1
00:00:04,630 --> 00:00:03,030
nasa's jet propulsion laboratory

2
00:00:07,269 --> 00:00:04,640
presents

3
00:00:09,350 --> 00:00:07,279
the von carmen lecture a series of talks

4
00:00:12,629 --> 00:00:09,360
by scientists and engineers who are

5
00:00:27,349 --> 00:00:12,639
exploring our planet our solar system

6
00:00:31,429 --> 00:00:29,109
hey good evening ladies and gentlemen

7
00:00:33,430 --> 00:00:31,439
how's everyone tonight

8
00:00:35,030 --> 00:00:33,440
good to hear good to hear thanks so

9
00:00:36,549 --> 00:00:35,040
thanks so much for coming out tonight as

10
00:00:39,110 --> 00:00:36,559
you can see our format's going to be a

11
00:00:41,270 --> 00:00:39,120
little bit different so to kick things

12
00:00:43,910 --> 00:00:41,280
off i'm just going to introduce an rmc

13
00:00:46,549 --> 00:00:43,920

this evening so to mcr panel tonight we

14
00:00:47,990 --> 00:00:46,559
have dr michael gunson whose day job is

15
00:00:49,830 --> 00:00:48,000
as the project scientist for the

16
00:00:51,830 --> 00:00:49,840
orbiting carbon observatory measuring

17
00:00:52,950 --> 00:00:51,840
the distribution of co2 in the

18
00:00:54,869 --> 00:00:52,960
atmosphere

19
00:00:56,790 --> 00:00:54,879
but he is also helping his colleagues

20
00:00:59,029 --> 00:00:56,800
bring their expertise to address

21
00:01:04,710 --> 00:00:59,039
emerging problems ladies and gentlemen

22
00:01:08,710 --> 00:01:07,190
thank you mark

23
00:01:10,870 --> 00:01:08,720
good evening everybody

24
00:01:13,109 --> 00:01:10,880
i think that

25
00:01:15,190 --> 00:01:13,119
when i first arrived in california which

26
00:01:17,270 --> 00:01:15,200
is i've spent most of my adult life in

27
00:01:19,670 --> 00:01:17,280
california so i think of myself as a

28
00:01:21,270 --> 00:01:19,680
californian by now but the first few

29
00:01:24,310 --> 00:01:21,280
words of spanish i learned and coming to

30
00:01:26,630 --> 00:01:24,320
california were el nino and la nina

31
00:01:28,710 --> 00:01:26,640
quickly followed by cerveza but that's a

32
00:01:31,510 --> 00:01:28,720
different story

33
00:01:32,950 --> 00:01:31,520
um it's a these are really really

34
00:01:35,270 --> 00:01:32,960
important words to everybody in southern

35
00:01:38,069 --> 00:01:35,280
california because we associate them

36
00:01:39,590 --> 00:01:38,079
with wild wet winters

37
00:01:41,030 --> 00:01:39,600
to help us understand what happened in

38
00:01:43,910 --> 00:01:41,040

this past

39
00:01:45,590 --> 00:01:43,920
godzilla el nino winter i've got four of

40
00:01:46,710 --> 00:01:45,600
my colleagues who are going to stand up

41
00:01:48,469 --> 00:01:46,720
and uh

42
00:01:50,630 --> 00:01:48,479
tell us something about their research

43
00:01:52,069 --> 00:01:50,640
interests and what they've understood

44
00:01:53,670 --> 00:01:52,079
and before i introduce them i was

45
00:01:55,910 --> 00:01:53,680
thinking on the way over here one of the

46
00:01:58,630 --> 00:01:55,920
things that i grew up with as uh in in

47
00:02:01,190 --> 00:01:58,640
britain was the stories that go an

48
00:02:03,830 --> 00:02:01,200
englishman an irishman a scotsman and a

49
00:02:06,789 --> 00:02:03,840
welshman walk into a pub

50
00:02:08,869 --> 00:02:06,799
and then it goes downhill from there so

51
00:02:10,869 --> 00:02:08,879
here i've got my four colleagues a

52
00:02:12,790 --> 00:02:10,879
geologist two hydrologists an

53
00:02:14,390 --> 00:02:12,800
atmospheric scientist and we're going to

54
00:02:16,309 --> 00:02:14,400
go uphill from here

55
00:02:17,990 --> 00:02:16,319
so without further ado i'd like to

56
00:02:19,030 --> 00:02:18,000
invite my colleague dwayne wallace to

57
00:02:21,190 --> 00:02:19,040
come up

58
00:02:22,949 --> 00:02:21,200
and after each of them have finished

59
00:02:24,470 --> 00:02:22,959
we'll get back together on stage and

60
00:02:31,990 --> 00:02:24,480
we'll take questions from the audience

61
00:02:35,670 --> 00:02:33,830
thank you mike

62
00:02:37,670 --> 00:02:35,680
so as you know the occurrence of el nino

63
00:02:40,309 --> 00:02:37,680

always necessitates a lot of discussion

64
00:02:41,910 --> 00:02:40,319
especially when it's in california and

65
00:02:43,910 --> 00:02:41,920
that discussion happens in the news and

66
00:02:45,430 --> 00:02:43,920
it happens around the water cooler

67
00:02:46,790 --> 00:02:45,440
and a lot of times it's around is it

68
00:02:49,030 --> 00:02:46,800
going to be a big el nino what's going

69
00:02:50,309 --> 00:02:49,040
to happen to california in the drought

70
00:02:51,990 --> 00:02:50,319
is there going to be floods associated

71
00:02:54,470 --> 00:02:52,000
with the heavy rains

72
00:02:57,030 --> 00:02:54,480
and those discussions that we hear about

73
00:02:59,110 --> 00:02:57,040
often muddle the difference between

74
00:03:01,270 --> 00:02:59,120
el nino on one hand

75
00:03:03,430 --> 00:03:01,280
and predicting el nino

76
00:03:04,869 --> 00:03:03,440
and the effects of el nino on the other

77
00:03:05,830 --> 00:03:04,879
hand and predicting the effects of el

78
00:03:07,350 --> 00:03:05,840
nino

79
00:03:08,790 --> 00:03:07,360
and the one objective i really have for

80
00:03:10,149 --> 00:03:08,800
the few minutes

81
00:03:12,869 --> 00:03:10,159
that my colleague has given me to talk

82
00:03:14,710 --> 00:03:12,879
to you is to clarify that difference

83
00:03:17,350 --> 00:03:14,720
what's an el nino and how good do we

84
00:03:20,630 --> 00:03:17,360
predict it versus the effects of el nino

85
00:03:23,030 --> 00:03:20,640
and how good we predict those okay

86
00:03:24,949 --> 00:03:23,040
so as far as el nino goes

87
00:03:26,149 --> 00:03:24,959
this last el nino that we had this last

88
00:03:27,910 --> 00:03:26,159

year was

89
00:03:29,750 --> 00:03:27,920
a very big

90
00:03:30,869 --> 00:03:29,760
el nino

91
00:03:34,149 --> 00:03:30,879
and in fact

92
00:03:36,309 --> 00:03:34,159
out of the last say 20 el ninos over the

93
00:03:38,390 --> 00:03:36,319
last 100 years it's easily in the top

94
00:03:39,910 --> 00:03:38,400
three and depending on how you count it

95
00:03:41,110 --> 00:03:39,920
or who's counting it it may be the

96
00:03:43,990 --> 00:03:41,120
biggest

97
00:03:45,990 --> 00:03:44,000
so it was a very very big el nino

98
00:03:47,030 --> 00:03:46,000
and the two slides and pictures i have

99
00:03:48,869 --> 00:03:47,040
there are

100
00:03:50,949 --> 00:03:48,879
observations from two different types of

101
00:03:52,630 --> 00:03:50,959
satellites the one on the left

102
00:03:54,470 --> 00:03:52,640
is taken from a satellite that uses

103
00:03:56,949 --> 00:03:54,480
infrared technology to sense the

104
00:03:57,830 --> 00:03:56,959
temperature of the surface of the earth

105
00:04:00,630 --> 00:03:57,840
and

106
00:04:02,789 --> 00:04:00,640
the colors on that map show temperature

107
00:04:05,350 --> 00:04:02,799
departures from normal of the surface of

108
00:04:08,229 --> 00:04:05,360
the ocean and the reds are on the order

109
00:04:09,990 --> 00:04:08,239
of five to eight degrees fahrenheit over

110
00:04:11,030 --> 00:04:10,000
that fairly large expanse of the eastern

111
00:04:12,630 --> 00:04:11,040
pacific

112
00:04:14,869 --> 00:04:12,640
and the one on the right

113
00:04:17,670 --> 00:04:14,879

are departures from normal of sea level

114
00:04:19,830 --> 00:04:17,680
the sea level rise sea level height

115
00:04:22,310 --> 00:04:19,840
and the reds in that diagram are on the

116
00:04:25,030 --> 00:04:22,320
order of one and a half to two feet

117
00:04:26,469 --> 00:04:25,040
and those are canonical pictures of el

118
00:04:27,990 --> 00:04:26,479
nino

119
00:04:29,670 --> 00:04:28,000
and to demonstrate a little bit about

120
00:04:30,870 --> 00:04:29,680
how that happens i'll

121
00:04:32,310 --> 00:04:30,880
animate and i know you're after a

122
00:04:34,230 --> 00:04:32,320
computer animation but i'm going to give

123
00:04:37,830 --> 00:04:34,240
you a different kind of animation

124
00:04:41,189 --> 00:04:37,840
pretend that my arms are sea level

125
00:04:42,790 --> 00:04:41,199
across the pacific ocean just sort of

126
00:04:45,030 --> 00:04:42,800
like that where this hand is south

127
00:04:46,870 --> 00:04:45,040
america and this hand is asia and

128
00:04:48,950 --> 00:04:46,880
australia okay

129
00:04:50,790 --> 00:04:48,960
so in the tropics the winds are

130
00:04:52,469 --> 00:04:50,800
typically easterly they blow from that

131
00:04:54,230 --> 00:04:52,479
direction over to this direction and

132
00:04:56,710 --> 00:04:54,240
those easterly winds we call trade winds

133
00:04:59,189 --> 00:04:56,720
right and as those winds constantly blow

134
00:05:00,469 --> 00:04:59,199
across the pacific they push water up on

135
00:05:01,990 --> 00:05:00,479
this side

136
00:05:03,430 --> 00:05:02,000
and there's just this tilt the sea level

137
00:05:05,030 --> 00:05:03,440
is higher over in the western pacific

138
00:05:06,870 --> 00:05:05,040

than it is in the eastern pacific and

139
00:05:09,430 --> 00:05:06,880
sea levels lower here and that's sort of

140
00:05:11,270 --> 00:05:09,440
the neutral or normal state of the

141
00:05:12,390 --> 00:05:11,280
pacific ocean

142
00:05:14,230 --> 00:05:12,400
so every once in a while there are

143
00:05:16,870 --> 00:05:14,240
conditions that conspire

144
00:05:17,830 --> 00:05:16,880
and the winds relax and when the winds

145
00:05:21,189 --> 00:05:17,840
relax

146
00:05:23,350 --> 00:05:21,199
the ocean slope lessens like that

147
00:05:25,510 --> 00:05:23,360
and the combination of those reduced

148
00:05:27,110 --> 00:05:25,520
winds but that cool the ocean surface

149
00:05:28,550 --> 00:05:27,120
just like wind across your skin cools

150
00:05:30,390 --> 00:05:28,560
the ocean surface when the winds relax

151
00:05:32,550 --> 00:05:30,400
it cools the ocean surface and when the

152
00:05:34,390 --> 00:05:32,560
sea level rises a little bit the surface

153
00:05:36,230 --> 00:05:34,400
waters stay farther away from the cool

154
00:05:37,590 --> 00:05:36,240
waters below and both conspire to make

155
00:05:39,830 --> 00:05:37,600
the water warm

156
00:05:41,909 --> 00:05:39,840
so that higher sea level

157
00:05:44,870 --> 00:05:41,919
and the warmer waters is sort of the

158
00:05:45,670 --> 00:05:44,880
canonical part of el nino okay

159
00:05:47,590 --> 00:05:45,680
so

160
00:05:49,830 --> 00:05:47,600
and that's what's depicted there

161
00:05:52,150 --> 00:05:49,840
and that's how el nino comes about so

162
00:05:53,990 --> 00:05:52,160
you might ask then well it sounds like

163
00:05:55,270 --> 00:05:54,000

they know something about it can they

164
00:05:56,550 --> 00:05:55,280
predict it well how well can they

165
00:05:57,590 --> 00:05:56,560
predict it

166
00:05:58,950 --> 00:05:57,600
and that's where i get into this

167
00:06:00,629 --> 00:05:58,960
distinction between now we're just

168
00:06:02,790 --> 00:06:00,639
talking about el nino

169
00:06:04,870 --> 00:06:02,800
and what's going on in tropical pacific

170
00:06:06,710 --> 00:06:04,880
because el nino is really a phenomena

171
00:06:08,390 --> 00:06:06,720
confined to the tropical pacific so how

172
00:06:10,950 --> 00:06:08,400
well do we predict it this is the

173
00:06:12,150 --> 00:06:10,960
official forecast from noaa

174
00:06:16,309 --> 00:06:12,160
the national oceanographic and

175
00:06:19,270 --> 00:06:16,319
atmospheric administration back in july

176
00:06:23,189 --> 00:06:19,280
and the x-axis started back here in

177
00:06:25,510 --> 00:06:23,199
october 2014 and goes to april 2015

178
00:06:28,230 --> 00:06:25,520
and when the forecast was initiated it

179
00:06:30,950 --> 00:06:28,240
was july last summer in july

180
00:06:32,830 --> 00:06:30,960
okay and the vertical axis

181
00:06:35,909 --> 00:06:32,840
is the temperature

182
00:06:38,710 --> 00:06:35,919
departure in this region right here okay

183
00:06:40,870 --> 00:06:38,720
the sea surface temperature departure so

184
00:06:43,110 --> 00:06:40,880
this is positive and a warming and these

185
00:06:44,629 --> 00:06:43,120
are negative temperatures or cooling

186
00:06:46,870 --> 00:06:44,639
and so in july we had a little bit of

187
00:06:48,550 --> 00:06:46,880
warming but looking forward you know

188
00:06:50,150 --> 00:06:48,560

that's in the future what's going to

189
00:06:51,749 --> 00:06:50,160
happen

190
00:06:53,270 --> 00:06:51,759
so they use models to predict what's

191
00:06:55,189 --> 00:06:53,280
going to happen and there's a nine month

192
00:06:57,510 --> 00:06:55,199
forecast rolling out here

193
00:06:59,110 --> 00:06:57,520
and if you just look at the solid dash

194
00:07:00,790 --> 00:06:59,120
line which is kind of a consensus or

195
00:07:03,350 --> 00:07:00,800
average forecast you can see it

196
00:07:05,430 --> 00:07:03,360
predicted the temperature to go up by

197
00:07:07,749 --> 00:07:05,440
one and a half degrees celsius which is

198
00:07:09,670 --> 00:07:07,759
about three or four degrees more warming

199
00:07:11,589 --> 00:07:09,680
in the next four months and continue to

200
00:07:13,350 --> 00:07:11,599
warm and then eventually cool

201
00:07:15,029 --> 00:07:13,360
and you can ask the question well how

202
00:07:17,110 --> 00:07:15,039
well did they do to that forecast so in

203
00:07:18,390 --> 00:07:17,120
july they issued that forecast for nine

204
00:07:20,150 --> 00:07:18,400
months and now

205
00:07:21,670 --> 00:07:20,160
having lived through all that and having

206
00:07:23,270 --> 00:07:21,680
the satellite data and the buoy

207
00:07:24,629 --> 00:07:23,280
information we can actually verify the

208
00:07:25,990 --> 00:07:24,639
forecast

209
00:07:27,830 --> 00:07:26,000
so the red dots are actually the

210
00:07:30,309 --> 00:07:27,840
observations and you can see that the

211
00:07:32,550 --> 00:07:30,319
forecast which started here actually

212
00:07:34,870 --> 00:07:32,560
ended up verifying quite well out into

213
00:07:36,390 --> 00:07:34,880

the future four to eight months ahead

214
00:07:38,790 --> 00:07:36,400
so the message is

215
00:07:40,629 --> 00:07:38,800
can we forecast el nino yes that

216
00:07:42,870 --> 00:07:40,639
phenomena that exists in the tropical

217
00:07:45,909 --> 00:07:42,880
pacific we we know something about it

218
00:07:48,150 --> 00:07:45,919
and we can predict it fairly well

219
00:07:51,270 --> 00:07:48,160
so then you might ask

220
00:07:52,870 --> 00:07:51,280
why do we want to predict el nino out in

221
00:07:54,230 --> 00:07:52,880
the tropical pacific there's not really

222
00:07:56,230 --> 00:07:54,240
that many people that live out there

223
00:07:58,390 --> 00:07:56,240
right so why do we need to predict it

224
00:07:59,990 --> 00:07:58,400
well we found out that over

225
00:08:02,550 --> 00:08:00,000
watching many el nino events that el

226
00:08:04,309 --> 00:08:02,560
nino has a pretty profound impact on the

227
00:08:05,589 --> 00:08:04,319
weather and climate patterns all over

228
00:08:07,270 --> 00:08:05,599
the globe

229
00:08:10,070 --> 00:08:07,280
and one area they have a pretty profound

230
00:08:12,469 --> 00:08:10,080
impact is in north america

231
00:08:13,670 --> 00:08:12,479
and this is a schematic that depicts the

232
00:08:17,510 --> 00:08:13,680
typical

233
00:08:18,950 --> 00:08:17,520
our sort of climate and weather in north

234
00:08:21,430 --> 00:08:18,960
america in the winter time in

235
00:08:23,670 --> 00:08:21,440
association with that el nino type

236
00:08:26,070 --> 00:08:23,680
pattern in the tropical pacific

237
00:08:28,150 --> 00:08:26,080
and under el nino conditions you'll

238
00:08:30,309 --> 00:08:28,160

typically find that the southern tier of

239
00:08:32,870 --> 00:08:30,319
the u.s is extra wet

240
00:08:35,430 --> 00:08:32,880
the northern u.s and part of canada is

241
00:08:38,469 --> 00:08:35,440
extra warm and the sort of the midwest

242
00:08:40,389 --> 00:08:38,479
east coast is is extra dry and that all

243
00:08:42,149 --> 00:08:40,399
comes about because

244
00:08:43,829 --> 00:08:42,159
those changes that occur way down here

245
00:08:45,269 --> 00:08:43,839
in the tropical pacific influence the

246
00:08:47,190 --> 00:08:45,279
circulation of the air down in the

247
00:08:49,910 --> 00:08:47,200
tropics and it turns out that that in

248
00:08:52,470 --> 00:08:49,920
turn ends up influencing the circulation

249
00:08:54,389 --> 00:08:52,480
up here in mid-latitudes namely that the

250
00:08:55,670 --> 00:08:54,399
jet stream which we

251
00:08:57,829 --> 00:08:55,680
you know just like i said there are

252
00:08:59,269 --> 00:08:57,839
easterly winds in the tropics

253
00:09:00,630 --> 00:08:59,279
the mid-latitudes where we live

254
00:09:01,990 --> 00:09:00,640
typically has westerlies and that's

255
00:09:03,670 --> 00:09:02,000
where all the weather comes from as you

256
00:09:05,110 --> 00:09:03,680
watch the weather forecast it comes in

257
00:09:07,509 --> 00:09:05,120
on the jet stream

258
00:09:09,110 --> 00:09:07,519
okay and during el nino rather than that

259
00:09:10,949 --> 00:09:09,120
jet stream bringing storms into the

260
00:09:13,509 --> 00:09:10,959
pacific northwest and keeping that

261
00:09:16,150 --> 00:09:13,519
normally very wet it dips southward and

262
00:09:18,389 --> 00:09:16,160
brings the storms more towards the south

263
00:09:19,110 --> 00:09:18,399

and those are the typical conditions

264
00:09:20,710 --> 00:09:19,120
so

265
00:09:22,550 --> 00:09:20,720
i just showed you that we could predict

266
00:09:24,949 --> 00:09:22,560
el nino very well

267
00:09:27,350 --> 00:09:24,959
relatively well how well can we predict

268
00:09:30,389 --> 00:09:27,360
these patterns in precipitation in north

269
00:09:32,710 --> 00:09:30,399
america or for example california

270
00:09:35,030 --> 00:09:32,720
and so this plot should set some

271
00:09:38,070 --> 00:09:35,040
expectations on what we should think can

272
00:09:40,389 --> 00:09:38,080
happen and what this is is

273
00:09:41,590 --> 00:09:40,399
the october 2 march or that's

274
00:09:43,030 --> 00:09:41,600
essentially the total annual

275
00:09:45,269 --> 00:09:43,040
precipitation

276
00:09:48,389 --> 00:09:45,279
for any given year in this region of

277
00:09:50,389 --> 00:09:48,399
southern california the total average

278
00:09:51,910 --> 00:09:50,399
and this line represents

279
00:09:53,990 --> 00:09:51,920
the average

280
00:09:56,710 --> 00:09:54,000
precipitation on any given year 15

281
00:09:58,949 --> 00:09:56,720
inches in this area

282
00:10:00,949 --> 00:09:58,959
and each dot is represented here each

283
00:10:03,829 --> 00:10:00,959
year is represented as a dot

284
00:10:06,070 --> 00:10:03,839
ever going back to 1933. so there's one

285
00:10:08,150 --> 00:10:06,080
dot for every year since 1933 and it's

286
00:10:10,150 --> 00:10:08,160
the average precipitation

287
00:10:12,070 --> 00:10:10,160
and along the bottom is an indication of

288
00:10:14,949 --> 00:10:12,080

what's going on in the tropical pacific

289
00:10:17,190 --> 00:10:14,959
in terms of the warming or the cooling

290
00:10:18,630 --> 00:10:17,200
and this is representing a cool pacific

291
00:10:20,550 --> 00:10:18,640
ocean so it's just sort of the opposite

292
00:10:22,150 --> 00:10:20,560
pattern that i showed you this is sort

293
00:10:23,430 --> 00:10:22,160
of neutral or in between and this is

294
00:10:24,710 --> 00:10:23,440
that warming that i showed you the

295
00:10:25,990 --> 00:10:24,720
pattern of

296
00:10:27,750 --> 00:10:26,000
and if you step back a little bit you

297
00:10:29,269 --> 00:10:27,760
say oh wow during these cool conditions

298
00:10:30,870 --> 00:10:29,279
in the tropical pacific which we refer

299
00:10:32,870 --> 00:10:30,880
to as la nina

300
00:10:35,110 --> 00:10:32,880
the average is below normal and so we

301
00:10:36,630 --> 00:10:35,120
typically have drier winters during la

302
00:10:39,030 --> 00:10:36,640
nina conditions

303
00:10:41,030 --> 00:10:39,040
if you look at the neutral or sort of

304
00:10:42,389 --> 00:10:41,040
neither condition and you average all

305
00:10:43,670 --> 00:10:42,399
those green dots together even though

306
00:10:45,110 --> 00:10:43,680
there's a lot of scatter you kind of get

307
00:10:47,430 --> 00:10:45,120
something about here

308
00:10:49,030 --> 00:10:47,440
normal normal precipitation

309
00:10:51,030 --> 00:10:49,040
and if you look at the red dots if you

310
00:10:52,470 --> 00:10:51,040
average them first the average would be

311
00:10:54,550 --> 00:10:52,480
up here and so you kind of have this

312
00:10:56,550 --> 00:10:54,560
sort of relation but the message in this

313
00:10:57,829 --> 00:10:56,560

plot is really in the scatter of those

314
00:11:00,630 --> 00:10:57,839
red dots

315
00:11:02,389 --> 00:11:00,640
you can get almost anything the driest

316
00:11:04,230 --> 00:11:02,399
winter occurred during an el nino and

317
00:11:06,470 --> 00:11:04,240
the wettest

318
00:11:08,069 --> 00:11:06,480
winter occurred during el nino and

319
00:11:10,870 --> 00:11:08,079
there's a lot of

320
00:11:12,389 --> 00:11:10,880
high precipitation years during el nino

321
00:11:15,190 --> 00:11:12,399
and that's why we can kind of come to

322
00:11:16,790 --> 00:11:15,200
learn or anticipate oh el nino may bring

323
00:11:18,389 --> 00:11:16,800
us a wet winter

324
00:11:19,910 --> 00:11:18,399
so how well do we do

325
00:11:21,990 --> 00:11:19,920
at predicting that you can see that's

326
00:11:23,829 --> 00:11:22,000
kind of a challenge right

327
00:11:27,030 --> 00:11:23,839
so this is the official forecast that

328
00:11:28,550 --> 00:11:27,040
was issued again by noaa back in october

329
00:11:30,949 --> 00:11:28,560
2015

330
00:11:32,790 --> 00:11:30,959
and it was for the following december

331
00:11:35,269 --> 00:11:32,800
january and february so it was in

332
00:11:37,910 --> 00:11:35,279
october 2015 and it represents what the

333
00:11:39,590 --> 00:11:37,920
precipitation likelihood would be

334
00:11:43,190 --> 00:11:39,600
in the subsequent december january and

335
00:11:45,590 --> 00:11:43,200
february this last winter and the

336
00:11:46,310 --> 00:11:45,600
greenish regions represent areas that

337
00:11:48,790 --> 00:11:46,320
are

338
00:11:51,190 --> 00:11:48,800

more likely to be wet and the tan

339
00:11:53,110 --> 00:11:51,200
regions are regions that are likely to

340
00:11:54,870 --> 00:11:53,120
be drier than normal and the language

341
00:11:57,430 --> 00:11:54,880
here is really important and then people

342
00:11:59,829 --> 00:11:57,440
at noaa and the forecasters pay a lot of

343
00:12:01,430 --> 00:11:59,839
attention to this language because they

344
00:12:03,030 --> 00:12:01,440
understand the shortcomings of what it

345
00:12:05,509 --> 00:12:03,040
is and it's a probabilistic type

346
00:12:07,590 --> 00:12:05,519
forecast so for california namely

347
00:12:09,030 --> 00:12:07,600
looking at say these two regions

348
00:12:10,389 --> 00:12:09,040
northern california and southern

349
00:12:12,629 --> 00:12:10,399
california

350
00:12:14,629 --> 00:12:12,639
if you read the details of that scale

351
00:12:16,949 --> 00:12:14,639
you the forecast says for california

352
00:12:18,629 --> 00:12:16,959
northern california you have a 33 to 40

353
00:12:20,230 --> 00:12:18,639
percent chance of being wetter than

354
00:12:22,230 --> 00:12:20,240
normal

355
00:12:25,110 --> 00:12:22,240
and for southern california the forecast

356
00:12:26,470 --> 00:12:25,120
was a 50 to 60 percent chance of being

357
00:12:28,470 --> 00:12:26,480
wetter than normal

358
00:12:30,629 --> 00:12:28,480
but you can see it's probabilistic it

359
00:12:34,230 --> 00:12:30,639
says what maybe most likely but it

360
00:12:37,509 --> 00:12:34,240
certainly re leaves room for uncertainty

361
00:12:39,990 --> 00:12:37,519
so how did it actually turn out

362
00:12:41,990 --> 00:12:40,000
this is um again after living through it

363
00:12:43,190 --> 00:12:42,000

all and adding up all the precipitation

364
00:12:45,030 --> 00:12:43,200
and all the gauges this is a

365
00:12:47,350 --> 00:12:45,040
representation of the wintertime

366
00:12:49,590 --> 00:12:47,360
precipitation in what we refer to as the

367
00:12:51,269 --> 00:12:49,600
climate divisions of california

368
00:12:53,350 --> 00:12:51,279
and each number here represents the

369
00:12:55,430 --> 00:12:53,360
percent of average over the historical

370
00:12:56,710 --> 00:12:55,440
average and you can see that in northern

371
00:12:57,750 --> 00:12:56,720
california

372
00:12:59,750 --> 00:12:57,760
we had

373
00:13:01,190 --> 00:12:59,760
close to normal rainfall which is good

374
00:13:02,470 --> 00:13:01,200
given the three or four years that we've

375
00:13:05,430 --> 00:13:02,480
lived through before that which are all

376
00:13:07,190 --> 00:13:05,440
below normal we got normal precipitation

377
00:13:08,949 --> 00:13:07,200
in northern california

378
00:13:12,710 --> 00:13:08,959
and down here in southern california you

379
00:13:14,069 --> 00:13:12,720
know it was a relatively dry winter

380
00:13:15,509 --> 00:13:14,079
we only received about half the

381
00:13:17,350 --> 00:13:15,519
precipitation that we might normally

382
00:13:19,910 --> 00:13:17,360
expect

383
00:13:21,430 --> 00:13:19,920
so you can ask us yourself well did the

384
00:13:26,949 --> 00:13:21,440
forecast

385
00:13:29,110 --> 00:13:26,959
it's just that the the the conditions

386
00:13:30,389 --> 00:13:29,120
that were thought to be most likely

387
00:13:32,069 --> 00:13:30,399
didn't occur

388
00:13:34,949 --> 00:13:32,079

okay but it doesn't mean it failed it

389
00:13:36,550 --> 00:13:34,959
just that was the case so why was that

390
00:13:38,069 --> 00:13:36,560
we're still wrestling with why we'd like

391
00:13:40,069 --> 00:13:38,079
to think that the forecast would always

392
00:13:41,910 --> 00:13:40,079
be right or the most likely condition

393
00:13:43,509 --> 00:13:41,920
that's being told would be the one that

394
00:13:44,949 --> 00:13:43,519
was manifest but it didn't turn out that

395
00:13:46,389 --> 00:13:44,959
way

396
00:13:48,470 --> 00:13:46,399
what was different about last year that

397
00:13:50,470 --> 00:13:48,480
might have taught us something

398
00:13:51,910 --> 00:13:50,480
or that might teach us something

399
00:13:53,190 --> 00:13:51,920
this is a comparison of those two

400
00:13:54,949 --> 00:13:53,200
pictures this is the picture i showed

401
00:13:57,910 --> 00:13:54,959
before and this is a picture i showed

402
00:13:59,910 --> 00:13:57,920
before for 2015. this is a comparison of

403
00:14:02,069 --> 00:13:59,920
what was another large el nino event

404
00:14:04,230 --> 00:14:02,079
1997 and 98

405
00:14:05,829 --> 00:14:04,240
and again sea surface temperature and

406
00:14:07,750 --> 00:14:05,839
sea level height

407
00:14:10,069 --> 00:14:07,760
and you can see at least in the tropics

408
00:14:11,990 --> 00:14:10,079
the patterns are fairly similar so there

409
00:14:15,350 --> 00:14:12,000
isn't an obvious distinction between

410
00:14:17,590 --> 00:14:15,360
those two winters even though the 97 el

411
00:14:18,949 --> 00:14:17,600
nino event actually was both predicted

412
00:14:20,790 --> 00:14:18,959
well here

413
00:14:22,550 --> 00:14:20,800

and it was relatively well predicted the

414
00:14:24,310 --> 00:14:22,560
precipitation up here in california and

415
00:14:25,750 --> 00:14:24,320
the west coast

416
00:14:27,430 --> 00:14:25,760
the difference might be that these

417
00:14:29,110 --> 00:14:27,440
temperatures off the west coast were

418
00:14:31,030 --> 00:14:29,120
different than they were in 1997 you

419
00:14:32,069 --> 00:14:31,040
might have heard the media refer to the

420
00:14:37,030 --> 00:14:32,079
blob

421
00:14:38,949 --> 00:14:37,040
occurring off the west coast of the u.s

422
00:14:40,790 --> 00:14:38,959
so this aspect is still a research

423
00:14:42,310 --> 00:14:40,800
problem the forecasters and scientists

424
00:14:43,670 --> 00:14:42,320
are undertaking research to try and

425
00:14:45,590 --> 00:14:43,680
understand what they can learn from that

426
00:14:47,189 --> 00:14:45,600
and maybe better anticipate and come up

427
00:14:50,629 --> 00:14:47,199
with the mo you know the correct most

428
00:14:51,590 --> 00:14:50,639
likely forecast next time

429
00:14:53,509 --> 00:14:51,600
so

430
00:14:55,189 --> 00:14:53,519
that's what i mainly wanted to tell you

431
00:14:57,430 --> 00:14:55,199
and in summary i just want to

432
00:15:00,310 --> 00:14:57,440
distinguish between the phenomena el

433
00:15:02,389 --> 00:15:00,320
nino which occurs in the tropics we know

434
00:15:03,910 --> 00:15:02,399
a fair bit about it and we can predict

435
00:15:05,509 --> 00:15:03,920
it relatively well

436
00:15:07,430 --> 00:15:05,519
then there's the effects of el nino

437
00:15:08,790 --> 00:15:07,440
which is a much more challenging problem

438
00:15:11,670 --> 00:15:08,800

and it is a much more challenging

439
00:15:12,629 --> 00:15:11,680
prediction problem as as you can see

440
00:15:14,550 --> 00:15:12,639
and so

441
00:15:16,629 --> 00:15:14,560
we're working on that and part of jpl's

442
00:15:18,310 --> 00:15:16,639
role in that process is to provide new

443
00:15:20,389 --> 00:15:18,320
and continued satellite information that

444
00:15:22,150 --> 00:15:20,399
will both inform that research and help

445
00:15:23,269 --> 00:15:22,160
advance the predictions

446
00:15:25,110 --> 00:15:23,279
so with that

447
00:15:26,470 --> 00:15:25,120
i invite my colleague tom painter to

448
00:15:29,030 --> 00:15:26,480
come up and talk about of the

449
00:15:30,629 --> 00:15:29,040
precipitation i talked about how that

450
00:15:39,350 --> 00:15:30,639
manifests itself in terms of a mountain

451
00:15:43,110 --> 00:15:40,949
can you hear me

452
00:15:44,629 --> 00:15:43,120
in the back okay great

453
00:15:47,829 --> 00:15:44,639
um

454
00:15:51,430 --> 00:15:47,839
thanks dwayne so this is a shot from uh

455
00:15:52,230 --> 00:15:51,440
the central sierra uh in mid-february

456
00:15:57,430 --> 00:15:52,240
and

457
00:16:01,189 --> 00:15:57,440
like the previous three years in the

458
00:16:03,350 --> 00:16:01,199
sierra nevadas it was a beautiful site

459
00:16:04,790 --> 00:16:03,360
and and we were really excited with our

460
00:16:06,550 --> 00:16:04,800
program to actually be able to finally

461
00:16:08,470 --> 00:16:06,560
measure deep snow

462
00:16:09,749 --> 00:16:08,480
as opposed to the stuff we've had

463
00:16:11,910 --> 00:16:09,759

so um

464
00:16:13,749 --> 00:16:11,920
so dwayne alluded to this but i the

465
00:16:15,030 --> 00:16:13,759
thing i want to start out with is

466
00:16:16,790 --> 00:16:15,040
if you took all the mountains of the

467
00:16:17,910 --> 00:16:16,800
western u.s and you just cut them all

468
00:16:19,509 --> 00:16:17,920
down

469
00:16:21,509 --> 00:16:19,519
it wouldn't there wouldn't be much

470
00:16:22,470 --> 00:16:21,519
precipitation in the western u.s all

471
00:16:25,269 --> 00:16:22,480
right and there wouldn't be the

472
00:16:28,389 --> 00:16:25,279
civilization that we have out here uh it

473
00:16:30,310 --> 00:16:28,399
is the it's the mountains that cause the

474
00:16:32,790 --> 00:16:30,320
lifting of the clouds coming off the

475
00:16:35,269 --> 00:16:32,800
water coming off of the ocean and that

476
00:16:37,509 --> 00:16:35,279
causes the precipitation here all right

477
00:16:39,509 --> 00:16:37,519
and you can see the the distribution of

478
00:16:41,590 --> 00:16:39,519
elevation so the rocky mountains in here

479
00:16:44,629 --> 00:16:41,600
the wasatch and utah and up into the

480
00:16:45,509 --> 00:16:44,639
northern rockies and these ranges across

481
00:16:46,389 --> 00:16:45,519
here

482
00:16:51,670 --> 00:16:46,399
and

483
00:16:52,710 --> 00:16:51,680
snow well the vast majority of that is

484
00:16:54,310 --> 00:16:52,720
snowfall

485
00:16:56,069 --> 00:16:54,320
all right because we have very high

486
00:16:58,629 --> 00:16:56,079
mountains out here in the western u.s so

487
00:17:00,310 --> 00:16:58,639
we really need to understand the

488
00:17:01,990 --> 00:17:00,320

mountain snowpack because that is our

489
00:17:06,949 --> 00:17:02,000
number one resource in the in the

490
00:17:09,669 --> 00:17:06,959
western u.s all right so 2015 was a grim

491
00:17:11,510 --> 00:17:09,679
year and frank gerke i'm not sure if you

492
00:17:12,789 --> 00:17:11,520
can see it above the the chairs but

493
00:17:14,630 --> 00:17:12,799
frank gehrke is the chief of the

494
00:17:16,630 --> 00:17:14,640
california cooperative snow survey

495
00:17:19,429 --> 00:17:16,640
program all right they gather all the

496
00:17:21,029 --> 00:17:19,439
information from all of the cooperators

497
00:17:22,710 --> 00:17:21,039
pacific gas and electric southern

498
00:17:25,669 --> 00:17:22,720
california edison

499
00:17:28,069 --> 00:17:25,679
city of san francisco on and on and on

500
00:17:30,549 --> 00:17:28,079
to combine that information and make the

501
00:17:32,630 --> 00:17:30,559
snowpack information available to the to

502
00:17:35,510 --> 00:17:32,640
the state uh he's otherwise known you'll

503
00:17:37,430 --> 00:17:35,520
see him on on april 1st uh talking about

504
00:17:40,710 --> 00:17:37,440
the snowpack right so he's otherwise

505
00:17:43,190 --> 00:17:40,720
known as california snow groundhog

506
00:17:44,710 --> 00:17:43,200
and here he is out with his bodyguards

507
00:17:46,630 --> 00:17:44,720
um

508
00:17:50,710 --> 00:17:46,640
at the phillips snow course up by south

509
00:17:52,710 --> 00:17:50,720
lake tahoe last year pointing to what uh

510
00:17:55,990 --> 00:17:52,720
the previous worst year was what the

511
00:17:56,870 --> 00:17:56,000
average was what 1983 was

512
00:17:59,350 --> 00:17:56,880
um

513
00:18:01,830 --> 00:17:59,360

and then here he is on this date with no

514
00:18:04,470 --> 00:18:01,840
snow

515
00:18:06,310 --> 00:18:04,480
this is this year on about the same date

516
00:18:07,990 --> 00:18:06,320
and it was a much better uh a much

517
00:18:10,230 --> 00:18:08,000
better feeling there was snow and he

518
00:18:12,789 --> 00:18:10,240
didn't have to put tape on his uh on his

519
00:18:14,470 --> 00:18:12,799
federal sampler and um and of course he

520
00:18:16,710 --> 00:18:14,480
didn't have the

521
00:18:18,390 --> 00:18:16,720
the governor and the head of dwr with

522
00:18:20,390 --> 00:18:18,400
him um

523
00:18:21,750 --> 00:18:20,400
so but at any rate it definitely was a

524
00:18:24,870 --> 00:18:21,760
much better year

525
00:18:27,110 --> 00:18:24,880
uh how much better was it well uh so we

526
00:18:28,470 --> 00:18:27,120
started out here in the in the early

527
00:18:30,870 --> 00:18:28,480
part of the year

528
00:18:32,789 --> 00:18:30,880
uh creeping up and bumping up against

529
00:18:36,070 --> 00:18:32,799
average conditions which which is what

530
00:18:38,710 --> 00:18:36,080
this uh this faint blue the cyan is

531
00:18:41,190 --> 00:18:38,720
and as we headed into uh into late

532
00:18:42,470 --> 00:18:41,200
january we were starting to crest

533
00:18:47,669 --> 00:18:42,480
above

534
00:18:50,710 --> 00:18:47,679
and northern mountains we actually were

535
00:18:53,110 --> 00:18:50,720
sneaking up above uh above average and

536
00:18:54,470 --> 00:18:53,120
we were getting really excited because

537
00:18:59,990 --> 00:18:54,480
el nino

538
00:19:02,310 --> 00:19:00,000

doesn't tend to come until february

539
00:19:04,950 --> 00:19:02,320
march april when the snowpack just can

540
00:19:07,029 --> 00:19:04,960
really start to accumulate like crazy

541
00:19:08,630 --> 00:19:07,039
and then it came february first and it

542
00:19:10,870 --> 00:19:08,640
shut off

543
00:19:14,070 --> 00:19:10,880
and that was a real bummer february was

544
00:19:15,350 --> 00:19:14,080
extraordinarily dry and then we went

545
00:19:16,870 --> 00:19:15,360
into march and we started getting a

546
00:19:19,909 --> 00:19:16,880
little bit more

547
00:19:21,510 --> 00:19:19,919
and then it fizzled out again and so

548
00:19:24,150 --> 00:19:21,520
it's pretty grim

549
00:19:26,070 --> 00:19:24,160
that in this year that was about 85

550
00:19:28,870 --> 00:19:26,080
percent of normal in the mountain

551
00:19:31,510 --> 00:19:28,880
snowpack but that was something to uh to

552
00:19:33,270 --> 00:19:31,520
shout about all right but we'll take

553
00:19:35,270 --> 00:19:33,280
what we can get uh in terms of the

554
00:19:37,909 --> 00:19:35,280
snowpack

555
00:19:39,750 --> 00:19:37,919
oh actually i want to point out also

556
00:19:42,870 --> 00:19:39,760
dwayne mentioned that there had been

557
00:19:44,630 --> 00:19:42,880
previously two el ninos that were of the

558
00:19:48,230 --> 00:19:44,640
magnitude of the el nino that we were

559
00:19:51,430 --> 00:19:48,240
experiencing all right so 1982 83 which

560
00:19:55,750 --> 00:19:51,440
is depicted here it's snowpack

561
00:19:57,830 --> 00:19:55,760
and then the 1997-98 el nino now in

562
00:19:58,870 --> 00:19:57,840
terms so i'm showing you part of that

563
00:20:01,029 --> 00:19:58,880

story

564
00:20:06,870 --> 00:20:01,039
and duane alluded to this but

565
00:20:08,630 --> 00:20:06,880
8283 9798 had huge snow packs so

566
00:20:10,070 --> 00:20:08,640
right we got another el nino of that

567
00:20:11,190 --> 00:20:10,080
magnitude it's going to be a huge

568
00:20:13,430 --> 00:20:11,200
snowpack

569
00:20:15,190 --> 00:20:13,440
and

570
00:20:17,350 --> 00:20:15,200
just do your statistics you know that

571
00:20:19,590 --> 00:20:17,360
two two samples is not really that

572
00:20:21,990 --> 00:20:19,600
reliable and and sure enough it didn't

573
00:20:24,070 --> 00:20:22,000
turn out quite like we had hoped uh and

574
00:20:24,950 --> 00:20:24,080
and we're desperately wanting all right

575
00:20:31,190 --> 00:20:24,960
so

576
00:20:32,870 --> 00:20:31,200
we pretty much measure the snowpack

577
00:20:35,510 --> 00:20:32,880
the same way we have for the last

578
00:20:38,149 --> 00:20:35,520
century and so this is the tuolumne

579
00:20:40,870 --> 00:20:38,159
river basin up in the northern half of

580
00:20:42,870 --> 00:20:40,880
yosemite national park um

581
00:20:44,149 --> 00:20:42,880
and the hatchet reservoir is right here

582
00:20:45,590 --> 00:20:44,159
you'll see it in a second but this is

583
00:20:49,270 --> 00:20:45,600
the water supply for the city of san

584
00:20:52,070 --> 00:20:49,280
francisco and uh these red dots which

585
00:20:53,110 --> 00:20:52,080
are expanded by 3 600 times

586
00:20:55,029 --> 00:20:53,120
represent

587
00:20:56,630 --> 00:20:55,039
snow pillows or snow courses and i'll

588
00:20:58,549 --> 00:20:56,640

show you in a second what those are but

589
00:21:00,390 --> 00:20:58,559
there are eight of these in the whole of

590
00:21:04,149 --> 00:21:00,400
the tuolumne river basin which is about

591
00:21:05,669 --> 00:21:04,159
460 square miles huge area right but

592
00:21:07,909 --> 00:21:05,679
they're only those measurements and then

593
00:21:09,510 --> 00:21:07,919
there's a big gap in here

594
00:21:11,990 --> 00:21:09,520
all right so what are these measurements

595
00:21:13,990 --> 00:21:12,000
so there's frank at an earlier time with

596
00:21:16,149 --> 00:21:14,000
his federal sampler where you plunge the

597
00:21:17,830 --> 00:21:16,159
tube in pull it out weigh it that tells

598
00:21:20,149 --> 00:21:17,840
you how much water there is in the snow

599
00:21:22,710 --> 00:21:20,159
pack right there and you do it at 10

600
00:21:24,149 --> 00:21:22,720
sites along what's called a snow course

601
00:21:27,350 --> 00:21:24,159
that's been done

602
00:21:29,909 --> 00:21:27,360
since about 1910 and that is the main

603
00:21:32,710 --> 00:21:29,919
measurement of snowpack that we have and

604
00:21:34,470 --> 00:21:32,720
then in the 1980s we brought in this was

605
00:21:37,990 --> 00:21:34,480
hot on the heels of waterbeds in the

606
00:21:40,470 --> 00:21:38,000
1970s how many of you remember waterbeds

607
00:21:42,149 --> 00:21:40,480
see look at that it's amazing how few

608
00:21:42,830 --> 00:21:42,159
people know waterbeds how many of you

609
00:21:47,669 --> 00:21:42,840
know

610
00:21:49,110 --> 00:21:47,679
water beds all right but

611
00:21:50,390 --> 00:21:49,120
somebody finally figured out what to do

612
00:21:53,110 --> 00:21:50,400
with the water bed and that's to put it

613
00:21:55,669 --> 00:21:53,120

in a ground and measure snow pack on top

614
00:21:57,669 --> 00:21:55,679
of it all right and so in the 1980s

615
00:21:59,909 --> 00:21:57,679
that's when we started inserting those

616
00:22:02,310 --> 00:21:59,919
but they're far more of the of these

617
00:22:04,070 --> 00:22:02,320
samples out here but these give you a

618
00:22:06,310 --> 00:22:04,080
daily measurement the problem is that

619
00:22:08,470 --> 00:22:06,320
they can get ice on them bears like to

620
00:22:09,510 --> 00:22:08,480
rip them apart bears like to sleep on

621
00:22:14,390 --> 00:22:09,520
them

622
00:22:17,909 --> 00:22:14,400
and so that makes you think that there's

623
00:22:20,070 --> 00:22:17,919
snow when there isn't snow and so these

624
00:22:21,909 --> 00:22:20,080
remain a bit of a problem all right so

625
00:22:25,350 --> 00:22:21,919
so we have

626
00:22:26,390 --> 00:22:25,360
not that great of of instrumentation so

627
00:22:27,669 --> 00:22:26,400
at any rate

628
00:22:29,669 --> 00:22:27,679
those are the measurements we have and

629
00:22:31,750 --> 00:22:29,679
we've done remarkably well with with how

630
00:22:33,669 --> 00:22:31,760
poor instrumentation we have but this is

631
00:22:35,270 --> 00:22:33,679
the way that we really want to see it we

632
00:22:36,870 --> 00:22:35,280
want to see it with 39 million times

633
00:22:38,549 --> 00:22:36,880
more coverage we want to have wall to

634
00:22:40,470 --> 00:22:38,559
wall mapping we don't want to have just

635
00:22:42,310 --> 00:22:40,480
distinct points

636
00:22:43,909 --> 00:22:42,320
we want to have the whole thing so we

637
00:22:46,549 --> 00:22:43,919
can add up all of the water in the

638
00:22:48,230 --> 00:22:46,559

snowpack so that led to the development

639
00:22:51,029 --> 00:22:48,240
of the the nasa airborne snow

640
00:22:52,390 --> 00:22:51,039
observatory which we fly out of jpl and

641
00:22:54,710 --> 00:22:52,400
we developed here

642
00:22:56,230 --> 00:22:54,720
and um there's a whole bunch of words up

643
00:22:57,990 --> 00:22:56,240
here but um

644
00:23:00,549 --> 00:22:58,000
the here's the plane at the mammoth

645
00:23:03,430 --> 00:23:00,559
airport there's mount morrison uh we get

646
00:23:05,270 --> 00:23:03,440
it snow depth which we then take to snow

647
00:23:06,710 --> 00:23:05,280
water equivalent which is just how much

648
00:23:09,510 --> 00:23:06,720
water there would be if you melted the

649
00:23:11,430 --> 00:23:09,520
snowpack down instantaneously and we get

650
00:23:13,990 --> 00:23:11,440
to snow depth using

651
00:23:16,710 --> 00:23:14,000
a dual laser system so just like in the

652
00:23:18,870 --> 00:23:16,720
movie wall-e when when eva comes down

653
00:23:21,430 --> 00:23:18,880
right and um

654
00:23:23,190 --> 00:23:21,440
so this maps topography and we map it

655
00:23:24,549 --> 00:23:23,200
when there's snow on the ground and we

656
00:23:25,990 --> 00:23:24,559
map it when there's no snow on the

657
00:23:28,310 --> 00:23:26,000
ground and the difference between those

658
00:23:29,430 --> 00:23:28,320
two tells you how deep the snow is wall

659
00:23:31,350 --> 00:23:29,440
to wall

660
00:23:32,950 --> 00:23:31,360
the resolution is about like this and we

661
00:23:35,190 --> 00:23:32,960
have all of those pixels so it's kind of

662
00:23:36,549 --> 00:23:35,200
like having a snow course or a snow

663
00:23:38,630 --> 00:23:36,559

pillow

664
00:23:40,630 --> 00:23:38,640
everywhere across the landscape without

665
00:23:43,669 --> 00:23:40,640
an environmental impact statement all

666
00:23:45,990 --> 00:23:43,679
right so so that sits on the on the

667
00:23:47,669 --> 00:23:46,000
front of the payload integration mount

668
00:23:48,870 --> 00:23:47,679
here in the plane looking straight out

669
00:23:50,870 --> 00:23:48,880
uh the bottom of the plane and then

670
00:23:52,470 --> 00:23:50,880
right behind it we have

671
00:23:55,190 --> 00:23:52,480
for the measurement of snow albedo which

672
00:23:56,789 --> 00:23:55,200
is the reflectivity of snow or what

673
00:23:59,190 --> 00:23:56,799
tells you how much sunlight is going to

674
00:24:00,710 --> 00:23:59,200
be absorbed by snow we use an imaging

675
00:24:03,270 --> 00:24:00,720
spectrometer and that measures the

676
00:24:06,310 --> 00:24:03,280
reflected sunlight in nearly 100

677
00:24:07,110 --> 00:24:06,320
different colors or wavelengths and that

678
00:24:07,830 --> 00:24:07,120
uh

679
00:24:14,710 --> 00:24:07,840
the

680
00:24:15,750 --> 00:24:14,720
that goes to melting snow

681
00:24:17,590 --> 00:24:15,760
all right

682
00:24:20,149 --> 00:24:17,600
now we do the wall-to-wall mapping of

683
00:24:21,669 --> 00:24:20,159
snow water equivalent and albedo we do

684
00:24:23,350 --> 00:24:21,679
roughly weekly flights through the

685
00:24:24,710 --> 00:24:23,360
winter and spring all the way out

686
00:24:27,190 --> 00:24:24,720
through snowmelt you'll see that in a

687
00:24:29,029 --> 00:24:27,200
second and we do 24-hour turnaround of

688
00:24:30,630 --> 00:24:29,039

the product so the water managers can

689
00:24:32,789 --> 00:24:30,640
have this information right away and

690
00:24:34,230 --> 00:24:32,799
then we hold on to that information for

691
00:24:36,870 --> 00:24:34,240
for the science community and so this

692
00:24:38,070 --> 00:24:36,880
has really been a uh a transitional tool

693
00:24:41,029 --> 00:24:38,080
for them

694
00:24:43,269 --> 00:24:41,039
so getting to the core of this snow

695
00:24:45,990 --> 00:24:43,279
water equivalent it is depth times the

696
00:24:48,310 --> 00:24:46,000
density that's how much water there is

697
00:24:50,070 --> 00:24:48,320
in that snowpack and we get the depth

698
00:24:53,110 --> 00:24:50,080
again from the plane and then we get

699
00:24:55,750 --> 00:24:53,120
density from a model that's nudged by

700
00:24:57,750 --> 00:24:55,760
those snow courses and the snow pillows

701
00:25:00,950 --> 00:24:57,760
which we do not want to see go away we

702
00:25:03,110 --> 00:25:00,960
absolutely need to have those all right

703
00:25:05,110 --> 00:25:03,120
so this is the last four years we

704
00:25:08,310 --> 00:25:05,120
started this was our first acquisition

705
00:25:10,630 --> 00:25:08,320
in 2013 and through 15 it had been the

706
00:25:12,549 --> 00:25:10,640
most amount of snow that we'd measured

707
00:25:15,029 --> 00:25:12,559
our program manager at nasa headquarters

708
00:25:17,110 --> 00:25:15,039
claimed that we started the drought

709
00:25:18,630 --> 00:25:17,120
but we weren't taking credit for that

710
00:25:21,110 --> 00:25:18,640
and um

711
00:25:23,510 --> 00:25:21,120
so it was a pretty good snowpack

712
00:25:25,430 --> 00:25:23,520
considering and then 2014 came along

713
00:25:27,750 --> 00:25:25,440

that was a bit grim

714
00:25:28,430 --> 00:25:27,760
and 2014 was trying to hang in there

715
00:25:31,549 --> 00:25:28,440
with

716
00:25:35,190 --> 00:25:31,559
1976-77 as the worst year on record then

717
00:25:37,350 --> 00:25:35,200
2015 came along and just destroyed that

718
00:25:39,590 --> 00:25:37,360
this is the roughly april one and this

719
00:25:41,750 --> 00:25:39,600
is an important time of the year because

720
00:25:42,549 --> 00:25:41,760
that is when allocation decisions are

721
00:25:44,870 --> 00:25:42,559
made

722
00:25:46,630 --> 00:25:44,880
for agriculture the the amount of water

723
00:25:49,909 --> 00:25:46,640
that's going to be distributed to the

724
00:25:52,789 --> 00:25:49,919
stakeholders is decided on in a very

725
00:25:54,710 --> 00:25:52,799
hard statement on around april first

726
00:25:56,549 --> 00:25:54,720
right so knowing how much snowpack there

727
00:25:58,470 --> 00:25:56,559
is is absolutely critical

728
00:25:59,830 --> 00:25:58,480
during this time and in this year so

729
00:26:01,830 --> 00:25:59,840
many of the snow pillows and the snow

730
00:26:03,190 --> 00:26:01,840
courses were melted out that they were

731
00:26:05,110 --> 00:26:03,200
like

732
00:26:08,230 --> 00:26:05,120
we don't know

733
00:26:10,390 --> 00:26:08,240
then 2016 came along and wow we had

734
00:26:13,110 --> 00:26:10,400
nearly double the amount of snowpack

735
00:26:14,870 --> 00:26:13,120
that uh that we had in 2013. we had to

736
00:26:17,750 --> 00:26:14,880
change all of our figures because our

737
00:26:19,510 --> 00:26:17,760
scales didn't go high enough so that was

738
00:26:20,549 --> 00:26:19,520

exciting all right now i'll go to the

739
00:26:21,990 --> 00:26:20,559
movie

740
00:26:24,630 --> 00:26:22,000
and this is going to take you all the

741
00:26:26,390 --> 00:26:24,640
way 2013 every acquisition that we've

742
00:26:28,789 --> 00:26:26,400
done in the tuolumne river basin and

743
00:26:30,470 --> 00:26:28,799
down here you'll see the total amount of

744
00:26:31,990 --> 00:26:30,480
water in the mountain snowpack and not

745
00:26:34,070 --> 00:26:32,000
one of these acquisitions before this

746
00:26:36,230 --> 00:26:34,080
program started had ever been

747
00:26:38,630 --> 00:26:36,240
had ever been possible so it's the first

748
00:26:40,630 --> 00:26:38,640
information of its kind and you'll see

749
00:26:42,310 --> 00:26:40,640
these years kind of compressed down in

750
00:26:45,110 --> 00:26:42,320
here

751
00:26:46,710 --> 00:26:45,120
largely because of 2016. but you see the

752
00:26:48,390 --> 00:26:46,720
snowpack melting away these are the

753
00:26:49,350 --> 00:26:48,400
higher elevations

754
00:26:53,590 --> 00:26:49,360
and

755
00:26:57,029 --> 00:26:53,600
the mcclure glacier down here

756
00:26:59,909 --> 00:26:57,039
and here's the grim 2015

757
00:27:01,350 --> 00:26:59,919
here comes 2016. wham

758
00:27:02,870 --> 00:27:01,360
all right now watch what's happening

759
00:27:06,230 --> 00:27:02,880
here

760
00:27:08,310 --> 00:27:06,240
we had a fair bit of snowfall and and

761
00:27:10,549 --> 00:27:08,320
then it starts to die off but we're

762
00:27:11,669 --> 00:27:10,559
headed toward having a snowpack in fact

763
00:27:14,789 --> 00:27:11,679

let me

764
00:27:17,190 --> 00:27:14,799
can i back it up without screwing it up

765
00:27:22,710 --> 00:27:17,200
okay i'll leave my hands off of it um at

766
00:27:24,870 --> 00:27:22,720
any rate so as of june 1st of this year

767
00:27:27,029 --> 00:27:24,880
we had more snow

768
00:27:29,590 --> 00:27:27,039
than we had at any point during the

769
00:27:31,830 --> 00:27:29,600
previous three years and peak snow water

770
00:27:34,149 --> 00:27:31,840
equivalent usually comes about april 1st

771
00:27:36,230 --> 00:27:34,159
it comes in the winter to early march

772
00:27:38,870 --> 00:27:36,240
but getting into summer almost at the

773
00:27:40,230 --> 00:27:38,880
beginning of summer we had more snow

774
00:27:42,230 --> 00:27:40,240
than we did

775
00:27:43,269 --> 00:27:42,240
in the previous three years now

776
00:27:45,590 --> 00:27:43,279
understand

777
00:27:46,549 --> 00:27:45,600
the snowpack was roughly 85 percent of

778
00:27:48,950 --> 00:27:46,559
normal

779
00:27:50,950 --> 00:27:48,960
so just because that we were nearly

780
00:27:52,149 --> 00:27:50,960
double and we had the same amount as at

781
00:27:54,149 --> 00:27:52,159
peak

782
00:27:55,430 --> 00:27:54,159
doesn't necessarily mean that we're out

783
00:27:58,389 --> 00:27:55,440
of the woods with respect to the

784
00:28:01,990 --> 00:27:58,399
snowpack it's simply we we got some

785
00:28:04,630 --> 00:28:02,000
breathing room out of this snowpack um

786
00:28:06,549 --> 00:28:04,640
so anyway i'll stop there

787
00:28:08,950 --> 00:28:06,559
and i'm going to hand it off to our

788
00:28:11,190 --> 00:28:08,960

senior water scientist jay family eddie

789
00:28:11,990 --> 00:28:11,200
who's going to give you the

790
00:28:15,750 --> 00:28:12,000
the

791
00:28:25,269 --> 00:28:15,760
minutes

792
00:28:29,430 --> 00:28:27,190
thanks everybody so while this is uh

793
00:28:32,789 --> 00:28:29,440
changing over oh i'm i'm responsible for

794
00:28:36,710 --> 00:28:33,590
so

795
00:28:39,190 --> 00:28:36,720
in contrast to what you heard from

796
00:28:41,909 --> 00:28:39,200
tom and dwayne what you'll hear after

797
00:28:44,389 --> 00:28:41,919
after me from from tom farr

798
00:28:46,710 --> 00:28:44,399
you saw some high resolution imagery

799
00:28:48,310 --> 00:28:46,720
uh what i'm going to show you comes from

800
00:28:49,990 --> 00:28:48,320
a satellite mission called grace which

801
00:28:52,389 --> 00:28:50,000
stands for gravity recovery and climate

802
00:28:55,430 --> 00:28:52,399
experiment and

803
00:28:57,990 --> 00:28:55,440
it's a different kind of mission

804
00:28:59,909 --> 00:28:58,000
and the results or the information that

805
00:29:02,630 --> 00:28:59,919
we get is a little bit

806
00:29:05,269 --> 00:29:02,640
lower resolution in

807
00:29:07,430 --> 00:29:05,279
both space and time meaning we can look

808
00:29:10,070 --> 00:29:07,440
at uh look at these data

809
00:29:12,630 --> 00:29:10,080
on regions that are 200 000 square

810
00:29:14,389 --> 00:29:12,640
kilometers or greater which is about

811
00:29:17,190 --> 00:29:14,399
the scale of the size of half of

812
00:29:20,149 --> 00:29:17,200
california and and um and monthly and

813
00:29:23,510 --> 00:29:20,159

longer okay so it's in sharp contrast to

814
00:29:26,149 --> 00:29:23,520
uh the the tom sandwich that i'm you

815
00:29:26,950 --> 00:29:26,159
know i'm sandwiched between tom and tom

816
00:29:29,830 --> 00:29:26,960
uh

817
00:29:33,029 --> 00:29:29,840
and and so i'm gonna slather on some low

818
00:29:34,230 --> 00:29:33,039
resolution grace data um this is an

819
00:29:37,590 --> 00:29:34,240
image

820
00:29:40,710 --> 00:29:37,600
that we put together in in 2014

821
00:29:41,669 --> 00:29:40,720
and i think it gives a sense

822
00:29:43,830 --> 00:29:41,679
of

823
00:29:45,669 --> 00:29:43,840
the declining

824
00:29:47,510 --> 00:29:45,679
amount of

825
00:29:50,230 --> 00:29:47,520
water that's stored

826
00:29:52,149 --> 00:29:50,240
across across the whole across the whole

827
00:29:54,389 --> 00:29:52,159
state

828
00:29:56,389 --> 00:29:54,399
so yes we have our ups and downs as

829
00:29:58,070 --> 00:29:56,399
you'll see we have wet seasons and dry

830
00:30:01,350 --> 00:29:58,080
seasons but one of the things that the

831
00:30:03,909 --> 00:30:01,360
grace mission has exposed

832
00:30:06,549 --> 00:30:03,919
is that we've been steadily losing water

833
00:30:08,870 --> 00:30:06,559
in california for for some time and a

834
00:30:10,950 --> 00:30:08,880
lot of that has to do with

835
00:30:12,710 --> 00:30:10,960
our over-reliance on groundwater and the

836
00:30:15,350 --> 00:30:12,720
fact that we grow a tremendous amount of

837
00:30:16,630 --> 00:30:15,360
food uh so we're not judging about

838
00:30:18,470 --> 00:30:16,640

whether it's right or wrong we're just

839
00:30:20,149 --> 00:30:18,480
sort of figuring out the accounting

840
00:30:22,710 --> 00:30:20,159
personally i love to eat

841
00:30:24,230 --> 00:30:22,720
i had a wonderful peanut butter and

842
00:30:26,870 --> 00:30:24,240
jelly sandwich before i came because

843
00:30:29,750 --> 00:30:26,880
it's an early early presentation tonight

844
00:30:32,149 --> 00:30:29,760
but you know i was thinking about it uh

845
00:30:34,830 --> 00:30:32,159
what's so this is the magical mat

846
00:30:37,110 --> 00:30:34,840
yes okay wonderful

847
00:30:38,310 --> 00:30:37,120
uh so i was thinking about the food that

848
00:30:40,230 --> 00:30:38,320
i ate and how much of it came from

849
00:30:42,389 --> 00:30:40,240
california well peanut butter and jelly

850
00:30:44,149 --> 00:30:42,399
so the jelly was strawberry jelly good

851
00:30:46,870 --> 00:30:44,159
chance those strawberries were grown in

852
00:30:48,389 --> 00:30:46,880
in california peanut butter not so sure

853
00:30:49,830 --> 00:30:48,399
about where the peanuts came from the

854
00:30:51,830 --> 00:30:49,840
bread had a lot of walnuts in it you

855
00:30:52,950 --> 00:30:51,840
know most the walnuts that we eat uh in

856
00:30:54,630 --> 00:30:52,960
the united states and most of the

857
00:30:56,870 --> 00:30:54,640
pistachios and most of the almonds come

858
00:30:58,310 --> 00:30:56,880
from come from uh come from the central

859
00:31:00,470 --> 00:30:58,320
valley it takes a tremendous amount of

860
00:31:02,789 --> 00:31:00,480
water to do that uh so we've been

861
00:31:05,269 --> 00:31:02,799
stressing out our our resources and it's

862
00:31:07,110 --> 00:31:05,279
it's so you know so much stress that

863
00:31:09,830 --> 00:31:07,120

we're seeing it show up in these in

864
00:31:11,510 --> 00:31:09,840
these satellite images so uh the mission

865
00:31:14,389 --> 00:31:11,520
is called grace gravity recovery and

866
00:31:16,389 --> 00:31:14,399
climate experiment uh it was launched in

867
00:31:18,230 --> 00:31:16,399
2002

868
00:31:20,870 --> 00:31:18,240
and i like to say that it functions like

869
00:31:23,269 --> 00:31:20,880
a scale in the sky that can weigh the

870
00:31:24,950 --> 00:31:23,279
monthly increases or decreases in total

871
00:31:27,430 --> 00:31:24,960
water storage which i'll explain in a

872
00:31:29,350 --> 00:31:27,440
second uh for large regions which which

873
00:31:31,350 --> 00:31:29,360
i explained already uh

874
00:31:35,350 --> 00:31:31,360
200 000 square kilometers and greater if

875
00:31:38,070 --> 00:31:35,360
you look at those uh two satellites um i

876
00:31:39,669 --> 00:31:38,080
think i have another image here uh you

877
00:31:42,149 --> 00:31:39,679
can see that they're not very big

878
00:31:45,430 --> 00:31:42,159
they're about the size of a half

879
00:31:46,389 --> 00:31:45,440
half the height of a of a minivan

880
00:31:50,310 --> 00:31:46,399
and

881
00:31:52,070 --> 00:31:50,320
in contrast to some of the other uh uh

882
00:31:54,149 --> 00:31:52,080
satellite missions that you

883
00:31:55,430 --> 00:31:54,159
that you've heard about from us before

884
00:31:57,350 --> 00:31:55,440
where we're sensing some kind of

885
00:31:59,750 --> 00:31:57,360
radiation from the surface or we're

886
00:32:01,830 --> 00:31:59,760
monitoring some kind of color or

887
00:32:04,070 --> 00:32:01,840
shooting laser beams down at the earth

888
00:32:06,149 --> 00:32:04,080

and looking at the travel time

889
00:32:07,509 --> 00:32:06,159
the grace mission is really sensing

890
00:32:10,389 --> 00:32:07,519
changes

891
00:32:12,870 --> 00:32:10,399
in earth's gravitational field

892
00:32:15,909 --> 00:32:12,880
and the changes that happen

893
00:32:18,710 --> 00:32:15,919
on these monthly time scales are very

894
00:32:20,950 --> 00:32:18,720
much driven by the movement of water

895
00:32:22,789 --> 00:32:20,960
over the earth's surface and so in a

896
00:32:24,870 --> 00:32:22,799
simple way what happens if these are the

897
00:32:26,389 --> 00:32:24,880
two satellites by the way they orbit

898
00:32:28,149 --> 00:32:26,399
we call it a near polar orbit they

899
00:32:30,710 --> 00:32:28,159
follow each other around they're up at

900
00:32:32,710 --> 00:32:30,720
400 kilometers and they're separated by

901
00:32:34,870 --> 00:32:32,720
about 200 kilometers they orbit around

902
00:32:36,310 --> 00:32:34,880
the earth they chase each other around

903
00:32:37,750 --> 00:32:36,320
sometimes we call them tom and jerry

904
00:32:40,230 --> 00:32:37,760
like the old cartoon if you remember

905
00:32:41,509 --> 00:32:40,240
what we're talking about waterbeds

906
00:32:43,350 --> 00:32:41,519
pong

907
00:32:44,950 --> 00:32:43,360
tom and jerry might go back a little bit

908
00:32:45,750 --> 00:32:44,960
a little bit further

909
00:32:47,190 --> 00:32:45,760
yeah

910
00:32:50,230 --> 00:32:47,200
that's right

911
00:32:54,070 --> 00:32:51,830
so tom and jerry are chasing each other

912
00:32:55,909 --> 00:32:54,080
around but as they orbit over a place

913
00:32:57,990 --> 00:32:55,919

like the sierras like tom was showing

914
00:32:59,669 --> 00:32:58,000
you right if there's snow on the ground

915
00:33:01,669 --> 00:32:59,679
there's a lot of water mass that region

916
00:33:03,509 --> 00:33:01,679
has gained water mass right it's gained

917
00:33:05,750 --> 00:33:03,519
water weight and so as the satellites

918
00:33:07,269 --> 00:33:05,760
fly over there at that region because

919
00:33:09,190 --> 00:33:07,279
it's gained water mass

920
00:33:11,190 --> 00:33:09,200
has

921
00:33:13,110 --> 00:33:11,200
exerts just a little bit greater

922
00:33:14,789 --> 00:33:13,120
gravitational tug on the satellites

923
00:33:16,630 --> 00:33:14,799
because there's more mass there and so

924
00:33:18,389 --> 00:33:16,640
it pulls the first one down a little bit

925
00:33:20,470 --> 00:33:18,399
as it's orbiting over it gets pulled

926
00:33:21,509 --> 00:33:20,480
down second one comes in it gets pulled

927
00:33:23,029 --> 00:33:21,519
down

928
00:33:24,870 --> 00:33:23,039
likewise if these two satellites are

929
00:33:26,710 --> 00:33:24,880
flying over the central valley which is

930
00:33:31,909 --> 00:33:26,720
losing water

931
00:33:33,830 --> 00:33:31,919
slightly less of a gravitational tug on

932
00:33:35,590 --> 00:33:33,840
the satellites and so as they orbit over

933
00:33:37,430 --> 00:33:35,600
the valley and they're not pulled down

934
00:33:39,350 --> 00:33:37,440
as much they might even float just a

935
00:33:40,789 --> 00:33:39,360
little bit higher in their orbit and the

936
00:33:43,190 --> 00:33:40,799
distance between them might change a

937
00:33:45,110 --> 00:33:43,200
little bit so by keeping track of the

938
00:33:47,830 --> 00:33:45,120

vertical and horizontal position of the

939
00:33:49,669 --> 00:33:47,840
satellites we're able to map out the

940
00:33:52,470 --> 00:33:49,679
regions around the world

941
00:33:54,789 --> 00:33:52,480
that are gaining or losing water mass on

942
00:33:55,830 --> 00:33:54,799
a monthly basis and so

943
00:33:57,830 --> 00:33:55,840
um

944
00:33:59,590 --> 00:33:57,840
like i think tom said those are first of

945
00:34:01,430 --> 00:33:59,600
their kind the for the aso first of

946
00:34:03,110 --> 00:34:01,440
their kind this is kind of a common

947
00:34:05,509 --> 00:34:03,120
theme right we have very novel

948
00:34:07,750 --> 00:34:05,519
measurements that that that we make here

949
00:34:08,869 --> 00:34:07,760
uh at jpl and nasa and so likewise the

950
00:34:09,909 --> 00:34:08,879
grace data

951
00:34:13,750 --> 00:34:09,919
uh

952
00:34:15,669 --> 00:34:13,760
are are firster of their kind um

953
00:34:18,230 --> 00:34:15,679
the caveats are you know it's relatively

954
00:34:20,950 --> 00:34:18,240
low resolution now what grace is really

955
00:34:23,589 --> 00:34:20,960
showing us is

956
00:34:26,310 --> 00:34:23,599
what we call a change in the total water

957
00:34:29,030 --> 00:34:26,320
storage so all of the snow all of the

958
00:34:31,349 --> 00:34:29,040
surface water all of the moisture in our

959
00:34:32,829 --> 00:34:31,359
soils which we call soil moisture and

960
00:34:35,349 --> 00:34:32,839
all of our groundwater

961
00:34:37,430 --> 00:34:35,359
together okay so we call that the total

962
00:34:39,750 --> 00:34:37,440
water storage and what grace is actually

963
00:34:42,230 --> 00:34:39,760

showing us is the change in the total

964
00:34:43,829 --> 00:34:42,240
water storage all the water shown in the

965
00:34:44,710 --> 00:34:43,839
surf schematic

966
00:34:46,710 --> 00:34:44,720
uh

967
00:34:48,230 --> 00:34:46,720
river basin so the snow the surface

968
00:34:49,829 --> 00:34:48,240
water in the lakes and rivers the soil

969
00:34:53,669 --> 00:34:49,839
moisture the groundwater on a monthly

970
00:34:55,270 --> 00:34:53,679
basis okay and the information

971
00:34:57,670 --> 00:34:55,280
uh that we've gotten from the grace

972
00:34:59,910 --> 00:34:57,680
mission has been more or less

973
00:35:02,470 --> 00:34:59,920
revolutionary when it comes to hydrology

974
00:35:04,950 --> 00:35:02,480
again because if you've never imagined

975
00:35:08,150 --> 00:35:04,960
never having gotten on a scale before

976
00:35:09,990 --> 00:35:08,160
yet you're trying to monitor your health

977
00:35:11,750 --> 00:35:10,000
and you're just kind of guessing at your

978
00:35:14,230 --> 00:35:11,760
weight over the years and

979
00:35:15,990 --> 00:35:14,240
and finally you know you you step on

980
00:35:17,670 --> 00:35:16,000
this thing called the scale the news

981
00:35:20,470 --> 00:35:17,680
might not be good but at least you can

982
00:35:22,790 --> 00:35:20,480
keep track of of what's going on

983
00:35:24,630 --> 00:35:22,800
um

984
00:35:27,190 --> 00:35:24,640
we like to look you know i s we gave

985
00:35:28,870 --> 00:35:27,200
these presentations earlier uh today to

986
00:35:31,910 --> 00:35:28,880
to a visitor i said my colleagues always

987
00:35:33,270 --> 00:35:31,920
show animation so i have to show one too

988
00:35:35,510 --> 00:35:33,280

and so we're looking at the ups and

989
00:35:37,910 --> 00:35:35,520
downs of water storage in california and

990
00:35:39,990 --> 00:35:37,920
the blues are wetter and the and the

991
00:35:41,829 --> 00:35:40,000
reds are wetter than normal and the and

992
00:35:43,670 --> 00:35:41,839
the reds are drier than normal so we

993
00:35:45,829 --> 00:35:43,680
just went through the we just went

994
00:35:47,670 --> 00:35:45,839
through the uh beginning of the

995
00:35:49,750 --> 00:35:47,680
of the california drought

996
00:35:50,870 --> 00:35:49,760
this is sort of like a moving

997
00:35:54,710 --> 00:35:50,880
job map

998
00:35:56,470 --> 00:35:54,720
right an animated an animated drop map

999
00:35:57,829 --> 00:35:56,480
so we can look at animations but we

1000
00:35:59,750 --> 00:35:57,839
don't really like to sit around and look

1001
00:36:03,589 --> 00:35:59,760
at movies well i do but

1002
00:36:07,510 --> 00:36:05,349
but we can also look at this chart this

1003
00:36:09,109 --> 00:36:07,520
is like the chart of the water weight

1004
00:36:11,190 --> 00:36:09,119
the ups and downs of the water weight

1005
00:36:13,829 --> 00:36:11,200
for the sacramento the san joaquin the

1006
00:36:16,069 --> 00:36:13,839
tilari lake basins and here's

1007
00:36:18,390 --> 00:36:16,079
here's um

1008
00:36:20,550 --> 00:36:18,400
the central valley shown in blue and so

1009
00:36:22,710 --> 00:36:20,560
we started in 2002

1010
00:36:24,790 --> 00:36:22,720
this finishes in november of 2016

1011
00:36:27,829 --> 00:36:24,800
actually march of 20

1012
00:36:30,790 --> 00:36:27,839
2016. now this finished november 2015

1013
00:36:32,230 --> 00:36:30,800

march of 2016 is right about here i've

1014
00:36:34,069 --> 00:36:32,240
seen the new data but i don't have it in

1015
00:36:35,670 --> 00:36:34,079
this plot

1016
00:36:37,589 --> 00:36:35,680
but anyway we see

1017
00:36:41,190 --> 00:36:37,599
wet season dry season wet season dry

1018
00:36:42,630 --> 00:36:41,200
season right of total water storage uh

1019
00:36:44,470 --> 00:36:42,640
in um

1020
00:36:46,550 --> 00:36:44,480
in the second this is most of the water

1021
00:36:48,230 --> 00:36:46,560
in california

1022
00:36:49,910 --> 00:36:48,240
so you know we've never seen we've never

1023
00:36:51,750 --> 00:36:49,920
had this kind of information before and

1024
00:36:53,349 --> 00:36:51,760
it's telling us some pretty important

1025
00:36:56,069 --> 00:36:53,359
things for example we can see the dry

1026
00:36:58,150 --> 00:36:56,079
seasons right these troughs in this in

1027
00:37:01,109 --> 00:36:58,160
this chart in this chart of our weight

1028
00:37:03,109 --> 00:37:01,119
change uh water weight change we can see

1029
00:37:05,589 --> 00:37:03,119
uh that the dry seasons are continually

1030
00:37:07,510 --> 00:37:05,599
getting drier we see our drought right

1031
00:37:08,470 --> 00:37:07,520
this is the cart drought

1032
00:37:11,349 --> 00:37:08,480
started

1033
00:37:13,430 --> 00:37:11,359
excuse me nominally in 2011

1034
00:37:14,870 --> 00:37:13,440
and so we can quantify this so we can

1035
00:37:16,230 --> 00:37:14,880
you know read the numbers off the scale

1036
00:37:18,710 --> 00:37:16,240
we've been losing

1037
00:37:21,109 --> 00:37:18,720
about 15 cubic kilometers or 12 million

1038
00:37:23,670 --> 00:37:21,119

acre feet of water per year

1039
00:37:26,950 --> 00:37:23,680
going back to 2011. that's that's more

1040
00:37:28,310 --> 00:37:26,960
water for reference in california the

1041
00:37:29,990 --> 00:37:28,320
total amount of water we use for

1042
00:37:31,990 --> 00:37:30,000
domestic and municipal supplies 10

1043
00:37:34,710 --> 00:37:32,000
million acre feet so we're losing more

1044
00:37:36,630 --> 00:37:34,720
water each year than all uh 39 million

1045
00:37:38,950 --> 00:37:36,640
californians use

1046
00:37:40,470 --> 00:37:38,960
um

1047
00:37:42,069 --> 00:37:40,480
about two thirds of that by the way is

1048
00:37:43,430 --> 00:37:42,079
coming from from groundwater pumping and

1049
00:37:44,710 --> 00:37:43,440
i'll show you that in the in the next

1050
00:37:45,589 --> 00:37:44,720
slide

1051
00:37:47,510 --> 00:37:45,599
um

1052
00:37:50,230 --> 00:37:47,520
but you know this this uh there's some

1053
00:37:52,470 --> 00:37:50,240
embedded time scales here that are worth

1054
00:37:54,470 --> 00:37:52,480
talking about and the second one is you

1055
00:37:56,470 --> 00:37:54,480
know when i look at this chart i think

1056
00:37:58,950 --> 00:37:56,480
it's easy to imagine that oh maybe this

1057
00:38:01,750 --> 00:37:58,960
drought started in 2006 and this was

1058
00:38:02,630 --> 00:38:01,760
just a little mini el nino which it was

1059
00:38:04,710 --> 00:38:02,640
okay

1060
00:38:07,270 --> 00:38:04,720
and really you can see that that we've

1061
00:38:09,829 --> 00:38:07,280
been losing water this whole time and so

1062
00:38:11,510 --> 00:38:09,839
this is sort of you know this orange

1063
00:38:13,109 --> 00:38:11,520

line here when you think about that

1064
00:38:15,670 --> 00:38:13,119
first image i showed you of the green

1065
00:38:17,030 --> 00:38:15,680
yellow red right that was the the green

1066
00:38:18,630 --> 00:38:17,040
and then the yellow one was here and the

1067
00:38:20,870 --> 00:38:18,640
red one was down here

1068
00:38:23,670 --> 00:38:20,880
so we've got this progressive loss of

1069
00:38:24,870 --> 00:38:23,680
water and the reason is

1070
00:38:28,390 --> 00:38:24,880
that

1071
00:38:31,349 --> 00:38:28,400
our winter rains the el ninos and the la

1072
00:38:33,349 --> 00:38:31,359
ninas and the normal winters come and go

1073
00:38:35,190 --> 00:38:33,359
we get most of our water most of our

1074
00:38:37,109 --> 00:38:35,200
precipitation happens in the winter we

1075
00:38:38,870 --> 00:38:37,119
have good years we have bad years

1076
00:38:40,710 --> 00:38:38,880
but our groundwater as i'll show you in

1077
00:38:42,150 --> 00:38:40,720
a second just go so just disappear so

1078
00:38:45,270 --> 00:38:42,160
when you add them together this is what

1079
00:38:46,950 --> 00:38:45,280
you see and so what i have been

1080
00:38:48,230 --> 00:38:46,960
calling this and what i think grace has

1081
00:38:50,310 --> 00:38:48,240
revealed

1082
00:38:51,270 --> 00:38:50,320
is that we have chronic

1083
00:38:53,349 --> 00:38:51,280
water

1084
00:38:55,589 --> 00:38:53,359
scarcity right and a lot of this is

1085
00:38:57,349 --> 00:38:55,599
driven by by agriculture and the need to

1086
00:38:59,910 --> 00:38:57,359
produce food and it's not just in

1087
00:39:02,550 --> 00:38:59,920
california it's really happening in all

1088
00:39:05,190 --> 00:39:02,560

of the main uh aquifers the groundwater

1089
00:39:08,790 --> 00:39:05,200
storage units of the world actually it's

1090
00:39:11,109 --> 00:39:08,800
happening in over half of 20 of the 37

1091
00:39:13,829 --> 00:39:11,119
uh world's largest aquifers are being

1092
00:39:16,310 --> 00:39:13,839
depleted at a pretty rapid clip

1093
00:39:18,630 --> 00:39:16,320
this is my last slide and it i think

1094
00:39:22,390 --> 00:39:18,640
underscores what's happening

1095
00:39:24,950 --> 00:39:22,400
with groundwater and so this is a

1096
00:39:27,190 --> 00:39:24,960
combination plot of data from the u.s

1097
00:39:29,829 --> 00:39:27,200
geological survey taken from wells in

1098
00:39:32,870 --> 00:39:29,839
their groundwater model in our estimates

1099
00:39:35,190 --> 00:39:32,880
of of uh groundwater losses

1100
00:39:36,870 --> 00:39:35,200
uh uh from the grace mission so we're

1101
00:39:38,710 --> 00:39:36,880
looking at the cumulative groundwater

1102
00:39:40,630 --> 00:39:38,720
depletion in the central valley going

1103
00:39:43,510 --> 00:39:40,640
back to 1962

1104
00:39:45,349 --> 00:39:43,520
and actually this plot if we were to

1105
00:39:47,270 --> 00:39:45,359
extend it we would see this this

1106
00:39:49,109 --> 00:39:47,280
decreasing trend actually goes back to

1107
00:39:51,589 --> 00:39:49,119
the 30s so this has been going on for

1108
00:39:53,030 --> 00:39:51,599
almost 100 years the colors in the

1109
00:39:54,829 --> 00:39:53,040
background represent whether we have a

1110
00:39:57,910 --> 00:39:54,839
wet period

1111
00:40:00,150 --> 00:39:57,920
uh with respect to precipitation right

1112
00:40:02,150 --> 00:40:00,160
uh greater than average rainfall a dry

1113
00:40:05,109 --> 00:40:02,160

period drought periods like we like

1114
00:40:07,270 --> 00:40:05,119
we're having right now or in between uh

1115
00:40:10,390 --> 00:40:07,280
variably wet to variably dry in those

1116
00:40:11,910 --> 00:40:10,400
light gray to light blue colors and so

1117
00:40:13,510 --> 00:40:11,920
you know the overall message is of

1118
00:40:14,710 --> 00:40:13,520
course the downward trend

1119
00:40:16,230 --> 00:40:14,720
right

1120
00:40:17,910 --> 00:40:16,240
and that's what we're trying to stop

1121
00:40:19,589 --> 00:40:17,920
we're trying to arrest this trend with

1122
00:40:21,910 --> 00:40:19,599
the sustainable groundwater management

1123
00:40:23,670 --> 00:40:21,920
plan it's not clear that that's possible

1124
00:40:25,190 --> 00:40:23,680
if we continue to grow so much food so

1125
00:40:27,430 --> 00:40:25,200
this is a national problem that we have

1126
00:40:29,109 --> 00:40:27,440
to be thinking about but

1127
00:40:30,630 --> 00:40:29,119
the other message here is that during

1128
00:40:32,470 --> 00:40:30,640
these wet periods sure we get a little

1129
00:40:33,990 --> 00:40:32,480
bit of recovery

1130
00:40:35,990 --> 00:40:34,000
but then during the drought periods we

1131
00:40:37,349 --> 00:40:36,000
really hit the groundwater really hard

1132
00:40:39,270 --> 00:40:37,359
and then we get a little recovery and

1133
00:40:41,910 --> 00:40:39,280
then we hit the groundwater really hard

1134
00:40:44,950 --> 00:40:41,920
so that's why we have this overall

1135
00:40:47,910 --> 00:40:44,960
downward excuse me downward trajectory

1136
00:40:49,589 --> 00:40:47,920
um so there are lots of implications

1137
00:40:51,430 --> 00:40:49,599
uh for that

1138
00:40:53,109 --> 00:40:51,440

and one is that the water table is

1139
00:40:55,190 --> 00:40:53,119
dropping quite a bit the average water

1140
00:40:57,750 --> 00:40:55,200
table depth in the central valley so the

1141
00:41:00,150 --> 00:40:57,760
top of the groundwater zone is at 2500

1142
00:41:01,589 --> 00:41:00,160
feet and so many many wells are running

1143
00:41:03,750 --> 00:41:01,599
dry

1144
00:41:06,470 --> 00:41:03,760
many people can't afford to dig new

1145
00:41:08,550 --> 00:41:06,480
wells which cost to go down 2500 feet

1146
00:41:11,349 --> 00:41:08,560
costs about 250 000

1147
00:41:12,309 --> 00:41:11,359
you may have to wait a year to two years

1148
00:41:14,870 --> 00:41:12,319
because

1149
00:41:16,870 --> 00:41:14,880
uh there's so much demand for uh for for

1150
00:41:19,270 --> 00:41:16,880
drilling new wells

1151
00:41:21,270 --> 00:41:19,280
not everybody can afford that

1152
00:41:22,870 --> 00:41:21,280
and there's other consequences streams

1153
00:41:24,309 --> 00:41:22,880
are running dry look around you know

1154
00:41:26,230 --> 00:41:24,319
look around southern california you

1155
00:41:28,470 --> 00:41:26,240
don't really see a lot of

1156
00:41:30,309 --> 00:41:28,480
naturally flowing streams and that's

1157
00:41:33,670 --> 00:41:30,319
because the water table

1158
00:41:35,990 --> 00:41:33,680
is so low and one of the kind of scary

1159
00:41:37,510 --> 00:41:36,000
things that happens that that tom my

1160
00:41:38,950 --> 00:41:37,520
colleague tom farr is going to tell us

1161
00:41:40,870 --> 00:41:38,960
about next

1162
00:41:43,190 --> 00:41:40,880
is that the ground is actually sinking

1163
00:41:47,510 --> 00:41:43,200

in some in some places and in some

1164
00:41:50,390 --> 00:41:47,520
places uh many inches to uh to feet

1165
00:41:52,309 --> 00:41:50,400
to to feet per year so to continue with

1166
00:41:56,069 --> 00:41:52,319
this theme of

1167
00:42:02,309 --> 00:41:56,079
of novel observations uh please welcome

1168
00:42:02,319 --> 00:42:06,470
thank you

1169
00:42:10,710 --> 00:42:08,309
thanks jay as a really great uh

1170
00:42:12,390 --> 00:42:10,720
background and introduction to uh what

1171
00:42:14,390 --> 00:42:12,400
i'm going to talk about

1172
00:42:17,430 --> 00:42:14,400
we can call it ground subsidence or as i

1173
00:42:19,270 --> 00:42:17,440
like to say it's that sinking feeling uh

1174
00:42:22,230 --> 00:42:19,280
this is an actual uh

1175
00:42:25,589 --> 00:42:22,240
picture here taken in 1977 showing where

1176
00:42:27,589 --> 00:42:25,599
the ground level was in 1925 in an area

1177
00:42:29,750 --> 00:42:27,599
of the central valley where there was a

1178
00:42:31,510 --> 00:42:29,760
lot of ground water pumping so i'll

1179
00:42:33,430 --> 00:42:31,520
explain it a little bit more

1180
00:42:35,670 --> 00:42:33,440
in a minute but as jay mentioned the

1181
00:42:38,069 --> 00:42:35,680
central valley is really important

1182
00:42:40,870 --> 00:42:38,079
for a lot of reasons

1183
00:42:43,190 --> 00:42:40,880
a lot of food is grown in that area

1184
00:42:45,030 --> 00:42:43,200
but at the same time especially in the

1185
00:42:47,030 --> 00:42:45,040
southern part of the the central valley

1186
00:42:48,230 --> 00:42:47,040
here in the san joaquin valley

1187
00:42:50,309 --> 00:42:48,240
most of that

1188
00:42:53,030 --> 00:42:50,319

that food is grown using groundwater

1189
00:42:54,550 --> 00:42:53,040
there's not that much surface water a

1190
00:42:55,910 --> 00:42:54,560
fair amount is brought down from the

1191
00:42:58,470 --> 00:42:55,920
northern part of the state in the

1192
00:43:01,190 --> 00:42:58,480
california aqueduct and other water

1193
00:43:03,990 --> 00:43:01,200
projects but again most of the water

1194
00:43:05,990 --> 00:43:04,000
being used to irrigate those crops

1195
00:43:07,510 --> 00:43:06,000
is groundwater

1196
00:43:09,430 --> 00:43:07,520
and you can see it's a it's a huge

1197
00:43:12,470 --> 00:43:09,440
amount even compared to

1198
00:43:14,230 --> 00:43:12,480
the the entire united states and we're

1199
00:43:16,309 --> 00:43:14,240
we're looking at the central valley for

1200
00:43:17,910 --> 00:43:16,319
a variety of reasons uh partly because

1201
00:43:20,790 --> 00:43:17,920
we have a lot of data there's a lot of

1202
00:43:23,270 --> 00:43:20,800
interest there but also there's a lot of

1203
00:43:25,829 --> 00:43:23,280
places uh what we call alluvial basins

1204
00:43:27,589 --> 00:43:25,839
around the world that jay mentioned that

1205
00:43:30,069 --> 00:43:27,599
are also experiencing these kinds of

1206
00:43:32,630 --> 00:43:30,079
problems where you have gravel sand and

1207
00:43:34,630 --> 00:43:32,640
other kinds of aquifers that respond to

1208
00:43:36,470 --> 00:43:34,640
this groundwater withdrawal in a variety

1209
00:43:38,550 --> 00:43:36,480
of ways and so we can use these remote

1210
00:43:41,589 --> 00:43:38,560
sensing techniques that i'll talk about

1211
00:43:43,349 --> 00:43:41,599
to to study that and also of course

1212
00:43:45,510 --> 00:43:43,359
policy makers the department of water

1213
00:43:47,109 --> 00:43:45,520

resources here in the state is really

1214
00:43:49,510 --> 00:43:47,119
interested in what's going on with the

1215
00:43:51,829 --> 00:43:49,520
groundwater in the state and can we help

1216
00:43:54,630 --> 00:43:51,839
them not only monitor the groundwater

1217
00:43:56,309 --> 00:43:54,640
but also the effects of the groundwater

1218
00:43:58,710 --> 00:43:56,319
withdrawal and the subsidence the

1219
00:44:00,470 --> 00:43:58,720
sinking that i'll show you in a minute

1220
00:44:02,710 --> 00:44:00,480
this is one of the tools that they use

1221
00:44:04,870 --> 00:44:02,720
the state of california here the central

1222
00:44:06,870 --> 00:44:04,880
valley and what they they're doing is

1223
00:44:09,190 --> 00:44:06,880
they're monitoring the water level in

1224
00:44:10,790 --> 00:44:09,200
wells throughout the the state

1225
00:44:12,390 --> 00:44:10,800
at least the wells that they have access

1226
00:44:14,150 --> 00:44:12,400
to of course a lot of people don't like

1227
00:44:15,589 --> 00:44:14,160
the the government

1228
00:44:17,349 --> 00:44:15,599
asking them what they do with their

1229
00:44:19,750 --> 00:44:17,359
groundwater and that's a problem that

1230
00:44:21,750 --> 00:44:19,760
i'll mention at the end

1231
00:44:23,589 --> 00:44:21,760
but you can see these uh

1232
00:44:26,069 --> 00:44:23,599
warmer colors down here in the southern

1233
00:44:28,870 --> 00:44:26,079
part of the central valley all indicate

1234
00:44:30,950 --> 00:44:28,880
a decrease of over 50 feet in the level

1235
00:44:33,030 --> 00:44:30,960
of water in the wells in that area over

1236
00:44:34,870 --> 00:44:33,040
this period of time which is

1237
00:44:36,550 --> 00:44:34,880
the last few years

1238
00:44:38,230 --> 00:44:36,560

so they're really seeing a decrease in

1239
00:44:40,950 --> 00:44:38,240
water you've probably heard that farmers

1240
00:44:43,910 --> 00:44:40,960
are drilling more wells deeper wells and

1241
00:44:46,309 --> 00:44:43,920
so we're experiencing this real strong

1242
00:44:48,230 --> 00:44:46,319
decrease in in the level of water here

1243
00:44:50,150 --> 00:44:48,240
not so much in the northern part of the

1244
00:44:53,270 --> 00:44:50,160
of the state because there's more

1245
00:44:55,190 --> 00:44:53,280
surface water and more precipitation

1246
00:44:58,230 --> 00:44:55,200
well going back to this image and a few

1247
00:45:00,630 --> 00:44:58,240
others here uh the problem uh one of the

1248
00:45:02,710 --> 00:45:00,640
problems that we're seeing not only in

1249
00:45:04,950 --> 00:45:02,720
the decrease in the water but the fact

1250
00:45:07,430 --> 00:45:04,960
that the ground surface sinks when you

1251
00:45:11,190 --> 00:45:07,440
withdraw the water uh this this period

1252
00:45:13,190 --> 00:45:11,200
here from 1925 to 1977 a famous image

1253
00:45:15,750 --> 00:45:13,200
with joe poland who is one of the early

1254
00:45:18,710 --> 00:45:15,760
researchers of this problem uh occurred

1255
00:45:20,470 --> 00:45:18,720
mainly before the california aqueduct

1256
00:45:22,870 --> 00:45:20,480
was put in place and surface water

1257
00:45:25,030 --> 00:45:22,880
deliveries came down and replaced a lot

1258
00:45:27,589 --> 00:45:25,040
of that groundwater pumping so that uh

1259
00:45:29,750 --> 00:45:27,599
some of the the the subsidence isn't

1260
00:45:31,750 --> 00:45:29,760
occurring quite as fast but you'll see

1261
00:45:33,589 --> 00:45:31,760
that it still is occurring other

1262
00:45:35,589 --> 00:45:33,599
examples here there's a pipeline here

1263
00:45:37,589 --> 00:45:35,599

that they've had to shore up to keep the

1264
00:45:39,510 --> 00:45:37,599
water flowing downhill

1265
00:45:40,710 --> 00:45:39,520
that's another problem with the aqueduct

1266
00:45:42,630 --> 00:45:40,720
of course

1267
00:45:43,589 --> 00:45:42,640
the aqueduct in certain areas that i'll

1268
00:45:45,510 --> 00:45:43,599
show you

1269
00:45:47,990 --> 00:45:45,520
has to be shored up so that the water

1270
00:45:49,589 --> 00:45:48,000
continue to flow here's another well

1271
00:45:51,829 --> 00:45:49,599
head here where it's

1272
00:45:53,829 --> 00:45:51,839
clearly separated from the ground by a

1273
00:45:57,270 --> 00:45:53,839
couple of feet and this is kind of an

1274
00:46:00,230 --> 00:45:57,280
interesting it's a old gas well pipe

1275
00:46:02,630 --> 00:46:00,240
that the farmer painted orange a couple

1276
00:46:04,790 --> 00:46:02,640
of years before the picture was taken so

1277
00:46:05,750 --> 00:46:04,800
he wouldn't run into it with his tractor

1278
00:46:07,750 --> 00:46:05,760
and

1279
00:46:09,829 --> 00:46:07,760
sure enough after a couple of years it's

1280
00:46:11,990 --> 00:46:09,839
sticking out another foot and a half

1281
00:46:13,750 --> 00:46:12,000
because of the subsidence in that area

1282
00:46:16,390 --> 00:46:13,760
so it's clearly a problem for

1283
00:46:18,950 --> 00:46:16,400
infrastructure and a problem for the

1284
00:46:21,190 --> 00:46:18,960
water resource itself now the technique

1285
00:46:22,870 --> 00:46:21,200
we're we're using uh is something i

1286
00:46:24,550 --> 00:46:22,880
always have trouble trying to explain

1287
00:46:28,390 --> 00:46:24,560
it's not as easy as

1288
00:46:30,230 --> 00:46:28,400

lidar or the the grace satellites we use

1289
00:46:33,109 --> 00:46:30,240
a technique called interferometric

1290
00:46:34,790 --> 00:46:33,119
synthetic aperture radar uh which is

1291
00:46:36,550 --> 00:46:34,800
such a mouthful that we always just call

1292
00:46:38,630 --> 00:46:36,560
it insar for short

1293
00:46:40,870 --> 00:46:38,640
and what we're doing is we're collecting

1294
00:46:43,589 --> 00:46:40,880
radar images over and over and over

1295
00:46:44,950 --> 00:46:43,599
again either by satellite or aircraft

1296
00:46:47,030 --> 00:46:44,960
over an area

1297
00:46:49,430 --> 00:46:47,040
every couple of weeks every month every

1298
00:46:51,670 --> 00:46:49,440
couple of months and every time we

1299
00:46:53,349 --> 00:46:51,680
collect a second image we can

1300
00:46:55,670 --> 00:46:53,359
pairwise

1301
00:46:57,510 --> 00:46:55,680
we can basically subtract one image from

1302
00:46:59,270 --> 00:46:57,520
the other and

1303
00:47:02,069 --> 00:46:59,280
radars are special because we can

1304
00:47:04,309 --> 00:47:02,079
subtract the phases of the radar images

1305
00:47:07,430 --> 00:47:04,319
and what that allows us to do is look at

1306
00:47:09,109 --> 00:47:07,440
changes at the wavelength scale of the

1307
00:47:11,510 --> 00:47:09,119
surface and these wavelengths we're

1308
00:47:13,990 --> 00:47:11,520
talking about are like an inch to a foot

1309
00:47:16,870 --> 00:47:14,000
type wavelengths so we can see changes

1310
00:47:19,910 --> 00:47:16,880
in the ground surface at the sub-inch

1311
00:47:21,750 --> 00:47:19,920
level we can see the ground changing at

1312
00:47:23,910 --> 00:47:21,760
fractions of an inch so what i'm going

1313
00:47:26,150 --> 00:47:23,920

to show you here is is an example of a

1314
00:47:28,790 --> 00:47:26,160
time series that we collected over and

1315
00:47:31,349 --> 00:47:28,800
over again over this time period of 1996

1316
00:47:33,430 --> 00:47:31,359
to 2002 we've got a lot more data but

1317
00:47:35,109 --> 00:47:33,440
this was one of my best examples so i

1318
00:47:37,190 --> 00:47:35,119
like to show it

1319
00:47:40,309 --> 00:47:37,200
to policy makers when we try to explain

1320
00:47:42,069 --> 00:47:40,319
to what we can do and the la basin here

1321
00:47:44,550 --> 00:47:42,079
and you'll see the color scale here goes

1322
00:47:47,270 --> 00:47:44,560
from minus five centimeters about minus

1323
00:47:50,069 --> 00:47:47,280
two inches to uh plus five centimeters

1324
00:47:52,470 --> 00:47:50,079
or two inches and what you'll see is uh

1325
00:47:54,950 --> 00:47:52,480
how the ground is going up and down in

1326
00:47:56,950 --> 00:47:54,960
the los angeles basin mainly because of

1327
00:47:59,109 --> 00:47:56,960
pumping of groundwater and then in the

1328
00:48:01,030 --> 00:47:59,119
winter times it recharges in the ground

1329
00:48:02,790 --> 00:48:01,040
level comes back up so if you're careful

1330
00:48:05,349 --> 00:48:02,800
you can watch the summers and the

1331
00:48:07,030 --> 00:48:05,359
winters go by as a geologist i always

1332
00:48:08,950 --> 00:48:07,040
have to point out the newport inglewood

1333
00:48:10,790 --> 00:48:08,960
fault runs right through here and that

1334
00:48:12,950 --> 00:48:10,800
serves as a barrier to the groundwater

1335
00:48:15,910 --> 00:48:12,960
so you see that the groundwater changes

1336
00:48:18,230 --> 00:48:15,920
differently on either side of that

1337
00:48:20,870 --> 00:48:18,240
surface so this is mainly

1338
00:48:23,670 --> 00:48:20,880

recovering every winter it's not a big

1339
00:48:25,510 --> 00:48:23,680
problem in terms of subsidence or or

1340
00:48:27,190 --> 00:48:25,520
problems with the water table and in

1341
00:48:28,630 --> 00:48:27,200
fact it's kind of interesting to notice

1342
00:48:31,349 --> 00:48:28,640
that uh uh

1343
00:48:33,510 --> 00:48:31,359
groundwater accounts for up to 50 of our

1344
00:48:35,670 --> 00:48:33,520
water use in the la basin you always

1345
00:48:38,630 --> 00:48:35,680
hear about the the aqueducts but we use

1346
00:48:40,390 --> 00:48:38,640
quite a bit of local groundwater

1347
00:48:42,230 --> 00:48:40,400
up here is one spot though you might

1348
00:48:44,230 --> 00:48:42,240
notice that didn't really recover during

1349
00:48:46,150 --> 00:48:44,240
that time period it didn't it just went

1350
00:48:48,710 --> 00:48:46,160
down it didn't come back up again that's

1351
00:48:50,309 --> 00:48:48,720
an area over in the the chino basin and

1352
00:48:52,549 --> 00:48:50,319
they're actually aware of that it's a

1353
00:48:55,030 --> 00:48:52,559
problem the subsidence is a problem and

1354
00:48:57,030 --> 00:48:55,040
they actually have a special uh board

1355
00:48:59,510 --> 00:48:57,040
that's monitoring that and they've

1356
00:49:01,510 --> 00:48:59,520
actually since this time period 2002

1357
00:49:03,430 --> 00:49:01,520
they've been able to control that and

1358
00:49:05,589 --> 00:49:03,440
it's subsiding much less now but they've

1359
00:49:07,190 --> 00:49:05,599
actually had to put controls into place

1360
00:49:09,030 --> 00:49:07,200
to deal with that

1361
00:49:11,270 --> 00:49:09,040
now i'll show you another animation here

1362
00:49:13,990 --> 00:49:11,280
that of the area of the southern central

1363
00:49:16,549 --> 00:49:14,000

valley the san joaquin valley and you'll

1364
00:49:18,470 --> 00:49:16,559
see here the towns bakersfield fresno

1365
00:49:21,670 --> 00:49:18,480
for reference and you'll see the time

1366
00:49:24,870 --> 00:49:21,680
scale here is about 2007 to 2011. you

1367
00:49:26,470 --> 00:49:24,880
see my color bar that only goes one way

1368
00:49:29,349 --> 00:49:26,480
and that's a problem

1369
00:49:31,270 --> 00:49:29,359
and uh that illustrates uh what the the

1370
00:49:33,190 --> 00:49:31,280
big problem is here in the in the san

1371
00:49:34,870 --> 00:49:33,200
joaquin valley you see this hole

1372
00:49:36,950 --> 00:49:34,880
developing and it just keeps going it

1373
00:49:39,270 --> 00:49:36,960
never comes back even in the winter when

1374
00:49:40,390 --> 00:49:39,280
when we get rainfall

1375
00:49:42,710 --> 00:49:40,400
it's just

1376
00:49:44,470 --> 00:49:42,720
caused by the pumping in that area and

1377
00:49:47,430 --> 00:49:44,480
also the fact that in this area the

1378
00:49:49,670 --> 00:49:47,440
geology is especially conducive to the

1379
00:49:51,030 --> 00:49:49,680
subsidence phenomena when they pump the

1380
00:49:52,950 --> 00:49:51,040
water out

1381
00:49:54,950 --> 00:49:52,960
so this is the kind of thing that that

1382
00:49:57,829 --> 00:49:54,960
the water resource managers are really

1383
00:50:00,470 --> 00:49:57,839
interested in getting a handle on and

1384
00:50:03,670 --> 00:50:00,480
and getting a more quantitative view of

1385
00:50:05,589 --> 00:50:03,680
what's going on so what we've developed

1386
00:50:07,990 --> 00:50:05,599
is a number of different products

1387
00:50:09,109 --> 00:50:08,000
including the animations but things like

1388
00:50:13,430 --> 00:50:09,119

this

1389
00:50:15,829 --> 00:50:13,440
is that feature that i just showed you

1390
00:50:19,030 --> 00:50:15,839
but this is a later time period this is

1391
00:50:21,750 --> 00:50:19,040
may 2015 to march of this year and in

1392
00:50:24,790 --> 00:50:21,760
fact we're adding more dates up into the

1393
00:50:26,710 --> 00:50:24,800
current time using a satellite that

1394
00:50:29,270 --> 00:50:26,720
the europeans launched called sentinel

1395
00:50:31,270 --> 00:50:29,280
one and what we're able to do then is

1396
00:50:33,270 --> 00:50:31,280
make these color maps of the total

1397
00:50:36,549 --> 00:50:33,280
amount of subsidence

1398
00:50:39,510 --> 00:50:36,559
over this time period and able to show

1399
00:50:41,190 --> 00:50:39,520
then how it relates to surface features

1400
00:50:43,750 --> 00:50:41,200
you'll notice another feature up here

1401
00:50:45,270 --> 00:50:43,760
near the town of illinido that's another

1402
00:50:48,150 --> 00:50:45,280
feature that's known it actually

1403
00:50:50,470 --> 00:50:48,160
developed about a decade or so ago

1404
00:50:52,470 --> 00:50:50,480
because the farmers in this area have

1405
00:50:54,309 --> 00:50:52,480
replaced a lot of their traditional

1406
00:50:56,710 --> 00:50:54,319
annual crops with tree crops like

1407
00:50:58,470 --> 00:50:56,720
almonds and pistachios those need water

1408
00:51:00,710 --> 00:50:58,480
all year round you can't stop growing

1409
00:51:02,549 --> 00:51:00,720
those you can't let your field go fallow

1410
00:51:05,030 --> 00:51:02,559
for a particular season

1411
00:51:07,349 --> 00:51:05,040
so they've started developing subsidence

1412
00:51:09,430 --> 00:51:07,359
in this area some other features you see

1413
00:51:11,190 --> 00:51:09,440

here is in in pink the california

1414
00:51:15,030 --> 00:51:11,200
aqueduct running down to give us our

1415
00:51:16,870 --> 00:51:15,040
water uh you see a canal here called the

1416
00:51:19,430 --> 00:51:16,880
east side bypass which is a flood

1417
00:51:21,750 --> 00:51:19,440
control feature you see that running

1418
00:51:23,270 --> 00:51:21,760
right through this subsidence feature

1419
00:51:25,670 --> 00:51:23,280
there's a lot of concern that that's no

1420
00:51:27,589 --> 00:51:25,680
longer going to prove to be a flood

1421
00:51:28,710 --> 00:51:27,599
control feature because of the low spot

1422
00:51:30,549 --> 00:51:28,720
in the middle

1423
00:51:32,470 --> 00:51:30,559
another interesting feature is this blue

1424
00:51:34,950 --> 00:51:32,480
line here is the proposed high-speed

1425
00:51:36,790 --> 00:51:34,960
rail line and i've actually been

1426
00:51:39,030 --> 00:51:36,800
fielding a lot of questions and emails

1427
00:51:41,589 --> 00:51:39,040
from the high-speed rail engineers uh

1428
00:51:43,349 --> 00:51:41,599
because of the feature that we see

1429
00:51:46,230 --> 00:51:43,359
uh but you'll see that the the

1430
00:51:48,150 --> 00:51:46,240
subsidence actually impinges on the the

1431
00:51:51,510 --> 00:51:48,160
aqueduct as well and i'll show you an

1432
00:51:54,069 --> 00:51:51,520
image of that in a minute uh but in this

1433
00:51:56,150 --> 00:51:54,079
area of the the uh maximum subsidence

1434
00:51:58,870 --> 00:51:56,160
here near uh corcoran which you see in

1435
00:52:01,750 --> 00:51:58,880
in this time period is about up to 20

1436
00:52:04,790 --> 00:52:01,760
inches over uh less than a year uh we

1437
00:52:06,390 --> 00:52:04,800
i've plotted a time history of what that

1438
00:52:08,230 --> 00:52:06,400

area looks like and this is another

1439
00:52:11,030 --> 00:52:08,240
thing we can do with this essentially

1440
00:52:12,950 --> 00:52:11,040
four-dimensional data set and what we're

1441
00:52:16,230 --> 00:52:12,960
showing here is a period from actually

1442
00:52:17,990 --> 00:52:16,240
may 2014 which we've used

1443
00:52:20,230 --> 00:52:18,000
which i can plot because this in this

1444
00:52:23,109 --> 00:52:20,240
red line here is a canadian satellite

1445
00:52:25,910 --> 00:52:23,119
that we've also processed and uh used to

1446
00:52:29,270 --> 00:52:25,920
create the subsidence maps uh then the

1447
00:52:30,950 --> 00:52:29,280
sentinel data is this continued uh data

1448
00:52:33,030 --> 00:52:30,960
and that clearly shows that the

1449
00:52:35,670 --> 00:52:33,040
subsidence is up to about two feet per

1450
00:52:37,910 --> 00:52:35,680
year in that area the maximum subsidence

1451
00:52:40,230 --> 00:52:37,920
in this area so we can show in a

1452
00:52:41,829 --> 00:52:40,240
quantitative sense what's going on

1453
00:52:45,750 --> 00:52:41,839
now i just wanted to show one more thing

1454
00:52:47,510 --> 00:52:45,760
here in this yellow band here is a the

1455
00:52:49,190 --> 00:52:47,520
path of an aircraft sensor that we've

1456
00:52:51,829 --> 00:52:49,200
been using and my colleague kathleen

1457
00:52:55,349 --> 00:52:51,839
jones here at jpl has been

1458
00:52:57,510 --> 00:52:55,359
flying this aircraft radar over and over

1459
00:53:00,230 --> 00:52:57,520
again along the same path

1460
00:53:01,430 --> 00:53:00,240
and able to create the same kind of data

1461
00:53:04,230 --> 00:53:01,440
for that

1462
00:53:07,430 --> 00:53:04,240
path and so you see here the path of the

1463
00:53:09,670 --> 00:53:07,440

aircraft the california aqueduct pathway

1464
00:53:11,829 --> 00:53:09,680
and then she's color coded here in red

1465
00:53:13,430 --> 00:53:11,839
the subsidence areas and what's nice

1466
00:53:15,990 --> 00:53:13,440
about this system is it's much higher

1467
00:53:18,309 --> 00:53:16,000
resolution than the satellite systems so

1468
00:53:19,990 --> 00:53:18,319
we can home in on an area here that we

1469
00:53:21,750 --> 00:53:20,000
saw in the satellite data but couldn't

1470
00:53:23,990 --> 00:53:21,760
really kind of pinpoint what was going

1471
00:53:25,510 --> 00:53:24,000
on and so she's enlarged it here and

1472
00:53:27,430 --> 00:53:25,520
this little bullseye here is sitting

1473
00:53:28,790 --> 00:53:27,440
right next to the aqueduct and sure

1474
00:53:30,790 --> 00:53:28,800
enough you look in the center of that

1475
00:53:33,349 --> 00:53:30,800
bullseye and there's a big well there

1476
00:53:34,470 --> 00:53:33,359
and it's pumping very hard and

1477
00:53:35,990 --> 00:53:34,480
they they

1478
00:53:39,030 --> 00:53:36,000
experienced most of the most of their

1479
00:53:40,790 --> 00:53:39,040
subsidence in the summer of 2014

1480
00:53:43,190 --> 00:53:40,800
before we gave this data to the

1481
00:53:45,670 --> 00:53:43,200
department of water resources and they

1482
00:53:48,150 --> 00:53:45,680
have contacted the the well operators

1483
00:53:50,630 --> 00:53:48,160
because it costs millions of dollars to

1484
00:53:52,710 --> 00:53:50,640
shore up the uh the aqueduct to keep the

1485
00:53:54,470 --> 00:53:52,720
water flowing so this is a pretty

1486
00:53:57,270 --> 00:53:54,480
important uh

1487
00:53:59,270 --> 00:53:57,280
aspect of the uh of the infrastructure

1488
00:54:01,190 --> 00:53:59,280

california

1489
00:54:04,309 --> 00:54:01,200
so i just wanted to to return to this

1490
00:54:06,630 --> 00:54:04,319
and and uh sum up by saying that uh uh

1491
00:54:08,230 --> 00:54:06,640
as i mentioned we're working closely

1492
00:54:10,390 --> 00:54:08,240
with the department of water resources

1493
00:54:11,910 --> 00:54:10,400
they're actually funding our work to

1494
00:54:13,510 --> 00:54:11,920
make these maps

1495
00:54:15,829 --> 00:54:13,520
and you've probably heard maybe in the

1496
00:54:16,790 --> 00:54:15,839
last year or so california finally

1497
00:54:19,829 --> 00:54:16,800
passed

1498
00:54:21,030 --> 00:54:19,839
regulations on groundwater in the state

1499
00:54:23,910 --> 00:54:21,040
and so they're

1500
00:54:27,349 --> 00:54:23,920
using our data then to inform their

1501
00:54:29,829 --> 00:54:27,359
decisions on how to regulate and control

1502
00:54:31,910 --> 00:54:29,839
the groundwater use and pumping in the

1503
00:54:33,430 --> 00:54:31,920
central valley we're also expanding to

1504
00:54:34,950 --> 00:54:33,440
other parts of california and other

1505
00:54:36,150 --> 00:54:34,960
parts of the west

1506
00:54:38,470 --> 00:54:36,160
and the world

1507
00:54:41,030 --> 00:54:38,480
to start looking at other problem areas

1508
00:54:43,670 --> 00:54:41,040
that have these same kinds of subsidence

1509
00:54:47,750 --> 00:54:43,680
issues so that's all i had and i guess

1510
00:54:47,760 --> 00:54:51,589
time

1511
00:54:55,670 --> 00:54:53,349
so with that

1512
00:54:57,589 --> 00:54:55,680
with that the fun starts

1513
00:55:00,549 --> 00:54:57,599

and i'd like to invite my colleagues to

1514
00:55:03,430 --> 00:55:00,559
come and sit in the comfy chairs

1515
00:55:04,470 --> 00:55:03,440
oh no monty python fans

1516
00:55:07,349 --> 00:55:04,480
oh

1517
00:55:09,990 --> 00:55:07,359
thank you thank you thank you

1518
00:55:12,309 --> 00:55:10,000
stick around i've got more so so please

1519
00:55:14,549 --> 00:55:12,319
come and join us on stage guys and

1520
00:55:15,750 --> 00:55:14,559
we're going to take questions from the

1521
00:55:17,910 --> 00:55:15,760
audience

1522
00:55:20,069 --> 00:55:17,920
and from online if you have a question

1523
00:55:22,470 --> 00:55:20,079
in the audience please use the

1524
00:55:25,910 --> 00:55:22,480
microphone at the center of the room

1525
00:55:29,190 --> 00:55:27,829
give a few moments for them to get

1526
00:55:31,430 --> 00:55:29,200
comfortable

1527
00:55:38,390 --> 00:55:34,870
just checking maybe

1528
00:55:40,230 --> 00:55:38,400
so any questions before i kick it off

1529
00:55:43,670 --> 00:55:40,240
oh yes we do have one

1530
00:55:47,670 --> 00:55:43,680
please come up and use the microphone

1531
00:55:49,829 --> 00:55:47,680
hi um i had two questions about the nasa

1532
00:55:51,270 --> 00:55:49,839
grace material that was shown and the

1533
00:55:54,789 --> 00:55:51,280
presentation there

1534
00:55:56,470 --> 00:55:54,799
um the first one is uh that you're using

1535
00:55:58,470 --> 00:55:56,480
the the

1536
00:56:00,870 --> 00:55:58,480
the satellite to sort of measure the

1537
00:56:03,190 --> 00:56:00,880
gravity changes in order to detect i

1538
00:56:05,190 --> 00:56:03,200

guess it's subsidence um or at least the

1539
00:56:06,789 --> 00:56:05,200
amounts of water that are there and i

1540
00:56:08,230 --> 00:56:06,799
wonder if um

1541
00:56:09,270 --> 00:56:08,240
is you probably i'm sure you probably

1542
00:56:11,270 --> 00:56:09,280
have thoughts are there other

1543
00:56:13,030 --> 00:56:11,280
confounding factors other

1544
00:56:14,950 --> 00:56:13,040
issues that would be changing the

1545
00:56:17,430 --> 00:56:14,960
gravitation the gravity of how much it's

1546
00:56:18,950 --> 00:56:17,440
pulling and how do you account for that

1547
00:56:21,270 --> 00:56:18,960
sure and then i have a second question

1548
00:56:22,710 --> 00:56:21,280
right so

1549
00:56:23,990 --> 00:56:22,720
should we let jay answer that one first

1550
00:56:27,190 --> 00:56:24,000
and we'll get to your second question

1551
00:56:28,390 --> 00:56:27,200
should we vote on it no no i voted

1552
00:56:31,109 --> 00:56:28,400
okay

1553
00:56:32,950 --> 00:56:31,119
so yeah uh so that that's a great

1554
00:56:36,789 --> 00:56:32,960
question and people ask all the time

1555
00:56:38,870 --> 00:56:36,799
about things like uh oil extraction

1556
00:56:41,510 --> 00:56:38,880
and erosion

1557
00:56:44,309 --> 00:56:41,520
uh trees growing you know leafing out

1558
00:56:45,510 --> 00:56:44,319
and and losing the leaves uh uh in the

1559
00:56:48,470 --> 00:56:45,520
fall and

1560
00:56:49,430 --> 00:56:48,480
and uh the wildebeest migration

1561
00:56:51,430 --> 00:56:49,440
uh

1562
00:56:53,430 --> 00:56:51,440
and far and away the number one thing

1563
00:56:55,829 --> 00:56:53,440

that is changing that's affecting the

1564
00:56:57,349 --> 00:56:55,839
gravity field is the is the movement of

1565
00:56:59,109 --> 00:56:57,359
water so those things contribute but

1566
00:57:00,710 --> 00:56:59,119
it's those their second and third order

1567
00:57:02,069 --> 00:57:00,720
effects one thing that can be a big

1568
00:57:04,309 --> 00:57:02,079
effect and we have to correct for is

1569
00:57:05,349 --> 00:57:04,319
really huge earthquakes like the sumatra

1570
00:57:07,589 --> 00:57:05,359
earthquake

1571
00:57:09,829 --> 00:57:07,599
in 2004.

1572
00:57:11,589 --> 00:57:09,839
um and also from that same uh

1573
00:57:13,190 --> 00:57:11,599
presentation you were saying that you

1574
00:57:15,270 --> 00:57:13,200
were showing that the drought could be

1575
00:57:16,789 --> 00:57:15,280
charted going back further and further

1576
00:57:17,670 --> 00:57:16,799
periods and you were saying it seems to

1577
00:57:20,710 --> 00:57:17,680
start

1578
00:57:23,270 --> 00:57:20,720
uh or decreased since the the 1930s i

1579
00:57:25,670 --> 00:57:23,280
don't know have you been able to

1580
00:57:26,789 --> 00:57:25,680
disentangle how much that is a is an

1581
00:57:28,549 --> 00:57:26,799
issue of

1582
00:57:30,390 --> 00:57:28,559
human cause climate change how much of

1583
00:57:32,470 --> 00:57:30,400
that is an issue of increased human

1584
00:57:34,789 --> 00:57:32,480
usage of water and how much is

1585
00:57:36,950 --> 00:57:34,799
that natural variation so the the

1586
00:57:38,630 --> 00:57:36,960
reference to going back to 1930 was the

1587
00:57:40,950 --> 00:57:38,640
groundwater depletion in the in the

1588
00:57:42,309 --> 00:57:40,960

central valley and so the pattern that

1589
00:57:44,150 --> 00:57:42,319
that we see there is pretty much the

1590
00:57:46,630 --> 00:57:44,160
pattern that that i showed you and that

1591
00:57:49,910 --> 00:57:46,640
is uh you know we're using the water to

1592
00:57:51,349 --> 00:57:49,920
grow food and we use less of it in wet

1593
00:57:54,150 --> 00:57:51,359
periods because there's more surface

1594
00:57:55,990 --> 00:57:54,160
water uh available there may be a

1595
00:57:58,309 --> 00:57:56,000
climate change component to it over the

1596
00:58:00,549 --> 00:57:58,319
long term as we get less replenishment

1597
00:58:01,829 --> 00:58:00,559
of the aquifers but we haven't tried to

1598
00:58:03,030 --> 00:58:01,839
tease that out

1599
00:58:04,230 --> 00:58:03,040
i'm kind of interested to see whether

1600
00:58:06,549 --> 00:58:04,240
dwayne has any comments about

1601
00:58:08,470 --> 00:58:06,559
disentangling human induced climate

1602
00:58:09,670 --> 00:58:08,480
change factors i have a name for his

1603
00:58:11,670 --> 00:58:09,680
animation

1604
00:58:14,549 --> 00:58:11,680
i'd like to i'd like to call it the the

1605
00:58:17,510 --> 00:58:15,750
that's good

1606
00:58:18,789 --> 00:58:17,520
let's let's not pick on poor dwayne but

1607
00:58:20,230 --> 00:58:18,799
that's

1608
00:58:22,390 --> 00:58:20,240
it was a good animation so what do you

1609
00:58:24,069 --> 00:58:22,400
think about disentangling human induced

1610
00:58:25,589 --> 00:58:24,079
climate change it's a certainly a

1611
00:58:27,109 --> 00:58:25,599
subject of research right now but i

1612
00:58:29,589 --> 00:58:27,119
don't think that's been teased out to

1613
00:58:33,109 --> 00:58:29,599

where the uncertainty is smaller than

1614
00:58:38,630 --> 00:58:36,069
i have uh two questions

1615
00:58:41,510 --> 00:58:38,640
first of all is there any one feature

1616
00:58:44,549 --> 00:58:41,520
that stands out that prevents the spread

1617
00:58:47,270 --> 00:58:44,559
of groundwater whereby the groundwater

1618
00:58:50,230 --> 00:58:47,280
cannot be instilled properly

1619
00:58:51,910 --> 00:58:50,240
and secondly of all this is kind of off

1620
00:58:54,789 --> 00:58:51,920
the subject

1621
00:58:58,470 --> 00:58:54,799
in regard to jason iii

1622
00:58:59,750 --> 00:58:58,480
was there a momentum wheel put on jason

1623
00:59:01,030 --> 00:58:59,760
3

1624
00:59:02,150 --> 00:59:01,040
whereby

1625
00:59:03,349 --> 00:59:02,160
the

1626
00:59:05,109 --> 00:59:03,359
topox

1627
00:59:06,230 --> 00:59:05,119
poseidon

1628
00:59:08,309 --> 00:59:06,240
mission

1629
00:59:11,190 --> 00:59:08,319
uh had to be entered in the satellite

1630
00:59:13,670 --> 00:59:11,200
turned off due to the fact uh that the

1631
00:59:16,309 --> 00:59:13,680
wheel failed and so i just wondered if

1632
00:59:18,309 --> 00:59:16,319
there was a replacement part i i'm going

1633
00:59:20,950 --> 00:59:18,319
to take the second one just to say i

1634
00:59:24,390 --> 00:59:20,960
don't think any of us here are experts

1635
00:59:27,109 --> 00:59:24,400
in jason 3 or topex poseidon i'd be

1636
00:59:28,390 --> 00:59:27,119
happy later to give you an opinion but

1637
00:59:30,829 --> 00:59:28,400
it would have to be

1638
00:59:31,750 --> 00:59:30,839

thank you for the first question but are

1639
00:59:33,109 --> 00:59:31,760
you uh

1640
00:59:35,670 --> 00:59:33,119
do you work here or are you like a

1641
00:59:37,990 --> 00:59:35,680
satellite groupie

1642
00:59:39,829 --> 00:59:38,000
no i don't work here

1643
00:59:41,670 --> 00:59:39,839
so back to your first question which was

1644
00:59:44,390 --> 00:59:41,680
i think a geological question i'm going

1645
00:59:45,829 --> 00:59:44,400
to put that one over to tom foss sir

1646
00:59:48,470 --> 00:59:45,839
you're thinking about the lateral

1647
00:59:51,190 --> 00:59:48,480
transport of groundwater the lateral

1648
00:59:54,470 --> 00:59:51,200
transport of groundwater in effect is

1649
00:59:57,030 --> 00:59:54,480
there any one feature that prevents a

1650
00:59:58,150 --> 00:59:57,040
ground water from being distributed

1651
01:00:00,710 --> 00:59:58,160
properly

1652
01:00:02,950 --> 01:00:00,720
yeah it does move horizontally uh

1653
01:00:05,430 --> 01:00:02,960
through these these basins uh it's a

1654
01:00:08,069 --> 01:00:05,440
fairly long time constant it can be you

1655
01:00:10,870 --> 01:00:08,079
know it can take uh centuries to move an

1656
01:00:13,910 --> 01:00:10,880
appreciable distance so it depends

1657
01:00:15,750 --> 01:00:13,920
mainly on the geology uh so no in

1658
01:00:17,589 --> 01:00:15,760
general there's no barriers that you can

1659
01:00:19,750 --> 01:00:17,599
have faults like the newport inglewood

1660
01:00:21,270 --> 01:00:19,760
fault in la does

1661
01:00:22,630 --> 01:00:21,280
present a barrier

1662
01:00:25,510 --> 01:00:22,640
but in the central valley there aren't

1663
01:00:27,750 --> 01:00:25,520

too many barriers so the water can move

1664
01:00:29,430 --> 01:00:27,760
freely but it takes very long time for

1665
01:00:35,270 --> 01:00:29,440
it to migrate

1666
01:00:38,870 --> 01:00:37,430
you described four

1667
01:00:40,390 --> 01:00:38,880
interlocking

1668
01:00:42,230 --> 01:00:40,400
processes

1669
01:00:46,069 --> 01:00:42,240
what is in your opinion i know that you

1670
01:00:47,510 --> 01:00:46,079
don't have enough data it's only 10 12

1671
01:00:49,829 --> 01:00:47,520
15 years

1672
01:00:52,950 --> 01:00:49,839
the long-term effect of the climate

1673
01:00:54,549 --> 01:00:52,960
change let's say for 100 years or 200

1674
01:00:57,910 --> 01:00:54,559
years

1675
01:00:59,910 --> 01:00:57,920
on all these uh four processes

1676
01:01:01,510 --> 01:00:59,920
so i'm gonna let

1677
01:01:03,589 --> 01:01:01,520
i'm gonna let every one of you have a

1678
01:01:05,109 --> 01:01:03,599
chance to feel that wow starting with

1679
01:01:06,950 --> 01:01:05,119
dwayne

1680
01:01:08,470 --> 01:01:06,960
i'm sorry i need a rephrasing of the

1681
01:01:10,630 --> 01:01:08,480
question i'm not sure so what do you

1682
01:01:12,630 --> 01:01:10,640
think is the long-term

1683
01:01:14,950 --> 01:01:12,640
influence of human climate change over

1684
01:01:17,109 --> 01:01:14,960
the time scale of 100 to 200 years is

1685
01:01:18,470 --> 01:01:17,119
that fair on those four different

1686
01:01:21,270 --> 01:01:18,480
processes

1687
01:01:23,750 --> 01:01:21,280
that we kind of touched on in our

1688
01:01:25,829 --> 01:01:23,760

presentations so i think the current

1689
01:01:30,390 --> 01:01:25,839
research and climate projections that

1690
01:01:34,150 --> 01:01:32,230
indicate that there would be

1691
01:01:36,390 --> 01:01:34,160
less rainfall falling in kind of the

1692
01:01:38,150 --> 01:01:36,400
southern latitude latitudes around the

1693
01:01:40,549 --> 01:01:38,160
world to sort of

1694
01:01:42,390 --> 01:01:40,559
substance belt or high pressure regions

1695
01:01:43,750 --> 01:01:42,400
and there'd be more rainfall falling to

1696
01:01:45,670 --> 01:01:43,760
the north of that so we call it

1697
01:01:47,190 --> 01:01:45,680
something like the dry gets drier and

1698
01:01:48,870 --> 01:01:47,200
the wet gets wetter

1699
01:01:50,710 --> 01:01:48,880
and that's what the projections look

1700
01:01:52,470 --> 01:01:50,720
like the model projections going forward

1701
01:01:54,630 --> 01:01:52,480
and there's just a tiny bit of evidence

1702
01:01:56,230 --> 01:01:54,640
that that may be happening in fact

1703
01:01:57,589 --> 01:01:56,240
jay showed some things i guess earlier

1704
01:01:58,870 --> 01:01:57,599
today but not

1705
01:02:00,630 --> 01:01:58,880
not during this talk that showed

1706
01:02:02,309 --> 01:02:00,640
evidence we actually published a paper

1707
01:02:03,670 --> 01:02:02,319
on that on that topic that shows with

1708
01:02:06,390 --> 01:02:03,680
the grace data that we're seeing the

1709
01:02:08,950 --> 01:02:06,400
mid-latitude areas get drier and the

1710
01:02:10,789 --> 01:02:08,960
high latitude areas and the tropics get

1711
01:02:12,309 --> 01:02:10,799
are getting wetter just

1712
01:02:14,470 --> 01:02:12,319
in the short time frame of the grace

1713
01:02:17,349 --> 01:02:14,480

data is it climate change well you know

1714
01:02:19,589 --> 01:02:17,359
give us a few more decades of grace

1715
01:02:21,190 --> 01:02:19,599
satellites and and we may know but

1716
01:02:24,870 --> 01:02:21,200
certainly matches what the what the

1717
01:02:29,910 --> 01:02:28,150
so in terms of the the snowpack

1718
01:02:32,710 --> 01:02:29,920
the

1719
01:02:35,670 --> 01:02:32,720
as temperatures increase in particular

1720
01:02:38,069 --> 01:02:35,680
then the phase of the precipitation

1721
01:02:41,349 --> 01:02:38,079
so instead of falling as snow

1722
01:02:43,670 --> 01:02:41,359
more of that will fall as rain and

1723
01:02:46,710 --> 01:02:43,680
so in the western u.s about 80 percent

1724
01:02:49,829 --> 01:02:46,720
of the precipitation that falls onto the

1725
01:02:52,390 --> 01:02:49,839
land comes in the form of snow

1726
01:02:54,470 --> 01:02:52,400
about 20 percent of it comes as rain and

1727
01:02:55,910 --> 01:02:54,480
this was a point that that tomorrow

1728
01:02:57,990 --> 01:02:55,920
night's talk

1729
01:03:00,470 --> 01:02:58,000
is going to have more explicitly we need

1730
01:03:02,230 --> 01:03:00,480
to we need to say this but

1731
01:03:05,589 --> 01:03:02,240
if you look at the california department

1732
01:03:07,190 --> 01:03:05,599
of water resources report and others on

1733
01:03:11,270 --> 01:03:07,200
uh on

1734
01:03:13,589 --> 01:03:11,280
water supply components in the state

1735
01:03:14,630 --> 01:03:13,599
snowpack represents about 30 to 40

1736
01:03:17,349 --> 01:03:14,640
percent

1737
01:03:19,349 --> 01:03:17,359
and yet the precipitation

1738
01:03:21,109 --> 01:03:19,359

is about 80 percent

1739
01:03:23,510 --> 01:03:21,119
what gives well what gives is the

1740
01:03:25,270 --> 01:03:23,520
groundwater pumping all right so that

1741
01:03:26,150 --> 01:03:25,280
you can have those statements back to

1742
01:03:28,390 --> 01:03:26,160
back

1743
01:03:30,309 --> 01:03:28,400
is in fact non-sustainable all right

1744
01:03:33,670 --> 01:03:30,319
you're getting you're getting snowfall

1745
01:03:36,230 --> 01:03:33,680
in 80 to 20 rainfall and yet you're in

1746
01:03:38,630 --> 01:03:36,240
using all of that snowfall

1747
01:03:41,270 --> 01:03:38,640
you're using even more water that pushes

1748
01:03:43,270 --> 01:03:41,280
its proportion down all right so that

1749
01:03:45,109 --> 01:03:43,280
that's why we're going to continue to

1750
01:03:47,190 --> 01:03:45,119
drop plain and simple just the

1751
01:03:48,710 --> 01:03:47,200
mathematics now in terms of the snowpack

1752
01:03:51,190 --> 01:03:48,720
and what that does

1753
01:03:53,510 --> 01:03:51,200
in terms of our water supply

1754
01:03:56,150 --> 01:03:53,520
as the phase changes so as more of the

1755
01:03:59,109 --> 01:03:56,160
precipitation falls as rain

1756
01:04:01,109 --> 01:03:59,119
the human-built reservoirs that we have

1757
01:04:04,069 --> 01:04:01,119
up in the mountains are going to be

1758
01:04:06,470 --> 01:04:04,079
tasked with capturing more of that water

1759
01:04:09,829 --> 01:04:06,480
in the winter right not just in the

1760
01:04:11,589 --> 01:04:09,839
spring when it's melting and the staging

1761
01:04:13,670 --> 01:04:11,599
of that water

1762
01:04:15,589 --> 01:04:13,680
is an important part of our our water

1763
01:04:17,990 --> 01:04:15,599

infrastructure right now right now we

1764
01:04:20,150 --> 01:04:18,000
have the the implicit reservoirs of the

1765
01:04:23,109 --> 01:04:20,160
mountain snowpack and the human-built

1766
01:04:26,710 --> 01:04:23,119
reservoirs and so we have two reservoirs

1767
01:04:29,190 --> 01:04:26,720
uh but as more and more of this

1768
01:04:31,109 --> 01:04:29,200
falls as rain it runs downhill right

1769
01:04:33,109 --> 01:04:31,119
away snow doesn't run downhill except in

1770
01:04:35,270 --> 01:04:33,119
avalanches fortunately not all of our

1771
01:04:37,109 --> 01:04:35,280
water supply falls or slides as

1772
01:04:39,430 --> 01:04:37,119
avalanches

1773
01:04:41,029 --> 01:04:39,440
but that's going to mean that we

1774
01:04:43,190 --> 01:04:41,039
if we're going to keep the same water

1775
01:04:45,750 --> 01:04:43,200
supply some would argue that we need to

1776
01:04:47,190 --> 01:04:45,760
build more reservoir capacity right

1777
01:04:48,230 --> 01:04:47,200
others are going to say that's not going

1778
01:04:50,470 --> 01:04:48,240
to happen

1779
01:04:53,029 --> 01:04:50,480
and and it would likely be tangled up

1780
01:04:54,870 --> 01:04:53,039
massively in in litigation for a very

1781
01:04:57,109 --> 01:04:54,880
long time but what you're looking at is

1782
01:04:59,270 --> 01:04:57,119
spilling of water over reservoir if the

1783
01:05:00,950 --> 01:04:59,280
precipitation stays the same right if

1784
01:05:04,470 --> 01:05:00,960
there's no change then you're going to

1785
01:05:06,549 --> 01:05:04,480
see spilling of water over dams and

1786
01:05:08,789 --> 01:05:06,559
and running out into the ocean and

1787
01:05:11,029 --> 01:05:08,799
essentially shrinking that water supply

1788
01:05:14,230 --> 01:05:11,039

thanks tom i see a familiar face coming

1789
01:05:19,750 --> 01:05:16,789
i i have a just quick question in the

1790
01:05:21,990 --> 01:05:19,760
pictures you showed of the subsidence

1791
01:05:24,390 --> 01:05:22,000
why did the man-made features not drop

1792
01:05:28,150 --> 01:05:26,470
uh the uh

1793
01:05:30,230 --> 01:05:28,160
like the pipes and things like that

1794
01:05:31,910 --> 01:05:30,240
right yeah the things that didn't appear

1795
01:05:35,190 --> 01:05:31,920
to drop are things that are rooted way

1796
01:05:37,750 --> 01:05:35,200
down deep so like that gas pipeline that

1797
01:05:39,270 --> 01:05:37,760
was painted orange that that's actually

1798
01:05:41,510 --> 01:05:39,280
going down you know i don't know

1799
01:05:43,589 --> 01:05:41,520
hundreds of feet or a thousand feet so

1800
01:05:44,950 --> 01:05:43,599
it's below the area that's compacting so

1801
01:05:47,109 --> 01:05:44,960
it's compacting

1802
01:05:48,630 --> 01:05:47,119
around it basically so even the wells

1803
01:05:51,109 --> 01:05:48,640
that are

1804
01:05:52,309 --> 01:05:51,119
kilometers deep they uh

1805
01:05:53,910 --> 01:05:52,319
they

1806
01:05:55,750 --> 01:05:53,920
that's not showing that drop as well

1807
01:05:58,230 --> 01:05:55,760
then is what you're saying

1808
01:06:00,470 --> 01:05:58,240
so if if the well is deeper it's pulling

1809
01:06:02,950 --> 01:06:00,480
water from deeper than the

1810
01:06:05,190 --> 01:06:02,960
uh those features then that would drop

1811
01:06:06,309 --> 01:06:05,200
those features as well that's true yes

1812
01:06:08,950 --> 01:06:06,319
yes

1813
01:06:09,829 --> 01:06:08,960

thanks sure

1814
01:06:12,230 --> 01:06:09,839
uh

1815
01:06:14,870 --> 01:06:12,240
hi i just wanted to say thank you it was

1816
01:06:16,069 --> 01:06:14,880
a really interesting

1817
01:06:17,510 --> 01:06:16,079
lecture

1818
01:06:19,270 --> 01:06:17,520
i was wondering i know you just

1819
01:06:20,630 --> 01:06:19,280
mentioned um

1820
01:06:23,430 --> 01:06:20,640
that uh

1821
01:06:25,750 --> 01:06:23,440
i guess a viable solution would be to

1822
01:06:26,710 --> 01:06:25,760
build more reservoirs to capture

1823
01:06:28,710 --> 01:06:26,720
um

1824
01:06:30,950 --> 01:06:28,720
like running

1825
01:06:33,270 --> 01:06:30,960
melting snowpack and stuff like that but

1826
01:06:35,589 --> 01:06:33,280
um what other viable solutions would

1827
01:06:37,910 --> 01:06:35,599
there be if the drought continues and we

1828
01:06:38,710 --> 01:06:37,920
continue to pull groundwater out and

1829
01:06:39,430 --> 01:06:38,720
yeah

1830
01:06:41,109 --> 01:06:39,440
so

1831
01:06:43,109 --> 01:06:41,119
we're as this is meant to be a

1832
01:06:44,789 --> 01:06:43,119
scientific panel yeah i'm going to give

1833
01:06:45,750 --> 01:06:44,799
them a get out there's some opinions i'm

1834
01:06:47,990 --> 01:06:45,760
sure

1835
01:06:50,309 --> 01:06:48,000
at least one of every the four of us

1836
01:06:51,510 --> 01:06:50,319
five of us up here could give you but

1837
01:06:53,029 --> 01:06:51,520
um

1838
01:06:57,510 --> 01:06:53,039

go ahead

1839
01:07:01,349 --> 01:06:57,520
think uh a non-controversial thing is to

1840
01:07:04,190 --> 01:07:01,359
just use use less uh so just be you know

1841
01:07:05,990 --> 01:07:04,200
conservation and efficiency are easy and

1842
01:07:07,109 --> 01:07:06,000
non-controversial and

1843
01:07:09,029 --> 01:07:07,119
and cheap

1844
01:07:11,910 --> 01:07:09,039
right and so if we do as much as we can

1845
01:07:13,510 --> 01:07:11,920
there especially in agriculture

1846
01:07:15,029 --> 01:07:13,520
we can have a tremendous amount of

1847
01:07:17,029 --> 01:07:15,039
savings in it

1848
01:07:19,510 --> 01:07:17,039
you know i don't think it would be

1849
01:07:21,670 --> 01:07:19,520
it wouldn't cost billions of dollars and

1850
01:07:24,549 --> 01:07:21,680
that's a big that's a big push by all of

1851
01:07:25,829 --> 01:07:24,559
the uh the water handling entities

1852
01:07:27,910 --> 01:07:25,839
so

1853
01:07:30,390 --> 01:07:27,920
another thing is uh what's called

1854
01:07:33,430 --> 01:07:30,400
managed aquifer recharge

1855
01:07:35,670 --> 01:07:33,440
that's essentially another reservoir

1856
01:07:37,670 --> 01:07:35,680
treating groundwater as a reservoir and

1857
01:07:39,670 --> 01:07:37,680
you can artificially get the water down

1858
01:07:41,190 --> 01:07:39,680
into the ground it's not as efficient as

1859
01:07:43,829 --> 01:07:41,200
other things but once you get it into

1860
01:07:45,270 --> 01:07:43,839
the ground it's less subject to

1861
01:07:47,270 --> 01:07:45,280
evaporation

1862
01:07:48,789 --> 01:07:47,280
so that that's really

1863
01:07:50,710 --> 01:07:48,799

getting a lot of attention right now and

1864
01:07:53,109 --> 01:07:50,720
we're looking at that with our radar

1865
01:07:55,270 --> 01:07:53,119
techniques as well so just to say that

1866
01:07:57,190 --> 01:07:55,280
in southern california i think uh any

1867
01:07:59,270 --> 01:07:57,200
meeting you go to which involves people

1868
01:08:01,589 --> 01:07:59,280
involved in water resource management

1869
01:08:03,750 --> 01:08:01,599
the theme is sustainability and what

1870
01:08:06,150 --> 01:08:03,760
they need to do to encourage

1871
01:08:09,589 --> 01:08:06,160
efficiency in savings how they make

1872
01:08:11,190 --> 01:08:09,599
better use of water storage in

1873
01:08:13,109 --> 01:08:11,200
all those kinds of things that's where

1874
01:08:15,430 --> 01:08:13,119
they're going to try and get the first

1875
01:08:17,430 --> 01:08:15,440
savings so within cities there's there's

1876
01:08:19,269 --> 01:08:17,440
no doubt that the manage recharge the

1877
01:08:22,470 --> 01:08:19,279
sewage recycling right we do it in my

1878
01:08:24,390 --> 01:08:22,480
home is in uh is in orange county and we

1879
01:08:25,669 --> 01:08:24,400
have a world-class sewage recycling

1880
01:08:27,030 --> 01:08:25,679
facility

1881
01:08:28,789 --> 01:08:27,040
there it's called the groundwater

1882
01:08:31,349 --> 01:08:28,799
groundwater replenishment system and

1883
01:08:32,709 --> 01:08:31,359
it's great and if you look around

1884
01:08:33,910 --> 01:08:32,719
orange county

1885
01:08:36,630 --> 01:08:33,920
you know it's

1886
01:08:38,470 --> 01:08:36,640
it's been able to stay relatively lush

1887
01:08:40,630 --> 01:08:38,480
compared to the rest of the state

1888
01:08:41,910 --> 01:08:40,640

because of the because of the management

1889
01:08:44,470 --> 01:08:41,920
okay

1890
01:08:46,550 --> 01:08:44,480
but there is real quick so

1891
01:08:47,990 --> 01:08:46,560
we didn't say desalination right yeah

1892
01:08:50,550 --> 01:08:48,000
that's d cells

1893
01:08:52,950 --> 01:08:50,560
desal is a big deal uh there are some

1894
01:08:56,229 --> 01:08:52,960
who who want to run an aqueduct from the

1895
01:08:57,669 --> 01:08:56,239
columbia river down here um

1896
01:09:01,189 --> 01:08:57,679
and there are others who want to drag

1897
01:09:03,749 --> 01:09:01,199
icebergs uh down here and i mean these

1898
01:09:19,030 --> 01:09:03,759
are all these are all serious uh

1899
01:09:24,709 --> 01:09:22,550
oh thank you hi um so like in a whole

1900
01:09:28,709 --> 01:09:24,719
presentation you guys are talking about

1901
01:09:30,390 --> 01:09:28,719
the climate in usa or and and california

1902
01:09:32,550 --> 01:09:30,400
but we're like

1903
01:09:34,789 --> 01:09:32,560
what about like the different region and

1904
01:09:38,550 --> 01:09:34,799
other place like maybe in europe where

1905
01:09:41,189 --> 01:09:38,560
they're like um or the climate of a usa

1906
01:09:42,630 --> 01:09:41,199
might affect the climate in like europe

1907
01:09:44,709 --> 01:09:42,640
or asia

1908
01:09:46,789 --> 01:09:44,719
yeah so it's a pretty big question we we

1909
01:09:48,789 --> 01:09:46,799
chose tonight to focus on california

1910
01:09:50,789 --> 01:09:48,799
because we thought that as californians

1911
01:09:53,349 --> 01:09:50,799
we'd be interested in what's happening

1912
01:09:54,229 --> 01:09:53,359
to our own local water supply

1913
01:09:55,430 --> 01:09:54,239

um

1914
01:09:57,510 --> 01:09:55,440
is there a quick answer to that

1915
01:09:59,590 --> 01:09:57,520
gentleman so i i can just give a quick

1916
01:10:01,189 --> 01:09:59,600
answer on uh groundwater depletion and

1917
01:10:02,630 --> 01:10:01,199
the stuff that i showed for california

1918
01:10:05,189 --> 01:10:02,640
is happening all over the world is

1919
01:10:07,990 --> 01:10:05,199
happening uh you know some of the uh

1920
01:10:09,910 --> 01:10:08,000
most rapidly depleting aquifers are in

1921
01:10:11,830 --> 01:10:09,920
india and in the middle east and in the

1922
01:10:14,070 --> 01:10:11,840
north china plain and in australia and

1923
01:10:17,110 --> 01:10:14,080
in south america so it's happening

1924
01:10:18,870 --> 01:10:17,120
on on every on every continent

1925
01:10:20,310 --> 01:10:18,880
i think it's a very good question the

1926
01:10:21,830 --> 01:10:20,320
the answers are probably a little bigger

1927
01:10:24,550 --> 01:10:21,840
than we've even got time to begin to

1928
01:10:27,270 --> 01:10:24,560
address every region is under different

1929
01:10:30,149 --> 01:10:27,280
kinds of regimes of stress from changes

1930
01:10:32,390 --> 01:10:30,159
in patterns of climate and weather but a

1931
01:10:33,990 --> 01:10:32,400
very good question thank you

1932
01:10:38,229 --> 01:10:34,000
i think we have one or two questions

1933
01:10:41,110 --> 01:10:39,189
so

1934
01:10:43,669 --> 01:10:41,120
matheny asks

1935
01:10:46,870 --> 01:10:43,679
what would be the most practical way

1936
01:10:49,189 --> 01:10:46,880
to emulate nasa's grace technology in

1937
01:10:53,750 --> 01:10:49,199
other parts of the world to gauge the

1938
01:10:57,189 --> 01:10:55,830

so the grace mission is actually a

1939
01:10:59,750 --> 01:10:57,199
global mission

1940
01:11:01,590 --> 01:10:59,760
uh so it sort of follows on that last

1941
01:11:02,790 --> 01:11:01,600
question is that we although we only

1942
01:11:05,270 --> 01:11:02,800
talked about

1943
01:11:06,870 --> 01:11:05,280
california here tonight

1944
01:11:08,229 --> 01:11:06,880
we do have a pretty compelling picture

1945
01:11:09,830 --> 01:11:08,239
of what's happening you know what we

1946
01:11:12,790 --> 01:11:09,840
what we saw in california serve a

1947
01:11:14,470 --> 01:11:12,800
microcosm for for what's happening all

1948
01:11:17,110 --> 01:11:14,480
over the world and it does allow us to

1949
01:11:19,990 --> 01:11:17,120
see uh some of the patterns that dwayne

1950
01:11:21,910 --> 01:11:20,000
had uh he had a u.s map that had you

1951
01:11:23,830 --> 01:11:21,920
know impacts of el nino wetter here

1952
01:11:25,830 --> 01:11:23,840
dryer there we can kind of see some of

1953
01:11:27,669 --> 01:11:25,840
that with with grace because it is a

1954
01:11:30,310 --> 01:11:27,679
global mission if you guys want the full

1955
01:11:33,270 --> 01:11:30,320
talk we can have a von carmen sleepover

1956
01:11:34,709 --> 01:11:33,280
we'll just go all night long

1957
01:11:37,990 --> 01:11:34,719
just let me go and get a couple of beers

1958
01:11:42,550 --> 01:11:40,790
well i could say that the the the radar

1959
01:11:44,229 --> 01:11:42,560
techniques are also global that we're

1960
01:11:46,630 --> 01:11:44,239
using satellites and

1961
01:11:48,229 --> 01:11:46,640
uh particularly the european one right

1962
01:11:50,229 --> 01:11:48,239
now is collecting data virtually

1963
01:11:53,270 --> 01:11:50,239

everywhere in the world and nasa has a

1964
01:11:55,189 --> 01:11:53,280
mission that will fly in about 2021 uh

1965
01:11:57,189 --> 01:11:55,199
that will will continue those kinds of

1966
01:11:58,550 --> 01:11:57,199
measurements so we'll have a continuous

1967
01:12:00,709 --> 01:11:58,560
time series of these kinds of

1968
01:12:03,430 --> 01:12:00,719
measurements uh basically globally so

1969
01:12:04,950 --> 01:12:03,440
we'll be looking at many alluvial basins

1970
01:12:07,270 --> 01:12:04,960
around the world

1971
01:12:08,470 --> 01:12:07,280
okay so the the next couple of questions

1972
01:12:11,910 --> 01:12:08,480
from online

1973
01:12:14,630 --> 01:12:11,920
are not necessarily scientific so you

1974
01:12:17,590 --> 01:12:14,640
can express your opinions at this point

1975
01:12:19,669 --> 01:12:17,600
dino asks are there any programs in

1976
01:12:24,790 --> 01:12:19,679
place starting to try to preserve as

1977
01:12:26,149 --> 01:12:24,800
much groundwater and snowpack as we can

1978
01:12:29,189 --> 01:12:26,159
start with groundwater no we'll start

1979
01:12:31,110 --> 01:12:29,199
with snow it's on top all right so

1980
01:12:33,750 --> 01:12:31,120
over to you tom that's right

1981
01:12:34,790 --> 01:12:33,760
so um so preserving snowpack one of the

1982
01:12:36,870 --> 01:12:34,800
one of the ways that we preserve

1983
01:12:38,870 --> 01:12:36,880
snowpack is by not changing the phase of

1984
01:12:41,669 --> 01:12:38,880
precipitation

1985
01:12:43,590 --> 01:12:41,679
and so so not warming with all of its

1986
01:12:46,070 --> 01:12:43,600
other implications

1987
01:12:47,270 --> 01:12:46,080
the other is that in in many parts of

1988
01:12:50,709 --> 01:12:47,280

the world

1989
01:12:53,510 --> 01:12:50,719
there is deposition from desertification

1990
01:12:55,430 --> 01:12:53,520
from disturbed lands of dust

1991
01:12:57,270 --> 01:12:55,440
on the snowpack which absorbs sunlight

1992
01:12:59,669 --> 01:12:57,280
and causes the snowpack to melt away

1993
01:13:01,350 --> 01:12:59,679
much faster and

1994
01:13:04,709 --> 01:13:01,360
and in many of those regions it also

1995
01:13:07,669 --> 01:13:04,719
causes us to get less total runoff

1996
01:13:10,149 --> 01:13:07,679
out the out the rivers so

1997
01:13:11,669 --> 01:13:10,159
in the colorado river basin the the

1998
01:13:14,310 --> 01:13:11,679
bureau of reclamation and the bureau of

1999
01:13:15,510 --> 01:13:14,320
land management are considering reducing

2000
01:13:17,430 --> 01:13:15,520
dust

2001
01:13:19,990 --> 01:13:17,440
emission from deserts

2002
01:13:21,110 --> 01:13:20,000
as a way to reclaim water to supplement

2003
01:13:22,470 --> 01:13:21,120
the amount of water that's coming the

2004
01:13:24,149 --> 01:13:22,480
colorado river

2005
01:13:26,630 --> 01:13:24,159
in the alps

2006
01:13:30,630 --> 01:13:26,640
they're draping

2007
01:13:33,030 --> 01:13:30,640
sheets to essentially reduce the amount

2008
01:13:35,510 --> 01:13:33,040
of absorbed sunlight on those glaciers

2009
01:13:37,750 --> 01:13:35,520
and to cause those to to stay up in the

2010
01:13:39,590 --> 01:13:37,760
mountains so that we have that much

2011
01:13:40,709 --> 01:13:39,600
longer so

2012
01:13:42,229 --> 01:13:40,719
it's one of the things that the world

2013
01:13:44,709 --> 01:13:42,239

bank has been working with various

2014
01:13:47,270 --> 01:13:44,719
scientists that i'm interacting with

2015
01:13:50,229 --> 01:13:47,280
to to pursue is a reduction in

2016
01:13:52,709 --> 01:13:50,239
particulate load um so that we can

2017
01:13:53,910 --> 01:13:52,719
particulate being dust and black carbon

2018
01:13:56,470 --> 01:13:53,920
um

2019
01:13:59,110 --> 01:13:56,480
to uh to preserve that snowpack not only

2020
01:14:02,149 --> 01:13:59,120
within the year but also over the longer

2021
01:14:03,430 --> 01:14:02,159
haul and keep those glaciers longer so

2022
01:14:05,830 --> 01:14:03,440
we asked a scientist a question and we

2023
01:14:07,189 --> 01:14:05,840
got a scientific answer you bet

2024
01:14:08,790 --> 01:14:07,199
actually i think the just to make a

2025
01:14:09,750 --> 01:14:08,800
comment to learn from a middle school

2026
01:14:11,590 --> 01:14:09,760
teacher

2027
01:14:13,590 --> 01:14:11,600
a few years ago she was very passionate

2028
01:14:15,350 --> 01:14:13,600
about preserving beaches and keeping

2029
01:14:17,189 --> 01:14:15,360
them clean and one of the things she

2030
01:14:19,030 --> 01:14:17,199
said is you can make small steps that's

2031
01:14:21,110 --> 01:14:19,040
the most important thing you can do and

2032
01:14:23,030 --> 01:14:21,120
i think as individuals you can make one

2033
01:14:25,590 --> 01:14:23,040
small step in using less water

2034
01:14:27,350 --> 01:14:25,600
personally it all adds up

2035
01:14:29,110 --> 01:14:27,360
so just want to follow up on that mike

2036
01:14:30,149 --> 01:14:29,120
because uh it can be pretty daunting

2037
01:14:31,750 --> 01:14:30,159
right when you put all the stuff that

2038
01:14:33,510 --> 01:14:31,760

you saw together and then you think

2039
01:14:35,110 --> 01:14:33,520
about the global picture you know you

2040
01:14:37,430 --> 01:14:35,120
might literally want to stick your head

2041
01:14:39,510 --> 01:14:37,440
in one of uh you know the big sinkholes

2042
01:14:41,030 --> 01:14:39,520
that tom was showing us

2043
01:14:42,790 --> 01:14:41,040
and so it's important to not get

2044
01:14:44,310 --> 01:14:42,800
overwhelmed and right i mean do a little

2045
01:14:46,229 --> 01:14:44,320
bit that you can cut back on your

2046
01:14:47,590 --> 01:14:46,239
watering of your yard i mean that's just

2047
01:14:52,310 --> 01:14:47,600
a small change

2048
01:14:55,430 --> 01:14:52,320
so

2049
01:14:58,070 --> 01:14:55,440
here's one more from online daniel asks

2050
01:15:01,430 --> 01:14:58,080
would california look into atmospheric

2051
01:15:03,110 --> 01:15:01,440
farming to help meet water needs and i

2052
01:15:04,630 --> 01:15:03,120
don't know whether that means seed cloud

2053
01:15:06,790 --> 01:15:04,640
seeding et cetera

2054
01:15:08,870 --> 01:15:06,800
i think it means uh vapor harvesting

2055
01:15:11,750 --> 01:15:08,880
that's about that okay

2056
01:15:13,430 --> 01:15:11,760
if you think you you can speak

2057
01:15:15,510 --> 01:15:13,440
well i mean my interpretation was

2058
01:15:17,350 --> 01:15:15,520
capturing water vapor maybe coming off

2059
01:15:19,590 --> 01:15:17,360
the ocean surface and making it condense

2060
01:15:22,550 --> 01:15:19,600
onto something and then capturing it but

2061
01:15:24,229 --> 01:15:22,560
i have never heard a tangible or real

2062
01:15:25,750 --> 01:15:24,239
conversation

2063
01:15:27,430 --> 01:15:25,760

from the state

2064
01:15:29,110 --> 01:15:27,440
suggesting that that's uh something

2065
01:15:31,030 --> 01:15:29,120
they're seriously considerate

2066
01:15:32,310 --> 01:15:31,040
as as you guys referred to but that

2067
01:15:34,149 --> 01:15:32,320
doesn't mean it's not happening or

2068
01:15:36,149 --> 01:15:34,159
doesn't exist you know it does happen

2069
01:15:38,870 --> 01:15:36,159
and it's a fairly uh so it's actually a

2070
01:15:40,950 --> 01:15:38,880
fairly primitive technique right but if

2071
01:15:42,229 --> 01:15:40,960
we had a lot of water vapor

2072
01:15:44,229 --> 01:15:42,239
uh

2073
01:15:45,669 --> 01:15:44,239
you know then we'd be having rain right

2074
01:15:47,030 --> 01:15:45,679
and so there's not a lot of water vapor

2075
01:15:49,669 --> 01:15:47,040
because of the dry climate there's not a

2076
01:15:51,590 --> 01:15:49,679
lot of water vapor so it's not really

2077
01:15:53,990 --> 01:15:51,600
going to yield that much that being said

2078
01:15:54,870 --> 01:15:54,000
i think that if you're like stranded at

2079
01:15:57,110 --> 01:15:54,880
sea

2080
01:15:59,270 --> 01:15:57,120
uh and you have no fresh water you might

2081
01:16:02,070 --> 01:15:59,280
want to think about right setting up

2082
01:16:05,030 --> 01:16:02,080
some kind of condensation system

2083
01:16:07,910 --> 01:16:05,040
so with that uh

2084
01:16:10,870 --> 01:16:07,920
stop laughing amy so with that

2085
01:16:11,990 --> 01:16:10,880
i'd like to thank our speakers and if