WEBVTT

 $1 \ 00:00:00.180 \longrightarrow 00:00:01.410 < v$ Professor Chen>We're ready.</v>

2 00:00:01.410 --> 00:00:03.313 So let's get (indistinct), everybody.

3 00:00:04.161 --> 00:00:06.784 Thanks everyone, for (indistinct).

400:00:06.784 --> 00:00:10.073 It's our second (indistinct) series on (indistinct) today,

 $5\ 00:00:13.440 \longrightarrow 00:00:16.534$ and I'm very pleased today

6 00:00:16.534 --> 00:00:21.534 to be able to invite Dr. Evi Samoli for today's seminar.

7 00:00:22.380 --> 00:00:25.350 Dr. Samoli is Associate Professor

8 00:00:25.350 --> 00:00:28.410 of Epidemiology and Medical Statistics

 $9~00{:}00{:}28{.}410$ --> $00{:}00{:}32{.}160$ in the Medical School of the National and Kapodistrian,

10 00:00:32.160 --> 00:00:34.950 University of Athens in Greece.

11 00:00:34.950 --> 00:00:37.890 And Dr. Samoli's research interests

12 00:00:37.890 --> 00:00:40.350 focus on environmental epidemiology,

 $13\ 00:00:40.350 \longrightarrow 00:00:41.880$ especially the health effects

14 00:00:41.880 --> 00:00:44.422 of air pollution and climate change,

 $15\ 00:00:44.422 \longrightarrow 00:00:46.530$ and the development and application

16 $00:00:46.530 \rightarrow 00:00:49.263$ of statistical methods in related research.

17 00:00:50.130 $\rightarrow 00:00:52.020$ She has organized and participated

18 00:00:52.020 $\rightarrow 00:00:54.270$ in several statistical workshops

 $19\ 00:00:54.270 \longrightarrow 00:00:56.733$ and Greek and international conferences.

20 00:00:58.770 --> 00:00:59.880 She has been a reviewer

21 $00{:}00{:}59{.}880 \dashrightarrow 00{:}01{:}02{.}310$ and also a research committee member

22 00:01:02.310 --> 00:01:05.430 of the US Health Effects Institute,

23 00:01:05.430 --> 00:01:07.773 and also as for the WHO.

 $24\ 00:01:09.690$ --> 00:01:14.690 She recently co-chaired this year's international conference

 $25\ 00{:}01{:}15.840$ --> $00{:}01{:}20.840$ for the International Society of Environmental Epidemiology.

 $26\ 00:01:20.940 \longrightarrow 00:01:22.380$ And her talk today will be

27 00:01:22.380 --> 00:01:25.020 Air Pollution Health Effects Under Climate Change:

28 00:01:25.020 --> 00:01:28.500 A Complex Interaction with Various Pathways.

 $29\ 00:01:28.500 \longrightarrow 00:01:30.223$ So without further ado, (indistinct).

30 00:01:32.800 --> 00:01:37.170 <v ->Thank you very much for the introduction, Professor Chen.</v>

 $31\ 00:01:37.170 \longrightarrow 00:01:41.160$ It's my pleasure to share some of the results

 $32\ 00:01:41.160 \longrightarrow 00:01:42.660$ with you and your class,

33 $00{:}01{:}42.660 \dashrightarrow 00{:}01{:}44.400$ and I would like to personally thank you

 $34\ 00:01:44.400 \longrightarrow 00:01:46.263$ for the invitation for this talk.

35 00:01:47.250 --> 00:01:51.750 Because I understand it's a rather diverse audience,

36 00:01:51.750 --> 00:01:54.090 I will focus my first slides

 $37\ 00:01:54.090 \longrightarrow 00:01:56.910$ on introducing the concept of air pollution,

38 00:01:56.910 --> 00:02:00.570 because as Professor Chen mentioned,

 $39\ 00:02:00.570 \longrightarrow 00:02:03.540$ my focus is on ambient air pollution,

 $40\ 00:02:03.540$ --> 00:02:06.900 and what we know now of the health effects of air pollution,

41 $00:02:06.900 \rightarrow 00:02:09.810$ and then go deeper into how this interacts

42 00:02:09.810 \rightarrow 00:02:13.590 with the climate change health effects.

 $43\ 00:02:13.590 \longrightarrow 00:02:16.920$ Now to start with, the pollutant that we know

44 00:02:16.920 --> 00:02:20.610 has most effects on health is particulate matter

45 00:02:20.610 --> 00:02:24.673 with an aerodynamic diameter of 2.5 micrometers.

46 00:02:26.070 --> 00:02:30.513 To get you an idea of what particular matter PM 2.5 means,

 $47\ 00:02:31.350 \longrightarrow 00:02:36.000$ it's matter that is airborne in the air,

48 00:02:36.000 --> 00:02:40.620 and with small, so small as you can see from the graph here,

49 00:02:40.620 $\rightarrow 00:02:44.970$ that's smaller in fact than a red blood cell.

50 00:02:44.970 --> 00:02:48.630 So initially, we had investigated particulate matter

 $51\ 00:02:48.630$ --> 00:02:53.010 that had a diameter of 10 micrometers, so was PM 10.

 $52\ 00:02:53.010 \longrightarrow 00:02:56.190$ But the most toxic effects of particulate matter

 $53\ 00:02:56.190 \longrightarrow 00:02:58.980$ are those associated with the smaller particles

54 00:02:58.980 $\rightarrow 00:03:02.220$ which are easier to penetrate into the lung

 $55\ 00:03:02.220 \longrightarrow 00:03:04.320$ from the respiratory tract

 $56\ 00:03:04.320 \longrightarrow 00:03:07.620$ and cause (indistinct) stress and inflammation.

57 00:03:07.620 --> 00:03:09.420 Now you must consider that

58 00:03:09.420 --> 00:03:13.263 because particulate matter is matter that is airborne,

59 00:03:14.400 --> 00:03:19.230 its composition changes according to its sources,

 $60\ 00{:}03{:}19{.}230$ --> $00{:}03{:}23{.}670$ and it also attracts different kind of chemical compounds

 $61 \ 00:03:23.670 \longrightarrow 00:03:25.500$ depending on the atmosphere.

 $62\ 00{:}03{:}25{.}500$ --> $00{:}03{:}29{.}970$ So we have particles that are directly emitted from sources

 $63\ 00:03:29.970 \longrightarrow 00:03:34.620$ such as tailpipe exhaustion sources,

 $64\ 00{:}03{:}34{.}620$ --> $00{:}03{:}38{.}010$ or we have secondary particles formed in the atmosphere

 $65\ 00:03:38.010 \longrightarrow 00:03:40.113$ through chemical reactions.

 $66\ 00:03:41.400 \longrightarrow 00:03:42.960$ In this part of the slide,

 $67\ 00:03:42.960 \longrightarrow 00:03:46.890$ you can see the different figures,

 $68\ 00{:}03{:}46{.}890 \dashrightarrow 00{:}03{:}49{.}470$ the different pictures of particulate matter

 $69\ 00:03:49.470 \longrightarrow 00:03:51.450$ that has different compositions.

70 $00:03:51.450 \rightarrow 00:03:55.200$ So for example, this is a biological source

 $71\ 00:03:55.200 \longrightarrow 00:03:57.120$ of particulate matter.

 $72\ 00{:}03{:}57{.}120$ --> $00{:}04{:}00{.}510$ The one next to it, I'm not sure if you can see my cursor,

 $73\ 00:04:00.510 \longrightarrow 00:04:02.700$ is my cursor visible while...

74 00:04:02.700 --> 00:04:04.530 <v ->Yes, we can see.</v> <v ->Excellent.</v>

 $75\ 00:04:04.530 \longrightarrow 00:04:07.020$ So this one is particulate matter

76 00:04:07.020 --> 00:04:09.720 that is emitted from tailpipes.

77 00:04:09.720 --> 00:04:12.390 It's soot particulate matter.

78 00:04:12.390 --> 00:04:17.390 This is from an unknown source, and this basically is dust.

 $79\ 00:04:18.570 \longrightarrow 00:04:22.620$ So not only the size of particulate matter differs,

 $80\ 00{:}04{:}22.620$ --> $00{:}04{:}26.280$ but also the composition differs according to sources.

81 00:04:26.280 --> 00:04:29.610 Of course, when we talk about ambient air pollution,

82 00:04:29.610 --> 00:04:32.210 apart from ambient particulate matter,

 $83\ 00:04:32.210 \longrightarrow 00:04:34.560$ we are exposed to a variety of gasses,

 $84\ 00:04:34.560$ --> 00:04:39.010 of which the most common are nitrogen oxides

85 00:04:39.930 --> 00:04:44.930 and sulfur dioxide, carbon monoxide,

86 00:04:45.000 --> 00:04:47.460 and several hydrocarbons.

87 00:04:47.460 --> 00:04:48.630 Here in this slide,

 $88\ 00:04:48.630 \longrightarrow 00:04:51.570$ you can see the sources of particulate matter

 $89\ 00:04:51.570 \longrightarrow 00:04:56.570$ or gaseous pollutants from research in the UK,

 $90\ 00:04:56.640 \longrightarrow 00:04:58.860$ because you must understand

91 00:04:58.860 --> 00:05:02.310 that the main sources will differ

92 00:05:02.310 --> 00:05:05.910 according to the location, because the sources will differ.

93 00:05:05.910 \rightarrow 00:05:07.170 But in general,

 $94\ 00:05:07.170 \longrightarrow 00:05:10.814$ nitrogen oxides are mainly emitted from traffic,

95 00:05:10.814 --> 00:05:13.110 traffic related pollutants,

96 $00:05:13.110 \rightarrow 00:05:16.560$ and are emitted from tailpipe emissions,

97 00:05:16.560 --> 00:05:20.190 while particulate matter, depends on the sources,

98 00:05:20.190 --> 00:05:22.170 comes heavily from residential

99 00:05:22.170 --> 00:05:25.590 and small scale commercial combustion, as you see here.

 $100\ 00:05:25.590 \rightarrow 00:05:28.530$ But also, it may be emitted from tailpipe,

 $101\ 00:05:28.530 \longrightarrow 00:05:31.413$ or non tailpipe sources, for example,

 $102\ 00:05:32.340 \longrightarrow 00:05:34.740$ they might be dust particles in the air

 $103\ 00:05:34.740 \longrightarrow 00:05:38.280$ that come also from the brakes

 $104\ 00:05:38.280 \longrightarrow 00:05:43.280$ and the tire contact of the car into the roads.

 $105\ 00:05:45.570 \longrightarrow 00:05:47.340$ From the gaseous pollutants,

 $106\ 00:05:47.340 \longrightarrow 00:05:49.440$ the one that has received most attention

107 00:05:49.440 --> 00:05:51.360 apart from nitrogen oxide,

 $108 \ 00:05:51.360 \longrightarrow 00:05:53.370$ and the one that is most relevant

 $109\ 00:05:53.370 \longrightarrow 00:05:55.980$ with climate change is ozone.

 $110\ 00:05:55.980 \longrightarrow 00:05:58.510$ So you may be aware that ozone

111 $00:05:58.510 \rightarrow 00:06:01.770$ is in different strata of the atmosphere.

112 $00:06:01.770 \rightarrow 00:06:04.680$ When ozone is on the external atmosphere,

 $113\ 00:06:04.680 \longrightarrow 00:06:06.960$ what that is called the stratosphere,

 $114\ 00:06:06.960$ --> 00:06:10.020 is the ozone that it's good for the environment,

 $115\ 00:06:10.020 \longrightarrow 00:06:11.730$ that protects, in fact,

116 $00{:}06{:}11.730 \dashrightarrow 00{:}06{:}15.180$ Earth from the sun's ultraviolet radiation.

117 00:06:15.180 --> 00:06:19.470 But when we talk about ozone in air pollution,

118 00:06:19.470 --> 00:06:23.730 we mean the ozone that is encountered in the troposphere,

119 $00:06:23.730 \dashrightarrow 00:06:26.760$ in the lower levels of the atmosphere.

120 00:06:26.760 --> 00:06:30.930 And this, in fact, is a secondary gaseous pollutant,

121 00:06:30.930 --> 00:06:35.760 because in order to form ozone in the troposphere,

122 00:06:35.760 --> 00:06:39.420 this is formed from secondary chemical reactions

123 00:06:39.420 --> 00:06:44.420 that require nitrogen oxides emitted from traffic sources

 $124\ 00:06:45.450 \longrightarrow 00:06:47.610$ in the presence of sunlight.

 $125\ 00:06:47.610 \longrightarrow 00:06:50.310$ That is why it is heavily dependent

126 00:06:50.310 --> 00:06:51.930 on climate change scenario,

127 00:06:51.930 --> 00:06:54.960 because as we expect that the heat will increase,

128 00:06:54.960 --> 00:06:58.560 the temperature will heat because of climate change,

 $129\ 00:06:58.560 \longrightarrow 00:07:01.533$ ozone levels are also expected to increase,

130 00:07:02.580 $\rightarrow 00:07:05.430$ and I will give a small presentation

131 00:07:05.430 --> 00:07:09.630 about the known health effects of these air pollutants.

132 00:07:09.630 --> 00:07:12.420 Now in general, air pollution health effects 133 00:07:12.420 --> 00:07:16.080 are very small, (indistinct) made very small relative risks

134 $00:07:16.080 \dashrightarrow 00:07:18.483$ compared to other risk factors for health.

 $135\ 00:07:19.440$ --> 00:07:24.440 For example, we might estimate relative risks

 $136\ 00:07:24.450 \longrightarrow 00:07:27.810$ of the scale of 1.06.

137 00:07:27.810 --> 00:07:31.470 So it's a very small relative risk for human health,

138 $00:07:31.470 \rightarrow 00:07:36.000$ but if we consider the involuntary exposure

139 00:07:36.000 $\rightarrow 00:07:38.970$ of the whole population to air pollution,

 $140\ 00:07:38.970 \longrightarrow 00:07:41.730$ we understand why this is considered

141 00:07:41.730 - 00:07:45.690 a major risk factor for human health.

142 $00:07:45.690 \dashrightarrow 00:07:49.530$ And this translates also to a large number

143 $00:07:49.530 \rightarrow 00:07:51.750$ of attributable deaths.

 $144\ 00:07:51.750 \longrightarrow 00:07:53.880$ So in general, in this pyramid,

145 00:07:53.880 --> 00:07:55.950 it's a classic pyramid portraying

 $146\ 00:07:55.950 \longrightarrow 00:07:57.870$ the effects of air pollution,

147 00:07:57.870 -> 00:07:59.970 where the majority of the population

 $148\ 00:07:59.970 \longrightarrow 00:08:02.040$ is in the bottom of the pyramid,

149 $00:08:02.040 \dashrightarrow> 00:08:07.040$ and is expected to have only very minor symptoms.

 $150\ 00:08:07.860 \longrightarrow 00:08:10.323$ But as we go up to the pyramid,

 $151\ 00:08:12.150 \longrightarrow 00:08:15.510$ the severity of the effect increases,

 $152\ 00:08:15.510 \longrightarrow 00:08:17.820$ and the proportion of the population

 $153\ 00:08:17.820 \longrightarrow 00:08:20.490$ that is expected to experience

 $154\ 00:08:20.490 \longrightarrow 00:08:23.280$ these severe health effects is reduced.

 $155\ 00:08:23.280 \dashrightarrow> 00:08:28.280$ But nevertheless, because exactly the exposure is so wide,

156 00:08:28.380 --> 00:08:31.890 this is a considerable number of attributable cases,

 $157\ 00:08:31.890 \longrightarrow 00:08:34.830$ and that is why it's a very critical matter

158 00:08:34.830 --> 00:08:35.943 for public health.

159 00:08:37.590 --> 00:08:41.760 How do we estimate the health effects of air pollution?

160 00:08:41.760 --> 00:08:45.120 There are two kinds of ways to approach and investigate

 $161\ 00:08:45.120 \longrightarrow 00:08:47.160$ health effects of air pollution.

 $162\ 00:08:47.160 \longrightarrow 00:08:49.350$ One is short term health effects,

163 00:08:49.350 --> 00:08:52.260 meaning the health effects that are encountered

 $164\ 00:08:52.260 \longrightarrow 00:08:55.950$ after a few days, or at most,

165 00:08:55.950 --> 00:09:00.451 a month prior to the event that we're interested in.

 $166\ 00:09:00.451 \longrightarrow 00:09:02.430$ Or the long term health effects,

167 00:09:02.430 --> 00:09:06.150 meaning that the health effects that are attributed

168 00:09:06.150 --> 00:09:09.210 to cumulative exposure to air pollution, for example,

169 00:09:09.210 --> 00:09:13.860 to air pollution we're exposed to at our residence.

 $170\ 00:09:13.860 \longrightarrow 00:09:17.700$ And this may help, as it has been shown

171 00:09:17.700 --> 00:09:21.450 to increase the incidence of cancers,

172 00:09:21.450 --> 00:09:22.980 and particularly lung cancer.

 $173\ 00:09:22.980 \longrightarrow 00:09:26.730$ So there's those two ways of effects,

 $174\ 00:09:26.730 \longrightarrow 00:09:29.010$ either short or long-term effects.

175 00:09:29.010 --> 00:09:31.650 But nevertheless, as you may imagine,

 $176\ 00:09:31.650 \longrightarrow 00:09:34.620$ there's a continuing, continuing, excuse me,

 $177\ 00:09:34.620 \longrightarrow 00:09:37.770$ between short and long term health effects,

 $178\ 00:09:37.770 \longrightarrow 00:09:41.580$ that it's not completely understood.

179 $00:09:41.580 \dashrightarrow 00:09:44.070$ Short term health effects are very smaller

180 00:09:44.070 --> 00:09:45.660 compared to magnitude,

181 00:09:45.660 --> 00:09:48.753 compared to longer term health effects in general.

182 00:09:50.760 --> 00:09:55.080 You may be aware of the Global Burden of Disease project,

183 $00:09:55.080 \rightarrow 00:09:59.610$ that classifies risk factor for health globally

 $184\ 00:09:59.610 \longrightarrow 00:10:03.480$ in a periodic time periods.

185 00:10:03.480 --> 00:10:06.270 Air pollution is always classified

 $186\ 00:10:06.270 \longrightarrow 00:10:09.120$ on the 10 most important risk factors

 $187\ 00:10:09.120 \longrightarrow 00:10:11.310$ for health globally,

188 00:10:11.310 --> 00:10:15.510 either if this is accounted for in number of deaths,

 $189\ 00:10:15.510 \longrightarrow 00:10:18.330$ or disability adjusted years.

 $190\ 00:10:18.330 \longrightarrow 00:10:20.160$ In the latest classification

191 00:10:20.160 --> 00:10:22.800 of the Global Burden of Disease project,

192 00:10:22.800 --> 00:10:26.610 you may see that air pollution in terms of mortality

193 00:10:26.610 \rightarrow 00:10:30.480 was classified as the fourth risk factor,

194 00:10:30.480 --> 00:10:34.260 only below high blood pressure, smoking habits,

 $195\ 00:10:34.260 \longrightarrow 00:10:38.010$ and dietary habits as well.

196 00:10:38.010 --> 00:10:39.690 And it accounted for about

 $197\ 00:10:39.690 \longrightarrow 00:10:42.933\ 6.7$ million deaths annually globally.

198 00:10:43.980 --> 00:10:47.160 Now these kinds of health effects are attributed,

199 $00{:}10{:}47.160 \dashrightarrow 00{:}10{:}51.450$ and this is what is estimated underneath these figures.

200 00:10:51.450 --> 00:10:55.860 These are health effects attributed to PM 2.5,

201 00:10:55.860 --> 00:10:59.850 as I introduced it earlier, and to ozone health effects.

 $202\ 00:10:59.850 \longrightarrow 00:11:02.220$ These are the two pollutants

203 00:11:02.220 --> 00:11:05.943 that we have the most consistent evidence on health effects.

204 00:11:06.840 --> 00:11:11.840 For PM 2.5, basically,

 $205\ 00:11:12.030 \longrightarrow 00:11:14.760$ this accounts for long term health effects,

206 00:11:14.760 --> 00:11:18.437 while for ozone, we are most certain

207 00:11:20.100 --> 00:11:22.290 about its short term lung effects,

208 00:11:22.290 --> 00:11:26.340 while the longer term health effects of ozone exposure

209 00:11:26.340 --> 00:11:28.353 are still under investigation.

 $210\ 00:11:29.250 \longrightarrow 00:11:31.770$ What kind of disease we are talking about

 $211\ 00{:}11{:}31{.}770 \dashrightarrow 00{:}11{:}35{.}670$ when we are talking about air pollution health effects?

212 00:11:35.670 --> 00:11:38.940 You can see here from the State of Global Air,

213 00:11:38.940 --> 00:11:42.090 that I urge you to visit, is a site

214 00:11:42.090 --> 00:11:44.850 that it's been sustained by the Health Effects Institute,

215 00:11:44.850 --> 00:11:47.610 and has similar figures

 $216\ 00:11:47.610 \longrightarrow 00:11:49.980$ of the levels of air pollution globally,

217 00:11:49.980 --> 00:11:52.240 or the attributable number of deaths

218 00:11:53.130 --> 00:11:56.340 attributable to PM 2.5 exposure,

219 00:11:56.340 --> 00:12:00.750 ozone exposure, or even household indoors exposure.

220 00:12:00.750 --> 00:12:05.750 So we can see that we have about 40% of COPD deaths

221 00:12:08.550 --> 00:12:11.910 attributed to PM 2.5.

222 00:12:11.910 --> 00:12:15.540 20% about from diabetes deaths

 $223\ 00:12:15.540 \longrightarrow 00:12:17.940$ are attributed to air pollution.

224 00:12:17.940 --> 00:12:20.100 20% of ischemic heart disease,

 $225\ 00:12:20.100 \longrightarrow 00:12:22.920$ or lower respiratory infections.

226 00:12:22.920 --> 00:12:27.180 About 20% of lung cancer cases are also attributed

227 00:12:27.180 --> 00:12:32.180 to ambient air pollution, and also to neonatal deaths,

228 00:12:32.550 --> 00:12:35.103 it's a similar percentage, or stroke.

229 00:12:37.500 --> 00:12:39.417 Following these severe health effects

 $230\ 00:12:39.417 \longrightarrow 00:12:41.010$ for the general population

231 00:12:41.010 --> 00:12:43.565 and the importance in public health.

232 00:12:43.565 --> 00:12:48.565 WHO releases air quality guidelines regularly,

233 00:12:48.630 --> 00:12:51.180 and in the last month,

 $234\ 00:12:51.180 \longrightarrow 00:12:56.180$ it has released the more strict guidelines,

235 00:12:56.940 --> 00:13:00.820 requiring air pollutant levels for PM 2.5

236 00:13:01.680 --> 00:13:04.770 to be less than five micrograms per cubic meter.

237 00:13:04.770 --> 00:13:07.983 This is a mean year average.

238 00:13:08.983 --> 00:13:12.750 PM 10 is a bit higher, it's 15 micrograms,

 $239\ 00:13:12.750 \longrightarrow 00:13:14.220$ the limit suggested.

240 00:13:14.220 --> 00:13:18.990 For ozone, you can see it's 60 micrograms per cubic meter.

241 00:13:18.990 --> 00:13:23.220 Ozone usually is measured in the US in parts per billion.

 $242\ 00:13:23.220 \longrightarrow 00:13:25.863$ So you may see the units in PPB.

243 00:13:26.850 --> 00:13:29.580 And the nitrogen dioxide is about

244 00:13:29.580 --> 00:13:34.560 10 micrograms per cubic meter as a annual average.

 $245\ 00:13:34.560 \longrightarrow 00:13:39.560\ 24$ daily averages are always a bit larger.

 $246\ 00:13:42.780 \longrightarrow 00:13:47.480$ Now how do this compare to the existing levels

247 00:13:47.480 --> 00:13:48.420 of air pollutants?

 $248\ 00:13:48.420 \longrightarrow 00:13:51.060$ I may assure you that both for US

 $249\ 00:13:51.060 \longrightarrow 00:13:55.770$ and the large majority of European countries,

250 00:13:55.770 --> 00:14:00.770 these are lower than the existing levels of air pollution,

 $251\ 00:14:00.780 \longrightarrow 00:14:04.110$ considering the year averages.

 $252\ 00:14:04.110 \longrightarrow 00:14:06.690$ The WHO air guidelines

 $253\ 00:14:06.690 \rightarrow 00:14:11.690$ are not legislative binding for the countries.

254 00:14:12.840 --> 00:14:16.080 They're based on protecting public health,

 $255\ 00:14:16.080 \longrightarrow 00:14:21.080$ and then the area specific authorities

 $256\ 00:14:22.470 \longrightarrow 00:14:24.360$ release their own guidelines,

257 00:14:24.360 --> 00:14:28.650 taking into account not only the interest of public health

 $258\ 00{:}14{:}28.650$ --> $00{:}14{:}31.980$ and how this is reflected in the WHO guide-lines,

25900:14:31.980 --> 00:14:34.740 but also, as you may imagine, other aspects

 $260\ 00:14:34.740 \longrightarrow 00:14:38.190$ such as the cost benefit fractions,

 $261\ 00:14:38.190 \longrightarrow 00:14:41.670$ and how would this impact the economy

262 00:14:41.670 --> 00:14:45.390 in order to lower the levels in terms of productivity,

263 00:14:45.390 --> 00:14:48.000 industry, and so on, and so on.

264 00:14:48.000 --> 00:14:53.000 So here, in this slide, you will see the limit values

 $265\ 00:14:53.160 \longrightarrow 00:14:56.940$ that are currently existing,

 $266\ 00{:}14{:}56{.}940 \dashrightarrow 00{:}15{:}00{.}240$ both in the European Commission on the left,

 $267\ 00:15:00.240 \longrightarrow 00:15:03.750$ and UN's on the right that you can see.

 $268\ 00:15:03.750 \longrightarrow 00:15:06.510$ The levels are higher than those

 $269\ 00:15:06.510 \longrightarrow 00:15:09.660$ that are proposed by the WHO.

270 00:15:09.660 --> 00:15:14.430 For example, for PM 2.5, you can see here,

271 00:15:14.430 --> 00:15:19.080 depending on the source, that EPA suggested limit values

 $272\ 00:15:19.080 \longrightarrow 00:15:21.240$ are very much higher

273 00:15:21.240 $\rightarrow 00:15:23.560$ than the five micrograms per cubic meter

274 00:15:24.450 --> 00:15:29.450 proposed by WHO, while for the same pollutant and metric

 $275\ 00:15:32.880 \longrightarrow 00:15:36.810$ in Europe, we have even larger limit values.

 $276\ 00:15:36.810 \longrightarrow 00:15:41.010$ These are the legislative binding limit values

277 00:15:41.010 --> 00:15:42.300 for the state members.

278 00:15:42.300 --> 00:15:47.040 So in Europe, for example, if we exceed this kind of limit,

279 00:15:47.040 --> 00:15:52.040 we are under fine to the European Commission.

280 00:15:53.100 --> 00:15:56.760 And nevertheless, it's clear that this is not a measure

 $281\ 00:15:56.760 \longrightarrow 00:15:58.020$ that protects public health,

 $282\ 00{:}15{:}58.020$ --> $00{:}16{:}01.620$ and it's a big pressure nowadays to lower the limits,

 $283\ 00:16:01.620 \longrightarrow 00:16:04.203$ both in US and the European Union.

 $284\ 00:16:06.120 \longrightarrow 00:16:07.980$ So coming into the interplay

 $285\ 00:16:07.980 \longrightarrow 00:16:10.500$ with climate change health effects. $286\ 00:16:10.500 \longrightarrow 00:16:14.520$ We know that the climate change health effects $287\ 00:16:14.520 \longrightarrow 00:16:17.550$ can be either direct or indirect. $288\ 00:16:17.550 \longrightarrow 00:16:20.580$ For example, we have direct health effects 289 00:16:20.580 --> 00:16:23.310 due to climate change extreme events, 290 00:16:23.310 --> 00:16:27.390 such as heat strokes under heat waves, 291 00:16:27.390 --> 00:16:31.620 or we may have fatalities in wildfires $292\ 00:16:31.620 \longrightarrow 00:16:33.750$ and similar extreme events. 293 00:16:33.750 --> 00:16:35.923 But we also have indirect health effects 294 00:16:35.923 --> 00:16:38.730 attributed to climate change, 295 00:16:38.730 --> 00:16:41.580 because climate change impacts also $296\ 00:16:41.580 \longrightarrow 00:16:45.480$ the quality of the air, $297\ 00:16:45.480 \longrightarrow 00:16:48.390$ so it worsens the levels of air pollutants. 298 00:16:48.390 --> 00:16:51.930 Hence, we have this indirect effect $299\ 00:16:51.930 \rightarrow 00:16:56.160$ from increasing the health effects of air pollution $300\ 00:16:56.160 \longrightarrow 00:16:57.843$ that I mentioned earlier. $301\ 00:16:59.010 \longrightarrow 00:17:02.100$ I will show in the later slides $302\ 00:17:02.100 \longrightarrow 00:17:06.030$ that this is a much more complex interaction $303\ 00:17:06.030$ --> 00:17:09.330 between climate change events and air pollutants. $304\ 00:17:09.330 \longrightarrow 00:17:11.520$ It also has indirect health effects, $305\ 00:17:11.520$ --> 00:17:16.520 because climate change impacts also public health services. $306\ 00:17:17.520 \longrightarrow 00:17:21.510$ So the public health sector is not ready $307\ 00:17:21.510 \longrightarrow 00:17:24.673$ to accommodate the extra events $308\ 00:17:24.673$ --> 00:17:27.210 attributed to climate change extreme events, $309\ 00:17:27.210 \longrightarrow 00:17:30.630$ but also to the entire effect that follow $310\ 00:17:30.630 \longrightarrow 00:17:32.043$ climate change events. $311\ 00:17:34.110$ --> 00:17:37.530 This comes from a report in the European Commission

312 00:17:37.530 --> 00:17:41.940 that somehow schematically illustrates what you may know,

 $313\ 00:17:41.940 \longrightarrow 00:17:45.270$ that temperature has effects on human health.

 $314\ 00:17:45.270 \longrightarrow 00:17:47.790$ We know that, for example,

315 00:17:47.790 --> 00:17:52.230 mortality occurs in low temperatures or in high temperature.

316 00:17:52.230 --> 00:17:55.980 The shape between temperature levels and health

 $317\ 00:17:55.980 \longrightarrow 00:17:58.680$ is a parabola, a U shape,

318 00:17:58.680 --> 00:18:02.190 where we see increasing events in the very low temperatures,

319 00:18:02.190 --> 00:18:05.490 as you may imagine, or the very high temperatures.

320 00:18:05.490 --> 00:18:09.227 So temperature has a direct effect on human health.

 $321\ 00:18:10.073 \longrightarrow 00:18:13.860$ And in fact, the temperature effects on health

 $322\ 00:18:13.860 \longrightarrow 00:18:15.990$ are more strong in magnitude

323 00:18:15.990 --> 00:18:20.223 than the effects of air pollution that I mentioned earlier.

324 00:18:21.450 --> 00:18:24.780 As you may see from the report of the European Commission,

 $325\ 00:18:24.780 \longrightarrow 00:18:27.510$ there's a geographical variability

326 00:18:27.510 --> 00:18:30.870 in the health effects of temperature,

 $327\ 00:18:30.870 \longrightarrow 00:18:33.930$ and generally of climate change.

 $328\ 00:18:33.930 \longrightarrow 00:18:37.500$ We have more severe effects in hotter climates,

 $329\ 00:18:37.500 \longrightarrow 00:18:40.500$ such as the southern Europe

 $330\ 00:18:40.500 \longrightarrow 00:18:42.900$ compared to the northern European countries.

331 00:18:42.900 --> 00:18:46.350 And we have also, not only geographical probability,

 $332\ 00:18:46.350 \longrightarrow 00:18:48.390$ but we have a (indistinct) effect

333 00:18:48.390 --> 00:18:52.350 depending on the subpopulation groups we are interested in.

 $334\ 00:18:52.350 \longrightarrow 00:18:56.850$ So people that are usually more sensitive

335 00:18:56.850 --> 00:19:00.480 to meteorological and air pollution health effects

336 00:19:00.480 --> 00:19:02.880 are children, pregnant women,

 $337\ 00{:}19{:}02{.}880 \dashrightarrow > 00{:}19{:}07{.}880$ and elderly citizens, or people with preexisting diseases.

338 00:19:11.640 --> 00:19:16.307 W
hy now climate change has a more complex pathway

 $339\ 00:19:17.700 \longrightarrow 00:19:20.010$ to health through air pollution?

340 00:19:20.010 --> 00:19:25.010 Because air pollution emissions also are a contributor

 $341\ 00:19:25.830 \longrightarrow 00:19:29.850$ to climate change events.

 $342\ 00:19:29.850 \longrightarrow 00:19:33.510$ So emissions increase temperature,

 $343\ 00:19:33.510 \longrightarrow 00:19:37.200$ that constitutes part of climate change,

344 00:19:37.200 --> 00:19:39.540 and this, in fact, the increase in temperature,

 $345\ 00:19:39.540 \longrightarrow 00:19:41.853$ as I mentioned in the beginning of the talk,

 $346\ 00:19:42.720 \longrightarrow 00:19:45.210$ is necessary to produce more ozone,

347 00:19:45.210 --> 00:19:49.470 that is also known to have adverse health effects

348 00:19:49.470 --> 00:19:50.970 to human health.

 $349\ 00:19:50.970 \longrightarrow 00:19:52.590$ There are also interactions

 $350\ 00:19:52.590 \longrightarrow 00:19:54.660$ between temperature and air pollution,

351 00:19:54.660 --> 00:19:58.280 meaning that we have higher effects of temperature

 $352\ 00:19:58.280 \longrightarrow 00:20:00.270$ in more polluted areas,

353 00:20:00.270 --> 00:20:04.500 or we have higher effects of air pollution in warmer areas.

354 00:20:04.500 --> 00:20:09.480 This still now have traditionally been studied separately,

 $355\ 00{:}20{:}09{.}480 \dashrightarrow 00{:}20{:}14{.}250$ but because of the complex interplay between climate change,

356 00:20:14.250 --> 00:20:18.210 and particularly temperature levels and air pollution,

 $357\ 00:20:18.210 \longrightarrow 00:20:19.740$ in the recent years,

 $358\ 00:20:19.740 \longrightarrow 00:20:23.130$ this have received increasing attention,

 $359\ 00:20:23.130 \longrightarrow 00:20:25.170$ and more publications are coming up,

360 00:20:25.170 --> 00:20:28.190 and I will just go through some main publications

 $361\ 00:20:28.190 \longrightarrow 00:20:30.723$ on the topic in the later slides.

362 00:20:31.740 --> 00:20:34.560 Apart from this interplay

363 00:20:34.560 --> 00:20:37.593 between temperature and air pollution,

 $364\ 00:20:38.580 \longrightarrow 00:20:40.530$ we know that climate change

 $365\ 00:20:40.530 \longrightarrow 00:20:44.730$ increases the occurrence of wildfires.

366 00:20:44.730 --> 00:20:48.360 Wildfires are a main source of emission

 $367\ 00:20:48.360 \longrightarrow 00:20:50.670$ of particulate matter in the air.

368 00:20:50.670 --> 00:20:52.410 For example, you may recall

369 00:20:52.410 --> 00:20:57.060 the very intense wild
fires that burnt over California,

370 00:20:57.060 --> 00:20:59.010 I think this was two years ago.

 $371\ 00:20:59.010 \longrightarrow 00:21:01.560$ The smoke reached all the way

 $372\ 00:21:01.560 \longrightarrow 00:21:03.660$ up to the east coast of the US.

 $373\ 00:21:03.660 \longrightarrow 00:21:06.630$ So we have the source of wildfires

374 00:21:06.630 --> 00:21:11.130 that not only impacts the location where wild fire occurs,

375 00:21:11.130 --> 00:21:15.600 but also depending on the wind direction and the atmosphere,

376 00:21:15.600 --> 00:21:20.600 atmospheric reaction, may also impact air quality levels

377 00:21:21.210 --> 00:21:23.493 in further distances.

 $378\ 00:21:25.020 \longrightarrow 00:21:26.580$ Further up to that,

379 00:21:26.580 --> 00:21:30.600 climate change is expected to increase drought,

 $380\ 00:21:30.600 \longrightarrow 00:21:35.490$ and also the frequency of desert dust episodes.

 $381\ 00:21:35.490 \longrightarrow 00:21:36.690$ I told you in the beginning

 $382\ 00:21:36.690 \longrightarrow 00:21:38.610$ that one source of particulate matter

383 00:21:38.610 --> 00:21:40.980 in ambient air is dust.

384 00:21:40.980 --> 00:21:44.490 So we have occurrences of desert dust transport,

385 00:21:44.490 --> 00:21:47.670 for example, in Greece, and in the southern of Europe,

 $386\ 00:21:47.670 \longrightarrow 00:21:50.730$ we have desert dust transport,

 $387\ 00:21:50.730 \rightarrow 00:21:53.820$ traditionally during spring or early summer,

388 00:21:53.820 --> 00:21:55.860 from the Sahara area.

389 00:21:55.860 --> 00:21:58.590 Depending on meteorological conditions,

390 00:21:58.590 --> 00:22:00.690 Sahara area has been shown

 $391\ 00:22:00.690 \longrightarrow 00:22:03.210$ also to reach the east coast of US sometimes.

392 $00{:}22{:}03{.}210 \dashrightarrow 00{:}22{:}06{.}420$ So these kinds of desert dust episodes

393 00:22:06.420 --> 00:22:11.420 are expected to increase both in frequency and duration.

394 00:22:12.120 --> 00:22:15.960 Apart from that, also the fact that climate change

395 00:22:15.960 --> 00:22:18.300 increases drought,

 $396\ 00:22:18.300 \longrightarrow 00:22:21.090$ we can understand that this also will increase

 $397\ 00:22:21.090 \longrightarrow 00:22:25.893$ suspended particles from dust sources.

 $398\ 00:22:28.020 \longrightarrow 00:22:31.650$ This publication is a nice figure,

399 00:22:31.650 --> 00:22:36.650 also graphically showing this direct and indirect effects

 $400\ 00:22:36.900 \longrightarrow 00:22:40.350$ between climate change and, in fact,

 $401\,00{:}22{:}40{.}350\,\text{--}{>}\,00{:}22{:}44{.}487$ the focus of this publication was cardiov ascular mortality,

402 00:22:46.410 --> 00:22:49.800 because you may know that cardiovascular mortality

403 00:22:49.800 --> 00:22:54.800 typically consists about 30 to 40% of total mortality.

 $404\ 00:22:56.160 \longrightarrow 00:22:59.640$ So we can see that from climate change

405 00:22:59.640 --> 00:23:02.880 can have a direct effect to cardiovascular...

 $406\ 00:23:02.880 \longrightarrow 00:23:06.720$ Climate change leads to extreme temperature.

407 00:23:06.720 --> 00:23:11.720 Extreme temperature may cause cardiovascular inflammation,

 $408\ 00:23:12.330 \longrightarrow 00:23:14.860$ that will lead to cardiovascular mortality

 $409\ 00:23:16.110 \longrightarrow 00:23:17.820$ through direct effect,

 $410\ 00:23:17.820 \longrightarrow 00:23:21.600$ but also through increases in the ozone levels,

411 00:23:21.600 --> 00:23:25.830 that we know has impacts on cardiovascular mortality,

 $412\ 00:23:25.830 \longrightarrow 00:23:28.773$ has an indirect weight towards there.

413 00:23:29.610 --> 00:23:31.710 As mentioned earlier, also,

414 00:23:31.710 --> 00:23:36.300 the wild
fires will increase due to climate change,

 $415\ 00:23:36.300 \longrightarrow 00:23:41.300$ and wildfires basically are causing increases

 $416\ 00:23:42.000$ --> 00:23:46.443 in the levels of nitrogen dioxide and particulate matter,

417 00:23:47.345 --> 00:23:51.840 and in a specific chemical composition of particulate matter

418 00:23:51.840 --> 00:23:53.490 that is black carbon

 $419\ 00:23:53.490 \longrightarrow 00:23:57.930$ because when solid fuel produces black carbon,

 $420\ 00:23:57.930 \longrightarrow 00:24:00.660$ which is one of the constituents,

421 00:24:00.660 --> 00:24:04.470 possible constituents of ambient particulate matter,

422 00:24:04.470 --> 00:24:06.330 that from research until now

423 00:24:06.330 --> 00:24:09.750 has been shown to be one of the most toxic components

 $424\ 00:24:09.750 \longrightarrow 00:24:11.370$ of particulate matter.

 $425\ 00{:}24{:}11{.}370 \dashrightarrow 00{:}24{:}16{.}370$ So wild fire is expected to affect cardiovascular mortality,

 $426\ 00:24:17.220 \longrightarrow 00:24:20.820$ again through the same biological pathway,

427 00:24:20.820 --> 00:24:25.560 either by increasing nitrogen dioxide particulate matter,

 $428\ 00:24:25.560 \longrightarrow 00:24:28.170$ and when nitrogen dioxide increases,

 $429\ 00:24:28.170 \longrightarrow 00:24:30.120$ because it's a necessary

430 00:24:30.120 --> 00:24:32.850 ingredient for the formation of stratospheric ozone,

431 00:24:32.850 --> 00:24:35.643 also ozone will increase.

432 00:24:38.100 --> 00:24:43.100 This is a very nice graph from a current European project

 $433\ 00:24:43.260 \longrightarrow 00:24:45.030$ we are running.

434 00:24:45.030 --> 00:24:47.340 Professor Chen is aware of this,

435 00:24:47.340 $\rightarrow 00:24:52.340$ and this has been a graphical display exactly 436 00:24:52.800 $\rightarrow 00:24:55.650$ of the impact of climate change on air pollution

 $437\ 00:24:55.650 \longrightarrow 00:24:57.690$ and related health effects,

438 00:24:57.690 --> 00:25:02.690 in order to communicate this to the general public.

439 00:25:02.790 --> 00:25:06.120 So you can see, again, that the title, I think, 440 00:25:06.120 --> 00:25:09.990 is very good for commercial and scientific reasons.

441 00:25:09.990 -> 00:25:12.330 We breathe climate change.

 $442\ 00:25:12.330 \longrightarrow 00:25:15.000$ So the impact on cardiovascular mortality

443 00:25:15.000 --> 00:25:16.800 comes from heat waves,

444 00:25:16.800 --> 00:25:20.430 tropospheric or ground level ozone particulate matter,

 $445\ 00:25:20.430 \longrightarrow 00:25:24.180$ wildfires, and then we have the health impacts,

446 00:25:24.180 --> 00:25:28.140 that especially in Europe, it has been estimated

447 00:25:28.140 --> 00:25:33.140 that air pollution may cause up to 800,000 premature deaths.

448 00:25:37.200 --> 00:25:38.433 Oops, I'm sorry.

 $449\ 00:25:40.200 \longrightarrow 00:25:43.920$ A few words, what we mean

 $450\ 00:25:43.920 \longrightarrow 00:25:46.620$ when we talk about ozone health effects.

 $451\ 00:25:46.620 \longrightarrow 00:25:49.650$ This is the results of the global study

 $452\ 00:25:49.650 \longrightarrow 00:25:53.190$ on the short term exposure to ozone,

 $453\ 00:25:53.190 \longrightarrow 00:25:56.130$ and all cause mortality.

454 00:25:56.130 --> 00:25:59.460 In the figure in the left, you may see the countries

 $455\ 00:25:59.460 \longrightarrow 00:26:04.460$ that provided data to the specific study,

 $456\ 00:26:04.620 \longrightarrow 00:26:06.387$ and here you can see per country,

 $457\ 00:26:06.387 \longrightarrow 00:26:09.930$ the number of cities that contributed to data.

458 00:26:09.930 --> 00:26:14.930 We had 188 cities from US that contributed data.

459 00:26:15.720 --> 00:26:18.120 You can see that US contributes

 $460\ 00:26:18.120 \longrightarrow 00:26:20.400$ a lot of ozone and mortality data,

461 00:26:20.400 --> 00:26:23.250 and also a lot of European cities

 $462\ 00:26:23.250 \longrightarrow 00:26:25.170$ contributed relevant data,

463 00:26:25.170 --> 00:26:29.400 and we had fewer countries in the Eastern Asia,

464 00:26:29.400 --> 00:26:34.200 a few in Asia and in Africa, and some in Australia.

465 00:26:34.200 \rightarrow 00:26:38.400 The figure shows the different levels of ozone,

 $466\ 00:26:38.400 \longrightarrow 00:26:42.510$ and here, you can see what the estimates,

 $467\ 00:26:42.510 \longrightarrow 00:26:46.350$ the relative risks in total mortality

468 00:26:46.350 --> 00:26:50.880 for a 10 micrograms per cubic meter increase in ozone.

469 $00{:}26{:}50{.}880 \dashrightarrow 00{:}26{:}54{.}780$ So this is short term health effects of ozone.

 $470\ 00:26:54.780 \longrightarrow 00:26:57.870$ It's the previous day ozone,

 $471\ 00:26:57.870 \longrightarrow 00:27:01.800$ and how this will increase the next day

 $472\ 00:27:01.800 \longrightarrow 00:27:03.990$ total mortality in the cities.

473 00:27:03.990 --> 00:27:07.860 And you can see, for example, that in the United States,

 $474\ 00:27:07.860 \longrightarrow 00:27:11.010$ the 10 micrograms increase in ozone

 $475\ 00:27:11.010 \longrightarrow 00:27:15.840$ is associated with about 0.2% increase

476 00:27:15.840 --> 00:27:17.430 in daily number of deaths.

477 00:27:17.430 --> 00:27:22.430 0.2% increase is a small increase in terms of magnitude.

478 00:27:24.120 --> 00:27:27.960 But when we translate this into number of deaths,

479 00:27:27.960 --> 00:27:32.010 you can see that this is a large number of deaths.

480 00:27:32.010 --> 00:27:37.010 For example, if ozone exceeds the guideline from WHO,

481 00:27:38.534 --> 00:27:42.930 at that point was 100 micrograms per cubic meter in the US,

 $482\ 00{:}27{:}42.930$ --> $00{:}27{:}47.930$ this was attributed to about 200 annual excess deaths

483 00:27:48.543 $\rightarrow 00:27:51.900$ attributed to ozone short term exposure.

484 00:27:51.900 --> 00:27:56.900 And this, in fact, was a 0.4% increase in total mortality.

485 00:27:57.360 --> 00:28:02.360 So about, rather, a large percent of total mortality

 $486\ 00:28:05.053 \longrightarrow 00:28:08.940$ could be attributed to ozone exposure.

487 00:28:08.940 --> 00:28:10.200 You can also see that

488 00:28:10.200 --> 00:28:13.290 depending on the area of the world analyzed,

489 00:28:13.290 $-\!>$ 00:28:15.900 the magnitude of effects differed.

490 00:28:15.900 --> 00:28:20.900 Okay, for example, in Athens, that's a smaller country,

491 00:28:22.470 --> 00:28:26.130 sorry, smaller city, because we only contributed one city

492 00:28:26.130 --> 00:28:30.660 to the analysis, compared to Los Angeles, for example,

 $493\ 00{:}28{:}30.660$ --> $00{:}28{:}35.400$ but is the estimate here, we have fewer number of deaths,

 $494\ 00:28:35.400 -> 00:28:37.743$ because we have a smaller population.

495 00:28:39.570 --> 00:28:42.870 Especially for USA, it has been estimated

496 00:28:42.870 $\rightarrow 00:28:47.100$ that one to four degrees Celsius increase

497 00:28:47.100 --> 00:28:51.210 in mean daily temperature will lead to an increase

498 00:28:51.210 --> 00:28:56.100 of ozone levels by one to five parts per billion.

499 00:28:56.100 --> 00:29:01.100 This is about 10 micrograms per cubic meter increase,

 $500\ 00:29:01.140 \longrightarrow 00:29:02.910$ and this is expected to account

501 $00:29:02.910 \rightarrow 00:29:05.940$ for tens of thousands of hospitalizations

 $502\ 00:29:05.940 \longrightarrow 00:29:10.380$ and deaths annually by 2030.

 $503\ 00:29:10.380 \longrightarrow 00:29:13.770$ It has also been an estimate,

 $504\ 00:29:13.770 \longrightarrow 00:29:16.830$ because you may recall that in 2003,

 $505\ 00:29:16.830 \longrightarrow 00:29:19.473$ we had a major heat wave in Europe,

506 00:29:21.210 --> 00:29:24.780 when a lot of excess deaths were attributed exactly

 $507\ 00:29:24.780 \longrightarrow 00:29:27.540$ to the effect of this heat wave.

 $508\ 00:29:27.540 \longrightarrow 00:29:30.420$ There was a recent study indicating

 $509\ 00:29:30.420 \longrightarrow 00:29:34.140$ that about half of these effects of these deaths

 $510\ 00:29:34.140 \longrightarrow 00:29:37.290$ could be attributed to the ozone exposure

 $511\ 00:29:37.290$ --> 00:29:42.290 that increased exactly because of this extreme heat days.

51200:29:45.450 --> 00:29:49.980 This is one of the first studies to address,

 $513\ 00:29:49.980 \longrightarrow 00:29:52.350$ is a study by Professor Chen, in fact,

 $514\ 00:29:52.350 \longrightarrow 00:29:54.000$ and it's one of the first studies

515 00:29:54.000 \rightarrow 00:29:57.153 to simultaneously assess the interaction,

516 00:29:57.153 --> 00:29:59.580 the interplay between temperature levels

 $517\ 00:29:59.580 \longrightarrow 00:30:01.560$ and air pollution levels,

 $518\ 00:30:01.560 \longrightarrow 00:30:04.430$ and their impact on the daily mortality.

519 00:30:04.430 --> 00:30:09.243 It was an analysis that incorporated data from,

520 00:30:10.170 --> 00:30:14.010 you can see, eight different areas in Europe,

 $521\ 00:30:14.010 \longrightarrow 00:30:16.770$ spanning from Finland to Greece.

522 00:30:16.770 --> 00:30:21.390 So we had cities from northern Europe,

 $523\ 00:30:21.390 \longrightarrow 00:30:24.450$ central Europe, and southern Europe,

 $524\ 00:30:24.450 \longrightarrow 00:30:28.380$ and the table below shows the results,

 $525\ 00:30:28.380 \longrightarrow 00:30:32.190$ how the air pollution health effects differ

526 00:30:32.190 --> 00:30:35.280 according to different levels of air pollution.

 $527\ 00:30:35.280 \longrightarrow 00:30:37.290$ Just to briefly mention,

 $528\ 00:30:37.290 \longrightarrow 00:30:40.800$ we have the previous day ozone health effects,

 $529\ 00:30:40.800 \longrightarrow 00:30:43.620$ the previous day PM 10 health effects,

530 00:30:43.620 --> 00:30:47.280 the previous day PM 2.5 health effects,

531 00:30:47.280 $\rightarrow 00:30:50.848$ and PNC are even smaller particles.

 $532\ 00:30:50.848 \longrightarrow 00:30:55.410$ It's a metric to study ultra fine particles,

533 00:30:55.410 \rightarrow 00:30:59.460 that are particles that have a diameter

534 00:30:59.460 --> 00:31:03.920 even smaller than 0.1 micrometer.

 $535\ 00:31:05.760 \longrightarrow 00:31:08.310$ So if you see a bit closer,

 $536\ 00:31:08.310 \longrightarrow 00:31:11.460$ the percent increase of mortality

537 00:31:11.460 --> 00:31:13.950 attributed to each pollutant

 $538\ 00:31:13.950 \longrightarrow 00:31:16.950$ depending on the levels of temperature,

 $539\ 00:31:16.950 \longrightarrow 00:31:19.680$ we can see steadily that there is a trend

 $540\ 00:31:19.680 \longrightarrow 00:31:23.550$ that we have higher effects for all air pollution,

541 00:31:23.550 --> 00:31:25.650 for all air pollutants studied

 $542\ 00:31:25.650 \longrightarrow 00:31:29.760$ when air temperature levels are higher.

543 $00:31:29.760 \rightarrow 00:31:33.153$ And the same goes for cardiovascular deaths.

 $544\ 00:31:35.280 \longrightarrow 00:31:38.040$ Following this study by Professor Chen,

 $545\ 00:31:38.040 \longrightarrow 00:31:39.930$ there have been many other studies

 $546\ 00:31:39.930 \longrightarrow 00:31:41.250$ following the same rationale,

 $547\ 00:31:41.250 \longrightarrow 00:31:43.170$ and investigating this interaction

548 00:31:43.170 $\rightarrow 00:31:45.030$ between temperature and air pollutants.

 $549\ 00:31:45.030 \longrightarrow 00:31:48.780$ And this is a nice review of several studies

550 00:31:48.780 \rightarrow 00:31:53.700 across the globe that have tried to assess

 $551~00{:}31{:}53.700$ --> $00{:}31{:}58.140$ the interaction between particles and temperature,

 $552\ 00:31:58.140 \longrightarrow 00:32:02.400$ and try to estimate future attributable events $553\ 00:32:02.400 \longrightarrow 00:32:05.370$ depending on emission scenarios,

554 00:32:05.370 --> 00:32:09.273 both for air pollution and future climatic scenarios.

555 00:32:10.830 --> 00:32:14.010 I see that we are running a bit out of time,

 $556\ 00:32:14.010 \longrightarrow 00:32:17.220$ so I will go very quickly through this.

 $557\ 00:32:17.220 \longrightarrow 00:32:18.660$ We have the slides,

 $558\ 00:32:18.660 \longrightarrow 00:32:22.110$ and you can follow up the references if needed,

 $559\ 00:32:22.110 \longrightarrow 00:32:24.780$ but depending on the area,

560 00:32:24.780 --> 00:32:28.050 you can see that we have different air pollutants

 $561\ 00:32:28.050 \longrightarrow 00:32:29.910$ that have been assessed.

562 00:32:29.910 --> 00:32:33.810 The majority of the studies assess the effects of ozone,

563 00:32:33.810 --> 00:32:36.900 and in all of them that assess the effects of ozone

 $564\ 00:32:36.900 \longrightarrow 00:32:38.610$ under different scenarios,

565 00:32:38.610 $\rightarrow 00:32:41.153$ assessed an increase in attributable cases

 $566\ 00:32:41.153 \longrightarrow 00:32:43.080$ to ozone exposure.

 $567\ 00:32:43.080 \longrightarrow 00:32:45.780$ Attributable cases to particle exposure

568 00:32:45.780 --> 00:32:48.180 depending on emissions of air pollution

 $569\ 00:32:48.180 \longrightarrow 00:32:50.100$ and climate change scenarios

 $570\ 00:32:50.100 \longrightarrow 00:32:53.010$ differed according to the study.

571 00:32:53.010 --> 00:32:56.884 We had peaks of particulate matter related deaths,

 $572\ 00:32:56.884 \longrightarrow 00:32:58.140$ then deaths stabilized,

 $573\ 00:32:58.140 \longrightarrow 00:32:59.670$ or depending on the scenario,

574 00:32:59.670 --> 00:33:04.023 this was not such a consistent pattern as was for ozone.

 $575\ 00:33:05.310 \longrightarrow 00:33:07.530$ In any case, the authors urge

576 00:33:07.530 $\rightarrow 00:33:10.980$ that future scenarios to try to account

 $577\ 00:33:10.980 \longrightarrow 00:33:14.610$ for both changes in emissions,

 $578\ 00:33:14.610 \longrightarrow 00:33:18.990$ because we have transitioned, for example,

 $579\ 00:33:18.990 \rightarrow 00:33:23.990$ from solid fuel to the electric fleet for traffic,

 $580\ 00:33:24.060 \longrightarrow 00:33:26.400$ but also to different measures

 $581\ 00:33:26.400 \longrightarrow 00:33:30.150$ that will account for different emissions

582 00:33:30.150 --> 00:33:33.690 that will change future climate change scenarios

 $583\ 00:33:33.690 \longrightarrow 00:33:35.823$ and associated temperature levels.

 $584\ 00:33:36.870 \longrightarrow 00:33:40.080$ This is a systematic review and meta-analysis

 $585\ 00:33:40.080 \longrightarrow 00:33:41.940$ trying to assess the evidence

 $586\ 00:33:41.940 \longrightarrow 00:33:44.760$ on the combined effects between air pollution,

 $587\ 00:33:44.760 \longrightarrow 00:33:47.310$ temperature, and pollen exposure.

 $588\ 00:33:47.310 \longrightarrow 00:33:49.470$ I will not go very much in depth,

 $589\ 00:33:49.470 \longrightarrow 00:33:54.470$ but this table shows a summary of the results

 $590\ 00:33:54.570 \longrightarrow 00:33:57.270$ that started all three exposures together,

591 00:33:57.270 --> 00:33:59.160 because climate change impact,

 $592\ 00:33:59.160 \longrightarrow 00:34:02.190$ my talk is focused on human health,

593 00:34:02.190 --> 00:34:06.780 but of course, climate change has impact on agriculture,

594 00:34:06.780 --> 00:34:10.620 and this is expected also to increase

595 00:34:10.620 --> 00:34:14.160 certain levels of pollen, that is also, as we know,

 $596\ 00:34:14.160 \longrightarrow 00:34:16.920$ associated with respiratory effects.

597 00:34:16.920 --> 00:34:20.910 So the authors only managed to appraise six studies

 $598\ 00:34:20.910 \longrightarrow 00:34:24.210$ that assessed the three exposures altogether,

599 00:34:24.210 --> 00:34:26.940 and depending on certain criteria

 $600\ 00:34:26.940 \longrightarrow 00:34:29.760$ of consistency of the evidence

 $601\ 00{:}34{:}29.760$ --> $00{:}34{:}33.270$ of the cumulative effect of these three exposures,

 $602\ 00{:}34{:}33{.}270$ --> $00{:}34{:}36{.}707$ concluded that overall, there was low quality

 $603\ 00:34:36.707 \rightarrow 00:34:40.980$ in the evidence to support interactive effects

 $604\ 00:34:40.980 \longrightarrow 00:34:43.710$ of all air pollutants,

 $605\ 00{:}34{:}43.710$ --> $00{:}34{:}47.250$ but there was some limited evidence for indications

 $606\ 00:34:47.250 \longrightarrow 00:34:49.083$ of interaction effects.

 $607\ 00{:}34{:}50{.}340$ --> $00{:}34{:}55{.}340$ They figured that there was a much larger literature

 $608\ 00:34:55.410 \longrightarrow 00:34:57.660$ that had assessed both heat effects

 $609\ 00:34:57.660 \rightarrow 00:35:00.000$ and air pollution simultaneously,

 $610\ 00:35:00.000 \longrightarrow 00:35:03.930$ and they managed to gather 39 studies

611 00:35:03.930 --> 00:35:07.140 that assess the interactive effects on both.

 $612\ 00:35:07.140 \longrightarrow 00:35:11.220$ And the conclusion of this systematical use

613 00:35:11.220 --> 00:35:15.480 is that, in fact, there was a moderate quality of evidence

61400:35:15.480 --> 00:35:20.480 that those response relationships in a number of studies

615 00:35:21.810 --> 00:35:25.530 was moderate, but there was sufficient evidence

 $616\ 00:35:25.530 \longrightarrow 00:35:27.690$ that there was synergistic effects

 $617\ 00:35:27.690 \longrightarrow 00:35:30.750$ between heat and air pollution exposures,

618 00:35:30.750 --> 00:35:33.603 specifically for ozone and particulate matter. 619 00:35:36.060 --> 00:35:40.380 This is a nice review on the climate change impact

 $620\ 00{:}35{:}40{.}380 \dashrightarrow 00{:}35{:}45{.}307$ on human health and a gricultural effects, productivity,

 $621\ 00:35:46.800 \longrightarrow 00:35:50.370$ and of course, the different impacts are studied $622\ 00:35:50.370 \longrightarrow 00:35:52.260$ according to different designs,

 $623\ 00:35:52.260 \longrightarrow 00:35:54.718$ and you can see that we have mainly, of course,

 $624\ 00:35:54.718$ --> 00:35:58.770 observational studies assessing the impact

625 00:35:58.770 --> 00:36:02.190 on human health, and mostly,

 $626\ 00{:}36{:}02.190$ --> $00{:}36{:}04.920$ when we talk about temperature and air pollution,

627 00:36:04.920 --> 00:36:09.060 I forgot to point out we are focusing on short term,

 $628\ 00{:}36{:}09{.}060 \dashrightarrow > 00{:}36{:}12{.}180$ because we know that temperature has a short term

 $629\ 00:36:12.180 \longrightarrow 00:36:15.180$ of human health, and in fact,

63000:36:15.180 --> 00:36:19.350 high warm temperature have a effect on health,

 $631\ 00:36:19.350 \rightarrow 00:36:21.900$ meaning have increasing hospitalizations

 $632\ 00:36:21.900 \longrightarrow 00:36:25.140$ due to cardiovascular or respiratory causes,

 $633\ 00:36:25.140 \longrightarrow 00:36:28.380$ or increase in cardiorespiratory mortality

 $634\ 00:36:28.380 \longrightarrow 00:36:30.630$ that spans from the same day

 $635\ 00:36:30.630 \longrightarrow 00:36:33.510$ up to three days later than the events,

636 00:36:33.510 --> 00:36:36.300 while the effect of the cold temperature

 $637\ 00:36:36.300 \longrightarrow 00:36:39.690$ is expected to have a much longer impact.

63800:36:39.690 --> 00:36:44.400 So we may observe hospitalization and mortality counts

 $639\ 00:36:44.400 \rightarrow 00:36:48.330$ associated with cold effects even following

640 00:36:48.330 --> 00:36:53.330 two weeks after the cold effect, the cold level observed.

 $641\ 00{:}36{:}54.360 \dashrightarrow 00{:}36{:}57.690$ So in any case, when we talk about interaction

 $642\ 00:36:57.690 \longrightarrow 00:37:00.510$ between temperature and air pollution,

643 00:37:00.510 --> 00:37:04.740 we are focusing on short term health effects of both.

64400:37:04.740 --> 00:37:09.510 And in this review, also, it pointed out several designs,

645 00:37:09.510 --> 00:37:12.330 and how this was studied both on human health

 $646\ 00:37:12.330 \longrightarrow 00:37:14.460$ and agricultural impacts,

 $647\ 00:37:14.460 \longrightarrow 00:37:17.130$ and there was this nice figure

 $648\ 00:37:17.130 \longrightarrow 00:37:19.830$ showing that temperature does modify

 $649\ 00:37:19.830 \longrightarrow 00:37:21.570$ air pollution impacts on health

650 00:37:21.570 --> 00:37:26.190 depending on the area, the pollutant studied,

 $651\ 00:37:27.300 \longrightarrow 00:37:30.123$ or the methodological parameters studied,

 $652\ 00:37:31.050$ --> 00:37:33.630 and that contributed to climate change effect,

 $653\ 00:37:33.630 \longrightarrow 00:37:35.250$ and also the vice versa,

65400:37:35.250 --> 00:37:39.213 that air pollution also modified temperature health effects.

65500:37:42.660 $\operatorname{-->}$ 00:37:47.167 I prefer to briefly show you some results.

 $656\ 00:37:50.340 \longrightarrow 00:37:54.030$ This is unpublished work, sorry about this.

657 00:37:54.030 --> 00:37:57.750 This is unpublished work for, again, a global study.

658 00:37:57.750 --> 00:38:01.560 You can see that this study includes about 500 cities

 $659\ 00:38:01.560 \longrightarrow 00:38:04.470$ spanning across the globe from 32 studies

 $660\ 00{:}38{:}04{.}470$ --> $00{:}38{:}08{.}880$ that contributed data on air pollution and temperature,

661 00:38:08.880 --> 00:38:13.380 and in fact, present results for the interaction effect

 $662\ 00:38:13.380 \longrightarrow 00:38:16.050$ between temperature and air pollution levels,

 $663\ 00{:}38{:}16.050$ --> $00{:}38{:}20.790$ the short term exposures, and the impact on total mortality.

664 00:38:20.790 --> 00:38:22.320 You can see in the graph again

665 00:38:22.320 --> 00:38:25.020 that the majority of the cities contributing data

 $666\ 00:38:25.020 \longrightarrow 00:38:27.093$ come from US and Europe,

 $667\ 00:38:27.965 \longrightarrow 00:38:29.580$ and the difference at the top

 $668\ 00:38:29.580 \longrightarrow 00:38:32.910$ is the different levels of average temperature,

669 00:38:32.910 --> 00:38:36.813 and lower is the different levels of ozone, for example.

 $670\ 00:38:38.010 \rightarrow 00:38:41.430$ To graphically quickly show you the results,

671 00:38:41.430 --> 00:38:44.490 these are the results from North, Central,

 $672\ 00:38:44.490 \longrightarrow 00:38:45.690$ and South America.

 $673\ 00:38:45.690 \longrightarrow 00:38:48.090$ So we have the PM 2.5,

 $674\ 00:38:48.090 \longrightarrow 00:38:51.570$ let's focus on the main central figure.

675 00:38:51.570 --> 00:38:54.030 It's PM 2.5 effects,

 $676\ 00:38:54.030 \longrightarrow 00:38:57.870$ or total mortality by levels of pollutant.

677 00:38:57.870 --> 00:39:01.380 So you can see again a steady trend,

678 00:39:01.380 --> 00:39:03.960 both for Canada, for example, and US,

 $679\ 00:39:03.960 \longrightarrow 00:39:07.600$ although this may not be statistically different

 $680\ 00:39:08.700 \longrightarrow 00:39:09.840$ between them.

681 00:39:09.840 --> 00:39:11.790 As temperature levels increased,

 $682\ 00:39:11.790 \longrightarrow 00:39:16.590$ the effect of PM 2.5 on mortality increases.

683 00:39:16.590 --> 00:39:20.250 This is not the pattern that is observed in Mexico

684 00:39:20.250 --> 00:39:24.810 or other areas of Latin America,

685 00:39:24.810 --> 00:39:27.540 but of course, you may consider that the number of cities

 $686\ 00:39:27.540$ --> 00:39:32.540 contributing data differs by the country shown here.

687 00:39:33.210 --> 00:39:36.420 The same patterns, pretty much,

68800:39:36.420 --> 00:39:39.990 was observed in the majority of the European cities.

689 00:39:39.990 --> 00:39:43.500 You can see here for PM 2.5 in Northern Europe,

 $690\ 00:39:43.500 \longrightarrow 00:39:47.283$ we have increasing terms in Norway,

69100:39:48.840 --> 00:39:52.410 but not a consistent pattern for other countries.

692 00:39:52.410 --> 00:39:54.570 There was a increasing trend

69300:39:54.570 --> 00:39:59.570 also for (indistinct) particles, and the levels, 69400:39:59.610 --> 00:40:03.750 the effect of ozone depending on temperature levels

 $695\ 00:40:03.750 \longrightarrow 00:40:07.443$ did not seem to vary in the European cities.

696 00:40:10.500 --> 00:40:13.740 To give you an idea in numbers,

 $697\ 00:40:13.740 \longrightarrow 00:40:17.940$ these are the overall global estimates

 $698\ 00:40:17.940 \longrightarrow 00:40:20.100$ of the health effects of the pollutants

 $699\ 00:40:20.100 \longrightarrow 00:40:22.740$ depending on the level of air pollution.

700 00:40:22.740 --> 00:40:25.710 So globally, we may see increasing effects,

701 00:40:25.710 --> 00:40:30.710 either of PM 10, PM 2.5, or ozone effects

 $702\ 00:40:31.260 \longrightarrow 00:40:32.760$ on total mortality.

703 00:40:32.760 \rightarrow 00:40:35.400 Of course, because these are global estimates

 $704\ 00:40:35.400 \longrightarrow 00:40:37.500$ of the air pollution health effects,

 $705\ 00{:}40{:}37.500 \dashrightarrow 00{:}40{:}42.500$ there is large (indistinct) in this kind of meta-analysis.

706 00:40:42.720 --> 00:40:45.360 As I mentioned earlier, indirect pathway

707 00:40:45.360 --> 00:40:48.780 between climate change and air pollution health effects

708 00:40:48.780 --> 00:40:51.360 comes from wildfires,

 $709\ 00:40:51.360 \longrightarrow 00:40:54.790$ and here is one study we had been doing

710 00:40:55.680 --> 00:40:58.560 about 20 years ago that studied the impact

 $711\ 00:40:58.560 \longrightarrow 00:41:00.960$ of forest fires on mortality,

712 00:41:00.960 --> 00:41:04.650 and how this could be associated from particulate matter.

713 00:41:04.650 --> 00:41:09.650 This is a dot diagram trying to figure out the pathway

 $714\ 00:41:10.920 \longrightarrow 00:41:13.320$ that this may have affected health.

 $715\ 00:41:13.320 \longrightarrow 00:41:15.810$ So we may have direct effect,

716 00:41:15.810 --> 00:41:18.540 direct death as an effect of forest fire,

 $717\ 00:41:18.540 \longrightarrow 00:41:22.200$ or we may have an indirect death

 $718\ 00:41:22.200 \longrightarrow 00:41:25.680$ through increases in particulate matter levels,

719 00:41:25.680 --> 00:41:28.230 or even through increases in temperature,

720 00:41:28.230 --> 00:41:32.520 because locally, the temperature levels also increase

 $721\ 00:41:32.520 \longrightarrow 00:41:33.660$ due to wildfire.

 $722\ 00{:}41{:}33.660$ --> $00{:}41{:}38.343$ So this may affect our health outcomes in multiple pathways.

 $723\ 00:41:39.540 \longrightarrow 00:41:43.140$ This figure shows the severity and occurrence

724 00:41:43.140 --> 00:41:47.347 of forest fires in the Southern Europe from 2003 to 2011.

 $725\ 00{:}41{:}48{.}540 \dashrightarrow 00{:}41{:}52{.}620$ Of course, there was variability depending on the country,

726 00:41:52.620 --> 00:41:57.620 but in general, we saw that there was not much difference

727 00:42:00.150 --> 00:42:05.150 on the effects of particles depending on forest fire days

728 00:42:05.160 --> 00:42:08.640 or non forest fire days.

 $729\ 00:42:08.640 \longrightarrow 00:42:10.830$ On smoke free days, for example,

 $730\ 00:42:10.830 \longrightarrow 00:42:15.830$ there was a 0.5% increase in total mortality,

731 00:42:16.500 --> 00:42:19.680 and on wildfire affected days,

732 00:42:19.680 --> 00:42:22.500 the increase in mortality was almost double,

733 00:42:22.500 $\rightarrow 00:42:25.710$ but it was not statistically significant,

 $734\ 00:42:25.710 \longrightarrow 00:42:27.837$ and it was a very wide (indistinct).

735 00:42:28.860 --> 00:42:30.930 But that's why I mentioned that,

 $736\ 00:42:30.930 \longrightarrow 00:42:32.850$ although the results may not be

737 00:42:32.850 --> 00:42:36.990 statistically significantly different between them,

738 00:42:36.990 --> 00:42:41.990 because we have much fewer count of wild fire affected days,

 $739\ 00:42:42.900 \longrightarrow 00:42:45.900$ we can see that in most of the cases,

 $740\ 00:42:45.900 \longrightarrow 00:42:49.263$ the impact is greater in wildfire affected days.

741 00:42:50.640 --> 00:42:52.020 I mentioned briefly

742 00:42:52.020 --> 00:42:56.130 that what solid fuel emits is black carbon,

743 00:42:56.130 --> 00:42:58.230 and I mentioned that black carbon

 $744\ 00:42:58.230 \longrightarrow 00:43:00.180$ is one of the most toxic components

745 00:43:00.180 --> 00:43:03.240 of ambient particulate matter.

746 00:43:03.240 --> 00:43:05.040 Black carbon health effects

747 $00:43:05.040 \rightarrow 00:43:06.840$ have been increasingly been studied.

748 00:43:06.840 --> 00:43:10.650 This is again from the same consortium that I showed you

 $749\ 00:43:10.650 \longrightarrow 00:43:13.170$ the paper before, from forest fires,

750 00:43:13.170 --> 00:43:17.553 that we assessed the effects of black carbon on mortality.

 $751\ 00:43:18.630 \longrightarrow 00:43:23.040$ And we can see that it had high health effects,

 $752\ 00:43:23.040 \longrightarrow 00:43:25.410$ either on the same day of exposure,

753 00:43:25.410 --> 00:43:29.550 or up to an average of three days before the events,

754 00:43:29.550 --> 00:43:31.710 both in Athens and Barcelona.

755 00:43:31.710 --> 00:43:34.290 And the effects of black carbon were much higher

756 00:43:34.290 --> 00:43:39.270 than the ones that usually are observed and attributed

757 00:43:39.270 --> 00:43:40.563 to particulate matter.

758 00:43:41.850 --> 00:43:46.850 This is another study on wild fire sourced PM 2.5,

759 00:43:49.290 $\rightarrow 00:43:51.540$ also coming from the same consortium

760 $00:43:51.540 \rightarrow 00:43:54.548$ studying short term health effects

761 $00:43:54.548 \rightarrow 00:43:56.697$ of air pollutants and temperature effects.

762 00:43:56.697 --> 00:44:00.600 And this study focused exactly on the health effects

763 00:44:00.600 --> 00:44:05.600 from PM 2.5 that was emitted from wildfire.

 $764\ 00:44:05.910 \longrightarrow 00:44:07.887$ And you can see again, the figure,

765 00:44:07.887 --> 00:44:12.887 the number of city that contributed data, sorry,

766 00:44:13.740 --> 00:44:18.740 and the level of wild
fire related PM 2.5 by city.

767 00:44:21.180 --> 00:44:25.680 They assessed the effect of wildfire PM 2.5,

768 00:44:25.680 --> 00:44:29.220 either on the same day, or up to six days before,

769 00:44:29.220 --> 00:44:30.860 or the red...

 $770\ 00:44:32.550 \longrightarrow 00:44:34.920$ The red point on the figure on the left

771 00:44:34.920 $\rightarrow 00:44:37.650$ stands for the three days moving average

 $772\ 00:44:37.650 \longrightarrow 00:44:42.650$ of the exposure to wildfire related PM 2.5.

773 $00{:}44{:}43{.}410 \dashrightarrow 00{:}44{:}46{.}710$ So in all cases, we see very high effects

 $774\ 00:44:46.710 \longrightarrow 00:44:49.920$ up to three days after the exposure,

 $775\ 00:44:49.920 \longrightarrow 00:44:52.800$ or on the average of the same

 $776\ 00:44:52.800 \longrightarrow 00:44:55.413$ and two days prior to the event.

 $777\ 00:44:56.250 \longrightarrow 00:45:01.080$ Particularly for US, there was a 0.3% increase

 $778\ 00:45:01.080 \longrightarrow 00:45:05.310$ in total mortality associated with PM 2.5

 $779\ 00:45:05.310 \longrightarrow 00:45:08.640$ that could be attributed to wildfires.

780 00:45:08.640 $\rightarrow 00:45:11.640$ And this was the same percent increase

781 00:45:11.640 --> 00:45:15.450 attributed also for cardiova
scular or respiratory mortality.

 $782\ 00:45:15.450 \longrightarrow 00:45:18.180$ Again, the magnitude on the effects

 $783\ 00{:}45{:}18.180 \dashrightarrow 00{:}45{:}21.963$ depending on the location, as you may expect, differs.

784 00:45:23.550 --> 00:45:26.840 I also mentioned briefly that we expect an increase

785 00:45:26.840 --> 00:45:31.260 in the frequency duration of desert dust episodes,

786 00:45:31.260 --> 00:45:34.140 and we know also that desert dust

 $787\ 00{:}45{:}34.140 \dashrightarrow 00{:}45{:}38.777$ may have impacts on health, and here is again a paper

788 $00:45:40.830 \rightarrow 00:45:44.650$ investigating the impact of desert dust

789 00:45:46.625 $\rightarrow 00:45:49.457$ on daily mortality in southern Europe.

790 00:45:50.520 --> 00:45:51.960 And you can see,

 $791\ 00{:}45{:}51.960 \dashrightarrow> 00{:}45{:}56.960$ because particles from desert dust are of larger diameter,

 $792\ 00{:}45{:}57.870$ --> 00:46:01.080 we assessed here the health effects of PM 10, $793\ 00{:}46{:}01.080$ --> 00:46:03.480 that are larger, as I mentioned in the beginning,

794 00:46:03.480 --> 00:46:07.800 compared to PM 2.5, and whether this could be attributed

 $795\ 00:46:07.800 \longrightarrow 00:46:09.840$ to non desert dust sources,

 $796\ 00:46:09.840 \longrightarrow 00:46:14.010$ or desert sources, excuse me.

797 00:46:14.010 --> 00:46:17.730 So in total, for example, for all cause mortality,

798 00:46:17.730 --> 00:46:21.390 an increase in PM 10 was associated

 $799\ 00:46:21.390 \longrightarrow 00:46:25.290$ with a 0.5% increase in total mortality.

800 00:46:25.290 --> 00:46:30.290 This was a bit higher, 0.55, for non desert PM 10,

 $801 \ 00:46:31.530 \longrightarrow 00:46:36.530$ and PM 10 originating from desert dust

 $802\ 00:46:37.710 \longrightarrow 00:46:41.520$ had even higher effect on total mortality,

 $803\ 00:46:41.520 \longrightarrow 00:46:44.400$ and pattern was pretty much the same

80400:46:44.400 --> 00:46:46.830 when we assessed cardiovascular mortality,

805 00:46:46.830 --> 00:46:48.300 respiratory mortality,

 $806\ 00{:}46{:}48{.}300$ --> $00{:}46{:}51{.}573$ and also there was an impact on hospital admissions.

 $807\ 00{:}46{:}52.800$ --> $00{:}46{:}56.820$ Just to close, and apologies for taking all the time.

 $808\ 00:46:56.820 \longrightarrow 00:47:00.330$ We had a major event in Athens last year

 $809\ 00:47:00.330 \longrightarrow 00:47:02.580$ that you may not be aware of,

 $810\;00{:}47{:}02.580 \dashrightarrow > 00{:}47{:}07.580$ but for our twisted mind as scientists was very intriguing,

 $811\ 00:47:09.090 \longrightarrow 00:47:12.060$ because we have a very intense heat wave

 $812\ 00:47:12.060 \longrightarrow 00:47:15.510$ that lasted more than three weeks,

 $813\ 00:47:15.510 \longrightarrow 00:47:18.030$ and after two weeks of heatwave,

 $814\ 00:47:18.030 \longrightarrow 00:47:21.720$ also a major wildfire started

 $815\ 00:47:21.720 \longrightarrow 00:47:24.270$ in the northern suburbs of Athens.

 $816\ 00:47:24.270 \longrightarrow 00:47:28.500$ So we are in the process of studying this

817 00:47:28.500 --> 00:47:32.250 on mortality in the general population of Athens.

 $818\ 00:47:32.250 \longrightarrow 00:47:36.300$ The graph shows the excess number of deaths,

819 $00{:}47{:}36{.}300 \dashrightarrow 00{:}47{:}41{.}300$ and you can see the counts in daily mean temperature

 $820\ 00:47:42.480 \longrightarrow 00:47:46.560$ in the previous years, compared to the period

 $821\ 00:47:46.560 \longrightarrow 00:47:48.870$ that the heat wave and the desert

 $822\ 00:47:48.870 \longrightarrow 00:47:52.560$ and the wildfire started in Athens,

 $823\ 00{:}47{:}52{.}560$ --> $00{:}47{:}57{.}560$ and also the average number of deaths in previous years,

 $824~00{:}47{:}57{.}870$ --> $00{:}48{:}00{.}810$ and the excess numbers of deaths during this episode,

 $825\ 00:48:00.810 \longrightarrow 00:48:02.930$ that we can see higher increases, of course,

 $826\ 00:48:02.930 \longrightarrow 00:48:05.490$ in temperature and excess deaths.

827 00:48:05.490 --> 00:48:08.730 And briefly, some very premature results.

 $828\ 00{:}48{:}08{.}730$ --> 00:48:12.600 When we try to associate the increase on mortality,

829 00:48:12.600 --> 00:48:14.010 on daily mortality

830 00:48:14.010 --> 00:48:17.430 attributed to this very intense heat wave,

831 00:48:17.430 --> 00:48:20.580 this accounted for about 20% increase.

 $832\ 00:48:20.580 \longrightarrow 00:48:21.870$ This is a huge increase.

83300:48:21.870 --> 00:48:26.870 If we consider, for example, that high temperature levels

83400:48:27.600 --> 00:48:32.600 account for about four to 5% increase in daily mortality,

835 00:48:33.102 --> 00:48:36.330 20% increase in daily mortality due to a heat wave

 $836\ 00:48:36.330 \longrightarrow 00:48:39.630$ is a very severe public health issue.

837 00:48:39.630 --> 00:48:43.590 And this even reached 70% increase in daily mortality

 $838\ 00:48:43.590 \longrightarrow 00:48:45.660$ when this intense heat wave

 $839\ 00{:}48{:}45.660$ --> $00{:}48{:}50.660$ was combined with a wild fire that lasted about a week

 $840\ 00:48:50.880 \longrightarrow 00:48:52.533$ in the outskirts of the city.

841 00:48:53.940 --> 00:48:57.780 So to conclude, and thank you for your attention,

842 00:48:57.780 --> 00:49:00.720 there seems to be synergistic and interactive effects

843 00:49:00.720 --> 00:49:03.030 between climate change variables,

 $844\ 00:49:03.030 \longrightarrow 00:49:05.670$ such as temperature and air pollution.

845 00:49:05.670 --> 00:49:08.086 There is heterogeneity on the effects,

846 00:49:08.086 --> 00:49:10.680 depending on the location we are studying,

 $847\ 00:49:10.680 \longrightarrow 00:49:12.600$ but this may be also attributed

848 00:49:12.600 --> 00:49:17.250 to a large variety of factors, also socioeconomic factors,

 $849\ 00:49:17.250 \longrightarrow 00:49:20.910$ the percent of aging of the population,

 $850\ 00:49:20.910 \longrightarrow 00:49:23.550$ and other demographic characteristics.

 $851\ 00:49:23.550 \longrightarrow 00:49:26.760$ There is a call for further research interactions

 $852\ 00:49:26.760 \longrightarrow 00:49:28.950$ between parameters of air pollution

 $853\ 00:49:28.950 \longrightarrow 00:49:30.810$ and climate change events,

854 00:49:30.810 --> 00:49:33.780 but also on the assessment of the cumulative effects

85500:49:33.780 --> 00:49:37.620 of all these environmental factors.

856 00:49:37.620 --> 00:49:38.970 And there's also a need

857 00:49:38.970 --> 00:49:42.090 to address more complex future scenarios,

 $858\ 00:49:42.090 \longrightarrow 00:49:46.380$ accounting for reduction on tailpipe emissions

 $859\ 00:49:46.380 \longrightarrow 00:49:49.950$ due to the electrification of the fleet,

860 00:49:49.950 --> 00:49:51.660 as I mentioned earlier.

861 00:49:51.660 --> 00:49:55.080 But this is also expected to account for an increase

 $862\;00{:}49{:}55{.}080 \dashrightarrow > 00{:}49{:}59{.}643$ in non tailpipe emissions, due to tire wear and brake wear.

863 00:50:00.750 --> 00:50:05.670 And we need to push through policy decisions 864 00:50:05.670 --> 00:50:08.880 to develop solutions that will effectively tackle

865 00:50:08.880 --> 00:50:12.900 both climate change and air pollution levels,

866 00:50:12.900 --> 00:50:14.920 because these seem to be

 $867\ 00:50:18.554 \longrightarrow 00:50:20.827$ undividedly interchanged between them.

868 00:50:22.410 --> 00:50:24.810 So thank you very much for your attention,

869 00:50:24.810 --> 00:50:27.510 and I would particularly like to thank my team

870 00:50:27.510 --> 00:50:29.010 in the University of Athens,

 $871\ 00{:}50{:}29.010$ --> $00{:}50{:}33.810$ and also the consortium of the EXHAUSTION research program

872 00:50:33.810 --> 00:50:35.880 at (indistinct) in Europe.

873 00:50:35.880 --> 00:50:39.330 And I will be happy to discuss any questions,

874 00:50:39.330 --> 00:50:44.313 either today, or in person in about two weeks time.

875 00:50:46.230 --> 00:50:47.213 <v Professor Chen>Thank you.</v>