WEBVTT - https://subtitletools.com

00:00:00.000 --> 00:00:03.167 (students chattering)

00:01:55.456 --> 00:01:57.623 - Okay, let's get started.

00:02:03.671 --> 00:02:04.583 Let's get started.

00:02:04.583 --> 00:02:07.080 Can you hear me okay at the back?

00:02:07.080 --> 00:02:08.790 Yeah, okay, great.

00:02:08.790 --> 00:02:12.990 So I'm Robert (mumbles) I'm a professor of epidemiology

00:02:12.990 --> 00:02:15.800 in our Department of Environmental Health Sciences.

00:02:15.800 --> 00:02:17.550 And I'm also the Faculty Director

00:02:17.550 --> 00:02:20.290 of the Yellow Climate Change and Health Initiative.

00:02:20.290 --> 00:02:23.670 And we're very pleased today as our first speaker

00:02:23.670 --> 00:02:27.010 of this academic year to have Jason West,

00:02:27.010 --> 00:02:30.520 who's from the Department of Environmental Sciences

00:02:30.520 --> 00:02:34.870 and Engineering at the University of North Carolina School

00:02:34.870 --> 00:02:35.703 of Public Health.

00:02:35.703 --> 00:02:37.880 And we were just talking about how few

00:02:39.870 --> 00:02:43.140 public health departments have engineering in the name

00:02:43.140 --> 00:02:46.970 and how actually valuable it is to have engineers

00:02:46.970 --> 00:02:49.890 within schools of public health, as hopefully,

00:02:49.890 --> 00:02:53.253 I think you'll see when you see the work that Jason does.

00:02:54.520 --> 00:02:57.880 So Jason, has a great publication record

00:02:57.880 --> 00:03:00.110 he's published in the high impact journals like

00:03:00.110 --> 00:03:03.200 Major Climate Change, and Nature Geoscience

00:03:03.200 --> 00:03:05.103 and Environmental Health Perspectives.

00:03:05.970 --> 00:03:09.150 He's also had funding from a variety of sources, 00:03:09.150 --> 00:03:14.150 including the EPA has a the National Science Foundation,

00:03:14.890 --> 00:03:18.840 and the National Institute of Environmental Health Sciences.

00:03:18.840 --> 00:03:21.980 And so he's got, as you know, he's gonna talk

00:03:21.980 --> 00:03:24.670 to you today about connecting climate change,

00:03:24.670 --> 00:03:27.063 air pollution, energy and human health.

00:03:29.896 --> 00:03:33.063 (students applauding)

00:03:34.170 --> 00:03:35.600 - So I'm really happy to be here today.

00:03:35.600 --> 00:03:37.670 Thanks for the invitation.

00:03:37.670 --> 00:03:41.330 I spent yesterday, an exciting day for me in New York City

00:03:41.330 --> 00:03:43.840 for the climate week, and--

00:03:43.840 --> 00:03:46.697 - Sorry, (mumbles) to just the lights a little bit.

00:03:46.697 --> 00:03:48.280 - All right, yeah.

00:03:48.280 --> 00:03:52.830 I was just gonna say, I was having a hard time in my mind,

00:03:52.830 --> 00:03:55.400 justifying flying up here just to attend

00:03:55.400 --> 00:03:58.350 a climate change event in New York.

00:03:58.350 --> 00:04:01.110 I had thought instead of about maybe taking a sale

00:04:02.097 --> 00:04:02.930 (students laughing)

00:04:02.930 --> 00:04:06.220 but then I contacted Rob who had already invited me

00:04:06.220 --> 00:04:09.530 and asked him if we could combine my trips.

00:04:09.530 --> 00:04:11.110 And that worked out really nicely.

00:04:11.110 --> 00:04:13.470 So Rob, if nothing else, I should thank you

00:04:13.470 --> 00:04:17.470 for making me feel less guilty about flying.

00:04:17.470 --> 00:04:21.480 Okay, so I'm gonna talk to you today really,

00:04:21.480 --> 00:04:23.960 this is a talk not on one theme,

00:04:23.960 --> 00:04:25.810 but I'll be talking about a lot of the work

00:04:25.810 --> 00:04:29.640 that I in my lab is done over the past decade or so.

00:04:29.640 --> 00:04:32.480 I'll motivate that in a minute by talking about

00:04:33.680 --> 00:04:36.060 especially the human health angle,

00:04:36.060 --> 00:04:39.190 that the work we do is really pretty interdisciplinary.

00:04:39.190 --> 00:04:40.260 And I think you'll see that

00:04:40.260 --> 00:04:43.690 so I work on climate change in air pollution.

00:04:43.690 --> 00:04:46.000 My main entry point to climate change is

00:04:46.000 --> 00:04:48.900 through atmospheric science, which is kinda my background.

00:04:49.740 --> 00:04:53.640 But in particular, this interest in climate change

00:04:53.640 --> 00:04:56.740 has kinda taken off in connecting climate change

00:04:56.740 --> 00:04:57.573 with air pollution.

00:04:57.573 --> 00:04:58.750 So as climate changes,

00:04:58.750 --> 00:05:00.880 what will that mean for air pollution?

00:05:00.880 --> 00:05:04.410 Or as we take the necessary steps to address climate change,

00:05:04.410 --> 00:05:06.910 what would that mean for pollution and for health?

00:05:06.910 --> 00:05:10.390 So those are a couple of the themes that are explored here.

00:05:10.390 --> 00:05:12.140 I thought I'd start with this paper,

00:05:12.140 --> 00:05:15.513 which Michelle (mumbles) here also contributed to.

00:05:16.370 --> 00:05:18.173 That appeared a few years ago.

00:05:19.070 --> 00:05:21.690 I and colleagues this, if you look at the list

00:05:21.690 --> 00:05:26.150 of authors here, this is a purposeful combination of

00:05:26.150 --> 00:05:27.510 air pollution scientists

00:05:27.510 --> 00:05:29.420 and air pollution health effects scientists,

00:05:29.420 --> 00:05:32.090 we all got together in a room and talked about

00:05:32.090 --> 00:05:34.930 what were some of the big issues of our day

00:05:34.930 --> 00:05:37.237 trying to take stock of what's known about air pollution

00:05:37.237 --> 00:05:39.880 and health, and what are the big opportunities

00:05:39.880 --> 00:05:41.470 for the future.

00:05:41.470 --> 00:05:45.520 Some of our main conclusions I've pointed out here,

00:05:45.520 --> 00:05:47.610 one is how important air pollution is

00:05:47.610 --> 00:05:50.040 for global public health.

00:05:50.040 --> 00:05:52.630 And what's been really instrumental in coming

00:05:52.630 --> 00:05:54.050 to this understanding has been

00:05:54.050 --> 00:05:55.920 the Global Burden of Disease Assessment.

00:05:55.920 --> 00:05:58.610 So as I go along, through this presentation,

00:05:58.610 --> 00:06:00.010 I'll show you some results from the

00:06:00.010 --> 00:06:02.210 Global Burden of Disease Assessment

00:06:02.210 --> 00:06:04.980 and show you how my lab is doing some work to contribute

00:06:04.980 --> 00:06:05.900 to that assessment

00:06:05.900 --> 00:06:09.743 by mapping global surface ozone concentrations.

00:06:10.860 --> 00:06:13.980 Air pollution, it's health impacts our changing globally

00:06:13.980 --> 00:06:17.123 and will change in ways interrelated with climate change.

00:06:18.240 --> 00:06:20.020 We looked also at air pollution science,

00:06:20.020 --> 00:06:22.690 which is making new possibilities through

00:06:22.690 --> 00:06:24.590 new ways of measuring air pollutants,

00:06:24.590 --> 00:06:27.590 measuring new chemical constituents that may be then

00:06:27.590 --> 00:06:30.960 we could put in epidemiological models to find out

00:06:30.960 --> 00:06:33.110 what component of air pollution is most

00:06:33.110 --> 00:06:34.760 important for health.

00:06:34.760 --> 00:06:37.730 We also have cheap sensors that can be widely deployed

00:06:37.730 --> 00:06:39.510 and are being widely deployed,

00:06:39.510 --> 00:06:41.730 providing a lot more information, 00:06:41.730 --> 00:06:44.920 even if the quality of those measurements is poor.

00:06:44.920 --> 00:06:47.680 We have satellites looking down at the world now

00:06:47.680 --> 00:06:51.260 giving us information every day about air pollution

00:06:51.260 --> 00:06:53.420 that's potentially useful for us.

00:06:53.420 --> 00:06:55.910 And computer models and that's what I do

00:06:55.910 --> 00:06:59.930 are becoming better for this kind of application too.

00:06:59.930 --> 00:07:02.445 One of the reasons why I wanted to start off with this,

00:07:02.445 --> 00:07:05.110 (mumbles) was we took some time in this article

00:07:05.110 --> 00:07:08.120 to talk about the need for the air pollution science

00:07:08.120 --> 00:07:11.160 community to work better and closer together

00:07:11.160 --> 00:07:12.900 with people that work in air pollution,

00:07:12.900 --> 00:07:14.470 health effects science.

00:07:14.470 --> 00:07:17.890 So when I think back to when I was a graduate student,

00:07:17.890 --> 00:07:21.060 I was firmly in the air pollution science world,

00:07:21.060 --> 00:07:23.600 I was not exposed at all really to help.

00:07:23.600 --> 00:07:27.230 And as I look out at even our air pollution science

00:07:27.230 --> 00:07:29.420 meetings, those are changing that I now see

00:07:29.420 --> 00:07:32.410 more presentations from health effects scientists

00:07:32.410 --> 00:07:34.930 or people that are making this bridge

00:07:34.930 --> 00:07:37.330 between air pollution science and health effects science.

00:07:37.330 --> 00:07:39.030 So that's a healthy change,

00:07:39.030 --> 00:07:41.030 but I think we have a long way to go still.

00:07:41.030 --> 00:07:42.760 Okay, in that regard, and maybe some

00:07:42.760 --> 00:07:46.420 of you will be interested to, in your career fill that void.

00:07:46.420 --> 00:07:49.870 Okay, my plan for today is to

00:07:49.870 --> 00:07:51.940 it's sort of the buckshot approach (mumbles)

00:07:51.940 --> 00:07:54.360 I'll talk about a lot of different themes, 00:07:54.360 --> 00:07:56.593 and we'll see if any of them stick with you.

00:07:57.460 --> 00:08:00.467 But first, I was gonna talk about global ozone

00:08:00.467 --> 00:08:03.660 and what drives global ozone changes?

00:08:03.660 --> 00:08:05.360 This is more atmospheric science.

00:08:05.360 --> 00:08:09.450 But the rest of the talk will be about,

00:08:09.450 --> 00:08:12.700 about air pollution and climate and health.

00:08:12.700 --> 00:08:14.900 So how many people die each year due

00:08:14.900 --> 00:08:17.500 to exposure to ambient air pollution?

00:08:17.500 --> 00:08:20.630 How can we best model global surfaces on distributions

00:08:20.630 --> 00:08:22.590 that's for the Global Burden of Disease?

00:08:22.590 --> 00:08:24.490 And I'll show you those results.

00:08:24.490 --> 00:08:26.920 How will climate change affect global air pollution

00:08:26.920 --> 00:08:28.560 and air pollution related deaths?

00:08:28.560 --> 00:08:32.700 So now turning our attention to climate a little bit.

00:08:32.700 --> 00:08:34.970 What are the trends in air pollution related deaths

00:08:34.970 --> 00:08:37.100 focusing on the United States?

00:08:37.100 --> 00:08:40.350 And the last question, if we slow down climate change,

00:08:40.350 --> 00:08:42.020 what are the benefits that we would see

00:08:42.020 --> 00:08:44.053 for air pollution and health, okay?

00:08:46.000 --> 00:08:46.833 Good.

00:08:48.050 --> 00:08:50.060 I'll talk a little bit about ozone.

00:08:50.060 --> 00:08:53.670 So I'm guessing many of the students in here (mumbles)

00:08:53.670 --> 00:08:56.520 from of a public health are studying public health

00:08:56.520 --> 00:08:58.210 and maybe don't know a lot about ozone

00:08:58.210 --> 00:08:59.410 so let me talk about that.

00:08:59.410 --> 00:09:03.610 So ozones forming the atmosphere by an interaction of

00:09:05.580 --> 00:09:07.290 non-methane volatile organic.

00:09:07.290 --> 00:09:10.100 So organics that come from motor vehicles

00:09:10.100 --> 00:09:14.750 from all kinds of different things, carbon monoxide as well.

00:09:14.750 --> 00:09:17.200 Trees emit volatile organics,

00:09:17.200 --> 00:09:19.290 those drive this cycle of radicals.

00:09:19.290 --> 00:09:22.770 The other important ingredient is nitrogen oxides,

00:09:22.770 --> 00:09:24.750 comes from motor vehicles and power plants

00:09:24.750 --> 00:09:27.680 and heavy industries, in the presence of sunlight

00:09:28.560 --> 00:09:29.393 gives us ozone.

00:09:29.393 --> 00:09:32.400 So the three important ingredients are in organic

00:09:33.766 --> 00:09:37.240 (mumbles) sunlight, and out of those chemical reactions,

00:09:37.240 --> 00:09:38.073 we get ozone.

00:09:39.170 --> 00:09:42.020 I'll be talking as well on the global scale.

00:09:42.020 --> 00:09:46.020 And when we look at the global scale, these fast reacting

00:09:46.020 --> 00:09:49.750 organics that are important in a place like Los Angeles

00:09:49.750 --> 00:09:52.830 for producing ozone very fast because these react

00:09:52.830 --> 00:09:56.500 on the order of hours are not very important than

00:09:56.500 --> 00:09:57.850 on the global scale.

00:09:57.850 --> 00:09:59.620 It's these more long live compounds.

00:09:59.620 --> 00:10:01.890 So carbon monoxide is really an important

00:10:01.890 --> 00:10:03.440 methane really important.

00:10:03.440 --> 00:10:06.600 Okay, so methane is admitted in large quantities,

00:10:06.600 --> 00:10:09.730 but it reacts so slowly contributes very little

00:10:09.730 --> 00:10:11.470 to urban air pollution.

00:10:11.470 --> 00:10:15.240 But on the global scale methane is one of the big drivers.

00:10:15.240 --> 00:10:19.060 Okay, so and by the way, methane and ozone

00:10:19.060 --> 00:10:21.640 are both greenhouse gases.

00:10:21.640 --> 00:10:24.470 So going back several years, I had a line of research

00:10:24.470 --> 00:10:27.850 looking at how emissions of these different precursors

00:10:27.850 --> 00:10:30.940 would affect both methane and ozone thinking about

00:10:30.940 --> 00:10:33.810 how do you control those, both from an air pollution point

00:10:33.810 --> 00:10:36.520 of view and from a climate point of view, okay.

00:10:36.520 --> 00:10:38.793 So as you motivate the first study here.

00:10:41.400 --> 00:10:43.510 We're interested in here in

00:10:43.510 --> 00:10:46.530 how global emissions are changing.

00:10:46.530 --> 00:10:50.160 This shows global emissions of nitrogen oxide

00:10:50.160 --> 00:10:53.063 one of those compounds that reacts to form ozone.

00:10:54.140 --> 00:10:59.140 Globally, in 1950, and I'm gonna flash forward

00:10:59.440 --> 00:11:04.440 by decade now, so in 1950, 1960, 1970 and 1980.

00:11:04.570 --> 00:11:06.210 So by the time we got to 1980,

00:11:06.210 --> 00:11:10.010 you see the emissions are dominated by the U.S and Europe.

00:11:10.010 --> 00:11:12.390 The spatial distribution, this is the latitude

00:11:12.390 --> 00:11:14.480 and they'll distribution on the right here,

00:11:14.480 --> 00:11:17.640 that hasn't really changed as emissions grew.

00:11:17.640 --> 00:11:22.640 But after that period, then this is 1990, 2000, 2010,

00:11:23.800 --> 00:11:26.640 we see emissions going down

00:11:26.640 --> 00:11:28.580 here in the U.S and Europe as

00:11:28.580 --> 00:11:30.920 we've implemented air pollution controls.

00:11:30.920 --> 00:11:32.860 And they've gone up pretty dramatically now

00:11:32.860 --> 00:11:33.870 in China and India.

00:11:33.870 --> 00:11:38.860 So the emission distribution is shifting southward.

00:11:38.860 --> 00:11:41.790 This is interesting, and perhaps troubling,

00:11:41.790 --> 00:11:44.070 because we understand from the point of view

00:11:44.070 --> 00:11:47.100 of atmospheric science, that a ton of emissions closer

00:11:47.100 --> 00:11:51.030 to the equator is expected to cause more ozone to be formed.

00:11:51.030 --> 00:11:54.423 And so we're asking the question here, basically,

00:11:55.480 --> 00:11:58.230 we'll focus on this period 1980 to 2010.

00:11:58.230 --> 00:12:02.900 So 1980 years before we had this change in the spatial

00:12:02.900 --> 00:12:06.550 distribution with emissions coming southward.

00:12:06.550 --> 00:12:10.450 We're gonna separate out the importance of the magnitude

00:12:10.450 --> 00:12:13.850 of the emission change versus the spatial distribution

00:12:13.850 --> 00:12:15.260 of the emission change.

00:12:15.260 --> 00:12:18.830 And the third ingredients here and the third factor

00:12:18.830 --> 00:12:22.060 that's really important is the global methane change.

00:12:22.060 --> 00:12:24.854 And we're gonna see how important each of those is

00:12:24.854 --> 00:12:26.820 for global troposphere ozone,

00:12:26.820 --> 00:12:30.120 that is the total amount of ozone in the lower level

00:12:30.120 --> 00:12:32.570 of the atmosphere, okay.

00:12:32.570 --> 00:12:35.980 So using a computer model, so I'm a computer modeler,

00:12:35.980 --> 00:12:38.443 and I work with models of the global atmosphere.

00:12:40.550 --> 00:12:42.860 We separated out these different influences.

00:12:42.860 --> 00:12:46.610 So according to our model, this is how the total ozone

00:12:46.610 --> 00:12:48.490 distribution has changed.

00:12:48.490 --> 00:12:52.120 Where it's increased the most is an indicator of

00:12:52.120 --> 00:12:55.730 where the biggest growth in emissions in the ozone

00:12:55.730 --> 00:12:59.763 has taken place, especially South and Southeast Asia.

00:13:00.970 --> 00:13:03.610 And then the contributions to this total.

00:13:03.610 --> 00:13:08.610 So 28 Teragrams of ozone contributions from the change

00:13:08.680 --> 00:13:11.680 in spatial distribution, the magnitude change

00:13:11.680 --> 00:13:13.890 and the methane change, these two on the bottom,

00:13:13.890 --> 00:13:15.790 though they contributed to the total amount

00:13:15.790 --> 00:13:19.260 of ozone present, have very little ability

00:13:19.260 --> 00:13:24.240 to explain this pattern of the total lows on growth.

00:13:24.240 --> 00:13:27.150 But if we look at the spatial distribution change,

00:13:27.150 --> 00:13:31.590 we have reductions in ozone, reductions in emissions,

00:13:31.590 --> 00:13:33.130 I should say, from the U.S and Europe,

00:13:33.130 --> 00:13:37.960 but pretty dramatic growth in South and Southeast Asia.

00:13:37.960 --> 00:13:41.610 And this gets us a lot further at explaining

00:13:41.610 --> 00:13:43.370 this total ozone growth.

00:13:43.370 --> 00:13:46.560 We were actually surprised by this that this is over half

00:13:46.560 --> 00:13:50.233 of the total, bigger than the effect of the magnitude

00:13:50.233 --> 00:13:52.690 and the effect of the methane change.

00:13:52.690 --> 00:13:55.610 This is another way of looking at this where

00:13:55.610 --> 00:13:58.100 this is the I should stay close to the mic,

00:13:58.100 --> 00:14:00.150 I'm told because we're recording.

00:14:00.150 --> 00:14:02.830 This is the equator, the North Pole, the South Pole,

00:14:02.830 --> 00:14:06.140 and then looking through the depth of the atmosphere here.

00:14:06.140 --> 00:14:09.410 This is the total change, the spatial distribution change,

00:14:09.410 --> 00:14:13.240 the magnitude change, and the changing global methane.

00:14:13.240 --> 00:14:16.490 In all of these cases, I should say in these two

00:14:16.490 --> 00:14:19.580 on the bottom, again, you don't explain the pattern

00:14:19.580 --> 00:14:21.930 that you see in the total ozone change.

00:14:21.930 --> 00:14:25.150 And this helps us to explain why this is so important.

00:14:25.150 --> 00:14:28.860 So as admissions have shifted, further southward,

00:14:28.860 --> 00:14:32.731 close to the equator now, those emissions are being lifted

00:14:32.731 --> 00:14:37.100 up by deep convection, we would say in a (mumbles)

00:14:37.100 --> 00:14:40.270 meteorological sense, reaching a higher level

00:14:40.270 --> 00:14:42.360 in the atmosphere than they do here.

00:14:42.360 --> 00:14:46.650 Once those emissions become part of the upper troposphere,

00:14:46.650 --> 00:14:49.820 they live longer, and they react to form ozone.

00:14:49.820 --> 00:14:52.700 That's what's driving this greater sensitivity

00:14:52.700 --> 00:14:56.710 of ozone to changes in our pollutant emissions

00:14:56.710 --> 00:14:57.960 near the equator.

00:14:57.960 --> 00:14:59.790 And you can see that really vividly here

00:14:59.790 --> 00:15:04.340 that these emissions that are from Southeast Asia in India

00:15:04.340 --> 00:15:07.770 are being distributed, lofted up very high,

00:15:07.770 --> 00:15:10.070 where they're reacting to form a lot of ozone.

00:15:11.220 --> 00:15:16.220 So our concern then was that as we shift

00:15:16.590 --> 00:15:20.040 and continue to to shift emissions toward the equator,

00:15:20.040 --> 00:15:22.780 that even if global emissions might decrease,

00:15:22.780 --> 00:15:25.240 if we're if the spatial pattern is changing,

00:15:25.240 --> 00:15:27.553 we might continue to increase global ozone.

00:15:28.830 --> 00:15:31.627 This was the work of Yuqiang Zhang who is my PhD student

00:15:31.627 --> 00:15:35.880 and that postdoc, he's continued that do a bunch more

00:15:37.100 --> 00:15:40.130 simulations where he's separating out then the influence

00:15:40.130 --> 00:15:44.750 of each we're looking again at the change from 1980 to 2010.

00:15:44.750 --> 00:15:48.890 Looking at the influence of each world region change

00:15:48.890 --> 00:15:50.260 on the total ozone change,

00:15:50.260 --> 00:15:52.430 and here's the methane change as well.

00:15:52.430 --> 00:15:54.390 So this is the total effect.

00:15:54.390 --> 00:15:57.350 And we see here that East Asia is important, that's China.

00:15:57.350 --> 00:16:00.980 That's not surprising, they led the world in

00:16:00.980 --> 00:16:04.510 manufacturing with huge emissions associated with it.

00:16:04.510 --> 00:16:05.840 What is surprising here,

00:16:05.840 --> 00:16:08.360 is right next to it is Southeast Asia

00:16:08.360 --> 00:16:10.840 as important for globalism.

00:16:10.840 --> 00:16:13.200 And if we look at the emissions,

00:16:13.200 --> 00:16:16.350 the emissions from Southeast Asia are much smaller

00:16:16.350 --> 00:16:18.930 than the emission growth that's taken place over

00:16:18.930 --> 00:16:21.820 these three decades from East Asia.

00:16:21.820 --> 00:16:25.310 So we're really highlighting here how important

00:16:25.310 --> 00:16:29.400 emissions are, that are near the equator,

00:16:29.400 --> 00:16:31.850 and in particular, from Southeast Asia, suggesting

00:16:31.850 --> 00:16:34.840 that there really are sort of emission hotspots

00:16:34.840 --> 00:16:38.760 where each ton of emissions has a much greater influence,

00:16:38.760 --> 00:16:42.460 on global air quality than emissions

00:16:42.460 --> 00:16:45.910 from further north, okay.

00:16:45.910 --> 00:16:48.650 So that's your bit of atmospheric science today.

00:16:48.650 --> 00:16:50.900 I'll turn our attention to health.

00:16:50.900 --> 00:16:53.490 And our first question will be,

00:16:53.490 --> 00:16:55.740 how many people die each year due to exposure

00:16:55.740 --> 00:16:57.010 to ambient air pollution?

00:16:57.010 --> 00:16:58.990 I'm gonna take a minute and get into that.

00:16:58.990 --> 00:17:02.440 So, Rob introduced me as an engineer

00:17:02.440 --> 00:17:04.440 and my background is engineering.

00:17:04.440 --> 00:17:06.360 I had no schooling and public health

00:17:06.360 --> 00:17:09.090 had no idea what public health was about,

00:17:09.090 --> 00:17:13.200 really until I did this study,

00:17:13.200 --> 00:17:14.850 I had been for a few years,

00:17:14.850 --> 00:17:18.840 I had a fellowship to work in UPA headquarters in DC.

00:17:18.840 --> 00:17:21.520 So there's a fellowship program for PhD scientists

00:17:21.520 --> 00:17:23.050 to go into government offices.

00:17:23.050 --> 00:17:26.090 And I thought at the time that I'd be leaving academics

00:17:26.090 --> 00:17:29.320 for good to pursue a career in policy.

00:17:29.320 --> 00:17:33.060 And I learned a lot about how people

00:17:33.060 --> 00:17:36.373 formulate policy questions in a place like DC.

00:17:37.310 --> 00:17:40.360 And that changed how I approached problems.

00:17:40.360 --> 00:17:42.433 So I became interested in health.

00:17:43.360 --> 00:17:46.300 Health is an interesting topic, but my main motivation

00:17:46.300 --> 00:17:49.380 actually was to think about it from a cost benefit

00:17:49.380 --> 00:17:51.070 of policy analysis point of view.

00:17:51.070 --> 00:17:53.487 The health was, to me the benefit

00:17:53.487 --> 00:17:55.380 of the cost benefit analysis.

00:17:55.380 --> 00:17:57.240 That's why I wanted to study it.

00:17:57.240 --> 00:18:01.230 So my first study, there was I became aware as I just sort

00:18:01.230 --> 00:18:04.230 of explained to you that methane affects

00:18:04.230 --> 00:18:05.923 the global background of ozone.

00:18:08.080 --> 00:18:10.500 We had been thinking about methane,

00:18:10.500 --> 00:18:12.420 obviously as a greenhouse gas.

00:18:12.420 --> 00:18:14.640 And there's good reasons to reduce methane

00:18:14.640 --> 00:18:16.060 as a greenhouse gas.

00:18:16.060 --> 00:18:18.317 I thought I look at it in different contexts.

00:18:18.317 --> 00:18:21.170 And I asked the question, could we justify

00:18:21.170 --> 00:18:24.980 reducing methane emissions, because of it's reductions

00:18:24.980 --> 00:18:27.650 in ozone, and the health benefits

00:18:27.650 --> 00:18:29.980 that would come about from that?

00:18:29.980 --> 00:18:32.720 So this was published in 2006.

00:18:32.720 --> 00:18:36.240 I called up Michelle Bell, who had the number one paper

00:18:36.240 --> 00:18:39.640 at the time on ozone related deaths

00:18:39.640 --> 00:18:41.290 and I talked through with her.

00:18:41.290 --> 00:18:43.790 How do I use that information in

00:18:43.790 --> 00:18:45.900 what I'll call now a risk assessment?

00:18:45.900 --> 00:18:50.020 So using epidemiological information to assess health.

00:18:50.020 --> 00:18:53.970 So what I did here was I use my global atmospheric model,

00:18:53.970 --> 00:18:57.350 put in a simulated a 20% reduction

00:18:57.350 --> 00:18:59.170 of global methane emissions,

00:18:59.170 --> 00:19:02.960 overlaid that on the world's population,

00:19:02.960 --> 00:19:06.270 and found that the reduction who knows on that came about

00:19:06.270 --> 00:19:10.990 from reducing methane avoided about 30,000 deaths in 2030.

00:19:11.830 --> 00:19:15.160 When I put dollar sign associated with those deaths,

00:19:15.160 --> 00:19:18.940 and compared it against the cost of reducing methane,

00:19:18.940 --> 00:19:21.600 and I could look up from the climate literature,

00:19:21.600 --> 00:19:23.890 the ways that we could think about reducing methane

00:19:23.890 --> 00:19:27.730 and how much it costs, I found actually that the benefits

00:19:27.730 --> 00:19:30.040 to health outweigh the cost.

00:19:30.040 --> 00:19:31.500 So that was kind of cool.

00:19:31.500 --> 00:19:34.420 And it’s suggested that we could be thinking about methane

00:19:34.420 --> 00:19:38.030 controls from an air pollution management point of view,

00:19:38.030 --> 00:19:42.360 as well as from climate change management point of view.

00:19:42.360 --> 00:19:45.250 Okay, but one of the things that I was only vaguely aware

00:19:45.250 --> 00:19:47.840 of at the time, this was actually the first time

00:19:47.840 --> 00:19:51.650 or certainly one of the first times that anybody had used

00:19:51.650 --> 00:19:53.560 global atmospheric model

00:19:53.560 --> 00:19:55.780 to drive a health impact assessment.

00:19:55.780 --> 00:19:58.610 And what I wasn’t anticipating at the time was,

00:19:58.610 --> 00:20:01.810 that would be that the major direction of my research

00:20:01.810 --> 00:20:03.630 ever since that, okay.

00:20:03.630 --> 00:20:05.290 So what I’ll talk to you through now

00:20:05.290 --> 00:20:07.010 or some more applications,

00:20:07.010 --> 00:20:09.560 where I’m using my global atmospheric model,

00:20:09.560 --> 00:20:12.300 or using models that are used in the community

00:20:12.300 --> 00:20:14.740 that I came from, and now using them

00:20:14.740 --> 00:20:17.820 for Health Impact Assessments.

00:20:17.820 --> 00:20:21.500 So the question that I asked just go back a couple slides

00:20:21.500 --> 00:20:24.460 how many people died prematurely due to exposure

00:20:24.460 --> 00:20:26.403 to outdoor air pollution every year?

00:20:28.010 --> 00:20:31.360 If we look back several Global Burden of Disease Assessments

00:20:31.360 --> 00:20:35.110 ago, the first answers to those questions only looked

00:20:35.110 --> 00:20:36.890 at cities because it was in cities

00:20:36.890 --> 00:20:38.270 that we had observations

00:20:38.270 --> 00:20:41.050 we didn’t have observations elsewhere.

00:20:41.050 --> 00:20:43.670 And so they were only estimating in the

00:20:43.670 --> 00:20:47.260 Global Burden of Disease, the effect of air pollution

00:20:47.260 --> 00:20:50.380 on health for the fraction of the world’s population

00:20:50.380 --> 00:20:52.810 that lived in the city, ignoring everybody else,

00:20:52.810 --> 00:20:55.940 but we know where pollution is going up in a lot of places,

00:20:55.940 --> 00:20:57.710 even rural places.

00:20:57.710 --> 00:20:59.860 So our first attempt at doing that was

00:20:59.860 --> 00:21:02.920 that you use a computer model, the computer model

00:21:02.920 --> 00:21:04.840 has an advantage because it’s got

00:21:04.840 --> 00:21:06.890 complete quote global coverage.

00:21:06.890 --> 00:21:09.980 It’s got disadvantages, of (mumbles) grid cells

00:21:09.980 --> 00:21:12.070 that don’t really tell you what people are breathing

00:21:12.070 --> 00:21:13.610 in an urban setting.

00:21:13.610 --> 00:21:16.580 And it’s got biases, okay.

00:21:16.580 --> 00:21:19.610 But nonetheless, we used it and that gave us the first

00:21:19.610 --> 00:21:23.750 estimate of global air pollution related deaths

00:21:24.840 --> 00:21:26.223 as a global total.

00:21:27.120 --> 00:21:29.100 Here was the next study in that line.

00:21:29.100 --> 00:21:31.660 This is Raquel Silva, who is my PhD.

00:21:31.660 --> 00:21:34.440 I use a bunch of chemistry and climate models.

00:21:34.440 --> 00:21:37.760 These are simulations that were run for climate research,

00:21:37.760 --> 00:21:41.640 but they also output ground level concentrations of ozone,

00:21:41.640 --> 00:21:45.700 and PM2.5 and one of the neat things is they simulated

00:21:45.700 --> 00:21:49.570 today, which in this study was year 2000.

00:21:49.570 --> 00:21:52.620 And they also simulated the year 1850 as being

00:21:52.620 --> 00:21:54.280 before the Industrial Revolution.

00:21:54.280 --> 00:21:58.560 So we took the difference between air pollution in 1850

00:21:58.560 --> 00:22:02.550 and 2000 and called that human caused air pollution.

00:22:02.550 --> 00:22:06.280 And then assess what that meant for global human health.

00:22:06.280 --> 00:22:08.460 So these are a bunch of different models

00:22:08.460 --> 00:22:10.590 that all ran the same experiment.

00:22:10.590 --> 00:22:12.980 This for ozone, you see, there's a spread

00:22:12.980 --> 00:22:16.600 of different results, using the different models.

00:22:16.600 --> 00:22:19.097 When we looked at this, this is the average of those.

00:22:19.097 --> 00:22:21.820 But the error bars here reflect both the uncertainty

00:22:21.820 --> 00:22:24.240 and the concentration response function,

00:22:24.240 --> 00:22:26.640 and the spread that we get from the different models.

00:22:26.640 --> 00:22:29.830 And it turns out that the uncertainty that comes

00:22:29.830 --> 00:22:32.020 from the spread of the different models,

00:22:32.020 --> 00:22:35.150 outweighs the uncertainty contributes more

00:22:35.150 --> 00:22:38.140 to this overall uncertainty, then does the uncertainty

00:22:38.140 --> 00:22:39.840 and the concentration response function.

00:22:39.840 --> 00:22:41.820 So that was kind of interesting as well.

00:22:41.820 --> 00:22:46.443 But globally, half a million or so, deaths related to ozone,

00:22:47.570 --> 00:22:50.920 related to PM2.5, about 2 million deaths.

00:22:50.920 --> 00:22:53.840 In a minute, I'll put those numbers into more context

00:22:53.840 --> 00:22:55.860 for you, you know, how do we think about that

00:22:55.860 --> 00:22:58.930 and how do we compare what that number means?

00:22:58.930 --> 00:23:01.420 I'll just finish talking about this study.

00:23:01.420 --> 00:23:04.700 This is the average of the many different models we use.

00:23:04.700 --> 00:23:08.980 This is for ozone, with most of the world’s deaths occurring

00:23:08.980 --> 00:23:13.000 in India and East Asia, obviously huge populations exposed

00:23:13.000 --> 00:23:15.770 to highly polluted air.

00:23:15.770 --> 00:23:18.090 Here, we’ve looked at it deaths per million people

00:23:18.090 --> 00:23:20.300 in these different regions, it’s certainly higher there.

00:23:20.300 --> 00:23:23.370 But even North America stands out is pretty high

00:23:23.370 --> 00:23:28.310 as well there, even though air pollution is has gotten

00:23:28.310 --> 00:23:31.260 less severe through time, okay.

00:23:31.260 --> 00:23:35.530 And in East Asia, I mean, (mumbles) PM2.5

00:23:35.530 --> 00:23:39.033 half the global total is in East Asia or so, okay.

00:23:40.410 --> 00:23:44.483 So that’s an example of the type of work that we can do,

00:23:45.360 --> 00:23:46.920 addressing this question.

00:23:46.920 --> 00:23:48.890 Will come back to that question when we look at the

00:23:48.890 --> 00:23:50.960 Global Burden of Disease Assessment.

00:23:50.960 --> 00:23:52.000 This was our

00:23:53.610 --> 00:23:57.560 contribution to the Global Burden of Disease Assessments,

00:23:57.560 --> 00:24:01.000 where my lab is now looking at the statistical methods

00:24:01.000 --> 00:24:03.640 for how we can best model global

00:24:03.640 --> 00:24:06.220 surface ozones concentration.

00:24:06.220 --> 00:24:08.150 So we wanna understand all around the world

00:24:08.150 --> 00:24:10.990 what people are breathing at ground level.

00:24:10.990 --> 00:24:14.340 The challenges that we’ve got a lot of measurements

00:24:14.340 --> 00:24:16.930 of ozone air pollution in the United States and Europe

00:24:16.930 --> 00:24:18.920 and much less elsewhere.

00:24:18.920 --> 00:24:21.490 And I'll show you later we have huge voids where

00:24:23.730 --> 00:24:27.330 of Africa for example, where there's very few observations.

00:24:27.330 --> 00:24:29.520 So going beyond where we started,

00:24:29.520 --> 00:24:32.130 which was let's just use a model to estimate

00:24:32.130 --> 00:24:33.960 what people are breathing.

00:24:33.960 --> 00:24:37.460 Now we're going to fuse together in a statistical way

00:24:38.770 --> 00:24:41.720 the global surface ozone concentrations,

00:24:41.720 --> 00:24:45.270 I'm sorry, the global ozone observations

00:24:45.270 --> 00:24:47.410 and an ensemble of global models, okay.

00:24:47.410 --> 00:24:49.840 So we have a big team working on this

00:24:49.840 --> 00:24:52.880 we're working with Owen Cooper and Kai-Lan Chang.

00:24:52.880 --> 00:24:55.790 Owen is the chair of what's known as the tropospheric goes

00:24:55.790 --> 00:24:57.470 on Assessment Report.

00:24:57.470 --> 00:25:00.110 They've compiled together, this is the biggest compilation

00:25:00.110 --> 00:25:02.620 of ozone related measurements

00:25:02.620 --> 00:25:05.880 that it's ever been put together from all around the world

00:25:05.880 --> 00:25:08.130 going back several decades, actually.

00:25:08.130 --> 00:25:10.480 So that was a huge undertaking, including, you know,

00:25:10.480 --> 00:25:13.210 calling up the government of Iran,

00:25:13.210 --> 00:25:16.420 and asking them that they would share their ozone data.

00:25:16.420 --> 00:25:18.440 There's a lot of work that went into that.

00:25:18.440 --> 00:25:20.530 I'm using a bunch of models that come out of what's

00:25:20.530 --> 00:25:23.540 known as the chemistry climate model initiative.

00:25:23.540 --> 00:25:27.030 And then we have a big team of people in all especially

00:25:27.030 --> 00:25:30.530 mentioned, Marc Serre, who's a space time statistician

00:25:30.530 --> 00:25:33.400 who works in my department, and will use his methods here.

00:25:33.400 --> 00:25:35.320 I'll explain that in a minute, okay.

00:25:35.320 --> 00:25:38.130 So Kai-Lan led our first study which was published

00:25:38.130 --> 00:25:41.730 this year, where we're combining,

00:25:41.730 --> 00:25:45.840 again, the observations and output for many models,

00:25:45.840 --> 00:25:48.180 and we're using here this health related metric,

00:25:48.180 --> 00:25:50.590 we're doing an average of several years.

00:25:50.590 --> 00:25:53.450 And the health related metric was requested

00:25:53.450 --> 00:25:56.030 by the Global Burden of Disease Assessment,

00:25:56.030 --> 00:25:59.280 because this is how they'll assess human health.

00:25:59.280 --> 00:26:02.630 Okay, so the big the picture we take tour observations

00:26:02.630 --> 00:26:03.890 this is what those look like.

00:26:03.890 --> 00:26:06.970 Again, a lot of observations in a few places,

00:26:06.970 --> 00:26:09.733 but other places very sparse observations.

00:26:10.760 --> 00:26:13.820 We have the, this is the multi model average,

00:26:13.820 --> 00:26:16.090 the average of all the models that we're using,

00:26:16.090 --> 00:26:17.950 you see that this is biased high,

00:26:17.950 --> 00:26:20.090 so we wanna correct that bias.

00:26:20.090 --> 00:26:22.540 Then combine these together, I'll talk about the steps

00:26:22.540 --> 00:26:26.580 that we go through to do this, to create this output map

00:26:26.580 --> 00:26:27.980 that was delivered for the

00:26:27.980 --> 00:26:30.623 Global Burden of Disease 2017 Assessment.

00:26:32.070 --> 00:26:35.050 So I'll go through the steps that Kai-Lan did in this study.

00:26:35.050 --> 00:26:37.450 First, he did a spatial interpolation

00:26:37.450 --> 00:26:39.723 of all the measurements which is shown here.

00:26:40.850 --> 00:26:44.263 He looked at all of the models, these are the models listed.

00:26:45.130 --> 00:26:50.130 And he did a full evaluation of each model with respect

00:26:50.680 --> 00:26:53.800 to all of the observations.

00:26:53.800 --> 00:26:56.370 Here is really the key to what Kai-Lan did,

00:26:56.370 --> 00:27:00.540 he found in each region of the world, so for North America,

00:27:00.540 --> 00:27:02.493 Europe, East Asia, et cetera.

00:27:03.430 --> 00:27:07.600 The combination of models that best represents

00:27:07.600 --> 00:27:10.350 the measurements, the best reproduces the measurements.

00:27:11.310 --> 00:27:14.860 So he is like an optimization routine that he goes through

00:27:14.860 --> 00:27:17.430 to find the linear combination of models

00:27:17.430 --> 00:27:19.530 that best reproduces the measurements.

00:27:19.530 --> 00:27:22.220 And he's correcting bias while he does that,

00:27:22.220 --> 00:27:25.150 that gives us this multimodal blend.

00:27:25.150 --> 00:27:28.380 And the last step is where we have observations,

00:27:28.380 --> 00:27:31.120 then, we're gonna correct within two degrees

00:27:31.120 --> 00:27:32.230 of those observations.

00:27:32.230 --> 00:27:35.280 The two degrees is fairly arbitrary,

00:27:35.280 --> 00:27:37.750 and I'll talk about that choice next.

00:27:37.750 --> 00:27:41.970 But we correct for the observations within two degrees

00:27:41.970 --> 00:27:43.163 of the observation.

00:27:44.200 --> 00:27:45.720 And this is our final product.

00:27:45.720 --> 00:27:49.840 So in the U.S where we had a lot of observation stations, 00:27:49.840 --> 00:27:52.955 it's going to because of this last step, basically

00:27:52.955 --> 00:27:56.880 be based mainly on the observations

00:27:56.880 --> 00:28:00.480 in a place like Africa where we have very few observations

00:28:00.480 --> 00:28:03.173 our output is going to be based mainly on the models.

00:28:04.380 --> 00:28:06.970 Okay, so that was our first attempt at it,

00:28:06.970 --> 00:28:11.380 which was produced for the Global Burden of Disease 2017.

00:28:11.380 --> 00:28:13.580 And we just finished our work for the new

00:28:13.580 --> 00:28:16.930 forthcoming Global Burden of Disease 2019.

00:28:16.930 --> 00:28:20.200 Here we did quite a few steps to improve upon that.

00:28:20.200 --> 00:28:22.460 We're now producing ozone maps for all years,

00:28:22.460 --> 00:28:24.513 from 1990 to 2017.

00:28:25.540 --> 00:28:28.630 Where you perform a new data fusion method

00:28:28.630 --> 00:28:31.100 that I'll explain in a minute, which is Marc Serre's method

00:28:31.100 --> 00:28:33.620 known as Bayesian Maximum Entropy.

00:28:33.620 --> 00:28:36.370 We add new observations from China and elsewhere.

00:28:36.370 --> 00:28:40.070 China really started measuring in 2015 or so.

00:28:40.070 --> 00:28:43.280 Now there's hundreds of stations in China operating

00:28:43.280 --> 00:28:46.040 which were not up operating before.

00:28:46.040 --> 00:28:51.040 And when we do this, we have really the observations

00:28:51.640 --> 00:28:53.040 if there's a lot of observations

00:28:53.040 --> 00:28:55.580 that can give us spatial information on a fine scale,

00:28:55.580 --> 00:28:57.760 such as around an urban area,

00:28:57.760 --> 00:28:59.990 but again, many places in the world

00:28:59.990 --> 00:29:01.950 have very few observations.

00:29:01.950 --> 00:29:04.960 So what we did is the last step was to use this

00:29:04.960 --> 00:29:09.600 NASA model that simulated the whole world at one eighth

00:29:09.600 --> 00:29:11.163 of a degree resolution.

00:29:12.030 --> 00:29:14.661 To add that find space or spatial structure

00:29:14.661 --> 00:29:17.120 (mumbles) output product is for the whole world,

00:29:17.120 --> 00:29:20.780 each year over this period, at .1 degree resolution.

00:29:20.780 --> 00:29:24.890 So we've delivered that to GVD, they're gonna use that.

00:29:24.890 --> 00:29:27.610 I'll explain the Bayesian Maximum Entropy method.

00:29:27.610 --> 00:29:32.050 So we use the output of the multi model blending

00:29:32.050 --> 00:29:34.010 that Kai-Lan Chang did.

00:29:34.010 --> 00:29:36.400 So we're now doing that and each year,

00:29:36.400 --> 00:29:38.960 that becomes in this framework, a global offset,

00:29:38.960 --> 00:29:43.140 which is shown in blue, the BME method would

00:29:43.140 --> 00:29:45.910 in suppose these are observations around it.

00:29:45.910 --> 00:29:50.280 So the BME method would exactly match an observation

00:29:50.280 --> 00:29:52.730 at the location of the observation

00:29:52.730 --> 00:29:55.660 and the influence of this observation.

00:29:55.660 --> 00:29:57.750 If you're very far away from the observations,

00:29:57.750 --> 00:30:00.680 you're gonna use the global offset which is this

00:30:00.680 --> 00:30:03.740 model output, so basing it on the models,

00:30:03.740 --> 00:30:07.333 and the influence of these observations falls off

00:30:07.333 --> 00:30:10.063 with distance from the observations.

00:30:11.130 --> 00:30:16.130 And that function by which it decreases with distance

00:30:16.130 --> 00:30:19.380 is a function of the spatial correlation

00:30:19.380 --> 00:30:22.200 of the observations themselves, okay.

00:30:22.200 --> 00:30:23.530 I'll talk more about that in a minute.

00:30:23.530 --> 00:30:25.920 So, the features of the output is

00:30:25.920 --> 00:30:28.220 that we're gonna match observations, 00:30:28.220 --> 00:30:30.840 where we have observations and far from the observations,

00:30:30.840 --> 00:30:33.780 we're gonna tend toward what the models are telling us

00:30:33.780 --> 00:30:35.130 after we bias correct them.

00:30:36.950 --> 00:30:39.020 I should say, though, this shows it in space,

00:30:39.020 --> 00:30:41.340 but we also do this in time actually.

00:30:41.340 --> 00:30:44.200 So we use information in different years.

00:30:44.200 --> 00:30:47.030 It's often the case that a monitoring station

00:30:47.030 --> 00:30:49.490 will come online in a particular year.

00:30:49.490 --> 00:30:54.160 We can use information from those monitoring values

00:30:54.160 --> 00:30:58.430 and use that to inform the years before that, okay,

00:30:58.430 --> 00:31:00.520 in a statistical sense, where

00:31:00.520 --> 00:31:02.510 again, the further we get away from it,

00:31:02.510 --> 00:31:05.560 the influence of those observations falls off

00:31:05.560 --> 00:31:06.833 with distance or time.

00:31:08.080 --> 00:31:09.990 This is what those correlations look like

00:31:09.990 --> 00:31:14.070 this is a covariance function with distance

00:31:14.070 --> 00:31:15.100 from the station.

00:31:15.100 --> 00:31:19.470 So spatially, it drops off quite a lot such that

00:31:19.470 --> 00:31:24.070 by the time we're one degree away from an observation,

00:31:24.070 --> 00:31:26.890 we've lost a lot of useful information.

00:31:26.890 --> 00:31:29.470 But in time, it drops off actually very slowly.

00:31:29.470 --> 00:31:33.700 So, one, this is to say that one year's observations

00:31:33.700 --> 00:31:36.375 is useful for informing the years around it,

00:31:36.375 --> 00:31:39.550 and (mumbles) we make use of that here, okay.

00:31:39.550 --> 00:31:41.990 So our final product, I'm just showing you results

00:31:41.990 --> 00:31:43.770 for a single year, but we've done this

00:31:43.770 --> 00:31:45.890 for all years over this period.

00:31:45.890 --> 00:31:48.070 We started with the observations.

00:31:48.070 --> 00:31:51.093 This is a multi model average which is bias high.

00:31:52.110 --> 00:31:54.010 If we go through this step of

00:31:55.000 --> 00:31:58.090 our first sort of methods of combining together

00:31:58.090 --> 00:32:00.690 the different models in an optimum sense,

00:32:00.690 --> 00:32:03.150 this is an correcting for bias.

00:32:03.150 --> 00:32:05.310 This is the result that we get.

00:32:05.310 --> 00:32:07.850 And then our final product, which doesn't look all

00:32:07.850 --> 00:32:08.960 that different from that one.

00:32:08.960 --> 00:32:12.540 But if you look at details around in urban area,

00:32:12.540 --> 00:32:16.370 for example, especially where we have measurements now,

00:32:16.370 --> 00:32:18.370 this is doing a lot better at reproducing

00:32:18.370 --> 00:32:19.863 those measurements, okay.

00:32:22.610 --> 00:32:24.750 So the most recent global,

00:32:24.750 --> 00:32:26.940 we've delivered that to Global Burden of Disease

00:32:26.940 --> 00:32:29.100 that's gonna come out in the forthcoming assessment,

00:32:29.100 --> 00:32:31.157 but these are the results that I'll take a bit

00:32:31.157 --> 00:32:33.510 and talk about to put air pollution related

00:32:33.510 --> 00:32:35.160 deaths into perspective.

00:32:35.160 --> 00:32:38.120 This is from the 2017 assessment that was done.

00:32:38.120 --> 00:32:43.120 So, Ambient PM2.5 pollution, that's 2.9 million deaths,

00:32:43.690 --> 00:32:47.230 Ambient noise, pollution, about half a million deaths.

00:32:47.230 --> 00:32:49.150 The third one here is household air pollution

00:32:49.150 --> 00:32:50.060 from solid fuels.

00:32:50.060 --> 00:32:55.060 That's people burning coal, and straw and wood,

00:32:55.250 --> 00:32:56.890 within a home environment,

00:32:56.890 --> 00:32:59.350 often where there's very poor ventilation.

00:32:59.350 --> 00:33:01.660 So this is not in the United States, 00:33:01.660 --> 00:33:04.280 but in the poorest regions of the world where people don't

00:33:04.280 --> 00:33:07.880 have access to electricity and things like that.

00:33:07.880 --> 00:33:10.120 So that's 1.6 or so million.

00:33:10.120 --> 00:33:13.200 If you were to add up PM2.5 and ozone,

00:33:13.200 --> 00:33:16.390 that's one of every 19 deaths globally.

00:33:16.390 --> 00:33:19.020 And what the Global Burden of Disease Assessment does

00:33:19.020 --> 00:33:22.040 is they assessed a whole bunch of different risk factors

00:33:23.110 --> 00:33:25.450 such that you can compare them against one another

00:33:25.450 --> 00:33:28.650 and here's Ambien PM2.5 pollution,

00:33:28.650 --> 00:33:30.750 coming in at number 10th in this list,

00:33:30.750 --> 00:33:35.180 if you only looked at death, it would be the number eighth

00:33:35.180 --> 00:33:37.880 most important risk factor but look at the things around it.

00:33:37.880 --> 00:33:41.140 So I think if you were to ask people, what's most important

00:33:41.140 --> 00:33:44.650 for health first, you know, PM2.5 pollution

00:33:44.650 --> 00:33:47.200 is the number one, it's shown in green,

00:33:47.200 --> 00:33:49.290 environmental risk factor.

00:33:49.290 --> 00:33:52.310 Here's unsafe water coming in after that,

00:33:52.310 --> 00:33:54.870 but around this are a lot of things

00:33:54.870 --> 00:33:56.293 that have to do with diet.

00:33:57.530 --> 00:34:00.110 Have to do with you know, obesity,

00:34:00.110 --> 00:34:02.010 high blood pressure, right?

00:34:02.010 --> 00:34:06.820 And here's PM2.5 pollution being comparable to all those

00:34:06.820 --> 00:34:08.180 many of those other sources.

00:34:08.180 --> 00:34:11.730 So that's been really very influential in

00:34:11.730 --> 00:34:15.090 changing people's minds about how important air pollution

00:34:15.090 --> 00:34:18.233 is globally as a driver of global public health.

00:34:19.880 --> 00:34:21.890 I'll mention as well that in the past year,

00:34:21.890 --> 00:34:24.720 there's been another study come out where

00:34:24.720 --> 00:34:27.233 they looked again at the epidemiological functions

00:34:27.233 --> 00:34:31.230 that they're using, constructed a new function,

00:34:31.230 --> 00:34:34.820 which gives us much greater number of deaths.

00:34:34.820 --> 00:34:36.903 So 8.9 is quite a bit bigger than 2.8.

00:34:38.400 --> 00:34:41.586 If they're gonna use this function in the forthcoming

00:34:41.586 --> 00:34:44.000 Global Burden of Disease Assessment,

00:34:44.000 --> 00:34:46.850 we should expect much bigger numbers to come out of that.

00:34:48.218 --> 00:34:49.830 Okay.

00:34:49.830 --> 00:34:52.440 How will climate change affect global air pollution

00:34:52.440 --> 00:34:55.070 and air pollution related deaths, okay?

00:34:55.070 --> 00:34:59.140 This is a figure from Arlene Fury that I collaborate with.

00:34:59.140 --> 00:35:03.470 There's all kinds of ways that climate change as it occurs

00:35:03.470 --> 00:35:05.630 is expected to affect air quality.

00:35:05.630 --> 00:35:08.380 So climate change affects meteorology.

00:35:08.380 --> 00:35:11.400 Meteorology, rainfall removes pollutants

00:35:11.400 --> 00:35:15.170 from the atmosphere, higher temperatures and more sunlight

00:35:16.320 --> 00:35:19.320 make chemical reactions happen more quickly

00:35:19.320 --> 00:35:21.910 that increases air pollution.

00:35:21.910 --> 00:35:25.100 If there's stronger winds that can ventilate

00:35:25.100 --> 00:35:27.690 polluted region taking pollution elsewhere,

00:35:27.690 --> 00:35:30.250 that might decrease air pollution.

00:35:30.250 --> 00:35:33.380 There might be influences we expect of climate change

00:35:33.380 --> 00:35:37.653 to increase the amount of organics the trees put out.

00:35:38.849 --> 00:35:42.380 The if we look at wind blowing dust,

00:35:42.380 --> 00:35:45.450 if we look at forest fires, all of these things will

00:35:45.450 --> 00:35:47.820 be affected by climate change, okay.

00:35:47.820 --> 00:35:50.810 So there's a lot of different pathways here, physical

00:35:50.810 --> 00:35:53.650 ways that climate change could affect air pollution.

00:35:53.650 --> 00:35:57.400 And we're again looking at a bunch of different global

00:35:57.400 --> 00:35:59.720 models that have addressed this so what.

00:35:59.720 --> 00:36:03.640 The experiment that they ran was to hold a mission constant

00:36:03.640 --> 00:36:08.410 at present day levels and then look at 2030 experiments

00:36:08.410 --> 00:36:11.890 with future climate change versus today's climate.

00:36:11.890 --> 00:36:16.230 And then 2100 with future climate versus today's climate,

00:36:16.230 --> 00:36:18.943 so there's singling out the effects of climate change.

00:36:19.780 --> 00:36:21.540 When we look over these different models,

00:36:21.540 --> 00:36:23.670 we get different answers from each model,

00:36:23.670 --> 00:36:27.520 including some models here, a few models for which,

00:36:27.520 --> 00:36:31.390 you know, depends a lot on how the spatial distribution

00:36:31.390 --> 00:36:33.470 of where air pollution is increasing because

00:36:33.470 --> 00:36:35.560 of climate change, and where it's decreasing

00:36:35.560 --> 00:36:37.410 overlays on population, right?

00:36:37.410 --> 00:36:41.270 So if we happen to have big increase that happens right over

00:36:41.270 --> 00:36:43.610 India, which is densely populated,

00:36:43.610 --> 00:36:45.380 that's gonna be really important.

00:36:45.380 --> 00:36:49.310 Okay, so our multi model average year is positive,

00:36:49.310 --> 00:36:51.820 not hugely positive, and there's big uncertainty

00:36:51.820 --> 00:36:54.560 that comes about from the spread of the different models, 00:36:54.560 --> 00:36:59.480 nonetheless, most of the models suggest increase

00:36:59.480 --> 00:37:02.460 of air pollution due to climate change,

00:37:02.460 --> 00:37:04.980 a few suggested decrease.

00:37:04.980 --> 00:37:08.710 And for PM2.5 we have fewer models that reported changes

00:37:08.710 --> 00:37:13.020 in PM2.5, but only one of them showed a small decrease.

00:37:13.020 --> 00:37:17.600 And now we have more of the models showing a big increase

00:37:17.600 --> 00:37:22.490 the magnitude here by 2100, 200 or so thousand

00:37:22.490 --> 00:37:26.050 deaths per year attributable to climate change

00:37:26.050 --> 00:37:27.850 by this mechanism.

00:37:27.850 --> 00:37:30.400 If we look at all of the ways that climate change

00:37:30.400 --> 00:37:33.520 could affect health, this actually is pretty important.

00:37:33.520 --> 00:37:37.100 Okay, you might not have guessed that climate changes

00:37:37.100 --> 00:37:40.810 effect on air pollution would be one of the important ways

00:37:40.810 --> 00:37:42.490 that it would affect health.

00:37:42.490 --> 00:37:45.780 You might think as well, right, heat stress,

00:37:45.780 --> 00:37:47.620 spread of infectious diseases,

00:37:47.620 --> 00:37:50.080 access to food and water population displaces.

00:37:50.080 --> 00:37:51.553 There's all kinds of ways that affects health

00:37:51.553 --> 00:37:56.010 but when we've tried to put numbers to it, this number,

00:37:56.010 --> 00:37:59.080 you know, of deaths, puts it in the same ballpark,

00:37:59.080 --> 00:38:00.690 as many of those other factors.

00:38:00.690 --> 00:38:03.220 So, maybe not what you would have guessed at first,

00:38:03.220 --> 00:38:06.220 but again, because air pollution kills a lot of people

00:38:06.220 --> 00:38:08.893 that becomes important here, okay.

00:38:11.490 --> 00:38:14.640 What are trends in air pollution related deaths in the U.S?

00:38:14.640 --> 00:38:17.450 I'm gonna, we've only got two topics left.

00:38:17.450 --> 00:38:20.430 I'm gonna try to wrap this up somewhat quickly.

00:38:20.430 --> 00:38:23.250 This is the work of Omar Nawaz and Yuqiang Zhang.

00:38:23.250 --> 00:38:24.633 Omar was a master student with me.

00:38:24.633 --> 00:38:28.170 Yuqiang was a PhD student and postdoc.

00:38:28.170 --> 00:38:31.860 Omar created this nice animation for you.

00:38:31.860 --> 00:38:34.640 This is from a satellite data set looking down

00:38:34.640 --> 00:38:38.190 in North America of PM2.5 concentration.

00:38:38.190 --> 00:38:43.190 This goes from 1998 I think it was to 2012

00:38:43.960 --> 00:38:45.270 I think that's right 2011.

00:38:46.830 --> 00:38:49.670 And we've taken steps in the United States

00:38:49.670 --> 00:38:53.210 to dramatically decrease air pollution and that's sort

00:38:53.210 --> 00:38:54.960 of actually a public health success story

00:38:54.960 --> 00:38:58.260 that hasn't been talked about quite as much as it could be.

00:38:58.260 --> 00:39:00.660 We still have a severe air pollution problem (mumbles)

00:39:00.660 --> 00:39:02.200 I'll talk about in a minute.

00:39:02.200 --> 00:39:04.295 But nonetheless, we've taken you know,

00:39:04.295 --> 00:39:07.970 it's mainly EPA regulations that have driven

00:39:09.650 --> 00:39:11.210 air pollution levels down.

00:39:11.210 --> 00:39:13.270 And the effects of that are pretty dramatic

00:39:13.270 --> 00:39:15.750 when we look at it in terms of concentrations.

00:39:15.750 --> 00:39:18.973 So we wanna look at that in terms of health as well.

00:39:19.950 --> 00:39:21.670 We're using three different data sets,

00:39:21.670 --> 00:39:22.930 they give us concentration.

00:39:22.930 --> 00:39:26.800 So one is this 21 year simulation using

00:39:26.800 --> 00:39:29.680 the CMAQ regional air quality model

00:39:29.680 --> 00:39:31.660 that was conducted at the EPA.

00:39:31.660 --> 00:39:35.110 So that's pretty unique resource we're using here.

00:39:35.110 --> 00:39:38.290 That's sort of extended here using another data set

00:39:38.290 --> 00:39:40.630 the North American Chemical Reanalysis.

00:39:40.630 --> 00:39:44.600 This is like air pollution forecast models

00:39:44.600 --> 00:39:47.563 that archive their results, and we're using them here.

00:39:48.570 --> 00:39:52.090 And then the satellite derived product that comes from

00:39:52.090 --> 00:39:55.970 Randall Martin's group, he's at the Dalhausser University

00:39:55.970 --> 00:39:58.470 in Canada, what we're using as well

00:39:58.470 --> 00:40:02.390 as we're using from the CDC county level population

00:40:02.390 --> 00:40:04.940 and baseline cause specific mortality rates

00:40:05.820 --> 00:40:07.850 to assess air pollution mortality, and each year.

00:40:07.850 --> 00:40:11.030 So we're gonna do air pollution related deaths in each year,

00:40:11.030 --> 00:40:14.210 over this whole period, using this information

00:40:14.210 --> 00:40:16.400 to also account for how population

00:40:16.400 --> 00:40:20.950 and other causes of death are changing.

00:40:20.950 --> 00:40:23.130 So the results that we get using our three different

00:40:23.130 --> 00:40:25.970 data sets all should have a pretty dramatic decrease

00:40:25.970 --> 00:40:28.720 this for PM2.5.

00:40:28.720 --> 00:40:32.090 The three different data sets over in the years they overlap

00:40:32.090 --> 00:40:34.630 disagree by quite a lot, unfortunately.

00:40:34.630 --> 00:40:36.700 And that's of course, because they're reporting

00:40:36.700 --> 00:40:39.010 different concentrations, but they all show

00:40:39.010 --> 00:40:41.710 a similar trend, okay.

00:40:41.710 --> 00:40:45.540 And that's it's itself sort of an interesting finding.

00:40:45.540 --> 00:40:49.320 Because we use this county level mortality rate, 00:40:49.320 --> 00:40:52.930 we were able to then separate out the total change in death,

00:40:52.930 --> 00:40:56.150 which is in black here with uncertainty around it,

00:40:56.150 --> 00:40:58.250 and then the deaths that would have come about

00:40:58.250 --> 00:41:00.540 from only the concentration change.

00:41:00.540 --> 00:41:05.170 If we held the population and the baseline death rate

00:41:05.170 --> 00:41:09.360 at 1990 levels, and then what the effect of population

00:41:09.360 --> 00:41:12.910 and base, of course, population is growing over this period,

00:41:12.910 --> 00:41:15.920 but fewer people are dying from heart attack and stroke,

00:41:15.920 --> 00:41:18.660 which are the things that air pollution affects.

00:41:18.660 --> 00:41:20.300 So that goes down over time.

00:41:20.300 --> 00:41:21.890 But the bigger influence is really

00:41:21.890 --> 00:41:23.760 this concentration change.

00:41:23.760 --> 00:41:26.670 So we can use this simulation to estimate

00:41:26.670 --> 00:41:30.900 that PM2.5 reductions since 1990 or so,

00:41:30.900 --> 00:41:33.640 have these decreased death in 2010,

00:41:33.640 --> 00:41:37.550 by about, this is using only the EPA data set,

00:41:37.550 --> 00:41:39.833 by about 35,000 deaths or so.

00:41:41.010 --> 00:41:46.010 Okay, we did it for ozone too, only the satellite data set

00:41:46.200 --> 00:41:47.240 doesn't apply to ozone.

00:41:47.240 --> 00:41:52.240 So we have air pollution, ozone related deaths getting worse

00:41:52.600 --> 00:41:55.760 than perhaps better, but quite a lot of year to year

00:41:55.760 --> 00:41:58.800 variability here as well, okay.

00:41:58.800 --> 00:42:03.310 And again, in this case, the baseline

00:42:03.310 --> 00:42:05.250 death rate is going up.

00:42:05.250 --> 00:42:09.143 So, without concentrations decreasing, 00:42:10.400 --> 00:42:12.300 air pollution related deaths would have gone up,

00:42:12.300 --> 00:42:15.180 but in fact, they have stayed about the same

00:42:15.180 --> 00:42:17.473 or have gone down a little bit, okay.

00:42:19.920 --> 00:42:22.670 This is my public service announcement

00:42:22.670 --> 00:42:24.133 since I have your attention.

00:42:25.060 --> 00:42:27.850 I've worked on different ways of talking about air pollution

00:42:27.850 --> 00:42:29.470 related deaths and how it's important.

00:42:29.470 --> 00:42:33.400 I use the number one in 19 deaths globally

00:42:34.500 --> 00:42:37.290 from the Global Burden of Disease Assessment.

00:42:37.290 --> 00:42:40.750 For the United States, it's about 110,000 deaths

00:42:41.650 --> 00:42:44.620 from our work about 47,000 deaths.

00:42:44.620 --> 00:42:47.510 This helps translating it to one in 25 deaths

00:42:47.510 --> 00:42:51.660 or for the United States, one in 60 or so deaths.

00:42:51.660 --> 00:42:54.330 But what I think helps more as compared against other

00:42:54.330 --> 00:42:56.270 causes of death.

00:42:56.270 --> 00:42:59.960 So in, when I talk with the public about air pollution

00:42:59.960 --> 00:43:03.970 related deaths, I try to go out of my way to say,

00:43:03.970 --> 00:43:08.040 you know, air pollution is more than all transportation

00:43:08.040 --> 00:43:10.780 accidents and all gun shootings combined.

00:43:10.780 --> 00:43:15.550 Or it's a breast cancer plus prostate cancer, okay.

00:43:15.550 --> 00:43:17.460 I think for a lot of people that gets their attention

00:43:17.460 --> 00:43:19.170 and puts it in a different light.

00:43:19.170 --> 00:43:20.830 Why is it so important?

00:43:20.830 --> 00:43:23.500 Because at the top of this list, this is just the causes

00:43:23.500 --> 00:43:27.540 of death from the CDC is heart attack and stroke,

00:43:27.540 --> 00:43:31.500 being, you know, a very large number of hundreds

00:43:31.500 --> 00:43:33.710 of thousands of deaths every year.

00:43:33.710 --> 00:43:37.070 And air pollution modifies that, air pollution affects

00:43:37.070 --> 00:43:40.180 those deaths, which means that at the end of the day,

00:43:40.180 --> 00:43:42.430 air pollution is really important here, okay.

00:43:43.880 --> 00:43:44.840 Let me skip over that.

00:43:44.840 --> 00:43:47.580 Okay, so, last question.

00:43:47.580 --> 00:43:48.910 If we slow down climate change,

00:43:48.910 --> 00:43:51.810 what are the benefits for global air pollution and health?

00:43:52.660 --> 00:43:56.000 This is known in the literature is that as CO-benefits

00:43:56.000 --> 00:44:00.290 so let’s say the world listen to

00:44:00.290 --> 00:44:03.370 the teenagers marching on the United Nations this week,

00:44:03.370 --> 00:44:07.460 right, got their act together and reduced greenhouse gas

00:44:08.810 --> 00:44:10.830 emissions to solve climate change.

00:44:10.830 --> 00:44:13.040 Many of the actions that would be taken would be

00:44:13.040 --> 00:44:14.830 to shift us away from fossil fuels.

00:44:14.830 --> 00:44:17.380 We know that fossil fuel combustion is the major source

00:44:17.380 --> 00:44:20.450 of air pollution that we care about

00:44:20.450 --> 00:44:22.040 that influences our health.

00:44:22.040 --> 00:44:25.060 So there ought to be called benefits associated with that.

00:44:25.060 --> 00:44:26.530 And there ought to be health benefits.

00:44:26.530 --> 00:44:28.960 Actually, Michelle has worked in this area too.

00:44:28.960 --> 00:44:31.080 If we look back historically at these studies,

00:44:31.080 --> 00:44:34.100 a lot of those studies were done by public health people

00:44:34.100 --> 00:44:37.470 that maybe didn’t take is a very sophisticated look

00:44:37.470 --> 00:44:39.650 at the atmospheric science part of the problem,

00:44:39.650 --> 00:44:41.290 or by economist, right?

00:44:41.290 --> 00:44:43.936 That we're motivated to understand,

00:44:43.936 --> 00:44:47.410 how big is this code benefit compared to the costs

00:44:47.410 --> 00:44:51.110 of reducing air pollution in the first place?

00:44:51.110 --> 00:44:55.580 When we take action to reduce emissions of greenhouse gases,

00:44:55.580 --> 00:44:57.360 that reduces greenhouse gases

00:44:57.360 --> 00:44:59.890 but also slows down air pollutant emissions,

00:44:59.890 --> 00:45:02.170 that's good for air pollution and human health.

00:45:02.170 --> 00:45:05.410 This is a pathway that is immediate local,

00:45:05.410 --> 00:45:09.160 but I also told you that climate change as it occurs,

00:45:09.160 --> 00:45:11.970 so in this context, we're slowing down climate change,

00:45:11.970 --> 00:45:13.940 climate change effects, air pollution.

00:45:13.940 --> 00:45:16.610 So we're slowing down that influence too.

00:45:16.610 --> 00:45:19.270 So our study was the first to look at

00:45:19.270 --> 00:45:21.270 these two different pathways,

00:45:21.270 --> 00:45:24.380 such a you could add them up together, okay.

00:45:24.380 --> 00:45:26.250 I'll show you some results of that study.

00:45:26.250 --> 00:45:29.440 So again, we're using our global atmospheric model.

00:45:29.440 --> 00:45:32.630 In this case, I've worked with a team of energy economics

00:45:32.630 --> 00:45:35.760 modelers using the what's known as the G-Cam,

00:45:35.760 --> 00:45:38.390 energy global energy economics model.

00:45:38.390 --> 00:45:41.760 So in doing this, they simulate what the future

00:45:41.760 --> 00:45:44.830 would be like under, you could say a reference case

00:45:44.830 --> 00:45:47.950 or a business as usual case without climate policy.

00:45:47.950 --> 00:45:52.730 In their model, then they apply to a global carbon tax.

00:45:52.730 --> 00:45:54.370 That was pretty aggressive, 00:45:54.370 --> 00:45:56.800 aggressive enough to really actually

00:45:56.800 --> 00:45:59.830 have a big effect of slowing down climate change.

00:45:59.830 --> 00:46:02.710 Within their model, the model is choosing the

00:46:02.710 --> 00:46:05.340 most cost effective ways of reducing greenhouse gas

00:46:05.340 --> 00:46:07.860 emissions, we were then able to see

00:46:07.860 --> 00:46:10.110 what is each of those actions have

00:46:11.280 --> 00:46:15.180 mean for air pollutant emissions,

00:46:15.180 --> 00:46:18.030 and then put that into our global atmospheric model

00:46:18.030 --> 00:46:20.640 overlay that on the global population.

00:46:20.640 --> 00:46:25.090 So these are global changes in global PM related deaths

00:46:25.090 --> 00:46:28.000 the solid lines in the reference case,

00:46:28.000 --> 00:46:29.900 and in the emission reduction case.

00:46:29.900 --> 00:46:32.970 So it's the difference between the blue and the red

00:46:32.970 --> 00:46:34.780 that is the CO-benefit.

00:46:34.780 --> 00:46:38.610 That is attributable, in this case of the climate policy.

00:46:38.610 --> 00:46:40.820 We're getting numbers that are half a million deaths

00:46:40.820 --> 00:46:42.050 or so by 2030.

00:46:42.050 --> 00:46:45.670 So immediately, we get a pretty big benefit by 2100.

00:46:45.670 --> 00:46:48.500 We're at one and a half million deaths avoided

00:46:48.500 --> 00:46:50.610 by this climate policy.

00:46:50.610 --> 00:46:54.180 For ozone, we also get by 2100, pretty big number.

00:46:54.180 --> 00:46:57.030 This is in part because the climate policy

00:46:57.030 --> 00:46:58.710 is reducing methane and I told you

00:46:58.710 --> 00:47:02.890 that methane is important for reacting to contribute

00:47:02.890 --> 00:47:05.830 to the globalism background, okay.

00:47:05.830 --> 00:47:09.540 When I put numbers, dollar signs associated with this

00:47:09.540 --> 00:47:12.810 I'm using here, red is using a high value of a life,

00:47:12.810 --> 00:47:14.780 blue is using a low value of a life

00:47:15.750 --> 00:47:19.127 looking at it in 2030, 2050, 2100,

00:47:19.127 --> 00:47:22.430 the different world regions and the global average here.

00:47:22.430 --> 00:47:25.110 So you get, you know, regions like

00:47:25.110 --> 00:47:26.520 that are densely populated,

00:47:26.520 --> 00:47:29.620 that have severe air pollution problems now,

00:47:29.620 --> 00:47:34.620 having pretty big monetize benefits that come out of this.

00:47:37.000 --> 00:47:40.980 Some regions here like Australia with a very low population,

00:47:40.980 --> 00:47:44.700 and it's gonna be the CO-benefits are gonna be much smaller.

00:47:44.700 --> 00:47:49.700 The green shows using 13 actually different

00:47:51.200 --> 00:47:53.010 global energy economics models

00:47:53.010 --> 00:47:55.190 that all ran a similar experiment,

00:47:55.190 --> 00:47:57.570 the cost of reducing emissions per time.

00:47:57.570 --> 00:48:00.960 So this is all normalized per ton of carbon dioxide.

00:48:00.960 --> 00:48:05.330 So, cost per ton, the solid line is the median

00:48:05.330 --> 00:48:08.660 of the 13 models and the dashed lines

00:48:08.660 --> 00:48:11.040 give you the full range of those models, okay.

00:48:11.040 --> 00:48:13.960 So that's shown here, the benefits outweigh

00:48:13.960 --> 00:48:15.910 the cost in 2030.

00:48:15.910 --> 00:48:19.800 Also for most world regions in the global average in 2050,

00:48:19.800 --> 00:48:23.670 by 2100, we've taken advantage of all the

00:48:23.670 --> 00:48:26.810 very cheap ways that we know about reducing

00:48:26.810 --> 00:48:29.930 greenhouse gas emissions and are moving up the cost curve.

00:48:29.930 --> 00:48:33.030 And there's quite a range of estimated costs

00:48:33.030 --> 00:48:35.440 here from this point to this point,

00:48:35.440 --> 00:48:37.500 nonetheless, the CO-benefits are still pretty

00:48:37.500 --> 00:48:39.050 comfortable with that.

00:48:39.050 --> 00:48:42.920 So, we found here then that the CO-benefits are comparable

00:48:42.920 --> 00:48:46.350 to or exceed the cost of reducing emissions

00:48:46.350 --> 00:48:49.000 in the first place apart obviously,

00:48:49.000 --> 00:48:52.420 from other benefits of slowing down climate change itself.

00:48:52.420 --> 00:48:55.600 And all the reasons that you go on to that.

00:48:55.600 --> 00:48:57.630 When we looked at the CO-benefits literature,

00:48:57.630 --> 00:49:00.550 so the the entire range of CO-benefits literature

00:49:00.550 --> 00:49:02.640 is here in yellow.

00:49:02.640 --> 00:49:05.730 Dollars per time, these are studies that were done

00:49:05.730 --> 00:49:08.560 in all kinds of using different methods over

00:49:08.560 --> 00:49:12.060 a couple of decades, in all many different world regions,

00:49:12.060 --> 00:49:15.793 but most of these studies were local, or for one country.

00:49:17.180 --> 00:49:19.650 And one of the novelties of our work,

00:49:19.650 --> 00:49:21.880 we put it into this global framework,

00:49:21.880 --> 00:49:25.080 we're now accounting for if the United States,

00:49:25.080 --> 00:49:28.260 for example, reduces emissions, that affects health

00:49:28.260 --> 00:49:30.980 in Europe, actually in Asia, because part

00:49:30.980 --> 00:49:33.930 of that air pollution reduction affects

00:49:33.930 --> 00:49:37.090 air quality elsewhere and benefits human health elsewhere,

00:49:37.090 --> 00:49:38.910 by putting this in a global framework,

00:49:38.910 --> 00:49:42.210 where accounting for all of those trans boundary

00:49:42.210 --> 00:49:44.440 and influences, okay.

00:49:44.440 --> 00:49:47.573 so that's our global CO-benefits study.

00:49:48.580 --> 00:49:51.950 Yuqiang Zhang is my PhD student then did quite a lot of work

00:49:51.950 --> 00:49:54.240 to downscale that to the United States,

00:49:54.240 --> 00:49:57.390 and I'll show you a couple of the results from that.

00:49:57.390 --> 00:49:59.250 When he did that for the United States.

00:49:59.250 --> 00:50:02.560 Again, we're similarly (mumbles) a global climate policy,

00:50:02.560 --> 00:50:05.250 but he ran a couple of experiments to separate out

00:50:05.250 --> 00:50:07.820 the effect of domestic within the United States

00:50:07.820 --> 00:50:11.020 emission reductions, right here

00:50:11.020 --> 00:50:13.860 versus what comes from foreign emission reduction.

00:50:13.860 --> 00:50:16.820 So when we look at PM2.5,

00:50:16.820 --> 00:50:19.500 most of the benefit is from domestic reductions

00:50:19.500 --> 00:50:22.250 that makes sense PM2.5 has a rather

00:50:22.250 --> 00:50:25.610 short lifetime in the atmosphere it doesn't move very far

00:50:25.610 --> 00:50:26.610 from it's source.

00:50:26.610 --> 00:50:28.890 So, most of the benefit is domestic

00:50:28.890 --> 00:50:31.370 with some influence for example, from

00:50:32.730 --> 00:50:35.000 the reductions in Mexico and Canada

00:50:35.000 --> 00:50:36.773 that effect in the United States.

00:50:37.610 --> 00:50:39.900 When we looked at the...

00:50:41.330 --> 00:50:44.680 when we looked at ozone, however, most of the emission

00:50:44.680 --> 00:50:47.160 most of the benefit actually came from

00:50:47.160 --> 00:50:49.520 actions that foreign countries took

00:50:49.520 --> 00:50:51.950 and the global reduction in methane.

00:50:51.950 --> 00:50:53.815 Okay so that was an interesting.

00:50:53.815 --> 00:50:55.500 (mumbles) Yuqiang, then looked at the

00:50:55.500 --> 00:50:59.490 health benefits associated, finding that most of the benefit

00:51:00.780 --> 00:51:04.870 for reduced PM2.5 came about

00:51:04.870 --> 00:51:07.610 from domestic reductions shown here.

00:51:07.610 --> 00:51:12.340 And most of the benefit for ozone related deaths came about

00:51:12.340 --> 00:51:14.380 from foreign reductions

00:51:14.380 --> 00:51:18.323 affecting health in the United States, great.

00:51:19.620 --> 00:51:21.140 I've covered a lot of ground today.

00:51:21.140 --> 00:51:22.630 I hope it wasn't too much for you.

00:51:22.630 --> 00:51:25.930 But I hope each of you maybe took away some nugget

00:51:25.930 --> 00:51:27.465 that you will carry with you.

00:51:27.465 --> 00:51:30.410 There was a lot of people that contributed a lot

00:51:30.410 --> 00:51:31.243 of work to this.

00:51:31.243 --> 00:51:33.410 Several graduate students over many years,

00:51:33.410 --> 00:51:36.260 I really highlighted the work of Yuqiang Zhang

00:51:36.260 --> 00:51:38.910 and Raquel Silva, over my PhD students

00:51:38.910 --> 00:51:41.220 and did a fine job doing this,

00:51:41.220 --> 00:51:43.620 and a lot of collaborators over these many studies.

00:51:43.620 --> 00:51:45.410 So thanks a lot for listening

00:51:45.410 --> 00:51:47.677 and I'm happy to take some questions.

00:51:47.677 --> 00:51:50.844 (students applauding)

00:51:57.700 --> 00:51:59.113 Yes, right here.

00:52:00.638 --> 00:52:04.560 - [Female Student] (background noise drowns out speaker)

00:52:04.560 --> 00:52:07.410 I have a question about the definition

00:52:07.410 --> 00:52:12.077 of ozone layer mortality or PM2.5, related to mortality.

00:52:13.769 --> 00:52:17.087 I mean, how do you define (faintly speaking)?

00:52:17.087 --> 00:52:18.650 - Right, so what we're doing here

00:52:18.650 --> 00:52:22.620 is we're using results of an epidemiological study

00:52:22.620 --> 00:52:27.620 that would have related PM2.5 and ozone to mortality.

00:52:28.780 --> 00:52:33.160 And then using our model, we come up with different

00:52:33.160 --> 00:52:36.570 estimates of concentration depending on the application.

00:52:36.570 --> 00:52:38.800 And then we apply that function.

00:52:38.800 --> 00:52:41.307 So it's the function, the epidemiological function

00:52:41.307 --> 00:52:43.590 and the epidemiological study.

00:52:43.590 --> 00:52:45.840 I should have made this clear up front more

00:52:45.840 --> 00:52:50.590 that relates PM2.5 and goes on with health.

00:52:50.590 --> 00:52:53.720 The studies that we're using are the big cohort studies

00:52:53.720 --> 00:52:55.950 that are from the United States, largely okay.

00:52:55.950 --> 00:52:58.823 So the American Cancer Society Study.

00:52:59.700 --> 00:53:01.800 So it's a bit of a leap of faith to say that

00:53:01.800 --> 00:53:05.260 that function applies elsewhere in the world.

00:53:05.260 --> 00:53:07.707 And we're also in some of our applications,

00:53:07.707 --> 00:53:10.420 assuming that, that function applies throughout

00:53:10.420 --> 00:53:13.400 the whole century to come, right?

00:53:13.400 --> 00:53:15.393 We don't know that that's true.

00:53:16.520 --> 00:53:19.330 And we don't know that they apply elsewhere.

00:53:19.330 --> 00:53:21.850 Now we're getting better information about

00:53:22.880 --> 00:53:25.350 air pollution related deaths in China and India

00:53:25.350 --> 00:53:29.740 and elsewhere, but still not the same quality

00:53:29.740 --> 00:53:32.560 and number of participants in the study

00:53:32.560 --> 00:53:35.420 as we have for the big cohort studies in the United States.

00:53:35.420 --> 00:53:38.660 In other words, I'm not sure what else you would assume

00:53:38.660 --> 00:53:40.650 about what happens elsewhere in the world

00:53:40.650 --> 00:53:41.950 or from the future.

00:53:41.950 --> 00:53:44.280 But we should acknowledge and I didn't say it,

00:53:44.280 --> 00:53:47.350 but I'll say it now that there's big uncertainties

00:53:47.350 --> 00:53:50.690 and assuming that those functions apply spatially

00:53:50.690 --> 00:53:53.100 and through time like that, and hopefully that helps

00:53:53.100 --> 00:53:55.350 with your question, yeah.

00:53:55.350 --> 00:53:59.140 - [Male Student] So particulate matter can be very diverse

00:53:59.140 --> 00:54:03.423 it's just size of a matter that you contain chromium six or

00:54:03.423 --> 00:54:06.060 (background noise drowns out other sounds)

00:54:06.060 --> 00:54:10.060 so how do you take that difference in the heterogeneity

00:54:10.060 --> 00:54:12.280 of this substance across different countries?

00:54:12.280 --> 00:54:13.940 Or is there a plan?

00:54:13.940 --> 00:54:15.311 Because you don't have the data, right?

00:54:15.311 --> 00:54:16.310 You have (faintly speaking).

00:54:16.310 --> 00:54:19.090 - Well, we don't have the epidemiological studies

00:54:19.090 --> 00:54:20.760 that tease out those relationships.

00:54:20.760 --> 00:54:22.600 I know Michelle is working in that area,

00:54:22.600 --> 00:54:24.643 and other people are as well.

00:54:24.643 --> 00:54:27.330 If we had that we if you know, give me a function,

00:54:27.330 --> 00:54:28.163 and I'll use it.

00:54:29.010 --> 00:54:33.440 But you know, short of that, it's a real question.

00:54:33.440 --> 00:54:35.990 And from an air pollution management point of view,

00:54:36.868 --> 00:54:39.770 you know, if we knew that it was the sulfates

00:54:39.770 --> 00:54:41.710 or it was the organic carbon,

00:54:41.710 --> 00:54:44.130 we could just regulate that rather than the mass.

00:54:44.130 --> 00:54:46.760 So the limiting factor is really actually

00:54:46.760 --> 00:54:50.343 where I started off the presentation talking.

00:54:51.350 --> 00:54:54.670 It were limited by measurements of air pollution

00:54:54.670 --> 00:54:57.420 that then could be used for epidemiology,

00:54:57.420 --> 00:54:59.210 that then could divert derive a function

00:54:59.210 --> 00:55:02.000 that then we could use for this kind of application, 00:55:02.000 --> 00:55:05.500 but, you know, we're learning more about

00:55:05.500 --> 00:55:07.620 using those different measurements and now becoming

00:55:07.620 --> 00:55:10.750 more creative combining satellites, you could use a model,

00:55:10.750 --> 00:55:14.390 for example, to estimate the contributions

00:55:14.390 --> 00:55:17.080 of different emission sources

00:55:17.080 --> 00:55:18.610 or different chemical components

00:55:18.610 --> 00:55:21.960 to an air pollution mixture, and then do epidemiology

00:55:21.960 --> 00:55:23.780 based on the model, right?

00:55:23.780 --> 00:55:28.010 Okay, so we're coming up with a lot of new and creative ways

00:55:28.010 --> 00:55:30.660 of approaching that question, but yet great question.

00:55:33.040 --> 00:55:34.073 Yes, please.

00:55:36.080 --> 00:55:38.420 - [Male Voice] I have a question about the,

00:55:38.420 --> 00:55:39.850 about your model versus the

00:55:39.850 --> 00:55:42.470 Global Burden of Disease model currently.

00:55:42.470 --> 00:55:45.440 So the estimates that you had for air pollution

00:55:45.440 --> 00:55:48.380 related deaths with something like 40,000

00:55:50.490 --> 00:55:52.410 versus, no...

00:55:52.410 --> 00:55:55.660 A 100,000 or so, versus by 40,000 with the

00:55:55.660 --> 00:55:57.080 Global Burden of Disease,

00:55:57.080 --> 00:56:00.350 What is the key differences in your model versus that?

00:56:00.350 --> 00:56:03.170 - Yeah, so one is the function that's used

00:56:03.170 --> 00:56:04.970 for to relate air pollution with health.

00:56:04.970 --> 00:56:07.000 The other is where we're getting exposed

00:56:07.000 --> 00:56:10.160 like concentrations from, is it from a model

00:56:10.160 --> 00:56:13.453 or from some model measurement blending.

00:56:14.830 --> 00:56:18.000 The factor of two is more than a greater difference.

00:56:18.000 --> 00:56:20.890 And we would ideally like to see (mumbles)

00:56:20.890 --> 00:56:23.160 I mean, we're really working to try to continue

00:56:23.160 --> 00:56:24.740 to tease out those differences

00:56:24.740 --> 00:56:27.180 and see if we can resolve them.

00:56:27.180 --> 00:56:30.500 I know the satellite people have now produced a new

00:56:30.500 --> 00:56:35.110 for PM2.5 the satellites have been really very important.

00:56:35.110 --> 00:56:37.960 Satellites can see ground level PM2.5,

00:56:37.960 --> 00:56:39.580 but they can't see ground with a low ozone.

00:56:39.580 --> 00:56:41.210 That's one of the important distinctions here,

00:56:41.210 --> 00:56:43.690 we didn't have the benefit of satellite

00:56:43.690 --> 00:56:45.880 providing information on ozone.

00:56:45.880 --> 00:56:47.990 And they can see it with the satellites

00:56:47.990 --> 00:56:50.750 can see it with very fine spatial resolution.

00:56:50.750 --> 00:56:54.330 So in the PM2.5 world, you know that

00:56:54.330 --> 00:56:57.640 it's actually the satellite that provides a fine spatial

00:56:57.640 --> 00:57:00.910 resolution whereas we used to fine resolution model

00:57:00.910 --> 00:57:03.900 to do that anyways, that goes beyond your question.

00:57:03.900 --> 00:57:06.220 But your question is a good one.

00:57:06.220 --> 00:57:09.550 And it troubles me that it's quite as different as it is.

00:57:09.550 --> 00:57:12.480 But, you know, I think we need to just continue

00:57:12.480 --> 00:57:13.400 to work on it.

00:57:13.400 --> 00:57:15.610 See if we can work out the differences

00:57:15.610 --> 00:57:17.210 between the different studies.

00:57:17.210 --> 00:57:20.773 - [Male Voice] So for the 2019 (faintly speaking)

00:57:20.773 --> 00:57:22.900 this model is gonna be adopted,

00:57:22.900 --> 00:57:24.357 because it is a very large change.

00:57:24.357 --> 00:57:27.080 And this is something I've noticed with other

00:57:27.080 --> 00:57:30.510 updates of the GDP numbers for the same years

00:57:30.510 --> 00:57:33.010 get updated dramatically as a result.

00:57:33.010 --> 00:57:34.210 - Yeah.

00:57:34.210 --> 00:57:35.920 - [Male Voice] And so depending on when you actually

00:57:35.920 --> 00:57:38.680 access the data, you might get pretty large

00:57:38.680 --> 00:57:42.920 in the estimates, so do you have a sense for

00:57:42.920 --> 00:57:44.803 what's gonna be done in the 2019 study?

00:57:45.860 --> 00:57:48.164 - Well, I know that I know what they're

00:57:48.164 --> 00:57:48.997 doing for concentration.

00:57:48.997 --> 00:57:51.100 So they're using a similar method for concentrations

00:57:51.100 --> 00:57:53.870 and then our ozone estimates, I mean,

00:57:53.870 --> 00:57:57.020 for PM2.5 concentrations and then our ozone estimates

00:57:57.020 --> 00:57:59.300 are gonna be used that I know well.

00:57:59.300 --> 00:58:02.560 I don't know what risk functions they're planning to use.

00:58:02.560 --> 00:58:04.100 And it's a good question.

00:58:04.100 --> 00:58:07.020 But that's, you know, they have a team of people,

00:58:07.020 --> 00:58:09.050 you know, some of the best epidemiologists in the world

00:58:09.050 --> 00:58:10.580 reviewing the literature.

00:58:10.580 --> 00:58:13.100 So I leave that up to them to use.

00:58:13.100 --> 00:58:16.650 I try to, you know, not push the envelope there

00:58:16.650 --> 00:58:20.150 our studies are pushing the envelope just by bringing

00:58:20.150 --> 00:58:22.720 different information from different fields together.

00:58:22.720 --> 00:58:25.080 That's why I (mumbles) so we gained nothing

00:58:25.080 --> 00:58:29.260 by using some epidemiological study that, you know,

00:58:29.260 --> 00:58:31.143 the people who really understand it,

00:58:32.140 --> 00:58:33.633 let them choose it, right?

00:58:34.800 --> 00:58:35.870 - [Robert] Okay, so I think we'll wrap

00:58:35.870 --> 00:58:37.150 it up, two announcements.

00:58:37.150 --> 00:58:40.440 So there's lunch in the LAPH 108.

00:58:40.440 --> 00:58:43.410 And also for students who are interested in available,

00:58:43.410 --> 00:58:45.800 Jason's gonna be having an informal discussion

00:58:45.800 --> 00:58:49.543 starting around 11:15 in room 101.

00:58:50.500 --> 00:58:52.258 So thanks again Jason. - Thank you.

00:58:52.258 --> 00:58:55.425 (students applauding)

00:58:57.847 --> 00:59:01.014 (students chattering)

00:59:21.630 --> 00:59:23.270 - Hi, I'm (speaking off mic)

00:59:23.270 --> 00:59:24.290 - Oh, hi.

00:59:24.290 --> 00:59:25.462 Thanks a lot

00:59:25.462 --> 00:59:30.462 - (faintly speaking) or maybe already know, right?

00:59:33.540 --> 00:59:35.283 - Oh, that's true.

00:59:36.180 --> 00:59:38.162 - Yeah, have you ever heard about that?

00:59:38.162 --> 00:59:43.162 - I saw (mumbles), I saw (mumbles), the day (mumbles).

00:59:43.973 --> 00:59:45.330 - There you go. (laughs)

00:59:45.330 --> 00:59:47.911 but we still need to hear (faintly speaking) (laughs).

00:59:47.911 --> 00:59:52.760 - So I wanted to ask, like do you your models initially,

00:59:52.760 --> 00:59:55.701 what sparked the question was when I saw (mumbles)

00:59:55.701 --> 00:59:57.923 one of the earlier ones your (mumbles) over.