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U.S. Senate Date: Wednesday, November 1, 2023

Committee on Environment
and Public Works

Washington, D.C.

THE SCIENCE OF EXTREME EVENT ATTRIBUTION: HOW CLIMATE CHANGE IS FUELING SEVERE WEATHER EVENTS

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The committee met, pursuant to notice, at 10:01 a.m. in room 406, Dirksen Senate Office Building, the Honorable Thomas R. Carper [chairman of the committee] presiding.

Present: Senators Carper, Capito, Whitehouse, Merkley, Markey, Kelly, Padilla, Boozman.

STATEMENT OF THE HONORABLE THOMAS R. CARPER, A UNITED STATES SENATOR FROM THE STATE OF DELAWARE

Senator Carper. Good morning, everyone. I am pleased to call the hearing to order.

Today, as you know, we are gathered to discuss a field of climate science known as extreme event attribution. My guess is you ask 100 people in this Country what they think that means, they wouldn't have a clue. Until a couple of weeks ago, some of us would not have, either. When we leave here today, hopefully we will know it and not just understand it ourselves, but actually be able to explain it to others.

I am told that this is the first-ever Congressional hearing on the topic of extreme event attribution. To understand why we are holding today's hearing, I think it might be helpful to ask and answer a few questions.

First, what is extreme event attribution anyway? Besides being quite a mouthful, extreme event attribution looks at how a specific extreme weather event, such as a particular heat wave or flood, was made worse by climate change.

Second, why is this kind of climate science important, real important? To answer that question, we need to first acknowledge the fact that human-caused climate change is increasing the frequency of extreme weather events.

Earlier this year, the American Meteorological Society

issued a report by many of our Nation's leading climate scientists and meteorologists. That report detailed, as I am sure our witnesses know, how climate change has driven unprecedented heat waves, floods, and droughts this year and in recent years. We know that continues to be the case.

When Phoenix, Arizona experiences an unprecedented 31 days of temperatures at or above 110 degrees Fahrenheit as they did this summer, or when historic rainfall leads to severe flooding in places like Florida and Vermont as it did this year, many of us find ourselves asking, is climate change to blame for this? The honest answer is yes, yes, it is.

It is true that we have always had heat waves, at least for as long as I have been around, 76 years. It is also true that climate change is making them more intense. So, the better question to ask ourselves is, how much worse did climate change make this heat wave or how much worse did it make that flood? That is the kind of question that extreme event attribution scientists, including at least one of our witnesses, Dr. Wehner, work to answer. These questions matter because the human harms and costs of climate change are massive, and sadly, they are growing.

As many of our colleagues know, I represent the lowest-lying State in our Nation, Delaware. In Delaware, we are already losing our dunes, we are losing our wetlands to sea

level rise and nor'easters. As we work to repair our homes, businesses, and infrastructure and replenish our beaches damaged by these events, we are already paying for the costs of climate change.

But this hearing is not just about Delaware. It is a hearing about 49 other States and a planet that we all share with people around the world. We are grappling with the costs of climate change.

Today, we are going to focus on how it is fueling extreme weather and, maybe even more important, what we can do about it.

Now, in one sense, climate change is already affecting every aspect of our weather. Overall, NASA tells us that global temperatures have increased a little more than 1 degree Celsius, that is about 2 degrees Fahrenheit, since 1880. That is due mostly to human-caused climate change.

Because our planet is warmer, on average, the hot days are becoming hotter. And, because a warmer atmosphere holds more water vapor, rain storms are growing more intense.

Warmer oceans are also producing stronger hurricanes. Last week, we saw Hurricane Otis wreak havoc, wreak devastation in Mexico when it rapidly intensified from a Category 1 to a Category 5 in less than 10 hours. Think about that. Less than 10 hours. I couldn’t believe it, but it is true.

Let me close and turn it over to Senator Capito, but first

let me say, you and I don't experience planetary averages. We live through and we clean up from and we pay for specific weather disasters. Extreme event attribution science helps us to explain those events.

So, recognizing that we as a planet must prepare for more frequent and intense weather in the future, as elected leaders we also need to understand what to expect in our States and our communities. How much worse will our heat waves become in the years to come? How likely is it that a community will experience an even larger flood next time?

Extreme event attribution science is helping us answer those questions, as well. The ability to do so will be critical as we plan future infrastructure projects, we work a lot on that kind of stuff here in this committee. We wrote big parts of the Bipartisan Infrastructure Law, this lady right here and I, and we had the privilege of managing it on the Floor, one of the biggest infrastructure bills in the history of the Country.

Making more informed policy decisions will help us protect more Americans from extreme weather and allow us to use taxpayer dollars more effectively.

Let me close by reminding everyone that while climate change is driving extreme weather, we are not helpless and we are not hopeless. The situation is not hopeless. Working together, we can prevent the worst impacts of global warming by

reducing greenhouse gas emissions. That is what we are doing.

Thanks to the Bipartisan Infrastructure Law that I just mentioned and the Inflation Reduction Act, we are beginning to turn this adversity into opportunity. Importantly, we are doing so in a way that invests in American-made clean energy, lowers energy costs, creates good-paying jobs all over the Country, and makes communities all over the Country more resilient.

Still, it is important to acknowledge that we have a lot more work to do ahead of us to tackle this challenge. So, as we take those steps to better prepare for extreme weather and manage its impacts, extreme event attribution can be an important tool.

With that, we look forward to hearing from our witnesses today about how communities can better understand and anticipate what is coming and increase their resilience to climate-fueled extreme weather.

Before we do that, we will hear from our Ranking Member, Senator Capito, for her opening statement. Senator Capito, welcome. You are recognized. Thank you.

[The prepared statement of Senator Carper follows:]

STATEMENT OF THE HONORABLE SHELLEY MOORE CAPITO, A UNITED STATES SENATOR FROM THE STATE OF WEST VIRGINIA

Senator Capito. Thank you, Chairman Carper.

Before I begin, I have a throat lozenge in my mouth, so if I sound weird, or if I start choking, I would ask you to help me out.

[Laughter.]

Senator Capito. So I apologize for that. It is preventing me from coughing.

Senator Carper. I can see the headline: "Carper saves Capito from throat lozenge."

Senator Capito. An extreme throat event.

Anyway, I want to thank our witnesses and our committee for its strong bipartisan work to reduce emissions and make our infrastructure more resilient. The Chairman talked about that.

Legislation such as the USE IT Act, reducing barriers to the deployment of carbon capture, the AIM Act, directing a phasedown of heat-trapping HFCs, the Nuclear Energy Innovation and Modernization Act, supporting carbon-free nuclear energy, and the Infrastructure Investment and Jobs Act that the Chairman talked about, with its investments in emissions reduction and resiliency, all passed in a bipartisan way.

As we continue to build on that record by passing the ADVANCE Act in the NDAA to help deploy advanced nuclear reactors

and technologies, as well as to renew our efforts on passing a permitting bill that will allow us to unlock American innovation across all types of technologies and bring American manufacturing back home.

Several provisions of the IIJA are especially relevant to today's topic. That law's reauthorization of our surface transportation programs included a climate title for the very first time, establishing formula programs to help States build more resilient infrastructure and reduce certain emissions.

The law also included funding for hydrogen hubs, like the Appalachian Regional Clean Hydrogen Hub, known as ARCH2, that will benefit my state of West Virginia and our region.

And the IIJA included $25 million to help EPA process Class VI permits and $50 million to help States obtain primacy for permitting Class VI wells, a necessary step towards broader deployment of carbon capture and storage.

Despite the resources we provided in the IIJA, the EPA has not granted Class VI primacy to any State under this Administration, nor has EPA granted an individual Class VI permit to store carbon dioxide since the Obama Administration, with 169 Class VI wells now waiting to be permitted, according to the EPA.

Commercial scale deployment of carbon capture and storage I think is vital if we are to meet our energy reliability needs

while also addressing emissions. The Administration must quickly review and process Class VI primacy applications from States, as well as individual permit applications for projects in States without primacy.

As our bipartisan work continues, there is widespread agreement that the climate is changing and that greenhouse gas emissions are contributing to that change. But I am not sure that is the focus of the hearing. I am not sure that the focus of the hearing is on that scientific consensus.

At the end of the Obama Administration, the National Oceanic and Atmospheric Administration published a question-and-answer page about extreme event attribution that remains on the agency's climate.gov website today.

One question posed there is, "What can't extreme event attribution tell us?" I will enter the entirety of the answer into the hearing record, but the short answer is it can't tell us whether global warming caused a specific event. With global warming and extreme events, it is not a yes or no question.

I want to be clear: this does not mean that climate change has no impact on the intensity of weather patterns. The trends are clear and we need to be ready, and with technologies and adaptation strategies like those I have described, are policy areas about which this Committee has demonstrated expertise.

It is critical and crucial that we have effective solutions

that reduce flood risk and coastal storm risk across the Country.

Since 2014, the Committee has kept to a biennial schedule of passing bipartisan water resources legislation to advance these solutions. I look forward to continuing this track record, we have already had several hearings, with our next, latest WRDA bill.

By contrast, I think some regressive regulatory policies or carbon taxes that pick winners and losers could inhibit our U.S. energy production and will disproportionately harm our most vulnerable communities through lost opportunities and displaced jobs. Rising energy costs and weakening of our grid will leave these constituents without access to affordable electricity and other basic necessities. Recognizing this, the government should not put in place a one-size-fits-all regulatory mandate.

Successful climate technologies of the future may not even exist today, so we need to make sure we provide adequate conditions for necessary innovation to take place. So I think there are reasons to be optimistic, and the Chairman shared that optimism. American innovation will rise to the occasion.

I am interested in today's discussion of developing research, but I will be more interested to hear from our panel on what we should do today to build on the committee's record of bipartisan solutions.

Thank you, Mr. Chairman.

[The prepared statement of Senator Capito follows:]

Senator Carper. Thank you very much, Senator Capito. ARCH is the name of your hydrogen hub, ARCH2?

Senator Capito. It is, ARCH2.

Senator Carper. That includes also Ohio and Pennsylvania?

Senator Capito. Southwest Pennsylvania, yes.

Senator Carper. First time I had ever heard of Arch, Arch One, was your father.

Senator Capito. That is why I can remember the name.

Senator Carper. He was Governor of West Virginia when my sister and I were little kids in Lavinia and Raleigh Counties, West Virginia. Arch Three could be another member of your family.

Senator Capito. I have a grandson named Arch, so I have Arch Two.

Senator Carper. And she has a son who, off the record, is running for governor of the State of West Virginia, which is a great job.

Now we are going to turn to our panel of esteemed witnesses. We are grateful to each of you for joining us today to discuss this important topic.

We are going to hear from our witnesses in this order. Dr. Michael Wehner is our lead-off hitter. The second witness will be Jennifer Jurado, and last but not least, we are going to hear from Paul Dabbar. Let me just say a word about each of our

witnesses.

Dr. Michael Wehner is a senior scientist within the Applied Mathematics and Computational Research Division at the U.S. Department of Energy Lawrence Berkeley National Lab, whose research focuses on extreme weather and a changing climate. Dr. Wehner was the lead author for the 2013 Fifth and 2021 Sixth Assessment Report of the Intergovernmental panel on Climate Change. He was also lead author for the second, third, fourth and upcoming fifth U.S. National Climate Assessment.

Our second witness is Dr. Jennifer Jurado, Chief Resilience Officer and Deputy Department Director for Broward County, Florida. In this role, Dr. Jurado is responsible for leading climate resilience and environmental planning initiatives for Broward County.

Then we are going to hear from Paul Dabbar, Former Under Secretary for Science at the U.S. Department of Energy. Mr. Dabbar is also a senior research scholar at Columbia University and serves as CEO of Bohr Quantum Technology.

In reading through the bios, I came across someone who may have served in the Navy, is that true?

Mr. Wehner. Yes, sir, Naval Academy.

Senator Carper. Naval Academy, good for you. I got wait-listed there, I had to go to Ohio State. But I turned out okay. So did you.

All right, with that in mind, we are going to hear from Dr. Wehner. Please proceed with your statement. Your entire statement will be made part of the record. Then we will hear from our other witnesses, then we will ask some questions.

Thank you. Welcome.

STATEMENT OF THE MICHAEL F. WEHNER, PH.D., SENIOR SCIENTIST, APPLIED MATHEMATICS AND COMPUTATIONAL RESEARCH DIVISION, LAWRENCE BERKLEY NATIONAL LABORATORY

Mr. Wehner. Thank you, Chairman Carper, Ranking Member Capito, and distinguished members of the committee. Good morning, and thank you for the invitation to testify at this important hearing on the science of extreme weather event attribution.

As you said, my research focuses on the behavior of extreme weather events and the changing climate. I must say that my remarks are my own, and not intended to represent positions of the Lawrence Berkley National Laboratory, the University of California, or the United States Department of Energy.

According to the U.S. National Climate Assessments Annual Report to the Intergovernmental Panel on Climate Change, it is unequivocal that humans have heated the Earth's climate. The best estimate is that human activities, principally the use of oil, coal, and gas is responsible for all of the observed global warming since 1900.

Our understanding about the effects of this human-caused global warming on specific, individual weather events has advanced considerably in the past two decades. For many types of weather events, scientists can identify and quantify the ways that the human interference in the climate system has influenced

extreme weather.

Obviously, as you said, we have always experienced extreme weather: heatwaves, droughts, extreme storms, and the like. Extreme weather attribution science attempts to quantify the influence of climate change on these specific individual events by answering two related questions. First, has global warming affected the severity of an event of a particular frequency, say, once in 100 years? And second, given the observed intensity of an event, has global warming affected how rare it is? I detailed this a little bit more in my written testimony.

Because we have only one planet Earth, to answer these questions, scientists must use both climate and statistical models to compare representations of weather events in the actual "world that was" to a "world that might have been" without climate change. Confidence is increased when multiple independent research teams use different approaches and arrive at similar conclusions consistent with observed trends.

Confidence in quantitative attribution statements is very high about the human influence on heatwaves, agricultural drought and certain classes of severe storms, including hurricanes. Indeed, as the earth warms, every heatwave that we now experience is hotter than it would have been without climate change, including those this past summer in the United States and throughout the Northern Hemisphere.

Throughout the lower 48 States, I estimate that any heatwave we now experience is two and a half to five degrees Fahrenheit hotter than it would have been. All Americans face increased health risks from these hotter heatwaves, particularly the very young, the very old, and the very poor in our society.

Extreme storms have been made wetter by climate change as well. For instance, more than 30 different hurricanes have been studied in an attribution context. All analysis reveals significant human finger print on the total rainfall amounts.

Recent advances in attribution science have gone beyond studying the human influence on the meteorology of extreme weather events to include the impacts of these events on real people. Take Hurricane Harvey and the record flooding it caused in the greater Houston area, for example. Global warming made the surface waters of the Gulf of Mexico about two degrees Fahrenheit warmer, increasing the rainfall during Hurricane Harvey by about 20 percent. This increased the area flooded by about 14 percent, importantly leading to a 32 percent increase in the number of flooded homes in Harris County.

I estimate that global warming is then responsible for about a third of the $150 billion in damages estimated by NOAA during Hurricane Harvey. These damages were not equally distributed across socioeconomic groups. Half of these flooded homes were in low-income, Hispanic neighborhoods. As about a

third of Harris County is characterized as low-income Hispanic, this disproportionate impact represents and environmental injustice, in my opinion. We are finding similar injustice to the most vulnerable of our society in an analysis of flooding in New York, New Jersey, Pennsylvania from the remnants of Hurricane Ida.

This recent extension of attribution science from weather to impacts could be informative in negotiation for the Loss and Damages Fund to aid nations particularly vulnerable to climate change. This fund was established but not financed at last year's meeting of the Conference of Parties, the COP27, part of the United Nations framework convention on climate change, and will certainly be one of the topics discussed later this month at the COP28 in Dubai.

The human influence on extreme weather and its impacts on people is quite clear. I am often asked, why do we do these attribution studies? I have three answers to this question. First, the public demand for information about how climate change affects them personally is very high. People want to know.

Second, increasing the number and variety of individual extreme events studied increases our understanding of the extent of the human influence on them. Third, and perhaps most importantly, our quantitative understanding can aid decision

makers, increasing the resilience of our society to a future hotter world.

Extreme weather event attribution has shown us that dangerous climate change is already happening. How much more dangerous we let it become is up to us.

Thank you, and I welcome your questions.

[The prepared statement of Mr. Wehner follows:]

Senator Carper. Thanks very much for your testimony. You mentioned one planet earth, I heard that at one point in your testimony, you said one planet earth. That reminds me of something, that, not a witness here, but a fellow who came from France a couple of years ago and spoke at a joint session of Congress, President Macron, he didn't say one planet earth, but he did say, no planet B. He said, there is no planet B. We are only going to get one planet, this is it. We have to take care of it. I was reminded of his comments when you said that.

Next, we are going to hear from Dr. Jurado. Dr. Jurado, we have already talked a little bit about your background. We are delighted that you are here. Please proceed.

STATEMENT OF JENNIFER JURADO, PH.D., CHIEF RESILIENCE OFFICER AND DEPUTY DIRECTOR, RESILIENT ENVIRONMENT DEPARTMENT, BROWARD COUNTY, FLORIDA

Ms. Jurado. Good morning, Chairman Carper, Ranking Member Capito. Thank you for your leadership in convening this hearing today.

As you shared, I am the Chief Resilience Officer for Broward County, the 17th largest county in the U.S. and the second most populous in the State of Florida, with nearly 2 million residents. While we are leaders in many ways in adapting to a changing climate, we remain at the forefront of significant impacts.

South Florida is no stranger to extreme weather. To manage nearly 60 inches of rainfall we receive annually, we have made extensive investments in drainage, flood control, stormwater management systems. Even so, as we grapple with the impacts of climate change, the limitations of these investments are evident and record-breaking events are becoming more damaging.

Most recently, on April 12th, 2023, a thunderstorm delivered an unprecedented 26 inches of rainfall in 12 hours, impacting much of our community. A 30-minute commute became a 3-hour navigation of flood waters. Flooded vehicles were abandoned en masse. The Fort Lauderdale-Hollywood International Airport shut down and remained closed for 40 hours. Fuel

distribution from Port Everglades was disrupted, affecting 12 counties and 5 international airports. Water levels reached two to three feet in several older neighborhoods, and the City of Fort Lauderdale remains without a city hall. Yet this event occurred outside the hurricane season, a one in a 1,000 year rainfall event.

Less than three years earlier, Tropical Storm Eta delivered 22 inches of rainfall in three days. The six-week rainfall total was four times the historic average in inland areas, some of which remained flooded for two weeks.

In 2017, an 18-inch rainfall event closed Sawgrass Mills, the region's largest shopping center, for three days. The economic loss was $30 million. These three extreme events all in the last six years account for the highest annual rainfall totals in the last 30, exceeding 88 inches in 2020.

Congress has helped to ensure South Florida remains dry during wet weather events. In 1948, Congress authorized the Central and Southern Florida Flood Control Project, the C&SF. It was constructed by the Army Corps of Engineers. Today, it serves 11 million residents, but it is under substantial stress, especially due to intense rainfall events and sea level rise.

Given these new extremes, we have advocated for a new look at the C&SF system, and thank the committee for its authorization of this comprehensive study of this flood control

project as part of the 2022 WRDA. Without this study and funding for improvements, our local efforts would not be as effective.

Of course, extreme conditions are not limited to flooding. This year, Broward County experienced 37 days with a heat index over 105 degrees Fahrenheit compared to an average of five days per year historically. We know that extreme heat disproportionately impacts the under-represented residents, outdoor workers, health-compromised individuals, our youth and elders, affecting finances, earnings and physical health.

To better prepare for extremes, Broward County has incorporated sea level rise and rainfall intensification in updated design standards for our drainage systems, seawalls and building elevations. We are developing a county-wide resilience plan to address both flood and heat risks with emphasis on green infrastructure, especially where heat islands and vulnerable communities intersect.

Although I am formally representing Broward County, I would like to highlight the efforts of our Southeast Florida Regional Climate Change Compact, a collaboration amongst Broward, Palm Beach, Miami Dade, and Monroe Counties to address shared climate challenges. Jointly, we are developing the priority climate action plan supported by the EPA's Climate Pollution Reduction Grant program under the Inflation Reduction Act, and expect to

emphasize energy efficient improvements in lower income housing.

We have also pursued grant proposals under NOAA's recent Coastal Resilience Challenge, and strongly support additional funding along these lines.

Additional Federal collaborations and programs aiding our efforts included modeling and monitoring supported by the USGS, technical assistance of NOAA, the Corps, USGS in providing future conditions guidance for planning, DOE grant support for electric vehicle charging infrastructure, the IRA's Direct Pay Tax Credits, aiding clean energy and energy efficient investments by local governments, FEMA's Brick and Hazard Mitigation grant programs, and the totality of the Corps' resilience efforts in our region, including shoreline protection, Everglades restoration, the C&SF project, Back Bay and navigation studies.

Climate change is one of the most pressing issues facing our region. Continued leadership and support for transitions to clean energy, alongside aggressive adaptation actions, is critical to our economic and community vitality. We look forward to continued collaborations with our Federal agency partners, and thank you again for the opportunity to speak today.

Thank you.

[The prepared statement of Ms. Jurado follows:]

Senator Carper. Thank you, Dr. Jurado. You packed a lot into five minutes. That is pretty impressive. I could learn from you.

Finally, we are going to hear from Mr. Dabbar. You are recognized. Thanks so much for joining us. Please proceed.

STATEMENT OF THE HONORABLE PAUL DABBAR, FORMER UNDER SECRETARY FOR SCIENCE, U.S. DEPARTMENT OF ENERGY, SENIOR RESEARCH SCHOLAR, COLUMBIA UNIVERSITY

Mr. Dabbar. Chair Carper, Ranking Member Capito, I am honored to be before the Senate again, for the first time before this committee, to discuss climate impact, energy innovation and policy.

Over my career, I have been engaged on all the various aspects of energy, including liberating neutrons at a reactor, and addressing solutions for the environment, in particular as Under Secretary for Science at the Department of Energy. Other than Senator Kelly, I have likely traveled to more remote locations to support collecting climate data. I am one of the few people who have been to both the geographic North and South Poles, both in government service, and in part both missions were around climate data gathering.

As Under Secretary, we supported gathering data and computer simulation of the climate, including the work of Dr. Wehner, at many of the national labs I ran including Lawrence Berkeley, as well as at NETL and others in support research at universities in everyone's State here at the committee.

The world has been successful at reducing different types of emissions, due to innovation. And I believe the right

strategy for the world today is to continue discovery, innovation and deployment of new options. America has been the dominant country at investing in discovery, and the lead in deployment of new energy technologies, and America is the global leader of the pipeline of new prospects.

I am quite positive about those prospects due to the U.S. being the world's leader in public and private energy R&D, including at the world's leading universities and national labs, the dominant winner of Nobel prizes in the physical sciences, and the global leader in venture capital and start-ups.

I reach this positive conclusion based on a lot of data. Most of what we are deploying today was invented within the last generation, such as commercially effective lithium-ion battery chemistry, wind turbines, innovative drilling technologies, and PV solar. As Under Secretary I enjoyed the Nobel prize reception in the Senate vestibule for us winning the Nobel for the lithium-ion chemistry.

The pipeline of future innovation is very strong. For example, Form Energy, which has recently opened a plant in West Virginia, has developed an iron-air battery, that literally rusts and de-rusts for its chemistry, that produces power for 25 times longer than lithium-ion, and is 80 percent cheaper. X-energy, an SMR fission company, is in the process of building the next generation of nuclear all over the Country. Montana

Technology has developed a MOF-based HVAC cooling technology that uses up to 75 percent less energy and emissions than current compressor systems, and no freon. American innovation has and will continue to lead the way to solutions.

One final innovation take-away that we should consider is that regulators or elected officials mandating winning energy technologies is poor technology policy. The innovation ecosystem has a track record of inventing new options that were not predicted.

For example, President Bush's famous 2001 energy assessment had a long list of predictions of winning energy technologies, and most them were significantly wrong. Unpredicted innovations in drilling, solar and batteries came along and remade the landscape, including for emissions. It is better policy for the EPA and States to allow for technology neutral, innovation-open strategies, and allow for the competition of discovery.

We need balance in energy policy. We need to concurrently care about increasing energy availability, lowering energy costs, lowering emissions, and national security. Due to American innovation and a solid all-of-the-above bipartisan pro-supply policies over the last generation, we were able to deliver on all those concurrently. I have confidence we can do that again this generation.

While we certainly need to understand the drivers of

climate change, we should focus on solutions also. America is the global energy superpower. We went from the largest energy importer in the world to the largest energy exporter. We invented for us and the world a portfolio of technologies that are making an impact on emissions. And there is a pipeline of even better ones to come. Policy to allow the ingenuity of Americans to harness and allow deployment of their new ideas, will be the solution.

[The prepared statement of Mr. Dabbar follows:]

Senator Carper. Great, thank you very much.

Let me start with Dr. Wehner. Your colleague to your right, Dr. Jurado, has told us that Fort Lauderdale and surrounding communities in southeast Florida have experienced several devastating torrential rainfall events over the last couple of years, including 26 inches of rainfall over 12 hours last April. My question, Dr. Wehner, is would you consider this torrential rainfall event unusual? Should we expect to see more extreme rainfall events as climate change worsens?

Mr. Wehner. Thank you, Senator. Yes, indeed, we talked briefly prior to the hearing about this storm. What she said to me about this astonishing amount of rainfall, and most of it falling in a very short period of time, is completely consistent with my previous work on extreme storms, showing that the rainfall increases at a rate greater than humidity increases.

Now, humidity increases at a certain rate determined, that we know, very rigorously from first principles. But rainfall seems to be supercharged from climate change.

So what I would interpret is that this storm has been made more violent and hence more efficient at increasing this available moisture. We would expect yet more of that throughout the Country, not just in Florida, actually throughout the world.

Senator Carper. How about heat waves? Absent climate change, would we be experiencing events such as the Pacific

Northwest 2021 heatwave, or this past summer's heatwave in the U.S.?

Mr. Wehner. It is interesting that you would highlight the 2021 heatwave in the Pacific Northwest. I consider this one a teachable moment for climate scientists. If you had asked me before that event when it would be 120 degrees in Canada, I would have said not for a long time.

Senator Carper. Would you have said when hell freezes over?

Mr. Wehner. No, I would have said about 2060.

[Laughter.]

Senator Carper. That is when it is scheduled to freeze over.

Mr. Wehner. So that was a surprise to us. This will be an event that is probably the most stunning extreme weather event of all time. Currently, there are at least 20 different papers on an event that happened over a year ago. I have three myself, three of those 20 are mine.

We are learning a lot. It is kind of scary, because it was scary beforehand, and clearly this event was unprecedented, caused a lot of people to die. How many more died because of climate change is not something I know.

But I would say that it was at least two degrees warmer from climate change, possibly four, not much more than that.

That doesn't sound like a lot. But when you look at the effect of high temperatures on mortality, a small change from 110 degrees to 114 degrees actually has a large effect on the number of people that die. So that is important.

Senator Carper. One last question of you, Dr. Wehner, then we will turn it over to Senator Capito. We have been joined by two of our colleagues, welcome, gentlemen.

Dr. Wehner, as communities across our Nation experience increasingly extreme weather events, resiliency and adaptation are front of mind for State and local officials, in Delaware and West Virginia and every State that is represented here. Our infrastructure, our roads, our bridges, our pipes, our wires, are essential to our daily lives. They have to be able to withstand more frequent and severe weather events.

My question is, would you please share an example of how attribution science can inform the design and engineering of infrastructure projects to better manage the impacts of these extreme weather events when they occur?

Mr. Wehner. Yes, Senator, I can. I had a project with the San Franciso Public Utilities Commission, which I believe is the first time that a city actually funded research at a national laboratory. The City of San Francisco is charged with rebuilding the wastewater management, the sewers. And they are charged with considering climate change in this. They had

people telling them about sea level rise.

They asked me about extreme precipitation. So what we did is ask them to give us a dozen storms since the satellite era that were impactful and we would take a look at them. We were able to analyze six of those. The atmospheric river storms that had the so-called bomb cyclone associated with them responded in a way that again I was surprised about twice the expected rate. That was used by their consultants to modify their IDF curves.

Senator Carper. What are IDF curves?

Mr. Wehner. Intensity Duration and Frequency. It is a design tool that engineers use. And that is the extent of my knowledge.

I will quote what Susan Leal said, who was the former director of the Public Utilities Commission, and now one of their consultants. She said, "There ain't no pipe big enough." That has sent the engineers and designers back to the drawing room, saying, how are we going to accommodate these storms, in a world that might be considerably warmer.

Senator Carper. I am going to ask you to hold it right there. Dr. Jurado, I am going to come back to my next round to ask another question, and ask you to follow up on what he has already said.

But now, Senator Capito.

Senator Capito. Thank you, Mr. Chairman.

Mr. Dabbar, I love this one term that you used in your statement, "technology neutral, innovation opened." I think we need to focus on solutions. Everybody has talked about it.

As one of the things we have seen in the data, that mortality from natural disasters is significantly lower in more technologically advanced societies with access to energy and resilient infrastructure. Recent reports by reliability experts show that we are projected to go, we as a Nation, are projected to go backwards on our grid reliability this decade. Many point to some regulations that will lead to early power plant retirements. We also see the rise of the electric economy that is being moved forward rather rapidly.

Everybody has mentioned that the most vulnerable are those that are in the lower economic echelon of our society. That is troublesome, obviously, for me.

How will extreme weather impact energy demand, and how do you think grid reliability will impact our vulnerability in these events?

Mr. Dabbar. Yes, Senator. I agree with your point that greater reliability has actually been decreasing. I think the most stark example that most people don't know about is that there have actually been more power plant shutdowns in many areas of the Country. New England is one, New York is another, Texas is another, it is actually all over.

More power plants are being decommissioned, for various reasons, than are being build. The ones that are getting build have a lower capacity factor, so the number of megawatt hours is way lower.

So I think we should be concerned about that. That gets to regulatory processes and siting, whether it is State or Federal. In the kind of world that we are trying to electrify, we are actually de-electrifying. I think that is a long and complicated process that needs to be streamlined.

Senator Capito. Okay, thank you.

We have had near-term emission reductions, but we are still and will continue, I think everybody is in agreement here, experience climate change impacts until globally our greenhouse gases are reduced. But it may continue then. There is stuff we don't know, that we don't know into our future.

How do we create economic conditions for innovative solutions, for technology neutral innovation opened, that would increase our resilience and our disaster readiness? At the Department of Energy you probably saw this, you probably see this as well, certainly overseeing the national labs. Dr. Wehner is at a national lab.

Are there near-term technologies that can be deployed to improve our adaptation strategies?

Mr. Dabbar. Yes, Senator. As I mentioned, we don't know,

we cannot clearly see which technologies are going to be best. So having regulatory processes or mandates from States and so on that allow for those new things, instead of mandating, we are only going to have this type of technology, we are only going to have EVs, we are only going to have nuclear, we are only going to have wind, whatever it is, is poor technology policy. We should be allowing all of those to be neutrally supported, whether it is through EPA or State approvals or through funding. Because if you overly fund one area, you are going to get more of that. Being more neutral across that for regulatory and funding purposes is better technology policy.

Senator Capito. Thank you.

In terms of where we are headed, I thought it was interesting in your statement you mentioned that President Bush in 2001 was trying to predict, his commission was trying to predict over 20 years where we are going to go. How do you see what accelerated now? I feel like we are on a much more accelerated path through some of the bills that we have passed. How do you see that developing? Are we the global leader here, or are there other technologies around the globe that we are looking at?

Mr. Dabbar. America by far leads the world in energy discovery. Manufacturing is a different topic. But when it comes to energy discovery, America rules the roost on many

different metrics.

So there are many things we are accelerating, Senator. There is a reason why that process has improved significantly. But you can look at California, or you can look at what is going on in Massachusetts, fusion is much more likely than it used to be for various reasons. And many others.

So I think the acceleration of discovery has dramatically improved. We are in a much better space on that front.

Senator Capito. Thank you.

Mr. Chairman, I want to go back to my first question, when I talked about electricity reliability. I want to submit a letter, it is to Administrator Regan from the Chairman of the West Virginia Public Service Commission and the Chairman of the Delaware Public Service Commission, that is cautioning what the Administration is doing on the Clean Power Plan to look at how it will impact our States.

Senator Carper. Without objection.

Senator Capito. Thank you.

[The referenced information follows:]

Senator Carper. I was reminded in that exchange that just took place that we can be proud as Americans that we are leading the pack in terms of addressing climate change. There is a statement, I don't know if it is in the Bible or what, to whom much is given, much is expected. We are a Nation richly blessed, as you know. And we are, frankly, a leader in putting emissions in the air in our planet that are actually leading to climate change and global warming.

So, given that we helped create this problem we have maybe an oversized obligation into addressing it. I think we are. I think we are, we are doing good work in this panel, we are doing good work with this Administration, and hopefully with the next Administration that comes, much will be put around the Country. Thank you.

Okay, we have been joined by Senator Markey. Senator Markey has been working on these things for a long time, and we are delighted that has joined us, along with Senator Boozman and Senator Padilla. Senator Markey?

Senator Markey. Thank you so much. So we are the first generation to suffer from climate change, but the last generation which can do anything about it. That is our challenge. In answer to Senator Capito, in terms of innovation, up in Massachusetts we have a center, it is called Green Town, there are 300 companies up there all doing, like MIT, Harvard,

Tufts related research. One of the companies is called Form Energy, which is actually creating a manufacturing plant down in West Virginia for 800 jobs.

Senator Capito. Mr. Dabbar talked about that in his opening.

Senator Markey. Great. That is a perfect partnership between the innovation community up in Massachusetts, the manufacturing capacity in West Virginia, and there are many more companies up there who are looking at West Virginia, for example, for where they will be doing the manufacturing to accelerate this.

By the way, their breakthrough is, for batteries, it is not lithium ion, it is iron, I-R-O-N, which is going to be the battery, the third most common element in the world. So that is a big breakthrough in terms of battery technology. There is just so much that is happening, because of the IRA, the tax benefits that flow, and then the State of West Virginia or other States then have initial benefits to manufacture there. So I think it is a good team effort to accelerate this transformation.

And just like the many things historically, this year alone we have seen severe flooding and deadly heatwaves. We need to be able to do something about it.

Dr. Jurado, you mentioned in your testimony that Melrose

Park, a predominantly Black neighborhood in Broward County, was disproportionately affected by flooding in April. Dr. Jurado, does effectively managing climate-fueled disasters, including flood management mean prioritizing investment in infrastructure in neighborhoods that have suffered from chronic disinvestment for decades, environmental justice communities like Melrose Park? Would they be benefited?

Ms. Jurado. Yes, Senator, absolutely. We are conducting comprehensive modeling, overlaying vulnerability and diseases, really focusing on the combined impacts and exposures with flood risks, damages, heat exposures, economic conditions, economic burden, all of those things being overlaid. We are desperately concerned about uninsured losses. We saw with the April event many residents lost their homes in addition to their vehicles. In the circumstance of Melrose Park, this is a community that is not in a flood zone and has been hit twice in the last six years with this level of flood impacts.

So it is bringing to light these very dramatic exposures, and the need to bring all of our community into the solutions to support their well-being.

Senator Markey. Thank you. And we know it is not a coincidence that disproportionately Black, Brown, and low-income communities are more likely to struggle with extreme weather events fueled by climate change. Dr. Wehner, in your research,

do disasters fueled by climate change hit some neighborhoods harder than others? Does that drive increasing inequality resulting from climate injustices?

Mr. Wehner. Yes, it certainly does. But I would caution that every event, every disaster is different, and affected differently. I think the important point is that the very poor are indeed the most vulnerable, because they are the least able to recover from these kinds of events. So that is pretty obvious.

Senator Markey. Yes, it is obvious. And do you agree with the research that says that extreme weather events are up from three times per year in the United States in the 1980s to 20 per year now in the 2020? Do you agree with that?

Mr. Wehner. I might have written that.

[Laughter.]

Senator Markey. Please expand. Because obviously that is a seven-fold increase in the number of extreme weather events in the United States over the last 40 years. We know it hits poor people disproportionately, although it hits all people who are impacted.

Mr. Wehner. Senator Capito made a point that climate change didn't cause these events. I think that is something I completely agree with. We borrow from epidemiology techniques to sort of understand how climate change has affected these

events. Some events might be less frequent, blizzards, for instance, in a warmer world, they become rainstorms.

But certainly for heatwaves and violent rainstorms, like hurricanes or this one that hit Fort Lauderdale, are more frequent.

Senator Markey. Let me ask another way. NOAA data shows that disasters that cause more than $1 billion in damage rose from three per year in the 1980s to more than 20 a year in the 2020s. Do you agree with that?

Mr. Wehner. Yes, absolutely.

Senator Markey. Dr. Wehner, does climate attribution science show that fossil fuel pollution is underpinning this rapid increase in devastating, expensive disasters?

Mr. Wehner. I would agree with that.

Senator Markey. Okay. I think that is the important factor, it has gone from three to 20, it is not all attributable to one thing, but from your research, it is the underpinning of the rapid increase, is that correct?

Mr. Wehner. Yes, it is.

Senator Markey. And then we know that poor people are going to be ultimately disproportionately negatively impacted.

Thank you so much, sir.

Senator Carper. Senator Padilla, welcome. You are on. Senator Whitehouse, nice to see you. Thanks for joining us.

Senator Padilla. Thank you, Mr. Chairman. I know I am speaking a little bit to the choir here, but for the record, according to the Fourth National Climate Assessment, which is a report from a Congressionally mandated program, climate attribution studies have indicated that throughout the western United States human induced climate change is substantially reducing winter and spring snow pack, which is then increasing the likelihood of chronic drought.

The report also indicates that under no change to water management practices, several important western U.S. snow pack reservoirs, including in Sierra Nevada, California, will effectively disappear by the end of this century. Dr. Wehner, as a contributor to the assessment, can you walk us through the impact of snow pack loss for California and other western States?

Mr. Wehner. Yes, Senator, I can. In fact, our research was initially performed by Dr. Alan Rhoades at Berkley Lab when he was a graduate student.

In that we are basically, if we continue on a business as usual or a no policy scenario of emissions, by the end of the century the snow pack in the Sierra would be effectively gone, as it would also in the Wasatch Mountains, which is an important source of water for Utah and Salt Lake City.

So in California and throughout the west, we rely on the

snow pack as a temporary reservoir to supply water for both agricultural needs and for our urban requirements. That infrastructure was built over the past century and was assuming that the snow would melt on a schedule that was in the past. That has changed. There are studies that show that the snow melt has begun earlier. As that continues, it will overwhelm our ability to manage water, so we will run out in the latter parts of, before it starts snowing again or raining again.

Senator Padilla. Yes, we are just compounding the effect. This last winter was an anomaly, so we have less precipitation earlier, quicker runoff that leads to very difficult scenarios later in the summer and early fall each and every year, with a growing population and a growing economy. So just laying that out for my colleagues. We need to do different going forward, and we need both policy and investments building on what we have done with the Inflation Reduction Act, building on what we have done with the Bipartisan Infrastructure Law.

Now, speaking of precipitation, I do want to also acknowledge the historic summer events that took place this last winter that illustrated our Nation's vulnerability to heavy precipitation and flooding, when we get the little rain that we do get too much too quickly. Atmospheric river rainstorms are responsible for nearly 85 percent of flooding on the west coast, which threatens our vital infrastructure and vulnerable

communities. In California specifically, we had nine successive atmospheric rivers in January, which caused flooding, power outrages and mudslides resulting in an estimated $4.6 billion worth of damages.

I lay that out because it is important to get the data to better understand what we are grappling with here, so we can inform how we adapt and how we respond. So I was actually glad to see the President's supplemental request funding for NOAA's acquisition of two current hurricane hunter aircraft replacements, which is something that both Senator Graham and I, both members of the committee, pushed hard on.

These plans can help provide real-time data from inside atmospheric rivers to increase vital decision making which is important to protect life and property.

Dr. Wehner, in your testimony you mentioned that climate attribution research in heatwaves and hurricanes is more advanced. Can you talk more about the need for research and development around atmospheric river events?

Mr. Wehner. Indeed, the literature on hurricanes is long and detailed. Although we don't know everything, obviously, about hurricanes. Atmospheric rivers weren't even named such until about 20 years ago. So it is a much younger field of research and there is much more to be done.

In fact, what you mentioned about sending airplanes out

into these storms has only just begun. But it is really critical to get that kind of data, so we understand why some of these disturbing findings that we have found about atmospheric rivers, particularly the ones that are associated with the so-called bomb cyclones, have such a sensitive response, large response in their precipitation amounts from climate change.

Senator Padilla. Thank you. I know my time is up. I will just end with this. Having been briefed post these atmospheric river events earlier this year, a lot of the impact on the ground to communities, particularly vulnerable communities, were a result of the atmospheric river storms not behaving as they were initially predicted, again, because of the lack of research historically when it comes to atmospheric rivers.

So the quicker and better we can understand how they are more likely to behave, whether they just stay stationary over a certain geographic area or move further north, south, east, west depending on greater climate factors, the more we can prepare to protect life and property on the ground.

I appreciate all your research and testimony here today. Thank you, Madam Chair.

Senator Capito. [Presiding.] Senator Whitehouse.

Senator Whitehouse. Thank you.

Dr. Jurado, I am a Senator from Rhode Island, a fellow ocean State. So I think I will focus my questions on you. I

gather you are seeing continuing and increasing tidal flooding, sometimes referred to as sunny day flooding that has nothing to do with a rainstorm, but has to do with sea level rise and tidal action?

Ms. Jurado. Yes, Senator, absolutely. I think these events were first observed with increased regularity about 10 years ago. Then we began to see longer fall tidal flooding. Now, the flooding also occurs into the spring months.

So you can really set your clock by the expansiveness and frequency of these events. They are particularly compounding flood conditions, because when it rains and we are having this high tide flooding, none of our flat land can drain. We actually find tidal flooding contributing to inland flooding miles inside the county, because of the interconnectedness of these systems.

Senator Whitehouse. A head-up to my next question, well done. So if you are nowhere near the coast in Rhode Island, but you are potentially in a riparian zone, near a river that is going by, or a canal that is going by, you could well be flooded with fresh water because of the sea level rise creating hydraulic back pressure on the escape of that fresh water from Florida's land surfaces?

Ms. Jurado. That is exactly the condition. In fact, some of our most western communities, we see tidal signals in the

canal network that are 15 miles inland. So that increase in water level that carries through the entire network is not constrained to the coast by any means. But clearly the most severe impacts are happening in the coastal area. That can extend six miles inland.

And is not only affecting what happens with surface water flooding, but we also find a rise in the groundwater table that is extending six miles inland as well. That affects all of the drainage infrastructure associated with site development, roadways, transportation projects as a whole.

Senator Whitehouse. Along with the rise in the groundwater from effectively hydraulic sea level rise pressure, are you also seeing that salt water is intruding through the limestone into what previously were freshwater wells and water sources for homes and businesses?

Ms. Jurado. That too is absolutely the case. We have estimated that we lost about 30 percent of the coastal wells, or will, to salt water intrusion by about the year 2050, 2060. We partnered with Palm Beach County to develop a very large surface water reservoir as an alternative water supply, holding 35 million gallons of water to help compensate for what is happening with salt water intrusion. It is very much driving the practices as we look at long-term water supply investments, and impacts on our wastewater collection system as well.

Because that water is driving into those connections.

Senator Whitehouse. Is the warming of the ocean offshore, including measured up to literally jacuzzi recommended temperatures, causing an effect on the strength of storms that hit Florida, particularly hurricane level storms that come from the ocean?

Ms. Jurado. I believe the science is well documented that the warming is causing an intensification of these systems that contributes to additional rainfall that indeed, these storms move more slowly, they carry more rain, they dump more water on communities. So those impacts are very real, in addition to the environmental consequences for the reefs, which are suffering under 100-plus temperatures.

I think we are very much interested in looking at, in addition, how much of this additional warming is going to drive sea level in the short term and what types of measures can we take to really work to constrain the upper limit on sea level rise in addition to just talking about temperature, what can we do to really drive a cap on how much we're willing to accommodate in additional rise in sea level and as it impacts our infrastructure.

Senator Whitehouse. How is the insurance industry responding to all these new risks?

Ms. Jurado. Certainly we have seen sizeable adjustments in

what is happening with flood insurance policies. We have our windstorm policies on top of that. I shared at a roundtable at the White House a couple of weeks ago while the national average on homeowner's policies is about $1,400, most of the people I know in Florida are paying about $8,000 a year currently. That is just windstorm, not counting flood.

Senator Whitehouse. From what I understand, nearly a dozen local insurance companies have gone bankrupt facing claims, others have stopped renewing policies in order to avoid future risk. National companies are walking away entirely from Florida markets. There is a resulting flood, if you wish, to a flight to your State-backed insurance company. How much of a burden do you think your State-based Citizens Property Insurance Company will end up carrying?

Ms. Jurado. It is hard to say. But currently, the Citizens program is trying to depopulate and I know that many are receiving notices that they are required to consider these alternative policies. One I read about recently was a 450 percent increase in the annual premium to move to a private holder.

So the options are significantly reduced. The costs are escalating beyond the level of affordability. I think that it is one of the most treacherous conditions affecting home ownership. And the ability to live in South Florida, where we

need people to be able to work and prosper, they can't even afford an annual insurance premium.

Senator Whitehouse. Thanks very much. I have gone over my time. I appreciate the indulgence of my colleagues.

I would only add that when I last checked, Citizens Property Insurance had reserves of $4 billion, Idalia so far is over $10 billion, Hurricane Ian was over $110 billion. So there is an enormous gap there.

Senator Carper. [Presiding.] There certainly is. Thank you, Sheldon.

Senator Merkley, good to see you. Welcome. Delighted you have joined us.

Senator Merkley. Thank you very much. I want to continue the impact on insurance. I picture middle class families who have a mortgage, and their mortgage generally says, you must maintain homeowner insurance. So the family gets a notice saying, sorry, we are canceling your homeowner insurance. And the family has to go out and find separate homeowner insurance, otherwise the mortgage company will put the homeowner insurance on a very, very expensive policy. But it becomes increasingly hard to find that.

So are middle class families who are really in the middle of a mortgage, they are not buying a new house, if you will, finding that they are in trouble in terms of securing the

insurance they need to maintain their mortgage in good standing?

Ms. Jurado. Thank you, Senator. I think the circumstance is one of, again, affordability. There is a lot of conversation of people simply needing to move out of the area because they can't afford the insurance options that allow them to afford their mortgage payment that allow them to stay in their home. Most recently, as well, the Citizens insurance provider has also required flood insurance coupled with the hurricane coverage.

So again, it is another cost that somebody who was able to barely afford a mortgage at the time, at which they secured it may be just in a situation of having to let go. We do see many individuals leaving the State as a result.

Senator Merkley. We do see in Oregon a lot of families affected by flood insurance issues. But I really want to focus, when you think about Oregon and climate chaos, you might hear people talk about the pine beetle infestation, you might hear them talk about the decreasing snow pack in the Cascades, which has dropped by an average of 240 inches over 90 years, so basically half the snow pack is gone. You might hear them talk about ocean acidification affecting the sea life off our coast. We have one of the richest grounds in the combination of the Pacific upwelling, the California current.

But the thing that really is on people's minds are fires. We have seen such a growth in forest fires. In 2020, we had

three simultaneous fires in three major watersheds. We had the Santiam Canyon fire, the Almeda Fire, the South Obenchain, and Echo Mountain, more than three. Essentially, we lost 4,000 homes. I traveled 600 miles up and down the State, never got out of the smoke. We had massive collapse of communities turning up at the fairgrounds in refugee status. Seeing the burned remains of towns, some 12 different towns were either obliterated or deeply damaged by those fires.

I think maybe this is more for you, Dr. Wehner. People used to talk about 100-year events, they used to talk about 1,000-year events. I think you framed in your testimony that things that occurred every 1,500 years have become once in a century events. Things that are very rare are happening with increasing frequency.

You didn't mention in your testimony wildfires as a category of extreme weather which can be attributed with reasonable certainty. What can climate attribution science tell us about individual wildfires?

Mr. Wehner. It can tell us quite a bit, Senator. I was the chapter lead author on chapter eight of the Fourth National Climate Assessment, Volume One, and fires was part of that chapter. That was back in 2017, and we saw a clear trend, particularly in Washington, Oregon, and California, of large wildfires, an increasing trend. That of course is much worse

since 2017, there have been a lot of major fires in all those States.

In anticipation of your question, I did do a little more research last night, trying to find specific things to Oregon. I don't have one. I have some more general statements, though. The leaders in this actually turned out to be Environment Canada and Victoria. They of course studied Canadian fires. But that is not all that different than Oregon.

They found that the fire weather metrics that led to that big fire in 2018 in British Columbia were made two to four times more likely, and more importantly, that the area of the fire was increased by a factor of seven to eleven. So it became a record kind of fire.

Senator Merkley. The fire was seven to eleven times more destructive?

Mr. Wehner. The area burned was seven times larger, at least.

Another study said that nearly all the observed increase of the burned area in California over the past half century is attributable to anthropogenic climate change. So I am sure this is true in Oregon as well.

Fire is very difficult, and perhaps one of the more challenging areas for event attribution, because there are, as all these kinds of extreme events, multiple causes. Wind is an

instigator, and one of the things that my research and others have found is that there is little trend in extreme wind. So this increase in fire weather conditions is almost entirely due to higher temperatures drawing out the fuel of the forest, so that the fire seasons are longer. This is also reflected in the budgets of firefighters, wildfire fighters. They have to pay more because they are out there longer.

Senator Merkley. We used to, if you asked an Oregonian 20 years ago, when to come to Oregon, they would be like, oh, well, July, August, into early September are our golden time. Now if you ask Oregonians, they will kind of pause and go, you know, we have had a lot of smoke in July and August and September. It is just a huge change. We have furniture stores that can't sell their inventory because of smoke damage, we have wine grapes that have been contaminated by smoke damage, we have people in the hospital with asthma aggravated by smoke, we have communities trying to set up clean air sectors.

In other words, it is so palpable, the change within a few decades is so real. If you are trying to hike the Pacific Crest Trail, there were hikers that used to come through in August, you cannot come through. There are so many fires on the Pacific Crest Trail or near it, threatening it. My wife and I have had to change our plans a number of times for those hikes. You don't want to be in the middle of wilderness with no cell phone

connection or knowledge of fires erupting and be on a very remote trail. It is so many dimensions of our life in Oregon that have been affected. The Ashland Shakespeare Festival, huge challenge with cancellations due to air smoke quality.

So it is very important for us to be able to capture this. We have seen the fire season grow longer. That one set of fires on Labor Day, 2020 burned over a million acres, and 4,000 homes. A dozen communities were affected. It sent a very powerful messages to people across the Country. They remember Paradise, California.

Well, the devastation was greater in Oregon, but it was kind of like, oh, well, now it is not new, devastating fires that burn a community to the ground, and you see cast iron bathtubs and steel staircases still standing in beds of ashes and molybdenum wheels, where they melted and ran across the ground, creating strange sculptures. It is an architecture that we have just never witnessed before, or a scene we have never witnessed.

So I think understanding this continued impact is incredibly important. Thank you all for bringing your insights to bear on the evolution and dynamics in many dimensions, certainly floods, droughts, and fires. Thank you.

Senator Carper. Thanks for those very thoughtful questions.

We are going to start a second round. You are both welcome to stick around if you can, and have another shot.

I want to go back to Dr. Jurado. We had a question earlier and I said I was going to ask you to pick it up. I think the question I asked was of Dr. Wehner, I asked him if he would give us an example or two of how attribution science can inform the design and engineering of infrastructure projects to better manage the impacts of these extreme events when they occur. I just want to ask, Dr. Jurado, are you the Chief Resilience Officer for Broward County?

Ms. Jurado. Correct.

Senator Carper. How important is it to have scientific information about the size of events that we may be faced with next? How important is that? And how can results of attribution studies inform local infrastructure planning and decision making?

Ms. Jurado. Thank you. It is an absolute criticality. One of the greatest challenges that we faced in South Florida was trying to account for rainfall intensification. We knew it was taking place. We have to be able to accommodate this additional volume of rainfall. If a one in 100-year event used to deliver 13 inches, but now it delivers 15 or 18, it alters the whole of infrastructure across the community, not just how we plan locally, but the integration with all of the State-

funded and federally funded projects as well.

So we need to have harmonization across infrastructure, and we need to know with certainty, at a decent level of certainty, what is the percent change that we should be accommodating in our infrastructure for this intensification. So we worked very deliberately with our Federal agency partners to account for initially a 13 percent increase in rainfall, and ultimately made that adjustment to 20 percent.

So this 20 percent intensification for rainfall events is now embedded in the design standards that we have for drainage infrastructure, surface water management infrastructure, we are ensuring that the improvements to the C&SF project also account for this rainfall intensification. It drives our flood elevations.

So absolutely, we needed to be able to embed this in the various types of design infrastructure, and then be able to account for how it influences change in groundwater table, plus the flood elevation, plus the conveyance and storage needs. Very critical.

And having that information allows us to not only design appropriately but also consider to the extent to which our mitigation activities in terms of reducing emissions and decreasing the intensity of these events can work to make a longer term difference over the course of the next several

decades, how much of that can we mitigate through our missions improvements.

Senator Carper. Thanks for that.

I am going to come back to Dr. Wehner for another question, one dealing with beliefs and attitudes. In fact, I will hold off on that. We have been joined by one of the two retired Navy captains who serves in the United States Senate these days, and a former astronaut, a guy who has done all kinds of things in life, a guy who married up, as I did, Mark Kelly. Mark, thank you.

Senator Kelly. Thank you, Mr. Chairman. Clearly married up, no doubt about that.

Thank you, everybody, for being here today. I apologize for running a little late.

Every summer in Arizona, it is hot. We know that. But this year, the heatwave hit a whole new level. In the month of July, Phoenix had a 31-day streak where the average temperature was above 110 degrees Fahrenheit, 31 days in a row. And in total, we had in Phoenix 55 days above 110 this summer. That is unprecedented.

The one stat that I saw describing this summer's heat stands out above the rest. I was just looking at a plot, this is a couple months ago, this is actually a global plot on worldwide temperature. When you look at the summer of 2023, it

kind of stands out. Data from the Copernicus Climate Change Service found that the average global temperature, which is what I am talking about, when I looked at this, it was a 3-sigma variation, three standard deviations away from the norm. To me, as somebody who used to do a lot of stuff with data as a test pilot, it could be a bad data point. Could be.

But you know, temperature is a pretty easy thing to measure. So in my view, and in my mind, it is either bad data, which it is not, or something very unusual has happened. That same data shows that in July and August of this year, we were 1.5 degrees Centigrade warmer than pre-industrial levels.

Dr. Wehner, when we see data like this, how easy or difficult is it to attribute all or even part of this to a change in the climate? When we see data increases like the change in summer temperatures from last year to this one, it is sometimes hard to communicate why this is such a big deal.

So how does climate attribution shape the ways that we talk about the impact of climate change on data? If you can address those.

Mr. Wehner. Thank you, Senator. Yes, this year is a particularly unusual one. Arizona wasn't the only place that had a heatwave. At the same time we had heatwaves in the United States, we had heatwaves in Europe and China simultaneously. So the whole norther hemisphere was hot. That is part of the

reason why the global mean is a 3-sigma event.

Now, some of that is going to be an El Nino effect, we can quantify that. But not nearly all of it. Some part of it is quite clearly the anthropogenic effect, the human-caused effect from our consumption of fossil fuels and our changes to the composition of the atmosphere.

Senator Kelly. Dr. Wehner, could I ask you, if you go back decades or over the last 100 years, has there been another 3-sigma event in temperature?

Mr. Wehner. Not that I am aware of. But my knowledge isn't complete on that.

So it is an unusual event. When I was coaching ice hockey, I would call this, in the words of the great basketball coach John Wooten, a teachable moment. This is a teachable moment for many of us, including climate scientists, so that we can better understand that. And attribution science is part of the key to understanding how all these different factors led to this 3-sigma event.

Senator Kelly. So part of it could be El Nino?

Mr. Wehner. Some of it certainly is. Some of it could be natural.

Senator Kelly. We have had El Ninos in the past.

Mr. Wehner. Of course.

Senator Kelly. What is the cycle on an El Nino?

Mr. Wehner. It is every four to seven years. But 1988 was another huge El Nino year, and then years afterwards were cooler. I had to write papers afterwards saying, the title of the paper was, "Is the Climate Warming or Cooling?" It is because people were saying, well, climate change stopped. That is wrong, of course, you can't just start your analysis in the hottest time of the year, or hottest data point.

Senator Kelly. Yes, the CO2, carbon monoxide, methane just didn't vanish from the atmosphere?

Mr. Wehner. No. So the longer the data records, the more informative it is.

Senator Kelly. Do you expect future 3-sigma events to occur more frequently?

Mr. Wehner. That I cannot say. I don't think we understand changes in variability nearly as well as we do changes in the average. But I certainly can tell you that this summer event throughout the world was unusual. But it will be the norm in a very short period of time.

Senator Kelly. Do you feel that the messaging in the United States and across the planet on this issue and this 3-sigma event is sufficient, or do you feel like maybe media and others are falling short?

Mr. Wehner. I am not sure how to answer that question. To me, the data always speaks for itself. But I am not an expert

on media relations. So I think I will defer on that question, if you don't mind.

Senator Kelly. When I saw the data, I was reading an article and just saw the plot. My reaction was wow, that is different.

Mr. Wehner. One of the things my colleagues and I are working on is would this temperature have been impossible without climate change, would this summer have been impossible without climate change. Give me a few more months and we will get back to you on that.

Senator Kelly. Yes, please, let me know. Thank you.

Thank you, Mr. Chairman.

Senator Carper. Thank you. Did you say that you were an ice hockey coach?

Mr. Wehner. Yes. I coached teenagers. It was fun.

Senator Carper. Do you still do it?

Mr. Wehner. Not any longer. I can't skate any more, unfortunately.

Senator Carper. Who do you think was maybe the greatest hockey player that ever played the sport?

Mr. Wehner. Wayne Gretsky.

Senator Carper. Wayne Gretsky was once asked, Mr. Gretsky, why are you the greatest hockey player on the planet? He replied, as you probably recall, he said, I go where the puck

will be, not where the puck is. That is a little bit like attribution science, you are going to help figure out where the puck is going to be to be able to address this. It works pretty well.

I was just coming back to Dr. Wehner for some follow-up questions. We may be joined by another colleague or two. I think every other committee in the Senate is meeting almost at the same time. We have a big bipartisan forum going on right now on artificial intelligence. This is our hearing here today, so we have some people who would like to be here and just can't be here. But they are very much interested. Some are watching, this is being televised, and some are watching it along with their staffs. So the impact you are having is probably far greater than you might imagine. It is really important.

I want to finish my question of you, and then I am going to tell a story and then maybe wrap it up. I was saying earlier, when we were joined by one of our colleagues, I said, in a recent poll on attitudes toward climate change, 55 percent of Americans said they had not personally felt the effects of climate change. During the July heatwave that Senator Kelly and others have alluded to, however, two-thirds of the U.S. population were under heat alerts and other climate-driven events from wildfires to hurricanes. It harmed a lot of folks.

It is worth noting that only 5 percent of TV news coverage

of the heatwave even mentioned climate change. Didn't even mention climate change. So I think attribution science provides an opportunity to help Americans understand that what they are experiencing is actually the effect of climate change, it is not their imagination, it is not something that may or not be happening, it is actually explainable.

As you explained in your testimony, Dr. Wehner, attribution studies detail the effects of climate change on extreme weather events. What are some specific ways that we can use this information to help the public better understand how climate change impacts their daily lives?

Joe Biden, he and I have a lot of sayings that we swap back and forth. We rode the trains together to D.C. for years. I think I know every one of his and he knows all of mine. One of my favorite Biden words is "splainer," as in explainer. He is always looking for good splainers, I am surrounded on either side by good splainers. We are looking for ways that we can be better splainers. How do we do a better job helping the public understand how climate change impacts their daily lives?

Mr. Wehner. In some sense, that is my job, is to try to put numbers on what has mainly this past few years become very painfully obvious. Maybe you don't even need me to tell you the climate is changing and the weather is getting worse. All you have to do is pay attention.

We talked about fires. I have lived in California now for almost 40 years, and I don't remember bad air days like we have had. I have a photograph taken from near my house where the sky was orange, an orange like an unnatural orange, like orange soda. It was apocalyptic, it was frightening.

You don't need to be a climate scientists to know that that is weird, and that is unusual. These heat waves have affected a lot of people, they have killed a lot of people. They have killed a lot of people's grandparents. I think that is a very personal and very distressing thing, if that were to happen.

These storms, Hurricane Ian in Florida was a very devastating storm. We learned recently that climate change made the storm 20 percent wetter, but that is only part of the damages. We had this huge storm surge in Fort Myers, like 15 or 20 feet, that wiped homes right off their foundations. Then a few days later, the fresh water, the rainfall ran through the systems and flooded a large fraction, a large number of homes outside of Tampa.

So the insurance rates are an issue, it is an issue in California. Mine went from $2,000 to $5,000, my own. How this information is used I think is a question for you. I can tell you what happened, what is going to happen, our best guess as to what is going to happen. But what we do about it is up to you, it is not something I decide. That is something that the people

decide through their elected representatives.

Senator Carper. Thank you. I want to follow up with Dr. Jurado. How could policy makers and the media more effectively communicate this information that we are talking about here to the public?

Ms. Jurado. Thank you for the question. I think the media conversation is the significant one. It is interesting; I have been in D.C. over the years and hear meteorologists speaking about climate change as part of the weather delivery. When it happens, it is almost stunning.

But why aren't our weather forecasters integrating discussion of climate as part of the weather forecast? When was the last time that we collectively looked at the CO2 concentrations at Mauna Loa? I remember when it passed 400 parts per million. Do we ever talk about having lost that benchmark, and where we are going, and how these conditions relate to on-the-ground effects?

Government at the local level, we are not the best communicators. We need assistance with this. No matter how many presentations we give and websites we deliver, the majority of the public are not aware of the conversation or the amount of work that is taking place.

So I think it is about recognizing impacts, celebrating wins, celebrating investments, talking about the change in

individual circumstance that comes with investing in resilience, broadcasting the types of programs that are available because of the concerns that are being expressed, providing more funding for the types of projects that the EPA, the Climate Production Reduction grant, great start. But $4.3 billion across all of the communities in the United States is just one shot at a much larger problem that we have in terms of helping residents adapt and celebrating the types of investments that are making quality of life improvements as climate change is taking place.

Senator Carper. Thanks for that response. As if things couldn't get any busier, the Senate is now beginning to vote. So we have all these hearings going on, this big bipartisan forum that is going on on AI, and we are trying to solve climate change here for the morning.

Senator Capito has gone to vote, and I don't know that she is going to be able to come back and finish up with another round of questions. I have one or two more that I am going to ask, then we will wrap it up.

One of the closing questions, I will ask you to think about this, I talked about ice hockey, and I am going to use a baseball metaphor, telegraphing my pitch. You can tell in baseball the way the pitcher holds the ball, maybe delivers the baseball to the batter, you can tell what kind of pitch it is, fast ball, curve ball, slider. But I am going to tell you my

pitch. I am going to ask a question: where do we agree? Where do the three of you agree? Maybe 15 or 20 years ago there wouldn't have been as much agreement in this room, at this table.

One of the Ranking Members here was a fellow named Jim Inhofe from Oklahoma, who was a climate change denier. He readily admitted it. I remember when it snowed here one time in warm weather, and we had about six inches of snow in the lawn in the front of the Capitol. He went out and made snowballs. He brought the snowballs onto the Senate Floor and said, climate change, I don't believe that is real, look at these snowballs here in August. By the time he left here, he was a senior Republican on this committee, he was my lead Republican on the Diesel Emission Reduction Act.

So people can change their minds. They can learn.

Quick question, then we will move toward wrapping it up. A question about how Inflation Reduction Act programs boost resiliency. The Inflation Reduction Act and the Bipartisan Infrastructure Law, which I am proud to say were largely written in this room, but in any event, they include programs to help States, programs to help tribes, to help cities, to help counties reduce greenhouse gas emissions and to improve their resiliency.

One example is the EPA's Climate Pollution Reduction

grants. My question, Dr. Jurado, is, does your community down in Broward County want and need this Federal assistance? A follow-up question to that is, how are you using Federal grant programs and clean energy tax credits? Is this assistance sufficient for communities to address climate change by driving down emissions and increasing resilience?

Ms. Jurado. Thank you for the question, Senator. The support is absolutely needed. I am sure that many are aware that our State passed on the CPRG funding, and most recently on the solar project funding for residential investment. If that money is not made directly available to communities, meaning municipalities, tribes, and counties, many of us will not be able to take advantage of these very critically needed investments. There frankly aren't alternative funding sources.

Another challenge that we have is we have no investment in energy efficiency by our local energy utility. There are no programs. The statement is made that it is not cost effective. Well, it is not cost effective for the utility provider, but no matter how clean the energy is that is being produced, you still have many lower income individuals who are contending with significant rise in temperature. They are already energy burdened, and many are struggling with how to provide air conditioning just to sleep through the night.

Older individuals who need that cooling, children cannot

sleep and study well if they don't have an opportunity for their bodies to cool at night. The CPRG funding, that Climate Pollution Reduction Act funding, is critical for being able to aid with investments that help energy efficiency in single family, multi-family residences that need that support. We are also very eager to take advantage of that funding to support solid waste improvements where we have clean energy initiatives, with waste energy plants and those investments that are taking place in our community.

It is a great initial start. We hope to see that funding renewed, or a continuation of that funding in some form. We know that those plans that are underway will be ignited with this individual investment, but the plans that are being worked on by our communities are intended to go far beyond the next five years and continued investment there would go a long way to help meet our own goals, which include net zero by 2050.

In addition, with regard to the direct pay tax credits, certainly in Broward County, we have been looking for innovative models to help support renewable energy projects over the years. We have maybe 14, 15 very large scale solar projects. But these tax credits are now allowing us to increase the size of our solar projects by 30 percent beyond what we could have otherwise.

So it is a tremendous benefit to our ability to participate

proactively with clean energy solutions that are coupled with our infrastructure and our sites, as well as electric vehicle charging networks, transitions within our fleets, support for community and local government projects.

Senator Carper. Thank you for that response. I telegraphed my pitch and said I was going to ask before we adjourned that, where do you all agree. Do you think there is a consensus in this panel, we might not have had it in this room at a similar hearing a couple of years ago, I won't ask you what has happened, I could ask you what has happened here, but let me start with Mr. Dabbar. Go ahead, if you would, please.

Mr. Dabbar. Yes, Senator. I think as we collect more data and look at new solutions, I think that is a consensus driver. I think coming out of the sequester, very large bipartisan support for innovation, which has led to a lot of these technologies like Form Energy and others that we have been talking about here today.

I would like to comment to the data aspect of fire that was brought up previously. There are solutions, and once again, you have these problems, but there are solutions.

Let me give you one example around data and solutions on fire, which is, you could use, I ran the National Quantum Initiative for the United States, you could use the photons on the fiber that go down the power lines, and you can detect the

power quality and ergo, the resistance of the power lines. You can predict when they are going to fault. We haven't been able to do that.

So, using quantum networking and quantum sensing for these things going on in California and elsewhere, you could use that sort of new technology and detect meter by meter as the resistance of that line is degrading, and you could go fix it before the line faults.

So this is an example of innovation that I think, back to your question, Senator, around consensus. I think the consensus around innovation, American leadership, things like the example I just gave you that would probably save lots of lives in Hawaii or California or elsewhere, I think that is part of the reason why things are moving forward.

Senator Carper. Good. Dr. Wehner, same question, please.

Mr. Wehner. I think we are in agreement on a lot of things. John Holdren, who was the science advisor for President Obama, said we have three choices. We can mitigate, we can adapt, or we can suffer. I would like to minimize the suffering. That means we have to mitigate more, and adapt more.

So the things that Mr. Dabbar has talked about in terms of making our energy systems more, reducing the emissions of these technologies, is something this Country can lead in. I strongly support that. But I think we also have to recognize that no

matter what we do, we are going to be continuing to experience more severe and more frequent weather disasters, so we need to adapt.

One thing I did not get to say with the fires, in particular, is all of us, myself included, are exposed to this smoke. The eastern part of the United States this year was exposed to, for the first time, I think, that westerners are used to. I am particularly concerned about the effect on children. I raised this with a local politician recently. He told me something I didn't know, that there is a program in California to distribute HEPA air filters to families in need. I think those kinds of actions are things that are really necessary if we are to protect our most vulnerable, especially our children.

Senator Carper. Great. Thank you for that.

Dr. Jurado?

Ms. Jurado. I think as we have moved on through time, we just see more in the way of personal impacts, friends and family that have been impacted in one way or another. It becomes undeniable that these conditions are being more broadly experienced.

We have also, though, I think, appreciated with time that there is a great ability to take advantage of an opportunity to innovate, to look at the economic opportunity that comes with

new technology, new investments, community betterment, areas where we have needed to make investments anyway, but we can add to the benefits being delivered.

So it isn't just about adaptation, it is about economic innovation and really embracing an opportunity to create a much better future through coupled investments that address energy and adaptation and community betterment and economic opportunity all tied together. So I think being able to look at it as not just a burden or exposure, but an opportunity for repositioning our communities at the same time.

Senator Carper. Thank you. Before we close, Senator Whitehouse is trying to get back here. He has already voted; I need to go vote very shortly.

Our staffs, Democrat and Republican staffs, have heard me tell this story before, so I will ask their indulgence. I like to take the train; I love the train up and down the northeast corridor. Albert Einstein used to take the train a lot, too. I think he taught at Princeton. He would get on the train at Princeton and go to New York, he would come down here. He was a regular on the train, similar to how Joe Biden and I have been over the years.

One day he got on the train and found a seat and started looking for his ticket. He reached into his pockets and his trousers and his briefcase, and he couldn't find his ticket.

And finally, the conductor came up to him and said, Dr. Einstein, you ride the train a lot, we know who you are. You don't have to worry about it, we know who you are.

Dr. Einstein kept looking for his ticket. The conductor walked away, and the conductor started walking into the next car, he turned around and looked back. Dr. Einstein was down on his hands and knees looking for his ticket. The conductor rushed back and said, Dr. Einstein, you don't have to do this. We know who you are.

And Dr. Einstein looked up at the conductor, on his hands and knees he looked up to the conductor and said, "I know who I am too, I just don't know where I am going."

[Laughter.]

Senator Carper. I think we know where we are going if we don't work together, pull together. We use science to guide us. I must say, I wish you could all have been here, I have been on this committee 22 years, I wanted to be on this committee when I got here 22 years ago. But to have heard the kinds of conversations we had them on climate change compared to what we had in this incredibly constructive conversation. I applaud each of you for taking the time to join us.

Everything, as proud as I am of the work we have done in the Inflation Reduction Act and the work we have done on the climate change provisions within the Bipartisan Infrastructure

Law, everything I do, everything we do we can do better.

It is one thing to write legislation and get it signed into law. The really important piece now is implementation. One of the things that Senator Whitehouse and my colleague, Senator Capito, are interested in doing is making sure we do a good job on the implementation. We don't just write legislation on this committee, we actually help implement, we do oversight. We need to do a whole lot of that in the days going forward.

I am going to hand the gavel over to Senator Whitehouse. Folks around the Country think we don't like each other, Democrats and Republicans hate each other, we never want to work together. I have people who say to me, at least every week, Sheldon, when I am getting on the train station and getting on a train here or up in Delaware, people say, can't you guys just work together? Can't you work together? Can't you get something done?

I wish they could have sat through this hearing. They might have been encouraged a little bit, because I think we have a pretty good idea of what is wrong. And we have a lot of good ideas about how to address it. If the American people would hear that, I think they would be encouraged.

There was once a woman who ran for President not long ago, and her campaign slogan was stronger together. Stronger together. And I think that really applies here. I think that

we are largely together, and we are stronger because of that. I just love getting things done. I love getting things done, and we are getting some good things done. If we keep this attitude going, we will do better still.

Thank you for what you do with your lives, and thank you for joining us today.

With that, a fellow who does great things with his life, from a small State, but as we know from Delaware, small States do great things, and they produce, at least in his case, in his State's case, great legislators.

Senator Whitehouse. Small coastal States are the best, I think.

Senator Carper. I am going to run and vote.

Senator Whitehouse. [Presiding.] I will close out the hearing after my questions.

I want to go back to Dr. Jurado again, because of the experience you have had. In Rhode Island, our CZMA agency, the Coastal Resources Management Council, took a look at the FEMA flood maps and determined that they were defective. We have seen, for instance, in the Houston flooding, that it hit about 50 percent accuracy rate. So FEMA really seriously needs to upgrade its mapping.

What has been your experience in your geographic area with respect to FEMA flood mapping and its predictive quality?

Ms. Jurado. Thank you, Senator Whitehouse. I know that when our last FEMA flood map, well, let me say two things. First of all, FEMA utilizes our, Broward County's hydrologic model. We developed a fully integrated surface groundwater model. FEMA has used our model; they have improved our model. The South Florida Water Management District has used our model and improved the model. Now we are utilizing the same model again. So we have the benefit of all of us utilizing the same model for existing planning, existing conditions and future conditions planning.

Senator Whitehouse. Just let me interject for one second. In working on future conditions, do you take things like climate change and resulting sea level rise and storm severity into account?

Ms. Jurado. Yes, sir. In fact, right now in our current modeling effort, we are coupling, we are evaluating two and three foot sea level rise scenarios, carrying the modeling out to 2070. It is actually 3.3 feet of sea level rise. We account for the change in the groundwater table.

We account for the high tide condition under each of those sea level rise scenarios. We account for various storm surge conditions including 25, 50, 100 year storm surge. We couple that with a variety of what we call design storm events. So 10, 25, 15, 100 year rainfall conditions, and look at the compound

flooding under all those scenarios.

So we are utilizing that now as the basis for our county-wide water management planning and redevelopment strategies. How far can we adapt through infrastructure investments and development approaches, versus how much can we not address, such as with the one in 1,000 year rainfall event. There is going to be some element of flooding that again, just can't build a large enough pipe or have enough storage area.

But with the FEMA flood mapping, I know at the time of our last update, we actually had 60 percent of the existing parcels that were removed from the map. Our engineers would say that that map by and large more accurately reflected current condition today flooding only because of a lot of refinements in the data. It was just better data, like LIDAR data that came into the modeling effort.

However, just like Melrose Park, we still have communities that are not in a flood zone, which is always the case, that are still vulnerable to flooding. So we knew that when that 60 percent of those parcels moved out that they would come right back in as climate conditions continue to evolve.

So we actually use our own future conditions flood map that is not what we use a variety of tools for setting finished floor elevations. FEMA is one. But we require the highest of all of our tools be used for planning. And w have a future conditions

flood map that integrates much of what I just described as one of those tools.

So in many areas of the county, we are not relying upon the FEMA flood map. The FEMA flood map is most impressive where it now incorporates the coastal A zone. The distinction there was that we account for sea level rise, but hadn't accounted for storm surge. FEMA was accounting for storm surge, but not sea level rise. That is why this current modeling effort is so critical, because it brings everything together.

Senator Whitehouse. So the multi-party effort has been a significant improvement over FEMA alone in the wild doing mapping?

Ms. Jurado. Improving the models with time and everyone jointly using the same models, but also integrating future conditions. Because we have to account for risk tomorrow, not just the risk today for all of our infrastructure. That is our perspective.

Senator Whitehouse. Do you think the flood insurance program requirement that you build back in place needs adjustment where properties are predictably going to be flooded over and over and over again in order to protect the integrity of the Federal Flood Insurance program?

Ms. Jurado. I think that we need to allow for a lot of flexibility in terms of where we reinvest and how we reinvest.

We need to ensure that we are building for future conditions in terms of the design approach. But there will be areas where it will become increasingly evident that it would be beneficial to not replace infrastructure in the same area, maybe utilize that land for storage and buffer the storm surge, and alternatives to allow densification in other areas that may not be as exposed.

Senator Whitehouse. Agreed.

I think my time is now expired, and you have all had a long morning. So let me follow Chairman Carper's lead and close out the hearing.

The housekeeping rule before we adjourn is that Senators must submit questions for the record by close of business Wednesday, November 15th. We will compile those questions and send them to the witnesses, and we urge that you reply by Wednesday, December 6th. It is a pain in the neck to have to chase you, so we hope we can get, if there are questions for the record, timely and punctual responses.

I thank you all for your presence here. With that, the hearing is adjourned.

[Whereupon, at 11:53 a.m., the hearing was adjourned.]