1
00:00:06,389 --> 00:00:04,789
nasa's jet propulsion laboratory

2
00:00:09,110 --> 00:00:06,399
presents

3
00:00:11,110 --> 00:00:09,120
the von carmen lecture a series of talks

4
00:00:11,830 --> 00:00:11,120
by scientists and engineers who are

5
00:00:15,190 --> 00:00:11,840
exploring

6
00:00:16,049 --> 00:00:15,200
our planet our solar system and all that

7
00:00:24,390 --> 00:00:16,059
lies beyond

8
00:00:26,710 --> 00:00:24,400
[Music]

9
00:00:27,910 --> 00:00:26,720
hello and welcome to another edition of

10
00:00:30,550 --> 00:00:27,920
the 2021

11
00:00:32,310 --> 00:00:30,560
von carmen lecture series i am nikki

12
00:00:34,310 --> 00:00:32,320
weirich from jpl's office of

13
00:00:35,990 --> 00:00:34,320

communications and education

14
00:00:38,389 --> 00:00:36,000
and i will be your host for our topic

15
00:00:42,229 --> 00:00:38,399
this evening an earth day special

16
00:00:45,270 --> 00:00:42,239
science on ice what ice says about past

17
00:00:46,910 --> 00:00:45,280
present and future climate earth's ice

18
00:00:49,750 --> 00:00:46,920
is both beautiful and

19
00:00:51,590 --> 00:00:49,760
awe-inspiring ice and the melting of

20
00:00:54,069 --> 00:00:51,600
glaciers and ice sheets

21
00:00:56,549 --> 00:00:54,079
are both a predictor and an observable

22
00:00:59,110 --> 00:00:56,559
part of earth's changing climate

23
00:01:01,349 --> 00:00:59,120
using ice cores and radar technology to

24
00:01:03,590 --> 00:01:01,359
see deep into earth's ice

25
00:01:05,270 --> 00:01:03,600
scientists can learn more about our

26
00:01:08,310 --> 00:01:05,280
planet's past

27
00:01:09,030 --> 00:01:08,320
nasa jpl and caltech are working to

28
00:01:11,590 --> 00:01:09,040
understand

29
00:01:12,230 --> 00:01:11,600
more about these changes how to protect

30
00:01:15,429 --> 00:01:12,240
our earth

31
00:01:18,070 --> 00:01:15,439
and to share it with you joining us

32
00:01:19,270 --> 00:01:18,080
as co-host this evening is jocelyn

33
00:01:21,749 --> 00:01:19,280
argeta

34
00:01:23,749 --> 00:01:21,759
jocelyn is a public outreach specialist

35
00:01:25,910 --> 00:01:23,759
for nasa's earth

36
00:01:27,030 --> 00:01:25,920
where she shares stories of how nasa

37
00:01:29,830 --> 00:01:27,040
data helps us

38
00:01:32,710 --> 00:01:29,840

learn more about our home planet hi

39
00:01:35,109 --> 00:01:32,720
jocelyn thanks for joining us

40
00:01:36,149 --> 00:01:35,119
hi nikki i'm so excited for the talk

41
00:01:37,510 --> 00:01:36,159
tonight and for

42
00:01:39,510 --> 00:01:37,520
all of the questions that are being

43
00:01:41,109 --> 00:01:39,520
submitted by our viewers at home

44
00:01:43,510 --> 00:01:41,119
so as always we'd like to remind

45
00:01:45,190 --> 00:01:43,520
everyone that this is your space program

46
00:01:46,389 --> 00:01:45,200
and we want you to be involved in the

47
00:01:48,550 --> 00:01:46,399
conversation

48
00:01:50,550 --> 00:01:48,560
so please add your questions to the chat

49
00:01:51,990 --> 00:01:50,560
and our amazing social media team will

50
00:01:53,990 --> 00:01:52,000
pass them along to us

51
00:01:55,510 --> 00:01:54,000
we'll do our best to answer as many of

52
00:01:57,350 --> 00:01:55,520
your questions as possible

53
00:01:58,550 --> 00:01:57,360
but if you don't see the chat just

54
00:02:01,749 --> 00:01:58,560
refresh the page

55
00:02:03,350 --> 00:02:01,759
and it should be there awesome thank you

56
00:02:05,590 --> 00:02:03,360
so much jocelyn

57
00:02:07,350 --> 00:02:05,600
as always if we run into any technical

58
00:02:09,190 --> 00:02:07,360
difficulties or small failures

59
00:02:11,270 --> 00:02:09,200
we ask for your patience and please

60
00:02:13,589 --> 00:02:11,280
stick with us we'll get them sorted out

61
00:02:15,910 --> 00:02:13,599
as soon as we can

62
00:02:17,910 --> 00:02:15,920
our speaker this evening is dr alex

63
00:02:20,229 --> 00:02:17,920

gardner a research scientist

64
00:02:21,990 --> 00:02:20,239
at the jet propulsion laboratory he

65
00:02:24,150 --> 00:02:22,000
earned a degree in engineering from the

66
00:02:26,550 --> 00:02:24,160
university of saskatchewan

67
00:02:28,309 --> 00:02:26,560
and a phd in earth science from the

68
00:02:29,990 --> 00:02:28,319
university of alberta

69
00:02:32,869 --> 00:02:30,000
he is a contributing author to the

70
00:02:34,949 --> 00:02:32,879
united nations intergovernmental panel

71
00:02:35,990 --> 00:02:34,959
on climate change's fifth assessment

72
00:02:38,309 --> 00:02:36,000
report

73
00:02:40,229 --> 00:02:38,319
alex is a member of the nasa c-level

74
00:02:42,869 --> 00:02:40,239
change icesat-2

75
00:02:45,110 --> 00:02:42,879
nysar and grace science teams and

76
00:02:47,830 --> 00:02:45,120
studies the earth's cryosphere

77
00:02:48,869 --> 00:02:47,840
or frozen earth with a particular focus

78
00:02:51,350 --> 00:02:48,879
on glaciers

79
00:02:52,229 --> 00:02:51,360
and ice sheets and their impacts on sea

80
00:02:55,110 --> 00:02:52,239
level rise

81
00:02:58,070 --> 00:02:55,120
and water resources hi alex thanks so

82
00:03:00,070 --> 00:02:58,080
much for joining us this evening

83
00:03:02,149 --> 00:03:00,080
hey thanks so much for having me uh this

84
00:03:04,149 --> 00:03:02,159
is great

85
00:03:06,550 --> 00:03:04,159
we're so excited to have you um can you

86
00:03:07,190 --> 00:03:06,560
tell us how did you get involved in this

87
00:03:09,110 --> 00:03:07,200
research

88
00:03:11,750 --> 00:03:09,120

and let's start with image number one

89
00:03:14,790 --> 00:03:14,390
yeah so i guess i i might not have the

90
00:03:16,790 --> 00:03:14,800
most

91
00:03:18,949 --> 00:03:16,800
direct route that people would envision

92
00:03:20,229 --> 00:03:18,959
um i actually i grew up in canada that's

93
00:03:22,309 --> 00:03:20,239
why you heard all the canadian

94
00:03:23,910 --> 00:03:22,319
universities there in the intro i grew

95
00:03:25,430 --> 00:03:23,920
up on vancouver island actually very

96
00:03:27,589 --> 00:03:25,440
beautiful place

97
00:03:29,030 --> 00:03:27,599
um but you know i i grew up with my own

98
00:03:31,030 --> 00:03:29,040
challenges uh

99
00:03:32,070 --> 00:03:31,040
i my parents divorced when i was quite

100
00:03:35,350 --> 00:03:32,080
young

101
00:03:38,309 --> 00:03:35,360
and i actually i grew up with a learning

102
00:03:42,390 --> 00:03:38,319
disability so i learned to speak late

103
00:03:44,830 --> 00:03:42,400
i learned to read late and it was a big

104
00:03:47,670 --> 00:03:44,840
challenge kind of early in my childhood

105
00:03:49,509 --> 00:03:47,680
and uh i went on and

106
00:03:51,190 --> 00:03:49,519
um you know went through high school and

107
00:03:52,869 --> 00:03:51,200
and some some stuff was

108
00:03:54,949 --> 00:03:52,879
was pretty easy for me like physics and

109
00:03:56,710 --> 00:03:54,959
math but i've always struggled with uh

110
00:04:00,070 --> 00:03:56,720
with english and

111
00:04:02,149 --> 00:04:00,080
anything that involved language and i

112
00:04:03,429 --> 00:04:02,159
i guess i i didn't really have strong

113
00:04:07,350 --> 00:04:03,439

ambitions

114
00:04:09,270 --> 00:04:07,360
uh to pursue a degree um and then

115
00:04:11,670 --> 00:04:09,280
uh decided that maybe you know

116
00:04:15,190 --> 00:04:11,680
engineering would be a good fit for me

117
00:04:17,349 --> 00:04:15,200
and uh kind of in my second year of

118
00:04:18,949 --> 00:04:17,359
of engineering i kind of i realized i

119
00:04:22,230 --> 00:04:18,959
had a talent i had a talent for

120
00:04:23,830 --> 00:04:22,240
for maths and i realized that uh it was

121
00:04:26,070 --> 00:04:23,840
it was maybe something that it was a

122
00:04:27,189 --> 00:04:26,080
skill that i could really use to to help

123
00:04:29,749 --> 00:04:27,199
the world so

124
00:04:31,189 --> 00:04:29,759
i i had thought for a while of of what

125
00:04:33,189 --> 00:04:31,199
what it was that i wanted to be my

126
00:04:36,950 --> 00:04:33,199
contribution and i wasn't too sure

127
00:04:40,950 --> 00:04:36,960
so um in my second year of university i

128
00:04:41,749 --> 00:04:40,960
i um went down to south america for a

129
00:04:44,629 --> 00:04:41,759
year with my

130
00:04:46,629 --> 00:04:44,639
with my wife and we just traveled around

131
00:04:49,670 --> 00:04:46,639
and at one point i found myself

132
00:04:50,390 --> 00:04:49,680
in the tip of south america uh in a

133
00:04:55,030 --> 00:04:50,400
place called

134
00:04:57,030 --> 00:04:55,040
uh um the the plato moreno glacier

135
00:04:59,749 --> 00:04:57,040
and i watched uh the sun come up over

136
00:05:02,070 --> 00:04:59,759
this glacier and i was just in awe

137
00:05:03,510 --> 00:05:02,080
as this thing started to break up and

138
00:05:05,029 --> 00:05:03,520

cave off into the ocean and actually

139
00:05:06,230 --> 00:05:05,039
that's the image on the right there it's

140
00:05:08,550 --> 00:05:06,240
sitting in front of that i kind of had

141
00:05:11,110 --> 00:05:08,560
this epiphany that that

142
00:05:12,150 --> 00:05:11,120
this is this is so much energy and mass

143
00:05:13,749 --> 00:05:12,160
held in

144
00:05:15,670 --> 00:05:13,759
um these systems and i kind of wondered

145
00:05:17,990 --> 00:05:15,680
if anyone had ever studied it and so

146
00:05:18,950 --> 00:05:18,000
after that i i went away and i started

147
00:05:22,550 --> 00:05:18,960
to think about

148
00:05:24,150 --> 00:05:22,560
uh pursuing a postgraduate degree a phd

149
00:05:25,830 --> 00:05:24,160
and just was wondering if there's

150
00:05:27,350 --> 00:05:25,840
anybody that studied this type of stuff

151
00:05:28,469 --> 00:05:27,360
and what the impact a future climate

152
00:05:30,070 --> 00:05:28,479
might have on it

153
00:05:32,550 --> 00:05:30,080
and lo and behold there's a lot of

154
00:05:36,150 --> 00:05:32,560
people that study this and it has a real

155
00:05:39,350 --> 00:05:36,160
importance for future climate

156
00:05:40,950 --> 00:05:39,360
and that's i'm i was just gonna say

157
00:05:42,469 --> 00:05:40,960
that's an incredible start to your

158
00:05:44,629 --> 00:05:42,479
journey tell us a little bit more about

159
00:05:48,310 --> 00:05:44,639
your secondary education let's bring up

160
00:05:51,350 --> 00:05:50,790
yeah so uh i got to go to the ends of

161
00:05:54,629 --> 00:05:51,360
the earth

162
00:05:57,350 --> 00:05:54,639
for for my phd studies and so we flew up

163
00:06:00,390 --> 00:05:57,360

to a place in far northern canada

164
00:06:01,029 --> 00:06:00,400
called the devon island ice cap and it

165
00:06:03,590 --> 00:06:01,039
was

166
00:06:05,270 --> 00:06:03,600
a flight from edmonton where the

167
00:06:07,029 --> 00:06:05,280
edmonton oilers are

168
00:06:08,950 --> 00:06:07,039
up to yellowknife which is in the far

169
00:06:11,749 --> 00:06:08,960
north where ice road truckers

170
00:06:13,590 --> 00:06:11,759
starts and then we'd fly to another

171
00:06:15,909 --> 00:06:13,600
northern community which was a

172
00:06:17,670 --> 00:06:15,919
native reserve and then we'd fly to even

173
00:06:18,629 --> 00:06:17,680
another northern community which was our

174
00:06:22,150 --> 00:06:18,639
base

175
00:06:24,390 --> 00:06:22,160
fly another four hours

176
00:06:26,230 --> 00:06:24,400
um onto the ice cap and the plane would

177
00:06:26,710 --> 00:06:26,240
have skis and it would land on the ice

178
00:06:29,670 --> 00:06:26,720
and

179
00:06:30,950 --> 00:06:29,680
it was kind of a uh dancing with wolves

180
00:06:32,790 --> 00:06:30,960
moment where all the

181
00:06:34,550 --> 00:06:32,800
equipment is pushed out of the plane and

182
00:06:37,749 --> 00:06:34,560
we're just kind of left to

183
00:06:39,270 --> 00:06:37,759
set up our camp and um do science for

184
00:06:41,189 --> 00:06:39,280
for six weeks at a time doing

185
00:06:43,510 --> 00:06:41,199
shallow ice cores validating satellite

186
00:06:44,790 --> 00:06:43,520
data making gps measurements

187
00:06:46,870 --> 00:06:44,800
um and every once in a while we'd have a

188
00:06:48,309 --> 00:06:46,880

helicopter come for support so we could

189
00:06:49,670 --> 00:06:48,319
access some of the more difficult parts

190
00:06:52,150 --> 00:06:49,680
of the glacier but

191
00:06:52,950 --> 00:06:52,160
um it was it was really eye-opening to

192
00:06:54,390 --> 00:06:52,960
see

193
00:06:56,309 --> 00:06:54,400
you know how much of our planet is

194
00:06:57,670 --> 00:06:56,319
actually covered by ice so

195
00:06:59,589 --> 00:06:57,680
most people probably have never heard of

196
00:07:02,070 --> 00:06:59,599
the devon island ice cap but it's

197
00:07:03,830 --> 00:07:02,080
it's 14 000 square kilometers and it's

198
00:07:04,550 --> 00:07:03,840
not even one of the larger ice caps we

199
00:07:07,510 --> 00:07:04,560
have

200
00:07:08,950 --> 00:07:07,520
the greenland ice sheet and the

201
00:07:12,309 --> 00:07:08,960
antarctic ice sheet

202
00:07:14,710 --> 00:07:12,319
and they lock up you know almost 90

203
00:07:16,230 --> 00:07:14,720
percent of all the world's fresh water

204
00:07:17,350 --> 00:07:16,240
it's huge amounts of water stored in

205
00:07:17,749 --> 00:07:17,360
these things but we don't live near them

206
00:07:19,110 --> 00:07:17,759
so

207
00:07:21,830 --> 00:07:19,120
we don't think about them that often and

208
00:07:25,830 --> 00:07:23,589
i think we can all see from the

209
00:07:26,309 --> 00:07:25,840
beautiful images that you have displayed

210
00:07:28,390 --> 00:07:26,319
just

211
00:07:30,469 --> 00:07:28,400
how beautiful ice is and how you got

212
00:07:32,550 --> 00:07:30,479
attached to studying this but

213
00:07:33,749 --> 00:07:32,560

can you tell me why is it important to

214
00:07:37,189 --> 00:07:33,759
study ice and

215
00:07:39,909 --> 00:07:37,199
what's the motivation really to study it

216
00:07:41,270 --> 00:07:39,919
yeah so i i think for me it started off

217
00:07:44,550 --> 00:07:41,280
as a bit of a nostalgia

218
00:07:47,589 --> 00:07:44,560
and as i became more and more involved

219
00:07:49,029 --> 00:07:47,599
um and really took it on in the phd you

220
00:07:51,430 --> 00:07:49,039
realize its importance

221
00:07:52,230 --> 00:07:51,440
so uh the world has been covered by

222
00:07:53,670 --> 00:07:52,240
large

223
00:07:55,270 --> 00:07:53,680
amounts of ice in the past that have

224
00:07:57,430 --> 00:07:55,280
waxed and waned

225
00:07:58,950 --> 00:07:57,440
so much so that that when it was um

226
00:07:59,990 --> 00:07:58,960
about four degrees colder in north

227
00:08:01,510 --> 00:08:00,000
america

228
00:08:03,510 --> 00:08:01,520
uh we had what was called the laurent

229
00:08:05,189 --> 00:08:03,520
haidaishi 20 000 years ago and that ice

230
00:08:06,230 --> 00:08:05,199
sheet was so massive that it came all

231
00:08:08,869 --> 00:08:06,240
the way down

232
00:08:10,629 --> 00:08:08,879
and covered uh boston and chicago with

233
00:08:12,469 --> 00:08:10,639
about a mile of ice

234
00:08:13,990 --> 00:08:12,479
and it created cape cod and then as the

235
00:08:16,869 --> 00:08:14,000
climate warmed uh

236
00:08:18,150 --> 00:08:16,879
that that ice mass retreated and that

237
00:08:19,430 --> 00:08:18,160
actually created a land bridge at the

238
00:08:21,110 --> 00:08:19,440

time because sea levels

239
00:08:22,629 --> 00:08:21,120
had had dropped so much because there

240
00:08:24,550 --> 00:08:22,639
was so much land on ice

241
00:08:26,309 --> 00:08:24,560
and people were able to move across the

242
00:08:29,589 --> 00:08:26,319
land bridge from asia

243
00:08:30,550 --> 00:08:29,599
into north america and it impacted the

244
00:08:32,709 --> 00:08:30,560
climate

245
00:08:34,310 --> 00:08:32,719
it impacted the sea levels and it even

246
00:08:36,149 --> 00:08:34,320
impacts the rotation of the earth so

247
00:08:37,909 --> 00:08:36,159
believe it or not when you have more ice

248
00:08:39,670 --> 00:08:37,919
caps

249
00:08:41,190 --> 00:08:39,680
there's more ice at the poles you put

250
00:08:42,790 --> 00:08:41,200
more mass at the poles

251
00:08:44,630 --> 00:08:42,800
which actually causes the earth to spin

252
00:08:46,550 --> 00:08:44,640
a little faster um

253
00:08:48,310 --> 00:08:46,560
and when you lose that ice it actually

254
00:08:49,110 --> 00:08:48,320
goes kind of sloshes down towards the

255
00:08:51,509 --> 00:08:49,120
equator

256
00:08:53,509 --> 00:08:51,519
and it's kind of like a ballerina

257
00:08:54,949 --> 00:08:53,519
putting her arms out when she's spinning

258
00:08:56,870 --> 00:08:54,959
if she wants if she puts her arms out

259
00:08:58,870 --> 00:08:56,880
she puts her arms out to slow down

260
00:09:00,949 --> 00:08:58,880
and so as the ice melt it actually slows

261
00:09:03,910 --> 00:09:00,959
the rotation of the planet

262
00:09:05,590 --> 00:09:03,920
um it's shaped a lot of the landscapes

263
00:09:07,750 --> 00:09:05,600

that we see

264
00:09:09,030 --> 00:09:07,760
it's responsible for all sorts of uh

265
00:09:11,670 --> 00:09:09,040
really interesting things

266
00:09:13,350 --> 00:09:11,680
and it's one of the most vulnerable to a

267
00:09:16,070 --> 00:09:13,360
changing climate and that's because

268
00:09:17,430 --> 00:09:16,080
ice on earth resides very close to zero

269
00:09:18,949 --> 00:09:17,440
degrees celsius so

270
00:09:20,630 --> 00:09:18,959
right near the melting point so you turn

271
00:09:22,790 --> 00:09:20,640
up the thermostat just a little bit

272
00:09:24,310 --> 00:09:22,800
and a lot of things change not only that

273
00:09:26,710 --> 00:09:24,320
but they've got these amazing

274
00:09:27,750 --> 00:09:26,720
what we call feedbacks where if you push

275
00:09:30,230 --> 00:09:27,760
it a lit a lot

276
00:09:32,150 --> 00:09:30,240
it starts to run away and it has some of

277
00:09:33,990 --> 00:09:32,160
the largest feedbacks uh in the earth

278
00:09:35,350 --> 00:09:34,000
system and they're fascinating as a

279
00:09:37,030 --> 00:09:35,360
researcher to study

280
00:09:38,630 --> 00:09:37,040
and highly important in terms of what

281
00:09:41,990 --> 00:09:38,640
the societal consequences of those

282
00:09:46,150 --> 00:09:44,389
it's good to understand that uh the ice

283
00:09:47,350 --> 00:09:46,160
is important i know you wanted to walk

284
00:09:49,509 --> 00:09:47,360
us through

285
00:09:50,949 --> 00:09:49,519
video 11 so let's go ahead and pull that

286
00:09:53,030 --> 00:09:50,959
up now and you can explain a little bit

287
00:09:56,230 --> 00:09:53,040
about what's going on there

288
00:09:57,590 --> 00:09:56,240

yeah so that

289
00:10:00,230 --> 00:09:57,600
let me let me give a little bit of an

290
00:10:03,269 --> 00:10:00,240
intro before we go to to image 11 here

291
00:10:04,230 --> 00:10:03,279
um so so the ice sheets are always

292
00:10:06,550 --> 00:10:04,240
gaining mass

293
00:10:07,269 --> 00:10:06,560
and always losing mass so so since the

294
00:10:09,110 --> 00:10:07,279
dawn of time

295
00:10:11,269 --> 00:10:09,120
an ice sheet has always had snow falling

296
00:10:12,150 --> 00:10:11,279
on it and it's always had water running

297
00:10:17,670 --> 00:10:12,160
off

298
00:10:22,870 --> 00:10:20,949
when the the climate is in equilibrium

299
00:10:24,870 --> 00:10:22,880
there's always as much coming in as

300
00:10:26,550 --> 00:10:24,880
there is going out and so the geometry

301
00:10:28,069 --> 00:10:26,560
of the ice sheet stays the same and so

302
00:10:29,670 --> 00:10:28,079
it's this amazing thing

303
00:10:31,269 --> 00:10:29,680
where uh the ice sheets always in

304
00:10:32,150 --> 00:10:31,279
balance it's always putting ice into the

305
00:10:34,389 --> 00:10:32,160
ocean

306
00:10:35,910 --> 00:10:34,399
and it's always getting uh snow from

307
00:10:38,230 --> 00:10:35,920
accumulation

308
00:10:39,750 --> 00:10:38,240
but as you turn up the thermostat you

309
00:10:41,430 --> 00:10:39,760
start to move things out of equilibrium

310
00:10:43,110 --> 00:10:41,440
and two things happen so first of all

311
00:10:44,069 --> 00:10:43,120
you get what you would normally expect

312
00:10:45,990 --> 00:10:44,079
and that is

313
00:10:47,190 --> 00:10:46,000

that the water runs off into the ocean

314
00:10:48,550 --> 00:10:47,200
so you melt the surface

315
00:10:50,550 --> 00:10:48,560
the surface melts and all that water

316
00:10:51,829 --> 00:10:50,560
runs off to the ocean but the thing we

317
00:10:54,630 --> 00:10:51,839
think about a little bit less

318
00:10:56,949 --> 00:10:54,640
is the ice is moving it's dynamic and so

319
00:10:58,389 --> 00:10:56,959
the image that you see here which is

320
00:11:00,150 --> 00:10:58,399
or sorry the movie that you see here is

321
00:11:02,150 --> 00:11:00,160
absolutely spectacular

322
00:11:04,069 --> 00:11:02,160
um this is just a single calving event

323
00:11:05,750 --> 00:11:04,079
and a calving event is is that ice in

324
00:11:09,350 --> 00:11:05,760
the background that you see

325
00:11:11,110 --> 00:11:09,360
it's flowing down slowly into the ocean

326
00:11:12,470 --> 00:11:11,120
and when we talk about future sea level

327
00:11:13,430 --> 00:11:12,480
rise and future sea level rise

328
00:11:15,350 --> 00:11:13,440
uncertainty

329
00:11:16,550 --> 00:11:15,360
it's this part that we're interested in

330
00:11:17,269 --> 00:11:16,560
this part that we're most concerned

331
00:11:19,670 --> 00:11:17,279
about because

332
00:11:21,430 --> 00:11:19,680
that ice can start to slip and so in

333
00:11:23,910 --> 00:11:21,440
this image what you see is this

334
00:11:25,750 --> 00:11:23,920
massive piece of ice cave off in the

335
00:11:27,350 --> 00:11:25,760
background and that person in the tent

336
00:11:28,870 --> 00:11:27,360
they've been waiting there for days to

337
00:11:30,470 --> 00:11:28,880
capture this calving event

338
00:11:32,310 --> 00:11:30,480

and you see him come out of the tent

339
00:11:33,509 --> 00:11:32,320
just before the calving event occurs

340
00:11:34,790 --> 00:11:33,519
he's coming out because he hears the

341
00:11:36,470 --> 00:11:34,800
cracking and he's wondering what's going

342
00:11:37,829 --> 00:11:36,480
on but he doesn't see anything yet

343
00:11:39,670 --> 00:11:37,839
and then runs out with his camera to

344
00:11:41,430 --> 00:11:39,680
take pictures and that

345
00:11:43,829 --> 00:11:41,440
that's a single iceberg this happens

346
00:11:46,470 --> 00:11:43,839
quite frequently that iceberg would be

347
00:11:47,670 --> 00:11:46,480
uh almost a mile thick and probably

348
00:11:50,230 --> 00:11:47,680
about a mile and a half

349
00:11:52,389 --> 00:11:50,240
wide and when that thing caps off it

350
00:11:55,430 --> 00:11:52,399
releases so much energy

351
00:11:56,069 --> 00:11:55,440
that the seismometers in in continental

352
00:11:57,590 --> 00:11:56,079
united states

353
00:11:59,430 --> 00:11:57,600
can pick up those events so you can

354
00:12:01,430 --> 00:11:59,440
actually see the earthquakes

355
00:12:02,470 --> 00:12:01,440
that this thing generates when when that

356
00:12:05,190 --> 00:12:02,480
big calving event

357
00:12:07,269 --> 00:12:05,200
rotates off and so it's just it shows

358
00:12:11,110 --> 00:12:07,279
you how much power and mass these

359
00:12:13,750 --> 00:12:11,120
um these ice sheets are moving around

360
00:12:14,949 --> 00:12:13,760
and so i i just say one more thing and

361
00:12:16,949 --> 00:12:14,959
that is is that

362
00:12:18,230 --> 00:12:16,959
that when we see the ice sheets change

363
00:12:20,949 --> 00:12:18,240

when when that when the

364
00:12:22,310 --> 00:12:20,959
topography or the elevation or when we

365
00:12:23,829 --> 00:12:22,320
start to see changes

366
00:12:26,150 --> 00:12:23,839
what that tells us is is that the

367
00:12:28,230 --> 00:12:26,160
climate that they exist in is no longer

368
00:12:29,829 --> 00:12:28,240
in balance with them and so the ice

369
00:12:30,710 --> 00:12:29,839
sheets have to respond they have no

370
00:12:33,269 --> 00:12:30,720
choice

371
00:12:34,069 --> 00:12:33,279
and so this is where nasa comes in and

372
00:12:37,829 --> 00:12:34,079
brings in a

373
00:12:39,509 --> 00:12:37,839
large suite of tools so tell us about

374
00:12:42,949 --> 00:12:39,519
those tools what are nasa scientists

375
00:12:45,670 --> 00:12:42,959
doing to study icing climate

376
00:12:46,710 --> 00:12:45,680
yeah so nasa's doing all sorts of really

377
00:12:49,350 --> 00:12:46,720
amazing things

378
00:12:51,910 --> 00:12:49,360
um maybe we could bring up uh the first

379
00:12:54,790 --> 00:12:51,920
image of the icesat-2

380
00:12:56,389 --> 00:12:54,800
and i'll talk about that satellite so

381
00:12:56,790 --> 00:12:56,399
i'm i'm just going to nerd out here for

382
00:12:59,829 --> 00:12:56,800
a bit

383
00:13:02,389 --> 00:12:59,839
i i am not a closet nerd i am totally

384
00:13:05,269 --> 00:13:02,399
out of the closet i am 100 nerd and i

385
00:13:06,069 --> 00:13:05,279
i love this stuff and this is some of

386
00:13:09,110 --> 00:13:06,079
the coolest

387
00:13:10,790 --> 00:13:09,120
engineering uh that you know we can

388
00:13:12,310 --> 00:13:10,800

imagine so

389
00:13:14,629 --> 00:13:12,320
this instrument that you're looking at

390
00:13:17,990 --> 00:13:14,639
here is called a laser altimeter

391
00:13:19,750 --> 00:13:18,000
now it is no different than that thing

392
00:13:21,590 --> 00:13:19,760
you go by at the hardware store to tell

393
00:13:23,110 --> 00:13:21,600
you how far you are from one wall you

394
00:13:23,509 --> 00:13:23,120
know it shoots out the little infrared

395
00:13:26,550 --> 00:13:23,519
beam

396
00:13:28,629 --> 00:13:26,560
and you can measure the distance

397
00:13:30,230 --> 00:13:28,639
well this is a much more sophisticated

398
00:13:32,710 --> 00:13:30,240
version of that and so

399
00:13:33,269 --> 00:13:32,720
it has a it has a laser that laser goes

400
00:13:35,430 --> 00:13:33,279
out

401
00:13:36,949 --> 00:13:35,440
and it splits into six different beams

402
00:13:39,910 --> 00:13:36,959
when it goes through a special lens and

403
00:13:43,030 --> 00:13:39,920
those three beams land on the earth

404
00:13:45,350 --> 00:13:43,040
and it releases trillions of photons

405
00:13:49,509 --> 00:13:45,360
trillions of photons with each shot

406
00:13:52,310 --> 00:13:49,519
and it takes 10 000 shots per second

407
00:13:53,990 --> 00:13:52,320
so it's operating incredibly fast and

408
00:13:55,990 --> 00:13:54,000
each one of those shots

409
00:13:58,069 --> 00:13:56,000
lands on the surface of the earth and

410
00:14:01,189 --> 00:13:58,079
those trillions of photons scatter

411
00:14:03,910 --> 00:14:01,199
all over the place and only

412
00:14:05,509 --> 00:14:03,920
six to 12 of those photons end up

413
00:14:08,550 --> 00:14:05,519

reaching the telescope back

414
00:14:11,509 --> 00:14:08,560
on the on the spacecraft and

415
00:14:13,910 --> 00:14:11,519
it can measure it can time take each

416
00:14:14,949 --> 00:14:13,920
individual photon so the smallest quanti

417
00:14:16,949 --> 00:14:14,959
of energy

418
00:14:18,230 --> 00:14:16,959
we can now measure it bouncing off the

419
00:14:20,310 --> 00:14:18,240
surface of the earth

420
00:14:21,269 --> 00:14:20,320
and we can make incredibly precise

421
00:14:22,870 --> 00:14:21,279
measurements

422
00:14:24,710 --> 00:14:22,880
of how the surface of the earth is

423
00:14:28,230 --> 00:14:24,720
changing so for an example i'm in los

424
00:14:31,590 --> 00:14:28,240
angeles and if you were on

425
00:14:33,110 --> 00:14:31,600
standing on the sidewalk in um san diego

426
00:14:34,629 --> 00:14:33,120
which is all the way down at the mexican

427
00:14:36,230 --> 00:14:34,639
border

428
00:14:38,069 --> 00:14:36,240
i could measure whether you stepped off

429
00:14:40,990 --> 00:14:38,079
the curb or not um

430
00:14:43,110 --> 00:14:41,000
that's how powerful this thing is um

431
00:14:46,150 --> 00:14:43,120
[Music]

432
00:14:48,310 --> 00:14:46,160
so that instrument what it allows us to

433
00:14:50,150 --> 00:14:48,320
do is it allows us to see

434
00:14:52,629 --> 00:14:50,160
the shape of the ice sheet as it

435
00:14:53,990 --> 00:14:52,639
responds so we might see it growing we

436
00:14:56,550 --> 00:14:54,000
might see it shrinking

437
00:14:58,310 --> 00:14:56,560
um in response to either a warming ocean

438
00:15:00,310 --> 00:14:58,320

changes in precipitation

439
00:15:01,990 --> 00:15:00,320
or changes in warming from the

440
00:15:04,870 --> 00:15:02,000
atmosphere and so it tells us

441
00:15:06,310 --> 00:15:04,880
a huge amount about what the ice sheets

442
00:15:08,710 --> 00:15:06,320
are doing in response to

443
00:15:10,790 --> 00:15:08,720
current changes in climate and the other

444
00:15:16,069 --> 00:15:10,800
satellite i wanted to talk about

445
00:15:20,069 --> 00:15:18,310
and this one's just as fascinating this

446
00:15:22,150 --> 00:15:20,079
is a follow-on satellite meaning we've

447
00:15:25,030 --> 00:15:22,160
we've done this once before but

448
00:15:25,990 --> 00:15:25,040
um i i used to be a professor in

449
00:15:28,790 --> 00:15:26,000
massachusetts

450
00:15:31,110 --> 00:15:28,800
and i taught remote sensing which is

451
00:15:33,590 --> 00:15:31,120
basically satellite observations

452
00:15:34,949 --> 00:15:33,600
and the start of all of those textbooks

453
00:15:37,030 --> 00:15:34,959
says you know

454
00:15:39,030 --> 00:15:37,040
satellites measure some spectrum of the

455
00:15:42,310 --> 00:15:39,040
electromagnetic spectrum

456
00:15:44,629 --> 00:15:42,320
and that was true until we put up grace

457
00:15:46,710 --> 00:15:44,639
so grace is is actually measuring

458
00:15:47,990 --> 00:15:46,720
changes in the earth's gravity and so

459
00:15:50,389 --> 00:15:48,000
you know you probably learned in school

460
00:15:53,670 --> 00:15:50,399
that gravity is 9.14

461
00:15:55,269 --> 00:15:53,680
um meters per second squared well it

462
00:15:56,710 --> 00:15:55,279
actually has slight variations

463
00:15:59,269 --> 00:15:56,720

everywhere on earth

464
00:16:00,069 --> 00:15:59,279
and where there's more mass like a large

465
00:16:02,150 --> 00:16:00,079
mountain

466
00:16:03,749 --> 00:16:02,160
you know the gravitational pull is ever

467
00:16:05,910 --> 00:16:03,759
so slightly higher

468
00:16:06,790 --> 00:16:05,920
and so these satellites orbit the earth

469
00:16:08,870 --> 00:16:06,800
and as they do

470
00:16:10,710 --> 00:16:08,880
they they very precisely measure the

471
00:16:12,870 --> 00:16:10,720
distance between themselves

472
00:16:14,790 --> 00:16:12,880
down to the fraction of the thickness of

473
00:16:15,990 --> 00:16:14,800
a human hair in distance between those

474
00:16:17,670 --> 00:16:16,000
satellites

475
00:16:19,110 --> 00:16:17,680
and it goes around and it repeats these

476
00:16:20,470 --> 00:16:19,120
measurements and so we can actually see

477
00:16:22,629 --> 00:16:20,480
where the gravity is stronger and where

478
00:16:23,509 --> 00:16:22,639
the gravity is weaker but even more

479
00:16:25,590 --> 00:16:23,519
amazing

480
00:16:28,069 --> 00:16:25,600
is it can see the changes over time and

481
00:16:30,230 --> 00:16:28,079
so when it rains in california

482
00:16:31,749 --> 00:16:30,240
we can see california get heavier

483
00:16:32,949 --> 00:16:31,759
because there's all this water sitting

484
00:16:35,829 --> 00:16:32,959
on the surface

485
00:16:37,749 --> 00:16:35,839
but the biggest changes that we see are

486
00:16:39,670 --> 00:16:37,759
the ice sheets the ice sheets are

487
00:16:42,310 --> 00:16:39,680
rapidly losing mass into the oceans and

488
00:16:43,990 --> 00:16:42,320

so we can see that in incredible detail

489
00:16:45,430 --> 00:16:44,000
on a monthly resolution so we can

490
00:16:47,829 --> 00:16:45,440
actually see these things gain

491
00:16:50,230 --> 00:16:47,839
mass in the winter and then lose a whole

492
00:16:53,030 --> 00:16:50,240
lot of ice in the summer

493
00:16:53,350 --> 00:16:53,040
and um it's it's just it's fascinating

494
00:16:56,790 --> 00:16:53,360
the

495
00:17:01,509 --> 00:16:56,800
don't think

496
00:17:05,429 --> 00:17:03,590
it really is a miracle of engineering

497
00:17:06,949 --> 00:17:05,439
and you know nasa's studying these

498
00:17:08,549 --> 00:17:06,959
things not just from space like you've

499
00:17:09,909 --> 00:17:08,559
talked about we're studying ice from

500
00:17:12,789 --> 00:17:09,919
using planes

501
00:17:14,789 --> 00:17:12,799
from the ground with ice cores but what

502
00:17:17,510 --> 00:17:14,799
have we learned from all this great

503
00:17:19,990 --> 00:17:17,520
engineering

504
00:17:20,630 --> 00:17:20,000
yeah that's that's a great question so

505
00:17:22,150 --> 00:17:20,640
um

506
00:17:23,429 --> 00:17:22,160
let me just start with the satellites

507
00:17:25,350 --> 00:17:23,439
and then i'm going to put the satellites

508
00:17:27,750 --> 00:17:25,360
into a bit of a broader perspective

509
00:17:29,110 --> 00:17:27,760
so um the satellites have really

510
00:17:31,669 --> 00:17:29,120
revealed a lot of things

511
00:17:32,150 --> 00:17:31,679
um they've revealed some concerning

512
00:17:34,630 --> 00:17:32,160
things

513
00:17:37,029 --> 00:17:34,640

in the antarctic uh there's there's very

514
00:17:39,830 --> 00:17:37,039
uh vulnerable places in the antarctic

515
00:17:42,789 --> 00:17:39,840
um specifically it's it's pine island

516
00:17:45,590 --> 00:17:42,799
and thwaites glaciers there's these two

517
00:17:45,990 --> 00:17:45,600
larger than you can imagine um streams

518
00:17:47,990 --> 00:17:46,000
of ice

519
00:17:49,909 --> 00:17:48,000
that pour ice from the interior of the

520
00:17:52,150 --> 00:17:49,919
ice sheets into the ocean

521
00:17:53,430 --> 00:17:52,160
and those two systems are particularly

522
00:17:55,430 --> 00:17:53,440
vulnerable to

523
00:17:57,430 --> 00:17:55,440
what we call the marine ice sheet

524
00:18:00,070 --> 00:17:57,440
instability and that is where you

525
00:18:01,270 --> 00:18:00,080
start melting uh you start putting the

526
00:18:03,270 --> 00:18:01,280
ice flows faster

527
00:18:04,870 --> 00:18:03,280
it puts more ice into the ocean that

528
00:18:06,310 --> 00:18:04,880
causes it to melt faster

529
00:18:08,230 --> 00:18:06,320
and there's this feedback loop and you

530
00:18:11,270 --> 00:18:08,240
can get these runaway effects where

531
00:18:12,630 --> 00:18:11,280
where the ice sheet collapses and we

532
00:18:14,230 --> 00:18:12,640
don't know if that's happening

533
00:18:15,669 --> 00:18:14,240
there's some speculation that is

534
00:18:17,190 --> 00:18:15,679
happening um

535
00:18:19,270 --> 00:18:17,200
and i i don't even know if we have a

536
00:18:20,070 --> 00:18:19,280
consensus on that but the satellites

537
00:18:23,110 --> 00:18:20,080
reveal that it

538
00:18:24,630 --> 00:18:23,120

is changing now and so it's an area that

539
00:18:25,110 --> 00:18:24,640
we're looking at a lot it's revealed

540
00:18:26,870 --> 00:18:25,120
that the

541
00:18:28,549 --> 00:18:26,880
the east antarctic is gaining a little

542
00:18:30,870 --> 00:18:28,559
bit of mass and then

543
00:18:32,150 --> 00:18:30,880
it's also revealed that the that since

544
00:18:34,390 --> 00:18:32,160
about 2000

545
00:18:36,230 --> 00:18:34,400
the greenland ice sheet has been rapidly

546
00:18:37,990 --> 00:18:36,240
losing mass as we've had much warmer

547
00:18:40,390 --> 00:18:38,000
arctic summers

548
00:18:42,150 --> 00:18:40,400
but you know we've unfortunately only

549
00:18:44,230 --> 00:18:42,160
had a really short record from from

550
00:18:45,430 --> 00:18:44,240
space and so there have been people with

551
00:18:47,270 --> 00:18:45,440
boots on the ground that have been

552
00:18:48,630 --> 00:18:47,280
taking all sorts of measurements

553
00:18:51,270 --> 00:18:48,640
and probably one of the most valuable

554
00:18:52,789 --> 00:18:51,280
measurements that we have is ice cores

555
00:18:54,549 --> 00:18:52,799
and so this is where they take a

556
00:18:56,070 --> 00:18:54,559
drilling rig and

557
00:18:58,470 --> 00:18:56,080
they bring it to the ice sheet and it's

558
00:19:00,470 --> 00:18:58,480
a huge huge operation

559
00:19:02,150 --> 00:19:00,480
and they spend years drilling these

560
00:19:05,190 --> 00:19:02,160
these long cores of ice

561
00:19:06,390 --> 00:19:05,200
and trapped within the ice are tiny

562
00:19:08,070 --> 00:19:06,400
little bubbles that were actually

563
00:19:09,990 --> 00:19:08,080

trapped from the atmosphere

564
00:19:12,070 --> 00:19:10,000
all the way up to a million years ago

565
00:19:14,150 --> 00:19:12,080
and so you can take that ice

566
00:19:15,510 --> 00:19:14,160
and you can bring it yeah seal it up and

567
00:19:16,549 --> 00:19:15,520
bring it back to a lab and you can

568
00:19:18,870 --> 00:19:16,559
actually extract

569
00:19:20,789 --> 00:19:18,880
the air that's in those bubbles and so

570
00:19:22,070 --> 00:19:20,799
we can see what the past concentration

571
00:19:22,870 --> 00:19:22,080
of greenhouse gases was in the

572
00:19:24,390 --> 00:19:22,880
atmosphere

573
00:19:26,549 --> 00:19:24,400
in incredible detail for the last

574
00:19:27,270 --> 00:19:26,559
million years so i'm going to bring up a

575
00:19:30,549 --> 00:19:27,280
figure here

576
00:19:32,230 --> 00:19:30,559
figure 17 and this is just a great

577
00:19:34,310 --> 00:19:32,240
example

578
00:19:35,430 --> 00:19:34,320
so here's a record from from one of the

579
00:19:37,430 --> 00:19:35,440
ice cores

580
00:19:39,190 --> 00:19:37,440
um and it goes back almost a million

581
00:19:41,510 --> 00:19:39,200
years so i'm showing 800

582
00:19:43,669 --> 00:19:41,520
000 years and to put that into

583
00:19:45,350 --> 00:19:43,679
perspective of how long that is

584
00:19:47,909 --> 00:19:45,360
i've marked on this figure where the

585
00:19:48,789 --> 00:19:47,919
birth of modern man was about 200 000

586
00:19:51,830 --> 00:19:48,799
years ago

587
00:19:52,710 --> 00:19:51,840
so modern man has existed for a climate

588
00:19:54,310 --> 00:19:52,720

that's kind of

589
00:19:56,070 --> 00:19:54,320
been within these wiggles ever since

590
00:19:58,150 --> 00:19:56,080
modern man was on earth

591
00:19:59,270 --> 00:19:58,160
and it's just incredible the information

592
00:20:01,590 --> 00:19:59,280
we can get so

593
00:20:02,870 --> 00:20:01,600
the red one that we see that is a proxy

594
00:20:06,310 --> 00:20:02,880
for temperature that's a

595
00:20:07,430 --> 00:20:06,320
it's a fraction between delta uh 018 and

596
00:20:09,990 --> 00:20:07,440
o16

597
00:20:11,029 --> 00:20:10,000
but what it tells us is is it tells us

598
00:20:12,549 --> 00:20:11,039
how much energy

599
00:20:14,549 --> 00:20:12,559
or what the temperature was of the

600
00:20:17,110 --> 00:20:14,559
atmosphere all the way to 100

601
00:20:18,630 --> 00:20:17,120
or sorry 800 000 years ago and then the

602
00:20:20,710 --> 00:20:18,640
other thing we can measure directly

603
00:20:21,669 --> 00:20:20,720
is the amount of co2 contained in those

604
00:20:23,270 --> 00:20:21,679
air samples

605
00:20:25,110 --> 00:20:23,280
and as you can see in this figure you

606
00:20:27,110 --> 00:20:25,120
know as the co2 goes up

607
00:20:29,029 --> 00:20:27,120
so does the temperature and when the co2

608
00:20:31,190 --> 00:20:29,039
goes down so does the temperature and so

609
00:20:32,789 --> 00:20:31,200
they follow each other incredibly well

610
00:20:34,230 --> 00:20:32,799
and there's all these complex feedbacks

611
00:20:38,230 --> 00:20:34,240
that we understand

612
00:20:39,669 --> 00:20:38,240
that are you know very difficult to

613
00:20:41,990 --> 00:20:39,679

anyway there's a lot of processes

614
00:20:42,710 --> 00:20:42,000
involved but the only thing that matters

615
00:20:45,110 --> 00:20:42,720
is is that

616
00:20:47,590 --> 00:20:45,120
you know the temperature of the planet

617
00:20:48,870 --> 00:20:47,600
is incredibly closely tied to the amount

618
00:20:52,070 --> 00:20:48,880
of greenhouse gases

619
00:20:53,830 --> 00:20:52,080
and in this case co2 in the atmosphere

620
00:20:55,350 --> 00:20:53,840
and i've plotted two other things on the

621
00:20:55,909 --> 00:20:55,360
right hand side of that figure you can

622
00:20:58,390 --> 00:20:55,919
see

623
00:20:59,110 --> 00:20:58,400
the concentrations of co2 in the

624
00:21:00,950 --> 00:20:59,120
atmosphere

625
00:21:02,470 --> 00:21:00,960
in 1940 so we call that the

626
00:21:04,950 --> 00:21:02,480
pre-industrial

627
00:21:06,230 --> 00:21:04,960
level of co2 and then i've also marked

628
00:21:07,510 --> 00:21:06,240
to scale on there

629
00:21:09,270 --> 00:21:07,520
what the measurements were from

630
00:21:12,149 --> 00:21:09,280
satellites um

631
00:21:13,510 --> 00:21:12,159
from uh 2017 and we know that those

632
00:21:14,390 --> 00:21:13,520
satellite measurements are really

633
00:21:16,149 --> 00:21:14,400
accurate because

634
00:21:17,909 --> 00:21:16,159
we validate them with all sorts of of

635
00:21:20,630 --> 00:21:17,919
measurements from the ground

636
00:21:22,470 --> 00:21:20,640
and this is this has taught us a lot and

637
00:21:24,630 --> 00:21:22,480
it's been fascinating to study as a

638
00:21:27,750 --> 00:21:24,640

glaciologist

639
00:21:30,230 --> 00:21:27,760
but it's it's also kind of terrifying um

640
00:21:31,510 --> 00:21:30,240
and i say that in the most sincere way

641
00:21:35,029 --> 00:21:31,520
because

642
00:21:36,630 --> 00:21:35,039
um i started my career in in glaciology

643
00:21:39,510 --> 00:21:36,640
in 2005

644
00:21:40,950 --> 00:21:39,520
and there wasn't a lot happening to the

645
00:21:42,390 --> 00:21:40,960
ice then

646
00:21:44,950 --> 00:21:42,400
and usually when we would think of

647
00:21:47,909 --> 00:21:44,960
glaciers we would think of glaciers as

648
00:21:49,430 --> 00:21:47,919
responding really slow to something

649
00:21:51,110 --> 00:21:49,440
and we used to say it happened at

650
00:21:52,950 --> 00:21:51,120
glacier time scales which meant it

651
00:21:57,110 --> 00:21:52,960
happened really slowly

652
00:21:59,190 --> 00:21:57,120
and even 10 15 20 years ago

653
00:22:00,710 --> 00:21:59,200
people kind of thought that it would

654
00:22:03,430 --> 00:22:00,720
take a while for the ice sheets to

655
00:22:05,029 --> 00:22:03,440
respond once the climate changed

656
00:22:06,789 --> 00:22:05,039
but what we started to learn is there

657
00:22:07,510 --> 00:22:06,799
were some processes that we didn't

658
00:22:10,710 --> 00:22:07,520
understand

659
00:22:13,669 --> 00:22:10,720
fully and the ice sheets are responding

660
00:22:14,310 --> 00:22:13,679
really fast and so just over this short

661
00:22:16,149 --> 00:22:14,320
period

662
00:22:17,909 --> 00:22:16,159
we've seen really rapid changes in the

663
00:22:18,789 --> 00:22:17,919

ice sheet we see the green land wasting

664
00:22:22,230 --> 00:22:18,799
away

665
00:22:23,350 --> 00:22:22,240
putting almost 250 cubic kilometers of

666
00:22:26,390 --> 00:22:23,360
water into the ocean

667
00:22:29,750 --> 00:22:26,400
every year causing measurable amounts of

668
00:22:32,230 --> 00:22:29,760
of change in sea levels and the glaciers

669
00:22:33,190 --> 00:22:32,240
every glacier region on earth is losing

670
00:22:36,549 --> 00:22:33,200
mass so

671
00:22:40,070 --> 00:22:36,559
the ocean so alaska

672
00:22:43,430 --> 00:22:40,080
patagonia high mountain asia um

673
00:22:47,110 --> 00:22:43,440
the the alps uh new zealand

674
00:22:49,190 --> 00:22:47,120
um all of the arctic islands everywhere

675
00:22:51,110 --> 00:22:49,200
there's ice it's all being wasted away

676
00:22:53,270 --> 00:22:51,120
which tells us that the ice is out of

677
00:22:56,710 --> 00:22:53,280
equilibrium with the climate

678
00:22:59,750 --> 00:22:56,720
and that's that's a lot to digest

679
00:23:01,590 --> 00:22:59,760
and we're we've learned a lot more about

680
00:23:03,430 --> 00:23:01,600
the systems but

681
00:23:05,590 --> 00:23:03,440
what what makes it what brings it all

682
00:23:08,870 --> 00:23:05,600
into perspective is this next slide

683
00:23:12,149 --> 00:23:08,880
um this next slide shows

684
00:23:13,830 --> 00:23:12,159
where we're expected to be at by

685
00:23:15,990 --> 00:23:13,840
uh the end of the century so that's only

686
00:23:19,270 --> 00:23:16,000
80 years from now so there's people

687
00:23:20,149 --> 00:23:19,280
that are um in cribs right now or

688
00:23:22,870 --> 00:23:20,159

possibly in

689
00:23:24,310 --> 00:23:22,880
in kindergarten that will still be alive

690
00:23:27,270 --> 00:23:24,320
when we hit these numbers

691
00:23:28,549 --> 00:23:27,280
and i've shown three dots on that graph

692
00:23:32,310 --> 00:23:28,559
and this is to scale

693
00:23:34,950 --> 00:23:32,320
um and it takes a minute to digest but

694
00:23:36,310 --> 00:23:34,960
um the the one best estimate there the

695
00:23:39,350 --> 00:23:36,320
the blue dot there

696
00:23:42,549 --> 00:23:39,360
uh that says peak emissions in um

697
00:23:47,350 --> 00:23:42,559
in in 2030

698
00:23:50,230 --> 00:23:47,360
um that is a probably over optimistic

699
00:23:51,909 --> 00:23:50,240
scenario i mean that right there sorry

700
00:23:54,070 --> 00:23:51,919
2040 not 2030.

701
00:23:55,110 --> 00:23:54,080
that right there is if we really got our

702
00:23:58,789 --> 00:23:55,120
act together

703
00:24:02,070 --> 00:23:58,799
as a as a people on this planet

704
00:24:03,110 --> 00:24:02,080
and we were able to stop or to to have

705
00:24:05,909 --> 00:24:03,120
peak emissions

706
00:24:07,510 --> 00:24:05,919
by 2040 we would have a three degrees

707
00:24:09,269 --> 00:24:07,520
fahrenheit rise in temperature and

708
00:24:12,070 --> 00:24:09,279
concentrations of co2 would be

709
00:24:13,590 --> 00:24:12,080
as indicated on that graph if we have p

710
00:24:15,350 --> 00:24:13,600
commissions in 2060

711
00:24:17,430 --> 00:24:15,360
which is still considered overly

712
00:24:18,870 --> 00:24:17,440
ambitious at this point considering

713
00:24:21,350 --> 00:24:18,880

the progress that we've been able to

714
00:24:23,590 --> 00:24:21,360
make so far we would have a four degrees

715
00:24:25,990 --> 00:24:23,600
rise in temperature

716
00:24:27,909 --> 00:24:26,000
and if we just kind of operate like

717
00:24:31,750 --> 00:24:27,919
we're operating right now

718
00:24:33,990 --> 00:24:31,760
and since this study came out in 2005

719
00:24:35,350 --> 00:24:34,000
all indications report that we are on

720
00:24:38,390 --> 00:24:35,360
this higher track

721
00:24:39,990 --> 00:24:38,400
it is the best uh prediction of of what

722
00:24:41,590 --> 00:24:40,000
track we're on right now

723
00:24:44,149 --> 00:24:41,600
and this is what we call the business as

724
00:24:45,909 --> 00:24:44,159
usual so if we start to account for

725
00:24:48,230 --> 00:24:45,919
improvements in technology that will

726
00:24:50,870 --> 00:24:48,240
slowly bring down the emissions you know

727
00:24:52,470 --> 00:24:50,880
improvements in in fuel economy if we

728
00:24:54,470 --> 00:24:52,480
assume that that the

729
00:24:56,549 --> 00:24:54,480
the poor countries will will want to

730
00:24:58,870 --> 00:24:56,559
have lifestyles more similar to

731
00:25:00,070 --> 00:24:58,880
to developed western nations um first

732
00:25:02,149 --> 00:25:00,080
world nations

733
00:25:04,470 --> 00:25:02,159
um you know if we account for these

734
00:25:06,950 --> 00:25:04,480
things then we also account for the

735
00:25:07,990 --> 00:25:06,960
the plateauing of of population growth

736
00:25:10,549 --> 00:25:08,000
as we expect that

737
00:25:12,310 --> 00:25:10,559
population growth will will peak um

738
00:25:15,350 --> 00:25:12,320

during this century

739
00:25:18,070 --> 00:25:15,360
this is where we'll be at and again

740
00:25:19,430 --> 00:25:18,080
that small figure at the bottom that is

741
00:25:22,549 --> 00:25:19,440
the variability

742
00:25:24,390 --> 00:25:22,559
over the last 800 000 years and

743
00:25:25,750 --> 00:25:24,400
what i'm showing to scale is the

744
00:25:27,190 --> 00:25:25,760
different scenarios of where we're

745
00:25:29,990 --> 00:25:27,200
headed and so

746
00:25:31,830 --> 00:25:30,000
when i do the science i'm doing i'm only

747
00:25:32,870 --> 00:25:31,840
studying the very bottom part of that

748
00:25:34,789 --> 00:25:32,880
graph

749
00:25:36,470 --> 00:25:34,799
and when we look at the models to tell

750
00:25:38,710 --> 00:25:36,480
us what does it mean when we look at

751
00:25:40,070 --> 00:25:38,720
these future scenarios

752
00:25:41,669 --> 00:25:40,080
they tell us that there's a lot of

753
00:25:43,190 --> 00:25:41,679
negative consequences coming down the

754
00:25:45,029 --> 00:25:43,200
pipeline they tell us that

755
00:25:46,710 --> 00:25:45,039
the ice is going to continue to melt

756
00:25:49,430 --> 00:25:46,720
that's a guarantee

757
00:25:51,029 --> 00:25:49,440
and they tell us that the wetter regions

758
00:25:52,710 --> 00:25:51,039
of earth will likely get wetter

759
00:25:55,430 --> 00:25:52,720
the drier regions of earth will likely

760
00:25:56,950 --> 00:25:55,440
get drier the frequency of storms and

761
00:25:58,630 --> 00:25:56,960
droughts will increase

762
00:26:00,149 --> 00:25:58,640
um and then there's some other impacts

763
00:26:03,430 --> 00:26:00,159

as well um

764
00:26:04,870 --> 00:26:03,440
rising rising oceans will start to cause

765
00:26:07,110 --> 00:26:04,880
problems for coastal communities where

766
00:26:10,149 --> 00:26:07,120
we've built a lot of our infrastructure

767
00:26:12,710 --> 00:26:10,159
and so i i don't want to be a a complete

768
00:26:13,590 --> 00:26:12,720
doomsday person i mean there are things

769
00:26:16,070 --> 00:26:13,600
we can do

770
00:26:17,990 --> 00:26:16,080
to mitigate this um and the best thing

771
00:26:21,029 --> 00:26:18,000
that we can do to mitigate this

772
00:26:22,470 --> 00:26:21,039
is really to focus on on the emissions

773
00:26:25,110 --> 00:26:22,480
and so really

774
00:26:26,950 --> 00:26:25,120
uh we're going to have to stop emitting

775
00:26:28,230 --> 00:26:26,960
greenhouse gases into the atmosphere and

776
00:26:30,950 --> 00:26:28,240
whatever we can do

777
00:26:32,230 --> 00:26:30,960
to get towards that path is positive but

778
00:26:33,430 --> 00:26:32,240
whatever it is it's going to have to be

779
00:26:35,590 --> 00:26:33,440
collective action

780
00:26:37,029 --> 00:26:35,600
and so we're kind of we're far beyond

781
00:26:38,470 --> 00:26:37,039
the point now of being able to do

782
00:26:39,990 --> 00:26:38,480
individual action

783
00:26:42,390 --> 00:26:40,000
to have a meaningful impact on the

784
00:26:44,230 --> 00:26:42,400
situation it is it is very serious

785
00:26:45,830 --> 00:26:44,240
uh and it is something that we need to

786
00:26:48,950 --> 00:26:45,840
to tackle uh

787
00:26:50,470 --> 00:26:48,960
starting now um and we're also gonna

788
00:26:53,350 --> 00:26:50,480

have to think about mitigation now we're

789
00:26:55,110 --> 00:26:53,360
not just talking about avoiding any harm

790
00:26:56,470 --> 00:26:55,120
some harm is already going to happen we

791
00:26:57,430 --> 00:26:56,480
already have enough co2 in the

792
00:26:58,870 --> 00:26:57,440
atmosphere

793
00:27:00,549 --> 00:26:58,880
that we're going to have to think about

794
00:27:01,750 --> 00:27:00,559
mitigation and so that is

795
00:27:03,110 --> 00:27:01,760
you know thinking about our coastal

796
00:27:04,230 --> 00:27:03,120
infrastructure and in which

797
00:27:06,070 --> 00:27:04,240
infrastructure we

798
00:27:07,669 --> 00:27:06,080
we would like to shore up and defend

799
00:27:09,750 --> 00:27:07,679
against a rising ocean

800
00:27:11,430 --> 00:27:09,760
which infrastructure uh it probably

801
00:27:13,269 --> 00:27:11,440
isn't cost effective to do that

802
00:27:15,029 --> 00:27:13,279
and what that means is that we have to

803
00:27:16,710 --> 00:27:15,039
spend taxpayer dollars

804
00:27:19,269 --> 00:27:16,720
on mitigating this and the most

805
00:27:21,269 --> 00:27:19,279
effective use of pac taxpayer dollars

806
00:27:22,549 --> 00:27:21,279
is really to prevent it going from going

807
00:27:23,110 --> 00:27:22,559
in the atmosphere in the first place

808
00:27:24,230 --> 00:27:23,120
because

809
00:27:26,389 --> 00:27:24,240
once you start trying to kind of

810
00:27:27,750 --> 00:27:26,399
mitigating all the the compounding

811
00:27:30,710 --> 00:27:27,760
consequences afterwards

812
00:27:32,470 --> 00:27:30,720
it gets really expensive and i'm sure

813
00:27:33,269 --> 00:27:32,480

we'd rather spend our tax dollars on

814
00:27:34,870 --> 00:27:33,279
healthcare

815
00:27:36,630 --> 00:27:34,880
or any of the other number of things or

816
00:27:37,990 --> 00:27:36,640
just keep it in our pockets

817
00:27:40,470 --> 00:27:38,000
than spending it on mitigating the

818
00:27:43,909 --> 00:27:40,480
damage we've done um

819
00:27:46,070 --> 00:27:43,919
yeah so i i listened to a very prominent

820
00:27:48,950 --> 00:27:46,080
science this scientist this morning

821
00:27:50,789 --> 00:27:48,960
and he said uh let's be the generation

822
00:27:52,389 --> 00:27:50,799
that rose to the challenge not the

823
00:27:54,710 --> 00:27:52,399
the generation that failed to rise to

824
00:27:57,750 --> 00:27:54,720
the challenge

825
00:27:59,269 --> 00:27:57,760
that's a great way to put it alex and i

826
00:28:01,990 --> 00:27:59,279
we've talked about the consequences

827
00:28:03,590 --> 00:28:02,000
we've talked about moving forward but

828
00:28:05,269 --> 00:28:03,600
i think the audience is really engaged

829
00:28:06,549 --> 00:28:05,279
so i want to give jocelyn a chance to

830
00:28:07,110 --> 00:28:06,559
ask some of those questions for our

831
00:28:10,230 --> 00:28:07,120
viewers

832
00:28:12,070 --> 00:28:10,240
jocelyn how's it looking out there lots

833
00:28:14,230 --> 00:28:12,080
of great questions coming across

834
00:28:16,789 --> 00:28:14,240
all of our social media platforms we

835
00:28:19,190 --> 00:28:16,799
have paychow on facebook that asks

836
00:28:20,389 --> 00:28:19,200
is there a relationship between ice and

837
00:28:22,870 --> 00:28:20,399
extreme weather

838
00:28:25,669 --> 00:28:22,880

and how will extreme climate affect the

839
00:28:30,070 --> 00:28:28,310
wow that is a great question and yes

840
00:28:33,029 --> 00:28:30,080
there are very strong links

841
00:28:34,870 --> 00:28:33,039
um there is an interesting thing that

842
00:28:35,510 --> 00:28:34,880
they believe happened in the past and

843
00:28:38,789 --> 00:28:35,520
that was

844
00:28:42,310 --> 00:28:38,799
is that there was so much water that

845
00:28:45,350 --> 00:28:42,320
poured off of the laurentide ice sheet

846
00:28:47,590 --> 00:28:45,360
that it actually put a freshwater cap um

847
00:28:49,430 --> 00:28:47,600
in the north atlantic and that

848
00:28:51,190 --> 00:28:49,440
freshwater cap

849
00:28:53,110 --> 00:28:51,200
prevented what we call the thermal

850
00:28:55,190 --> 00:28:53,120
haline circulation which is

851
00:28:56,549 --> 00:28:55,200
how the oceans move how the oceans

852
00:28:58,389 --> 00:28:56,559
circulate water

853
00:29:01,110 --> 00:28:58,399
and at the time it actually prevented it

854
00:29:03,909 --> 00:29:01,120
and it caught us a very cold europe

855
00:29:05,269 --> 00:29:03,919
and people are studying this in a lot of

856
00:29:09,190 --> 00:29:05,279
detail

857
00:29:10,710 --> 00:29:09,200
uh and there is a real risk that that

858
00:29:11,190 --> 00:29:10,720
could happen i think the risk of it

859
00:29:14,870 --> 00:29:11,200
happening

860
00:29:16,310 --> 00:29:14,880
is unlikely um but there is a risk that

861
00:29:18,389 --> 00:29:16,320
it could happen

862
00:29:19,990 --> 00:29:18,399
but most of the extreme comes from

863
00:29:23,750 --> 00:29:20,000

changes in precipitation

864
00:29:24,630 --> 00:29:23,760
so uh we have uh a stronger gradient

865
00:29:27,669 --> 00:29:24,640
between

866
00:29:28,710 --> 00:29:27,679
the polar regions and uh the lower

867
00:29:31,669 --> 00:29:28,720
latitudes and that

868
00:29:32,710 --> 00:29:31,679
that drives a much more uh vigorous

869
00:29:34,789 --> 00:29:32,720
climate

870
00:29:35,750 --> 00:29:34,799
and so that's that's where we expect a

871
00:29:38,950 --> 00:29:35,760
lot of the extreme

872
00:29:42,950 --> 00:29:38,960
drought and extreme um uh precipitation

873
00:29:46,789 --> 00:29:44,549
let's go with another question from the

874
00:29:49,110 --> 00:29:46,799
audience jocelyn

875
00:29:50,389 --> 00:29:49,120
yes corey on linkedin asks has the

876
00:29:52,830 --> 00:29:50,399
quality

877
00:29:54,870 --> 00:29:52,840
images changed over the duration of your

878
00:29:58,149 --> 00:29:54,880
career

879
00:30:02,549 --> 00:29:58,159
oh it's incredible um the the

880
00:30:06,070 --> 00:30:02,559
engineering advances are phenomenal so

881
00:30:09,830 --> 00:30:06,080
i was born in 1980

882
00:30:12,870 --> 00:30:09,840
uh so the first

883
00:30:13,510 --> 00:30:12,880
kind of earth satellite was launched

884
00:30:17,190 --> 00:30:13,520
really

885
00:30:19,350 --> 00:30:17,200
uh was was the landsat uh landsat first

886
00:30:22,630 --> 00:30:19,360
landsat satellite kind of in the 19 mid

887
00:30:25,830 --> 00:30:22,640
1970s so not much before i came around

888
00:30:27,269 --> 00:30:25,840

um and in the 1970s the military was

889
00:30:29,510 --> 00:30:27,279
flying planes

890
00:30:30,950 --> 00:30:29,520
sorry flying satellites flying

891
00:30:34,710 --> 00:30:30,960
satellites is part of the

892
00:30:37,909 --> 00:30:34,720
the hexagon missions in the 70s

893
00:30:40,230 --> 00:30:37,919
they were taking pictures with film and

894
00:30:41,029 --> 00:30:40,240
ejecting those deorbiting the canisters

895
00:30:43,590 --> 00:30:41,039
of film

896
00:30:44,789 --> 00:30:43,600
and then picking those up with planes

897
00:30:47,590 --> 00:30:44,799
and

898
00:30:48,070 --> 00:30:47,600
so the quality has changed immensely i

899
00:30:49,669 --> 00:30:48,080
mean i

900
00:30:51,029 --> 00:30:49,679
so i bring up that data because i use

901
00:30:52,549 --> 00:30:51,039
that data in my research because it's

902
00:30:53,990 --> 00:30:52,559
the only record we have it's the one

903
00:30:56,310 --> 00:30:54,000
that goes furthest back is

904
00:30:57,590 --> 00:30:56,320
is this military record from the 70s and

905
00:30:59,509 --> 00:30:57,600
you could imagine they were

906
00:31:00,630 --> 00:30:59,519
catching this stuff with planes and then

907
00:31:03,509 --> 00:31:00,640
developing it

908
00:31:04,870 --> 00:31:03,519
on earth in a in a dark room um and so

909
00:31:07,190 --> 00:31:04,880
we've just seen a rapid

910
00:31:10,789 --> 00:31:07,200
advancement in our ability to to observe

911
00:31:14,470 --> 00:31:12,149
it's great to hear that we've had that

912
00:31:16,310 --> 00:31:14,480
advancement i'm sure there's lots more

913
00:31:19,029 --> 00:31:16,320

questions jocelyn what else are they

914
00:31:20,630 --> 00:31:19,039
asking for alex

915
00:31:23,190 --> 00:31:20,640
you know you mentioned earlier how we

916
00:31:23,590 --> 00:31:23,200
use ice to look into the past and tim on

917
00:31:26,070 --> 00:31:23,600
youtube

918
00:31:29,029 --> 00:31:26,080
asks what is the date of the oldest ice

919
00:31:32,230 --> 00:31:29,039
that's being studied

920
00:31:34,710 --> 00:31:32,240
wow that that's a great question um so

921
00:31:35,509 --> 00:31:34,720
we have that very detailed record all

922
00:31:38,630 --> 00:31:35,519
the way back

923
00:31:40,389 --> 00:31:38,640
800 000 years but they're going back

924
00:31:42,630 --> 00:31:40,399
millions of years in some of the ice

925
00:31:45,110 --> 00:31:42,640
cores but the problem is is that ice is

926
00:31:47,190 --> 00:31:45,120
so old and it's so deep that it's all

927
00:31:48,710 --> 00:31:47,200
been squished and squashed right at the

928
00:31:51,830 --> 00:31:48,720
bottom of the ice sheet

929
00:31:54,710 --> 00:31:51,840
and so it's a real challenge to

930
00:31:56,389 --> 00:31:54,720
to get the data out of there and so they

931
00:31:57,909 --> 00:31:56,399
actually have other ways they look even

932
00:31:59,590 --> 00:31:57,919
further back in time

933
00:32:02,230 --> 00:31:59,600
and so one of the ways they look further

934
00:32:05,430 --> 00:32:02,240
back in time is you can imagine that

935
00:32:07,830 --> 00:32:05,440
um when the earth is drier

936
00:32:08,950 --> 00:32:07,840
uh there can be more dust storms and

937
00:32:12,470 --> 00:32:08,960
that dust

938
00:32:14,070 --> 00:32:12,480

can can deposit over lakes and so we can

939
00:32:16,149 --> 00:32:14,080
actually go and take these lake

940
00:32:18,310 --> 00:32:16,159
cores and we can see back millions of

941
00:32:21,350 --> 00:32:18,320
years and we can see records of

942
00:32:23,430 --> 00:32:21,360
drought and flooding we can see um

943
00:32:25,110 --> 00:32:23,440
we can look at the isotopic record we

944
00:32:27,350 --> 00:32:25,120
can even go into the deep ocean

945
00:32:28,230 --> 00:32:27,360
and take uh mud cores from the bottom of

946
00:32:30,070 --> 00:32:28,240
the ocean

947
00:32:31,750 --> 00:32:30,080
we can look at what we these tiny little

948
00:32:33,990 --> 00:32:31,760
creatures called diatoms

949
00:32:35,350 --> 00:32:34,000
and they tell us the the concentrations

950
00:32:37,110 --> 00:32:35,360
of different gases and what the

951
00:32:38,630 --> 00:32:37,120
environment was like back in the day

952
00:32:41,509 --> 00:32:38,640
and we can also see sediment records

953
00:32:44,070 --> 00:32:41,519
from when the greenland ice sheet uh

954
00:32:45,190 --> 00:32:44,080
was last uh gone and so we can see a gap

955
00:32:46,549 --> 00:32:45,200
in the record where

956
00:32:48,630 --> 00:32:46,559
there there's stopped being any of the

957
00:32:49,909 --> 00:32:48,640
glacial deposits being put out by the

958
00:32:51,909 --> 00:32:49,919
glaciers so there's all these different

959
00:32:57,110 --> 00:32:51,919
ways we can look back in time

960
00:32:58,389 --> 00:32:57,120
to understand the past climate

961
00:32:59,990 --> 00:32:58,399
i'm so glad we've had so many

962
00:33:01,430 --> 00:33:00,000
advancements jocelyn go ahead i'm sure

963
00:33:03,029 --> 00:33:01,440

they're itching out there to ask alex

964
00:33:04,630 --> 00:33:03,039
some more questions

965
00:33:06,549 --> 00:33:04,640
they are you've mentioned a lot of

966
00:33:08,549 --> 00:33:06,559
really interesting data and kayla

967
00:33:10,310 --> 00:33:08,559
schneider on facebook asks

968
00:33:13,830 --> 00:33:10,320
what does this mean as far as being

969
00:33:16,149 --> 00:33:13,840
helpful how can this data help

970
00:33:17,750 --> 00:33:16,159
so that's a great question and it's one

971
00:33:21,029 --> 00:33:17,760
i struggle with myself

972
00:33:23,110 --> 00:33:21,039
um this this data is incredibly helpful

973
00:33:24,549 --> 00:33:23,120
it tells us what the earth system is

974
00:33:26,549 --> 00:33:24,559
doing

975
00:33:28,549 --> 00:33:26,559
it tells us all of the complexities

976
00:33:29,350 --> 00:33:28,559
about how all of these different parts

977
00:33:31,350 --> 00:33:29,360
interact

978
00:33:32,710 --> 00:33:31,360
when you raise co2 you warm the ocean

979
00:33:34,310 --> 00:33:32,720
when you warm the ocean

980
00:33:35,590 --> 00:33:34,320
you increase the melting of ice around

981
00:33:37,669 --> 00:33:35,600
the antarctic when you increase the

982
00:33:41,190 --> 00:33:37,679
melting of ice around the antarctic

983
00:33:42,630 --> 00:33:41,200
you cause less ice to resist the flow of

984
00:33:43,990 --> 00:33:42,640
ice into the ocean and so you actually

985
00:33:47,669 --> 00:33:44,000
see the ice speed up

986
00:33:49,669 --> 00:33:47,679
you actually see the gravity change

987
00:33:51,110 --> 00:33:49,679
when the gravity changes you can see the

988
00:33:52,789 --> 00:33:51,120

ice going into the ocean and then you

989
00:33:54,070 --> 00:33:52,799
can see the sea levels rise

990
00:33:55,669 --> 00:33:54,080
and then you can see where the sea

991
00:33:57,750 --> 00:33:55,679
levels are rising as the gravity

992
00:33:59,990 --> 00:33:57,760
redistributes that ice around the world

993
00:34:02,230 --> 00:34:00,000
you can it's these observations from

994
00:34:03,190 --> 00:34:02,240
space that are the only way we can see

995
00:34:05,750 --> 00:34:03,200
the earth

996
00:34:07,269 --> 00:34:05,760
as a complete system right it is really

997
00:34:10,069 --> 00:34:07,279
a self-contained

998
00:34:11,510 --> 00:34:10,079
small ecosystem a marble in space and

999
00:34:13,510 --> 00:34:11,520
the only way we can understand

1000
00:34:15,750 --> 00:34:13,520
all of the interconnectivity is through

1001
00:34:17,909 --> 00:34:15,760
these satellite observations

1002
00:34:20,790 --> 00:34:17,919
but i preface that with i struggle and

1003
00:34:23,109 --> 00:34:20,800
the reason i struggle is because

1004
00:34:25,270 --> 00:34:23,119
it's only useful if we can take the

1005
00:34:27,669 --> 00:34:25,280
science and we can learn from it

1006
00:34:29,510 --> 00:34:27,679
and the science has clearly shown over

1007
00:34:32,310 --> 00:34:29,520
the last two decades

1008
00:34:34,069 --> 00:34:32,320
that the ice is incredibly sensitive to

1009
00:34:36,629 --> 00:34:34,079
changes in temperature

1010
00:34:37,829 --> 00:34:36,639
and it is responding now and we know

1011
00:34:39,829 --> 00:34:37,839
that it's going to keep

1012
00:34:41,270 --> 00:34:39,839
increasing sea levels into the future

1013
00:34:42,310 --> 00:34:41,280

and we know a bunch of other things that

1014
00:34:43,109 --> 00:34:42,320
are going to change in the climate

1015
00:34:45,430 --> 00:34:43,119
system

1016
00:34:46,629 --> 00:34:45,440
most of which the vast majority of which

1017
00:34:49,109 --> 00:34:46,639
are are going to be negative

1018
00:34:50,950 --> 00:34:49,119
for for most societies there are some

1019
00:34:51,430 --> 00:34:50,960
countries that will benefit in the short

1020
00:34:53,430 --> 00:34:51,440
term

1021
00:34:55,589 --> 00:34:53,440
so places like canada will will have

1022
00:34:57,510 --> 00:34:55,599
increased agricultural productivity

1023
00:34:59,030 --> 00:34:57,520
that's a benefit to them but they'll

1024
00:34:59,829 --> 00:34:59,040
also have to deal with the increased

1025
00:35:02,230 --> 00:34:59,839
stresses of

1026
00:35:04,630 --> 00:35:02,240
other countries having less and so

1027
00:35:06,150 --> 00:35:04,640
increased global food insecurity

1028
00:35:08,470 --> 00:35:06,160
is going to be one of the biggest future

1029
00:35:09,670 --> 00:35:08,480
consequences and so the data is really

1030
00:35:11,670 --> 00:35:09,680
only useful

1031
00:35:13,829 --> 00:35:11,680
if we use it if we listen to the

1032
00:35:15,990 --> 00:35:13,839
scientists that interpret the data

1033
00:35:17,510 --> 00:35:16,000
we listen to the modelers that project

1034
00:35:18,470 --> 00:35:17,520
the future and then we take that

1035
00:35:20,310 --> 00:35:18,480
information

1036
00:35:22,230 --> 00:35:20,320
and we start to think deeply as a

1037
00:35:23,589 --> 00:35:22,240
society what are the decisions that we

1038
00:35:27,030 --> 00:35:23,599

would like to make

1039
00:35:27,589 --> 00:35:27,040
to include the information that we get

1040
00:35:29,589 --> 00:35:27,599
from this

1041
00:35:32,870 --> 00:35:29,599
incredible sensor array that we have in

1042
00:35:36,630 --> 00:35:34,310
i think we've got time for about two

1043
00:35:38,150 --> 00:35:36,640
more questions

1044
00:35:39,990 --> 00:35:38,160
we have a really interesting question

1045
00:35:41,510 --> 00:35:40,000
from curtis on facebook who wants to

1046
00:35:43,589 --> 00:35:41,520
know are there any risks for

1047
00:35:45,030 --> 00:35:43,599
substantial methane release from

1048
00:35:47,190 --> 00:35:45,040
undersea storage

1049
00:35:50,950 --> 00:35:47,200
as it gets warmer and has this view

1050
00:35:55,510 --> 00:35:53,109
yeah that's a that's a that's a big

1051
00:35:57,190 --> 00:35:55,520
question um this is obviously a very

1052
00:36:01,190 --> 00:35:57,200
well-educated uh

1053
00:36:04,069 --> 00:36:01,200
um listener um yeah it's it's not

1054
00:36:04,790 --> 00:36:04,079
it's a real thing so there's this uh ice

1055
00:36:08,630 --> 00:36:04,800
that's trap

1056
00:36:11,270 --> 00:36:08,640
the arctic and it's trapped

1057
00:36:11,990 --> 00:36:11,280
it's encased and frozen in permafrost

1058
00:36:13,829 --> 00:36:12,000
and the fear

1059
00:36:16,150 --> 00:36:13,839
is that it's it's mostly under the

1060
00:36:17,589 --> 00:36:16,160
arctic ocean that if the arctic ocean

1061
00:36:19,349 --> 00:36:17,599
warms enough

1062
00:36:21,190 --> 00:36:19,359
that the layer that's trapping all of

1063
00:36:23,030 --> 00:36:21,200

that methane um

1064
00:36:25,109 --> 00:36:23,040
would thaw and give access of the

1065
00:36:26,310 --> 00:36:25,119
methane to the atmosphere and that would

1066
00:36:28,870 --> 00:36:26,320
cause a huge

1067
00:36:30,069 --> 00:36:28,880
belch into the atmosphere of methane and

1068
00:36:33,190 --> 00:36:30,079
now methane is a different

1069
00:36:34,550 --> 00:36:33,200
beast than co2 co2 has a resident

1070
00:36:36,470 --> 00:36:34,560
residence time in the atmosphere of

1071
00:36:39,190 --> 00:36:36,480
about 2000 years so

1072
00:36:40,150 --> 00:36:39,200
if you drive your car and it emits co2

1073
00:36:41,990 --> 00:36:40,160
into the atmosphere

1074
00:36:43,270 --> 00:36:42,000
it's going to last for about 2 000 years

1075
00:36:44,310 --> 00:36:43,280
until it starts to come out of the

1076
00:36:45,829 --> 00:36:44,320
atmosphere

1077
00:36:48,950 --> 00:36:45,839
methane is much shorter lived in the

1078
00:36:50,390 --> 00:36:48,960
atmosphere but it's much more potent

1079
00:36:52,230 --> 00:36:50,400
if i remember correctly i think it's on

1080
00:36:53,109 --> 00:36:52,240
the order of about 10 000 times more

1081
00:36:55,270 --> 00:36:53,119
potent

1082
00:36:57,109 --> 00:36:55,280
as a greenhouse gas and so if that

1083
00:36:58,950 --> 00:36:57,119
methane leaks into the atmosphere

1084
00:37:01,190 --> 00:36:58,960
um it would accept it would cause a

1085
00:37:03,109 --> 00:37:01,200
short-term acceleration

1086
00:37:04,230 --> 00:37:03,119
to climate which then could ignite some

1087
00:37:07,270 --> 00:37:04,240
other feedbacks

1088
00:37:10,390 --> 00:37:07,280

but i think the probability is low

1089
00:37:12,790 --> 00:37:10,400
but we people are uh

1090
00:37:14,390 --> 00:37:12,800
studying it in a lot of detail so it's

1091
00:37:15,750 --> 00:37:14,400
it's a concern to scientists

1092
00:37:19,829 --> 00:37:15,760
i think they think the probability is

1093
00:37:24,470 --> 00:37:22,150
and we've got time for one last question

1094
00:37:26,710 --> 00:37:24,480
this evening

1095
00:37:29,190 --> 00:37:26,720
michelle on facebook wants to know how

1096
00:37:30,870 --> 00:37:29,200
quickly does this information come in

1097
00:37:34,870 --> 00:37:30,880
that we're getting and in relation to

1098
00:37:38,630 --> 00:37:37,430
that that's a that's a great question so

1099
00:37:40,470 --> 00:37:38,640
um we have some

1100
00:37:42,390 --> 00:37:40,480
satellites that are are designed for

1101
00:37:44,950 --> 00:37:42,400
disaster response

1102
00:37:46,470 --> 00:37:44,960
and um noaa has satellites that are

1103
00:37:48,230 --> 00:37:46,480
designed for weather

1104
00:37:49,829 --> 00:37:48,240
those types of satellites the data has

1105
00:37:51,510 --> 00:37:49,839
to come back really quick has to get

1106
00:37:52,790 --> 00:37:51,520
analyzed has to go through all the super

1107
00:37:55,030 --> 00:37:52,800
computers to turn the

1108
00:37:56,230 --> 00:37:55,040
raw measurements into data that people

1109
00:37:59,670 --> 00:37:56,240
can interpret

1110
00:38:01,670 --> 00:37:59,680
and that can go out within hours um

1111
00:38:03,430 --> 00:38:01,680
a lot of the data we work with it has to

1112
00:38:05,829 --> 00:38:03,440
be incredibly precise

1113
00:38:06,950 --> 00:38:05,839

and so the first satellite i showed was

1114
00:38:09,430 --> 00:38:06,960
that icesat-2

1115
00:38:11,670 --> 00:38:09,440
satellite and we're talking about you

1116
00:38:13,190 --> 00:38:11,680
know centimeter precision on the

1117
00:38:14,230 --> 00:38:13,200
all of these different things and you

1118
00:38:15,109 --> 00:38:14,240
need to know the position of the

1119
00:38:16,950 --> 00:38:15,119
satellite

1120
00:38:18,710 --> 00:38:16,960
so there's a lot of complex things that

1121
00:38:20,550 --> 00:38:18,720
need to be known from other satellites

1122
00:38:22,310 --> 00:38:20,560
as well from the gps network and

1123
00:38:23,910 --> 00:38:22,320
a bunch of other stuff and it's a lot of

1124
00:38:25,990 --> 00:38:23,920
computation that has to be done

1125
00:38:27,910 --> 00:38:26,000
and so typically we see that data you

1126
00:38:32,870 --> 00:38:27,920
know within two to three months

1127
00:38:33,910 --> 00:38:32,880
um it's it's on my desk as a scientist

1128
00:38:36,390 --> 00:38:33,920
it's good that you can get the

1129
00:38:38,069 --> 00:38:36,400
information out alex um

1130
00:38:39,430 --> 00:38:38,079
that was all the time we had for

1131
00:38:40,310 --> 00:38:39,440
questions this evening although they

1132
00:38:41,750 --> 00:38:40,320
have been great

1133
00:38:43,349 --> 00:38:41,760
questions thank you for all of those

1134
00:38:44,950 --> 00:38:43,359
that are watching this evening

1135
00:38:47,190 --> 00:38:44,960
i do want to give our speaker alex a

1136
00:38:52,390 --> 00:38:47,200
chance for one last final word

1137
00:38:55,829 --> 00:38:54,630
yeah so so thank you so much for taking

1138
00:38:57,670 --> 00:38:55,839

the time and listening

1139
00:38:58,950 --> 00:38:57,680
and you know i really hope that that

1140
00:39:00,870 --> 00:38:58,960
you're able to relate

1141
00:39:02,310 --> 00:39:00,880
kind of to what what we're doing here

1142
00:39:04,069 --> 00:39:02,320
and you know kind of the career path

1143
00:39:06,230 --> 00:39:04,079
that got me to where i am

1144
00:39:07,109 --> 00:39:06,240
um i did not ever think i would be

1145
00:39:09,910 --> 00:39:07,119
sitting

1146
00:39:11,270 --> 00:39:09,920
at a desk at nasa or in my home during a

1147
00:39:14,790 --> 00:39:11,280
pandemic either

1148
00:39:18,470 --> 00:39:14,800
um and i just want to say

1149
00:39:20,550 --> 00:39:18,480
that uh sometimes i get quite apathetic

1150
00:39:23,510 --> 00:39:20,560
about the research and that's because

1151
00:39:24,710 --> 00:39:23,520
the research is only useful if we can

1152
00:39:26,950 --> 00:39:24,720
act on it and

1153
00:39:28,550 --> 00:39:26,960
we don't need any more research to know

1154
00:39:30,230 --> 00:39:28,560
the actions that we should take and the

1155
00:39:30,950 --> 00:39:30,240
action is is simply that we need to

1156
00:39:33,510 --> 00:39:30,960
start

1157
00:39:35,270 --> 00:39:33,520
taking climate change very seriously uh

1158
00:39:37,750 --> 00:39:35,280
and we need to start acting now

1159
00:39:38,390 --> 00:39:37,760
uh and we need to act collectively and

1160
00:39:40,470 --> 00:39:38,400
so

1161
00:39:42,150 --> 00:39:40,480
it's these kiddos in the picture here my

1162
00:39:45,190 --> 00:39:42,160
lovely daughter

1163
00:39:47,109 --> 00:39:45,200

and my wonderful son that

1164
00:39:48,950 --> 00:39:47,119
when i have their picture on my desk i

1165
00:39:51,670 --> 00:39:48,960
just think that

1166
00:39:52,870 --> 00:39:51,680
we really need to focus our attention on

1167
00:39:54,950 --> 00:39:52,880
making right by them

1168
00:39:56,870 --> 00:39:54,960
and rising to the occasion we've done it

1169
00:39:58,390 --> 00:39:56,880
before we've put a man on the moon

1170
00:40:01,670 --> 00:39:58,400
there's no reason we can arise to this

1171
00:40:06,069 --> 00:40:03,750
incredible sentiment to leave us on so

1172
00:40:08,230 --> 00:40:06,079
that's all the time we have for today

1173
00:40:10,069 --> 00:40:08,240
join us next month for our lecture

1174
00:40:12,150 --> 00:40:10,079
entitled space cameras a

1175
00:40:14,470 --> 00:40:12,160
sharper image i want to thank our

1176
00:40:16,630 --> 00:40:14,480
speaker alex gardner for joining us

1177
00:40:17,670 --> 00:40:16,640
and discussing this very urgent topic

1178
00:40:21,030 --> 00:40:17,680
thank you

1179
00:40:23,510 --> 00:40:21,040
questions co-host jocelyn

1180
00:40:25,589 --> 00:40:23,520
arketta and everyone working behind the

1181
00:40:27,109 --> 00:40:25,599
scenes to make this all possible

1182
00:40:28,790 --> 00:40:27,119
to all of you watching thank you for

1183
00:40:29,750 --> 00:40:28,800
taking the time to join us each and

1184
00:40:31,190 --> 00:40:29,760
every month

1185
00:40:33,270 --> 00:40:31,200
if you've missed one or would like to

1186
00:40:34,550 --> 00:40:33,280
revisit any of our von carmen talks from

1187
00:40:37,670 --> 00:40:34,560
the past five years

1188
00:40:39,829 --> 00:40:37,680

they are available on jpl's youtube page

1189
00:40:52,670 --> 00:40:39,839
be well have a wonderful evening and

1190
00:41:08,710 --> 00:40:52,680
we'll see you in may