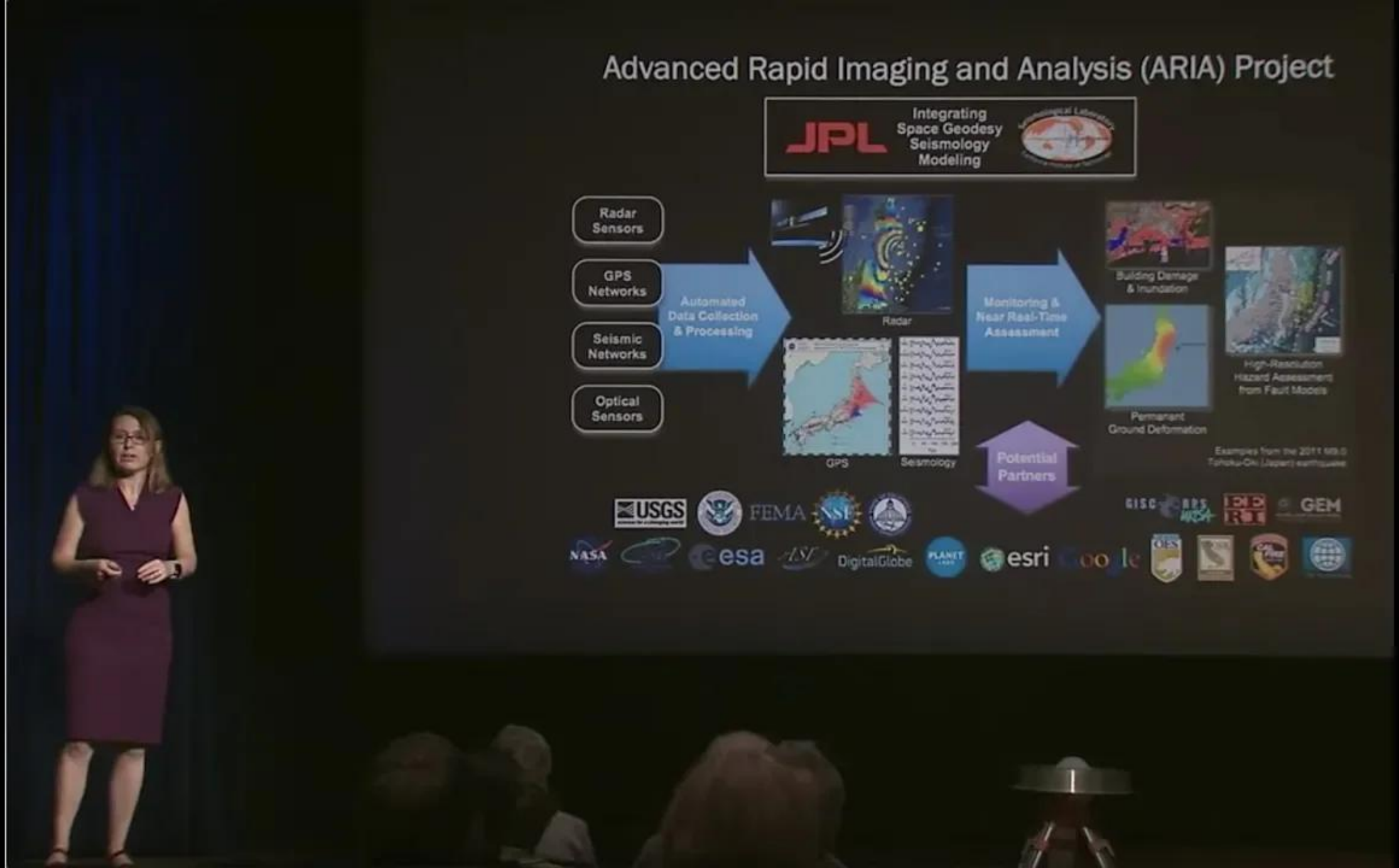
Advanced Rapid Imaging and Analysis (ARIA) Project
JPL
Integrating
Space Geodesy
Seismology
Modeling
Radar Sensors
GPS Networks
Seismic Networks
Optical Sensors
Automated Data Collection & Processing
Radar
GPS
Seismology
Monitoring & Near Real-Time Assessment
Building Damage & Inundation
Permanent Ground Deformation
High-Resolution Hazard Assessment from Fault Models
Potential Partners
USGS
FEMA
NSF
NASA
esa
ASI
DigitalGlobe
PLANET
esri
Google
GEM

1
00:00:00,000 --> 00:00:03,640
[Music]

2
00:00:10,129 --> 00:00:06,289
good evening ladies and gents how we all

3
00:00:12,789 --> 00:00:10,139
doing tonight backwards well thank you

4
00:00:15,289 --> 00:00:12,799
all as always for coming out to join us

5
00:00:17,180 --> 00:00:15,299
space-based measurement techniques have

6
00:00:19,490 --> 00:00:17,190
recently become critical additions to

7
00:00:21,550 --> 00:00:19,500
our toolset for understanding and

8
00:00:26,359 --> 00:00:21,560
mapping the damage caused by earthquakes

9
00:00:28,029 --> 00:00:26,369
volcanic eruptions landslides and yes

10
00:00:30,470 --> 00:00:28,039
and last night's hurricanes and floods

11
00:00:32,630 --> 00:00:30,480
for example the ability to see through

12
00:00:34,459 --> 00:00:32,640
clouds to image changes on the ground to

13
00:00:36,139 --> 00:00:34,469

provided valuable data for FEMA's

14
00:00:36,770 --> 00:00:36,149
response to last year's hurricanes

15
00:00:39,709 --> 00:00:36,780
Harvey

16
00:00:41,630 --> 00:00:39,719
Irma and Maria the advanced rapid

17
00:00:44,660 --> 00:00:41,640
imaging and analysis project a joint

18
00:00:46,910 --> 00:00:44,670
Caltech JPL venture is focused on

19
00:00:49,729 --> 00:00:46,920
rapidly generating higher-level near

20
00:00:51,529 --> 00:00:49,739
real-time imaging products and placing

21
00:00:54,369 --> 00:00:51,539
them in the hands of the various natural

22
00:00:56,689 --> 00:00:54,379
hazard communities to help improve

23
00:00:59,660 --> 00:00:56,699
situational awareness for disaster

24
00:01:02,389 --> 00:00:59,670
response tonight's guest is a JPL

25
00:01:04,759 --> 00:01:02,399
principal section manager discipline

26
00:01:06,560 --> 00:01:04,769
program manager and the project lead for

27
00:01:09,140 --> 00:01:06,570
the advanced rapid imaging and analysis

28
00:01:11,780 --> 00:01:09,150
project she's also currently serving as

29
00:01:13,880 --> 00:01:11,790
president of the AG ug Odyssey section

30
00:01:17,749 --> 00:01:13,890
as she was previously board chair of

31
00:01:19,550 --> 00:01:17,759
Univ Co through 2011 and 2012 her

32
00:01:22,280 --> 00:01:19,560
science interests include geodetic

33
00:01:25,219 --> 00:01:22,290
imaging of solid earth processes and

34
00:01:27,170 --> 00:01:25,229
natural hazards in particular GPS data

35
00:01:28,999 --> 00:01:27,180
analysis techniques for improving

36
00:01:32,090 --> 00:01:29,009
understanding of earthquake and volcanic

37
00:01:34,999 --> 00:01:32,100
processes her personal interests include

38
00:01:38,120 --> 00:01:35,009

running to the extent that once she

39
00:01:41,539 --> 00:01:38,130
competed in and completed a 100-mile

40
00:01:44,300 --> 00:01:41,549
ultramarathon back in 2015 it took

41
00:01:46,480 --> 00:01:44,310
forever but she finished which is far

42
00:01:48,980 --> 00:01:46,490
more than what I ever would have done so

43
00:01:58,570 --> 00:01:48,990
so ladies and gents please help me

44
00:02:02,030 --> 00:02:00,050
hello

45
00:02:05,030 --> 00:02:02,040
thank you all for coming thank you for

46
00:02:07,160 --> 00:02:05,040
inviting me to be here I'm really

47
00:02:08,810 --> 00:02:07,170
excited to talk to you tonight about a

48
00:02:14,180 --> 00:02:08,820
project that we've been working on for

49
00:02:18,080 --> 00:02:14,190
about eight years or so so this project

50
00:02:20,300 --> 00:02:18,090
has been to take data that we've been

51
00:02:24,140 --> 00:02:20,310
using to study natural hazards and apply

52
00:02:26,540 --> 00:02:24,150
it to disaster response and sorry I

53
00:02:31,520 --> 00:02:26,550
should have tested this out there there

54
00:02:34,160 --> 00:02:31,530
got it so there's a difference between a

55
00:02:36,170 --> 00:02:34,170
natural hazard and a disaster and this

56
00:02:38,180 --> 00:02:36,180
quote is one way to think about the

57
00:02:40,400 --> 00:02:38,190
difference another way to think about

58
00:02:42,470 --> 00:02:40,410
the difference is if a big earthquake

59
00:02:45,050 --> 00:02:42,480
happen in the middle of the woods and

60
00:02:46,820 --> 00:02:45,060
there wasn't any buildings around to

61
00:02:49,910 --> 00:02:46,830
collapse or any people around to be

62
00:02:52,250 --> 00:02:49,920
injured would anybody really care well

63
00:02:54,650 --> 00:02:52,260

if you're a scientist like me the answer

64
00:02:55,880 --> 00:02:54,660
is yes yes you care very much and you're

65
00:02:57,680 --> 00:02:55,890
really interested in studying the

66
00:02:59,810 --> 00:02:57,690
earthquake but if you're the fire

67
00:03:02,210 --> 00:02:59,820
department if you're FEMA if you're the

68
00:03:03,560 --> 00:03:02,220
news media you probably don't care all

69
00:03:06,650 --> 00:03:03,570
that much and it probably you know

70
00:03:08,540 --> 00:03:06,660
doesn't really get on your radar so

71
00:03:11,270 --> 00:03:08,550
another example of a difference between

72
00:03:13,430 --> 00:03:11,280
a hazard and a disaster is from the

73
00:03:15,830 --> 00:03:13,440
recent event hurricane Florence

74
00:03:18,770 --> 00:03:15,840
so when Hurricane Florence is over the

75
00:03:21,110 --> 00:03:18,780
ocean for the most people it's big and

76
00:03:23,540 --> 00:03:21,120
it's scary and it's massive it's a

77
00:03:25,970 --> 00:03:23,550
hazard but it doesn't become a disaster

78
00:03:28,220 --> 00:03:25,980
until it intersects with where people

79
00:03:32,120 --> 00:03:28,230
live causing flooding causing a lot of

80
00:03:34,880 --> 00:03:32,130
building damage so when a disaster

81
00:03:36,440 --> 00:03:34,890
happens it's really important to get

82
00:03:40,070 --> 00:03:36,450
information and there's different types

83
00:03:42,800 --> 00:03:40,080
of information that we want in order to

84
00:03:44,900 --> 00:03:42,810
improve our disaster response the first

85
00:03:47,180 --> 00:03:44,910
thing that we want is a really good

86
00:03:49,160 --> 00:03:47,190
forecast so these are two examples of

87
00:03:51,979 --> 00:03:49,170
two different types of forecasts there's

88
00:03:53,930 --> 00:03:51,989

forecasts for rain that helps us predict

89
00:03:55,520 --> 00:03:53,940
where the where the really bad flooding

90
00:03:58,190 --> 00:03:55,530
is going to be where people need to

91
00:04:00,110 --> 00:03:58,200
evacuate and then there's forecasts for

92
00:04:02,740 --> 00:04:00,120
earthquakes which are forecasts that

93
00:04:05,540 --> 00:04:02,750
occur on a much different time scale

94
00:04:08,420 --> 00:04:05,550
rainfall forecast we get days and

95
00:04:11,120 --> 00:04:08,430
and gets updated frequently earthquake

96
00:04:13,100 --> 00:04:11,130
forecasts we're looking at predicting

97
00:04:15,710 --> 00:04:13,110
the probability of a significant

98
00:04:17,960 --> 00:04:15,720
earthquake over the next 30 years it's

99
00:04:19,850 --> 00:04:17,970
still useful for planning if you're in

100
00:04:21,740 --> 00:04:19,860
one of the blue areas on this map over

101
00:04:23,690 --> 00:04:21,750
here you don't really have to worry too

102
00:04:28,700 --> 00:04:23,700
much about earthquakes but if you live

103
00:04:32,180 --> 00:04:28,710
here in Pasadena you do and so we know

104
00:04:33,740 --> 00:04:32,190
that through forecasts like this user

105
00:04:37,280 --> 00:04:33,750
forecasts that have been put together by

106
00:04:39,680 --> 00:04:37,290
scientists another type of information

107
00:04:42,230 --> 00:04:39,690
that we get that helps us improve our

108
00:04:45,770 --> 00:04:42,240
ability to respond to disasters is data

109
00:04:48,200 --> 00:04:45,780
that we collect during the event so how

110
00:04:50,570 --> 00:04:48,210
the streams are rising after the

111
00:04:53,570 --> 00:04:50,580
rainfall has started in response to

112
00:04:56,330 --> 00:04:53,580
Hurricane Florence or there's buoys that

113
00:04:58,340 --> 00:04:56,340

people put out into the ocean to try and

114
00:05:00,440 --> 00:04:58,350
measure tsunamis so after the earthquake

115
00:05:02,900 --> 00:05:00,450
has happened and the tsunami has started

116
00:05:05,000 --> 00:05:02,910
these buoys can measure the wave height

117
00:05:06,950 --> 00:05:05,010
of the tsunami and warn people on the

118
00:05:09,160 --> 00:05:06,960
coast about exactly how large it's going

119
00:05:12,350 --> 00:05:09,170
to be but the event has already started

120
00:05:14,480 --> 00:05:12,360
then on the far right there there's an

121
00:05:16,160 --> 00:05:14,490
image of Kilauea Volcano and those

122
00:05:19,160 --> 00:05:16,170
little dots are earthquakes earthquakes

123
00:05:21,560 --> 00:05:19,170
are another way of us understanding a

124
00:05:23,900 --> 00:05:21,570
volcanic eruption wallets in process and

125
00:05:26,020 --> 00:05:23,910
also an earthquake sequence while it's

126
00:05:28,460 --> 00:05:26,030
starting so seismic data is another

127
00:05:30,740 --> 00:05:28,470
important data set that we can measure

128
00:05:34,670 --> 00:05:30,750
in order to understand a hazard or

129
00:05:37,490 --> 00:05:34,680
disaster as it's happening and then

130
00:05:41,120 --> 00:05:37,500
there is the information that tells us

131
00:05:44,240 --> 00:05:41,130
how has this hazard actually impacted

132
00:05:45,800 --> 00:05:44,250
people so where is the damage where is

133
00:05:48,409 --> 00:05:45,810
the infrastructure down where are the

134
00:05:51,350 --> 00:05:48,419
bridges out so following a lot of

135
00:05:53,570 --> 00:05:51,360
disasters it's pretty common for police

136
00:05:55,370 --> 00:05:53,580
fire departments to go out and do what's

137
00:05:57,170 --> 00:05:55,380
called a windshield survey so they'll

138
00:05:59,030 --> 00:05:57,180

drive around and trying to get an

139
00:06:01,070 --> 00:05:59,040
assessment of you know where the

140
00:06:03,560 --> 00:06:01,080
buildings damaged where is the flooding

141
00:06:06,170 --> 00:06:03,570
what roads are operational things like

142
00:06:08,630 --> 00:06:06,180
that and it's really important to

143
00:06:11,270 --> 00:06:08,640
understand in the you know after an

144
00:06:14,780 --> 00:06:11,280
earthquake or after a storm

145
00:06:17,719 --> 00:06:14,790
what infrastructure is still in place so

146
00:06:18,589 --> 00:06:17,729
this figure here of the bridge collapse

147
00:06:21,260 --> 00:06:18,599
from the

148
00:06:23,239 --> 00:06:21,270
Loma Prieta earthquake in 1989 is an

149
00:06:25,129 --> 00:06:23,249
example of where you know there's

150
00:06:27,529 --> 00:06:25,139
transportation infrastructure that's

151
00:06:29,659 --> 00:06:27,539
down and understanding the statuses

152
00:06:31,010 --> 00:06:29,669
transportation infrastructure is really

153
00:06:33,049 --> 00:06:31,020
important because in order to get

154
00:06:35,540 --> 00:06:33,059
resources into an area that's been

155
00:06:37,369 --> 00:06:35,550
affected by a disaster we need to know

156
00:06:40,699 --> 00:06:37,379
you know are the airports open and

157
00:06:43,239 --> 00:06:40,709
operable are the roads open are the

158
00:06:48,199 --> 00:06:43,249
ports open things like that and often

159
00:06:50,600 --> 00:06:48,209
telecommunications can be limited so all

160
00:06:53,269 --> 00:06:50,610
of this information builds a picture

161
00:06:55,730 --> 00:06:53,279
that we call situational awareness and

162
00:06:58,100 --> 00:06:55,740
all of this information is needed by

163
00:06:59,709 --> 00:06:58,110

people who work in emergency operation

164
00:07:03,589 --> 00:06:59,719
centers like this one

165
00:07:07,070 --> 00:07:03,599
so FEMA state and local agencies have

166
00:07:10,009 --> 00:07:07,080
emergency operation centers that get

167
00:07:12,980 --> 00:07:10,019
stood up and man's during a during a

168
00:07:14,509 --> 00:07:12,990
disaster and while it might not look

169
00:07:16,790 --> 00:07:14,519
like there's a lot happening here

170
00:07:18,529 --> 00:07:16,800
there's a lot of people on laptops maybe

171
00:07:21,529 --> 00:07:18,539
they're checking their email but in

172
00:07:24,469 --> 00:07:21,539
disaster response this is the room where

173
00:07:25,699 --> 00:07:24,479
it happens so in a disaster response

174
00:07:28,249 --> 00:07:25,709
what these people are doing is

175
00:07:30,649 --> 00:07:28,259
collecting information and sending it

176
00:07:33,049 --> 00:07:30,659
out to people so they know where to move

177
00:07:36,439 --> 00:07:33,059
the resources where to move the food and

178
00:07:40,069 --> 00:07:36,449
the water and the crews to help get the

179
00:07:41,959 --> 00:07:40,079
power back up so all that information is

180
00:07:46,309 --> 00:07:41,969
helping us build a picture of our

181
00:07:48,409 --> 00:07:46,319
situational awareness so we can help

182
00:07:50,629 --> 00:07:48,419
improve this picture of situational

183
00:07:53,059 --> 00:07:50,639
awareness by making observations from

184
00:07:54,859 --> 00:07:53,069
space and space gives us a unique

185
00:07:57,409 --> 00:07:54,869
perspective and so here are some

186
00:07:59,540 --> 00:07:57,419
examples of viewing hazards from space

187
00:08:02,119 --> 00:07:59,550
and I'm not going to talk about all the

188
00:08:04,369 --> 00:08:02,129

different techniques that nASA uses to

189
00:08:07,399 --> 00:08:04,379
measure disasters from space but here's

190
00:08:10,670 --> 00:08:07,409
here's just a sample and the point that

191
00:08:11,929 --> 00:08:10,680
I want to make here is that space gives

192
00:08:14,600 --> 00:08:11,939
us the ability to monitor things

193
00:08:16,429 --> 00:08:14,610
globally so you don't need to know in

194
00:08:18,619 --> 00:08:16,439
advance if the next volcanic eruption is

195
00:08:21,019 --> 00:08:18,629
going to be in Indonesia or in Iceland

196
00:08:23,749 --> 00:08:21,029
if you have a satellite that's

197
00:08:25,850 --> 00:08:23,759
monitoring the globe you don't you don't

198
00:08:28,279 --> 00:08:25,860
need to know which particular region you

199
00:08:30,920 --> 00:08:28,289
need to look at or focus on and space

200
00:08:31,690 --> 00:08:30,930
also gives us the opportunity to monitor

201
00:08:33,880 --> 00:08:31,700
things on a very

202
00:08:36,580 --> 00:08:33,890
large-scale we can see hurricanes from

203
00:08:38,740 --> 00:08:36,590
space we can see the entire island of

204
00:08:41,800 --> 00:08:38,750
Puerto Rico from space and we can see in

205
00:08:44,110 --> 00:08:41,810
this before and after image that after

206
00:08:47,110 --> 00:08:44,120
Hurricane Maria hit a lot of the lights

207
00:08:49,990 --> 00:08:47,120
were out so they had massive power

208
00:08:52,810 --> 00:08:50,000
outages caused by Hurricane Marija we

209
00:08:56,260 --> 00:08:52,820
can also see the entire extent of how

210
00:08:59,680 --> 00:08:56,270
the earth moved in in response to a

211
00:09:01,930 --> 00:08:59,690
massive earthquake so space gives us the

212
00:09:04,090 --> 00:09:01,940
ability to monitor to monitor globally

213
00:09:07,300 --> 00:09:04,100

and to see things in a very large scale

214
00:09:09,550 --> 00:09:07,310
that's difficult to do from a car from a

215
00:09:14,560 --> 00:09:09,560
windshield or even from an aerial survey

216
00:09:17,050 --> 00:09:14,570
from a plane there's another key feature

217
00:09:20,140 --> 00:09:17,060
of observing things from space observing

218
00:09:21,490 --> 00:09:20,150
hazards from space and that's that space

219
00:09:24,280 --> 00:09:21,500
is out of harm's way

220
00:09:25,870 --> 00:09:24,290
so if you're an astronaut or you're in

221
00:09:27,280 --> 00:09:25,880
space you might not think of space as

222
00:09:29,200 --> 00:09:27,290
being out of harm's way

223
00:09:31,360 --> 00:09:29,210
but if you're a researcher who's

224
00:09:32,950 --> 00:09:31,370
collecting observations from an Earth

225
00:09:34,990 --> 00:09:32,960
observing satellite you're sitting in

226
00:09:37,030 --> 00:09:35,000
your office it is out of harm's way

227
00:09:39,730 --> 00:09:37,040
you're not on the volcano you're not in

228
00:09:41,020 --> 00:09:39,740
the middle of this storm and the

229
00:09:42,960 --> 00:09:41,030
importance of this I want to illustrate

230
00:09:47,050 --> 00:09:42,970
the importance of this from a story from

231
00:09:48,280 --> 00:09:47,060
1980 the eruption of Mount st. Helens so

232
00:09:51,670 --> 00:09:48,290
some of you might have remembered that

233
00:09:55,570 --> 00:09:51,680
eruption is up in Washington State these

234
00:09:57,220 --> 00:09:55,580
pictures here were taken from the

235
00:10:00,280 --> 00:09:57,230
location where David Johnston

236
00:10:04,480 --> 00:10:00,290
a USGS geologist was making observations

237
00:10:07,210 --> 00:10:04,490
of the active volcano so it's it was

238
00:10:09,700 --> 00:10:07,220

about six miles from the summit of Mount

239
00:10:12,310 --> 00:10:09,710
st. Helens it was in a relatively safe

240
00:10:14,050 --> 00:10:12,320
location he was measuring the gas being

241
00:10:15,610 --> 00:10:14,060
emitted from the volcano and he was

242
00:10:17,650 --> 00:10:15,620
measuring how much the volcano was

243
00:10:19,990 --> 00:10:17,660
bulging and these observations were

244
00:10:23,410 --> 00:10:20,000
critical in us understanding the

245
00:10:26,050 --> 00:10:23,420
activity of the volcano and for having

246
00:10:29,110 --> 00:10:26,060
an area around the volcano that was

247
00:10:32,290 --> 00:10:29,120
evacuated we knew it was very active and

248
00:10:35,260 --> 00:10:32,300
so we kept people away but he was there

249
00:10:37,390 --> 00:10:35,270
and he was there the day that the

250
00:10:40,450 --> 00:10:37,400
eruption happened and because the

251
00:10:42,250 --> 00:10:40,460
eruption went to this side as much as it

252
00:10:44,110 --> 00:10:42,260
went up they thought it was going to go

253
00:10:44,670 --> 00:10:44,120
straight up but because he went to the

254
00:10:47,129 --> 00:10:44,680
side

255
00:10:49,829 --> 00:10:47,139
in addition to up and it went straight

256
00:10:52,769 --> 00:10:49,839
at the ridge where David Johnson was

257
00:10:56,400 --> 00:10:52,779
sitting and observing the volcano he was

258
00:10:57,960 --> 00:10:56,410
killed in this eruption so if we have

259
00:11:00,359 --> 00:10:57,970
the ability to make these types of

260
00:11:02,970 --> 00:11:00,369
observations from space then that helps

261
00:11:05,249 --> 00:11:02,980
keep researchers out of harm's way

262
00:11:09,059 --> 00:11:05,259
and helps us make these types of data

263
00:11:15,569 --> 00:11:09,069

collections out out of the way of where

264
00:11:17,970 --> 00:11:15,579
the researchers are in danger so I'm

265
00:11:19,889 --> 00:11:17,980
going to talk about a particular type of

266
00:11:22,679 --> 00:11:19,899
observation that we're making from a

267
00:11:25,290 --> 00:11:22,689
space that we have been the focus of my

268
00:11:29,129 --> 00:11:25,300
research and many researchers here at

269
00:11:32,069 --> 00:11:29,139
JPL so the term is geodetic imaging

270
00:11:34,049 --> 00:11:32,079
which is really a fancy term for how we

271
00:11:36,509 --> 00:11:34,059
measure how the surface of the earth

272
00:11:38,519 --> 00:11:36,519
moves and I'm going to talk about two

273
00:11:40,619 --> 00:11:38,529
ways that we make those measurements I'm

274
00:11:42,449 --> 00:11:40,629
going to talk about how we use radar to

275
00:11:44,759 --> 00:11:42,459
make those types of measurements and how

276
00:11:46,650 --> 00:11:44,769
we use the global positioning system to

277
00:11:48,989 --> 00:11:46,660
make those type of measurements the

278
00:11:52,350 --> 00:11:48,999
radar image here on the right is showing

279
00:11:55,410 --> 00:11:52,360
how much the earth moved in response to

280
00:11:56,879 --> 00:11:55,420
the earthquake in Nepal in 2015 and I'll

281
00:11:59,939 --> 00:11:56,889
talk more about that later in the talk

282
00:12:02,160 --> 00:11:59,949
and then the image on the image on the

283
00:12:04,739 --> 00:12:02,170
right is showing how much the earth

284
00:12:08,309 --> 00:12:04,749
moved in response to the Tohoku

285
00:12:11,040 --> 00:12:08,319
earthquake in 2011 in Japan and the

286
00:12:13,350 --> 00:12:11,050
arrows that you see the red arrows show

287
00:12:15,809 --> 00:12:13,360
the motion of the earth in response to

288
00:12:17,699 --> 00:12:15,819

the magnitude 9 earthquake so the arrow

289
00:12:20,429 --> 00:12:17,709
shows the direction and the magnitude

290
00:12:22,710 --> 00:12:20,439
the most the the stations that move the

291
00:12:25,889 --> 00:12:22,720
farthest in response to the earthquake

292
00:12:28,530 --> 00:12:25,899
moved about 5 meters the blue arrows

293
00:12:30,900 --> 00:12:28,540
show the motion caused by an aftershock

294
00:12:33,600 --> 00:12:30,910
about a half an hour after the magnitude

295
00:12:36,869 --> 00:12:33,610
9 there was magnitude seven point nine

296
00:12:38,100 --> 00:12:36,879
aftershock and you can see how even

297
00:12:40,739 --> 00:12:38,110
though we've made the blue arrow of

298
00:12:42,179 --> 00:12:40,749
scale a little bit bigger you can see

299
00:12:43,799 --> 00:12:42,189
how much smaller those errors are

300
00:12:47,129 --> 00:12:43,809
compared to the movement caused by the

301
00:12:49,799 --> 00:12:47,139
magnitude 9 so I'm going to talk first

302
00:12:52,319 --> 00:12:49,809
about GPS and just want to say that the

303
00:12:55,010 --> 00:12:52,329
GPS satellites that we use they're the

304
00:12:57,440 --> 00:12:55,020
same GPS satellites that you

305
00:12:59,740 --> 00:12:57,450
to make your you know to do your mapping

306
00:13:02,270 --> 00:12:59,750
and to get your position on your phone

307
00:13:04,570 --> 00:13:02,280
it's a constellation of satellites

308
00:13:07,610 --> 00:13:04,580
operated by the Department of Defense

309
00:13:11,270 --> 00:13:07,620
but we use this data in a different way

310
00:13:12,560 --> 00:13:11,280
then your phone uses the data and I'm

311
00:13:14,270 --> 00:13:12,570
not going to go into a lot of detail

312
00:13:16,940 --> 00:13:14,280
about how we get the precise

313
00:13:19,670 --> 00:13:16,950

measurements but I just mentioned a few

314
00:13:23,000 --> 00:13:19,680
things that we do differently primarily

315
00:13:25,490 --> 00:13:23,010
we're using multiple stations and we're

316
00:13:28,070 --> 00:13:25,500
getting a relative measurement between

317
00:13:30,200 --> 00:13:28,080
two GPS stations on the ground and that

318
00:13:32,900 --> 00:13:30,210
allows us to cancel out a lot of the

319
00:13:35,860 --> 00:13:32,910
errors that cause the imprecise

320
00:13:38,840 --> 00:13:35,870
measurements that you get on your phone

321
00:13:40,820 --> 00:13:38,850
another thing that we're doing so we're

322
00:13:42,590 --> 00:13:40,830
using an antenna this is actually an

323
00:13:44,600 --> 00:13:42,600
antenna right here a GPS antenna right

324
00:13:46,310 --> 00:13:44,610
there that's a little bit bigger than

325
00:13:49,520 --> 00:13:46,320
the antenna you have in your phone and

326
00:13:51,890 --> 00:13:49,530
we're tracking the carrier phase that

327
00:13:55,460 --> 00:13:51,900
the GPS satellite broadcasts that's a

328
00:13:56,870 --> 00:13:55,470
smaller wavelength signal and so that

329
00:13:59,690 --> 00:13:56,880
allows us to get a more precise

330
00:14:02,510 --> 00:13:59,700
measurement we also do a lot of

331
00:14:04,810 --> 00:14:02,520
processing and have a lot of models for

332
00:14:07,580 --> 00:14:04,820
how the GPS signal is propagating and

333
00:14:09,260 --> 00:14:07,590
combining all those techniques we

334
00:14:11,960 --> 00:14:09,270
actually measure how much the earth

335
00:14:15,140 --> 00:14:11,970
moves to a precision of about one to two

336
00:14:17,900 --> 00:14:15,150
millimeters in the horizontal and about

337
00:14:19,960 --> 00:14:17,910
five millimeters in the vertical so

338
00:14:22,220 --> 00:14:19,970

that's about the size of a grain of rice

339
00:14:25,250 --> 00:14:22,230
so that's a lot better than you get on

340
00:14:30,050 --> 00:14:25,260
your phone but it takes a lot of effort

341
00:14:33,530 --> 00:14:30,060
to get that so this is an example of a

342
00:14:37,730 --> 00:14:33,540
GPS receiver in the field so this this

343
00:14:40,850 --> 00:14:37,740
is me many years ago so I started out my

344
00:14:44,450 --> 00:14:40,860
research doing five GPS measurements on

345
00:14:46,700 --> 00:14:44,460
Kilauea volcano in Hawaii many of you

346
00:14:48,380 --> 00:14:46,710
have probably been to Hawaii many of you

347
00:14:52,130 --> 00:14:48,390
probably heard that Kilauea has gotten

348
00:14:54,740 --> 00:14:52,140
very active recently so back in the 90s

349
00:14:56,240 --> 00:14:54,750
there was a ongoing eruption but it

350
00:14:58,580 --> 00:14:56,250
wasn't quite as dramatic as what's been

351
00:15:00,560 --> 00:14:58,590
happening over the summer and so we

352
00:15:05,720 --> 00:15:00,570
would go out and set up these GPS

353
00:15:07,710 --> 00:15:05,730
antennas that's the flat flat thing

354
00:15:09,900 --> 00:15:07,720
right there

355
00:15:12,119 --> 00:15:09,910
and then sits sitting on a tripod and

356
00:15:14,160 --> 00:15:12,129
it's centered over a benchmark on the

357
00:15:16,050 --> 00:15:14,170
ground which is how we know where to go

358
00:15:17,999 --> 00:15:16,060
back to the same spot to make our

359
00:15:19,860 --> 00:15:18,009
measurements and it's connected to a

360
00:15:22,850 --> 00:15:19,870
receiver and that's collecting the GPS

361
00:15:24,990 --> 00:15:22,860
signals and then that's my first selfie

362
00:15:26,519 --> 00:15:25,000
taken while I was probably waiting for a

363
00:15:31,710 --> 00:15:26,529

helicopter to pick me up because I've

364
00:15:33,689 --> 00:15:31,720
got the flight suit on that's the old

365
00:15:36,660 --> 00:15:33,699
way of collecting GPS data and people

366
00:15:38,970 --> 00:15:36,670
still go out and set up GPS antennas on

367
00:15:41,309 --> 00:15:38,980
tripods but it's gotten very rare

368
00:15:44,119 --> 00:15:41,319
because for the most part we use data

369
00:15:46,920 --> 00:15:44,129
collected from continuous GPS stations

370
00:15:49,230 --> 00:15:46,930
so this is a permanent GPS station where

371
00:15:52,170 --> 00:15:49,240
we replace the tripod with a permanent

372
00:15:54,840 --> 00:15:52,180
post that's put into the ground about as

373
00:15:56,639 --> 00:15:54,850
deep as you can afford you know the

374
00:15:58,199 --> 00:15:56,649
bigger the drilling equipment the deeper

375
00:16:00,689 --> 00:15:58,209
you can go and the more stable it's

376
00:16:03,150 --> 00:16:00,699
going to be and then you screw the

377
00:16:05,819 --> 00:16:03,160
antenna up there you hook it up to a

378
00:16:08,100 --> 00:16:05,829
receiver two solar panels two till up to

379
00:16:11,699 --> 00:16:08,110
some telemetry and then the GPS data

380
00:16:14,040 --> 00:16:11,709
just comes to you so this has been very

381
00:16:17,009 --> 00:16:14,050
useful for monitoring volcanoes there's

382
00:16:20,759 --> 00:16:17,019
continuous GPS stations all over Kilauea

383
00:16:25,139 --> 00:16:20,769
Volcano they lost one in the recent

384
00:16:28,590 --> 00:16:25,149
event so this GPS station end pit which

385
00:16:30,900 --> 00:16:28,600
was within the summit caldera so it was

386
00:16:33,749 --> 00:16:30,910
used to monitor how the summit was going

387
00:16:36,499 --> 00:16:33,759
down now the volcanoes erupting on the

388
00:16:40,049 --> 00:16:36,509

side of the volcano and the summit is

389
00:16:41,910 --> 00:16:40,059
losing magma and it's in the summit

390
00:16:44,400 --> 00:16:41,920
magma chamber and as that summit magma

391
00:16:45,720 --> 00:16:44,410
chamber is deflating the summit the

392
00:16:48,030 --> 00:16:45,730
ground the surface of the ground is

393
00:16:50,879 --> 00:16:48,040
being pulled down so that's causing this

394
00:16:53,400 --> 00:16:50,889
subsidence this down downward motion

395
00:16:56,759 --> 00:16:53,410
that we're seeing in this plot and it's

396
00:16:58,410 --> 00:16:56,769
been a really dramatic downward motion

397
00:17:02,189 --> 00:16:58,420
or subsidence being caused by this

398
00:17:04,049 --> 00:17:02,199
current eruption the ground floor of the

399
00:17:07,079 --> 00:17:04,059
summit caldera is basically collapsing

400
00:17:10,199 --> 00:17:07,089
and as it's collapsing it it ate the

401
00:17:11,669 --> 00:17:10,209
usgs GPS receivers but that also makes

402
00:17:13,470 --> 00:17:11,679
the point that you really don't want

403
00:17:15,120 --> 00:17:13,480
people going out and making these

404
00:17:17,720 --> 00:17:15,130
measurements and that's the way we used

405
00:17:20,350 --> 00:17:17,730
to monitor subsidence a long time ago

406
00:17:22,840 --> 00:17:20,360
within within Kilauea Volcano

407
00:17:27,220 --> 00:17:22,850
so it's it's better that we have these

408
00:17:30,160 --> 00:17:27,230
remotely kilometer observations so this

409
00:17:32,770 --> 00:17:30,170
is an image that shows the extent of the

410
00:17:35,080 --> 00:17:32,780
continuous GPS networks around the globe

411
00:17:37,780 --> 00:17:35,090
these actually are all the continuous

412
00:17:41,110 --> 00:17:37,790
GPS network GPS stations each little red

413
00:17:42,460 --> 00:17:41,120

dot is a continuous GPS station but

414
00:17:45,070 --> 00:17:42,470
these are all the ones that GPL is

415
00:17:47,260 --> 00:17:45,080
currently downloading and processing and

416
00:17:50,110 --> 00:17:47,270
you'll see that there is a lot of GPS

417
00:17:52,000 --> 00:17:50,120
stations in North America as well as in

418
00:17:54,520 --> 00:17:52,010
Japan Japan was one of the first

419
00:17:57,610 --> 00:17:54,530
countries to install a lot of continuous

420
00:18:00,909 --> 00:17:57,620
GPS stations they had 1,200 GPS stations

421
00:18:01,600 --> 00:18:00,919
installed in the 1990s and so they were

422
00:18:03,580 --> 00:18:01,610
there

423
00:18:08,680 --> 00:18:03,590
at the time of the Tohoku earthquake in

424
00:18:10,740 --> 00:18:08,690
2011 in order to monitor an image how

425
00:18:14,140 --> 00:18:10,750
much the earth moved in that earthquake

426
00:18:17,230 --> 00:18:14,150
so this movie is going to show you the

427
00:18:19,180 --> 00:18:17,240
motion of all the GPS stations and here

428
00:18:23,020 --> 00:18:19,190
we're getting a position every second

429
00:18:25,600 --> 00:18:23,030
and the figure on the left is showing

430
00:18:27,730 --> 00:18:25,610
you the horizontal motion so the colors

431
00:18:30,159 --> 00:18:27,740
show you the total displacement in the

432
00:18:31,480 --> 00:18:30,169
horizontal direction and here the little

433
00:18:34,270 --> 00:18:31,490
arrows are just showing you the

434
00:18:36,490 --> 00:18:34,280
directions they don't grow with with

435
00:18:38,080 --> 00:18:36,500
amplitude as they did in that first

436
00:18:39,730 --> 00:18:38,090
figure that I showed you that's being

437
00:18:42,100 --> 00:18:39,740
shown the amplitude is being shown by

438
00:18:45,460 --> 00:18:42,110

the colors and then on the left you see

439
00:18:48,010 --> 00:18:45,470
the vertical and this is going to loop

440
00:18:50,680 --> 00:18:48,020
through again but on the bottom you can

441
00:18:52,870 --> 00:18:50,690
see second since main shock so the

442
00:18:55,030 --> 00:18:52,880
earthquake starts at that little beach

443
00:18:57,070 --> 00:18:55,040
ball and then you can see the

444
00:18:58,510 --> 00:18:57,080
displacement propagating outwards and

445
00:19:01,120 --> 00:18:58,520
you can see the total displacement

446
00:19:03,760 --> 00:19:01,130
propagating outwards and reaching its

447
00:19:06,310 --> 00:19:03,770
peak within about three three and a half

448
00:19:07,930 --> 00:19:06,320
minutes from the start of the earthquake

449
00:19:10,600 --> 00:19:07,940
and then you can actually see some of

450
00:19:12,700 --> 00:19:10,610
the seismic waves so it's really it's a

451
00:19:14,680 --> 00:19:12,710
really impressive picture of the

452
00:19:17,320 --> 00:19:14,690
earthquake that we were able to see from

453
00:19:18,640 --> 00:19:17,330
these continuous GPS stations and the

454
00:19:20,470 --> 00:19:18,650
scientists were really interested in

455
00:19:22,240 --> 00:19:20,480
this but okay I said this was going to

456
00:19:24,430 --> 00:19:22,250
be talking about disasters how is this

457
00:19:26,919 --> 00:19:24,440
important for us understanding the

458
00:19:32,590 --> 00:19:26,929
disaster and helping to improve our

459
00:19:35,800 --> 00:19:32,600
disaster response well that goes back to

460
00:19:38,650 --> 00:19:35,810
how we guesstimate the magnitude of an

461
00:19:42,100 --> 00:19:38,660
earthquake so in most taught most

462
00:19:44,410 --> 00:19:42,110
networks use seismic data to estimate

463
00:19:46,240 --> 00:19:44,420

the magnitude of an earthquake and we've

464
00:19:47,920 --> 00:19:46,250
gotten really good at estimating the

465
00:19:49,830 --> 00:19:47,930
magnitude of an earthquake really

466
00:19:52,300 --> 00:19:49,840
quickly and this is the premise behind

467
00:19:54,130 --> 00:19:52,310
earthquake early warning we can get the

468
00:19:58,090 --> 00:19:54,140
magnitude of an earthquake within

469
00:20:00,670 --> 00:19:58,100
seconds unless the earthquake is above a

470
00:20:02,980 --> 00:20:00,680
magnitude seven if it's above a

471
00:20:04,870 --> 00:20:02,990
magnitude seven our ability to see the

472
00:20:08,920 --> 00:20:04,880
magnitude of the earthquake saturates

473
00:20:11,050 --> 00:20:08,930
and it's you can't use seismic data

474
00:20:13,240 --> 00:20:11,060
alone to get the true magnitude of the

475
00:20:15,490 --> 00:20:13,250
earthquake if you want to get it within

476
00:20:19,560 --> 00:20:15,500
at just a few minutes so this is an

477
00:20:22,540 --> 00:20:19,570
example of a USGS map that was generated

478
00:20:24,310 --> 00:20:22,550
from the Tohoku earthquake and so

479
00:20:27,010 --> 00:20:24,320
twenty-one minutes after the earthquake

480
00:20:30,430 --> 00:20:27,020
it estimated to Hoku had a magnitude

481
00:20:33,250 --> 00:20:30,440
seven point nine as more seismic waves

482
00:20:35,230 --> 00:20:33,260
came in and more analysis was done forty

483
00:20:37,840 --> 00:20:35,240
minutes later it was estimated to be a

484
00:20:40,060 --> 00:20:37,850
magnitude eight point eight you can see

485
00:20:42,270 --> 00:20:40,070
when you compare these two maps that are

486
00:20:46,420 --> 00:20:42,280
showing the strength of the shaking

487
00:20:48,490 --> 00:20:46,430
predicted from this earthquake so strong

488
00:20:51,370 --> 00:20:48,500

and very strong is this yellow and

489
00:20:52,930 --> 00:20:51,380
orange you can see it's much greater for

490
00:20:55,600 --> 00:20:52,940
a magnitude eight point eight a much

491
00:20:58,870 --> 00:20:55,610
larger area than for a magnitude seven

492
00:21:00,730 --> 00:20:58,880
point nine and the tsunami predicted by

493
00:21:02,440 --> 00:21:00,740
a magnitude seven point nine or

494
00:21:03,070 --> 00:21:02,450
magnitude seven is going to be much

495
00:21:05,230 --> 00:21:03,080
smaller

496
00:21:06,970 --> 00:21:05,240
the initial warning that went out to

497
00:21:09,190 --> 00:21:06,980
Japan they have a great earthquake early

498
00:21:11,050 --> 00:21:09,200
warning system and a great tsunami

499
00:21:13,750 --> 00:21:11,060
warning systems but because they thought

500
00:21:15,160 --> 00:21:13,760
it was closer to a magnitude seven the

501
00:21:17,800 --> 00:21:15,170
initial warning said that it was going

502
00:21:21,790 --> 00:21:17,810
to be a three meter tsunami it was a ten

503
00:21:23,560 --> 00:21:21,800
meter tsunami and 20,000 people died so

504
00:21:27,400 --> 00:21:23,570
there's been a lot of interest in

505
00:21:30,010 --> 00:21:27,410
figuring out how to get a better rapid

506
00:21:33,490 --> 00:21:30,020
magnitude estimate and that's where the

507
00:21:35,680 --> 00:21:33,500
GPS comes in so Japan has real-time GPS

508
00:21:38,530 --> 00:21:35,690
capability and they've been linking

509
00:21:40,930 --> 00:21:38,540
their GPS stations into their earthquake

510
00:21:43,120 --> 00:21:40,940
early warning and tsunami warning system

511
00:21:44,000 --> 00:21:43,130
and a lot of the tsunami warning systems

512
00:21:47,960 --> 00:21:44,010
around the globe

513
00:21:49,940 --> 00:21:47,970

are using GPS now because you can see on

514
00:21:52,370 --> 00:21:49,950
the bottom second since main shock so

515
00:21:54,380 --> 00:21:52,380
about three and a half minutes in you

516
00:21:57,200 --> 00:21:54,390
could see the size of the earthquake

517
00:21:59,480 --> 00:21:57,210
from GPS so if you combine the GPS data

518
00:22:01,730 --> 00:21:59,490
with a seismic data you can get that it

519
00:22:06,410 --> 00:22:01,740
was a magnitude nine within enough time

520
00:22:10,160 --> 00:22:06,420
to give an accurate tsunami warning and

521
00:22:13,760 --> 00:22:10,170
then this figure just shows the extent

522
00:22:15,710 --> 00:22:13,770
of the real-time GPS in in western US so

523
00:22:18,320 --> 00:22:15,720
the and I want to make the point that

524
00:22:20,390 --> 00:22:18,330
real-time GPS is being incorporated into

525
00:22:23,360 --> 00:22:20,400
the earthquake early warning system

526
00:22:27,500 --> 00:22:23,370
that's being built for California and

527
00:22:32,690 --> 00:22:27,510
Washington and Oregon so I'm going to

528
00:22:35,390 --> 00:22:32,700
switch gears now and talk about radar so

529
00:22:37,700 --> 00:22:35,400
radar in a radar satellite radar imaging

530
00:22:39,920 --> 00:22:37,710
satellite it's transmitting radar down

531
00:22:42,350 --> 00:22:39,930
to the ground and then receiving the

532
00:22:44,120 --> 00:22:42,360
reflected signal and it's called

533
00:22:46,610 --> 00:22:44,130
synthetic aperture radar because it's

534
00:22:49,940 --> 00:22:46,620
using the motion of the satellite to

535
00:22:52,550 --> 00:22:49,950
effectively receive data over a larger

536
00:22:55,040 --> 00:22:52,560
area so it that forms what's called a

537
00:22:57,740 --> 00:22:55,050
synthetic aperture so it's as if the

538
00:22:59,180 --> 00:22:57,750

reflecting dish was larger than or the

539
00:23:02,000 --> 00:22:59,190
receiving dish was larger than it

540
00:23:05,180 --> 00:23:02,010
actually is and so that allows us to get

541
00:23:06,260 --> 00:23:05,190
higher resolution on the ground the

542
00:23:09,140 --> 00:23:06,270
other thing I want to point out about

543
00:23:11,990 --> 00:23:09,150
radar in this slide is that it can see

544
00:23:14,180 --> 00:23:12,000
what another good property of radar is

545
00:23:17,120 --> 00:23:14,190
it can see through clouds there's a lot

546
00:23:19,610 --> 00:23:17,130
of damage imaging and disaster response

547
00:23:21,500 --> 00:23:19,620
that's done with optical satellites

548
00:23:25,280 --> 00:23:21,510
that's basically a digital camera in the

549
00:23:28,070 --> 00:23:25,290
sky but if the area is cloudy which it

550
00:23:30,140 --> 00:23:28,080
often is around hurricanes then it's

551
00:23:33,470 --> 00:23:30,150
very hard to see below the clouds and so

552
00:23:37,370 --> 00:23:33,480
radar is uniquely able to image the

553
00:23:39,740 --> 00:23:37,380
ground through the clouds so how do we

554
00:23:41,890 --> 00:23:39,750
use the radar to map the surface motion

555
00:23:44,330 --> 00:23:41,900
so the technique is called

556
00:23:47,210 --> 00:23:44,340
interferometric synthetic aperture radar

557
00:23:51,200 --> 00:23:47,220
in SAR and i'm just going to go over at

558
00:23:53,480 --> 00:23:51,210
a high level how this works and so a

559
00:23:56,090 --> 00:23:53,490
really simple way of thinking about in

560
00:23:57,409 --> 00:23:56,100
SAR is to think about the rate

561
00:24:00,680 --> 00:23:57,419
satellite being kind of like a giant

562
00:24:04,130 --> 00:24:00,690
speed gun in the sky measuring how fast

563
00:24:06,289 --> 00:24:04,140

the earth is moving it works a little

564
00:24:08,840 --> 00:24:06,299
differently in reality than a speed gun

565
00:24:11,600 --> 00:24:08,850
and so we're not just pointing it at the

566
00:24:13,640 --> 00:24:11,610
earth and holding it in one position so

567
00:24:19,700 --> 00:24:13,650
the satellites orbiting around the earth

568
00:24:22,250 --> 00:24:19,710
so we have a first image here it's taken

569
00:24:25,220 --> 00:24:22,260
by the satellite and then it goes around

570
00:24:28,370 --> 00:24:25,230
comes back several days later then we

571
00:24:31,100 --> 00:24:28,380
take a second image and we compare the

572
00:24:33,529 --> 00:24:31,110
images the waves received from those two

573
00:24:36,680 --> 00:24:33,539
images we interfere them to form what's

574
00:24:39,409 --> 00:24:36,690
called an interference and that's this

575
00:24:41,539 --> 00:24:39,419
colorful map down here and that's

576
00:24:44,419 --> 00:24:41,549
measuring how much the surface moved

577
00:24:46,730 --> 00:24:44,429
between the first image and the second

578
00:24:49,430 --> 00:24:46,740
image another thing I want to point out

579
00:24:52,220 --> 00:24:49,440
in this lesson about InSAR before I go

580
00:24:54,220 --> 00:24:52,230
on is that the measurement that we're

581
00:24:56,960 --> 00:24:54,230
making is really just the motion

582
00:24:58,970 --> 00:24:56,970
relative to the satellite so we're

583
00:25:00,830 --> 00:24:58,980
getting a continuous map of the

584
00:25:04,070 --> 00:25:00,840
deformation but we're only getting it in

585
00:25:10,610 --> 00:25:04,080
one direction there will be a test on

586
00:25:14,270 --> 00:25:10,620
this at the end let's see so here is an

587
00:25:17,060 --> 00:25:14,280
example of an interfere gram from an

588
00:25:20,870 --> 00:25:17,070

earthquake so is that magnitude 6.6

589
00:25:23,840 --> 00:25:20,880
earthquake in Iran near the city of BAM

590
00:25:26,990 --> 00:25:23,850
so we call it the BAM earthquake in 2003

591
00:25:29,870 --> 00:25:27,000
and Eric fielding research scientist

592
00:25:33,200 --> 00:25:29,880
here at JPL generated this interfere

593
00:25:36,529 --> 00:25:33,210
graph so I should explain a little bit

594
00:25:38,270 --> 00:25:36,539
more about what these color bands how

595
00:25:41,539 --> 00:25:38,280
these color glands can be interpreted so

596
00:25:44,899 --> 00:25:41,549
we call them fringes and one fringe or

597
00:25:47,480 --> 00:25:44,909
one cycle is say from one blue band here

598
00:25:50,590 --> 00:25:47,490
to the next blue band there when you go

599
00:25:54,260 --> 00:25:50,600
through one cycle that's equivalent to

600
00:25:57,230 --> 00:25:54,270
28 for this image 28 millimeters of

601
00:26:00,799 --> 00:25:57,240
range change so for each cycle the

602
00:26:02,720 --> 00:26:00,809
ground is moving 28 millimeters another

603
00:26:04,549 --> 00:26:02,730
way it may be an easier way to think

604
00:26:05,090 --> 00:26:04,559
about this is it's kind of like a topo

605
00:26:09,680 --> 00:26:05,100
map

606
00:26:12,590 --> 00:26:09,690
so for each blue like for along a line

607
00:26:14,960 --> 00:26:12,600
of say blue here the earth is moving a

608
00:26:17,090 --> 00:26:14,970
constant amount relative to some

609
00:26:19,549 --> 00:26:17,100
reference point in this image the same

610
00:26:22,249 --> 00:26:19,559
way a line on a topo map is a line of

611
00:26:23,930 --> 00:26:22,259
constant height and in the same way in a

612
00:26:25,580 --> 00:26:23,940
topo map when you have lines really

613
00:26:26,600 --> 00:26:25,590

close together that means that the

614
00:26:28,879 --> 00:26:26,610
terrain is steep

615
00:26:30,980 --> 00:26:28,889
when these fringes are really packed

616
00:26:33,860 --> 00:26:30,990
tight close together that means the

617
00:26:35,840 --> 00:26:33,870
ground is moving a lot and so you can

618
00:26:38,509 --> 00:26:35,850
see that the fringes are packed tightly

619
00:26:41,299 --> 00:26:38,519
here close to the fault which is here

620
00:26:43,570 --> 00:26:41,309
and then they get spread out further

621
00:26:45,710 --> 00:26:43,580
away as you move away from the fault and

622
00:26:48,409 --> 00:26:45,720
so that's one way to think about

623
00:26:50,269 --> 00:26:48,419
interpreting these images we like to

624
00:26:52,430 --> 00:26:50,279
show the fringes because it's easier to

625
00:26:55,999 --> 00:26:52,440
see some of the details but it is we

626
00:26:57,289 --> 00:26:56,009
admit a little hard to interpret the

627
00:26:59,389 --> 00:26:57,299
other thing I want to point out with

628
00:27:03,669 --> 00:26:59,399
this image is this was one of the first

629
00:27:06,320 --> 00:27:03,679
images where we were looking at the

630
00:27:09,950 --> 00:27:06,330
image we saw that there are these areas

631
00:27:11,600 --> 00:27:09,960
that were black and the areas that are

632
00:27:14,960 --> 00:27:11,610
black are areas where the ground moved

633
00:27:17,990 --> 00:27:14,970
so much in between the first image and

634
00:27:19,580 --> 00:27:18,000
the second image that you can't form

635
00:27:24,889 --> 00:27:19,590
this interferogram it's called D

636
00:27:27,200 --> 00:27:24,899
correlation and the D correlation in

637
00:27:29,419 --> 00:27:27,210
this earthquake people noticed was

638
00:27:31,730 --> 00:27:29,429

caused by the fact that there's a city

639
00:27:34,519 --> 00:27:31,740
in here and a lot of the buildings

640
00:27:37,700 --> 00:27:34,529
collapsed so it wasn't just D

641
00:27:39,619 --> 00:27:37,710
correlation along the fault where the

642
00:27:43,039 --> 00:27:39,629
ground ruptured it was also a D

643
00:27:45,110 --> 00:27:43,049
correlation in an urban area and so this

644
00:27:47,779 --> 00:27:45,120
gave people the idea that maybe they can

645
00:27:50,930 --> 00:27:47,789
use this type of data to help look at

646
00:27:53,330 --> 00:27:50,940
damage following an earthquake and so

647
00:27:55,730 --> 00:27:53,340
people here at JPL started thinking

648
00:27:57,230 --> 00:27:55,740
about well whether or not you know this

649
00:27:59,509 --> 00:27:57,240
was something that we could do and one

650
00:28:01,100 --> 00:27:59,519
of the things that that we asked

651
00:28:04,460 --> 00:28:01,110
ourselves was well how do we show that

652
00:28:07,009 --> 00:28:04,470
we can do it well talked about that and

653
00:28:10,159 --> 00:28:07,019
we came up with the idea that we should

654
00:28:13,970 --> 00:28:10,169
look to see if we can image a building

655
00:28:17,080 --> 00:28:13,980
that we know has been destroyed and we

656
00:28:19,879 --> 00:28:17,090
knew there was a apartment complex in

657
00:28:23,040 --> 00:28:19,889
Pasadena this is a map of Pasadena that

658
00:28:24,930 --> 00:28:23,050
had been leveled in the recent past

659
00:28:27,630 --> 00:28:24,940
and we knew we could get some radar data

660
00:28:30,570 --> 00:28:27,640
before and after to see if we could map

661
00:28:33,660 --> 00:28:30,580
that damage and so this is the this is a

662
00:28:35,550 --> 00:28:33,670
technique that was developed to map

663
00:28:38,670 --> 00:28:35,560

whether or not buildings had been

664
00:28:41,100 --> 00:28:38,680
changed or destroyed and in this first

665
00:28:43,620 --> 00:28:41,110
map that we generated we decided that

666
00:28:46,200 --> 00:28:43,630
the pixels indicating that the map that

667
00:28:49,830 --> 00:28:46,210
the building had been destroyed should

668
00:28:52,020 --> 00:28:49,840
be red um so red pixels mean that

669
00:28:54,240 --> 00:28:52,030
something bad has happened or or less

670
00:28:57,750 --> 00:28:54,250
and in this image it's always a building

671
00:29:00,510 --> 00:28:57,760
change so we we were able to show that

672
00:29:02,280 --> 00:29:00,520
we could image this this apartment

673
00:29:03,630 --> 00:29:02,290
complex we weren't even sure we could

674
00:29:06,330 --> 00:29:03,640
see something on the scale of a city

675
00:29:07,890 --> 00:29:06,340
block and so we were really happy to see

676
00:29:09,960 --> 00:29:07,900
that the radar could pick up something

677
00:29:13,470 --> 00:29:09,970
on the scale of a city block but then we

678
00:29:15,780 --> 00:29:13,480
looked at these other red dots and we're

679
00:29:18,240 --> 00:29:15,790
wondering why is that noise or is that

680
00:29:20,400 --> 00:29:18,250
other change and sang-ho u n-- who is

681
00:29:22,200 --> 00:29:20,410
the the research scientist at JPL who

682
00:29:24,420 --> 00:29:22,210
developed this map and developed this

683
00:29:26,100 --> 00:29:24,430
technique he went and he looked to see

684
00:29:28,860 --> 00:29:26,110
well what's behind those little red dots

685
00:29:30,780 --> 00:29:28,870
and they found that for all those will

686
00:29:33,780 --> 00:29:30,790
red dots there were actually other types

687
00:29:35,940 --> 00:29:33,790
of change building change that had

688
00:29:38,040 --> 00:29:35,950

actually happened so I think this was

689
00:29:41,880 --> 00:29:38,050
like PCC doing something to their

690
00:29:44,910 --> 00:29:41,890
parking lot or tennis courts and these

691
00:29:47,730 --> 00:29:44,920
other red dots he went to Pasadena City

692
00:29:50,700 --> 00:29:47,740
Hall and you can pull building permits

693
00:29:52,620 --> 00:29:50,710
and he found out that for these other

694
00:29:55,200 --> 00:29:52,630
red dots there's actually construction

695
00:29:58,800 --> 00:29:55,210
that had happened on the houses and so

696
00:30:00,600 --> 00:29:58,810
that got us really you know enthusiastic

697
00:30:03,360 --> 00:30:00,610
about the idea that this technique could

698
00:30:04,950 --> 00:30:03,370
work well in mapping building damage the

699
00:30:08,670 --> 00:30:04,960
fact that we were able to see things on

700
00:30:11,430 --> 00:30:08,680
the residential house scale so the next

701
00:30:14,810 --> 00:30:11,440
step was to then try and apply the

702
00:30:17,670 --> 00:30:14,820
technique to an earthquake so sang-ho

703
00:30:20,130 --> 00:30:17,680
took some data that would image the

704
00:30:23,100 --> 00:30:20,140
damage caused by the Christchurch

705
00:30:25,200 --> 00:30:23,110
earthquake in New Zealand in 2011 this

706
00:30:27,720 --> 00:30:25,210
was well after the earthquake so this

707
00:30:31,890 --> 00:30:27,730
was done sort of in research mode not in

708
00:30:34,550 --> 00:30:31,900
response mode and so again the red dots

709
00:30:36,470 --> 00:30:34,560
here this is his radar based damage map

710
00:30:40,350 --> 00:30:36,480
show where there was

711
00:30:43,139 --> 00:30:40,360
significant change caused by the

712
00:30:44,700 --> 00:30:43,149
earthquake and then we compared it for

713
00:30:48,180 --> 00:30:44,710

ground truth to an engineering

714
00:30:50,519 --> 00:30:48,190
assessment that was collected by people

715
00:30:52,409 --> 00:30:50,529
by geotechnical engineers over the

716
00:30:54,869 --> 00:30:52,419
course of four months and we saw that

717
00:30:57,930 --> 00:30:54,879
there was a lot of correlation between

718
00:30:59,639 --> 00:30:57,940
the red that we saw in the radar and the

719
00:31:03,570 --> 00:30:59,649
zones that were mapped by the

720
00:31:06,090 --> 00:31:03,580
geotechnical engineers so this this was

721
00:31:10,470 --> 00:31:06,100
really promising as well we also looked

722
00:31:12,659 --> 00:31:10,480
at individual buildings and so we knew

723
00:31:15,960 --> 00:31:12,669
the Christchurch Cathedral had lost its

724
00:31:19,169 --> 00:31:15,970
spire that was picked up by the damage

725
00:31:20,399 --> 00:31:19,179
map as well as the CTV building which

726
00:31:23,100 --> 00:31:20,409
was the building where most of the

727
00:31:25,739 --> 00:31:23,110
fatalities happened in this earthquake

728
00:31:27,899 --> 00:31:25,749
and so at the building level we were

729
00:31:30,450 --> 00:31:27,909
able to resolve that that there had been

730
00:31:31,889 --> 00:31:30,460
damage we are also able to see in

731
00:31:33,629 --> 00:31:31,899
looking at this earthquake that some of

732
00:31:36,419 --> 00:31:33,639
the red areas were actually caused by

733
00:31:38,970 --> 00:31:36,429
liquefaction when the ground liquefies

734
00:31:41,940 --> 00:31:38,980
in response to the earthquake as well as

735
00:31:44,310 --> 00:31:41,950
landslides so and unfortunately we can't

736
00:31:45,960 --> 00:31:44,320
really tell from radar whether the red

737
00:31:48,359 --> 00:31:45,970
dots being caused by building damaged

738
00:31:50,279 --> 00:31:48,369

liquefaction or landslides but if you

739
00:31:52,830 --> 00:31:50,289
combine the radar with a map of the

740
00:31:55,320 --> 00:31:52,840
ground where we can see where it's

741
00:31:59,369 --> 00:31:55,330
likely to be a building or landslides or

742
00:32:01,289 --> 00:31:59,379
liquefaction so the first earthquake

743
00:32:03,659 --> 00:32:01,299
where we applied this technique in

744
00:32:08,879 --> 00:32:03,669
response mode was the Nepal earthquake

745
00:32:11,580 --> 00:32:08,889
in 2015 this was a magnitude 7.8 and it

746
00:32:14,460 --> 00:32:11,590
did it was a disaster there were over

747
00:32:18,049 --> 00:32:14,470
8,000 fatalities many people's houses

748
00:32:21,149 --> 00:32:18,059
were destroyed many people were injured

749
00:32:23,909 --> 00:32:21,159
we generated two damaged maps for this

750
00:32:26,940 --> 00:32:23,919
earthquake I using two different radar

751
00:32:29,129 --> 00:32:26,950
sensors so this this particular radar

752
00:32:31,560 --> 00:32:29,139
sensor was was particularly sensitive to

753
00:32:34,049 --> 00:32:31,570
landslides so there was a village that

754
00:32:37,169 --> 00:32:34,059
was destroyed by a massive landslide and

755
00:32:38,639 --> 00:32:37,179
we were able to image that with the with

756
00:32:40,409 --> 00:32:38,649
the radar beam we found out about the

757
00:32:41,970 --> 00:32:40,419
the village being destroyed before we

758
00:32:44,489 --> 00:32:41,980
actually generated that damage map in

759
00:32:47,039 --> 00:32:44,499
this case but this was helpful for

760
00:32:49,160 --> 00:32:47,049
identifying other landslides in the area

761
00:32:51,530 --> 00:32:49,170
there were a lot of mountain landslides

762
00:32:53,860 --> 00:32:51,540
triggered by this earthquake and then we

763
00:32:56,840 --> 00:32:53,870

used a different sensor to image the

764
00:32:59,330 --> 00:32:56,850
building damage in Katmandu and the

765
00:33:02,090 --> 00:32:59,340
surrounding villages and this damage map

766
00:33:04,370 --> 00:33:02,100
was used to help with search-and-rescue

767
00:33:08,180 --> 00:33:04,380
efforts to localize search-and-rescue

768
00:33:10,280 --> 00:33:08,190
efforts in response to the earthquake so

769
00:33:14,420 --> 00:33:10,290
this is a list of some of the agencies

770
00:33:17,030 --> 00:33:14,430
that were able to use this damage map in

771
00:33:20,440 --> 00:33:17,040
order to help with their response so it

772
00:33:24,610 --> 00:33:20,450
varies from people who are using it to

773
00:33:29,480 --> 00:33:24,620
inform ground response so USAID and the

774
00:33:32,980 --> 00:33:29,490
NGA we're able to use it to guide where

775
00:33:35,450 --> 00:33:32,990
to where to send search-and-rescue teams

776
00:33:38,390 --> 00:33:35,460
other people were able to use it to

777
00:33:40,730 --> 00:33:38,400
guide where they would collect more

778
00:33:43,070 --> 00:33:40,740
high-resolution imagery so DigitalGlobe

779
00:33:45,320 --> 00:33:43,080
a company that does a lot of optical

780
00:33:48,680 --> 00:33:45,330
imagery more digital cameras in space

781
00:33:50,060 --> 00:33:48,690
and so that's also again very useful for

782
00:33:52,190 --> 00:33:50,070
damage response but it's a small

783
00:33:54,920 --> 00:33:52,200
footprint they're only able to collect

784
00:33:56,570 --> 00:33:54,930
those images over a small area the one

785
00:33:58,580 --> 00:33:56,580
of the nice things about radar is it can

786
00:34:02,180 --> 00:33:58,590
image a very large area and it can

787
00:34:04,220 --> 00:34:02,190
highlight where the damage is most

788
00:34:06,230 --> 00:34:04,230

likely to happen and then you can focus

789
00:34:10,280 --> 00:34:06,240
your high-resolution imagery in those

790
00:34:13,100 --> 00:34:10,290
areas we also generated the surface

791
00:34:15,530 --> 00:34:13,110
deformation map and this time thankfully

792
00:34:18,890 --> 00:34:15,540
we generated a map that doesn't have the

793
00:34:21,290 --> 00:34:18,900
colorful fringes so you can see the

794
00:34:23,890 --> 00:34:21,300
surface deformation we overlaid the GPS

795
00:34:26,870 --> 00:34:23,900
vectors that were off that we also

796
00:34:29,659 --> 00:34:26,880
generated for this earthquake so you can

797
00:34:32,180 --> 00:34:29,669
see there was a lot of uplift as well as

798
00:34:34,700 --> 00:34:32,190
horizontal displacement why is this

799
00:34:37,460 --> 00:34:34,710
important one of the things that were

800
00:34:39,620 --> 00:34:37,470
this is important is because it helps

801
00:34:40,040 --> 00:34:39,630
define the area that ruptured in the

802
00:34:42,770 --> 00:34:40,050
earthquake

803
00:34:44,540 --> 00:34:42,780
you see here this this green star is

804
00:34:46,640 --> 00:34:44,550
where the earthquake happened the

805
00:34:49,040 --> 00:34:46,650
earthquake propagated to the web to the

806
00:34:51,290 --> 00:34:49,050
east and so it wasn't centered around

807
00:34:53,470 --> 00:34:51,300
the epicenter so by making these surface

808
00:34:56,360 --> 00:34:53,480
deformation measurements we can confirm

809
00:34:58,520 --> 00:34:56,370
where the surface rubber where the fault

810
00:35:00,560 --> 00:34:58,530
ruptured and where the shaking is most

811
00:35:02,600 --> 00:35:00,570
likely to be great the greatest caused

812
00:35:05,450 --> 00:35:02,610
by the earthquake

813
00:35:08,270 --> 00:35:05,460

is also important for future earthquake

814
00:35:12,590 --> 00:35:08,280
hazards so this earthquake ruptured

815
00:35:13,910 --> 00:35:12,600
along a long fault zone so it would be

816
00:35:15,380 --> 00:35:13,920
like one section of the San Andreas

817
00:35:17,660 --> 00:35:15,390
Fault rupturing it's not going to

818
00:35:21,740 --> 00:35:17,670
rupture the whole San Andreas the same

819
00:35:25,460 --> 00:35:21,750
is true in Nepal and so these areas

820
00:35:27,500 --> 00:35:25,470
adjacent to where this magnitude 7.8

821
00:35:30,440 --> 00:35:27,510
earthquake happened are now loaded and

822
00:35:33,770 --> 00:35:30,450
primed for a future earthquake so this

823
00:35:36,050 --> 00:35:33,780
type of information helps us with our

824
00:35:38,450 --> 00:35:36,060
future forecasts for earthquakes

825
00:35:40,520 --> 00:35:38,460
it also helps us image where the fault

826
00:35:42,080 --> 00:35:40,530
rupture happened or didn't happen in

827
00:35:45,530 --> 00:35:42,090
this case the fault didn't reach the

828
00:35:47,090 --> 00:35:45,540
surface this figure over here is

829
00:35:49,460 --> 00:35:47,100
actually a surface rupture that was

830
00:35:52,460 --> 00:35:49,470
caused by shaking localized liquefaction

831
00:35:55,130 --> 00:35:52,470
but the fault rupture would have come up

832
00:35:57,500 --> 00:35:55,140
in this region over here farther from

833
00:35:59,090 --> 00:35:57,510
Katmandu and there was no surface break

834
00:36:00,890 --> 00:35:59,100
caused by the earthquake and that's

835
00:36:03,980 --> 00:36:00,900
something that's easy to image with

836
00:36:05,390 --> 00:36:03,990
radar from space but harder to do on the

837
00:36:08,750 --> 00:36:05,400
ground when you have such a large

838
00:36:10,970 --> 00:36:08,760

earthquake and even when you don't have

839
00:36:13,400 --> 00:36:10,980
such a large earthquake it can sometimes

840
00:36:16,190 --> 00:36:13,410
be easier to use space-based techniques

841
00:36:17,930 --> 00:36:16,200
to find these cracks than it is from

842
00:36:20,450 --> 00:36:17,940
geologists on the ground or the to work

843
00:36:22,820 --> 00:36:20,460
together so this is now going back to

844
00:36:27,080 --> 00:36:22,830
California back in time a little bit

845
00:36:28,580 --> 00:36:27,090
there was the Napa earthquake in 2014

846
00:36:31,010 --> 00:36:28,590
forwards a lot of building damage caused

847
00:36:33,380 --> 00:36:31,020
by this earthquake but we we formed an

848
00:36:36,260 --> 00:36:33,390
interferogram and we were able to look

849
00:36:39,950 --> 00:36:36,270
at the changes in the fringes here you

850
00:36:43,340 --> 00:36:39,960
can see this crack this offset in the

851
00:36:44,210 --> 00:36:43,350
fringes in this figure and the

852
00:36:47,090 --> 00:36:44,220
geologists

853
00:36:48,500 --> 00:36:47,100
use this use this map to go out and find

854
00:36:50,060 --> 00:36:48,510
the cracks on the ground and it turned

855
00:36:52,130 --> 00:36:50,070
out one of the cracks went right through

856
00:36:54,950 --> 00:36:52,140
the Napa Airport and they were able to

857
00:36:58,070 --> 00:36:54,960
inform the airport that their that their

858
00:37:00,440 --> 00:36:58,080
runway had a big crack in it and this

859
00:37:02,630 --> 00:37:00,450
might not have prevented planes from

860
00:37:05,600 --> 00:37:02,640
landing but it's this this type of thing

861
00:37:08,030 --> 00:37:05,610
is important for understanding where the

862
00:37:10,130 --> 00:37:08,040
ground is being strained especially

863
00:37:13,130 --> 00:37:10,140

where you have like buried gas pipelines

864
00:37:15,770 --> 00:37:13,140
and and buried infrastructure so these

865
00:37:17,660 --> 00:37:15,780
types of Maps can help us identify

866
00:37:20,030 --> 00:37:17,670
small shifts in the ground that could

867
00:37:23,920 --> 00:37:20,040
affect not only things like airport

868
00:37:27,710 --> 00:37:23,930
runways but also buried infrastructure

869
00:37:31,520 --> 00:37:27,720
so last year we generated several damage

870
00:37:33,560 --> 00:37:31,530
maps for the Mexico earthquakes there

871
00:37:36,800 --> 00:37:33,570
were two earthquakes in the course of

872
00:37:38,630 --> 00:37:36,810
about a month and in this slide I kind

873
00:37:40,640 --> 00:37:38,640
of want to talk about the timeline I

874
00:37:43,370 --> 00:37:40,650
haven't really talked too much about how

875
00:37:45,890 --> 00:37:43,380
long it takes us to get these images

876
00:37:48,589 --> 00:37:45,900
into the hands of the responders because

877
00:37:50,410 --> 00:37:48,599
obviously quicker is better well one of

878
00:37:53,359 --> 00:37:50,420
the limiting factors and our ability to

879
00:37:55,580 --> 00:37:53,369
get this data to responders is the fact

880
00:37:57,170 --> 00:37:55,590
that we have to wait for a satellite to

881
00:38:00,440 --> 00:37:57,180
come over the area that's been affected

882
00:38:03,349 --> 00:38:00,450
and so this timeline shows you the time

883
00:38:06,560 --> 00:38:03,359
of the quake and then there is a once

884
00:38:08,930 --> 00:38:06,570
our satellite a low Stu flew over two

885
00:38:12,320 --> 00:38:08,940
days later and then another one flew

886
00:38:14,870 --> 00:38:12,330
over several days later and then it took

887
00:38:16,730 --> 00:38:14,880
us several days to generate the the

888
00:38:19,339 --> 00:38:16,740

damage map we call those DPMS

889
00:38:23,210 --> 00:38:19,349
but that's the damage map but then for

890
00:38:25,640 --> 00:38:23,220
the for the September 19th magnitude 7.1

891
00:38:29,660 --> 00:38:25,650
earthquake that caused building damage

892
00:38:32,570 --> 00:38:29,670
in Mexico City there we were lucky the

893
00:38:35,270 --> 00:38:32,580
first over flight of a satellite after

894
00:38:36,740 --> 00:38:35,280
the earthquake was within 24 hours we

895
00:38:39,560 --> 00:38:36,750
were able to get the data and generate

896
00:38:41,630 --> 00:38:39,570
the damage proxy map and give it to the

897
00:38:43,820 --> 00:38:41,640
Mexico Mexico is equivalent of FEMA

898
00:38:48,109 --> 00:38:43,830
within 24 hours and they were able to

899
00:38:50,210 --> 00:38:48,119
use it for their disaster response so

900
00:38:52,579 --> 00:38:50,220
this is a this is an example or this is

901
00:38:55,460 --> 00:38:52,589
a close-up and an image of the damage

902
00:38:57,589 --> 00:38:55,470
proxy map that we generated for Mexico

903
00:39:00,410 --> 00:38:57,599
City earthquake and so you can see the

904
00:39:03,650 --> 00:39:00,420
little red dots are where we estimated

905
00:39:06,380 --> 00:39:03,660
there to be building damage so this was

906
00:39:09,829 --> 00:39:06,390
helpful for the Mexicans and Mexican

907
00:39:12,770 --> 00:39:09,839
equivalent of FEMA Sena pred to to find

908
00:39:14,630 --> 00:39:12,780
out where the buildings might be damaged

909
00:39:16,730 --> 00:39:14,640
not only within Mexico City but outside

910
00:39:20,450 --> 00:39:16,740
of Mexico City and helped with their

911
00:39:22,250 --> 00:39:20,460
resource allocation so at the same time

912
00:39:26,690 --> 00:39:22,260
there are a lot of hurricanes happening

913
00:39:29,070 --> 00:39:26,700

in the US and in Puerto Rico so we had

914
00:39:32,070 --> 00:39:29,080
we had a very active September

915
00:39:33,810 --> 00:39:32,080
years so there were flood maps generated

916
00:39:36,090 --> 00:39:33,820
we can actually use the radar to image

917
00:39:38,340 --> 00:39:36,100
floods I'm not going to talk about that

918
00:39:41,190 --> 00:39:38,350
tonight but we generated flood maps for

919
00:39:43,530 --> 00:39:41,200
Hurricane Harvey we generated a damage

920
00:39:45,120 --> 00:39:43,540
map for a hurricane Irma when it hit

921
00:39:47,460 --> 00:39:45,130
Florida because there the wind it was

922
00:39:49,950 --> 00:39:47,470
more wind damaged than water damage and

923
00:39:52,680 --> 00:39:49,960
then we generated a damage map for

924
00:39:55,440 --> 00:39:52,690
Puerto Rico after it was hit by

925
00:39:59,670 --> 00:39:55,450
Hurricane Maria and the Puerto Rican map

926
00:40:02,810 --> 00:39:59,680
was very useful for FEMA they were able

927
00:40:06,330 --> 00:40:02,820
to generate they turned our damage map

928
00:40:08,640 --> 00:40:06,340
into a damage density map that they were

929
00:40:11,520 --> 00:40:08,650
able to use again for planning purposes

930
00:40:14,670 --> 00:40:11,530
to see where the hotspots were where

931
00:40:16,920 --> 00:40:14,680
they needed to send their aid resources

932
00:40:18,900 --> 00:40:16,930
and where they should focus on in terms

933
00:40:23,700 --> 00:40:18,910
of getting more information about

934
00:40:27,020 --> 00:40:23,710
potential possible damage so I'm going

935
00:40:28,770 --> 00:40:27,030
to return to volcanoes for a little bit

936
00:40:31,280 --> 00:40:28,780
so we talked a little bit about

937
00:40:35,280 --> 00:40:31,290
volcanoes before but we've also been

938
00:40:37,530 --> 00:40:35,290

making progress with helping the USGS in

939
00:40:39,300 --> 00:40:37,540
the Kilauea volcano eruptions so we've

940
00:40:43,290 --> 00:40:39,310
been working with them providing them

941
00:40:45,600 --> 00:40:43,300
with some some interferogram some SAR in

942
00:40:47,690 --> 00:40:45,610
SAR data this is an example this is

943
00:40:51,270 --> 00:40:47,700
another one of these lovely fringe maps

944
00:40:53,760 --> 00:40:51,280
so this is actually an image and it's

945
00:40:55,320 --> 00:40:53,770
recognized I recognize this but it's the

946
00:40:59,580 --> 00:40:55,330
coastline of the Big Island of Hawaii

947
00:41:04,020 --> 00:40:59,590
here so helos up here the summit of

948
00:41:06,180 --> 00:41:04,030
kilauea would be over here and this is

949
00:41:08,190 --> 00:41:06,190
the area that this area down here is

950
00:41:10,920 --> 00:41:08,200
where all the lava flows have been

951
00:41:13,230 --> 00:41:10,930
occurring so there was magma that was

952
00:41:16,350 --> 00:41:13,240
pushed from the summit into the side of

953
00:41:19,020 --> 00:41:16,360
the volcano down to this area here and

954
00:41:21,450 --> 00:41:19,030
when the magma moves there it pushes the

955
00:41:23,760 --> 00:41:21,460
ground up and outwards and that's what

956
00:41:26,790 --> 00:41:23,770
we're seeing with this interferogram

957
00:41:28,890 --> 00:41:26,800
here with these fringes and so by this

958
00:41:31,200 --> 00:41:28,900
by using this view from space by having

959
00:41:34,320 --> 00:41:31,210
this view from space that helped the

960
00:41:37,890 --> 00:41:34,330
USGS understand what the extents of the

961
00:41:40,260 --> 00:41:37,900
magma motion was and the magma motion

962
00:41:42,540 --> 00:41:40,270
down here is really important because it

963
00:41:44,970 --> 00:41:42,550

is coming out to the surface

964
00:41:46,350 --> 00:41:44,980
and forming lava flows and destroying

965
00:41:48,630 --> 00:41:46,360
neighborhoods and destroying people's

966
00:41:50,700 --> 00:41:48,640
homes for a long time that a Kilauea

967
00:41:52,830 --> 00:41:50,710
eruption was a was kind of a friendly

968
00:41:54,390 --> 00:41:52,840
hazard that mostly the eruption was

969
00:41:57,690 --> 00:41:54,400
occurring within volcanoes national park

970
00:42:01,080 --> 00:41:57,700
but this past summer it has not been so

971
00:42:05,120 --> 00:42:01,090
friendly and that it's it's destroyed a

972
00:42:07,890 --> 00:42:05,130
lot of people's homes and neighborhoods

973
00:42:10,230 --> 00:42:07,900
so all these examples that I've been

974
00:42:12,000 --> 00:42:10,240
showing you have been part of a project

975
00:42:14,190 --> 00:42:12,010
that I mentioned at the beginning and

976
00:42:17,460 --> 00:42:14,200
with that was part of the intro called

977
00:42:20,070 --> 00:42:17,470
Aria Aria stands for advanced rapid

978
00:42:22,370 --> 00:42:20,080
imaging and analysis project so this was

979
00:42:26,310 --> 00:42:22,380
the project that we started a while ago

980
00:42:28,260 --> 00:42:26,320
because we as scientists would get asked

981
00:42:30,090 --> 00:42:28,270
for information when earthquakes and

982
00:42:32,330 --> 00:42:30,100
volcanic eruptions occurred and we

983
00:42:34,320 --> 00:42:32,340
realized that we should spend some time

984
00:42:36,770 --> 00:42:34,330
automating the way that we do our

985
00:42:40,110 --> 00:42:36,780
analysis so that we can provide

986
00:42:42,900 --> 00:42:40,120
information reliably and rapidly as

987
00:42:45,180 --> 00:42:42,910
possible to the people who need that

988
00:42:48,090 --> 00:42:45,190

information not just for science but for

989
00:42:51,210 --> 00:42:48,100
disaster response and also it motivated

990
00:42:54,300 --> 00:42:51,220
us to develop the maps like the damage

991
00:42:56,280 --> 00:42:54,310
maps so how can we use this data in a

992
00:42:57,660 --> 00:42:56,290
slightly different way that would be

993
00:42:59,730 --> 00:42:57,670
more useful for people who are

994
00:43:02,940 --> 00:42:59,740
interested in understanding where the

995
00:43:05,640 --> 00:43:02,950
damages as opposed to say the earthquake

996
00:43:08,970 --> 00:43:05,650
process or the volcanic process and so

997
00:43:11,760 --> 00:43:08,980
the Aria project has been been working

998
00:43:13,830 --> 00:43:11,770
on developing the processing systems the

999
00:43:16,860 --> 00:43:13,840
downloading the data automating the

1000
00:43:18,870 --> 00:43:16,870
download of the data and the processing

1001
00:43:20,910 --> 00:43:18,880
and then generating these research

1002
00:43:26,510 --> 00:43:20,920
projects sorry

1003
00:43:28,530 --> 00:43:26,520
research projects damage products and

1004
00:43:31,470 --> 00:43:28,540
we've been working with a lot of

1005
00:43:34,680 --> 00:43:31,480
partners over the years and this is an

1006
00:43:36,720 --> 00:43:34,690
ongoing project we're always looking for

1007
00:43:39,030 --> 00:43:36,730
ways to do things better

1008
00:43:42,060 --> 00:43:39,040
there's always another satellite that

1009
00:43:44,400 --> 00:43:42,070
we're trying to get into our automated

1010
00:43:45,960 --> 00:43:44,410
processing system but just in case you

1011
00:43:47,070 --> 00:43:45,970
think I've been talking for a really

1012
00:43:50,829 --> 00:43:47,080
long time about a lot of different

1013
00:43:53,649 --> 00:43:50,839

examples I actually cherry-picked

1014
00:43:55,719 --> 00:43:53,659
the examples of the events that we've

1015
00:43:58,179 --> 00:43:55,729
responded to and the product and the

1016
00:44:00,459 --> 00:43:58,189
areas that we've processed data over

1017
00:44:02,589 --> 00:44:00,469
some of these are disasters some of

1018
00:44:05,919 --> 00:44:02,599
these are floods a few of them are

1019
00:44:07,539 --> 00:44:05,929
actual science but for the most part you

1020
00:44:09,459 --> 00:44:07,549
know we've we've been working hard at

1021
00:44:11,949 --> 00:44:09,469
this for a number of years and we've

1022
00:44:14,890 --> 00:44:11,959
worked all over the globe in trying to

1023
00:44:18,630 --> 00:44:14,900
help with situational awareness for

1024
00:44:21,099 --> 00:44:18,640
these hazards and disaster response so

1025
00:44:24,099 --> 00:44:21,109
one thing that we're always trying to do

1026
00:44:26,229 --> 00:44:24,109
is to provide the data faster that's a

1027
00:44:29,529 --> 00:44:26,239
big reason for the Aria project to exist

1028
00:44:33,069 --> 00:44:29,539
is to get the information to the

1029
00:44:34,749 --> 00:44:33,079
disaster response agencies faster but as

1030
00:44:38,140 --> 00:44:34,759
I mentioned before the major limiting

1031
00:44:40,419 --> 00:44:38,150
factor is when the SAR satellite is

1032
00:44:43,839 --> 00:44:40,429
going to fly back over the area that

1033
00:44:45,909 --> 00:44:43,849
we're interested in and since the

1034
00:44:48,219 --> 00:44:45,919
Sentinel satellites have been launched

1035
00:44:51,549 --> 00:44:48,229
that's a set of SAR satellites that the

1036
00:44:53,199 --> 00:44:51,559
europeans launched it back in 2014 and

1037
00:44:55,779 --> 00:44:53,209
the second one in 2016

1038
00:44:57,880 --> 00:44:55,789

things have gotten really good much

1039
00:45:00,039 --> 00:44:57,890
better because it's the only SAR

1040
00:45:02,799 --> 00:45:00,049
satellite up there with free and open

1041
00:45:06,579 --> 00:45:02,809
data policy we've used data from these

1042
00:45:09,399 --> 00:45:06,589
other satellite missions the Italians

1043
00:45:14,949 --> 00:45:09,409
have a SAR satellite Japan has a star

1044
00:45:17,380 --> 00:45:14,959
satellite I Flags Germany does and

1045
00:45:20,789 --> 00:45:17,390
Canada and oddly enough for my

1046
00:45:23,529 --> 00:45:20,799
experience the Canadians have like the

1047
00:45:26,049 --> 00:45:23,539
tightest data policy we can get data

1048
00:45:29,890 --> 00:45:26,059
from the it from from the Aussie cosmos

1049
00:45:33,279 --> 00:45:29,900
sky Med and from Japan but but it's hard

1050
00:45:34,539 --> 00:45:33,289
to get radar set data and you know it's

1051
00:45:35,979 --> 00:45:34,549
not like they don't want to share their

1052
00:45:38,289 --> 00:45:35,989
data there's there's a lot of reasons

1053
00:45:40,299 --> 00:45:38,299
why they have closed data policies

1054
00:45:42,189 --> 00:45:40,309
they're not they're not being protective

1055
00:45:43,839 --> 00:45:42,199
it's it's the business model that they

1056
00:45:48,159 --> 00:45:43,849
have for launching star satellites our

1057
00:45:49,449 --> 00:45:48,169
satellites are really expensive but one

1058
00:45:52,479 --> 00:45:49,459
of the things you might have noticed is

1059
00:45:54,130 --> 00:45:52,489
that there isn't a NASA satellite up

1060
00:45:56,799 --> 00:45:54,140
here

1061
00:45:58,870 --> 00:45:56,809
all the star data and the star imagery

1062
00:46:04,090 --> 00:45:58,880
that I've been showing is actually not

1063
00:46:08,980 --> 00:46:04,100

from a NASA mission and that's coming up

1064
00:46:12,520 --> 00:46:08,990
so nice our which is the NASA is Rho is

1065
00:46:15,310 --> 00:46:12,530
Rho is the the Indian Space Agency nice

1066
00:46:17,890 --> 00:46:15,320
R is being built now they had one of

1067
00:46:22,480 --> 00:46:17,900
their major reviews this week and it's

1068
00:46:24,490 --> 00:46:22,490
being launched in 2022 which is seems

1069
00:46:28,870 --> 00:46:24,500
like it's far away but seems really

1070
00:46:30,490 --> 00:46:28,880
close for us and it's going to be free

1071
00:46:32,920 --> 00:46:30,500
and open data it's going to have a

1072
00:46:34,960 --> 00:46:32,930
12-day repeat which means because of the

1073
00:46:37,030 --> 00:46:34,970
way that the orbits work it means that

1074
00:46:41,050 --> 00:46:37,040
over a particular area we'll be able to

1075
00:46:43,810 --> 00:46:41,060
image it once every six days and so that

1076
00:46:45,550 --> 00:46:43,820
will help out a lot in us being able to

1077
00:46:47,620 --> 00:46:45,560
respond to these types of disasters

1078
00:46:49,270 --> 00:46:47,630
faster and that's another thing that Ari

1079
00:46:51,790 --> 00:46:49,280
is trying to do is basically to get

1080
00:46:54,340 --> 00:46:51,800
ready for nice R so that once this

1081
00:46:57,070 --> 00:46:54,350
launches we have everything in place to

1082
00:47:00,490 --> 00:46:57,080
take the data and be able to generate

1083
00:47:04,600 --> 00:47:00,500
the disaster response products and so

1084
00:47:07,630 --> 00:47:04,610
with that I want to say thank you to the

1085
00:47:11,320 --> 00:47:07,640
Aria team it's a large group of people

1086
00:47:14,260 --> 00:47:11,330
at JPL it's been a really fun group to

1087
00:47:16,030 --> 00:47:14,270
work with a lot of the there's a lot of

1088
00:47:20,140 --> 00:47:16,040

names here the photos here are people

1089
00:47:24,790 --> 00:47:20,150
who provided figures and an input to

1090
00:47:27,220 --> 00:47:24,800
this talk and I think that I will go to

1091
00:47:36,440 --> 00:47:27,230
the my last slide and we can open it up

1092
00:47:45,320 --> 00:47:40,760
oh I'm supposed to say if you do have

1093
00:47:53,420 --> 00:47:45,330
any questions please go up to the mic in

1094
00:47:55,700 --> 00:47:53,430
the middle so thank you Susan

1095
00:47:59,420 --> 00:47:55,710
the first question I have is to do that

1096
00:48:02,450 --> 00:47:59,430
high high resolution on the order of

1097
00:48:04,780 --> 00:48:02,460
millimeters interferometry I assume you

1098
00:48:08,090 --> 00:48:04,790
need precision orbit determination yes

1099
00:48:09,710 --> 00:48:08,100
so do you have the kinds of things that

1100
00:48:11,990 --> 00:48:09,720
we use on topics for example laser

1101
00:48:15,710 --> 00:48:12,000
rangefinders and all those kinds of

1102
00:48:19,700 --> 00:48:15,720
things that were used to get we're using

1103
00:48:21,380 --> 00:48:19,710
GPS to get the precision orbits or you

1104
00:48:22,790 --> 00:48:21,390
don't need the laser rangefinders that

1105
00:48:25,280 --> 00:48:22,800
topik said don't need the laser

1106
00:48:27,860 --> 00:48:25,290
rangefinders no GPS gives you a precise

1107
00:48:30,380 --> 00:48:27,870
enough orbit that's good the other

1108
00:48:32,650 --> 00:48:30,390
question is your your map of Pasadena

1109
00:48:35,150 --> 00:48:32,660
that showed you know the red dots yeah

1110
00:48:36,530 --> 00:48:35,160
the building permits Department want to

1111
00:48:39,280 --> 00:48:36,540
really go and look at all those red dots

1112
00:48:42,680 --> 00:48:39,290
and make sure people did pull permits

1113
00:48:46,310 --> 00:48:42,690

well I think what so what sang-ho did

1114
00:48:50,540 --> 00:48:46,320
was he was able to reverse geo locate so

1115
00:48:52,370 --> 00:48:50,550
he got addresses from the map and then

1116
00:48:55,550 --> 00:48:52,380
yeah he was able they were able to do

1117
00:48:57,320 --> 00:48:55,560
that well you're a researcher went and

1118
00:48:59,000 --> 00:48:57,330
looked at them a good pasadena wanted to

1119
00:49:00,620 --> 00:48:59,010
say hey that that red dot there if they

1120
00:49:02,240 --> 00:49:00,630
never pulled up early Oh could they want

1121
00:49:07,250 --> 00:49:02,250
to do that oh yeah okay sorry

1122
00:49:10,370 --> 00:49:07,260
that that question yeah we haven't we've

1123
00:49:13,690 --> 00:49:10,380
thought about that but sang-ho didn't go

1124
00:49:16,570 --> 00:49:13,700
to the Pasadena City Hall with the map

1125
00:49:20,260 --> 00:49:16,580
he went with with a list of addresses

1126
00:49:22,940 --> 00:49:20,270
and so so yeah they they didn't seem to

1127
00:49:25,400 --> 00:49:22,950
see this as an opportunity although we

1128
00:49:27,560 --> 00:49:25,410
have suggested that not you know amongst

1129
00:49:28,940 --> 00:49:27,570
ourselves we want to use this for

1130
00:49:39,470 --> 00:49:28,950
disasters we don't want people shutting

1131
00:49:45,500 --> 00:49:39,480
us down okay okay thank you so there's

1132
00:49:47,330 --> 00:49:45,510
questions from online sea with GPS data

1133
00:49:50,010 --> 00:49:47,340
can we detect changes in the shape of

1134
00:49:57,830 --> 00:49:50,020
the planet due to gravitational

1135
00:50:03,690 --> 00:50:00,750
due to gravitational variations as we

1136
00:50:05,010 --> 00:50:03,700
orbit so the best way I mean what I want

1137
00:50:07,050 --> 00:50:05,020
to say is the best way to detect

1138
00:50:08,550 --> 00:50:07,060

gravitational variations is with a

1139
00:50:10,850 --> 00:50:08,560
different satellite that we have for

1140
00:50:14,370 --> 00:50:10,860
measuring gravity which is called grace

1141
00:50:17,970 --> 00:50:14,380
and I'm trying to think of it we do sea

1142
00:50:20,790 --> 00:50:17,980
tides though in GPS so when you're

1143
00:50:22,920 --> 00:50:20,800
looking at GPS second-by-second you can

1144
00:50:26,280 --> 00:50:22,930
see tidal variations in the GPS so I'm

1145
00:50:29,460 --> 00:50:26,290
going to answer that one yes let's see

1146
00:50:32,790 --> 00:50:29,470
how can citizen scientists contribute to

1147
00:50:35,070 --> 00:50:32,800
mapping eg and Mexico City that's a good

1148
00:50:37,770 --> 00:50:35,080
question so often when we do these

1149
00:50:39,630 --> 00:50:37,780
damage maps we you know we post them

1150
00:50:40,710 --> 00:50:39,640
online there are some news stories we

1151
00:50:43,440 --> 00:50:40,720
give them to the disaster response

1152
00:50:46,740 --> 00:50:43,450
agencies and we get we actually get

1153
00:50:48,510 --> 00:50:46,750
emails from people saying that they're

1154
00:50:49,950 --> 00:50:48,520
trying to do their own you know they're

1155
00:50:51,870 --> 00:50:49,960
their citizen scientists and they're

1156
00:50:57,630 --> 00:50:51,880
very interested in the map

1157
00:51:01,650 --> 00:50:57,640
I think they're are trying to think now

1158
00:51:04,650 --> 00:51:01,660
if there's a good organization to send

1159
00:51:06,240 --> 00:51:04,660
you to off the top of my head I'm not

1160
00:51:09,300 --> 00:51:06,250
thinking about thinking of them but I

1161
00:51:12,210 --> 00:51:09,310
think there are some online groups that

1162
00:51:15,960 --> 00:51:12,220
are trying to coordinate damage mapping

1163
00:51:18,540 --> 00:51:15,970

I think Google actually sets up a site

1164
00:51:21,300 --> 00:51:18,550
for large disasters where they try and

1165
00:51:27,420 --> 00:51:21,310
collect information and so you might

1166
00:51:32,970 --> 00:51:27,430
check out Google does InSAR have a

1167
00:51:35,010 --> 00:51:32,980
maneuvering engine so let me see if I

1168
00:51:37,680 --> 00:51:35,020
can guess actually let me first let me

1169
00:51:39,600 --> 00:51:37,690
say that there is a picture of nice are

1170
00:51:43,200 --> 00:51:39,610
up here we actually also have a model a

1171
00:51:47,580 --> 00:51:43,210
scale model of nice are here so it does

1172
00:51:49,590 --> 00:51:47,590
have the ability to shift the way that

1173
00:51:51,930 --> 00:51:49,600
it's looking at the earth but in the

1174
00:51:54,540 --> 00:51:51,940
nice our orbital plan an observation

1175
00:51:56,970 --> 00:51:54,550
plan we're not planning on targeting it

1176
00:51:59,610 --> 00:51:56,980
so we're not planning on shifting it

1177
00:52:02,430 --> 00:51:59,620
back and forth so if a disaster happens

1178
00:52:05,190 --> 00:52:02,440
we're not going to task it

1179
00:52:08,819 --> 00:52:05,200
to change the way it's looking so that

1180
00:52:11,190 --> 00:52:08,829
it will image that disaster faster it

1181
00:52:16,859 --> 00:52:11,200
does not have the resources to do that

1182
00:52:19,410 --> 00:52:16,869
uh let's see another question can we no

1183
00:52:26,940 --> 00:52:19,420
wait wait can we use these techniques

1184
00:52:29,819 --> 00:52:26,950
for earthquakes within the ocean no in

1185
00:52:33,180 --> 00:52:29,829
SAR well let me put it this let me put

1186
00:52:36,390 --> 00:52:33,190
it slightly differently so so Tohoku was

1187
00:52:39,420 --> 00:52:36,400
an earthquake in the ocean it kurd

1188
00:52:41,520 --> 00:52:39,430

offshore the earthquakes down in Chile

1189
00:52:43,230 --> 00:52:41,530
there epicenters are usually offshore

1190
00:52:46,050 --> 00:52:43,240
and so if they're big enough and they

1191
00:52:50,940 --> 00:52:46,060
cause motion on land we can see the

1192
00:52:52,680 --> 00:52:50,950
earthquake in the ocean but we can't we

1193
00:52:54,059 --> 00:52:52,690
can't use it if it's like way out in the

1194
00:52:58,280 --> 00:52:54,069
middle of the ocean and it doesn't cause

1195
00:53:02,089 --> 00:52:58,290
any surface you know hard land to move

1196
00:53:05,730 --> 00:53:02,099
for GPS there is a technique called

1197
00:53:09,420 --> 00:53:05,740
seafloor GPS which I didn't talk about

1198
00:53:11,579 --> 00:53:09,430
but they put they put transponders down

1199
00:53:15,300 --> 00:53:11,589
on the bottom of the ocean and then they

1200
00:53:17,220 --> 00:53:15,310
use the GPS on a ship that goes over the

1201
00:53:19,470 --> 00:53:17,230
transponder and then they do repeat

1202
00:53:21,690 --> 00:53:19,480
surveys of the location of the

1203
00:53:24,690 --> 00:53:21,700
transponder and they can measure the

1204
00:53:27,150 --> 00:53:24,700
motion of the transponder on the ocean

1205
00:53:30,329 --> 00:53:27,160
floor so they can track the motion of

1206
00:53:33,000 --> 00:53:30,339
plates or that the crust the oceanic

1207
00:53:34,910 --> 00:53:33,010
crust that way and they actually have

1208
00:53:37,319 --> 00:53:34,920
these transponders off the shore of

1209
00:53:39,300 --> 00:53:37,329
Japan where they have fairly high rates

1210
00:53:42,270 --> 00:53:39,310
of motion and they've also tested them

1211
00:53:44,819 --> 00:53:42,280
off the shore of Pacific Northwest but

1212
00:53:46,079 --> 00:53:44,829
it's not really out in the middle of out

1213
00:53:48,750 --> 00:53:46,089

in the middle of the ocean so I think

1214
00:53:52,319 --> 00:53:48,760
that's that question and then that's it

1215
00:53:56,579 --> 00:53:52,329
so did you have one of the first

1216
00:54:00,839 --> 00:53:56,589
applications of synthetic aperture radar

1217
00:54:02,670 --> 00:54:00,849
was Magellan spacecraft well okay the

1218
00:54:07,650 --> 00:54:02,680
first time actually a planet has been

1219
00:54:11,400 --> 00:54:07,660
and after the first year the second year

1220
00:54:13,240 --> 00:54:11,410
we saw the differences and you can tell

1221
00:54:19,150 --> 00:54:13,250
the changes

1222
00:54:22,650 --> 00:54:19,160
that was back in 1980s no can you

1223
00:54:27,640 --> 00:54:22,660
quickly talk about the changes in the

1224
00:54:32,530 --> 00:54:27,650
technology and instrumentation from over

1225
00:54:36,730 --> 00:54:32,540
this thirty years because back then it

1226
00:54:40,510 --> 00:54:36,740
was we did the best we can do right yeah

1227
00:54:42,160 --> 00:54:40,520
well I know a lot of people who can

1228
00:54:45,069 --> 00:54:42,170
answer that in a lot greater detail but

1229
00:54:47,020 --> 00:54:45,079
in my eye I don't go all the way back to

1230
00:54:49,540 --> 00:54:47,030
Magellan but in the years that I've been

1231
00:54:52,030 --> 00:54:49,550
working with the InSAR scientists I'll

1232
00:54:54,819 --> 00:54:52,040
tell you you know what I've observed in

1233
00:54:56,770 --> 00:54:54,829
terms of our ability and the improvement

1234
00:55:01,410 --> 00:54:56,780
in the technology one of them it one of

1235
00:55:05,440 --> 00:55:01,420
the improvements is the ability to get

1236
00:55:08,230 --> 00:55:05,450
precise orbits and to have the satellite

1237
00:55:11,290 --> 00:55:08,240
track precisely that were a bit so in

1238
00:55:14,319 --> 00:55:11,300

the early days of the synthetic aperture

1239
00:55:18,370 --> 00:55:14,329
radar you you might get an image over

1240
00:55:21,190 --> 00:55:18,380
say la a repeat image overlay but the

1241
00:55:23,829 --> 00:55:21,200
satellite was so far it doesn't travel

1242
00:55:26,530 --> 00:55:23,839
and precisely the same path and if it's

1243
00:55:29,650 --> 00:55:26,540
too far away from the prior image the

1244
00:55:30,490 --> 00:55:29,660
baseline that they call it if that was

1245
00:55:32,819 --> 00:55:30,500
too long

1246
00:55:36,550 --> 00:55:32,829
you couldn't form an interferogram and

1247
00:55:38,380 --> 00:55:36,560
that happened a lot and so the number of

1248
00:55:42,280 --> 00:55:38,390
images that you could actually make

1249
00:55:45,130 --> 00:55:42,290
pairs from was much smaller now with

1250
00:55:48,520 --> 00:55:45,140
like with sentinel seems like every time

1251
00:55:49,900 --> 00:55:48,530
it's going over la you know that that

1252
00:55:52,300 --> 00:55:49,910
base line is going to be short enough

1253
00:55:54,099 --> 00:55:52,310
that you can form that image to make to

1254
00:55:56,589 --> 00:55:54,109
make the difference so that's the

1255
00:55:59,140 --> 00:55:56,599
biggest change that I've seen I know

1256
00:56:00,790 --> 00:55:59,150
that nice R has this sweep serve

1257
00:56:04,089 --> 00:56:00,800
technology that I'm not even going to

1258
00:56:06,940 --> 00:56:04,099
try to explain but it allows this

1259
00:56:09,130 --> 00:56:06,950
satellite to get a wide swath and yet

1260
00:56:10,960 --> 00:56:09,140
also still get fairly high resolution

1261
00:56:12,970 --> 00:56:10,970
because usually it's a trade-off between

1262
00:56:15,370 --> 00:56:12,980
you know the area that you're imaging

1263
00:56:18,099 --> 00:56:15,380

and the resolution that you can get was

1264
00:56:20,079 --> 00:56:18,109
the pixel size but with the sweeps are

1265
00:56:24,870 --> 00:56:20,089
technology they're able to get kind of

1266
00:56:31,500 --> 00:56:28,720
any other questions okay all right

1267
00:56:49,710 --> 00:56:31,510
well thank you everybody