



1
00:00:17,510 --> 00:00:26,070

[Music]

2
00:00:31,269 --> 00:00:28,230

hello and welcome to another devon

3
00:00:33,350 --> 00:00:31,279

carmen lecture series rising tides i am

4
00:00:35,750 --> 00:00:33,360

nikki weirich from jpl's office of

5
00:00:37,590 --> 00:00:35,760

communications and education

6
00:00:40,069 --> 00:00:37,600

tonight as we approach the one-year

7
00:00:42,950 --> 00:00:40,079

anniversary of nasa's earth flagship

8
00:00:44,549 --> 00:00:42,960

mission sentinel 6 michael freilich we

9
00:00:47,270 --> 00:00:44,559

will take a look at how we study our

10
00:00:48,709 --> 00:00:47,280

oceans our planet and what is coming

11
00:00:50,630 --> 00:00:48,719

next

12
00:00:52,709 --> 00:00:50,640

joining us as co-host fielding your

13
00:00:55,750 --> 00:00:52,719

questions this evening is earth public

14

00:00:57,510 --> 00:00:55,760

outreach specialist jocelyn argeta hi

15

00:00:58,790 --> 00:00:57,520

jocelyn

16

00:01:00,869 --> 00:00:58,800

hey nikki

17

00:01:02,869 --> 00:01:00,879

great to be here tonight and i want to

18

00:01:05,429 --> 00:01:02,879

take a moment to just remind all of our

19

00:01:07,590 --> 00:01:05,439

viewers that this is your space program

20

00:01:09,270 --> 00:01:07,600

and we want you to be involved in the

21

00:01:11,190 --> 00:01:09,280

conversation tonight so from wherever

22

00:01:13,590 --> 00:01:11,200

you're watching this feel free to add

23

00:01:15,270 --> 00:01:13,600

your questions to the chat our amazing

24

00:01:16,950 --> 00:01:15,280

social media team is going to get those

25

00:01:19,350 --> 00:01:16,960

questions to us and we'll try to get

26

00:01:21,030 --> 00:01:19,360

through as many as we can and if for

27

00:01:22,630 --> 00:01:21,040

whatever reason you don't see the chat

28

00:01:24,149 --> 00:01:22,640

just hit refresh and it should come

29

00:01:26,070 --> 00:01:24,159

right up

30

00:01:27,270 --> 00:01:26,080

awesome thank you jocelyn we're so glad

31

00:01:29,429 --> 00:01:27,280

to have you with us this evening

32

00:01:30,870 --> 00:01:29,439

fielding all those wonderful questions

33

00:01:33,429 --> 00:01:30,880

uh just a reminder to all of you

34

00:01:35,670 --> 00:01:33,439

watching this evening if we do run into

35

00:01:37,429 --> 00:01:35,680

any technical difficulties we do ask

36

00:01:39,190 --> 00:01:37,439

that you stick with us as we get these

37

00:01:41,590 --> 00:01:39,200

sorted out

38

00:01:43,910 --> 00:01:41,600

now our speaker this evening dr josh

39

00:01:46,550 --> 00:01:43,920

willis is the lead nasa scientist for

40

00:01:49,350 --> 00:01:46,560

the jason and sentinel 6 satellites

41

00:01:51,830 --> 00:01:49,360

which measures sea level from space

42

00:01:54,710 --> 00:01:51,840

he is also the lead scientist for nasa's

43

00:01:57,270 --> 00:01:54,720

recent airborne mission ocean's melting

44

00:01:59,590 --> 00:01:57,280

greenland or omg

45

00:02:02,230 --> 00:01:59,600

josh will discuss these missions and how

46

00:02:04,469 --> 00:02:02,240

understanding and predicting sea level

47

00:02:06,870 --> 00:02:04,479

rise is one of the most urgent problems

48

00:02:09,669 --> 00:02:06,880

in climate science today

49

00:02:13,030 --> 00:02:09,679

hi josh how are you doing tonight

50

00:02:14,550 --> 00:02:13,040

hi so good to be here thank you

51
00:02:15,670 --> 00:02:14,560
we are so happy to have you and i'm

52
00:02:17,430 --> 00:02:15,680
going to turn it over to you because

53
00:02:19,750 --> 00:02:17,440
you've got a lot of great information to

54
00:02:22,869 --> 00:02:19,760
share with us tonight

55
00:02:25,110 --> 00:02:22,879
fantastic well thank you so much and

56
00:02:27,350 --> 00:02:25,120
i just want to say before we start if

57
00:02:29,510 --> 00:02:27,360
you're watching this live it's veterans

58
00:02:31,110 --> 00:02:29,520
day and i'd like to take a moment if

59
00:02:33,350 --> 00:02:31,120
you're a veteran whether you're watching

60
00:02:35,670 --> 00:02:33,360
live or not to thank you for your

61
00:02:38,229 --> 00:02:35,680
service

62
00:02:40,470 --> 00:02:38,239
so let's get started uh

63
00:02:43,830 --> 00:02:40,480

why am i here

64

00:02:46,710 --> 00:02:43,840

well i'm an oceanographer and i study

65

00:02:49,509 --> 00:02:46,720

the oceans using data from nasa

66

00:02:50,390 --> 00:02:49,519

satellites of all different kinds

67

00:02:53,509 --> 00:02:50,400

but

68

00:02:56,390 --> 00:02:53,519

as nikki said i'm also the lead nasa

69

00:02:58,309 --> 00:02:56,400

scientist for the sentinel 6 and jason

70

00:02:59,670 --> 00:02:58,319

missions which measures sea level from

71

00:03:01,430 --> 00:02:59,680

space

72

00:03:04,309 --> 00:03:01,440

so what i really want to talk to you

73

00:03:07,589 --> 00:03:04,319

about tonight is climate change or the

74

00:03:11,430 --> 00:03:07,599

warming of our planet now when we think

75

00:03:14,390 --> 00:03:11,440

of the planet warming we typically think

76
00:03:16,949 --> 00:03:14,400
of the atmosphere warming and that's

77
00:03:18,630 --> 00:03:16,959
what this first graph that i'm going to

78
00:03:21,350 --> 00:03:18,640
show you

79
00:03:24,309 --> 00:03:21,360
tells us now i'll i promise i won't show

80
00:03:27,670 --> 00:03:24,319
you too many plots like this

81
00:03:29,670 --> 00:03:27,680
but if you'll bear with me uh on the on

82
00:03:32,070 --> 00:03:29,680
the bottom axis we have time this plot

83
00:03:34,470 --> 00:03:32,080
goes back to the 1880s

84
00:03:36,789 --> 00:03:34,480
and what we have on the vertical axis is

85
00:03:38,869 --> 00:03:36,799
temperature and this is not just any

86
00:03:41,509 --> 00:03:38,879
temperature it's the average temperature

87
00:03:44,470 --> 00:03:41,519
of the entire planet and this tells us a

88
00:03:47,509 --> 00:03:44,480

very simple story that the earth is

89

00:03:51,430 --> 00:03:47,519

getting warmer and it's getting warmer

90

00:03:53,509 --> 00:03:51,440

pretty fast a degree of warming a degree

91

00:03:56,070 --> 00:03:53,519

celsius of warming may not seem like a

92

00:03:58,390 --> 00:03:56,080

lot but it's actually a huge change to

93

00:04:01,670 --> 00:03:58,400

our climate and it's happening

94

00:04:02,789 --> 00:04:01,680

right now and the big question of course

95

00:04:06,149 --> 00:04:02,799

is why

96

00:04:08,390 --> 00:04:06,159

and the answer is actually us

97

00:04:12,070 --> 00:04:08,400

we are actually warming the planet's

98

00:04:13,990 --> 00:04:12,080

climate by adding carbon dioxide to the

99

00:04:15,990 --> 00:04:14,000

atmosphere and

100

00:04:19,349 --> 00:04:16,000

increasing the amount of heat that we

101
00:04:22,950 --> 00:04:19,359
trap from the sun now if we look back in

102
00:04:25,749 --> 00:04:22,960
time at the record of carbon dioxide

103
00:04:27,590 --> 00:04:25,759
since about a half million years ago it

104
00:04:28,390 --> 00:04:27,600
looks something like this where you can

105
00:04:31,030 --> 00:04:28,400
see

106
00:04:32,629 --> 00:04:31,040
carbon dioxide's gone up and down and up

107
00:04:35,110 --> 00:04:32,639
and down for

108
00:04:38,230 --> 00:04:35,120
about every hundred thousand years

109
00:04:39,830 --> 00:04:38,240
and right now we were actually in a warm

110
00:04:41,749 --> 00:04:39,840
period about

111
00:04:43,909 --> 00:04:41,759
twenty thousand years ago

112
00:04:47,189 --> 00:04:43,919
we were in a cold period and carbon

113
00:04:49,749 --> 00:04:47,199

dioxide levels were low on the planet

114

00:04:52,070 --> 00:04:49,759

and then it started to warm up naturally

115

00:04:55,030 --> 00:04:52,080

it warmed up and we've been in a warm

116

00:04:56,950 --> 00:04:55,040

period for about 10 000 years and during

117

00:04:59,510 --> 00:04:56,960

that time co2 increased in the

118

00:05:01,510 --> 00:04:59,520

atmosphere and we trapped more and more

119

00:05:03,189 --> 00:05:01,520

heat but if you look back at the last

120

00:05:06,469 --> 00:05:03,199

half million years

121

00:05:09,189 --> 00:05:06,479

carbon dioxide today is higher than at

122

00:05:11,670 --> 00:05:09,199

any time in the last half million years

123

00:05:14,710 --> 00:05:11,680

and the reason why is right here on the

124

00:05:17,029 --> 00:05:14,720

back of this slide we've been burning

125

00:05:20,230 --> 00:05:17,039

fossil fuels which

126

00:05:23,189 --> 00:05:20,240

add carbon dioxide to the atmosphere and

127

00:05:25,830 --> 00:05:23,199

this is trapping extra heat

128

00:05:28,870 --> 00:05:25,840

now how does that happen well

129

00:05:30,550 --> 00:05:28,880

extra heat is actually added to the

130

00:05:32,790 --> 00:05:30,560

atmosphere

131

00:05:34,310 --> 00:05:32,800

when sunlight passes through the

132

00:05:36,710 --> 00:05:34,320

atmosphere

133

00:05:39,430 --> 00:05:36,720

it actually warms the surface of the

134

00:05:42,950 --> 00:05:39,440

earth and that warm surface

135

00:05:45,510 --> 00:05:42,960

sends heat back out towards space

136

00:05:47,510 --> 00:05:45,520

but as the heat goes back towards space

137

00:05:49,590 --> 00:05:47,520

it's actually different than the light

138

00:05:51,990 --> 00:05:49,600

coming from the sun the light coming

139

00:05:54,469 --> 00:05:52,000

from the sun is in the form of visible

140

00:05:57,110 --> 00:05:54,479

light and it goes right through the

141

00:05:59,110 --> 00:05:57,120

atmosphere but the energy that heads

142

00:06:01,990 --> 00:05:59,120

back out towards space

143

00:06:04,790 --> 00:06:02,000

gets stuck and the amount that gets

144

00:06:06,710 --> 00:06:04,800

stuck depends on how much carbon dioxide

145

00:06:09,510 --> 00:06:06,720

there is in the atmosphere

146

00:06:11,590 --> 00:06:09,520

so if we trap this extra heat in the

147

00:06:14,390 --> 00:06:11,600

atmosphere if we add carbon dioxide to

148

00:06:17,590 --> 00:06:14,400

the atmosphere we trap the extra heat

149

00:06:19,270 --> 00:06:17,600

and keep it from leaving back out

150

00:06:22,710 --> 00:06:19,280

towards space

151
00:06:24,950 --> 00:06:22,720
so what happens to the heat now i said

152
00:06:27,029 --> 00:06:24,960
at the beginning i'm an oceanographer so

153
00:06:30,629 --> 00:06:27,039
you probably have a hint

154
00:06:33,670 --> 00:06:30,639
but you may not realize just how big an

155
00:06:34,870 --> 00:06:33,680
influence the ocean is on our planet's

156
00:06:38,150 --> 00:06:34,880
climate

157
00:06:41,270 --> 00:06:38,160
and this chart is a stark reminder of

158
00:06:43,590 --> 00:06:41,280
just how important the oceans are

159
00:06:47,350 --> 00:06:43,600
for understanding what's happening to

160
00:06:49,110 --> 00:06:47,360
our planet over 90 percent of the extra

161
00:06:52,790 --> 00:06:49,120
heat that we're trapping with the

162
00:06:54,629 --> 00:06:52,800
greenhouse gases is warming the oceans

163
00:06:56,790 --> 00:06:54,639

now the very first

164

00:06:59,909 --> 00:06:56,800

graph that i showed you showed that the

165

00:07:02,550 --> 00:06:59,919

atmosphere is warming up but in fact

166

00:07:04,790 --> 00:07:02,560

the real action the real place where

167

00:07:07,110 --> 00:07:04,800

most of global warming is occurring is

168

00:07:09,909 --> 00:07:07,120

in the oceans and you can think of the

169

00:07:12,309 --> 00:07:09,919

atmosphere as sort of like a piece of

170

00:07:13,430 --> 00:07:12,319

aluminum foil wrapped around a potato in

171

00:07:16,150 --> 00:07:13,440

the oven

172

00:07:18,390 --> 00:07:16,160

if you reach into an oven that's 350

173

00:07:21,110 --> 00:07:18,400

degrees and you grab a piece of aluminum

174

00:07:23,589 --> 00:07:21,120

foil it actually won't burn you if it's

175

00:07:25,990 --> 00:07:23,599

all by itself because the aluminum foil

176

00:07:28,070 --> 00:07:26,000

can't carry that much heat but if you

177

00:07:30,390 --> 00:07:28,080

wrap it around a hot potato then you're

178

00:07:32,390 --> 00:07:30,400

in big trouble and the oceans are sort

179

00:07:34,230 --> 00:07:32,400

of like the world's

180

00:07:35,589 --> 00:07:34,240

heat potato

181

00:07:38,070 --> 00:07:35,599

they trap

182

00:07:40,230 --> 00:07:38,080

over 90 of this heat

183

00:07:42,309 --> 00:07:40,240

and they can absorb heat very quickly

184

00:07:44,309 --> 00:07:42,319

and and very efficiently so

185

00:07:46,390 --> 00:07:44,319

really when we think about global

186

00:07:48,390 --> 00:07:46,400

warming we should be think about we

187

00:07:49,270 --> 00:07:48,400

should be thinking about ocean warming

188

00:07:52,710 --> 00:07:49,280

because

189

00:07:53,510 --> 00:07:52,720

that's where most of it is happening

190

00:07:56,950 --> 00:07:53,520

now

191

00:07:59,110 --> 00:07:56,960

as the planet warms we see effects all

192

00:08:01,909 --> 00:07:59,120

over the world the oceans are warming

193

00:08:04,950 --> 00:08:01,919

the air is warming and as this happens

194

00:08:07,270 --> 00:08:04,960

we can see that ice around the planet is

195

00:08:09,350 --> 00:08:07,280

actually melting as well

196

00:08:12,629 --> 00:08:09,360

and if you look at the black and white

197

00:08:15,990 --> 00:08:12,639

picture here this is a picture of an

198

00:08:18,230 --> 00:08:16,000

alaskan glacier taken in 1941

199

00:08:20,710 --> 00:08:18,240

and you can see the ice

200

00:08:22,950 --> 00:08:20,720

running through this canyon as it snakes

201
00:08:25,670 --> 00:08:22,960
around between mountains

202
00:08:27,749 --> 00:08:25,680
but in 2004 someone went back to the

203
00:08:29,990 --> 00:08:27,759
exact same spot and took the exact same

204
00:08:31,749 --> 00:08:30,000
photograph and you can see that the ice

205
00:08:34,230 --> 00:08:31,759
has now retreated

206
00:08:35,589 --> 00:08:34,240
far into the canyon many miles into the

207
00:08:37,350 --> 00:08:35,599
canyon

208
00:08:39,990 --> 00:08:37,360
and this is something that's actually

209
00:08:42,709 --> 00:08:40,000
happening all over the planet over 90

210
00:08:45,110 --> 00:08:42,719
percent of all the glaciers in the world

211
00:08:46,949 --> 00:08:45,120
are retreating and getting smaller as

212
00:08:50,389 --> 00:08:46,959
the climate warms

213
00:08:52,710 --> 00:08:50,399

and as that happens it actually raises

214

00:08:54,310 --> 00:08:52,720

sea levels around the planet as well

215

00:08:57,509 --> 00:08:54,320

because the ice that's lost from the

216

00:09:00,870 --> 00:08:57,519

glaciers runs off into the oceans and

217

00:09:03,590 --> 00:09:00,880

adds that extra water to the ocean level

218

00:09:06,790 --> 00:09:03,600

raising sea levels everywhere

219

00:09:09,430 --> 00:09:06,800

now we know that sea levels are rising

220

00:09:12,710 --> 00:09:09,440

for some really interesting reasons

221

00:09:15,350 --> 00:09:12,720

and one of my favorite uh one of my

222

00:09:16,790 --> 00:09:15,360

favorite plots one of my favorite graphs

223

00:09:17,910 --> 00:09:16,800

i told you i wouldn't show you too many

224

00:09:19,190 --> 00:09:17,920

graphs but i'm going to show you a

225

00:09:22,870 --> 00:09:19,200

couple more

226
00:09:24,150 --> 00:09:22,880
but one of my favorite most interesting

227
00:09:27,190 --> 00:09:24,160
records

228
00:09:28,790 --> 00:09:27,200
is this record of sea level change

229
00:09:30,150 --> 00:09:28,800
from northern care alliance from north

230
00:09:31,750 --> 00:09:30,160
carolina

231
00:09:34,870 --> 00:09:31,760
along the coast

232
00:09:36,470 --> 00:09:34,880
collected in a salt marsh and

233
00:09:38,870 --> 00:09:36,480
this is one of my colleagues who went

234
00:09:40,550 --> 00:09:38,880
out and they drill holes to this salt

235
00:09:42,870 --> 00:09:40,560
marsh and

236
00:09:46,070 --> 00:09:42,880
dig up the mud and it gives them a

237
00:09:47,269 --> 00:09:46,080
record back in time of how high sea

238
00:09:49,670 --> 00:09:47,279

level was

239

00:09:52,310 --> 00:09:49,680

along the north carolina coast

240

00:09:55,030 --> 00:09:52,320

and if you look back at the record you

241

00:09:58,150 --> 00:09:55,040

can actually see that from

242

00:10:00,310 --> 00:09:58,160

the year 0 to about 1 000

243

00:10:02,870 --> 00:10:00,320

sea levels really were not changing in

244

00:10:05,430 --> 00:10:02,880

the atlantic ocean they were very stable

245

00:10:08,550 --> 00:10:05,440

and that's because we had reached a warm

246

00:10:11,030 --> 00:10:08,560

climate and sea levels had stopped

247

00:10:13,190 --> 00:10:11,040

rising after the end of the last ice age

248

00:10:16,550 --> 00:10:13,200

and they were very very stable

249

00:10:18,389 --> 00:10:16,560

and then about 1000 a.d we entered what

250

00:10:20,710 --> 00:10:18,399

was called the little the medieval warm

251
00:10:22,470 --> 00:10:20,720
period and this was a period where there

252
00:10:24,150 --> 00:10:22,480
was a little bit of warming and there's

253
00:10:25,670 --> 00:10:24,160
a little bit of sea level rise you can

254
00:10:26,389 --> 00:10:25,680
see right here

255
00:10:29,910 --> 00:10:26,399
uh

256
00:10:31,509 --> 00:10:29,920
um after that in about 1500 there was

257
00:10:33,269 --> 00:10:31,519
the little ice age where there was a

258
00:10:35,590 --> 00:10:33,279
small amount of cooling so maybe sea

259
00:10:37,590 --> 00:10:35,600
levels fell just a little bit but what

260
00:10:39,509 --> 00:10:37,600
really leaps out in this record is the

261
00:10:43,110 --> 00:10:39,519
beginning of the industrial revolution

262
00:10:45,030 --> 00:10:43,120
in the 1850s or so we began adding a lot

263
00:10:47,110 --> 00:10:45,040

of carbon dioxide to the atmosphere we

264

00:10:48,870 --> 00:10:47,120

begin heating up the planet as you saw

265

00:10:51,829 --> 00:10:48,880

in the very first slide

266

00:10:54,550 --> 00:10:51,839

and sea levels began to take off and

267

00:10:56,949 --> 00:10:54,560

rocket upward and the salt marshes which

268

00:10:59,509 --> 00:10:56,959

are shown there in the red curve

269

00:11:02,470 --> 00:10:59,519

actually tell the same story as the tide

270

00:11:04,870 --> 00:11:02,480

gauge which goes back over 100 years

271

00:11:07,030 --> 00:11:04,880

nearby in this location and they both

272

00:11:08,150 --> 00:11:07,040

show that sea levels were rising very

273

00:11:10,470 --> 00:11:08,160

quickly

274

00:11:13,269 --> 00:11:10,480

after the industrial revolution began so

275

00:11:15,190 --> 00:11:13,279

what's happening to our oceans is

276

00:11:17,509 --> 00:11:15,200

something that hasn't happened in

277

00:11:19,910 --> 00:11:17,519

thousands of years and it's a reminder

278

00:11:22,389 --> 00:11:19,920

of just how big an impact we're having

279

00:11:24,710 --> 00:11:22,399

on the climate now of course i've talked

280

00:11:27,990 --> 00:11:24,720

a lot about climate change but where is

281

00:11:31,030 --> 00:11:28,000

nasa in all this well nasa actually

282

00:11:32,150 --> 00:11:31,040

flies satellites that measure sea level

283

00:11:35,269 --> 00:11:32,160

directly

284

00:11:38,069 --> 00:11:35,279

and this is the sentinel-6 satellite it

285

00:11:41,430 --> 00:11:38,079

works in a very simple way it bounces a

286

00:11:43,829 --> 00:11:41,440

radar off of the ocean and measures how

287

00:11:44,550 --> 00:11:43,839

long it takes to go down and come back

288

00:11:46,949 --> 00:11:44,560

up

289

00:11:50,150 --> 00:11:46,959

this tells the satellite how far away

290

00:11:52,949 --> 00:11:50,160

the water is and then using positioning

291

00:11:54,310 --> 00:11:52,959

systems like gps and a couple of others

292

00:11:56,230 --> 00:11:54,320

we can tell

293

00:11:58,470 --> 00:11:56,240

where the satellite is so if we know

294

00:12:01,670 --> 00:11:58,480

where the satellite is and how far away

295

00:12:04,470 --> 00:12:01,680

the water is we can say how high the

296

00:12:06,550 --> 00:12:04,480

water is how high sea levels are

297

00:12:07,430 --> 00:12:06,560

everywhere in the world once every 10

298

00:12:09,509 --> 00:12:07,440

days

299

00:12:11,990 --> 00:12:09,519

and this gives us a really powerful tool

300

00:12:13,990 --> 00:12:12,000

for measuring sea level rise and one

301
00:12:17,829 --> 00:12:14,000
that we've actually been

302
00:12:20,069 --> 00:12:17,839
using for almost 30 years now

303
00:12:21,590 --> 00:12:20,079
but as we heard at the very beginning of

304
00:12:24,389 --> 00:12:21,600
the program

305
00:12:26,629 --> 00:12:24,399
our latest sea level mission sentinel 6

306
00:12:29,350 --> 00:12:26,639
michael freilich was launched on

307
00:12:31,990 --> 00:12:29,360
november 21st 2020

308
00:12:34,550 --> 00:12:32,000
and this is actually the most

309
00:12:37,590 --> 00:12:34,560
accurate mission to date to measure

310
00:12:39,670 --> 00:12:37,600
global sea levels it'll give us

311
00:12:41,509 --> 00:12:39,680
all kinds of really fascinating

312
00:12:43,910 --> 00:12:41,519
information but one of the most

313
00:12:46,870 --> 00:12:43,920

important things is it's the satellite

314

00:12:49,430 --> 00:12:46,880

so nice we built it twice in fact

315

00:12:51,670 --> 00:12:49,440

there's two sentinel 6 satellites the

316

00:12:54,790 --> 00:12:51,680

sentinel 6 michael freilich was launched

317

00:12:57,030 --> 00:12:54,800

last year and in 2025

318

00:12:59,910 --> 00:12:57,040

an exact copy of the satellite will

319

00:13:02,230 --> 00:12:59,920

launch and replace the sentinel 6

320

00:13:05,430 --> 00:13:02,240

michael freilax satellite so each one

321

00:13:08,310 --> 00:13:05,440

will last 5 years giving us a 10 year

322

00:13:11,910 --> 00:13:08,320

extension to our record of sea level

323

00:13:14,069 --> 00:13:11,920

rise which goes back to the early 1990s

324

00:13:15,509 --> 00:13:14,079

now the launch of michael freilick was

325

00:13:18,230 --> 00:13:15,519

kind of exciting

326
00:13:20,629 --> 00:13:18,240
because it it launched on a rocket that

327
00:13:22,870 --> 00:13:20,639
went up but the rocket actually came

328
00:13:24,790 --> 00:13:22,880
back down and it landed on the same

329
00:13:26,069 --> 00:13:24,800
launch pad it took off from

330
00:13:28,069 --> 00:13:26,079
i was there and it was kind of an

331
00:13:29,750 --> 00:13:28,079
exciting day because when the rocket

332
00:13:31,350 --> 00:13:29,760
came back down

333
00:13:34,470 --> 00:13:31,360
it's going faster than the speed of

334
00:13:36,790 --> 00:13:34,480
sound so it creates a sonic boom and i

335
00:13:38,870 --> 00:13:36,800
happen to get a little video of it where

336
00:13:41,509 --> 00:13:38,880
you can hear the sonic boom so

337
00:13:42,790 --> 00:13:41,519
if you're listening to this really loud

338
00:13:44,870 --> 00:13:42,800

you may want to turn your volume down a

339

00:14:03,350 --> 00:13:44,880

little bit here we go check out this

340

00:14:09,590 --> 00:14:06,230

well it wasn't just the rocket that made

341

00:14:12,629 --> 00:14:09,600

a boom that day uh in fact um sentinel 6

342

00:14:14,949 --> 00:14:12,639

michael freilich was a huge boom for

343

00:14:17,910 --> 00:14:14,959

advancing our knowledge of sea level

344

00:14:19,189 --> 00:14:17,920

rise and uh the fact that it launched

345

00:14:22,629 --> 00:14:19,199

successfully

346

00:14:25,269 --> 00:14:22,639

was incredibly satisfying and uh um in

347

00:14:27,750 --> 00:14:25,279

fact we've gotten the very first data

348

00:14:29,430 --> 00:14:27,760

back from it uh was released in june

349

00:14:32,230 --> 00:14:29,440

publicly

350

00:14:35,110 --> 00:14:32,240

this image shows the height of the

351

00:14:37,509 --> 00:14:35,120

oceans uh in the pacific and a little

352

00:14:40,310 --> 00:14:37,519

bit in the atlantic red is higher than

353

00:14:41,430 --> 00:14:40,320

average by about 10 or 20 centimeters in

354

00:14:42,629 --> 00:14:41,440

blue

355

00:14:45,030 --> 00:14:42,639

and and

356

00:14:46,870 --> 00:14:45,040

green or a little bit lower than

357

00:14:49,189 --> 00:14:46,880

average sea level but what you can

358

00:14:51,350 --> 00:14:49,199

notice is actually most of the globe is

359

00:14:54,629 --> 00:14:51,360

pretty red that's because sea levels

360

00:14:56,870 --> 00:14:54,639

have been rising now for about 30 years

361

00:14:58,470 --> 00:14:56,880

and i mentioned that

362

00:15:01,269 --> 00:14:58,480

michael fry like the sentinel six

363

00:15:04,389 --> 00:15:01,279

michael freilax satellite is was part of

364

00:15:07,829 --> 00:15:04,399

uh a set of missions that go back to the

365

00:15:09,990 --> 00:15:07,839

early 1990s and this slide gives us a

366

00:15:12,790 --> 00:15:10,000

sense of just how

367

00:15:14,949 --> 00:15:12,800

lucky we are in the oceanographic

368

00:15:17,430 --> 00:15:14,959

community and the climate community to

369

00:15:20,230 --> 00:15:17,440

have had a series of satellites that go

370

00:15:22,389 --> 00:15:20,240

all the way back to 1992

371

00:15:24,310 --> 00:15:22,399

which starting with topex poseidon which

372

00:15:26,069 --> 00:15:24,320

is actually the satellite that got me my

373

00:15:29,189 --> 00:15:26,079

phd

374

00:15:32,230 --> 00:15:29,199

that satellite and its successor jason 1

375

00:15:33,509 --> 00:15:32,240

jason 2 and now jason 3

376
00:15:34,870 --> 00:15:33,519
have

377
00:15:37,110 --> 00:15:34,880
overlapped

378
00:15:40,310 --> 00:15:37,120
one after the next going all the way

379
00:15:42,949 --> 00:15:40,320
back to 1992 and that overlaps

380
00:15:45,269 --> 00:15:42,959
incredibly important because it gives us

381
00:15:48,710 --> 00:15:45,279
a continuous record of how sea level is

382
00:15:51,269 --> 00:15:48,720
changing that is incredibly accurate in

383
00:15:54,870 --> 00:15:51,279
fact it is so accurate that we can

384
00:15:57,829 --> 00:15:54,880
measure the rise of the oceans

385
00:16:00,150 --> 00:15:57,839
with an accuracy of just about

386
00:16:01,350 --> 00:16:00,160
half a centimeter that's about a quarter

387
00:16:05,110 --> 00:16:01,360
of an inch

388
00:16:08,389 --> 00:16:05,120

once every 10 days and so every 10 days

389

00:16:11,430 --> 00:16:08,399

we get this incredibly accurate look at

390

00:16:13,590 --> 00:16:11,440

the average height of the entire planet

391

00:16:15,910 --> 00:16:13,600

that's a huge feat because remember more

392

00:16:18,870 --> 00:16:15,920

than two-thirds of the planet's surface

393

00:16:21,110 --> 00:16:18,880

are covered by oceans so as we watch the

394

00:16:23,269 --> 00:16:21,120

sea levels change globally we're

395

00:16:24,790 --> 00:16:23,279

literally watching how the earth is

396

00:16:27,030 --> 00:16:24,800

reshaped

397

00:16:29,590 --> 00:16:27,040

one week after the next

398

00:16:32,870 --> 00:16:29,600

and when we look at the data you can see

399

00:16:35,189 --> 00:16:32,880

right here this uh up and down that

400

00:16:37,829 --> 00:16:35,199

happens every year this

401

00:16:40,949 --> 00:16:37,839

sort of rise and fall

402

00:16:44,230 --> 00:16:40,959

in global sea level and this is actually

403

00:16:47,030 --> 00:16:44,240

due to the exchange of water between the

404

00:16:49,509 --> 00:16:47,040

oceans and the land every year in the

405

00:16:51,269 --> 00:16:49,519

summertime in the northern hemisphere

406

00:16:53,269 --> 00:16:51,279

the ocean uh

407

00:16:56,150 --> 00:16:53,279

evaporates lots of water up into the

408

00:16:58,389 --> 00:16:56,160

atmosphere and it rains down over land

409

00:17:00,710 --> 00:16:58,399

it takes that water some time to reach

410

00:17:05,270 --> 00:17:00,720

the ocean again and during that time sea

411

00:17:07,590 --> 00:17:05,280

level actually falls um until the

412

00:17:09,270 --> 00:17:07,600

until the water begins to run back off

413

00:17:11,590 --> 00:17:09,280

the seasonal cycle shifts to the

414

00:17:15,510 --> 00:17:11,600

southern hemisphere and sea levels begin

415

00:17:18,549 --> 00:17:15,520

to rise again so this rise and fall of

416

00:17:21,189 --> 00:17:18,559

the oceans which is about a centimeter

417

00:17:23,669 --> 00:17:21,199

every year or about half an inch

418

00:17:26,150 --> 00:17:23,679

that is sort of like the heartbeat of

419

00:17:29,669 --> 00:17:26,160

our planet it's it's like the exchange

420

00:17:31,669 --> 00:17:29,679

of water uh is really telling us

421

00:17:33,909 --> 00:17:31,679

how our planet's changing in an

422

00:17:39,029 --> 00:17:33,919

incredibly

423

00:17:40,950 --> 00:17:39,039

but what's fascinating really to me is

424

00:17:42,470 --> 00:17:40,960

that if you look at this

425

00:17:45,430 --> 00:17:42,480

if you look at this record that goes

426

00:17:46,789 --> 00:17:45,440

back from the early 1990s to today

427

00:17:49,110 --> 00:17:46,799

the most

428

00:17:51,510 --> 00:17:49,120

visible part of it the the thing that

429

00:17:54,310 --> 00:17:51,520

jumps out at you the most is the steady

430

00:17:57,750 --> 00:17:54,320

rise of the oceans and i say steady but

431

00:18:00,390 --> 00:17:57,760

it's actually really not steady because

432

00:18:03,190 --> 00:18:00,400

the rate of rise has increased and you

433

00:18:05,430 --> 00:18:03,200

can almost see it in this curve but in

434

00:18:07,590 --> 00:18:05,440

the early nineties the rate of rise was

435

00:18:09,669 --> 00:18:07,600

about two millimeters per year

436

00:18:12,630 --> 00:18:09,679

in the 2000s it was three millimeters

437

00:18:14,710 --> 00:18:12,640

per year and today it's between four and

438

00:18:16,950 --> 00:18:14,720

five millimeters per year so we're

439

00:18:19,669 --> 00:18:16,960

literally watching the rate of sea level

440

00:18:22,070 --> 00:18:19,679

rise increase from one decade to the

441

00:18:24,390 --> 00:18:22,080

next and it's satellites like the

442

00:18:26,390 --> 00:18:24,400

sentinel six michael freilick mission

443

00:18:28,950 --> 00:18:26,400

and the jason missions before it that

444

00:18:31,510 --> 00:18:28,960

allow us to do this

445

00:18:34,789 --> 00:18:31,520

now i want to shift gears just a little

446

00:18:39,830 --> 00:18:37,110

talk for a second about the causes of

447

00:18:43,270 --> 00:18:39,840

this rise and one of the reasons we're

448

00:18:46,070 --> 00:18:43,280

seeing this increase in sea level is the

449

00:18:49,350 --> 00:18:46,080

melting of the ice sheets now nasa has

450

00:18:50,310 --> 00:18:49,360

another neat tool in collaboration with

451

00:18:52,630 --> 00:18:50,320

uh

452

00:18:55,029 --> 00:18:52,640

with the german space agency

453

00:18:58,070 --> 00:18:55,039

it's called the grace mission or now the

454

00:19:00,549 --> 00:18:58,080

grace follow-on mission and this

455

00:19:03,110 --> 00:19:00,559

satellite is actually a pair of

456

00:19:05,110 --> 00:19:03,120

satellites these two satellites chase

457

00:19:07,510 --> 00:19:05,120

each other around the earth their names

458

00:19:09,430 --> 00:19:07,520

are tom and jerry in fact

459

00:19:11,110 --> 00:19:09,440

just like the cartoon characters and

460

00:19:13,270 --> 00:19:11,120

whenever the first one goes over

461

00:19:16,630 --> 00:19:13,280

something heavy the pull of gravity

462

00:19:19,590 --> 00:19:16,640

causes it to speed up and move away from

463

00:19:21,669 --> 00:19:19,600

the second satellite just a little bit

464

00:19:23,590 --> 00:19:21,679

so what we do is we measure the distance

465

00:19:25,750 --> 00:19:23,600

between the two satellites very very

466

00:19:29,669 --> 00:19:25,760

accurately and by watching them move

467

00:19:31,830 --> 00:19:29,679

together and apart we can infer how

468

00:19:34,549 --> 00:19:31,840

heavy the things are that we're flying

469

00:19:36,870 --> 00:19:34,559

over so for instance when we fly over a

470

00:19:38,789 --> 00:19:36,880

mountain with this satellite we see the

471

00:19:40,150 --> 00:19:38,799

satellites pull apart at the beginning

472

00:19:41,830 --> 00:19:40,160

and then come back together when the

473

00:19:43,669 --> 00:19:41,840

mountain is between them

474

00:19:46,630 --> 00:19:43,679

so using this information we can

475

00:19:49,909 --> 00:19:46,640

literally weigh the continents and when

476
00:19:52,950 --> 00:19:49,919
we weigh the continents or the islands

477
00:19:55,430 --> 00:19:52,960
like greenland that are covered in ice

478
00:19:58,310 --> 00:19:55,440
we see that the ice in greenland is

479
00:19:59,510 --> 00:19:58,320
actually disappearing now

480
00:20:02,149 --> 00:19:59,520
this

481
00:20:04,390 --> 00:20:02,159
animation shows

482
00:20:07,029 --> 00:20:04,400
the ice beginning to disappear and

483
00:20:09,270 --> 00:20:07,039
you'll see the reds start to appear

484
00:20:10,870 --> 00:20:09,280
around the edges of greenland

485
00:20:13,830 --> 00:20:10,880
that represents

486
00:20:16,070 --> 00:20:13,840
tons and tons of ice that are being lost

487
00:20:21,350 --> 00:20:16,080
from the edges of the ice sheet

488
00:20:23,270 --> 00:20:21,360

and during the last 15 or so years

489

00:20:27,590 --> 00:20:23,280

greenland has lost

490

00:20:30,230 --> 00:20:27,600

5 trillion tons of ice and that's enough

491

00:20:31,909 --> 00:20:30,240

to raise sea levels by more than a

492

00:20:34,630 --> 00:20:31,919

centimeter

493

00:20:37,110 --> 00:20:34,640

almost three quarters of an inch so

494

00:20:39,830 --> 00:20:37,120

this rise that we're seeing in the

495

00:20:42,470 --> 00:20:39,840

oceans is directly driven

496

00:20:44,710 --> 00:20:42,480

by the loss of ice in the great ice

497

00:20:46,230 --> 00:20:44,720

sheets like greenland

498

00:20:48,950 --> 00:20:46,240

now uh

499

00:20:50,789 --> 00:20:48,960

before we uh get too deep into greenland

500

00:20:52,950 --> 00:20:50,799

i'm going to shift gears again and we're

501
00:20:56,230 --> 00:20:52,960
going to talk a little bit about a

502
00:20:57,430 --> 00:20:56,240
mission that i uh helped propose

503
00:21:00,710 --> 00:20:57,440
about

504
00:21:03,510 --> 00:21:00,720
in 2014 many many years ago called

505
00:21:05,590 --> 00:21:03,520
ocean's melting greenland or omg for

506
00:21:06,950 --> 00:21:05,600
short and i'll show you just a quick

507
00:21:08,710 --> 00:21:06,960
little video

508
00:21:11,570 --> 00:21:08,720
to give you an introduction to what that

509
00:21:19,270 --> 00:21:11,580
mission's all about

510
00:21:24,549 --> 00:21:21,510
there's enough ice here in greenland to

511
00:21:26,549 --> 00:21:24,559
raise sea levels by 25 feet all the way

512
00:21:28,070 --> 00:21:26,559
around the world it's an incredible

513
00:21:30,630 --> 00:21:28,080

amount of ice

514

00:21:32,230 --> 00:21:30,640

and it's melting and adding to sea level

515

00:21:34,230 --> 00:21:32,240

rise

516

00:21:36,950 --> 00:21:34,240

for oceans melting greenland what we

517

00:21:39,590 --> 00:21:36,960

really want to do is measure the oceans

518

00:21:41,430 --> 00:21:39,600

measure the ice and watch them change

519

00:21:43,590 --> 00:21:41,440

together year on year

520

00:21:45,270 --> 00:21:43,600

and try and answer the question how much

521

00:21:47,270 --> 00:21:45,280

are the oceans

522

00:21:49,750 --> 00:21:47,280

melting away the ice as opposed to the

523

00:21:49,930 --> 00:21:49,760

air which is what most people studied so

524

00:21:57,270 --> 00:21:49,940

far

525

00:22:02,230 --> 00:21:59,990

it's really a breathtaking landscape

526

00:22:04,950 --> 00:22:02,240

these giant mountains and

527

00:22:06,549 --> 00:22:04,960

canyons are all along the coast

528

00:22:08,950 --> 00:22:06,559

when you look out the window you really

529

00:22:11,750 --> 00:22:08,960

get a sense of just how huge these

530

00:22:12,390 --> 00:22:11,760

glaciers are these gigantic rivers of

531

00:22:15,990 --> 00:22:12,400

ice

532

00:22:17,430 --> 00:22:16,000

greenland into the ocean

533

00:22:20,070 --> 00:22:17,440

and then they reach the ocean and it

534

00:22:25,669 --> 00:22:20,080

gets all broken and craggy and big

535

00:22:30,390 --> 00:22:28,230

coolasuke is just a tiny little town in

536

00:22:32,230 --> 00:22:30,400

southeast greenland and

537

00:22:35,029 --> 00:22:32,240

we've been launching probes out of here

538

00:22:37,190 --> 00:22:35,039

for the past four or five days

539

00:22:39,580 --> 00:22:37,200

it's already been a fantastic year for

540

00:22:41,029 --> 00:22:39,590

omg measuring the oceans

541

00:22:43,110 --> 00:22:41,039

[Music]

542

00:22:45,190 --> 00:22:43,120

we launch them right out of this tube

543

00:22:47,270 --> 00:22:45,200

right over here open up the tube you can

544

00:22:49,430 --> 00:22:47,280

look right down and see the water

545

00:22:50,870 --> 00:22:49,440

passing by or sometimes the icebergs or

546

00:22:53,110 --> 00:22:50,880

clouds or whatever it is we're flying

547

00:22:54,789 --> 00:22:53,120

over

548

00:22:57,110 --> 00:22:54,799

we slow down a little bit and we just

549

00:22:59,029 --> 00:22:57,120

push these big gray cylinders out of the

550

00:23:01,190 --> 00:22:59,039

bottom of the plane and they fall to the

551
00:23:03,270 --> 00:23:01,200
ocean and measure the temperature and

552
00:23:05,590 --> 00:23:03,280
salinity when they get there and radio

553
00:23:07,590 --> 00:23:05,600
it back to the plane

554
00:23:09,669 --> 00:23:07,600
we're really trying to look at the ice

555
00:23:12,870 --> 00:23:09,679
and ocean all the way around greenland

556
00:23:14,789 --> 00:23:12,880
so we're dropping 250 profilers we're

557
00:23:17,990 --> 00:23:14,799
going to cover the coastline all the way

558
00:23:20,950 --> 00:23:18,000
around and in the spring we map out the

559
00:23:23,270 --> 00:23:20,960
glaciers with a radar also all the way

560
00:23:25,029 --> 00:23:23,280
around so we're really looking at

561
00:23:27,110 --> 00:23:25,039
mapping all of the ocean ice

562
00:23:32,310 --> 00:23:27,120
interactions in greenland as best we can

563
00:23:37,590 --> 00:23:34,630

so there's a little information about

564

00:23:40,310 --> 00:23:37,600

oceans melting greenland or omg for

565

00:23:43,909 --> 00:23:40,320

short and as you're probably wondering

566

00:23:45,750 --> 00:23:43,919

yes i did come up with the name omg

567

00:23:47,830 --> 00:23:45,760

in part because

568

00:23:50,070 --> 00:23:47,840

i wanted people to remember how

569

00:23:52,230 --> 00:23:50,080

surprising it is that we're having such

570

00:23:55,190 --> 00:23:52,240

a big impact on greenland but also

571

00:23:57,590 --> 00:23:55,200

because those three words really embody

572

00:24:00,230 --> 00:23:57,600

what the mission's all about which is

573

00:24:03,669 --> 00:24:00,240

that the oceans are playing a big role

574

00:24:05,909 --> 00:24:03,679

in the ice loss in greenland so we

575

00:24:08,789 --> 00:24:05,919

started out really thinking about how

576
00:24:11,990 --> 00:24:08,799
the earth was warming and the oceans

577
00:24:14,789 --> 00:24:12,000
reminded us that they play an enormous

578
00:24:17,269 --> 00:24:14,799
role in how the climate is changing well

579
00:24:20,230 --> 00:24:17,279
ocean's melting greenland is

580
00:24:24,310 --> 00:24:20,240
zooming in on how they're changing the

581
00:24:26,710 --> 00:24:24,320
ice in greenland now the idea behind omg

582
00:24:29,830 --> 00:24:26,720
as i said in the video was to measure

583
00:24:32,789 --> 00:24:29,840
both the oceans and the ice and try and

584
00:24:36,310 --> 00:24:32,799
understand how changes in the ocean

585
00:24:38,549 --> 00:24:36,320
could lead to changes in the glaciers

586
00:24:40,390 --> 00:24:38,559
all around the edges of greenland you're

587
00:24:42,149 --> 00:24:40,400
probably also wondering if i'm wearing

588
00:24:43,830 --> 00:24:42,159

the same shirt as i was in that video

589

00:24:46,630 --> 00:24:43,840

and yes would be the answer to that

590

00:24:51,590 --> 00:24:46,640

question so uh let's take a little

591

00:24:52,470 --> 00:24:51,600

deeper dive into the uh into the process

592

00:24:55,590 --> 00:24:52,480

that

593

00:24:57,990 --> 00:24:55,600

allows the oceans to reach in and melt

594

00:25:00,710 --> 00:24:58,000

these glaciers now we normally think of

595

00:25:03,350 --> 00:25:00,720

greenland as melting from above like a

596

00:25:05,830 --> 00:25:03,360

big ice block under a hair dryer but

597

00:25:08,230 --> 00:25:05,840

actually the ice on greenland is sliding

598

00:25:10,630 --> 00:25:08,240

off into the ocean in the form of these

599

00:25:13,269 --> 00:25:10,640

glaciers and if we look at how the

600

00:25:15,430 --> 00:25:13,279

glaciers are changing we can actually

601
00:25:18,310 --> 00:25:15,440
get an idea of why the oceans might be

602
00:25:20,710 --> 00:25:18,320
playing such an important role now many

603
00:25:21,909 --> 00:25:20,720
of the glaciers in greenland reach right

604
00:25:26,070 --> 00:25:21,919
to the sea

605
00:25:28,470 --> 00:25:26,080
and as melt from the surface

606
00:25:31,909 --> 00:25:28,480
accumulates on the ice it actually

607
00:25:34,149 --> 00:25:31,919
drills a hole down through the glacier

608
00:25:36,789 --> 00:25:34,159
and it allows the water to run

609
00:25:37,909 --> 00:25:36,799
underneath the glacier along the glacier

610
00:25:40,230 --> 00:25:37,919
bed

611
00:25:43,029 --> 00:25:40,240
this melt water when it reaches the

612
00:25:45,590 --> 00:25:43,039
ocean it's actually very fresh which

613
00:25:48,950 --> 00:25:45,600

means it's much lighter than normal

614

00:25:52,470 --> 00:25:48,960

seawater so this fresh water begins to

615

00:25:55,190 --> 00:25:52,480

rise up the face of the glacier and as

616

00:25:57,430 --> 00:25:55,200

it does it runs into a very interesting

617

00:25:59,269 --> 00:25:57,440

situation because the water around

618

00:26:02,310 --> 00:25:59,279

greenland is

619

00:26:04,950 --> 00:26:02,320

warm down deep it's warm in the deep

620

00:26:08,230 --> 00:26:04,960

parts because that water is salty and

621

00:26:10,549 --> 00:26:08,240

from the atlantic ocean now as the water

622

00:26:12,630 --> 00:26:10,559

rises up the face of the glacier it

623

00:26:15,190 --> 00:26:12,640

actually eats away at the bottom and

624

00:26:17,909 --> 00:26:15,200

eventually breaks off a chunk of the

625

00:26:21,269 --> 00:26:17,919

glacier in a process called calving

626

00:26:24,390 --> 00:26:21,279

and as calving increases

627

00:26:27,510 --> 00:26:24,400

then the glacier can actually retreat

628

00:26:29,430 --> 00:26:27,520

and if it retreats it speeds up dumping

629

00:26:32,310 --> 00:26:29,440

more and more ice into the ocean more

630

00:26:33,510 --> 00:26:32,320

quickly and driving sea levels higher

631

00:26:36,310 --> 00:26:33,520

and higher

632

00:26:37,510 --> 00:26:36,320

so the ocean temperature the water

633

00:26:39,269 --> 00:26:37,520

that's actually

634

00:26:40,390 --> 00:26:39,279

reaching up towards the glacier and

635

00:26:42,870 --> 00:26:40,400

warming it

636

00:26:46,870 --> 00:26:42,880

is actually really important for the

637

00:26:49,430 --> 00:26:46,880

speed at which the glaciers cave off

638

00:26:52,710 --> 00:26:49,440

and the rate at which they speed up and

639

00:26:55,430 --> 00:26:52,720

dump ice into the oceans so that's sort

640

00:26:58,070 --> 00:26:55,440

of how the oceans can affect greenland

641

00:27:01,029 --> 00:26:58,080

and for oceans melting greenland this

642

00:27:03,269 --> 00:27:01,039

was an airborne mission so we used

643

00:27:05,590 --> 00:27:03,279

airplanes to try and understand these

644

00:27:08,710 --> 00:27:05,600

two questions and we flew the airplanes

645

00:27:11,510 --> 00:27:08,720

around uh for two different surveys each

646

00:27:14,710 --> 00:27:11,520

year for five or six years in the four

647

00:27:16,470 --> 00:27:14,720

or six years in the case of the ocean um

648

00:27:17,909 --> 00:27:16,480

for the ocean part of the survey we

649

00:27:19,029 --> 00:27:17,919

dropped those cylinders out of the

650

00:27:21,750 --> 00:27:19,039

airplane

651
00:27:24,549 --> 00:27:21,760
they fall to the water and actually

652
00:27:26,630 --> 00:27:24,559
split into two parts one part stays at

653
00:27:29,269 --> 00:27:26,640
the surface and radios the data back to

654
00:27:31,510 --> 00:27:29,279
the plane and the other part falls down

655
00:27:32,870 --> 00:27:31,520
connected by a very thin wire and

656
00:27:35,029 --> 00:27:32,880
measures the temperature and the

657
00:27:37,269 --> 00:27:35,039
saltiness as it goes

658
00:27:41,990 --> 00:27:37,279
the ice survey looked at how the ice

659
00:27:43,750 --> 00:27:42,000
edge changed with a radar so when we

660
00:27:46,230 --> 00:27:43,760
looked at these things together we tried

661
00:27:48,470 --> 00:27:46,240
to understand how changes in the ocean

662
00:27:50,630 --> 00:27:48,480
could lead to changes in the ice and our

663
00:27:53,909 --> 00:27:50,640

records really showed us that the oceans

664

00:27:56,549 --> 00:27:53,919

are playing a huge role in how quickly

665

00:27:59,430 --> 00:27:56,559

the ice retreats

666

00:28:00,830 --> 00:27:59,440

now uh one of the things we saw were

667

00:28:04,310 --> 00:28:00,840

really beautiful

668

00:28:07,269 --> 00:28:04,320

uh scenes like this one which show

669

00:28:08,950 --> 00:28:07,279

the ice edge with a large plume this is

670

00:28:10,549 --> 00:28:08,960

what the plumes actually look like in

671

00:28:11,669 --> 00:28:10,559

real life when they reach all the way to

672

00:28:13,909 --> 00:28:11,679

the surface

673

00:28:15,669 --> 00:28:13,919

we flew past this plume and dropped the

674

00:28:17,590 --> 00:28:15,679

sensor into it measuring it all the way

675

00:28:20,310 --> 00:28:17,600

down to the sea floor was a very

676

00:28:22,230 --> 00:28:20,320

exciting day now these plumes as you can

677

00:28:24,950 --> 00:28:22,240

imagine are important places for us to

678

00:28:27,110 --> 00:28:24,960

measure and this year when we were in

679

00:28:30,310 --> 00:28:27,120

greenland in august

680

00:28:32,630 --> 00:28:30,320

we found in september we found a single

681

00:28:36,630 --> 00:28:32,640

plume on a very big glacier in east

682

00:28:39,909 --> 00:28:36,640

greenland and this picture on uh this

683

00:28:41,350 --> 00:28:39,919

this picture here with the blue plume uh

684

00:28:45,990 --> 00:28:41,360

pointed out

685

00:28:47,909 --> 00:28:46,000

actually a satellite image that i saw

686

00:28:49,350 --> 00:28:47,919

the day before we

687

00:28:51,110 --> 00:28:49,360

got in the airplane

688

00:28:52,710 --> 00:28:51,120

and flew all the way across the ice

689

00:28:54,070 --> 00:28:52,720

sheet and

690

00:28:56,149 --> 00:28:54,080

we did this

691

00:28:59,430 --> 00:28:56,159

just on the basis of this picture

692

00:29:01,269 --> 00:28:59,440

because in that tiny plume uh we

693

00:29:03,830 --> 00:29:01,279

realized that there would be

694

00:29:05,510 --> 00:29:03,840

water coming up um and reaching the

695

00:29:07,909 --> 00:29:05,520

surface and it was an opportunity to

696

00:29:10,470 --> 00:29:07,919

measure the oceans right next to the

697

00:29:14,470 --> 00:29:10,480

glacier edge when we got there what we

698

00:29:17,510 --> 00:29:14,480

saw was here where you can see this huge

699

00:29:19,909 --> 00:29:17,520

open area of water which is about 300

700

00:29:21,510 --> 00:29:19,919

feet across in diameter

701
00:29:24,549 --> 00:29:21,520
right next to

702
00:29:27,269 --> 00:29:24,559
the ice edge which is a couple hundred

703
00:29:29,590 --> 00:29:27,279
feet tall so it was an incredibly uh

704
00:29:31,909 --> 00:29:29,600
beautiful thing to see but one that we

705
00:29:34,070 --> 00:29:31,919
were actually able to

706
00:29:35,669 --> 00:29:34,080
to measure because

707
00:29:37,909 --> 00:29:35,679
we were able to use

708
00:29:39,510 --> 00:29:37,919
satellite images like this one

709
00:29:41,269 --> 00:29:39,520
and get from one place to the other

710
00:29:44,230 --> 00:29:41,279
across the ice sheet

711
00:29:47,190 --> 00:29:44,240
with our really cool looking airplane

712
00:29:49,029 --> 00:29:47,200
which was a dc-3 now we also got to fly

713
00:29:51,669 --> 00:29:49,039

around and see neat things

714

00:29:54,549 --> 00:29:51,679

like icebergs which you can see here in

715

00:29:56,389 --> 00:29:54,559

this uh in this flyby you'll notice as

716

00:29:58,549 --> 00:29:56,399

the wing tip goes by

717

00:30:00,789 --> 00:29:58,559

the iceberg is actually higher than our

718

00:30:03,350 --> 00:30:00,799

wingtip so some of these things are

719

00:30:05,990 --> 00:30:03,360

really enormous and it's a reminder of

720

00:30:07,430 --> 00:30:06,000

just how much ice is coming off of the

721

00:30:09,990 --> 00:30:07,440

ice sheet

722

00:30:10,870 --> 00:30:10,000

which is important for sea level rise

723

00:30:13,190 --> 00:30:10,880

now

724

00:30:14,789 --> 00:30:13,200

in the first couple years of omg we

725

00:30:17,510 --> 00:30:14,799

actually

726

00:30:20,630 --> 00:30:17,520

measured one of its biggest glaciers

727

00:30:22,149 --> 00:30:20,640

and found that this glacier was actually

728

00:30:24,149 --> 00:30:22,159

growing

729

00:30:26,230 --> 00:30:24,159

this was a big surprise because

730

00:30:28,710 --> 00:30:26,240

greenland's fastest moving glacier

731

00:30:31,350 --> 00:30:28,720

called jakob saban had actually been in

732

00:30:33,750 --> 00:30:31,360

retreat for about 20 years now

733

00:30:37,269 --> 00:30:33,760

jakobsovin is on the

734

00:30:40,470 --> 00:30:37,279

western coast of greenland and it's

735

00:30:42,070 --> 00:30:40,480

next to a huge bay right here

736

00:30:43,990 --> 00:30:42,080

and inside

737

00:30:46,470 --> 00:30:44,000

this long fjord

738

00:30:49,510 --> 00:30:46,480

right where the pointer is right now

739

00:30:52,870 --> 00:30:49,520

is the edge of this mighty glacier which

740

00:30:55,230 --> 00:30:52,880

is known locally as the alulasac glacier

741

00:30:56,870 --> 00:30:55,240

now this glacier is famous among

742

00:30:59,590 --> 00:30:56,880

glaciologists because it's been

743

00:31:02,230 --> 00:30:59,600

retreating so fast but in the first year

744

00:31:04,070 --> 00:31:02,240

of omg or the first two years of omg we

745

00:31:05,509 --> 00:31:04,080

found that the glacier was actually

746

00:31:08,630 --> 00:31:05,519

growing

747

00:31:10,070 --> 00:31:08,640

and these images which were taken by our

748

00:31:12,389 --> 00:31:10,080

aircraft

749

00:31:14,710 --> 00:31:12,399

measuring the glacier show

750

00:31:16,950 --> 00:31:14,720

in blue where the glacier was actually

751

00:31:21,029 --> 00:31:16,960

getting thicker from one year to the

752

00:31:25,830 --> 00:31:21,039

next and this happened from 2016 to 2017

753

00:31:28,230 --> 00:31:25,840

2017 to 2018 and 2018 to 2019. so why

754

00:31:30,710 --> 00:31:28,240

was it getting thicker well it turned

755

00:31:32,470 --> 00:31:30,720

out the answer much like

756

00:31:35,269 --> 00:31:32,480

all the answers to the questions in this

757

00:31:37,990 --> 00:31:35,279

talk was the oceans

758

00:31:40,470 --> 00:31:38,000

when we looked at the oceans nearby in

759

00:31:44,070 --> 00:31:40,480

this bay in disco bay

760

00:31:45,110 --> 00:31:44,080

we found that the oceans had cooled down

761

00:31:47,590 --> 00:31:45,120

after

762

00:31:49,669 --> 00:31:47,600

uh decades of being two almost two

763

00:31:52,549 --> 00:31:49,679

decades of being warm

764

00:31:54,630 --> 00:31:52,559

the the waters in front of this glacier

765

00:31:57,029 --> 00:31:54,640

actually cooled off

766

00:31:59,509 --> 00:31:57,039

and when they cooled as part of a

767

00:32:02,070 --> 00:31:59,519

natural cycle in the atlantic ocean

768

00:32:05,909 --> 00:32:02,080

the glacier began to grow again

769

00:32:07,350 --> 00:32:05,919

so omg essentially proved its major

770

00:32:10,470 --> 00:32:07,360

hypothesis

771

00:32:13,190 --> 00:32:10,480

which was that the oceans are playing a

772

00:32:15,430 --> 00:32:13,200

huge part in controlling how fast the

773

00:32:18,630 --> 00:32:15,440

glaciers are retreating because when we

774

00:32:20,789 --> 00:32:18,640

saw this particular glacier react so

775

00:32:23,110 --> 00:32:20,799

strongly to the oceans we knew without a

776

00:32:24,870 --> 00:32:23,120

doubt they were playing a big role in

777

00:32:26,470 --> 00:32:24,880

greenland's ice loss

778

00:32:27,750 --> 00:32:26,480

now if you'd like to learn more about

779

00:32:36,149 --> 00:32:27,760

omg

780

00:32:38,549 --> 00:32:36,159

you can see yet another picture of me

781

00:32:40,310 --> 00:32:38,559

wearing this red shirt and watch all the

782

00:32:42,470 --> 00:32:40,320

fun videos that i showed

783

00:32:45,269 --> 00:32:42,480

so far now before

784

00:32:48,470 --> 00:32:45,279

i uh wrap up i want to talk about one

785

00:32:51,990 --> 00:32:48,480

last thing which is the future of these

786

00:32:55,110 --> 00:32:52,000

kinds of uh missions to study sea level

787

00:32:56,950 --> 00:32:55,120

and at nasa and the front with in

788

00:33:00,870 --> 00:32:56,960

collaboration with the french space

789

00:33:03,269 --> 00:33:00,880

agency uh canes um and also uh with the

790

00:33:07,110 --> 00:33:03,279

canadians and the british

791

00:33:08,789 --> 00:33:07,120

we're hoping to launch in 2022

792

00:33:11,669 --> 00:33:08,799

late 2022

793

00:33:14,230 --> 00:33:11,679

the next revolution in sea level

794

00:33:16,710 --> 00:33:14,240

measuring missions from space this is

795

00:33:20,070 --> 00:33:16,720

called swat which stands for surface

796

00:33:22,950 --> 00:33:20,080

water and ocean out uh ocean topography

797

00:33:25,669 --> 00:33:22,960

and essentially what it will do

798

00:33:27,590 --> 00:33:25,679

is look down and measure sea level but

799

00:33:30,470 --> 00:33:27,600

instead of measuring it in one small

800

00:33:32,310 --> 00:33:30,480

spot and taking 10 days to fly around

801
00:33:34,310 --> 00:33:32,320
the world and cover pretty much the

802
00:33:37,909 --> 00:33:34,320
entire oceans

803
00:33:40,950 --> 00:33:37,919
swat will measure an entire swath of the

804
00:33:44,389 --> 00:33:40,960
ocean all at once as it flies by

805
00:33:47,830 --> 00:33:44,399
and this will sweep out a much

806
00:33:50,789 --> 00:33:47,840
finer look at the oceans you can think

807
00:33:54,070 --> 00:33:50,799
of it as sort of like turning turning in

808
00:33:57,830 --> 00:33:54,080
your old standard definition tv

809
00:34:00,710 --> 00:33:57,840
um and getting a high definition tv

810
00:34:03,509 --> 00:34:00,720
or maybe even a 4k tv

811
00:34:05,909 --> 00:34:03,519
swat will allow us to see very small

812
00:34:08,550 --> 00:34:05,919
structures in the ocean allow us to see

813
00:34:10,069 --> 00:34:08,560

sea level as it changes right up next to

814

00:34:12,230 --> 00:34:10,079

the coastline

815

00:34:14,790 --> 00:34:12,240

and really be a powerful tool for

816

00:34:17,109 --> 00:34:14,800

measuring how the oceans are changing

817

00:34:19,669 --> 00:34:17,119

their shape over time

818

00:34:20,790 --> 00:34:19,679

it's exciting too because it will also

819

00:34:23,909 --> 00:34:20,800

allow

820

00:34:25,030 --> 00:34:23,919

hydrologists folks who study water on

821

00:34:28,230 --> 00:34:25,040

land

822

00:34:30,470 --> 00:34:28,240

a much broader look at lakes and rivers

823

00:34:32,389 --> 00:34:30,480

all around the world so it's a really

824

00:34:36,230 --> 00:34:32,399

exciting mission coming down

825

00:34:38,389 --> 00:34:36,240

the pipeline uh it'll launch in 2022 and

826

00:34:41,349 --> 00:34:38,399

we're all really excited about it

827

00:34:43,430 --> 00:34:41,359

and with that i will stop and be happy

828

00:34:45,349 --> 00:34:43,440

to answer some questions

829

00:34:47,349 --> 00:34:45,359

yeah absolutely josh you've given us a

830

00:34:49,030 --> 00:34:47,359

ton of information and i'm sure we've

831

00:34:52,389 --> 00:34:49,040

got a ton of great questions out there

832

00:34:54,470 --> 00:34:52,399

so jocelyn what are they asking us

833

00:34:55,829 --> 00:34:54,480

yes we do have a lot of really great

834

00:34:58,069 --> 00:34:55,839

questions coming in through our social

835

00:35:00,950 --> 00:34:58,079

media uh the first one let's kick it off

836

00:35:05,349 --> 00:35:00,960

with filanka on youtube wants to know

837

00:35:09,510 --> 00:35:07,109

well that's a great question you know a

838

00:35:10,310 --> 00:35:09,520

lot of people want to know

839

00:35:12,390 --> 00:35:10,320

how

840

00:35:15,190 --> 00:35:12,400

much of the current warming of the

841

00:35:16,550 --> 00:35:15,200

planet is part of a natural cycle but if

842

00:35:17,670 --> 00:35:16,560

you remember back at the beginning of

843

00:35:20,630 --> 00:35:17,680

the talk

844

00:35:21,750 --> 00:35:20,640

the planet was already in a very warm

845

00:35:24,069 --> 00:35:21,760

period

846

00:35:26,870 --> 00:35:24,079

and what's happened in the last 150

847

00:35:28,790 --> 00:35:26,880

years has been warming on top of that

848

00:35:31,349 --> 00:35:28,800

already warm period

849

00:35:34,390 --> 00:35:31,359

so the warming that's happening today

850

00:35:37,510 --> 00:35:34,400

the warming that's happened since 1850

851
00:35:40,310 --> 00:35:37,520
that's almost entirely human caused and

852
00:35:41,030 --> 00:35:40,320
it's driven by adding fossil fuels to

853
00:35:42,870 --> 00:35:41,040
the

854
00:35:45,270 --> 00:35:42,880
burning fossil fuels and adding carbon

855
00:35:48,470 --> 00:35:45,280
dioxide and other greenhouse gases to

856
00:35:53,589 --> 00:35:49,349
great

857
00:35:56,230 --> 00:35:53,599
follow-up question to that they want to

858
00:35:59,510 --> 00:35:56,240
know does nasa keep up with all the

859
00:36:02,150 --> 00:35:59,520
underwater volcanic activity going on

860
00:36:02,870 --> 00:36:02,160
and does the volcano have anything to do

861
00:36:05,109 --> 00:36:02,880
with

862
00:36:07,190 --> 00:36:05,119
oceans heating up

863
00:36:09,510 --> 00:36:07,200

well that's a great question you know

864

00:36:11,510 --> 00:36:09,520

there are sources of heat in the ocean

865

00:36:13,430 --> 00:36:11,520

from down below their underwater

866

00:36:15,910 --> 00:36:13,440

volcanoes there are things like

867

00:36:18,150 --> 00:36:15,920

hydrothermal vents but when you compare

868

00:36:20,790 --> 00:36:18,160

the amount of heat that comes out of all

869

00:36:21,910 --> 00:36:20,800

of those volcanoes and vents all around

870

00:36:23,910 --> 00:36:21,920

the world

871

00:36:27,349 --> 00:36:23,920

with the heat that we get from the sun

872

00:36:30,550 --> 00:36:27,359

every day it's really really tiny way

873

00:36:33,270 --> 00:36:30,560

too small to be a major impact on

874

00:36:36,069 --> 00:36:33,280

today's warming so

875

00:36:38,069 --> 00:36:36,079

do we track every volcano from space we

876

00:36:40,550 --> 00:36:38,079

don't track every volcano from space but

877

00:36:42,870 --> 00:36:40,560

we do know about how many there are and

878

00:36:45,589 --> 00:36:42,880

about how much heat is coming up and

879

00:36:48,790 --> 00:36:45,599

we're pretty sure that it's way too

880

00:36:51,270 --> 00:36:48,800

small to be a major cause of today's

881

00:36:53,829 --> 00:36:51,280

warming not to mention that if you look

882

00:36:57,510 --> 00:36:53,839

at the planet it's warming from the top

883

00:37:00,870 --> 00:36:59,510

interesting and now switching gears to a

884

00:37:03,910 --> 00:37:00,880

little bit about your time out in

885

00:37:05,990 --> 00:37:03,920

greenland with omg dt on youtube wants

886

00:37:08,150 --> 00:37:06,000

to know what kind of aircraft does the

887

00:37:10,230 --> 00:37:08,160

team fly with

888

00:37:13,670 --> 00:37:10,240

oh that's a great question

889

00:37:15,910 --> 00:37:13,680

we actually fly with uh and we for the

890

00:37:20,150 --> 00:37:15,920

last few years we've been flying with an

891

00:37:23,430 --> 00:37:20,160

old dc-3 aircraft that was modified and

892

00:37:26,310 --> 00:37:23,440

more or less rebuilt to carry out

893

00:37:28,390 --> 00:37:26,320

science in the arctic and these old

894

00:37:30,710 --> 00:37:28,400

planes are really neat um they the

895

00:37:33,430 --> 00:37:30,720

pilots call them tail draggers because

896

00:37:35,750 --> 00:37:33,440

when they're parked they're sitting on a

897

00:37:38,069 --> 00:37:35,760

slant the rear tail wheel is much

898

00:37:40,230 --> 00:37:38,079

smaller than the main landing gear and

899

00:37:42,630 --> 00:37:40,240

so when you take off

900

00:37:44,950 --> 00:37:42,640

you're already tilted up and then the

901
00:37:47,589 --> 00:37:44,960
tail comes up like this and you take off

902
00:37:49,430 --> 00:37:47,599
and when you land the opposite happens

903
00:37:52,230 --> 00:37:49,440
the main wheels come down and then the

904
00:37:54,310 --> 00:37:52,240
rear wheel goes down so you tilt back up

905
00:37:55,510 --> 00:37:54,320
almost like you're taking off again but

906
00:37:58,710 --> 00:37:55,520
they're really

907
00:38:01,910 --> 00:37:58,720
really neat planes and fanta fantastic

908
00:38:03,589 --> 00:38:01,920
tools for science and omg benefited

909
00:38:06,310 --> 00:38:03,599
enormously from

910
00:38:08,310 --> 00:38:06,320
being able to use them

911
00:38:10,310 --> 00:38:08,320
amazing and i know that you get a lot of

912
00:38:12,270 --> 00:38:10,320
great data from up there mike on

913
00:38:14,950 --> 00:38:12,280

facebook wants to know how much

914

00:38:18,470 --> 00:38:14,960

uncertainty is in the measurements plus

915

00:38:19,270 --> 00:38:18,480

or minus what's a rough estimate

916

00:38:21,510 --> 00:38:19,280

well

917

00:38:23,270 --> 00:38:21,520

of course with any measurement the

918

00:38:25,190 --> 00:38:23,280

uncertainty depends on what it is you're

919

00:38:27,829 --> 00:38:25,200

trying to measure so when we're talking

920

00:38:29,349 --> 00:38:27,839

about things like global sea level rise

921

00:38:32,950 --> 00:38:29,359

for example

922

00:38:34,550 --> 00:38:32,960

every 10 days we get an estimate of the

923

00:38:35,910 --> 00:38:34,560

height of the average height of the

924

00:38:38,950 --> 00:38:35,920

oceans

925

00:38:40,870 --> 00:38:38,960

with an error bar and uncertainty of

926

00:38:44,150 --> 00:38:40,880

about half a centimeter or a few

927

00:38:46,790 --> 00:38:44,160

millimeters now we get many of these per

928

00:38:49,910 --> 00:38:46,800

year so if we average together a year of

929

00:38:52,550 --> 00:38:49,920

data we can really say how high the

930

00:38:55,349 --> 00:38:52,560

oceans are from one year to the next

931

00:38:56,150 --> 00:38:55,359

with an accuracy of just a millimeter or

932

00:38:58,870 --> 00:38:56,160

so

933

00:39:01,190 --> 00:38:58,880

and that's what allows us to see

934

00:39:03,349 --> 00:39:01,200

the rise and fall of the oceans that i

935

00:39:05,190 --> 00:39:03,359

talked about with the exchange of water

936

00:39:07,349 --> 00:39:05,200

between ocean and land like the

937

00:39:10,710 --> 00:39:07,359

heartbeat of the planet but it's also

938

00:39:12,550 --> 00:39:10,720

what allows us to see the increasing sea

939

00:39:17,829 --> 00:39:12,560

levels caused by the warming of the

940

00:39:22,230 --> 00:39:19,190

interesting

941

00:39:24,790 --> 00:39:22,240

dan cooper on youtube is asking don't

942

00:39:27,589 --> 00:39:24,800

the oceans absorb most of the carbon

943

00:39:29,750 --> 00:39:27,599

dioxide as well

944

00:39:31,510 --> 00:39:29,760

that is a really great question the

945

00:39:34,230 --> 00:39:31,520

oceans absorb a lot of the carbon

946

00:39:36,150 --> 00:39:34,240

dioxide it's between a quarter or a

947

00:39:38,950 --> 00:39:36,160

third something like that depending on

948

00:39:41,589 --> 00:39:38,960

how long a period you look at but it's

949

00:39:43,990 --> 00:39:41,599

important to remember that the co2 is

950

00:39:46,230 --> 00:39:44,000

not just staying in the atmosphere

951
00:39:48,550 --> 00:39:46,240
a big chunk of it is being absorbed by

952
00:39:50,950 --> 00:39:48,560
the oceans and that means that even if

953
00:39:53,589 --> 00:39:50,960
we were to somehow which would be very

954
00:39:56,069 --> 00:39:53,599
difficult take carbon dioxide out of the

955
00:39:58,230 --> 00:39:56,079
atmosphere some of what we added to the

956
00:39:59,990 --> 00:39:58,240
oceans could come back

957
00:40:02,550 --> 00:40:00,000
to haunt us so

958
00:40:05,030 --> 00:40:02,560
we're not just adding co2 to the air

959
00:40:07,670 --> 00:40:05,040
we're adding it to the oceans which also

960
00:40:10,309 --> 00:40:07,680
makes the oceans more acidic and this

961
00:40:12,309 --> 00:40:10,319
has a big impact on marine life and

962
00:40:16,390 --> 00:40:12,319
marine ecosystems and one that we're

963
00:40:19,990 --> 00:40:18,150

you've given us so many so much great

964

00:40:21,910 --> 00:40:20,000

information about

965

00:40:23,670 --> 00:40:21,920

sea level rise and how it's happening

966

00:40:26,150 --> 00:40:23,680

and looking to the future

967

00:40:28,150 --> 00:40:26,160

tko scar loves on youtube wants to know

968

00:40:29,990 --> 00:40:28,160

what do you think will happen

969

00:40:32,390 --> 00:40:30,000

to the future at this rate with sea

970

00:40:35,190 --> 00:40:32,400

levels rising

971

00:40:37,430 --> 00:40:35,200

well one thing that's clear is that sea

972

00:40:40,230 --> 00:40:37,440

levels are going to continue to rise for

973

00:40:42,630 --> 00:40:40,240

a very long time the warming that we've

974

00:40:45,589 --> 00:40:42,640

already caused is going to continue to

975

00:40:47,190 --> 00:40:45,599

raise sea levels at a slow rate

976
00:40:49,270 --> 00:40:47,200
for up to

977
00:40:52,230 --> 00:40:49,280
thousands of years from now

978
00:40:54,950 --> 00:40:52,240
so we're looking at continued rise but

979
00:40:59,109 --> 00:40:54,960
the question really is how much rise do

980
00:41:01,829 --> 00:40:59,119
we want to allow and some scenarios are

981
00:41:05,190 --> 00:41:01,839
are feasible where we could have many

982
00:41:07,670 --> 00:41:05,200
feet of sea level rise in the next 50 or

983
00:41:09,910 --> 00:41:07,680
even more in the next hundred years

984
00:41:11,270 --> 00:41:09,920
and if we allow that to happen it will

985
00:41:13,910 --> 00:41:11,280
it would really be

986
00:41:15,829 --> 00:41:13,920
devastating to millions and millions of

987
00:41:18,470 --> 00:41:15,839
people along the coast

988
00:41:20,870 --> 00:41:18,480

in fact every centimeter or about a half

989

00:41:23,109 --> 00:41:20,880

an inch of sea level rise

990

00:41:24,630 --> 00:41:23,119

affects another 3 million people

991

00:41:27,430 --> 00:41:24,640

worldwide

992

00:41:29,910 --> 00:41:27,440

with increased frequency of flooding

993

00:41:31,750 --> 00:41:29,920

erosion of coastlines and damage to

994

00:41:35,430 --> 00:41:31,760

infrastructure so

995

00:41:39,829 --> 00:41:35,440

it's really a creeping problem and one

996

00:41:43,510 --> 00:41:41,510

well josh thank you for answering those

997

00:41:45,349 --> 00:41:43,520

wonderful questions and for sharing this

998

00:41:47,349 --> 00:41:45,359

very important information for us

999

00:41:49,430 --> 00:41:47,359

unfortunately that is all the time we

1000

00:41:51,750 --> 00:41:49,440

have for tonight i want to thank you

1001
00:41:54,230 --> 00:41:51,760
josh as our speaker dr josh willis for

1002
00:41:55,829 --> 00:41:54,240
your insight and excitement tonight i

1003
00:41:58,150 --> 00:41:55,839
also want to take a moment to thank you

1004
00:42:00,230 --> 00:41:58,160
jocelyn for being our wonderful co-host

1005
00:42:02,550 --> 00:42:00,240
and for all the people behind the scenes

1006
00:42:04,870 --> 00:42:02,560
who really make these talks possible

1007
00:42:06,950 --> 00:42:04,880
and finally a big thank you to all of us

1008
00:42:08,390 --> 00:42:06,960
who join us every month for these

1009
00:42:10,550 --> 00:42:08,400
wonderful talks

1010
00:42:13,349 --> 00:42:10,560
please remember you can watch past von

1011
00:42:15,589 --> 00:42:13,359
carmen lectures on jpl's website or

1012
00:42:18,309 --> 00:42:15,599
youtube channel as this is the final

1013
00:42:20,790 --> 00:42:18,319

lecture of 2021 we hope you have a happy

1014

00:42:23,510 --> 00:42:20,800

and safe holiday season and we will see

1015

00:42:25,670 --> 00:42:23,520

you next year for our january talk where

1016

00:42:27,990 --> 00:42:25,680

we will continue this conversation with

1017

00:42:31,030 --> 00:42:28,000

the surface water and ocean topography

1018

00:42:32,870 --> 00:42:31,040

mission or swat thanks again for joining

1019

00:42:38,740 --> 00:42:32,880

us this evening and we'll see you in