Dr. Richard Alley

Nobel Conference 55

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Oh, think you, Jeff. Wow, this is truly exciting. It is such an honor and a privilege to be here. I asked them if I could wander around because I'm not good at standing still but at any rate, thank you for coming out The organizers have done such a fantastic job. And the fact that this exists here is such a good thing so it's my honor and my privilege to share the stage with this amazing panel.

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Um, I will show you a little big picture and some penguins. The penguins, I like going to Antarctica, so the penguins are just for fun. Maybe a reminder of something on the line down the road. But at any rate, I'm gonna give you the big picture first and then I'll focus in on some hard science, right. So the big picture, we love what we get from energy. A human diet is 2,000 calories per person per day, plus the icing on the cake I had at lunch. I'm a little over. But at any rate, if you put 2,000 calories on the table and burned it over a day, it gives off 100 watts.

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Your genius, your genius is done with the same energy as one old lightbulb. Which is a truly amazing thing if you think about it. If I had to ride my bicycle to make the electricity to drive the projector so that you could see my slides, I would be out of breath, because that's all I can do. But I don't. In the U.S., what is done for us, you can see the numbers, more than 200,000 calories per person per day. More than 10,000 watts. It's as if each of us has more than 100 energy serfs to do our bidding.

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And right now more than 80 percent of that is fossil fuel, and right now if you remember you load 16 tons, we're putting out more than 16 tons of CO_2 per person per year in the U.S. This is unequivocally unsustainable. It is an immense amount. The comparison there, we know what trash looks like, we throw away a half a ton of trash per person per year in the U.S. 16 tons of CO_2. OK.

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So we got to do, this is the big issue, the understanding that this is warming the climate and this is affecting us rests on so much evidence, it’s a four-legged stool. The physics is completely unavoidable. The data show the globe warming. The models did indeed tell us this was going to happen 30 years ago. What is happening was predicted. And then I’ll take you through history, which is my topic for today. But recognize, I’m giving you just a little bit of one leg of this stool of evidence.

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All right. The physics, the warming influence, the CO_2 was discovered in the 1800s. The modern understanding was worked out by the Air Force after WWII. They were not doing global warming but the hot exhaust of an enemy bomber gives out infrared and the CO_2 absorbs that. The sun warms the earth that gives out infrared and the CO_2 absorbs that and the CO_2 doesn’t care. And in some bizarre sense, if you deny global warming, you deny that the Air Force knows how to target a heat-seeking missile. It’s absurd.

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All right. You’ll meet the people who say, ‘Do you believe in global warming?’ Do you believe in gravity? I mean, this is physics, all right. So let’s [inaudible] Now, there’s a picture here. You’ll, you’ll, Gabby is going to be up later. At any rate, here we are in Paris in 2007 at the IPCC. There’s a new report about to come out from the IPCC. There have been five major reports with three working groups of each with sort of a thousand pages in each one. If you piled all of that up here it would tilt the stage. And most people look at it as bad news.

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But if you were to say, what happens if we use that knowledge? Compared to a future where we don't. What happens if we build policies that are efficient that use that knowledge. And the answer is if we use the knowledge well, we get a bigger economy. We get more jobs. We improve our health. We improve national security, we get a cleaner environment, which is more ethical. It’s more consistent with the golden rule.

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The biggest picture is we can use this knowledge to make ourselves better off or we can ignore what we know and make ourselves worse off. All right. And I’m not gonna discuss much of that. I’ll show a slide on the economics. I served on a committee with Bill Nordhaus. He won the real Nobel Prize in economics, the co-recipient last year, for building tools that show that if we use our knowledge efficiently, it helps the economy. Right, you will meet the person who says, yeah, yeah, yeah, the climate is changing but we can’t afford to deal with it. In some very real sense, the Nobel Prize in economics says we can’t afford not to deal with it.

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All right. This is an important thing. And there’s this additional piece that will come bubbling through. The students who are sitting here are the first generation in the history of the world that knows that they can build a sustainable energy system that will power essentially everyone essentially forever. We have gone through energy crisis over, and we burned all the trees and we didn't have trees to burn and we burned all the whales and we didn't have whales to burn and now we’re trying to burn all the fossil fuels. There’s a generation that now knows they can fix this. And it will take them 30 years. It will take an immense investment. It is a huge effort to replace all that energy we’re getting. But they now know they can. And this is a deeply optimistic thing that we can do good with this.

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All right. So I’m going to tell you just a little tiny bit of the science holding up one leg of the stool of understanding that this is out there. Right? And I’m going to walk you through just a little bit of the fantastic interwoven tapestry of evidence that is so strong that it gives us the confidence to tell you that the science is there, go use it. OK. And so what I’m gonna do, what do we do in climate history? We, we find history of climate. We find history of causes of climate change. If it changed, it’s changeable. And if it changed together, that doesn’t tell you who caused what but it sure is interesting. So that’s where we’re going to go with this.

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This is a predictive science. We say if that story is right, then we should measure something else. We should take new samples. We should use new geochemical indicators and we predict what they will show, and it comes out right. So this is a predictive science. And then we use that history to test the models. So Gabi's models, we can test them, they're good. If anything, the climate change is a little more than the models like but they've very good. And we can demonstrate this. And we can demonstrate this across a very wide range of things, right? So what we do learn is that the climate science is really good. The history weaves in beautifully with the other things. Or maybe it's a little conservative, that the climate is a little more changeable, the impacts on life are maybe a little larger than what we're expecting. But no support for it being alarmist.

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OK. All right. So let me show you just a little bit, tiny little window on the life of a climate historian. So let's go to Greenland. There actually is a climate history. In this one the ice was right at the bottom of this picture when, 100 years ago and now it's moved back and you can see that in the little features on the sides. So there is some climate history here. The ice is retreating.

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These are caribou. Food is on the tundra. Mosquitos are on the tundra. So they eat breakfast and then they go sit on the ice. OK. And this is yours truly many years ago getting ready to go up into Central Greenland. That's a big plane. I used to do a lot of field work. Now I answer e-mail. [laughter] I was in the field on our first wedding anniversary and our fifth and our ninth and our tenth and our twel-, and she's still married to me. I just, yeah. [laughs] Maybe it's good that I'm gone. But at any, so here is Central Greenland. We are on 2 miles of ice. It's pretty cold up there. Here is a camp, all of the glories of home. This is, we are 200 miles from the nearest rock and this fox comes trotting into camp. Glorious, glorious creature. My goodness.

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This is the 4th of July. You've been working for a month and now, you know, you kick back and Eric Saltzman is in the snow trap up there. And the laundry is sort of a month of wearing your long jobs, why freeze-dried laundry is a good idea. So what do you, right?

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I'll let you enjoy this, right? It's labeled a good day in Greenland. The newspaper over here on the side is actually a month old. We haven't had resupply in a month. But if you look on the right, newspaper's just fine, no problems here, right. This is a good day in Greenland. This is a bad day in Greenland. [laughs] What can we say, right? So we're going to do some science. So this is, in the flannel shirt is Joan Fitzpatrick and the USGS and that's me without the shirt and we're digging two holes in the snow with a little wall between them. And we're going to put a lid on one of those holes, the sun shines into the other one and it shines through the wall and we can see the layers in the snow, which you see right there.

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That's sort of my height. Snow is blue. And in there are the deposits of storms and the influence of the changing seasons. And there is in there snow that fell during the previous winter, and then the summer and the winter and the summer and the winter and the summer. There is a fantastic amount of science by a whole lot of people that underlies my ability to tell you that with a completely straight face and high confidence. Things like digging down to the fallout of atomic bombs. When we blue Bikini Atoll, we put a radioactive layer. We know its age, its works. So this [inaudible] and the ice heats, we can count down to that [RD] really is a history of snowfall.

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So let's drill an ice core two miles down, right. and so there's Katherine from Alaska. We had these t-shirts said, 'Big Boots, Big Science,' right? It was really cool. And this is our under snow laboratory. The Dean would love this. If your lab isn't big enough, you get a chain saw and you make it bigger, right? [laughs] Right? [laughs] And these are cores from almost a mile down. Here is a couple of Penn Stater's. Kurt Cuffey's now a professor at Berkely. Wanda Kapsner Hanlon runs a winery not too far from here. She had studied at Minnesota Morris. Great, great, great people studying the ice core.

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And here's their ice core. And it's on the side. And there's the winter and the summer and the winter and the summer and the winter. All right. And so what do we get? We can date the core by counting layers and in other ways. A year with more snow is a thicker layer, we have a history of snowfall. If it's in the air, it's in the snow. We have lead from the Roman lead mines in the snow of Greenland. We have micro meteorites. We have things made by cosmic rays. We have forest fire smoke, pollen, all sorts of things. We have indications of past temperature. We have the atmosphere itself trapped in little bubbles. And all of them are in thre together, in Greenland, in Antarctica, on some of the high mountain glaciers elsewhere.

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At the same time, we have all sorts of other friends who are doing other indicators of the history of climate. So on the right is permafrost in Greenland that hasn't yet thawed. And on the left is evidence of permafrost in Pennsylvania that thawed 20,000 years ago.

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This is Brenda Hall, a brilliant scientist from the University of Miane. She has found a scallop almost 8,000 years old on a raised beach on the coast of Greenland. There's climate history in there. Who lived where and when and what was the land doing and what was the ocean doing? Glorious stuff.

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This is a picture of little mountain glaciers on the east side of Greenland. You can see where the ice ends. You can see where the ice ended recently. But if you're a geologist, you might see lines on the hillside where the ice ended a lot longer ago. And you can go ask those older lines on the hillside, when was the ice here? So here's Tom Lowell from the University of Cincinnati. He is going to ask that rock, when did the glacier dig you up and deposit you here? If you go down to the beach and you see people who forgot their sunscreen, you can tell how long they've been out in the sun from how red they are. He's asking how much cosmic ray burn that rock has gotten that gives him an age.

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So here's a picture of the world on the right is sort of today and on the left is what it looked like during the last ice age. Here is was under ice. And you can do the kinds of things that Tom did and date that. This is a picture of the elevation of the land's surface, very carefully shaded to show this, and if you don't know where you are, there's the tip of Lake Michigan, and you can see Illinois and Michigan and Indiana. So it's just down the road here. And what you're looking at is the footprint of an old ice sheet. And the ice came out 24,000 years ago and it put down a ring around it [inaudible] and then it backed up some and it came out a little and it backed up and it came out. At some point it had gotten back to there. Every one of those white ridges is a little wiggle of the edge of the ice. And then the ice went away. And that's a picture of climate change.

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The president of the National Academy once asked me, he said send me a picture of climate change and make it not a cow skull in a dry lake bed. I sent him this one. OK. And then there's lots of older things. So I collected this in Antarctica, many years ago. That fern does not grow in Antarctica now, OK. There's a climate story here. So if we do this, this big community of historians of climate, the geochemist and the isotope people and the what-have-you, what do we learn? And it's more or less like this.

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When the sun changes, the climate notices. But the sun doesn't change much. It is a very faithful furnace up there keeping us going. Volcanoes confuse everybody. One volcano blocks the sun and the next year is cold. If volcanoes were to erupt faster for 100,000 years, they would actually warm us because eventually the dust falls down and the CO_2 stays up. So volcanoes are different at different time scales, but volcanoes are sort of random. A volcano in Indonesia cannot call a volcano in Alaska and say, erupt on three, one two, right? It doesn't work that way. So they're random. We have tried really hard to find fun weird ness. The magnetic field changed. The cosmic rays changed. The climate ignored it. It didn't care.

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There isn't, yeah, a meteorite killed the dinosaurs but there hasn't been enough space dust since then to make much of a difference. I will come back to regional things. Sometimes a place doesn't get the same as another place and those really can matter and they can surprise us, abrupt climate change. And I will come back to features of Earth’s orbit. But what keeps screaming at us out of this history is that greenhouse effect is really important. CO_2 is really important.

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And so if you were to take, you know, 10,000 papers on this or something and sort of try to boil ‘em down into a couple of tweets, this is probably a good chunk of it. Greenhouse gases are a big deal. OK So, put it this way, simple. If I lose you on anything that follows, here’s the punchline to take home which is that many things affect climate but especially CO_2. OK. And that’s a whole lot of science behind that one.

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So at any rate, let me walk you through, this is a figure out of that 2007 IPCC and I’m gonna, they were supposed to show you their caption and I’ll get it, OK. So over here on the right it says 400. That’s 400 million years ago. And over on your, oh, sorry, your left. On your right it says zero, that’s today. There’s two things on here. The blue is ice. If there’s blue, there was ice. If there’s no blue, there’s no ice. It’s too hot to have ice in Antarctica in Greenland. The Poles are ice free. On the bottom are a whole bunch of different ways to estimate CO_2 and you’ll see they broadly agree with each other.

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So there’s just two things on here, the history of ice, the history of CO_2. Now what happened, over here there’s a time that CO_2 was high and there’s no ice at the Poles. And then CO_2 dropped nd the ice grew and then CO_2 rose and the ice melted. And then CO_2 dropped and the ice grew. And very, very broadly that is the history of the climate over 400 million years. Now it is, I teach this class. We spend a month on this, OK. We do know the direction of the arrow, that it is more CO_2 makes it warmer and melts the ice, not going the other way. And it does take us a few days to get through in class but we do understand the direction of the arrow. This is causation. OK So but we won't quite get to that today. If you want to talk about that in the discussion or meet the scientists later, great. OK.

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Now what was causing this? It is complicated because CO_2 really does do so many things on the planet. But part of the story over here is coal was forming. Plants take CO_2, they make plant, and then they got buried with their carbon. And that CO_2 didn't get back in the air. And so CO_2 was taken out of the air, it is put in the coal, over tens of millions of years. We burn it up over 100 or 200 years. We're undoing what nature did way, way faster than nature did it.

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What went on here is there were some extra volcanoes and a few other things are happening again and we're not making as much coal but then we made some oil up there on top so there were some extra volcanoes, a lot slower than what we're doing. Today volcanoes are only 1 percent of the human CO_2. So that was going on there. I want to focus in on, so things start to drop because we were making more shells mostly. But I want to focus in on a little blip right there that had some extra volcanoes.

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OK. 55.9 million years ago, nature released maybe about as much CO_2 as we might release, more than we have so far by a good bit but as much as we might. Nature wasn't as fast as we're doing, but it was a time that the world was sort of recognizable. There's mammals. The continents are sort of where they are today and nature put out a lot of CO_2 in a big experiment that we can watch. And what happened if you were in Wyoming, there were a bunch of mammals and they got small. Being a big, warm-blooded creature in that warmed world with the high CO_2 didn't work. And so big, warm-blooded creatures became smaller warm-blooded creatures.

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That's a bit disturbing, maybe. Pretty much everything that lived in Wyoming moved or died or both. It was huge changes in the ecosystems that were going on. I'll show you the leaves. Soils changed. Things are washing off the mountainsides and so there's all sorts of geomorphic changes. The leaf damage, right, these are leaf fossils, paper from the PNAS by a team of really good people. But what you can see in these leaf fossils is they're getting the heck munched out of 'em, right. Ecosystems are perturbed by this rise in CO_2 and the change in climate.

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In the ocean what happens? It gets warm, you get migrations, you get extinctions, you reduce oxygen, you start making a little bit of hydrogen sulfide. You acidify coral reefs. Coral survived but coral reefs, these big, beautiful structures sort of got flattened. They didn't get through and they didn't come back for a long time afterwards. There's an extinction event, the acidification is, this is pretty cool. So this is something I swiped from the IODT people. They have a wonderful site and the stratigraphic correlator, Sandy, here, I don't know, I swiped the picture, but she's doing important work. And this is a core that goes across that CO_2 release.

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And it would've been in the ground when it came out. And here it is in a bigger context, a different one, this picture from Jim Zachos. All of that brown gray mud has little white shells of sea critters in it. And that red bit, they dissolved because the CO_2 made the ocean acidic and it dissolved the shells. So you can see this thing and that goes along with that there's an extinction on the sea floor, right.

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So this was a big deal. Now when people try to model this, either their models are good or the world changed a little more than the models like. This is one paper that just came out last week. It is not the only word. Don't take one paper as gospel, but there's other things that say that if we have a problem, as it gets warmer, the CO_2 causes more warming than we're expecting. Either the models are good or it's a little worse but not a little better. OK.

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Now I'm going to do one more. I'm going to try desperately to get away from CO_2. You will meet the people who say, all you people do is study CO_2. Well, no, we keep trying to study other things and it keeps leading us back to CO_2. So I'm going to try to explain the Ice Ages. The Ice Ages start as a story that has nothing to do with CO_2 and then it comes back to CO_2. If I lose you, the point is down here in red at the right. Ice Ages show that many things affect climate, but especially CO_2. And if I lose you, I apologize because I shouldn't. I should be able to explain this. But we'll try. And so we'll see what we can do, right?

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So this is a history of temperature in Antarctica, the 400 over here is now 400,000 years, not 400 million. And today is over here. And this is just temperature in Antarctica, but if you blur your eyes and squint a little, it’s pretty much temperature in the whole world. Not exactly but fairly close. And what you’ll notice, we’re over here today where it’s warm. And then it was cold and then it was warm and then it was cold and then it was warm and then it was cold, you see that.

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And that’s the Ice Age cycle. And if I push arrows down on the warm times, you’ll get the idea that maybe this isn’t a random number generator. There’s something ticking along here in a regular cycle. And you can just see it going tick, tick, tick, tick. That was predicted 50 years before it was observed. This fellow Milankovitch working from Croll and Adhemar and others said, you know, there’s features of Earth’s orbit. And those features, the Earth is like a top and it wobbles and wiggles like a spinning top. And that moves the sunshine on the planet. And sometimes the Poles get more and sometimes, right, so.

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The one in the upper left there, I’ll try to do for you. So I want each of you for a moment to imagine that you are the sun. This is the Earth. This is my North Pole and we don't need a South Pole but this is my North Pole. If my North Pole stuck straight up, you as the sun could never give me a sun burn on my artic bald spot. But it doesn’t. It’s tipped over and so you can give me a sunburn on my artic bald spot. This tip gets a little more and a little less and that’s 41,000 years. A little more and a little less, that’s 41,000 years, like a top wobbling a little bit. And when it tips more you give me more sun at the artic and less at the equator. More at the equator, less in the artic More in the artic, less in the equator. And the same for the Antarctic, right? So the sun is mo-, total sun to the total planet, almost no change. Sun in Minnesota, 10 percent change. Big difference.

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And so Milankovitch said, “When you people finally learn how to measure the history of Ice Ages, you will find 41,000 years, you will find a 19 to 23 thousand year wobble and you will find a 100,000 year change in the shape of the orbit. And 50 years later, when we got the records, he was right. This is caused by features of Earth's orbit.

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But when the ice melted in Minnesota, the whole world warmed. And half of the world was getting less sun and the whole world warmed. And that's weird. You're moving sun around, not changing the total sun to the total planet, you're just moving it around Why doesn't the ice run away from the sun and go to the no-sun places? Instead the world goes together. All the records look like this, right. And this is necessary to explain that. No one has come up with a good explanation that does not involve this. This is the history of CO_2. And what you'll notice is when it's warm, CO_2 is high and when it's cold, CO_2 is low. And so half the world warmed with less sun and CO_2 explains most of the signal and no explanation has come out yet that doesn't involve CO_2.

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Now what happened? Again, we spend about a week in class on this one. Ultimately, you melt your ice, it goes in the ocean, the currents change, the winds change, a whole bunch of things change, and a little of the CO_2 in the deep ocean came out into the air. And so an Ice Age is a big enough thing that it shifts CO_2 between the air and the deep ocean, and in shifting CO_2 between the air and the deep ocean, it then globalizes it. So this starts as a non- CO_2 story and then ends up as a CO_2 story.

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Now if I take this and I squeeze it down, that's the previous plot. We've done that and we're headed for there. And that may raise questions in your mind, OK? So what have we hit here? Right. Fires have always burned and so we worry about humans setting fires. People have always died and so we worry about humans killing other humans. The climate has always changed. And I had a senator say to me, 'So we should not worry about humans changing the climate?' Can you imagine a senator saying, Fires have always burned, so don't worry about arson. People have always died, so don't worry about murder. But climate has always changed. What does that actually tell us?

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Climate is changeable. Climate change has always affected life. We see the record in who's living. That means it's important. Climate has changed for a lot of reasons but especially CO_2, which especially focuses attention on our CO_2. We could rival the bigger of the natural changes and faster than virtually any of them if we keep going. All right. Climate has always changed is important.

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Now one more little point and then we'll try to close up here. This is some records I helped make from Greenland. 15 over here is 15,000 years ago. Zero is today. This is the end of the last Ice Age. CO_2 is rising. Your ice in Minnesota is melting and the warming is in the green. And you'll notice there's a stagger in the middle. When the climate was forced to move, it was maybe a little bit like, I know you don't have any drunken humans at Gustavus, but up the road here they probably do. It was a little bit like a drunken human, when left alone, it sits. When forced to move, it staggers.

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And this is linked to fresh water and the ocean circulation and the sea ice and a whole bunch of things that I'd love to talk about because they're so fascinating. But the lesson, when we force the climate, sometimes it behaved itself. It was smooth and gradual. You could see what was coming. And sometimes it jumped. And the National Academy of Sciences looked at this and they said, you know something, if we see it coming, we can be ready for it, we can deal with it.

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But if we don't see it coming, it costs more, it hurts more, it causes more damage. And so this knowledge that there really are abrupt changes in the climate system says that the danger is maybe greater than we're expecting,

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So let me do this, right. I ride my bicycle at home but suppose you were a commuter up to the Twin Cities here, or D.C. And on the bottom here I a list of problems and on the side is how likely that is. And so what does a commuter face? You get in a car, you get stuck in traffic, you turn on the radio and it's boring, right? What's the best thing that I can ever happen to a commuter? You get in the car, there's no traffic, and it's the Beach Boys Festival, right? That doesn't happen to you. What happens it you, you get in the car and you're really stuck in traffic and they're testing the emergency broadcast system.

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But why are you stuck in traffic? Because somebody got run over by a drunk driver. What we expect is on the good end of what's possible. What we do about that is we have airbags and crumple zones and seatbelts and child seats and Mothers Against Drunk Drinking and we have police officers out there trying to stop the drunk drivers and we have traffic engineers. We put a lot of our investment into something we don't expect because it would be such a big deal.

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Now if you look at traffic change, or look at climate change, there's a best estimate. Maybe it's a little better. That's possible. It's real. That's science. But maybe we hit an abrupt climate change. Maybe an ice sheet collapses and rather than 3 feet of sea level, we get 10 or 15. Maybe the ecosystem burns and it doesn't grow back. Maybe we tip economies over and start fighting each other rather than getting along.

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And so when you look at this distribution, there are drunk drivers in the real world. Now I have spent a fair amount of my life having this argument. This is what the IPCC says, couldn't it be better, this is what the IPCC says, couldn't it be better, this is what the IPCC says. Well, we've heard both sides now. No, you haven't. There's probably more room for an environmentalist to criticize the scientist than somebody who's not worried.

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So I think the answer is that we really are all on the same side. The arguments that are now presented to me is why we should not take action on climate change, actually are all arguments why we should take action on climate change. "Climate has always changed." Once you understand that, you realize what a big thing our CO_2 is. "Science is uncertain", yeah. There's a long tail. If you were driving the Titanic and you're not sure if there's an iceberg ahead, do you slow down or not?

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You know, the, ‘We can’t afford it’, I showed you the Nobel Prize in economics slide. And I really believe that if we got through the cloud and the confusion, that we’re all on the same side. And that that same side really is that if we use our knowledge with respect with commitment, which recognition of how much good we get from fossil fuels and how much we owe the people who gave it to us, but with commitment to build something better, that we really do get a better economy, more jobs, improve our health, greater national security, cleaner environment, more consistent with the golden rule. Thank you so much.