate the effect of human contributions from natural variability.

Attribution science has several subfields. Trend attribution analyzes how human contributions have altered long-term trends like global warming or sea-level rise. For example, scientists have concluded that “[h]uman activities, principally through emissions of greenhouse gases, have unequivocally caused global warming[.]” Sixth-IPCC-SR at 4. Event attribution assesses the role of climate change in individual extreme weather events such as heatwaves, floods, and hurricanes. Event attribution studies quantify changes in the likelihood, intensity, or frequency of a given extreme event. For example, scientists have estimated that in 2017, Hurricane Harvey’s rainfall was “about 15%–20% heavier than it would have been without human-caused warming.” Fifth-NCA at 2-4. Impact attribution quantifies the contribution of climate change to real-world harms, such as crop failures, property damage, and mortality. For example, one study found that during Hurricane Sandy, human-caused sea level rise resulted in approximately \$8.1 billion of damages (with a range of \$4.7–\$14 billion) and increased the flood area to affect 71,000 additional people (with a range of 40,000–131,000 additional people). See Benjamin H. Strauss et al., *Economic Damages from Hurricane Sandy Attributable to Sea Level Rise Caused by Anthropogenic Climate Change*, 12 *Nature Commc’ns*, no. 2720, May 18, 2021, at 1, <https://tinyurl.com/3j5jdfw7>. Source attribution quantifies the impact of emissions from specific entities—such as countries or fossil fuel producers—on changes in climate trends or extreme weather events. For example, one study found that emissions from 88 major fossil fuel producers and cement manufacturers were responsible for more than 50% of

ocean acidification since 1880. *See* R. Licker et al., *Attributing Ocean Acidification to Major Carbon Producers*, 14 *Env'tl Rsch. Letters*, no. 124060, Dec. 11, 2019, at 1, <https://tinyurl.com/5ybwmrh5>.

Preeminent national and international scientific organizations have recognized attribution science for at least a decade. This includes the National Academies, which published a landmark report in 2016 on the capabilities of attribution science and a subsequent report in 2026 on the further advancements of the field. *See generally* NAS-2016; NAS-2026. The second report was released just weeks after Petitioners asserted in their opening brief that the impacts of greenhouse gas emissions cannot be disaggregated and traced. *See* NAS-2026. The leading climate authorities on the international and national levels, the IPCC and the USGCRP, both rely on attribution science in preparing their scientific reports. The IPCC is the United Nations body responsible for reviewing and synthesizing peer-reviewed climate literature to create comprehensive Assessment Reports. The USGCRP coordinates fifteen federal agencies to synthesize the state of climate research and prepare a National Climate Assessment, which is peer-reviewed by the National Academies and presented to Congress and the President. Attribution studies appear in prominent peer-reviewed scientific journals including *Nature*, *Science*, *Environmental Research Letters*, and *Proceedings of the National Academy of Sciences (PNAS)*.

The IPCC and USGCRP have evaluated attribution studies across multiple report cycles and concluded that attribution science has continued to strengthen. In its most recent Assessment, the IPCC

stated with “high confidence” that the attribution of human influence on changes in extreme events “such as heatwaves, heavy precipitation, droughts, and tropical cyclones” had “further strengthened since” its preceding Assessment. Sixth-IPCC-SR 5. The IPCC also stated that, since its last Assessment, the impacts from extreme events were also “increasingly” attributed to human-induced climate change, including “heat-related human mortality (medium confidence),” “drought-related tree mortality (high confidence),” and “areas burned by wildfires (medium to high confidence).” IPCC, *Summary for Policymakers, in Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report* 9 (2022), <https://tinyurl.com/2p7scevc>.

The National Academies similarly stated in its 2026 report that “methodological advances have significantly enhanced attribution capabilities,” strengthening its scientific foundation since 2016. NAS-2026 at 21. This progress reflects deeper “scientific understanding of the physical drivers of extreme events, expanded observational data, new statistical techniques and improved physical and empirical models.” *Id.* at 10. There has been an “exponential increase in the number of published attribution studies covering more regions of the globe and more event types.” *Id.* at 170. Attribution science is beginning to be integrated into a range of societal applications. The private sector has begun using it for insurance and other risk management work. *Id.* at 35-36.

Consistent with scientific best practices, scientists in the field acknowledge that there is higher

confidence in attribution results for some types of extreme weather events than for others. “In general, confidence in attribution results is strongest for extreme event types that have a long-term historical record of observations to place the event in an appropriate historical context; are simulated adequately in climate models; and are either purely meteorological in nature (i.e., the nature of the event is not strongly influenced by the built infrastructure, resource management actions, etc.) or occur in circumstances where these confounding factors can be carefully and reliably considered.” NAS-2016 at 5-6.

Confidence in attribution results is reflected in the language scientists use to communicate their findings to the public. For example, the IPCC uses a scale of confidence levels from “very high” to “very low confidence” to qualitatively express “the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement.” IPCC, Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties 3 (2010), <https://tinyurl.com/5yt9mz9w>. Scientists also use probabilistic language to describe any statistical uncertainty in their results. For example, the IPCC uses a scale of “virtually certain” to “exceptionally unlikely” to communicate these uncertainties. *See id.*

In sum, climate attribution science has developed well-recognized and credible methodologies that answer questions about the causes and contributions of climatic changes and their resulting damages. As further elaborated in the sections to follow, these

methodologies have been used to attribute the severity or frequency of certain types of extreme weather events to human greenhouse gas emissions generally, and to the emissions of fossil fuel producers in particular. Petitioners' repeated suggestion that it would be impossible for Boulder to draw a line between their products and Boulder's harms simply ignores these methodologies, all of which Boulder could draw on should the case proceed to the merits.

III. Attribution science has identified and quantified the contributing causes of global warming.

The scientific record has established that human greenhouse gas emissions cause global warming. In its most recent Assessment, the IPCC concluded that “[h]uman activities, principally through emissions of greenhouse gases, have unequivocally caused global warming.” Sixth-IPCC-SR 4; *see also* Fifth-NCA at 3-5 (same). As a result of human greenhouse gas emissions, the planet is on average 2°F warmer than it was in the late 1800s. Fifth-NCA at 2-4. “No natural processes known to science could have caused this long-term temperature trend. The only credible explanation for the observed warming is human activities.” *Id.*

Multiple lines of evidence support the conclusion that human greenhouse gas emissions are the dominant cause of climate change. NAS-2025 at 9. This includes isotopic fingerprinting, which shows that atmospheric carbon dioxide predominantly originates from fossil fuels. NAS-2025 at 19. It also includes evidence that the lowest atmospheric layer (the troposphere) is warming while the layer directly above it (the stratosphere) is cooling, which provides

“incontrovertible evidence” that our global warming is not caused by natural forces like incoming solar radiation. Benjamin D. Santer et al., *Exceptional Stratospheric Contribution to Human Fingerprints on Atmospheric Temperature*, 120 PNAS 1, 9 (2023), <https://tinyurl.com/48tsfx9r>; *see also* NAS-2025 at 9.

IV. Attribution science has identified and quantified the contributing causes of worsening extreme weather events.

As to the more granular question of how human greenhouse gas emissions contribute to particular types of extreme weather events, climate attribution science has shown that they are increasing the intensity or frequency of various types of extreme weather events, including extreme heat and heatwaves, drought, extreme precipitation, and wildfires. This body of work—and the methodologies behind it—would all be available to Boulder at the merits stage to make its case that greenhouse gas emissions have increased the severity and frequency of extreme weather events harming Boulder, and have resulted in economic, public health, and other harms to Boulder.

A. Extreme Heat and Heatwaves

Heat extremes are the most widely studied event type in the field of extreme event attribution. *See* NAS-2026 at 97. Approximately 150 studies have attributed the likelihood or severity of heat extremes on every continent. *Id.* The National Academies concluded in 2016 that confidence was highest in attributing temperature extremes, *see* NAS-2016 at 128, and that “level of confidence has strengthened . . . since the 2016 report[.]” NAS-2026 at 100. Although some challenges remain in conducting attribution studies,

“[l]ong observational records, strong understanding of key physical drivers, and high model skill in simulating observed temperature distributions and extremes contribute to very high confidence in the attribution of hot and cold extremes in most regions.” *Id.*

The National Academies has accordingly concluded that “[t]he evidence shows a clear and widespread increase in the frequency, intensity, and duration of heat extremes, alongside decreases in cold extremes, driven primarily by thermodynamic shifts in temperature distributions under anthropogenic warming.” NAS-2026 at 50. The IPCC also concluded with “virtual certainty” that human greenhouse gas emissions are the “main driver of the observed changes in hot and cold extremes on the global scale.” *Id.* at 97–98.

Attribution studies have examined the role that human contributions have played in exacerbating heatwaves. Several have studied the record-breaking 2021 Pacific Northwest heatwave. One study concluded “that human activities caused” approximately a “0.8°C–1°C increase in the observed daily maximum temperatures” during the heatwave. Emily Bercos-Hickey et al., *Anthropogenic Contributions to the 2021 Pacific Northwest Heatwave*, 49 Geophysical Resch. Letters, no. e2022GL099396, Dec. 16, 2022, at 1, <https://tinyurl.com/2af844t3>. Another found that human influence on the climate made the heatwave at least 8 times more likely (with a range of 2–50 times more likely). See Leach et al., *Heatwave Attribution Based on Reliable Operational Weather Forecasts*, *supra* at 1.

Scientists have also attributed the serious health impacts of extreme heat to human emissions. One study found that from 1991–2018, 37% of warm-season heat-related deaths (with a range of 20.5%–76.3%) were attributable to anthropogenic climate change. See Vicedo-Cabrera et al., *The Burden of Heat-Related Mortality Attributable to Recent Human-Induced Climate Change*, *supra* at 492.

B. Droughts

Drought, while “a complex phenomenon due to the many physical processes involved and the broad range of societal factors that influence its occurrence and intensity,” is “influenced by temperature in ways that are better understood, and thus more amenable to attribution.” NAS-2016 at 98. For example, “temperature exacerbates hydrological drought in some regions by increasing surface evaporation, so that increasing temperature causes an increasing risk of hydrological drought even if precipitation does not change.” *Id.*

The IPCC has concluded with medium confidence that human-induced climate change has contributed to increased agricultural and ecological droughts in some regions, including in western North America, due to global warming’s effect on evapotranspiration. Sixth-IPCC-Chapter11 at 1518-19. The National Academies 2026 report similarly concluded that “there is medium confidence in attributing drought events to climate change, supported by expanding observational datasets and improved modeling techniques,” even as attribution of hydrological and agricultural droughts remains “complicated by human factors and data availability.” NAS-2026 at 103.

The National Climate Assessment found that even with the complexities in defining a drought and accounting for its various drivers, “some robust regional trends are emerging.” Fifth-NCA at 2-19. For example, the Colorado River streamflow from 2000–2014 was 19% lower than the 20th century average. *Id.* A study found that “[a]pproximately one-third of the flow loss is due to high temperatures now common in the basin, a result of human-caused climate change.” Bradley Udall & Jonathan Overpeck, *The Twenty-First Century Colorado River Hot Drought and Implications for the Future*, 53 Water Res. Rsch. 2404, 2404 (2017), <https://tinyurl.com/365nrcrp>; see also Fifth-NCA at 2-19 (same).

Several other studies have examined the role of human contributions to drought in the western United States. One found that anthropogenic climate change was responsible for 46% of the drought severity in southwestern North America from 2000–2018, “pushing an otherwise moderate drought onto a trajectory comparable to the worst [southwestern North America] megadroughts since 800 CE.” A. Park Williams et al., *Large Contribution from Anthropogenic Warming to an Emerging North American Megadrought*, 368 Science 314, 314 (2020), <https://tinyurl.com/424rxa5s>. Another study on drought in the Four Corners region of the western United States found that human-induced warming increased vapor pressure deficits by approximately 18%–30% and reduced snow water equivalent by approximately 20%. Emily Williams et al., *Quantifying Human-Induced Temperature Impacts on the 2018 United States Four Corners Hydrologic and Agro-pastoral Drought*, 101 Bulletin Am. Meteorological Soc’y 15, 15 (2020),

<https://tinyurl.com/b8pts7pn>; see also NAS-2026 at 101 (same). And another, on the drought in California’s Central Valley, found that over one-third of the increase in irrigation demand was attributable to human-caused climate change. See Emily L. Williams & John T. Abatzoglou, *Climate Change Increases Evaporative and Crop Irrigation Demand in North America*, 13 *Earth’s Future*, no. e2025EF005931, July 2, 2025, at 1, <https://tinyurl.com/2d24a27v>.

C. Extreme Precipitation

“Since 2016, the attribution of extreme rainfall has advanced considerably” and “[e]vidence linking observed increases in heavy precipitation events to human influence has strengthened.” NAS-2026 at 103. The National Academies has concluded that in areas with “rich observational data and regional model configuration, there is medium to high confidence in the attribution of individual extreme rainfall events to climate change.” NAS-2026 at 104. For its part, the IPCC has concluded that “human influence, in particular greenhouse gas emissions, is likely the main driver of the observed global-scale intensification of heavy precipitation over land regions.” Sixth-IPCC-Chapter11 at 1518. In the United States, the National Climate Assessment concluded that “[t]here is robust evidence that human-caused warming has contributed to increases in the frequency and severity of the heaviest precipitation events across nearly 70%” of the country. Fifth-NCA at 2-18. One study established that anthropogenic climate change has contributed to the intensification of continental and regional extreme precipitation in North America. See Megan C. Kirchmeier-Young & Xuebin Zhang, *Human Influence*

has Intensified Extreme Precipitation in North America, 117 PNAS 13308, 13308 (2020), <https://tinyurl.com/4td2yc3f>; Sixth-IPCC-Chapter11 at 1563 (same).

The National Academies reported an increase in the number of studies on individual rainfall events and noted that many found that anthropogenic influence increased extreme precipitation, though others did not. NAS-2026 at 103. Event attribution studies in parts of the United States have found that anthropogenic activity has influenced the probability or magnitude of observed extreme precipitation for individual events. Sixth-IPCC-Chapter11 at 1562–63. One study found that human-caused climate change made the 2018 heavy precipitation and flooding events that occurred in the mid-Atlantic states 1.1–2.3 times more likely. See Jonathan M. Winter et al., *Anthropogenic Impacts on the Exceptional Precipitation of 2018 in the Mid-Atlantic United States*, 101 Bulletin Am. Meteorological Soc’y 5, 8 (2020), <https://tinyurl.com/yc3ty5e8>.

D. Wildfires

The National Academies has noted that the attribution of wildfires is challenging due to various factors such as the role of humans in ignitions and in fire suppression and management, the role of lightning in igniting large fire outbreaks, and the importance of multiple weather factors, like wind and humidity for fire spread, and rain for extinguishing fire outbreak. See NAS-2026 at 110. For these reasons, “there is low confidence in attributing specific wildfire events.” *Id.* at 113. However, “[i]t is very likely that climate change has increased the likelihood and severity of extreme fire weather[,]” which includes

“conditions such as high temperatures, low humidity, and dry vegetation that promote wildfire activity.” *Id.* “In some cases, increases in high temperatures and drier vegetation have likely contributed to the increased likelihood of frequency and total burned area in many regions.” *Id.*

As the National Climate Assessment highlighted, one study found that between 1979–2020, anthropogenic warming caused 68%–88% of the vapor pressure deficit trend in the western United States. Yizhou Zhuang et al., *Quantifying Contributions of Natural Variability and Anthropogenic Forcings on Increased Fire Weather Risk over the Western United States*, 118 PNAS, no. e2111875118, Nov. 1, 2021, at 1, <https://tinyurl.com/3vupkya9>; *see also* Fifth-NCA at 2-20 (same). Another study found that anthropogenic climate change caused approximately 55% of the documented increases in vegetation dryness in the western United States since the 1970s and contributed to an additional 4.2 million hectares of forest fire area during 1984–2015, nearly doubling the forest fire area expected in its absence. *See* John T. Abatzoglou & A. Park Williams, *Impact of Anthropogenic Climate Change on Wildfire Across Western US Forests*, 113 PNAS 11770, 11770 (2016), <https://tinyurl.com/2kbj37x7>; *see also* Fifth-NCA at 3-32 (same). And yet another study found that nearly all increases in burned area in California over the past half-century were attributable to anthropogenic climate change. *See* Marco Turco et al., *Anthropogenic Climate Change Impacts Exacerbate Summer Forest Fires in California*, 120 PNAS, no. e2213815120, June 12, 2023, at 1, <https://tinyurl.com/ywyhx7ue>.

Other attribution studies have quantified the health and economic impacts of wildfires. One found that climate change contributed to approximately 15,000 wildfire particulate matter deaths over fifteen years and a cumulative economic burden of \$160 billion in the contiguous United States. Beverly E. Law et al., *Anthropogenic Climate Change Contributes to Wildfire Particulate Matter and Related Mortality in the United States*, 6 Commc'ns Earth & Env't, no. 336, May 2, 2025, at 1, <https://tinyurl.com/3shraz85>.

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The studies discussed above are just a few examples of event attribution studies that have identified and quantified the extent to which human greenhouse gas emissions have increased the severity or frequency of various types of extreme weather events, including event types that Boulder has alleged are harming its people and property. If Boulder's case proceeds to the merits, these event attribution methodologies could be used to answer whether and to what extent greenhouse gas emissions have caused Boulder's alleged harms.

V. Attribution science has identified and quantified the contributions of particular entities to global warming and worsening extreme weather events.

The final link that Boulder would seek to prove if this case proceeds to the merits is that Petitioners' greenhouse gas emissions contributed to Boulder's injuries. This brief takes no position on whether Boulder *will* show that Petitioners contributed to its alleged harms. That question is not before the Court, and Boulder has not yet had the opportunity to present the factual and expert evidence needed to make its

case. The critical point at this stage in the proceedings is that, notwithstanding Petitioners' assumption to the contrary, scientists have developed established methodologies for assessing exactly that question.

Source attribution studies have ascribed observed climate change harms to particular entities, including major fossil fuel producers. Like other types of attribution science and other types of scientific disciplines, source attribution studies rely on counterfactual modeling to isolate and quantify the effect of particular entities' greenhouse gas emissions on the climate system. To do so, these studies use record data to establish entities' greenhouse gas contributions and employ climate models to simulate the climate system with and without these entities' contributions.

A landmark study traced the amount of carbon dioxide and methane emissions attributable to the 90 largest investor- and state-owned fossil fuel companies and cement manufacturers. See Richard Heede, *Tracing Anthropogenic Carbon Dioxide and Methane Emissions to Fossil Fuel and Cement Producers, 1854–2010*, *supra* at 229. Subsequent studies expanded on this work, linking entities' greenhouse gas emissions to changes in the climate system. One study found that emissions traced to those 90 largest carbon producers have contributed approximately 57% of the observed rise in atmospheric carbon dioxide, 42%–50% of the rise in global mean surface temperature, and 26%–32% of global sea level rise since 1880. B. Ekwurzel et al., *The Rise in Global Atmospheric CO₂, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers*, 144 *Climatic Change* 579, 579 (2017), <https://tinyurl.com/3ysc4kks>. And in the

time period from 1980 to 2010—a time when fossil fuel companies were aware that their products were causing global warming—those same 90 producers contributed approximately 43% of the rise in atmospheric carbon dioxide, 29%–35% of the rise in global mean surface temperature, and 11%–14% of global sea level rise. *Id.*

Another study found that emissions from the world’s 122 largest fossil fuel and cement producers from 1854–2020 contributed 37%–58% to present-day surface air temperature rise and 24%–37% of the observed global mean sea level rise to date. *See* Shaina Sadai, *Estimating the Sea Level Rise Responsibility of Industrial Carbon Producers*, 20 Env’t Rsch. Letters, no. 044012, Mar. 18, 2025, at 1, <https://tinyurl.com/48jacr76>. In addition, the study found that emissions from those entities through 2020 are expected to contribute an additional 0.26–0.55 meters of global sea level rise through 2300. *Id.*

Other source attribution studies have identified and quantified the extent to which entities have contributed to increasing the severity or likelihood of extreme weather events. For example, one study found that 180 fossil fuel and cement producers “substantially contributed” to making 213 historical heatwaves from 2000–2023 “more likely and more intense.” Quilcaille et al., *Systemic Attribution of Heatwaves to the Emissions of Carbon Majors*, *supra* at 392. Individual entities’ contributions were “high enough to enable the occurrence of 16–53 heatwaves that would have been virtually impossible in a preindustrial climate.” *Id.* Another study found that emissions traced to 88 major fossil fuel producers and cement manufacturers contributed 48% (with an

interquartile range of 38%–63%) of the long-term rise in vapor pressure deficit from 1901–2021. *See* Kristina A. Dahl et al., *Quantifying the Contribution of Major Carbon Producers to Increases in Vapor Pressure Deficit and Burned Area in Western US and Southwestern Canadian Forests*, 18 *Env't Rsch. Letters*, no. 064011, May 16, 2023, at 1, <https://tinyurl.com/2s3jp5fp>. Those emissions also contributed 37% (with an interquartile range of 26%–47%) of the cumulative area burned by forest fires between 1986–2021 in the western United States and southwestern Canada. *Id.*

Source attribution studies have also linked particular entities' contributions to the losses resulting from extreme weather events. One study estimated trillions of dollars in economic losses attributable to the extreme heat caused by emissions from major fossil fuel companies. *See* Christopher Callahan & Justin Mankin, *Carbon Majors and the Scientific Case for Climate Liability*, 640 *Nature* 893, 893 (2025), <https://tinyurl.com/crv48eua>. That study found that emissions linked to Chevron, for example, “very likely caused between US\$791 billion and \$3.6 trillion in heat-related losses over the period 1991–2020.” *Id.* at 893. Another study found that the top five emitting nations—the United States, China, Russia, Brazil, and India—have collectively caused \$6 trillion in income losses from warming since 1990, comparable to 11% of annual global gross domestic product. *See* Christopher Callahan & Justin Mankin, *National Attribution of Historical Climate Damages*, 172 *Climatic Change*, no. 40, July 12, 2022, at 1, <https://tinyurl.com/4tdhwj37>.

In short, attribution science has developed methodologies to identify and quantify the contributions that major fossil fuel producers have had in warming the planet, increasing the severity or frequency of extreme weather events, and causing economic and public health harms. Whether those methodologies will show that the Petitioners in this case are responsible for the harms Boulder alleges is precisely what a merits trial would test. Petitioners err in assuming the answer at the outset.

CONCLUSION

For the foregoing reasons, and those stated in the Brief for Respondents, the judgment of the Colorado Supreme Court should be affirmed if the petition is not dismissed for lack of jurisdiction.

Respectfully submitted,

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