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MAKING THE CASE FOR CLIMATE ACTION: THE GROWING RISKS AND COSTS OF INACTION

HEARING

BEFORE THE

SELECT COMMITTEE ON THE CLIMATE CRISIS HOUSE OF REPRESENTATIVES

ONE HUNDRED SEVENTEENTH CONGRESS

FIRST SESSION

HEARING HELD
APRIL 15, 2021

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MAKING THE CASE FOR CLIMATE ACTION: THE GROWING RISKS AND COSTS OF INACTION

THURSDAY, APRIL 15, 2021

HOUSE OF REPRESENTATIVES,
SELECT COMMITTEE ON THE CLIMATE CRISIS,
Washington, DC.

The committee met, pursuant to call, at 12:03 p.m., via Zoom, Hon. Kathy Castor [chairwoman of the committee] presiding.

Present: Representatives Castor, Bonamici, Brownley, Huffman, Levin, Casten, Neguse, Escobar, Graves, Palmer, Carter, Miller, Armstrong, and Gonzalez.

Ms. CASTOR. The committee will come to order.

Without objection, the chair is authorized to declare a recess at any time.

As a reminder, members participating in the hearing remotely should be visible on camera throughout the hearing.

As with in-person meetings, members are responsible for controlling their own microphones. Members can be muted by staff only to avoid inadvertent background noise.

In addition, statements, documents, and/or motions must be submitted to the electronic repository to sccc.repository@mail.house.gov.

Finally, members or witnesses experiencing technical problems should inform committee staff immediately.

And, also at the outset, I would like to wish our colleague, Congressman Dan Crenshaw—wish him well and let him know that we really look forward to his swift return.

So good afternoon, and thank you all for joining this remote hearing. Today, we will discuss the physical, economic, and health impacts of the climate crisis and the cost of inaction.

I now recognize myself for 5 minutes for an opening statement.

Well, welcome to our first hearing of the 117th Congress. I am proud to return as chair of the select committee. I look forward to working with all the members on the select committee on solving the climate crisis with a focus on rebuilding our economy and securing environmental justice.

The case for climate action is as urgent as ever. The consequences of inaction are too costly to bear.

In just the first few months of 2021, we have seen the impact of extreme weather on infrastructure that is aging and fragile. Deadly winter storms knocked out power and water in Texas and across the South, tragically killing more than 100 people. Western States are facing historic drought with the water shortages and risk of

wildfires that come with it. And, on the East Coast, increasing rainfall impacts put dams and water infrastructure at risk for catastrophic collapse, as unfortunately I have seen very close to home at the Piney Point gypsum impoundment on the edge of Tampa Bay.

The science is simply undeniable. In the past two decades, we have experienced the 10 hottest years ever on record with 2020 near the top of the list. And, as temperatures keep rising, we will continue to face incalculable loss of life and property that follows these climate-fueled disasters.

Monster storms, destructive wildfires, persistent droughts, and extreme flooding, these are—these risks are upending small businesses, and they are harming our economy. They are threatening industries like agriculture, real estate, healthcare, and manufacturing.

Climate change also impacts the health of the American people. Worsening air and water quality, infectious diseases, and increased extreme weather affect mental health and well-being.

Workers whose jobs expose them to the elements, from farmers to construction workers, are at increasing risk as temperatures continue to rise. Increased levels of air pollution in communities of color correlate with higher levels of asthma and other respiratory diseases. Fenceline communities that experience greater exposures to toxins and other pollution every day are at greater risk when storms spread contamination across their neighborhoods.

Communities of color, which have experienced longstanding racism, systemic inequities, and disinvestment, are on the front lines of the climate crisis. It is a reality we must reckon with as we move forward. We have a moral imperative to protect public health, ensure quality of life, and expand economic opportunity to every American, regardless of their ZIP Code or the color of their skin.

The good news is that we have the tools to better prepare for these threats and design effective solutions. Thanks to advances in monitoring and computing power, it is now possible to understand the physical and economic climate risks that are impacting different regions across the United States.

As the climate crisis makes extreme weather events more frequent, it is crucial that we plan for new scenarios and make the long-term investments to keep Americans safe. We have the tools, the science, and the policy solutions in front of us. We are proud of the great progress being made back home by cities and states, Tribes, and businesses that are investing in clean energy and resilience.

And, speaking of businesses, it is apparent now that investing in clean energy and resilience will help us counter China and our up-and-coming competitors. We are very thankful for President Biden's work on strengthening America's global leadership, especially as he prepares to welcome dozens of world leaders next week as part of his Leaders Summit on Climate. Now it is time for us in Congress to do our part.

Today, we have an excellent panel of witnesses to help us understand the growing risks and the costs of the climate crisis. They will update us on the latest climate science so we can better under-

stand the change in climate and its physical and economic impacts on everyday Americans.

We will also shine a light on how certain Americans face these impacts disproportionately, especially within communities of color and low-income households. And we will look at how we currently measure these impacts and how we can improve to better protect American families and businesses.

I really look forward to today's discussion.

And, at this time, I will recognize our Ranking Member Graves for 5 minutes for his opening statement.

Thanks.

[The statement of Ms. Castor follows:]

Opening Statement of Chair Kathy Castor

Hearing on "Making the Case for Climate Action: The Growing Risks & Costs of Inaction"

Select Committee on the Climate Crisis

April 15, 2021

As prepared for delivery

Welcome to our first hearing of the 117th Congress. I'm proud to return as Chair of the Select Committee. I look forward to working with the Members of the Committee on solving the climate crisis—with a focus on rebuilding our economy and securing environmental justice.

The case for climate action is as urgent as ever—and the consequences of inaction are too costly to bear. In just the first few months of 2021, we've seen the impact of extreme weather on infrastructure that is aging and fragile. Deadly winter storms knocked out power and water in Texas and across the south, tragically killing more than 100 people. Western states are facing a historic drought, with the water shortages and risk of wildfires that come with it. And on the East Coast, increasing rainfall puts dams and water infrastructure at risk for catastrophic collapse, as we are seeing at Piney Point on the edge of Tampa Bay.

The science is undeniable. In the past two decades, we've experienced the 10 hottest years ever on record, with 2020 near the top of the list. And as temperatures keep rising, we'll continue to face the incalculable loss of life and property that follows climate-fueled disasters. Monster storms, destructive wildfires, persistent droughts, and extreme flooding—these risks are upending small businesses and harming our economy, threatening industries like agriculture, real estate, health care, and manufacturing.

Climate change also impacts the health of the American people. Worsening air and water quality, infectious diseases, and increased extreme weather affect mental health and well-being. Workers whose jobs expose them to the elements—from farmers to construction workers—are at increasing risk, as temperatures continue to rise. Increased levels of air pollution in communities of color correlate with higher levels of asthma and other respiratory diseases. Fenceline communities that experience greater exposures to toxins and other pollution every day are at greater risk when storms spread contamination across their neighborhoods.

Communities of color—which have experienced longstanding racism, systemic inequities, and disinvestment—are on the frontlines of the climate crisis. It's a reality that we must reckon with as we move forward. We have a moral imperative to protect public health, ensure quality of life, and expand economic opportunity for every American, regardless of their zip code or the color of their skin.

The good news is we have the tools to better prepare for these threats and design effective solutions. Thanks to advances in monitoring and computing power, it is now possible to understand the physical and economic climate risks that are impacting different regions of the United States. As the climate crisis makes extreme weather events more frequent, it is crucial that we plan for new scenarios and make long-term investments to keep Americans safe.

We have the tools, the science, and the policy solutions in front of us. We're proud of the great progress being made by cities, states, tribes, and businesses that are investing in clean energy and resilience. And we're thankful for President Biden's work on strengthening America's leadership abroad, especially as he prepares to

welcome dozens of world leaders next week as part of his Leaders Summit on Climate. Now it's time for us in Congress to do our part.

Today, we have an excellent panel of witnesses to help us understand the growing risks and cost of the climate crisis. They will update us on the latest climate science, so we can better understand the changing climate and its physical and economic impacts on everyday Americans. We'll also shine a light on how certain Americans face these impacts disproportionately, especially within communities of color and low-income households. And we'll look at how we currently measure these impacts—and how we can improve to better protect American families.

I look forward to today's discussion.

Mr. GRAVES. Thank you, Madam Chair.

And I want to thank you for recognizing the challenges associated with our colleague, Congressman Crenshaw. Certainly keeping him in our prayers as he goes through these incredibly challenging times.

And also excited to have Congressman Gonzalez, a new member of the committee, on and joining us today.

Madam Chair, I want to thank you for the hearing topic that we are having today, the cost of inaction. Very important point. And I know, as you and I have discussed both at hearings and just one on one, the real—how topical this is to our congressional districts, the fact that we both represent coastal areas and areas that—on the Gulf Coast that have been exposed to extraordinary impacts as a result of disastrous hurricanes, floods, and other challenges.

As a matter of fact, Madam Chair, just this past week, in south Louisiana, we had just a storm that came through that had 75-mile-per-hour winds associated with it. And so, while—as we are all well aware on this committee—we don't all agree on everything—we do agree that investing—a no-regrets move is us investing in resiliency, and we have made extraordinary progress in terms of changing the trajectory of our investment and changing our policies toward more resilient policies. But we must continue to work to double and triple down on those successful policies that are helping to improve the resilience of our communities and resilience of our environment.

Madam Chair, I also—I know you mentioned China, and you did cut out for just a minute, so I missed a little bit of what you said there. But, in regard to China—and I want to thank Secretary Kerry for going over to China because, as we all know, the greenhouse gas concentrations that we are experiencing in our atmosphere today are—they are global.

And, as my friends, Gary Palmer and others, like to often point out, this is not something that can be solved domestically alone. And that is why it continues to perplex me seeing all the celebration over the Paris Climate Accords when the agreement actually results in a net increase in global emissions. It is the wrong direction.

So I do want to thank Secretary Kerry for keeping China on the front burner and going over there to negotiate with China because, as we have discussed in this committee before, the United States is actually leading the world in reducing emissions. We have reduced emissions more than the next 12 emissions-reducing countries combined.

And, as we have done that, for every ton of emissions we have reduced, China has increased by four. It is a global initiative. It is a global effort. And, if we are out there making progress and that

progress is being offset by other countries, that is not a move in the right direction.

And so, I am hopeful that Secretary Kerry is able to secure a commitment from China under their NDC to where it would result in actually having a net reduction in emissions and not allowing China to just offset the progress of the United States, many of our European allies, and others, in terms of emissions reduction.

So I fully support that aggressive engagement with China and efforts to try to reduce their—well, to, I guess, strengthen their NDC commitments under the Paris Accords to where we can have an agreement that actually moves in the right direction, not an agreement that then moves in the wrong direction.

But, in closing, Madam Chair, I want to circle back to those areas where we absolutely are in full agreement, and that is in making investments in the resilience of our communities. I know that, today, we actually have someone—a witness who is on the ground working daily to defend the people that are in her community. She represents—Dr. Gillen—so I am very—I look forward to hearing her testimony as well as witnesses from the academic sphere and NGO sphere today.

I am looking forward to hearing some of the comments—I think we have a mayor from Mississippi as well. I look forward to the comments and finding other areas of where we have consensus, where we have agreement, where we can continue moving forward and make successful policies at the Federal level that help to improve the conditions on the ground for the people that we represent.

I yield back.

Ms. CASTOR. Thank you very much, Ranking Member Graves.

At this time, I will recognize Representative Joe Neguse to represent—to introduce Dr. Waleed Abdalati from his district.

Mr. NEGUSE. Thank you, Madam Chair, for your indulgence. I appreciate that.

And it is, of course, a privilege and honor to be able to introduce my constituent, Dr. Waleed Abdalati, who is the director of the Cooperative Institute for Research and Environmental Sciences at the University of Colorado, Boulder, my alma mater.

The doctor leads a team of more than 800 scientists, who work in collaboration with the National Oceanic and Atmospheric Administration to study issues related to weather and climate change at Earth's poles, air quality and atmospheric chemistry, water resources, and solid earth sciences.

He is a professor of geography, and he also works on research that uses satellites and other science-based observations to measure changes in Earth's glaciers and to measure ice sheets, studying the processes that contribute to sea-level rise.

He is an expert in his field, recognized across the globe. And of course many of you had an opportunity to visit with him in person prepandemic during our field hearing in Boulder 2 years ago.

So, with that, I again thank him for being here, for his service, and for his testimony, as well as all the other witnesses.

And I would yield back to you, Madam Chair. Thank you again.

Ms. CASTOR. Thank you, Rep. Neguse.

Dr. Abdalati, you are recognized for 5 minutes.

STATEMENTS OF WALEED ABDALATI, DIRECTOR, COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES AT UNIVERSITY OF COLORADO, BOULDER; THE HONORABLE HEATHER MCTEER TONEY, CLIMATE JUSTICE LIAISON, ENVIRONMENTAL DEFENSE FUND, SENIOR ADVISOR, MOMS CLEAN AIR FORCE; SHAWN GILLEN, CITY MANAGER, TYBEE ISLAND, GEORGIA; AND MICHAEL GREENSTONE, MILTON FRIEDMAN DISTINGUISHED SERVICE PROFESSOR IN ECONOMICS, UNIVERSITY OF CHICAGO

STATEMENT OF WALEED ABDALATI

Dr. ABDALATI. Thank you, Congressman and Chair Castor, Ranking Member Graves and members of the committee. I would like to thank you for the opportunity to testify on this truly critical topic.

I greatly appreciate the work of this committee and your bipartisan efforts to consider the implications of climate change and to address the associated challenges in a meaningful way. The risks and costs are growing greater with time, and the consequences, if not managed aggressively and now, are likely to be quite severe.

Earth's temperatures have warmed unequivocally since the records began in 1880. Each of the last six decades has been warmer than the previous, and the last 6 years have been the warmest in the 140-year record.

With these warmer temperatures, we have been experiencing the very trends that the scientific community began anticipating decades ago. These include increases in the number, intensity, and costs of severe weather events, greater flooding, more severe droughts, more wildfires, disappearing glaciers, and shrinking ice sheets, rising seas at an accelerating rate, and rapidly shrinking arctic sea ice.

To be clear, all of these trends are happening now. They are no longer just predictions. And the implications of these changes are significant and come at costs in the economic, humanitarian, and the security domains.

Among the impacts we face are continued increases in extreme weather and its costly consequences; inhibited economic growth; reduced water availability for agriculture, energy production, industry, and the environment; dangerous health effects; harm to the interests of indigenous people; degradation of outdoor recreation environments; destruction of critical ecosystems; loss of biodiversity; food and water insecurity; infrastructure damage and deterioration; damage to high-risk coastal communities in particular—or damage and high risk to coastal communities in particular; high adaptation costs; forced migration in the case of climate refugees; political, economic, and humanitarian instability posing national security risks; impact to military operational capabilities, and so much more. It is a long list. I haven't touched it all.

And, without a doubt, there will be cascading effects that reach far beyond the obvious direct impacts, threatening essential services and capabilities on the domestic and international fronts. Moreover, and importantly, the impacts of change will hit those hardest who have the fewest resources to deal with them and where resilience is lowest. We talked about and we will hear about

underserved and minority communities, and they are being hit the hardest.

Successfully meeting the challenges posed by our changing climate requires science, objective assessments of the risks of action and inaction, and political will.

Sorry. I got muted. Can you hear me?

Okay. It also requires a long-term view, as the Founders had, that hard choices must be made today to ensure the success of generations that follow us.

On the scientific front, the science community, which has worked diligently to understand the mechanisms, manifestations, and implications of climate change, will be critical in providing guidance for addressing changes going forward. Observational capabilities, particularly global satellite observations, as well as modeling and analysis capabilities, need to be sustained and enhanced so we can track conditions, understand implications, assess likely outcomes, and inform action.

On the policy front, I defer to you, members of the committee and your colleagues, to integrate scientific, strategic, economic, and other information as you develop policies that lead to effective action.

This is a national and global challenge with highly impactful national and global consequences, and it needs to be tackled with national and global perspectives in a coordinated and integrated way.

The science is clear. The costs of too little action are dangerously high, and our chances for success are diminishing. We have lost time, and we cannot afford to lose more.

With the political and societal will and with strategic and scientifically informed action, the dangerous trajectory we are on can be altered. Our generation's story can be one of great success rather than failure. As a citizen, I look forward to this body exercising its will, making hard choices, and setting the nation on a proactive course. And, as a scientist, I and my colleagues stand ready to provide you with the best information possible to inform these choices and actions.

Thank you very much for your time and your efforts in tackling what is truly an existential challenge.

[The statement of Dr. Abdalati follows:]

Climate Change

Expression, Implications, and the Urgency of Success

Statement of

Waleed Abdalati

Director, Cooperative Institute for Research in Environmental Sciences

Professor, Department of Geography

University of Colorado, Boulder

before the

Select Committee on The Climate Crisis

U.S. House of Representatives

for the hearing

Making the Case for Climate Action: The Growing Risks and Costs of Inaction

15 April, 2021

Chairwoman Castor, Ranking Member Graves, and members of the House Select Committee on the Climate Crisis, thank you for the opportunity to testify on the critical issue of climate change. I greatly appreciate the work of this committee and its bipartisan efforts to consider the implications of climate change and approaches to addressing the associated challenges. The subject of this hearing, "Making the Case for Climate Action: The Growing Risks and Costs of Inaction" is one of continually increasing importance and urgency, because the risks and costs associated with the changes that are currently well underway grow greater with time. With each passing year, it will be more and more difficult and costly to avoid some of the most severe impacts. The consequences of change, if not properly managed in a timely way, are likely to be quite severe.

The mechanisms of greenhouse warming, a key driver of and component of climate change—were understood as far back as 1896, when they were articulated by physicist, chemist, and Nobel Laureate, Svante Arrhenius (Arrhenius, 1896). What was an academic exercise well over a century ago has now become a fact of life in today's environment, with increasing impacts on the lives and livelihoods of people around the world. From those early experiments and postulations, the science community has significantly evolved in its understanding of the chemistry and physics of climate change. This is particularly so in the last 30 years, as observations, modeling and analysis have become more sophisticated and as the expression of climate change has become more observable. Science foresaw the changes that we are experiencing now, and that very science is now critical to addressing the challenges we do and will face. I am grateful to the members of the committee for the time and energy you are putting into this subject, which is so complex, given physical, human, economic, and political dimensions. Our success as a nation and society are at stake, and the legacy we leave for our children and grandchildren in the future depends on how well we handle these significant challenges today.

Unfortunately, climate change is often viewed from diametrically opposed perspectives, with the focus being solely on *either* the burden that will be borne by future generations as a result of little or no action to address the crisis aggressively *or* the burden to members of the current generation that could result from the actions taken. Successfully rising to the challenge of addressing climate change depends on considering all of its dimensions and seeking an optimized solution. That is why I am so appreciative of the work of this bipartisan committee, examining the challenges and seeking solutions from a multi-dimensional perspective.

Climate is changing. It always has throughout the history of our planet, and it always will. But we are at a unique time in civilization's trajectory: Today, humans are not only having to respond to the changes, we are driving them. This fact is overwhelmingly recognized by the scientific community, and it has become less and less controversial in other domains—political, social, and economic—as people and communities around the country have been directly feeling the effects of climate change. This converging consensus presents an opportunity—an opportunity to turn what could be a story of loss and despair into a story of triumph and success. Doing so, however, requires a serious examination of the causes of climate change and the

implications of both action and inaction, in order to meet the goals that we all share: heading off the worst effects of climate change and thriving nevertheless.

Current expressions of climate change.

While the effects of climate change and its links to greenhouse emissions have been theoretically understood for more than 125 years, the recognition that greenhouse warming was well underway and that its effects would soon be felt began to gain traction in the late 1980s. At that time, and as was articulated in the Intergovernmental Panel on Climate Change First Assessment Report (IPCC, 1990), the mechanisms were clearly understood, and there were indications that the anticipated change was under way. The scientific community, however, could not say with certainty then that the warming observed was sufficiently in excess of the natural variability that it could be attributed to greenhouse gas emissions. A definitive community consensus statement was possible by the time of the 2013 IPCC report, which found "unequivocal" warming of the climate system, as a result of the greenhouse effect (IPCC, 2013). The warming trend is shown in Figure 1. It is notable that every decade since the 1960s has been hotter than the previous ones, and the last six years have been the warmest in the 140-year record.

The observation of warming, and the linking of it to greenhouse gases, is straightforward, and the last time the Earth's temperature was at today's levels was about 125,000 years ago (Petit et al, 1999). However, unlike today, those ancient warm temperatures were driven by the Earth's orbital parameters with respect to the sun; these Milankovitch Cycles have historically been responsible for ice ages and warm periods, and they are described in Campisano, 2012. Today's warming is being driven by something very different: greenhouse gas emissions. The physics are clear and quite simple—increasing the amount of heat-trapping gases in the atmosphere will cause the atmosphere to trap more heat, subsequently raising global temperatures. It is more challenging to directly link environmental conditions and events to that warming, but despite these "attribution" challenges, the overall trends are clear. As with temperature, we are seeing—as we have come to expect to see—trends that exceed natural variability. And these changes directly impact lives and livelihoods in multiple ways.

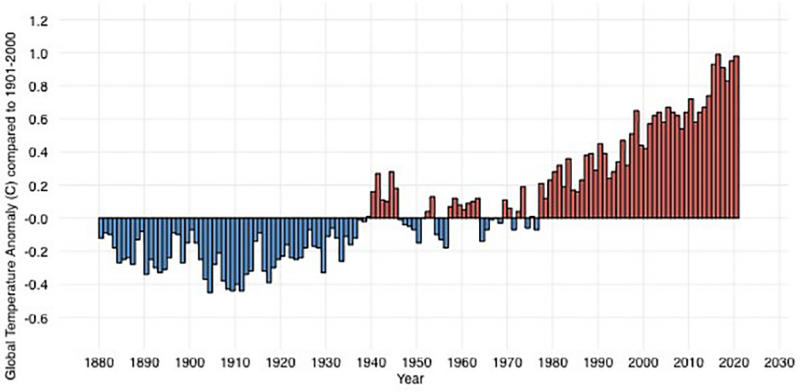

Figure 1: Average temperature differences between annual global temperatures (1880–2020) and the long-term average (1901–2000, which is shown as the zero-line). Blue bars indicate temperatures that were below the average red bars indicate temperatures that were above the average. (NOAA National Centers for Environmental Information, Climate at a Glance: Global Time Series)

Extreme weather

The intensity and frequency of extreme weather events has increased as climate has warmed (NAS, 2016). The recent evolution of such events globally and their underlying causes are shown in Figure 2, and the number of events in the United States costing over one billion dollars and their associated costs are shown in Figure 3. While direct attribution to climate change remains a challenge, the increased occurrences and intensity are in line with what would be expected, given the greater amount of energy that is trapped by the Earth system. So while we can't say that

a particular event or set of events is driven by climate change, we can say that climate change has set up conditions that make such events more likely.

Flooding

One expression of extreme events is flooding, and similarly, attribution of a flood or set of floods to climate change is challenging, and we are not yet at the point where we can say that excessive flooding in a given year is directly attributable to changes in climate. As with warming itself, however, we do understand the mechanics very well, and it is clear that a warming environment creates conditions that are conducive to increased flooding and flood intensity. This arises because warmer air is capable of holding more moister than cooler air. So as the atmosphere warms, it carries more moisture, and when that moisture is released, it can be released in greater amounts than has historically been the case. Models to date indicate, absent a decrease in emissions, a substantial increase in flooding by the end of the century (Tabari, 2020), and one study does link an increase in precipitation over the 50-year period from 1950–1999 to climate warming for 2/3 of the Northern Hemisphere (Min et al., *Nature,* 2011).

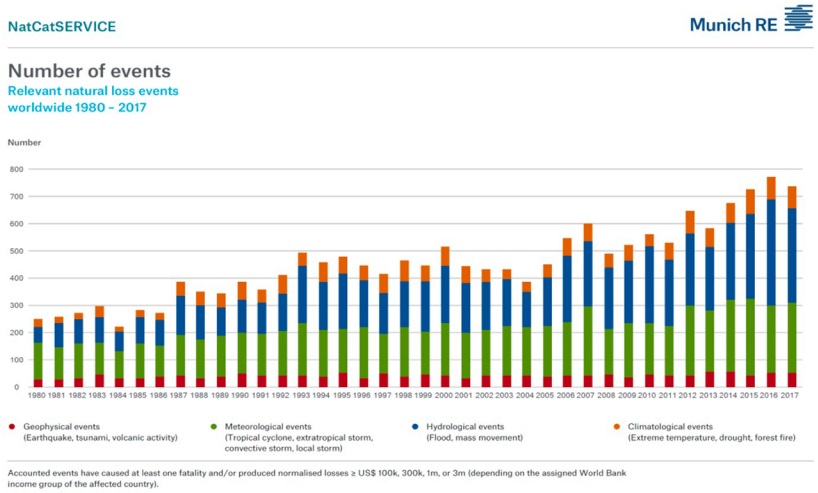

Figure 2: Number of extreme events from 1980 to 2017 related to weather (green, blue, and orange) and non-weather (red) events from 1980 to 2017. Compiled by Munich Re, 2018: https://natcatservice.munichre.com.

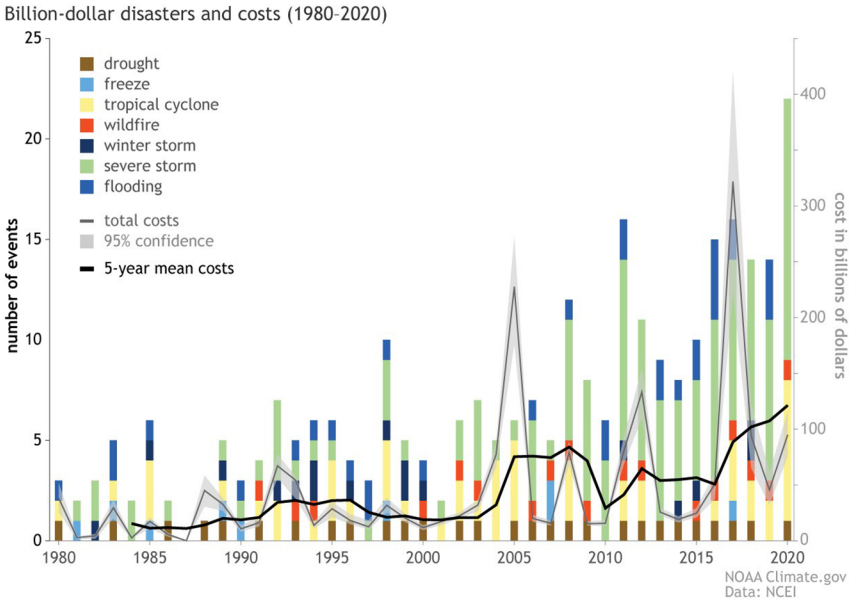

Figure 3: Costs and numbers of billion-dollar disaster events (accounting for inflation) in the U.S. from 1980–2020 (NOAA Centers for Environmental Information, 2021)

Drought

The western United States has been in a drought for the last 20 years, with the current drought ranking among the worst of the last 1,000 years. This drought is attributed, about 50%, to the climate change (Williams et al., 2020). These droughts set the stage for increased wildfires and wildfire intensity, as we have observed recently in the United States. On a global scale, we are seeing declining trends in water storage on land. These trends and regional patterns can be seen in Figure 4. In short: As the Earth is warming, the continents are drying out. That water, once stored as ice and snow, in lakes and rivers, or underground, is making its way into the oceans, and when coupled with the expansion of the warming oceans, is contributing substantially to sea level rise, while also leaving the land drier and more susceptible to droughts and fires.

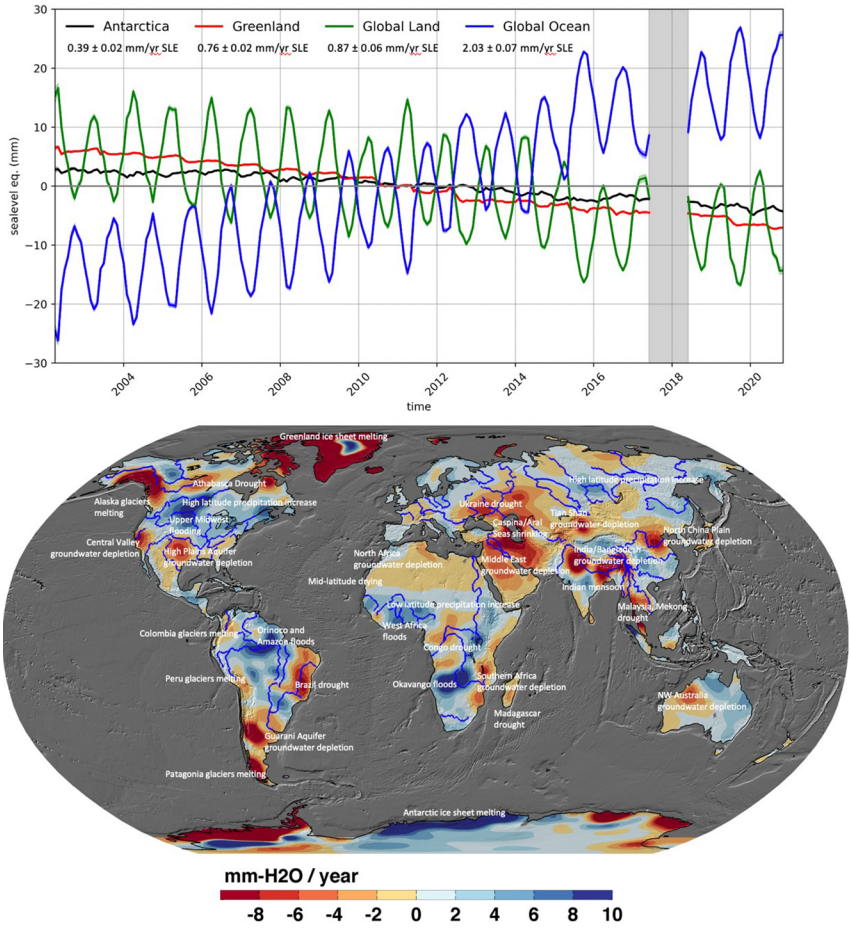

Figure 4: Trends in water mass derived from the Gravity Recovery and Climate Experiment (GRACE) satellite mission and its follow-on (top; Rodell et al., 2018), and regional distribution of mass changes along with the factors driving those changes (bottom; Chandanpurkar et al. 2021). While the effects are variable with gains and losses occurring in different locations, the trends show a drying out of the continents and significant mass loss on Greenland and much of Antarctica, and an increase in ocean mass (and subsequently sea level rise) as water flows from land to the ocean.

Fires

Models and surface data enable us to examine fire season characteristics, and more recently, satellites have been able to effectively and consistently observe fire season length, fire extent, and fire intensity across the globe. Analyses show that as temperatures have warmed, snowmelt has occurred earlier, drought has increased, and forests have remained drier for longer periods of time, the number of fires and fire intensity in the United States have been increasing. (https://climate.nasa.gov/news/2912/satellite-data-record-shows-climate-changes-impact-on-fires/).

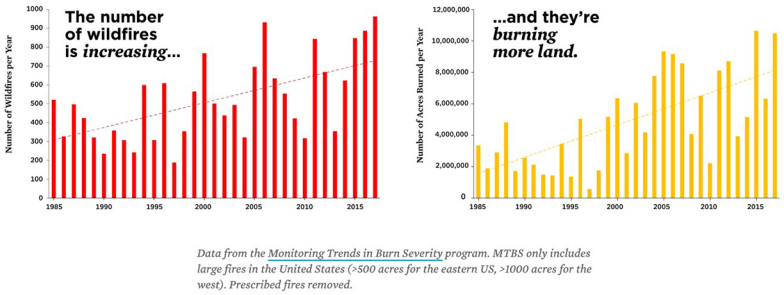

Figure 5: Number of wildfires in the U.S. (left) and area burned (right) from 1985 to 2015. The graphs are from https://www.ucsusa.org/resources/infographic-wildfires-and-climate-change, and the underlying data are from https://www.mtbs.gov.

While Figure 5 ends with 2015, the years since have been even worse, as shown in Figure 6.

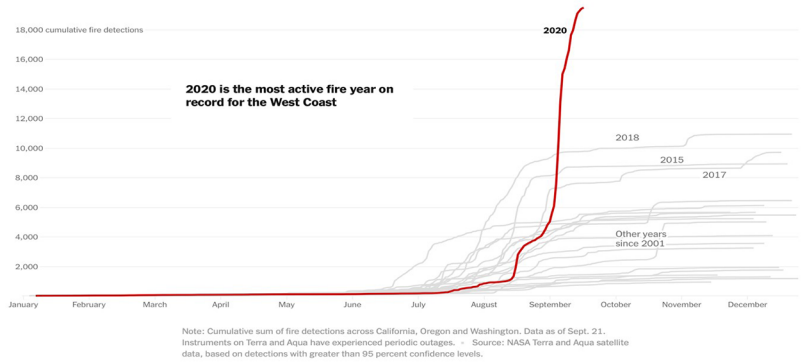

Figure 6: Cumulative Fire Detections since 2001 (Figure from NY Times, Sept. 24, 2020, based on data from the NASA Terra and Aqua Satellites).

Sea Level Rise

In another area that is especially close to home for some members of this committee in particular, oceans continue to rise. They have been doing so at an accelerating rate and will do so for centuries to come (Pörtner et al, 2019). Global mean sea level rise is also accelerating, increasing from its 1901–1990 rate of 1.4 mm/yr to a rate of 3.6 mm/yr during 2006–2015. In some areas, such as in the Southeastern United States, this acceleration is exacerbated by the subsidence or sinking of land. Subsidence results in part from the way the Earth adjusts to the loss of ice from its polar regions (which will get worse as polar land-ice shrinks), and in part because of the sinking of land as a result of extraction of oil and other resources from the land.

Projections for future sea level rise under the current emissions scenario range from 0.61 to 1.1 m (2 to 3.6 ft) by 2100, at which time the rate of rise is projected to be nearly 5x greater than the current rate (15 mm, or more than ½ an inch per year in 2100). Even at a significantly reduced emissions level, in accordance with the Paris Accord, sea level is projected to rise by 0.20 to 0.59 meters (Pörtner et al, 2019). However there are wildcards in the system, locked up in the ice sheets. In the past, oceans have risen rapidly as ice sheets have shed large amounts of ice in short periods of time. Ice loss results from surface melt, in which the water runs off of the ice into the oceans, and from discharge through the calving of icebergs. The latter is tied to the stability—or instability—of the floating rivers of ice at the margins of Greenland and Antarctica. These rivers and their fronts, where the icebergs calve, tend to hold back the large amounts of ice that feed them. As the ice

around the perimeter of the ice sheets recedes, ice's buttressing effect is reduced and there is the potential for large amounts of ice to flush into the ocean.

Because this is not yet predictable, this wildcard tends to be left out of sea level rise estimates, but it does mean that the far more substantial rises in sea level could occur. History does offer a cautionary warning in that the last time the earth was as warm as it is today, oceans were 5–10 m higher, and the rates of rise were nearly ten times greater than what we are seeing today (Rohling et al., 2019). So even though the estimates for the current century are high, there is a possibility that reality will be much worse.

Sea Ice

Sea ice in the Arctic has been retreating since the first reliable satellite observations were made in 1979 (Figure 7). The retreat of September sea ice (when ice extent is at its minimum) has been at a rate of about 13 percent per decade. Today, sea ice in the Arctic stretches across an area about half the size of what it covered at the start of the 40-year record.

From a climatological perspective, the loss of sea ice is an amplifier to climate change, as the change from bright cold ice to dark wet ice or open ocean causes the region to absorb more heat than it otherwise would. This "albedo" change is one reason the Arctic is warming more rapidly than the rest of the planet. From a weather perspective, the disappearance of ice is a major perturbation to a structure that has helped govern global air circulation throughout modern civilization. The implications of such a loss are as yet unknown, however there is some evidence that a rapidly warming Arctic and the complex interplay ocean, ice and atmosphere can impact us down here in the US, changing drought, heat, wildfires and storminess patterns from West to East.

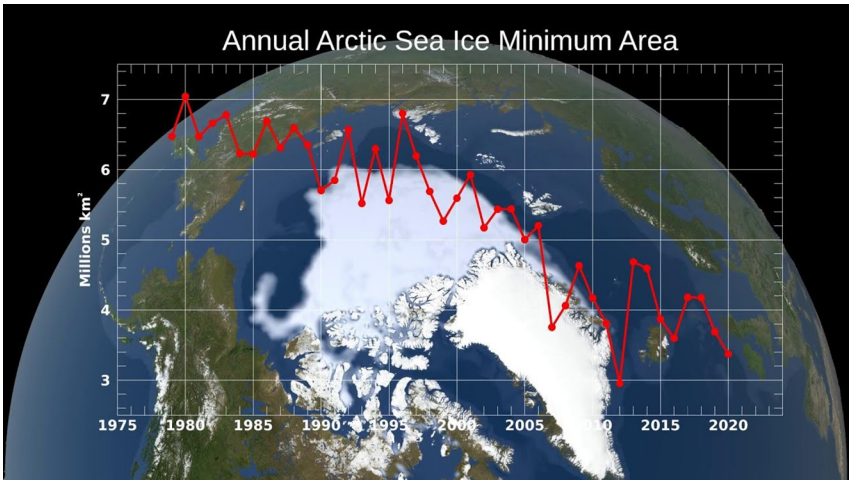

Figure 7: Annual extent of Arctic sea ice, at its minimum extent each year (late September). Minimum extent is indicative of the overall state, since it includes the ice that survives the summer melt season (https://climate.nasa.gov/climate_resources/155/video-annual-arctic-sea-ice-minimum-1979–2020-with-area-graph/).

It is difficult to predict when we will experience an ice-free Arctic in the summertime, something human civilization has never known, but the median estimates are around 2040. While the absence of ice is a major and observable parameter, of greater importance is simply the shrinking and thinning trend that the region is currently experiencing. In addition to its impacts on ocean and atmospheric circulation, the losses are beginning to make the Arctic commercially navigable in the summertime. Such navigability has tremendous economic and security implications as the area becomes commercially and strategically much more valuable than it has been in the past.

In the Southern Hemisphere, Antarctic sea ice had seen increases in extent from the start of the satellite record in 1979 to a peak in 2014. Since then, the Antarctic has experienced such large and rapid loss (Figure 8) that by 2018, the ice extent was less than it was at the start of the record, changing the increasing trend of the first 36 years to a significant net loss over the 1979–2018 40-year period (Parkinson,

2019). Since 2018, there has been some recovery of Antarctic sea ice, toward its initial state.

The Earth's ice cover continues to surprise us, from the loss of Arctic sea ice, which has been much more dramatic than our models had anticipated (Stroeve et al., 2007), to the enormous loss of Antarctic sea ice in a few short years that was far greater than the gains observed in the decades prior, to rapid accelerations in ice sheet outlet glaciers and resulting significant dumping of ice sheet mass into the ocean. Unfortunately, these surprises indicate that in some cases our estimates of one of the fundamental and amplifying variables of the climate system—polar ice cover—are sometimes overly conservative.

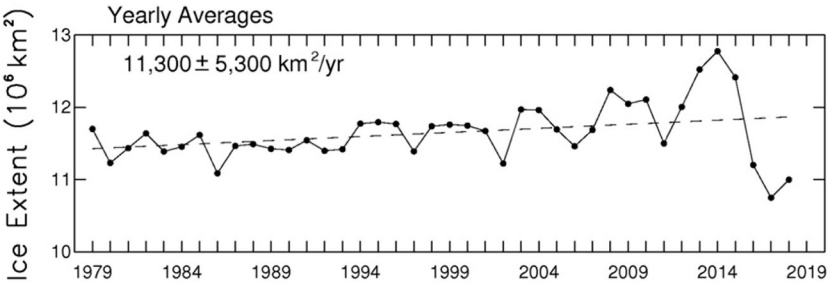

Figure 8: Yearly averages of Antarctic sea ice extent (Parkinson, 2019)

Implications

All of these changes affect the ways we live and will have impacts well into the future. These impacts go well beyond the physical realm, and they can and will be felt in the security, social, and political domains as well. The National Climate Assessment (Reidmiller et al, 2018) captured many of these implications for the United States in their key findings which were:

- The presence of new risks and enhanced vulnerabilities that impact overall well-being in the form of human health, safety, quality of life, and inhibited economic growth.
- Adverse effects on infrastructure and property, with significant economic impacts.
- Poor water quality and reduced water availability, with potentially significant negative effects on agriculture, energy production, industry, recreation, and the environment.
- Dangerous health effects resulting from poorer air and water quality, extreme weather and climate events (e.g. drought, heat, floods, etc.), and disease transmission mechanisms.
- Disruption and destruction of the livelihoods, cultural identities, and interests of indigenous people as their social, physical, and ecological systems are damaged.
- Destruction of critical ecosystems on which our livelihoods depend, including agricultural productivity and food security; examples include crop production, livestock health, etc.
- Further deterioration of an already stressed infrastructure system in the United States, resulting from heavy precipitation events, intense heat, flooding, wildfires and other extreme events.
- Excessive risks to coastal communities resulting from sea level rise, severe storms, and the associated storm surges. From an economic perspective, these phenomena will cause displacement, high adaptation costs and reduced property values.
- Degradation of outdoor recreation environments and economies in areas that are heavily reliant on tourism.
- Cascading effects that will reach far beyond the obvious direct impacts that can threaten essential services on the domestic and international fronts.

On a broader scale, the National Intelligence Council, in its quadrennial *Global Trends* report (National Intelligence Council, 2021), which examines global trends and assesses threats and risks to U.S. national interests, has identified climate change as a key driver of both U.S. and international conditions and well-being. The impacts of these changes across the globe will affect strategic, humanitarian, and security interests worldwide. In particular the National Intelligence Council report identifies the following implications of climate change:

- Increased sea level rise, threatening coastal communities and low-lying islands
- More intense heat waves, posing risks to health and well-being
- Increased extreme weather, including more intense and more frequent natural disasters, such as stronger storms, flooding in coastal regions, and more drought in arid regions, and changes in weather patterns, with both posing risks to health, safety, economic interests, and infrastructure.
- Loss of biodiversity, impacting food and health security
- Food and water insecurity from changes in precipitation, increased extreme weather, and saltwater intrusion (from rising seas and storm surges)
- Greater human health risks driven by changes in environmental conditions that control the locations, prevalence, and movements of disease
- Forced migration (climate refugees) as currently inhabitable areas become uninhabitable as a result of sea level rise, flooding, extreme heat, excessive drought, etc.
- A disproportionate impact on those in the developing world with fewer means to manage the adverse effects of climate change and adapt accordingly.

It is noteworthy that these flags are being raised by the intelligence community, as these conditions have significant impacts on U.S. national security and other national interests. Some of these items identified are similar to what was reported in the most recent *Quadrennial Defense Review* (Department of Defense, 2014), which identified climate change as an important consideration in U.S. defense interests. In particular, the QDR speaks to the role of climate change in potentially creating political, economic, and humanitarian instability, and the potential for climate change to impact operational capabilities, both in terms of theaters of operation and impacts to military installations and infrastructure.

By 2018, however, the *Quadrennial Defense Review* was replaced by the *National Defense Strategy*—a classified document, with only a summary made available to the general public (Department of Defense, 2018). The NDS summary, entitled "Sharpening the American Military's Competitive Edge," makes no mention of climate change. Given this absence, and given the importance of understanding, anticipating, and preparing for climate change to the U.S.'s position on the international stage and our national security interests, its inclusion in the National Intelligence Committee report is essential.

Successfully Meeting the Climate Change Challenge

Successfully meeting the challenges posed by our changing climate, while ensuring that the solutions that we employ are optimized to balance the climate risks with economic interests, requires, science, honesty about the risks of action and inaction, the political will to resist forces that work against solutions. It also requires a long-term view—as the Founders had—that hard choices must be made today to ensure the success of the generations that follow us.

On the scientific front, the science community has worked diligently to understand the mechanisms, manifestations, and implications of climate change. The community foresaw the changes that we are seeing today and will be critical in providing guidance for addressing changes going forward, by continuing to understand these changes, assessing the effectiveness of mitigative measures, and providing the insights necessary to inform adaptation strategies. Observational capabilities as well as modeling and analysis capabilities need to be maintained and enhanced, so we can observe the conditions, understand the implications, inform action, and assess likely outcomes.

Because changes occur on global scales, and with significant regional variability (e.g. Figure 4), and because different components of the Earth/Climate system interact with one another in complex ways that vary spatially and temporally, sustained space-based observations are critical tools for monitoring and understanding climate change. In fact, what we know about fire seasons and intensity, hurricane and large-storm processes, changes in polar ice, movement of water across the globe, the radiative balance (heating/cooling) of the Earth, and so much more, is directly derived from satellite observations. Satellites (which need to be complemented by ground-based and airborne, and other observations), provide a consistent global set of measurements that capture the local and regional nature of the fundamental environmental variables and the interactions among them. Consequently, investments in space-based observations of the Earth are an essential component of a global observing system that is robust enough to help us address the climate challenge. A prioritized blueprint for U.S. investments in space-based Earth observations was developed by National Academy of Sciences (NAS, 2018).

Such investments in observations, as well as in modeling and analyses, are critical to ensuring that we are an informed nation and society, and that decision-making is done with a clear view of what is at stake and the implications of our choices.

While I am referring primarily to the observation and analysis of physical processes that drive climate change, it is similarly important that we study and understand resilience in the economic and social domains, so that we understand the factors driving behaviors and economic impacts of our actions. Such understanding in all of these areas is necessary for not only meeting the challenges in the most optimal and least damaging ways but continuing to thrive despite them.

On the policy front, I defer to you, members of the committee, and your colleagues, as well as the Presidential Administrations (plural, because this is a multi-Administration and multi-generational challenge) to integrate all of the information and make decisions that lead to sound policies and effective action. It is absolutely critical, however, that all dimensions of this existential challenge be considered. This is a national and global challenge, with highly impactful national and global consequences. It needs to be met with a national and global perspective in a coordinated and integrated way. The science is clear—the costs of little or no action are dangerously high. Choosing the "best" action requires an appreciation of all of the aspects of the challenge we face. In too many instances, science has not played its appropriate role in decision-making as it relates to sound policies to manage the risks and threats of climate change. As a result, we have lost precious time. I am not prone to alarmist statements, as I think they force people to fortify their postures rather than flex and consider solutions. But our chances for success are diminishing. We have lost time, and we cannot afford to lose more. The consequences of too little action will be dire. There currently remains opportunity to manage the challenge, but it requires bold action. It is urgent and imperative that those entrusted with the strength, security, and well-being of our Nation, its citizens, and its future generations, adequately consider the science, as well as all the other dimensions of the challenge, and make choices that will secure the future that we all wish for our children, grandchildren, and beyond.

I will end as I began. Climate has always changed, and it always will. But today it is changing in ways that can profoundly impact our health, security, lives, livelihoods, and well-being. Because of our relationship with our environment and the fact that modern civilization has realized the success it has through its industriousness and other activities that contribute to the very crisis we seek to avoid, the solutions are hard. But, the success of society and its ability to thrive in the face of a changing environment depend on: 1) the magnitude of those changes, 2) the rates at which they occur, and 3) our ability to anticipate, prepare for, and adapt to them. The magnitude and rate can be affected by mitigation measures—reducing greenhouse gas emission, particularly carbon dioxide. These measures depend on policies that are informed by science. Similarly, our ability to anticipate, prepare for, and adapt to climate change requires guidance from science, guidance from the very science that anticipated the changes we are seeing today.

The limited actions to address this climate-change crisis have resulted in lost opportunity and have produced a challenge that is even greater than it was even just a few years ago. With the political and societal will, and with strategic and scientifically informed action that considers the social, physical, economic, and political dimensions of the climate change challenge, the dangerous trajectory we are on can be altered such that our generation's story can be one of success, not failure. Making it so requires hard choices, commitment, will, and a respect for the science. And as a citizen, I look forward to this body demonstrating the will and commitment and make the hard choices. And as a scientist, I and my colleagues stand ready to provide you with the best information possible to inform those choices and actions.

Thank you very much for your time and for your efforts in tackling what truly is an existential challenge.

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Ms. CASTOR. Thank you very much.

Next, we will go to Heather Toney. Mrs. Toney is the environmental justice liaison for—

Mr. GRAVES. Madam Chair, I am not sure if it is just me. I couldn't hear you. Is there other people not able to hear her?

Ms. ESCOBAR. Yeah. Madam Chair, you are cutting in and out.

Ms. CASTOR. All right. Maybe I will get closer to the microphone. Does that improve the audio?

Ms. ESCOBAR. You know, your audio is good. It is just that it came in and out, so it was cutting in and out. So hopefully fingers crossed.

Mr. GRAVES. It did it once in your introduction as well, but it was very brief. This time, it cut out longer.

Mr. CASTOR. Okay.

Dr. ABDALATI. If you are closer and louder, it should be better.

Ms. CASTOR. All right. I will do that, because I want you all to hear about the terrific Heather Toney. So I am going to do this again.

Mrs. Toney is the environmental justice liaison for the Environmental Defense Fund and senior adviser for Moms Clean Air Force, where she led the National Field Team and the Moms and Mayors Program.

She served as the first African-American, first female, and youngest mayor of Greenville, Mississippi. And, in 2014, Mrs. Toney was appointed by President Obama to be the regional ad-

ministrator for the Environmental Protection Agency's Southeast Region, where she served until 2017.

Mrs. Toney, welcome. You are recognized for 5 minutes.

STATEMENT OF THE HONORABLE HEATHER MCTEER TONEY

Mrs. TONEY. Thank you so much, Chairwoman Castor and Ranking Member Graves, and members of this committee. Thank you for prioritizing the need for bold action on the climate crisis by hosting this hearing.

As this committee is comprised of members under no disillusionment about the existing climate crisis we face, I will cut straight to the chase.

For every moment that our country delays response to this emergency, we become more and more responsible for the business livelihoods lost and families destroyed because we failed to act when we had both the science and the facts to back our actions.

What is worse is that inaction will multiply the climate-based impacts to communities of color and marginalized communities fighting simply to experience the equal access to elements necessary for life: breathable clean air, drinkable water, and nontoxic land. There are so many overlaps of social justice inequities in climate such that inaction is inconceivable.

I am a wife, a mother of three, a former mayor, and a former regional administrator for EPA, but I am triggered by the fact that I see voting rights suppressions enacted that disproportionately impact people of color, yet study after study shows us that Black and Brown people are more likely to vote for climate policies.

I am praying daily for the safety of my Black American husband and sons because I know that the science shows us we are going to continue to experience an increase in violence related to warming, and there appears to be an attack on African-American men, particularly in urban areas and heat islands.

I live in Mississippi, and I monitor the schools my children attend because I know that extreme heat impacts education, and data shows us that those who live in heat-impacted areas perform worse on tests than others who do not. So climate justice impacts every aspect, and none of us can afford inaction.

I must also stress that mayors and local officials don't have the luxury of inaction. When the fire department is unable to pump water to a fire, homes and businesses burn. And when traffic lights cease to work and oxygen tanks stop pumping, people die. So local communities require bold, mandatory action and climate action as a means of safety and protection. And this responsibility should be shared by government, regulators, and business industry alike.

Now, EDF is currently conducting a leaflet series entitled "Understanding the Cost of Inaction on Climate Change" and studying the near-term costs of climate inaction. And each report crystallizes for us the fact that not only is climate change devastating local communities and economies, but already overburdened communities are bearing the brunt of this cost. Climate costs are growing rapidly and will be felt over the next 10 to 20 years, in addition to the next 50. And there is no question that extreme weather impacts Black and Brown communities worse than any other demographic in the nation.

In our most recent report on the State of North Carolina, we found that, over the last decade alone, the state experienced four major hurricanes at a cost topping $1 billion of combined crop and livestock loss after Hurricane Florence alone. But, to make matters worse, the studies conducted by Rice University and the University of Pittsburgh show that predominantly White areas realized an increase in the average wealth post-disaster versus minority communities that see noticeable wealth decrease.

And inaction is further compounded with the onset of coronavirus and the looming threat of future pandemics as a result of climate change. So not only are people fighting a pandemic in the middle of a climate emergency, we are having to do it within a system of structural racism and inequity.

Recently EDF and Moms Clean Air Force signed a letter in support of RISE Saint James as an action calling on the bank to cease financing of a Formosa project in the Saint James Parish in Louisiana. Not only is the project dangerous and unnecessary, but it continues to perpetuate inaction on calls for environmental justice, particular for communities on the front lines of pollution every day.

And I often think about Moms Clean Air Force organizer, Columba Sainz, in Phoenix, Arizona. She is a mother of three, but she explained it best. She said: Energy poverty is real. People in the lowest income groups spend the most on energy. And the hotter it gets, the more it costs, and the more we need. Who can afford to pay over half their paycheck on air conditioning in the middle of the pandemic in a heat wave?

So we often quote saying that we are all in this boat together, so let's make sure we are all rowing in the same direction, but I disagree. We are in the same storm, but we are not all in the same boat. Some of us are in row boats while others are in yachts. Some of us are sitting on aircraft carriers while others are just bobbing along on a floaty.

Whatever our mode of traversing this storm, none of us can afford inaction, and the failure to acknowledge this fact in and of itself is inaction. It is a choice to ignore the others in the storm. And justice and equity require a new focus on urgent action with an eye towards funding the scientific research and ground infrastructure necessary to respond in a manner that demonstrates a societal commitment to righting the imbalance.

I look forward to answering the questions of the committee. Thank you.

[The statement of Mrs. Toney follows:]

Before the United States House of Representatives

Select Committee on the Climate Crisis

"Making the Case for Climate Action: The Growing Risk and Cost of Inaction"

Written and Oral Testimony of Heather Toney

Climate Justice Liaison, Environmental Defense Fund

Senior Advisor, Moms Clean Air Force

April 15, 2021

Chairwoman Castor, Ranking Member Graves, and members of the committee, thank you for prioritizing the need for bold action on the climate crisis by hosting this hearing. As this committee is comprised of members under no disillusionment about the existing climate crisis we face, I will cut straight to the chase—for every moment our country delays response to this emergency, we become more and more responsible for the business livelihoods lost and families destroyed because we failed to act when we had both science and fact to back our actions. What's worse, is that inaction will multiply the climate based impacts to communities of color and marginalized communities fighting simply to experience equal access to the elements necessary for life—breathable clean air, drinkable water and non-toxic land.

There are so many overlaps of social justice inequities and climate such that inaction is inconceivable. I am a wife, a mother of 3, former mayor and former regional administrator of EPA. I am triggered by the fact that I see voting right suppressions enacted that disproportionally impact people of color yet after studies have shown time and time again that black and brown people are most likely to vote for climate policy [1] and we fail to make that connection. I pray daily for my black American husband and son because I have seen far too many African American men fail to return home due to completely unwarranted violence by those in authority. Yet I know the science and data that show we are and will continue to experience an increase in violence related to warming [2] [3], particularly in urban areas and heat islands [4]. Yet we have not made the connection. I live in Mississippi, monitor the schools my children attend and do my best to assist teachers with common classroom needs, because I know that extreme heat impacts education and data shows that those who live in heat impacted areas perform worse than those who do not [5]. Climate justice impacts every aspect of life, and none of us can afford inaction.

I must also stress that Mayors and local officials do not have the luxury of inaction. When the fire department is unable to pump water to a fire, homes and businesses burn and people die. When the waste water sewer systems and drinking water systems fail, people die. When the traffic lights cease to work, oxygen tanks stop pumping and heating/cooling systems shut down because the electrical grid is overwhelmed due to a climate crisis, people die. Our responsibilities to protect the very communities in which we live mandate life and death decisions daily and at a moment's notice. Local communities require bold mandatory action climate action as a means of safety and protection and this responsibility should be shared by government, regulators and business industry [6].

EDF is currently conducting a research series entitled, Understanding the Cost of Inaction on Climate Change," [7] and studying the near-term cost of climate inaction. Each reports crystalizes the fact that not only is climate change devastating local communities and economies, but already overburdened communities are bearing the brunt of the cost. Climate costs are growing rapidly, and will be felt over

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[3] https://www.nytimes.com/2018/09/21/upshot/a-rise-in-murder-lets-talk-about-the-weather.html

[4] https://www.nytimes.com/interactive/2020/08/24/climate/racism-redlining-cities-global-warming.html

[5] https://fse.fsi.stanford.edu/news/how-extreme-heat-affects-learning#:~:text=The%20findings%20show%20that%20the,number%20of%20hot%20school%20days.&text=In%20addition%2C%20minority%20and%20low,of%20heat%2C%20the%20research%20found.

[6] https://www.usmayors.org/programs/mayors-climate-protection-center/

[7] https://docs.google.com/document/d/1pju1DNz5EPQ-yRkrE03u6F7Y91RHdl0Yg7V_Lmp2FZg/edit

the next 10–20 years in addition to the next 50. In essence, it means that our inaction isn't just costing our children and grandchildren, it's costing us now.

North Carolina is titled as the state that gave birth to the very movement we now call "Environmental Justice"[8] and the disparities of economic loss and environmental injustices continue to exist. In our most recent report on the state of North Carolina, we found that over the last decade alone the state experienced four major hurricanes at a cost topping $1 billion dollars of combined crop and livestock loss after hurricane Florence alone. Black communities were forced to deal with the impacts of overflow from CAFOs (Controlled Animal Feeding Operations) with no recourse—after Florence, overflows in the swine industry "occurred at 50 waste ponds used to collect animal manure, with two cases causing roughly 7 million gallons of waste to spill into local waterways. Meanwhile, poultry farmers struggled with how to deal with the 4.2 million dead chickens and turkeys that drowned as a result of flooded poultry houses in the southeast."[9] Without a plan of action, these numbers will continue to climb year after year. Currently, President Biden has proposed, "The American Jobs Plan" which in North Carolina, calls for $50 billion in resiliency dollars to help communities protect against these impact with an additional $16.8 billion to support safe drinking water.[10] It's a start. What we are sure of is that we simply cannot fail to act on what we know is necessary.

There is no questions that extreme weather impacts black and brown communities worse than any other demographic in the nation[11]. To make matters worse, studies conducted by Rice University and the University of Pittsburg show that predominantly white areas realize an increase in the average wealth post disaster versus minority communities that see a noticeable wealth decrease. This dynamic is caused by the levels of reinvestment into communities post climate disasters.[12] Researchers further concluded that despite accounting for controlled factors including, but not limited to; age, education, and homeownership, wealth inequality increases in regions hit more by natural disasters[13]. How is it that in a system managed by federal oversight of agencies responsible for the disaster assessment and response, inequities continue to exist? Add the additional climate impacts like vector borne diseases and heat—the EDF North Carolina study found that the most serious temperature-related impacts are likely to be those associated with extreme heat. Emergency room visits due to heat stroke and other hyperthermia conditions will likely increase two to threefold from 2010 to 2050, and in many cases, these costs and impacts will be disproportionately felt by low-income and socially disadvantaged populations who have fewer resources and options for protecting themselves.

Inaction is further compounded with the onset of Coronavirus and the looming threats of future pandemics as a result of climate change. We already know what inaction looks like. We've buried far too many of our mothers, fathers, best friends and yes, children as a result of inaction. Not only are people fighting a pandemic in the midst of a climate emergency, we're having to do it within a system of structural racism and inequity. A study from Yale found that Black Americans are 3.5 times more likely to die of Coronavirus than white Americans.[14] While this should not have been a surprise to any of us, it was certainly acknowledged within minority communities early. These COVID–19 disparities stem from multiple interrelated factors, all driven by longstanding structural racism and inequity.

How our government, corporations and communities respond right now will determine whether or not we have learned for our history of systemic racism and exclusion by following the science and listening to community experts in order to create a more efficient and equitable process that saves our economy, ecosystem and lives at the same time.

Inaction on climate change carries a substantial risk to our country's financial system and our ability to continue support of our economy. It cannot be ignored and should be undergirded by a stable federal mandatory climate risk disclosure requirement. While there is the opinion that voluntary climate risk disclosures create a better opportunity for corporations to self-regulate while protecting their proprietary information, the bottom line is that the astronomical rates in the deregulated system represent a failure of market incentives. It also demonstrates that some over-

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[8] https://www.washingtonpost.com/climate-environment/interactive/2021/environmental-justice-race/

[9] *Climate Change and North Carolina: Near-term Impacts on Society and Recommended Actions,* George Van Houtven, Jared Woollcott and Alison Bean, EDF and RTI International, pg. 35–36

[10] https://www.whitehouse.gov/wp-content/uploads/2021/04/AJP-State-Fact-Sheet-NC.pdf

[11] https://www.greenamerica.org/climate-justice-all/people-color-are-front-lines-climate-crisis

[12] https://www.eurekalert.org/pub_releases/2018–08/ru-ndw082018.php

[13] https://psci.princeton.edu/tips/2020/8/15/racial-disparities-and-climate-change

[14] *https://www.medrxiv.org/content/10.1101/2020.05.07.20094250v1.full.pdf*

sight is necessary to protect those most at risk from the economic fallout of these intense climate related weather events.

When I was Mayor of Greenville, I was blessed with a good corporate partner with respect to disclosure. Mars Foods, Inc. has operated Uncle Bens Rice, now known as Ben's Original Rice, in Greenville, Mississippi for over 40 years. They not only supply needed jobs to the community but also hold an important role as a major public asset, occupying over 80 acres, 250,000 square feet and producing 100,000 tons of rice annually. It is the largest Mars Food factory in the world.[15] It sits right on the Mississippi River and serves as an anchor to a majority African-American community that has worked hard to overcome systemic poverty for generations. During my time of public service, I had to manage not one, but two [16]500 year flood events[17]. Both events caused extensive and expensive damage to the infrastructure of the community. Roads, bridges, water system were all impacted by the heavy rainfall and incessant storms that battered the city year after year. Quite frankly, the tax base of the city couldn't handle the existing infrastructure needs, let alone the added pressure of becoming resilient to climate impacts. It's the type of activity that would cause a major business to close up shop, and move someplace else. Nevertheless, the Mars Food climate sustainability plan took into account the asset placement, needs, preparation and mitigation necessary to continue strong global economic growth while supporting local community needs. Their willingness to not only assess climate risk but share the information meant that I was prepared to account for the necessary support: street upgrades, police and fire in case of emergency, water system points of weakness, potential levee breaches and places to point the Army Corp of Engineers for review. All of these calculated cost added value to the company while protecting the invisible investor: the citizens of my city that through tax dollars, were able to defer repairs to other places it was needed. Not only does Mars Food have a multipage climate action statement[18], they continue to share information and support the local community through advanced risk assessment for climate. In 2020 they invested $2.5 Million dollars into Greenville and continue to coordinate closely with local government solidifying even further their commitment to stability for their investors, the market and the community.

How I wish that same energy could have emerged in Texas with the recent winter storms and energy debacle that arose from the complete failure of publically traded energy corporations to prepare, let alone disclose their climate risk.

Due to longstanding environmental and social disparities, minority communities also have higher rates of chronic conditions that put us at risk for more severe illness. As an example, we know that black and brown people as well as lower income people tend to have higher average exposure to air pollution. We also know that air pollution exposure causes many of the same chronic diseases that make COVID more deadly, including heart disease, diabetes, and asthma. Inequity in healthcare access and quality of care may then further contribute to worse outcomes, including higher mortality. Add to this the fact there is ample evidence that racism in healthcare settings often results in people of color receiving a lower standard of care, and that black folks just plain don't trust these systems and may delay or avoid seeking care for COVID symptoms because of past negative experiences or distrust stemming from the legacy of racist and unethical medical research and experimentation on people of color. Just today, the announcement of concerns around the Johnson & Johnson vaccine are creating additional mistrust for a vaccine already fragilely accepted in minority communities. Failure to provide other methods of climate protection—reducing carbon emissions, supporting grid stability, etc., will further exasperate climate impacts to communities of color.

Finally, lower healthcare access and quality may also worsen chronic health conditions, and influence access to COVID testing and diagnosis, which in turn impacts infection rates if people are more likely to be living and working with undiagnosed illness.

While we don't yet know exactly how extreme heat compounds the effects of COVID–19 on low income communities and people of color, we can see that a relationship exist and it is exasperated by oppressive systems of racial inequity. Dr.

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[15] https://www.usarice.com/news-and-events/publications/usa-rice-daily/article/usa-rice-daily/2018/09/28/mars-food-celebrates-40-years-in-greenville-mississippihttps://www.usarice.com/news-and-events/publications/usa-rice-daily/article/usa-rice-daily/2018/09/28/mars-food-celebrates-40-years-in-greenville-mississippi

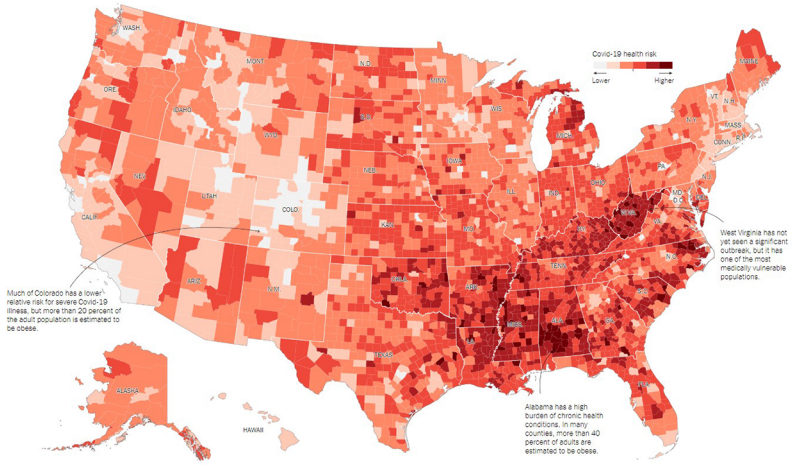
[16] https://deltabusinessjournal.com/flooding-on-the-mississippi-river-becoming-more-common-and-severe/

[17] http://extension.msstate.edu/news/extension-outdoors/2017/understand-historic-record-breaking-floods—*Noted that this is based upon 2017 numbers. More recent floods have caused an increase from the recorded floods of this article.

[18] https://www.mars.com/about/policies-and-practices/climate-action

Linda Ray Murray of Chicago, IL outlined a stunningly familiar relationship between the death rate of COVID and the Chicago Heat Wave of 1995, the deadliest in the city's history.[19] Over 700 people died in Chicago's housing projects in what can be explained as death by virtue of being poor. Moms Clean Air Force Organizer Columba Sainz, wife and mother of 3 in Phoenix, Arizona, explained it best. "Energy poverty is real; people in the lowest income groups spend the most on energy. The hotter it gets, the more it cost and the more we need. Who can afford to pay over half of their paycheck on air conditioning in the middle of a pandemic and a heat wave? Communities of color are energy poor and 25 years later, we see the exact same dynamics played out on the exact same people in the exact same way: we have not legislated to lessen the impacts of structural racism but instead, have placed a higher burden and lower value on the lives of black and brown people through racist policies like the 100 rollbacks of EPA. Systems that are meant to protect the health of the most vulnerable among us are being cast aside for profit and Coronavirus has revealed just how deadly inaction can be.

The New York Times published a map (Figure 1) [20] which displays the proportion of adults in each county who have one or more of the conditions known to worsen COVID illness: diabetes, high blood pressure, obesity, heart disease, and chronic lung disease; southern states have a larger proportion of their populations who have these underlying conditions. With extreme heat projected in many of these states over the summer, we expect these conditions may worsen, especially with increases in ozone concentrations that are seen in the warmer months.



We also know that there are clear disparities by race and income in the prevalence of chronic diseases that put people at higher risk of severe COVID illness. 69% of American Indian seniors and 61% of black seniors have chronic diseases putting them at elevated risk of severe COVID illness, versus 54% of white seniors. 40% of low income people under 65 are at higher risk, versus 24% of those with higher income. COVID–19 death rates in the U.S. also vary dramatically by race. Based on mortality data through June 24, 2020, the mortality rate for black Americans (65.8 deaths per 100,000 people, or 1 in 1,500) is more than twice as high as the rate for whites. Black Americans represent 12.4% of the population in the US, but have suffered 23.8% of deaths as of June 24.

With economic resources stretched thin by COVID–19, thoughtful spending and prioritizing projects that produce the most immediate benefit are needed—this includes having better information regarding mapping of heat islands and a better understanding of the risks associated with low income and minority communities. To better understand the disproportionate impacts of extreme weather on communities of color, we need to deploy many existing tools—and develop some new ones—with the specific goal of understanding the complex web of interactions that result in heightened weather-related risk to such communities. We absolutely must demand

[19] *https://chicago.suntimes.com/2020/6/28/21302962/25th-anniversary-heat-wave-racism-covid-19-chicago-linda-murray*

[20] Figure 1: NY Times, May 18, 2020

a halt to EPA reversing lifesaving protections and that they revisit their mission of protecting human health and the environment. This is our call to action at Moms, demanding "Justice in Every Breathe" of every policy impacting the health and well-being of children.

An inter-disciplinary approach is needed, one that begins with better understanding the localized impacts of climate change-fueled heatwaves and other extreme weather events. Research is needed to quantify how much more communities of color may be impacted during an extreme event and the historical reasons for such disproportionate impacts. For example, are communities of color living in a more vulnerable area such as an urban heat island lacking green space? Are residents living in low-lying neighborhoods without sufficient flood control? These data must be incorporated into a larger framework that can evaluate community-level risks with the knowledge of pollution exposure, housing stock, health characteristics, age distribution, indoor air quality, and other household risks such as overcrowding and the prevalence of lead in water and paint.

More information is needed about the public health risks of expanding petrochemical operations in areas susceptible to climate change-induced storms, flooding, and sea level rise. Studies in the area of St. James Parish in Louisiana, part of Cancer Alley have already shown a correlation between the rampant air pollution in the area and Coronavirus deaths.[21] Recently EDF and Moms Clean Air Force signed a letter in support of Rise St. James, calling on bank to cease financing of the Formosa project in St. James Parish. Not only is the project dangerous and unnecessary, it continues to perpetuate inaction on calls for environmental justice, particularly for communities on the frontlines of pollution every day. It's case study of why we must collect this information now to protect people in the future. Local governments need resources to support sustainability planning efforts such as development of climate action and mitigation plans and renewable energy portfolios. Supporting NGO organizations and allies need to know where and how to help best. A comprehensive understanding of current conditions will also help project future extreme weather-related risks to communities of color as the climate continues to warm.

We often quote the saying, "We're all in the boat together so let's make sure we're rowing in the same direction". I disagree. We're in the same storm, but we're not all in the same boat. Some of us are in rowboats, while others are in yachts. Some are sitting on an aircraft carrier while others are just bobbing along on a floatie. Whatever our mode of traversing this storm, none of us can afford inaction and the failure to acknowledge this fact in and of itself is an action. It's a choice to ignore the others in the storm. Justice and equity require a new focus on urgent action with an eye towards funding the scientific research and ground infrastructure necessary to respond in a manner that demonstrates a societal commitment to righting that imbalance.

I have attached additional documents for review of this committee and as part of my written testimony. They include the following:

A. USGCRP. (2018) Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf.
This report, developed by an interagency working group and published by the US government, documents how the impacts from human-caused climate change are intensifying and threatening our physical, social and economic well-being. In particular, it highlights that impacts will not be distributed equally and vulnerable communities that have lower capacity to cope with extreme climate-related events are expected to experience greater impacts.

B. Hsiang, S., Kopp, R., Jina, A., Rising, J., et al. (2017) Estimating economic damage from climate change in the United States. Science 356(6345), 1362–1369. https://doi.org/10.1126/science.aal4369
This study integrated data with climate models to examine how six sectors—agriculture, crime, coastal storms, energy, human mortality, and labor—would respond to climate change, estimating future costs through the end of the century. The authors project that a large transfer of value northward and westward will take place, increasing economic inequality. The poorest third of counties would be hardest hit and are projected to experience damages between 2 and 20% of county income (90% chance) under a business-as-usual emissions scenario (RCP 8.5).

[21] *https://earther.gizmodo.com/im-scared-study-links-cancer-alley-air-pollution-to-hi-1843484042*

C. Raval, A., Chen, T., & Shah, P. (2019) Mapping Resilience: A Blueprint for Thriving in the Face of Climate Disasters. Asian Pacific Environmental Network. https://apen4ej.org/wp-content/uploads/2019/10/APEN-Mapping_Resilience-Report.pdf
This report aims to raise the public visibility of the needs of frontline communities for climate adaptation and resilience efforts. Though focused largely on California, it highlights lessons learned across the US in terms of communities disproportionately impacted by climate change-related disasters, and ways to understand and build resilience for such groups

D. Union of Concerned Scientists. (2018) Underwater: Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate. https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-full-report.pdf
This analysis identified residential and commercial properties at risk of chronic inundation as sea levels rise. They found that within the next 15 years, roughly 147,000 existing homes and 7,000 commercial properties—currently worth $63 billion—are at risk of being inundated an average of 26 times per year or more.

E. First Street Foundation. (2020) The First National Flood Risk Assessment: Defining America's Growing Risk. https://assets.firststreet.org/uploads/2020/06/first_street_foundation__first_national_flood_risk_assessment.pdf
First Street Foundation created an online database and visualization tool that shows past, present, and future flood risk due to climate change. They identified around 1.7 times the number of properties as having substantial risk compared to the FEMA 1-in-100 SFHA designation. This means that of the 14.6 million properties across the country identifies as being as at substantial risk, 5.9 million properties and property owners are currently unaware of or underestimating the risk they face. Vulnerable communities with less resources to insure themselves will face greater risk from flooding events.

I stand available to answer any questions of the Committee.

Ms. CASTOR. Thank you very much.

Now I am pleased to recognize Representative Buddy Carter to introduce Dr. Shawn Gillen.

Rep. Carter.

Mr. CARTER. Thank you, Madam Chair.

Shawn Gillen is the City Manager of Tybee Island, Georgia. Tybee Island is located in the First Congressional District of Georgia, where I have the honor and privilege of representing, by the way.

Mr. Gillen grew up in western Illinois and went to the University of Iowa, where he played on the Hawkeyes football team. While part-time coaching at Monmouth College in Illinois, he decided to run for mayor of the City of Monmouth.

He spent 4 years as mayor there, beginning his career in public administration. Since then, he has spent time in Kentucky, Minnesota, and in Doraville, Georgia, helping manage cities. He holds a Ph.D. in public administration and sits as a faculty member of Walden University.

In 2017, Mr. Gillen came to the First District of Georgia to be the City Manager of Tybee Island. He has done a fantastic job as City Manager and has been a great partner.

Specifically related to the business of this committee, my office and Tybee Island have worked together on beach renourishment, FEMA grants, and other ways to build up the resiliency of the island. The City of Tybee Island has taken to responding to rising sea levels and hurricanes very seriously, and we are very appreciative of that. It is a model for cities across the country that are trying to prepare for those situations.

Welcome, Mr. Gillen. We appreciate you joining us.

Ms. CASTOR. Thank you, Rep. Carter.

Dr. Gillen, you are recognized for 5 minutes.

STATEMENT OF SHAWN GILLEN

Dr. GILLEN. Thank you, Representative Carter.

Madam Chair and committee members, thank you for inviting me here today.

As Representative Carter said, my name is Shawn Gillen. I am the City Manager of Tybee Island, Georgia. I would like to speak with you today about some of the steps that the City of Tybee Island has taken to address the current and future impacts of climate change on our beach and within our community.

In each of the past 5 years, Tybee Island has been impacted by hurricane activity in the Atlantic. In 2016, Hurricane Matthew caused massive wind damage and flooding damage.

Less than 12 months later, Hurricane Irma hit Tybee Island, flooding nearly 700 homes and disrupting numerous businesses. Tybee Island saw impacts from hurricanes Michael, Florence, and Dorian during that timeframe.

In 2016, Tybee Island completed a Sea Level Rise Adaptation Plan. During the process of completion of that plan, we looked at tidal gauge data from 1980 to 2015. We discovered that the frequency of tidal events in excess of 9.2 feet has steadily increased. This translates to more frequent flooding of the one road on and off Tybee Island. From 1935 to 2010, the tidal gauge at Fort Pulaski has recorded approximately ten inches of sea-level rise. Couple this data with the recent increase in Atlantic hurricane activity impacting Tybee Island and one can understand our sense of urgency.

Since the completion of the plan and Hurricanes Matthew and Irma, Tybee Island has taken a three-pronged approach to addressing the impacts of sea-level rise: defend, adapt, and retreat. We have been aggressive in our building of our seaward defenses of the island. Through a cooperative effort of the city, the U.S. Army Corps of Engineers, and the State of Georgia, we have renourished our beach and, for the first time, incorporated the construction of sand dunes as part of the renourishment project.

The challenge we are faced with now is our Federal beach nourishment project with the U.S. Army Corps of Engineers expires in 2024. Under the current Corps' models, our beach does not qualify for an extension. In essence, the Federal Government is seeing significantly reduced damages from a partnership that it now plans to terminate.

It must be noted that the study done by the U.S. Corps of Engineers research arm, ERDC, concluded that 78 percent of the erosion on Tybee Island was the result of the Savannah shipping channel. With the uncertainty of the future of our partnership with the Corps of Engineers, we have been exploring the possibility of beneficial reuse of dredge material as an alternative approach. This is a less-than- ideal approach, but one that we are forced to pursue.

As successful as we have been in defending the seaward side of the island, we struggle with the marsh side. Through a National Fish and Wildlife grant, we are studying how to defend the city from flooding from the marsh side of the island. The results of the

study will likely call for innovative approaches to help us adapt to serious flooding that has occurred in the past.

We are currently adapting our island by raising houses above the flood level. The city has achieved a rating of five in FEMA's Community Rating System and offers our residents a 25-percent discount in their insurance premiums.

We have also been successful in procuring FEMA hazard mitigation funding to move forward with the raising of 12 homes. We are waiting to hear from FEMA if we are receiving grant funding for 49 additional homes.

We are entering our fourth year of this process, and, as you can imagine, the homeowners are getting anxious, as are city leaders. Increasing the speed and efficiency of these grant programs would go a long way to helping cities like Tybee Island adapt.

Speed and efficiency of the approval process are not the only improvements that could be made. We also need increased flexibility of the program to allow for the purchase of properties where frequent flooding occurs, turn these properties into green space that can absorb the flooding waters and make the city more resilient to frequent flooding events.

Retreat can only work if we have a partner in the U.S. Government to help us get over the financial burden that a city like Tybee Island could never afford. Regrettably, the Federal Government's investment in resilience is much less than it should be. Cities will be the leaders in climate adaptation, and the Federal Government needs to provide them with technical and financial assistance to implement solutions that are based on sound science.

Our defend, adapt, and retreat approach means we will be able to absorb a blow and bounce back quickly. This is how we define resilience on Tybee Island. This is—this will only be possible with a continued partnership with the U.S. Army Corps of Engineers and FEMA as well as our partners in the State of Georgia.

I thank you for allowing me to speak today on behalf of my community, and thank you, Madam Chair.

[The statement of Dr. Gillen follows:]

Madam Chair and Members of the Committee, thank you for inviting me here today. My name is Shawn Gillen and I am the City Manager of Tybee Island Georgia. I would like to speak with you today about some of the steps the City of Tybee Island has taken to address the current and future impacts of climate change on our beach and within our community.

In each of the past five years Tybee Island has been impacted by hurricane activity in the Atlantic. In 2016 Hurricane Matthew caused massive wind in a flooding damage. Less than twelve months later, Hurricane Irma hit Tybee Island flooding nearly 700 houses and disrupting numerous businesses. Tybee Island also saw impacts from Hurricanes, Michael, Florence and Dorian.

In 2016 Tybee Island completed a Sea Level Rise Adaptation Plan. During the process of completing that plan we looked at tidal gauge data from 1980 to 2015. We discovered that the frequency of tidal events in excess of 9.2 feet has steadily increased. This translates to more frequent flooding of the one road on and off Tybee Island. From 1935 to 2010 the tidal Gauge at Fort Pulaski has recorded approximately 10 inches of sea level rise.

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State of Georgia, we have renourished our beach and for the first time incorporated the construction of sand dunes as part of the renourishment project. The challenge we are faced with now is our federal beach nourishment project with the US Corps of Engineers expires in 2024 and, under the current Corps models, our beach does not qualify for an extension. In essence, the federal government is seeing significantly reduced damages from a partnership that it now plans to terminate.

It must be noted that a study done by the US Corps of Engineers research arm, ERDC, concluded that 78% of the erosion on Tybee was a result of the Savannah shipping channel. With the uncertainty of the future of our partnership with the Corps of Engineers we have been exploring the possibility of beneficial reuse of dredge material as an alternative approach. This is less than an ideal approach, but one that we are forced to pursue.

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We are currently adapting our Island by raising houses above the flood level. The City has achieved a rating of 5 in FEMA's Community Rating System which offers our residents a 25% discount on their insurance premiums. We have also been successful in procuring FEMA Hazard Mitigation funding to move forward with the raising of 12 houses. We are waiting to hear if we will receive funding for 49 more homes. We are entering our fourth year of this process, and as you can imagine the homeowners are getting anxious as are City leaders.

Increasing the speed and efficiency of these grant programs would go a long way to helping cities like Tybee Island adapt. Speed and efficiency of the approval process are not the only improvements that could be made. We also need increased flexibility of the program to allow for the purchase of properties where frequent flooding occurs, turn those properties into greenspace that can absorb the flood waters, and make the City more resilient to frequent flooding events.

Retreat can only work if we have a partner in the US Government to help us get over the financial burden that a city like Tybee Island could never afford. Regrettably, the federal government's investment in resilience is much less than it should be. Cities will be the leaders in climate adaptation, and the federal government needs to provide them with technical and financial assistance to implement solutions that are based on sound science.

Our "defend, adapt and retreat" approach means we will be able to absorb a blow and bounce back quickly. This is how we define resilience on Tybee Island. This will only be possible with continued partnerships with the USACE and FEMA, as well as our partners in the State of Georgia.

I thank you for allowing me to speak here today on behalf of my community.

Thank you, Madam Chair

NOAA, 2015, Tide Gauge, National Weather Service, Advanced Hydrologic Prediction Service. http://water.weather.gov/ahps2/hydragraph.php?gage=fpkg1&wfo=chs. Accessed June 12, 2015

Channel Impact Study (ERDC/CHL TR–08–5 iii)

Ms. CASTOR. Thank you, Dr. Gillen.

And you will be pleased to know that Representative Carter has frequently briefed us on the challenges with Tybee Island.

Next, we will go to Congressman Sean Casten to introduce Dr. Michael Greenstone.

Mr. CASTEN. Thank you so much. It is a pleasure to be here and really an honor to introduce Dr. Michael Greenstone, fellow Illinoisan, a friend. More importantly, he is the Milton Friedman Distinguished Service Professor in economics, as well as the director of the Becker Friedman Institute and the Energy Policy Institute at the University of Chicago, or EPIC.

He was a gracious enough a couple years ago, I think, to use at least 8 or 10 hours, it felt like, going through all of just the fascinating research. It is a tremendous resource both to the Chicago region and to our country as a whole, and I hope we can perhaps, this term, invite some of the committee out to see your good work.

Previously, Dr. Greenstone was the chief economist for President Obama's Council of Economic Advisers, where he co-led the devel-

opment of the U.S. Government's social cost of carbon. He was also the 3M professor of environmental economics at MIT.

His research, which has influenced policies around the globe, has focused on uncovering the benefits and costs of environmental quality and society's energy choices.

Ms. CASTOR. Thank you, Rep. Casten.

Dr. Greenstone, you are recognized for 5 minutes.

STATEMENT OF MICHAEL GREENSTONE

Dr. GREENSTONE. Thank you very much, Chair Castor, Ranking Member Graves, and of course Representative Casten, who is a terrific friend and is as curious and insightful as almost anyone I have ever encountered, and willing to put up with academics talking about their work for 8 to 10 hours, most importantly. And of course let me thank the other members of the committee for inviting me to speak today.

So I appreciate the opportunity to talk with you about the growing risk of climate change and the cost of inaction. I think the best way to measure the monetary cost of inaction is through a number that is known as the social cost of carbon, or the SCC.

It is the cost of an additional ton of carbon released into the atmosphere, and it measures kind of everything that that ton does: the destruction of property from storms and floods to climbing agriculture and labor productivity, elevated mortality, and so forth.

By capturing the cost of climate change, SCC allows for the calculation of the benefits of regulations which are necessary for cost-benefited regulation. But, critically, the SCC can also be used to determine an efficient price for market-based policies for combating climate change, such as a carbon tax or a cap and trade system. Those approaches unleash market forces that uncover the least expensive ways to reduce emissions and thereby minimizing the cost to the economy, kind of a cheapest ton approach.

Regardless of the policy approach used, the social cost of carbon, or SCC, based on the best available science and economics, best serves the interests of the American people.

So let me give you some history. As the chief economist for President Obama's Council of Economic Advisers, I co-led the creation of the original government-wide SCC in 2010, which eventually landed at $51 per ton.

The Trump administration subsequently lowered SCC to just $4, failing to justify it with science or economics, and then used it to roll back key environmental regulations.

The Biden administration has since returned it to $51 on an interim basis while they elevate recent advances and understanding.

To fill the gap that was left by the Trump administration's actions, I cofounded the Climate Impact Lab in 2015. Its aims are to return the SCC to the frontier of understanding and illustrate how climate change will impact people and communities.

Our first results relate to climate change impact on mortality, finding that continuing on a high-emissions trajectory that raises global temperatures by about five degrees C at the end of the century would increase global mortality risk by about 85,000 deaths per 100,000 people. That is like increased—that is somewhere be-

tween the current mortality rate from cancer and infectious diseases.

In the United States, the risk would rise by about 10 deaths per 100,000. That is about on par with auto accidents. Of course, this is an average, and some areas are going to experience mortality risks that are higher, and some lower. I have included a table in my written testimony with data from—for each of your districts, but I thought some examples might be instructive.

In my beloved home town of Chicago, also Representative Casten's town, the mortality risk is projected to actually decrease by about 34 lives per 100,000 by 2100. That is because the benefits of fewer very cold winter days are larger than the harms from the increase in hot summer days. But other places will be harmed on net.

In Raleigh, West Virginia, the district of Representative Miller, the projected increase is 27 deaths per 100,000. In El Paso, the district of Representative Escobar, it is 42 deaths per 100,000. In Jefferson, Alabama, home to Representative Palmer, it is projected to increase by about 29 deaths per 100,000.

However—and this is a really important point—the level of emissions is not a law of physics, or did not come down in Ten Commandments; it is a reflection of policy choices. And bringing global emissions down to moderate levels—say, 2 percent—2.6 degree C increase by the end of the century, not even as low as the Paris Agreement's long-term targets, would reduce the mortality risk globally by about 84 percent and, in the United States, would make it almost entirely disappear.

Our findings also show, importantly, that the release of an additional ton of CO_2 will cause about $37 worth of mortality damage, nearly 20 times larger than the mortality costs that are embedded in the current social cost of carbon, underscoring the really critical need to update this metric.

As the Biden administration updates the SCC, I recommend several changes, including, one, recognizing the profound changes in capital markets that would lead to using a discount rate of no higher than 2 percent; two, the SCC should rely on modern climate models and estimates of damages from climate change; three, there is considerable uncertainty around economic impacts of climate change, and this uncertainty should be incorporated into valuing damages; and, four, climate impacts are projected to be highly unequal, and the SCC can and should reflect this inequality.

In summary, the social costs of climate change have the potential to be large, both in dollars, measured in dollars, or measured in human well-being. However, robust climate policies guided by a scientifically and economically sound SCC would lay the foundation for extraordinary improvements in human well-being.

Thank you for the opportunity to share my views today. I look forward to any questions that you might have.

Thank you.

[The statement of Dr. Greenstone follows:]

Statement of Michael Greenstone

Milton Friedman Distinguished Service Professor in Economics

University of Chicago

Director, Becker Friedman Institute

Director, Energy Policy Institute at the University of Chicago

Co-Director, The Climate Impact Lab

To be presented to: Select Committee on the Climate Crisis, hearing on "Making the Case for Climate Action: The Growing Risks and Costs of Inaction"

April 15, 2021

Thank you Chair Castor, Ranking Member Graves, and members of the Committee for inviting me to speak today.

My name is Michael Greenstone, and I am the Milton Friedman Distinguished Service Professor in Economics and Director of the Becker Friedman Institute and Energy Policy Institute at the University of Chicago. I also serve as co-director of the Climate Impact Lab, a multi-disciplinary collaboration of researchers working to quantify the long-term impacts of climate change. My own research focuses on estimating the costs and benefits of environmental quality, with a particular emphasis on the impacts of government regulations.

I appreciate the opportunity to speak with you today about the growing risk of climate change and the costs of inaction.

The best way to summarize the economic impacts of climate change and the benefits of regulations to slow it is with a number known as the social cost of carbon (SCC). The SCC is the monetary cost of the damages caused by the release of an additional ton of carbon dioxide into the atmosphere. Simply put, it reflects the monetary cost of inaction—measured in the destruction of property from storms and floods, declining agricultural and labor productivity, elevated mortality rates, and so forth.

The SCC is arguably the most important component of regulatory policy in this area because, by calculating the costs of climate change, the social cost of carbon allows for the calculation of the monetary benefits of regulations that reduce greenhouse gases. So, for example, a regulation that reduces carbon dioxide emissions by 10 tons would have societal benefits of $510 if the value of the social cost of carbon was $51, which is the value currently being used by the Biden administration. These benefits can then be compared to the costs that the regulation imposes to determine whether the regulation is beneficial on net. Since the establishment of the United States Government's SCC in 2010, it had been used to guide the design of more than 80 regulations as of 2017. These regulations have resulted in more than $1 trillion of gross benefits.[1]

Critically, the SCC can also be used to determine an efficient price for market-based policies for combatting climate change, such as a carbon tax or cap-and-trade system. If set at the value of the SCC, these pricing approaches will ensure that we are pursuing policies where the benefits exceed their costs. A great appeal of these approaches is that they unleash market forces to uncover the least expensive ways to reduce emissions, thereby minimizing the costs to the economy, and do not require the ex-ante knowledge of which sector they will emerge from.

Regardless of the policy approach used, a social cost of carbon based on the best available peer reviewed research is a key ingredient in beneficial policy to confront climate change. To detail how we get there, it's important to first understand where the SCC came from, what it tells us about the costs of inaction, and how it can be improved to better guide policy action. In the remainder of my statement, I will make the following points:

1. The original SCC was created in 2010 after a year-long process that included intense assessment of the best available peer-reviewed research and careful consideration of public comments. Updated to reflect scientific advances, it was set at $51 per ton in 2016. The Trump administration then lowered the SCC to roughly $4 based on decisions that were not scientifically justified and ran counter to recommendations from the National Academy of Sciences issued in 2017. Following an executive order on the first day of the Biden

[1] Nordhaus, William D. "Revisiting the social cost of carbon." *Proceedings of the National Academy of Sciences* 114, no. 7 (2017): 1518–1523.

administration, the SCC was returned to $51 in February on an interim basis while they evaluate the advances in economics and science.

2. An interdisciplinary team I co-direct, the Climate Impact Lab (CIL), is calculating an updated, data-driven social cost of carbon. Its broad aim is to capture the rapid advances in the economics and science of climate change that have taken place over the last decade and use them to update the SCC.
3. Our approach seeks to project changes in mortality, energy use, agricultural yields, labor productivity, and coastal vulnerability due to an additional ton of CO_2; and then monetize those costs to society. The first sector-specific projections relate to climate change's impact on mortality, finding that continuing a high emissions trajectory raises global mortality risk by 85 deaths per 100,000 people by 2100.[2] To put this in context, it is roughly between the annual mortality risk of cancer and infectious diseases.
4. The mortality consequences will be largest in places that today are hot and/or poor. In the United States, the mortality risk will be 10 deaths per 100,000, about on par with the current fatality rate from auto accidents in the United States. Many areas will experience mortality risks that are significantly higher. That includes areas represented by members of this committee, which I will detail.
5. Policy has the potential to deliver some of the most significant public health gains in human history. Bringing global emissions down to moderate levels—not even as low as the Paris Agreement's long-term targets—would reduce the mortality risk by 84% compared to the high emissions pathway. Under this moderate emissions scenario, climate-induced temperature changes are projected to be responsible for 14 additional deaths per 100,000 globally at the end of the century. In the United States, that risk would be 1.3 deaths per 100,000, eliminating almost all of the mortality risk.[3]
6. We estimate that the release of an additional metric ton of CO_2 will cause about $37 worth of mortality damages—about three-quarters of the overall or total SCC used by the Obama administration and by the Biden administration on an interim basis. The fact that this is almost twenty times larger than the mortality costs underlying the current SCC underscores the need to update the SCC.
7. As the Biden administration comprehensively updates the SCC, I recommend several changes to the way the SCC is calculated. These include using the latest climate modeling, applying a new valuation of climate damages, employing lower discount rates, accounting for uncertainty and equity, and better incorporating socioeconomic projections.
8. While my work suggests that the social costs from climate change are projected to be large—both in dollars and in terms of human lives— robust climate policies guided by an updated SCC based on the latest knowledge would lay the foundation for some of the greatest public policy benefits in history.

The Social Cost of Carbon as a Guidepost

The development of the social cost of carbon has a history that goes back to my time as the Chief Economist for President Obama's Council of Economic Advisors. In 2008, the 9th Circuit Court of Appeals ruled[4] that the Department of Transportation needed to update its regulatory impact analysis for fuel economy rules with an estimate of the SCC. The court directed that, "while the record shows that there is a range of values, the value of carbon emissions reduction is certainly not zero." So, the Department of Energy, the Department of Transportation and EPA began to incorporate a variety of individually developed estimates of the SCC into their regulatory analyses. These estimates were derived from academic literature and ranged from zero—which they were instructed by the court to no longer use—to $159 per metric ton of carbon dioxide emitted.[5]

To improve consistency in the government's use of the SCC, I, along with Cass Sunstein, then

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[2] Mortality risk is a measure that accounts for the increase in death rates and the costs of adaptation. Our research finds that climate-induced temperature changes raise global death rates by 73 deaths per 100,000 and will cost society 12 death-equivalents per 100,000 in adaptation expenditures, for an overall total of 85 deaths per 100,000.

[3] This value is an average of the impacts from 2095 to 2099.

[4] *Center for Biological Diversity v. National Highway Traffic Safety Administration,* 538 F. 3d 1172 (9th Cir. 2008).

[5] United States Government Accountability Office, "Social Cost of Carbon: Identifying a Federal Entity to Address the National Academies' Recommendations Could Strengthen Regulatory Analysis," 2020.

the Administrator of the White House Office of Information and Regulatory Affairs, assembled and co-led an interagency working group to determine a consistent government-wide SCC. The team consisted of the top economists, scientists and lawyers from four other offices in the Executive Office of the President and six federal agencies, including the EPA and the Departments of Agriculture, Commerce, Energy, Transportation and Treasury.

The process for developing the SCC took approximately a year and included an intense assessment of the best available peer-reviewed research, and significant debate and discussion amongst the team of climate scientists, economists, lawyers and other experts across the federal government. It also included a careful consideration of public comments on the interim values that agencies had been using and an interim value determined by the interagency group. Ultimately, the interagency working group determined[6] a central estimate of $21 per metric ton. That estimate was later revised to reflect scientific advances and as of 2016 was about $51.

To ensure that the next SCC update kept up with the latest available science and economics, in 2015 the Office of Management and Budget directed the National Academies of Sciences (NAS) to help in providing advice on the pros and cons of potential approaches to future updates, informed by ongoing public comments and the peer-reviewed literature. In 2017, the NAS released its recommendations[7] after a comprehensive assessment, for which I testified and served as a reviewer. The NAS report identified important ways to take advantage of improved understanding of the social and economic impacts of climate change. It proposed a new framework that strengthened the scientific basis of the calculation, provided greater transparency in the process, and improved characterization of the uncertainties of the estimates.

In March of 2017, President Trump's Executive Order 13783 disbanded the Interagency Working Group on Social Cost of Greenhouse Gases, withdrawing its official estimates of the SCC. In 2018, the EPA released a regulatory impact analysis for greenhouse gas emission guidelines that established a new SCC between $1 and $7.[8] To arrive at this number, the Trump administration made methodological changes that in my judgment cannot be justified by science or economics and in this respect moved the SCC away from the frontier of understanding. During the Trump administration, the controversial and substantially lower SCC estimates paved the way for the rollback of key environmental regulations, such as fuel economy standards.

The Biden administration has since made important steps to bring the SCC back to the frontier of understanding. On his first day in office, President Biden released an "Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis." Among the actions included, President Biden restored the Interagency Working Group and set a deadline for an interim SCC within 30 days, as well as a new, robust SCC based on the latest climate science and economics no later than January 2022. On February 26, President Biden returned the SCC—on an interim basis—to the Obama estimate of $51.

Measuring the Costs of Inaction

a. Climate Impact Lab Overview

While the SCC is a valuation of what inaction could look like in the form of dollars and cents, unfolding the layers of that number illustrates how climate change will impact real people and communities. To both quantify those impacts and use that rigorous data to produce the world's first empirically derived estimate of the social cost of carbon, I joined with Trevor Houser from the Rhodium Group, Solomon Hsiang from the University of California, Berkeley, and Robert Kopp from Rutgers University to establish a multi-disciplinary research institute, the Climate Impact Lab (CIL).

The Climate Impact Lab includes more than 20 climate scientists, economists, data engineers, and other experts who are combining an immense body of historical data on social, economic and climate indicators with climate models to develop pro-

[6] Interagency Working Group on Social Cost of Carbon, United States Government, Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866. (February 2010).

[7] National Academies of Sciences, Engineering, and Medicine, Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide (2017).

[8] U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Health and Environmental Impact Division, Regulatory Impact Analysis for the Proposed Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units; Revisions to Emission Guideline Implementing Regulations; Revisions to New Source Review Program (August 2018).

jections of the long-term effect of a "high emissions" climate change scenario.[9] We are examining five core sectors—labor productivity, coastal vulnerability, energy, agriculture, and mortality—in each of about 25,000 local regions spanning the globe, which are each about the size of a U.S. county. These sector-specific projections are then monetized and aggregated across all regions to determine the cost that emitting an additional ton of carbon imposes on a future society and economy.

b. Key Climate Impact Lab Findings

The first sector-specific projections we have thus far relate to climate change's impact on mortality. Climate change has a demonstrable impact on mortality rates, as extreme temperatures, both hot and cold, affect health outcomes such as heat stroke and cardiovascular disease. To measure the impact of climate-driven temperature changes on mortality risk, my colleagues and I compiled the largest subnational vital statistics database in the world, detailing 399 million deaths across 41 countries accounting for 55% of the global population.

If we continue on a trajectory of high emissions, increasing average global temperatures by around 4.8°C (8.6°F) at the end of the century, relative to pre-industrial temperatures, our research finds that temperature-related global mortality risk is projected to rise by the equivalent of 85 deaths per 100,000 people in 2100, compared to a world with no warming.[10] I say full mortality risk, because our projections reflect changes in both the number of deaths and the resources people devote to protect themselves against high and low temperatures through adaptation. When this increase in mortality risk is monetized using standard techniques, the costs are equal to roughly 3.2% of global economic output in 2100.

The projected impact of temperature on mortality at the end of the century is on par with the current death rate for all infectious diseases (except the novel coronavirus)—including tuberculosis, HIV, malaria, dengue, yellow fever, and diseases transmitted by ticks, mosquitos, and parasites—combined: approximately 74 deaths per 100,000 globally (See Figure 1). It is smaller, but comparable to, the overall cancer mortality rate, which is 126 deaths per 100,000 globally.[11] The damages from climate-induced temperature changes discussed above will be unevenly distributed among populations on both a global and national scale, as illustrated in Figure 2.

Globally, we find that the mortality risk of climate-induced temperature changes disproportionately falls on regions that are poorest and hottest today, exacerbating existing inequality. For example, Accra, Ghana, is projected to see an increase in days above 32°C (90°F) from one to 102 days per year by the end of the century under a continued high emissions scenario. This increase raises the city's mortality rate by about 19%. The climate-induced temperature-related mortality risk at the end of the century is projected at roughly 160 deaths per 100,000 people.

In contrast, colder and relatively wealthier Oslo, Norway, is projected to see benefits equivalent to saving approximately 230 lives per 100,000 people. These differences reflect Oslo's means to adapt to additional warm days, as a wealthy nation, and the benefit that the population experiences as climate change reduces the number of deadly cold days. In fact, in high-income places such as Oslo, the mortality-related risks of climate-induced temperature changes are mainly damages to the economy because of increased adaptation costs. In contrast, in low-income places like Accra, the damages of climate-induced temperature changes are projected to be felt as significant increases in death rates on hot days.

The United States is projected to see its mortality risk rise to 10 deaths per 100,000 by the end of the century under a high-emissions scenario. That's about on par with the current fatality rate from auto accidents in the U.S.—roughly 12 deaths per 100,000.[12]

Again, risk differs depending on where you live. I have included a table (See Table 1) with the data for each of the Members of this committee's district to give you a sense of the risks your constituents are projected to face. I will list some examples here.

In my hometown of Chicago (which includes the district of Representative Casten), the mortality risk decreases by about 34 lives per 100,000 by 2100. My city

[9] All discussed CIL projections follow the RCP8.5, or "high emissions", scenario from the IPCC's 2014 "Mitigation of Climate Change: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change". Cambridge, United Kingdom: Cambridge University Press.

[10] Carleton, et al. "Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits." (2018).

[11] World Health Organization. "Global Health Estimates 2016: Deaths by Cause, Age, Sex, by Country and by Region, 2000–2016". Geneva, 2018.

[12] World Health Organization. "Global Status Report on Road Safety 2018." Geneva, 2018.

will see more hot days, and it will pay to adapt to them. But, it also typically sees a lot of extremely cold days. Over time, we'll see fewer of those cold days, decreasing mortality risk during the winter and—combined with the additional adaptation measures—giving Chicago a net benefit.

Richmond, Virginia (which includes the district of Representative McEachin), on the other hand, doesn't have the chance to benefit from a reduction in cold days—there are few already. People there can pay to adapt to additional hot days, but it won't be enough to offset the loss of life. There, temperature-related mortality risk is projected to increase by 36 deaths for every 100,000 people. That is on par with the current U.S. death rate for Alzheimer's disease (37 deaths per 100,000).

Raleigh, West Virginia (which includes the district of Representative Miller) is also projected to experience a higher mortality risk under this scenario—around 27 deaths per 100,000 by 2100. In El Paso (which includes the district of Representative Escobar), it's 42 deaths per 100,000. Jefferson, Alabama (which includes the district of Representative Palmer) is projected to increase by about 29 deaths per 100,000. In all of these cases, the mortality risk is higher than the current U.S. mortality rate for diabetes (26 deaths per 100,000) and for the flu and pneumonia (17 deaths per 100,000).[13]

Here in the United States and around the world, climate-induced temperature changes will leave some regions as winners and others as losers—with more losers than winners. But the clear message from the data is that on net the world and the United States will lose.

Policy Projected to Deliver High Returns

The level of greenhouse gas emissions is not a law of physics, but rather reflects policy choices. It is therefore instructive to consider the benefits of policy that would lead to a moderate emissions path—reducing warming at the end of the century from 4.8°C to 2.6°C (or 8.6°F to 4.7°F).

This reduction in warming, which falls short of the Paris Agreement's long-term targets, would still lead to dramatically lower mortality risks compared to the high-emissions scenario. For example, the projected total global mortality impact of climate-induced temperature changes falls by 84% by the end of the century, relative to a scenario of continued high emissions. Under this moderate emissions scenario, projections show climate-induced temperature changes would be responsible for 14 additional deaths per 100,000 by the end of the century. Accra, Ghana would see the increase in its mortality risk sink from 160 deaths per 100,000 people to 29 deaths per 100,000 people.

In the United States, the risk to mortality would be almost completely eliminated, with just 1.3 deaths for every 100,000 people instead of 10 deaths per 100,000.

Looking around the country, Chicago sees a slight improvement. But the real gains happen in higher risk areas. Richmond reduces its temperature-related mortality risk increase from 36 deaths per 100,000 to 20 deaths. In Jefferson, the mortality risk increase falls from 29 deaths per 100,000 to 17 deaths per 100,000. Raleigh, West Virginia, sees even greater improvements from lower emissions, with the mortality risk increase falling from 27 deaths per 100,000 to just 10 deaths per 100,000. And, El Paso sees its mortality risk increase cut by about half—from 42 deaths per 100,000 to 22 deaths.

It is apparent that reducing emissions offers substantial benefits both globally and in the United States. Put plainly, our research suggests that some of the most significant public health gains in human history could be achieved by cutting greenhouse gas emissions.

Bringing the Social Cost of Carbon to the Frontier of Knowledge

Using the Climate Impact Lab's new approach, we're able to calculate the mortality-only impact from the cost of a ton of carbon, which comes to $36.60 under a scenario of continued high emissions. That is about three-quarters of the overall or total SCC used by the Obama administration and by the Biden administration on an interim basis (See Figure 3). It is also almost twenty times larger than the mortality costs underlying the Obama and Biden administration's metric. Within their total estimate of $51 per ton, mortality risk is worth only about $2.[14]

Comparing old and new projections of the costs from mortality damages underscores that the old estimates significantly understate the costs. Figure 3 also reveals

[13] Centers for Disease Control and Prevention. "Deaths: Final Data for 2017." National Vital Statistics Reports, 2019, 68(9).

[14] Carleton, Tamma, et al. "Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits." No. w27599. National Bureau of Economic Research, 2020.

that our understanding of the damages to agriculture and energy use has also changed significantly. This is because, in the decade since the SCC was first established, the scientific and economic understanding about climate change has evolved dramatically.

As the Biden administration's Interagency Working Group completes the process of fully updating the SCC in the months ahead, there are several essential changes they should make, and other useful changes that should be considered. I detailed these changes in a recent paper co-authored by Tamma Carleton from the University of California, Santa Barbara.[15] I will outline those here:

a. Essential Updates Based on Advances in Understanding

1. First, the Biden administration should acknowledge the profound changes in capital markets over the last two decades and use a discount rate of no higher than 2%. The choice of a discount rate is so vital because it determines how much we value the climate that our children and grandchildren will face. If we choose a discount rate that is too low, then we will pay too much today for mitigation efforts. If we choose a discount rate that is too high, then we will impose higher costs on our children and grandchildren than we intend. Without any other modifications, changing the discount rate to 2% would increase the SCC to $125 per ton from $51.
2. Second, it is essential that the SCC rely on modern climate models to more accurately reflect the effect of emissions on the climate system. The climate models behind the current SCC substantially underestimate the speed of temperature increase. A simple Earth system model that can conduct uncertainty analysis while also matching predictions from more complex, state-of-the-art models is necessary. This model can be paired with semi-empirical models of sea level rise.
3. Finally, it is essential that the measurement of economic damages from changes in the physical climate, for example, temperature and sea level rise, be updated to meet three important criteria. Damage functions in the current SCC are derived from ad-hoc assumptions and simplified relationships. But large-scale empirical evidence has since deepened our understanding of the economic impacts of climate change. An updated damage function should: i) be derived from empirical estimates that reflect plausibly causal impacts of weather events on socioeconomic outcomes; ii) capture local-level nonlinearities for the entire global population (not just high-income, temperate regions); and iii) account for future adaptation.

b. Important Changes Justified by Advances in Understanding

Other changes to the SCC are merited.

1. Any SCC calculation relies on a set of predictions regarding how the global economy, population, and CO_2 emissions will evolve in the future. Unfortunately, there has been only modest scientific progress in developing these scenarios due to the stubborn difficulties in making long-run population and economic growth projections. An updated SCC should either combine standard socioeconomic projections (e.g., SSPs) with the RCP emissions scenarios, or use new probabilistic estimates relying on statistical and expert elicitation approaches.
2. An updated SCC should reflect the costs of uncertainty, just as people pay to purchase insurance to protect against uncertainty of fires and auto accidents. There are several sources of uncertainty in the calculation of the SCC (i.e. future socioeconomics, the sensitivity of the climate to emissions, economic damages from climate change). Previous SCC estimates, however, chose not to account for uncertainty in valuing climate damages. Due to recent advances in computing, it is now possible to characterize these uncertainties and to incorporate their value into the calculation of the SCC.
3. Finally, climate impacts are projected to be highly unequal. Recent research suggests that the poorest 5% of U.S. counties will experience nine times the economic damages experienced by the richest 5%.[16] It is possible to have the SCC reflect that damages to the poor are of greater concern than damages to the rich and I would recommend doing so. However, conducting equity weighting would represent a significant departure from standard United States

[15] Carleton, Tamma, and Michael Greenstone. "Updating the United States Government's Social Cost of Carbon." University of Chicago, Becker Friedman Institute for Economics Working Paper No. 2021–04. (2021).

[16] Hsiang, Solomon, Robert Kopp, Amir Jina, James Rising, Michael Delgado, Shashank Mohan, D. J. Rasmussen et al. "Estimating economic damage from climate change in the United States." Science 356, no. 6345 (2017): 1362–1369.

cost-benefit analysis. As such, this change should probably be considered as part of a holistic overview of the approach to regulatory cost-benefit analysis.

Conclusions

Ultimately, society needs to balance the costs to our economy of mitigating climate change today with climate damages. The social cost of carbon, estimated using the best available evidence, is a key tool in this balancing act. My ongoing work with the Climate Impact Lab suggests that the social costs are large, both in dollars and in terms of human lives. Further, it reveals that the current SCC does not reflect the frontier of understanding about climate economics and science—the interests of the American people would be best served by returning the SCC to the frontier. This is because robust climate policies guided by a social cost of carbon based on the latest knowledge can change our trajectory—delivering some of the greatest public health gains in human history and preventing a wide range of other climate damages in our nation and around the world.

Thank you for the opportunity to share my views with the Committee.

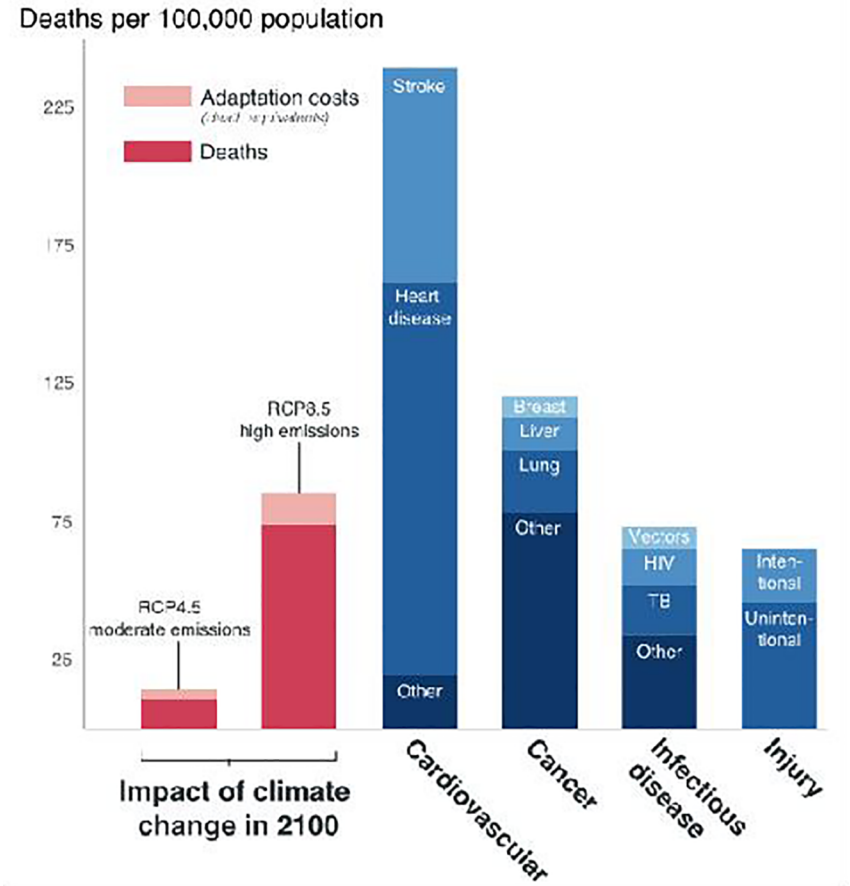

Figure 1: The impact of climate change in 2100 is comparable to contemporary leading causes of death. Impacts of climate change (coral) are calculated for the year 2100 under the high emissions scenario (SSP3-RCP8.5) and moderate emissions scenario (SSP3-RCP4.5) and include changes in death rates (solid colors) and changes in adaptation costs, measured in death-equivalents (light shading). Blue bars on the right indicate average mortality rates globally in 2018, with values from WHO (2018). Figure from Carleton, Tamma, et al. "Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits" (2020).

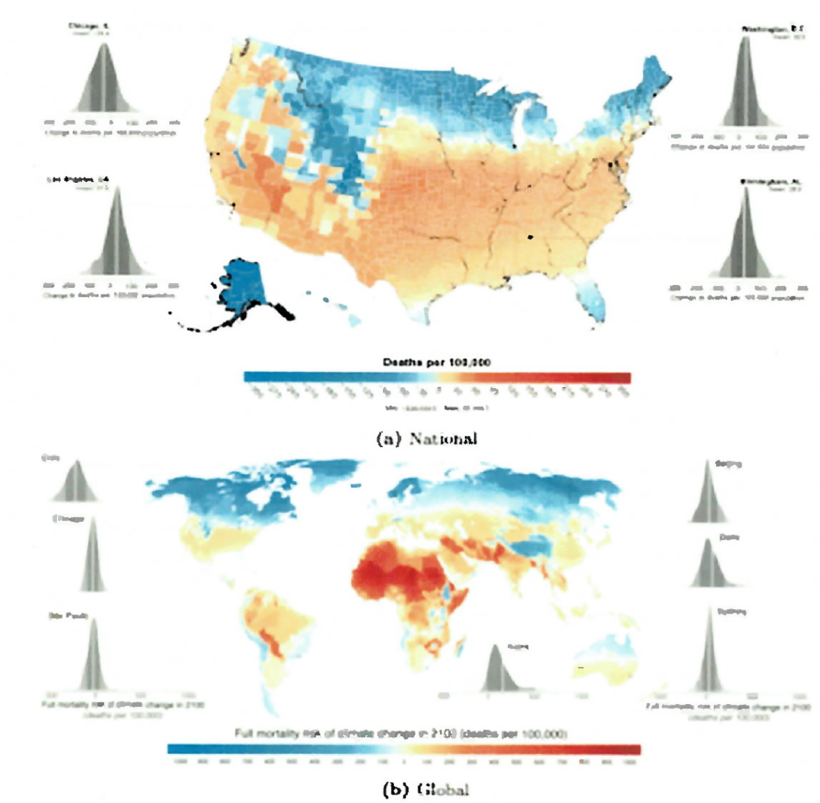

Figure 2: The mortality risk of future climate change. The maps indicates the full mortality risk of climate change, measured in units of deaths per 100,000 population, in the year 2100. Panel A displays risk results for the United States, while Panel B displays results for the world. Estimates come from a model accounting for both the costs and the benefits of adaptation, and the map shows the climate model weighted mean estimate across Monte Carlo simulations conducted on 33 climate models; density plots for select regions indicate the full distribution of estimated impacts across all Monte Carlo simulations. In each density plot, solid white lines indicate the mean estimate shown on the map, while shading indicates one, two, and three standard deviations from the mean. All values shown refer to the RCP8.5 emissions scenario and the SSP3 socioeconomic scenario. Figure adapted from Carleton, Tamma, et al. "Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits" (2020).

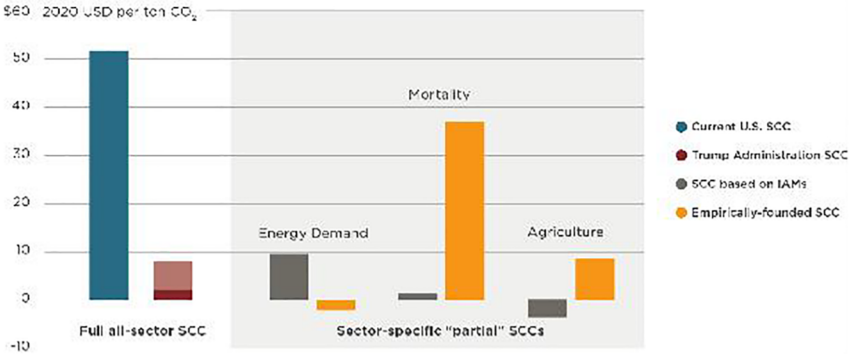

Figure 3: Estimates of partial Social Costs of Carbon (SCC), compared to existing US SCC estimates. The figure compares current and past U.S. federal SCCs to those produced by recent scientific and economic research. The full all-sector SCCs shown on the left are U.S. federal SCCs by the Trump administration (dark red/light red) and as the interim estimate under the Biden administration (blue). Sector-specific "partial" SCCs on the right come from the Interagency Working Group (IWG) 2013 implementation of the FUND model (grey) and recent scientific literature (yellow). Sources: Rode et al. (2020b), Carleton et al. (2020), Moore et al. (2017), and Antho and Tol (2014), as decomposed by Diaz (2014). All estimates indicate the willingness-to-pay to avoid an increase in emissions in the year 2020, rely on an approximate "business-as-usual" emissions scenario (e.g., RCP8.5), and use the discount rate preferred by each set of authors or each administration. The Trump administration did not choose a central estimate, so estimates using a 3 percent discount rate (light red) and a 7 percent discount rate (dark red) are both shown. Estimates not originally stated in 2020 USD are converted to 2020 USD using the annual GDP Implicit Price Deflator values in the U.S. Bureau of Economic Analysis' (BEA) National Income and Product Accounts Table 1.1.9.

				Mortality Risk Per 100,000	
Representative	State	District	County	High Emissions	Moderate Emissions
Armstrong	North Dakota	At Large	Cass	-75.7	-52.1
Bonamici	Oregon	1	Washington	20.3	15.5
Brownley	California	26	Ventura	22.4	12.6
Carter	Georgia	1	Chatham	18.9	13.4
Casten	Illinois	6	Cook	-33.6	-31.6
Castor	Florida	14	Hillsborough	-13.8	-1.6
Crenshaw	Texas	2	Harris	23.3	14.8
Escobar	Texas	16	El Paso	42.1	21.7
Gonzalez	Ohio	16	Cuyahoga	-21.2	-24.0
Graves	Louisiana	6	East Baton Rouge	18.9	12.8
Huffman	California	2	Marin	20.7	13.9
Levin	California	49	San Diego	17.2	10.7
McEachin	Virginia	4	Richmond	36.3	19.6
Miller	West Virginia	3	Raleigh	27.0	9.9
Neguse	Colorado	2	Boulder	-33.4	-25.8
Palmer	Alabama	6	Jefferson	28.9	16.5
	United States			10.1	1.3

Table 1: Climate-Induced Mortality Risk Impacts for Select Counties at End of Century. Mortality risk estimates are from Carleton et al.'s "Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits" (2020). Table includes one county for each Representative's congressional district. The high emissions and moderate emissions columns compare the effect of increased temperatures on mortality risk for SSP3 under the RCP8.5 and RCP4.5 emissions scenarios, respectively, from the IPCC's 2014 "Mitigation of Climate Change: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change". Impacts of climate change are calculated for the year 2100 for RCP8.5, and are averaged across the five end-of-century years for RCP4.5. Impacts include changes in mortality risk accounting for adaptation costs and benefits.

Ms. CASTOR. Well, thank you very much. And I want to thank all of the witnesses for your very insightful—and I—and, frankly, I have to say disturbing testimony today, but that is what we asked for. We want to get a handle on this.

So I recognize myself for 5 minutes for the first question.

Dr. Abdalati, you really laid out the escalating impacts of extreme weather events, kind of a glimpse into the future as well. We know that we must be prepared at the Federal level with the tools to understand and monitor the rising temperatures and all of the related impacts.

Where are the most important areas to invest in climate science from your point of view going forward?

Dr. ABDALATI. Well, in the simplest sense, it is observations and modeling, but it is a little more involved than that. One area—and this isn't just because it is my expertise, but satellite observations of the Earth. This is, as has been said, a global challenge, but with implications on regional and local scales.

So we need to look at the Earth as a system, the interactions of the components, both the different physical components with one another, but also the spacial interactions. You know, when we look at imagery that shows the pollution from China blowing over to California, that is impactful. It helps us understand the transport processes.

So looking at the Earth as a system—and the most powerful tools for doing that are in our satellites—is one area.

Another is investments—it may seem simple—observations and modeling, but another is investments in modeling capabilities so that we can take those data, understand the processes, and improve our predictive capabilities.

But I think, structurally or institutionally, one of the biggest challenges is ensuring that agency missions are clear and incorporate climate as part of their missions. There are lots of gaps in the areas of satellite observations. We have NASA developing exquisite observing capabilities, but there is nobody there to pick up the baton for a sustained monitoring of change, and so that needs to be built into the missions.

There is—in the modeling framework, if I look at NOAA, the agency I partner with, historically, it has vacillated, but a lot of its mission has been tied to weather, improving weather forecasts, other things—oceans, fisheries, et cetera. But climate has kind of come and gone from the mission. And there is—it needs to be squarely in the mission assignments at USGS, at NOAA, at NASA, with all the roles appropriately assigned and the resources that go with them.

And the last thing I will point out is a lot of this is addressed in the President's budget request. And I think that the stage has been set, or the opening offer or request has been made, and I understand that Congress deals with tradeoffs that I will never fully comprehend, and there are budgets to balance and issues—other issues to deal with, but, as particularly Dr. Greenstone said but also other witnesses, there are real costs to not doing this.

So I believe that dollars invested save far more dollars than they cost. So those are the areas that I would recommend.

And the President has requested them, and all I will say is, in my view as a scientist and a citizen, it is well worth the money.

Ms. CASTOR. Thank you very much.

It is interesting. Right before our hearing today, I was looking at NOAA satellite data of Tampa Bay to determine where that toxic wastewater that—from the overflow and breach at a phos-

phate mining gypsum stack was flowing into Tampa Bay, so I am with you on the NOAA satellite investments.

Ms. Toney, we know that, from your testimony and the research that this committee has done, we hear day in and day out the climate crisis hits Black and Brown neighbors harder, compounding existing and health—health and economic disparities.

Where do you think are areas for Federal investment moving forward to counteract the rising costs and impacts of climate?

Mrs. TONEY. Well, I absolutely agree that we have to look at all of the different ways that we can find and identify the air pollution and any pollutants, and that includes our satellites that we are working on, satellites across different agencies, as well as nonprofit organizations and educational institutions, and also on the ground monitoring.

But I also think that it is very important to engage the community and work specifically with and alongside marginalized groups that have been trying to do this work but have not been afforded the same resources.

So it is one of the reasons why we work very hard to make sure that we are working right alongside marginalized Black and Brown communities that historically and systemically have not been afforded the same opportunities but need those resources, and we need to understand from those perspectives.

So, to the extent that, from a Federal perspective, we can encourage that, absolutely. The more data we get, the better the solution we can provide.

Ms. CASTOR. Thank you.

Next, I understand we are going to go to Congressman Armstrong. You are recognized for 5 minutes.

Mr. ARMSTRONG. I am not used to going first. Thank you. And thanks, Chair Castor, for arranging this hearing.

You know, we have heard from witnesses today that we need to take action now, and, as—I am going to butcher this—I apologize—Dr. Abdalati noted in a scientific and informed way. And we already have the tools and technologies at our disposal to meet the demand for action.

We know that the expanded use of natural gas has led to a significant decrease in emissions over the last decade. The problem is we continue to demonize natural gas.

We know that pipelines are the safest, most reliable, most low-efficient method that we currently have of transporting both oil and natural gas, yet we continue to frustrate the permitting process and demonize pipelines.

We know increased deployment of carbon capture technologies significantly helps mitigate emissions. Unfortunately, it is involved with coal, and we continue to demonize coal.

But here is the thing we also know: We are going to burn more of these fuels in the next 5 years, whether we shut down American projects or not. And if we take ourselves out of the marketplace, somebody else is going to fill that space. If we take oil out of pipelines, it is going to be transported by rail. It is going to be transported by truck. It is going to actually drive up our emissions.

If we frustrate allowing natural gas pipelines to get energy—a cheaper, more efficient form of energy, it is going to cause us on

the East Coast to burn more heating oil, actually raising our emissions.

But, more importantly, if we are talking about this, raising the cost of electric to the people who can least afford it—of energy, that is what happens, that is what is happening now. And we continue to have this conversation in a way where we don't allow for existing technologies to develop because we favor other technologies, but it is even worse than that, and you are going to hear this a lot from me throughout the course of this, because a lot of what we are doing is outsourcing our guilt. And I am going to continue to say this until somebody can answer the question.

We don't produce the things we need for renewables in the United States. The current technology for solar panels is—the max you can turn photons into electrons is 33 percent. We are at 25 percent. The maximum efficiency you can get under wind—our wind and renewables right now is 60 percent. We are currently at 45 percent.

The technologies that we are asking for do not exist yet. Investing in technology-neutral R&D—Representative Graves and I have talked about this at length. As long as we are driving down carbon prices, increasing efficiency, there are things we can agree on. We can agree on more energy-efficient windows. We have ways to do this. We can utilize infrastructure when we are putting out—when we are building out highways and dealing with those issues and working on carbon capture in areas of technology.

But you can't have a 45Q problem—a 45Q program that doesn't involve enhanced oil recovery because the economics simply don't work. And we are going to continue to do these things. We are going to do it. We are just going to rely on lithium from other countries, cobalt from other countries, rare earth metals from other places, and we are going to continue to push this problem overseas so we don't have to talk about it at cocktail parties from work here.

That is what is going on. That is where we are at. That is how we are continuing to move forward. I am fully—listen, I come from a place where we produce a ton of oil, a ton of natural gas, a ton of production agriculture. I have never met anybody in my state in any of those businesses that doesn't want clean air and doesn't want clean water.

But we have got to—we have to continue moving forward with technologies that exist, investing in areas where we can be part of the solution and not part of the problem. And I think the very first place where we can actually probably hopefully come to some kind of bipartisan agreement is in how we get infrastructure into the ground because this is one of the things that I have learned over the course of this: If we want to stop permitting for pipelines, that is fine—it is not, but the hardest thing to permit is a highway. It takes 10 years. Raising access to capital for these types of things and shortening the permitting process, investing in these infrastructure things—and we heard this during the last Congress. You think it is hard to get a pipeline through a neighborhood? Try and get a high-voltage transmission line to a renewable energy source through a neighborhood.

We have ways we can do this. The United States has led in reducing emissions over the last 5 years. We will continue to lead

moving forward, but only if we are talking about doing this in reality and in the areas in which we can utilize existing resources that we have in the United States in order to help drive down climate emissions.

And, with that, I will yield back.

Ms. CASTOR. Thank you very much.

Next, we will go to Representative Bonamici. You are recognized for 5 minutes.

Ms. BONAMICI. Thank you so much, Chair Castor and Ranking Member Graves.

Thank you to our witnesses.

In the Pacific Northwest, climate change is not a distant threat. It is our reality. And, like Dr. Abdalati—okay.

Dr. ABDALATI. Abdalati.

Ms. BONAMICI. Abdalati—thanks—said, these are no longer just predictions. Within the last year, Oregonians have faced intense flooding, severe drought, unprecedented wildfires, treacherous ice storms, and the number of Federal disaster declarations in a single year alone, demonstrates the cost of inaction to address the climate crisis is too significant to ignore.

So Portland State University recently released a study demonstrating how systemically racist redlining housing policies in northeast Portland have exacerbated the effects of warming temperatures and poor air quality for Black people and people of color. Extreme heat events are expected to increase in frequency and intensity because of the climate crisis. And, as a result, the same historically underserved neighborhoods will face the health risks of increasing temperatures, higher energy bills, and often inequitable access to green spaces.

So, Ms. Toney, I appreciated the analogy in your testimony, all being in the same storm but not in the same boat. And you noted the need for a larger framework that can elevate community level risks with the knowledge of pollution exposures. What are the current gaps in our understanding of heat events on communities of color, and how can Congress support the creation of this interdisciplinary framework?

Mrs. TONEY. Thank you so much for that question. I think it is important for us to understand that there are significant holes, and the all-of-government approach that has been initiated by this Administration begins to help us fill those because it requires each agency to look at climate from their perspective. When you just raised the issue of housing, the systemic and historic redlining has been part of the problem that created the heat islands that we have seen, particularly in urban communities across this country.

But even in addition to what Dr. Greenstone was sharing and the amazing maps that have come out of the organization and the Climate Impact Lab, we can see it just—it is just blatantly clear. We can see over time, not only today, but also midcentury and by the end of the century how, when you layer those heat islands on top of an increase, it becomes very obvious that Black and Brown communities will bear the brunt.

So identifying across all of the agencies where these holes exist—education, social justice, violence, housing, even to the military—and our deficiencies when we fail to recognize the impacts of heat

and climate for our own vulnerability in our country, as this—as the Administration is putting resources in, we should definitely make sure we are doing it in marginalized communities and identifying those holes.

Ms. BONAMICI. Thank you so much.

And I have a question now for Dr. Abdalati.

The northern boundary of the district I represent is the Columbia River. The western boundary is the Pacific Ocean. Coastal communities across northwest Oregon are acutely aware of the risks from flooding and sea-level rise. The increasing presence of high tides provide us with a glimpse into the future if we fail to reduce emissions.

So, in your testimony, you noted some of the challenges in projecting future sea-level rise, but also the costs from the adverse effects: infrastructure and property; disruption to livelihoods; cultural identities; interests of indigenous communities, for example. So how can Congress increase and improve the communication of the socioeconomic effects of sea-level rise and coastal flooding?

Dr. ABDALATI. You know, that—that is a real challenge. I appreciate the question. And a lot of it is in the framing. And I, frankly, to some degree, have faulted my own community for, you know, focusing on the negatives, and, if you don't do this, and if you don't listen to us, and if you don't do that, you are in big trouble.

People who are opposed to mitigative actions or adaptive actions or understanding the consequences we are facing will tend to shrink from that, and it is not an inviting conversation about what do we do about this, how do we move forward?

And I think from a communications perspective, bringing it home to individual areas—and I appreciated—I appreciated Dr. Gillen's comments because he lives it. He experiences it.

Ms. BONAMICI. Right.

Dr. ABDALATI. I think making it personal facilitates that communication, but making it personal with a full awareness that it is not simply you have to do X to make Y happen, recognizing the many dimensions of the challenge—I appreciated Representative Armstrong's comments because there are—there is a lot to think about.

So, in my view, the most effective communication is, you know, not focusing on the dire, although I did focus on that in the testimony I gave, but really being clear about the threat and hopeful about solutions. But you can't be hopeful about solutions without recognizing the many dimensions.

So, for—I am not exactly answering your question, but to effectively communicate, I think we need to make it local in nature so people can relate to it and be open-minded in the discussion of solutions.

That is why I really love the work of this committee because it is bipartisan, and it is looking at the many dimensions.

Ms. BONAMICI. I appreciate that. Thank you.

We just, in the Science Committee, had former Energy Secretary Moniz, and we are talking about regional innovations and solutions because, as we know, it is different across the country.

Thank you very much. I yield back.

Ms. CASTOR. Great.

Representative Gonzalez, you are recognized for 5 minutes.

Mr. GONZALEZ. Thank you, Chairwoman Castor and Ranking Member Graves, for holding this hearing today, and to our distinguished witnesses for joining us.

Dr. Abdalati, I appreciate the last thing you were saying about being clear-eyed about sort of the full scope of what we are talking about here, not just the risks but also the potential solution sets that we are considering and the current state of technology.

I do think we are all in agreement that we need to follow the science to effectively solve climate change challenge, but that does mean that we need to be clear-eyed about the current state of the technology and its ability to, quote, solve the climate crisis, while also realizing that any and all decisions that we make have real tradeoffs associated with them.

It is not true that this is somehow a political will question. All the political will in the world won't change the fact that developing economies around the world are fossil-based economies, and the existing options available to them are not nearly affordable nor reliable enough to get them to switch to renewable alternatives. That is not domestic politics. That is science, and that is the current state of technology.

This is because those technologies aren't there. They are not enough on farming. They are not enough on electricity generation. They are not there on transportation, and they are not there on manufacturing. And that lends us to, I believe, what I have been advocating for on the Science Committee, which is more robust funding to invent our way out of this.

We have a great example of what happens when we focus investment on big problems with the development of the vaccines through Operation Warp Speed, and I would argue a similar program could be in order here.

It is also the case that pricing carbon has an enormous set of tradeoffs, and we seem to be reluctant to talk about or admit that when I see the carbon pricing debate play out. And I want to start there specifically with Dr. Greenstone. And we will start with steel.

So I am from northeast Ohio. We produce a ton of steel or a lot of steel. So just some basic questions. Per ton of steel produced, who produces more carbon, us or China? So a ton of steel produced in the United States versus a ton of steel produced in China, which one is going to emit more carbon?

Dr. GREENSTONE. I presume from the question that it is a ton of steel in China, but I don't actually have data.

Mr. GONZALEZ. That is correct. By 20 percent.

And so, if we raise the cost to produce steel in the U.S., is it more likely or less likely that that production will move to a place like China, which is our biggest competitor in steel?

Dr. GREENSTONE. Oh, well that depends on how you structure pricing carbon. I think you are imagining pricing carbon without taking account of the possibility of border tariff adjustments or other mechanisms that would allow a price signal to be sent while not penalizing the important industries in your district and many other parts of the country.

And so that is just a question of policy design. That is not hard to solve.

And, you know, as long as you have raised the question of carbon pricing, I think—I couldn't agree with you more, Representative Gonzalez, about the critical need for more R&D and more innovation to get the low-carbon energy sources to be less expensive. And there is no doubt that there is a market failure that would require—that motivates and justifies R&D spending. But, you know, the most tried and true method we have to unleash innovation in any sector of the economy——

Mr. GONZALEZ. Just reclaiming my time for a quick second, sir, and I want to——

Dr. GREENSTONE [continuing]. Is the price signal. And so, essentially, that is the best way to——

Mr. GONZALEZ. Dr. Greenstone, the time belongs to me. The time belongs to me. Thank you.

So, just for your awareness, there are zero proposals with legitimate border adjustment benefit proposed, but it is also the case that that would raise the cost of steel.

And then, finally, with the final question, so who spends a greater percentage of their income on energy, rich or poor?

Dr. GREENSTONE. Certainly, from the nature of the question and from my own research, the poor do. But, again, that is a question of policy design. It is—there are several proposals floating around Congress that would rebate money to low-income households that would more than fix up the inequitable or adverse distributional components of carbon price. So it is——

Mr. GONZALEZ. I think you are——

Dr. GREENSTONE. You are asking a question about a carbon policy that doesn't happen to exist.

Mr. GONZALEZ. Sir, reclaiming the time.

Dr. GREENSTONE. It is like a boogeyman.

Mr. GONZALEZ. No, it is not like a boogeyman. It is absolutely not.

So, if you are going to raise the cost of carbon, you are going to price carbon and think you are going to distribute the dividend without any overhead being taken, and it is just a dollar-for-dollar trade, that is not a policy design question. I think it is living in fantasy land, if I am being honest.

There is always—always tradeoffs associated with that. And we cannot implement a full Federal bureaucracy to price carbon and do the dividend rebate without having certain tradeoffs in that. That is always the case with tax policy. It is never a one-to-one tradeoff.

And, with that, I yield back. Thank you.

Ms. CASTOR. Thank you very much.

All right. Rep. Huffman, you are recognized for 5 minutes.

Mr. HUFFMAN. Thank you very much, Madam Chair, for starting our work with this hearing. I think, as we begin to work together in this new Congress, it is appropriate that we start with a really clear-eyed understanding of the climate impacts that are already hurting communities and our economy, that we understand that it is going to get worse, but it will get a lot worse if we fail to take bold action. I think this conversation has really helped bring clarity to that understanding.

We know in northern California, where my district is, firsthand how wildfires driven by extreme heat and persistent drought are not only devastating land and property; they are blanketing communities near and far with clouds of toxic smoke. Wildfires unfortunately, in recent years, have become just a fact of life, and they cause huge disruptions to the lives of many families, along with the destruction of infrastructure and property that you see on the news.

And so, Dr. Abdalati, I would like to start with you. You highlighted many of the changes in the climate system that are impacting all of our well-being now and are going to continue doing so in the future. Science can aid our understanding of risks and enhanced vulnerabilities to help us anticipate and adapt to these impacts.

What progress are we making, though—and you alluded to this somewhat—but being able to understand climate risks at the local to regional scale so that we can inform planning and adaptation efforts?

And how can the science inform our understanding of how this disproportionately impacts people of color and marginalized communities, particularly when it comes to what I just mentioned, the impacts of wildfire smoke?

Dr. ABDALATI. So, to the second question, there is a lot of social science activity. I am a physical scientist. There is a lot of social science activity that can be brought to bear on that question. And I think that requires investment as well because the implications are tremendous and disproportionate.

To your first question, science has made a lot of progress. You know, there are two dimensions we try and work in—getting predictions and forecasts further out in time, and getting them more and more local in space. And we are still not to the place we need to be for actionable local preparation.

You know, there are some floods that take us by surprise. I forget the hurricane where the trajectory was off, you know, and I think one area braces for something that doesn't come, and another area is hit by something that was supposed to go somewhere else.

So we still have a ways to go, but we are in pretty good shape to at least have a sense of what is coming nearby, and the smart communities will recognize the uncertainties in the models and prepare and act accordingly.

Mr. HUFFMAN. Thank you.

I would like to go to Mrs. Toney. I was just talking about climate-induced wildfires and the severe impacts on air quality. It can be—I know firsthand from my district, it can be so hazardous that it is unsafe for children to leave the house to play, to attend school, without all kinds of elaborate protections.

At the same time, children and families all over our country these days have been stuck inside with remote learning. And you mentioned that children living in heat-impacted areas really face a disproportionate negative impact to their education.

So could you speak to how climate—our climate crisis exacerbating these existing inequalities affects educational outcomes, and how can we design responsive climate policy solutions to ensure more equitable outcomes?

Mrs. TONEY. Thank you for that question, and you are absolutely right.

This past year certainly has seen families tackle the issue of trying to deal with a variety of climate crisis from wildfires to derechos in Iowa, the hurricanes coming in the Gulf, and laying on top of that the impacts of COVID and trying to do virtual learning, when they don't even have the broadband infrastructure to sustain the system.

So I think that understanding how each area is layered and the community engagement is critical. We have to hear from people on the ground about how and what the holes are.

We learned in Moms that, you know, when we had parents who were trying to go to work and parents of color in particular that were on the front lines of the COVID crisis, that even understanding the rural broadband problems that we have across this country were making worse their ability to both do their work, make sure that their children were safe in their homes from COVID and from air pollution and climate crisis, while making sure they were educated.

So we are seeing these holes now. And the more we are studying them and engaging and listening to the community, it gives us a better sense of what needs to be fixed and how quickly we can do it.

Mr. HUFFMAN. All right. Thank you. I yield back.

Ms. CASTOR. Thank you.

Rep. Carter, you are recognized for 5 minutes.

Mr. CARTER. Thank you, Madam Chair. I appreciate the opportunity to be here.

And thank you all for your testimony today. This has been very enlightening.

Mr. Gillen, I want to go to you. Again, thank you for being here and joining us.

There has been a lot of talk today about data and how we can use data to demonstrate climate change and how to—and how to respond. In your testimony, Mr. Gillen, you said that—you mentioned some partners, like the University of Georgia, the Army Corps of Engineers, and Fish and Wildlife Services, to help with the understanding of the unique climate changes in Tybee Island.

Also, I believe you have been working with Georgia Tech and its Smart Sea Level Sensors along the coast. I am very familiar with that project. It is a great project.

Can you speak, Mr. Gillen, to some of these partnerships and the access to the data that contributes to Tybee's ability to respond to rising sea levels and adaptation efforts?

Dr. GILLEN. Thank you, Representative Carter, Madam Chair, committee members.

Yes. Thank you. Two different ways. One is we are doing measurement of what the sea level is in a sense of what it means to Tybee Island, tidal gauge levels at Fort Pulaski and other areas around the island. Again, as I said in my statement, we are seeing that, more frequently, they are getting higher and higher.

The road to Tybee Island was raised about eight inches 2 years ago to help address that frequent flooding. It was getting to the

point we were closing it down every time we had a high tide over 9 feet. But that is continuing to become more and more frequent.

We are also dealing with some—the shipping channel itself is the one thing that we are dealing with. That stops that natural migration of sand from the Carolinas down to Tybee Island, which is how Tybee Island was formed. When the shipping channel gets dredged, it gets deeper and deeper. That just stops that sand migration in its tracks. And that is where that 78 percent of the erosion damage on Tybee Island comes from.

And, also, as that channel gets deeper, the boats get bigger. Some of the largest ships ever to come to the Eastern seaboard come to Savannah. And, when those ships go by, they create huge waves. They are tsunamis essentially that can sweep people from the beach out into the shipping channel. We see it happen. We have had to run rescue operations on it. We have got warning signs and methodology for that.

Through partnership with UGA, we are doing—we are placing several sensors in the channel between the channel and the island to try to gather some data on what that—those impacts.

The other piece of it is: How can we grow the dunes that we have put into place? So our partnership with universities are measuring the growth of the dunes that we built in parts of the island where no dunes naturally grow.

And what we are discovering along with that is that we have already lost about 30 percent of our beach. So we renourished the beach less than 2 years ago, and we have lost more than a meter in some areas of the beach. And that measurement and data collection will continue to go on so we can help the Corps of Engineers determine what is the best methodology for coastal defense?

The beach itself is part of our defense mechanism against a storm surge. The dunes helps absorb that final blow and helps reduce the flooding risk on the front end. But once we have got a better idea of how those dunes grow naturally and what—the deterioration of the dunes system and the beach over time through the natural erosion, and what we are seeing is, with the storm activity being more frequent, that erosion happens faster and faster.

Mr. CARTER. Good. And thank you for mentioning that about the natural barriers because that is one thing—in fact, I believe Tybee Island was one of five places to be awarded the 2020 Best Restored Beach Award, and I know a lot of that has been because of your innovative efforts, if you will, at using natural solutions to address that situation.

And how much of the coastal resiliency and adaptation efforts can be done through natural solutions? I mean, I have always said that adaptation and mitigation are two important things in the way of climate change.

Dr. GILLEN. That is a big question, Congressman. Thank you.

I could speak to what we see happening on Tybee as far as how we can use that to adapt. We are looking at not only trying to get the dunes in places where they are not and getting them to grow naturally, but also, on the back side of the island, when we are finished our study for how to protect our island from flooding that comes up through the marsh, like—which happened in Hurricane Irma, we are going to have to get real creative in that sense, is we

are looking at ways to—the water is going to go where the water wants to go, and we are trying to get it to go to those places that aren't going to be structures and homes built and allow for the water to flow in and flow out naturally.

So it is going to be a combination of stormwater systems, improving the marsh areas, physical defenses to the back side of the island, and that sort of thing.

So it is going to be a combination of all of that together. We know that just letting the water go where it wants to go and then leave is going to be part of the plan.

Mr. CARTER. Madam Chair, I don't see a clock, but if I could just ask one more question of Mr. Gillen.

Tybee Island created Georgia's first sea-level rise plan, and I am very appreciative of that. I think you set a great example. And, as you mentioned earlier, there is only one road going on and off of Tybee Island, and I would venture to say—and correct me if I am wrong—at least once a month, whenever you are talking about spring tides and high tides and—you know, it floods to where people can't get across, and it makes access a big problem.

How can we more better incentivize communities to build resiliency, because resiliency is something, I think, is very important?

Ms. CASTOR. Give us a brief answer, Dr. Gillen.

Dr. GILLEN. Okay. I think you can incentivize by creating easier pathways to dealing with—giving technical assistance and the financial assistance we need to help create those green spaces in those areas where the water can come and go. And dealing with issues with the environmental regulations that we have to go through to build a road on the Tybee Island is a trick. It is a long time coming that the——

Mr. CARTER. Okay. Thank you, Madam Chair, and I yield back.

Ms. CASTOR. Thank you.

Next, we will go to Rep. Casten for 5 minutes.

Mr. CASTEN. Thank you, Madam Chair.

Thank you to our speakers.

Just before I start, I would note—you know, a lot of you guys know this, but maybe some of the newer members on our committee don't know I spent 20 years before I got here deploying [inaudible] clean energy technologies that were all antiquated, totally robust, saved a ton of money, created a ton of value, were never blocked by value creation or technology, but were often blocked by state and local laws.

And so let us not perpetuate the fiction that we have to hold up on technology. And those of us who have the distinct honor to have the ability to write laws, let's embrace that opportunity because this is a win-win all around.

I want to start with Dr. Abdalati. And pleasure to see you again. Sorry it is not in person as it was out in Boulder a year or two ago.

I want to follow up on a conversation we had out there that you alluded to in your testimony, and we were looking at that big chart on the wall that I think you showed that the last time the temperature was this hot was 125,000 years ago. And 125,000 years ago, the sea level was 5 to 10 meters higher. And, 125,000 years ago, the temperature rise preceded the CO_2 increase, and, of course, we

are now seeing the CO_2 increase before the temperature rise, such as manmade global warming.

That means we have got a lag built into the system. I don't often hear people talk about 5 to 10 levels—meters of sea-level rise being in things we should plan for, but is there any reason why that is not at least within the scenarios we should consider since the last time it was this hot, that was where the sea level was?

Dr. ABDALATI. It is absolutely within the scenarios we should consider. The problem is, you know, science by its nature is conservative, and it doesn't handle wild cards well. And so there is a wild card in the system, and that is the ice that is in the ice sheets. How rapidly is that going to flow out?

And, you know, glaciologically and when we look at what is happening to the ice—in particular, the margins where the action is—it is pretty easy to see the first 2 or 3 feet. It gets a lot harder from the mechanics of glaciers to see—we understand how it can happen, but it gets a lot harder to ascribe a likelihood to 10 feet, 5 feet, 10 feet.

So, when we can't ascribe some level of confidence to it, the way we treat it is to say: This is what we are pretty confident of; we can't rule out that.

So, yes, it may—and this is in my written testimony. It may well be in our future, but it would be irresponsible of the scientific community based on what we know to say: Expect it.

It is much more responsible to say: It might be out there.

Mr. CASTEN. That is all right. I want to get to Dr. Greenstone here before I am done, but, just quickly, help us understand 5 to 10 meters. What percent of the U.S. is underwater at that level?

Dr. ABDALATI. I can't really put a percent on it, but I would say even 1 meter is about a fifth of Florida. So imagine 10 or—you know, 10 meters of sea level is pretty much all of Florida.

Mr. CASTEN. Wow. Wow.

Dr. ABDALATI. Big parts of Georgia and Louisiana and Texas and elsewhere.

Ms. CASTOR. And I know some people would say that is a risk they are willing to take, but no.

Mr. CASTEN. I want to move to Mr. Greenstone.

One of the things that I love about the research you have done is how granular it is and how you have been able to show how actually calculating the cost of carbon at a more and more local level helps us better understand where the spread is going to be. I have been really focused on the Financial Services Committee on getting our regulators to look at the endemic systemic risk to our financial system, both because of those parts of our geography that are going to change.

Some of you may have seen E&E reported this week that eight counties in the U.S. accounted for 50 percent of all flood insurance claims. Those counties were all in Alabama, Florida, and Louisiana. That is a big financial shock.

But—but of course there is also big transition shocks because, you know, the shift from energy producers to energy consumers that happens every time you shut down a coal plant and install a solar field is also a shift from typically more rural, less populated energy producing areas to places where the people are.

And so, with the time I have got left, Mr. Greenstone, can you just help us understand what your model shows about which parts of the country are going to experience the greatest economic pain in a change in climate and the degree to which those tools can be used to help inform our financial regulators as they build the necessary scenario analysis?

And I think you are muted.

Dr. GREENSTONE. Thank you, Representative Casten.

I think it depends actually on what sector you are looking at. And so, you know, with some of the mortality numbers that I was talking about, the southern part of the United States, which already has very hot summers, those are the places where the costs are going to be the greatest.

What is interesting is different parts of the country pick up different parts of the damages. I know Chair Castor has been very focused—and I understand why—on sea-level rise. And I think, you know, there will be a series of conversations that will be held by all of you and your successors on, you know, it is almost unimaginable, but, like, which parts of the country we are going to let go because we are not going to build a seawall all over the entire Atlantic Coast. And so there is parts of the Atlantic Coast that are going to be hit very hard.

Now, with respect to the Corn Belt, where you and I are from, I think there is also going to be really concentrated damages there. The best evidence is that the Corn Belt, which produces so much corn and soybeans, will basically become unusable for those crops.

And so you will have generations of families, who have grown those crops and produced them for the American people and the world will no longer be able to do that, and there will be very large transition costs associated there.

So it is a little bit hard to pinpoint any one place that is most exposed, partially because climate change is so multifaceted and will influence every element of our life, and some areas are going to be more in the bull's eye than others on particular sectors of the economy.

So I apologize for not having a single answer to your question.

Mr. CASTEN. Well, I would love to follow up, and I am out of time, but, you know, we are thinking a lot about how can our regulators build scenario analyses to better understand these. And if you have got tools and insights, let's continue the conversation.

Thank you. I yield back.

Ms. CASTOR. Thank you.

Next, we will go to Rep. Palmer. Rep. Palmer, you are recognized for 5 minutes.

Mr. PALMER. Thank you, Madam Chairman.

We keep talking about sea-level rise, and I would just like to point out, if you look at the historical record, the sea level rose about 8 inches between 1900 and 2000. So, over one century, an 8-inch rise. But the average annual sea-level rise for the previous 210 centuries was 2 feet.

And so we are well behind what we have seen historically. And, as I pointed out to one of your colleagues at one point, that the climate does change and that those are the things that we need to be preparing for.

I also want to talk about something else that comes up in every one of these hearings, and that is injustice, but I want to talk about energy and economic injustice for all low-income people.

As I pointed out several times in these hearings—and, Madam Chairman, I can't wait until we get back to live hearings. This fear-based Democrat remote stuff has got to stop. But I grew up dirt poor in northwest Alabama, and we couldn't afford—didn't have access to natural gas. We heated our home with a coal-fired heater, had a stovepipe that went through the exterior wall. And, in the summertime—and Alabama gets really hot—all we had was a box fan in a window—in one window, not every window.

So I understand what it means to live in a house that is inadequately heated and inadequately cooled. And climate impacts low-income families. In terms of economic injustice for low-income families on energy, they already spend—the bottom 20 percent of wage earners spend five times as much of their disposable income for heating and cooling their homes.

If you look at the average salary for Americans, about $56,000 a year, they spend 2.5 percent of their income on energy costs, and—but families earning less than $20,000 a year are spending almost three times—more than three times what—if you are below $16,000, you are more than three times what the average salary is just to keep their homes heated and cooled, and it has an enormous impact on people.

There was a study from—the National Bureau of Economic Research put out a paper and found that, as a result of hydraulic fracturing and the revolution that it created, particularly in natural gas, that, since the late 2000s, we have reduced the number of health—of cold health-related deaths by 11,000. I mean, to consider some of the policies that are being pushed by my colleagues across the aisle, I hope you don't consider those people collateral damage because that is primarily the elderly and low-income families.

It is also an issue, I think, particularly targeting minority families. There is the city in Illinois, Pembroke Township, where there is 2,100 people live there, 80 percent are African American, and they don't have access to natural gas. They are having to heat their homes with propane and with wood-burning stoves.

And Jesse Jackson and Al Sharpton and others are leading an effort to provide more access to natural gas. You are not going to do that without pipelines. And, yet, I can't find a single—in all the hearings we have had, I have yet to find a single Democrat witness that would support the efforts of Jesse Jackson to bring energy justice to that community. So it is very disturbing to me the direction we are going.

And, in terms of this carbon pricing, I want to associate myself with my colleague—distinguished colleague from Ohio, Mr. Gonzalez, as he clearly has—the guy is brilliant in the area of economics and finance, and he has an understanding of the impact of the carbon tax. And it is shocking to me that Michael Greenstone does not know whether it is the United States or China that produces more steel.

For your educational purposes, China produces 10 times more steel than the United States. You add these tariffs, you add this

cost to the U.S. economy, and I can assure you China will be the beneficiary of it.

With that, Madam Chairman, I yield back.

Ms. CASTOR. Well, thank you, Mr. Palmer.

And I do want to say on—we are all eager to get back to normal and have in-person hearings. Fortunately, the vaccines now are ramping up dramatically. I know it is incumbent upon all of the Members of Congress to get vaccinated, and we are waiting for that. And now the good—more good news is that staff members are getting vaccinated. So that is the key to unlocking our in-person hearings. We are all eager to get there. So——

Mr. PALMER. May I give one encouraging point on that end? There is clinical trials underway right now on a nasal vaccination, a spray, that began at University of Alabama, Birmingham. The preclinical trials began there. They are in clinical trials now. And I talked to Dr. Fauci about that. Not only will it provide the vaccination benefit, but it prevents transmission, so hopefully we can all get that.

Ms. CASTOR. Wouldn't that be a blessing for the entire world if we can get there?

So, next, I don't see Rep. Neguse, so Rep. Levin, or—excuse me—Rep. Escobar, you are next. You are recognized for 5 minutes.

Ms. ESCOBAR. Thank you so much, Madam Chair, for this really—and to the ranking member for this really important hearing.

Many thanks to our panelists as well.

To the panelists, I represent El Paso, Texas, which is in the great American Southwest, on the safe and secure U.S.-Mexico border. And, as you all have, I am sure, been reading about in the news, we have had a number of migrants for well over a decade now arriving at our nation's front door from Central America.

And, as I have spent a lot of my time at home speaking with many of the families and the single adults and the children, one of the drivers of late especially—I would say since 2018—has been their inability to use their farmland. So many of them are facing famine as a result of droughts, lots of flooding in other regions as a result of storms and hurricanes, the recent hurricanes in their region.

Can one of our experts speak to what we should probably anticipate in terms of increased migration patterns, especially in the Western Hemisphere? You know, the United States of America is not used to the same kind of refugee crises that other parts of the globe have had to live with for generations. And so I would really appreciate any one of our experts who might be willing to speak to this, what we should anticipate.

Dr. ABDALATI. Well, I will offer some thoughts and then yield to others, but what we can anticipate is more of the extremes, more floods in humid areas and more drought in arid areas, warm areas getting warmer. And that tends to move populations higher and more poleward.

And the United States—in the United States, we are very fortunate to be sitting in a region that is climatically friendly and adaptable, and so it is a desirable place to be because there are people in locations who can't get away from the storms, from the drought, from the hunger that is caused by impacts to agriculture.

So we can certainly expect more extreme events which, in turn, will lead to more migration of the sort that we are seeing.

So that problem—and I am not offering a perspective on how to deal with it, but—again, that is policy domain. But that challenge is one that we can expect to ramp up.

And I will tell you. The defense community, the intelligence community know that and are preparing for that in their domains. And so, when it is—when a more conservative body, such as the Department of Defense, recognizes the threats to its mission, it needs to be taken seriously.

Ms. ESCOBAR. Thank you so much.

Yes, sir? Yes?

Dr. GREENSTONE. So, Representative Escobar, I would just add that we have entered a new era in kind of—due to advances in computing and new data sets where we can get much more granular information—and I think that is what Representative Casten was asking me about—on what the impacts of climate change will be and where they will be.

And a very striking thing which has been a thread through this whole hearing is that they are going to be unequal, and they will be concentrated in particular places.

And when you look at the global map, you know, if you were trying to summarize it, there are places that are going to benefit. And, you know, those places tend to be pretty cold currently. And there are places where the costs are really going to be concentrated.

And if you had a world without borders, you just can't imagine that people in the concentrated damage places aren't going to want to move. And, to your question, you know, what form does that take? Well, that is going to lead to all kinds of climate migration.

And, you know, how political systems handle that is going to be very—you know, that will be something for our leaders, certainly including you and your colleagues, to sort out. But it will put a lot of pressure——

Mrs. TONEY. Can I add one——

Dr. GREENSTONE. It will put a lot of pressure on the system.

Ms. ESCOBAR. Thank you, Dr. Greenstone.

Ms. Toney.

Mrs. TONEY. Yes. I just want to add the layer. This really undergirds the necessity for equitable access to resiliency funds to communities because green—this idea that we can come into communities and have them to move to another space is very, very real. And so, when lower income, marginalized communities don't have access to the same type of funds so they can create the infrastructure that provides resiliency for their communities so that they can stay in the spaces that are culturally important to them and that are generationally a part of their families, then we are not allowing them to continue to thrive in the way that other communities are.

Green gentrification is real, and so we must ensure that people have the same equitable access to funds and resources and make sure that everyone is able to provide the resiliency in the way that their community needs it best.

Ms. ESCOBAR. Thank you so much. I appreciate it.

I am out of time. Madam Chair, I yield back.

Ms. CASTOR. Thank you very much.

Next, we will go to Representative Miller. You are recognized for 5 minutes.

Mrs. MILLER. Thank you. Thank you. I have a new laptop here, and I am still learning a bit.

Thank you, Chair Castor and Ranking Member Graves, and thanks to all of you for being here today.

Last Congress, I worked with Republican and Democrat colleagues to establish the Congressional Energy Export Caucus. This caucus was focused on exporting America's abundant natural resources to markets all across the world.

American energy not only helps promote our own national security, but it also helps our allies. For example, many of our European allies are reliant on Russia for natural gas. Not only does Russian natural gas have a worse emission profile than American gas, but Russia itself is a malign actor in the region, if you remember what they did to the Ukraine. American exports could help remedy this problem by providing cleaner LNG without the baggage.

Furthermore, as developing nations start to need more kilowatt-hours—and they want them—America stands ready to provide key baseload energy.

This caucus not only focused on energy but also on energy technology like carbon capture. Developing carbon capture in America and being able to export that technology around the world will help these developing countries to continue to use affordable baseload energy, while also significantly reducing their own carbon footprint.

I believe that our reliable, cheap baseload energy has the ability to lift people out of poverty both here at home, and in the United States, and also abroad.

Dr. Greenstone, developing nations around the world are starting to require more natural gas as their economies are starting to grow. Shouldn't these countries have the option to purchase American natural gas, which has a lower emission profile than Russian natural gas?

Dr. GREENSTONE. That is a terrific question, Representative Miller.

There is no question that there is a really urgent need for more energy consumption in today's developing countries, and I think U.S. natural gas should certainly be available. I think the best way to make it available, of course, is to have a level playing field where the carbon—where all energy sources face the same penalty for their carbon content.

Mrs. MILLER. That is an excellent point.

Mrs. Toney, you have spent your career working to lift people out of poverty. Shouldn't the United States' energy and energy technology markets be available to developing countries in order to give those individuals abroad the opportunity for the most prosperous life possible?

Mrs. TONEY. We should by making sure that we are giving access to all of our ideas around clean energy and our innovation. I have complete and total faith in the United States' citizens, our academics, our students, and our children that we are raising today that they will come up with beyond innovative ideas that can really

explore how clean energy can be effective not only in the United States, but also across this world.

But what I have heard repeatedly is this false narrative that there—that we are denying one as opposed to showing and providing ways that we can use renewable and clean energy to create jobs and show other communities how to do the same regardless of where they are.

One of the things I saw this past week was a wonderful article that came out, actually in 2020, that showed flaring in Nigeria from some of the same companies that we see using pollution as a source in—right off the Gulf of Mexico. And the imagery was that, you know, the companies that are doing some of the polluting in the United States are not showing the same value to people across the world.

And I just don't think that is who we are. When we are talking about how we make sure that there is equitable access but also that these polluting sources are valuing people in the same way, it is very important to have conversations with people on the ground about how they see these impacts and what has happened over the years.

I have had many conversations with impoverished communities, and certainly have led an impoverished community to help bring out of that state. Go ahead.

Mrs. MILLER. I need to reclaim my time. I am sorry.

Shifting our focus to energy poverty here in America, often the renewable standards increase the cost of electric bills for Americans. And, in West Virginia, we had a renewables requirement that left people having to choose between putting food on the table and keeping their lights on because their bills tripled.

Do you think that the option for reliable, cheap baseload energy is the best way to help people in poverty? To you again.

Mrs. TONEY. Yes. Let me ask first permission because I know that we are out of time, but, Representative Castor——

Ms. CASTOR. I would very much——

Mrs. TONEY.—I would appreciate the opportunity—okay.

Okay. Yes. Again, absolutely. I have—I live in Mississippi, and I have been to places all over this country, and I absolutely agree we have to provide spaces, but going back to what another Representative said a bit earlier about Reverend Jesse Jackson and what was happening in Illinois, one of the first things that Reverend Jackson did was seek out renewable energy sources, looking for how he could help incorporate renewable and clean energy as the beginning point for Black and Brown communities to find ways that we can have low energy costs, and low energy costs that were sustainable over time.

And so I want to make sure that we are telling the whole story here. As we are developing an understanding how technology can help us to have clean energy and how this can build infrastructure and community and help bring us all out of the impoverished state, we have to give same value and saying—understanding of what the different renewable and clean energy sources can do.

And I will stop there.

Mrs. MILLER. Thank you, ma'am.

Ms. CASTOR. Thank you very much.

Next, we will go to Rep. Brownley. You are recognized for 5 minutes.

Ms. BROWNLEY. Thank you, Chair Castor. And this has been a great hearing, and I really appreciate you putting it together and really appreciate all who have testified.

My first question is to, you know, Dr. Greenstone. You—in your opening comments, you talked about, during the Obama administration, you put together the social cost of carbon at $51 per ton of carbon.

You know, I am just curious, quickly, if, you know, fast forward, we are, you know, a couple of years later, and I know the Biden administration will reevaluate it, but do you think there is going to be a significant difference, or insignificant difference, or somewhat of a difference between then and now?

Dr. GREENSTONE. Yeah. Thank you for your question.

Let me start by making a couple points. First, if you didn't change anything except the discount rate—and there is very strong reasons from the changes in international capital markets to change the discount rate—and so, if you reduce it from 3 percent to 2 percent—it is a wonky thing, but it is totally justified by financial markets—that would increase the social cost of carbon from $51 to $125.

Ms. BROWNLEY. Oh.

Dr. GREENSTONE. Now, what is equally important is, in the roughly dozen years since the social cost of carbon was—or a decade since social cost of carbon was first set, there have been tremendous advances in our understanding about climate science.

Dr. Abdalati, I am sure, can talk about that much more authoritatively than I can, but I can talk about the tremendous advances in our understanding about economic damages from climate change, and those have also advanced really.

Neither of those sets of advances are in the current foundation of the social cost of carbon, and I expect that both of them would lead to, you know, significant changes in the value of social cost of carbon.

I was talking about the mortality—some of my work on temperature-induced mortality from climate change in my spoken testimony. Just that one sector, we are finding impacts that are about 20 times larger than what had undergirded the Obama approach.

So there is really, I would say, an imperative to bring the social cost of carbon back to the frontier of understanding. It has fallen behind. And I expect that that would lead to substantial changes in its value, and, you know, lead to new directions for policy.

Ms. BROWNLEY. Thank you. I am glad I asked the question. I hope the Biden administration calls upon you in their pursuit of finding—to finding a new value on that.

Mr. Abdalati, I wanted to ask you—you know, you talked a lot about, you know, looking—improving upon observations and modeling and looking at the Earth as a system.

You also, in your—I think in your opening comments, you talked about, you know, in terms of projections, whether it is sea-level rise or drought. You know, it is reality now, so reality trumps projections. So I am just curious to know, you know, without having the more sophisticated tools that you believe—and I agree with you—

that we need, you know, to really be looking, you know, in the deeper future of stuff to be able to—you know, for policy purposes and the like. I am just curious to know where you think or, you know, what are some of the areas that are most severe? We talked a lot about sea-level rise.

My county, for example, is—my county is in California. We are a big agricultural community, and, you know, we have been experiencing really bad drought for the last couple of years. My county actually is warming faster than any other county in California. But—so what—you know, where are we based on what we know right now in terms of—from, you know, reality versus projections, if that makes any sense at all?

Dr. ABDALATI. I think I understand what you are asking.

And what I will say is I mentioned earlier that, you know, in the context of sea-level rise, science tends to be conservative. If we can't confidently explain something, we don't really incorporate that.

So, when we have been wrong, we have usually been wrong in the undervalued direction. The disappearance of arctic sea ice, it disappeared more rapidly than our models predicted. The rates of sea-level rise, I commented earlier. We talk about what we have got some confidence in. There are wild cards out there that can certainly come into play, but we don't build those in explicitly.

I think the same is true with severe weather. And, to the first part of what you were saying, I think you were asking, you know, what—where are the biggest touch points here? And I think severe weather, that ultimately leads to droughts, floods, heat waves, you know, storms, storm surges in coastal areas, are really where the biggest challenges are going to come from, the most costly impacts.

And we are pretty good at it. You know, we have—if you just look at weather forecasts, we have gone from being reliable for 24 to 48 hours to, you know, 3, 4, even 5 days in some cases. But we need to go further in time. And we need to think, from a climate perspective, seasonal forecasts. What is the drought forecast going to look like, and how do farmers prepare for that, right? This touches every aspect of society.

And, just very quickly, I ran down a litany that makes it sound like, oh, gosh, the world is coming to an end, and I am a doom-and-gloom guy. I am not a doom-and-gloom guy. The situation is dire, but it is complicated.

And, to the comments that others have made, other Representatives, all the dimensions need to be included—the economic impacts, the environmental impacts—but I think, to your point, severe weather is where it is going to hit the hardest. It is going to hit hard in sea level, but it will hit a little more slowly.

And the—in my written testimony, there is a chart that shows the number of billion-dollar weather events for the last—since 1980. I encourage you to look at that because that makes very clear the impacts by weather category of the changes we are seeing.

Ms. BROWNLEY. Thank you very much.

And I yield back, Chair Castor.

Ms. CASTOR. Great. Next, we will go to Ranking Member Graves. You are recognized for 5 minutes.

Mr. GRAVES. Thank you, Madam Chair.

And I also—I want to thank all the witnesses. It has been—it has been really informative sitting here listening to the dialogue, so I appreciate your testimony and appreciate all the questions.

Dr. Greenstone, I heard in your testimony you were talking about the social cost of carbon, the calculation, and you talked about the reliance upon some sort of cost-to- benefit analysis in order to inform decisions, which I agree we should be making decisions based on an analysis of cost versus benefits.

In some of the calculations that I have seen associated with the White House's 2035 commitment, social cost of carbon would probably be—it looks like about quadruple the $51 a ton number. So I assume it is safe to say to—just to apply the principles of your testimony, that, if something does exceed cost, then you would suggest that is not an appropriate path forward for us. Is that accurate?

Dr. GREENSTONE. I am sorry. I want to make sure I understood your question. The social cost of carbon provides a marker for the benefits of reducing a ton of CO_2.

Mr. GRAVES. Yep. So, if one of the—so, if one of the solutions proposed by the—by the 2035 target would be $200 a ton, then you would suggest that that is not the right path? It is not cost-effective to employ that strategy?

Dr. GREENSTONE. Yeah. So I think, if the cost exceeds the benefits, the case for going ahead with the policy is much weaker.

Mr. GRAVES. Okay. And then one other thing. In reading the—I guess the way that the cost was developed, it is my understanding that the benefits that would accrue—so let's just make something up and say that you are able to use a natural gas fuel to send a shipment of widgets across the ocean, so there is some degree of benefit associated with that activity. But, in the social cost of carbon calculation, the benefits weren't actually included; it was only the adverse impacts. Can you explain that and why that is rational?

Dr. GREENSTONE. I don't—with all due respect, I don't think that is correct, Representative Graves.

Mr. GRAVES. Well, please correct me if I am wrong, because I am——

Dr. GREENSTONE. Well, no. So the——

Mr. GRAVES [continuing]. That was my understanding from the—from the way that the cost was developed.

Dr. GREENSTONE. No. So the social cost of carbon is a summary of all of the benefits and all of the costs of climate change, and so, actually, in my testimony—forgive me. I believe you are from North Dakota, and North Dakota, in terms of mortality, will benefit because the winters are very hard—I haven't been to North Dakota in winter, but, looking at the data, the winters look very challenging.

Mr. GRAVES. Ouch.

Dr. GREENSTONE. So there will be some benefits to North Dakota for that for sure, and——

Mr. GRAVES. Well, let's not go down that rabbit hole too far. I am from near North Dakota. I am from south Louisiana. So that is close, but——

Dr. GREENSTONE. Oh, gosh, I am so sorry.

Mr. ARMSTRONG. Very, very similar winters.

Dr. GREENSTONE. That is very, very embarrassing.

Mr. GRAVES. No, I have got to put a shirt on during the winters. It gets cold at home.

Dr. GREENSTONE. Okay. But, in answer to your question—I am so sorry about that. In answer to your question, there are benefits and costs to the change in climate, and the social cost of carbon calculates them equally, or includes them equally.

Mr. GRAVES. Okay. I want to go back and reread what I read before because I took away a different understanding.

So another one. So I listened to your dialogue with Congressman Gonzalez in regard to the steel. And I continue—I think, on this whole committee, we get in these conflicts on the committee about this issue.

So, talking about a BCA, the whole point that I think Congressman Gonzalez was trying to make is that, if we continue allowing China to do what they are doing without holding them accountable—and Dr. Abdalati brought up the satellites, which I actually love it, because China has proven to be untrustworthy on HFCs and other emissions, so I think it is an important verification tool to invest in satellite technologies and other things to figure out where this is coming from.

But, if we did a BCA, that would only potentially impact the United States, not the rest of the global market.

And we have—the biggest gaping hole in what has been going on with the climate strategy is what has been happening with many of these other countries that are increasing emissions while the U.S. and many EU countries and others are reducing.

So does that make sense? And, look, you are an economist. You are smarter than I am on this stuff. But I think that is the point that Congressman Gonzalez was trying to make, and it is very concerning.

Dr. GREENSTONE. It is a terrific point. And, yeah, I am so smart that I confused Louisiana and North Dakota.

But, in answer to your question, let me pose what you are saying a slightly different way.

Look, the United States is just 12 or 13 percent of global emissions of CO_2. That is just a fact. And the challenge of the climate problem is that everyone has to do something, or it is not going to—it is not going to work, and I—Representative Gonzalez, if that was his point, was making a good point, and I couldn't agree with it more.

I think what we sometimes miss in these discussions is that the nature of reciprocity in international negotiation, and the purpose of the United States reducing, in my view, CO_2 emissions is not just to make ourselves feel better, that we cleaned up our act or—and, you know, cleaned up our own country, but it is to make some contribution to the reduction of global emissions but also to leverage reductions in other countries.

And, if you don't have that dynamic in there, it is not going to work. And I couldn't agree with you more, and I couldn't agree with Representative Gonzalez more. And, fortunately, I think the track record is pretty good on that.

There is a recent analysis by the Rhodium Group that suggested that, for every ton of CO_2 that we pledge to reduce in Paris, we got back like seven additional tons of reductions from other countries. And why that is so important is that, whether or not a ton is reduced in Mumbai or Moscow or Oslo or wherever, that produces the same benefit for U.S. citizens as a reduction of a ton that took place in Detroit or Bismarck or New Orleans.

And so we should be pursuing policies that generate reductions abroad, and I think a precondition for that is doing some cleaning up in our own country. That is my argument.

Mr. GRAVES. Great. Thank you.

And, Madam Chair, thank you, and I want to reiterate what I said at the beginning. I really do—while I don't agree with Secretary Kerry on a lot of things, I pray he is wildly successful in China because I think it is such a key part of this overall strategy.

I yield back.

Ms. CASTOR. Great. Great. Next, we will go to Rep. Levin. You are recognized for 5 minutes.

Mr. LEVIN. Thank you, Chair Castor.

I do not represent either Louisiana or North Dakota. I represent a coastal district in southern California, two other Representatives here from coastal districts in California, and it is what you said, Dr. Abdalati. Like you, I am not a doom-and-gloom guy, but the situation is dire. And the impact of sea-level rise in my district is not theoretical. In addition to the safety issues to our residents—we had a horrible bluff collapse in the city of Encinitas a couple years ago. Three people tragically died.

But this threatens our entire regional economy in southern California. I have in my district—for those that know that area, you have got one of the busiest rail corridors in the United States that connects Los Angeles and San Diego to the larger metropolitan centers in the country. It is called the LOSSAN Rail Corridor, Los Angeles, San Diego.

And I think my colleagues are probably going to hear this a few more times from me about the LOSSAN Rail Corridor and the threat that it faces. It is a billion dollars-plus a year conservatively in terms of its impact on commerce, and parts of it are falling into the ocean.

I was interested and encouraged to hear what Mr. Gillen mentioned with regard to Georgia because I think, look, there are differences in different areas of the country, but this ought to be something we work together on, Republicans and Democrats together working on climate adaptation, climate resiliency, and I hope that we can.

Dr. Abdalati, the U.S. Geological Survey projected even higher levels of climate-change-driven coastal erosion in our region, in southern California, over the next century. Can you please tell us more about projections for future sea-level rise under different emission scenarios, and do you have any thoughts on the connection between sea-level rise and coastal erosion?

Dr. ABDALATI. Sure. I—sorry. Let me bring up a couple notes.

Some of this was in my written testimony, but predictions for sea-level rise under the different scenarios, let's see. So, in the most modest—you know, the most aggressive reduction in green-

house gas emissions still puts sea-level rise by 2100 at about 0.43 meters, so about a little less than a foot and a half. And the more—or, in the sort of all bets are off and let's just burn the energy, puts it at about 0.84 meters, or more than 2 feet.

And, you know, the other scenarios are somewhere in between, but those are the bounds that are predicted to be likely. It can—you know, we talk about unequivocal, very likely, likely, you know, in terms of how confident we are in these estimates. So, even with sea-level rise, likely is not a high degree of confidence; it is a reasonable degree of confidence, and that is because of the wild cards.

So, even though I say a couple feet by 2100, it could well be 5 or 10 feet by 2100. And I don't want to come across as: Look out, it is going to be horrible.

Well, 2 feet is horrible. But I want to make sure people are aware that that is potentially in the system, and it can't be ignored. We are not predicting it, but it can't be ignored.

Regarding coastal erosion, as the seas rise, erosion is actually more severely affected than simply the rising of the oceans. As the seas rise, as storms intensify, the coastal erosion increases substantially because it is a multiplicative effect of the two—strong winds, rising seas, strong tides.

And so we can expect an erosion that is even greater than might be suggested by simply rising the seas that height because there is a lot more at play, and every time the tide comes in and goes out, it takes sand with it. So I think the expression of erosion is going to be more severe than one might infer from the sea level numbers themselves.

Mr. LEVIN. Thank you for that.

And if there is time, I would like to ask you about one other thing in your testimony. And that is wildfire smoke emissions, another huge problem in California, all throughout our State, throughout the Western United States.

Do you see value in strengthening wildfire smoke emissions modeling? And if so, why?

Dr. ABDALATI. Absolutely, because the costs are tremendous. Our ability to capture them in models is still pretty limited. And I liken it to weather forecasts. We save a lot of money with good weather forecasts. I think we can save a lot of lives and dollars with more robust fire forecasts.

Mr. LEVIN. Thank you.

Thank you, Chair. I yield back.

Ms. CASTOR. Very good.

Well, this has been very eye-opening to discuss the growing risks and costs of inaction when it comes to climate. I want to thank you all for this excellent start to the 117th Congress.

You know, Representative Gonzalez raised a point regarding the development of the COVID vaccine earlier in the hearing, and I think that is a good analogy for solving the climate crisis. The quick development of the COVID vaccine was possible because of years of underlying research that was often sponsored, paid for by U.S. taxpayers and other governments across the world, and it was—the work was done by researchers around the world.

But development of the vaccine is just one step. As we have seen with COVID, the deployment of a technology is even more impor-

tant, and the same is true with clean technology. And I am hopeful that President Biden's American Jobs Plan is going to drive deployment of clean energy.

So, next Tuesday, at noon, we are going to have our next Select Committee hearing looking at the benefits of solving the climate crisis and talk about just those things.

But the witnesses have been terrific. The members have been engaged, and I appreciate that.

So thank you, and, without objection, all members will have 10 business days within which to submit additional written questions for the witnesses, and I ask our witnesses to respond promptly, as promptly as you are able.

Thank you all very much. The hearing is adjourned.

[Whereupon, at 2:05 p.m., the committee was adjourned.]

United States House of Representatives
Select Committee on the Climate Crisis

Hearing on April 15, 2021
"Making the Case for Climate Action:
The Growing Risks and Costs of Inaction"

Questions for the Record

Dr. Waleed Abdalati
Director
Cooperative Institute for Research in Environmental Sciences (CIRES)
Professor of Geography
University of Colorado Boulder

THE HONORABLE KATHY CASTOR

1. **In your testimony, you discussed some of the ways that the Earth's ice cover, a critical element to being able to forecast sea level rise and other changes to our ocean, can surprise us with changes that warrant changes in our estimates. What has been the trend over recent years between forecasts and observations? What are the implications if we do not adjust trajectory to reflect potentially accelerating changes?**

The trend has been that forecasts tend to underestimate ice changes. That is, observed changes are often more significant than we've expected.

With regard to sea-level rise, I noted that there are "wildcards" in the system. One of these wildcards is related to rapid break-up of floating ice at the ends of the outlet glaciers and ice streams that drain the ice sheet. These areas of floating ice (called ice shelves or ice tongues) provide a resistive force to the glaciers and ice streams that flow into them, and when they melt (as they are currently), that resistive or "buttressing" force is removed and the glacier flow accelerates. Then, the ice is discharged more rapidly into the seas, causing accelerated sea-level rise. The basic concept of how this process works is pretty well-understood and we have observed the effect in nature. However, the details of the physics are very complicated and are not yet fully captured in ice-sheet models, making it very difficult to predict their behavior.

Without the robust physics to describe these processes, the scientific community cannot say with confidence how likely such rapid loss will be and how much ice loss is likely to result. Therefore, the best we can do is capture the processes we can model well, and make clear that this wildcard exists, which could cause far greater sea-level rise than we can confidently predict today. It is notable that there are no known "wildcards" that will suddenly *slow* or *reduce* sea-level rise, so the uncertainty in prediction associated with large effects exists only in one direction—higher sea-level rise than we can confidently predict. In fact, history has shown that when the Earth's temperatures were this warm in the past (125,000 years ago), oceans were 5–10 meters (16–33 ft) higher, and the rates of rise were nearly 10 times greater than what we are seeing today (Rohling et al., 2019).

In the case of sea ice, the ice can melt from warm air above, from warm sea water below, and by being transported from colder areas at high latitudes to warmer areas at lower latitudes. While there are not the same kinds of "wildcards" as found on land ice, the models have historically been conservative and careful not to over-ascribe ice loss mechanisms. As a result, models do not yet fully capture the amount of sea-ice loss that is occurring in the Arctic as climate warms (SIMIP Community, 2020). On a positive note, however, when nature surprises us with excessive rates of loss, we have an opportunity to understand why there are discrepancies between models and reality, and we are able to improve our models. So progress is being made. But as with ice sheets, we need to recognize that while models provide our best estimates of future states, they may not fully capture all of the processes at work, and we need to allow for the possibility that the situation could be more adverse than predicted or projected.

If we do not take into account potentially accelerating changes in ice on both the land and sea and adjust our trajectory accordingly to avoid those larger changes, we can expect impacts that are significantly greater than predicted. In the case of sea-level rise, the difference between a 2-foot or 5-foot rise by 2100 equates to billions and possibly trillions of dollars of expense globally, associated with damage to buildings and infrastructure and displacement of individuals. Being able to understand what lies ahead is critical to motivating action to avoid the worst of the change, and to meeting the challenges associated with the change that does occur.

2. You testified that science has not played its appropriate role in decision-making as it relates to sound policies to manage the risks and threats of climate change. As Congress develops infrastructure legislation, how important is it that we update standards and requirements to ensure that those projects will be resilient to current and future sea level rise and extreme weather? Are projections of these impacts sufficiently well-developed and available to include in federal infrastructure policy such as eligibility requirements for federal funding so that projects are built to better withstand those impacts?

As Congress develops infrastructure legislation, it is extremely important that standards and requirements are updated to account for our best understanding of their likely vulnerability to rising seas and extreme events. While my expertise is in the science rather than policy or economics, it is easy to recognize that absent such standards and requirements, an enormous risk would be taken that could very easily result in tremendous costs in terms of dollars, health, lives, and livelihoods. The risk posture we, as a nation, choose to take is something for policy-makers to debate and decide, but determining the implications and likelihood of such risk postures requires an understanding of the types, magnitudes, and rates of change, and their associated implications. As a result, the best available scientific information should be incorporated into all decision-making and planning, so that informed actions can be taken and appropriate preparations for managing the risks and consequences can be made. Being wrong can cost us dearly, and appropriately incorporating science into our decision-making and planning best positions us to minimize unforeseen consequences.

3. What resources are available to measure and manage climate risks at localized scales to support decisions about the siting and design of critical infrastructure, housing, and important public assets like schools and hospitals?

The resources are available and exist within our global, national, and regional *scientific* infrastructure. This scientific infrastructure includes climate and weather models, developed at national labs and facilities, in partnership with universities. It also involves observational networks, made possible by international, national, state, and local investments, as well as satellites to observe processes at scales from global to local. Finally, it involves the scientists, engineers, and others who develop, maintain, and operate these observing capabilities and models, work to understand the processes that govern climate and weather, and seek to understand the implications of change. The United States has a strong scientific workforce to carry out these activities, but observational and modeling capabilities are resource-limited.

An additional consideration that needs to be brought to bear, as was raised in the hearing, is the fact that the adverse effects of climate change on infrastructure disproportionately affect minority and underrepresented communities. As climate risk is incorporated into infrastructure decisions, it is important that these social dimensions of climate change are also considered in the planning, design, and maintenance of buildings, roads, bridges, and other infrastructure elements.

4. How can the federal government help decision-makers at all levels of government and in the private sector interpret the uncertainties in the models to make better decisions?

The federal government can help decision-makers interpret uncertainty to make more fully-informed decisions first by ensuring decision-makers are aware that the ranges of predictions provided by the scientific community are themselves just estimates and not hard boundaries/limits on which to base decisions. Decision-makers, faced with real-world challenges and costs associated with decisions, want "a number" to work with. Whether it's how much sea level will rise by a certain date, how many category 5 hurricanes they can expect in a year, or some other manifestation of climate change, and the best that can be provided is a range of predictions with estimates of likelihood. It needs to be understood that even when we say we predict something with 90% confidence, there is still a 10 percent likelihood that what we are predicting will not be the case. That can easily be overlooked.

It would be valuable for government decision-makers to ensure that they or someone on their staff have a clear understanding (through training or experience) of what uncertainty really is, how it is calculated, what it means for planning, and the difference between mathematical uncertainty (the statistical output of a range of scenarios and outcomes) and physical uncertainty (the degree to which we do and do not understand physical processes). Uncertainty will always be a fundamental part of decision-making, but an understanding of uncertainty and its nuances by those who have to make decisions will ensure that decisions will be made with a full awareness of the risks associated with them. Such risk is inherent in any action or planning, and ensuring the most sound use of resources in the face of uncertainty requires an accurate understanding of the bases for that uncertainty and the implications of that uncertainty.

THE HONORABLE GARRET GRAVES

1. **In your exchange with Representative Bonamici, you both indicated that climate change impacts different regions and communities differently (this was also noted by Dr. Greenstone's data). Do you think this conclusion highlights the importance of a collaborative approach between the federal government and states and local communities, rather than a top-down, centralized approach that doesn't take into account the regional differences that exist in the United States?**

This is more of a policy question, but I will do my best to answer from the perspective of a climate scientist. Consider the need for some local/regional entities to determine the heights of sea walls needed to manage sea-level rise. Or they might be setting building codes to manage storm surges and extreme weather, water practices to manage severe droughts, etc. Those are local/regional issues. However, responses to those issues, in my mind, should be informed by research and investments in broader scale practices at the national level. While I would expect a coastal manager to understand that a certain sea-level rise will impact their region in a particular way, I would not expect such a coastal manager to know what the likely sea-level rise would be nor the character of future weather conditions that will impact storm surge. Likewise, I would not expect state and local governments to be in a position to fund studies and test management measures under a variety of conditions. I view these larger-scale activities more as a federal responsibility that can benefit all locales without requiring all local and state governments to make investments in such studies. As a result, in my view, the best approach is a shared approach in which the federal government conducts studies related to predictions, adaptation measures, and their effectiveness, and other aspects of climate change that will affect large areas; and the state and local governments determine which of the adaptation/mitigation measures are best suited to their particular circumstances. The former will involve larger investments, while the latter will permit tailored management approaches.

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Questions for the Record

The Honorable Heather McTeer Toney
Climate Justice Liaison
Environmental Defense Fund, and
Senior Advisor
Moms Clean Air Force

THE HONORABLE KATHY CASTOR

1. **What has your research found about the effects of extreme weather and disasters on communities of color and their pace of recovery? How can we change federal disaster recovery programs to help them "Build Back Better" with resilience?**

Reiterating part of my original testimony—there is no questions that extreme weather impacts black and brown communities worse than any other demographic in the nation [1]. At the time of this writing, Lake Charles, Louisiana is under day 3 of a flood watch that has caused over 600 people to abandon their homes.[2] Not only is Lake Charles a minority community, it sits in the middle of Louisiana's notorious Cancer Alley, subjecting residents to the constant harm of air pollution. This comes as many are still recovering from Hurricane Delta and the traumatic winter storm that crossed Texas and Louisiana, leaving thousands without power. To make matters worse, we have yet to enter the 2021 Atlantic hurricane season—one that is already predicted to be as active [3], if not more so, than 2020.

It bears repeating that studies conducted by Rice University and the University of Pittsburg show that predominantly white areas realize an increase in the average wealth post disaster versus minority communities that see a noticeable wealth decrease. This dynamic is caused by the levels of reinvestment into communities post climate disasters.[4] Researchers further concluded that despite accounting for controlled factors including, but not limited to; age, education, and homeownership, wealth inequality increases in regions hit more by natural disasters [5]. Add the additional climate impacts like vector borne diseases and heat—the EDF North Carolina study found that the most serious temperature-related impacts are likely to be those associated with extreme heat.

Recognizing that federal disaster response is subject to the request of aid from states, the federal government can assist in the mitigation of potential damages by helping communities become climate resilient ahead of time and quickly. To correct systemic inequities, federal agencies should investigate the barriers that prevent disadvantaged communities from experiencing the same access and, in turn, recovery that other more affluent communities receive. Agencies should take a hard look at the percentage of residents in disadvantaged communities that receive help and assess the type of help most requested. For example, if a larger percentage of minority residents in an impacted community are renters vs. home owners, partnering with HUD could be a way to provide an opportunity to transition renters to homeownership if they so desire. FEMA's current goal in disaster response is to repair a home back to a safe and sanitary standard. This is not sufficient to consider an additional need of resiliency and creates an unfair advantage to those unable to afford the real cost of rebuilding. Building back better means providing additional resources to account for new and/or proposed standards and efficiencies as well. Homeowners and businesses would benefit greatly if provided the incentive to build back with EV infrastructure, sustainable building materials and cooling roof options vs. replacing with what was there before the storm.

2. **What steps should we take to ensure that the momentum of the economic recovery includes everyone, and not just those who have the capacities to leverage investments or other program benefits?**

How this Congress and administration manages economic equity while assuring environmental justice may be the single most important factor in every piece of legislation and/or economic funding package through November of 2022. Keeping the promise of access, equity and opportunity is not only important to the economic success of our country's families, but also denotes whether or not we can truly trust

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[1] https://www.greenamerica.org/climate-justice-all/people-color-are-front-lines-climate-crisis
[2] https://abc13.com/lake-charles-flooded-louisiana-storm-severe-weather-national-service/10657835/
[3] https://www.accuweather.com/en/hurricane/accuweathers-2021-atlantic-hurricane-season-forecast/924431
[4] https://www.eurekalert.org/pub_releases/2018–08/ru-ndw082018.php
[5] https://psci.princeton.edu/tips/2020/8/15/racial-disparities-and-climate-change

that our federal government has the best interest of the people at heart. Congress should fully support the recommendations of the White House Environmental Justice Council (WHEJC) and advocacy for the "Justice 40"—insuring that 40 percent federal funding goes to the most disadvantaged communities first. In addition, the 40 percent should apply to infrastructure funding initiatives with an eye towards sustainability and resiliency efforts that create jobs in marginalized communities. While President Biden signed an executive order on January 27, 2021 outlining the general goals of the Justice 40 initiative, it speaks to broadly of 40 percent of the overall benefits to disadvantaged communities and not 40 percent of the actually funding. This goal could be assumed achieved without a dime being spent in the communities that need it most. For example, Jackson, Mississippi is in dire need of infrastructure dollars to correct and upgrade the municipal water system. If the majority, wealthy, neighboring suburb is able to secure infrastructure funding to leverage and upgrade their system in an effort to support at least 40 percent of the Jackson area, the goal of "benefiting" a disadvantaged community is realized with no actual dollars spent or benefiting the residents of Jackson, Mississippi. Congress can and must go further to demand that 40 percent of the actual funding gets to disadvantaged communities if we are to ensure the economic recovery truly meets everywhere where they are.

Congress can support legislation and/or funding plans that help small business owners in disadvantaged communities take advantage of environmental economic infrastructure. 38.75 percent of truckers in America are minority and of that, roughly 21 percent are owner operators.[6] Financial assistance incentives that recognizes the inequities of how vehicles/infrastructure are currently deployed would be a tremendous opportunity to provide direct economic benefit and clean energy opportunities to those who are the frontlines of the industry and pollution. Upfront purchase incentives that have an adder for businesses operating in pollution-burdened communities (i.e. California's HVIP program[7]) could create and grow momentum for clean energy alternatives in disadvantaged communities and/or communities of color. By accompanying with education and technical assistance for small businesses, we can, in general, ensure that rebates/loans etc. are not biased against small businesses with less capital and access to resources.

Two examples of legislative opportunities are outlined below.

a. The Clean School Bus Act/Clean Commute for Kids Act—this bill provides grants for zero-emission school buses *and* infrastructure. It also allows grant money to be used for job training programs and has a scrappage requirement to prevent diesel vehicles from winding up in pollution-burdened communities. The Clean School Bus Act gives priority to eligible entities "(i) that have significant aging, inefficient, or high emission bus fleets that need improvement; [and] (ii) (I) that serve a high percentage of students from low-income families, as determined by the Secretary using data from the Small Area Income and Poverty Estimates Program of the Bureau of the Census" and the Clean Commute for Kids Act says "the Administrator shall give highest priority to applicants that propose to replace school buses that serve the highest number of students . . . who are eligible for free or reduced price lunches." Both acts have provisions for education and outreach programs, which should help increase the efficacy of these programs in achieving their prioritization aims. Additional recommendations such as a requiring a percentage of local hires and a process to include community informed placement of new infrastructure would invite community buy-in and support long term, future sustainable development.

b. The Climate Smart Ports Act awards grants for zero-emissions port equipment and technology. One of the criteria for prioritizing grants is the degree to which the money will "reduce public health disparities in communities that receive a disproportionate quantity of air pollution from a port." Additionally, studies continue to show that low-income and communities of color are most likely to be located near ports and impacted by more likely to live near ports/be affected by drayage pollu-

[6] United States Census, "America Keeps on Truckin'"

[7] https://californiahvip.org/

[8] "Climate policy, environmental justice, and local air pollution", Meredith Fowlie, Reed Walker & David Wooley, for Economic Studies at Brookings, pg. 6

tion.[8,9] The Climate Smart Ports Act has equitable labor practices—
an eligible entity has to ensure at least 40 percent of hired labor is domiciled near the installation area, is or was a member of the Armed Forces, was previously incarcerated, has a disability, is homeless, receiving public assistance, etc.

3. As the Administration plans to develop and create a geospatial Climate and Economic Justice Screening Tool, how important is it for this resource to meet the needs of environmental justice communities and policymakers by providing granular, neighborhood level data, that identifies the sources of pollution and other risks and harmful factors? How important is it for that resource to include flood, wildfire, and urban heat risks that compound environmental hazards? What data partners and existing datasets, models, and technologies should the federal government consider including in the development of the tool?

Black Americans are three times more likely to die from pollution exposure[10] and overburdened communities are facing grave immediate health risks from disproportionate exposure to pollution, as well as greater climate risk. The existing EPA network is outdated and must be modernized to meet the urgent needs of today as well as prevention planning for the future. Late last year, the Government Accountability Office reported that National Ambient Air Quality Standards and regulatory monitors are in disrepair and unable to meet the need for information on pollution hotspots at the community scale. In other words, if the administration were to use the current information to disperse funding from the "Justice 40" initiative, it would fall far short of the goal of getting resources to those on the frontlines of the climate crisis. EJSCREEN has served its purpose, but it is no longer reflective of the most modern and cutting edge science. It cannot accurately identify communities burdened by high pollution.

Time is of the essence. While I have been encouraged by the Biden Administration's focus on a Climate and Economic Justice Screening Tool, communities that are exposed to pollution right now should not have to wait months or years while the government incrementally improves EJSCREEN.

A Climate and Economic Justice Screening Tool cannot meet the needs of environmental justice communities without incorporating granular neighborhood-level measurement data about pollution sources and exposures as well as health and climate risks. Environmental justice and environmental health experts have advocated for a tool that can clearly identify and quantify the risks that environmental pollutants and climate change pose to the most at-risk people in our country. Presently, governments assess climate change and environmental effects in the aggregate. We know which characteristics make a person or group of people more susceptible and more vulnerable to climate and environmental hazards in general. We do not know exactly where the people or communities who are more vulnerable or susceptible are located across the United States. Knowing this information is essential to making sure that any and all climate and environmental policies and interventions prioritize those who are most susceptible and vulnerable to pollution and the impacts of climate change. This is the point of the Climate and Economic Justice Screening tool, to fill that gap. In filling that gap, we know that inferences can change based on the spatial aggregation used. This is why policymakers and scientists including citizen scientists need data that's as close as possible to the individual experience and risk. In the case of the Climate and Economic Justice screening tool, it aims to identify highly-burdened and underinvested people and communities. This is why the tool needs to have a higher spatial resolution at the census block level or greater. EDF is a global leader in embracing new technology critical for tackling air pollution around the world and we've worked with partners that include Google Earth Outreach in this effort. While we cannot endorse any one organization over another, we know that seeing pollution mapped out as detailed as possible helps us to be better advocates for cleaner air and smart development choices.[11] For example, EDF participated in a recently published study in the peer-reviewed journal *Environmental Health Perspectives*[12] which indicates that mobile monitoring at the hyperlocal level more precisely informs health risk assessments

[9] "Drayage" is a term used in shipping logistics to define short distance transportation from a port to truck/rail or vice versa. This method of transport is typically first in the freight moving process and involves heavy polluting vehicle such as diesel trucks.

[10] https://naacp.org/know-issues/environment-climate-justice

[11] https://www.edf.org/airqualitymaps

[12] https://ehp.niehs.nih.gov/doi/10.1289/EHP7679

[13] https://cdn.americanprogress.org/content/uploads/2021/03/16083513/Justice40-Recommenda-

than land-use regression models and satellites. This underscores the need to measure air pollution exposures at the most granular level possible while making that ground-truthed data accessible to communities and scientists working to protect public health and support environmental justice.

In my personal capacity, I volunteer and serve on the climate justice advisory board for Aclima, an organization that is considered a pioneer in the field, having introduced block-by-block mapping of air pollution and greenhouse gases at unprecedented scale. Their tools combine granular pollution measurements with contextual data to derive the most advanced environmental justice screening available today. They have validated their approaches through a multi-year collaboration with the U.S. EPA. In addition, the Senior Scientist that leads development of Aclima's screening tool is one of the leading environmental health scientists across the U.S. who grew up in what would be considered an environmental justice community in New Jersey. With so few women of color in the innovative sphere of environmental technology, let alone initiatives that support community engagement, job creation and pollution reduction, it remains personally important to me to volunteer my support as much as possible.

Finally, the EJ Community and its partners stand ready to help. The lived experience and constant participation of Environmental Justice communities should be key as you develop this tool. The Administration and Congress should seek the help and input of these communities, along with partner organizations that have developed innovative measurement, analysis, and screening methods that could dramatically help the government in development of this tool. I encourage the Administration and Congress to work closely with our Environmental Justice communities and technology leaders to modernize this country's equity mapping and monitoring capabilities.

4. As Congress and the Biden Administration work to ensure that federal policy embeds equity in recovery, infrastructure, and other federal investments, how can we track and measure progress along the way, identify problems, and make mid-course corrections to ensure that federally supported projects for climate action reflect local priorities and benefit our most vulnerable who need help most?

In addition to creating a solid climate and economic justice tool as outlined above, agencies should be required to track infrastructure funding and specifically track "Justice 40" spending, in a way that accounts for the following:

- Dollars directly to marginalized/disadvantaged communities as defined by the White House Environmental Justice Advisory Council (WHEJAC)
- Number of long term and seasonal jobs created
- Benefit to disadvantaged communities vs. dollars spent in same communities
- Expansion of renewable energy program access to marginalized communities
- Creation and required agency participation in an open, online scoring system that displays each agencies progress in achieving the Justice 40 goals

The Equitable & Just National Climate Platform, in partnership with the Center for American Progress and the Tishman Environment and Design Center, has developed a set of Justice 40 Recommendations comprised from two convenings of national environmental justice leaders. I strongly recommend adhering to the expert advice of this document, particularly recommendations of stakeholder engagement and accountability and fund tracking.[13]

5. In your testimony, you described a great public-private partnership with a major employer that worked with your community to invest in community-building and resilience. How do climate disclosures help private entities become better partners to advance climate action and to anchor justice and prosperity in their communities?

The science is clear. We do not need a financial forecast to calculate the climate risk posed to not only major US corporations, but local and state governments, small businesses, our entire domestic economy and families across our country. Right now today, we are experiencing, in real time, the devastation, physical and financial loss borne by those most unable to stand the burden due to failures of corporations to adequately prepare and disclose their climate risk. Private entities usually think of investors as those who contribute monetary value to their business or corporation and as a result, calculate risk based upon the impact to this specific group of individuals. But strengthening climate risk disclosure is a necessity for more than markets and investors. Somehow, we've allowed the idea that publically traded companies are excluded from sharing information with the "public"—also identified as the places in which corporate assets sit and the communities in which people live when

[13] https://cdn.americanprogress.org/content/uploads/2021/03/16083513/Justice40-Recommendations.pdf

those assets suffer loss. These are the "invisible investors"—the American tax payers invested in the infrastructure and assets of our communities' nationwide. More often than not, the brunt of climate related disaster expenses fall on communities most at risk to the impacts of climate change; communities of color and economically depressed regions. These "invisible investors" pay a high price when there is a market crash. They cannot short sell their stock in the community. They're not able to redistribute the loss among other assets. Invisible investors will not be able to categorize the outrageously high electric and water bills as a capital loss and reduce their tax rate

There is hope. In addition to the broad benefits associated with managing systemic risk, improved reporting is also beneficial for the health of society as a whole, while ensuring the safety and welfare of vulnerable communities in particular. As corporations are required to undertake and disclose careful analyses of their exposures to climate risk, they will be incentivized by their investors to develop transition plans that diminish exposure to these risks. In addition, the transparency of climate risk and subsequent preparation will be an asset to public planning. As metrics to determine the potential financial risk to a company's assets become more and more measurable, sharing this information can drive investment to marginalized communities as additional justification and leverage for infrastructure support. Correlating physical climate risk to public sustainability and resiliency preparations could not only result in reducing the impact of the threat, but also reduce the cost mitigation and future climate disaster related expenditures. Because policy risks—including the enactment of a carbon tax—are particularly salient for many corporations, disclosure of climate risks will likely prompt greater efforts by corporations to mitigate their greenhouse gas emissions. Economic research indicates that other related forms of disclosure have already resulted in reduced emissions: one study found that UK-incorporated firms reduced their emissions by an average of 14 to 18% after the government mandated that companies disclose their emissions in 2013.[14] To the extent that such mitigation occurs, they will provide climate benefits to society by reducing the severity of air pollution, the spread of infectious disease, the intensity of severe weather events, and the risks to the global food supply.[15] These benefits are multiplied in low income communities and communities of color. Given that the harms of climate change have been demonstrated to disproportionately harm those communities, strengthening risk disclosures can help corporations and regulators address disproportionate impacts of the physical risk to marginalized communities. Public policy is shifting to safeguard marginalized communities from further damage while spurring sustainable and resilient economic development. This includes not only direct physical effects like flooding and heat island effect,[16] but also economic impacts from increased food and energy prices and human health impacts due to respiratory illness and other diseases that are exacerbated by climate change.[17]

THE HONORABLE GARRET GRAVES

1. In responding to a question from Representative Miller, you asserted that United States companies that also operated in other countries were "not showing the same value to people across the world," due to increased flaring in Nigeria. Do you think this speaks to the difference between the environmental standards and regulations in the United States as opposed to the less stringent standards in nations around the world?

I think it speaks more to our lack of holding companies accountable to the same standards of protecting disadvantaged communities around the world. In the same way that the United States can and does limit trade, exchange and subsidies to companies who operate in certain countries for various human rights concerns, we should hold accountability the polluting industries in a similar manner. They are not only contributing to the disenfranchisement of marginalized people, but also contributing to the overall global emissions of our planet.

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[14] Benedikt Downar, et. al., *The Impact of Carbon Disclosure Mandates on Emissions and Financial Operating Performance* (Stanford Graduate School of Business Working Paper No. 3873, May 2020), https://perma.cc/ET7A52TV.

[15] Megan Ceronsky & Peter Heisler, *The Many Benefits of Reducing Carbon Pollution from Existing Power Plants,* EDF (May 15, 2014), https://perma.cc/67CC–H9FW.

[16] IPI report; also studies on redlining that implicate flooding and heat ILIANA PAUL, ET. AL., IMPROVING ENVIRONMENTAL JUSTICE ANALYSIS: EXECUTIVE ORDER 12,898 AND CLIMATE CHANGE 6–7, INSTITUTE FOR POLICY INTEGRITY (Jan. 2021), https://perma.cc/58A2–M477.

[17] *Id.* at 6.

2. **As you know 90% of the world's solar panels come from China, and critical minerals used in solar panels and batteries include cobalt that is mined in the Congo. According to multiple accounts, the use of forced (including assigned) labor to make these solar panels in China is common. Also, in the Congo, the use of child labor to mine cobalt—an important mineral used in renewable energy—is common. Given your comments on not showing the same value to people across the world, isn't this a concern to you as well? Should we be importing solar panels or battery components that have any connection to forced or assigned labor, or any connection to child labor? Would you support legislation that requires, as a condition of receiving any federal subsidy for electric vehicles or solar panels, certification by the granting agency that no forced/assigned labor or child labor was used anywhere in the supply chain of these products?**

The United States government currently has an active policy regarding the procurement of goods produced with child labor under Executive Order 13126,[18]. It requires the US Department of Labor to maintain a list of products and their countries of origin that have been produced by forced child labor.[19] Federal contractors who supply products on the list must prove they have made a good faith effort to determine if the products were produced under forced labor. In addition, Solar Companies have stood in solidarity against using products procured through the use of forced and/or child labor. In February of this year, over 175 companies signed a pledge to not only avoid use, but also advocate and help prevent these practices, specifically identifying Xinjiang, China as an example.[20] Combined, the United States is already well positioned to use existing regulations and agency guidance to assure that no products procured through forced or child labor enter any stream of supply chain that is in any way funded, even in part, with federal dollars. Congress should however, formalize Executive Order 13126 into law such that this cannot be reversed by any future administration.

Questions for the Record

Dr. Shawn Gillen
City Manager
City of Tybee Island, Georgia

THE HONORABLE GARRET GRAVES

1. **In the hearing you noted the importance of the federal government working quickly and efficiently to support local communities' efforts and creating "easier pathways" to resiliency. What do you think is the best model in terms of decision-making authority, funding priorities and removing obstacles; one that centralizes control at the federal level or one that empowers the local communities?**

Representative Graves,

Thank you for your question and the opportunity to follow up with the committee.

Given our experience over the past four years of improving Tybee's coastal resilience, we strongly recommend a model that empowers local communities. Local communities know best for their particular situation: strong points, weak points, priorities. We had a plan in place, but as usual, funding was an issue. In contrast when we were given a grant by the State, based on our plan, we were able to implement immediately. We were given enough money to execute quickly and successfully, negotiating seasonal issues of tourists, turtle nesting, USACE schedules, DNR schedules, and the like.

The complexities are such that any plan needs to be adapted to meet contingencies. Even with funding, we needed to deal in the moment with various regulatory schedules, permitting requirements, and, of course, storms. The closer to the immediate problem, the more effective the solution can be implemented.

Contrast this speed to implement and ability to react and adapt to changing circumstance with our experience with FEMA grants. It has been five years since Hurricane Matthew and four since Irma, and we continue to wait on FEMA funds to complete lifting homes. Several homeowners went ahead and funded their house lifting themselves. Several others continue to be at risk of the next storm. We applied

[18] formally titled Prohibition of Acquisition of Products Produced by Forced or Indentured Child Labor

[19] https://www.dol.gov/agencies/ilab/resources/reports/child-labor/congo-republic

[20] https://www.seia.org/news/solar-companies-unite-prevent-forced-labor-solar-supply-chain

for a Safe Shelter grant from FEMA in April of last year and have been told it may take another 6–12 months before we know if we get it or not.

We see a great deal of time and energy on the front-side of Federal (and State) grants, to determine who should be funded, and then a great deal of scrutiny and auditing after the fact, upon completion of a project. It seems to us funds could be awarded more quickly and effectively based on the merits of a plan, and scrutinized after the project has completed with existing audit requirements, rather than have delays on both ends of a project.

Our experience in speaking with other coastal communities in similar situations suggests most communities have identified their weak points and prioritized their plans but need funding to execute. Getting funding to the local level quickly would be a vast improvement over the current practice. Time is truly of the essence in building Tybee's coastal resilience, with a storm season coming each year. We suffered a hurricane or tropical storm in each of the four years we have been building our resilience. We were fortunate to have been spared last year's record number of hurricanes. With every passing year that coastal communities such as Tybee cannot fund their resilience initiatives, the risk of more devastation increases.

Questions for the Record

Dr. Michael Greenstone
Milton Friedman Distinguished Service Professor in Economics
University of Chicago

THE HONORABLE KATHY CASTOR

1. **The benefits of climate policies like a clean energy standard include pollution reduction, public health benefits, job creation and economic development benefits, and more. The Social Cost of Greenhouse Gases might help quantify some of these concerns, but not all of them. How would you recommend that Congress account for all of the benefits of climate and clean air policies when developing legislation?**

It is true that the social cost of greenhouse gases will capture the benefits associated only with the reduction of those greenhouse gases. Indeed, there are other benefits from climate policies, and good policy will account for all of them. Importantly, the current regulatory process has a long track record of accounting for a wide set of benefits, critically including improvements in local air quality and the resulting health benefits. I think it would be very powerful if Congress required regulatory reviews that measure the benefits that regulations actually deliver, not just those that they are projected to deliver. Currently, regulations are only formally evaluated ex ante which, of course, is the moment that we know the least about how they will perform. The results from ex post evaluations could be used to improve policy on a continuing basis.

In testimony I presented to the Senate Subcommittee on Regulatory Affairs and Federal Management in 2015, I proposed the development of a Regulatory Analysis Division within the non-partisan Congressional Budget Office (Greenstone, 2015). This is an idea originally introduced by Senator Klobuchar. It would help to ensure that we are getting what we intend out of the regulatory process. I would be happy to have a further discussion about how such an institution could be useful in confronting the climate crisis.

2. **Any net costs associated with climate policies like a clean energy standard will depend on the impact of complementary policies like infrastructure investments and transmission build out, investments in innovation leading to cost reductions in renewables and storage, and strategic use of demand response and load flexibility. Would you agree that Federal policy can be designed to minimize the net costs of climate policies?**

Federal policy can certainly be designed to minimize the net costs and maximize the net benefits. Often the best way to understand these costs and benefits is to conduct real world analyses of these policies. For example, you mentioned the net costs associated with clean energy standards. For years, states have pursued similar programs, renewable portfolio standards (RPS). We've learned from studying these RPS programs that they often exclude some carbon-free electricity sources, favor some sources over others, and limit the degree of trade across regions. These and other limitations have made electricity more expensive for consumers and RPS policies less cost effective in reducing emissions than they could have been (Greenstone et. al., 2020). Drawing on the lessons from state RPS programs can help guide the

most effective clean energy standard. Such a standard would be flexible and technology neutral, link to carbon reduction policies in other sectors, and be paired with complementary policies that facilitate grid integration and directly support technological innovation (Roadmap, 2021).

Additionally, there is a central role for the federal government to support research and development, as well as demonstration, in cases where the private sector is unlikely to fully participate. The climate crisis provides many opportunities for the federal government to play this role, ranging from supporting the development of carbon removal technologies to foundational infrastructure investment.

3. You've recommended that the federal government account for the disproportionate climate impacts in benefit cost analyses through equity weighting. How might the Social Cost of Carbon incorporate these disparate impacts and evaluate impacts differently based on who is being affected?

Standard economic theory and empirical observations from insurance markets suggest that people are risk averse, valuing a dollar more in times of economic hardship than in good economic times. The same logic extends across individuals; a dollar is worth more to someone in poverty than to a wealthy person. When computing the SCC, these principles can be applied to the valuation of climate damages using standard economic tools that calculate the premium people typically pay to protect themselves against outcomes that dramatically reduce their income. Just as individuals are willing to pay more for financial assets that provide insurance in hard times, societies may be willing to pay more for investments in climate change mitigation that disproportionately protect the poor. In plain English, societies tend to care more about a low-income family losing $1,000 (e.g., due to climate change) than Jeff Bezos losing $1,000 precisely because the $1,000 loss is much more meaningful to the low-income family.

4. Your testimony provided helpful background on the work to value the social costs of carbon and other greenhouse gasses, which will help evaluate policy actions to reflect a fuller scope of costs and benefits. You, along with others, including FEMA's National Advisory Council, have recommended that agencies use a lower discount rate to ensure that we do not pass on the heavy economic burdens on to future generations. What are the changes that you are seeing in the capital markets that prompts your recommendation for a lower discount rate? What discount rate would you recommend that the federal government use for infrastructure investments?

U.S. government agencies generally follow the Office of Management and Budget's (OMB's) recommendations in Circular A–4, which was formed in 2003 and uses 3 percent and 7 percent discount rates in cost-benefit analyses (OMB, 2003). These two values were justified based on observed market rates of return: the 3 percent discount rate was a proxy for the real, after-tax riskless interest rate associated with U.S. government bonds at the time. The 7 percent rate was intended to reflect real equity returns like those in the stock market at the time.

The 2010 Interagency Working Group on the Social Cost of Carbon (IWG) set 3 percent as the central case to be consistent with guidance from the OMB regarding the interest rate on U.S. government bonds. This decision was also motivated by asset pricing theory and the assumption that climate damages are uncorrelated with overall market returns (Greenstone et al., 2013).

However, there have been substantial changes in global capital markets since the publication of Circular A–4 in 2003 that make it challenging to justify 3 percent as an accurate estimate of the real return on riskless investments. For example, the average ten-year Treasury Inflation-Indexed Security (TIPS) rate since its inception (2003-present) is just 1.01 percent. This is illustrated very clearly in Figure 1. Similarly, recent research suggests that the equilibrium real interest rate has declined substantially since the 1990s (Bauer and Rudebusch, 2020).

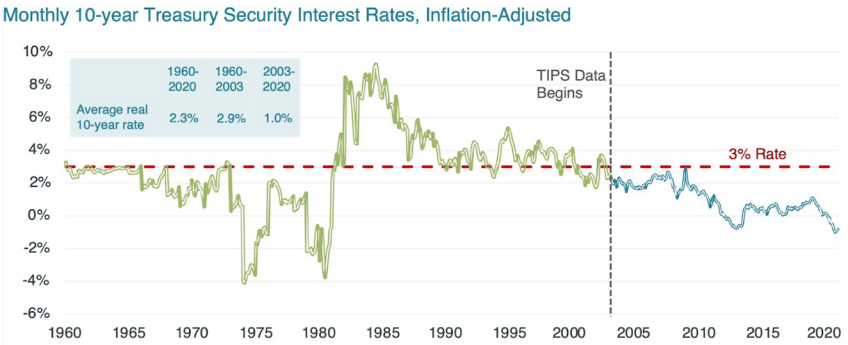

Figure 1: Monthly 10-year inflation-adjusted Treasury security interest rates. Figure shows monthly 10-year Treasury security interest rates, adjusted for inflation, from 1960 to 2020. Nominal interest rates, Treasury Inflation-Indexed Security (TIPS), and inflation data were retrieved from the Federal Reserve Bank of St. Louis. The TIPS rate is available starting in January 2003. Interest rates prior to 2003 are imputed by subtracting the annual inflation rate from the nominal interest rate.

Overall, my judgement is that there is now a compelling case for a riskless discount rate of no higher than 2 percent and this should apply to climate and standard infrastructure investments. I have reached this conclusion by applying the same criteria that were applied to set the 3 percent discount rate in 2003.

5. What is your research finding about the economic impacts of climate change for coastal regions, and how might climate impact their economic productivity against rising seas and risks from coastal storms?

The Climate Impact Lab that I co-direct is doing a great deal of research on the impact of climate change on coastal regions. Impacts in coastal regions are driven by two factors: the amplification of tropical and extratropical cyclone (i.e. hurricane) storm tides due to average sea level rise and the change in the frequency and intensity of these cyclones. However, coastal impacts are distributed highly unequally, with larger impacts felt in eastern coastal states. Locations with dense capital stocks (such as the New York city area), as well as Gulf Coast regions and most of Florida, are projected to experience the greatest magnitude of economic impacts. Earlier research (Hsiang et al., 2017) finds that sea level rise alone raises the direct annual economic damage by 0.6 to 1.3 percent of state gross domestic product in South Carolina, Louisiana, and Florida. If we follow a scenario close to that laid out by the Paris accords, average annual economic impacts by the end of the century are likely to cost tens of billions of dollars—double that under a continued high emissions scenario. These damages only account for direct flood damages and do not consider other costs like business interruption (e.g., Basker and Miranda, 2018) or other fiscal costs that could be many times larger than direct damages (e.g., Deryugina, 2017).

Changes to storm patterns are even more uncertain than sea level rise, but the best estimates suggest that the magnitude of damages caused by changing storms will be roughly on par with that of sea level rise. Sea level rise and storm patterns are of course related, and the magnitude of storm related damages in the second half of the century are strongly controlled by sea level rise because greater sea level rise leads to greater flood damages from storm surges. In specific work related to New Jersey, my colleagues have discovered that since 1980, the number of homes at risk of frequent flooding in the state has more than doubled (27,000 buildings worth about $15 billion), and the number of homes expected to experience at least one hurricane-driven flood event during a 30-year mortgage has increased by about 70,000 ($60 billion in value). In non-coastal New Jersey counties, the odds that the average home would experience hurricane force winds has increased from more than a one-in-two hundred risk to somewhere between one-in-one hundred and one-in-thirty risk. Average annual losses from hurricanes in New Jersey today are expected to be about $0.6 billion to $1.3 billion higher than in 1980.

6. How will the climate crisis affect the cost and reliability of energy supply?

Climate change is expected to affect all aspects of the energy system. Warmer temperatures are expected to increase U.S. electricity consumption while decreasing direct consumption of other fuels (i.e. natural gas, oil, coal) that are typically used

for heating (Rode et al., 2021). Although future warming is projected to increase average electricity consumption, it is expected to have an even larger impact on peak load. Peak load is projected to increase by 18 percent under a high emission scenario, requiring substantial investment in peak generating capacity. Installing an additional 18 percent of capacity in the United States at current prices would cost around $180 billion (Auffhammer et al., 2017).

There is limited research on the effects of climate change on energy costs and reliability, and much remains unknown. However, some themes emerge from the literature:

1) Hydropower facilities require water. If precipitation and temperature patterns change such that dams receive less water or lose more water to evaporation, then hydropower supply may decline (van Vliet et al. 2013, Bartos and Chester 2015).
2) Thermoelectric power plants such as nuclear and fossil fuel plants require cooling water for their safe operation. Changes to precipitation patterns may affect the supply of cooling water due to reductions in stream flow. Increases in temperature warm rivers where cooling water is discharged and may increase curtailments of power production as river temperatures exceed regulatory thresholds (Förster and Lilliestam 2010, van Vliet et al. 2012, Bartos and Chester 2015).
3) High temperatures pose a challenge to keeping thermoelectric power plants cool enough to function properly. Recent research shows that on the hottest days, power plant capacity can be reduced by more than 10 percent because the air and water used to cool the plants is too warm. These effects will be magnified as hot days become more frequent under future warming. Under 2 degrees Celsius of global warming, power plant outages from hot days are projected to nearly double relative to present-day levels (Coffel, 2021).
4) More anecdotally, recent experiences in California and Texas demonstrate that increased demand for heating and cooling, as well as damage to energy infrastructure caused by disasters like wildfires, can affect grid stability. This occurs for two reasons: the decreased supply as facilities or transmission infrastructure may be temporarily lost, and the peak demand increases during times of extreme weather.

7. What are the anticipated effects of the climate crisis on workers and U.S. labor productivity? What are the labor sectors that will be the most affected?

Climate change is expected to lead to substantial losses to labor supply, increased discomfort to workers, and impaired labor productivity. Labor supply has been found to be negatively affected by extremely hot days. While all sectors are affected, the effects are especially large in weather-exposed sectors such as agriculture, mining, construction, and manufacturing. A day with maximum temperature above 100 degrees Fahrenheit has been shown to reduce labor supply by up to one hour per worker in these sectors, relative to a day with a maximum temperature of 75 degrees F to 80 degrees F (Graff Zivin and Neidell, 2014). Under a high emissions scenario, overall U.S. labor supply losses in 2099 are projected to be comparable to losing roughly half a million full-time-equivalent workers, and the increased labor disutility from a warmer climate is valued at roughly 0.5 percent of 2099 U.S. Gross Domestic Product (Rode et al., 2021).

Recent research also finds evidence consistent with declines in productivity on hot days, both at micro and macro levels. Cachon et al. (2012) find that days with a maximum temperature above 90 degrees F reduce production in U.S. automobile plants, with six such days in a week being associated with an 8 percent decline in production relative to a week with no such days. These types of effects are reflected in aggregate measures. Behrer and Park (2017) find that one additional day above 95 degree F causes a 0.23 percent reduction in county-level payroll per-capita in non-agricultural, weather-exposed sectors.

THE HONORABLE GARRET GRAVES

1. In an exchange with Representative Miller, you stated that natural gas "should certainly be available" as an energy source in the United States. I agree with that and believe that U.S. produced natural gas should play an important role in meeting global demand, particularly given the low lifecycle emissions profile compared to global competitors such as Russia. Should U.S. produced natural gas continue to be part of our efforts to reduce emissions and provide affordable energy both domestically and globally? Isn't it important to continue to develop technologies, such as carbon capture, that allow

for the utilization of natural gas with much lower emissions—particularly given projections of 40% and greater increased global demand for natural gas in the coming decades? Given the fact the Russian natural gas exported to China has a lifecycle emissions profile 47% greater than U.S. LNG exported to China, should we really be pursuing energy policies that could potentially eliminate natural gas as an energy source in the U.S. or that unilaterally make the lower emission resource less competitive globally than our higher emitting competitors?

Natural gas is an essential player in the national and global energy mix, and it is important that we develop low-cost technology—namely, carbon capture and sequestration (CCS)—to make natural gas not just low carbon but no carbon in the future. The best approach is a price on carbon or a properly designed, technology-neutral clean electricity standard that allows lower or zero carbon technologies to compete on a level playing field. Like a carbon tax or cap-and-trade system, a clean electricity standard that includes natural gas with CCS would allow the market to decide fuel choices, while accounting for their climate impacts, and provide the profit motive to industry to drive investment in lower carbon technologies, like natural gas with CCS. All of these policies can be designed to protect lower income Americans through progressive rebates and to protect U.S. competitiveness through border tax adjustments.

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