

UNITED STATES DISTRICT COURT  
NORTHERN DISTRICT OF CALIFORNIA

BEFORE THE HONORABLE WILLIAM H. ALSUP, JUDGE

5	THE PEOPLE OF THE STATE OF	)	
6	CALIFORNIA, acting by and through	)	
7	Oakland City Attorney BARBARA J.	)	
8	PARKER,	)	
		)	
	Plaintiff and Real	)	
	Party in Interest,	)	
	VS.	)	NO. C 17-6011 WHA
		)	
9	BP P.L.C., a public limited company)	)	
10	of England and Wales, CHEVRON	)	
11	CORPORATION, a Delaware corporation)	)	San Francisco,
12	CONOCOPHILLIPS COMPANY, a Delaware	)	California
13	corporation, EXXON MOBIL	)	
14	CORPORATION, a New Jersey	)	
15	corporation, ROYAL DUTCH SHELL	)	
16	PLC, a public limited company of	)	
17	England and Wales, and Does 1	)	
18	through 10,	)	
19		)	
20	Defendants.	)	Wednesday
21		)	March 21, 2018
22		)	8:00 a.m.

Continued on next page.

Reported By: Katherine Wyatt, CSR 9866, RPR, RMR,

1 THE PEOPLE OF THE STATE OF )  
 2 CALIFORNIA, acting by and through )  
 3 San Francisco City Attorney DENNIS )  
 HERRERA, )  
 4 )  
 Plaintiff and Real )  
 Party in Interest, )  
 VS. ) NO. C 17-6012 WHA  
 5 )  
 BP P.L.C., a public limited company) )  
 6 of England and Wales, CHEVRON )  
 CORPORATION, a Delaware corporation) )  
 7 CONOCOPHILLIPS COMPANY, a Delaware )  
 corporation, EXXON MOBIL )  
 8 CORPORATION, a New Jersey )  
 corporation, ROYAL DUTCH SHELL )  
 9 PLC, a public limited company of )  
 England and Wales, and Does 1 )  
 10 through 10, )  
 )  
 11 Defendants. )  
 )

12  
 13  
 14 **TRANSCRIPT OF PROCEEDINGS**

15  
 16 **APPEARANCES:**

17 **For Plaintiffs:** **HAGENS BERMAN SOBOL SHAPIRO LLP**  
 18 1918 Eighth Avenue, Suite 3300  
 Seattle, Washington 98101  
**By: STEVE W. BERMAN, ESQUIRE**

19 AND

20 **HAGENS BERMAN SOBOL SHAPIRO LLP**  
 21 1280 Centre Street, Suite 230  
 Newton Centre, Ma. 02459  
**By: MATTHEW F. PAWA, ESQUIRE**

22  
 23  
 24 AND FURTHER APPEARANCES ON NEXT PAGE  
 25

1 **ALSO FOR PLAINTIFFS:**

2 **FOR THE CITY OF OAKLAND:**

3 **BARBARA J. PARKER, CITY ATTORNEY OAKLAND**

4 1 Frank H. Ogawa Plaza, 6th Floor

5 Oakland, California 94612

6 **By: Barbara J. Parker, City Attorney**

7 **Erin Bernstein, Senior Deputy City Attorney**

8 **Maria Bee, Supervising Attorney**

9 **Malia McPherson, Stanford Law Public Interest Fellow**

10  
11  
12 **FOR THE CITY OF SAN FRANCISCO:**

13 **DENNIS J. HERRERA, CITY ATTORNEY**

14 1390 Market Street, Seventh Floor

15 San Francisco, California 94102

16 **By: Matthew Goldberg, Deputy City Attorney**

17 **DENNIS J. HERRERA, CITY ATTORNEY**

18 City Hall, Room 234

19 1 Dr. Carlton B. Goodlett Place

20 San Francisco, California 94102

21 **By: Robb W. Kapla, Deputy City Attorney**

22 **Ronald P. Flynn, Deputy City Attorney**

23  
24 **FURTHER APPEARANCES ON NEXT PAGE.**

25

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25

**For Defendants:**

**GIBSON, DUNN & CRUTCHER LLP**

333 South Grand Avenue

Los Angeles, California 90071

**By: Theodore J. Boutrous, Jr., Esquire**

P R O C E E D I N G S

1  
2 **March 21, 2018**

**8:00 A.M.**

3 **THE COURT:** Welcome everyone. Please be seated.

4 **THE CLERK:** Calling Civil Action 17-6011 and 17-6012,  
5 People of the State of California versus BP P.L.C., et al.  
6 Counsel, please approach the podium, and state your  
7 appearances for the record.

8 **MR. BERMAN:** Good morning, Your Honor. Steve Berman on  
9 behalf of the People. And with me here today are City Attorney  
10 Barbara Parker, Erin Bernstein of the City Attorney's Office from  
11 Oakland.

12 Also with me from the City Attorney's Office of San  
13 Francisco is Robb Kapla, Matthew Goldberg and Ronald Flynn.

14 **THE COURT:** Great. Welcome to all of you.

15 And?

16 **MR. BOUTROUS:** Good morning, Your Honor. Theodore J.  
17 Boutrous, Junior. I'm here representing Chevron here today, and  
18 I'll be presenting the tutorial on behalf of Chevron.

19 Counsel for the other defendants have submitted a sheet  
20 of paper to speed things up with their appearances with the  
21 Court.

22 **THE COURT:** All right. Are all defendants present  
23 today?

24 **MR. BOUTROUS:** I believe so, Your Honor.

25 **THE COURT:** Including the ones who have objected to

1 jurisdiction?

2 **MR. BOUTROUS:** I believe they are here and that their  
3 counsel made appearances.

4 **THE COURT:** Is that true? The other counsel?

5 **UNKNOWN SPEAKER:** Yes, Your Honor.

6 **UNKNOWN SPEAKER:** Yes, Your Honor, on behalf of Shell.

7 **UNKNOWN SPEAKER:** On behalf of Exxonmobil, Your Honor.

8 **UNKNOWN SPEAKER:** On behalf of BP, Your Honor.

9 **THE COURT:** Thank you. So just to be fair, all of you  
10 who have objected to jurisdiction and/or service of process, this  
11 will be deemed to be a special appearance. But I don't want you  
12 to hold back on the theory that if you say something you'll have  
13 waived your procedural argument.

14 So okay. Welcome to everyone, and thank you for  
15 coming. And I'm interested to see this turnout on such a wet,  
16 miserable day out there. We're going to have a tutorial on  
17 science in just a moment.

18 You all are ready to start?

19 **MR. BERMAN:** We are, Your Honor.

20 **THE COURT:** Okay. So let me just say to you two, as  
21 well as to the public, that I read in the paper a couple of weeks  
22 ago that this was going to be like the Scopes Monkey Trial. And  
23 I was -- I couldn't help but laugh. But this is not a trial.

24 I want everyone out there, the newspaper people, please  
25 don't call this a trial. This is not a trial.

1           In these technology cases, mainly the patent cases, but  
2 not just patent, we often have these tutorials so that the poor  
3 Judge can learn some science, and it helps to understand the  
4 science.

5           So you will find this probably boring. This will not  
6 be withering cross-examinations and so forth. It will be numbers  
7 and diagrams. And if you get bored you can just leave. Okay?

8           But I'm not promising fireworks or anything like that.  
9 This is a serious proposition to try to educate the Judge. So  
10 that's the purpose.

11           Now, we're going to proceed today in two chapters.  
12 Chapter one is the history of the development. There's a name  
13 for that that I've forgotten the history of the history. But,  
14 anyway, that's part one.

15           Then, part two will be the best available knowledge  
16 that we have today on the issue of carbon dioxide in the  
17 atmosphere and how that affects global temperature.

18           So are we ready to start?

19           **MR. BOUTROUS:** We're ready, Your Honor.

20           **THE COURT:** So what I want to do is on the first part  
21 give each side an hour.

22           Plaintiff, you can go first.

23           You can go second, Mr. Boutrous. And if you want to  
24 reserve any of your one hour, you can, but you don't have to.  
25 But don't ask for more time if you use up your one hour.

1 So you want to reserve anything or not?

2 **MR. BERMAN:** No reserve, Your Honor.

3 **THE COURT:** No reserve. All right.

4 **MR. BERMAN:** One housekeeping question?

5 **THE COURT:** Of course. Go ahead.

6 **MR. BERMAN:** And Mr. Boutrous was kind enough to  
7 accommodate this, if the Court would. I understand we're going  
8 to go one hour and one hour on history. We have a witness issue.  
9 And so if we could have just 20 minutes after the hour on part  
10 two, take them out of order a little bit.

11 **THE COURT:** What do you mean "a witness issue"?

12 **MR. BERMAN:** Well, he's got a conflict. He's got a  
13 conflict. He has to be somewhere else in the afternoon, and he's  
14 our --

15 **THE COURT:** Is this person going to be presenting?

16 **MR. BERMAN:** Yes.

17 **THE COURT:** Oh, so you want to do what?

18 **MR. BERMAN:** I want to have part of my part two right  
19 after part one.

20 **THE COURT:** And that's okay with you?

21 **MR. BOUTROUS:** That's okay with me, Your Honor.

22 **THE COURT:** Okay. That's fine.

23 **MR. BERMAN:** Thank you.

24 **THE COURT:** We might take a break in there somewhere,  
25 but I want to give you great flexibility. You can split this up

1 any way you want. They are not going to be under oath. This is  
2 not cross-examination. That will all come later if we get that  
3 far.

4 So you can use an expert for part, all, anything you  
5 want to do. And the lawyers can do it. It's perfectly okay.

6 Okay. Ready?

7 **MR. BOUTROUS:** Yes. Thank you, Your Honor.

8 **MR. BERMAN:** Thank you, Your Honor. Again, Steve  
9 Berman.

10 **THE COURT:** The floor is yours, Mr. Berman.

11 **MR. BERMAN:** Thank you, Your Honor. I'm going to, first  
12 of all, hand out some handouts, if I may.

13 **THE COURT:** Sure.

14 **MR. BERMAN:** This is a notebook for you. I have one  
15 for your clerks.

16 **THE COURT:** Yes, please.

17 **MR. BERMAN:** Also, I have a timeline, historical  
18 timeline we'll hand up, as well, in horizontal format, as you  
19 requested.

20 **THE COURT:** Great.

21 **MR. BERMAN:** I'm going to call as our first speaker,  
22 Professor Myles Allen. Professor Allen is from Oxford. He's in  
23 the School of Geography and Environment, in the Department of  
24 Physics.

25 His resume is in the first tab in your notebook. He

1 received the Appleton Award from the Institute of Physics for his  
2 contribution to the detection and attribution of human influence  
3 on climate change.

4           And before he comes up, I want to say one thing in  
5 response to Your Honor's comments. We view this, just so the  
6 audience understands and the Court understands where we're coming  
7 from, as science. This is not, as the papers called it from our  
8 perspective, our time to say when the defendants knew about  
9 climate change and what statements they made. We're just talking  
10 about the science of climate change today.

11           **THE COURT:** Well, I appreciate that. I hope we stick  
12 to that and keep politics and -- you know, I know that there  
13 are -- there's politics sometimes involved in this, but I --  
14 let's stick to the science, if we can.

15           All right. So give me the name of that -- of your  
16 presenter. Professor?

17           **MR. BERMAN:** Myles Allen.

18           **THE COURT:** Myles A-L-L --

19           **MR. BERMAN:** Myles, M-Y-L-E-S, Robert Allen, A-L-L-E-N.

20           **THE COURT:** Okay.

21           **MR. BERMAN:** He's from Oxford. He talks a little  
22 funny, but I'm sure you'll be able to understand him.

23           **THE COURT:** Very good.

24           Now, are you Dr. Allen?

25           **DR. ALLEN:** I am, yes.

1           **THE COURT:** Okay. So what -- see that microphone there?  
2 Try to -- it's a good microphone, but it's got to be directed  
3 toward your voice so the public can hear.

4           **DR. ALLEN:** Thank you.

5           **THE COURT:** It's important that the public hear, too.

6           **DR. ALLEN:** Yes.

7           Thank you. Thank you, Your Honor. And we deeply  
8 appreciate the opportunity on behalf of the scientific community  
9 to present the history of the science of climate change, the  
10 evolution of our understanding of how carbon dioxide has affected  
11 global climates.

12           And the way I will -- it's difficult to explain the  
13 history without also explaining the science. So my presentation  
14 will combine the two, as will the others after the -- as will the  
15 later presentations, as well, and explain to you how our -- both  
16 what our current understanding is of the basic physics of how  
17 carbon dioxide affects global climates and how it's evolved over  
18 the past century.

19           And then, the following two experts will talk about the  
20 modern understanding of what is happening in the U.S. and  
21 California. The way I'm proposing to structure my talk is to  
22 talk about initially just the basic physics of how rising CO2  
23 causes global warming. And, in particular, then I shall go on to  
24 looking at the -- looking at the understanding where carbon  
25 dioxide is coming from and going through the common cycle, and

1 how that understanding has evolved over the centuries.

2 I'll talk about our bottom-up approaches to quantifying  
3 how much warming to expect as a result of a doubling of  
4 preindustrial carbon dioxide concentrations, for example. And  
5 then, top-down approaches to try to quantify the scale of human  
6 influence on global climate, recognizing also the role of natural  
7 influences in climate change.

8 There will be at that point a brief digression on ice  
9 ages. The Court specifically asked about our understanding of  
10 ice ages, so I will take you through that.

11 But we will then come back to our main line of  
12 evidence, which is our understanding what has been happening over  
13 the past century.

14 I will conclude with talking about how rising  
15 temperatures are affecting sea level and the permanent cumulative  
16 impact of carbon dioxide emissions from fossil fuels.

17 So we begin with the basic physics. And going back, we  
18 have to go back now to the early 19th century. Fourier and  
19 Tyndall understood the -- they knew about a mysterious, invisible  
20 form of energy, infrared radiation, which had been discussed and  
21 discovered only a few decades earlier. And Fourier, with a  
22 remarkable piece of intuition, recognized that the Earth had to  
23 get rid of the energy it received from the sun in this form.

24 And that he speculated that the atmosphere played a  
25 role in keeping the Earth warmer than it would otherwise be by

1 interfering with this outgoing infrared radiation. But he didn't  
2 quantify this effect, specifically.

3 John Tyndall, an Irishman, then identified the specific  
4 greenhouse gases, carbon dioxide and methane, in particular, and  
5 characterized the way they interact with infrared radiation.

6 Now, among your questions you raised specifically this  
7 question of how it is that certain gases interact with radiation  
8 and others don't.

9 So that's illustrated in the next slide, which shows a  
10 carbon dioxide molecule. It's a molecule of a carbon. That  
11 black blob in the center is the atom of carbon, and two atoms of  
12 oxygen.

13 Normally, a carbon dioxide molecule is straight, but it  
14 can move in many ways because of its temperature. In particular,  
15 it can bend, vibrate up and down, and it can also -- and it can  
16 also vibrate from side to side, unlike an oxygen or nitrogen  
17 molecule, which consists of two identical atoms, and, therefore,  
18 has many fewer ways of moving.

19 And, importantly, two of these modes of motion of the  
20 carbon dioxide molecule, the bending mode, which I've highlighted  
21 at the top there, and this asymmetric stretch mode, these create  
22 an asymmetric dipole, meaning there's more charge on one side  
23 than the other.

24 And just like a little antenna, this can therefore  
25 interact with the electromagnetic field.

1           So we're talking about a mini antenna interacting with  
2 the electromagnetic field specifically in the wavelengths  
3 associated with the infrared.

4           The Court asked whether carbon dioxide is also  
5 responsible for --

6           **THE COURT:** Well --

7           **DR. ALLEN:** And I should have said at the beginning I'm  
8 delighted for you to interrupt me and explain, if I need to  
9 explain.

10          **THE COURT:** So you have like this one on the bottom  
11 left, you've got red, black, red.

12          **DR. ALLEN:** Yes.

13          **THE COURT:** And that's lined up?

14          **DR. ALLEN:** Yes.

15          **THE COURT:** So does it matter in the atmosphere whether  
16 the red, black, red is facing the Earth broadside, or what if it  
17 was the other --

18          **DR. ALLEN:** No. No.

19          **THE COURT:** Wouldn't make any difference?

20          **DR. ALLEN:** It doesn't matter.

21          **THE COURT:** Okay.

22          **DR. ALLEN:** It doesn't matter. What matters, just like  
23 the radio --

24          **THE COURT:** But with the radio it does matter if the  
25 antenna is broadside to the signal or not.

1           **DR. ALLEN:** Your Honor's quite correct. Thank you for  
2 raising that. But in this case, because we have a mixture of  
3 molecules in the atmosphere, we see the combined effect of all of  
4 these orientations of molecules. And these interact with  
5 infrared radiation.

6           And, yes, Your Honor's quite correct. The orientation  
7 of the molecule would affect the polarity of the emitted photon  
8 or infrared radiation. But since this doesn't actually affect  
9 the amount of energy lost, we don't need to concern ourselves  
10 with this.

11           **THE COURT:** Well, this infrared is coming off the  
12 Earth. Right? And it gets somewhere into the atmosphere. And  
13 it passes by one of these CO<sub>2</sub>'s.

14           **DR. ALLEN:** Yep.

15           **THE COURT:** Here's what I don't quite get. As it goes  
16 by, describe the step-by-step of how that energy gets absorbed  
17 into the molecule. And then, after that does it then get  
18 re-radiated again somewhere else?

19           **DR. ALLEN:** Yes.

20           **THE COURT:** It's unclear to me how that works. So  
21 please go ahead.

22           **DR. ALLEN:** So because the molecule -- the molecule in  
23 its ground state is sort of like this: Straight (indicating).  
24 Okay? And if a photon interacts, comes, as it were, close enough  
25 to it to interact with it, it sets it vibrating. Yeah? Like a

1 chicken dance (indicating). Yeah?

2           Alternatively, sets it vibrating like an asymmetric  
3 stretch. I don't know what the name of that dance is. But,  
4 crucially, these are the modes of vibration that create an  
5 asymmetric dipole mode. This one doesn't do anything. Yeah?  
6 Because it doesn't make it -- so this mode of vibration --

7           **THE COURT:** What do you mean "It doesn't do anything"?

8           **DR. ALLEN:** Well, because it doesn't do anything to the  
9 dipole. If you measure, my head is the positive charge on top.  
10 My hands are the negatively charged oxygen. You can see that  
11 moving the oxygen in and out doesn't actually create a dipole.  
12 It doesn't -- it is still symmetric.

13           The average charge of the whole molecule is still zero  
14 in the center. Yes? Because I'm moving them. If I move these  
15 charges to and froe, I'm not moving the whole charge around.

16           Whereas, if I move them together, and then I've got the  
17 positive charge in the center, negative charges on either side.

18           **THE COURT:** There's some asymmetry.

19           **DR. ALLEN:** It is the asymmetry which is crucial. And  
20 the reason this is crucial is to now imagine I'm an oxygen  
21 molecule. So I just have the two hands up, the oxygen.

22           Now, there's no way that can vibrate to create an  
23 asymmetric charge, because the two halves of it are identical.

24           So that's why an oxygen molecule cannot interact with  
25 infrared radiation, but a carbon dioxide molecule can. And a

1 water molecule --

2 **THE COURT:** So when it does absorb, the CO2 does  
3 absorb, is it infrared or --

4 **DR. ALLEN:** It absorbs in the infrared.

5 **THE COURT:** Is that electromagnetic --

6 **DR. ALLEN:** Electromagnetic radiation.

7 **THE COURT:** -- that causes that movement that you  
8 described, the asymmetric movement?

9 **DR. ALLEN:** Yes. And then, it's left in this state  
10 (indicating).

11 **THE COURT:** Yes.

12 **DR. ALLEN:** And then, it releases that energy again,  
13 and it goes back to its original state. And it releases the  
14 energy in the same wavelength that it's absorbed it.

15 **THE COURT:** Now, right there. Okay. I've read some  
16 literature on this trying to get ready for today. Does the  
17 energy when it's released go into space or does it -- some go to  
18 space? Some go to the ground? Does it go in all directions or  
19 does it just get re-radiated back to the ground?

20 **DR. ALLEN:** It could go in any direction. And,  
21 crucially, the amount of energy that these molecules radiate is  
22 proportional to their temperature.

23 **THE COURT:** To what?

24 **DR. ALLEN:** And that brings us --

25 **THE COURT:** To what?

1           **DR. ALLEN:** The amount of energy these molecules  
2 radiate is proportional to their temperature.

3           And that brings us to the next crucial step in the  
4 argument.

5           **THE COURT:** Go ahead.

6           **DR. ALLEN:** Yes. Which was understood for the first  
7 time by a Swedish chemist, Svante Arrhenius. And he was the  
8 first one to quantitatively understand how rising concentrations  
9 of carbon dioxide affect -- could affect global temperatures or  
10 must affect global temperatures.

11           And I'm quoting here from his paper, which was  
12 published around the turn of the century, around the end of the  
13 19th century. And this particular sentence is remarkably --  
14 shows remarkable insight because he says:

15                   "Any doubling of the percentage of carbon dioxide  
16 in the air would raise the temperature of the Earth by four  
17 degrees."

18           It's on the high side, but it's within the range of the  
19 uncertainty of the modern estimates.

20           But then, he goes on to say:

21                   "If the carbon dioxide were increased by fourfold,  
22 the temperature would rise by eight degrees."

23           And it's interesting because, of course, the additional  
24 amount of carbon required to go from a twofold increase to a  
25 fourfold increase is twice as much as you need to go from a

1 preindustrial to a twofold increase.

2           So what he's pointing out here is that every time you  
3 double you get the same amount of warming, which is not the most  
4 obvious. Sort of intuitively you might think that, you know,  
5 every ton of carbon put into the atmosphere has the same impact  
6 as the last.

7           And what's impressive here is therefore he's making a  
8 quantitative prediction, this sort of logarithmic relationship of  
9 carbon dioxide concentrations with temperature, which wasn't  
10 intuitively obvious.

11           And as a physicist we're always very impressed if  
12 someone has a theory that makes a prediction that is not  
13 completely obvious, which turns out to be true. And this  
14 prediction does, indeed, turn out to be true.

15           **THE COURT:** You said it was logarithmic. But if you  
16 double it, according to this quote, it goes up by four, and  
17 then --

18           **DR. ALLEN:** Four degrees.

19           **THE COURT:** Four degrees.

20           **DR. ALLEN:** If you increase it by fourfold, it goes up  
21 by eight degrees.

22           **THE COURT:** Right. So if you double it again it goes  
23 up by eight. So that seems -- that doesn't seem like  
24 logarithmic. That seems linear.

25           **DR. ALLEN:** So the doubling, it's two, four, eight,

1 sixteen, by giving me each one the same amount of warming.

2 So if I was to plot carbon dioxide concentration in the  
3 horizontal and temperature in the vertical, you would see points  
4 going two, four, eight, sixteen.

5 **THE COURT:** All right. So if he had gone on to say  
6 eight, eightfold, then it would have been --

7 **DR. ALLEN:** Only 12 degrees.

8 **THE COURT:** -- twelve degrees.

9 **DR. ALLEN:** Exactly. Yes. You got it.

10 **THE COURT:** All right.

11 **DR. ALLEN:** So how did he come to this insight? Well,  
12 this shows essentially Arrhenius' reasoning. This is a view of  
13 carbon dioxide molecules in the atmosphere. And I've used color  
14 to denote their temperature. And you recall I stressed that the  
15 amount of infrared radiation emitted by these carbon dioxide  
16 molecules is related directly to their temperature. That was  
17 well-understood in the 19th century.

18 So colder is blue. So air gets colder with height.  
19 That's a well-known consequence of basic thermodynamics. And air  
20 also gets less dense with height, which is why the little carbon  
21 dioxide molecules are further apart as we go up through the  
22 atmosphere.

23 Now, if I try doubling the concentration of carbon  
24 dioxide in my model atmosphere, I want you to focus on the -- I  
25 would like the Court to focus on the lower right panel, which is

1 the view of the atmosphere from above in the infrared.

2           So this would be analogous to thinking of the view of a  
3 house you might use with one of those cameras which one can take  
4 to see if you have got enough loft insulation. You know, they  
5 can do a color image of your house, and they show in bright red  
6 where energy is escaping from the house.

7           Now, if I double the amount of carbon dioxide in the  
8 atmosphere, it's like increasing the amount of loft insulation.  
9 And so we immediately see less energy escaping into space.

10           So that view from above now looks colder when viewed  
11 from space, because less energy is escaping as a result of the  
12 increase in carbon dioxide concentrations.

13           What's happened is that the additional carbon dioxide  
14 in the atmosphere is forcing the atmosphere to radiate heat from  
15 higher altitudes in order to escape into space. And because  
16 higher air is colder, it's radiating energy at a slower rate.

17           So if you reduce --

18           **THE COURT:** Say that last couple of sentences again.

19           **DR. ALLEN:** Yes.

20           **THE COURT:** I want to go back on your other -- okay.  
21 Say the last two sentences again.

22           **DR. ALLEN:** Sure. So because we've increased the total  
23 amount of carbon dioxide in the atmosphere -- and I should stress  
24 carbon dioxide is well-mixed through the atmosphere, so when the  
25 concentration increases, it increases everywhere -- photons, the

1 little corpuscles of energy that are released by these carbon  
2 dioxide molecules, they can only escape to space from a higher  
3 altitude, because there's more carbon dioxide there getting in  
4 the way of photons escaping to space from further down.

5           And as a result, because higher air is colder, the  
6 amount of radiation escaping to space goes down. And, I mean,  
7 the diagram should make this reasonably intuitive. You can see  
8 as I -- sorry -- as I increase the amount of CO2 molecules, if I  
9 go back to the original, as I increase the amount of CO2  
10 molecules, you can see there's been no change in temperature, if  
11 you look at the view from the side.

12           But looking down from above, we can't see as deep into  
13 the atmosphere because of all this extra carbon dioxide.

14           The atmosphere has become more opaque, so we're seeing  
15 higher air and less.

16           **THE COURT:** All right. I see your point there. But  
17 let me quiz you about that. You have started off with a large  
18 number of blue dots. Right? Looks to me like a large number of  
19 blue dots.

20           But the things that I've been reading say that the  
21 actual amount of carbon dioxide is trace elements. It's like 400  
22 parts per million. But the way you've got it diagrammed there,  
23 it looks like 10,000 parts per million.

24           So is it -- would that make it -- in other words, if  
25 you started with just two dots there, and then you doubled it to

1 four dots you would still see a lot of red.

2 **DR. ALLEN:** Your Honor is quite correct there. But, of  
3 course, even though it's only 300 parts per million, that's still  
4 an awful lot of molecules in a cubic meter of air, and crucially,  
5 a lot of molecules relative to the wavelength of infrared  
6 energy.

7 So infrared, infrared radiation has a wavelength much,  
8 much longer than the size of these molecules. And so the actual  
9 sort of -- the actual absolute number of molecules is not  
10 important. It's the opacity of the atmosphere in the infrared,  
11 which is entirely driven in this example by the amount of CO2 in  
12 it.

13 Because the oxygen and nitrogen molecules, as far as  
14 the infrared radiation is concerned, might as well not be there,  
15 because they can't interact with it.

16 **THE COURT:** What you're saying is even if there were  
17 just a small number of dots, as the infrared comes off the Earth  
18 the wavelength is long, so much longer than the molecule -- is  
19 that right, or something that --

20 **DR. ALLEN:** Yes.

21 **THE COURT:** -- that even though it doesn't hit it smack  
22 on, it just has to get close.

23 **DR. ALLEN:** Exactly.

24 **THE COURT:** Okay.

25 **DR. ALLEN:** So, in fact, it's the scale of the

1 radiation that actually sets the chance of it hitting a molecule  
2 rather than the scale of the molecule itself. You know, the  
3 molecules are tiny. But the wavelengths we're talking about of  
4 infrared radiation are of the order of, you know, 10 microns or  
5 so. So that sounds like a small number. But compared to a  
6 molecule it's actually a huge number.

7           So that's why there's very little chance of a photon of  
8 infrared radiation emitted from the surface actually making it  
9 all the way through the atmosphere to space. It's around less  
10 than a sixth of a chance.

11           **THE COURT:** The point you made, the ones that are  
12 higher up are the ones that would emit radiation into space as  
13 opposed -- but wouldn't the ones that are further down, once they  
14 absorb, and then they re-radiate, wouldn't it progressively go up  
15 and still go out into space? Or is there some sort of  
16 diminishing returns problem?

17           **DR. ALLEN:** Oh, the atmosphere is being heated from  
18 below, for sure. But the crucial point which determines the net  
19 rate at which the planet as a whole can radiate energy to space  
20 is determined by the temperature of the molecules from which  
21 photons finally escape all the way out into space.

22           It's that sort of last emission that matters, because  
23 photons are bouncing around in the atmosphere all the time. But  
24 it's the ones that make it out into space that determine the rate  
25 of energy lost to space by the planet as a whole.

1           And so by adding more carbon dioxide in the atmosphere,  
2 we thicken this sort of foggy blanket of greenhouse gases around  
3 the planet. We force the planet to emit from a higher altitude,  
4 and, therefore, we reduce the rate at which the planet is  
5 shedding energy to space.

6           **THE COURT:** How would that affect what you showed me  
7 about what Tyndall said about what you said was the logarithmic  
8 relationship? How would it affect that?

9           **DR. ALLEN:** Let me show you what happens next. So we  
10 now have an imbalance. One of the crucial insights of Fourier  
11 and Tyndall was that carbon dioxide does not interact with solar  
12 radiation. In fact, the Court asked:

13                       "Does carbon dioxide reflect solar radiation?"

14           The answer is: "It doesn't, and/or to a negligible  
15 degree." And, therefore, this increase in carbon dioxide has no  
16 impact on the amount of energy received from the sun. So no  
17 additional energy is reflected away because of the increase in  
18 carbon dioxide.

19           And, therefore, as a result, there's an imbalance now  
20 between the incoming energy from the sun and the outgoing energy  
21 to space, because the outgoing energy to space has been reduced  
22 as a result of the increase in carbon dioxide concentrations.

23           Because of that imbalance, the Earth has to warm up  
24 because it's accumulating energy at the surface and in the lower  
25 atmosphere.

1           And that's shown here by the warming, more red colors  
2 appearing. And it has to keep warming until the color in the  
3 lower left -- in the lower right is the same color as it was  
4 before, until it's releasing energy to space at the same rate  
5 that it was before.

6           Again, thinking back to the home insulation example, if  
7 you put more loft insulation -- if you put more insulation in  
8 your loft, then if you look at the house with the camera from  
9 outside it looks -- you see a bluer color because it's losing  
10 energy at a slower rate.

11           If you leave the heating on at the same rate, the house  
12 gets warmer, and the house will keep getting warmer until it's  
13 losing energy at the same rate. You might wind up uncomfortably  
14 hot.

15           So that's how the analogy -- it's not a bad one. It's  
16 not a great analogy, but it makes the point.

17           So this is why we get to this point about the  
18 logarithmic relationship. Suppose now after the warming I double  
19 carbon dioxide concentrations again. You'll notice that it has  
20 the same impact as the first doubling on the reduction in  
21 radiation into space.

22           Because of the way temperatures fall off with height  
23 and the density of carbon dioxide molecules falls off with  
24 height, every doubling of carbon dioxide has the same impact as  
25 the last on outgoing energy into space.

1           So that's, in essence --

2           **THE COURT:** Okay. Say that last sentence again.

3 "Every" --

4           **DR. ALLEN:** Every doubling of carbon dioxide has  
5 roughly the same impact on the reduction of energy released to  
6 space as the last.

7           **THE COURT:** Well, give me a numerical example so that I  
8 can see that.

9           **DR. ALLEN:** So the first doubling might reduce outgoing  
10 radiation to space by 3.7 watts per square -- let's say 4 watts  
11 per square meter, for sake of the small number.

12           The second doubling, even though it requires twice as  
13 much additional carbon in the atmosphere to do it, would reduce  
14 outgoing radiation into space by an additional 4 watts per square  
15 meter.

16           And third doubling, which would require even more  
17 carbon, would also reduce radiation to space by 4 watts per  
18 square meter.

19           So the reduction in energy to space goes up four,  
20 eight, twelve, while the amount of carbon in the atmosphere goes  
21 up two, four, eight, sixteen.

22           **THE COURT:** Okay. I see what you're saying. I think I  
23 see what you're saying. All right.

24           **DR. ALLEN:** Crucially -- so this is the point here  
25 about if we compare that reduction with the impact of the first

1 doubling, we see the same reduction in energy.

2           Crucially, you don't need to take my word for it. I do  
3 appreciate you're taking the time to understand this, this  
4 element of the basic physics. But we have seen this effect  
5 happening in observations made of the planet from space.

6           In a truly impressive sequence, series of observations,  
7 NASA flew an interferometer on the Nimbus 4 spacecraft in 1970.  
8 And a very similar instrument was flown by a Japanese satellite  
9 in 1997.

10           And by comparing these two spectra, by comparing the  
11 outgoing infrared radiation measured by these two satellites 27  
12 years apart, John Harries, and his co-workers, in 2001 was able  
13 to identify the reduction in outgoing energy resulting from the  
14 increase in carbon dioxide and other greenhouse gases over the  
15 intervening 27 years.

16           So we've observed this effect that was predicted by  
17 Svante Arrhenius almost a hundred years earlier, we've observed  
18 it directly in satellite observations made of the planet as a  
19 whole.

20           **THE COURT:** Could you explain that graph?

21           **DR. ALLEN:** The graph at the bottom shows the spectrum  
22 of outgoing radiation. If you look very closely you can see  
23 there are two.

24           The difference between the two spectra's very small.  
25 This is a very fine and precise observation. It was only

1 possible because of the extraordinary precision of those NASA  
2 engineers building that interferometer back in the late 1960's.

3 But we can actually see the reduction in outgoing  
4 energy to space, the change in the spectrum in outgoing energy to  
5 space that we would expect because of the increase in greenhouse  
6 gas concentrations.

7 **THE COURT:** I still don't get it. Is one of these --  
8 is there a 1997 line?

9 **DR. ALLEN:** There's two lines there. One of the lines  
10 is 1970. The other line is 1997.

11 **THE COURT:** Are you sure? On mine it says "IMG" and  
12 "IRIS."

13 **DR. ALLEN:** Sorry. Yes. Yes. So the IRIS instrument  
14 was flown in 1970. The IMG instrument was flown in 1997. So  
15 they are 27 years apart.

16 **THE COURT:** But I don't see any -- they are so close  
17 together some people would say there's no difference. Where is  
18 the difference that you're pointing out?

19 **DR. ALLEN:** Well, the difference -- so I could -- I  
20 could give the Court a more detailed zoom-in on the figure from  
21 the Harries, et al paper. And I'd be happy to do so. I was just  
22 showing this spectrum as an illustration.

23 But there if you -- if you look carefully, as John  
24 Harries and co-workers did, at these two spectra, and also  
25 account for the various changes that have happened over the

1 intervening 27 year periods, you can see directly the reduction  
2 in outgoing energy due to carbon dioxide and other greenhouse  
3 gases and in precisely the wavelengths you would expect to. You  
4 would expect to find that.

5 **THE COURT:** Which part of the wavelength is infrared?

6 **DR. ALLEN:** The infrared spectrum is -- this is -- by  
7 the way, this is the near infrared. This is only part of the  
8 infrared spectrum because it wasn't possible to measure the full  
9 infrared spectrum with the interferometers they were able to fly  
10 in 1970.

11 But it shows for the wavelengths that they could  
12 observe the reduction expected due to the increase in greenhouse  
13 gases.

14 So the crucial point here is that we don't just have a  
15 theory that rising CO2 opaques the outgoing spectrum of  
16 radiation, but we have direct observations from space of that  
17 theory.

18 **THE COURT:** I have to take your word for it because  
19 this diagram, to me it looks like it was very -- the only place I  
20 see a reduction is on 1300. It looks to me like there there is a  
21 reduction but --

22 **DR. ALLEN:** Okay. I would --

23 **THE COURT:** My eyesight gone bad or what?

24 **DR. ALLEN:** Okay. I would happily -- there is a -- I  
25 would happily furnish the breakdown which they give in their

1 paper. I just put the spectrum in because --

2 **THE COURT:** You are the one that came up with the  
3 chart, and I just don't think your chart demonstrates what you're  
4 telling me. And I take your word for it that that's what they  
5 concluded. Okay. Good. I accept that point. But this chart  
6 doesn't convincingly show it.

7 **DR. ALLEN:** I'm sorry. I'm having to sort of take  
8 figures from scientific papers and sort of show illustrations of  
9 what we've done. And you are absolutely right. This doesn't, in  
10 itself, demonstrate the answer. And there are further diagrams  
11 in the paper which I could --

12 **THE COURT:** Forget the chart for a minute. When they  
13 did these satellite comparisons over the 27-year difference, what  
14 did they measure was the infrared reduction being emitted off the  
15 Earth in that twenty -- what was the reduction? Was it  
16 10 percent, a hundred percent? What order of magnitude?

17 **DR. ALLEN:** In the wavelengths -- in the wavelengths  
18 that were being affected, I mean I'd have to get the numbers.  
19 But they were seeing over that period -- a useful way of thinking  
20 of it is in terms of the equivalent temperature of those  
21 molecules. That's a useful unit to use.

22 They were seeing a reduction of several degrees in the  
23 equivalent temperature of the molecules they were observing at  
24 those particular wavelengths.

25 So it was a substantial change relative to the sort of

1 warming we talk about in terms of -- so they were seeing a  
2 substantial reduction in the wavelengths that are affected by  
3 these particular gases.

4 **THE COURT:** Okay.

5 **DR. ALLEN:** And, crucially, it was the reduction of the  
6 size and in the frequencies that we would have expected to see  
7 that reduction as a result of the increase in greenhouse gases.  
8 So we've observed this effect directly from space monitorings.

9 **THE COURT:** All right. So you jumped from Tyndall to  
10 the space satellite, but there must be something in-between. I'm  
11 interested in the history, too.

12 **DR. ALLEN:** Yes. I'm just coming back to the history.

13 So I was also going to stress that the models we use  
14 for weather forecasting incorporate this basic physics of how  
15 carbon dioxide and other constituents of the atmosphere interact  
16 with infrared radiation. And these are tested millions of times  
17 per day in performing the weather forecasts.

18 But to get back to the physics, Gilbert Plass, in 1955,  
19 during the sort of early part of the 20th century, he noted that  
20 there had been some criticism of this CO2 theory, because people  
21 had observed -- other scientists had observed that water vapor  
22 also absorbed strongly in the infrared wavelengths that were  
23 absorbed by carbon dioxide.

24 So in his paper in 1955, Gilbert Plass noted correctly  
25 that at the altitudes in the regions and also in the wavelengths

1 that matter for carbon dioxide, the air was relatively dry  
2 because they were above the moist lower atmosphere, and therefore  
3 carbon dioxide was the dominant greenhouse gas.

4           So even though people had noticed the water vapor  
5 absorbed strongly at the surface, as those diagrams illustrating  
6 the outgoing radiation to space actually emanates from further up  
7 in the atmosphere above the moist lower troposphere above the  
8 moist region near the surface where water vapor is less  
9 important.

10           It's still an important greenhouse gas, but carbon  
11 dioxide plays a big role because the radiation is emerging from  
12 these dry regions of the atmosphere where water vapor doesn't get  
13 in the way.

14           **THE COURT:** So okay. I'll save my questions.

15           Go ahead.

16           **DR. ALLEN:** Near the surface -- I mean, near the  
17 surface, so in the conditions in this room the main absorber will  
18 be water vapor because, you know, the surface, you know, is warm.  
19 It can hold a lot of water.

20           And so because of the enormous amount of water vapor in  
21 the atmosphere, the actual amount of attenuation by CO2 between  
22 one side of this room and the other would be less than the  
23 attenuation by water vapor.

24           However, Gilbert Plass' crucial insight was it doesn't  
25 matter what is happening in this room. What matters is what is

1 happening at the emission level, at the level at which the planet  
2 is actually radiating energy to space.

3 And at those altitudes, because we're higher up in the  
4 atmosphere and the air is colder, it can now hold less water.  
5 The air is dryer and CO2 plays a dominant role.

6 **THE COURT:** Is CO2 lighter than oxygen and nitrogen, or  
7 does that even matter, the relative weights?

8 **DR. ALLEN:** A CO2 molecule is heavier than nitrogen and  
9 oxygen, but it is -- that doesn't affect the fact that it is  
10 well-mixed through the atmosphere. The individual molecular  
11 weights only matter when you get right up into the fringes of  
12 the --

13 **THE COURT:** So the concentrations 10 feet above the  
14 Earth are about the same as at 10 miles above the Earth?

15 **DR. ALLEN:** In CO2, yes. But in water vapor absolutely  
16 not.

17 **THE COURT:** Right. Okay.

18 **DR. ALLEN:** Because water vapor, as we know, as soon as  
19 the air cools, condenses and so on. So there's much less water  
20 vapor around as you go up through the atmosphere.

21 **THE COURT:** So Gilbert Plass, his point again was what?

22 **DR. ALLEN:** Oh, his point was he picked up Arrhenius'  
23 work. He noted that over the intervening decades Arrhenius' work  
24 had been criticized by people observing strong absorption by  
25 water vapor.

1           And he then made the point, yes, there is strong  
2 absorption by water vapor at the surface, but at the altitudes  
3 that matter for the planet's energy budget, CO2 is still the  
4 dominant greenhouse gas.

5           So he -- I mean, it's interesting. It's been very  
6 interesting for me as going back over these papers, one tends to  
7 find the papers which are right, because they survive.

8           And so it's only in the sort of asides in these papers  
9 that you learn about the papers that were wrong.

10           And so evidently there were a bunch of papers published  
11 in the 1930S's, or so, sort of poo-pooing the carbon dioxide  
12 theory, because there were a lot of them that were talking about  
13 water vapor.

14           And so Gilbert Plass was pointing out yes, that  
15 absorption happens at the surface, but it doesn't -- it's not  
16 happening at the rate to interfere with CO2 at the altitudes that  
17 matter for the energy lost to space.

18           **THE COURT:** Okay.

19           **DR. ALLEN:** So coming home from this, Plass also  
20 emphasized the need -- having sort of reidentifying carbon  
21 dioxide as a very important greenhouse gas.

22           I sense you checking the time, but don't worry. That  
23 was the longest component of my talk.

24           **THE COURT:** I'm absorbed by this, but I want you to  
25 know that I am going to keep a clock on both sides.

1           **DR. ALLEN:** I do appreciate the constraint, and I will  
2 do my best.

3           So -- and so but the next -- but the question was still  
4 open in the 1950's, up to the 1950's: How much fossil fuel  
5 emissions were likely to affect the global atmosphere?

6           One thing which people had noticed was that there was  
7 40 times more carbon in the oceans than in our total fossil fuel  
8 reserves, even if you burnt the lot.

9           And so that might have made you think, well, you know,  
10 if we release all this carbon, it would just get diluted by the  
11 oceans, and it wouldn't really make very much difference in the  
12 long run.

13           Roger Revelle, in 1957, made the crucial observation  
14 that some simple high school chemistry, sort of buffer chemistry,  
15 limits the amount of carbon dioxide that the ocean can take up.

16           Carbon dioxide -- well, carbon exists in the ocean in  
17 three forms. If we -- if you'll bear with me and we ignore  
18 biology for the time being.

19           The three forms are dissolved carbon dioxide, the  
20 hydrogen carbonate ion,  $\text{HCO}_3^-$  and the carbonate ion.

21           **THE COURT:** Say the last one again?

22           **DR. ALLEN:** The hydrogen carbonate ion,  $\text{HCO}_3^-$ , single  
23 minus, and the carbonate ion,  $\text{CO}_3^{2-}$  ions.

24           Every molecule of carbon dioxide that dissolves into  
25 the ocean, requires the conversion of a carbonate ion to a

1 hydrogen carbonate ion in order to preserve charge.

2           It's a simple -- the operation of a buffer, the kind of  
3 things that one uses at school to maintain a constant pH.

4           It's a good thing this is happening, because otherwise  
5 the oceans would have acidified much more than they have done as  
6 a result of the solution of carbon dioxide into the oceans.

7           But what it does mean is it's that store of carbonates  
8 in the oceans that actually determines the capacity of the oceans  
9 to take up CO<sub>2</sub> from the atmosphere. And only 10 percent of the  
10 carbon in the oceans is in the form of carbonate.

11           So Revelle's insight was that actually the oceans were  
12 ten times smaller than you might think as a carbon pool. And  
13 that, therefore, we couldn't count on the oceans to simply dilute  
14 away all the carbon we have been releasing from fossil fuels.

15           **THE COURT:** Is it true that Revelle initially thought  
16 that the oceans would absorb all of the excess, and that he came  
17 to this buffer theory a little later around 1957?

18           **DR. ALLEN:** You may know more of the history of this  
19 than I do in that case. I'm aware, as I say -- I read the right  
20 papers. I read the final papers, so to speak. So this is the  
21 paper.

22           Actually, I suspect it probably was the case in the  
23 sense that he was thinking about the problem.

24           **THE COURT:** He was an oceanographer. Right?

25           **DR. ALLEN:** He was an oceanographer. He was thinking

1 about the problem.

2 **THE COURT:** Scripps.

3 **DR. ALLEN:** Exactly. He was at Scripps. And in the  
4 process of thinking about the problem he came to this crucial  
5 insight. And it was a good insight at the time.

6 Up until that time, you know, the community, they  
7 weren't sure how long it would take for the carbon to be taken up  
8 by the oceans. But the community were just aware there was this  
9 vast carbon store in the oceans. And, therefore, there was some  
10 doubt in the community as to whether fossil fuel emissions would  
11 actually make any difference.

12 So having made this observation, Roger Revelle, he  
13 emphasized -- and I think he used the phrase:

14 "We're conducting geophysical experiments." And  
15 he emphasized the importance of measuring CO<sub>2</sub> in the atmosphere  
16 to see if it was actually going up.

17 Which brings us to the next crucial step in our story.

18 Charles David Keeling, also at Scripps, measured --  
19 started measuring carbon dioxide in the atmosphere, Mauna Loa in  
20 Hawaii, very precisely in the late 1950'S.

21 And he saw the famous Keeling Curve, this annual cycle  
22 of carbon dioxide resulting from the, in effect, the respiration  
23 of the northern hemisphere. And -- but on top of that, a steady  
24 increase which could you not account for by respiration.

25 The Court asked essentially about what happens to

1 carbon dioxide breathed in by humans and, indeed, by animal life  
2 and so forth.

3           That does play a role in determining this annual cycle.  
4 So the annual cycle shows the sort of annual growth and the  
5 annual growth and decay of forests in the northern hemisphere  
6 taking up and releasing carbon. But it cannot account for the  
7 upward trend.

8           And, in fact, we're seeing carbon dioxide levels rising  
9 to levels that have not been seen for over 20 million years.

10           They are now past -- well past 400 parts per million,  
11 around 410 parts per million.

12           **THE COURT:** Keep that chart there.

13           **DR. ALLEN:** This --

14           **THE COURT:** Explain the ones you have on the screen,  
15 please.

16           **DR. ALLEN:** Yes. So this chart shows the combination  
17 of David Keeling's observations in blue on the right, and ice  
18 core measurements of carbon dioxide going back over much longer  
19 period, back to zero on the left.

20           So those two different time scales here, the left-hand  
21 panel has almost ten times longer time scale. And because, of  
22 course, we can measure carbon dioxide contained in bubbles in ice  
23 very precisely back over many thousands of years, and we see that  
24 carbon dioxide concentrations have been relatively constant  
25 throughout the Holocene period.

1           **THE COURT:** This is -- that's like a 2000 year?

2           **DR. ALLEN:** Two thousand year record. Almost no  
3 change. In fact, I could take that record a few thousand years  
4 beyond that, it would also be flat.

5           **THE COURT:** You said 20 million at the top, but it's  
6 really only 2000. Is that right or am I --

7           **DR. ALLEN:** Yes. I've got another figure addressing  
8 that in a minute.

9           **THE COURT:** But let's pause on this one.

10           Let's see. It starts down at 280. I can't read that.

11           **DR. ALLEN:** The preindustrial concentration's around  
12 280 parts per million, and we are now at 400, 410.

13           **THE COURT:** All right. So that is -- that's not a  
14 doubling, but what is that?

15           **DR. ALLEN:** Well, we're about in the units we need to  
16 use, which are, of course, logarithmic, we are just over halfway  
17 to doubling.

18           **THE COURT:** Say that again about logarithmic?

19           **DR. ALLEN:** Sorry. But you remember our discussion  
20 earlier about the fact that --

21           **THE COURT:** I do, but --

22           **DR. ALLEN:** So because there's a curve -- in fact,  
23 there was a paper my colleague just pointed this out. We crossed  
24 the halfway mark to doubling last year.

25           **THE COURT:** But when Arrhenius said "doubling," he

1 wasn't talking logarithmic, was he? Or is that something you've  
2 added to it?

3 **DR. ALLEN:** No, he was -- I mean, the point about the  
4 logarithmic relationship is the fact that every doubling --

5 **THE COURT:** Did he use the word "logarithmic"?

6 No.

7 **DR. ALLEN:** Yes.

8 **THE COURT:** No.

9 **DR. ALLEN:** Logarithmic? Well, he was writing --

10 **THE COURT:** Did he use -- in his paper did he use the  
11 word "logarithmic"?

12 **DR. ALLEN:** I'm not sure. He was writing --

13 **THE COURT:** Arrhenius, I'm talking about.

14 **DR. ALLEN:** Yes. No. He talked about the logarithm of  
15 carbon dioxide. He talked about the fact that --

16 **THE COURT:** No. No. That doubling thing.

17 **DR. ALLEN:** Yes.

18 **THE COURT:** Did he say that would be a logarithmic  
19 function?

20 **DR. ALLEN:** Well, it is a logarithmic function. If we  
21 go back to that quote --

22 **THE COURT:** No. I'm asking: Did he say that?

23 **DR. ALLEN:** Whether he used the word "logarithmic" in  
24 his paper, I mean, I don't know.

25 **THE COURT:** Okay. Don't answer. It's okay. But I

1 don't want you reading modern day politics into this. I'd just  
2 like to know did he say it was a logarithmic relationship?

3 **DR. ALLEN:** So whether said -- whether he used the word  
4 "logarithmic," mathematically, if he said something equivalent,  
5 mathematician wouldn't care what word he used.

6 **THE COURT:** Yes, but the two examples he gave are not  
7 necessarily -- it could also be linear.

8 **DR. ALLEN:** Yes.

9 **THE COURT:** The doubling and quadruple thing.

10 **DR. ALLEN:** Yes. Yes.

11 **THE COURT:** If you look at those, that part if it's  
12 both linear and logarithmic.

13 **DR. ALLEN:** If a double -- if a doubling has the same  
14 impact as the last doubling, then it's logarithmic. If a  
15 doubling -- if the second doubling has twice as much impact as  
16 the first doubling, then it's linear.

17 **THE COURT:** Okay.

18 I'm not sure I agree with that.

19 **DR. ALLEN:** Can I use the board?

20 **THE COURT:** Well, first go back to -- if we are going  
21 to argue about this, go back to the very first chart where you  
22 quoted him.

23 **DR. ALLEN:** Arrhenius.

24 **THE COURT:** I want to see the Arrhenius chart.

25 Here we go. Right there. So he says any -- so 2X

1 equals 4C. Right?

2 **DR. ALLEN:** Yes.

3 **THE COURT:** And 4X equals 8C.

4 All right? So I readily agree that that would fit a  
5 logarithmic, but for just two data points which is all we got  
6 here. Doesn't it also fit a linear function?

7 **DR. ALLEN:** You also have the third data point, which  
8 is preindustrial equals 0C. So 1X equals 0C. So there are three  
9 data points, because if you have no increase in carbon dioxide,  
10 then you have no warming.

11 So that's why there are three points.

12 **THE COURT:** Wait. So you're saying 0X. All right.  
13 Let's say 0X would equal --

14 **DR. ALLEN:** 1X. 1X. 1X equals 0C, meaning same as  
15 preindustrial.

16 **THE COURT:** All right. So I have to think about  
17 whether or not that's right. But I'll that your word for it that  
18 that is a logarithmic.

19 Okay. All right. I'm using up your time with my dumb  
20 questions. Okay. Go ahead.

21 **DR. ALLEN:** Okay. So where do we go to. Keeling and  
22 what's happened to carbon dioxide. So confirmation that this  
23 carbon dioxide was being created by combustion and not, for  
24 example, just being released by the oceans because of the warming  
25 was provided by some observations by Ralph Keeling, also Scripps,

1 Charles Keeling's son, who showed that oxygen concentration in  
2 the atmosphere was falling at the same rate that CO<sub>2</sub>  
3 concentration was rising, because, of course, to create a  
4 molecule of CO<sub>2</sub>, you need a molecule of oxygen, if you are  
5 creating that CO<sub>2</sub> by burning carbon.

6           So that confirmed that this increase in CO<sub>2</sub> in the  
7 atmosphere was being -- was caused by burning something, if there  
8 was any remaining doubt about that question.

9           We could also see from the lower panel here the  
10 isotopic signature. That's the ratio of carbon 13. Carbon 13  
11 means it's a form of carbon which has 13 nucleons rather than the  
12 normal 12.

13           That isotope of carbon was declining again at precisely  
14 the rate we would expect if this additional CO<sub>2</sub> in the atmosphere  
15 was appearing there because of combustion.

16           **THE COURT:** I haven't -- explain this upward chart here  
17 that has the green line going --

18           **DR. ALLEN:** The green line going up is this CO<sub>2</sub>.

19           **THE COURT:** I got that. What is the blue line then?

20           **DR. ALLEN:** The blue line are observations of the  
21 concentration of oxygen in the atmosphere.

22           Now, oxygen is almost 29 percent of the atmosphere is  
23 oxygen. So there's a lot more oxygen around. But oxygen  
24 concentrations are falling ever so slightly because we're using  
25 up the oxygen to burn the carbon to make the CO<sub>2</sub>.

1           **THE COURT:** Okay.

2           **DR. ALLEN:** So in --

3           **THE COURT:** And where did that data come from?

4           **DR. ALLEN:** The oxygen data?

5           **THE COURT:** Yes. I was wondering about that very point.

6 If the amount of oxygen -- I know it's many times greater, but I  
7 had wondered, well, is it actually falling off ever so slightly?

8           And one of the books I looked at said that they  
9 couldn't measure it. But you're telling me they have measured  
10 it.

11           **DR. ALLEN:** It's been measured. It's very delicate  
12 measurements, because obviously there's a lot of oxygen there, so  
13 it's actually quite hard to measure a very tiny percentage-wise  
14 reduction. But he did measure it and he saw this very clear  
15 reduction in the ozone.

16           **THE COURT:** Who measured that?

17           **DR. ALLEN:** Ralph Keeling, Charles Keeling's son,  
18 actually did the oxygen measurement. And that was done in the  
19 1990's. So --

20           **THE COURT:** What was the -- did the parts per million  
21 of oxygen decline somehow correspond to the increase in CO2?

22           **DR. ALLEN:** The reduction in oxygen was exactly the  
23 rate that was expected if all of the CO2, all of the additional  
24 CO2 in the atmosphere was appearing there because of combustion.  
25 So this --

1           **THE COURT:** I'd be very interested in reading that. Is  
2 that in a paper someplace?

3           **DR. ALLEN:** Absolutely.

4           **THE COURT:** Okay. Can you tell me --

5           **DR. ALLEN:** Yes, I can provide that to the Court.

6           **THE COURT:** All right. Thank you.

7           **DR. ALLEN:** So now we get to the breakdown of where  
8 this carbon dioxide is coming from. These are the key sources of  
9 emissions per year over the past century. And as you can see up  
10 until the middle of the century the beige band, which is the  
11 emissions from land use change actually were more than half the  
12 total that the contributions from fossil fuels, coal, oil and gas  
13 have taken off in the second half of the 20th century.

14           If we add up these emissions over time, so this is  
15 taking those -- this --

16           **THE COURT:** Wait. Wait. Wait. Keep that. That's a  
17 very interesting chart. Who is the -- who constructed that  
18 chart?

19           **DR. ALLEN:** This is data from the Global Carbon  
20 Project, led by Corinne Le Quere, at the University -- now at the  
21 University of East Anglia. And they compile information on both  
22 where carbon is coming from and where it's going to in the global  
23 carbon cycle.

24           **THE COURT:** Okay. So go back to the one you had up.  
25 Yes, that one. Just a minute. Let me -- "Land-use changes." Is

1 that deforestation? What's included?

2 **DR. ALLEN:** Deforestation would be a big part of that.  
3 Also, conversion of land for agriculture. I mean, land-use  
4 changes is meant to be a value system. It's a formatted work.

5 And the key message of this is that land-use change  
6 emissions were really important up until mid-century. They have  
7 actually been declining in absolute terms since over the past few  
8 decades. And in relative to fossil fuels emissions, of course,  
9 they are now a relatively small fraction of the total.

10 **THE COURT:** And what's in the category of "Others"?

11 **DR. ALLEN:** That would be mostly cement manufacturing.

12 **THE COURT:** Gas is natural gas? Is that what that  
13 means?

14 **DR. ALLEN:** Yes, natural gas.

15 **THE COURT:** Hard to tell the difference between oil and  
16 the coal. I can't quite see it. Is there a difference? On my  
17 screen it's impossible to tell, but roughly present day what  
18 would be the difference.

19 **DR. ALLEN:** Present day emissions would be roughly --  
20 of that lower band it would be roughly fifty/fifty oil, coal.

21 **THE COURT:** Okay.

22 **DR. ALLEN:** So if we go to -- so this shows exactly the  
23 same data, but just added up over time. So accumulating these  
24 emissions over time, and we can see from this that half of total  
25 emissions from fossil fuels into the atmosphere have occurred

1 since 1980.

2           And we can also see the contribution from products sold  
3 by individual companies has also increased rapidly since the  
4 1960's So it's possible to trace these emissions directly to  
5 products sold by individual companies.

6           Thanks to the work of the Global Carbon Project we  
7 understand where this carbon is going. About half of it is  
8 accumulating in the atmosphere. That's the pale blue band here  
9 (indicating). And other half is being taken up by the land and  
10 the oceans.

11           So the Court asked specifically about whether plants  
12 take up this additional carbon dioxide. And the answer is they  
13 do through something called a "CO2 fertilization effect." Plants  
14 grow faster in a higher CO2 world, and so they are taking up some  
15 of the excess carbon dioxide being put into the atmosphere.

16           Unfortunately, because of the warming that is going on,  
17 an even more important store of carbon on land, which is the  
18 carbon in soils, may actually start to release carbon because  
19 soil bacteria respire, and then release that carbon dioxide back  
20 into the atmosphere.

21           So the general consensus is that the ability of the  
22 land to take up excess carbon will weaken through the century,  
23 and it may even turn into a source.

24           Two: The crucial point here, and the main point of  
25 this is if you look at the thin, dotted line at the top here

1 which is the total input from the sources, you can see that we  
2 can understand where that carbon has gone. So we know where the  
3 carbon is coming from, and we know where it's going. And about  
4 half of it is remaining in the atmosphere.

5 **THE COURT:** Wait. Let's try to digest this.  
6 "Atmosphere" I understand. "Ocean sink" I understand. What does  
7 "land sink" mean?

8 **DR. ALLEN:** That is the additional carbon which is  
9 being taken up by plants and soils in the land biosphere as a  
10 result of the plants growing faster, for example, due to the CO<sub>2</sub>  
11 fertilization effect.

12 **THE COURT:** So let's say that we have the world pumping  
13 exhaust out of our collective tailpipes and the smokestacks and  
14 lots of CO<sub>2</sub> that is definitely going into the atmosphere. So  
15 does this imply that some of that that goes into the atmosphere  
16 is then getting absorbed by plants for the green part, but it's  
17 from the atmosphere?

18 **DR. ALLEN:** So individual molecules are being cycled  
19 around all the time between these three different pools of  
20 carbon. What we're seeing here is the impact of the additional  
21 carbon dumped into the atmosphere on the carbon stored in both  
22 land and ocean. And you can see the more carbon is being stored  
23 on land than was before.

24 But, as I say, because of the impact of rising  
25 temperatures on soil bacteria, the concern is that the ability of

1 the land to take up extra carbon may be becoming exhausted  
2 sooner, for example, than the ocean sink is likely to get  
3 exhausted.

4 I mentioned earlier Revelle's work showing that the  
5 ocean sink was smaller than expected. Well, we also have a land  
6 sink here, which is more complicated, involves more biology. But  
7 the result, there is evidence it's running out and its ability to  
8 take up half, to take up a quarter of the carbon we are putting  
9 into the atmosphere is running out.

10 **THE COURT:** In just a couple of sentences, what is that  
11 evidence that the land sink is running out of space?

12 **DR. ALLEN:** We know that as we warm soils, the bacteria  
13 in the soils -- there's more biomass in the world in the form of  
14 bacteria than just about anything else. So anything that changes  
15 the behavior of bacteria has a really big impact on global carbon  
16 cycle. And as we warm back the soil, bacteria respire faster,  
17 and then they convert carbon in the soil to CO<sub>2</sub> just through  
18 respiration.

19 So that is a well-documented effect. But the magnitude  
20 of this effect is quite uncertain. So we don't know  
21 whether -- we know that it will reduce the effectiveness of the  
22 carbon sink.

23 We don't know whether it will be strong enough to turn  
24 it into a net source.

25 **THE COURT:** Okay.

1           **DR. ALLEN:** I now go to understanding the earlier, to  
2 understand the impact of increasing carbon dioxide concentrations  
3 on temperature. Just to come back to where -- you know, where  
4 we've got to, the increase in CO2 and other forms of pollution in  
5 the atmosphere to date is a perturbation on the global energy  
6 budget of two-and-a-half watts per square meter. Two-and-a-half  
7 watts per square meter is the power consumption of a not very  
8 efficient cell phone.

9           So it doesn't sound like a very large amount of energy,  
10 but, of course, because the Earth surface area is so large it  
11 adds up to twelve-and-a-half million Terawatt hours per year, or  
12 60 times global primary energy consumption.

13           So one of the questions the Court asked is: What  
14 happens to the energy that is actually generated by combustion of  
15 fossil fuels?

16           And the answer is: That energy, it might have a local  
17 impact in the vicinity of a power station or something. But  
18 globally, it's completely dwarfed by the impact of the emissions  
19 from those fossil fuels on the global climate through their  
20 interaction with infrared radiation.

21           **THE COURT:** Help me understand that part. So heat, the  
22 heat that is created by combustion, does that somehow -- I know  
23 your point about -- I understand you're making the point about  
24 the CO2 is much more important to look at than the heat itself.  
25 But I do want to understand the heat part.

1           So we have heat -- technical name.

2           **DR. ALLEN:** Yep.

3           **THE COURT:** That is burning up and very hot, if you  
4 touch it. So that heat, does that at some point get converted to  
5 infrared energy?

6           **DR. ALLEN:** Yes.

7           **THE COURT:** Which then tries to get out in space?

8           **DR. ALLEN:** Yes. It becomes -- it warms the  
9 atmosphere. It eventually will be emitted in space as infrared  
10 energy.

11          **THE COURT:** How does it get converted? Does all  
12 heat -- does all just normal, thermal heat immediately start  
13 radiating infrared?

14          **DR. ALLEN:** Yep. Yep. It would potentially warm the  
15 air around it, for example, just directly warm the air. Or if it  
16 was water vapor being released from a cooling tower, then it  
17 would be released in the form of latent heat of water vapor in  
18 that steam. And then, that would condense. Many ways that that  
19 heat would escape into the atmosphere.

20                 But its ultimate fate is same as all other heat, which  
21 is it radiates on in space as infrared radiation. But the  
22 crucial point here is that heat source is tiny compared to the  
23 impact of the emissions of CO2 on outgoing radiation through that  
24 impact on the greenhouse effect.

25          **THE COURT:** Is there any other planets in the solar

1 system like Venus, maybe, that has an atmosphere that's more  
2 concentrated in CO2?

3 **DR. ALLEN:** Venus absolutely has a lot of CO2 in the  
4 atmosphere. And, in fact, one of the best tests of our  
5 understanding of the behavior of atmosphere is to look at other  
6 planets and understand. We use the same models that we use the  
7 model CO2 on our planet. We use those models to model the  
8 behavior of other planets' atmosphere. And it's an excellent  
9 test of the physics which we incorporate into those models. And  
10 one --

11 **THE COURT:** What happens on Venus? How hot is it  
12 there?

13 **DR. ALLEN:** Well, the surface of Venus is extremely hot  
14 because it has what some call a sort of "super greenhouse  
15 effect."

16 The Venusian atmosphere is very different from the  
17 Earth. I'm also not a -- I mean, it has a very dense cloud  
18 cover, so the radiating temperature from Venus is determined by  
19 the temperature of very high clouds. Underneath the clouds, you  
20 have just like on Earth, you have this increase of energy with  
21 depth which just results from the fact that the atmosphere is  
22 getting more dense as it goes down.

23 And as a result, the surface of Venus is at many  
24 hundreds of degrees --

25 **THE COURT:** How about Mars? Doesn't it have CO2?

1           **DR. ALLEN:** Mars has only a very thin atmosphere, and  
2 it doesn't have enough CO<sub>2</sub>. It doesn't have enough of an  
3 atmosphere to keep the surface warm, so Mars is relatively cold.

4           **THE COURT:** All right. So I'm using up -- your hour is  
5 up, but why don't you take five more minutes to wind up your  
6 first part of your presentation?

7           **DR. ALLEN:** Right. Okay. So there's sort of a natural  
8 break coming up pretty soon.

9           So we're in this situation. We've disturbed the global  
10 energy balance. And you can think of the global energy budget as  
11 like a bathtub. We've got an additional two-and-a-half watts per  
12 square meter going in because of this increase in greenhouse gas  
13 concentration. This is the situation I'm describing today.

14           We've got an additional 1.75, one-and-three-quarter  
15 watts per square meter going out because of the warming that's  
16 already happened. And there's a difference between those two  
17 numbers. So we have an additional three-quarters of a watt per  
18 square meter accumulating in the climate system.

19           **THE COURT:** The one where it says "1.75," does that  
20 mean it's going into space?

21           **DR. ALLEN:** It's going back out into space because the  
22 planet is already warmed as a result of past emissions.

23           And we can see this energy imbalance accumulating  
24 crucially in the world ocean. This is another very important  
25 milestone was that we were able to see the energy imbalance

1 thanks to observations from Sydney Levitus.

2           And in 2000, he was able to show that the global oceans  
3 were warming again at the rate we would expect as a result of the  
4 energy imbalance due to the increase in greenhouse gas  
5 concentrations.

6           Which brings us to the way which we've framed our  
7 understanding of the climate system in terms of the global energy  
8 budget. And if I can have about -- as you say, I have about five  
9 more minutes --

10           **THE COURT:** Please go ahead.

11           **DR. ALLEN:** -- I can finish at a natural break. This  
12 is the way -- this is the only equation in my talk. It shows the  
13 situation now.

14           By the way, our understanding of the global energy  
15 budget was a lot of it down to the work of Stephen Schneider in  
16 the 1970's. Stephen Schneider, from Stanford. In fact, I'm sure  
17 if Stephen Schneider was alive today he would certainly be in  
18 this courtroom and probably giving this tutorial. So I'm doing  
19 my best.

20           We've already said the net energy imbalance due to  
21 external drivers about two-and-a-half watts per square meter.

22           We have the warming due to preindustrial of about 1  
23 degree. And we also have this additional .75 degrees going into  
24 the oceans.

25           In equilibrium, we know what the forcing would be due

1 to CO<sub>2</sub>. That's 3.7 watts per square meter. And we know that the  
2 equilibrium warming, the thing which people have often been  
3 trying to work out, is what is the equilibrium warming due to  
4 doubling CO<sub>2</sub>.

5           And the crucial part about this equation, this is an  
6 equation to represent the behavior of the climate system. But it  
7 contains two unknown quantities, these lambda and mu terms,  
8 which represent the additional radiation to space per degree of  
9 warming that results from the warming. And this is something  
10 which is -- which we can't derive. We can't observe it directly.  
11 It's not something we can observe. It's something we have to  
12 infer from other things.

13           And also an extra term, which is the additional energy  
14 released into space due to the fact that the system is now in  
15 disequilibrium.

16           And so we can work out the response to doubling CO<sub>2</sub> by  
17 putting all the mechanisms that we think affect these lambda and  
18 mu terms into a computer simulation. And this is the sort of  
19 bottom-up estimate of how we estimate the warming due to doubling  
20 CO<sub>2</sub> that is done with global climate models.

21           And the first of these modeling experiments were done  
22 by -- first of all, by Manabe and Wetherald in 1967, using a  
23 single-column model, which modeled the entire Earth as a spatial  
24 average. And then, later on in 1975, was using three-dimensional  
25 general circulation models.

1           It's important to stress these complex climate models  
2 get a lot of attention in the discussion of climate change, but  
3 they have appeared relatively late in my talk.

4           They weren't essential to our understanding of the  
5 impact of enhanced greenhouse warming.

6           Drawing all this together, drawing both our  
7 understanding of basic physics and understanding of the -- both  
8 understanding of the basic physics and the early simulations from  
9 global climate models, the 1979 National Academy of Sciences was  
10 able to draw the conclusions that they were expecting a warming  
11 of between one-and-a-half and four-and-a-half degrees for the  
12 equilibrium warming on doubling CO2.

13           They also stressed -- and I suspect we can detect the  
14 hand of Carl Wunsch in these sentences -- that the oceans could  
15 delay the estimated warming for several decades. And, crucially,  
16 they made the statements:

17                        "We may not be given a warming until the CO2  
18 loading is such that an appreciable climate change is  
19 inevitable."

20           So they not only identified the possibility of a  
21 serious warming, but they also recognized that it was going to be  
22 potentially awhile before we could see what was happening  
23 directly in the observations.

24           Reading these papers, it seems to me the situation in  
25 the late 1970's was somewhat analogous to a doctor who detects a

1 virus count going up in a patient, but the patient has not yet  
2 developed a fever.

3           And the doctor might know that there's a one in three  
4 chance that the patient is resistant in which case the virus  
5 might continue up, but there would be no further symptoms. But  
6 there's a two in three chance that the patient could actually end  
7 up getting very sick. And so that's really the situation they  
8 were in.

9           They knew that if they waited until the patient  
10 developed a fever so that they knew whether or not it was a  
11 resistant patient or not, it would be too late to do anything  
12 about it. But they could see the virus is going up if you think  
13 of the virus as analogous to the CO<sub>2</sub> molecules in the atmosphere.

14           So that seems to me to be a way of assessing their  
15 state of mind at the time.

16           And just to finish up, I want to sort of show you that  
17 it wasn't necessary for scientists in the late 19th century --  
18 the late 1970's to detect the warming, in order for them to  
19 predict what was likely to happen next because of the fossil fuel  
20 emissions.

21           This is a figure from a paper by William Nordhaus, an  
22 economist from Yale. He was drawing from the climate science  
23 that was available at the time. And the dashed line on this  
24 figure shows his projection of the impact of rising CO<sub>2</sub> on future  
25 temperature that results under a business-as-usual scenario of

1 continued emissions.

2           And on the right here I'm showing you what has  
3 happened. And that's observed temperatures. I'm showing the  
4 pre-1977 observations in blue, red -- and the post-1977  
5 observations in red.

6           And if I slide those over each other we realize that it  
7 was possible for scientists in the 1970's to make a remarkably  
8 accurate prediction of what has actually happened since 1980 to  
9 global temperatures.

10           And speaking as a climate scientist, I find it slightly  
11 sobering that such an accurate prediction was made when I was  
12 barely out of primary school. So --

13           **THE COURT:** Did he do this without the aid of computer  
14 models?

15           **DR. ALLEN:** He was using the results from the computer  
16 models that Syukuro Manabe and Richard Wetherald had run, but he  
17 was incorporating those results into a simple computer model of  
18 the climate system, and he was coupling that to make a computer  
19 model of the global economy, as well.

20           So this was the early efforts of the so-called  
21 "integrated assessment model exercise."

22           I think that's actually a good point to sort of  
23 illustrate to you the state of thinking at the end -- at the end  
24 of the 1970's.

25           The rest of my talk was about understanding how we

1 detected human influence on the global climate over the more  
2 recent decades and the discussion of the role of natural and  
3 human influences.

4 **THE COURT:** Well, are you the witness who needs to go  
5 somewhere or is that somebody else?

6 **MR. BERMAN:** Somebody else.

7 **THE COURT:** Well, we're well past the one hour, so I  
8 think we have to move on.

9 And so, Dr. Allen, you are a genius. And thank you for  
10 helping me to understand this. I hope you stay with us for a  
11 while in case some other question comes up.

12 **DR. ALLEN:** I'm very happy to stay around. Thank you.

13 **THE COURT:** Thank you.

14 Let's see. Is it 20 minutes that you wanted? Tell me  
15 what your druthers are on time.

16 **MR. BERMAN:** We need 20 minutes.

17 **THE COURT:** Let's do the 20 minutes now, and then we'll  
18 take a break.

19 **MR. BERMAN:** Yes.

20 **THE COURT:** Can we do that?

21 **MR. BOUTROUS:** Yes, Your Honor. In part two of your  
22 topics you asked for a tutorial on the best science on CUIs and  
23 coastal flooding. So we're going to call Professor Gary Griggs  
24 to explain that topic to you.

25 **THE COURT:** Very good.

1                   **MR. BERMAN:** Professor Griggs has a Ph.D. in  
2 oceanography. He's at the University of California at Santa  
3 Cruz. His resume is in your notebook. And also in your  
4 notebook, Your Honor, we did a Q and A of the questions you  
5 asked, the eight questions. There's a Q and A to those in your  
6 notebook.

7                   **THE COURT:** Thank you.

8                   All right. So you're Professor Griggs?

9                   **PROFESSOR GRIGGS:** Correct, Your Honor.

10                  **THE COURT:** From The Cruz.

11                  **PROFESSOR GRIGGS:** The Cruz. I'm a banana slug.

12                  **THE COURT:** The Cruz. That's where my daughter went,  
13 The Cruz. Okay. So please go right ahead.

14                  **PROFESSOR GRIGGS:** Thank you for the opportunity to  
15 speak today. And I'm going to be talking primarily about sea  
16 level rise and how that relates to the climate change and also  
17 San Francisco Bay.

18                         So the initial slide is just showing high tide today on  
19 the Embarcadero. Doesn't take physics or math to understand  
20 that.

21                         This is just sea level for last 18,000 years. And sea  
22 level responds, very closely corresponds to climate change.

23                         If we heat up the climate, heat up the Earth, ocean  
24 water expands and ice melts, which both raise sea level. And  
25 that's been happening -- we've had climate change happening ever

1 since we've had an Earth and a Sun going back four-and-a-half  
2 billion years, plus or minus a few million. So as the --

3 **THE COURT:** What do you think caused the ice age?

4 **PROFESSOR GRIGGS:** We know the Milankovitch cycles,  
5 which you probably read about, where --

6 **THE COURT:** Yes, I did read about that.

7 **PROFESSOR GRIGGS:** Three orbital cycles with the Earth  
8 and the Sun. One of these is a wobble. It has a cycle of about  
9 26,000 years. One is a tilt on the axis which gives us the  
10 seasons which has a cycle of about 42,000 years, and that tilt  
11 actually increases and decreases which takes us a little further  
12 away from the sun.

13 And then, the earth's orbit around the sun is an oval,  
14 or an ellipse rather than a circle. So that takes the Earth a  
15 little further away from the sun.

16 When you put all those three together, we start to see  
17 warmer and cooler periods that can begin to bring on an ice age.  
18 but there's also some feedbacks working. So, for example, as the  
19 Earth starts to heat up from those orbital cycles, the ocean gets  
20 warmer. It's releases carbon dioxide, which then adds to the  
21 warming.

22 We start to melt the Artic ice back. And instead of  
23 ice, which reflects sunlight, we have ocean left which absorbs  
24 heat. So that also adds to the heating effect. And permafrost  
25 starts to thaw and it gets warmer and more CO2 and methane are

1 released.

2           So those we call "positive feedback loops." So  
3 those -- it's unclear if the Milankovitch cycles, those orbital  
4 cycles can completely bring on an ice age by themselves. But the  
5 timing fit's perfectly with those hundred thousand year, 42,000  
6 year.

7           **THE COURT:** Does the oval elliptical -- I think you  
8 called it "elliptical orbit" -- does that change or around the  
9 sun or is that fixed, but the other two wobble?

10           **PROFESSOR GRIGGS:** So all three are changing on those  
11 cycles so that oval that takes us a little further away, and then  
12 comes back again, has a cycle of about a hundred thousand years  
13 until it returns to where it was before.

14           That wobble, roughly 26,000 years till it's back where  
15 it was. So each of those takes us a little further from the sun  
16 and brings us a little closer over time to bring on glacial and  
17 interglacial --

18           **THE COURT:** One last question on this. If the northern  
19 hemisphere and the north pole gets frozen over, does that then  
20 mean that the southern is exposed more to the sun and is  
21 tropical? What is the answer there?

22           **PROFESSOR GRIGGS:** Certainly during -- I mean, we're in  
23 northern hemisphere winter now. So this is the sun. The axis  
24 rotation, it's tilted, so we're further away and the southern  
25 hemisphere is having their summer.

1           When we get on the opposite side, we're now facing the  
2 sun.

3           **THE COURT:** Right.

4           **PROFESSOR GRIGGS:** If we go back in geologic time, we  
5 have had extremes. Again, before there were humans on the  
6 planet, we've had a period we call "hot house Earth" when all the  
7 ice melted. We had fossils of palm trees and alligators in the  
8 Artic.

9           And we've had a period called "snow ballers" when we  
10 think the entire Earth was frozen due to changes in things like  
11 methane released from the ocean. Some other things we're still  
12 starting to understand. So it may not be tropical in the South  
13 Pole, but it would be different temperature depending on  
14 whether --

15           **THE COURT:** It would not be frozen over like the  
16 north -- in other words, if the North Pole was completely Artic  
17 and frozen, then the South Pole would be warmer than normal; is  
18 that right?

19           **PROFESSOR GRIGGS:** Depending on where we are in our  
20 climate cycle.

21           The other difference is the South Pole Antarctica is a  
22 continent with ice on it, which we'll talk about in a second,  
23 whereas the North Pole is a sea covered with floating ice.

24           So the point here is at the end of the last ice age,  
25 about 18,000 years ago, things started to warm up quickly, and

1 sea level rose quite rapidly, maybe a half an inch a year until  
2 about 8,000 years ago.

3           Again, this is in the absence of any real human  
4 activity on the Earth that was affecting that. Within that,  
5 however, within that rise there was some periods when sea level  
6 rose maybe an inch a year, which we can almost stand out there  
7 and watch. We think now those were due to ice sheet collapse in  
8 Antarctica, which is a concern.

9           About 8,000 years ago, sea level leveled off, and for  
10 the next 8,000 years, which corresponds to essentially the entire  
11 period of human civilization, sea level was constant.

12           So civilization has never before had to deal with a  
13 rapid change in sea level. Very slow rise over that period.  
14 That red dashed line is the present average rate of sea level  
15 rise from satellite measurements, a little over a foot per  
16 hundred years.

17           And in all likelihood, with the increasing greenhouse  
18 gas emissions and increased warming that rate is going to  
19 increase, and that's the thing that many of us are concerned  
20 about.

21           **THE COURT:** Can I ask a question? Way back there where  
22 the big arrow is, does that mean that the -- what would be the  
23 difference in height change? I'm not following that very well.

24           **PROFESSOR GRIGGS:** So on the right side is an elevation  
25 difference. At the end of the last ice age about 20,000 years

1 ago, sea level was about 400 feet lower.

2 **THE COURT:** I got it.

3 **PROFESSOR GRIGGS:** So you could have walked out to the  
4 Farallons for lunch if you walked really fast.

5 **THE COURT:** Really? How about would the Bering Straits  
6 have been --

7 **PROFESSOR GRIGGS:** Yes.

8 **THE COURT:** You can walk across there?

9 **PROFESSOR GRIGGS:** And early humans did. We're quite  
10 certain of that.

11 **THE COURT:** So maybe in that period when it was low  
12 tide, so to speak, that's when they came across?

13 **PROFESSOR GRIGGS:** It didn't have to be low tide. The  
14 whole Bering Strait was exposed. And we've got lots of  
15 archeological evidence now of early humans making it into North  
16 America probably 25,000 years ago.

17 But the main point of that white arrow is that that  
18 rate of increase was very steep there, perhaps an inch a year,  
19 which looks like something happened fairly quickly, which we  
20 think was probably ice.

21 **THE COURT:** What do you think did happen that caused  
22 that ice age to melt away.

23 **PROFESSOR GRIGGS:** At that point we think a collapse of  
24 one of these big ice shelves, in other words, one of these  
25 glaciers moving rapidly into the ocean. And that's what I'm

1 going to talk about in just a second.

2 **THE COURT:** Sure. Go ahead.

3 **PROFESSOR GRIGGS:** So this is -- I'm trying to think  
4 which one we're on. Yes, this is just a quick animation of sea  
5 level rising corresponding to that 20,000 year period. So this  
6 is the San Francisco Bay Area. And you can see, if this runs.  
7 Sometimes this works.

8 Let's see here.

9 **THE COURT:** This is going to be an animation that shows  
10 the coastline shrinking. Is that it?

11 **PROFESSOR GRIGGS:** Yes. Okay. We'll do it another way  
12 here. Is this up on the screen?

13 **THE COURT:** What I see is it's not that map anymore.  
14 It's a pretty picture of a sunset.

15 **PROFESSOR GRIGGS:** It's showing up on my screen.

16 **THE COURT:** Here comings a helper.

17 If it would help, we can take a break and let you fix  
18 it during the break.

19 **PROFESSOR GRIGGS:** Can you see that on the screen?

20 **THE COURT:** I can now. Okay. There. It worked. It  
21 worked. All right. Please go ahead.

22 **PROFESSOR GRIGGS:** We got to go back and do it again.  
23 So this is 18,000 years ago in --

24 **THE COURT:** Okay.

25 **PROFESSOR GRIGGS:** This is about the most embarrassing

1 thing.

2           **THE COURT:** I think about 30 seconds you'll get it.  
3 Try that little YouTube thing that you had out there and click on  
4 that.

5           **PROFESSOR GRIGGS:** Well, the years are going by, but  
6 the water isn't moving. But it's moving on my screen here.  
7 What's wrong?

8           **THE COURT:** Okay. Here's what we'll do. You take a  
9 few minutes. We're going to take a break. It's time for a  
10 break, anyway.

11           **PROFESSOR GRIGGS:** Okay.

12           **THE COURT:** And when we come back maybe you'll have it  
13 fixed and ready to go.

14           **PROFESSOR GRIGGS:** Well fix it.

15           **THE COURT:** All right. Thank you.

16           **PROFESSOR GRIGGS:** Thanks.

17           (Thereupon, a recess was taken.)

18           **THE COURT:** Okay. Welcome back. Let's go back to  
19 work.

20           **PROFESSOR GRIGGS:** Okay. All right.

21           You're just going to have to take my word that the sea  
22 level rose from the Farallons, up to the Golden Gate, into the  
23 Golden Gate, up to Sacramento and back out again.

24           **THE COURT:** I'll take your word for it.

25           **PROFESSOR GRIGGS:** Okay. So this is just looking at sea

1 level rise past, present and future back from the 1800's to the  
2 early 19 -- or the late 1800's we're using geological evidence.

3 Beginning in the late 1800's to the present we used  
4 tide gauges to measure sea level. And that black line shows the  
5 global average of about five-and-a-half inches per --

6 **THE COURT:** Wait. I made a mistake. I left my watch  
7 somewhere.

8 **PROFESSOR GRIGGS:** That's okay.

9 **THE COURT:** Wait. Let me see it. I found it. It's in  
10 my pocket.

11 Okay. Go ahead. You got some free time here.

12 **PROFESSOR GRIGGS:** So up until 1993 we used tide  
13 gauges, which was just water level recorders. We have one up at  
14 Golden Gate.

15 Tide gauges actually give you a local measurement. So  
16 it shows what the ocean is doing, it's rising. But if the land  
17 is rising or the land sinking, tide gauges will show you  
18 something different around the world. In Venice, it's sinking  
19 and in Alaska the land is rising.

20 In 1993, we lost a couple of satellites that measure  
21 global sea level from space. And those numbers are around  
22 13 inches per hundred years on average. So maybe two-and-a-half  
23 times faster than those tide gauges.

24 And in this report, which I was involved with for the  
25 National Academy of Science and National Research Council, we

1 were asked to project into the future. 2030, 2050, 2100.

2           So those are some of the ranges we got -- I won't go  
3 into detail -- based on different greenhouse gas emissions, and  
4 I'll come back to that in a second.

5           So if we look at cities around the world today, most of  
6 the; world's big cities are on the coastlines, because a lot of  
7 reasons. That was a good place to build. There's now Oakland  
8 and San Francisco here (indicating).

9           But maybe 200 million people around the world living  
10 within 3 feet of high tide. So sea level is an issue for a lot  
11 of places.

12           This is the tide gauge for San Francisco, which is out  
13 at the Golden Gate, the oldest in the country. And it averages  
14 about 7.7 inches per century. They weren't put in to measure sea  
15 level rise. They were put in to measure water depth so ships  
16 could come in and out without grounding on the bottom.

17           But what it's shown over time is the sea level is  
18 rising there.

19           This is now the satellite record since 1993. And the  
20 average rate, which I mentioned earlier, is about 13 inches per  
21 century. But if you look at the first several years, it's rising  
22 at maybe one-and-a-half millimeters per year, or six inches per  
23 hundred years.

24           The middle stretch from, say, 1997 up to 2009, or so,  
25 is equivalent to the long-term average of a little over 12 inches

1 per hundred years. But if you look at the most recent it's at an  
2 even faster rate.

3           So it looks like from satellite measurements sea level  
4 rises are accelerating or increasing. The thing that concerns us  
5 is the ice on the planet. And there's three big chunks of ice.  
6 One are the mountain glaciers. Actually, not all that much ice.  
7 If we melt it all maybe we would raise sea level a foot and a  
8 half.

9           It's okay unless you live a foot and a half within sea  
10 level.

11           Greenland, if we melted it all would be about 24 feet.  
12 And Antarctica contains about 190 feet of sea level rise  
13 equivalent. So 216 feet total if we melt all that ice. No  
14 scientist thinks that's going to happen this year or next or this  
15 century or next century. But we don't need to melt all of it to  
16 create problems for coastal cities around the world or San  
17 Francisco Bay.

18           Just two years ago a couple of scientists, DeConto and  
19 Pollard, tried to figure out what was really happening in  
20 Antarctica. And they realized that there are times in the recent  
21 past, one about 130 million years ago, one about 3 million years  
22 ago, where sea level was 20 to 30 feet higher than today, but the  
23 temperatures were only slightly warmer.

24           And they feel the Antarctica ice sheet breakdown  
25 collapse was the reason for that. So what they did was put

1 together the physics to try to understand what is happening and  
2 what could happen next.

3 State of California --

4 **THE COURT:** One more time. 130 million years ago what?

5 **PROFESSOR GRIGGS:** I'm sorry. 130,000 (sic) years ago  
6 and 3 million years ago were both warm periods when we know sea  
7 level was 20 to 30 feet higher than today, but the temperatures  
8 were only slightly warmer, which suggested something could happen  
9 fairly quickly and get us to those levels. And they wanted to  
10 understand what it would take for that to happen. Is that  
11 something that could happen, you know.

12 **THE COURT:** I thought you meant -- but did that mean  
13 Antarctica was underwater? I just didn't understand. I thought  
14 you said something about Antarctica in that.

15 **PROFESSOR GRIGGS:** Antarctica is where the biggest  
16 amount of ice is that looks like there's the greatest potential  
17 for --

18 **THE COURT:** Was it always ice? Was there ever a period  
19 it wasn't ice?

20 **PROFESSOR GRIGGS:** There's a period where Antarctica  
21 wasn't where it is today. It was further away in warmer  
22 climates, about 30 million years ago.

23 **THE COURT:** Since it got to the pole it's been covered  
24 with ice; is that it?

25 **PROFESSOR GRIGGS:** Right. Roughly the last 30 million

1 years or so. I realize those are really big numbers and it's  
2 sort of like way back there, but it's been there for awhile.

3 So the State of California asked the Ocean Protection  
4 Council Science Advisory Team to look at the present status. I  
5 was asked to chair that committee. We finished that April last  
6 year.

7 And what comes out of that was first Antarctica holds  
8 about 61 percent of the earth's fresh water, about 190 feet of  
9 potential sea level rise. And the understanding that DeConto and  
10 Pollard came up with is this image that these huge ice sheets are  
11 being held in by these floating ice shelves.

12 And two things they began to understand are happening,  
13 and I kind of liken it to taking the cork out of a champagne  
14 bottle, if these ice shelves start to break up and move out, then  
15 these glaciers can advance. And they are now melting at the  
16 surface as the air gets warmer, and they are melting from  
17 underneath as the water gets warmer.

18 **THE COURT:** They are melting, are they the ones on land  
19 or sea?

20 **PROFESSOR GRIGGS:** The ones on the sea, these corks.

21 So they understood that you can't keep that thing  
22 melting and still keep it in place. And that these ice cliffs  
23 when it breaks off can only get so high. So when that happens  
24 those glaciers can advance more rapidly. And we do see ice  
25 shelves breaking off now, one in north part of Antarctica that is

1 equivalent to the size of Delaware, which is fairly sizable.

2           So that the process is being witnessed and these are  
3 the findings from that report that we did just a year a little  
4 over a year ago. We know the direction of sea level rise. We  
5 see the rate of loss from Greenland and Antarctica are  
6 increasing.

7           This work highlights the potential for an extreme sea  
8 level rise. And we worked out probabilities. And those should  
9 begin to shape our decisions on how we begin to deal with coastal  
10 infrastructure, coastal facilities, coastal instruction.

11           And waiting for absolute scientific uncertainty is not  
12 a prudent option because of what is at stake.

13           This was a projection of what we saw potentially  
14 happening in the future. And on the left side, so there's today.  
15 The left side are the tide gauge and the satellite records. And  
16 then, we were tasked with looking out again to 2050, 2100.

17           And, basically, we used two of these RCP scenarios,  
18 which are these representative concentration pathways for  
19 greenhouse gases. A low one, 2.6, which is in the blue. And  
20 that's meaning that scenario means we get control of greenhouse  
21 gases very quickly. Huge reduction in carbon emissions. Do  
22 everything we can to stop that, those emissions.

23           The red is RCP 8.5, which means we just keep going as  
24 we are. Our use of fossil fuels continues. So you can start to  
25 see after 2050, after that second dashed line, those projections

1 begin to diverge.

2           And we show both a midpoint, which is the solid line.

3 And then those dashed lines, we are looking out at the ends of  
4 the distribution, the 5th and the 95th percentiles.

5           So by 2100, we could be 2 feet, 3 feet, 4 feet, over  
6 4 feet. But then, there's also the potential like we saw on  
7 those earlier slides of a major collapse.

8           In the work that's been done in these models with  
9 greenhouse gas show it could be 8 feet or 10 feet. We don't know  
10 what the probability is, but we can't discount that.

11           So just to give you a little sense, this is the Oakland  
12 International Airport, which is all built on fill. And this is  
13 from a site that we can actually project future sea level at the  
14 Oakland Airport in Oakland, as a whole.

15           So this is today's high tide. This is if we add 1 foot  
16 of sea level rise. So the blue is now going to be wet. We can  
17 add 3 feet, and you can look around and see more of the airport  
18 in some areas of Oakland.

19           And I'm just going to use these, for example. We could  
20 add five feet and we could see a lot more of Oakland. The area  
21 around the Bay Bridge goes underwater. I didn't go to 10 feet,  
22 but 8 feet gets pretty grim. So we can look out in the future  
23 and see what those elevations mean for coastal areas and Oakland  
24 and San Francisco.

25           In addition to the sea level rise, which is this

1 gradual sort of incline that's looking like it's going to get  
2 steeper, we also have these short-term events which become more  
3 important.

4           And El Niños are one of those short-term events. And  
5 those red arrows point to the major El Niños in 1941, 1983,  
6 1997-'98.

7           So the tide gauge in San Francisco shows water level  
8 was a foot higher for several months.

9           This is just showing that event, and San Francisco, in  
10 particular, where the highest recorded level was 1.77 feet above  
11 what the tide table would have predicted -- projected from that  
12 El Niño, which is this warm bulge of water that moves up from the  
13 equator along the coast of western North America every 3, 4, 5  
14 years.

15           So these short-term events are going to be problematic  
16 in the short-term, but as sea level continues to rise they are  
17 going to be on top of that.

18           **THE COURT:** In brief, why is it that an El Niño would  
19 have that surge effect?

20           **PROFESSOR GRIGGS:** So an El Niño occurs when the  
21 circulation of the equatorial Pacific reverses. Normally, the  
22 water moves from -- I'll do it facing you -- from the Trade Winds  
23 blow the water from the South America side over to the Western  
24 Pacific off the Philippines and Japan. Every three or four, five  
25 years, that system breaks down, the Trade Wind breaks down, and

1 the water, this warm bulge of water in the Western Pacific flows  
2 back across to Ecuador and Peru. It shuts down upwelling the  
3 fisheries, and then moves north and south.

4 Brings a lot of warm water organisms, fish and so  
5 forth. So that bulge actually moves up the coast: California,  
6 Oregon, Washington, and moves down the coast of South America.

7 We still don't know exactly what drives an El Niño, but  
8 we've seen them happening and seen them in the geologic records  
9 for hundreds of years.

10 **THE COURT:** It's just the force of all that massive  
11 water that causes -- forces itself on the way to the land up by  
12 1.77 feet?

13 **PROFESSOR GRIGGS:** Right.

14 **THE COURT:** Okay.

15 **PROFESSOR GRIGGS:** It's been called a "Kelvin wave," so  
16 it's like a wave of water sort of slowly moving up the coast over  
17 weeks or months. But it stays for a couple of months. So,  
18 again, that's on top of sea level.

19 The next several slides are the other short-term event,  
20 which we've now called a King Tide. So the tide is driven by  
21 attraction of the moon on the earth's water, and also the Sun,  
22 and those two working together.

23 Couple of times a year the moon is a little closer to  
24 the Earth, and the Earth-Moon system is a little closer to the  
25 Sun, so the gravitational pull is greater, and we get these

1 extreme tides. So this is the Embarcadero at an extreme tide  
2 with today's high tide. I mean, today's sea level. And I just  
3 through a couple other ones in here. This has become sort of  
4 ground zero for King Tides.

5           So these are now coming on top of any slowly rising sea  
6 level around the Bay margin. Just recently another study came  
7 out that's looking at changing flood frequencies. And this is  
8 not river flood, but a coastal flood. So when high tides and  
9 storm waves wash water up into the public streets or the coastal  
10 area --

11           (Thereupon, an alarm sounded.)

12           **THE COURT:** Coastal flood alert.

13           **PROFESSOR GRIGGS:** From the 19th floor.

14           **THE COURT:** Once a month at 10:00 o'clock this thing  
15 goes off. And sometimes there's an announcement. Usually not.  
16 But about one out of three times they come on and tell us not to  
17 worry.

18           I suggest you go ahead, but they may interrupt.

19           **PROFESSOR GRIGGS:** I just got two more slides.

20           **THE COURT:** Go ahead.

21           **PROFESSOR GRIGGS:** So basically what this is showing,  
22 the bottom two panels, are the top is under intermediate  
23 emissions scenario, RCP 4.5. This is telling us -- and I'll pick  
24 San Francisco because we're here -- that the 10-year flood, which  
25 means it would have happened on average about every 10 years,

1 will now happen 6.8 times a year by 2050.

2 By 2100, the 10-year flood in San Francisco will occur  
3 every third day because the water's now higher than it was  
4 before. So these extreme events are going to push the water even  
5 higher.

6 If we go to the bottom panel -- and I'm not going to go  
7 over to the 500-year flood. That's way beyond our lifetime.

8 The bottom is RCP 8.5, which is really our today.  
9 That's the direction we're heading. And what that shows by --

10 **THE COURT:** "RCP" means what?

11 **PROFESSOR GRIGGS:** Representative concentration  
12 pathways. And that's how many watts per square meter the Earth  
13 is sort of gaining heat. It's just a measurement that has been  
14 used to talk about how much more warming.

15 So if you look at 8.5, you know, we can look at 2050  
16 again in San Francisco, the 10-year flood, which would have  
17 occurred once every ten years is now coming 10 times a year,  
18 because the water level's higher, and these other -- these King  
19 tides, these El Niños, these storms events are going to simply be  
20 further inland and higher in elevation.

21 So based on all the work we did on the rising seas  
22 report the state put together a sea level rise guidance for all  
23 the state agencies.

24 This was just accepted by the Ocean Protection Council  
25 last week. And, essentially, it's giving direction as the sea

1 level continues to rise, how each individual facility or future  
2 construction needs to take into account the future projections  
3 based on the tolerance that that particular facility can manage.

4 Is it an airport? Is it a bike path? Is it a walkway?

5 And so the state is now invested in these, and we're looking to  
6 how we're planning for the future.

7 Thank you very much.

8 **THE COURT:** Thank you. All right. So just to -- it's  
9 your turn, Mr. Butrous. And here's what I suggest we do. The  
10 Plaintiffs' side has about 30 minutes left total, because of  
11 your -- that took actually more than 30 minutes but -- and so I  
12 think we ought to do the defendants' side on both presentations,  
13 and then the Plaintiffs' side will have 30 minutes at the end.

14 All right? Your turn.

15 **MR. BOUTROUS:** Thank you very much, Your Honor. Really  
16 appreciate the opportunity to be here to address the questions  
17 and issues the Court identified in its request for tutorial  
18 regarding climate science.

19 I'm here today representing Chevron Corporation.  
20 Chevron does not do original climate science research. Chevron  
21 accepts the consensus of the scientific community on climate  
22 change.

23 That scientific consensus is embodied in the results of  
24 the Intergovernmental Panel on Climate Change, the IPCC. And  
25 that has been Chevron's position for over a decade.

1           And before we leave today we're going to leave behind a  
2 couple of pieces of the lengthy reports from the IPCC and also  
3 give you guidance on easy ways to get to those reports and also  
4 provide our timeline. And we also have a hyperlinked timeline  
5 for the Court. We'll figure out the best way to transmit it so  
6 the Court can use that.

7           The IPCC's latest report issued in 2013 is known as the  
8 Fifth Assessment Report, or AR5. And you are going to here quite  
9 a bit from me about that because it's an amazing resource, Your  
10 Honor, in terms of collecting and assessing the work of  
11 scientists and work that goes back to 1988.

12           And that report is literally the collective work of  
13 thousands of scientists and experts, including, I believe,  
14 Dr. Allen, who started off today. And it was very interesting  
15 listening to Dr. Allen. He's one of the thousands of scientists  
16 who participate and have participated in this IPCC process to  
17 reach a global scientific consensus.

18           And as I mentioned, the most recent IPCC report, was  
19 issued in 2013, is called "AR5." And it concluded -- and I'll  
20 just read it, and quote it.

21           Quote:

22                   "It is extremely likely that human influence has  
23 been the dominant cause of the observed warming since the  
24 mid-20th century," close quote.

25           And I'm glad the Court mentioned the Scopes Trial talk

1 out there because from Chevron's perspective there's no debate  
2 about climate science. First, because Chevron accepts what this  
3 scientific body and includes scientists and others, but what the  
4 IPCC has reached consensus on in terms of science on climate  
5 change.

6 But also because it won't surprise the Court we believe  
7 the resolution of climate science issues aren't going to be  
8 determinative here for all the reasons in our motion to dismiss.

9 That's for another day.

10 From Chevron's perspective there's also no debate about  
11 another of the IPCC's conclusions. And that's climate change is  
12 a global issue that requires global engagement and global action.

13 And that global action requires a balancing of these  
14 environmental issues, the climate issues with issues of energy  
15 security and socioeconomic issues.

16 In other words, global warming presents complex  
17 international policy issues based on this scientific consensus  
18 that has been reached up till the 2013 report. And it's  
19 continuing to evolve.

20 The AR6 is coming out in 2021. So scientists are, you  
21 know, looking forward to that 2021, there's going to be a new  
22 IPCC report then with new conclusions and evolving science.

23 Chevron does not agree with all the policy proposals  
24 analyzed by the IPCC. It includes not just the science in  
25 Working Group 1. And I'm going to come back to this. But it

1 also includes sections that have -- they don't recommend certain  
2 policies, but it's meant to give policymakers a predicate for  
3 debating and making these decisions.

4           AR5 itself notes these are complicated policy issues  
5 about the future currently being debated by individuals,  
6 communities, countries, NGOs, international organizations.

7           So as a prelude to launching into my detailed  
8 discussion, I want to make clear that this is not a case about a  
9 dispute concerning the consensus of climate scientists.

10           It is about the policy choices that have been made,  
11 including by Oakland and San Francisco, and the policy choices to  
12 be made in the future. And it's about whether a tort suit like  
13 this one is the right way to debate and decide those policy  
14 choices.

15           Here's my plan, and for part one of the tutorial, Your  
16 Honor. First, I will explain how climate science developed. I  
17 think Dr. Allen covered much of the areas. But there are a  
18 couple of areas I'm going to try to fill in a few blanks here.  
19 And I think the Court was asking some questions that got to that.

20           Then, I'll describe the evolution of the science on  
21 greenhouse gases and the growth of scientists' understanding of  
22 their impact on climate change.

23           And throughout the day I'm going to be referring to  
24 most often AR5, the IPCC report. There's also a synthesis  
25 report, which includes the summary for policymakers. And then,

1 it really captures this thousand-plus page report. And we'll  
2 leave a copy with the Court of that, as well.

3 Before I jump into the history, I want to talk a little  
4 bit more about the IPCC, because I really did appreciate the  
5 Court's tutorial saying:

6 "Let's take a look at what's out there in terms of  
7 science. What's the history?"

8 And as I said, the IPCC materials are really an  
9 extraordinary body of literature. IPCC was formed in 1988. It's  
10 an international body established by the World Meteorological  
11 Organization, WMO, and the United Nations Environmental Program.  
12 And I think 195 countries participate.

13 And as I suggested, the purpose is to assess the  
14 scientific, technical and socioeconomic information necessary to  
15 understand climate change and assist policymakers in addressing  
16 it.

17 The IPCC also evaluates potential impacts from climate  
18 change as well as adaptation and mitigation issues and measures.

19 The IPCC is divided into three working groups. And  
20 I've just displayed a chart from the IPCC itself that explains  
21 what they are.

22 The first working group is the one I'll be really  
23 focusing principally on today. It's the group that addresses the  
24 science of climate change, the physical science bases.

25 Working Group II is the group that addresses

1 socioeconomic impacts and policy options for adapting to climate  
2 change.

3           And then, Working Group III is the group that addresses  
4 options for mitigating for climate change. Seeing if we can  
5 restrain it, if we can stop it or slow it from occurring.

6           And the Working Group III discusses policy options for  
7 limiting greenhouse gases and enhancing activities that remove  
8 them from the atmosphere, as well as the costs and benefits of  
9 different approaches to mitigation.

10           So that structure really reflects the over-arching  
11 purpose of the IPCC.

12           Now, I mentioned the assessment reports. And I think  
13 it's -- they are very illuminating. The first one was in 1990  
14 and most recent one was published in 2013.

15           To give you an idea of the work that goes into these  
16 reports for AR5 alone, there were more than 830 authors and  
17 review editors from more than 80 countries.

18           They drew on the work of over a thousand contributing  
19 authors and about 2000 expert reviewers who provided over 140,000  
20 review comments.

21           When I saw that I thought of the person who had to  
22 incorporate all the comments into the final draft. Quite the  
23 task.

24           But the reports describe the current understanding of  
25 climate science at the time they were issued, including areas of

1 uncertainty and areas where additional research was needed.

2           And, in fact, the reports talk about the uncertainty  
3 and probabilities and likelihoods in very specific ways, so some  
4 of the quotes that I'll direct the Court to include "very likely,  
5 likely." The one I showed "extremely likely."

6           Here's the chart from AR5 that -- we're going to leave  
7 behind our slides, as well, for the Court. But this, the chart  
8 expresses how likely something is. And so the top chart measures  
9 confidence in terms of how much agreement there is among  
10 scientists and the quality of evidence supporting the finding.

11           The IPCC also has terms to express the probability of a  
12 specific outcome, ranking from "exceptionally unlikely" to the  
13 "virtually certain."

14           And that's at the bottom of the screen.

15           "Extremely likely" is not on this chart, but the IPCC  
16 notes in its report that they view that as a 95-100 percent  
17 likelihood. So we've got a note on that there.

18           The IPCC report, it addresses key uncertainties in its  
19 own words.

20           So if we look at AR5 Technical Summary, the IPCC  
21 summarizes the key uncertainties that still exist in climate  
22 science.

23           And I'll just read the first sentence there:

24                   "This final section of the Technical Summary  
25 provides readers with a short overview of key uncertainties in

1 the understanding of the climate system and the ability to  
2 project changes in response to anthropogenic influences," close  
3 quote.

4           And the IPCC alternately refers to human factors and  
5 human influences and anthropogenic influences.

6           So as we dig into the history of climate science -- and  
7 I'm going to take a slightly different approach than Dr. Allen,  
8 but I think it will compliment the approach he took.

9           I think the IPCC report are both a tremendous resource  
10 and a great way to just watch how things have evolved and changed  
11 over the past 30 years, and how scientific uncertainty and  
12 confidence has changed, and how the scientific process functions.

13           So first let me talk about the IPCC conclusions  
14 concerning human influence on climate in the various reports.

15           In the IPCC AR5 actually tracks through how their  
16 findings have evolved each year. So 1990 was the year when the  
17 IPCC issued its first assessment. So it's two years after it was  
18 formed. And it's typically abbreviated FAR, so I'll sometimes  
19 refer to this 1990 report as FAR.

20           And it conclude based on the best science available at  
21 the time, quote:

22                   "The size of this warming is broadly consistent  
23 with predictions of climate models, but it is also of the same  
24 magnitude as natural climate variability. Thus the observed  
25 increase could be largely due to this natural variability;

1 alternatively this variability and other human factors could have  
2 offset a still larger human-induced greenhouse warming. The  
3 unequivocal detection of the enhanced greenhouse effect from  
4 observations is not likely for a decade or more," close quote.

5           So, they believed there was a warming trend. They were  
6 able to conclude that. They understood that human activity,  
7 including the burning of coal, oil and natural gas increased the  
8 concentration of CO2 in the atmosphere.

9           But at that point, they concluded it was not possible  
10 to link the two. And as you'll see they correctly predict that  
11 it would take about a decade before this group of thousands of  
12 scientists from around the world could make that sort of finding.

13           1995 came the second assessment report known as the  
14 SAR.

15           It concluded, quote:

16           "Our ability to quantify the human influence on  
17 global climate is currently limited because the expected signal  
18 is" -- and we heard Dr. Allen talk about signal -- the expected  
19 signal is still emerging from the noise of natural variability,  
20 and because there are uncertainties in key factors. Nonetheless,  
21 the balance of the evidence suggests -- suggest that there's a  
22 discernable human influence on global climate. Simulations with  
23 coupled atmosphere, ocean models have provided important  
24 information about the decade to century time scale, natural  
25 internal climate variability," close quote.

1           So the message from the IPCC is we've made  
2 advancements. We've learned more since 1990. And that  
3 human -- or it's the data suggesting a discernible influence of  
4 human activity. But it's only starting to emerge from the noise  
5 of natural variability in light of some of the uncertainties in  
6 key factors.

7           So that's in 1995.

8           The next report is the Third Assessment Report, and  
9 that rolled in in 2001. And, again, we've seen advancements in  
10 the degree of certainty or confidence that the IPCC has. And  
11 here's what they say in 1991.

12           "There is new and stronger evidence that most of  
13 the warming observed over the last 50 years is attributable to  
14 human activities. There is a longer and more scrutinized  
15 temperature record and new model estimates of variability.  
16 Reconstructions of climate data for the past 1,000 years indicate  
17 this warming was unusual and is unlikely to be entirely natural  
18 in origin. The warming over the past 100 years is very likely  
19 unlikely to be due to internal variability alone," close quote.

20           And the IPCC alternately talks about natural  
21 variability and internal variability. Basically, they mean the  
22 same thing. When they say "internal variability," they are  
23 talking about natural, natural factors other than human  
24 activities.

25           So in 2007, AR4 issued the fourth report. And this one

1 is known as AR4. And the IPCC won a Nobel Prize for this in  
2 connection with its work on this.

3 And the AR4 is more definitive, and it's I think viewed  
4 as a more definitive assessment by the scientific community.

5 The AR4 finds that:

6 "Most of the observed increase in global average  
7 temperatures since the mid-20th century is very likely due to the  
8 observed increase in anthropogenic greenhouse gas concentrations.

9 "Discernible human influences now extend to other  
10 aspects of climate, including ocean warming, continental-average  
11 temperatures, temperature extremes and wind patterns."

12 Then, as I mentioned earlier, we have AR5, the most  
13 recent report from the IPCC.

14 And it concluded, among other things, that, quote:

15 "It is extremely likely that human influence has  
16 been the dominant cause of the observed warming since the  
17 mid-20th century."

18 So we see how the arc, the conclusions have evolved  
19 through the years, beginning in 1990 through 2013. And as I  
20 mentioned, AR6 will be coming in 2021.

21 And I have another quote displayed for the Court that  
22 the AR5 concludes that these emissions are driven and increases  
23 are driven largely by economic and population growth resulting in  
24 increased burning of fossil fuel, like coal, oil and natural gas.

25 And quoting, quote:

1 "Globally, economic and population growth  
2 continued to be the most important drivers of increases in CO2  
3 emission from fossil fuel combustion," close quote.

4 And you'll see, Your Honor, I'll come back to this.  
5 But in the AR5 report they don't say that it's the production and  
6 extraction that is driving increases. It's the way people are  
7 living their lives, the way society it's developing economic and  
8 population growth. I'll come back to that.

9 I alluded to this in my opening. The IPCC and AR5 really  
10 articulates a view in its evaluation of potential policy options  
11 for addressing climate change in a very consistent way.

12 It says -- and here's the quote in AR5. Says:

13 "Climate change has the characteristics of a collective  
14 action problem at the global scale."

15 And the Court in its remand ruling gave a nod to this  
16 concept:

17 "Because most greenhouse gases accumulate over time and  
18 mix globally, and emissions by any agent, e.g. individual,  
19 community, company, country, affect other agents. International  
20 cooperation is therefore required to effectively mitigate  
21 greenhouse gas emissions and address other climate issues," close  
22 quote.

23 So with that as a predicate, now I would like to go back in  
24 time with a little more history.

25 The notion that we know of today, that we have today of a

1 dynamic changing climate that can shift is relatively new in  
2 terms of human understanding.

3         For more than a thousand years dating back to Aristotle,  
4 philosophers and scientists viewed the climate as a static thing  
5 that really just depended on where you were on the globe.

6         So I have up on the screen a map from -- I think from it's  
7 from Spain -- from 1575 that reflects Aristotle's concept of the  
8 climates. And he kind of came pretty close. He has at the top  
9 we have five different climates. The top and bottom are cold and  
10 zones became warmer towards the equator.

11         And because people believed that climate didn't change and  
12 it was just based on where on the Earth you lived, early climate  
13 study focused on local efforts to understand the weather and to  
14 assist in decisions about where to live, what to plant, just how  
15 to live everyday life.

16         There are also early cloud records. And these are from the  
17 Ming Dynasty. Just records of what the cloud patterns were. And  
18 there were early records of temperatures. The temperatures  
19 started being recorded when the model thermometer was invented in  
20 the 1600's. And the Fahrenheit scale was developed in the  
21 1700's.

22         And I particularly like this. Thomas Jefferson has to be  
23 one of the most amazing multi-taskers in the world history,  
24 because these are temperature records that he recorded during the  
25 second constitutional convention, including on July 4, 1776, what

1 the temperature was then.

2 And so temperature records were being kept by people, and  
3 then thermometers were developing. So on July 4, at 6:00 A.M.  
4 the way I read this it was 68 degrees Fahrenheit.

5 And this was still during the little ice age. So Jefferson  
6 was doing many things at this time.

7 So climate science during this period was really about  
8 observing temperatures and trying to predict the weather and  
9 those sorts of things.

10 But that said, there are some early records of efforts to  
11 understand global climate. And one of the first was from Edmond  
12 Halley, of Halley's Comet fame in 1686. He theorized that Trade  
13 Winds were generated when sun heated the air near the equator,  
14 and then the air rose, and then that forced denser air from  
15 higher altitudes to rush in.

16 This map on the slide shows the directions of Trade Winds  
17 across the oceans. This explanation proved to be wrong. But the  
18 concept of atmospheric circulation in the climate system and the  
19 energy transfer system is still a fundamental feature of climate  
20 science.

21 In fact, it's really at the core of it. The Court asked  
22 about the ice ages. And I think it was a great way to focus us,  
23 in part, because the focus of climatology really began to change  
24 when scientists and geologists start to look at the ice ages.

25 When they found that ice had once covered large portions of

1 the Earth that upended the notion that climate was static. So  
2 there was a different climate at some point earlier.

3 So much of the basic science about climate came out of the  
4 efforts to understand the ice ages.

5 I'm going to show you a couple of charts here. And they  
6 really show the patterns of heating and cooling over time.

7 These are from the first assessment report from the IPCC.  
8 The top graph shows the cyclical patterns of temperature change  
9 over hundreds of thousands of years, including patterns of  
10 periodic heating and cooling, some of which were cold enough to  
11 be ice ages.

12 And then, the bottom graph shows the history of temperature  
13 over the last 1,000 years showing the temperature drop that  
14 created the most recent cooling period which the Court also asked  
15 about, the little ice age.

16 And then, you also see the medieval warming period that  
17 preceded the little ice age. And then, the little ice age ended  
18 in 1850. And I'm going to come back to that.

19 Dr. Allen talked about this a bit, but just as a prelude the  
20 causes of the ice ages, there's still some uncertainty, some  
21 disagreement. But scientists believe that they are triggered by  
22 the cyclical changes in the earth's orbit around the sun  
23 Milankovitch cycles.

24 In addition, I think Dr. Allen touched on the various  
25 feedback loops, the Albedo Feedback Loop where as more as ice and

1 snow build up, Earth reflects more sunlight. The ice doesn't  
2 melt. It grows. Makes the Earth even cooler.

3 John Croll described that in 1875.

4 **THE COURT:** Maybe you know the answer. So because it  
5 gets worse and worse, right, it feeds on itself. Whatever, what  
6 was it that busted us out of that cold spell and allowed the ice  
7 to melt away and to -- what happened that reversed that terrible  
8 trend?

9 **MR. BOUTROUS:** As I understand it from the IPCC reports  
10 and some of the history, the process started to reverse. So the  
11 Milankovitch cycle, the orbit returns, so the Earth was getting  
12 more sun. Then that started to melt the ice and snow. The  
13 feedback loop reversed itself. So now you had less sun being  
14 reflected back, more being absorbed. The Earth started to heat.

15 And the last component of it was the IPCC noted that  
16 their research shows that during the ice ages the CO2 levels had  
17 dropped as things got colder, once the first, the other two  
18 features, the orbit and the Albedo, which is the reflective  
19 capacity of the snow on the Earth and ice.

20 Then, the CO2 started to rise back up. That created  
21 warming and that's how we --

22 **THE COURT:** What caused the CO2 to go up?

23 **MR. BOUTROUS:** I think just the fact that as the  
24 warming that occurred because of the change in the orbit, that  
25 gradually caused CO2 to increase. And I think it's AR4 that

1 talks about this.

2 That they just detected that during the ice ages there  
3 was this drop, and then when things started to warm up CO2, there  
4 was more of it just coming into the air because of the natural  
5 functioning of the atmosphere.

6 **THE COURT:** Let me ask you a question. The other side,  
7 too. I went to -- just letting you know I got interested in this,  
8 so I went back to look at Al Gore's movie called "An Inconvenient  
9 Truth."

10 **MR. BOUTROUS:** I did, too.

11 **THE COURT:** How about that? You did? You looked at  
12 it? Okay. All right.

13 So at one point he has this -- kind of that chart of  
14 when the ice ages were, and then he superimposed onto that  
15 samples of the carbon dioxide levels that they had been able to  
16 reconstruct over the eons of time from, I think he said, ice core  
17 samples.

18 And it seemed to be a pretty good match. In other  
19 words, when the CO2 levels were extremely low, then we were in an  
20 ice age. And then, when the CO2 levels -- so do you know? I may  
21 not be remembering it right. But I wondered what your view of  
22 that, that exercise was.

23 **MR. BOUTROUS:** Yes. I mean, I can't specifically  
24 comment on that, but I do remember that. And I think what I can  
25 go back to the IPCC report, and I'll just read you a quote from

1 the AR4.

2 Here's what it says:

3 "Although it is not their primary cause,  
4 atmospheric carbon dioxide also plays an important role in the  
5 ice ages. Antarctic ice core data" -- I think maybe this is  
6 what the doctor was referring to -- "show that CO2 concentration  
7 is low in the cold glacial times, and high in the warm  
8 interglacials."

9 So I think just as part of the natural process CO2 is  
10 very low. And this is what they get from the these core samples.  
11 And then, has things come back to life, so to speak, it just  
12 naturally starts to increase.

13 And as the Court knows, a certain level of greenhouse  
14 gas effect is required for us to survive and to have it be warm  
15 enough so we can live.

16 **THE COURT:** I read somewhere that if we had no carbon  
17 dioxide it would be too cold.

18 **MR. BOUTROUS:** Exactly.

19 **THE COURT:** And we would all die --

20 **MR. BOUTROUS:** Exactly.

21 **THE COURT:** -- a thermostat function.

22 **MR. BOUTROUS:** Yes. And, in fact, that's what I  
23 believe Fourier, who Mr. Allen mentioned -- and I'm going to talk  
24 about him briefly, too -- that he did the calculation. And just  
25 based on the math he said something, the atmosphere must be

1 having some sort of warming effect, otherwise we wouldn't be  
2 here.

3           So these are -- Arrhenius, who you'll hear from me  
4 about it again and who Dr. Allen -- really was an early -- he  
5 really was focused on CO2. And I'll talk about him more on  
6 greenhouse gases.

7           So the little ice age, Your Honor -- Your Honor, again,  
8 I was glad you asked the question about it.

9           If we go to slide 21, it's very interesting. It went  
10 from 1450 to 1850. Scientists do not fully understand or  
11 entirely agree on the exact causes, but the leading theories are  
12 that it resulted from low solar activity, so the sun's intensity  
13 was reduced during this period, and high volcanic eruptions, plus  
14 a small drop in the amount of greenhouse gas in the atmosphere.

15           Volcanic eruptions, Your Honor, have a cooling effect  
16 because they inject particles into the atmosphere that then block  
17 the sunlight from reaching Earth. And so they have a cooling  
18 effect. They increase the amount of sunlight reflected back into  
19 space by the atmosphere.

20           **THE COURT:** Can I quiz you on that now?

21           **MR. BOUTROUS:** Yes.

22           **THE COURT:** I understand the volcano part. I can see  
23 that. I can see a small drop in greenhouse gases would have that  
24 effect.

25           But the solar thing, I want to question you on that.

1 My understanding for a long time has been there's this 11-year  
2 sunspot cycle that goes on 11 years. And it's just like  
3 clockwork with small variability.

4 But that has been uniform since they started making  
5 records more than 150 years ago about the sunspots. So what --  
6 you're talking about a 400-year period here. Right? So what did  
7 the sun do? What happened to the sun that caused it to emit  
8 less energy for 400 years?

9 **MR. BOUTROUS:** The IPCC, which I'll go back to, talks  
10 about what they say are natural forcings. I don't think --

11 **THE COURT:** Natural what?

12 **MR. BOUTROUS:** Natural forcings. So things like this  
13 where that the sun will sometimes reduce or intensify its output  
14 of radiation.

15 They don't really explain or have a particular, you  
16 know, explanation for when and why it's going to do that. As I  
17 am standing here right now I can't recall. But I'll go back and  
18 take a look, Your Honor. It just happens.

19 **THE COURT:** Does it happen every 400 -- how often does  
20 it happen?

21 **MR. BOUTROUS:** I don't think there were cycles that  
22 they have identified. But let me go back and take a look because  
23 I think it's a very good point, and it's important, you know, in  
24 some of the analysis that he -- looking forward, when I come back  
25 to that. The IPCC, the scientific consensus is, you know,

1 assuming that doesn't happen in the future, i.e., that there's an  
2 intensifying or reduction in solar energy.

3 So I'll put a marker on that and may come back with a  
4 supplement, probably highly-technical, response on that point.

5 **THE COURT:** Okay. How cold did it get in the little  
6 ice age? Do we have any information about that?

7 **MR. BOUTROUS:** Well, it's cold enough. Here we have,  
8 you know, people. The Thames froze. And it was cold enough to  
9 survive. But in terms of -- and it was the northern hemisphere,  
10 but much colder in terms of actual temperature. And I can get  
11 you the actual data on that, as well.

12 The focus on -- the Court also asked after the little  
13 ice age ended, the sea level rose about a foot since 1850 when it  
14 ended.

15 This was a large like academic study, the Ice Age  
16 Inquiry. I think led to important advancements in climate  
17 science. But a big breakthrough, I think, came as a result of  
18 World War II in military research.

19 World War II prompted, I think, some significant  
20 breakthroughs, and it was a turning point for climatology.

21 Both sides during the war recognized that the weather  
22 and climate were important for military operations. And so the  
23 U.S. Government funded the training of thousands of military  
24 meteorologists. Basically, an army to conduct basic climate  
25 research. And the effort ultimately paid off.

1 I'm sure as the Court knows on D-Day a German  
2 meteorologist got it wrong. They thought that storms would  
3 prevent an invasion of Normandy. Normandy in June of 1944, while  
4 the allied scientists correctly predicted a short break that  
5 allowed the invasion to happen.

6 That, in turn, immediately after World War II resulted  
7 in an expansion of climate science funded in significant part of  
8 the U.S. Office of Naval Research and other military branches.

9 I thought the Court would find this interesting, that  
10 that military research, if you look at it, led to the development  
11 of several aspects of climate science that really go directly to  
12 the issues we're talking about today.

13 For example, discovery and development of radiocarbon  
14 dating as an offshoot of the Manhattan Project, which allowed  
15 scientists to estimate how much CO<sub>2</sub> has recently been added to  
16 the atmosphere by the burning of fossil fuels.

17 Another one: Understanding how infrared waves move  
18 through the atmosphere as part of research into heat-seeking  
19 missiles. And, obviously, that science goes to, you know, why  
20 the infrared waves are captured by CO<sub>2</sub> molecules, and, in turn,  
21 heat the Earth.

22 And then, deep ocean circulation, that was part of  
23 research into the disposal into the ocean of radioactive bomb  
24 debris. And that helped them determine how the ocean absorbs  
25 carbon and why the oceans have not absorbed all the excess CO<sub>2</sub>,

1 which, as Dr. Allen has noted has been an issue.

2           Throughout the Cold War the U.S. Government has funded  
3 a number of nonmilitary research organizations, like NOAA, the  
4 National Oceanic and Atmospheric Administration.

5           NCAR, the National Center for Atmospheric Research,  
6 which continues to operate today.

7           And then, in 1965 President Johnson made a statement  
8 sort of in the middle of this about in his message to Congress  
9 based on the Presidential Science Advisory Committee Report of  
10 the same year.

11           And he said, quote:

12                   "This generation has altered the composition of  
13 the atmosphere on a global scale through radioactive materials  
14 and a steady increase in carbon dioxide from the burning of  
15 fossil fuels."

16           So these building blocks of climate knowledge were  
17 being assembled. And as I'll discuss in a moment, it was during  
18 this period that scientific knowledge about climate change began  
19 to grow exponentially.

20           There was literally an explosion, Your Honor. If we  
21 look at the publications that were put out, this is a graph I'm  
22 about to put up from a 2001 study by Gerald Stanhill. And it  
23 shows how the volume of scientific literature on climate grew  
24 from the 1800's to 2000.

25           And note, Your Honor, this is on a logarithmic scale,

1 so it shows -- truly, I knew I was going to get to use that.

2 And so it looks like it's kind of, you know, linear,  
3 but it's actually --

4 **THE COURT:** I understand. The one on the left going up  
5 is base-10 logarithmic scale.

6 **MR. BOUTROUS:** Exactly. And it's really -- the  
7 explosion has continued. Another study from 2011, the solid  
8 lines shows the increase in published climate change articles  
9 between 1991 and 2010.

10 The authors of this study found that more than 110,000  
11 scientific articles about climate change published between 1991  
12 and 2010. And more than half of those articles were between 2006  
13 and 2009. So 55,000 articles in that period.

14 That's why I thought, you know, the IPCC reports and  
15 the scientific consensus embodied in those were really a great  
16 place to focus principally today. And but notwithstanding all  
17 that, the work is continuing. More discovery and theories are  
18 out there. And then, we have the AR6 coming in 2021, as I  
19 mentioned.

20 The IPCC isn't the only organization that collects and  
21 reviews climate research. The Court may have heard about the  
22 issuance of the report from the United States Global Change  
23 Research Program.

24 It has issued four national climate assessments  
25 starting in 2000. They involve a number of different U.S.

1 Government agencies, some 13 agencies contributed to the most  
2 recent report which came out in 2017.

3 And they focus on the state of climate science with  
4 respect to the United States. So they are focused on the United  
5 States.

6 They, in turn, rely substantially on the IPCC reports  
7 that I'm principally relying on, that I'm relying on today.

8 So, with that, I'd like to get into -- just go back in  
9 time a little bit more to fill in a couple of the other areas of  
10 history that Dr. Allen alluded to, but didn't discuss in detail.

11 The climate scientists have identified three  
12 fundamental processes that can change global temperature.  
13 Changing them out of incoming solar radiation. And that can  
14 happen based on variations in the Earth orbit or variances in the  
15 sun's output, changing the fraction of sunlight that is reflected  
16 back into space when the Earth is brighter or when there are  
17 particles from volcanos injected into the atmosphere.

18 And then, changing the fraction of infrared radiation  
19 from the Earth that is absorbed by greenhouse gases in the  
20 atmosphere.

21 For obvious reasons I'm going to focus principally on  
22 the historical development of the science there.

23 As Dr. Allen mentioned, Joseph Fourier in 1824 first  
24 determined that the amount of energy reaching the Earth from the  
25 sun was not enough to explain the earth's warm temperatures.

1 He concluded that the atmosphere had to be keeping the  
2 Earth warm. Then, 35 years later, Irish scientist, John Tyndall,  
3 through a series of lab experiments, determined that water vapor  
4 and CO2 in the atmosphere can cause the greenhouse effect.

5 And then, it was in 1896 that Svante Arrhenius used  
6 calculations of CO2 emissions from factories burning coal to  
7 conclude that, like volcanos, but on a tiny scale, these  
8 factories could increase the Earth temperature by increasing the  
9 concentration of CO2 in the atmosphere.

10 **THE COURT:** What did he do? He made some specific  
11 predictions. Right?

12 **MR. BOUTROUS:** Yes.

13 **THE COURT:** What were those predictions?

14 **MR. BOUTROUS:** Well, he predicted that, as you know,  
15 the more coal -- and this is one of the charts we had earlier --  
16 the more coal that was burned and the more CO2 that was injected  
17 into the atmosphere based on human activity, that could have a  
18 warming effect.

19 And so you would think with those three the building  
20 blocks would have been laid for this entire world climate  
21 scientist. But there's a missing chapter from Dr. Allen's story.  
22 He referred to it, but there was another scientist that rolled  
23 around four years later, Knut Angstrom. And he was another  
24 Swedish scientist.

25 In 1900, he purported to disprove Arrhenius' theory and

1 his prediction that changes in CO2 could impact global  
2 temperature.

3 He used lab experiments, spectrographs, and concluded  
4 that any infrared radiation that would be absorbed by CO2 was  
5 already being absorbed by the much larger concentration of water  
6 vapor.

7 In other words, the CO2 was duplicative and irrelevant.  
8 Water vapor was already absorbing all infrared radiation.

9 And you'll see from this quote from the Monthly Weather  
10 Review put out by the U.S. Department of Agriculture in 1901,  
11 they were pretty much giving their battle, the wind to Angstrom.

12 They said, quote:

13 "The remainder of Angstrom's paper is devoted to a  
14 destructive criticism of the theories put forth by the Swedish  
15 chemist, S. Arrhenius, in which the total absorption of CO2 is  
16 quite inadmissibly inferred from the data which include the  
17 combined absorption of CO2 and the vapor water," close quote.

18 And I think Dr. Allen mentioned the papers in the  
19 1930's, I think, sort of touching on this issue.

20 It appears that Angstrom's conclusion rejecting  
21 Arrhenius' theory remained the accepted view for more than 50  
22 years.

23 And in 1951, Your Honor, the American Metrological  
24 Societies Compendium of Meteorology noted, quote:

25 "Arrhenius saw in this cause of climatic changes,

1 but the theory was never wildly accepted and was abandoned when  
2 it was found that all the long-wave radiation absorbed by CO2 is  
3 also absorbed by water vapor," close quote.

4 **THE COURT:** What year was that statement?

5 **MR. BOUTROUS:** That was 1951 from the American  
6 Meteorological Society. But the '50's turn out to be a period of  
7 significant advancement where Arrhenius comes back, back into  
8 favor.

9 **THE COURT:** Wait a minute. Before you -- you jumped  
10 over 1938. Right? Who was in 1938?

11 **MR. BOUTROUS:** 1938? Now, you are going to stump me.

12 **THE COURT:** Maybe I'm not remembering right, but wasn't  
13 a guy named "Callendar," and they even called it the "Callendar  
14 Effect," not like the calendar, but C-A-L-L-E-N-D-A-R.

15 And he did the little line, the same line about CO2  
16 going up, and also said that it was causing the Earth to get  
17 warmer. And this was a formal scientific paper. Right? I mean,  
18 so that seems like there was somebody who was continuing to keep  
19 the story alive that CO2 was a bad thing.

20 **MR. BOUTROUS:** Right. Yes.

21 **THE COURT:** Well, maybe not a bad thing. Just going to  
22 get warmer. I think he said it was actually a beneficial thing.  
23 It was going to make everything warmer and we wouldn't have to  
24 worry about the ice age again. But, nevertheless, it was getting  
25 warmer.

1           **MR. BOUTROUS:** You are right, Your Honor. I didn't  
2 mean to suggest that there were no other papers out there.

3           **THE COURT:** But you said that by 1950 that this guy  
4 Angstrom, his theory held sway, and that even in 1950 it was  
5 still holding sway, so wouldn't it be more accurate to say there  
6 were two views?

7           **MR. BOUTROUS:** Perhaps, Your Honor, because I'm going  
8 to get to the point at the end of the day it really is going to  
9 prove a point about science.

10           But Callendar agreed with Arrhenius, but it wasn't  
11 viewed, as far as we can tell, as the accepted view. The  
12 accepted view was that Arrhenius was wrong.

13           But here's where the stories turn.

14           **THE COURT:** Okay.

15           **MR. BOUTROUS:** And, you know, science is about  
16 debating things because I think Dr. Allen referred to Gilbert  
17 Plass. And I think, for example, in 1950 Benedict and Plyler  
18 came in to say that they discovered that CO<sub>2</sub> can absorb different  
19 wavelengths of radiation on CO<sub>2</sub>.

20           Angstrom thought that they were be absorbing the same  
21 type of infrared radiation, therefore CO<sub>2</sub> is duplicative. Among  
22 other Benedict and Plyler opinions said, no, they have more  
23 powerful spectrographs. They could see the different wavelengths  
24 and determined that, no, CO<sub>2</sub> was having its own effect as a  
25 greenhouse gas.

1           **THE COURT:** I'm sorry.

2           **MR. BOUTROUS:** Yes.

3           **THE COURT:** Say this Benedict, what year was that?

4           **MR. BOUTROUS:** Plyler? That was in 195 --

5           **THE COURT:** One.

6           **MR. BOUTROUS:** Fifty-one.

7           **THE COURT:** What's the conclusion that they reached?

8           **MR. BOUTROUS:** They reached -- they refuted Angstrom's  
9 theory. They determined CO2 is absorbing a different radiation  
10 length than water, therefore it was a greenhouse gas that was  
11 having an effect.

12           **THE COURT:** All right. So we're back. At least in '51  
13 we're back to Arrhenius is correct.

14           **MR. BOUTROUS:** He's back. He's back. And others then  
15 picked up on that theory. And that's the theory that has held  
16 today. But I think the point I really wanted to make is that's  
17 how science works. It's trial and error. It's experimentation.  
18 Scientists debating each other.

19           It's cumulative. It is self-correcting. And I like  
20 the book Brilliant Blunders by Mario Livio that sometimes a big  
21 mistake can lead to a big discovery.

22           He says:

23                   "The road to discovery and innovation can be  
24 constructed even through the unlikely path of blunders," close  
25 quote.

1           And so sometimes discoveries are unintentional.  
2 Sometimes they come from questioning other scientists' views.  
3 And it's really part of the scientific process.

4           Another significant development in the '50's came from  
5 Revelle and Suess. Dr. Allen talked about Revelle. I want to  
6 give Suess his day in the sun here.

7           In a related finding, they determined that -- they  
8 looked at whether the ocean could absorb all the excess CO2. And  
9 this was in 1956. They determined that while the CO2 mixes  
10 rapidly in the upper layers of the ocean, it can take centuries  
11 to mix with the deeper parts of the ocean.

12           And at that point scientists began to really question  
13 the notion that the oceans could eliminate all the excess CO2.  
14 So it was going somewhere else. It wasn't being absorbed in the  
15 ocean.

16           And then, Keeling came along, ended his study, his  
17 family's study with the Keeling Curve in Mauna Loa, and  
18 determined that the amount of CO2 in the atmosphere was  
19 increasing and that the excess was not being absorbed in the  
20 atmosphere.

21           Picking up on sort of how things developed, not  
22 necessarily when there's a focus on the particular subject  
23 matter, greenhouse gases. In the early '60's, I think one of the  
24 Court's orders asked about the ozone. So here's a connection  
25 that I found interesting.

1 Congress instructed NASA to study the impact of the  
2 ozone layer of proposed supersonic airplanes and the space  
3 shuttle. And there was concern, the Court will recall, that the  
4 exhaust could destroy the ozone.

5 And that led to an examination of CFCs,  
6 chlorofluorocarbons, and their impact on the ozone layer. And  
7 ultimately those synthetic chemicals were determined to be  
8 greenhouse gases, the chlorofluorocarbons. And there was a  
9 showing they could have a significant greenhouse gas effect,  
10 greenhouse effect. It also shows that they did have a  
11 significant effect on the ozone layer.

12 And they were then banned in 1987 by the -- they  
13 actually -- the Montreal Protocol, they were limited, and then  
14 banned in 1996.

15 But the examination as greenhouse gases led to other  
16 discoveries of synthetic chemicals that could have a greenhouse  
17 effect. And I just put up on the screen a number of examples.

18 The one that I wanted to just point out is the HFC,  
19 hydrofluorocarbons. Those were the chemicals developed in the  
20 1980's to replace CFCs, and they turned out to be greenhouse  
21 gases, as well. So there are other synthetic greenhouse gases  
22 out there.

23 **THE COURT:** Help me understand the ozone part. Is it  
24 CF -- give me the code word again.

25 **MR. BOUTROUS:** CFC's.

1           **THE COURT:** CFC's. All right. So I definitely  
2 remember that period when we were alarmed over that. And in some  
3 of the reading I did it seemed to me that there was a suggestion  
4 that the ozone layer in its natural state reflects back some of  
5 the sunlight from the sun so that it tends to cool the Earth. Am  
6 I right about that?

7           I know the ozone layer also has other -- it keeps  
8 ultraviolet radiation from coming through. I believe that's true.

9           But what does it -- does it also have an effect of  
10 reflecting back sunlight that would otherwise hit the Earth and  
11 therefore make it even warmer? What's the answer to that?

12           **MR. BOUTROUS:** I don't know the answer to that, Your  
13 Honor. I know that it does have an effect in terms of a warming  
14 effect and the other effects. But I don't know. You know, you  
15 asked about carbon dioxide and whether it's reflecting sunlight  
16 back. It's transparent to the visible light. But I'm not sure  
17 with respect to the ozone layer's cooling effect in that regard.

18           And, again, I can follow up.

19           **THE COURT:** All right. So but CFC's also act as a --  
20 like carbon dioxide as something that traps heat on the Earth?

21           **MR. BOUTROUS:** Yes. They have a powerful greenhouse  
22 effect.

23           **THE COURT:** Now, in terms of which one is more  
24 problematic right now, is it carbon dioxide or is it CFC?

25           **MR. BOUTROUS:** Carbon dioxide. Now, synthetic with

1 CFC's having been banned, they are not having as much of an  
2 effect now.

3 But there are other synthetic greenhouse gases, but  
4 they are not having the effect, the degree to which carbon  
5 dioxide and other greenhouse gases are.

6 **THE COURT:** Thank you.

7 **MR. BOUTROUS:** Thank you.

8 So with that, Your Honor, I think I'm going to maybe  
9 end this portion of my discussion really about in terms of where  
10 science is now with the concept of modeling and projecting into  
11 the future.

12 And the IPCC AR5, and other reports, talk about  
13 modeling and so at the same time scientists were making these  
14 discoveries, the modeling tools became more powerful and more  
15 complicated. The models began to allow scientists to simulate  
16 interactions between components of the climate system over time.

17 And computers in the 1970's were becoming more  
18 powerful. They used algorithms to represent the interaction of  
19 different elements of the climate system, like the atmosphere,  
20 land surface and ocean and sea ice.

21 And you see this chart from AR5 shows that with each  
22 iteration of the IPCC Assessment Reports, climate models added  
23 more components over time. And those have become increasingly  
24 complex.

25 That can make the modeling more powerful. You can try

1 to -- you kind see more. You can try to understand more. But  
2 because it's an attempt to represent things happening in the real  
3 world, the complexity can also bring --

4 **THE COURT:** Was there a model that you think is  
5 reasonably accurate?

6 **MR. BOUTROUS:** Well, I think that, you know, we,  
7 Chevron, accepts the approach that the IPCC uses, which involves  
8 a bunch of different models. And I'm going to talk about that if  
9 I segue into part two. And, in fact, I'll show you and give you  
10 an example.

11 They say there's no one best model; that different  
12 models can do different things better, and they haven't found one  
13 that does it all.

14 So they run many, many models on different emission  
15 scenarios, and I'm going to turn to that.

16 **THE COURT:** Kind of like the hurricane models that each  
17 one predicts a slightly different path?

18 **MR. BOUTROUS:** Right. Exactly.

19 **THE COURT:** Okay.

20 **MR. BOUTROUS:** And so, and then the IPCC looks, and the  
21 scientists get together, you know, and try to come to a consensus  
22 and make determinations about the likely range, for example, of  
23 temperature increase or sea level increase based on this table of  
24 models.

25 And I'll show you that in a minute. The point I want

1 to make here is that the IPCC itself says:

2 "Climate models of today are, in principle, better  
3 than their predecessors. However, every bit of added complexity,  
4 while intended to improve some aspect of simulated climate, also  
5 introduces new sources of possible error," close quote.

6 So, you know, you can do certain things. But then  
7 you're -- you know, you're limiting other features. And so the  
8 IPCC points to that and grapples with that as it makes its  
9 assessments.

10 Let me go to the next slide before we go --

11 **THE COURT:** Don't you think it's amazing that that guy  
12 Arrhenius --

13 **MR. BOUTROUS:** Yes.

14 **THE COURT:** -- with no models, no computers --

15 **MR. BOUTROUS:** Yes.

16 **THE COURT:** Just the back of an envelope and pencil and  
17 paper could have made that prediction which even today sounds  
18 pretty reasonable, doesn't it? That if you doubled the amount of  
19 carbon dioxide from those levels that -- what was it -- 4 degrees  
20 Centigrade I think the Earth would go up?

21 That's in the ballpark of what I think these models are  
22 saying. Right?

23 **MR. BOUTROUS:** These scientists are brilliant. I mean,  
24 again, when you look back what they were doing, they were just  
25 coming up with this themselves and making a hypothesis and

1 testing it. So I --

2 **THE COURT:** But he was just one guy.

3 **MR. BOUTROUS:** He was just one guy.

4 **THE COURT:** One guy in an early age and using his brain  
5 and some data, but not -- but just thinking it through. You have  
6 to admire that.

7 Okay. I'm sorry. Go ahead.

8 **MR. BOUTROUS:** Yes. No. And now this is a good time.  
9 One guy back in 1896, and now we have these models that can do a  
10 lot. And this is just for illustration, and I'll talk about it  
11 more in the next segment.

12 But this graph from AR5 shows model projections for the  
13 Earth temperature through 2050. And just to give the Court a  
14 feel for it, the solid black line shows the observed  
15 temperatures, so that's what actually happened.

16 The colored lines show the modeling estimates based on  
17 various emissions inputs. And so you'll see it says those are  
18 the RCPs. So the RCP 2.6 is the lowest emissions scenario they  
19 are looking at, they are assuming.

20 And then, RCP 8.5 is the highest emission scenario.  
21 They are assuming the highest level emissions going forward.

22 And then, this goes to the Court's earlier question.  
23 They ran multiple different models that had different factors  
24 included in them at each scenario.

25 So 42 models for 4.5, 39 models for RCP 8.5. And

1 that's -- then you see this tangle of projections going into the  
2 future.

3           Based on the models and the mission scenarios the range  
4 gets wider as it gets farther out in the future, reflecting, I  
5 think, just the common sense notion that it's harder to predict  
6 things as they go into the future.

7           **THE COURT:** Just so we can -- so the model that would  
8 be the most conservative in year 2050, if it's correct, what does  
9 that mean? The temperature would go up by about 1 degree in  
10 Centigrade?

11           **MR. BOUTROUS:** Well, you know, it depends, Your Honor.  
12 In fact, I'm going to show you how the IPCC put that. But, yes,  
13 if you just looked, if you picked one of those lines, and then  
14 you picked the year, you'll see some of the RCP 2.6 models, they  
15 are at different places because the model is different in terms  
16 of the factors they were using.

17           **THE COURT:** Anomaly:" means difference. Right?

18           **MR. BOUTROUS:** Yes.

19           **THE COURT:** That is what that means?

20           **MR. BOUTROUS:** Exactly.

21           **THE COURT:** Compared to what year? What year are we --

22           **MR. BOUTROUS:** So what year did you mention, Your  
23 Honor? You said --

24           **THE COURT:** 2050 at the very far right. But what is  
25 the base year that we're comparing it against?

1           **MR. BOUTROUS:** The base year here -- and, Your Honor, I  
2 think you're right.

3           **THE COURT:** Must be 1986.

4           **MR. BOUTROUS:** Yes.

5           **THE COURT:** I'm not sure.

6           **MR. BOUTROUS:** I've got that here for you, Your Honor  
7 but I think it would be -- as you pointed out, the lowest one  
8 would be about a .5 degree increase as I look at it.

9           **THE COURT:** I see. I see. Okay. And then, the highest  
10 would be almost 2.5.

11          **MR. BOUTROUS:** Right.

12          **THE COURT:** Centigrade.

13          **MR. BOUTROUS:** Yes. And then, I'll return to this in  
14 the next segment to give you an example of what the IPCC does to  
15 try to make an estimated range of temperature increases based on  
16 these models.

17          **THE COURT:** Okay. You want to stop there? You've used  
18 an hour. So you have an hour left, and then we have 30 minutes  
19 for the Plaintiff side left. And we'll take a break now so the  
20 public can use the facilities.

21                 Where is Dr. Allen?

22                 I want you to know that I think you are right about the  
23 logarithm thing. And I want -- on base two that would definitely  
24 be a logarithmic scale.

25                 All right. We'll see you in about 15 minutes. Thank

1 you.

2 **MR. BOUTROUS:** Excellent. Thank you.

3 **THE CLERK:** Court is recess.

4 (Thereupon, a recess was taken.)

5 **THE CLERK:** Please remain seated.

6 **THE COURT:** All right. Back to work. Please remain  
7 seated. Okay.

8 So let's finish your half. So you have another hour to  
9 go, and then we will return to the Plaintiffs' side for the  
10 finale.

11 **MR. BOUTROUS:** Okay.

12 **THE COURT:** But before I go, while I have you here, Mr.  
13 Boutrous, is your side going to consent or object or have any  
14 problem with those amicus submissions? There were two that came  
15 in, and I received a paper from Plaintiffs that they have no  
16 objection. So if you don't have any objection, then I'm going to  
17 just approve it.

18 So do you have any objection?

19 **MR. BOUTROUS:** We have no objection, Your Honor.

20 **THE COURT:** All right. Then, I will eventually get an  
21 order out approving the amicus submissions.

22 Okay. Please go ahead.

23 **MR. BOUTROUS:** Thank you, Your Honor. I'm now going to  
24 move to part two of the tutorial, which the Court asked us to  
25 address the best science now available on global warning, glacier

1 melt, sea rise and coastal flooding.

2 I'm going to walk through those topics basically in  
3 order.

4 Just as in part one, I'm going to be relying on the AR5  
5 from the IPCC, and, in particular, I will be citing a Working  
6 Group I report on the physical science basis of climate change.

7 **THE COURT:** Okay.

8 **MR. BOUTROUS:** The first topic I'm going to discuss is  
9 global warming. And the Court's already on top of this. I can  
10 tell from the questions. But just a couple of terms.

11 So global, when we talk about global warming and  
12 temperature, there's no one global temperature. And scientists  
13 have developed "global" means "surface temperature," which in  
14 laymen's terms an average of the temperatures around the world.

15 And it's not measured directly. It's done by  
16 estimating and using measurements at various places.

17 So we will all be using that term a lot during this  
18 segment.

19 As the Court also already noted, the IPCC -- maybe  
20 we'll go to slide three -- does use a baseline. So in every  
21 slide here are the baselines. And that means I have them in  
22 here. I have them for our convenience. And it's the state  
23 against which the change is measured, as the IPCC points out.

24 So on this chart which I'm going to talk about in a  
25 second, it's from AR5. Anomalies are being plotted on the graph

1 with respect to the baseline of 1881 to 1980.

2 **THE COURT:** No, this goes back 2000 years. Am I  
3 looking at the wrong chart?

4 **MR. BOUTROUS:** Yes. This is the temperature variations  
5 during the last 2000 years.

6 **THE COURT:** All right. Explain that one to me.

7 **MR. BOUTROUS:** Sure. So this figure is from Working  
8 Group I. It's in the -- it is, as it is titled. That's the  
9 title from the IPCC. The dotted line represents the baseline,  
10 which is the average global temperature from 1881 too 1980.

11 So they are comparing those other temperatures to that  
12 baseline global average, global mean temperature from 1881 to  
13 1980.

14 **THE COURT:** The dotted line?

15 **MR. BOUTROUS:** Yes.

16 **THE COURT:** On mine it looks like this a bunch of red  
17 dots that go back to 1600.

18 **MR. BOUTROUS:** So, Your Honor, if we're looking at the  
19 same chart, so it's the chart titled: "Temperature variations  
20 during the last 2000 years."

21 **THE COURT:** Right.

22 **MR. BOUTROUS:** And I think he has got the --

23 **THE COURT:** Curser. Go ahead.

24 **MR. BOUTROUS:** So if you look at the 0.0? That is the  
25 baseline. So then the temperatures are being compared against

1 that baseline, 1881 to 1980, throughout that period. It really  
2 starts at, you know, 500.

3 **THE COURT:** It looks like way back in the medieval era.  
4 Right?

5 **MR. BOUTROUS:** Yes.

6 **THE COURT:** The temperature was higher than the  
7 baseline; is that right?

8 **MR. BOUTROUS:** Correct, the medieval warming period.

9 **THE COURT:** Then, starting around 1300, 1400 it  
10 dropped.

11 **MR. BOUTROUS:** Correct, the little ice age.

12 **THE COURT:** Little ice age. And then, it stayed --  
13 looks like, according to your chart, it stayed below the mean  
14 until about 1900? And then, it is skyrocketing up. Right?

15 **MR. BOUTROUS:** It stayed below the mean. And then,  
16 around 1900 in 1901, I think temperatures start to rise again.

17 **THE COURT:** But it's pretty fast, it's rising, not just  
18 a big rise. But okay. But you said something about a dotted  
19 line that went back on my -- the one I'm looking at, the red dots  
20 go back to 1600.

21 **MR. BOUTROUS:** Right. You are right. My fault. I was  
22 just referring to the dotted lines that reflected the base line.

23 **THE COURT:** The dashed line.

24 **MR. BOUTROUS:** Yes, exactly. Just to pick up, the  
25 colored lines and the black lines indicate baseline using

1 different data sets. So the black lines on the figure are  
2 instrument data. So that's measured.

3 And then, the colored lines and dots represent various  
4 reconstructions of the past.

5 **THE COURT:** Okay.

6 **MR. BOUTROUS:** So that's that figure. And let me go  
7 into a little bit more recent period, 1850 to 2012. And, again,  
8 1850 was the end of the little ice age. And this is really the  
9 point the Court was just making. The IPCC AR5 concludes that:

10 "Since 1901 almost the whole world has experienced  
11 surface warming. Warming has not been linear; most warming  
12 occurred in two periods: Around 1900 to around 1940 and around  
13 1970 onwards."

14 And so, again, this -- each of the colored lines shows  
15 the average global temperature anomaly based on a different  
16 dataset from 1850 to 2012. And the baseline is the global means  
17 surface temperature from 1961 to 1990. So they are comparing  
18 against that.

19 The next slide is basically the same slide, I believe.  
20 But if we look at the 20th century warming, the early period,  
21 Your Honor, from 1901 to 1950, here's the conclusion of the IPCC.

22 Quote:

23 "The early 20th century warming is very unlikely  
24 to be due to internal variability alone. It remains difficult to  
25 quantify the contribution to this warming from internal

1 variability, natural forcing and anthropogenic forcing, due to  
2 forcing and response uncertainties and incomplete observation,"  
3 close quote.

4           And since I knew you would ask me what caused that  
5 warming I thought I would just go with that quote because I think  
6 what they are basically saying is that in the early 20th century,  
7 while it's unlikely that the climate was functioning -- the  
8 warming was caused by the climate functioning in its natural  
9 course, internal variability, the IPCC couldn't quantify any  
10 contributions to the warming from potential other causes, like  
11 changes in the sun or volcanos. That's the natural forcing.

12           **THE COURT:** What does "internal variability" mean?

13           **MR. BOUTROUS:** That is their phrase for just describing  
14 the natural, natural variability in the climate without some  
15 event like a volcanic eruption, which is what they call a natural  
16 forcing sort of an event.

17           And then, anthropogenic forcing is human activity like  
18 the kind of things we're talking about here.

19           **THE COURT:** When was that Krakatoa volcano? Wasn't  
20 that about 1880 something?

21           **MR. BOUTROUS:** That sounds about right, Your Honor.

22           **THE COURT:** So that was supposed to have had a cooling  
23 effect. Right?

24           **MR. BOUTROUS:** Volcanos generally have a cooling  
25 effect.

1           **THE COURT:** So part of that downward curve might be --  
2 anyway, but around 1901 it starts to go up. And what this  
3 statement is saying to us, if I got it right, is that it's very  
4 unlikely to be due to internal. Is that a roundabout way of  
5 saying it is due to CO2?

6           **MR. BOUTROUS:** They are saying they think something  
7 other than just internal variability, natural climate  
8 fluctuations.

9           **THE COURT:** Well, that would be human. Right? They  
10 are saying it must be human, but they are not saying it directly.

11           **MR. BOUTROUS:** They are saying, you know, they can't  
12 tell. In addition to internal variability there are other  
13 natural causes. So sort of, as I said, an event, an increase in  
14 the sun's solar power, something.

15                   But, and then, but anthropogenic forcing is human  
16 activity.

17                   So they are saying they think something other than  
18 natural activities is causing the warming. But they don't have  
19 enough data. They are not able to pin that down for that period.

20                   Now, things get different. I'm going to move to the  
21 next slide, Your Honor, because here when we get into the more  
22 recent period, the period 1951 to 2010, they are able to draw  
23 conclusions.

24                   And this is a variant of what I displayed at the  
25 beginning. In the second half of the 20th century they analyzed

1 that data and concluded that it, quote:

2 "It is extremely likely that more than half of the  
3 observed increase in global average surface temperature from 1951  
4 to 2010 was caused by the anthropogenic increases in greenhouse  
5 gas concentrations and other anthropogenic forcings together."

6 **THE COURT:** "Anthropogenic" means "human"?

7 **MR. BOUTROUS:** Yes.

8 **THE COURT:** Right. Okay.

9 **MR. BOUTROUS:** So that's this most, you know -- that  
10 period there they are able to make that conclusion.

11 So since they talked about the anthropogenic increase  
12 in greenhouse gas concentrations, Your Honor, I thought I would  
13 briefly touch on historic CO2 emissions, just to make a couple of  
14 things clear.

15 So this chart has the historic human CO2 emissions for  
16 the United States, China and India from about 1970 to 2010.

17 They are on different scales, Your Honor. The top  
18 chart has China, United States and India. And you'll see that  
19 China is increasing. India is increasing. The United States,  
20 the emissions went -- leveled off and then dropped down as of  
21 2005.

22 And the quote I have up there is one I mentioned  
23 earlier.

24 Quote:

25 "Anthropogenic greenhouse gas emissions are mainly

1 driven by population size, economic activity, lifestyle, energy  
2 use, land use patterns, technology and climate policy," period,  
3 question mark. Excuse me, quote mark.

4 And I think it's important when you think about it, as  
5 the Court probably is aware, that China is burning more coal than  
6 the United States. With the hydraulic fracturing or sometimes  
7 called "fracking," that has caused reduced coal burning in the  
8 United States and reduced greenhouse gas emissions.

9 So you see how different energy uses can change and  
10 affect the greenhouse gas emissions.

11 And I said this earlier, I think the IPCC does not say  
12 it's the extraction and production of oil that is driving these  
13 emissions. It's the energy use. It's economic activity that  
14 creates demand for energy. And that leads to emissions,  
15 especially due to the importance of having affordable energy  
16 sources.

17 **THE COURT:** What is the -- the vertical column, I know,  
18 measures CO2. Right?

19 **MR. BOUTROUS:** Yes.

20 **THE COURT:** Is that tons or --

21 **MR. BOUTROUS:** Megatons.

22 **THE COURT:** Megaton.

23 **MR. BOUTROUS:** Megatons per year.

24 And then, the bottom scale for the world is doing the  
25 same thing, but it's on a different scale because the world has

1 more megatons. But it, again, shows the increase.

2 **THE COURT:** On the top, this chart comes from the IPCC.  
3 Right?

4 **MR. BOUTROUS:** Yes. Well, both charts are from IPCC  
5 AR5. We took, just so the Court knows, we took the China, U.S.  
6 and India and put them all on the same chart, same scale, just so  
7 the Court could see it altogether.

8 **THE COURT:** One thing that surprises me about this is  
9 the U.S. line, while it has gone up, has not gone up that much.

10 But the China one has gone up dramatically --

11 **MR. BOUTROUS:** Correct. And that is because, you know,  
12 their economy --

13 **THE COURT:** -- and surpassed the USA.

14 **MR. BOUTROUS:** Yes. And it really goes to the global  
15 nature of this. Their economy has been expanding. That leads to  
16 more activities. That creates a demand for more energy. They  
17 are burning coal, more coal than the U.S.

18 The U.S. has been using other sources of energy:  
19 Natural gas. That has been one of the contributing factors to  
20 the levels you see comparing the United States and China.

21 **THE COURT:** On the India graph, there seem to be two  
22 lines, an orange one and a green one or something. So what is  
23 the point of the two lines?

24 **MR. BOUTROUS:** I think those are different datasets,  
25 Your Honor. We had all three. So you'll see there are different

1 colors for each. And so they did these analyses using different  
2 datasets, and they are pretty comparable.

3 **THE COURT:** All right. So go to the one on the bottom?  
4 That's worldwide.

5 **MR. BOUTROUS:** Yes.

6 **THE COURT:** And as of right now, the most recent  
7 data -- it's hard to read.

8 **MR. BOUTROUS:** I can enlarge.

9 **THE COURT:** What is the total, 30,000 31 something?  
10 33? Let's say 30,000.

11 **MR. BOUTROUS:** Yes.

12 **THE COURT:** All right. So 30,000. So the USA would be  
13 what portion of the 30,000?

14 **MR. BOUTROUS:** So if we go back up to the top chart, on  
15 this graphic from the IPCC it looks like about, you know --

16 **THE COURT:** 6,000.

17 **MR. BOUTROUS:** Six thousand, 5900.

18 **THE COURT:** So that would put us at -- here's where I  
19 need Dr. Allen.

20 Well, what is the percentage of that? 6,000 into --

21 **MR. BOUTROUS:** 30,000.

22 **THE COURT:** -- 30,000. 20 percent?

23 **MR. BOUTROUS:** Yes.

24 **THE COURT:** Okay. So the USA is responsible for  
25 20 percent. Is that right, about roughly?

1           **MR. BOUTROUS:** Based on your calculations, Your Honor.

2           **THE COURT:** Well, I'm asking you. All right. Okay. so  
3 still, USA is pretty big. I wonder where Europe would fit in  
4 here. Have you done -- where would Europe be? Comparable to the  
5 USA? What would it be?

6           **MR. BOUTROUS:** We can get you that data.

7           **THE COURT:** No, that's okay. All right. Go ahead.

8           **MR. BOUTROUS:** Okay. Thank you, Your Honor.

9           So that's historic CO2 emissions.

10           Let's turn to future temperature projections. And this  
11 is sort of where I left off with the modeling discussion. And I  
12 think Dr. Griggs mentioned the emission scenarios. I referred to  
13 them earlier.

14           Just to illustrate what they are, this chart from the  
15 AR5, is kind of laying out what they are. So the representative  
16 concentration pathways are also called, just in shorthand, "The  
17 Emission Scenarios."

18           They reflect less potential future mitigation efforts,  
19 such as carbon capture the higher up we go. So if we look at the  
20 chart, the black line represents the historic CO2 emissions  
21 through 2011.

22           And then, they start looking out to the future. The  
23 2.6, the dark blue line is considered the lower, the low  
24 emissions scenario.

25           RCP 8.5, the red line, is the high emission scenario.

1 And then, 4.5 and 6.0 are the two intermediate scenarios.

2 So as I mentioned, the IPCC runs different models based  
3 on different scenarios in terms of the quantity of emissions from  
4 human activities.

5 **THE COURT:** Here's something.

6 **MR. BOUTROUS:** Yes.

7 **THE COURT:** How can this be? I got some that are going  
8 downward. Some of these projections go down. Right?

9 **MR. BOUTROUS:** Correct, yes.

10 **THE COURT:** So what assumptions are made that would  
11 cause the amount of CO2 to go down?

12 **MR. BOUTROUS:** For example, that one, the lowest one,  
13 which is RCP 2.6, they are modeling and calculating in different  
14 mitigation efforts, such as carbon capture and storage, and  
15 other -- that other mitigation efforts will be made as a policy  
16 matter. And so they factor that into that.

17 And then, on the red line they are assuming that those  
18 sorts of things won't have been done. And that emissions will go  
19 forward.

20 So then the next chart, you will recall, the next  
21 graph, this is, again, from the AR5. And it's the one that I  
22 displayed earlier. This is -- I kind of want to walk through  
23 what they actually do with it, with the Court's permission.

24 The various models that are in the parentheses on the  
25 left-hand side of the screen and the top, next to the RCP

1 emission scenarios have different factors and different  
2 considerations built into them. And there are many, many of  
3 these models.

4 This is the Working Group I from its chapter on near  
5 term climate change. And this is just to illustrate how they go  
6 through the process of projecting future temperature change.

7 As I mentioned earlier, the colored lines on the figure  
8 are the various model runs, with the solid black line is the  
9 historical actual observed temperatures.

10 And if you -- you'll see that the black line here when  
11 it crosses the dotted line it is at the lower end of the bottom  
12 end of the projections. So to the bottom end of the tan-colored  
13 lines.

14 And that, the IPCC observed -- and this is the quote up  
15 on the side, quote:

16 "Some models may be too sensitive to anthropogenic  
17 forcing," close quote.

18 So they are saying that the models were assuming a  
19 greater effect from human activity on the temperature than turned  
20 out to be the case in actual observed temperatures.

21 **THE COURT:** All right. Let's -- okay. I think I  
22 understand your point. But all right. There's the obvious dark  
23 line, black line on the left that says "historical." And then,  
24 there's a dashed vertical, but that is hard to see.

25 But the black solid line continues on a few years

1 thereafter. Right?

2 **MR. BOUTROUS:** Yes.

3 **THE COURT:** So the squiggly colored lines, are those  
4 what the models that existed back at the time of the dashed line,  
5 vertical line, what they would have projected?

6 **MR. BOUTROUS:** That's what they were projecting, so --

7 **THE COURT:** By what point? At the point of the dashed  
8 lines?

9 **MR. BOUTROUS:** Yes. So as I understand it from the  
10 IPCC report, that's what they were projecting from that period,  
11 from the dotted line forward.

12 And then, as it turned out, you see the observed  
13 temperatures, what actually happened at least with respect to  
14 some of them, the observed temperatures were lower than those  
15 models were predicting.

16 **THE COURT:** And that was true for how many years?  
17 Looks like five years maybe?

18 **MR. BOUTROUS:** Yeah. Yeah. Well, really --

19 **THE COURT:** Six.

20 **MR. BOUTROUS:** -- pretty much going from 2000 to about  
21 2012, really. Almost to the end when you look at that, because I  
22 think that's when they are -- this is from -- yeah, really almost  
23 the entire time. Some are below. Some of the models do run --  
24 were predicting less.

25 But it's really from, let's see, 2000. I think it's

1 about 2005 to 2012.

2 **THE COURT:** All right. So your point is the models  
3 overstate the problem.

4 **MR. BOUTROUS:** At least -- at least with respect to  
5 that period of time.

6 **THE COURT:** And instead of doom and gloom, it's just  
7 gloom. But it's still going up.

8 **MR. BOUTROUS:** You know, Your Honor -- and, again, I'm  
9 just really reporting the way the IPCC has looked at this. And  
10 you'll see that the going farther into the future you have the  
11 various different models based on different RCP scenarios, kind  
12 of going out in the future.

13 And the other quote I have displayed is again from the  
14 IPCC, quote:

15 "By mid-21st century, the magnitude of the projected  
16 climate change is substantially affected by the choice of  
17 emissions scenario," close quote.

18 So, in other words, as a policy matter, but also just  
19 as a modeling matter, the more emissions you anticipate, the  
20 magnitude of projected climate change is going to be a function,  
21 but a function substantially affected by that choice.

22 So then, the question is: How do they make a  
23 prediction?

24 **THE COURT:** Is this in the IPCC report?

25 **MR. BOUTROUS:** Yes, it is. And we'll give you copies

1 of all this.

2 **THE COURT:** All right.

3 **MR. BOUTROUS:** It's right out of AR5.

4 **THE COURT:** Can you give me color copies?

5 **MR. BOUTROUS:** You bet. Absolutely. And we'll give  
6 Plaintiffs a copy, too.

7 So now, just to give you a sense of how -- what they do  
8 once they have this data, we'll go to the next slide.

9 And here this is the chart, the graph that represents  
10 the IPCC Working Group I, making a determination based on all  
11 that data, all the models, the various scenarios, what's the  
12 likely range of temperature from 2016 to 2035?

13 And so they -- what they do, they added the -- that's  
14 the IPCC red box to represent their determination of likely -- to  
15 them that's greater than 66 percent -- future increases in global  
16 mean temperature.

17 And I'll just read the conclusion, and then I have a  
18 feeling you might have a couple of questions.

19 So, quote:

20 "Overall, in the absence of major volcanic  
21 eruptions -- which would cause significant but temporary  
22 cooling -- and, assuming no significant future long term changes  
23 in solar irradiance, it is likely, 60 percent (sic) probability  
24 that the Global Mean Surface Temperature anomaly for the period  
25 2016 to 2035, relative to the reference period of 1986 to 2005

1 will be in the range of .3 centimeters -- Celsius -- excuse me  
2 .3-degree Celsius to .7-degree Celsius."

3 And then, they say:

4 "(Expert assessment, to one significant figure:  
5 Medium confidence)," close paren, close quote.

6 And that would translate to about .5 degrees Fahrenheit  
7 to 1.3 degrees Fahrenheit. So that's their like predicted likely  
8 range for that period and potential increase.

9 **THE COURT:** Ending in the year 2035.

10 **MR. BOUTROUS:** Yes.

11 **THE COURT:** Okay. Well, okay. Just a minute. This  
12 IPCC, Intergovernmental -- what does the P stand for?

13 **MR. BOUTROUS:** Panel on Climate Change.

14 **THE COURT:** Climate change.

15 **MR. BOUTROUS:** Yes.

16 **THE COURT:** And the U.S. is part of that. Correct?

17 **MR. BOUTROUS:** Yes.

18 **THE COURT:** So that is saying that "likely," meaning  
19 more than 66 percent probability that between 2016 and 2035,  
20 there will be an increase and it will be in the range of .3 to .7  
21 C.

22 **MR. BOUTROUS:** Yes.

23 **THE COURT:** Okay. And .7 C is, did you say,  
24 one-and-a-half degrees Fahrenheit.

25 **MR. BOUTROUS:** 1.3 degrees Fahrenheit.

1           **THE COURT:** 1.3. All right.

2           **MR. BOUTROUS:** So that's their process. And they have  
3 a process for, you know, reaching consensus for analyzing issues.  
4 And that's how they -- how they do that and project into the  
5 future.

6           **THE COURT:** I'm sure you are going to get to it, but  
7 let's say that that prediction is correct. So what would that  
8 translate to in terms of sea level increases?

9           **MR. BOUTROUS:** I'm about to turn to glacier melt and  
10 sea level, because you'll see it's a somewhat complex analysis in  
11 terms of translating actual contributions of human activity to  
12 warming, and then translating that to sea level rise. But I'm  
13 about to -- perfect -- it's a perfect segue, Your Honor. Let me  
14 start with the glacial melt.

15           So the Court asked about glaciers. And in addition to  
16 glaciers, which are a form of land ice, there are ice sheets.  
17 And ice sheets are another type of land ice, obviously, but much  
18 larger.

19           In IPCC's words they are of continental size and the  
20 only two are Greenland and Iceland. And this is another graphic  
21 from IPCC AR5, to orienting us all. It's shows the glaciers in  
22 yellow. You can see on the graphic the ice sheets are in white.

23           And then, you've got sea ice as the light blue around  
24 it.

25           And Your Court will recognize Greenland in the

1 northern, the top view, and Antarctica in the southern bottom  
2 view.

3           And Your Honor, again, for reference Chapter Four of  
4 the AR5 Working Group I goes into great detail on the ice masses.

5           And so, again, so we've got Greenland at the top,  
6 Antarctica on the bottom. Let me start with glaciers, and just  
7 give the Court a few of the key findings from the IPCC on  
8 glaciers.

9           First quote:

10                   "The arithmetic-mean estimate of Leclercq, et al,  
11 2011, indicates continuous mass loss from glaciers after about  
12 1850," close quote. Again, was the end of the little ice age.

13           Another finding:

14                   "Overall, there is very high confidence that  
15 globally, the mass loss from glaciers has increased since the  
16 1960's," close quote.

17           And then, another finding is, quote:

18                   "Anthropogenic influences likely contributed to  
19 the retreat of glaciers since the 1960's," close quote.

20           So that is what they have found in terms of glaciers.

21 And there's a likely effect from human activities since the  
22 1960's. That's glaciers.

23           And then, if we go to ice sheets of Greenland and  
24 Antarctica. Starting with Greenland, the IPCC has found that,  
25 quote:

1 "Over Greenland, temperature has risen  
2 significantly since the early 1990's, reaching values similar to  
3 those in the 1930's," close quote.

4 Then, they find, quote:

5 "There's a very high confidence that the Greenland  
6 ice sheet has lost ice during the last two decades," close quote.

7 Third, they find, quote:

8 "It is likely that anthropogenic forcing has  
9 contributed to surface melting of the Greenland ice sheets since  
10 1993," close quote.

11 And they also find that, quote:

12 "Since 2007, internal variability is likely to  
13 have further enhanced the melt over Greenland," close quote.

14 **THE COURT:** What does "internal variability" mean?

15 **MR. BOUTROUS:** Just natural changes in the atmosphere  
16 and the temperature aside from human activities, including  
17 emissions of greenhouse gases.

18 Now, let's turn to Antarctica. It's a very different  
19 story in terms of the conclusions and the ability of scientists  
20 to understand what is happening in Antarctica.

21 First on Antarctica, and it's the biggest sheet, the  
22 IPCC says, quote:

23 "Overall, there is high confidence that the  
24 Antarctic ice sheet is currently losing mass," close quote.

25 Second, they say, quote:

1 "There is low confidence that the rate of  
2 Antarctic ice loss has increased over the last two decades,"  
3 close quote.

4 Third:

5 "Anthropogenic forcings" -- human activities --  
6 "have likely made a substantial contribution to surface  
7 temperature increases since the mid-20th century over every  
8 continental region except Antarctica," close quote.

9 So they are not able to make that determination that  
10 there's been a likely contribution to increased surface  
11 temperatures caused by human activity in Antarctica.

12 And --

13 **THE COURT:** Why would that be? Why would it be  
14 different for Antarctica?

15 **MR. BOUTROUS:** In fact, let me go to the next slide.

16 I think I mentioned that a key uncertainties summary --  
17 and it's very helpful. The reports are pretty easy to navigate.  
18 But they have one -- they have three key uncertainties about  
19 Antarctica. And this is kind of one that captures it.

20 So key uncertainties captures the key uncertainties in  
21 understanding the climate system and its recent changes.

22 "In some aspects of the climate system, including  
23 Antarctic warming, Antarctic sea ice extent, and Antarctic mass  
24 balance, confidence in attribution to human influence remains;  
25 low due to modeling uncertainties and low agreement between

1 scientific studies," close quote.

2 They also, I think, in another spot say that the,  
3 quote:

4 "The observational record of Antarctic mass loss  
5 is short and the internal variability to ice sheet is poorly  
6 understood. Due to a low level of scientific understanding,  
7 there's low confidence in attributing the causes of the observed  
8 loss of mass from the Antarctic ice sheet since 1993."

9 So they just -- their record of observation is short.  
10 Their understanding of the natural causes is poorly -- they have  
11 a poor understanding of that. And that's just because science is  
12 studying these things and different scientists are disagreeing.

13 And that goes back to my point. Chevron looks to the  
14 IPCC because you have all these scientists coming together trying  
15 to reach scientific --

16 **THE COURT:** When you say "Chevron," I thought you were  
17 talking for all the defendants. But are you just -- do all  
18 defendants agree with that?

19 **MR. BOUTROUS:** I'm just talking for Chevron today.

20 **THE COURT:** All right. Okay. I'm going to ask them at  
21 some point whether they agree with everything you've said.

22 **MR. BOUTROUS:** Okay, Your Honor. I don't think anyone  
23 has ever agreed with everything I've said. But maybe it will  
24 happen.

25 **THE COURT:** Okay.

1           **MR. BOUTROUS:** And so that's Antarctica. And maybe  
2 this is a good place to pause. The Plaintiffs have taken a  
3 different approach today, I think, and citing studies sort of  
4 different studies from different folks. And some those go  
5 beyond IPCC AR5.

6           But Chevron -- and we focus on what is the scientific  
7 consensus as the best available science pursuant to the Court's  
8 request. And then, we have AR6. We will no doubt, you know,  
9 look at these issues again, and we'll see what it says.

10           **THE COURT:** I got a question for you that relates to  
11 this Antarctica part. It may be since you know the IPCC report,  
12 a few weeks ago on television I saw a geology show. And it was  
13 about volcanos, but it described an under see thing called: "The  
14 Ring of Fire."

15           Doesn't that sound like something from Johnny Cash?  
16 But, honestly, I'm not making that up. It's called "The Ring of  
17 Fire." And it's a undersea system of volcanic accretions, or  
18 something, that's under the Pacific Ocean. And it starts down  
19 there at the bottom of South America, runs along the coast all  
20 the way up to Alaska, curves over to Japan, then goes down into  
21 Indonesia. And the idea is that it is pumping out lava under the  
22 ocean which sometimes forms islands and is one possible result.

23           And it also affects the undersea life and other things.  
24 It had nothing to do with this, but I got to wondering: Do these  
25 models -- and maybe you may know -- does the IPCC, that seems

1 like heat from inside the Earth that's normally insulated, you  
2 know, molten lava way down there, but it's coming out. Does that  
3 warm up the ocean and have anything to do with Antarctica melting  
4 away? Or has that obviously been debunked by somebody?

5 **MR. BOUTROUS:** Your Honor, I'm going to say I don't  
6 know. We'll take a look.

7 **THE COURT:** The IPCC, any of that.

8 **MR. BOUTROUS:** Not that I remember specifically. You  
9 know, they talk about different features that can heat the ocean  
10 and natural formations and the like.

11 But we'll go back and take a look. And I'm going to  
12 leave behind for you the big Working Group I.

13 **THE COURT:** I promise you that is a real scientific  
14 term. I did not make that up. It really exists. And I've seen  
15 it in other places. Okay.

16 A note has come from the rear.

17 **MR. BOUTROUS:** A note has come, Your Honor. It just  
18 came back to me that it's a very recent discovery, and so it was  
19 too recent for the IPCC.

20 **THE COURT:** No, this Ring of Fire thing has been around  
21 since at least 20 years. This is not recent.

22 **MR. BOUTROUS:** Well, I'm going to look into this  
23 further.

24 **THE COURT:** Look into it.

25 **MR. BOUTROUS:** I like the name of it and it sounds

1 interesting, so I'm going to look into that further.

2 So and I think Dr. Griggs had talked about -- and I  
3 just to tie it a little bit to what he's talking about -- he was  
4 talking about the contribution of Antarctica and the melting, but  
5 just to finish up on Antarctica, the IPCC in its latest report  
6 says, you know, there are uncertainties about the degree to which  
7 human activities are contributing to the ice melt there.

8 **THE COURT:** Okay. But, nevertheless, it is melting,  
9 isn't it? So how much is -- what is the level of sea? Let's go  
10 to that question.

11 **MR. BOUTROUS:** I was just going to sea level.

12 **THE COURT:** Your view of how much this ocean is rising.

13 **MR. BOUTROUS:** I'm going to give the Court the IPCC  
14 conclusions that cuts right into this.

15 **THE COURT:** All right.

16 **MR. BOUTROUS:** So Chapter 13 of the Working Group I has  
17 an entire discussion. It's all about sea level change. This  
18 figure is from the IPCC, and it simply just depicts the  
19 components of sea level. You see the glaciers on the left, ice  
20 sheets on the right, ocean properties, which refers to ocean  
21 warming which would tie into the Ring -- was it "Reign of Fire"?

22 **THE COURT:** Ring, Ring of Fire.

23 **MR. BOUTROUS:** Which we're going to check into.

24 And the ocean, because when the ocean warms it expands  
25 which can cause sea level to rise. And then, you have geocentric

1 sea level, which refers to a method for measuring sea level from  
2 the center of Earth that I'll touch on more in a minute.

3 And in looking at the many components of the sea level  
4 and the sea level rise the IPCC states, quote:

5 "The primary contributors to contemporary sea  
6 level change are the expansion of the ocean as it warms and the  
7 transfer of water currently stored on land to the ocean,  
8 particularly from land ice glaciers and ice sheets," close quote.

9 So we go to the next slide. And this is heading  
10 towards your the question you just asked me. This chart reflects  
11 global sea level since 1700.

12 You see that the IPCC says, quote:

13 "Evidence indicates that the global mean sea level  
14 is rising, and it is likely resulting from global climate change,  
15 ocean warming includes land ice."

16 If we go to the next slide --

17 **THE COURT:** Wait. Wait. Wait. Stick there.

18 **MR. BOUTROUS:** Yes.

19 **THE COURT:** It says:

20 "Corrected for isostatic and tectonic  
21 contributions."

22 What does that mean?

23 **MR. BOUTROUS:** Isostatic, Your Honor, refers to the  
24 reaction of land. Once the ice melts, it releases pressure, so  
25 the land will rise. And so they are correcting for that feature.

1           So if the glacier starts to melt land has -- the  
2 pressure on it releases so it rises, so they are corrected.

3           Tectonic contributions just refer, I believe, to  
4 natural shifting, tectonic shifting. So they have corrected for  
5 those features to try to factor them out of the analysis.

6           **THE COURT:** Well, all right. But does that mean that  
7 the sea level actually has not risen or has risen even more?

8           Okay. According to this, the sea level is going up. I  
9 can see that. But it's corrected for two things. So is the  
10 actual sea level going up, as measured, say, at Santa Cruz or at  
11 San Francisco?

12           **MR. BOUTROUS:** I can't go beyond really what the IPCC  
13 has said here with respect to their view, taking those factors  
14 out. But the Court's question goes to how do you translate these  
15 global assessments to localities. And that's another topic that  
16 I'm going to get to, because it's a very good -- what does it  
17 actually mean for a particular place? And so maybe I'll just  
18 move to -- kind of move to that.

19           **THE COURT:** All right. Go ahead.

20           **MR. BOUTROUS:** So the Court can see that. So just to  
21 kind of finish off the sea level change and the rate, this chart  
22 has the sea level rise, the rate in terms of sea level rise over  
23 decades.

24           And the IPCC concludes that, quote:

25                       "Variability is marked by an increasing trend

1 starting in 1910 to 1920, and a downward trend starting around  
2 1950, and then an increasing trend in terms of the rate of sea  
3 level around 1980."

4 So it starts increasing. Then --

5 **THE COURT:** Wait. Wait. Wait.

6 **MR. BOUTROUS:** Yes.

7 **THE COURT:** So this is saying that even as far back  
8 as -- that as far back as 1900 the sea level has been going up.

9 **MR. BOUTROUS:** And that the rate of increase at least  
10 in 1910 to 1920 was increasing. Then, there was a downward  
11 trend. And then, starting around 1950 an increasing trend.

12 But you are right. I think if we go back to one of my  
13 earlier slides, that is the sea levels have been rising for  
14 thousands of years.

15 **THE COURT:** All right. But the rate of change of the  
16 increase or rate of the increase, it looks like from 1950 to --  
17 1940 something to 1960, it went down. But it was still going up.  
18 But the rate of change was smaller, but then it started coming  
19 back up again. The rate started creeping back up again.

20 **MR. BOUTROUS:** Your Honor, you'll see --

21 **THE COURT:** Is that about right? Okay.

22 **MR. BOUTROUS:** I think that's correct looking at the  
23 chart. And if you go to the next slide, it's interesting to  
24 compare. And the IPCC does this. So the IPCC concludes that:

25 "It is likely that the global mean sea level rose

1 between 1920 and 1950 at a rate comparable to that observed  
2 between 1993 and 2010," close quote.

3 So back in that 1920-1950 period the rate was  
4 comparable to the rate that the IPCC detects from 1993 to 2010.

5 **THE COURT:** So what happened? What was going on in  
6 1920 to 1950 that might have influenced that?

7 **MR. BOUTROUS:** Well, there was the warming that was  
8 going on then, if we go back. It was, I think, the period when  
9 they were having difficulty discerning precisely what the cause  
10 of it was. That's, I think, Your Honor, where they say "natural  
11 forcings." Probably -- excuse me -- internal variability. I'm  
12 not sure that -- well, in fact, I don't think the IPCC does  
13 actually explain in terms of causation what was causing that  
14 warming compared to more recent times, and then make the  
15 connection.

16 So if we go to the next slide, this is -- I'm going to  
17 kind of get local. Talk a little bit about taking these  
18 conclusions to globally.

19 This is, again, right out of the IPCC AR5. And I  
20 mentioned geocentric sea level earlier. And here's how the IPCC  
21 describes it, quote:

22 "Since the late 20th century, satellite  
23 measurements of the height of the ocean surface relative to the  
24 center of the Earth, known as geocentric sea level, show  
25 differing rates of geocentric sea level change around the world,"

1 close quote.

2           And just to orient all of us, you have the bar, the  
3 colored bar on the right, the sea level. The blues are sea level  
4 decreasing, sea level rates decreasing.

5           And then, you have, as we go up we get into yellow,  
6 towards the red. That's the increase. And so with respect to  
7 San Francisco and the West Coast of California, the measurements,  
8 they have measurements for that.

9           And if we go to the next slide --

10           **THE COURT:** Well, wait.

11           **MR. BOUTROUS:** Yes.

12           **THE COURT:** If this is accurate, San Francisco has gone  
13 down.

14           **MR. BOUTROUS:** That's what the IPCC report says using  
15 the geocentric sea level change measurement. So you anticipated  
16 the very next quote I was going to put up there. That the,  
17 quote:

18                       "Those in the Eastern Pacific Ocean, those sea  
19 level increases are lower than the global mean value with much of  
20 the West Coast of the Americas experiencing a fall in sea surface  
21 height over the same period," close quote.

22           **THE COURT:** You know, it's funny. It's odd to me. You  
23 would think like a pond, the pond is the same height all the way  
24 across. Right? But you're saying the ocean can have a higher  
25 sea level in Indonesia than it could at, say, Easter Island.

1           Seems to me like it ought to all be the same. Right?

2           **MR. BOUTROUS:** There are a lot of different factors in  
3 play. And I mean, I think this just shows using this geocentric  
4 sea level measurement -- and, again, talking about the rates of  
5 increase here they show the blue. And the light blue would mean  
6 that the sea level rate has gone down. And it differs around the  
7 globe. So that is kind of what has happened --

8           **THE COURT:** That red up there by Greenland is where the  
9 Greenland is melting away. And so it's deeper there, that is --  
10 what's going on up there?

11           **MR. BOUTROUS:** You can definitely see the differences  
12 on this chart in terms of how the IPCC is depicting it.

13           **THE COURT:** Okay. You can see it very clearcut over  
14 there by Indonesia, New Guinea, Philippines. It's a big  
15 difference there. What accounts for that?

16           Or does the report say why it would be so much higher  
17 there?

18           **MR. BOUTROUS:** Your Honor, I have to go dig into that  
19 particular locale. But it's really -- what I'm sort of about to  
20 get to is the complications of, you know, translating the  
21 projections and the global rates around to different places.

22           **THE COURT:** Okay. Go ahead.

23           **MR. BOUTROUS:** Okay. So just to kind of put this in  
24 perspective, these are looking to the future, and projecting sea  
25 levels. The IPCC has made some projections. And I will just

1 walk the Court through this. Another one from AR5.

2 And you'll see that on the left we have the scenarios  
3 which we've talked about before, the different emission scenarios  
4 ranging from the lowest scenario of 2.6, and the highest of 8.5.

5 And then, if we go -- let's start with 8.5. If we go  
6 all the way over to the right to likely range, the IPCC is saying  
7 that -- it's saying that the likely range of sea level rise  
8 during the period that they are depicting here is -- this goes  
9 all the way to 2100.

10 So I think Dr. Griggs and Plaintiffs has talked about  
11 2100. They say the likely range in sea level rise at the most  
12 extreme emission scenario is .45 to .82 meters. And that  
13 translates to about 1.5 to 2.7 feet. They say that the lower  
14 emissions scenario, the likely range is .26 to .55 meters, or  
15 about .9 to 1.8 feet.

16 So that's what that is depicting, that chart is  
17 depicting.

18 Then they say -- this is the quote at the bottom from  
19 the IPCC, quote:

20 "The basis for higher projections of global mean  
21 sea level rise in the 21st century has been considered and it has  
22 been concluded that there is currently insufficient evidence to  
23 evaluate the probability of specific levels above the assessed  
24 likely range."

25 So they are saying that they -- I'm sure you

1 understand. They are saying they can't predict a higher range  
2 above the likely range that is assessed here.

3 And that really --

4 **THE COURT:** Well, okay.

5 **MR. BOUTROUS:** Go ahead.

6 **THE COURT:** Wait. Wait. Says it's 2046 to 2065.

7 **MR. BOUTROUS:** Um-hum.

8 **THE COURT:** That's an odd -- why are they trying  
9 to -- what is that calculation? What is happening in 2046 that  
10 would cause them to select 2046?

11 **MR. BOUTROUS:** Your Honor, I'm not sure what the  
12 predicate was for picking these two time frames. But, again, I  
13 can go back and nail that down.

14 **THE COURT:** No. No. No. Well, all right. Let me  
15 just make sure I understand.

16 **MR. BOUTROUS:** Yes.

17 **THE COURT:** In the time period of 2046 to 2065, is this  
18 chart saying that at the most favorable, the mean rise will be  
19 .24 meters?

20 **MR. BOUTROUS:** Yes, Your Honor.

21 **THE COURT:** All right. So that's a -- what is that?  
22 About 10 inches? What does that turn out to be? I think so, but  
23 that's meters or is it -- it's meters.

24 **MR. BOUTROUS:** Yes, that's meters.

25 **THE COURT:** .24 meters here?

1           **MR. BOUTROUS:** Yes.

2           **THE COURT:** So that would be a quarter of a meter,  
3 which is about nine and a little over nine inches.

4           **MR. BOUTROUS:** Right.

5           **THE COURT:** So that is saying at the most conservative  
6 level, the sea level around the world will go up 9 inches by the  
7 time period indicated, 2046 to 2065. Is that what that means?

8           **MR. BOUTROUS:** That's how I read it, Your Honor.

9           **THE COURT:** And then, the other end it goes up to .3,  
10 which would be more like 12 inches.

11          **MR. BOUTROUS:** Um-hum.

12          **THE COURT:** All right. So okay.

13          **MR. BOUTROUS:** Yes.

14          **THE COURT:** All right. Okay. Thank you. I think I  
15 understand. This is from the IPCC, as well.

16          **MR. BOUTROUS:** Yes, correct. And that really ties or  
17 brings me to just briefly to address several of what Dr. Griggs  
18 was discussing. And now that he's left, I can really -- perfect  
19 time to address it.

20          **THE COURT:** You can go to town.

21          **MR. BOUTROUS:** Yes. But I won't because I'm going to  
22 go right to what they say. So he talked about the -- if we go to  
23 the next slide, this is a chart from Rising Seas in California,  
24 the study that you'll see he's one of the authors.

25                 And he talked about the 10-foot scenario. And he said

1 it could happen. And as I said, the IPCC in that last chart said  
2 we can't predict higher ranges than we do on this chart. There's  
3 just not evidence.

4 But even Dr. Griggs' study, if you look at the 2100  
5 line, and this is at the 8.5 scenario. So this is the most  
6 extreme emissions scenario.

7 If you go to 2100, Dr. Griggs' study says there's a .1  
8 percent chance of a 10-foot sea rise.

9 **THE COURT:** Over what period? Over what period of  
10 time?

11 **MR. BOUTROUS:** Up till 2100. So this goes -- this is  
12 their projection. It's a 2017 study. So it's projecting forward  
13 2100. So .1 percent.

14 **THE COURT:** So between now and the end of this century.

15 **MR. BOUTROUS:** Yes.

16 **THE COURT:** There's a 1 percent chance.

17 **MR. BOUTROUS:** .1 percent.

18 **THE COURT:** I think it says 1 percent. Maybe I'm  
19 looking -- oh, I see. It's way out there.

20 **MR. BOUTROUS:** Way out there, yes.

21 **THE COURT:** A .1 percent chance. I can't read the top  
22 of that.

23 **MR. BOUTROUS:** 10-foot.

24 **THE COURT:** 10-foot what?

25 **MR. BOUTROUS:** 10-foot rise in the sea level in San

1 Francisco. And that you'll recall the Plaintiffs do mention that  
2 10-foot number in their complaint. Dr. Griggs mentioned it  
3 today.

4 But even his own study is saying that is, you know --  
5 there's a .1 percent chance. Even if you look at a 3-foot rise  
6 they say a .2 or 28 percent chance of a 3-foot rise.

7 **THE COURT:** All right. So 2 feet is 70 percent.  
8 Right?

9 **MR. BOUTROUS:** Let me go to two. Yes.

10 **THE COURT:** And 3 feet is 28 percent.

11 **MR. BOUTROUS:** Yes.

12 **THE COURT:** So somewhere in-between is 50 percent.

13 What would you think that is, two-and-a-half?

14 .4? So in other words, fifty/fifty chance of something  
15 in the range of 2 to 3 feet --

16 **MR. BOUTROUS:** Yes, in fact --

17 **THE COURT:** -- by 2100. That's still a lot of water,  
18 isn't it?

19 **MR. BOUTROUS:** Well, really, it's -- if you look  
20 back -- and this is the most extreme emissions scenario and it's  
21 sort of more in the ballpark, if you look their actual where  
22 something is more likely than not to happen, it's in the one  
23 to --

24 **THE COURT:** How do you know? You said it was the most  
25 extreme scenario. How do you know it's the most extreme?

1           **MR. BOUTROUS:** It's the most extreme scenario that the  
2 IPCC used. You see up in the corner "RCP 8.5"? That's the  
3 highest emissions scenario that the IPCC uses.

4           **THE COURT:** "RCP" again stands for?

5           **MR. BOUTROUS:** Re-concentration of -- testing my memory.  
6 RPC -- probably have it on another note.

7           And, by the way, Your Honor, I should say we don't  
8 necessarily agree with Dr. Griggs' numbers. But I'm just giving  
9 you sort of what they reported, which is just as a matter of fact  
10 the likelihoods they have used.

11           **THE COURT:** All right. It would be interesting to know  
12 if it really is the most aggressive scenario. So you're telling  
13 me it is, but how do you know that?

14           **MR. BOUTROUS:** And when I say that, Your Honor, I'm not  
15 saying that it's the most aggressive scenario anyone has come up  
16 with.

17           It's the representative concentration pathways, what  
18 "RCP" stands for.

19           It's the most -- the highest emission scenario that the  
20 IPCC used in AR5.

21           **THE COURT:** Okay. So -- so the underlying, or the  
22 beginning assumption it's the highest emissions projections. But  
23 in terms of just the modeling of what would happen is it  
24 conservative, medium, aggressive? Do we know?

25           **MR. BOUTROUS:** It's aggressive. It's the one that

1 assumes that -- and I'm using laymen's terms -- but that nothing  
2 will change in terms of any mitigation or to slow down or alter  
3 greenhouse gas emissions.

4           So, again, I really just wanted to make the simple  
5 point that Dr. Griggs mentioned 10 feet. The complaint mentions  
6 10 feet.

7           .1 percent possibility. And then, back when you go  
8 into again, not even forcing their data, but the sea level rises  
9 are closer to and slightly higher than the IPCC assessments for  
10 through 2100.

11           So with that, I'd like to just now move a little bit  
12 into the coastal flooding questions the Court asked about and  
13 just really quickly zip through the sort of the principal  
14 findings from the IPCC.

15           They said that:

16           "Due to sea level rise projected throughout the  
17 21st century and beyond, coastal systems and low-lying areas  
18 will increasingly experience adverse impacts such as  
19 submergence, coastal flooding, and coastal erosion, open paren,  
20 (very high confidence)," close paren, period, close quote.

21           They also make a finding that predicting local effects  
22 and local trends -- well, let me just read it.

23           This is the point. It goes back to one of your earlier  
24 questions that I said I was going to address. They say they make  
25 that broad finding that I just read, but then they say:

1 "While it is likely that extreme sea levels have  
2 increased globally since the 1970's comma, mainly as a result of  
3 mean sea level rise due in part to anthropogenic warming, comma,  
4 local sea level trends are also influenced by factors such as  
5 regional variability in ocean and atmospheric circulation,  
6 subsidence, isostatic adjustment, coastal erosion, and coastal  
7 modification.

8 As a consequence, the detection of the impact of  
9 climate change in observed changes in relative sea level remains  
10 challenging."

11 And I think if I am remembering right Dr. Griggs' slide  
12 said something along the following lines:

13 "Probabilities of specific sea level increases can  
14 inform decisions."

15 And what the IPCC is saying there are all these other  
16 factors when you're looking at what is the impact going to be on  
17 a local locality.

18 And in terms of informing decisions I thought I would  
19 just end with given the state of science and looking forward, in  
20 language really consistent with what I just read, San Francisco  
21 said it's to bond 20-year bond investors. This was 2017.

22 That's, quote:

23 "The City is unable to predict whether sea level  
24 rise or other impacts of climate change or flooding from a major  
25 storm will occur, when they may occur and if any such events

1 occur, whether they will have a material adverse effect on the  
2 business operations or financial condition of the city and the  
3 local economy," close quote.

4 And then Oakland in August, 2017, made a very similar  
5 disclosure to its investors. So translating all of this to what  
6 is going to happen in a local city is, I think, reflected in the  
7 terms of the somewhat unpredictable nature of that by the very  
8 recent bond disclosure of two cities.

9 And with that, I have concluded my part two.

10 **THE COURT:** Thank you, Mr. Boutrous.

11 **MR. BOUTROUS:** Thank you.

12 **THE COURT:** Great. I'd like to see if my court  
13 reporter is able to continue on? Let's see if we can finish up  
14 and go back to the Plaintiff.

15 **MR. BOUTROUS:** Your Honor, just one more. You had  
16 asked in your order about two documents and asked the Plaintiffs  
17 to produce them.

18 **THE COURT:** Yes.

19 **MR. BOUTROUS:** I don't know if the Court -- I'm happy  
20 to address them. I can very briefly address them because I do  
21 have just two minutes.

22 **THE COURT:** No, let's do it -- I want to give the  
23 Plaintiff an opportunity. If we have time you can address it.

24 **MR. BOUTROUS:** Okay.

25 **THE COURT:** I want to go back to the Plaintiffs' side

1 first on the tutorial.

2 **MR. BOUTROUS:** Thank you.

3 **THE COURT:** All right. About half an hour, please.

4 **MR. BERMAN:** Thank you, Your Honor.

5 We are going to -- with respect to the state of the  
6 science, I thought you would like to hear from a scientist who  
7 has worked on the U.S. Climate Assessment. The U.S. Climate  
8 Assessment is the government's state of the art announcement as  
9 to climate change.

10 So rather than refer to the IPCC, as Mr. Boutrous has  
11 done, Dr. Wuebbles -- that's W-U-E-B-B-L-E-S, who is one of the  
12 coauthors of the report and also has been an author of many of  
13 IPCC's studies, is going to present what we think the state of  
14 the science is.

15 And I thought it would be helpful to hand up to the  
16 Court the summary of the U.S. Government's special assessment.

17 **THE COURT:** Sure. Make sure you show Mr. Boutrous --

18 **MR. BERMAN:** Yes, I will.

19 **THE COURT:** -- what you're giving me.

20 Angie, could you hand that up to me? Thank you.

21 All right. This is called: "U.S. Global Change  
22 Research Program entitled Climate Science, Special Report,  
23 Executive Summary, Fourth National Climate Assessment, Volume I."

24 All right. And you are Doctor?

25 **MR. WUEBBLES:** I'm Don Wuebbles.

1           **THE COURT:** Wuebbles.

2           **MR. WUEBBLES:** Wuebbles.

3           **THE COURT:** Got it. Go ahead.

4           **MR. WUEBBLES:** Yes. Thank you, Your Honor.

5           It's a pleasure to try to talk about the outcome from  
6 that assessment.

7           Before we get into that, though, I think it's also  
8 important to recognize that -- well first of all, I led chapter  
9 one of IPCC AR5.

10          **THE COURT:** You read or wrote?

11          **MR. WUEBBLES:** I wrote.

12          **THE COURT:** You wrote.

13          **MR. WUEBBLES:** I led, so I led chapter one.

14          **THE COURT:** You're the one who wrote it?

15          **MR. WUEBBLES:** I wrote a chapter along with colleagues.

16          **THE COURT:** All right.

17          **MR. WUEBBLES:** We had colleagues on the team. And we  
18 had to stop referencing any papers after 2012 in that document.

19                 And I think it's important to recognize that science  
20 did not stop. There's a lot we have learned over the last five  
21 years. And the National Climate Assessment does reflect that.

22                 So but what you have is the Executive Summary of, is  
23 part of a 475-page report that's available on the web through  
24 "science2017.globalchange.gov."

25                 And I'm going to talk to that today. That assessment is

1 the most comprehensive assessment of climate science ever done  
2 for the American people. It was required by Congress, in  
3 general. The Global Change Act of 1990 requires that every so  
4 often there be an assessment of the state of the understanding of  
5 climate change and what it means to the American people. And  
6 this is the fourth such assessment.

7 And this was the most comprehensive look at the science  
8 that we've done in those assessments.

9 It involved over 50 scientists from throughout the  
10 country representing all sectors: Government, academia and  
11 industry. and it went through a very extensive review process.

12 The six different levels of review: A public review,  
13 reviewed by the National Academy of Sciences and four different  
14 reviews by the U.S. agencies, ending up being finally released  
15 through the White House after the final signoff by the U.S.  
16 agencies. And we released it in November of 2017.

17 The second volume will look at the impacts of climate  
18 change, and that will be published later this year.

19 So what does that assessment tell us? This is more  
20 like many of the things we've been hearing today. Our climate is  
21 changing. It's changing very, very rapidly. It's happening now,  
22 but it's changing so fast that it's about ten times more faster  
23 than we've seen in any other changes since the end of the last  
24 ice age.

25 So it's very unusual, certainly in human experience.

1 It's not just the temperature that is changing. We're seeing  
2 severe weather becoming more intense in many cases.

3 We've had a lot of discussion today about sea level  
4 rise and certainly sea level is rising. And the evidence  
5 strongly indicates it's largely happening because of human  
6 activities.

7 And that the climate will continue to change over the  
8 coming decades, no matter what we do. But certainly our choices  
9 for the future could make a strong impact on just how large those  
10 changes are.

11 In fact, that's probably the single largest factor, as  
12 we look at those scenarios once again that you've already seen  
13 several times today.

14 So we have many different types of indicators of the  
15 fact that the climate is changing. These are just some of them.  
16 So it's not just temperatures, not just looking at the land air  
17 temperature or sea surface temperatures, or even atmospheric  
18 temperatures in the middle of the troposphere, but also the fact  
19 that the heat content of the oceans is increasing dramatically.

20 About 90 percent -- over 90 percent of that heat is  
21 produced by the increasing amount of greenhouse gases and carbon  
22 dioxide and other gases is ending up in the oceans.

23 And that is increasing the heat content and we have  
24 that well measured now.

25 On top of that, a warmer atmosphere should hold more

1 water vapor. And if you look at the second from the bottom graph  
2 of specific humidity, you find specific humidity is being  
3 observed increased.

4           And then, we've already talked a lot already today  
5 about how glaciers and land ice are decreasing. Also the Artic  
6 sea ice is increasing extensively.

7           In addition to that, the Northern Hemisphere's snow  
8 cover has decreased dramatically.

9           Going back to the temperature record you have seen  
10 several times now, we've seen about a 1.8-degree Fahrenheit  
11 increase in temperature from 1901 to 2016.

12           And if you looked at that temperature record over the  
13 last five decades, you'd see that the temperature on a decadal  
14 scale has increased dramatically over that time period. And that  
15 that's likely to continue to happen over the coming decades.

16           Now, if we take that temperature record, that observed  
17 temperature record, and go back to some of the proxies that  
18 analyze what the climate looked like, say, over the last 2000  
19 years, we find that those proxies show the medieval warm period.  
20 They show the period that was the period when the Vikings were in  
21 Southern Greenland.

22           They also show the little ice age when it was extremely  
23 cold in North America and Europe.

24           And then, if you look at the current temperatures you  
25 see that those current temperatures are well above anytime in

1 those past 2000 years.

2           So the kind of temperatures we're already seeing are  
3 well beyond the past human experience and having a significant  
4 impact on us in many different ways.

5           If we look globally at those changes in temperature we  
6 don't have observations in the Arctic or the Antarctic region,  
7 going all the way back to 1901. They basically started in the  
8 Arctic region around 1940's.

9           But -- and so I can't show the change for those. But  
10 mostly the area of the globe is increasing dramatically in terms  
11 of its climate. The largest changes are happening in the Arctic.  
12 I'll show you them a little bit more later.

13           But we've also seen the most significant changes over  
14 land masses because the oceans have a very large heat capacity.  
15 And so the oceans respond at a much slower rate.

16           There's two areas on here that are not showing an  
17 increase. One is -- the biggest area is the area off the coast  
18 of the Greenland in the Atlantic Ocean where all that fresh water  
19 we're getting into the Atlantic from Greenland and from melting  
20 the sea ice is causing a change in the circulation pattern in the  
21 Atlantic Ocean, and actually causing a slight cooling effect in  
22 that region.

23           The other area is actually in the Southeast United  
24 States. Before going on to that, though, I wanted to mention  
25 that if we look at that period since the end of the last IPCC

1 report, 2014 was then the warmest year on record. 2015 was even  
2 warmer. 2016 was warmer yet. And now we have the records for  
3 2017 which ended up being either second or third in that list.

4 In total, 17 of the last 18 years on record are the  
5 warmest years over that entire -- over that entire period since  
6 1881, when we have global representations of the temperature  
7 record. So we're in a very unusual time period.

8 Looking at the United States, most areas of the United  
9 States have also seen extensive warming. The one exception is  
10 some parts of the Southeast. We don't fully understand why the  
11 Southeast is different. There's some suggestion it could be due  
12 to some changes in weather circulation patterns.

13 But on top of that, there was a deforestation in the  
14 19th century in that part of the country and a reforestation in  
15 the 20th century that could also be a major contributor to what  
16 is occurring there.

17 But, nonetheless, most of the United States has seen a  
18 warming. And the overall temperature change for the United  
19 States is 1.8 degrees Fahrenheit since the 1890's.

20 Looking at precipitation we've seen about a 4 percent  
21 increase in precipitation over the United States as a whole. But  
22 the changes aren't happening even, nor do we expect them to. In  
23 fact, generally globally what is happening is the weather is  
24 getting wetter and the dryer is getting dryer.

25 And so in the United States we're seeing particularly

1 an increase in precipitation in the Midwest and Northeast, while  
2 the Southeast and Southwest -- most of the West, actually -- has  
3 seen a decrease in overall precipitation.

4 Changing to the Arctic, just to mention this one more  
5 time, that it's increasing at twice the rate -- this temperature  
6 is increasing at twice the rate of the rest of the world. Kind  
7 of the canary in the coalmine, to some extent.

8 And then, we're seeing much larger changes there, and  
9 it's causing issues as a result.

10 We're seeing very significant decreases in sea ice  
11 cover and in glaciers in Alaska, for example, but also major mass  
12 losses in the Greenland ice sheet and reduced snow cover.

13 And, perhaps most importantly, a melting of the  
14 permafrost. And that's causing infrastructure damage already in  
15 Alaska and other parts of the Arctic.

16 But on top of that, the big fear with those melting  
17 permafrosts is that before the end of the century we could see an  
18 emission of carbon dioxide and methane that is trapped in that  
19 permafrost actually being released back into the atmosphere and  
20 causing additional warming.

21 It's one of those surprise factors that I'll talk about  
22 a little later.

23 So I mentioned that it's not just temperature and  
24 precipitation. It's really having many effects on us because of  
25 effects on extreme weather and weather and climate events, many

1 different types. And we'll talk about some of these as I go  
2 forward. But, you know, they include things like heatwaves,  
3 colder waves, wildfires, major storms, et cetera.

4           One of the ways we know that climate change is already  
5 having an effect on the American people -- and actually there are  
6 similar analyses being done for the entire world -- is to look at  
7 what NOAA has been tracking for the last 37 years -- almost 38  
8 years now -- in terms of looking at what are called the "Billion  
9 dollar events."

10           These are events that cause at least \$1 billion in  
11 infrastructure damage, for a particular event. And if you go  
12 back to the early 1980's you see that we used to have a couple  
13 such events, and now we're tending to get well over ten such  
14 events. And these do account for economic changes and other  
15 factors. And they affect all parts of the country.

16           So the net effects on the American economy has been now  
17 about \$1.5 trillion, including 2017.

18           If you looked at 2016, there were 15 such events. 2017  
19 had 16 such events. And, in fact, was the costliest yet on  
20 record beating out the year of Katrina.

21           If we look at extreme events, and what's happening to  
22 these extreme events -- and we discuss this in much more detail  
23 in the assessment -- heatwaves, generally, are increasing in the  
24 United States, particularly since 1960, globally, since the turn  
25 of the century.

1           In the U.S. we also had some special events happening  
2 in the 1930's with the Dust Bowl that caused that to also be a  
3 period of high heat in the United States.

4           But since 1960, we nonetheless have been seeing  
5 increase in the number of the heatwaves. These are multi-day  
6 events where the temperatures are above normal where you tend to  
7 get the most damage.

8           Cold waves, generally, are decreasing.

9           More precipitation is coming as larger events. I  
10 mentioned that warmer atmosphere holding more water vapor. Well,  
11 that leads to extra precipitation. Almost all parts of the  
12 country have been seeing an increase in the amount of  
13 precipitation when it does happen.

14           So when you get a rainfall or snowfall you're more  
15 likely to get larger events than you had in the past. That means  
16 that in some areas you're getting the largest effect of those  
17 increases in precipitation. We're seeing more risk of floods,  
18 particularly in the Northeast and Midwest. And other areas where  
19 it tends to be dry, we're getting less precipitation and dryer  
20 spots and warmer temperatures.

21           We're tending to get more droughts, particularly in the  
22 Southwest and Southeast. We're also seeing significant incidents  
23 of larger wildfires. More areas being burned as a result of the  
24 warming and how that's impacting upon the biosphere.

25           And the result is that we're seeing significant

1 increases in such wildfires in the West and Alaska. Talk about  
2 that a little more in detail in a second.

3           And, overall, we're seeing an increase in intensity of  
4 hurricanes, particularly Atlantic hurricanes. And if we look at  
5 the projections for the future very careful analyses are now  
6 suggesting through several different approaches that hurricanes  
7 are likely to become more intense in the future.

8           Tornado activity and hail are something we know less  
9 about because we just don't have sufficient data. But,  
10 nonetheless, we are generally finding that tornadoes are  
11 increasing in number of outbreaks. So when you get one tornado,  
12 you're more likely to have multiple tornadoes.

13           And also that hail appears to be becoming more intense.  
14 All of these trends are likely to continue over the coming  
15 decades.

16           So if we look at the -- just one way of looking at  
17 heat, how many records are being set each year?

18           We're generally finding that many more heat records are  
19 being set than cold records. And that's just one way of looking  
20 at that.

21           If you look at extreme precipitation we're seeing  
22 strong trends. The one -- the graph on the left is for the  
23 United States, Continental United States as a whole. Looking at  
24 the one-in-five-year events and showing a general increase over  
25 the last five decades; that in such events the amount of -- the

1 amount of precipitation from such events.

2           And the right-hand side looks at the 1 percent, top  
3 1 percent of precipitation and showing an increase throughout the  
4 entire Continental United States, but particularly in the Midwest  
5 and Northeast. A little bit less over the West where we have  
6 less overall precipitation in general.

7           Looking at wildfires this last year we had more than  
8 9.2 million U.S. acres burned, one of the largest years on  
9 record.

10           The U.S. fire season now is about three months longer  
11 than it was 40 years ago because of the warmer temperatures that  
12 are affecting our climate.

13           The average fire is much bigger and hotter than before.  
14 They are burning as hot as 2000 degrees Fahrenheit compared to  
15 1300 for a small --

16           **THE COURT:** Can I ask you a question about the fires?

17           **MR. WUEBBLES:** Sure.

18           **THE COURT:** I totally agree that the fires have gotten  
19 worse and worse. I think it's 1.3 percent of California alone  
20 burned up last year just in one year. Now, when that happens,  
21 though, doesn't that put a lot of carbon dioxide in the air?

22           **MR. WUEBBLES:** It does. You do readmit carbon that had  
23 been trapped in the soil and in trees into the air. Yes, it does  
24 contribute.

25           **THE COURT:** Well, that could be -- is that a tiny

1 factor --

2 **MR. WUEBBLES:** In terms of the overall change that's  
3 still a small factor because there's also -- you tend to not too  
4 long after such an event, you then start having trees growing  
5 again, and you start pulling carbon back out.

6 So the overall factor is small, but you do see  
7 fluctuations in the amount of CO2 growth per year.

8 **THE COURT:** You know, those trees -- listen. I know  
9 how fast those trees grow. They don't grow fast. It takes 40  
10 years to replace a tree.

11 **MR. WUEBBLES:** Yes, to replace a tree the same size.  
12 Yes, definitely.

13 **THE COURT:** So in the meantime you're putting all that  
14 carbon dioxide in the air.

15 **MR. WUEBBLES:** Yes.

16 **THE COURT:** And I'd be interested to know how -- is  
17 that a small factor compared to fossil fuel? Wood is not a  
18 fossil, so it's not a fossil fuel, but it is a fuel. So I'd be  
19 interested to know how the wildfires factor in to the overall CO2  
20 contribution.

21 **MR. WUEBBLES:** I think in terms of the over -- I don't  
22 have the statistics on that. I think because of the total areas  
23 being burned each year it is still relatively small compared to  
24 the planet. That is still a rather minor contributor.

25 **THE COURT:** I saw a satellite picture. They can see

1 the fires from the satellites.

2 **MR. WUEBBLES:** Oh, definitely.

3 **THE COURT:** So I don't know how small. I think  
4 it's -- okay. I just wondered if somebody could do the math to  
5 figure out how much CO2 is coming out of the wildfires.

6 And by the way, you know you got them in Australia,  
7 too. They have them in many places in the world.

8 **MR. WUEBBLES:** No, that's true.

9 **THE COURT:** In Canada. So all right. I interrupted  
10 you. Let's see. I think we got about ten more minutes to go.

11 **MR. WUEBBLES:** Uh-ho.

12 **THE COURT:** And we got to bring it to a close.

13 **MR. WUEBBLES:** Okay. So in the Alaska, even the tundra  
14 is experiencing wildfires.

15 So as we heard today -- and I just want to emphasize  
16 this one more time -- that there are many lines of evidence  
17 demonstrating that human activities are primarily responsible for  
18 the observed climate change.

19 It is not the sun. The sun has decreased slightly, if  
20 anything, over recent decades based on very accurate satellites  
21 observations.

22 It's not natural variability. There are no natural  
23 cycles that can explain the long-term record.

24 **THE COURT:** In your last ten minutes, you heard what  
25 the other side said. Right? Right? You were here.

1           **MR. WUEBBLES:** Yes.

2           **THE COURT:** So they seem to be agreeing that -- not  
3 "seem to be" -- they do agree that humans are putting CO2 into  
4 the air. That that does, in fact, cause warming. That does, in  
5 fact, cause sea level rise.

6           Now, there may be a disagreement over which model you  
7 use and how fast, how much damage that is going to do and how  
8 soon.

9           What critique would you make of what I just heard from  
10 the other side? They seem to be largely agreeing --

11           **MR. WUEBBLES:** No, that's exactly right. But that's  
12 not what you see overall in the media, and so that's why these  
13 points are emphasized.

14           The evidence does clearly point to the increase in  
15 greenhouse gases being primarily responsible for the observed  
16 change.

17           And if we look at the next slide, if we looked at the  
18 forcing on the climate, this is the -- climate doesn't just  
19 change beyond a small amount due to natural variability in the  
20 climate system, without some major forcing externally.

21           And that, such a change is that, for example, from  
22 greenhouse gases. So if you look at the human cause forcings  
23 over the last 250 years, relative to what's happened with the  
24 sun, sun has changed very, very little, and in terms of its  
25 output. In fact, we were looking at the period of the little ice

1 age earlier.

2 The best analyses we have indicate that the minimum  
3 period where we had very little sunspots was, in fact, a small  
4 change in the amount of solar radiations.

5 The big factor there was because of very large volcanic  
6 eruptions and the effects that those actually had on the oceans.

7 So --

8 **THE COURT:** So your point there is for the little ice  
9 age you're saying the major cause was more than normal amount of  
10 volcanic eruptions, which puts stuff in the air which cooled off  
11 the air.

12 **MR. WUEBBLES:** Yes, that's the best analysis we have.

13 **THE COURT:** Okay. Good to know.

14 **MR. WUEBBLES:** So human activities really have  
15 dominated the changes we've seen since the industrial ages  
16 started. And they'll really -- the bottom line here, and that's  
17 why IPCC came to the conclusion that the previous speaker showed  
18 that extremely likely that human activities, especially emissions  
19 of greenhouse gases, are the dominant cause of the observed  
20 warming seen in the mid-20th century.

21 Now, I want to get into looking -- you know, all the  
22 analyses of the past is really based on observations. Now, we  
23 look at the future we have to use numerical models of the Earth  
24 system, as others have talked about.

25 You've heard of these four different scenarios we tend

1 to use to look at that. Those are scenarios that try to look at  
2 the business-as-usual case, what we're already doing. Current  
3 emissions are higher, at or higher than any of these cases, but  
4 certainly most similarly to the RCP 8.5 scenario.

5 The other scenarios are basically choices we can make,  
6 whether they are due to policy or not policy, is that humans  
7 decide for one reason or another, for example to move to  
8 alternative fuels and other ways of dealing with transportation  
9 or energy.

10 And that's why we looked at four different scenarios.

11 **THE COURT:** Well, what are those fuels? What are the  
12 alternative fuels you just mentioned?

13 **MR. WUEBBLES:** So using solar or wind power, for  
14 example.

15 **THE COURT:** What other are there?

16 **MR. WUEBBLES:** There are certainly a number of others.

17 **THE COURT:** Like what?

18 **MR. WUEBBLES:** They are starting to extract power from  
19 ocean waves. You can use thermal radiation or thermal --

20 **THE COURT:** Geothermal.

21 **MR. WUEBBLES:** Geothermal, yes.

22 **THE COURT:** Okay.

23 **MR. WUEBBLES:** Or nuclear.

24 **THE COURT:** If we had, you know, back in the '50's we  
25 had nuclear power.

1           **MR. WUEBBLES:** Right.

2           **THE COURT:** So if we had stuck with nuclear power --  
3 I'm just being a devil for a minute. If we had stuck with  
4 nuclear power, we would not have needed to use so much fossil  
5 fuels. Right? Because we would have had nuclear power.

6           **MR. WUEBBLES:** If we had recognized in 1990 all the  
7 science we recognized and had started to do something, yes, we  
8 would have probably used largely nuclear as the primary --

9           **THE COURT:** You think nuclear is safe?

10          **MR. WUEBBLES:** We have -- in my state of Illinois, we  
11 have seven or eight -- I don't remember how many it is exactly --  
12 nuclear plants. And they have been fine. Nuclear can be safe.  
13 You know, obviously there are things to be concerned about that.

14           I spent 20 years at Lawrence Livermore National  
15 Laboratory, which is, of course, a nuclear --

16          **THE COURT:** I'm sorry. Which lab?

17          **MR. WUEBBLES:** Lawrence Livermore.

18          **THE COURT:** Oh, Lawrence Livermore.

19          **MR. WUEBBLES:** Thirty miles from here, yes.

20          **THE COURT:** Well, but a nuclear would not put out any  
21 CO2. Right?

22          **MR. WUEBBLES:** That is correct.

23          **THE COURT:** And that would be -- we might get some  
24 radiation as we drive by, but we don't get any CO2.

25          **MR. WUEBBLES:** Right.

1           **THE COURT:** So that would have been -- in retrospect,  
2 maybe we should have taken a harder look at nuclear to reduce  
3 some of this CO2.

4           **MR. WUEBBLES:** As you already heard --

5           **THE COURT:** Just a thought. But let's go to the other  
6 things. Solar. Okay. There's no doubt that solar is good where  
7 you can use it.

8           But do you really think that could have ever really  
9 been a substitute for supplying the kind of power that America  
10 has used up in the last 30 years?

11          **MR. WUEBBLES:** I think it could be -- this is all  
12 getting beyond my scientific expertise, but --

13          **THE COURT:** Yes, okay.

14          **MR. WUEBBLES:** -- I think solar could certainly be a  
15 significant factor of our energy future. I don't think there is  
16 any one silver bullet.

17           It's a whole combination of things that are likely  
18 going to be the way we look at energy in the future.

19          **THE COURT:** Okay. I need to ask you -- I'll give you  
20 five more minutes, and then we got to bring it to a close.

21          **MR. WUEBBLES:** So if you go to the right-hand side, the  
22 left-hand side was looking at emissions. The right-hand side  
23 looks at the change in temperature for those different scenarios  
24 or three other of the four scenarios.

25           It's really the difference in the emissions that make

1 the biggest effect. So our choices for the future in the way of  
2 emissions is really is what matters. So if we want to -- it's  
3 not the uncertainty of the models that matter as much there.

4           There are uncertainties in the models. We would  
5 acknowledge that, and we can discuss more. But I don't have time  
6 for it. But, nonetheless, we're talking about a very significant  
7 impact.

8           If we continue to follow that highest pathway, that  
9 business-as-usual pathway, we're talking about changes of eight,  
10 nine, ten degrees globally Fahrenheit by the end of this century.

11           And much tending to be even more so on land masses. So  
12 if we look at -- this is from IPCC, actually -- look over the  
13 next few decades we get about a 1 degree further change.

14           Doesn't seem to matter which scenario you followed,  
15 because emissions we've already made are going to cause that 1  
16 degree.

17           Even that's a very significant effect on us, because  
18 we've already seen a significant effect from the 1 degree we  
19 already have.

20           But by the end of the century we can separate out these  
21 different scenarios and really see it really matters in terms of  
22 how big an effect on Earth climate we get depends on which of  
23 those pathways we follow.

24           Now, we can also talk more about extremes. I'm going  
25 to kind of skip over that in terms of like the number of days

1 above 90 degrees, numbers of days below 32 degrees, and get a  
2 little bit of looking at the oceans.

3 Now, we've already seen 7 to 8 inches since 1900 of sea  
4 level rise. Dr. Griggs showed you that the most recent rate of  
5 increase happening really since the end of the last IPCC report  
6 is that rate of increase is higher than any time we have seen  
7 over the last 2800 years as of result that came out of a NOAA  
8 report, but appears to hold well.

9 We're also seeing acidification of the oceans, because  
10 about 25 percent of that CO2 ends up in the oceans and converts  
11 it to carbonic acid and contributes to the acidification of the  
12 ocean. And we're seeing a change in ocean circulation, as I  
13 mentioned earlier.

14 **THE COURT:** Wait. I want to go back to the  
15 acidification thing.

16 **MR. WUEBBLES:** Yes.

17 **THE COURT:** You know, we've had a -- I've seen programs  
18 on how the coral reefs are dying off. Is that what that is a  
19 picture of there? I can't tell.

20 **MR. WUEBBLES:** Looks like a reef.

21 **THE COURT:** But are you suggesting that the reason the  
22 coral reefs are dying is because there's more CO2 being absorbed  
23 into the ocean?

24 **MR. WUEBBLES:** That's one of the contributors. The  
25 warming ocean is also a very strong contributor. The fact that

1 the oceans themselves are warming is affecting it.

2 And also in certain areas, the reefs are also being  
3 affected by global pollution. But, overall, the oceans, in  
4 general, are being affected by both of those other factors.

5 **THE COURT:** All right.

6 **MR. WUEBBLES:** So I'm going to skip over the nuisance  
7 flooding, which you've already heard more about.

8 If you look at the top graph here it shows that greatly  
9 increasing rate of sea level rise compared to the past.

10 From our assessment we came to the conclusion that  
11 there's been the projections for the future should be a  
12 one-to-four plus increase over this century in sea level rise.  
13 But we could not say for sure. It could be as high as 8 feet.

14 And that eight feet reflects this uncertainty about  
15 what is happening on western ice sheet. And that the very recent  
16 work since IPCC 2013 has really demonstrated that area is much  
17 more vulnerable than we thought before m.

18 And so that -- so these -- this risk level of something  
19 that could be much higher is really resulting from new knowledge  
20 that has really changed the picture.

21 Now, I think one last thing is that the previous  
22 speaker talked about sea level rise on the Pacific Coast and that  
23 there was this period, which is actually 1993 to 2012, that  
24 showed a slight decrease over that time period.

25 If you looked at the long-term time change, which Dr.

1 Griggs did show, then you see that overall there's been a trend,  
2 and of increasing sea level rise over that, and he came up to  
3 about, I think, 7.7 inches over the last century.

4 If you look at the time period since 2012, you actually  
5 go back to seeing an increase in this region. So that is a  
6 little different than the picture he was trying to paint in his  
7 presentation. Again, the science does not stop at 2012.

8 **THE COURT:** If you had no ice whatever, no ice sheets,  
9 no, you know, Greenland melted and Antarctica melted, how -- so  
10 what would be the maximum possible water level on the Earth?

11 **MR. WUEBBLES:** If everything melted? So Dr. Griggs  
12 showed you that there was -- in Antarctica there was an  
13 equivalent to 190 feet of sea level to, in Greenland, an extra  
14 24 feet and about an extra one-and-a-half feet in all the other  
15 glaciers.

16 **THE COURT:** Give me those three numbers again.

17 **MR. WUEBBLES:** 190 feet from Antarctica, 24 feet from  
18 Greenland, and about one-and-a-half feet from other glaciers.

19 **THE COURT:** If we add all of those, that would be over  
20 200 feet. Right?

21 **MR. WUEBBLES:** Yes. My house in the Midwest could be  
22 coastal property.

23 **THE COURT:** That could be not quite to the top of Mount  
24 Diablo.

25 **MR. WUEBBLES:** Oh, yes.

1           **THE COURT:** That's 3,000 feet, but most of it would be  
2 submerged.

3           I guess San Francisco would become --

4           **MR. WUEBBLES:** We don't expect that to happen, so --

5           **THE COURT:** -- Atlantis. Right?

6           But you don't expect that?

7           **MR. WUEBBLES:** We don't expect that to happen in the  
8 next few centuries, by any means. It would probably take a  
9 number of centuries before that could possibly happen.

10           One of our concerns, one of the things I wasn't able to  
11 get to here was the question of potential surprises.

12           I've already mentioned the permafrost melting, but you  
13 know how much the glaciers do change, how much sea level rise  
14 does change could have a --

15           **THE COURT:** Give us an example. Give us an example of  
16 a theoretical or plausible surprise out of the blue.

17           **MR. WUEBBLES:** Besides the permafrost melting?

18           **THE COURT:** Yes. Yes, that's a good example, but give  
19 us another one.

20           **MR. WUEBBLES:** So another one would be the melting of  
21 Artic sea ice. We're already having questions of whether the  
22 large deviations we're seeing in the jetstream across,  
23 particularly affecting various parts of North America, is related  
24 to the decrease in sea ice. And whether that in the future would  
25 have an even larger effect on our weather patterns.

1           So that's another aspect. The hydrates, the methane  
2 hydrate, the coastal areas of most of the oceans have a lot of  
3 methane trapped belowground in the ocean. If that methane gets  
4 released, it's going to add to the further warming. We don't  
5 think it's going to happen.

6           **THE COURT:** Why is methane -- what causes that methane  
7 that's underground?

8           **MR. WUEBBLES:** It was due to bios, biospheric  
9 production.

10          **THE COURT:** What kind?

11          **MR. WUEBBLES:** Biospheric production.

12          **THE COURT:** Oh, biosphere. Okay.

13          **MR. WUEBBLES:** Yes. So the changes in El Niño events.  
14 You know, if we were to have a lot more El Niño events that would  
15 add to the overall warming.

16           There's a lot of other aspects that are surprises,  
17 things we don't really expect but they are things we just don't  
18 know about.

19          **THE COURT:** When the amount of CO2 goes up, do the  
20 plants get more active and flourish more and take more of the CO2  
21 out of the air?

22          **MR. WUEBBLES:** Yes, I saw that in one of the graphs  
23 earlier today, yes. It does happen. I'm a son of a farmer so one  
24 of the things we've been concerned about, well, could the  
25 increase in CO2 really help farming for the future?

1 But ends up it doesn't help seed production that much.  
2 So farming is more like agricultural production, crop production  
3 is likely to be affected more by the temperature increases than  
4 by that factor.

5 **THE COURT:** Is there any type of plant like a forest or  
6 a rain forest that would benefit from more CO2 in the air?

7 **MR. WUEBBLES:** I think they all benefit to some degree,  
8 but you have to put that alongside what changes are happening in  
9 the rest of the climate system in terms of the change in  
10 temperature and changes in precipitation patterns.

11 And when you do that, then it's hard to -- it's much  
12 more difficult to find benefits in any part of that system.

13 **THE COURT:** I wish we had all day, but I got to bring  
14 it to a close. So thank you very much.

15 **MR. WUEBBLES:** You're welcome.

16 **THE COURT:** All right. So I got a couple of follow-up  
17 things here. Take your time there, by the way.

18 You can -- I want to give an order to all the other  
19 defendants that if you agree (sic) with anything that Mr.  
20 Boutrous said you have one week from today to file a statement  
21 explaining each and every statement that you disagree with.  
22 Otherwise, I'm going to deem it that you agree.

23 Any questions on that?

24 You want two weeks? I'll give it to you. But you  
25 can't get away with sitting there in silence, and then later

1 saying:

2 "Oh, he wasn't speaking for us."

3 I'll give you two weeks from today at noon.

4 All right. So that's number one.

5 Number two. What was number two?

6 Oh, yes. Are you going to take an interlocutory appeal  
7 on the jurisdictional issue?

8 **MR. BERMAN:** We are not, Your Honor.

9 **THE COURT:** You're not.

10 **MR. BERMAN:** We're not.

11 **THE COURT:** All right. Then, are you in the other case  
12 going to take any kind -- I don't think you have a 1292 B, but  
13 are you going to try to make some appeal?

14 **MR. BOUTROUS:** We are, Your Honor. We are going to  
15 appeal that order, Your Honor.

16 **THE COURT:** All right. Now, you wanted to -- I'll give  
17 you -- I don't have much more time, but I'll give you two minutes  
18 if you wanted to say something about the documents. And I did  
19 read the documents carefully.

20 So I am up to speed on what those two documents said.  
21 But I want to give you a chance to make your point on it.

22 **MR. BOUTROUS:** I'll be really brief, Your Honor. The  
23 timeline that I walked through paragraph 67, for example, the  
24 Oakland complaint, when I read it it read to me like they were  
25 talking about a document that was secret inside knowledge by this

1 organization they were pointing to.

2 Well, it turned out it was a summary of the IPCC report  
3 from 1995. It was -- those were quotes from the Power Point  
4 deck. So I found it to be a bit misleading, very misleading.

5 And, secondly, that report as I mentioned today talked  
6 about the uncertainties and the limits on knowledge.

7 The next paragraph that the Court asked about the  
8 document was a public relations document that talked about making  
9 sure the public had more information; that there were  
10 uncertainties.

11 So I thought that the -- I was glad the Court had been  
12 produced those documents. We hadn't seen them.

13 **THE COURT:** How could you have not seen them? They  
14 were from maybe not Chevron files, but from the files of those  
15 organizations that Chevron has something to do with.

16 **MR. BOUTROUS:** One person attended a meeting or  
17 participated in something. We just had not seen those documents.  
18 So it was helpful that the Court had them because I think they  
19 tell a different story than the Plaintiffs do.

20 **THE COURT:** Well, if there's another document in there,  
21 too, that you think should be for assessing the complaint I'll  
22 make the other side do that.

23 I found it useful, and I think Mr. Boutrous is correct.  
24 I read that paragraph 67 the same way; that there was a  
25 conspiratorial document within the defendants about how they knew

1 good and well that global warming was right around the corner.

2 And I said:

3 "Okay. That's going to be a big thing. I want to  
4 see it."

5 Well, it turned out it wasn't quite that. What it was  
6 was a slide show that somebody had gone to the IPCC and was  
7 reporting on what the IPCC had reported, and that was it.

8 Nothing more.

9 So they were on notice of what in IPCC said from that  
10 document, but it's hard to say that they were secretly aware.

11 By that point they knew. Everybody knew everything in  
12 the IPCC. So I don't know. I think Mr. Boutrous makes a fair  
13 point.

14 If you want to respond, I'll let you respond. But I  
15 don't know if that had as much to do with today, but if he wanted  
16 to respond okay.

17 Anything you want to say?

18 **MR. BERMAN:** No.

19 **MR. BOUTROUS:** Thank you very much, Your Honor.

20 **THE COURT:** All right. So I want to thank all members  
21 of the public. I wore my science tie today. This is something I  
22 got with my son at the Lawrence, some lab over in Berkeley. It's  
23 a solar system. Earth is on here, Mars. So I hope somebody took  
24 notice of it.

25 All right, my friends. Thank you very much.

1 We're in adjournment.

2 **MR. BOUTROUS:** Thank you.

3 **THE COURT:** Oh, please remember all those things you  
4 promised me you would get me you have a few days to do it, but I  
5 would like color copies, please.

6 All right. Thank you.

7 **MR. BOUTROUS:** Thank you, Your Honor.

8 (Thereupon, this hearing was concluded.)

9 Stenography certification

10 "I certify that the foregoing is a correct transcript  
11 from the record of proceedings in the above-entitled matter."

12 March 25, 2018

13 /s/Katherine Wyatt

---

14

15

16

17

18

19

20

21

22

23

24

25