
Josh Willis
NASA Climate Scientist

1
00:00:12,950 --> 00:00:11,350
nasa's jet propulsion laboratory

2
00:00:15,669 --> 00:00:12,960
presents

3
00:00:17,590 --> 00:00:15,679
the von carmen lecture a series of talks

4
00:00:20,950 --> 00:00:17,600
by scientists and engineers who are

5
00:00:34,389 --> 00:00:20,960
exploring our planet our solar system

6
00:00:38,310 --> 00:00:36,310
hey good evening ladies and gentlemen

7
00:00:39,830 --> 00:00:38,320
how's everyone tonight

8
00:00:41,270 --> 00:00:39,840
good well thanks for coming out to join

9
00:00:43,270 --> 00:00:41,280
us this evening

10
00:00:45,270 --> 00:00:43,280
as humans drive earth's climate into a

11
00:00:47,270 --> 00:00:45,280
new regime it is critical to keep our

12
00:00:49,430 --> 00:00:47,280
fingers on the pulse of the planet

13
00:00:51,190 --> 00:00:49,440

sea level rise is both a stark reminder

14
00:00:52,790 --> 00:00:51,200
of our impact on the climate and its

15
00:00:54,790 --> 00:00:52,800
impact on us

16
00:00:56,869 --> 00:00:54,800
the oceans capture over 90 percent of

17
00:00:59,430 --> 00:00:56,879
the heat trapped by greenhouse gases

18
00:01:01,189 --> 00:00:59,440
expanding as they warm they also collect

19
00:01:03,510 --> 00:01:01,199
water from melting glaciers and ice

20
00:01:05,750 --> 00:01:03,520
sheets making sea level rise a doubly

21
00:01:07,910 --> 00:01:05,760
important indicator of global warming

22
00:01:10,830 --> 00:01:07,920
without adaptation a two meter rise

23
00:01:12,870 --> 00:01:10,840
would displace 187 million people

24
00:01:13,990 --> 00:01:12,880
worldwide sea level will continue to

25
00:01:15,910 --> 00:01:14,000
rise

26
00:01:17,749 --> 00:01:15,920
but we don't know how fast

27
00:01:19,670 --> 00:01:17,759
like its predecessors the jason-3

28
00:01:21,190 --> 00:01:19,680
mission will serve as our eyes on sea

29
00:01:23,190 --> 00:01:21,200
level rise

30
00:01:24,950 --> 00:01:23,200
measuring global sea level once every 10

31
00:01:26,870 --> 00:01:24,960
days it will chart out the global rise

32
00:01:29,350 --> 00:01:26,880
of the oceans a rise that is unlikely to

33
00:01:31,990 --> 00:01:29,360
subside or reverse for generations

34
00:01:34,149 --> 00:01:32,000
but jason 3 will be more than a senten a

35
00:01:35,670 --> 00:01:34,159
sentinel of climate change as it will

36
00:01:37,429 --> 00:01:35,680
also measure the tilt of the ocean's

37
00:01:39,590 --> 00:01:37,439
surface providing oceanographers with

38
00:01:41,109 --> 00:01:39,600

information about ocean currents

39
00:01:43,510 --> 00:01:41,119
measure wind and waves helping

40
00:01:45,670 --> 00:01:43,520
forecasters predict marine weather and

41
00:01:48,310 --> 00:01:45,680
even find local warm spots

42
00:01:50,789 --> 00:01:48,320
that can intensify hurricanes in short

43
00:01:52,830 --> 00:01:50,799
jason 3 will be pretty cool

44
00:01:55,350 --> 00:01:52,840
our guest tonight has been at jpl since

45
00:01:57,190 --> 00:01:55,360
2004 and is now the nasa project

46
00:01:58,709 --> 00:01:57,200
scientist for the soon to be launched

47
00:02:00,789 --> 00:01:58,719
jason 3 mission

48
00:02:02,630 --> 00:02:00,799
in 2010 he was awarded a presidential

49
00:02:04,870 --> 00:02:02,640
early career award for scientists and

50
00:02:06,630 --> 00:02:04,880
engineers by president obama for his

51
00:02:08,949 --> 00:02:06,640
pioneering research on understanding the

52
00:02:10,790 --> 00:02:08,959
causes of sea level rise and the ocean's

53
00:02:13,270 --> 00:02:10,800
role in a warming climate

54
00:02:16,869 --> 00:02:13,280
most recently his project ocean's

55
00:02:18,790 --> 00:02:16,879
melting greenland or omg for short

56
00:02:20,710 --> 00:02:18,800
was selected by nasa as an earth

57
00:02:22,470 --> 00:02:20,720
ventures mission to study how the oceans

58
00:02:23,510 --> 00:02:22,480
are melting the greenland ice sheet from

59
00:02:25,589 --> 00:02:23,520
below

60
00:02:27,830 --> 00:02:25,599
in his spare time he studies comedy and

61
00:02:29,589 --> 00:02:27,840
improvisational theater last year he

62
00:02:31,350 --> 00:02:29,599
graduated from the second city improv

63
00:02:32,949 --> 00:02:31,360

program in hollywood we learned to

64
00:02:34,150 --> 00:02:32,959
communicate about climate change through

65
00:02:36,150 --> 00:02:34,160
comedy

66
00:02:38,550 --> 00:02:36,160
despite his love of laughter though he

67
00:02:39,910 --> 00:02:38,560
has not yet quit his day job

68
00:02:41,110 --> 00:02:39,920
ladies and gentlemen please help me

69
00:02:45,750 --> 00:02:41,120
welcome tonight's guest and a good

70
00:02:45,760 --> 00:02:50,550
thanks

71
00:02:53,990 --> 00:02:52,630
wow thank you mark that was uh

72
00:02:57,030 --> 00:02:54,000
incredibly

73
00:03:00,229 --> 00:02:57,040
erudite and well written um

74
00:03:01,670 --> 00:03:00,239
so i just will end there uh

75
00:03:03,750 --> 00:03:01,680
see you guys

76
00:03:05,509 --> 00:03:03,760
no i really appreciate the uh the warm

77
00:03:06,790 --> 00:03:05,519
welcome and i really appreciate

78
00:03:09,110 --> 00:03:06,800
everybody coming out tonight and

79
00:03:12,390 --> 00:03:09,120
everybody who's watching us streaming on

80
00:03:16,070 --> 00:03:12,400
the interwebs and uh on nasa tv when it

81
00:03:17,430 --> 00:03:16,080
airs tomorrow night uh so uh why am i

82
00:03:21,430 --> 00:03:17,440
here

83
00:03:24,070 --> 00:03:21,440
which is

84
00:03:25,270 --> 00:03:24,080
the successor to the successor to the

85
00:03:27,670 --> 00:03:25,280
successor

86
00:03:29,670 --> 00:03:27,680
to the mission that got me my phd back

87
00:03:32,149 --> 00:03:29,680
in graduate school and that mission was

88
00:03:33,350 --> 00:03:32,159

called topex poseidon and it was our

89
00:03:35,990 --> 00:03:33,360
very first

90
00:03:37,830 --> 00:03:36,000
look at the oceans from space in a way

91
00:03:39,509 --> 00:03:37,840
that we could really measure them well

92
00:03:41,190 --> 00:03:39,519
enough to tell us something incredibly

93
00:03:42,390 --> 00:03:41,200
useful to oceanographers and i'll talk a

94
00:03:43,350 --> 00:03:42,400
little bit more about that as we go

95
00:03:45,350 --> 00:03:43,360
along

96
00:03:46,869 --> 00:03:45,360
but i also want to really drive home the

97
00:03:49,910 --> 00:03:46,879
theme tonight

98
00:03:52,229 --> 00:03:49,920
that this is one of the fundamental ways

99
00:03:55,270 --> 00:03:52,239
in which we measure human-caused climate

100
00:03:56,869 --> 00:03:55,280
change or global warming really

101
00:03:59,910 --> 00:03:56,879
two-thirds of the planet are covered

102
00:04:02,390 --> 00:03:59,920
with ocean and as we look at our

103
00:04:04,229 --> 00:04:02,400
changing climate and our changing planet

104
00:04:06,070 --> 00:04:04,239
uh really we need to be looking to the

105
00:04:06,949 --> 00:04:06,080
oceans because that's where the action

106
00:04:09,110 --> 00:04:06,959
is

107
00:04:10,789 --> 00:04:09,120
so uh you guys look like a really nice

108
00:04:12,550 --> 00:04:10,799
crowd so hopefully i'm not gonna say

109
00:04:14,070 --> 00:04:12,560
anything uh that will get me beat up

110
00:04:15,990 --> 00:04:14,080
later

111
00:04:19,189 --> 00:04:16,000
i ask you know because

112
00:04:23,909 --> 00:04:20,629
so i am going to say global warming is

113
00:04:25,990 --> 00:04:23,919

real so so please don't beat me up

114
00:04:28,070 --> 00:04:26,000
and i want to start off with this slide

115
00:04:29,909 --> 00:04:28,080
i like to start with this slide because

116
00:04:31,350 --> 00:04:29,919
it's a reminder of just how big the

117
00:04:33,909 --> 00:04:31,360
oceans are

118
00:04:36,310 --> 00:04:33,919
the pacific ocean covers about one third

119
00:04:38,390 --> 00:04:36,320
of the planet's surface all by itself if

120
00:04:40,390 --> 00:04:38,400
you were to rotate this globe just a

121
00:04:42,550 --> 00:04:40,400
little bit to the east and look at it

122
00:04:45,270 --> 00:04:42,560
from this same view almost the only

123
00:04:47,110 --> 00:04:45,280
thing you would see is the pacific ocean

124
00:04:48,469 --> 00:04:47,120
the oceans cover two-thirds of our

125
00:04:50,469 --> 00:04:48,479
planet's surface

126
00:04:54,710 --> 00:04:50,479
and they play an incredibly important

127
00:04:57,030 --> 00:04:54,720
role in our overall changing climate so

128
00:04:59,590 --> 00:04:57,040
in this sense um you might not be

129
00:05:01,590 --> 00:04:59,600
surprised that it's an ocean mission

130
00:05:05,110 --> 00:05:01,600
that's really measuring uh the most

131
00:05:07,990 --> 00:05:05,120
fundamental aspect of climate change

132
00:05:10,550 --> 00:05:08,000
so uh as uh mark kind of set up a little

133
00:05:13,029 --> 00:05:10,560
bit here uh this is the uh

134
00:05:15,749 --> 00:05:13,039
actual fourth mission in a long line of

135
00:05:17,110 --> 00:05:15,759
missions that have measured sea level

136
00:05:18,710 --> 00:05:17,120
from space

137
00:05:20,629 --> 00:05:18,720
starting with topex poseidon which was

138
00:05:23,270 --> 00:05:20,639

launched in 1992

139
00:05:26,469 --> 00:05:23,280
jason won in 2001 and this graphics a

140
00:05:29,110 --> 00:05:26,479
little old actually we lost jason one

141
00:05:30,550 --> 00:05:29,120
just a little under two years ago

142
00:05:33,029 --> 00:05:30,560
and jason two which is still in

143
00:05:35,029 --> 00:05:33,039
operation and of course jason three

144
00:05:37,830 --> 00:05:35,039
which we hope to launch this summer uh

145
00:05:39,510 --> 00:05:37,840
if all goes well

146
00:05:41,029 --> 00:05:39,520
why do we need to keep measuring the

147
00:05:43,830 --> 00:05:41,039
oceans like this

148
00:05:45,270 --> 00:05:43,840
uh well if we take a look at how jason

149
00:05:47,590 --> 00:05:45,280
works just to give you kind of a

150
00:05:49,590 --> 00:05:47,600
fundamental idea of what's going on with

151
00:05:51,510 --> 00:05:49,600
this satellite it looks something like

152
00:05:53,350 --> 00:05:51,520
this and in a sense it's one of the

153
00:05:55,189 --> 00:05:53,360
simplest measurements we can make from

154
00:05:57,510 --> 00:05:55,199
space it doesn't require a whole lot of

155
00:05:58,790 --> 00:05:57,520
interpretation or guesswork to kind of

156
00:06:01,029 --> 00:05:58,800
figure out what it is you're really

157
00:06:03,110 --> 00:06:01,039
measuring all you do is you bounce a

158
00:06:05,830 --> 00:06:03,120
radar wave off the surface of the ocean

159
00:06:07,830 --> 00:06:05,840
from your satellite so we shoot a radar

160
00:06:09,510 --> 00:06:07,840
wave down it comes back up

161
00:06:11,350 --> 00:06:09,520
it travels through the atmosphere and

162
00:06:13,510 --> 00:06:11,360
the ionosphere and some other things and

163
00:06:16,309 --> 00:06:13,520

we have to do some corrections in order

164
00:06:17,749 --> 00:06:16,319
to uh in order to understand this real

165
00:06:19,430 --> 00:06:17,759
distance but essentially we're just

166
00:06:20,629 --> 00:06:19,440
measuring how long it takes for this

167
00:06:22,629 --> 00:06:20,639
wave

168
00:06:24,950 --> 00:06:22,639
of electromagnetic energy essentially a

169
00:06:26,230 --> 00:06:24,960
radio wave to go down to the surface of

170
00:06:28,309 --> 00:06:26,240
the earth and

171
00:06:30,150 --> 00:06:28,319
come back up and that tells us the

172
00:06:31,590 --> 00:06:30,160
distance between the satellite and the

173
00:06:34,390 --> 00:06:31,600
surface of the ocean

174
00:06:36,870 --> 00:06:34,400
so if we know where the satellite is

175
00:06:39,430 --> 00:06:36,880
then we can figure out how tall the

176
00:06:41,430 --> 00:06:39,440
ocean is and essentially this

177
00:06:42,309 --> 00:06:41,440
mission flies about 800 miles out in

178
00:06:45,029 --> 00:06:42,319
space

179
00:06:48,309 --> 00:06:45,039
and it can measure the accuracy of about

180
00:06:49,590 --> 00:06:48,319
a 10 kilometer square on the ocean it

181
00:06:51,909 --> 00:06:49,600
can measure the sea level with an

182
00:06:54,309 --> 00:06:51,919
accuracy of about one inch from 800

183
00:06:55,110 --> 00:06:54,319
miles up so it's really an amazing piece

184
00:06:57,510 --> 00:06:55,120
of

185
00:06:59,909 --> 00:06:57,520
engineering and an amazing technological

186
00:07:00,790 --> 00:06:59,919
feat and when you do this

187
00:07:02,870 --> 00:07:00,800
once

188
00:07:05,110 --> 00:07:02,880

every few every second really for 10

189
00:07:08,150 --> 00:07:05,120
days you cover the entire surface of the

190
00:07:10,629 --> 00:07:08,160
earth earth's oceans uh or almost the

191
00:07:13,029 --> 00:07:10,639
entire surface once every 10 days you

192
00:07:14,710 --> 00:07:13,039
can see not only changes in the ocean

193
00:07:16,790 --> 00:07:14,720
that have to do with changes in ocean

194
00:07:18,870 --> 00:07:16,800
currents but you can also also see the

195
00:07:19,990 --> 00:07:18,880
increasing volume of the ocean as a

196
00:07:21,670 --> 00:07:20,000
whole

197
00:07:23,510 --> 00:07:21,680
so this is the way in which it really is

198
00:07:25,189 --> 00:07:23,520
one of the most fundamental tools for

199
00:07:27,990 --> 00:07:25,199
measuring climate change

200
00:07:29,189 --> 00:07:28,000
so uh uh just to give you an idea uh you

201
00:07:31,189 --> 00:07:29,199
know we keep talking about ocean

202
00:07:33,270 --> 00:07:31,199
currents and essentially whenever a

203
00:07:36,150 --> 00:07:33,280
large current happens in the ocean and

204
00:07:38,390 --> 00:07:36,160
it persists for several days or weeks

205
00:07:40,469 --> 00:07:38,400
then it literally tilts the surface of

206
00:07:41,909 --> 00:07:40,479
the ocean and we can measure that tilt

207
00:07:43,830 --> 00:07:41,919
with this satellite we can figure out

208
00:07:45,430 --> 00:07:43,840
what the currents are and how they're

209
00:07:46,710 --> 00:07:45,440
changing especially

210
00:07:48,629 --> 00:07:46,720
but when you average over the whole

211
00:07:49,830 --> 00:07:48,639
planet you really see this other signal

212
00:07:51,350 --> 00:07:49,840
which i'll talk more about as we go

213
00:07:52,390 --> 00:07:51,360

along

214
00:07:53,990 --> 00:07:52,400
now

215
00:07:59,110 --> 00:07:54,000
the

216
00:08:01,029 --> 00:07:59,120
all kinds of important uses and in april

217
00:08:03,189 --> 00:08:01,039
of 2010

218
00:08:04,390 --> 00:08:03,199
there was an explosion aboard the

219
00:08:07,670 --> 00:08:04,400
deepwater

220
00:08:10,390 --> 00:08:07,680
horizon oil rig in the gulf of mexico

221
00:08:13,430 --> 00:08:10,400
11 people were killed during the

222
00:08:15,909 --> 00:08:13,440
eventual sinking of this uh of this

223
00:08:18,710 --> 00:08:15,919
platform and many others were injured

224
00:08:21,029 --> 00:08:18,720
and eventually uh the platform uh was

225
00:08:22,790 --> 00:08:21,039
lost completely and

226
00:08:25,510 --> 00:08:22,800
the well it had been drilling began to

227
00:08:26,390 --> 00:08:25,520
spew oil into the gulf of mexico

228
00:08:28,710 --> 00:08:26,400
and

229
00:08:30,550 --> 00:08:28,720
it was because of satellites like the

230
00:08:32,709 --> 00:08:30,560
jason missions that we were really able

231
00:08:35,350 --> 00:08:32,719
to understand and predict

232
00:08:36,870 --> 00:08:35,360
the currents that would carry this oil

233
00:08:38,870 --> 00:08:36,880
around in the gulf stream eventually

234
00:08:41,029 --> 00:08:38,880
mixing it up and dispersing it

235
00:08:42,070 --> 00:08:41,039
some of it eventually probably even left

236
00:08:42,949 --> 00:08:42,080
the gulf

237
00:08:44,630 --> 00:08:42,959
through

238
00:08:46,310 --> 00:08:44,640

the gulf stream which runs around the

239
00:08:48,070 --> 00:08:46,320
southern tip of florida and heads out

240
00:08:50,150 --> 00:08:48,080
into the atlantic ocean

241
00:08:51,990 --> 00:08:50,160
so this is really an incredibly powerful

242
00:08:54,870 --> 00:08:52,000
tool for for understanding ocean

243
00:08:57,110 --> 00:08:54,880
currents and the json mission both one

244
00:08:59,030 --> 00:08:57,120
and two were in operation at this time

245
00:09:00,230 --> 00:08:59,040
and another satellite which measures sea

246
00:09:01,509 --> 00:09:00,240
surface height but in a slightly

247
00:09:04,389 --> 00:09:01,519
different way

248
00:09:07,110 --> 00:09:04,399
envysat was also used to

249
00:09:08,790 --> 00:09:07,120
map this oil slick so

250
00:09:10,710 --> 00:09:08,800
measuring the ocean currents from space

251
00:09:12,150 --> 00:09:10,720
has long been important to people like

252
00:09:14,790 --> 00:09:12,160
the navy

253
00:09:17,110 --> 00:09:14,800
and and other users of of data that

254
00:09:20,150 --> 00:09:17,120
tells you how the currents are are

255
00:09:21,990 --> 00:09:20,160
moving in the ocean fishermen as well

256
00:09:24,470 --> 00:09:22,000
another thing that measuring how tall

257
00:09:26,550 --> 00:09:24,480
the ocean tells you is how how warm the

258
00:09:30,150 --> 00:09:26,560
water is this is a really fundamental

259
00:09:32,470 --> 00:09:30,160
piece of uh how the oceans change warm

260
00:09:35,269 --> 00:09:32,480
water literally expands

261
00:09:38,389 --> 00:09:35,279
so a blob of warm water in the ocean

262
00:09:39,829 --> 00:09:38,399
stands taller than a blob of cold water

263
00:09:42,389 --> 00:09:39,839

and this is incredibly important for

264
00:09:44,790 --> 00:09:42,399
things like hurricanes which suck their

265
00:09:47,350 --> 00:09:44,800
energy out of the ocean in order to

266
00:09:49,590 --> 00:09:47,360
survive so these massive storms are

267
00:09:51,110 --> 00:09:49,600
skating over the surface of the ocean

268
00:09:54,070 --> 00:09:51,120
sucking up heat out of it and putting it

269
00:09:56,070 --> 00:09:54,080
into the atmosphere and as they do

270
00:09:57,590 --> 00:09:56,080
they mix up the ocean

271
00:10:00,070 --> 00:09:57,600
but what's really amazing about the

272
00:10:01,670 --> 00:10:00,080
satellite altimetry is it tells you not

273
00:10:03,990 --> 00:10:01,680
just that the ocean's warm right at the

274
00:10:07,030 --> 00:10:04,000
surface but that it's warm over depth

275
00:10:10,310 --> 00:10:07,040
too and so uh this is a plot showing the

276
00:10:12,630 --> 00:10:10,320
path of hurricane katrina where um

277
00:10:14,949 --> 00:10:12,640
uh essentially the the hurricane was

278
00:10:16,710 --> 00:10:14,959
fairly small as it had uh passed over

279
00:10:18,949 --> 00:10:16,720
the uh

280
00:10:20,790 --> 00:10:18,959
the southern tip of florida entered the

281
00:10:23,910 --> 00:10:20,800
gulf and as it started to turn north it

282
00:10:27,350 --> 00:10:23,920
hit this huge blob of warm water that

283
00:10:29,509 --> 00:10:27,360
was a giant eddy uh and this pool of

284
00:10:32,470 --> 00:10:29,519
warm water fueled it into the category

285
00:10:34,150 --> 00:10:32,480
four and eventually five hurricane which

286
00:10:36,310 --> 00:10:34,160
you which sped up and eventually made

287
00:10:38,870 --> 00:10:36,320
landfall very close to new orleans as

288
00:10:40,230 --> 00:10:38,880

you all know with disastrous results but

289
00:10:41,910 --> 00:10:40,240
if you only looked at the surface

290
00:10:44,470 --> 00:10:41,920
temperature of the oceans you wouldn't

291
00:10:46,389 --> 00:10:44,480
have been able to tell why the hurricane

292
00:10:49,509 --> 00:10:46,399
sped up right as it went across this big

293
00:10:52,550 --> 00:10:49,519
blob of warm water so it turns out that

294
00:10:54,550 --> 00:10:52,560
satellite altimeters also tell us about

295
00:10:56,790 --> 00:10:54,560
hurricanes and and how and where they

296
00:10:58,790 --> 00:10:56,800
might speed up due to the presence of

297
00:11:01,910 --> 00:10:58,800
extra warm water that's really hidden

298
00:11:05,910 --> 00:11:04,150
another trick that we can do with our

299
00:11:08,230 --> 00:11:05,920
altimeter data you know i said at the

300
00:11:10,710 --> 00:11:08,240
beginning that this is a follow-on

301
00:11:11,829 --> 00:11:10,720
mission to a series of satellites that's

302
00:11:14,150 --> 00:11:11,839
been flying

303
00:11:15,590 --> 00:11:14,160
since the early 90s so we now have over

304
00:11:17,910 --> 00:11:15,600
20 years

305
00:11:19,829 --> 00:11:17,920
of an incredibly accurate record of how

306
00:11:21,190 --> 00:11:19,839
the sea levels have changed all around

307
00:11:22,870 --> 00:11:21,200
the world

308
00:11:24,949 --> 00:11:22,880
and what's interesting is that we're

309
00:11:25,670 --> 00:11:24,959
slowly now starting to be able to tease

310
00:11:28,389 --> 00:11:25,680
out

311
00:11:31,910 --> 00:11:28,399
the part of sea level change

312
00:11:34,069 --> 00:11:31,920
local sea level change that's caused by

313
00:11:36,069 --> 00:11:34,079

human-caused climate change from the

314
00:11:37,910 --> 00:11:36,079
kind of natural fluctuations that happen

315
00:11:40,310 --> 00:11:37,920
in the ocean now if we look at the ocean

316
00:11:42,389 --> 00:11:40,320
as a whole if we average over the entire

317
00:11:45,030 --> 00:11:42,399
planet it's easy to see the human-caused

318
00:11:47,590 --> 00:11:45,040
component the long-term trend of global

319
00:11:49,910 --> 00:11:47,600
warming but if you look locally it can

320
00:11:51,910 --> 00:11:49,920
be swamped for a period of 20 years or

321
00:11:53,990 --> 00:11:51,920
so as a matter of fact on our coast

322
00:11:56,150 --> 00:11:54,000
right here in southern california we've

323
00:11:59,350 --> 00:11:56,160
had almost zero sea level rise for the

324
00:12:02,069 --> 00:11:59,360
last 20 years that's despite the fact

325
00:12:03,750 --> 00:12:02,079
that the entire planet has seen a couple

326
00:12:05,750 --> 00:12:03,760
inches of sea level rise

327
00:12:07,590 --> 00:12:05,760
so where did our sea level rise go well

328
00:12:09,350 --> 00:12:07,600
it turns out it went into the western

329
00:12:11,829 --> 00:12:09,360
pacific ocean

330
00:12:14,629 --> 00:12:11,839
due to a sort of natural cycle which we

331
00:12:16,629 --> 00:12:14,639
call the pacific decadal oscillation and

332
00:12:19,509 --> 00:12:16,639
finally now that we have this 20-year

333
00:12:22,310 --> 00:12:19,519
record of how the ocean levels are

334
00:12:24,550 --> 00:12:22,320
changing we can begin to tease apart the

335
00:12:25,509 --> 00:12:24,560
natural cycle which looks something like

336
00:12:28,870 --> 00:12:25,519
this

337
00:12:30,949 --> 00:12:28,880
from the part that's caused by uh that's

338
00:12:33,509 --> 00:12:30,959

really driven by human-caused climate

339
00:12:35,910 --> 00:12:33,519
change so this is a very recent study

340
00:12:37,829 --> 00:12:35,920
which was really exciting because it was

341
00:12:39,430 --> 00:12:37,839
the first one to really say look some of

342
00:12:41,190 --> 00:12:39,440
this warming in the western pacific

343
00:12:44,069 --> 00:12:41,200
which we used to think was just a

344
00:12:45,590 --> 00:12:44,079
natural cycle and would eventually

345
00:12:47,670 --> 00:12:45,600
cool back down

346
00:12:49,190 --> 00:12:47,680
maybe kind of permanent it may stick

347
00:12:51,509 --> 00:12:49,200
around and if we look in our climate

348
00:12:53,829 --> 00:12:51,519
models we see very similar patterns

349
00:12:56,310 --> 00:12:53,839
to where these things are warming so so

350
00:12:57,750 --> 00:12:56,320
this altimeter data is really helping us

351
00:13:01,110 --> 00:12:57,760
tease apart

352
00:13:02,389 --> 00:13:01,120
the human caused changes in our oceans

353
00:13:03,509 --> 00:13:02,399
from the

354
00:13:05,350 --> 00:13:03,519
kind of

355
00:13:07,509 --> 00:13:05,360
natural cycles that have always been

356
00:13:09,190 --> 00:13:07,519
there and will continue to be there so

357
00:13:10,949 --> 00:13:09,200
it's really an incredibly powerful data

358
00:13:13,030 --> 00:13:10,959
set and there's one last quick result i

359
00:13:13,910 --> 00:13:13,040
want to show you that's sort of new and

360
00:13:15,910 --> 00:13:13,920
fun

361
00:13:18,150 --> 00:13:15,920
i've been working with my colleague

362
00:13:20,790 --> 00:13:18,160
veronica neves to

363
00:13:23,430 --> 00:13:20,800

look at the recent global warming hiatus

364
00:13:24,790 --> 00:13:23,440
as it's been called now uh you may have

365
00:13:26,230 --> 00:13:24,800
heard something about this in the news

366
00:13:28,710 --> 00:13:26,240
scientists have been kind of puzzling

367
00:13:31,350 --> 00:13:28,720
over what's going on with uh global

368
00:13:33,350 --> 00:13:31,360
warming in the last 10 or 20 years um

369
00:13:34,389 --> 00:13:33,360
and it turns out that's actually a

370
00:13:35,990 --> 00:13:34,399
misnomer

371
00:13:38,470 --> 00:13:36,000
you shouldn't really be calling it the

372
00:13:41,030 --> 00:13:38,480
global warming hiatus because if we look

373
00:13:43,030 --> 00:13:41,040
at the surface temperature in the last

374
00:13:45,110 --> 00:13:43,040
20 years

375
00:13:48,550 --> 00:13:45,120
it was rising pretty fast in the 80s and

376
00:13:50,150 --> 00:13:48,560
90s and then in the last decade

377
00:13:51,350 --> 00:13:50,160
global surface temperature kind of

378
00:13:53,269 --> 00:13:51,360
flattened out

379
00:13:55,269 --> 00:13:53,279
and we didn't have a very fast rise in

380
00:13:57,189 --> 00:13:55,279
global surface temperature

381
00:13:58,949 --> 00:13:57,199
and it turns out if you look at the

382
00:14:01,269 --> 00:13:58,959
different places in the ocean that are

383
00:14:02,870 --> 00:14:01,279
either warming or cooling in the pacific

384
00:14:05,350 --> 00:14:02,880
ocean right at the surface we've had

385
00:14:07,670 --> 00:14:05,360
this enormous cooling

386
00:14:10,069 --> 00:14:07,680
so you know what's going on this cooling

387
00:14:12,870 --> 00:14:10,079
was big enough to kind of hide the

388
00:14:14,629 --> 00:14:12,880

increase in global surface temperature

389
00:14:16,389 --> 00:14:14,639
for the last 10 years

390
00:14:18,629 --> 00:14:16,399
um but

391
00:14:20,310 --> 00:14:18,639
as i probably already mentioned as we'll

392
00:14:22,710 --> 00:14:20,320
get to in a little bit

393
00:14:24,550 --> 00:14:22,720
global warming didn't really stop

394
00:14:28,150 --> 00:14:24,560
the surface temperature stopped

395
00:14:30,310 --> 00:14:28,160
increasing but the warming as a whole

396
00:14:31,590 --> 00:14:30,320
continued and it turns out that even

397
00:14:33,590 --> 00:14:31,600
though there wasn't much warming at the

398
00:14:35,750 --> 00:14:33,600
surface there was a lot of warming going

399
00:14:38,470 --> 00:14:35,760
on just below the surface in the pacific

400
00:14:41,590 --> 00:14:38,480
so a lot of this heat was hiding in what

401
00:14:44,470 --> 00:14:41,600
we call the pacific warm pool so really

402
00:14:46,470 --> 00:14:44,480
there is no hiatus in global warming

403
00:14:47,750 --> 00:14:46,480
there was a bit of a hiatus in surface

404
00:14:49,910 --> 00:14:47,760
temperature

405
00:14:51,750 --> 00:14:49,920
but in terms of global warming we're

406
00:14:54,550 --> 00:14:51,760
still chugging right along as you'll see

407
00:14:56,150 --> 00:14:54,560
in some slides a little bit later

408
00:14:57,350 --> 00:14:56,160
so you know i want to talk about global

409
00:14:58,870 --> 00:14:57,360
warming but you can't really talk about

410
00:15:00,790 --> 00:14:58,880
global warming without talking about the

411
00:15:02,389 --> 00:15:00,800
weather a little bit and it's important

412
00:15:04,470 --> 00:15:02,399
to remember that the weather is

413
00:15:07,030 --> 00:15:04,480

different than climate so you know right

414
00:15:08,949 --> 00:15:07,040
now we're having a heat wave it's hot

415
00:15:10,870 --> 00:15:08,959
you know i got in my car

416
00:15:13,269 --> 00:15:10,880
on the lab this afternoon and the little

417
00:15:14,230 --> 00:15:13,279
thermometer read 91 degrees

418
00:15:15,509 --> 00:15:14,240
so

419
00:15:17,910 --> 00:15:15,519
it's been a heatwave we've had a little

420
00:15:19,670 --> 00:15:17,920
mini heat wave here in in california and

421
00:15:22,710 --> 00:15:19,680
of course on the east coast they're

422
00:15:24,230 --> 00:15:22,720
getting blasted with huge snowstorms

423
00:15:25,670 --> 00:15:24,240
but you got to remember that not

424
00:15:28,230 --> 00:15:25,680
everything

425
00:15:30,710 --> 00:15:28,240
is related to global warming we get

426
00:15:32,230 --> 00:15:30,720
these warm spells and cold spells and

427
00:15:34,629 --> 00:15:32,240
they come and go and this is just part

428
00:15:37,269 --> 00:15:34,639
of the natural weather that we've had

429
00:15:38,710 --> 00:15:37,279
for for decades for millennia

430
00:15:41,509 --> 00:15:38,720
so you know

431
00:15:43,189 --> 00:15:41,519
sometimes we try and we go wait uh

432
00:15:45,269 --> 00:15:43,199
tonight's lecture is cancelled on global

433
00:15:46,949 --> 00:15:45,279
warming because we're snowed out right

434
00:15:48,949 --> 00:15:46,959
so global warming must not be real but

435
00:15:51,189 --> 00:15:48,959
but hold on you know you got to remember

436
00:15:52,949 --> 00:15:51,199
this is really a weather phenomenon it's

437
00:15:54,389 --> 00:15:52,959
not a climate phenomenon this is

438
00:15:56,389 --> 00:15:54,399

something that comes and goes in the

439
00:15:59,030 --> 00:15:56,399
matter of a week or two

440
00:16:00,790 --> 00:15:59,040
and it can take us on an awful wild ride

441
00:16:02,230 --> 00:16:00,800
but it's really not human-caused climate

442
00:16:03,749 --> 00:16:02,240
change it's important to keep that in

443
00:16:05,749 --> 00:16:03,759
mind

444
00:16:09,030 --> 00:16:05,759
the climate you could define as the

445
00:16:12,470 --> 00:16:09,040
long-term usual weather conditions of an

446
00:16:14,150 --> 00:16:12,480
area a country or a planet so

447
00:16:15,749 --> 00:16:14,160
you have to keep in mind that climate is

448
00:16:18,470 --> 00:16:15,759
something that changes over the course

449
00:16:20,230 --> 00:16:18,480
of decades or a century

450
00:16:22,710 --> 00:16:20,240
but not two weeks

451
00:16:24,550 --> 00:16:22,720
that's not climate change

452
00:16:26,389 --> 00:16:24,560
but what is climate change when i talk

453
00:16:28,069 --> 00:16:26,399
about global warming we often look at

454
00:16:31,829 --> 00:16:28,079
this curve this is the temperature curve

455
00:16:33,910 --> 00:16:31,839
for the last 120 or 30 years

456
00:16:36,069 --> 00:16:33,920
and it's the surface temperature this is

457
00:16:37,829 --> 00:16:36,079
again how the surface temperature has

458
00:16:39,910 --> 00:16:37,839
changed and you can see right at the end

459
00:16:41,350 --> 00:16:39,920
of this this is not a this is not

460
00:16:43,910 --> 00:16:41,360
totally up to date but right at the end

461
00:16:45,430 --> 00:16:43,920
here's our hiatus right this tiny little

462
00:16:46,230 --> 00:16:45,440
flat plateau

463
00:16:47,590 --> 00:16:46,240

but

464
00:16:48,870 --> 00:16:47,600
what's global warming well global

465
00:16:50,790 --> 00:16:48,880
warming is this

466
00:16:52,949 --> 00:16:50,800
degree and a half fahrenheit of increase

467
00:16:55,829 --> 00:16:52,959
that we've seen over the last 100 years

468
00:16:58,310 --> 00:16:55,839
and that's actually not stopping

469
00:16:59,590 --> 00:16:58,320
if uh if we look at at climate change

470
00:17:02,790 --> 00:16:59,600
and global warming and kind of the

471
00:17:05,110 --> 00:17:02,800
context of the last 10 000 years it

472
00:17:07,189 --> 00:17:05,120
really brings to light why this is such

473
00:17:09,429 --> 00:17:07,199
an important issue and one we we can't

474
00:17:11,029 --> 00:17:09,439
really afford to just ignore

475
00:17:13,350 --> 00:17:11,039
or blow off

476
00:17:15,909 --> 00:17:13,360
for the last 10 000 years

477
00:17:17,510 --> 00:17:15,919
human beings have enjoyed a very stable

478
00:17:19,590 --> 00:17:17,520
climate

479
00:17:21,750 --> 00:17:19,600
prior to this

480
00:17:23,110 --> 00:17:21,760
people were more or less evolved into

481
00:17:25,189 --> 00:17:23,120
what they are today

482
00:17:28,230 --> 00:17:25,199
but we were nomadic we would

483
00:17:30,630 --> 00:17:28,240
not settle in single places and

484
00:17:33,190 --> 00:17:30,640
farming was not really developed until

485
00:17:35,350 --> 00:17:33,200
the climate stabilized about 10 000

486
00:17:37,830 --> 00:17:35,360
years ago and it stabilized into this

487
00:17:39,750 --> 00:17:37,840
relatively warm climate now that's not

488
00:17:41,750 --> 00:17:39,760

to say nothing was going on in terms of

489
00:17:44,630 --> 00:17:41,760
climate you guys might have heard about

490
00:17:46,630 --> 00:17:44,640
the little ice age uh well

491
00:17:48,310 --> 00:17:46,640
the little ice age followed what was

492
00:17:50,230 --> 00:17:48,320
called the medieval warm period which

493
00:17:52,470 --> 00:17:50,240
was a little warm period right here this

494
00:17:54,070 --> 00:17:52,480
is surface temperature over the last 20

495
00:17:55,909 --> 00:17:54,080
000 years

496
00:17:58,150 --> 00:17:55,919
and the scale gets a little finer as you

497
00:18:00,630 --> 00:17:58,160
go to the right but 20 000 years ago we

498
00:18:01,830 --> 00:18:00,640
were in the middle of an enormous

499
00:18:03,350 --> 00:18:01,840
ice age

500
00:18:04,549 --> 00:18:03,360
excuse me

501
00:18:07,029 --> 00:18:04,559
and this

502
00:18:09,590 --> 00:18:07,039
was a period of time when glaciers

503
00:18:11,830 --> 00:18:09,600
covered much of north america chicago

504
00:18:14,230 --> 00:18:11,840
was buried under two miles of ice

505
00:18:16,230 --> 00:18:14,240
the great lakes were being formed and it

506
00:18:19,270 --> 00:18:16,240
was an incredibly different climate and

507
00:18:20,710 --> 00:18:19,280
human beings didn't really settle down

508
00:18:21,669 --> 00:18:20,720
and begin to

509
00:18:25,029 --> 00:18:21,679
develop

510
00:18:28,630 --> 00:18:25,039
farming techniques and eventually

511
00:18:30,789 --> 00:18:28,640
cities and states and technology and

512
00:18:31,669 --> 00:18:30,799
iphones right we didn't get iphones

513
00:18:34,630 --> 00:18:31,679

until

514
00:18:37,270 --> 00:18:34,640
10 000 years of a stable climate

515
00:18:39,590 --> 00:18:37,280
so if we look out into the future

516
00:18:41,830 --> 00:18:39,600
this was the change out of the last ice

517
00:18:43,750 --> 00:18:41,840
age into the stable period it's about

518
00:18:46,070 --> 00:18:43,760
five degrees celsius in the global

519
00:18:48,789 --> 00:18:46,080
average and what we're looking at in the

520
00:18:50,710 --> 00:18:48,799
next 100 years relatively short time

521
00:18:52,070 --> 00:18:50,720
period compared to the last 10 000 in

522
00:18:54,789 --> 00:18:52,080
the next 100 years we're looking at

523
00:18:58,390 --> 00:18:54,799
something between two and five degrees

524
00:19:00,230 --> 00:18:58,400
celsius of warming so this is a major

525
00:19:02,870 --> 00:19:00,240
change in our climate we're looking at

526
00:19:05,110 --> 00:19:02,880
an incredibly different planet compared

527
00:19:07,029 --> 00:19:05,120
to the one we've had and enjoyed for ten

528
00:19:08,710 --> 00:19:07,039
thousand years the one we've built our

529
00:19:11,350 --> 00:19:08,720
civilization on

530
00:19:13,190 --> 00:19:11,360
so it's a pretty major change now i'm

531
00:19:14,630 --> 00:19:13,200
not saying it's the end of the world

532
00:19:16,789 --> 00:19:14,640
but it's definitely something we're

533
00:19:18,870 --> 00:19:16,799
going to have to deal with

534
00:19:21,510 --> 00:19:18,880
so uh what do you think causes climate

535
00:19:24,710 --> 00:19:23,190
this is the interactive portion so feel

536
00:19:26,789 --> 00:19:24,720
free to

537
00:19:29,270 --> 00:19:26,799
just yell it out

538
00:19:31,669 --> 00:19:29,280

co2 somebody said uh some would say

539
00:19:33,029 --> 00:19:31,679
democrats

540
00:19:36,310 --> 00:19:33,039
um

541
00:19:38,549 --> 00:19:36,320
it's not al gore's fault uh you know

542
00:19:39,669 --> 00:19:38,559
not everybody loves al but uh but you

543
00:19:41,190 --> 00:19:39,679
know it's not his fault that we're

544
00:19:43,830 --> 00:19:41,200
heating up the planet he was really just

545
00:19:45,190 --> 00:19:43,840
the messenger or one of them um but what

546
00:19:48,549 --> 00:19:45,200
what really causes climate change you

547
00:19:50,549 --> 00:19:48,559
guys got it it's co2 um if we look back

548
00:19:53,990 --> 00:19:50,559
over the last hundred thousand years of

549
00:19:56,549 --> 00:19:54,000
the planet's history we see these rises

550
00:19:59,350 --> 00:19:56,559
and falls in co2 and these actually

551
00:20:02,070 --> 00:19:59,360
track the rises and falls in the

552
00:20:02,870 --> 00:20:02,080
temperature of uh the

553
00:20:07,430 --> 00:20:02,880
the

554
00:20:09,029 --> 00:20:07,440
sort of

555
00:20:11,590 --> 00:20:09,039
ten thousand years of warming in a

556
00:20:14,070 --> 00:20:11,600
hundred thousand years of cooling

557
00:20:15,510 --> 00:20:14,080
go back for millions of years and what

558
00:20:17,029 --> 00:20:15,520
had happened was you know we talked

559
00:20:19,590 --> 00:20:17,039
about twenty thousand years ago that was

560
00:20:21,750 --> 00:20:19,600
the end of this last cold period

561
00:20:24,549 --> 00:20:21,760
and then we warmed up out of this

562
00:20:27,350 --> 00:20:24,559
cold period into the holocene that 10

563
00:20:28,870 --> 00:20:27,360

000 years of sweet climate

564
00:20:30,950 --> 00:20:28,880
and now what we're doing is we're

565
00:20:34,390 --> 00:20:30,960
looking at putting carbon dioxide up to

566
00:20:36,070 --> 00:20:34,400
levels that haven't been seen for

567
00:20:37,190 --> 00:20:36,080
hundreds of thousands probably millions

568
00:20:39,110 --> 00:20:37,200
of years

569
00:20:40,390 --> 00:20:39,120
so we're changing our

570
00:20:42,789 --> 00:20:40,400
composition we're changing the

571
00:20:45,270 --> 00:20:42,799
composition of our atmosphere in a way

572
00:20:48,149 --> 00:20:45,280
we've now pushed past the 400 parts per

573
00:20:49,350 --> 00:20:48,159
million mark which is about right here

574
00:20:51,590 --> 00:20:49,360
and we've done it in the last hundred

575
00:20:53,350 --> 00:20:51,600
years so this is a major change in the

576
00:20:55,830 --> 00:20:53,360
composition of our atmosphere now often

577
00:20:57,350 --> 00:20:55,840
people ask me how do you know that and

578
00:20:59,590 --> 00:20:57,360
we have all kinds of techniques i like

579
00:21:00,870 --> 00:20:59,600
to talk a little bit about how we know

580
00:21:02,470 --> 00:21:00,880
the information we know because i think

581
00:21:03,909 --> 00:21:02,480
it's important

582
00:21:05,909 --> 00:21:03,919
you know if you drill down through the

583
00:21:07,110 --> 00:21:05,919
ice cores uh if you drill down through

584
00:21:10,390 --> 00:21:07,120
glaciers

585
00:21:11,270 --> 00:21:10,400
for the moment

586
00:21:13,029 --> 00:21:11,280
where

587
00:21:15,029 --> 00:21:13,039
the snow doesn't melt completely every

588
00:21:17,190 --> 00:21:15,039

year and it stacks on top of each other

589
00:21:19,110 --> 00:21:17,200
and you can see these annual layers and

590
00:21:21,190 --> 00:21:19,120
if you drill down through that through

591
00:21:23,190 --> 00:21:21,200
these annual layers you can find tiny

592
00:21:25,669 --> 00:21:23,200
little bubbles where the air has been

593
00:21:27,430 --> 00:21:25,679
captured and you can measure the old

594
00:21:29,350 --> 00:21:27,440
atmosphere

595
00:21:31,270 --> 00:21:29,360
all the way back hundreds of thousands

596
00:21:33,510 --> 00:21:31,280
of years and that's how we build these

597
00:21:35,350 --> 00:21:33,520
records of carbon dioxide and you can

598
00:21:37,270 --> 00:21:35,360
actually measure temperature separately

599
00:21:39,590 --> 00:21:37,280
so you can measure both carbon dioxide

600
00:21:41,510 --> 00:21:39,600
and temperature based on the isotopes

601
00:21:43,909 --> 00:21:41,520
that get taken up

602
00:21:45,110 --> 00:21:43,919
and the amount of actual co2 trapped in

603
00:21:47,510 --> 00:21:45,120
the little bubbles

604
00:21:48,710 --> 00:21:47,520
so uh we have a pretty good record you

605
00:21:50,310 --> 00:21:48,720
know often people say well there was

606
00:21:52,710 --> 00:21:50,320
nobody around a million years ago how do

607
00:21:55,590 --> 00:21:52,720
you know co2 was what it was well this

608
00:21:57,590 --> 00:21:55,600
is how we know we we dig it up

609
00:22:00,070 --> 00:21:57,600
now every global warming talk has a

610
00:22:01,029 --> 00:22:00,080
slide like this and this is mine

611
00:22:04,549 --> 00:22:01,039
uh

612
00:22:07,190 --> 00:22:04,559
this is a a just a simple schematic

613
00:22:09,990 --> 00:22:07,200

of what causes global warming so all of

614
00:22:12,470 --> 00:22:10,000
the important energy that we get for

615
00:22:14,549 --> 00:22:12,480
our planet's climate comes from the sun

616
00:22:16,149 --> 00:22:14,559
and this energy essentially goes right

617
00:22:17,990 --> 00:22:16,159
through the atmosphere

618
00:22:19,990 --> 00:22:18,000
you can see the sunlight when you walk

619
00:22:21,430 --> 00:22:20,000
outside and even though it's gone all

620
00:22:23,270 --> 00:22:21,440
the way through the atmosphere and the

621
00:22:25,270 --> 00:22:23,280
reason is because the sunlight is

622
00:22:26,390 --> 00:22:25,280
basically uh the atmosphere is

623
00:22:28,230 --> 00:22:26,400
transparent

624
00:22:29,750 --> 00:22:28,240
when it comes to sunlight sunlight goes

625
00:22:31,990 --> 00:22:29,760
right through now some bounces off

626
00:22:33,669 --> 00:22:32,000
clouds and other things yes but by and

627
00:22:35,510 --> 00:22:33,679
large most of the energy goes right

628
00:22:38,230 --> 00:22:35,520
through the atmosphere and it gets

629
00:22:39,750 --> 00:22:38,240
absorbed at the surface and remember

630
00:22:42,310 --> 00:22:39,760
two-thirds of the ocean two-thirds of

631
00:22:43,830 --> 00:22:42,320
the surfaces i gave it away

632
00:22:47,190 --> 00:22:43,840
ocean right

633
00:22:48,470 --> 00:22:47,200
so by and large this energy is heating

634
00:22:51,909 --> 00:22:48,480
up the oceans

635
00:22:54,630 --> 00:22:51,919
and that warm uh ocean

636
00:22:56,950 --> 00:22:54,640
radiates energy back out towards space

637
00:22:58,630 --> 00:22:56,960
so we've got the energy coming in gets

638
00:23:00,710 --> 00:22:58,640

sucked up by the ocean and gets spit

639
00:23:03,029 --> 00:23:00,720
back out toward the atmosphere now the

640
00:23:03,990 --> 00:23:03,039
problem is that the energy going out is

641
00:23:08,230 --> 00:23:04,000
different

642
00:23:10,549 --> 00:23:08,240
it's long wave radiation what we call uh

643
00:23:13,510 --> 00:23:10,559
infrared radiation and the atmosphere

644
00:23:15,430 --> 00:23:13,520
actually absorbs that and the amount

645
00:23:18,630 --> 00:23:15,440
that it absorbs it depends on how much

646
00:23:20,390 --> 00:23:18,640
carbon dioxide there is so very simply

647
00:23:23,669 --> 00:23:20,400
if we change the composition of the

648
00:23:27,029 --> 00:23:23,679
atmosphere we're trapping extra heat on

649
00:23:28,710 --> 00:23:27,039
the planet right so the question is

650
00:23:31,750 --> 00:23:28,720
where does the heat go

651
00:23:33,830 --> 00:23:31,760
well mark ruined the answer already

652
00:23:37,750 --> 00:23:33,840
by telling you in the beginning

653
00:23:40,470 --> 00:23:37,760
but anybody want to guess

654
00:23:43,110 --> 00:23:40,480
the oceans yes i heard somebody say it

655
00:23:45,830 --> 00:23:43,120
that counts you get extra credit

656
00:23:47,669 --> 00:23:45,840
uh yeah over 90 percent of the heat

657
00:23:49,590 --> 00:23:47,679
trapped by global warming is going into

658
00:23:51,350 --> 00:23:49,600
the oceans so if you're not really

659
00:23:54,230 --> 00:23:51,360
looking in the oceans you're not really

660
00:23:57,190 --> 00:23:54,240
seeing the signal so even though we

661
00:23:58,789 --> 00:23:57,200
think of global warming as global

662
00:24:01,830 --> 00:23:58,799
temperature increase

663
00:24:03,510 --> 00:24:01,840

really it's here it's global heating

664
00:24:05,830 --> 00:24:03,520
it's that extra heat that's trapped in

665
00:24:07,990 --> 00:24:05,840
the ocean that's really important that's

666
00:24:09,510 --> 00:24:08,000
really changing our climate so almost

667
00:24:11,830 --> 00:24:09,520
all of the action in terms of global

668
00:24:14,230 --> 00:24:11,840
warming is really in the oceans now why

669
00:24:16,149 --> 00:24:14,240
is that now you can do a simple

670
00:24:18,630 --> 00:24:16,159
experiment if you take a a simple

671
00:24:22,310 --> 00:24:18,640
balloon and you fill it with air and you

672
00:24:24,470 --> 00:24:22,320
hold a lighter to it what happens

673
00:24:26,710 --> 00:24:24,480
it pops yes someone on the internet said

674
00:24:28,549 --> 00:24:26,720
it pops

675
00:24:30,710 --> 00:24:28,559
if you take a balloon filled with water

676
00:24:33,590 --> 00:24:30,720
and you do the same trick

677
00:24:35,909 --> 00:24:33,600
what happens

678
00:24:36,870 --> 00:24:35,919
it doesn't pop that's right somebody

679
00:24:39,830 --> 00:24:36,880
said it

680
00:24:41,190 --> 00:24:39,840
in fact the water is so good at sucking

681
00:24:43,350 --> 00:24:41,200
up the heat

682
00:24:45,669 --> 00:24:43,360
that the skin on the balloon the rubber

683
00:24:47,190 --> 00:24:45,679
doesn't have time to melt so

684
00:24:48,390 --> 00:24:47,200
this is an experiment you can try at

685
00:24:49,909 --> 00:24:48,400
home

686
00:24:53,590 --> 00:24:49,919
or it's an experiment you can try in

687
00:24:56,630 --> 00:24:53,600
about about a room full of 100 people

688
00:25:00,390 --> 00:24:57,909

since i'm in a room filled with 100

689
00:25:03,510 --> 00:25:00,400
people i figured i'll try it

690
00:25:06,470 --> 00:25:03,520
so some of you in the front row

691
00:25:07,909 --> 00:25:06,480
may be in harm's way

692
00:25:09,830 --> 00:25:07,919
so

693
00:25:13,029 --> 00:25:09,840
trust me

694
00:25:21,029 --> 00:25:14,630
all right so this is a balloon that's

695
00:25:25,269 --> 00:25:22,310
and i could keep going and fill it with

696
00:25:25,279 --> 00:25:29,750
you guys want to keep going

697
00:25:32,789 --> 00:25:30,630
and

698
00:25:34,310 --> 00:25:32,799
if i tie it off

699
00:25:35,750 --> 00:25:34,320
which i'm going to make a big production

700
00:25:36,789 --> 00:25:35,760
of

701
00:25:37,990 --> 00:25:36,799
um

702
00:25:40,310 --> 00:25:38,000
no i'm not i'm just going to hold the

703
00:25:41,990 --> 00:25:40,320
flame to it if i tie it off

704
00:25:44,310 --> 00:25:42,000
and hold the flame to it you guys can

705
00:25:46,390 --> 00:25:44,320
guess that it's going to pop so let's

706
00:25:48,710 --> 00:25:46,400
see how long it takes to pop the balloon

707
00:25:50,870 --> 00:25:48,720
filled with air with a lighter

708
00:25:52,390 --> 00:25:50,880
are you guys ready

709
00:25:53,990 --> 00:25:52,400
are you sure you're ready

710
00:25:55,669 --> 00:25:54,000
all right here we go

711
00:25:57,669 --> 00:25:55,679
you should close your eyes and your ears

712
00:25:59,350 --> 00:25:57,679
and anyone with a pacemaker heart

713
00:26:00,789 --> 00:25:59,360

condition

714
00:26:04,149 --> 00:26:00,799
now would be the time to leave the room

715
00:26:10,630 --> 00:26:05,430
boom

716
00:26:14,470 --> 00:26:12,950
um so there's only one thing left to do

717
00:26:16,630 --> 00:26:14,480
and that's try it with a water balloon

718
00:26:19,029 --> 00:26:16,640
so we're gonna do that um the water

719
00:26:21,110 --> 00:26:19,039
balloon won't pop either uh

720
00:26:22,870 --> 00:26:21,120
just like in the video

721
00:26:29,510 --> 00:26:22,880
and i know this because i'm a scientist

722
00:26:31,990 --> 00:26:30,630
all right

723
00:26:35,830 --> 00:26:32,000
you people in the front row are in

724
00:26:41,269 --> 00:26:38,789
this is strictly the policy of uh the

725
00:26:42,390 --> 00:26:41,279
auditorium that i use this bucket

726
00:26:44,630 --> 00:26:42,400
um because there's all kinds of

727
00:26:47,669 --> 00:26:44,640
sensitive electronic equipment you guys

728
00:26:50,230 --> 00:26:47,679
are fine that would be great um in honor

729
00:26:52,070 --> 00:26:50,240
because it's valentine's day

730
00:26:53,269 --> 00:26:52,080
i decided it should be a pink ocean

731
00:26:57,190 --> 00:26:53,279
today

732
00:26:59,909 --> 00:26:58,149
okay

733
00:27:01,909 --> 00:26:59,919
uh we're gonna try this and and just see

734
00:27:03,590 --> 00:27:01,919
what happens what i want you guys to do

735
00:27:06,230 --> 00:27:03,600
is count how long

736
00:27:07,590 --> 00:27:06,240
it takes for me to pop the balloon okay

737
00:27:10,230 --> 00:27:07,600
filled with water

738
00:27:11,909 --> 00:27:10,240

you're gonna be fine

739
00:27:14,549 --> 00:27:11,919
um

740
00:27:23,990 --> 00:27:14,559
this almost always works

741
00:27:24,000 --> 00:27:27,669
getting kind of nervous guys

742
00:27:27,679 --> 00:27:35,029
you guys are good at counting

743
00:27:35,039 --> 00:27:40,630
getting hot in here

744
00:27:45,190 --> 00:27:42,230
20 is good right

745
00:27:47,269 --> 00:27:45,200
yay we can stop at 20. look

746
00:27:49,190 --> 00:27:47,279
look um and actually if you want to feel

747
00:27:50,870 --> 00:27:49,200
it uh

748
00:27:53,909 --> 00:27:50,880
it's not even hot right

749
00:27:55,350 --> 00:27:53,919
yeah it's because

750
00:27:56,950 --> 00:27:55,360
it's because the balloon is so good at

751
00:27:58,149 --> 00:27:56,960
taking up heat and the water sucks up

752
00:28:02,389 --> 00:27:58,159
all the heat and that's that's why it

753
00:28:05,269 --> 00:28:03,590
ah

754
00:28:06,630 --> 00:28:05,279
all right

755
00:28:08,230 --> 00:28:06,640
so

756
00:28:10,950 --> 00:28:08,240
that was the scariest part for me i know

757
00:28:12,710 --> 00:28:10,960
it was for you too

758
00:28:15,029 --> 00:28:12,720
that's why i got to drink some water so

759
00:28:17,350 --> 00:28:15,039
uh what did we learn

760
00:28:18,149 --> 00:28:17,360
nothing i knew it great

761
00:28:20,470 --> 00:28:18,159
um

762
00:28:22,389 --> 00:28:20,480
so uh really the point here is that

763
00:28:23,190 --> 00:28:22,399

water is kind of an amazing substance

764
00:28:25,350 --> 00:28:23,200
and

765
00:28:26,149 --> 00:28:25,360
two-thirds of our planet is covered by

766
00:28:29,110 --> 00:28:26,159
it

767
00:28:30,549 --> 00:28:29,120
to a depth of about four kilometers

768
00:28:33,909 --> 00:28:30,559
couple of miles

769
00:28:35,350 --> 00:28:33,919
so this is a huge volume of water and

770
00:28:37,590 --> 00:28:35,360
essentially what we're doing with

771
00:28:40,630 --> 00:28:37,600
climate change is holding a great big

772
00:28:45,669 --> 00:28:40,640
lighter to it and waiting for sea level

773
00:28:48,310 --> 00:28:47,430
on that happy note

774
00:28:50,149 --> 00:28:48,320
um

775
00:28:52,389 --> 00:28:50,159
just to kind of revisit what's going on

776
00:28:53,990 --> 00:28:52,399
uh you know if we imagine our sun again

777
00:28:56,310 --> 00:28:54,000
and our atmosphere

778
00:28:59,110 --> 00:28:56,320
before climate change started so say

779
00:29:01,430 --> 00:28:59,120
during that 10 000 year period of

780
00:29:02,789 --> 00:29:01,440
climate happiness um

781
00:29:05,029 --> 00:29:02,799
essentially we were getting the same

782
00:29:07,350 --> 00:29:05,039
amount of energy coming in from the sun

783
00:29:09,909 --> 00:29:07,360
as was going back out into space

784
00:29:13,110 --> 00:29:09,919
and what happened in the last 150 years

785
00:29:14,549 --> 00:29:13,120
is we reshaped the atmosphere we changed

786
00:29:17,029 --> 00:29:14,559
the composition of the atmosphere and we

787
00:29:18,549 --> 00:29:17,039
started keeping more of this heat on the

788
00:29:20,389 --> 00:29:18,559

planet

789
00:29:21,990 --> 00:29:20,399
so if you look at our our little happy

790
00:29:23,510 --> 00:29:22,000
earth what's happening is he's getting

791
00:29:26,870 --> 00:29:23,520
warmer right

792
00:29:29,350 --> 00:29:26,880
he's turning into hot earth now uh

793
00:29:31,029 --> 00:29:29,360
eventually this heat goes somewhere it

794
00:29:32,149 --> 00:29:31,039
warms up the oceans it warms up the

795
00:29:33,590 --> 00:29:32,159
atmosphere

796
00:29:35,350 --> 00:29:33,600
eventually

797
00:29:38,149 --> 00:29:35,360
you get a warm enough

798
00:29:40,710 --> 00:29:38,159
atmosphere that it starts sending more

799
00:29:43,669 --> 00:29:40,720
radiation back out into space so you

800
00:29:46,470 --> 00:29:43,679
achieve a new balance a new

801
00:29:48,870 --> 00:29:46,480
earth a new climate but the penalty for

802
00:29:50,870 --> 00:29:48,880
that new balance is that now you've got

803
00:29:52,310 --> 00:29:50,880
a warmer earth you've heated up your

804
00:29:54,789 --> 00:29:52,320
planet

805
00:29:56,950 --> 00:29:54,799
but remember i said that global warming

806
00:29:59,990 --> 00:29:56,960
is all happening in the oceans

807
00:30:02,230 --> 00:30:00,000
so in order to get from the left earth

808
00:30:04,789 --> 00:30:02,240
that's normal and cool to the right

809
00:30:06,630 --> 00:30:04,799
earth that's hot and sweaty you have to

810
00:30:09,430 --> 00:30:06,640
first heat up the oceans

811
00:30:10,870 --> 00:30:09,440
and heating up the oceans is a huge task

812
00:30:12,789 --> 00:30:10,880
because they're so big

813
00:30:14,310 --> 00:30:12,799

in fact it takes something like a

814
00:30:16,310 --> 00:30:14,320
thousand years

815
00:30:19,190 --> 00:30:16,320
for the heat we put in the ocean today

816
00:30:21,590 --> 00:30:19,200
to spread through the entire oceans uh

817
00:30:24,230 --> 00:30:21,600
and eventually circulate back up

818
00:30:26,310 --> 00:30:24,240
to the surface so we're setting in

819
00:30:27,909 --> 00:30:26,320
motion changes by changing this

820
00:30:29,750 --> 00:30:27,919
composition the atmosphere that are

821
00:30:31,190 --> 00:30:29,760
going to be with us for something like a

822
00:30:33,510 --> 00:30:31,200
thousand years

823
00:30:37,110 --> 00:30:33,520
so if you go back to my title about

824
00:30:39,590 --> 00:30:37,120
irreversibility no way back um you know

825
00:30:41,510 --> 00:30:39,600
in terms of a human scale in terms of

826
00:30:43,510 --> 00:30:41,520
people alive today our children our

827
00:30:44,950 --> 00:30:43,520
grandchildren our great grandchildren

828
00:30:47,110 --> 00:30:44,960
we're really looking at changes that

829
00:30:49,110 --> 00:30:47,120
we're not going to be able to undo in

830
00:30:51,190 --> 00:30:49,120
any easy way

831
00:30:53,269 --> 00:30:51,200
for thousands of years

832
00:30:55,269 --> 00:30:53,279
sea level rise will continue to happen

833
00:30:57,350 --> 00:30:55,279
even after we stop putting carbon

834
00:31:00,230 --> 00:30:57,360
dioxide in the atmosphere because it

835
00:31:03,669 --> 00:31:00,240
takes the oceans so long to absorb and

836
00:31:04,710 --> 00:31:03,679
eventually redistribute this heat

837
00:31:07,909 --> 00:31:04,720
so

838
00:31:09,990 --> 00:31:07,919

is global warming really happening um

839
00:31:11,830 --> 00:31:10,000
i say yes um

840
00:31:12,950 --> 00:31:11,840
my friends say yes

841
00:31:15,110 --> 00:31:12,960
uh

842
00:31:16,710 --> 00:31:15,120
if you haven't seen ice age two global

843
00:31:18,230 --> 00:31:16,720
warming is like the bad guy and sea

844
00:31:20,310 --> 00:31:18,240
level rise is happening it's a great

845
00:31:22,070 --> 00:31:20,320
movie anyway

846
00:31:24,310 --> 00:31:22,080
but not everybody believes that global

847
00:31:26,070 --> 00:31:24,320
warming is real some of our

848
00:31:29,590 --> 00:31:26,080
some of our friends on the radio

849
00:31:31,590 --> 00:31:29,600
still don't uh don't agree and in fact

850
00:31:33,750 --> 00:31:31,600
also since valentine's day is coming up

851
00:31:35,990 --> 00:31:33,760
i thought i'd just take a second and

852
00:31:38,630 --> 00:31:36,000
tell this little story a couple years

853
00:31:40,549 --> 00:31:38,640
ago i wrote a paper about

854
00:31:42,070 --> 00:31:40,559
about climate change

855
00:31:44,070 --> 00:31:42,080
suggesting that the oceans had actually

856
00:31:46,549 --> 00:31:44,080
cooled off a little bit

857
00:31:49,509 --> 00:31:46,559
and rush limbaugh actually mentioned it

858
00:31:51,990 --> 00:31:49,519
on his show uh he

859
00:31:54,149 --> 00:31:52,000
had this fantastic quote he said you

860
00:31:55,830 --> 00:31:54,159
know this paper by josh willis and john

861
00:31:57,190 --> 00:31:55,840
lymon these other guys

862
00:31:58,950 --> 00:31:57,200
is uh

863
00:32:01,029 --> 00:31:58,960

totally crazy they have no idea what's

864
00:32:03,430 --> 00:32:01,039
happening in the climate it doesn't make

865
00:32:05,669 --> 00:32:03,440
any sense and he said

866
00:32:08,230 --> 00:32:05,679
to overturn the world economy based on

867
00:32:10,149 --> 00:32:08,240
the musings of a few idiot leftist

868
00:32:12,230 --> 00:32:10,159
scientists

869
00:32:14,389 --> 00:32:12,240
is just stupid and that's what global

870
00:32:15,909 --> 00:32:14,399
warming is actually all

871
00:32:18,549 --> 00:32:15,919
about

872
00:32:19,350 --> 00:32:18,559
thank you rush and uh

873
00:32:21,430 --> 00:32:19,360
uh

874
00:32:23,110 --> 00:32:21,440
so it was you know some of my colleagues

875
00:32:25,029 --> 00:32:23,120
that wrote the paper with me were of

876
00:32:28,310 --> 00:32:25,039
course horrified that rush limbaugh had

877
00:32:30,310 --> 00:32:28,320
talked about us on the radio um and uh

878
00:32:32,230 --> 00:32:30,320
it turned out that um i kept looking at

879
00:32:34,070 --> 00:32:32,240
this data and this the signal of ocean

880
00:32:36,470 --> 00:32:34,080
cooling which actually in a sense really

881
00:32:39,110 --> 00:32:36,480
didn't even make sense to me um and i

882
00:32:41,110 --> 00:32:39,120
dug a little further and um it was uh

883
00:32:42,710 --> 00:32:41,120
february of i think

884
00:32:44,310 --> 00:32:42,720
2008

885
00:32:45,509 --> 00:32:44,320
i want to say

886
00:32:47,190 --> 00:32:45,519
and i was

887
00:32:49,430 --> 00:32:47,200
standing with my wife in the kitchen and

888
00:32:51,990 --> 00:32:49,440

i was looking over a talk about ocean

889
00:32:53,669 --> 00:32:52,000
cooling that i was supposed to give at a

890
00:32:55,590 --> 00:32:53,679
big climate center in colorado the

891
00:32:57,029 --> 00:32:55,600
following weekend and

892
00:32:58,789 --> 00:32:57,039
i uh

893
00:33:00,470 --> 00:32:58,799
i found this result and i i thought it

894
00:33:02,789 --> 00:33:00,480
was really surprising

895
00:33:04,549 --> 00:33:02,799
um some of the data that was going into

896
00:33:07,190 --> 00:33:04,559
it looked like it had been flawed like

897
00:33:09,110 --> 00:33:07,200
it was too cold and i wrote a friend of

898
00:33:10,310 --> 00:33:09,120
mine an email and he wrote back kind of

899
00:33:11,830 --> 00:33:10,320
quickly and said yeah you know

900
00:33:13,269 --> 00:33:11,840
something's definitely wrong with that

901
00:33:15,669 --> 00:33:13,279
data

902
00:33:18,230 --> 00:33:15,679
and i turned to my wife uh

903
00:33:19,909 --> 00:33:18,240
um it was actually valentine's day and

904
00:33:21,909 --> 00:33:19,919
we were getting ready to go out for a

905
00:33:22,710 --> 00:33:21,919
nice dinner and i said i think i'm wrong

906
00:33:25,590 --> 00:33:22,720
about

907
00:33:28,789 --> 00:33:25,600
ocean cooling

908
00:33:30,549 --> 00:33:28,799
and she said okay let's go get dinner

909
00:33:31,990 --> 00:33:30,559
but dinner was kind of ruined because i

910
00:33:34,389 --> 00:33:32,000
was really worried i had to give a talk

911
00:33:36,389 --> 00:33:34,399
literally the next day

912
00:33:37,990 --> 00:33:36,399
at a big climate center and so i was

913
00:33:40,389 --> 00:33:38,000

just worrying the whole time and dinner

914
00:33:42,070 --> 00:33:40,399
was completely ruined

915
00:33:43,750 --> 00:33:42,080
and

916
00:33:45,590 --> 00:33:43,760
as a reminder

917
00:33:48,549 --> 00:33:45,600
my wife actually

918
00:33:51,190 --> 00:33:48,559
had a small business card made for me

919
00:33:53,110 --> 00:33:51,200
which has my job title listed as idiot

920
00:33:54,870 --> 00:33:53,120
leftist scientist so

921
00:33:56,470 --> 00:33:54,880
if anybody wants one you can see me

922
00:33:59,110 --> 00:33:56,480
after the show

923
00:34:00,950 --> 00:33:59,120
um yeah so uh you know but i think this

924
00:34:02,789 --> 00:34:00,960
is an important lesson in how science

925
00:34:06,070 --> 00:34:02,799
works because you know we don't get the

926
00:34:08,950 --> 00:34:06,080
answer right the first time every time

927
00:34:10,230 --> 00:34:08,960
but we keep hacking away at it and so uh

928
00:34:12,149 --> 00:34:10,240
you know eventually i wrote another

929
00:34:14,470 --> 00:34:12,159
paper and said okay i was wrong about

930
00:34:16,950 --> 00:34:14,480
ocean cooling and rush was right i am a

931
00:34:17,750 --> 00:34:16,960
big fat idiot

932
00:34:21,990 --> 00:34:17,760
but

933
00:34:24,869 --> 00:34:22,000
certain about and stands on a whole lot

934
00:34:27,190 --> 00:34:24,879
more uh research and papers than uh just

935
00:34:28,790 --> 00:34:27,200
my one bad one that rush uh mocked me

936
00:34:31,909 --> 00:34:28,800
for um

937
00:34:33,510 --> 00:34:31,919
is the rise of sea levels over time

938
00:34:35,669 --> 00:34:33,520

you know i mentioned a little while ago

939
00:34:38,389 --> 00:34:35,679
that temperatures went up and down with

940
00:34:41,190 --> 00:34:38,399
the cycles of the ice ages and co2

941
00:34:43,510 --> 00:34:41,200
followed those as well and uh

942
00:34:45,990 --> 00:34:43,520
sea level actually also went up and down

943
00:34:48,950 --> 00:34:46,000
with the ice ages because as you build a

944
00:34:50,470 --> 00:34:48,960
gigantic ice sheet over north america

945
00:34:52,149 --> 00:34:50,480
the water has to come from somewhere and

946
00:34:54,950 --> 00:34:52,159
it comes from the oceans

947
00:34:58,310 --> 00:34:54,960
so during that period 20 000 years ago

948
00:35:00,470 --> 00:34:58,320
the oceans were 120 meters lower than

949
00:35:02,870 --> 00:35:00,480
they were today so this is when you had

950
00:35:05,670 --> 00:35:02,880
things like a land bridge across the

951
00:35:07,829 --> 00:35:05,680
bering strait and north america and

952
00:35:08,790 --> 00:35:07,839
siberia were essentially connected and

953
00:35:11,670 --> 00:35:08,800
so

954
00:35:13,670 --> 00:35:11,680
as we warmed up out of that period

955
00:35:15,270 --> 00:35:13,680
sea levels began to rise and those ice

956
00:35:17,589 --> 00:35:15,280
sheets began to melt and we had

957
00:35:19,109 --> 00:35:17,599
incredibly fast sea level rise about ten

958
00:35:21,430 --> 00:35:19,119
thousand years ago

959
00:35:23,510 --> 00:35:21,440
and then it really started to level out

960
00:35:25,589 --> 00:35:23,520
and if you look at just the last couple

961
00:35:27,510 --> 00:35:25,599
thousand years we have a very new very

962
00:35:29,430 --> 00:35:27,520
exciting record of this

963
00:35:32,150 --> 00:35:29,440

incredibly accurate from

964
00:35:35,750 --> 00:35:32,160
of all places north carolina

965
00:35:37,910 --> 00:35:35,760
and in north carolina the land itself

966
00:35:41,990 --> 00:35:37,920
is sinking a little bit

967
00:35:43,910 --> 00:35:42,000
and as it does the ocean crawls up these

968
00:35:46,630 --> 00:35:43,920
salt marshes the sea level crawls up

969
00:35:48,550 --> 00:35:46,640
these salt marshes and you can it leaves

970
00:35:50,230 --> 00:35:48,560
behind a record because

971
00:35:53,030 --> 00:35:50,240
they're little critters that like to

972
00:35:55,829 --> 00:35:53,040
live in very specific levels

973
00:35:56,790 --> 00:35:55,839
in the tidal range you can dig a core in

974
00:35:59,109 --> 00:35:56,800
these

975
00:36:02,310 --> 00:35:59,119
salt marshes or a number of cores and

976
00:36:03,910 --> 00:36:02,320
you can reconstruct sea level back two

977
00:36:05,750 --> 00:36:03,920
thousand years

978
00:36:07,270 --> 00:36:05,760
and when you do that

979
00:36:08,870 --> 00:36:07,280
and you account for the local land

980
00:36:10,710 --> 00:36:08,880
motion what you see

981
00:36:12,790 --> 00:36:10,720
is that we essentially had two thousand

982
00:36:15,270 --> 00:36:12,800
years or at least a thousand years a

983
00:36:17,670 --> 00:36:15,280
very stable sea level sea levels were

984
00:36:19,430 --> 00:36:17,680
not changing hardly at all

985
00:36:21,589 --> 00:36:19,440
then during what was called the medieval

986
00:36:23,510 --> 00:36:21,599
warm period we had a little bit of rise

987
00:36:25,750 --> 00:36:23,520
right through here and during what was

988
00:36:27,990 --> 00:36:25,760

called the little ice age we had maybe a

989
00:36:29,910 --> 00:36:28,000
little bit of decline but what's really

990
00:36:32,550 --> 00:36:29,920
striking about this picture what's

991
00:36:34,790 --> 00:36:32,560
really the amazing part the last 150

992
00:36:37,030 --> 00:36:34,800
years where sea levels rising at two

993
00:36:38,950 --> 00:36:37,040
millimeters per year in agreement with

994
00:36:41,109 --> 00:36:38,960
local tide gauges by the way these data

995
00:36:43,829 --> 00:36:41,119
have been verified by nearby actual

996
00:36:46,790 --> 00:36:43,839
instruments and uh

997
00:36:48,150 --> 00:36:46,800
incredibly this rate of sea level rise

998
00:36:50,150 --> 00:36:48,160
is different than anything we've seen in

999
00:36:51,750 --> 00:36:50,160
the last two thousand years

1000
00:36:53,750 --> 00:36:51,760
so you know remember we've been through

1001
00:36:55,990 --> 00:36:53,760
these ice ages little ice ages and

1002
00:36:57,670 --> 00:36:56,000
little warm periods cycles of the sun

1003
00:37:00,150 --> 00:36:57,680
coming and going and tilt of the earth's

1004
00:37:01,910 --> 00:37:00,160
axis and so forth but nothing until the

1005
00:37:04,550 --> 00:37:01,920
industrial revolution

1006
00:37:06,470 --> 00:37:04,560
until the rise of co2 put there in the

1007
00:37:09,430 --> 00:37:06,480
atmosphere by people

1008
00:37:11,430 --> 00:37:09,440
can really explain the warming and the

1009
00:37:13,589 --> 00:37:11,440
incredible rate of sea level rise we've

1010
00:37:15,750 --> 00:37:13,599
seen in the last hundred years

1011
00:37:18,390 --> 00:37:15,760
so to me this is really the nail in the

1012
00:37:19,990 --> 00:37:18,400
coffin in terms of the deniers argument

1013
00:37:22,150 --> 00:37:20,000

that global warming is not happening or

1014
00:37:24,550 --> 00:37:22,160
that it's not caused by people because

1015
00:37:27,670 --> 00:37:24,560
you can't really explain this rise in

1016
00:37:28,470 --> 00:37:27,680
the last 100 years without it

1017
00:37:29,829 --> 00:37:28,480
so

1018
00:37:31,589 --> 00:37:29,839
i like to

1019
00:37:33,829 --> 00:37:31,599
drone on about this but i'll move on and

1020
00:37:35,430 --> 00:37:33,839
look at just the last hundred years and

1021
00:37:37,750 --> 00:37:35,440
this is the period where we kind of have

1022
00:37:40,630 --> 00:37:37,760
enough actual tide gauges in different

1023
00:37:42,470 --> 00:37:40,640
places in the planet to get a good sense

1024
00:37:46,150 --> 00:37:42,480
of how sea levels have changed in the

1025
00:37:48,710 --> 00:37:46,160
last 150 years 130 years and if you look

1026
00:37:51,270 --> 00:37:48,720
they haven't increased at a stable rate

1027
00:37:52,790 --> 00:37:51,280
in fact if you look at the first

1028
00:37:53,990 --> 00:37:52,800
50 years

1029
00:37:56,390 --> 00:37:54,000
they were going up at about one

1030
00:37:59,430 --> 00:37:56,400
millimeter per year in the second 50

1031
00:38:01,430 --> 00:37:59,440
years about two in the last 20 years

1032
00:38:03,910 --> 00:38:01,440
about three so there's actually been an

1033
00:38:05,510 --> 00:38:03,920
acceleration in the last hundred years

1034
00:38:07,349 --> 00:38:05,520
and even

1035
00:38:08,710 --> 00:38:07,359
more recent research than this suggests

1036
00:38:10,550 --> 00:38:08,720
that that acceleration might even be a

1037
00:38:12,230 --> 00:38:10,560
little bit bigger than what we show here

1038
00:38:14,470 --> 00:38:12,240

because the early part might have been

1039
00:38:16,310 --> 00:38:14,480
overestimated we see a little less sea

1040
00:38:18,550 --> 00:38:16,320
level rise in that first hundred first

1041
00:38:20,230 --> 00:38:18,560
50 years than is shown here

1042
00:38:23,190 --> 00:38:20,240
so

1043
00:38:25,270 --> 00:38:23,200
this seems small it's only about

1044
00:38:26,310 --> 00:38:25,280
20 centimeters about eight inches and

1045
00:38:28,710 --> 00:38:26,320
when you're standing on the beach

1046
00:38:30,870 --> 00:38:28,720
watching the waves crash in that seems

1047
00:38:33,270 --> 00:38:30,880
like a small number but remember

1048
00:38:35,349 --> 00:38:33,280
two-thirds of the planet's surface right

1049
00:38:37,510 --> 00:38:35,359
so this is a huge area and this turns

1050
00:38:40,150 --> 00:38:37,520
out to be an enormous volume sixteen

1051
00:38:42,950 --> 00:38:40,160
thousand cubic miles of extra ocean in

1052
00:38:45,349 --> 00:38:42,960
the last 130 years so finally we get to

1053
00:38:47,030 --> 00:38:45,359
kind of the more recent stuff the

1054
00:38:49,510 --> 00:38:47,040
altimeter period the period where

1055
00:38:51,030 --> 00:38:49,520
satellites really dominate our record of

1056
00:38:54,790 --> 00:38:51,040
sea level rise

1057
00:38:57,030 --> 00:38:54,800
and we look in the last 20 years

1058
00:38:59,430 --> 00:38:57,040
my phd was

1059
00:39:01,510 --> 00:38:59,440
somewhere in here and rush was making

1060
00:39:03,750 --> 00:39:01,520
fun of me somewhere in here

1061
00:39:05,829 --> 00:39:03,760
and finally we're out here but what's

1062
00:39:07,589 --> 00:39:05,839
striking about this and if you think

1063
00:39:09,190 --> 00:39:07,599

back to my earlier discussion about the

1064
00:39:13,829 --> 00:39:09,200
hiatus

1065
00:39:15,670 --> 00:39:13,839
this is the global warming curve and

1066
00:39:17,349 --> 00:39:15,680
there's really no hiatus in it anywhere

1067
00:39:19,670 --> 00:39:17,359
to be found a few small bumps and

1068
00:39:21,670 --> 00:39:19,680
wiggles but nothing like what you see in

1069
00:39:23,270 --> 00:39:21,680
the temperature record

1070
00:39:26,310 --> 00:39:23,280
but if you're not convinced by satellite

1071
00:39:28,790 --> 00:39:26,320
data of sea level rise you can look at

1072
00:39:31,030 --> 00:39:28,800
satellite data of the arctic um this is

1073
00:39:33,430 --> 00:39:31,040
the minimum amount of sea ice we had in

1074
00:39:35,750 --> 00:39:33,440
1979 the first year we had a satellite

1075
00:39:38,310 --> 00:39:35,760
to really look at the top of the planet

1076
00:39:39,910 --> 00:39:38,320
and this is the minimum in 2008

1077
00:39:42,550 --> 00:39:39,920
and so you go back and forth and you see

1078
00:39:45,030 --> 00:39:42,560
really it's an incredible

1079
00:39:47,349 --> 00:39:45,040
wastage of floating ice at the top of

1080
00:39:48,790 --> 00:39:47,359
the planet and i didn't just cherry pick

1081
00:39:51,109 --> 00:39:48,800
two years if you

1082
00:39:51,829 --> 00:39:51,119
plot the time series it looks like this

1083
00:39:54,550 --> 00:39:51,839
so

1084
00:39:57,430 --> 00:39:54,560
we've lost about half of the area of the

1085
00:39:59,349 --> 00:39:57,440
ice that's floating on the arctic ocean

1086
00:40:01,430 --> 00:39:59,359
and in fact actually that ice is thinned

1087
00:40:02,950 --> 00:40:01,440
by about a factor of two so if you're

1088
00:40:05,589 --> 00:40:02,960

thinking about the volume of ice

1089
00:40:08,230 --> 00:40:05,599
floating in the arctic it's decreased by

1090
00:40:11,670 --> 00:40:08,240
a factor of four in the last 20 or 30

1091
00:40:13,349 --> 00:40:11,680
years so it's a pretty major change

1092
00:40:15,430 --> 00:40:13,359
but nothing says global warming like a

1093
00:40:18,470 --> 00:40:15,440
polar bear right

1094
00:40:20,470 --> 00:40:18,480
so in 2007 we had this major minimum and

1095
00:40:23,030 --> 00:40:20,480
you know the ice was being blown north

1096
00:40:24,870 --> 00:40:23,040
away from canada and the polar bears are

1097
00:40:27,030 --> 00:40:24,880
hunters they use the ice to try and

1098
00:40:29,829 --> 00:40:27,040
catch seals which are better swimmers

1099
00:40:32,870 --> 00:40:29,839
than they are uh but the ice gives them

1100
00:40:34,390 --> 00:40:32,880
a kind of tactical advantage uh so polar

1101
00:40:36,950 --> 00:40:34,400
bears were literally starving to death

1102
00:40:39,750 --> 00:40:36,960
because they couldn't find enough ice uh

1103
00:40:42,310 --> 00:40:39,760
to hunt on hunt seals with now i'm not a

1104
00:40:43,910 --> 00:40:42,320
biologist but my guess is the polar

1105
00:40:45,829 --> 00:40:43,920
bears will survive global warming

1106
00:40:48,950 --> 00:40:45,839
because they can always just move south

1107
00:40:52,870 --> 00:40:49,910
but

1108
00:40:54,630 --> 00:40:52,880
at the same time this is a reminder that

1109
00:40:57,510 --> 00:40:54,640
some of really the world's top level

1110
00:41:01,030 --> 00:40:57,520
predators besides people are beginning

1111
00:41:02,550 --> 00:41:01,040
to feel the pressure of our changing

1112
00:41:04,390 --> 00:41:02,560
climate

1113
00:41:06,630 --> 00:41:04,400

and and so they do serve as an important

1114
00:41:07,910 --> 00:41:06,640
reminder kind of an iconic one i think

1115
00:41:09,270 --> 00:41:07,920
but of course you don't have to take the

1116
00:41:11,190 --> 00:41:09,280
polar bear's word we have another

1117
00:41:12,710 --> 00:41:11,200
satellite called grace

1118
00:41:15,510 --> 00:41:12,720
this is a fun satellite because it

1119
00:41:17,750 --> 00:41:15,520
literally weighs the continents

1120
00:41:19,190 --> 00:41:17,760
one satellite flies ahead of the other

1121
00:41:21,510 --> 00:41:19,200
and whenever it goes over something

1122
00:41:23,510 --> 00:41:21,520
heavy the pull of gravity literally

1123
00:41:25,270 --> 00:41:23,520
causes it to speed up then when the

1124
00:41:27,589 --> 00:41:25,280
second one follows it eventually catches

1125
00:41:29,589 --> 00:41:27,599
up and by measuring the distance between

1126
00:41:31,349 --> 00:41:29,599
the two satellites you can actually

1127
00:41:33,190 --> 00:41:31,359
infer the weight of the thing you're

1128
00:41:35,990 --> 00:41:33,200
flying over so if you're flying over

1129
00:41:39,430 --> 00:41:36,000
something like greenland you can chart

1130
00:41:41,190 --> 00:41:39,440
its uh its ice loss over time this is a

1131
00:41:45,990 --> 00:41:41,200
little bit older

1132
00:41:47,829 --> 00:41:46,000
continued through the present period

1133
00:41:50,309 --> 00:41:47,839
and greenland has been on jenny craig

1134
00:41:51,270 --> 00:41:50,319
it's lost uh a couple trillion tons

1135
00:41:53,270 --> 00:41:51,280
already

1136
00:41:56,309 --> 00:41:53,280
so um uh

1137
00:41:58,150 --> 00:41:56,319
go jenny um anyway uh the point here is

1138
00:42:00,390 --> 00:41:58,160

that we're really

1139
00:42:02,309 --> 00:42:00,400
seeing these huge changes in the ice

1140
00:42:03,670 --> 00:42:02,319
sheets that are unlike anything that's

1141
00:42:05,190 --> 00:42:03,680
been happening in the last several

1142
00:42:07,349 --> 00:42:05,200
thousand years if this had been going on

1143
00:42:09,430 --> 00:42:07,359
in greenland for two or three thousand

1144
00:42:12,790 --> 00:42:09,440
years sea levels would be

1145
00:42:14,790 --> 00:42:12,800
many feet higher than they are today

1146
00:42:17,750 --> 00:42:14,800
it's interesting too because greenland

1147
00:42:19,190 --> 00:42:17,760
is kind of melting in an interesting way

1148
00:42:21,349 --> 00:42:19,200
it starts

1149
00:42:23,910 --> 00:42:21,359
with the most melting the most ice loss

1150
00:42:25,109 --> 00:42:23,920
in the southeast sector but actually

1151
00:42:26,470 --> 00:42:25,119
there's also

1152
00:42:28,230 --> 00:42:26,480
ice loss

1153
00:42:29,750 --> 00:42:28,240
further to the north up up on the

1154
00:42:31,750 --> 00:42:29,760
western coast

1155
00:42:33,349 --> 00:42:31,760
and if you start asking

1156
00:42:34,950 --> 00:42:33,359
why is that

1157
00:42:36,150 --> 00:42:34,960
you immediately start

1158
00:42:38,150 --> 00:42:36,160
well i'll come back to this in a little

1159
00:42:40,309 --> 00:42:38,160
bit immediately start looking toward the

1160
00:42:41,990 --> 00:42:40,319
oceans it turns out the oceans are kind

1161
00:42:44,470 --> 00:42:42,000
of eating away at the edges of the

1162
00:42:45,990 --> 00:42:44,480
glaciers here and causing the ice loss

1163
00:42:48,150 --> 00:42:46,000

to accelerate

1164
00:42:51,589 --> 00:42:48,160
but again a picture is worth a thousand

1165
00:42:53,349 --> 00:42:51,599
words and a picture of a glacier is

1166
00:42:54,550 --> 00:42:53,359
worth at least a couple of satellites i

1167
00:42:56,069 --> 00:42:54,560
think

1168
00:42:58,630 --> 00:42:56,079
and this is a picture of a glacier in

1169
00:43:00,870 --> 00:42:58,640
alaska now some of the glaciers were in

1170
00:43:03,589 --> 00:43:00,880
retreat before global warming started in

1171
00:43:05,990 --> 00:43:03,599
alaska but not like they are today and

1172
00:43:08,150 --> 00:43:06,000
and the fact is that over 90 percent of

1173
00:43:11,030 --> 00:43:08,160
all the glaciers everywhere in the world

1174
00:43:12,710 --> 00:43:11,040
today are retreating so this is a global

1175
00:43:14,710 --> 00:43:12,720
signal that we're seeing all over the

1176
00:43:17,109 --> 00:43:14,720
place but this glacier is retreated

1177
00:43:19,349 --> 00:43:17,119
miles this was a night picture in 1941

1178
00:43:20,390 --> 00:43:19,359
this was 2004

1179
00:43:22,710 --> 00:43:20,400
and

1180
00:43:25,109 --> 00:43:22,720
many of the glaciers there in retreat in

1181
00:43:26,550 --> 00:43:25,119
really quite a spectacular fashion

1182
00:43:27,829 --> 00:43:26,560
but one of my favorite pieces of

1183
00:43:30,390 --> 00:43:27,839
evidence for

1184
00:43:32,550 --> 00:43:30,400
human-caused climate change

1185
00:43:35,670 --> 00:43:32,560
was the breakup of the larsen b ice

1186
00:43:37,270 --> 00:43:35,680
shelf in 2002 and this was interesting

1187
00:43:40,630 --> 00:43:37,280
this was a couple of images captured

1188
00:43:41,750 --> 00:43:40,640

again by nasa satellites and in january

1189
00:43:44,309 --> 00:43:41,760
which is summer in the southern

1190
00:43:46,230 --> 00:43:44,319
hemisphere this is um the continent of

1191
00:43:48,550 --> 00:43:46,240
antarctica is below here and this is

1192
00:43:52,069 --> 00:43:48,560
part of the big peninsula that sticks up

1193
00:43:53,990 --> 00:43:52,079
uh into the in the oceans and um this

1194
00:43:57,829 --> 00:43:54,000
region of this ice shelf is essentially

1195
00:43:59,829 --> 00:43:57,839
a giant floating pillow of ice that lays

1196
00:44:02,069 --> 00:43:59,839
out over the surface of the ocean that

1197
00:44:04,069 --> 00:44:02,079
comes from the flow of glaciers which

1198
00:44:06,069 --> 00:44:04,079
cut down through the mountains and then

1199
00:44:07,750 --> 00:44:06,079
spread out over the water so this is a

1200
00:44:08,790 --> 00:44:07,760
piece of floating ice

1201
00:44:11,349 --> 00:44:08,800
and

1202
00:44:12,630 --> 00:44:11,359
in january 2002 they saw these puddles

1203
00:44:14,470 --> 00:44:12,640
appear

1204
00:44:15,990 --> 00:44:14,480
these are little dark spots where the

1205
00:44:17,510 --> 00:44:16,000
sunlight's being

1206
00:44:19,270 --> 00:44:17,520
taken up instead of getting reflected

1207
00:44:20,550 --> 00:44:19,280
back out into space

1208
00:44:22,230 --> 00:44:20,560
and then in march when they flew back

1209
00:44:25,589 --> 00:44:22,240
over and took another picture this

1210
00:44:27,510 --> 00:44:25,599
entire shelf had broken up and collapsed

1211
00:44:30,309 --> 00:44:27,520
so all this fuzzy stuff are little

1212
00:44:32,309 --> 00:44:30,319
icebergs which are what is left of this

1213
00:44:34,150 --> 00:44:32,319

enormous ice shelf

1214
00:44:36,710 --> 00:44:34,160
now what's interesting to me is not so

1215
00:44:38,230 --> 00:44:36,720
much that a giant ice shelf broke up but

1216
00:44:41,190 --> 00:44:38,240
oceanographers went back and they

1217
00:44:42,870 --> 00:44:41,200
drilled a sediment cores where the ice

1218
00:44:44,950 --> 00:44:42,880
shelf had been and they found that the

1219
00:44:46,069 --> 00:44:44,960
ice shelf had been there for 10 000

1220
00:44:48,069 --> 00:44:46,079
years old

1221
00:44:49,510 --> 00:44:48,079
so through the little ice age and the

1222
00:44:51,510 --> 00:44:49,520
medieval warm period and all these

1223
00:44:53,829 --> 00:44:51,520
things that we think of all the way back

1224
00:44:55,349 --> 00:44:53,839
to when there was way more ice in the

1225
00:44:57,270 --> 00:44:55,359
world than there is today so these ice

1226
00:44:58,630 --> 00:44:57,280
shelves go way way back

1227
00:45:00,230 --> 00:44:58,640
they're the only thing older than hugh

1228
00:45:03,990 --> 00:45:00,240
hefner to break up in the last hundred

1229
00:45:07,829 --> 00:45:05,750
um i really need a rim shot anybody got

1230
00:45:10,870 --> 00:45:07,839
one of those anyways um

1231
00:45:12,630 --> 00:45:10,880
but the larson bi shelf uh i think um is

1232
00:45:14,390 --> 00:45:12,640
is another really striking piece of

1233
00:45:16,870 --> 00:45:14,400
evidence that something's happening

1234
00:45:18,470 --> 00:45:16,880
today in this hundred years that really

1235
00:45:21,750 --> 00:45:18,480
hasn't been happening for the last

1236
00:45:23,190 --> 00:45:21,760
several thousand and that's us um

1237
00:45:25,750 --> 00:45:23,200
you know if you ask where's global

1238
00:45:27,430 --> 00:45:25,760

warming uh and and you you still think

1239
00:45:29,829 --> 00:45:27,440
you can't see it i think then you're

1240
00:45:31,990 --> 00:45:29,839
really just not looking for it

1241
00:45:33,589 --> 00:45:32,000
so i want to come back really quick to

1242
00:45:34,870 --> 00:45:33,599
greenland with just the last couple of

1243
00:45:36,630 --> 00:45:34,880
minutes here and

1244
00:45:39,349 --> 00:45:36,640
talk about

1245
00:45:40,790 --> 00:45:39,359
the ice loss there

1246
00:45:43,670 --> 00:45:40,800
i'm going to skip ahead

1247
00:45:49,190 --> 00:45:46,790
mark mentioned my new uh uh mission

1248
00:45:51,910 --> 00:45:49,200
coming up which is called omg ocean's

1249
00:45:53,829 --> 00:45:51,920
melting greenland and uh

1250
00:45:55,910 --> 00:45:53,839
that was the best omg picture i found in

1251
00:45:57,349 --> 00:45:55,920
all the internet so if you have a better

1252
00:45:58,870 --> 00:45:57,359
one please send it to me see me after

1253
00:46:00,710 --> 00:45:58,880
the talk but i want to talk just for a

1254
00:46:03,030 --> 00:46:00,720
second about this because i talked a lot

1255
00:46:05,030 --> 00:46:03,040
about sea level rise but what's really

1256
00:46:07,109 --> 00:46:05,040
amazing is the cause of sea level rise

1257
00:46:08,150 --> 00:46:07,119
so if you look at greenland and i talked

1258
00:46:10,069 --> 00:46:08,160
about how

1259
00:46:12,150 --> 00:46:10,079
this south eastern quadrant and the

1260
00:46:13,030 --> 00:46:12,160
northwestern quadrant are both warming

1261
00:46:16,150 --> 00:46:13,040
what's

1262
00:46:17,750 --> 00:46:16,160
this is the place where the oceans are

1263
00:46:19,270 --> 00:46:17,760

warming the fastest

1264
00:46:20,950 --> 00:46:19,280
and so when we started to look when

1265
00:46:24,470 --> 00:46:20,960
researchers started to go up close to

1266
00:46:26,309 --> 00:46:24,480
these uh ice shelves or glaciers

1267
00:46:28,790 --> 00:46:26,319
the glaciers here literally run right

1268
00:46:30,150 --> 00:46:28,800
off of the continent and into the ocean

1269
00:46:31,670 --> 00:46:30,160
so they're

1270
00:46:33,589 --> 00:46:31,680
they're literally sticking right into

1271
00:46:35,349 --> 00:46:33,599
the water and that means ocean water can

1272
00:46:37,670 --> 00:46:35,359
come right up to the face

1273
00:46:40,069 --> 00:46:37,680
and melt away the face and as they do

1274
00:46:42,150 --> 00:46:40,079
that then the glacier itself is free to

1275
00:46:44,390 --> 00:46:42,160
speed up and dump more ice into the

1276
00:46:46,150 --> 00:46:44,400
ocean more quickly and that's what

1277
00:46:48,069 --> 00:46:46,160
causes the sea level rise and the

1278
00:46:50,950 --> 00:46:48,079
acceleration so

1279
00:46:53,109 --> 00:46:50,960
we proposed this a couple years ago to

1280
00:46:55,030 --> 00:46:53,119
do an aircraft mission to essentially

1281
00:46:56,470 --> 00:46:55,040
fly around greenland

1282
00:46:58,710 --> 00:46:56,480
and drop little sensors that would

1283
00:47:00,150 --> 00:46:58,720
measure the ocean temperatures and you

1284
00:47:02,230 --> 00:47:00,160
can't just measure the ocean temperature

1285
00:47:05,349 --> 00:47:02,240
at the surface because it turns out that

1286
00:47:08,230 --> 00:47:05,359
the oceans here have a cold fresh layer

1287
00:47:10,069 --> 00:47:08,240
that caps this warm salty layer which is

1288
00:47:11,589 --> 00:47:10,079

climbing up into the fjords and into

1289
00:47:14,470 --> 00:47:11,599
these trenches to eat away at the

1290
00:47:16,150 --> 00:47:14,480
glaciers so we designed an aircraft

1291
00:47:18,470 --> 00:47:16,160
mission to drop little sensors and

1292
00:47:19,670 --> 00:47:18,480
measure these things uh directly in the

1293
00:47:21,829 --> 00:47:19,680
ocean

1294
00:47:24,390 --> 00:47:21,839
another aircraft mission to fly over the

1295
00:47:26,870 --> 00:47:24,400
ice and measure it with a radar

1296
00:47:28,950 --> 00:47:26,880
and over the next five years we're

1297
00:47:31,030 --> 00:47:28,960
hoping to

1298
00:47:33,430 --> 00:47:31,040
literally kind of shower greenland with

1299
00:47:35,670 --> 00:47:33,440
observations new observations of

1300
00:47:38,390 --> 00:47:35,680
how the ocean is changing

1301
00:47:40,950 --> 00:47:38,400
in the in the region right up close

1302
00:47:43,349 --> 00:47:40,960
uh to the land and also to fly over all

1303
00:47:45,349 --> 00:47:43,359
the all the places where we know

1304
00:47:47,750 --> 00:47:45,359
glaciers are literally sitting right

1305
00:47:49,030 --> 00:47:47,760
into the water and feeling the impact of

1306
00:47:50,950 --> 00:47:49,040
these currents

1307
00:47:54,150 --> 00:47:50,960
and try to answer the question

1308
00:47:56,550 --> 00:47:54,160
how much of the ice loss here is really

1309
00:47:59,030 --> 00:47:56,560
because of the oceans and how much of

1310
00:48:00,710 --> 00:47:59,040
the ocean's really threatening the ice

1311
00:48:02,790 --> 00:48:00,720
sheet in the future

1312
00:48:06,470 --> 00:48:02,800
so we're really excited about

1313
00:48:08,790 --> 00:48:06,480

excuse me omg and hopefully in a year or

1314
00:48:10,630 --> 00:48:08,800
so i'll come back and give you a talk

1315
00:48:12,950 --> 00:48:10,640
all about this one and say all kinds of

1316
00:48:15,270 --> 00:48:12,960
crazy stuff about greenland um but in

1317
00:48:25,109 --> 00:48:15,280
the meantime i'll stop and answer

1318
00:48:27,990 --> 00:48:26,390
so we're going to do a little question

1319
00:48:29,589 --> 00:48:28,000
and answer session here so if you have a

1320
00:48:31,510 --> 00:48:29,599
question please come up to the

1321
00:48:32,870 --> 00:48:31,520
microphone and ask me through the

1322
00:48:34,470 --> 00:48:32,880
microphone

1323
00:48:36,790 --> 00:48:34,480
so that everybody can hear

1324
00:48:39,030 --> 00:48:36,800
even people on the internets

1325
00:48:41,430 --> 00:48:39,040
and uh i think we may also get some

1326
00:48:43,510 --> 00:48:41,440
questions from uh online

1327
00:48:45,990 --> 00:48:43,520
uh if we have any so uh

1328
00:48:49,750 --> 00:48:46,000
please thanks

1329
00:48:51,750 --> 00:48:49,760
how long is uh florida going to uh

1330
00:48:54,069 --> 00:48:51,760
going to be but by the time florida

1331
00:48:56,230 --> 00:48:54,079
sinks into the ocean

1332
00:48:57,990 --> 00:48:56,240
um when do we finally get rid of florida

1333
00:49:00,710 --> 00:48:58,000
is that what you're asking

1334
00:49:02,309 --> 00:49:00,720
yeah that's a great question well

1335
00:49:04,150 --> 00:49:02,319
florida's already beginning to feel the

1336
00:49:06,390 --> 00:49:04,160
impact of sea level rise they've had

1337
00:49:08,230 --> 00:49:06,400
about that same eight inches that we've

1338
00:49:09,190 --> 00:49:08,240

had pretty much everywhere else in the

1339
00:49:11,109 --> 00:49:09,200
world

1340
00:49:13,430 --> 00:49:11,119
and

1341
00:49:15,670 --> 00:49:13,440
they're beginning to have to protect

1342
00:49:18,710 --> 00:49:15,680
areas that they want to keep and decide

1343
00:49:20,790 --> 00:49:18,720
which areas they want to lose but in the

1344
00:49:23,030 --> 00:49:20,800
next hundred years

1345
00:49:24,390 --> 00:49:23,040
excuse me we face somewhere between

1346
00:49:26,870 --> 00:49:24,400
one foot

1347
00:49:28,870 --> 00:49:26,880
which is probably unlikely and six feet

1348
00:49:31,190 --> 00:49:28,880
of sea level rise

1349
00:49:34,549 --> 00:49:31,200
if it's six feet then

1350
00:49:35,510 --> 00:49:34,559
really a whole lot of florida is gonna

1351
00:49:38,150 --> 00:49:35,520
be

1352
00:49:40,150 --> 00:49:38,160
underwater um and it doesn't happen sort

1353
00:49:41,430 --> 00:49:40,160
of all you know like one day you walk

1354
00:49:44,309 --> 00:49:41,440
out and

1355
00:49:46,069 --> 00:49:44,319
your backyard is flooded um you know

1356
00:49:47,829 --> 00:49:46,079
it's that storm that didn't used to get

1357
00:49:48,710 --> 00:49:47,839
you now it gets you

1358
00:49:50,790 --> 00:49:48,720
uh

1359
00:49:52,390 --> 00:49:50,800
it's that high tide that didn't use to

1360
00:49:54,390 --> 00:49:52,400
get you now it gets you

1361
00:49:55,990 --> 00:49:54,400
and so it's kind of this creeping thing

1362
00:49:56,829 --> 00:49:56,000
and one that that people are going to

1363
00:49:59,109 --> 00:49:56,839

have to

1364
00:50:01,030 --> 00:49:59,119
decide what kind of stuff they want to

1365
00:50:04,230 --> 00:50:01,040
protect and what kind of stuff they want

1366
00:50:06,390 --> 00:50:04,240
to let the oceans reclaim so

1367
00:50:08,069 --> 00:50:06,400
so you know florida is going to face

1368
00:50:10,069 --> 00:50:08,079
some tough decisions in the next hundred

1369
00:50:12,870 --> 00:50:10,079
years now is it all going to be at

1370
00:50:14,790 --> 00:50:12,880
underwater by the end of the 21st

1371
00:50:17,030 --> 00:50:14,800
century no

1372
00:50:19,030 --> 00:50:17,040
but major cities

1373
00:50:21,270 --> 00:50:19,040
along the coast of florida will face

1374
00:50:23,349 --> 00:50:21,280
trouble from sea level rise

1375
00:50:26,549 --> 00:50:23,359
the question is how much

1376
00:50:28,950 --> 00:50:26,559
and um part of it is we don't know the

1377
00:50:30,630 --> 00:50:28,960
answer entirely we we have some idea

1378
00:50:32,710 --> 00:50:30,640
like i said between one foot and six

1379
00:50:34,470 --> 00:50:32,720
feet but these things like the oceans

1380
00:50:36,150 --> 00:50:34,480
eating away the glaciers

1381
00:50:38,549 --> 00:50:36,160
uh there's a whole lot that we really

1382
00:50:41,670 --> 00:50:38,559
don't understand about that so

1383
00:50:44,069 --> 00:50:41,680
our ability to say one foot or six feet

1384
00:50:45,990 --> 00:50:44,079
is limited at this point

1385
00:50:47,349 --> 00:50:46,000
and in a way that's a bigger risk than

1386
00:50:48,790 --> 00:50:47,359
if we already knew

1387
00:50:51,349 --> 00:50:48,800
if i could tell you it's definitely

1388
00:50:53,589 --> 00:50:51,359

going to be 2.5 feet by the middle of

1389
00:50:55,109 --> 00:50:53,599
the century then you could say okay well

1390
00:50:57,670 --> 00:50:55,119
it's time to abandon this city in this

1391
00:50:59,430 --> 00:50:57,680
city and and move on

1392
00:51:02,150 --> 00:50:59,440
but because there's this uncertainty in

1393
00:51:04,630 --> 00:51:02,160
a way we face bigger risk because we

1394
00:51:06,549 --> 00:51:04,640
might choose to ignore it

1395
00:51:08,790 --> 00:51:06,559
and then you know then you really have

1396
00:51:10,390 --> 00:51:08,800
troubles well i used to be stationed on

1397
00:51:12,230 --> 00:51:10,400
kwajalein

1398
00:51:13,750 --> 00:51:12,240
in the pacific

1399
00:51:16,870 --> 00:51:13,760
and just a foot

1400
00:51:19,750 --> 00:51:16,880
rise would sink that entire island

1401
00:51:20,870 --> 00:51:19,760
and a lot of islands in the pacific

1402
00:51:23,270 --> 00:51:20,880
now my

1403
00:51:24,950 --> 00:51:23,280
other my question is

1404
00:51:29,670 --> 00:51:24,960
how do we

1405
00:51:32,390 --> 00:51:29,680
all our fault

1406
00:51:34,710 --> 00:51:32,400
do we ruin our economy do we stop

1407
00:51:37,589 --> 00:51:34,720
putting our you know we got to watch the

1408
00:51:39,829 --> 00:51:37,599
way we are our light bulbs what we use

1409
00:51:42,950 --> 00:51:39,839
what kind of cars we drive

1410
00:51:43,750 --> 00:51:42,960
our whole life becomes all screwed up

1411
00:51:48,549 --> 00:51:43,760
or

1412
00:51:51,030 --> 00:51:48,559
cause of global warming besides me

1413
00:51:54,470 --> 00:51:51,040

and us individuals that are being

1414
00:51:56,150 --> 00:51:54,480
hounded by the left yeah well uh oh some

1415
00:51:59,589 --> 00:51:56,160
applause

1416
00:52:01,270 --> 00:51:59,599
um well you know i think uh uh i think

1417
00:52:03,030 --> 00:52:01,280
the fact is that we're gonna pay the

1418
00:52:04,950 --> 00:52:03,040
costs of global warming whether it's

1419
00:52:06,710 --> 00:52:04,960
today or tomorrow

1420
00:52:08,549 --> 00:52:06,720
and

1421
00:52:11,109 --> 00:52:08,559
we

1422
00:52:13,589 --> 00:52:11,119
human activity is definitely the cause

1423
00:52:16,470 --> 00:52:13,599
of modern day sea level rise

1424
00:52:18,950 --> 00:52:16,480
it's the burning of fossil fuels

1425
00:52:21,990 --> 00:52:18,960
and um but that's not to say that it's

1426
00:52:23,510 --> 00:52:22,000
hopeless uh i think there's uh plenty of

1427
00:52:27,109 --> 00:52:23,520
opportunity to

1428
00:52:29,589 --> 00:52:27,119
innovate new forms of energy and to wean

1429
00:52:31,829 --> 00:52:29,599
ourselves off of our addiction to oil

1430
00:52:33,829 --> 00:52:31,839
and if we do then i think we can stave

1431
00:52:35,589 --> 00:52:33,839
off some of the biggest

1432
00:52:37,910 --> 00:52:35,599
consequences

1433
00:52:39,910 --> 00:52:37,920
but if we don't we'll eventually pay for

1434
00:52:41,349 --> 00:52:39,920
them one way or another

1435
00:52:42,470 --> 00:52:41,359
well the way it looks to me like it's

1436
00:52:45,030 --> 00:52:42,480
just

1437
00:52:47,030 --> 00:52:45,040
global pollution

1438
00:52:49,190 --> 00:52:47,040

basically yeah pollutions yeah we don't

1439
00:52:51,589 --> 00:52:49,200
do nothing with china or india they just

1440
00:52:52,950 --> 00:52:51,599
going wild with it and we are the one in

1441
00:52:55,349 --> 00:52:52,960
america they get

1442
00:52:56,870 --> 00:52:55,359
uh always told that we're the bad guys

1443
00:52:58,470 --> 00:52:56,880
well of course uh there's plenty of

1444
00:53:01,190 --> 00:52:58,480
blame to go around

1445
00:53:03,589 --> 00:53:01,200
um but you know uh china and india are

1446
00:53:05,589 --> 00:53:03,599
trying to innovate solutions uh just

1447
00:53:07,990 --> 00:53:05,599
like we are in fact china is better at

1448
00:53:09,990 --> 00:53:08,000
building solar panels than we are so you

1449
00:53:11,270 --> 00:53:10,000
know uh we got to pick up the pace a

1450
00:53:15,990 --> 00:53:11,280
little bit

1451
00:53:19,990 --> 00:53:17,270
oh hello

1452
00:53:22,549 --> 00:53:20,000
uh is jason 3 equipped with the

1453
00:53:25,589 --> 00:53:22,559
microwave and a rodometer

1454
00:53:27,589 --> 00:53:25,599
uh there's a uh there is a radiometer on

1455
00:53:30,870 --> 00:53:27,599
board jason 3

1456
00:53:32,870 --> 00:53:30,880
that will measure how much

1457
00:53:35,030 --> 00:53:32,880
water the

1458
00:53:37,990 --> 00:53:35,040
signal has to travel through when it

1459
00:53:39,829 --> 00:53:38,000
travels down through the atmosphere

1460
00:53:42,150 --> 00:53:39,839
if it goes through water and clouds then

1461
00:53:44,309 --> 00:53:42,160
it it changes the travel time a little

1462
00:53:46,950 --> 00:53:44,319
bit so the radiometer essentially

1463
00:53:49,030 --> 00:53:46,960

measures that separately uh so that you

1464
00:53:51,829 --> 00:53:49,040
can correct for it but yes it does have

1465
00:53:54,549 --> 00:53:51,839
a radiometer in addition to

1466
00:53:56,710 --> 00:53:54,559
the actual radar instrument itself which

1467
00:53:58,390 --> 00:53:56,720
is measuring the the travel time and

1468
00:54:00,790 --> 00:53:58,400
telling us the height

1469
00:54:03,109 --> 00:54:00,800
when is the launch going to occur

1470
00:54:05,430 --> 00:54:03,119
well uh right now

1471
00:54:08,549 --> 00:54:05,440
the launch has slipped past its original

1472
00:54:11,190 --> 00:54:08,559
march 31st date uh we don't yet have a

1473
00:54:14,230 --> 00:54:11,200
firm date for a new launch but we're

1474
00:54:15,829 --> 00:54:14,240
looking at the summer maybe july

1475
00:54:17,910 --> 00:54:15,839
sometime around there

1476
00:54:19,589 --> 00:54:17,920
but we haven't been given a firm launch

1477
00:54:21,589 --> 00:54:19,599
date yet so

1478
00:54:24,069 --> 00:54:21,599
we're still they're still

1479
00:54:27,430 --> 00:54:24,079
looking at issues with the uh

1480
00:54:29,510 --> 00:54:27,440
trying to qualify the spacex rocket

1481
00:54:31,030 --> 00:54:29,520
which is going to be our ride to space

1482
00:54:32,790 --> 00:54:31,040
you know nasa makes you jump through a

1483
00:54:34,069 --> 00:54:32,800
bunch of hoops before you uh before

1484
00:54:34,950 --> 00:54:34,079
they'll put one of their babies on your

1485
00:54:37,270 --> 00:54:34,960
rocket

1486
00:54:40,790 --> 00:54:37,280
and uh so uh

1487
00:54:41,589 --> 00:54:40,800
but uh we are uh excited that um you

1488
00:54:43,829 --> 00:54:41,599

know

1489
00:54:45,910 --> 00:54:43,839
uh a lot of the waiting is is hopefully

1490
00:54:46,630 --> 00:54:45,920
behind us and we're hopeful that it'll

1491
00:54:48,630 --> 00:54:46,640
be

1492
00:54:49,589 --> 00:54:48,640
this summer we we really got our fingers

1493
00:54:53,030 --> 00:54:49,599
crossed

1494
00:54:55,750 --> 00:54:53,040
oftentimes uh lodges are

1495
00:54:57,750 --> 00:54:55,760
delayed due to high winds or something

1496
00:54:59,270 --> 00:54:57,760
like the launch of the discover every

1497
00:55:01,589 --> 00:54:59,280
day it's supposed to be launched and

1498
00:55:02,630 --> 00:55:01,599
then the window opens and closes and

1499
00:55:06,150 --> 00:55:02,640
whatever

1500
00:55:08,950 --> 00:55:06,160
and yet it's so inept because it's

1501
00:55:10,630 --> 00:55:08,960
dependent upon like data from

1502
00:55:13,589 --> 00:55:10,640
soho

1503
00:55:18,069 --> 00:55:13,599
with the uh actual measurements that can

1504
00:55:19,750 --> 00:55:18,079
be passed on to a dragon and discovered

1505
00:55:21,270 --> 00:55:19,760
right well you know we we we want the

1506
00:55:24,069 --> 00:55:21,280
good weather and a good window so that

1507
00:55:27,270 --> 00:55:24,079
we can hit the right target right uh so

1508
00:55:28,870 --> 00:55:27,280
uh but uh you know i i we've had a

1509
00:55:31,430 --> 00:55:28,880
couple of successful launches out of

1510
00:55:33,670 --> 00:55:31,440
vandenberg on previous missions and uh

1511
00:55:36,069 --> 00:55:33,680
you know we're we're really excited so

1512
00:55:38,630 --> 00:55:36,079
uh we're optimistic and and looking

1513
00:55:40,549 --> 00:55:38,640

forward to a launch this summer so keep

1514
00:55:44,710 --> 00:55:40,559
your fingers crossed for us i certainly

1515
00:55:48,549 --> 00:55:46,710
hi my name is ben i'm from redmond

1516
00:55:50,470 --> 00:55:48,559
washington um

1517
00:55:52,710 --> 00:55:50,480
and i'm a huge fan of the earth

1518
00:55:55,109 --> 00:55:52,720
observation satellite program so don't

1519
00:55:57,670 --> 00:55:55,119
take this as criticism but uh what is

1520
00:55:59,910 --> 00:55:57,680
the advantage to having multiple json

1521
00:56:02,230 --> 00:55:59,920
missions active at the same time is it

1522
00:56:03,670 --> 00:56:02,240
just that the new ones have better or

1523
00:56:05,990 --> 00:56:03,680
newer instruments

1524
00:56:07,670 --> 00:56:06,000
oh that's a great question uh there's a

1525
00:56:08,950 --> 00:56:07,680
couple reasons you want them to operate

1526
00:56:10,870 --> 00:56:08,960
at the same time

1527
00:56:12,150 --> 00:56:10,880
one is so that you have this unbroken

1528
00:56:14,230 --> 00:56:12,160
record

1529
00:56:18,549 --> 00:56:14,240
you know all of our missions so far

1530
00:56:21,349 --> 00:56:18,559
topex jason one jason one jason ii

1531
00:56:23,750 --> 00:56:21,359
have had some overlap and that overlap

1532
00:56:26,470 --> 00:56:23,760
has really allowed us to get an unbroken

1533
00:56:27,829 --> 00:56:26,480
record of sea level rise for 20 years so

1534
00:56:29,829 --> 00:56:27,839
part of the reason we want to fly them

1535
00:56:31,430 --> 00:56:29,839
both at the same time is so we can make

1536
00:56:33,589 --> 00:56:31,440
sure we really understand the new

1537
00:56:35,670 --> 00:56:33,599
instrument before we turn over the main

1538
00:56:37,829 --> 00:56:35,680

mission to it but there's other reasons

1539
00:56:38,630 --> 00:56:37,839
to fly them both at the same time too if

1540
00:56:41,109 --> 00:56:38,640
you

1541
00:56:43,270 --> 00:56:41,119
move one over into a slightly adjacent

1542
00:56:45,910 --> 00:56:43,280
orbit which is what we did between jason

1543
00:56:48,870 --> 00:56:45,920
1 and jason ii then you can essentially

1544
00:56:50,710 --> 00:56:48,880
double the resolution you get these

1545
00:56:52,870 --> 00:56:50,720
missions look straight down and they

1546
00:56:54,470 --> 00:56:52,880
give you a single point and they fly in

1547
00:56:56,789 --> 00:56:54,480
a pattern to kind of cover the whole

1548
00:56:59,270 --> 00:56:56,799
earth in 10 days but if you have two of

1549
00:57:01,510 --> 00:56:59,280
them you can uh essentially double your

1550
00:57:03,510 --> 00:57:01,520
resolution and you can see smaller scale

1551
00:57:04,870 --> 00:57:03,520
stuff in the ocean things like the

1552
00:57:06,789 --> 00:57:04,880
eddies that

1553
00:57:11,030 --> 00:57:06,799
push the oil slick around in the gulf of

1554
00:57:15,510 --> 00:57:12,549
catastrophe

1555
00:57:18,069 --> 00:57:15,520
those things uh are smaller and the more

1556
00:57:20,150 --> 00:57:18,079
satellites you have looking uh the finer

1557
00:57:22,710 --> 00:57:20,160
the resolution of things you can see

1558
00:57:24,789 --> 00:57:22,720
um a final reason which is something we

1559
00:57:26,870 --> 00:57:24,799
did with jason one is eventually we

1560
00:57:29,910 --> 00:57:26,880
might repurpose the mission and instead

1561
00:57:33,030 --> 00:57:29,920
of trying to do oceanography

1562
00:57:35,829 --> 00:57:33,040
really try and look at marine gravity so

1563
00:57:37,670 --> 00:57:35,839

it turns out that little mountains and

1564
00:57:40,230 --> 00:57:37,680
troughs and ridges on the bottom of the

1565
00:57:42,789 --> 00:57:40,240
ocean actually bend the shape of the sea

1566
00:57:45,030 --> 00:57:42,799
surface also from the pull of gravity

1567
00:57:47,030 --> 00:57:45,040
now this is a something they don't move

1568
00:57:50,470 --> 00:57:47,040
around the the mountains stay pretty

1569
00:57:52,069 --> 00:57:50,480
still so if you subtract out the time

1570
00:57:54,069 --> 00:57:52,079
average signal you can really look at

1571
00:57:57,349 --> 00:57:54,079
the oceanography but if you look at the

1572
00:57:59,190 --> 00:57:57,359
actual complete signal then those

1573
00:58:00,630 --> 00:57:59,200
little bumps and wiggles tell you where

1574
00:58:03,190 --> 00:58:00,640
the sea mounts are they tell you where

1575
00:58:05,030 --> 00:58:03,200
the under water mountains are so what we

1576
00:58:06,950 --> 00:58:05,040
actually did with jason one was move it

1577
00:58:08,390 --> 00:58:06,960
into a slightly different orbit where it

1578
00:58:10,150 --> 00:58:08,400
didn't really repeat

1579
00:58:12,069 --> 00:58:10,160
and it

1580
00:58:13,510 --> 00:58:12,079
you know measured a small swath that

1581
00:58:15,270 --> 00:58:13,520
traced along

1582
00:58:18,150 --> 00:58:15,280
the equator and covered the entire

1583
00:58:20,470 --> 00:58:18,160
oceans in a much finer mesh and that's

1584
00:58:22,710 --> 00:58:20,480
how they began to really improve the the

1585
00:58:24,710 --> 00:58:22,720
knowledge of the shape of the sea floor

1586
00:58:27,589 --> 00:58:24,720
so we might do something like that with

1587
00:58:29,750 --> 00:58:27,599
jason ii uh in a couple of years as it

1588
00:58:32,230 --> 00:58:29,760

starts to age and becomes more likely to

1589
00:58:36,150 --> 00:58:32,240
uh to eventually

1590
00:58:40,230 --> 00:58:38,470
your response just uh partly answered my

1591
00:58:41,990 --> 00:58:40,240
question but i was curious what kind of

1592
00:58:44,150 --> 00:58:42,000
techniques do you use to validate the

1593
00:58:45,589 --> 00:58:44,160
accuracy of your measurements

1594
00:58:48,150 --> 00:58:45,599
for example you mentioned about that

1595
00:58:51,190 --> 00:58:48,160
valentine's day episode

1596
00:58:53,270 --> 00:58:51,200
where you realize i don't know if it was

1597
00:58:55,349 --> 00:58:53,280
by intuition that that

1598
00:58:57,430 --> 00:58:55,359
you understood the data wrong like what

1599
00:58:59,510 --> 00:58:57,440
was the thought process um going into

1600
00:59:01,430 --> 00:58:59,520
that oh yeah what's what's keeping rush

1601
00:59:03,030 --> 00:59:01,440
off my back with the satellites

1602
00:59:04,470 --> 00:59:03,040
yeah that's a great question well we

1603
00:59:06,150 --> 00:59:04,480
have a lot of ways to

1604
00:59:08,069 --> 00:59:06,160
we have a lot of other things to compare

1605
00:59:10,309 --> 00:59:08,079
our satellite mission with so we have

1606
00:59:13,109 --> 00:59:10,319
tide gauges that are spread all across

1607
00:59:14,950 --> 00:59:13,119
the planet on coasts everywhere that

1608
00:59:16,870 --> 00:59:14,960
measure how the sea level changes and we

1609
00:59:18,470 --> 00:59:16,880
compare those with how the satellite's

1610
00:59:20,789 --> 00:59:18,480
telling us it changes

1611
00:59:22,950 --> 00:59:20,799
we also have a few dedicated places that

1612
00:59:25,109 --> 00:59:22,960
the satellite flies directly over

1613
00:59:27,829 --> 00:59:25,119

there's one right off the coast of santa

1614
00:59:29,910 --> 00:59:27,839
barbara called the harvest oil platform

1615
00:59:32,230 --> 00:59:29,920
it's just off the coast and it's had a

1616
00:59:33,990 --> 00:59:32,240
continuous sea level measurement right

1617
00:59:36,470 --> 00:59:34,000
there on the platform

1618
00:59:38,789 --> 00:59:36,480
and our satellite flies right over it so

1619
00:59:40,870 --> 00:59:38,799
we get a direct look and we can compare

1620
00:59:43,270 --> 00:59:40,880
directly and see just how good the

1621
00:59:44,870 --> 00:59:43,280
satellite is doing so

1622
00:59:47,510 --> 00:59:44,880
we also have a whole other suite of

1623
00:59:50,390 --> 00:59:47,520
satellites and and an entire team of

1624
00:59:52,549 --> 00:59:50,400
about 200 people who every year all the

1625
00:59:54,230 --> 00:59:52,559
time are just looking at this data

1626
00:59:56,150 --> 00:59:54,240
trying to uh make sure that it's

1627
00:59:58,309 --> 00:59:56,160
accurate and and agrees with other

1628
01:00:00,150 --> 00:59:58,319
things we're measuring uh that that are

1629
01:00:03,270 --> 01:00:00,160
consistent

1630
01:00:06,069 --> 01:00:03,280
what happened to me on my phd was

1631
01:00:08,470 --> 01:00:06,079
a different story and um that was a

1632
01:00:10,309 --> 01:00:08,480
actually a symptom of changing to a new

1633
01:00:13,109 --> 01:00:10,319
kind of data we had been measuring the

1634
01:00:14,870 --> 01:00:13,119
temperatures of the ocean with a

1635
01:00:17,109 --> 01:00:14,880
small probes

1636
01:00:18,789 --> 01:00:17,119
for decades and we switched over to a

1637
01:00:20,069 --> 01:00:18,799
new system and there were some

1638
01:00:21,910 --> 01:00:20,079

differences

1639
01:00:23,270 --> 01:00:21,920
that was part of the problem and then

1640
01:00:25,270 --> 01:00:23,280
part of the problem was that some of the

1641
01:00:27,750 --> 01:00:25,280
new floats just weren't some of the new

1642
01:00:28,390 --> 01:00:27,760
instruments just weren't working right

1643
01:00:30,870 --> 01:00:28,400
but

1644
01:00:32,789 --> 01:00:30,880
what eventually allowed us to tease out

1645
01:00:36,870 --> 01:00:32,799
the difference between the new and old

1646
01:00:39,510 --> 01:00:36,880
data was actually satellites like json

1647
01:00:41,349 --> 01:00:39,520
because as the bad data accumulated and

1648
01:00:42,950 --> 01:00:41,359
you got enough of it you begin to look

1649
01:00:44,789 --> 01:00:42,960
at the difference between what the

1650
01:00:47,750 --> 01:00:44,799
satellite was telling us and and what

1651
01:00:49,430 --> 01:00:47,760
the floats were telling us so uh

1652
01:00:51,030 --> 01:00:49,440
it's really a

1653
01:00:52,630 --> 01:00:51,040
an ongoing it's always a work in

1654
01:00:53,990 --> 01:00:52,640
progress we're always double checking

1655
01:00:55,589 --> 01:00:54,000
the data we're always looking back at

1656
01:00:57,109 --> 01:00:55,599
the results trying to make sure that

1657
01:00:59,829 --> 01:00:57,119
we're getting it really right and you

1658
01:01:01,430 --> 01:00:59,839
know science is a it's not a

1659
01:01:03,430 --> 01:01:01,440
you know

1660
01:01:05,270 --> 01:01:03,440
one big discovery after another kind of

1661
01:01:07,990 --> 01:01:05,280
thing it's a kind of a three steps

1662
01:01:09,589 --> 01:01:08,000
forward two steps back process um and

1663
01:01:11,510 --> 01:01:09,599

that's really part of what makes it so

1664
01:01:14,630 --> 01:01:11,520
accurate in the long run so we're always

1665
01:01:16,230 --> 01:01:14,640
checking ourselves but uh uh you know

1666
01:01:18,069 --> 01:01:16,240
you're still left with those occasional

1667
01:01:20,710 --> 01:01:18,079
moments where rush limbaugh's making fun

1668
01:01:24,950 --> 01:01:22,309
i think you said the precision of the

1669
01:01:27,910 --> 01:01:24,960
radio altimeter is about one inch that's

1670
01:01:29,750 --> 01:01:27,920
right yeah so for a sea level rise of a

1671
01:01:32,069 --> 01:01:29,760
few millimeters per year obviously

1672
01:01:33,750 --> 01:01:32,079
that's not particularly precise so how

1673
01:01:35,670 --> 01:01:33,760
do you actually tease it out do you just

1674
01:01:37,829 --> 01:01:35,680
take lots of measurements and

1675
01:01:39,670 --> 01:01:37,839
statistically yeah that's exactly it

1676
01:01:41,030 --> 01:01:39,680
that's a that's a great question that's

1677
01:01:42,870 --> 01:01:41,040
really good what'd he tell you that was

1678
01:01:45,750 --> 01:01:42,880
a great question i said no that's right

1679
01:01:51,349 --> 01:01:48,230
and yeah you said um you also measure

1680
01:01:52,870 --> 01:01:51,359
something else tilt or something yeah so

1681
01:01:54,549 --> 01:01:52,880
so essentially if i measure the height

1682
01:01:55,589 --> 01:01:54,559
over here yeah okay and the height over

1683
01:01:57,430 --> 01:01:55,599
here

1684
01:01:59,910 --> 01:01:57,440
and they go like this

1685
01:02:01,990 --> 01:01:59,920
then um the reason they went like this

1686
01:02:04,789 --> 01:02:02,000
is probably because there was a current

1687
01:02:07,510 --> 01:02:04,799
uh an ocean current at the surface so

1688
01:02:09,829 --> 01:02:07,520

literally when when the water's moving

1689
01:02:12,789 --> 01:02:09,839
it feels the rotation of the earth

1690
01:02:16,069 --> 01:02:12,799
and it winds up causing a tilt

1691
01:02:17,750 --> 01:02:16,079
in the surface of the ocean so

1692
01:02:19,670 --> 01:02:17,760
originally these satellites were

1693
01:02:22,390 --> 01:02:19,680
designed just to measure that tilt we

1694
01:02:23,829 --> 01:02:22,400
weren't thinking about global warming

1695
01:02:25,190 --> 01:02:23,839
the guy sitting next to you by the way

1696
01:02:27,349 --> 01:02:25,200
is one of the uh

1697
01:02:29,829 --> 01:02:27,359
one of the guys who made this first

1698
01:02:32,390 --> 01:02:29,839
mission topex poseidon happened so

1699
01:02:33,589 --> 01:02:32,400
uh any questions that uh yeah there he

1700
01:02:36,549 --> 01:02:33,599
goes

1701
01:02:38,390 --> 01:02:36,559
bill i can answer but uh

1702
01:02:39,990 --> 01:02:38,400
you know essentially it was designed to

1703
01:02:41,990 --> 01:02:40,000
measure that tilt we were really looking

1704
01:02:44,470 --> 01:02:42,000
for the currents but it turned out that

1705
01:02:46,710 --> 01:02:44,480
it was so accurate and and you know by

1706
01:02:48,069 --> 01:02:46,720
averaging over the whole globe

1707
01:02:50,150 --> 01:02:48,079
and really looking at the kind of

1708
01:02:51,829 --> 01:02:50,160
biggest scales you get millions and

1709
01:02:53,910 --> 01:02:51,839
millions of measurements every time

1710
01:02:55,190 --> 01:02:53,920
every 10 days and you average them all

1711
01:02:56,630 --> 01:02:55,200
together and you average a bunch of

1712
01:02:59,430 --> 01:02:56,640
10-day periods together and you can

1713
01:03:01,030 --> 01:02:59,440

really see this long-term change it's

1714
01:03:03,670 --> 01:03:01,040
like looking for an exoplanet just that

1715
01:03:07,510 --> 01:03:03,680
little bulge in the star motion yeah

1716
01:03:11,030 --> 01:03:09,750
my question is about the pacific decal

1717
01:03:13,030 --> 01:03:11,040
oscillation

1718
01:03:15,109 --> 01:03:13,040
and my impression is that we don't

1719
01:03:17,430 --> 01:03:15,119
really understand it very well

1720
01:03:19,670 --> 01:03:17,440
and so my question is to what extent

1721
01:03:21,190 --> 01:03:19,680
json data and maybe

1722
01:03:23,510 --> 01:03:21,200
data from

1723
01:03:25,589 --> 01:03:23,520
from probes that flowed up and down in

1724
01:03:27,589 --> 01:03:25,599
the ocean to what extent do we think

1725
01:03:29,430 --> 01:03:27,599
that that oscillation is chaotic and

1726
01:03:31,270 --> 01:03:29,440
really can't be predicted or what extent

1727
01:03:33,750 --> 01:03:31,280
do you think you'll you'll be able to

1728
01:03:35,109 --> 01:03:33,760
understand it better so because my

1729
01:03:38,069 --> 01:03:35,119
impression is we've only sort of seen

1730
01:03:40,150 --> 01:03:38,079
one cycle right 20 or 20 years or so

1731
01:03:42,549 --> 01:03:40,160
we don't have any way of knowing what it

1732
01:03:45,190 --> 01:03:42,559
was on previous cycles yeah it's a great

1733
01:03:47,029 --> 01:03:45,200
question um you know uh

1734
01:03:49,750 --> 01:03:47,039
just like you said the pacific decadal

1735
01:03:52,470 --> 01:03:49,760
oscillation is something that's decadal

1736
01:03:54,950 --> 01:03:52,480
takes a decade or two to change from one

1737
01:03:57,029 --> 01:03:54,960
sign to another one phase to another and

1738
01:03:59,750 --> 01:03:57,039

we've only had our satellite for two

1739
01:04:01,829 --> 01:03:59,760
decades so we don't have an especially

1740
01:04:03,750 --> 01:04:01,839
long look at the pacific decatal

1741
01:04:06,230 --> 01:04:03,760
oscillation but what's interesting is

1742
01:04:08,069 --> 01:04:06,240
that over those last two decades it's

1743
01:04:10,789 --> 01:04:08,079
really changed a lot it's changed a lot

1744
01:04:12,710 --> 01:04:10,799
from a very positive phase

1745
01:04:15,510 --> 01:04:12,720
which is associated here in california

1746
01:04:17,990 --> 01:04:15,520
with more rain to a very negative phase

1747
01:04:19,829 --> 01:04:18,000
which is associated with more drought

1748
01:04:21,430 --> 01:04:19,839
here in california

1749
01:04:23,990 --> 01:04:21,440
and it's interesting that there are

1750
01:04:26,069 --> 01:04:24,000
these weather connections because those

1751
01:04:27,430 --> 01:04:26,079
actually allow you to trace back over

1752
01:04:29,270 --> 01:04:27,440
time

1753
01:04:31,349 --> 01:04:29,280
things like the pacific decatal

1754
01:04:33,589 --> 01:04:31,359
oscillation by looking at the growth of

1755
01:04:36,150 --> 01:04:33,599
trees from tree rings and and other

1756
01:04:38,230 --> 01:04:36,160
proxies so our satellites only go back

1757
01:04:40,870 --> 01:04:38,240
20 years but we have a few other data

1758
01:04:43,190 --> 01:04:40,880
sets surface temperature goes back maybe

1759
01:04:45,109 --> 01:04:43,200
40 50 years

1760
01:04:47,270 --> 01:04:45,119
some surface pressure measurements maybe

1761
01:04:48,710 --> 01:04:47,280
go back farther than that and when you

1762
01:04:50,950 --> 01:04:48,720
get into longer time series you're

1763
01:04:53,349 --> 01:04:50,960

really looking at these tree rings

1764
01:04:56,150 --> 01:04:53,359
and and proxies

1765
01:04:57,910 --> 01:04:56,160
for the pacific decadal oscillation

1766
01:04:59,750 --> 01:04:57,920
but you're right in that our ability to

1767
01:05:02,230 --> 01:04:59,760
really tease all that apart we've only

1768
01:05:03,990 --> 01:05:02,240
got about 10 or 20 years worth of data

1769
01:05:05,670 --> 01:05:04,000
so we really are we really do have a lot

1770
01:05:08,390 --> 01:05:05,680
to learn about the pacific decatal

1771
01:05:09,750 --> 01:05:08,400
oscillation but at the very least we can

1772
01:05:11,829 --> 01:05:09,760
say that

1773
01:05:13,990 --> 01:05:11,839
it kind of goes back and forth between a

1774
01:05:16,309 --> 01:05:14,000
range a certain range

1775
01:05:17,190 --> 01:05:16,319
and that at least over the last say 50

1776
01:05:20,230 --> 01:05:17,200
years

1777
01:05:22,789 --> 01:05:20,240
it probably takes somewhere between 5

1778
01:05:24,789 --> 01:05:22,799
and 20 years to change

1779
01:05:28,069 --> 01:05:24,799
so we have some sense that it's kind of

1780
01:05:29,829 --> 01:05:28,079
these decades-long time scales but uh

1781
01:05:31,750 --> 01:05:29,839
but you're right the real

1782
01:05:33,270 --> 01:05:31,760
underlying cause

1783
01:05:35,270 --> 01:05:33,280
probably has something to do with the

1784
01:05:37,670 --> 01:05:35,280
ocean probably has something to do with

1785
01:05:39,829 --> 01:05:37,680
the way it interacts back and forth with

1786
01:05:42,630 --> 01:05:39,839
the atmosphere but what's really driving

1787
01:05:43,589 --> 01:05:42,640
this oscillation i think um is still

1788
01:05:47,109 --> 01:05:43,599

unknown

1789
01:05:52,309 --> 01:05:50,150
oh we have questions from people out in

1790
01:05:54,950 --> 01:05:52,319
interspace

1791
01:05:57,829 --> 01:05:54,960
great um so uh how long you want me to

1792
01:05:59,589 --> 01:05:57,839
drone on up here mark

1793
01:06:00,789 --> 01:05:59,599
as long as it takes to answer all of

1794
01:06:02,870 --> 01:06:00,799
these

1795
01:06:04,950 --> 01:06:02,880
um

1796
01:06:06,230 --> 01:06:04,960
okay so uh i'll just if you have other

1797
01:06:08,309 --> 01:06:06,240
questions feel free to go ahead and line

1798
01:06:09,510 --> 01:06:08,319
up at the mic but i'll um

1799
01:06:10,630 --> 01:06:09,520
i'll just go through a couple of these

1800
01:06:12,069 --> 01:06:10,640
really fun really quick because i think

1801
01:06:15,349 --> 01:06:12,079
they'll be fun so

1802
01:06:17,510 --> 01:06:15,359
elijah michael asks how long will jason

1803
01:06:21,349 --> 01:06:17,520
3 be active

1804
01:06:22,150 --> 01:06:21,359
we hope uh longer than rush limbaugh

1805
01:06:26,630 --> 01:06:22,160
but

1806
01:06:29,750 --> 01:06:26,640
between three and five years

1807
01:06:33,190 --> 01:06:29,760
so the they have a

1808
01:06:35,270 --> 01:06:33,200
must live for three-year kind of design

1809
01:06:37,349 --> 01:06:35,280
and we really hope they live for five

1810
01:06:39,349 --> 01:06:37,359
years and we kind of expect them to but

1811
01:06:41,510 --> 01:06:39,359
of course its predecessors have done

1812
01:06:43,349 --> 01:06:41,520
fantastic topex

1813
01:06:46,710 --> 01:06:43,359

lasted 13 years

1814
01:06:47,589 --> 01:06:46,720
jason lasted 11. jason one jason two is

1815
01:06:50,150 --> 01:06:47,599
now

1816
01:06:53,349 --> 01:06:50,160
let's see 2008 what year is it

1817
01:06:55,750 --> 01:06:53,359
it's getting up to seven years old so um

1818
01:06:58,470 --> 01:06:55,760
we're uh we're optimistic that it will

1819
01:07:00,789 --> 01:06:58,480
outlast the five-year life expectancy

1820
01:07:03,349 --> 01:07:00,799
and maybe it'll go 10 if we're lucky

1821
01:07:06,230 --> 01:07:03,359
but but we can't really plan on longer

1822
01:07:10,470 --> 01:07:09,109
uh jeffrey b boy lizard

1823
01:07:13,190 --> 01:07:10,480
asks

1824
01:07:15,750 --> 01:07:13,200
are there other things besides co2

1825
01:07:19,430 --> 01:07:15,760
affecting global warming well jeffrey b

1826
01:07:23,670 --> 01:07:21,589
co2 is the big dog when it comes to

1827
01:07:26,710 --> 01:07:23,680
causing global warming

1828
01:07:28,630 --> 01:07:26,720
there are other things that we do like

1829
01:07:30,309 --> 01:07:28,640
things that emit methane there are other

1830
01:07:32,150 --> 01:07:30,319
greenhouse gases

1831
01:07:33,670 --> 01:07:32,160
there are some other effects like

1832
01:07:36,150 --> 01:07:33,680
reshaping

1833
01:07:37,750 --> 01:07:36,160
the surface of the planet turning

1834
01:07:39,829 --> 01:07:37,760
the desert like we used to live in

1835
01:07:41,510 --> 01:07:39,839
around here into parking lots and golf

1836
01:07:43,349 --> 01:07:41,520
courses

1837
01:07:45,510 --> 01:07:43,359
these things all affect the climate but

1838
01:07:46,230 --> 01:07:45,520

in terms of the global climate in terms

1839
01:07:49,190 --> 01:07:46,240
of

1840
01:07:51,270 --> 01:07:49,200
the whole planet's heating up really co2

1841
01:07:52,870 --> 01:07:51,280
is the major cause

1842
01:07:54,710 --> 01:07:52,880
it's definitely

1843
01:07:57,270 --> 01:07:54,720
the biggest dog and it's the one that

1844
01:07:59,430 --> 01:07:57,280
lives the longest in the atmosphere so

1845
01:08:01,829 --> 01:07:59,440
co2 has an expected lifetime in the

1846
01:08:04,150 --> 01:08:01,839
atmosphere of hundreds if not thousands

1847
01:08:05,190 --> 01:08:04,160
of years the ocean sucks up a little bit

1848
01:08:07,349 --> 01:08:05,200
of it but

1849
01:08:10,630 --> 01:08:07,359
but by and large what we put there we're

1850
01:08:11,430 --> 01:08:10,640
stuck with for a long time

1851
01:08:13,990 --> 01:08:11,440
oh

1852
01:08:15,109 --> 01:08:14,000
this last one's from marvin the martian

1853
01:08:17,430 --> 01:08:15,119
um

1854
01:08:19,510 --> 01:08:17,440
what effect would a large volcanic

1855
01:08:20,950 --> 01:08:19,520
eruption or asteroid strike have on our

1856
01:08:22,309 --> 01:08:20,960
climate

1857
01:08:27,749 --> 01:08:22,319
uh

1858
01:08:29,990 --> 01:08:27,759
blow up the earth um

1859
01:08:33,349 --> 01:08:30,000
but uh

1860
01:08:35,030 --> 01:08:33,359
and uh you know an asteroid or a giant

1861
01:08:36,950 --> 01:08:35,040
volcanic eruption could have a pretty

1862
01:08:39,749 --> 01:08:36,960
major impact on the climate

1863
01:08:42,309 --> 01:08:39,759

in fact it's been suggested that this

1864
01:08:46,070 --> 01:08:42,319
was partly the cause for extinctions in

1865
01:08:47,510 --> 01:08:46,080
the past a big meteor would hit the

1866
01:08:50,070 --> 01:08:47,520
hit the

1867
01:08:52,550 --> 01:08:50,080
planet and blow dust up into the

1868
01:08:54,550 --> 01:08:52,560
stratosphere and effectively you know a

1869
01:08:57,269 --> 01:08:54,560
volcano can do the same thing it can put

1870
01:08:59,269 --> 01:08:57,279
all this soot into the stratosphere and

1871
01:09:02,550 --> 01:08:59,279
this can actually cool off the planet so

1872
01:09:03,669 --> 01:09:02,560
you can get a little ice age or a little

1873
01:09:05,030 --> 01:09:03,679
winter

1874
01:09:06,950 --> 01:09:05,040
in fact

1875
01:09:09,669 --> 01:09:06,960
we've seen this in the not too distant

1876
01:09:12,630 --> 01:09:09,679
past mount pinatubo was a major eruption

1877
01:09:14,789 --> 01:09:12,640
in the early 1990s interestingly right

1878
01:09:17,749 --> 01:09:14,799
at the launch of jason or of topex

1879
01:09:19,189 --> 01:09:17,759
poseidon and um it's been suggested that

1880
01:09:22,870 --> 01:09:19,199
it cooled off the earth just a little

1881
01:09:25,510 --> 01:09:22,880
bit for a couple of years so these kinds

1882
01:09:28,070 --> 01:09:25,520
of things can have a big impact

1883
01:09:29,910 --> 01:09:28,080
but of course soot eventually settles

1884
01:09:32,229 --> 01:09:29,920
out of the atmosphere

1885
01:09:34,390 --> 01:09:32,239
and these things eventually

1886
01:09:37,110 --> 01:09:34,400
kind of go back to the way they were

1887
01:09:38,950 --> 01:09:37,120
whereas co2 can really last uh hundreds

1888
01:09:40,709 --> 01:09:38,960

if if not thousands of years like i said

1889
01:09:42,470 --> 01:09:40,719
so um

1890
01:09:46,070 --> 01:09:42,480
uh keep working at it marvin but we're