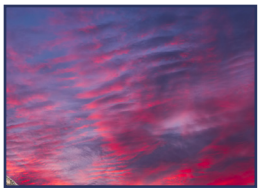

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The Fourth National Climate Assessment: A Crisis of Its Own Making

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Key Points

- The Fourth National Climate Assessment (NCA4) is not an unbiased assessment of climate science. It largely follows the climate change catastrophe narrative that advocates for reducing CO_2 emissions as quickly as possible.
- NCA4 relies heavily on an outdated and extreme emissions scenario, RCP8.5, to create unrealistic predictions of widespread environmental and economic damage from rising temperatures.
- NCA4 fails to adequately justify the level of confidence that it ascribes to most of its predictions and makes only passing references to many of the uncertainties highlighted in its underlying studies.
- The next National Climate Assessment should be subject to review by scientists willing to argue against its main conclusions, with alternative viewpoints noted in the final document.
- Recent history contradicts the pessimistic predictions of NCA4. Climate resiliency and quality of life have improved dramatically for most of humanity as energy consumption and temperatures have risen over the past century.

Executive Summary

The public discourse surrounding climate change has for many decades been dominated by the catastrophe narrative, which posits that without significant reduction in carbon dioxide (CO_2) emissions by the end of the 21st century, mankind will witness widespread destruction of ecosystems as well as massive economic and societal disruption. The alarming forecasts of this narrative—substantial losses in economic output, extensive damage to public infrastructure and coastal real estate, and significant loss of life, especially in distressed and vulnerable communities—continually serve as justification for polarizing policy proposals such as the Green New Deal.

The catastrophe narrative has become so pervasive that even the U.S. government's latest assessment of climate science, the Fourth National Climate Assessment (NCA4 or the "Assessment"), is heavily influenced by it. NCA4 is the fourth of a series of quadrennial reports produced by the U.S. Global Change Research Program with the purpose of informing Congress and the public about the latest developments in climate change science. Unfortunately, the Assessment suffers from numerous methodological errors that lead to exaggerated and unqualified predictions, elevating the catastrophe narrative rather than providing a balanced scientific assessment.

This paper will focus on two of the most important errors of NCA4: (a) the improper use of future CO_2 emission scenarios that exaggerate the ramifications of emission reductions, and (b) the use of flawed economic models to predict damage as a result of climate change. The paper will also address how these errors can be corrected in the next Assessment.

The first fundamental error of NCA4 is its extensive use of Representative Concentration Pathway 8.5 (RCP8.5), one of four projections of 21st century CO_2 emissions developed in the late 2000s for the U.N. Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report. This scenario was originally designed to simulate a future global economy in which CO_2 emissions increase dramatically throughout the 21st century. It was not designed to simulate the most likely scenario, and most official forecasts of future emissions (EIA, 2019, IEA, 2019) are far lower than what RCP8.5 forecasts. Nevertheless, NCA4 repeatedly characterizes RCP8.5 as a "business as usual" emissions scenario that would likely occur without policy changes to reduce CO_2 emissions, fueling the misleading media and political focus on extreme predictions of future climate change.

Based on RCP8.5, the Assessment projects future temperatures and climate conditions up to year 2100 and compiles a multitude of frightening predictions,

continued

including increased coastal flooding, larger wildfires, increased air pollution, and disruptions to food supplies. The Assessment goes to great lengths to make climate change more tangible for everyday Americans and their elected leaders, describing both current and future impacts region by region. Then, in the last chapter, it makes the even bolder step (and second fundamental error) of attempting to quantify economic damages from climate change and the supposed benefits of reducing CO_2 emissions now. The clear policy implications of this chapter have made it the subject of much attention from environmental groups and the press.

However, most of the calculated losses, totaling more than $500 billion annually by the end of the century (U.S. Global Change Research Program [USGCRP], 2018a, p. 1349), come from predictions suffering from significant methodological errors. Despite the fact that Americans have adapted spectacularly well to rising temperatures over the past 70-80 years, with dramatic reductions in climate-related deaths and notable environmental improvements, these economic forecasts are based on models that assume similar long-term adaptations will not take place in the 21st century. In this area and many others, the Assessment fails to highlight assumptions, uncertainties, and sensitivity analyses, projecting an unwarranted air of certainty into very uncertain predictions.

In light of these errors, several needed changes for the next Assessment (NCA5) become readily apparent. First, the IPCC has developed five new emissions scenarios to replace the RCP scenarios, and NCA5 should incorporate all five of them, rather than emphasizing the highest one, which is similar to RCP8.5. NCA5 should make it clear that current projections are tracking more closely to the lowest of the five scenarios, with the highest being very unlikely and suitable only for modeling purposes. It should also do more to detail uncertainties and sensitivity analyses for major predictions such as increases in temperature, sea level, and extreme weather, instead of assigning arbitrary confidence levels for its predictions. Finally, the Assessment authors should utilize stringent peer review with scientists willing to honor the scientific method and argue against all of the primary conclusions. It should also make clear mention of alternative points of view throughout the final document.

Introduction

In recent years, scientific and policy discussions regarding climate change have become increasingly dominated by what is often called the catastrophe narrative. The catastrophe narrative holds that, absent deep cuts to carbon dioxide (CO_2) emissions, we are heading toward a global-warming catastrophe that will destroy ecosystems and upend human civilization by the end of the 21st century. This narrative is primarily propagated by scientists, policymakers, environmental activists, and journalists who also advocate for dramatic CO_2 emissions cuts via government mandates.

The most recent and popular manifestation of the catastrophe narrative is the Green New Deal, which began as a resolution authored by New York Rep. Alexandria Ocasio-Cortez (H. Res. 109, 2019) and has now become a catch-all term for the policy prescriptions of the most ardent proponents of the narrative. The Green New Deal is a classic example of the polarization that the narrative creates—a rallying cry for proponents, including Sen. Bernie Sanders, who made the term a staple of the 2020 Democratic presidential primaries, and a lightning rod for critics of the narrative and its policy proposals.

Some of the predictions cited in the Green New Deal as justification for action include (H. Res. 109, 2019)

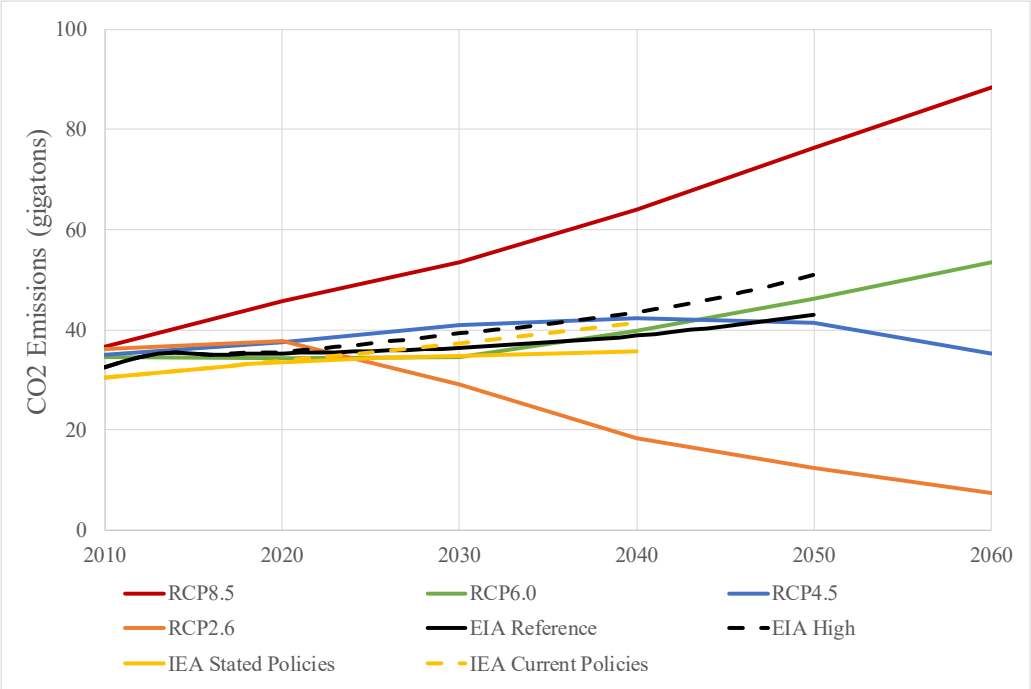
- More than $500 million in lost annual economic output in the U.S. by the year 2100;
- Wildfires that will burn more than twice as much area in the U.S. as they have in recent history;
- The potential for a trillion dollars in damages to public infrastructure and coastal real estate in the U.S.

These predictions come from a document that is less known than the Green New Deal but is of far greater importance to the larger debates around climate science and policy: the Fourth National Climate Assessment, known as NCA4 or "the Assessment."

NCA4 is the latest in a series of recurring reports produced by the U.S. Global Change Research Program (USGCRP), which was created by Congress in 1990 to "provide for development and coordination of a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change," (Global Change Research Act of 1990, 101(b)). It brings together representatives of 13 federal agencies (USGCRP, n.d.) under the auspices of the Subcommittee on Global Change Research of the Committee on Environment within the National Science and Technology Council.

NCA4 contains multiple causes for concern—from its poor choice of climate models, to its underreporting of uncertainties and opposing conclusions, to its attributions of current extreme weather events to anthropogenic emissions. This paper will focus on two of the most important errors: (a) the improper use of emissions scenarios that inflate both predicted changes and the effects of reducing emissions and

Figure 1
Comparison of RCP Emissions to EIA and IEA Forecasts



Note. See Appendix.

(b) the use of economic models with flawed assumptions to predict future damage from climate change, with the explicit purpose of influencing public opinion on climate policy. These errors will serve as concise examples of how NCA4, a document with immense impacts on U.S. climate research and policy, has been used to advance the catastrophe narrative.

Many observers have told pieces of this story—from the origin and misuse of emissions scenarios and economic models (Hausfather, 2019, Pielke, 2019, Helm, 2015, Cass, 2018), to the prominence of these errors in NCA4 (Pielke, 2020, Loris, 2018), to the media coverage that confidently broadcasts the most catastrophic predictions to the public (Liebowitz, 2019, DeVore, 2018). This paper seeks to provide a synthesis of these pieces and show how these errors moved from the scientific literature to NCA4 and finally into the public forum with an escalating degree of certainty and alarm that the original science does not justify. The paper concludes with a list of changes that should be incorporated into development of the Fifth National Climate Assessment (NCA5), which is due to be published in 2022 and will be immensely impactful for U.S. climate policy in this coming decade.

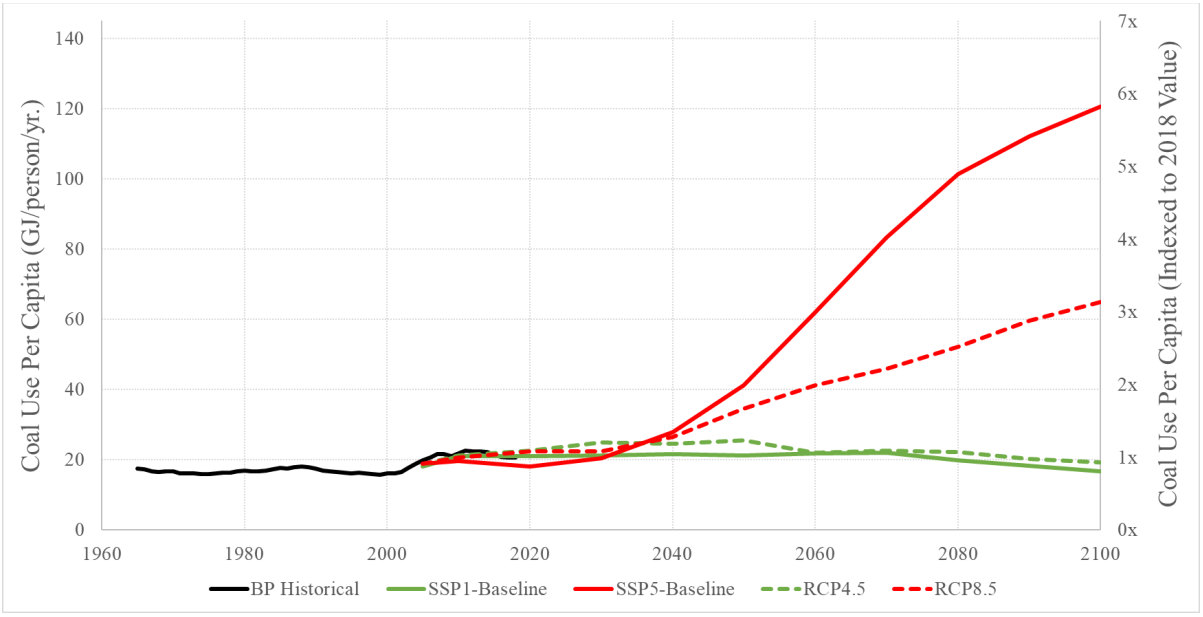
Extreme Emissions Scenarios in NCA4

The problems with NCA4 begin with its heavy reliance on a future CO_2 emissions scenario called Representative Concentration Pathway 8.5 (RCP8.5), one of four emissions scenarios developed in the late 2000s for the U.N. IPCC Fifth Assessment Report (Moss et al., 2010). It reflects a scenario in which global CO_2 emissions increase dramatically throughout most of the 21st century, rising to 3 times current levels by 2100 (van Vuuren et al., 2011, p. 21). According to Pielke and Ritchie, RCP8.5 comprises 54% of the scenario references in Volume 1 and 58% in Volume 2 of the Assessment (2020, p. 30).

Most of the climate science community considers RCP8.5 to be the "business as usual" scenario, that is, the most likely scenario absent policies to reduce CO_2 emissions. However, it has come under increased scrutiny from many scientists (Pielke & Ritchie, 2020), who argue that it represents an extreme case that ignores current trends in energy consumption and is far above current emissions forecasts from government energy agencies. The CO_2 emissions in RCP8.5 are more than 50% higher than the Energy Information Administration's (EIA) forecasts through 2050 (EIA, 2019) and those of the International Energy Agency (IEA) through 2040 (Hausfather & Ritchie, 2019, IEA, 2019). Both of these forecasts, in their reference (solid line) and higher (dotted line) emissions scenarios, hew more closely to RCP6.0 or RCP4.5.

The most remarkable feature of RCP8.5 is the assumption of a "return to coal" as the world's dominant energy resource and an increase in per capita coal consumption from about 20 gigajoules/year today to more than 60 gigajoules/year in

Figure 2
Historical per Capita Coal Usage vs. IPCC Model Projections



Note. See Appendix.

2100. As **Figure 2** shows, this is a steep departure from historical per-capita coal consumption, which, aside from an increase in the 2000s due to a rapid buildout of coal power plants in China, has changed little over the past 50 years.

This prediction of coal as the dominant energy resource of the 21st century is partly a function of the prevailing wisdom at the time the RCPs were developed more than a decade ago. Coal use was rising rapidly in the developing world, oil and natural gas prices were at all-time highs, and it was theorized that oil and gas production would enter into terminal decline during the 21st century (the "peak oil" theory) and that coal-to-liquids would be needed to offset that decline. The shale revolution has since transformed oil and gas markets and turned these predictions on their heads. Since 2005, prices for natural gas have fallen more than 85% (EIA, 2020), and CO_2 emissions in OECD countries (i.e., most developed nations) have declined 10% (IEA, 2020a). Worldwide coal consumption has declined since 2014 (IEA, 2020b), and a return to coal is even more unlikely now than it was 15 years ago. But the climate science community has not caught up with the times.

Not only is the use of RCP8.5 as a reference or "no-policy" scenario counter to the latest evidence, but it also runs counter to the intent of the RCP developers. The lead author of the paper introducing RCP8.5, Dr. Keywan Riahi, recently said that RCP8.5 was designed to be "on the higher end of the range of possible baseline scenarios" and that he wishes he had been clearer with his use of the term "business as usual" in his paper (quoted in Hausfather, 2019, "A worst case scenario" section). The original paper summarizing the RCPs notes that the RCP8.5 represents the upper range of future CO_2 emissions if no additional policies are passed to reduce emissions, not the most likely outcome. "Most non-climate policy scenarios, in fact, predict emissions … close to the emission level of the RCP6" (van Vuuren et al., 2011, p. 20). This intention is even restated in Volume I of NCA4: "RCP8.5 reflects the upper range of the open literature on emissions, but is not intended to serve as an upper limit on possible emissions nor as a business-as-usual or reference scenario for the other three scenarios" (Hayhoe et al., 2017, p. 136).

Yet NCA4, while never explicitly referring to RCP8.5 as "business-as-usual," repeatedly characterizes it as a likely scenario absent emissions reductions. Appendix 3 in Volume 2 justifies this reliance on RCP8.5 by stating, "Comparing outcomes under the two pathways [RCP 8.5 and RCP4.5] shows the degree to which significant emissions mitigation at the global scale can avoid some impacts" (USGCRP, 2018a, p. 1415). This practice places RCP8.5 as the most-likely "no-policy" reference scenario and assumes that emissions mitigation policies can "move" the world to a lower RCP scenario, directly counter to the intention of the RCP creators.

Unfortunately, the new Shared Socioeconomic Pathways (SSPs) from the IPCC, which are designed to supersede the RCPs, do not appear to be improving this situation. As described by Burgess et al. (2020, p. 3), only the lowest of the "no-policy" baseline scenarios hew closely to predictions from the IEA and EIA over the next 20 years, and the highest emissions scenario, SSP5, forecasts nearly twice the

level of CO_2 emissions by 2040 as the IEA and EIA. Also, as shown in **Figure 2**, only the lowest scenario, SSP1, maintains per-capita coal use at close to its historical average. SSP5 predicts nearly twice as much coal use per capita as RCP8.5 by 2100, 6 times the current value. Given this development within the broader climate science community, it is unlikely NCA5 will show improvements in its choice and application of emissions scenarios without significant changes in its development process and in its priorities.

The Decision to Use RCP8.5 in NCA4

If the use of RCP8.5 as a "no-policy" reference scenario runs counter to the intent of its creators and the latest evidence, why did the authors of NCA4 make that choice? The primary reason appears to be historical inertia. As noted in Volume 2, "the range represented by RCP8.5 and RCP4.5, therefore, provides the most continuity and consistency with the IPCC scenarios used for framing purposes by the previous NCA3" (USGCRP, 2018a, p. 1414). This choice traces back to a 2015 USGCRP memo, which cites "maintaining continuity and consistency with other major assessments" and previous NCAs as the top 2 reasons to use RCP8.5 and RCP4.5 (USGCRP, 2015, p. 2).

The authors of NCA4 either did not attempt to survey the most up-to-date emissions forecasts or, if they did, they ignored them and failed to note the discrepancy in the Assessment. Chapter 1 of Volume 2 claims that "current trends in annual greenhouse gas emissions, globally, are consistent with RCP8.5" (USGCRP, 2018a, p. 41), while saying nothing about the latest forecasts at the time (IEA, 2017, p. 78), which, consistent with the forecasts in **Figure 1**, were predicting emissions to be at least a third lower than RCP8.5 by 2040.

While the 2015 memo never claims RCP8.5 should be used as a "business-as-usual" scenario, it notes that "outcomes under RCP4.5 may show the degree to which significant emissions mitigation (at the global scale) can *avoid* risks and impacts *that are expected under RCP8.5* [emphasis added]" (USGCRP, 2015, p. 3). This "framing" of future impacts and mitigation issues foreshadows the extensive use of RCP8.5 as the "higher" scenario and RCP4.5 as the "lower" scenario in Volume 2 of NCA4.

This decision suggests that NCA4 was shaped as much by politics and the prevailing opinion of its authors as it was by the latest scientific data. Hence the choice to compare RCP8.5 and RCP4.5 with the misleading suggestion that policy decisions can play a large role in dictating one outcome or the other. The fact that NCA4 applies this methodology, without addressing the growing evidence against doing so, indicates that it is straying from its statutory obligation to provide an unbiased assessment of the latest science and toward using the Assessment as another tool to persuade policymakers and the public to adopt policies to reduce CO_2 emissions as quickly as possible.

Making Climate Change Real: The Risky Business Project

The next chapter of the story revolves around a little-known venture called the Risky Business Project (Risky Business, n.d.), which generated a report and subsequent academic papers that exerted significant influence on NCA4 and the broader catastrophe narrative.

As described in a 2015 *New York Times* piece, the project has its origins in a meeting organized by billionaire and climate activist Tom Steyer in November 2012 (Helm, 2015). The meeting included both prominent climate activists, such as Bill McKibben of 350.org, and political figures, such as John Podesta of the Center for American Progress. These attendees recruited a number of well-heeled partners from across the political spectrum, including Michael Bloomberg and Hank Paulson, who became the primary funders of the project.

Steyer and his staff at Next Generation, the nonprofit he founded, were trying to find ways to make climate change real and immediate for the average person (Helm, 2015). Thus, the goal of the Risky Business Project became quantifying the future economic risks of climate change in order to justify spending money in the present to mitigate those risks. The project contracted the Rhodium Group to perform the research and published a report in June 2014 titled *Risky Business: The Economic Risks of Climate Change in the United States* (Gordon et al., 2014).

The report offers a concise example of how the catastrophe narrative is built. It begins by characterizing RCP8.5 as "business as usual" and basing its predictions on that scenario (Gordon et al., 2014, p. 10). The report then goes to great lengths to articulate predicted economic effects of climate change under this scenario, including damage to coastal property from sea-level rise, lost labor hours and increased mortality from high temperatures, increases in air pollution and energy demand, and lower agricultural yields.

The influence of this project on NCA4 is difficult to overstate. Dr. Roger Pielke, Jr., a historian of federal climate research and the USGCRP, found that "the work initiated by the *Risky Business* project was cited almost 200 times" in NCA4 (2020). The report's lead researchers collaborated on a subsequent paper (Hsiang et al., 2017), published in the journal *Science*, that was cited in a key chapter in NCA4 on the benefits of reducing emissions (USGCRP, 2018a, p. 1360). Many of these same modeling practices also underlie the EPA's Climate Change Impacts and Risk Analysis

(CIRA) project (2017), which forms the foundation of that chapter. In the next section, we will examine how these studies created the exaggerated economic damage predictions in NCA4.

Economic Damage Modeling in NCA4

The task taken up by the Risky Business Project and the EPA's CIRA project—quantifying the annual economic costs of climate change at the end of the 21st century—is a daunting one considering the vast economic and societal changes that are likely to take place over the next 70 to 80 years. It is similar to a person in 1940 or 1950 trying to guess what today's economy would look like and then assessing the potential effects of rising temperatures and sea levels on that economy.

In many ways, the Risky Busines Project and the CIRA project mirror the EPA's effort to calculate a social cost of carbon, and they suffer from many of the same problems, primarily the selection of a discount rate for pricing future damages in present dollars, sensitivity of global temperatures to CO_2, and undercounting of the benefits of higher CO_2 and global temperatures, such as improved crop yields from CO_2 fertilization. Many studies have noted how different choices for these parameters can drive the social cost of carbon toward zero or even negative (e.g., Dayaratna et al., 2020; Ginn and Ingram, 2018). While these are all critical problems, we will focus on the models that are used to calculate the projected damages, a subject that has not received as much attention.

The EPA and Hsiang et al. apply different approaches to the problem of quantifying economic costs many decades into the future. The EPA CIRA report forecasts changes in population and gross domestic product (GDP) out to 2090, running time-series models to determine changes in GDP for different global temperature scenarios relative to a no-change scenario, then discounting the costs back to 2015 dollars (EPA, 2017, pp. 13-16). Hsiang et al. make the simple assumption that the scale and spatial distribution of the U.S. economy will remain unchanged from their 2012 values (Hsiang et al., 2017). In essence, they apply the effects of future climate change to today's economy, a sleight of hand that circumvents the problems associated with running a time-series model far into the future and choosing a method for discounting the results back to present dollars.

The two approaches are mostly aligned on the kinds of damages they choose to quantify, but they differ in how they quantify the damages. Because the EPA CIRA report is more foundational to the chapter on mitigation in NCA4 (Hsiang et al. are barely referenced in the text outside of Figure 29.3), we will focus on those results. For reference, the report projects a median annual temperature change across a majority of the U.S. in 2090, relative to 1986 to 2005, greater than 5°C under RCP8.5 and about 3°C under RCP4.5 (EPA, 2017, p. 18).

Table 1, which corresponds to Figure 29.2 in NCA4 (USGCRP, 2018a, p. 1349), provides an overview of the top 10 categories of economic damages and the forecasted damages in 2090 from the EPA CIRA report. The top 4 categories—lost labor hours, extreme temperature mortality, coastal property, and air quality—comprise more than 85% of the total damages. Each of these damages is calculated based on a series of tenuous assumptions that deserve closer inspection.

The critical flaw in the estimates of labor productivity and extreme temperature mortality is the assumption of limited to no adaptation. As explained in greater detail by Oren Cass of the Manhattan Institute (2018), these models rely on historical observations of changes in mortality and labor productivity due to sudden changes in temperatures, instead of modeling long-term climate adaptations, which occurred throughout the 20th century. The EPA even forecasts rising electricity demand in its models, a clear indicator of adaptation to extreme heat, yet still uses this no-adaptation assumption in forecasting mortality and lost labor hours.

Regarding labor productivity, the EPA relies on a study (Zivin & Neidell, 2014) that finds no statistically significant change in time allocated to labor due to changes in

Table 1

Predicted Median Annual Economic Damages in 2090 by Sector **(billions of 2015 USD)**

Sector	Annual Damages Under RCP 8.5	Annual Damages Under RCP4.5
Lost Labor Hours	$155	$81
Extreme Temperature Mortality	$141	$59
Coastal Property	$118	$92
Air Quality	$26	$18
Roads	$20	$8
Electricity Supply and Demand	$9	$3
Inland Flooding	$8	$4
Urban Drainage	$6	$4
Rail	$6	$4
Water Quality	$5	$3

Note. From *Impacts, risks, and adaptation in the United States: Fourth national climate assessment, Volume II*, by U.S. Global Change Research Program, 2018a, p. 1349 (https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf)

temperature, except for certain "high-risk" industries such as agriculture, construction, and manufacturing. For those industries, the study finds a reduction of almost one hour per day for temperatures over 100°F (p. 15), which the EPA used to estimate the loss in economic activity in 2090. However, the study finds that in aggregate, high-risk workers in warm climates work more hours than high-risk workers in cold climates (p. 12).

Regarding extreme temperature mortality, the EPA CIRA report projects greater than 10 deaths per 100,000 residents in cities such as Pittsburgh and Chicago in 2090 (p. 51), nearly *100 times* its estimated death rate from extreme heat in 2000 in Phoenix, which is the hottest city in its model (EPA, 2015). While the EPA clearly acknowledges this assumption, highlighting in its key findings that mortality decreased more than 50% when Dallas's threshold for extreme heat was applied to all cities (EPA, 2017, p. 48), this point only warrants a passing reference in NCA4 (USGCRP, 2018a, p. 1361).

To suggest that residents of Pittsburgh will not adapt to hotter temperatures in the 21st century in the same way residents of Dallas or Phoenix have in the 20th century defies common sense. A recent study found that the mortality due to days with a mean temperature greater than 80°F declined by 75% during the 20th century, with almost the entire decline occurring after 1960 due to the widespread adoption of air conditioning (Barreca et al., 2016, pp. 105-106). And the net migration of over 10 million Americans to the Southern U.S. over the past 40 years (U.S. Census Bureau, 2018) stands in stark contrast to the idea that higher temperatures will have a significantly negative impact on the American economy.

Coastal property is another major damage category, and the EPA CIRA report notes that it is also very sensitive to adaptation measures. Adaptation can reduce cumulative costs by 2100 from $3.6 trillion to $800 billion through 2100 (EPA, 2017, p. 115), whereas reducing CO_2 emissions only affects these projected damages by a few percent because much of the damage is "locked in" by anticipated sea-level rise over the next 30 years. The massive coastal development and rise in coastal property values over the past century in the U.S. is clear evidence that these adaptation measures are already being applied. The EPA CIRA report mentions this sensitivity to adaptation in its key findings (2017, p. 113) and devotes a figure to it (p. 115), yet NCA4 makes only passing references to it (USGCRP, 2018a, pp. 1348-1349).

The fourth largest category is air quality. The economic damages in this category come from the assumption that higher temperatures will increase levels of ozone and particulate matter, *absent further reductions in human emissions*, and lead to more premature deaths from respiratory and cardiovascular conditions. However, as noted briefly in the chapter on air quality in the Assessment (USGCRP, 2018a, p. 518) and explained in detail by the EPA in their annual *Our Nation's Air* report (EPA, 2020), pollution levels have fallen by over 50% on average in the U.S. over the past several decades and are expected to continue falling. The changes in ozone levels under RCP8.5 modeled in the EPA CIRA report represent, at most, a shift from current levels to levels from roughly a decade ago, with large portions of the U.S. experiencing declines (EPA, 2017, p. 37).

There are further uncertainties and methodological problems in how the damages are computed. The EPA CIRA report calculates the number of life-years lost due to premature death, adding those years up into "statistical lives" and then multiplying those statistical lives by an estimate of their economic value (EPA, 2017, p. 36). The shortcomings of this method have been well documented within the context of setting air quality regulations (White & Bennett, 2019), and there is a robust debate occurring within the EPA about whether current pollution levels and small changes around those levels are exacerbating certain health conditions enough to lead to premature deaths (Cox et al., 2019). Yet there is no mention of these issues in the EPA CIRA report, much less in NCA4.

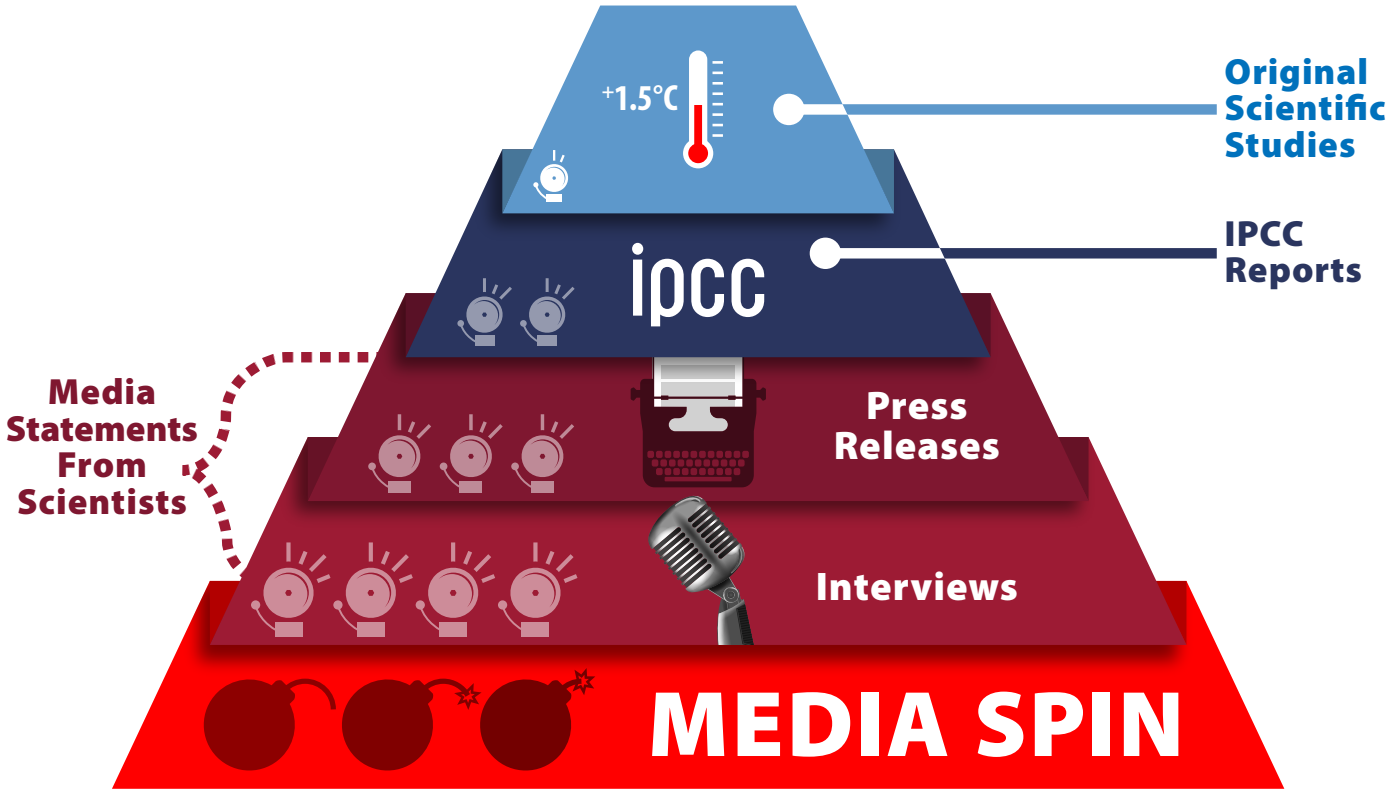
Even if the warming of greater than 5°C for most of the U.S. under RCP8.5 is taken at face value, it is clear that these damage predictions are overstated. NCA4 fails to provide a reasonable forecast for how people adapt to changing temperatures over the long term, exemplified by the migration of Americans to southern states in recent years, and vastly overstates the effect of long-term climate change. The degree of overconfidence in these results and the underreporting of uncertainties displays a clear bias on the part of the authors and reviewers toward the catastrophe narrative. Sadly, this house of cards that NCA4 builds is further exaggerated by the media coverage of the report, which firmly embeds the catastrophe narrative in the public consciousness.

Media Coverage of NCA4: Highlighting the Extreme Findings

With a number of alarming predictions firmly embedded in NCA4, the final step in molding it around the catastrophe narrative is the media coverage. This process is abetted by the fact that the media needs the most alarming predictions to sell stories. The more mundane conclusions and explanations of uncertainty in the Assessment won't fit into a small front-page article or 30-second sound bite.

This problem is systemic in the media coverage of climate change, and the headlines about economic damage predictions from NCA4 provide a telling example. Much of

Figure 3
The Escalating Chain of Alarm and Certainty in the 2018 IPCC Special Report



- **First, the studies cited by the IPCC report** are usually careful to delineate the uncertainties in their findings and qualify their conclusions. One of the studies, which appeared in *Environmental Research Letters*, accurately summarizes the difficulties of climate models. "The advantage of climate model based approaches is that large samples of climate with and without human emissions can be simulated, which in turn can be used to estimate the probabilities. Climate models, however, suffer from incomplete process knowledge and other model uncertainties" (Gudmundsson & Seneviratne, 2016, p. 3).

- **The report summaries, including the summary for policymakers,** dramatize the conclusions and attribute a high degree of certainty to them. "Climate models project robust differences in regional climate characteristics between present-day and global warming of 1.5°C, and between 1.5°C and 2°C. These differences include increases in: mean temperature in most land and ocean regions (high confidence), hot extremes in most inhabited regions (high confidence), heavy precipitation in several regions (medium confidence), and the probability of drought and precipitation deficits in some regions (medium confidence)" (IPCC 2018b, p. 9).

- **In the press release for the report,** the degree of alarm is escalated. "Every extra bit of warming matters, especially since warming of 1.5°C or higher increases the risk associated with long-lasting or irreversible changes," said Hans-Otto Pörtner, Co-Chair of IPCC Working Group II (IPCC, 2018a, p. 1).

- **In a press interview, one of the IPCC authors,** Cornell physicist Natalie Mahowald, went a bit further, "For some people, this is a life or death situation, without a doubt" (Burkholder et al., 2018). Erik Solheim, executive director of the U.N. Environment Program, compared the report to a "deafening, piercing smoke alarm going off in the kitchen" (Mooney and Dennis, 2018).

- **Finally, in the mainstream media articles,** headlines portray the 1.5°C or 2°C levels and the deadlines for eliminating carbon emissions as tipping points beyond which the world will suffer catastrophic harm. For example, the *Washington Post* headline following the report read, "The world has just over a decade to get climate change under control, U.N. scientists say" (Mooney and Dennis, 2018).

the media coverage carried the extreme prediction that unchecked warming could reduce U.S. GDP by up to 10% by the end of the century (Silverstein, 2018, Christensen & Nedelman, 2018, Davenport & Pierre-Louis, 2018). That data point is buried in a figure in Chapter 29 (USGCRP, 2018a, p. 1360), which happens to come from the Hsiang et al. paper (2017).

Chapter 29 and Chapter 1 (USGCRP, 2018a, p. 71) of the Assessment highlight the findings of the EPA CIRA study, and the NCA4 summary findings (USGCRP, 2018a, pp. 25-32) and the report-in-brief (USGCRP, 2018b) also do not cite the Hsiang et al. paper. Yet journalists from multiple news outlets zeroed in on the figure from Hsiang et al. and wrote it up within hours of the report's release. Two weeks later, one of the authors of the *Science* paper wrote an op-ed to explain why the 10% statistic "mischaracterizes the evidence" and is at the extreme end of their scenarios (Jina, 2018), but the damage to the public impression of the Assessment's findings was already done.

Figure 3 provides an additional example, modified from Bennett (2018), of how media coverage exaggerates the findings of climate science studies, drawing from the IPCC Special Report in October 2018, which attempted to summarize the consequences of warming greater than 1.5°C above pre-industrial levels. This example clearly shows how the predictions in the underlying studies are given greater certainty in the IPCC report and then magnified by the public statements of the IPCC authors and finally the media coverage surrounding the report.

Opportunities to Improve NCA5

The process for creating NCA5, due to be completed in 2022, has already begun with requests for submissions from researchers (Waldman, 2020). Reforms should be suggested and implemented now, at the beginning of the development process. The following three suggestions would have the most impact on correcting the errors noted in this paper.

1. *Report results based on all five SSP scenarios from the IPCC, explain the assumptions underlying each scenario, and note that current projections of CO_2 emissions from the EIA and IEA lie close to those of the lowest baseline scenarios.*

   NCA5 should recognize the unique socioeconomic assumptions of each SSP and consider the effects of policies to reduce CO_2 emissions within the context of each scenario, rather than making comparisons between scenarios. If NCA5 chooses to focus on any emissions scenarios for the sake of real-world policy considerations, it should focus on the scenarios that hew closest to projections from the IEA and EIA, namely the SSP1 baseline or another scenario with some CO_2 mitigation. Pielke and Ritchie also offer a number of broader reforms that could address the misuse of emissions scenarios in the climate science community (2020, p. 55).

2. *Clearly report confidence intervals for future emissions, temperature, sea-level rise, economic damages, etc., and offer extensive discussion of uncertainties and confidence. These discussions need to be near their relevant predictions and not buried in the back of each chapter or in the underlying studies.*

   Proper scientific assessments are always careful to note uncertainties and provide confidence intervals, but NCA4 adds precious few qualifications to its conclusions. While the Assessment briefly mentions key uncertainties (USGCRP, 2018a, p. 41) and provides traceable accounts for each of its main messages, it reports almost all of its conclusions with very high confidence. The attributions of confidence seem to be unrelated to the extent of the major uncertainties, which are often identified but rarely quantified. As noted by Dr. Judith Curry (2019), former chair of the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology, NCA4 often expresses more confidence in many conclusions than the IPCC while providing less evidence. NCA5 must be more honest in this regard.

   Part of the challenge in reporting uncertainties and alternatives is that those explanations will take up more space in what is already a massive document, and NCA5 will need to balance those competing priorities. Also, if all possibilities and confidence intervals are reported, instead of only the mean value, the media will tend to report the most extreme values, as noted in the previous section. But these challenges do not mean NCA5 should avoid the effort altogether, as seems to have happened with NCA4.

3. *Utilize stringent peer review involving scientists who are willing to argue against all of the major conclusions and include alternative points of view.*

   NCA4 stresses that its development process included multiple layers of review, including outside review from the public and from a National Academies panel (USGCRP, 2018a, pp. 1398-1399). But it is clear that peer review is not a panacea for the groupthink and overconfidence that leads to the errors presented in this paper. The review process needs to include scientists who are willing to challenge all of the conclusions in the Assessment, as advocated by Dr. Will Happer and Dr. Steve Koonin (Waldman, 2020), and the final

document should describe alternative conclusions and possibilities where relevant.

There are signs that the Trump administration is open to reforming the NCA process. As spokeswoman Lindsay Walters noted after the release of NCA4, "The Fifth National Climate Assessment gives us the opportunity to provide for a more transparent and data-driven process that includes fuller information on the range of potential scenarios and outcomes" (quoted in Waldman, 2018). Such a change would be welcome, but the administration so far has not taken any concrete steps in that direction (Waldman, 2020). Regardless of who wins the November election, the White House National Science and Technology Council can take these reasonable steps to ensure NCA5 provides a more balanced and accurate assessment of climate science.

Conclusion

As we move into another decade of the endless debates about climate change, we should all keep in mind the wise words of Dr. Curry: "Not only do we need to think harder and more carefully about [climate change], but we need to think better, with better ways [of] justifying our arguments and assessing uncertainty, confidence and ignorance," (2019, "JC reflections" section). Her fellow climate scientists would do well to heed her words and adopt a more scientific approach to NCA5—instead of the current one-sided approach—incorporating the reforms proposed in this paper and more.

However, given the rooted influence of money, politics, and historical and bureaucratic momentum, the bias of the USGCRP toward the catastrophe narrative seems only likely to grow stronger, both in the scientific literature it relies upon and in the development of its reports. Without some of the reforms mentioned in this paper and a wholesale change in the funding and direction of academic climate science, we are in danger of being led toward disastrous policies that will fundamentally alter our energy system and our economy on the basis of what is, at best, highly uncertain science.

This problem does not mean that opponents of the catastrophe narrative should disparage climate science as a whole or ignore everything that climate scientists say. That attitude furthers the polarization of the debate and further serves the goals of the catastrophe narrative. We must also adopt a careful, scientific, and, in some cases, courageous skepticism toward NCA4 and similar reports. Finally, our policymakers need to understand how the catastrophe narrative is deceiving them about the "consensus" on the need to make dramatic reductions in CO_2 emissions. Any policy to reduce CO_2 emissions should be examined with a careful eye on the underlying science and a clear focus on the supposed costs and benefits.

We should also emphasize that, contrary to the gloomy predictions in NCA4, the quality of life for most humans around the globe, especially in developed nations, has improved dramatically as CO_2 emissions and temperatures have risen over the past century. Climate resiliency is also improving. According to the Centre for Research on the Epidemiology of Disasters (CRED), global deaths from natural disasters plummeted from nearly 5 million in the 1920s to just under 200,000 in the past decade (CRED, 2020).

Instead of worrying about whether future climate change will have catastrophic consequences and spending trillions of dollars to defend against that remote possibility, we should focus our time and money on improving human lives now. Providing energy for the billions of people around the world living with zero or limited access to energy, and improving energy affordability in the developed world, will enable current and future generations to better handle whatever nature throws their way.

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Appendix: Comparison of Energy Consumption and Emissions Forecasts in Figures 1 and 2

The data in Figures 1 and 2, while straightforward to read and interpret, require a few steps to gather and harmonize into a single plot. The CO_2 emissions for the four RCP scenarios in Figure 1 are taken from the online RCP database, which is managed by the International Institute for Applied Systems Analysis (IIASA, 2009). The data is compiled from each RCP model and can be queried and downloaded directly from the database. The EIA data is from the 2019 International Energy Outlook online data browser (2019), using only the reference and high economic growth scenarios. The IEA data is from the 2019 World Energy Outlook (pp. 680-681), using total CO_2 emissions from the Stated and Current Policy Scenarios.

In Figure 2, it was necessary to gather both annual population and coal consumption data and divide them, since coal consumption per capita is not reported as a single value in the emissions scenarios. In this case, the AR5 Database (IIASA, 2014) and the SSP Database (IIASA, 2018) were used for the RCP and SSP scenario data, respectively. RCP8.5 is taken from the RCP8.5 file under the MESSAGE V.2 folder, and RCP4.5 is taken from the LIMITS-StrPol file under the GCAM 3.1 folder in the AR5 Database. SSP1 and SSP5 scenarios are taken from the Marker folder in the SSP Database, using the baseline scenario in each case.

The 2019 BP Statistical Review of World Energy was chosen for the historical data because it had the longest time-series with consistent data reporting, stretching back to 1965. Coal consumption is given directly in the report (45). Population data, which is not given directly, is derived by dividing primary energy consumption (9) by primary energy consumption per capita (12). The values on the secondary y-axis in Figure 2 are indexed relative to the BP data for 2018, which is the most recent year reported at the time of publication.

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